

DTU Physics

Sources and Monitors

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Sources: In general

- A source component generates Monte Carlo neutrons.
In McStas terms this means:
 - Set the neutron state to something representative of the source we are trying to model.
 - i.e.: insert values in the neutron state vector $\{x, y, z, v_x, v_y, v_z, t, s_x, s_y, s_z, p\}$ drawn from appropriate distributions.

EXAMPLE:

Neutrons from a uniform wavelength distribution emerging from a circular aperture.

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Access the docs

IMPORTANT:

All (and more) of this information can be found in the online pdf component documentation, e.g.

<http://www.mcstas.org/documentation/manual/mcstas-2.5-components.pdf>

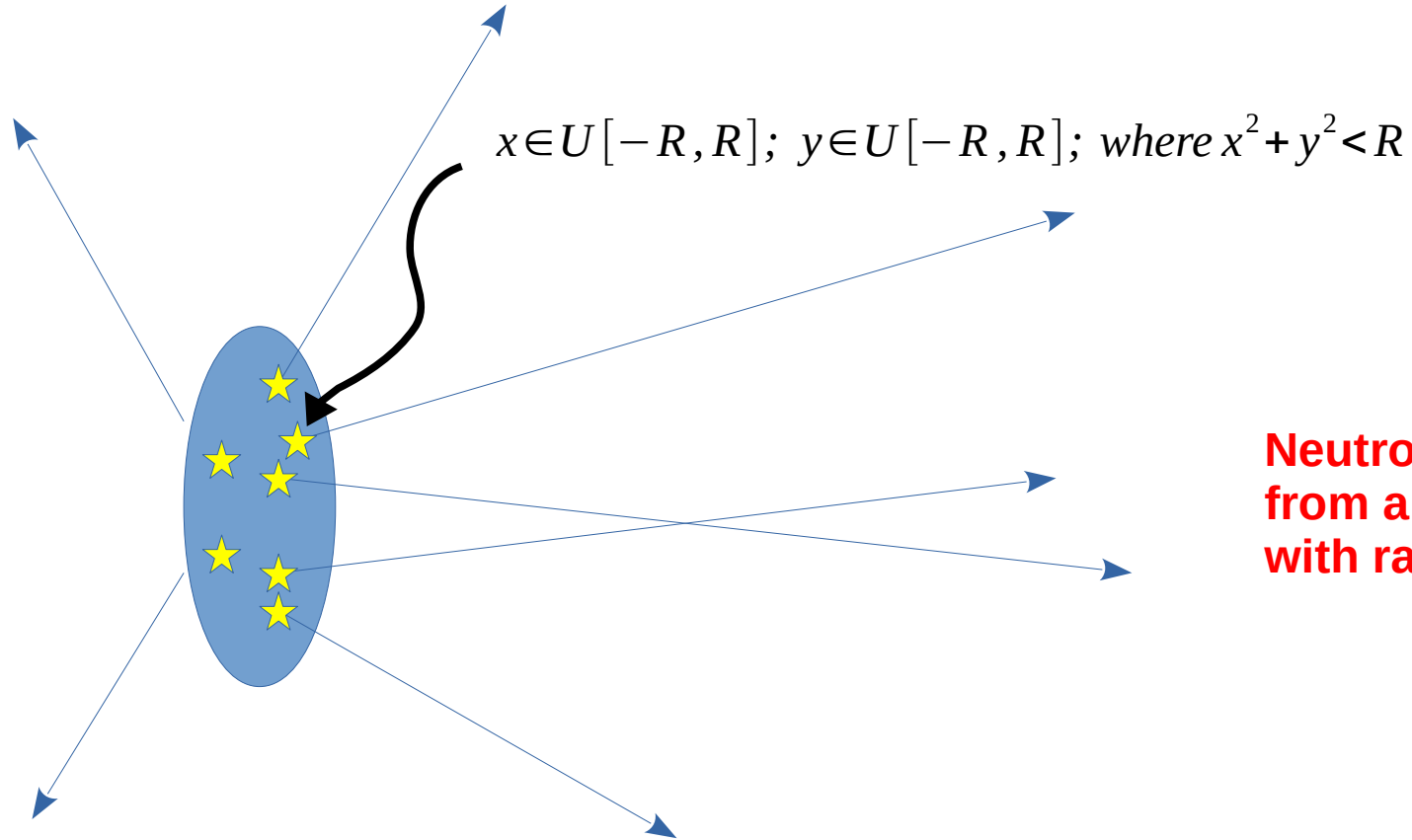
- also distributed with your McStas installation - `mcdoc -c`

The component documentation along with the command:

`“mcdoc <component_you_are_searching_for>”`

are your best friends when using McStas

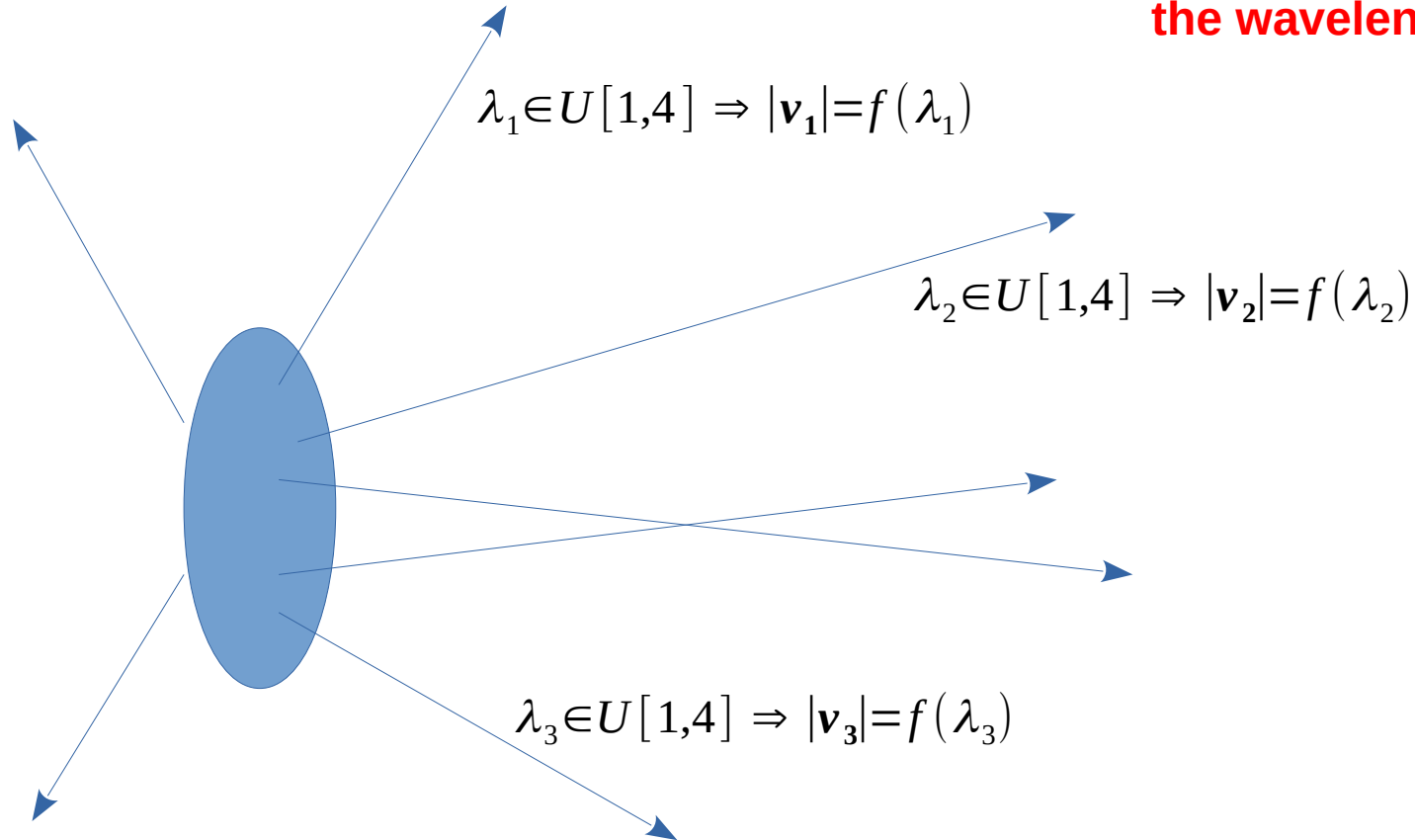
Sources: Example 1



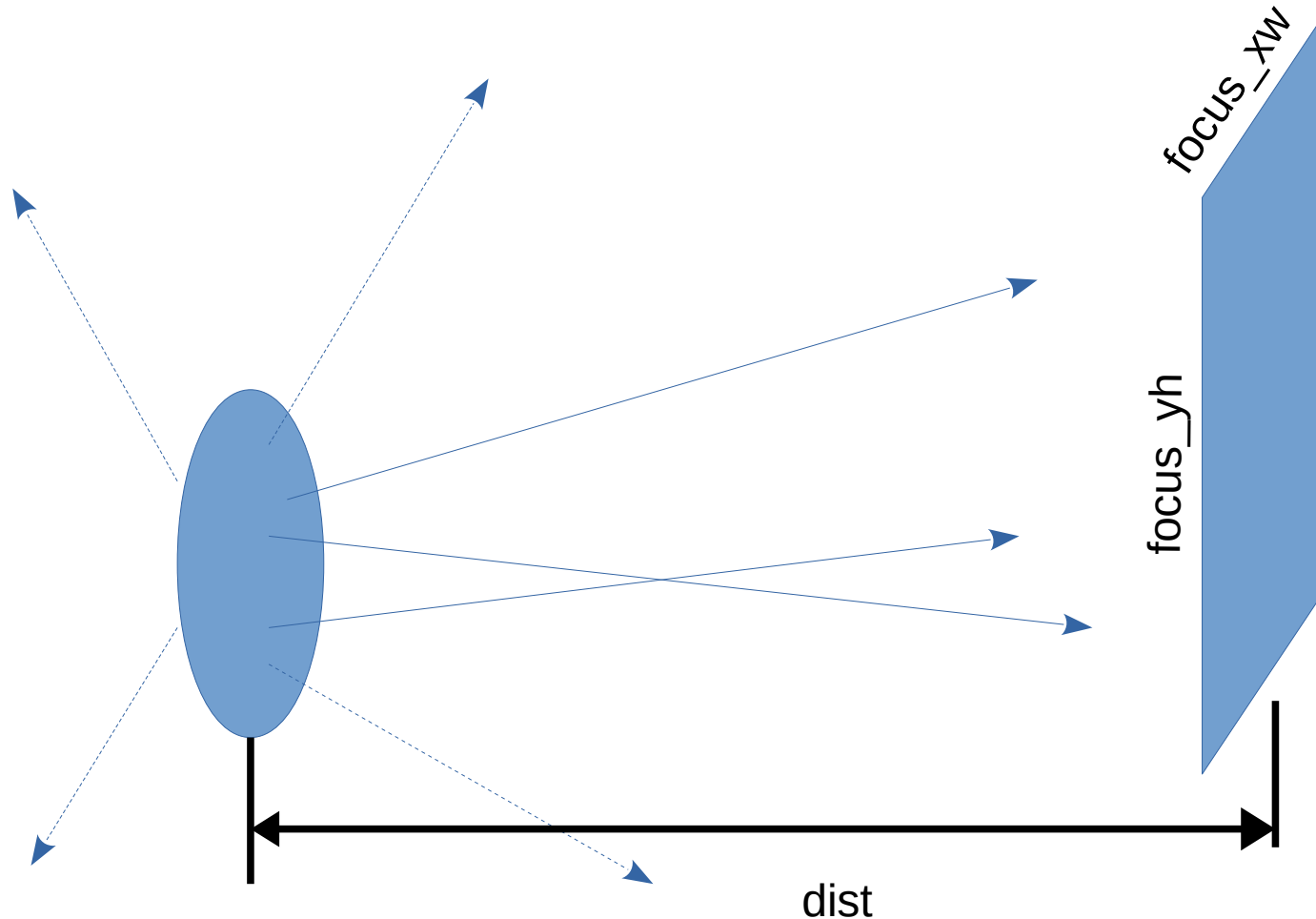
Neutron spatial coordinates are picked from a uniform distribution on a circle with radius R .

