Planck HFI systematic effects, strategy for COrE

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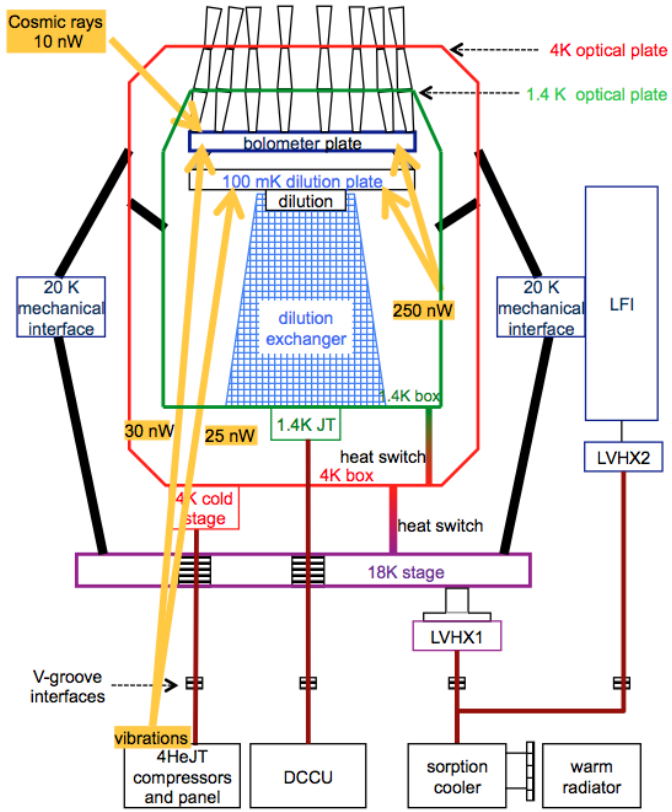
Planck Thermal stability

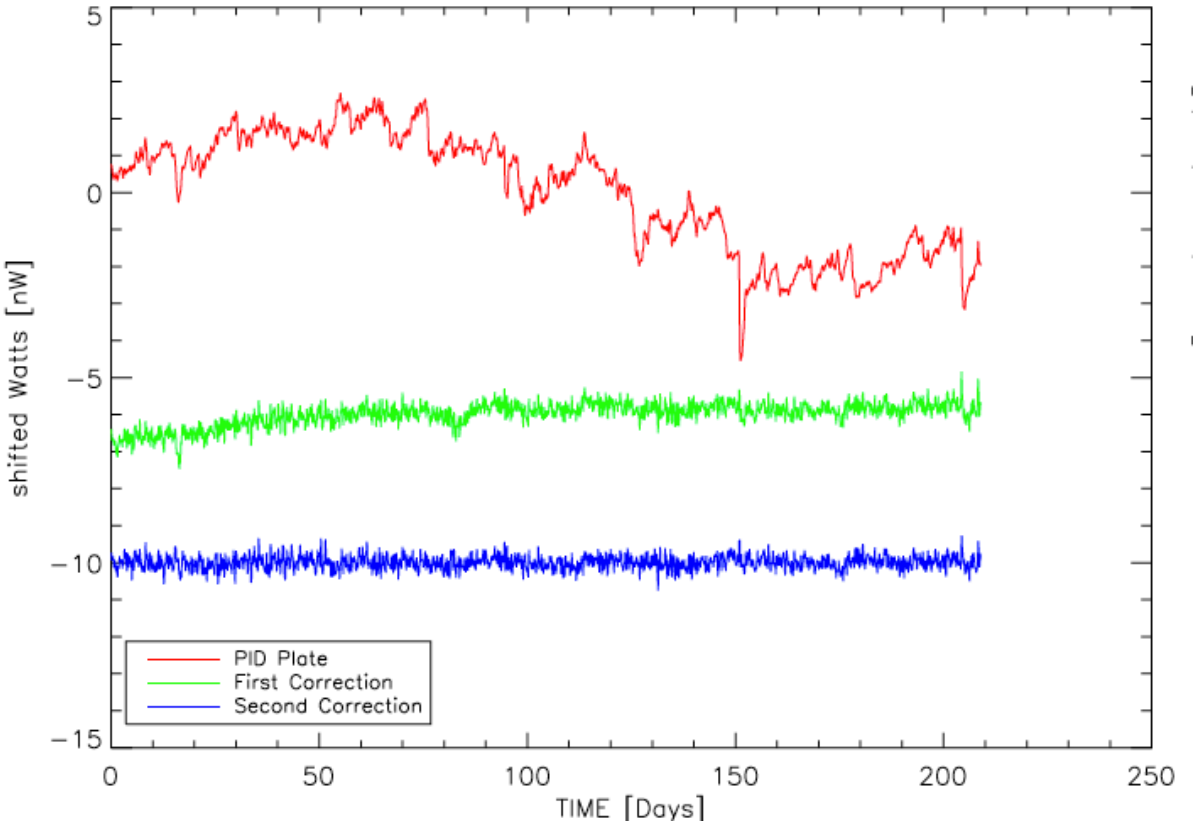
Temperature fluctuations induced by cosmic ray hit fluctuations!!

