SPIROU-4800-LAM-UM-00961

SPIRou Data Reduction Software

User Guide

0.0.42

For DRS SPIRou 0.1.022 (alpha pre-release)

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Abstract

This is the guide to installing, running, and using the SPIRou DRS.

Contents

Chapter 1

Introduction

This documentation will cover the installation, data architecture, , using the DRS (with a working example), descriptions of the variables , and the recipes .

Variables are defined in detail in section 7 and will be defined throughout via the following syntax: VARIABLE. When refered to, one should take it as using the value set in section 7 by default or in the file described in the variables description 'Defined in' section. Clicking these variables will go to the appriopriate variable description.

Certain sections will be written in code blocks, these imply text that is written into a text editor, the command shell console, or a python terminal/script. Below explains how one can distinguish these in this document.

The following denotes a line of text (or lines of text) that are to be edited in a text editor.

Generic text file

```
# A variable name that can be changes to a specific value
VARIABLE_NAME = "Variable Value"
```

These can also be shell scripts in a certain language:

For example in ~/.bashrc

```
#!/usr/bin/bash
# Find out which console you are using
echo $0
# Set environment Hello
export Hello="Hello"
```

For example in ~/.tcshrc

```
#!/usr/bin/tcsh
# Find out which console you are using
echo $0
# Set environment Hello
setenv Hello "Hello"
```

The following denotes a command to run in the command shell console

```
>> cd ~/Downloads
```

The following denotes a command line print out

```
This is a print out in the command line
produced by using the echo command
```

The following denotes a python terminal or python script

Python/Ipython

```
import numpy as np
print("Hello world")
print("{0} seconds".format(np.sqrt(25)))
```

Chapter 2

Quick Install Guide

2.1 Linux

This is a quick guide to installation, for a more full description please see Chapter 3 . This assumes you have the latest version of Anaconda for python 3 (or python 2) and are using BASH.

1. Get the latest version of the DRS (for SPIRou version 0.1.022 (alpha pre-release)). from here: https://github.com/njcuk9999/spirou_py3
2. Download the test data from here: http://genesis.astro.umontreal.ca/neil/spirou_test_data_alpha0.1.003.zip (if required).
3. Extract the DRS (make a note of the path, hereinafter DRS_ROOT)
4. Add the following paths to your PATH and PYTHON PATH environmental variables (in for example .bashrc)

   e.g. in ~/.bashrc

   ```
   export PATH="DRS_ROOT/bin/:<$PATH>"
   export PYTHONPATH="DRS_ROOT:DRS_ROOT/bin/:<$PYTHONPATH>"
   ```

5. make sure your paths are set

   ```
   >>  source ~/.bashrc
   >>  echo $PATH
   ```

6. Make recipes executable (found in the DRS_ROOT /bin folder) - to use from the command line.
7. Setup the DRS paths (edit the file: '../config /config.txt '):

TDATA	= /drs/data/	/	Define the DATA directory
DRS_ROOT	= /drs/INTROOT/	/	Define the installation directory
DRS_DATA_RAW	= /drs/data/raw	/	Define the folder with the raw data files in
DRS_DATA_REDUC	= /drs/data/reduced	/	Define the directory that the reduced data should be saved to/read from
DRS_CALIB_DB	= /drs/data/calibDB	/	Define the directory that the calibration files should be saved to/read from
DRS_DATA_MSG	= /drs/data/msg	/	Define the directory that the log messages are stored in
DRS_DATA_WORKING	= /drs/data/tmp/	/	Define the working directory

8. validate the DRS installation:

   ```
   >> cal_validate_spirou
   ```

   or

   ```
   >> python cal_validate_spirou
   ```

The DRS is now installed and setup. To run see section 5 .

2.2 Mac

This is a quick guide to installation, for a more full description please see Chapter 3 . This assumes you have the latest version of Anaconda for python 3 (or python 2) and are using BASH.

1. Get the latest version of the DRS (for SPIRou version 0.1.022 (alpha pre-release)). from here: https://github.com/njcuk9999/spirou_py3

2. Download the test data from here: http://genesis.astro.umontreal.ca/neil/spirou_test_data_alpha0.1.003.zip (if required).

3. Extract the DRS (make a note of the path, hereinafter DRS_ROOT)

4. Add the following paths to your PATH and PYTHON PATH environmental variables (in for example .bashrc)

   e.g. in ~/.bashrc

   ```
   export PATH="DRS_ROOT/bin/:<$PATH>"
   export PYTHONPATH="DRS_ROOT:DRS_ROOT/bin/:<$PYTHONPATH>"
   ```

5. make sure your paths are set

   ```
   >>  source ~/.bashrc
   >>  echo $PATH
   ```

6. Make recipes executable (found in the DRS_ROOT /bin folder) - to use from the command line.

7. Setup the DRS paths (edit the file: '../config /config.txt '):

TDATA	=	/drs/data/	/	Define the DATA directory
DRS_ROOT	=	/drs/INTROOT/	/	Define the installation directory
DRS_DATA_RAW	=	/drs/data/raw	/	Define the folder with the raw data files in
DRS_DATA_REDUC	=	/drs/data/reduced	/	Define the directory that the reduced data should be saved to/read from
DRS_CALIB_DB	=	/drs/data/calibDB	/	Define the directory that the calibration files should be saved to/read from
DRS_DATA_MSG	=	/drs/data/msg	/	Define the directory that the log messages are stored in
DRS_DATA_WORKING	=	/drs/data/tmp/	/	Define the working directory

8. validate the DRS installation:

   ```
   >> cal_validate_spirou
   ```

   or

   ```
   >> python cal_validate_spirou
   ```

The DRS is now installed and setup. To run see section 5 .

2.3 Windows

This is a quick guide to installation, for a more full description please see Chapter 3 . This assumes you have the latest version of Anaconda for python 3 (or python 2)

1. Get the latest version of the DRS (for SPIRou version 0.1.022 (alpha pre-release)). from here: https://github.com/njcuk9999/spirou_py3
2. Download the test data from here: http://genesis.astro.umontreal.ca/neil/spirou_test_data_alpha0.1.003.zip (if required).
3. Extract the DRS (make a note of the path, hereinafter DRS_ROOT)
4. Add the following paths to your PATH environmental variable

   In "Enviromental Variables"

   ```
   DRS_ROOT\bin\;
   ```

5. Add the following paths to your PYTHONPATH environmental variable

   In "Enviromental Variables"

   ```
   %PYTHONPATH%;DRS_ROOT;DRS_ROOT\bin\;
   ```

6. Setup the DRS paths (edit the file: '../config /config.txt '):

   ```
   TDATA              = C:\\Users\\User\\Documents\\drs\\data          / Define the DATA directory
   DRS_ROOT           = C:\\Users\\User\\Documents\\drs\\INTROOT       / Define the installation directory
   DRS_DATA_RAW       = C:\\Users\\User\\Documents\\drs\\data\\raw     / Define the folder with the raw data files in
   DRS_DATA_REDUC     = C:\\Users\\User\\Documents\\drs\\data\\reduced / Define the directory that the reduced data should be saved to/read from
   DRS_CALIB_DB       = C:\\Users\\User\\Documents\\drs\\data\\calibDB / Define the directory that the calibration files should be saved to/read from
   DRS_DATA_MSG       = C:\\Users\\User\\Documents\\drs\\data\\msg     / Define the directory that the log messages are stored in
   DRS_DATA_WORKING   = C:\\Users\\User\\Documents\\drs\\data\\tmp     / Define the working directory
   ```

   Note: Note paths in windows must have a '\\' also the python files must be open with a valid editor such as sublime text, notepad++, spyder or pycharm for example

7. validate the DRS installation:

   ```
   >> python cal_validate_spirou
   ```

The DRS is now installed and setup. To run see section 5 .

Chapter 3

Installation

3.1 Introduction

Once finalized the installation should just be a download, run setup.py and configure the DRS directories, however, during development the following stages are required.

3.2 Download

Get the latest version of the DRS (for SPIRou version 0.1.022 (alpha pre-release)). Use any of the following ways:

- manually download from here: https://github.com/njcuk9999/spirou_py3\protect\kern+.1667em\relax
- use Git:

```
>> git checkout https://github.com/njcuk9999/spirou_py3.git
```

- use SVN:

```
>> svn checkout  https://github.com/njcuk9999/spirou_py3.git
```

- use ssh:

```
>> scp -r git@github.com:njcuk9999/spirou_py3.git
```

3.3 Prerequisites

It is recommended to install the latest version of Anaconda python distribution, available for Windows, macOS and Linux (here: https://www.anaconda.com/download/). However one can run the DRS on a native python installation.

We recommend python 3 over python 2 for long term continued support (however the latest version of the DRS supports the newest versions of python 2.7).

Note: Before installing the DRS you must have one of the following:

- Latest version of Anaconda (for python 2 or python 3) — RECOMMENDED
- An Up-to-date version of python (python 2 or python 3)

3.3.1 Anaconda python distribution

A valid version of the Anaconda python distribution (for python2 or python 3) Currently tested version of python are:

- Python 2.7.13 and Anaconda 4.4.0
- Python 3.6.3 and Anaconda 5.0.1 — RECOMMENDED

3.3.2 Separate python installation

An up-to-date version of python (either python 2 or python 3) and the following python modules (with version of python they were tested with).

- Python 3.6
  - ASTROPY (tested with version 2.0)
  - MATPLOTLIB (tested with version 2.0)
  - NUMPY (tested with version 1.12)
  - SCIPY (tested with version 0.19)
  - and the following built-in modules (comes with python): DATETIME, FILECMP, GLOB, OS, PKG_RESOURCES, SHUTIL, SYS, TIME, WARNINGS
- Python 2.7
  - astropy (tested with version 1.2)
  - matplotlib (tested with version 2.1)
  - numpy (tested with version 1.13)
  - scipy (tested with version 1.0)
  - and the following built-in modules (comes with python): __FUTURE__, COLLECTIONS, DATETIME, FILECMP, GLOB, OS, PKG_RESOURCES, SHUTIL, SYS, TIME, WARNINGS

3.4 Installation Linux and macOS

Currently the DRS has to be installed manually. This involves the following steps:

1. Extraction (Section 3.4.1)
2. Modify environmental settings (Section 3.4.2)
3. Make recipes executable (Section 3.4.3)

3.4.1 Extraction

The first step is to extract the DRS into a folder (the DRS_ROOT).
Do this by using the following commands:

```
>> cd  DRS_ROOT
>> unzip DRS.zip
```

3.4.2 Modify environmental settings

The next step is to modify your PATH and PYTHONPATH environmental variables (to include the DRS_ROOT. This depends which shell you are using (type 'echo $0' to find out which).

- In bash open the '.bashrc' text file in your home (~) directory (or create it if it doesn't exist)

  e.g. in ~/.bashrc

  ```
  export PATH="DRS_ROOT/bin/:<$PATH>"
  export PYTHONPATH="DRS_ROOT:DRS_ROOT/bin/:<$PYTHONPATH>"
  ```

- In csh /tcsh open the '.cshrc' or '.tcshrc' text file in your home (~) directory (or create it if it doesn't exist)

  e.g. in ~/.tcshrc

  ```
  setenv PATH "DRS_ROOT/bin/":${PATH}"
  @setenv@ <PYTHONPATH> "DRS_ROOT:DRS_ROOT/bin/:${PYTHONPATH}"
  ```

3.4.3 Make recipes executable

To run the recipes from the command line (without starting python) one must make them executable.
Do this by using the following command:

```
>> chmod +x DRS_ROOT/bin/*.py
```

3.5 Setting up the DRS on Linux and macOS

Before running the DRS one must set the data paths.

The '../config /config.txt' file is located in the DRS_ROOT in the config folder.
i.e. at DRS_ROOT /config/../config /config.txt

The following keywords **must** be changed (and must be a valid path):

TDATA	=	/drs/data/	/	Define the DATA directory
DRS_ROOT	=	/drs/INTROOT/	/	Define the installation directory
DRS_DATA_RAW	=	/drs/data/raw	/	Define the folder with the raw data files in
DRS_DATA_REDUC	=	/drs/data/reduced	/	Define the directory that the reduced data should be saved to/read from
DRS_CALIB_DB	=	/drs/data/calibDB	/	Define the directory that the calibration files should be saved to/read from
DRS_DATA_MSG	=	/drs/data/msg	/	Define the directory that the log messages are stored in
DRS_DATA_WORKING	=	/drs/data/tmp/	/	Define the working directory

The directories here are for linux and macOS systems another example would be '/home/user/INTROOT' for the DRS_ROOT directory.
On Windows machines this would be equivalent to '`C:\\Users\\User\\Documents\\drs\\`'.

Note: Note: On windows paths in windows must have a '\\' also the python files must be open with a valid editor such as sublime text, notepad++, spyder or pycharm for example

The following keywords can be changed:

DRS_PLOT	=	1	/	Whether to show plots
PRINT_LEVEL	=	"all"	/	Level at which to print
LOG_LEVEL	=	"all"	/	Level at which to log in log file

For the 'PRINT_LEVEL and LOG_LEVEL keywords the values are set as follows:

- "all" – prints all events
- "info" – prints info, warning and error events
- "warning" – prints warning and error events
- "error" – print only error events

3.6 Validating Installation on Linux and macOS

> **Note:** One must install the DRS (Section 3.4) AND set up the DRS (Section 3.5) before validation will be successful.

There are four ways to run the DRS in Linux and macOS (thus four ways to verify installation was correct).

- To validate running from command line type:

```
>> cal_validate_spirou
```

- To validate running from python/ipython from the command line type:

```
>> python cal_validate_spirou
>> ipython cal_validate_spirou
```

- To validate running from ipython, open ipython and type:

Python/Ipython

```
run cal_validate_spirou
```

- To validate running from import from python/ipython, open python/ipython and type:

Python/Ipython

```
import cal_validate_spirou
cal_validate_spirou.main()
```

If validation is successful the following should appear:

```
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (0.0.1)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp/
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||
HH:MM:SS.S -   ||Validation successful. DRS installed corrected.
```

3.7 Installation Windows

This is very similar currently to the Linux/macOS installation (in the future a '.exe' file will be given).

1. Extract to DRS_ROOT with your favourite unzipping softwear.
2. Add DRS_ROOT to your PYTHONPATH (Section 3.7.1)

3.7.1 How to modify environmental settings in windows

This process is a little more convoluted than on Linux or macOS system.

1. Go to 'My computer > Properties > Advanced System Settings > Enviromental Variables'. Note in windows 10 you can also click the windows icon and type 'Advanced System Settings' then click 'Environment Variables'.
2. under system variable 'Path' click edit and add:

   In "Enviromental Variables"
   ```
   DRS_ROOT;DRS_ROOT\bin;
   ```
3. if under system variable 'PYTHONPATH' exists click edit and add 'DRS_ROOT;' to the end. i.e.

   In "Enviromental Variables"
   ```
   DRS_ROOT;DRS_ROOT\bin;
   ```
4. if under system variables 'PYTHONPATH' does not exist create a new variable called 'PYTHONPATH' and add:

   In "Enviromental Variables"
   ```
   %PYTHONPATH%;DRS_ROOT;DRS_ROOT\bin\;
   ```

Figure 3.1 shows screengrabs of the various steps above to aid in updating PATH and PYTHONPATH. For problems/troubleshooting see here: https://stackoverflow.com/questions/3701646.

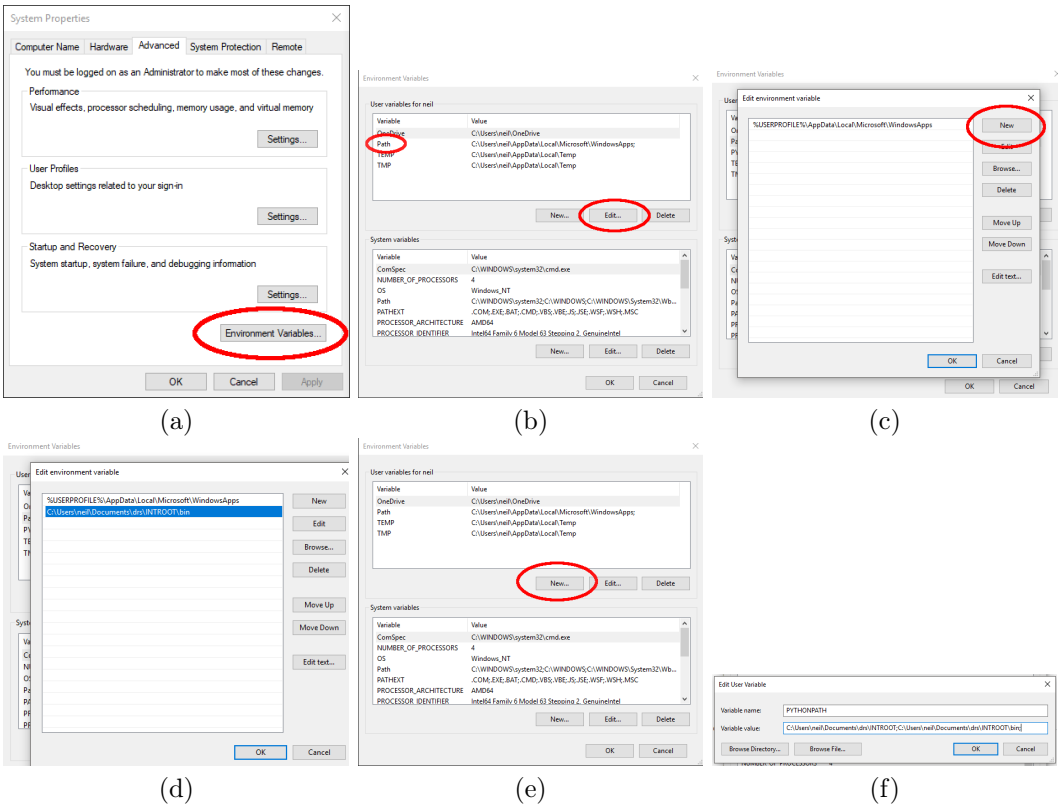


Figure 3.1 (a) Once in "Advanced system properties" click "Environment Variables" (b) Click "Path" and click "Edit..." to edit the "Path" environmental variable (c) Once in the "Path" environmental variable click "New" to add a new path (d) Type in the new line to add variable and click "OK" (e) Once back in the Enivronmental variable page click "New" to add 'PYTHONPATH' (f) Set the variable name to "PYTHONPATH" and edit the variable value accordingly.

