ArTéMiS Data Reduction package for IDL

User and Reference Manual

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1) How to use the IDL reduction pipeline for ArTéMiS data

1) Create a project directory.

2) Unzip the Artemis_IDL package in this directory.

It contains 3 directories:

- **apexpro**: contains the IDL procedures.
- **Calib_partemis**: contains the calibration files: calibration_table, flat_field, maps of the good and bad pixels, rcp, information to calibrate the data from V to pW etc.
- **apexdata**: will contain the raw and reduced data, the masks and the source models.

The 'apexdata' directory itself contains 5 subdirectories:

- **basic_xdr**: contains the data calibrated in pW (in xdr IDL format), for each subscan.
- **map_otf_xdr/E-094.C-0001A-2014**: change the name of the subdirectory with your own project name. The directory will contain the reduced data for each subscan in xdr IDL format. If the subdirectory does not exist during the reduction, it will be automatically created.
- **map_otf_fits**: contains the masks, the source models and the reduced maps in fits format.
- **obslogs**: contains the observing logs of your observations.
- **rawdata**: contains the raw data in MBFits format.

3) Download the rawdata from the ESO archive

Copy the files to the 'apexdata/rawdata/' directory.

Convert the files provided by ESO (in 'APEXBOL.2014….fits' format) to a different MBfits format 'APEX-00001-2014-01-01-E-094.B-0001A-2014.fits'. This new name contains the scan number of the observation (00001 in our example). To convert your MBfits files, use thesh script 'arc2orig.sh' provided in the 'apexpro' directory.

Once converted, use the 'unzip_artemis.pro' procedure provided in the 'apexpro' directory to directly extract the MBfits files. In IDL, type:

```
IDL> unzip_artemis, scan_number, work_dir
```

with - **scan_number**: the number of the scan you want to extract
- **work_dir**: the path to the project directory

For each scan, the extraction creates a directory containing the observations (stored in subdirectories '1', '2', etc.) and two fits files 'ARTEMIS350-BEAR1-FEBEPAR.fits' and 'SCAN.fits'. An IDL loop can be used to extract all the scans at once.

4) Save the obslog files in the 'apexdata/obslogs/' directory.

These products contain additional information not included in the data and are provided in the ESO archive. The obslogs are contained in 'Products' (second column of the ESO archive query results).

Build a master obslog file by typing in IDL:

```
IDL> build_apexobslog, log_struct, savefilename=savefilename
```

with - **logstruct**: the IDL structure that will contain the result master obslog
- **savefilename**: optional. By default the 'apexdata/obslogs' directory.

5) In the 'apexpro/' subdirectory, update the configuration file 'obs1_artemis_config'

```
COMMON obs1_configb, work_dir, project_name, calibration_table

work_dir='$home/artemis/'
project_name='E-094.C-0001A-2014'
calibration_table='calibration_table_350_2014'
```

with: - **work_dir**: the project directory
- **project_name**: the project name
- **calibration_table**: the calibration table

The calibration file, located in the 'Calib_partemis/' directory, follows the structure:

scan_number	conversion_factor	goodpix_ima	flatfield	…
00001	1e.4	goodpix_ima_00001.xdr	flat_00000.xdr	…
29000	0.12	goodpix_ima_mars_30227_jun2014.xdr	flat_mars_30227_jun14.xdr	…

…	calibration camera	rcp file	pfov
…	ACQ_130528_160053_HK.fits	rcp_00001.xdr	3.9
…	ACQ_130528_160053_HK.fits	rcp_mars_30227_jun14.xdr	3.87

with:

- **scan_number**: the scan number
- **conversion_factor**: the conversion factor in 10^{-4} pW/Jy/beam
- **goodpix_ima**: a table of integers whose dimensions are equal to the number of detectors.
- **flatfield**: a table of doubles whose dimensions are equal to the number of pixels of the detectors.
- **calibration camera**: a FITS file containing information on the conversion from V to pW : in particular the VL, VH and OFFSET. Two other files are necessary (xdr format), one for the conversion of the keithley output signal in middle points, the other to convert middle points into forward power.
- **rcp file**: information relative to the distortion (right channel position). Contains 2 tables of double numbers: dx_best and dy_best of equal dimensions (number of pixels of the detector). Those are the relative offsets between each pixel in one of the 2 directions of the detector matrix: if there is no distorsion, dx_best is constant whatever the y and dy_best is constant whatever the x.
- **pfov**: pixel size in arcsec.

