Mission and Spacecraft Design Concepts for the Euclid Satellite

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Contents

Design Drivers

Multiple DE probes

- ➔ One telescope feeding 3 instruments

Survey speed

- ➔ Large Field of View (0.5 deg^2) / Optimised sky survey strategy / Fast attitude slews

Survey depth and signal to noise ratios

- ➔ Well baffled design / Cold telescope for low background / On board data processing for noise limitation / Cryo optics and detectors

Size reconstruction and stability of the Point Spread Function

- ➔ High image quality / Large data rates / Payload in the AOCS loop
- ➔ Permanently shaded, temperature-controlled telescope (thermoelastic stability)

M-mission cost ceiling and target launch date

- ➔ Passive cooling ($\rightarrow$ L2) / Telescope aperture limited to 1.2 m / Limited number of NIR detectors / Any new technology demonstrated by test by 2011.

Satellite configuration rationale

Sunshield

- Stable, controlled thermal environment with little variation between hot and cold cases

Baffle

- Straylight suppression (pending future analysis)
- Contamination protection (baffle cover, not shown in drawings)

Pre-integrated instruments

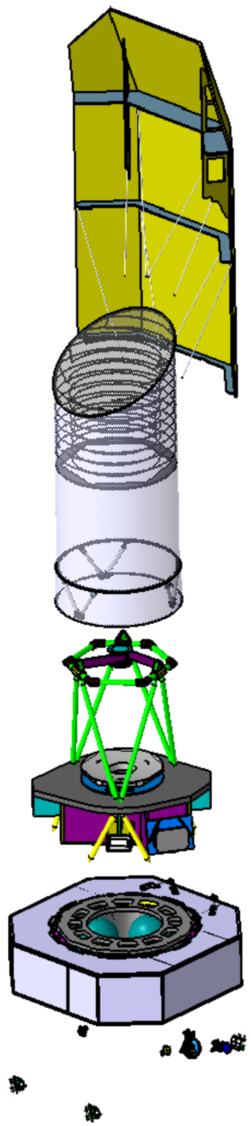
- Parallel developments to relax schedule constraints

PLM mechanical-thermal concept

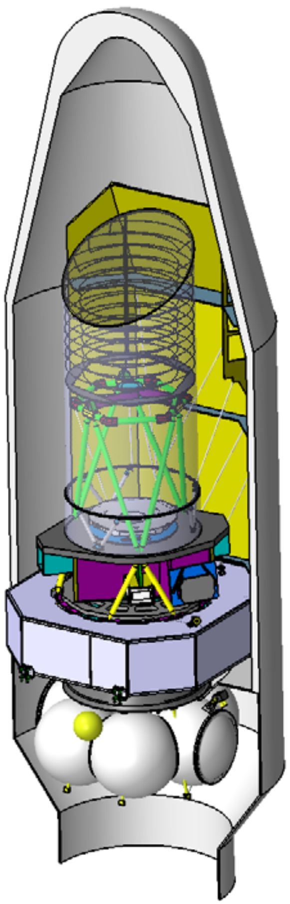
- Double truss for low deformation, ease of AIT
- Separate, controlled thermal environments

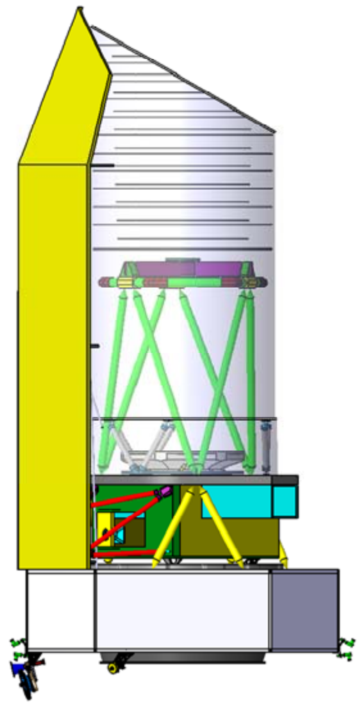
Herschel-like SVM

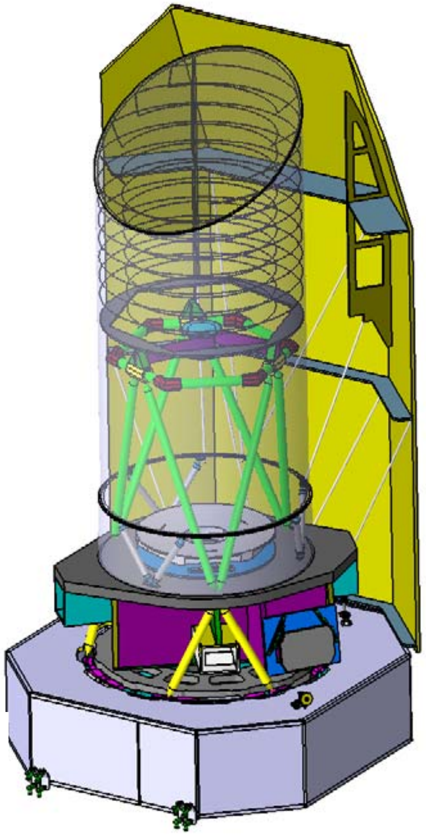
- Design and development heritage
- Wide room for warm payload electronics

