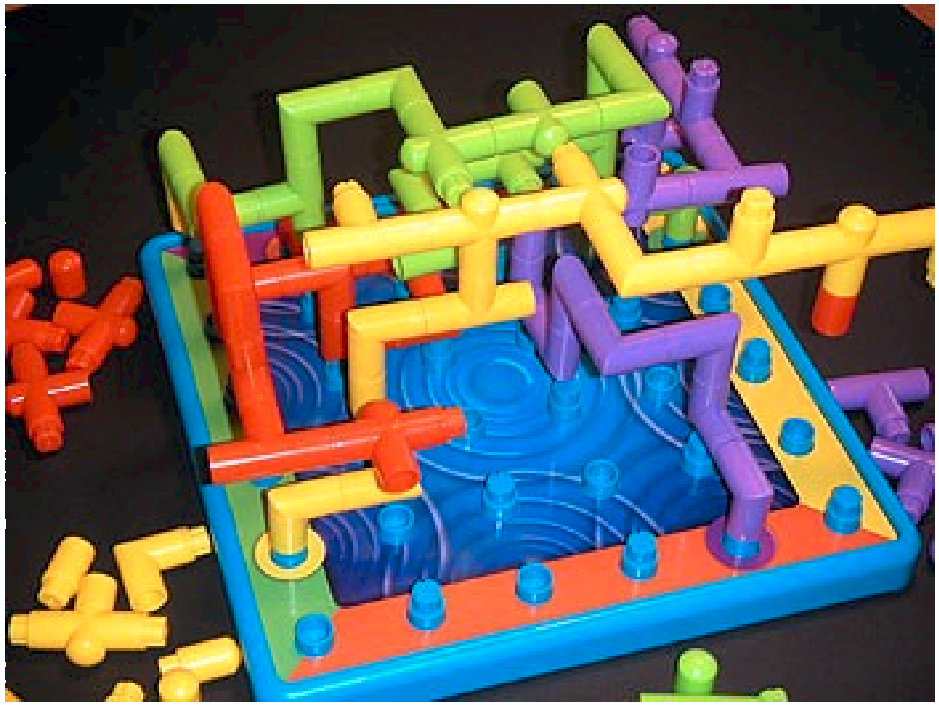
PACS SPECTROMETER PIPELINE



Concept, status,plans

A.Contursi and the PACS ICC

Outlines

- Pipeline concept
- Structure of the input data
- Pipeline description
- Summary pipeline current status
- Plans & caveats

Concept

- Keep pipelines independent of AORs as much as possible
- Natural definition of products at different processing levels
- Take fully advantage of interactive system:
  - *Each pipeline branch corresponds to a set of tasks, that can be executed step by step.*
  - *Users can inspect data at any time using plotting and displays tools available in the DP system*

Data Structure (Obs. Context)

- **Level-0**
  - + instrument detector readout timeline
  - + instrument housekeeping
  - + other instrument-specific data
- **Auxiliary**
  - + Pointing
  - + Orbit
  - + spacecraft housekeeping
  - + ...
- **Level-1**
  - + All instrument effects taken out
- **Level-2**
  - + Rebinned, publishable products
- **Calibration**
  - + Calibration products used to process level-1 and level-2 delivered by the HSA

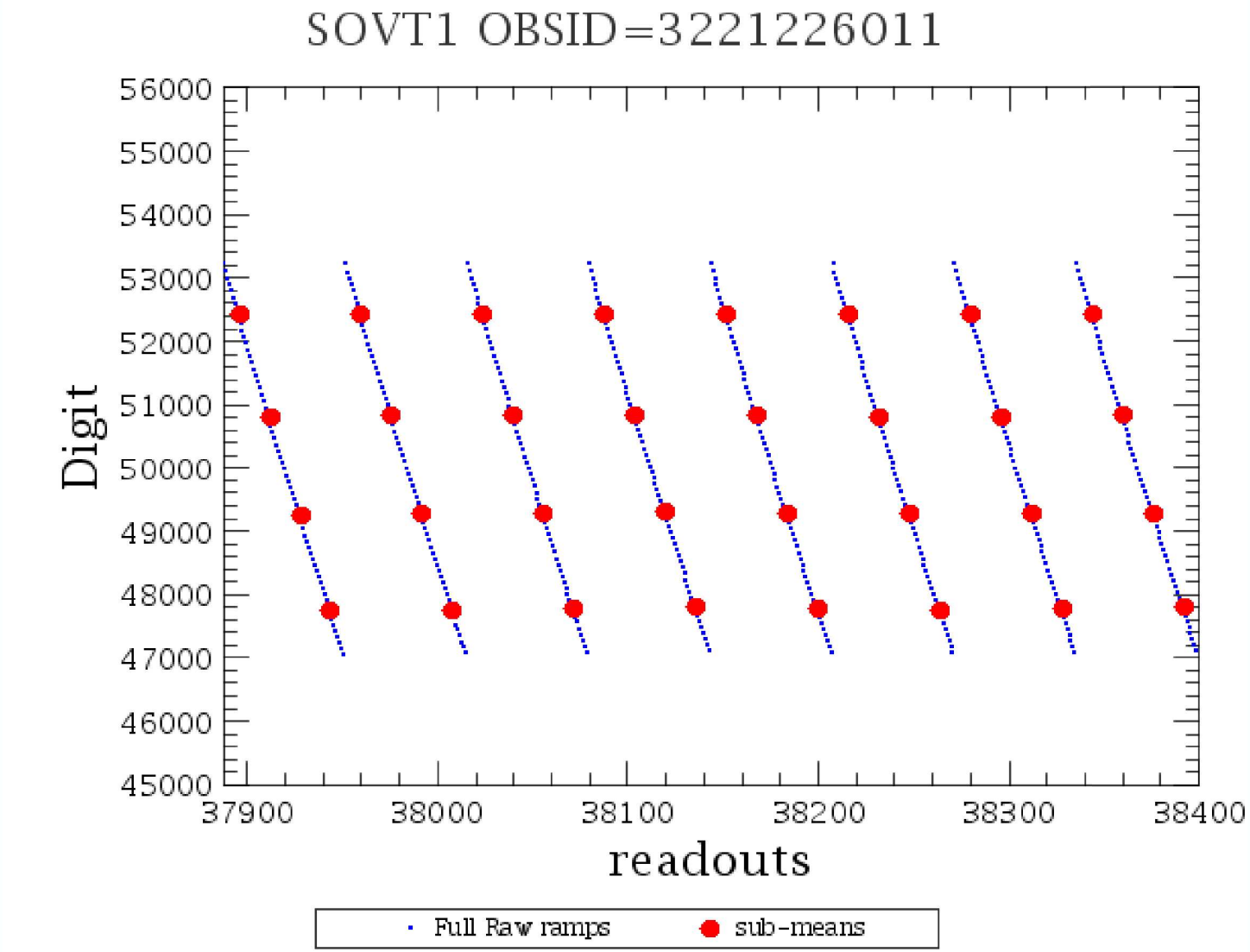
PACS raw signal

- PACS detectors are Photoconductors.
- Infalling photons change photoconductor resistance
- Photocurrent is integrated on a capacitance in the read-out circuit: generation of ramps (64 readouts)
- Increase of Voltage over the capacitance measures infalling photons. This changes ramp's slope (signal)
- Data rate limit: we have to average 8 read-outs on board (over 64 ro). So “raw” signals (i.e. Level 0 products) to astronomers are ramps with sub-means

Pipeline input data

Level 0 Products

Raw data: ramps with sub-means



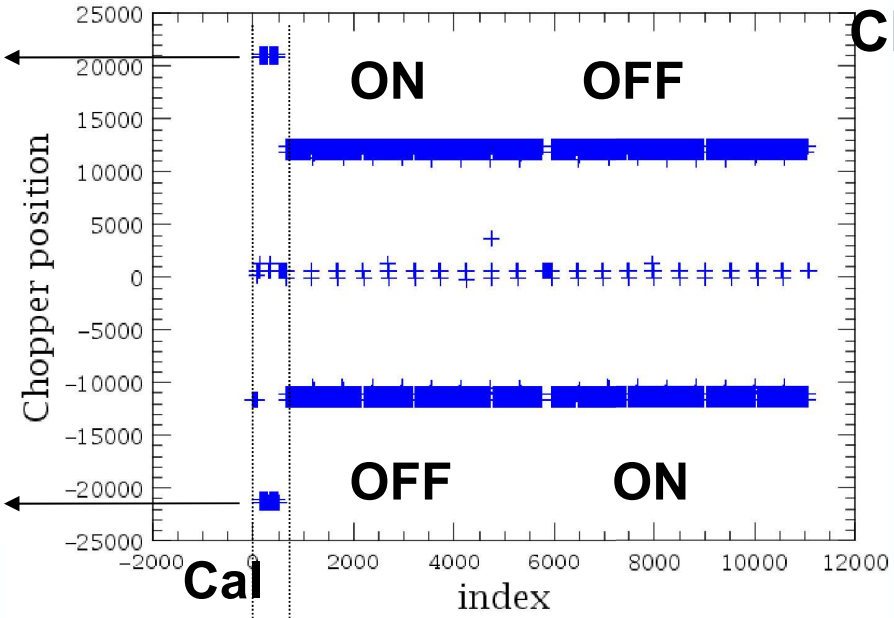
Signal=ramp's slope

Mechanisms

Internal Calibration Source 2 (CS2)