3.8 Setting up the DRS (Windows)

Before running the DRS one must set the data paths.

The '../config /config.txt' file is located in the DRS_ROOT in the config folder.
i.e. at DRS_ROOT \\config\\configtxtfile

The following keywords **must** be changed (and must be a valid path):

TDATA	= C:\\Users\\User\\Documents\\drs\\data	/	Define the DATA directory
DRS_ROOT	= C:\\Users\\User\\Documents\\drs\\INTROOT	/	Define the installation directory
DRS_DATA_RAW	= C:\\Users\\User\\Documents\\drs\\data\\raw	/	Define the folder with the raw data files in
DRS_DATA_REDUC	= C:\\Users\\User\\Documents\\drs\\data\\reduced	/	Define the directory that the reduced data should be saved to/read from
DRS_CALIB_DB	= C:\\Users\\User\\Documents\\drs\\data\\calibDB	/	Define the directory that the calibration files should be saved to/read from
DRS_DATA_MSG	= C:\\Users\\User\\Documents\\drs\\data\\msg	/	Define the directory that the log messages are stored in
DRS_DATA_WORKING	= C:\\Users\\User\\Documents\\drs\\data\\tmp	/	Define the working directory

Note: Note: On windows paths in windows must have a '\\' also the python files must be open with a valid editor such as sublime text, notepad++, spyder or pycharm for example

The following keywords can be changed:

DRS_PLOT	= 1	/	Whether to show plots
PRINT_LEVEL	= "all"	/	Level at which to print
LOG_LEVEL	= "all"	/	Level at which to log in log file

For the 'PRINT_LEVEL and LOG_LEVEL keywords the values are set as follows:

- "all" – prints all events
- "info" – prints info, warning and error events
- "warning" – prints warning and error events
- "error" – print only error events

3.9 Validating Installation on Windows

> **Note:** One must install the DRS (Section 3.7) AND set up the DRS (Section 3.5) before validation will be successful.

In windows there are currently 3 ways to run the RS (running in python/ipython).

- To validate running from python/ipython from the command line type:

```
>> python cal_validate_spirou
>> ipython cal_validate_spirou
```

- To validate running from ipython, open ipython and type:

Python/Ipython

```
run cal_validate_spirou
```

- To validate running from import from python/ipython, open python/ipython and type:

Python/Ipython

```
import cal_validate_spirou
cal_validate_spirou.main()
```

If validation is successful the following should appear:

```
17:34:19.0 -   || ****************************************
17:34:19.0 -   || * SPIROU @(#) Geneva Observatory (0.1.016)
17:34:19.0 -   || ****************************************
17:34:19.0 -   ||(dir_data_raw)      DRS_DATA_RAW=C:\\Users\\User\\Documents\\drs\\data\\raw
17:34:19.0 -   ||(dir_data_reduc)    DRS_DATA_REDUC=C:\\Users\\User\\Documents\\drs\\data\\reduced
17:34:19.0 -   ||(dir_calib_db)      DRS_CALIB_DB=C:\\Users\\User\\Documents\\drs\\data\\calibDB
17:34:19.0 -   ||(dir_data_msg)      DRS_DATA_MSG=C:\\Users\\User\\Documents\\drs\\data\\msg
17:34:19.0 -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
17:34:19.0 -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
17:34:19.0 -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
17:34:19.0 -   ||(used_date)         DRS_USED_DATE=undefined
17:34:19.0 -   ||(working_dir)       DRS_DATA_WORKING=C:\\Users\\User\\Documents\\drs\\data\\tmp
17:34:19.0 -   ||                   DRS_INTERACTIVE is not set, running on-line mode
17:34:19.0 -   ||                   DRS_DEBUG is set, debug mode level:1
17:34:19.0 -   ||
17:34:19.0 -   ||Validation successful. DRS installed corrected.
```

Chapter 4

Data Architecture

Described below is the file structure, after correct installation (Chapter 3).

4.1 Installed file structure

The file structure should look as follows:

```
{dir}
├── {DRS_ROOT}
│   ├── bin
│   │   └── ..................................................... Recipes
│   ├── config
│   │   └── ..................................................... Configuration files
│   ├── documentation
│   │   └── ..................................................... Documentation files
│   └── SpirouDRS
│       └── ..................................................... The DRS Module
└── {TDATA}*
    ├── calibDB
    ├── msg
    ├── raw
    │   └── YYYYMMDD ..................................... Observation directory
    │       └── ..................................... Raw observation files
    ├── reduced
    └── tmp
```

* This is the recommended file structure and raw, reduced, calibDB, msg and tmp can be changed using the DRS_DATA_RAW, DRS_DATA_REDUC, DRS_CALIB_DB, DRS_DATA_MSG, and DRS_DATA_WORKING variables in Section 3.5.

i.e. for the paths given in Section 3.5 this would be:

```
drs
├── INTROOT
│   ├── bin
│   ├── config
│   ├── documentation
│   └── SpirouDRS
└── data
    ├── calibDB
    ├── msg
    ├── raw
    │   └── YYYYMMDD
    ├── reduced
    └── tmp
```

4.2 The Installation root directory

The DRS_ROOT contains all the installed recipes, modules functions, documentation and configuration files needed to run the DRS. The file structure is set up as below:

```
{dir}
└─ {DRS_ROOT}
   ├─ bin ..................................................Recipes
   ├─ config ...............................................Configuration files
   ├─ documentation ........................................Documentation files
   └─ SpirouDRS ............................................The DRS Module
```

4.2.1 The bin directory

The bin directory is located in the DRS_ROOT directory. This contains all the recipes that can be used. A detailed description of all recipes can be found in Chapter 8 but are listed here for completeness.

```
{dir}
└─ {DRS_ROOT}
   └─ bin ..................................................Recipes
      ├─ cal_BADPIX_spirou
      │  └─ ...............................................See Section 8.2
      ├─ cal_CCF_E2DS_spirou
      │  └─ ...............................................See Section 8.8
      ├─ cal_DARK_spirou
      │  └─ ...............................................See Section 8.1
      ├─ cal_DRIFT_RAW_spirou
      │  └─ ...............................................See Section 8.7
      ├─ cal_DRIFT_E2DS_spirou
      │  └─ ...............................................See Section 8.7
      ├─ cal_DRIFTPEAK_E2DS_spirou
      │  └─ ...............................................See Section 8.7
      ├─ cal_extract_RAW_spirou
      │  └─ ...............................................See Section 8.6
      ├─ cal_extract_RAW_spirouAB
      │  └─ ...............................................See Section 8.6
      ├─ cal_extract_RAW_spirouC
      │  └─ ...............................................See Section 8.6
      ├─ cal_FF_RAW_spirou
      │  └─ ...............................................See Section 8.5
      ├─ cal_HC_E2DS_spirou
      │  └─ ..............................................See Section 8.10
      ├─ cal_loc_RAW_spirou
      │  └─ ...............................................See Section 8.3
      ├─ cal_SLIT_spirou
      │  └─ ...............................................See Section 8.4
      ├─ cal_validate_spirou
      │  └─ ...............................................See Section 8.9
      └─ cal_WAVE_E2DS_spirou
         └─ ..............................................See Section 8.11
```

4.3 The data root directory

This is the directory where all the data should be stored. The default and recommended design is to haveDRS_DATA_RAW, DRS_DATA_REDUC, DRS_CALIB_DB, DRS_DATA_MSG, and DRS_DATA_WORKING as sub-directories of DRS_ROOT. However as in Section 3.5. these sub-directories can be defined elsewhere.

4.3.1 The raw and reduced data directories

The raw observed data is stored under the DRS_DATA_RAW path, the files are stored by night in the form YYYYMMDD .

The file structure can be seen below:

```
{DRS_DATA_RAW}
└─ YYYYMMDD ..........................................night_repository
   ├─ ..............................................Raw observation files
   ├─ dark_dark{name}.fits
   ├─ dark_flat{name}.fits
   ├─ flat_dark{name}.fits
   └─ fp_fp{name}.fits
```

4.4 The calibration database directory

```
{TDATA}
└─ calibDB or {DRS_CALIB_DB}
   ├─ master_calib_SPIROU.txt
   └─ ..................................................The calibration fits files
```

The calibDB contains all the calibration files that pass the quality tests and a test file ic_calibDB_filename. It is located at DRS_CALIB_DB or if this is not defined is located by default at the TDATA directory. Each line in this file is a unique calibration file and lines are formatted in the following manner:

In calibration database file

```
{key} {night_repository} {filename} {human readable date} {unix time}
```

where

- key is a code assigned for each type of calibration file. Currently accepted keys are:
  - DARK - Created from cal_DARK_spirou
  - ORDER_PROFIL_fiber - Created in cal_loc_RAW_spirou
  - LOC_C - Created in cal_loc_RAW_spirou
  - TILT - Created in cal_SLIT_spirou
  - FLAT_fiber - Created in cal_FF_RAW_spirou
  - WAVE - Currently manually added
- night_repository is the raw data observation directory (in DRS_DATA_RAW) normally in the form YYYYMMDD.
- filename is the filename of the calibration file (located in the calibDB).
- human readable date is the date in DD/MM/YY/HH:MM:SS.ss format taken from the header keyword 'ACQTIME1' of the file that created the calibration file.
- unix time is the time (as in human readable date) but in unix time (in seconds).

An example working ic_calibDB_filename is shown below (assuming the listed files are present in DRS_CALIB_DB)

In calibration database file

```
DARK 20170710 dark_dark02d406.fits 07/10/17/16:37:48 1499704668.0
ORDER_PROFIL_C 20170710 dark_flat02f10_order_profil_C.fits 07/10/17/17:03:50 1499706230.0
LOC_C 20170710 dark_flat02f10_loco_C.fits 07/10/17/17:03:50 1499706230.0
ORDER_PROFIL_AB 20170710 flat_dark02f10_order_profil_AB.fits 07/10/17/17:07:08 1499706428.0
LOC_AB 20170710 flat_dark02f10_loco_AB.fits 07/10/17/17:07:08 1499706428.0
TILT 20170710 fp_fp02a203_tilt.fits 07/10/17/17:25:15 1499705515.0
FLAT_C 20170710 dark_flat02f10_flat_C.fits 07/10/17/17:03:50 1499706230.0
WAVE 20170710 spirou_wave_ini3.fits 07/10/17/17:03:50 1499706230.0
```

Chapter 5

Using the DRS

There are two ways to run the DRS recipes. The first (described in Section 5.1) directly calls the code and inputs arguments (either from the command line or from python), the second way is to import the recipes in a python script and define arguments in a call to a function (see Section 5.2).

5.1 Running the DRS recipes directly

As in Chapter 3, using Linux or macOS one can run DRS recipes from the command line or from python, in windows one is required to be in python before running the scipts. Below we use cal_DARK_spirou as an example:

- To run from command line type:

```
>> cal_DARK_spirou YYMMDD Filenames
```

- To run from python/ipython from the command line type:

```
>> python cal_DARK_spirou YYMMDD Filenames
>> ipython cal_DARK_spirou YYMMDD Filenames
```

- To run from ipython, open ipython and type:

Python/Ipython

```
run cal_DARK_spirou YYMMDD Filenames
```

5.2 Running the DRS recipes from a python script

In any operating system one can also import a recipe and call a function to run the code. This is useful in batch operations, timing tests and unit tests for example. Below we use cal_DARK_spirou as an example:

Python/Ipython

```
# import the recipe
import cal_DARK_spirou
# define the night folder name
night_name = "20170710"
# define the file(s) to run through the code
files = ['dark_dark02d406.fits']
# run code
cal_validate_spirou.main(night_name=night_name, files=files)
```

5.3 Working example of the code for SPIRou

5.3.1 Overview

For this example all files are from:

```
>> spirou@10.102.14.81:/data/RawImages/H2RG-AT4/AT4-04/2017-07-10_15-36-18/ramps/
```

following our example data architecture (from Section 3.5 and shown explicity in Section 4.1) all files should be places in the DRS_DATA_RAW (/drs/data/raw in our case).
and we will also need the current WAVE file from here:

```
>> spirou@10.102.14.81:/data/reduced/DATA-CALIB/spirou_wave_ini3.fits
```

which needs to be placed in the DRS_CALIB_DB dirctory (/drs/data/calibDB in our case).
Starting with RAMP files and ending with extracted orders and calculated drifts we need to run six codes:

1. cal_DARK_spirou (See Section 8.1)
2. cal_loc_RAW_spirou (×2) (See Section 8.3)
3. cal_SLIT_spirou (See Section 8.4)
4. cal_FF_RAW_spirou (×2) (See Section 8.5)
5. (add spirou_wave_ini3.fits to calibDB)
6. cal_extract_RAW_spirouAB and cal_extract_RAW_spirouC (many times) (See Section 8.6)
7. cal_DRIFT_RAW_spirou (See Section 8.7)

5.3.2 Run through from command line/python shell (Linux and macOS)

As long as all codes are excutable (see Section 3.4.3) one can run all codes from the command line or if not excutable or one has a preference for python one can run the following with 'python {command}', 'ipython {command}' or indeed through an interactive ipython session using 'run {command}'.

1. run the dark extraction on the 'dark_dark' file:

```
>> cal_DARK_spirou.py 20170710 dark_dark02d406.fits
```

2. run the order localisation on the 'dark_flat' files:

```
>> cal_loc_RAW_spirou.py 20170710 dark_flat02f10.fits dark_flat03f10.fits dark_flat04f10.fits
    dark_flat05f10.fits dark_flat06f10.fits
```

3. run the order localisation on the 'flat_dark' files:

```
>> cal_loc_RAW_spirou.py 20170710 flat_dark02f10.fits flat_dark03f10.fits flat_dark04f10.fits
    flat_dark05f10.fits flat_dark06f10.fits
```

4. run the slit calibration on the 'fp_fp' files.

```
>> cal_SLIT_spirou.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
```

5. run the flat field creation on the 'dark_flat' files:

> **Note:** if using same files as above AND `calib_db_match="older"` you will get an error message when running the file (the tilt file is newer than input data) to solve this change `calib_db_match ="closest"`.

```
>> cal_FF_RAW_spirou.py 20170710 dark_flat02f10.fits dark_flat03f10.fits dark_flat04f10.fits
    dark_flat05f10.fits dark_flat06f10.fits
```

6. Currently we do not create a new wavelength calibration file for this run.

   Therefore we need one (as stated in the above section). We use the ones from here:

```
>> spirou@10.102.14.81:/data/reduced/DATA-CALIB/spirou_wave_ini3.fits
>> spirou@10.102.14.81:/data/.../AT4-04/2017-10-11_21-32-17 2017
    -10-11_21-32-17_hcone_hcone02c406_wave_AB.fits
>> spirou@10.102.14.81:/data/.../AT4-04/2017-10-11_21-32-17 2017
    -10-11_21-32-17_hcone_hcone02c406_wave_C.fits
```

   then place it in the DRS_CALIB_DB folder. You will also need to edit the 'ic_calibDB_filename' file located in DRS_CALIB_DB.

   Add the folloing line to 'ic_calibDB_filename'

In calibration database file

```
WAVE_AB AT4-04/2017-10-11_21-32-17 2017-10-11_21-32-17_hcone_hcone02c406_wave_AB.fits
    2014-08-11-03:42:12.000000 1407728532
WAVE_A 20170710 spirou_wave_ini3.fits 2000-01-01-00:00:00.00 946684800
WAVE_B 20170710 spirou_wave_ini3.fits 2000-01-01-00:00:00.00 946684800
WAVE_C AT4-04/2017-10-11_21-32-17 2017-10-11_21-32-17_hcone_hcone02c406_wave_C.fits
```

   and the 'master_calib_SPIROU.txt' should look like this:

In calibration database file

```
WAVE_AB AT4-04/2017-10-11_21-32-17 2017-10-11_21-32-17_hcone_hcone02c406_wave_AB.fits
    2014-08-11-03:42:12.000000 1407728532
WAVE_A 20170710 spirou_wave_ini3.fits 2000-01-01-00:00:00.00 946684800
WAVE_B 20170710 spirou_wave_ini3.fits 2000-01-01-00:00:00.00 946684800
WAVE_C AT4-04/2017-10-11_21-32-17 2017-10-11_21-32-17_hcone_hcone02c406_wave_C.fits
DARK 20170710 dark_dark02d406.fits 07/10/17/16:37:48 1499704668.0
ORDER_PROFIL_C 20170710 dark_flat02f10_order_profil_C.fits 07/10/17/17:03:50 1499706230.0
LOC_C 20170710 dark_flat02f10_loco_C.fits 07/10/17/17:03:50 1499706230.0
ORDER_PROFIL_AB 20170710 flat_dark02f10_order_profil_AB.fits 07/10/17/17:07:08 1499706428.0
LOC_AB 20170710 flat_dark02f10_loco_AB.fits 07/10/17/17:07:08 1499706428.0
TILT 20170710 fp_fp02a203_tilt.fits 07/10/17/17:07:08 1499706428.0
```

7. run the extraction files on the 'hcone_dark', 'dark_hcone', 'hcone_hcone', 'dark_dark_AHC1', 'hctwo_dark', 'dark_hctwo', 'hctwo-hctwo', 'dark_dark_AHC2' and 'fp_fp' files. For example for the 'fp_fp' files:

```
>> cal_extract_RAW_spirouAB.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
>> cal_extract_RAW_spirouC.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
```

8. run the drift calculation on the 'fp_fp' files:

```
>> @cal_DRIFT_RAW_spirou.py 20170710 @fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
```

5.3.3 Run through python script

The process is in the same order as Section 5.3.2, including adding the 'WAVE' lines to the calibDB folder).

