# Overview of SPIRE Photometer Data Reduction Pipeline

Kevin Xu
NHSC/IPAC
on behalf of the SPIRE ICC,
HSC and NHSC

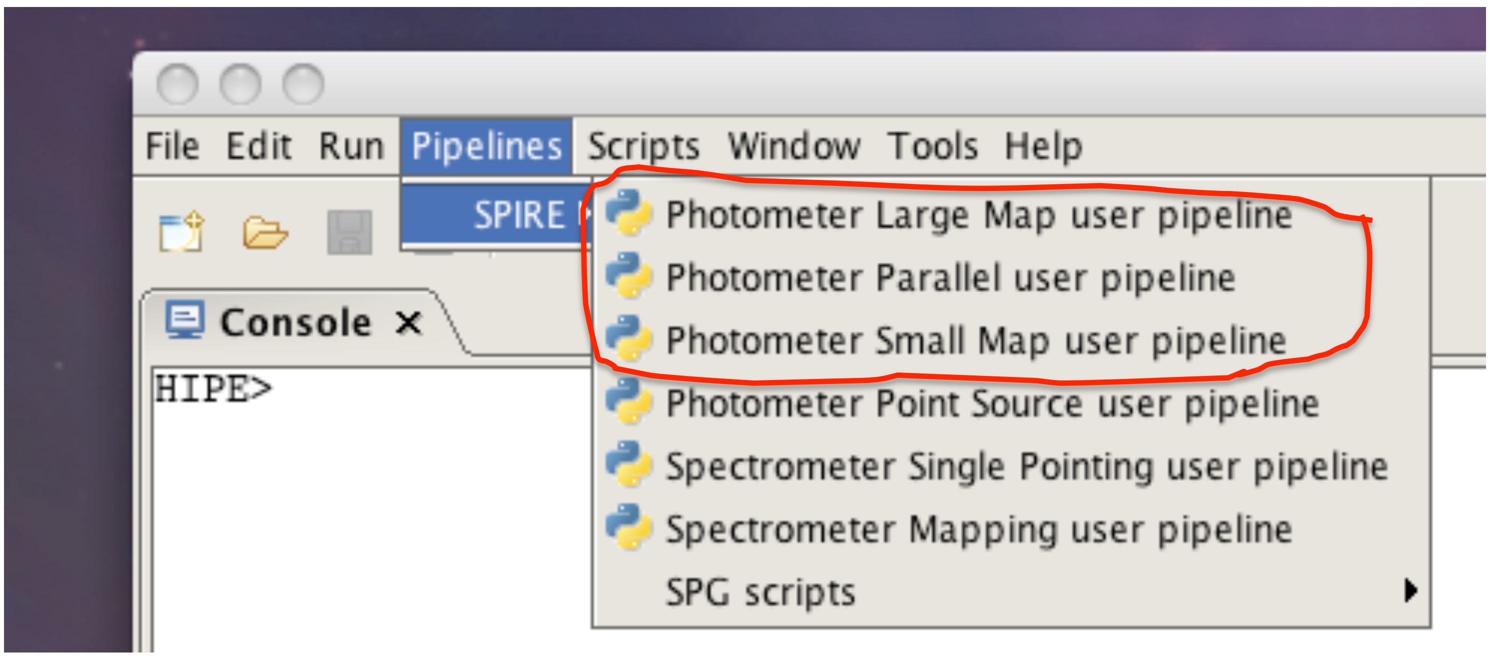
# The Goal

- Show how SPIRE Photometer pipeline works (functionalities of major modules).
- Will concentrate on scan map "user pipelines" (cover small map, large map, SPIRE/PACS parallel modes).

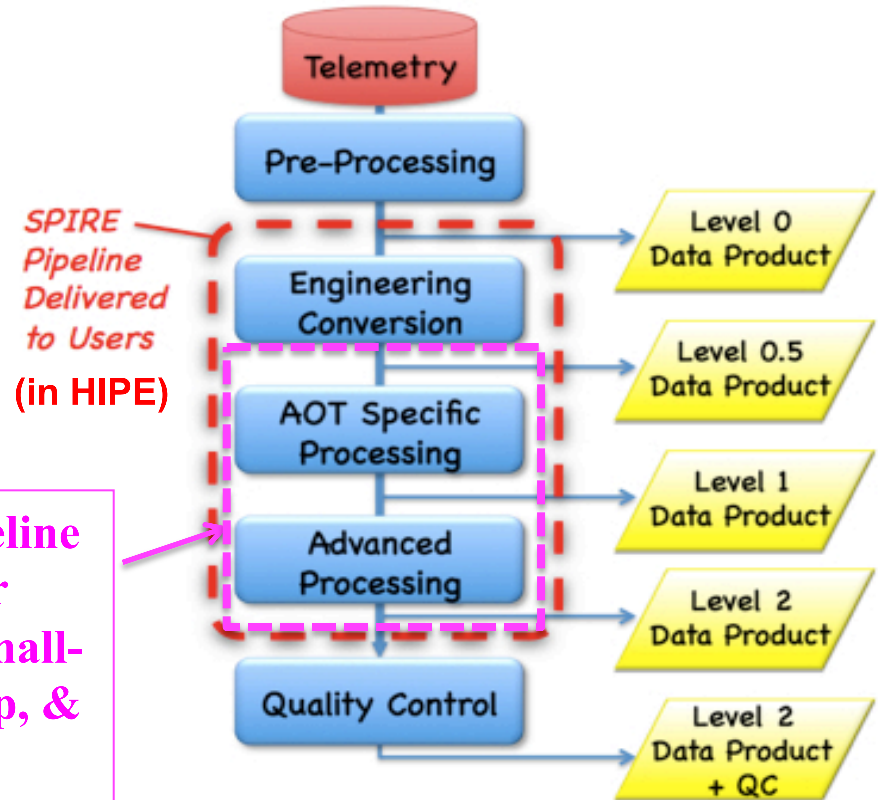
**Reference:** *"SPIRE Data Reduction Guide"* in HIPE (under "Help") or in:
http://herschel.esac.esa.int/hcss-doc-12.0/load/spire_drg/html/spire_drg.html

# User Pipelines

- User pipelines: simplified version of Standard Product Generation (SPG) pipelines.
- They are Jython scripts for data re-processing.
- Can be found in HIPE:



# Pipeline & Data Products



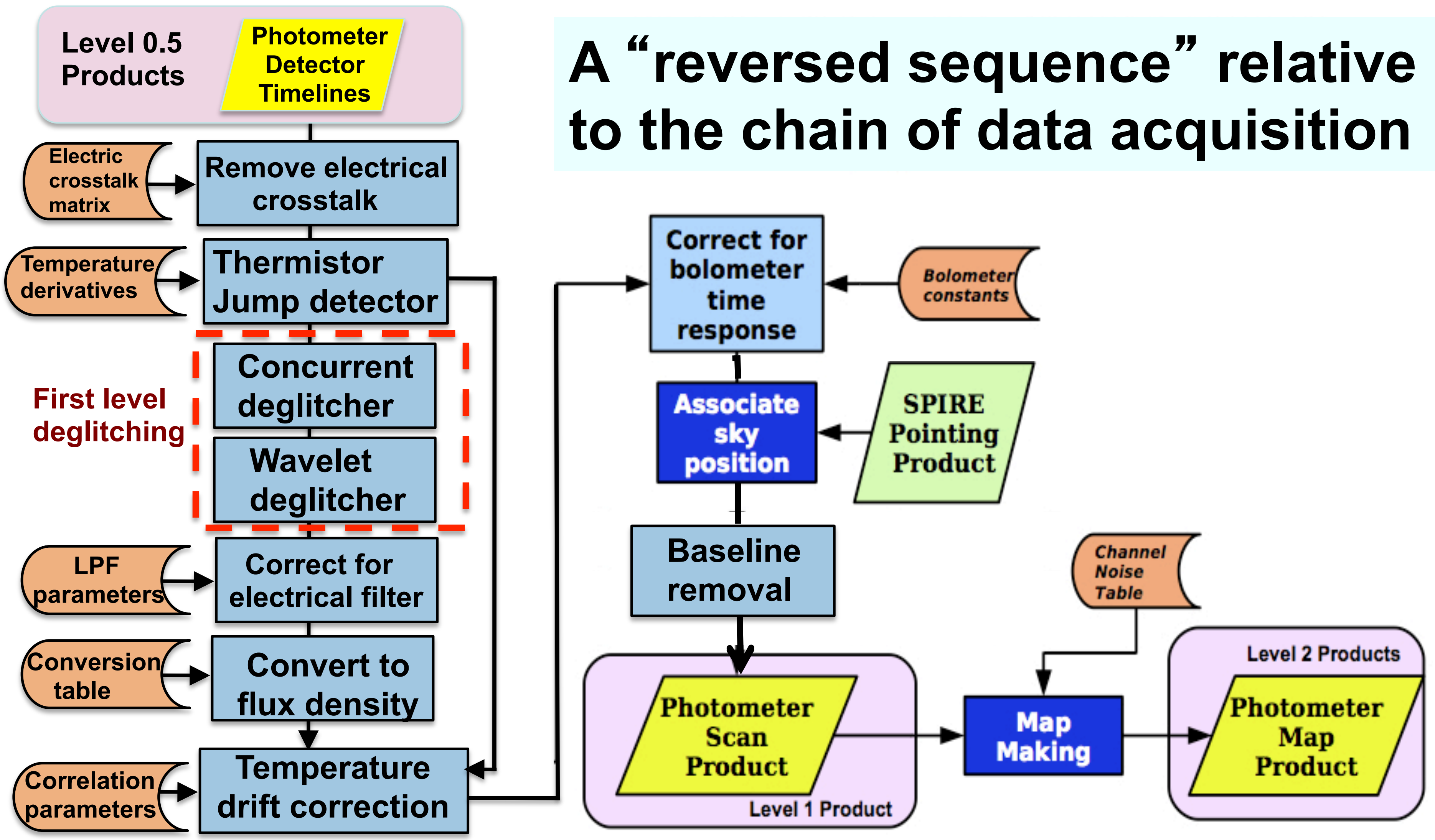

- Raw Data Products
- Raw ADU counts converted to meaningful units
- Calibrated Timelines
- Maps
- Quality Control

**Scan-Map Pipeline (shared by user pipelines for small-map, large-map, & SPIRE/PACS parallel modes).**

**Since HIPE 11 (only in archive data from HSA) →**

| | |
|---|---|
| Level 2.5 Data Product | Maps of combined parallel observations with cross-scans |
| Level 3 Data Product | Maps of overlap observations belonging to the same proposal |

