

Laboratoire d'Astrophysique de Marseille

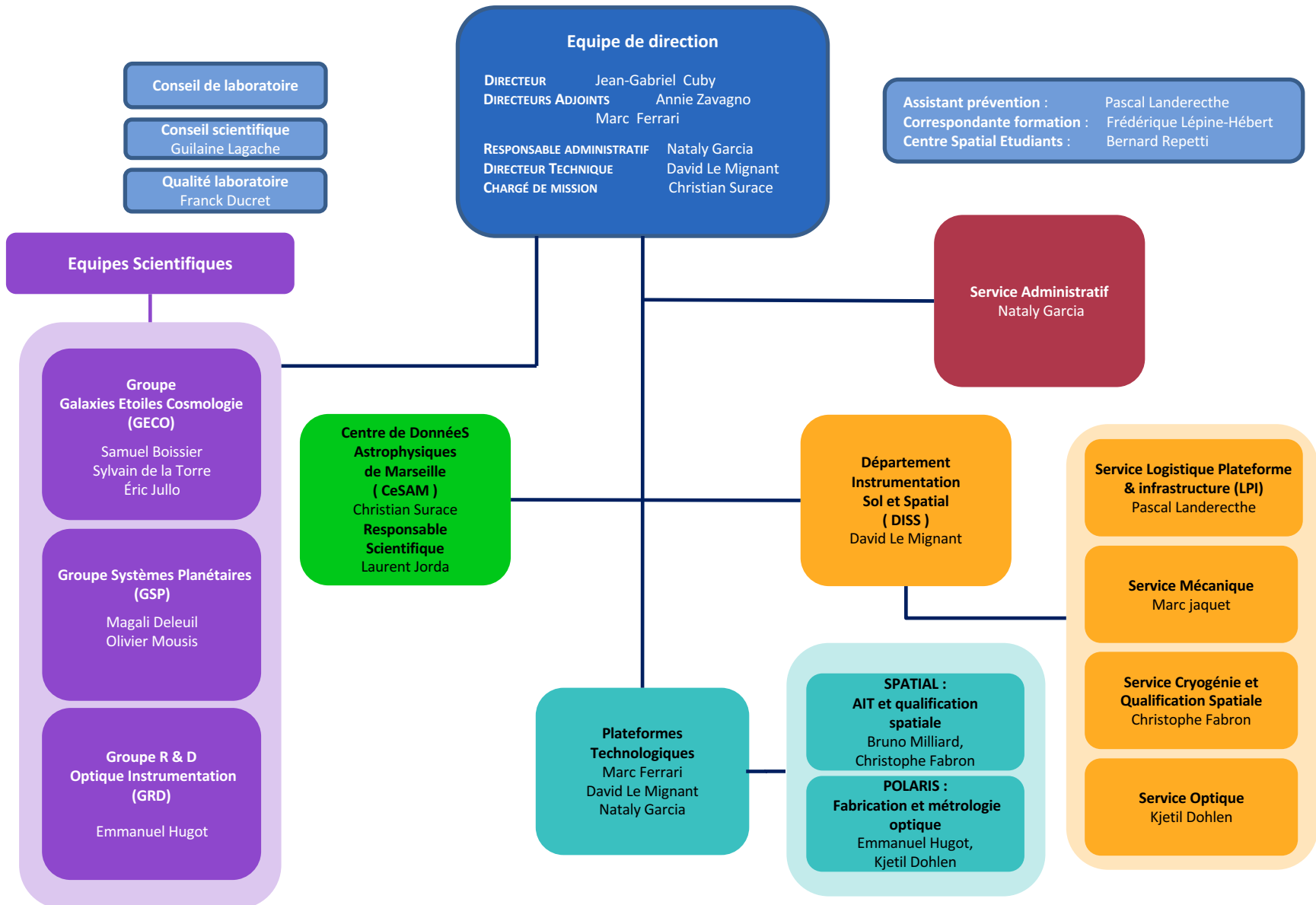
<https://www.lam.fr>

D. Le Mignant
Directeur Technique



Le LAM en une planche

- UMR Aix-Marseille Université / CNRS-INSU + Tutelle CNES au 1^{er} Janvier 2018
- Effectif : ~ 200 personnes
- 3 équipes scientifiques, 55 chercheurs, 15 postdoctorants, 30 doctorants
 - Galaxies, étoiles, Cosmologie (GECO) ~65 scientifiques
 - Systèmes planétaires (GSP) ~ 15 scientifiques
 - Groupe R&D optique instrumentation ~ 20 scientifiques
- Centre de données astrophysiques: CeSAM (22 I&T, dont ~10 CDDs)
- Département Instrumentation sol et Spatial (DISS):
 - optique, mécanique, cryogénie et qualification spatiale, logistique : (55 I&T dont ~15 CDDs)
- De nombreux projets internationaux avec partenaires prestigieux
 - CNES, ESA, ESO, Europe, US (Caltech, Princeton, JHU, LBNL, STScI, etc.), Japon, Chine, etc.
- Des plateformes technologiques sol et spatial
 - 17 salles propres ISO 5 à ISO 8 sur une superficie totale de 1000 m² (Grand hall 425 m²)
 - Moyens d'essais en environnement spatial, dont ERIOS 45 m³
 - Moyens de polissage (jusqu'à 2.5m), moyens de métrologie (tunnel 25 m, 2 tours optiques)
- Une R&D active, transverse aux équipes scientifiques et services techniques
 - 10 Brevets depuis 2006 + 3 licences
- Classé ZRR (4 zones)



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LABORATOIRE D'ASTROPHYSIQUE
DE MARSEILLE



DÉPARTEMENT INSTRUMENTATION (DISS)

Optical Engineering Department

→ **Architecture optique et projet (management, système)**

Kacem El Hadi (IGR)
Robert Grange (IR)
Eric Prieto (IR)
Sébastien Vives (IR)

→ **Conception et tolérancement optiques**

Sandrine Pascal (IE)

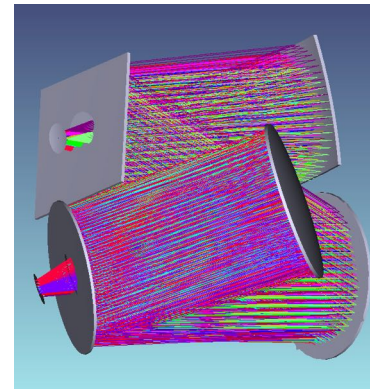
→ **R&D, Instrumentation, AIT/AIV**

Thibault Behaghel (CDD-IR)
Mohamed Belhadi (CDD-AI)
Amandine Caillat (IE)
Johan Floriot (IGR)
Fabrice Madec (IE)
Michel Marcos (ASI)

→ **Etudiant**

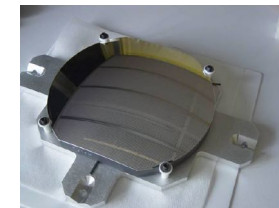
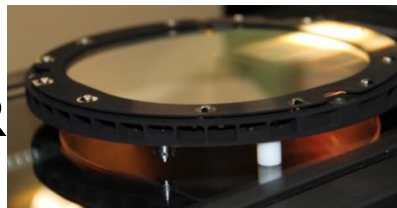
Cyril Jomni (Doctorant)
Raphaël Pourcelot (Apprenti)

- ## Mission
- UV to NIR optical design
 - Component and optical system design and analysis
 - spectrograph
 - Optical system AIT/V
 - Optical fabrication
 - Optical system metrology



Projects / R&D

- PM & system eng.
- Grating and grisms
- AIT



Major contributor to POLAR manpower

- Stress polishing techniques
- Optical surface and system metrology



Mechanical Engineering Department

→ **Architecture et dimensionnement mécanique
Projet (management, système)**

Anne Bonnefoi (CDD-IR)
Jean-Luc Gimenez (IE)
Laurent Martin (IR)
Tony Pamplona (IR)
Pascal Vola (IR)