Python/Ipython

```
import cal_DARK_spirou, cal_loc_RAW_spirou
import cal_SLIT_spirou, cal_FF_RAW_spirou
import cal_extract_RAW_spirou, cal_DRIFT_RAW_spirou
import matplotlib.pyplot as plt
# define constants
NIGHT_NAME = '20170710'
# cal_dark_spirou
files = ['dark_dark02d406.fits']          # set up files
cal_DARK_spirou.main(NIGHT_NAME, files)   # run cal_dark_spirou
plt.close('all')                          # close graphs
# cal_loc_RAW_spirou - flat_dark
files = ['flat_dark02f10.fits', 'flat_dark03f10.fits', 'flat_dark04f10.fits',
         'flat_dark05f10.fits','flat_dark06f10.fits']
cal_loc_RAW_spirou.main(NIGHT_NAME, files)
plt.close('all')
# cal_loc_RAW_spirou - dark_flat
files = ['dark_flat02f10.fits', 'dark_flat03f10.fits', 'dark_flat04f10.fits',
         'dark_flat05f10.fits', 'dark_flat06f10.fits']
cal_loc_RAW_spirou.main(NIGHT_NAME, files)
plt.close('all')
# cal_SLIT_spirou
files = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
cal_SLIT_spirou.main(NIGHT_NAME, files)
plt.close('all')
# cal_FF_RAW_spirou - flat_dark
files = ['flat_dark02f10.fits', 'flat_dark03f10.fits','flat_dark04f10.fits',
         'flat_dark05f10.fits', 'flat_dark06f10.fits']
cal_FF_RAW_spirou.main(NIGHT_NAME, files)
plt.close('all')
# cal_FF_RAW_spirou - dark_flat
files = ['dark_flat02f10.fits', 'dark_flat03f10.fits', 'dark_flat04f10.fits',
         'dark_flat05f10.fits', 'dark_flat06f10.fits']
cal_FF_RAW_spirou.main(NIGHT_NAME, files)
plt.close('all')
# cal_extract_RAW_spirou - fp_fp AB
files = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
cal_extract_RAW_spirou.main(NIGHT_NAME, files, 'AB')
plt.close('all')
# cal_extract_RAW_spirou - fp_fp C
files = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
cal_extract_RAW_spirou.main(NIGHT_NAME, files, 'C')
plt.close('all')
# test cal_DRIFT_RAW_spirou
files = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
cal_DRIFT_RAW_spirou.main(NIGHT_NAME, files)
plt.close('all')
```

Chapter 6

Required input header keywords

6.1 Required keywords

The following keywords are required by the current recipes to run.

- **Data fits file type (kw_DPRTYPE)**

  The data fits file type (template Name)

  kw_DPRTYPE = ["TPL_NAME", ""DATA"", "template Name"]

  HEADER file entry:

  TPL_NAME = "DATA" \ template Name

  Used in: All Recipes
  Defined in: SpirouDRS.spirouConfig.spirouKeywords

- **Acquisition time (human readable) (kw_ACQTIME_KEY)**

  The acquisition time in format YYYY-mm-dd-HH-MM-SS.ss

  kw_ACQTIME_KEY = ["ACQTIME1", "YYYY-mm-dd-HH-MM-SS.ss", "Date at start of observation"]

  HEADER file entry:

  ACQTIME1 = YYYY-mm-dd-HH-MM-SS.ss \ Date at start of observation

  Used in: All Recipes
  Defined in: SpirouDRS.spirouConfig.spirouKeywords

- **Acquisition time (unix time format) (kw_ACQTIME_KEY_UNIX)**

  The acquisition time in in unix time format (time since 1970-01-01-00-00-00)

  kw_ACQTIME_KEY_UNIX = ["ACQTIME", "000000000.00", "Date in unix time at start of observation"]

  HEADER file entry:

  ACQTIME = 000000000.00 \ Date in unix time at start of observation

  Used in: All Recipes
  Defined in: SpirouDRS.spirouConfig.spirouKeywords

- **Read noise (kw_RDNOISE)**

  The read noise (used for sigdet) [e-]

  kw_RDNOISE = ["RDNOISE", "0.0", "read noise (electrons)"]

  HEADER file entry:

  ```
  RDNOISE  =  0.0  \  read noise (electrons)
  ```

  Used in: All Recipes
  Defined in: SpirouDRS.spirouConfig.spirouKeywords

- **Gain (kw_GAIN)**

  The gain [e-/ADU]

  kw_GAIN = ["GAIN", "0.0", "gain (electrons/ADU)"]

  HEADER file entry:

  ```
  GAIN  =  0.0  \  gain (electrons/ADU)
  ```

  Used in: All Recipes
  Defined in: SpirouDRS.spirouConfig.spirouKeywords

- **Exposure time (kw_EXPTIME)**

  The integration time in seconds

  kw_EXPTIME = ["EXPTIME", "0.0", "Integration time (seconds)"]

  HEADER file entry:

  ```
  EXPTIME  =  0.0  \  Integration time (seconds)
  ```

  Used in: All Recipes
  Defined in: SpirouDRS.spirouConfig.spirouKeywords

Chapter 7

User modifiable variables

To better understand the variables in the DRS we have laid out each variable in the following way:

- **Variable title (VARIABLE_NAME)**

  Description of the variable

  VARIABLE_NAME = Default Value

  Used in: The recipe used the variable is used in.
  Defined in: The place where the variable is defined.

7.1 Variable file locations

The variables are currently stored in two places. The first (../config /config.txt) contains constants that deal with initial set up. These were mentioned in Section 3.5 and are located in DRS_ROOT /config / ../config /config.txt .

The other variables modify how the DRS runs. These are located in constants_SPIROU.txt (located at DRS_ROOT /config /constants_SPIROU.txt).

7.2 Global variables

- **Plotting switch (DRS_PLOT)**

  Defines whether to show plots (A value of 1 to show plots, a value of 0 to not show plots). Value must be an integer (0 or 1) or boolean (True or False)

  DRS_PLOT = 1

  Used in: All Recipes
  Defined in: ../config /config.txt

- **Debug mode (DRS_DEBUG)**

  Defines whether we should run the DRS in debug mode. Certain print/log statements and certain graphs only plot in debug mode. On an error the option to enter the python debugger is asked (allows user to look into functions/current memory and see what variables are currently defined. Value must be an integer. Value must be an integer where:

  - 0 = No debug
  - 1 = basic debugging on errors (prompted to enter python debugger)
  - 2 = Same as 1 and recipes specific (plots and some code runs)

  DRS_DEBUG = 0

  Used in: All Recipes
  Defined in: ../config /config.txt

- **Plot interval (ic_display_timeout)**

  Set the interval between plots in seconds (for certain interactive graphs). Value must be a valid float larger than zero.

  ic_display_timeout = 0.5

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

7.3 Directory variables

- **The data directory (TDATA)**

  Defines the path to the data directory. Value must be a string containing a valid file location.

  TDATA = /drs/data/

  Used in: All Recipes
  Defined in: ../config /config.txt

- **The installation directory (DRS_ROOT)**

  Defines the installation directory (DRS_ROOT). Value must be a string containing a valid file location.

  DRS_ROOT = /drs/INTROOT/

  Used in: All Recipes
  Defined in: ../config /config.txt

- **The raw data directory (DRS_DATA_RAW)**

  Defines the directory that the reduced data will be saved to/read from. Value must be a string containing a valid file location.

  DRS_DATA_RAW = /drs/data/raw

  Used in: All Recipes
  Defined in: ../config /config.txt

- **The reduced data directory (DRS_DATA_REDUC)**

  Defines the directory that the reduced data will be saved to/read from. Value must be a string containing a valid file location.

  DRS_DATA_REDUC = /drs/data/reduced

  Used in: All Recipes
  Defined in: ../config /config.txt

- **The calibration database and calibration file directory (DRS_CALIB_DB)**

  Defines the directory that the calibration files and database will be saved to/read from. Value must be a string containing a valid file location.

  DRS_CALIB_DB = /drs/data/calibDB

  Used in: All Recipes
  Defined in: ../config /config.txt

- **The log directory (DRS_DATA_MSG)**

  Defines the directory that the log messages are stored in. Value must be a string containing a valid file location.

  DRS_DATA_MSG = /drs/data/msg

  Used in: All Recipes
  Defined in: ../config /config.txt

- **The working directory (DRS_DATA_WORKING)**

  Defines the working directory. Value must be a string containing a valid file location.

  DRS_DATA_WORKING = /drs/data/tmp/

  Used in: All Recipes
  Defined in: ../config /config.txt

7.4 Image variables

- **Resizing blue window (ic_ccd{x/y}_blue_{low/high})**

  The blue window used in cal_DARK_spirou. Each value must be a integer between 0 and the maximum array size in each dimension.

  ic_ccdx_blue_low = 2048-200
  ic_ccdx_blue_high = 2048-1500
  ic_ccdy_blue_low = 2048-20
  ic_ccdy_blue_high = 2048-350

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Resizing red window (ic_ccd{x/y}_red_{low/high})**

  The blue window used in cal_DARK_spirou. Each value must be a integer between 0 and the maximum array size in each dimension.

  ic_ccdx_red_low = 2048-20
  ic_ccdx_red_high = 2048-1750
  ic_ccdy_red_low = 2048-1570
  ic_ccdy_red_high = 2048-1910

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Resizing red window (ic_ccd{x/y}_{low/high})**

  The blue window used in cal_DARK_spirou. Each value must be a integer between 0 and the maximum array size in each dimension.

  ic_ccdx_low = 5
  ic_ccdx_high = 2040
  ic_ccdy_low = 5
  ic_ccdy_high = 1935

  Used in: cal_loc_RAW_spirou, cal_SLIT_spirou, cal_FF_RAW_spirou, cal_extract_RAW_spirou, cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Available fiber types (fiber_types)**

  Defines the type of fiber we have (used in various codes). Theses are define in a python list of string, where the earlier a fiber is in the list the more it takes priority in searches (i.e. AB over A or B if AB is first)

  fiber_types = ['AB', 'A', 'B', 'C']

  Used in: cal_extract_RAW_spirou, cal_DRIFT_E2DS_spirou
  Defined in: constants_SPIROU.txt

7.5 Fiber variables

These variables are defined for each type of fiber and thus are defined as a python dictionary of values . As such they all must contain the same dictionary keys (currently 'AB', 'A', 'B' and 'C').

- **Number of fibers (nbfib_fpall)**

  This describes the number of fibers of a given type. Must be a python dictionary with identical keys to all other fiber parameters (each value must be an integer).

  nbfib_fpall = `{'AB':2, 'A':1, 'B':1, 'C':1}`

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Order skip number (ic_first_order_jump_fpall)**

  Describes the number of orders to skip at the start of an image. Must be a python dictionary with identical keys to all other fiber parameters (each value must be an integer).

  ic_first_order_jump_fpall = `{'AB':2, 'A':0, 'B':0, 'C':0}`

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum order numbers (ic_locnbmaxo_fpall)**

  Describes the maximum allowed number of orders. Must be a python dictionary with identical keys to all other fiber parameters (each value must be an integer).

  ic_locnbmaxo_fpall = `{'AB':72, 'A':36, 'B':36, 'C':36}`

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Number of orders to fit (QC) (qc_loc_nbo_fpall)**

  Quality control parameter for the number of orders on fiber to fit. Must be a python dictionary with identical keys to all other fiber parameters (each value must be an integer).

  qc_loc_nbo_fpall = `{'AB':72, 'A':36, 'B':36, 'C':36}`

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Fiber types for this fiber (fib_type_fpall)**

  The fiber type(s) – as a list – for this fiber. Must be a python dictionary with identical keys to all other fiber parameters (each value must be a list of strings).

  fib_type_fpall = `{'AB':["AB"], 'A':["A"], 'B':["B"], 'C':["C"]}`

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Half-zone extraction width (left/top) (ic_ext_range1_fpall)**

  The pixels are extracted from the center of the order out to the edges in the row direction (y-axis), i.e. defines the illuminated part of the order - this number defines the **top** side (if one requires a symmetric extraction around the order fit both range 1 and range 2 – below – should be the same). This can also be used to extract A and B separately (where the fit order is defined at the center of the AB pair). Must be a python dictionary with identical keys to all other fiber parameters.

  ic_ext_range1_fpall = `{'AB':14.5, 'A':0.0, 'B':14.5, 'C':7.5}`

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Half-zone extraction width (right/bottom) (ic_ext_range2_fpall)**

  The pixels are extracted from the center of the order out to the edges in the row direction (y-axis), i.e. defines the illuminated part of the order - this number defines the **bottom** side (if one requires a symmetric extraction around the order fit both range 1 and range 2 – below – should be the same). This can also be used to extract A and B separately (where the fit order is defined at the center of the AB pair). Must be a python dictionary with identical keys to all other fiber parameters.

  ic_ext_range2_fpall = `{'AB':14.5, 'A':14.5, 'B':0.0, 'C':7.5}`

  Used in: cal_FF_RAW_spirou, cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Half-zone extraction width for full extraction (ic_ext_range_fpall)**

  The pixels are extracted from the center of the order out to the edges in the row direction (y-axis), i.e. defines the illuminated part of the order. In cal_extract_RAW_spirou both sides of the fit order are extracted at with the same width (symmetric). Must be a python dictionary with identical keys to all other fiber parameters.

  ic_ext_range_fpall = `{'AB':14.5, 'A':14.5, 'B':14.5, 'C':7.5}`

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Localization fiber for extraction (loc_file_fpall)**

  Defines the localization fiber to use for each fiber type. This is the file in calibDB that is used i.e. the keyword ic_calibDB_filename used will be ÌLOC_{loc_file_fpall}' (e.g. for fiber='AB' use 'LOC_AB'). Must be a python dictionary with identical keys to all other fiber parameters.

  loc_file_fpall = `{'AB':'AB', 'A':'AB', 'B':'AB', 'C':'C'}`

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Order profile fiber for extraction (orderp_file_fpall)**

  Defines the order profile fiber to use for each fiber type. This is the file in calibDB that is used i.e. the keyword ic_calibDB_filename used will be ÒRDER_PROFILE_{orderp_file_fpall}' (e.g. for fiber='AB' use 'ORDER_PROFILE_AB'). Must be a python dictionary with identical keys to all other fiber parameters.

  orderp_file_fpall = `{'AB':'AB', 'A':'AB', 'B':'AB', 'C':'C'}`

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Half-zone extract width cal_DRIFT_RAW_spirou (ic_ext_d_range_fpall)**

  The size in pixels of the extraction away from the order localization fit (to the top and bottom) - defines the illuminated area of the order for extraction. Must be a python dictionary with identical keys to all other fiber parameters.

  ic_ext_d_range_fpall = `{'AB':14.0, 'A':14.0, 'B':14.0, 'C':7.0}`

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

7.6 Dark calibration variables

- **Lower percentile for dead pixel stats (dark_qmin)**

  This defines the lower percentile to be logged for the fraction of dead pixels statistics. Value must be an integer between 0 and 100 (1 sigma below the mean is ~16).

  dark_qmin = 5

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Upper percentile for dead pixel stats (dark_qmax)**

  This defines the upper percentile to be logged for the fraction of dead pixels statistics. Value must be an integer between 0 and 100 (1 sigma above the mean is ~84).

  dark_qmax = 95

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Dark stat histogram bins (histo_bins)**

  Defines the number of bins to use in the dark histogram plot. Value must be a positive integer.

  histo_bins = 200

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Lower bound for the Dark stat histogram (histo_range_low)**

  Defines the lower bound for the dark statistic histogram. Value must be a float less than (no equal to) the value of 'histo_range_high'

  histo_range_low = -0.5

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Upper bound for the Dark stat histogram (histo_range_high)**

  Defines the upper bound for the dark statistic histogram. Value must be a float greater than (not equal to) the value of 'histo_range_low'

  histo_range_high = 5

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Bad pixel cut limit (dark_cutlimit)**

  Defines the bad pixel cut limit in ADU/s.

  $$badpixels = (image > \text{dark\_cut\_limit}) \text{ OR (non-finite)} \quad (7.1)$$

  dark_cutlimit = 100.0

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

7.7 Localization calibration variables

- **Order profile smoothed box size (loc_box_size)**

  Defines the size of the order profile smoothing box (from the central pixel minus size to the central pixel plus size). Value must be an integer larger than zero.

  loc_box_size = 10

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Image row offset (ic_offset)**

  The row number (y axis) of the image to start localization at (below this row orders will not be fit). Value must be an integer equal to or larger than zero.

  ic_offset = 40

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Central column of the image (ic_cent_col)**

  The column which is to be used as the central column (x-axis), this is the column that is initially used to find the order locations. Value must be an integer between 0 and the number of columns (x-axis dimension).

  ic_cent_col = 1000

  Used in: cal_loc_RAW_spirou, cal_FF_RAW_spirou, cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Localization window row size (ic_ext_window)**

  Defines the size of the localization window in rows (y-axis). Value must be an integer larger than zero and less than the number of rows (y-axis dimension).

  ic_ext_window = 12

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Localization window column step (ic_locstepc)**

  For the initial localization procedure interval points along the order (x-axis) are defined and the centers are found, this is used as the first estimate of the order shape. This parameter defines that interval step in columns (x-axis). Value must be an integer larger than zero and less than the number of columns (x-axis dimension).

  ic_locstepc = 12

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Image gap index (ic_image_gap)**

  Defines the image gap index. The order is skipped if the top of the row (row number - ic_ext_window) or bottom of the row (row number + ic_ext_window) is inside this image gap index. i.e. a order is skipped if:

  $$(\text{top of the row} < \text{ic\_image\_gap}) \text{ OR } (\text{bottom of the row} > \text{ic\_image\_gap}) \quad (7.2)$$

  Value must be an integer between zero and the number of rows (y-axis dimension).

  ic_image_gap = 0

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Minimum order row size (ic_widthmin)**

  Defines the minimum row width (width in y-axis) to accept an order as valid. If below this threshold order is not recorded. Value must be an integer between zero and the number of rows (y-axis dimension).

  ic_widthmin = 5

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Min/Max smoothing box size (ic_locnbpix)**

  Defines the half-size of the rows to use when smoothing the image to work out the minimum and maximum pixel values. This defines the half-spacing between orders and is used to estimate background and the maximum signal. Value must be greater than zero and less than the number of rows (y-axis dimension).

  ic_locnbpix = 45

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Minimum signal amplitude (ic_min_amplitude)**

  Defines a cut off (in e-) where below this point the central pixel values will be set to zero. Value must be a float greater than zero.