# Scan Map Pipeline Flow Chart



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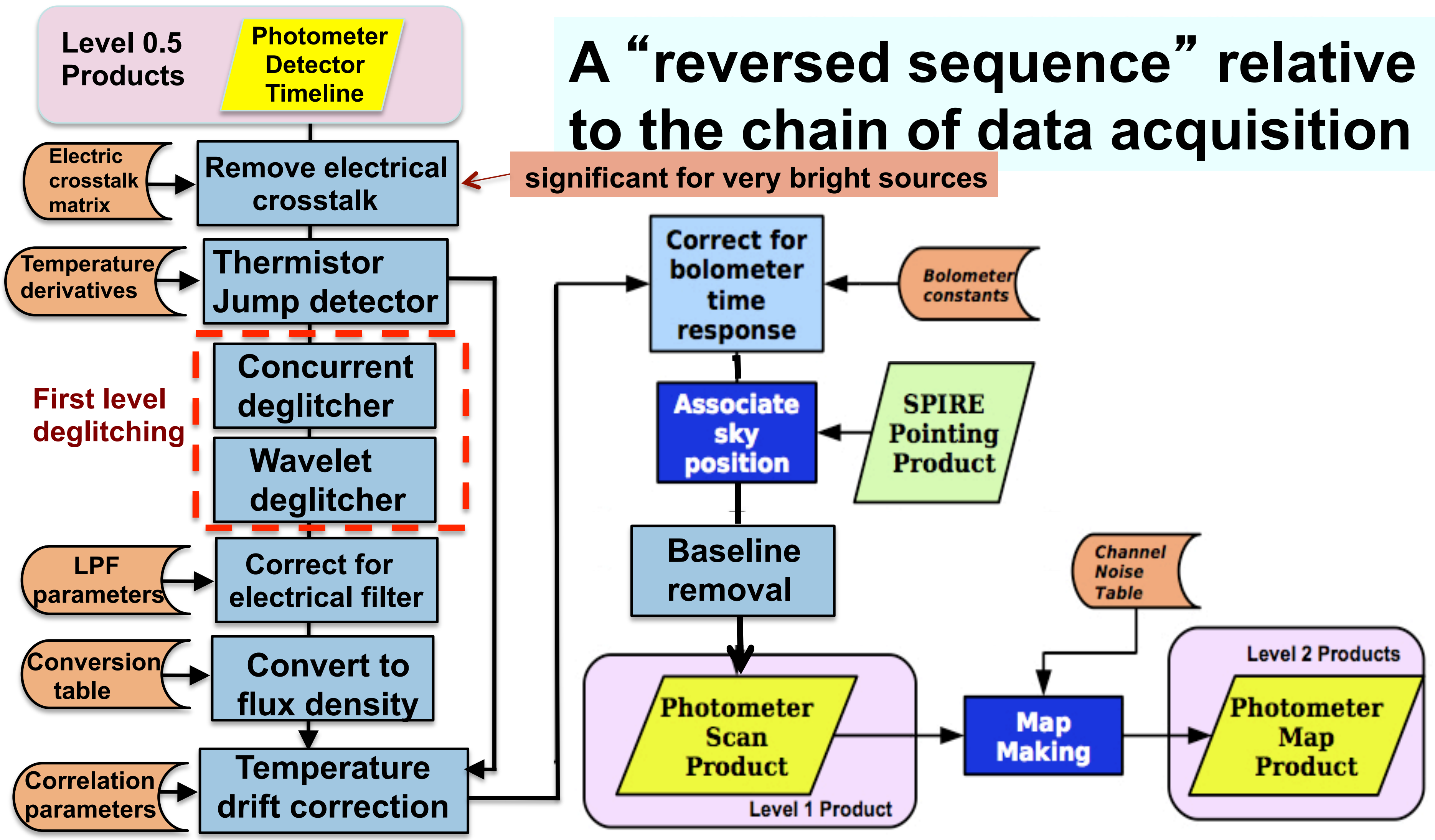

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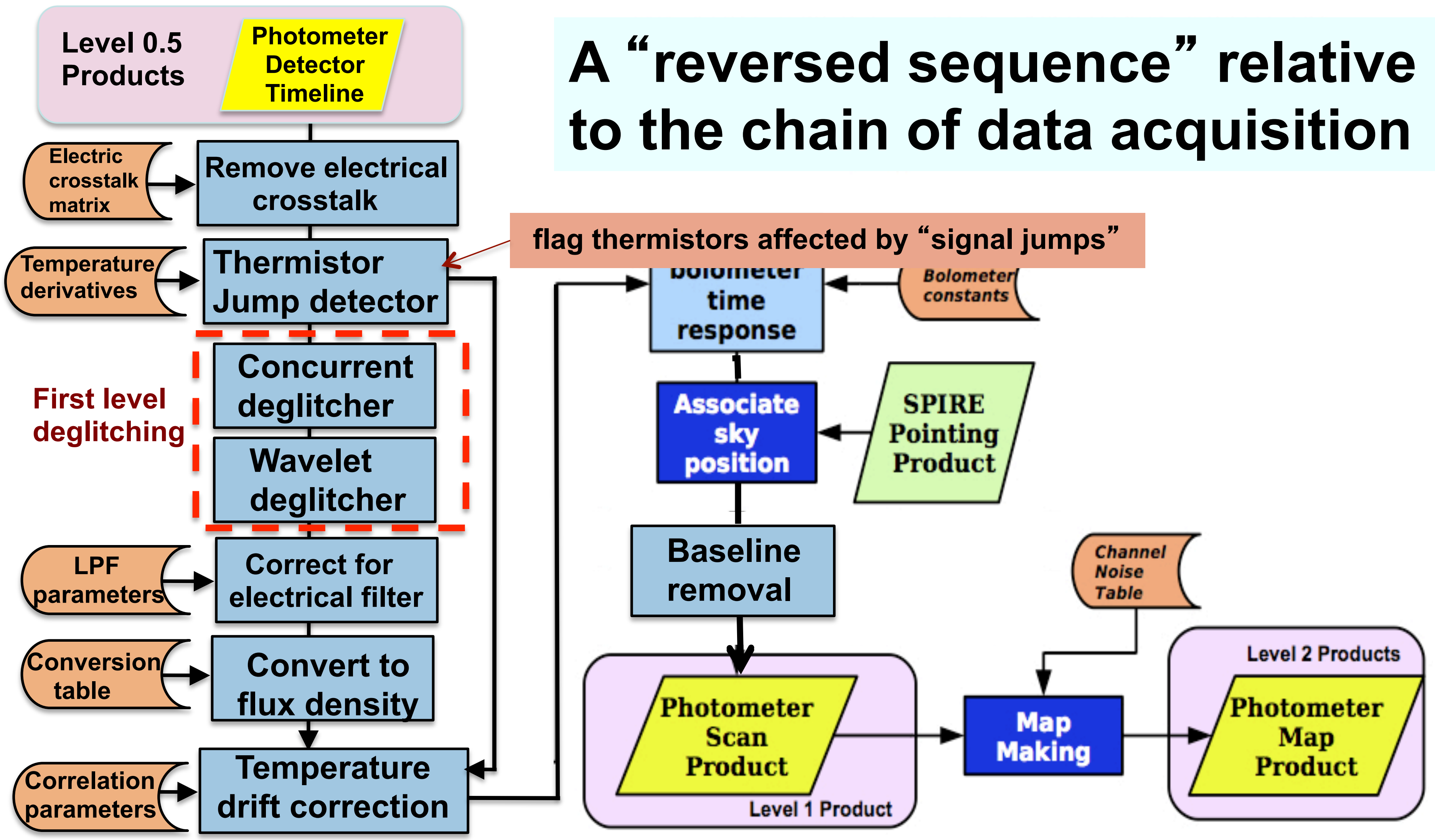
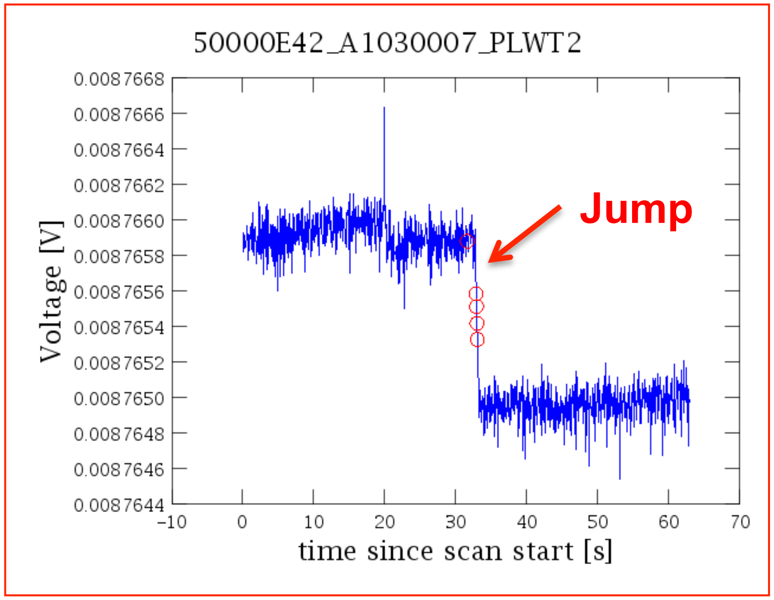
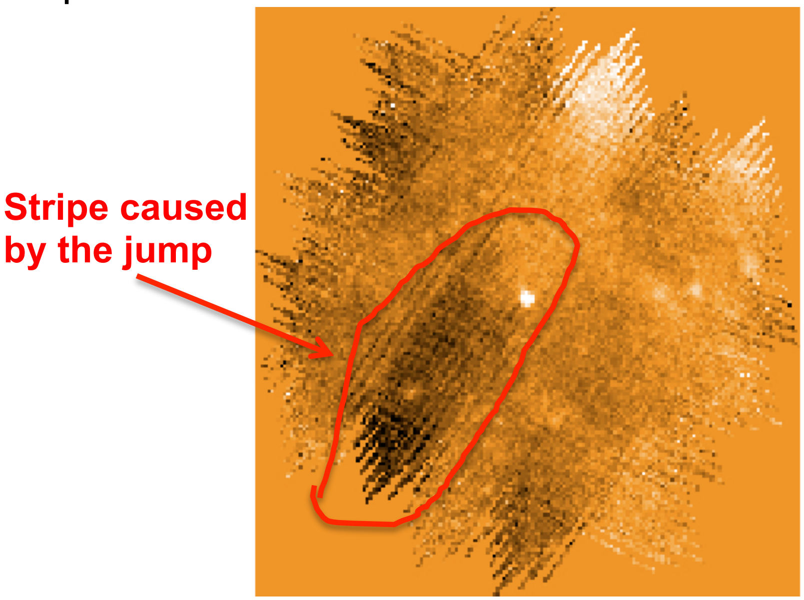


# Thermistor Signal Jump

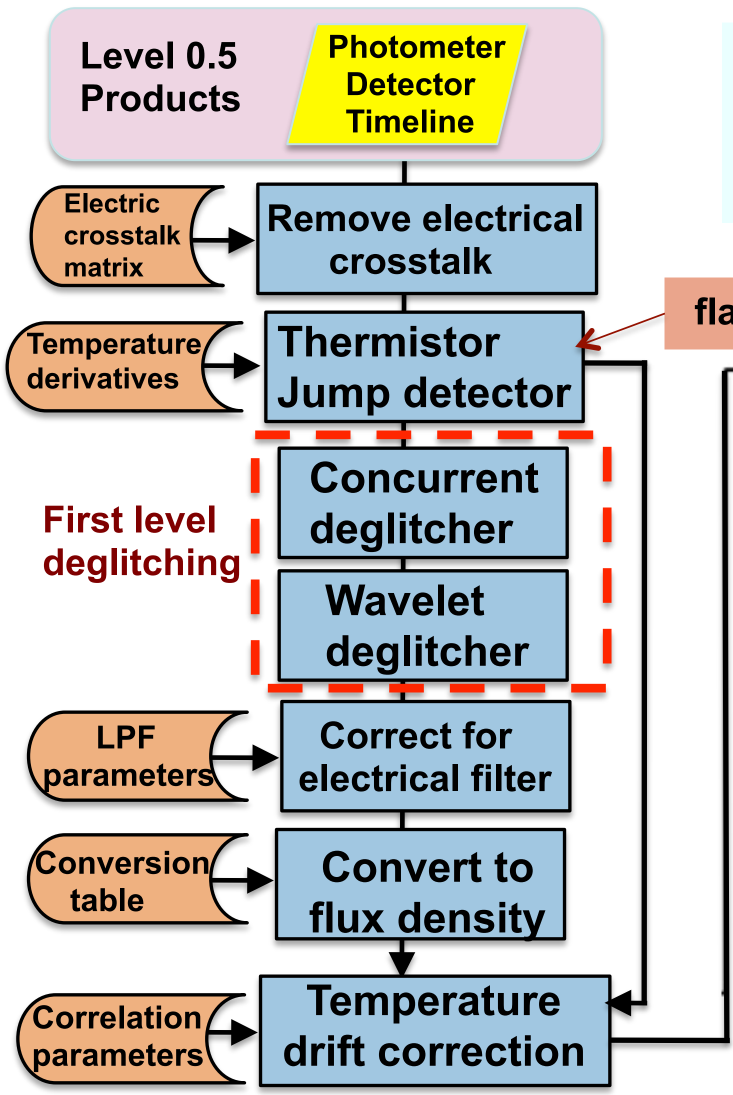
- Sudden spontaneous jump in a thermistor timeline.
- The average frequency is ~ 1/day.
- Effect: The pipeline uses thermistor timelines in the correction for detector signal drift due to array temperature drift. A thermistor "jump" affects this correction, causing artificial (broad) stripes in the final map.

