SPIRE Photometer Map Making

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on behalf of the SPIRE ICC

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  - Destriper (minimizing stripes iteratively, pipeline default)
  - Median baseline remover
  - Polynomial baseline remover

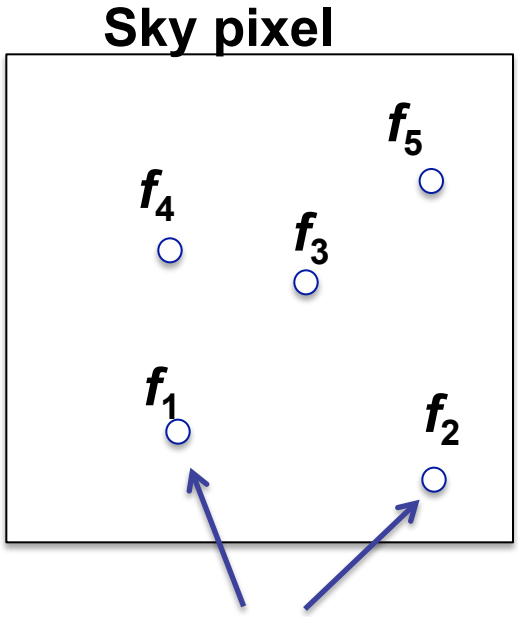
- Mapmakers:
  - Naïve Mapper (a simple mapper, used in Destriper)
  - MADMapper (more complicated, but not better)

SPIRE Naïve Mapper

Two options:

(1) **No weighting**: Flux of a sky pixel is the **simple average** of all signal samplings (by all detectors) in the pixel:

$$f_{pixel} = \frac{\sum_i^n f_i}{n}, \qquad error_{pixel} = \sqrt{\frac{\sum_i^n (f_i - f_{pixel})^2}{n(n-1)}}$$



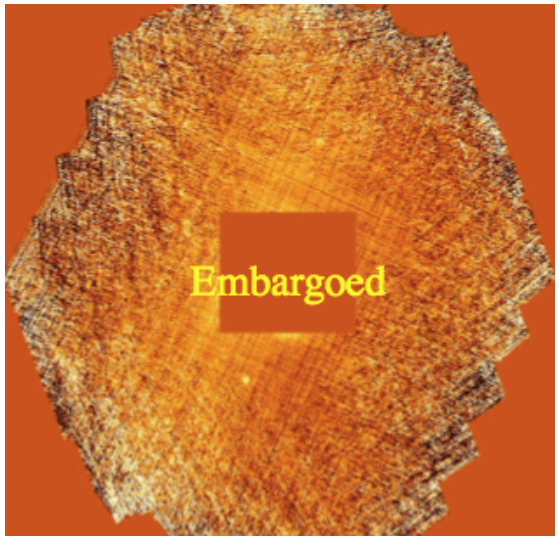
(2) **Inverse variance (of instrument noise) weighted:** Flux of a sky pixel is the **inverse variance weighted mean** of all signal samplings in the pixel, the variance is calculated using the white noise of the detector with which a given sampling is taken:

$$f_{pixel} = \frac{\sum_i^n f_i/\sigma_i^2}{\sum_i^n 1/\sigma_i^2} \qquad error_{pixel} = \sqrt{\frac{\sum_i^n (f_i - f_{pixel})^2/\sigma_i^4}{\left(\sum_i^n 1/\sigma_i^2\right)^2 - \sum_i^n 1/\sigma_i^4}}$$

MADMapper

- A mapper originally developed for the CMB measurements (MAD: Microwave Anisotropy Dataset).
- The algorithm is FFT based.
- Strength: Minimize stripes due to uncorrelated detector drifts ("1/f noise").