  ic_min_amplitude = 100.0

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Normalized background amplitude threshold (ic_locseuil)**

  Defines the normalized amplitude threshold to accept pixels for background calculation (pixels below this normalized value will be used for the background calculation). Value must be a float between zero and one.

  ic_locseuil = 0.2

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Saturation threshold on the order profile plot (ic_satseuil)**

  Defines the saturation threshold on the order profile plot, pixels above this value will be set this value (ic_satseuil). Value must be a float greater than zero.

  ic_satseuil = 64536

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Degree of the fitting polynomial for localization position (ic_locdfitc)**

  Defines the degree of the fitting polynomial for locating the positions of each order i.e. if value is 1 is a linear fit, if the value is 2 is a quadratic fit. The value must be a positive integer equal to or greater than zero (zero would lead to a constant fit along the column direction (x-axis direction).

  ic_locdfitc = 5

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Degree of the fitting polynomial for localization width (ic_locdfitw)**

  Defines the degree of the fitting polynomial for measuring the width of each order i.e. if value is 1 is a linear fit, if the value is 2 is a quadratic fit. The value must be a positive integer equal to or greater than zero (zero would lead to a constant fit along the row direction (y-axis direction).

  ic_locdfitw = 5

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Degree of the fitting polynomial for localization position error (ic_locdfitp)**

  Defines the degree of the fitting polynomial for locating the positions error of each order i.e. if value is 1 is a linear fit, if the value is 2 is a quadratic fit. The value must be a positive integer equal to or greater than zero (zero would lead to a constant fit along the column direction (x-axis direction).

  ic_locdfitp = 3

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum RMS for sigma-clipping order fit (positions) (ic_max_rms_center)**

  Defines the maximum RMS allowed for an order, if RMS is above this value the position with the highest residual is removed and the fit is recalculated without that position (sigma-clipped). Value must be a positive float. i.e. position fit is recalculated if:

  $$max(RMS) > \text{ic\_max\_rms\_center} \tag{7.3}$$

  ic_max_rms_center = 0.2

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum peak-to-peak for sigma-clipping order fit (positions) (ic_max_ptp_center)**

  Defines the maximum peak-to-peak value allowed for an order, if the peak to peak is above this value the position with the highest residual is removed and the fit is recalculated without that position (sigma-clipped). Value must be a positive float. i.e. position fit is recalculated if:

  $$max(|\text{residuals}|) > \text{ic\_max\_ptp\_center} \tag{7.4}$$

  ic_max_ptp_center = 0.2

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum peak-to-peak-RMS ratio for sigma-clipping order fit(positions) (ic_ptporms_center)**

  Defines the maximum ratio of peak-to-peak residuals and rms value allowed for an order, if the ratio is above this value the position with the highest residual is removed and the fit is recalculated without that position (sigma-clipped). Value must be a positive float. i.e. position fit is recalculated if:

  $$max(|\text{residuals}|)/\text{RMS} > \text{ic\_ptporms\_center} \tag{7.5}$$

  ic_ptporms_center = 8.0

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum RMS for sigma-clipping order fit (width) (ic_max_rms_fwhm)**

  Defines the maximum RMS allowed for an order, if RMS is above this value the width with the highest residual is removed and the fit is recalculated without that width (sigma-clipped). Value must be a positive float. i.e. width fit is recalculated if:

  $$max(RMS) > \text{ic\_max\_rms\_width} \tag{7.6}$$

  ic_max_rms_fwhm = 1.0

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum peak-to-peak for sigma-clipping order fit (widths) (ic_max_ptp_fracfwhm)**

  Defines the maximum peak-to-peak value allowed for an order, if the peak to peak is above this value the width with the highest residual is removed and the fit is recalculated without that width (sigma-clipped). Value must be a positive float. i.e. width fit is recalculated if:

  $$max(|\text{residuals/data}|) \times 100 > \text{ic\_max\_ptp\_fracfwhm} \quad (7.7)$$

  ic_max_ptp_fracfwhm = 1.0

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Delta width 3 convolve shape model (ic_loc_delta_width)**

  Defines the delta width in pixels for the 3 convolve shape model - currently not used. Value must be a positive float.

  ic_loc_delta_width = 1.85

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Localization archiving option (ic_locopt1)**

  Whether we save the location image with the superposition of the fit (zeros). If this option is 1 or True it will save the file to '_with-order_fiber.fits' if 0 or False it will not save this file. Value must be 1, 0, True or False.

  ic_locopt1 = 1

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

7.8 Slit calibration variables

- **Tilt oversampling factor (ic_tilt_coi)**

  Defines the oversampling factor used to work out the tilt of the slit. Value must be an integer value larger than zero.

  ic_tilt_coi = 10

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

- **Slit fit order plot offset factor (ic_facdec)**

  Defines an offset of the position fit to show the edges of the illuminated area. (Final offset is ±× 2 of this offset away from the order fit. Value must be a positive float.)

  ic_facdec = 1.6

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

- **Degree of the fitting polynomial for the tilt (ic_tilt_fit)**

  Defines the degree of the fitting polynomial for determining the tilt i.e. i.e. if value is 1 is a linear fit, if the value is 2 is a quadratic fit. The value must be a positive integer equal to or greater than zero (zero would lead to a constant fit).

  ic_tilt_fit = 4

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

- **Selected order in Slit fit order plot (ic_slit_order_plot)**

  Defines the selected order to plot the fit for in the Slit fir order plot. Value must be between zero and the maximum number of orders.

  ic_slit_order_plot = 10

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

7.9 Flat fielding calibration variables

- **Measure background (ic_do_bkgr_subtraction)**

  Define whether to measure the background and do a background subtraction. Value must be True or 1 to do the background measurement and subtraction or be False or 0 to not do the background measurement and subtraction.

  ic_do_bkgr_subtraction = 0

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Half-size of background window (ic_bkgr_window)**

  Defines the half-size (in pixels) of the background window to create a sub-frame to find the minimum 2× ic_bkgr_window pixels for which to calculate the background from. Size is used in both row and column (y and x) direction. Value must be an integer between zero and the minimum(row number, column number) (minimum(x-axis dimension, y-axis dimension)).

  ic_bkgr_window = 100

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Number of orders in tilt measurement (ic_tilt_nbo)**

  Defines the number of orders in the tilt measurement file (TILT key in the ic_calibDB_filename). This is the number of tilts that will be extracted. Value must be an integer larger than zero and smaller than or equal to the total number of orders present in the TILT file.

  ic_tilt_nbo = 36

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **The manually set sigdet for flat fielding. (ic_ff_sigdet)**

  This defines the sigdet to use in the weighted tilt extraction. Set to -1 to use from the input file ('fitsfilename') HEADER. Value must be either -1 or a positive float.

  ic_ff_sigdet = 100.0

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Half size blaze window (ic_extfblaz)**

  Defines the distance from the central column that should be used to measure the blaze for each order. Value must be an integer greater than zero and less than half the number of columns (x-axis dimension).

  ic_extfblaz = 50

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Fit degree for the blaze polynomial fit (ic_blaze_fitn)**

  Defines the degree of the fitting polynomial for fitting the blaze function of each order i.e. if value is 1 is a linear fit, if the value is 2 is a quadratic fit. The value must be a positive integer equal to or greater than zero (zero would lead to a constant fit along the column direction (x-axis direction).

  ic_blaze_fitn = 5

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Selected order for flat fielding plot (ic_ff_order_plot)**

  Defines the selected order to plot on the flat fielding image plot. Value must be a integer between zero and the number of orders.

  ic_ff_order_plot = 5

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Plot all order fits for flat fielding plot (ic_ff_plot_all_orders)**

  If True or 1, instead of plotting the selected order from ic_ff_order_plot will plot the order fits (and edges) for all orders. This is slower than just plotting one. Value must be True or 1 or False or 0.

  ic_ff_plot_all_orders = 0

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

7.10 Extraction calibration variables

- **Extraction option - rough extraction (ic_extopt)**

  Extraction option for rough extraction:

  - if 0 extraction by summation over a constant range
  - if 1 extraction by summation over constants sigma (not currently available)
  - if 2 horne extraction without cosmic elimination (not currently available)
  - if 3 horne extraction with cosmic elimination (not currently available)

  Used for estimating the slit tilt and in calculating the blaze/flat fielding. Value must be a integer between 0 and 3.

  ic_extopt = 0

  Used in: cal_SLIT_spirou , cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Extraction distance - rough extraction (ic_extnbsig)**

  The pixels are extracted from the center of the order out to the edges in the row direction (y-axis), i.e. defines the illuminated part of the order). Used for estimating the slit tilt and in calculating the blaze/flat fielding. Value must be a positive float between 0 and the total number of rows (y-axis dimension).

  ic_extnbsig = 2.5

  Used in: cal_SLIT_spirou , cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Extraction type (ic_extract_type)**

  Defines which type of extraction should be used in cal_extract_RAW_spirou. This variable is overwritten if using cal_extract_RAW_spirouAB or cal_extract_RAW_spirouC. The value must be one of the following:

  - simple ..... just does extraction as is.
  - tilt ..... does the extraction and corrects for tilt
  - weight ..... does the extraction with a weighting for bad pixels
  - tiltweight ..... does the extraction + 'tilt' + 'weight'
  - all ..... performs all extractions (saves separately). The E2DS file='weight'.

  Value should be a python string with one of the above values only. Any other value will cause an error and a recipe to exit.

  ic_extract_type = tiltweight

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Manually set the extraction sigdet (ic_ext_sigdet)**

  Set the sigdet used in the extraction process instead of using the sigdet in the FITS rec HEADER file. If the value is set to -1 the sigdet from the HEADER is used instead.

  ic_ext_sigdet = 100

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Selected order in extract fit order plot (ic_ext_order_plot)**

  Defines the selected order to plot the fit for in the extract fit order plot. Value must be between zero and the maximum number of orders.

  ic_ext_order_plot = 20

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

7.11 Drift calibration variables

- **Noise value for SNR drift calculation (ic_drift_noise)**

  Define the noise value for the signal to noise ratio in the drift calculation.

  $$snr = flux/\sqrt{(\text{flux} + \text{noise}^2)} \tag{7.8}$$

  Value must be a float larger than zero.

  ic_drift_noise = 100.0

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **The maximum flux for a good (unsaturated) pixel (ic_drift_maxflux)**

  Defines the maximum flux to define a good pixel. This pixels and those that surround it will not be used in determining the RV parameters. Value must be a float greater than zero.

  ic_drift_maxflux = 1.e9

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Saturated pixel flag size (ic_drift_boxsize)**

  Defines the number of pixels around a saturated pixel to flag as unusable (and hence not used in determining the RV parameters). Value must be a integer larger than zero.

  ic_drift_boxsize = 12

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Large number of files for skip (drift_nlarge)**

  Defines the number of files that is large enough to require the 'drift_file_skip' parameter (only uses one file in every 'drift_file_skip' files). This is done to speed up the code and avoid a bug. Value must be an integer larger than zero.

  drift_nlarge = 300

  Used in: cal_DRIFT_RAW_spirou, cal_DRIFT_E2DS_spirou, cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Large number of files skip parameter (cal_DRIFT_RAW_spirou) (drift_file_skip)**

  Defines how many files we skip. This is done by selecting one file every 'drift_file_skip' files. i.e. if skip is 3 the code uses every 3rd file to calculate the drift. Value must be an integer larger than zero. A value of 1 is equivalent to no skipping of files regardless of the file number.

  drift_file_skip = 3

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Large number of files skip parameter (cal_DRIFT_E2DS_spirou) (drift_e2ds_file_skip)**

  Defines how many files we skip. This is done by selecting one file every 'drift_file_skip' files. i.e. if skip is 3 the code uses every 3rd file to calculate the drift. Value must be an integer larger than zero. A value of 1 is equivalent to no skipping of files regardless of the file number.

  drift_e2ds_file_skip = 1

  Used in: cal_DRIFT_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Number of sigmas to cut in cosmic renormalization (cal_DRIFT_RAW_spirou) (ic_drift_cut_raw)**

  Defines the number of standard deviations to remove fluxes at (and replace with the reference flux) for cal_DRIFT_RAW_spirou. Value must be a float larger than zero.

  ic_drift_cut_raw = 3

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Number of sigmas to cut in cosmic renormalization (cal_DRIFT_E2DS_spirou) (ic_drift_cut_e2ds)**

  Defines the number of standard deviations to remove fluxes at (and replace with the reference flux) for cal_DRIFT_E2DS_spirou. Value must be a float larger than zero.

  ic_drift_cut_e2ds = 4.5

  Used in: cal_DRIFT_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Number of orders to use in drift (ic_drift_n_order_max)**

  Defines the number of orders to use (starting from zero to maximum number). This is used to get the median drift. Value must be an integer between 0 and the maximum number of orders.

  ic_drift_n_order_max = 28

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Define the way to combine orders for drift (for cal_DRIFT_RAW_spirou) (ic_drift_type_raw)**

  Defines the way to calculate the combine order drifts (to one drift per image) should either be 'weighted mean' (Equation 7.9) or 'median' (Equation 7.10) for cal_DRIFT_RAW_spirou.

  $$\text{drift} = \frac{\sum(\text{drift}_i * w_i)}{\sum w_i} \tag{7.9}$$

  where w_i is $1/\Delta v_{rms}$

  $$\text{drift} = \text{median}(\text{drift}_i) \tag{7.10}$$

  Value should be a valid python string either 'median' or 'weighted mean'.

  ic_drift_type_raw = median

  Used in: cal_DRIFT_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Define the way to combine orders for drift cal_DRIFT_E2DS_spirou) (ic_drift_type_e2ds)**

  Defines the way to calculate the combine order drifts (to one drift per image) should either be 'weighted mean' (Equation 7.11) or 'median' (Equation 7.12) for cal_DRIFT_E2DS_spirou.

  $$\text{drift} = \frac{\sum(\text{drift}_i * w_i)}{\sum w_i} \tag{7.11}$$

  where w_i is $1/\Delta v_{rms}$

  $$\text{drift} = \text{median}(\text{drift}_i) \tag{7.12}$$

  Value should be a valid python string either 'median' or 'weighted mean'.

  ic_drift_type_e2ds = weighted mean

  Used in: cal_DRIFT_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Selected order in drift fit order plot (ic_drift_order_plot)**

  Defines the selected order to plot the fit for in the drift fit order plot. Value must be between zero and the maximum number of orders.

  ic_drift_order_plot = 20

  Used in: cal_DRIFT_RAW_spirou , cal_DRIFT_E2DS_spirou
  Defined in: constants_SPIROU.txt

7.12 Drift-Peak calibration variables

- **First order to use in drift-peak (ic_drift_peak_n_order_min)**

  Defines the first order to use (from this to ic_drift_peak_n_order_max). This is used to get the median drift. Value must be an integer greater than or equal to 0 and less than ic_drift_peak_n_order_max.

  ic_drift_peak_n_order_min = 2

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Last order to use in drift-peak (ic_drift_peak_n_order_max)**

  Defines the last order to use (from ic_drift_peak_n_order_min to this). This is used to get the median drift. Value must be an integer greater than ic_drift_peak_n_order_min and less than or equal to the maximum number of orders.

  ic_drift_peak_n_order_max = 30

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Large number of files skip parameter (cal_DRIFT_E2DS_spirou) (drift_e2ds_file_skip)**

  Defines how many files we skip. This is done by selecting one file every 'drift_file_skip' files. i.e. if skip is 3 the code uses every 3rd file to calculate the drift. Value must be an integer larger than zero. A value of 1 is equivalent to no skipping of files regardless of the file number.

  drift_e2ds_file_skip = 1

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Minimum box size for min max smoothing (drift_peak_minmax_boxsize)**

  Defines the minimum size of the box used to get the minimum and maximum pixel values (specifically minimum pixel values). Each box (defined as the pixel position ±box size) is used to work out the background value for that pixel. Value must be an integer larger than zero and less than half the number of columns (x-dimension).

  drift_peak_minmax_boxsize = 6

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Image column (x-dim) border size (drift_peak_border_size)**

  Defines the number of pixels on either side of an image that should not be used to find FP peaks. This size must be larger to or equal to drift_peak_fpbox_size, therefore the fit to an individual FP does not go off the edge of the image. Value must be an integer larger to or equal to drift_peak_fpbox_size and less than and less than half the number of columns (x-dimension).

  drift_peak_border_size = 3

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Box size for fitting individual FP peak. (drift_peak_fpbox_size)**

  Defines the half-box size (i.e. central position ±box size) of the box used to fit an individual FP peak. This size must be large enough to fit a peak but not too large as to encompass multiple FP peaks. The value must be an integer larger than zero and smaller than or equal to drift_peak_border_size (to avoid fitting off the edges of the image).

  drift_peak_fpbox_size = 3

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Minimum sigma above median for valid peak (drift_peak_peak_sig_lim)**

  Defines the flux a valid peak must have in order to be recognized as a valid peak (before the peak fitting is done). If a peaks meaximum is below this threshold it will not be used as a valid peak in finding the drifts. Value is a dictionary containing keys equivalient to the lamp types (currently this is 'fp' and 'hc'. The values of each must be a float greater than 1 for above the median and, between zero and 1 for below the median).

  drift_peak_peak_sig_lim = `fp':1.0, 'hc':7.0'fp':1.0, 'hc':7.0`

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Minimum spacing between valid peaks (drift_peak_inter_peak_spacing)**

  Defines the minimum spacing peaks must have (between neighbouring peaks) in order to recognized as valid peaks (before the peak fitting is done). If peak is closer than this sepration to a previous peak the peak will not be used as a valid peak in finding the drifts. Value must be an integer greater than zero.

  drift_peak_inter_peak_spacing = 5

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Expected width of FP peaks (drift_peak_exp_width)**

  Defines the expected width of the FP peaks. Parameter is used to 'normalise' the peaks which are then subsequently removed if:

  $$\text{normalized FP FWHM} > \text{drift\_peak\_norm\_width\_cut} \tag{7.13}$$

  this is equivalent to:

  $$\text{FP FWHM} > (\text{drift\_peak\_exp\_width} + \text{drift\_peak\_norm\_width\_cut}) \tag{7.14}$$

