The SPIRE Destriper

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on behalf of the SPIRE ICC

Introductory Notes

- This presentation reflects the status of the following configuration:
  - HIPE 9 (build 3054) with SPIA 1.9 and spire_cal_9_1.
- The HIPE version is a pre-release, but very close to HIPE 9.1 which will be used for archive re-processing.
- SPIA 1.9 is released.
- The calibration tree spire_cal_9_1 is released.

What does it do and why?

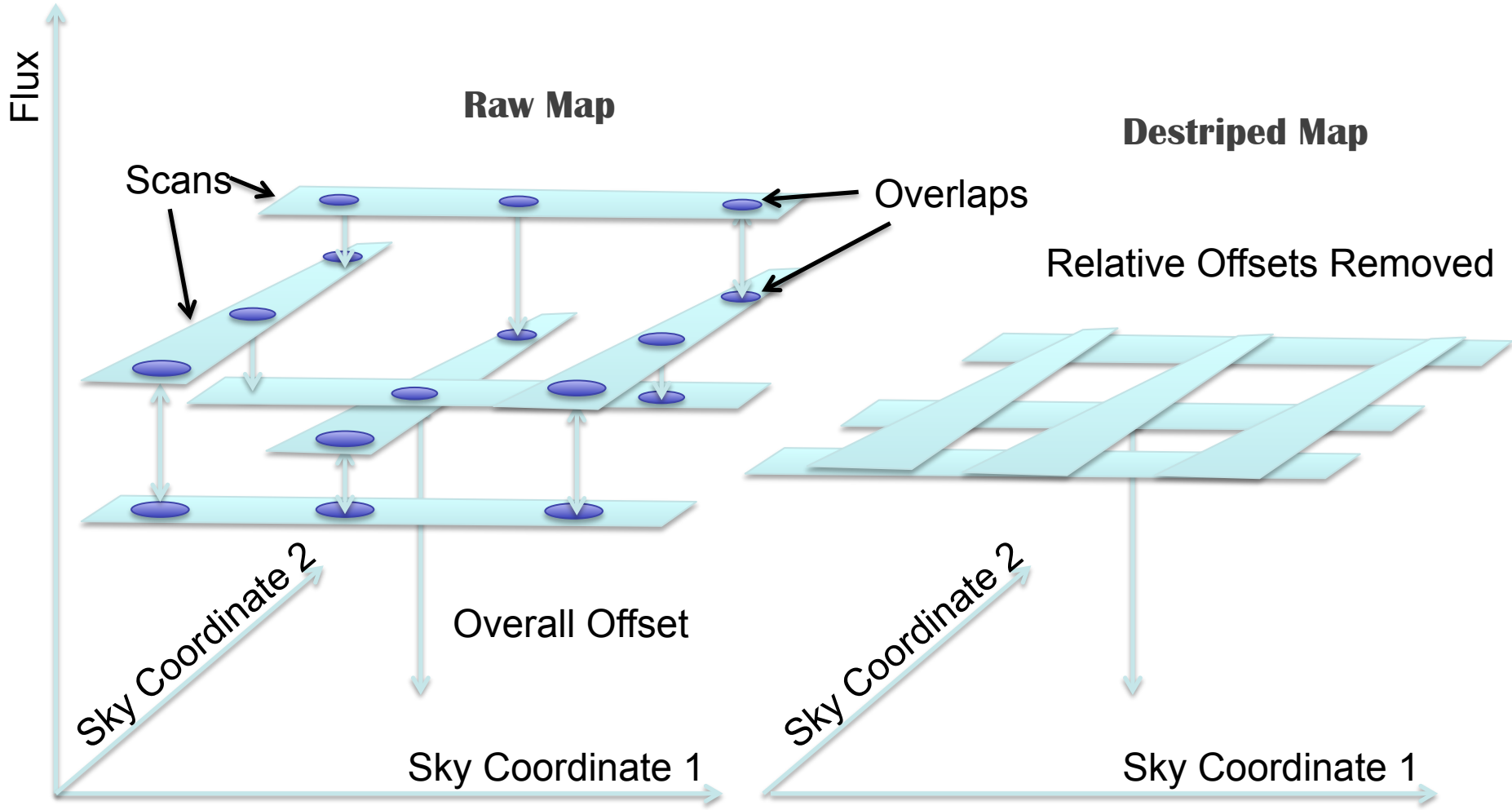
Signal Offsets

- Each SPIRE bolometer is at a different arbitrary offset level
- Dark sky measurements were used as a reference during signal linearization and flux calibration, but…
- Thermal drifts of telescope and instrument will still create offsets that vary with time, that are typically larger than astronomical signals, and can not be cast into a static calibration table.