Example (taken from an earlier talk of PACS team): Naïve map of a PACS observation

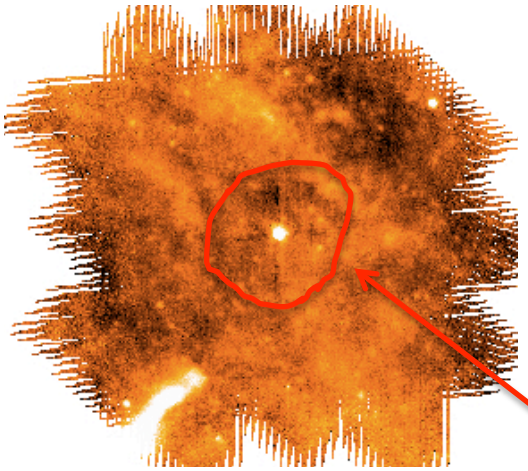


MADmap of the same observation

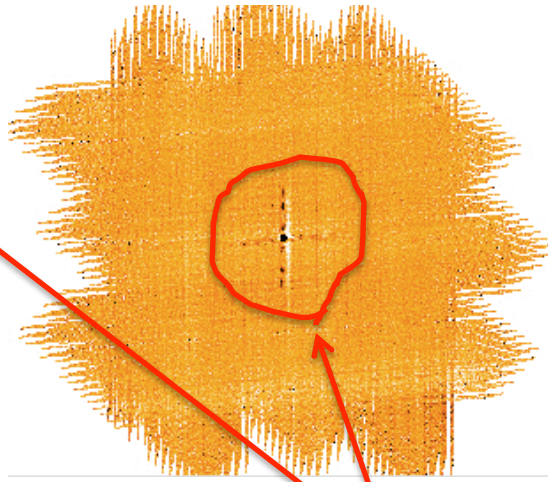
- Weakness: ringing effect (in the time domain) at any places the timelines have sharp changes (bright sources, edges of scans, etc.)

SPIRE Photometer : Comparison between MADMapper & NaïveMapper

MADMapper:
FFT based, minimize uncorrelated 1/f noise

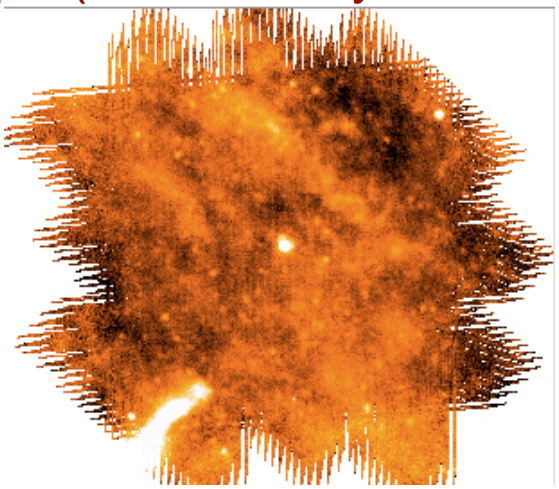


Diff. map:



- mapPlw=madScanMapper(level1, array="PLW")

NaïveMapper:
simple average



- mapPlw=naiveScanMapper(level1, array="PLW")

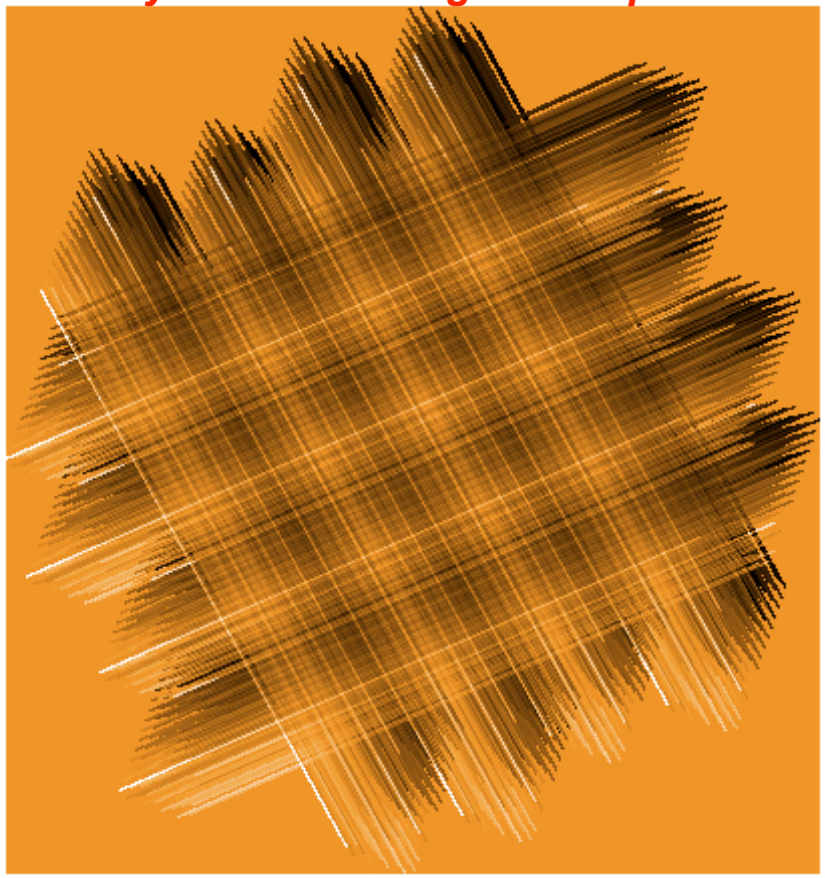
- MADmap has shadows around the central bright source, due to ringing!!
- MADMap does not improve over the simple naïve map: weak uncorr. 1/f in SPIRE!!

