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FIS Slow Scan Tool, advanced

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I. Detector properties and various effects in orbit

Survey pipe line (FISV - Quick viewer)

1. Taking data from LDS
2. Initial process and QL with FISV

Slow-scan tools (SS_RUN_SS)

Time domain:

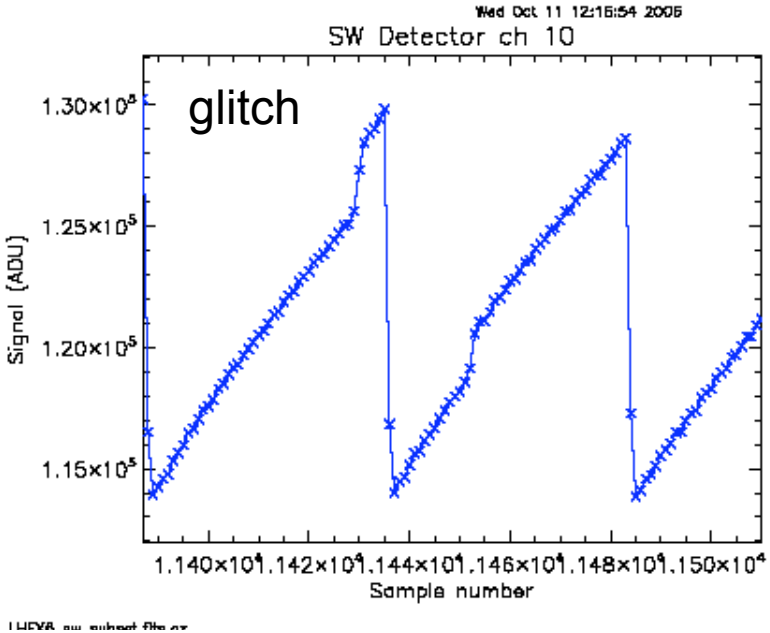
3. Treatment for transient effects
4. Stray light removal
5. Relative responsivity correction (flat field)
6. Absolute scale

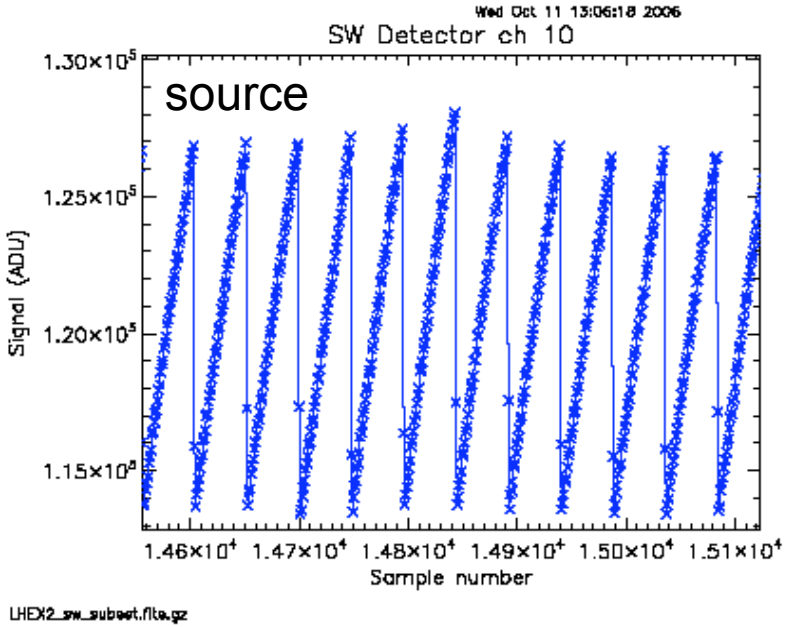
Image:

7. Production of image data
8. Source extraction and photometry

1. Removing glitches of cosmic-ray hits

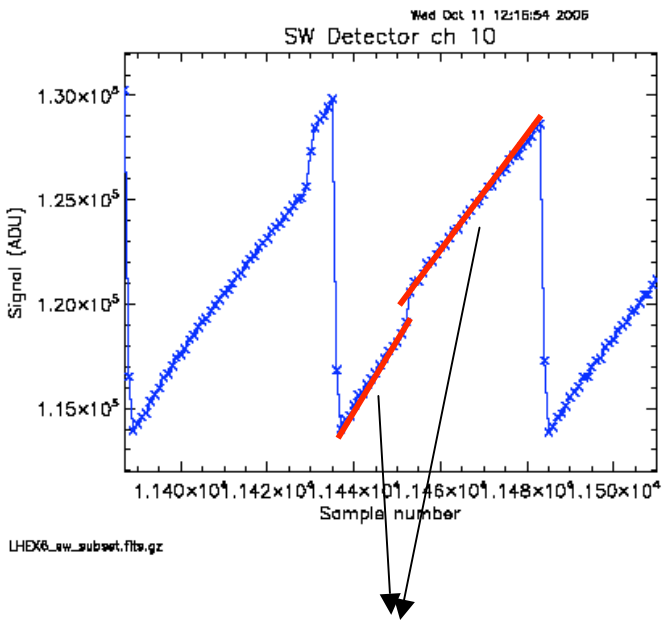
- Glitch detection by 1st & 2nd derivative (differentiation)
  - Diff signal > RMS noise (3-5sigma)
  - Source should show slow time profile (~1s)
  - Glitch shows abrupt change of signal (~0.1s)
  - Easy to discriminate glitch from source signal in time domain
- Making glitch flag for each pixel