A Mathematical Problem

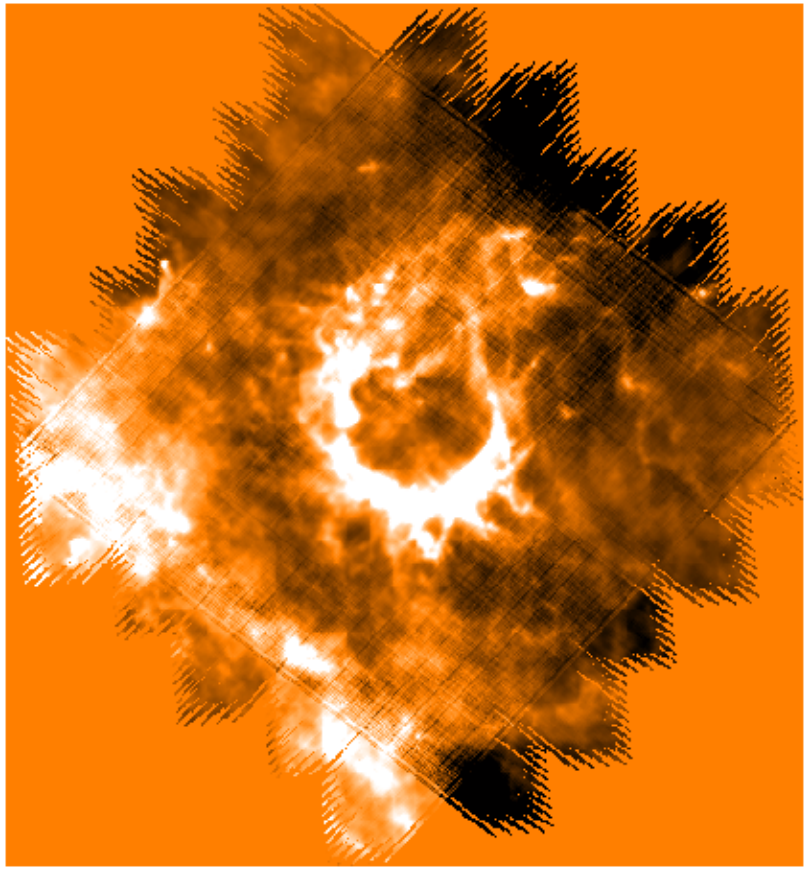
- The scans of different bolometers across the sky typically overlap in some positions.
- Each readout in a signal timeline S(t) is associated with a specific position on the sky.
- Positions in the sky where timelines of different detectors and scan directions cross, constrain the solution for the offsets sufficiently.

