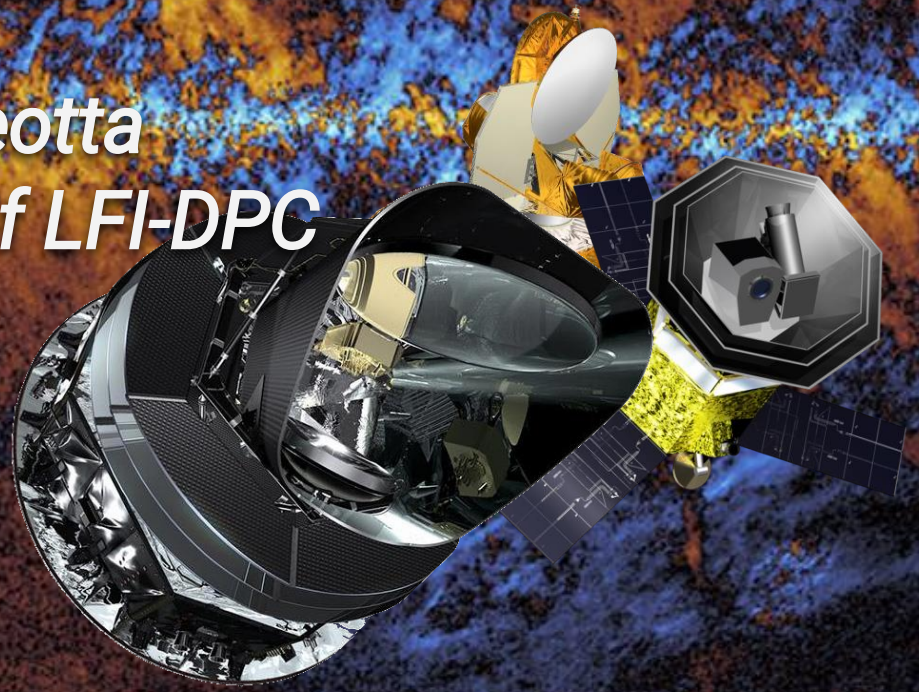
Planck LFI DPC processing history and end of mission status

S.Galeotta
on behalf of LFI-DPC



BeyondPlanck online release conference, November 18-20, 2020

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Summary

- Quick overview on LFI-DPC general structure
- From launch to early release: correct the strategy
- From early release to 2013: refine the strategy
- From 2013 to 2015: fine tuning the strategy
- From 2015 to legacy: go beyond

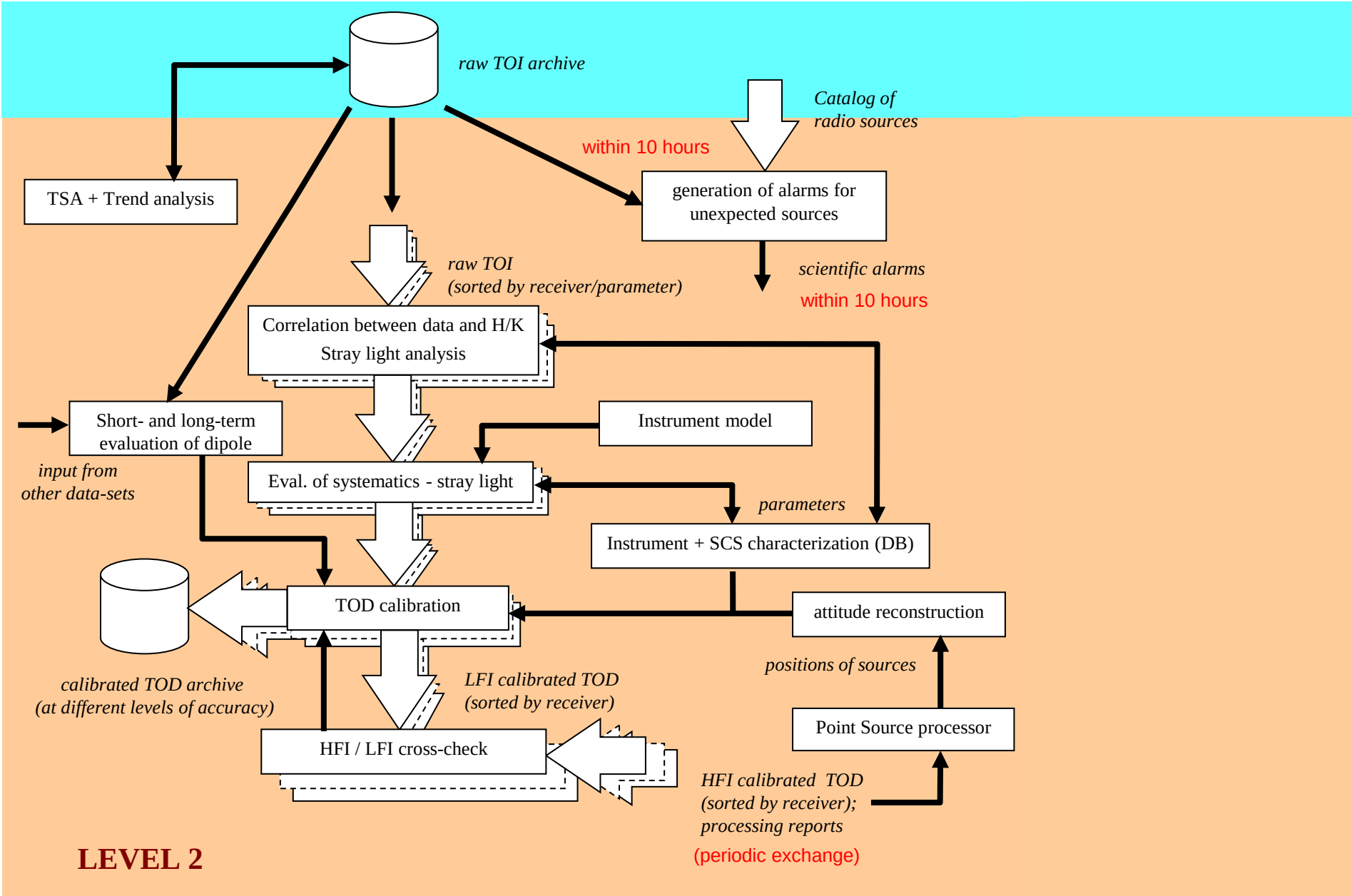
LFI-DPC Analysis Pipeline

DPC approaches data reduction with specific tasks aiming to estimate and correct instrumental systematic effects

There are three main logical levels:

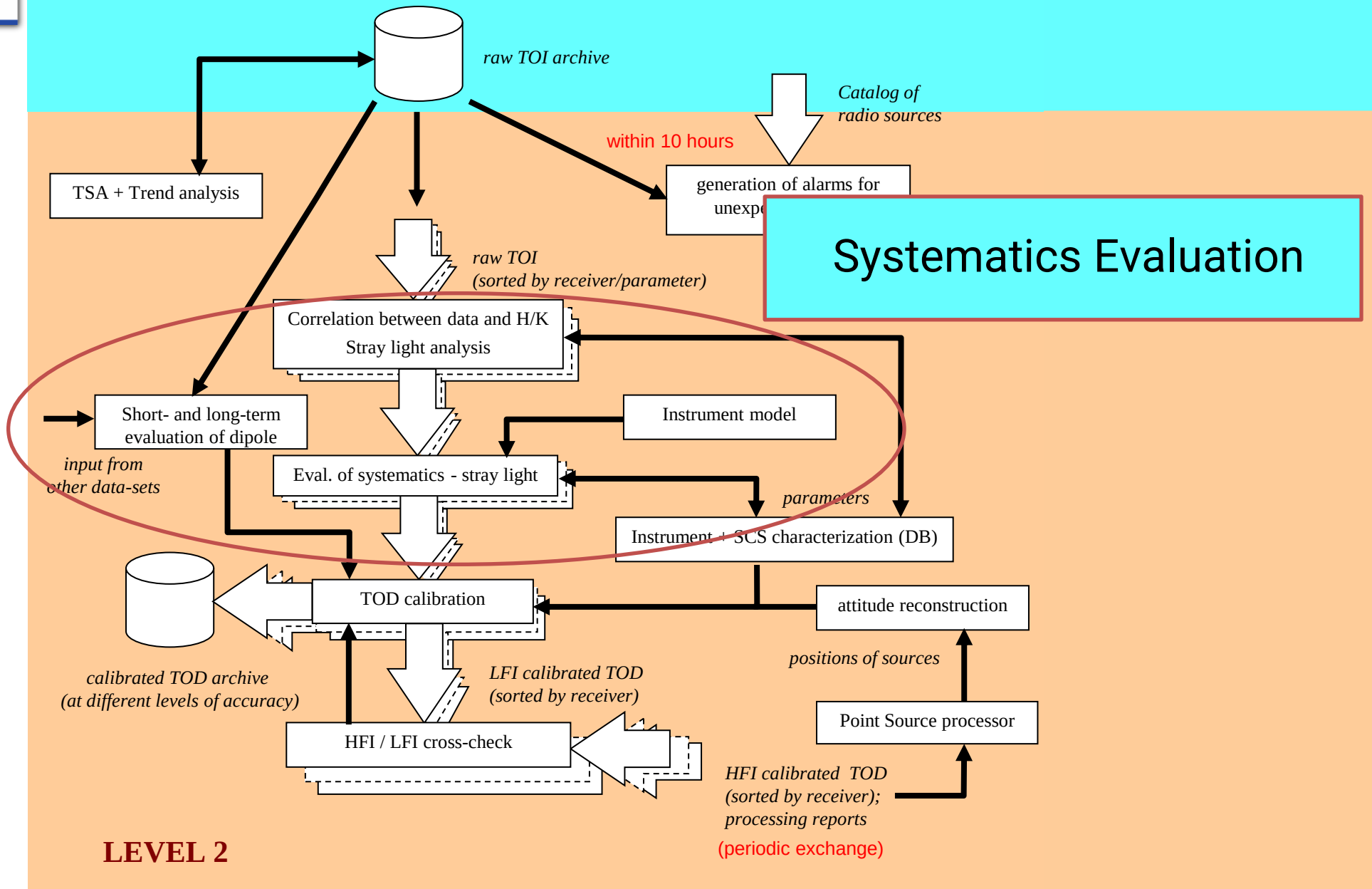
- Level 1: H/K and Science telemetry from the satellite are transformed into raw timelines and stored into dedicated databases with the associated time information
- Level 2: instrument information is gathered and ingested into the Instrument Model, removal of systematic effects, flag data of suspected quality, photometric calibration and creation of maps and ancillary products
- Level 3: more science here with component separation, power spectra estimation and extraction of cosmological parameters

