AIRSplorer

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1. Description

The AIRSplorer package contains convenience functions usefull to display or characterize ARIEL data.

A majority of tools come from MIRITools, but some functions could have a different behavior, and some other did not exist at the time.

The package is split into sub-packages that I'm going to describe in the next sections. The tools you're most likely to use are in the **plot** subpackage and include quick look functions.

2. How to install

From PyPI (when available):

```
python -m pip install airsplorer
```

Update to latest version of airsplorer

```
python -m pip install  --upgrade airsplorer
```

Or developer install to have easy updates later, **activate the anaconda environment** you want to use airsplorer in, then do:

```
git clone https://github.com/ccossou/airsplorer.git
cd airsplorer
python -m pip install -e .
```

3. Quick Look

3.1. Unified QL interface

The simplest way to run a quick look is to use the CLI tool:

```
> airsql myfile_uncal.fits
```

This tool will find the correct Quick Look, assuming your file is either:

- a bin2fits .fits file
- a ramp file (_uncal, _ramp or any intermediate equivalent)

Below is an example for the 2 available quick look, but in theory, you don't have to do the example code given, calling **airsql** should be enough

3.2. bin2fits quick look

```
import airsplorer

# Use bin2fits folder
#filename =
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG2\CH0\Ref1_Tests_scripts\260427_094316_1013_ifpa_em_ch0"

# Or fits path directly
filename =
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG2\CH0\Ref1_Tests_scripts\260427_094316_1013_ifpa_em_ch0\260427_094316_1013_ifpa_em_ch0_0.fits"

interactive_ramp = airsplorer.gui.ql_super_raw.interactive_super_raw(filename, ypos=1, xpos=1)
```

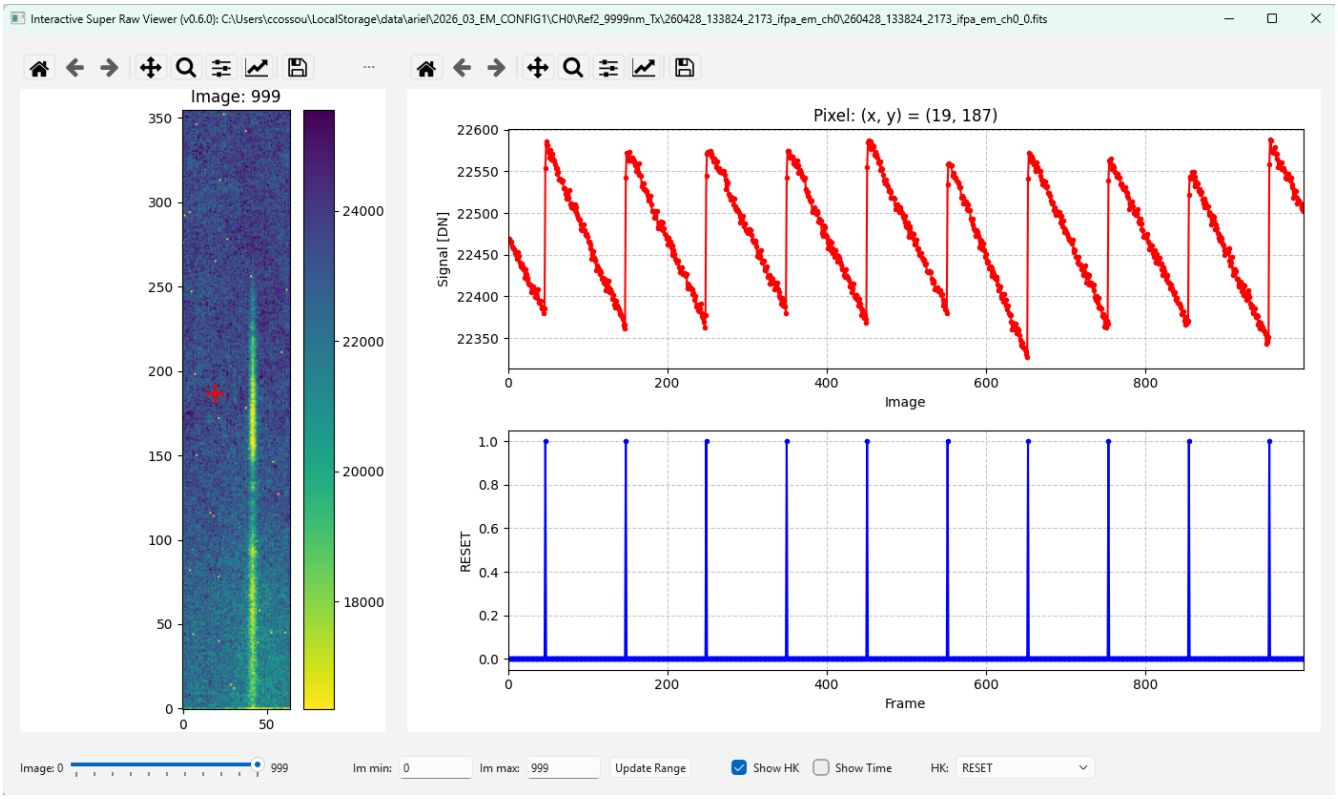


Figure 1. Example of Interactive_super_raw

3.3. uncal/ramp quick look



This documentation is only valid for v0.6.0+ and above. A major change occured in ramp quick look, changing completely how to call it.

```
"""
Using a _ramp .fits, explore the datacube, click on a pixel to see its integration and
correspondant group flags.
Select group and integration to see the corresponding image.
"""
import airsplorer

filename =
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\26041
6_135957_2107_ifpa_em_ch0_ramp.fits"

interactive_ramp = airsplorer.gui.ql_ramp.interactive_ramp(filename)
```

What you can do:

- Open an _uncal or _ramp .fits file. For _uncal, DQ display is not available because the extension do not exist. Any intermediate ramp file from a detector1 step can also be used.
- Choose an integration (by typing the value in the corresponding box)
- choose a pixel (either by clicking on the image or typing its coordinates in the corresponding box)
- Change pixel by using `Ctrl` + `Up/Down/Left/Right`
- display DQ or any HK columns
- Display neigbors by selecting what type of neighbors you want:
  - `None`: No neighbors
  - `-`: left and right neighbors
  - `|`: top and bottom
  - `+`: left, right, top, bottom
  - `x`: north-west, north-east, south-west, south-east
  - `all`: n, s, e, w, ne, nw, se, sw
- use right click on the ramp axis to select 2 points and do a quick flux estimate in DN/s (only works for FUR obviously).



clicking again reset the previous estimate and define new points.

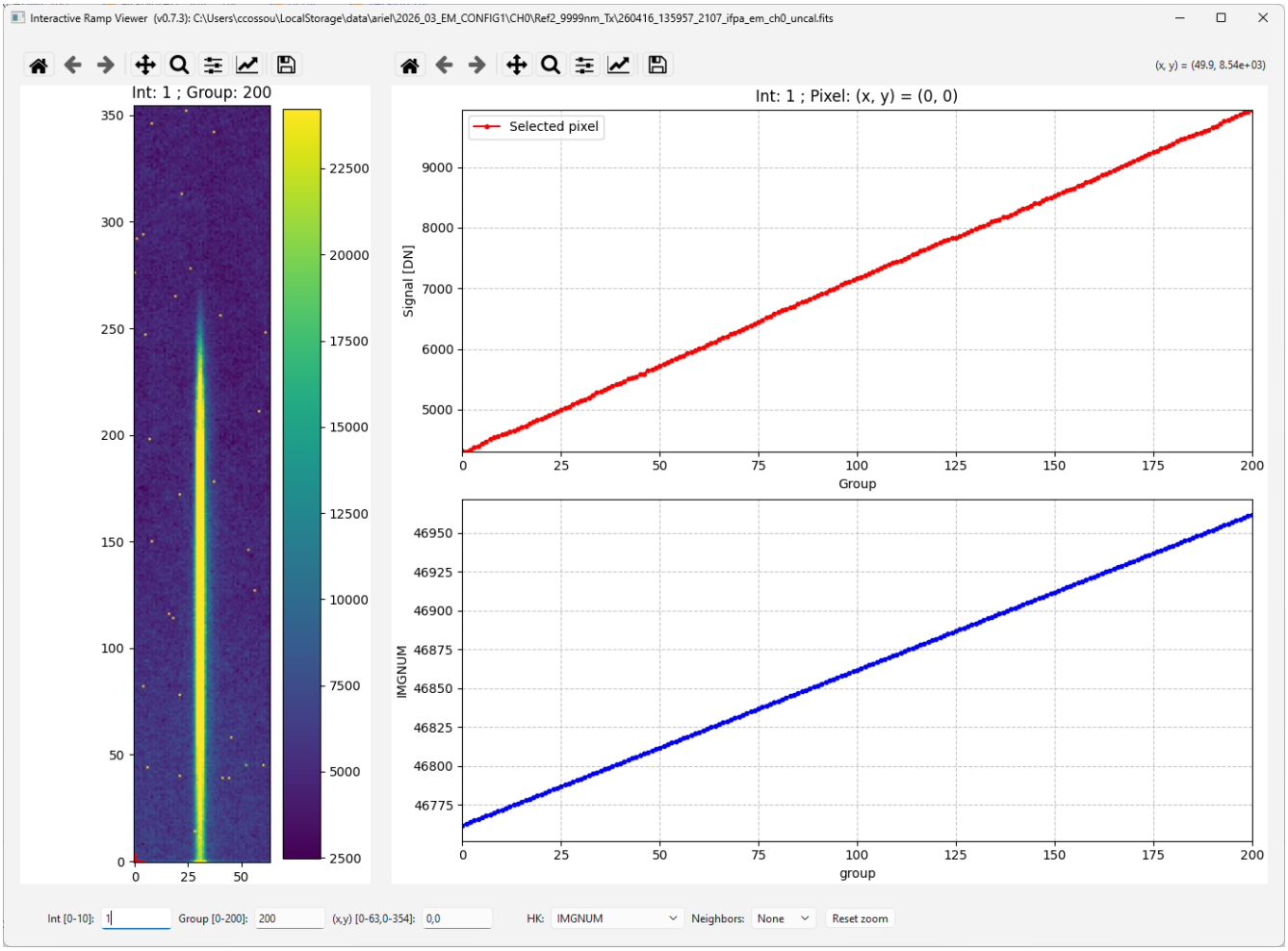


Figure 2. Example of InteractiveRampDQ on an _uncal file

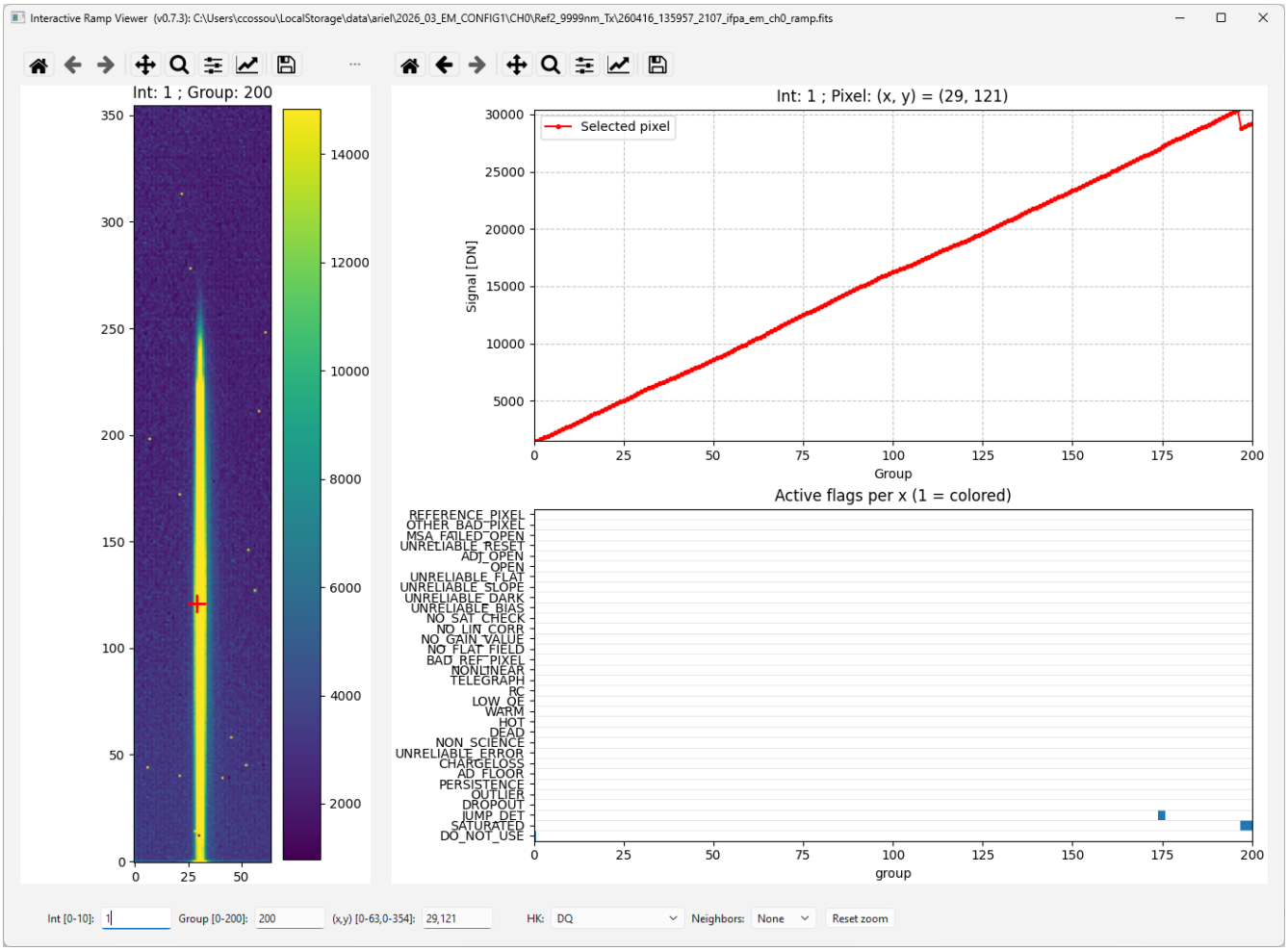


Figure 3. Example of InteractiveRampDQ on a _ramp file. I showed the DQ display, but the HK display is also available for _ramp file.