Sources: Example 1

Length of the velocity vector encodes the wavelength



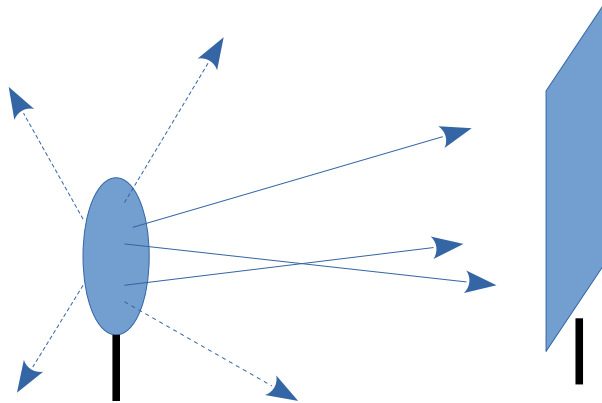
Sources: Example 1



Neutron velocity vector is picked to point at a ROI.

In McStas: this is defined by the parameters: `focus_xw`, `focus_yh`, and `dist`

Sources: Example 1



TRACE

COMPONENT origin = Progress_bar()

AT(0,0,0) ABSOLUTE

COMPONENT src = Source_simple(
 radius=0.05, lambda0=2.5, dlambda=1.5,
 focus_xw=0.1, focus_yh=0.1, dist=5)
AT(0,0,0) RELATIVE origin

Monitors: in general

REALITY:

Monitors:

- Intensity probe of the beam
- Transparent to neutrons → Efficiency <1%

Detectors:

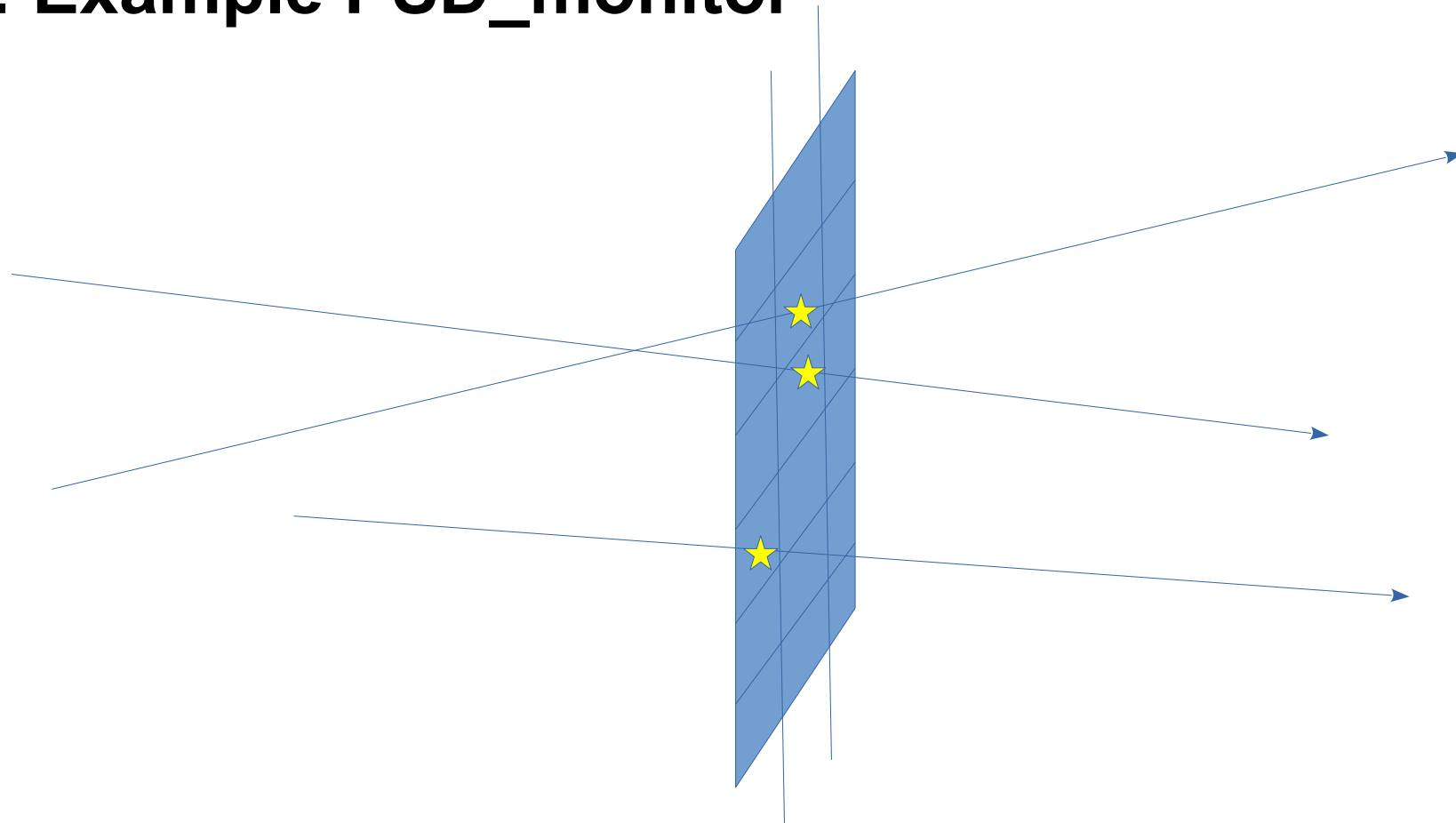
- Should detect *all* neutrons → Efficiency as high as possible

SIMULATIONS (McStas):

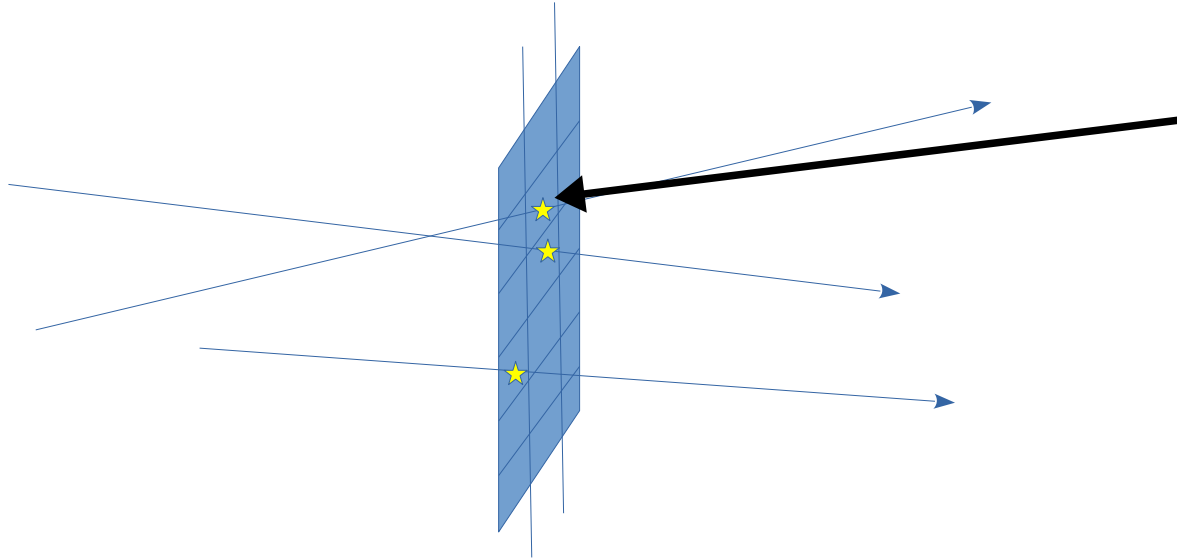
In McStas:

- We can program monitors and detectors to behave any way we like. We refer to both of those indistinguishably as 'monitors'.
- E.g. monitor with Efficiency =100% and Transparency=100%
- (With exception of PSD_Detector that models a "physical" He³ detector)

Monitors: Example PSD_monitor



Monitors: Example PSD_monitor



When the simulation has been completed, the detected intensity in pixel (i,j) is:

$$I(i, j) = \sum_{x_k, y_k \in \text{pixel}(i, j)} p_k; k = \text{ray number}.$$

... during simulation, the pixels are maintained as running sums.

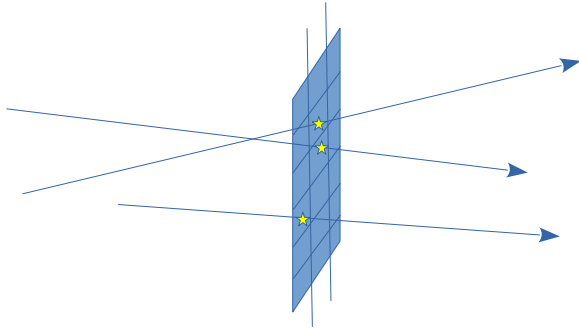
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Monitors: Example PSD_monitor and L_monitor



...