Baseline Remover: Why Is It Needed?

- stripes: offsets of individual detector channels on the order of ~ 0.1Jy/beam. (mainly caused by errors of Temperature Drift Correction).

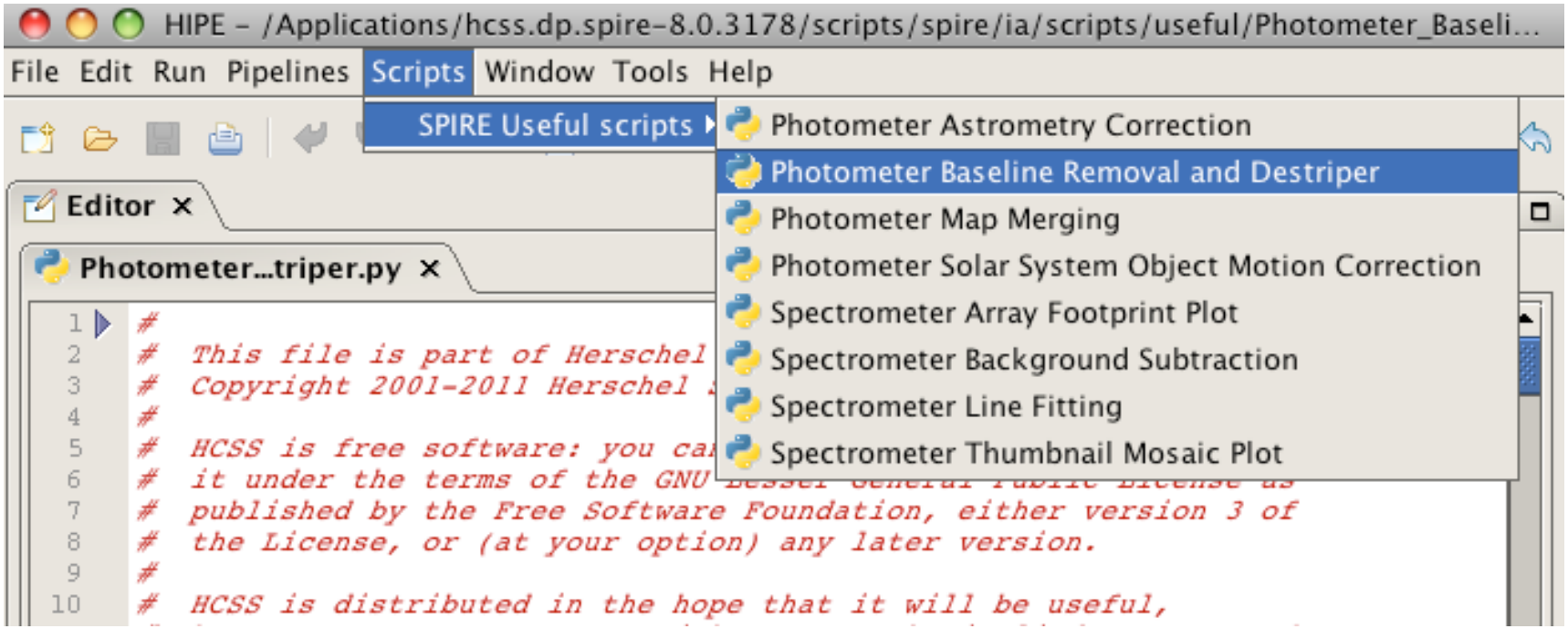
example: PSW map without baseline removal