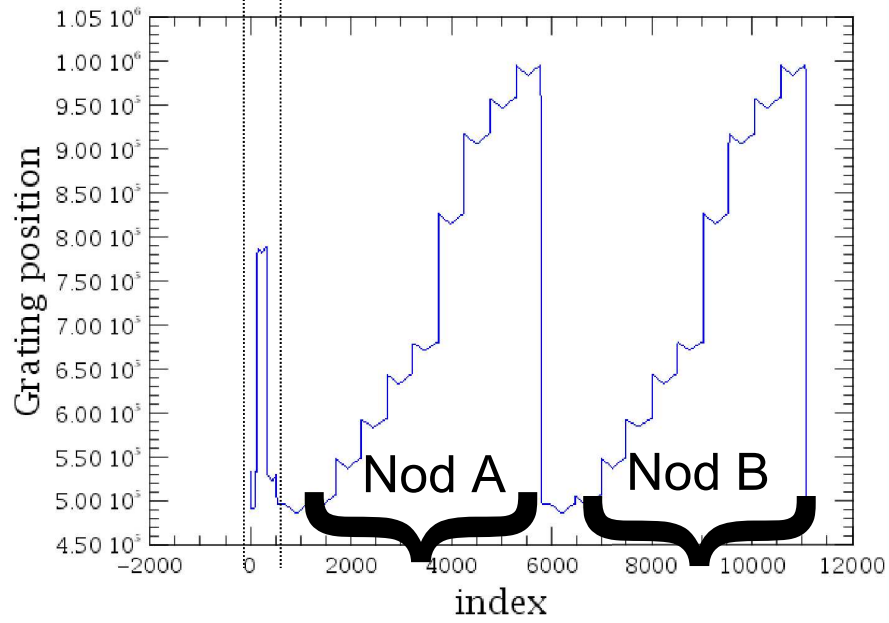
Internal Calibration Source 1 (CS1)