Overlaps Constrain Offsets

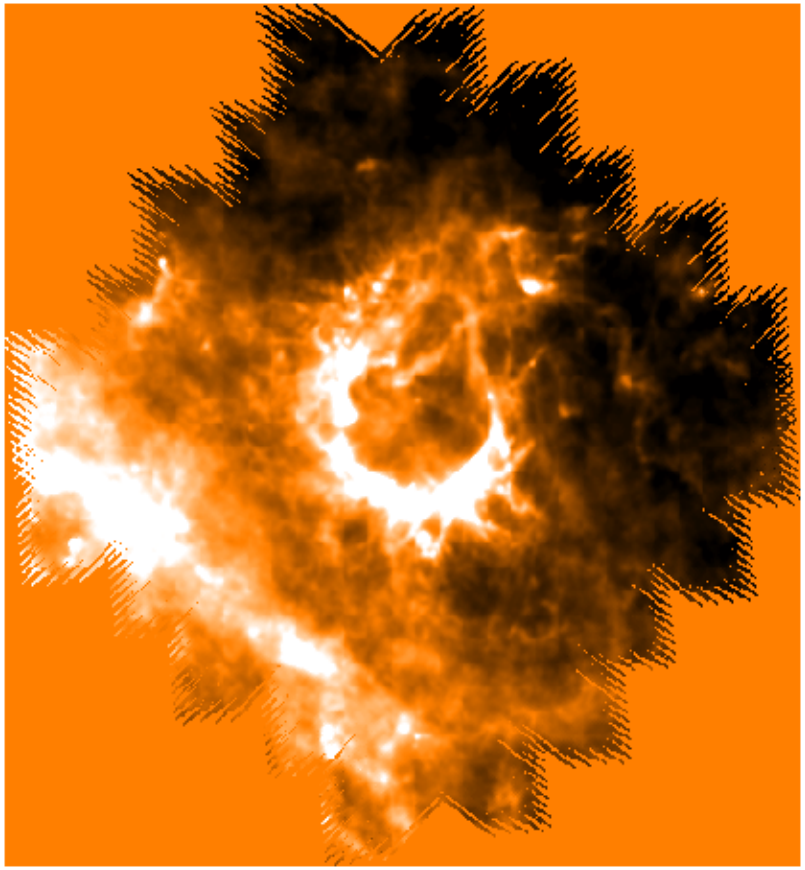


The Difference

Median Subtracted



Destriped



PSW

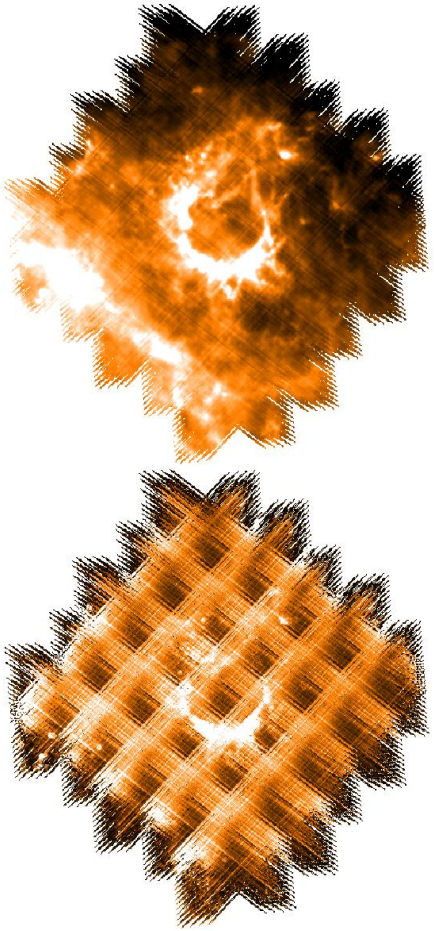
same cuts horizontally

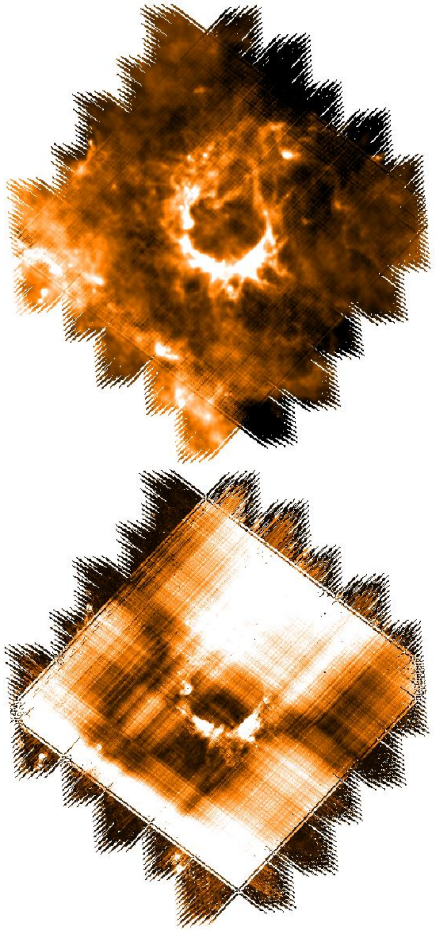
The Difference

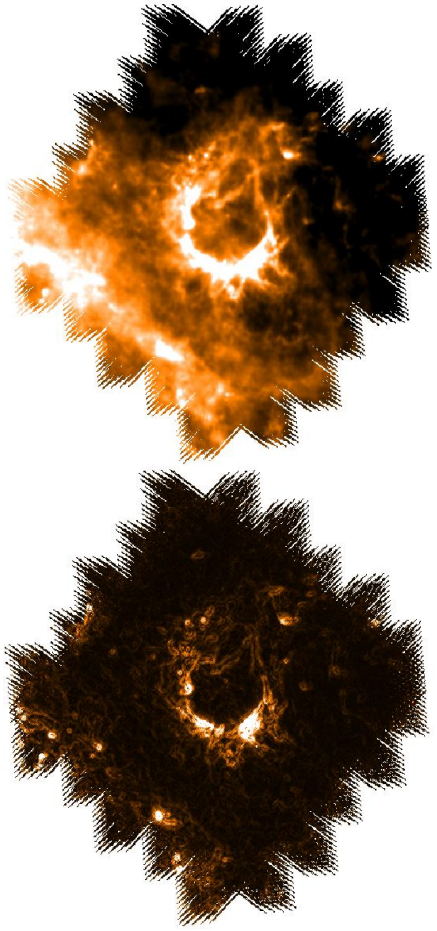
this is a bright image!