TRACE

COMPONENT origin = Progress_bar()

AT (0,0,0) **ABSOLUTE**

COMPONENT src = Source_simple(
 radius=0.05, lambda0=2.5, dlambd=1.5,
 focus_xw=0.1, focus_yh=0.1, dist=5)

AT (0,0,0) **RELATIVE** origin

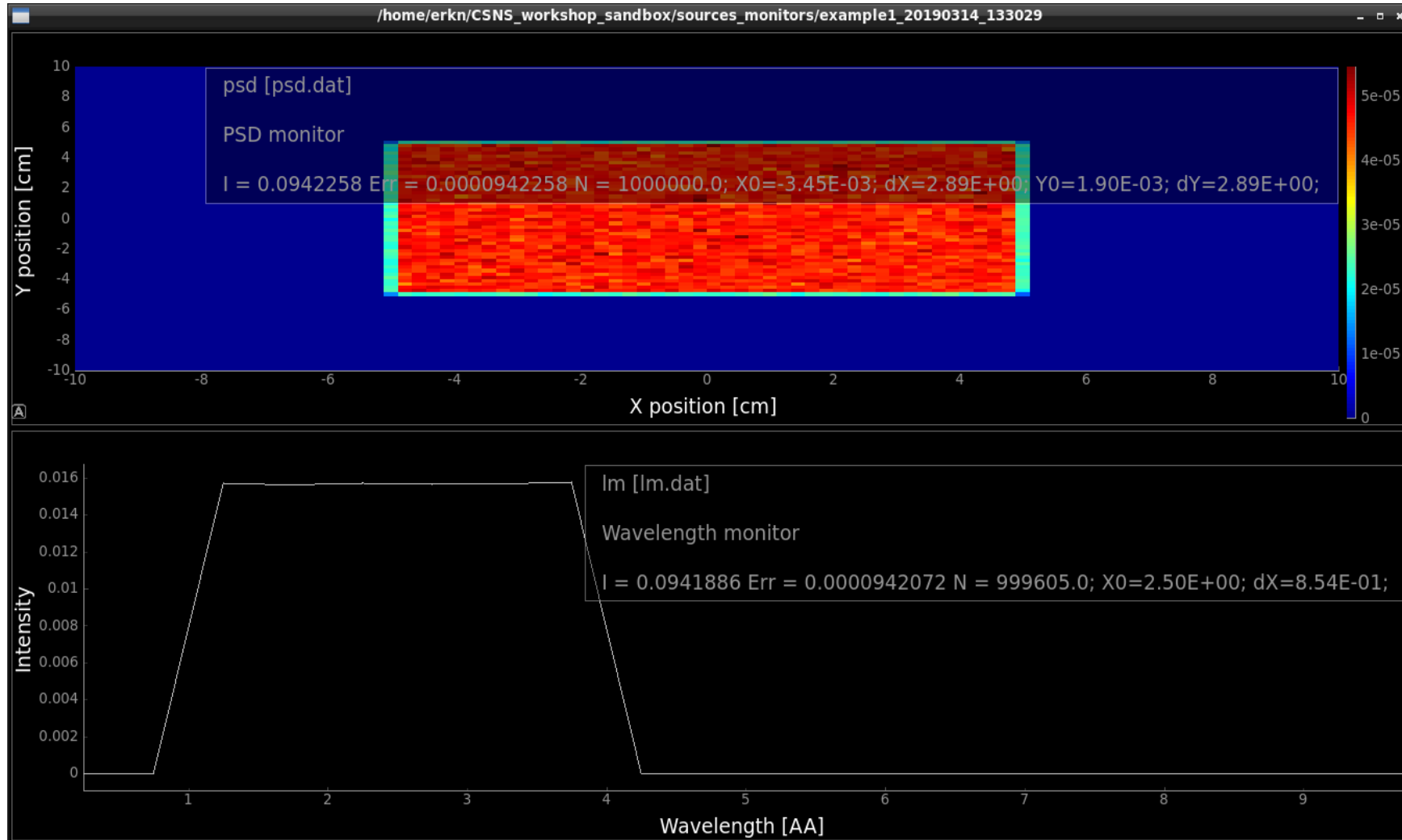
COMPONENT psd = PSD_monitor(
 xwidth=0.2, yheight=0.2, filename="psd.dat")

AT (0,0,5) **RELATIVE** src

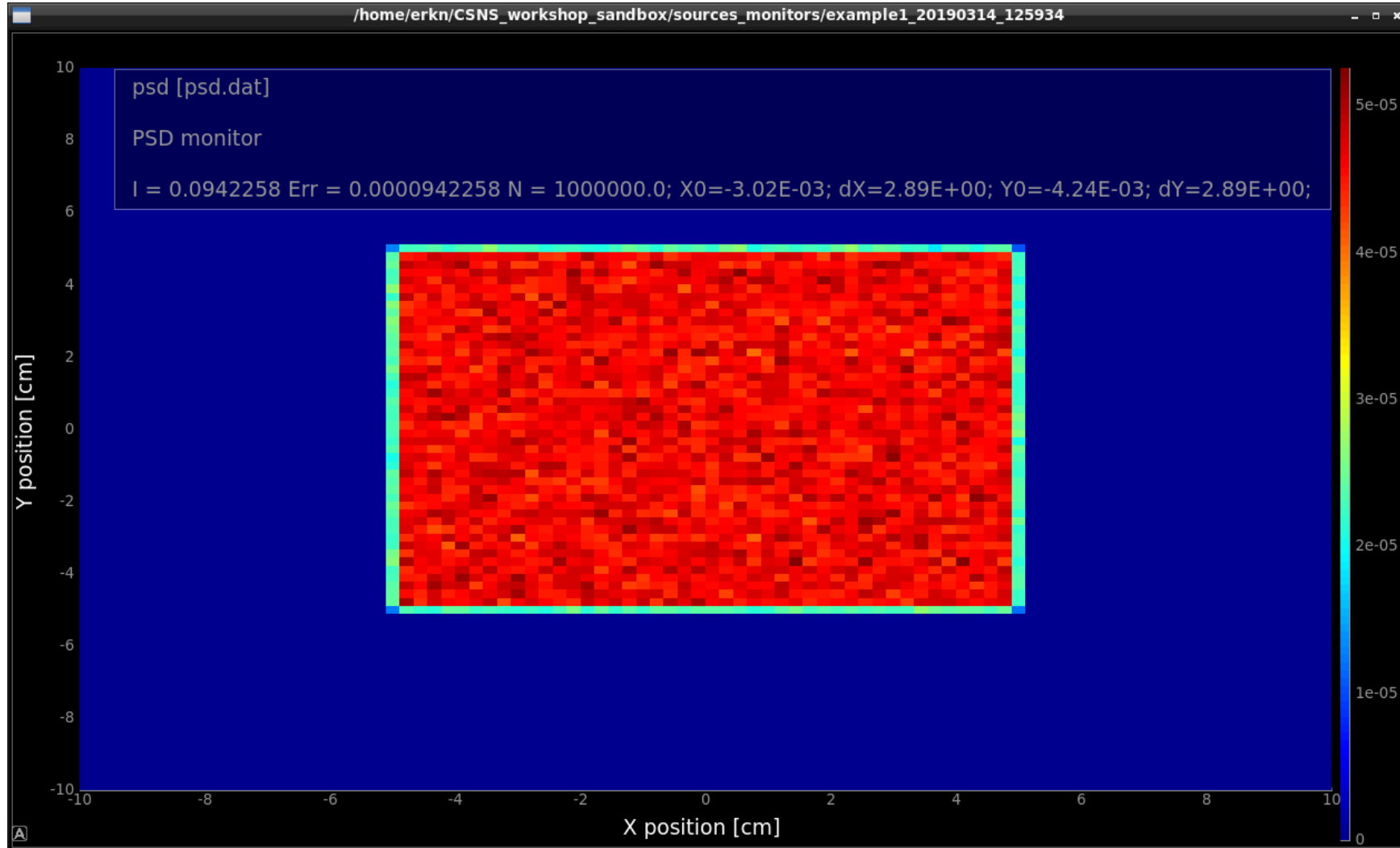
COMPONENT lm = L_monitor(
 xwidth=0.2, yheight=0.2, filename="lm.dat",
 Lmin=0, Lmax=8)