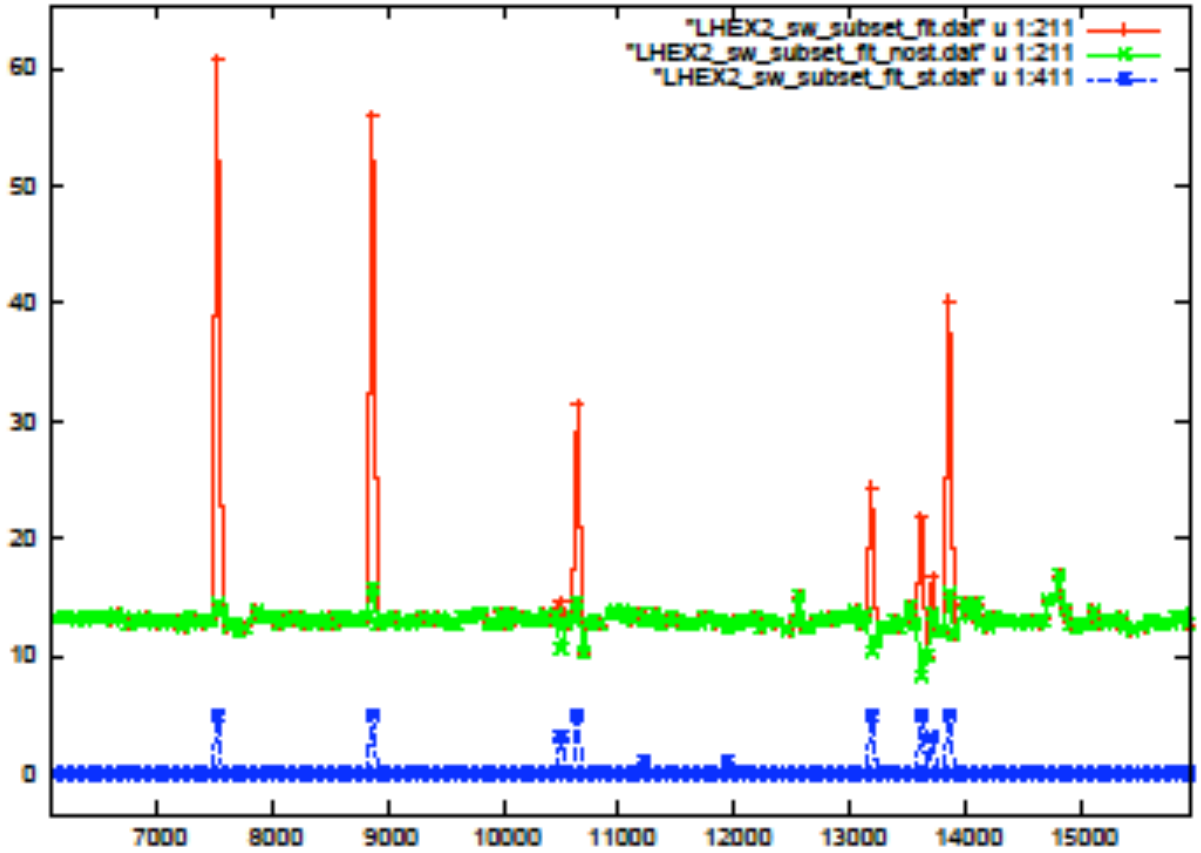
2. Calculation of detector current

- No glitch → 1 ramp gives 1 data point
- If glitch exists …



Average slope

Result of deglitch



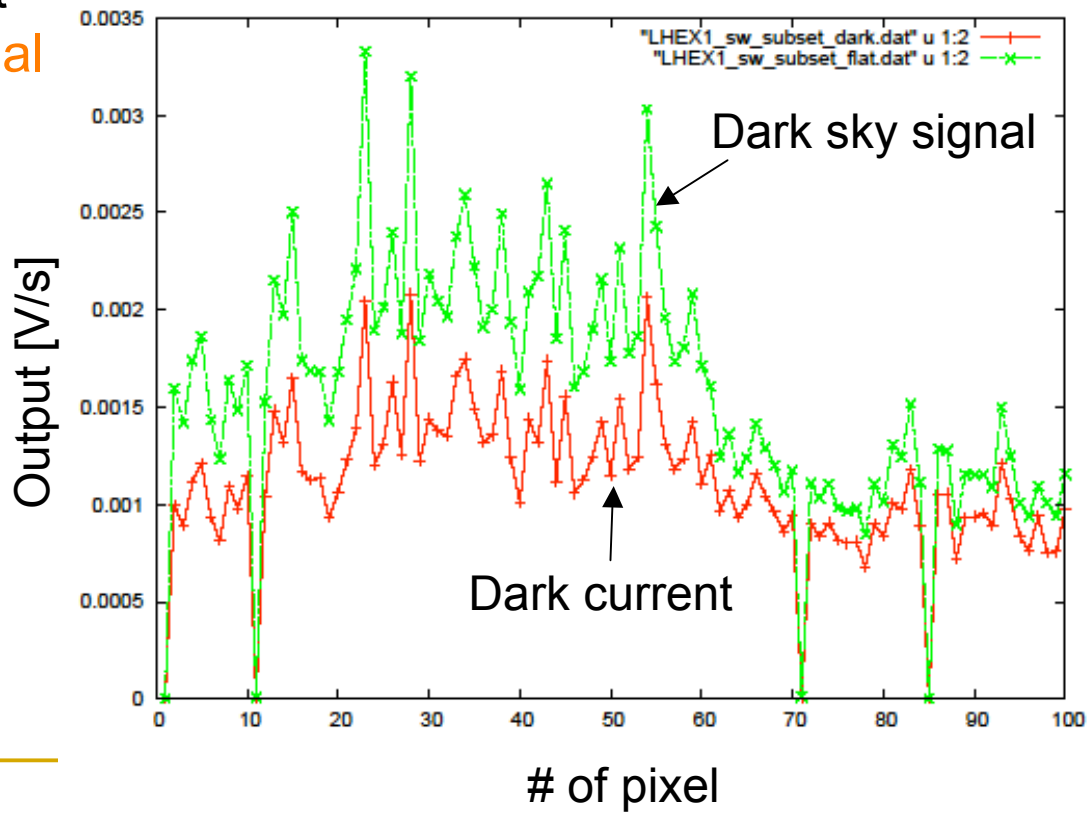
3. Dark, Responsivity, and flat field

- Dark current measurement
  time-averaged dark current
  " ***_dark.sav "

- Responsivity measurement
  time-averaged cal-light signal
  " ***_cal.sav "

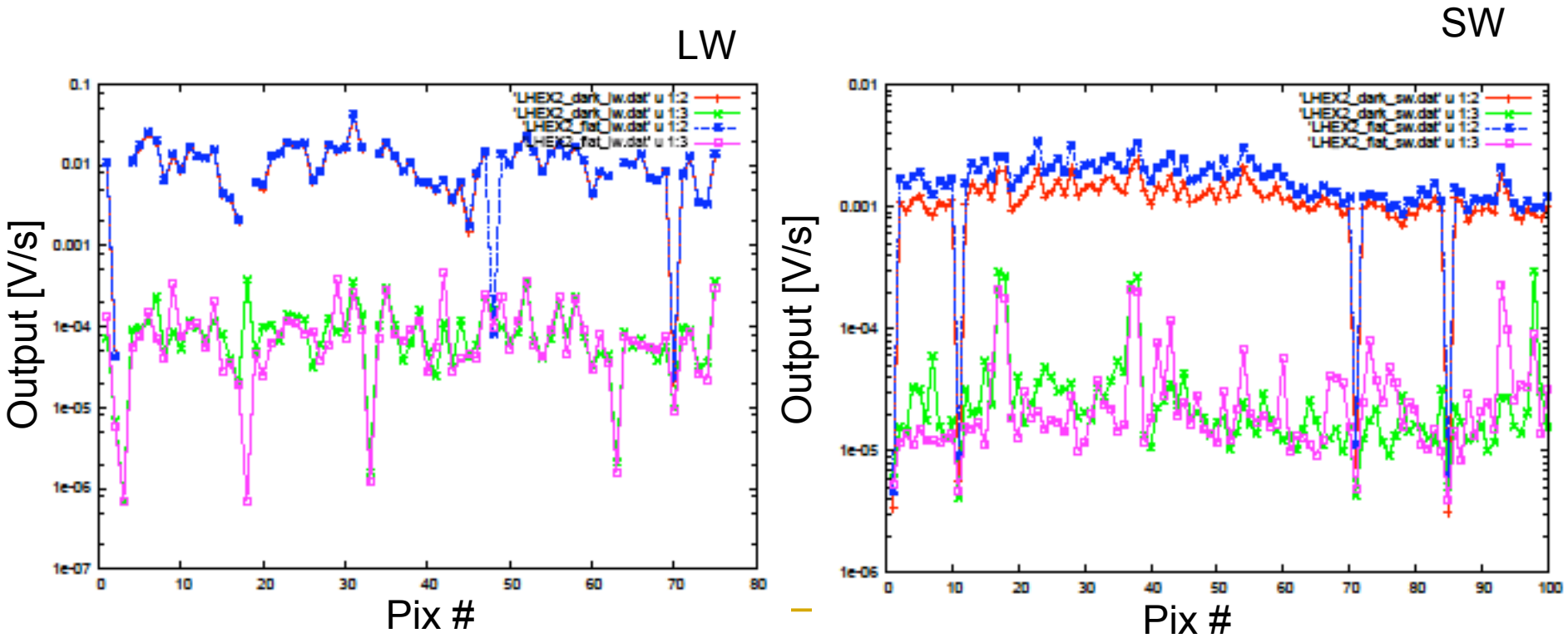
- Flat field
  - Pre-measured flat data
    or
  - Local flat data
    at observed sky

  in case of local flat
  " ***_flat.sav "



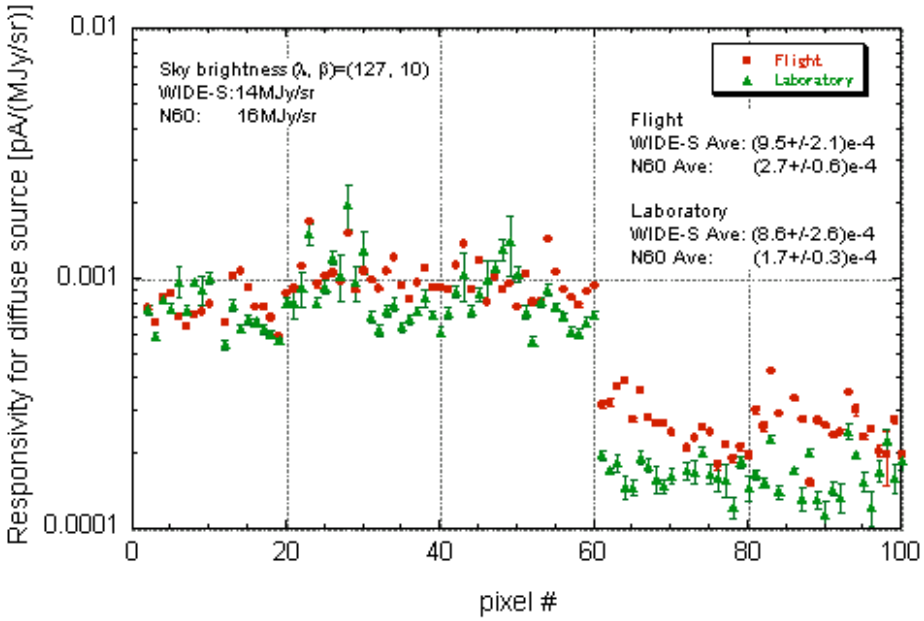
3. Dark current and Noise

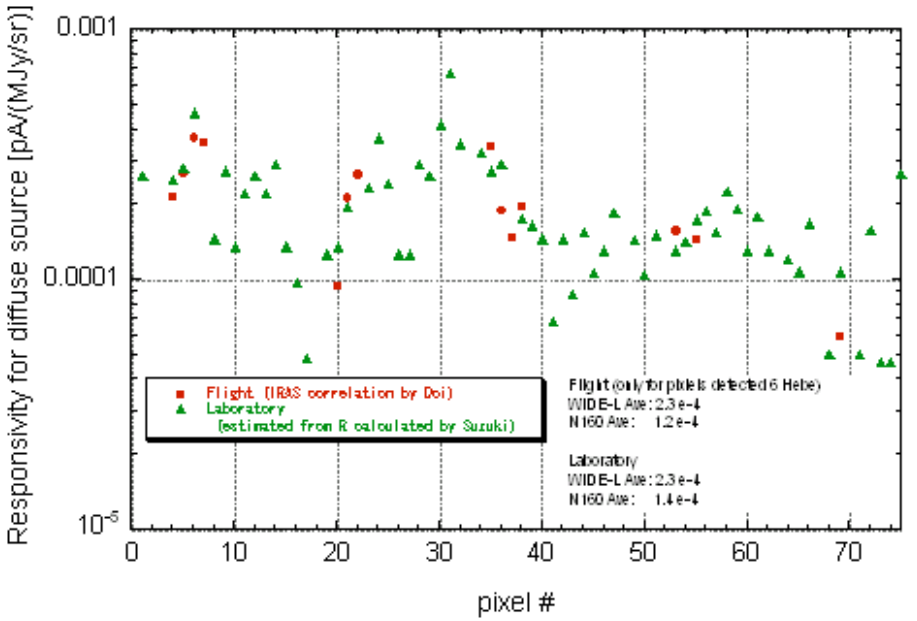
- Signal current and RMS noise in [MJy/sr] of all pixels
- No clear difference between shutter-close and –open
  - Shutter-open noise of SW is slightly higher than that of shutter-close



4. Absolute calibration

- Current to flux Conversion factor measured by zodiacal light and cirrus observations
- Relying on DIRBE map.
- Responsivity for diffuse source is consistent with pre-flight measurements in lab.
- Calibration for point sources is separately done using the observation data for asteroids and stars.