3.4. Rate Quick Look



CRDS_PATH environment variable need to be defined and point to the folder that host all CDP files. You can add that to .bashrc for instance.

This tool is intended to show a rate image, choose a pixel and display all values from calibration files to help understand an issue with the flux of that pixel. superbias and saturation are shown in the uncal ramp axis to further understand.

In addition, right click on the ramp axis will compute a flux estimate by a crude ramp fit on the 2 consecutive points selected.



The simplest way to use that tool is just to call **airsql** on a fits rate file.

What you can do:

- Open a _rate .fits file.
- Choose an integration (by typing the value in the corresponding box)
- choose a pixel (either by clicking on the image or typing its coordinates in the corresponding box)

- use right click on the calibrated or uncalibrated axis to select 2 points and do a quick flux estimate in DN/s (only works for FUR obviously).



clicking again reset the previous estimate and define new points.

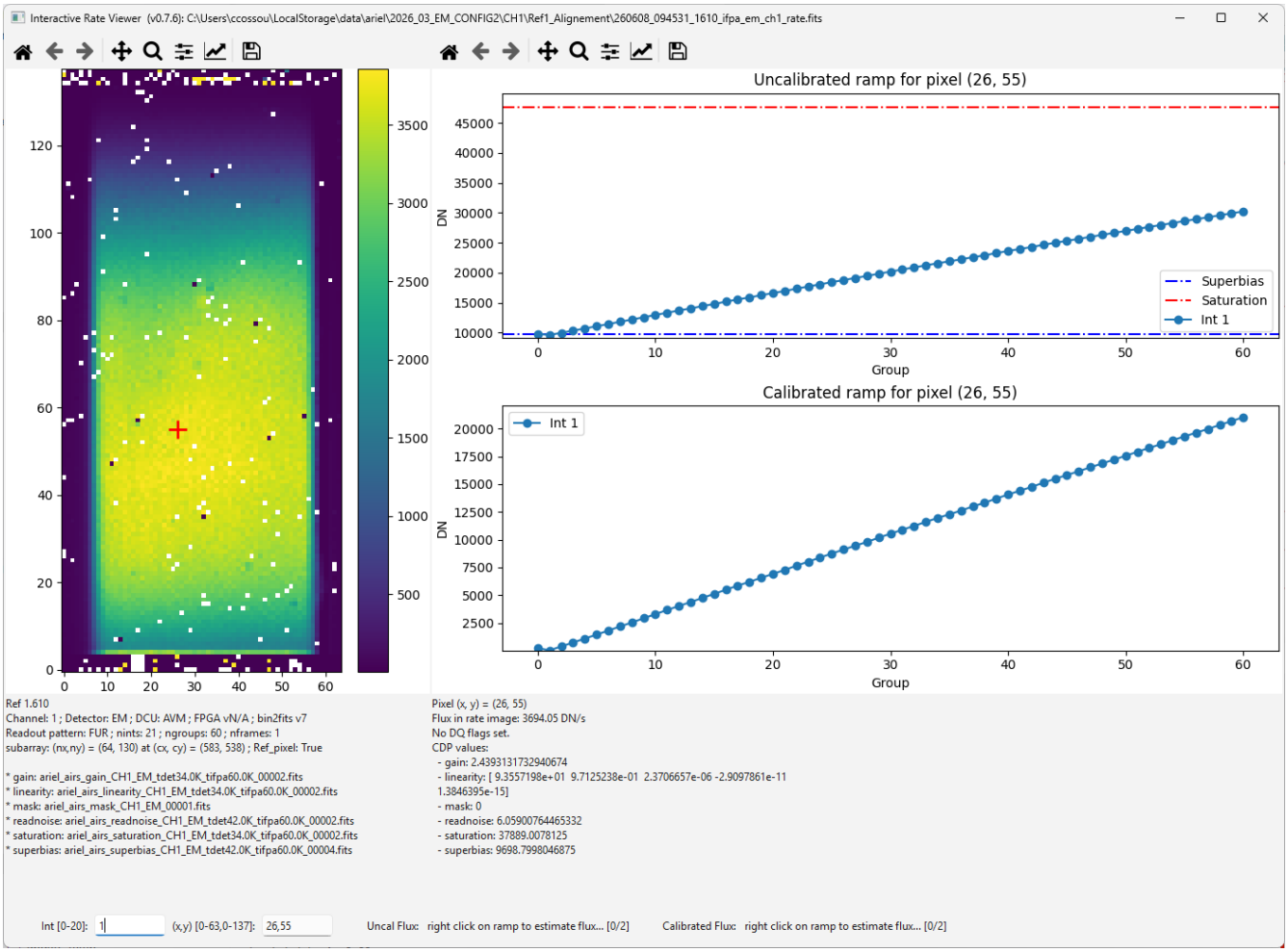


Figure 4. Example of InteractiveRate on a _rate file.

3.5. Compare fits

3.5.1. compare_headers

```
from airsplorer import filediag

files = [
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\archive_processing\260414_220959_4104_ifpa_em_ch1_rate.fits",
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH1\Ref4_background_full_frame\260414_220959_4104_ifpa_em_ch1_rate.fits",
]

# Compare headers
print(filediag.compare_headers(files))
```

Result:

```
Common values:
    B2F_VERS: 7
    BITPIX: 8
    CAMPAIGN: GROUND LIRA
    CATEGORY: 4
    [...]
    VREFCHAI: 1
    VRESET: 0.15
Unique values:
Filename     PIPE_VER    R_GAIN
R_LINEAR                                                        R_SUPERB
-----------  ----------  ------------------------------------------------------------
------------------------------------------------------------------
------------------------------------------------------------------
...old.fits              1.2.5       crds://ariel_airs_gain_CH1_EM_00000.fits
crds://ariel_airs_linearity_CH1_EM_tdet34.0K_tifpa60.0K_00001.fits  crds:
//ariel_airs_superbias_CH1_EM_tdet42.0K_tifpa60.0K_00002.fits
...new.fits  1.3.1       crds://ariel_airs_gain_CH1_EM_tdet34.0K_tifpa60.0K_00002.fits
crds://ariel_airs_linearity_CH1_EM_tdet34.0K_tifpa60.0K_00002.fits  crds:
//ariel_airs_superbias_CH1_EM_tdet42.0K_tifpa60.0K_00003.fits
```

3.5.2. pixel value in multiple images

```
from airsplorer import comp, filediag

files = [
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\26041
4_125643_2029_ifpa_em_ch0_ramp.fits",
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\26041
4_125052_2028_ifpa_em_ch0_ramp.fits",
]

# Compare values of multiple files at the same slice
comp.compare_values(files, extension=1, slice=(1,0, 40, 6))

plt.show()
```

Result for 2nd integration, and first frame, of pixel (y,x) = (40,6):

```
260414_125643_2029_ifpa_em_ch0_ramp.fits: 1609.73583984375
260414_125052_2028_ifpa_em_ch0_ramp.fits: 1667.87646484375
```

3.5.3. Multiple images

```
import astropy.io.fits as fits
import matplotlib.pyplot as plt
from airsplorer import comp, filediag

files = [
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\260414_125643_2029_ifpa_em_ch0_rate.fits",
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\260414_125052_2028_ifpa_em_ch0_rate.fits",
]

# Compare rates
comp.compare_fits(files, titles=['2029', '2028'])

# Or DQ image
# comp.compare_fits(files, titles=['2029', '2028'], ext=2)

plt.show()
```

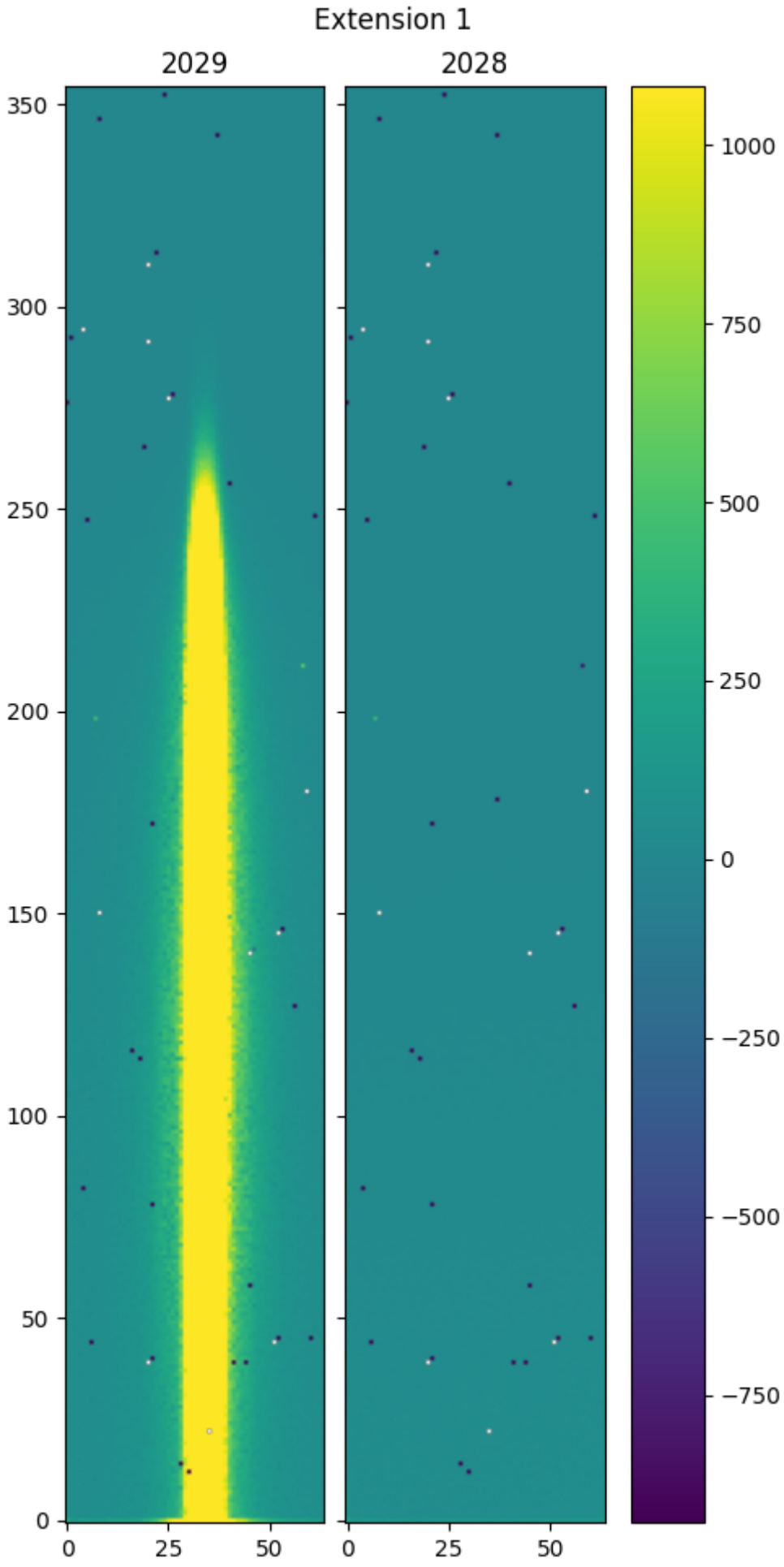


Figure 5. Example of image comparison (same zoom and vrange)