Chopper



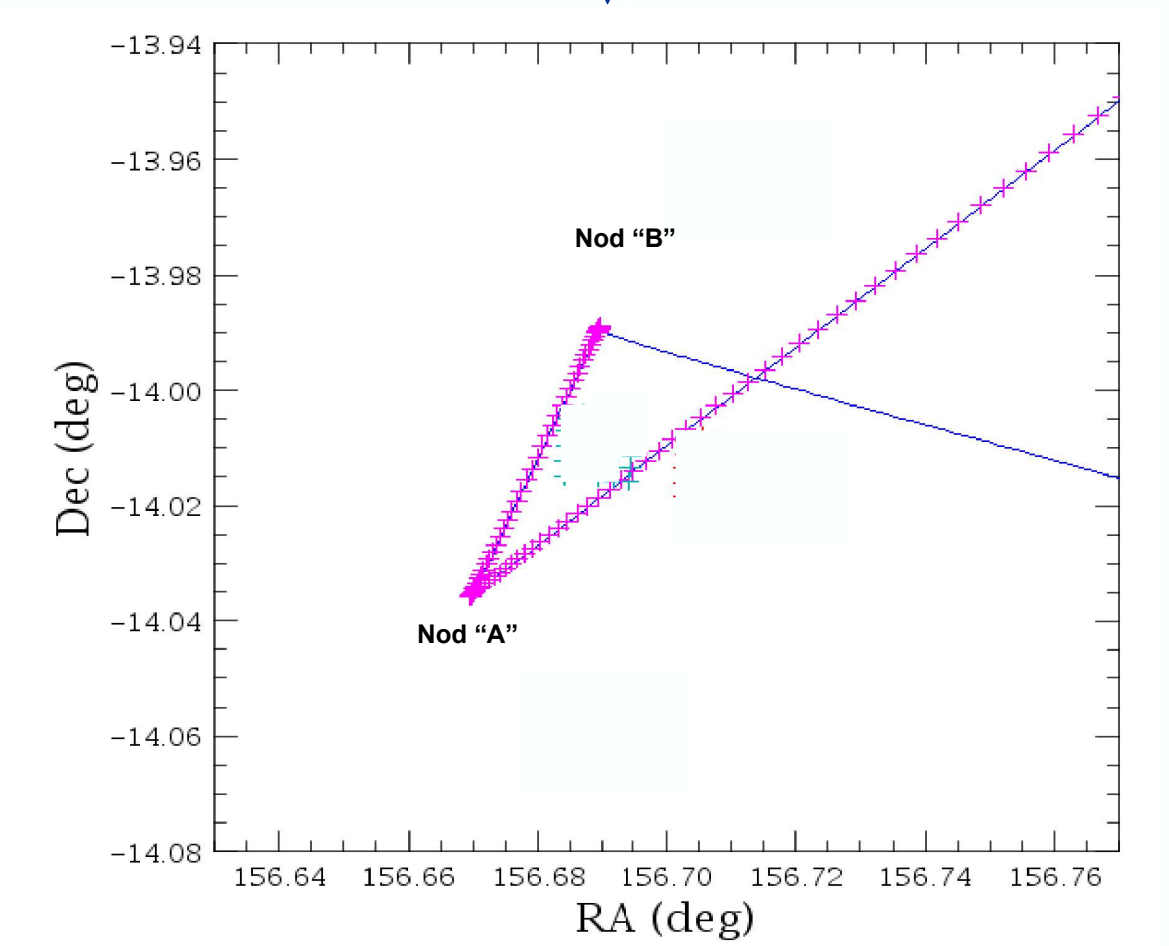
Cal Block

Grating

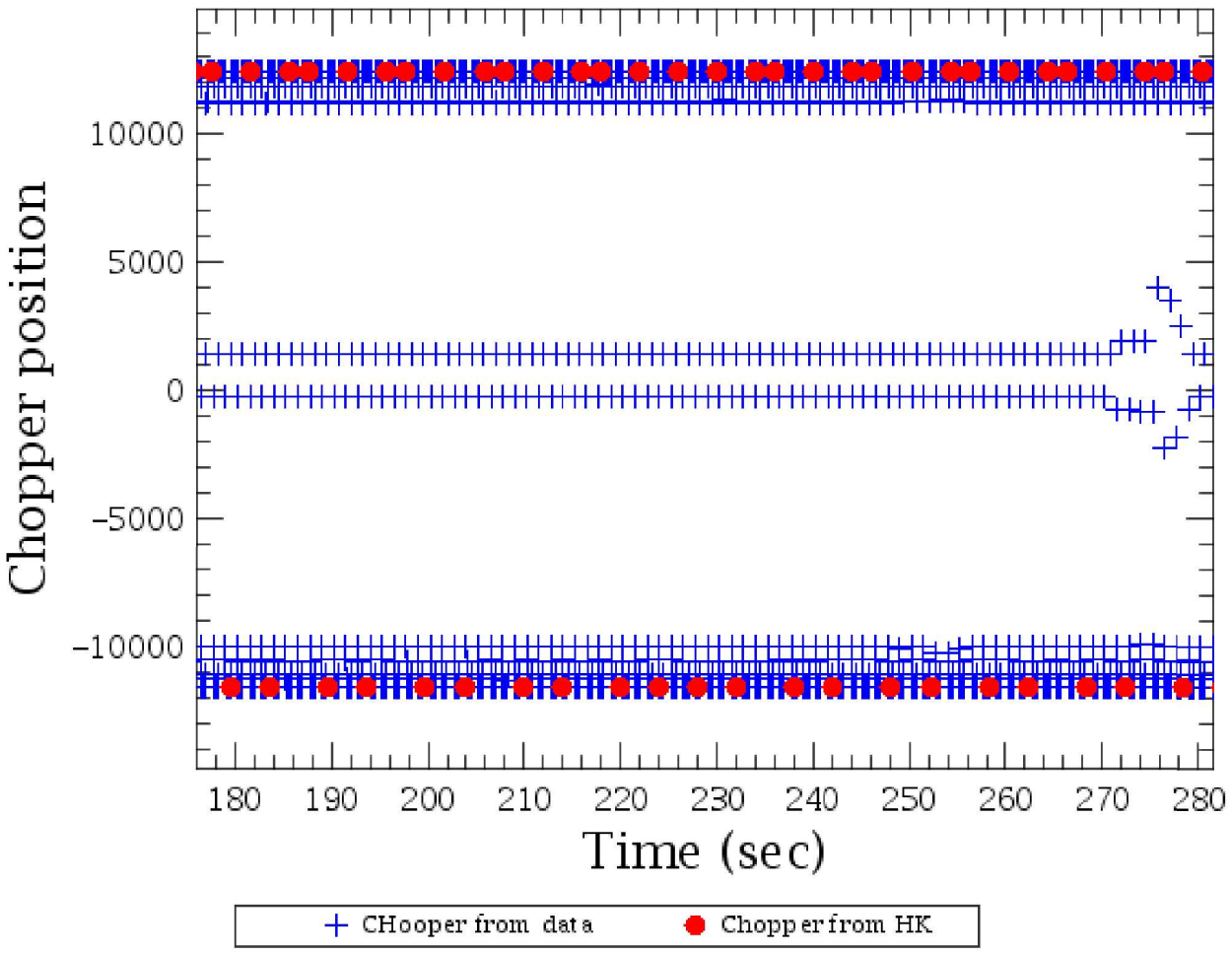


Pointing

Telescope boresight attitude info



Housekeeping

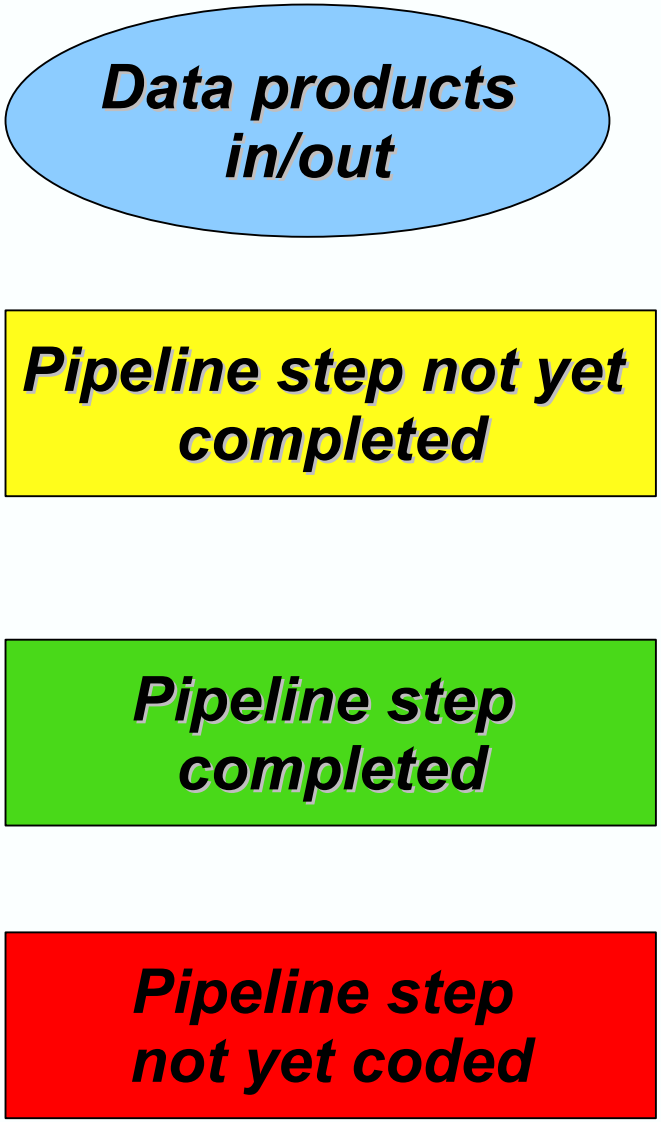


Some of the HK data essential for data reduction are associated with science data at high time resolution e.g.:

- **Chopper position**
- **Grating position**
- **Filter wheel position**
- **AOT block ID**
- **…**

Data volume for ~3h observation in default mode ~ 2.5 GB

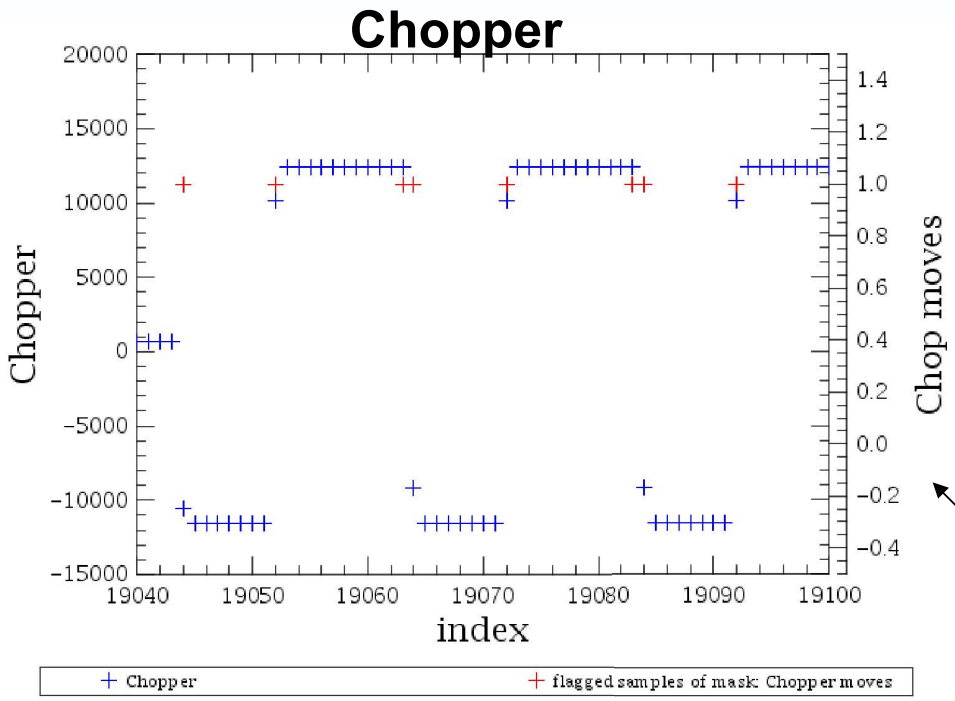
Color scheme for pipeline block diagrams