Early Pipeline



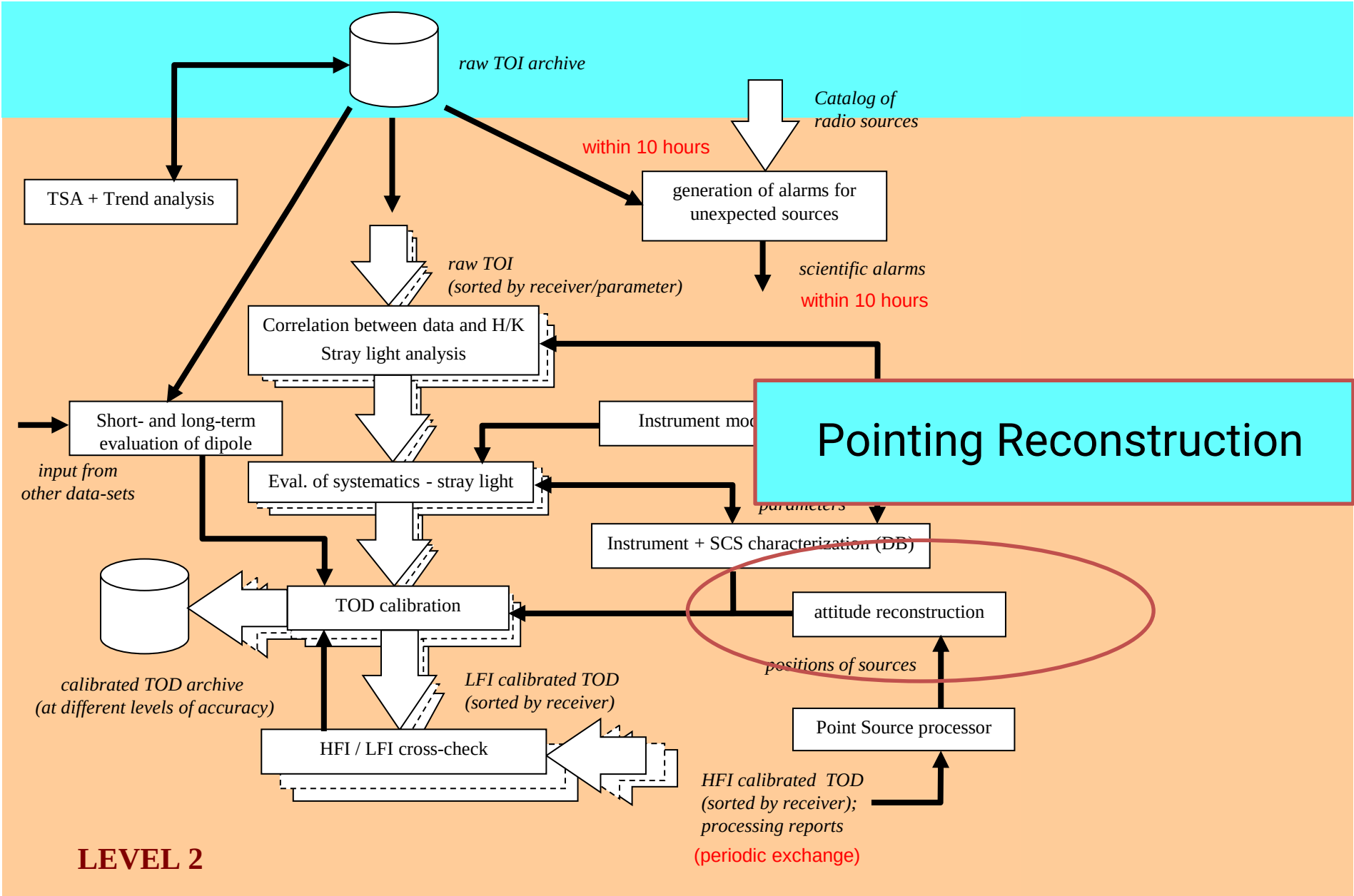
Mandolesi et al.; “Planck pre-launch status: The Planck-LFI programme”, 2010, A&A

