

# Package ‘Luminescence’

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**Type** Package

**Title** Comprehensive Luminescence Dating Data Analysis

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**Description** A collection of various R functions for the purpose of Luminescence dating data analysis. This includes, amongst others, data import, export, application of age models, curve deconvolution, sequence analysis and plotting of equivalent dose distributions.

**Contact** Package Developers <[developers@r-luminescence.org](mailto:developers@r-luminescence.org)>

**License** GPL-3

**BugReports** <https://github.com/R-Lum/Luminescence/issues>

**Depends** R (>= 4.3),  
utils

**LinkingTo** Rcpp (>= 1.0.12),  
RcppArmadillo (>= 0.12.8.2.1)

**Imports** bbmle (>= 1.0.25.1),  
data.table (>= 1.15.4),  
DEoptim (>= 2.2-8),  
httr (>= 1.4.7),  
interp (>= 1.1-6),  
lamW (>= 2.2.3),  
matrixStats (>= 1.3.0),  
methods,  
minpack.lm (>= 1.2-4),  
mclust (>= 6.1),  
readxl (>= 1.4.3),  
Rcpp (>= 1.0.12),  
shape (>= 1.4.6),  
parallel,  
XML (>= 3.99-0.16),  
zoo (>= 1.8-12)

**Suggests** spelling (>= 2.3.0),  
plotly (>= 4.10.2),  
rmarkdown (>= 2.26),  
rstudioapi (>= 0.16.0),  
rjags (>= 4-15),  
coda (>= 0.19-4),  
pander (>= 0.6.5),  
testthat (>= 3.2.1),  
tiff (>= 0.1-12),  
devtools (>= 2.4.5),  
R.rsp (>= 0.46.0)

**VignetteBuilder** R.rsp

**URL** <https://CRAN.R-project.org/package=Luminescence>

**Encoding** UTF-8

**Language** en-US

**Collate** 'Analyse\_SAR.OSLdata.R'  
'CW2pHMi.R'  
'CW2pLM.R'  
'CW2pLMi.R'  
'CW2pPMi.R'  
'Luminescence-package.R'  
'PSL2Risoe.BINfileData.R'  
'RcppExports.R'  
'replicate\_RLum.R'  
'RLum-class.R'  
'smooth\_RLum.R'  
'names\_RLum.R'  
'structure\_RLum.R'  
'length\_RLum.R'  
'set\_RLum.R'  
'get\_RLum.R'  
'RLum.Analysis-class.R'

```

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'bin_RLum.Data.R'
'RLum.Data.Curve-class.R'
'RLum.Data.Image-class.R'
'RLum.Data.Spectrum-class.R'
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'analyse_Al2O3C_CrossTalk.R'
'analyse_Al2O3C_ITC.R'
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### **RoxygenNote 7.3.1**

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Luminescence-package    *Comprehensive Luminescence Dating Data Analysis*

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## Description

A collection of various R functions for the purpose of luminescence dating data analysis. This includes, amongst others, data import, export, application of age models, curve deconvolution, sequence analysis and plotting of equivalent dose distributions.

## Details

### Supervisor of the initial version in 2012

Markus Fuchs, Justus-Liebig-University Giessen, Germany

### Support contact

- <developers@r-luminescence.org>
- <https://github.com/R-Lum/Luminescence/discussions>

### Bug reporting

- <developers@r-luminescence.org> or
- <https://github.com/R-Lum/Luminescence/issues>

### Project website

- <https://r-luminescence.org>

### Project source code repository

- <https://github.com/R-Lum/Luminescence>

### Related package projects

- <https://cran.r-project.org/package=RLumShiny>
- <https://cran.r-project.org/package=RLumModel>



- <https://cran.r-project.org/package=RLumCarlo>
- <https://cran.r-project.org/package=RCarb>

### Funding

- 2011-2013: The initial version of the package was developed, while Sebastian Kreutzer was funded through the DFG programme "Rekonstruktion der Umweltbedingungen des Spätpleistozäns in Mittelsachsen anhand von Löss-Paläobodensequenzen" (DFG id: 46526743)
- 2014-2018: Cooperation and personal exchange between the developers is gratefully funded by the DFG (SCHM 3051/3-1) in the framework of the program "Scientific Networks". Project title: "RLum.Network: Ein Wissenschaftsnetzwerk zur Analyse von Lumineszenzdaten mit R" (2014-2018)
- 05/2014-12/2019: The work of Sebastian Kreutzer as maintainer of the package was supported by LabEx LaScArBx (ANR - n. ANR-10-LABX-52).
- 01/2020-04/2022: Sebastian Kreutzer as maintainer of the package has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 844457 (CREdit), and could continue maintaining the package.
- since 03/2023: Sebastian Kreutzer as maintainer of the package receives funding from the DFG Heisenberg programme No 505822867.
- All other authors gratefully received additional funding from various public funding bodies.

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## References

Dietze, M., Kreutzer, S., Fuchs, M.C., Burow, C., Fischer, M., Schmidt, C., 2013. A practical guide to the R package Luminescence. *Ancient TL*, 31 (1), 11-18.

Dietze, M., Kreutzer, S., Burow, C., Fuchs, M.C., Fischer, M., Schmidt, C., 2016. The abanico plot: visualising chronometric data with individual standard errors. *Quaternary Geochronology* 31, 1-7. <https://doi.org/10.1016/j.quageo.2015.09.003>

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Mercier, N., Kreutzer, S., Christophe, C., Guérin, G., Guibert, P., Lahaye, C., Lanos, P., Philippe, A., Tribolo, C., 2016. Bayesian statistics in luminescence dating: The 'baSAR'-model and its implementation in the R package 'Luminescence'. *Ancient TL* 34 (2), 14-21.

Mercier, N., Galharret, J.-M., Tribolo, C., Kreutzer, S., Philippe, A., 2022. Luminescence age calculation through Bayesian convolution of equivalent dose and dose-rate distributions: the De\_Dr model. *Geochronology* 4, 297–310. <https://doi.org/10.5194/gchron-4-297-2022>

Smedley, R.K., 2015. A new R function for the Internal External Uncertainty (IEU) model. *Ancient TL*, 33 (1), 16-21.

King, E.G., Burow, C., Roberts, H., Pearce, N.J.G., 2018. Age determination using feldspar: evaluating fading-correction model performance. *Radiation Measurements* 119, 58-73. <https://doi.org/10.1016/j.radmeas.2018>

## See Also

Useful links:

- <https://CRAN.R-project.org/package=Luminescence>
- Report bugs at <https://github.com/R-Lum/Luminescence/issues>

---

analyse\_Al2O3C\_CrossTalk

*Al2O3:C Reader Cross Talk Analysis*

---

## Description

The function provides the analysis of cross-talk measurements on a FI lexsy SMART reader using Al2O3:C chips

**Usage**

```
analyse_Al2O3C_CrossTalk(
  object,
  signal_integral = NULL,
  dose_points = c(0, 4),
  recordType = c("OSL (UVVIS)"),
  irradiation_time_correction = NULL,
  method_control = NULL,
  plot = TRUE,
  ...
)
```

**Arguments**

**object** [RLum.Analysis](#) (**required**): measurement input

**signal\_integral** [numeric](#) (*optional*): signal integral, used for the signal and the background. If nothing is provided the full range is used

**dose\_points** [numeric](#) (*with default*): vector with dose points, if dose points are repeated, only the general pattern needs to be provided. Default values follow the suggestions made by Kreutzer et al., 2018

**recordType** [character](#) (*with default*): input curve selection, which is passed to function [get\\_RLum](#). To deactivate the automatic selection set the argument to NULL

**irradiation\_time\_correction** [numeric](#) or [RLum.Results](#) (*optional*): information on the used irradiation time correction obtained by another experiments.

**method\_control** [list](#) (*optional*): optional parameters to control the calculation. See details for further explanations

**plot** [logical](#) (*with default*): enable/disable plot output

**...** further arguments that can be passed to the plot output

**Value**

Function returns results numerically and graphically:

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
\$data	data.frame	summed apparent dose table
\$data_full	data.frame	full apparent dose table
\$fit	lm	the linear model obtained from fitting
\$col.seq	numeric	the used colour vector

**slot:** @info

The original function call

---

[ PLOT OUTPUT ]

---

- An overview of the obtained apparent dose values

### Function version

0.1.3

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### References

Kreutzer, S., Martin, L., Guérin, G., Tribolo, C., Selva, P., Mercier, N., 2018. Environmental Dose Rate Determination Using a Passive Dosimeter: Techniques and Workflow for alpha-Al2O3:C Chips. *Geochronometria* 45, 56-67. doi: 10.1515/geochr-2015-0086

### See Also

[analyse\\_Al2O3C\\_ITC](#)

### Examples

```
##load data
data(ExampleData.Al2O3C, envir = environment())

##run analysis
analyse_Al2O3C_CrossTalk(data_CrossTalk)
```

---

analyse_Al2O3C_ITC	<i>Al2O3 Irradiation Time Correction Analysis</i>
--------------------	---

---

### Description

The function provides a very particular analysis to correct the irradiation time while irradiating Al2O3:C chips in a luminescence reader.

### Usage

```
analyse_Al2O3C_ITC(
  object,
  signal_integral = NULL,
  dose_points = c(2, 4, 8, 12, 16),
  recordType = c("OSL (UVVIS)"),
  method_control = NULL,
  verbose = TRUE,
```

```

    plot = TRUE,
    ...
)

```

### Arguments

object	<a href="#">RLum.Analysis</a> or <b>list (required)</b> : results obtained from the measurement. Alternatively a list of <a href="#">RLum.Analysis</a> objects can be provided to allow an automatic analysis
signal_integral	<a href="#">numeric</a> ( <i>optional</i> ): signal integral, used for the signal and the background. If nothing is provided the full range is used. Argument can be provided as <a href="#">list</a> .
dose_points	<a href="#">numeric</a> ( <i>with default</i> ): vector with dose points, if dose points are repeated, only the general pattern needs to be provided. Default values follow the suggestions made by Kreutzer et al., 2018. Argument can be provided as <a href="#">list</a> .
recordType	<a href="#">character</a> ( <i>with default</i> ): input curve selection, which is passed to function <a href="#">get_RLum</a> . To deactivate the automatic selection set the argument to NULL
method_control	<a href="#">list</a> ( <i>optional</i> ): optional parameters to control the calculation. See details for further explanations
verbose	<a href="#">logical</a> ( <i>with default</i> ): enable/disable verbose mode
plot	<a href="#">logical</a> ( <i>with default</i> ): enable/disable plot output
...	further arguments that can be passed to the plot output

### Details

Background: Due to their high dose sensitivity Al<sub>2</sub>O<sub>3</sub>:C chips are usually irradiated for only a very short duration or under the closed beta-source within a luminescence reader. However, due to its high dose sensitivity, during the movement towards the beta-source, the pellet already receives and non-negligible dose. Based on measurements following a protocol suggested by Kreutzer et al., 2018, a dose response curve is constructed and the intersection (absolute value) with the time axis is taken as real irradiation time.

method\_control

To keep the generic argument list as clear as possible, arguments to allow a deeper control of the method are all preset with meaningful default parameters and can be handled using the argument method\_control only, e.g., method\_control = list(fit.method = "LIN"). Supported arguments are:

ARGUMENT	FUNCTION	DESCRIPTION
mode	plot_GrowthCurve	as in <a href="#">plot_GrowthCurve</a> ; sets the mode used for fitting
fit.method	plot_GrowthCurve	as in <a href="#">plot_GrowthCurve</a> ; sets the function applied for fitting

### Value

Function returns results numerically and graphically:

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
\$data	data.frame	correction value and error
\$table	data.frame	table used for plotting
\$table_mean	data.frame	table used for fitting
\$fit	lm or nls	the fitting as returned by the function <a href="#">plot_GrowthCurve</a>

**slot:** @info

The original function call

---

[ PLOT OUTPUT ]

---

- A dose response curve with the marked correction values

### Function version

0.1.1

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### References

Kreutzer, S., Martin, L., Guérin, G., Tribolo, C., Selva, P., Mercier, N., 2018. Environmental Dose Rate Determination Using a Passive Dosimeter: Techniques and Workflow for alpha-Al2O3:C Chips. *Geochronometria* 45, 56-67. doi: 10.1515/geochr-2015-0086

### See Also

[plot\\_GrowthCurve](#)

### Examples

```
##load data
data(ExampleData.Al2O3C, envir = environment())

##run analysis
analyse_Al2O3C_ITC(data_ITC)
```

---

analyse\_Al2O3C\_Measurement

*Al2O3:C Passive Dosimeter Measurement Analysis*


---

## Description

The function provides the analysis routines for measurements on a FI lexsyg SMART reader using Al2O3:C chips according to Kreutzer et al., 2018

## Usage

```
analyse_Al2O3C_Measurement(
  object,
  signal_integral = NULL,
  dose_points = c(0, 4),
  recordType = c("OSL (UVVIS)", "TL (UVVIS)"),
  calculate_TL_dose = FALSE,
  irradiation_time_correction = NULL,
  cross_talk_correction = NULL,
  travel_dosimeter = NULL,
  test_parameters = NULL,
  verbose = TRUE,
  plot = TRUE,
  ...
)
```

## Arguments

object	<b>RLum.Analysis (required)</b> : measurement input
signal_integral	<b>numeric (optional)</b> : signal integral, used for the signal and the background. Example: <code>c(1:10)</code> for the first 10 channels. If nothing is provided the full range is used
dose_points	<b>numeric (with default)</b> : vector with dose points, if dose points are repeated, only the general pattern needs to be provided. Default values follow the suggestions made by Kreutzer et al., 2018
recordType	<b>character (with default)</b> : input curve selection, which is passed to function <code>get_RLum</code> . To deactivate the automatic selection set the argument to NULL
calculate_TL_dose	<b>logical (with default)</b> : Enables/disables experimental dose estimation based on the TL curves. Taken is the ratio of the peak sums of each curves +/- 5 channels.
irradiation_time_correction	<b>numeric or RLum.Results (optional)</b> : information on the used irradiation time correction obtained by another experiments. If a numeric is provided it has to be of length two: mean, standard error
cross_talk_correction	<b>numeric or RLum.Results (optional)</b> : information on the used irradiation time correction obtained by another experiments. If a numeric vector is provided it has to be of length three: mean, 2.5 % quantile, 97.5 % quantile.

`travel_dosimeter` **numeric** (*optional*): specify the position of the travel dosimeter (so far measured a the same time). The dose of travel dosimeter will be subtracted from all other values.

`test_parameters` **list** (*with default*): set test parameters. Supported parameters are: `TL_peak_shift`  
All input: **numeric** values, NA and NULL (s. Details)

`verbose` **logical** (*with default*): enable/disable verbose mode

`plot` **logical** (*with default*): enable/disable plot output, if object is of type **list**, a **numeric** vector can be provided to limit the plot output to certain aliquots

`...` further arguments that can be passed to the plot output, supported are `norm`, `main`, `mtext`, `title` (for self-call mode to specify, e.g., sample names)

## Details

### Working with a travel dosimeter

The function allows to define particular aliquots as travel dosimeters. For example: `travel_dosimeter = c(1, 3, 5)` sets aliquots 1, 3 and 5 as travel dosimeters. These dose values of this dosimeters are combined and automatically subtracted from the obtained dose values of the other dosimeters.

### Calculate TL dose

The argument `calculate_TL_dose` provides the possibility to experimentally calculate a TL-dose, i.e. an apparent dose value derived from the TL curve ratio. However, it should be noted that this value is only a fall back in case something went wrong during the measurement of the optical stimulation. The TL derived dose value is corrected for cross-talk and for the irradiation time, but not considered if a travel dosimeter is defined.

Calculating the palaeodose is possible without **any TL** curve in the sequence!

### Test parameters

`TL_peak_shift` **numeric** (default: 15):

Checks whether the TL peak shift is bigger > 15 K, indicating a problem with the thermal contact of the chip.

`stimulation_power` **numeric** (default: 0.05):

So far available, information on the delivered optical stimulation are compared. Compared are the information from the first curves with all others. If the ratio differs more from unity than the defined by the threshold, a warning is returned.

## Value

Function returns results numerically and graphically:

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
<code>\$data</code>	<code>data.frame</code>	the estimated equivalent dose
<code>\$data_table</code>	<code>data.frame</code>	full dose and signal table



test_parameters	data.frame	results with test parameters
data_TDcorrected	data.frame	travel dosimeter corrected results (only if TD was provided)

*Note: If correction the irradiation time and the cross-talk correction method is used, the De values in the table data table are already corrected, i.e. if you want to get an uncorrected value, you can use the column CT\_CORRECTION remove the correction*

**slot:** @info

The original function call

---

[ PLOT OUTPUT ]

---

- OSL and TL curves, combined on two plots.

## Function version

0.2.6

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## References

Kreutzer, S., Martin, L., Guérin, G., Tribolo, C., Selva, P., Mercier, N., 2018. Environmental Dose Rate Determination Using a Passive Dosimeter: Techniques and Workflow for alpha-Al2O3:C Chips. *Geochronometria* 45, 56-67.

## See Also

[analyse\\_Al2O3C\\_ITC](#)

## Examples

```
##load data
data(ExampleData.AL203C, envir = environment())

##run analysis
analyse_Al203C_Measurement(data_CrossTalk)
```

analyse\_baSAR

*Bayesian models (baSAR) applied on luminescence data*

## Description

This function allows the application of Bayesian models on luminescence data, measured with the single-aliquot regenerative-dose (SAR, Murray and Wintle, 2000) protocol. In particular, it follows the idea proposed by Combès et al., 2015 of using an hierarchical model for estimating a central equivalent dose from a set of luminescence measurements. This function is (I) the adoption of this approach for the R environment and (II) an extension and a technical refinement of the published code.

## Usage

```
analyse_baSAR(
  object,
  XLS_file = NULL,
  aliquot_range = NULL,
  source_doserate = NULL,
  signal.integral,
  signal.integral.Tx = NULL,
  background.integral,
  background.integral.Tx = NULL,
  irradiation_times = NULL,
  sigmab = 0,
  sig0 = 0.025,
  distribution = "cauchy",
  baSAR_model = NULL,
  n.MCMC = 1e+05,
  fit.method = "EXP",
  fit.force_through_origin = TRUE,
  fit.includingRepeatedRegPoints = TRUE,
  method_control = list(),
  digits = 3L,
  distribution_plot = "kde",
  plot = TRUE,
  plot_reduced = TRUE,
  plot.single = FALSE,
  verbose = TRUE,
  ...
)
```

## Arguments

**object** [Risoe.BINfileData](#), [RLum.Results](#), [list](#) of [RLum.Analysis](#), [character](#) or [list](#) (**required**): input object used for the Bayesian analysis. If a character is provided the function assumes a file connection and tries to import a BIN/BINX-file using the provided path. If a list is provided the list can only contain either [Risoe.BINfileData](#) objects or characters providing a file connection. Mixing of both types is not allowed. If an [RLum.Results](#) is provided the function directly starts with the Bayesian Analysis (see details)

XLS_file	<b>character</b> ( <i>optional</i> ): XLS_file with data for the analysis. This file must contain 3 columns: the name of the file, the disc position and the grain position (the last being 0 for multi-grain measurements). Alternatively a data.frame of similar structure can be provided.
aliquot_range	<b>numeric</b> ( <i>optional</i> ): allows to limit the range of the aliquots used for the analysis. This argument has only an effect if the argument XLS_file is used or the input is the previous output (i.e. is <a href="#">RLum.Results</a> ). In this case the new selection will add the aliquots to the removed aliquots table.
source_doserate	<b>numeric</b> ( <b>required</b> ): source dose rate of beta-source used for the measurement and its uncertainty in Gy/s, e.g., source_doserate = c(0.12, 0.04). Parameter can be provided as list, for the case that more than one BIN-file is provided, e.g., source_doserate = list(c(0.04, 0.004), c(0.05, 0.004)).
signal.integral	<b>vector</b> ( <b>required</b> ): vector with the limits for the signal integral used for the calculation, e.g., signal.integral = c(1:5). Ignored if object is an <a href="#">RLum.Results</a> object. The parameter can be provided as list, see source_doserate.
signal.integral.Tx	<b>vector</b> ( <i>optional</i> ): vector with the limits for the signal integral for the Tx curve. If nothing is provided the value from signal.integral is used and it is ignored if object is an <a href="#">RLum.Results</a> object. The parameter can be provided as list, see source_doserate.
background.integral	<b>vector</b> ( <b>required</b> ): vector with the bounds for the background integral. Ignored if object is an <a href="#">RLum.Results</a> object. The parameter can be provided as list, see source_doserate.
background.integral.Tx	<b>vector</b> ( <i>optional</i> ): vector with the limits for the background integral for the Tx curve. If nothing is provided the value from background.integral is used. Ignored if object is an <a href="#">RLum.Results</a> object. The parameter can be provided as list, see source_doserate.
irradiation_times	<b>numeric</b> ( <i>optional</i> ): if set this vector replaces all irradiation times for one aliquot and one cycle (Lx and Tx curves) and recycles it for all others cycles and aliquots. Please note that if this argument is used, for every(!) single curve in the dataset an irradiation time needs to be set.
sigmab	<b>numeric</b> ( <i>with default</i> ): option to set a manual value for the overdispersion (for LnTx and TnTx), used for the Lx/Tx error calculation. The value should be provided as absolute squared count values, cf. <a href="#">calc_OSLLxTxRatio</a> . The parameter can be provided as list, see source_doserate.
sig0	<b>numeric</b> ( <i>with default</i> ): allow adding an extra component of error to the final Lx/Tx error value (e.g., instrumental error, see details is <a href="#">calc_OSLLxTxRatio</a> ). The parameter can be provided as list, see source_doserate.
distribution	<b>character</b> ( <i>with default</i> ): type of distribution that is used during Bayesian calculations for determining the Central dose and overdispersion values. Allowed inputs are "cauchy", "normal" and "log_normal".
baSAR_model	<b>character</b> ( <i>optional</i> ): option to provide an own modified or new model for the Bayesian calculation (see details). If an own model is provided the argument distribution is ignored and set to 'user_defined'

n.MCMC	<b>integer</b> ( <i>with default</i> ): number of iterations for the Markov chain Monte Carlo (MCMC) simulations
fit.method	<b>character</b> ( <i>with default</i> ): equation used for the fitting of the dose-response curve using the function <code>plot_GrowthCurve</code> and then for the Bayesian modelling. Here supported methods: EXP, EXP+LIN and LIN
fit.force_through_origin	<b>logical</b> ( <i>with default</i> ): force fitting through origin
fit.includingRepeatedRegPoints	<b>logical</b> ( <i>with default</i> ): includes the recycling point (assumed to be measured during the last cycle)
method_control	<b>list</b> ( <i>optional</i> ): named list of control parameters that can be directly passed to the Bayesian analysis, e.g., <code>method_control = list(n.chains = 4)</code> . See details for further information
digits	<b>integer</b> ( <i>with default</i> ): round output to the number of given digits
distribution_plot	<b>character</b> ( <i>with default</i> ): sets the final distribution plot that shows equivalent doses obtained using the frequentist approach and sets in the central dose as comparison obtained using baSAR. Allowed input is 'abanico' or 'kde'. If set to NULL nothing is plotted.
plot	<b>logical</b> ( <i>with default</i> ): enables or disables plot output
plot_reduced	<b>logical</b> ( <i>with default</i> ): enables or disables the advanced plot output
plot.single	<b>logical</b> ( <i>with default</i> ): enables or disables single plots or plots arranged by <code>analyse_baSAR</code>
verbose	<b>logical</b> ( <i>with default</i> ): enables or disables verbose mode
...	parameters that can be passed to the function <code>calc_OSLLxTxRatio</code> (almost full support), <code>readxl::read_excel</code> (full support), <code>read_BIN2R</code> (n.records, position, duplicated.rm), see details.

## Details

Internally the function consists of two parts: (I) The Bayesian core for the Bayesian calculations and applying the hierarchical model and (II) a data pre-processing part. The Bayesian core can be run independently, if the input data are sufficient (see below). The data pre-processing part was implemented to simplify the analysis for the user as all needed data pre-processing is done by the function, i.e. in theory it is enough to provide a BIN/BINX-file with the SAR measurement data. For the Bayesian analysis for each aliquot the following information are needed from the SAR analysis. LxTx, the LxTx error and the dose values for all regeneration points.

### How the systematic error contribution is calculated?

Standard errors (so far) provided with the source dose rate are considered as systematic uncertainties and added to final central dose by:

$$systematic.error = 1/n \sum SE(source.doserate)$$

$$SE(central.dose.final) = \sqrt{SE(central.dose)^2 + systematic.error^2}$$

Please note that this approach is rather rough and can only be valid if the source dose rate errors, in case different readers had been used, are similar. In cases where more than one source dose rate is provided a warning is given.

### Input / output scenarios

Various inputs are allowed for this function. Unfortunately this makes the function handling rather complex, but at the same time very powerful. Available scenarios:

#### (1) - object is BIN-file or link to a BIN-file

Finally it does not matter how the information of the BIN/BINX file are provided. The function supports **(a)** either a path to a file or directory or a list of file names or paths or **(b)** a [Risoe.BINfileData](#) object or a list of these objects. The latter one can be produced by using the function [read\\_BIN2R](#), but this function is called automatically if only a file name and/or a path is provided. In both cases it will become the data that can be used for the analysis.

[XLS\_file = NULL]

If no XLS file (or data frame with the same format) is provided the functions runs an automatic process that consists of the following steps:

1. Select all valid aliquots using the function [verify\\_SingleGrainData](#)
2. Calculate Lx/Tx values using the function [calc\\_OSLLxTxRatio](#)
3. Calculate De values using the function [plot\\_GrowthCurve](#)

These proceeded data are subsequently used in for the Bayesian analysis

[XLS\_file != NULL]

If an XLS-file is provided or a data.frame providing similar information the pre-processing steps consists of the following steps:

1. Calculate Lx/Tx values using the function [calc\\_OSLLxTxRatio](#)
2. Calculate De values using the function [plot\\_GrowthCurve](#)

Means, the XLS file should contain a selection of the BIN-file names and the aliquots selected for the further analysis. This allows a manual selection of input data, as the automatic selection by [verify\\_SingleGrainData](#) might be not totally sufficient.

#### (2) - object RLum.Results object

If an [RLum.Results](#) object is provided as input and(!) this object was previously created by the function `analyse_baSAR()` itself, the pre-processing part is skipped and the function starts directly the Bayesian analysis. This option is very powerful as it allows to change parameters for the Bayesian analysis without the need to repeat the data pre-processing. If furthermore the argument `aliquot_range` is set, aliquots can be manually excluded based on previous runs.

`method_control`

These are arguments that can be passed directly to the Bayesian calculation core, supported arguments are:

Parameter	Type	Description
<code>lower_centralD</code>	numeric	sets the lower bound for the expected De range. Change it only if you know what you are
<code>upper_centralD</code>	numeric	sets the upper bound for the expected De range. Change it only if you know what you are
<code>n.chains</code>	integer	sets number of parallel chains for the model (default = 3) (cf. <a href="#">rjags::jags.model</a> )
<code>inits</code>	list	option to set initialisation values (cf. <a href="#">rjags::jags.model</a> )
<code>thin</code>	numeric	thinning interval for monitoring the Bayesian process (cf. <a href="#">rjags::jags.model</a> )
<code>variable.names</code>	character	set the variables to be monitored during the MCMC run, default: 'central_D', 'sigma_L

### User defined models

The function provides the option to modify and to define own models that can be used for the Bayesian calculation. In the case the user wants to modify a model, a new model can be piped into

the function via the argument `baSAR_model` as character. The model has to be provided in the JAGS dialect of the BUGS language (cf. [rjags::jags.model](#)) and parameter names given with the pre-defined names have to be respected, otherwise the function will break.

### FAQ

Q: How can I set the seed for the random number generator (RNG)?

A: Use the argument `method_control`, e.g., for three MCMC chains (as it is the default):

```
method_control = list(
  inits = list(
    list(.RNG.name = "base::Wichmann-Hill", .RNG.seed = 1),
    list(.RNG.name = "base::Wichmann-Hill", .RNG.seed = 2),
    list(.RNG.name = "base::Wichmann-Hill", .RNG.seed = 3)
  ))
```

This sets a reproducible set for every chain separately.

Q: How can I modify the output plots?

A: You can't, but you can use the function output to create own, modified plots.

Q: Can I change the boundaries for the central\_D?

A: Yes, we made it possible, but we DO NOT recommend it, except you know what you are doing!

Example: `method_control = list(lower_centralD = 10)`

Q: The lines in the baSAR-model appear to be in a wrong logical order?

A: This is correct and allowed (cf. JAGS manual)

### Additional arguments support via the ... argument

This list summarizes the additional arguments that can be passed to the internally used functions.

Supported argument	Corresponding function	Default	**Short description **
<code>threshold</code>	<a href="#">verify_SingleGrainData</a>	30	change rejection threshold for curve
<code>sheet</code>	<a href="#">readxl::read_excel</a>	1	select XLS-sheet for import
<code>col_names</code>	<a href="#">readxl::read_excel</a>	TRUE	first row in XLS-file is header
<code>col_types</code>	<a href="#">readxl::read_excel</a>	NULL	limit import to specific columns
<code>skip</code>	<a href="#">readxl::read_excel</a>	0	number of rows to be skipped during
<code>n.records</code>	<a href="#">read_BIN2R</a>	NULL	limit records during BIN-file import
<code>duplicated.rm</code>	<a href="#">read_BIN2R</a>	TRUE	remove duplicated records in the B
<code>pattern</code>	<a href="#">read_BIN2R</a>	TRUE	select BIN-file by name pattern
<code>position</code>	<a href="#">read_BIN2R</a>	NULL	limit import to a specific position
<code>background.count.distribution</code>	<a href="#">calc_OSLLxTxRatio</a>	"non-poisson"	set assumed count distribution
<code>fit.weights</code>	<a href="#">plot_GrowthCurve</a>	TRUE	enables / disables fit weights
<code>fit.bounds</code>	<a href="#">plot_GrowthCurve</a>	TRUE	enables / disables fit bounds
<code>NumberIterations.MC</code>	<a href="#">plot_GrowthCurve</a>	100	number of MC runs for error calcul
<code>output.plot</code>	<a href="#">plot_GrowthCurve</a>	TRUE	enables / disables dose response cu
<code>output.plotExtended</code>	<a href="#">plot_GrowthCurve</a>	TRUE	enables / disables extended dose re

### Value

Function returns results numerically and graphically:

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
\$summary	data.frame	statistical summary, including the central dose
\$mcmc	mcmc	<a href="#">coda::mcmc.list</a> object including raw output
\$models	character	implemented models used in the baSAR-model core
\$input_object	data.frame	summarising table (same format as the XLS-file) including, e.g., Lx/Tx values
\$removed_aliquots	data.frame	table with removed aliquots (e.g., NaN, or Inf Lx/Tx values). If nothing was removed

**slot:** @info

The original function call

---

[ PLOT OUTPUT ]

---

- (A) Ln/Tn curves with set integration limits,
- (B) trace plots are returned by the baSAR-model, showing the convergence of the parameters (trace) and the resulting kernel density plots. If `plot_reduced = FALSE` for every(!) dose a trace and a density plot is returned (this may take a long time),
- (C) dose plots showing the dose for every aliquot as boxplots and the marked HPD in within. If boxes are coloured 'orange' or 'red' the aliquot itself should be checked,
- (D) the dose response curve resulting from the monitoring of the Bayesian modelling are provided along with the Lx/Tx values and the HPD. Note: The amount for curves displayed is limited to 1000 (random choice) for performance reasons,
- (E) the final plot is the De distribution as calculated using the conventional (frequentist) approach and the central dose with the HPDs marked within. This figure is only provided for a comparison, no further statistical conclusion should be drawn from it.

**Please note: If distribution was set to `log_normal` the central dose is given as geometric mean!**

### Function version

0.1.33

### Note

**If you provide more than one BIN-file**, it is **strongly** recommended to provide a list with the same number of elements for the following parameters:

`source_doserate`, `signal.integral`, `signal.integral.Tx`, `background.integral`, `background.integral.Tx`, `sigmab`, `sig0`.

Example for two BIN-files: `source_doserate = list(c(0.04, 0.006), c(0.05, 0.006))`

**The function is currently limited to work with standard Risoe BIN-files only!**

**Author(s)**

Norbert Mercier, IRAMAT-CRP2A, Université Bordeaux Montaigne (France)  
 Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 The underlying Bayesian model based on a contribution by Combès et al., 2015. , RLum Developer Team

**References**

Combès, B., Philippe, A., Lanos, P., Mercier, N., Tribolo, C., Guerin, G., Guibert, P., Lahaye, C., 2015. A Bayesian central equivalent dose model for optically stimulated luminescence dating. *Quaternary Geochronology* 28, 62-70. doi:10.1016/j.quageo.2015.04.001

Mercier, N., Kreutzer, S., Christophe, C., Guerin, G., Guibert, P., Lahaye, C., Lanos, P., Philippe, A., Tribolo, C., 2016. Bayesian statistics in luminescence dating: The 'baSAR'-model and its implementation in the R package 'Luminescence'. *Ancient TL* 34, 14-21.

**Further reading**

Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., Rubin, D.B., 2013. *Bayesian Data Analysis*, Third Edition. CRC Press.

Murray, A.S., Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32, 57-73. doi:10.1016/S1350-4487(99)00253-X

Plummer, M., 2017. JAGS Version 4.3.0 user manual. <https://sourceforge.net/projects/mcmc-jags/files/Manual/>

**See Also**

[read\\_BIN2R](#), [calc\\_OSLLxTxRatio](#), [plot\\_GrowthCurve](#), [readxl::read\\_excel](#), [verify\\_SingleGrainData](#), [rjags::jags.model](#), [rjags::coda.samples](#), [boxplot.default](#)

**Examples**

```
##(1) load package test data set
data(ExampleData.BINfileData, envir = environment())

##(2) selecting relevant curves, and limit dataset
CWOSL.SAR.Data <- subset(
  CWOSL.SAR.Data,
  subset = POSITION%in%c(1:3) & LTYPE == "OSL")

## Not run:
##(3) run analysis
##please not that the here selected parameters are
##chosen for performance, not for reliability
results <- analyse_baSAR(
  object = CWOSL.SAR.Data,
  source_doserate = c(0.04, 0.001),
  signal.integral = c(1:2),
  background.integral = c(80:100),
  fit.method = "LIN",
  plot = FALSE,
  n.MCMC = 200
)

print(results)
```



```
##XLS_file template
##copy and paste this the code below in the terminal
##you can further use the function write.csv() to export the example

XLS_file <-
structure(
list(
BIN_FILE = NA_character_,
DISC = NA_real_,
GRAIN = NA_real_),
.Names = c("BIN_FILE", "DISC", "GRAIN"),
class = "data.frame",
row.names = 1L
)

## End(Not run)
```

---

```
analyse_FadingMeasurement
```

*Analyse fading measurements and returns the fading rate per decade  
(g-value)*

---

## Description

The function analysis fading measurements and returns a fading rate including an error estimation. The function is not limited to standard fading measurements, as can be seen, e.g., Huntley and Lamothe (2001). Additionally, the density of recombination centres ( $\rho$ ) is estimated after Kars et al. (2008).

## Usage

```
analyse_FadingMeasurement(
  object,
  structure = c("Lx", "Tx"),
  signal.integral,
  background.integral,
  t_star = "half",
  n.MC = 100,
  verbose = TRUE,
  plot = TRUE,
  plot.single = FALSE,
  ...
)
```

## Arguments

**object** [RLum.Analysis \(required\)](#): input object with the measurement data. Alternatively, a [list](#) containing [RLum.Analysis](#) objects or a [data.frame](#) with three

columns ( $x = LxTx$ ,  $y = LxTx$  error,  $z =$  time since irradiation) can be provided. Can also be a wide table, i.e. a `data.frame` with a number of columns divisible by 3 and where each triplet has the before mentioned column structure.

**Please note: The input object should solely consists of the curve needed for the data analysis, i.e. only IRSL curves representing  $Lx$  (and  $Tx$ )**

If data from multiple aliquots are provided please see the details below with regard to  $Lx/Tx$  normalisation. **The function assumes that all your measurements are related to one (comparable) sample. If you to treat independent samples, you have use this function in a loop.**

structure	<b>character</b> (with default): sets the structure of the measurement data. Allowed are 'Lx' or c('Lx', 'Tx'). Other input is ignored
signal.integral	<b>vector (required)</b> : vector with channels for the signal integral (e.g., c(1:10)). Not required if a <code>data.frame</code> with $LxTx$ values is provided.
background.integral	<b>vector (required)</b> : vector with channels for the background integral (e.g., c(90:100)). Not required if a <code>data.frame</code> with $LxTx$ values is provided.
t_star	<b>character</b> (with default): method for calculating the time elapsed since irradiation if input is <b>not</b> a <code>data.frame</code> . Options are: 'half' (the default), 'half_complex', which uses the long equation in Auclair et al. 2003, and 'end', which takes the time between irradiation and the measurement step. Alternatively, <code>t_star</code> can be a function with one parameter which works on <code>t1</code> . For more information see details.  <i>t_star has no effect if the input is a <code>data.frame</code>, because this input comes without irradiation times.</i>
n.MC	<b>integer</b> (with default): number for Monte Carlo runs for the error estimation
verbose	<b>logical</b> (with default): enables/disables verbose mode
plot	<b>logical</b> (with default): enables/disables plot output
plot.single	<b>logical</b> (with default): enables/disables single plot mode, i.e. one plot window per plot. Alternatively a vector specifying the plot to be drawn, e.g., <code>plot.single = c(3,4)</code> draws only the last two plots
...	(optional) further arguments that can be passed to internally used functions. Supported arguments: <code>xlab</code> , <code>log</code> , <code>mtext</code> and <code>xlim</code> for the two first curve plots, and <code>ylim</code> for the fading curve plot. For further plot customization please use the numerical output of the functions for own plots.

## Details

All provided output corresponds to the  $t_c$  value obtained by this analysis. Additionally in the output object the g-value normalised to 2-days is provided. The output of this function can be passed to the function `calc_FadingCorr`.

### Fitting and error estimation

For the fitting the function `stats::lm` is used without applying weights. For the error estimation all input values, except  $t_c$ , as the precision can be considered as sufficiently high enough with regard to the underlying problem, are sampled assuming a normal distribution for each value with the value as the mean and the provided uncertainty as standard deviation.

### The options for `t_star`

- `t_star = "half"` (the default) The calculation follows the simplified version in Auclair et al. (2003), which reads

$$t_{star} := t_1 + (t_2 - t_1)/2$$

- `t_star = "half_complex"` This option applies the complex function shown in Auclair et al. (2003), which is derived from Aitken (1985) appendix F, equations 9 and 11. It reads

$$t_{star} = t_0 * 10^{[(t_2 \log(t_2/t_0) - t_1 \log(t_1/t_0) - 0.43(t_2 - t_1))/(t_2 - t_1)]}$$

where  $0.43 = 1/\ln(10)$ .  $t_0$ , which is an arbitrary constant, is set to 1. Please note that the equation in Auclair et al. (2003) is incorrect insofar that it reads  $10\exp(\dots)$ , where the base should be 10 and not the Euler's number. Here we use the correct version (base 10).

- `t_star = "end"` This option uses the simplest possible form for `t_star` which is the time since irradiation without taking into account any addition parameter and it equals `t1` in Auclair et al. (2003)
- `t_star = <function>` This last option allows you to provide an R function object that works on `t1` and gives you all possible freedom. For instance, you may want to define the following function `fun <- function(x) {x^2}`, this would square all values of `t1`, because internally it calls `fun(t1)`. The name of the function does not matter.

### Density of recombination centres

The density of recombination centres, expressed by the dimensionless variable  $\rho'$ , is estimated by fitting equation 5 in Kars et al. 2008 to the data. For the fitting the function `stats::nls` is used without applying weights. For the error estimation the same procedure as for the g-value is applied (see above).

### Multiple aliquots & Lx/Tx normalisation

Be aware that this function will always normalise all  $Lx/Tx$  values by the  $Lx/Tx$  value of the prompt measurement of the first aliquot. This implicitly assumes that there are no systematic inter-aliquot variations in the  $Lx/Tx$  values. If deemed necessary to normalise the  $Lx/Tx$  values of each aliquot by its individual prompt measurement please do so **before** running `analyse_FadingMeasurement` and provide the already normalised values for object instead.

**Shine-down curve plots** Please note that the shine-down curve plots are for information only. As such not all pause steps are plotted to avoid graphically overloaded plots. However, *all* pause times are taken into consideration for the analysis.

### Value

An `RLum.Results` object is returned:

Slot: **@data**

OBJECT	TYPE	COMMENT
<code>fading_results</code>	<code>data.frame</code>	results of the fading measurement in a table
<code>fit</code>	<code>lm</code>	object returned by the used linear fitting function <code>stats::lm</code>
<code>rho_prime</code>	<code>data.frame</code>	results of $\rho'$ estimation after Kars et al. (2008)
<code>LxTx_table</code>	<code>data.frame</code>	$Lx/Tx$ table, if curve data had been provided
<code>irr.times</code>	<code>integer</code>	vector with the irradiation times in seconds

Slot: **@info**

OBJECT	TYPE	COMMENT
--------	------	---------

call      call    the original function call

### Function version

0.1.21

### Author(s)

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Christoph Burow, University of Cologne (Germany) , RLum Developer Team

### References

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### See Also

[calc\\_OSLLxTxRatio](#), [read\\_BIN2R](#), [read\\_XSYG2R](#), [extract\\_IrradiationTimes](#), [calc\\_FadingCorr](#)

### Examples

```
## load example data (sample UNIL/NB123, see ?ExampleData.Fading)
data("ExampleData.Fading", envir = environment())

##(1) get fading measurement data (here a three column data.frame)
fading_data <- ExampleData.Fading$fading.data$IR50

##(2) run analysis
g_value <- analyse_FadingMeasurement(
  fading_data,
  plot = TRUE,
  verbose = TRUE,
  n.MC = 10)

##(3) this can be further used in the function
## to correct the age according to Huntley & Lamothe, 2001
results <- calc_FadingCorr(
  age.faded = c(100,2),
  g_value = g_value,
  n.MC = 10)
```

analyse\_IRSAR.RF

*Analyse IRSAR RF measurements*

## Description

Function to analyse IRSAR RF measurements on K-feldspar samples, performed using the protocol according to Erfurt et al. (2003) and beyond.

## Usage

```
analyse_IRSAR.RF(
  object,
  sequence_structure = c("NATURAL", "REGENERATED"),
  RF_nat.lim = NULL,
  RF_reg.lim = NULL,
  method = "FIT",
  method.control = NULL,
  test_parameters = NULL,
  n.MC = 10,
  txtProgressBar = TRUE,
  plot = TRUE,
  plot_reduced = FALSE,
  ...
)
```

## Arguments

- |                    |  |
|--------------------|--|
| object             | <a href="#">RLum.Analysis</a> or a <a href="#">list</a> of <a href="#">RLum.Analysis</a> -objects ( <b>required</b> ): input object containing data for protocol analysis. The function expects to find at least two curves in the <a href="#">RLum.Analysis</a> object: (1) RF_nat, (2) RF_reg. If a list is provided as input all other parameters can be provided as list as well to gain full control. |
| sequence_structure | <a href="#">vector character</a> ( <i>with default</i> ): specifies the general sequence structure. Allowed steps are NATURAL, REGENERATED. In addition any other character is allowed in the sequence structure; such curves will be ignored during the analysis.   |
| RF_nat.lim         | <a href="#">vector</a> ( <i>with default</i> ): set minimum and maximum channel range for natural signal fitting and sliding. If only one value is provided this will be treated as minimum value and the maximum limit will be added automatically.   |
| RF_reg.lim         | <a href="#">vector</a> ( <i>with default</i> ): set minimum and maximum channel range for regenerated signal fitting and sliding. If only one value is provided this will be treated as minimum value and the maximum limit will be added automatically.   |
| method             | <a href="#">character</a> ( <i>with default</i> ): select method applied for the data analysis. Possible options are "FIT", "SLIDE", "VSLIDE".   |
| method.control     | <a href="#">list</a> ( <i>optional</i> ): parameters to control the method, that can be passed to the chosen method. These are for (1) method = "FIT": 'trace', 'maxiter', 'warnOnly', 'minFactor' and for (2) method = "SLIDE": 'correct_onset', 'show_density', 'show_fit', 'trace'. See details.  |

**test\_parameters**

**list** (*with default*): set test parameters. Supported parameters are: `curves_ratio`, `residuals_slope` (only for `method = "SLIDE"`), `curves_bounds`, `dynamic_ratio`, `lambda`, `beta` and `delta.phi`. All input: **numeric** values, NA and NULL (s. Details)

(see Details for further information)

**n.MC**

**numeric** (*with default*): set number of Monte Carlo runs for start parameter estimation (`method = "FIT"`) or error estimation (`method = "SLIDE"`). This value can be set to NULL to skip the MC runs. Note: Large values will significantly increase the computation time

**txtProgressBar**

**logical** (*with default*): enables TRUE or disables FALSE the progression bar during MC runs

**plot**

**logical** (*with default*): plot output (TRUE or FALSE)

**plot\_reduced**

**logical** (*optional*): provides a reduced plot output if enabled to allow common R plot combinations, e.g., `par(mfrow(...))`. If TRUE no residual plot is returned; it has no effect if `plot = FALSE`

**...**

further arguments that will be passed to the plot output. Currently supported arguments are `main`, `xlab`, `ylab`, `xlim`, `ylim`, `log`, `legend` (TRUE/FALSE), `legend.pos`, `legend.text` (passes argument to `x,y` in `graphics::legend`), `xaxt`

**Details**

The function performs an IRSAR analysis described for K-feldspar samples by Erfurt et al. (2003) assuming a negligible sensitivity change of the RF signal.

**General Sequence Structure** (according to Erfurt et al., 2003)

1. Measuring IR-RF intensity of the natural dose for a few seconds ( $RF_{nat}$ )
2. Bleach the samples under solar conditions for at least 30 min without changing the geometry
3. Waiting for at least one hour
4. Regeneration of the IR-RF signal to at least the natural level (measuring ( $RF_{reg}$ ))
5. Fitting data with a stretched exponential function
6. Calculate the the palaeodose  $D_e$  using the parameters from the fitting

Actually two methods are supported to obtain the  $D_e$ : `method = "FIT"` and `method = "SLIDE"`:

`method = "FIT"`

The principle is described above and follows the original suggestions by Erfurt et al., 2003. For the fitting the mean count value of the `RF_nat` curve is used.

Function used for the fitting (according to Erfurt et al. (2003)):

$$\phi(D) = \phi_0 - \Delta\phi(1 - \exp(-\lambda * D))^{\beta}$$

with  $\phi(D)$  the dose dependent IR-RF flux,  $\phi_0$  the initial IR-RF flux,  $\Delta\phi$  the dose dependent change of the IR-RF flux,  $\lambda$  the exponential parameter,  $D$  the dose and  $\beta$  the dispersive factor.

To obtain the palaeodose  $D_e$  the function is changed to:

$$D_e = \ln(-(\phi(D) - \phi_0)/(-\lambda * \phi)^{1/\beta} + 1)/-\lambda$$

The fitting is done using the port algorithm of the **nls** function.

method = "SLIDE"

For this method, the natural curve is slid along the x-axis until congruence with the regenerated curve is reached. Instead of fitting this allows working with the original data without the need for any physical model. This approach was introduced for RF curves by Buylaert et al., 2012 and Lapp et al., 2012.

Here the sliding is done by searching for the minimum of the squared residuals. For the mathematical details of the implementation see Frouin et al., 2017

method = "VSLIDE"

Same as "SLIDE" but searching also vertically for the best match (i.e. in xy-direction.) See Kreutzer et al. (2017) and Murari et al. (2021). By default the vertical sliding range will be set to "auto" (see method.control). This setting can be still changed with method.control.

method.control

To keep the generic argument list as clear as possible, arguments to control the methods for De estimation are all pre set with meaningful default parameters and can be handled using the argument method.control only, e.g., method.control = list(trace = TRUE). Supported arguments are:

ARGUMENT	METHOD	DESCRIPTION
trace	FIT, SLIDE or VSLIDE	as in <a href="#">nls</a> ; shows sum of squared residuals
trace_vslide	SLIDE or VSLIDE	<a href="#">logical</a> argument to enable or disable the tracing of the vertical sliding
maxiter	FIT	as in <a href="#">nls</a>
warnOnly	FIT	as in <a href="#">nls</a>
minFactor	FIT	as in <a href="#">nls</a>
correct_onset	SLIDE or VSLIDE	The logical argument shifts the curves along the x-axis by the first channel, as
show_density	SLIDE or VSLIDE	<a href="#">logical</a> ( <i>with default</i> ) enables or disables KDE plots for MC run results. If the
show_fit	SLIDE or VSLIDE	<a href="#">logical</a> ( <i>with default</i> ) enables or disables the plot of the fitted curve routinely c
n.MC	SLIDE or VSLIDE	<a href="#">integer</a> ( <i>with default</i> ): This controls the number of MC runs within the sliding
vslide_range	SLIDE or VSLIDE	<a href="#">logical</a> or <a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): This argument sets the boundar
cores	SLIDE or VSLIDE	number or character ( <i>with default</i> ): set number of cores to be allocated for a

### Error estimation

For method = "FIT" the asymmetric error range is obtained by using the 2.5 % (lower) and the 97.5 % (upper) quantiles of the  $RF_{nat}$  curve for calculating the  $D_e$  error range.

For method = "SLIDE" the error is obtained by bootstrapping the residuals of the slid curve to construct new natural curves for a Monte Carlo simulation. The error is returned in two ways: (a) the standard deviation of the herewith obtained  $D_e$  from the MC runs and (b) the confidence interval using the 2.5 % (lower) and the 97.5 % (upper) quantiles. The results of the MC runs are returned with the function output.

### Test parameters

The argument test\_parameters allows to pass some thresholds for several test parameters, which will be evaluated during the function run. If a threshold is set and it will be exceeded the test parameter status will be set to "FAILED". Intentionally this parameter is not termed 'rejection criteria' as not all test parameters are evaluated for both methods and some parameters are calculated by not evaluated by default. Common for all parameters are the allowed argument options NA and NULL. If the parameter is set to NA the value is calculated but the result will not be evaluated, means it has no effect on the status ("OK" or "FAILED") of the parameter. Setting the parameter to NULL disables the parameter entirely and the parameter will be also removed from the function output. This might be useful in cases where a particular parameter asks for long computation times. Currently supported parameters are:

curves\_ratio [numeric](#) (default: 1.001):

The ratio of  $RF_{nat}$  over  $RF_{reg}$  in the range of  $RF_{nat}$  of is calculated and should not exceed the threshold value.

intersection\_ratio **numeric** (default: NA):

Calculated as absolute difference from 1 of the ratio of the integral of the normalised RF-curves. This value indicates intersection of the RF-curves and should be close to 0 if the curves have a similar shape. For this calculation first the corresponding time-count pair value on the RF\_reg curve is obtained using the maximum count value of the RF\_nat curve and only this segment (fitting to the RF\_nat curve) on the RF\_reg curve is taken for further calculating this ratio. If nothing is found at all, Inf is returned.

residuals\_slope **numeric** (default: NA; only for method = "SLIDE"):

A linear function is fitted on the residuals after sliding. The corresponding slope can be used to discard values as a high (positive, negative) slope may indicate that both curves are fundamentally different and the method cannot be applied at all. Per default the value of this parameter is calculated but not evaluated.

curves\_bounds **numeric** (default:  $\max(RF_{reg\_counts})$ ):

This measure uses the maximum time (x) value of the regenerated curve. The maximum time (x) value of the natural curve cannot be larger than this value. However, although this is not recommended the value can be changed or disabled.

dynamic\_ratio **numeric** (default: NA):

The dynamic ratio of the regenerated curve is calculated as ratio of the minimum and maximum count values.

lambda, beta and delta.phi **numeric** (default: NA; method = "SLIDE"):

The stretched exponential function suggested by Erfurt et al. (2003) describing the decay of the RF signal, comprises several parameters that might be useful to evaluate the shape of the curves. For method = "FIT" this parameter is obtained during the fitting, for method = "SLIDE" a rather rough estimation is made using the function `minpack.lm::nlsLM` and the equation given above. Note: As this procedure requests more computation time, setting of one of these three parameters to NULL also prevents a calculation of the remaining two.

## Value

The function returns numerical output and an (*optional*) plot.

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

[.. \$data : data.frame]

Column	Type	Description
DE	numeric	the obtained equivalent dose
DE.ERROR	numeric	(only method = "SLIDE") standard deviation obtained from MC runs
DE.LOWER	numeric	2.5% quantile for De values obtained by MC runs
DE.UPPER	numeric	97.5% quantile for De values obtained by MC runs
DE.STATUS	character	test parameter status
RF_NAT.LIM	character	used RF_nat curve limits
RF_REG.LIM	character	used RF_reg curve limits



POSITION	integer	( <i>optional</i> ) position of the curves
DATE	character	( <i>optional</i> ) measurement date
SEQUENCE_NAME	character	( <i>optional</i> ) sequence name
UID	character	unique data set ID

```
[.. $De.MC : numeric]
```

A numeric vector with all the De values obtained by the MC runs.

```
[.. $test_parameters : data.frame]
```

Column	Type	Description
POSITION	numeric	aliquot position
PARAMETER	character	test parameter name
THRESHOLD	numeric	set test parameter threshold value
VALUE	numeric	the calculated test parameter value (to be compared with the threshold)
STATUS	character	test parameter status either "OK" or "FAILED"
SEQUENCE_NAME	character	name of the sequence, so far available
UID	character	unique data set ID

```
[.. $fit : data.frame]
```

An [nls](#) object produced by the fitting.

```
[.. $slide : list]
```

A [list](#) with data produced during the sliding. Some elements are previously reported with the summary object data. List elements are:

Element	Type	Description
De	numeric	the final De obtained with the sliding approach
De.MC	numeric	all De values obtained by the MC runs
residuals	numeric	the obtained residuals for each channel of the curve
trend.fit	lm	fitting results produced by the fitting of the residuals
RF_nat.slid	matrix	the slid RF_nat curve
t_n.id	numeric	the index of the t_n offset
I_n	numeric	the vertical intensity offset if a vertical slide was applied
algorithm_error	numeric	the vertical sliding suffers from a systematic effect induced by the used algorithm. The
vslide_range	numeric	the range used for the vertical sliding
squared_residuals	numeric	the squared residuals (horizontal sliding)

**slot:** @info

The original function call ([methods::language-object](#))

The output (data) should be accessed using the function [get\\_RLum](#)

---

```
[ PLOT OUTPUT ]
```

---

The slid IR-RF curves with the finally obtained De

## Function version

0.7.10

**Note**

This function assumes that there is no sensitivity change during the measurements (natural vs. regenerated signal), which is in contrast to the findings by Buylaert et al. (2012).

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

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- \*\* Further reading\*\***
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**See Also**

[RLum.Analysis](#), [RLum.Results](#), [get\\_RLum](#), [nls](#), [minpack.lm::nlsLM](#), [parallel::mclapply](#)

**Examples**

```
##load data
data(ExampleData.RLum.Analysis, envir = environment())

##(1) perform analysis using the method 'FIT'
results <- analyse_IRSAR.RF(object = IRSAR.RF.Data)

##show De results and test paramter results
get_RLum(results, data.object = "data")
get_RLum(results, data.object = "test_parameters")

##(2) perform analysis using the method 'SLIDE'
results <- analyse_IRSAR.RF(object = IRSAR.RF.Data, method = "SLIDE", n.MC = 1)

## Not run:
##(3) perform analysis using the method 'SLIDE' and method control option
## 'trace'
results <- analyse_IRSAR.RF(
  object = IRSAR.RF.Data,
  method = "SLIDE",
  method.control = list(trace = TRUE))

## End(Not run)
```

---

analyse\_pIRIRSequence *Analyse post-IR IRSL measurement sequences*

---

**Description**

The function performs an analysis of post-IR IRSL sequences including curve fitting on [RLum.Analysis](#) objects.

**Usage**

```
analyse_pIRIRSequence(
  object,
  signal.integral.min,
  signal.integral.max,
  background.integral.min,
  background.integral.max,
  dose.points = NULL,
  sequence.structure = c("TL", "IR50", "pIRIR225"),
  plot = TRUE,
  plot.single = FALSE,
  ...
)
```

## Arguments

object	<a href="#">RLum.Analysis</a> or <a href="#">list</a> of <a href="#">RLum.Analysis</a> objects ( <b>required</b> ): input object containing data for analysis. If a <a href="#">list</a> is provided the functions tries to iterate over the list.
signal.integral.min	<a href="#">integer</a> ( <b>required</b> ): lower bound of the signal integral. Provide this value as vector for different integration limits for the different IRSL curves.
signal.integral.max	<a href="#">integer</a> ( <b>required</b> ): upper bound of the signal integral. Provide this value as vector for different integration limits for the different IRSL curves.
background.integral.min	<a href="#">integer</a> ( <b>required</b> ): lower bound of the background integral. Provide this value as vector for different integration limits for the different IRSL curves.
background.integral.max	<a href="#">integer</a> ( <b>required</b> ): upper bound of the background integral. Provide this value as vector for different integration limits for the different IRSL curves.
dose.points	<a href="#">numeric</a> ( <i>optional</i> ): a numeric vector containing the dose points values. Using this argument overwrites dose point values in the signal curves.
sequence.structure	<a href="#">vector character</a> ( <i>with default</i> ): specifies the general sequence structure. Allowed values are "TL" and any "IR" combination (e.g., "IR50", "pIRIR225"). Additionally a parameter "EXCLUDE" is allowed to exclude curves from the analysis (Note: If a preheat without PMT measurement is used, i.e. preheat as none TL, remove the TL step.)
plot	<a href="#">logical</a> ( <i>with default</i> ): enables or disables plot output.
plot.single	<a href="#">logical</a> ( <i>with default</i> ): single plot output (TRUE/FALSE) to allow for plotting the results in single plot windows. Requires plot = TRUE.
...	further arguments that will be passed to the function <a href="#">analyse_SAR.CWOSL</a> and <a href="#">plot_GrowthCurve</a> . Furthermore, the arguments main (headers), log (IRSL curves), cex (control the size) and mtext.outer (additional text on the plot area) can be passed to influence the plotting. If the input is list, main can be passed as <a href="#">vector</a> or <a href="#">list</a> .

## Details

To allow post-IR IRSL protocol (Thomsen et al., 2008) measurement analyses this function has been written as extended wrapper function for the function [analyse\\_SAR.CWOSL](#), facilitating an entire sequence analysis in one run. With this, its functionality is strictly limited by the functionality of the function [analyse\\_SAR.CWOSL](#).

### Defining the sequence structure

The argument `sequence.structure` expects a shortened pattern of your sequence structure and was mainly introduced to ease the use of the function. For example: If your measurement data contains the following curves: TL, IRSL, IRSL, TL, IRSL, IRSL, the sequence pattern in `sequence.structure` becomes `c('TL', 'IRSL', 'IRSL')`. The second part of your sequence for one cycle should be similar and can be discarded. If this is not the case (e.g., additional hotbleach) such curves have to be removed before using the function.

### If the input is a list

If the input is a list of [RLum.Analysis](#)-objects, every argument can be provided as list to allow for different sets of parameters for every single input element. For further information see [analyse\\_SAR.CWOSL](#).

**Value**

Plots (*optional*) and an [RLum.Results](#) object is returned containing the following elements:

DATA.OBJECT	TYPE	DESCRIPTION
..\$data :	data.frame	Table with De values
..\$LnLxTnTx.table :	data.frame	with the LnLxTnTx values
..\$rejection.criteria :	<a href="#">data.frame</a>	rejection criteria
..\$Formula :	<a href="#">list</a>	Function used for fitting of the dose response curve
..\$call :	<a href="#">call</a>	the original function call

The output should be accessed using the function [get\\_RLum](#).

**Function version**

0.2.4

**Note**

Best graphical output can be achieved by using the function pdf with the following options:

```
pdf(file = "<YOUR FILENAME>", height = 15, width = 15)
```

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Murray, A.S., Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32, 57-73. doi:10.1016/S13504487(99)00253-X

Thomsen, K.J., Murray, A.S., Jain, M., Boetter-Jensen, L., 2008. Laboratory fading rates of various luminescence signals from feldspar-rich sediment extracts. *Radiation Measurements* 43, 1474-1486. doi:10.1016/j.radmeas.2008.06.002

**See Also**

[analyse\\_SAR.CWOSL](#), [calc\\_OSLLxTxRatio](#), [plot\\_GrowthCurve](#), [RLum.Analysis](#), [RLum.Results](#), [get\\_RLum](#)

**Examples**

```
### NOTE: For this example existing example data are used. These data are non pIRIR data.
###
##(1) Compile example data set based on existing example data (SAR quartz measurement)
##(a) Load example data
data(ExampleData.BINfileData, envir = environment())

##(b) Transform the values from the first position in a RLum.Analysis object
object <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos=1)

##(c) Grep curves and exclude the last two (one TL and one IRSL)
```

```

object <- get_RLum(object, record.id = c(-29,-30))

##(d) Define new sequence structure and set new RLum.Analysis object
sequence.structure <- c(1,2,2,3,4,4)
sequence.structure <- as.vector(sapply(seq(0,length(object)-1,by = 4),
                                     function(x){sequence.structure + x}))

object <- sapply(1:length(sequence.structure), function(x){
  object[[sequence.structure[x]]]
})

object <- set_RLum(class = "RLum.Analysis", records = object, protocol = "pIRIR")

##(2) Perform pIRIR analysis (for this example with quartz OSL data!)
## Note: output as single plots to avoid problems with this example
results <- analyse_pIRIRSequence(object,
  signal.integral.min = 1,
  signal.integral.max = 2,
  background.integral.min = 900,
  background.integral.max = 1000,
  fit.method = "EXP",
  sequence.structure = c("TL", "pseudoIRSL1", "pseudoIRSL2"),
  main = "Pseudo pIRIR data set based on quartz OSL",
  plot.single = TRUE)

##(3) Perform pIRIR analysis (for this example with quartz OSL data!)
## Alternative for PDF output, uncomment and complete for usage
## Not run:
tempfile <- tempfile(fileext = ".pdf")
pdf(file = tempfile, height = 15, width = 15)
results <- analyse_pIRIRSequence(object,
  signal.integral.min = 1,
  signal.integral.max = 2,
  background.integral.min = 900,
  background.integral.max = 1000,
  fit.method = "EXP",
  main = "Pseudo pIRIR data set based on quartz OSL")

dev.off()

## End(Not run)

```

---

analyse\_portableOSL     *Analyse portable CW-OSL measurements*

---

## Description

The function analyses CW-OSL curve data produced by a SUERC portable OSL reader and produces a combined plot of OSL/IRSL signal intensities, OSL/IRSL depletion ratios and the IRSL/OSL ratio.

## Usage

```
analyse_portableOSL(
  object,
  signal.integral = NULL,
  invert = FALSE,
  normalise = FALSE,
  mode = "profile",
  coord = NULL,
  plot = TRUE,
  ...
)
```

## Arguments

object	<b>RLum.Analysis (required)</b> : <a href="#">RLum.Analysis</a> object produced by <a href="#">read_PSL2R</a> . The input can be a <a href="#">list</a> of such objects, in such case each input is treated as a separate sample and the results are merged.
signal.integral	<b>numeric (required)</b> : A vector of two values specifying the lower and upper channel used to calculate the OSL/IRSL signal. Can be provided in form of <code>c(1, 5)</code> or <code>1:5</code> .
invert	<b>logical (with default)</b> : TRUE flip the plot the data in reverse order.
normalise	<b>logical (with default)</b> : TRUE to normalise the OSL/IRSL signals to the <i>mean</i> of all corresponding data curves.
mode	<b>character (with default)</b> : defines the analysis mode, allowed are "profile" (the default) and "surface" for surface interpolation. If you select something else, nothing will be plotted (similar to <code>plot = FALSE</code> ).
coord	<b>list matrix (optional)</b> : a list or matrix of the same length as number of samples measured with coordinates for the sampling positions. Coordinates are expected to be provided in meter (unit: m). Expected are x and y coordinates, e.g., <code>coord = list(samp1 = c(0.1, 0.2))</code> . If you have not measured x coordinates, please x should be 0.
plot	<b>logical (with default)</b> : enable/disable plot output
...	other parameters to be passed to modify the plot output. Supported are run to provide the run name, if the input is a list, this is set automatically. Further plot parameters are <code>surface_values</code> ( <b>character</b> with value to plot), <code>legend</code> (TRUE/FALSE), <code>col_ramp</code> (for surface mode), <code>contour</code> (contour lines TRUE/FALSE in surface mode), <code>grid</code> (TRUE/FALSE), <code>col</code> , <code>pch</code> (for profile mode), <code>xlim</code> (a name <a href="#">list</a> for profile mode), <code>ylim</code> , <code>zlim</code> (surface mode only), <code>ylab</code> , <code>xlab</code> , <code>zlab</code> (here x-axis labelling), <code>main</code> , <code>bg_img</code> (for profile mode background image, usually a profile photo; should be a raster object), <code>bg_img_positions</code> (a vector with the four corner positions, cf. <a href="#">graphics::rasterImage</a> )

## Details

This function only works with [RLum.Analysis](#) objects produced by [read\\_PSL2R](#). It further assumes (or rather requires) an equal amount of OSL and IRSL curves that are pairwise combined for calculating the IRSL/OSL ratio. For calculating the depletion ratios the cumulative signal of the last `n` channels (same number of channels as specified by `signal.integral`) is divided by cumulative signal of the first `n` channels (`signal.integral`).

**Note: The function assumes the following sequence pattern:** DARK COUNT, IRSL, DARK COUNT, BSL, DARK COUNT. **If you have written a different sequence, the analysis function will (likely) not work!.**

**Signal processing** The function processes the signals as follows: BSL and IRSL signals are extracted using the chosen signal integral, dark counts are taken in full.

**Working with coordinates** Usually samples are taken from a profile with a certain stratigraphy. In the past the function calculated an index. With this newer version, you have two options of passing on xy-coordinates to the function:

- (1) Add coordinates to the sample name during measurement. The form is rather strict and has to follow the scheme `_x:<number>|y:<number>`. Example: `sample_x:0.2|y:0.4`.
- (2) Alternatively, you can provide a [list](#) or [matrix](#) with the sample coordinates. Example: `coord = list(c(0.2, 1), c(0.3, 1.2))`

Please note that the unit is meter (m) and the function expects always xy-coordinates. The latter one is useful for surface interpolations. If you have measured a profile where the x-coordinates to not measure, x-coordinates should be 0.

## Value

Returns an S4 [RLum.Results](#) object with the following elements:

```
$data
.. $summary: data.frame with the results
.. $data: list with the RLum.Analysis objects
.. $args: list the input arguments
```

## Function version

0.1.0

## Author(s)

Christoph Burow, University of Cologne (Germany), Sebastian Kreutzer, Institute of Geography, Ruprecht-Karl University of Heidelberg, Germany , [RLum Developer Team](#)

## See Also

[RLum.Analysis](#), [RLum.Data.Curve](#), [read\\_PSL2R](#)

## Examples

```
## example profile plot
# (1) load example data set
data("ExampleData.portableOSL", envir = environment())

# (2) merge and plot all RLum.Analysis objects
merged <- merge_RLum(ExampleData.portableOSL)
plot_RLum(
  object = merged,
  combine = TRUE,
  records_max = 5,
  legend.pos = "outside")
merged
```