6) Execute the configuration file.

```
IDL> @obs1_artemis_config
```

7) Basic reduction steps

You can use the 'traite_otf_map_main.pro' procedure to reduce your scans. The result files are stored in xdr format in the 'apexdata/map_otf_xdr/ directory under your project number (‘E-094.C-0001A-2014/' directory in our example)

You can then combine different scans using the ‘combine_otf_map’ procedure.

And finally convert the intermediary or combined structures into a fite file using the ‘make_fits’ procedure. The reduced maps are stored in the 'apexdata/map_otf_fits/ directory.

For instance:

```
IDL> traite_otf_map_main, scan_number= 00001, type = ‘decorrel’, Mysource_00001_str, tau=0.8, /newreduc, /do_rcp

IDL> traite_otf_map_main, scan_number= 00002, type = ' decorrel ', Mysource_00002_str, tau=0.8, /newreduc, /do_rcp

IDL> combine_otf_map, [00001,00002], Mysource_total_str

IDL> make_fits, Mysource_total_str, fileout=’Mysource_tot_str’
```

Here are other examples of how the ArTéMiS pipeline can be used.
A full detail of the procedures are provided in Section 3 and in the Pipeline Design Document:

with type = 'decorrel'

```
IDL> traite_otf_map_main, scan_number=00001, type = 'decorrel', map_
00001_str, tau=1.1
```

with type = 'map'

```
IDL>  traite_otf_map_main,  scan_number=00002,  type  =  'map',
map_00002_str, tau=1.1
```

with a model

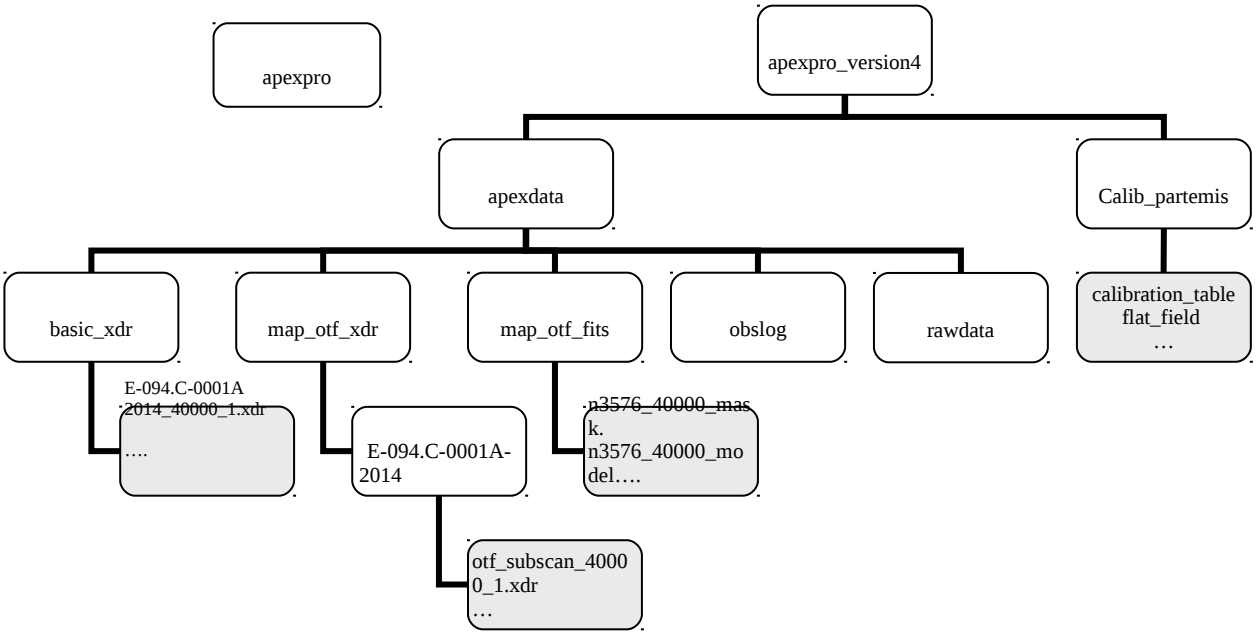
```
IDL> traite_otf_map_main, scan_number= 45000, type = 'decorrel',
mysource_45000_decorrel_str,
champ_base='mysource_mask_base_str.xdr',
model='mysource_model2_str.xdr',
champ_masque='mysource_mask2_str.xdr', tau=1.04, /do_rcp

IDL> traite_otf_map_main, scan_number= 46000, type = 'decorrel',
mysource _46000_decorrel_str,
champ_base='mysource_mask_base_str.xdr',
model='mysource_model2_str.xdr',
champ_masque='mysource_mask2_str.xdr', tau=0.91, /do_rcp

IDL> combine_otf_map, [45000,46000], mysource_combined_rdrift,
/removedrift, /do_rcp
```