Early Pipeline

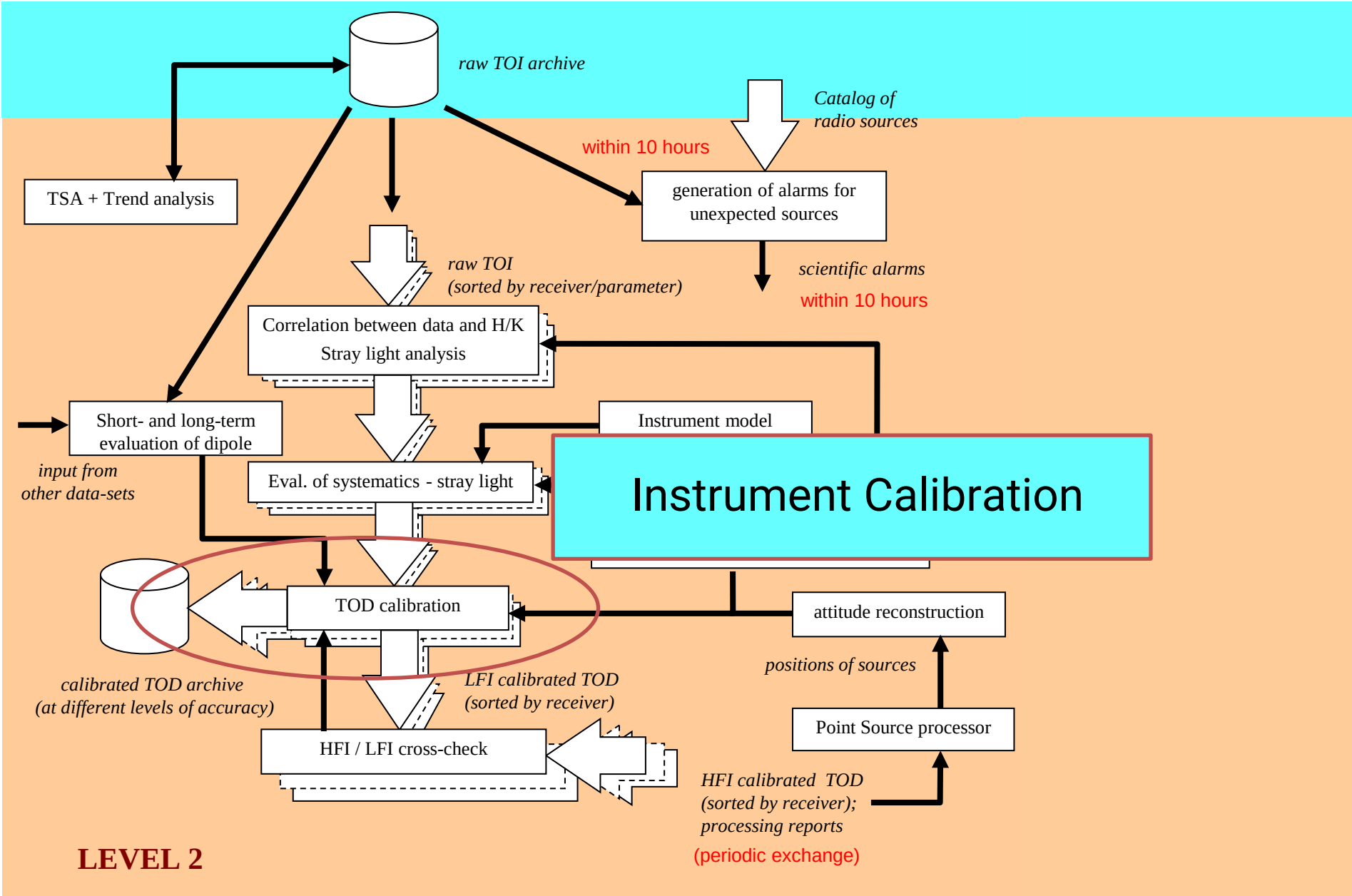


Systematics Evaluation

Early Pipeline



Early Pipeline



Early Pipeline

- Level2 pipeline composed by separated softwares to perform different operations
  - Systematic correction: only the well known 1Hz spikes removal
  - Differentiation: gain modulation factor computed on single diodes and applied
  - Detector pointing reconstruction: rotation of Satellite Attitude to radiometer position
  - Calibration: use of the Solar Dipole to fit differentiated data and compute Volt to Kelvin conversion for each pointing ID
  - Application of the conversion factors to differentiated data
- Noise estimation using calibrated data
- Map making using Madam with estimated noise, detector pointings and calibrated data on single diode data streams
- Validated through 2 End-To-End campaigns before the launch

Added two steps to the Systematics analysis and correction

- Diode combination to reduce noise effects
- AD/C non linearities in deep analysis, study and implementation of a correction

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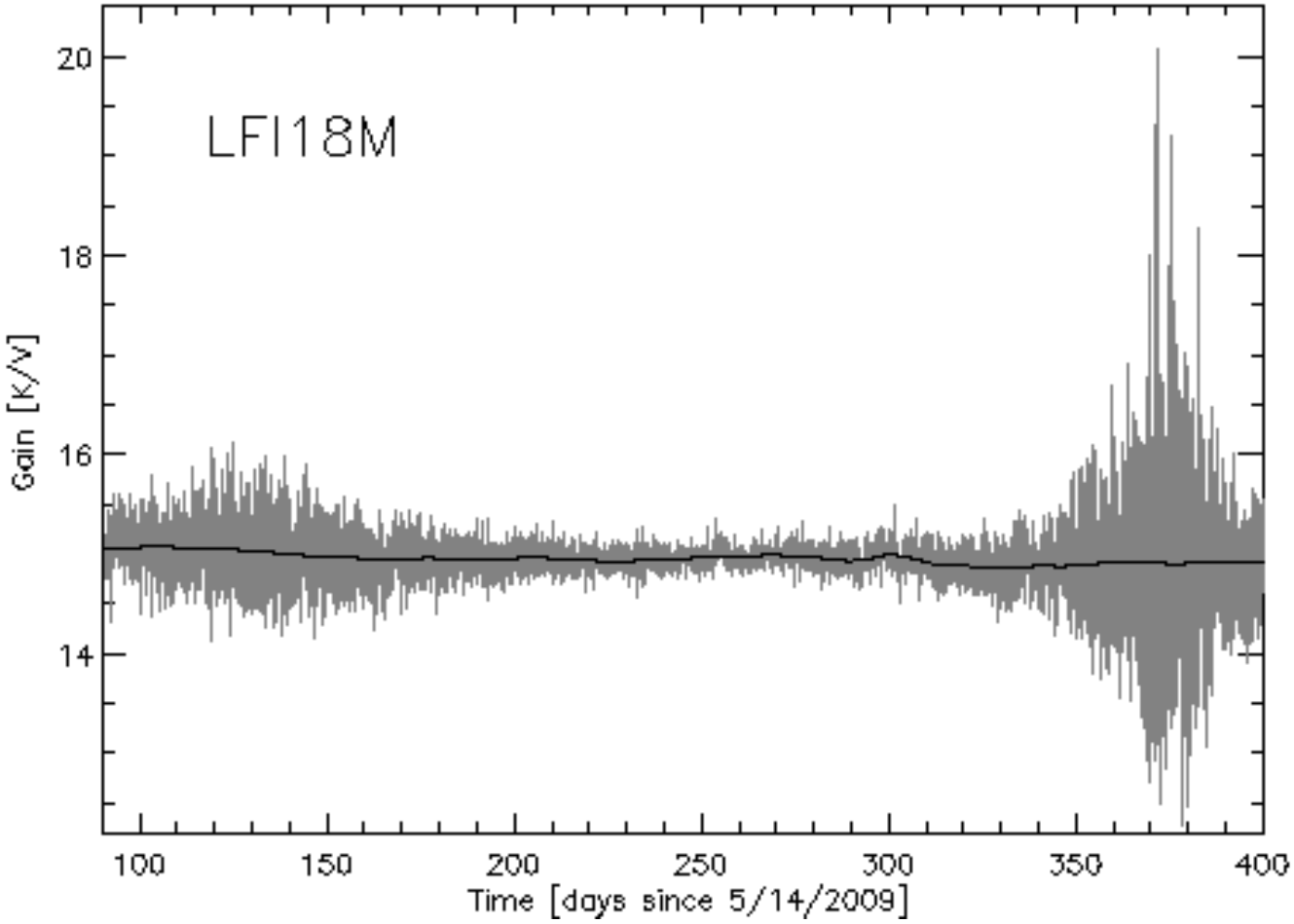
Change in the calibration algorithm