AT (0,0,5+0.01) **RELATIVE** src

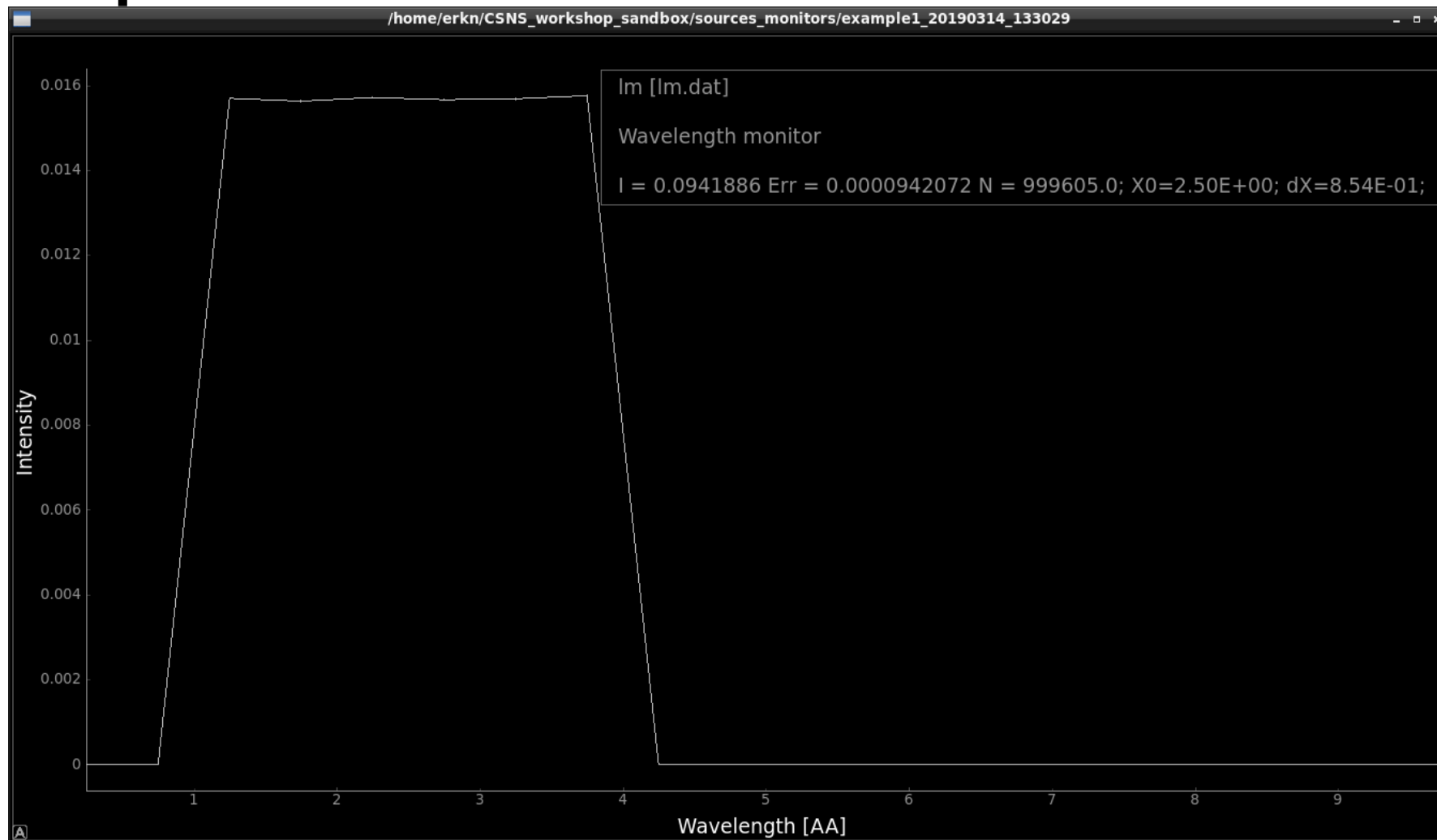
Example 1: Results



Example 1: Results

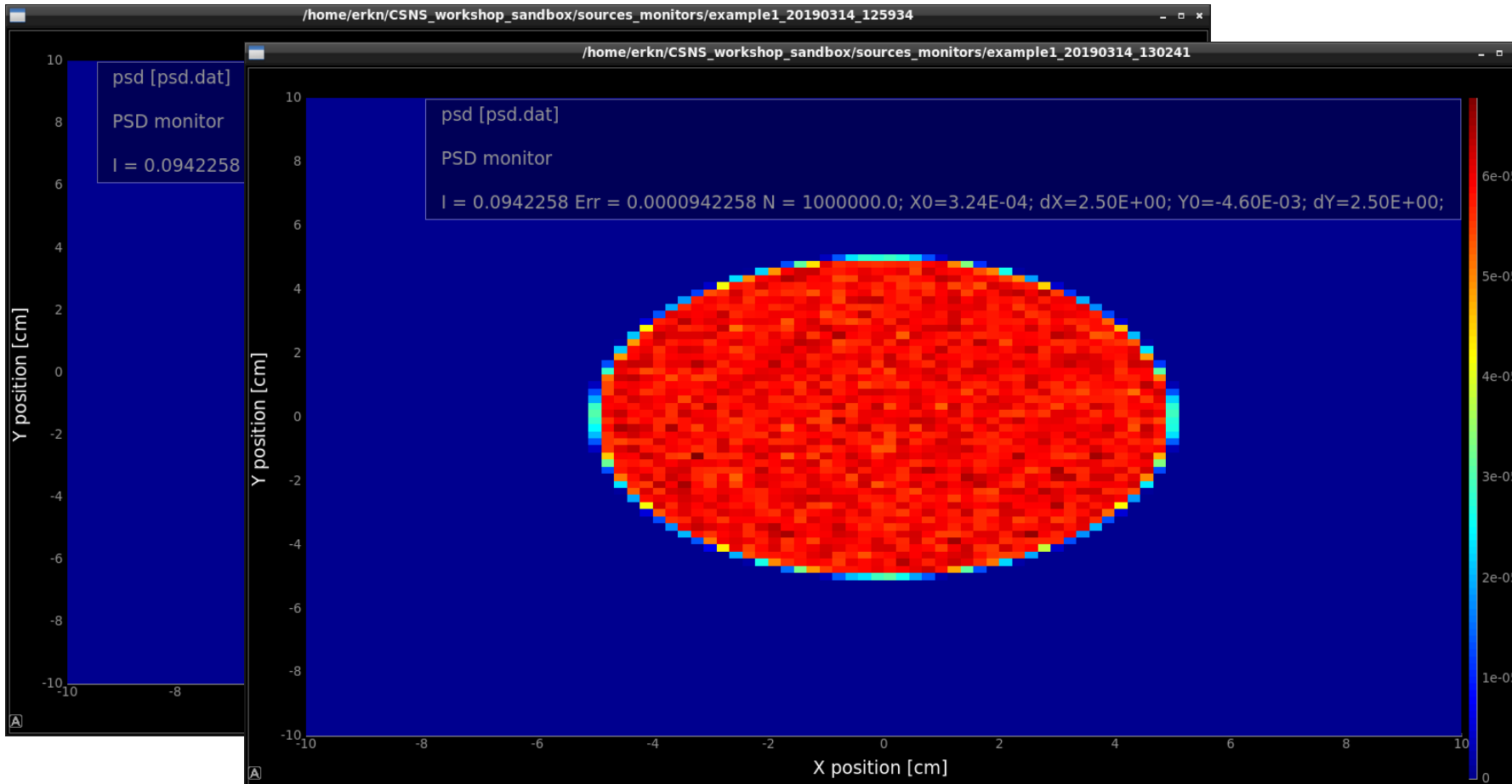


Example 1: Results

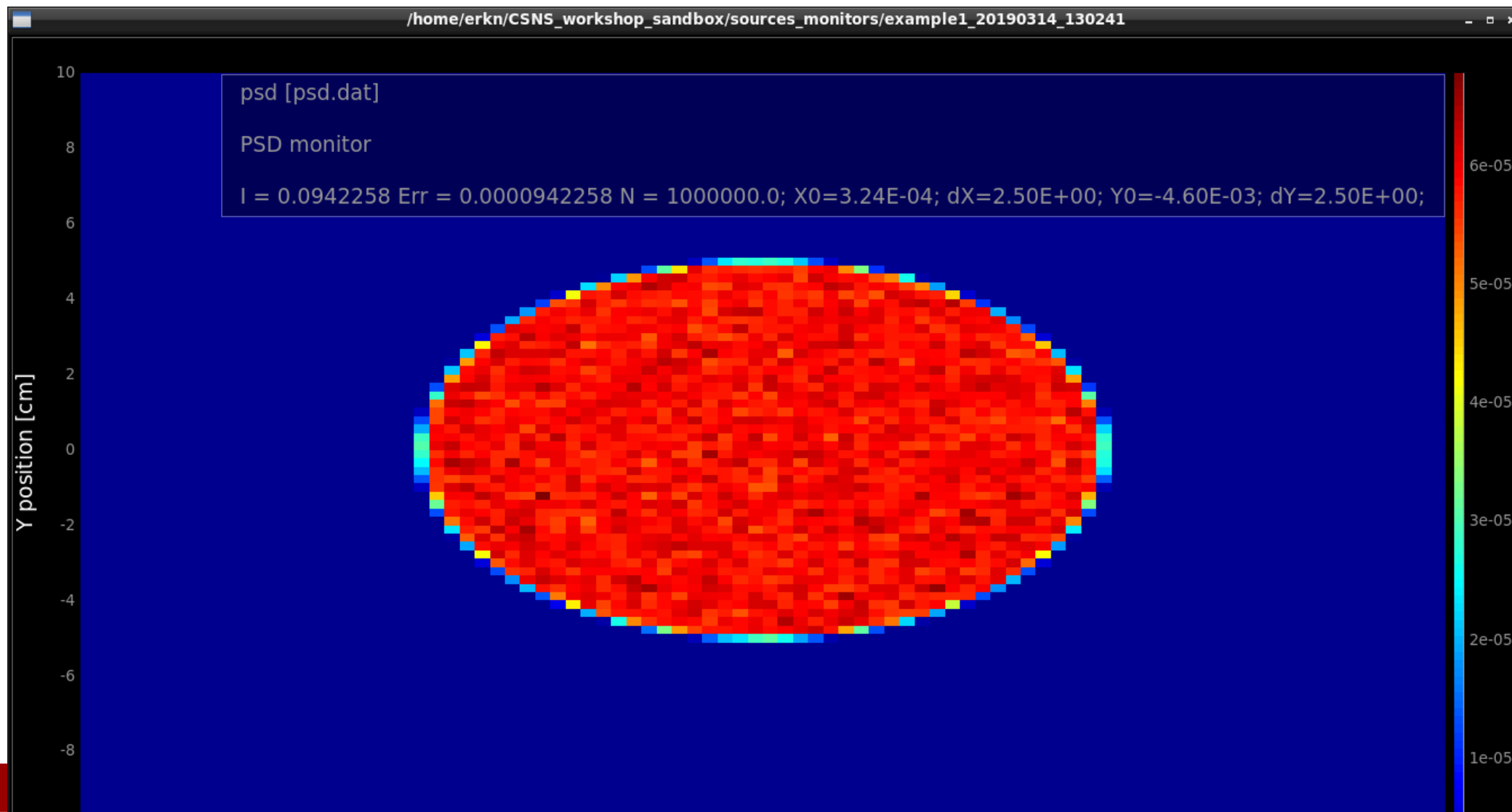


Example 1: Results

If we move the PSD_monitor close to the src...



Monitors: information content



Sources: Mathematical sources

Source_simple:

- Square or circular surface emitting neutrons from either uniform or Gaussian wavelength (or energy) distribution.
- Neutrons are directed towards a square target.

Source_div:

- Square surface emitting neutrons from either uniform or Gaussian wavelength (or energy) distribution.
- Neutrons have a divergence defined by either uniform or Gaussian distribution.