3.5.4. one group image of multiple ramps files

```
import astropy.io.fits as fits
import matplotlib.pyplot as plt
from airsplorer import comp, filediag

files = [
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\260414_125643_2029_ifpa_em_ch0_ramp.fits",
r"C:\Users\ccossou\LocalStorage\data\ariel\2026_03_EM_CONFIG1\CH0\Ref2_9999nm_Tx\260414_125052_2028_ifpa_em_ch0_ramp.fits",
]

# Compare rates
comp.compare_fits(files, titles=['2029', '2028'], slice=(1,10))

plt.show()
```

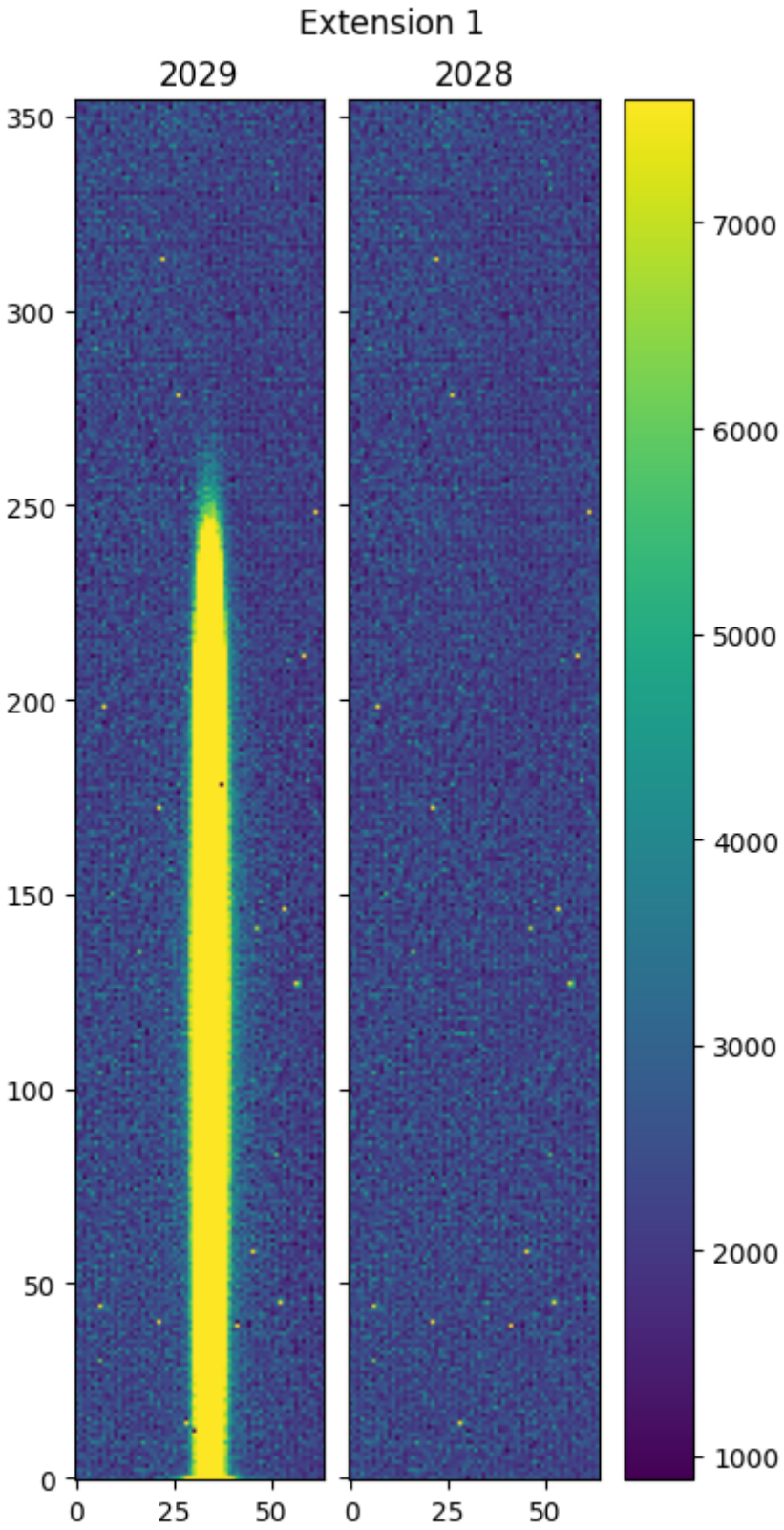


Figure 6. Example of image comparison (same zoom and vrange)

3.5.5. inspect_datamodel_schema

you need to have airspipe installed for that, but this utility allow for datamodel inspection and quickly find all available metadata in it.

```
from airsplorer import filediag
from airspipe.datamodels import datamodels
```

```
dm = datamodels.open("filename.fits")

print(filediag.inspect_datamodel_schema(dm))
```