- Dipole fitting alone not enough



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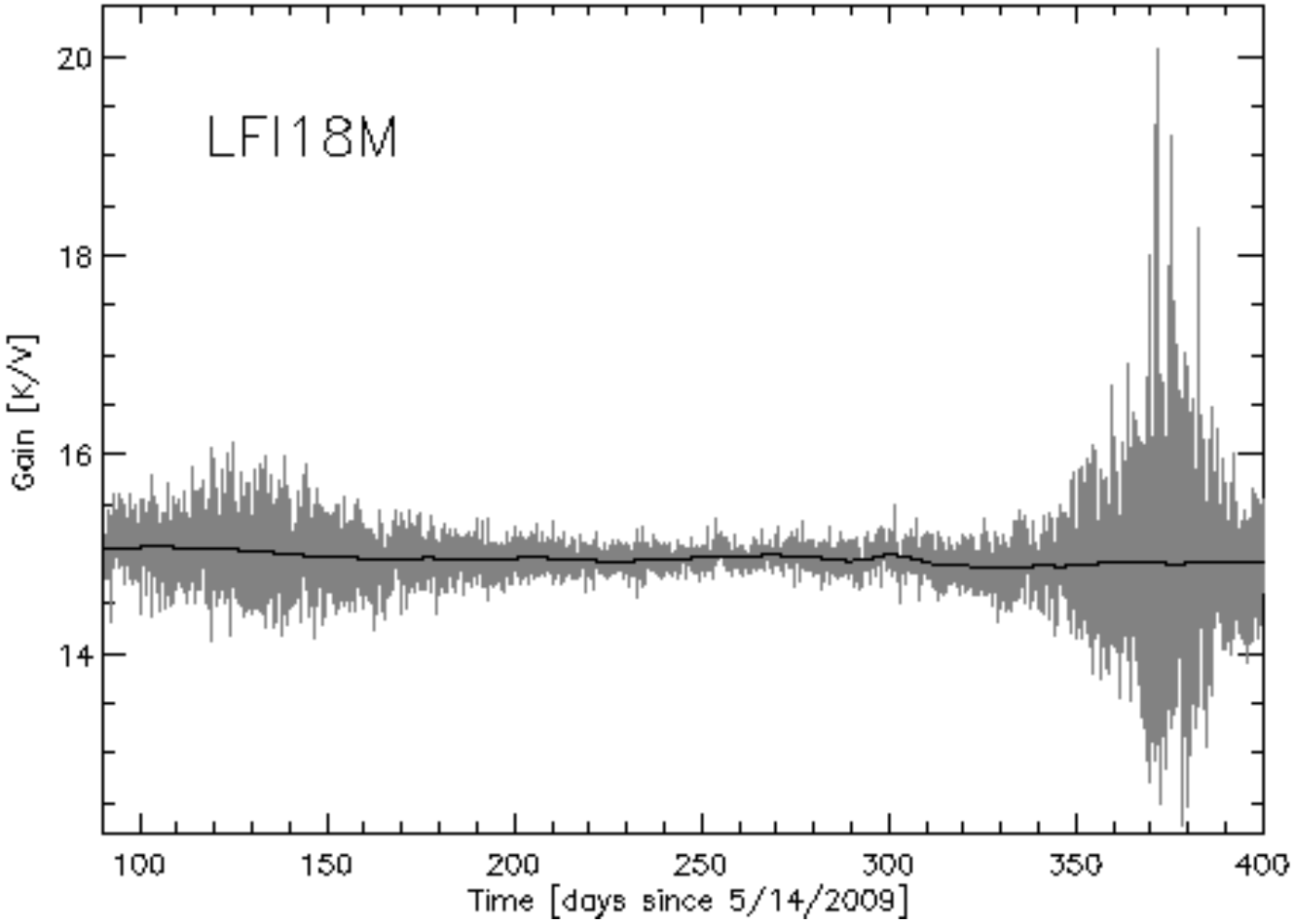
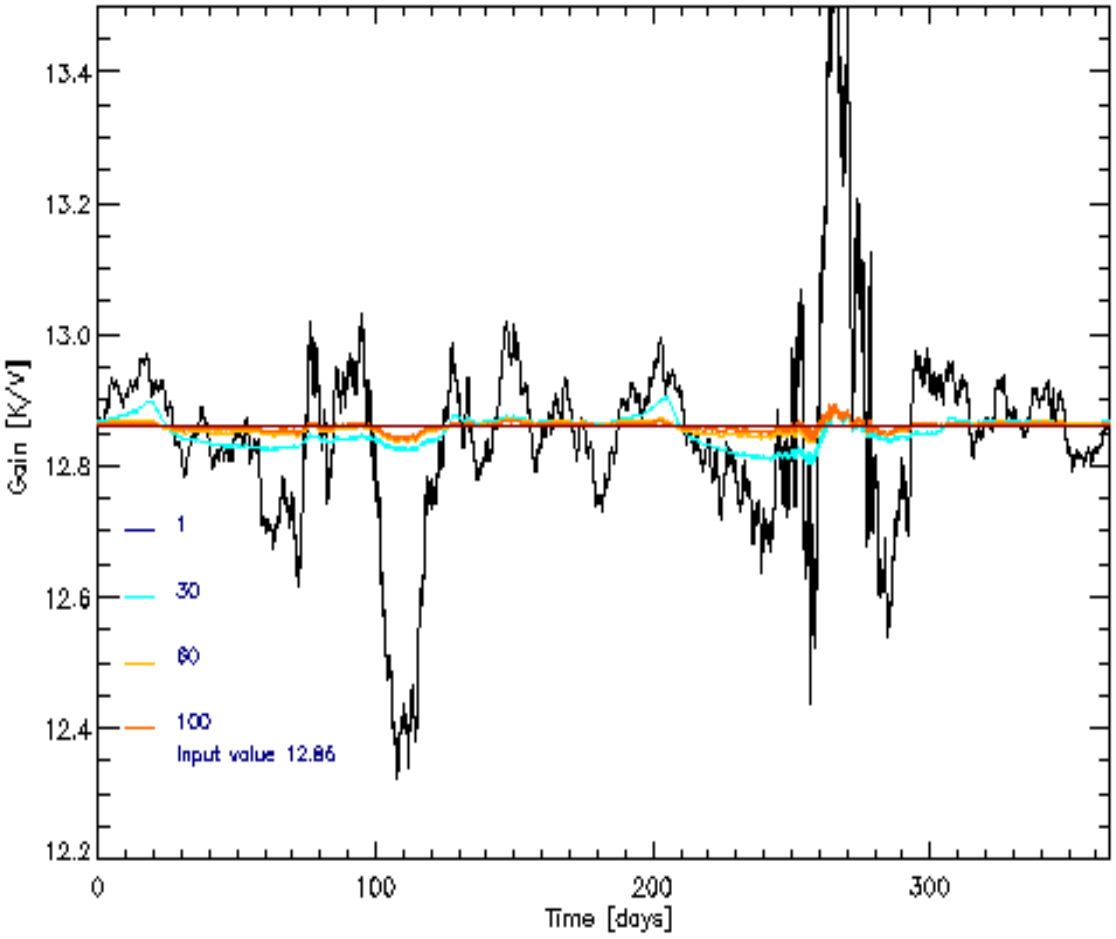
Change in the calibration algorithm

- Dipole fitting alone not enough

- Iterative procedure (mademoiselle)
- Gain smoothing



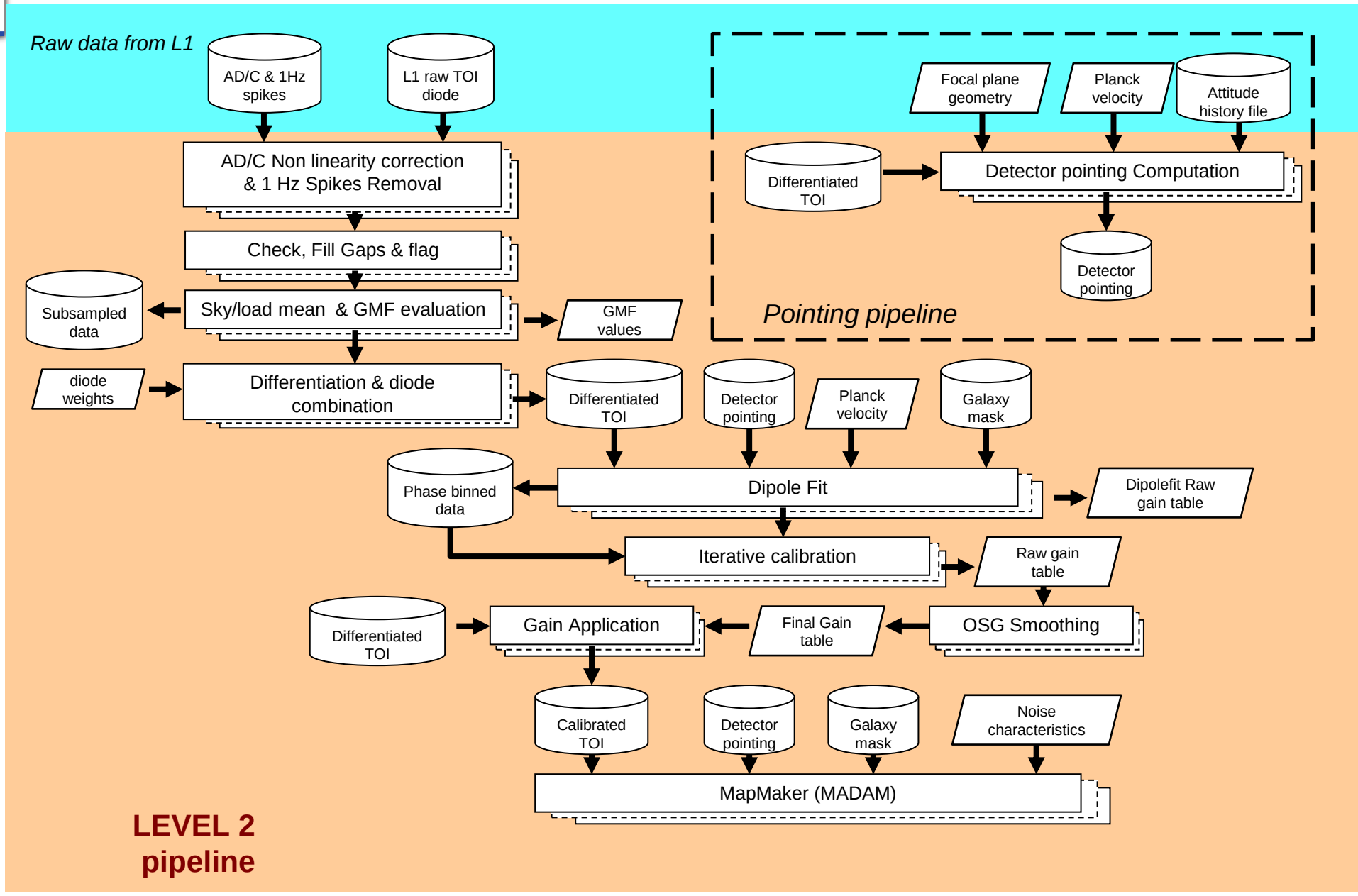
- Calibration strategy: iterative procedure study through simulations with single value
- Converge to the value with very small residual noise
- Wavelet algorithm to smooth out the residual



Level2 Pipeline converted in C++ and implemented as single software

- Detector pointing precision improved for seasonal variations
- Use of the Orbital Dipole in the Calibration
- Use of the Beam information in the Calibration