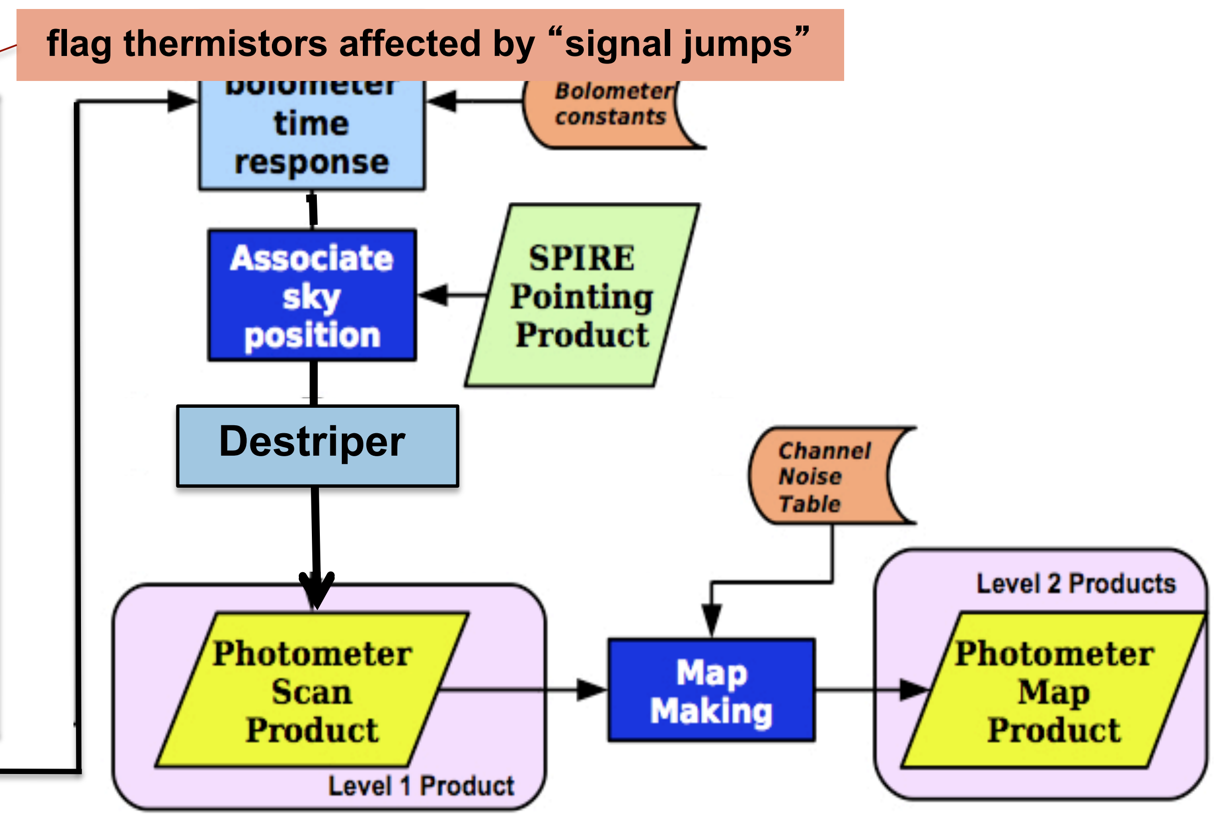


# Scan Map Pipeline Flow Chart

**A "reversed sequence" relative to the chain of data acquisition**



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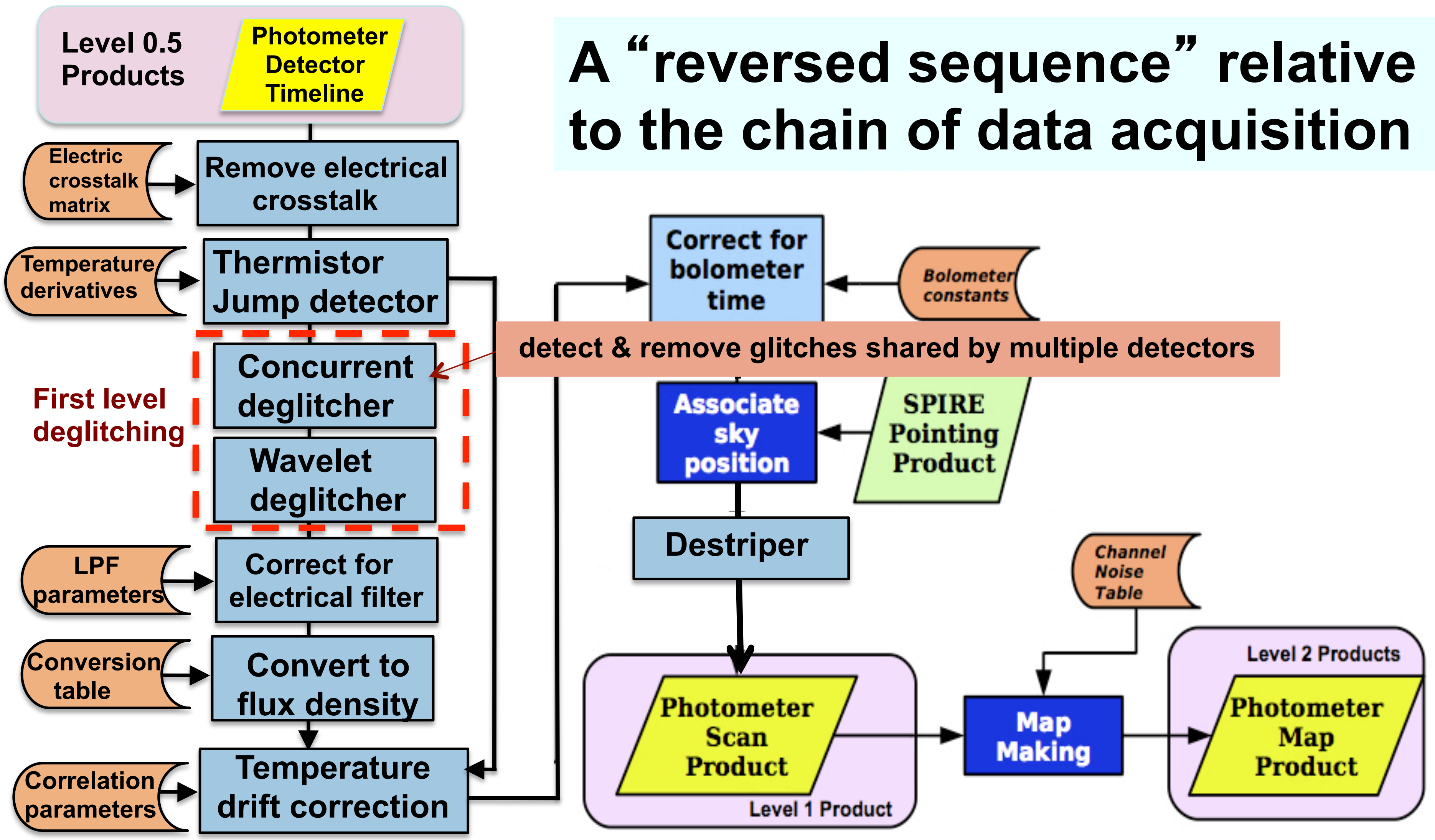

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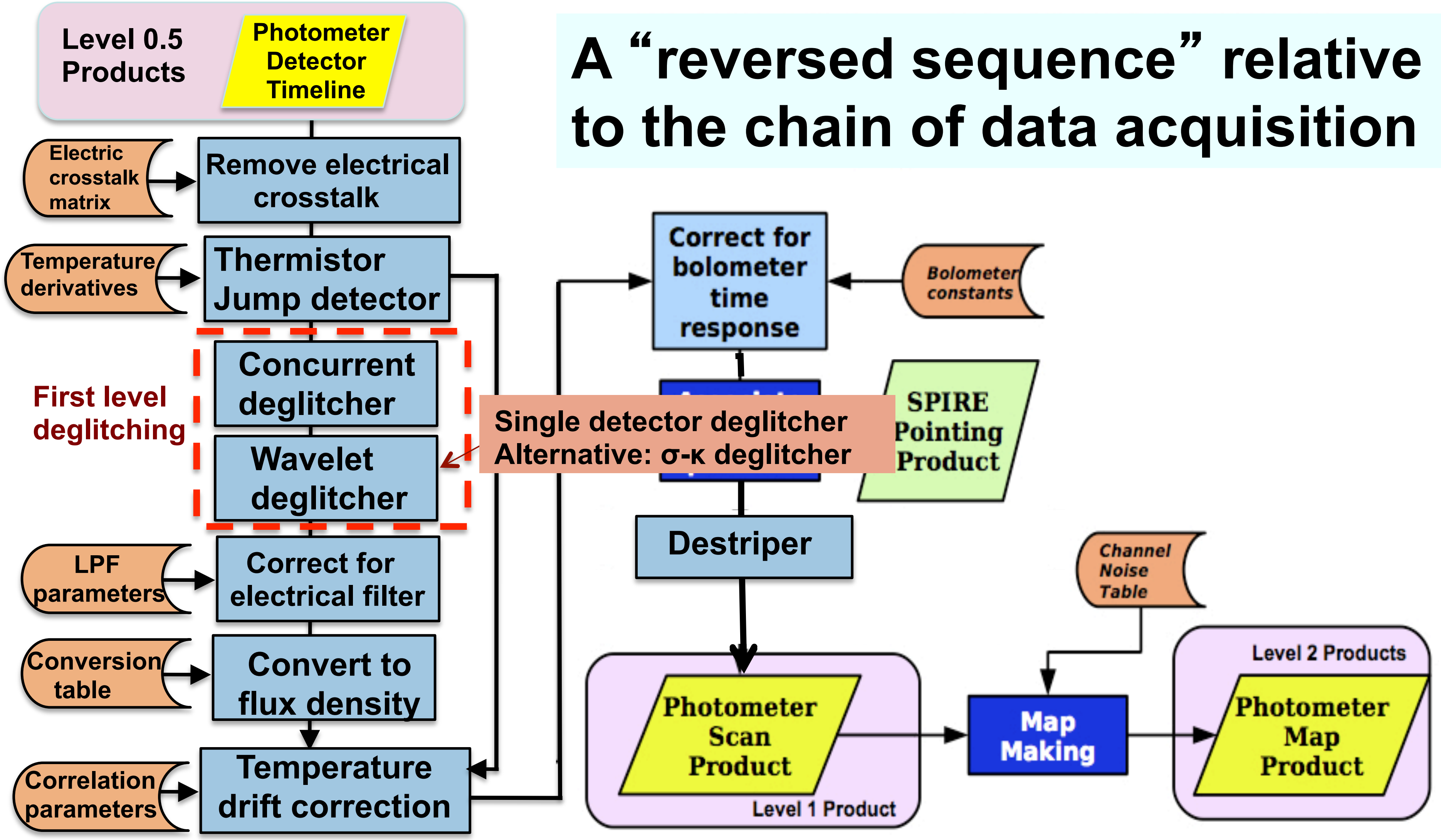