Image

Error Image







no treatment

median subtracted

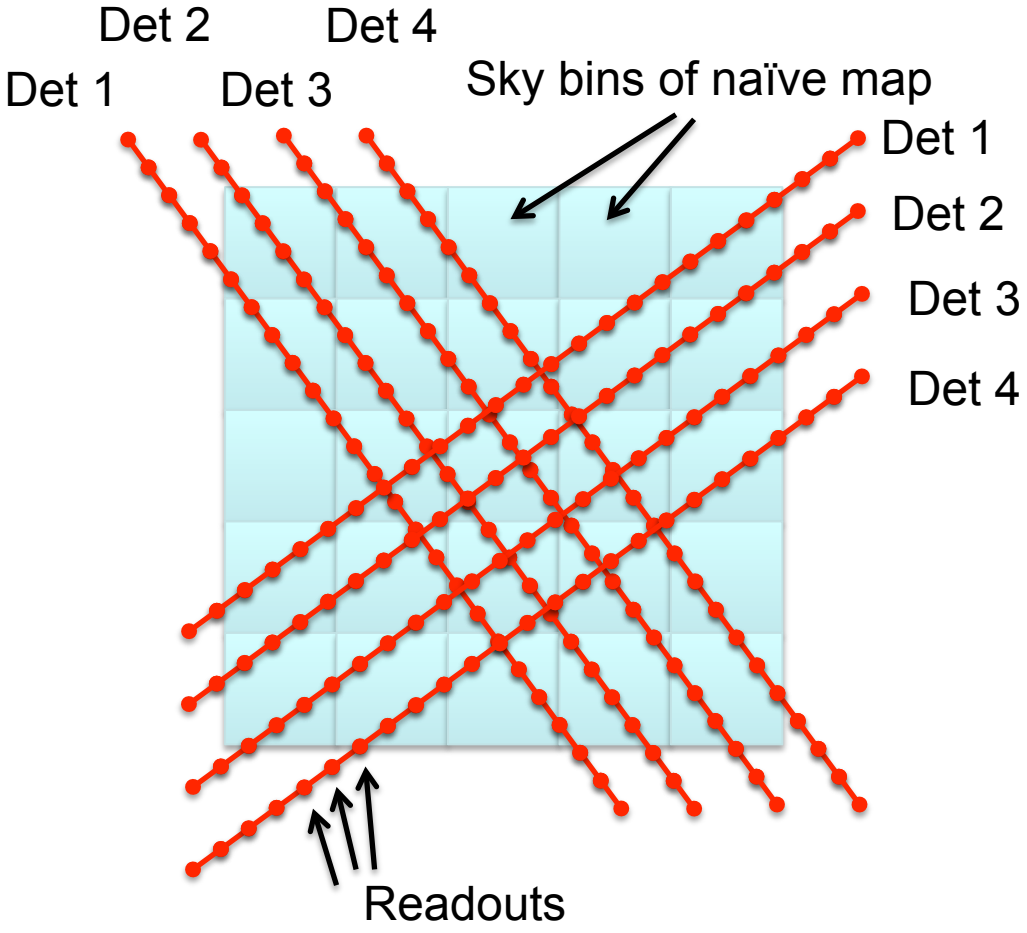
destriped

Basic Algorithm

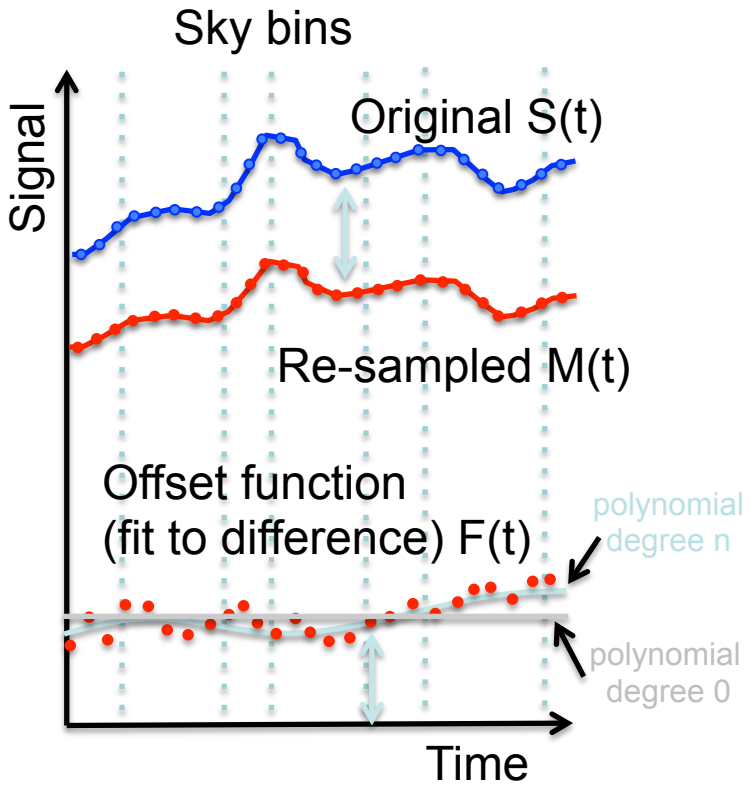
- Make first map.
  - Optionally start with median offsets
- Re-sample readouts within map.
- Compare each re-sampled signal timeline with the corresponding original timeline.
- For each timeline: Fit offset function to difference.
  - simplest case is zero order polynomial, i.e. an offset (default)
- Subtract fitted offset function from original timeline and make another map.
- Calculate χ^2 and continue with re-sampling step while difference between consecutive χ^2s is above threshold.
- These iterations actually converge by themselves.