you see nothing but stripes



Baseline Removers in HIPE

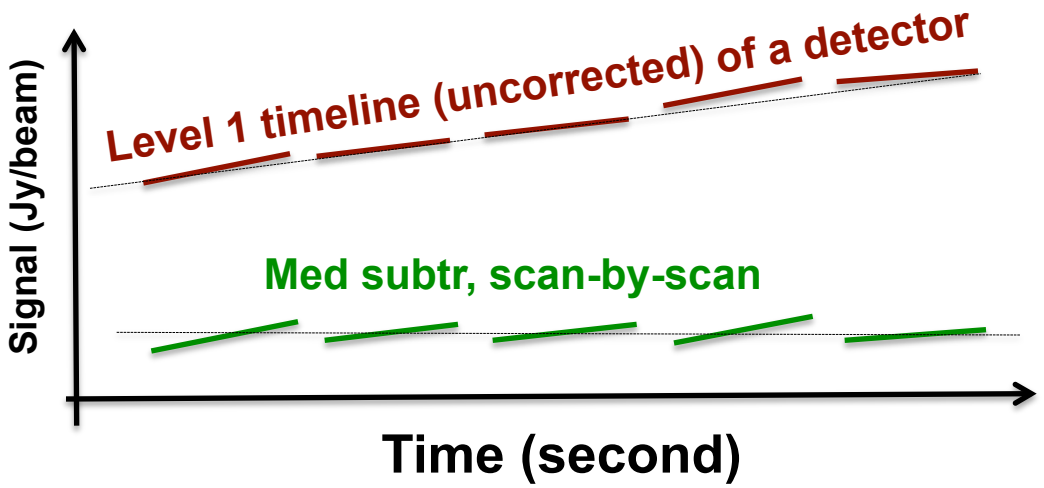
- 3 Baseline Removers:
  - Median baseline remover.
  - Polynomial baseline remover.
  - Destriper (pipeline default).

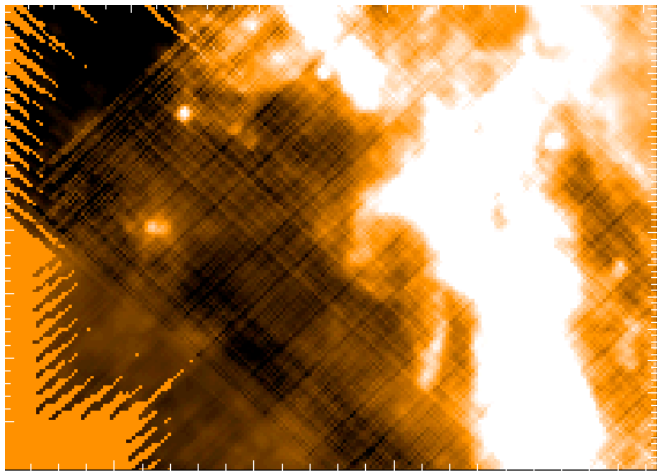


Median Baseline Remover

Module name: baselineRemovalMedian

1. Subtract the median scan-by-scan and detector-by-detector (default).
2. Subtract the median of each timeline detector-by-detector.