2) Pipeline description:

2.1) Structure



2.2) Description of some of the result files

in the ‘basic_xdr’ subdirectory

- E-094.C-0001A-2014_40000_1.xdr: “E-094.C-0001A-2014” is the name of the project, “47213” is the observation number and “1” is the subscan number. The file includes the structure ‘datastr’ which includes the data calibrated in pW and all the other parameters included in the raw MBFITS files. For more information on the MBFITS format, please have a look at Dirk Muders’ « Multi-Beam FITS Raw Data Format » document.

in the ‘map_otf_xdr/E-094.C-0001A-2014/’ subdirectory

- otf_subscan_40000_1.xdr: Those files are located in a subdirectory called with the project name (“E-094.C-0001A-2014” in our example). “40000” is the scan number and “1” the subscan number. These files include “donnees”, “donnees_red”, “donnees_uncal”, “carte_scan” and “subscan_name”

with:

- **donnees_uncal:** structure of the type ‘datastr’ that includes the raw data in pW,
- **donnees:** structure of the type ‘datastr’ that includes the raw data in Jy/beam,
- **donnees_red**: structure of the type ‘datastr’ that includes the reduced data in Jy/beam,
- **carte_scan**: contains the subscan map and its weight map, as well as parameters related to the subscan position,
- **subscan_name**: is the subscan name (string format).

3) Structure and Call syntax of the procedures:

3.1) traite_otf_map_main.pro

Syntax:

```
IDL> traite_otf_map_main, scan_number=, type=, mapradecstr, [tau= , flat=,
dir_dat=, /newreduc, /do_rcp, champ_base= , model= , champ_masque= ,
rmode=, /nopowermap, project=, /med_base, /med_noise_rem]
```

Inputs:

- **scan_number**: scan number (integer or string)
- **type:** data treatment and map-making method: 'DECORREL' (baseline subtraction and correlated median noise subtraction, map-making), 'MAP' (baseline subtraction and map-making) or 'CHMAP' (baseline subtraction, map-making of a 'channel map', namely a map from every pixel)

Optional inputs:

- **tau:** optical opacity of the atmosphere,
- **flat:** use of another flatfield,
- **dir_dat:** data directory if different from the default one,
- **newreduc:** start the reduction or a new reduction when the 'MAP' or 'CHMAP' type are used,
- **do_rcp:** correction of the optical distortions of the matrix,
- **champ_base:** ?
- **model:** source model,
- **champ_masque:** source mask,
- **rmode:** 'TP', 'SAA' or 'EKH'
- **nopowermap:** prevent from calibrating the raw data from V to pW if the data in pW do not exist in pW in 'basic_xdr/'
- **project:** name of the '/apexdata/map_otf_xdr/' directory where the reduced data are stored (name of the project by default),
- **med_base:** median baseline subtraction,
- **med_noise_rem:** median noise subtraction.

