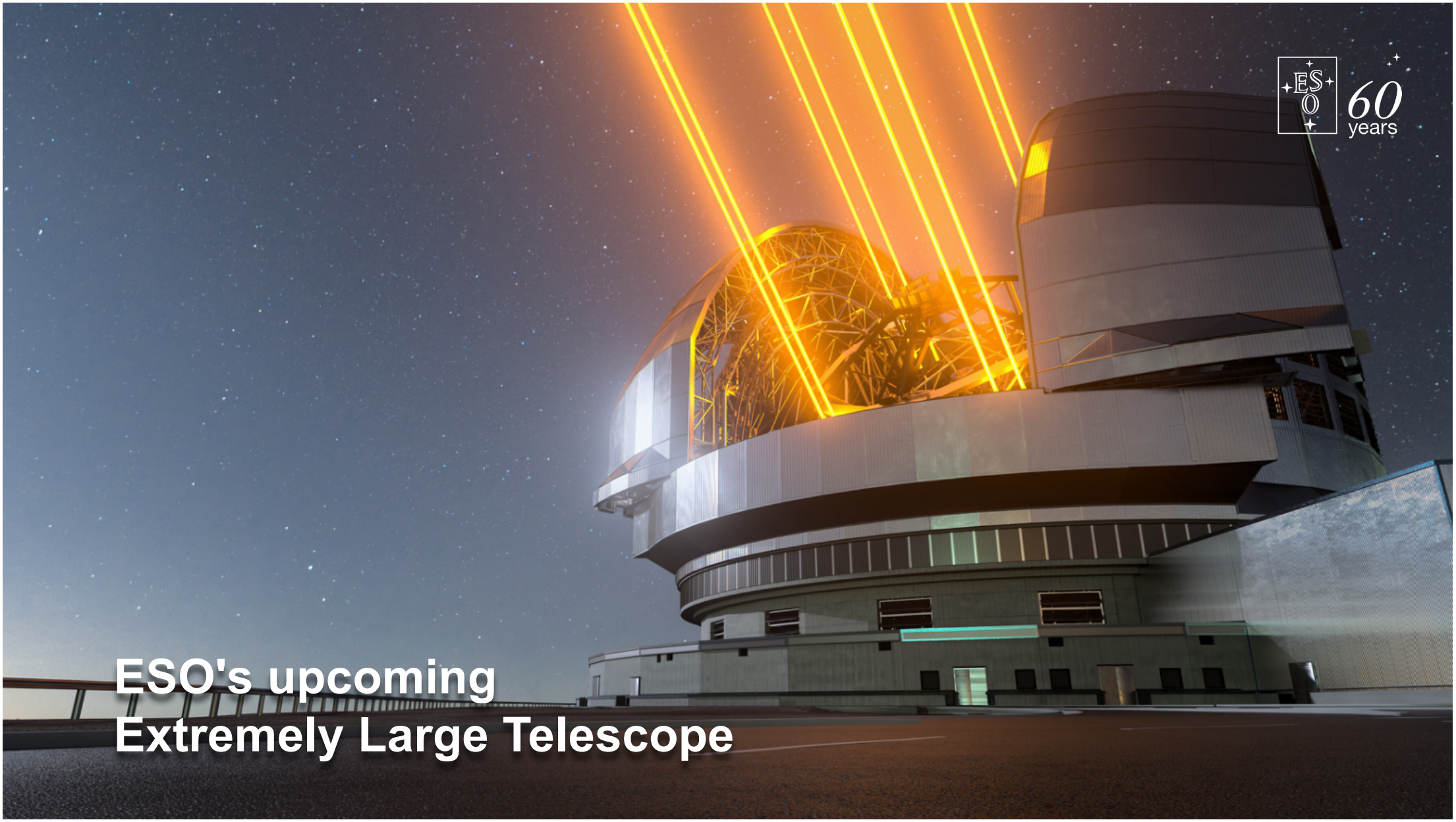
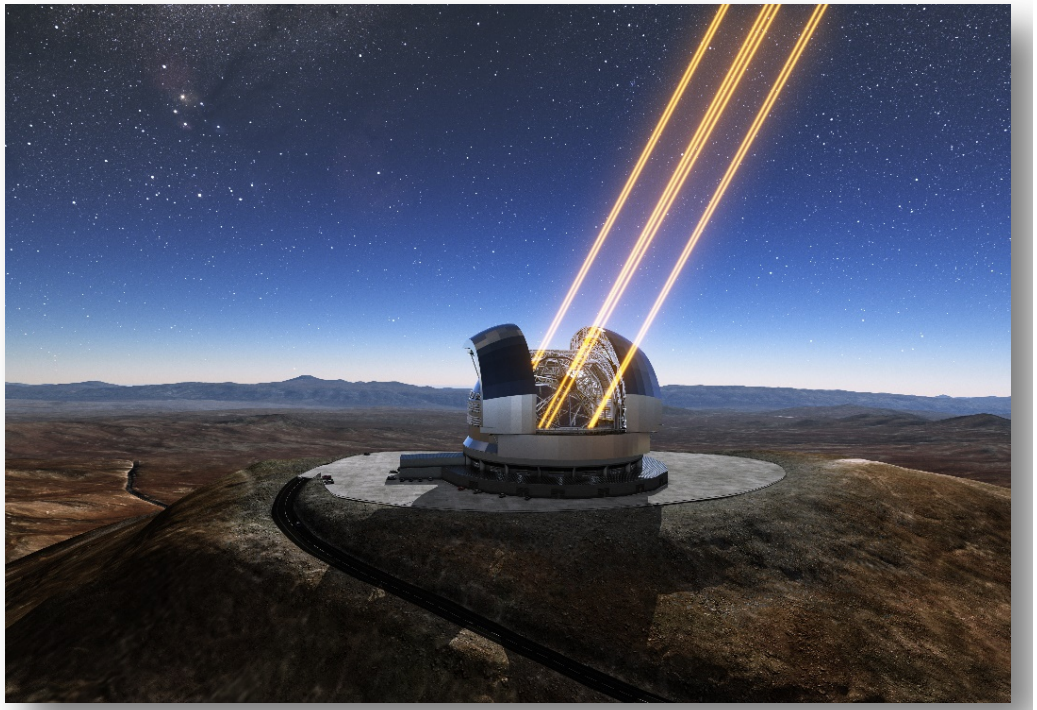

ESO
60 years
FEET ON THE GROUND
EYES ON THE SKY
The ELT Programme
ESO'S 60th Anniversary