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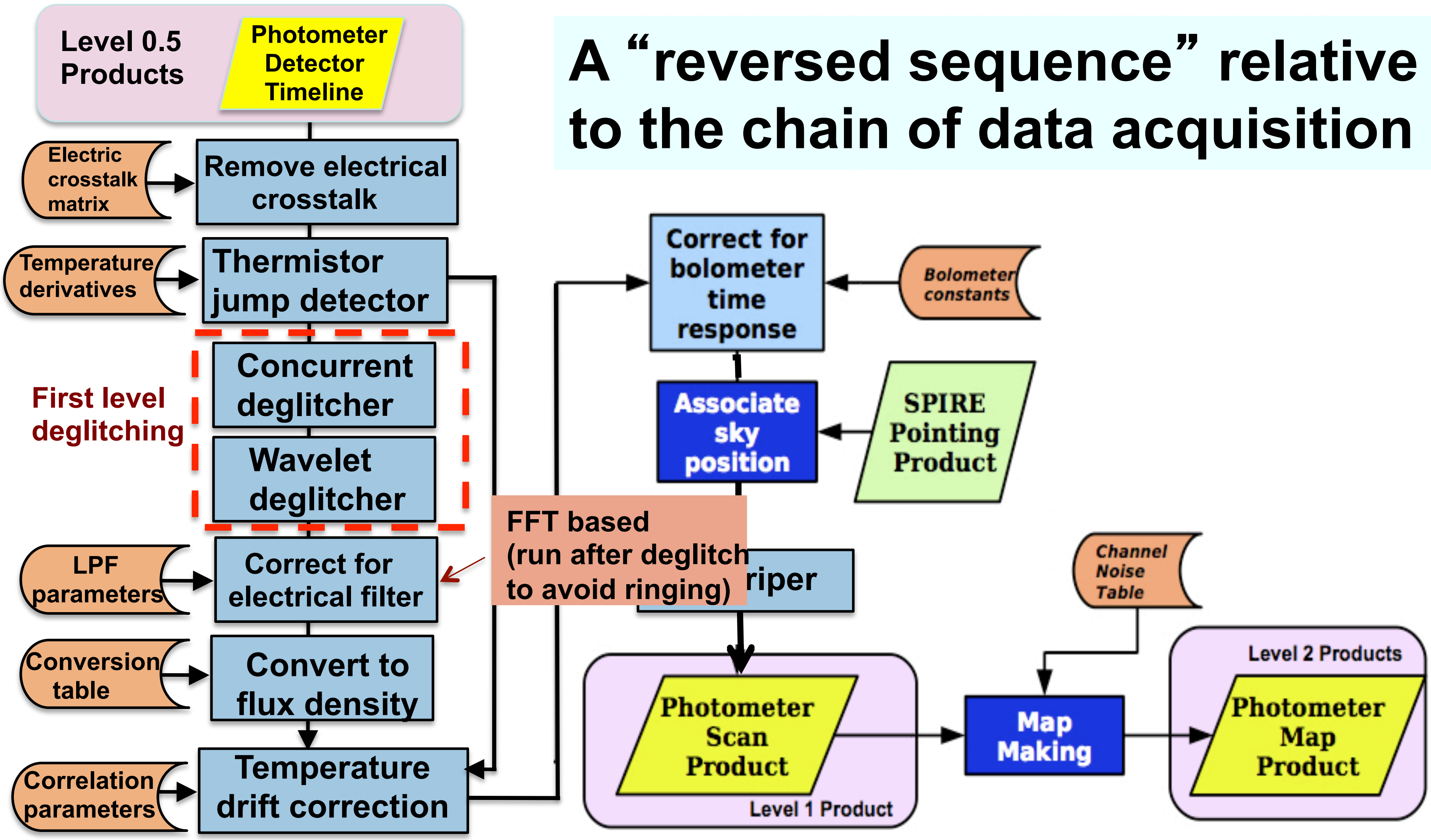

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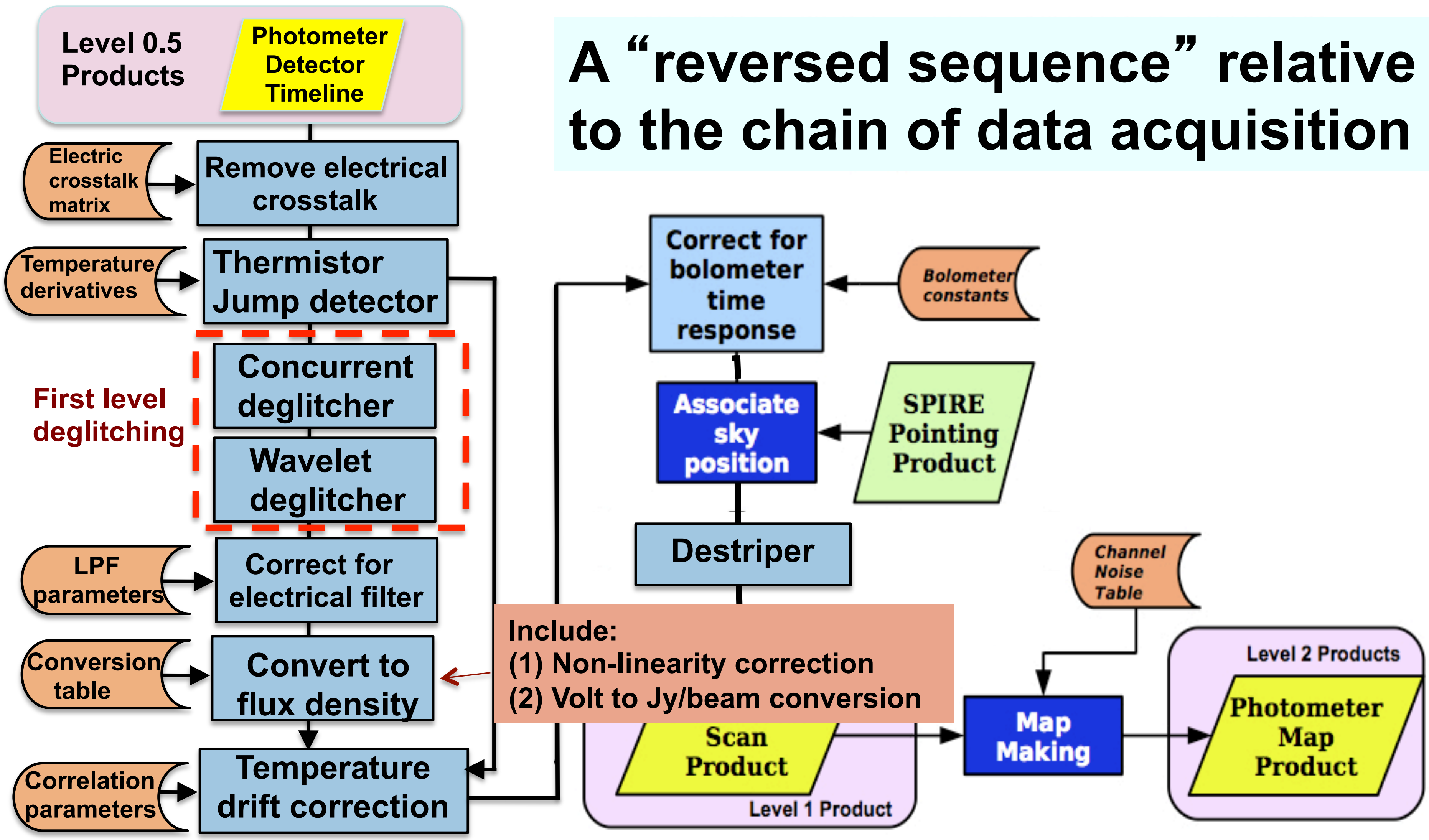

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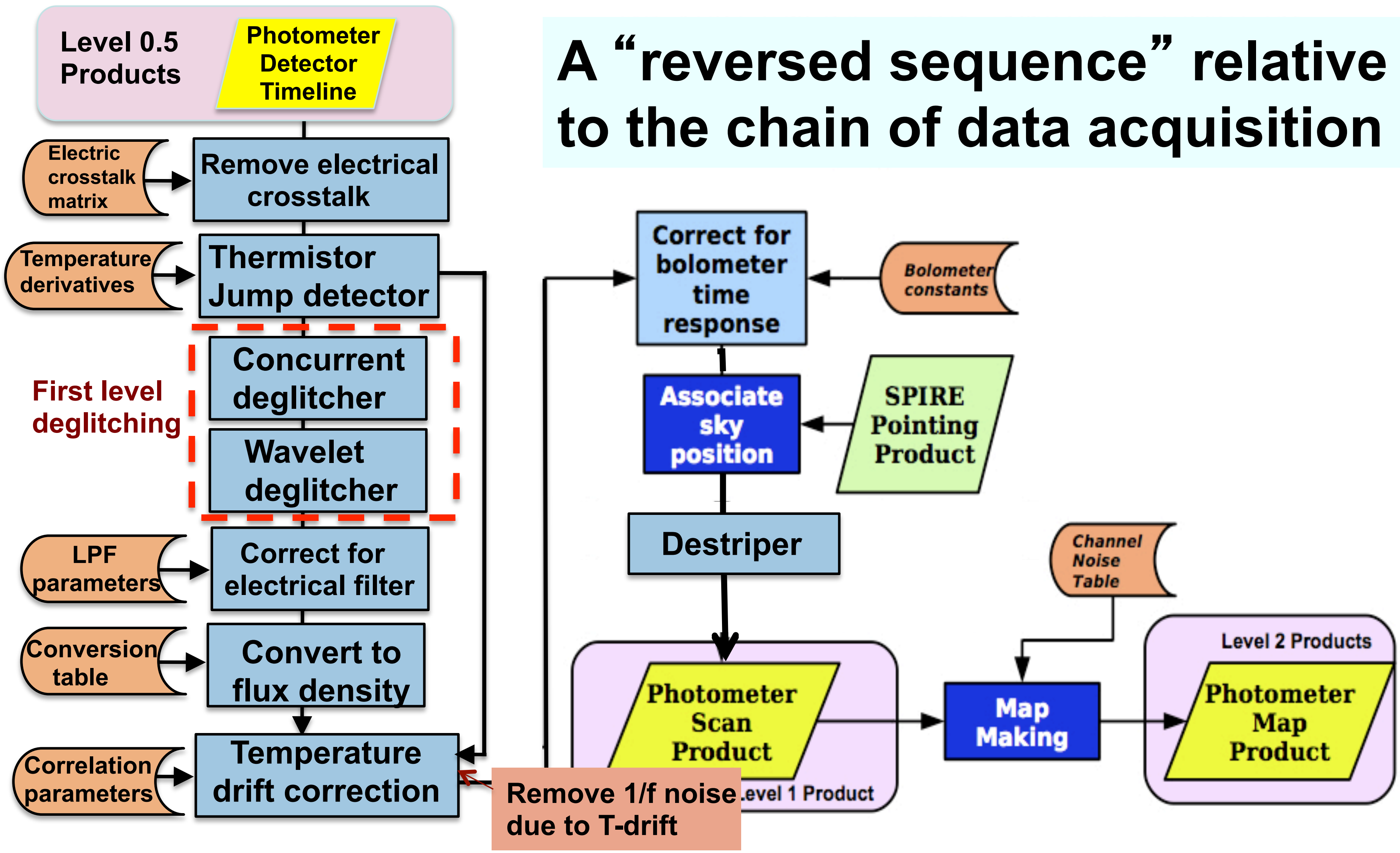