Corrected by PID at time scales larger than the hour

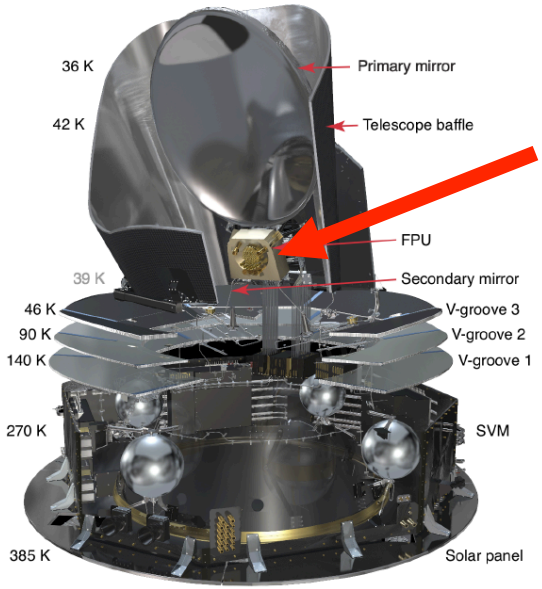
Great thermal stability of detectors

Second correction from the dilution plate PID



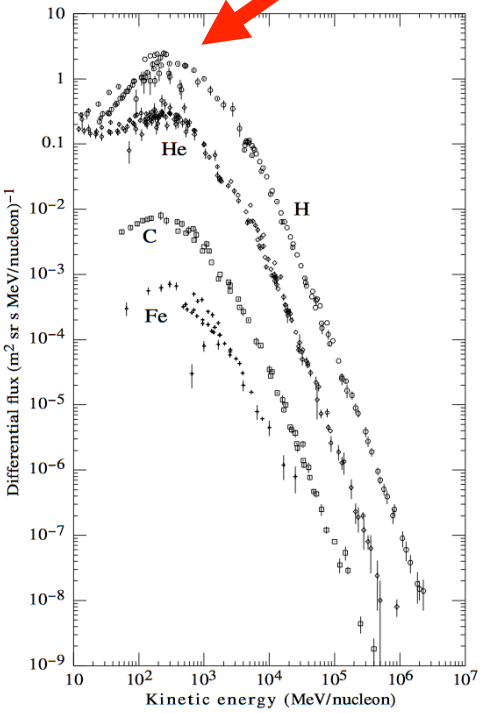


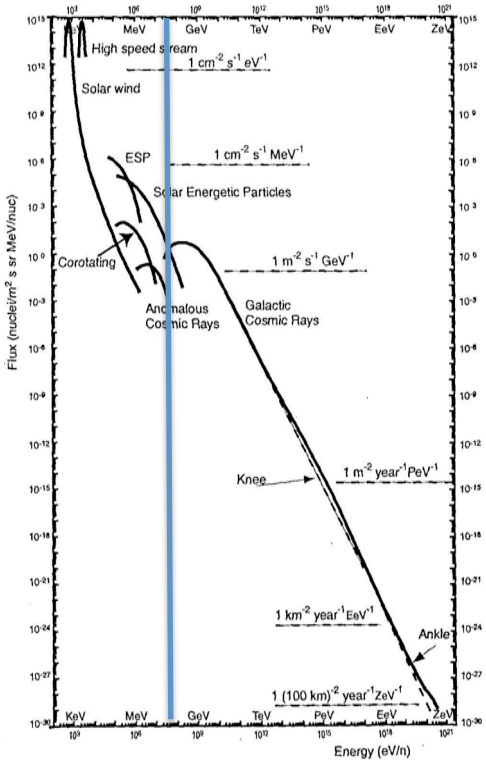
Cosmic rays



Mainly galactic protons and Helium nuclei

CR of ~ 1 GeV dominate





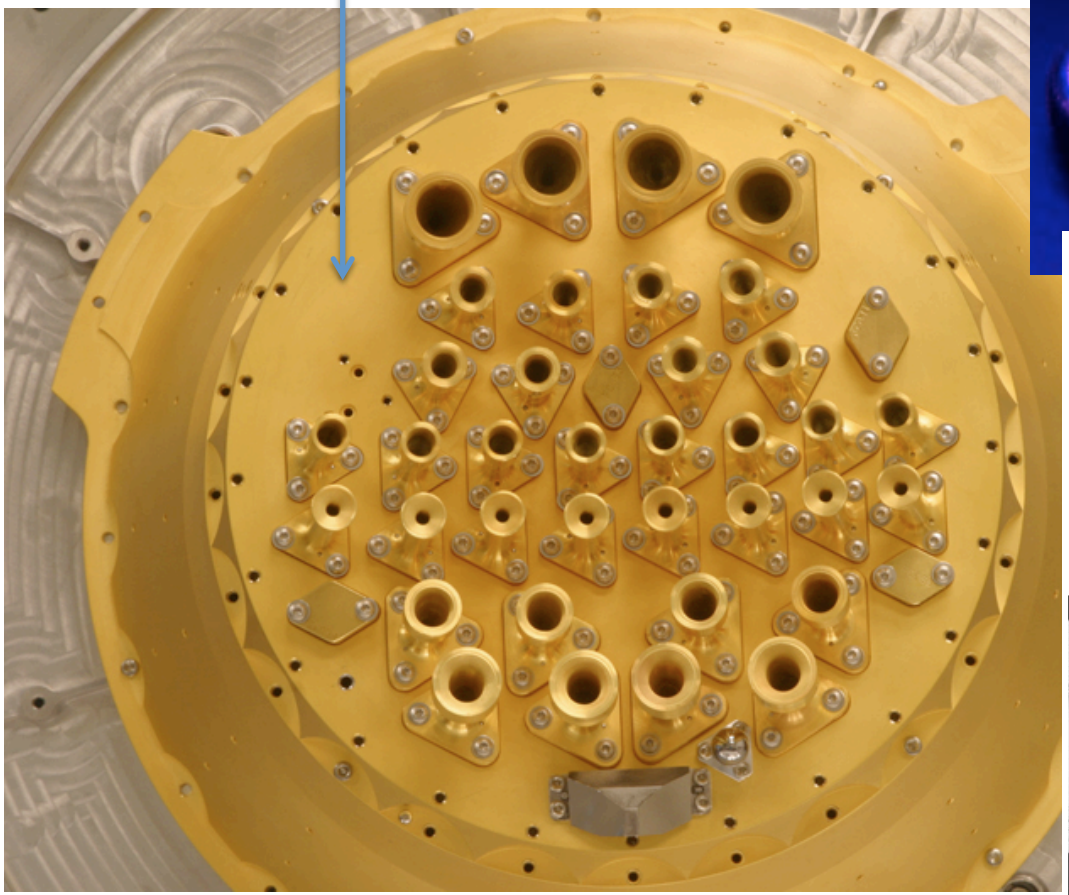
Cut off due to material around the detectors at ~ 50 MeV

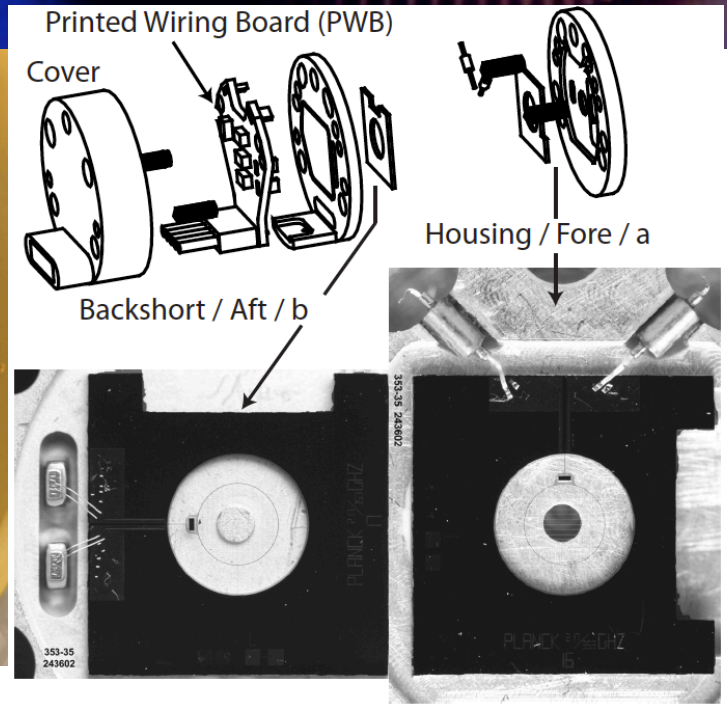
No contribution from solar particles which can not reach the detectors, except during flares