Example output:

```
Keyword                                  fits_keyword    type     title
---------------------------------------  --------------  -------
-------------------------------------------------------------------------------
----------------------
meta.date                                DATE            string   UTC date file
created
meta.origin                              ORIGIN          string   Organization
responsible for creating file
meta.time_sys                            TIMESYS         string   principal time
system for time-related keywords
meta.time_unit                           TIMEUNIT        string   Default unit
applicable to all time values
meta.filename                            FILENAME        string   Name of the file
meta.data_processing_software_version    SDP_VER         string   Data processing
software version number
meta.prd_software_version                PRD_VER         string   S&OC PRD version
number used in data processing
meta.oss_software_version                OSS_VER         string   Observatory
Scheduling Software (OSS) version number
meta.airspipe_software_version           PIPE_VER        string   AIRSPipe version
meta.bin2fits_version                    B2F_VERS        string   BIN2FITS version
meta.calibration_software_revision       CAL_VCS         string   Calibration software
version control sys number
meta.model_type                          DATAMODL        string   Type of data model
meta.telescope                           TELESCOP        string   Telescope used to
acquire the data
meta.hga_move                            HGA_MOVE        boolean  High Gain Antenna
moved during data collection
meta.hga_start_time                      HGA_STRT        string   Start time of HGA
motion
meta.hga_stop_time                       HGA_STOP        string   Stop time of HGA
motion
meta.pwfseet                             PWFSEET         number   Previous WFS
exposure end time
meta.nwfsest                             NWFSEST         number   Next WFS exposure
start time
meta.compress                            COMPRESS        boolean  On-board data
compression was used (T/F)
meta.asn.pool_name                       ASNPOOL         string   Name of the ASN pool
meta.asn.table_name                      ASNTABLE        string   Name of the ASN
table
meta.program.title                       TITLE           string   Test title
meta.program.pi_name                     PI_NAME         string   Principal
```

```
investigator name
meta.program.campaign                   CAMPAIGN        string   Test campaign
meta.program.category                   CATEGORY        string   Test category
meta.program.sub_category               SUBCAT          string   Test sub-category
meta.program.science_category           SCICAT          string   Science category
assigned during TAC process
meta.program.continuation_id            CONT_ID         integer  Continuation of
previous program
meta.observation.date                   DATE-OBS        string   [yyyy-mm-dd] UTC
date at start of exposure
meta.observation.time                   TIME-OBS        string   [hh:mm:ss.sss] UTC
time at start of exposure
meta.observation.date_beg               DATE-BEG        string   Date-time start of
exposure
meta.observation.date_end               DATE-END        string   Date-time end of
exposure
meta.observation.obs_id                 OBS_ID          string   Programmatic
observation identifier
meta.observation.visit_id               VISIT_ID        string   Visit identifier
meta.observation.program_number         PROGRAM         string   Program number
meta.observation.observation_number     OBSERVTN        string   Observation number
meta.observation.visit_number           VISIT           string   Visit number
meta.observation.visit_group            VISITGRP        string   Visit group
identifier
meta.observation.sequence_id            SEQ_ID          string   Parallel sequence
identifier
meta.observation.activity_id            ACT_ID          string   Activity identifier
meta.observation.exposure_number        EXPOSURE        string   Exposure request
number
meta.observation.bkgdtarg               BKGDTARG        boolean  Background target
meta.observation.template               TEMPLATE        string   Observation template
used
meta.observation.observation_label      OBSLABEL        string   Proposer label for
the observation
meta.observation.observation_folder     OBSFOLDR        string   Name of the APT
observation folder
meta.visit.engineering_quality          ENG_QUAL        string   Engineering data
quality indicator from EngDB
meta.visit.engdb_pointing_quality       ENGQLPTG        string   Quality of pointing
information from EngDB
meta.visit.type                         VISITYPE        string   Visit type
meta.visit.start_time                   VSTSTART        string   UTC visit start time
meta.visit.status                       VISITSTA        string   Status of a visit
meta.visit.total_exposures              NEXPOSUR        integer  Total number of
planned exposures in visit
meta.visit.internal_target              INTARGET        boolean  At least one
exposure in visit is internal
meta.visit.too_visit                    TARGOOPP        boolean  Visit scheduled as
target of opportunity
meta.visit.tsovisit                     TSOVISIT        boolean  Time Series
Observation visit indicator
```

```
meta.visit.exp_only                    EXP_ONLY       boolean  Special commanding
without SI configuration
meta.visit.crowded_field               CROWDFLD       boolean  Are the FGSes in a
crowded field?
meta.target.proposer_name              TARGPROP       string   Proposer's name for
the target
meta.target.catalog_name               TARGNAME       string   Standard
astronomical catalog name for target
meta.target.type                       TARGTYPE       string   Type of target
(fixed, moving, generic)
meta.target.ra                         TARG_RA        number   Target RA at mid
time of exposure
meta.target.dec                        TARG_DEC       number   Target Dec at mid
time of exposure
meta.target.ra_uncertainty             TARGURA        number   Target RA
uncertainty
meta.target.dec_uncertainty            TARGUDEC       number   Target Dec
uncertainty
meta.target.proper_motion_ra           MU_RA          number   Target proper motion
in RA
meta.target.proper_motion_dec          MU_DEC         number   Target proper motion
in Dec
meta.target.proper_motion_epoch        MU_EPOCH       string   Target proper motion
epoch
meta.target.proposer_ra                PROP_RA        number   Proposer's target RA
meta.target.proposer_dec               PROP_DEC       number   Proposer's target
Dec
meta.target.source_type_apt            SRCTYAPT       string   Source type from APT
(point/extended)
meta.target.source_type                SRCTYPE        string   Source type used for
calibration
meta.instrument.name                   INSTRUME       string   Instrument used to
acquire the data
meta.instrument.detector               DETECTOR       string   Name of detector
used to acquire the data
meta.instrument.dcu_version            DCUVERS        string   Version of the DCU
meta.instrument.channel                CHANNEL        string   Instrument channel
meta.instrument.detector_temperature   DET_TEMP       number   Detector temperature
(in K)
meta.instrument.ifpa_temperature       FPA_TEMP       number   iFPA Temperature (in
K)
meta.instrument.focus_position         FOCUSPOS       number   Focus position
meta.instrument.pre_image_id           PREIMAGE       string   Pre-image ID from
PPS DB
meta.instrument.lamp_state             LAMP           string   Internal lamp state
meta.instrument.lamp_mode              OPMODE         string   Lamp operating mode
meta.exposure.count                    EXPCOUNT       integer  Running count of
exposures in visit
meta.exposure.prime_parallel           EXPRIPAR       string   Prime or parallel
exposure
meta.exposure.type                     EXP_TYPE       string   Type of data in the
```

```
exposure
meta.exposure.start_time                EXPSTART        number   [d] exposure start
time in MJD
meta.exposure.start_time_mjd            MJD-BEG         number   [d] exposure start
time in MJD
meta.exposure.mid_time                  EXPMID          number   [d] exposure mid
time in MJD
meta.exposure.mid_time_mjd              MJD-AVG         number   [d] exposure mid-
point in MJD
meta.exposure.end_time                  EXPEND          number   [d] exposure end
time in MJD
meta.exposure.end_time_mjd              MJD-END         number   [d] exposure end
time in MJD
meta.exposure.start_time_tdb            TDB-BEG         number   [d] TDB time of
exposure start in MJD
meta.exposure.mid_time_tdb              TDB-MID         number   [d] TDB time of
exposure mid-point in MJD
meta.exposure.end_time_tdb              TDB-END         number   [d] TDB time of
exposure end in MJD
meta.exposure.start_time_eng            EXPSTENG        string   UTC exposure start
time from engineering data
meta.exposure.osf_file                  OSF_FILE        string   Observatory Status
File name covering this exposure
meta.exposure.readpatt                  READPATT        string   Readout pattern
meta.exposure.reset_type                RES_TYPE        string   Reset Type
meta.exposure.segment_number            EXSEGNUM        integer  Sequential segment
number
meta.exposure.segment_total             EXSEGTOT        integer  Total number of
segments
meta.exposure.noutputs                  NOUTPUTS        integer  Number of detector
outputs used
meta.exposure.nints                     NINTS           integer  Number of
integrations in exposure
meta.exposure.integration_start         INTSTART        integer  Segment first
integration (0-indexed)
meta.exposure.integration_end           INTEND          integer  Segment last
integration (0-indexed)
meta.exposure.partial_start             PARTSTRT        integer  First real group in
first int. [0-ind]
meta.exposure.partial_stop              PARTSTOP        integer  Last real group in
last int. [0-ind]
meta.exposure.ngroups                   NGROUPS         integer  Number of groups in
integration
meta.exposure.nframes                   NFRAMES         integer  Number of frames per
group
meta.exposure.detmode                   DETMODE         string   Detector mode
indicator
meta.exposure.cmd_tsel                  CMD_TSEL        string   Test pattern
selection
meta.exposure.frame_divisor             FRMDIVSR        integer  Divisor applied to
frame-averaged groups
```

```
meta.exposure.groupgap                  GROUPGAP        integer  Number of frames
dropped at beginning of groups
meta.exposure.drop_frames1              DRPFRMS1        integer  Frames dropped prior
to first integration
meta.exposure.drop_frames3              DRPFRMS3        integer  Frames dropped
between integrations
meta.exposure.nsamples                  NSAMPLES        integer  Number of A/D
samples per pixel
meta.exposure.t_pause                   TPAUSE          number   [s] Pause duration
added in the timing of the chronograms to increase integration time. (only for
resetread)
meta.exposure.group_averaged            AVERAGED        boolean  if frames in a group
are averaged or not
meta.exposure.sample_time               TSAMPLE         number   [us] Time between
samples
meta.exposure.frame_time                TFRAME          number   [s] Time between
frames
meta.exposure.group_time                TGROUP          number   [s] Time between
groups
meta.exposure.integration_time          EFFINTTM        number   [s] Effective
integration time
meta.exposure.exposure_time             EFFEXPTM        number   [s] Effective
exposure time
meta.exposure.effective_exposure_time   XPOSURE         number   [s] Effective
exposure time
meta.exposure.duration                  DURATION        number   [s] Total duration
of exposure
meta.exposure.elapsed_exposure_time     TELAPSE         number   [s] Total elapsed
exposure time
meta.exposure.nresets_at_start          NRSTSTRT        integer  Number of resets at
start of exposure
meta.exposure.nresets_between_ints      NRESETS         integer  Number of resets
between integrations
meta.exposure.zero_frame                ZEROFRAM        boolean  Zero frame was
downlinked separately
meta.exposure.data_problem              DATAPROB        boolean  Science telemetry
indicated a problem
meta.exposure.sca_num                   SCA_NUM         integer  Sensor Chip Assembly
number
meta.exposure.datamode                  DATAMODE        integer  post-processing
method used in FPAP
meta.exposure.nrs_normal                NRS_NORM        integer  Number of normal
pixels in IRS2 readout
meta.exposure.nrs_reference             NRS_REF         integer  Number of reference
pixels in IRS2 readout
meta.exposure.clock_adjust_rate         SCTARATE        number   [ms/s] Spacecraft
Clock Time Adjust RATE
meta.exposure.gain_factor               GAINFACT        number   Gain scale factor
meta.exposure.imprint                   IS_IMPRT        boolean  NIRSpec imprint
exposure
meta.exposure.psf_reference             IS_PSF          boolean  exposure is PSF
```

```
reference
meta.exposure.self_reference_survey      SELFREF         boolean  self-referencing PSF
meta.subarray.name                       SUBARRAY        string   Subarray used
meta.subarray.xstart                     SUBSTRT1        integer  Starting pixel in
axis 1 direction (1-indexed)
meta.subarray.ystart                     SUBSTRT2        integer  Starting pixel in
axis 2 direction (1-indexed)
meta.subarray.xsize                      SUBSIZE1        integer  Number of pixels in
axis 1 direction
meta.subarray.ysize                      SUBSIZE2        integer  Number of pixels in
axis 2 direction
meta.subarray.fastaxis                   FASTAXIS        integer  Fast readout axis
direction
meta.subarray.slowaxis                   SLOWAXIS        integer  Slow readout axis
direction
meta.subarray.ref_pixel                  REFPIXEL        boolean  if refpix windows
read (top/bottom)
meta.subarray.detxcor                    DETXCOR         integer  Starting pixel in
detector x-axis direction
meta.subarray.detycor                    DETYCOR         integer  Starting pixel in
detector y-axis direction
meta.subarray.detxsiz                    DETXSIZ         integer  Number of pixels in
detector x-axis direction
meta.subarray.detysiz                    DETYSIZ         integer  Number of pixels in
detector y-axis direction
meta.ephemeris.reference_frame           REFFRAME        string   Ephemeris reference
frame
meta.ephemeris.type                      EPH_TYPE        string   Definitive or
Predicted
meta.ephemeris.time                      EPH_TIME        number   [d] MJD time of
position and velocity vectors
meta.ephemeris.spatial_x_bary            JWST_X          number   [km] barycentric
JWST X coordinate at MJD_AVG
meta.ephemeris.spatial_y_bary            JWST_Y          number   [km] barycentric
JWST Y coordinate at MJD_AVG
meta.ephemeris.spatial_z_bary            JWST_Z          number   [km] barycentric
JWST Z coordinate at MJD_AVG
meta.ephemeris.spatial_x_geo             OBSGEO-X        number   [m] geocentric JWST
X coordinate at MJD_AVG
meta.ephemeris.spatial_y_geo             OBSGEO-Y        number   [m] geocentric JWST
Y coordinate at MJD_AVG
meta.ephemeris.spatial_z_geo             OBSGEO-Z        number   [m] geocentric JWST
Z coordinate at MJD_AVG
meta.ephemeris.velocity_x_bary           JWST_DX         number   [km/s] barycentric
JWST X velocity at MJD_AVG
meta.ephemeris.velocity_y_bary           JWST_DY         number   [km/s] barycentric
JWST Y velocity at MJD_AVG
meta.ephemeris.velocity_z_bary           JWST_DZ         number   [km/s] barycentric
JWST Z velocity at MJD_AVG
meta.ephemeris.velocity_x_geo            OBSGEODX        number   [m/s] geocentric
JWST X velocity at MJD_AVG
```

```
meta.ephemeris.velocity_y_geo           OBSGEODY        number   [m/s] geocentric
JWST Y velocity at MJD_AVG
meta.ephemeris.velocity_z_geo           OBSGEODZ        number   [m/s] geocentric
JWST Z velocity at MJD_AVG
meta.aperture.name                      APERNAME        string   PRD science aperture
used
meta.aperture.pps_name                  PPS_APER        string   original AperName
supplied by PPS
meta.aperture.position_angle            PA_APER         number   [deg] Position angle
of aperture used
meta.velocity_aberration.va_ra_ref      VA_RA           number   [deg] Velocity
aberrated apparent reference RA
meta.velocity_aberration.va_dec_ref     VA_DEC          number   [deg] Velocity
aberrated apparent reference Dec
meta.velocity_aberration.scale_factor   VA_SCALE        number   Velocity aberration
scale factor
meta.time.barycentric_correction        BARTDELT        number   Barycentric time
correction
meta.time.barycentric_expstart          BSTRTIME        number   [d] Barycentric
exposure start time in MJD
meta.time.barycentric_expend            BENDTIME        number   [d] Barycentric
exposure end time in MJD
meta.time.barycentric_expmid            BMIDTIME        number   [d] Barycentric
exposure mid time in MJD
meta.time.heliocentric_correction       HELIDELT        number   Heliocentric time
correction
meta.time.heliocentric_expstart         HSTRTIME        number   [d] Heliocentric
exposure start time in MJD
meta.time.heliocentric_expend           HENDTIME        number   [d] Heliocentric
exposure end time in MJD
meta.time.heliocentric_expmid           HMIDTIME        number   [d] Heliocentric
exposure mid time in MJD
meta.guidestar.gs_order                 GS_ORDER        integer  index of guide star
within list of selected guide stars
meta.guidestar.gs_start_time            GSSTRTTM        string   UTC time when guide
star activity started
meta.guidestar.gs_stop_time             GSENDTIM        string   UTC time when guide
star activity completed
meta.guidestar.gs_id                    GDSTARID        string   guide star
identifier
meta.guidestar.gs_ra                    GS_RA           number   guide star right
ascension
meta.guidestar.gs_dec                   GS_DEC          number   guide star
declination
meta.guidestar.gs_ura                   GS_URA          number   guide star right
ascension uncertainty
meta.guidestar.gs_udec                  GS_UDEC         number   guide star
declination uncertainty
meta.guidestar.gs_mag                   GS_MAG          number   guide star magnitude
in FGS detector
meta.guidestar.gs_umag                  GS_UMAG         number   guide star magnitude
```

```
uncertainty
meta.guidestar.gs_v3_pa_science          GS_V3_PA        number   V3 Position Angle of
guide star for science
meta.guidestar.gs_pcs_mode               PCS_MODE        string   Pointing Control
System mode
meta.guidestar.visit_end_time            VISITEND        string   Observatory UTC time
when the visit completed
meta.guidestar.gs_function_start_time    GF_START        string   Observatory UTC time
at guider function start
meta.guidestar.gs_function_end_time      GF_END          string   Observatory UTC time
at guider function end
meta.guidestar.data_start                DATASTRT        number   MJD start time of
guider data within this file
meta.guidestar.data_end                  DATAEND         number   MJD end time of
guider data within this file
meta.guidestar.gs_acq_exec_stat          GSACSTAT        string   Guide star
acquisition execution status
meta.guidestar.gs_ctd_x                  GSCENTX         number   [arcsec] guide star
centroid x position in FGS ideal frame
meta.guidestar.gs_ctd_y                  GSCENTY         number   [arcsec] guide star
centroid y position in FGS ideal frame
meta.guidestar.gs_epoch                  GS_EPOCH        string   Epoch of guide star
coordinates
meta.guidestar.gs_mura                   GS_MURA         number   Guide star IRCS
right ascension proper motion
meta.guidestar.gs_mudec                  GS_MUDEC        number   Guide star IRCS
declination proper motion
meta.guidestar.gs_para                   GS_PARA         number   Guide star annual
parallax
meta.ref_file.area.name                  R_AREA          string   Pixel area reference
file name
meta.ref_file.badshutter.name            R_MSAOPE        string   NIRSpec operability
reference file name
meta.ref_file.barshadow.name             R_BARSHA        string   Nirspec Barshadow
reference file name
meta.ref_file.camera.name                R_CAMERA        string   Nirspec Camera
reference file name
meta.ref_file.collimator.name            R_COLLIM        string   Nirspec Collimator
reference file name
meta.ref_file.cubepar.name               R_CUBPAR        string   IFU cube parameters
reference file name
meta.ref_file.dark.name                  R_DARK          string   Dark reference file
name
meta.ref_file.disperser.name             R_DISPER        string   Disperser reference
file name
meta.ref_file.distortion.name            R_DISTOR        string   Distortion reference
file name
meta.ref_file.drizpars.name              R_DRZPAR        string   Drizzle parameters
reference file name
meta.ref_file.extract1d.name             R_EXTR1D        string   1-D extraction
parameters reference file name
```

```
meta.ref_file.filteroffset.name          R_FILOFF        string   Filter Offset
reference file name
meta.ref_file.flat.name                  R_FLAT          string   Flat reference file
name
meta.ref_file.dflat.name                 R_DFLAT         string   DFlat reference file
name
meta.ref_file.fflat.name                 R_FFLAT         string   FFlat reference file
name
meta.ref_file.sflat.name                 R_SFLAT         string   SFlat reference file
name
meta.ref_file.fore.name                  R_FORE          string   Nirspec FORE Model
reference file name
meta.ref_file.fpa.name                   R_FPA           string   Nirspec FPA Model
reference file name
meta.ref_file.fringe.name                R_FRINGE        string   Fringe reference
file name
meta.ref_file.fringefreq.name            R_FRIFRQ        string   Fringe Frequency
reference file name
meta.ref_file.gain.name                  R_GAIN          string   Gain reference file
name
meta.ref_file.ifufore.name               R_IFUFOR        string   ifufore reference
file name
meta.ref_file.ifupost.name               R_IFUPOS        string   ifupost reference
file name
meta.ref_file.ifuslicer.name             R_IFUSLI        string   ifuslicer reference
file name
meta.ref_file.ipc.name                   R_IPC           string   IPC reference file
name
meta.ref_file.lastframe.name             R_LASTFR        string   Last Frame reference
file name
meta.ref_file.linearity.name             R_LINEAR        string   Linearity reference
file name
meta.ref_file.mask.name                  R_MASK          string   Mask reference file
name
meta.ref_file.msa.name                   R_MSA           string   Nirspec MSA Model
reference file name