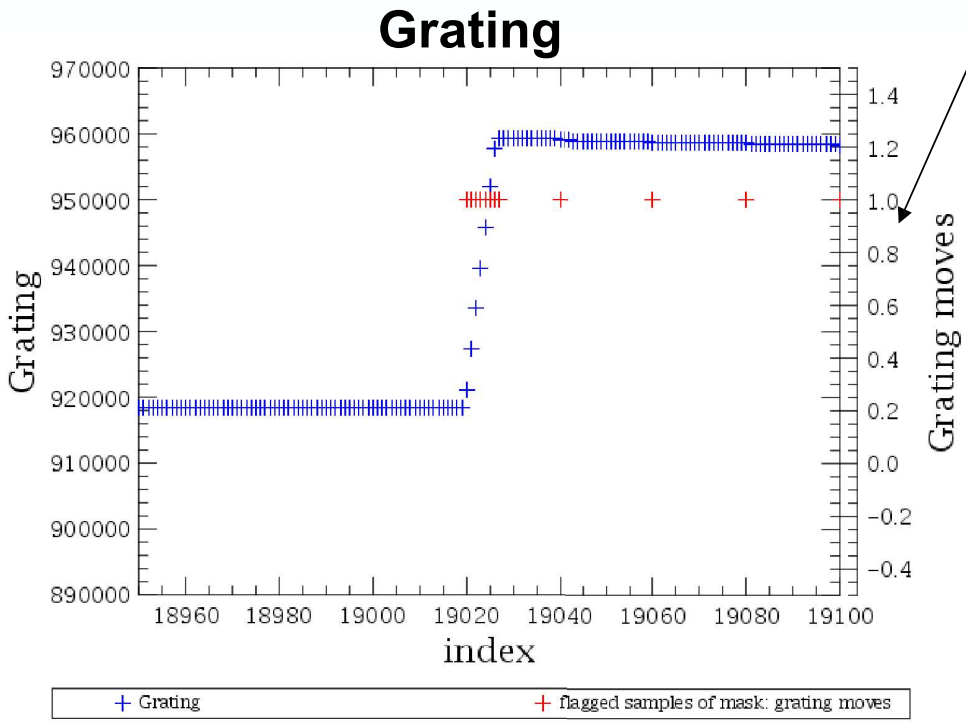


From Level 0 to 0.5

AOR independent

LEVEL 0





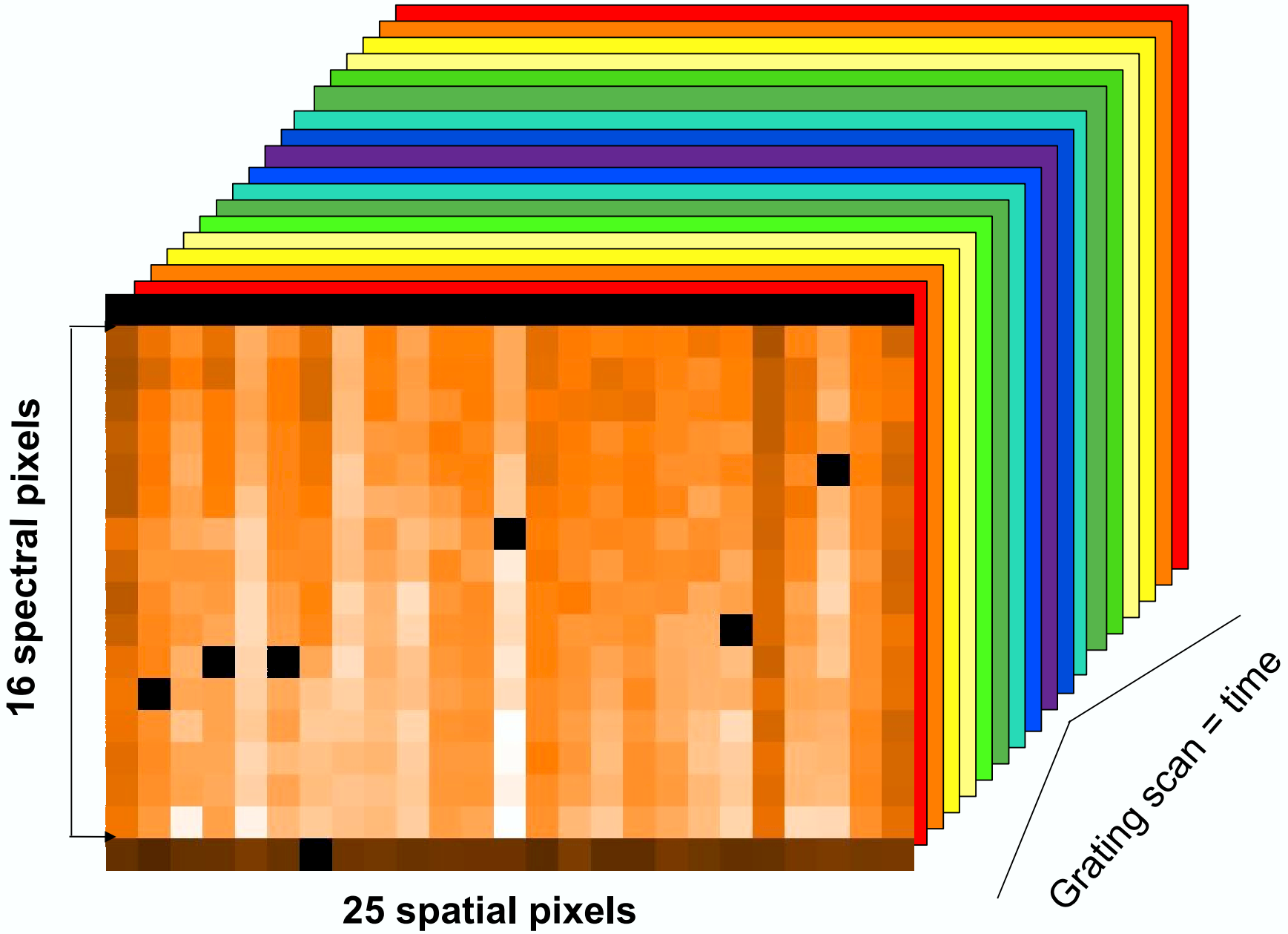
Ramps

Flag data (including glitches)

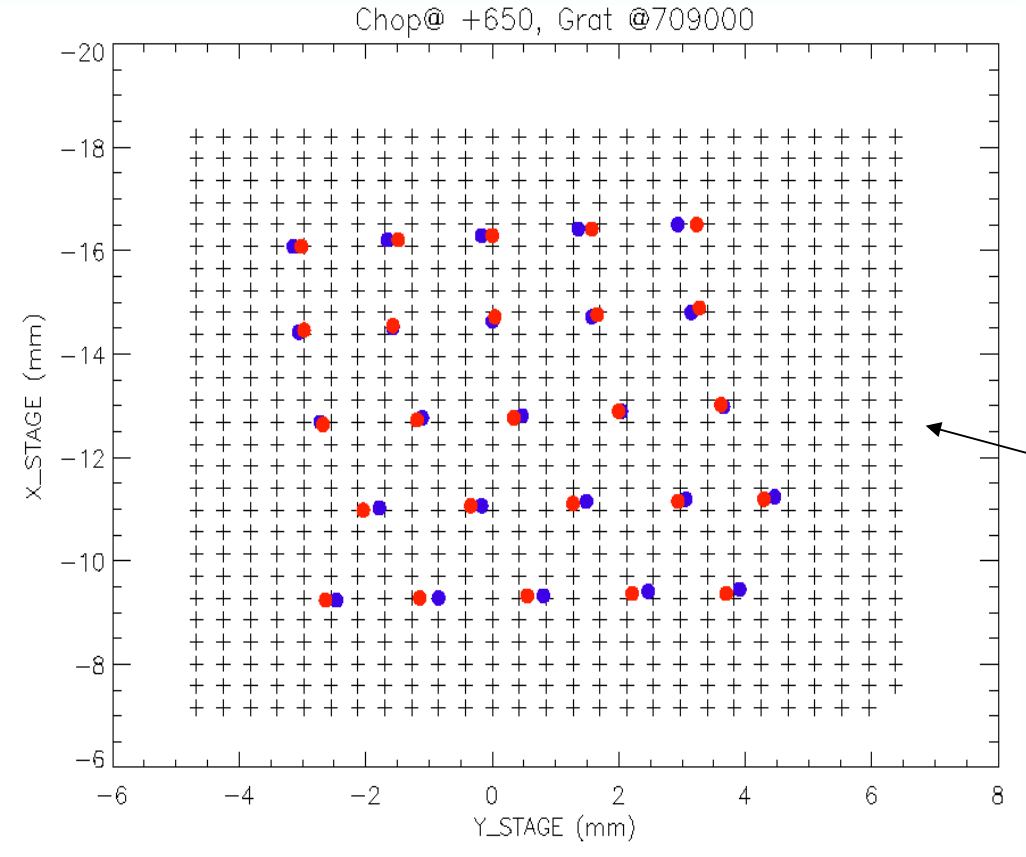
Fit ramps and calculate slopes

Frames

What do frames look like?



5x5 FOV

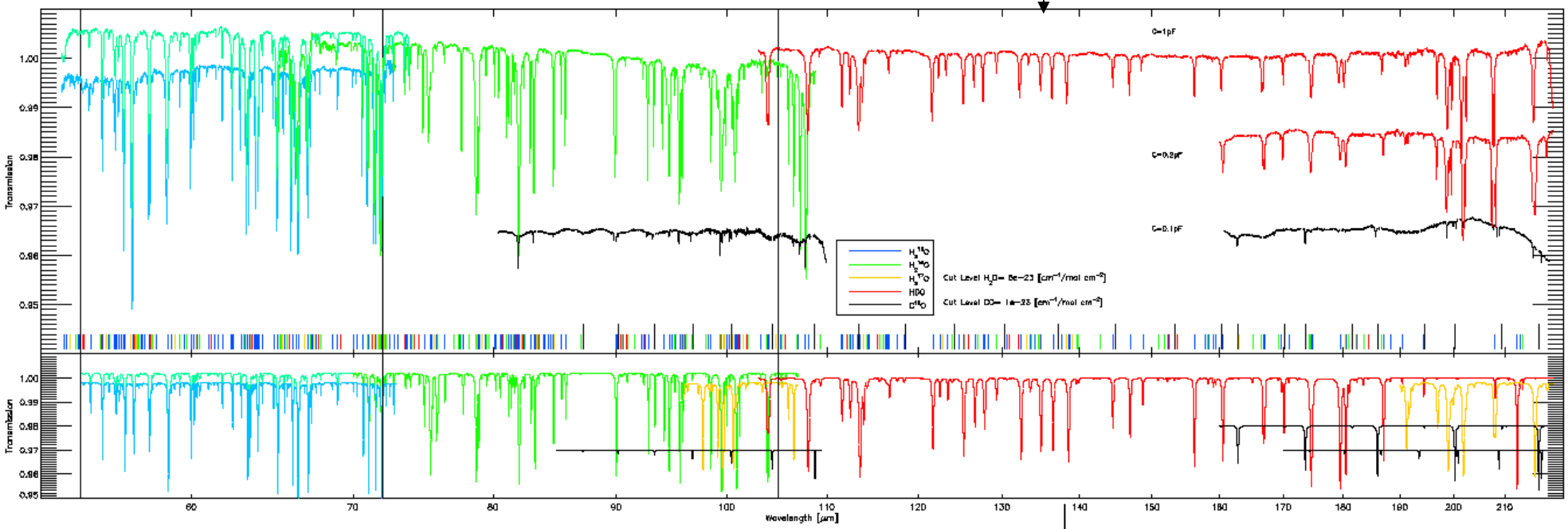


Frames

Identify logic blocks (nods, lines,etc..)