Amplitude of the spectrum at L2 is modulated by solar activity

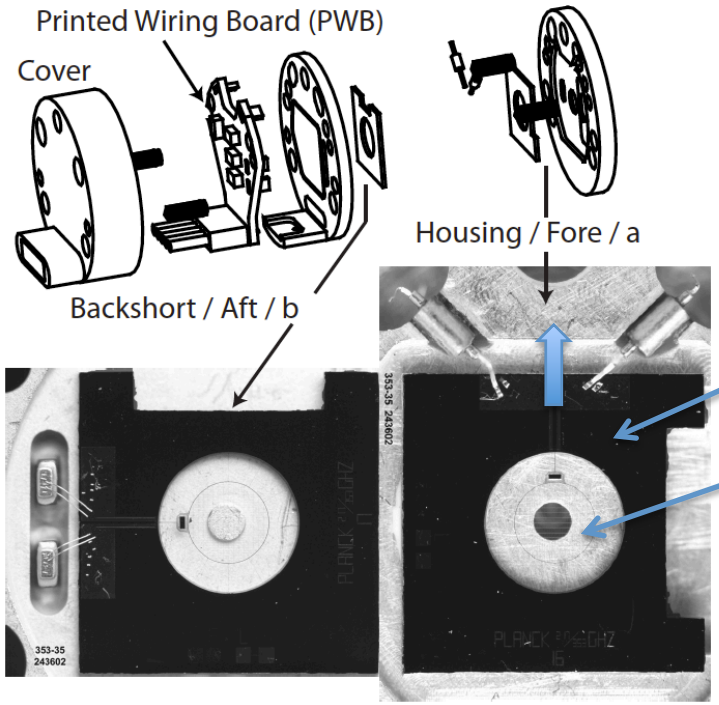
HFI focal plane

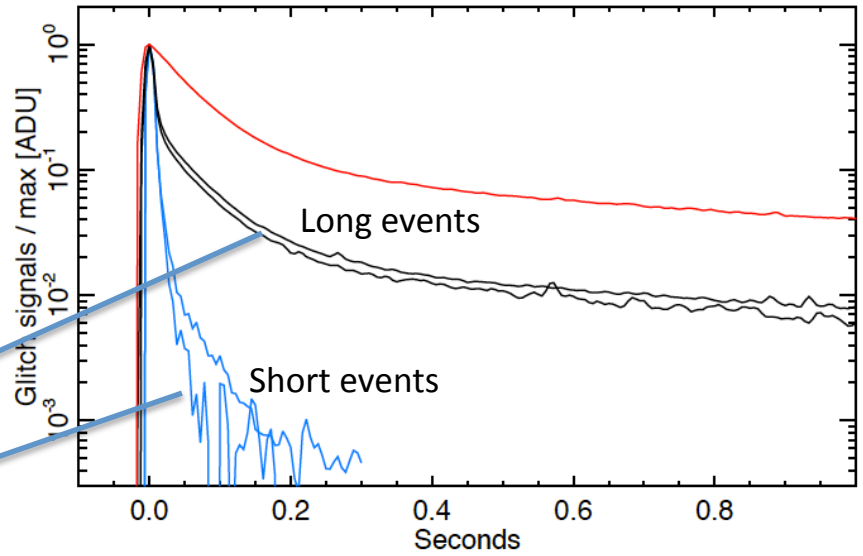
Cosmic rays interact with all components of the focal plane





CR interaction with detectors

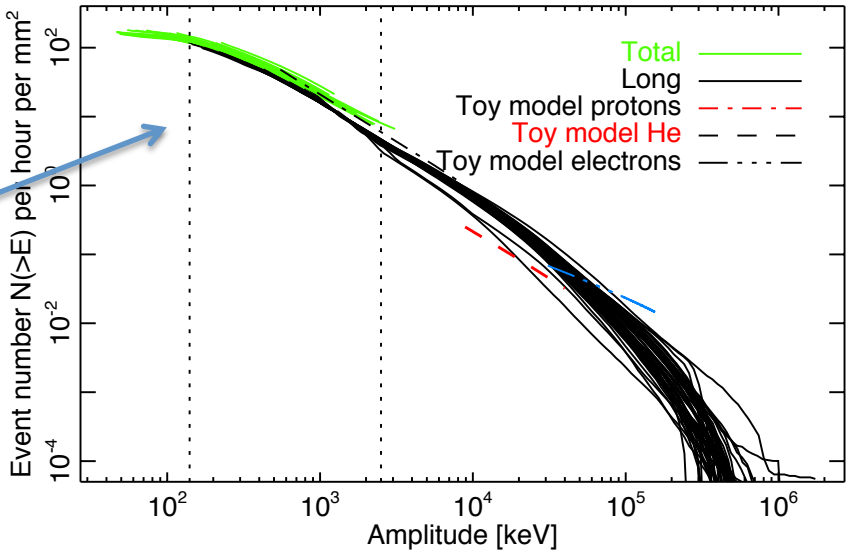




- Only 3 families of glitches

- Almost all depositing energy on the wafer are glitches detected !
Partly because of ballistic phonon