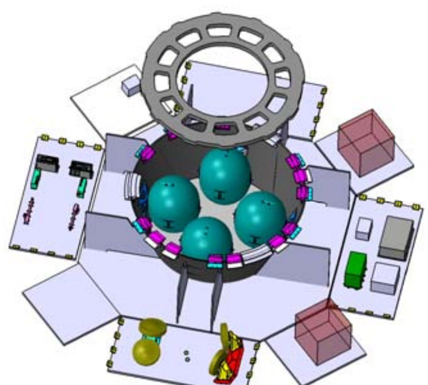


System configuration









Design trade-offs overview

Experiment policy trades (ESA)

- Step-and-stare vs. continuous scan
- Instrument-level vs. satellite-level dithering
- Multi-slit vs. slitless spectroscopy

Telescope accommodation trades

- Straylight & stray heat protection: Baffle-and-sunshield solution preferred
- Low vs. ambient telescope temperature: 240 K, driven by NIR background

Experiment accommodation trades

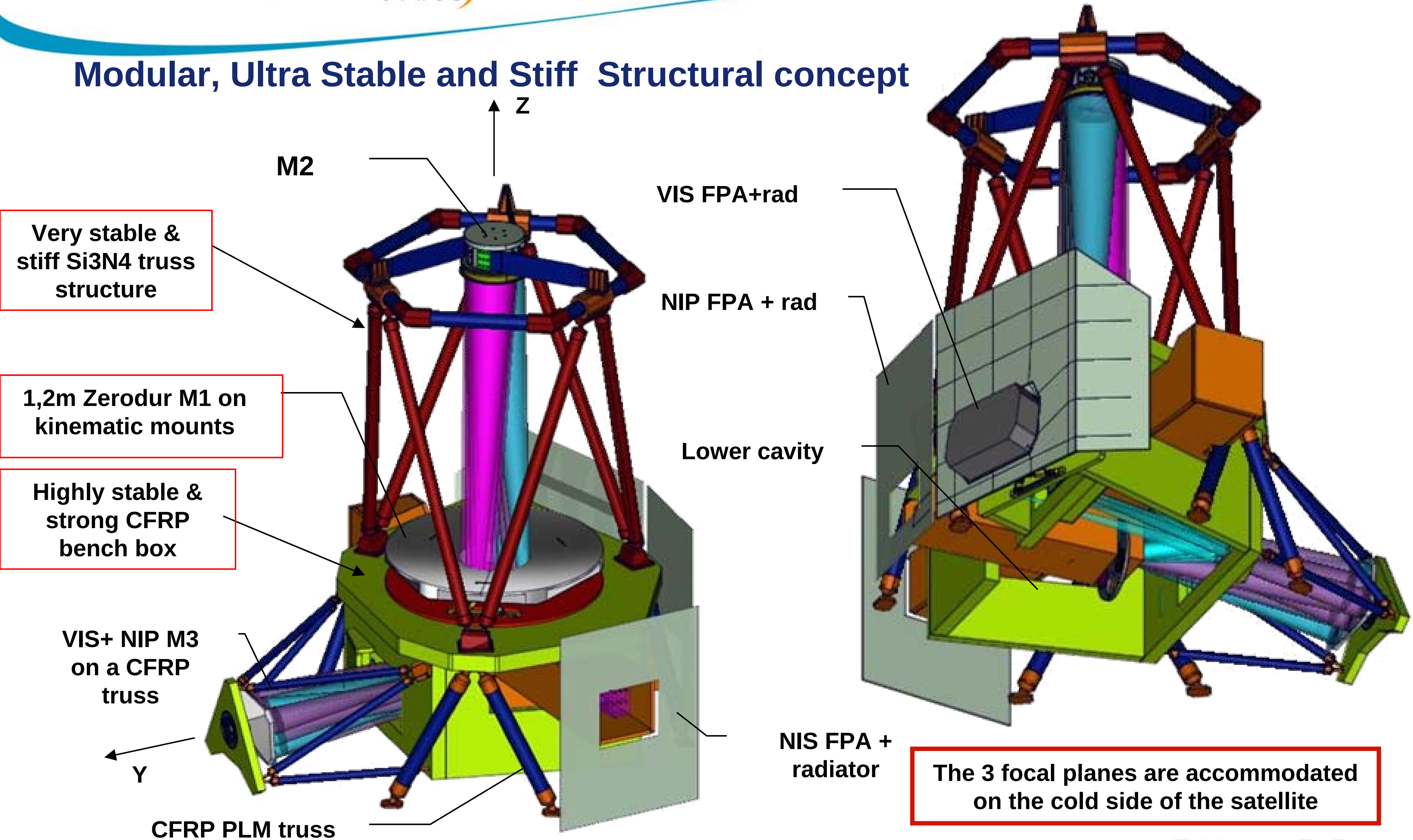
- Highly modular accommodation: each instrument can be specified, developed, tested and integrated as a self standing unit.
- Decentralized instrument data handing architecture: instrument-own ICU (control and drive) / DPU (data processing and compression)

Attitude measurement and control trades

- Fine Guidance Sensor co-located with VIS focal plane and sharing VIS optics
- GAIA type micro thrusters vs. magnetic-bearing reaction wheels : driven by mass budget

PLM Design

Modular, Ultra Stable and Stiff Structural concept

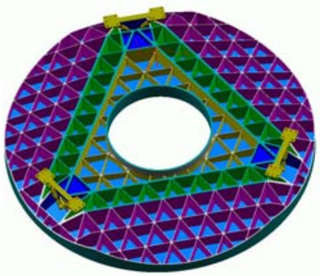


The 3 focal planes are accommodated on the cold side of the satellite

Materials selection

- Mirrors
  - M1 specification
    - Residual WFE (PTF)(1g-0g ⊕ polishing ⊕ 300K- op T[ure]) <20nm RMS
    - Focus stab :R= 4.6m ; ΔR<10µm (2390s)

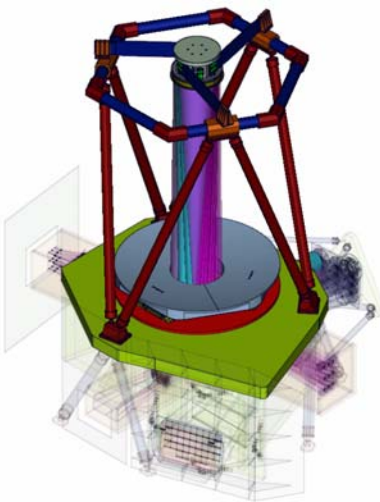
      ➔ Mirrors thermal stability needs



	300 K			170K	
	CTE	thermal stability (K/40')	Tgradient stab (K/40'	thermal stability (K/40')	Tgradient stab (K/40'
zerodur	<2 E-8	109	4,2	18	0,71
sic	2,20E-06	1	0,04	2	0,1

➔ Performances already demonstrated on Zerodur equivalent mirror

- M1-M2 structure thermal stability needs 3 µm

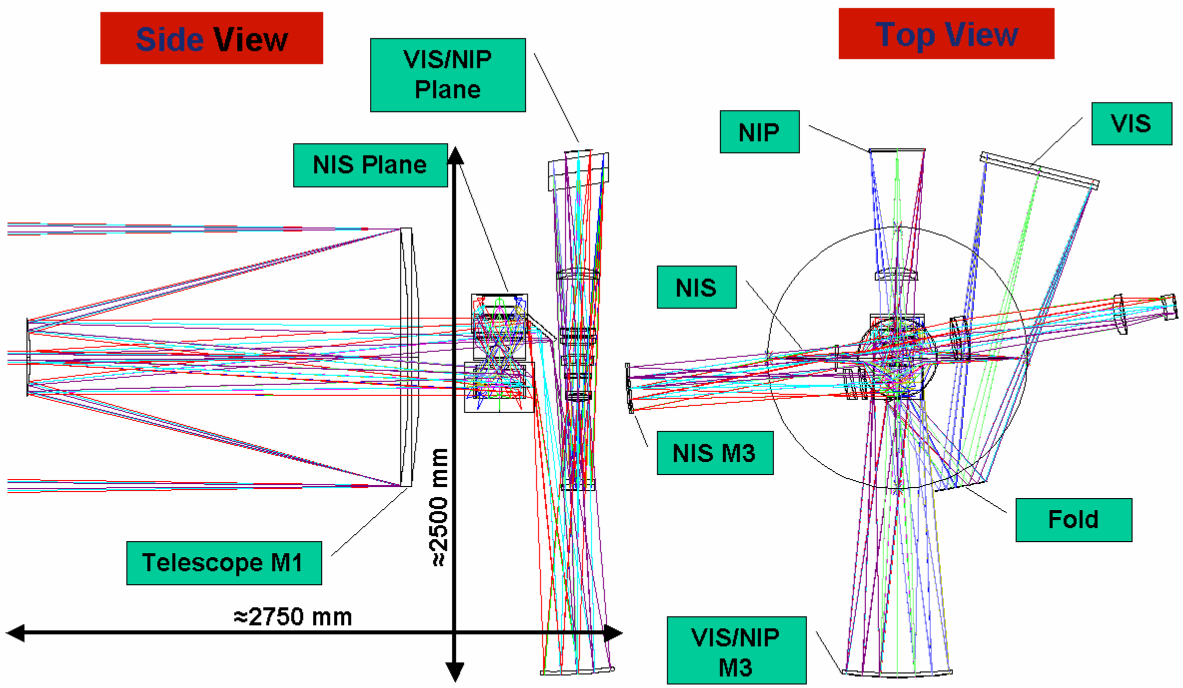


	300K			170 K			200 K
	CFRP	Sic	Si3N3	CFRP	Sic	Si3N4	Si3N4
CTE µm/m°C	0,6	2,2	1	0,5	0,9	0,1	0,3
temperature stability need M1-M2 structure °C	2,7	0,9	2	3,3	1,8	16	6

Over a large temperature range (ambient to 170 K), Zerodur mirrors and Si3N4 structural parts provide the highest M1M2 stability, and the most affordable demand on thermal control.

Optical design

The optical design was received from ESA and adapted by the TAS team to improve its accommodability



Rationale

- improve accommodation of elements
- reduce volume (height) and mass of payload and S/C structure
- facilitate assembly and integration of instruments (avoid oblique mechanical I/F)

Solutions

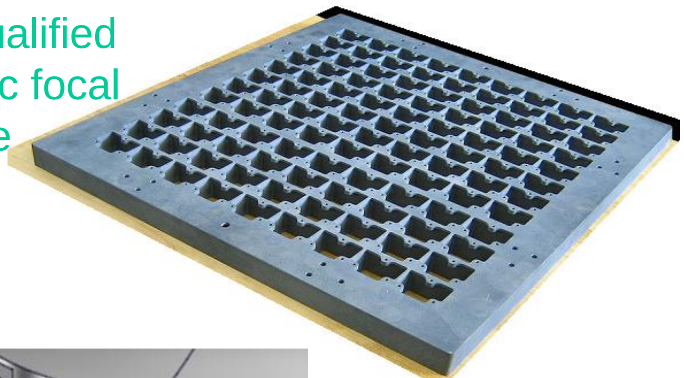
- increased distance between M1 and NIS folding mirror (accommodation issue);
- VIS and NIP put on the same XY plane to reduce satellite height (volume, mass issue);
- all FPAs placed on the same side to make thermal design feasible (thermal design aspects);
- NIS rotated in the XY plane by 90° to remove conflict with VIS/NIP components and rays;
- dichroic tilted to improve VIS accommodation.

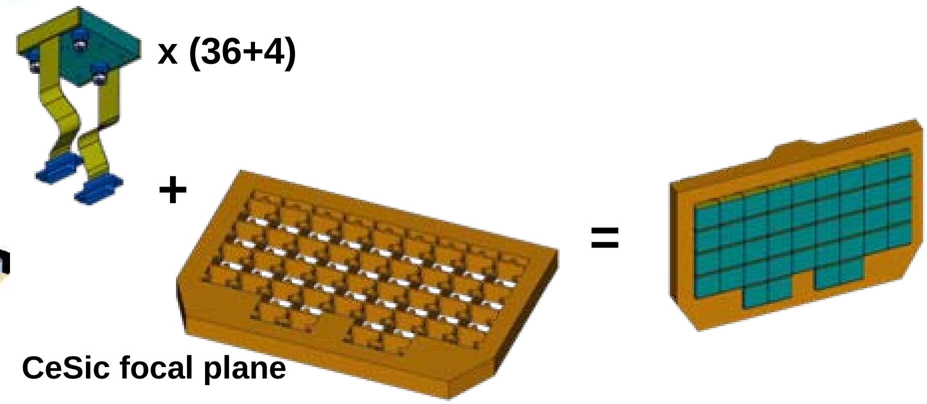
The new design is completely compliant with the requirements

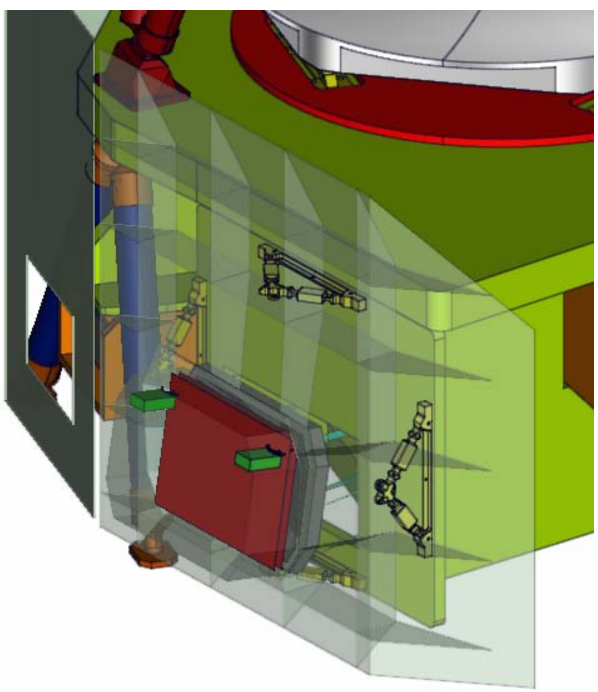
VIS Design

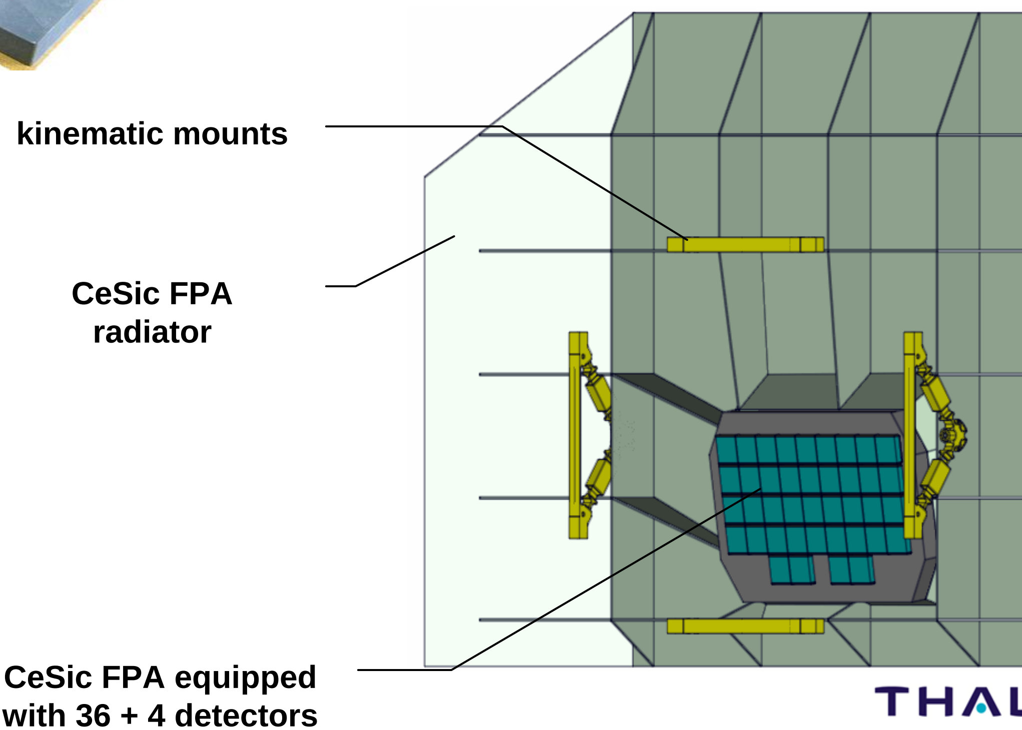
Equipped focal plane preliminary design

Already qualified large CeSic focal plane

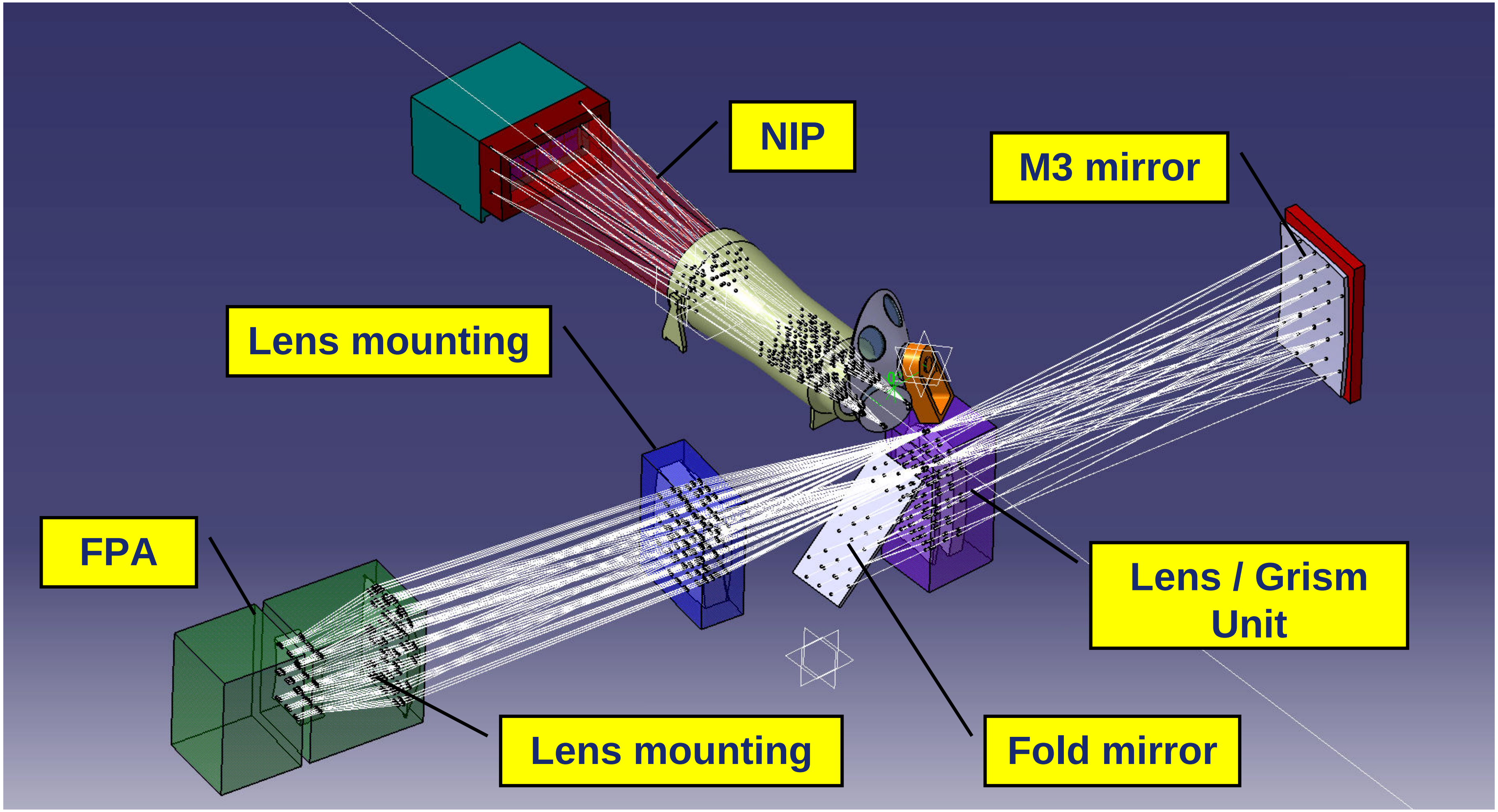






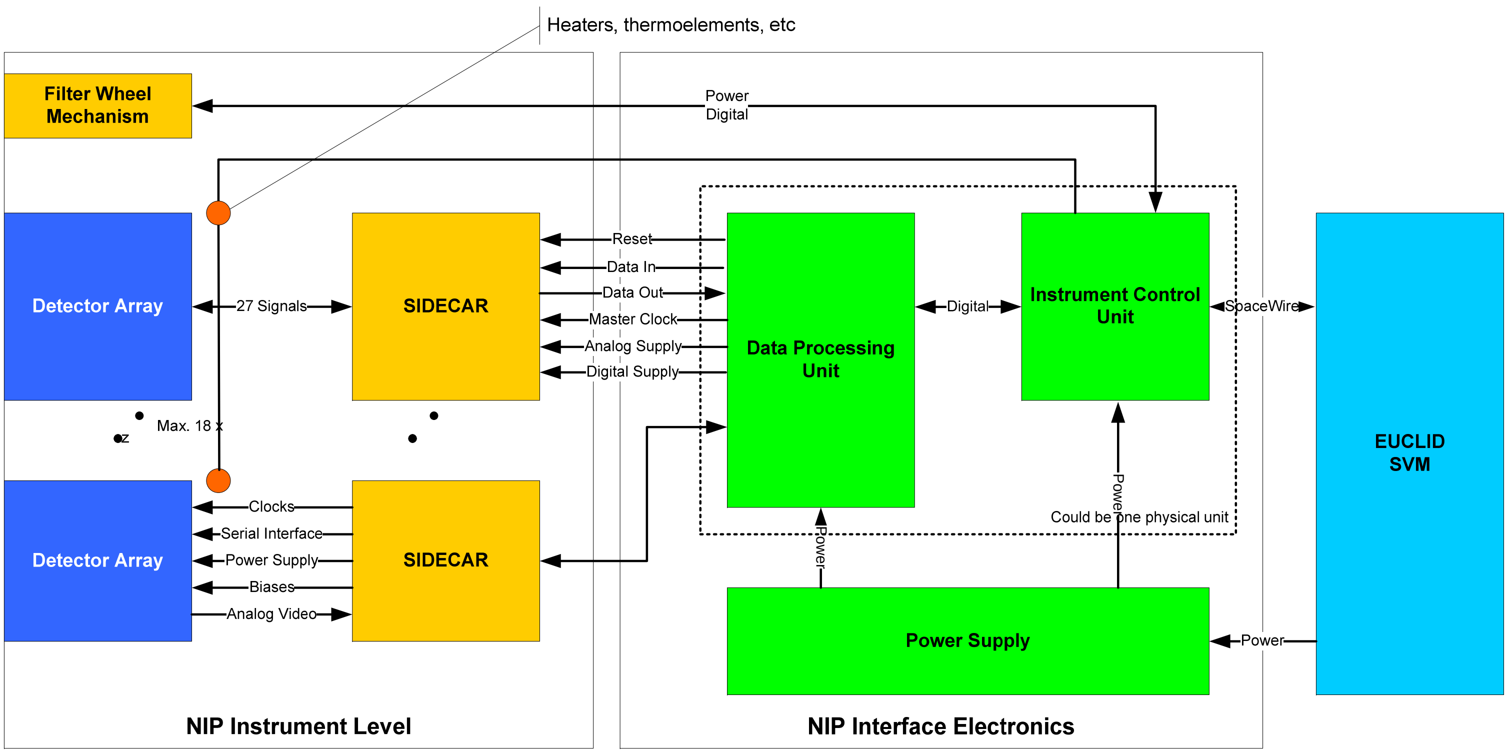


THALES


NIP
M3 mirror
Lens mounting
FPA
Lens / Grism Unit
Lens mounting
Fold mirror

Instrument Electrical Architecture

- ❑ Large on board data processing load
- ❑ Independent instruments from different consortia
- ❑ Individual development and test requirements
- ➔ Decentralized architecture



NIP electrical block diagram

NIR Photometric Model

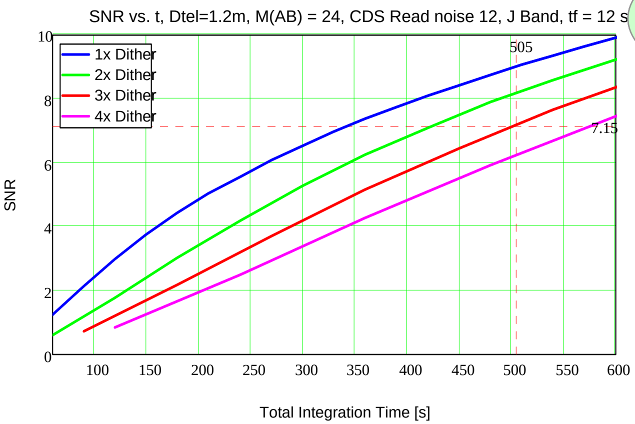
Detailed Photometric Model
- Detector sampling,
- NIR Instrument BG
- Dithering

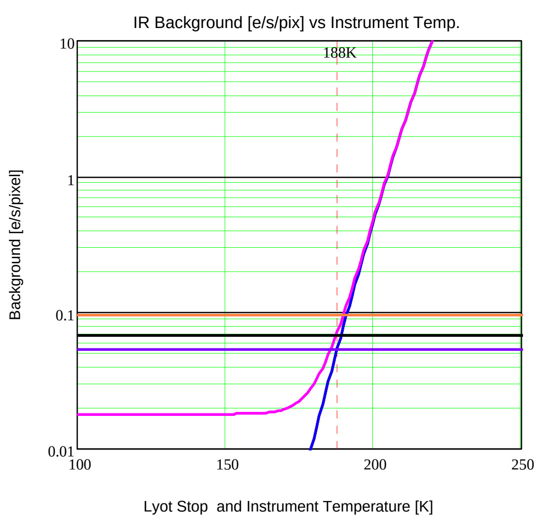
Observation Time
- WES
- Deep Survey

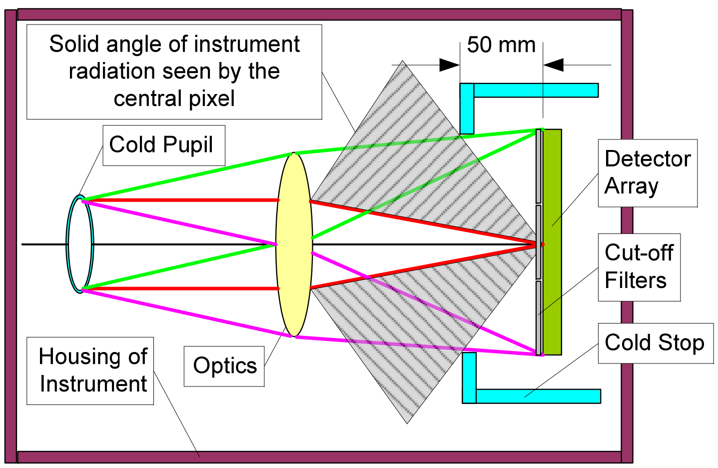
Data Handling
- Up-the-ramp sampling
- Data budget (339 MFLOP)
- Data processing

Operating Temp
- Telescope (240 K)
- Instrument (188 K)
- Components (188 K)