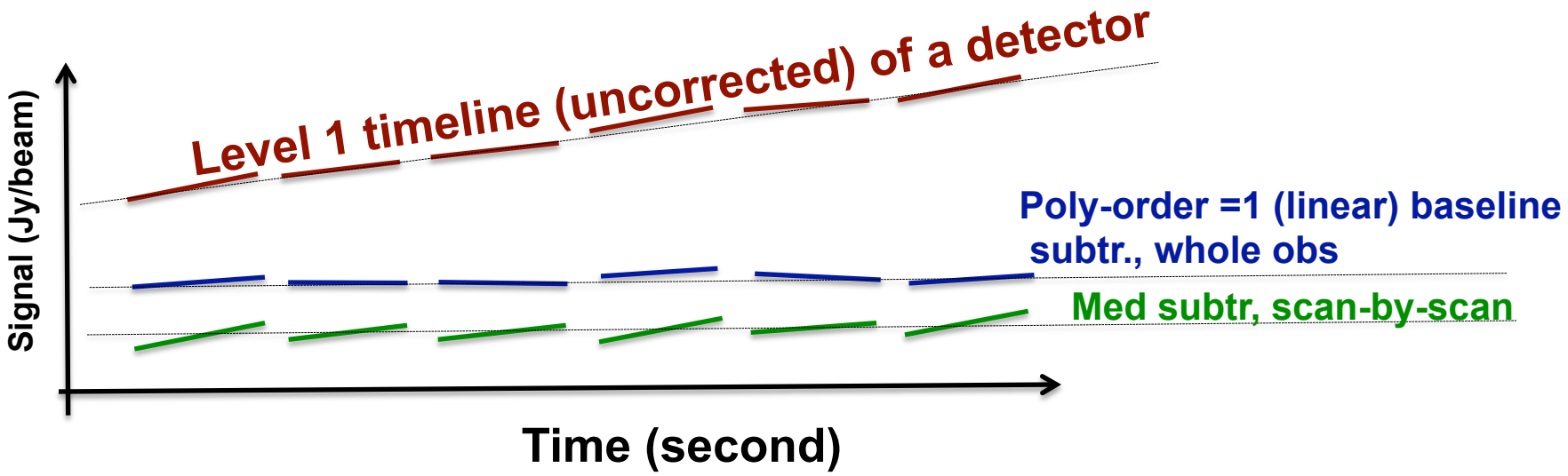


- **Strength: simple (you know what you are doing).**
- **Weakness:**
  - **residual drifts (as shown in the illustration);**
  - **over subtraction when there is extended emission.**

Polynomial Baseline Remover

Module name: baselineRemovalPolynomial

1. Subtract a polynomial baseline scan-by-scan and detector-by-detector.
2. Subtract a polynomial baseline of each timeline detector-by-detector.