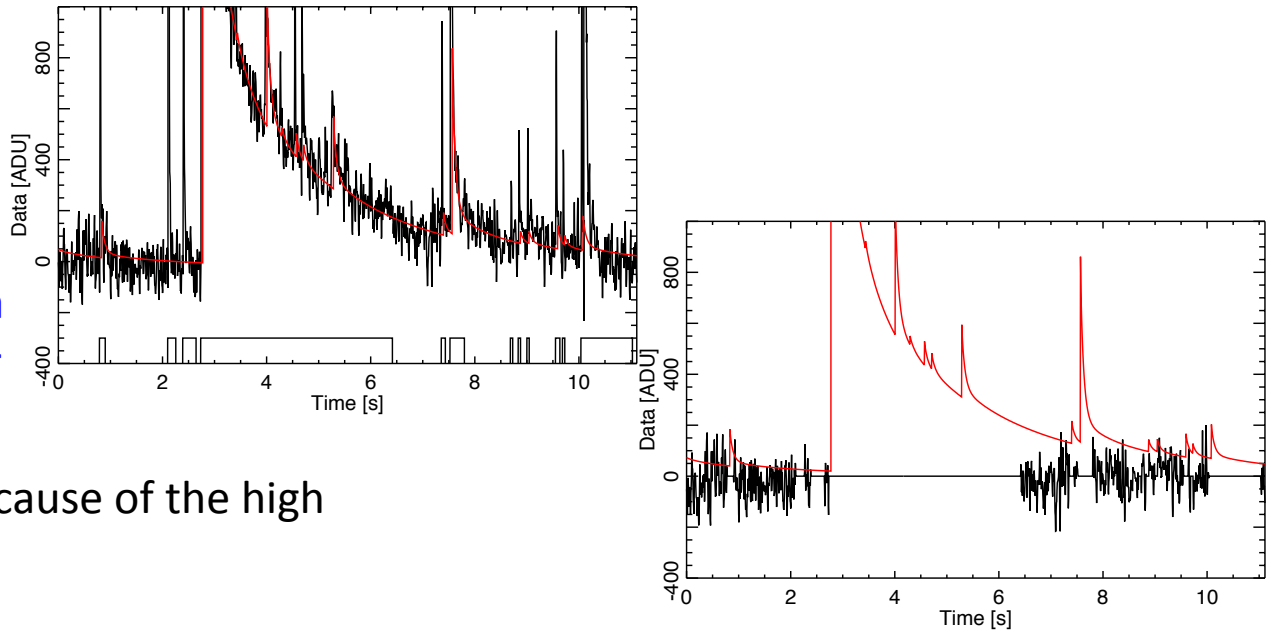
- Long events mostly correlated between PSB a/b



Cosmic ray removal

Joint fit of templates for each detected event.

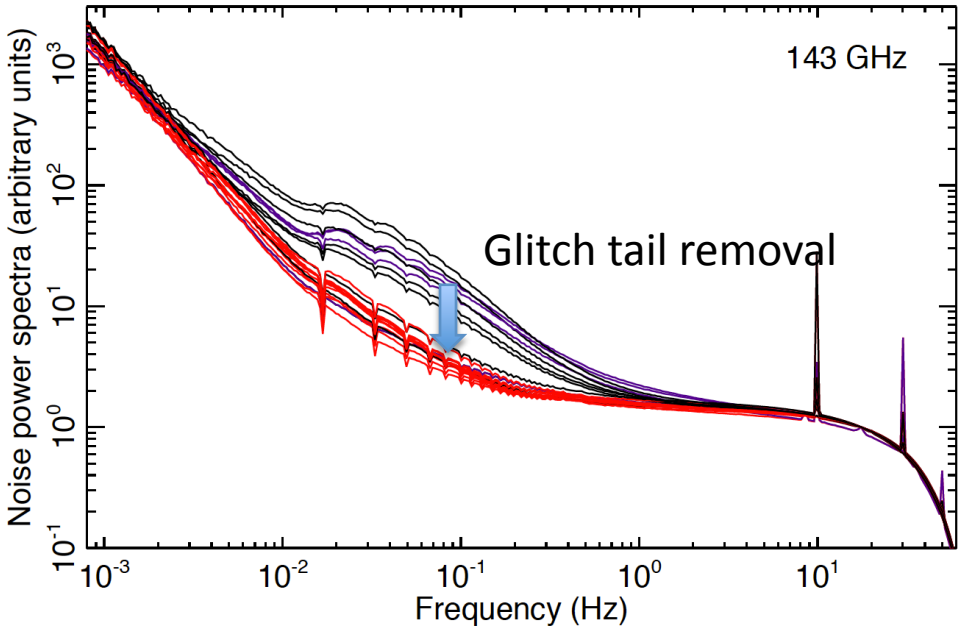
- Removal of long glitch tails
- Flagging 10 to 25 % of data depending on the detector



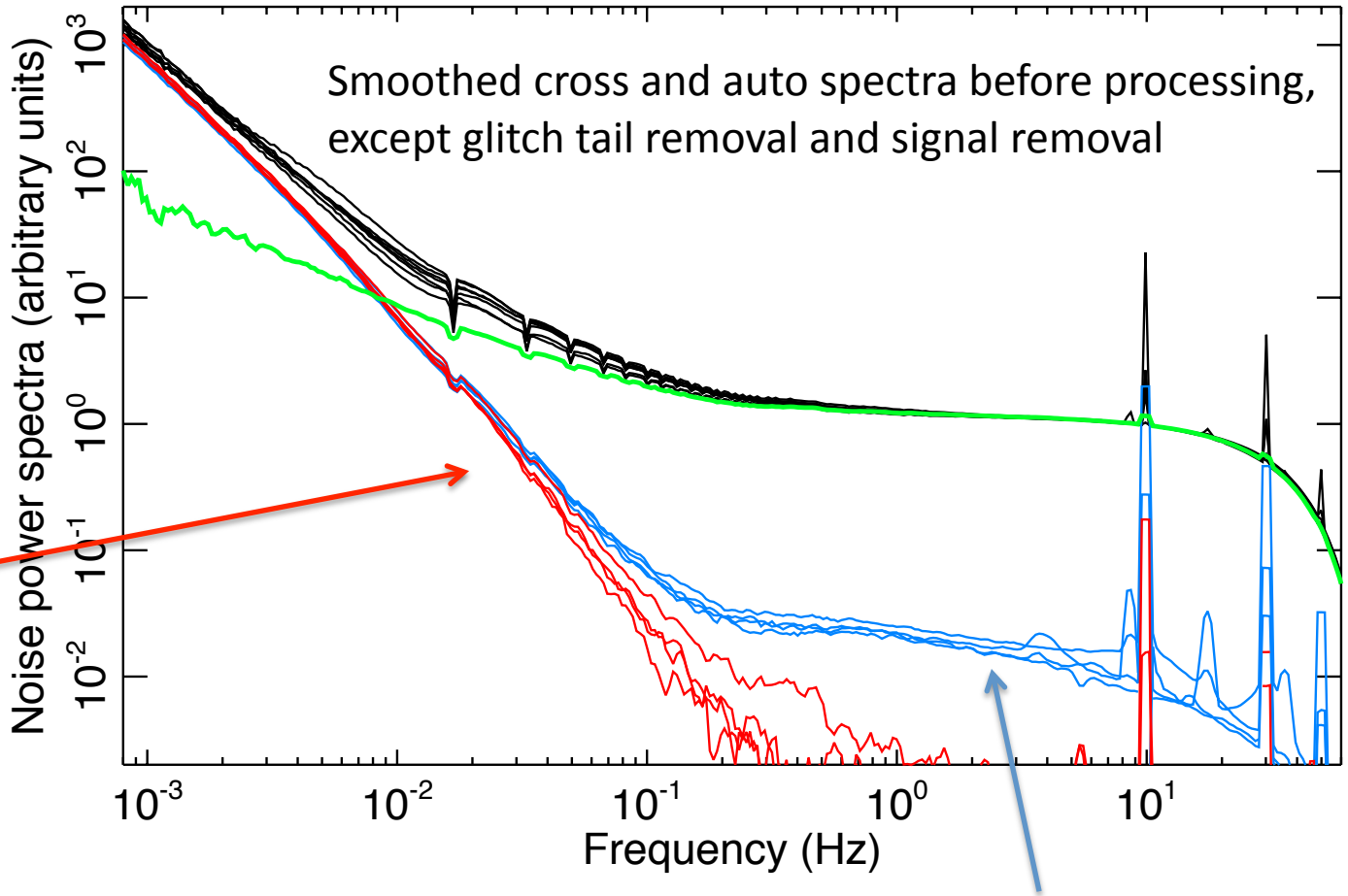
Analysis made difficult because of the high confusion of events