```
# (3) analyse and plot
results <- analyse_portableOSL(
  merged,
  signal.integral = 1:5,
  invert = FALSE,
  normalise = TRUE)
get_RLum(results)
```

---

analyse_SAR.CWOSL	<i>Analyse SAR CW-OSL measurements</i>
-------------------	--

---

## Description

The function performs a SAR CW-OSL analysis on an [RLum.Analysis](#) object including growth curve fitting.

## Usage

```
analyse_SAR.CWOSL(
  object,
  signal.integral.min = NA,
  signal.integral.max = NA,
  background.integral.min = NA,
  background.integral.max = NA,
  OSL.component = NULL,
  rejection.criteria = list(),
  dose.points = NULL,
  trim_channels = FALSE,
  mtext.outer = "",
  plot = TRUE,
  plot_onePage = FALSE,
  plot.single = FALSE,
  onlyLxTxTable = FALSE,
  ...
)
```

## Arguments

object	<a href="#">RLum.Analysis</a> ( <b>required</b> ): input object containing data for analysis, alternatively a <a href="#">list</a> of <a href="#">RLum.Analysis</a> objects can be provided. The object should contain <b>only</b> curves considered part of the SAR protocol (see Details.)
signal.integral.min	<a href="#">integer</a> ( <b>required</b> ): lower bound of the signal integral. Can be a <a href="#">list</a> of <a href="#">integers</a> , if object is of type <a href="#">list</a> . If the input is vector (e.g., <code>c(1, 2)</code> ) the 2nd value will be interpreted as the minimum signal integral for the Tx curve. Can be set to NA, in this case no integrals are taken into account.
signal.integral.max	<a href="#">integer</a> ( <b>required</b> ): upper bound of the signal integral. Can be a <a href="#">list</a> of <a href="#">integers</a> , if object is of type <a href="#">list</a> . If the input is vector (e.g., <code>c(1, 2)</code> ) the 2nd value will be interpreted as the maximum signal integral for the Tx curve. Can be set to NA, in this case no integrals are taken into account.

background.integral.min

**integer (required)**: lower bound of the background integral. Can be a **list** of **integers**, if object is of type **list**. If the input is vector (e.g., `c(1,2)`) the 2nd value will be interpreted as the minimum background integral for the Tx curve. Can be set to NA, in this case no integrals are taken into account.

background.integral.max

**integer (required)**: upper bound of the background integral. Can be a **list** of **integers**, if object is of type **list**. If the input is vector (e.g., `c(1,2)`) the 2nd value will be interpreted as the maximum background integral for the Tx curve. Can be set to NA, in this case no integrals are taken into account.

OSL.component

**character** or **integer (optional)**: s single index or a **character** defining the signal component to be evaluated. It requires that the object was processed by `[OSLdecomposition::RLum.OSL_decomposition]`. This argument can either be the name of the OSL component assigned by `[OSLdecomposition::RLum.OSL_global_fitting]` or the index in the descending order of decay rates. Then "1" selects the fastest decaying component, "2" the second fastest and so on. Can be a **list** of **integers** or strings (or mixed) If object is a **list** and this parameter is provided as **list** it alternates over the elements (aliquots) of the object list, e.g., `list(1,2)` processes the first aliquot with component 1 and the second aliquot with component 2. NULL does not process any component.

rejection.criteria

**list (with default)**: provide a *named* list and set rejection criteria in **percentage** for further calculation. Can be a **list** in a **list**, if object is of type **list**. Note: If an *unnamed* **list** is provided the new settings are ignored!

Allowed arguments are `recycling.ratio`, `recuperation.rate`, `palaeodose.error`, `testdose.error`, `exceed.max.regpoint = TRUE/FALSE`, `recuperation_reference = "Natural"` (or any other dose point, e.g., "R1"). Example: `rejection.criteria = list(recycling.ratio = 10)`. Per default all numerical values are set to 10, `exceed.max.regpoint = TRUE`. Every criterion can be set to NA. In this value are calculated, but not considered, i.e. the `RC.Status` becomes always 'OK'

dose.points

**numeric (optional)**: a numeric vector containing the dose points values. Using this argument overwrites dose point values extracted from other data. Can be a **list** of **numeric** vectors, if object is of type **list**

trim\_channels

**logical (with default)**: trim channels per record category to the lowest number of channels in the category by using `trim_RLum.Data`. Applies only to OSL and IRSL curves. For a more granular control use `trim_RLum.Data` before passing the input object.

mtext.outer

**character (optional)**: option to provide an outer margin mtext. Can be a **list** of **characters**, if object is of type **list**

plot

**logical (with default)**: enables or disables plot output.

plot\_onePage

**logical (with default)**: enables or disables on page plot output

plot.single

**logical (with default)** or **numeric (optional)**: single plot output (TRUE/FALSE) to allow for plotting the results in single plot windows. If a **numeric** vector is provided the plots can be selected individually, i.e. `plot.single = c(1,2,3,4)` will plot the TL and Lx, Tx curves but not the legend (5) or the growth curve (6), (7) and (8) belong to rejection criteria plots. Requires `plot = TRUE`.

onlyLxTxTable

**logical (with default)**: If TRUE the dose response curve fitting and plotting is skipped. This allows to get hands on the Lx/Tx table for large datasets without the need for a curve fitting.

... further arguments that will be passed to the function [plot\\_GrowthCurve](#) or [calc\\_OSLLxTxRatio](#) (supported: `background.count.distribution`, `sigmab`, `sig0`). **Please note** that if you consider to use the early light subtraction method you should provide your own `sigmab` value!

## Details

The function performs an analysis for a standard SAR protocol measurements introduced by Murray and Wintle (2000) with CW-OSL curves. For the calculation of the  $L_x/T_x$  value the function [calc\\_OSLLxTxRatio](#) is used. For **changing the way the  $L_x/T_x$  error is calculated** use the argument `background.count.distribution` and `sigmab`, which will be passed to the function [calc\\_OSLLxTxRatio](#).

### What is part of a SAR sequence?

The function is rather picky when it comes down to accepted curve input (OSL,IRSL,...) and structure. A SAR sequence is basically a set of  $L_x/T_x$  curves. Hence, every 2nd curve is considered a shine-down curve related to the test dose. It also means that the number of curves for  $L_x$  has to be equal to the number of  $T_x$  curves, and that hot-bleach curves **do not** belong into a SAR sequence; at least not for the analysis. Other curves allowed and processed are preheat curves, or preheat curves measured as TL, and irradiation curves. The later one indicates the duration of the irradiation, the dose and test dose points, e.g., as part of XSYG files.

### Argument object is of type list

If the argument object is of type [list](#) containing **only** [RLum.Analysis](#) objects, the function recalls itself as often as elements are in the list. This is useful if an entire measurement wanted to be analysed without writing separate for-loops. To gain in full control of the parameters (e.g., `dose.points`) for every aliquot (corresponding to one [RLum.Analysis](#) object in the list), in this case the arguments can be provided as [list](#). This list should be of similar length as the list provided with the argument object, otherwise the function will create an own list of the requested length. Function output will be just one single [RLum.Results](#) object.

Please be careful when using this option. It may allow a fast and efficient data analysis, but the function may also break with an unclear error message, due to wrong input data.

### Working with IRSL data

The function was originally designed to work just for 'OSL' curves, following the principles of the SAR protocol. An IRSL measurement protocol may follow this procedure, e.g., post-IR IRSL protocol (Thomsen et al., 2008). Therefore this functions has been enhanced to work with IRSL data, however, the function is only capable of analysing curves that follow the SAR protocol structure, i.e., to analyse a post-IR IRSL protocol, curve data have to be pre-selected by the user to fit the standards of the SAR protocol, i.e.,  $L_x, T_x, L_x, T_x$  and so on.

Example: Imagine the measurement contains pIRIR50 and pIRIR225 IRSL curves. Only one curve type can be analysed at the same time: The pIRIR50 curves or the pIRIR225 curves.

### Supported rejection criteria

[`recycling.ratio`]: calculated for every repeated regeneration dose point.

[`recuperation.rate`]: recuperation rate calculated by comparing the  $L_x/T_x$  values of the zero regeneration point with the  $L_n/T_n$  value (the  $L_x/T_x$  ratio of the natural signal). For methodological background see Aitken and Smith (1988). As a variant with the argument `recuperation_reference` another dose point can be selected as reference instead of  $L_n/T_n$ .

[`testdose.error`]: set the allowed error for the test dose, which per default should not exceed 10%. The test dose error is calculated as  $T_{x\_net}.error/T_{x\_net}$ . The calculation of the  $T_n$  error is detailed in [calc\\_OSLLxTxRatio](#).

[`palaeodose.error`]: set the allowed error for the  $D_e$  value, which per default should not exceed 10%.

### Irradiation times

The function makes two attempts to extra irradiation data (dose points) automatically from the input object, if the argument `dose.points` was not set (aka set to `NULL`).

1. It searches in every curve for an info object called `IRR_TIME`. If this was set, any value set here is taken as dose point.
2. If the object contains curves of type `irradiation`, the function tries to use this information to assign these values to the curves. However, the function does **not** overwrite values preset in `IRR_TIME`.

### Value

A plot (*optional*) and an `RLum.Results` object is returned containing the following elements:

<code>data</code>	<code>data.frame</code> containing De-values, De-error and further parameters
<code>LnLxTnTx.values</code>	<code>data.frame</code> of all calculated Lx/Tx values including signal, background counts and the dose points
<code>rejection.criteria</code>	<code>data.frame</code> with values that might be used as rejection criteria. NA is produced if no R0 dose point exists.
<code>Formula</code>	<code>formula</code> formula that have been used for the growth curve fitting

The output should be accessed using the function `get_RLum`.

### Function version

0.10.3

### Note

This function must not be mixed up with the function `Analyse_SAR.OSLdata`, which works with `Risoe.BINfileData` objects.

**The function currently does support only 'OSL', 'IRSL' and 'POSL' data!**

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### References

- Aitken, M.J. and Smith, B.W., 1988. Optical dating: recuperation after bleaching. *Quaternary Science Reviews* 7, 387-393.
- Duller, G., 2003. Distinguishing quartz and feldspar in single grain luminescence measurements. *Radiation Measurements*, 37 (2), 161-165.
- Murray, A.S. and Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32, 57-73.
- Thomsen, K.J., Murray, A.S., Jain, M., Boetter-Jensen, L., 2008. Laboratory fading rates of various luminescence signals from feldspar-rich sediment extracts. *Radiation Measurements* 43, 1474-1486. doi:10.1016/j.radmeas.2008.06.002

**See Also**

[calc\\_OSLLxTxRatio](#), [plot\\_GrowthCurve](#), [RLum.Analysis](#), [RLum.Results](#), [get\\_RLum](#)

**Examples**

```
##load data
##ExampleData.BINfileData contains two BINfileData objects
##CWOSL.SAR.Data and TL.SAR.Data
data(ExampleData.BINfileData, envir = environment())

##transform the values from the first position in a RLum.Analysis object
object <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos=1)

##perform SAR analysis and set rejection criteria
results <- analyse_SAR.CWOSL(
  object = object,
  signal.integral.min = 1,
  signal.integral.max = 2,
  background.integral.min = 900,
  background.integral.max = 1000,
  log = "x",
  fit.method = "EXP",
  rejection.criteria = list(
    recycling.ratio = 10,
    recuperation.rate = 10,
    testdose.error = 10,
    palaeodose.error = 10,
    recuperation_reference = "Natural",
    exceed.max.regpoint = TRUE)
)

##show De results
get_RLum(results)

##show LnTnLxTx table
get_RLum(results, data.object = "LnLxTnTx.table")
```

---

Analyse_SAR.OSLdata	<i>Analyse SAR CW-OSL measurements.</i>
---------------------	---

---

**Description**

The function analyses SAR CW-OSL curve data and provides a summary of the measured data for every position. The output of the function is optimised for SAR OSL measurements on quartz.

**Usage**

```
Analyse_SAR.OSLdata(
  input.data,
  signal.integral,
  background.integral,
  position,
```

```

run,
set,
dtype,
keep.SEL = FALSE,
info.measurement = "unkown measurement",
output.plot = FALSE,
output.plot.single = FALSE,
cex.global = 1,
...
)

```

## Arguments

input.data	<a href="#">Risoe.BINfileData</a> ( <b>required</b> ): input data from a Risø BIN file, produced by the function <a href="#">read_BIN2R</a> .
signal.integral	<a href="#">vector</a> ( <b>required</b> ): channels used for the signal integral, e.g. <code>signal.integral=c(1:2)</code>
background.integral	<a href="#">vector</a> ( <b>required</b> ): channels used for the background integral, e.g. <code>background.integral=c(85:100)</code>
position	<a href="#">vector</a> ( <i>optional</i> ): reader positions that want to be analysed (e.g. <code>position=c(1:48)</code> ). Empty positions are automatically omitted. If no value is given all positions are analysed by default.
run	<a href="#">vector</a> ( <i>optional</i> ): range of runs used for the analysis. If no value is given the range of the runs in the sequence is deduced from the <a href="#">Risoe.BINfileData</a> object.
set	<a href="#">vector</a> ( <i>optional</i> ): range of sets used for the analysis. If no value is given the range of the sets in the sequence is deduced from the <a href="#">Risoe.BINfileData</a> object.
dtype	<a href="#">character</a> ( <i>optional</i> ): allows to further limit the curves by their data type (DTYPE), e.g., <code>dtype = c("Natural", "Dose")</code> limits the curves to this two data types. By default all values are allowed. See <a href="#">Risoe.BINfileData</a> for allowed data types.
keep.SEL	<a href="#">logical</a> (default): option allowing to use the SEL element of the <a href="#">Risoe.BINfileData</a> manually. <b>NOTE:</b> In this case any limitation provided by run, set and dtype are ignored!
info.measurement	<a href="#">character</a> ( <i>with default</i> ): option to provide information about the measurement on the plot output (e.g. name of the BIN or BINX file).
output.plot	<a href="#">logical</a> ( <i>with default</i> ): plot output (TRUE/FALSE)
output.plot.single	<a href="#">logical</a> ( <i>with default</i> ): single plot output (TRUE/FALSE) to allow for plotting the results in single plot windows. Requires <code>output.plot = TRUE</code> .
cex.global	<a href="#">numeric</a> ( <i>with default</i> ): global scaling factor.
...	further arguments that will be passed to the function <a href="#">calc_OSLLxTxRatio</a> (supported: <code>background.count.distribution</code> , <code>sigmab</code> , <code>sig0</code> ; e.g., for instrumental error) and can be used to adjust the plot. Supported" mtext, log

## Details

The function works only for standard SAR protocol measurements introduced by Murray and Wintle (2000) with CW-OSL curves. For the calculation of the Lx/Tx value the function [calc\\_OSLLxTxRatio](#) is used.

**Provided rejection criteria**

[recycling ratio]: calculated for every repeated regeneration dose point.

[recuperation]: recuperation rate calculated by comparing the  $L_x/T_x$  values of the zero regeneration point with the  $L_n/T_n$  value (the  $L_x/T_x$  ratio of the natural signal). For methodological background see Aitken and Smith (1988)

[IRSL/BOSL]: the integrated counts (`signal.integral`) of an IRSL curve are compared to the integrated counts of the first regenerated dose point. It is assumed that IRSL curves got the same dose as the first regenerated dose point. **Note:** This is not the IR depletion ratio described by Duller (2003).

**Value**

A plot (*optional*) and [list](#) is returned containing the following elements:

<code>LnLxTnTx</code>	<a href="#">data.frame</a> of all calculated $L_x/T_x$ values including signal, background counts and the dose points.
<code>RejectionCriteria</code>	<a href="#">data.frame</a> with values that might be used as rejection criteria. NA is produced if no R0 dose point exists.
<code>SARParameters</code>	<a href="#">data.frame</a> of additional measurement parameters obtained from the BIN file, e.g. preheat or read temperature (not valid for all types of measurements).

**Function version**

0.2.17

**Note**

Rejection criteria are calculated but not considered during the analysis to discard values.

**The analysis of IRSL data is not directly supported.** You may want to consider using the functions [analyse\\_SAR.CWOSL](#) or [analyse\\_pIRIRSequence](#) instead.

**The development of this function will not be continued. We recommend to use the function [analyse\\_SAR.CWOSL](#) or instead.**

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
Margret C. Fuchs, HZDR, Freiberg (Germany) , RLum Developer Team

**References**

- Aitken, M.J. and Smith, B.W., 1988. Optical dating: recuperation after bleaching. *Quaternary Science Reviews* 7, 387-393.
- Duller, G., 2003. Distinguishing quartz and feldspar in single grain luminescence measurements. *Radiation Measurements*, 37 (2), 161-165.
- Murray, A.S. and Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32, 57-73.

**See Also**

[calc\\_OSLLxTxRatio](#), [Risoe.BINfileData](#), [read\\_BIN2R](#), [plot\\_GrowthCurve](#)

## Examples

```
##load data
data(ExampleData.BINfileData, envir = environment())

##analyse data
output <- Analyse_SAR.OSLdata(input.data = CWOSL.SAR.Data,
                              signal.integral = c(1:5),
                              background.integral = c(900:1000),
                              position = c(1:1),
                              output.plot = TRUE)

##combine results relevant for further analysis
output.SAR <- data.frame(Dose = output$LnLxTnTx[[1]]$Dose,
                        LxTx = output$LnLxTnTx[[1]]$LxTx,
                        LxTx.Error = output$LnLxTnTx[[1]]$LxTx.Error)

output.SAR
```

---

analyse\_SAR.TL

*Analyse SAR TL measurements*

---

## Description

The function performs a SAR TL analysis on a [RLum.Analysis](#) object including growth curve fitting.

## Usage

```
analyse_SAR.TL(
  object,
  object.background,
  signal.integral.min,
  signal.integral.max,
  integral_input = "channel",
  sequence.structure = c("PREHEAT", "SIGNAL", "BACKGROUND"),
  rejection.criteria = list(recycling.ratio = 10, recuperation.rate = 10),
  dose.points,
  log = "",
  ...
)
```

## Arguments

**object** [RLum.Analysis](#) or a [list](#) of such objects (**required**) : input object containing data for analysis

**object.background** currently not used

**signal.integral.min** [integer \(required\)](#): requires the channel number for the lower signal integral bound (e.g. `signal.integral.min = 100`)



`signal.integral.max` **integer (required)**: requires the channel number for the upper signal integral bound (e.g. `signal.integral.max = 200`)

`integral_input` **character (with default)**: defines the input for the the arguments `signal.integral.min` and `signal.integral.max`. These limits can be either provided 'channel' number (the default) or 'temperature'. If 'temperature' is chosen the best matching channel is selected.

`sequence.structure` **vector character (with default)**: specifies the general sequence structure. Three steps are allowed ("PREHEAT", "SIGNAL", "BACKGROUND"), in addition a parameter "EXCLUDE". This allows excluding TL curves which are not relevant for the protocol analysis. (**Note:** None TL are removed by default)

`rejection.criteria` **list (with default)**: list containing rejection criteria in percentage for the calculation.

`dose.points` **numeric (optional)**: option set dose points manually

`log` **character (with default)**: a character string which contains "x" if the x-axis is to be logarithmic, "y" if the y axis is to be logarithmic and "xy" or "yx" if both axes are to be logarithmic. See [plot.default](#).

`...` further arguments that will be passed to the function [plot\\_GrowthCurve](#)

## Details

This function performs a SAR TL analysis on a set of curves. The SAR procedure in general is given by Murray and Wintle (2000). For the calculation of the  $L_x/T_x$  value the function [calc\\_TLLxTxRatio](#) is used.

### Provided rejection criteria

[recycling.ratio]: calculated for every repeated regeneration dose point.

[recuperation.rate]: recuperation rate calculated by comparing the  $L_x/T_x$  values of the zero regeneration point with the  $L_n/T_n$  value (the  $L_x/T_x$  ratio of the natural signal). For methodological background see Aitken and Smith (1988)

## Value

A plot (*optional*) and an [RLum.Results](#) object is returned containing the following elements:

`De.values` **data.frame** containing De-values and further parameters

`LnLxTnTx.values` **data.frame** of all calculated  $L_x/T_x$  values including signal, background counts and the dose points.

`rejection.criteria` **data.frame** with values that might be used as rejection criteria. NA is produced if no R0 dose point exists.

**note:** the output should be accessed using the function [get\\_RLum](#)

## Function version

0.3.0

**Note****THIS IS A BETA VERSION**

None TL curves will be removed from the input object without further warning.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Aitken, M.J. and Smith, B.W., 1988. Optical dating: recuperation after bleaching. *Quaternary Science Reviews* 7, 387-393.

Murray, A.S. and Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32, 57-73.

**See Also**

[calc\\_TLLxTxRatio](#), [plot\\_GrowthCurve](#), [RLum.Analysis](#), [RLum.Results](#), [get\\_RLum](#)

**Examples**

```
##load data
data(ExampleData.BINfileData, envir = environment())

##transform the values from the first position in a RLum.Analysis object
object <- Risoe.BINfileData2RLum.Analysis(TL.SAR.Data, pos=3)

##perform analysis
analyse_SAR.TL(
  object = object,
  signal.integral.min = 210,
  signal.integral.max = 220,
  fit.method = "EXP OR LIN",
  sequence.structure = c("SIGNAL", "BACKGROUND"))
```

---

apply\_CosmicRayRemoval

*Function to remove cosmic rays from an RLum.Data.Spectrum S4 class object*

---

**Description**

The function provides several methods for cosmic-ray removal and spectrum smoothing [RLum.Data.Spectrum](#) objects and such objects embedded in [list](#) or [RLum.Analysis](#) objects.

**Usage**

```

apply_CosmicRayRemoval(
  object,
  method = "smooth",
  method.Pych.smoothing = 2,
  method.Pych.threshold_factor = 3,
  MARGIN = 2,
  verbose = FALSE,
  plot = FALSE,
  ...
)

```

**Arguments**

object	<a href="#">RLum.Data.Spectrum</a> or <a href="#">RLum.Analysis</a> ( <b>required</b> ): input object to be treated. This can be also provided as <a href="#">list</a> . If an <a href="#">RLum.Analysis</a> object is provided, only the <a href="#">RLum.Data.Spectrum</a> objects are treated. Please note: this mixing of objects do not work for a list of <a href="#">RLum.Data</a> objects.
method	<a href="#">character</a> ( <i>with default</i> ): Defines method that is applied for cosmic ray removal. Allowed methods are smooth, the default, ( <a href="#">smooth</a> ), smooth.spline ( <a href="#">smooth.spline</a> ) and Pych. See details for further information.
method.Pych.smoothing	<a href="#">integer</a> ( <i>with default</i> ): Smoothing parameter for cosmic ray removal according to Pych (2003). The value defines how many neighbouring values in each frame are used for smoothing (e.g., 2 means that the two previous and two following values are used).
method.Pych.threshold_factor	<a href="#">numeric</a> ( <i>with default</i> ): Threshold for zero-bins in the histogram. Small values mean that more peaks are removed, but signal might be also affected by this removal.
MARGIN	<a href="#">integer</a> ( <i>with default</i> ): on which part the function cosmic ray removal should be applied on: <ul style="list-style-type: none"> <li>• 1 = along the time axis (line by line),</li> <li>• 2 = along the wavelength axis (column by column).</li> </ul> <b>Note:</b> This argument currently only affects the methods smooth and smooth.spline
verbose	<a href="#">logical</a> ( <i>with default</i> ): Option to suppress terminal output.,
plot	<a href="#">logical</a> ( <i>with default</i> ): If TRUE the histograms used for the cosmic-ray removal are returned as plot including the used threshold. Note: A separate plot is returned for each frame! Currently only for method = "Pych" a graphical output is provided.
...	further arguments and graphical parameters that will be passed to the <a href="#">smooth</a> function.

**Details**

method = "Pych"

This method applies the cosmic-ray removal algorithm described by Pych (2003). Some aspects that are different to the publication:

- For interpolation between neighbouring values the median and not the mean is used.

- The number of breaks to construct the histogram is set to: `length(number.of.input.values)/2`

For further details see references below.

`method = "smooth"`

Method uses the function [smooth](#) to remove cosmic rays.

Arguments that can be passed are: `kind`, `twiceit`

`method = "smooth.spline"`

Method uses the function [smooth.spline](#) to remove cosmic rays.

Arguments that can be passed are: `spar`

### How to combine methods?

Different methods can be combined by applying the method repeatedly to the dataset (see example).

### Value

Returns same object as input.

### Function version

0.3.0

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### References

Pych, W., 2004. A Fast Algorithm for Cosmic-Ray Removal from Single Images. The Astronomical Society of the Pacific 116 (816), 148-153. doi:[10.1086/381786](#)

### See Also

[RLum.Data.Spectrum](#), [RLum.Analysis](#), [smooth](#), [smooth.spline](#), [apply\\_CosmicRayRemoval](#)

### Examples

```
##(1) - use with your own data and combine (uncomment for usage)
## run two times the default method and smooth with another method
## your.spectrum <- apply_CosmicRayRemoval(your.spectrum, method = "Pych")
## your.spectrum <- apply_CosmicRayRemoval(your.spectrum, method = "Pych")
## your.spectrum <- apply_CosmicRayRemoval(your.spectrum, method = "smooth")
```

---

`apply_EfficiencyCorrection`*Function to apply spectral efficiency correction to  
RLum.Data.Spectrum S4 class objects*

---

## Description

The function allows spectral efficiency corrections for `RLum.Data.Spectrum` S4 class objects

## Usage

```
apply_EfficiencyCorrection(object, spectral.efficiency)
```

## Arguments

`object` [RLum.Data.Spectrum](#) or [RLum.Analysis](#) (**required**): S4 object of class `RLum.Data.Spectrum`, `RLum.Analysis` or a [list](#) of such objects. Other objects in the list are skipped.

`spectral.efficiency` [data.frame](#) (**required**): Data set containing wavelengths (x-column) and relative spectral response values (y-column) (values between 0 and 1). The provided data will be used to correct all spectra if `object` is a [list](#)

## Details

The efficiency correction is based on a spectral response dataset provided by the user. Usually the data set for the quantum efficiency is of lower resolution and values are interpolated for the required spectral resolution using the function [stats::approx](#)

If the energy calibration differs for both data set NA values are produced that will be removed from the matrix.

## Value

Returns same object as provided as input

## Function version

0.2.0

## Note

Please note that the spectral efficiency data from the camera alone may not sufficiently correct for spectral efficiency of the entire optical system (e.g., spectrometer, camera ...).

## Author(s)

Sebastian Kreutzer, IRAMAT-CRP2A, UMR 5060, CNRS-Université Bordeaux Montaigne (France)  
Johannes Friedrich, University of Bayreuth (Germany) , `RLum` Developer Team

## See Also

[RLum.Data.Spectrum](#), [RLum.Analysis](#)

Examples

```
##(1) - use with your own data (uncomment for usage)
## spectral.efficiency <- read.csv("your data")
##
## your.spectrum <- apply_EfficiencyCorrection(your.spectrum, )
```

---

as	<i>as() - RLum-object coercion</i>
----	------------------------------------

---

Description

- for [RLum.Analysis-class]
- for [RLum.Data.Curve-class]
- for [RLum.Data.Image-class]
- for [RLum.Data.Spectrum-class]
- for [RLum.Results-class]

Arguments

- from [RLum](#), [list](#), [data.frame](#), [matrix](#) (**required**): object to be coerced from
- to [character](#) (**required**): class name to be coerced to

Details

[RLum.Analysis](#)

from	to
list	list

Given that the [list](#) consists of [RLum.Analysis](#) objects.

[RLum.Data.Curve](#)

from	to
list	list
data.frame	data.frame
matrix	matrix

[RLum.Data.Image](#)

from	to
data.frame	data.frame
matrix	matrix

[RLum.Data.Spectrum](#)

from	to
data.frame	data.frame
matrix	matrix

**RLum.Results**

from	to
list	list

Given that the [list](#) consists of [RLum.Results](#) objects.

**Note**

Due to the complex structure of the RLum objects itself a coercing to standard R data structures will be always loosely!

**See Also**

[methods::as](#)

---

BaseDataSet.ConversionFactors  
*Base data set of dose-rate conversion factors*

---

**Description**

Collection of published dose-rate conversion factors to convert concentrations of radioactive isotopes to dose rate values.

**Format**

A [list](#) with three elements with dose-rate conversion factors sorted by article and radiation type (alpha, beta, gamma):

AdamiecAitken1998:	Conversion factors from Tables 5 and 6
Cresswelletal2018:	Conversion factors from Tables 5 and 6
Guerinetal2011:	Conversion factors from Tables 1, 2 and 3
Liritzisetal2013:	Conversion factors from Tables 1, 2 and 3

**Version**

0.2.0

**Source**

All gamma conversion factors were carefully read from the tables given in the references above.

## References

- Adamiec, G., Aitken, M.J., 1998. Dose-rate conversion factors: update. *Ancient TL* 16, 37-46.
- Cresswell., A.J., Carter, J., Sanderson, D.C.W., 2018. Dose rate conversion parameters: Assessment of nuclear data. *Radiation Measurements* 120, 195-201.
- Guerin, G., Mercier, N., Adamiec, G., 2011. Dose-rate conversion factors: update. *Ancient TL*, 29, 5-8.
- Liritzis, I., Stamoulis, K., Papachristodoulou, C., Ioannides, K., 2013. A re-evaluation of radiation dose-rate conversion factors. *Mediterranean Archaeology and Archaeometry* 13, 1-15.

## Examples

```
## Load data
data("BaseDataSet.ConversionFactors", envir = environment())
```

---

BaseDataSet.CosmicDoseRate

*Base data set for cosmic dose rate calculation*

---

## Description

Collection of data from various sources needed for cosmic dose rate calculation

## Format

values.cosmic.Softcomp: data frame containing cosmic dose rates for shallow depths (< 167 g cm<sup>-2</sup>) obtained using  
 values.factor.Altitude: data frame containing altitude factors for adjusting geomagnetic field-change factors. Value  
 values.par.FJH: data frame containing values for parameters F, J and H (read from Fig. 2 in Prescott & Hutcheon)

$$Dc = D0 * (F + J * \exp((altitude/1000)/H))$$

## Version

0.1

## Source

The following data were carefully read from figures in mentioned sources and used for fitting procedures. The derived expressions are used in the function calc\_CosmicDoseRate.

### values.cosmic.Softcomp

Program: "AGE"  
 Reference: Gruen (2009)  
 Fit: Polynomials in the form of

For depths between 40-167 g cm<sup>-2</sup>:



$$y = 2 * 10^{-6} * x^2 - 0.0008 * x + 0.2535$$

(For depths <40 g cm<sup>-2</sup>)

$$y = -6 * 10^{-8} * x^3 + 2 * 10^{-5} * x^2 - 0.0025 * x + 0.2969$$

values.factor.Altitude

Reference: Prescott & Hutton (1994)  
 Page: 499  
 Figure: 1  
 Fit: 2-degree polynomial in the form of

$$y = -0.026 * x^2 + 0.6628 * x + 1.0435$$

values.par.FJH

Reference: Prescott & Hutton (1994)  
 Page: 500  
 Figure: 2  
 Fits: 3-degree polynomials and linear fits

F (non-linear part,  $\lambda < 36.5$  deg.):

$$y = -7 * 10^{-7} * x^3 - 8 * 10^{-5} * x^2 - 0.0009 * x + 0.3988$$

F (linear part,  $\lambda > 36.5$  deg.):

$$y = -0.0001 * x + 0.2347$$

J (non-linear part,  $\lambda < 34$  deg.):

$$y = 5 * 10^{-6} * x^3 - 5 * 10^{-5} * x^2 + 0.0026 * x + 0.5177$$

J (linear part,  $\lambda > 34$  deg.):

$$y = 0.0005 * x + 0.7388$$

H (non-linear part,  $\lambda < 36$  deg.):

$$y = -3 * 10^{-6} * x^3 - 5 * 10^{-5} * x^2 - 0.0031 * x + 4.398$$

H (linear part,  $\lambda > 36$  deg.):

$$y = 0.0002 * x + 4.0914$$

## References

- Gruen, R., 2009. The "AGE" program for the calculation of luminescence age estimates. *Ancient TL*, 27, pp. 45-46.
- Prescott, J.R., Hutton, J.T., 1988. Cosmic ray and gamma ray dosimetry for TL and ESR. *Nuclear Tracks and Radiation Measurements*, 14, pp. 223-227.
- Prescott, J.R., Hutton, J.T., 1994. Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations. *Radiation Measurements*, 23, pp. 497-500.

## Examples

```
##load data
data(BaseDataSet.CosmicDoseRate)
```

---

```
BaseDataSet.FractionalGammaDose
```

*Base data set of fractional gamma-dose values*

---

## Description

Collection of (un-)published fractional gamma dose-rate values to scale the gamma-dose rate considering layer-to-layer variations in soil radioactivity.

## Format

A [list](#) with fractional gamma dose-rate values sorted by article:

```
Aitken1985: Fractional gamma-dose values from table H.1
```

## Version

0.1

## Source

Fractional gamma dose values were carefully read from the tables given in the references above.

## References

- Aitken, M.J., 1985. *Thermoluminescence Dating*. Academic Press, London.

## Examples

```
## Load data
data("BaseDataSet.FractionalGammaDose", envir = environment())
```

---

BaseDataSet.GrainSizeAttenuation

*Base dataset for grain size attenuation data by Gu  rin et al. (2012)*


---

### Description

Grain size correction data for beta-dose rates published by Gu  rin et al. (2012).

#' @format

A [data.frame](#) seven columns and sixteen rows. Column headers are GrainSize, Q\_K, FS\_K, Q\_Th, FS\_Th, Q\_U, FS\_U. Grain sizes are quoted in  $\mu\text{m}$  (e.g., 20, 40, 60 etc.)

### Version

0.1.0

### Source

Gu  rin, G., Mercier, N., Nathan, R., Adamiec, G., Lefrais, Y., 2012. On the use of the infinite matrix assumption and associated concepts: A critical review. *Radiation Measurements*, 47, 778-785.

### Examples

```
## load data
data("BaseDataSet.GrainSizeAttenuation", envir = environment())
```

---

bin\_RLum.Data

*Channel binning - method dispatcher*


---

### Description

Function calls the object-specific bin functions for RLum.Data S4 class objects.

### Usage

```
bin_RLum.Data(object, ...)
```

### Arguments

object	<a href="#">RLum.Data</a> ( <b>required</b> ): S4 object of class RLum.Data
...	further arguments passed to the specific class method

### Details

The function provides a generalised access point for specific [RLum.Data](#) objects. Depending on the input object, the corresponding function will be selected. Allowed arguments can be found in the documentations of the corresponding [RLum.Data](#) class.

**Value**

An object of the same type as the input object is provided

**Function version**

0.2.0

**Note**

Currently only RLum.Data objects of class [RLum.Data.Curve](#) and [RLum.Data.Spectrum](#) are supported!

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Curve](#), [RLum.Data.Spectrum](#)

**Examples**

```
##load example data
data(ExampleData.CW_OSL_Curve, envir = environment())

##create RLum.Data.Curve object from this example
curve <-
  set_RLum(
    class = "RLum.Data.Curve",
    recordType = "OSL",
    data = as.matrix(ExampleData.CW_OSL_Curve)
  )

##plot data without and with 2 and 4 channel binning
plot_RLum(curve)
plot_RLum(bin_RLum.Data(curve, bin_size = 2))
plot_RLum(bin_RLum.Data(curve, bin_size = 4))
```

---

calc\_AliquotSize

*Estimate the amount of grains on an aliquot*

---

**Description**

Estimate the number of grains on an aliquot. Alternatively, the packing density of an aliquot is computed.

**Usage**

```
calc_AliquotSize(
  grain.size,
  sample.diameter,
  packing.density = 0.65,
  MC = TRUE,
  grains.counted,
  plot = TRUE,
  ...
)
```

**Arguments**

**grain.size** **numeric (required)**: mean grain size (microns) or a range of grain sizes from which the mean grain size is computed (e.g. `c(100, 200)`).

**sample.diameter** **numeric (required)**: diameter (mm) of the targeted area on the sample carrier.

**packing.density** **numeric (with default)**: empirical value for mean packing density. If `packing.density = "Inf"` a hexagonal structure on an infinite plane with a packing density of 0.906... is assumed.

**MC** **logical (optional)**: if TRUE the function performs a Monte Carlo simulation for estimating the amount of grains on the sample carrier and assumes random errors in grain size distribution and packing density. Requires a vector with min and max grain size for `grain.size`. For more information see details.

**grains.counted** **numeric (optional)**: grains counted on a sample carrier. If a non-zero positive integer is provided this function will calculate the packing density of the aliquot. If more than one value is provided the mean packing density and its standard deviation is calculated. Note that this overrides `packing.density`.

**plot** **logical (with default)**: plot output (TRUE/FALSE)

**...** further arguments to pass (`main`, `xlab`, `MC.iter`).

**Details**

This function can be used to either estimate the number of grains on an aliquot or to compute the packing density depending on the the arguments provided.

The following function is used to estimate the number of grains  $n$ :

$$n = (\pi * x^2) / (\pi * y^2) * d$$

where  $x$  is the radius of the aliquot size (microns),  $y$  is the mean radius of the mineral grains (mm) and  $d$  is the packing density (value between 0 and 1).

**Packing density**

The default value for `packing.density` is 0.65, which is the mean of empirical values determined by Heer et al. (2012) and unpublished data from the Cologne luminescence laboratory. If `packing.density = "Inf"` a maximum density of  $\pi/\sqrt{12} = 0.9068\dots$  is used. However, note that this value is not appropriate as the standard preparation procedure of aliquots resembles a PECC ("*Packing Equal Circles in a Circle*") problem where the maximum packing density is asymptotic to about 0.87.

### Monte Carlo simulation

The number of grains on an aliquot can be estimated by Monte Carlo simulation when setting `MC = TRUE`. Each of the parameters necessary to calculate  $n(x, y, d)$  are assumed to be normally distributed with means  $\mu_x, \mu_y, \mu_d$  and standard deviations  $\sigma_x, \sigma_y, \sigma_d$ .

For the mean grain size random samples are taken first from  $N(\mu_y, \sigma_y)$ , where  $\mu_y = \text{mean.grain.size}$  and  $\sigma_y = (\text{max.grain.size} - \text{min.grain.size})/4$  so that 95\ grains are within the provided the grain size range. This effectively takes into account that after sieving the sample there is still a small chance of having grains smaller or larger than the used mesh sizes. For each random sample the mean grain size is calculated, from which random subsamples are drawn for the Monte Carlo simulation.

The packing density is assumed to be normally distributed with an empirically determined  $\mu = 0.65$  (or provided value) and  $\sigma = 0.18$ . The normal distribution is truncated at  $d = 0.87$  as this is approximately the maximum packing density that can be achieved in PECC problem.

The sample diameter has  $\mu = \text{sample.diameter}$  and  $\sigma = 0.2$  to take into account variations in sample disc preparation (i.e. applying silicon spray to the disc). A lower truncation point at  $x = 0.5$  is used, which assumes that aliquots with smaller sample diameters of 0.5 mm are discarded. Likewise, the normal distribution is truncated at 9.8 mm, which is the diameter of the sample disc.

For each random sample drawn from the normal distributions the amount of grains on the aliquot is calculated. By default,  $10^5$  iterations are used, but can be reduced/increased with `MC.iter` (see ...). The results are visualised in a bar- and boxplot together with a statistical summary.

### Value

Returns a terminal output. In addition an [RLum.Results](#) object is returned containing the following element:

<code>.\$summary</code>	<a href="#">data.frame</a> summary of all relevant calculation results.
<code>.\$args</code>	<a href="#">list</a> used arguments
<code>.\$call</code>	<a href="#">call</a> the function call
<code>.\$MC</code>	<a href="#">list</a> results of the Monte Carlo simulation

The output should be accessed using the function [get\\_RLum](#).

### Function version

0.31

### Author(s)

Christoph Burow, University of Cologne (Germany) , RLum Developer Team

### References

Duller, G.A.T., 2008. Single-grain optical dating of Quaternary sediments: why aliquot size matters in luminescence dating. *Boreas* 37, 589-612.

Heer, A.J., Adamiec, G., Moska, P., 2012. How many grains are there on a single aliquot?. *Ancient TL* 30, 9-16.

### Further reading

Chang, H.-C., Wang, L.-C., 2010. A simple proof of Thue's Theorem on Circle Packing. <https://arxiv.org/pdf/1009.4322v1.pdf>, 2013-09-13.

Graham, R.L., Lubachevsky, B.D., Nurmela, K.J., Oestergard, P.R.J., 1998. Dense packings of congruent circles in a circle. *Discrete Mathematics* 181, 139-154.

Huang, W., Ye, T., 2011. Global optimization method for finding dense packings of equal circles in a circle. *European Journal of Operational Research* 210, 474-481.

## Examples

```
## Estimate the amount of grains on a small aliquot
calc_AliquotSize(grain.size = c(100,150), sample.diameter = 1, MC.iter = 100)

## Calculate the mean packing density of large aliquots
calc_AliquotSize(grain.size = c(100,200), sample.diameter = 8,
                 grains.counted = c(2525,2312,2880), MC.iter = 100)
```

---

calc_AverageDose	<i>Calculate the Average Dose and the dose rate dispersion</i>
------------------	--

---

## Description

This functions calculates the Average Dose and their extrinsic dispersion and estimates the standard errors by bootstrapping based on the Average Dose Model by Guerin et al., 2017

## Usage

```
calc_AverageDose(
  data,
  sigma_m = NULL,
  Nb_BE = 500,
  na.rm = TRUE,
  plot = TRUE,
  verbose = TRUE,
  ...
)
```

## Arguments

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[,1]) and De error (values[,2])
sigma_m	<a href="#">numeric</a> ( <b>required</b> ): the overdispersion resulting from a dose recovery experiment, i.e. when all grains have received the same dose. Indeed in such a case, any overdispersion (i.e. dispersion on top of analytical uncertainties) is, by definition, an unrecognised measurement uncertainty.
Nb_BE	<a href="#">integer</a> ( <i>with default</i> ): sample size used for the bootstrapping
na.rm	<a href="#">logical</a> ( <i>with default</i> ): exclude NA values from the data set prior to any further operation.
plot	<a href="#">logical</a> ( <i>with default</i> ): enables/disables plot output
verbose	<a href="#">logical</a> ( <i>with default</i> ): enables/disables terminal output

... further arguments that can be passed to [graphics::hist](#). As three plots are returned all arguments need to be provided as [list](#), e.g., `main = list("Plot 1", "Plot 2", "Plot 3")`. Note: not all arguments of `hist` are supported, but the output of `hist` is returned and can be used of own plots.

Further supported arguments: `mtext` ([character](#)), `rug` (TRUE/FALSE).

Details

sigma\_m

The program requires the input of a known value of `sigma_m`, which corresponds to the intrinsic overdispersion, as determined by a dose recovery experiment. Then the dispersion in doses (`sigma_d`) will be that over and above `sigma_m` (and individual uncertainties `sigma_wi`).

Value

The function returns numerical output and an (*optional*) plot.

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

[.. \$summary : data.frame]

Column	Type	Description
AVERAGE_DOSE	<a href="#">numeric</a>	the obtained average dose
AVERAGE_DOSE.SE	<a href="#">numeric</a>	the average dose error
SIGMA_D	<a href="#">numeric</a>	sigma
SIGMA_D.SE	<a href="#">numeric</a>	standard error of the sigma
IC_AVERAGE_DOSE.LEVEL	<a href="#">character</a>	confidence level average dose
IC_AVERAGE_DOSE.LOWER	<a href="#">character</a>	lower quantile of average dose
IC_AVERAGE_DOSE.UPPER	<a href="#">character</a>	upper quantile of average dose
IC_SIGMA_D.LEVEL	<a href="#">integer</a>	confidence level sigma
IC_SIGMA_D.LOWER	<a href="#">character</a>	lower sigma quantile
IC_SIGMA_D.UPPER	<a href="#">character</a>	upper sigma quantile
L_MAX	<a href="#">character</a>	maximum likelihood value

[.. \$dstar : matrix]

Matrix with bootstrap values

[.. \$hist : list]

Object as produced by the function histogram

---

[ PLOT OUTPUT ]



---

The function returns two different plot panels.

- (1) An abanico plot with the dose values
- (2) A histogram panel comprising 3 histograms with the equivalent dose and the bootstrapped average dose and the sigma values.

### Function version

0.1.5

### Note

This function has beta status!

### Author(s)

Claire Christophe, IRAMAT-CRP2A, Université de Nantes (France), Anne Philippe, Université de Nantes, (France), Guillaume Guérin, IRAMAT-CRP2A, Université Bordeaux Montaigne, (France), Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### References

Guerin, G., Christophe, C., Philippe, A., Murray, A.S., Thomsen, K.J., Tribolo, C., Urbanova, P., Jain, M., Guibert, P., Mercier, N., Kreutzer, S., Lahaye, C., 2017. Absorbed dose, equivalent dose, measured dose rates, and implications for OSL age estimates: Introducing the Average Dose Model. Quaternary Geochronology 1-32. doi:10.1016/j.quageo.2017.04.002

### Further reading

Efron, B., Tibshirani, R., 1986. Bootstrap Methods for Standard Errors, Confidence Intervals, and Other Measures of Statistical Accuracy. Statistical Science 1, 54-75.

### See Also

[read.table](#), [graphics::hist](#)

### Examples

```
##Example 01 using package example data
##load example data
data(ExampleData.DeValues, envir = environment())

##calculate Average dose
##(use only the first 56 values here)
AD <- calc_AverageDose(ExampleData.DeValues$CA1[1:56,], sigma_m = 0.1)

##plot De and set Average dose as central value
plot_AbanicoPlot(
  data = ExampleData.DeValues$CA1[1:56,],
  z.0 = AD$summary$AVERAGE_DOSE)
```

---

calc_CentralDose	<i>Apply the central age model (CAM) after Galbraith et al. (1999) to a given De distribution</i>
------------------	---

---

## Description

This function calculates the central dose and dispersion of the De distribution, their standard errors and the profile log likelihood function for sigma.

## Usage

```
calc_CentralDose(data, sigmab, log = TRUE, na.rm = FALSE, plot = TRUE, ...)
```

## Arguments

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[,1]) and De error (data[,2])
sigmab	<a href="#">numeric</a> ( <i>with default</i> ): additional spread in De values. This value represents the expected overdispersion in the data should the sample be well-bleached (Cunningham & Walling 2012, p. 100). <b>NOTE</b> : For the logged model (log = TRUE) this value must be a fraction, e.g. 0.2 (= 20 \ sigmab must be provided in the same absolute units of the De values (seconds or Gray).
log	<a href="#">logical</a> ( <i>with default</i> ): fit the (un-)logged central age model to De data
na.rm	<a href="#">logical</a> ( <i>with default</i> ): strip NA values before the computation proceeds
plot	<a href="#">logical</a> ( <i>with default</i> ): plot output
...	further arguments (trace, verbose).

## Details

This function uses the equations of Galbraith & Roberts (2012). The parameters delta and sigma are estimated by numerically solving eq. 15 and 16. Their standard errors are approximated using eq. 17. In addition, the profile log-likelihood function for sigma is calculated using eq. 18 and presented as a plot. Numerical values of the maximum likelihood approach are **only** presented in the plot and **not** in the console. A detailed explanation on maximum likelihood estimation can be found in the appendix of Galbraith & Laslett (1993, 468-470) and Galbraith & Roberts (2012, 15)

## Value

Returns a plot (*optional*) and terminal output. In addition an [RLum.Results](#) object is returned containing the following elements:

.\$summary	<a href="#">data.frame</a> summary of all relevant model results.
.\$data	<a href="#">data.frame</a> original input data
.\$args	<a href="#">list</a> used arguments
.\$call	<a href="#">call</a> the function call
.\$profile	<a href="#">data.frame</a> the log likelihood profile for sigma

The output should be accessed using the function [get\\_RLum](#)

**Function version**

1.4.1

**Author(s)**

Christoph Burow, University of Cologne (Germany)  
Based on a rewritten S script of Rex Galbraith, 2010 , RLum Developer Team

**References**

- Galbraith, R.F. & Laslett, G.M., 1993. Statistical models for mixed fission track ages. *Nuclear Tracks Radiation Measurements* 4, 459-470.
- Galbraith, R.F., Roberts, R.G., Laslett, G.M., Yoshida, H. & Olley, J.M., 1999. Optical dating of single grains of quartz from Jinmium rock shelter, northern Australia. Part I: experimental design and statistical models. *Archaeometry* 41, 339-364.
- Galbraith, R.F. & Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations. *Quaternary Geochronology* 11, 1-27.

**Further reading**

- Arnold, L.J. & Roberts, R.G., 2009. Stochastic modelling of multi-grain equivalent dose (De) distributions: Implications for OSL dating of sediment mixtures. *Quaternary Geochronology* 4, 204-230.
- Bailey, R.M. & Arnold, L.J., 2006. Statistical modelling of single grain quartz De distributions and an assessment of procedures for estimating burial dose. *Quaternary Science Reviews* 25, 2475-2502.
- Cunningham, A.C. & Wallinga, J., 2012. Realizing the potential of fluvial archives using robust OSL chronologies. *Quaternary Geochronology* 12, 98-106.
- Rodnight, H., Duller, G.A.T., Wintle, A.G. & Tooth, S., 2006. Assessing the reproducibility and accuracy of optical dating of fluvial deposits. *Quaternary Geochronology*, 1 109-120.
- Rodnight, H., 2008. How many equivalent dose values are needed to obtain a reproducible distribution?. *Ancient TL* 26, 3-10.

**See Also**

[plot](#), [calc\\_CommonDose](#), [calc\\_FiniteMixture](#), [calc\\_FuchsLang2001](#), [calc\\_MinDose](#)

**Examples**

```
##load example data
data(ExampleData.DeValues, envir = environment())

##apply the central dose model
calc_CentralDose(ExampleData.DeValues$CA1)
```

---

calc\_CobbleDoseRate     *Calculate dose rate of slices in a spherical cobble*

---

### Description

Calculates the dose rate profile through the cobble based on Riedesel and Autzen (2020).  
 Corrects the beta dose rate in the cobble for the grain size following results of Guérin et al. (2012).  
 Sediment beta and gamma dose rates are corrected for the water content of the sediment using the correction factors of Aitken (1985). Water content in the cobble is assumed to be 0.

### Usage

```
calc_CobbleDoseRate(input, conversion = "Guerinetal2011")
```

### Arguments

input                [data.frame](#) (**required**): A table containing all relevant information for each individual layer. For the table layout see details.  
 conversion        Which dose rate conversion factors to use. For accepted values see [BaseDataSet.ConversionFactors](#)

### Details

#### The input table layout

COLUMN	DATA TYPE	DESCRIPTION
Distance	numeric	distance from the surface of the cobble to the top of each rock slice in mm. The distance is measured from the top of the cobble to the top of the slice.
DistanceError	numeric	Error on the distance in mm
Thickness	numeric	Thickness of each slice in mm
ThicknessError	numeric	uncertainty of the thickness in mm.
Mineral	character	'FS' for feldspar, 'Q' for quartz, depending which mineral in the cobble is used for dating
Cobble_K	numeric	K nuclide content in % of the bulk cobble
Cobble_K_SE	numeric	error on K nuclide content in % of the bulk cobble
Cobble_Th	numeric	Th nuclide content in ppm of the bulk cobble
Cobble_Th_SE	numeric	error on Th nuclide content in ppm of the bulk cobble
Cobble_U	numeric	U nuclide content in ppm of the bulk cobble
CobbleU_SE	numeric	error on U nuclide content in ppm of the bulk cobble
GrainSize	numeric	average grain size in $\mu\text{m}$ of the grains used for dating
Density	numeric	Density of the cobble. Default is $2.7 \text{ g cm}^{-3}$
CobbleDiameter	numeric	Diameter of the cobble in cm.
Sed_K	numeric	K nuclide content in % of the sediment matrix
Sed_K_SE	numeric	error on K nuclide content in % of the sediment matrix
Sed_Th	numeric	Th nuclide content in ppm of the sediment matrix
Sed_Th_SE	numeric	error on Th nuclide content in ppm of the sediment matrix
Sed_U	numeric	U nuclide content in ppm of the sediment matrix
Sed_U_SE	numeric	error on U nuclide content in ppm of the sediment matrix
GrainSize	numeric	average grain size of the sediment matrix
WaterContent	numeric	mean water content of the sediment matrix in %
WaterContent_SE	numeric	relative error on water content

**Water content** The water content provided by the user should be calculated according to:

$$(Wet_{weight} - Dry_{weight}) / Dry_{weight} * 100$$

**Value**

The function returns an [RLum.Results](#) object for which the first element is a [matrix](#) ([DataIndividual](#)) that gives the dose rate results for each slice for each decay chain individually, for both, the cobble dose rate and the sediment dose rate. The second element is also a [matrix](#) ([DataComponent](#)) that gives the total beta and gamma-dose rates for the cobble and the adjacent sediment for each slice of the cobble.

**Function version**

0.1.0

**Author(s)**

Svenja Riedesel, Aberystwyth University (United Kingdom)  
 Martin Autzen, DTU NUTECH Center for Nuclear Technologies (Denmark) , RLum Developer Team

**References**

Riedesel, S., Autzen, M., 2020. Beta and gamma dose rate attenuation in rocks and sediment. *Radiation Measurements* 133, 106295.

**See Also**

[convert\\_Concentration2DoseRate](#)

**Examples**

```
## load example data
data("ExampleData.CobbleData", envir = environment())

## run function
calc_CobbleDoseRate(ExampleData.CobbleData)
```

---

calc\_CommonDose

*Apply the (un-)logged common age model after Galbraith et al. (1999) to a given De distribution*

---

**Description**

Function to calculate the common dose of a De distribution.

**Usage**

```
calc_CommonDose(data, sigmab, log = TRUE, ...)
```

**Arguments**

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[, 1]) and De error (data[, 2])
sigmab	<a href="#">numeric</a> ( <i>with default</i> ): additional spread in De values. This value represents the expected overdispersion in the data should the sample be well-bleached (Cunningham & Walling 2012, p. 100). <b>NOTE</b> : For the logged model (log = TRUE) this value must be a fraction, e.g. 0.2 (= 20 \ sigmab must be provided in the same absolute units of the De values (seconds or Gray).
log	<a href="#">logical</a> ( <i>with default</i> ): fit the (un-)logged central age model to De data
...	currently not used.

**Details****(Un-)logged model**

When log = TRUE this function calculates the weighted mean of logarithmic De values. Each of the estimates is weighted by the inverse square of its relative standard error. The weighted mean is then transformed back to the dose scale (Galbraith & Roberts 2012, p. 14).

The log transformation is not applicable if the De estimates are close to zero or negative. In this case the un-logged model can be applied instead (log = FALSE). The weighted mean is then calculated using the un-logged estimates of De and their absolute standard error (Galbraith & Roberts 2012, p. 14).

**Value**

Returns a terminal output. In addition an [RLum.Results](#) object is returned containing the following element:

.\$summary	<a href="#">data.frame</a> summary of all relevant model results.
.\$data	<a href="#">data.frame</a> original input data
.\$args	<a href="#">list</a> used arguments
.\$call	<a href="#">call</a> the function call

The output should be accessed using the function [get\\_RLum](#)

**Function version**

0.1.1

**Author(s)**

Christoph Burow, University of Cologne (Germany) , RLum Developer Team

**References**

- Galbraith, R.F. & Laslett, G.M., 1993. Statistical models for mixed fission track ages. Nuclear Tracks Radiation Measurements 4, 459-470.
- Galbraith, R.F., Roberts, R.G., Laslett, G.M., Yoshida, H. & Olley, J.M., 1999. Optical dating of single grains of quartz from Jinnium rock shelter, northern Australia. Part I: experimental design and statistical models. Archaeometry 41, 339-364.

Galbraith, R.F. & Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations. *Quaternary Geochronology* 11, 1-27.

#### Further reading

Arnold, L.J. & Roberts, R.G., 2009. Stochastic modelling of multi-grain equivalent dose (De) distributions: Implications for OSL dating of sediment mixtures. *Quaternary Geochronology* 4, 204-230.

Bailey, R.M. & Arnold, L.J., 2006. Statistical modelling of single grain quartz De distributions and an assessment of procedures for estimating burial dose. *Quaternary Science Reviews* 25, 2475-2502.

Cunningham, A.C. & Wallinga, J., 2012. Realizing the potential of fluvial archives using robust OSL chronologies. *Quaternary Geochronology* 12, 98-106.

Rodnight, H., Duller, G.A.T., Wintle, A.G. & Tooth, S., 2006. Assessing the reproducibility and accuracy of optical dating of fluvial deposits. *Quaternary Geochronology*, 1 109-120.

Rodnight, H., 2008. How many equivalent dose values are needed to obtain a reproducible distribution?. *Ancient TL* 26, 3-10.

#### See Also

[calc\\_CentralDose](#), [calc\\_FiniteMixture](#), [calc\\_FuchsLang2001](#), [calc\\_MinDose](#)

#### Examples

```
## load example data
data(ExampleData.DeValues, envir = environment())

## apply the common dose model
calc_CommonDose(ExampleData.DeValues$CA1)
```

---

calc_CosmicDoseRate	<i>Calculate the cosmic dose rate</i>
---------------------	---------------------------------------

---

#### Description

This function calculates the cosmic dose rate taking into account the soft- and hard-component of the cosmic ray flux and allows corrections for geomagnetic latitude, altitude above sea-level and geomagnetic field changes.

#### Usage

```
calc_CosmicDoseRate(
  depth,
  density,
  latitude,
  longitude,
  altitude,
  corr.fieldChanges = FALSE,
  est.age = NA,
  half.depth = FALSE,
```

```

    error = 10,
    ...
)

```

### Arguments

depth	<b>numeric (required)</b> : depth of overburden (m). For more than one absorber use <code>c(depth_1, depth_2, ..., depth_n)</code>
density	<b>numeric (required)</b> : average overburden density (g/cm <sup>3</sup> ). For more than one absorber use <code>c(density_1, density_2, ..., density_n)</code>
latitude	<b>numeric (required)</b> : latitude (decimal degree), N positive
longitude	<b>numeric (required)</b> : longitude (decimal degree), E positive
altitude	<b>numeric (required)</b> : altitude (m above sea-level)
corr.fieldChanges	<b>logical (with default)</b> : correct for geomagnetic field changes after Prescott & Hutton (1994). Apply only when justified by the data.
est.age	<b>numeric (with default)</b> : estimated age range (ka) for geomagnetic field change correction (0-80 ka allowed)
half.depth	<b>logical (with default)</b> : How to overcome with varying overburden thickness. If TRUE only half the depth is used for calculation. Apply only when justified, i.e. when a constant sedimentation rate can safely be assumed.
error	<b>numeric (with default)</b> : general error (percentage) to be implemented on corrected cosmic dose rate estimate
...	further arguments (verbose to disable/enable console output).

### Details

This function calculates the total cosmic dose rate considering both the soft- and hard-component of the cosmic ray flux.

#### Internal calculation steps

- (1) Calculate total depth of all absorber in hg/cm<sup>2</sup> (1 hg/cm<sup>2</sup> = 100 g/cm<sup>2</sup>)

$$absorber = depth_1 * density_1 + depth_2 * density_2 + ... + depth_n * density_n$$

- (2) If `half.depth = TRUE`

$$absorber = absorber / 2$$

- (3) Calculate cosmic dose rate at sea-level and 55 deg. latitude

- a) If absorber is > 167 g/cm<sup>2</sup> (only hard-component; Allkofer et al. 1975): apply equation given by Prescott & Hutton (1994) (c.f. Barbouti & Rastin 1983)

$$D0 = C / (((absorber + d)^\alpha + a) * (absorber + H)) * \exp(-B * absorber)$$

- b) If absorber is < 167 g/cm<sup>2</sup> (soft- and hard-component): derive D0 from Fig. 1 in Prescott & Hutton (1988).

- (4) Calculate geomagnetic latitude (Prescott & Stephan 1982, Prescott & Hutton 1994)



$$\lambda = \arcsin(0.203 * \cos(latitude) * \cos(longitude - 291) + 0.979 * \sin(latitude))$$

(5) Apply correction for geomagnetic latitude and altitude above sea-level. Values for F, J and H were read from Fig. 3 shown in Prescott & Stephan (1982) and fitted with 3-degree polynomials for  $\lambda < 35$  degree and a linear fit for  $\lambda > 35$  degree.

$$Dc = D0 * (F + J * \exp((altitude/1000)/H))$$

(6) Optional: Apply correction for geomagnetic field changes in the last 0-80 ka (Prescott & Hutton 1994). Correction and altitude factors are given in Table 1 and Fig. 1 in Prescott & Hutton (1994). Values for altitude factor were fitted with a 2-degree polynomial. The altitude factor is operated on the decimal part of the correction factor.

$$Dc' = Dc * correctionFactor$$

#### Usage of depth and density

- (1) If only one value for depth and density is provided, the cosmic dose rate is calculated for exactly one sample and one absorber as overburden (i.e. depth\*density).
- (2) In some cases it might be useful to calculate the cosmic dose rate for a sample that is overlain by more than one absorber, e.g. in a profile with soil layers of different thickness and a distinct difference in density. This can be calculated by providing a matching number of values for depth and density (e.g. depth = c(1, 2), density = c(1.7, 2.4))
- (3) Another possibility is to calculate the cosmic dose rate for more than one sample of the same profile. This is done by providing more than one values for depth and only one for density. For example, depth = c(1, 2, 3) and density = 1.7 will calculate the cosmic dose rate for three samples in 1, 2 and 3 m depth in a sediment of density 1.7 g/cm<sup>3</sup>.

#### Value

Returns a terminal output. In addition an [RLum.Results](#)-object is returned containing the following element:

summary	<a href="#">data.frame</a> summary of all relevant calculation results.
args	<a href="#">list</a> used arguments
call	<a href="#">call</a> the function call

The output should be accessed using the function [get\\_RLum](#)

#### Function version

0.5.2

#### Note

Despite its universal use the equation to calculate the cosmic dose rate provided by Prescott & Hutton (1994) is falsely stated to be valid from the surface to 10<sup>4</sup> hg/cm<sup>2</sup> of standard rock. The original expression by Barbouti & Rastin (1983) only considers the muon flux (i.e. hard-component) and is by their own definition only valid for depths between 10-10<sup>4</sup> hg/cm<sup>2</sup>.

Thus, for near-surface samples (i.e. for depths < 167 g/cm<sup>2</sup>) the equation of Prescott & Hutton (1994) underestimates the total cosmic dose rate, as it neglects the influence of the soft-component of the cosmic ray flux. For samples at zero depth and at sea-level the underestimation can be as

large as ~0.1 Gy/ka. In a previous article, Prescott & Hutton (1988) give another approximation of Barbouti & Rastin's equation in the form of

$$D = 0.21 * \exp(-0.070 * absorber + 0.0005 * absorber^2)$$

which is valid for depths between 150-5000 g/cm<sup>2</sup>. For shallower depths (< 150 g/cm<sup>2</sup>) they provided a graph (Fig. 1) from which the dose rate can be read.

As a result, this function employs the equation of Prescott & Hutton (1994) only for depths > 167 g/cm<sup>2</sup>, i.e. only for the hard-component of the cosmic ray flux. Cosmic dose rate values for depths < 167 g/cm<sup>2</sup> were obtained from the "AGE" program (Gruen 2009) and fitted with a 6-degree polynomial curve (and hence reproduces the graph shown in Prescott & Hutton 1988). However, these values assume an average overburden density of 2 g/cm<sup>3</sup>.

It is currently not possible to obtain more precise cosmic dose rate values for near-surface samples as there is no equation known to the author of this function at the time of writing.

### Author(s)

Christoph Burow, University of Cologne (Germany) , RLum Developer Team

### References

- Allkofer, O.C., Carstensen, K., Dau, W.D., Jokisch, H., 1975. Letter to the editor. The absolute cosmic ray flux at sea level. *Journal of Physics G: Nuclear and Particle Physics* 1, L51-L52.
- Barbouti, A.I., Rastin, B.C., 1983. A study of the absolute intensity of muons at sea level and under various thicknesses of absorber. *Journal of Physics G: Nuclear and Particle Physics* 9, 1577-1595.
- Crookes, J.N., Rastin, B.C., 1972. An investigation of the absolute intensity of muons at sea-level. *Nuclear Physics B* 39, 493-508.
- Gruen, R., 2009. The "AGE" program for the calculation of luminescence age estimates. *Ancient TL* 27, 45-46.
- Prescott, J.R., Hutton, J.T., 1988. Cosmic ray and gamma ray dosimetry for TL and ESR. *Nuclear Tracks and Radiation Measurements* 14, 223-227.
- Prescott, J.R., Hutton, J.T., 1994. Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations. *Radiation Measurements* 23, 497-500.
- Prescott, J.R., Stephan, L.G., 1982. The contribution of cosmic radiation to the environmental dose for thermoluminescence dating. Latitude, altitude and depth dependences. *PACT* 6, 17-25.

### See Also

[BaseDataSet.CosmicDoseRate](#)

### Examples

```
##(1) calculate cosmic dose rate (one absorber)
calc_CosmicDoseRate(depth = 2.78, density = 1.7,
                    latitude = 38.06451, longitude = 1.49646,
                    altitude = 364, error = 10)

##(2a) calculate cosmic dose rate (two absorber)
calc_CosmicDoseRate(depth = c(5.0, 2.78), density = c(2.65, 1.7),
                    latitude = 38.06451, longitude = 1.49646,
                    altitude = 364, error = 10)
```

```

##(2b) calculate cosmic dose rate (two absorber) and
##correct for geomagnetic field changes
calc_CosmicDoseRate(depth = c(5.0, 2.78), density = c(2.65, 1.7),
                    latitude = 12.04332, longitude = 4.43243,
                    altitude = 364, corr.fieldChanges = TRUE,
                    est.age = 67, error = 15)

##(3) calculate cosmic dose rate and export results to .csv file
#calculate cosmic dose rate and save to variable
results<- calc_CosmicDoseRate(depth = 2.78, density = 1.7,
                             latitude = 38.06451, longitude = 1.49646,
                             altitude = 364, error = 10)

# the results can be accessed by
get_RLum(results, "summary")

#export results to .csv file - uncomment for usage
#write.csv(results, file = "c:/users/public/results.csv")

##(4) calculate cosmic dose rate for 6 samples from the same profile
## and save to .csv file
#calculate cosmic dose rate and save to variable
results<- calc_CosmicDoseRate(depth = c(0.1, 0.5 , 2.1, 2.7, 4.2, 6.3),
                             density = 1.7, latitude = 38.06451,
                             longitude = 1.49646, altitude = 364,
                             error = 10)

#export results to .csv file - uncomment for usage
#write.csv(results, file = "c:/users/public/results_profile.csv")

```

calc\_FadingCorr

*Apply a fading correction according to Huntley & Lamothe (2001) for a given g-value and a given tc*

## Description

This function solves the equation used for correcting the fading affected age including the error for a given g-value according to Huntley & Lamothe (2001).

## Usage