meta.ref_file.ote.name                   R_OTE           string   Nirspec OTE Model
reference file name
meta.ref_file.pathloss.name              R_PTHLOS        string   Pathloss reference
file name
meta.ref_file.persat.name                R_PERSAT        string   Persistence
saturation reference file name
meta.ref_file.photom.name                R_PHOTOM        string   Photometric
reference file name
meta.ref_file.psfmask.name               R_PSFMAS        string   PSF mask reference
file name
meta.ref_file.readnoise.name             R_READNO        string   Read noise reference
file name
meta.ref_file.refpix.name                R_REFPIX        string   Reference pixels
reference file name
meta.ref_file.regions.name               R_REGION        string   Regions reference
```

```
file name
meta.ref_file.resample.name              R_RESAMP        string   Resample parameters
reference file name
meta.ref_file.resolution.name            R_RESOL         string   MRS resolution
reference file name
meta.ref_file.reset.name                 R_RESET         string   Reset reference file
name
meta.ref_file.rscd.name                  R_RSCD          string   RSCD reference file
name
meta.ref_file.saturation.name            R_SATURA        string   Saturation reference
file name
meta.ref_file.speckernel.name            R_SPKERN        string   Spectral convolution
kernel reference file name
meta.ref_file.specprofile.name           R_SPPROF        string   Spectral profile
reference file name
meta.ref_file.spectrace.name             R_SPTRAC        string   Spectral trace
reference file name
meta.ref_file.specwcs.name               R_SPCWCS        string   Spectral distortion
reference file name
meta.ref_file.straylight.name            R_STRAY         string   Straylight reference
file name
meta.ref_file.superbias.name             R_SUPERB        string   Superbias reference
file name
meta.ref_file.throughput.name            R_THRPUT        string   Filter throughput
reference file name
meta.ref_file.trapdensity.name           R_TRPDEN        string   Trap density
reference file name
meta.ref_file.trappars.name              R_TRPPAR        string   Trap parameters
reference file name
meta.ref_file.tso_photometry.name        R_TSPHOT        string   TSO imaging
photometry reference file name
meta.ref_file.v2v3.name                  R_V2V3          string   V2_V3 Model
reference file name
meta.ref_file.wavecorr.name              R_WAVCOR        string   Zero point
wavelength correction reference file name
meta.ref_file.wavelengthrange.name       R_WAVRAN        string   Wavelength Range
reference file name
meta.ref_file.wavemap.name               R_WAVMAP        string   Wavelength map
reference file name
meta.cal_step.adcu_invert                S_ADCINV        string   Invert DCU value to
have an increasing ramp
meta.cal_step.adcu_limit                 S_ADCSAT        string   Correct ADCU
saturated values
meta.cal_step.bin2fits                   S_BIN2FI        string   Extract information
from .bin file and create datamodel
meta.cal_step.background                 S_BACKGD        string   Ground Background
subtraction
meta.cal_step.auto_bkg                   S_AUTBKG        string   Auto background
subtraction
meta.cal_step.dark_sub                   S_DARK          string   Dark Subtraction
meta.cal_step.dq_init                    S_DQINIT        string   Data Quality
```

```
Initialization
meta.cal_step.fake_groups               S_FAKEIM        string   Flag fake group
images
meta.cal_step.extract_1d                S_EXTR1D        string   1-D Spectral
Extraction
meta.cal_step.flat_field                S_FLAT          string   Flat Field
Correction
meta.cal_step.firstframe                S_FFRAME        string   Flag out first frame
of each integration
meta.cal_step.jump                      S_JUMP          string   Jump Detection
meta.cal_step.linearity                 S_LINEAR        string   Linearity Correction
meta.cal_step.outlier_detection         S_OUTLIR        string   Outlier Detection
meta.cal_step.persistence               S_PERSIS        string   Persistence
Correction
meta.cal_step.photom                    S_PHOTOM        string   Photometric
Calibration
meta.cal_step.ramp_fit                  S_RAMP          string   Ramp Fitting
meta.cal_step.refpix                    S_REFPIX        string   Reference Pixel
Correction
meta.cal_step.saturation                S_SATURA        string   Saturation Checking
meta.cal_step.superbias                 S_SUPERB        string   Superbias
Subtraction
meta.resample.pointings                 NDRIZ           integer  Number of
groups/pointings included in resampled product
meta.resample.product_exposure_time     TEXPTIME        number   [s] Total exposure
time for product
meta.resample.weight_type               RESWHT          string   Type of drizzle
weighting to use in resampling input
meta.resample.pixfrac                   PIXFRAC         number   Drizzle parameter
describing pixel shrinking
meta.resample.pixel_scale_ratio         PXSCLRT         number   Pixel scale ratio
relative to native detector scale
meta.background.method                  BKGMETH         string   Background
computation method
meta.background.level                   BKGLEVEL        number   Computed/Matched
constant background level
meta.background.subtracted              BKGSUB          boolean  Has background been
subtracted from data?
meta.background.master_background_file  MASTERBG        string   Master background
file used
meta.bunit_data                         BUNIT           string   physical units of
the array values
meta.bunit_err                          BUNIT           string   physical units of
the array values
meta.photometry.conversion_megajanskys  PHOTMJSR        number   Flux density
(MJy/steradian) producing 1 cps
meta.photometry.conversion_microjanskys PHOTUJA2        number   Flux density
(uJy/arcsec2) producing 1 cps
meta.photometry.pixelarea_steradians    PIXAR_SR        number   Nominal pixel area
in steradians
meta.photometry.pixelarea_arcsecsq      PIXAR_A2        number   Nominal pixel area
```

```
in arcsec^2
meta.coordinates.reference_frame        RADESYS         string   Name of the
coordinate reference frame
meta.pointing.ra_v1                     RA_V1           number   [deg] RA of
telescope V1 axis
meta.pointing.dec_v1                    DEC_V1          number   [deg] Dec of
telescope V1 axis
meta.pointing.pa_v3                     PA_V3           number   [deg] Position angle
of telescope V3 axis
meta.wcsinfo.wcsaxes                    WCSAXES         integer  number of World
Coordinate System axes
meta.wcsinfo.crpix1                     CRPIX1          number   axis 1 coordinate of
the reference pixel
meta.wcsinfo.crpix2                     CRPIX2          number   axis 2 coordinate of
the reference pixel
meta.wcsinfo.crpix3                     CRPIX3          number   axis 3 coordinate of
the reference pixel
meta.wcsinfo.crval1                     CRVAL1          number   first axis value at
the reference pixel
meta.wcsinfo.crval2                     CRVAL2          number   second axis value at
the reference pixel
meta.wcsinfo.crval3                     CRVAL3          number   third axis value at
the reference pixel
meta.wcsinfo.ctype1                     CTYPE1          string   Axis 1 type
meta.wcsinfo.ctype2                     CTYPE2          string   Axis 2 type
meta.wcsinfo.ctype3                     CTYPE3          string   Axis 3 type
meta.wcsinfo.cunit1                     CUNIT1          string   Axis 1 units
meta.wcsinfo.cunit2                     CUNIT2          string   Axis 2 units
meta.wcsinfo.cunit3                     CUNIT3          string   Axis 3 units
meta.wcsinfo.cdelt1                     CDELT1          number   Axis 1 coordinate
increment at reference point
meta.wcsinfo.cdelt2                     CDELT2          number   Axis 2 coordinate
increment at reference point
meta.wcsinfo.cdelt3                     CDELT3          number   Axis 3 coordinate
increment at reference point
meta.wcsinfo.pc1_1                      PC1_1           number   linear
transformation matrix element
meta.wcsinfo.pc1_2                      PC1_2           number   linear
transformation matrix element
meta.wcsinfo.pc1_3                      PC1_3           number   linear
transformation matrix element
meta.wcsinfo.pc2_1                      PC2_1           number   linear
transformation matrix element
meta.wcsinfo.pc2_2                      PC2_2           number   linear
transformation matrix element
meta.wcsinfo.pc2_3                      PC2_3           number   linear
transformation matrix element
meta.wcsinfo.pc3_1                      PC3_1           number   linear
transformation matrix element
meta.wcsinfo.pc3_2                      PC3_2           number   linear
transformation matrix element
```

```
meta.wcsinfo.pc3_3                      PC3_3          number   linear
transformation matrix element
meta.wcsinfo.cd1_1                      CD1_1          number   linear
transformation matrix element, CD matrix
meta.wcsinfo.cd1_2                      CD1_2          number   linear
transformation matrix element, CD matrix
meta.wcsinfo.cd2_1                      CD2_1          number   linear
transformation matrix element, CD matrix
meta.wcsinfo.cd2_2                      CD2_2          number   linear
transformation matrix element, CD matrix
meta.wcsinfo.ps3_0                      PS3_0          string   Coordinate table
extension name
meta.wcsinfo.ps3_1                      PS3_1          string   Coordinate table
column name
meta.wcsinfo.s_region                   S_REGION       string   spatial extent of
the observation
meta.wcsinfo.waverange_start            WAVSTART       number   lower bound of the
default wavelength range
meta.wcsinfo.waverange_end              WAVEND         number   upper bound of the
default wavelength range
meta.wcsinfo.dispersion_direction       DISPAXIS       integer  Dispersion direction
meta.wcsinfo.spectral_order             SPORDER        integer  Spectral order
number
meta.wcsinfo.v2_ref                     V2_REF         number   [arcsec] Telescope
V2 coord of reference point
meta.wcsinfo.v3_ref                     V3_REF         number   [arcsec] Telescope
V3 coord of reference point
meta.wcsinfo.vparity                    VPARITY        integer  Relative sense of
rotation between Ideal xy and V2V3
meta.wcsinfo.v3yangle                   V3I_YANG       number   [deg] Angle from V3
axis to Ideal y axis
meta.wcsinfo.ra_ref                     RA_REF         number   [deg] Right
ascension of the reference point
meta.wcsinfo.dec_ref                    DEC_REF        number   [deg] Declination of
the reference point
meta.wcsinfo.roll_ref                   ROLL_REF       number   [deg] V3 roll angle
at the ref point (N over E)
meta.wcsinfo.velosys                    VELOSYS        number   [m/s] Barycentric
correction to radial velocity
meta.wcsinfo.specsys                    SPECSYS        string   Spectral reference
frame
meta.wcsinfo.siaf_xref_sci              XREF_SCI       number   Aperture X reference
point in SCI frame
meta.wcsinfo.siaf_yref_sci              YREF_SCI       number   Aperture Y reference
point in SCI frame
meta.wcsinfo.mt_ra                      MT_RA          number   [deg] Moving target
RA at exposure mid-point
meta.wcsinfo.mt_dec                     MT_DEC         number   [deg] Moving target
Dec at exposure mid-point
meta.wcsinfo.mt_avra                    MT_AVRA        number   [deg] Moving target
average RA over exposures
```

```
meta.wcsinfo.mt_avdec                   MT_AVDEC        number   [deg] Moving target
average Dec over exposures
meta.wcsinfo.a_order                    A_ORDER         integer  Degree of forward
SIP polynomial
meta.wcsinfo.b_order                    B_ORDER         integer  Degree of forward
SIP polynomial
meta.wcsinfo.ap_order                   AP_ORDER        integer  Degree of inverse
SIP polynomial
meta.wcsinfo.bp_order                   BP_ORDER        integer  Degree of inverse
SIP polynomial
meta.wcsinfo.a_0_2                      A_0_2           number   SIP coefficient,
forward transform
meta.wcsinfo.a_0_3                      A_0_3           number   SIP coefficient,
forward transform
meta.wcsinfo.a_0_4                      A_0_4           number   SIP coefficient,
forward transform
meta.wcsinfo.a_0_5                      A_0_5           number   SIP coefficient,
forward transform
meta.wcsinfo.a_0_6                      A_0_6           number   SIP coefficient,
forward transform
meta.wcsinfo.a_1_1                      A_1_1           number   SIP coefficient,
forward transform
meta.wcsinfo.a_1_2                      A_1_2           number   SIP coefficient,
forward transform
meta.wcsinfo.a_1_3                      A_1_3           number   SIP coefficient,
forward transform
meta.wcsinfo.a_1_4                      A_1_4           number   SIP coefficient,
forward transform
meta.wcsinfo.a_1_5                      A_1_5           number   SIP coefficient,
forward transform
meta.wcsinfo.a_2_0                      A_2_0           number   SIP coefficient,
forward transform
meta.wcsinfo.a_2_1                      A_2_1           number   SIP coefficient,
forward transform
meta.wcsinfo.a_2_2                      A_2_2           number   SIP coefficient,
forward transform
meta.wcsinfo.a_2_3                      A_2_3           number   SIP coefficient,
forward transform
meta.wcsinfo.a_2_4                      A_2_4           number   SIP coefficient,
forward transform
meta.wcsinfo.a_3_0                      A_3_0           number   SIP coefficient,
forward transform
meta.wcsinfo.a_3_1                      A_3_1           number   SIP coefficient,
forward transform
meta.wcsinfo.a_3_2                      A_3_2           number   SIP coefficient,
forward transform
meta.wcsinfo.a_3_3                      A_3_3           number   SIP coefficient,
forward transform
meta.wcsinfo.a_4_0                      A_4_0           number   SIP coefficient,
forward transform
meta.wcsinfo.a_4_1                      A_4_1           number   SIP coefficient,
```

```
forward transform
meta.wcsinfo.a_4_2                    A_4_2          number   SIP coefficient,
forward transform
meta.wcsinfo.a_5_0                    A_5_0          number   SIP coefficient,
forward transform
meta.wcsinfo.a_5_1                    A_5_1          number   SIP coefficient,
forward transform
meta.wcsinfo.a_6_0                    A_6_0          number   SIP coefficient,
forward transform
meta.wcsinfo.b_0_2                    B_0_2          number   SIP coefficient,
forward transform
meta.wcsinfo.b_0_3                    B_0_3          number   SIP coefficient,
forward transform
meta.wcsinfo.b_0_4                    B_0_4          number   SIP coefficient,
forward transform
meta.wcsinfo.b_0_5                    B_0_5          number   SIP coefficient,
forward transform
meta.wcsinfo.b_0_6                    B_0_6          number   SIP coefficient,
forward transform
meta.wcsinfo.b_1_1                    B_1_1          number   SIP coefficient,
forward transform
meta.wcsinfo.b_1_2                    B_1_2          number   SIP coefficient,
forward transform
meta.wcsinfo.b_1_3                    B_1_3          number   SIP coefficient,
forward transform
meta.wcsinfo.b_1_4                    B_1_4          number   SIP coefficient,
forward transform
meta.wcsinfo.b_1_5                    B_1_5          number   SIP coefficient,
forward transform
meta.wcsinfo.b_2_0                    B_2_0          number   SIP coefficient,
forward transform
meta.wcsinfo.b_2_1                    B_2_1          number   SIP coefficient,
forward transform
meta.wcsinfo.b_2_2                    B_2_2          number   SIP coefficient,
forward transform
meta.wcsinfo.b_2_3                    B_2_3          number   SIP coefficient,
forward transform
meta.wcsinfo.b_2_4                    B_2_4          number   SIP coefficient,
forward transform
meta.wcsinfo.b_3_0                    B_3_0          number   SIP coefficient,
forward transform
meta.wcsinfo.b_3_1                    B_3_1          number   SIP coefficient,
forward transform
meta.wcsinfo.b_3_2                    B_3_2          number   SIP coefficient,
forward transform
meta.wcsinfo.b_3_3                    B_3_3          number   SIP coefficient,
forward transform
meta.wcsinfo.b_4_0                    B_4_0          number   SIP coefficient,
forward transform
meta.wcsinfo.b_4_1                    B_4_1          number   SIP coefficient,
forward transform
```

```
meta.wcsinfo.b_4_2                  B_4_2          number   SIP coefficient,
forward transform
meta.wcsinfo.b_5_0                  B_5_0          number   SIP coefficient,
forward transform
meta.wcsinfo.b_5_1                  B_5_1          number   SIP coefficient,
forward transform
meta.wcsinfo.b_6_0                  B_6_0          number   SIP coefficient,
forward transform
meta.wcsinfo.ap_0_2                 AP_0_2         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_0_3                 AP_0_3         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_0_4                 AP_0_4         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_0_5                 AP_0_5         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_0_6                 AP_0_6         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_1_1                 AP_1_1         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_1_2                 AP_1_2         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_1_3                 AP_1_3         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_1_4                 AP_1_4         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_1_5                 AP_1_5         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_2_0                 AP_2_0         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_2_1                 AP_2_1         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_2_2                 AP_2_2         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_2_3                 AP_2_3         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_2_4                 AP_2_4         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_3_0                 AP_3_0         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_3_1                 AP_3_1         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_3_2                 AP_3_2         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_3_3                 AP_3_3         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_4_0                 AP_4_0         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_4_1                 AP_4_1         number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_4_2                 AP_4_2         number   SIP coefficient,
```

```
inverse transform
meta.wcsinfo.ap_5_0                    AP_5_0          number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_5_1                    AP_5_1          number   SIP coefficient,
inverse transform
meta.wcsinfo.ap_6_0                    AP_6_0          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_0_2                    BP_0_2          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_0_3                    BP_0_3          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_0_4                    BP_0_4          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_0_5                    BP_0_5          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_0_6                    BP_0_6          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_1_1                    BP_1_1          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_1_2                    BP_1_2          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_1_3                    BP_1_3          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_1_4                    BP_1_4          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_1_5                    BP_1_5          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_2_0                    BP_2_0          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_2_1                    BP_2_1          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_2_2                    BP_2_2          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_2_3                    BP_2_3          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_2_4                    BP_2_4          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_3_0                    BP_3_0          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_3_1                    BP_3_1          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_3_2                    BP_3_2          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_3_3                    BP_3_3          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_4_0                    BP_4_0          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_4_1                    BP_4_1          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_4_2                    BP_4_2          number   SIP coefficient,
inverse transform
```

```
meta.wcsinfo.bp_5_0                    BP_5_0          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_5_1                    BP_5_1          number   SIP coefficient,
inverse transform
meta.wcsinfo.bp_6_0                    BP_6_0          number   SIP coefficient,
inverse transform
meta.flags.first_ramp_partial          F_PARSTA        boolean  Partial first
integration
meta.flags.last_ramp_partial           F_PAREND        boolean  Partial last
integration
meta.flags.nints_mismatch              F_NINTS         boolean  nints != requested
meta.flags.ngroups_mismatch            F_NGRPS         boolean  ngroups != requested
meta.flags.nimgs_mismatch              F_NIMGS         boolean  n_total_imgs !=
requested
meta.ground.rst                        RST             string   RST
meta.ground.clk                        CLK             string   CLK
meta.ground.opt                        OPT             string   OPT
meta.ground.fpga_version               FPGA_VER        string   FPGA Version
meta.ground.cn_temp                    CN_TEMP         number   cn_temp (in K)
meta.ground.vdd                        VDD             number   VDD (in V)
meta.ground.vdda                       VDDA            number   VDDA (in V)
meta.ground.vbiaspower                 VBIASPOW        number   VBIASPOWER (in V)
meta.ground.vbiasgate                  VBIASGAT        number   VBIASGATE (in V)
meta.ground.vreset                     VRESET          number   VRESET (in V)
meta.ground.dsub                       DSUB            number   DSUB (in V)
meta.ground.gnda_cell_drain            CELL_DRA        number   GNDA_CELL_DRAIN (in
V)
meta.ground.vrefchain                  VREFCHAI        number   VREFCHAIN (in V)
```

