Planck LFI Operations towards Euclid NISP

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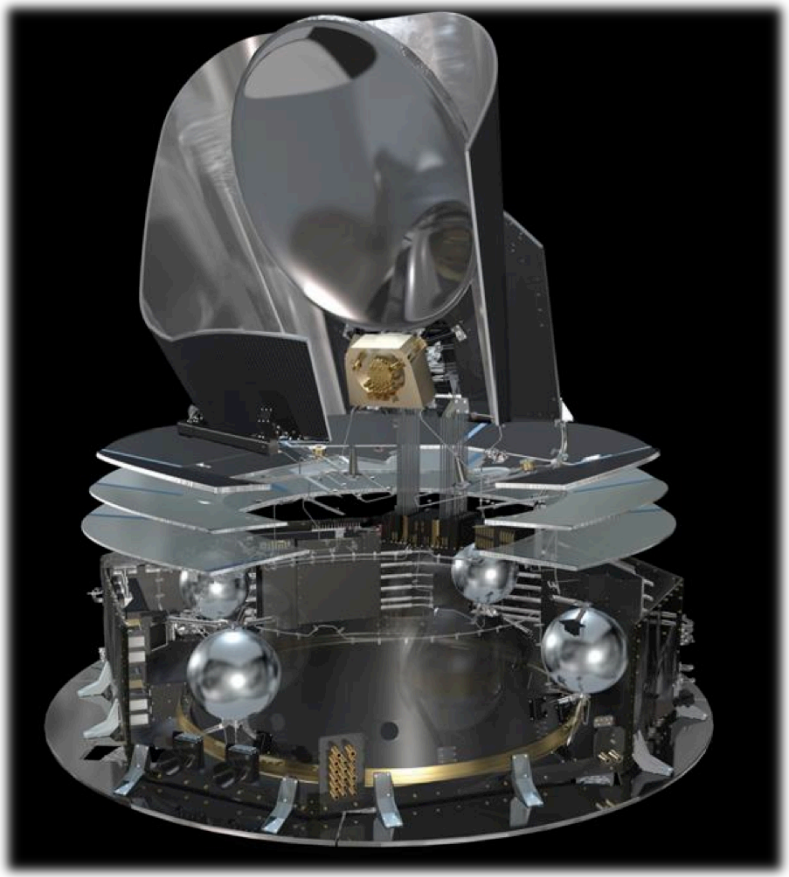
Euclid Instrument Operation Teams Coordinator

Overview

- Planck & LFI …
- Euclid & NISP …
- Instrument Operations
- Lessons learned
- Conclusions

The Planck Mission

The CMB gives us the picture of the Universe at the early times (recombination), its properties (cosmological parameters) have not changed since then. Using the CMB those numbers are measured with high accuracy



3rd CMB space mission - 1st ESA in collaboration with European, US and Canadian scientific community

Mass 2˙000 kg
Power 1˙600 W
Size 4.2 × 4.2 m
Cost 600×10^6 €

50˙000 electronic components
3 cooling stages 20 K, 4 K, 0.1 K
36˙000 l ^{4}He
12˙000 l ^{3}He

11˙400 Documents

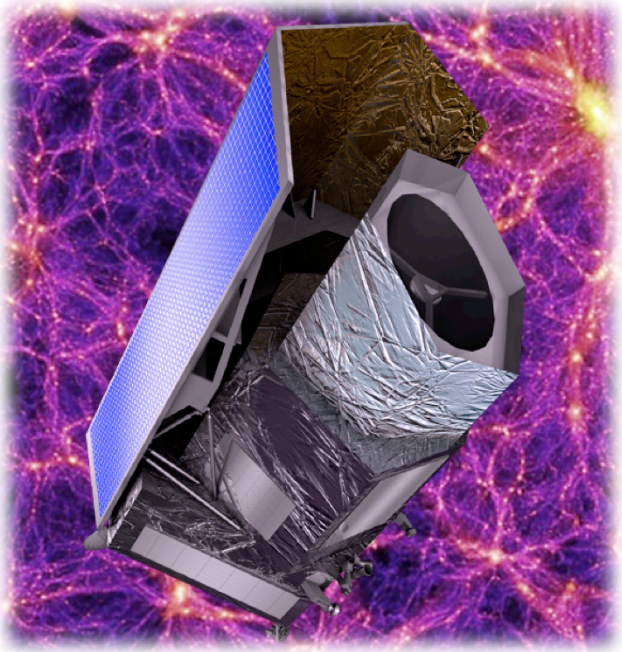
20 yrs between project & results

2 instruments & consortia LFI & HFI
16 countries
400 researchers

Nominal life: 14 months, 2 sky surveys
Extension: 5 surveys LFI & HFI (+ 3 LFI)

The Euclid Mission

Euclid: a space telescope designed to explore the dark Universe.
The mission will map out the large-scale structure of the Universe across 10 billion light years, revealing the history of its expansion and the growth of structure during the last three-quarters of its history



ESA M-size mission, to date 13 European countries (Austria, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Romania, Spain, Switzerland and UK), NASA and few US laboratories

Mass 2˙100 kg
Payload Mass 855 kg
Size 4.5 × 3.1 m
Telemetry 855 Gbit/day

$36 \times 16 \times 10^6$ Visible CCD pixels
$16 \times 4 \times 10^6$ NIR detector pixels

Launch date Q1 2020

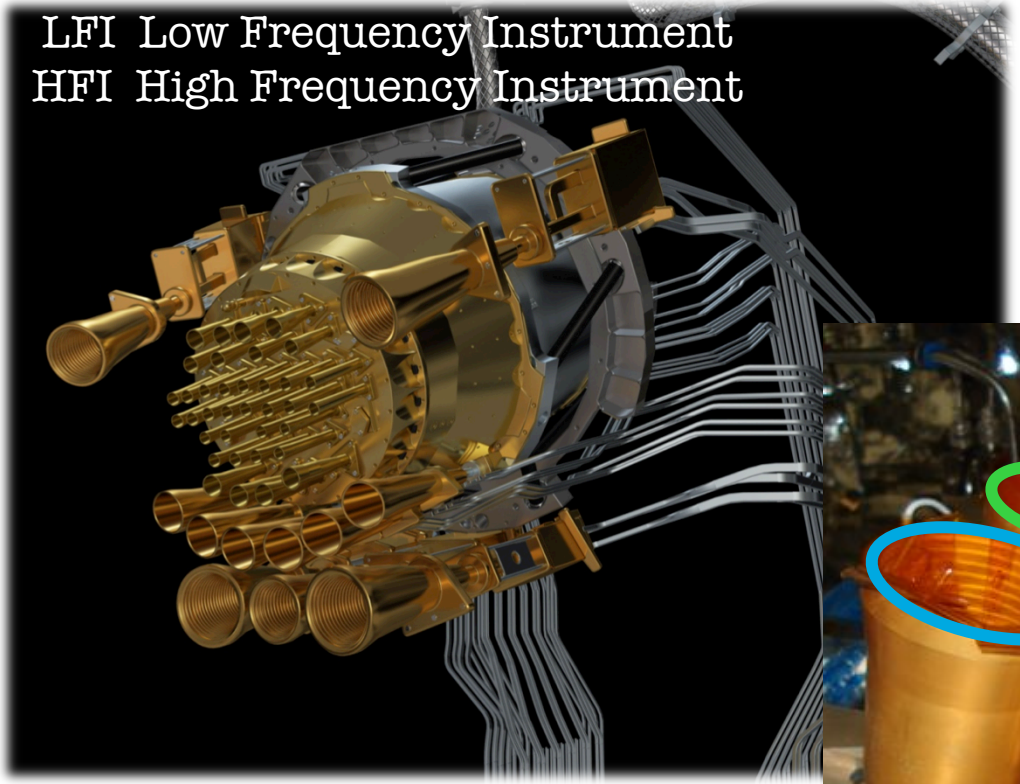
2 instruments VIS,NISP & 1 consortium
~100 institutes
>1000 researchers