```

calc_FadingCorr(
  age.faded,
  g_value,
  tc = NULL,
  tc.g_value = tc,
  n.MC = 10000,
  seed = NULL,
  interval = c(0.01, 500),
  txtProgressBar = TRUE,
  verbose = TRUE
)

```

## Arguments

age.faded	<b>numeric vector (required)</b> : uncorrected age with error in ka (see example)
g_value	<b>vector (required)</b> : g-value and error obtained from separate fading measurements (see example). Alternatively an <a href="#">RLum.Results</a> object can be provided produced by the function <a href="#">analyse_FadingMeasurement</a> , in this case tc is set automatically
tc	<b>numeric (required)</b> : time in seconds between irradiation and the prompt measurement (cf. Huntley & Lamothe 2001). Argument will be ignored if g_value was an <a href="#">RLum.Results</a> object
tc.g_value	<b>numeric (with default)</b> : the time in seconds between irradiation and the prompt measurement used for estimating the g-value. If the g-value was normalised to, e.g., 2 days, this time in seconds (i.e., 172800) should be given here. If nothing is provided the time is set to tc, which is usual case for g-values obtained using the SAR method and g-values that had been not normalised to 2 days.
n.MC	<b>integer (with default)</b> : number of Monte Carlo simulation runs for error estimation. If n.MC = 'auto' is used the function tries to find a 'stable' error for the age. <b>Note</b> : This may take a while!
seed	<b>integer (optional)</b> : sets the seed for the random number generator in R using <a href="#">set.seed</a>
interval	<b>numeric (with default)</b> : a vector containing the end-points (age interval) of the interval to be searched for the root in 'ka'. This argument is passed to the function <a href="#">stats::uniroot</a> used for solving the equation.
txtProgressBar	<b>logical (with default)</b> : enables or disables <a href="#">txtProgressBar</a>
verbose	<b>logical (with default)</b> : enables or disables terminal output

## Details

As the g-value slightly depends on the time between irradiation and the prompt measurement, this is tc, always a tc value needs to be provided. If the g-value was normalised to a distinct time or evaluated with a different tc value (e.g., external irradiation), also the tc value for the g-value needs to be provided (argument tc.g\_value and then the g-value is recalculated to tc of the measurement used for estimating the age applying the following equation:

$$\kappa_{tc} = \kappa_{tc.g} / (1 - \kappa_{tc.g} * \log(tc/tc.g))$$

where

$$\kappa_{tc.g} = g/100/\log(10)$$

with log the natural logarithm.

The error of the fading-corrected age is determined using a Monte Carlo simulation approach. Solving of the equation is realised using [uniroot](#). Large values for n.MC will significantly increase the computation time.

n.MC = 'auto'

The error estimation based on a stochastic process, i.e. for a small number of MC runs the calculated error varies considerably every time the function is called, even with the same input values. The argument option n.MC = 'auto' tries to find a stable value for the standard error, i.e. the standard

deviation of values calculated during the MC runs (`age.corr.MC`), within a given precision (2 digits) by increasing the number of MC runs stepwise and calculating the corresponding error.

If the determined error does not differ from the 9 values calculated previously within a precision of (here) 3 digits the calculation is stopped as it is assumed that the error is stable. Please note that (a) the duration depends on the input values as well as on the provided computation resources and it may take a while, (b) the length (size) of the output vector `age.corr.MC`, where all the single values produced during the MC runs are stored, equals the number of MC runs (here termed observations).

To avoid an endless loop the calculation is stopped if the number of observations exceeds  $10^7$ . This limitation can be overwritten by setting the number of MC runs manually, e.g. `n.MC = 10000001`. Note: For this case the function is not checking whether the calculated error is stable.

**seed**

This option allows to recreate previously calculated results by setting the seed for the R random number generator (see [set.seed](#) for details). This option should not be mixed up with the option `n.MC = 'auto'`. The results may appear similar, but they are not comparable!

## FAQ

Q: Which `tc` value is expected?

A: `tc` is the time in seconds between irradiation and the prompt measurement applied during your De measurement. However, this `tc` might differ from the `tc` used for estimating the `g`-value. In the case of an SAR measurement `tc` should be similar, however, if it differs, you have to provide this `tc` value (the one used for estimating the `g`-value) using the argument `tc.g_value`.

## Value

Returns an S4 object of type [RLum.Results](#).

Slot: `@data`

Object	Type	Comment
<code>age.corr</code>	<a href="#">data.frame</a>	Corrected age
<code>age.corr.MC</code>	<a href="#">numeric</a>	MC simulation results with all possible ages from that simulation

Slot: `@info`

Object	Type	Comment
<code>info</code>	<a href="#">character</a>	the original function call

## Function version

0.4.3

## Note

Special thanks to Sébastien Huot for his support and clarification via e-mail.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Huntley, D.J., Lamothe, M., 2001. Ubiquity of anomalous fading in K-feldspars and the measurement and correction for it in optical dating. Canadian Journal of Earth Sciences, 38, 1093-1106.

**See Also**

[RLum.Results](#), [analyse\\_FadingMeasurement](#), [get\\_RLum](#), [uniroot](#)

**Examples**

```
##run the examples given in the appendix of Huntley and Lamothe, 2001

##(1) faded age: 100 a
results <- calc_FadingCorr(
  age.faded = c(0.1,0),
  g_value = c(5.0, 1.0),
  tc = 2592000,
  tc.g_value = 172800,
  n.MC = 100)

##(2) faded age: 1 ka
results <- calc_FadingCorr(
  age.faded = c(1,0),
  g_value = c(5.0, 1.0),
  tc = 2592000,
  tc.g_value = 172800,
  n.MC = 100)

##(3) faded age: 10.0 ka
results <- calc_FadingCorr(
  age.faded = c(10,0),
  g_value = c(5.0, 1.0),
  tc = 2592000,
  tc.g_value = 172800,
  n.MC = 100)

##access the last output
get_RLum(results)
```

---

calc\_FastRatio

*Calculate the Fast Ratio for CW-OSL curves*

---

**Description**

Function to calculate the fast ratio of quartz CW-OSL single grain or single aliquot curves after Durcan & Duller (2011).

## Usage

```
calc_FastRatio(
  object,
  stimulation.power = 30.6,
  wavelength = 470,
  sigmaF = 2.6e-17,
  sigmaM = 4.28e-18,
  Ch_L1 = 1,
  Ch_L2 = NULL,
  Ch_L3 = NULL,
  x = 1,
  x2 = 0.1,
  dead.channels = c(0, 0),
  fitCW.sigma = FALSE,
  fitCW.curve = FALSE,
  plot = TRUE,
  ...
)
```

## Arguments

object	<a href="#">RLum.Analysis</a> , <a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <b>required</b> ): x, y data of measured values (time and counts).
stimulation.power	<a href="#">numeric</a> (with default): Stimulation power in mW/cm <sup>2</sup>
wavelength	<a href="#">numeric</a> (with default): Stimulation wavelength in nm
sigmaF	<a href="#">numeric</a> (with default): Photoionisation cross-section (cm <sup>2</sup> ) of the fast component. Default value after Durcan & Duller (2011).
sigmaM	<a href="#">numeric</a> (with default): Photoionisation cross-section (cm <sup>2</sup> ) of the medium component. Default value after Durcan & Duller (2011).
Ch_L1	<a href="#">numeric</a> (with default): An integer specifying the channel for L1.
Ch_L2	<a href="#">numeric</a> (optional): An integer specifying the channel for L2.
Ch_L3	<a href="#">numeric</a> (optional): A vector of length 2 with integer values specifying the start and end channels for L3 (e.g., c(40, 50)).
x	<a href="#">numeric</a> (with default): \ Used to define the location of L2 and L3 (start).
x2	<a href="#">numeric</a> (with default): \ Used to define the location of L3 (end).
dead.channels	<a href="#">numeric</a> (with default): Vector of length 2 in the form of c(x, y). Channels that do not contain OSL data, i.e. at the start or end of measurement.
fitCW.sigma	<a href="#">logical</a> (optional): fit CW-OSL curve using <a href="#">fit_CWCurve</a> to calculate sigmaF and sigmaM ( <b>experimental</b> ).
fitCW.curve	<a href="#">logical</a> (optional): fit CW-OSL curve using <a href="#">fit_CWCurve</a> and derive the counts of L2 and L3 from the fitted OSL curve ( <b>experimental</b> ).
plot	<a href="#">logical</a> (with default): plot output (TRUE/FALSE)
...	available options: verbose ( <a href="#">logical</a> ). Further arguments passed to <a href="#">fit_CWCurve</a> .

## Details

This function follows the equations of Durcan & Duller (2011). The energy required to reduce the fast and medium quartz OSL components to x and x2 \ and end). The fast ratio is then calculated from:  $(L1 - L3)/(L2 - L3)$ .

**Value**

Returns a plot (*optional*) and an S4 object of type [RLum.Results](#). The slot data contains a [list](#) with the following elements:

summary	<a href="#">data.frame</a> summary of all relevant results
data	the original input data
fit	<a href="#">RLum.Results</a> object if either fitCW.sigma or fitCW.curve is TRUE
args	<a href="#">list</a> of used arguments
call	[call] the function call

**Function version**

0.1.1

**Author(s)**

Georgina E. King, University of Bern (Switzerland)  
 Julie A. Durcan, University of Oxford (United Kingdom)  
 Christoph Burow, University of Cologne (Germany) , RLum Developer Team

**References**

Durcan, J.A. & Duller, G.A.T., 2011. The fast ratio: A rapid measure for testing the dominance of the fast component in the initial OSL signal from quartz. *Radiation Measurements* 46, 1065-1072.

Madsen, A.T., Duller, G.A.T., Donnelly, J.P., Roberts, H.M. & Wintle, A.G., 2009. A chronology of hurricane landfalls at Little Sippewissett Marsh, Massachusetts, USA, using optical dating. *Geomorphology* 109, 36-45.

**Further reading**

Steffen, D., Preusser, F. & Schlunegger, 2009. OSL quartz age underestimation due to unstable signal components. *Quaternary Geochronology* 4, 353-362.

**See Also**

[fit\\_CWCurve](#), [get\\_RLum](#), [RLum.Analysis](#), [RLum.Results](#), [RLum.Data.Curve](#)

**Examples**

```
# load example CW-OSL curve
data("ExampleData.CW_OSL_Curve")

# calculate the fast ratio w/o further adjustments
res <- calc_FastRatio(ExampleData.CW_OSL_Curve)

# show the summary table
get_RLum(res)
```



---

calc_FiniteMixture	<i>Apply the finite mixture model (FMM) after Galbraith (2005) to a given De distribution</i>
--------------------	---

---

## Description

This function fits a k-component mixture to a De distribution with differing known standard errors. Parameters (doses and mixing proportions) are estimated by maximum likelihood assuming that the log dose estimates are from a mixture of normal distributions.

## Usage

```
calc_FiniteMixture(
  data,
  sigmab,
  n.components,
  grain.probability = FALSE,
  dose.scale,
  pdf.weight = TRUE,
  pdf.sigma = "sigmab",
  pdf.colors = "gray",
  pdf.scale,
  plot.proportions = TRUE,
  plot = TRUE,
  ...
)
```

## Arguments

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[,1]) and De error (values[,2])
sigmab	<a href="#">numeric</a> ( <b>required</b> ): spread in De values given as a fraction (e.g. 0.2). This value represents the expected overdispersion in the data should the sample be well-bleached (Cunningham & Wallinga 2012, p. 100).
n.components	<a href="#">numeric</a> ( <b>required</b> ): number of components to be fitted. If a vector is provided (e.g. c(2:8)) the finite mixtures for 2, 3 ... 8 components are calculated and a plot and a statistical evaluation of the model performance (BIC score and maximum log-likelihood) is provided.
grain.probability	<a href="#">logical</a> ( <i>with default</i> ): prints the estimated probabilities of which component each grain is in
dose.scale	<a href="#">numeric</a> : manually set the scaling of the y-axis of the first plot with a vector in the form of c(min, max)
pdf.weight	<a href="#">logical</a> ( <i>with default</i> ): weight the probability density functions by the components proportion (applies only when a vector is provided for n.components)
pdf.sigma	<a href="#">character</a> ( <i>with default</i> ): if "sigmab" the components normal distributions are plotted with a common standard deviation (i.e. sigmab) as assumed by the FFM. Alternatively, "se" takes the standard error of each component for the sigma parameter of the normal distribution

pdf.colors	<a href="#">character</a> (with default): colour coding of the components in the the plot. Possible options are "gray", "colors" and "none"
pdf.scale	<a href="#">numeric</a> : manually set the max density value for proper scaling of the x-axis of the first plot
plot.proportions	<a href="#">logical</a> (with default): plot <a href="#">graphics::barplot</a> showing the proportions of components if n.components a vector with a length > 1 (e.g., n.components = c(2:3))
plot	<a href="#">logical</a> (with default): plot output
...	further arguments to pass. See details for their usage.

## Details

This model uses the maximum likelihood and Bayesian Information Criterion (BIC) approaches.

Indications of overfitting are:

- increasing BIC
- repeated dose estimates
- covariance matrix not positive definite
- covariance matrix produces NaN
- convergence problems

## Plot

If a vector (c(k.min:k.max)) is provided for n.components a plot is generated showing the the k components equivalent doses as normal distributions. By default pdf.weight is set to FALSE, so that the area under each normal distribution is always 1. If TRUE, the probability density functions are weighted by the components proportion for each iteration of k components, so the sum of areas of each component equals 1. While the density values are on the same scale when no weights are used, the y-axis are individually scaled if the probability density are weighted by the components proportion.

The standard deviation (sigma) of the normal distributions is by default determined by a common sigmab (see pdf.sigma). For pdf.sigma = "se" the standard error of each component is taken instead.

The stacked [graphics::barplot](#) shows the proportion of each component (in per cent) calculated by the FFM. The last plot shows the achieved BIC scores and maximum log-likelihood estimates for each iteration of k.

## Value

Returns a plot (*optional*) and terminal output. In addition an [RLum.Results](#) object is returned containing the following elements:

.\$summary	<a href="#">data.frame</a> summary of all relevant model results.
.\$data	<a href="#">data.frame</a> original input data
.\$args	<a href="#">list</a> used arguments
.\$call	<a href="#">call</a> the function call
.\$mle	covariance matrices of the log likelihoods
.\$BIC	BIC score
.\$llik	maximum log likelihood

.`$grain.probability` probabilities of a grain belonging to a component

.`$components` [matrix](#) estimates of the de, de error and proportion for each component

.`$single.comp` [data.frame](#) single component FFM estimate

If a vector for `n.components` is provided (e.g. `c(2:8)`), `mle` and `grain.probability` are lists containing matrices of the results for each iteration of the model.

The output should be accessed using the function [get\\_RLum](#)

## Function version

0.4.2

## Author(s)

Christoph Burow, University of Cologne (Germany)  
Based on a rewritten S script of Rex Galbraith, 2006. , [RLum Developer Team](#)

## References

- Galbraith, R.F. & Green, P.F., 1990. Estimating the component ages in a finite mixture. *Nuclear Tracks and Radiation Measurements* 17, 197-206.
- Galbraith, R.F. & Laslett, G.M., 1993. Statistical models for mixed fission track ages. *Nuclear Tracks Radiation Measurements* 4, 459-470.
- Galbraith, R.F. & Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations. *Quaternary Geochronology* 11, 1-27.
- Roberts, R.G., Galbraith, R.F., Yoshida, H., Laslett, G.M. & Olley, J.M., 2000. Distinguishing dose populations in sediment mixtures: a test of single-grain optical dating procedures using mixtures of laboratory-dosed quartz. *Radiation Measurements* 32, 459-465.
- Galbraith, R.F., 2005. *Statistics for Fission Track Analysis*, Chapman & Hall/CRC, Boca Raton.

## Further reading

- Arnold, L.J. & Roberts, R.G., 2009. Stochastic modelling of multi-grain equivalent dose (De) distributions: Implications for OSL dating of sediment mixtures. *Quaternary Geochronology* 4, 204-230.
- Cunningham, A.C. & Wallinga, J., 2012. Realizing the potential of fluvial archives using robust OSL chronologies. *Quaternary Geochronology* 12, 98-106.
- Rodnight, H., Duller, G.A.T., Wintle, A.G. & Tooth, S., 2006. Assessing the reproducibility and accuracy of optical dating of fluvial deposits. *Quaternary Geochronology* 1, 109-120.
- Rodnight, H. 2008. How many equivalent dose values are needed to obtain a reproducible distribution?. *Ancient TL* 26, 3-10.

## See Also

[calc\\_CentralDose](#), [calc\\_CommonDose](#), [calc\\_FuchsLang2001](#), [calc\\_MinDose](#)

## Examples

```
## load example data
data(ExampleData.DeValues, envir = environment())

## (1) apply the finite mixture model
## NOTE: the data set is not suitable for the finite mixture model,
## which is why a very small sigmab is necessary
calc_FiniteMixture(ExampleData.DeValues$CA1,
  sigmab = 0.2, n.components = 2,
  grain.probability = TRUE)

## (2) repeat the finite mixture model for 2, 3 and 4 maximum number of fitted
## components and save results
## NOTE: The following example is computationally intensive. Please un-comment
## the following lines to make the example work.
FMM<- calc_FiniteMixture(ExampleData.DeValues$CA1,
  sigmab = 0.2, n.components = c(2:4),
  pdf.weight = TRUE, dose.scale = c(0, 100))

## show structure of the results
FMM

## show the results on equivalent dose, standard error and proportion of
## fitted components
get_RLum(object = FMM, data.object = "components")
```

---

calc_FuchsLang2001	<i>Apply the model after Fuchs &amp; Lang (2001) to a given De distribution.</i>
--------------------	--

---

## Description

This function applies the method according to Fuchs & Lang (2001) for heterogeneously bleached samples with a given coefficient of variation threshold.

## Usage

```
calc_FuchsLang2001(data, cvThreshold = 5, startDeValue = 1, plot = TRUE, ...)
```

## Arguments

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[,1]) and De error (values[,2])
cvThreshold	<a href="#">numeric</a> ( <i>with default</i> ): coefficient of variation in percent, as threshold for the method, e.g. cvThreshold = 3. See details .
startDeValue	<a href="#">numeric</a> ( <i>with default</i> ): number of the first aliquot that is used for the calculations
plot	<a href="#">logical</a> ( <i>with default</i> ): plot output TRUE/FALSE
...	further arguments and graphical parameters passed to <a href="#">plot</a>

## Details

### Used values

If the coefficient of variation ( $c[v]$ ) of the first two values is larger than the threshold  $c[v\_threshold]$ , the first value is skipped. Use the `startDeValue` argument to define a start value for calculation (e.g. 2nd or 3rd value).

### Basic steps of the approach

1. Estimate natural relative variation of the sample using a dose recovery test
2. Sort the input values ascendantly
3. Calculate a running mean, starting with the lowermost two values and add values iteratively.
4. Stop if the calculated  $c[v]$  exceeds the specified `cvThreshold`

## Value

Returns a plot (*optional*) and terminal output. In addition an [RLum.Results](#) object is returned containing the following elements:

<code>summary</code>	<a href="#">data.frame</a> summary of all relevant model results.
<code>data</code>	<a href="#">data.frame</a> original input data
<code>args</code>	<a href="#">list</a> used arguments
<code>call</code>	<a href="#">call</a> the function call
<code>usedDeValues</code>	<a href="#">data.frame</a> containing the used values for the calculation

## Function version

0.4.1

## Note

Please consider the requirements and the constraints of this method (see Fuchs & Lang, 2001)

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 Christoph Burow, University of Cologne (Germany) , RLum Developer Team

## References

- Fuchs, M. & Lang, A., 2001. OSL dating of coarse-grain fluvial quartz using single-aliquot protocols on sediments from NE Peloponnese, Greece. In: Quaternary Science Reviews 20, 783-787.
- Fuchs, M. & Wagner, G.A., 2003. Recognition of insufficient bleaching by small aliquots of quartz for reconstructing soil erosion in Greece. Quaternary Science Reviews 22, 1161-1167.

## See Also

[plot](#), [calc\\_MinDose](#), [calc\\_FiniteMixture](#), [calc\\_CentralDose](#), [calc\\_CommonDose](#), [RLum.Results](#)

## Examples

```
## load example data
data(ExampleData.DeValues, envir = environment())

## calculate De according to Fuchs & Lang (2001)
temp<- calc_FuchsLang2001(ExampleData.DeValues$BT998, cvThreshold = 5)
```

---

calc\_gSGC

---

*Calculate De value based on the gSGC by Li et al., 2015*


---

## Description

Function returns De value and De value error using the global standardised growth curve (gSGC) assumption proposed by Li et al., 2015 for OSL dating of sedimentary quartz

## Usage

```
calc_gSGC(
  data,
  gSGC.type = "0-250",
  gSGC.parameters,
  n.MC = 100,
  verbose = TRUE,
  plot = TRUE,
  ...
)
```

## Arguments

data	<b>data.frame (required):</b> input data of providing the following columns: LnTn, LnTn.error, Lr1Tr1, Lr1Tr1.error, Dr1 <b>Note:</b> column names are not required. The function expect the input data in the given order
gSGC.type	<b>character (with default):</b> define the function parameters that should be used for the iteration procedure: Li et al., 2015 (Table 2) presented function parameters for two dose ranges: "0-450" and "0-250"
gSGC.parameters	<b>list (optional):</b> option to provide own function parameters used for fitting as named list. Nomenclature follows Li et al., 2015, i.e. list(A, A.error, D0, D0.error, c, c.error, Y, range requires a vector for the range the function is considered as valid, e.g. range = c(0, 250) Using this option overwrites the default parameter list of the gSGC, meaning the argument gSGC.type will be without effect
n.MC	<b>integer (with default):</b> number of Monte Carlo simulation runs for error estimation, see details.
verbose	<b>logical:</b> enable or disable terminal output
plot	<b>logical:</b> enable or disable graphical feedback as plot
...	parameters will be passed to the plot output

## Details

The error of the De value is determined using a Monte Carlo simulation approach. Solving of the equation is realised using [uniroot](#). Large values for n.MC will significantly increase the computation time.

## Value

Returns an S4 object of type [RLum.Results](#).

```
@data
$ De.value (data.frame)
.. $ De
.. $ De.error
.. $ Eta
$ De.MC (list) contains the matrices from the error estimation.
$ uniroot (list) contains the uniroot outputs of the De estimations

@info
'$ call' (call) the original function call
```

## Function version

0.1.1

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## References

Li, B., Roberts, R.G., Jacobs, Z., Li, S.-H., 2015. Potential of establishing a 'global standardised growth curve' (gSGC) for optical dating of quartz from sediments. Quaternary Geochronology 27, 94-104. doi:10.1016/j.quageo.2015.02.011

## See Also

[RLum.Results](#), [get\\_RLum](#), [uniroot](#)

## Examples

```
results <- calc_gSGC(data = data.frame(
  LnTn = 2.361, LnTn.error = 0.087,
  Lr1Tr1 = 2.744, Lr1Tr1.error = 0.091,
  Dr1 = 34.4))

get_RLum(results, data.object = "De")
```

---

calc_gSGC_feldspar	<i>Calculate Global Standardised Growth Curve (gSGC) for Feldspar MET-pIRIR</i>
--------------------	---

---

## Description

Implementation of the gSGC approach for feldspar MET-pIRIR by Li et al. (2015)

## Usage

```
calc_gSGC_feldspar(
  data,
  gSGC.type = "50LxTx",
  gSGC.parameters,
  n.MC = 100,
  plot = FALSE
)
```

## Arguments

data	<b>data.frame (required)</b> : data frame with five columns per sample c("LnTn", "LnTn.error", "Lr1Tr1", "Lr1Tr1.error", "Dr1")
gSGC.type	<b>character (with default)</b> : growth curve type to be selected according to Table 3 in Li et al. (2015). Allowed options are "50LxTx", "50Lx", "50Tx", "100LxTx", "100Lx", "100Tx", "150LxTx", "150Lx", "150Tx", "200LxTx", "200Lx", "200Tx", "250LxTx", "250Lx", "250Tx"
gSGC.parameters	<b>data.frame (optional)</b> : an own parameter set for the gSGC with the following columns y1, y1_err, D1 D1_err, y2, y2_err, y0, y0_err.
n.MC	<b>numeric (with default)</b> : number of Monte-Carlo runs for the error calculation
plot	<b>logical (with default)</b> : enables/disables the control plot output

## Details

##TODO

## Value

Returns an S4 object of type **RLum.Results**.

```
@data
$ df (data.frame)
.. $DE the calculated equivalent dose
.. $DE.ERROR error on the equivalent dose, which is the standard deviation of the MC runs
.. $HPD95_LOWER lower boundary of the highest probability density (95%)
.. $HPD95_UPPER upper boundary of the highest probability density (95%)
$ m.MC (list) numeric vector with results from the MC runs.

@info
'$ call' (call) the original function call
```



**Function version**

0.1.0

**Author(s)**

Harrison Gray, USGS (United States), Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Li, B., Roberts, R.G., Jacobs, Z., Li, S.-H., Guo, Y.-J., 2015. Construction of a “global standardised growth curve” (gSGC) for infrared stimulated luminescence dating of K-feldspar 27, 119–130. [doi:10.1016/j.quageo.2015.02.010](https://doi.org/10.1016/j.quageo.2015.02.010)

**See Also**

[RLum.Results](#), [get\\_RLum](#), [uniroot](#), [calc\\_gSGC](#)

**Examples**

```
##test on a generated random sample
n_samples <- 10
data <- data.frame(
  LnTn = rnorm(n=n_samples, mean=1.0, sd=0.02),
  LnTn.error = rnorm(n=n_samples, mean=0.05, sd=0.002),
  Lr1Tr1 = rnorm(n=n_samples, mean=1.0, sd=0.02),
  Lr1Tr1.error = rnorm(n=n_samples, mean=0.05, sd=0.002),
  Dr1 = rep(100,n_samples))

results <- calc_gSGC_feldspar(
  data = data, gSGC.type = "50LxTx",
  plot = FALSE)

plot_AbanicoPlot(results)
```

---

calc\_HomogeneityTest    *Apply a simple homogeneity test after Galbraith (2003)*

---

**Description**

A simple homogeneity test for De estimates

**Usage**

```
calc_HomogeneityTest(data, log = TRUE, ...)
```

**Arguments**

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[,1]) and De error (values[,2])
log	<a href="#">logical</a> ( <i>with default</i> ): perform the homogeneity test with (un-)logged data
...	further arguments (for internal compatibility only).

## Details

For details see Galbraith (2003).

## Value

Returns a terminal output. In addition an [RLum.Results](#)-object is returned containing the following elements:

summary	<a href="#">data.frame</a> summary of all relevant model results.
data	<a href="#">data.frame</a> original input data
args	<a href="#">list</a> used arguments
call	<a href="#">call</a> the function call

The output should be accessed using the function [get\\_RLum](#)

## Function version

0.3.0

## Author(s)

Christoph Burow, University of Cologne (Germany), Sebastian Kreutzer, IRAMAT-CRP2A, Université Bordeaux Montaigne (France) , RLum Developer Team

## References

Galbraith, R.F., 2003. A simple homogeneity test for estimates of dose obtained using OSL. Ancient TL 21, 75-77.

## See Also

[pchisq](#)

## Examples

```
## load example data
data(ExampleData.DeValues, envir = environment())

## apply the homogeneity test
calc_HomogeneityTest(ExampleData.DeValues$BT998)

## using the data presented by Galbraith (2003)
df <-
  data.frame(
    x = c(30.1, 53.8, 54.3, 29.0, 47.6, 44.2, 43.1),
    y = c(4.8, 7.1, 6.8, 4.3, 5.2, 5.9, 3.0))

calc_HomogeneityTest(df)
```

---

calc_Huntley2006	<i>Apply the Huntley (2006) model</i>
------------------	---------------------------------------

---

**Description**

A function to calculate the expected sample specific fraction of saturation based on the model of Huntley (2006) using the approach as implemented in Kars et al. (2008) or Guralnik et al. (2015).

**Usage**

```
calc_Huntley2006(  
  data,  
  LnTn = NULL,  
  rhop,  
  ddot,  
  readerDdot,  
  normalise = TRUE,  
  fit.method = c("EXP", "GOK"),  
  lower.bounds = c(-Inf, -Inf, -Inf, -Inf),  
  summary = TRUE,  
  plot = TRUE,  
  ...  
)
```

**Arguments**

data **data.frame (required)**: A data.frame with one of the following structures:

- A **three column** data frame with numeric values on a) dose (s), b) LxTx and c) LxTx error.
- If a **two column** data frame is provided it is automatically assumed that errors on LxTx are missing. A third column will be attached with an arbitrary 5 \
- Can also be a **wide table**, i.e. a **data.frame** with a number of columns divisible by 3 and where each triplet has the aforementioned column structure.

(optional)			
	dose (s)	LxTx	LxTx error
	[ ,1]	[ ,2]	[ ,3]
	-----	-----	-----
[1, ]	0	LnTn	LnTn error (optional, see arg 'LnTn')
[2, ]	R1	L1T1	L1T1 error
...	...	...	...
[x, ]	Rx	LxTx	LxTx error

**NOTE:** The function assumes the first row of the function to be the Ln/Tn-value. If you want to provide more than one Ln/Tn-value consider using the argument LnTn.

LnTn **data.frame (optional)**: This argument should **only** be used to provide more than one Ln/Tn-value. It assumes a two column data frame with the following structure:

	LnTn   LnTn error
	[ ,1]   [ ,2]
	----- -----
[1, ]	LnTn_1   LnTn_1 error
[2, ]	LnTn_2   LnTn_2 error
...	...   ...
[x, ]	LnTn_x   LnTn_x error

The function will calculate a **mean** Ln/Tn-value and uses either the standard deviation or the highest individual error, whichever is larger. If another mean value (e.g. a weighted mean or median) or error is preferred, this value must be calculated beforehand and used in the first row in the data frame for argument data.

**NOTE:** If you provide LnTn-values with this argument the data frame for the data-argument **must not** contain any LnTn-values!

rhop	<b>numeric (required):</b> The density of recombination centres ( $\rho'$ ) and its error (see Huntley 2006), given as numeric vector of length two. Note that $\rho'$ must <b>not</b> be provided as the common logarithm. Example: <code>rhop = c(2.92e-06, 4.93e-07)</code> .
ddot	<b>numeric (required):</b> Environmental dose rate and its error, given as a numeric vector of length two. Expected unit: Gy/ka. Example: <code>ddot = c(3.7, 0.4)</code> .
readerDdot	<b>numeric (required):</b> Dose rate of the irradiation source of the OSL reader and its error, given as a numeric vector of length two. Expected unit: Gy/s. Example: <code>readerDdot = c(0.08, 0.01)</code> .
normalise	<b>logical (with default):</b> If TRUE (the default) all measured and computed $\frac{L_x}{T_x}$ values are normalised by the pre-exponential factor A (see details).
fit.method	<b>character (with default):</b> Fit function of the dose response curve. Can either be EXP (the default) or GOK. Note that EXP (single saturating exponential) is the original function the model after Huntley (2006) and Kars et al. (2008) was designed to use. The use of a general-order kinetics function (GOK) is an experimental adaptation of the model and should be used with great care.
lower.bounds	<b>numeric (with default):</b> Only applicable for <code>fit.method = 'GOK'</code> . A vector of length 3 that contains the lower bound values for fitting the general-order kinetics function using <code>minpack.lm::nlsLM</code> . In most cases, the default values ( <code>c(-Inf, -Inf, -Inf)</code> ) are appropriate for finding a best fit, but sometimes it may be useful to restrict the lower bounds to e.g. <code>c(0, 0, 0)</code> . The values of the vector are for parameters a, D0 and c in that particular order (see details in <a href="#">plot_GrowthCurve</a> ).
summary	<b>logical (with default):</b> If TRUE (the default) various parameters provided by the user and calculated by the model are added as text on the right-hand side of the plot.
plot	<b>logical (with default):</b> enables/disables plot output.
...	Further parameters: <ul style="list-style-type: none"> <li>• verbose <b>logical:</b> Show or hide console output</li> <li>• n.MC <b>numeric:</b> Number of Monte Carlo iterations (default = 100000). <b>Note</b> that it is generally advised to have a large number of Monte Carlo iterations for the results to converge. Decreasing the number of iterations will often result in unstable estimates.</li> </ul>

All other arguments are passed to [plot](#) and [plot\\_GrowthCurve](#) (in particular mode for the fit mode and `fit.force_through_origin`)

## Details

This function applies the approach described in Kars et al. (2008) or Guralnik et al. (2015), which are both developed from the model of Huntley (2006) to calculate the expected sample specific fraction of saturation of a feldspar and also to calculate fading corrected age using this model.  $\rho'$  (rhop), the density of recombination centres, is a crucial parameter of this model and must be determined separately from a fading measurement. The function [analyse\\_FadingMeasurement](#) can be used to calculate the sample specific  $\rho'$  value.

### Kars et al. (2008) - Single saturating exponential

To apply the approach after Kars et al. (2008) use `fit.method = "EXP"`.

Firstly, the unfaded  $D_0$  value is determined through applying equation 5 of Kars et al. (2008) to the measured  $\frac{L_x}{T_x}$  data as a function of irradiation time, and fitting the data with a single saturating exponential of the form:

$$\frac{L_x}{T_x}(t^*) = A\phi(t^*)\{1 - \exp(-\frac{t^*}{D_0})\}$$

where

$$\phi(t^*) = \exp(-\rho' \ln(1.8\tilde{s}t^*)^3)$$

after King et al. (2016) where  $A$  is a pre-exponential factor,  $t^*$  (s) is the irradiation time, starting at the mid-point of irradiation (Auclair et al. 2003) and  $\tilde{s}$  ( $3 \times 10^{15} \text{ s}^{-1}$ ) is the athermal frequency factor after Huntley (2006).

Using fit parameters  $A$  and  $D_0$ , the function then computes a natural dose response curve using the environmental dose rate,  $\dot{D}$  (Gy/s) and equations [1] and [2]. Computed  $\frac{L_x}{T_x}$  values are then fitted using the [plot\\_GrowthCurve](#) function and the laboratory measured LnTn can then be interpolated onto this curve to determine the fading corrected  $D_e$  value, from which the fading corrected age is calculated.

### Guralnik et al. (2015) - General-order kinetics

To apply the approach after Guralnik et al. (2015) use `fit.method = "GOK"`.

The approach of Guralnik et al. (2015) is very similar to that of Kars et al. (2008), but instead of using a single saturating exponential the model fits a general-order kinetics function of the form:

$$\frac{L_x}{T_x}(t^*) = A\phi(t^*)(1 - (1 + (\frac{1}{D_0})t^*c)^{-1/c})$$

where  $A$ ,  $\phi$ ,  $t^*$  and  $D_0$  are the same as above and  $c$  is a dimensionless kinetic order modifier (cf. equation 10 in Guralnik et al., 2015).

### Level of saturation

The [calc\\_Huntley2006](#) function also calculates the level of saturation ( $\frac{n}{N}$ ) and the field saturation (i.e. athermal steady state, (n/N)\_SS) value for the sample under investigation using the sample specific  $\rho'$ , unfaded  $D_0$  and  $\dot{D}$  values, following the approach of Kars et al. (2008).

### Uncertainties

Uncertainties are reported at  $1\sigma$  and are assumed to be normally distributed and are estimated using Monte-Carlo re-sampling (n.MC = 1000) of  $\rho'$  and  $\frac{L_x}{T_x}$  during dose response curve fitting, and of  $\rho'$  in the derivation of (n/N) and (n/N)\_SS.

### Age calculated from 2D0 of the simulated natural DRC

In addition to the age calculated from the equivalent dose derived from  $\frac{L_n}{T_n}$  projected on the simulated natural dose response curve (DRC), this function also calculates an age from twice the characteristic saturation dose ( $D_0$ ) of the simulated natural DRC. This can be a useful information for (over)saturated samples (i.e., no intersect of  $\frac{L_n}{T_n}$  on the natural DRC) to obtain at least a "minimum age" estimate of the sample. In the console output this value is denoted by "Age @2D0 (ka):".

### Value

An **RLum.Results** object is returned:

Slot: **@data**

OBJECT	TYPE	COMMENT
results	<a href="#">data.frame</a>	results of the of Kars et al. 2008 model
data	<a href="#">data.frame</a>	original input data
Ln	<a href="#">numeric</a>	Ln and its error
LxTx_tables	list	A list of <code>data.frame</code> s containing data on dose, LxTx and LxTx error for each of the dose
fits	list	A list of nls objects produced by <a href="#">minpack.lm::nlsLM</a> when fitting the dose response curve

Slot: **@info**

OBJECT	TYPE	COMMENT
call	call	the original function call
args	list	arguments of the original function call

### Function version

0.4.5

### Note

This function has BETA status, in particular for the GOK implementation. Please verify your results carefully

### Author(s)

Georgina E. King, University of Lausanne (Switzerland)  
 Christoph Burow, University of Cologne (Germany)  
 Sebastian Kreutzer, Ruprecht-Karl University of Heidelberg (Germany) , RLum Developer Team

### References

- Kars, R.H., Wallinga, J., Cohen, K.M., 2008. A new approach towards anomalous fading correction for feldspar IRSL dating-tests on samples in field saturation. *Radiation Measurements* 43, 786-790. doi:10.1016/j.radmeas.2008.01.021
- Guralnik, B., Li, B., Jain, M., Chen, R., Paris, R.B., Murray, A.S., Li, S.-H., Pagonis, P., Herman, F., 2015. Radiation-induced growth and isothermal decay of infrared-stimulated luminescence from feldspar. *Radiation Measurements* 81, 224-231.
- Huntley, D.J., 2006. An explanation of the power-law decay of luminescence. *Journal of Physics: Condensed Matter* 18, 1359-1365. doi:10.1088/0953-8984/18/4/020

King, G.E., Herman, F., Lambert, R., Valla, P.G., Guralnik, B., 2016. Multi-OSL-thermochronometry of feldspar. *Quaternary Geochronology* 33, 76-87. doi:10.1016/j.quageo.2016.01.004

### Further reading

Morthekai, P., Jain, M., Cunha, P.P., Azevedo, J.M., Singhvi, A.K., 2011. An attempt to correct for the fading in million year old basaltic rocks. *Geochronometria* 38(3), 223-230.

### Examples

```
## Load example data (sample UNIL/NB123, see ?ExampleData.Fading)
data("ExampleData.Fading", envir = environment())

## (1) Set all relevant parameters
# a. fading measurement data (IR50)
fading_data <- ExampleData.Fading$fading.data$IR50

# b. Dose response curve data
data <- ExampleData.Fading$equivalentDose.data$IR50

## (2) Define required function parameters
ddot <- c(7.00, 0.004)
readerDdot <- c(0.134, 0.0067)

# Analyse fading measurement and get an estimate of rho'.
# Note that the RLum.Results object can be directly used for further processing.
# The number of MC runs is reduced for this example
rhop <- analyse_FadingMeasurement(fading_data, plot = TRUE, verbose = FALSE, n.MC = 10)

## (3) Apply the Kars et al. (2008) model to the data
kars <- calc_Huntley2006(
  data = data,
  rhop = rhop,
  ddot = ddot,
  readerDdot = readerDdot,
  n.MC = 25)

## Not run:
# You can also provide LnTn values separately via the 'LnTn' argument.
# Note, however, that the data frame for 'data' must then NOT contain
# a LnTn value. See argument descriptions!
LnTn <- data.frame(
  LnTn = c(1.84833, 2.24833),
  nTn.error = c(0.17, 0.22))

LxTx <- data[2:nrow(data), ]

kars <- calc_Huntley2006(
  data = LxTx,
  LnTn = LnTn,
  rhop = rhop,
  ddot = ddot,
  readerDdot = readerDdot,
  n.MC = 25)

## End(Not run)
```

---

calc_IEU	<i>Apply the internal-external-uncertainty (IEU) model after Thomsen et al. (2007) to a given De distribution</i>
----------	---

---

## Description

Function to calculate the IEU De for a De data set.

## Usage

```
calc_IEU(data, a, b, interval, decimal.point = 2, plot = TRUE, ...)
```

## Arguments

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[,1]) and De error (values[,2])
a	<a href="#">numeric</a> ( <b>required</b> ): slope
b	<a href="#">numeric</a> ( <b>required</b> ): intercept
interval	<a href="#">numeric</a> ( <b>required</b> ): fixed interval (e.g. 5 Gy) used for iteration of Dbar, from the mean to Lowest.De used to create Graph.IEU [Dbar.Fixed vs Z]
decimal.point	<a href="#">numeric</a> ( <i>with default</i> ): number of decimal points for rounding calculations (e.g. 2)
plot	<a href="#">logical</a> ( <i>with default</i> ): plot output
...	further arguments (trace, verbose).

## Details

This function uses the equations of Thomsen et al. (2007). The parameters a and b are estimated from dose-recovery experiments.

## Value

Returns a plot (*optional*) and terminal output. In addition an [RLum.Results](#) object is returned containing the following elements:

.\$summary	<a href="#">data.frame</a> summary of all relevant model results.
.\$data	<a href="#">data.frame</a> original input data
.\$args	<a href="#">list</a> used arguments
.\$call	<a href="#">call</a> the function call
.\$tables	<a href="#">list</a> a list of data frames containing all calculation tables

The output should be accessed using the function [get\\_RLum](#).

## Function version

0.1.1



**Author(s)**

Rachel Smedley, Geography & Earth Sciences, Aberystwyth University (United Kingdom)  
 Based on an excel spreadsheet and accompanying macro written by Kristina Thomsen. , RLum  
 Developer Team

**References**

Smedley, R.K., 2015. A new R function for the Internal External Uncertainty (IEU) model. Ancient TL 33, 16-21.

Thomsen, K.J., Murray, A.S., Boetter-Jensen, L. & Kinahan, J., 2007. Determination of burial dose in incompletely bleached fluvial samples using single grains of quartz. Radiation Measurements 42, 370-379.

**See Also**

[plot](#), [calc\\_CommonDose](#), [calc\\_CentralDose](#), [calc\\_FiniteMixture](#), [calc\\_FuchsLang2001](#), [calc\\_MinDose](#)

**Examples**

```
## load data
data(ExampleData.DeValues, envir = environment())

## apply the IEU model
ieu <- calc_IEU(ExampleData.DeValues$CA1, a = 0.2, b = 1.9, interval = 1)
```

---

calc\_Kars2008

---

*Apply the Kars et al. (2008) model (deprecated)*


---

**Description**

A function to calculate the expected sample specific fraction of saturation following Kars et al. (2008) and Huntley (2006). This function is deprecated and will eventually be removed. Please use `calc_Huntley2006()` instead.

**Usage**

```
calc_Kars2008(fit.method = "EXP", ...)
```

**Arguments**

<code>fit.method</code>	<b>character</b> ( <i>with default</i> ): Fit function of the dose response curve. Can either be EXP (the default) or GOK. Note that EXP (single saturating exponential) is the original function the model after Huntley (2006) and Kars et al. (2008) was designed to use. The use of a general-order kinetics function (GOK) is an experimental adaption of the model and should only be used with great care.
<code>...</code>	Parameters passed to <a href="#">calc_Huntley2006</a> .

## Details

This function applies the approach described in Kars et al. (2008), developed from the model of Huntley (2006) to calculate the expected sample specific fraction of saturation of a feldspar and also to calculate fading corrected age using this model.  $\rho'$  (rhop), the density of recombination centres, is a crucial parameter of this model and must be determined separately from a fading measurement. The function [analyse\\_FadingMeasurement](#) can be used to calculate the sample specific  $\rho'$  value.

## Value

An [RLum.Results](#) object is returned:

## Function version

0.4.0

## Note

**This function is deprecated and will eventually be removed from the package. Please use the function [calc\\_Huntley2006\(\)](#) instead (use `fit.method = "EXP"` to apply the model after Kars et al., 2008).**

## Author(s)

Georgina E. King, University of Bern (Switzerland)  
Christoph Burow, University of Cologne (Germany) , RLum Developer Team

## References

- Kars, R.H., Wallinga, J., Cohen, K.M., 2008. A new approach towards anomalous fading correction for feldspar IRSL dating-tests on samples in field saturation. *Radiation Measurements* 43, 786-790. doi:10.1016/j.radmeas.2008.01.021
- Huntley, D.J., 2006. An explanation of the power-law decay of luminescence. *Journal of Physics: Condensed Matter* 18, 1359-1365. doi:10.1088/0953-8984/18/4/020
- King, G.E., Herman, F., Lambert, R., Valla, P.G., Guralnik, B., 2016. Multi-OSL-thermochronometry of feldspar. *Quaternary Geochronology* 33, 76-87. doi:10.1016/j.quageo.2016.01.004

## Further reading

Morthekai, P., Jain, M., Cunha, P.P., Azevedo, J.M., Singhvi, A.K., 2011. An attempt to correct for the fading in million year old basaltic rocks. *Geochronometria* 38(3), 223-230.

## Examples

```
## Load example data (sample UNIL/NB123, see ?ExampleData.Fading)
data("ExampleData.Fading", envir = environment())

## (1) Set all relevant parameters
# a. fading measurement data (IR50)
fading_data <- ExampleData.Fading$fading.data$IR50

# b. Dose response curve data
data <- ExampleData.Fading$equivalentDose.data$IR50

## (2) Define required function parameters
ddot <- c(7.00, 0.004)
```

```

readerDdot <- c(0.134, 0.0067)

# Analyse fading measurement and get an estimate of rho'.
# Note that the RLum.Results object can be directly used for further processing.
# The number of MC runs is reduced for this example
rhop <- analyse_FadingMeasurement(fading_data, plot = TRUE, verbose = FALSE, n.MC = 10)

## (3) Apply the Kars et al. (2008) model to the data
kars <- suppressWarnings(
  calc_Kars2008(data = data,
               rhop = rhop,
               ddot = ddot,
               readerDdot = readerDdot,
               n.MC = 25)
)

```

calc\_Lamothe2003

*Apply fading correction after Lamothe et al., 2003*

## Description

This function applies the fading correction for the prediction of long-term fading as suggested by Lamothe et al., 2003. The function basically adjusts the  $L_n/T_n$  values and fit a new dose-response curve using the function [plot\\_GrowthCurve](#).

## Usage

```

calc_Lamothe2003(
  object,
  dose_rate.envir,
  dose_rate.source,
  g_value,
  tc = NULL,
  tc.g_value = tc,
  verbose = TRUE,
  plot = TRUE,
  ...
)

```

## Arguments

object	<a href="#">RLum.Results data.frame</a> ( <b>required</b> ): Input data for applying the fading correction. Allow are (1) <a href="#">data.frame</a> with three columns (dose, LxTx, LxTx error; see details), (2) <a href="#">RLum.Results</a> object created by the function <a href="#">analyse_SAR.CWOSL</a> or <a href="#">analyse_pIRIRSequence</a>
dose_rate.envir	<a href="#">numeric</a> vector of length 2 ( <b>required</b> ): Environmental dose rate in mGy/a
dose_rate.source	<a href="#">numeric</a> vector of length 2 ( <b>required</b> ): Irradiation source dose rate in Gy/s, which is, according to Lamothe et al. (2003) De/t*.

g_value	<a href="#">numeric</a> vector of length 2 ( <b>required</b> ): g_value in \ the equivalent dose was calculated, i.e. tc is either similar for the g-value measurement <b>and</b> the De measurement or needs be to recalculated (cf. <a href="#">calc_FadingCorr</a> ). Inserting a normalised g-value, e.g., normalised to 2-days , will lead to wrong results
tc	<a href="#">numeric</a> (optional): time in seconds between the <b>end</b> of the irradiation and the prompt measurement used in the equivalent dose estimation (cf. Huntley & Lamothe 2001). If set to NULL it is assumed that tc is similar for the equivalent dose estimation and the g-value estimation
tc.g_value	<a href="#">numeric</a> (with default): the time in seconds between irradiation and the prompt measurement estimating the g-value. If the g-value was normalised to, e.g., 2 days, this time in seconds (i.e., 172800) should be entered here along with the time used for the equivalent dose estimation. If nothing is provided the time is set to tc, which is the usual case for g-values obtained using the SAR method and g-values that had been not normalised to 2 days. Note: If this value is not NULL the functions expects a <a href="#">numeric</a> value for tc.
verbose	<a href="#">logical</a> (with default): Enables/disables terminal verbose mode
plot	<a href="#">logical</a> (with default): Enables/disables plot output
...	further arguments passed to the function <a href="#">plot_GrowthCurve</a>

## Details

### Format of object if data.frame

If object is of type [data.frame](#), all input values must be of type [numeric](#). Dose values are excepted in seconds (s) not Gray (Gy). No NA values are allowed and the value for the natural dose (first row) should be 0. Example for three dose points, column names are arbitrary:

```
object <- data.frame(
  dose = c(0, 25, 50),
  LxTx = c(4.2, 2.5, 5.0),
  LxTx_error = c(0.2, 0.1, 0.2))
```

### Note on the g-value and tc

Users new to R and fading measurements are often confused about what to enter for tc and why it may differ from tc.g\_value. The tc value is, by convention (Huntley & Lamothe 2001), the time elapsed between the end of the irradiation and the prompt measurement. Usually there is no reason for having a tc value different for the equivalent dose measurement and the g-value measurement, except if different equipment was used. However, if, for instance, the g-value measurement sequence was analysed with the *Analyst* (Duller 2015) and the 'Luminescence is used to correct for fading, there is a high chance that the value returned by the *Analyst* comes normalised to 2-days; even the tc values of the measurement were identical. In such cases, the fading correction cannot be correct until the tc.g\_value was manually set to 2-days (172800 s) because the function will internally recalculate values to an identical tc value.

## Value

The function returns are graphical output produced by the function [plot\\_GrowthCurve](#) and an [RLum.Results](#).

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
\$data	data.frame	the fading corrected values
\$fit	nls	the object returned by the dose response curve fitting

**'slot:** @info

The original function call

### Function version

0.1.0

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany), Norbert Mercier, IRAMAT-CRP2A, Université Bordeaux Montaigne (France) , RLum Developer Team

### References

Huntley, D.J., Lamothe, M., 2001. Ubiquity of anomalous fading in K-feldspars and the measurement and correction for it in optical dating. *Canadian Journal of Earth Sciences* 38, 1093-1106.

Duller, G.A.T., 2015. The Analyst software package for luminescence data: overview and recent improvements. *Ancient TL* 33, 35–42.

Lamothe, M., Auclair, M., Hamzaoui, C., Huot, S., 2003. Towards a prediction of long-term anomalous fading of feldspar IRSL. *Radiation Measurements* 37, 493-498.

### See Also

[plot\\_GrowthCurve](#), [calc\\_FadingCorr](#), [analyse\\_SAR.CWOSL](#), [analyse\\_pIRIRSequence](#)

### Examples

```
##load data
##ExampleData.BINfileData contains two BINfileData objects
##CWOSL.SAR.Data and TL.SAR.Data
data(ExampleData.BINfileData, envir = environment())

##transform the values from the first position in a RLum.Analysis object
object <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos=1)

##perform SAR analysis and set rejection criteria
results <- analyse_SAR.CWOSL(
  object = object,
  signal.integral.min = 1,
  signal.integral.max = 2,
  background.integral.min = 900,
  background.integral.max = 1000,
  verbose = FALSE,
  plot = FALSE,
  onlyLxTxTable = TRUE
)
```

```
##run fading correction
results_corr <- calc_Lamothe2003(
  object = results,
  dose_rate.envir = c(1.676 , 0.180),
  dose_rate.source = c(0.184, 0.003),
  g_value = c(2.36, 0.6),
  plot = TRUE,
  fit.method = "EXP")
```

---

calc\_MaxDose

*Apply the maximum age model to a given De distribution*


---

### Description

Function to fit the maximum age model to De data. This is a wrapper function that calls [calc\\_MinDose](#) and applies a similar approach as described in Olley et al. (2006).

### Usage

```
calc_MaxDose(
  data,
  sigmab,
  log = TRUE,
  par = 3,
  bootstrap = FALSE,
  init.values,
  plot = TRUE,
  ...
)
```

### Arguments

- |           |   |
|-----------|---|
| data      | <a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[, 1]) and De error (data[, 2]).  |
| sigmab    | <a href="#">numeric</a> ( <b>required</b> ): additional spread in De values. This value represents the expected overdispersion in the data should the sample be well-bleached (Cunningham & Walling 2012, p. 100). <b>NOTE</b> : For the logged model (log = TRUE) this value must be a fraction, e.g. 0.2 (= 20 \ sigmab must be provided in the same absolute units of the De values (seconds or Gray). See details ( <a href="#">calc_MinDose</a> ). |
| log       | <a href="#">logical</a> ( <i>with default</i> ): fit the (un-)logged three parameter minimum dose model to De data  |
| par       | <a href="#">numeric</a> ( <i>with default</i> ): apply the 3- or 4-parameter minimum age model (par=3 or par=4).  |
| bootstrap | <a href="#">logical</a> ( <i>with default</i> ): apply the recycled bootstrap approach of Cunningham & Wallinga (2012).   |

init.values     [numeric](#) (*with default*): starting values for gamma, sigma, p0 and mu. Custom values need to be provided in a vector of length three in the form of c(gamma, sigma, p0).

plot            [logical](#) (*with default*): plot output (TRUE/FALSE)

...             further arguments for bootstrapping (bs.M, bs.N, bs.h, sigmab.sd). See details for their usage.

## Details

### Data transformation

To estimate the maximum dose population and its standard error, the three parameter minimum age model of Galbraith et al. (1999) is adapted. The measured De values are transformed as follows:

1. convert De values to natural logs
2. multiply the logged data to create a mirror image of the De distribution
3. shift De values along x-axis by the smallest x-value found to obtain only positive values
4. combine in quadrature the measurement error associated with each De value with a relative error specified by sigmab
5. apply the MAM to these data

When all calculations are done the results are then converted as follows

1. subtract the x-offset
2. multiply the natural logs by -1
3. take the exponent to obtain the maximum dose estimate in Gy

### Further documentation

Please see [calc\\_MinDose](#).

## Value

Please see [calc\\_MinDose](#).

## Function version

0.3.1

## Author(s)

Christoph Burow, University of Cologne (Germany)  
Based on a rewritten S script of Rex Galbraith, 2010 , RLum Developer Team

## References

- Arnold, L.J., Roberts, R.G., Galbraith, R.F. & DeLong, S.B., 2009. A revised burial dose estimation procedure for optical dating of young and modern-age sediments. *Quaternary Geochronology* 4, 306-325.
- Galbraith, R.F. & Laslett, G.M., 1993. Statistical models for mixed fission track ages. *Nuclear Tracks Radiation Measurements* 4, 459-470.
- Galbraith, R.F., Roberts, R.G., Laslett, G.M., Yoshida, H. & Olley, J.M., 1999. Optical dating of single grains of quartz from Jinmium rock shelter, northern Australia. Part I: experimental design and statistical models. *Archaeometry* 41, 339-364.

Galbraith, R.F., 2005. Statistics for Fission Track Analysis, Chapman & Hall/CRC, Boca Raton.

Galbraith, R.F. & Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations. *Quaternary Geochronology* 11, 1-27.

Olley, J.M., Roberts, R.G., Yoshida, H., Bowler, J.M., 2006. Single-grain optical dating of grave-infill associated with human burials at Lake Mungo, Australia. *Quaternary Science Reviews* 25, 2469-2474

### Further reading

Arnold, L.J. & Roberts, R.G., 2009. Stochastic modelling of multi-grain equivalent dose (De) distributions: Implications for OSL dating of sediment mixtures. *Quaternary Geochronology* 4, 204-230.

Bailey, R.M. & Arnold, L.J., 2006. Statistical modelling of single grain quartz De distributions and an assessment of procedures for estimating burial dose. *Quaternary Science Reviews* 25, 2475-2502.

Cunningham, A.C. & Wallinga, J., 2012. Realizing the potential of fluvial archives using robust OSL chronologies. *Quaternary Geochronology* 12, 98-106.

Rodnight, H., Duller, G.A.T., Wintle, A.G. & Tooth, S., 2006. Assessing the reproducibility and accuracy of optical dating of fluvial deposits. *Quaternary Geochronology* 1, 109-120.

Rodnight, H., 2008. How many equivalent dose values are needed to obtain a reproducible distribution?. *Ancient TL* 26, 3-10.

### See Also

[calc\\_CentralDose](#), [calc\\_CommonDose](#), [calc\\_FiniteMixture](#), [calc\\_FuchsLang2001](#), [calc\\_MinDose](#)

### Examples

```
## load example data
data(ExampleData.DeValues, envir = environment())

# apply the maximum dose model
calc_MaxDose(ExampleData.DeValues$CA1, sigmab = 0.2, par = 3)
```

---

calc\_MinDose

*Apply the (un-)logged minimum age model (MAM) after Galbraith et al. (1999) to a given De distribution*

---

### Description

Function to fit the (un-)logged three or four parameter minimum dose model (MAM-3/4) to De data.

### Usage

```
calc_MinDose(
  data,
  sigmab,
  log = TRUE,
```



```

    par = 3,
    bootstrap = FALSE,
    init.values,
    level = 0.95,
    log.output = FALSE,
    plot = TRUE,
    multicore = FALSE,
    ...
)

```

## Arguments

data	<a href="#">RLum.Results</a> or <a href="#">data.frame</a> ( <b>required</b> ): for <a href="#">data.frame</a> : two columns with De (data[, 1]) and De error (data[, 2]).
sigmab	<a href="#">numeric</a> ( <b>required</b> ): additional spread in De values. This value represents the expected overdispersion in the data should the sample be well-bleached (Cunningham & Walling 2012, p. 100). <b>NOTE</b> : For the logged model (log = TRUE) this value must be a fraction, e.g. 0.2 (= 20 \ sigmab must be provided in the same absolute units of the De values (seconds or Gray). See details.
log	<a href="#">logical</a> ( <i>with default</i> ): fit the (un-)logged minimum dose model to De data.
par	<a href="#">numeric</a> ( <i>with default</i> ): apply the 3- or 4-parameter minimum age model (par=3 or par=4). The MAM-3 is used by default.
bootstrap	<a href="#">logical</a> ( <i>with default</i> ): apply the recycled bootstrap approach of Cunningham & Wallinga (2012).
init.values	<a href="#">numeric</a> ( <i>optional</i> ): a named list with starting values for gamma, sigma, p0 and mu (e.g. list(gamma=100, sigma=1.5, p0=0.1, mu=100)). If no values are provided reasonable values are tried to be estimated from the data. <b>NOTE</b> that the initial values must always be given in the absolute units. The the logged model is applied (log = TRUE), the provided init.values are automatically log transformed.
level	<a href="#">logical</a> ( <i>with default</i> ): the confidence level required (defaults to 0.95).
log.output	<a href="#">logical</a> ( <i>with default</i> ): If TRUE the console output will also show the logged values of the final parameter estimates and confidence intervals (only applicable if log = TRUE).
plot	<a href="#">logical</a> ( <i>with default</i> ): plot output (TRUE/FALSE)
multicore	<a href="#">logical</a> ( <i>with default</i> ): enable parallel computation of the bootstrap by creating a multicore SNOW cluster. Depending on the number of available logical CPU cores this may drastically reduce the computation time. Note that this option is highly experimental and may not work on all machines. (TRUE/FALSE)
...	( <i>optional</i> ) further arguments for bootstrapping (bs.M, bs.N, bs.h, sigmab.sd). See details for their usage. Further arguments are <ul style="list-style-type: none"> <li>• verbose to de-/activate console output (logical),</li> <li>• debug for extended console output (logical) and</li> <li>• cores (integer) to manually specify the number of cores to be used when multicore=TRUE.</li> </ul>

## Details

### Parameters

This model has four parameters:

```

gamma:  minimum dose on the log scale
mu:     mean of the non-truncated normal distribution
sigma:  spread in ages above the minimum
p0:     proportion of grains at gamma

```

If `par=3` (default) the 3-parameter minimum age model is applied, where `gamma=mu`. For `par=4` the 4-parameter model is applied instead.

### (Un-)logged model

In the original version of the minimum dose model, the basic data are the natural logarithms of the De estimates and relative standard errors of the De estimates. The value for `sigmab` must be provided as a ratio (e.g, 0.2 for 20 \

If `log=FALSE`, the modified un-logged model will be applied instead. This has essentially the same form as the original version. `gamma` and `sigma` are in Gy and `gamma` becomes the minimum true dose in the population. **Note** that the un-logged model requires `sigmab` to be in the same absolute unit as the provided De values (seconds or Gray).

While the original (logged) version of the minimum dose model may be appropriate for most samples (i.e. De distributions), the modified (un-logged) version is specially designed for modern-age and young samples containing negative, zero or near-zero De estimates (Arnold et al. 2009, p. 323).

### Initial values & boundaries

The log likelihood calculations use the `nlminb` function for box-constrained optimisation using PORT routines. Accordingly, initial values for the four parameters can be specified via `init.values`. If no values are provided for `init.values` reasonable starting values are estimated from the input data. If the final estimates of `gamma`, `mu`, `sigma` and `p0` are totally off target, consider providing custom starting values via `init.values`. In contrast to previous versions of this function the boundaries for the individual model parameters are no longer required to be explicitly specified. If you want to override the default boundary values use the arguments `gamma.lower`, `gamma.upper`, `sigma.lower`, `sigma.upper`, `p0.lower`, `p0.upper`, `mu.lower` and `mu.upper`.

### Bootstrap

When `bootstrap=TRUE` the function applies the bootstrapping method as described in Wallinga & Cunningham (2012). By default, the minimum age model produces 1000 first level and 3000 second level bootstrap replicates (actually, the number of second level bootstrap replicates is three times the number of first level replicates unless specified otherwise). The uncertainty on `sigmab` is 0.04 by default. These values can be changed by using the arguments `bs.M` (first level replicates), `bs.N` (second level replicates) and `sigmab.sd` (error on `sigmab`). With `bs.h` the bandwidth of the kernel density estimate can be specified. By default, `h` is calculated as

$$h = (2 * \sigma_{DE}) / \sqrt{n}$$

### Multicore support

This function supports parallel computing and can be activated by `multicore=TRUE`. By default, the number of available logical CPU cores is determined automatically, but can be changed with `cores`. The multicore support is only available when `bootstrap=TRUE` and spawns `n` R instances for each core to get MAM estimates for each of the `N` and `M` bootstrap replicates. Note that this option is highly experimental and may or may not work for your machine. Also the performance gain increases for larger number of bootstrap replicates. Also note that with each additional core and hence R instance and depending on the number of bootstrap replicates the memory usage can

significantly increase. Make sure that memory is always available, otherwise there will be a massive performance hit.

### Likelihood profiles

The likelihood profiles are generated and plotted by the `bbmle` package. The profile likelihood plots look different to ordinary profile likelihood as

"[ . . . ] the plot method for likelihood profiles displays the square root of the the deviance difference (twice the difference in negative log-likelihood from the best fit), so it will be V-shaped for cases where the quadratic approximation works well [ . . . ]." (Bolker 2016).

For more details on the profile likelihood calculations and plots please see the vignettes of the `bbmle` package (also available here: <https://CRAN.R-project.org/package=bbmle>).

### Value

Returns a plot (*optional*) and terminal output. In addition an `RLum.Results` object is returned containing the following elements:

<code>.\$summary</code>	<code>data.frame</code> summary of all relevant model results.
<code>.\$data</code>	<code>data.frame</code> original input data
<code>args</code>	<code>list</code> used arguments
<code>call</code>	<code>call</code> the function call
<code>.\$mle</code>	<code>mle2</code> object containing the maximum log likelihood functions for all parameters
<code>BIC</code>	<code>numeric</code> BIC score
<code>.\$confint</code>	<code>data.frame</code> confidence intervals for all parameters
<code>.\$profile</code>	<code>profile.mle2</code> the log likelihood profiles
<code>.\$bootstrap</code>	<code>list</code> bootstrap results

The output should be accessed using the function `get_RLum`

### Function version

0.4.4

### Note

The default starting values for *gamma*, *mu*, *sigma* and *p0* may only be appropriate for some De data sets and may need to be changed for other data. This is especially true when the un-logged version is applied.

Also note that all R warning messages are suppressed when running this function. If the results seem odd consider re-running the model with `debug=TRUE` which provides extended console output and forwards all internal warning messages.

### Author(s)

Christoph Burow, University of Cologne (Germany)

Based on a rewritten S script of Rex Galbraith, 2010

The bootstrap approach is based on a rewritten MATLAB script of Alastair Cunningham.

Alastair Cunningham is thanked for his help in implementing and cross-checking the code. , `RLum` Developer Team

## References

- Arnold, L.J., Roberts, R.G., Galbraith, R.F. & DeLong, S.B., 2009. A revised burial dose estimation procedure for optical dating of young and modern-age sediments. *Quaternary Geochronology* 4, 306-325.
- Galbraith, R.F. & Laslett, G.M., 1993. Statistical models for mixed fission track ages. *Nuclear Tracks Radiation Measurements* 4, 459-470.
- Galbraith, R.F., Roberts, R.G., Laslett, G.M., Yoshida, H. & Olley, J.M., 1999. Optical dating of single grains of quartz from Jinmium rock shelter, northern Australia. Part I: experimental design and statistical models. *Archaeometry* 41, 339-364.
- Galbraith, R.F., 2005. *Statistics for Fission Track Analysis*, Chapman & Hall/CRC, Boca Raton.
- Galbraith, R.F. & Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations. *Quaternary Geochronology* 11, 1-27.
- Olley, J.M., Roberts, R.G., Yoshida, H., Bowler, J.M., 2006. Single-grain optical dating of grave-infill associated with human burials at Lake Mungo, Australia. *Quaternary Science Reviews* 25, 2469-2474.

## Further reading

- Arnold, L.J. & Roberts, R.G., 2009. Stochastic modelling of multi-grain equivalent dose (De) distributions: Implications for OSL dating of sediment mixtures. *Quaternary Geochronology* 4, 204-230.
- Bolker, B., 2016. Maximum likelihood estimation analysis with the bbmle package. In: Bolker, B., R Development Core Team, 2016. *bbmle: Tools for General Maximum Likelihood Estimation*. R package version 1.0.18. <https://CRAN.R-project.org/package=bbmle>
- Bailey, R.M. & Arnold, L.J., 2006. Statistical modelling of single grain quartz De distributions and an assessment of procedures for estimating burial dose. *Quaternary Science Reviews* 25, 2475-2502.
- Cunningham, A.C. & Wallinga, J., 2012. Realizing the potential of fluvial archives using robust OSL chronologies. *Quaternary Geochronology* 12, 98-106.
- Rodnight, H., Duller, G.A.T., Wintle, A.G. & Tooth, S., 2006. Assessing the reproducibility and accuracy of optical dating of fluvial deposits. *Quaternary Geochronology* 1, 109-120.
- Rodnight, H., 2008. How many equivalent dose values are needed to obtain a reproducible distribution?. *Ancient TL* 26, 3-10.

## See Also

[calc\\_CentralDose](#), [calc\\_CommonDose](#), [calc\\_FiniteMixture](#), [calc\\_FuchsLang2001](#), [calc\\_MaxDose](#)

## Examples

```
## Load example data
data(ExampleData.DeValues, envir = environment())

# (1) Apply the minimum age model with minimum required parameters.
# By default, this will apply the un-logged 3-parameter MAM.
calc_MinDose(data = ExampleData.DeValues$CA1, sigmab = 0.1)

## Not run:
# (2) Re-run the model, but save results to a variable and turn
# plotting of the log-likelihood profiles off.
```

```
mam <- calc_MinDose(data = ExampleData.DeValues$CA1,
                    sigmab = 0.1,
                    plot = FALSE)

# Show structure of the RLum.Results object
mam

# Show summary table that contains the most relevant results
res <- get_RLum(mam, "summary")
res

# Plot the log likelihood profiles retroactively, because before
# we set plot = FALSE
plot_RLum(mam)

# Plot the dose distribution in an abanico plot and draw a line
# at the minimum dose estimate
plot_AbanicoPlot(data = ExampleData.DeValues$CA1,
                 main = "3-parameter Minimum Age Model",
                 line = mam, polygon.col = "none",
                 hist = TRUE,
                 rug = TRUE,
                 summary = c("n", "mean", "mean.weighted", "median", "in.ci"),
                 centrality = res$de,
                 line.col = "red",
                 grid.col = "none",
                 line.label = paste0(round(res$de, 1), "\u00B1",
                                     round(res$de_err, 1), " Gy"),
                 bw = 0.1,
                 ylim = c(-25, 18),
                 summary.pos = "topleft",
                 mtext = bquote("Parameters: " ~
                               sigma[b] == .(get_RLum(mam, "args")$sigmab) ~ ", " ~
                               gamma == .(round(log(res$de), 1)) ~ ", " ~
                               sigma == .(round(res$sig, 1)) ~ ", " ~
                               rho == .(round(res$p0, 2))))