  Value must be a float larger than zero and less than the number of columns (x-dimension).

  drift_peak_exp_width = 0.8

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Normalized FP width threshold (drift_peak_norm_width_cut)**

  Defines the maximum 'normalized' width of FP peaks that is acceptable for a valid FP peak. i.e. widths above this threshold are rejected as valid FP peaks. This works as follows:

  $$\text{normalized FP FWHM} > \text{drift\_peak\_norm\_width\_cut} \tag{7.15}$$

  this is equivalent to:

  $$\text{FP FWHM} > (\text{drift\_peak\_exp\_width} + \text{drift\_peak\_norm\_width\_cut}) \tag{7.16}$$

  Value must be a float larger than zero and less than the number of columns (x-dimension) but if drift_peak_exp_width is defined sensibly then this number should be small.

  drift_peak_norm_width_cut = 0.2

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Get drift via a Gaussian fitting process (drift_peak_getdrift_gaussfit)**

  Defines whether the drift is calculated via a Gaussian fitting process (fitting the targeted order with a Gaussian) – $\sim \times 10$ slower, or adjusts a barycenter to get the drift. Value must be True or 1 to do the Gaussian fit, or False or 0 to use the barycenter adjustment.

  drift_peak_getdrift_gaussfit = False

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Pearson R coefficient (between reference and image) (drift_peak_pearsonr_cut)**

  Defines the threshold below which a image is deemed to dissimilar from the reference image to be used. A Pearson R test is performed between the reference image (e2ds file) and the current iteration image (e2ds file), the minimum of all usable orders is then tested. If any order does not pass the criteria:

  $$\text{coefficient}_{\text{order}} > \text{drift\_peak\_pearsonr\_cut} \tag{7.17}$$

  then the whole image (e2ds file) is rejected. Value must be a float larger than zero and less than 1.0, values should be close to unity for a good fit i.e. 0.97.

  drift_peak_pearsonr_cut = 0.9

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Sigma clip for found FP peaks (drift_peak_sigmaclip)**

  Defines the number of sigmas above the median that is used to remove bad FP peaks from the drift calculation process. Value must be a float larger than zero.

  drift_peak_sigmaclip = 1.0

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Plot linelist vs log Amplitude (drift_peak_plot_line_log_amp)**

  Defines whether we plot the line list against log amplitude. Value must be 1 or True to plot, or 0 or False to not plot

  drift_peak_plot_line_log_amp = False

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

- **Selected order for linelist vs log Amplitude plot (drift_peak_selected_order)**

  Defines the selected order to plot the wave vs extracted spectrum for overplotting on the line list against log amplitude plot. Value must be an integer between 0 and the number of orders

  drift_peak_selected_order = 30

  Used in: cal_DRIFTPEAK_E2DS_spirou
  Defined in: constants_SPIROU.txt

7.13 Bad pixel calibration variables

- **Bad pixel median image box width (badpix_flat_med_wid)**

  A similar flat is produced by taking the running median of the flat in the column direction (x-dimension) over a boxcar width of badpix_flat_med_wid. This assumes that the flux level varies only by a small amount over badpix_flat_med_wid pixels and that the bad pixels are isolated enough that the median along that box will be representative of the flux they should have if they were not bad. Value should be an integer larger than zero and less than the number of columns (x-axis dimension).

  badpix_flat_med_wid = 7

  Used in: cal_BADPIX_spirou
  Defined in: constants_SPIROU.txt

- **Bad pixel illumination cut parameter (badpix_illum_cut)**

  Threshold below which a pixel is considered unilluminated. As we cut the pixels that fractionally deviate by more than a certain amount (badpix_flat_cut_ratio) this would lead to lots of bad pixels in unilluminated regions of the array. This parameter stops this, as the pixels are normalised this value must be a float greater than zero and less than 1.

  badpix_illum_cut = 0.05

  Used in: cal_BADPIX_spirou
  Defined in: constants_SPIROU.txt

- **Bad pixel maximum differential pixel cut ratio (badpix_flat_cut_ratio)**

  This sets the maximum differential pixel response relative to the expected value. Value must be a float larger than zero.

  badpix_flat_cut_ratio = 0.5

  Used in: cal_BADPIX_spirou
  Defined in: constants_SPIROU.txt

- **Bad pixel maximum flux to considered too hot (badpix_max_hotpix)**

  Defines the maximum flux value to be considered too hot to user.

  badpix_max_hotpix = 100.0

  Used in: cal_BADPIX_spirou
  Defined in: constants_SPIROU.txt

- **Bad pixel normalisation percentile (badpix_norm_percentile)**

  Defines the percentile at which the bad pixels are normalised to in order to locate bad and dead pixels.

  badpix_norm_percentile = 90.0

  Used in: cal_BADPIX_spirou
  Defined in: constants_SPIROU.txt

7.14 Quality control variables

- **Maximum dark median level (qc_max_darklevel)**

  Defines the maximum dark median level in ADU/s. If this is greater than median flux it does not pass the quality control criteria:

  $$\text{Median Flux} < \text{qc\_max\_darklevel} \tag{7.18}$$

  Value must be a float equal to or larger than zero.

  qc_max_darklevel = 0.5

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Maximum percentage of dead pixels (qc_max_dead)**

  Defines the maximum allowed percentage of dead pixels in a dark image. If the number of dead pixels is greater than this it does not pass the quality control criteria:

  $$\text{dead pixels} = (\text{pixel value} > \text{dark\_cutlimit}) \text{ and } (\text{pixel value} \neq \text{NaN}) \tag{7.19}$$

  $$\text{Percentage of dead pixels} < \text{qc\_max\_dead} \tag{7.20}$$

  qc_max_dead = 20.0

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Maximum percentage of bad dark pixels (qc_max_dark)**

  Defines the maximum allowed percentage of bad dark pixels in a dark image. If the number of dead pixels is greater than this it does not pass the quality control criteria:

  $$\text{bad dark pixels} = \text{pixel value} > \text{dark\_cutlimit} \tag{7.21}$$

  $$\text{Percentage of bad dark pixels} < \text{qc\_max\_dead} \tag{7.22}$$

  qc_max_dark = 6.0

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Minimum dark exposure time (qc_dark_time)**

  Defines the minimum dark exposure time. If exposure time (from FITS rec HEADER) is below this the code will exit with 'Dark exposure time too short' message. Value must be a float greater than zero.

  qc_dark_time = 599.0

  Used in: cal_DARK_spirou
  Defined in: constants_SPIROU.txt

- **Maximum points removed in localization position fit (qc_loc_maxlocfit_removed_ctr)**

  Defines the maximum allowed number of points removed in the position fitting process (during localization). If number is more than this it does not pass the quality control criteria:

  $$\text{Number of rejected orders in center fit} > \text{qc\_loc\_maxlocfit\_removed\_ctr} \quad (7.23)$$

  Value must be a integer greater than zero.

  qc_loc_maxlocfit_removed_ctr = 1500

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum points removed in localization width fit (qc_loc_maxlocfit_removed_wid)**

  Defines the maximum allowed number of points removed in the width fitting process (during localization). If number is more than this it does not pass the quality control criteria:

  $$\text{Number of rejected orders in width fit} > \text{qc\_loc\_maxlocfit\_removed\_width} \quad (7.24)$$

  Value must be a integer greater than zero.

  qc_loc_maxlocfit_removed_wid = 105

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum allowed RMS in fitting in localization position fit (qc_loc_rmsmax_center)**

  Defines the maximum RMS allowed in the position fitting process (during localization). If the RMs is higher than this value it does not pass the quality control criteria:

  $$\text{Mean rms center fit} > \text{qc\_loc\_rmsmax\_center} \quad (7.25)$$

  Value must be a float greater than zero.

  qc_loc_rmsmax_center = 100

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum allowed RMS in fitting in localization width fit (qc_loc_rmsmax_fwhm)**

  Defines the maximum RMS allowed in the width fitting process (during localization). If the RMs is higher than this value it does not pass the quality control criteria:

  $$\text{Mean rms width fit} > \text{qc\_loc\_rmsmax\_fwhm} \tag{7.26}$$

  Value must be a float greater than zero.

  qc_loc_rmsmax_fwhm = 500

  Used in: cal_loc_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum allowed RMS (qc_ff_rms)**

  Defines the maximum RMS allowed to accept a flat-field for calibration. Value must be a float greater than zero.

  qc_ff_rms = 0.12

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Saturation level reached warning (qc_loc_flumax)**

  Defines the level above which a warning is generated in the form 'SATURATION LEVEL REACHED on Fiber fiber'. Value must be a float greater than zero.

  qc_loc_flumax = 64500

  Used in: cal_FF_RAW_spirou
  Defined in: constants_SPIROU.txt

- **Maximum RMS allowed for slit TILT (qc_slit_rms)**

  Defines the maximum allowed RMS in the calculated TILT to add TILT profile to the calibration database. Value must be a float larger than zero.

  qc_slit_rms = 0.1

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

- **Minimum angle allowed for slit TILT (qc_slit_min)**

  Defines the minimum tilt angle allowed to add TILT profile to the calibration databse. Value must be a float and must be less than qc_slit_max

  qc_slit_min = -8.0

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

- **Maximum angle allowed for slit TILT (qc_slit_max)**

  Defines the maximum tiult angle allowed to add TILT profile to the calibration databse. Value must be a float and must be greater than qc_slit_min

  qc_slit_max = 0.0

  Used in: cal_SLIT_spirou
  Defined in: constants_SPIROU.txt

- **Saturation point (qc_max_signal)**

  Defines the maximum signal allowed (when defining saturation limit). Currently this does not contribute to failing the quality test. Value must be a float greater than zero.

  qc_max_signal = 65500

  Used in: cal_extract_RAW_spirou
  Defined in: constants_SPIROU.txt

7.15 Calibration database variables

- **The calibration database master filename (ic_calibDB_filename)**

  Defines the name of the master calibration database text file for use in all calibration database operation.

  ic_calibDB_filename = master_calib_SPIROU.txt

  Used in: All Recipes
  Defined in: constants_SPIROU.txt

- **Maximum wait time for locked calibration database (calib_max_wait)**

  Defines the maximum time the code waits for the calibration database when it is locked. A locked file is created every time the calibration database is open (and subsequently closed when reading of the database was successful). If a lock file is present the code will wait a maximum of this many seconds and keep checking whether the lock file has been removed. After which time the code will exit with an error. Value must be a positive float greater than zero. Measured in seconds.

  calib_max_wait = 3600

  Used in: All Recipes
  Defined in: constants_SPIROU.txt

- **Calibration database duplicate key handler (calib_db_match)**

  Defines the mechanism to use in deciding between duplicate keys in the calibration database file. Value must be a string and must be either 'older' or 'closest'. If 'older' the calibration database will only use keys that are older than the timestamp in the input fits file (first argument) using the key kw_ACQTIME_KEY

  calib_db_match = 'closest'

  Used in: All Recipes
  Defined in: constants_SPIROU.txt

7.16 Logging and printing variables

- **Print message level (PRINT_LEVEL)**

  The level of messages to print, values can be as follows:

  - "all" – prints all events
  - "info" – prints info, warning and error events
  - "warning" – prints warning and error events
  - "error" – print only error events

  Value must be a valid string.

  PRINT_LEVEL = all

  Used in: All Recipes
  Defined in: ../config /config.txt

- **Log message level (LOG_LEVEL)**

  The level of messages to print, values can be as follows:

  - "all" – prints all events
  - "info" – prints info, warning and error events
  - "warning" – prints warning and error events
  - "error" – print only error events

  Value must be a valid string.

  LOG_LEVEL = all

  Used in: All Recipes
  Defined in: ../config /config.txt

- **Toggle coloured log (COLOURED_LOG)**

  Defines whether the log (printed to the standard output) is coloured . Value must be True or 1 to colour the log or False or 0 to use the default console colour throughout.

  COLOURED_LOG = True

  Used in: All Recipes
  Defined in: ../config /config.txt

Chapter 8

The Recipes

8.1 The cal_DARK recipe

Dark with short exposure time (5min, to be defined during AT-4) to check if read-out noise, dark current and hot pixel mask are consistent with the ones obtained during technical night. Quality control is done automatically by the pipeline

8.1.1 The inputs

The input of cal_DARK_spirou is as follows:

```
>> cal_DARK_spirou.py night_repository filenames
```

for example:

example

```
>> cal_DARK_spirou.py 20170710 dark_dark02d406.fits
```

or

Python/Ipython

```
import cal_DARK_spirou
night_repository = '20170710'
filenames = ['dark_dark02d406.fits']
cal_DARK_spirou.main(night_repository, files=filenames)
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names . All files in filenames must be valid python strings separated by a space (command line) or in a line (python).

Filename prefixes allowed are:

- dark_dark

8.1.2 The outputs

The outputs of cal_DARK_spirou are as follows:

- darkfile in form:

  {reduced_dir }/{date prefix}_{file}.fits

- darkbadpixfile in form:

  {reduced_dir }/{date prefix}_{file}_badpixel.fits

where 'date prefix' is constructed from arg_night_name and the file name is the first file in arg_file_names .

For example for reduced_dir ='/drs/data/reduced/20170710' and arg_file_names =['dark_dark02d406.fits'] the output files would be:

- /drs/data/reduced/20170710/20170710_dark_dark02d406.fits
- /drs/data/reduced/20170710/20170710_dark_dark02d406_badpixel.fits

8.1.3 Summary of procedure

1. adds defined 'dark_dark' files together
2. resizes the image
3. calculates the fraction of dead pixels [full, blue part, red part]
4. calculates median dark level [full, blue part, red part]
5. calculates threshold of dark level to retain
6. removes dead pixels by setting them to 0
7. does some quality control
8. updates calibDB with key "DARK"

8.1.4 Quality Control

There are currently three quality control checks for cal_DARK_spirou

- Unexpected median dark level if:

$$\text{Median Flux} > \text{qc\_max\_darklevel} \tag{8.1}$$

- Unexpected fraction of dead pixels if:

$$\text{Number of dead pixels} > \text{qc\_max\_dead} \tag{8.2}$$

- Unexpected fraction of dark pixels if:

$$\text{Number of bad dark pixels} > \text{qc\_max\_dark} \tag{8.3}$$

If none of these quality control criteria are valid then the output file is passed into the calibration database with key 'DARK' for the 'darkfile' and 'BADPIX' for the 'darkbadpixfile'.

For example the following lines are added to the calibration database for arg_night_name = "20170710" and arg_file_names = "dark_dark02d406.fits" .

In calibration database file

```
DARK 20170710 20170710_dark_dark02d406.fits 2017-07-10-12:37:48.260000 1499690268.26
BADPIX 20170710 20170710_dark_dark02d406_badpixel.fits 2017-07-10-12:37:48.260000 1499690268.26
```

8.1.5 Example working run

An example run where everything worked is below:

example

```
>> cal_DARK_spirou.py 20170710 dark_dark02d406.fits
```

```
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp/
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   |ipython:2d406|Now running : ipython on file(s): dark_dark02d406.fits
HH:MM:SS.S -   |ipython:2d406|On directory /drs/data/raw/20170710
HH:MM:SS.S -   |ipython:2d406|ICDP_NAME loaded from: /drs/INTROOT/config/constants_SPIROU.py
HH:MM:SS.S - * |ipython:2d406|Correct type of image for dark (dark_dark)
HH:MM:SS.S - * |ipython:2d406|Now processing Image TYPE UNKNOWN with ipython recipe
HH:MM:SS.S -   |ipython:2d406|Reading Image /drs/data/raw/20170710/dark_dark02d406.fits
HH:MM:SS.S -   |ipython:2d406|Image 2048 x 2048 loaded
HH:MM:SS.S - * |ipython:2d406|Dark Time = 597.489 s
HH:MM:SS.S -   |ipython:2d406|Doing Dark measurement
HH:MM:SS.S - * |ipython:2d406|In Whole det: Frac dead pixels= 14.7 % - Median= 0.35 ADU/s - Percent
     [5:95]= 0.08-99.57 ADU/s
HH:MM:SS.S - * |ipython:2d406|In Blue part: Frac dead pixels= 1.0 % - Median= 0.15 ADU/s - Percent
     [5:95]= 0.09-0.53 ADU/s
HH:MM:SS.S - * |ipython:2d406|In Red part : Frac dead pixels= 20.5 % - Median= 2.11 ADU/s - Percent
     [5:95]= 0.18-232.09 ADU/s
HH:MM:SS.S - * |ipython:2d406|Frac pixels with DARK > 100.0 ADU/s = 4.3 %
HH:MM:SS.S - @ |python warning|Line 138 warning reads: invalid value encountered in greater
HH:MM:SS.S - * |ipython:2d406|Total Frac dead pixels (N.A.N) + DARK > 100.0 ADU/s = 18.9 %
HH:MM:SS.S - * |ipython:2d406|QUALITY CONTROL SUCCESSFUL - Well Done -
HH:MM:SS.S -   |ipython:2d406|Saving Dark frame in 20170710_dark_dark02d406.fits
HH:MM:SS.S - @ |python warning|Line 980 warning reads: Card is too long, comment will be truncated.
HH:MM:SS.S -   |ipython:2d406|Saving Bad Pixel Map in 20170710_dark_dark02d406_badpixel.fits
HH:MM:SS.S - @ |python warning|Line 980 warning reads: Card is too long, comment will be truncated.
HH:MM:SS.S - * |ipython:2d406|Updating Calib Data Base with DARK
HH:MM:SS.S - * |ipython:2d406|Updating Calib Data Base with BADPIX
HH:MM:SS.S - * |ipython:2d406|Recipe ipython has been succesfully completed
```

8.1.6 Interactive mode

In interactive mode (DRS_PLOT = 1) three figures will also appear (see Figure 8.1).

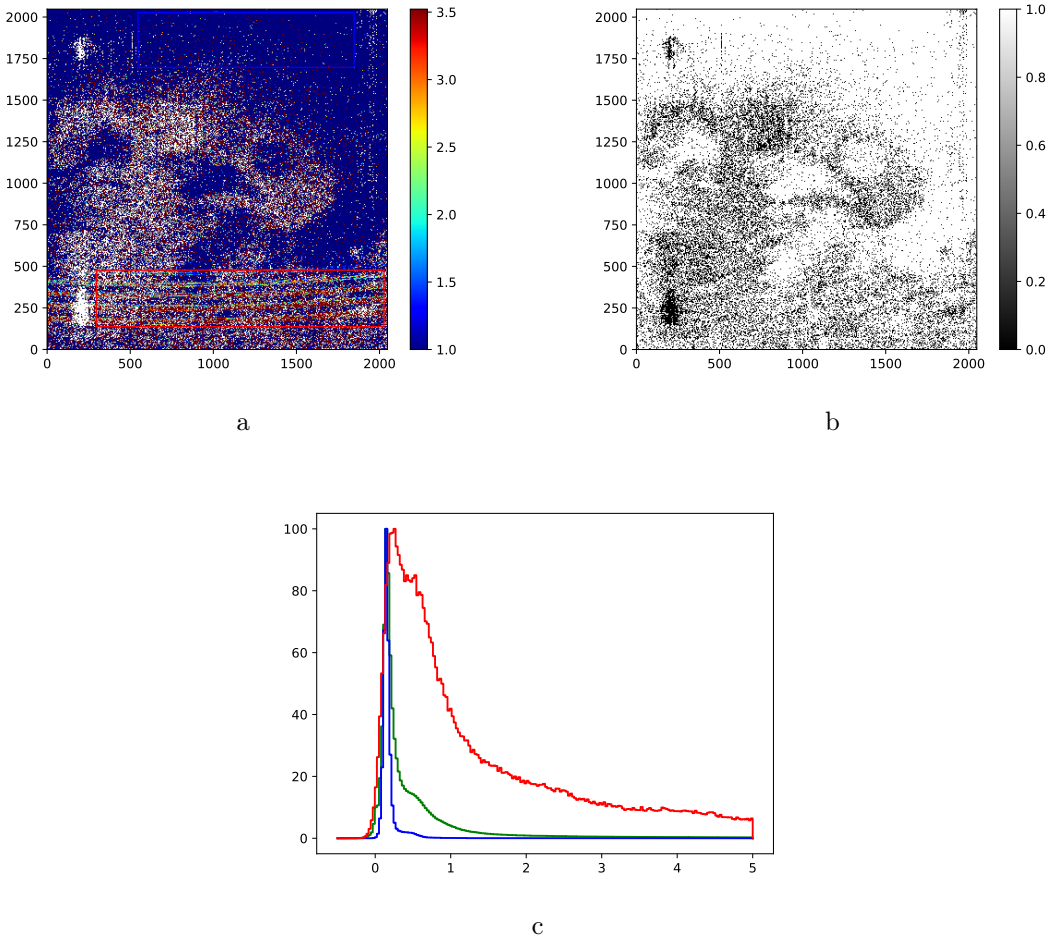


Figure 8.1 (a) The image with over-plot red and blue regions (red/blue rectangles). **(b)** The bad pixel mask, bad pixels have a value=1 (in black) and good pixels have a value=0 (in white). **(c)** Histograms of the image regions, the full image (in green), the blue section (in blue) and the red section (in red).

8.2 The cal_BADPIX recipe

Recipe to generate the bad pixel map.

8.2.1 The inputs

The input of cal_BADPIX_spirou is as follows:

```
>> cal_BADPIX_spirou.py night_repository flatfile darkfile
```

for example:

example

```
>> cal_BADPIX_spirou.py 20170710 flat_flat02f10.fits dark_dark02d406.fits
```

or

Python/Ipython

```
import cal_DARK_spirou
night_reposityory = '20170710'
darkfile = 'dark_dark02d406.fits'
flatfile = 'flat_flat02f10.fits'
cal_DARK_spirou.main(night_repository, flatfile=flatfile, darkfile=darkfile)
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names. All files in filenames must be valid python strings separated by a space (command line) or in a line (python) and must have the folowing prefixes: File prefixes allowed:

- flat_flat (flatfile)
- dark_dark (darkfile)

8.2.2 The outputs

The outputs of badpixelfits are as follows:

- badpixelfits in form:

  {reduced_dir}/{date prefix}_{file}_badpixelfits.fits

where 'date prefix' is constructed from arg_night_name and the file name is the flatfile name.
for example for reduced_dir ='/drs/data/reduced/20170710' and flatfile='flat_flat02f10.fits' the output file would be:

- /drs/data/reduced/20170710/20170710_flat_flat02f10_badpixelfits.fits

8.2.3 Summary of procedure

1. Normalise the flats
2. Look for isolated hot pixels
3. Calculate how much pixels deviate compared to expected values

4. Select hot pixels compared to neighbours
5. Combine bad pixel map
6. Save bad pixel mask to file

8.2.4 Quality Control

There are no quality control parameters for cal_BADPIX_spirou.

The output file is passed into the calibration database with key 'BADPIX' for the 'badpixfile'.

For example the following lines are added to the calibration database for arg_night_name = "20170710", flatfile = "flat_flat02f10.fits" and darkfile = "dark_dark02d406.fits".

In calibration database file

```
BADPIX 20170710 20170710_flat_flat02f10_badpixel.fits 2017-07-10-13:07:49.470000 1499692069.47
```

8.2.5 Example working run

An example run where everything worked is below:

example

```
>> cal_BADPIX_spirou.py 20170710 flat_flat02f10.fits dark_dark02d406.fits
```

```
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   |cal_BADPIX_spirou|Now running : cal_BADPIX_spirou with:
HH:MM:SS.S -   |cal_BADPIX_spirou|       -- flatfile=flat_flat02f10.fits
HH:MM:SS.S -   |cal_BADPIX_spirou|       -- darkfile=dark_dark02d406.fits
HH:MM:SS.S -   |cal_BADPIX_spirou|Config Error: ICDP_NAME loaded from: /drs/spirou_py3/INTROOT/config/
    constants_SPIROU.py
HH:MM:SS.S - * |cal_BADPIX_spirou|Now processing Image TYPE FLAT with cal_BADPIX_spirou recipe
HH:MM:SS.S - * |cal_BADPIX_spirou|Now processing Image TYPE DARK with cal_BADPIX_spirou recipe
HH:MM:SS.S -   |cal_BADPIX_spirou|Reading FLAT Image /drs/data/raw/20170710/flat_flat02f10.fits
HH:MM:SS.S -   |cal_BADPIX_spirou|FLAT Image 2048 x 2048 loaded
HH:MM:SS.S -   |cal_BADPIX_spirou|Reading DARK Image /drs/data/raw/20170710/dark_dark02d406.fits
HH:MM:SS.S -   |cal_BADPIX_spirou|DARK Image 2048 x 2048 loaded
HH:MM:SS.S -   |cal_BADPIX_spirou|Normalising the flat
HH:MM:SS.S -   |cal_BADPIX_spirou|Looking for bad pixels
HH:MM:SS.S -   |cal_BADPIX_spirou|Fraction of hot pixels from dark: 3.01 %
HH:MM:SS.S -   |cal_BADPIX_spirou|Fraction of bad pixels from flat: 1.66 %
HH:MM:SS.S -   |cal_BADPIX_spirou|Fraction of non-finite pixels in dark: 20.76 %
HH:MM:SS.S -   |cal_BADPIX_spirou|Fraction of non-finite pixels in flat: 14.66 %
HH:MM:SS.S -   |cal_BADPIX_spirou|Fraction of bad pixels with all criteria: 24.87 %
HH:MM:SS.S - * |cal_BADPIX_spirou|QUALITY CONTROL SUCCESSFUL - Well Done -
HH:MM:SS.S -   |cal_BADPIX_spirou|Saving Bad Pixel Map in 20170710_flat_flat02f10_badpixel.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S - * |cal_BADPIX_spirou|Updating Calib Data Base with BADPIX
HH:MM:SS.S - * |cal_BADPIX_spirou|Recipe cal_BADPIX_spirou has been successfully completed
```

8.3 The cal_loc recipe

Locates the orders on the 'dark_flat' or 'flat_dark' images.

8.3.1 The inputs

The input of cal_loc_RAW_spirou is as follows:

```
>> cal_loc_RAW_spirou.py night_repository filenames
```

for example:

example

```
>> cal_loc_RAW_spirou.py 20170710 flat_dark02f10.fits
```

or

Python/Ipython

```
import cal_loc_RAW_spirou
night_repository = '20170710'
filenames = ['flat_dark02f10.fits']
cal_loc_RAW_spirou.main(night_repository, files=filenames)
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names. All files in filenames must be valid python strings separated by a space (command line) or in a line (python) and must have the folowing prefixes: File prefixes allowed:

- dark_flat
- flat_dark

8.3.2 The outputs

The outputs of cal_loc_RAW_spirou are as follows:

- order_profile in form:
  {reduced_dir}/{date prefix}_{file}_order_profile_{fiber}.fits
- locofitsfile in form:
  {reduced_dir}/{date prefix}_{file}_loco_{fiber}.fits
- locofitsfile2 in form:
  {reduced_dir}/{date prefix}_{file}_fwhm-order_{fiber}.fits
- locofitsfile3 in form:
  {reduced_dir}/{date prefix}_{file}_with-order_{fiber}.fits

where 'date prefix' is constructed from arg_night_name and the file name is the first file in arg_file_names.

For example for reduced_dir='/drs/data/reduced/20170710' and arg_file_names=['flat_dark02f10.fits'] the output files would be:

- /drs/data/reduced/20170710/20170710_flat_dark02f10_order_profile_{fiber}.fits
- /drs/data/reduced/20170710/20170710_flat_dark02f10_loco_{fiber}.fits
- /drs/data/reduced/20170710/20170710_flat_dark02f10_fwhm-order_{fiber}.fits
- /drs/data/reduced/20170710/20170710_flat_dark02f10_with-order_{fiber}.fits

8.3.3 Summary of procedure

1. adds all defined 'dark_flat' or 'flat_dark' files together
2. corrects for darks
3. resizes the image
4. constructs 'order_profile' image
5. locates the central pixel of each order
6. steps out in large steps along the order (toward beginning and end)
7. fits the position of each order (using a small 2D box around each fit point)
   - includes a rejection of bad points (while loop)
8. fits the width of each order (using a small 2D box around each fit point)
   - includes a rejection of bad points (while loop)
9. saves the 'order_profile' image (with a superposition of the fit orders as zero values)
10. does some quality control
11. updates calibDB with keys "ORDER_PROFILE_{fiber}" "LOC_{fiber}" where {fiber} = [AB, C] etc

8.3.4 Quality Control

There are currently five quality control checks for cal_loc_RAW_spirou

- Too many rejected orders in center position fit:

$$\text{Number of rejected orders in center fit} > \texttt{qc\_loc\_maxlocfit\_removed\_ctr} \tag{8.4}$$

- Too many rejected orders in width fit:

$$\text{Number of rejected orders in width fit} > \texttt{qc\_loc\_maxlocfit\_removed\_wid} \tag{8.5}$$

- RMS on center fit too high:

$$\text{Mean rms center fit} > \texttt{qc\_loc\_rmsmax\_center} \tag{8.6}$$

- RMS on width fit too high:

$$\text{Mean rms width fit} > \texttt{qc\_loc\_rmsmax\_fwhm} \tag{8.7}$$

- Abnormal number of identified orders:

$$\text{Number of orders found} \neq \texttt{qc\_loc\_nbo} \tag{8.8}$$

If none of these quality control criteria are valid then the output file is passed into the calibration database with keys 'ORDER_PROFILE_{fiber}' for the 'order_profile' file and 'LOC_{fiber}' for the 'locofitsname' file.

For example the following lines are added to the calibration database for arg_night_name = "20170710" and arg_file_names = ["flat_dark02f10.fits"] .

In calibration database file

```
ORDER_PROFILE_AB 20170710 20170710_flat_dark02f10_order_profile_AB.fits 2017-07-10-13:04:34.440000
    1499691874.44
LOC_AB 20170710 20170710_flat_dark02f10_loco_AB.fits 2017-07-10-13:04:34.440000 1499691874.44
```

8.3.5 Example working run

An example run where everything worked is below:

example

```
>> cal_loc_RAW_spirou.py 20170710 flat_dark02f10.fits
```

```
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Now running : cal_loc_RAW_spirou on file(s): flat_dark02f10.
    fits
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|On directory /drs/data/raw/20170710
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ICDP_NAME loaded from: /drs/spirou_py3/INTROOT/config/
    constants_SPIROU.py
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Correct type of image for localisation (dark_flat or
    flat_dark)
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Calibration file: 20170710_flat_flat02f10_badpixel.fits
    already exists - not copied
```

```
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Calibration file: 20170710_dark_dark02d406.fits already
    exists - not copied
...
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Now processing Image TYPE UNKNOWN with cal_loc_RAW_spirou
    recipe
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Reading Image /drs/data/raw/20170710/flat_dark02f10.fits
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Image 2048 x 2048 loaded
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Doing Dark Correction using /drs/data/calibDB/20170710
    _dark_dark02d406.fits
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Image format changed to 1930x2035
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Saving processed raw frame in 20170710
    _flat_dark02f10_order_profile_AB.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Updating Calib Data Base with ORDER_PROFILE_AB
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Maximum flux/pixel in the spectrum: 82388.4 [e-]
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Average background level: 1.39 [%]
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Searching order center on central column
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|On fiber AB 36 orders have been detected on 2 fiber(s)
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 0 center at pixel 102.5 width 11.6 rms 0.049
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.049/0.140/2.855 with 0
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.434/0.740/6.726 with 0 rejected
     points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 1 center at pixel 116.9 width 11.4 rms 0.073
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.073/0.164/2.240 with 0
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.448/0.794/6.618 with 0 rejected
     points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 2 center at pixel 149.8 width 11.7 rms 0.049
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.049/0.116/2.374 with 0
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.421/0.881/8.006 with 0 rejected
     points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 3 center at pixel 164.2 width 11.5 rms 0.075
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.075/0.173/2.309 with 0
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.420/0.806/7.119 with 0 rejected
     points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 4 center at pixel 196.6 width 11.5 rms 0.051
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.051/0.140/2.762 with 0
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.403/0.989/8.889 with 0 rejected
     points
...
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 69 center at pixel 1801.4 width 10.4 rms 0.168
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      center fit converging with rms/ptp/sigrms:
    0.168/1.465/8.710
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.067/0.167/2.490 with 1
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      fwhm fit converging with rms/ptp/ptp%:
    0.535/2.337/29.218
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      fwhm fit converging with rms/ptp/ptp%:
    0.478/1.105/11.053
```

```
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.466/0.936/9.357 with 2 rejected
     points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 70 center at pixel 1851.8 width 7.1 rms 2.565
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      center fit converging with rms/ptp/sigrms:
    2.565/8.719/3.399
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.077/0.158/2.047 with 22
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      fwhm fit converging with rms/ptp/ptp%:
    1.070/2.674/44.574
...
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.300/0.623/9.965 with 17
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|ORDER: 71 center at pixel 1869.1 width 10.7 rms 0.296
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      center fit converging with rms/ptp/sigrms:
    0.296/0.889/3.008
...
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - center fit rms/ptp/sigrms: 0.099/0.199/1.998 with 30
    rejected points
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|      fwhm fit converging with rms/ptp/ptp%:
    0.995/3.544/23.627
...
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10| - width  fit rms/ptp/ptp%: 0.468/0.838/8.383 with 23
    rejected points
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|On fiber AB 72 orders geometry have been measured
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Average uncertainty on position: 66.42 [mpix]
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Average uncertainty on width: 381.93 [mpix]
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|QUALITY CONTROL SUCCESSFUL - Well Done -
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Saving localization information in file: 20170710
    _flat_dark02f10_loco_AB.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Saving FWHM information in file: 20170710_flat_dark02f10_fwhm
    -order_AB.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|Saving localization image with superposition of orders in
HH:MM:SS.S -   |cal_loc_RAW_spirou:02f10|file: 20170710_flat_dark02f10_with-order_AB.fits
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Updating Calib Data Base with LOC_AB
HH:MM:SS.S - * |cal_loc_RAW_spirou:02f10|Recipe cal_loc_RAW_spirou has been successfully completed
```

8.3.6 Interactive mode

In interactive mode three figures will also appear (see Figure 8.2).

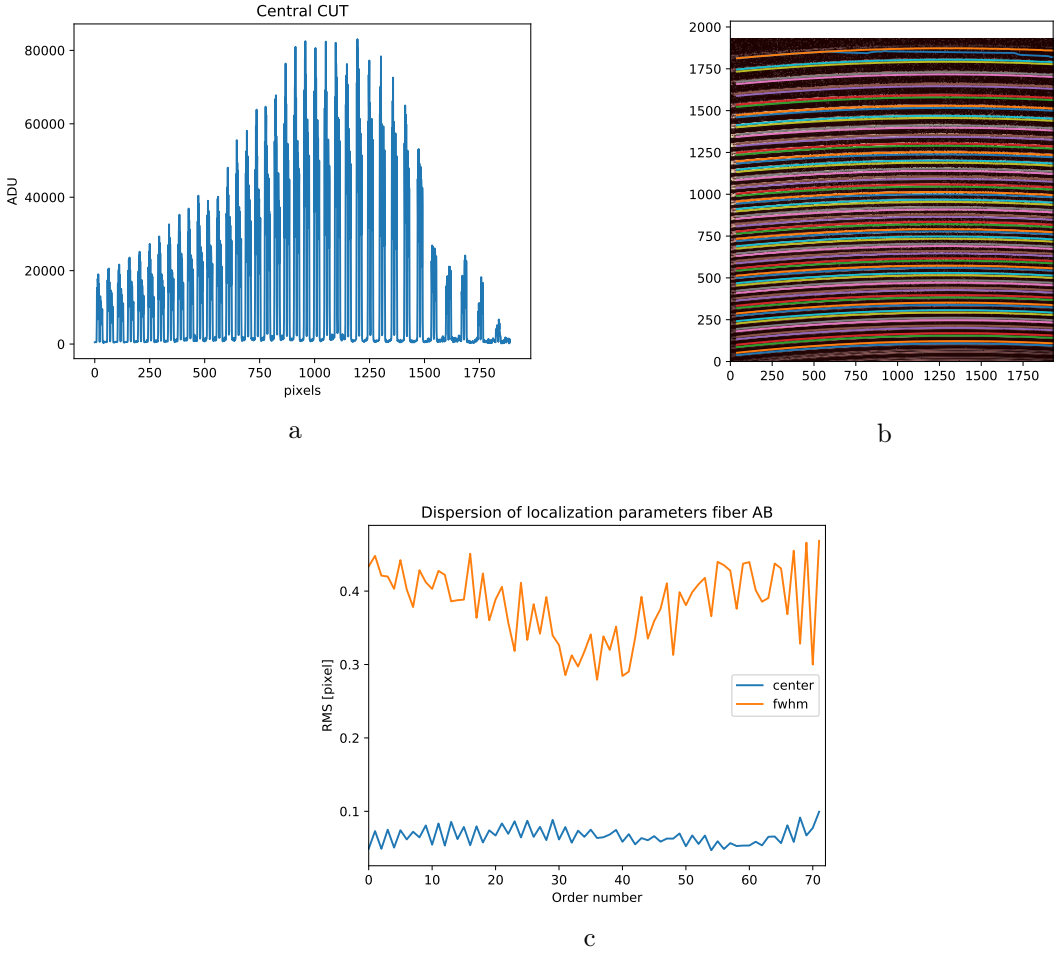


Figure 8.2 (a) Pixel number (across order) against flux value of central pixel. **(b)** Image with fits to each order. **(c)** The dispersion of localization parameters.

8.4 The cal_SLIT recipe

Fabry-Perot exposures in which the three fibres are simultaneously fed by light from the Fabry-Perot filter. Each exposure is used to build the slit orientation. Finds the tilt of the orders.

8.4.1 The inputs

The input of cal_SLIT_spirou is as follows:

```
>> cal_SLIT_spirou.py night_repository filenames
```

for example:

```
>> cal_SLIT_spirou.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
```

or

Python/Ipython

```
import cal_SLIT_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
cal_SLIT_spirou.main(night_repository, files=filenames)
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names. All files in filenames must be valid python strings separated by a space (command line) or in a line (python) and must have the folowing prefixes:

- fp_fp

8.4.2 The outputs

The outputs of cal_SLIT_spirou are as follows:

- tiltfits in form:

  {reduced_dir}/{date prefix}_{file}_tilt.fits

where 'date prefix' is constructed from arg_night_name and the file name is the first file in arg_file_names. for example for reduced_dir ='/drs/data/reduced/20170710' and arg_file_names =['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits'] the output files would be:

- /drs/data/reduced/20170710/20170710_fp_fp02a203_tilt.fits

8.4.3 Summary of procedure

1. adds all fp_fp files together
2. corrects for dark
3. resizes the image
4. extracts the orders (no weight no tilt)
5. works out the tilt for each order using the location and width

6. saves the tilt to file
7. should do some quality control
8. updates calibDB with key "TILT"

8.4.4 Quality Control

There are currently two quality control checks for cal_SLIT_spirou

- Abnormal RMS of SLIT angle if:

$$\mathrm{RMS}_{\mathrm{tilt}} > \mathrm{qc\_slit\_rms} \tag{8.9}$$

- Abnormal SLIT angle if:

$$\max(\mathrm{tilt}) > \mathrm{qc\_slit\_max} \tag{8.10}$$

or

$$\min(\mathrm{tilt}) < \mathrm{qc\_slit\_min} \tag{8.11}$$

If none of these quality control criteria are valid then the output file is passed into the calibration database with key 'TILT'.

For example the following lines are added to the calibration database for arg_night_name `= "20170710"` and arg_file_names `= ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']` .

In calibration database file

```
TILT 20170710 20170710_fp_fp02a203_tilt.fits 2017-07-10-13:25:15.590000 1499693115.59
```

8.4.5 Example working run

An example run where everything worked is below:

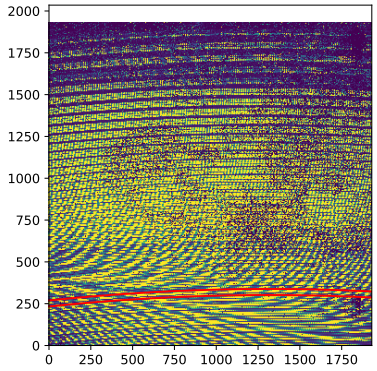
```
>> cal_SLIT_spirou.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
```

```
HH:MM:SS.S -   || ***************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ***************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Now running : cal_SLIT_spirou on file(s): fp_fp02a203.fits
    , fp_fp03a203.fits, fp_fp04a203.fits
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|On directory /drs/data/raw/20170710
```

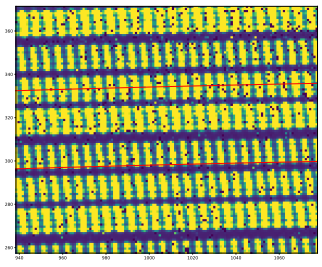
```
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|ICDP_NAME loaded from: /scratch/Projects/spirou_py3/
    spirou_py3/INTROOT/config/constants_SPIROU.py
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|Correct type of image for slit (f or p or _ or f or p)
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Calibration file: 20170710_flat_flat02f10_badpixel.fits
    already exists - not copied
...
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Calibration file: spirou_wave_ini3.fits already exists -
    not copied
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Calibration file: 2017-10-11_21-32-17
    _hcone_hcone02c406_wave_AB.fits already exists - not copied
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Calibration file: spirou_wave_ini3.fits already exists -
    not copied
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Calibration file: 2017-10-11_21-32-17
    _hcone_hcone02c406_wave_C.fits already exists - not copied
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|Now processing Image TYPE UNKNOWN with cal_SLIT_spirou
    recipe
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Reading Image /drs/data/raw/20170710/fp_fp02a203.fits
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Image 2048 x 2048 loaded
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|Adding 2 frame(s)
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Reading File: /drs/data/raw/20170710/fp_fp03a203.fits
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Reading File: /drs/data/raw/20170710/fp_fp04a203.fits
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Doing Dark Correction using /drs/data/calibDB/20170710
    _dark_dark02d406.fits
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Image format changed to 1930x2035
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|Nb dead pixels = 611716 / 15.58 %
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Reading localization parameters of Fiber AB
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 0.0: Tilt = 4.70 on pixel 37.0 = -7.23 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 1.0: Tilt = 4.60 on pixel 37.4 = -7.02 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 2.0: Tilt = 4.50 on pixel 36.8 = -6.97 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 3.0: Tilt = 4.30 on pixel 36.3 = -6.75 deg
...
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 32.0: Tilt = 1.40 on pixel 33.3 = -2.41 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 33.0: Tilt = 1.10 on pixel 32.3 = -1.95 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 34.0: Tilt = 1.00 on pixel 32.1 = -1.79 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Order 35.0: Tilt = 0.30 on pixel 17.1 = -1.01 deg
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]AB|Tilt dispersion = 0.091 deg
HH:MM:SS.S -   |cal_SLIT_spirou:2a203+[...]|Saving tilt  information in file: 20170710
    _fp_fp02a203_tilt.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|QUALITY CONTROL SUCCESSFUL - Well Done -
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|Updating Calib Data Base with TILT
HH:MM:SS.S - * |cal_SLIT_spirou:2a203+[...]|Recipe cal_SLIT_spirou has been successfully completed
    HHMSSS
```

8.4.6 Interactive mode

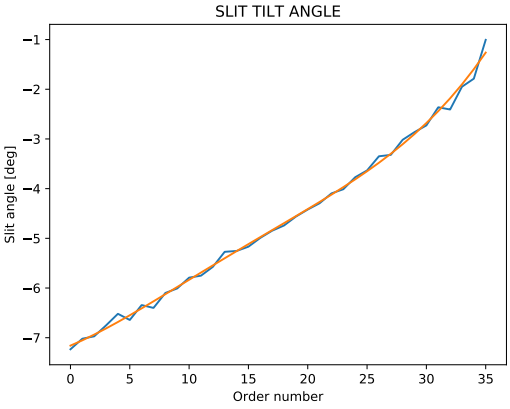
In interactive mode three figures will also appear (see Figure 8.3).



a



b



c

Figure 8.3 (a) The full 'fp_fp' image with one orders fit plotted. **(b)** Zoom in on a section of the 'fp_fp' image showing the tilt. **(c)** Slit aginle as a function of order number with the fit to the tilt also show.

8.5 The cal_FF recipe

Creates the flat fields.

8.5.1 The inputs

The input of cal_FF_RAW_spirou is as follows:

```
>> cal_FF_RAW_spirou.py night_repository filenames
```

for example

example

```
>> cal_FF_RAW_spirou.py 20170710 dark_flat02f10.fits dark_flat03f10.fits dark_flat04f10.fits
    dark_flat05f10.fits dark_flat06f10.fits
```

or

Python/Ipython

```
import cal_FF_RAW_spirou
night_repository = '20170710'
filenames = ['dark_flat02f10.fits', 'dark_flat03f10.fits', 'dark_flat04f10.fits',
             'dark_flat05f10.fits', 'dark_flat06f10.fits']
cal_FF_RAW_spirou.main()
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names. All files in filenames must be valid python strings separated by a space (command line) or in a line (python) and must have the folowing prefixes:

- dark_flat
- flat_dark

8.5.2 The outputs

The outputs of cal_FF_RAW_spirou are as follows:

- blazefits in form:

  {reduced_dir}/{date prefix}_{file}_blaze_{fiber}.fits

- flatfits in form:

  {reduced_dir}/{date prefix}_{file}_flat_{fiber}.fits

where 'date prefix' is constructed from arg_night_name and the file name is the first file in arg_file_names. for example for reduced_dir='/drs/data/reduced/20170710' and arg_file_names=['dark_flat02f10.fits', 'dark_flat03f10.fits', 'dark_flat04f10.fits', 'dark_flat05f10.fits', 'dark_flat06f10.fits'] the output files would be:

- /drs/data/reduced/20170710/20170710_flat_dark02f10_blaze_AB.fits
- /drs/data/reduced/20170710/20170710_flat_dark02f10_flat_AB.fits

8.5.3 Summary of procedure

1. adds all 'dark_flat' or 'flat_dark' files together
2. corrects for darks
3. resizes the image
4. possible background subtraction?
5. extracts the orders using tilt and weight
6. calculates the blaze
7. calculates the flat field, (flat = extraction / blaze)
8. stores the flat fields
9. does some quality control
10. updates calibDB with key "FLAT_{fiber}" where {fiber} = [AB, C] etc

8.5.4 Quality Control

There is currently one quality control check for cal_FF_RAW_spirou

- Too much flux in the image:

$$\text{maximum signal} > \text{qc\_max\_signal} * \text{nbframes} \tag{8.12}$$

Note: This check does not currently lead to a failed run and all files are processed as passing quality checks

The output file is passed into the calibration database with key 'FLAT_{fiber}' for the 'flatfits' file.

For example the following lines are added to the calibration database for arg_night_name = "20170710" and arg_file_names=['dark_flat02f10.fits', 'dark_flat03f10.fits', 'dark_flat04f10.fits', 'dark_flat05f10.fits', 'dark_flat06f10.fits'].

In calibration database file

```
FLAT_C 20170710 20170710_dark_flat02f10_flat_C.fits 2017-07-10-13:03:50.440000 1499691830.44
BLAZE_C 20170710 20170710_dark_flat02f10_blaze_C.fits 2017-07-10-13:03:50.440000 1499691830.44
```

8.5.5 Example working run

An example run where everything worked is below:

example

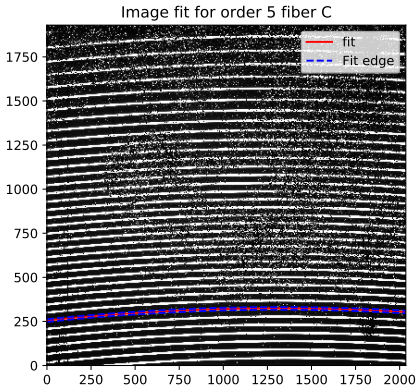
```
>> cal_FF_RAW_spirou.py 20170710 dark_flat02f10.fits dark_flat03f10.fits dark_flat04f10.fits
    dark_flat05f10.fits dark_flat06f10.fits
```

```
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Now running : cal_FF_RAW_spirou on file(s):
    dark_flat02f10.fits, dark_flat03f10.fits, dark_flat04f10.fits, dark_flat05f10.fits,
    dark_flat06f10.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On directory /drs/data/raw/20170710
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|ICDP_NAME loaded from: /scratch/Projects/spirou_py3/
    spirou_py3/INTROOT/config/constants_SPIROU.py
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Correct type of image for Flat-field (dark_flat or
    flat_dark)
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 20170710_flat_flat02f10_badpixel.fits
    already exists - not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 20170710_dark_dark02d406.fits already
    exists - not copied
...
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 20170710
    _flat_dark02f10_order_profile_AB.fits already exists - not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 20170710
    _dark_flat02f10_order_profile_C.fits already exists - not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 20170710_fp_fp02a203_tilt.fits already
     exists - not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: spirou_wave_ini3.fits already exists -
     not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 2017-10-11_21-32-17
    _hcone_hcone02c406_wave_AB.fits already exists - not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: spirou_wave_ini3.fits already exists -
     not copied
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Calibration file: 2017-10-11_21-32-17
    _hcone_hcone02c406_wave_C.fits already exists - not copied
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Now processing Image TYPE UNKNOWN with cal_FF_RAW_spirou
     recipe
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Reading Image /drs/data/raw/20170710/dark_flat02f10.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Image 2048 x 2048 loaded
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Adding 4 frame(s)
```

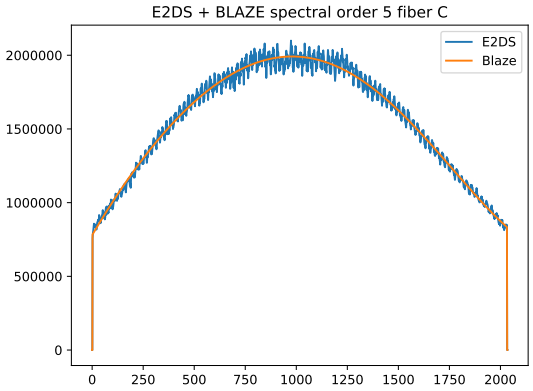
```
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Reading File: /drs/data/raw/20170710/dark_flat03f10.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Reading File: /drs/data/raw/20170710/dark_flat04f10.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Reading File: /drs/data/raw/20170710/dark_flat05f10.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Reading File: /drs/data/raw/20170710/dark_flat06f10.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Doing Dark Correction using /drs/data/calibDB/20170710
    _dark_dark02d406.fits
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Image format changed to 2035x1930
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Nb dead pixels = 568541 / 14.48 %
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Maximum average flux/pixel in the spectrum: 73636.3 [ADU
    ]
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|Reading localization parameters of Fiber C
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]C|Reading order profile of Fiber C
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On fiber C order 0: S/N= 1158.4  - FF rms=4.68 %
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On fiber C order 1: S/N= 1193.9  - FF rms=4.80 %
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On fiber C order 2: S/N= 1232.6  - FF rms=4.76 %
...
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On fiber C order 33: S/N= 1686.9  - FF rms=5.67 %
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On fiber C order 34: S/N= 1574.5  - FF rms=8.17 %
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]|On fiber C order 35: S/N= 1260.6  - FF rms=8.10 %
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]C|Saving blaze spectrum for fiber: C in 20170710
    _dark_flat02f10_blaze_C.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S -   |cal_FF_RAW_spirou:02f10+[...]C|Saving FF spectrum for fiber: C in 20170710
    _dark_flat02f10_flat_C.fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|QUALITY CONTROL SUCCESSFUL - Well Done -
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Updating Calib Data Base with FLAT_C
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Updating Calib Data Base with BLAZE_C
HH:MM:SS.S - * |cal_FF_RAW_spirou:02f10+[...]|Recipe cal_FF_RAW_spirou has been successfully completed
```

8.5.6 Interactive mode

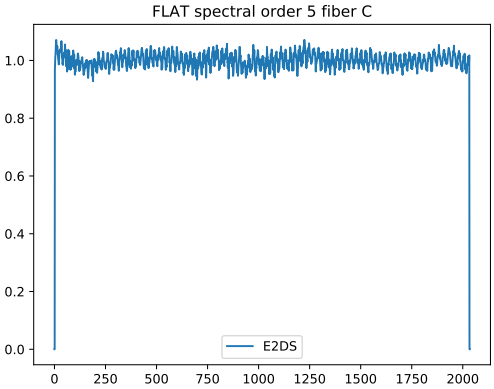
In interactive mode three figures will also appear (see Figure 8.4).



a



b



c

Figure 8.4 (a) the full processed image with one order fit highlighted. **(b)** An extracted overplotted with the blaze fit. **(c)** A flattened order.

8.6 The cal_extract recipes

Extracts orders for specific fibers and files. There are currently three extraction recipes. There is the main extraction recipe (cal_extract_RAW_spirou) and two wrapper recipes (cal_extract_RAW_spirouAB and cal_extract_RAW_spirouC, which push certain options into cal_extract_RAW_spirou).

8.6.1 The inputs

The input of cal_extract_RAW_spirou is as follows:

```
>> cal_extract_RAW_spirou.py night_repository filenames
```

for example

example

```
>> cal_extract_RAW_spirou.py 20170710 fp_fp02a203.fits
```

or

Python/Ipython

```
import cal_extract_RAW_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits']
cal_extract_RAW_spirou.main(night_repository, files=filenames)
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names. In addition to this one can add optional arguments (and this is the case for the wrapper recipes of cal_extract_RAW_spirouAB and cal_extract_RAW_spirouC).