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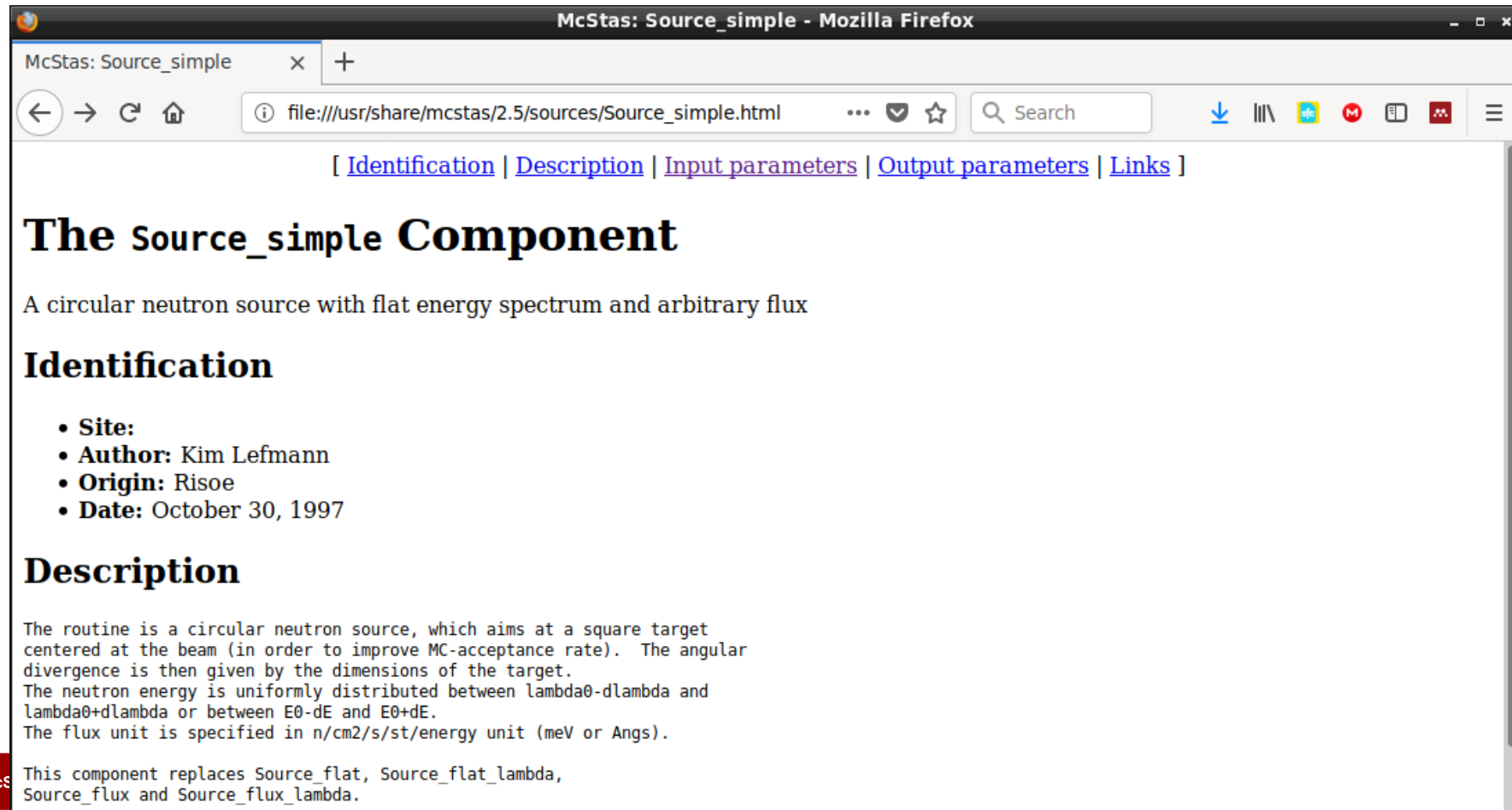


Source_simple docs

Try “**mcdoc Source_simple**”

or

(in GUI) **Help** → **mcdoc Component Reference** → (In Webpage) **Source_simple**



McStas: Source_simple - Mozilla Firefox

McStas: Source_simple x +

file:///usr/share/mcstas/2.5/sources/Source_simple.html

[[Identification](#) | [Description](#) | [Input parameters](#) | [Output parameters](#) | [Links](#)]

The Source_simple Component

A circular neutron source with flat energy spectrum and arbitrary flux

Identification

- **Site:**
- **Author:** Kim Lefmann
- **Origin:** Risoe
- **Date:** October 30, 1997

Description

The routine is a circular neutron source, which aims at a square target centered at the beam (in order to improve MC-acceptance rate). The angular divergence is then given by the dimensions of the target. The neutron energy is uniformly distributed between λ_{min} and λ_{max} or between E_{min} and E_{max} . The flux unit is specified in n/cm²/s/st/energy unit (meV or Angs).

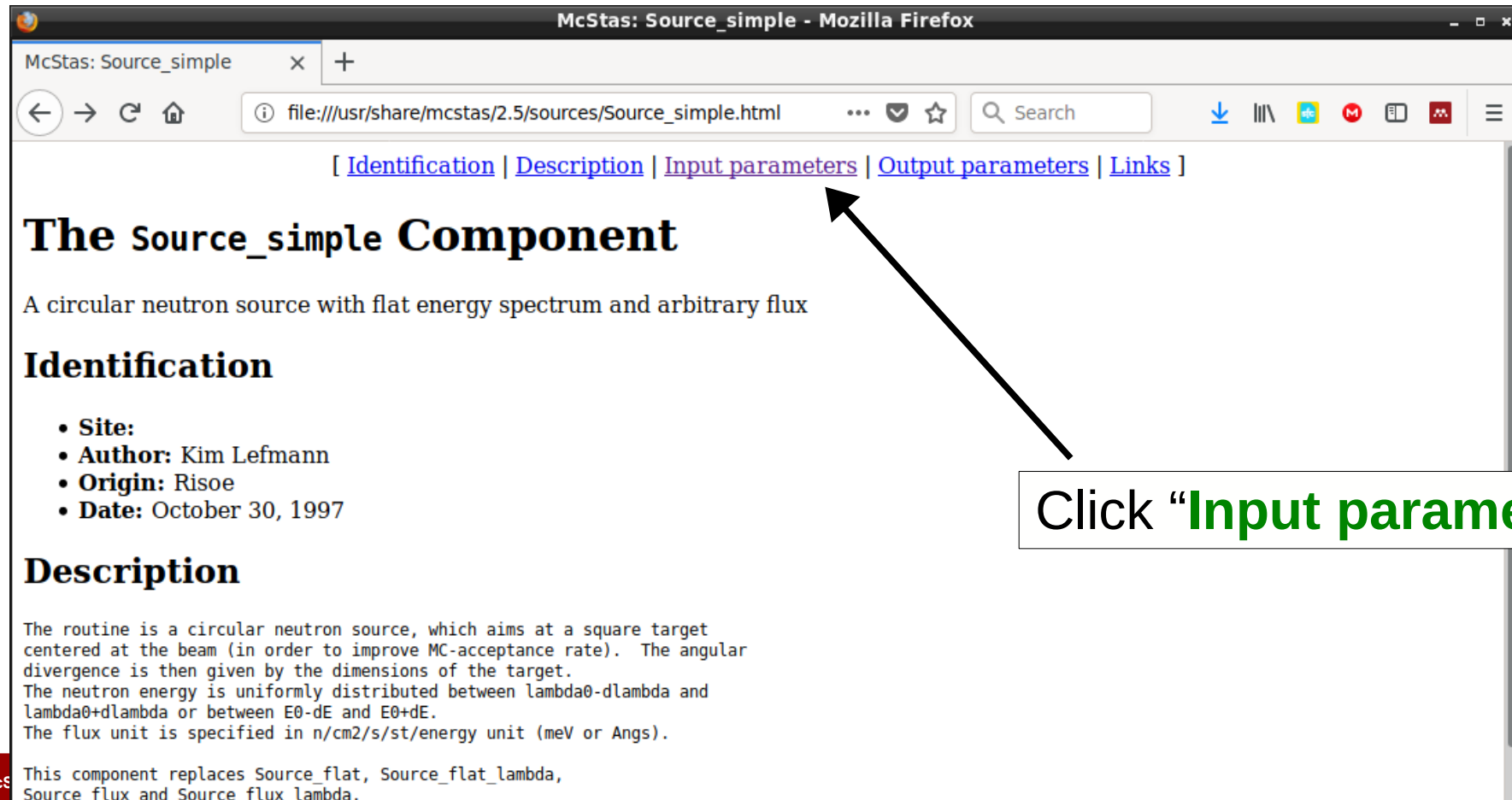
This component replaces Source_flat, Source_flat_lambda, Source_flux and Source_flux_lambda.

Source_simple docs

Try “**mcdoc Source_simple**”

or

(in GUI) **Help** → **mcdoc Component Reference** → (In Webpage) **Source_simple**



McStas: Source_simple - Mozilla Firefox

file:///usr/share/mcstas/2.5/sources/Source_simple.html

[[Identification](#) | [Description](#) | [Input parameters](#) | [Output parameters](#) | [Links](#)]

The Source_simple Component

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- **Site:**
- **Author:** Kim Lefmann
- **Origin:** Risoe
- **Date:** October 30, 1997

Description

The routine is a circular neutron source, which aims at a square target centered at the beam (in order to improve MC-acceptance rate). The angular divergence is then given by the dimensions of the target. The neutron energy is uniformly distributed between $\lambda_0 - \Delta\lambda$ and $\lambda_0 + \Delta\lambda$ or between $E_0 - \Delta E$ and $E_0 + \Delta E$. The flux unit is specified in $n/cm^2/s/st/energy$ unit (meV or Angs).

This component replaces Source_flat, Source_flat_lambda, Source_flux and Source_flux_lambda.

Click “**Input parameters**”

Source_simple docs

McStas: Source_simple - Mozilla Firefox

McStas: Source_simple x +

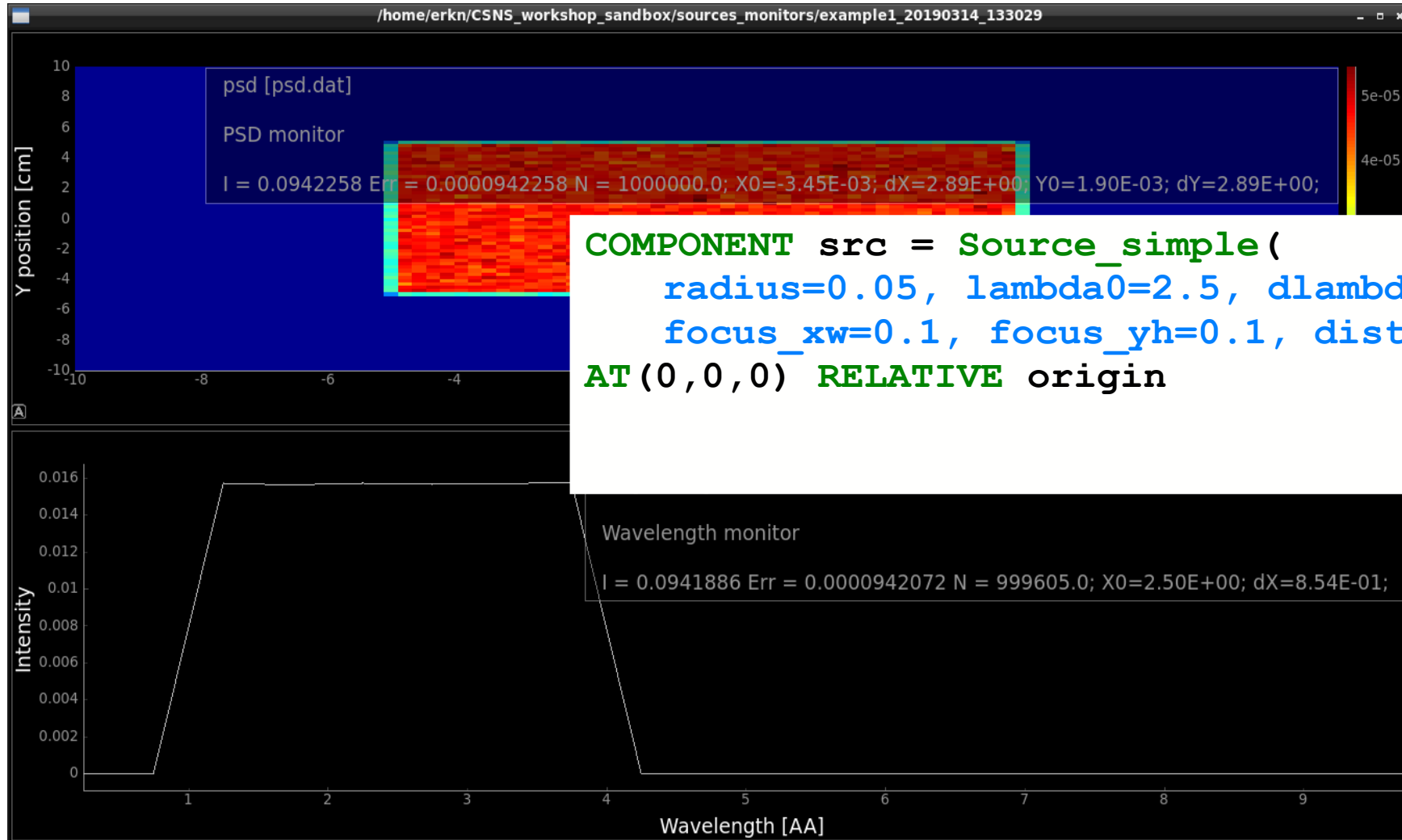
file:///usr/share/mcstas/2.5/sources/Source_simple.html#