# (3) Run the minimum age model with bootstrap
# NOTE: Bootstrapping is computationally intensive
# (3.1) run the minimum age model with default values for bootstrapping
calc_MinDose(data = ExampleData.DeValues$CA1,
             sigmab = 0.15,
             bootstrap = TRUE)

# (3.2) Bootstrap control parameters
mam <- calc_MinDose(data = ExampleData.DeValues$CA1,
                  sigmab = 0.15,
                  bootstrap = TRUE,
                  bs.M = 300,
                  bs.N = 500,
                  bs.h = 4,
                  sigmab.sd = 0.06,
                  plot = FALSE)

# Plot the results
```

```

plot_RLum(mam)

# save bootstrap results in a separate variable
bs <- get_RLum(mam, "bootstrap")

# show structure of the bootstrap results
str(bs, max.level = 2, give.attr = FALSE)

# print summary of minimum dose and likelihood pairs
summary(bs$pairs$gamma)

# Show polynomial fits of the bootstrap pairs
bs$poly.fits$poly.three

# Plot various statistics of the fit using the generic plot() function
par(mfcol=c(2,2))
plot(bs$poly.fits$poly.three, ask = FALSE)

# Show the fitted values of the polynomials
summary(bs$poly.fits$poly.three$fitted.values)

## End(Not run)

```

---

calc\_OSLLxTxDecomposed

*Calculate Lx/Tx ratio for decomposed CW-OSL signal components*

---

## Description

Calculate Lx/Tx ratios from a given set of decomposed CW-OSL curves decomposed by [OSLdecomposition::RLum.OSLdecomposition]

## Usage

```

calc_OSLLxTxDecomposed(
  Lx.data,
  Tx.data = NULL,
  OSL.component = 1L,
  sig0 = 0,
  digits = NULL
)

```

## Arguments

Lx.data	<b>data.frame (required):</b> Component table created by [OSLdecomposition::RLum.OSLdecomposition] and per default located at object@records[[...]]@info\$COMPONENTS. The value of \$n[OSL.component] is set as LnLx. The value of \$n.error[OSL.component] is set as LnLx.error
Tx.data	<b>data.frame (optional):</b> Component table created by [OSLdecomposition::RLum.OSLdecomposition] and per default located at object@records[[...]]@info\$COMPONENTS. The value of \$n[OSL.component] is set as TnTx. The value of \$n.error[OSL.component] is set as TnTx.error

- OSL.component **integer** or **character** (*optional*): a single index or a name describing which OSL signal component shall be evaluated. This argument can either be the name of the OSL component assigned by [OSLdecomposition::RLum.OSL\_global\_fitting] or the index of component. Then '1' selects the fastest decaying component, '2' the second fastest and so on. If not defined, the fastest decaying component is selected.
- sig0 **numeric** (*with default*): allows adding an extra error component to the final Lx/Tx error value (e.g., instrumental error).
- digits **integer** (*with default*): round numbers to the specified digits. If digits is set to NULL nothing is rounded.

### Value

Returns an S4 object of type **RLum.Results**.

Slot data contains a **list** with the following structure:

#### @data

```
$LxTx.table (data.frame)
.. $ LnLx
.. $ TnTx
.. $ Net_LnLx
.. $ Net_LnLx.Error
.. $ Net_TnTx
.. $ Net_TnTx.Error
.. $ LxTx
.. $ LxTx.relError
.. $ LxTx.Error
```

### Function version

0.1.0

### Author(s)

Dirk Mittelstrass , RLum Developer Team

### References

Mittelstrass D., Schmidt C., Beyer J., Straessner A., 2019. Automated identification and separation of quartz CW-OSL signal components with R. talk presented at DLED 2019, Bingen, Germany  
[http://luminescence.de/OSLdecomp\\_talk.pdf](http://luminescence.de/OSLdecomp_talk.pdf)

### See Also

[RLum.Data.Curve](#), [plot\\_GrowthCurve](#), [analyse\\_SAR.CWOSL](#)

---

calc_OSLLxTxRatio	<i>Calculate Lx/Tx ratio for CW-OSL curves</i>
-------------------	--

---

## Description

Calculate Lx/Tx ratios from a given set of CW-OSL curves assuming late light background subtraction.

## Usage

```
calc_OSLLxTxRatio(
  Lx.data,
  Tx.data = NULL,
  signal.integral,
  signal.integral.Tx = NULL,
  background.integral,
  background.integral.Tx = NULL,
  background.count.distribution = "non-poisson",
  use_previousBG = FALSE,
  sigmab = NULL,
  sig0 = 0,
  digits = NULL
)
```

## Arguments

Lx.data	<a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <b>required</b> ): requires a CW-OSL shine down curve (x = time, y = counts)
Tx.data	<a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <i>optional</i> ): requires a CW-OSL shine down curve (x = time, y = counts). If no input is given the Tx.data will be treated as NA and no Lx/Tx ratio is calculated.
signal.integral	<a href="#">numeric</a> ( <b>required</b> ): vector with the limits for the signal integral. Can be set to NA than now integrals are considered and all other integrals are set to NA as well.
signal.integral.Tx	<a href="#">numeric</a> ( <i>optional</i> ): vector with the limits for the signal integral for the Tx-curve. If nothing is provided the value from signal.integral is used.
background.integral	<a href="#">numeric</a> ( <b>required</b> ): vector with the bounds for the background integral. Can be set to NA than now integrals are considered and all other integrals are set to NA as well.
background.integral.Tx	<a href="#">numeric</a> ( <i>optional</i> ): vector with the limits for the background integral for the Tx curve. If nothing is provided the value from background.integral is used.
background.count.distribution	<a href="#">character</a> ( <i>with default</i> ): sets the count distribution assumed for the error calculation. Possible arguments poisson or non-poisson. See details for further information



use_previousBG	<b>logical</b> ( <i>with default</i> ): If set to TRUE the background of the Lx-signal is subtracted also from the Tx-signal. Please note that in this case separate signal integral limits for the Tx-signal are not allowed and will be reset.
sigmab	<b>numeric</b> ( <i>optional</i> ): option to set a manual value for the overdispersion (for LnTx and TnTx), used for the Lx/Tx error calculation. The value should be provided as absolute squared count values, e.g. sigmab = c(300, 300). <b>Note:</b> If only one value is provided this value is taken for both (LnTx and TnTx) signals.
sig0	<b>numeric</b> ( <i>with default</i> ): allow adding an extra component of error to the final Lx/Tx error value (e.g., instrumental error, see details).
digits	<b>integer</b> ( <i>with default</i> ): round numbers to the specified digits. If digits is set to NULL nothing is rounded.

## Details

The integrity of the chosen values for the signal and background integral is checked by the function; the signal integral limits have to be lower than the background integral limits. If a **vector** is given as input instead of a **data.frame**, an artificial **data.frame** is produced. The error calculation is done according to Galbraith (2002).

**Please note:** In cases where the calculation results in NaN values (for example due to zero-signal, and therefore a division of 0 by 0), these NaN values are replaced by 0.

sigmab

The default value of sigmab is calculated assuming the background is constant and **would not** applicable when the background varies as, e.g., as observed for the early light subtraction method.

**sig0**

This argument allows to add an extra component of error to the final Lx/Tx error value. The input will be treated as factor that is multiplied with the already calculated LxTx and the result is add up by:

$$se(LxTx) = \sqrt{(se(LxTx))^2 + (LxTx * sig0)^2}$$

## background.count.distribution

This argument allows selecting the distribution assumption that is used for the error calculation. According to Galbraith (2002, 2014) the background counts may be overdispersed (i.e. do not follow a Poisson distribution, which is assumed for the photomultiplier counts). In that case (might be the normal case) it has to be accounted for the overdispersion by estimating  $\sigma^2$  (i.e. the overdispersion value). Therefore the relative standard error is calculated as:

- poisson

$$rse(\mu_S) \approx \sqrt{(Y_0 + Y_1/k^2)/Y_0 - Y_1/k}$$

- non-poisson

$$rse(\mu_S) \approx \sqrt{(Y_0 + Y_1/k^2 + \sigma^2(1 + 1/k))/Y_0 - Y_1/k}$$

**Please note** that when using the early background subtraction method in combination with the 'non-poisson' distribution argument, the corresponding Lx/Tx error may considerably increase due to a high sigmab value. Please check whether this is valid for your data set and if necessary consider to provide an own sigmab value using the corresponding argument sigmab.

**Value**

Returns an S4 object of type [RLum.Results](#).

Slot data contains a [list](#) with the following structure:

**@data**

```
$LxTx.table (data.frame)
.. $ LnLx
.. $ LnLx.BG
.. $ TnTx
.. $ TnTx.BG
.. $ Net_LnLx
.. $ Net_LnLx.Error
.. $ Net_TnTx
.. $ Net_TnTx.Error
.. $ LxTx
.. $ LxTx.Error
$ calc.parameters (list)
.. $ sigmab.LnTx
.. $ sigmab.TnTx
.. $ k
```

**@info**

```
$ call (original function call)
```

**Function version**

0.8.0

**Note**

The results of this function have been cross-checked with the Analyst (version 3.24b). Access to the results object via [get\\_RLum](#).

**Caution:** If you are using early light subtraction (EBG), please either provide your own sigmab value or use `background.count.distribution = "poisson"`.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Duller, G., 2018. Analyst v4.57 - User Manual. <https://users.aber.ac.uk/ggd>

Galbraith, R.F., 2002. A note on the variance of a background-corrected OSL count. *Ancient TL*, 20 (2), 49-51.

Galbraith, R.F., 2014. A further note on the variance of a background-corrected OSL count. *Ancient TL*, 31 (2), 1-3.

**See Also**

[RLum.Data.Curve](#), [Analyse\\_SAR.OSLdata](#), [plot\\_GrowthCurve](#), [analyse\\_SAR.CWOSL](#)

**Examples**

```
##load data
data(ExampleData.LxTxOSLData, envir = environment())

##calculate Lx/Tx ratio
results <- calc_OSLLxTxRatio(
  Lx.data = Lx.data,
  Tx.data = Tx.data,
  signal.integral = c(1:2),
  background.integral = c(85:100))

##get results object
get_RLum(results)
```

---

calc_SourceDoseRate	<i>Calculation of the source dose rate via the date of measurement</i>
---------------------	--

---

**Description**

Calculating the dose rate of the irradiation source via the date of measurement based on: source calibration date, source dose rate, dose rate error. The function returns a data.frame that provides the input argument dose\_rate for the function [Second2Gray](#).

**Usage**

```
calc_SourceDoseRate(
  measurement.date = Sys.Date(),
  calib.date,
  calib.dose.rate,
  calib.error,
  source.type = "Sr-90",
  dose.rate.unit = "Gy/s",
  predict = NULL
)
```

**Arguments**

measurement.date	<a href="#">character</a> or <a href="#">Date</a> (with default): Date of measurement in "YYYY-MM-DD". If no value is provided, the date will be set to today. The argument can be provided as vector.
calib.date	<a href="#">character</a> or <a href="#">Date</a> ( <b>required</b> ): date of source calibration in "YYYY-MM-DD"
calib.dose.rate	<a href="#">numeric</a> ( <b>required</b> ): dose rate at date of calibration in Gy/s or Gy/min
calib.error	<a href="#">numeric</a> ( <b>required</b> ): error of dose rate at date of calibration Gy/s or Gy/min

source.type **character** (*with default*): specify irradiation source (Sr-90, Co-60, Cs-137, Am-214), see details for further information

dose.rate.unit **character** (*with default*): specify dose rate unit for input (Gy/min or Gy/s), the output is given in Gy/s as valid for the function [Second2Gray](#)

predict **integer** (*with default*): option allowing to predict the dose rate of the source over time in days set by the provided value. Starting date is the value set with measurement.date, e.g., `calc_SourceDoseRate(..., predict = 100)` calculates the source dose rate for the next 100 days.

## Details

Calculation of the source dose rate based on the time elapsed since the last calibration of the irradiation source. Decay parameters assume a Sr-90 beta source.

$$dose.rate = D0 * exp(-log(2)/T.1/2 * t)$$

with: `D0` <- calibration dose rate `T.1/2` <- half-life of the source nuclide (here in days) `t` <- time since source calibration (in days) `log(2) / T.1/2` equals the decay constant `lambda`

Information on the date of measurements may be taken from the data's original .BIN file (using e.g., `BINfile <- readBIN2R()` and the slot `BINfile@METADATA$DATE`)

## Allowed source types and related values

#	Source type	T.1/2	Reference
[1]	Sr-90	28.90 y	NNDC, Brookhaven National Laboratory
[2]	Am-214	432.6 y	NNDC, Brookhaven National Laboratory
[3]	Co-60	5.274 y	NNDC, Brookhaven National Laboratory
[4]	Cs-137	30.08 y	NNDC, Brookhaven National Laboratory

## Value

Returns an S4 object of type [RLum.Results](#). Slot data contains a [list](#) with the following structure:

```
$ dose.rate (data.frame)
.. $ dose.rate
.. $ dose.rate.error
.. $ date (corresponding measurement date)
$ parameters (list)
.. $ source.type
.. $ halflife
.. $ dose.rate.unit
$ call (the original function call)
```

The output should be accessed using the function [get\\_RLum](#).

A plot method of the output is provided via [plot\\_RLum](#)

## Function version

0.3.2

**Note**

Please be careful when using the option `predict`, especially when a multiple set for `measurement.date` and `calib.date` is provided. For the source dose rate prediction the function takes the last value `measurement.date` and predicts from that the the source source dose rate for the number of days requested, means: the (multiple) original input will be replaced. However, the function do not change entries for the calibration dates, but mix them up. Therefore, it is not recommended to use this option when multiple calibration dates (`calib.date`) are provided.

**Author(s)**

Margret C. Fuchs, HZDR, Helmholtz-Institute Freiberg for Resource Technology (Germany)  
Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

NNDC, Brookhaven National Laboratory <http://www.nndc.bnl.gov/>

**See Also**

[Second2Gray](#), [get\\_RLum](#), [plot\\_RLum](#)

**Examples**

```
##(1) Simple function usage
##Basic calculation of the dose rate for a specific date
dose.rate <- calc_SourceDoseRate(measurement.date = "2012-01-27",
                                calib.date = "2014-12-19",
                                calib.dose.rate = 0.0438,
                                calib.error = 0.0019)

##show results
get_RLum(dose.rate)

##(2) Usage in combination with another function (e.g., Second2Gray() )
## load example data
data(ExampleData.DeValues, envir = environment())

## use the calculated variable dose.rate as input argument
## to convert De(s) to De(Gy)
Second2Gray(ExampleData.DeValues$BT998, dose.rate)

##(3) source rate prediction and plotting
dose.rate <- calc_SourceDoseRate(measurement.date = "2012-01-27",
                                calib.date = "2014-12-19",
                                calib.dose.rate = 0.0438,
                                calib.error = 0.0019,
                                predict = 1000)

plot_RLum(dose.rate)

##(4) export output to a LaTeX table (example using the package 'xtable')
## Not run:
xtable::xtable(get_RLum(dose.rate))
```

```
## End(Not run)
```

---

calc\_Statistics

*Function to calculate statistic measures*

---

## Description

This function calculates a number of descriptive statistics for estimates with a given standard error (SE), most fundamentally using error-weighted approaches.

## Usage

```
calc_Statistics(
  data,
  weight.calc = "square",
  digits = NULL,
  n.MCM = NULL,
  na.rm = TRUE
)
```

## Arguments

data	<a href="#">data.frame</a> or <a href="#">RLum.Results</a> object ( <b>required</b> ): for <a href="#">data.frame</a> two columns: De (data[,1]) and De error (data[,2]). To plot several data sets in one plot the data sets must be provided as list, e.g. list(data.1, data.2).
weight.calc	<a href="#">character</a> : type of weight calculation. One out of "reciprocal" (weight is 1/error), "square" (weight is 1/error^2). Default is "square".
digits	<a href="#">integer</a> ( <i>with default</i> ): round numbers to the specified digits. If digits is set to NULL nothing is rounded.
n.MCM	<a href="#">numeric</a> ( <i>with default</i> ): number of samples drawn for Monte Carlo-based statistics. NULL (the default) disables MC runs.
na.rm	<a href="#">logical</a> ( <i>with default</i> ): indicating whether NA values should be stripped before the computation proceeds.

## Details

The option to use Monte Carlo Methods (n.MCM) allows calculating all descriptive statistics based on random values. The distribution of these random values is based on the Normal distribution with De values as means and De\_error values as one standard deviation. Increasing the number of MCM-samples linearly increases computation time. On a Lenovo X230 machine evaluation of 25 Aliquots with n.MCM = 1000 takes 0.01 s, with n = 100000, ca. 1.65 s. It might be useful to work with logarithms of these values. See Dietze et al. (2016, Quaternary Geochronology) and the function [plot\\_AbanicoPlot](#) for details.

## Value

Returns a list with weighted and unweighted statistic measures.

**Function version**

0.1.7

**Author(s)**

Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

**Examples**

```
## load example data
data(ExampleData.DeValues, envir = environment())

## show a rough plot of the data to illustrate the non-normal distribution
plot_KDE(ExampleData.DeValues$BT998)

## calculate statistics and show output
str(calc_Statistics(ExampleData.DeValues$BT998))

## Not run:
## now the same for 10000 normal distributed random numbers with equal errors
x <- as.data.frame(cbind(rnorm(n = 10^5, mean = 0, sd = 1),
                          rep(0.001, 10^5)))

## note the congruent results for weighted and unweighted measures
str(calc_Statistics(x))

## End(Not run)
```

---

calc\_ThermalLifetime    *Calculates the Thermal Lifetime using the Arrhenius equation*

---

**Description**

The function calculates the thermal lifetime of charges for given E (in eV), s (in 1/s) and T (in deg. C.) parameters. The function can be used in two operational modes:

**Usage**

```
calc_ThermalLifetime(
  E,
  s,
  T = 20,
  output_unit = "Ma",
  profiling = FALSE,
  profiling_config = NULL,
  verbose = TRUE,
  plot = TRUE,
  ...
)
```

**Arguments**

E	<b>numeric (required)</b> : vector of trap depths in eV, if profiling = TRUE only the first two elements are considered
s	<b>numeric (required)</b> : vector of frequency factor in 1/s, if profiling = TRUE only the first two elements are considered
T	<b>numeric (with default)</b> : temperature in deg. C for which the lifetime(s) will be calculated. A vector can be provided.
output_unit	<b>character (with default)</b> : output unit of the calculated lifetimes, accepted entries are: "Ma", "ka", "a", "d", "h", "min", "s"
profiling	<b>logical (with default)</b> : this option allows to estimate uncertainties based on given E and s parameters and their corresponding standard error (cf. details and examples section)
profiling_config	<b>list (optional)</b> : allows to set configuration parameters used for the profiling (and only have an effect here). Supported parameters are: <ul style="list-style-type: none"> <li>• n (number of MC runs),</li> <li>• E.distribution (distribution used for the re-sampling for E) and</li> <li>• s.distribution (distribution used for the re-sampling for s).</li> </ul> Currently only the normal distribution is supported (e.g., profiling_config = list(E.distribution = "norm"))
verbose	<b>logical</b> : enables/disables verbose mode
plot	<b>logical</b> : enables/disables output plot, currently only in combination with profiling = TRUE.
...	further arguments that can be passed in combination with the plot output. Standard plot parameters are supported ( <a href="#">plot.default</a> )

**Details****Mode 1** (profiling = FALSE)

An arbitrary set of input parameters (E, s, T) can be provided and the function calculates the thermal lifetimes using the Arrhenius equation for all possible combinations of these input parameters. An array with 3-dimensions is returned that can be used for further analyses or graphical output (see example 1)

**Mode 2** (profiling = TRUE)

This mode tries to profile the variation of the thermal lifetime for a chosen temperature by accounting for the provided E and s parameters and their corresponding standard errors, e.g.,  $E = c(1.600, 0.001)$ . The calculation based on a Monte Carlo simulation, where values are sampled from a normal distribution (for E and s).

**Used equation (Arrhenius equation)**

$$\tau = 1/s \exp(E/kT)$$

where:  $\tau$  in s as the mean time an electron spends in the trap for a given  $T$ ,  $E$  trap depth in eV,  $s$  the frequency factor in 1/s,  $T$  the temperature in K and  $k$  the Boltzmann constant in eV/K (cf. Furetta, 2010).



**Value**

A [RLum.Results](#) object is returned along with a plot (for `profiling = TRUE`). The output object contains the following slots:

@data

Object	Type	Description
lifetimes	<a href="#">array</a> or <a href="#">numeric</a>	calculated lifetimes
profiling_matrix	<a href="#">matrix</a>	profiling matrix used for the MC runs

@info

Object	Type	Description
call	call	the original function call

**Function version**

0.1.0

**Note**

The profiling is currently based on re-sampling from a normal distribution, this distribution assumption might be, however, not valid for given E and s parameters.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Furetta, C., 2010. Handbook of Thermoluminescence, Second Edition. World Scientific.

**See Also**

[graphics::matplot](#), [stats::rnorm](#), [get\\_RLum](#)

**Examples**

```
##EXAMPLE 1
##calculation for two trap-depths with similar frequency factor for different temperatures
E <- c(1.66, 1.70)
s <- 1e+13
T <- 10:20
temp <- calc_ThermalLifetime(
  E = E,
  s = s,
  T = T,
  output_unit = "Ma"
)
contour(x = E, y = T, z = temp$lifetimes[1,,],
        ylab = "Temperature [\u00B0C]",
        xlab = "Trap depth [eV]",
        main = "Thermal Lifetime Contour Plot"
)
mtext(side = 3, "(values quoted in Ma)")
```

```
##EXAMPLE 2
##profiling of thermal life time for E and s and their standard error
E <- c(1.600, 0.003)
s <- c(1e+13, 1e+011)
T <- 20
calc_ThermalLifetime(
  E = E,
  s = s,
  T = T,
  profiling = TRUE,
  output_unit = "Ma"
)
```

---

calc_TLLxTxRatio	<i>Calculate the Lx/Tx ratio for a given set of TL curves -beta version-</i>
------------------	--

---

## Description

Calculate Lx/Tx ratio for a given set of TL curves.

## Usage

```
calc_TLLxTxRatio(
  Lx.data.signal,
  Lx.data.background = NULL,
  Tx.data.signal,
  Tx.data.background = NULL,
  signal.integral.min,
  signal.integral.max
)
```

## Arguments

Lx.data.signal [RLum.Data.Curve](#) or [data.frame](#) (**required**): TL data (x = temperature, y = counts) (TL signal)

Lx.data.background [RLum.Data.Curve](#) or [data.frame](#) (*optional*): TL data (x = temperature, y = counts). If no data are provided no background subtraction is performed.

Tx.data.signal [RLum.Data.Curve](#) or [data.frame](#) (**required**): TL data (x = temperature, y = counts) (TL test signal)

Tx.data.background [RLum.Data.Curve](#) or [data.frame](#) (*optional*): TL data (x = temperature, y = counts). If no data are provided no background subtraction is performed.

signal.integral.min [integer](#) (**required**): channel number for the lower signal integral bound (e.g. signal.integral.min = 100)

signal.integral.max [integer](#) (**required**): channel number for the upper signal integral bound (e.g. signal.integral.max = 200)

## Details

### Uncertainty estimation

The standard errors are calculated using the following generalised equation:

$$SE_{signal} = abs(Signal_{net} * BG_f / BG_{signal})$$

where  $BG_f$  is a term estimated by calculating the standard deviation of the sum of the  $L_x$  background counts and the sum of the  $T_x$  background counts. However, if both signals are similar the error becomes zero.

## Value

Returns an S4 object of type [RLum.Results](#). Slot data contains a [list](#) with the following structure:

```
$ LxTx.table
.. $ LnLx
.. $ LnLx.BG
.. $ TnTx
.. $ TnTx.BG
.. $ Net_LnLx
.. $ Net_LnLx.Error
```

## Function version

0.3.3

## Note

**This function has still BETA status!** Please further note that a similar background for both curves results in a zero error and is therefore set to NA.

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 Christoph Schmidt, University of Bayreuth (Germany) , RLum Developer Team

## See Also

[RLum.Results](#), [analyse\\_SAR.TL](#)

## Examples

```
##load package example data
data(ExampleData.BINfileData, envir = environment())

##convert Risoe.BINfileData into a curve object
temp <- Risoe.BINfileData2RLum.Analysis(TL.SAR.Data, pos = 3)

Lx.data.signal <- get_RLum(temp, record.id=1)
Lx.data.background <- get_RLum(temp, record.id=2)
Tx.data.signal <- get_RLum(temp, record.id=3)
Tx.data.background <- get_RLum(temp, record.id=4)
signal.integral.min <- 210
```

```

signal.integral.max <- 230

output <- calc_TLLxTxRatio(
  Lx.data.signal,
  Lx.data.background,
  Tx.data.signal,
  Tx.data.background,
  signal.integral.min,
  signal.integral.max)
get_RLum(output)

```

---

calc_WodaFuchs2008	<i>Obtain the equivalent dose using the approach by Woda and Fuchs 2008</i>
--------------------	---

---

## Description

The function generates a histogram-like reorganisation of the data, to assess counts per bin. The log-transformed counts per bin are used to calculate the second derivative of the data (i.e., the curvature of the curve) and to find the central value of the bin hosting the distribution maximum. A normal distribution model is fitted to the counts per bin data to estimate the dose distribution parameters. The uncertainty of the model is estimated based on all input equivalent doses smaller than that of the modelled central value.

## Usage

```
calc_WodaFuchs2008(data, breaks = NULL, plot = TRUE, ...)
```

## Arguments

data	<a href="#">data.frame</a> or <a href="#">RLum.Results</a> object ( <b>required</b> ): for <a href="#">data.frame</a> : two columns: De (values[,1]) and De error (values[,2]). For plotting multiple data sets, these must be provided as list (e.g. list(dataset1, dataset2)).
breaks	<a href="#">numeric</a> : Either number or locations of breaks. See [hist] for details. If missing, the number of breaks will be estimated based on the bin width (as function of median error).
plot	<a href="#">logical</a> ( <i>with default</i> ): enable plot output.
...	Further plot arguments passed to the function.

## Function version

0.2.0

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany),  
Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

## References

Woda, C., Fuchs, M., 2008. On the applicability of the leading edge method to obtain equivalent doses in OSL dating and dosimetry. Radiation Measurements 43, 26-37.

**See Also**

[calc\\_FuchsLang2001](#), [calc\\_CentralDose](#)

**Examples**

```
## read example data set
data(ExampleData.DeValues, envir = environment())

results <- calc_WodaFuchs2008(
  data = ExampleData.DeValues$CA1,
  xlab = expression(paste(D[e], " [Gy]"))
)
```

---

 combine\_De\_Dr

---

*Combine Dose Rate and Equivalent Dose Distribution*


---

**Description**

A Bayesian statistical analysis of OSL age requiring dose rate sample. Estimation contains a preliminary step for detecting outliers in the equivalent dose sample.

**Usage**

```
combine_De_Dr(
  De,
  s,
  Dr,
  int_OD,
  Age_range = c(1, 300),
  outlier_threshold = 0.05,
  outlier_method = "default",
  outlier_analysis_plot = FALSE,
  method_control = list(),
  par_local = TRUE,
  verbose = TRUE,
  plot = TRUE,
  ...
)
```

**Arguments**

De	<b>numeric (required)</b> : a equivalent dose sample
s	<b>numeric (required)</b> : a vector of measurement errors on the equivalent dose
Dr	<b>numeric (required)</b> : a dose rate sample
int_OD	<b>numeric (required)</b> : the intrinsic overdispersion, typically the standard deviation characterizing a dose-recovery test distribution
Age_range	<b>numeric (with default)</b> : the age range to be investigated by the algorithm, the larger the value the more iterations are needed and the longer it takes. Should not be set too narrow, cut the algorithm some slack.

outlier_threshold	<b>numeric</b> ( <i>with default</i> ): the required significance level used for the outlier detection. If set to 1, no outliers are removed. If outlier_method = "RousseeuwCroux1993", the median distance is used as outlier threshold. Please see details for further information.
outlier_method	<b>character</b> ( <i>with default</i> ): select the outlier detection method, either "default" or "RousseeuwCroux1993". See details for further information.
outlier_analysis_plot	<b>logical</b> ( <i>with default</i> ): enables/disables the outlier analysis plot. Note: the outlier analysis will happen with or without plot output
method_control	<b>list</b> ( <i>with default</i> ): named <b>list</b> of further parameters passed down to the <b>rjags::rjags</b> modelling
par_local	<b>logical</b> ( <i>with default</i> ): if set to TRUE the function uses its own <b>graphics::par</b> settings (which will end in two plots next to each other)
verbose	<b>logical</b> ( <i>with default</i> ): enable/disable terminal feedback
plot	<b>logical</b> ( <i>with default</i> ): enable/disable plot output
...	a few further arguments to fine-tune the plot output such as <b>cdf_ADr_quantiles</b> (TRUE/FALSE), <b>legend.pos</b> , <b>legend</b> (TRUE/FALSE)

## Details

### Outlier detection

Two different outlier detection methods are implemented (full details are given in the cited literature).

1. The *default* and *recommend* method, uses quantiles to compare prior and posterior distributions of the individual variances of the equivalent doses. If the corresponding quantile in the corresponding posterior distribution is larger than the quantile in the prior distribution, the value is marked as outlier (cf. Galharret et al., preprint)
2. The alternative method employs the method suggested by Rousseeuw and Croux (1993) using the absolute median distance.

### Parameters available for method\_control

The parameters listed below are used to granular control Bayesian modelling using **rjags::rjags**. Internally the functions **.calc\_IndividualAgeModel()** and **.calc\_BayesianCentralAgeModel()**. The parameter settings affect both models. Note: **method\_control** expects a **named** list of parameters

PARAMETER	TYPE	DEFAULT	REMARKS
variable.names_IAM	<b>character</b>	c('A', 'a', 'sig_a')	variables names to be monitored in the modelling process
variable.names_BCAM	<b>character</b>	c('A', 'D_e')	variables names to be monitored in the modelling process
n.chains	<b>integer</b>	4	number of MCMC chains
n.adapt	<b>integer</b>	1000	number of iterations for the adaptation
n.iter	<b>integer</b>	5000	number of iterations to monitor cf. <b>rjags::coda.samples</b>
thin	<b>numeric</b>	1	thinning interval for the monitoring cf. <b>rjags::coda.samples</b>
diag	<b>logical</b>	FALSE	additional terminal convergence diagnostic. FALSE if verbose = TRUE
progress.bar	<b>logical</b>	FALSE	enable/disable progress bar. FALSE if verbose = FALSE
quiet	<b>logical</b>	TRUE	silence terminal output. Set to TRUE if verbose = FALSE
return_mcmc	<b>logical</b>	FALSE	return additional MCMC diagnostic information

**Value**

The function returns a plot if `plot = TRUE` and an [RLum.Results](#) object with the following slots:

@data

```
.. $Ages: a numeric vector with the modelled ages to be further analysed or visualised
.. $Ages_stats: a data.frame with sum HPD, CI 68% and CI 95% for the ages
.. $outliers_index: the index with the detected outliers
.. $cdf_ADr_mean : empirical cumulative density distribution A * Dr (mean)
.. $cdf_ADr_quantiles : empirical cumulative density distribution A * Dr (quantiles .025,.975)
.. $cdf_De_no_outlier : empirical cumulative density distribution of the De with no outliers
.. $cdf_De_initial : empirical cumulative density distribution of the initial De
.. $mcmc_IAM: the MCMC list of the Individual Age Model, only of method_control = list(return_mcmc = TRUE) otherwise NULL
.. $mcmc_BCAM: the MCMC list of the Bayesian Central Age Model, only of method_control = list(return_mcmc = TRUE) otherwise NULL
```

@info

```
.. $call: the original function call
.. $model_IAM: the BUGS model used to derive the individual age
.. $model_BCAM: the BUGS model used to calculate the Bayesian Central Age
```

**Function version**

0.1.0

**Author(s)**

Anne Philippe, Université de Nantes (France), Jean-Michel Galharret, Université de Nantes (France), Norbert Mercier, IRAMAT-CRP2A, Université Bordeaux Montaigne (France), Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Mercier, N., Galharret, J.-M., Tribolo, C., Kreutzer, S., Philippe, A., preprint. Luminescence age calculation through Bayesian convolution of equivalent dose and dose-rate distributions: the De\_Dr model. *Geochronology*, 1-22.

Galharret, J-M., Philippe, A., Mercier, N., preprint. Detection of outliers with a Bayesian hierarchical model: application to the single-grain luminescence dating method. *Electronic Journal of Applied Statistics*

**Further reading**

Rousseeuw, P.J., Croux, C., 1993. Alternatives to the median absolute deviation. *Journal of the American Statistical Association* 88, 1273–1283. doi:10.2307/2291267

Rousseeuw, P.J., Debruyne, M., Engelen, S., Hubert, M., 2006. Robustness and outlier detection in chemometrics. *Critical Reviews in Analytical Chemistry* 36, 221–242. doi:10.1080/10408340600969403

**See Also**

[plot\\_OSLAgeSummary](#), [rjags::rjags](#), [mclust-package](#)

**Examples**

```
## set parameters
Dr <- stats::rlnorm (1000, 0, 0.3)
De <- 50*sample(Dr, 50, replace = TRUE)
s <- stats::rnorm(50, 10, 2)

## run modelling
## note: modify parameters for more realistic results
## Not run:
results <- combine_De_Dr(
  Dr = Dr,
  int_OD = 0.1,
  De,
  s,
  Age_range = c(0,100),
  method_control = list(
    n.iter = 100,
    n.chains = 1))

## show models used
writelines(results$info$model_IAM)
writelines(results$info$model_BCAM)

## End(Not run)
```

---

convert\_Activity2Concentration

*Convert Nuclide Activities to Abundance and Vice Versa*

---

**Description**

The function performs the conversion of the specific activities into mass abundance and vice versa for the radioelements U, Th, and K to harmonise the measurement unit with the required data input unit of potential analytical tools for, e.g. dose rate calculation or related functions such as [use\\_DRAC](#).

**Usage**

```
convert_Activity2Concentration(data, input_unit = "activity", verbose = TRUE)
```

**Arguments**

data	<b>data.frame (required)</b> : provide dose rate data (activity or concentration) in three columns. The first column indicates the nuclide, the 2nd column measured value and in the 3rd column its error value. Allowed nuclide data are 'U-238', 'Th-232' and 'K-40'. See examples for an example.
input_unit	<b>character (with default)</b> : specify unit of input data given in the dose rate data frame, choose between "activity" (considered as given Bq/kg) and "abundance" (considered as given in mug/g or mass. %). The default value is "activity"
verbose	<b>logical (with default)</b> : enable or disable verbose mode



## Details

The conversion from nuclide activity of a sample to nuclide concentration is performed using conversion factors that are based on the mass-related specific activity of the respective nuclide.

Constants used in this function were obtained from <https://physics.nist.gov/cuu/Constants/> all atomic weights and composition values from <https://www.nist.gov/pml/atomic-weights-and-isotopic-composition> and the nuclide data from <https://www.iaea.org/resources/databases/livechart-of-nuclides-advanced-version>

The factors can be calculated using the equation:

$$A = N_A \frac{N_{abund}}{N_{mol.mass}} \ln(2) / N_{half.life}$$

to convert in µg/g we further use:

$$f = A / 10^6$$

where:

- $N_A$  - Avogadro constant in 1/mol
- $A$  - specific activity of the nuclide in Bq/kg
- $N_{abund}$  - relative natural abundance of the isotope
- $N_{mol.mass}$  molar mass in kg/mol
- $N_{half.life}$  half-life of the nuclide in s

example for calculating the activity of the radionuclide U-238:

- $N_A = 6.02214076 \times 10^{23}$  (1/mol)
- $T_{0.5} = 1.41 \times 10^{17}$  (s)
- $m_{U-238} = 0.23802891$  (kg/mol)
- $U_{abund} = 0.992745$  (unitless)

$$A_U = N_A * U_{abund} / m_{U-238} * \ln(2) / T_{1/2} = 2347046$$

(Bq/kg)

$$f.U = A_U / 10^6$$

## Value

Returns an `RLum.Results` object with a `data.frame` containing input and newly calculated values. Please note that in the column header µg/g is written as mug/g due to the R requirement to maintain packages portable using ASCII characters only.

## Function version

0.1.2

## Note

Although written otherwise for historical reasons. Input values must be element values. For instance, if a value is provided for U-238 the function assumes that this value represents the sum (activity or abundance) of U-238, U-235 and U-234. In other words, 1 µg/g of U means that this is the composition of 0.992 parts of U-238, 0.000054 parts of U-234, and 0.00072 parts of U-235.

**Author(s)**

Margret C. Fuchs, Helmholtz-Institute Freiberg for Resource Technology (Germany) , RLum Developer Team

**References**

Debertin, K., Helmer, R.G., 1988. Gamma- and X-ray Spectrometry with Semiconductor Detectors, Elsevier Science Publishers, p.283

Wiechen, A., Ruehle, H., Vogl, K., 2013. Bestimmung der massebezogenen Aktivitaet von Radionukliden. AEQUIVAL/MASSAKT, ISSN 1865-8725, [https://www.bmu.de/fileadmin/Daten\\_BMU/Download\\_PDF/Strahlenschutz/aequival-massakt\\_v2013-07\\_bf.pdf](https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Strahlenschutz/aequival-massakt_v2013-07_bf.pdf)

**Examples**

```
##construct data.frame
data <- data.frame(
  NUCLIDES = c("U-238", "Th-232", "K-40"),
  VALUE = c(40,80,100),
  VALUE_ERROR = c(4,8,10),
  stringsAsFactors = FALSE)

##perform analysis
convert_Activity2Concentration(data)
```

---

 convert\_BIN2CSV

---

*Export Risoe BIN-file(s) to CSV-files*


---

**Description**

This function is a wrapper function around the functions [read\\_BIN2R](#) and [write\\_RLum2CSV](#) and it imports a Risoe BIN-file and directly exports its content to CSV-files. If nothing is set for the argument path ([write\\_RLum2CSV](#)) the input folder will become the output folder.

**Usage**

```
convert_BIN2CSV(file, ...)
```

**Arguments**

`file` **character (required)**: name of the BIN-file to be converted to CSV-files  
`...` further arguments that will be passed to the function [read\\_BIN2R](#) and [write\\_RLum2CSV](#)

**Value**

The function returns either a CSV-file (or many of them) or for the option `export == FALSE` a list comprising objects of type [data.frame](#) and [matrix](#)

**Function version**

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Analysis](#), [RLum.Data](#), [RLum.Results](#), [utils::write.table](#), [write\\_RLum2CSV](#), [read\\_BIN2R](#)

**Examples**

```
##transform Risoe.BINfileData values to a list
data(ExampleData.BINfileData, envir = environment())
convert_BIN2CSV(subset(CWOSL.SAR.Data, POSITION == 1), export = FALSE)

## Not run:
##select your BIN-file
file <- file.choose()

##convert
convert_BIN2CSV(file)

## End(Not run)
```

---

convert\_Concentration2DoseRate

*Dose-rate conversion function*

---

**Description**

This function converts radionuclide concentrations (K in %, Th and U in ppm) into dose rates (Gy/ka). Beta-dose rates are also attenuated for the grain size. Beta and gamma-dose rates are corrected for the water content. This function converts concentrations into dose rates (Gy/ka) and corrects for grain size attenuation and water content

Dose rate conversion factors can be chosen from Adamiec and Aitken (1998), Guerin et al. (2011), Liritzis et al. (201) and Cresswell et al. (2018). Default is Guerin et al. (2011).

Grain size correction for beta dose rates is achieved using the correction factors published by Guérin et al. (2012).

Water content correction is based on factors provided by Aitken (1985), with the factor for beta dose rate being 1.25 and for gamma 1.14.

**Usage**

```
convert_Concentration2DoseRate(input, conversion = "Guerinetal2011")
```

**Arguments**

input	<a href="#">data.frame</a> ( <i>optional</i> ): a table containing all relevant information for each individual layer if nothing is provided, the function returns a template <a href="#">data.frame</a> . Please note that until one dataset per input is supported!
conversion	<a href="#">character</a> ( <i>with default</i> ): which dose rate conversion factors to use, defaults uses Guérin et al. (2011). For accepted values see <a href="#">BaseDataSet.ConversionFactors</a>

## Details

### The input data

COLUMN	DATA TYPE	DESCRIPTION
Mineral	character	'FS' for feldspar, 'Q' for quartz
K	numeric	K nuclide content in %
K_SE	numeric	error on K nuclide content in %
Th	numeric	Th nuclide content in ppm
Th_SE	numeric	error on Th nuclide content in ppm
U	numeric	U nuclide content in ppm
U_SE	numeric	error on U nuclide content in ppm
GrainSize	numeric	average grain size in $\mu\text{m}$
WaterContent	numeric	mean water content in %
WaterContent_SE	numeric	relative error on water content

**Water content** The water content provided by the user should be calculated according to:

$$(Wet_{weight} - Dry_{weight}) / Dry_{weight} * 100$$

The unit for the weight is gram (g).

## Value

The function returns an [RLum.Results](#) object for which the first element is [matrix](#) with the converted values. If no input is provided, the function returns a template [data.frame](#) that can be used as input.

## Function version

0.1.0

## Author(s)

Svenja Riedesel, Aberystwyth University (United Kingdom)  
 Martin Autzen, DTU NUTECH Center for Nuclear Technologies (Denmark) , RLum Developer Team

## References

- Adamiec, G., Aitken, M.J., 1998. Dose-rate conversion factors: update. *Ancient TL* 16, 37-46.
- Cresswell., A.J., Carter, J., Sanderson, D.C.W., 2018. Dose rate conversion parameters: Assessment of nuclear data. *Radiation Measurements* 120, 195-201.
- Guerin, G., Mercier, N., Adamiec, G., 2011. Dose-rate conversion factors: update. *Ancient TL*, 29, 5-8.
- Guerin, G., Mercier, N., Nathan, R., Adamiec, G., Lefrais, Y., 2012. On the use of the infinite matrix assumption and associated concepts: A critical review. *Radiation Measurements*, 47, 778-785.
- Liritzis, I., Stamoulis, K., Papachristodoulou, C., Ioannides, K., 2013. A re-evaluation of radiation dose-rate conversion factors. *Mediterranean Archaeology and Archaeometry* 13, 1-15.

## Examples

```
## create input template
input <- convert_Concentration2DoseRate()

## fill input
input$Mineral <- "FS"
input$K <- 2.13
input$K_SE <- 0.07
input$Th <- 9.76
input$Th_SE <- 0.32
input$U <- 2.24
input$U_SE <- 0.12
input$GrainSize <- 200
input$WaterContent <- 30
input$WaterContent_SE <- 5

## convert
convert_Concentration2DoseRate(input)
```

---

convert_Daybreak2CSV	<i>Export measurement data produced by a Daybreak luminescence reader to CSV-files</i>
----------------------	--

---

## Description

This function is a wrapper function around the functions [read\\_Daybreak2R](#) and [write\\_RLum2CSV](#) and it imports an Daybreak-file (TXT-file, DAT-file) and directly exports its content to CSV-files. If nothing is set for the argument path ([write\\_RLum2CSV](#)) the input folder will become the output folder.

## Usage

```
convert_Daybreak2CSV(file, ...)
```

## Arguments

file	<b>character (required)</b> : name of the Daybreak-file (TXT-file, DAT-file) to be converted to CSV-files
...	further arguments that will be passed to the function <a href="#">read_Daybreak2R</a> and <a href="#">write_RLum2CSV</a>

## Value

The function returns either a CSV-file (or many of them) or for the option `export = FALSE` a list comprising objects of type [data.frame](#) and [matrix](#)

## Function version

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Analysis](#), [RLum.Data](#), [RLum.Results](#), [utils::write.table](#), [write\\_RLum2CSV](#), [read\\_Daybreak2R](#)

**Examples**

```
## Not run:
##select your BIN-file
file <- file.choose()

##convert
convert_Daybreak2CSV(file)

## End(Not run)
```

---

convert\_PSL2CSV

*Export PSL-file(s) to CSV-files*

---

**Description**

This function is a wrapper function around the functions [read\\_PSL2R](#) and [write\\_RLum2CSV](#) and it imports an PSL-file (SUERC portable OSL reader file format) and directly exports its content to CSV-files. If nothing is set for the argument path ([write\\_RLum2CSV](#)) the input folder will become the output folder.

**Usage**

```
convert_PSL2CSV(file, extract_raw_data = FALSE, single_table = FALSE, ...)
```

**Arguments**

file	<b>character (required):</b> name of the PSL-file to be converted to CSV-files
extract_raw_data	<b>logical (with default):</b> enable/disable raw data extraction. The PSL files imported into R contain an element <code>\$raw_data</code> , which provides a few more information (e.g., count errors), sometimes it makes sense to use this data of the more compact standard values created by <a href="#">read_PSL2R</a>
single_table	<b>logical (with default):</b> enable/disable the creation of single table with n rows and n columns, instead of separate <a href="#">data.frame</a> objects. Each curve will be represented by two columns for time and counts
...	further arguments that will be passed to the function <a href="#">read_PSL2R</a> and <a href="#">write_RLum2CSV</a>

**Value**

The function returns either a CSV-file (or many of them) or for the option `export = FALSE` a list comprising objects of type [data.frame](#) and [matrix](#)

**Function version**

0.1.2

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Analysis](#), [RLum.Data](#), [RLum.Results](#), [utils::write.table](#), [write\\_RLum2CSV](#), [read\\_PSL2R](#)

**Examples**

```
## export into single data.frame
file <- system.file("extdata/DorNie_0016.psl", package="Luminescence")
convert_PSL2CSV(file, export = FALSE, single_table = TRUE)

## Not run:
##select your BIN-file
file <- file.choose()

##convert
convert_PSL2CSV(file)

## End(Not run)
```

---

convert\_RLum2Risoe.BINfileData

*Converts RLum.Analysis-objects and RLum.Data.Curve-objects to  
RLum2Risoe.BINfileData-objects*

---

**Description**

The functions converts [RLum.Analysis](#) and [RLum.Data.Curve](#) objects and a [list](#) of those to [Risoe.BINfileData](#) objects. The function intends to provide a minimum of compatibility between both formats. The created [RLum.Analysis](#) object can be later exported to a BIN-file using the function [write\\_R2BIN](#).

**Usage**

```
convert_RLum2Risoe.BINfileData(object, keep.position.number = FALSE)
```

**Arguments**

**object** [RLum.Analysis](#) or [RLum.Data.Curve](#) (**required**): input object to be converted

**keep.position.number** [logical](#) (with default): keeps the original position number or re-calculate the numbers to avoid doubling

**Value**

The function returns a [Risoe.BINfileData](#) object.

**Function version**

0.1.3

**Note**

The conversion can be never perfect. The RLum objects may contain information which are not part of the [Risoe.BINfileData](#) definition.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Analysis](#), [RLum.Data.Curve](#), [write\\_R2BIN](#)

**Examples**

```
##simple conversion using the example dataset
data(ExampleData.RLum.Analysis, envir = environment())
convert_RLum2Risoe.BINfileData(IRSAR.RF.Data)
```

---

convert\_SG2MG

*Converts Single-Grain Data to Multiple-Grain Data*

---

**Description**

Conversion of single-grain data to multiple-grain data by adding signals from grains belonging to one disc (unique pairs of position, set and run).

**Usage**

```
convert_SG2MG(object, write_file = FALSE, ...)
```

**Arguments**

object	<a href="#">Risoe.BINfileData</a> character ( <b>required</b> ): <a href="#">Risoe.BINfileData</a> object or BIN/BINX-file name
write_file	<a href="#">logical</a> ( <i>with default</i> ): if the input was a path to a file, the output can be written to a file if TRUE. The multiple grain file will be written into the same folder and with extension -SG to the file name.
...	further arguments passed down to <a href="#">read_BIN2R</a> if input is file path



**Value**

[Risoe.BINfileData](#) object and if `write_file = TRUE` and the input was a file path, a file is written to origin folder.

**Function version**

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany), Norbert Mercier, IRAMAT-CRP2A, UMR 5060, CNRS-Université Bordeaux Montaigne (France); , RLum Developer Team

**See Also**

[Risoe.BINfileData](#), [read\\_BIN2R](#), [write\\_R2BIN](#)

**Examples**

```
## simple run
## (please not that the example is not using SG data)
data(ExampleData.BINfileData, envir = environment())
convert_SG2MG(CWOSL.SAR.Data)
```

---

convert\_Wavelength2Energy

*Emission Spectra Conversion from Wavelength to Energy Scales (Jacobian Conversion)*

---

**Description**

The function provides a convenient and fast way to convert emission spectra wavelength to energy scales. The function works on [RLum.Data.Spectrum](#), [data.frame](#) and [matrix](#) and a [list](#) of such objects. The function was written to smooth the workflow while analysing emission spectra data. This is in particular useful if you want to further treat your data and apply, e.g., a signal deconvolution.

**Usage**

```
convert_Wavelength2Energy(object, digits = 3L, order = FALSE)
```

**Arguments**

object	<a href="#">RLum.Data.Spectrum</a> , <a href="#">data.frame</a> , <a href="#">matrix</a> ( <b>required</b> ): input object to be converted. If the input is not an <a href="#">RLum.Data.Spectrum</a> , the first column is always treated as the wavelength column. The function supports a list of allowed input objects.
digits	<a href="#">integer</a> ( <i>with default</i> ): set the number of digits on the returned energy axis
order	<a href="#">logical</a> ( <i>with default</i> ): enables/disables sorting of the values in ascending energy order. After the conversion the longest wavelength has the lowest energy value and the shortest wavelength the highest. While this is correct, some R functions expect increasing x-values.

**Details**

The intensity of the spectrum is re-calculated using the following approach to recalculate wavelength and corresponding intensity values (e.g., Appendix 4 in Blasse and Grabmeier, 1994; Mooney and Kambhampati, 2013):

$$\phi_E = \phi_\lambda * \lambda^2 / (hc)$$

with  $\phi_E$  the intensity per interval of energy  $E$  (1/eV),  $\phi_\lambda$  the intensity per interval of wavelength  $\lambda$  (1/nm) and  $h$  (eV \* s) the Planck constant and  $c$  (nm/s) the velocity of light.

For transforming the wavelength axis (x-values) the equation as follow is used

$$E = hc/\lambda$$

**Value**

The same object class as provided as input is returned.

**Function version**

0.1.1

**Note**

This conversion works solely for emission spectra. In case of absorption spectra only the x-axis has to be converted.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

- Blasse, G., Grabmaier, B.C., 1994. Luminescent Materials. Springer.
- Mooney, J., Kambhampati, P., 2013. Get the Basics Right: Jacobian Conversion of Wavelength and Energy Scales for Quantitative Analysis of Emission Spectra. J. Phys. Chem. Lett. 4, 3316–3318. doi:10.1021/jz401508t
- Mooney, J., Kambhampati, P., 2013. Correction to “Get the Basics Right: Jacobian Conversion of Wavelength and Energy Scales for Quantitative Analysis of Emission Spectra.” J. Phys. Chem. Lett. 4, 3316–3318. doi:10.1021/jz401508t

**Further reading**

- Angulo, G., Grampp, G., Rosspeintner, A., 2006. Recalling the appropriate representation of electronic spectra. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 65, 727–731. doi:10.1016/j.saa.2006.01.007
- Wang, Y., Townsend, P.D., 2013. Potential problems in collection and data processing of luminescence signals. Journal of Luminescence 142, 202–211. doi:10.1016/j.jlumin.2013.03.052

**See Also**

[RLum.Data.Spectrum](#), [plot\\_RLum](#)

**Examples**

```

#####
##(1) Literature example after Mooney et al. (2013)
##(1.1) create matrix
m <- matrix(
  data = c(seq(400, 800, 50), rep(1, 9)), ncol = 2)

##(1.2) set plot function to reproduce the
##literature figure
p <- function(m) {
  plot(x = m[, 1], y = m[, 2])
  polygon(
    x = c(m[, 1], rev(m[, 1])),
    y = c(m[, 2], rep(0, nrow(m))))
  for (i in 1:nrow(m)) {
    lines(x = rep(m[i, 1], 2), y = c(0, m[i, 2]))
  }
}

##(1.3) plot curves
par(mfrow = c(1,2))
p(m)
p(convert_Wavelength2Energy(m))

#####
##(2) Another example using density curves
##create dataset
xy <- density(
  c(rnorm(n = 100, mean = 500, sd = 20),
    rnorm(n = 100, mean = 800, sd = 20)))
xy <- data.frame(xy$x, xy$y)

##plot
par(mfrow = c(1,2))
plot(
  xy,
  type = "l",
  xlim = c(150, 1000),
  xlab = "Wavelength [nm]",
  ylab = "Luminescence [a.u.]"
)
plot(
  convert_Wavelength2Energy(xy),
  xy$y,
  type = "l",
  xlim = c(1.23, 8.3),
  xlab = "Energy [eV]",
  ylab = "Luminescence [a.u.]"
)

```

## Description

This function is a wrapper function around the functions [read\\_XSYG2R](#) and [write\\_RLum2CSV](#) and it imports an XSYG-file and directly exports its content to CSV-files. If nothing is set for the argument path ([write\\_RLum2CSV](#)) the input folder will become the output folder.

## Usage

```
convert_XSYG2CSV(file, ...)
```

## Arguments

file	<b>character (required)</b> : name of the XSYG-file to be converted to CSV-files
...	further arguments that will be passed to the function <a href="#">read_XSYG2R</a> and <a href="#">write_RLum2CSV</a>

## Value

The function returns either a CSV-file (or many of them) or for the option `export = FALSE` a list comprising objects of type [data.frame](#) and [matrix](#)

## Function version

0.1.0

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## See Also

[RLum.Analysis](#), [RLum.Data](#), [RLum.Results](#), [utils::write.table](#), [write\\_RLum2CSV](#), [read\\_XSYG2R](#)

## Examples

```
##transform XSYG-file values to a list
data(ExampleData.XSYG, envir = environment())
convert_XSYG2CSV(OSL.SARMeasurement$Sequence.Object[1:10], export = FALSE)

## Not run:
##select your BIN-file
file <- file.choose()

##convert
convert_XSYG2CSV(file)

## End(Not run)
```

CW2pHMi

*Transform a CW-OSL curve into a pHM-OSL curve via interpolation under hyperbolic modulation conditions*

## Description

This function transforms a conventionally measured continuous-wave (CW) OSL-curve to a pseudo hyperbolic modulated (pHM) curve under hyperbolic modulation conditions using the interpolation procedure described by Bos & Wallinga (2012).

## Usage

```
CW2pHMi(values, delta)
```

## Arguments

**values** [RLum.Data.Curve](#) or [data.frame](#) (**required**): [RLum.Data.Curve](#) or [data.frame](#) with measured curve data of type stimulation time (t) (values[,1]) and measured counts (cts) (values[,2]).

**delta** [vector](#) (*optional*): stimulation rate parameter, if no value is given, the optimal value is estimated automatically (see details). Smaller values of delta produce more points in the rising tail of the curve.

## Details

The complete procedure of the transformation is described in Bos & Wallinga (2012). The input `data.frame` consists of two columns: time (t) and count values (CW(t))

### Internal transformation steps

- (1) log(CW-OSL) values
- (2) Calculate  $t'$  which is the transformed time:

$$t' = t - (1/\delta) * \log(1 + \delta * t)$$

- (3) Interpolate CW( $t'$ ), i.e. use the log(CW(t)) to obtain the count values for the transformed time ( $t'$ ). Values beyond  $\min(t)$  and  $\max(t)$  produce NA values.

- (4) Select all values for  $t' < \min(t)$ , i.e. values beyond the time resolution of t. Select the first two values of the transformed data set which contain no NA values and use these values for a linear fit using [lm](#).

- (5) Extrapolate values for  $t' < \min(t)$  based on the previously obtained fit parameters.

- (6) Transform values using

$$pHM(t) = (\delta * t / (1 + \delta * t)) * c * CW(t')$$

$$c = (1 + \delta * P) / \delta * P$$

$$P = \text{length}(\text{stimulation period})$$

- (7) Combine all values and truncate all values for  $t' > \max(t)$

**NOTE:** The number of values for  $t' < \min(t)$  depends on the stimulation rate parameter delta. To avoid the production of too many artificial data at the raising tail of the determined pHM curve, it is recommended to use the automatic estimation routine for delta, i.e. provide no value for delta.

**Value**

The function returns the same data type as the input data type with the transformed curve values.

`RLum.Data.Curve`

`$CW2pHMi.x.t` : transformed time values  
`$CW2pHMi.method` : used method for the production of the new data points

`data.frame`

`$x` : time  
`$y.t` : transformed count values  
`$x.t` : transformed time values  
`$method` : used method for the production of the new data points

**Function version**

0.2.2

**Note**

According to Bos & Wallinga (2012), the number of extrapolated points should be limited to avoid artificial intensity data. If `delta` is provided manually and more than two points are extrapolated, a warning message is returned.

The function [approx](#) may produce some `Inf` and `NaN` data. The function tries to manually interpolate these values by calculating the mean using the adjacent channels. If two invalid values are succeeding, the values are removed and no further interpolation is attempted. In every case a warning message is shown.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)

Based on comments and suggestions from:

Adrie J.J. Bos, Delft University of Technology, The Netherlands , RLum Developer Team

**References**

Bos, A.J.J. & Wallinga, J., 2012. How to visualize quartz OSL signal components. *Radiation Measurements*, 47, 752-758.

**Further Reading**

Bulur, E., 1996. An Alternative Technique For Optically Stimulated Luminescence (OSL) Experiment. *Radiation Measurements*, 26, 701-709.

Bulur, E., 2000. A simple transformation for converting CW-OSL curves to LM-OSL curves. *Radiation Measurements*, 32, 141-145.

**See Also**

[CW2pLM](#), [CW2pLMi](#), [CW2pPMi](#), [fit\\_LMCurve](#), [lm](#), [RLum.Data.Curve](#)

**Examples**

```

##(1) - simple transformation

##load CW-OSL curve data
data(ExampleData.CW_OSL_Curve, envir = environment())

##transform values
values.transformed<-CW2pHMi(ExampleData.CW_OSL_Curve)

##plot
plot(values.transformed$x, values.transformed$y.t, log = "x")

##(2) - load CW-OSL curve from BIN-file and plot transformed values

##load BINfile
#BINfileData<-readBIN2R("[path to BIN-file]")
data(ExampleData.BINfileData, envir = environment())

##grep first CW-OSL curve from ALQ 1
curve.ID<-CWOSL.SAR.Data@METADATA[CWOSL.SAR.Data@METADATA[, "LTYPE"]=="OSL" &
                                   CWOSL.SAR.Data@METADATA[, "POSITION"]==1
                                   , "ID"]

curve.HIGH<-CWOSL.SAR.Data@METADATA[CWOSL.SAR.Data@METADATA[, "ID"]==curve.ID[1]
                                   , "HIGH"]

curve.NPOINTS<-CWOSL.SAR.Data@METADATA[CWOSL.SAR.Data@METADATA[, "ID"]==curve.ID[1]
                                   , "NPOINTS"]

##combine curve to data set

curve<-data.frame(x = seq(curve.HIGH/curve.NPOINTS, curve.HIGH,
                          by = curve.HIGH/curve.NPOINTS),
                  y=unlist(CWOSL.SAR.Data@DATA[curve.ID[1]]))

##transform values

curve.transformed <- CW2pHMi(curve)

##plot curve
plot(curve.transformed$x, curve.transformed$y.t, log = "x")

##(3) - produce Fig. 4 from Bos & Wallinga (2012)

##load data
data(ExampleData.CW_OSL_Curve, envir = environment())
values <- CW_Curve.BosWallinga2012

##open plot area
plot(NA, NA,
     xlim=c(0.001,10),
     ylim=c(0,8000),
     ylab="pseudo OSL (cts/0.01 s)",
     xlab="t [s]",

```

```

log="x",
main="Fig. 4 - Bos & Wallinga (2012)")

values.t<-CW2pLMi(values, P=1/20)
lines(values[1:length(values.t[,1]),1],CW2pLMi(values, P=1/20)[,2],
      col="red" ,lwd=1.3)
text(0.03,4500,"LM", col="red" ,cex=.8)

values.t<-CW2pHMi(values, delta=40)
lines(values[1:length(values.t[,1]),1],CW2pHMi(values, delta=40)[,2],
      col="black", lwd=1.3)
text(0.005,3000,"HM", cex=.8)

values.t<-CW2pPMi(values, P=1/10)
lines(values[1:length(values.t[,1]),1],CW2pPMi(values, P=1/10)[,2],
      col="blue", lwd=1.3)
text(0.5,6500,"PM", col="blue" ,cex=.8)

```

CW2pLM

*Transform a CW-OSL curve into a pLM-OSL curve*

### Description

Transforms a conventionally measured continuous-wave (CW) curve into a pseudo linearly modulated (pLM) curve using the equations given in Bulur (2000).

### Usage

```
CW2pLM(values)
```

### Arguments

**values** [RLum.Data.Curve](#) or [data.frame](#) (**required**): [RLum.Data.Curve](#) data object. Alternatively, a `data.frame` of the measured curve data of type stimulation time (t) (`values[,1]`) and measured counts (cts) (`values[,2]`) can be provided.

### Details

According to Bulur (2000) the curve data are transformed by introducing two new parameters P (stimulation period) and u (transformed time):

$$P = 2 * \max(t)$$

$$u = \sqrt{(2 * t * P)}$$

The new count values are then calculated by

$$cts_{NEW} = cts(u/P)$$

and the returned `data.frame` is produced by: `data.frame(u, ctsNEW)`

The output of the function can be further used for LM-OSL fitting.



**Value**

The function returns the same data type as the input data type with the transformed curve values ([data.frame](#) or [RLum.Data.Curve](#)).

**Function version**

0.4.1

**Note**

The transformation is recommended for curves recorded with a channel resolution of at least 0.05 s/channel.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Bulur, E., 2000. A simple transformation for converting CW-OSL curves to LM-OSL curves. Radiation Measurements, 32, 141-145.

**Further Reading**

Bulur, E., 1996. An Alternative Technique For Optically Stimulated Luminescence (OSL) Experiment. Radiation Measurements, 26, 701-709.

**See Also**

[CW2pHMi](#), [CW2pLMi](#), [CW2pPMi](#), [fit\\_LMCurve](#), [lm](#), [RLum.Data.Curve](#)

**Examples**

```
##read curve from CWOSL.SAR.Data transform curve and plot values
data(ExampleData.BINfileData, envir = environment())

##read id for the 1st OSL curve
id.OSL <- CWOSL.SAR.Data@METADATA[CWOSL.SAR.Data@METADATA[, "LTYPE"] == "OSL", "ID"]

##produce x and y (time and count data for the data set)
x<-seq(CWOSL.SAR.Data@METADATA[id.OSL[1], "HIGH"]/CWOSL.SAR.Data@METADATA[id.OSL[1], "NPOINTS"],
       CWOSL.SAR.Data@METADATA[id.OSL[1], "HIGH"],
       by = CWOSL.SAR.Data@METADATA[id.OSL[1], "HIGH"]/CWOSL.SAR.Data@METADATA[id.OSL[1], "NPOINTS"])
y <- unlist(CWOSL.SAR.Data@DATA[id.OSL[1]])
values <- data.frame(x,y)

##transform values
values.transformed <- CW2pLM(values)

##plot
plot(values.transformed)
```

CW2pLMi

*Transform a CW-OSL curve into a pLM-OSL curve via interpolation under linear modulation conditions*

## Description

Transforms a conventionally measured continuous-wave (CW) OSL-curve into a pseudo linearly modulated (pLM) curve under linear modulation conditions using the interpolation procedure described by Bos & Wallinga (2012).

## Usage

```
CW2pLMi(values, P)
```

## Arguments

**values** [RLum.Data.Curve](#) or [data.frame](#) (**required**): [RLum.Data.Curve](#) or [data.frame](#) with measured curve data of type stimulation time (t) (values[,1]) and measured counts (cts) (values[,2])

**P** [vector](#) (*optional*): stimulation time in seconds. If no value is given the optimal value is estimated automatically (see details). Greater values of P produce more points in the rising tail of the curve.

## Details

The complete procedure of the transformation is given in Bos & Wallinga (2012). The input [data.frame](#) consists of two columns: time (t) and count values (CW(t))

### Nomenclature

- P = stimulation time (s)
- 1/P = stimulation rate (1/s)

### Internal transformation steps

(1) log(CW-OSL) values

(2) Calculate  $t'$  which is the transformed time:

$$t' = 1/2 * 1/P * t^2$$

(3) Interpolate CW( $t'$ ), i.e. use the log(CW(t)) to obtain the count values for the transformed time ( $t'$ ). Values beyond  $\min(t)$  and  $\max(t)$  produce NA values.

(4) Select all values for  $t' < \min(t)$ , i.e. values beyond the time resolution of t. Select the first two values of the transformed data set which contain no NA values and use these values for a linear fit using [lm](#).

(5) Extrapolate values for  $t' < \min(t)$  based on the previously obtained fit parameters.

(6) Transform values using

$$pLM(t) = t/P * CW(t')$$

(7) Combine values and truncate all values for  $t' > \max(t)$

**NOTE:** The number of values for  $t' < \min(t)$  depends on the stimulation period (P) and therefore on the stimulation rate 1/P. To avoid the production of too many artificial data at the raising tail of the determined pLM curves it is recommended to use the automatic estimation routine for P, i.e. provide no own value for P.

**Value**

The function returns the same data type as the input data type with the transformed curve values.

RLum.Data.Curve

`$CW2pLMi.x.t` : transformed time values  
`$CW2pLMi.method` : used method for the production of the new data points

**Function version**

0.3.1

**Note**

According to Bos & Wallinga (2012) the number of extrapolated points should be limited to avoid artificial intensity data. If P is provided manually and more than two points are extrapolated, a warning message is returned.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)

Based on comments and suggestions from:

Adrie J.J. Bos, Delft University of Technology, The Netherlands , RLum Developer Team

**References**

Bos, A.J.J. & Wallinga, J., 2012. How to visualize quartz OSL signal components. Radiation Measurements, 47, 752-758.

**Further Reading**

Bulur, E., 1996. An Alternative Technique For Optically Stimulated Luminescence (OSL) Experiment. Radiation Measurements, 26, 701-709.

Bulur, E., 2000. A simple transformation for converting CW-OSL curves to LM-OSL curves. Radiation Measurements, 32, 141-145.

**See Also**

[CW2pLM](#), [CW2pHMi](#), [CW2pPMi](#), [fit\\_LMCurve](#), [RLum.Data.Curve](#)

**Examples**

```
##(1)
##load CW-OSL curve data
data(ExampleData.CW_OSL_Curve, envir = environment())

##transform values
values.transformed <- CW2pLMi(ExampleData.CW_OSL_Curve)

##plot
plot(values.transformed$x, values.transformed$y.t, log = "x")

##(2) - produce Fig. 4 from Bos & Wallinga (2012)
##load data
data(ExampleData.CW_OSL_Curve, envir = environment())
values <- CW_Curve.BosWallinga2012
```