ESO
60
years
ESO's upcoming
Extremely Large Telescope

ESO's Extremely Large Telescope (ELT)

elt.eso.org

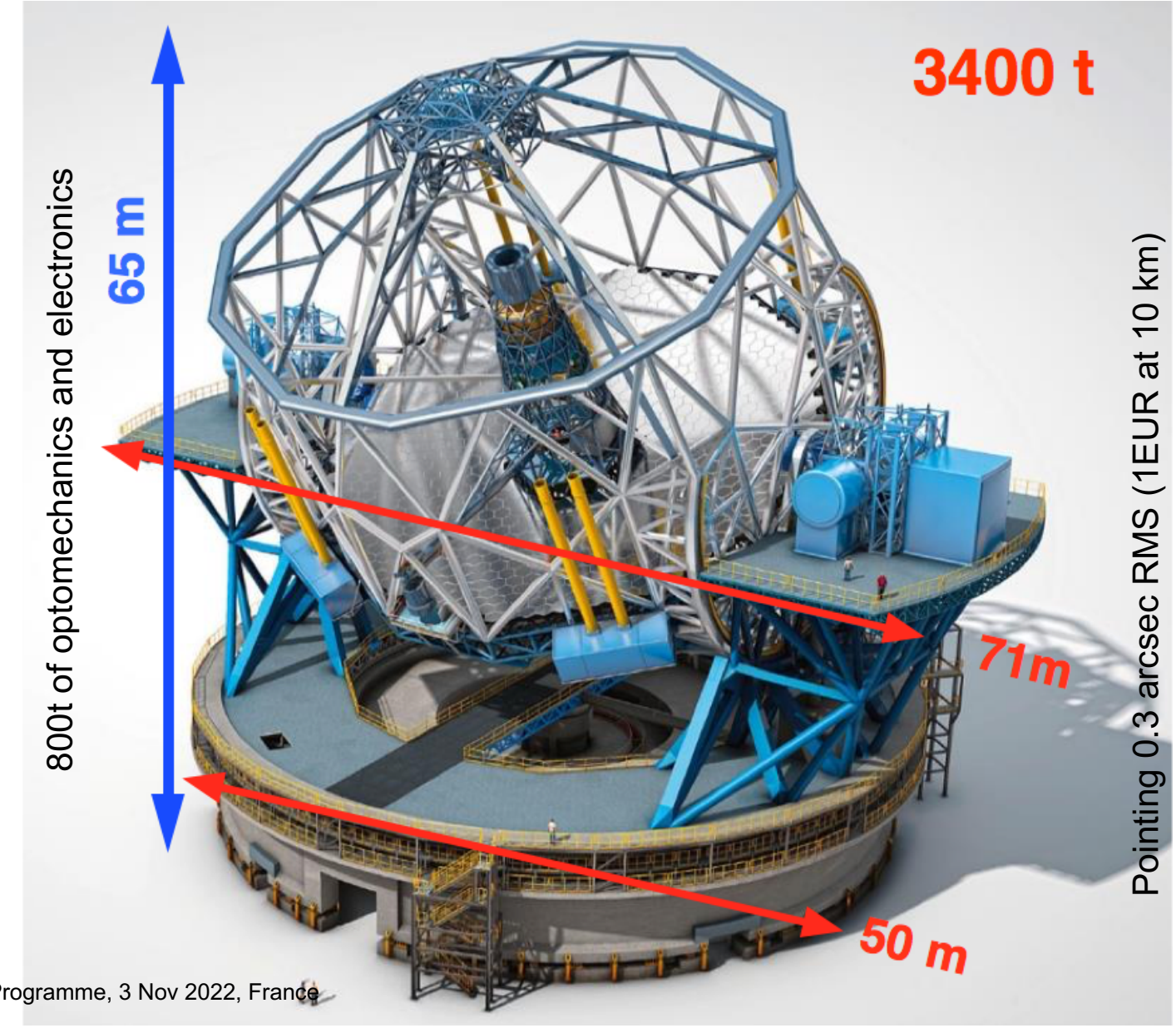
- Largest optical/infrared telescope in the world
- 39.3 m segmented primary mirror with 798 segments and adaptive optics
- Transformational science objectives
- Construction 2015-2028 €1.3 bn
- On Cerro Armazones, to be operated as part of the Paranal observatory



The Path to the ELT

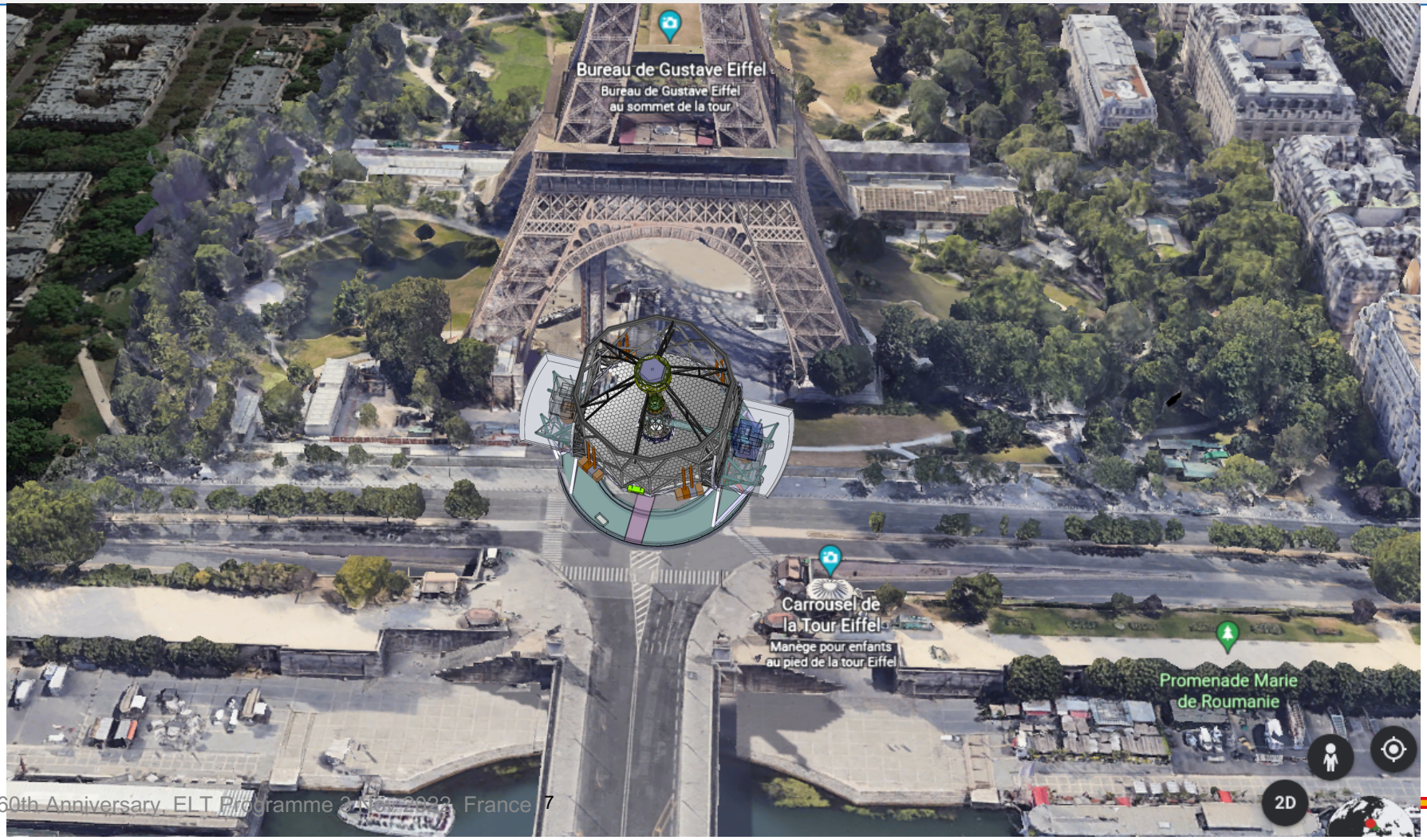
- Key Milestones:
  - 2006: Community together behind a single project (ELT)
  - 2012: ESO Council approves ELT Programme
  - 2014: ESO Council authorizes Phase 1 construction
  - 2020: ESO Council secures full funding for ELT
- Long path to approval, but once approved, steady progress
- The ESO ELT is:
  - the most powerful of the ELTs (vs GMT and TMT)
  - the only fully funded of the ELTs
  - the most advanced in construction
  - hopefully the first on-sky to make the first discoveries