→ **Conception mécanique**

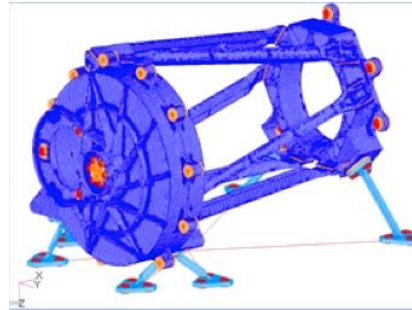
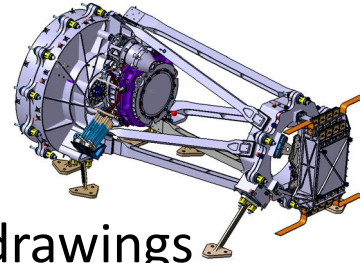
William Bon (AI)
Yannick Charles (CDD-IE)
Jonathan Garidel (CDD-AI)
Patrice Joulié (T)
Joël Le Merrer (T)
Marc Llored (AI)
Anne-Sophie Rouquette-Hutter (CDD-AI)
Patrice Sanchez (AI)
Nicolas Tchoubaklian (CDD-IE)

→ **Fabrication, AIT, Métrologie**

Alain Abbinanti (T)
Patrick Blanchard (AI)
José Garcia (AI)

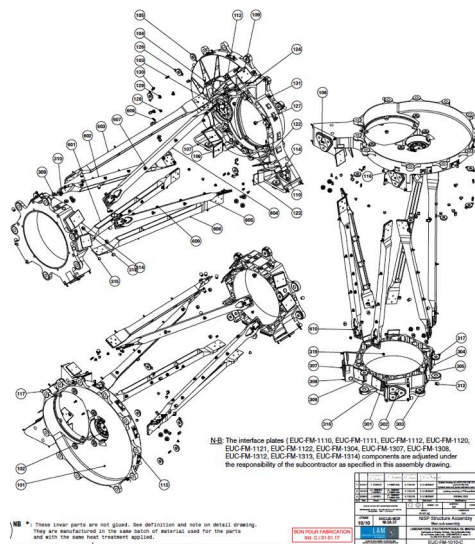
Mission

- Mechanical architecture
- CAD 3D detailed design & drawings
- FEM analysis
- Mechanical fabrication,
- Dimensional control
- AIT



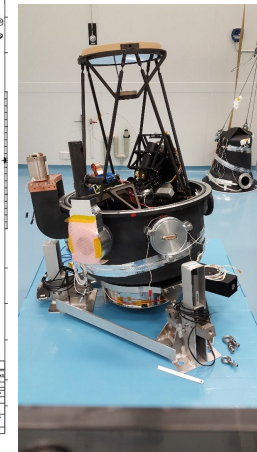
Projects

- NISP SiC design
- Optical mounts
- Hexapodes



Fabrication workshop

- CNC machine tools



Cryogenics and Space Qualification Department

→ **Groupe Essais d'Environnements et de
Contrôle commande**

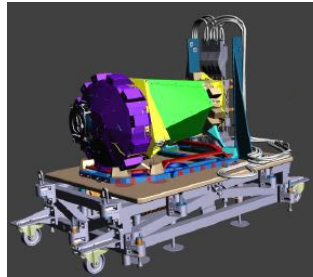
Rudy Barette (T)
Jean-Antoine Benedetti (T)
Olivier Boissin (AI)
Michael Carle (IGE)
Emmanuel Grassi (IR)
Patrick Lanzoni (IGE)
Philippe Laurent (IE)
Patrick Vors (T)

→ **AIT/AIV**

Anne Costille (IR)
Florent Beaumont (CDD-IR)
Alexandre Bozier (CDD-AI)
Marc Pons (CDD-AI)

• Mission

- Thermal -vacuum testing design and analysis
- Thermal vacuum chamber specifications & AIT
- Vibrations testing
- Cryostat AIT, cabling



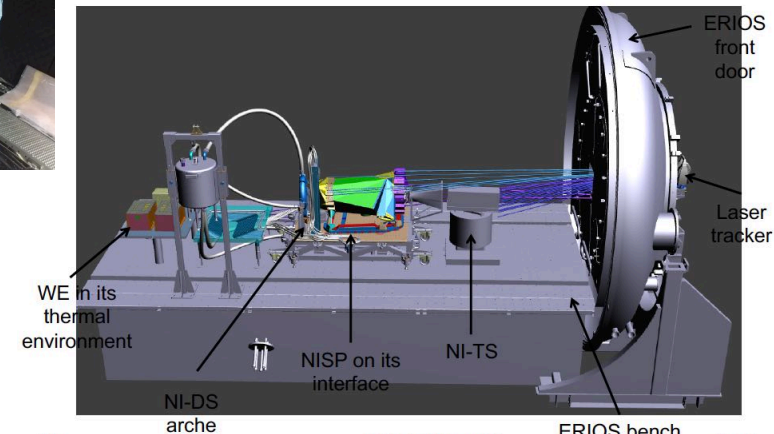
• Projects

- AIT lead
- T/M/O Ground Support



• Major contribution in SPATIAL facilities

- Maintenance, operations, devlpt
- See slides SPATIAL



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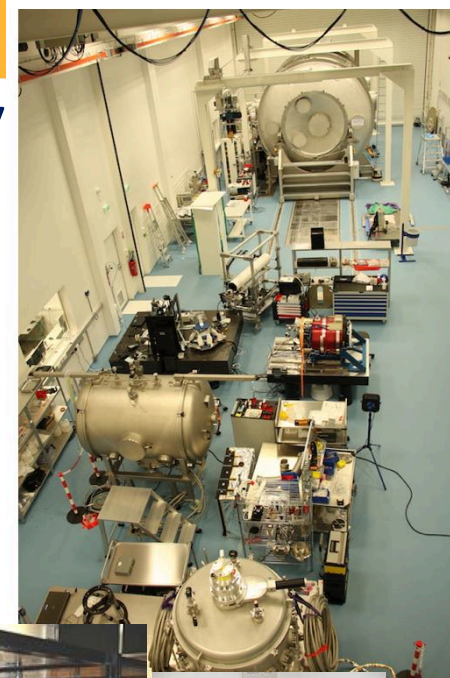


PLATEFORMES SPATIAL & POLARIS

Technical facilities summary

SPATIAL – Space Qualification and AIT/AIV

- **11 clean rooms over 750 m²**
 - 2 rooms ISO 5 (Class 100) – 70 m²
 - 2 rooms ISO 7 (Class 10 000) – 65 m²
 - 6 rooms ISO 8 (Class 100 000) – 190 m²
 - Large Integration Hall ISO 8 – 425 m²
- **Thermal vacuum facilities**
 - ERIOS cryostat 45 m³ (77 K, locally 4K)
 - NAC cryostat 2.5 m³ (77 K – 323 K)
 - Herschel cryostat 0.5 m³ (5K-323 K)
 - Heating/outgazing chamber 7 m³
 - COL – cryostat 0.5 m³ (5K-323 K)
- **Vibration testing system**
- **Micro-optical components characterization**



SPATIAL equipment
vacuum chambers, vibration shaker (35kN)

POLARIS – Optical Fabrication and Metrology

- **Polishing facilities :**
 - 2.5 m, 1.5m, 1.0 m, and smaller diameters
- **Metrology :**
 - 6 clean rooms ISO 8 (class 100 000) – 180 m²
 - 25m optical tunnel, 2 optical towers, 75m total length
- **Technical rooms** with a total of 350 m²