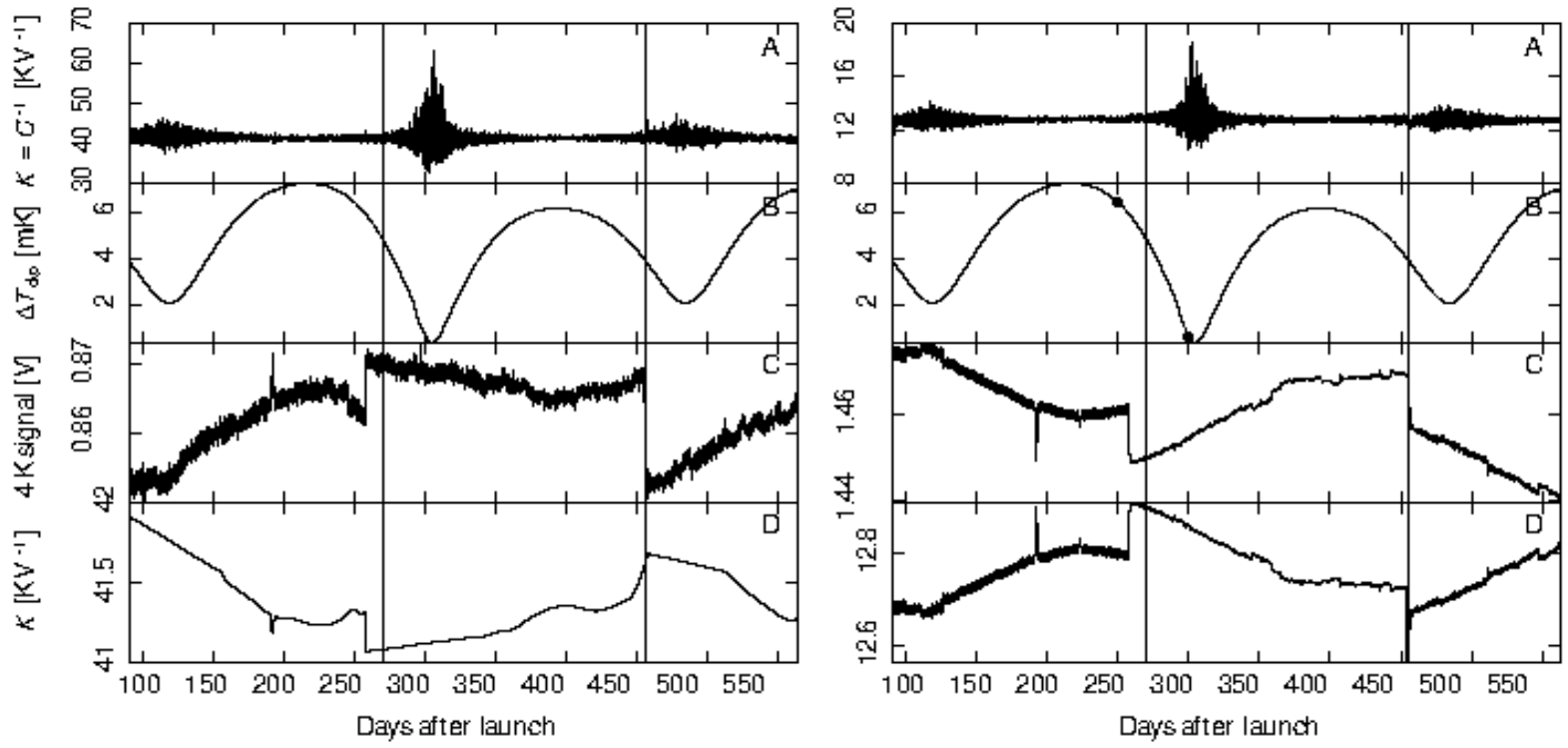
Planck 2013



Planck Collaboration; "Planck 2013 results. II. Low Frequency Instrument data processing" , 2014, A&A

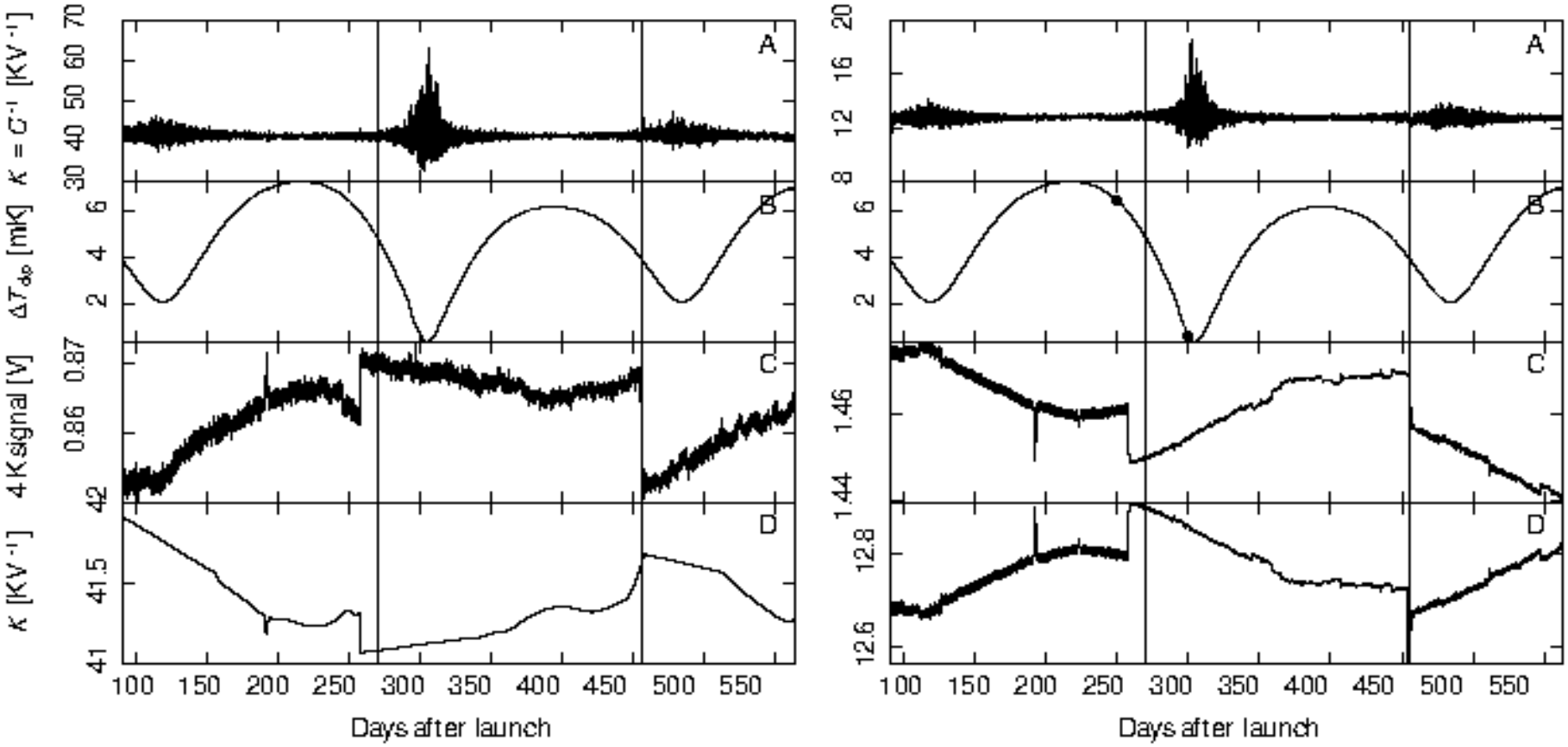
Separated calibration strategy between 44/70 GHz and 30 GHz

- Use of on-board housekeeping at 30 GHz
- Iterative procedure and smoothing at 44 and 70 GHz