- ESO's successful strategy:
  - Strong and steady governance – funding agencies and astronomers work together in Council
  - Striving for consensus
  - Programmatic and financial stability
  - Engagement with the community and industry at all levels
  - Partnership with MS institutes and advanced instrumentation development

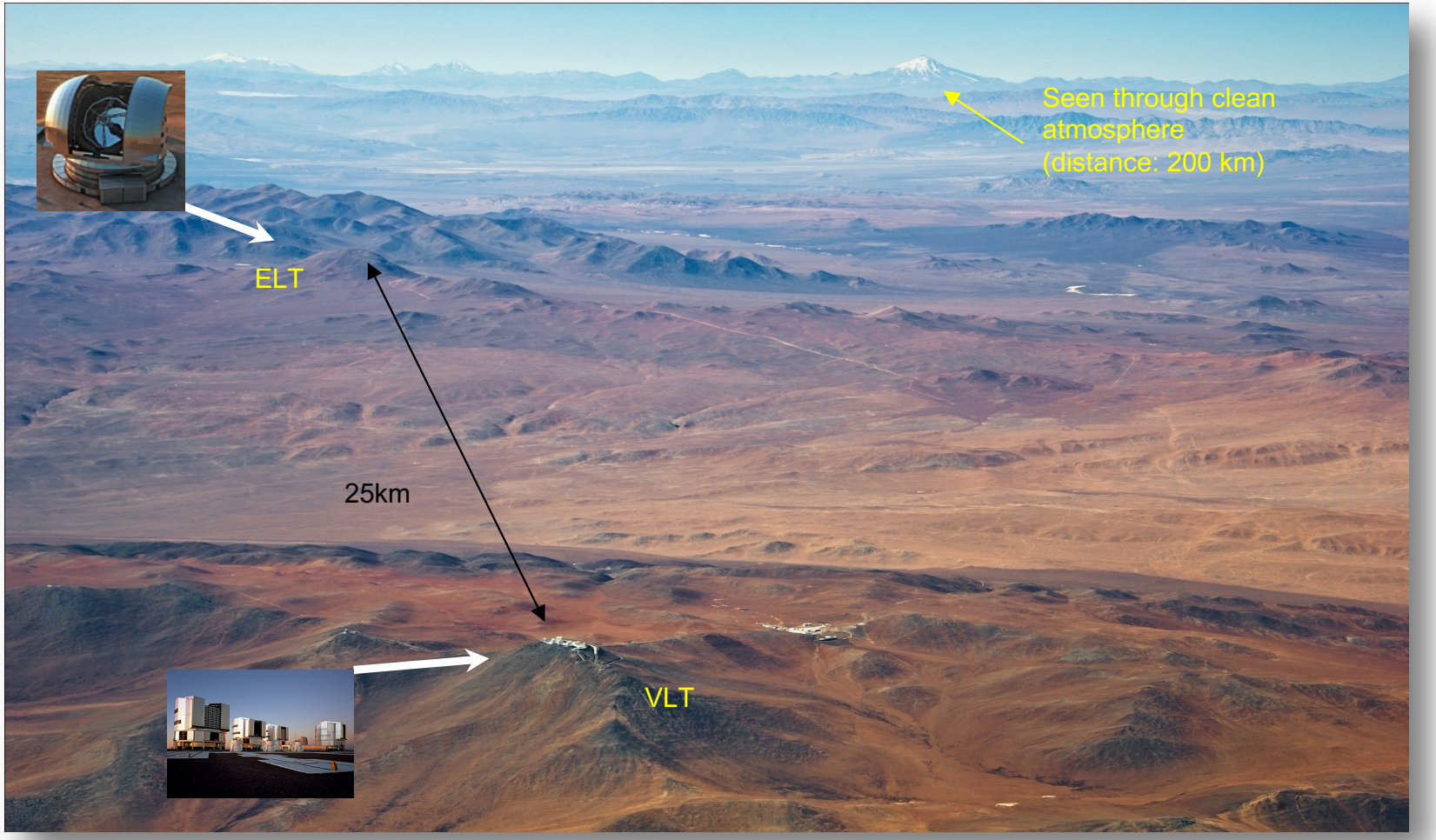

3400 t
65 m
800t of optomechanics and electronics
71m
50 m
Pointing 0.3 arcsec RMS (1EUR at 10 km)