Add pointing and assign Ra and Dec

Assign Ra-Dec to central pixel reading the Herschel pointing and assign coordinates to all other pixels from spatial distortion calibration files (derived from ground tests.)

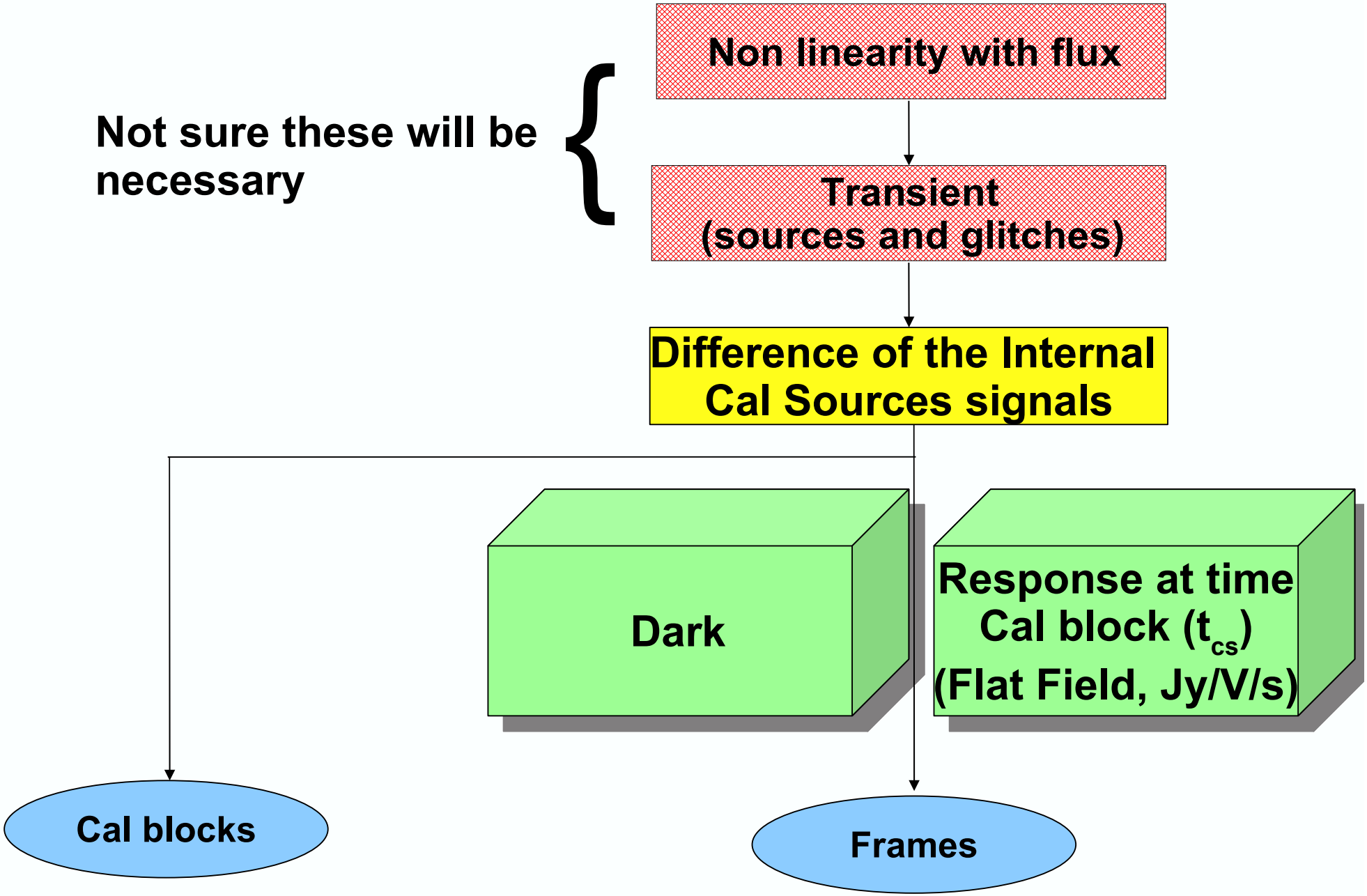


Assign wavelength to each pixel. Polynomial fit based on water cell wavelength spectrum observed in ground tests

Wave calib

Corr-non-linearity due to cryo electronics

Derived from ground tests


Not sure these will be necessary
Non linearity with flux
Transient (sources and glitches)
Difference of the Internal Cal Sources signals
Dark
Response at time Cal block (t_{cs}) (Flat Field, Jy/V/s)
Cal blocks
Frames

Level 0.5

From Level 0.5 to 1

AOR dependent !

Flux calibration concept for chopped obs.

- Difference of Internal Cal Sources signals gives Dark(pix,t) and $R(pix,t_{cs})$

- On-Off difference of the data nods A and B is:

$$\Delta^{A}(pix,\lambda)=(S_{Source}+S_{Tel+}-S_{Tel-})^{*}\ RSRF(pix,\lambda)^{*}\ R(pix,t)$$
$$\Delta^{B}(pix,\lambda)=(S_{Source}+S_{Tel-}-S_{Tel+})^{*}\ RSRF(pix,\lambda)^{*}\ R(pix,t)$$

Known from ground tests

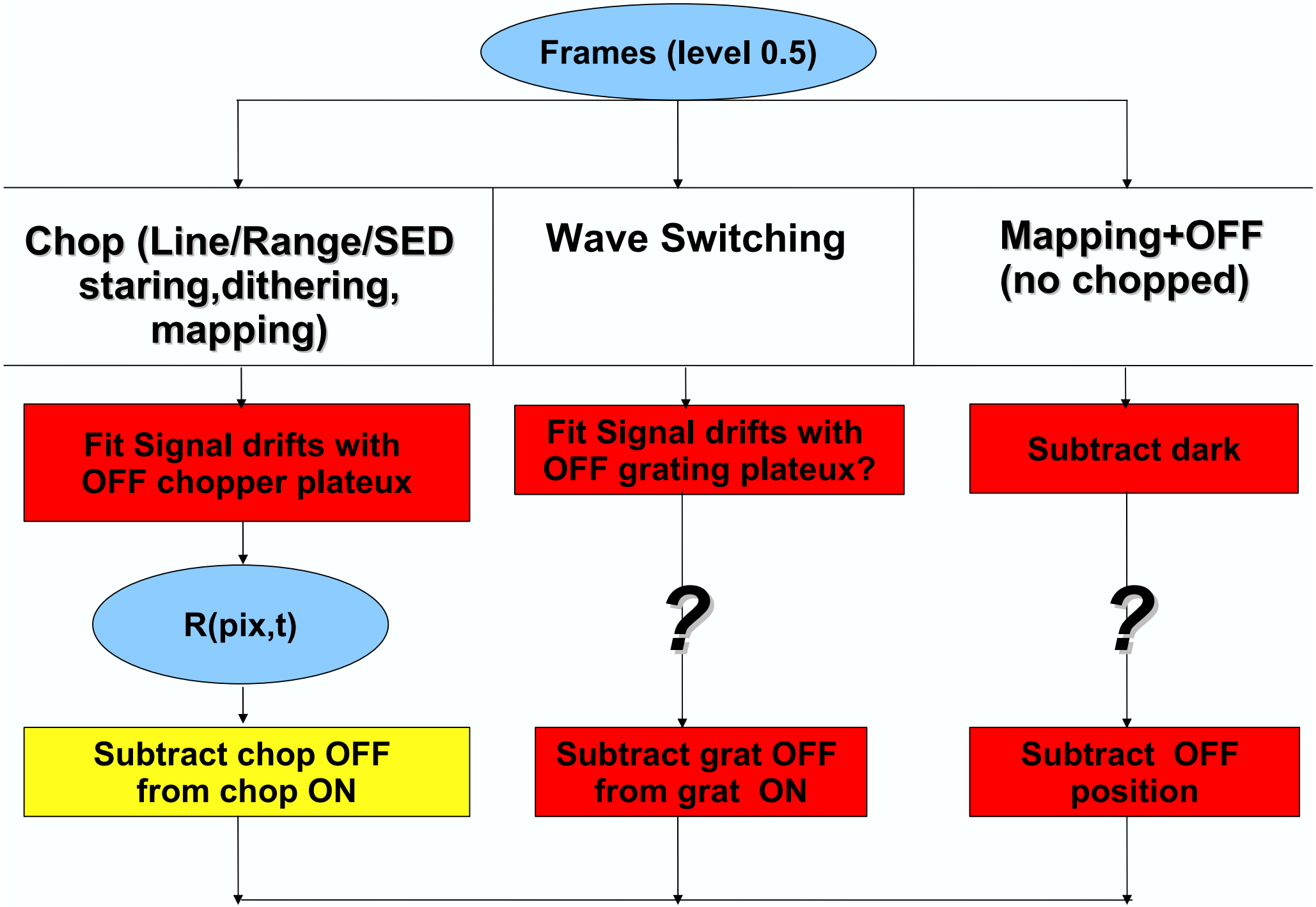
- $R(pix,t) \neq R(pix,t_{cs})$ due to glitches