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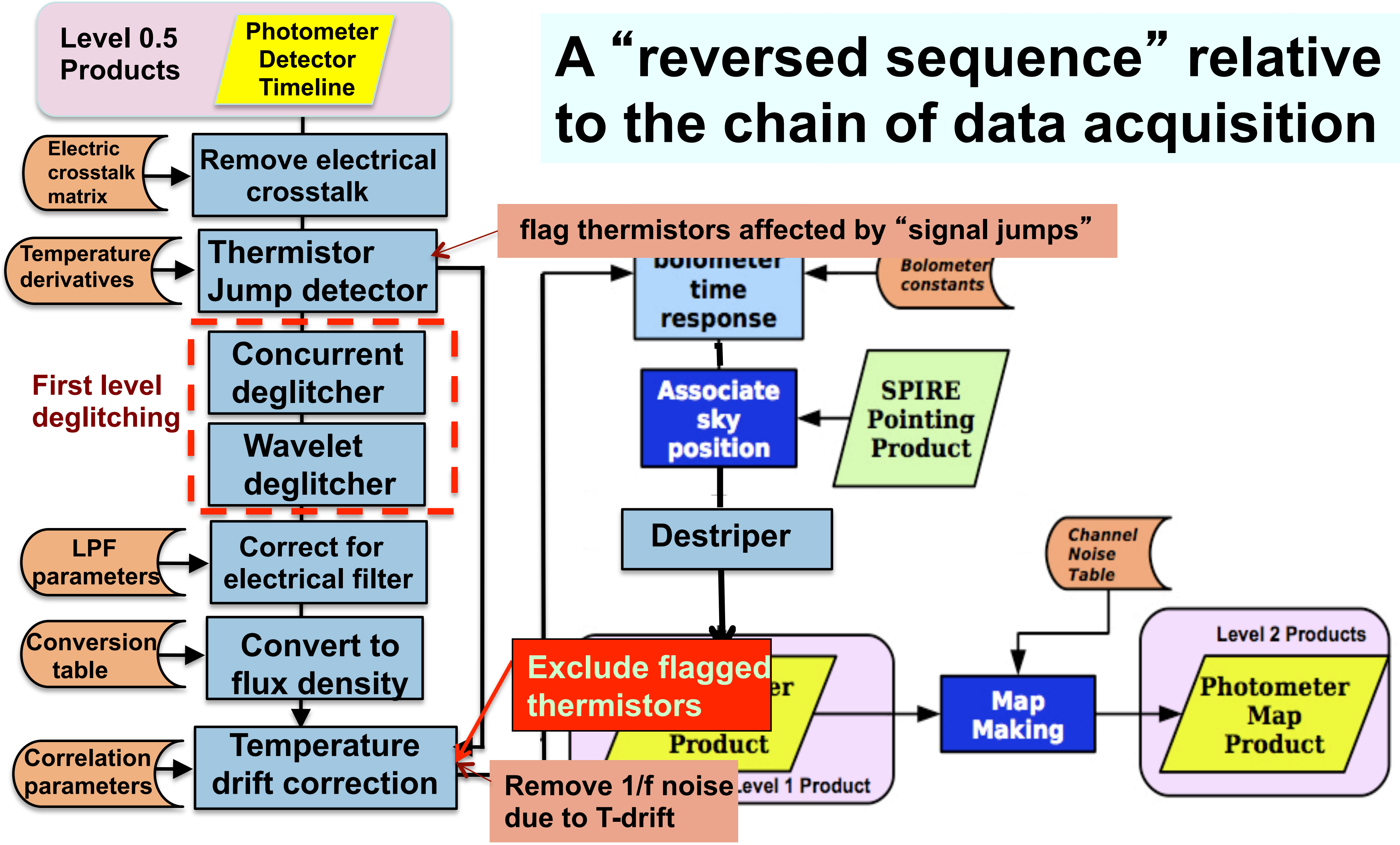

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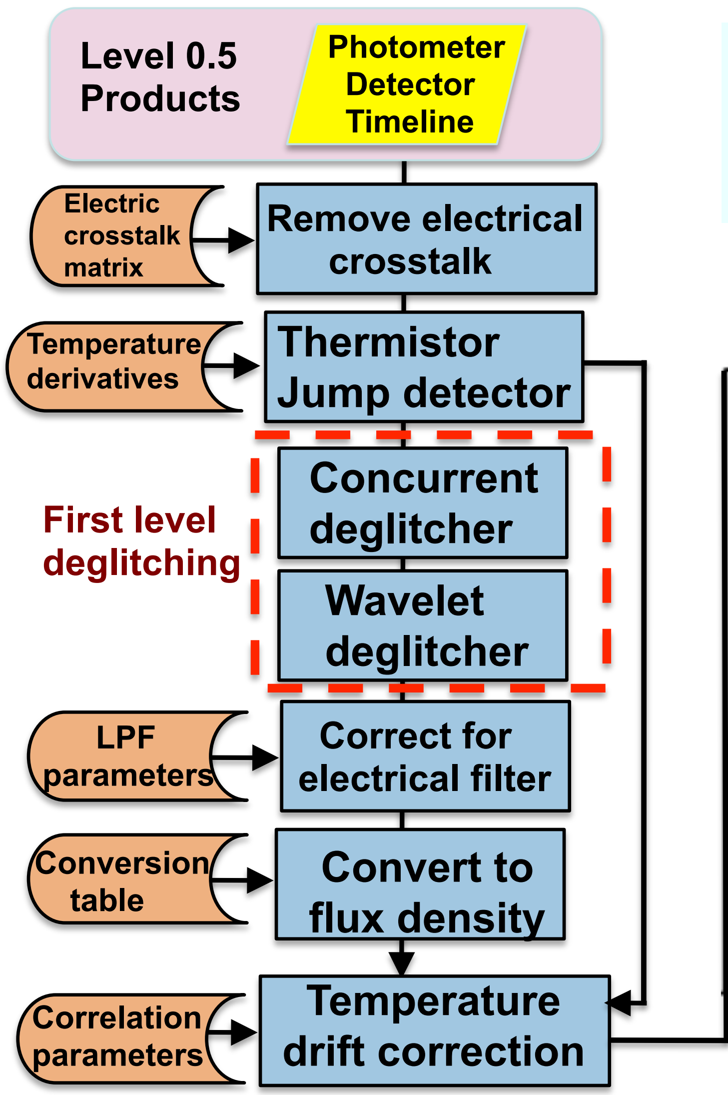


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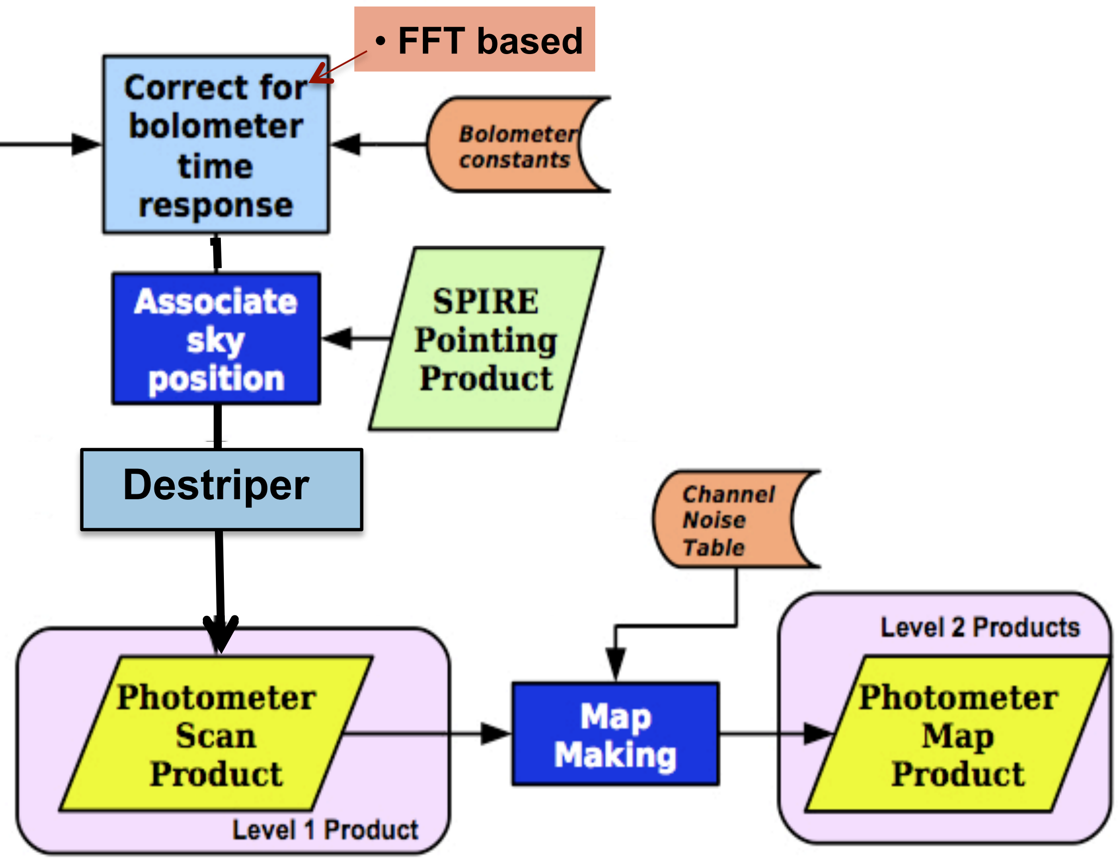

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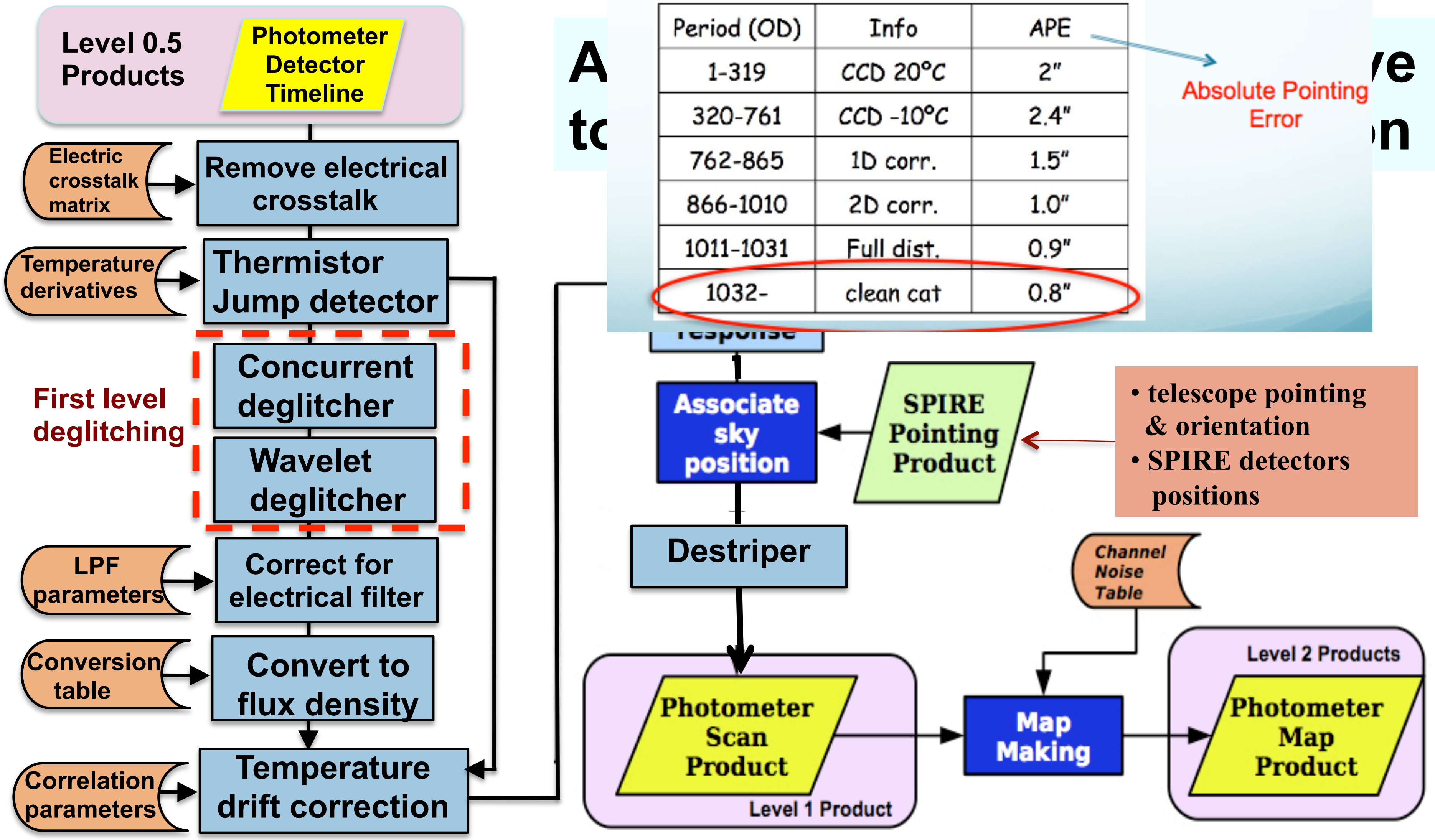
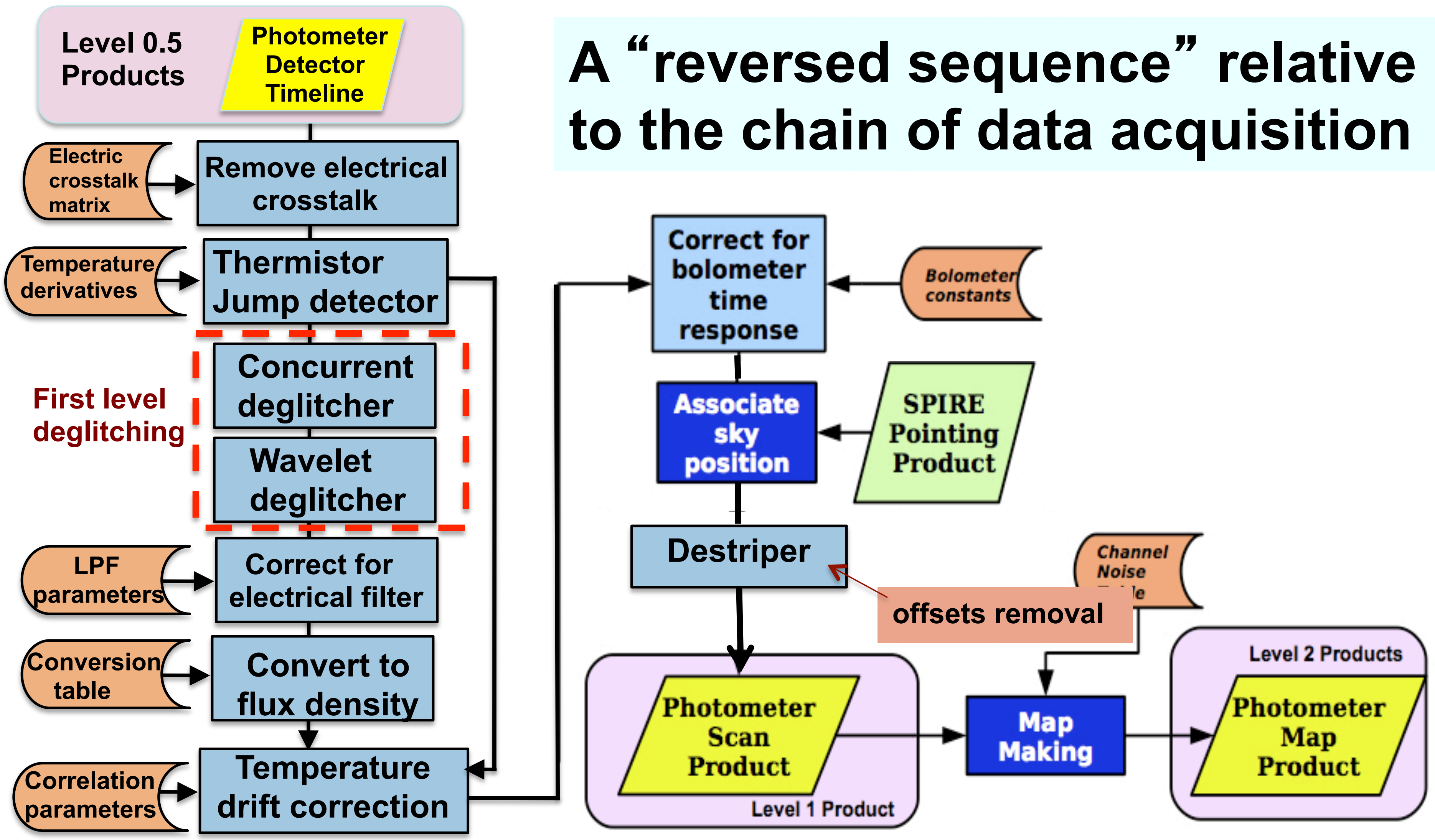