To put it in perspective…

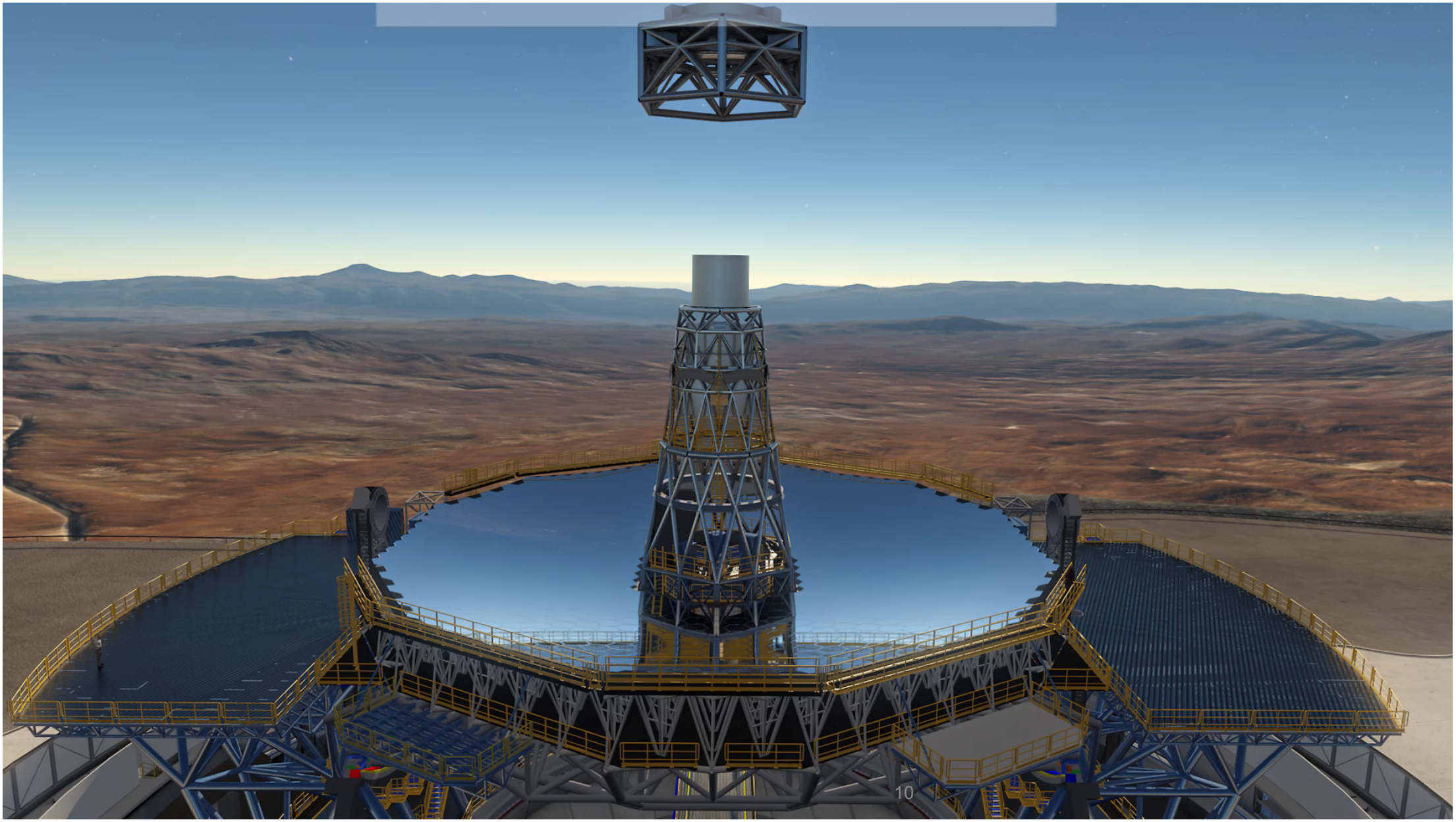
To put it in perspective…



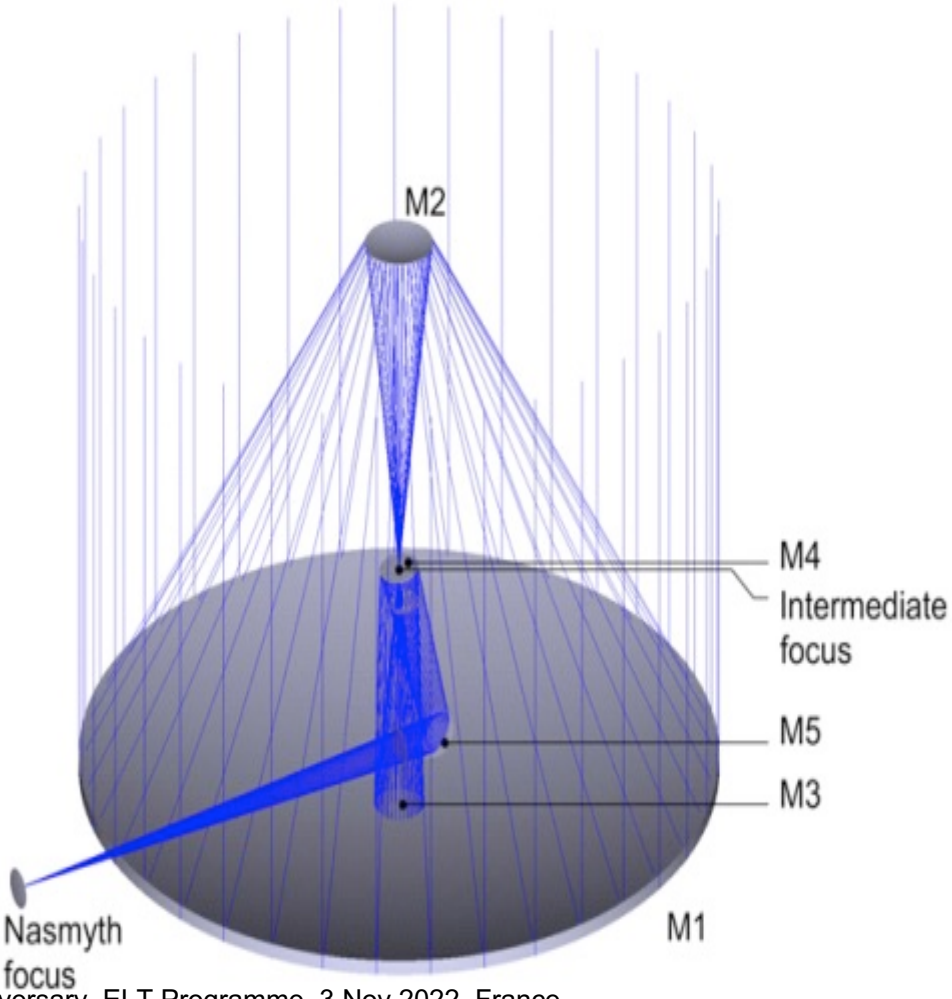
Armazones and Paranal



Our Main Partners in the Endeavour



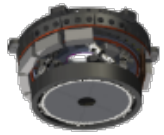
ELT Optomechanics



M1 Unit
39-m
Concave – Aspheric f/0.9
Segmented (798 Segments)
Active + Segment shape Control