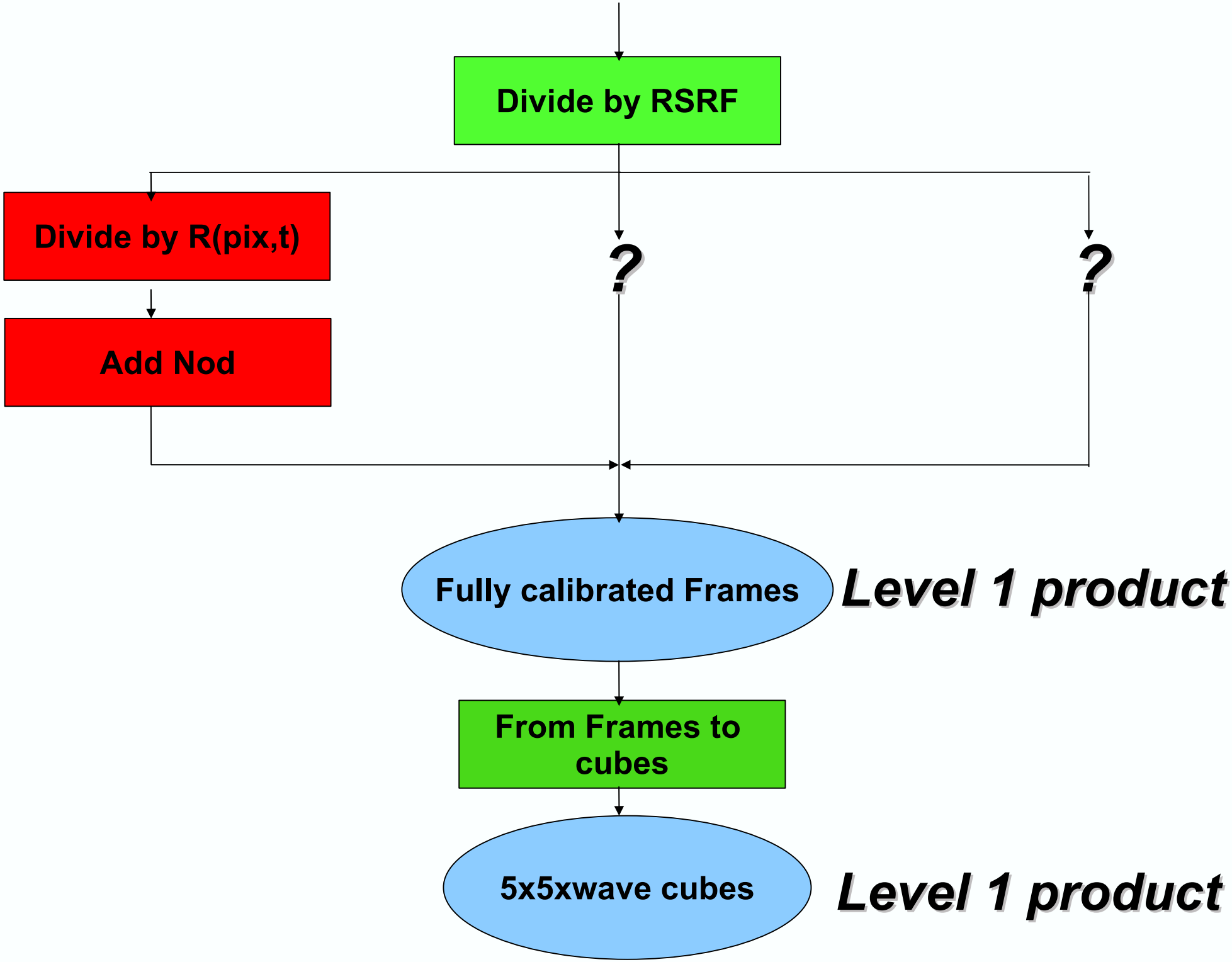
- R(pix,t) derived using the off plateaux signal and assuming that the telescope background spectrum as measured in the mean of all pixels is not affected by response drifts:

$$\langle R(pix,t)/R(pix,t_{cs})\rangle_{pix(i,j)} = 1$$

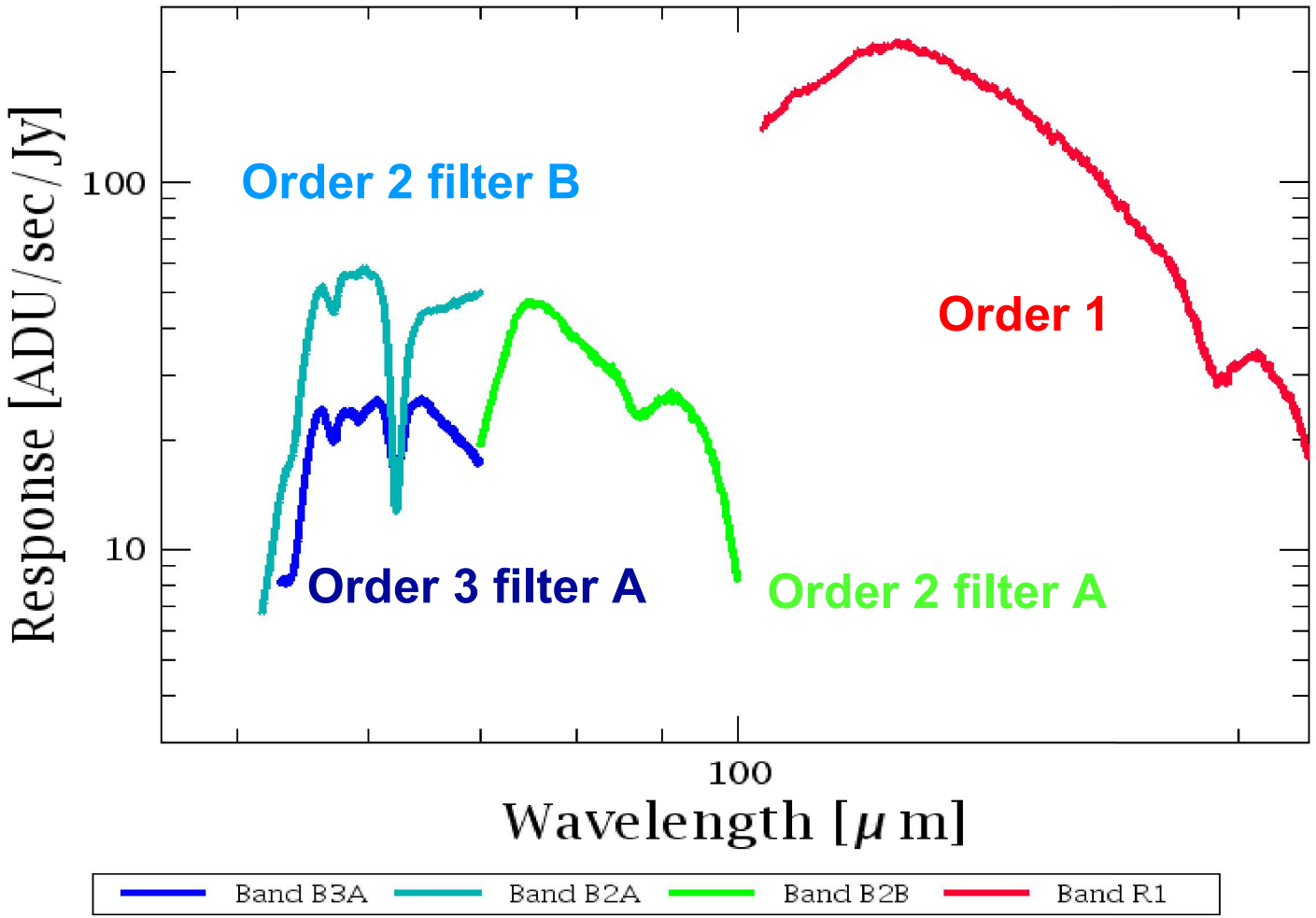
$$R(pix,t)=S_{off}/\left(\langle S_{sky}\rangle_{pix(i,j)} + \langle S_{T-}\rangle_{pix(i,j)}\right) \qquad \text{Nod A}$$

$$R(pix,t)=S_{off}/\left(\langle S_{sky}\rangle_{pix(i,j)} + \langle S_{T+}\rangle_{pix(i,j)}\right) \qquad \text{Nod B}$$


Frames (level 0.5)
Chop (Line/Range/SED staring,dithering, mapping)
Wave Switching
Mapping+OFF (no chopped)
Fit Signal drifts with OFF chopper plateux
Fit Signal drifts with OFF grating plateux?
Subtract dark
R(pix,t)
?
?
Subtract chop OFF from chop ON
Subtract grat OFF from grat ON
Subtract OFF position