Re-Sampling and Offset-Function

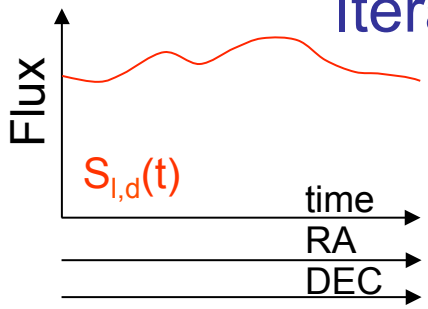
Scans projected on sky



Scans as signal timeline

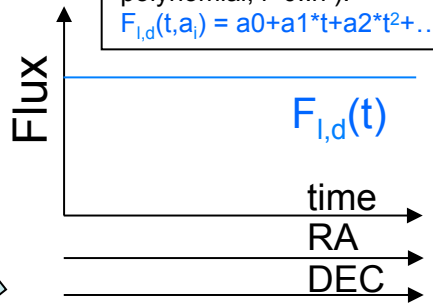


Iterative Baseline Remover ("Destriper")



Initial offset function $F_{l,d}(t)$ is polynomial with a0 set to median of $S_{l,d}(t)$ all other parameters are zero.

Fit Function (user choice is grade n of polynomial, i=0..n):
$F_{l,d}(t,a_i) = a0+a1*t+a2*t^2+\ldots$

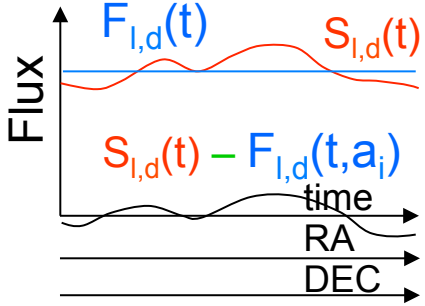


1. One for each detector (d)
2. One for each building block (l) or one for all building blocks (user choice). In the latter case the index (l) disappears.

(t) index for time
(d) index for detector
(l) index for each building block
(o) index for observation if level 1 products belong to more than one

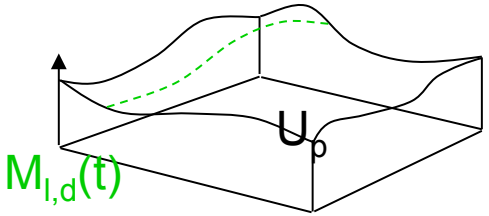
2nd Level Deglitcher

Exclude iteratively all readouts $S_{l,d}(t)$ with ABS($M_{l,d}(t) - S_{l,d}(t) + F_{l,d}(t)$) > $\sigma * \kappa$, where σ is the standard deviation of all readouts within the respective sky bin

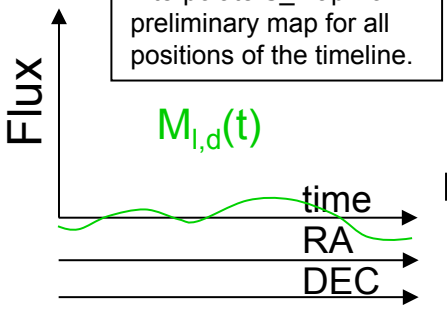


Take all difference timelines $S_{l,d}(t) - F_{l,d}(t)$ and make map U_p.

