CENTRE NATIONAL D'ÉTUDES SPATIALES

IASI-NG :

CNES phase 0 study presentation

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2nd IASI conference
Annecy, January 2010

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1- IASI-NG performance objective and compliance with the EUMETSAT POST-EPS IRS Mission Requirement Doc

2- IASI-NG CNES phase 0 technical synthesis

3- IASI-NG CNES phase 0 expected performances and budgets

4- IASI lessons learned from technical point of view

5- IASI-NG activities in 2010

IASI-NG performance objective

- **Improve the IASI demonstrated performances :**
  - **Spectral Resolution by factor 2**
  - **Radiometric noise by factor 2**

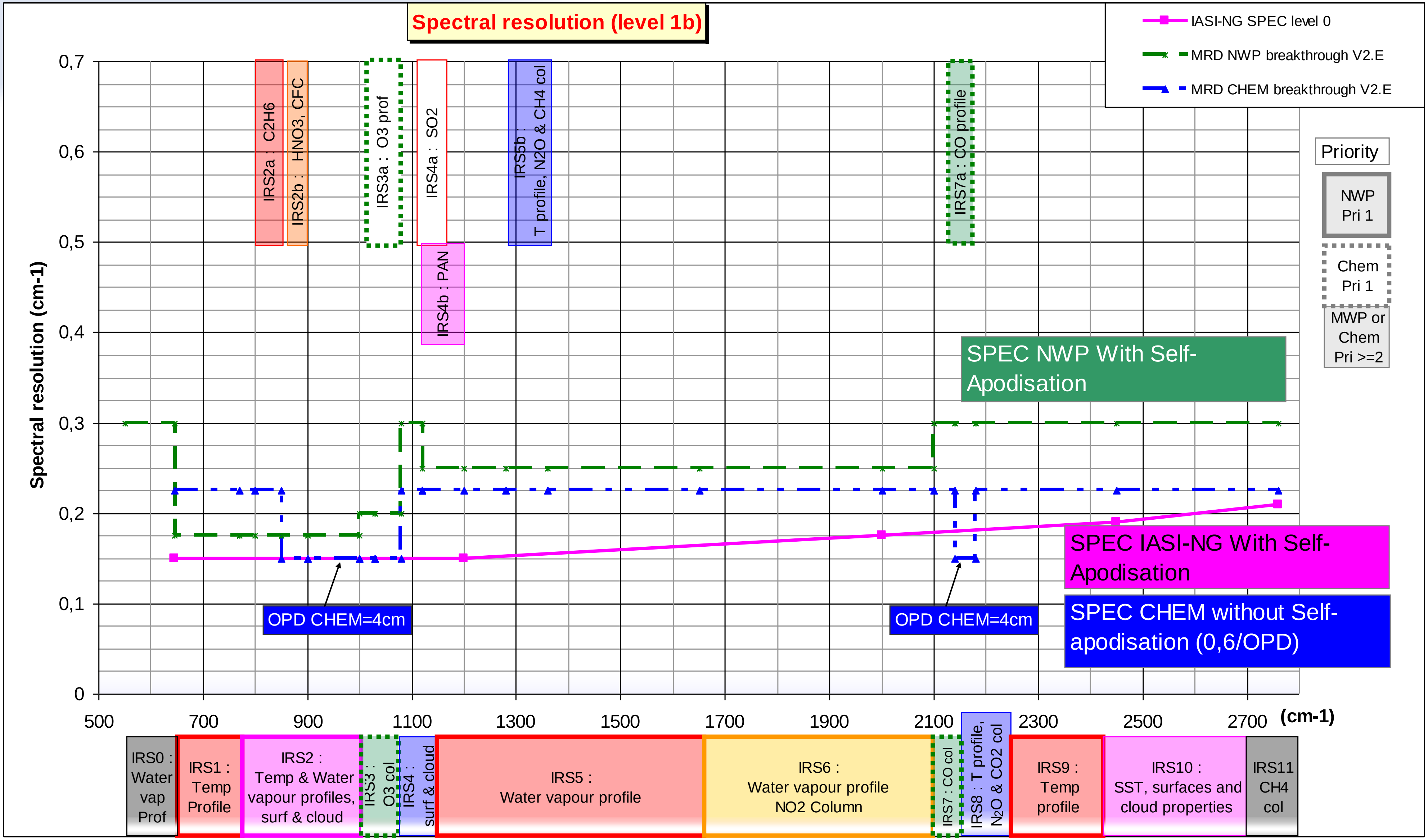
    ==> comparable to Post-EPS MRD 2.E breakthrough data

- **Keep the same spatial resolution as IASI (25km in average on ground at nadir) and the same IASI pixel size (12km)**

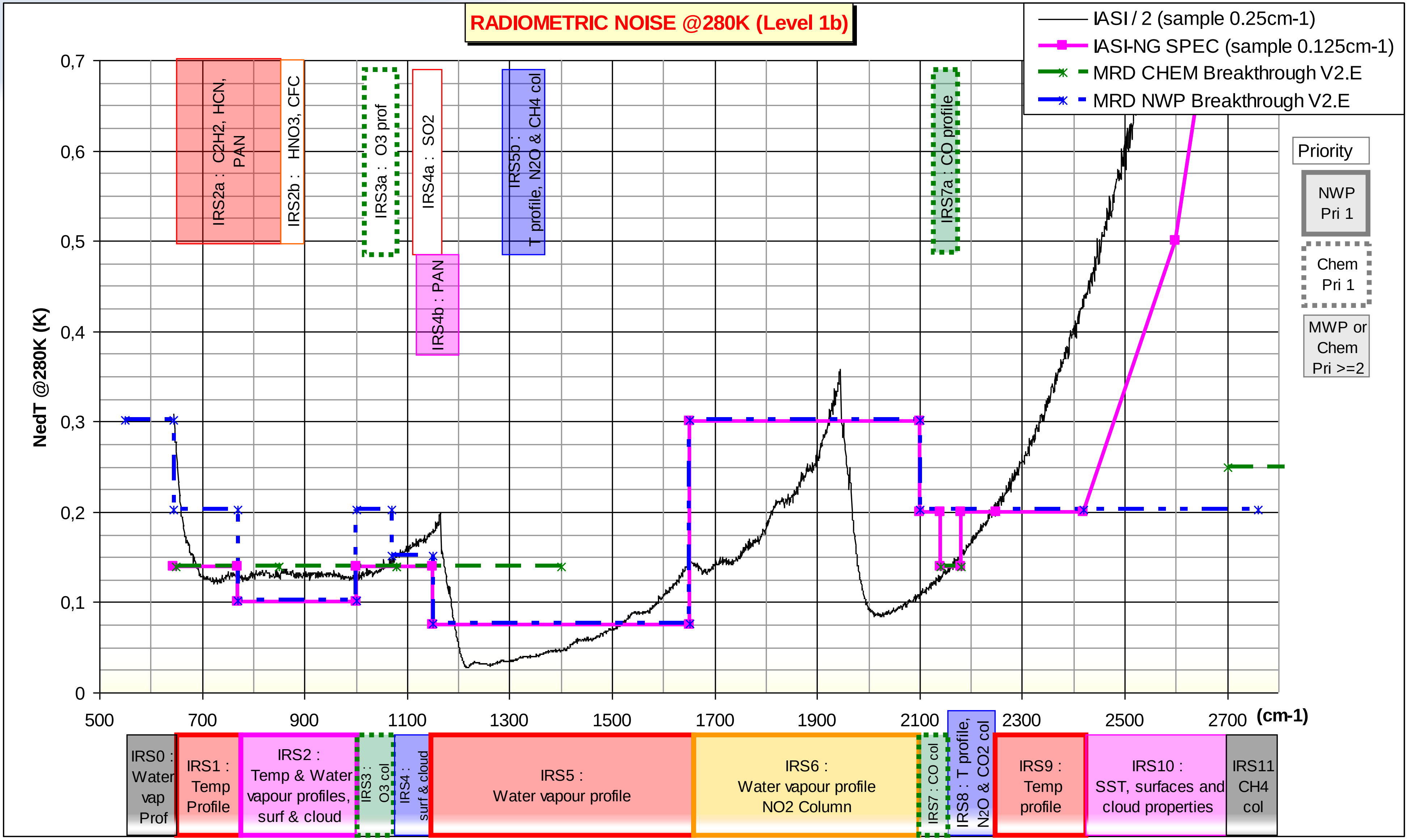
- **Compliance of the IASI-NG specification to Post-EPS IRS requirements presented to PMET end of 2009.**
  Main non compliances with MRD 2.E:
  - **Viewing angle and coverage (will be the IASI one for IASI-NG)**
  - **Pointing knowledge (will be just a bit better than the IASI one)**
  - **Radiometric noise below 645cm^{-1} and above 2400cm^{-1}**

  Accepted by PMET : MRD to be updated

IASI-NG performance objective versus Post EPS MRD



IASI-NG performance objective versus Post EPS MRD



IASI-NG : radiometric and spectral improvements

Different trade off's done only for dynamic FTS

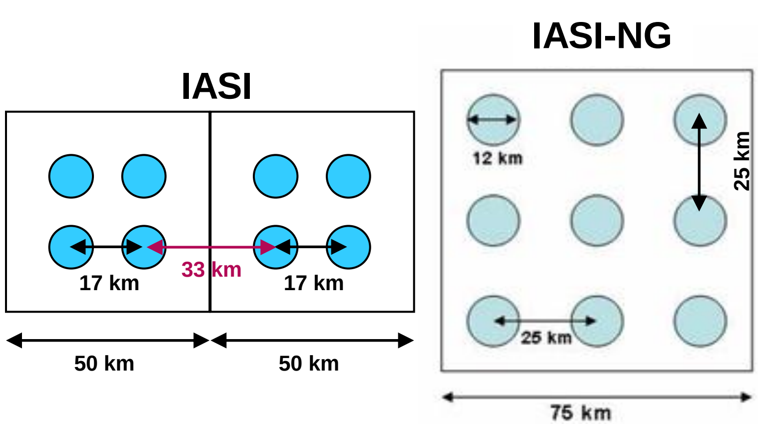
Radiometry

- Entrance ***pupil diameter*** Increase (→flux):
  - ➢ IASI-NG = 120mm versus IASI = 80 mm
- Instrument ***Field of view*** Increase (→integration time):
  - ➢ IASI-NG = 75*75km (9 pixels) versus IASI = 50*50km (4 pixels) ➔ acquisition duration for each interferogram = 450ms versus 150ms for IASI
- Detectors ***temperature*** reduction (active cooling)
  - ➢ IASI-NG T detector < 65K versus IASI = 92K

Spectral resolution

Optical Path difference increase by factor 2:

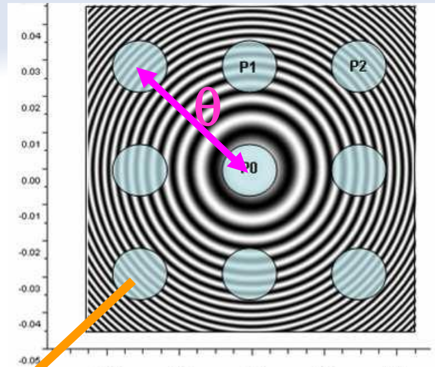
- single sided interferometer
  - one mobile cube having the same IASI stroke
  - TWO mobile cubes having the IASI stroke / 2
- double sided interferometer
  - one mobile cubes having the IASI stroke x 2
  - TWO mobile cubes having the same IASI stroke



BUT: «self-apodisation»

For the spectral resolution, both the Optical Path Difference AND the self-apodisation must be improved.