30 GHz

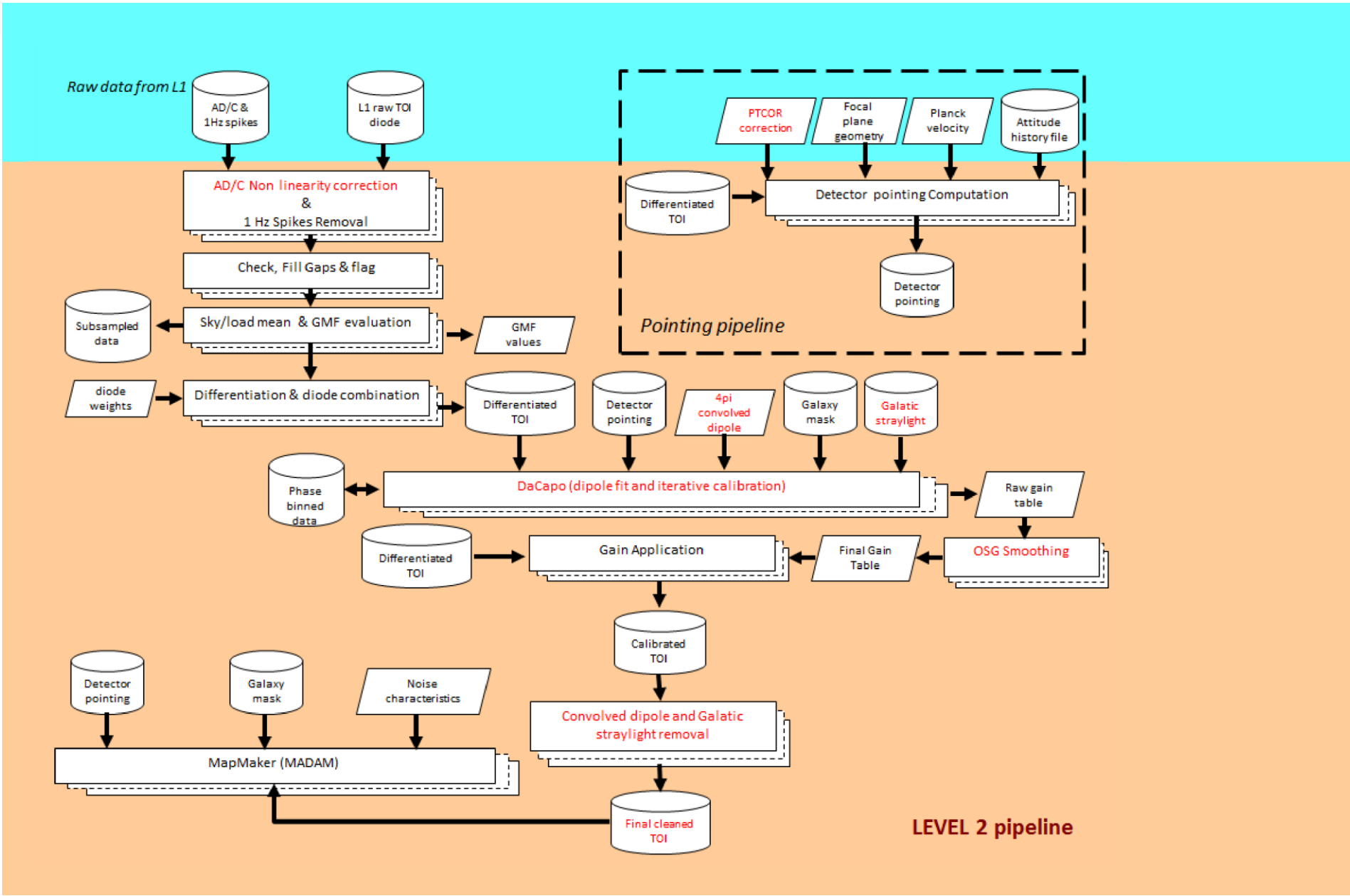
70 GHz



Changes only in the Calibration strategy

- Full beam convolution of the Dipole signal with a new algorithm
- Calibration iteration: from Mademoiselle (simple destriper) to DaCapo (C++, fully iterative procedure)
- Revisited the smoothing algorithm
- Removal of Galactic straylight from Calibrated output

Planck 2015



Planck Collaboration, "Planck 2015 results II. Low Frequency Instrument data processing", 2016, A&A

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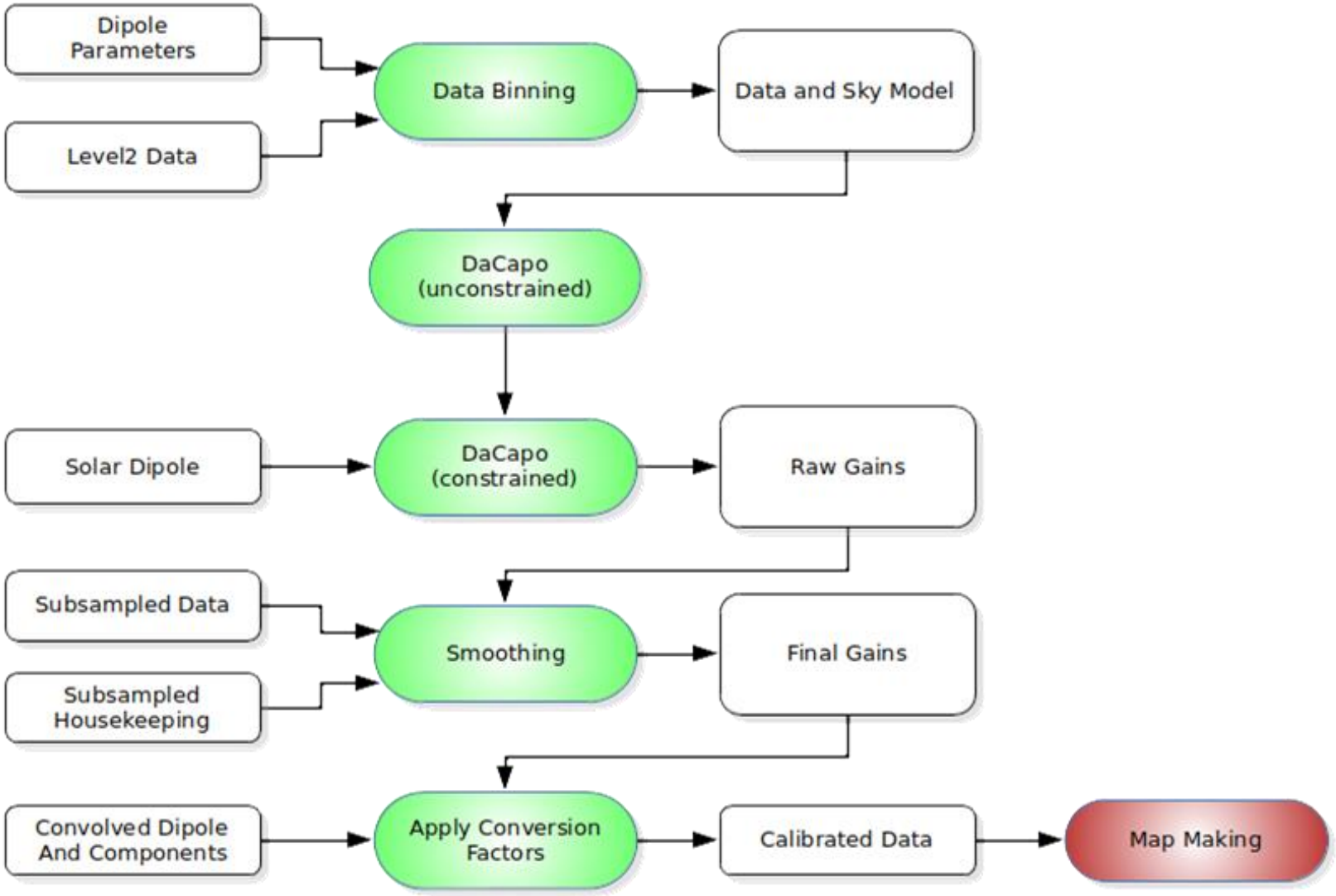
The 2015 calibration strategy



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Before the final release

- Problems revealed by internal null-test when considering Survey 2 and Survey 4
- Due to Planck scanning strategy, Survey 2 and 4 present a very faint minimum of the dipole modulation
- Several dedicated E2E sims

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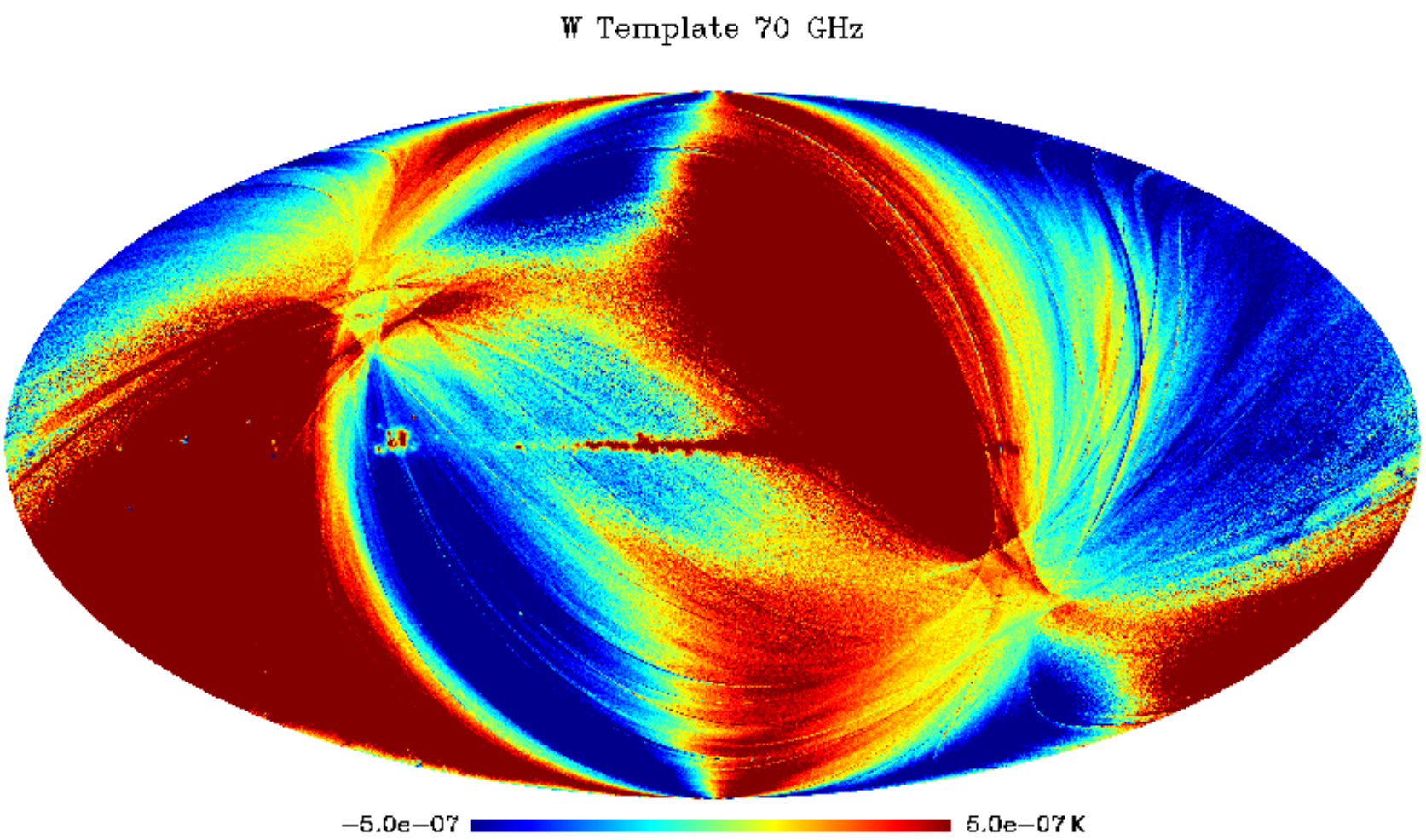
And *this* happened