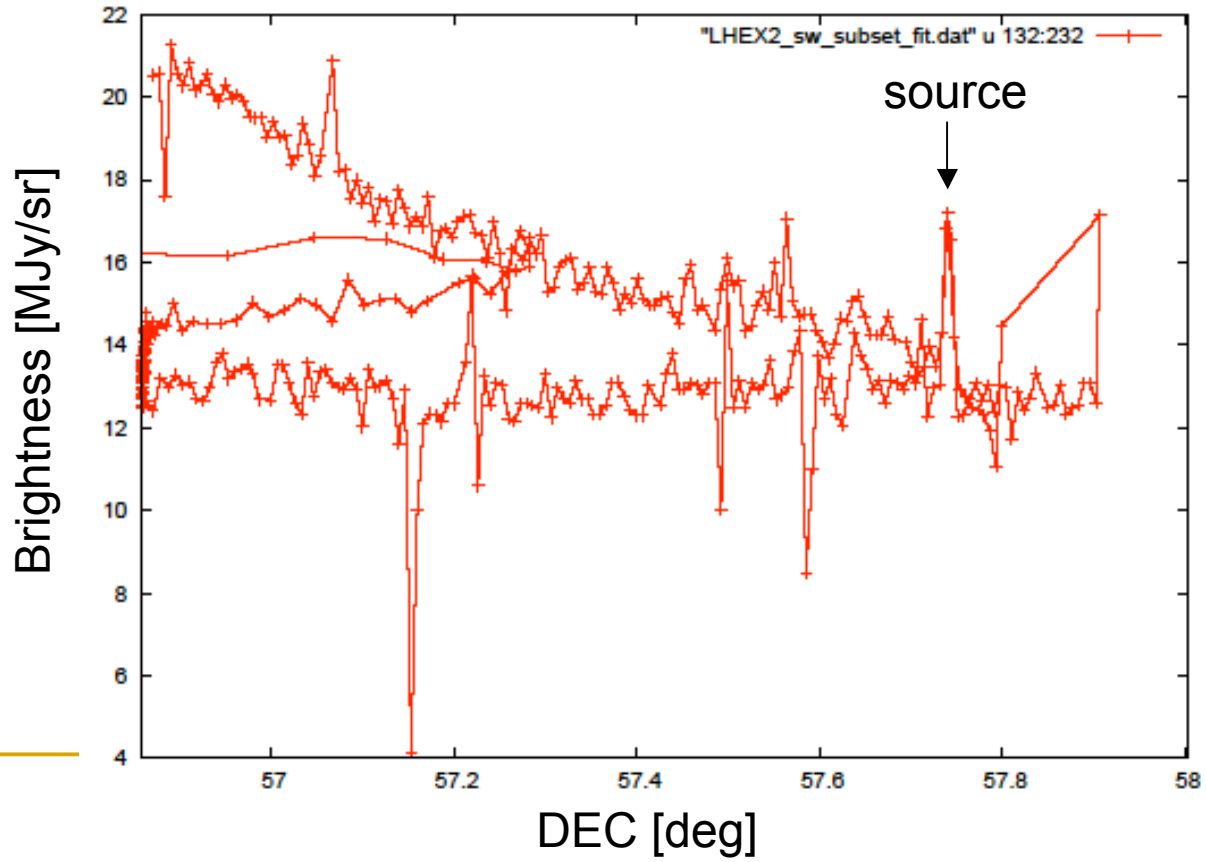
5. Treatment for transient effects

- After-effect induced by CAL & dark measurements – implemented
- Responsivity drift after a strong glitch – to be implemented soon
- Slow response to astronomical signals – no
- After-effect induced by weak glitches – no

6. Image process by co-adding

- Calculation of pixel position in equatorial coordinate from GADS
  - Pixel position table based on the simulation
  - Corrected table based on the flight data - no

Time-series surface brightness data with position for each pixel



II. Optional functions of “ss_run_ss.pro”

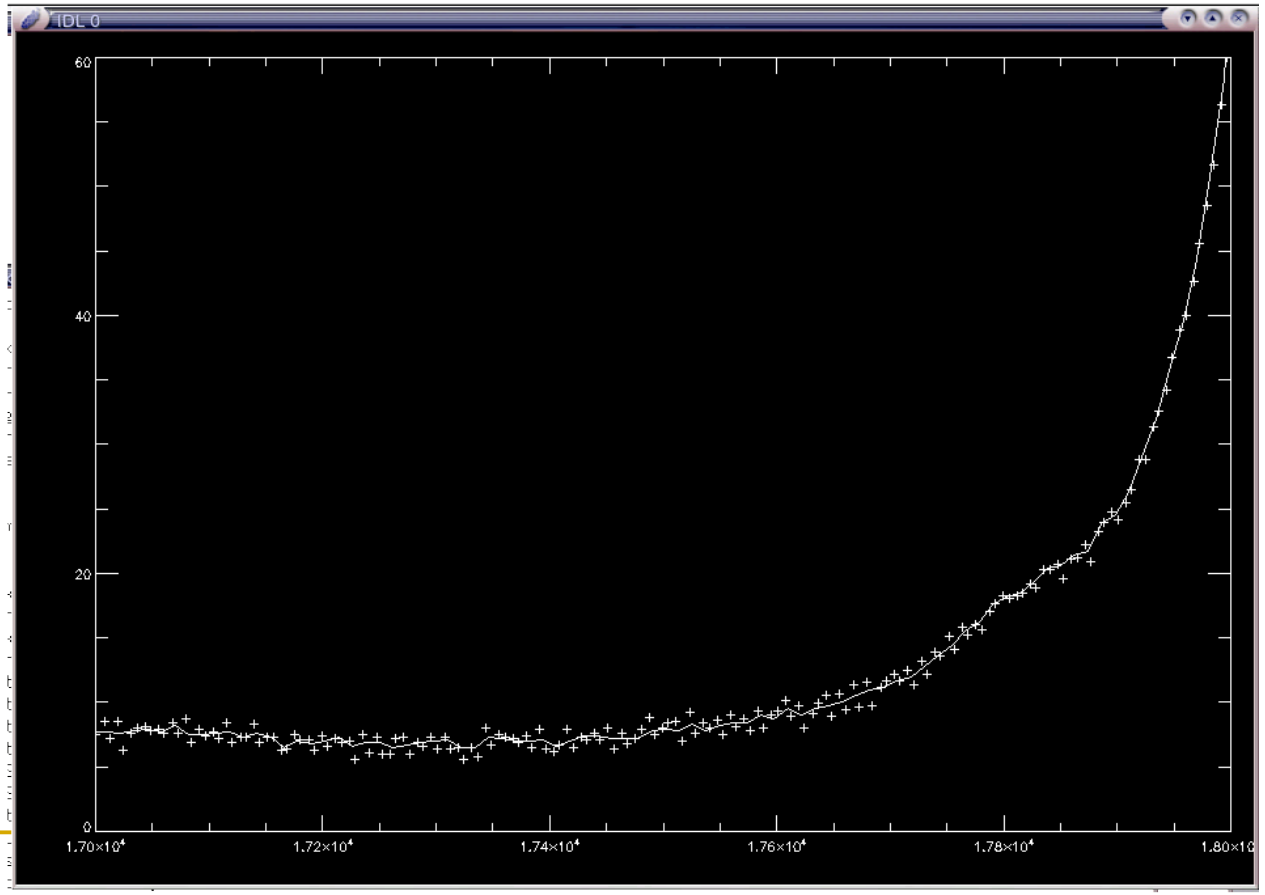
1. N_RAMP_DIV=value
   Each ramp is divided into this number.
2. /LOCAL_FLAT (,T_FLAT_START=value, T_FLAT_END=value)
   Produce a flat field by integrating the data for a given time range.
3. /TRANS_COR
   Correction of the drift after shutter close/open.
4. /SL_RMV
   Stray light removal with a very slow filter.
5. /SMOOTH_FILTER or /MEDIAN_FILTER (,WIDTH_FILTER=value) :
   High-pass filter with smooth or median function for a given time width.
6. BAD_THRSHLD=value
   Threshold for the bad-pixel rejection by checking the responsivity.
7. SIGMA=value
   Threshold for the bad-pixel rejection in the co-add process.
8. /PIX_MAPPING
   To produce a smooth image with finer pixel by the pixel convolution.
9. /SCUT
   To produce individual co-added images for all 4(2) scans of FIS01(02).

II-1. N_RAMP_DIV=value

- A ramp is divided into the specified number.
- Linear fitting is done for each sub-ramp.
- Useful to obtain finer grid image.

- Some artifacts may appear due to incompleteness of non-linear ramp correction.