4. Other utilities

By default, importing airsplorer, you have access to plot, mask and lib.

Other subpackages need to be imported via:

```
from airsplorer import flux
```

4.1. plot: various plots

4.1.1. compare_images_flag

Expect list (or one) filenames for a rate/cal FITS file, will display the flag image for each file. (e.g. saturation is the flag DQ=2 ; Combined flags also work e.g. 7=4+2+1). The title can be constructed from a header keyword (using the title_keyword parameter), or be provided as a list (using the titles parameter, that expect one title per file)

```
fig = airsplorer.plot.compare_images_flag(filenames, flag=2, title_keyword="NGROUPS")
fig2 = airsplorer.plot.compare_images_flag(filenames, flag=2, titles=["file1",
"file2"])
```

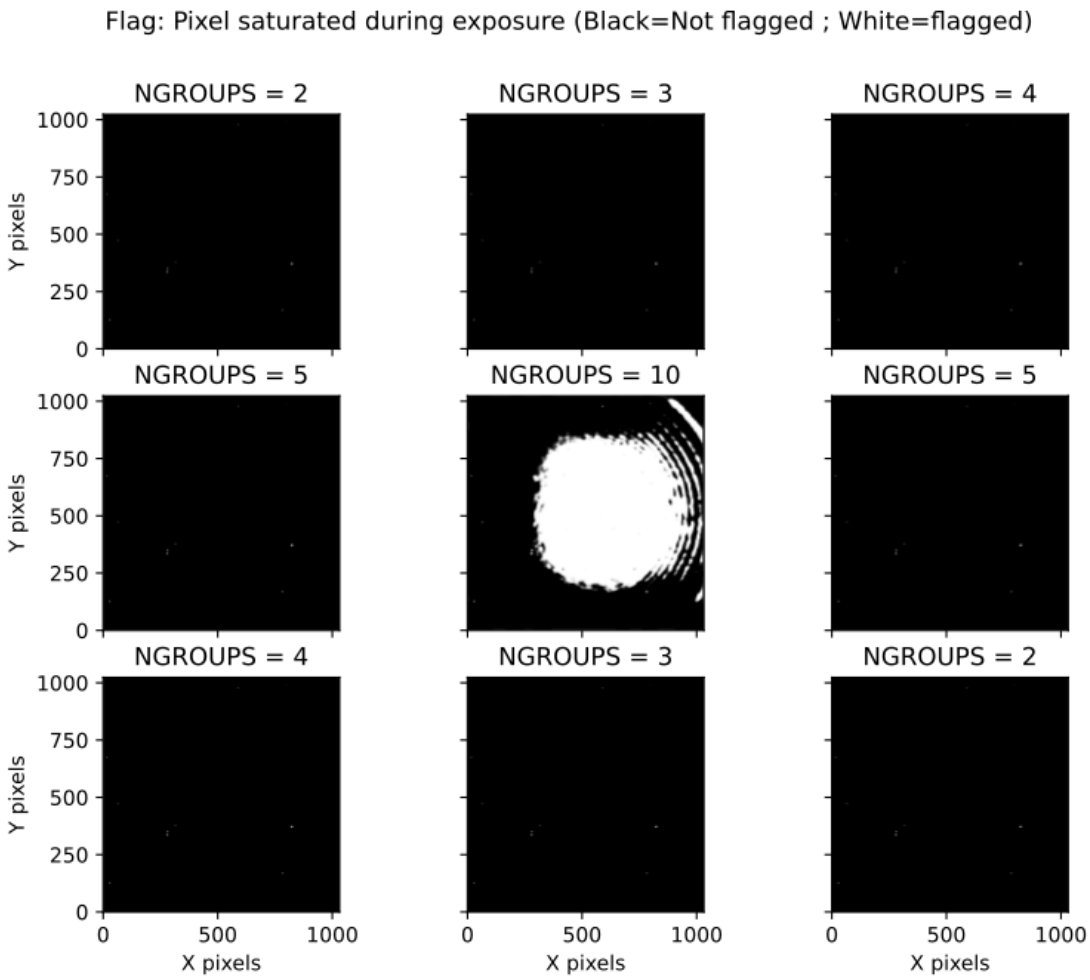


Figure 7. Example of the compare_images_flag function

4.1.2. compare_pixel_ramps

Will display all integrations from a pixel in a single level 1b exposure.

```
fig = airsplorer.plot.compare_pixel_ramps(ramp_image=data, metadata=header, pixel=(
639, 367),
                            filename="all_ramps.svg", substract_first=True)
```