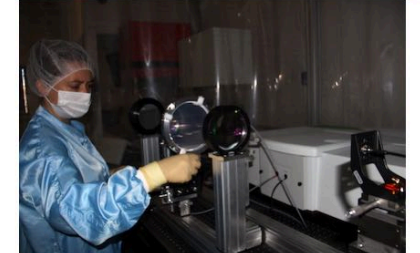
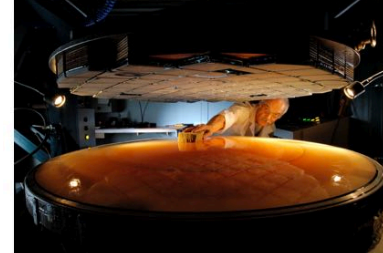
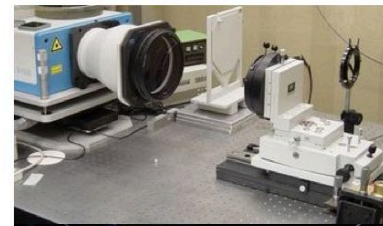
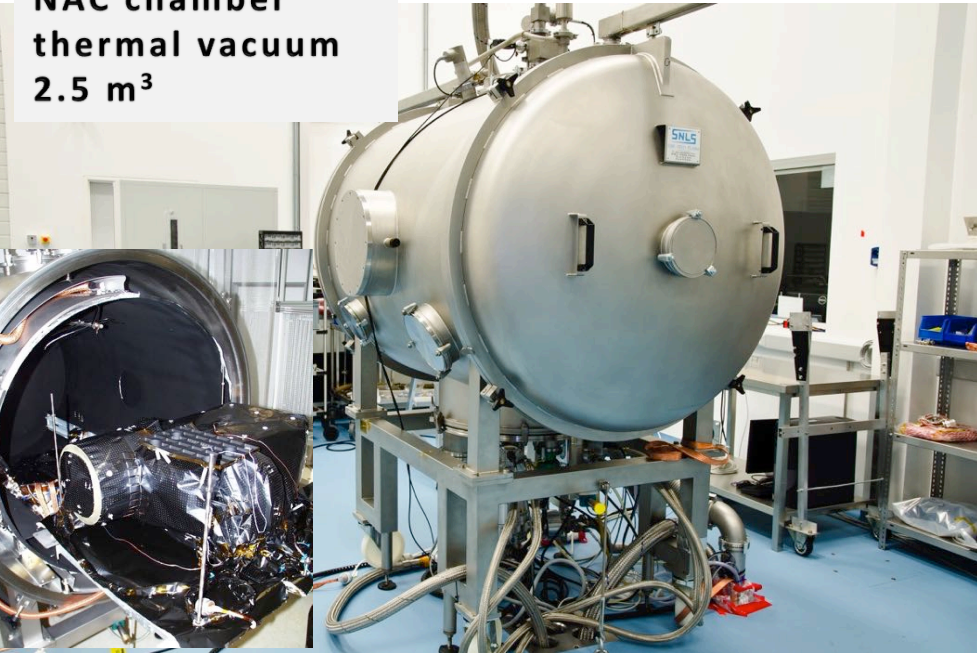


Figure 13: POLARIS equipment
One of the polishing machines (1.5m Ø) and various interferometry or optical metrology systems.



**NAC chamber
thermal vacuum
2.5 m³**



**ERIOS thermal vacuum chamber
45 m³ – currently ~80K – 10⁻⁶ mBar
Ultra-stable optical bench 10⁻⁷g**



**COL thermal vacuum chamber
0.2 m³ – Top ~40K – P ~10⁻⁶ mBar
Designed for μ -optical device testing**



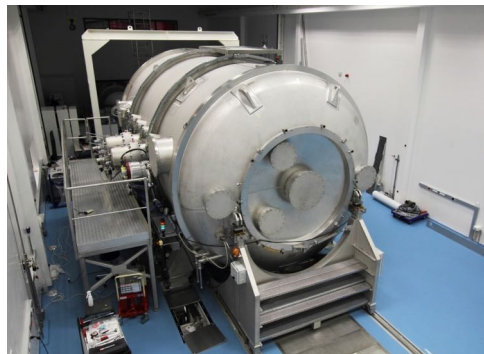
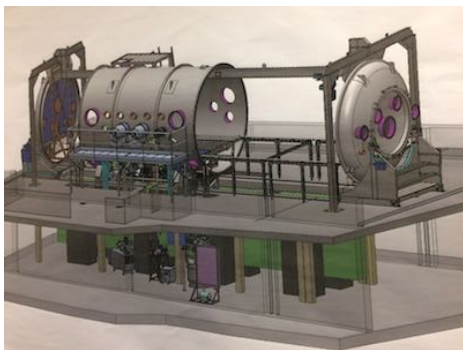
**Herschel thermal vacuum chamber
0.25 m³ – Top ~5K – P ~ 10⁻⁶ mBar**



SPATIAL: ERIOS chamber

ERIOS Space Simulation Chamber

- **Envelope:**
 - 4m x 6m
- **Optical table:**
 - 6m x 1.5m
 - Decoupled from chamber and building: 10^{-7} g (5-100Hz)
 - Use a 100 metric-T seismic mass
- **Liquid nitrogen shrouds**
 - Cold volume @ 80K : 50 m³
- **Working pressure: 10^{-6} mbar**
 - 2 cryogenic pump 10,000 liter/sec
- **Adaptive configuration**
 - Rotating flange with optical windows
 - Possible changes to use with helium or cryocooler



SPATIAL: Dimensional metrology

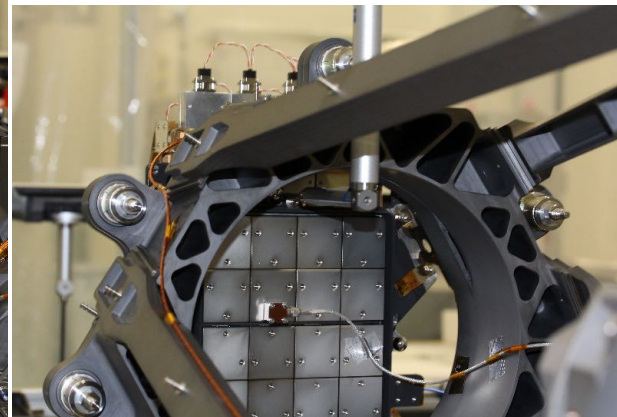
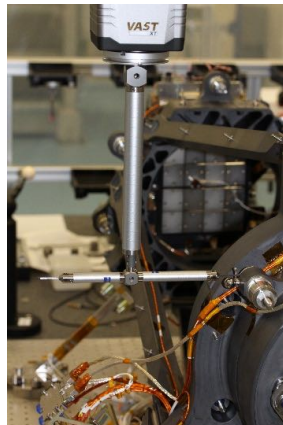
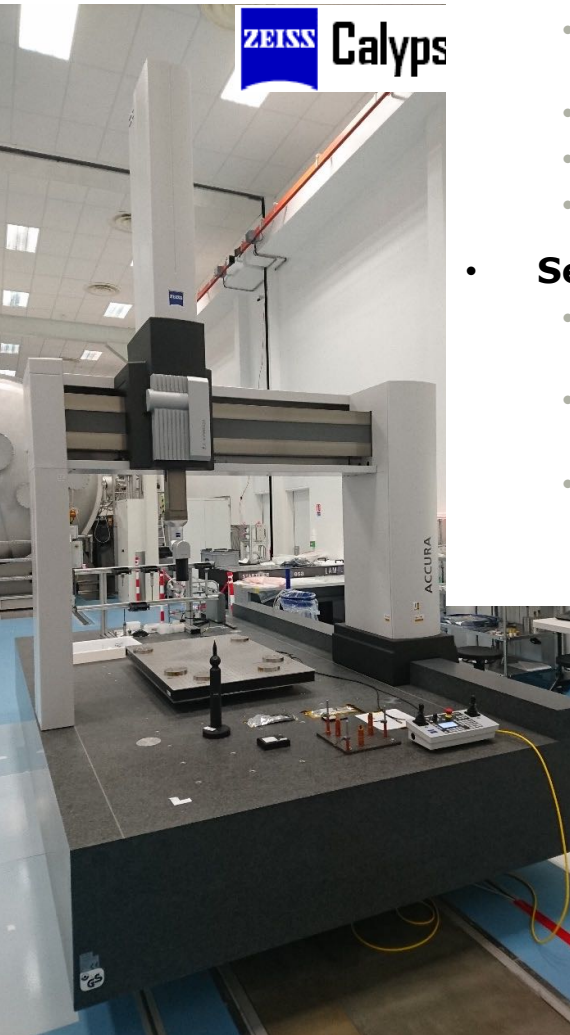
ZEISS ACCURA II CMM

- **Characteristics**

- Measurement volume: (w) 1.2m, (L) 3.0m, (H) 1.0m
- Bench surface: (w) 2.6m and (L) 3.7m
- Maximum load: 5000kg
- ISO5 compatible

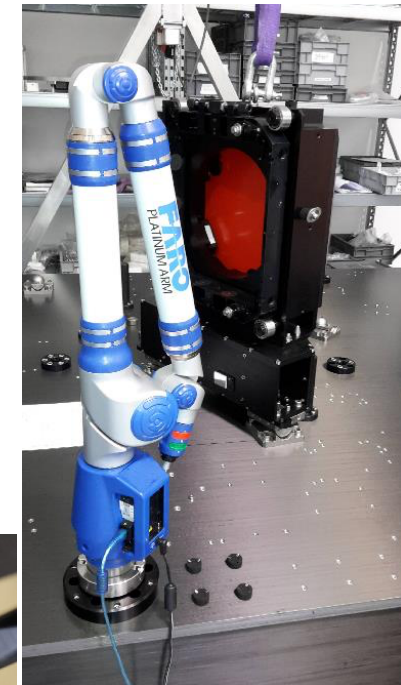
- **Sensors and accuracy**

- Active scanning and multipoint sensor $(1.9+L/300)\mu\text{m}$
- Dynamic RDS-D articulating unit $(2.2+L/300)\mu\text{m}$
- Optical 2D image sensor with autofocus $(10+L/300)\mu\text{m}$



FARO arm

- Portable CMM
- Platinum series – 6ft
- $\sim 30 \mu\text{m}$ vol. deviation



SPATIAL: Vibration testing system

Vibration system suitable for high-acceleration shock and testing with sinusoidal, random and transient excitations

- Air-cooled electrodynamic shaker : LDS V875/440 35 KN
- Slip Low Pressure Table: LPT 600, 600mm x 600 mm
- Power amplifier : LDS SPAK 35/40
- Acquisition & control system :
 - Spectral Dynamics SD 2560 with 18 channels

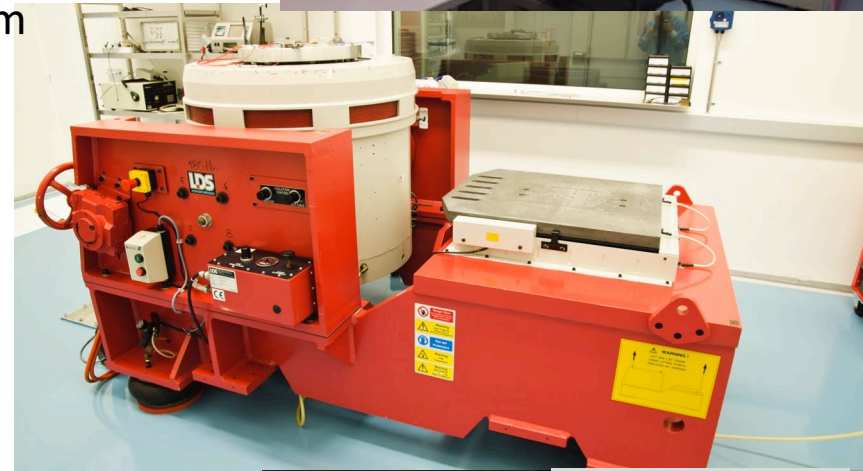
Piezo and ICP Accelerometers

- ~ 30 ENDEVCO and ~15 B&K types

Signal conditioning

- B&K 2525 pre-amp stage : 2 dedicated channels for pilot and control
- B&K NEXUS : 16 voies

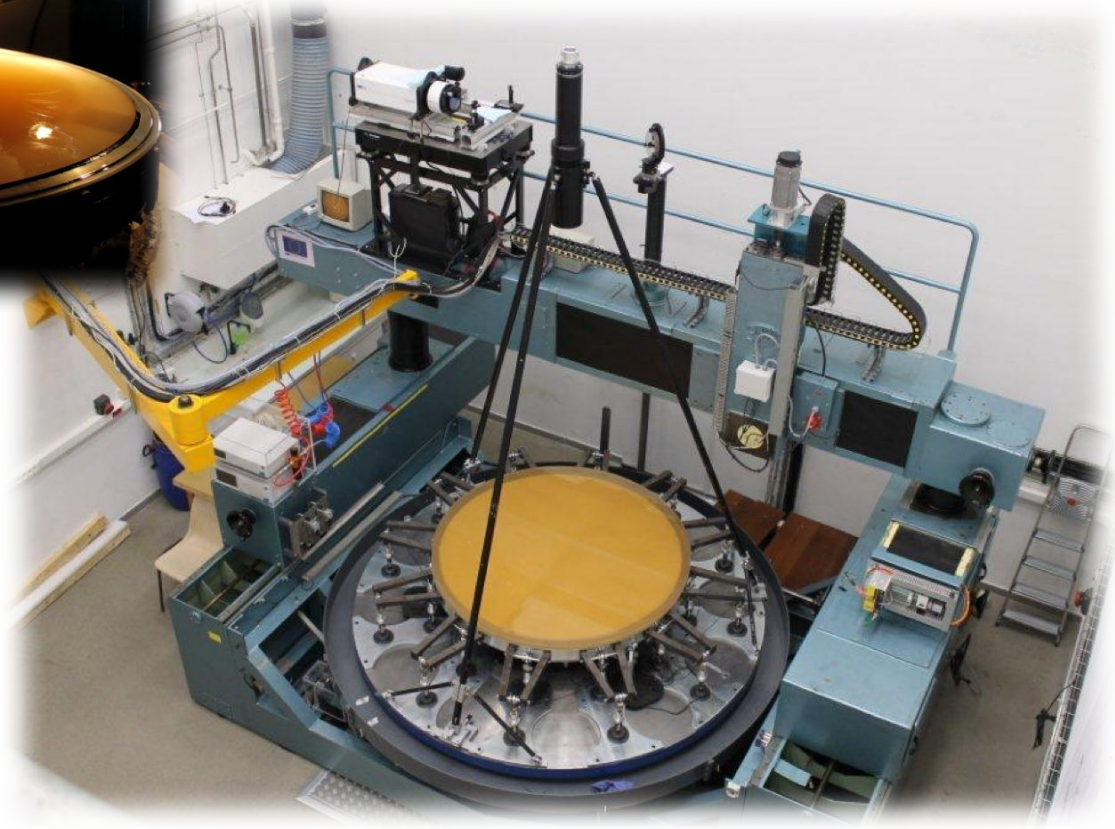
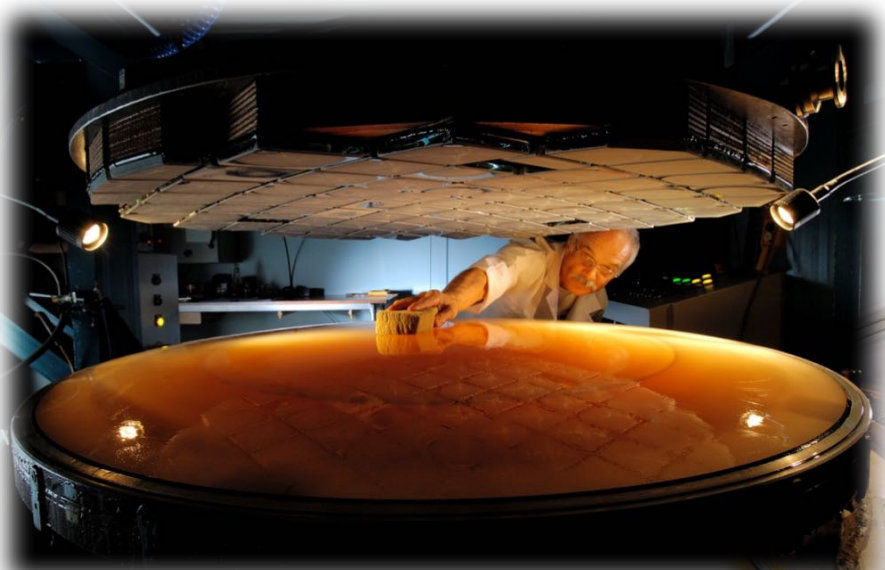
More at : <https://www.lam.fr/projets-plateformes/plateformes-spatial-et-polaris/centre-spatial-ait-aiv/article/l-installation-de-vibrations?lang=fr>



POLARIS : Optical Fabrication

Active Polishing facilities
(stress mirror polishing)

- Six machines ranging from 0.1m to 2.5m \varnothing
- All designed for active optics fabrication techniques



Polishing of the 40cm extreme quality active toric mirror for the VLT SPHERE

POLARIS: Optical systems and surface metrology

Interferometers:

- ⊙ Simultaneous or phase shift acquisition
- ⊙ Various plane of spherical calibers
- ⊙ Off-axis and large focal measurements

Microscopes:

- ⊙ Interferometric or confocal
- ⊙ Surface roughness accuracy < 1nm RMS

Spectrophotometers:

- ⊙ Perkin Elmer Lambda 900 and 1050
- ⊙ UV-Vis-NIR spectral range, $\Delta\lambda=0,1\text{nm}$
- ⊙ Specular or diffuse measurements
- ⊙ Custom accessories for gratings efficiency
- ⊙ Rejection down to 8Abs

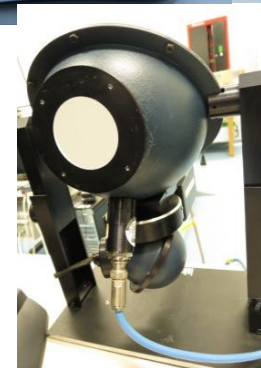
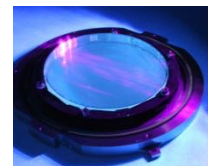
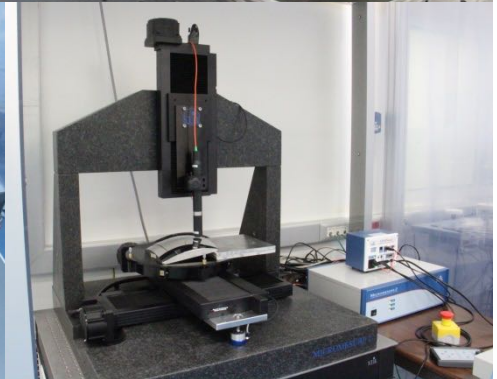
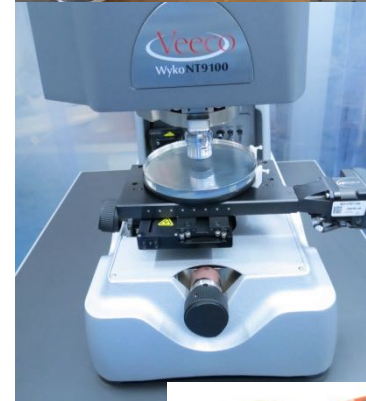
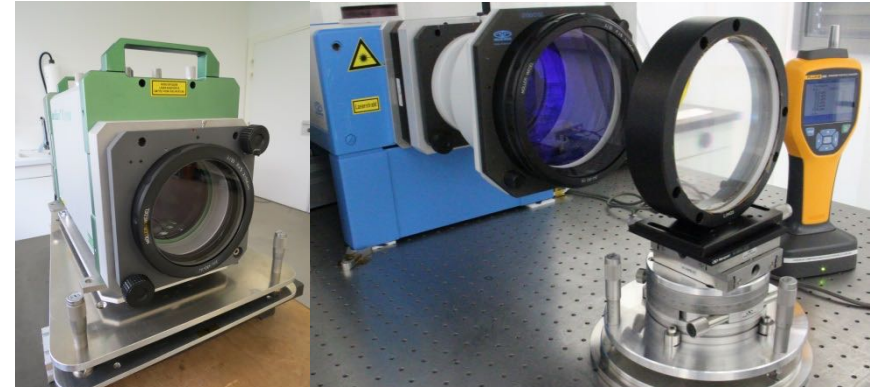
Sources and detectors

- ⊙ UV-Vis-NIR illumination and imagery

Binocular and UV lamp

- ⊙ Surface inspections

ISO 8 environment with ISO 5 laminar flux for each setup

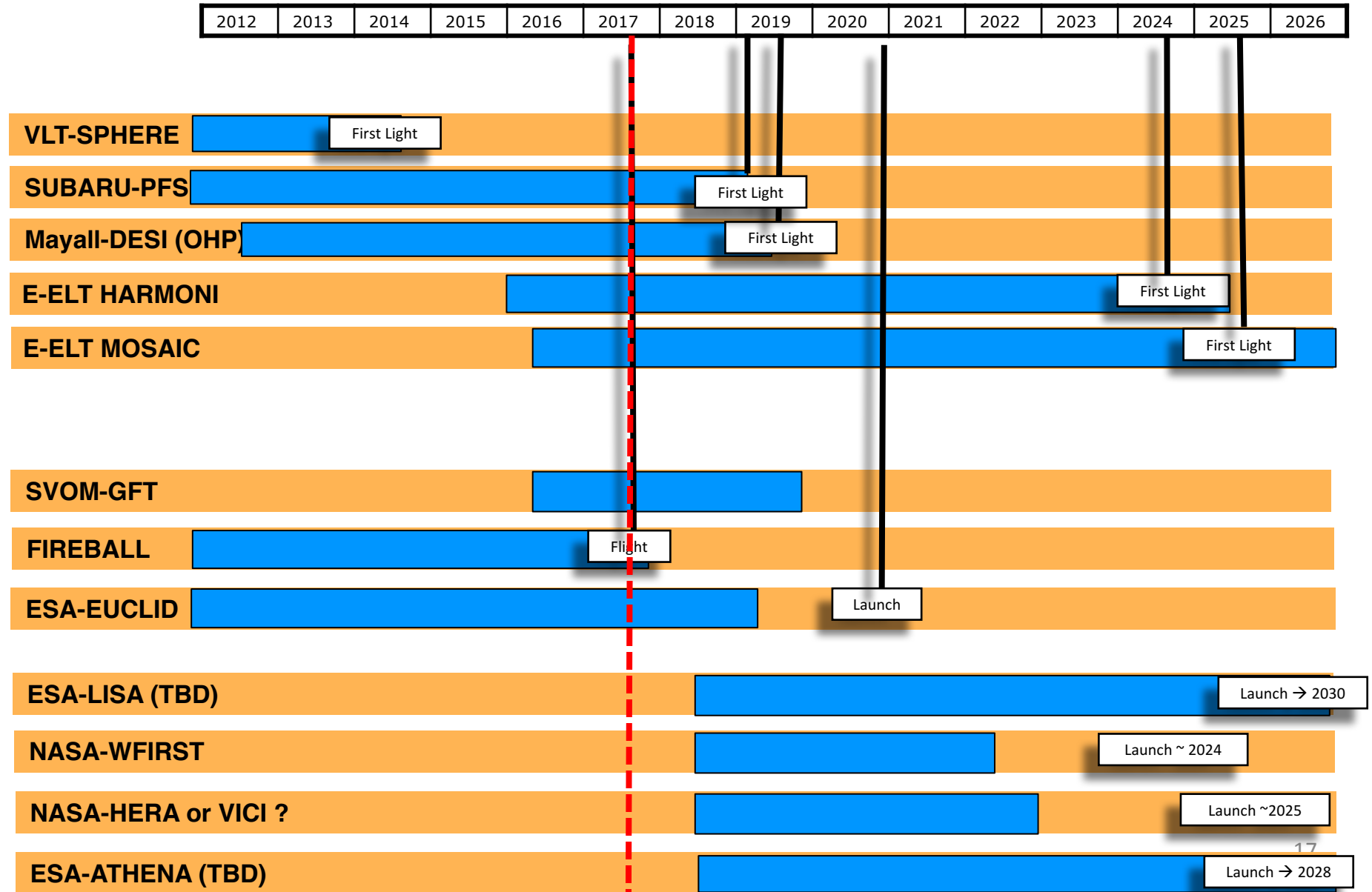


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PROJETS SOLS ET SPATIAUX



ESA-Euclid Near Infrared SpectroPhotometer



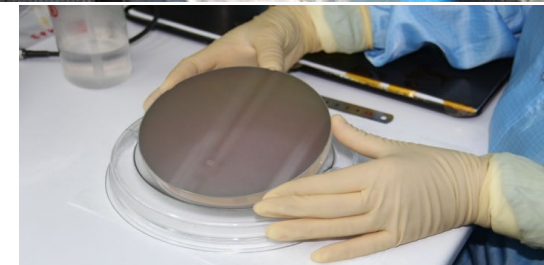
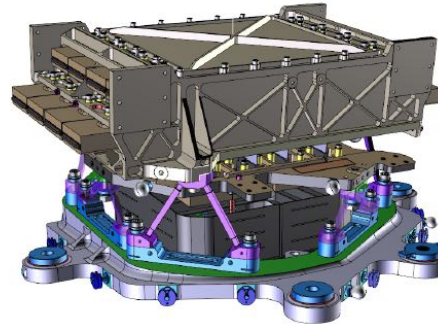
LAM, NISP Project Responsible

- PM CNES @LAM
- Project office, system, PA/QA
- NISP AIT/V @LAM



4 NISP sub-systems @LAM

- ⊙ SiC structure!
- ⊙ B+3R Grisms : from R&D
- ⊙ FPA mechanical structure
- ⊙ Thermal control



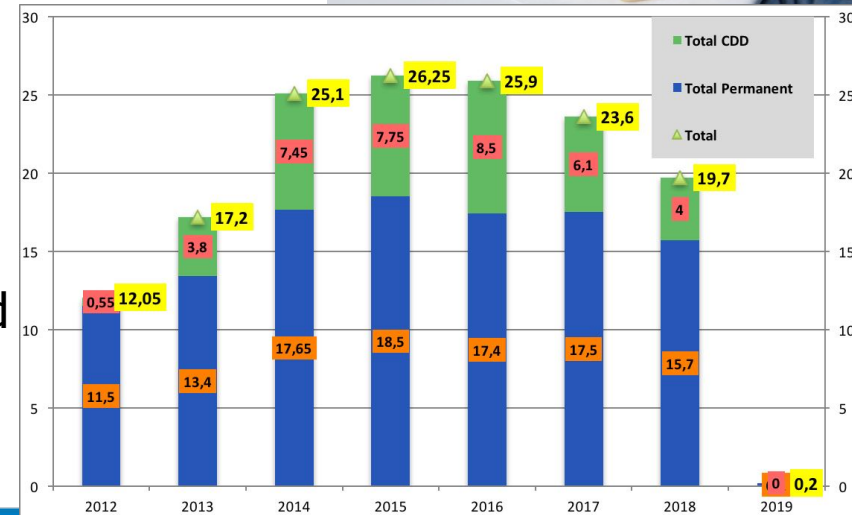
Effort: ~150 FTE / 7 yrs

- ⊙ Support from admin, LAM

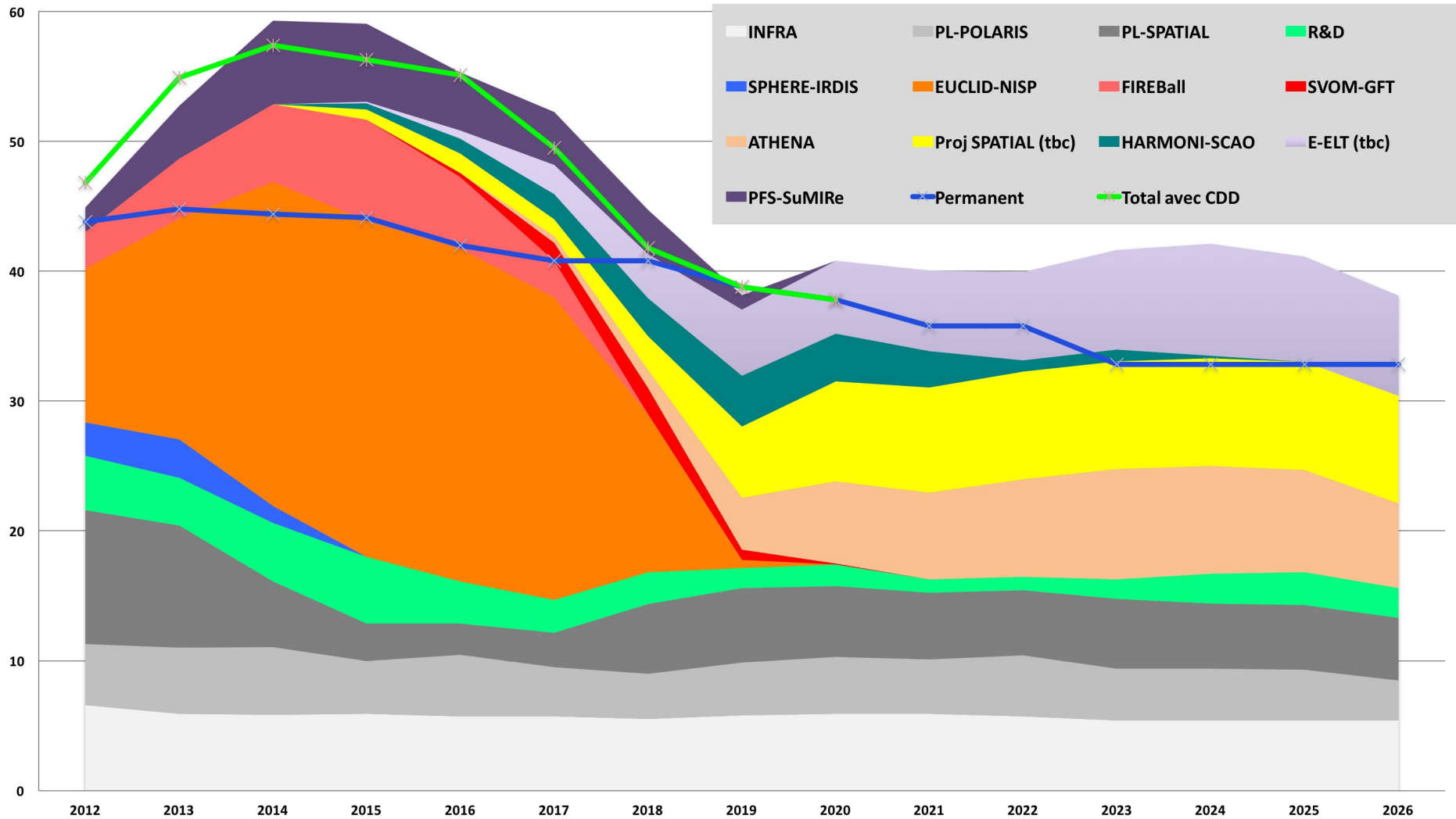
Full use of SPATIAL and POLARIS facilities

Three models: STM, EM and FM

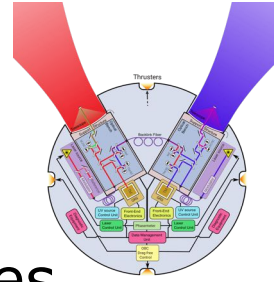
- ⊙ STM completed, awaiting Airbus with congratulations from CNES and ESA 😊
- ⊙ EM/AVM for 2017.11
- ⊙ FM for 2018.09



Plan de Charge 2012-2026 Sol, Spatial, R&D et Plateformes

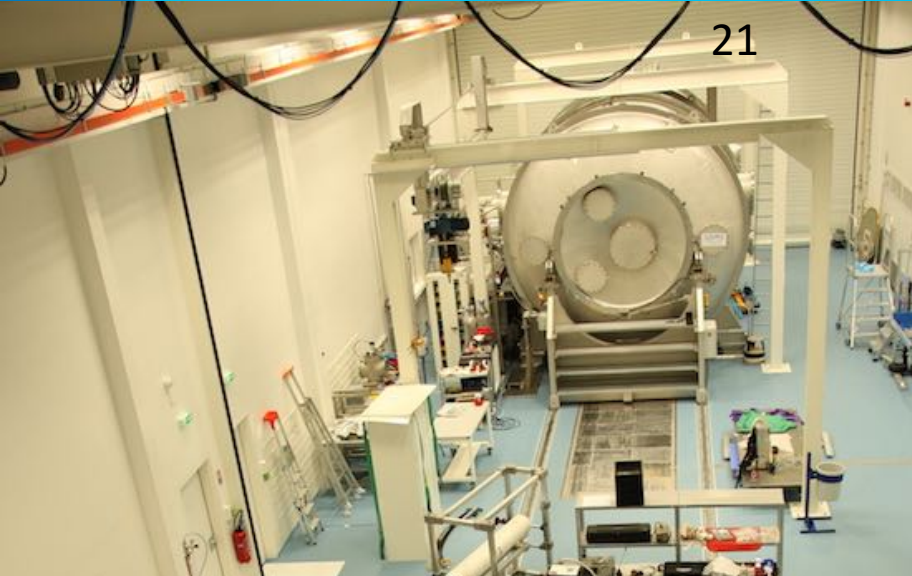


LISA au LAM ?

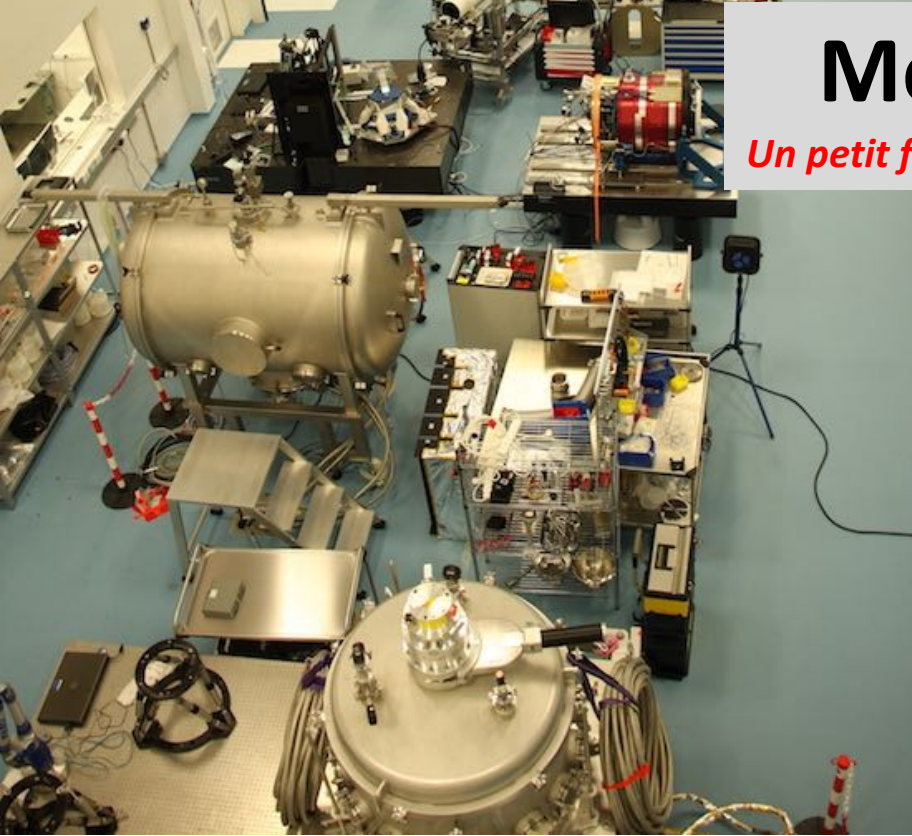


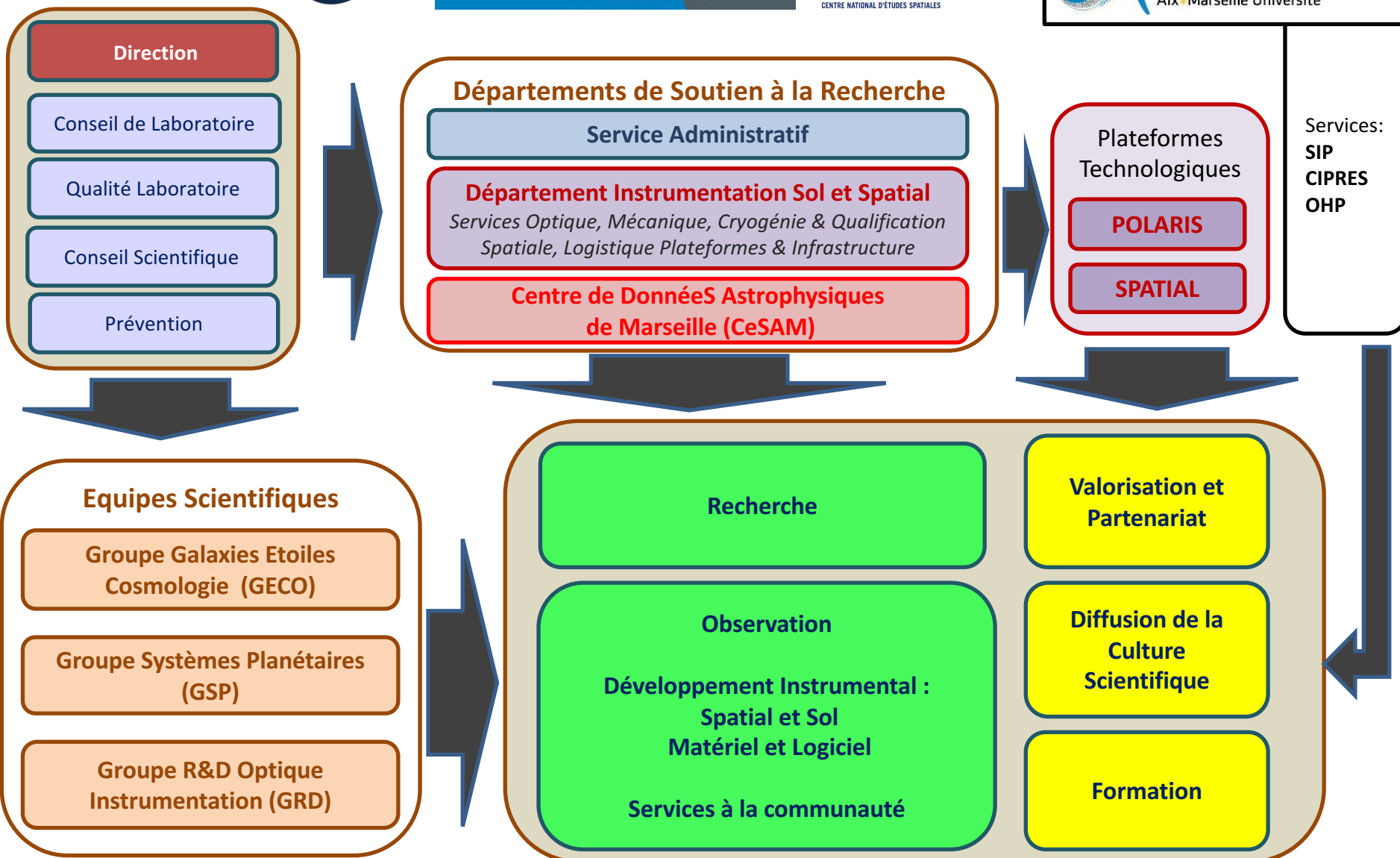
Laser Interferometer Space Antenna

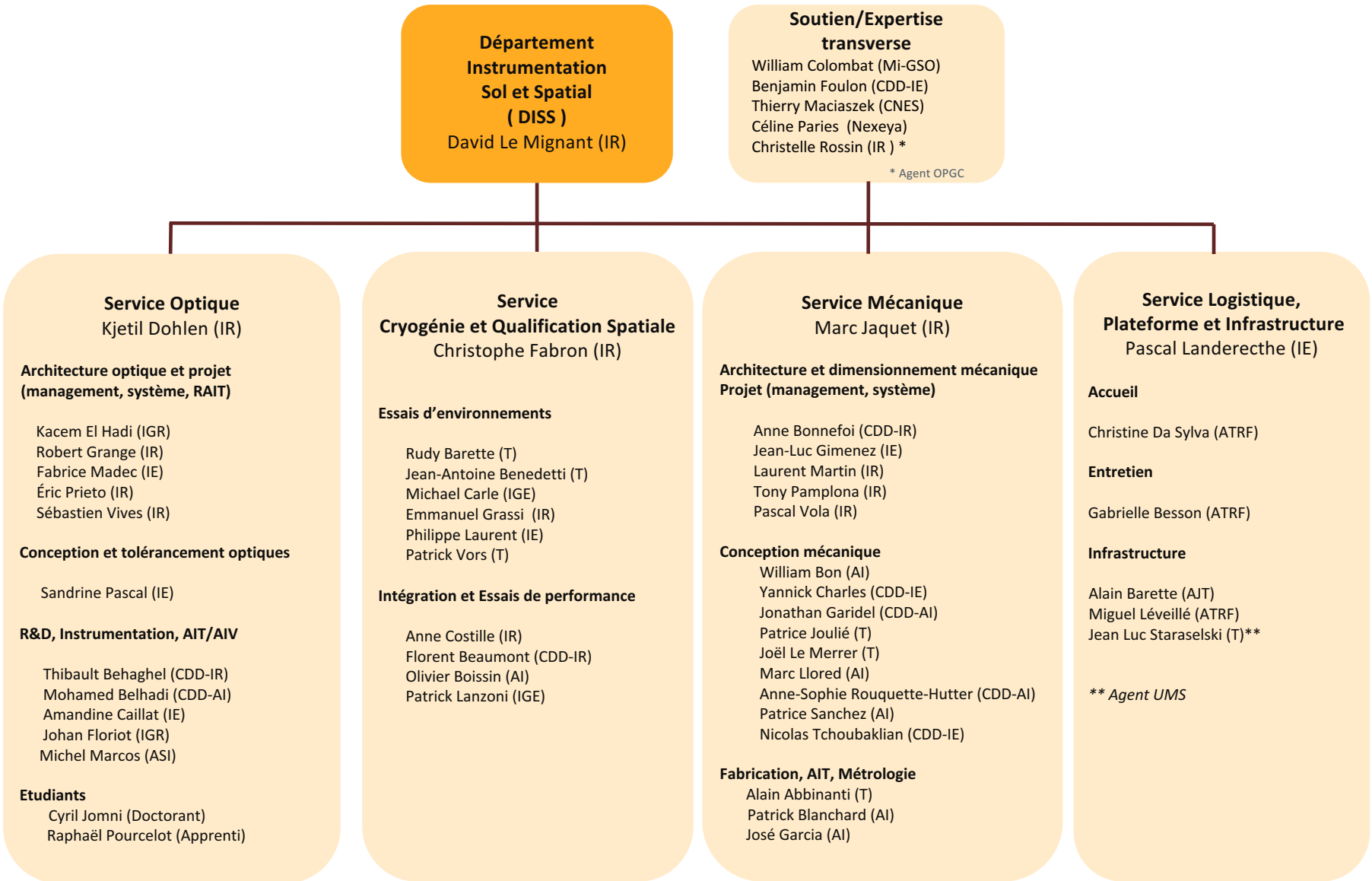
- LAM: Laboratoire Spatial, fort soutien des tutelles
- LISA sous-système : support structure en SiC ?
- Fortes compétences en management et ingénierie système de gros projets
- Fortes compétences en optique, mécanique
- Fortes compétences en essais en environnement
- Moyens importants : plateformes CNRS/AMU
 - optiques super-polies : haut-contraste et lasers
 - intégrations et tests optiques en ISO5/ISO7 et ISO8
 - caisson ultra-stable ERIOS et pot vibrations
 - 1000 m2 de salles blanches et moyens généraux
 - → intégration finale bras local ?
- Compatibilité plan de charge et intérêts technique / scientifique