IASI-NG : the self-apodisation issue

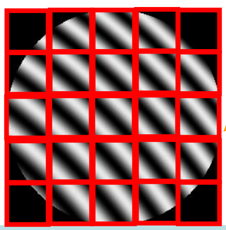


IASI-NG: Optical signal in the detectors plane for ν=2760cm-1 and OPDmax=4cm

The use of IASI like pixel acquisition concept is not possible. Two options has been studied.

Split the sounder pixel into many smaller pixels
→ Matrix detectors

Sounder pixel



- **For each of the 9 sounding pixel, acquisition of sub-pixels interferograms (typically 5x5 sub-pixels), then combination of the interferograms by resampling at "constant" OPD + filtering to generate one sounding pixel interferogram**
- **Final Self-apodisation for the corner pixels = IASI one**

Huge Data Processing (1Gbit/s of data at the matrix output)

Need a very GOOD focal plane image quality → complex focal plane

Suppress/mitigate the self-apodisation effect
→ self-apodisation compensation

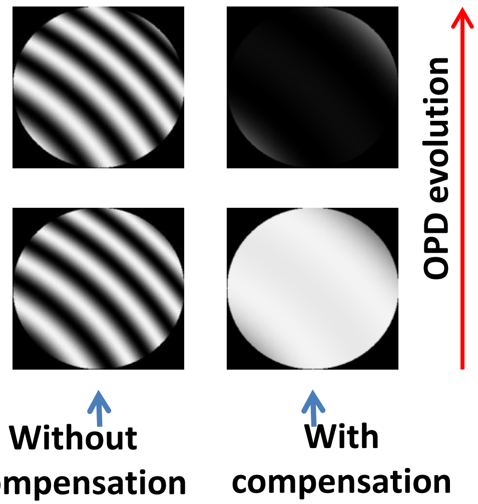
- **Introduce, in the interferometer, a specific mechanism that works in synchronization with the Corner Cube Mechanism and that corrects, for each sounding pixel (but the center one), the Optical Path Difference by : $\delta_O (1 - \cos\theta)$, where δ_O is the OPD for a zero field → ALL the pixels should have a similar behavior than the central pixel**

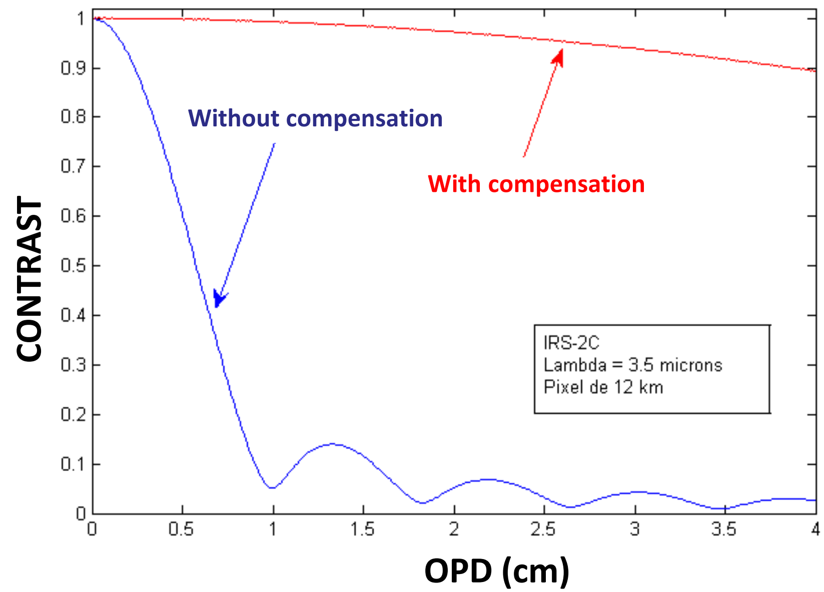
IASI-NG CNES Phase 0 Reference option

IASI-NG : Self-Apodisation compensation option

Optical simulation with and without active optical field compensation

Evolution of a corner pixel optical signal for monochromatic ray at 4µm, for OPD variation of 1µm, (between max and min signal (λ/4)) at OPD of 4cm





Advantages

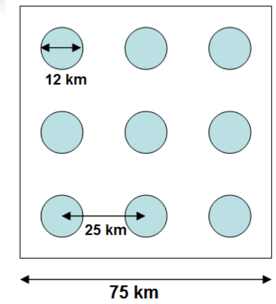
- Direct acquisition of one interferogram by sounder pixel using monoelement pixel detectors (IASI like) or by matrix detectors with hardware binning of the elementary pixels
- Data processing IASI like (excepted for the single sided processing)
- IASI like cold optical focal plane
- Reduction of the different defaults sensitivity with regard to IASI (CCM, microvib's)

Drawbacks

- New Genzel concept
- New mechanism
- Complexification of the Laser Reference accommodation

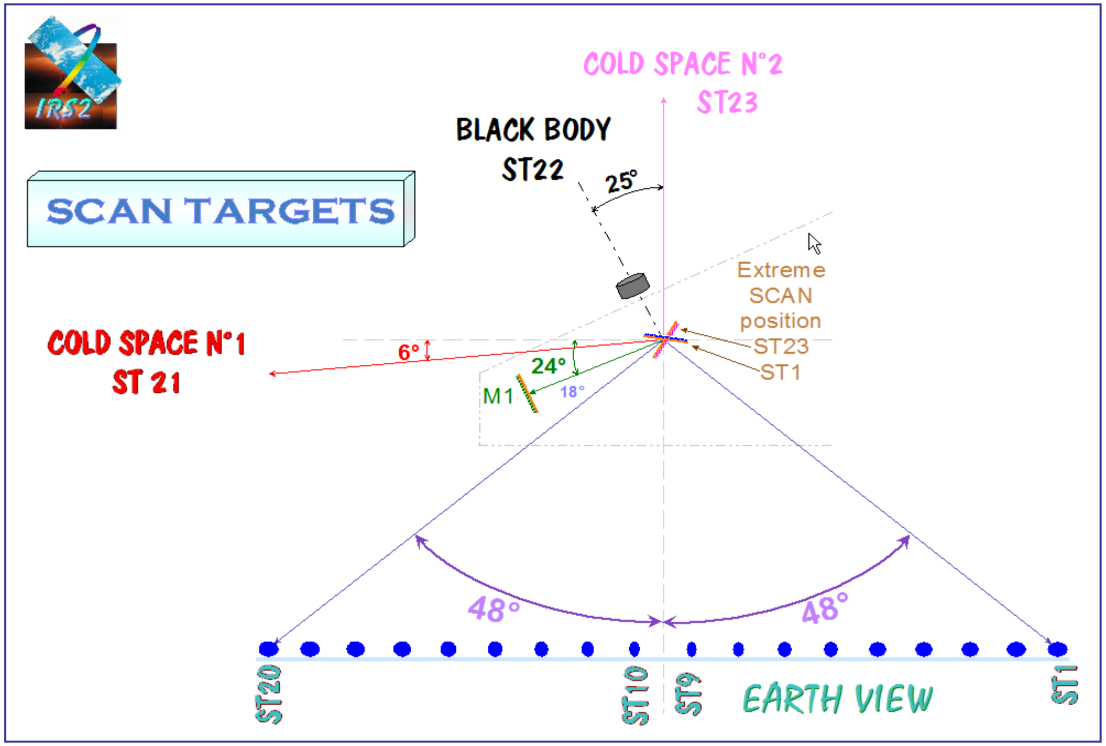
IASI-NG : *Baseline characteristics (CNES phase 0)*

- Ground Pixel diameter of 12km (=IASI)
- Ground sampling of 25km (both axis)
- Number of sounder pixels per acquisition = 9 (IASI=4)
- Number of earth view per line = 20 (30 IASI)
- Interferogram acquisition duration = 450ms (IASI=150ms)



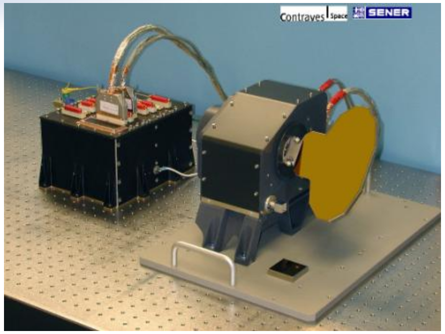
- Inlet PUPIL = 120mm (IASI=80mm)

- Focal plane :
  - **4 bands (IASI=3)**
  - **9 sounder pixels per band (IASI=4)**
  - **PV detectors for all bands (IASI PC for B1; PV for B2/B3)**
  - **detectors cooled at 65K with one active cooler (LPTC) (IASI=92K passive)**
  - **IASI like cold optic concept**