All files in filenames must be valid python strings separated by a space (command line) or in a line (python) and should have the folowing prefixes:

- fp_fp
- hcone_dark
- dark_hcone
- hcone_hcone
- dark_dark_AHC1
- dark_hctwo
- hctwo_hctwo
- dark_dark_AHC2

8.6.1.1 Optional arguments

By default cal_extract_RAW_spirou will extract all fibers defiend in fiber_types (i.e. 'AB', 'A', 'B' and 'C'). It may be the case that one wishes to extract only one fiber, this can be done by setting the 'fiber_type' option (when run from python). For example:

Python/Ipython

```
import cal_extract_RAW_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits']
cal_DARK_spirou.main(night_repository, filenames, fiber_type='A')
```

where 'fiber_type' must be a valid python string and defined in fiber_types. On can also overwrite any other variable that is (or even is not) defined in any of the constant files (or run time) by simply adding it as an optional argument in the python function call:

Python/Ipython

```
import cal_extract_RAW_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
kwargs = dict(parameter1='This', parameter2='That')
cal_DARK_spirou.main(night_repository, filenames, fiber_type='A', **kwargs)
```

Note: This will extract fiber 'A' and also set the values `parameter1='This'` and `parameter2='That'` in the main constant parameter dictionary.

This is the case for the two wrapper recipes (cal_extract_RAW_spirouAB and cal_extract_RAW_spirouC) which add some specific keywords that are used to individually extract fibers 'AB' and 'C' respectively. The two calls to the main extraction code are shown below but can be called from the console or python as with all other recipes.

```
>> cal_extract_RAW_spirouAB.py night_repository filenames
>> cal_extract_RAW_spirouC.py night_repository filenames
```

for example

example

```
>> cal_extract_RAW_spirouAB.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
>> cal_extract_RAW_spirouC.py 20170710 fp_fp02a203.fits fp_fp03a203.fits fp_fp04a203.fits
```

or

Python/Ipython

```
import cal_extract_RAW_spirouAB
import cal_extract_RAW_spirouC
night_repository = '20170710'
filenames = ['fp_fp02a203.fits']
# extract fiber AB
cal_extract_RAW_spirouAB.main(night_repository, files=filenames)
# extract fiber C
cal_extract_RAW_spirouC.main(night_repository, files=filenames)
```

as mentioned above this can also be done in python just by adding additional arguments to cal_extract_RAW_spirou:

Python/Ipython

```
import cal_extract_RAW_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits', 'fp_fp03a203.fits', 'fp_fp04a203.fits']
# extract fiber AB (for all extraction types)
cal_extract_RAW_spirou.main(night_repository, files=filenames,fiber_type='AB',
                            ic_extract_type='all', ic_ext_sigdet=-1)
# extract fiber C (for all extraction types)
cal_extract_RAW_spirou.main(night_repository, files=filenames,fiber_type='C',
                            ic_extract_type='all', ic_ext_sigdet=-1)
```

Note: Here we set the optional arguments `ic_extract_type='all', ic_ext_sigdet=-1`. ic_extract_type defines which type of extraction should be used (simple, tilt, widht, tiltweight, all) and ic_ext_sigdet manually sets the extraction sigdet (-1 sets it to the value from the HEADER else it is defined in constants_SPIROU.txt).

The above python code is exactly what cal_extract_RAW_spirouAB and cal_extract_RAW_spirouC do by default.

8.6.2 The outputs

The outputs of cal_extract_RAW_spirou depend on the extraction type (ic_extract_type).

- e2ds in form:

  {reduced_dir}/{date prefix}_{file}_e2ds_{fiber}.fits

- simple in form:

  {reduced_dir}/{date prefix}_{file}_e2ds_{fiber}_simple.fits

  Note: Only if ic_extract_type is 'all'

- tilt in form:

  {reduced_dir}/{date prefix}_{file}_e2ds_{fiber}_tilt.fits

  Note: Only if ic_extract_type is 'all'

- tiltweight in form:

  {reduced_dir}/{date prefix}_{file}_e2ds_{fiber}_tiltweight.fits

  Note: Only if ic_extract_type is 'all'

- tiltweight2 in form:

{reduced_dir}/{date prefix}_{file}_e2ds_{fiber}_tiltweight2.fits

Note: Only if ic_extract_type is 'all'

- weight in form:

{reduced_dir}/{date prefix}_{file}_e2ds_{fiber}_weight.fits

Note: Only if ic_extract_type is 'all'

where 'date prefix' is constructed from arg_night_name and the file name is the first file in arg_file_names. for example for reduced_dir `='/drs/data/reduced/20170710'` and arg_file_names `=['fp_fp02a203.fits']` and, `fiber_type ='all'` the output files would be:

- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_A.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_B.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_C.fits

or if `ic_extract_type='all'` and `fiber_type='AB'` the output files would be:

- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_simple.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_tilt.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_tiltweight.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_tiltweight2.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_weight.fits

8.6.3 Summary of procedure

1. adds all files together (if more than one)
2. corrects for darks
3. resizes the image
4. checks for saturation
5. possible background subtraction?
6. extracts orders (depending on ic_extract_type)
   - without tilt/weight fortran
   - without tilt/weight python
   - with tilt (no weight)

- with tilt and weight
- with weight (no tilt)

7. saves extraction to e2ds file(s)

8.6.4 Quality Control

There is currently one quality control check for cal_extract_RAW_spirou

- Too much flux in the image:

$$\text{maximum signal} > \text{qc\_max\_signal} * \text{nbframes} \tag{8.13}$$

Note: This check does not currently lead to a failed run and all files are processed as passing quality checks

8.6.5 Example working run

An example run where everything worked is below:

example

```
>> cal_extract_RAW_spirou.py 20170710 fp_fp02a203.fits
```

```
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Now running : cal_extract_RAW_spirou on file(s):
    fp_fp02a203.fits
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On directory /drs/data/raw/20170710
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|ICDP_NAME loaded from: /scratch/Projects/spirou_py3/
    spirou_py3/INTROOT/config/constants_SPIROU.py
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Calibration file: 20170710_flat_flat02f10_badpixel.fits
    already exists - not copied
...
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Calibration file: 2017-10-11_21-32-17
    _hcone_hcone02c406_wave_C.fits already exists - not copied
HH:MM:SS.S - * |cal_extract_RAW_spirou:2a203|Now processing Image TYPE UNKNOWN with
    cal_extract_RAW_spirou recipe
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Reading Image /drs/data/raw/20170710/fp_fp02a203.fits
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Image 2048 x 2048 loaded
```

```
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Doing Dark Correction using /drs/data/calibDB/20170710
    _dark_dark02d406.fits
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Image format changed to 2035x1930
HH:MM:SS.S - * |cal_extract_RAW_spirou:2a203|Nb dead pixels = 568485 / 14.47 %
HH:MM:SS.S - * |cal_extract_RAW_spirou:2a203|Maximum average flux/pixel in the spectrum: 109726.7 [ADU
    ]
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Reading localization parameters of Fiber AB
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203AB|Reading order profile of Fiber AB
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber AB order 0: S/N= 352.4
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber AB order 1: S/N= 398.4
...
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber AB order 34: S/N= 138.8
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber AB order 35: S/N= 47.8
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Saving E2DS spectrum of Fiber AB in fp_fp02a203_e2ds_AB.
    fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Reading localization parameters of Fiber A
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203A|Reading order profile of Fiber A
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber A order 0: S/N= 210.2
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber A order 1: S/N= 237.4
...
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber A order 34: S/N= 114.3
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber A order 35: S/N= 33.8
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Saving E2DS spectrum of Fiber A in fp_fp02a203_e2ds_A.
    fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Reading localization parameters of Fiber B
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203B|Reading order profile of Fiber B
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber B order 0: S/N= 286.8
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber B order 1: S/N= 324.4
...
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber B order 34: S/N= 87.2
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber B order 35: S/N= 36.1
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Saving E2DS spectrum of Fiber B in fp_fp02a203_e2ds_B.
    fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Reading localization parameters of Fiber C
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203C|Reading order profile of Fiber C
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber C order 0: S/N= 376.6
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber C order 1: S/N= 424.3
...
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber C order 34: S/N= 252.7
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|On fiber C order 35: S/N= 130.0
HH:MM:SS.S -   |cal_extract_RAW_spirou:2a203|Saving E2DS spectrum of Fiber C in fp_fp02a203_e2ds_C.
    fits
HH:MM:SS.S - @ |python warning Line 980  warning reads: Card is too long, comment will be truncated.|
HH:MM:SS.S - * |cal_extract_RAW_spirou:2a203|Too much flux in the image (max authorized=65500)
HH:MM:SS.S - * |cal_extract_RAW_spirou:2a203|QUALITY CONTROL SUCCESSFUL - Well Done -
HH:MM:SS.S - * |cal_extract_RAW_spirou:2a203|Recipe cal_extract_RAW_spirou has been successfully
    complted
```

8.7 The cal_DRIFT recipes

There are currently three different drift recipes: cal_DRIFT_RAW_spirou , cal_DRIFT_E2DS_spirou and cal_DRIFTPEAK_E2DS_spirou . The cal_DRIFT_E2DS_spirou and cal_DRIFTPEAK_E2DS_spirou recipes are the primary drift code recipes and cal_DRIFT_RAW_spirou is an older version where spectra are re-extracted.

8.7.1 The inputs

8.7.1.1 cal_DRIFT_E2DS_spirou and cal_DRIFTPEAK_E2DS_spirou

The input of cal_DRIFT_E2DS_spirou and cal_DRIFTPEAK_E2DS_spirou are as follows:

```
>> cal_DRIFT_E2DS_spirou.py night_repository referenece_file
>> cal_DRIFTPEAK_E2DS_spirou.py night_repository referenece_file
```

for example

example

```
>> cal_DRIFT_E2DS_spirou.py 20170710 fp_fp02a203_e2ds_AB.fits
>> cal_DRIFTPEAK_E2DS_Spirou.py 20170710 fp_fp02a203_e2ds_AB.fits
```

or

Python/Ipython

```
import cal_DRIFT_E2DS_spirou
import cal_DRIFTPEAK_E2DS_Spirou
night_repository = '20170710'
reffilename = 'fp_fp02a203_e2ds_AB.fits'
cal_DRIFT_E2DS_spirou.main(night_repository, reffile=reffilename)
cal_DRIFTPEAK_E2DS_Spirou.main(night_repository, reffile=reffilename)
```

where 'night_repository' defines arg_night_name and 'refilename' define the file to use as the reference spectrum. The reference file must be a valid python string and must have the folowing prefixes:

- fp_fp

and must contain the fiber type (i.e. 'AB' or 'A' or 'C').

8.7.1.2 cal_DRIFT_RAW_spirou

The input of cal_DRIFT_RAW_spirou is as follows:

```
>> cal_DRIFT_RAW_spirou.py night_repository files
```

for example

example

```
>> cal_DRIFT_RAW_spirou.py 20170710 fp_fp02a203.fits
```

or

Python/Ipython

```
import cal_DRIFT_RAW_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits']
cal_DRIFT_RAW_spirou.main(night_repository, files=filenames)
```

where 'night_repository' defines arg_night_name and 'filenames' define the list of files in arg_file_names. All files in filenames must be valid python strings separated by a space (command line) or in a line (python) and must have the folowing prefixes:

- fp_fp

Note: cal_DRIFT_RAW_spirou can also take an addition argument. By default it will extract fiber 'AB', but this can be changed if using python by specifying the 'fiber' keyword, for example:

Python/Ipython

```
import cal_DRIFT_RAW_spirou
night_repository = '20170710'
filenames = ['fp_fp02a203.fits']
cal_DRIFT_RAW_spirou.main(night_repository, files=filenames, fiber='A')
```

8.7.2 The outputs

8.7.2.1 cal_DRIFT_E2DS_spirou

The outputs of cal_DRIFT_E2DS_spirou is as follows:

- driftfits_e2ds in form:

  {reduced_dir}/{date prefix}_{file}_drift_{fiber}.fits

- drifttblfilename_e2ds in form:

  {reduced_dir}/{date prefix}_{file}_drift_{fiber}.tbl

where 'date prefix' is constructed from arg_night_name and the file name is the 'reference filename'. for example for reduced_dir `='/drs/data/reduced/20170710'`, `reffile = 'fp_fp02a203_e2ds_AB.fits'` and `fiber='AB'` the output files would be:

- `/drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_drift_AB.fits`
- `/drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_drift_AB.tbl`

8.7.2.2 cal_DRIFTPEAK_E2DS_spirou

The outputs of cal_DRIFTPEAK_E2DS_spirou is as follows:

- driftfits_peak_e2ds in form:

  {reduced_dir}/{date prefix}_{file}_driftnew_{fiber}.fits

- drifttblfilename_peak_e2ds in form:

  {reduced_dir}/{date prefix}_{file}_driftnew_{fiber}.tbl

where 'date prefix' is constructed from arg_night_name and the file name is the 'reference filename'. for example for reduced_dir='/drs/data/reduced/20170710', reffile = 'fp_fp02a203_e2ds_AB.fits' and fiber='AB' the output files would be:

- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_driftnew_AB.fits
- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_driftnew_AB.tbl

8.7.2.3 cal_DRIFT_RAW_spirou

The outputs of cal_DRIFT_RAW_spirou are as follows:

- driftfits_raw in form:

  {reduced_dir}/{date prefix}_{file}_drift_{fiber}.fits

where 'date prefix' is constructed from arg_night_name and the file name is the first file in arg_file_names. for example for reduced_dir='/drs/data/reduced/20170710', arg_file_names=['fp_fp02a203.fits'] and fiber='AB' the output files would be:

- /drs/data/reduced/20170710/fp_fp02a203_e2ds_AB_drift_AB.fits

8.7.3 Summary of procedure

8.7.3.1 cal_DRIFT_E2DS_spirou

1. first file is reference image (must be an E2DS file) extracted using one of the cal_extract_RAW recipes
2. loops around all other '*_e2ds_{fiber}.fits' files in directory
3. calculates photon noise uncertainty and estimated RV uncertainty on spectrum
   - uses wave file
4. calculates RV drift and mean RV drift between reference (mean of files) and other 'fp_fp' files
5. saves drift values to file

8.7.3.2 cal_DRIFTPEAK_E2DS_spirou

1. first file is reference image
2. resizes the image
3. background correction
4. Identifies FP peaks in reference file
5. Creates a reference ascii file that contains the positions of the FP peaks
6. Removes lines with suspicious widths
7. loops around all other '*_e2ds_{fiber}.fits' files

8. Gets the centroid of all peaks using Gaussian fitting
9. Performs a Pearson R test to look for issues with extraction and/or illumination
10. Performs sigma clipping on measured drift
11. Saves drifts to file

8.7.3.3 cal_DRIFT_RAW_spirou

1. first file is reference image
2. resizes the image
3. extracts with weight (no tilt)
4. loops around all other 'fp_fp' files in directory
5. calculates photon noise uncertainty and estimated RV uncertainty on spectrum
    - uses wave file
6. calculates RV drift and mean RV drift between reference (mean of files) and other 'fp_fp' files
7. saves drift values to file

8.8 The cal_CCF recipe

8.9 The validation recipe

This recipe validates that the DRS has be installed correctly and insures that all recipes should run. This is mentioned in Section 3.6.

> **Note:** The validation recipe does not protect against incorrect or missing constants and keywrods. If all constants are defined as they were when installed and if all paths were set up correctly, then running the validation recipe should be enough to confirm that the DRS installed correctly. Again this does not protect against invalid files and other user inputs.

8.9.1 The inputs

cal_validate_spirou requires no input. Thus run the validation as follows:

```
>> cal_validate_spirou.py
```

or

Python/Ipython

```
import cal_validate_spirou
cal_validate_spirou.main()
```

One can also define an optional argument to put the validation recipe into debug mode with:

Python/Ipython

```
import cal_validate_spirou
cal_validate_spirou.main(DEBUG=1)
```

where a value of True or 1 runs the validation script in debugging mode. This lists all sub-module tests that are performed during the validation and thus allows problems to be identified more easily.

8.9.2 The outputs

There are no outputs to cal_validate_spirou other than printing to screen and the log file (see Section 8.9.4).

8.9.3 Summary of procedure

1. checks core module imports:
   - SpirouDRS
   - SpirouDRS.spirouConfig
   - SpirouDRS.spirouCore
2. checks that configuration files can be read
3. checks recipe modules
   - SpirouDRS.spirouBACK
   - SpirouDRS.spirouCDB
   - SpirouDRS.spirouEXTOR
   - SpirouDRS.spirouFLAT

- SpirouDRS.spirouImage
- SpirouDRS.spirouLOCOR
- SpirouDRS.spirouRV
- SpirouDRS.spirouStartup
- SpirouDRS.spirouTHORCA

4. displays and prints the configuration file paths
5. confirms validation of the DRS installation

8.9.4 Example working run

An example run where everything worked is below:

```
>> cal_validate_spirou.py
```

```
 ****************************************
 *        VALIDATING DRS
 ****************************************

1) Running core module tests

2) Running config test

        Testing /drs/INTROOT/config/config.py

               Congraulations all paths in /drs/INTROOT/config/config.py set up correctly.

2) Running sub-module tests

4) Running recipe test

HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   || * SPIROU @(#) Geneva Observatory (VERSION)
HH:MM:SS.S -   || ****************************************
HH:MM:SS.S -   ||(dir_data_raw)      DRS_DATA_RAW=/drs/data/raw
HH:MM:SS.S -   ||(dir_data_reduc)    DRS_DATA_REDUC=/drs/data/reduced
HH:MM:SS.S -   ||(dir_calib_db)      DRS_CALIB_DB=/drs/data/calibDB
HH:MM:SS.S -   ||(dir_data_msg)      DRS_DATA_MSG=/drs/data/msg
HH:MM:SS.S -   ||(print_level)       PRINT_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(log_level)         LOG_LEVEL=all         %(error/warning/info/all)
HH:MM:SS.S -   ||(plot_graph)        DRS_PLOT=1            %(def/undef/trigger)
HH:MM:SS.S -   ||(used_date)         DRS_USED_DATE=undefined
HH:MM:SS.S -   ||(working_dir)       DRS_DATA_WORKING=/drs/data/tmp
HH:MM:SS.S -   ||                    DRS_INTERACTIVE is not set, running on-line mode
HH:MM:SS.S -   ||                    DRS_DEBUG is set, debug mode level:1
HH:MM:SS.S -   ||
HH:MM:SS.S -   ||Validation successful. DRS installed corrected.
```

8.10 The cal_HC recipe

Recipe not yet updated.

8.11 The cal_WAVE recipe

Recipe not yet updated.

8.12 The pol_spirou recipe

Recipe not yet updated.