```

##open plot area
plot(NA, NA,
     xlim = c(0.001,10),
     ylim = c(0,8000),
     ylab = "pseudo OSL (cts/0.01 s)",
     xlab = "t [s]",
     log = "x",
     main = "Fig. 4 - Bos & Wallinga (2012)")

values.t <- CW2pLMi(values, P = 1/20)
lines(values[1:length(values.t[,1]),1],CW2pLMi(values, P = 1/20)[,2],
      col = "red", lwd = 1.3)
text(0.03,4500,"LM", col = "red", cex = .8)

values.t <- CW2pHMi(values, delta = 40)
lines(values[1:length(values.t[,1]),1],CW2pHMi(values, delta = 40)[,2],
      col = "black", lwd = 1.3)
text(0.005,3000,"HM", cex = .8)

values.t <- CW2pPMi(values, P = 1/10)
lines(values[1:length(values.t[,1]),1], CW2pPMi(values, P = 1/10)[,2],
      col = "blue", lwd = 1.3)
text(0.5,6500,"PM", col = "blue", cex = .8)

```

CW2pPMi

*Transform a CW-OSL curve into a pPM-OSL curve via interpolation under parabolic modulation conditions*

## Description

Transforms a conventionally measured continuous-wave (CW) OSL-curve into a pseudo parabolic modulated (pPM) curve under parabolic modulation conditions using the interpolation procedure described by Bos & Wallinga (2012).

## Usage

```
CW2pPMi(values, P)
```

## Arguments

values	<a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <b>required</b> ): <a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> with measured curve data of type stimulation time (t) (values[,1]) and measured counts (cts) (values[,2])
P	<a href="#">vector</a> ( <i>optional</i> ): stimulation period in seconds. If no value is given, the optimal value is estimated automatically (see details). Greater values of P produce more points in the rising tail of the curve.

## Details

The complete procedure of the transformation is given in Bos & Wallinga (2012). The input `data.frame` consists of two columns: time (`t`) and count values (`CW(t)`)

### Nomenclature

- $P$  = stimulation time (s)
- $1/P$  = stimulation rate (1/s)

### Internal transformation steps

(1)  $\log(\text{CW-OSL})$  values

(2) Calculate  $t'$  which is the transformed time:

$$t' = (1/3) * (1/P^2)t^3$$

(3) Interpolate  $\text{CW}(t')$ , i.e. use the  $\log(\text{CW}(t))$  to obtain the count values for the transformed time ( $t'$ ). Values beyond  $\min(t)$  and  $\max(t)$  produce NA values.

(4) Select all values for  $t' < \min(t)$ , i.e. values beyond the time resolution of  $t$ . Select the first two values of the transformed data set which contain no NA values and use these values for a linear fit using [lm](#).

(5) Extrapolate values for  $t' < \min(t)$  based on the previously obtained fit parameters. The extrapolation is limited to two values. Other values at the beginning of the transformed curve are set to 0.

(6) Transform values using

$$pLM(t) = t^2 / P^2 * \text{CW}(t')$$

(7) Combine all values and truncate all values for  $t' > \max(t)$

**NOTE:** The number of values for  $t' < \min(t)$  depends on the stimulation period  $P$ . To avoid the production of too many artificial data at the raising tail of the determined pPM curve, it is recommended to use the automatic estimation routine for  $P$ , i.e. provide no value for  $P$ .

## Value

The function returns the same data type as the input data type with the transformed curve values.

`RLum.Data.Curve`

`$CW2pPMi.x.t` : transformed time values  
`$CW2pPMi.method` : used method for the production of the new data points

`data.frame`

`$x` : time  
`$y.t` : transformed count values  
`$x.t` : transformed time values  
`$method` : used method for the production of the new data points

## Function version

0.2.1

**Note**

According to Bos & Wallinga (2012), the number of extrapolated points should be limited to avoid artificial intensity data. If P is provided manually, not more than two points are extrapolated.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)

Based on comments and suggestions from:

Adrie J.J. Bos, Delft University of Technology, The Netherlands , RLum Developer Team

**References**

Bos, A.J.J. & Wallinga, J., 2012. How to visualize quartz OSL signal components. *Radiation Measurements*, 47, 752-758.

**Further Reading**

Bulur, E., 1996. An Alternative Technique For Optically Stimulated Luminescence (OSL) Experiment. *Radiation Measurements*, 26, 701-709.

Bulur, E., 2000. A simple transformation for converting CW-OSL curves to LM-OSL curves. *Radiation Measurements*, 32, 141-145.

**See Also**

[CW2pLM](#), [CW2pLMi](#), [CW2pHMi](#), [fit\\_LMCurve](#), [RLum.Data.Curve](#)

**Examples**

```
##(1)
##load CW-OSL curve data
data(ExampleData.CW_OSL_Curve, envir = environment())

##transform values
values.transformed <- CW2pPMi(ExampleData.CW_OSL_Curve)

##plot
plot(values.transformed$x, values.transformed$y.t, log = "x")

##(2) - produce Fig. 4 from Bos & Wallinga (2012)

##load data
data(ExampleData.CW_OSL_Curve, envir = environment())
values <- CW_Curve.BosWallinga2012

##open plot area
plot(NA, NA,
     xlim = c(0.001, 10),
     ylim = c(0, 8000),
     ylab = "pseudo OSL (cts/0.01 s)",
     xlab = "t [s]",
     log = "x",
     main = "Fig. 4 - Bos & Wallinga (2012)")

values.t <- CW2pLMi(values, P = 1/20)
lines(values[1:length(values.t[,1]),1], CW2pLMi(values, P = 1/20)[,2],
```

```

col = "red", lwd = 1.3)
text(0.03, 4500, "LM", col = "red", cex = .8)

values.t <- CW2pHMi(values, delta = 40)
lines(values[1:length(values.t[,1]),1], CW2pHMi(values, delta = 40)[,2],
      col = "black", lwd = 1.3)
text(0.005, 3000, "HM", cex = .8)

values.t <- CW2pPMi(values, P = 1/10)
lines(values[1:length(values.t[,1]),1], CW2pPMi(values, P = 1/10)[,2],
      col = "blue", lwd = 1.3)
text(0.5, 6500, "PM", col = "blue", cex = .8)

```

---

ExampleData.AI2O3C	<i>Example AI2O3:C Measurement Data</i>
--------------------	---

---

## Description

Measurement data obtained from measuring AI2O3:C chips at the IRAMAT-CRP2A, Université Bordeaux Montaigne in 2017 on a Freiberg Instruments lexsyg SMART reader. The example data used in particular to allow test of the functions developed in framework of the work by Kreutzer et al., 2018.

## Format

Two datasets comprising [RLum.Analysis](#) data imported using the function [read\\_XSYG2R](#)

data\_ITC: Measurement data to determine the irradiation time correction, the data can be analysed with the function [analyse\\_AI2O3C\\_ITC](#)

data\_CrossTalk: Measurement data obtained while estimating the irradiation cross-talk of the reader used for the experiments. The data can be analysed either with the function [analyse\\_AI2O3C\\_CrossTalk](#) or [analyse\\_AI2O3C\\_Measurement](#)

## Note

From both datasets unneeded curves have been removed and the number of aliquots have been reduced to a required minimum to keep the file size small, but still being able to run the corresponding functions.

## References

Kreutzer, S., Martin, L., Guérin, G., Tribolo, C., Selva, P., Mercier, N., 2018. Environmental Dose Rate Determination Using a Passive Dosimeter: Techniques and Workflow for alpha-AI2O3:C Chips. *Geochronometria* 45, 56–67.

## See Also

[analyse\\_AI2O3C\\_ITC](#), [analyse\\_AI2O3C\\_CrossTalk](#), [analyse\\_AI2O3C\\_Measurement](#)

**Examples**

```
##(1) curves
data(ExampleData.A1203C, envir = environment())
plot_RLum(data_ITC[1:2])
```

---

ExampleData.BINfileData

*Example data from a SAR OSL and SAR TL measurement for the package Luminescence*

---

**Description**

Example data from a SAR OSL and TL measurement for package Luminescence directly extracted from a Risoe BIN-file and provided in an object of type [Risoe.BINfileData](#)

**Format**

CWOSL.SAR.Data: SAR OSL measurement data

TL.SAR.Data: SAR TL measurement data

Each class object contains two slots: (a) METADATA is a [data.frame](#) with all metadata stored in the BIN file of the measurements and (b) DATA contains a list of vectors of the measured data (usually count values).

**Version**

0.1

**Note**

Please note that this example data cannot be exported to a BIN-file using the function `writer2BIN` as it was generated and implemented in the package long time ago. In the meantime the BIN-file format changed.

**Source****CWOSL.SAR.Data**

Lab: Luminescence Laboratory Bayreuth  
 Lab-Code: BT607  
 Location: Saxony/Germany  
 Material: Middle grain quartz measured on aluminium cups on a Risø TL/OSL DA-15 reader  
 Reference: unpublished

**TL.SAR.Data**

Lab: Luminescence Laboratory of Cologne  
 Lab-Code: LP1\_5  
 Location: Spain  
 Material: Flint



Setup: Risoe TL/OSL DA-20 reader (Filter: Semrock Brightline, HC475/50, N2, unpolished steel discs)  
Reference: unpublished  
Remarks: dataset limited to one position

## References

**CWOSL.SAR.Data:** unpublished data

**TL.SAR.Data:** unpublished data

## Examples

```
## show first 5 elements of the METADATA and DATA elements in the terminal
data(ExampleData.BINfileData, envir = environment())
CWOSL.SAR.Data@METADATA[1:5,]
CWOSL.SAR.Data@DATA[1:5]
```

---

ExampleData.CobbleData

*Example data for `calc_CobbleDoseRate()`*

---

## Description

An example data set for the function [calc\\_CobbleDoseRate](#) containing layer specific information for the cobble to be used in the function.

## Format

A [data.frame](#). Please see [calc\\_CobbleDoseRate](#) for detailed information on the structure of the [data.frame](#).

## Version

0.1.0

## Examples

```
## Load data
data("ExampleData.CobbleData", envir = environment())
```

---

ExampleData.CW\_OSL\_Curve

*Example CW-OSL curve data for the package Luminescence*

---

## Description

data.frame containing CW-OSL curve data (time, counts)

## Format

Data frame with 1000 observations on the following 2 variables:

- list("x"): a numeric vector, time
- list("y"): a numeric vector, counts

## Source

### ExampleData.CW\_OSL\_Curve

Lab: Luminescence Laboratory Bayreuth  
 Lab-Code: BT607  
 Location: Saxony/Germany  
 Material: Middle grain quartz measured on aluminium cups on a Risø TL/OSL DA-15 reader.  
 Reference: unpublished data

### CW\_Curve.BosWallinga2012

Lab: Netherlands Centre for Luminescence Dating (NCL)  
 Lab-Code: NCL-2108077  
 Location: Guadalentin Basin, Spain  
 Material: Coarse grain quartz  
 Reference: Bos & Wallinga (2012) and Baartman et al. (2011)

## References

Baartman, J.E.M., Veldkamp, A., Schoorl, J.M., Wallinga, J., Cammeraat, L.H., 2011. Unravelling Late Pleistocene and Holocene landscape dynamics: The Upper Guadalentin Basin, SE Spain. *Geomorphology*, 125, 172-185.

Bos, A.J.J. & Wallinga, J., 2012. How to visualize quartz OSL signal components. *Radiation Measurements*, 47, 752-758.

## Examples

```
data(ExampleData.CW_OSL_Curve, envir = environment())
plot(ExampleData.CW_OSL_Curve)
```

---

ExampleData.DeValues    *Example De data sets for the package Luminescence*

---

## Description

Equivalent dose (De) values measured for a fine grain quartz sample from a loess section in Rottewitz (Saxony/Germany) and for a coarse grain quartz sample from a fluvial deposit in the rock shelter of Cueva Anton (Murcia/Spain).

## Format

A [list](#) with two elements, each containing a two column [data.frame](#):

\$BT998: De and De error values for a fine grain quartz sample from a loess section in Rottewitz.

\$CA1: Single grain De and De error values for a coarse grain quartz sample from a fluvial deposit in the rock shelter of Cueva Anton

## References

### BT998

Unpublished data

### CA1

Burow, C., Kehl, M., Hilgers, A., Weniger, G.-C., Angelucci, D., Villaverde, V., Zapata, J. and Zilhao, J. (2015). Luminescence dating of fluvial deposits in the rock shelter of Cueva Anton, Spain. *Geochronometria* 52, 107-125.

### BT998

Lab:	Luminescence Laboratory Bayreuth
Lab-Code:	BT998
Location:	Rottewitz (Saxony/Germany)
Material:	Fine grain quartz measured on aluminium discs on a Risø TL/OSL DA-15 reader
Units:	Values are given in seconds
Dose Rate:	Dose rate of the beta-source at measurement ca. 0.0438 Gy/s +/- 0.0019 Gy/s
Measurement Date:	2012-01-27

### CA1

Lab:	Cologne Luminescence Laboratory (CLL)
Lab-Code:	C-L2941
Location:	Cueva Anton (Murcia/Spain)
Material:	Coarse grain quartz (200-250 microns) measured on single grain discs on a Risoe TL/OSL DA-20 r
Units:	Values are given in Gray
Measurement Date:	2012

## Examples

```
##(1) plot values as histogram
data(ExampleData.DeValues, envir = environment())
plot_Histogram(ExampleData.DeValues$BT998, xlab = "De [s]")
```

```
##(2) plot values as histogram (with second to gray conversion)
data(ExampleData.DeValues, envir = environment())

De.values <- Second2Gray(ExampleData.DeValues$BT998,
                        dose.rate = c(0.0438, 0.0019))

plot_Histogram(De.values, xlab = "De [Gy]")
```

---

ExampleData.Fading

*Example data for feldspar fading measurements*


---

## Description

Example data set for fading measurements of the IR50, IR100, IR150 and IR225 feldspar signals of sample UNIL/NB123. It further contains regular equivalent dose measurement data of the same sample, which can be used to apply a fading correction to.

## Format

A [list](#) with two elements, each containing a further [list](#) of [data.frames](#) containing the data on the fading and equivalent dose measurements:

```
$fading.data: A named list of data.frames, each having three named columns (LxTx, LxTx.error, timeSinceIr)
..$IR50: Fading data of the IR50 signal.
..$IR100: Fading data of the IR100 signal.
..$IR150: Fading data of the IR150 signal.
..$IR225: Fading data of the IR225 signal.

$equivalentDose.data: A named of data.frames, each having three named columns (dose, LxTx, LxTx.error).
..$IR50: Equivalent dose measurement data of the IR50 signal.
..$IR100: Equivalent dose measurement data of the IR100 signal.
..$IR150: Equivalent dose measurement data of the IR150 signal.
..$IR225: Equivalent dose measurement data of the IR225 signal.
```

## Source

These data were kindly provided by Georgina E. King. Detailed information on the sample UNIL/NB123 can be found in the reference given below. The raw data can be found in the accompanying supplementary information.

## References

King, G.E., Herman, F., Lambert, R., Valla, P.G., Guralnik, B., 2016. Multi-OSL-thermochronometry of feldspar. *Quaternary Geochronology* 33, 76-87. doi:10.1016/j.quageo.2016.01.004

## Details

Lab:	University of Lausanne
Lab-Code:	UNIL/NB123
Location:	Namche Barwa (eastern Himalayas)
Material:	Coarse grained (180-212 microns) potassium feldspar

Units: Values are given in seconds  
 Lab Dose Rate: Dose rate of the beta-source at measurement ca. 0.1335 +/- 0.004 Gy/s  
 Environmental Dose Rate: 7.00 +/- 0.92 Gy/ka (includes internal dose rate)

## Examples

```
## Load example data
data("ExampleData.Fading", envir = environment())

## Get fading measurement data of the IR50 signal
IR50_fading <- ExampleData.Fading$fading.data$IR50
head(IR50_fading)

## Determine g-value and rho' for the IR50 signal
IR50_fading.res <- analyse_FadingMeasurement(IR50_fading)

## Show g-value and rho' results
gval <- get_RLum(IR50_fading.res)
rhop <- get_RLum(IR50_fading.res, "rho_prime")

gval
rhop

## Get LxTx values of the IR50 DE measurement
IR50_De.LxTx <- ExampleData.Fading$equivalentDose.data$IR50

## Calculate the De of the IR50 signal
IR50_De <- plot_GrowthCurve(IR50_De.LxTx,
                           mode = "interpolation",
                           fit.method = "EXP")

## Extract the calculated De and its error
IR50_De.res <- get_RLum(IR50_De)
De <- c(IR50_De.res$De, IR50_De.res$De.Error)

## Apply fading correction (age conversion greatly simplified)
IR50_Age <- De / 7.00
IR50_Age.corr <- calc_FadingCorr(IR50_Age, g_value = IR50_fading.res)
```

---

ExampleData.FittingLM *Example data for fit\_LMCurve() in the package Luminescence*

---

## Description

Linearly modulated (LM) measurement data from a quartz sample from Norway including background measurement. Measurements carried out in the luminescence laboratory at the University of Bayreuth.

## Format

Two objects (data.frames) with two columns (time and counts).

**Source**

Lab: Luminescence Laboratory Bayreuth  
 Lab-Code: BT900  
 Location: Norway  
 Material: Beach deposit, coarse grain quartz measured on aluminium discs on a Risø TL/OSL DA-15 reader

**References**

Fuchs, M., Kreutzer, S., Fischer, M., Sauer, D., Soerensen, R., 2012. OSL and IRSL dating of raised beach sand deposits along the south-eastern coast of Norway. *Quaternary Geochronology*, 10, 195-200.

**Examples**

```
##show LM data
data(ExampleData.FittingLM, envir = environment())
plot(values.curve, log="x")
```

---

ExampleData.LxTxData    *Example Lx/Tx data from CW-OSL SAR measurement*

---

**Description**

LxTx data from a SAR measurement for the package Luminescence.

**Format**

A [data.frame](#) with 4 columns (Dose, LxTx, LxTx.Error, TnTx).

**Source**

Lab: Luminescence Laboratory Bayreuth  
 Lab-Code: BT607  
 Location: Ostrau (Saxony-Anhalt/Germany)  
 Material: Middle grain (38-63  $\mu\text{m}$ ) quartz measured on a Risoe TL/OSL DA-15 reader.

**References**

unpublished data

**Examples**

```
## plot Lx/Tx data vs dose [s]
data(ExampleData.LxTxData, envir = environment())
plot(LxTxData$Dose, LxTxData$LxTx)
```

---

`ExampleData.LxTxOSLData`*Example Lx and Tx curve data from an artificial OSL measurement*

---

**Description**

Lx and Tx data of continuous wave (CW-) OSL signal curves.

**Format**

Two `data.frames` containing time and count values.

**Source**

Arbitrary OSL measurement.

**References**

unpublished data

**Examples**

```
##load data
data(ExampleData.LxTxOSLData, envir = environment())

##plot data
plot(Lx.data)
plot(Tx.data)
```

---

`ExampleData.MortarData`*Example equivalent dose data from mortar samples*

---

**Description**

Arbitrary data to test the function `calc_EED_Model`

**Format**

Two `data.frames` containing De and De error

**Source**

Arbitrary measurements.

**References**

unpublished data

**Examples**

```
##load data
data(ExampleData.MortarData, envir = environment())

##plot data
plot(MortarData)
```

---

```
ExampleData.portableOSL
```

*Example portable OSL curve data for the package Luminescence*

---

**Description**

A list of [RLum.Analysis](#) objects, each containing the same number of [RLum.Data.Curve](#) objects representing individual OSL, IRSL and dark count measurements of a sample.

**Source****ExampleData.portableOSL**

Lab:	Cologne Luminescence Laboratory
Lab-Code:	none
Location:	Nievenheim/Germany
Material:	Fine grain quartz
Reference:	unpublished data

**Examples**

```
data(ExampleData.portableOSL, envir = environment())
plot_RLum(ExampleData.portableOSL)
```

---

```
ExampleData.RLum.Analysis
```

*Example data as [RLum.Analysis](#) objects*

---

**Description**

Collection of different [RLum.Analysis](#) objects for protocol analysis.

**Format**

IRSAR.RF.Data: IRSAR.RF.Data on coarse grain feldspar

Each object contains data needed for the given protocol analysis.

**Version**

0.1



**Source****IRSAR.RF.Data**

These data were kindly provided by Tobias Lauer and Matthias Krbetschek.

Lab:	Luminescence Laboratory TU Bergakademie Freiberg
Lab-Code:	ZEU/SA1
Location:	Zeuchfeld (Zeuchfeld Sandur; Saxony-Anhalt/Germany)
Material:	K-feldspar (130-200 $\mu\text{m}$ )
Reference:	Kreutzer et al. (2014)

**References****IRSAR.RF.Data**

Kreutzer, S., Lauer, T., Meszner, S., Krbetschek, M.R., Faust, D., Fuchs, M., 2014. Chronology of the Quaternary profile Zeuchfeld in Saxony-Anhalt / Germany - a preliminary luminescence dating study. Zeitschrift fuer Geomorphologie 58, 5-26. doi: 10.1127/0372-8854/2012/S-00112

**Examples**

```
##load data
data(ExampleData.RLum.Analysis, envir = environment())

##plot data
plot_RLum(IRSAR.RF.Data)
```

---

ExampleData.RLum.Data.Image

*Example data as [RLum.Data.Image](#) objects*

---

**Description**

Measurement of Princeton Instruments camera imported with the function [read\\_SPE2R](#) to R to produce an [RLum.Data.Image](#) object.

**Format**

Object of class [RLum.Data.Image](#)

**Version**

0.1

**Source****ExampleData.RLum.Data.Image**

These data were kindly provided by Regina DeWitt.

Lab.:	Department of Physics, East-Carolina University, NC, USA
Lab-Code:	-

Location: -  
Material: -  
Reference: -

Image data is a measurement of fluorescent ceiling lights with a cooled Princeton Instruments (TM) camera fitted on Risø DA-20 TL/OSL reader.

### Examples

```
##load data
data(ExampleData.RLum.Data.Image, envir = environment())

##plot data
plot_RLum(ExampleData.RLum.Data.Image)
```

---

ExampleData.ScaleGammaDose

*Example data for scale\_GammaDose()*

---

### Description

An example data set for the function `scale_GammaDose()` containing layer specific information to scale the gamma dose rate considering variations in soil radioactivity.

### Format

A [data.frame](#). Please see `?scale_GammaDose()` for a detailed description of its structure.

### Version

0.1

### Examples

```
## Load data
data("ExampleData.ScaleGammaDose", envir = environment())
```

---

ExampleData.SurfaceExposure

*Example OSL surface exposure dating data*


---

## Description

A set of synthetic OSL surface exposure dating data to demonstrate the [fit\\_SurfaceExposure](#) functionality. See examples to reproduce the data interactively.

## Format

A [list](#) with 4 elements:

Element	Content
\$sample_1	A <a href="#">data.frame</a> with 3 columns (depth, intensity, error)
\$sample_2	A <a href="#">data.frame</a> with 3 columns (depth, intensity, error)
\$set_1	A <a href="#">list</a> of 4 <a href="#">data.frames</a> , each representing a sample with different ages
\$set_2	A <a href="#">list</a> of 5 <a href="#">data.frames</a> , each representing a sample with different ages

## Details

\$sample\_1

<b>mu</b>	<b>sigmaphi</b>	<b>age</b>
0.9	5e-10	10000

\$sample\_2

<b>mu</b>	<b>sigmaphi</b>	<b>age</b>	<b>Dose rate</b>	<b>D0</b>
0.9	5e-10	10000	2.5	40

\$set\_1

<b>mu</b>	<b>sigmaphi</b>	<b>ages</b>
0.9	5e-10	1e3, 1e4, 1e5, 1e6

\$set\_2

<b>mu</b>	<b>sigmaphi</b>	<b>ages</b>	<b>Dose rate</b>	<b>D0</b>
0.9	5e-10	1e2, 1e3, 1e4, 1e5, 1e6	1.0	40

## Source

See examples for the code used to create the data sets.

## References

Unpublished synthetic data

## Examples

[illegible]

```

## VALIDATE set_1
fit_SurfaceExposure(synth_3, age = age, sigmaphi = sigmaphi)

## ExampleData.SurfaceExposure$set_2
sigmaphi <- 5e-10
mu <- 0.9
x <- seq(0, 15, 0.2)
age <- c(1e2, 1e3, 1e4, 1e5, 1e6)
Ddot <- 1.0 / 1000 / 365.25 / 24 / 60 / 60 # 2.0 Gy/ka in Seconds
D0 <- 40
set.seed(666)

synth_4 <- vector("list", length = length(age))

for (i in 1:length(age)) {
  fun <- (sigmaphi * exp(-mu * x) *
    exp(-(age[i] * 365.25*24*3600) *
      (sigmaphi * exp(-mu * x) + Ddot/D0)) + Ddot/D0) /
    (sigmaphi * exp(-mu * x) + Ddot/D0)

  synth_4[[i]] <- data.frame(depth = x,
    intensity = jitter(fun, 1, 0.05))
}

## VALIDATE set_2
fit_SurfaceExposure(synth_4, age = age, sigmaphi = sigmaphi, D0 = D0, Ddot = 1.0)

## Not run:
ExampleData.SurfaceExposure <- list(
  sample_1 = synth_1,
  sample_2 = synth_2,
  set_1 = synth_3,
  set_2 = synth_4
)

## End(Not run)

```

---

ExampleData.TR_OSL	<i>Example TR-OSL data</i>
--------------------	----------------------------

---

## Description

Single TR-OSL curve obtained by Schmidt et al. (under review) for quartz sample BT729 (origin: Trebgast Valley, Germany, quartz, 90-200  $\mu\text{m}$ , unpublished data).

## Format

One [RLum.Data.Curve](#) dataset imported using the function [read\\_XSYG2R](#)

ExampleData.TR\_OSL: A single [RLum.Data.Curve](#) object with the TR-OSL data

## References

Schmidt, C., Simmank, O., Kreutzer, S., under review. Time-Resolved Optically Stimulated Luminescence of Quartz in the Nanosecond Time Domain. Journal of Luminescence, 1-90

## See Also

[fit\\_OSLLifeTimes](#)

## Examples

```
##(1) curves
data(ExampleData.TR_OSL, envir = environment())
plot_RLum(ExampleData.TR_OSL)
```

---

ExampleData.XSYG	<i>Example data for a SAR OSL measurement and a TL spectrum using a lexsyg reader</i>
------------------	---

---

## Description

Example data from a SAR OSL measurement and a TL spectrum for package Luminescence imported from a Freiberg Instruments XSYG file using the function [read\\_XSYG2R](#).

## Format

OSL.SARMeasurement: SAR OSL measurement data

The data contain two elements: (a) \$Sequence.Header is a [data.frame](#) with metadata from the measurement, (b) Sequence.Object contains an [RLum.Analysis](#) object for further analysis.

TL.Spectrum: TL spectrum data

[RLum.Data.Spectrum](#) object for further analysis. The spectrum was cleaned from cosmic-rays using the function

`apply_CosmicRayRemoval`. Note that no quantum efficiency calibration was performed.

## Version

0.1

## Source

### OSL.SARMeasurement

Lab:	Luminescence Laboratory Giessen
Lab-Code:	no code
Location:	not specified
Material:	Coarse grain quartz on steel cups on lexsyg research reader
Reference:	unpublished

### TL.Spectrum

Lab: Luminescence Laboratory Giessen  
 Lab-Code: BT753  
 Location: Dolni Vestonice/Czech Republic  
 Material: Fine grain polymineral on steel cups on lexsyg research reader  
 Reference: Fuchs et al., 2013  
 Spectrum: Integration time 19 s, channel time 20 s  
 Heating: 1 K/s, up to 500 deg. C

## References

Unpublished data measured to serve as example data for that package. Location origin of sample BT753 is given here:

Fuchs, M., Kreutzer, S., Rousseau, D.D., Antoine, P., Hatte, C., Lacroix, F., Moine, O., Gauthier, C., Svoboda, J., Lisa, L., 2013. The loess sequence of Dolni Vestonice, Czech Republic: A new OSL-based chronology of the Last Climatic Cycle. *Boreas*, 42, 664–677.

## See Also

[read\\_XSYG2R](#), [RLum.Analysis](#), [RLum.Data.Spectrum](#), [plot\\_RLum](#), [plot\\_RLum.Analysis](#), [plot\\_RLum.Data.Spectrum](#)

## Examples

```
##show data
data(ExampleData.XSYG, envir = environment())

## =====
##(1) OSL.SARMeasurement
OSL.SARMeasurement

##show $Sequence.Object
OSL.SARMeasurement$Sequence.Object

##grep OSL curves and plot the first curve
OSLcurve <- get_RLum(OSL.SARMeasurement$Sequence.Object,
  recordType="OSL")[[1]]
plot_RLum(OSLcurve)

## =====
##(2) TL.Spectrum
TL.Spectrum

##plot simple spectrum (2D)
plot_RLum.Data.Spectrum(TL.Spectrum,
  plot.type="contour",
  xlim = c(310,750),
  ylim = c(0,300),
  bin.rows=10,
  bin.cols = 1)

##plot 3d spectrum (uncomment for usage)
# plot_RLum.Data.Spectrum(TL.Spectrum, plot.type="persp",
# xlim = c(310,750), ylim = c(0,300), bin.rows=10,
# bin.cols = 1)
```

extdata

*Collection of External Data***Description**

Description and listing of data provided in the folder data/extdata

**Details**

The **R** package Luminescence includes a number of raw data files, which are mostly used in the example sections of appropriate functions. They are also used internally for testing corresponding functions using the testthat package (see files in tests/testthat/) to ensure their operational reliability.

**Accessibility**

If the **R** package Luminescence is installed correctly the preferred way to access and use these data from within **R** is as follows:

```
system.file("extdata/<FILENAME>", package = "Luminescence")
```

**Individual file descriptions**

»Daybreak\_TestFile.DAT/.txt«

**Type:** raw measurement data

**Device:** Daybreak OSL/TL reader

**Measurement date:** unknown

**Location:** unknown

**Provided by:** unknown

**Related R function(s):** read\_Daybreak2R()

**Reference:** unknown

»DorNie\_0016.psl«

**Type:** raw measurement data

**Device:** SUERC portable OSL reader

**Measurement date:** 19/05/2016

**Location:** Dormagen-Nievenheim, Germany

**Provided by:** Christoph Burow (University of Cologne)

**Related R function(s):** read\_PSL2R()

**Reference:** unpublished

**Additional information:** Sample measured at an archaeological site near Dormagen-Nievenheim (Germany) during a practical course on Luminescence dating in 2016.

»QNL84\_2\_bleached.txt, QNL84\_2\_unbleached.txt«

**Type:** Test data for exponential fits

**Reference:** Berger, G.W., Huntley, D.J., 1989. Test data for exponential fits. Ancient TL 7, 43-46.

»STRB87\_1\_bleached.txt, STRB87\_1\_unbleached.txt«

**Type:** Test data for exponential fits

**Reference:** Berger, G.W., Huntley, D.J., 1989. Test data for exponential fits. Ancient TL 7, 43-46.

»XSYG\_file.xsyg



**Type:** XSYG-file stump

**\*\*Info:** \*\* XSYG-file with some basic curves to test functions

**Reference:** no reference available

---

extract\_IrradiationTimes

*Extract Irradiation Times from an XSYG-file*

---

## Description

Extracts irradiation times, dose and times since last irradiation, from a Freiberg Instruments XSYG-file. These information can be further used to update an existing BINX-file.

## Usage

```
extract_IrradiationTimes(
  object,
  file.BINX,
  recordType = c("irradiation (NA)", "IRSL (UVVIS)", "OSL (UVVIS)", "TL (UVVIS)"),
  compatibility.mode = TRUE,
  txtProgressBar = TRUE
)
```

## Arguments

- |                    |   |
|--------------------|---|
| object             | <p><a href="#">character</a>, <a href="#">RLum.Analysis</a> or <a href="#">list</a> (<b>required</b>): path and file name of the XSYG file or an <a href="#">RLum.Analysis</a> produced by the function <a href="#">read_XSYG2R</a>; alternatively a list of <a href="#">RLum.Analysis</a> can be provided.</p> <p><b>Note:</b> If an <a href="#">RLum.Analysis</a> is used, any input for the arguments <code>file.BINX</code> and <code>recordType</code> will be ignored!</p>  |
| file.BINX          | <p><a href="#">character</a> (<i>optional</i>): path and file name of an existing BINX-file. If a file name is provided the file will be updated with the information from the XSYG file in the same folder as the original BINX-file.</p> <p><b>Note:</b> The XSYG and the BINX-file have to be originate from the same measurement!</p>   |
| recordType         | <p><a href="#">character</a> (<i>with default</i>): select relevant curves types from the XSYG file or <a href="#">RLum.Analysis</a> object. As the XSYG-file format comprises much more information than usually needed for routine data analysis and allowed in the BINX-file format, only the relevant curves are selected by using the function <a href="#">get_RLum</a>. The argument <code>recordType</code> works as described for this function.</p> <p><b>Note:</b> A wrong selection will causes a function error. Please change this argument only if you have reasons to do so.</p> |
| compatibility.mode | <p><a href="#">logical</a> (<i>with default</i>): this option is parsed only if a BIN/BINX file is produced and it will reset all position values to a max. value of 48, cf. <a href="#">write_R2BIN</a></p>  |
| txtProgressBar     | <p><a href="#">logical</a> (<i>with default</i>): enables TRUE or disables FALSE the progression bars during import and export</p>  |

## Details

The function was written to compensate missing information in the BINX-file output of Freiberg Instruments lexsyg readers. As all information are available within the XSYG-file anyway, these information can be extracted and used for further analysis or/and to stored in a new BINX-file, which can be further used by other software, e.g., Analyst (Geoff Duller).

Typical application example: g-value estimation from fading measurements using the Analyst or any other self written script.

Beside the some simple data transformation steps the function applies the functions [read\\_XSYG2R](#), [read\\_BIN2R](#), [write\\_R2BIN](#) for data import and export.

## Value

An [RLum.Results](#) object is returned with the following structure:

```
.. $irr.times (data.frame)
```

If a BINX-file path and name is set, the output will be additionally transferred into a new BINX-file with the function name as suffix. For the output the path of the input BINX-file itself is used. Note that this will not work if the input object is a file path to an XSYG-file, instead of a link to only one file. In this case the argument input for file.BINX is ignored.

In the self call mode (input is a list of [RLum.Analysis](#) objects) a list of [RLum.Results](#) is returned.

## Function version

0.3.3

## Note

The function can be also used to extract irradiation times from [RLum.Analysis](#) objects previously imported via [read\\_BIN2R](#) (fastForward = TRUE) or in combination with [Riso.BINfileData2RLum.Analysis](#). Unfortunately the timestamp might not be very precise (or even invalid), but it allows to essentially treat different formats in a similar manner.

The produced output object contains still the irradiation steps to keep the output transparent. However, for the BINX-file export this steps are removed as the BINX-file format description does not allow irradiations as separate sequences steps.

### **BINX-file 'Time Since Irradiation' value differs from the table output?**

The way the value 'Time Since Irradiation' is defined differs. In the BINX-file the 'Time Since Irradiation' is calculated as the 'Time Since Irradiation' plus the 'Irradiation Time'. The table output returns only the real 'Time Since Irradiation', i.e. time between the end of the irradiation and the next step.

### **Negative values for TIMESINCELAS.STEP?**

Yes, this is possible and no bug, as in the XSYG-file multiple curves are stored for one step. Example: TL step may comprise three curves:

- (a) counts vs. time,
- (b) measured temperature vs. time and
- (c) predefined temperature vs. time.

Three curves, but they are all belonging to one TL measurement step, but with regard to the time stamps this could produce negative values as the important function ([read\\_XSYG2R](#)) do not change the order of entries for one step towards a correct time order.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Duller, G.A.T., 2015. The Analyst software package for luminescence data: overview and recent improvements. Ancient TL 33, 35-42.

**See Also**

[RLum.Analysis](#), [RLum.Results](#), [Risoe.BINfileData](#), [read\\_XSYG2R](#), [read\\_BIN2R](#), [write\\_R2BIN](#)

**Examples**

```
## (1) - example for your own data
##
## set files and run function
#
# file.XSYG <- file.choose()
# file.BINX <- file.choose()
#
# output <- extract_IrradiationTimes(file.XSYG = file.XSYG, file.BINX = file.BINX)
# get_RLum(output)
#
## export results additionally to a CSV.file in the same directory as the XSYG-file
# write.table(x = get_RLum(output),
#             file = paste0(file.BINX,"_extract_IrradiationTimes.csv"),
#             sep = ";",
#             row.names = FALSE)
```

---

extract_ROI	<i>Extract Pixel Values through Circular Region-of-Interests (ROI) from an Image</i>
-------------	--

---

**Description**

Light-weighted function to extract pixel values from pre-defined regions-of-interest (ROI) from [RLum.Data.Image](#), [array](#) or [matrix](#) objects and provide simple image processing capacity. The function is limited to circular ROIs.

**Usage**

```
extract_ROI(object, roi, roi_summary = "mean", plot = FALSE)
```

**Arguments**

object	<a href="#">RLum.Data.Image</a> , <a href="#">array</a> or <a href="#">matrix</a> ( <b>required</b> ): input image data
roi	<a href="#">matrix</a> ( <b>required</b> ): matrix with three columns containing the centre coordinates of the ROI (first two columns) and the diameter of the circular ROI. All numbers must be of type <a href="#">integer</a> and will forcefully be coerced into such numbers using <code>as.integer()</code> regardless.

`roi_summary`      **(with default)**: if "mean" (the default) defines what is returned in the element `roi_summary`; alternatively "mean", "median", "sd" or "sum" can be chosen. Pixel values are conveniently summarised using the above defined keyword.

`plot`              **logical** (*optional*): enables/disables control plot. Only the first image frame is shown

### Details

The function uses a cheap approach to decide whether a pixel lies within a circle or not. It assumes that pixel coordinates are integer values and that a pixel centring within the circle is satisfied by:

$$x^2 + y^2 \leq (d/2)^2$$

where  $x$  and  $y$  are integer pixel coordinates and  $d$  is the integer diameter of the circle in pixel.

### Value

**RLum.Results** object with the following elements: `..$roi_signals`: a named **list** with all ROI values and their coordinates `..$roi_summary`: an **matrix** where rows are frames from the image, and columns are different ROI The element has two attributes: `summary` (the method used to summarise pixels) and `area` (the pixel area) `..$roi_coord`: a **matrix** that can be passed to `plot_ROI`

If `plot = TRUE` a control plot is returned.

### Function version

0.1.0

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### See Also

[RLum.Data.Image](#)

### Examples

```
m <- matrix(runif(100,0,255), ncol = 10, nrow = 10)
roi <- matrix(c(2.,4,2,5,6,7,3,1,1), ncol = 3)
extract_ROI(object = m, roi = roi, plot = TRUE)
```

fit\_CWCurve

*Nonlinear Least Squares Fit for CW-OSL curves -beta version-*

## Description

The function determines the weighted least-squares estimates of the component parameters of a CW-OSL signal for a given maximum number of components and returns various component parameters. The fitting procedure uses the [nls](#) function with the port algorithm.

## Usage

```
fit_CWCurve(
  values,
  n.components.max,
  fit.failure_threshold = 5,
  fit.method = "port",
  fit.trace = FALSE,
  fit.calcError = FALSE,
  LED.power = 36,
  LED.wavelength = 470,
  cex.global = 0.6,
  sample_code = "Default",
  output.path,
  output.terminal = TRUE,
  output.terminalAdvanced = TRUE,
  plot = TRUE,
  ...
)
```

## Arguments

- |                       |   |
|-----------------------|---|
| values                | <a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <b>required</b> ): x, y data of measured values (time and counts). See examples.  |
| n.components.max      | <a href="#">vector</a> ( <i>optional</i> ): maximum number of components that are to be used for fitting. The upper limit is 7.   |
| fit.failure_threshold | <a href="#">vector</a> ( <i>with default</i> ): limits the failed fitting attempts.   |
| fit.method            | <a href="#">character</a> ( <i>with default</i> ): select fit method, allowed values: 'port' and 'LM'. 'port' uses the 'port' routine from the function <a href="#">nls</a> 'LM' utilises the function <a href="#">nlsLM</a> from the package <a href="#">minpack.lm</a> and with that the Levenberg-Marquardt algorithm. |
| fit.trace             | <a href="#">logical</a> ( <i>with default</i> ): traces the fitting process on the terminal.  |
| fit.calcError         | <a href="#">logical</a> ( <i>with default</i> ): calculate 1-sigma error range of components using <a href="#">stats::confint</a>   |
| LED.power             | <a href="#">numeric</a> ( <i>with default</i> ): LED power (max.) used for intensity ramping in mW/cm <sup>2</sup> .<br><b>Note:</b> The value is used for the calculation of the absolute photoionisation cross section.   |
| LED.wavelength        | <a href="#">numeric</a> ( <i>with default</i> ): LED wavelength used for stimulation in nm. <b>Note:</b> The value is used for the calculation of the absolute photoionisation cross section.   |

<code>cex.global</code>	<a href="#">numeric</a> ( <i>with default</i> ): global scaling factor.
<code>sample_code</code>	<a href="#">character</a> ( <i>optional</i> ): sample code used for the plot and the optional output table ( <code>mtext</code> ).
<code>output.path</code>	<a href="#">character</a> ( <i>optional</i> ): output path for table output containing the results of the fit. The file name is set automatically. If the file already exists in the directory, the values are appended.
<code>output.terminal</code>	<a href="#">logical</a> ( <i>with default</i> ): terminal output with fitting results.
<code>output.terminalAdvanced</code>	<a href="#">logical</a> ( <i>with default</i> ): enhanced terminal output. Requires <code>output.terminal = TRUE</code> . If <code>output.terminal = FALSE</code> no advanced output is possible.
<code>plot</code>	<a href="#">logical</a> ( <i>with default</i> ): returns a plot of the fitted curves.
<code>...</code>	further arguments and graphical parameters passed to <a href="#">plot</a> .

## Details

### Fitting function

The function for the CW-OSL fitting has the general form:

$$y = I0_1 * \lambda_1 * \exp(-\lambda_1 * x) + \dots + I0_i * \lambda_i * \exp(-\lambda_i * x)$$

where  $0 < i < 8$

and  $\lambda$  is the decay constant

and  $I0$  the initial number of trapped electrons.

(for the used equation cf. Boetter-Jensen et al., 2003, Eq. 2.31)

### Start values

Start values are estimated automatically by fitting a linear function to the logarithmized input data set. Currently, there is no option to manually provide start parameters.

### Goodness of fit

The goodness of the fit is given as  $\text{pseudoR}^2$  value (pseudo coefficient of determination). According to Lave (1970), the value is calculated as:

$$\text{pseudoR}^2 = 1 - \text{RSS}/\text{TSS}$$

where  $\text{RSS} = \text{Residual Sum of Squares}$

and  $\text{TSS} = \text{Total Sum of Squares}$

### Error of fitted component parameters

The 1-sigma error for the components is calculated using the function [stats::confint](#). Due to considerable calculation time, this option is deactivated by default. In addition, the error for the components can be estimated by using internal R functions like [summary](#). See the [nls](#) help page for more information.

For details on the nonlinear regression in R, see Ritz & Streibig (2008).

**Value****plot (optional)**

the fitted CW-OSL curves are returned as plot.

**table (optional)**

an output table (\*.csv) with parameters of the fitted components is provided if the output.path is set.

**RLum.Results**

Beside the plot and table output options, an [RLum.Results](#) object is returned.

fit: an nls object (\$fit) for which generic R functions are provided, e.g. [summary](#), [stats::confint](#), [profile](#). For more details, see [nls](#).

output.table: a [data.frame](#) containing the summarised parameters including the error

component.contribution.matrix: [matrix](#) containing the values for the component to sum contribution plot (\$component.contribution.matrix).

Matrix structure:

Column 1 and 2: time and rev(time) values

Additional columns are used for the components, two for each component, containing I0 and n0. The last columns cont. provide information on the relative component contribution for each time interval including the row sum for this values.

**object**

beside the plot and table output options, an [RLum.Results](#) object is returned.

fit: an nls object (\$fit) for which generic R functions are provided, e.g. [summary](#), [confint](#), [profile](#). For more details, see [nls](#).

output.table: a [data.frame](#) containing the summarised parameters including the error

component.contribution.matrix: [matrix](#) containing the values for the component to sum contribution plot (\$component.contribution.matrix).

Matrix structure:

Column 1 and 2: time and rev(time) values

Additional columns are used for the components, two for each component, containing I0 and n0. The last columns cont. provide information on the relative component contribution for each time interval including the row sum for this values.

**Function version**

0.5.2

**Note**

**Beta version - This function has not been properly tested yet and should therefore not be used for publication purposes!**

The pseudo-R<sup>2</sup> may not be the best parameter to describe the goodness of the fit. The trade off between the n.components and the pseudo-R<sup>2</sup> value is currently not considered.

The function **does not** ensure that the fitting procedure has reached a global minimum rather than a local minimum!

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

- Boetter-Jensen, L., McKeever, S.W.S., Wintle, A.G., 2003. Optically Stimulated Luminescence Dosimetry. Elsevier Science B.V.
- Lave, C.A.T., 1970. The Demand for Urban Mass Transportation. The Review of Economics and Statistics, 52 (3), 320-323.
- Ritz, C. & Streibig, J.C., 2008. Nonlinear Regression with R. In: R. Gentleman, K. Hornik, G. Parmigiani, eds., Springer, p. 150.

**See Also**

[fit\\_LMCurve](#), [plot,nls](#), [RLum.Data.Curve](#), [RLum.Results](#), [get\\_RLum](#), [minpack.lm::nlsLM](#)

**Examples**

```
##load data
data(ExampleData.CW_OSL_Curve, envir = environment())

##fit data
fit <- fit_CWCurve(values = ExampleData.CW_OSL_Curve,
                  main = "CW Curve Fit",
                  n.components.max = 4,
                  log = "x")
```

---

fit_EmissionSpectra	<i>Luminescence Emission Spectra Deconvolution</i>
---------------------	--

---

**Description**

Luminescence spectra deconvolution on [RLum.Data.Spectrum](#) and [matrix](#) objects on an **energy scale**. The function is optimised for emission spectra typically obtained in the context of TL, OSL and RF measurements detected between 200 and 1000 nm. The function is not prepared to deconvolve TL curves (counts against temperature; no wavelength scale). If you are interested in such analysis, please check, e.g., the package 'tgcd'.

**Usage**

```
fit_EmissionSpectra(
  object,
  frame = NULL,
  n_components = NULL,
  start_parameters = NULL,
  sub_negative = 0,
  input_scale = NULL,
  method_control = list(),
  verbose = TRUE,
```



```

    plot = TRUE,
    ...
)

```

## Arguments

object	<a href="#">RLum.Data.Spectrum</a> , <b>matrix</b> ( <b>required</b> ): input object. Please note that an energy spectrum is expected
frame	<a href="#">numeric</a> ( <i>optional</i> ): defines the frame to be analysed
n_components	<a href="#">numeric</a> ( <i>optional</i> ): allows a number of the aimed number of components. However, it defines rather a maximum than a minimum. Can be combined with other parameters.
start_parameters	<a href="#">numeric</a> ( <i>optional</i> ): allows to provide own start parameters for a semi-automated procedure. Parameters need to be provided in eV. Every value provided replaces a value from the automated peak finding algorithm (in ascending order).
sub_negative	<a href="#">numeric</a> ( <i>with default</i> ): substitute negative values in the input object by the number provided here (default: 0). Can be set to NULL, i.e. negative values are kept.
input_scale	<a href="#">character</a> ( <i>optional</i> ): defines whether your x-values define wavelength or energy values. For the analysis an energy scale is expected, allowed values are 'wavelength' and 'energy'. If nothing (NULL) is defined, the function tries to understand the input automatically.
method_control	<a href="#">list</a> ( <i>optional</i> ): options to control the fit method, see details
verbose	<a href="#">logical</a> ( <i>with default</i> ): enable/disable verbose mode
plot	<a href="#">logical</a> ( <i>with default</i> ): enable/disable plot output
...	further arguments to be passed to control the plot output (supported: main, xlab, ylab, xlim, ylim, log, mtext, legend (TRUE or FALSE), legend.text, legend.pos)

## Details

### Used equation

The emission spectra (on an energy scale) can be best described as the sum of multiple Gaussian components:

,

$$y = \sum C_i * 1/(\sigma_i * \sqrt{2 * \pi}) * \exp(-1/2 * ((x - \mu_i)/\sigma_i)^2)$$

with the parameters  $\sigma$  (peak width) and  $\mu$  (peak centre) and  $C$  (scaling factor).

### Start parameter estimation and fitting algorithm

The spectrum deconvolution consists of the following steps:

1. Peak finding
2. Start parameter estimation
3. Fitting via [minpack.lm::nls.lm](#)

The peak finding is realised by an approach (re-)suggested by Petr Pikal via the R-help mailing list (<https://stat.ethz.ch/pipermail/r-help/2005-November/thread.html>) in November 2005. This goes back to even earlier discussion in 2001 based on Prof Brian Ripley's idea. It smartly uses the functions `stats::embed` and `max.col` to identify peaks positions. For the use in this context, the algorithm has been further modified to scale on the input data resolution (cf. source code).

The start parameter estimation uses random sampling from a range of meaningful parameters and repeats the fitting until 1000 successful fits have been produced or the set `max.runs` value is exceeded.

Currently the best fit is the one with the lowest number for squared residuals, but other parameters are returned as well. If a series of curves needs to be analysed, it is recommended to make few trial runs, then fix the number of components and run at least 10,000 iterations (parameter `method_control = list(max.runs = 10000)`).

#### Supported `method_control` settings

Parameter	Type	Default	Description
<code>max.runs</code>	<a href="#">integer</a>	10000	maximum allowed search iterations, if exceed the searching stops
<code>graining</code>	<a href="#">numeric</a>	15	gives control over how coarse or fine the spectrum is split into search intervals for the
<code>norm</code>	<a href="#">logical</a>	TRUE	normalises data to the highest count value before fitting
<code>trace</code>	<a href="#">logical</a>	FALSE	enables/disables the tracing of the minimisation routine

#### Value

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
<code>\$data</code>	matrix	the final fit matrix
<code>\$fit</code>	nls	the fit object returned by <a href="#">minpack.lm::nls.lm</a>
<code>\$fit_info</code>	list	a few additional parameters that can be used to asses the quality of the fit

**slot:** @info

The original function call

---

[ TERMINAL OUTPUT ]

---

The terminal output provides brief information on the deconvolution process and the obtained results. Terminal output is only shown of the argument `verbose = TRUE`.

---

[ PLOT OUTPUT ]

---

The function returns a plot showing the raw signal with the detected components. If the fitting failed, a basic plot is returned showing the raw data and indicating the peaks detected for the start

parameter estimation. The grey band in the residual plot indicates the 10% deviation from 0 (means no residual).

**Function version**

0.1.1

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Spectrum](#), [RLum.Results](#), [plot\\_RLum](#), [convert\\_Wavelength2Energy](#), [minpack.lm::nls.lm](#)

**Examples**

```
##load example data
data(ExampleData.XSYG, envir = environment())

##subtract background
TL.Spectrum@data <- TL.Spectrum@data[] - TL.Spectrum@data[,15]

results <- fit_EmissionSpectra(
  object = TL.Spectrum,
  frame = 5,
  method_control = list(max.runs = 10)
)

##deconvolution of a TL spectrum
## Not run:

##load example data

##replace 0 values
results <- fit_EmissionSpectra(
  object = TL.Spectrum,
  frame = 5, main = "TL spectrum"
)

## End(Not run)
```

**Description**

The function determines weighted nonlinear least-squares estimates of the component parameters of an LM-OSL curve (Bulur 1996) for a given number of components and returns various component parameters. The fitting procedure uses the function [nls](#) with the port algorithm.

**Usage**

```

fit_LMCurve(
  values,
  values.bg,
  n.components = 3,
  start_values,
  input.dataType = "LM",
  fit.method = "port",
  sample_code = "",
  sample_ID = "",
  LED.power = 36,
  LED.wavelength = 470,
  fit.trace = FALSE,
  fit.advanced = FALSE,
  fit.calcError = FALSE,
  bg.subtraction = "polynomial",
  verbose = TRUE,
  plot = TRUE,
  plot.BG = FALSE,
  ...
)

```

**Arguments**

values	<a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <b>required</b> ): x,y data of measured values (time and counts). See examples.
values.bg	<a href="#">RLum.Data.Curve</a> or <a href="#">data.frame</a> ( <i>optional</i> ): x,y data of measured values (time and counts) for background subtraction.
n.components	<a href="#">integer</a> ( <i>with default</i> ): fixed number of components that are to be recognised during fitting (min = 1, max = 7).
start_values	<a href="#">data.frame</a> ( <i>optional</i> ): start parameters for lm and xm data for the fit. If no start values are given, an automatic start value estimation is attempted (see details).
input.dataType	<a href="#">character</a> ( <i>with default</i> ): alter the plot output depending on the input data: "LM" or "pLM" (pseudo-LM). See: <a href="#">CW2pLM</a>
fit.method	<a href="#">character</a> ( <i>with default</i> ): select fit method, allowed values: 'port' and 'LM'. 'port' uses the 'port' routine from the function <a href="#">nls</a> 'LM' utilises the function <a href="#">nlsLM</a> from the package <a href="#">minpack.lm</a> and with that the Levenberg-Marquardt algorithm.
sample_code	<a href="#">character</a> ( <i>optional</i> ): sample code used for the plot and the optional output table (mtext).
sample_ID	<a href="#">character</a> ( <i>optional</i> ): additional identifier used as column header for the table output.
LED.power	<a href="#">numeric</a> ( <i>with default</i> ): LED power (max.) used for intensity ramping in mW/cm <sup>2</sup> . <b>Note:</b> This value is used for the calculation of the absolute photoionisation cross section.
LED.wavelength	<a href="#">numeric</a> ( <i>with default</i> ): LED wavelength in nm used for stimulation. <b>Note:</b> This value is used for the calculation of the absolute photoionisation cross section.
fit.trace	<a href="#">logical</a> ( <i>with default</i> ): traces the fitting process on the terminal.

fit.advanced	<b>logical</b> ( <i>with default</i> ): enables advanced fitting attempt for automatic start parameter recognition. Works only if no start parameters are provided. <b>Note:</b> It may take a while and it is not compatible with <code>fit.method = "LM"</code> .
fit.calcError	<b>logical</b> ( <i>with default</i> ): calculate 1-sigma error range of components using <code>stats::confint</code> .
bg.subtraction	<b>character</b> ( <i>with default</i> ): specifies method for background subtraction (polynomial, linear, channel, see Details). <b>Note:</b> requires input for values.bg.
verbose	<b>logical</b> ( <i>with default</i> ): terminal output with fitting results.
plot	<b>logical</b> ( <i>with default</i> ): returns a plot of the fitted curves.
plot.BG	<b>logical</b> ( <i>with default</i> ): returns a plot of the background values with the fit used for the background subtraction.
...	Further arguments that may be passed to the plot output, e.g. <code>xlab</code> , <code>ylab</code> , <code>main</code> , <code>log</code> .

## Details

### Fitting function

The function for the fitting has the general form:

$$y = (\exp(0.5) * Im_1 * x / xm_1) * \exp(-x^2 / (2 * xm_1^2)) + \dots + \exp(0.5) * Im_i * x / xm_i * \exp(-x^2 / (2 * xm_i^2))$$

where  $1 < i < 8$

This function and the equations for the conversion to  $b$  (detrapping probability) and  $n0$  (proportional to initially trapped charge) have been taken from Kitis et al. (2008):

$$xm_i = \sqrt{\max(t) / b_i}$$

$$Im_i = \exp(-0.5) n0 / xm_i$$

### Background subtraction

Three methods for background subtraction are provided for a given background signal (values.bg).

- **polynomial**: default method. A polynomial function is fitted using `glm` and the resulting function is used for background subtraction:

$$y = a * x^4 + b * x^3 + c * x^2 + d * x + e$$

- **linear**: a linear function is fitted using `glm` and the resulting function is used for background subtraction:

$$y = a * x + b$$

- **channel**: the measured background signal is subtracted channel wise from the measured signal.

### Start values

The choice of the initial parameters for the nls-fitting is a crucial point and the fitting procedure may mainly fail due to ill chosen start parameters. Here, three options are provided:

(a) If no start values (`start_values`) are provided by the user, a cheap guess is made by using the detrapping values found by Jain et al. (2003) for quartz for a maximum of 7 components. Based on these values, the pseudo start parameters  $xm$  and  $Im$  are recalculated for the given data set. In all cases, the fitting starts with the ultra-fast component and (depending on `n.components`) steps

through the following values. If no fit could be achieved, an error plot (for `plot = TRUE`) with the pseudo curve (based on the pseudo start parameters) is provided. This may give the opportunity to identify appropriate start parameters visually.

(b) If start values are provided, the function works like a simple [nls](#) fitting approach.

(c) If no start parameters are provided and the option `fit.advanced = TRUE` is chosen, an advanced start parameter estimation is applied using a stochastic attempt. Therefore, the recalculated start parameters (a) are used to construct a normal distribution. The start parameters are then sampled randomly from this distribution. A maximum of 100 attempts will be made. **Note:** This process may be time consuming.

### Goodness of fit

The goodness of the fit is given by a pseudo- $R^2$  value (pseudo coefficient of determination). According to Lave (1970), the value is calculated as:

$$pseudoR^2 = 1 - RSS/TSS$$

where  $RSS = Residual\ Sum\ of\ Squares$  and  $TSS = Total\ Sum\ of\ Squares$

### Error of fitted component parameters

The 1-sigma error for the components is calculated using the function [stats::confint](#). Due to considerable calculation time, this option is deactivated by default. In addition, the error for the components can be estimated by using internal R functions like [summary](#). See the [nls](#) help page for more information.

*For more details on the nonlinear regression in R, see Ritz & Streibig (2008).*

### Value

Various types of plots are returned. For details see above. Furthermore an `RLum.Results` object is returned with the following structure:

@data:

```
.. $data : data.frame with fitting results
.. $fit : nls (nls object)
.. $component_matrix : matrix with numerical xy-values of the single fitted components with the
resolution of the input data .. $component.contribution.matrix : list component distribution
matrix
info:
```

```
.. $call : call the original function call
```

Matrix structure for the distribution matrix:

Column 1 and 2: time and `rev(time)` values

Additional columns are used for the components, two for each component, containing `IO` and `n0`. The last columns `cont.` provide information on the relative component contribution for each time interval including the row sum for this values.

### Function version

0.3.4

**Note**

The pseudo- $R^2$  may not be the best parameter to describe the goodness of the fit. The trade off between the n.components and the pseudo- $R^2$  value currently remains unconsidered.

The function **does not** ensure that the fitting procedure has reached a global minimum rather than a local minimum! In any case of doubt, the use of manual start values is highly recommended.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

- Bulur, E., 1996. An Alternative Technique For Optically Stimulated Luminescence (OSL) Experiment. *Radiation Measurements*, 26, 5, 701-709.
- Jain, M., Murray, A.S., Boetter-Jensen, L., 2003. Characterisation of blue-light stimulated luminescence components in different quartz samples: implications for dose measurement. *Radiation Measurements*, 37 (4-5), 441-449.
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- Lave, C.A.T., 1970. The Demand for Urban Mass Transportation. *The Review of Economics and Statistics*, 52 (3), 320-323.
- Ritz, C. & Streibig, J.C., 2008. Nonlinear Regression with R. R. Gentleman, K. Hornik, & G. Parmigiani, eds., Springer, p. 150.

**See Also**

[fit\\_CWCurve](#), [plot](#), [nls](#), [minpack.lm::nlsLM](#), [get\\_RLum](#)

**Examples**

```
##(1) fit LM data without background subtraction
data(ExampleData.FittingLM, envir = environment())
fit_LMCurve(values = values.curve, n.components = 3, log = "x")

##(2) fit LM data with background subtraction and export as JPEG
## -alter file path for your preferred system
##jpeg(file = "~/Desktop/Fit_Output\\%03d.jpg", quality = 100,
## height = 3000, width = 3000, res = 300)
data(ExampleData.FittingLM, envir = environment())
fit_LMCurve(values = values.curve, values.bg = values.curveBG,
            n.components = 2, log = "x", plot.BG = TRUE)
##dev.off()

##(3) fit LM data with manual start parameters
data(ExampleData.FittingLM, envir = environment())
fit_LMCurve(values = values.curve,
            values.bg = values.curveBG,
            n.components = 3,
            log = "x",
            start_values = data.frame(lm = c(170,25,400), xm = c(56,200,1500)))
```

## Description

Fitting and Deconvolution of OSL Lifetime Components

## Usage

```
fit_OSLLifeTimes(
  object,
  tp = 0,
  signal_range = NULL,
  n.components = NULL,
  method_control = list(),
  plot = TRUE,
  plot_simple = FALSE,
  verbose = TRUE,
  ...
)
```

## Arguments

object	<a href="#">RLum.Data.Curve</a> , <a href="#">RLum.Analysis</a> , <a href="#">data.frame</a> or <a href="#">matrix</a> ( <b>required</b> ): Input object containing the data to be analysed. All objects can be provided also as list for an automated processing. Please note: NA values are automatically removed and the dataset should comprise at least 5 data points.
tp	<a href="#">numeric</a> ( <i>with default</i> ): option to account for the stimulation pulse width. For off-time measurements the default value is 0. tp has the same unit as the measurement data, e.g., $\mu\text{s}$ . Please set this parameter carefully, if it all, otherwise you may heavily bias your fit results.
signal_range	<a href="#">numeric</a> ( <i>optional</i> ): allows to set a channel range, by default all channels are used, e.g. <code>signal_range = c(2, 100)</code> considers only channels 2 to 100 and <code>signal_range = c(2)</code> considers only channels from channel 2 onwards.
n.components	<a href="#">numeric</a> ( <i>optional</i> ): Fix the number of components. If set the algorithm will try to fit the number of predefined components. If nothing is set, the algorithm will try to find the best number of components.
method_control	<a href="#">list</a> ( <i>optional</i> ): Named to allow a more fine control of the fitting process. See details for allowed options.
plot	<a href="#">logical</a> ( <i>with default</i> ): Enable/disable plot output
plot_simple	<a href="#">logical</a> ( <i>with default</i> ): Enable/disable reduced plot output. If TRUE, no residual plot is shown, however, plot output can be combined using the standard R layout options, such as <code>par(mfrow = c(2, 2))</code> .
verbose	<a href="#">logical</a> ( <i>with default</i> ): Enable/disable terminal feedback
...	parameters passed to <a href="#">plot.default</a> to control the plot output, supported are: <code>main</code> , <code>xlab</code> , <code>ylab</code> , <code>log</code> , <code>xlim</code> , <code>ylim</code> , <code>col</code> , <code>lty</code> , <code>legend.pos</code> , <code>legend.text</code> . If the input object is of type <a href="#">RLum.Analysis</a> this arguments can be provided as a <a href="#">list</a> .



Details

The function intends to provide an easy access to pulsed optically stimulated luminescence (POSL) data, in order determine signal lifetimes. The fitting is currently optimised to work with the off-time flank of POSL measurements only. For the signal deconvolution, a differential evolution optimisation is combined with nonlinear least-square fitting following the approach by Bluszcz & Adamiec (2006).

Component deconvolution algorithm

The component deconvolution consists of two steps:

(1) Adaptation phase

In the adaptation phase the function tries to figure out the optimal and statistically justified number of signal components following roughly the approach suggested by Bluszcz & Adamiec (2006). In contrast to their work, for the optimisation by differential evolution here the package 'DEoptim' is used.

The function to be optimized has the form:

$$\chi^2 = \sum (w * (n_i/c - \sum (A_i * exp(-x/(tau_i + t_p))))^2)$$

with  $w = 1$  for unweighted regression analysis (`method_control = list(weights = FALSE)`) or  $w = c^2/n_i$  for weighted regression analysis. The default values is TRUE.

$$F = (\Delta\chi^2/2)/(\chi^2/(N - 2 * m - 2))$$

(2) Final fitting

method\_control

Parameter	Type	Description
p	numeric	controls the probability for the F statistic reference values. For a significance level of 5 %
seed	numeric	set the seed for the random number generator, provide a value here to get reproducible res
DEoptim.trace	logical	enables/disables the tracing of the differential evolution (cf. <a href="#">DEoptim::DEoptim.control</a> )
DEoptim.itermax	logical	controls the number of the allowed generations (cf. <a href="#">DEoptim::DEoptim.control</a> )
weights	logical	enables/disables the weighting for the start parameter estimation and fitting (see equation
nlsLM.trace	logical	enables/disables trace mode for the nls fitting ( <a href="#">minpack.lm::nlsLM</a> ), can be used to identi
nlsLM.upper	logical	enables/disables upper parameter boundary, default is TRUE
nlsLM.lower	logical	enables/disables lower parameter boundary, default is TRUE

Value

[ NUMERICAL OUTPUT ]

RLum.Results-object

slot: @data

Element	Type	Description
\$data	matrix	the final fit matrix
\$start_matrix	matrix	the start matrix used for the fitting
\$total_counts	integer	Photon count sum
\$fit	nls	the fit object returned by <a href="#">minpack.lm::nls.lm</a>

**slot:** @info

The original function call

---

[ TERMINAL OUTPUT ]

---

Terminal output is only shown of the argument verbose = TRUE.

*(1) Start parameter and component adaption*

Trace of the parameter adaptation process

*(2) Fitting results (sorted by ascending tau)*

The fitting results sorted by ascending tau value. Please note that if you access the nls fitting object, the values are not sorted.

*(3) Further information*

- The photon count sum
- Durbin-Watson residual statistic to assess whether the residuals are correlated, ideally the residuals should be not correlated at all. Rough measures are:
  - D = 0: the residuals are systematically correlated
  - D = 2: the residuals are randomly distributed
  - D = 4: the residuals are systematically anti-correlated

You should be suspicious if D differs largely from 2.

---

[ PLOT OUTPUT ]

---

A plot showing the original data and the fit so far possible. The lower plot shows the residuals of the fit.

### Function version

0.1.5

### Author(s)

Sebastian Kreutzer, Geography & Earth Sciences, Aberystwyth University, Christoph Schmidt, University of Bayreuth (Germany) , RLum Developer Team

### References

Bluszcz, A., Adamiec, G., 2006. Application of differential evolution to fitting OSL decay curves. Radiation Measurements 41, 886-891. doi:10.1016/j.radmeas.2006.05.016

Durbin, J., Watson, G.S., 1950. Testing for Serial Correlation in Least Squares Regression: I. Biometrika 37, 409-21. doi:10.2307/2332391

### Further reading

Hughes, I., Hase, T., 2010. Measurements and Their Uncertainties. Oxford University Press.

Storn, R., Price, K., 1997. Differential Evolution – A Simple and Efficient Heuristic for Global Optimization over Continuous Spaces. Journal of Global Optimization 11, 341–359.

### See Also

[minpack.lm::nls.lm](#), [DEoptim::DEoptim](#)

### Examples

```
##load example data
data(ExampleData.TR_OSL, envir = environment())

##fit lifetimes (short run)
fit_OSLLifeTimes(
  object = ExampleData.TR_OSL,
  n.components = 1)

##long example
## Not run:
fit_OSLLifeTimes(
  object = ExampleData.TR_OSL)

## End(Not run)
```

---

fit_SurfaceExposure	<i>Nonlinear Least Squares Fit for OSL surface exposure data</i>
---------------------	--

---

### Description

This function determines the (weighted) least-squares estimates of the parameters of either equation 1 in *Sohbati et al. (2012a)* or equation 12 in *Sohbati et al. (2012b)* for a given OSL surface exposure data set (**BETA**).

### Usage