Input parameters

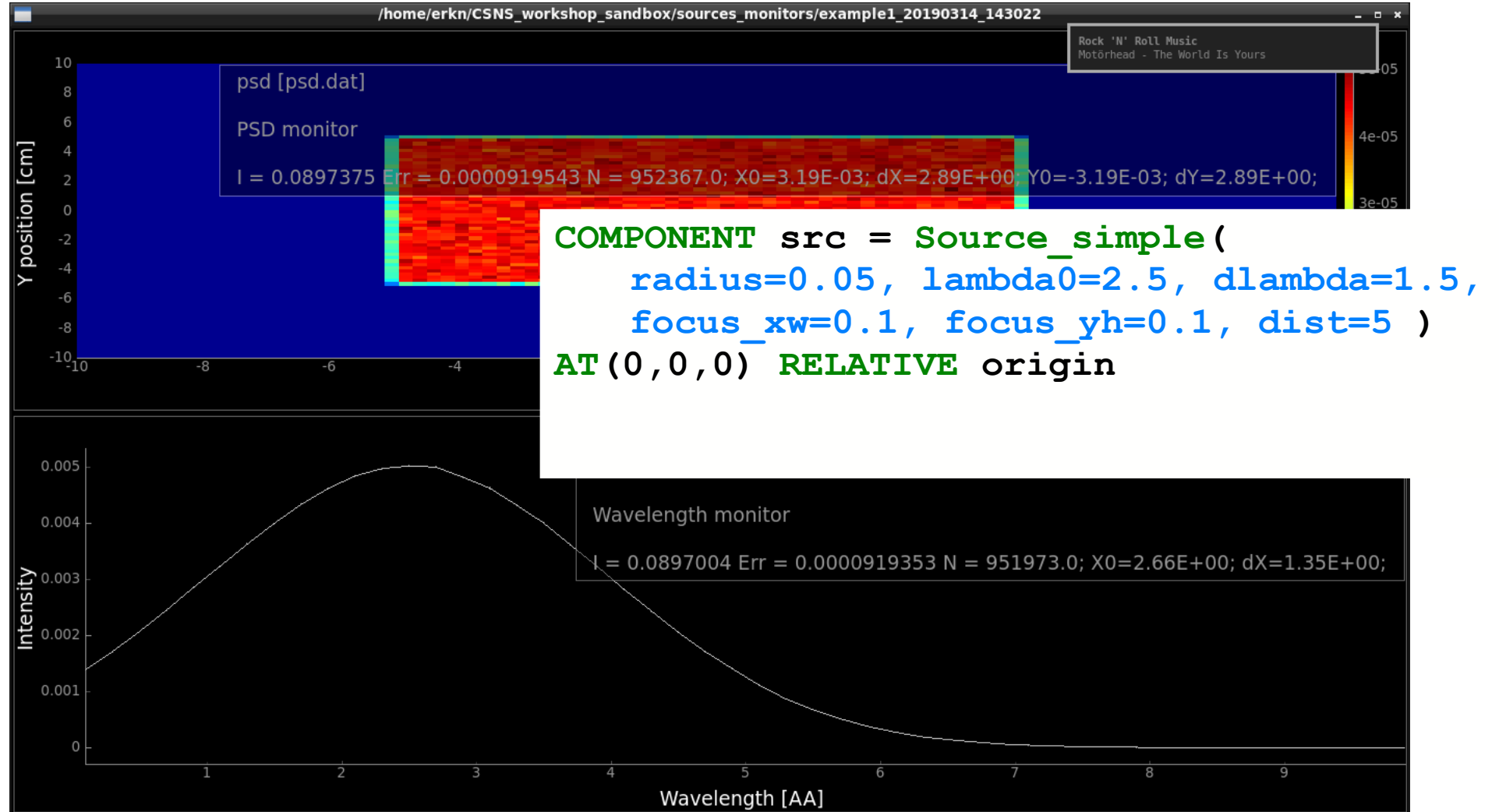
Parameters in **boldface** are required; the others are optional.

Name	Unit	Description	Default
radius	m	Radius of circle in (x,y,0) plane where neutrons are generated.	0.1
yheight	m	Height of rectangle in (x,y,0) plane where neutrons are generated.	0
xwidth	m	Width of rectangle in (x,y,0) plane where neutrons are generated.	0
dist	m	Distance to target along z axis.	0
focus_xw	m	Width of target	.045
focus_yh	m	Height of target	.12
E0	meV	Mean energy of neutrons.	0
dE	meV	Energy half spread of neutrons (flat or gaussian sigma).	0
lambda0	AA	Mean wavelength of neutrons.	0
dlambda	AA	Wavelength half spread of neutrons.	0
flux	1/(s*cm**2*st*energy unit)	flux per energy unit, Angs or meV if flux=0, the source emits 1 in 4*PI whole space.	1
gauss	1	Gaussian (1) or Flat (0) energy/wavelength distribution	0
target_index	1	relative index of component to focus at, e.g. next is +1 this is used to compute 'dist' automatically.	+1

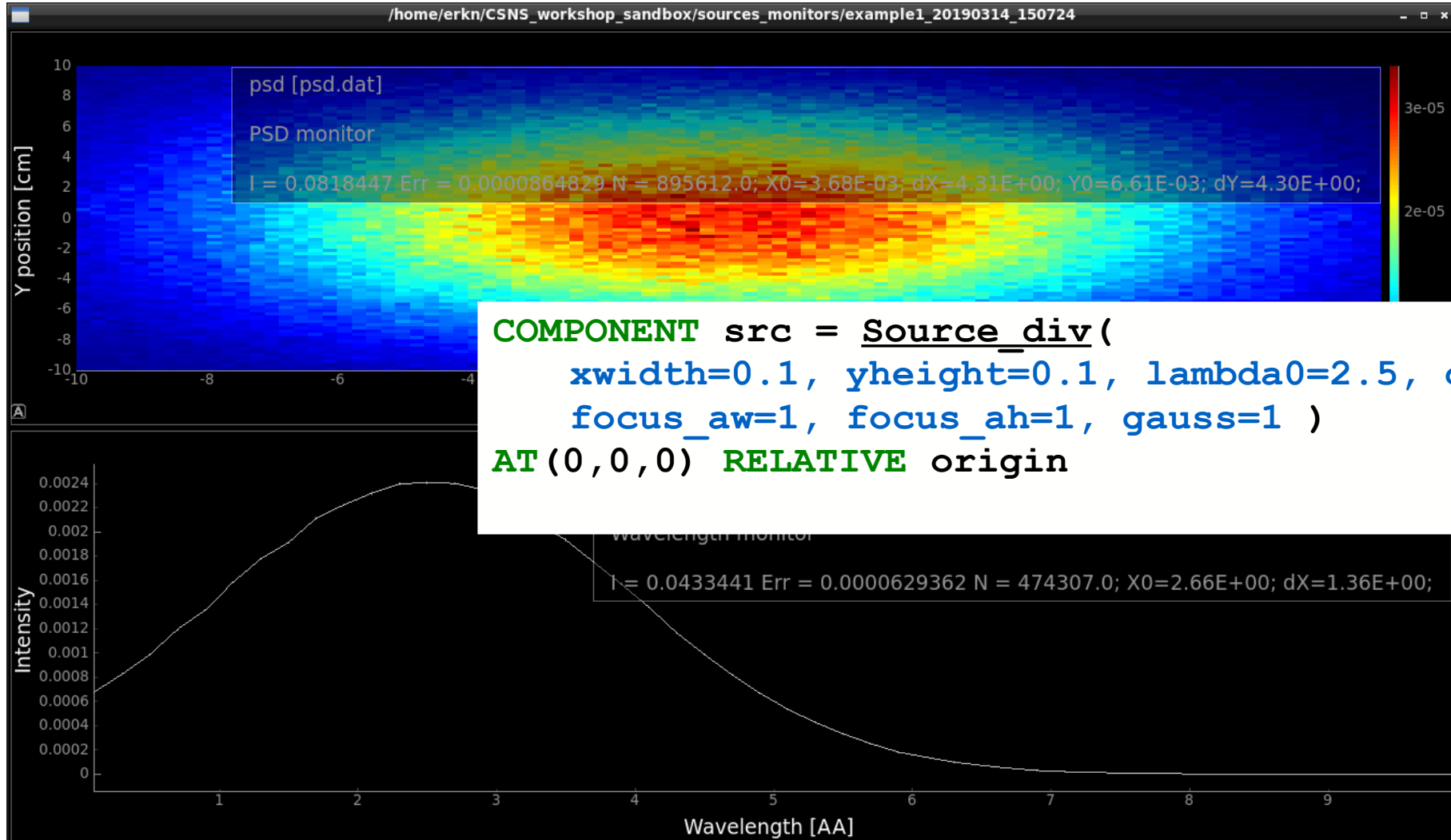
Example 1: Results revisited



Example 1: Results revisited



Example 1: Results revisited



```
COMPONENT src = Source_div(
    xwidth=0.1, yheight=0.1, lambda0=2.5, dlambda=1.5
    focus_aw=1, focus_ah=1, gauss=1 )
AT(0,0,0) RELATIVE origin
```