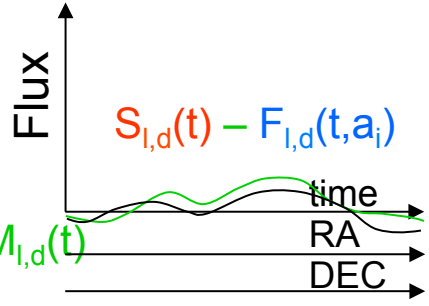
Preliminary Map



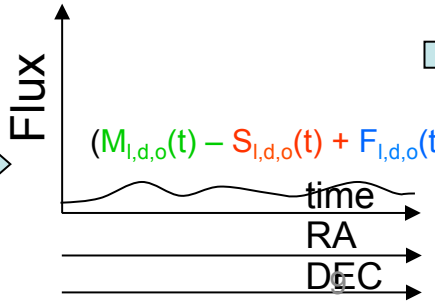
Interpolate S_map from preliminary map for all positions of the timeline.



Determine new set of a_0, a_1, a_2, … by fitting a new offset function $F_{l,d}(t,a_i)$ to the difference $S_{l,d}(t) - M_{l,d}(t)$.



Determine $\chi^2_{d,l,o}$ = sqrt(sum_t($M_{l,d,o}(t) - S_{l,d,o}(t) + F_{l,d,o}(t,a_i)$)^2) for each scan and detector. Mark scan converged if $\chi^2_{new} - \chi^2_{previous}$ < threshold



All scans converged?

No

?

Yes

End

Destriper Features

Input

- Polynomial offset function selection
- Iteration limit by number and c2 threshold
- Choice between per-scan and full-observation timelines
- Option to start with median offsets (default)
- Level 2 deglitcher with repeat control
- Bright source exclusion (default)
- Sky bin size control
- Weighted fitting (under development)
- TOD output control
- Start parameter feedback from diagnostic product
- Temporary pool control
- Thread Control
- Level 2 deglitcher two threshold algorithm
- Level 2 deglitcher: Iteration control within one destriper step

Output

- Offset subtracted Level 1
- Reconstructed map
- Diagnostic product
- TOD
- Difference timelines

Destriper Default GUI (HIPE 9)

Level 1 context *
Array to work on *
Pixel size
TOD input (optional)

* mandatory parameters

Minimum scan velocity
Maximum scan velocity

Destriper max. repeat
$\Delta\chi^2$ threshold

Offset function size
Polynomial degree
Start parameter
Median start parameter
Weight fitting switch

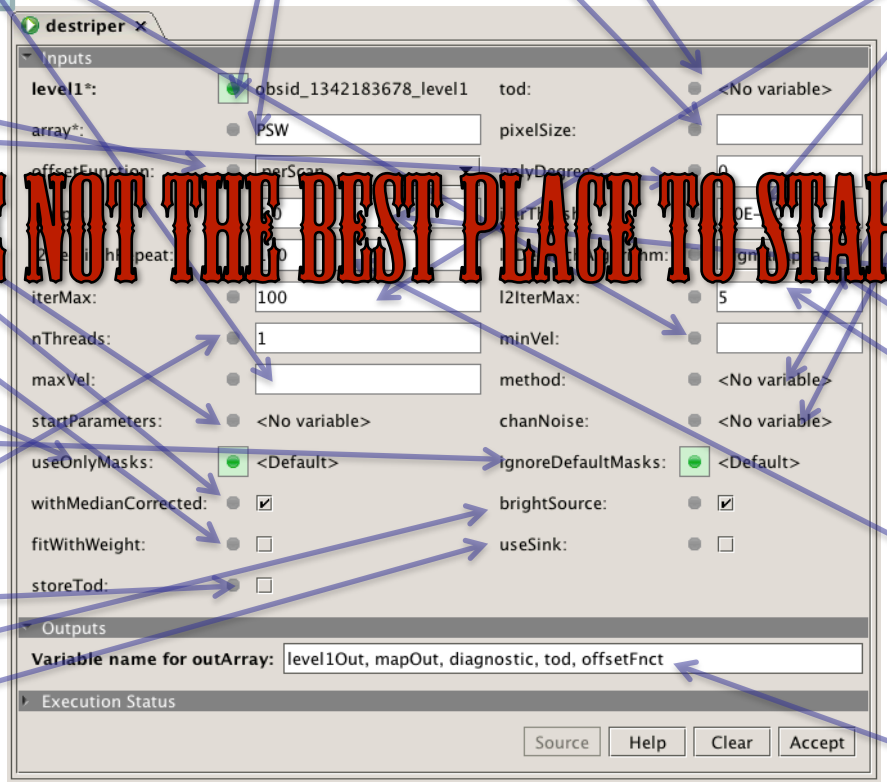
Mapping method
Noise calibration file

MAYBE NOT THE BEST PLACE TO START!!!