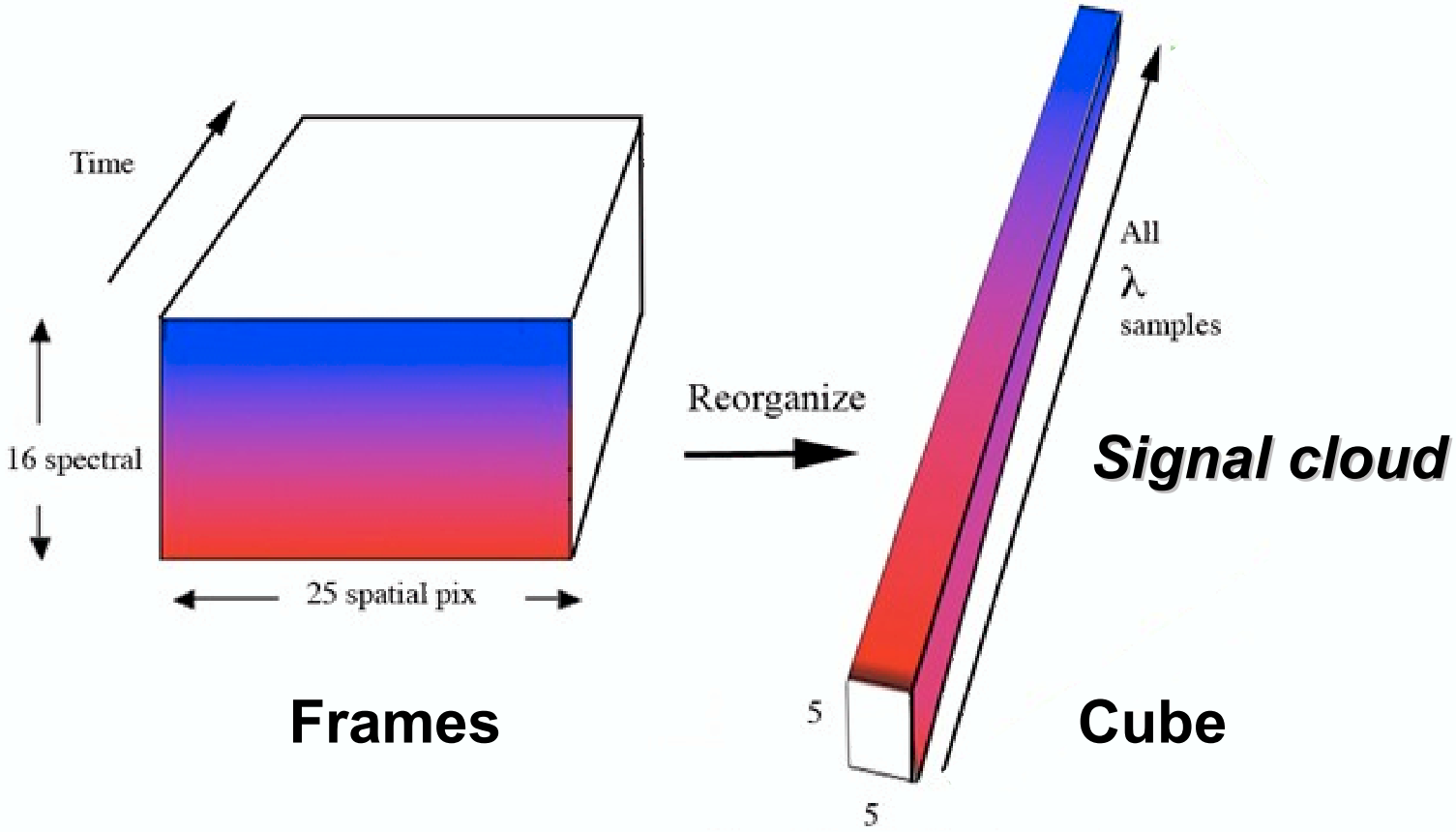

Divide by RSRF
Divide by R(pix,t)
?
?
Add Nod
Fully calibrated Frames
Level 1 product
From Frames to cubes
5x5xwave cubes
Level 1 product

PACS RSRF: From ground tests



NOTE: this is not relative!
We currently use it to flux calibrate data. Will become relative a.s.a. new flux calibration concept in place

2 Level 1 products! Same thing but different organization



25x16xN ⟶ 5x5xNX16

From Level 1 to 2

Where user interaction becomes important

Cube

Wave grid

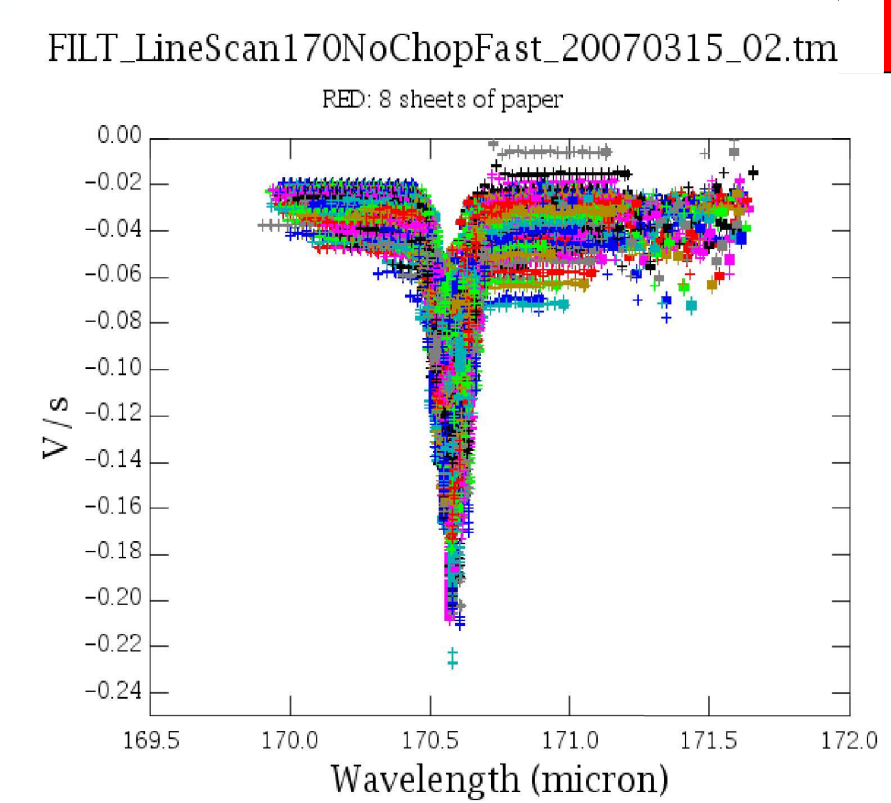
Flag outliers

Wave rebin

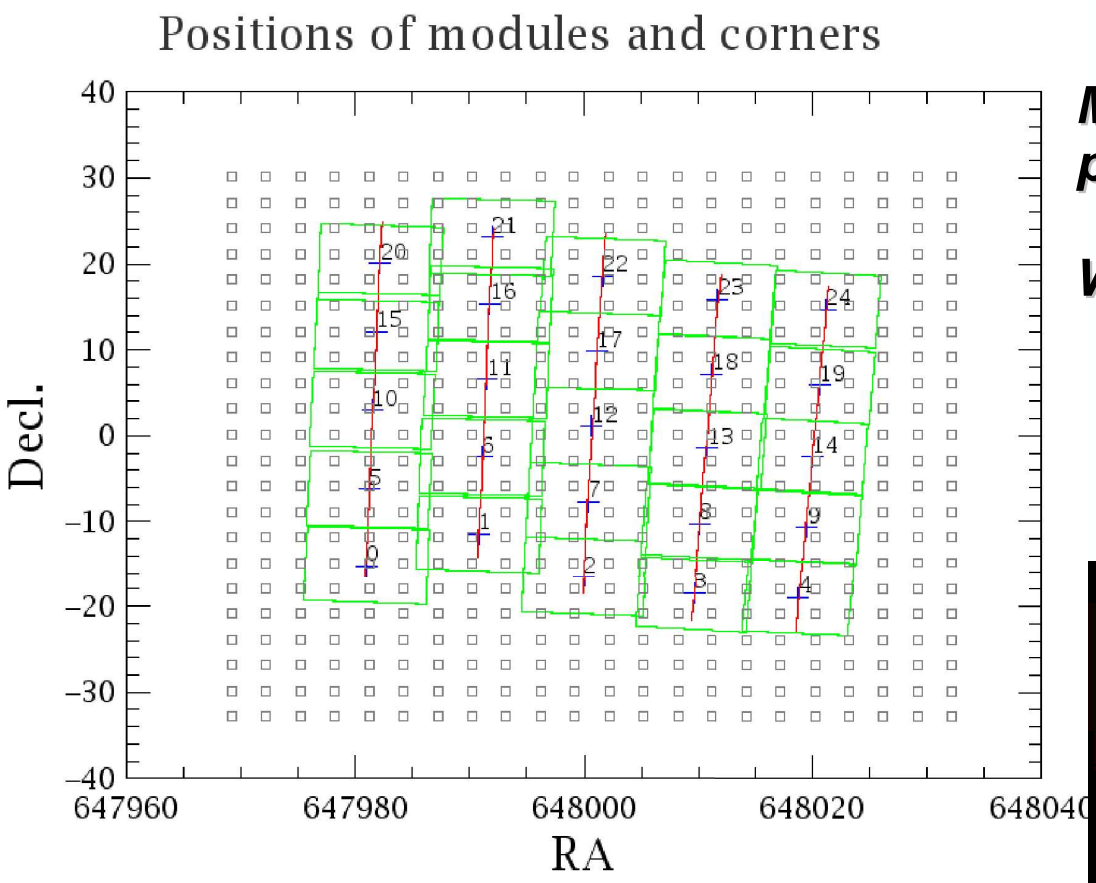
Project in the sky
Combine
dither/rasters