Residual at the level of noise for the worst channels at low frequencies < 0.2 Hz

At the end, the glitch contribution to the noise on the maps is significant only for ell < 10, still smaller than detector noise



Noise spectra on TOIs



Correlated noise between detectors. Related to thermal fluctuations of the plate due to CR hits

Glitches below the detection threshold common between PSB-a and PSB-b

Provide a limit on the level of remaining glitches in data 2 to 7% contribution

Lessons for future missions

- Large detector arrays will receive many events.

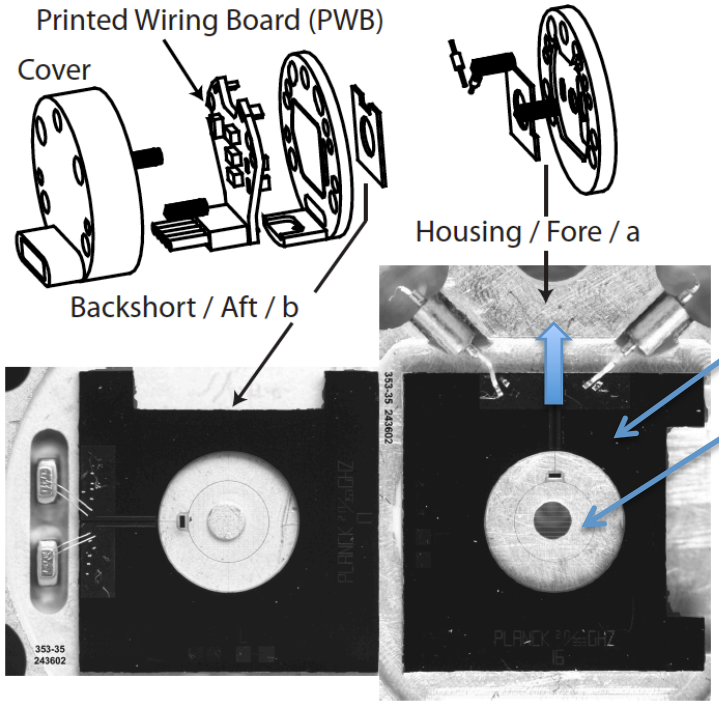
- Correlated noise might be induced by events on the array.
  - low frequency noise related to thermal propagation
  - noise at all scales potentially due to ballistic photons reaching all detectors in the same time.

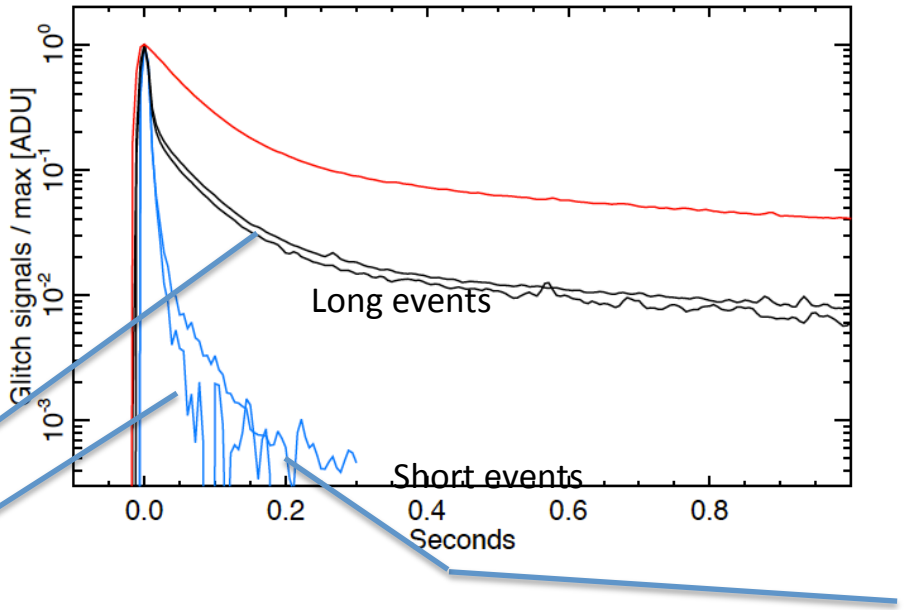
- Characterizations from the ground with radioactive sources are crucial

- Simulations necessary to evaluate the impact of correlated noise on polarization reconstruction based on Planck experience.