L2 deglitcher threshold
L2 deglitcher algorithm
L2 deglitcher iterate max.
how often to iterate in one deglitcher run
L2 deglitcher repeat
After how many destriper iterations to run deglitcher

Mask flags to ignore
Modify mask selection

Number of threads
Provide TOD switch
Bright source switch
Temporary store switch



Output is 5 element array

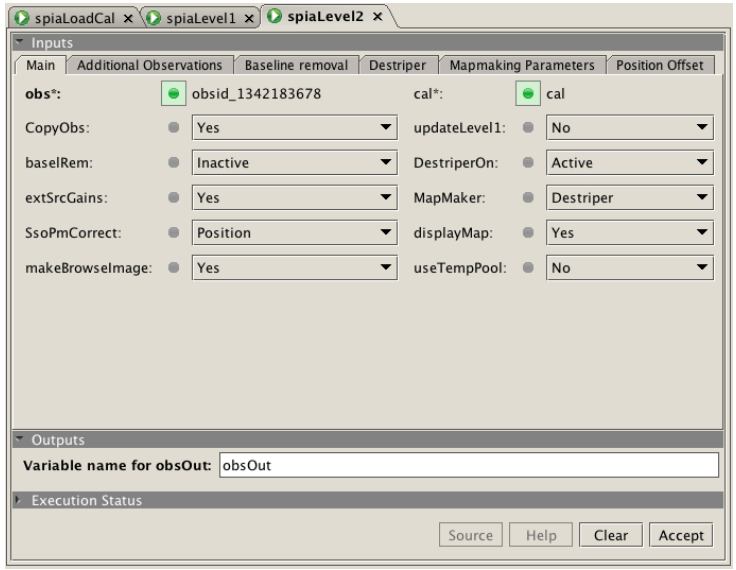
General Remarks

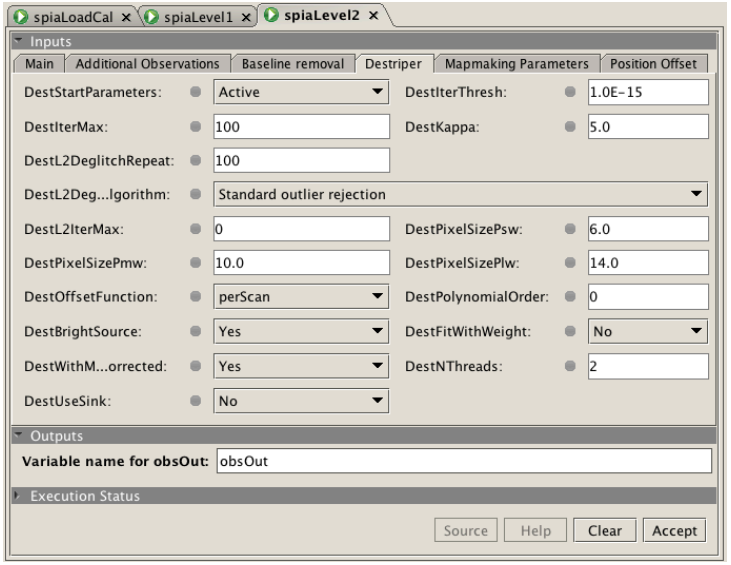
- The destriper is a complex tool to use.
- The destriper is still under active development.
- More improvements will be added.
- We tried to make the current (HIPE 9) version more accessible through integration into SPIA.
- Generally the destriper will already perform very well without touching any of the parameters.
- Many parameters are there just to help calibration scientists improve the tool.
- Parameters to play with:
  - Map Quality:
    - pixelSize, brightSource, withMedianCorrected, minVel, maxVel, startParameters, offsetFunction, polyDegree
  - Performance:
    - nThreads, useSink, tod/storeTod