History of Pointing Accuracy

| Period (OD) | Info | APE |
|---|---|---|
| 1-319 | CCD 20°C | 2″ |
| 320-761 | CCD -10°C | 2.4″ |
| 762-865 | 1D corr. | 1.5″ |
| 866-1010 | 2D corr. | 1.0″ |
| 1011-1031 | Full dist. | 0.9″ |
| 1032- | clean cat | 0.8″ |

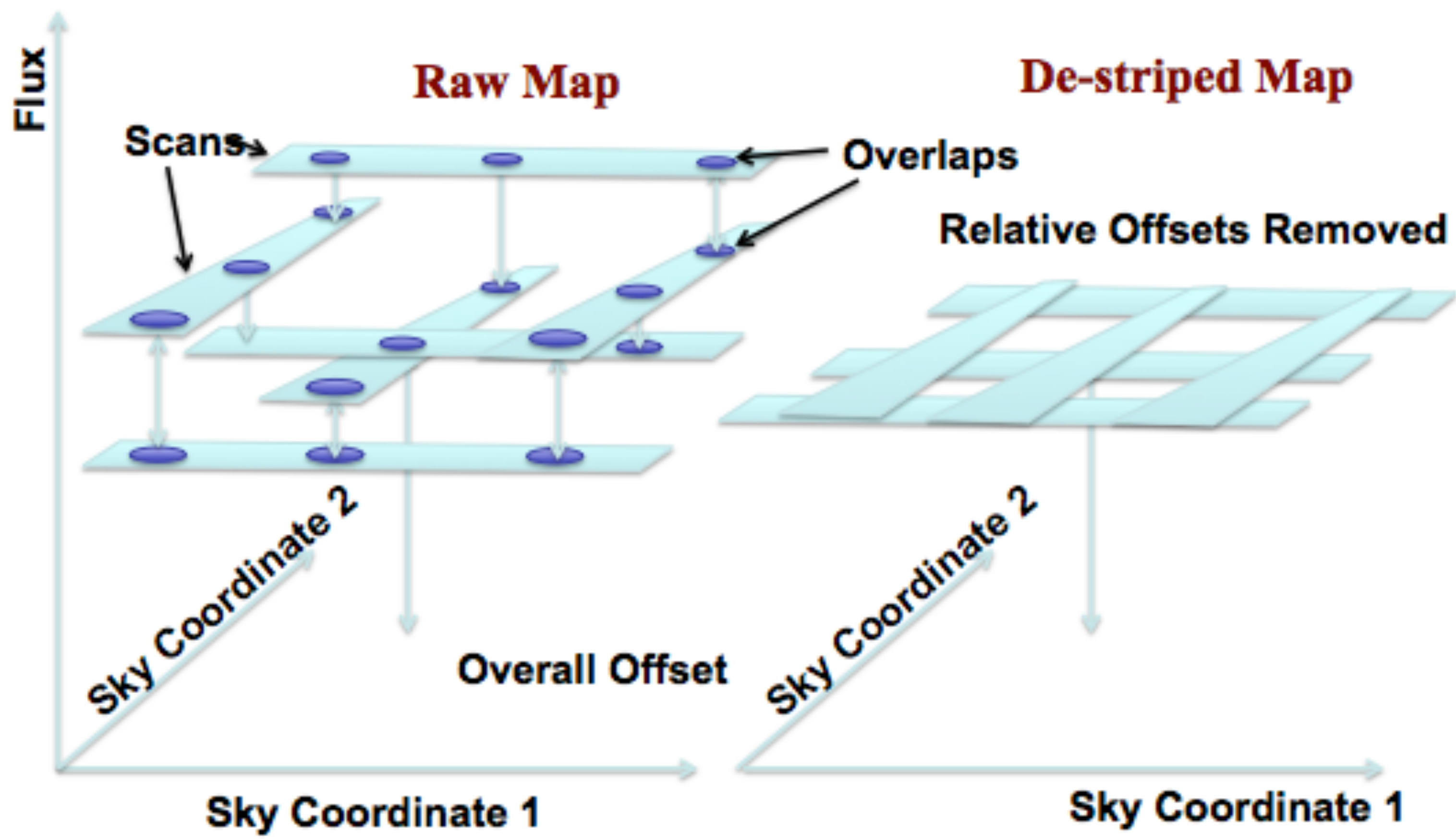
# Scan Pipeline Flow Chart

A "reversed sequence" relative to the chain of data acquisition



# Destriper: Offsets Removal

**Destriper:** remove the relative offsets of timelines of individual bolometers by minimizing the dispersions in overlap sky pixels (using the Naïve-Mapper iteratively).



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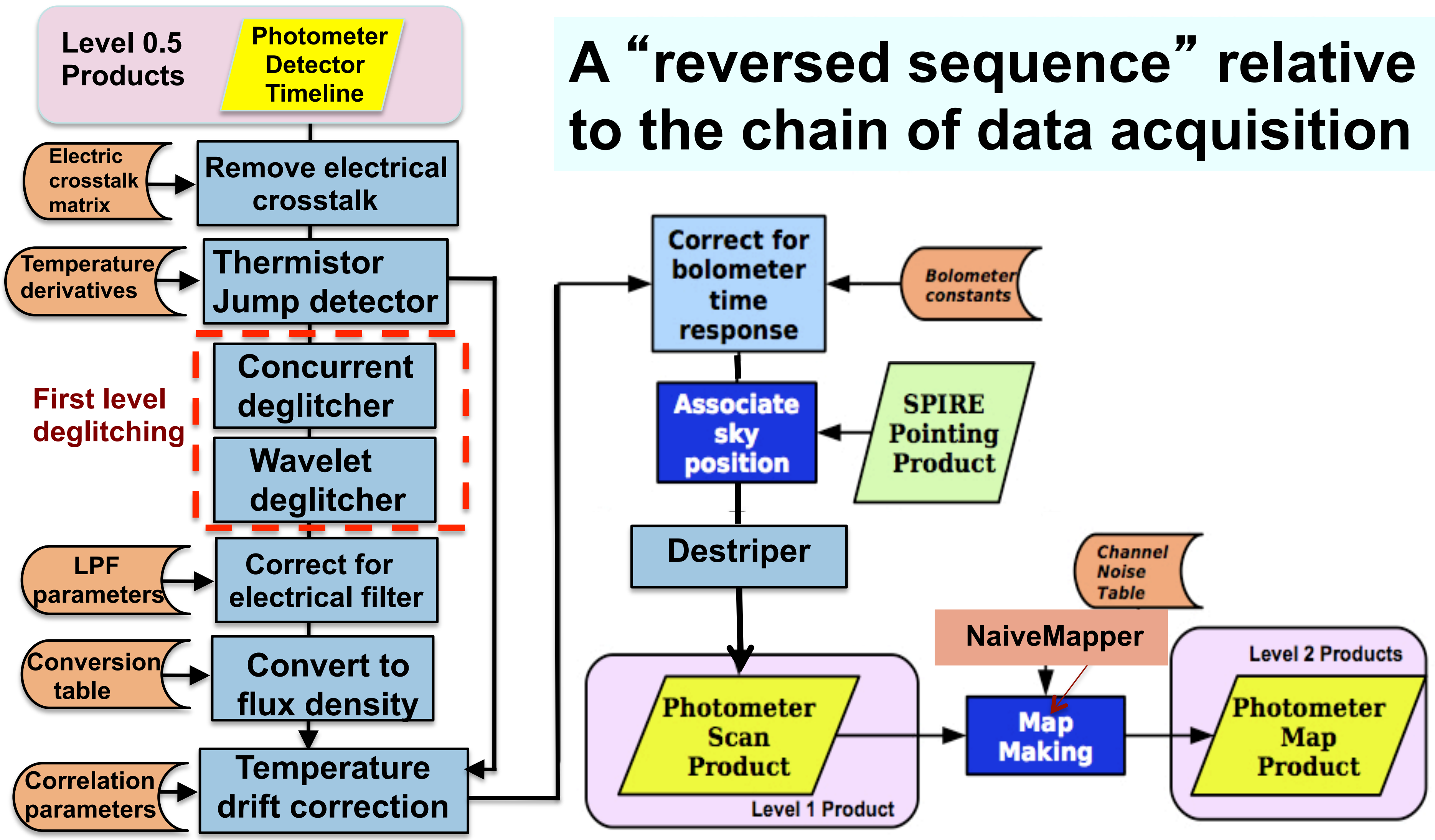


# SPIRE Naïve Mapper

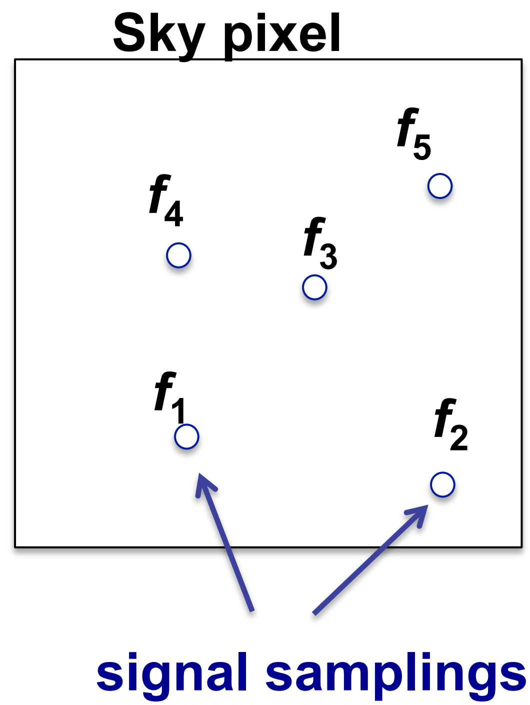
## Two options:

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

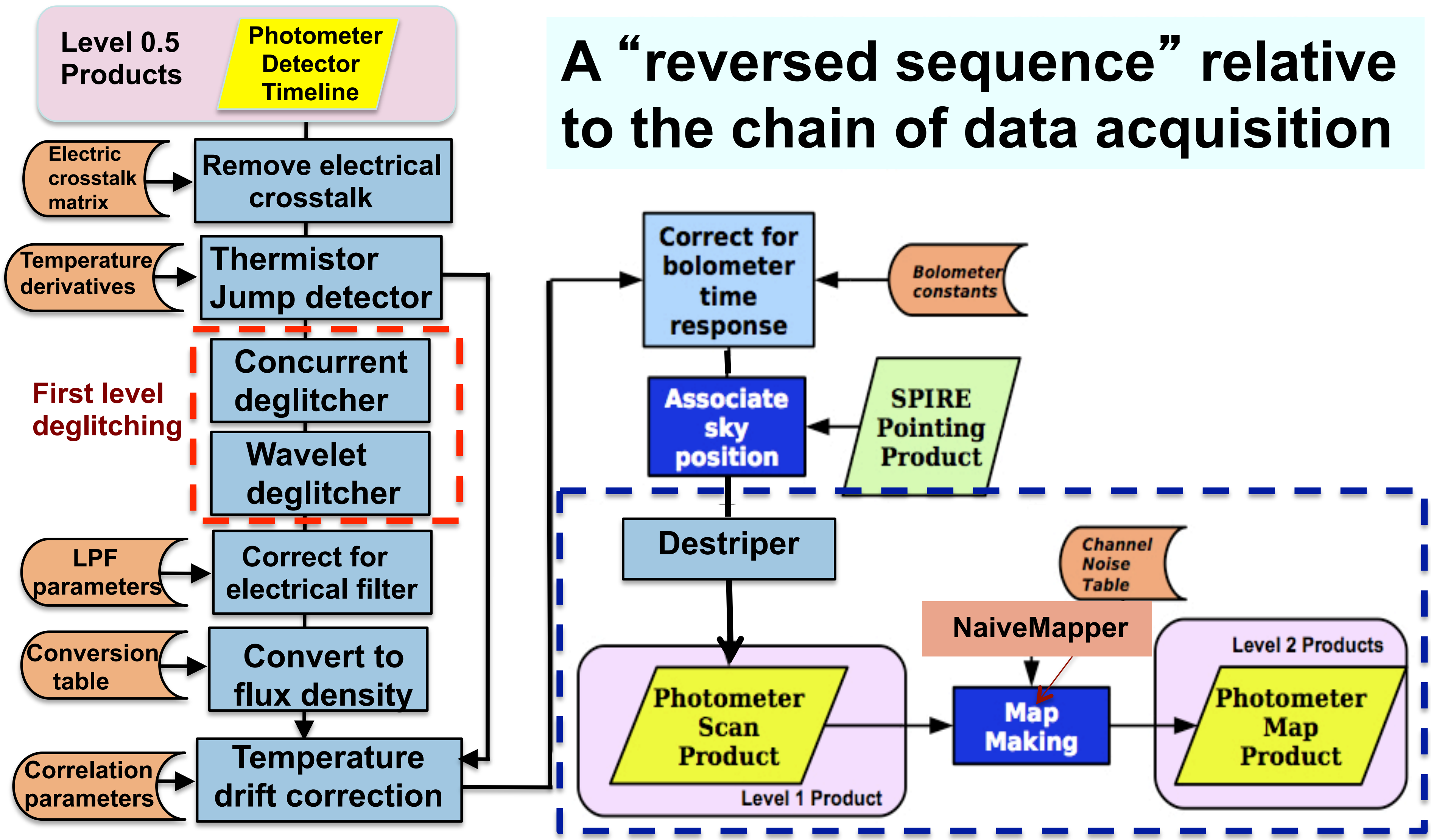
$$f_{pixel} = \frac{\sum_i^n f_i}{n}, \quad error_{pixel} = \sqrt{\frac{\sum_i^n (f_i - f_{pixel})^2}{n(n-1)}}$$

(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 bolometer with which a given sampling is taken:

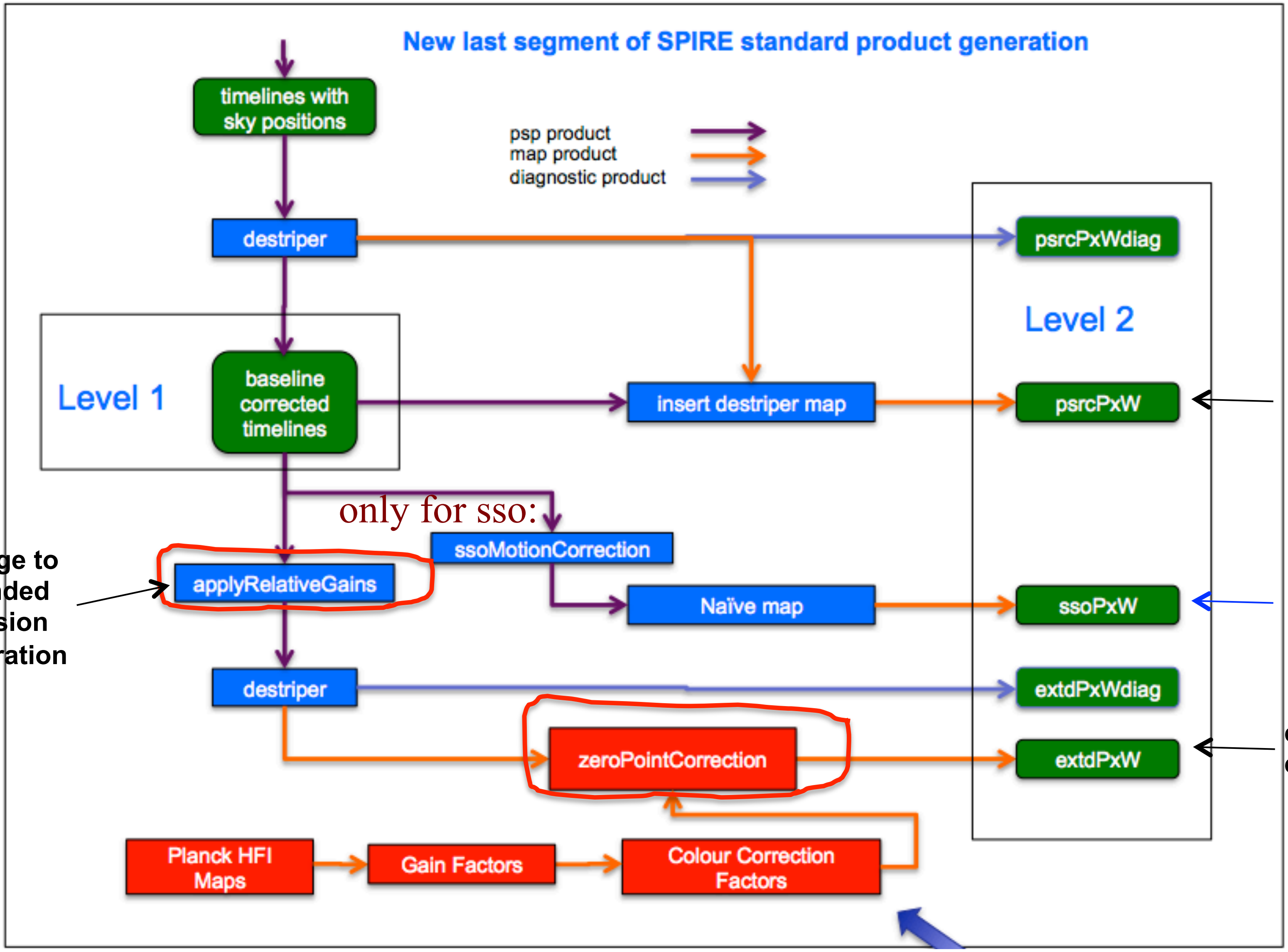
$$f_{pixel} = \frac{\sum_i^n f_i / \sigma_i^2}{\sum_i^n 1/\sigma_i^2} \qquad error_{pixel} = \sqrt{\frac{\sum_i^n (f_i - f_{pixel})^2 / \sigma_i^4}{\left(\sum_i^n 1/\sigma_i^2\right)^2 - \sum_i^n 1/\sigma_i^4}}$$



# Scan Pipeline Flow Chart



# Details on Level 2 Products Generation




change to extended emission calibration

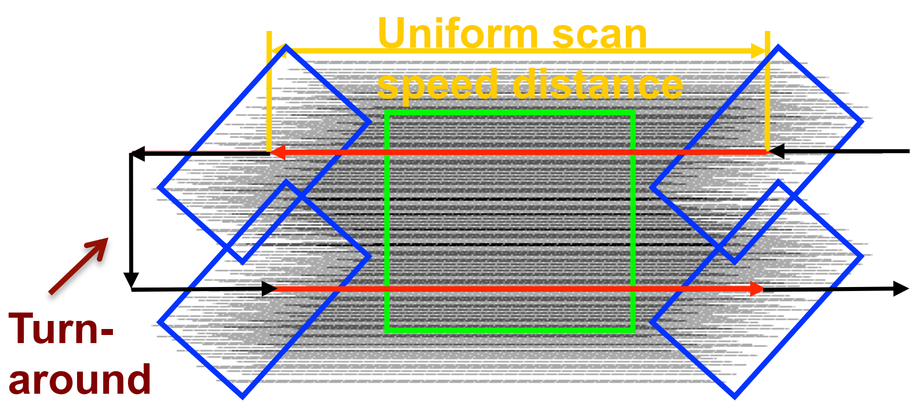
point source maps (PLW, PMW, PSW)

sso maps (only for solar system objects)

extended emission maps

# Scan-By-Scan Processing

- The pipeline processes timelines scan by scan (to ease the demand on RAM).
- Problem: ringing at the two ends of each scan due to FFT based modules.
- Solution:
  (1) Before the process, attaching "turn-around" data blocks to ends of the scan.
  (2) After the process, cut-off the "turn-around" data blocks from the scan.