Nominal life: 6.25 years

http://www.esa.int/Our_Activities/Space_Science/Euclid_overview

Planck Payload

LFI Low Frequency Instrument
HFI High Frequency Instrument

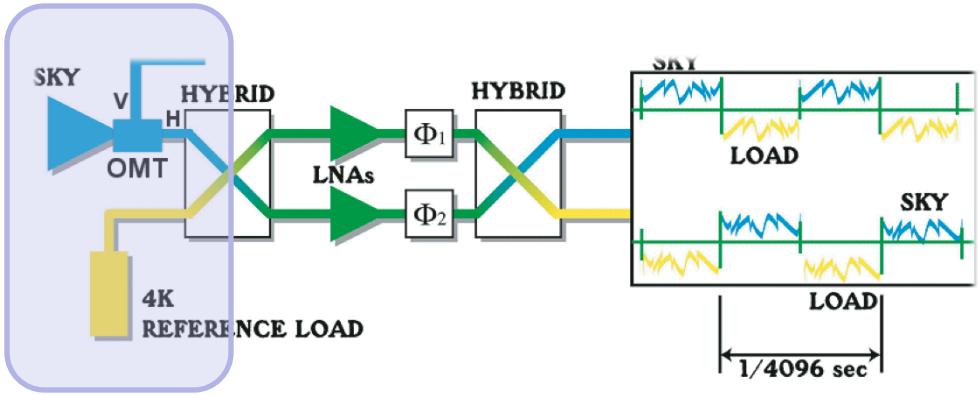


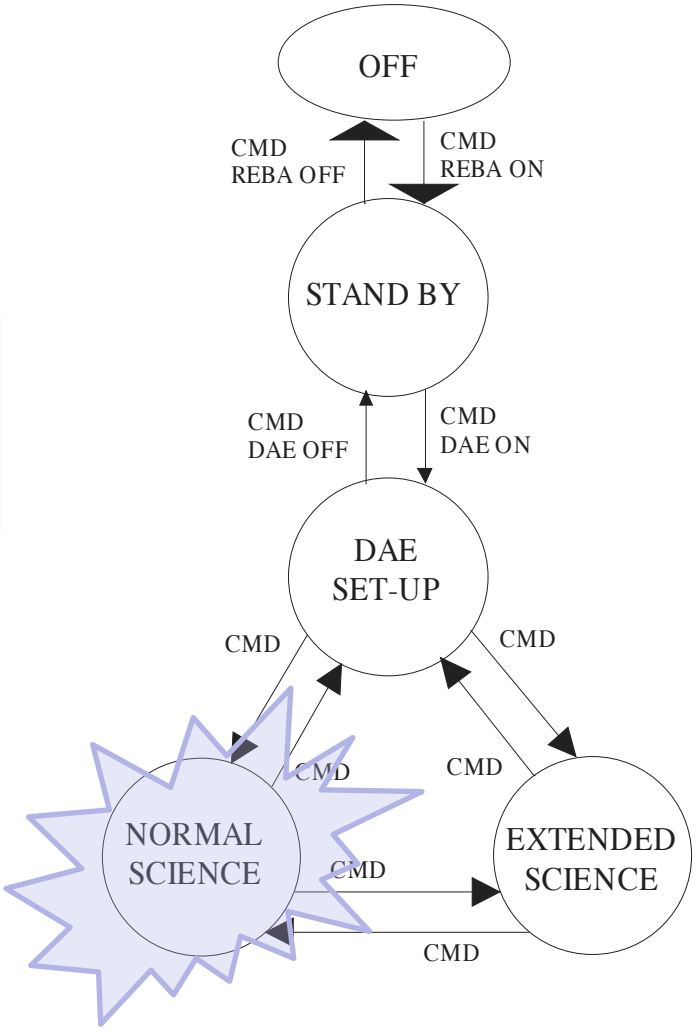
LFI	HFI
30 GHz	100 GHz
44 GHz	143 GHz
70 GHz	217 GHz
	353GHz
	545 GHz
	857 GHz

The LFI Instrument

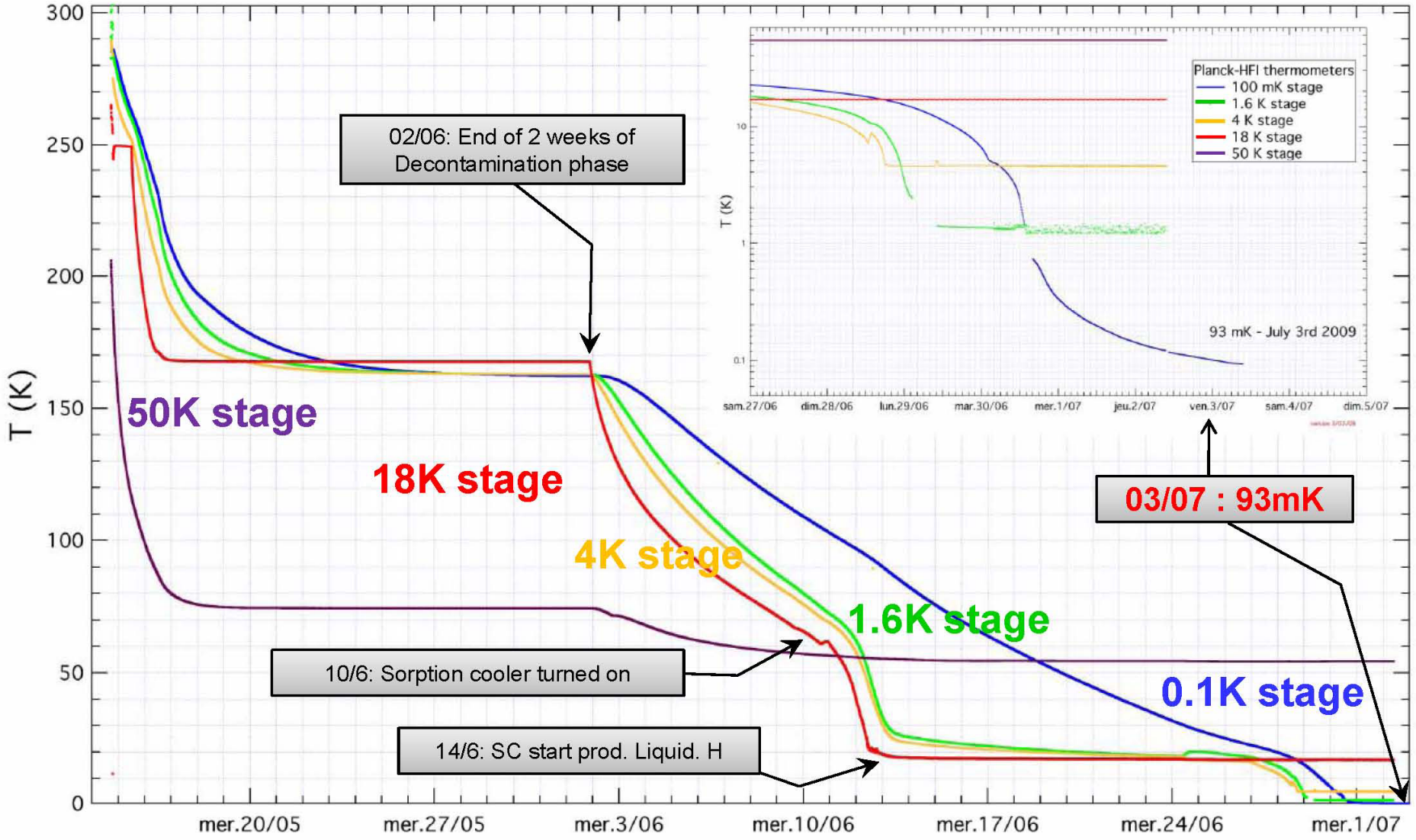
LFI:

- 2 × 11 Radiometer Chains
- Differentiated schema

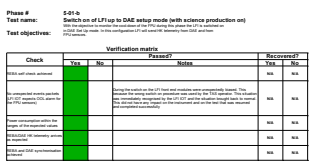


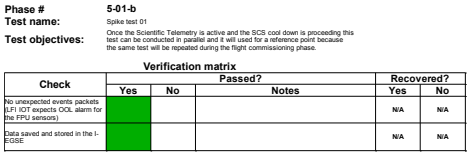


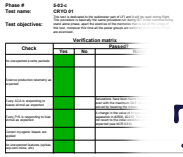
LFI Calibration: Planck Cooling



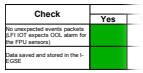
LFI Calibration: Planck Cooling



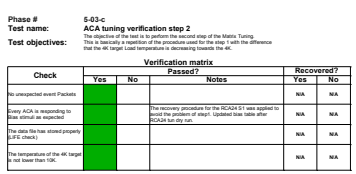


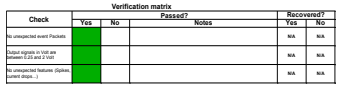


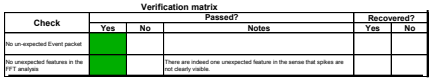
Too complex!!!
Thousands of TCs...



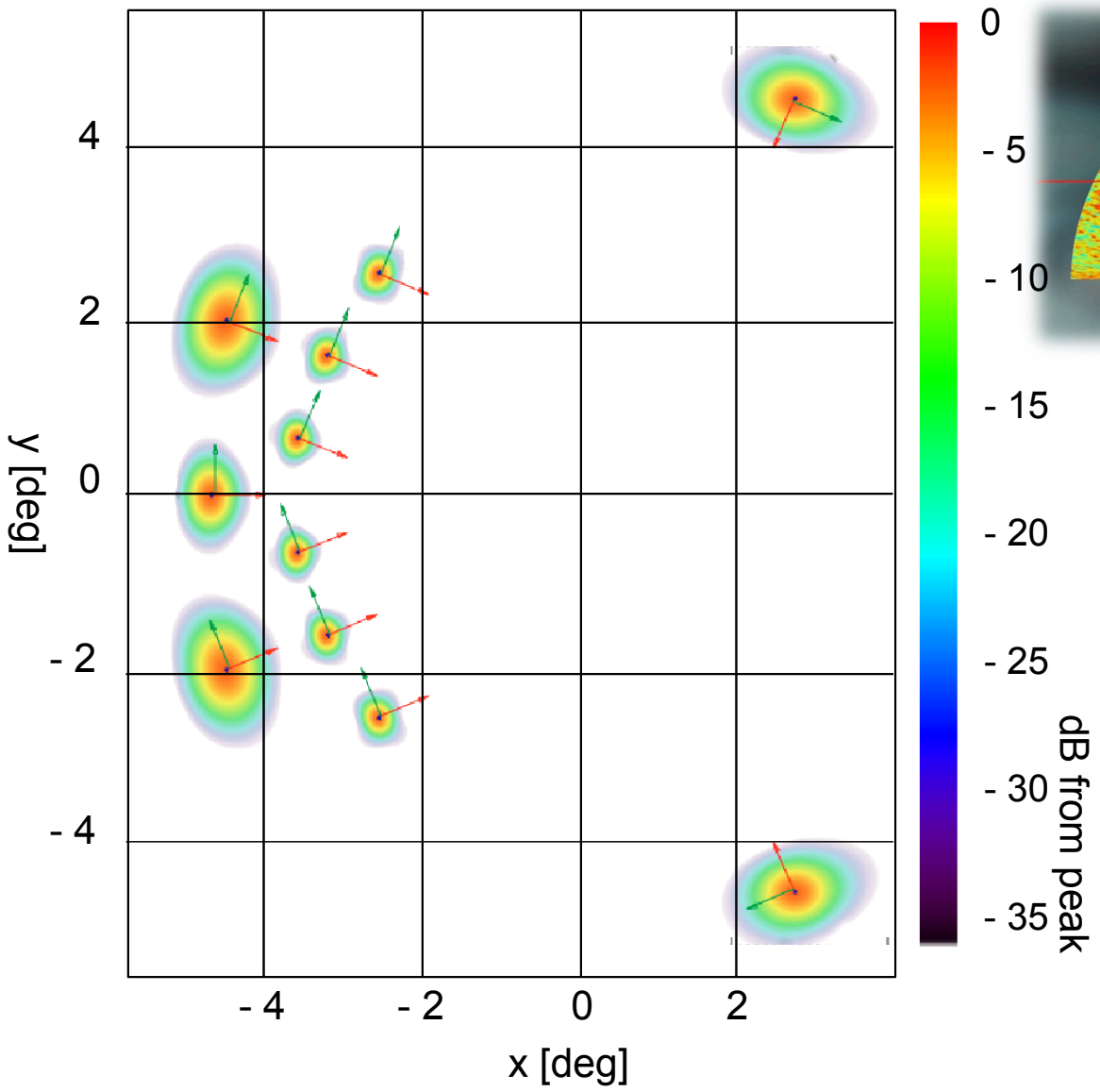
In-flight calibration and verification of the Planck-LFI instrument
A Gregorio et al 2013, JINST 8 T07001
DOI: 10.1088/1748-0221/8/07/T07001
97 pages!!!