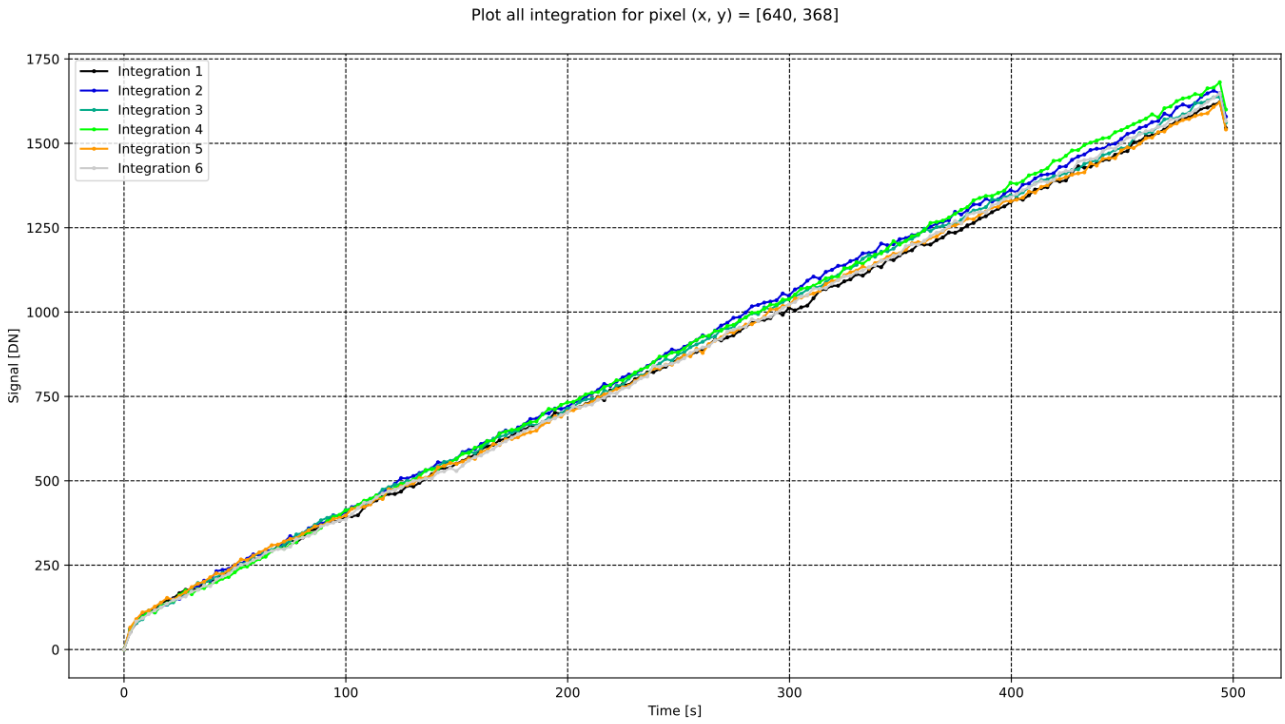


Figure 8. Example of the compare_pixel_ramps function

4.1.3. histogram

Quickly display an histogram for an input dataset, using optimised number of bins

```
import airsplorer
import numpy as np

data = np.random.normal(size=10000)

fig = airsplorer.plot.histogram(data, xlabel="Random gaussian")
# fig2 = histogram(data, xlabel="My data", title="My title")
```

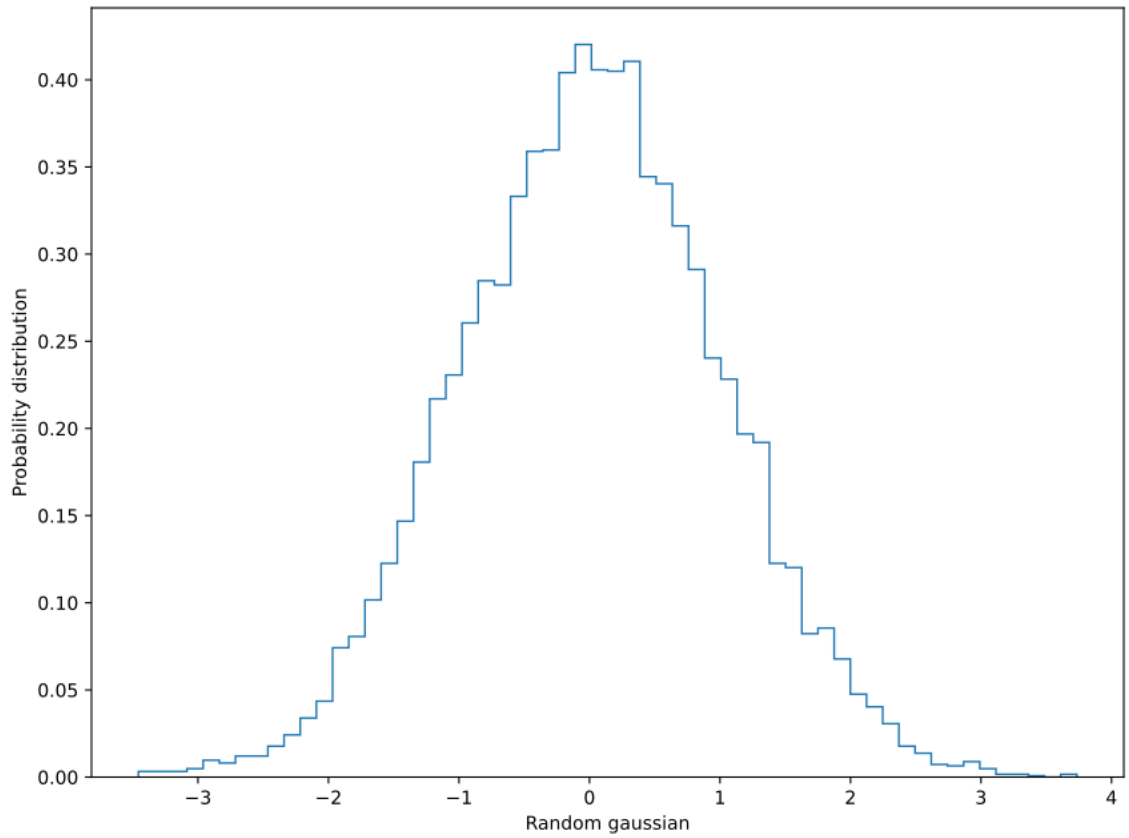


Figure 9. Example of the histogram function

4.1.4. image_flags

Will display all individual flag mask of a single exposure (rate or cal) to identify quickly which flag is causing one specific region to be masked.

Another plot is created, for convenience, with a little explanation for each of the individual flag so you don't have to look for it

```
filename = 'jw01052001001_02105_00001_mirimage_rate.fits'

fig = airsplorer.plot.image_flags(filename)
plt.show()
```

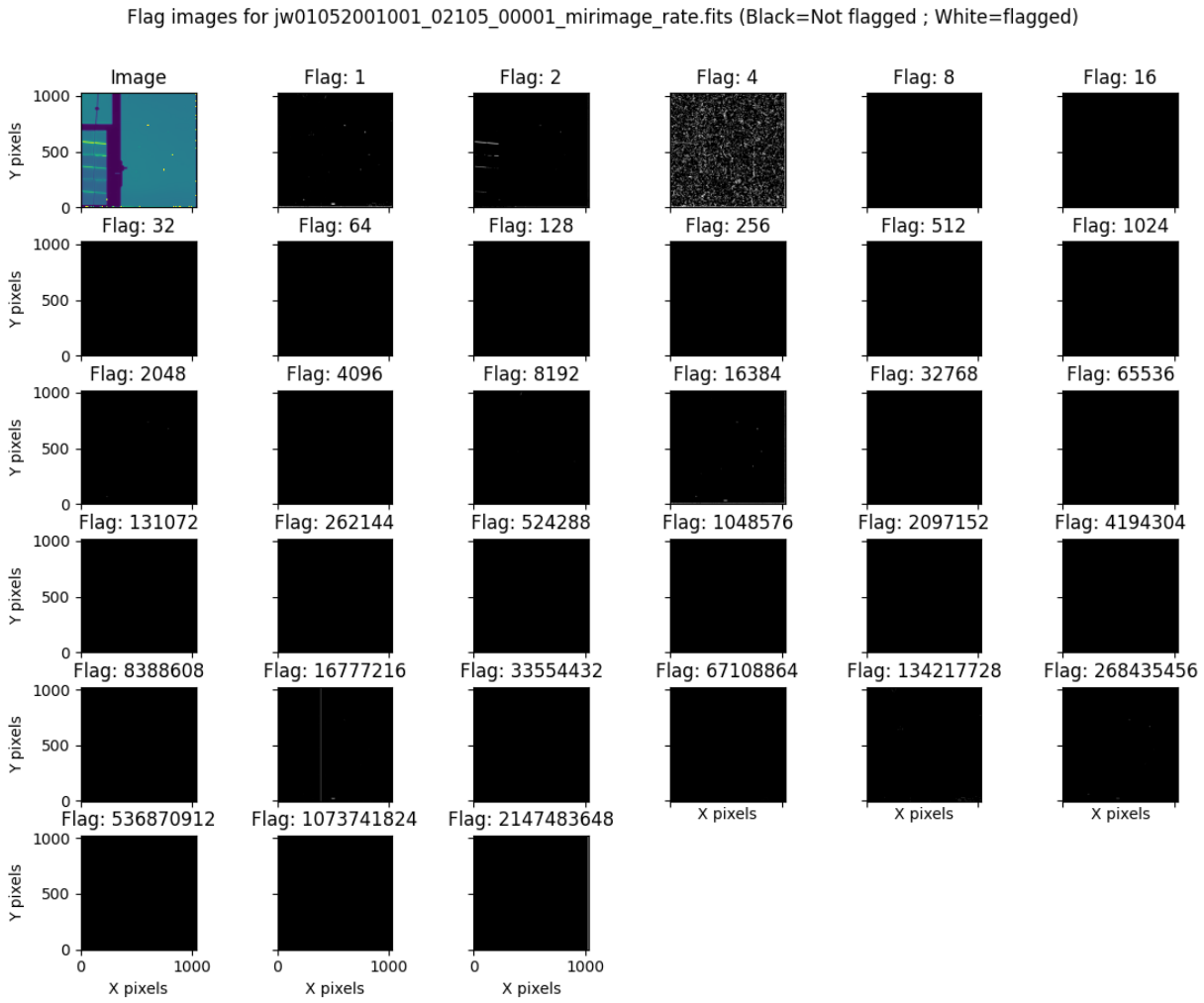


Figure 10. Example of the image_flags function

4.1.5. integration_first_threshold_group

Given one integration ramp image, return the frame number at which each pixel reach a given ADU count.

Default is:

- figure is not saved to file but you can if you define the filename keyword
- frame_to_plot is the last one (for the left image used as a reference)
- sat_limit=62000 (at what point the pixel is considered saturated)

```
# Normal use
fig = airsplorer.plot.integration_first_threshold_group(ramp_image, filename
="saturation.svg")
```

Mandatory parameters:

- ramp_image as a numpy 3D cube (frame, y, x). Only one integration is accepted, but a cube with an extra 4-th dimension of only one value (1, frame, y, x) will also work.

Optional:

- frame_to_plot: Frame used in reference image (left). By default it's the last one
- adu_threshold: DN count at which the pixel is considered saturated. By default 62000
- filename: If given, will save the figure to a file.

You can do that later since the figure is returned by the function.