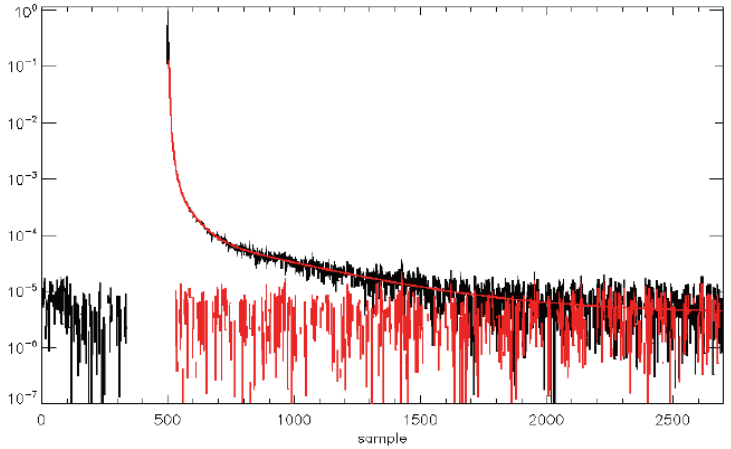
Evidence for long time constants

Only 3 families !





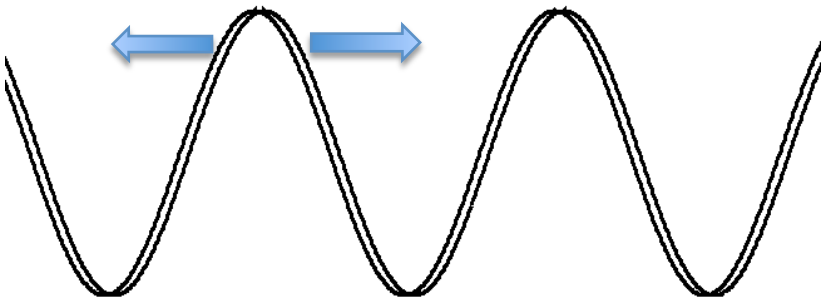
Long time constants seen by stacking all events related to CR hitting on the wafer



Thermal modeling is important. Long time constants might come from the links between the wafer and the detector housing and are seen on both categories of glitches

Impact of long time constants on data

- Long time constants are observed in data ~ 2 s for the longest
  - seen in the tail of short glitches
  - seen on planet maps
  - induces a shift of the dipole



- Induce percent effect in the calibration if not properly corrected as it affects the highest and lowest multipoles in a different way

- Time constants are variable from detector to detector

- Having different survey with nearly opposite scan directions helped to constrain and correct the longest time constants

- Solved at the map-making stage by template fitting (largest multipole shifts)

Uncorrelated noise

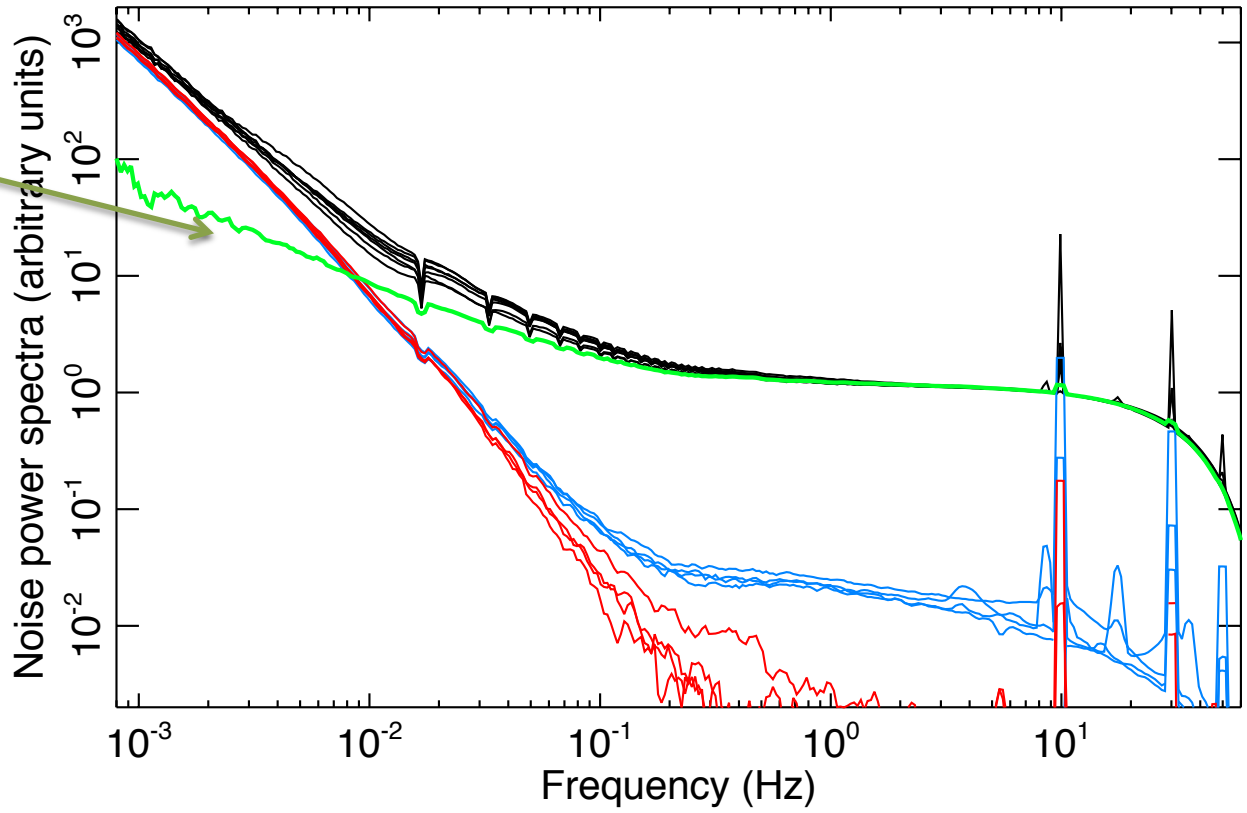
Uncorrelated component seen in all detector time-streams

- Not observed while measuring intrinsic detector noise
- Observed to some extent after plug in to the electronic box