Sources: Source model overview

➤ *Mathematical:*

- *Source_simple.comp*
- *Source_div.comp*

➤ *Pulsed sources:*

- *ESS_butterfly.comp*
- *ESS_moderator.comp*
- *Moderator.comp*
- *SNS_source.comp (*)*
- *SNS_source_analytic (*)*
- *ViewModISIS (*)*
- *ISIS_moderator.comp (*)*

➤ *Reactors :*

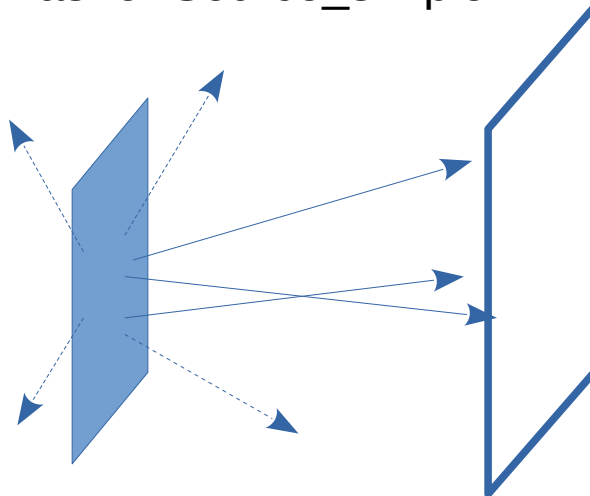
- *Source_Maxwell_3.comp*
- *Source_gen.comp*
- *Source_gen4.comp*
- *Source_multi_surfaces.comp (*)*
- *I/O mechanisms:*
 - ***MCPL_input/output.comp***
 - *Virtual_input/output.comp*
 - *Virtual_mcnp_ss_input/output.comp*
 - *Virtual_tripoli4_input/output.comp*
 - *Vitess_input/output.comp*

Sources: Source_Maxwell_3

```
COMPONENT source = Source_Maxwell_3(yheight=0.156, xwidth=0.126,  
    Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,  
    T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Parameters from the PSI cold source

Initial position and direction: as for Source_simple



Sources: Source_Maxwell_3

```
COMPONENT source = Source_Maxwell_3(yheight=0.156, xwidth=0.126,  
Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,  
T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Parameters from the PSI cold source

Intensity at a given wavelength drawn from a sum of (up to) 3 normalized Maxwellian distributions:

$$I(\lambda) = \sum_{i \in 1,2,3} I_i M(\lambda, T_i); \quad M(\lambda, T_i) = 2 \alpha^2 \exp\left(\frac{-\alpha}{\lambda^2}\right) / \lambda^5;$$

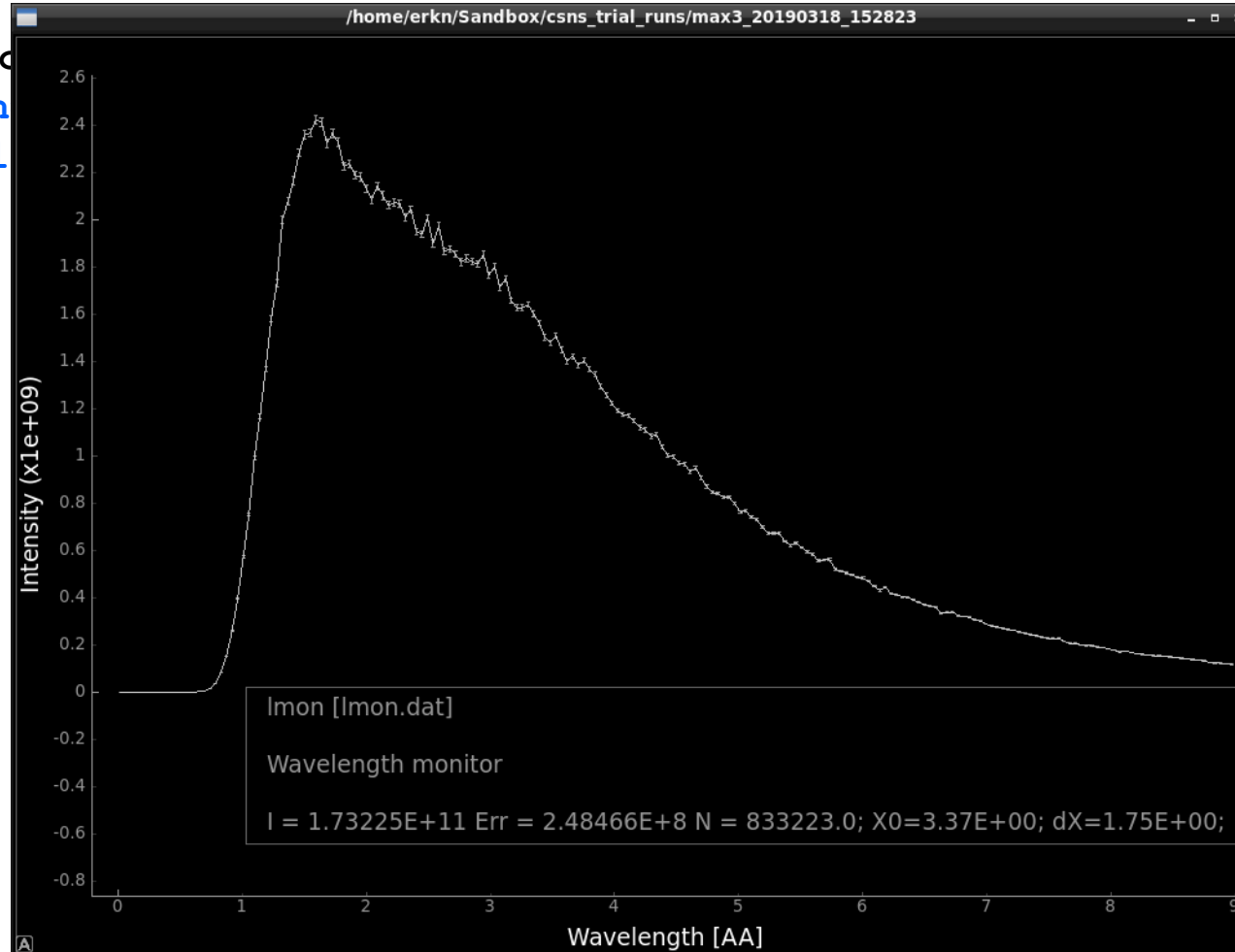
$$\alpha = 949.0 \text{ K } AA^2 / T_i$$

Sources: Source_Maxwell_3

COMPONENT source

Lmin

T1=1



26,

yh = 0.12,

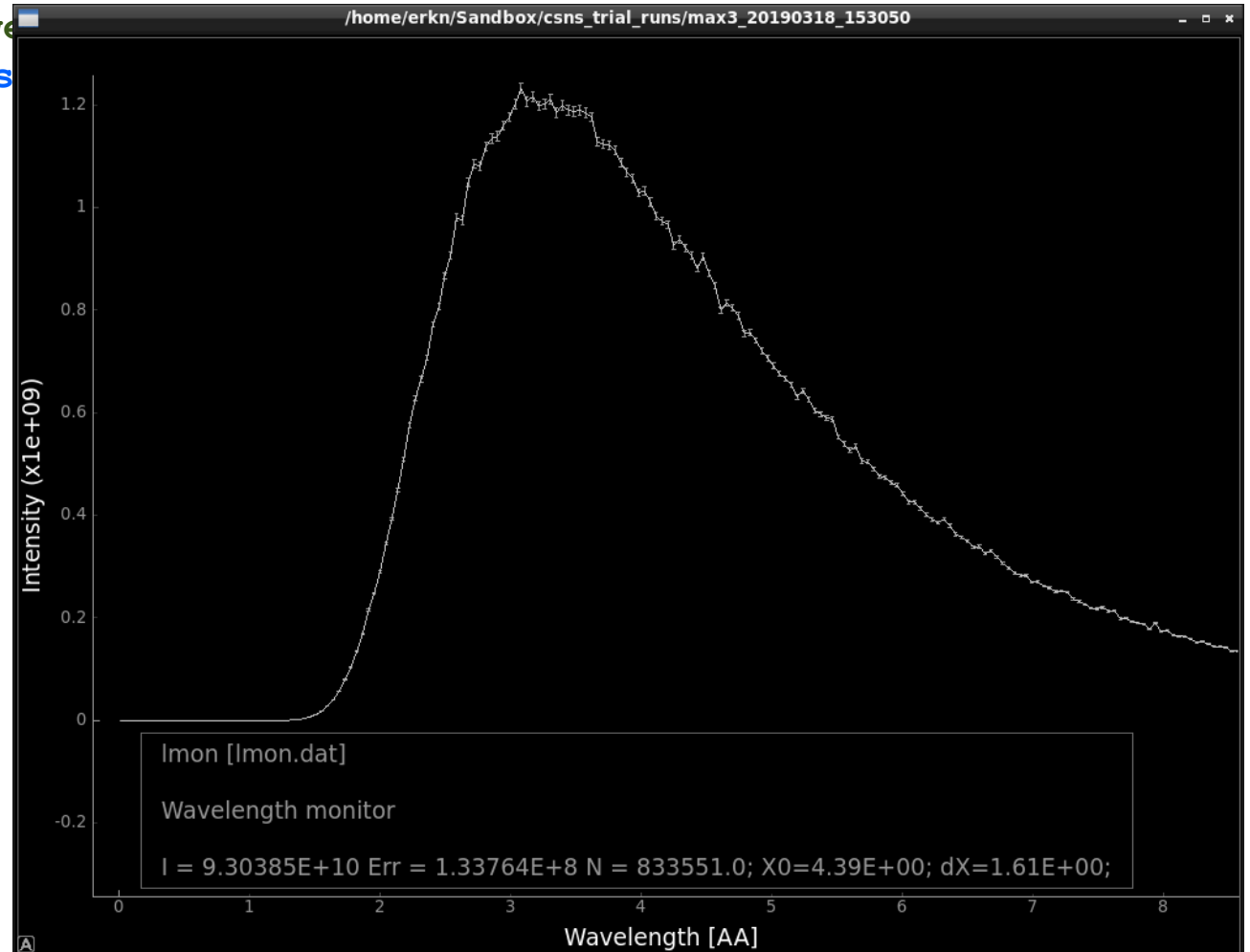
I3=0.95E11)

from the PSI cold source

Sources: Source_Maxwell_3

```
COMPONENT source = Source_Maxwell_3
  Lmin=0.1, Lmax=9.0, dist=150.42,
  T1=150.42, I1=3.67E11,
```

Just for fun – let's see what happens if we remove the fast peak...



Input parameters

Parameters in **boldface** are required; the others are optional.

