pandora.lreducer

Lucifer Reduction Pipeline

Cookbook

version 0.1

Marco Fumana
INAF, IASF-Milano

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Introduction

The pandora.lreducer is a data reduction pipeline, designed to carry out the reduction of spectroscopic data acquired with Lucifer the infrared LBT spectro graph.

This pipeline is based on VIPGI[1] recipes modified and customized to reduce near infrared data; data reduction recipes running on FASE[2] framework.

1 Scodeggio, M. et al. PASP, 117: 1284-1295
2 Paioro, L. et al. 2009, ADASS XIX, ASP Conference Series, vol. 434: 349-352

Lreducer: recipe descriptions

AppendBadPixelImage

Append bad pixel image to a file

Usage

```
pandora.lreducer AppendBadPixelImage fileList badPixelImage
```

CreateMasterDark

Recipe used to create the master dark

Usage

```
pandora.lreducer CreateMasterDark darkList msDark
```

Description

From a given set of dark with the same exposure time (`darklist`), you can apply this recipe to create the master dark (`msDark`).

CreateDeadPixelMap

Create a dead pixel map

Usage

```
pandora.lreducer CreateDeadPixelMap frameList deadMap
```

Description

Given a list of imaging flat fields (`frameList`), with the same intensity (i.e. no grism, no mask and same exposure time), this recipe produce a dead pixels map and append it to the `deadMap` file.

CreateHotPixelMap

Create the hot pixels map

Usage

```
pandora.lreducer CreateHotPixelMap darkList hotMap
```

Description

Given a list of dark images (same exposure time), you can create a hot pixels image.

Optional parameters

SIGMA_FACTOR	Threshold to determine hot pixels
LLX	Lower left x border
LLY	Lower left y border
URX	Upper right x border
URY	Upper right y border

CreateNolinearPixelMap

Create the no linear pixel map

Usage

```
pandora.lreducer CreateNolinearPixelMap flatList nolinearMap
```

Description

Given a list of imaging flats (`flatList`) with increasing intensity, this recipe produces a map of no linear pixels and append it to `nolinearMap`.

CreateSphTable

Recipe used to create a sensitivity function.

Usage

```
pandora.lreducer CreateSphTable starReducedFiles\
--SPHTABLE_DIR=outdir
```

Description

This recipe creates a sensitivity function in the `outdir` directory using, or reduced files obtained by `ReduceSpObsSingle` (FCR files), either seq file obtained by `ReduceSpObsSeq`.

In the MOS case you have to cover a lambda range larger than a single slit, so you have to use 2 telluric spectra obtained from different slits: the first spectrum which cover the blu range and the second spectrum which cover the red range. If the reduced file list (`starReducedFiles`) has the same number of: blue spectra on the head and red spectra on the tail, the recipe is able to join them to obtain a global sensitivity function.

Optional parameters

LAMBDA_SPLIT	Lamba value where join red and blu spectra
RED_AS_MASTER	Determine either red or blue spectra must be used as reference level
RED_AND_BLUE	Determine either merge or not spectra (MOS case)

CreateSpMasterFlat

Recipe used to create the master flat.

Usage

```
pandora.lreducer CreateSpMasterFlat flatList msFlat
```

Description

Given a set of flat (`flatList`) which have the same exposure time and the same halo lamp on, you can apply this recipe to create the master flat (`msFlat`).

Master flat is the file used to detect the slit position, correct slit curvatures and perform the pixel to pixel correction.

Optional parameters

MOCK_FF	allow to create a mock flat (the recipe runs faster). This kind of flat is used to detect slit position, but it is not useful to perform the pixel to pixel correction.
EXTRA_PIXELS	change the size of window used to detect slit

CreateSpMasterLamp

Recipe used to create the master lamp.

Usage

```
pandora.lreducer CreateSpMasterLamp lampList msLamp msFlat
```

Description

From a given set of lamp (`lampList`) and a master flat previous created (`msFlat`), you can apply this recipe to create the master Lamp.

Master Lamp is used to calibrate spectra along dispersion direction.

FlatSubtractOff

Recipe used to subtract flat (with lamp) off from flat (with lamp) on

Usage

```
pandora.lreducer FlatSubtractOff flat_on_list flat_off_list
```

Description

Given a list of flat on (`flat_on_list`) and a list of flat off (`flat_off_list`), this recipe produces a list of subtracted on-off flats.

MergeBadPixelMap

Merge previous created images in a global bad pixels image.

Usage

```
pandora.lreducer MergeBadPixelMap badMaps outBadPixelImage
```

PreliminaryReduction

This recipe prepares and cleans images before reduce them.

Usage

```
pandora.lreducer PreliminaryReduction fileList
```

Description

Given a list of scientific frame this recipe performs a set of operation on these files:

- apply master Flat;
- apply master Dark;
- clean cosmic ray;
- clean bad pixel.