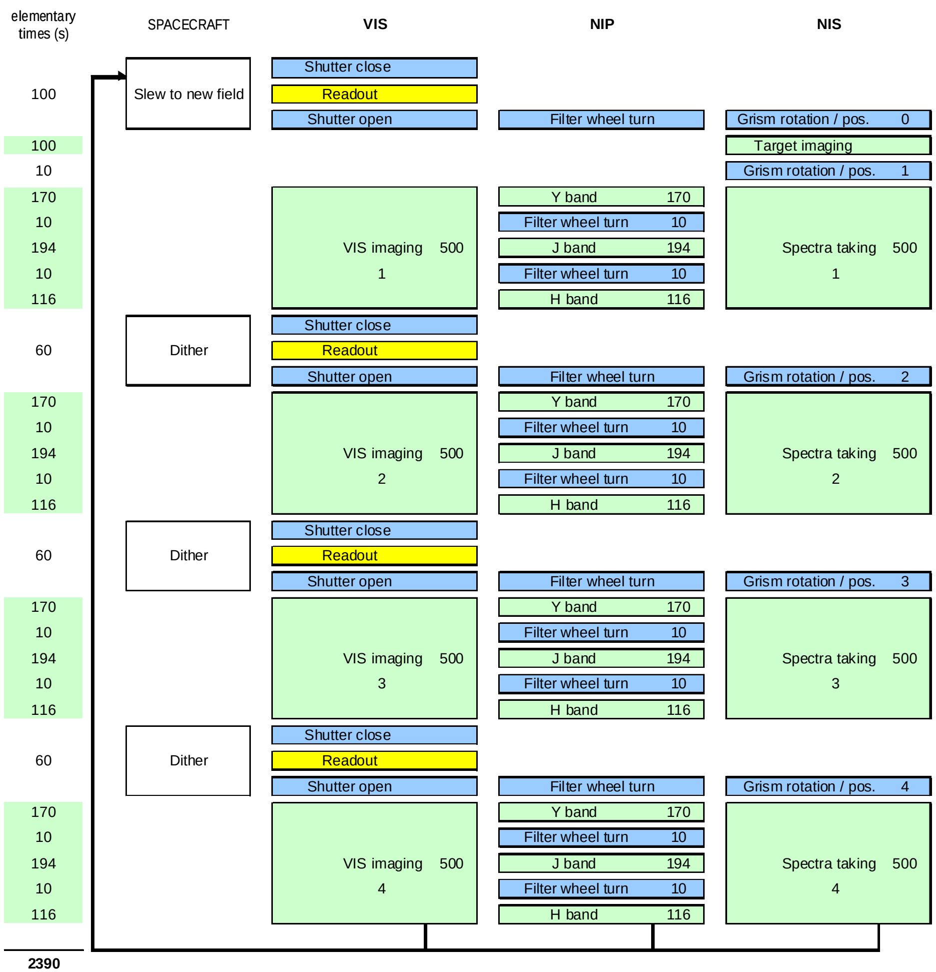
Instrument Design
- Lyot-stop
- Cut-off filter
- Baffle design







Observation procedure



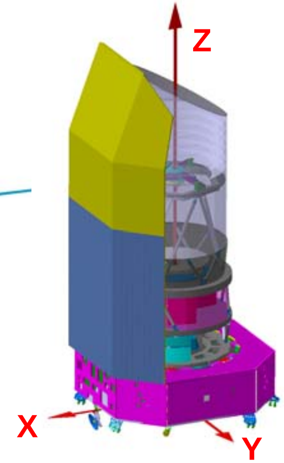
Dithering by s/c, 4 dithers, 3 NIP bands

- Filter wheel turn does not disturb observations → requirement
- Shutter operation incompatible with continued observations
- 4 x 500 s + short (100s) NIS imaging phase

Total cycle of about 2400s

- 36 x 0.48 deg² fields/day

Sky survey strategy

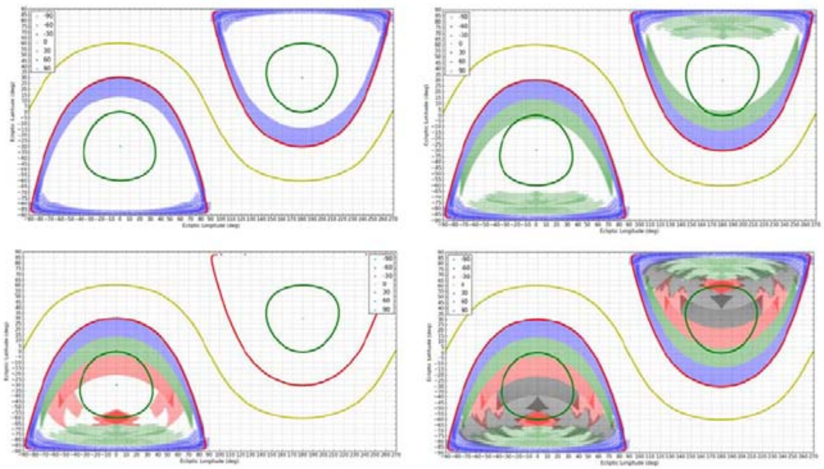


Basic Strategy

- Scan strip by rotating S/C about X-axis (nominally the sun line)
- After the S/C has moved 1º on its orbit around the Sun, rotate S/C about its Z-axis to restore SAA, and start new strip
- Strips lie on great circles perpendicular to the S/C-Sun direction; movement of the S/C around the Sun changes the longitude of the great circle scanned

Modified strategy

- Flexible time: time when basic strategy would produce redundant observations (ecliptic poles & equinoxes)
- In flexible time, use 30-deg SAA d.o.f. to cover blank spots
- Strategy succeeds to cover extragalactic caps in 4 yr
- However, longer field dwell time has reduced pass redundancy at high ecliptic latitudes (important for Deep Survey)



		Ecliptic Longitude			
Flexi Time		Year 1	Year 2	Year 3	Year 4
Spring	Start	84º	73º	55º	40º
	End	96º	107º	125º	140º
Autumn	Start	-96º	-107º	-125º	-140º
	End	-84º	-73º	-55º	-40º