Output:

- **mapradecstr:** contains the final map + weight map

Examples:

```
IDL> traite_otf_map_main, scan_number= 40000, type = 'decorrel',
map_decorrel_40000_str, tau=1.1
```

Reduction steps:
- extinction correction and conversion in Jy/beam
- subtraction of the 50 Hz noise
- mask creation
- median baseline subtraction (interpolation by ordre 1 polynoms)
- correlated median noise removal
- map-making

```
IDL> traite_otf_map_main, scan_number= 49020, type = 'map', map_49020_str,
tau=1.1,/newreduc, /do_rcp
```

Reduction steps:
- extinction correction and conversion in Jy/beam
- subtraction of the 50 Hz noise
- mask creation
- median baseline subtraction (interpolation by ordre 1 polynoms)
- map-making using the rcp files, namely taking the optical distortion into account.

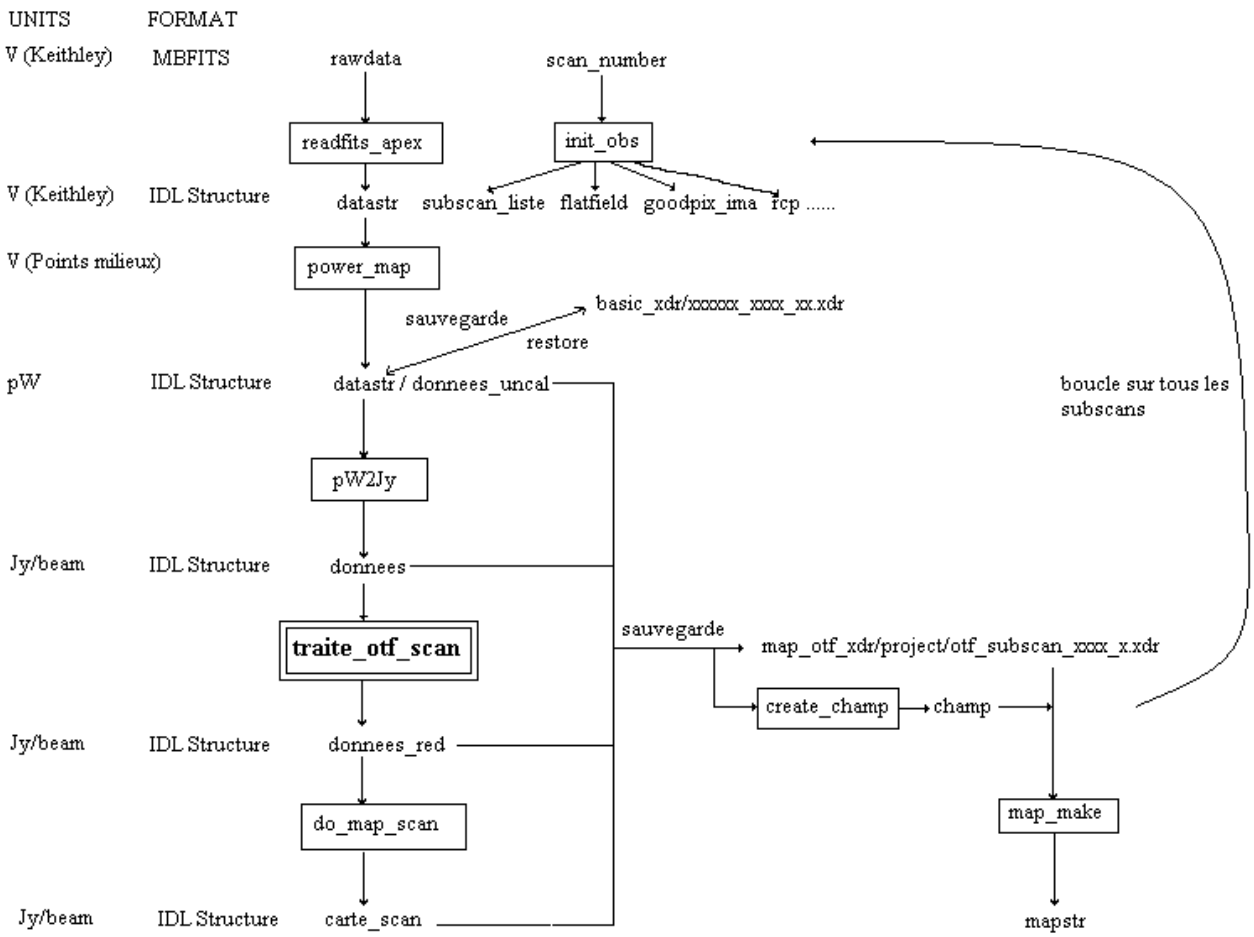
```
IDL> traite_otf_map_main, scan_number= 48973, type = 'decorrel',
s255_48973_decorrel_str, champ_base='s255_mask_base_str.xdr',
model='s255_model_str.xdr', champ_masque='s255_mask_str.xdr',tau=0.825,
/do_rcp
```