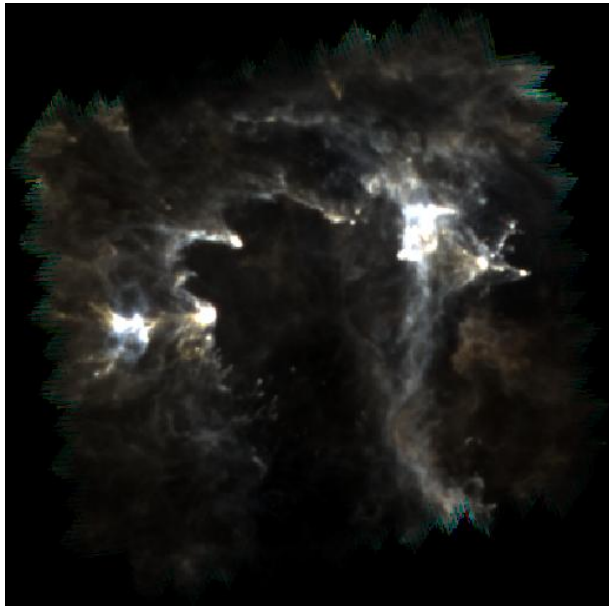
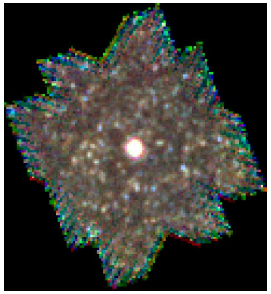
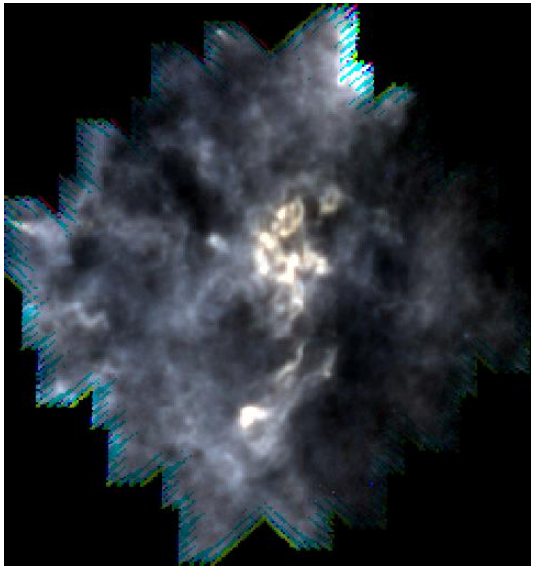
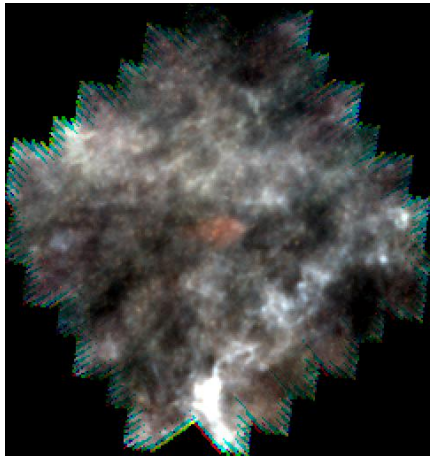
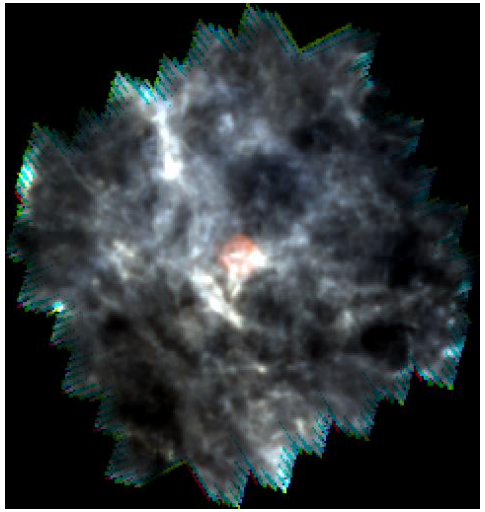
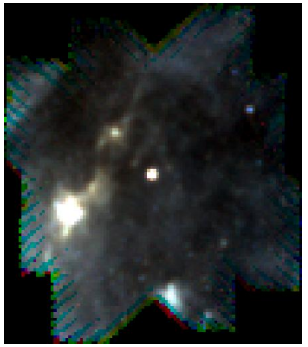
Destriper in SPIA 1.9 (HIPE 9)

- By default active and using the last destriper map as final map. Optionally other map makers can be used after destriping.
- Baseline remover is off by default but can be run before the destriper.

- All three arrays will run sequentially.
- Pixel sizes can be set independently for destriper.
- Destriper attaches diagnostic products to Level2 context.
- DestStartParameters is active by default and will use diagnostic products if available in previous Level 2. In this case the parameters and flags are used as new start parameters and for scan selection.





Further Reading

- Destriper Homepage
  - https://nhscsci.ipac.caltech.edu/sc/index.php/Spire/PhotScanMapDestriper
- SPIRE Data Reduction Guide
  - http://herschel.esac.esa.int/hcss-doc-9.0/load/spire_drg/html/spire_drg.html
- SPIRE instrument and calibration web pages
  - http://herschel.esac.esa.int/twiki/bin/view/Public/SpireCalibrationWeb?template=viewprint
- SPIA Homepage
  - https://nhscsci.ipac.caltech.edu/sc/index.php/Spire/SPIA