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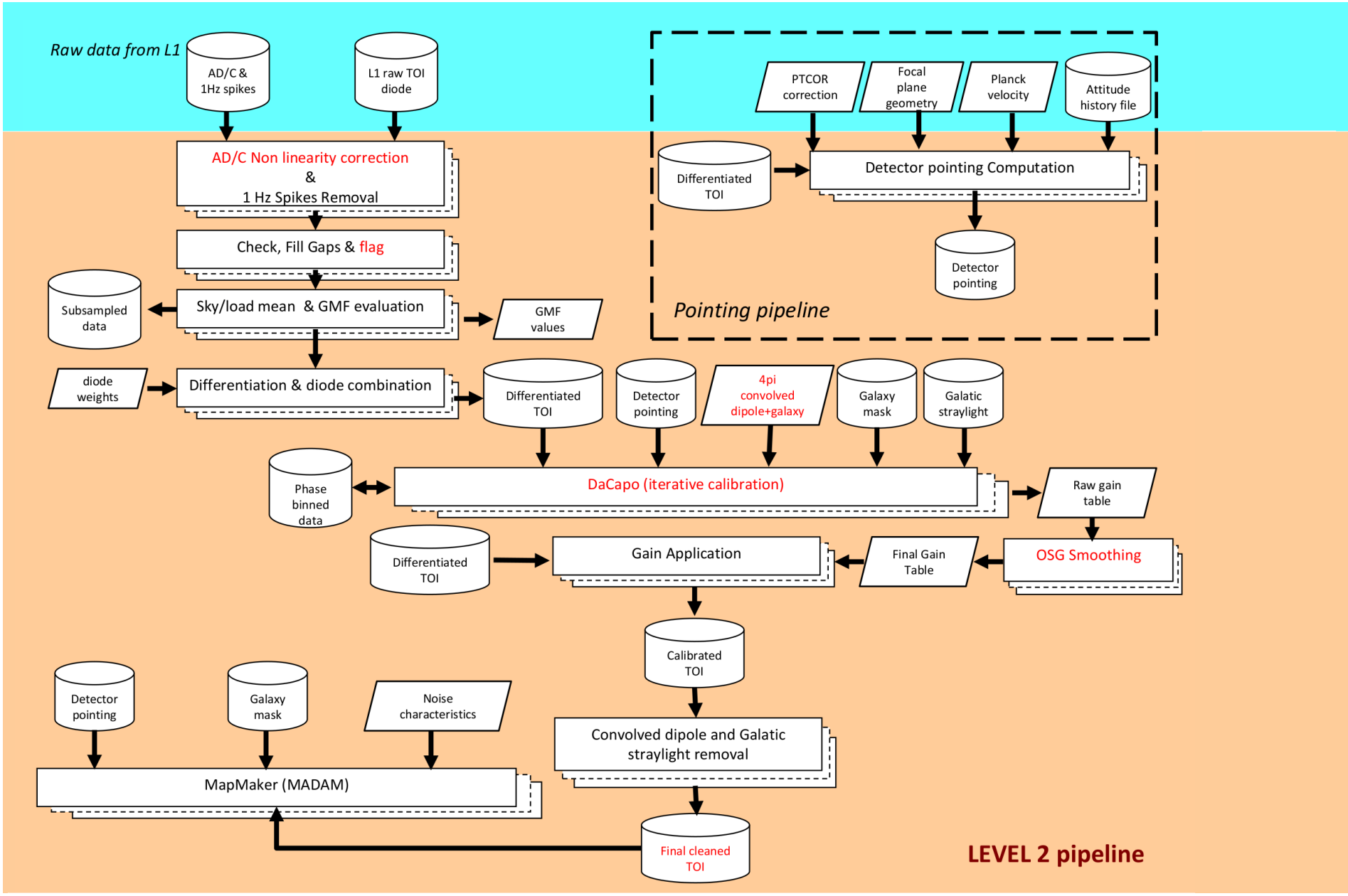
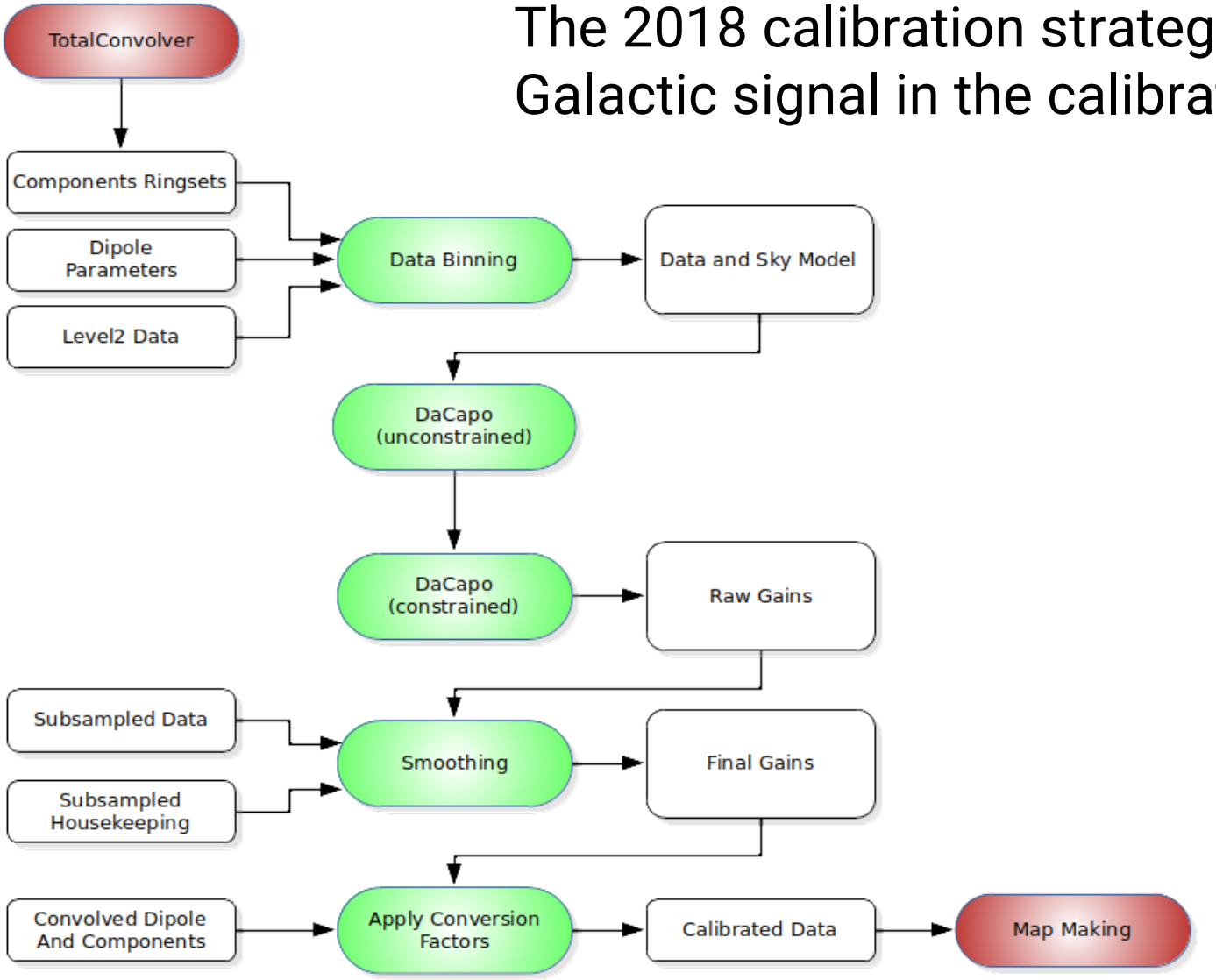
Planck 2018