$P(f) = A\,[\,1 + (f/f_{knee})^{\alpha}\,]$

$f_{knee} \sim 0.15$ Hz

$\alpha = -1$

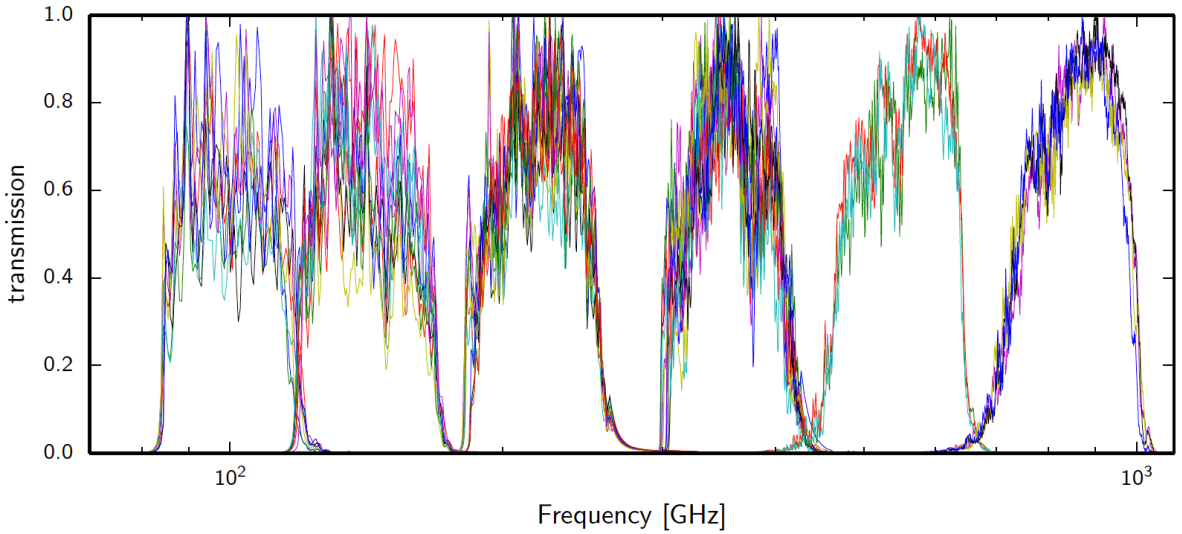


No clear explanation, can't be due to CRs since not modulated as glitch rate. Telegraphic noise?

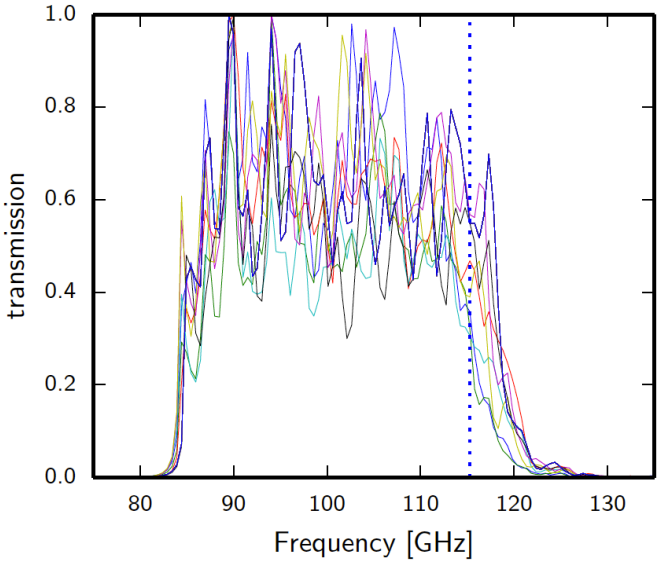
Can be used as baseline for simulations

Band-pass mismatch

Differences in the band shapes from detector to detector induced intensity to polarization of galactic components when calibrating on CMB



A few percent effects for the amplitude of the dust from detector to detector

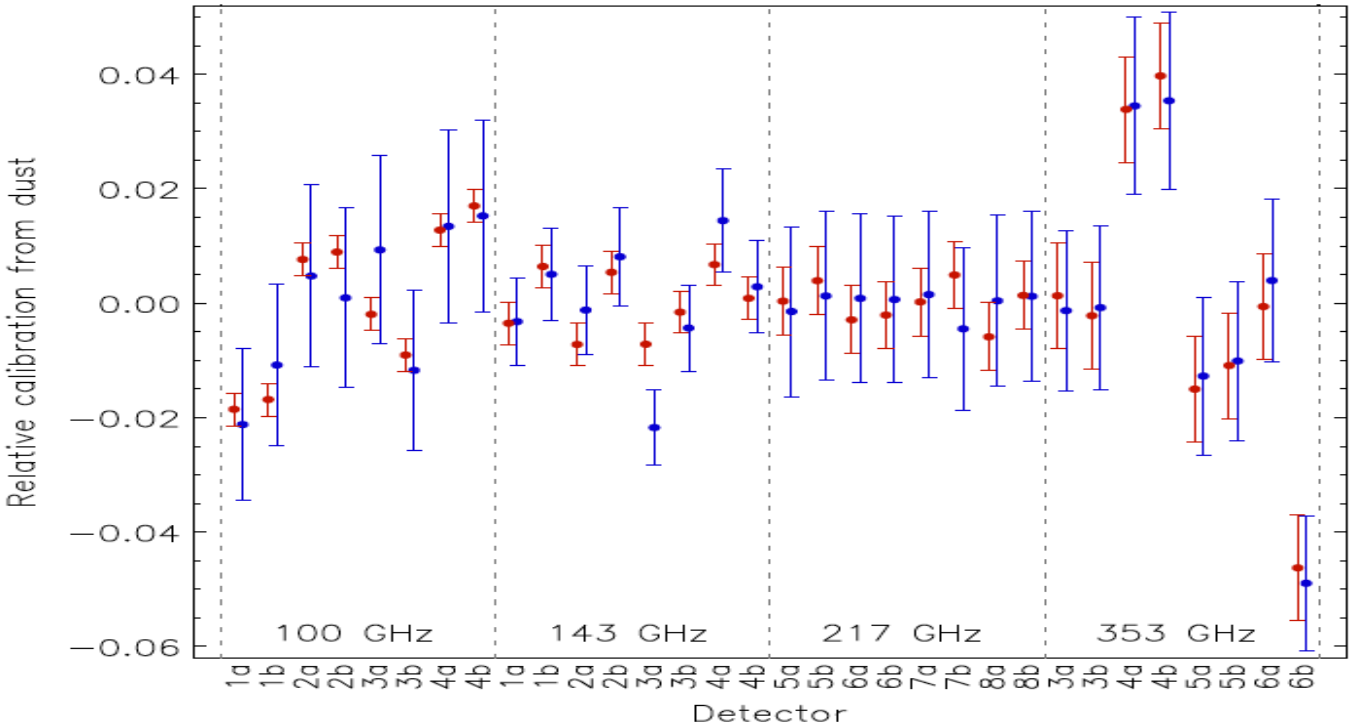


CO transition line 1-> 0 falls at the edge of the 100 Hz filters so the CO components has very different amplitude from detector to detector