```
fit_SurfaceExposure(
  data,
  sigmaphi = NULL,
  mu = NULL,
  age = NULL,
  Ddot = NULL,
  D0 = NULL,
  weights = FALSE,
  plot = TRUE,
  legend = TRUE,
  errorBars = TRUE,
  coord_flip = FALSE,
  ...
)
```

## Arguments

**data** [data.frame](#) or [list](#) (**required**): Measured OSL surface exposure data with the following structure:

		(optional)	
	depth (a.u.)	intensity	error
	[ ,1]	[ ,2]	[ ,3]
	-----	-----	-----
[1, ]	~~~~	~~~~	~~~~
[2, ]	~~~~	~~~~	~~~~
...	...	...	...
[x, ]	~~~~	~~~~	~~~~

Alternatively, a [list](#) of `data.frame`s can be provided, where each `data.frame` has the same structure as shown above, with the exception that they must **not** include the optional error column. Providing a [list](#) as input automatically activates the global fitting procedure (see details).

**sigmaphi** [numeric](#) (*optional*): A numeric value for sigmaphi, i.e. the charge detrapping rate. Example: `sigmaphi = 5e-10`

**mu** [numeric](#) (*optional*): A numeric value for mu, i.e. the light attenuation coefficient. Example: `mu = 0.9`

**age** [numeric](#) (*optional*): The age (a) of the sample, if known. If data is a [list](#) of *x* samples, then age must be a numeric vector of length *x*. Example: `age = 10000`, or `age = c(1e4, 1e5, 1e6)`.

**Ddot** [numeric](#) (*optional*): A numeric value for the environmental dose rate (Gy/ka). For this argument to be considered a value for  $D_0$  must also be provided; otherwise it will be ignored.

**$D_0$**  [numeric](#) (*optional*): A numeric value for the characteristic saturation dose (Gy). For this argument to be considered a value for `Ddot` must also be provided; otherwise it will be ignored.

**weights** [logical](#) (*optional*): If TRUE the fit will be weighted by the inverse square of the error. Requires data to be a [data.frame](#) with three columns.

**plot** [logical](#) (*optional*): Show or hide the plot.

**legend** [logical](#) (*optional*): Show or hide the equation inside the plot.

**errorBars** [logical](#) (*optional*): Show or hide error bars (only applies if errors were provided).

**coord\_flip** [logical](#) (*optional*): Flip the coordinate system.

**...** Further parameters passed to [plot](#). Custom parameters include:

- `verbose` ([logical](#)): show or hide console output
- `line_col`: Colour of the fitted line
- `line_lty`: Type of the fitted line (see `lty` in `?par`)
- `line_lwd`: Line width of the fitted line (see `lwd` in `?par`)

## Details

### Weighted fitting

If `weights = TRUE` the function will use the inverse square of the error ( $1/\sigma^2$ ) as weights during fitting using [minpack.lm::nlsLM](#). Naturally, for this to take effect individual errors must be provided

in the third column of the `data.frame` for data. Weighted fitting is **not** supported if data is a list of multiple `data.frames`, i.e., it is not available for global fitting.

**Dose rate** If any of the arguments `Ddot` or `D0` is at its default value (NULL), this function will fit equation 1 in Sohbaty et al. (2012a) to the data. If the effect of dose rate (i.e., signal saturation) needs to be considered, numeric values for the dose rate (`Ddot`) (in Gy/ka) and the characteristic saturation dose (`D0`) (in Gy) must be provided. The function will then fit equation 12 in Sohbaty et al. (2012b) to the data.

**NOTE:** Currently, this function does **not** consider the variability of the dose rate with sample depth ( $x$ )! In the original equation the dose rate  $D$  is an arbitrary function of  $x$  (term  $D(x)$ ), but here  $D$  is assumed constant.

**Global fitting** If data is [list](#) of multiple `data.frames`, each representing a separate sample, the function automatically performs a global fit to the data. This may be useful to better constrain the parameters `sigmaphi` or `mu` and **requires** that known ages for each sample is provided (e.g., `age = c(100, 1000)` if data is a list with two samples).

## Value

Function returns results numerically and graphically:

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
<code>\$summary</code>	<code>data.frame</code>	summary of the fitting results
<code>\$data</code>	<code>data.frame</code>	the original input data
<code>\$fit</code>	<code>nls</code>	the fitting object produced by <a href="#">minpack.lm::nlsLM</a>
<code>\$args</code>	<code>character</code>	arguments of the call
<code>\$call</code>	<code>call</code>	the original function call

**slot:** @info

Currently unused.

---

[ PLOT OUTPUT ]

---

A scatter plot of the provided depth-intensity OSL surface exposure data with the fitted model.

## Function version

0.1.0

## Note

**This function has BETA status. If possible, results should be cross-checked.**

**Author(s)**

Christoph Burow, University of Cologne (Germany) , RLum Developer Team

**References**

Sohbati, R., Murray, A.S., Chapot, M.S., Jain, M., Pederson, J., 2012a. Optically stimulated luminescence (OSL) as a chronometer for surface exposure dating. *Journal of Geophysical Research* 117, B09202. doi: [doi:10.1029/2012JB009383](https://doi.org/10.1029/2012JB009383)

Sohbati, R., Jain, M., Murray, A.S., 2012b. Surface exposure dating of non-terrestrial bodies using optically stimulated luminescence: A new method. *Icarus* 221, 160-166.

**See Also**

[ExampleData.SurfaceExposure](#), [minpack.lm::nlsLM](#)

**Examples**

```
## Load example data
data("ExampleData.SurfaceExposure")

## Example 1 - Single sample
# Known parameters: 10000 a, mu = 0.9, sigmaphi = 5e-10
sample_1 <- ExampleData.SurfaceExposure$sample_1
head(sample_1)
results <- fit_SurfaceExposure(
  data = sample_1,
  mu = 0.9,
  sigmaphi = 5e-10)
get_RLum(results)

## Example 2 - Single sample and considering dose rate
# Known parameters: 10000 a, mu = 0.9, sigmaphi = 5e-10,
# dose rate = 2.5 Gy/ka, D0 = 40 Gy
sample_2 <- ExampleData.SurfaceExposure$sample_2
head(sample_2)
results <- fit_SurfaceExposure(
  data = sample_2,
  mu = 0.9,
  sigmaphi = 5e-10,
  Ddot = 2.5,
  D0 = 40)
get_RLum(results)

## Example 3 - Multiple samples (global fit) to better constrain 'mu'
# Known parameters: ages = 1e3, 1e4, 1e5, 1e6 a, mu = 0.9, sigmaphi = 5e-10
set_1 <- ExampleData.SurfaceExposure$set_1
str(set_1, max.level = 2)
results <- fit_SurfaceExposure(
  data = set_1,
  age = c(1e3, 1e4, 1e5, 1e6),
  sigmaphi = 5e-10)
get_RLum(results)
```

```
## Example 4 - Multiple samples (global fit) and considering dose rate
# Known parameters: ages = 1e2, 1e3, 1e4, 1e5, 1e6 a, mu = 0.9, sigmaphi = 5e-10,
# dose rate = 1.0 Ga/ka, D0 = 40 Gy
set_2 <- ExampleData.SurfaceExposure$set_2
str(set_2, max.level = 2)
results <- fit_SurfaceExposure(
  data = set_2,
  age = c(1e2, 1e3, 1e4, 1e5, 1e6),
  sigmaphi = 5e-10,
  Ddot = 1,
  D0 = 40)
get_RLum(results)
```

---

fit\_ThermalQuenching    *Fitting Thermal Quenching Data*

---

## Description

Applying a nls-fitting to thermal quenching data.

## Usage

```
fit_ThermalQuenching(
  data,
  start_param = list(),
  method_control = list(),
  n.MC = 100,
  verbose = TRUE,
  plot = TRUE,
  ...
)
```

## Arguments

data	<b>data.frame (required)</b> : input data with three columns, the first column contains temperature values in deg. C, columns 2 and 3 the dependent values with its error
start_param	<b>list</b> (optional): option to provide own start parameters for the fitting, see details
method_control	<b>list</b> (optional): further options to fine tune the fitting, see details for further information
n.MC	<b>numeric</b> (with default): number of Monte Carlo runs for the error estimation. If n.MC is NULL or <=1, the error estimation is skipped
verbose	<b>logical</b> (with default): enables/disables terminal output
plot	<b>logical</b> (with default): enables/disables plot output
...	further arguments that can be passed to control the plotting, support are main, pch, col_fit, col_points, lty, lwd, xlab, ylab, xlim, ylim, xaxt

Details

Used equation

The equation used for the fitting is

$$y = (A/(1 + C * (exp(-W/(k * x))))) + c$$

$W$  is the energy depth in eV and  $C$  is dimensionless constant.  $A$  and  $c$  are used to adjust the curve for the given signal.  $k$  is the Boltzmann in eV/K and  $x$  is the absolute temperature in K.

Error estimation

The error estimation is done by varying the input parameters using the given uncertainties in a Monte Carlo simulation. Errors are assumed to follow a normal distribution.

start\_param

The function allows the injection of own start parameters via the argument `start_param`. The parameters need to be provided as names list. The names are the parameters to be optimised. Examples: `start_param = list(A = 1, C = 1e+5, W = 0.5, c = 0)`

method\_control

The following arguments can be provided via `method_control`. Please note that arguments provided via `method_control` are not further tested, i.e., if the function crashes your input was probably wrong.

ARGUMENT	TYPE	DESCRIPTION
upper	named <a href="#">vector</a>	sets upper fitting boundaries, if provided boundaries for all arguments are required, e.g.,
lower	names <a href="#">vector</a>	sets lower fitting boundaries (see upper for details)
trace	<a href="#">logical</a>	enables/disables progression trace for <a href="#">minpack.lm::nlsLM</a>
weights	<a href="#">numeric</a>	option to provide own weights for the fitting, the length of this vector needs to be equal to

Value

The function returns numerical output and an (*optional*) plot.

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data  
[.. \$data : data.frame]

A table with all fitting parameters and the number of Monte Carlo runs used for the error estimation.  
[.. \$fit : nls object]

The nls [stats::nls](#) object returned by the function [minpack.lm::nlsLM](#). This object can be further passed to other functions supporting an nls object (cf. details section in [stats::nls](#))

**slot:** @info



```
[... $call : call]
```

The original function call.

---

[ GRAPHICAL OUTPUT ]

---

Plotted are temperature against the signal and their uncertainties. The fit is shown as dashed-line (can be modified). Please note that for the fitting the absolute temperature values are used but are re-calculated to deg. C for the plot.

### Function version

0.1.0

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### References

Wintle, A.G., 1975. Thermal Quenching of Thermoluminescence in Quartz. Geophys. J. R. astr. Soc. 41, 107–113.

### See Also

[minpack.lm::nlsLM](#)

### Examples

```
##create short example dataset
data <- data.frame(
  T = c(25, 40, 50, 60, 70, 80, 90, 100, 110),
  V = c(0.06, 0.058, 0.052, 0.051, 0.041, 0.034, 0.035, 0.033, 0.032),
  V_X = c(0.012, 0.009, 0.008, 0.008, 0.007, 0.006, 0.005, 0.005, 0.004))

##fit
fit_ThermalQuenching(
  data = data,
  n.MC = NULL)
```

---

get\_Layout

*Collection of layout definitions*

---

### Description

This helper function returns a list with layout definitions for homogeneous plotting.

### Usage

```
get_Layout(layout)
```

## Arguments

**layout** **character** or **list** object (**required**): name of the layout definition to be returned. If name is provided the respective definition is returned. One of the following supported layout definitions is possible: "default", "journal.1", "small", "empty".

User-specific layout definitions must be provided as a list object of predefined structure, see details.

## Details

The easiest way to create a user-specific layout definition is perhaps to create either an empty or a default layout object and fill/modify the definitions (`user.layout <- get_Layout(data = "empty")`).

## Value

A list object with layout definitions for plot functions.

## Function version

0.1

## Author(s)

Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

## Examples

```
## read example data set
data(ExampleData.DeValues, envir = environment())

## show structure of the default layout definition
layout.default <- get_Layout(layout = "default")
str(layout.default)

## show colour definitions for Abanico plot, only
layout.default$abanico$colour

## set Abanico plot title colour to orange
layout.default$abanico$colour$main <- "orange"

## create Abanico plot with modified layout definition
plot_AbanicoPlot(data = ExampleData.DeValues,
                 layout = layout.default)

## create Abanico plot with predefined layout "journal"
plot_AbanicoPlot(data = ExampleData.DeValues,
                 layout = "journal")
```

---

get_Quote	<i>Function to return essential quotes</i>
-----------	--

---

**Description**

This function returns one of the collected essential quotes in the growing library. If called without any parameters, a random quote is returned.

**Usage**

```
get_Quote(ID, separated = FALSE)
```

**Arguments**

ID	<b>character</b> ( <i>optional</i> ): quote ID to be returned.
separated	<b>logical</b> ( <i>with default</i> ): return result in separated form.

**Value**

Returns a character with quote and respective (false) author.

**Function version**

0.1.5

**Author(s)**

Quote credits: Michael Dietze, GFZ Potsdam (Germany), Sebastian Kreutzer, Geography & Earth Science, Aberystwyth University (United Kingdom), Dirk Mittelstraß, TU Dresden (Germany), Jakob Wallinga (Wageningen University, Netherlands) , RLum Developer Team

**Examples**

```
## ask for an arbitrary quote  
get_Quote()
```

---

get_rightAnswer	<i>Function to get the right answer</i>
-----------------	---

---

**Description**

This function returns just the right answer

**Usage**

```
get_rightAnswer(...)
```

**Arguments**

...	you can pass an infinite number of further arguments
-----	--

**Value**

Returns the right answer

**Function version**

0.1.0

**Author(s)**

inspired by R.G. , RLum Developer Team

**Examples**

```
## you really want to know?  
get_rightAnswer()
```

---

get\_Risoe.BINfileData *General accessor function for RLum S4 class objects*

---

**Description**

Function calls object-specific get functions for RisoeBINfileData S4 class objects.

**Usage**

```
get_Risoe.BINfileData(object, ...)
```

**Arguments**

object	<a href="#">Risoe.BINfileData</a> ( <b>required</b> ): S4 object of class RLum
...	further arguments that one might want to pass to the specific get function

**Details**

The function provides a generalised access point for specific [Risoe.BINfileData](#) objects. Depending on the input object, the corresponding get function will be selected. Allowed arguments can be found in the documentations of the corresponding [Risoe.BINfileData](#) class.

**Value**

Return is the same as input objects as provided in the list

**Function version**

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[Risoe.BINfileData](#)

---

get\_RLum

*General accessors function for RLum S4 class objects*


---

**Description**

Function calls object-specific get functions for RLum S4 class objects.

**Usage**

```
get_RLum(object, ...)

## S4 method for signature 'list'
get_RLum(object, class = NULL, null.rm = FALSE, ...)

## S4 method for signature 'NULL'
get_RLum(object, ...)
```

**Arguments**

object	<b>RLum (required)</b> : S4 object of class RLum or an object of type <a href="#">list</a> containing only objects of type <a href="#">RLum</a>
...	further arguments that will be passed to the object specific methods. For further details on the supported arguments please see the class documentation: <a href="#">RLum.Data.Curve</a> , <a href="#">RLum.Data.Spectrum</a> , <a href="#">RLum.Data.Image</a> , <a href="#">RLum.Analysis</a> and <a href="#">RLum.Results</a>
class	<b>character (optional)</b> : allows to define the class that gets selected if applied to a list, e.g., if a list consists of different type of RLum-class objects, this arguments allows to make selection. If nothing is provided, all RLum-objects are treated.
null.rm	<b>logical (with default)</b> : option to get rid of empty and NULL objects

**Details**

The function provides a generalised access point for specific [RLum](#) objects. Depending on the input object, the corresponding get function will be selected. Allowed arguments can be found in the documentations of the corresponding [RLum](#) class.

**Value**

Return is the same as input objects as provided in the list.

**Functions**

- `get_RLum(list)`: Returns a list of [RLum](#) objects that had been passed to [get\\_RLum](#)
- `get_RLum(~NULL~)`: Returns NULL

**Function version**

0.3.3

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Curve](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#), [RLum.Analysis](#), [RLum.Results](#)

**Examples**

```
##Example based using data and from the calc_CentralDose() function

##load example data
data(ExampleData.DeValues, envir = environment())

##apply the central dose model 1st time
temp1 <- calc_CentralDose(ExampleData.DeValues$CA1)

##get results and store them in a new object
temp.get <- get_RLum(object = temp1)
```

---

GitHub-API

*GitHub API*


---

**Description**

R Interface to the GitHub API v3.

**Usage**

```
github_commits(user = "r-lum", repo = "luminescence", branch = "master", n = 5)

github_branches(user = "r-lum", repo = "luminescence")

github_issues(user = "r-lum", repo = "luminescence", verbose = TRUE)
```

**Arguments**

user	<a href="#">character</a> (with default): GitHub user name (defaults to 'r-lum').
repo	<a href="#">character</a> (with default): name of a GitHub repository (defaults to 'luminescence').
branch	<a href="#">character</a> (with default): branch of a GitHub repository (defaults to 'master').
n	<a href="#">integer</a> (with default): number of commits returned (defaults to 5).
verbose	<a href="#">logical</a> (with default): print the output to the console (defaults to TRUE).

## Details

These functions can be used to query a specific repository hosted on GitHub.

`github_commits` lists the most recent `n` commits of a specific branch of a repository.

`github_branches` can be used to list all current branches of a repository and returns the corresponding SHA hash as well as an installation command to install the branch in R via the 'devtools' package.

`github_issues` lists all open issues for a repository in valid YAML.

## Value

`github_commits`: [data.frame](#) with columns:

```
[ ,1]  SHA
[ ,2]  AUTHOR
[ ,3]  DATE
[ ,4]  MESSAGE
```

`github_branches`: [data.frame](#) with columns:

```
[ ,1]  BRANCH
[ ,2]  SHA
[ ,3]  INSTALL
```

`github_commits`: Nested [list](#) with `n` elements. Each commit element is a list with elements:

```
[[1]]  NUMBER
[[2]]  TITLE
[[3]]  BODY
[[4]]  CREATED
[[5]]  UPDATED
[[6]]  CREATOR
[[7]]  URL
[[8]]  STATUS
```

## Function version

0.1.0

## Author(s)

Christoph Burow, University of Cologne (Germany) , RLum Developer Team

## References

GitHub Developer API v3. <https://docs.github.com/v3/>, last accessed: 10/01/2017.

## Examples

```
## Not run:
github_branches(user = "r-lum", repo = "luminescence")
github_issues(user = "r-lum", repo = "luminescence")
github_commits(user = "r-lum", repo = "luminescence", branch = "master", n = 10)

## End(Not run)
```

---

import\_Data

---

*Import Luminescence Data into R*


---

## Description

Convenience wrapper function to provide a quicker and more standardised way of reading data into R by looping through all in the package available data import functions starting with read\_.

## Usage

```
import_Data(file, ..., fastForward = TRUE, verbose = FALSE)
```

## Arguments

file	<b>character (required)</b> : file to be imported, can be a <a href="#">list</a>
...	arguments to be further passed down to supported functions (please check the functions to determine the correct arguments)
fastForward	<b>logical (with default)</b> : option to create <a href="#">RLum</a> objects during import or a <a href="#">list</a> of such objects
verbose	<b>logical (with default)</b> : enable/disable verbose mode

## Function version

0.1.0

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## See Also

[read\\_BIN2R](#), [read\\_XSYG2R](#), [read\\_PSL2R](#), [read\\_SPE2R](#), [read\\_TIFF2R](#), [read\\_RF2R](#), [read\\_Daybreak2R](#)

## Examples

```
## import BINX/BIN
file <- system.file("extdata/BINfile_V8.binx", package = "Luminescence")
temp <- import_Data(file)

## RF data
file <- system.file("extdata", "RF_file.rf", package = "Luminescence")
temp <- import_Data(file)
```



---

`install_DevelopmentVersion`*Attempts to install the development version of the 'Luminescence' package*

---

## Description

This function is a convenient method for installing the development version of the R package 'Luminescence' directly from GitHub.

## Usage

```
install_DevelopmentVersion(force_install = FALSE)
```

## Arguments

`force_install` **logical** (optional): If FALSE (the default) the function produces and prints the required code to the console for the user to run manually afterwards. When TRUE and all requirements are fulfilled (see details) this function attempts to install the package itself.

## Details

This function uses `Luminescence::github_branches` to check which development branches of the R package 'Luminescence' are currently available on GitHub. The user is then prompted to choose one of the branches to be installed. It further checks whether the R package 'devtools' is currently installed and available on the system. Finally, it prints R code to the console that the user can copy and paste to the R console in order to install the desired development version of the package.

If `force_install=TRUE` the function checks if 'devtools' is available and then attempts to install the chosen development branch via `devtools::remote-reexports`.

## Value

This function requires user input at the command prompt to choose the desired development branch to be installed. The required R code to install the package is then printed to the console.

## Examples

```
## Not run:  
install_DevelopmentVersion()  
  
## End(Not run)
```

length\_RLum

*General accessor function for RLum S4 class objects***Description**

Function calls object-specific get functions for RLum S4 class objects.

**Usage**

```
length_RLum(object)
```

**Arguments**

object                [RLum](#) (**required**): S4 object of class RLum

**Details**

The function provides a generalised access point for specific [RLum](#) objects. Depending on the input object, the corresponding get function will be selected. Allowed arguments can be found in the documentations of the corresponding [RLum](#) class.

**Value**

Return is the same as input objects as provided in the list.

**Function version**

0.1.0

**Author(s)**

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**See Also**

[RLum.Data.Curve](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#), [RLum.Analysis](#), [RLum.Results](#)

merge\_Risoe.BINfileData

*Merge Risoe.BINfileData objects or Risoe BIN-files***Description**

Function allows merging Risoe BIN/BINX files or [Risoe.BINfileData](#) objects.

## Usage

```
merge_Risoe.BINfileData(  
  input.objects,  
  output.file,  
  keep.position.number = FALSE,  
  position.number.append.gap = 0  
)
```

## Arguments

`input.objects` **character** with [Risoe.BINfileData](#) objects (**required**): Character vector with path and files names (e.g. `input.objects = c("path/file1.bin", "path/file2.bin")`) or [Risoe.BINfileData](#) objects (e.g. `input.objects = c(object1, object2)`). Alternatively a list is supported.

`output.file` **character** (*optional*): File output path and name. If no value is given, a [Risoe.BINfileData](#) is returned instead of a file.

`keep.position.number` **logical** (*with default*): Allows keeping the original position numbers of the input objects. Otherwise the position numbers are recalculated.

`position.number.append.gap` **integer** (*with default*): Set the position number gap between merged BIN-file sets, if the option `keep.position.number = FALSE` is used. See details for further information.

## Details

The function allows merging different measurements to one file or one object. The record IDs are recalculated for the new object. Other values are kept for each object. The number of input objects is not limited.

`position.number.append.gap` option

If the option `keep.position.number = FALSE` is used, the position numbers of the new data set are recalculated by adding the highest position number of the previous data set to the each position number of the next data set. For example: The highest position number is 48, then this number will be added to all other position numbers of the next data set (e.g.  $1 + 48 = 49$ )

However, there might be cases where an additional addend (summand) is needed before the next position starts. Example:

- Position number set (A): 1, 3, 5, 7
- Position number set (B): 1, 3, 5, 7

With no additional summand the new position numbers would be: 1, 3, 5, 7, 8, 9, 10, 11. That might be unwanted. Using the argument `position.number.append.gap = 1` it will become: 1, 3, 5, 7, 9, 11, 13, 15, 17.

## Value

Returns a file or a [Risoe.BINfileData](#) object.

## Function version

0.2.9

**Note**

The validity of the output objects is not further checked.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Duller, G.A.T., 2007. Analyst (Version 3.24) (manual). Aberystwyth University, Aberystwyth.

**See Also**

[Risoe.BINfileData](#), [read\\_BIN2R](#), [write\\_R2BIN](#)

**Examples**

```
##merge two objects
data(ExampleData.BINfileData, envir = environment())

object1 <- CWOSL.SAR.Data
object2 <- CWOSL.SAR.Data

object.new <- merge_Risoe.BINfileData(c(object1, object2))
```

---

merge\_RLum

*General merge function for RLum S4 class objects*


---

**Description**

Function calls object-specific merge functions for RLum S4 class objects.

**Usage**

```
merge_RLum(objects, ...)
```

**Arguments**

objects	<a href="#">list of RLum (required)</a> : list of S4 object of class RLum
...	further arguments that one might want to pass to the specific merge function

**Details**

The function provides a generalised access point for merge specific [RLum](#) objects. Depending on the input object, the corresponding merge function will be selected. Allowed arguments can be found in the documentations of each merge function. Empty list elements (NULL) are automatically removed from the input list.

object	corresponding merge function
<a href="#">RLum.Data.Curve</a>	: <code>merge_RLum.Data.Curve</code>

```

RLum.Analysis      : merge_RLum.Analysis
RLum.Results       : merge_RLum.Results

```

**Value**

Return is the same as input objects as provided in the list.

**Function version**

0.1.3

**Note**

So far not for every RLum object a merging function exists.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Curve](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#), [RLum.Analysis](#), [RLum.Results](#)

**Examples**

```

##Example based using data and from the calc_CentralDose() function

##load example data
data(ExampleData.DeValues, envir = environment())

##apply the central dose model 1st time
temp1 <- calc_CentralDose(ExampleData.DeValues$CA1)

##apply the central dose model 2nd time
temp2 <- calc_CentralDose(ExampleData.DeValues$CA1)

##merge the results and store them in a new object
temp.merged <- get_RLum(merge_RLum(objects = list(temp1, temp2)))

```

---

names\_RLum

*S4-names function for RLum S4 class objects*


---

**Description**

Function calls object-specific names functions for RLum S4 class objects.

**Usage**

```

names_RLum(object)

## S4 method for signature 'list'
names_RLum(object)

```

## Arguments

object                    [RLum](#) (**required**): S4 object of class [RLum](#)

## Details

The function provides a generalised access point for specific [RLum](#) objects. Depending on the input object, the corresponding 'names' function will be selected. Allowed arguments can be found in the documentations of the corresponding [RLum](#) class.

## Value

Returns a [character](#)

## Functions

- `names_RLum(list)`: Returns a list of [RLum](#) objects that had been passed to [names\\_RLum](#)

## Function version

0.1.0

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , [RLum Developer Team](#)

## See Also

[RLum.Data.Curve](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#), [RLum.Analysis](#), [RLum.Results](#)

---

`plot_AbanicoPlot`

*Function to create an Abanico Plot.*

---

## Description

A plot is produced which allows comprehensive presentation of data precision and its dispersion around a central value as well as illustration of a kernel density estimate, histogram and/or dot plot of the dose values.

## Usage

```
plot_AbanicoPlot(  
  data,  
  na.rm = TRUE,  
  log.z = TRUE,  
  z.0 = "mean.weighted",  
  dispersion = "qr",  
  plot.ratio = 0.75,  
  rotate = FALSE,  
  mtext,  
  summary,  
  summary.pos,
```

```

summary.method = "MCM",
legend,
legend.pos,
stats,
rug = FALSE,
kde = TRUE,
hist = FALSE,
dots = FALSE,
boxplot = FALSE,
y.axis = TRUE,
error.bars = FALSE,
bar,
bar.col,
polygon.col,
line,
line.col,
line.lty,
line.label,
grid.col,
frame = 1,
bw = "SJ",
interactive = FALSE,
...
)

```

### Arguments

data	<a href="#">data.frame</a> or <a href="#">RLum.Results</a> object ( <b>required</b> ): for data.frame two columns: De (data[,1]) and De error (data[,2]). To plot several data sets in one plot the data sets must be provided as list, e.g. list(data.1, data.2).
na.rm	<a href="#">logical</a> ( <i>with default</i> ): exclude NA values from the data set prior to any further operations.
log.z	<a href="#">logical</a> ( <i>with default</i> ): Option to display the z-axis in logarithmic scale. Default is TRUE.
z.0	<a href="#">character</a> or <a href="#">numeric</a> : User-defined central value, used for centring of data. One out of "mean", "mean.weighted" and "median" or a numeric value (not its logarithm). Default is "mean.weighted".
dispersion	<a href="#">character</a> ( <i>with default</i> ): measure of dispersion, used for drawing the scatter polygon. One out of <ul style="list-style-type: none"> <li>• "qr" (quartile range),</li> <li>• "pnn" (symmetric percentile range with nn the lower percentile, e.g.</li> <li>• "p05" depicting the range between 5 and 95 %),</li> <li>• "sd" (standard deviation) and</li> <li>• "2sd" (2 standard deviations),</li> </ul> The default is "qr". Note that "sd" and "2sd" are only meaningful in combination with "z.0 = 'mean'" because the unweighted mean is used to centre the polygon.
plot.ratio	<a href="#">numeric</a> : Relative space, given to the radial versus the cartesian plot part, default is 0.75.
rotate	<a href="#">logical</a> : Option to turn the plot by 90 degrees.

mtext	<a href="#">character</a> : additional text below the plot title.
summary	<a href="#">character</a> ( <i>optional</i> ): add statistic measures of centrality and dispersion to the plot. Can be one or more of several keywords. See details for available keywords. Results differ depending on the log-option for the z-scale (see details).
summary.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the statistical summary. Alternatively, the keyword "sub" may be specified to place the summary below the plot header. However, this latter option is only possible if mtext is not used.
summary.method	<a href="#">character</a> ( <i>with default</i> ): keyword indicating the method used to calculate the statistic summary. One out of <ul style="list-style-type: none"> <li>• "unweighted",</li> <li>• "weighted" and</li> <li>• "MCM".</li> </ul> See <a href="#">calc_Statistics</a> for details.
legend	<a href="#">character</a> vector ( <i>optional</i> ): legend content to be added to the plot.
legend.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the legend to be plotted.
stats	<a href="#">character</a> : additional labels of statistically important values in the plot. One or more out of the following: <ul style="list-style-type: none"> <li>• "min",</li> <li>• "max",</li> <li>• "median".</li> </ul>
rug	<a href="#">logical</a> : Option to add a rug to the KDE part, to indicate the location of individual values.
kde	<a href="#">logical</a> : Option to add a KDE plot to the dispersion part, default is TRUE.
hist	<a href="#">logical</a> : Option to add a histogram to the dispersion part. Only meaningful when not more than one data set is plotted.
dots	<a href="#">logical</a> : Option to add a dot plot to the dispersion part. If number of dots exceeds space in the dispersion part, a square indicates this.
boxplot	<a href="#">logical</a> : Option to add a boxplot to the dispersion part, default is FALSE.
y.axis	<a href="#">logical</a> : Option to hide standard y-axis labels and show 0 only. Useful for data with small scatter. If you want to suppress the y-axis entirely please use yaxt == 'n' (the standard <a href="#">graphics::par</a> setting) instead.
error.bars	<a href="#">logical</a> : Option to show De-errors as error bars on De-points. Useful in combination with y.axis = FALSE, bar.col = "none".
bar	<a href="#">numeric</a> ( <i>with default</i> ): option to add one or more dispersion bars (i.e., bar showing the 2-sigma range) centred at the defined values. By default a bar is drawn according to "z.0". To omit the bar set "bar = FALSE".
bar.col	<a href="#">character</a> or <a href="#">numeric</a> ( <i>with default</i> ): colour of the dispersion bar. Default is "grey60".
polygon.col	<a href="#">character</a> or <a href="#">numeric</a> ( <i>with default</i> ): colour of the polygon showing the data scatter. Sometimes this polygon may be omitted for clarity. To disable it use FALSE or polygon = FALSE. Default is "grey80".
line	<a href="#">numeric</a> : numeric values of the additional lines to be added.
line.col	<a href="#">character</a> or <a href="#">numeric</a> : colour of the additional lines.



line.lty	<b>integer</b> : line type of additional lines
line.label	<b>character</b> : labels for the additional lines.
grid.col	<b>character</b> or <b>numeric</b> ( <i>with default</i> ): colour of the grid lines (originating at $[0, 0]$ and stretching to the z-scale). To disable grid lines use FALSE. Default is "grey".
frame	<b>numeric</b> ( <i>with default</i> ): option to modify the plot frame type. Can be one out of <ul style="list-style-type: none"> <li>• 0 (no frame),</li> <li>• 1 (frame originates at 0,0 and runs along min/max isochrons),</li> <li>• 2 (frame embraces the 2-sigma bar),</li> <li>• 3 (frame embraces the entire plot as a rectangle).</li> </ul> Default is 1.
bw	<b>character</b> ( <i>with default</i> ): bin-width for KDE, choose a numeric value for manual setting.
interactive	<b>logical</b> ( <i>with default</i> ): create an interactive abanico plot (requires the 'plotly' package)
...	Further plot arguments to pass (see <a href="#">graphics::plot.default</a> ). Supported are: main, sub, ylab, xlab, zlab, zlim, ylim, cex, lty, lwd, pch, col, tck, tcl, at, breaks. xlab must be a vector of length two, specifying the upper and lower x-axes labels.

## Details

The Abanico Plot is a combination of the classic Radial Plot (`plot_RadialPlot`) and a kernel density estimate plot (e.g. `plot_KDE`). It allows straightforward visualisation of data precision, error scatter around a user-defined central value and the combined distribution of the values, on the actual scale of the measured data (e.g. seconds, equivalent dose, years). The principle of the plot is shown in Galbraith & Green (1990). The function authors are thankful for the thought provoking figure in this article.

The semi circle (z-axis) of the classic Radial Plot is bent to a straight line here, which actually is the basis for combining this polar (radial) part of the plot with any other Cartesian visualisation method (KDE, histogram, PDF and so on). Note that the plot allows displaying two measures of distribution. One is the 2-sigma bar, which illustrates the spread in value errors, and the other is the polygon, which stretches over both parts of the Abanico Plot (polar and Cartesian) and illustrates the actual spread in the values themselves.

Since the 2-sigma-bar is a polygon, it can be (and is) filled with shaded lines. To change density (lines per inch, default is 15) and angle (default is 45 degrees) of the shading lines, specify these parameters. See `?polygon()` for further help.

The Abanico Plot supports other than the weighted mean as measure of centrality. When it is obvious that the data is not (log-)normally distributed, the mean (weighted or not) cannot be a valid measure of centrality and hence central dose. Accordingly, the median and the weighted median can be chosen as well to represent a proper measure of centrality (e.g. `centrality = "median.weighted"`). Also user-defined numeric values (e.g. from the central age model) can be used if this appears appropriate.

The proportion of the polar part and the cartesian part of the Abanico Plot can be modified for display reasons (`plot.ratio = 0.75`). By default, the polar part spreads over 75 \ shows the KDE graph.

A statistic summary, i.e. a collection of statistic measures of centrality and dispersion (and further measures) can be added by specifying one or more of the following keywords:

- "n" (number of samples)

- "mean" (mean De value)
- "median" (median of the De values)
- "sd.rel" (relative standard deviation in percent)
- "sd.abs" (absolute standard deviation)
- "se.rel" (relative standard error)
- "se.abs" (absolute standard error)
- "in.2s" (percent of samples in 2-sigma range)
- "kurtosis" (kurtosis)
- "skewness" (skewness)

**Note** that the input data for the statistic summary is sent to the function `calc_Statistics()` depending on the `log`-option for the z-scale. If `"log.z = TRUE"`, the summary is based on the logarithms of the input data. If `"log.z = FALSE"` the linearly scaled data is used.

**Note** as well, that `"calc_Statistics()"` calculates these statistic measures in three different ways: unweighted, weighted and MCM-based (i.e., based on Monte Carlo Methods). By default, the MCM-based version is used. If you wish to use another method, indicate this with the appropriate keyword using the argument `summary.method`.

The optional parameter `layout` allows to modify the entire plot more sophisticated. Each element of the plot can be addressed and its properties can be defined. This includes font type, size and decoration, colours and sizes of all plot items. To infer the definition of a specific layout style cf. `get_Layout()` or type e.g., for the layout type "journal" `get_Layout("journal")`. A layout type can be modified by the user by assigning new values to the list object.

It is possible for the z-scale to specify where ticks are to be drawn by using the parameter `at`, e.g. `at = seq(80, 200, 20)`, cf. function documentation of `axis`. Specifying tick positions manually overrides a `zlim`-definition.

## Value

returns a plot object and, optionally, a list with plot calculus data.

## Function version

0.1.17

## Author(s)

Michael Dietze, GFZ Potsdam (Germany)  
 Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 Inspired by a plot introduced by Galbraith & Green (1990) , RLum Developer Team

## References

- Galbraith, R. & Green, P., 1990. Estimating the component ages in a finite mixture. *International Journal of Radiation Applications and Instrumentation. Part D. Nuclear Tracks and Radiation Measurements*, 17 (3), 197-206.
- Dietze, M., Kreutzer, S., Burow, C., Fuchs, M.C., Fischer, M., Schmidt, C., 2015. The abanico plot: visualising chronometric data with individual standard errors. *Quaternary Geochronology*. doi:10.1016/j.quageo.2015.09.003

**See Also**

[plot\\_RadialPlot](#), [plot\\_KDE](#), [plot\\_Histogram](#), [plot\\_ViolinPlot](#)

**Examples**

```
## load example data and recalculate to Gray
data(ExampleData.DeValues, envir = environment())
ExampleData.DeValues <- ExampleData.DeValues$CA1

## plot the example data straightforward
plot_AbanicoPlot(data = ExampleData.DeValues)

## now with linear z-scale
plot_AbanicoPlot(data = ExampleData.DeValues,
                 log.z = FALSE)

## now with output of the plot parameters
plot1 <- plot_AbanicoPlot(data = ExampleData.DeValues,
                        output = TRUE)
str(plot1)
plot1$zlim

## now with adjusted z-scale limits
plot_AbanicoPlot(data = ExampleData.DeValues,
                 zlim = c(10, 200))

## now with adjusted x-scale limits
plot_AbanicoPlot(data = ExampleData.DeValues,
                 xlim = c(0, 20))

## now with rug to indicate individual values in KDE part
plot_AbanicoPlot(data = ExampleData.DeValues,
                 rug = TRUE)

## now with a smaller bandwidth for the KDE plot
plot_AbanicoPlot(data = ExampleData.DeValues,
                 bw = 0.04)

## now with a histogram instead of the KDE plot
plot_AbanicoPlot(data = ExampleData.DeValues,
                 hist = TRUE,
                 kde = FALSE)

## now with a KDE plot and histogram with manual number of bins
plot_AbanicoPlot(data = ExampleData.DeValues,
                 hist = TRUE,
                 breaks = 20)

## now with a KDE plot and a dot plot
plot_AbanicoPlot(data = ExampleData.DeValues,
                 dots = TRUE)

## now with user-defined plot ratio
plot_AbanicoPlot(data = ExampleData.DeValues,
                 plot.ratio = 0.5)

## now with user-defined central value
```

```

plot_AbanicoPlot(data = ExampleData.DeValues,
                 z.0 = 70)

## now with median as central value
plot_AbanicoPlot(data = ExampleData.DeValues,
                 z.0 = "median")

## now with the 17-83 percentile range as definition of scatter
plot_AbanicoPlot(data = ExampleData.DeValues,
                 z.0 = "median",
                 dispersion = "p17")

## now with user-defined green line for minimum age model
CAM <- calc_CentralDose(ExampleData.DeValues,
                      plot = FALSE)

plot_AbanicoPlot(data = ExampleData.DeValues,
                 line = CAM,
                 line.col = "darkgreen",
                 line.label = "CAM")

## now create plot with legend, colour, different points and smaller scale
plot_AbanicoPlot(data = ExampleData.DeValues,
                 legend = "Sample 1",
                 col = "tomato4",
                 bar.col = "peachpuff",
                 pch = "R",
                 cex = 0.8)

## now without 2-sigma bar, polygon, grid lines and central value line
plot_AbanicoPlot(data = ExampleData.DeValues,
                 bar.col = FALSE,
                 polygon.col = FALSE,
                 grid.col = FALSE,
                 y.axis = FALSE,
                 lwd = 0)

## now with direct display of De errors, without 2-sigma bar
plot_AbanicoPlot(data = ExampleData.DeValues,
                 bar.col = FALSE,
                 ylab = "",
                 y.axis = FALSE,
                 error.bars = TRUE)

## now with user-defined axes labels
plot_AbanicoPlot(data = ExampleData.DeValues,
                 xlab = c("Data error (%)",
                         "Data precision"),
                 ylab = "Scatter",
                 zlab = "Equivalent dose [Gy]")

## now with minimum, maximum and median value indicated
plot_AbanicoPlot(data = ExampleData.DeValues,
                 stats = c("min", "max", "median"))

## now with a brief statistical summary as subheader
plot_AbanicoPlot(data = ExampleData.DeValues,

```

```

summary = c("n", "in.2s"))

## now with another statistical summary
plot_AbanicoPlot(data = ExampleData.DeValues,
  summary = c("mean.weighted", "median"),
  summary.pos = "topleft")

## now a plot with two 2-sigma bars for one data set
plot_AbanicoPlot(data = ExampleData.DeValues,
  bar = c(30, 100))

## now the data set is split into sub-groups, one is manipulated
data.1 <- ExampleData.DeValues[1:30,]
data.2 <- ExampleData.DeValues[31:62,] * 1.3

## now a common dataset is created from the two subgroups
data.3 <- list(data.1, data.2)

## now the two data sets are plotted in one plot
plot_AbanicoPlot(data = data.3)

## now with some graphical modification
plot_AbanicoPlot(data = data.3,
  z.0 = "median",
  col = c("steelblue4", "orange4"),
  bar.col = c("steelblue3", "orange3"),
  polygon.col = c("steelblue1", "orange1"),
  pch = c(2, 6),
  angle = c(30, 50),
  summary = c("n", "in.2s", "median"))

## create Abanico plot with predefined layout definition
plot_AbanicoPlot(data = ExampleData.DeValues,
  layout = "journal")

## now with predefined layout definition and further modifications
plot_AbanicoPlot(
  data = data.3,
  z.0 = "median",
  layout = "journal",
  col = c("steelblue4", "orange4"),
  bar.col = adjustcolor(c("steelblue3", "orange3"),
    alpha.f = 0.5),
  polygon.col = c("steelblue3", "orange3"))

## for further information on layout definitions see documentation
## of function get_Layout()

## now with manually added plot content
## create empty plot with numeric output
AP <- plot_AbanicoPlot(data = ExampleData.DeValues,
  pch = NA,
  output = TRUE)

## identify data in 2 sigma range
in_2sigma <- AP$data[[1]]$data.in.2s

```

```
## restore function-internal plot parameters
par(AP$par)

## add points inside 2-sigma range
points(x = AP$data[[1]]$precision[in_2sigma],
       y = AP$data[[1]]$std.estimate.plot[in_2sigma],
       pch = 16)

## add points outside 2-sigma range
points(x = AP$data[[1]]$precision[!in_2sigma],
       y = AP$data[[1]]$std.estimate.plot[!in_2sigma],
       pch = 1)
```

---

plot_DetPlot	<i>Create <math>De(t)</math> plot</i>
--------------	---------------------------------------

---

### Description

Plots the equivalent dose ( $D_e$ ) in dependency of the chosen signal integral (cf. Bailey et al., 2003). The function is simply passing several arguments to the function [plot](#) and the used analysis functions and runs it in a loop. Example: `legend.pos` for legend position, `legend` for legend text.

### Usage

```
plot_DetPlot(
  object,
  signal.integral.min,
  signal.integral.max,
  background.integral.min,
  background.integral.max,
  method = "shift",
  signal_integral.seq = NULL,
  analyse_function = "analyse_SAR.CWOSL",
  analyse_function.control = list(),
  n.channels = NULL,
  show_ShineDownCurve = TRUE,
  respect_RC.Status = FALSE,
  multicore = TRUE,
  verbose = TRUE,
  plot = TRUE,
  ...
)
```

### Arguments

<code>object</code>	<a href="#">RLum.Analysis</a> ( <b>required</b> ): input object containing data for analysis Can be provided as a <a href="#">list</a> of such objects.
<code>signal.integral.min</code>	<a href="#">integer</a> ( <b>required</b> ): lower bound of the signal integral.
<code>signal.integral.max</code>	<a href="#">integer</a> ( <b>required</b> ): upper bound of the signal integral.

background.integral.min	<b>integer (required)</b> : lower bound of the background integral.
background.integral.max	<b>integer (required)</b> : upper bound of the background integral.
method	<b>character (with default)</b> : method applied for constructing the De(t) plot. <ul style="list-style-type: none"> <li>• <i>shift (the default)</i>: the chosen signal integral is shifted the shine down curve,</li> <li>• <i>expansion</i>: the chosen signal integral is expanded each time by its length</li> </ul>
signal_integral.seq	<b>numeric (optional)</b> : argument to provide an own signal integral sequence for constructing the De(t) plot
analyse_function	<b>character (with default)</b> : name of the analyse function to be called. Supported functions are: <a href="#">analyse_SAR.CWOSL</a> , <a href="#">analyse_pIRIRSequence</a>
analyse_function.control	<b>list (optional)</b> : selected arguments to be passed to the supported analyse functions ( <a href="#">analyse_SAR.CWOSL</a> , <a href="#">analyse_pIRIRSequence</a> )
n.channels	<b>integer (optional)</b> : number of channels used for the De(t) plot. If nothing is provided all De-values are calculated and plotted until the start of the background integral.
show_ShineDownCurve	<b>logical (with default)</b> : enables or disables shine down curve in the plot output
respect_RC.Status	<b>logical (with default)</b> : remove De-values with 'FAILED' RC.Status from the plot (cf. <a href="#">analyse_SAR.CWOSL</a> and <a href="#">analyse_pIRIRSequence</a> )
multicore	<b>logical (with default)</b> : enables/disables multi core calculation if object is a <b>list</b> of <a href="#">RLum.Analysis</a> objects. Can be an <b>integer</b> specifying the number of cores
verbose	<b>logical (with default)</b> : enables or disables terminal feedback
plot	<b>logical (with default)</b> : enables/disables plot output Disabling the plot is useful in cases where the output need to be processed differently.
...	further arguments and graphical parameters passed to <a href="#">plot.default</a> , <a href="#">analyse_SAR.CWOSL</a> and <a href="#">analyse_pIRIRSequence</a> (see details for further information). Plot control parameters are: ylim, xlim, ylab, xlab, main, pch, mtext, cex, legend, legend.text, legend.pos

## Details

### method

The original method presented by Bailey et al., 2003 shifted the signal integrals and slightly extended them accounting for changes in the counting statistics. Example: `c(1:3, 3:5, 5:7)`. However, here also another method is provided allowing to expand the signal integral by consecutively expanding the integral by its chosen length. Example: `c(1:3, 1:5, 1:7)`

Note that in both cases the integral limits are overlap. The finally applied limits are part of the function output.

### analyse\_function.control

The argument `analyse_function.control` currently supports the following arguments `sequence.structure`, `dose.points`, `mtext.outer`, `fit.method`, `fit.force_through_origin`, `plot`, `plot.single`

**Value**

A plot and an [RLum.Results](#) object with the produced  $D_e$  values  
@data:

Object	Type	Description
De.values	data.frame	table with De values
signal_integral.seq	numeric	integral sequence used for the calculation

@info:

Object	Type	Description
call	call	the original function call

**Function version**

0.1.7

**Note**

The entire analysis is based on the used analysis functions, namely [analyse\\_SAR.CWOSL](#) and [analyse\\_pIRIRSequence](#). However, the integrity checks of this function are not that thoughtful as in these functions itself. It means, that every sequence should be checked carefully before running long calculations using several hundreds of channels.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Ruprecht-Karl University of Heidelberg (Germany) ,  
RLum Developer Team

**References**

Bailey, R.M., Singarayer, J.S., Ward, S., Stokes, S., 2003. Identification of partial resetting using  $D_e$  as a function of illumination time. *Radiation Measurements* 37, 511-518. doi:10.1016/S1350-4487(03)00063-5

**See Also**

[plot](#), [analyse\\_SAR.CWOSL](#), [analyse\\_pIRIRSequence](#)

**Examples**

```
## Not run:
##load data
##ExampleData.BINfileData contains two BINfileData objects
##CWOSL.SAR.Data and TL.SAR.Data
data(ExampleData.BINfileData, envir = environment())

##transform the values from the first position in a RLum.Analysis object
object <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos=1)

plot_DetPlot(
  object,
  signal.integral.min = 1,
  signal.integral.max = 3,
```



```

background.integral.min = 900,
background.integral.max = 1000,
n.channels = 5)

## End(Not run)

```

---

plot\_DRCSummary

---

Create a Dose-Response Curve Summary Plot

---

## Description

While analysing OSL SAR or pIRIR-data the view on the data is limited usually to one dose-response curve (DRC) at the time for one aliquot. This function overcomes this limitation by plotting all DRC from an [RLum.Results](#) object created by the function [analyse\\_SAR.CWOSL](#) in one single plot.

## Usage

```

plot_DRCSummary(
  object,
  source_dose_rate = NULL,
  sel_curves = NULL,
  show_dose_points = FALSE,
  show_natural = FALSE,
  n = 51L,
  ...
)

```

## Arguments

object	<a href="#">RLum.Results</a> object ( <b>required</b> ): input object created by the function <a href="#">analyse_SAR.CWOSL</a> . The input object can be provided as <a href="#">list</a> .
source_dose_rate	<a href="#">numeric</a> ( <i>optional</i> ): allows to modify the axis and show values in Gy, instead seconds. Only a single numerical values is allowed.
sel_curves	<a href="#">numeric</a> ( <i>optional</i> ): id of the curves to be plotting in its occurring order. A sequence can be provided for selecting, e.g., only every 2nd curve from the input object
show_dose_points	<a href="#">logical</a> (with default): enable or disable plot of dose points in the graph
show_natural	<a href="#">logical</a> (with default): enable or disable the plot of the natural Lx/Tx values
n	<a href="#">integer</a> (with default): the number of x-values used to evaluate one curve object. Large numbers slow down the plotting process and are usually not needed
...	Further arguments and graphical parameters to be passed. In particular: main, xlab, ylab, xlim, ylim, lty, lwd, pch, col.pch, col.lty, mtext

## Details

If you want plot your DRC on an energy scale (dose in Gy), you can either use the option `source_dose_rate` provided below or your can SAR analysis with the dose points in Gy (better axis scaling).

**Value**

An [RLum.Results](#) object is returned:

Slot: **@data**

OBJECT	TYPE	COMMENT
results	<a href="#">data.frame</a>	with dose and LxTx values
data	<a href="#">RLum.Results</a>	original input data

Slot: **@info**

OBJECT	TYPE	COMMENT
call	call	the original function call
args	list	arguments of the original function call

*Note: If the input object is a [list](#) a list of [RLum.Results](#) objects is returned.*

**Function version**

0.2.3

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
Christoph Burow, University of Cologne (Germany) , RLum Developer Team

**See Also**

[RLum.Results](#), [analyse\\_SAR.CWOSL](#)

**Examples**

```
#load data example data
data(ExampleData.BINfileData, envir = environment())

#transform the values from the first position in a RLum.Analysis object
object <- Riseo.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos=1)

results <- analyse_SAR.CWOSL(
  object = object,
  signal.integral.min = 1,
  signal.integral.max = 2,
  background.integral.min = 900,
  background.integral.max = 1000,
  plot = FALSE
)

##plot only DRC
plot_DRCSummary(results)
```

plot\_DRTRResults

*Visualise dose recovery test results***Description**

The function provides a standardised plot output for dose recovery test measurements.

**Usage**

```
plot_DRTRResults(
  values,
  given.dose = NULL,
  error.range = 10,
  preheat,
  boxplot = FALSE,
  mtext,
  summary,
  summary.pos,
  legend,
  legend.pos,
  par.local = TRUE,
  na.rm = FALSE,
  ...
)
```

**Arguments**

values	<b>RLum.Results</b> or <b>data.frame</b> ( <b>required</b> ): input values containing at least De and De error. To plot more than one data set in one figure, a list of the individual data sets must be provided (e.g. <code>list(dataset.1, dataset.2)</code> ).
given.dose	<b>numeric</b> ( <i>optional</i> ): given dose used for the dose recovery test to normalise data. If only one given dose is provided this given dose is valid for all input data sets (i.e., values is a list). Otherwise a given dose for each input data set has to be provided (e.g., <code>given.dose = c(100, 200)</code> ). If given.dose is NULL the values are plotted without normalisation (might be useful for preheat plateau tests). <b>Note:</b> Unit has to be the same as from the input values (e.g., Seconds or Gray).
error.range	<b>numeric</b> : symmetric error range in percent will be shown as dashed lines in the plot. Set <code>error.range</code> to 0 to void plotting of error ranges.
preheat	<b>numeric</b> : optional vector of preheat temperatures to be used for grouping the De values. If specified, the temperatures are assigned to the x-axis.
boxplot	<b>logical</b> : optionally plot values, that are grouped by preheat temperature as boxplots. Only possible when preheat vector is specified.
mtext	<b>character</b> : additional text below the plot title.
summary	<b>character</b> ( <i>optional</i> ): adds numerical output to the plot. Can be one or more out of: <ul style="list-style-type: none"> <li>• "n" (number of samples),</li> <li>• "mean" (mean De value),</li> <li>• "weighted\$mean" (error-weighted mean),</li> </ul>

	<ul style="list-style-type: none"> <li>• "median" (median of the De values),</li> <li>• "sd.rel" (relative standard deviation in percent),</li> <li>• "sd.abs" (absolute standard deviation),</li> <li>• "se.rel" (relative standard error) and</li> <li>• "se.abs" (absolute standard error)</li> </ul>
	and all other measures returned by the function <a href="#">calc_Statistics</a> .
summary.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the statistical summary. Alternatively, the keyword "sub" may be specified to place the summary below the plot header. However, this latter option is only possible if mtext is not used.
legend	<a href="#">character</a> vector ( <i>optional</i> ): legend content to be added to the plot.
legend.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the legend to be plotted.
par.local	<a href="#">logical</a> ( <i>with default</i> ): use local graphical parameters for plotting, e.g. the plot is shown in one column and one row. If par.local = FALSE, global parameters are inherited, i.e. parameters provided via par() work
na.rm	<a href="#">logical</a> : indicating whether NA values are removed before plotting from the input data set
...	further arguments and graphical parameters passed to <a href="#">plot</a> , supported are: xlab, ylab, xlim, ylim, main, cex, las and 'pch'

## Details

Procedure to test the accuracy of a measurement protocol to reliably determine the dose of a specific sample. Here, the natural signal is erased and a known laboratory dose administered which is treated as unknown. Then the De measurement is carried out and the degree of congruence between administered and recovered dose is a measure of the protocol's accuracy for this sample.

In the plot the normalised De is shown on the y-axis, i.e. obtained De/Given Dose.

## Value

A plot is returned.

## Function version

0.1.14

## Note

Further data and plot arguments can be added by using the appropriate R commands.

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

## References

Wintle, A.G., Murray, A.S., 2006. A review of quartz optically stimulated luminescence characteristics and their relevance in single-aliquot regeneration dating protocols. *Radiation Measurements*, 41, 369-391.

**See Also**[plot](#)**Examples**

```
## read example data set and misapply them for this plot type
data(ExampleData.DeValues, envir = environment())

## plot values
plot_DRTResults(
  values = ExampleData.DeValues$BT998[7:11,],
  given.dose = 2800,
  mtext = "Example data")

## plot values with legend
plot_DRTResults(
  values = ExampleData.DeValues$BT998[7:11,],
  given.dose = 2800,
  legend = "Test data set")

## create and plot two subsets with randomised values
x.1 <- ExampleData.DeValues$BT998[7:11,]
x.2 <- ExampleData.DeValues$BT998[7:11,] * c(runif(5, 0.9, 1.1), 1)

plot_DRTResults(
  values = list(x.1, x.2),
  given.dose = 2800)

## some more user-defined plot parameters
plot_DRTResults(
  values = list(x.1, x.2),
  given.dose = 2800,
  pch = c(2, 5),
  col = c("orange", "blue"),
  xlim = c(0, 8),
  ylim = c(0.85, 1.15),
  xlab = "Sample aliquot")

## plot the data with user-defined statistical measures as legend
plot_DRTResults(
  values = list(x.1, x.2),
  given.dose = 2800,
  summary = c("n", "weighted$mean", "sd.abs"))

## plot the data with user-defined statistical measures as sub-header
plot_DRTResults(
  values = list(x.1, x.2),
  given.dose = 2800,
  summary = c("n", "weighted$mean", "sd.abs"),
  summary.pos = "sub")

## plot the data grouped by preheat temperatures
plot_DRTResults(
  values = ExampleData.DeValues$BT998[7:11,],
  given.dose = 2800,
  preheat = c(200, 200, 200, 240, 240))
```

```
## read example data set and misapply them for this plot type
data(ExampleData.DeValues, envir = environment())

## plot values
plot_DRTResults(
  values = ExampleData.DeValues$BT998[7:11,],
  given.dose = 2800,
  mtext = "Example data")

## plot two data sets grouped by preheat temperatures
plot_DRTResults(
  values = list(x.1, x.2),
  given.dose = 2800,
  preheat = c(200, 200, 200, 240, 240))

## plot the data grouped by preheat temperatures as boxplots
plot_DRTResults(
  values = ExampleData.DeValues$BT998[7:11,],
  given.dose = 2800,
  preheat = c(200, 200, 200, 240, 240),
  boxplot = TRUE)
```

---

plot\_FilterCombinations

*Plot filter combinations along with the (optional) net transmission window*

---

## Description

The function allows to plot transmission windows for different filters. Missing data for specific wavelengths are automatically interpolated for the given filter data using the function [approx](#). With that a standardised output is reached and a net transmission window can be shown.

## Usage

```
plot_FilterCombinations(
  filters,
  wavelength_range = 200:1000,
  show_net_transmission = TRUE,
  interactive = FALSE,
  plot = TRUE,
  ...
)
```

## Arguments

filters	<b>list (required)</b> : a named list of filter data for each filter to be shown. The filter data itself should be either provided as <a href="#">data.frame</a> or <a href="#">matrix</a> . (for more options s. Details)
wavelength_range	<b>numeric (with default)</b> : wavelength range used for the interpolation

show\_net\_transmission      **logical** (with default): show net transmission window as polygon.

interactive      **logical** (with default): enable/disable interactive plot

plot      **logical** (with default): enables or disables the plot output

...      further arguments that can be passed to control the plot output. Supported are main, xlab, ylab, xlim, ylim, type, lty, lwd. For non common plotting parameters see the details section.

## Details

### Calculations

#### Net transmission window

The net transmission window of two filters is approximated by

$$T_{final} = T_1 * T_2$$

#### Optical density

$$OD = -\log_{10}(T)$$

#### Total optical density

$$OD_{total} = OD_1 + OD_2$$

Please consider using own calculations for more precise values.

#### How to provide input data?

##### CASE 1

The function expects that all filter values are either of type `matrix` or `data.frame` with two columns. The first columns contains the wavelength, the second the relative transmission (but not in percentage, i.e. the maximum transmission can be only become 1).

In this case only the transmission window is show as provided. Changes in filter thickness and reflection factor are not considered.

##### CASE 2

The filter data itself are provided as list element containing a `matrix` or `data.frame` and additional information on the thickness of the filter, e.g., `list(filter1 = list(filter_matrix, d = 2))`. The given filter data are always considered as standard input and the filter thickness value is taken into account by

$$Transmission = Transmission^{(d)}$$

with `d` given in the same dimension as the original filter data.

##### CASE 3

Same as CASE 2 but additionally a reflection factor `P` is provided, e.g., `list(filter1 = list(filter_matrix, d = 2, P = 0.9))`. The final transmission becomes:

$$Transmission = Transmission^{(d)} * P$$

### Advanced plotting parameters

The following further non-common plotting parameters can be passed to the function:

Argument	Datatype	Description
legend	logical	enable/disable legend
legend.pos	character	change legend position ( <a href="#">graphics::legend</a> )
legend.text	character	same as the argument legend in ( <a href="#">graphics::legend</a> )
net_transmission.col	col	colour of net transmission window polygon
net_transmission.col_lines	col	colour of net transmission window polygon lines
net_transmission.density	numeric	specify line density in the transmission polygon
grid	list	full list of arguments that can be passed to the function <a href="#">graphics::grid</a>

For further modifications standard additional R plot functions are recommend, e.g., the legend can be fully customised by disabling the standard legend and use the function [graphics::legend](#) instead.

### Value

Returns an S4 object of type [RLum.Results](#).

#### @data

Object	Type	Description
net_transmission_window	matrix	the resulting net transmission window
OD_total	matrix	the total optical density
filter_matrix	matrix	the filter matrix used for plotting

#### @info

Object	Type	Description
call	<a href="#">call</a>	the original function call

### Function version

0.3.2

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

### See Also

[RLum.Results](#), [approx](#)

### Examples

```
## (For legal reasons no real filter data are provided)

## Create filter sets
filter1 <- density(rnorm(100, mean = 450, sd = 20))
filter1 <- matrix(c(filter1$x, filter1$y/max(filter1$y)), ncol = 2)
filter2 <- matrix(c(200:799,rep(c(0,0.8,0),each = 200)), ncol = 2)

## Example 1 (standard)
plot_FilterCombinations(filters = list(filter1, filter2))
```



```
## Example 2 (with d and P value and name for filter 2)
results <- plot_FilterCombinations(
  filters = list(filter_1 = filter1, Rectangle = list(filter2, d = 2, P = 0.6)))
results

## Example 3 show optical density
plot(results$OD_total)

## Not run:
##Example 4
##show the filters using the interactive mode
plot_FilterCombinations(filters = list(filter1, filter2), interactive = TRUE)

## End(Not run)
```

---

plot_GrowthCurve	<i>Fit and plot a dose-response curve for luminescence data (Lx/Tx against dose)</i>
------------------	--

---

## Description

A dose-response curve is produced for luminescence measurements using a regenerative or additive protocol. The function supports interpolation and extrapolation to calculate the equivalent dose.

## Usage

```
plot_GrowthCurve(
  sample,
  na.rm = TRUE,
  mode = "interpolation",
  fit.method = "EXP",
  fit.force_through_origin = FALSE,
  fit.weights = TRUE,
  fit.includingRepeatedRegPoints = TRUE,
  fit.NumberRegPoints = NULL,
  fit.NumberRegPointsReal = NULL,
  fit.bounds = TRUE,
  NumberIterations.MC = 100,
  output.plot = TRUE,
  output.plotExtended = TRUE,
  output.plotExtended.single = FALSE,
  cex.global = 1,
  txtProgressBar = TRUE,
  verbose = TRUE,
  ...
)
```

**Arguments**

sample	<b>data.frame (required)</b> : data frame with three columns for $x = \text{Dose}$ , $y = \text{LxTx}$ , $z = \text{LxTx.Error}$ , $y1 = \text{TnTx}$ . The column for the test dose response is optional, but requires 'TnTx' as column name if used. For exponential fits at least three dose points (including the natural) should be provided.
na.rm	<b>logical (with default)</b> : excludes NA values from the data set prior to any further operations. This argument is defunct and will be removed in a future version!
mode	<b>character (with default)</b> : selects calculation mode of the function. <ul style="list-style-type: none"> <li>• "interpolation" (default) calculates the De by interpolation,</li> <li>• "extrapolation" calculates the equivalent dose by extrapolation (useful for MAAD measurements) and</li> <li>• "alternate" calculates no equivalent dose and just fits the data points.</li> </ul> <p>Please note that for option "regenerative" the first point is considered as natural dose</p>
fit.method	<b>character (with default)</b> : function used for fitting. Possible options are: <ul style="list-style-type: none"> <li>• LIN,</li> <li>• QDR,</li> <li>• EXP,</li> <li>• EXP OR LIN,</li> <li>• EXP+LIN,</li> <li>• EXP+EXP,</li> <li>• GOK,</li> <li>• LambertW</li> </ul> <p>See details.</p>
fit.force_through_origin	<b>logical (with default)</b> allow to force the fitted function through the origin. For method = "EXP+EXP" the function will be fixed through the origin in either case, so this option will have no effect.
fit.weights	<b>logical (with default)</b> : option whether the fitting is done with or without weights. See details.
fit.includingRepeatedRegPoints	<b>logical (with default)</b> : includes repeated points for fitting (TRUE/FALSE).
fit.NumberRegPoints	<b>integer (optional)</b> : set number of regeneration points manually. By default the number of all (!) regeneration points is used automatically.
fit.NumberRegPointsReal	<b>integer (optional)</b> : if the number of regeneration points is provided manually, the value of the real, regeneration points = all points (repeated points) including reg 0, has to be inserted.
fit.bounds	<b>logical (with default)</b> : set lower fit bounds for all fitting parameters to 0. Limited for the use with the fit methods EXP, EXP+LIN, EXP OR LIN, GOK, LambertW Argument to be inserted for experimental application only!
NumberIterations.MC	<b>integer (with default)</b> : number of Monte Carlo simulations for error estimation. See details.
output.plot	<b>logical (with default)</b> : plot output (TRUE/FALSE).

output.plotExtended

**logical** (with default): If TRUE, 3 plots on one plot area are provided:

1. growth curve,
2. histogram from Monte Carlo error simulation and
3. a test dose response plot.

If FALSE, just the growth curve will be plotted. **Requires:** output.plot = TRUE.

output.plotExtended.single

**logical** (with default): single plot output (TRUE/FALSE) to allow for plotting the results in single plot windows. Requires output.plot = TRUE and output.plotExtended = TRUE.

cex.global

**numeric** (with default): global scaling factor.

txtProgressBar

**logical** (with default): enables or disables txtProgressBar. If verbose = FALSE also no txtProgressBar is shown.

verbose

**logical** (with default): enables or disables terminal feedback.

...

Further arguments and graphical parameters to be passed. Note: Standard arguments will only be passed to the growth curve plot. Supported: xlim, ylim, main, xlab, ylab

## Details

### Fitting methods

For all options (except for the LIN, QDR and the EXP OR LIN), the `minpack.lm::nlsLM` function with the LM (Levenberg-Marquardt algorithm) algorithm is used. Note: For historical reasons for the Monte Carlo simulations partly the function `nls` using the port algorithm.

The solution is found by transforming the function or using `uniroot`.

LIN: fits a linear function to the data using `lm`:

$$y = mx + n$$

QDR: fits a linear function to the data using `lm`:

$$y = a + bx + cx^2$$

EXP: tries to fit a function of the form

$$y = a(1 - \exp(-\frac{(x + c)}{b}))$$

Parameters b and c are approximated by a linear fit using `lm`. Note: b = D0

EXP OR LIN: works for some cases where an EXP fit fails. If the EXP fit fails, a LIN fit is done instead.

EXP+LIN: tries to fit an exponential plus linear function of the form:

$$y = a(1 - \exp(-\frac{x + c}{b})) + (gx)$$

The  $D_e$  is calculated by iteration.

**Note:** In the context of luminescence dating, this function has no physical meaning. Therefore, no D0 value is returned.

EXP+EXP: tries to fit a double exponential function of the form

$$y = (a_1(1 - \exp(-\frac{x}{b_1}))) + (a_2(1 - \exp(-\frac{x}{b_2})))$$

This fitting procedure is not robust against wrong start parameters and should be further improved.  
 GOK: tries to fit the general-order kinetics function after Guralnik et al. (2015) of the form of

$$y = a(d - (1 + (\frac{1}{b})xc)^{(-1/c)})$$

where  $c > 0$  is a kinetic order modifier (not to be confused with  $c$  in EXP or EXP+LIN!).

LambertW: tries to fit a dose-response curve based on the Lambert W function according to Pagonis et al. (2020). The function has the form

$$y (1 + (W((R - 1) * \exp(R - 1 - ((x + D_{int})/D_c)))/(1 - R))) * N$$

with  $W$  the Lambert W function, calculated using the package `lamW::lambertW0`,  $R$  the dimensionless retrapping ratio,  $N$  the total concentration of trappings states in  $\text{cm}^{-3}$  and  $D_c = N/R$  a constant.  $D_{int}$  is the offset on the x-axis. Please not that finding the root in mode = "extrapolation" is a non-easy task due to the shape of the function and the results might be unexpected.

### Fit weighting

If the option `fit.weights = TRUE` is chosen, weights are calculated using provided signal errors (Lx/Tx error):

$$fit.weights = \frac{\frac{1}{error}}{\sum \frac{1}{error}}$$

### Error estimation using Monte Carlo simulation

Error estimation is done using a parametric bootstrapping approach. A set of Lx/Tx values is constructed by randomly drawing curve data sampled from normal distributions. The normal distribution is defined by the input values (mean = value, sd = value.error). Then, a dose-response curve fit is attempted for each dataset resulting in a new distribution of single De values. The standard deviation of this distribution is becomes then the error of the De. With increasing iterations, the error value becomes more stable. However, naturally the error will not decrease with more MC runs.

Alternatively, the function returns highest probability density interval estimates as output, users may find more useful under certain circumstances.

**Note:** It may take some calculation time with increasing MC runs, especially for the composed functions (EXP+LIN and EXP+EXP).

Each error estimation is done with the function of the chosen fitting method.

### Subtitle information

To avoid plotting the subtitle information, provide an empty user `mtext` `mtext = ""`. To plot any other subtitle text, use `mtext`.

### Value

Along with a plot (so far wanted) an `RLum.Results` object is returned containing, the slot data contains the following elements:

DATA.OBJECT	TYPE	DESCRIPTION
<code>..\$De :</code>	<code>data.frame</code>	Table with De values
<code>..\$De.MC :</code>	<code>numeric</code>	Table with De values from MC runs
<code>..\$Fit :</code>	<code>nls</code> or <code>lm</code>	object from the fitting for EXP, EXP+LIN and EXP+EXP. In case of a resulting linear fit w
<code>..\$Formula :</code>	<code>expression</code>	Fitting formula as R expression
<code>..\$call :</code>	<code>call</code>	The original function call

**Function version**

1.11.12

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

**References**

Berger, G.W., Huntley, D.J., 1989. Test data for exponential fits. *Ancient TL* 7, 43-46.

Guralnik, B., Li, B., Jain, M., Chen, R., Paris, R.B., Murray, A.S., Li, S.-H., Pagonis, P., Herman, F., 2015. Radiation-induced growth and isothermal decay of infrared-stimulated luminescence from feldspar. *Radiation Measurements* 81, 224-231.

Pagonis, V., Kitis, G., Chen, R., 2020. A new analytical equation for the dose response of dosimetric materials, based on the Lambert W function. *Journal of Luminescence* 225, 117333. doi:10.1016/j.jlumin.2020.117333

**See Also**

[nls](#), [RLum.Results](#), [get\\_RLum](#), [minpack.lm::nlsLM](#), [lm](#), [uniroot](#), [lamW::lamertW0](#)

**Examples**