Reduction steps:
- extinction correction and conversion in Jy/beam
- subtraction of the 50 Hz noise
- mask creation
- median baseline subtraction (interpolation by ordre 1 polynoms)
- creation of a model cube of the source from the 2D model of the source and the observation
- creation of a model cube of the mask from the 2D model of the mask and the observation
- subtraction of the correlated noise once the source model is subtracted from the data (using the mask),
- new baseline removal
- map-making using the rcp files, namely taking the optical distortion into account.

```
IDL> traite_otf_map_main, scan_number= 50010, type = 'chmap',
map_mars_50010_str, tau=0.8
```

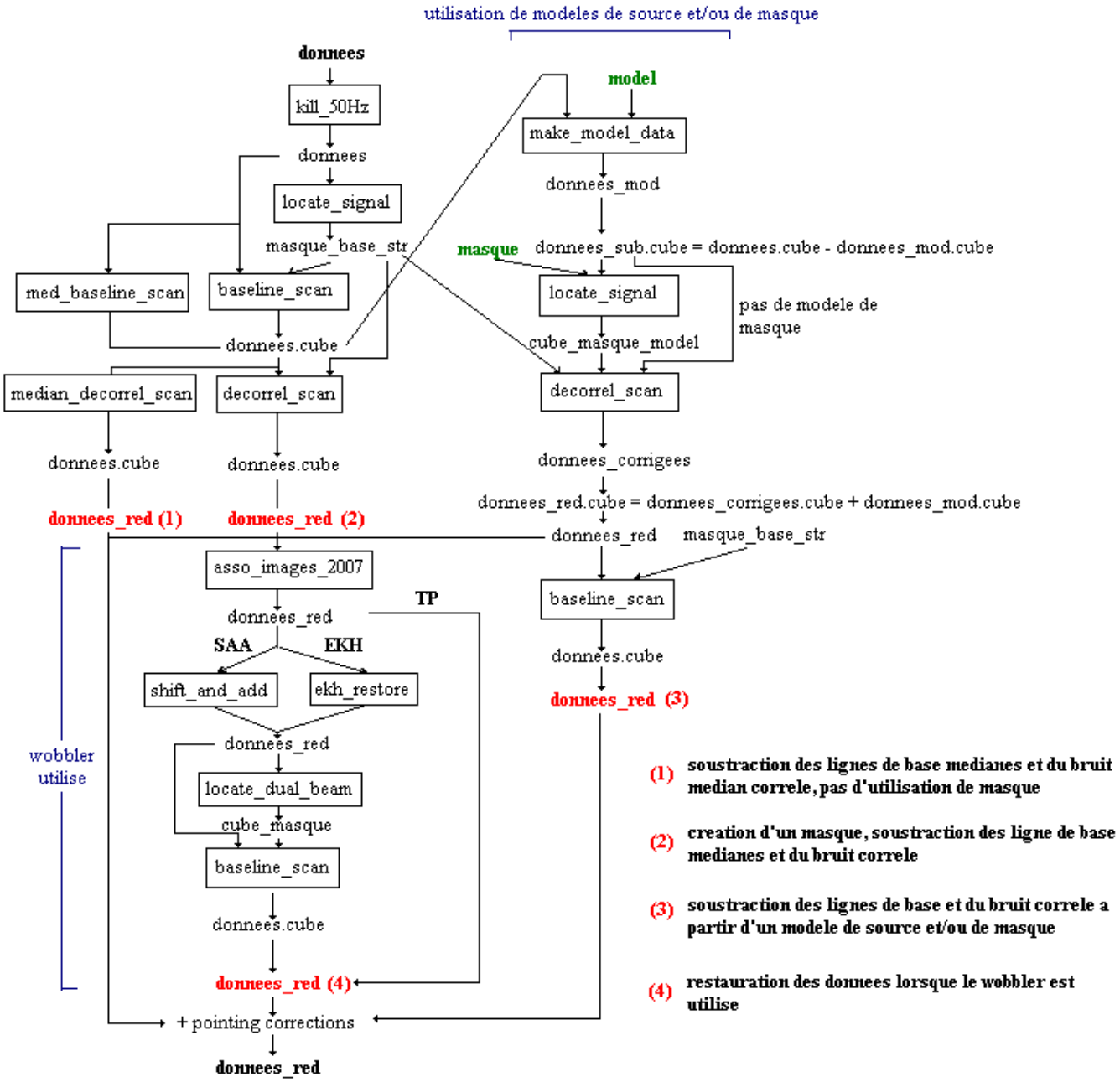
Reduction steps:
- extinction correction and conversion in Jy/beam
- subtraction of the 50 Hz noise
- mask creation
- median baseline subtraction (interpolation by ordre 1 polynoms)
- creation of a map for each pixel

Structure of the procedure:
(most of the reduction happens in “traite_otf_scan.pro” (described later)



3.2) traite_otf_scan.pro

Structure of the procedure:



3.3) combine_otf_map.pro

Syntax:

```
IDL> combine_otf_map, scan_list=, mapradecstr, [/removedrift, /do_rcp, pro-
ject_list=]
```

Inputs:

- **scan_list:** list of the scan numbers to combine (integers or string format)

Optional inputs:

- **removedrift:** routine from the Scanamorphos pipeline (Roussel et al. 2014). Removal of the 1/f non-correlated noise,
- **do_rcp:** correction of the optical distortions of the matrix for the '/removedrift' option,
- **project_list:** name of the '/apexdata/map_otf_xdr/' directory where the reduced data are stored for each scan. By default, all data are stored in the same subdirectory.

Outputs:

- **mapradecstr:** contains the final map + weight map

Examples:

```
IDL> combine_otf_map, [49170,48973], s255_comb_decorrel_str
```

Reduction steps:
- restore the reduced data
- create a combined map with all the scans

```
IDL> combine_otf_map, [48814,48971], ngc2264c_48814_48971_rdrift,
/removedrift,$ /do_rcp
```

Reduction steps:
- restore the reduced data
- remove the non-correlated 1/f noise and save the new data in '/apexdata/map_otf_xdr/otf_subscan_nodrifts_xxxx_x.xdr'
- map-making using the rcp files, namely taking the optical distortion into account.

Structure of the procedure: