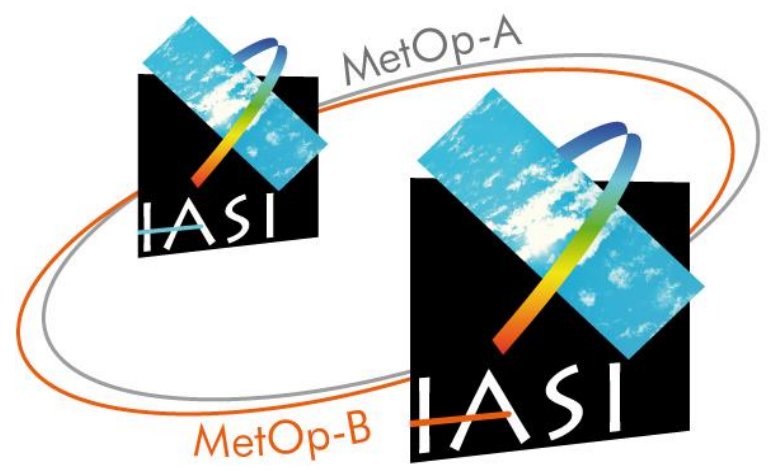


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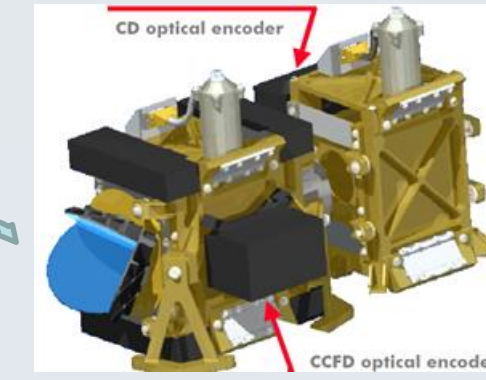
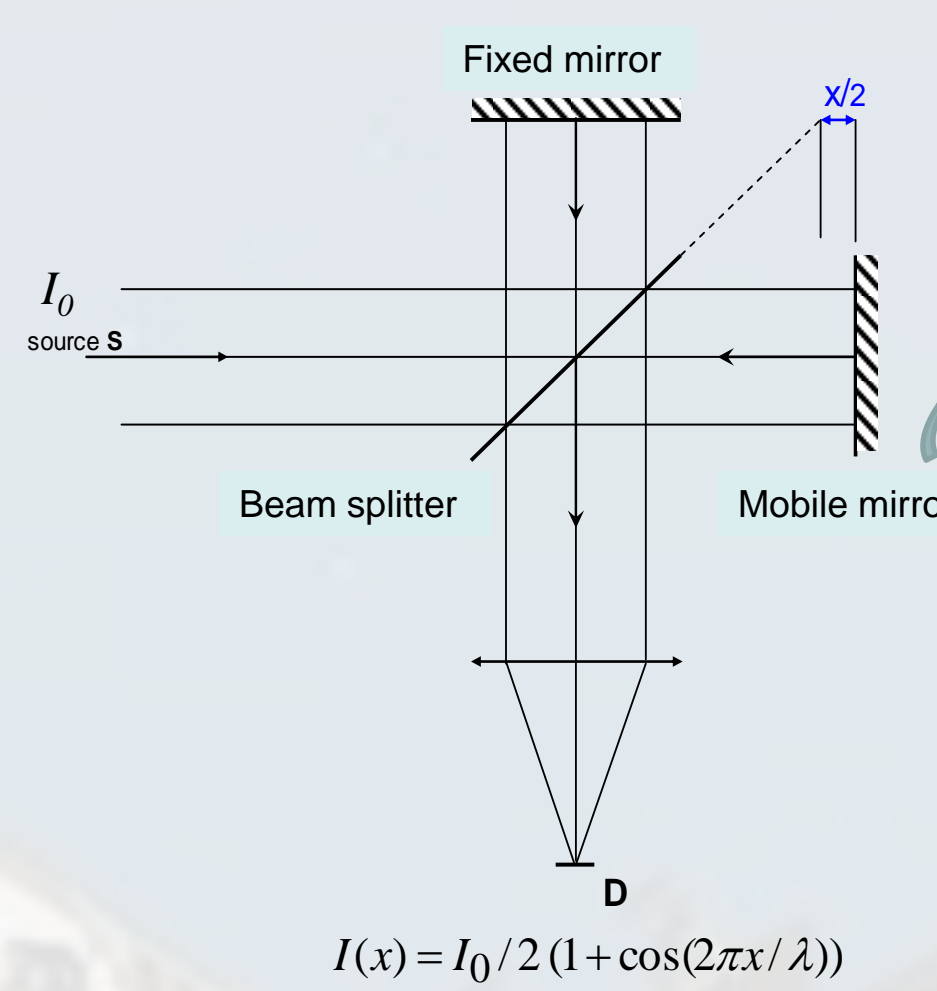


4<sup>th</sup> IASI Conference



## IASI instrument

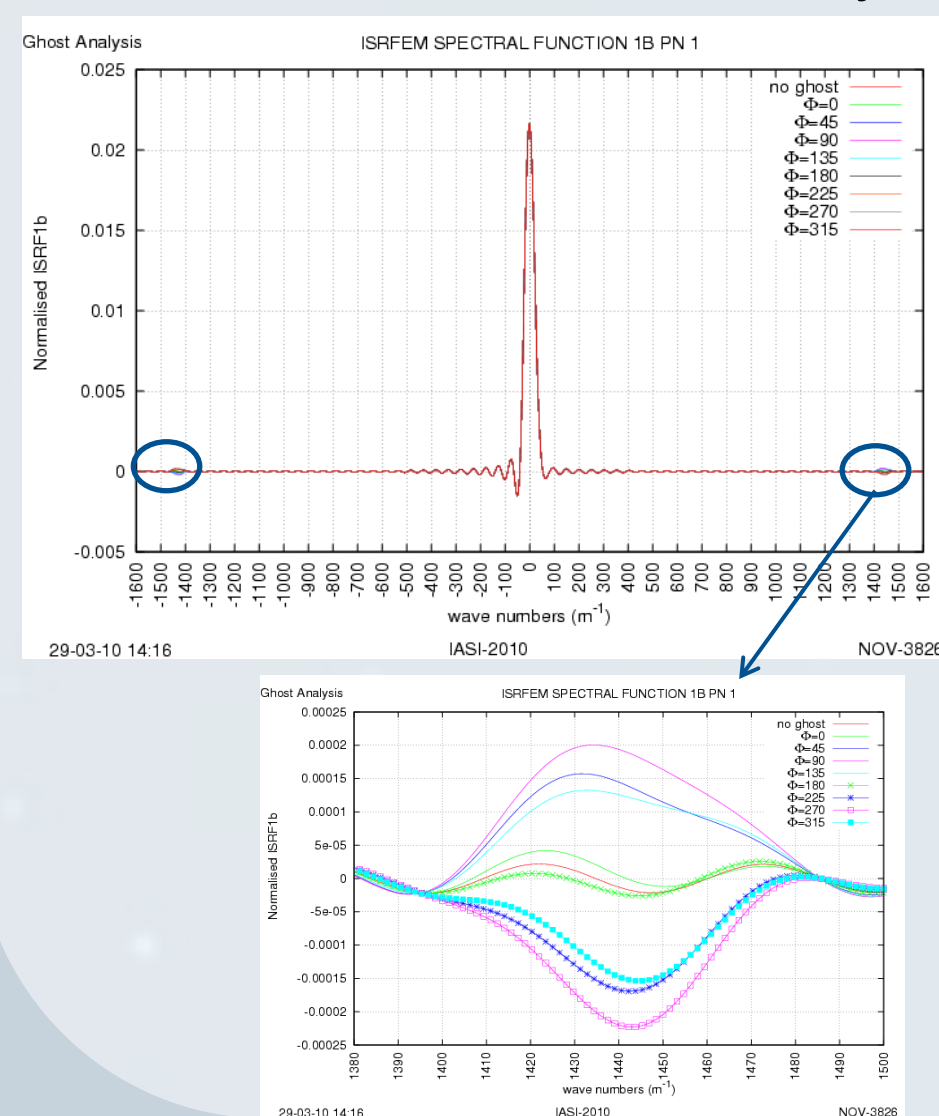
- The Infrared Atmospheric Sounding Interferometer (IASI) instrument is based on the Michelson interferometer.
- The interferogram is the Fourier transform of incident spectrum.
- IASI provides radiance spectra, in a spectral range from 645 cm<sup>-1</sup> to 2760 cm<sup>-1</sup> (3.6 μm to 15.5 μm in 3 bands), with a spectral resolution of 0.5 cm<sup>-1</sup>, a spectral sampling of 0.25 cm<sup>-1</sup> and an absolute radiometric accuracy of 0.5 K at user level. It has 4 pixels, the sounder pixel size is 12 km and the spatial sampling is about 25 km (at nadir).



- Cube corners are used to play the role of mirrors
- A cube corner compensation device (CD) was made to compensate the perturbations created by the Cube Corner Functional Device (CCFD) motion on the satellite attitude and orbital control systems (AOCS), in the case that IASI would be operated with passive dampers (LFD) released
- LFD were not released neither on MetOp-A nor on MetOp-B

## Ghost Effect

- In nominal configuration (both CCFD and CD activated), the impact of the CD activated is a parasitic line ("ghost") in IASI Instrument Spectral Response Function (ISRF), measured during on-ground test of the instrument. It is due to the excitation of the interferometer beam splitter by micro-vibrations coming from the CD, transmitted by the optical bench structure.