```
##(1) plot growth curve for a dummy data.set and show De value
data(ExampleData.LxTxData, envir = environment())
temp <- plot_GrowthCurve(LxTxData)
get_RLum(temp)

##(1b) horizontal plot arrangement
layout(mat = matrix(c(1,1,2,3), ncol = 2))
plot_GrowthCurve(LxTxData, output.plotExtended.single = TRUE)

##(1c) to access the fitting value try
get_RLum(temp, data.object = "Fit")

##(2) plot the growth curve only - uncomment to use
##pdf(file = "~/Desktop/Growth_Curve_Dummy.pdf", paper = "special")
plot_GrowthCurve(LxTxData)
##dev.off()

##(3) plot growth curve with pdf output - uncomment to use, single output
##pdf(file = "~/Desktop/Growth_Curve_Dummy.pdf", paper = "special")
plot_GrowthCurve(LxTxData, output.plotExtended.single = TRUE)
##dev.off()

##(4) plot resulting function for given intervall x
x <- seq(1,10000, by = 100)
plot(
  x = x,
  y = eval(temp$Formula),
  type = "l"
```

```

)

##(5) plot using the 'extrapolation' mode
LxTxData[1,2:3] <- c(0.5, 0.001)
print(plot_GrowthCurve(LxTxData,mode = "extrapolation"))

##(6) plot using the 'alternate' mode
LxTxData[1,2:3] <- c(0.5, 0.001)
print(plot_GrowthCurve(LxTxData,mode = "alternate"))

##(7) import and fit test data set by Berger & Huntley 1989
QNL84_2_unbleached <-
read.table(system.file("extdata/QNL84_2_unbleached.txt", package = "Luminescence"))

results <- plot_GrowthCurve(
  QNL84_2_unbleached,
  mode = "extrapolation",
  plot = FALSE,
  verbose = FALSE)

#calculate confidence interval for the parameters
#as alternative error estimation
confint(results$Fit, level = 0.68)

## Not run:
QNL84_2_bleached <-
read.table(system.file("extdata/QNL84_2_bleached.txt", package = "Luminescence"))
STRB87_1_unbleached <-
read.table(system.file("extdata/STRB87_1_unbleached.txt", package = "Luminescence"))
STRB87_1_bleached <-
read.table(system.file("extdata/STRB87_1_bleached.txt", package = "Luminescence"))

print(
  plot_GrowthCurve(
    QNL84_2_bleached,
    mode = "alternate",
    plot = FALSE,
    verbose = FALSE)$Fit)

print(
  plot_GrowthCurve(
    STRB87_1_unbleached,
    mode = "alternate",
    plot = FALSE,
    verbose = FALSE)$Fit)

print(
  plot_GrowthCurve(
    STRB87_1_bleached,
    mode = "alternate",
    plot = FALSE,
    verbose = FALSE)$Fit)

## End(Not run)

```

---

plot_Histogram	<i>Plot a histogram with separate error plot</i>
----------------	--

---

## Description

Function plots a predefined histogram with an accompanying error plot as suggested by Rex Galbraith at the UK LED in Oxford 2010.

## Usage

```
plot_Histogram(
  data,
  na.rm = TRUE,
  mtext,
  cex.global,
  se,
  rug,
  normal_curve,
  summary,
  summary.pos,
  colour,
  interactive = FALSE,
  ...
)
```

## Arguments

data	<a href="#">data.frame</a> or <a href="#">RLum.Results</a> object ( <b>required</b> ): for <code>data.frame</code> : two columns: De ( <code>data[, 1]</code> ) and De error ( <code>data[, 2]</code> )
na.rm	<a href="#">logical</a> ( <i>with default</i> ): excludes NA values from the data set prior to any further operations.
mtext	<a href="#">character</a> ( <i>optional</i> ): further sample information ( <a href="#">mtext</a> ).
cex.global	<a href="#">numeric</a> ( <i>with default</i> ): global scaling factor.
se	<a href="#">logical</a> ( <i>optional</i> ): plots standard error points over the histogram, default is FALSE.
rug	<a href="#">logical</a> ( <i>optional</i> ): adds rugs to the histogram, default is TRUE.
normal_curve	<a href="#">logical</a> ( <i>with default</i> ): adds a normal curve to the histogram. Mean and standard deviation are calculated from the input data. More see details section.
summary	<a href="#">character</a> ( <i>optional</i> ): add statistic measures of centrality and dispersion to the plot. Can be one or more of several keywords. See details for available keywords.
summary.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the statistical summary. Alternatively, the keyword "sub" may be specified to place the summary below the plot header. However, this latter option is only possible if <code>mtext</code> is not used. In case of coordinate specification, y-coordinate refers to the right y-axis.

colour	<b>numeric</b> or <b>character</b> ( <i>with default</i> ): optional vector of length 4 which specifies the colours of the following plot items in exactly this order: histogram bars, rug lines, normal distribution curve and standard error points (e.g., <code>c("grey", "black", "red", "grey")</code> ).
interactive	<b>logical</b> ( <i>with default</i> ): create an interactive histogram plot (requires the 'plotly' package)
...	further arguments and graphical parameters passed to <b>plot</b> or <b>hist</b> . If y-axis labels are provided, these must be specified as a vector of length 2 since the plot features two axes (e.g. <code>ylab = c("axis label 1", "axis label 2")</code> ). Y-axes limits ( <code>ylim</code> ) must be provided as vector of length four, with the first two elements specifying the left axes limits and the latter two elements giving the right axis limits.

## Details

If the normal curve is added, the y-axis in the histogram will show the probability density.

A statistic summary, i.e. a collection of statistic measures of centrality and dispersion (and further measures) can be added by specifying one or more of the following keywords:

- "n" (number of samples),
- "mean" (mean De value),
- "mean.weighted" (error-weighted mean),
- "median" (median of the De values),
- "sdrel" (relative standard deviation in percent),
- "sdrel.weighted" (error-weighted relative standard deviation in percent),
- "sdabs" (absolute standard deviation),
- "sdabs.weighted" (error-weighted absolute standard deviation),
- "serel" (relative standard error),
- "serel.weighted" (error-weighted relative standard error),
- "seabs" (absolute standard error),
- "seabs.weighted" (error-weighted absolute standard error),
- "kurtosis" (kurtosis) and
- "skewness" (skewness).

## Function version

0.4.5

## Note

The input data is not restricted to a special type.

## Author(s)

Michael Dietze, GFZ Potsdam (Germany)  
 Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team



**See Also**[hist](#), [plot](#)**Examples**

```
## load data
data(ExampleData.DeValues, envir = environment())
ExampleData.DeValues <-
  Second2Gray(ExampleData.DeValues$BT998, dose.rate = c(0.0438,0.0019))

## plot histogram the easiest way
plot_Histogram(ExampleData.DeValues)

## plot histogram with some more modifications
plot_Histogram(ExampleData.DeValues,
  rug = TRUE,
  normal_curve = TRUE,
  cex.global = 0.9,
  pch = 2,
  colour = c("grey", "black", "blue", "green"),
  summary = c("n", "mean", "sdrel"),
  summary.pos = "topleft",
  main = "Histogram of De-values",
  mtext = "Example data set",
  ylab = c(expression(paste(D[e], " distribution")),
    "Standard error"),
  xlim = c(100, 250),
  ylim = c(0, 0.1, 5, 20))
```

plot\_KDE

*Plot kernel density estimate with statistics***Description**

Plot a kernel density estimate of measurement values in combination with the actual values and associated error bars in ascending order. If enabled, the boxplot will show the usual distribution parameters (median as bold line, box delimited by the first and third quartile, whiskers defined by the extremes and outliers shown as points) and also the mean and standard deviation as pale bold line and pale polygon, respectively.

**Usage**

```
plot_KDE(
  data,
  na.rm = TRUE,
  values.cumulative = TRUE,
  order = TRUE,
  boxplot = TRUE,
  rug = TRUE,
  summary,
  summary.pos,
```

```
summary.method = "MCM",
bw = "nrd0",
output = TRUE,
...
)
```

## Arguments

data	<a href="#">data.frame</a> or <a href="#">RLum.Results</a> object ( <b>required</b> ): for <code>data.frame</code> : two columns: De ( <code>values[,1]</code> ) and De error ( <code>values[,2]</code> ). For plotting multiple data sets, these must be provided as list (e.g. <code>list(dataset1, dataset2)</code> ).
na.rm	<a href="#">logical</a> ( <i>with default</i> ): exclude NA values from the data set prior to any further operation.
values.cumulative	<a href="#">logical</a> ( <i>with default</i> ): show cumulative individual data.
order	<a href="#">logical</a> : Order data in ascending order.
boxplot	<a href="#">logical</a> ( <i>with default</i> ): optionally show a boxplot (depicting median as thick central line, first and third quartile as box limits, whiskers denoting $\pm 1.5$ interquartile ranges and dots further outliers).
rug	<a href="#">logical</a> ( <i>with default</i> ): optionally add rug.
summary	<a href="#">character</a> ( <i>optional</i> ): add statistic measures of centrality and dispersion to the plot. Can be one or more of several keywords. See details for available keywords.
summary.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the statistical summary. Alternatively, the keyword "sub" may be specified to place the summary below the plot header. However, this latter option is only possible if <code>mtext</code> is not used. In case of coordinate specification, y-coordinate refers to the right y-axis.
summary.method	<a href="#">character</a> ( <i>with default</i> ): keyword indicating the method used to calculate the statistic summary. One out of "unweighted", "weighted" and "MCM". See <a href="#">calc_Statistics</a> for details.
bw	<a href="#">character</a> ( <i>with default</i> ): bin-width, chose a numeric value for manual setting.
output	<a href="#">logical</a> : Optional output of numerical plot parameters. These can be useful to reproduce similar plots. Default is TRUE.
...	further arguments and graphical parameters passed to <a href="#">plot</a> .

## Details

The function allows passing several plot arguments, such as `main`, `xlab`, `cex`. However, as the figure is an overlay of two separate plots, `ylim` must be specified in the order: `c(ymin_axis1, ymax_axis1, ymin_axis2, ymax_axis2)` when using the cumulative values plot option. See examples for some further explanations. For details on the calculation of the bin-width (parameter `bw`) see [density](#).

A statistic summary, i.e. a collection of statistic measures of centrality and dispersion (and further measures) can be added by specifying one or more of the following keywords:

- "n" (number of samples)
- "mean" (mean De value)
- "median" (median of the De values)
- "sd.rel" (relative standard deviation in percent)

- "sd.abs" (absolute standard deviation)
- "se.rel" (relative standard error)
- "se.abs" (absolute standard error)
- "in.2s" (percent of samples in 2-sigma range)
- "kurtosis" (kurtosis)
- "skewness" (skewness)

**Note** that the input data for the statistic summary is sent to the function `calc_Statistics()` depending on the log-option for the z-scale. If `"log.z = TRUE"`, the summary is based on the logarithms of the input data. If `"log.z = FALSE"` the linearly scaled data is used.

**Note** as well, that `"calc_Statistics()"` calculates these statistic measures in three different ways: unweighted, weighted and MCM-based (i.e., based on Monte Carlo Methods). By default, the MCM-based version is used. If you wish to use another method, indicate this with the appropriate keyword using the argument `summary.method`.

### Function version

3.6.0

### Note

The plot output is no 'probability density' plot (cf. the discussion of Berger and Galbraith in Ancient TL; see references)!

### Author(s)

Michael Dietze, GFZ Potsdam (Germany)  
Geography & Earth Sciences, Aberystwyth University (United Kingdom) , RLum Developer Team

### See Also

[density](#), [plot](#)

### Examples

```
## read example data set
data(ExampleData.DeValues, envir = environment())
ExampleData.DeValues <-
  Second2Gray(ExampleData.DeValues$BT998, c(0.0438,0.0019))

## create plot straightforward
plot_KDE(data = ExampleData.DeValues)

## create plot with logarithmic x-axis
plot_KDE(data = ExampleData.DeValues,
  log = "x")

## create plot with user-defined labels and axes limits
plot_KDE(data = ExampleData.DeValues,
  main = "Dose distribution",
  xlab = "Dose (s)",
  ylab = c("KDE estimate", "Cumulative dose value"),
  xlim = c(100, 250),
  ylim = c(0, 0.08, 0, 30))
```

```

## create plot with boxplot option
plot_KDE(data = ExampleData.DeValues,
          boxplot = TRUE)

## create plot with statistical summary below header
plot_KDE(data = ExampleData.DeValues,
          summary = c("n", "median", "skewness", "in.2s"))

## create plot with statistical summary as legend
plot_KDE(data = ExampleData.DeValues,
          summary = c("n", "mean", "sd.rel", "se.abs"),
          summary.pos = "topleft")

## split data set into sub-groups, one is manipulated, and merge again
data.1 <- ExampleData.DeValues[1:15,]
data.2 <- ExampleData.DeValues[16:25,] * 1.3
data.3 <- list(data.1, data.2)

## create plot with two subsets straightforward
plot_KDE(data = data.3)

## create plot with two subsets and summary legend at user coordinates
plot_KDE(data = data.3,
          summary = c("n", "median", "skewness"),
          summary.pos = c(110, 0.07),
          col = c("blue", "orange"))

## example of how to use the numerical output of the function
## return plot output to draw a thicker KDE line
KDE_out <- plot_KDE(data = ExampleData.DeValues,
                    output = TRUE)

```

---

plot\_NRt

*Visualise natural/regenerated signal ratios*


---

## Description

This function creates a Natural/Regenerated signal vs. time (NR(t)) plot as shown in Steffen et al. 2009

## Usage

```

plot_NRt(
  data,
  log = FALSE,
  smooth = c("none", "spline", "rmean"),
  k = 3,
  legend = TRUE,
  legend.pos = "topright",
  ...
)

```

## Arguments

data	<a href="#">list</a> , <a href="#">data.frame</a> , <a href="#">matrix</a> or <a href="#">RLum.Analysis</a> ( <b>required</b> ): X,Y data of measured values (time and counts). See details on individual data structure.
log	<a href="#">character</a> ( <i>optional</i> ): logarithmic axes (c("x", "y", "xy")).
smooth	<a href="#">character</a> ( <i>optional</i> ): apply data smoothing. Use "rmean" to calculate the rolling where k determines the width of the rolling window (see <a href="#">rollmean</a> ). "spline" applies a smoothing spline to each curve (see <a href="#">smooth.spline</a> )
k	<a href="#">integer</a> ( <i>with default</i> ): integer width of the rolling window.
legend	<a href="#">logical</a> ( <i>with default</i> ): show or hide the plot legend.
legend.pos	<a href="#">character</a> ( <i>with default</i> ): keyword specifying the position of the legend (see <a href="#">legend</a> ).
...	further parameters passed to <a href="#">plot</a> (also see <a href="#">par</a> ).

## Details

This function accepts the individual curve data in many different formats. If data is a [list](#), each element of the list must contain a two column [data.frame](#) or [matrix](#) containing the XY data of the curves (time and counts). Alternatively, the elements can be objects of class [RLum.Data.Curve](#).

Input values can also be provided as a [data.frame](#) or [matrix](#) where the first column contains the time values and each following column contains the counts of each curve.

## Value

Returns a plot and [RLum.Analysis](#) object.

## Author(s)

Christoph Burow, University of Cologne (Germany) , RLum Developer Team

## References

Steffen, D., Preusser, F., Schlunegger, F., 2009. OSL quartz underestimation due to unstable signal components. *Quaternary Geochronology*, 4, 353-362.

## See Also

[plot](#)

## Examples

```
## load example data
data("ExampleData.BINfileData", envir = environment())

## EXAMPLE 1

## convert Risoe.BINfileData object to RLum.Analysis object
data <- Risoe.BINfileData2RLum.Analysis(object = CWOSL.SAR.Data, pos = 8, ltype = "OSL")

## extract all OSL curves
allCurves <- get_RLum(data)

## keep only the natural and regenerated signal curves
```

```

pos <- seq(1, 9, 2)
curves <- allCurves[pos]

## plot a standard NR(t) plot
plot_NRt(curves)

## re-plot with rolling mean data smoothing
plot_NRt(curves, smooth = "rmean", k = 10)

## re-plot with a logarithmic x-axis
plot_NRt(curves, log = "x", smooth = "rmean", k = 5)

## re-plot with custom axes ranges
plot_NRt(curves, smooth = "rmean", k = 5,
          xlim = c(0.1, 5), ylim = c(0.4, 1.6),
          legend.pos = "bottomleft")

## re-plot with smoothing spline on log scale
plot_NRt(curves, smooth = "spline", log = "x",
          legend.pos = "top")

## EXAMPLE 2

# you may also use this function to check whether all
# TD curves follow the same shape (making it a TnTx(t) plot).
posTD <- seq(2, 14, 2)
curves <- allCurves[posTD]

plot_NRt(curves, main = "TnTx(t) Plot",
          smooth = "rmean", k = 20,
          ylab = "TD natural / TD regenerated",
          xlim = c(0, 20), legend = FALSE)

## EXAMPLE 3

# extract data from all positions
data <- lapply(1:24, FUN = function(pos) {
  Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos = pos, ltype = "OSL")
})

# get individual curve data from each aliquot
aliquot <- lapply(data, get_RLum)

# set graphical parameters
par(mfrow = c(2, 2))

# create NR(t) plots for all aliquots
for (i in 1:length(aliquot)) {
  plot_NRt(aliquot[[i]][pos],
            main = paste0("Aliquot #", i),
            smooth = "rmean", k = 20,
            xlim = c(0, 10),
            cex = 0.6, legend.pos = "bottomleft")
}

# reset graphical parameters
par(mfrow = c(1, 1))

```

---

plot\_OSLAgeSummary      *Plot Posterior OSL-Age Summary*


---

## Description

A graphical summary of the statistical inference of an OSL age

## Usage

```
plot_OSLAgeSummary(object, level = 0.95, digits = 1L, verbose = TRUE, ...)
```

## Arguments

object	<a href="#">RLum.Results</a> , <b>numeric (required)</b> : an object produced by <a href="#">combine_De_Dr</a> . Alternatively, a <b>numeric</b> vector of a parameter from an MCMC process
level	<b>numeric</b> ( <i>with default</i> ): probability of shown credible interval
digits	<b>integer</b> ( <i>with default</i> ): number of digits considered for the calculation
verbose	<b>logical</b> ( <i>with default</i> ): enable/disable additional terminal output
...	further arguments to modify the plot, supported: xlim, ylim, xlab, ylab, main, lwd, lty, col, polygon_col, polygon_density, rug

## Details

The function is called automatically by [combine\\_De\\_Dr](#)

## Value

A posterior distribution plot and an [RLum.Results](#) object with the credible interval.

## Function version

0.1.0

## Author(s)

Anne Philippe, Université de Nantes (France), Jean-Michel Galharret, Université de Nantes (France), Norbert Mercier, IRAMAT-CRP2A, Université Bordeaux Montaigne (France), Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , [RLum Developer Team](#)

## See Also

[combine\\_De\\_Dr](#), [plot.default](#), [rjags::rjags](#)

## Examples

```
##generate random data
set.seed(1234)
object <- rnorm(1000, 100, 10)
plot_OSLAgeSummary(object)
```

---

plot_RadialPlot	<i>Function to create a Radial Plot</i>
-----------------	---

---

## Description

A Galbraith's radial plot is produced on a logarithmic or a linear scale.

## Usage

```
plot_RadialPlot(
  data,
  na.rm = TRUE,
  log.z = TRUE,
  central.value,
  centrality = "mean.weighted",
  mtext,
  summary,
  summary.pos,
  legend,
  legend.pos,
  stats,
  rug = FALSE,
  plot.ratio,
  bar.col,
  y.ticks = TRUE,
  grid.col,
  line,
  line.col,
  line.label,
  output = FALSE,
  ...
)
```

## Arguments

data	<a href="#">data.frame</a> or <a href="#">RLum.Results</a> object ( <b>required</b> ): for <code>data.frame</code> two columns: De ( <code>data[, 1]</code> ) and De error ( <code>data[, 2]</code> ). To plot several data sets in one plot, the data sets must be provided as <code>list</code> , e.g. <code>list(data.1, data.2)</code> .
na.rm	<a href="#">logical</a> ( <i>with default</i> ): excludes NA values from the data set prior to any further operations.
log.z	<a href="#">logical</a> ( <i>with default</i> ): Option to display the z-axis in logarithmic scale. Default is TRUE.
central.value	<a href="#">numeric</a> : User-defined central value, primarily used for horizontal centring of the z-axis.
centrality	<a href="#">character</a> or <a href="#">numeric</a> ( <i>with default</i> ): measure of centrality, used for automatically centring the plot and drawing the central line. Can either be one out of <ul style="list-style-type: none"> <li>• "mean",</li> <li>• "median",</li> <li>• "mean.weighted" and</li> </ul>



	<ul style="list-style-type: none"> <li>• "median.weighted" or a</li> <li>• numeric value used for the standardisation.</li> </ul>
mtext	<b>character</b> : additional text below the plot title.
summary	<b>character</b> ( <i>optional</i> ): add statistic measures of centrality and dispersion to the plot. Can be one or more of several keywords. See details for available keywords.
summary.pos	<b>numeric</b> or <b>character</b> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the statistical summary. Alternatively, the keyword "sub" may be specified to place the summary below the plot header. However, this latter option is only possible if mtext is not used.
legend	<b>character</b> vector ( <i>optional</i> ): legend content to be added to the plot.
legend.pos	<b>numeric</b> or <b>character</b> ( <i>with default</i> ): optional position coordinates or keyword (e.g. "topright") for the legend to be plotted.
stats	<b>character</b> : additional labels of statistically important values in the plot. One or more out of the following: <ul style="list-style-type: none"> <li>• "min",</li> <li>• "max",</li> <li>• "median".</li> </ul>
rug	<b>logical</b> : Option to add a rug to the z-scale, to indicate the location of individual values
plot.ratio	<b>numeric</b> : User-defined plot area ratio (i.e. curvature of the z-axis). If omitted, the default value (4.5/5.5) is used and modified automatically to optimise the z-axis curvature. The parameter should be decreased when data points are plotted outside the z-axis or when the z-axis gets too elliptic.
bar.col	<b>character</b> or <b>numeric</b> ( <i>with default</i> ): colour of the bar showing the 2-sigma range around the central value. To disable the bar, use "none". Default is "grey".
y.ticks	<b>logical</b> : Option to hide y-axis labels. Useful for data with small scatter.
grid.col	<b>character</b> or <b>numeric</b> ( <i>with default</i> ): colour of the grid lines (originating at $[0, 0]$ and stretching to the z-scale). To disable grid lines, use "none". Default is "grey".
line	<b>numeric</b> : numeric values of the additional lines to be added.
line.col	<b>character</b> or <b>numeric</b> : colour of the additional lines.
line.label	<b>character</b> : labels for the additional lines.
output	<b>logical</b> : Optional output of numerical plot parameters. These can be useful to reproduce similar plots. Default is FALSE.
...	Further plot arguments to pass. xlab must be a vector of length 2, specifying the upper and lower x-axes labels.

## Details

Details and the theoretical background of the radial plot are given in the cited literature. This function is based on an S script of Rex Galbraith. To reduce the manual adjustments, the function has been rewritten. Thanks to Rex Galbraith for useful comments on this function. Plotting can be disabled by adding the argument `plot = "FALSE"`, e.g. to return only numeric plot output.

Earlier versions of the Radial Plot in this package had the 2-sigma-bar drawn onto the z-axis. However, this might have caused misunderstanding in that the 2-sigma range may also refer to the

z-scale, which it does not! Rather it applies only to the x-y-coordinate system (standardised error vs. precision). A spread in doses or ages must be drawn as lines originating at zero precision (x0) and zero standardised estimate (y0). Such a range may be drawn by adding lines to the radial plot ( `line`, `line.col`, `line.label`, cf. examples).

A statistic summary, i.e. a collection of statistic measures of centrality and dispersion (and further measures) can be added by specifying one or more of the following keywords:

- "n" (number of samples),
- "mean" (mean De value),
- "mean.weighted" (error-weighted mean),
- "median" (median of the De values),
- "sdrel" (relative standard deviation in percent),
- "sdrel.weighted" (error-weighted relative standard deviation in percent),
- "sdabs" (absolute standard deviation),
- "sdabs.weighted" (error-weighted absolute standard deviation),
- "serel" (relative standard error),
- "serel.weighted" (error-weighted relative standard error),
- "seabs" (absolute standard error),
- "seabs.weighted" (error-weighted absolute standard error),
- "in.2s" (percent of samples in 2-sigma range),
- "kurtosis" (kurtosis) and
- "skewness" (skewness).

### Value

Returns a plot object.

### Function version

0.5.9

### Author(s)

Michael Dietze, GFZ Potsdam (Germany)  
 Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 Based on a rewritten S script of Rex Galbraith, 2010 , RLum Developer Team

### References

- Galbraith, R.F., 1988. Graphical Display of Estimates Having Differing Standard Errors. *Technometrics*, 30 (3), 271-281.
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### See Also

[plot](#), [plot\\_KDE](#), [plot\\_Histogram](#), [plot\\_AbanicoPlot](#)

### Examples

```
## load example data
data(ExampleData.DeValues, envir = environment())
ExampleData.DeValues <- Second2Gray(
  ExampleData.DeValues$BT998, c(0.0438, 0.0019))

## plot the example data straightforward
plot_RadialPlot(data = ExampleData.DeValues)

## now with linear z-scale
plot_RadialPlot(
  data = ExampleData.DeValues,
  log.z = FALSE)

## now with output of the plot parameters
plot1 <- plot_RadialPlot(
  data = ExampleData.DeValues,
  log.z = FALSE,
  output = TRUE)
plot1
plot1$zlim

## now with adjusted z-scale limits
plot_RadialPlot(
  data = ExampleData.DeValues,
  log.z = FALSE,
  zlim = c(100, 200))

## now the two plots with serious but seasonally changing fun
#plot_RadialPlot(data = data.3, fun = TRUE)

## now with user-defined central value, in log-scale again
plot_RadialPlot(
  data = ExampleData.DeValues,
  central.value = 150)

## now with a rug, indicating individual De values at the z-scale
plot_RadialPlot(
  data = ExampleData.DeValues,
  rug = TRUE)
```

```

## now with legend, colour, different points and smaller scale
plot_RadialPlot(
  data = ExampleData.DeValues,
  legend.text = "Sample 1",
  col = "tomato4",
  bar.col = "peachpuff",
  pch = "R",
  cex = 0.8)

## now without 2-sigma bar, y-axis, grid lines and central value line
plot_RadialPlot(
  data = ExampleData.DeValues,
  bar.col = "none",
  grid.col = "none",
  y.ticks = FALSE,
  lwd = 0)

## now with user-defined axes labels
plot_RadialPlot(
  data = ExampleData.DeValues,
  xlab = c("Data error (%)", "Data precision"),
  ylab = "Scatter",
  zlab = "Equivalent dose [Gy]")

## now with minimum, maximum and median value indicated
plot_RadialPlot(
  data = ExampleData.DeValues,
  central.value = 150,
  stats = c("min", "max", "median"))

## now with a brief statistical summary
plot_RadialPlot(
  data = ExampleData.DeValues,
  summary = c("n", "in.2s"))

## now with another statistical summary as subheader
plot_RadialPlot(
  data = ExampleData.DeValues,
  summary = c("mean.weighted", "median"),
  summary.pos = "sub")

## now the data set is split into sub-groups, one is manipulated
data.1 <- ExampleData.DeValues[1:15,]
data.2 <- ExampleData.DeValues[16:25,] * 1.3

## now a common dataset is created from the two subgroups
data.3 <- list(data.1, data.2)

## now the two data sets are plotted in one plot
plot_RadialPlot(data = data.3)

## now with some graphical modification
plot_RadialPlot(
  data = data.3,
  col = c("darkblue", "darkgreen"),
  bar.col = c("lightblue", "lightgreen"),
  pch = c(2, 6),

```

```
summary = c("n", "in.2s"),
summary.pos = "sub",
legend = c("Sample 1", "Sample 2"))
```

---

plot\_Risoe.BINfileData

*Plot single luminescence curves from a BIN file object*


---

## Description

Plots single luminescence curves from an object returned by the [read\\_BIN2R](#) function.

## Usage

```
plot_Risoe.BINfileData(
  BINfileData,
  position,
  run,
  set,
  sorter = "POSITION",
  ltype = c("IRSL", "OSL", "TL", "RIR", "RBR", "RL"),
  curve.transformation,
  dose_rate,
  temp.lab,
  cex.global = 1,
  ...
)
```

## Arguments

- |                      |  |
|----------------------|--|
| BINfileData          | <a href="#">Risoe.BINfileData</a> ( <b>required</b> ): requires an S4 object returned by the <a href="#">read_BIN2R</a> function.  |
| position             | <a href="#">vector</a> ( <i>optional</i> ): option to limit the plotted curves by position (e.g. position = 1, position = c(1,3,5)).   |
| run                  | <a href="#">vector</a> ( <i>optional</i> ): option to limit the plotted curves by run (e.g., run = 1, run = c(1,3,5)).   |
| set                  | <a href="#">vector</a> ( <i>optional</i> ): option to limit the plotted curves by set (e.g., set = 1, set = c(1,3,5)).   |
| sorter               | <a href="#">character</a> ( <i>with default</i> ): the plot output can be ordered by "POSITION", "SET" or "RUN". POSITION, SET and RUN are options defined in the Risoe Sequence Editor.   |
| ltype                | <a href="#">character</a> ( <i>with default</i> ): option to limit the plotted curves by the type of luminescence stimulation. Allowed values: "IRSL", "OSL", "TL", "RIR", "RBR" (corresponds to LM-OSL), "RL". All type of curves are plotted by default. |
| curve.transformation | <a href="#">character</a> ( <i>optional</i> ): allows transforming CW-OSL and CW-IRSL curves to pseudo-LM curves via transformation functions. Allowed values are: CW2pLM, CW2pLMi, CW2pHMi and CW2pPMi. See details.                                      |

dose_rate	<b>numeric</b> ( <i>optional</i> ): dose rate of the irradiation source at the measurement date. If set, the given irradiation dose will be shown in Gy. See details.
temp.lab	<b>character</b> ( <i>optional</i> ): option to allow for different temperature units. If no value is set deg. C is chosen.
cex.global	<b>numeric</b> ( <i>with default</i> ): global scaling factor.
...	further undocumented plot arguments.

## Details

### Nomenclature

See [Risoe.BINfileData](#)

### curve.transformation

This argument allows transforming continuous wave (CW) curves to pseudo (linear) modulated curves. For the transformation, the functions of the package are used. Currently, it is not possible to pass further arguments to the transformation functions. The argument works only for 1 type OSL and IRSL.

### Irradiation time

Plotting the irradiation time (s) or the given dose (Gy) requires that the variable IRR\_TIME has been set within the BIN-file. This is normally done by using the 'Run Info' option within the Sequence Editor or by editing in R.

## Value

Returns a plot.

## Function version

0.4.1

## Note

The function has been successfully tested for the Sequence Editor file output version 3 and 4.

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

## References

Duller, G., 2007. Analyst. pp. 1-45.

## See Also

[Risoe.BINfileData](#), [read\\_BIN2R](#), [CW2pLM](#), [CW2pLMi](#), [CW2pPMi](#), [CW2pHMi](#)

## Examples

```
##load data
data(ExampleData.BINfileData, envir = environment())

##plot all curves from the first position to the desktop
#pdf(file = "~/Desktop/CurveOutput.pdf", paper = "a4", height = 11, onefile = TRUE)

##example - load from *.bin file
#BINfile<- file.choose()
#BINfileData<-read_BIN2R(BINfile)

#par(mfrow = c(4,3), oma = c(0.5,1,0.5,1))
#plot_Risoe.BINfileData(CWOSL.SAR.Data,position = 1)
#mtext(side = 4, BINfile, outer = TRUE, col = "blue", cex = .7)
#dev.off()
```

---

plot\_RLum

General plot function for RLum S4 class objects

---

## Description

Function calls object specific plot functions for RLum S4 class objects.

## Usage

```
plot_RLum(object, ...)
```

## Arguments

object	<b>RLum (required):</b> S4 object of class RLum. Optional a <a href="#">list</a> containing objects of class <a href="#">RLum</a> can be provided. In this case the function tries to plot every object in this list according to its RLum class. Non-RLum objects are removed.
...	further arguments and graphical parameters that will be passed to the specific plot functions. The only argument that is supported directly is main (setting the plot title). In contrast to the normal behaviour main can be here provided as <a href="#">list</a> and the arguments in the list will dispatched to the plots if the object is of type list as well.

## Details

The function provides a generalised access point for plotting specific [RLum](#) objects. Depending on the input object, the corresponding plot function will be selected. Allowed arguments can be found in the documentations of each plot function.

object	corresponding plot function
<a href="#">RLum.Data.Curve</a>	: <a href="#">plot_RLum.Data.Curve</a>
<a href="#">RLum.Data.Spectrum</a>	: <a href="#">plot_RLum.Data.Spectrum</a>
<a href="#">RLum.Data.Image</a>	: <a href="#">plot_RLum.Data.Image</a>
<a href="#">RLum.Analysis</a>	: <a href="#">plot_RLum.Analysis</a>
<a href="#">RLum.Results</a>	: <a href="#">plot_RLum.Results</a>

**Value**

Returns a plot.

**Function version**

0.4.4

**Note**

The provided plot output depends on the input object.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[plot\\_RLum.Data.Curve](#), [RLum.Data.Curve](#), [plot\\_RLum.Data.Spectrum](#), [RLum.Data.Spectrum](#), [plot\\_RLum.Data.Image](#), [RLum.Data.Image](#), [plot\\_RLum.Analysis](#), [RLum.Analysis](#), [plot\\_RLum.Results](#), [RLum.Results](#)

**Examples**

```
#load Example data
data(ExampleData.CW_OSL_Curve, envir = environment())

#transform data.frame to RLum.Data.Curve object
temp <- as(ExampleData.CW_OSL_Curve, "RLum.Data.Curve")

#plot RLum object
plot_RLum(temp)
```

---

plot_RLum.Analysis	<i>Plot function for an RLum.Analysis S4 class object</i>
--------------------	---

---

**Description**

The function provides a standardised plot output for curve data of an RLum.Analysis S4 class object

**Usage**

```
plot_RLum.Analysis(
  object,
  subset = NULL,
  nrows,
  ncols,
  abline = NULL,
  combine = FALSE,
  records_max = NULL,
  curve.transformation,
  plot.single = FALSE,
  ...
)
```



**Arguments**

object	<a href="#">RLum.Analysis</a> ( <b>required</b> ): S4 object of class <code>RLum.Analysis</code>
subset	named <a href="#">list</a> ( <i>optional</i> ): subsets elements for plotting. The arguments in the named <a href="#">list</a> will be directly passed to the function <a href="#">get_RLum</a> (e.g., <code>subset = list(curveType = "measured")</code> )
nrows	<a href="#">integer</a> ( <i>optional</i> ): sets number of rows for plot output, if nothing is set the function tries to find a value.
ncols	<a href="#">integer</a> ( <i>optional</i> ): sets number of columns for plot output, if nothing is set the function tries to find a value.
abline	<a href="#">list</a> ( <i>optional</i> ): allows to add ab-lines to the plot. Argument are provided in a list and will be forward to the function <a href="#">abline</a> , e.g., <code>list(v = c(10, 100))</code> adds two vertical lines add 10 and 100 to all plots. In contrast <code>list(v = c(10), v = c(100))</code> adds a vertical at 10 to the first and a vertical line at 100 to the 2nd plot.
combine	<a href="#">logical</a> ( <i>with default</i> ): allows to combine all <a href="#">RLum.Data.Curve</a> objects in one single plot.
records_max	<a href="#">numeric</a> ( <i>optional</i> ): limits number of records shown if <code>combine = TRUE</code> . Shown are always the first and the last curve, the other number of curves to be shown a distributed evenly, this may result in less number of curves plotted as specified. This parameter has only an effect for <code>n &gt; 2</code> .
curve.transformation	<a href="#">character</a> ( <i>optional</i> ): allows transforming CW-OSL and CW-IRSL curves to pseudo-LM curves via transformation functions. Allowed values are: <code>CW2pLM</code> , <code>CW2pLMi</code> , <code>CW2pHMi</code> and <code>CW2pPMi</code> . See details.
plot.single	<a href="#">logical</a> ( <i>with default</i> ): global par settings are considered, normally this should end in one plot per page
...	further arguments and graphical parameters will be passed to the plot function. Supported arguments: <code>main</code> , <code>mtext</code> , <code>log</code> , <code>lwd</code> , <code>lty</code> type, <code>pch</code> , <code>col</code> , <code>norm</code> (see <a href="#">plot_RLum.Data.Curve</a> ), <code>xlim</code> , <code>ylim</code> , <code>xlab</code> , <code>ylab</code> , ... and for <code>combine = TRUE</code> also: <code>sub_title</code> , <code>legend</code> , <code>legend.text</code> , <code>legend.pos</code> (typical plus 'outside'), <code>legend.col</code> , <code>smooth</code> . All arguments can be provided as vector or list to gain in full control of all plot settings.

**Details**

The function produces a multiple plot output. A file output is recommended (e.g., [pdf](#)).

**curve.transformation**

This argument allows transforming continuous wave (CW) curves to pseudo (linear) modulated curves. For the transformation, the functions of the package are used. Currently, it is not possible to pass further arguments to the transformation functions. The argument works only for 1type OSL and IRSL.

Please note: The curve transformation within this functions works roughly, i.e. every IRSL or OSL curve is transformed, without considering whether it is measured with the PMT or not! However, for a fast look it might be helpful.

**Value**

Returns multiple plots.

**Function version**

0.3.14

**Note**

Not all arguments available for [plot](#) will be passed and they partly do not behave in the way you might expect them to work. This function was designed to serve as an overview plot, if you want to have more control, extract the objects and plot them individually.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[plot](#), [plot\\_RLum](#), [plot\\_RLum.Data.Curve](#)

**Examples**

```
##load data
data(ExampleData.BINfileData, envir = environment())

##convert values for position 1
temp <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos=1)

##(1) plot (combine) TL curves in one plot
plot_RLum.Analysis(
  temp,
  subset = list(recordType = "TL"),
  combine = TRUE,
  norm = TRUE,
  abline = list(v = c(110))
)

##(2) same as example (1) but using
## the argument smooth = TRUE
plot_RLum.Analysis(
  temp,
  subset = list(recordType = "TL"),
  combine = TRUE,
  norm = TRUE,
  smooth = TRUE,
  abline = list(v = c(110))
)
```

---

plot\_RLum.Data.Curve    *Plot function for an RLum.Data.Curve S4 class object*

---

**Description**

The function provides a standardised plot output for curve data of an RLum.Data.Curve S4-class object.

**Usage**

```
plot_RLum.Data.Curve(
  object,
  par.local = TRUE,
  norm = FALSE,
  smooth = FALSE,
  ...
)
```

**Arguments**

object	<a href="#">RLum.Data.Curve</a> ( <b>required</b> ): S4 object of class <code>RLum.Data.Curve</code>
par.local	<a href="#">logical</a> ( <i>with default</i> ): use local graphical parameters for plotting, e.g. the plot is shown in one column and one row. If <code>par.local = FALSE</code> , global parameters are inherited.
norm	<a href="#">logical character</a> ( <i>with default</i> ): allows curve normalisation to the highest count value ('default'). Alternatively, the function offers the modes "max", "min" and "huot" for a background corrected normalisation, see details.
smooth	<a href="#">logical</a> ( <i>with default</i> ): provides an automatic curve smoothing based on <a href="#">zoo::rollmean</a>
...	further arguments and graphical parameters that will be passed to the <code>plot</code> function

**Details**

Only single curve data can be plotted with this function. Arguments according to [plot](#).

**Curve normalisation**

The argument `norm` normalises all count values, to date the following options are supported:

`norm = TRUE` or `norm = "max"`: Curve values are normalised to the highest count value in the curve

`norm = "last"`: Curves values are normalised to the last count value (this can be useful in particular for radiofluorescence curves)

`norm = "huot"`: Curve values are normalised as suggested by Sébastien Huot via GitHub:

$$y = (\text{observed} - \text{median}(\text{background})) / (\text{max}(\text{observed}) - \text{median}(\text{background}))$$

The background of the curve is defined as the last 20 % of the count values of a curve.

**Value**

Returns a plot.

**Function version**

0.2.6

**Note**

Not all arguments of [plot](#) will be passed!

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[plot](#), [plot\\_RLum](#)

**Examples**

```
##plot curve data

#load Example data
data(ExampleData.CW_OSL_Curve, envir = environment())

#transform data.frame to RLum.Data.Curve object
temp <- as(ExampleData.CW_OSL_Curve, "RLum.Data.Curve")

#plot RLum.Data.Curve object
plot_RLum.Data.Curve(temp)
```

---

`plot_RLum.Data.Image` *Plot function for an RLum.Data.Image S4 class object*

---

**Description**

The function provides very basic plot functionality for image data of an [RLum.Data.Image](#) object. For more sophisticated plotting it is recommended to use other very powerful packages for image processing.

**Details on the plot functions**

Supported plot types:

`plot.type = "plot.raster"`

Uses the standard plot function of R [graphics::image](#). If wanted, the image is enhanced, using the argument `stretch`. Possible values are `hist`, `lin`, and `NULL`. The latter does nothing. The argument `useRaster = TRUE` is used by default, but can be set to `FALSE`.

`plot.type = "contour"`

This uses the function [graphics::contour](#)

**Usage**

```
plot_RLum.Data.Image(  
  object,  
  frames = NULL,  
  par.local = TRUE,  
  plot.type = "plot.raster",  
  ...  
)
```

**Arguments**

object	<a href="#">RLum.Data.Image</a> ( <b>required</b> ): S4 object of class <code>RLum.Data.Image</code>
frames	<a href="#">numeric</a> ( <i>optional</i> ): sets the frames to be set, by default all frames are plotted. Can be sequence of numbers, as long as the frame number is valid.
par.local	<a href="#">logical</a> ( <i>with default</i> ): use local graphical parameters for plotting, e.g. the plot is shown in one column and one row. If <code>par.local = FALSE</code> global parameters are inherited.
plot.type	<a href="#">character</a> ( <i>with default</i> ): plot types. Supported types are <code>plot.raster</code> , <code>contour</code>
...	further arguments and graphical parameters that will be passed to the specific plot functions. Standard supported parameters are <code>xlim</code> , <code>ylim</code> , <code>zlim</code> , <code>xlab</code> , <code>ylab</code> , <code>main</code> , <code>legend</code> (TRUE or FALSE), <code>col</code> , <code>cex</code> , <code>axes</code> (TRUE or FALSE), <code>zlim_image</code> (adjust the z-scale over different images), <code>stretch</code>

**Value**

Returns a plot

**Function version**

0.2.1

**Note**

The axes limitations (`xlim`, `zlim`, `zlim`) work directly on the object, so that regardless of the chosen limits the image parameters can be adjusted for best visibility. However, in particular for z-scale limitations this is not always wanted, please use `zlim_image` to maintain a particular value range over a series of images.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Image](#), [plot](#), [plot\\_RLum](#), [graphics::image](#), [graphics::contour](#)

**Examples**

```
##load data
data(ExampleData.RLum.Data.Image, envir = environment())

##plot data
plot_RLum.Data.Image(ExampleData.RLum.Data.Image)
```

---

plot\_RLum.Data.Spectrum

*Plot function for an RLum.Data.Spectrum S4 class object*


---

## Description

The function provides a standardised plot output for spectrum data of an [RLum.Data.Spectrum](#) class object. The purpose of this function is to provide easy and straight-forward spectra plotting, not provide a full customised access to all plot parameters. If this is wanted, standard R plot functionality should be used instead.

### Matrix structure

(cf. [RLum.Data.Spectrum](#))

- rows (x-values): wavelengths/channels (xlim, xlab)
- columns (y-values): time/temperature (ylim, ylab)
- cells (z-values): count values (zlim, zlab)

*Note: This nomenclature is valid for all plot types of this function!*

### Nomenclature for value limiting

- xlim: Limits values along the wavelength axis
- ylim: Limits values along the time/temperature axis
- zlim: Limits values along the count value axis

### Details on the plot functions

Spectrum is visualised as 3D or 2D plot. Both plot types are based on internal R plot functions.

plot.type = "persp"

Arguments that will be passed to [graphics::persp](#):

- shade: default is 0.4
- phi: default is 15
- theta: default is -30
- expand: default is 1
- axes: default is TRUE
- box: default is TRUE; accepts "alternate" for a custom plot design
- ticktype: default is detailed, r: default is 10

**Note:** Further parameters can be adjusted via par. For example to set the background transparent and reduce the thickness of the lines use: par(bg = NA, lwd = 0.7) previous the function call.

plot.type = "single"

Per frame a single curve is returned. Frames are time or temperature steps.

-frames: pick the frames to be plotted (depends on the binning!). Check without this setting before plotting.

plot.type = "multiple.lines"

All frames plotted in one frame.

-frames: pick the frames to be plotted (depends on the binning!). Check without this setting before plotting.

```
##plot.type = "image" or 'plot.type = "contour" ##
```

These plot types use the R functions `graphics::image` or `graphics::contour`. The advantage is that many plots can be arranged conveniently using standard R plot functionality. If `plot.type = "image"` a contour is added by default, which can be disabled using the argument `contour = FALSE` to add own contour lines of choice.

```
plot.type = "transect"
```

Depending on the selected wavelength/channel range a transect over the time/temperature (y-axis) will be plotted along the wavelength/channels (x-axis). If the range contains more than one channel, values (z-values) are summed up. To select a transect use the `xlim` argument, e.g. `xlim = c(300, 310)` plot along the summed up count values of channel 300 to 310.

#### Further arguments that will be passed (depending on the plot type)

```
xlab, ylab, zlab, xlim, ylim, box, zlim, main, mtext, pch, type ("single", "multiple.lines",
"interactive"), col, border, lwd, bty, showscale ("interactive", "image") contour, contour.col
("image")
```

### Usage

```
plot_RLum.Data.Spectrum(
  object,
  par.local = TRUE,
  plot.type = "contour",
  optical.wavelength.colours = TRUE,
  bg.spectrum = NULL,
  bg.channels = NULL,
  bin.rows = 1,
  bin.cols = 1,
  norm = NULL,
  rug = TRUE,
  limit_counts = NULL,
  xaxis.energy = FALSE,
  legend.text,
  plot = TRUE,
  ...
)
```

### Arguments

- |           |   |
|-----------|---|
| object    | <code>RLum.Data.Spectrum</code> or <b>matrix (required)</b> : S4 object of class <code>RLum.Data.Spectrum</code> or a matrix containing count values of the spectrum.<br>Please note that in case of a matrix row names and col names are set automatically if not provided.  |
| par.local | <b>logical</b> (with default): use local graphical parameters for plotting, e.g. the plot is shown in one column and one row. If <code>par.local = FALSE</code> global parameters are inherited.  |
| plot.type | <b>character</b> (with default): plot type, for 3D-plot use <code>persp</code> , or <code>interactive</code> , for a 2D-plot <code>image</code> , <code>contour</code> , <code>single</code> or <code>multiple.lines</code> (along the time or temperature axis) or <code>transect</code> (along the wavelength axis) |

optical.wavelength.colours	<b>logical</b> ( <i>with default</i> ): use optical wavelength colour palette. Note: For this, the spectrum range is limited: c(350,750). Own colours can be set with the argument col. If you provide already binned spectra, the colour assignment is likely to be wrong, since the colour gradients are calculated using the bin number.
bg.spectrum	<b>RLum.Data.Spectrum</b> or <b>matrix</b> ( <i>optional</i> ): Spectrum used for the background subtraction. By definition, the background spectrum should have been measured with the same setting as the signal spectrum. If a spectrum is provided, the argument bg.channels works only on the provided background spectrum.
bg.channels	<b>vector</b> ( <i>optional</i> ): defines channel for background subtraction. If a vector is provided the mean of the channels is used for subtraction. If a spectrum is provided via bg.spectrum, this argument only works on the bg.spectrum. <b>Note:</b> Background subtraction is applied prior to channel binning
bin.rows	<b>integer</b> ( <i>with default</i> ): allow summing-up wavelength channels (horizontal binning), e.g. bin.rows = 2 two channels are summed up. Binning is applied after the background subtraction.
bin.cols	<b>integer</b> ( <i>with default</i> ): allow summing-up channel counts (vertical binning) for plotting, e.g. bin.cols = 2 two channels are summed up. Binning is applied after the background subtraction.
norm	<b>character</b> ( <i>optional</i> ): Normalise data to the maximum (norm = "max") or minimum (norm = "min") count values. The normalisation is applied after the binning.
rug	<b>logical</b> ( <i>with default</i> ): enables or disables colour rug. Currently only implemented for plot type multiple.lines and single
limit_counts	<b>numeric</b> ( <i>optional</i> ): value to limit all count values to this value, i.e. all count values above this threshold will be replaced by this threshold. This is helpful especially in case of TL-spectra.
xaxis.energy	<b>logical</b> ( <i>with default</i> ): enables or disables energy instead of wavelength axis. For the conversion the function <b>convert_Wavelength2Energy</b> is used. <b>Note:</b> This option means not only simply redrawing the axis, instead the spectrum in terms of intensity is recalculated, s. details.
legend.text	<b>character</b> ( <i>with default</i> ): possibility to provide own legend text. This argument is only considered for plot types providing a legend, e.g. plot.type="transect"
plot	<b>logical</b> ( <i>with default</i> ): enables/disables plot output. If the plot output is disabled, the <b>matrix</b> used for the plotting and the calculated colour values (as attributes) are returned. This way, the (binned, transformed etc.) output can be used in other functions and packages, such as plotting with the package 'plot3D'
...	further arguments and graphical parameters that will be passed to the plot function.

### Value

Returns a plot and the transformed matrix used for plotting with some useful attributes such as the colour and pmat (the transpose matrix from **graphics::persp**)

### Function version

0.6.8



**Note**

Not all additional arguments (...) will be passed similarly!

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Spectrum](#), [convert\\_Wavelength2Energy](#), [plot](#), [plot\\_RLum](#), [graphics::persp](#), [plotly::plot\\_ly](#), [graphics::contour](#), [graphics::image](#)

**Examples**

```
##load example data
data(ExampleData.XSYG, envir = environment())

##(1)plot simple spectrum (2D) - image
plot_RLum.Data.Spectrum(
  TL.Spectrum,
  plot.type="image",
  xlim = c(310,750),
  ylim = c(0,300),
  bin.rows=10,
  bin.cols = 1)

##(2) plot spectrum (3D)
plot_RLum.Data.Spectrum(
  TL.Spectrum,
  plot.type="persp",
  xlim = c(310,750),
  ylim = c(0,100),
  bin.rows=10,
  bin.cols = 1)

##(3) plot spectrum on energy axis
##please note the background subtraction
plot_RLum.Data.Spectrum(TL.Spectrum,
  plot.type="persp",
  ylim = c(0,200),
  bin.rows=10,
  bg.channels = 10,
  bin.cols = 1,
  xaxis.energy = TRUE)

##(4) plot multiple lines (2D) - multiple.lines (with ylim)
plot_RLum.Data.Spectrum(
  TL.Spectrum,
  plot.type="multiple.lines",
  xlim = c(310,750),
  ylim = c(0,100),
  bin.rows=10,
  bin.cols = 1)

## Not run:
```

```

##(4) interactive plot using the package plotly ("surface")
plot_RLum.Data.Spectrum(TL.Spectrum, plot.type="interactive",
xlim = c(310,750), ylim = c(0,300), bin.rows=10,
bin.cols = 1)

##(5) interactive plot using the package plotly ("contour")
plot_RLum.Data.Spectrum(TL.Spectrum, plot.type="interactive",
xlim = c(310,750), ylim = c(0,300), bin.rows=10,
bin.cols = 1,
type = "contour",
showscale = TRUE)

##(6) interactive plot using the package plotly ("heatmap")
plot_RLum.Data.Spectrum(TL.Spectrum, plot.type="interactive",
xlim = c(310,750), ylim = c(0,300), bin.rows=10,
bin.cols = 1,
type = "heatmap",
showscale = TRUE)

## End(Not run)

```

---

plot\_RLum.Results

---

*Plot function for an RLum.Results S4 class object*


---

## Description

The function provides a standardised plot output for data of an RLum.Results S4 class object

## Usage

```
plot_RLum.Results(object, single = TRUE, ...)
```

## Arguments

object	<a href="#">RLum.Results</a> ( <b>required</b> ): S4 object of class RLum.Results
single	<a href="#">logical</a> ( <i>with default</i> ): single plot output (TRUE/FALSE) to allow for plotting the results in as few plot windows as possible.
...	further arguments and graphical parameters will be passed to the plot function.

## Details

The function produces a multiple plot output. A file output is recommended (e.g., [pdf](#)).

## Value

Returns multiple plots.

## Function version

0.2.1

**Note**

Not all arguments available for [plot](#) will be passed! Only plotting of `RLum.Results` objects are supported.

**Author(s)**

Christoph Burow, University of Cologne (Germany)  
 Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , `RLum` Developer Team

**See Also**

[plot](#), [plot\\_RLum](#)

**Examples**

```
###load data
data(ExampleData.DeValues, envir = environment())

# apply the un-logged minimum age model
mam <- calc_MinDose(data = ExampleData.DeValues$CA1, sigmab = 0.2, log = TRUE, plot = FALSE)

##plot
plot_RLum.Results(mam)

# estimate the number of grains on an aliquot
grains<- calc_AliquotSize(grain.size = c(100,150), sample.diameter = 1, plot = FALSE, MC.iter = 100)

##plot
plot_RLum.Results(grains)
```

---

plot\_ROI

---

*Create Regions of Interest (ROI) Graphic*


---

**Description**

Create ROI graphic with data extracted from the data imported via [read\\_RF2R](#). This function is used internally by [analyse\\_IRSAR.RF](#) but might be of use to work with reduced data from spatially resolved measurements. The plot dimensions mimic the original image dimensions

**Usage**

```
plot_ROI(
  object,
  exclude_ROI = c(1),
  dist_thre = -Inf,
  dim.CCD = NULL,
  bg_image = NULL,
  plot = TRUE,
  ...
)
```

## Arguments

object	<a href="#">RLum.Analysis</a> , <a href="#">RLum.Results</a> or a <a href="#">list</a> of such objects ( <b>required</b> ): data input. Please note that to avoid function errors, only input created by the functions <a href="#">read_RF2R</a> or <a href="#">extract_ROI</a> is accepted
exclude_ROI	<a href="#">numeric</a> ( <i>with default</i> ): option to remove particular ROIs from the analysis. Those ROIs are plotted but not coloured and not taken into account in distance analysis. NULL excludes nothing.
dist_thre	<a href="#">numeric</a> ( <i>optional</i> ): euclidean distance threshold in pixel distance. All ROI for which the euclidean distance is smaller are marked. This helps to identify ROIs that might be affected by signal cross-talk. Note: the distance is calculated from the centre of an ROI, e.g., the threshold should include consider the ROIs or grain radius.
dim.CCD	<a href="#">numeric</a> ( <i>optional</i> ): metric x and y for the recorded (chip) surface in $\mu\text{m}$ . For instance c(8192,8192), if set additional x and y-axes are shown
bg_image	<a href="#">RLum.Data.Image</a> ( <i>optional</i> ): background image object please note that the dimensions are not checked.
plot	<a href="#">logical</a> ( <i>with default</i> ): enable or disable plot output to use the function only to extract the ROI data
...	further parameters to manipulate the plot. On top of all arguments of <a href="#">graphics::plot.default</a> the following arguments are supported: <code>lwd.ROI</code> , <code>lty.ROI</code> , <code>col.ROI</code> , <code>col.pixel</code> , <code>text.labels</code> , <code>text.offset</code> , <code>grid(TRUE/FALSE)</code> , <code>legend(TRUE/FALSE)</code> , <code>legend.text</code> , <code>legend.pos</code>

## Value

An ROI plot and an [RLum.Results](#) object with a matrix containing the extracted ROI data and a object produced by [stats::dist](#) containing the euclidean distance between the ROIs.

## Function version

0.2.0

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## See Also

[read\\_RF2R](#), [analyse\\_IRSAR.RF](#)

## Examples

```
## simple example
file <- system.file("extdata", "RF_file.rf", package = "Luminescence")
temp <- read_RF2R(file)
plot_ROI(temp)

## in combination with extract_ROI()
m <- matrix(runif(100,0,255), ncol = 10, nrow = 10)
roi <- matrix(c(2.,4,2,5,6,7,3,1,1), ncol = 3)
t <- extract_ROI(object = m, roi = roi)
```

```
plot_ROI(t, bg_image = m)
```

---

plot_ViolinPlot	Create a violin plot
-----------------	----------------------

---

## Description

Draws a kernel density plot in combination with a boxplot in its middle. The shape of the violin is constructed using a mirrored density curve. This plot is especially designed for cases where the individual errors are zero or too small to be visualised. The idea for this plot is based on the 'volcano plot' in the ggplot2 package by Hadley Wickham and Winston Chang. The general idea for the violin plot seems to be introduced by Hintze and Nelson (1998).

The function is passing several arguments to the function [plot](#), [stats::density](#), [graphics::boxplot](#):

Supported arguments are: xlim, main, xlab, ylab, col.violin, col.boxplot, mtext, cex, mtext  
Valid summary keywords

'n', 'mean', 'median', 'sd.abs', 'sd.rel', 'se.abs', 'se.rel', 'skewness', 'kurtosis'

## Usage

```
plot_ViolinPlot(
  data,
  boxplot = TRUE,
  rug = TRUE,
  summary = NULL,
  summary.pos = "sub",
  na.rm = TRUE,
  ...
)
```

## Arguments

data	<a href="#">numeric</a> or <a href="#">RLum.Results</a> ( <b>required</b> ): input data for plotting. Alternatively a <a href="#">data.frame</a> or a <a href="#">matrix</a> can be provided, but only the first column will be considered by the function
boxplot	<a href="#">logical</a> ( <i>with default</i> ): enable or disable boxplot
rug	<a href="#">logical</a> ( <i>with default</i> ): enable or disable rug
summary	<a href="#">character</a> ( <i>optional</i> ): add statistic measures of centrality and dispersion to the plot. Can be one or more of several keywords. See details for available keywords.
summary.pos	<a href="#">numeric</a> or <a href="#">character</a> ( <i>with default</i> ): optional position keywords (cf. <a href="#">legend</a> ) for the statistical summary. Alternatively, the keyword "sub" may be specified to place the summary below the plot header. However, this latter option is only possible if mtext is not used.
na.rm	<a href="#">logical</a> ( <i>with default</i> ): exclude NA values from the data set prior to any further operations.
...	further arguments and graphical parameters passed to <a href="#">plot.default</a> , <a href="#">stats::density</a> and <a href="#">boxplot</a> . See details for further information

**Function version**

0.1.4

**Note**

Although the code for this function was developed independently and just the idea for the plot was based on the 'ggplot2' package plot type 'volcano', it should be mentioned that, beyond this, two other R packages exist providing a possibility to produce this kind of plot, namely: 'vioplot' and 'violinmplot' (see references for details).

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Daniel Adler (2005). vioplot: A violin plot is a combination of a box plot and a kernel density plot. R package version 0.2 <http://CRAN.R-project.org/package=vioplot>

Hintze, J.L., Nelson, R.D., 1998. A Box Plot-Density Trace Synergism. The American Statistician 52, 181-184.

Raphael W. Majeed (2012). violinmplot: Combination of violin plot with mean and standard deviation. R package version 0.2.1. <http://CRAN.R-project.org/package=violinmplot>

Wickham. H (2009). ggplot2: elegant graphics for data analysis. Springer New York.

**See Also**

[stats::density](#), [plot](#), [boxplot](#), [rug](#), [calc\\_Statistics](#)

**Examples**

```
## read example data set
data(ExampleData.DeValues, envir = environment())
ExampleData.DeValues <- Second2Gray(ExampleData.DeValues$BT998, c(0.0438,0.0019))

## create plot straightforward
plot_ViolinPlot(data = ExampleData.DeValues)
```

---

PSL2Risoe.BINfileData *Convert portable OSL data to an Risoe.BINfileData object*

---

**Description**

Converts an RLum.Analysis object produced by the function read\_PSL2R() to an Risoe.BINfileData object (**BETA**).

**Usage**

```
PSL2Risoe.BINfileData(object, ...)
```

## Arguments

object            [RLum.Analysis](#) (**required**): [RLum.Analysis](#) object produced by [read\\_PSL2R](#)  
...                currently not used.

## Details

This function converts an [RLum.Analysis](#) object that was produced by the [read\\_PSL2R](#) function to an [Risoe.BINfileData](#). The [Risoe.BINfileData](#) can be used to write a Risoe BIN file via [write\\_R2BIN](#).

## Value

Returns an S4 [Risoe.BINfileData](#) object that can be used to write a BIN file using [write\\_R2BIN](#).

## Function version

0.0.1

## Author(s)

Christoph Burow, University of Cologne (Germany) , [RLum Developer Team](#)

## See Also

[RLum.Analysis](#), [RLum.Data.Curve](#), [Risoe.BINfileData](#)

## Examples

```
# (1) load and plot example data set
data("ExampleData.portableOSL", envir = environment())
plot_RLum(ExampleData.portableOSL)

# (2) merge all RLum.Analysis objects into one
merged <- merge_RLum(ExampleData.portableOSL)
merged

# (3) convert to RisoeBINfile object
bin <- PSL2Risoe.BINfileData(merged)
bin

# (4) write Risoe BIN file
## Not run:
write_R2BIN(bin, "~/portableOSL.binx")

## End(Not run)
```

read\_BIN2R

*Import Risø BIN/BINX-files into R***Description**

Import a \*.bin or a \*.binx file produced by a Risø DA15 and DA20 TL/OSL reader into R.

**Usage**

```
read_BIN2R(
  file,
  show.raw.values = FALSE,
  position = NULL,
  n.records = NULL,
  zero_data.rm = TRUE,
  duplicated.rm = FALSE,
  fastForward = FALSE,
  show.record.number = FALSE,
  txtProgressBar = TRUE,
  forced.VersionNumber = NULL,
  ignore.RECTYPE = FALSE,
  pattern = NULL,
  verbose = TRUE,
  ...
)
```

**Arguments**

- |                 |  |
|-----------------|--|
| file            | <b>character</b> or <b>list (required)</b> : path and file name of the BIN/BINX file (URLs are supported). If input is a list it should comprise only characters representing each valid path and BIN/BINX-file names. Alternatively the input character can be just a directory (path), in this case the the function tries to detect and import all BIN/BINX files found in the directory. |
| show.raw.values | <b>logical</b> ( <i>with default</i> ): shows raw values from BIN-file for LTYPE, DTYPE and LIGHTSOURCE without translation in characters. Can be provided as list if file is a list.  |
| position        | <b>numeric</b> ( <i>optional</i> ): imports only the selected position. Note: the import performance will not benefit by any selection made here. Can be provided as list if file is a list.   |
| n.records       | <b>numeric</b> ( <i>optional</i> ): limits the number of imported records to the provided record id (e.g., n.records = 1:10 imports the first ten records, while n.records = 3 imports only record number 3. Can be used in combination with show.record.number for debugging purposes, e.g. corrupt BIN-files. Can be provided as list if file is a list.                                   |
| zero_data.rm    | <b>logical</b> ( <i>with default</i> ): remove erroneous data with no count values. As such data are usually not needed for the subsequent data analysis they will be removed by default. Can be provided as list if file is a list.   |



<code>duplicated.rm</code>	<b>logical</b> ( <i>with default</i> ): remove duplicated entries if TRUE. This may happen due to an erroneous produced BIN/BINX-file. This option compares only predecessor and successor. Can be provided as list if file is a list.
<code>fastForward</code>	<b>logical</b> ( <i>with default</i> ): if TRUE for a more efficient data processing only a list of <code>RLum.Analysis</code> objects is returned instead of a <code>Risoe.BINfileData</code> object. Can be provided as list if file is a list.
<code>show.record.number</code>	<b>logical</b> ( <i>with default</i> ): shows record number of the imported record, for debugging usage only. Can be provided as list if file is a list.
<code>txtProgressBar</code>	<b>logical</b> ( <i>with default</i> ): enables or disables <code>txtProgressBar</code> .
<code>forced.VersionNumber</code>	<b>integer</b> ( <i>optional</i> ): allows to cheat the version number check in the function by own values for cases where the BIN-file version is not supported. Can be provided as list if file is a list. <b>Note:</b> The usage is at own risk, only supported BIN-file versions have been tested.
<code>ignore.RECTYPE</code>	<b>logical</b> ( <i>with default</i> ): this argument allows to ignore values in the byte 'RECTYPE' (BIN-file version 08), in case there are not documented or faulty set. In this case the corrupted records are skipped.
<code>pattern</code>	<b>character</b> ( <i>optional</i> ): argument that is used if only a path is provided. The argument will then be passed to the function <code>list.files</code> used internally to construct a list of wanted files
<code>verbose</code>	<b>logical</b> ( <i>with default</i> ): enables or disables verbose mode
<code>...</code>	further arguments that will be passed to the function <code>Risoe.BINfileData2RLum.Analysis</code> . Please note that any matching argument automatically sets <code>fastForward = TRUE</code>

## Details

The binary data file is parsed byte by byte following the data structure published in the Appendices of the Analyst manual p. 42.

For the general BIN/BINX-file structure, the reader is referred to the Risø website: <https://www.fysik.dtu.dk>

## Value

Returns an S4 `Risoe.BINfileData` object containing two slots:

<code>METADATA</code>	A <b>data.frame</b> containing all variables stored in the BIN-file.
<code>DATA</code>	A <b>list</b> containing a numeric <b>vector</b> of the measured data. The ID corresponds to the record ID in <code>METADATA</code> .

If `fastForward = TRUE` a list of `RLum.Analysis` object is returned. The internal coercing is done using the function `Risoe.BINfileData2RLum.Analysis`

## Function version

0.17.0

**Note**

The function works for BIN/BINX-format versions 03, 04, 05, 06, 07 and 08. The version number depends on the used Sequence Editor.

**ROI data sets introduced with BIN-file version 8 are not supported and skipped during import.**

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
Margret C. Fuchs, HZDR Freiberg, (Germany)  
based on information provided by Torben Lapp and Karsten Bracht Nielsen (Risø DTU, Denmark)  
, RLum Developer Team

**References**

DTU Nutech, 2016. The Sequence Editor, Users Manual, February, 2016. <https://www.fysik.dtu.dk>

**See Also**

[write\\_R2BIN](#), [Risoe.BINfileData](#), [base::readBin](#), [merge\\_Risoe.BINfileData](#), [RLum.Analysis](#) [utils::txtProgressBar](#), [list.files](#)

**Examples**