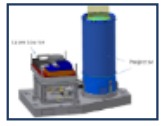
M2 Unit
4-m
Convex Aspheric f/1.1
Passive + Position Control

M3 Unit
4-m – Concave – Aspheric f/2.6
Active + Position Control



M4 Unit
2.4-m
Flat
Segmented (6 petals)
Adaptive + Position Control

M5 Unit
2.7x2.1-m
Flat
Passive + Fast Tip/Tilt



LGSU
(Laser Guide Star Units)
Laser Sources + Laser Beacons
shaping and emitting

M1 Unit

931 x M1 Segments
931 x Blanks + 19 x Spare Blanks
931 x Segments Polishing

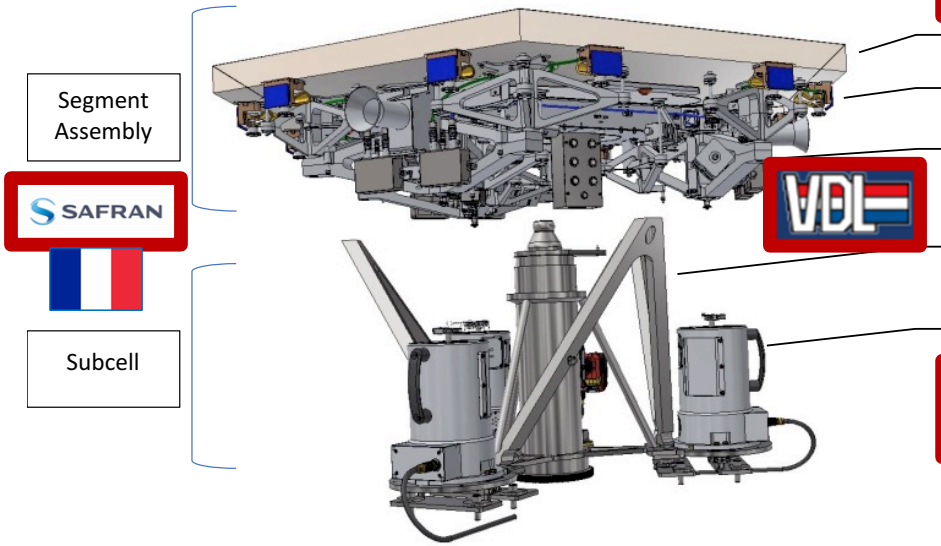
4566 x M1 Edge Sensors
4566 x Sensors +805 x Electronics + Spares

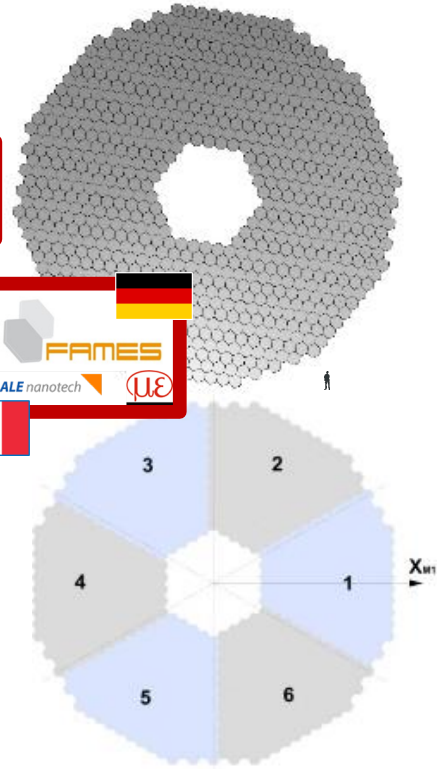
931 x M1 Segment Supports
& SA Auxiliary Equipment
[SA Handling Tools, SA Transport Containers, SA AIV Tools]

2418 x M1 Position Actuators
2394 x Actuators + 806 x Control Modules + Spares

M1 Auxiliary Equipment
Aux. Sensors, Mass Dummies. Carts, Stands, Manipulator, Phasing Gun, Alignment Tools

39-m diameter
6 x 133 segments (1.4-m)
1 x 133 spare segments
Total: 931 segments



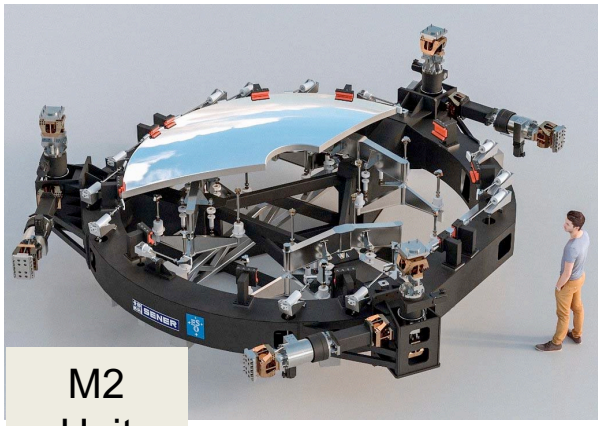


Including glass, mechanics, electronics:
⇒ more than 10 000 components

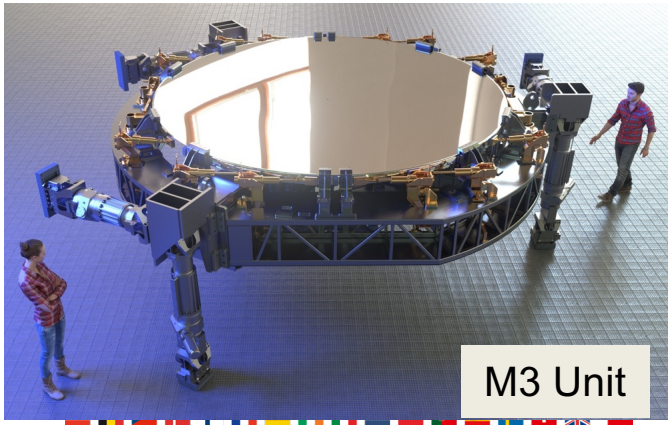
M1 Mirror	
Outer diameter (mm)	39146.0
Inner diameter (mm)	9418.4
M1 Optical Prescription	
Radius of curvature (mm)	68685
Conic constant	-0.996473

M2 & M3 Units : Synergies

- M2: Passive 4-m f/1.1 convex mirror, highly aspheric (+ shape control provision)