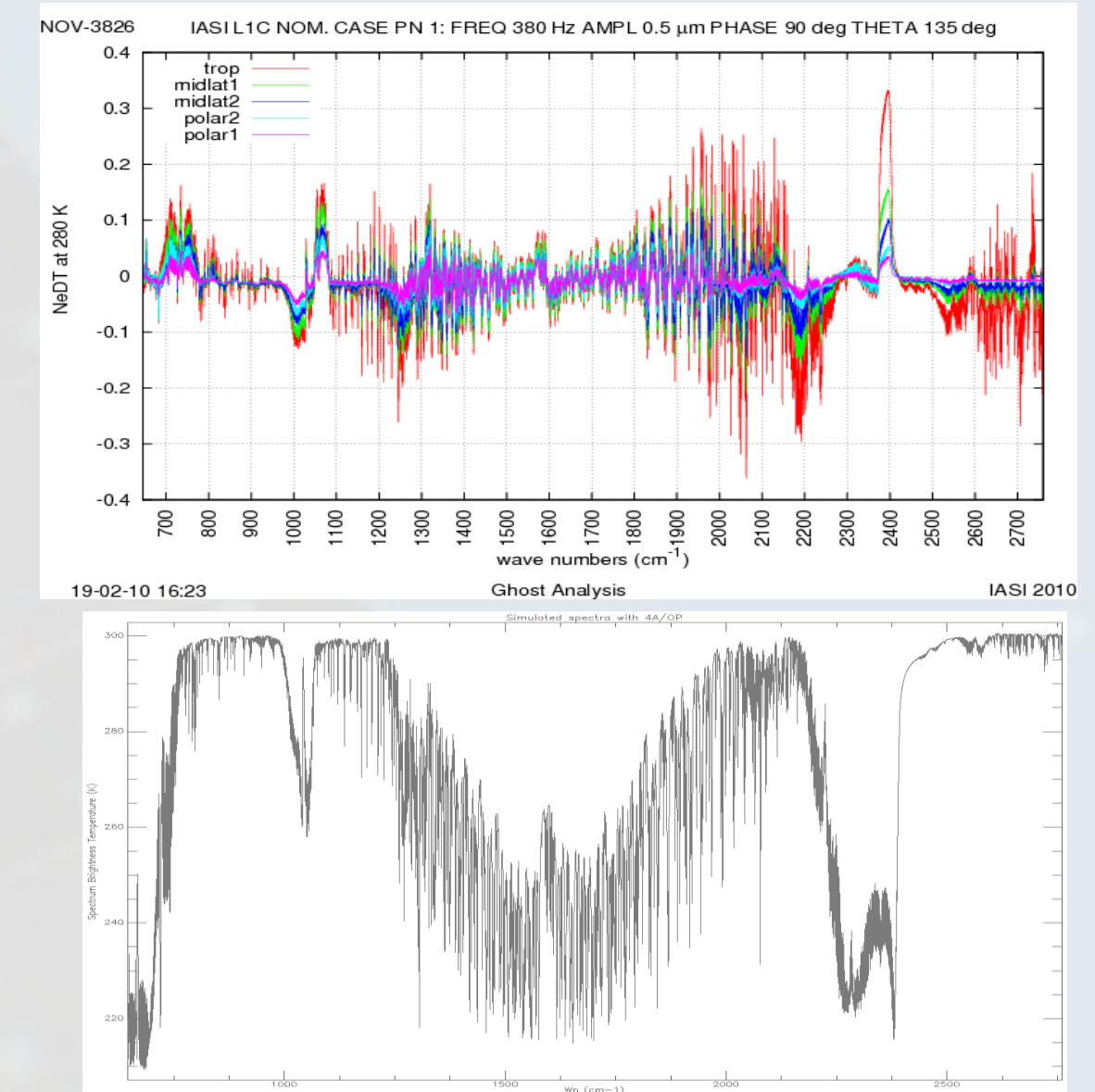
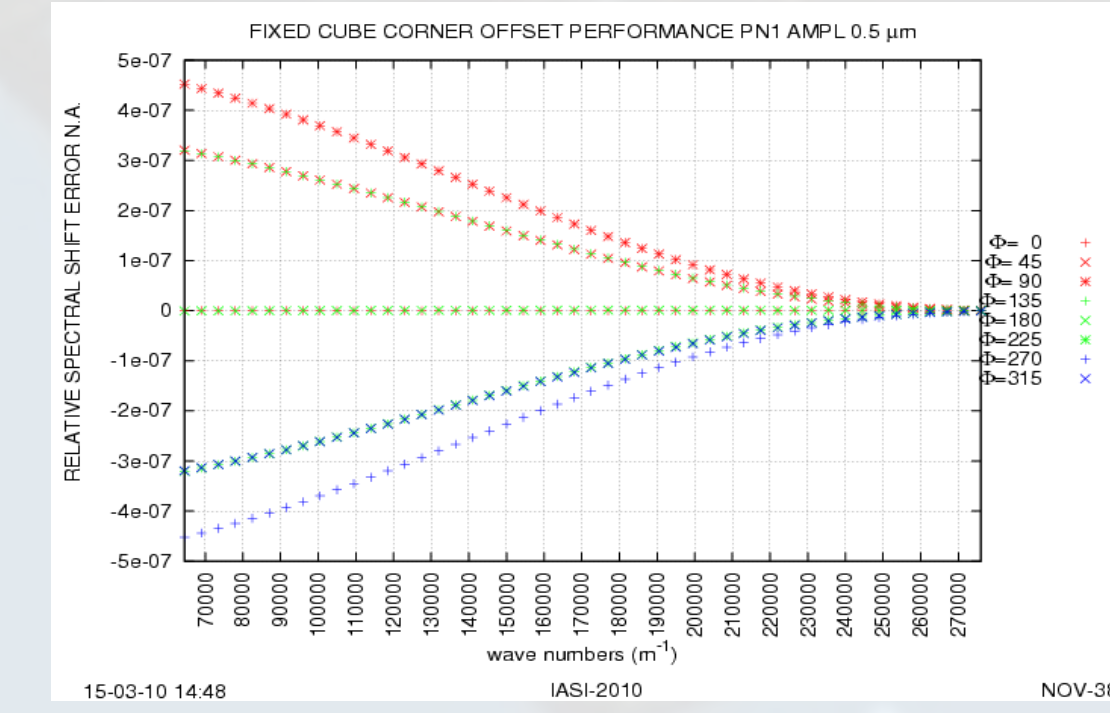