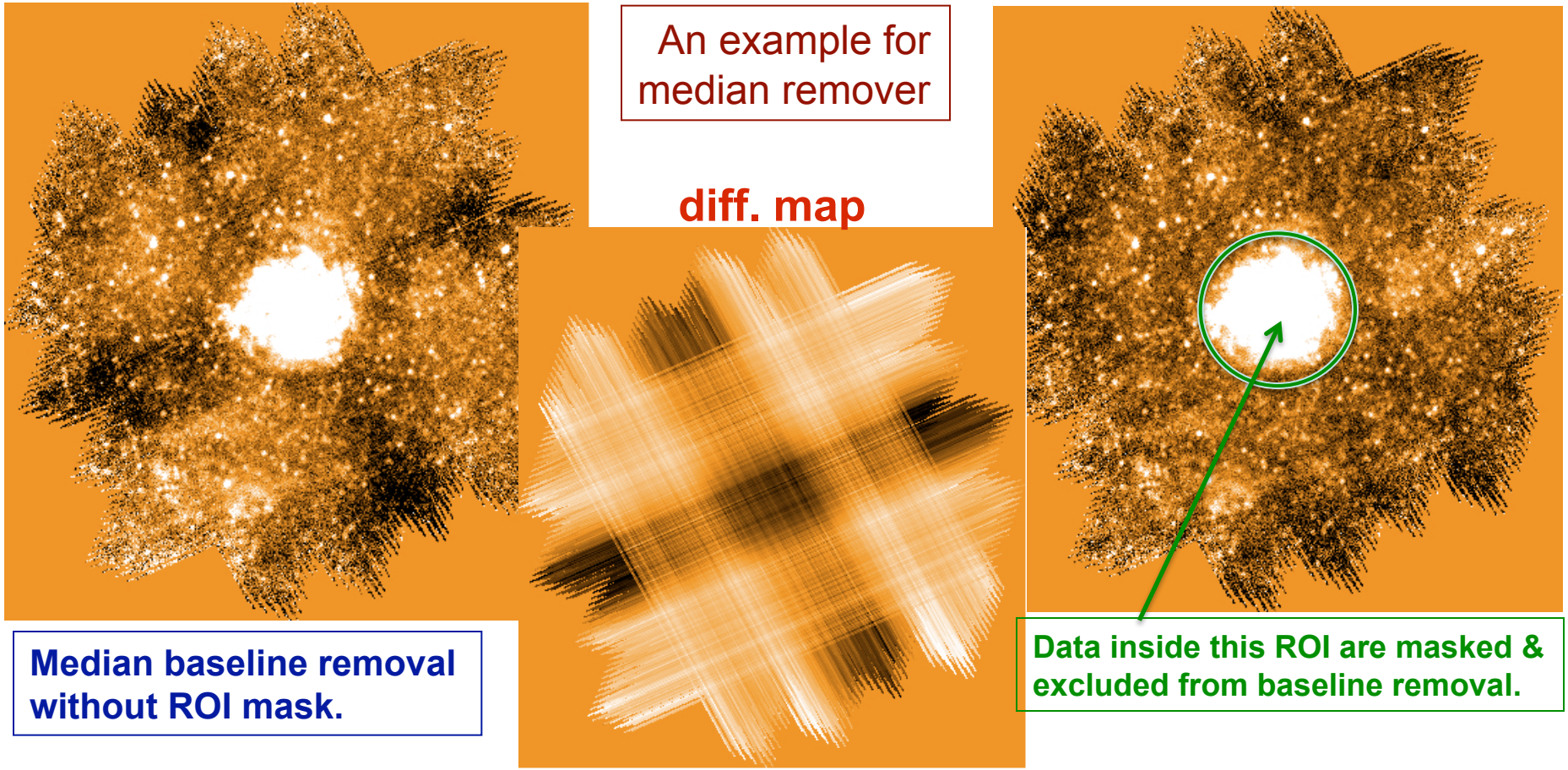


- **Strength: more flexible than median removal (often means less residual drifts).**
- **Weakness (compare to median removal):**
  - **more severe over-subtraction when the polynomial order is high.**

ROI: Region Of Interest

ROI (available for both median & polynomial baseline removers):

Excluding bright regions from baseline estimate to minimize the over-subtraction.

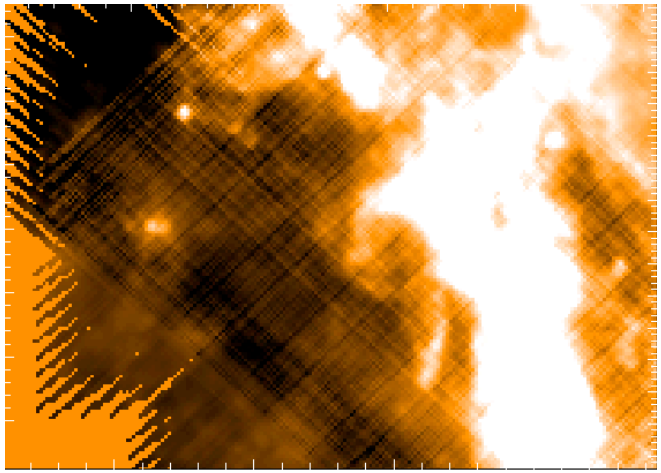


Destriper

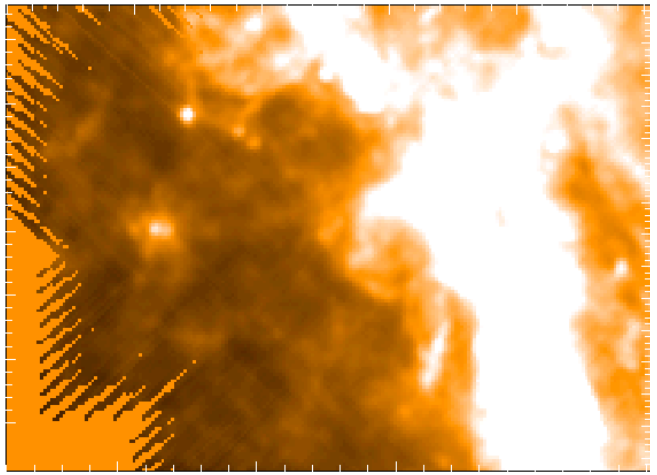
- Destriper (pipeline default)
  - Minimize map stripes by adjusting the baseline subtraction (median or polynomial) iteratively using the naïve mapper.

- Strength:
  - make better maps in general (no significant over-subtraction);
  - the only SPIRE baseline remover in HIPE for structured emission regions;
  - can do the 2nd order deglitching (HIPE 9.1).
- Weakness:
  - longer computation time, higher demand on RAM.