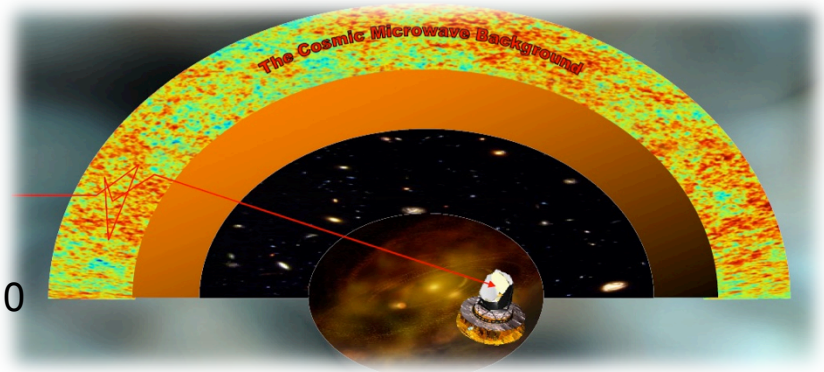






Planck's Eyes

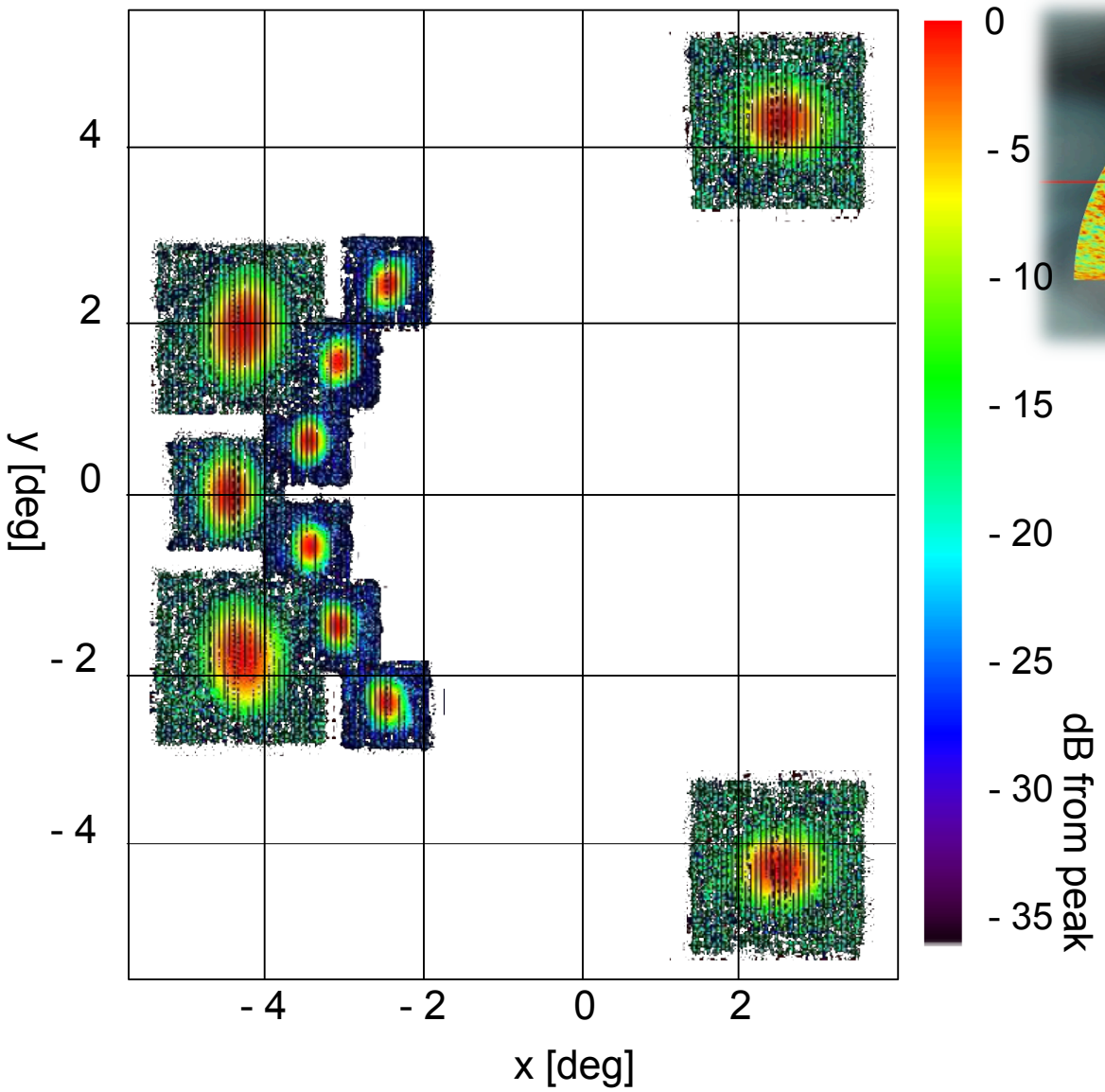


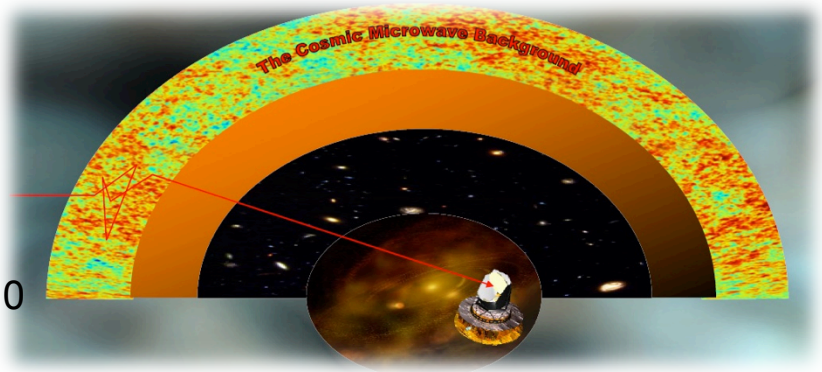


Simulations

Thank you Jupiter!

Planck's Eyes

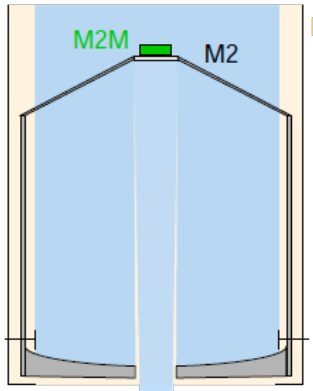




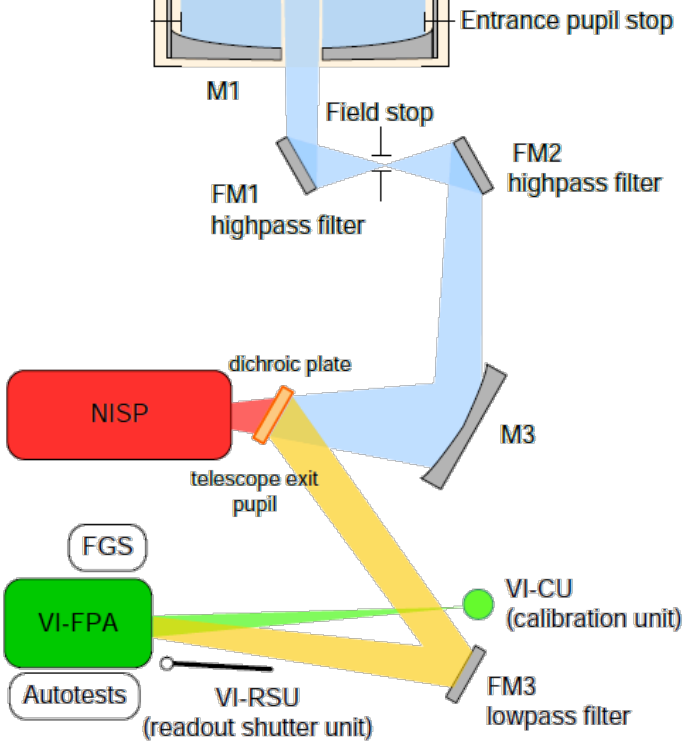
Flight measurements

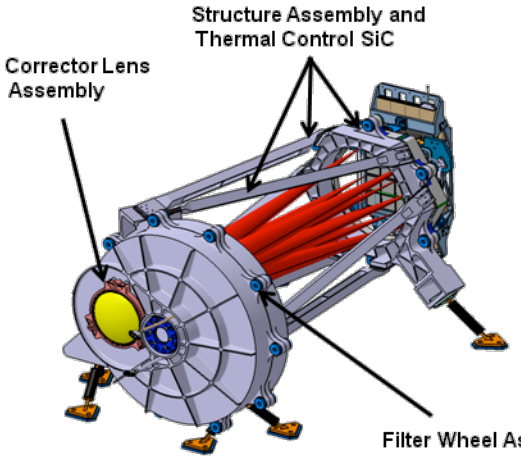
Thank you Jupiter!

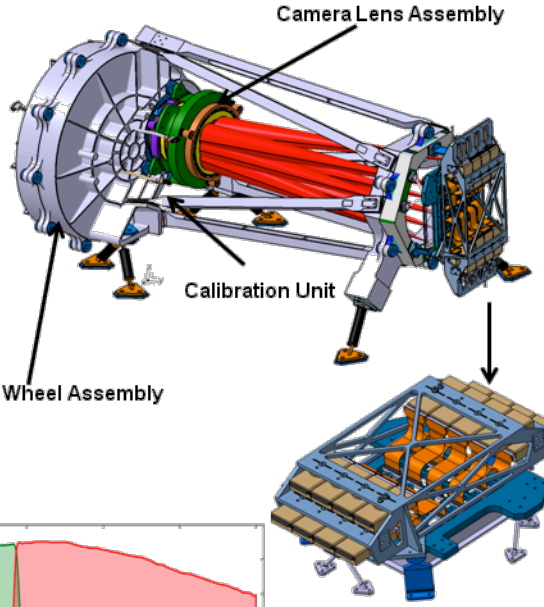
Euclid Satellite and Instruments

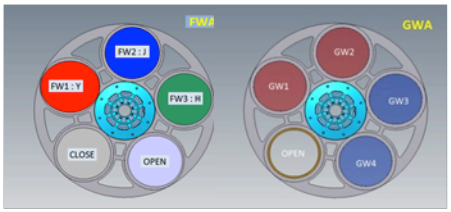


VIS Visible imager
NISP Near Infrared Spectrometer and Photometer

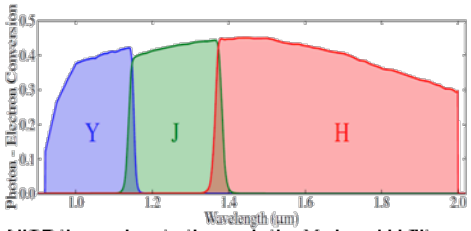






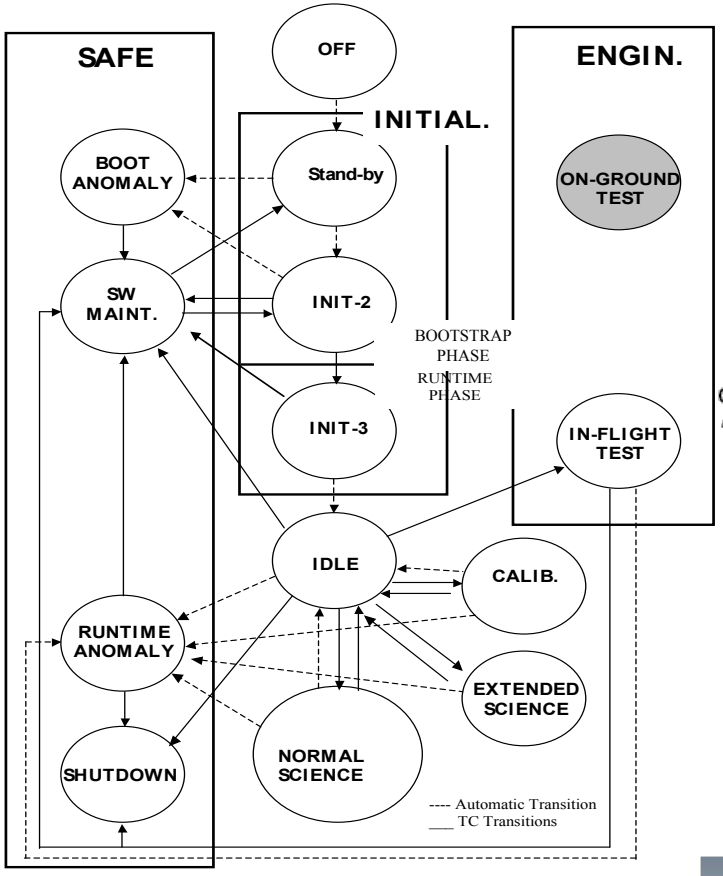


Filters and grisms positions in wheels



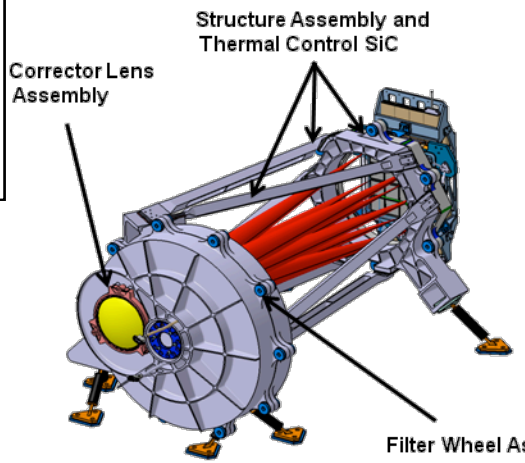
NISP throughputs through the Y, J and H filters

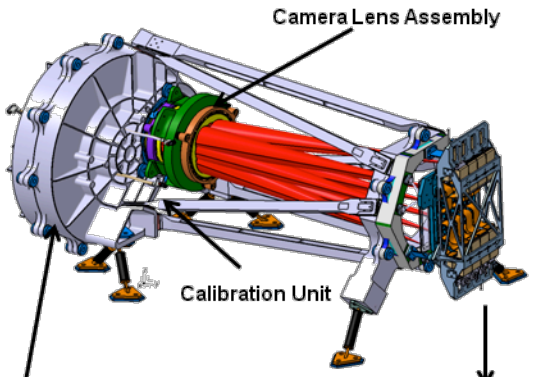
Euclid Satellite and Instruments

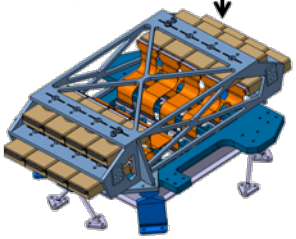


NISP:

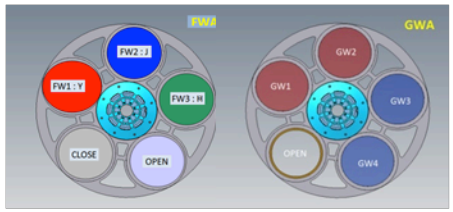
- Slitless spectrometer
- A three bands photometer



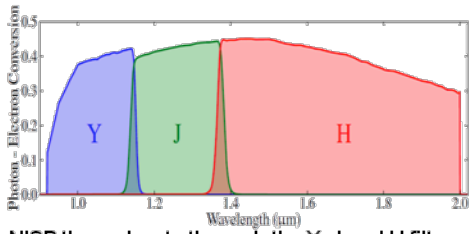




16 H2GR detectors



Filters and grisms positions in wheels



NISP throughputs through the Y, J and H filters

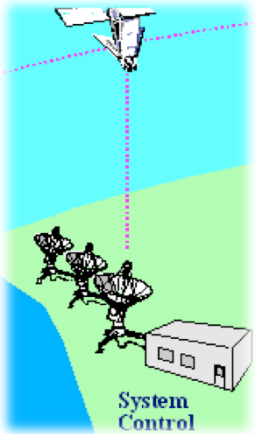
Euclid: NISP Routine Calibrations…

To monitor and update the instrument model, a number of calibration steps are required involving astronomical source observation and on-board calibration hardware

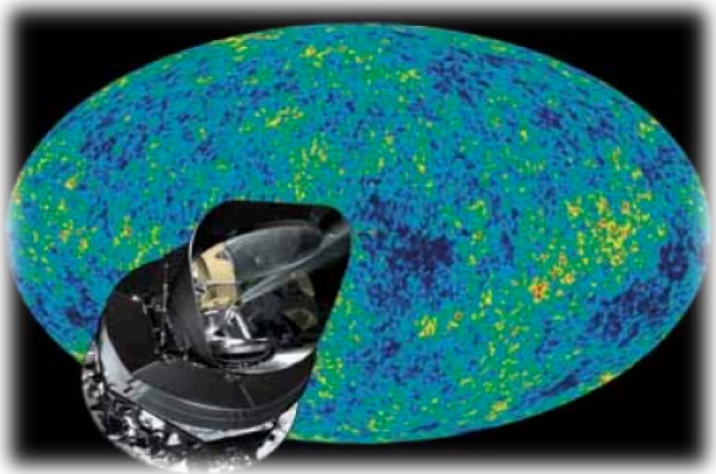
- Photometric Calibration (absolute, relative, cross-calibration…)
  - Calibration source, dark exposure, absolute sources…
- Spectroscopy Calibration (wavelength, background subtraction, spectro-photometric, deep field monitoring, flat field…)
  - Calibration source, absolute source, emission lines sources, open cluster, deep field…
- Detector Calibration (flat field, dark field, bias control, on/off check..)
  - Calibration source, long dark exposure, short dark exposure

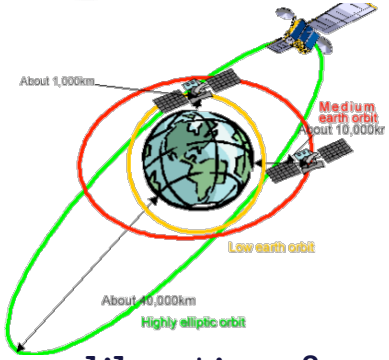
Possibly less complex calibration procedures but require a continuous support and planning by the IOT (Instrument Operation Team)

The Planck Mission

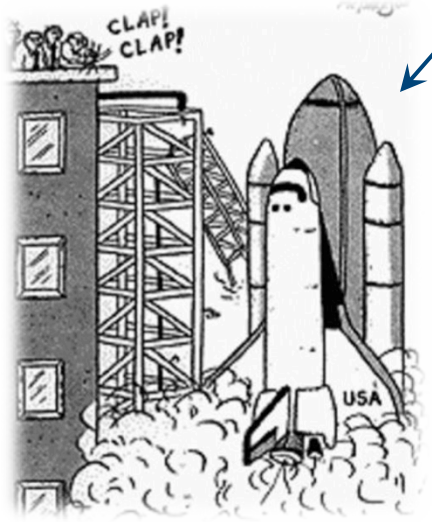


telecommunication





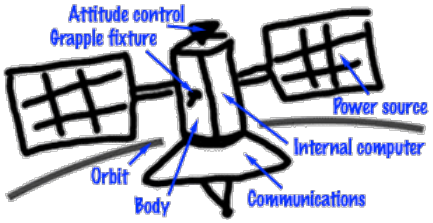
orbit, calibration &
performance verification
3 months



transport
14 May 2009

© Alex Bannykh * www.ClipartOf.com/73729

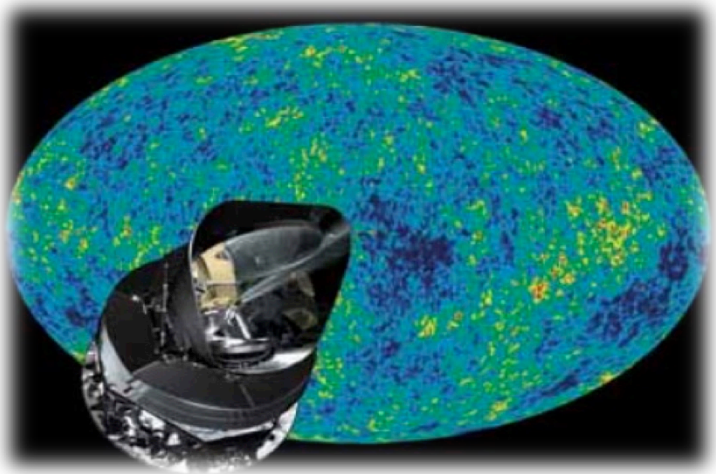
operations
up to October
2013...



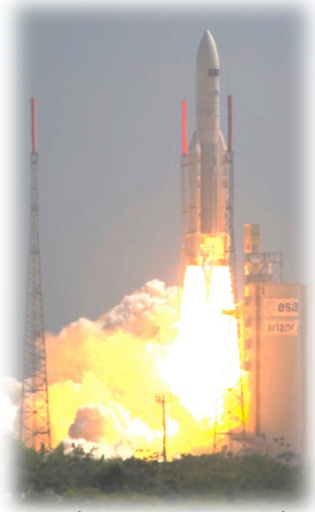
satellite

The Planck Mission

telecommunication

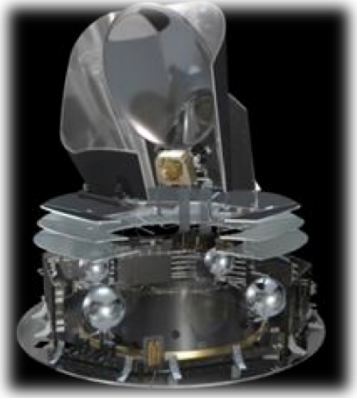


orbit, calibration & performance verification
3 months



transport
14 May 2009

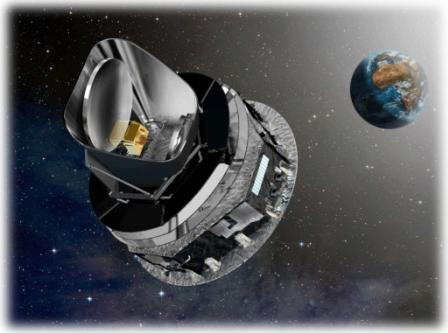
operations
up to October 2013...



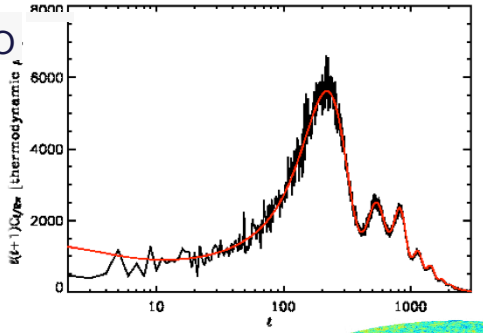
satellite

Planck In Flight

2-5 hrs/day



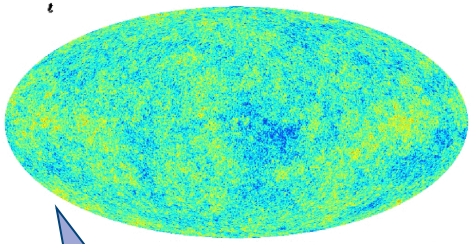
BAO



Ground Station
(Spain, Australia)

0110101
1110110

every 6
months



Mission Operation Center
(ESA/ESOC - Germany)

Data Processing
Centers

HFI Paris

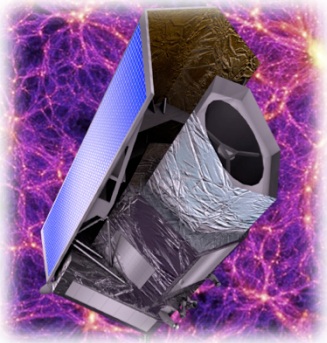
LFI Trieste

24 hrs/day

6-7 days/week

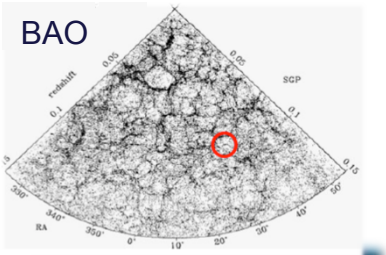
Euclid In Flight

2-5 hrs/day

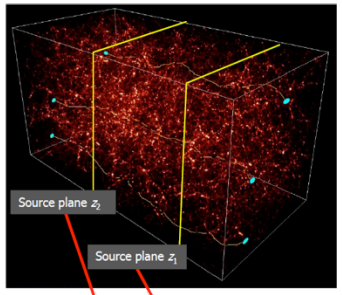


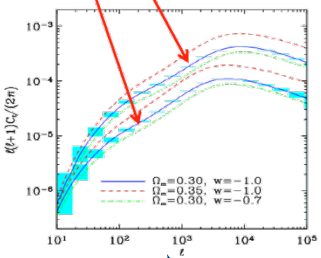
Ground Station
(Spain, Australia)

0110101
1110110



1.5 billion sources with shapes, 10 slices





Mission Operation Center
(ESA/ESOC - Germany)

Science Operation Center
(ESA/ESAC – Spain)

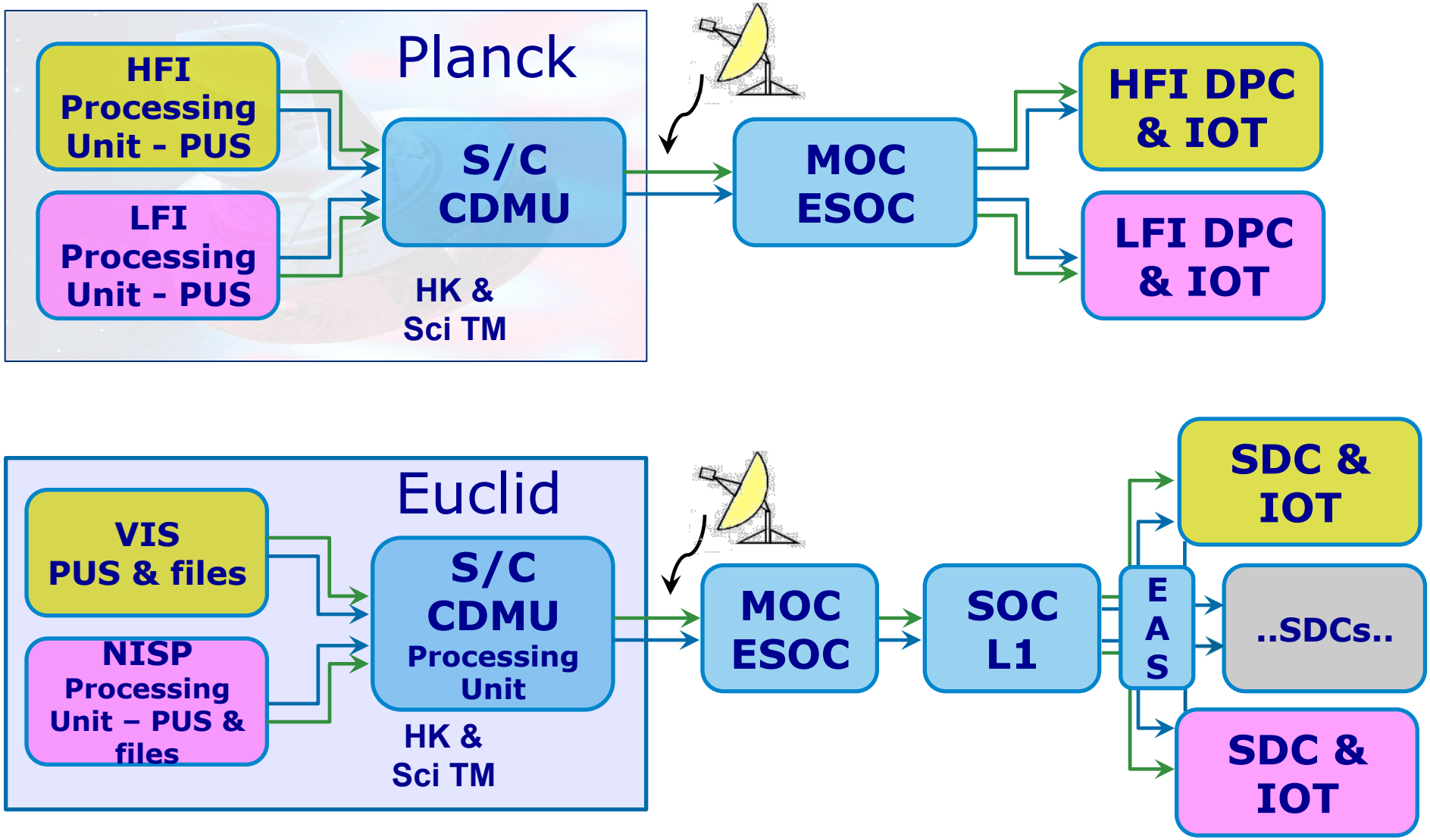
EAS
(archive)

SDCs
IOTs

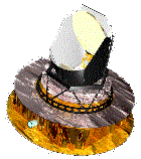
24 hrs/day

6-7 days/week

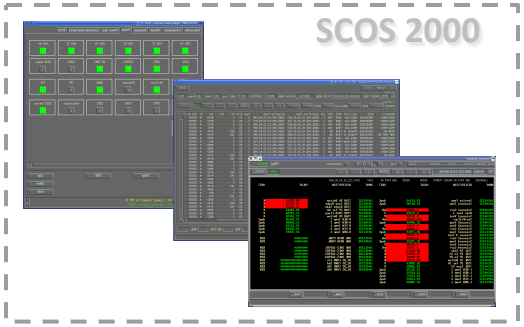
Euclid VS Planck: data flow

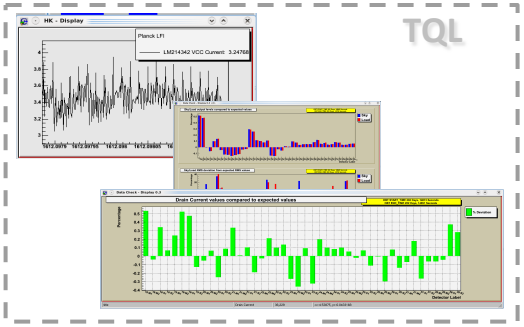


MOC to Planck LFI



Off-line Instrument Verification and Tuning: LIFE Developed by the instrument team





Deep Space Antenna (New Norcia, Cebreros)