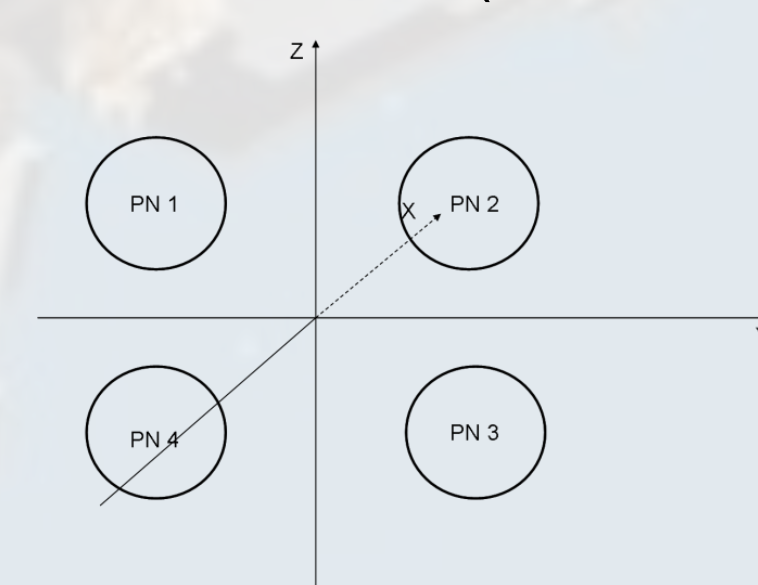
- Sampling jitter of the interferogram  