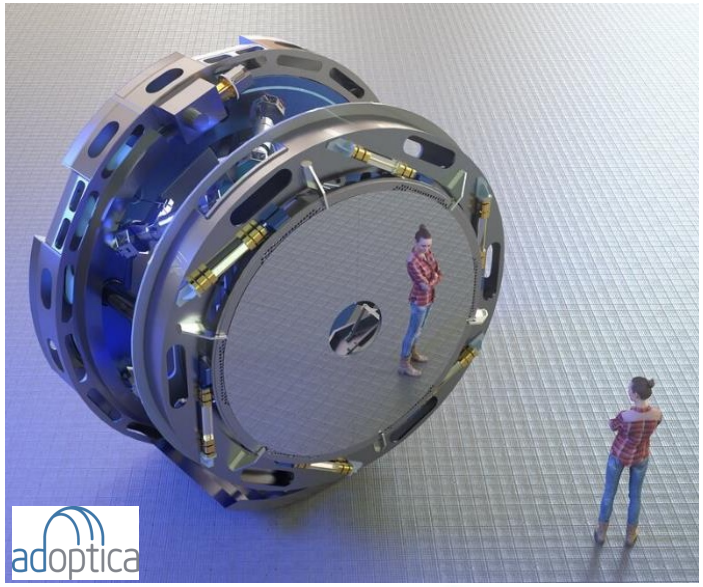


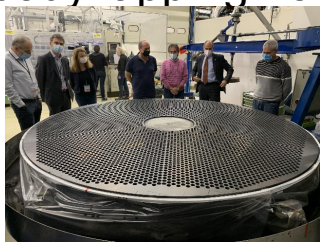
- M3: Active 4-m f/2.6 concave mirror, mild aspheric (+ shape control)
  - Same size, support (18pts axial, 12 lateral), mass, stiffness, shaping system (warping harness), positioning system (sub-micron precision hexapod), common auxiliary equipment (handling, transport, …)
  - ➔ One single contract for M2/M3 Cell design and manufacturing to SENER (SP)

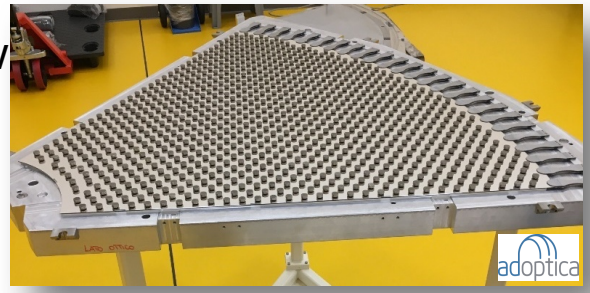


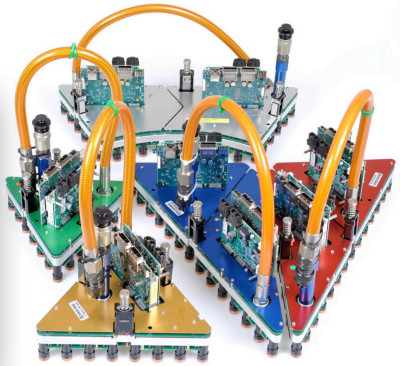
M4 Unit

- M4 Shells polished by Safran-Reosc (FR)
  - Blank (Zerodur®) by SHOTT (DE)
  - Mirror D2.4m made of 6 sectors,1.95mm thick only!
  - 6 + 4 (spares) shells completed and delivered to AdOptica
- M4 Adaptive Support developed by AdOptica (IT)
  - >5000 voice coil actuators & capacitive sensors
  - High bandwidth control @ 1kHz
  - Design & qualification completed
  - Procurement and sub-assembly almost completed
  - Long-lasting SiC reference body lapping now completed allowing M4 Unit integration to proceed



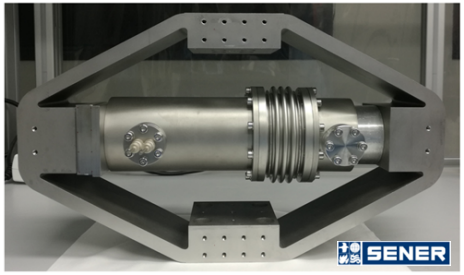


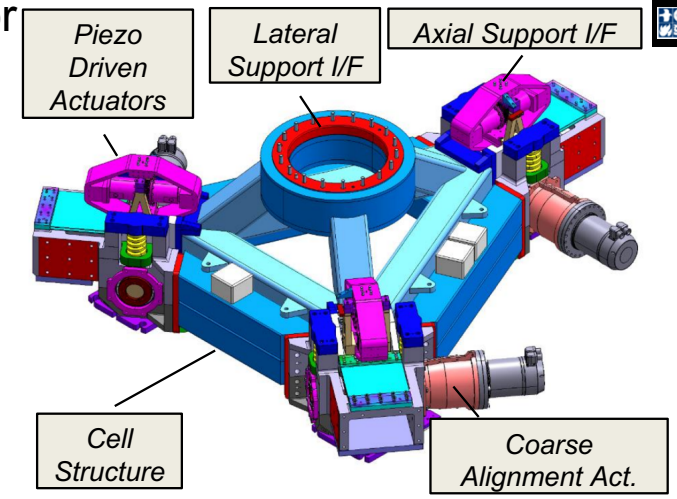


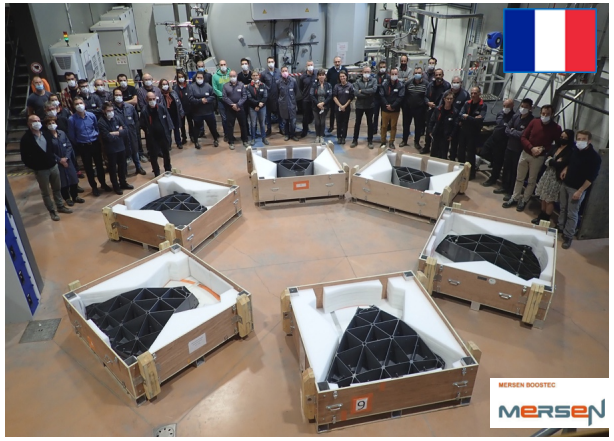


M5 Unit

- M5 mirror produced by Safran- Reosc (FR)
  - 2.7 x 2.3 m flat made of 6 sectors in SiC
  - Technical challenges: CVD coating & brazing (Boostec)
  - 6 sectors already manufactured and CVD coated
  - Ready for brazing before delivery to Reosc for polishing
- M5 Cell developed by SENER (SP)
  - Custom-designed Piezo act. for fast tip-tilt stabilisation
  - Final design and qualification about to be completed