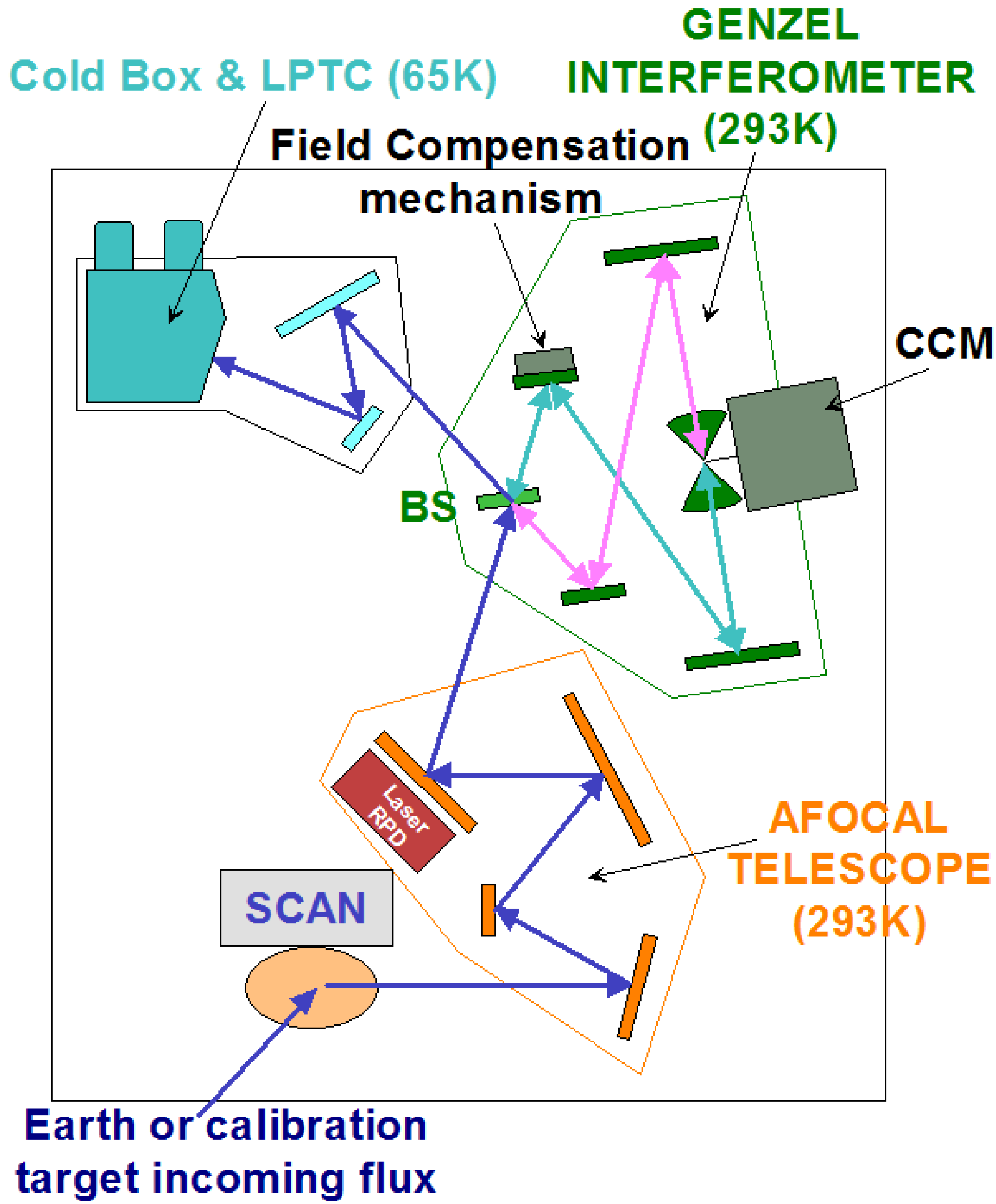


IASI-NG : *Baseline characteristics (CNES phase 0)*

- IASI like SCAN with slight increase of the motorization

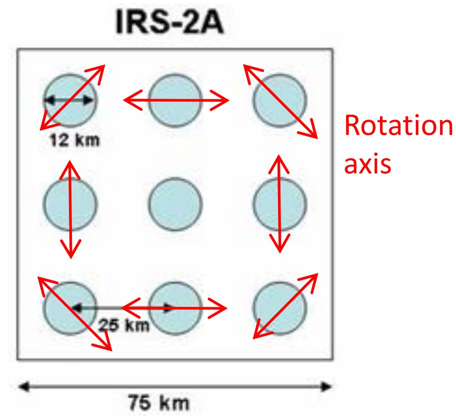


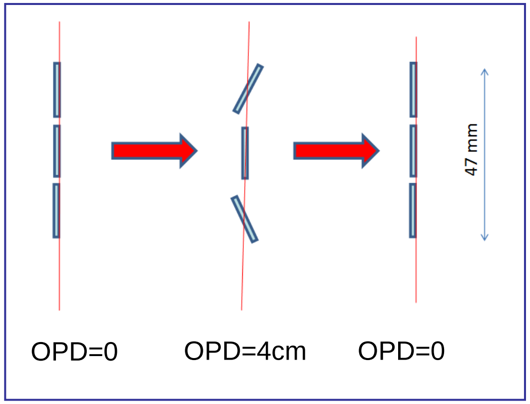
- One afocal telescope
- One GENZEL interferometer
  - **1 ZnSe Beam Splitter (80mm typical)**
  - **Single sided configuration**
    (to be justified more deeply)
  - **2 Corner Cubes are linked together and are activated by a single mechanism (CCM) with a stroke of 11mm (IASI=20mm for one CC)**
  - **1 field compensation mechanism**
  - **One laser beam for OPD sampling for each pixel**



IASI-NG : *Baseline characteristics (CNES phase 0)*

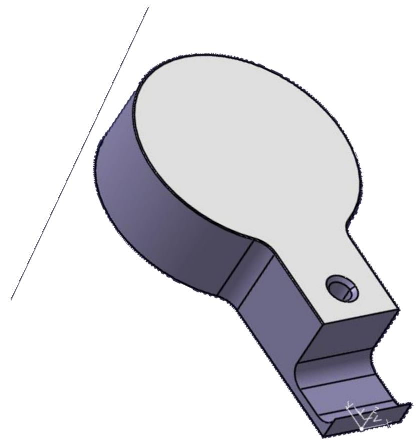
- ***Genzel interferometer :***
  Mechanism for field compensation

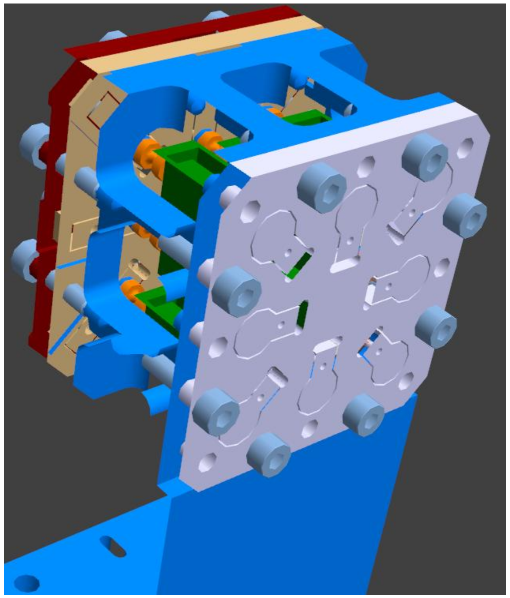




- *9 individual independent flat mirrors. 8 mirrors are mobile. The central one is not moving.*

- *Each individual mirror is activated in rotation by one independent piezzo in coordination with the Corner Cube Mechanism (the mirror on the center is not moving) :*
  - *OPD=0 ➔ No rotation; all the mirrors are in the same plane*
  - *OPD max ➔ maximum rotation of typically 1.5mrad*