Please check
" ***_ar.sav "
(processed
time series data)

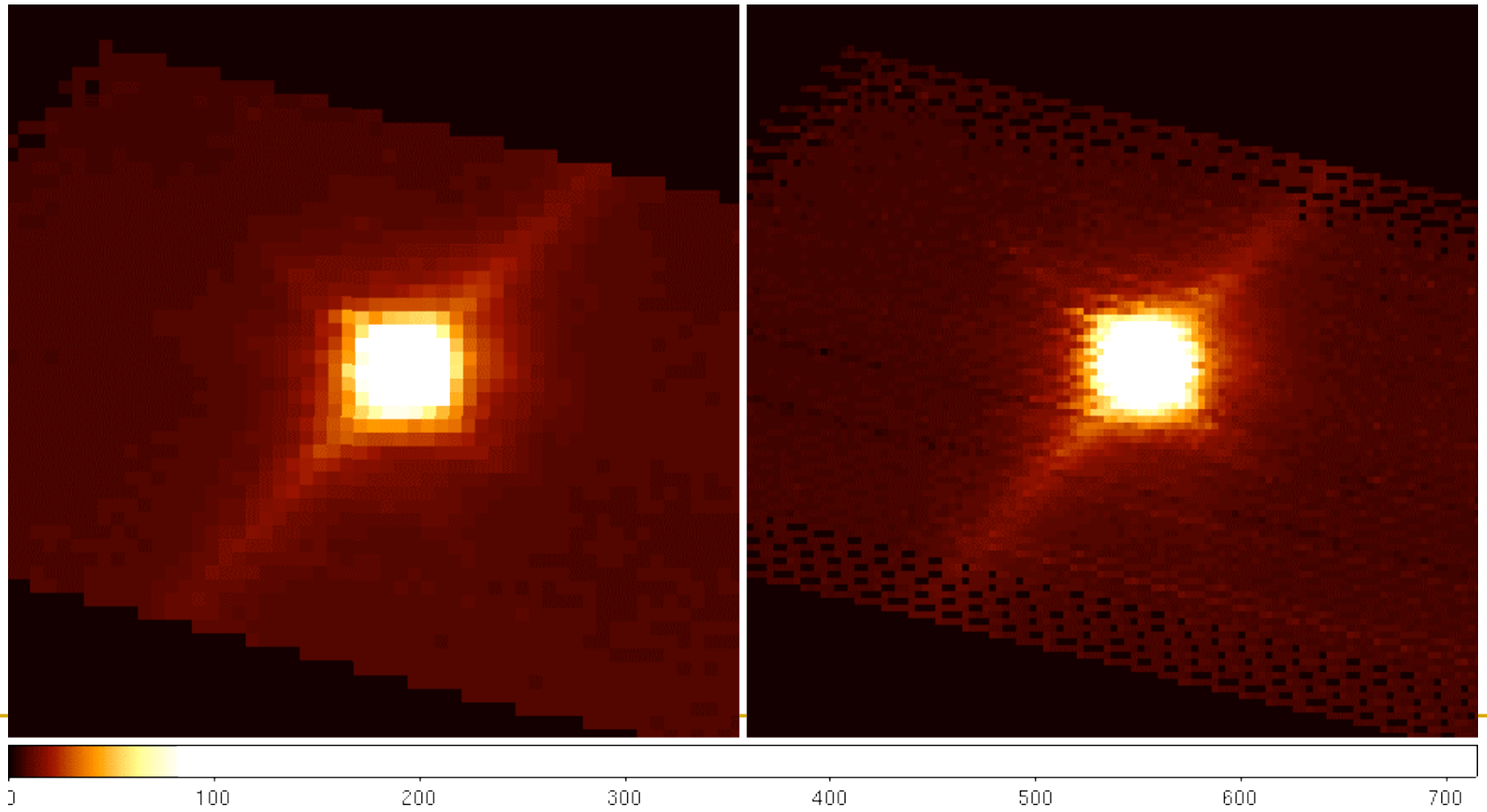


II-1. N_RAMP_DIV=value

- Finer image is obtained with and smaller GRID_SW/LW.
- To keep the redundancy, N_RAMP has to be larger corresponding to the grid size.