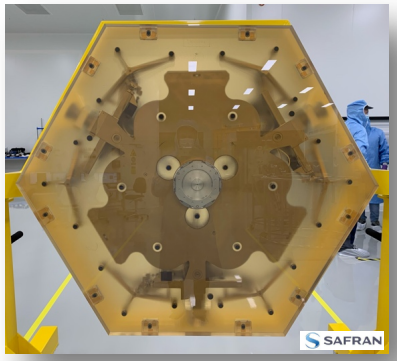


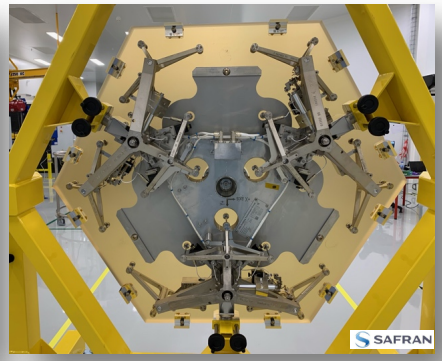


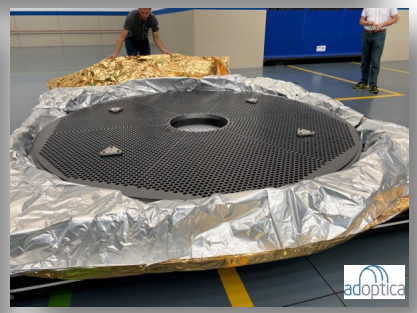


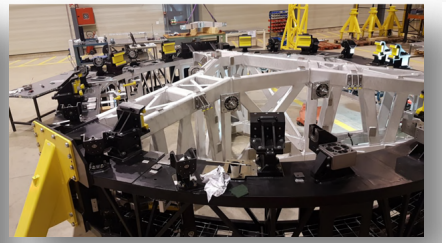
Armazones Construction Site (Oct. 2022)

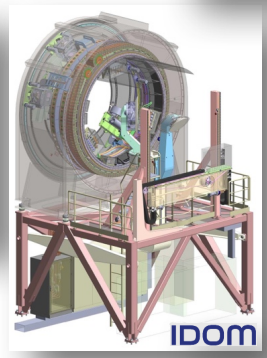
Much Hardware Already Produced

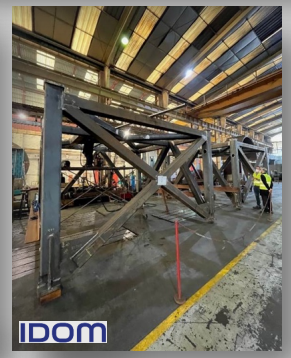


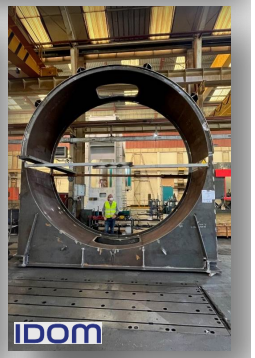


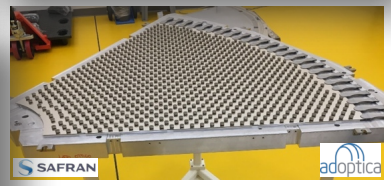


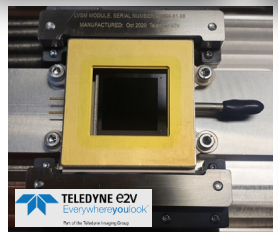












ELT First set of Instruments

HARMONI

- **3D spectrograph** (IFU)
- **Optical** (0.47 µm) to **NIR** (2.45 µm)
- Resolving power **R=3500 - 20000**
- **Image scales** 4mas to 60mas
- Final Design Review (**FDR**) on-going
  - FDR 1 (Mar 21) … FDR 5 (TBC)

METIS

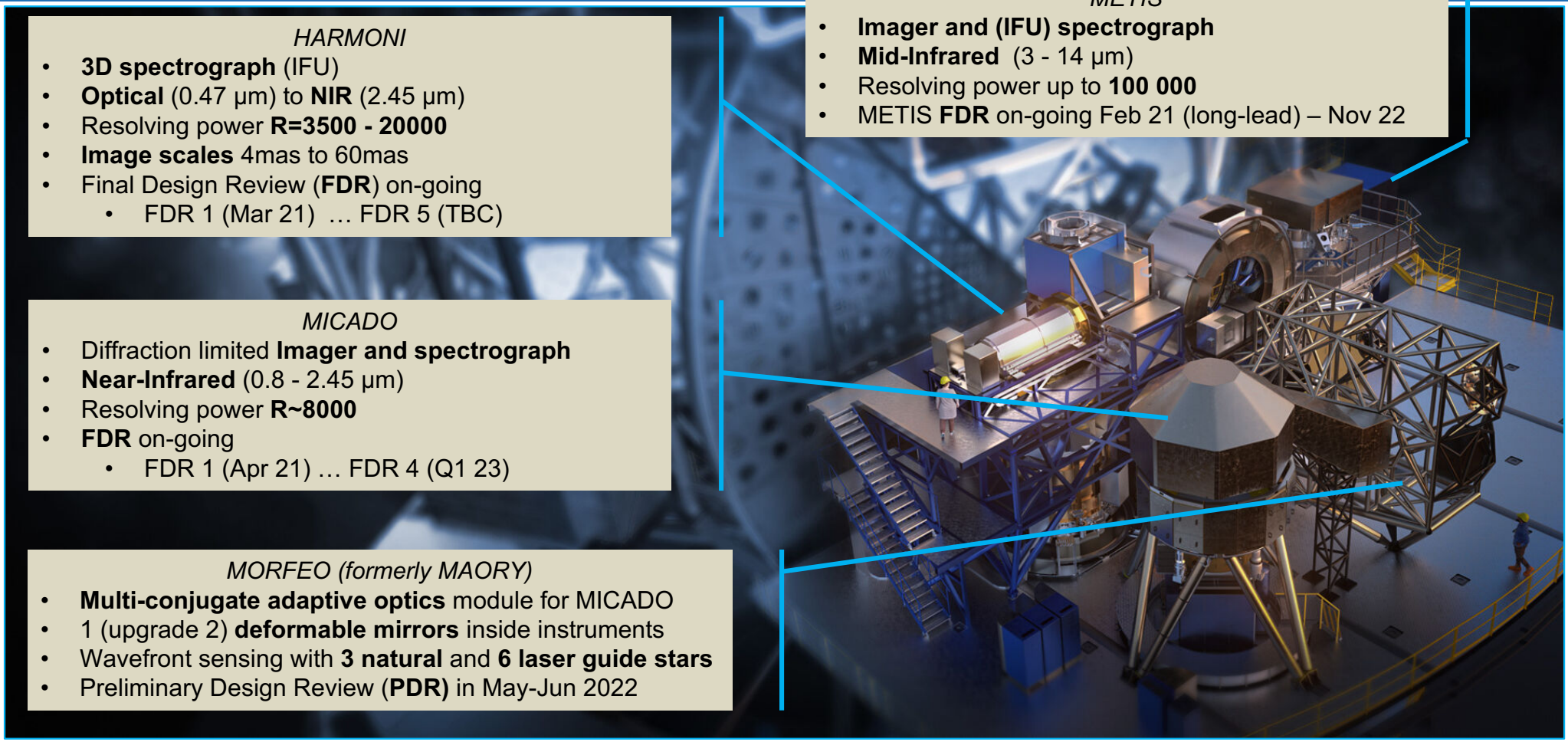
- **Imager and (IFU) spectrograph**
- **Mid-Infrared** (3 - 14 µm)
- Resolving power up to **100 000**
- METIS **FDR** on-going Feb 21 (long-lead) – Nov 22