Name	Unit	Description	Default
size	m	Edge of cube shaped source (for backward compatibility)	0
yheight	m	Height of rectangular source	0
xwidth	m	Width of rectangular source	0
Lmin	AA	Lower edge of lambda distribution	
Lmax	AA	Upper edge of lambda distribution	
dist	m	Distance from source to focusing rectangle; at (0,0,dist)	
focus_xw	m	Width of focusing rectangle	
focus_yh	m	Height of focusing rectangle	
T1	K	1st temperature of thermal distribution	
T2	K	2nd temperature of thermal distribution	300
T3	K	3rd temperature of - - -	300
I1	1/(cm**2*st)	flux, 1 (in flux units, see above)	
I2	1/(cm**2*st)	flux, 2 (in flux units, see above)	0
I3	1/(cm**2*st)	flux, 3 - - -	0
target_index	1	relative index of component to focus at, e.g. next is +1 this is used to compute 'dist' automatically.	+1
lambda0	AA	Mean wavelength of neutrons.	0
dlambda	AA	Wavelength spread of neutrons.	0

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Sources: Source_gen (Source_gen4)

```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,  
    Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,  
    T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Almost the same as Source_Maxwell_3: but with optional flux-files as input.

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Sources: Source_gen (Source_gen4)

Input parameters

Parameters in **boldface** are required; the others are optional.

Name	Unit	Description	Default
flux_file	str	Name of a two columns [lambda flux] text file that contains the wavelength distribution of the flux in either $[1/(s \cdot cm^2 \cdot st)]$ or $[1/(s \cdot cm^2 \cdot st \cdot AA)]$ (see flux_file_perAA flag) Comments (#) and further columns are ignored. Format is compatible with McStas/PGPLOT wavelength monitor files. When specified, temperature and intensity values are ignored.	"NULL"
xdiv_file	str	Name of the x-horiz. divergence distribution file, given as a free format text matrix, preceeded with a line '# xylimits: xmin xmax xdiv_min xdiv_max'	"NULL"
ydiv_file	str	Name of the y-vert. divergence distribution file, given as a free format text matrix, preceeded with a line '# xylimits: ymin ymax ydiv_min ydiv_max'	"NULL"
radius	m	Radius of circle in (x,y,0) plane where neutrons are generated. You may also use 'yheight' and 'xwidth' for a square source	0.0
dist	m	Distance to target along z axis.	0
focus_xw	m	Width of target.	0.045
focus_yh	m	Height of target.	0.12
focus_ah	deg	maximal (uniform) horz. width divergence	0
focus_ah	deg	maximal (uniform) vert. height divergence	0
E0	meV	Mean energy of neutrons.	0
dE	meV	Energy spread of neutrons, half width.	0
lambda0	AA	Mean wavelength of neutrons.	0
dlambda	AA	Wavelength spread of neutrons, half width	0
I1	$1/(cm^2 \cdot sr)$	Source flux per solid angle, area and Angstrom if I1=0, the source emits 1 in $4 \cdot \pi$ whole space.	1
yheight	m	Source y-height, then does not use radius parameter	0.1
xwidth	m	Source x-width, then does not use radius parameter	0.1
verbose	0/1	display info about the source. -1 unactivate source.	0
T1	K	Temperature of the Maxwellian source, 0=none	0

Sources: Source_gen (Source_gen4)

```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,  
    flux_file="file1.dat", xdiv_file="file2.dat", ydiv_file="file3.dat")
```

Almost the same as Source_Maxwell_3: but with optional flux- and divergence-files as input.

Source_gen4: Same as for Source_gen but more accurate tail-description for PSI.

To generate files – e.g.

```
Monitor_nD(options="auto lambda per cm2", filename="file1.dat")  
Monitor_nD(options="x hdiv, all auto", filename="file2.dat")  
Monitor_nD(options="y vdiv, all auto", filename="file3.dat")
```


Sources: Source_gen (Source_gen4)

```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,  
    Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,  
    T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Almost the same as Source_Maxwell_3: but with optional flux-files as input.

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Sources: Pulsed sources

Simplest case:

Use a continuous mathematical source and add time dependence:

```
COMPONENT src = Source_simple(
    radius=0.05, lambda0=2.5, dlambda=1.5,
    focus_xw=0.1, focus_yh=0.1, dist=5 )
AT(0,0,0) RELATIVE origin
EXTEND
%{
    t=rand01()*1e-6;
%}
```

Sources: Pulsed sources

Simplest case:

Use a continuous mathematical source and add time dependence:

```
COMPONENT src = Source_simple'
    radius=0.05, lambda=0.05,
    focus_xw=0.1, lambda=1.5,
    st=5 )
AT (0,0,0)
EXTEND
%{
    t=ranf(0,1)
%}
```

Or: Use a chopper



Sources: SNS_source

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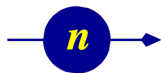
Sources: ViewModISIS

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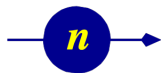
Sources: ESS_butterfly

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Monitors (some)

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源

1D

- L_monitor $\rightarrow I(\lambda)$
- TOF_monitor $\rightarrow I(t)$
- Hdiv_monitor $\rightarrow I(\text{divergence}_x)$
- MeanPolLambda $\rightarrow \langle \bar{P} \rangle(\lambda)$
- E_monitor $\rightarrow I(E)$

2D

- PSD_monitor $\rightarrow I(x, y)$
- PSD_monitor_4PI $\rightarrow I(\theta, \phi)$
- PolLambda_monitor $\rightarrow I(\bar{P}, \lambda)$

nD

- Monitor_nD

$$I(X)$$

or

$$I(X, Y)$$

or

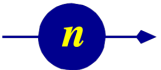
$$Z(X, Y, Z)$$

or ...

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Monitors: Quick examples

```
COMPONENT my_L_monitor = L_monitor(xwidth=0.2, yheight=0.2,  
                                     nL=20, filename="Output.L", Lmin=2, Lmax=10)
```

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Statistics computed on the fly

my_L_monitor [Output.L]

Wavelength monitor

$I = 9.18944\text{E}+10$ Err = $1.33658\text{E}+8$ N = 655688.0; X0=4.42E+00; dX=1.60E+00;

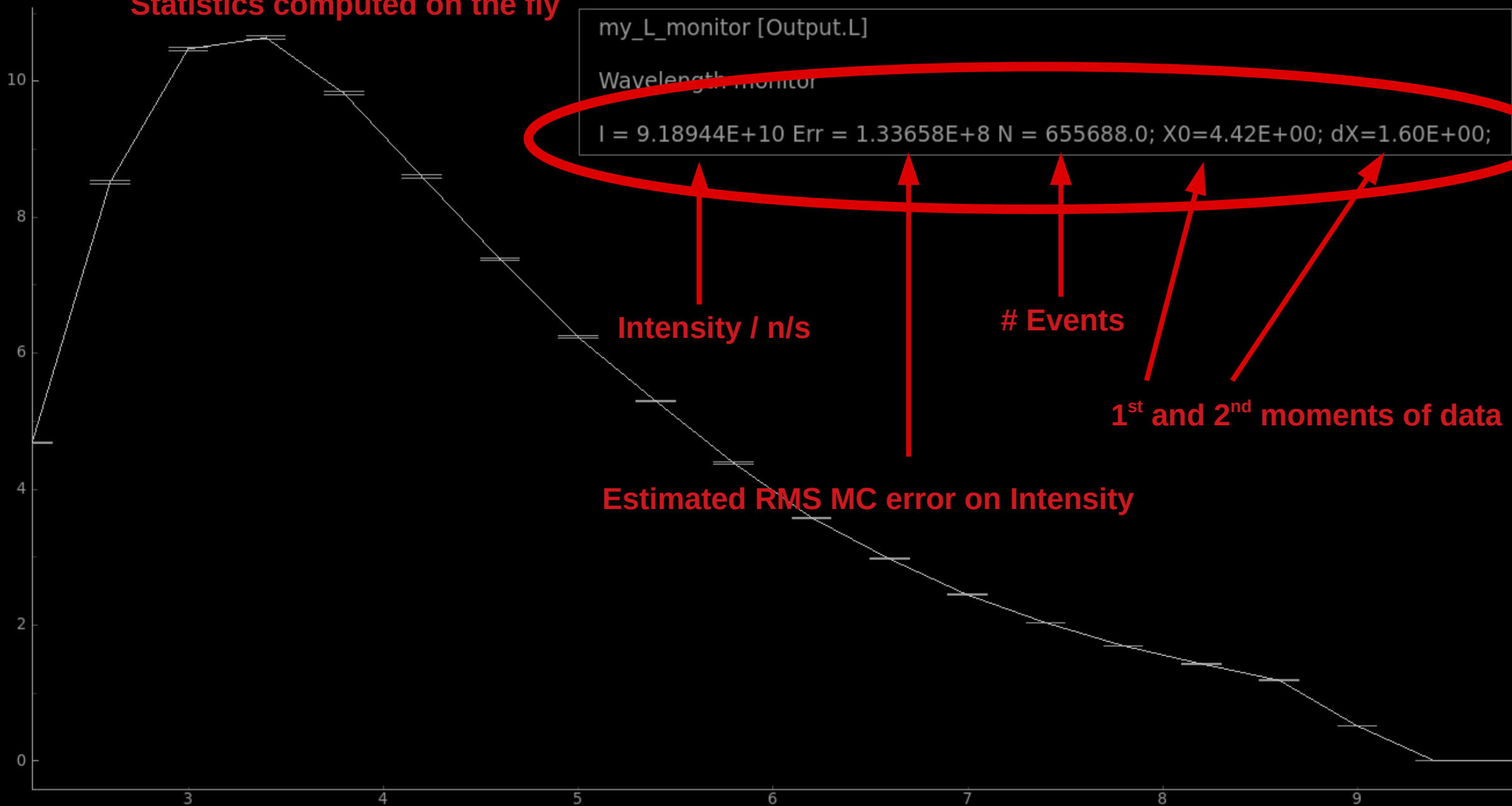
Intensity (x1e+09)

Intensity / n/s

Events

1st and 2nd moments of data

Estimated RMS MC error on Intensity





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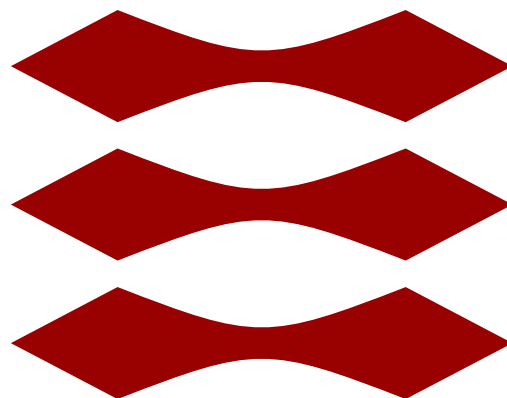


EUROPEAN
SPALLATION
SOURCE

McStas



DTU



中国散裂中子源

China Spallation Neutron Source

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