Merci !
Un petit film pour finir ?







FIREBall (Faint Intergalactic Redshifted Emission Balloon)

UV multi-object spectrograph

CNES/LAM; Caltech; Columbia University

LAM is responsible for spectrograph development

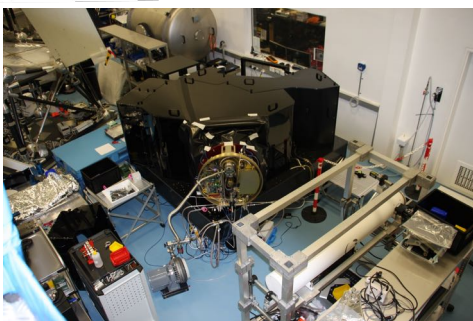
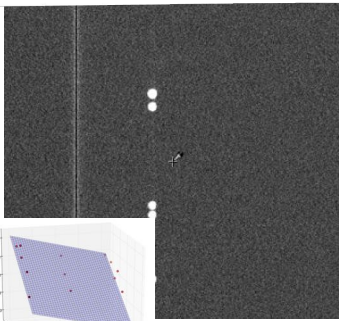
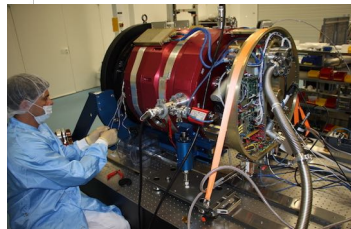
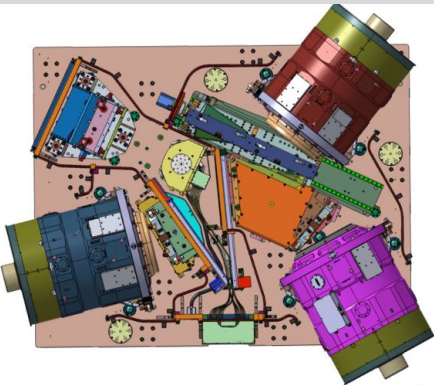
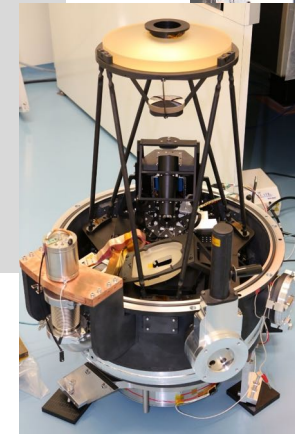
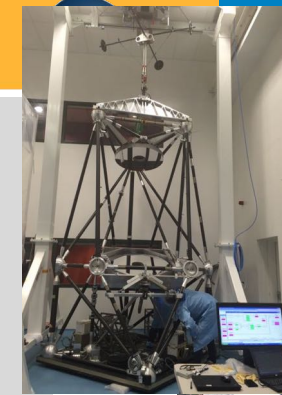
Contribution to algorithms for gondola guiding

Instrument AIT at LAM since 2015

- Issue with UV coating led to one-year delay

End-to-end testing at LAM then CNES (April to June 2017)

Flight underway in USA Fort Sumner September 2017

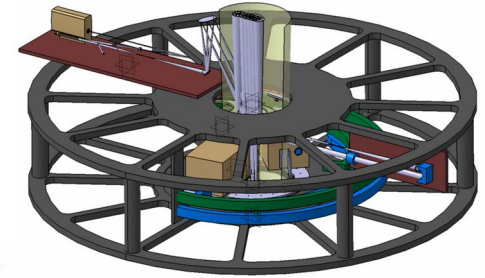


SUBARU Prime Focus Spectrograph (PFS)

- 2400 fibers over $1,3 \times 1,3 \text{ deg}^2$ for massive spectroscopic survey
- IPMU, Princeton, JHU, Caltech, Brazil, China, MaxPlanck, NAOJ, Taiwan.. and LAM
- LAM: spectrograph system and AIT lead
 - Work with French industry: Winlight
 - (B+R+NIR) spectro channels x 4 optical benches
- On-going tests for the first unit
- 1st science light in 2019



E-ELT programme

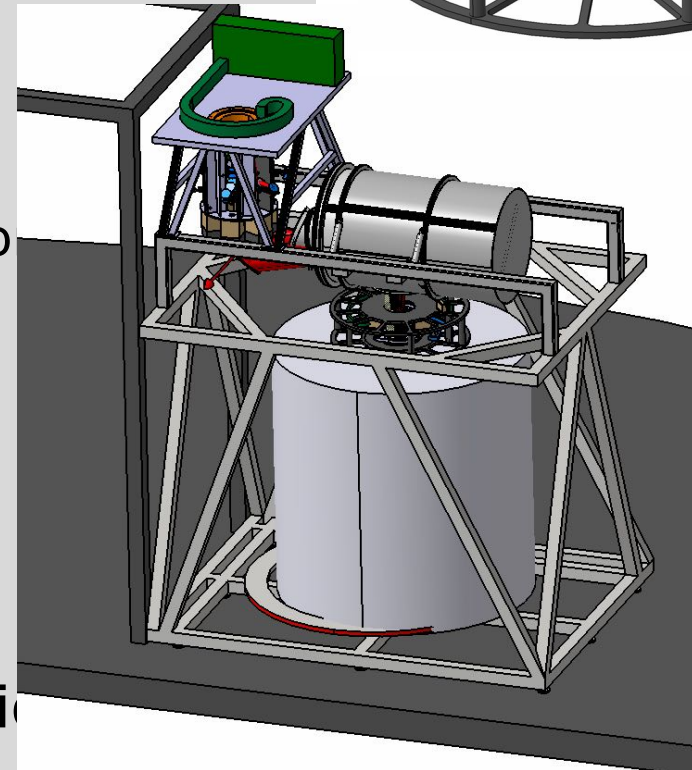


HARMONI (-AO) – E-ELT IFU

Phase B

- SCAO full dvlpt @LAM
- LTAO till FDR,
– then pending ESO's decisio

1light 2024



MOSAIC - E-ELT-MOS

Phase A

- WP GLAO + WP AIT
- then, pending ESO's decisio
- AIT/V MOSAIC @LAM

1st light 2026