Projected Cube

3d drizzling

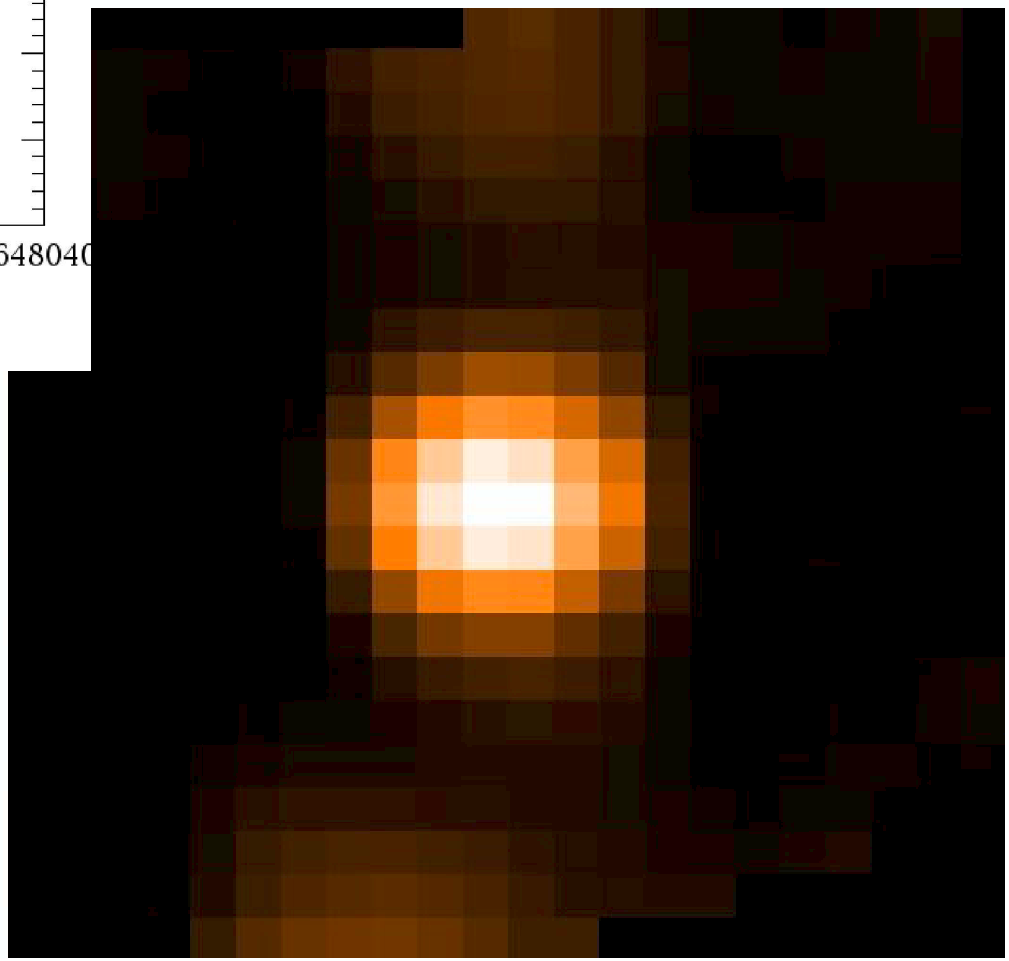


Projected Cube

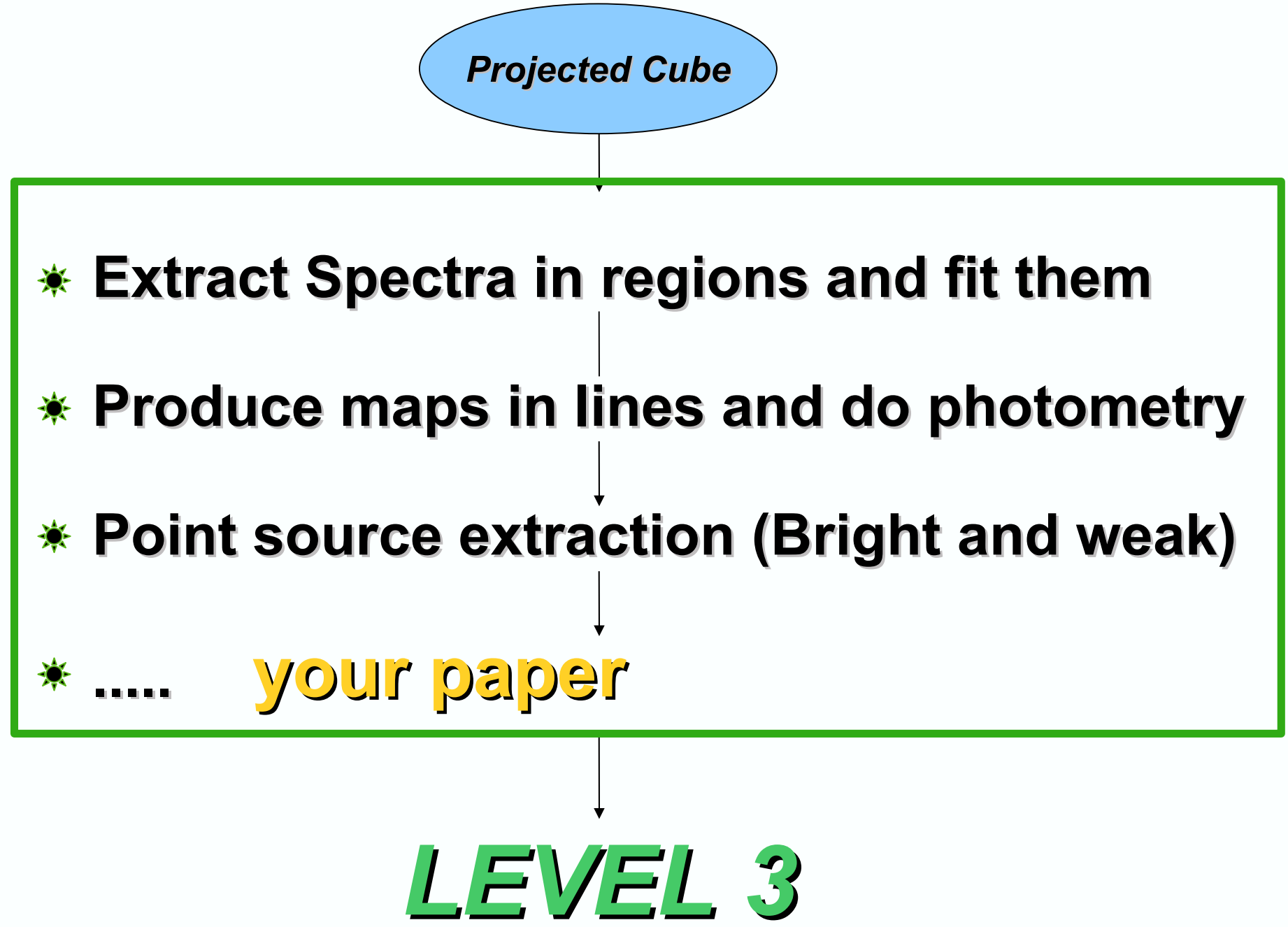


Messy spatial FOV;
pixels not physically squared.

We have to regrid onto a regular grid



Result of specProject on a ground based test data with a point source.



See A. Gueguen and S. Regibo demos

Summary status

- Most advanced pipeline for Chopped AORs (most test data in this mode)
- Flux calibration strategy for wave switch still to be defined
- Proper sky projection for well sampled maps now starting
- PACS Spec pipeline explained in a updated chapter of the UM

Plans

- Advance in the wave switching pipeline: Flight Spare specific tests
- 3d drizzling algorithm testing
- Flux calibration strategy for map without chopping
- Data chunking @ Level 0 in logical blocks (could be necessary for big data set).
- Pacs data reduction guide: with reduction recipes for each AOR

Things to keep in mind

- Signal behavior after glitch impacts will be fully characterized only AFTER launch
- AOR validation campaign in PV could lead to (some) AORs logic change. Impact on pipeline.