$$I_1(r) = \frac{I_{01}}{2} \cos[2\pi\nu_0 \{x_{nom}(r) + \delta x(r)\}]$$
 With  $\delta x(r) = U_0 \cos(2\pi f t + \psi)$   
Affects the ISRF by replicating it at about ±14 cm<sup>-1</sup>.

Characteristics of the ghost:

- Frequency f = 380 Hz.
- Amplitude U<sub>0</sub> : ~ 0.5 μm. Difficult to quantify in flight.
- The phase ψ (along X) is random, vary with time.
- Rotation in (Y,Z) plan : angle theta around 90° (along Z).

- The maximum impact on IASI spectra have been quantified with simulation on a worst case: high amplitude (0.5 μm), phase and rotation plan with the maximum impact (phase 90° and theta 135°). Error in terms of NedT @280 K for 5 typical atmospheric profiles
- The error due to the ghost effect is proportional to its amplitude and the energy of the spectrum.
- @2380 cm<sup>-1</sup>: sharp gradient: little spectral shift = high temperature difference.
- Error in terms of relative spectral shift:  
The error proportional to its amplitude, higher for phase = 90° (IASI case).

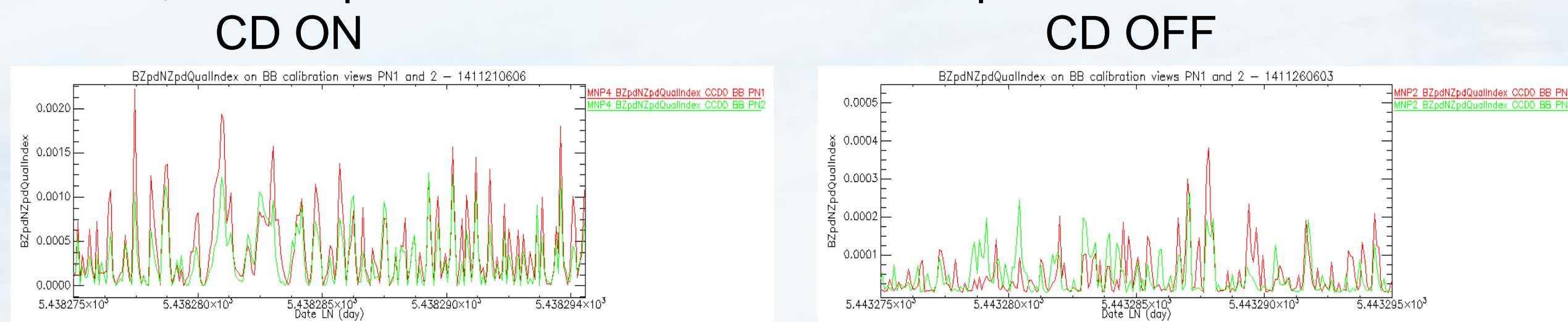
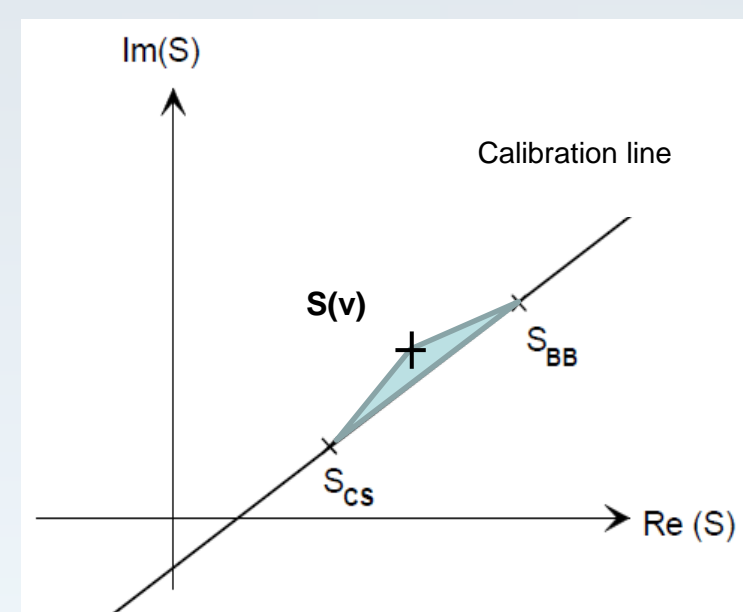