- *A breadboard is under development at CNES*

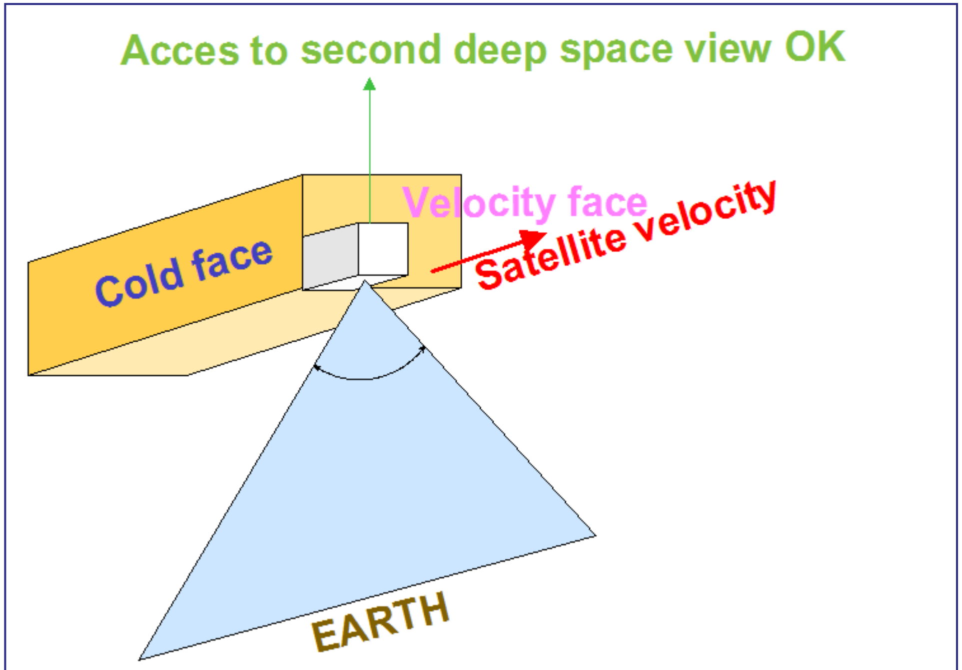
IASI-NG : *Baseline characteristics (CNES phase 0)*

- ***Data processing :***
  - *Earth precalibrated spectra are downloaded + IR image*
  - *DPS with high heritage of IASI for the algorithms excepted for the single sided interferogram processing*
  - *LEON's processor + FFT coprocessors (FFT of 65536 samples is done in 1ms)*
  - *Spacewire bus*

- ***IR integrated Imager :***
  - *IASI like with increased field of view*

- ***Instrument Management :***
  - *Classical with 1553 bus*

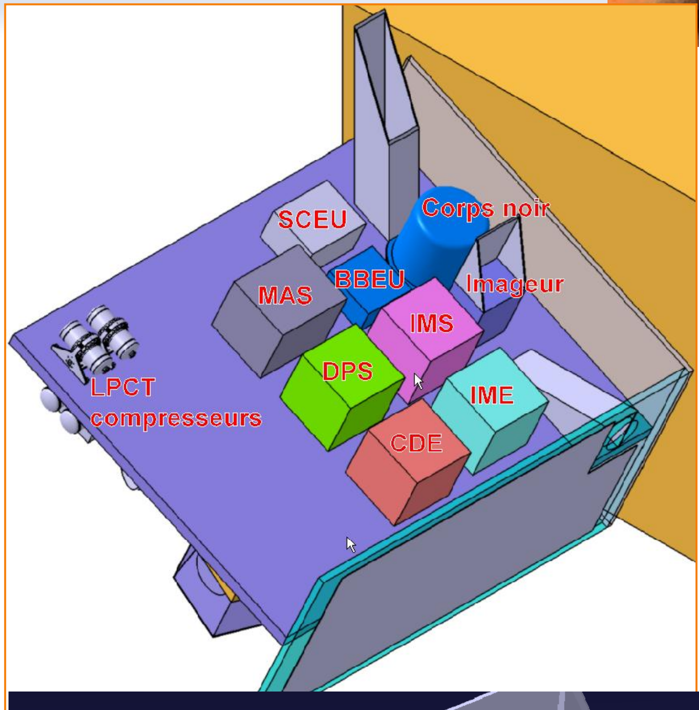
- ***Mechanical & thermal:***
  - *IASI-NG accommodation on the satellite velocity face with access to a second deep space calibration view*

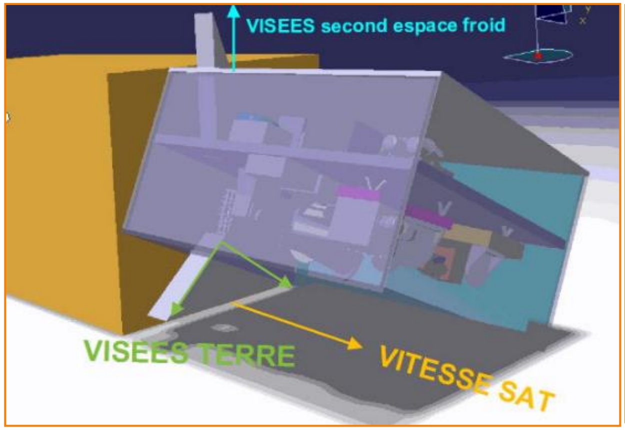


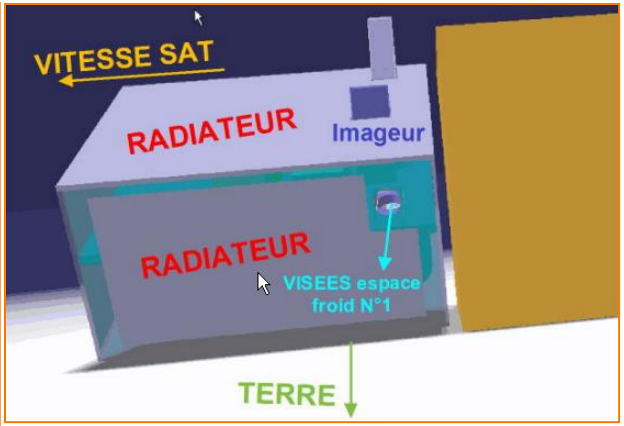
IRS accomodation on the satellite velocity face

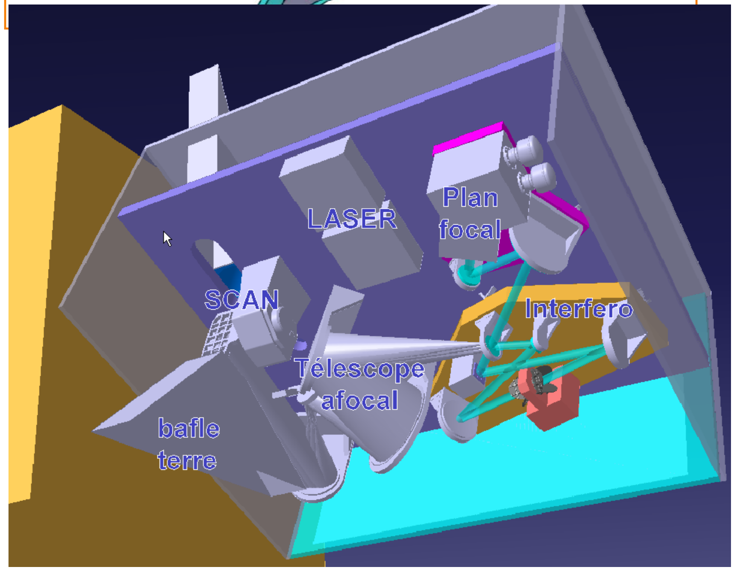
IASI-NG : *Baseline characteristics (CNES phase 0)*

- ***Mechanical & thermal:***
  - *Interferometer equipments are mounted on a stiff CFRP optical bench*
  - *ALL the others panels are aluminum honeycomb panels*
  - *ALL equipments, panels and baffles are controlled at 293K (excepted the detectors at 65K)*
  - *No Launch Locking and microvibrations Filtering Device*









IASI-NG : *Baseline characteristics (CNES phase 0)*

- ***MASS***
  - **IASI-NG : 260Kg (best estimate without margin)**
  - **IASI = 235Kg**

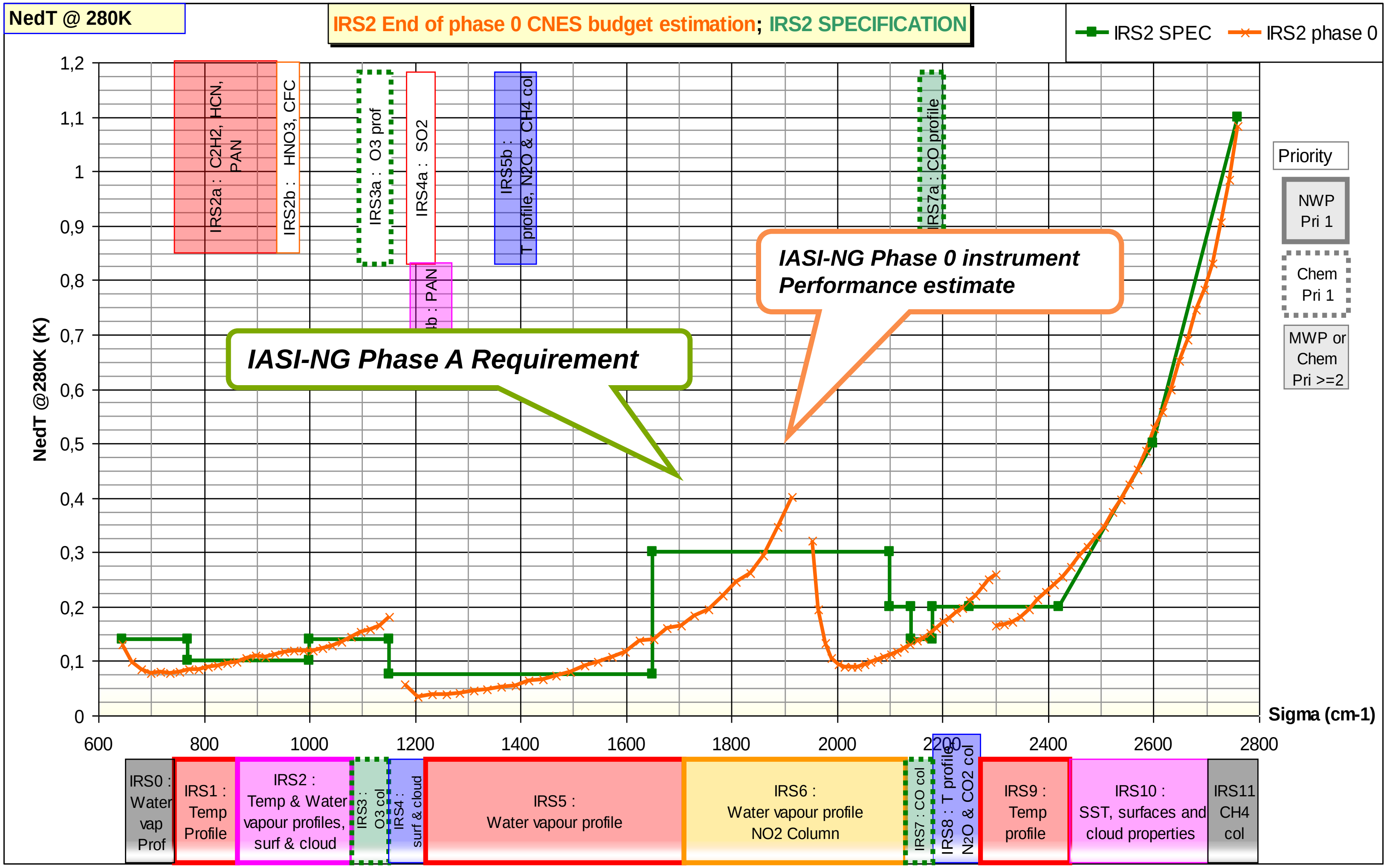
- ***VOLUME***
  - **IASI-NG : 1700mm x 1400mm x 800mm in a single box (1,9m3)**
    - Optimization can be envisaged
  - **IASI : one sensor module + deported IMS/DPS inside the satellite ==> total = 1,7m3**