Optional Parameters

msFlat	Master flat to apply
msDark	Master dark to apply
CLEAN_BAD_PIX	Remove bad pixels from images
CLEAN_COSMIC	Remove cosmic rays from images

ReduceSpObsSeq

This recipe detects and extracts spectra from scientific frames.

Usage

```
pandora.lreducer ReduceSpObsSeq mosList seqFile msLamp
```

Description

This recipe creates a mono-dimensional extension containing spectra, performing a set of operation on scientific frames already processed by `PreliminaryReduction`:

- correct curvature slit
- extract list and calibrates them in lambda (using `msLamp` input file)
- subtract sky from images
- create EXR2D and SKY2D for each frame

- combine images
- detect and extract spectra
- apply flux calibration or on mono dimensional extension either on combined bidimensional EXR2D extension

Results of these steps are saved in the `seqFile`.

Optional Parameters

SLIT_MARGIN	Excluded pixels at slit ends for object search/sky level determination
DETECTION_LEVEL	Object detection level in units of sigma
MIN_OBJ_SIZE	Minimum size for an object candidate
MAX_OBJ_SIZE	Minimum size for possible object deblending
CALIB_EXR2D	Apply spectro-photometric calibration on EXR2D
OFF_FROM_FILE	Get shifts from “offs.list” file (in pixels)
SLIT_POSITION	Y slit position in trow slit acquisition. Used to compute astrometria in long-slit case
CHECK_DITHER	Check if 2 consecutive images have a shift
SKIP_DAVIES_SUB	Skip davies sky subtraction

ReduceSpObsSingle

This recipe reduces scientific files without combines them.

Usage

```
pandora.lreducer ReduceSpObsSingle mosList msLamp
```

Description

This recipe reduce single frames (`mosList`) without combine them togheter.

Optiona Parameters

SLIT_MARGIN	Excluded pixels at slit ends for object search/sky level determination
DETECTION_LEVEL	Object detection level in units of sigma
MIN_OBJ_SIZE	Minimum size for an object candidate
MAX_OBJ_SIZE	Minimum size for possible object deblending

ShowStats

Show basic statistic information on input files.

Usage

```
pandora.lreducer ShowStats filelist
```

Optional Parameters

hdu Change extension used to compute statistic information

Split1D

This recipe extracts mono-dimensional spectra from reduced SEQ file.

Usage

```
pandora.lreducer Split1D seqFile
```

Description

By this recipe you are able to obtain mono-dimensional fits spectra, splitting the Primary extension.

Optional parameters

EXTENSION Change the extension to split (default is Primary)

SpManualDetect

Recipe used to create a new seq after you have manually modified the window table

Usage

```
pandora.lreducer SpManualDetect modifiedSeqFile newSeqFile msLamp
```

Description

Sometime automatic object detection fails, so you have to manually detect objects on EXR2D modifying the WIN table by hand and then extract again the spectra from the modified seq file (`modifiedSeqFile`).

Once you have modified the window table, the recipe create e new seq file (`newSeqFile`) with newly extracted spectra.

DRS: recipe descriptions

CheckLambdaCal

This recipe checks the quality of a master Lamp

Usage

```
pandora.drs CheckLambdaCal msLamp 0 --output=checkFile -lamp=lamp
```

Description

The recipe checks the quality of a master lamp (`msLamp`) showing useful statistical values.

Basing on line catalog attached to the lamp file (`lamp`), the recipe creates a new file (`checkFile`) which displays expected line position and GRISM table borders on the lamp file image.

Hits: to check first guesses quality you can use a master flat as `msLamp` file.

FirstLambdaCal

Compute IDS model coefficients n_0_0.

Usage

```
pandora.drs FirstLambdaCal inputFile fitOrder lambdaCen
```

Description

Once you have the relation between line positions (in Angstrom) and its positions on image (in pixel), this recipe allow you to compute IDS model coefficients, following the next steps:

- looking over a lamp image, create an ASCII file (`inputFile`) with 2 columns: line pixel positions and lambda values
- from the lambda values in the `inputFile`, pick out a lambda central (`lambdaCen`) wavelength
- set IDS relation order (`fitOrder`)
- run recipe

Values displayed by the recipe are IDS MAT_n_0_0 coefficients.

TraceCurves

Check the master flat quality.

Usage

```
pandora.drs TraceCurves msFlat scientificFrame checkFile
```

Description

This recipe uses master Flat (`msFlat`) extraction table, to plot expected slit position on input image (`scientificFrame`), creating a new image (`checkFile`).

This allow you to check if `msFlat` properly fits the slit profiles.

Data reduction workflow

This chapter shows how to collect in a workflow, the single recipes previous described, in order to reduce Lucifer infrared data.

I. Reduce data of a single night

1. *Create Bad pixel map*

   (a) Create dead pixels map

   ```
   pandora.lreducer CreateDeadPixelMap @dark.list badMaps.fits
   ```

   (b) Create hot pixel map

   ```
   pandora.lreducer CreateHotPixelMap @hot.list badMaps.fits
   ```

   (c) Create no linear pixel map

   ```
   pandora.lreducer CreateNolinearPixelMap @nl.list badMaps.fits
   ```

   (d) Merge bad pixel images

   ```
   pandora.lreducer MergeBadPixelMap badMaps.fits\
   badPixelImage.fits
   ```

2. *Create Master Dark*

   (a) Append bad pixel image to dark frames

   ```
   pandora.lreducer AppendBadPixelImage @file.list\
   badPixelImage.fits
   ```

   (b) Create the Master

   ```
   pandora.lreducer CreateMasterDark @dark_2s.list msDark2s.fits
   pandora.lreducer CreateMasterDark @dark_300s.list\
   msDark300s.fits
   ```

3. *Create Master Flat*

   (a) Subtract flat off from on

   ```
   pandora.lreducer FlatSubtractOff @on.list @off.list
   ```

   (b) Append bad pixel image to newly created flat frames

   ```
   pandora.lreducer AppendBadPixelImage @on_off.list\
   badPixelImage.fits
   ```

   (c) Create the Master

   ```
   pandora.lreducer CreateSpMasterFlat @on_off.list msFlat.fits\ --
   CLEAN_BAD_PIX=True --CLEAN_COSMIC=True --EXTRA_PIXELS=25\ --
   OVERWRITE=True
   ```

   (d) Check the master flat

   ```
   pandora.drs TraceCurves msFlat.fits sc.fits check.fits
   ```

4. *Create Master Lamp (using scientific frame)*

(a) Use a copy of a scientific frame as lamp frame (sky lines)

(b) Append suitable line catalog

```
el
VmAppTable lp_sky.fits line_catalog.fits
pngs
```

(c) Append bad pixel image

```
pandora.lreducer AppendBadPixelImage lp_sky.fits\
badPixelImage.fits
```

(d) Create the Master

```
pandora.lreducer CreateSpMasterLamp lp_sky.fits msLamp.fits\
msFlat.fits --CLEAN_COSMIC=True -OVERWRITE=True
```

(e) Check the master lamp

```
CheckLambdaCal msLamp.fits 0 -output=check.fits\
--lamp=lp_sky.fits
```

5. *Reduce telluric star*

(a) Append bad pixel image

```
pandora.lreducer AppendBadPixelImage @star.list\
badPixelImage.fits
```

(b) Apply preliminary reduction

```
pandora.lreducer PreliminaryReduction @star.list\ --
msFlat=msFlat.fits -CLEAN_BAD_PIX=True\
--CLEAN_COSMIC=False --msDark=msDark2s.fits
```

(c) Create BFR (or SEQ file)

```
pandora.lreducer ReduceSpObsSingle @starDF.list msLamp.fits\
--DETECTION_LEVEL=10 --MAX_OBJ_SIZE=40
```

6. *Create Sensitivity Function*

```
pandora.lreducer CreateSphTable @starDFR.list\
--SPHTABLE_DIR=SphTableDir
```

7. *Reduce Scientific Data*

(a) Append bad pixel image to scientific frame

```
pandora.lreducer AppendBadPixelImage @sc.list\
BadPixelImage.fits
```

(b) Apply preliminary reduction on scientific frame

```
pandora.lreducer PreliminaryReduction @sc.list\
--msFlat=msFlat.fits --CLEAN_BAD_PIX=True -CLEAN_COSMIC=True\
--sDark=msDark300s.fits
```

(c) Create seq file and DFCS files

either EXR2D in counts

```
pandora.lreducer ReduceSpObsSeq @scDFC.list seq.fits\
msLamp.fits -sphotTable=SphTableDir/Tab_HIP40841.fits\
```

```
--APPLY_FLUX_CAL=True
```

or EXR2D in fluxes

```
pandora.lreducer ReduceSpObsSeq @sc_all.list seq.fits \
msLamp. fits --APPLY_FLUX_CAL=True --CALIB_EXR2D=True --
sphotTable=SphTableDir/Tab_HIP40841.fits
```

II. Perform previous point on each observed nights

III. Create a global seq file using DFCS files of each nights

```
pandora.lreducer ReduceSpObsSeq @scAll.list seqAll.fits msLamp.fits
--APPLY_FLUX_CAL=False --CHECK_DITHER=False --2DEX_FLAG=True
```

IV. Detect manually the targets

Find object by hand and modify or add it to the window table:

1. *Edit window table of seq file. If object is added from scratch, set its IFUFIB_NO = -1*
2. *Append CCD table*
3. *Change VIP Status (put it in lower case)*
4. *Run manual detections*

```
pandora.lreducer SpManualDetect seq.fits seq_new.fits msLamp.fits
```

V. Extract mono-dimensional files

```
pandora.lreducer Split1D seq_new.fits
```