```
file <- system.file("extdata/BINfile_V8.binx", package = "Luminescence")
temp <- read_BIN2R(file)
temp
```

---

read_Daybreak2R	<i>Import measurement data produced by a Daybreak TL/OSL reader into R</i>
-----------------	--

---

**Description**

Import a TXT-file (ASCII file) or a DAT-file (binary file) produced by a Daybreak reader into R. The import of the DAT-files is limited to the file format described for the software TLAPPLIC v.3.2 used for a Daybreak, model 1100.

**Usage**

```
read_Daybreak2R(file, raw = FALSE, verbose = TRUE, txtProgressBar = TRUE, ...)
```

**Arguments**

file	<a href="#">character</a> or <a href="#">list</a> ( <b>required</b> ): path and file name of the file to be imported. Alternatively a list of file names can be provided or just the path a folder containing measurement data. Please note that the specific, common, file extension (txt) is likely leading to function failures during import when just a path is provided.
raw	<a href="#">logical</a> ( <i>with default</i> ): if the input is a DAT-file (binary) a <a href="#">data.table::data.table</a> instead of the <a href="#">RLum.Analysis</a> object can be returned for debugging purposes.

verbose            [logical](#) (*with default*): enables or disables terminal feedback  
 txtProgressBar   [logical](#) (*with default*): enables or disables [txtProgressBar](#).  
 ...                not in use, for compatibility reasons only

### Value

A list of [RLum.Analysis](#) objects (each per position) is provided.

### Function version

0.3.2

### Note

[BETA VERSION] This function still needs to be tested properly. In particular the function has underwent only very rough tests using a few files.

### Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)

Antoine Zink, C2RMF, Palais du Louvre, Paris (France)

The ASCII-file import is based on a suggestion by William Amidon and Andrew Louis Gorin ,  
 RLum Developer Team

### See Also

[RLum.Analysis](#), [RLum.Data.Curve](#), [data.table::data.table](#)

### Examples

```
## Not run:
file <- system.file("extdata/Daybreak_TestFile.txt", package = "Luminescence")
temp <- read_Daybreak2R(file)

## End(Not run)
```

---

read\_PSL2R

---

*Import PSL files to R*


---

### Description

Imports PSL files produced by a SUERC portable OSL reader into R (**BETA**).

### Usage

```
read_PSL2R(
  file,
  drop_bg = FALSE,
  as_decay_curve = TRUE,
  smooth = FALSE,
  merge = FALSE,
  ...
)
```

## Arguments

file	<b>character (required)</b> : path and file name of the PSL file. If input is a vector it should comprise only characters representing valid paths and PSL file names. Alternatively the input character can be just a directory (path). In this case the function tries to detect and import all PSL files found in the directory.
drop_bg	<b>logical (with default)</b> : TRUE to automatically remove all non-OSL/IRSL curves.
as_decay_curve	<b>logical (with default)</b> : Portable OSL Reader curves are often given as cumulative light sum curves. Use TRUE (default) to convert the curves to the more usual decay form.
smooth	<b>logical (with default)</b> : TRUE to apply Tukey's Running Median Smoothing for OSL and IRSL decay curves. Smoothing is encouraged if you see random signal drops within the decay curves related to hardware errors.
merge	<b>logical (with default)</b> : TRUE to merge all <code>RLum.Analysis</code> objects. Only applicable if multiple files are imported.
...	currently not used.

## Details

This function provides an import routine for the SUERC portable OSL Reader PSL format. PSL files are just plain text and can be viewed with any text editor. Due to the formatting of PSL files this import function relies heavily on regular expression to find and extract all relevant information. See **note**.

## Value

Returns an S4 `RLum.Analysis` object containing `RLum.Data.Curve` objects for each curve.

## Function version

0.0.2

## Note

Because this function relies heavily on regular expressions to parse PSL files it is currently only in beta status. If the routine fails to import a specific PSL file please report to <christoph.burow@gmx.net> so the function can be updated.

## Author(s)

Christoph Burow, University of Cologne (Germany) , `RLum` Developer Team

## See Also

[RLum.Analysis](#), [RLum.Data.Curve](#), [RLum.Data.Curve](#)

## Examples

```
# (1) Import PSL file to R

file <- system.file("extdata", "DorNie_0016.psl", package = "Luminescence")
psl <- read_PSL2R(file, drop_bg = FALSE, as_decay_curve = TRUE, smooth = TRUE, merge = FALSE)
print(str(psl, max.level = 3))
```

```
plot(psl, combine = TRUE)
```

---

read\_RF2R

---

*Import RF-files to R*


---

## Description

Import files produced by the IR-RF 'ImageJ' macro (SR-RF.ijm; Mittelstraß and Kreutzer, 2021) into R and create a list of [RLum.Analysis](#) objects

## Usage

```
read_RF2R(file, ...)
```

## Arguments

file	<a href="#">character</a> ( <b>required</b> ): path and file name of the RF file. Alternatively a list of file names can be provided.
...	not used, only for compatible reasons

## Details

The results of spatially resolved IR-RF data are summarised in so-called RF-files ((Mittelstraß and Kreutzer, 2021). This functions provides an easy import to process the data seamlessly with the R package 'Luminescence'. The output of the function can be passed to the function [analyse\\_IRSAR.RF](#)

## Value

Returns an S4 [RLum.Analysis](#) object containing [RLum.Data.Curve](#) objects for each curve.

## Function version

0.1.1

## Author(s)

Sebastian Kreutzer, Geography & Earth Science, Aberystwyth University (United Kingdom) ,  
RLum Developer Team

## References

Mittelstraß, D., Kreutzer, S., 2021. Spatially resolved infrared radiofluorescence: single-grain K-feldspar dating using CCD imaging. *Geochronology* 3, 299–319. doi:10.5194/gchron32992021

## See Also

[RLum.Analysis](#), [RLum.Data.Curve](#), [analyse\\_IRSAR.RF](#)

## Examples

```
##Import
file <- system.file("extdata", "RF_file.rf", package = "Luminescence")
temp <- read_RF2R(file)
```

---

read\_SPE2R

---

*Import Princeton Instruments (TM) SPE-file into R*


---

## Description

Function imports Princeton Instruments (TM) SPE-files into R environment and provides [RLum.Data.Image](#) objects as output.

## Usage

```
read_SPE2R(
  file,
  output.object = "RLum.Data.Image",
  frame.range,
  txtProgressBar = TRUE,
  verbose = TRUE,
  ...
)
```

## Arguments

file	<a href="#">character</a> ( <b>required</b> ): SPE-file name (including path), e.g. <ul style="list-style-type: none"> <li>• [WIN]: <code>read_SPE2R("C:/Desktop/test.spe")</code></li> <li>• [MAC/LINUX]: <code>read_SPE2R("/User/test/Desktop/test.spe")</code>. Additionally internet connections are supported.</li> </ul>
output.object	<a href="#">character</a> ( <i>with default</i> ): set RLum output object. Allowed types are "RLum.Data.Spectrum", "RLum.Data.Image" or "matrix"
frame.range	<a href="#">vector</a> ( <i>optional</i> ): limit frame range, e.g. select first 100 frames by <code>frame.range = c(1,100)</code>
txtProgressBar	<a href="#">logical</a> ( <i>with default</i> ): enables or disables <a href="#">txtProgressBar</a> .
verbose	<a href="#">logical</a> ( <i>with default</i> ): enables or disables verbose mode
...	not used, for compatibility reasons only

## Details

Function provides an R only import routine for the Princeton Instruments SPE format. Import functionality is based on the file format description provided by Princeton Instruments and a MatLab script written by Carl Hall (s. references).

**Value**

Depending on the chosen option the functions returns three different type of objects:

`output.object`

`RLum.Data.Spectrum`

An object of type `RLum.Data.Spectrum` is returned. Row sums are used to integrate all counts over one channel.

`RLum.Data.Image`

An object of type `RLum.Data.Image` is returned. Due to performance reasons the import is aborted for files containing more than 100 frames. This limitation can be overwritten manually by using the argument `frame.range`.

`matrix`

Returns a matrix of the form: Rows = Channels, columns = Frames. For the transformation the function `get_RLum` is used, meaning that the same results can be obtained by using the function `get_RLum` on an `RLum.Data.Spectrum` or `RLum.Data.Image` object.

**Function version**

0.1.5

**Note**

**The function does not test whether the input data are spectra or pictures for spatial resolved analysis!**

The function has been successfully tested for SPE format versions 2.x.

*Currently not all information provided by the SPE format are supported.*

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Princeton Instruments, 2014. Princeton Instruments SPE 3.0 File Format Specification, Version 1.A (for document URL please use an internet search machine)

Hall, C., 2012: readSPE.m. <https://www.mathworks.com/matlabcentral/fileexchange/35940-readspe>

**See Also**

`readBin`, `RLum.Data.Spectrum`

**Examples**

```
## to run examples uncomment lines and run the code
```

```
##(1) Import data as RLum.Data.Spectrum object
#file <- file.choose()
#temp <- read_SPE2R(file)
#temp
```

```
##(2) Import data as RLum.Data.Image object
```

```

#file <- file.choose()
#temp <- read_SPE2R(file, output.object = "RLum.Data.Image")
#temp

##(3) Import data as matrix object
#file <- file.choose()
#temp <- read_SPE2R(file, output.object = "matrix")
#temp

##(4) Export raw data to csv, if temp is a RLum.Data.Spectrum object
# write.table(x = get_RLum(temp),
#             file = "[your path and filename]",
#             sep = ";", row.names = FALSE)

```

---

read\_TIFF2R

---

*Import TIFF Image Data into R*


---

## Description

Simple wrapper around [tiff::readTIFF](#) to import TIFF images and TIFF image stacks to be further processed within the package 'Luminescence'

## Usage

```
read_TIFF2R(file, ...)
```

## Arguments

file	<a href="#">character</a> ( <b>required</b> ): file name
...	not in use, for compatibility reasons only

## Value

[RLum.Data.Image](#) object

## Function version

0.1.2

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## See Also

[tiff::readTIFF](#), [RLum.Data.Image](#)



## Examples

```
## Not run:
file <- file.choose()
image <- read_TIFF2R(file)

## End(Not run)
```

---

read\_XSYG2R

---

*Import XSYG files to R*


---

## Description

Imports XSYG-files produced by a Freiberg Instruments lexsyg reader into R.

## Usage

```
read_XSYG2R(
  file,
  recalculate.TL.curves = TRUE,
  fastForward = FALSE,
  import = TRUE,
  pattern = ".xsysg",
  verbose = TRUE,
  txtProgressBar = TRUE
)
```

## Arguments

file	<b>character</b> or <b>list (required)</b> : path and file name of the XSYG file. If input is a list it should comprise only characters representing each valid path and XSYG-file names. Alternatively the input character can be just a directory (path), in this case the the function tries to detect and import all XSYG-files found in the directory.
recalculate.TL.curves	<b>logical</b> ( <i>with default</i> ): if set to TRUE, TL curves are returned as temperature against count values (see details for more information) Note: The option overwrites the time vs. count TL curve. Select FALSE to import the raw data delivered by the lexsyg. Works for TL curves and spectra.
fastForward	<b>logical</b> ( <i>with default</i> ): if TRUE for a more efficient data processing only a list of <a href="#">RLum.Analysis</a> objects is returned.
import	<b>logical</b> ( <i>with default</i> ): if set to FALSE, only the XSYG file structure is shown.
pattern	<b>regex</b> ( <i>with default</i> ): optional regular expression if file is a link to a folder, to select just specific XSYG-files
verbose	<b>logical</b> ( <i>with default</i> ): enable or disable verbose mode. If verbose is FALSE the txtProgressBar is also switched off
txtProgressBar	<b>logical</b> ( <i>with default</i> ): enables TRUE or disables FALSE the progression bar during import

## Details

### How does the import function work?

The function uses the [xml](#) package to parse the file structure. Each sequence is subsequently translated into an [RLum.Analysis](#) object.

### General structure XSYG format

```
<?xml?>
<Sample>
  <Sequence>
    <Record>
      <Curve name="first curve" />
      <Curve name="curve with data">x0 , y0 ; x1 , y1 ; x2 , y2 ; x3 , y3</Curve>
    </Record>
  </Sequence>
</Sample>
```

So far, each XSYG file can only contain one <Sample></Sample>, but multiple sequences.

Each record may comprise several curves.

### TL curve recalculation

On the FI lexsyg device TL curves are recorded as time against count values. Temperature values are monitored on the heating plate and stored in a separate curve (time vs. temperature). If the option `recalculate.TL.curves = TRUE` is chosen, the time values for each TL curve are replaced by temperature values.

Practically, this means combining two matrices (Time vs. Counts and Time vs. Temperature) with different row numbers by their time values. Three cases are considered:

1. HE: Heating element
2. PMT: Photomultiplier tube
3. Interpolation is done using the function [approx](#)

CASE (1): `nrow(matrix(PMT)) > nrow(matrix(HE))`

Missing temperature values from the heating element are calculated using time values from the PMT measurement.

CASE (2): `nrow(matrix(PMT)) < nrow(matrix(HE))`

Missing count values from the PMT are calculated using time values from the heating element measurement.

CASE (3): `nrow(matrix(PMT)) == nrow(matrix(HE))`

A new matrix is produced using temperature values from the heating element and count values from the PMT.

**Note:** Please note that due to the recalculation of the temperature values based on values delivered by the heating element, it may happen that multiple count values exists for each temperature value and temperature values may also decrease during heating, not only increase.

### Advanced file import

To allow for a more efficient usage of the function, instead of single path to a file just a directory can be passed as input. In this particular case the function tries to extract all XSYG-files found in the directory and import them all. Using this option internally the function constructs as list of the XSYG-files found in the directory. Please note no recursive detection is supported as this may lead to endless loops.

**Value**

**Using the option** `import = FALSE`

A list consisting of two elements is shown:

- `data.frame` with information on file.
- `data.frame` with information on the sequences stored in the XSYG file.

**Using the option** `import = TRUE (default)`

A list is provided, the list elements contain:

`Sequence.Header`

`data.frame` with information on the sequence.

`Sequence.Object`

`RLum.Analysis` containing the curves.

**Function version**

0.6.10

**Note**

This function is a beta version as the XSYG file format is not yet fully specified. Thus, further file operations (merge, export, write) should be done using the functions provided with the package `xml`.

**So far, no image data import is provided!**

Corresponding values in the XSYG file are skipped.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Grehl, S., Kreutzer, S., Hoehne, M., 2013. Documentation of the XSYG file format. Unpublished Technical Note. Freiberg, Germany

**Further reading**

XML: <https://en.wikipedia.org/wiki/XML>

**See Also**

`xml`, `RLum.Analysis`, `RLum.Data.Curve`, `approx`

**Examples**

```
##(1) import XSYG file to R (uncomment for usage)
```

```
#FILE <- file.choose()
#temp <- read_XSYG2R(FILE)
```

```
##(2) additional examples for pure XML import using the package XML
##      (uncomment for usage)
```

```
##import entire XML file
#FILE <- file.choose()
#temp <- XML::xmlRoot(XML::xmlTreeParse(FILE))

##search for specific subnodes with curves containing 'OSL'
#getNodeSet(temp, "//Sample/Sequence/Record[@recordType = 'OSL']/Curve")

##(2) How to extract single curves ... after import
data(ExampleData.XSYG, envir = environment())

##grep one OSL curves and plot the first curve
OSLcurve <- get_RLum(OSL.SARMeasurement$Sequence.Object, recordType="OSL")[[1]]

##(3) How to see the structure of an object?
structure_RLum(OSL.SARMeasurement$Sequence.Object)
```

---

replicate\_RLum

*General replication function for RLum S4 class objects*


---

## Description

Function replicates RLum S4 class objects and returns a list for this objects

## Usage

```
replicate_RLum(object, times = NULL)
```

## Arguments

object	<b>RLum (required)</b> : an <b>RLum</b> object
times	<b>integer (optional)</b> : number for times each element is repeated element

## Value

Returns a [list](#) of the object to be repeated

## Function version

0.1.0

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## See Also

[RLum](#)

report\_RLum

Create a HTML-report for (RLum) objects

## Description

Create a HTML-report for (RLum) objects

## Usage

```
report_RLum(
  object,
  file = tempfile(),
  title = "RLum.Report",
  compact = TRUE,
  timestamp = TRUE,
  show_report = TRUE,
  launch.browser = FALSE,
  css.file = NULL,
  quiet = TRUE,
  clean = TRUE,
  ...
)
```

## Arguments

object	<b>(required)</b> : The object to be reported on, preferably of any RLum-class.
file	<b>character</b> (with default): A character string naming the output file. If no filename is provided a temporary file is created.
title	<b>character</b> (with default): A character string specifying the title of the document.
compact	<b>logical</b> (with default): When TRUE the following report components are hidden: @.pid, @.uid, 'Object structure', 'Session Info' and only the first and last 5 rows of long matrices and data frames are shown. See details.
timestamp	<b>logical</b> (with default): TRUE to add a timestamp to the filename (suffix).
show_report	<b>logical</b> (with default): If set to TRUE the function tries to display the report output in the local viewer, e.g., within <i>RStudio</i> after rendering.
launch.browser	<b>logical</b> (with default): TRUE to open the HTML file in the system's default web browser after it has been rendered.
css.file	<b>character</b> (optional): Path to a CSS file to change the default styling of the HTML document.
quiet	<b>logical</b> (with default): TRUE to suppress printing of the pandoc command line.
clean	<b>logical</b> (with default): TRUE to clean intermediate files created during rendering.
...	further arguments passed to or from other methods and to control the document's structure (see details).

## Details

This function creates a HTML-report for a given object, listing its complete structure and content. The object itself is saved as a serialised .Rds file. The report file serves both as a convenient way of browsing through objects with complex data structures as well as a mean of properly documenting and saving objects.

The HTML report is created with `rmarkdown::render` and has the following structure:

Section	Description
Header	A summary of general characteristics of the object
Object content	A comprehensive list of the complete structure and content of the provided object.
Object structure	Summary of the objects structure given as a table
File	Information on the saved RDS file
Session Info	Captured output from <code>sessionInfo()</code>
Plots	( <i>optional</i> ) For RLum-class objects a variable number of plots

The structure of the report can be controlled individually by providing one or more of the following arguments (all logical):

Argument	Description
header	Hide or show general information on the object
main	Hide or show the object's content
structure	Hide or show object's structure
rds	Hide or show information on the saved RDS file
session	Hide or show the session info
plot	Hide or show the plots (depending on object)

Note that these arguments have higher precedence than `compact`.

Further options that can be provided via the `...` argument:

Argument	Description
short_table	If TRUE only show the first and last 5 rows of long tables.
theme	Specifies the Bootstrap theme to use for the report. Valid themes include "default", "cerulean", "journal", "readable", "solarized", "united", "yeti".
highlight	Specifies the syntax highlighting style. Supported styles include "default", "tango", "pygments", "katex", "kate".
css	TRUE or FALSE to enable/disable custom CSS styling

The following arguments can be used to customise the report via CSS (Cascading Style Sheets):

Argument	Description
font_family	Define the font family of the HTML document (default: "arial")
headings_size	Size of the <h1> to <h6> tags used to define HTML headings (default: 166%).
content_color	Colour of the object's content (default: #a72925).

Note that these arguments must all be of class `character` and follow standard CSS syntax. For exhaustive CSS styling you can provide a custom CSS file for argument `css.file`. CSS styling can be turned off using `css = FALSE`.

**Value**

Writes a HTML and .Rds file.

**Function version**

0.1.5

**Note**

This function requires the R packages 'rmarkdown', 'pander' and 'rstudioapi'.

**Author(s)**

Christoph Burow, University of Cologne (Germany), Sebastian Kreutzer, Institute of Geography,  
Heidelberg University (Germany)  
, RLum Developer Team

**See Also**

[rmarkdown::render](#), [pander::pander\\_return](#), [pander::openFileInOS](#), [rstudioapi::viewer](#), [browseURL](#)

**Examples**

```
## Not run:
## Example: RLum.Results ----

# load example data
data("ExampleData.DeValues")

# apply the MAM-3 age model and save results
mam <- calc_MinDose(ExampleData.DeValues$CA1, sigmab = 0.2)

# create the HTML report
report_RLum(object = mam, file = "~/CA1_MAM.Rmd",
            timestamp = FALSE,
            title = "MAM-3 for sample CA1")

# when creating a report the input file is automatically saved to a
# .Rds file (see saveRDS()).
mam_report <- readRDS("~/CA1_MAM.Rds")
all.equal(mam, mam_report)

## Example: Temporary file & Viewer/Browser ----

# (a)
# Specifying a filename is not necessarily required. If no filename is provided,
# the report is rendered in a temporary file. If you use the RStudio IDE, the
# temporary report is shown in the interactive Viewer pane.
report_RLum(object = mam)

# (b)
# Additionally, you can view the HTML report in your system's default web browser.
report_RLum(object = mam, launch.browser = TRUE)
```

```
## Example: RLum.Analysis ----

data("ExampleData.RLum.Analysis")

# create the HTML report (note that specifying a file
# extension is not necessary)
report_RLum(object = IRSAR.RF.Data, file = "~/IRSAR_RF")

## Example: RLum.Data.Curve ----

data.curve <- get_RLum(IRSAR.RF.Data)[[1]]

# create the HTML report
report_RLum(object = data.curve, file = "~/Data_Curve")

## Example: Any other object ----
x <- list(x = 1:10,
         y = runif(10, -5, 5),
         z = data.frame(a = LETTERS[1:20], b = dnorm(0:9)),
         NA)

report_RLum(object = x, file = "~/arbitray_list")

## End(Not run)
```

---

Risoe.BINfileData2RLum.Analysis

*Convert Risoe.BINfileData object to an RLum.Analysis object*

---

## Description

Converts values from one specific position of a Risoe.BINfileData S4-class object to an RLum.Analysis object.

## Usage

```
Risoe.BINfileData2RLum.Analysis(
  object,
  pos = NULL,
  grain = NULL,
  run = NULL,
  set = NULL,
  ltype = NULL,
  dtype = NULL,
  protocol = "unknown",
  keep.empty = TRUE,
  txtProgressBar = FALSE
)
```



**Arguments**

object	<a href="#">Risoe.BINfileData</a> ( <b>required</b> ): <a href="#">Risoe.BINfileData</a> object
pos	<a href="#">numeric</a> ( <i>optional</i> ): position number of the <a href="#">Risoe.BINfileData</a> object for which the curves are stored in the <a href="#">RLum.Analysis</a> object. If <code>length(position)&gt;1</code> a list of <a href="#">RLum.Analysis</a> objects is returned. If nothing is provided every position will be converted. If the position is not valid NA is returned.
grain	<a href="#">vector</a> , <a href="#">numeric</a> ( <i>optional</i> ): grain number from the measurement to limit the converted data set (e.g., <code>grain = c(1:48)</code> ). Please be aware that this option may lead to unwanted effects, as the output is strictly limited to the chosen grain number for all position numbers
run	<a href="#">vector</a> , <a href="#">numeric</a> ( <i>optional</i> ): run number from the measurement to limit the converted data set (e.g., <code>run = c(1:48)</code> ).
set	<a href="#">vector</a> , <a href="#">numeric</a> ( <i>optional</i> ): set number from the measurement to limit the converted data set (e.g., <code>set = c(1:48)</code> ).
ltype	<a href="#">vector</a> , <a href="#">character</a> ( <i>optional</i> ): curve type to limit the converted data. Commonly allowed values are: IRSL, OSL, TL, RIR, RBR and USER (see also <a href="#">Risoe.BINfileData</a> )
dtype	<a href="#">vector</a> , <a href="#">character</a> ( <i>optional</i> ): data type to limit the converted data. Commonly allowed values are listed in <a href="#">Risoe.BINfileData</a>
protocol	<a href="#">character</a> ( <i>optional</i> ): sets protocol type for analysis object. Value may be used by subsequent analysis functions.
keep.empty	<a href="#">logical</a> ( <i>with default</i> ): If TRUE (default) an <a href="#">RLum.Analysis</a> object is returned even if it does not contain any records. Set to FALSE to discard all empty objects.
txtProgressBar	<a href="#">logical</a> ( <i>with default</i> ): enables or disables <a href="#">txtProgressBar</a> .

**Details**

The [RLum.Analysis](#) object requires a set of curves for specific further protocol analyses. However, the [Risoe.BINfileData](#) usually contains a set of curves for different aliquots and different protocol types that may be mixed up. Therefore, a conversion is needed.

**Value**

Returns an [RLum.Analysis](#) object.

**Function version**

0.4.3

**Note**

The protocol argument of the [RLum.Analysis](#) object is set to 'unknown' if not stated otherwise.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , [RLum Developer Team](#)

**See Also**

[Risoe.BINfileData](#), [RLum.Analysis](#), [read\\_BIN2R](#)

## Examples

```
##load data
data(ExampleData.BINfileData, envir = environment())

##convert values for position 1
Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos = 1)
```

---

RLum-class	<i>Class "RLum"</i>
------------	---------------------

---

## Description

Abstract class for data in the package Luminescence Subclasses are:

## Usage

```
## S4 method for signature 'RLum'
replicate_RLum(object, times = NULL)
```

## Arguments

object	<b>RLum (required)</b> : an object of class <a href="#">RLum</a>
times	<a href="#">integer</a> ( <i>optional</i> ): number for times each element is repeated element

## Details

**RLum-class**

```
|
|—RLum.Data
|—|— RLum.Data.Curve
|—|— RLum.Data.Spectrum
|—|— RLum.Data.Image
|—RLum.Analysis
|—RLum.Results
```

## Methods (by generic)

- replicate\_RLum(RLum): Replication method RLum-objects

## Slots

**originator** Object of class [character](#) containing the name of the producing function for the object. Set automatically by using the function [set\\_RLum](#).

**info** Object of class [list](#) for additional information on the object itself

**.uid** Object of class [character](#) for a unique object identifier. This id is usually calculated using the internal function create\_UID() if the function [set\\_RLum](#) is called.

**.pid** Object of class [character](#) for a parent id. This allows nesting RLum-objects at will. The parent id can be the uid of another object.

**Objects from the Class**

A virtual Class: No objects can be created from it.

**Class version**

0.4.0

**Note**

RLum is a virtual class.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data](#), [RLum.Data.Curve](#), [RLum.Data.Spectrum](#), [RLum.Data.Image](#), [RLum.Analysis](#), [RLum.Results](#), [methods\\_RLum](#)

**Examples**

```
showClass("RLum")
```

---

scale_GammaDose	<i>Calculate the gamma dose deposited within a sample taking layer-to-layer variations in radioactivity into account (according to Aitken, 1985)</i>
-----------------	--

---

**Description**

This function calculates the gamma dose deposited in a luminescence sample taking into account layer-to-layer variations in sediment radioactivity . The function scales user inputs of uranium, thorium and potassium based on input parameters for sediment density, water content and given layer thicknesses and distances to the sample.

**Usage**

```
scale_GammaDose(
  data,
  conversion_factors = c("Cresswelletal2018", "Guerinetal2011", "AdamiecAitken1998",
    "Liritzisetal2013")[1],
  fractional_gamma_dose = c("Aitken1985")[1],
  verbose = TRUE,
  plot = TRUE,
  plot_single = TRUE,
  ...
)
```

## Arguments

data	<p><b>data.frame (required):</b> A table containing all relevant information for each individual layer. The table must have the following named columns:</p> <ul style="list-style-type: none"> <li>• id (<b>character</b>): an arbitrary id or name of each layer</li> <li>• thickness (<b>numeric</b>): vertical extent of each layer in cm</li> <li>• sample_offset (<b>logical</b>): distance of the sample in cm, <b>measured from the BOTTOM OF THE TARGET LAYER</b>. Except for the target layer all values must be NA.</li> <li>• K (<b>numeric</b>): K nuclide content in %</li> <li>• K_se (<b>numeric</b>): error on the K content</li> <li>• Th (<b>numeric</b>): Th nuclide content in ppm</li> <li>• Th_se (<b>numeric</b>): error on the Th content</li> <li>• U (<b>numeric</b>): U nuclide content in ppm</li> <li>• U_se (<b>numeric</b>): error on the U content</li> <li>• water_content (<b>numeric</b>): water content of each layer in %</li> <li>• water_content_se (<b>numeric</b>): error on the water content</li> <li>• density (<b>numeric</b>): bulk density of each layer in g/cm<sup>-3</sup></li> </ul>
conversion_factors	<p><b>character (optional):</b> The conversion factors used to calculate the dose rate from sediment nuclide contents. Valid options are:</p> <ul style="list-style-type: none"> <li>• "Cresswelletal2018" (default)</li> <li>• "Liritzisetetal2013"</li> <li>• "Guerinetal2011"</li> <li>• "AdamiecAitken1998"</li> </ul>
fractional_gamma_dose	<p><b>character (optional):</b> Factors to scale gamma dose rate values. Valid options are:</p> <ul style="list-style-type: none"> <li>• "Aitken1985" (default): Table H1 in the appendix</li> </ul>
verbose	<b>logical (optional):</b> Show or hide console output (defaults to TRUE).
plot	<b>logical (optional):</b> Show or hide the plot (defaults to TRUE).
plot_single	<b>logical (optional):</b> Show all plots in one panel (defaults to TRUE).
...	Further parameters passed to <b>barplot</b> .

## Details

### User Input

To calculate the gamma dose which is deposited in a sample, the user needs to provide information on those samples influencing the luminescence sample. As a rule of thumb, all sediment layers within at least 30 cm radius from the luminescence sample taken should be taken into account when calculating the gamma dose rate. However, the actual range of gamma radiation might be different, depending on the emitting radioelement, the water content and the sediment density of each layer (Aitken, 1985). Therefore the user is advised to provide as much detail as possible and physically sensible.

The function requires a **data.frame** that is to be structured in columns and rows, with samples listed in rows. The first column contains information on the layer/sample ID, the second on the thickness (in cm) of each layer, whilst column 3 should contain NA for all layers that are not sampled for OSL/TL. For the layer the OSL/TL sample was taken from a numerical value must be provided, which is the distance (in cm) measured from **bottom** of the layer of interest. If the whole layer was

sampled insert 0. If the sample was taken from *within* the layer, insert a numerical value >0, which describes the distance from the middle of the sample to the bottom of the layer in cm. Columns 4 to 9 should contain radionuclide concentrations and their standard errors for potassium (in %), thorium (in ppm) and uranium (in ppm). Columns 10 and 11 give information on the water content and its uncertainty (standard error) in %. The layer density (in g/cm<sup>3</sup>) should be given in column 12. No cell should be left blank. Please ensure to keep the column titles as given in the example dataset (data('ExampleData.ScaleGammaDose'), see examples).

The user can decide which dose rate conversion factors should be used to calculate the gamma dose rates. The options are:

- "Cresswelletal2018" (Cresswell et al., 2018)
- "Liritzisetetal2013" (Liritzis et al., 2013)
- "Guerinetal2011" (Guerin et al., 2011)
- "AdamiecAitken1998" (Adamiec and Aitken, 1998)

### Water content

The water content provided by the user should be calculated according to:

$$(Wetweight[g] - Dryweight[g]) / Dryweight[g] * 100$$

### Calculations

After converting the radionuclide concentrations into dose rates, the function will scale the dose rates based on the thickness of the layers, the distances to the sample, the water content and the density of the sediment. The calculations are based on Aitken (1985, Appendix H). As an example (equivalent to Aitken, 1985), assuming three layers of sediment, where **L** is inert and positioned in between the infinite thick and equally active layers **A** and **B**, the dose in **L** and **B** due to **A** is given by

$$1 - f(x)D_A$$

Where  $x$  is the distance into the inert medium, so  $f(x)$  is the weighted average fractional dose at  $x$  and  $D_A$  denotes that the dose is delivered by **A**.  $f(x)$  is derived from table H1 (Aitken, 1985), when setting  $z = x$ . Consequently, the dose in **A** and **L** due to **B** is given by

$$1 - f(t - x)D_B$$

Here  $t$  is the thickness of **L** and the other parameters are denoted as above, just for the dose being delivered by **B**.  $f(t - x)$  is derived from table H1 (Aitken, 1985), when setting  $z$  equal to  $t - x$ . Following this, the dose in **L** delivered by **A** and **B** is given by

$$2 - f(x) - f(t - x)D_{AB}$$

Since **A** and **B** are equally active  $D_{\{AB\}} = D_A = D_B$ .

The function uses the value of the fractional dose rate at the layer boundary to start the calculation for the next layer. This way, the function is able to scale the gamma dose rate accurately for distant layers when the density and water content is not constant for the entire section.

**Value**

After performing the calculations the user is provided with different outputs.

1. The total gamma dose rate received by the sample (+/- uncertainties) as a print in the console.
2. A plot showing the sediment sequence, the user input sample information and the contribution to total gamma dose rate.
3. RLum Results. If the user wishes to save these results, writing a script to run the function and to save the results would look like this:

```
mydata <- read.table("c:/path/to/input/file.txt")
results <- scale_GammaDose(mydata)
table <- get_RLum(results)
write.csv(table, "c:/path/to/results.csv")
```

---

[ NUMERICAL OUTPUT ]

---

RLum.Results-object

**slot:** @data

Element	Type	Description
\$summary	data.frame	summary of the model results
\$data	data.frame	the original input data
\$dose_rates	list	two data.frames for the scaled and infinite matrix dose rates
\$tables	list	several data.frames containing intermediate results
\$args	character	arguments of the call
\$call	call	the original function call

**slot:** @info

Currently unused.

---

[ PLOT OUTPUT ]

---

Three plots are produced:

- A visualisation of the provided sediment layer structure to quickly assess whether the data was provided and interpreted correctly.
- A scatter plot of the nuclide contents per layer (K, Th, U) as well as the water content. This may help to correlate the dose rate contribution of specific layers to the layer of interest.
- A barplot visualising the contribution of each layer to the total dose rate received by the sample in the target layer.

**Function version**

0.1.2



Second2Gray

*Converting equivalent dose values from seconds (s) to Gray (Gy)***Description**

Conversion of absorbed radiation dose in seconds (s) to the SI unit Gray (Gy) including error propagation. Normally used for equivalent dose data.

**Usage**

```
Second2Gray(data, dose.rate, error.propagation = "omit")
```

**Arguments**

**data** [data.frame](#) (**required**): input values, structure: data (values[,1]) and data error (values[,2]) are required

**dose.rate** [RLum.Results](#), [data.frame](#) or [numeric](#) (**required**): [RLum.Results](#) needs to be originated from the function [calc\\_SourceDoseRate](#), for vector dose rate in Gy/s and dose rate error in Gy/s

**error.propagation** [character](#) (*with default*): error propagation method used for error calculation (omit, gaussian or absolute), see details for further information

**Details**

Calculation of De values from seconds (s) to Gray (Gy)

$$De[Gy] = De[s] * DoseRate[Gy/s]$$

Provided calculation error propagation methods for error calculation (with 'se' as the standard error and 'DR' of the dose rate of the beta-source):

(1) omit (default)

$$se(De)[Gy] = se(De)[s] * DR[Gy/s]$$

In this case the standard error of the dose rate of the beta-source is treated as systematic (i.e. non-random), its error propagation is omitted. However, the error must be considered during calculation of the final age. (cf. Aitken, 1985, pp. 242). This approach can be seen as method (2) (gaussian) for the case the (random) standard error of the beta-source calibration is 0. Which particular method is requested depends on the situation and cannot be prescriptive.

(2) gaussian error propagation

$$se(De)[Gy] = \sqrt{((DR[Gy/s] * se(De)[s])^2 + (De[s] * se(DR)[Gy/s])^2)}$$

Applicable under the assumption that errors of De and se are uncorrelated.

(3) absolute error propagation

$$se(De)[Gy] = abs(DR[Gy/s] * se(De)[s]) + abs(De[s] * se(DR)[Gy/s])$$

Applicable under the assumption that errors of De and se are correlated.



**Value**

Returns a [data.frame](#) with converted values.

**Function version**

0.6.0

**Note**

If no or a wrong error propagation method is given, the execution of the function is stopped. Furthermore, if a `data.frame` is provided for the dose rate values it has to be of the same length as the data frame provided with the argument `data`

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
Michael Dietze, GFZ Potsdam (Germany)  
Margret C. Fuchs, HZDR, Helmholtz-Institute Freiberg for Resource Technology (Germany) ,  
RLum Developer Team

**References**

Aitken, M.J., 1985. Thermoluminescence dating. Academic Press.

**See Also**

[calc\\_SourceDoseRate](#)

**Examples**

```
##(A) for known source dose rate at date of measurement
## - load De data from the example data help file
data(ExampleData.DeValues, envir = environment())
## - convert De(s) to De(Gy)
Second2Gray(ExampleData.DeValues$BT998, c(0.0438,0.0019))

##(B) for source dose rate calibration data
## - calculate source dose rate first
dose.rate <- calc_SourceDoseRate(measurement.date = "2012-01-27",
                                calib.date = "2014-12-19",
                                calib.dose.rate = 0.0438,
                                calib.error = 0.0019)

# read example data
data(ExampleData.DeValues, envir = environment())

# apply dose.rate to convert De(s) to De(Gy)
Second2Gray(ExampleData.DeValues$BT998, dose.rate)
```

---

set\_Risoe.BINfileData *General accessor function for RLum S4 class objects*

---

## Description

Function calls object-specific get functions for RisoeBINfileData S4 class objects.

## Usage

```
set_Risoe.BINfileData(  
  METADATA = data.frame(),  
  DATA = list(),  
  .RESERVED = list()  
)
```

## Arguments

METADATA	x
DATA	x
.RESERVED	x

## Details

The function provides a generalised access point for specific [Risoe.BINfileData](#) objects. Depending on the input object, the corresponding get function will be selected. Allowed arguments can be found in the documentations of the corresponding [Risoe.BINfileData](#) class.

## Value

Return is the same as input objects as provided in the list.

## Function version

0.1

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## See Also

[Risoe.BINfileData](#)

---

set\_RLum*General set function for RLum S4 class objects*

---

**Description**

Function calls object-specific set functions for RLum S4 class objects.

**Usage**

```
set_RLum(class, originator, .uid = create_UID(), .pid = NA_character_, ...)
```

**Arguments**

class	<a href="#">RLum</a> ( <b>required</b> ): name of the S4 class to create
originator	<a href="#">character</a> ( <i>automatic</i> ): contains the name of the calling function (the function that produces this object); can be set manually.
.uid	<a href="#">character</a> ( <i>automatic</i> ): sets an unique ID for this object using the internal C++ function <code>create_UID</code> .
.pid	<a href="#">character</a> ( <i>with default</i> ): option to provide a parent id for nesting at will.
...	further arguments that one might want to pass to the specific set method

**Details**

The function provides a generalised access point for specific [RLum](#) objects.

Depending on the given class, the corresponding method to create an object from this class will be selected. Allowed additional arguments can be found in the documentations of the corresponding [RLum](#) class:

- [RLum.Data.Curve](#),
- [RLum.Data.Image](#),
- [RLum.Data.Spectrum](#),
- [RLum.Analysis](#),
- [RLum.Results](#)

**Value**

Returns an object of the specified class.

**Function version**

0.3.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Curve](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#), [RLum.Analysis](#), [RLum.Results](#)

## Examples

```
##produce empty objects from each class
set_RLum(class = "RLum.Data.Curve")
set_RLum(class = "RLum.Data.Spectrum")
set_RLum(class = "RLum.Data.Spectrum")
set_RLum(class = "RLum.Analysis")
set_RLum(class = "RLum.Results")

##produce a curve object with arbitrary curve values
object <- set_RLum(
  class = "RLum.Data.Curve",
  curveType = "arbitrary",
  recordType = "OSL",
  data = matrix(c(1:100,exp(-c(1:100))),ncol = 2))

##plot this curve object
plot_RLum(object)
```

---

smooth\_RLum

*Smoothing of data*


---

## Description

Function calls the object-specific smooth functions for provided RLum S4-class objects.

## Usage

```
smooth_RLum(object, ...)

## S4 method for signature 'list'
smooth_RLum(object, ...)
```

## Arguments

object	<a href="#">RLum</a> ( <b>required</b> ): S4 object of class RLum
...	further arguments passed to the specific class method

## Details

The function provides a generalised access point for specific [RLum](#) objects. Depending on the input object, the corresponding function will be selected. Allowed arguments can be found in the documentations of the corresponding [RLum](#) class. The smoothing is based on an internal function called `.smoothing`.

## Value

An object of the same type as the input object is provided

## Functions

- `smooth_RLum(list)`: Returns a list of [RLum](#) objects that had been passed to [smooth\\_RLum](#)

**Function version**

0.1.0

**Note**

Currently only RLum objects of class `RLum.Data.Curve` and `RLum.Analysis` (with curve data) are supported!

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data.Curve](#), [RLum.Analysis](#)

**Examples**

```
##load example data
data(ExampleData.CW_OSL_Curve, envir = environment())

##create RLum.Data.Curve object from this example
curve <-
  set_RLum(
    class = "RLum.Data.Curve",
    recordType = "OSL",
    data = as.matrix(ExampleData.CW_OSL_Curve)
  )

##plot data without and with smoothing
plot_RLum(curve)
plot_RLum(smooth_RLum(curve))
```

---

sTeve*sTeve - sophisticated tool for efficient data validation and evaluation*

---

**Description**

This function provides a sophisticated routine for comprehensive luminescence dating data analysis.

**Usage**

```
sTeve(n_frames = 10, t_animation = 2, n.tree = 7, type)
```

**Arguments**

n_frames	<a href="#">integer</a> (with default): n frames
t_animation	<a href="#">integer</a> (with default): t animation
n.tree	<a href="#">integer</a> (with default): how many trees do you want to cut?
type	<a href="#">integer</a> (optional): Make a decision: 1, 2 or 3

**Details**

This amazing sophisticated function validates your data seriously.

**Value**

Validates your data.

**Note**

This function should not be taken too seriously.

**Author(s)**

R Luminescence Team, 2012-2046 , RLum Developer Team

**See Also**

[plot\\_KDE](#)

**Examples**

```
##no example available
```

---

structure\_RLum

*General structure function for RLum S4 class objects*

---

**Description**

Function calls object-specific get functions for RLum S4 class objects.

**Usage**

```
structure_RLum(object, ...)  
  
## S4 method for signature 'list'  
structure_RLum(object, ...)
```

**Arguments**

object	<a href="#">RLum</a> ( <b>required</b> ): S4 object of class RLum
...	further arguments that one might want to pass to the specific structure method

**Details**

The function provides a generalised access point for specific [RLum](#) objects. Depending on the input object, the corresponding structure function will be selected. Allowed arguments can be found in the documentations of the corresponding [RLum](#) class.

**Value**

Returns a [data.frame](#) with structure of the object.

**Functions**

- `structure_RLum(list)`: Returns a list of [RLum](#) objects that had been passed to [structure\\_RLum](#)

**Function version**

0.2.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , [RLum Developer Team](#)

**See Also**

[RLum.Data.Curve](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#), [RLum.Analysis](#), [RLum.Results](#)

**Examples**

```
##load example data
data(ExampleData.XSYG, envir = environment())

##show structure
structure_RLum(OSL.SARMeasurement$Sequence.Object)
```

---

subset\_SingleGrainData

*Simple Subsetting of Single Grain Data from Risø BIN/BINX files*

---

**Description**

Most measured single grains do not exhibit light and it makes usually sense to subset single grain datasets using a table of position and grain pairs

**Usage**

```
subset_SingleGrainData(object, selection)
```

**Arguments**

object	<a href="#">Risoe.BINfileData</a> ( <b>required</b> ): input object with the data to subset
selection	<a href="#">data.frame</a> ( <b>required</b> ): selection table with two columns for position (1st column) and grain (2nd column) (columns names do not matter)

**Value**

A subset [Risoe.BINfileData](#) object

**Function version**

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[Risoe.BINfileData](#), [read\\_BIN2R](#), [verify\\_SingleGrainData](#)

**Examples**

```
## load example data
data(ExampleData.BINfileData, envir = environment())

## set POSITION/GRAIN pair dataset
selection <- data.frame(POSITION = c(1,5,7), GRAIN = c(0,0,0))

##subset
subset_SingleGrainData(object = CWOSL.SAR.Data, selection = selection)
```

---

template\_DRAC

---

*Create a DRAC input data template (v1.2)*


---

**Description**

This function returns a DRAC input template (v1.2) to be used in conjunction with the [use\\_DRAC](#) function

**Usage**

```
template_DRAC(nrow = 1L, preset = NULL, notification = TRUE)
```

**Arguments**

- |              |   |
|--------------|---|
| nrow         | <a href="#">integer</a> ( <i>with default</i> ): specifies the number of rows of the template (i.e., the number of data sets you want to submit).   |
| preset       | <p><a href="#">character</a> (<i>optional</i>): By default, all values of the template are set to NA, which means that the user needs to fill in <b>all</b> data first before submitting to DRAC using <code>use_DRAC()</code>. To reduce the number of values that need to be provided, <code>preset</code> can be used to create a template with at least a minimum of reasonable preset values.</p> <p><code>preset</code> can be one of the following:</p> <ul style="list-style-type: none"> <li>• quartz_coarse</li> <li>• quartz_fine</li> <li>• feldspar_coarse</li> <li>• polymineral_fine</li> <li>• DRAC-example_quartz</li> <li>• DRAC-example_feldspar</li> <li>• DRAC-example_polymineral</li> </ul> <p>Note that the last three options can be used to produce a template with values directly taken from the official DRAC input .csv file.</p> |
| notification | <a href="#">logical</a> ( <i>with default</i> ): show or hide the notification  |



**Value**

A list.

**Author(s)**

Christoph Burow, University of Cologne (Germany), Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**References**

Durcan, J.A., King, G.E., Duller, G.A.T., 2015. DRAC: Dose Rate and Age Calculator for trapped charge dating. *Quaternary Geochronology* 28, 54-61. doi:10.1016/j.quageo.2015.03.012

**See Also**

[as.data.frame](#), [list](#)

**Examples**

```
# create a new DRAC input input
input <- template_DRAC(preset = "DRAC-example_quartz")

# show content of the input
print(input)
print(input$`Project ID`)
print(input[[4]])

## Example: DRAC Quartz example
# note that you only have to assign new values where they
# are different to the default values
input$`Project ID` <- "DRAC-Example"
input$`Sample ID` <- "Quartz"
input$`Conversion factors` <- "AdamiecAitken1998"
input$`External U (ppm)` <- 3.4
input$`errExternal U (ppm)` <- 0.51
input$`External Th (ppm)` <- 14.47
input$`errExternal Th (ppm)` <- 1.69
input$`External K (%)` <- 1.2
input$`errExternal K (%)` <- 0.14
input$`Calculate external Rb from K conc?` <- "N"
input$`Calculate internal Rb from K conc?` <- "N"
input$`Scale gammadoserate at shallow depths?` <- "N"
input$`Grain size min (microns)` <- 90
input$`Grain size max (microns)` <- 125
input$`Water content ((wet weight - dry weight)/dry weight) %` <- 5
input$`errWater content %` <- 2
input$`Depth (m)` <- 2.2
input$`errDepth (m)` <- 0.22
input$`Overburden density (g cm-3)` <- 1.8
input$`errOverburden density (g cm-3)` <- 0.1
input$`Latitude (decimal degrees)` <- 30.0000
input$`Longitude (decimal degrees)` <- 70.0000
input$`Altitude (m)` <- 150
input$`De (Gy)` <- 20
input$`errDe (Gy)` <- 0.2
```

```
# use DRAC
## Not run:
output <- use_DRAC(input)

## End(Not run)
```

---

trim\_RLum.Data

*Trim Channels of RLum.Data-class Objects*


---

## Description

Trim off the number of channels of [RLum.Data](#) objects of similar record type on the time domain. This function is useful in cases where objects have different lengths (short/longer measurement time) but should be analysed jointly by other functions.

## Usage

```
trim_RLum.Data(object, recordType = NULL, trim_range = NULL)
```

## Arguments

object	<a href="#">RLum.Data</a> <a href="#">RLum.Analysis</a> ( <b>required</b> ): input object, can be a <a href="#">list</a> of objects. Please note that in the latter case the function works only isolated on each element of the <a href="#">list</a> .
recordType	<a href="#">character</a> ( <i>optional</i> ): type of the record where the trim should be applied. If not set, the types are determined automatically and applied for each record type classes. Can be provided as <a href="#">list</a> .
trim_range	<a href="#">numeric</a> ( <i>optional</i> ): sets the trim range (everything within the range + 1 is kept). If nothing is set all curves are trimmed to a similar maximum length. Can be provided as <a href="#">list</a> .

## Details

The function has two modes of operation:

1. Single [RLum.Data](#) objects or a [list](#) of such objects The function is applied separately over each object.
2. Multiple curves via [RLum.Analysis](#) or a [list](#) of such objects In this mode, the function first determines the minimum number of channels for each category of records and then jointly processes them. For instance, the object contains one TL curve with 100 channels and two OSL curves with 100 and 99 channels, respectively. Then the minimum for TL would be set to 100 channels and 99 for the OSL curves. If no further parameters are applied, the function will shorten all OSL curves to 99 channels, but leave the TL curve untouched.

## Value

A trimmed object or [list](#) of such objects similar to the input objects

## Function version

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[RLum.Data](#), [RLum.Analysis](#)

**Examples**

```
## trim all TL curves in the object to channels 10 to 20
data(ExampleData.BINfileData, envir = environment())
temp <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data, pos = 1)

c <- trim_RLum.Data(
  object = temp,
  recordType = "TL",
  trim_range = c(10,20))

plot_RLum.Analysis(
  object = c,
  combine = TRUE,
  subset = list(recordType = "TL"))

## simulate a situation where one OSL curve
## in the dataset has only 999 channels instead of 1000
## all curves should be limited to 999
temp@records[[2]]@data <- temp@records[[2]]@data[-nrow(temp[[2]]@data),]

c <- trim_RLum.Data(object = temp)
nrow(c@records[[4]]@data)
```

---

tune\_Data

*Tune data for experimental purpose*


---

**Description**

The error can be reduced and sample size increased for specific purpose.

**Usage**

```
tune_Data(data, decrease.error = 0, increase.data = 0)
```

**Arguments**

**data** [data.frame \(required\)](#): input values, structure: data (values[, 1]) and data error (values [, 2]) are required

**decrease.error** [numeric](#): factor by which the error is decreased, ranges between 0 and 1.

**increase.data** [numeric](#): factor by which the error is decreased, ranges between 0 and Inf.

**Value**

Returns a [data.frame](#) with tuned values.

**Function version**

0.5.0

**Note**

You should not use this function to improve your poor data set!

**Author(s)**

Michael Dietze, GFZ Potsdam (Germany) , RLum Developer Team

**Examples**

```
## load example data set
data(ExampleData.DeValues, envir = environment())
x <- ExampleData.DeValues$CA1

## plot original data
plot_AbanicoPlot(data = x,
                  summary = c("n", "mean"))

## decrease error by 10 %
plot_AbanicoPlot(data = tune_Data(x, decrease.error = 0.1),
                  summary = c("n", "mean"))

## increase sample size by 200 %
#plot_AbanicoPlot(data = tune_Data(x, increase.data = 2) ,
#                  summary = c("n", "mean"))
```

---

use\_DRAC

*Use DRAC to calculate dose rate data*

---

**Description**

The function provides an interface from R to DRAC. An R-object or a pre-formatted XLS/XLSX file is passed to the DRAC website and the results are re-imported into R.

**Usage**

```
use_DRAC(file, name, print_references = TRUE, citation_style = "text", ...)
```

**Arguments**

**file** [character](#) (**required**): spreadsheet to be passed to the DRAC website for calculation. Can also be a DRAC template object obtained from `template_DRAC()`.

**name** [character](#) (*with default*): Optional user name submitted to DRAC. If omitted, a random name will be generated

```
print_references
  (with default): Print all references used in the input data table to the console.
citation_style (with default): If print_references = TRUE this argument determines the out-
  put style of the used references. Valid options are "Bibtex", "citation",
  "html", "latex" or "R". Default is "text".
...
  Further arguments.
  • url character: provide an alternative URL to DRAC
  • verbose logical: show or hide console output
```

## Value

Returns an **RLum.Results** object containing the following elements:

```
DRAC      list: a named list containing the following elements in slot @data:

$highlights data.frame summary of 25 most important input/output fields
$header     character HTTP header from the DRAC server response
$labels     data.frame descriptive headers of all input/output fields
$content    data.frame complete DRAC input/output table
$input      data.frame DRAC input table
$output     data.frame DRAC output table
references  list       A list of bib entries of used references

data      character or list path to the input spreadsheet or a DRAC template
call      call the function call
args      list used arguments
```

The output should be accessed using the function **get\_RLum**.

## Function version

0.14

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany)  
 Michael Dietze, GFZ Potsdam (Germany)  
 Christoph Burow, University of Cologne (Germany) , RLum Developer Team

## References

Durcan, J.A., King, G.E., Duller, G.A.T., 2015. DRAC: Dose Rate and Age Calculator for trapped charge dating. Quaternary Geochronology 28, 54-61. doi:10.1016/j.quageo.2015.03.012

## Examples

```
## (1) Method using the DRAC spreadsheet

file <-  "/PATH/TO/DRAC_Input_Template.csv"

# send the actual IO template spreadsheet to DRAC
## Not run:
```

```

use_DRAC(file = file)

## End(Not run)

## (2) Method using an R template object

# Create a template
input <- template_DRAC(preset = "DRAC-example_quartz")

# Fill the template with values
input$`Project ID` <- "DRAC-Example"
input$`Sample ID` <- "Quartz"
input$`Conversion factors` <- "AdamiecAitken1998"
input$`External U (ppm)` <- 3.4
input$`errExternal U (ppm)` <- 0.51
input$`External Th (ppm)` <- 14.47
input$`errExternal Th (ppm)` <- 1.69
input$`External K (%)` <- 1.2
input$`errExternal K (%)` <- 0.14
input$`Calculate external Rb from K conc?` <- "N"
input$`Calculate internal Rb from K conc?` <- "N"
input$`Scale gammadoserate at shallow depths?` <- "N"
input$`Grain size min (microns)` <- 90
input$`Grain size max (microns)` <- 125
input$`Water content ((wet weight - dry weight)/dry weight) %` <- 5
input$`errWater content %` <- 2
input$`Depth (m)` <- 2.2
input$`errDepth (m)` <- 0.22
input$`Overburden density (g cm-3)` <- 1.8
input$`errOverburden density (g cm-3)` <- 0.1
input$`Latitude (decimal degrees)` <- 30.0000
input$`Longitude (decimal degrees)` <- 70.0000
input$`Altitude (m)` <- 150
input$`De (Gy)` <- 20
input$`errDe (Gy)` <- 0.2

# use DRAC
## Not run:
output <- use_DRAC(input)

## End(Not run)

```

---

```
verify_SingleGrainData
```

*Verify single grain data sets and check for invalid grains, i.e. zero-light level grains*

---

## Description

This function tries to identify automatically zero-light level curves (grains) from single grain data measurements.

**Usage**

```
verify_SingleGrainData(
  object,
  threshold = 10,
  cleanup = FALSE,
  cleanup_level = "aliquot",
  verbose = TRUE,
  plot = FALSE,
  ...
)
```

**Arguments**

object	<a href="#">Risoe.BINfileData</a> or <a href="#">RLum.Analysis</a> ( <b>required</b> ): input object. The function also accepts a list with objects of allowed type.
threshold	<a href="#">numeric</a> ( <i>with default</i> ): numeric threshold value for the allowed difference between the mean and the var of the count values (see details)
cleanup	<a href="#">logical</a> ( <i>with default</i> ): if set to TRUE curves identified as zero light level curves are automatically removed. Output is an object as same type as the input, i.e. either <a href="#">Risoe.BINfileData</a> or <a href="#">RLum.Analysis</a>
cleanup_level	<a href="#">character</a> ( <i>with default</i> ): selects the level for the clean-up of the input data sets. Two options are allowed: "curve" or "aliquot": <ul style="list-style-type: none"> <li>• If "curve" is selected every single curve marked as invalid is removed.</li> <li>• If "aliquot" is selected, curves of one aliquot (grain or disc) can be marked as invalid, but will not be removed. An aliquot will be only removed if all curves of this aliquot are marked as invalid.</li> </ul>
verbose	<a href="#">logical</a> ( <i>with default</i> ): enables or disables the terminal feedback
plot	<a href="#">logical</a> ( <i>with default</i> ): enables or disables the graphical feedback
...	further parameters to control the plot output; if selected. Supported arguments main, ylim

**Details****How does the method work?**

The function compares the expected values ( $E(X)$ ) and the variance ( $Var(X)$ ) of the count values for each curve. Assuming that the background roughly follows a Poisson distribution the absolute difference of both values should be zero or at least around zero as

$$E(x) = Var(x) = \lambda$$

Thus the function checks for:

$$abs(E(x) - Var(x)) >= \Theta$$

With  $\Theta$  an arbitrary, user defined, threshold. Values above the threshold indicating curves comprising a signal.

Note: the absolute difference of  $E(X)$  and  $Var(x)$  instead of the ratio was chosen as both terms can become 0 which would result in 0 or Inf, if the ratio is calculated.

**Value**

The function returns

---

```
[ NUMERICAL OUTPUT ]
```

---

RLum.Results-object

**slot:\*\*\*\*@data**

Element	Type	Description
\$unique_pairs	data.frame	the unique position and grain pairs
\$selection_id	numeric	the selection as record ID
\$selection_full	data.frame	implemented models used in the baSAR-model core

**slot:\*\*\*\*@info**

The original function call

**Output variation**

For `cleanup = TRUE` the same object as the input is returned, but cleaned up (invalid curves were removed). This means: Either an [Risoef.BINfileData](#) or an [RLum.Analysis](#) object is returned in such cases. An [Risoef.BINfileData](#) object can be exported to a BIN-file by using the function [write\\_R2BIN](#).

**Function version**

0.2.3

**Note**

This function can work with [Risoef.BINfileData](#) objects or [RLum.Analysis](#) objects (or a list of it). However, the function is highly optimised for [Risoef.BINfileData](#) objects as it make sense to remove identify invalid grains before the conversion to an [RLum.Analysis](#) object.

The function checking for invalid curves works rather robust and it is likely that Reg0 curves within a SAR cycle are removed as well. Therefore it is strongly recommended to use the argument `cleanup = TRUE` carefully.

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[Risoef.BINfileData](#), [RLum.Analysis](#), [write\\_R2BIN](#), [read\\_BIN2R](#)



## Examples

```
##01 - basic example I
##just show how to apply the function
data(ExampleData.XSYG, envir = environment())

##verify and get data.frame out of it
verify_SingleGrainData(OSL.SARMeasurement$Sequence.Object)$selection_full

##02 - basic example II
data(ExampleData.BINfileData, envir = environment())
id <- verify_SingleGrainData(object = CWOSL.SAR.Data,
cleanup_level = "aliquot")$selection_id

## Not run:
##03 - advanced example I
##importing and exporting a BIN-file

##select and import file
file <- file.choose()
object <- read_BIN2R(file)

##remove invalid aliquots(!)
object <- verify_SingleGrainData(object, cleanup = TRUE)

##export to new BIN-file
write_R2BIN(object, paste0(dirname(file),"/", basename(file), "_CLEANED.BIN"))

## End(Not run)
```

---

write\_R2BIN

---

Export Risoe.BINfileData into Risø BIN/BINX-file

---

## Description

Exports a Risoe.BINfileData object in a \*.bin or \*.binx file that can be opened by the Analyst software or other Risø software.

## Usage

```
write_R2BIN(
  object,
  file,
  version,
  compatibility.mode = FALSE,
  txtProgressBar = TRUE
)
```

## Arguments

**object** [Risoe.BINfileData \(required\)](#): input object to be stored in a bin file.  
**file** [character \(required\)](#): file name and path of the output file

- [WIN]: write\_R2BIN(object, "C:/Desktop/test.bin")
  - [MAC/LINUX]: write\_R2BIN("/User/test/Desktop/test.bin")
- version [character](#) (*optional*): version number for the output file. If no value is provided the highest version number from the [Risoe.BINfileData](#) is taken automatically.  
**Note:** This argument can be used to convert BIN-file versions.
- compatibility.mode [logical](#) (*with default*): this option recalculates the position values if necessary and set the max. value to 48. The old position number is appended as comment (e.g., 'OP: 70). This option accounts for potential compatibility problems with the Analyst software. It further limits the maximum number of points per curve to 9,999. If a curve contains more data the curve data got binned using the smallest possible bin width.
- txtProgressBar [logical](#) (*with default*): enables or disables [txtProgressBar](#).

## Details

The structure of the exported binary data follows the data structure published in the Appendices of the *Analyst* manual p. 42.

If LTYPE, DTYPE and LIGHTSOURCE are not of type [character](#), no transformation into numeric values is done.

## Value

Write a binary file.

## Function version

0.5.2

## Note

The function just roughly checks the data structures. The validity of the output data depends on the user.

The validity of the file path is not further checked. BIN-file conversions using the argument `version` may be a lossy conversion, depending on the chosen input and output data (e.g., conversion from version 08 to 07 to 06 to 05 to 04 or 03).

## Warning

Although the coding was done carefully it seems that the BIN/BINX-files produced by Risø DA 15/20 TL/OSL readers slightly differ on the byte level. No obvious differences are observed in the METADATA, however, the BIN/BINX-file may not fully compatible, at least not similar to the once directly produced by the Risø readers!

ROI definitions (introduced in BIN-file version 8) are not supported! There are furthermore ignored by the function [read\\_BIN2R](#).

## Author(s)

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

## References

DTU Nutech, 2016. The Sequence Editor, Users Manual, February, 2016. <https://www.fysik.dtu.dk>

## See Also

[read\\_BIN2R](#), [Risoe.BINfileData](#), [writeBin](#)

## Examples

```
##load exempld dataset
file <- system.file("extdata/BINfile_V8.binx", package = "Luminescence")
temp <- read_BIN2R(file)

##create temporary file path
##(for usage replace by own path)
temp_file <- tempfile(pattern = "output", fileext = ".binx")

##export to temporary file path
write_R2BIN(temp, file = temp_file)
```

---

write_R2TIFF	<i>Export RLum.Data.Image and RLum.Data.Spectrum objects to TIFF Images</i>
--------------	---

---

## Description

Simple wrapper around [tiff::writeTIFF](#) to export suitable RLum-class objects to TIFF images. Per default 16-bit TIFF files are exported.

## Usage

```
write_R2TIFF(object, file = tempfile(), norm = 65535, ...)
```

## Arguments

object	<a href="#">RLum.Data.Image</a> or <a href="#">RLum.Data.Spectrum</a> object ( <b>required</b> ): input object, can be a <a href="#">list</a> of such objects
file	<a href="#">character</a> ( <b>required</b> ): the file name and path
norm	<a href="#">numeric</a> ( <i>with default</i> ): normalisation values. Values in TIFF files must range between 0-1, however, usually in imaging applications the pixel values are real integer count values. The normalisation to the to the highest 16-bit integer values -1 ensures that the numerical values are retained in the exported image. If 1 nothing is normalised.
...	further arguments to be passed to <a href="#">tiff::writeTIFF</a> .

## Value

A TIFF file

**Function version**

0.1.0

**Author(s)**

Sebastian Kreutzer, Institute of Geography, Heidelberg University (Germany) , RLum Developer Team

**See Also**

[tiff::writeTIFF](#), [RLum.Data.Image](#), [RLum.Data.Spectrum](#)

**Examples**

```
data(ExampleData.RLum.Data.Image, envir = environment())
write_R2TIFF(ExampleData.RLum.Data.Image, file = tempfile())
```

---

write\_RLum2CSV

---

Export RLum-objects to CSV

---

**Description**

This function exports [RLum](#)-objects to CSV-files using the R function [utils::write.table](#). All [RLum](#)-objects are supported, but the export is lossy, i.e. the pure numerical values are exported only. Information that cannot be coerced to a [data.frame](#) or a [matrix](#) are discarded as well as metadata.

**Usage**

```
write_RLum2CSV(
  object,
  path = NULL,
  prefix = "",
  export = TRUE,
  compact = TRUE,
  ...
)
```

**Arguments**

object	<a href="#">RLum</a> or a <a href="#">list</a> of RLum objects ( <b>required</b> ): objects to be written. Can be a <a href="#">data.frame</a> if needed internally.
path	<a href="#">character</a> ( <i>optional</i> ): character string naming folder for the output to be written. If nothing is provided path will be set to the working directory. <b>Note:</b> this argument is ignored if the the argument export is set to FALSE.
prefix	<a href="#">character</a> ( <i>with default</i> ): optional prefix to name the files. This prefix is valid for all written files
export	<a href="#">logical</a> ( <i>with default</i> ): enable or disable the file export. If set to FALSE nothing is written to the file connection, but a list comprising objects of type <a href="#">data.frame</a> and <a href="#">matrix</a> is returned instead

`compact` [logical](#) (*with default*): if TRUE (the default) the output will be more simple but less comprehensive, means not all elements in the objects will be fully broken down. This is in particular useful for writing `RLum.Results` objects to CSV-files, such objects can be rather complex and not all information are needed in a CSV-file or can be meaningful translated to it.

`...` further arguments that will be passed to the function `utils::write.table`. All arguments except the argument `file` are supported

### Details

However, in combination with the implemented import functions, nearly every supported import data format can be exported to CSV-files, this gives a great deal of freedom in terms of compatibility with other tools.

#### Input is a list of objects

If the input is a [list](#) of objects all explicit function arguments can be provided as [list](#).

### Value

The function returns either a CSV-file (or many of them) or for the option `export == FALSE` a list comprising objects of type [data.frame](#) and [matrix](#)

### Function version

0.2.2

### Author(s)

Sebastian Kreutzer, Geography & Earth Science, Aberystwyth University (United Kingdom) ,  
RLum Developer Team

### See Also

[RLum.Analysis](#), [RLum.Data](#), [RLum.Results](#), [utils::write.table](#)

### Examples

```
##transform values to a list (and do not write)
data(ExampleData.BINfileData, envir = environment())
object <- Risoe.BINfileData2RLum.Analysis(CWOSL.SAR.Data)[[1]]
write_RLum2CSV(object, export = FALSE)

## Not run:

##create temporary filepath
##(for usage replace by own path)
temp_file <- tempfile(pattern = "output", fileext = ".csv")

##write CSV-file to working directory
write_RLum2CSV(temp_file)

## End(Not run)
```

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