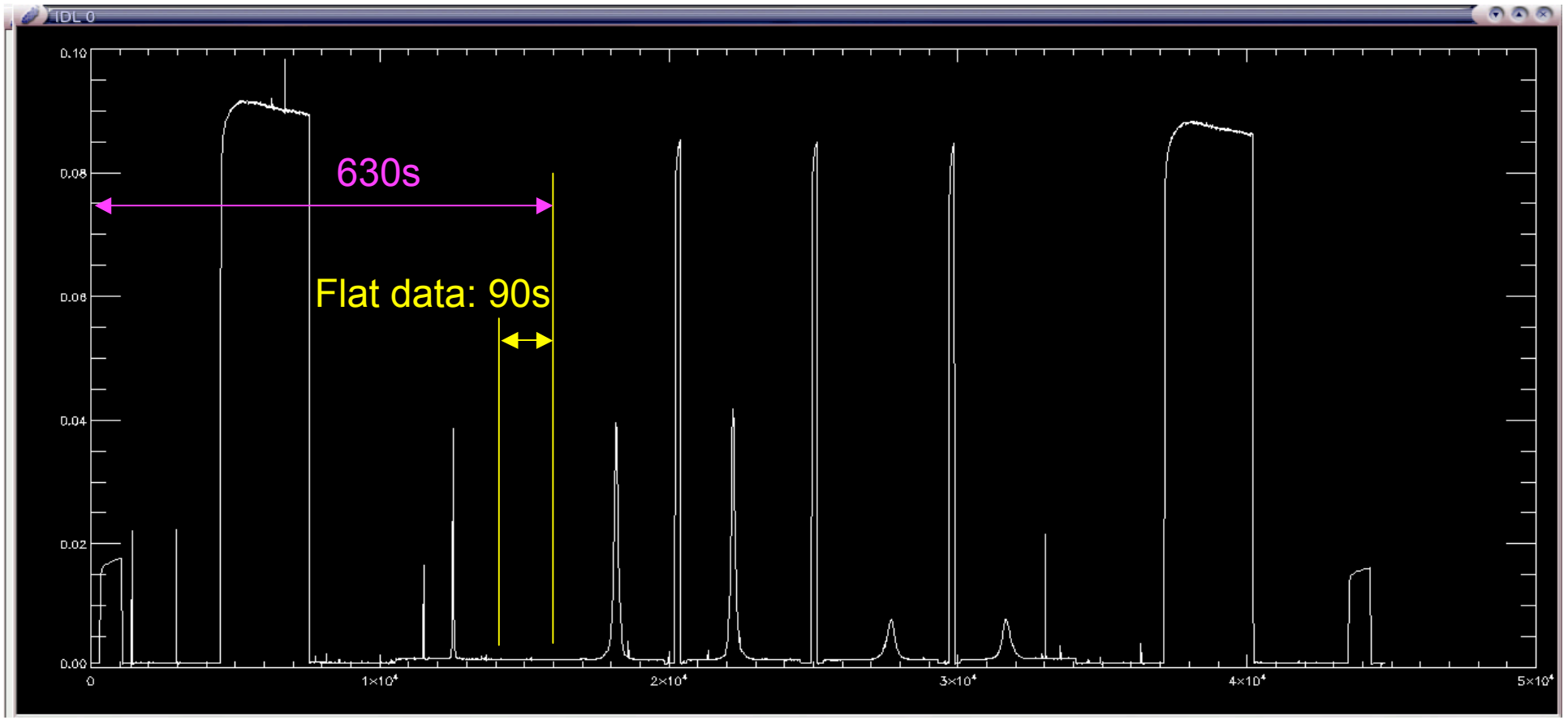
Default: N_RAMP=1, GRID_SW=15

N_RAMP=2, GRID_SW=7.5



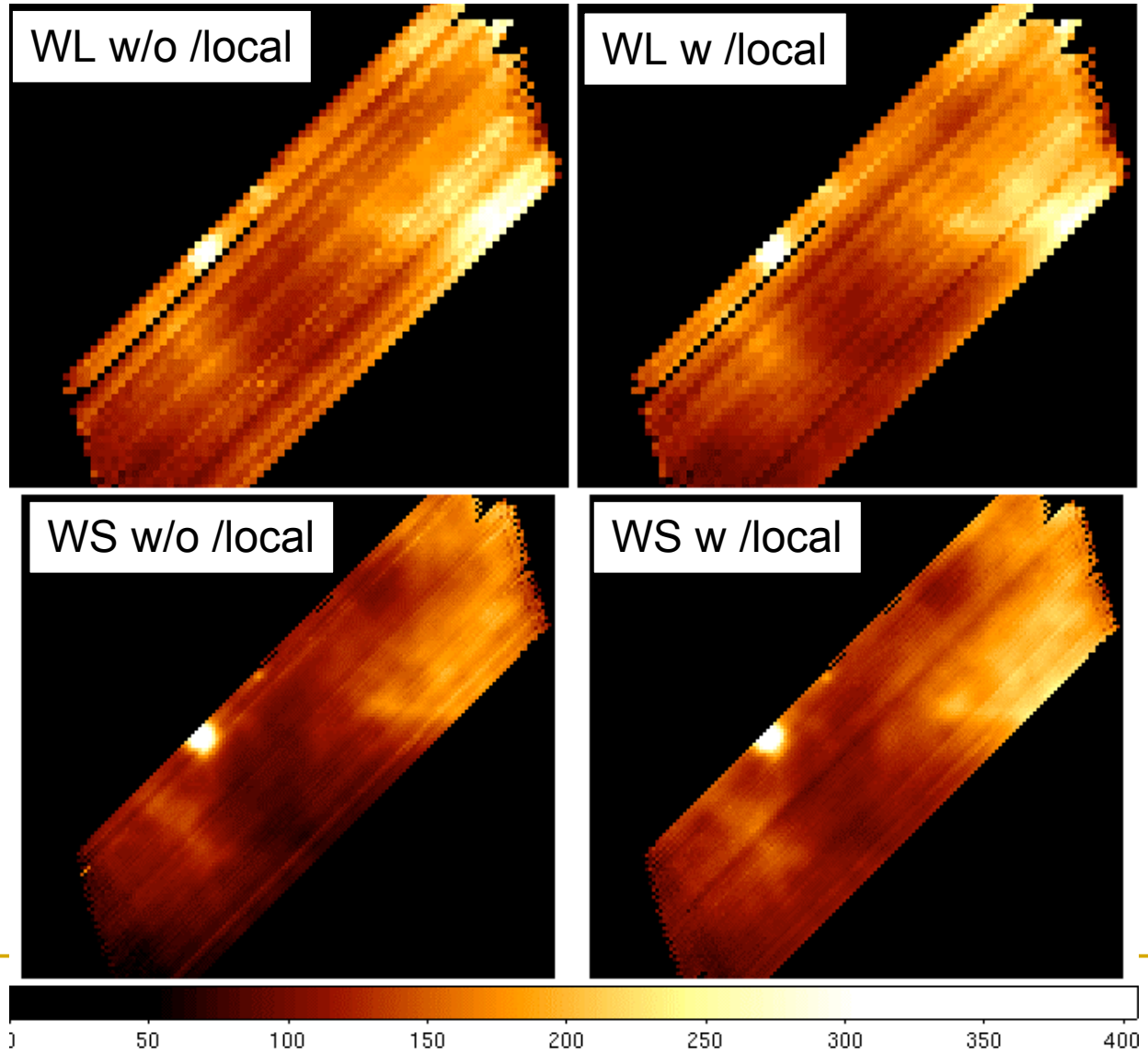
II-2. /LOCAL_FLAT

- A flat field is produced by integrating the data during the attitude settling time (after CAL sequence and before starting the scan).
- Time range used for the flat field can be specified as : T_FLAT_START=value and T_FLAT_END=value.
- Especially useful for dark sky.



II-2. /LOCAL_FLAT

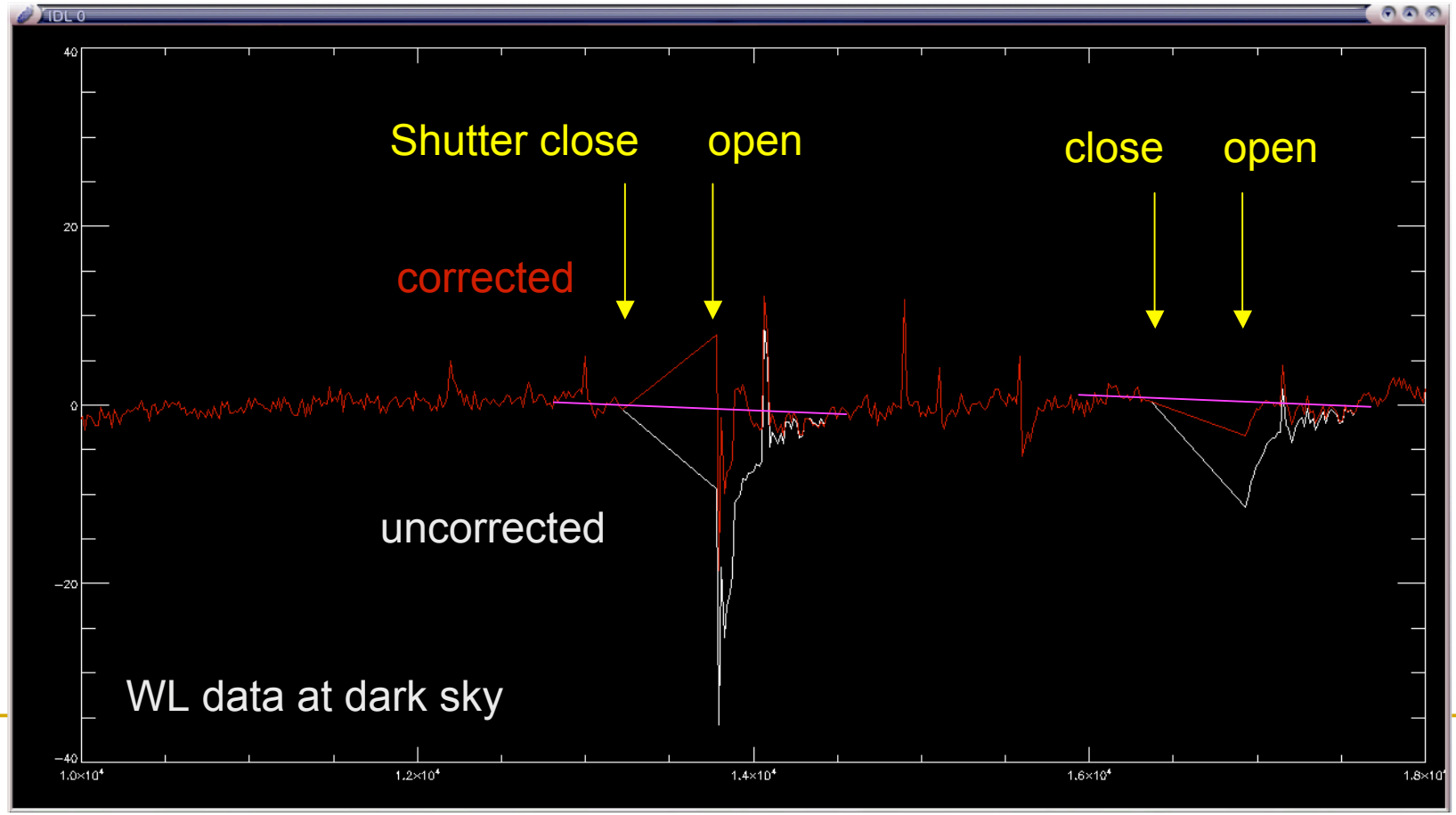
- /LOCAL option is effective to clean stripes.



II-3. /TRANS_COR

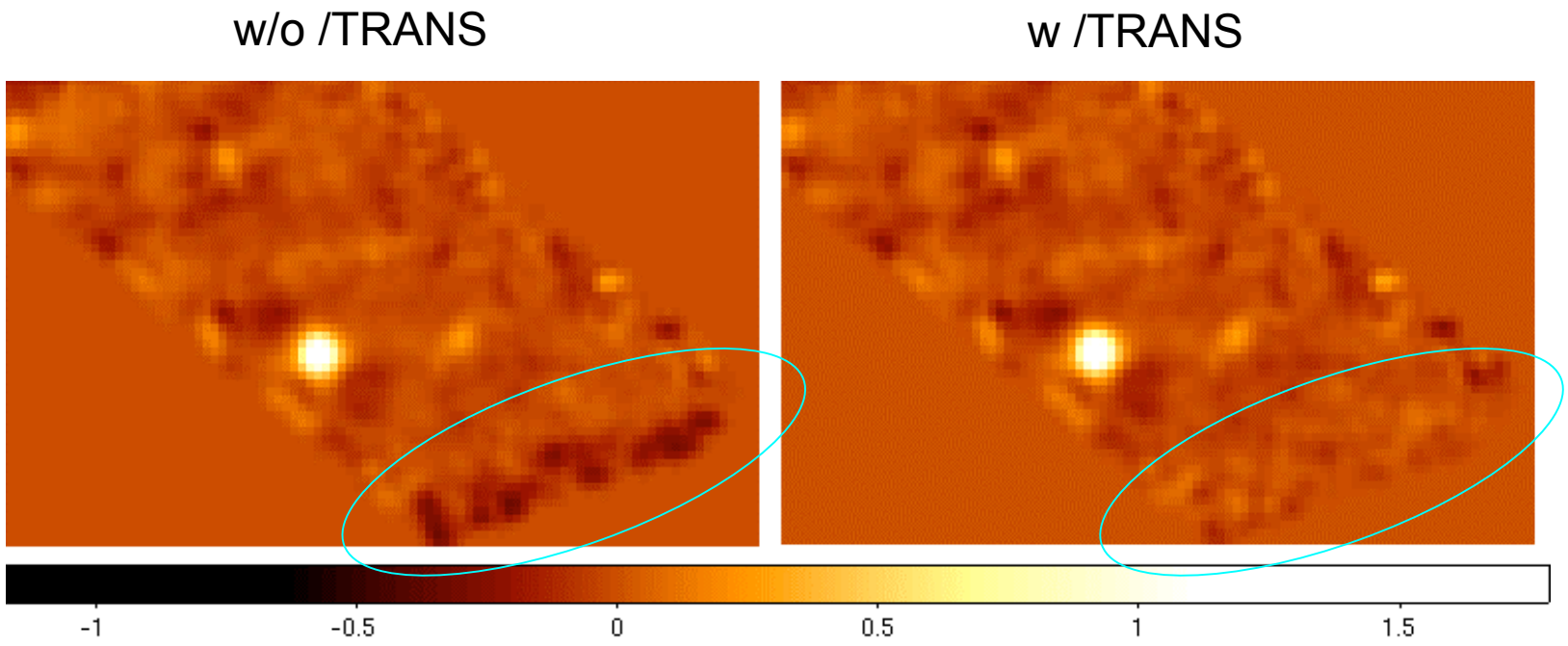
- Slow transient correction for the data after shutter close/open.
- Applicable in any observations, but failure of the correction may happen in some rare cases.