# Highlights of a User Pipeline (Jython Script)

**LEVEL 0.5**

| | |
| --- | --- |
| pdt=joinPhotDetTimelines(pdt,pdtLead,pdtTrail)<br>nhkt=joinNhkTimelines(nhkt,nhktLead,nhktTrail) | Add turnarounds to Scans |
| bat=calcBsmAngles(nhkt,bsmPos=bsmPos)<br>spp=createSpirePointing(detAngOff=detAngOff,bat=bat,hpp=hpp, siam=siam) | Pointing information |
| pdt = signalJumpDetector(pdt, tempDriftCorr=tempDriftCorr,kappa = 3.0,......)<br>pdt=concurrentGlitchDeglitcher(pdt,chanNum=chanNum,kappa=2.0,.....)<br>pdt=waveletDeglitcher(pdt, scaleMin=1.0, scaleMax=8.0, .........................)<br>pdt=lpfResponseCorrection(pdt,lpfPar=lpfPar)<br>pdt=photFluxConversion(pdt,fluxConv=fluxConv)<br>pdt=temperatureDriftCorrection(pdt,tempDriftCorr=tempDriftCorr)<br>pdt=bolometerResponseCorrection(pdt,chanTimeConst=chanTimeConst) | Detector effects |
| psp=associateSkyPosition(pdt,spp=spp) | Attach Pointing |
| psp=cutPhotDetTimelines(psp, extend=includeTurnaround) | Detach turnarounds |
| psp=timeCorrelation(psp,timeCorr) | Correct timing |

**LEVEL 1**

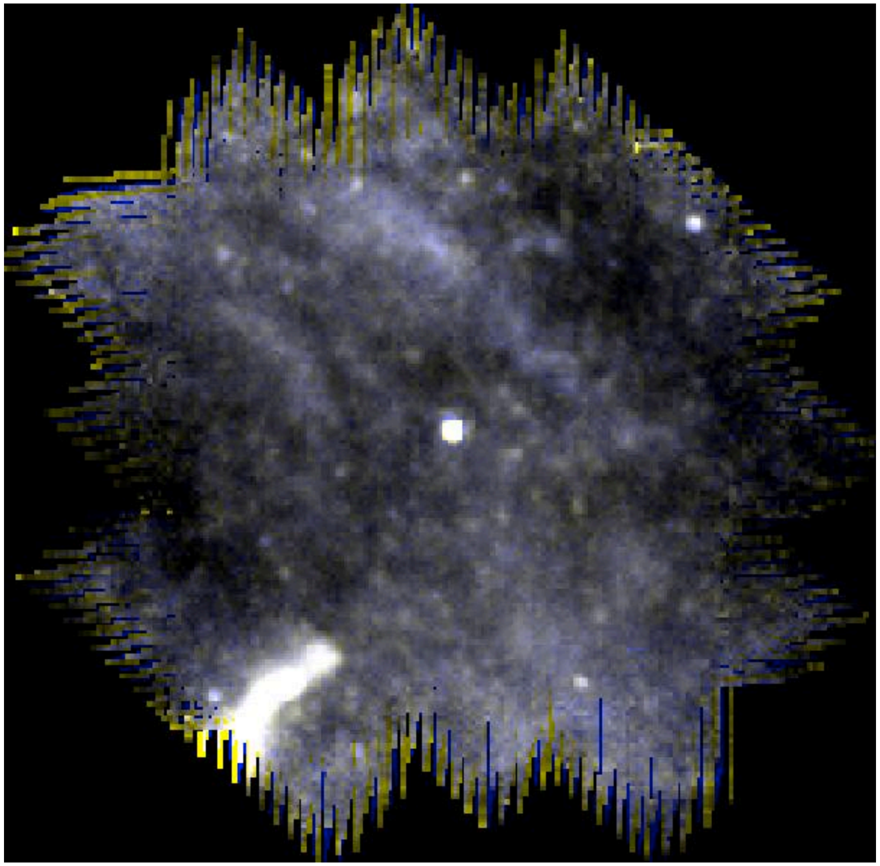
| | |
| --- | --- |
| applyRelativeGains(level1.getProduct(i), gains = chanRelGains) | Extended Emission |
| psp=removeBaseline(psp,chanNum=chanNum) | Baseline Removal |
| mapPlw=naiveScanMapper(scans, array="PLW") | Mapping |

**LEVEL 2**

# Status of SPIRE Photometer Pipeline in HIPE 12.1

- General assessment
  Overall, It works very well.
  In most cases, data from HSA are already science ready!
  (No need for reprocessing.)
- The absolute calibration accuracy is ±6% (4% systematic from flux standard model, 2% RMS).
- An example (on the right):
  The image from HSA looks good.
- Known issue:
  residual stripes due to "cooler burp" (affecting a few observations)

SPIRE 3-color map of NGC 5315 (a planetary nebula)



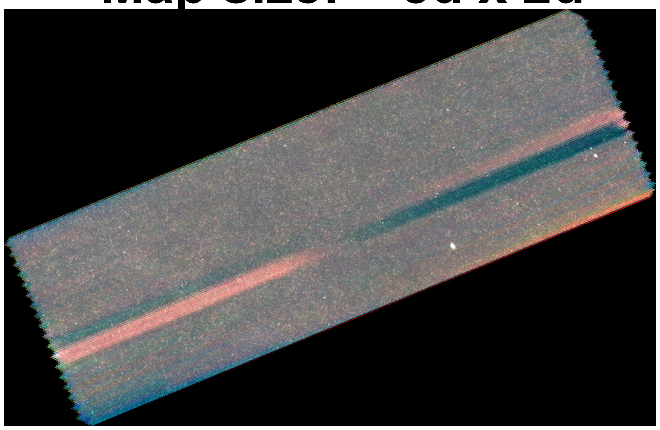
(Public data taken from HSA)

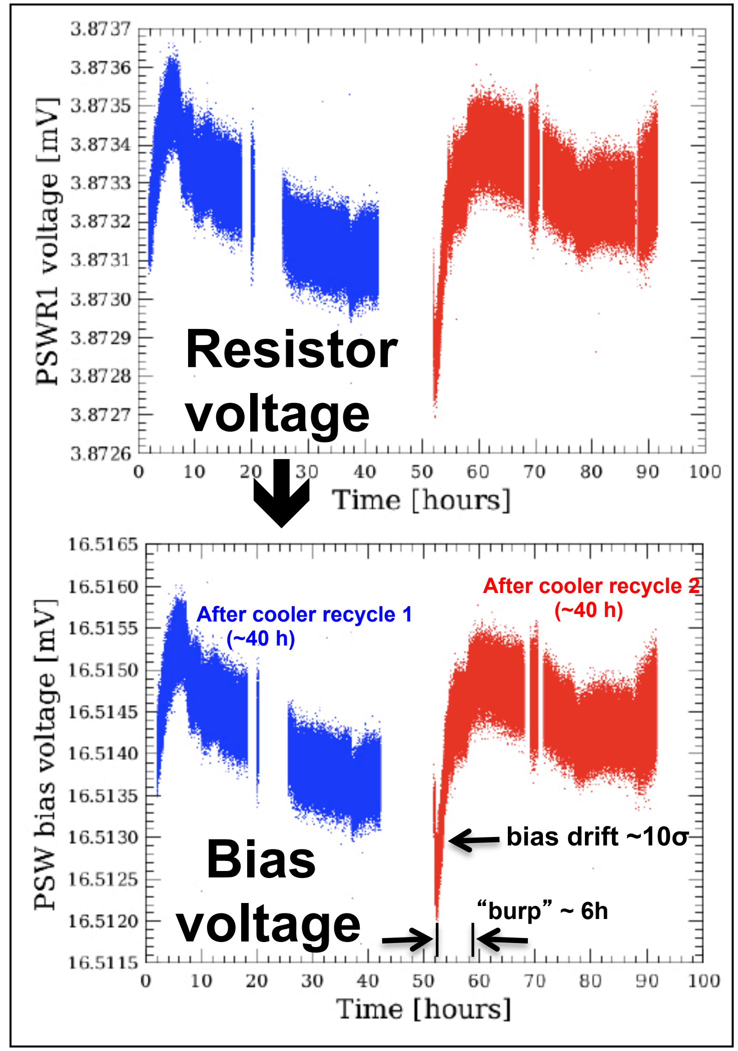
# "Cooler Burp"

- Every time when SPIRE was switched on after a cooler recycle, the first ~6 h saw rapid drifts of the temperature and of the bias voltage.
- It caused abnormal drifts in detector timelines, which in turn caused stripes in maps observed during the "cooler burp" period.

**Map size: ~ 8d x 2d**

An example of stripes caused by cooler burp:



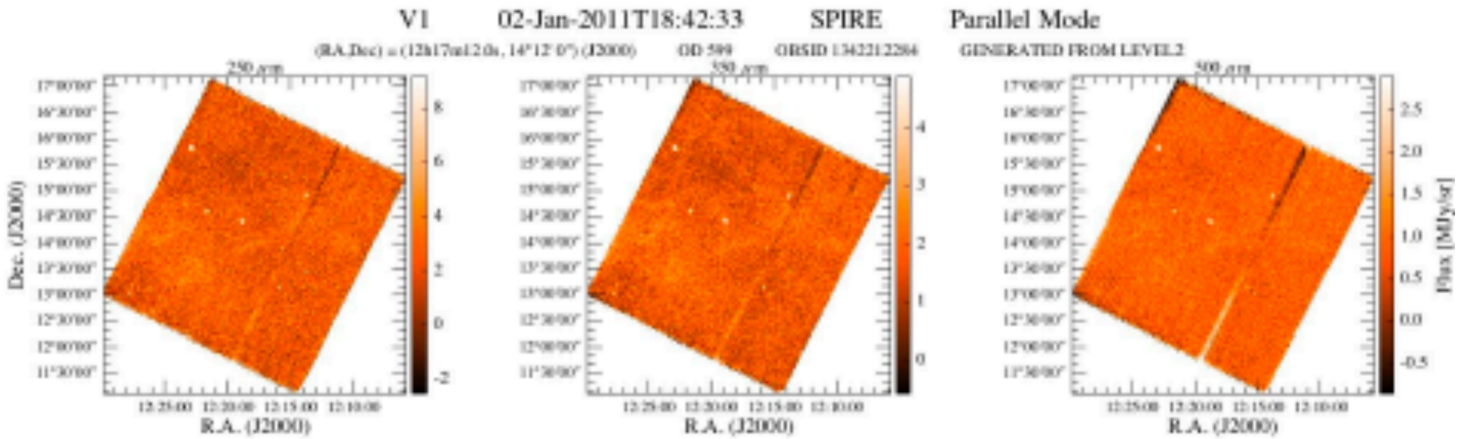



- Already corrected in the standard (SPG) pipeline products, but in a few cases residual stripes can still be seen.

## Residuals after Cooler-Burp Correction

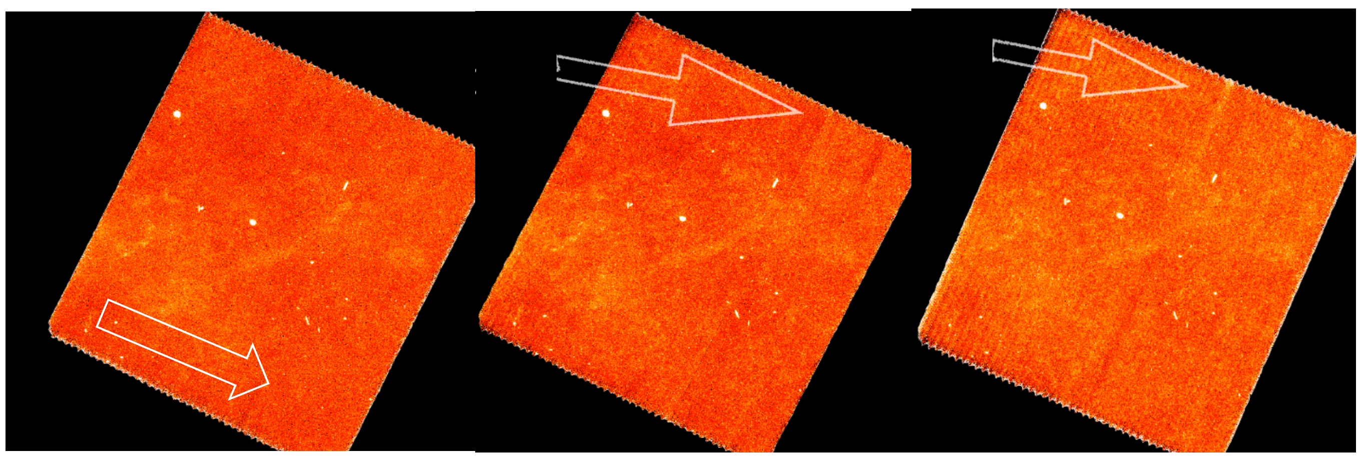
**An example for results of the Cooler-Burp correction:**

before correction →




**PSW** **PMW** **PLW**

after correction: →



residual stripes
(much fainter)

# Summary

- SPIRE Photometer Scan Map Pipeline handles data in the following observational modes: Small Map, Large Map, SPIRE/PACS Parallel Mode.
- Corrections for instrumental effects (between Level 0.5 and Level 1 products) follow a "reversed sequence" relative to the chain of data acquisition.
- The map-making of SPIRE Photometer maps is carried out using a Destriper-NaiveMapper combination.
- The current pipeline (HIPE 12.1) does a good job ("science ready") in general.
- There are still some issues (e.g. residual "cooler burp" stripes, missing glitches, etc.) which may require interactive reprocessing (to be covered in more details in a later talk).