- **POWER (EOL):**
  - **IASI-NG : 370W (best estimate without margin) (active cooling main contributor)**
  - **IASI = 240W**

- **TM DATA RATE:**
  - **IASI-NG : 3.1Mbit/s**
  - **IASI : 1.5Mbit/s**

IASI-NG : *Baseline characteristics (CNES phase 0)*

- ***Spectral resolution at level 1b = 0.15cm^{-1} almost constant all over the spectral bandwidth. =0.25cm^{-1} at level 1c (after numerical apodisation)***
- ***Radiometric noise (level 0 for samples of 0.125cm-1):***



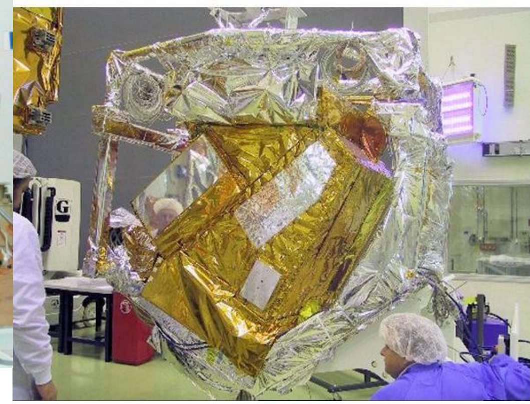
IASI lessons learned applicable for IASI-NG

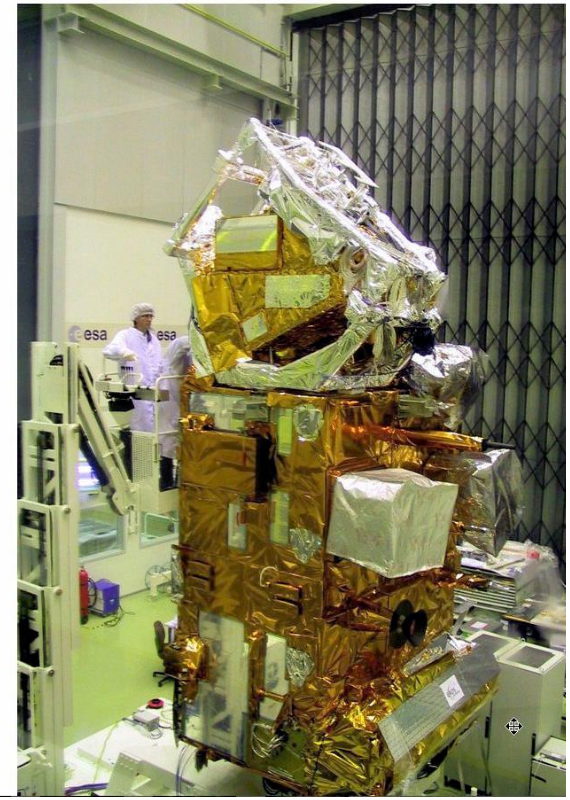
- **Engineering & AIT constraints improvements / IASI**
  - **Thanks to a very stiff interferometer :**
    - The instrument performances should not be sensitive to gravity
    - The instrument performances should be much less sensitive to microvibrations
  - **The corner cube compensation mechanism (<10Hz) should be avoided (one main source of microvibration for IASI)**
  - **Thanks to an active cryocooler and a sealed cold box/focal plane:**
    - the instrument should be able to cool the detectors by itself at ambient cleanroom condition (Possibility to do representative EMC tests at ambient, ...)
    - No need of the quite complex IASI test jig and cryopannel for the satellite TV tests
    - The ice contamination of the cold optics should be minimized
    - Can fly on any sun-synchronous orbit <10h30 and >13h30 with minor modification on the warm thermal radiators

IASI lessons learned applicable for IASI-NG

IASI flight configuration

IASI configuration for TV test !!





IASI lessons learned applicable for IASI-NG

- **Engineering & AIT constraints improvements / IASI**
  - Should avoid Locking and Filtering device → no storage and transportation constraints
  - The CCM locking/unlocking mechanism should be simplified
  - The instrument shall be able to be fully functional with the satellite in vertical position and for one horizontal position
  - No deported equipments (IMS/DPS for IASI) inside the satellite
  - Easy accessibility to all of the equipments including the cold focal plane should be possible

- **Operational improvements / IASI**
  - The unavailability period due to ice decontamination should be significantly reduced
  - Following an anomaly, the recovery time should be significantly reduced

IASI-NG Phase A in 2010

- A competitive industrial IASI-NG instrument phase A has started with ASTRIUM and THALES beginning of 2010.
- Both industries will evaluate the CNES phase 0 concept AND some others ones. A concept selection will be done before mid 2010 for more deep analysis studies.
- The end of this IASI-NG phase A is expected for beginning of 2011.
- Discussion start with EUMETSAT about IASI-NG ground segment