" ***_ar.sav "



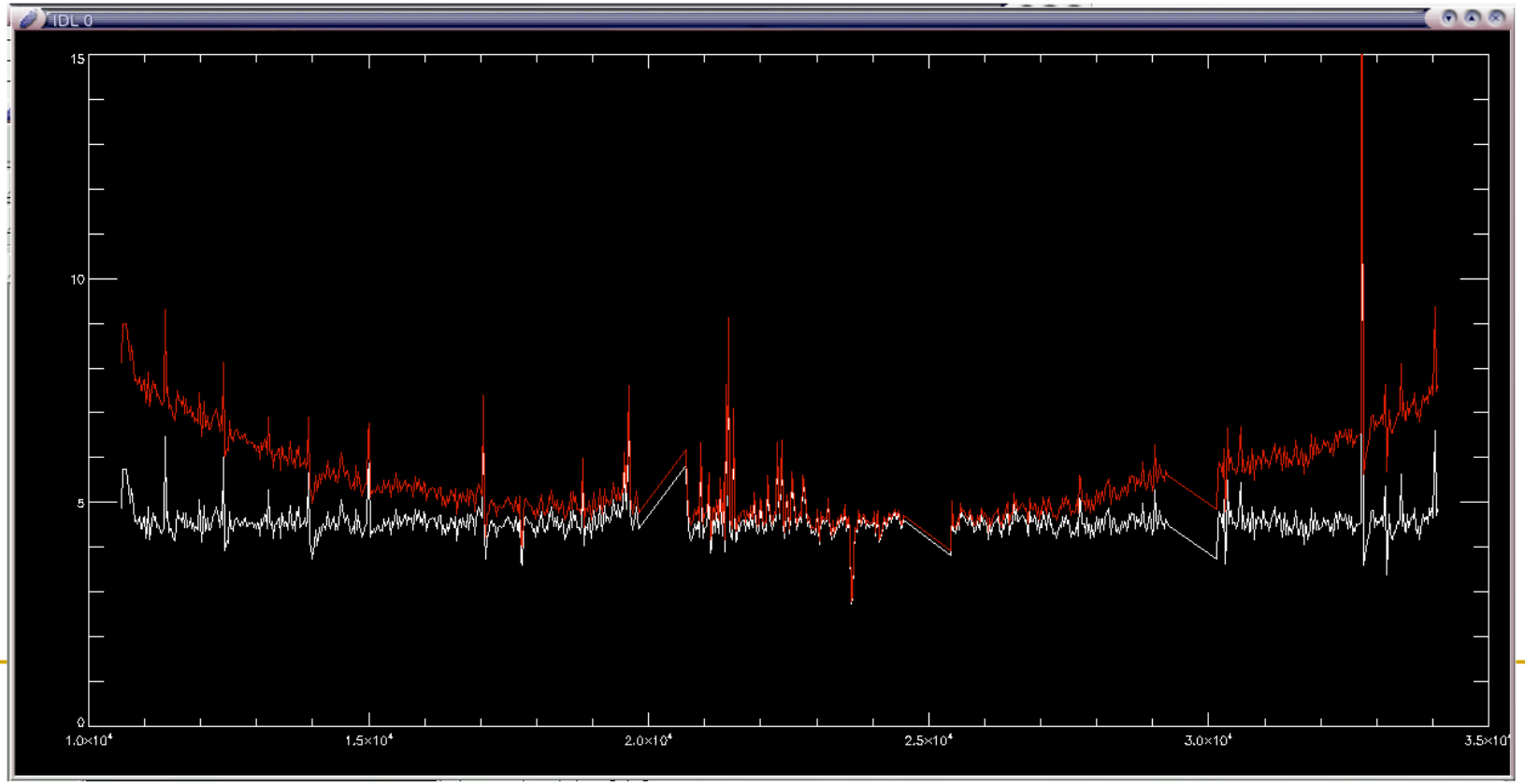
II-3. /TRANS_COR

- Useful for mosaic imaging which requires smooth connection between different observations at the edge.



II-4. /SL_RMV

- Stray light intensity depends on the earth avoidance angle (EAA).
- High-pass filtering but with a very long time constant (fixed to 90s).
- Minimum brightness during the observation at the maximum EAA is assumed to be “real” sky brightness.
  - If monotonic increase/decrease of signal exists, mean brightness around the maximum EAA is used as “real” sky brightness.

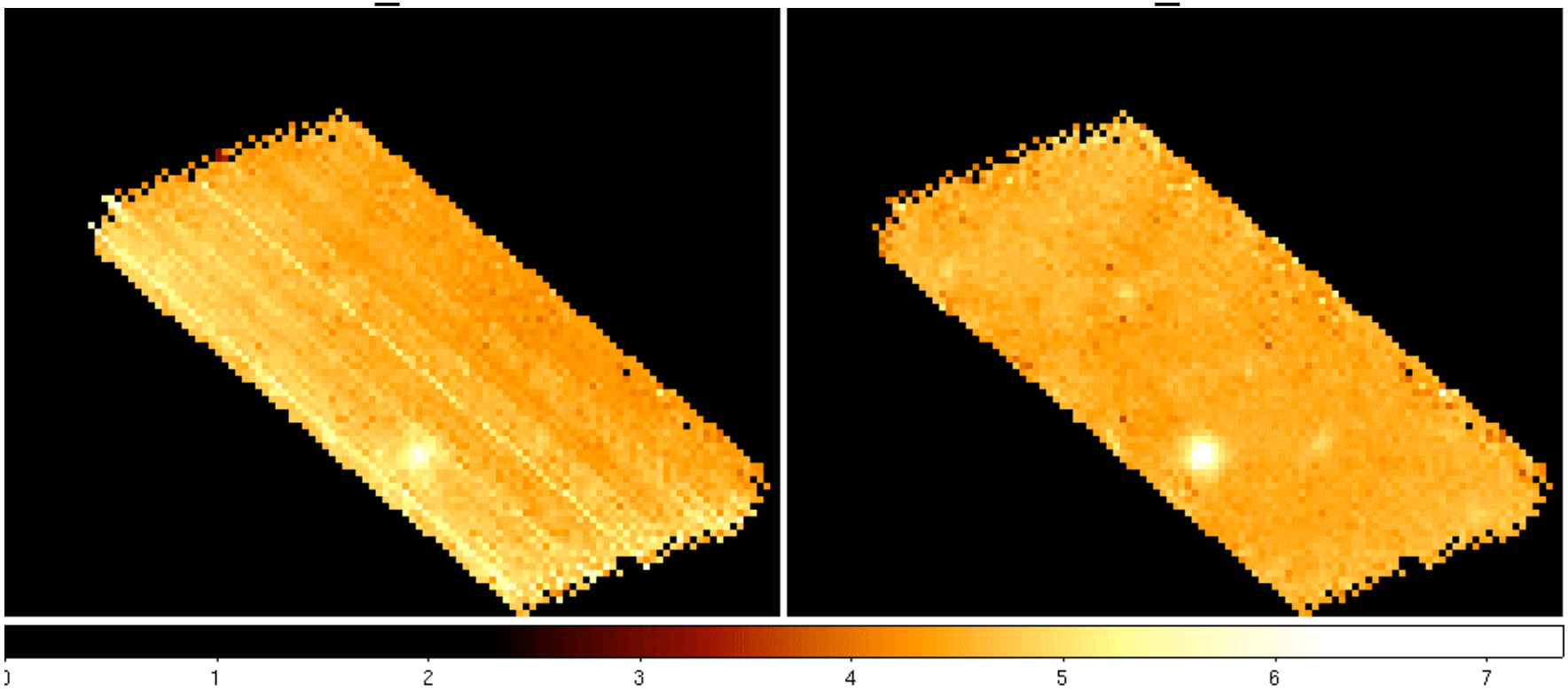


II-4. /SL_RMV

- WS data at dark sky (~5 MJy/sr)
- Stray light (max~3 MJy/sr) has non-negligible contribution.
- Co-addition of data including the stray light is awful.
- Applicable only for dark sky (<10 MJy) in general, or for compact source with a size smaller than (90s x scan-speed).

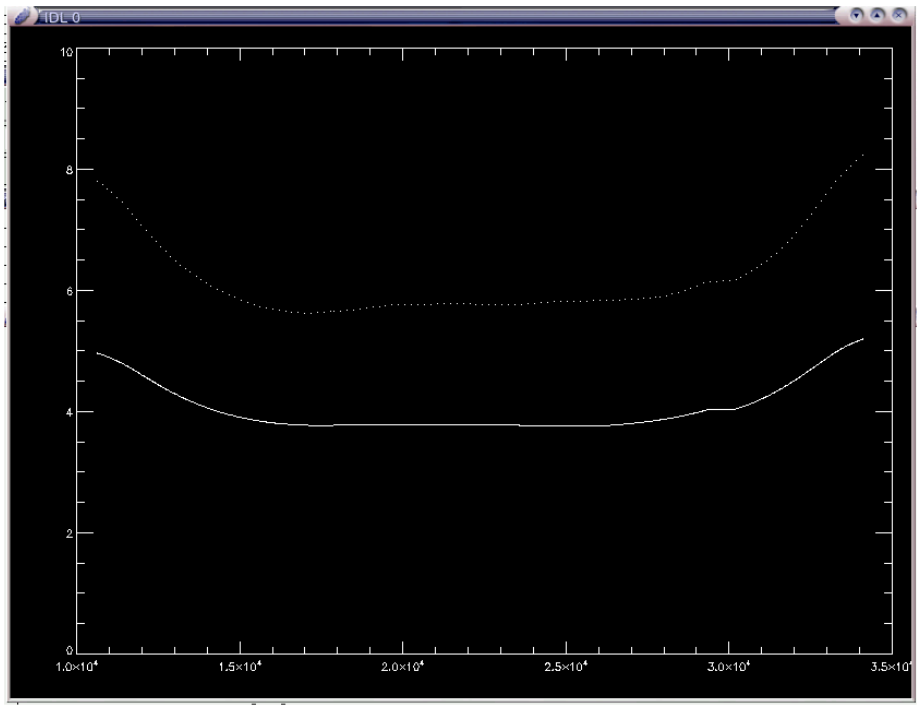
w/o /SL_RMV

w /SL_RMV

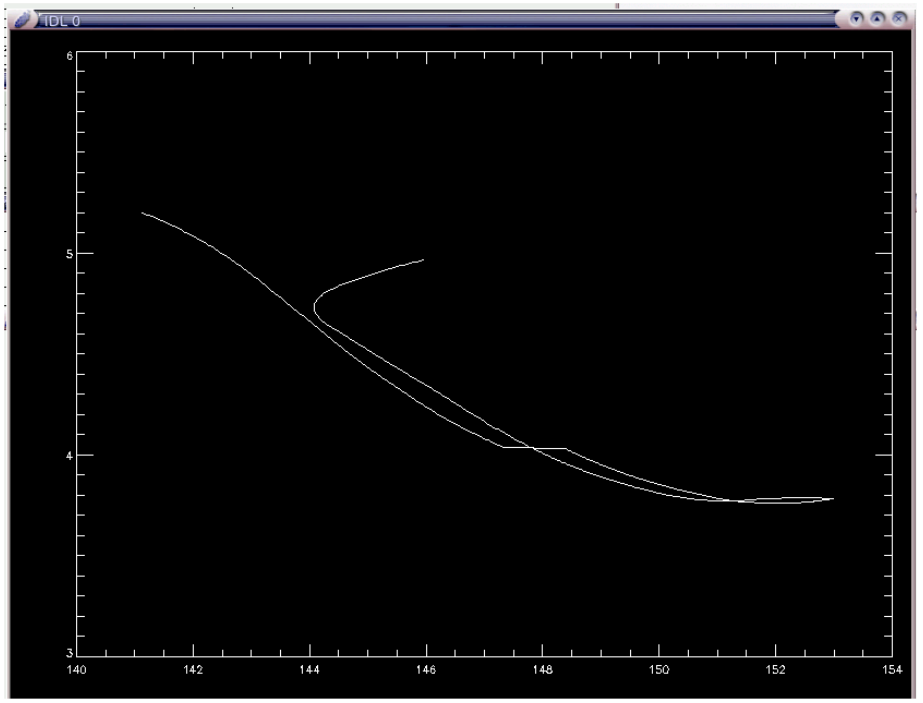


II-4. /SL_RMV

- Average intensity of the stray light as functions of time and EAA.
- This information is saved as “*_sl.sav”.



time



Earth Avoidance Angle

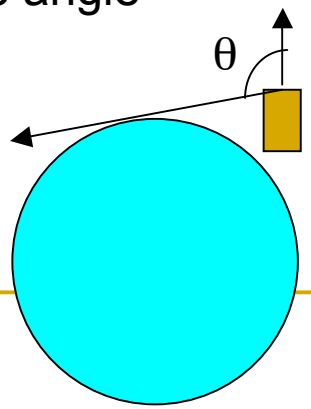
Another method of stray light removal

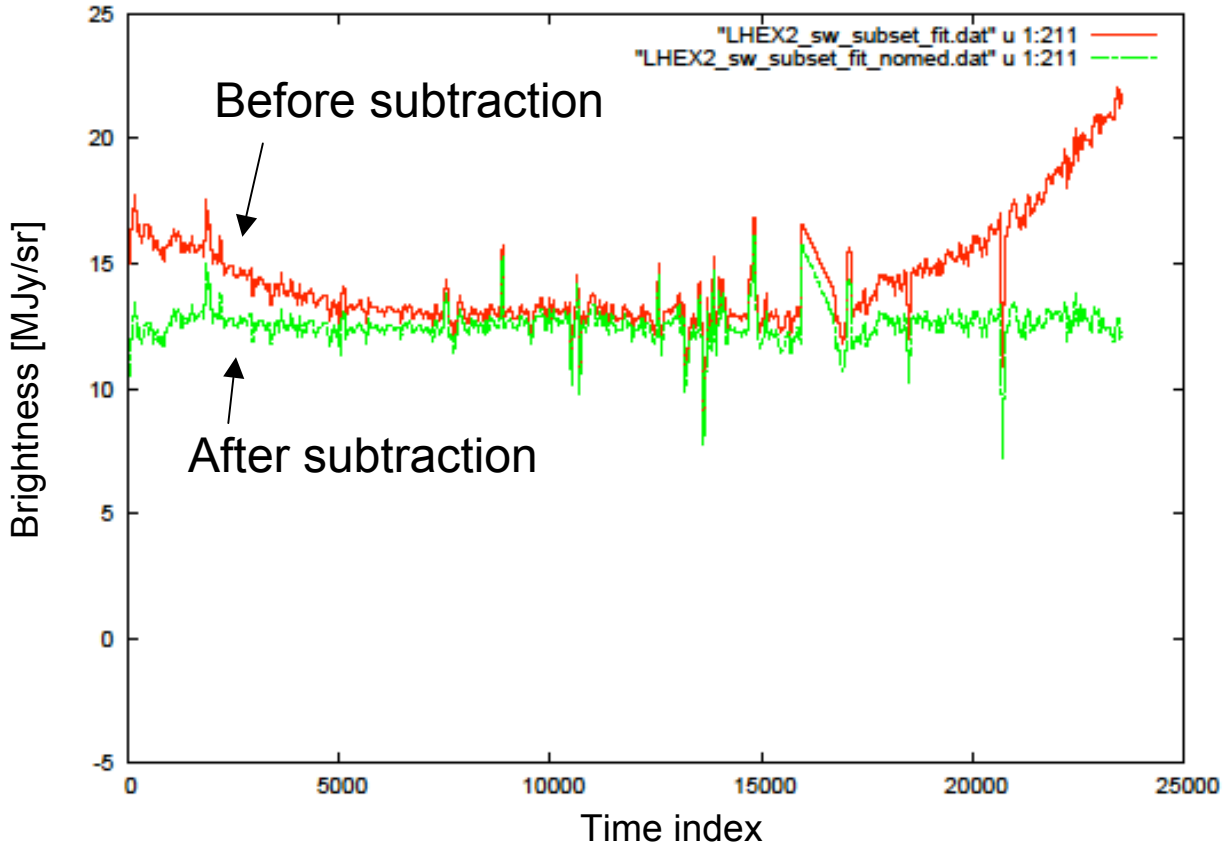
- Note that the use of /SL_RMV option is one of practical methods.
  - Development of more advanced method, modeling the stray light profiles as functions of EAA and satellite orbit, is in progress.

Baffle function is assumed to follow exp-law

$I = B + A*\exp[-(\theta/C)^2]$

I: total signal
B: sky background
A: fitting constant
θ: earth avoidance angle
C: scale angle

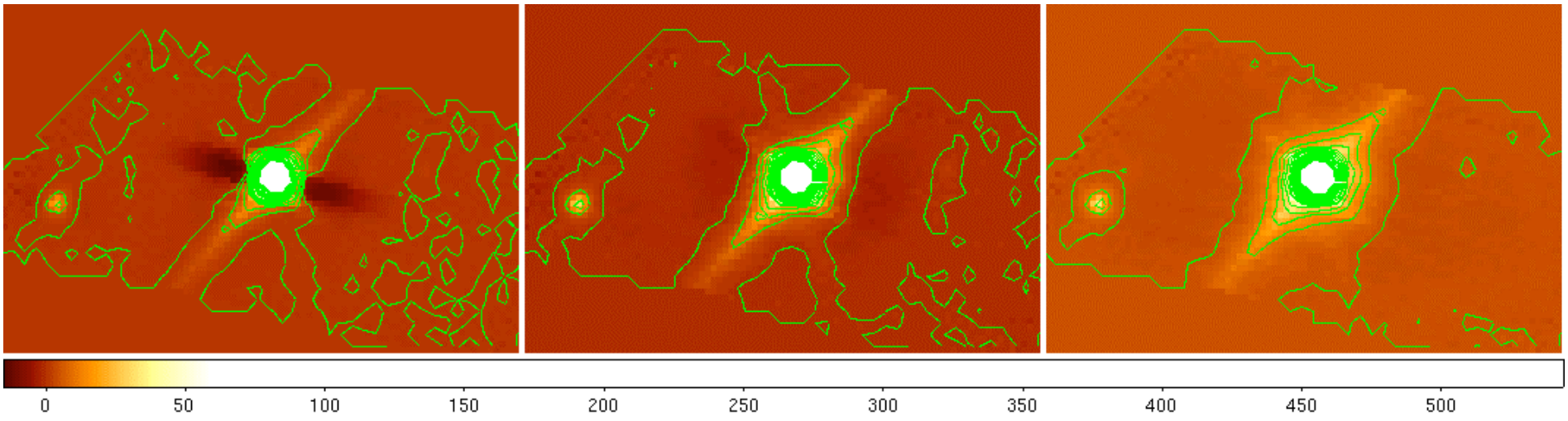




II-5. /SMOOTH_FILTER or /MEDIAN_FILTER

- High-pass filtering with a default/user-specified time constant as WIDTH_FILTER=value in [s].
- WIDTH_FLITER=40 by default.
- Sky background is subtracted.
- (WIDTH_FILTER x scan-speed) has to be larger than the size of the source of interest.