Planck Collaboration; "Planck 2018 results II. Low Frequency Instrument data processing", 2020, A&A

European Commission

The 2018 calibration strategy: Galactic signal in the calibration model



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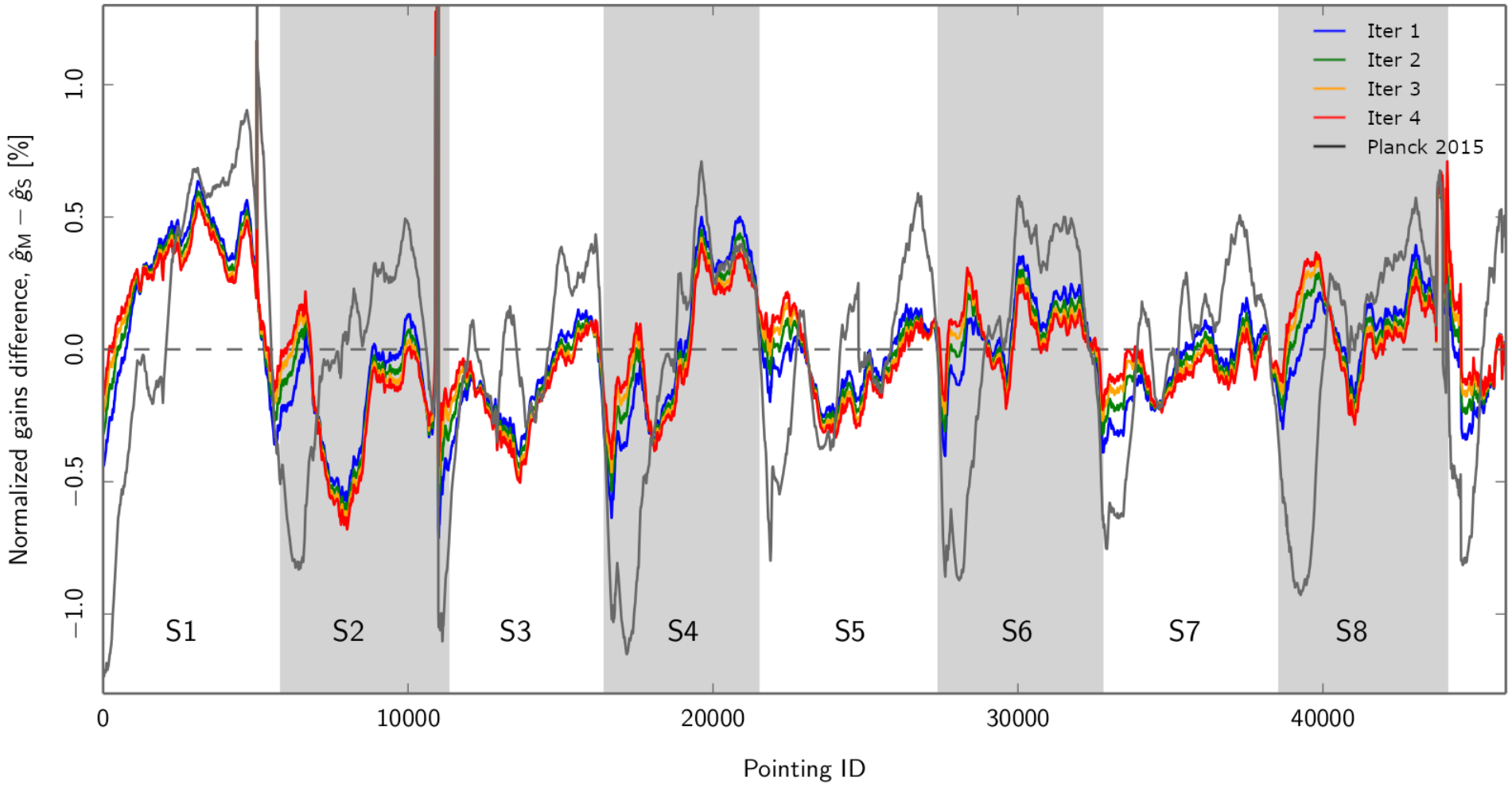
- Iterative approach including gain calibration, map-making and component separation
  - Tsky is the full best-fit from 2015 data release including: CMB, synch, free-free, thermal and spinning dust and CO for temperature maps and polarized components for CMB, synch and thermal dust
  - Estimate G including this Tsky in the calibrator
  - Compute frequency maps from these new gains
  - Determine new astrophysical model from these new maps
  - Iterate step (1) to (3)

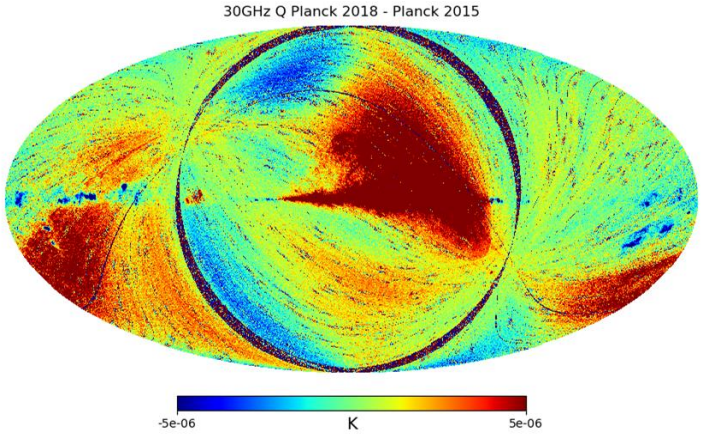
- The process converges: as a Gibbs sampler iterating through all involved conditional PDF converging to the joint maximum likelihood

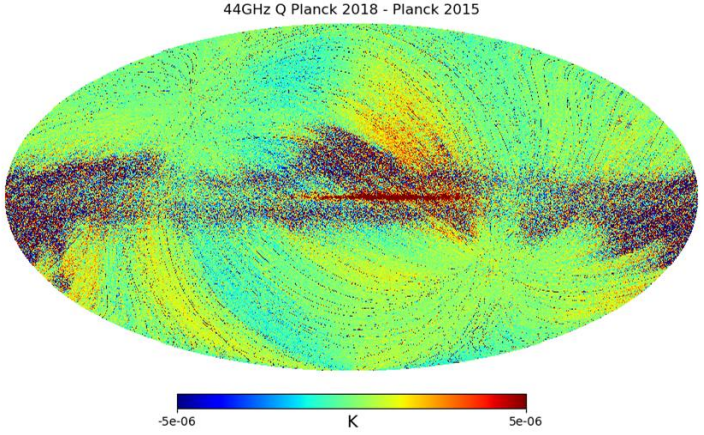
Planck 2018

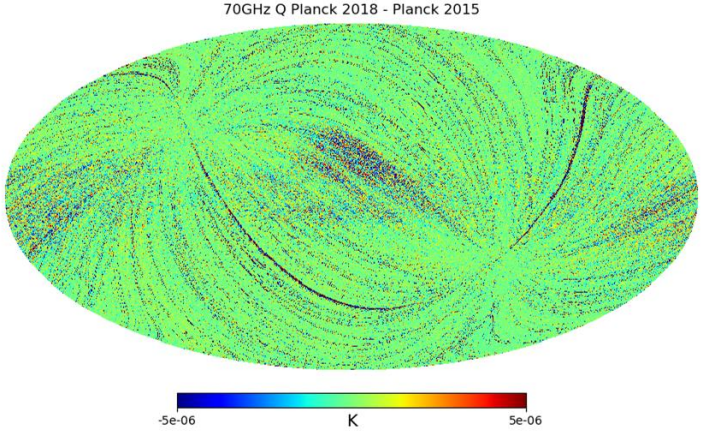


- Four full complete manual iterations
- Convergence not reached with residual present

Planck 2018







Difference with Planck 2015

- Spurious Magnitude decreases by a factor of 1.5 - 2
- Gain uncertainties dominated by few strong modes
- Not formal convergence and not applied at 70 GHz

Lesson Learned

- The Pipeline is going to evolve during the data analysis
- Instrument characterization is fundamental
- Calibration Model

Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776282

- "*BeyondPlanck*"
  - COMPET-4 program
  - PI: Hans Kristian Eriksen
  - Grant no.: 776282
  - Period: Mar 2018 to Nov 2020

Collaborating projects:

- "*bits2cosmology*"
  - ERC Consolidator Grant
  - PI: Hans Kristian Eriksen
  - Grant no: 772 253
  - Period: April 2018 to March 2023
- "*Cosmoglobe*"
  - ERC Consolidator Grant
  - PI: Ingunn Wehus
  - Grant no: 819 478
  - Period: June 2019 to May 2024