TM

ESOC MOC

NCTRS

Operational LAN

Relay LAN

MCS

Packetizer

Archive

FDS

RTSI

DDS

FTS

TM

TM/AUX data

Requests

Data

RT SCI/HK

Single Request

Requests

Dump

SCI/HK

Firewall

Firewall

LFI Instument Workstation

RTSI

LFI DPC

FD

APPL, AHF

PPL

PSO

DQR, WHR

L1 DB

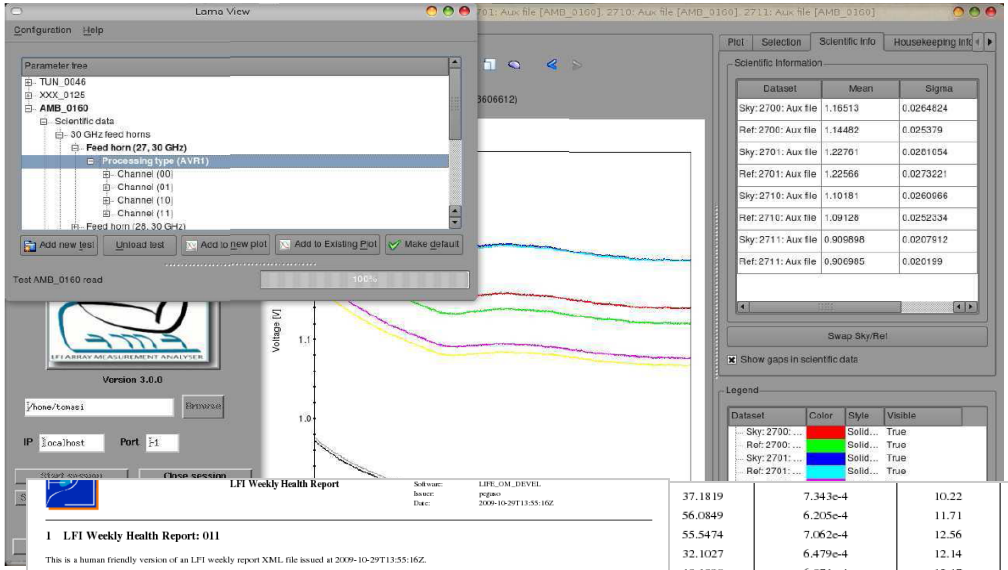
HFI DPC

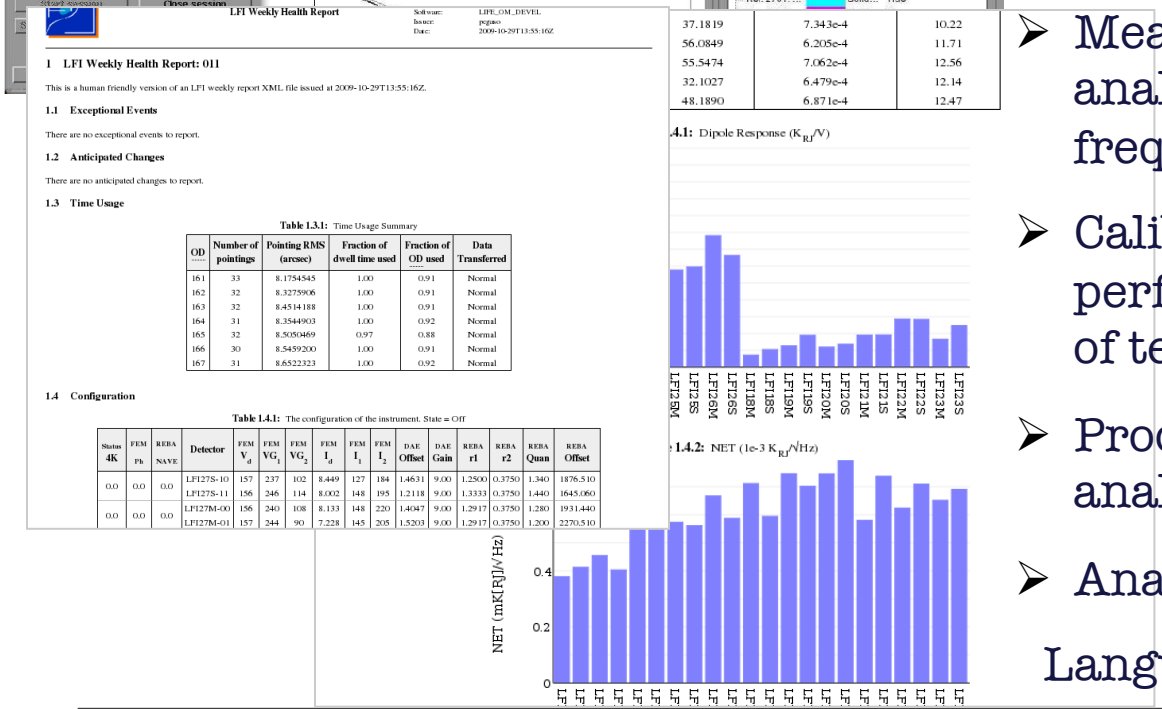
Timeline exchange MAPs Calibration Info SIAM

Instrument Performance

Spectrum analysis

LIFE - LFI Integrated perFormance Evaluator





LFI off-line verification and tuning, used to test "*her*" at different integration level: 1st release for instrument level tests, evolved to integration tests and operations

- Check proper operation of critical parts of the instrument
- Measure quantities needed for data analysis (white noise level, knee frequency, ...)
- Calibrate the instrument and perform susceptibility tests (impact of temperature fluctuations)
- Produce daily quality reports and analyze anomalies in the data
- Analyse systematic effects

Languages and libraries: IDL and C++

Lessons Learned

- Instrument - from ILT to in flight calibration
  - Design and build the instruments so that it can be tested and calibrated in a “reasonable” way!
    - A complex instrument is not necessarily the best instrument
  - Define successful criteria (verification matrices)
  - Freeze calibration procedure (*male/mad* scientists…)
  - On-board software: smooth transition and keep knowledge
  - User Manual: keep everything in, updated (especially contingencies)
- Operations
  - Define EGSE Standards, I/F, environments: Scos, Database/MIB tables, Raw TM, TC parameters, MOIS/CUS, RTA, QLA, IDT/IOT Level 1 sw, …
  - SDC/SOC/IOT: define interfaces, roles and tasks, de-couple works, deliverables, schedule, who does what and when…
  - Smooth transition from IDTs to IOTs
  - Quasi-automatic tools to plan and check instrument operations and the survey, to daily check data quality and flag data (Operation Plan)

Conclusions: Euclid VS Planck

- Main Difference
  - Planck – Cryo & Surveys vs Euclid – *"Survey"* (20˙000 deg^2)
  - Planck – PI mission vs Euclid – ESA lead
  - Planck – 2 consortia vs Euclid – 1 consortium
  - Planck – 2 DPCs running Level 1 pipelines (LFI, HFI)
  - Euclid – only the SOC running the Level 1 pipeline
  - Euclid advantage: one industry (prime contractor) for both instrument electronics

Harmonization and smooth transitions can be the key-words

Discussion with industry and instrument teams …

- Avoid heavy bureaucracy, flexibility is anyway required
- Plan (wo)man-power!!!

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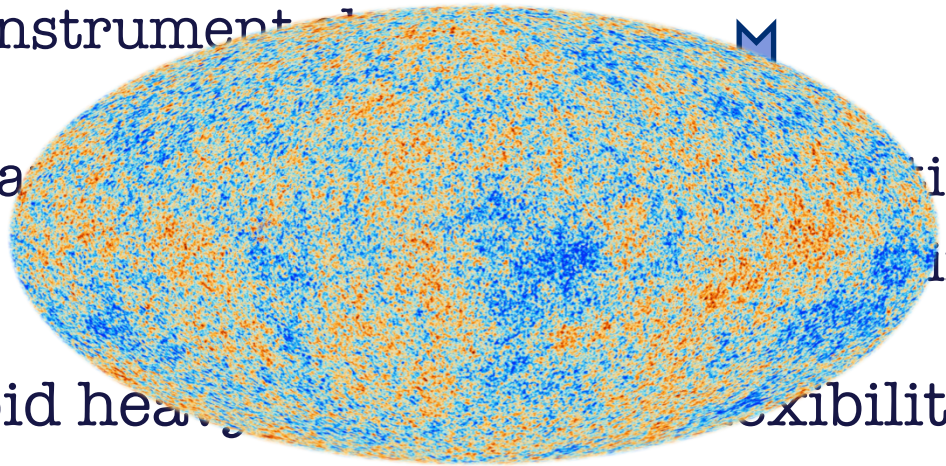
Thank you!
(and thank MOC, Project, PSO, HFI)



Planck Collaboration