Width=20 Width=40 (default) Width=90 (same as SL_RMV)



Contour: 0-100 (every 5), peak ~550

II-6. BAD_THRSHLD

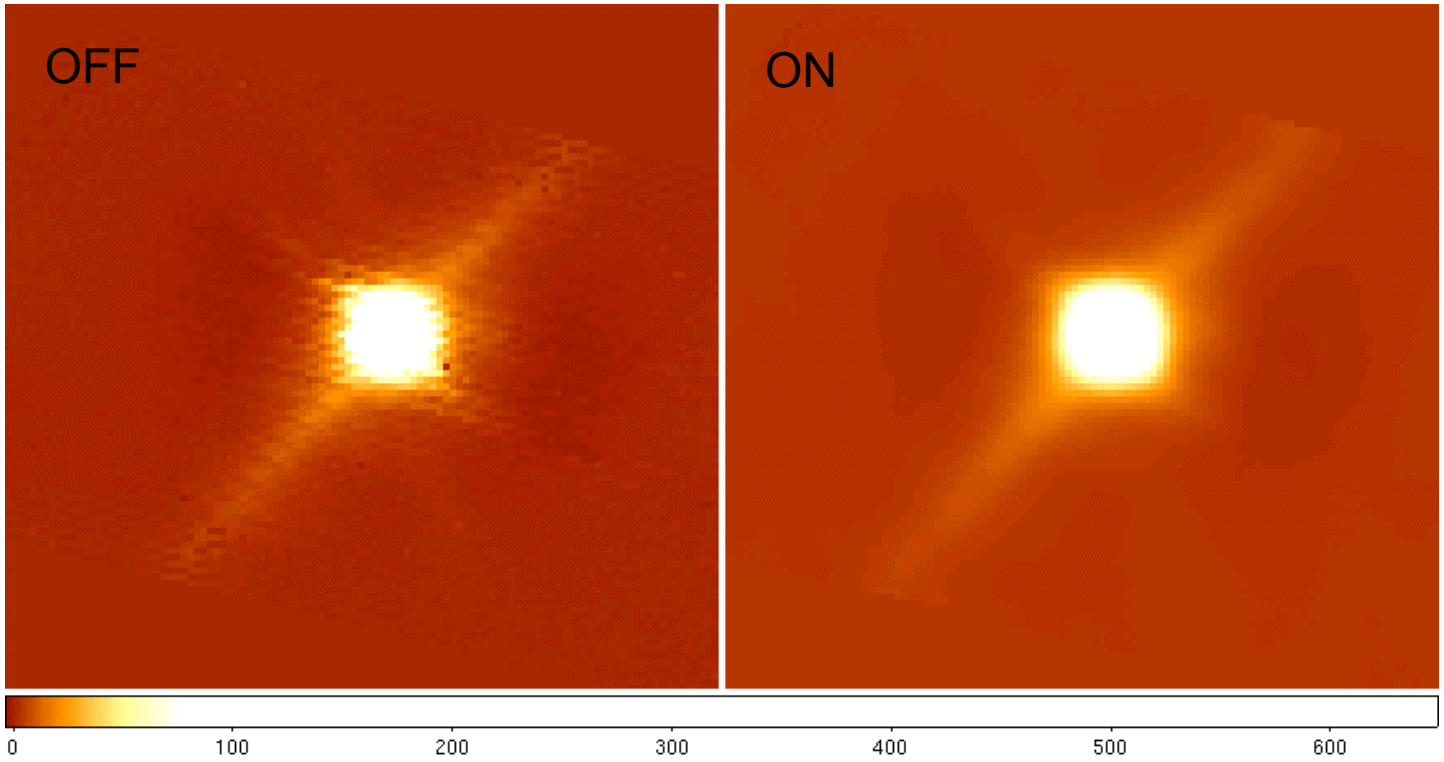
- Threshold for the bad-pixel rejection in a process of responsivity correction, as BAD_THRSHLD=value.
- After strong radiation events, the detector responsivity changes with a very long decaying time.
- Detector responsivity is checked by the CAL light measurements in the sequence.
- If the CAL signal of a certain pixel is stronger/weaker than the pixel-averaged CAL signal by a factor of BAD_THRSHLD, this pixel is removed from the as a bad pixel.
- BAD_THRSHLD may take any positive value.
- Default setting is a large value of 10, and this function is not effective.

II-7. SIGMA

- Threshold for the sigma clipping in the co-addition process, as SIGMA=value in [sigma].
- Default setting is SIGMA=2.
- User can specify smaller value, e.g. SIGMA=1.5, as far as number of non-rejected data points is sufficiently large.

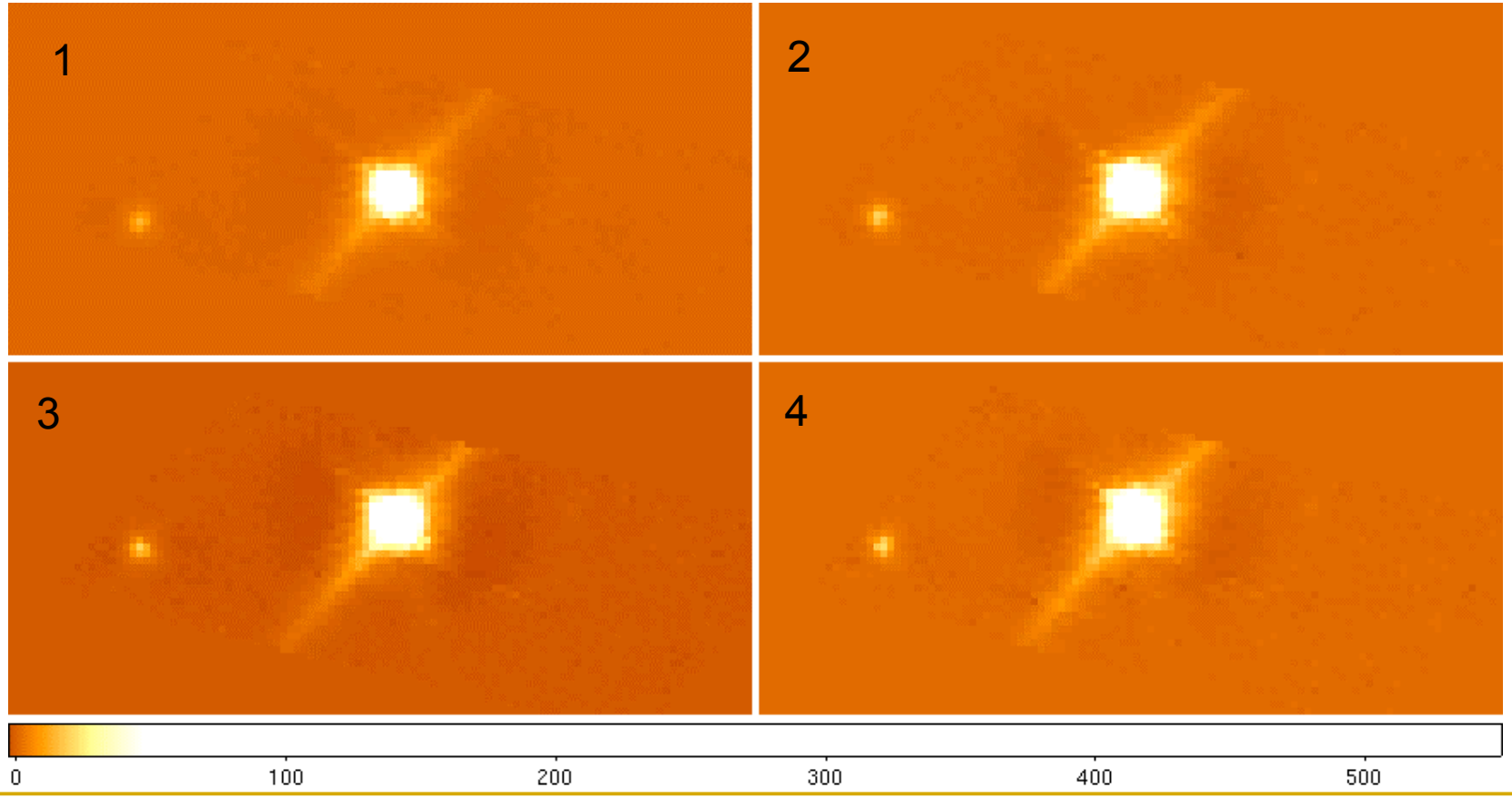
II-8. /PIX_MAPPING

- To produce a smooth image with finer grid by the pixel convolution.
- Note that, for too small grid size, most of the data may be rejected in the co-addition process; data with no redundancy are not allowed for current version of SS-tool.



II-9. /SCUT

- It produces individual co-added images for all 4(2) scans of FIS01(02).
- Useful to check the multiple viewing of a source.
- Outputs “FIS_*_[1-4].sav” and “FIS_*_[1-4]_[w|n].fits”



III. Recommended combination of options

Point source:

Bright (>10 Jy)

ss_run_ss, ‘dir’ (, /local, /smooth, width_filter = 90)

Isolated, medium (0.2 ~ 10 Jy)

ss_run_ss, ‘dir’, /local, /smooth, width_filter = 60 ~ 90

Faint source(s) (<0.2 Jy)

ss_run_ss, ‘dir’, /local, /trans, /sl_rmv, /smooth

Diffuse source:

Bright (>10 MJy/sr)

ss_run_ss, ‘dir’, /local, /trans

* T_flat_start/end should be specified for better flat

Faint (<10 MJy/sr)

ss_run_ss, ‘dir’, /local, /trans, /sl_rmv