## Performance assessment after CD stop

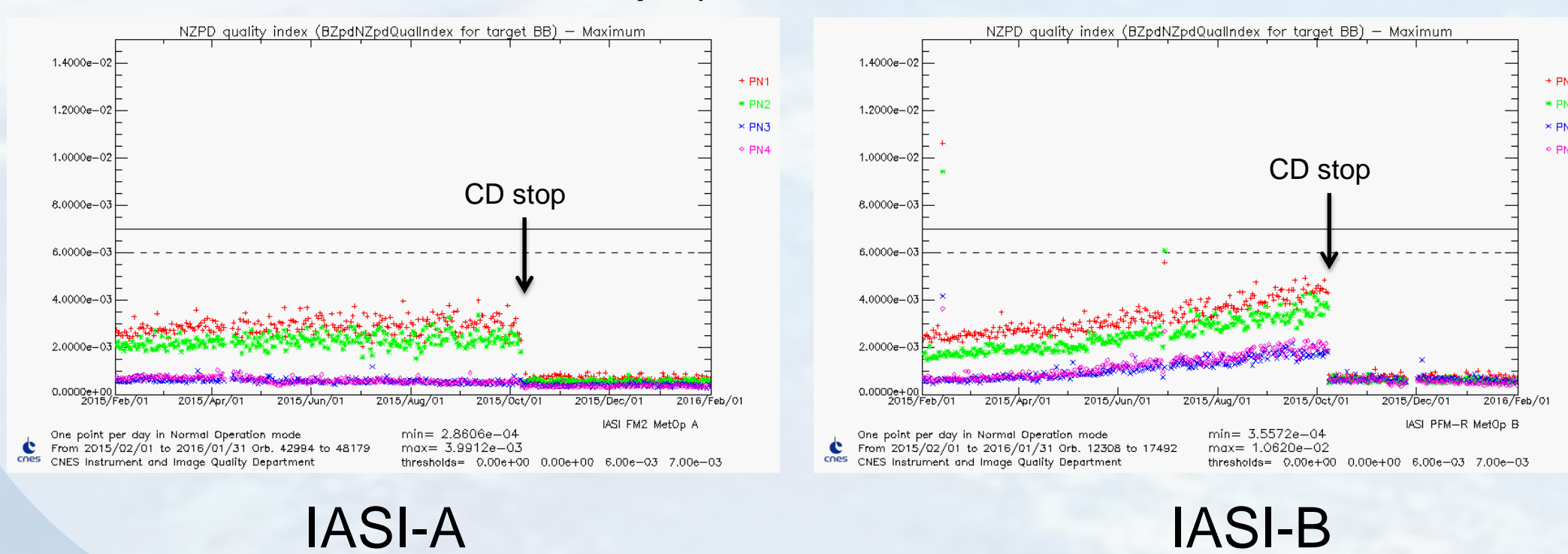
- The ghost impact on the spectral and radiometric performances is routinely monitored in flight for IASI-A and IASI-B and has been evidenced independently by some users of IASI data.
- Some tests in flight between November 2014 and January 2015 on the two IASI have shown that the ghost effect disappears when the CD is switched off.
- It was thus decided to stop the CD permanently on both IASI since October 7<sup>th</sup> 2015.

### ZPD (zero path difference) position determination

- Position in the interferogram where the optical path difference is null
- Determined in the spectrum space
- ZPD quality index: quality of the Zpd (Zero Path Difference position) computed on board. Proportional to the residual distance of the spectrum to the calibration line defined by the calibration reduced spectra (applied on band 3 interferograms only).
- NZpdQualIndex on the BB views is sensitive to the ghost effect  
Time series of NZPD Quality Index: signals for PN 1 and 2 are in phase (and periodic) when the CD is ON, it is not the case when the CD is OFF. We have the same behaviour for CD1, and for pixel 3 and 4 with a weaker amplitude. Same for IASI-A and IASI-B.

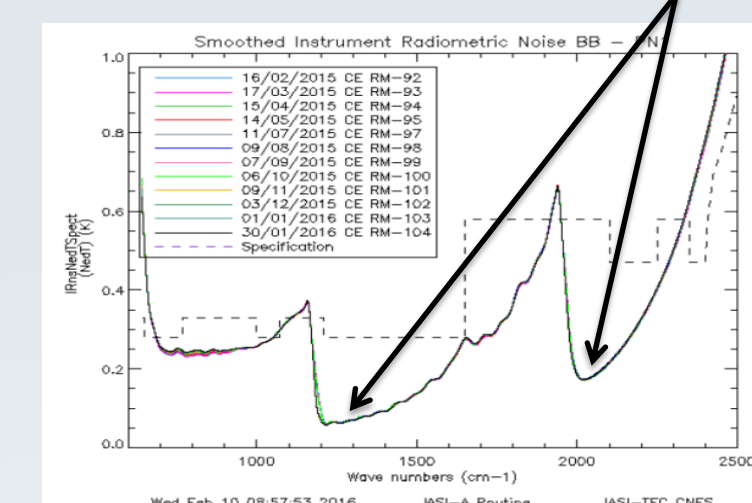


- Quality of the Zpd widely increased with permanent CD stop on the 7<sup>th</sup> October 2015, especially on calibration views where the index is particularly low.
- Due to the elimination of the ghost in the interferograms (add an error and perturbs the determination of the Zpd).