Band-pass mismatch correction

-Band passes were measured from the ground. The precision is not accurate enough to remove the dust intensity to polarization leakage with the predicted coefficients

- Estimated at the map-making level. Naturally minimizes the survey difference contamination



Effect mostly removed at the end

Lessons for future mission

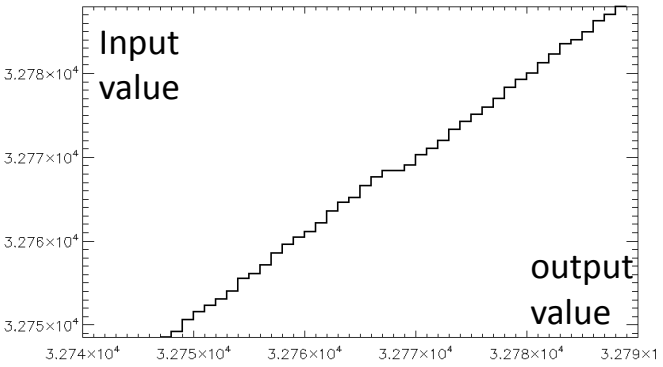
- Evaluation of the impact in progress starting from current FTS measurement constraints, dedicated talk during parallel sessions.

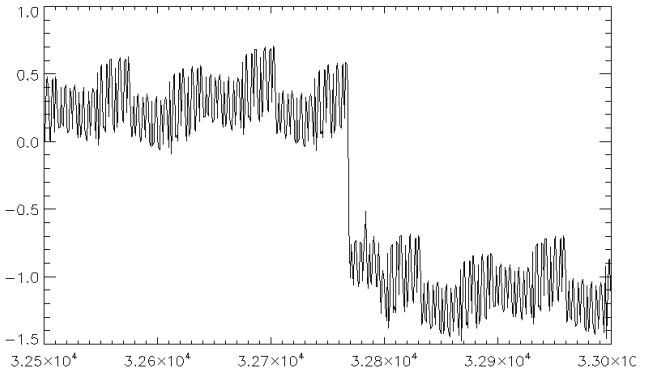
- Ability to do single bolometer I, Q, U maps would allow to remove potential intensity to polarization leakage effects as band-pass mismatch

- First order corrections using high frequency channels enough?

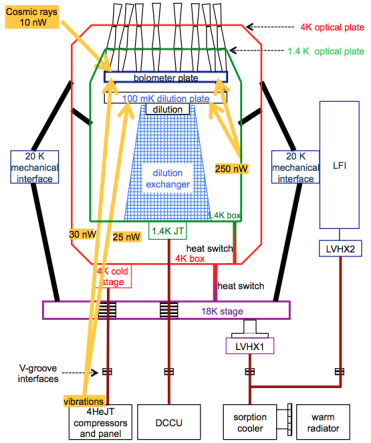
Do not neglect effect coupling

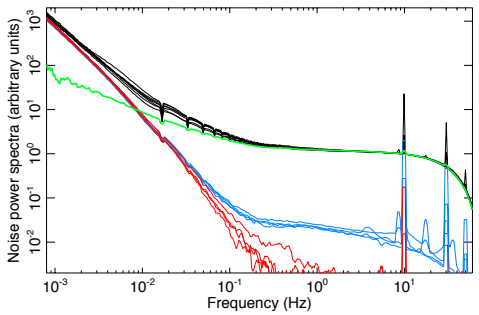
- ADC non-linearities was the dominant systematic effect for Planck low ell polarization





- 4He – JT cooler induced sharp lines in the data, due to electromagnetic and microphonics interference to the detector wires



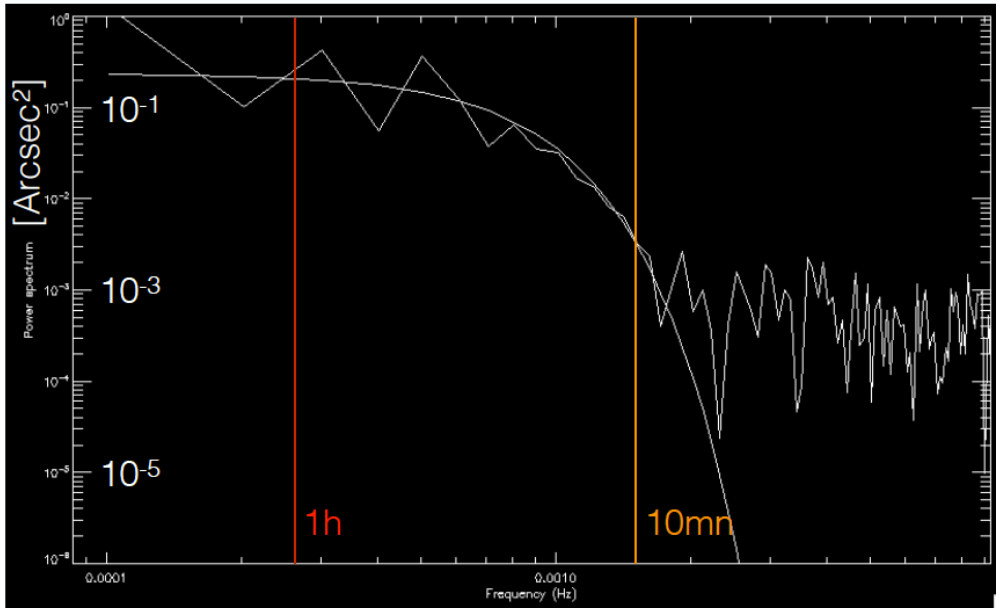


The 4K lines, by changing the electronic response, interfered with the ADC correction

Coupling between the two effects was a major problem for Planck and limited our ability to correct the effect

Pointing reconstruction errors

- Pointing reconstruction errors of the order of 3” rms. Measured on planet signal.



- Beam reconstruction was difficult due to glitches combined with those errors.

Conclusions

- A few systematic effects affecting the low multipoles were not expected as such level in Planck HFI data:
  - ADC non-linearities/ 4K lines
  - CR glitches
  - Band-pass mismatches
  - Long time constants
  - Far side-lobes

- Quite unexpected low frequency uncorrelated noise at f_{knee} = 0.15 Hz. Low frequency correlated noise due to CRs in the bolometer plate. Coincident CRs in PSB a/b produce ~ 5% correlation at all frequencies.

- Planck gives a baseline for the preparation of COrE, even if we expect different systematics depending on the technology used.