Median Baseline Remover:

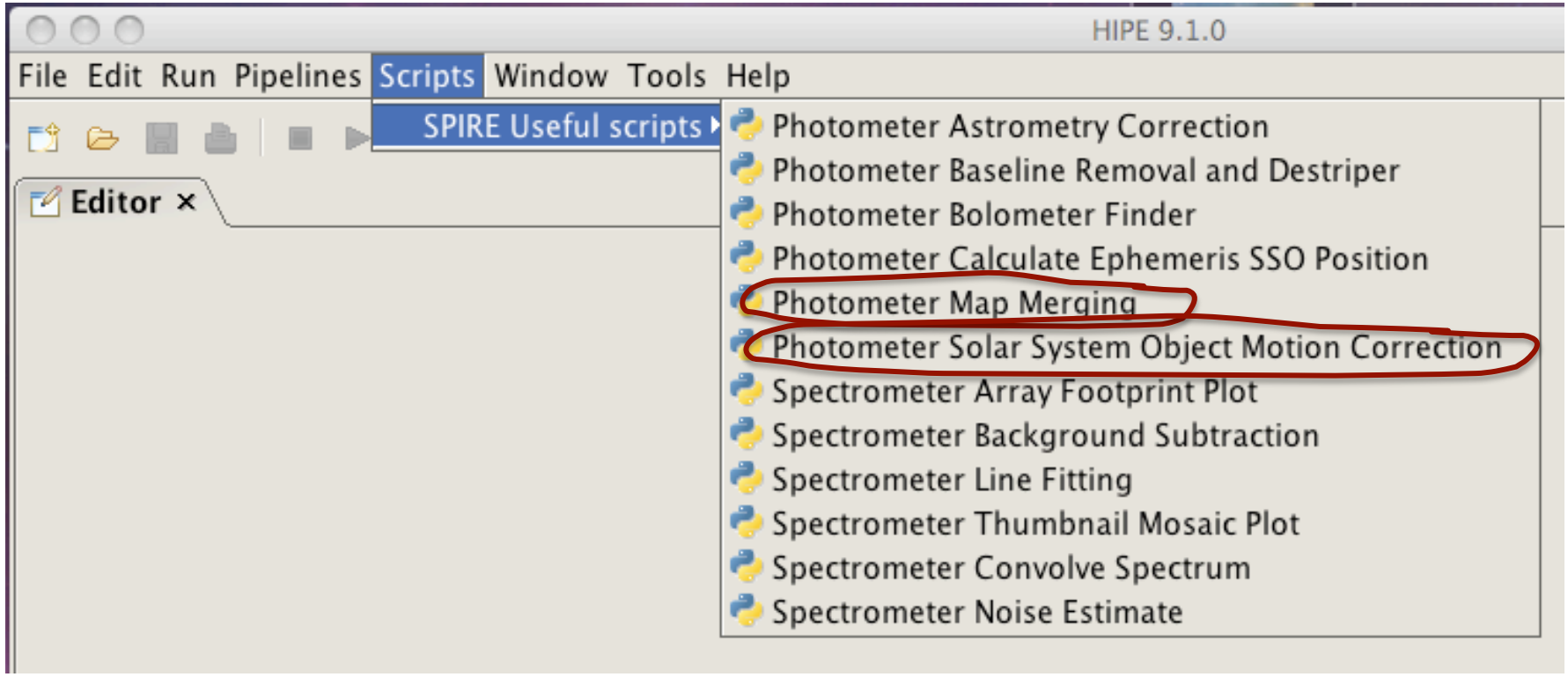


Destriper:



Other Two HIPE Scripts Related to SPIRE Mapmaking

- Map Merging: Make maps using timelines of more than 1 observations (particularly useful for parallel mode observations with cross-scans).
- Solar System Object Motion Correction: Correct the proper motion of solar system objects (causing blurred images) before the mapmaking.



Summary

- As default, the pipeline makes map using the destriper, which minimizes the stripes due to baseline-offsets iteratively.
- In the reprocessing, if the map does not have much structure, one can opt to use naivemapper + baseline remover (median of polynomial, with or without ROI masking) to save time and RAM.
- We **do not** recommend to use MADMapper for SPIRE photometer maps.