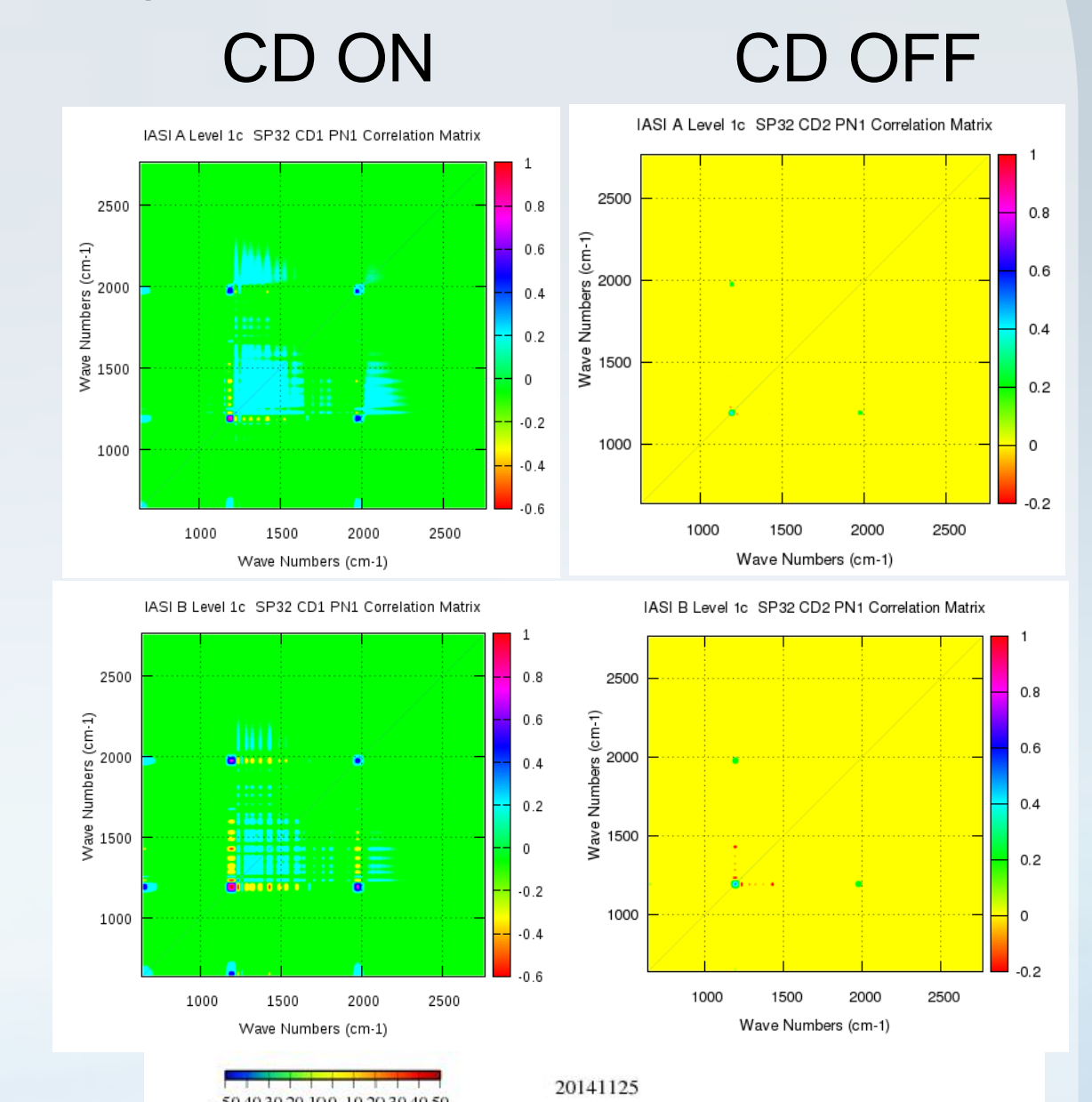


## Correlation matrix

- Correlation of all the IASI channels (8461) of black body (BB) spectra acquired on BB external calibration. One major contributor of the correlation between channels when the noise is low is the ghost effect.