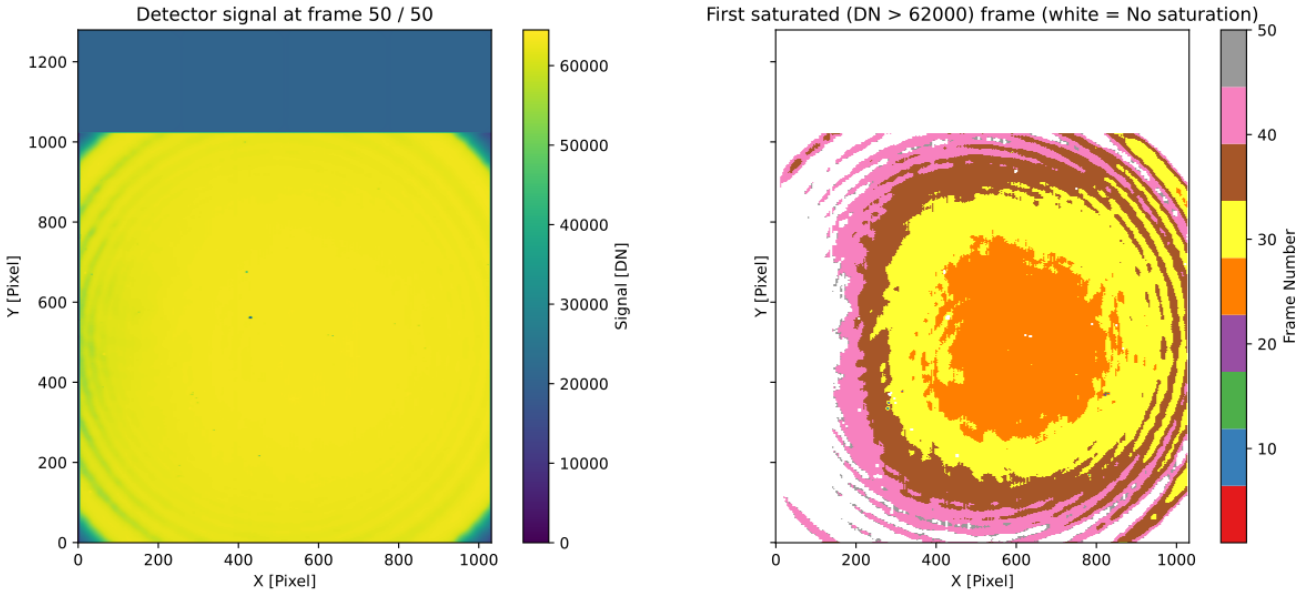


Figure 11. Example of the integration_first_threshold_group function

4.1.6. ramp_flag_first_occurence

This function need a ramp image. The subtelty is that you can't use the _uncal format that doesn't have any flag information in it. You have to you the _ramp image that is not saved by default but you can save it manually by reprocessing your data through level 1 with the correct options.

```
filename = "jw0xxxx006001_03101_00001-seg000_mirimage_ramp.fits"
airsplorer.plot.ramp_flag_first_occurence(filename, flag=4)
```

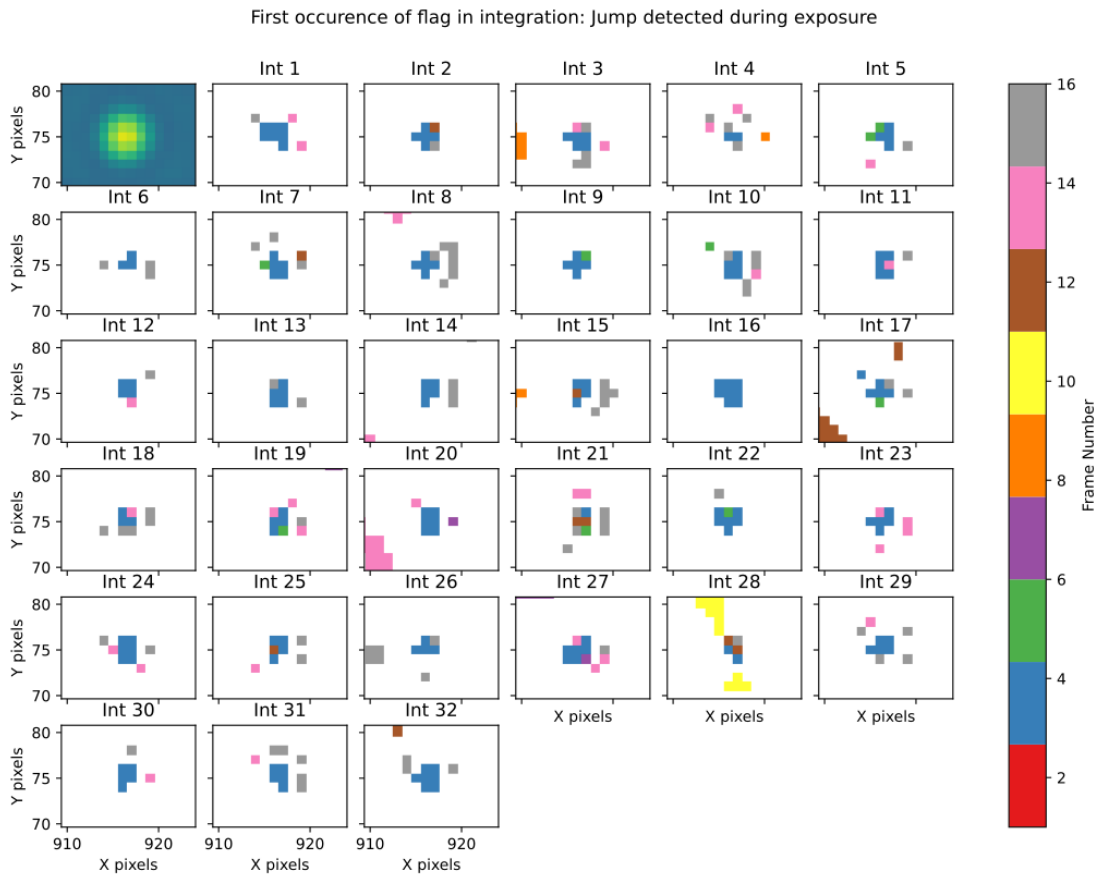


Figure 12. Example of the ramp_flag_first_occurence function

4.1.7. single_image

plot one image with ZScale

```
import airsplorer
import numpy as np

image = np.random.random(size=(50, 50))

fig = airsplorer.plot.single_image(image, vlabel="Flux [mJy]", title="My plot")
fig.savefig("single_image.svg")
```

Optional parameter:

- force_positive: If True, will exclude negative values when computing the Zscale

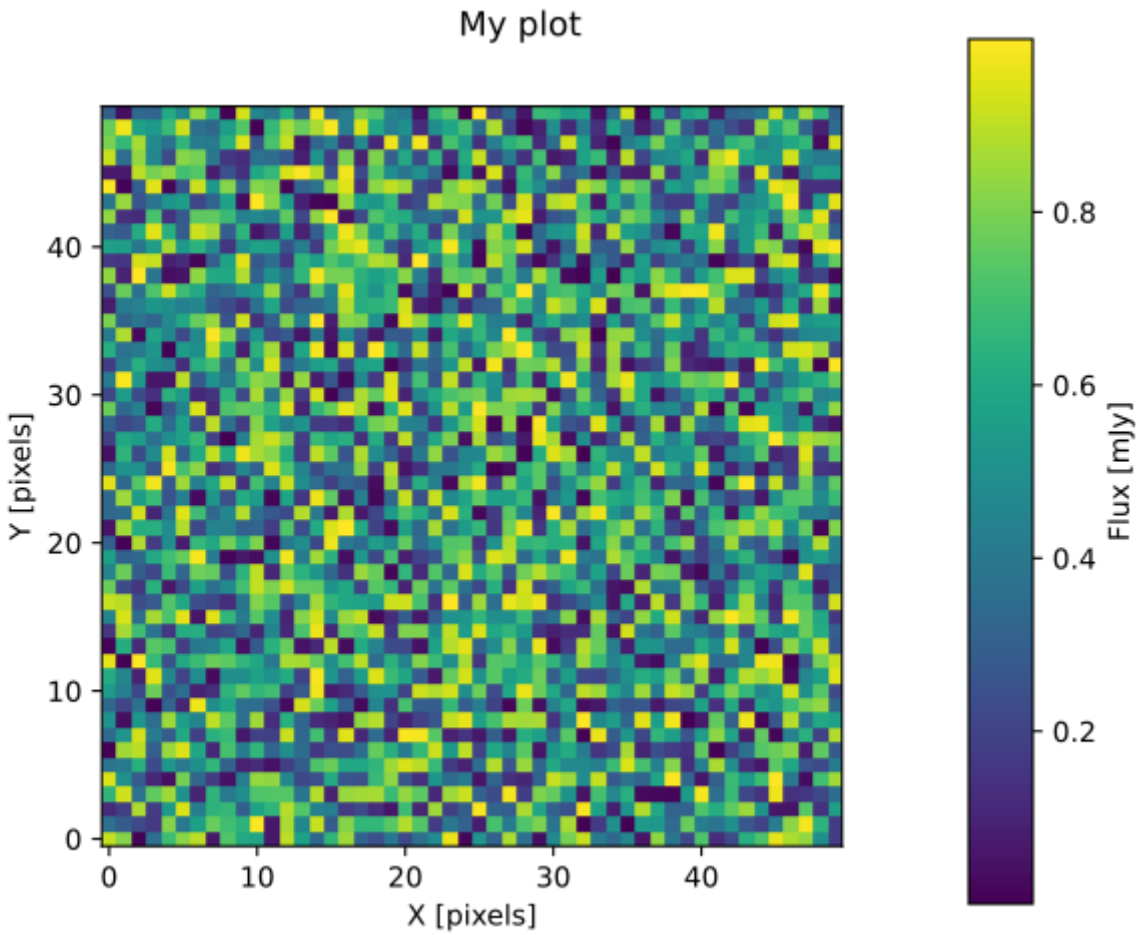


Figure 13. Example of the single_image function

4.2. mask: Data Quality and bad pixels

Data Quality for AIRSPipe images is copied from AIRSPipe to avoid a dependency. Any change require to update the hard coded values here.

4.2.1. change_mask

Force some pixel DQ as visible (and exclude them from the mask). Combined DQ are allowed (value of 5 will consider only the pixel with DQ = 1 and DQ = 4)

```
output_mask = airsplorer.mask.change_mask(input_mask, exclude_from_mask=[2])
```



If a pixel had multiple statuses (e.g 1 and 4) and you remove the status 1 from the mask, that pixel will still be masked because status 4 is still here. combine_masks

Merge multiple mask into one were a pixel is visible only if never masked in all individual masks.

```
combined = airsplorer.mask.combine_masks([m1, m2, m3])
```

4.2.2. decompose_mask_status

Detail the DQ status of a pixel (because a single pixel can have multiple statuses at once ; e.g. noisy and cosmic ray). A parameter can tell if this status comes from JPL or the official datamodel

```
result = airsplorer.mask.mask.decompose_mask_status(768)
>>> print(result)
[256, 512]
```

4.2.3. decompose_to_bits

Same as the function before, but return bits instead of flag value:

```
result = airsplorer.mask.mask.decompose_to_bits(768)
>>> print(result)
[8, 9] # 2^8, 2^9
```

4.2.4. extract_flag_image

From a full DQ image, will extract only the image of a given flag or combination of flags. Compared to get_separated_dq_array, this also work with flag=5 (i.e pixels that are flagged with 1 and 4 at the same time).

```
single_flag = airsplorer.mask.extract_flag_image(mask, 2)
```

4.2.5. get_separated_dq_array

From the original DQ array array(y, x) (that have all flags combined, i.e a pixel with flag 1 and 4 will have the value 5), will return a cube of individual flag array array(y, x, 32)

```
result = airsplorer.mask.get_separated_dq_array(dq_mask)

saturation_image = result[:, :, 1]  # because saturation flag: 2^1
```

4.2.6. mask_statistic

Given a mask, will tell the different DQ status combination seen, and how many pixels are affected (a threshold can be defined to skip statuses with low number of pixels, by default < 3 pixels)

```
print(airsplorer.mask.mask_statistic(mask, min_pix=20))
```

4.3. flux: flux conversion and estimate

4.3.1. flux2mag

convert flux in mJy into magnitude to the request band assuming this flux correspond to the wref of that band

```
mag = airsplorer.flux.flux2mag(flux, band="V", system="Johnson")
```

4.3.2. mag2flux

convert magnitude in a given band into flux in mJy (associated with the wref of that band)

```
flux, wref = airsplorer.flux.mag2flux(mag, band="V", system="Johnson")
```

4.3.3. extrapolate_flux

given a blackbody temperature, will extrapolate a flux (in mJy) at a given wavelength into a list of other wavelengths and return an Astropy quantity.

```
extr_flux = airsplorer.flux.extrapolate_flux(2, 5.2, 10., 5000) # in_flux, in_wref,
out_wave, temperature
fluxes = airsplorer.flux.extrapolate_flux(2, 5.2, [10, 20], 5000)
```

4.3.4. photon2jansky

Convert a flux in photon/m2/s/microns to Jy given the associated wavelength

```
wave = 10  # microns
flux = 1509  # photons/m2/s/microns
f_Jy = airsplorer.flux.photon2jansky(flux, wave)
```

4.3.5. jansky2photon

Convert a flux in Jy to photon/m2/s/microns given the associated wavelength

```
wave = 10  # microns
flux = 1e-3  # Jy
f_phot = airsplorer.flux.jansky2photon(flux, wave)
```

4.4. lib: various utility functions

4.4.1. optimum_nbins

Based on the input data statistics, determine the best number of bin to visualize the histogram using the Freedman-Diaconis rule.

```
nbins = optimum_nbins(data.flatten())
```