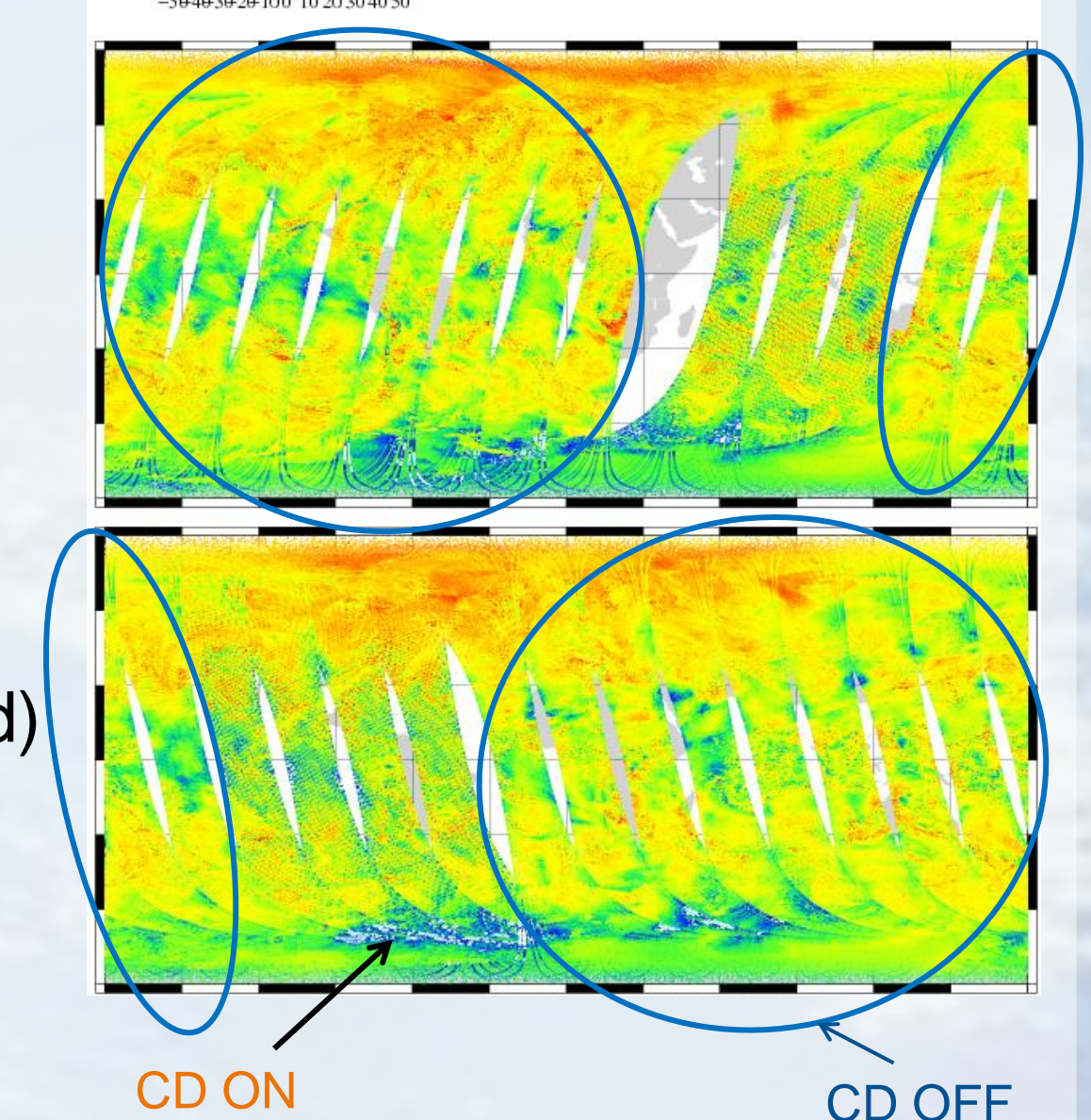


- IASI-A  
BB CE orbits from: ON: 09/11/2013 to 06/01/2014  
OFF: 09/11/2015
- IASI-B  
BB CE orbits from: ON: 20/04/2014 to 17/06/2014  
OFF: 23/10/2015
- When the CD is stopped, the correlation pattern is weaker.
- The correlation due to the ghost is gone.



## Principal Component Scores (EUMETSAT)

- 1 Principal Component (PC n°24) over the 120 PCs computed in band 2 is related to the ghost (or at least instrument remaining effect) for both IASI.
- Particular pattern, commonly called snake pattern, disappears (or at least is mostly reduced) when the Compensation device is stopped.



## Other performances

- Imaginary residuals of radiometric calibration decreased after CD stop
- The ghost has an effect on the radiometric calibration and lead to a imaginary residual because the phase at Zpd of the micro-vibration is random and change each time the mobile cube corner change its direction. So the phase added by the ghost is not the same on the black body view and on the cold space view of the line LN, and on the black body view of the line LN+1.
- The CD stop doesn't disrupt the geolocation, at IASI level (checked with IIS) or Platform level (checked with AVHRR).

## Conclusion

- The "ghost effect", due to the micro-vibration of the beam splitter, has been almost totally eliminated by the stop of the permanent CD stop on 7<sup>th</sup> October 2015, leading to an improvement of IASI spectral and radiometric performances (sources of vibration in the interferometer reduced).
- The ghost effect can't be corrected in the ground segment, so stopping the CD was the only way to eliminate it.
- Users analysed the difference between IASI observations and simulations : less variability at the band head of the CO<sub>2</sub> band (~ 2385 cm<sup>-1</sup>).
- No perceptible improvements for numerical weather prediction (NWP) because the channels assimilated in the NWP system are not contiguous, and many other sources of error are combined into the diagnosed matrix. However, future NWP assimilation techniques could take advantage of full IASI spectra and so removing the ghost effects could have a benefit in future NWP applications.
- Stopping the CD seems to stabilize the system, i.e. some users have seen a better stability of the radiometric noise estimation on Earth views.