MICADO

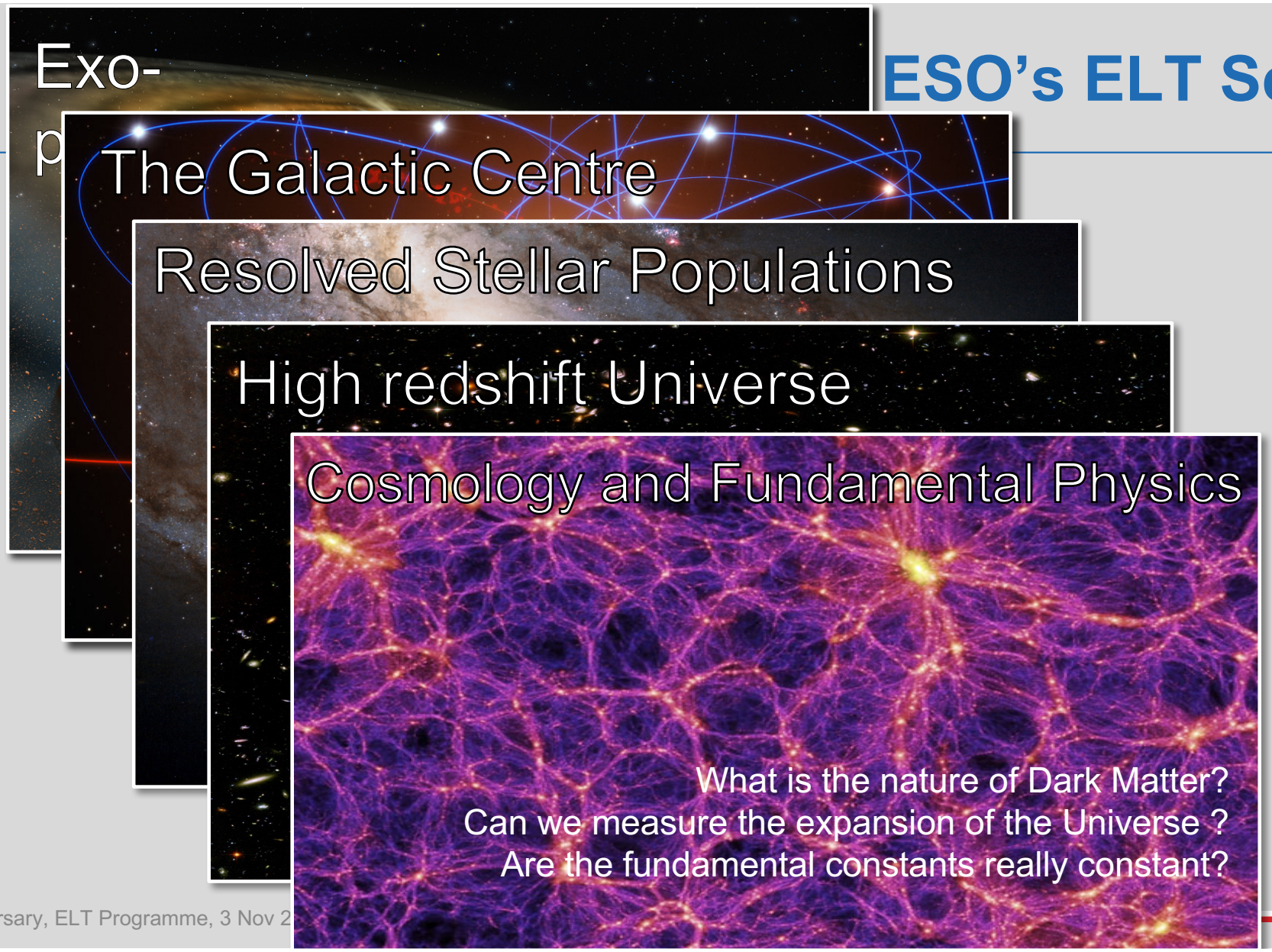
- Diffraction limited **Imager and spectrograph**
- **Near-Infrared** (0.8 - 2.45 µm)
- Resolving power **R~8000**
- **FDR** on-going
  - FDR 1 (Apr 21) … FDR 4 (Q1 23)

MORFEO (formerly MAORY)

- **Multi-conjugate adaptive optics** module for MICADO
- 1 (upgrade 2) **deformable mirrors** inside instruments
- Wavefront sensing with **3 natural** and **6 laser guide stars**
- Preliminary Design Review (**PDR)** in May-Jun 2022

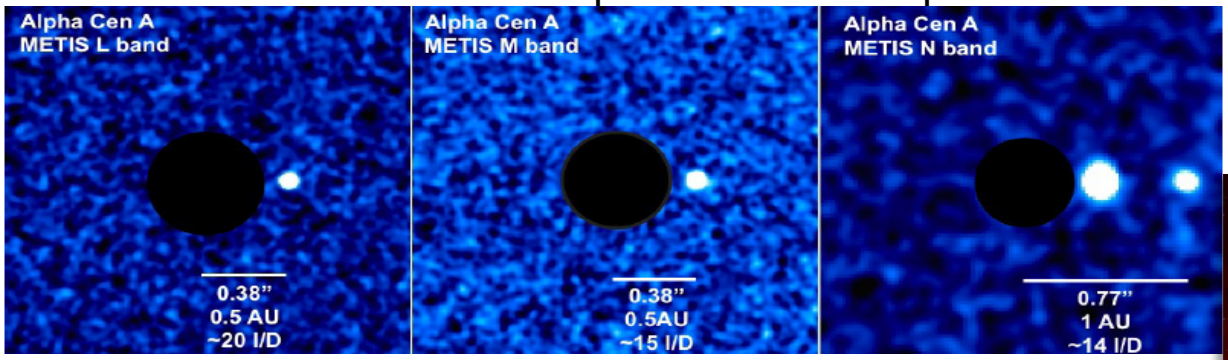


ESO's ELT Science

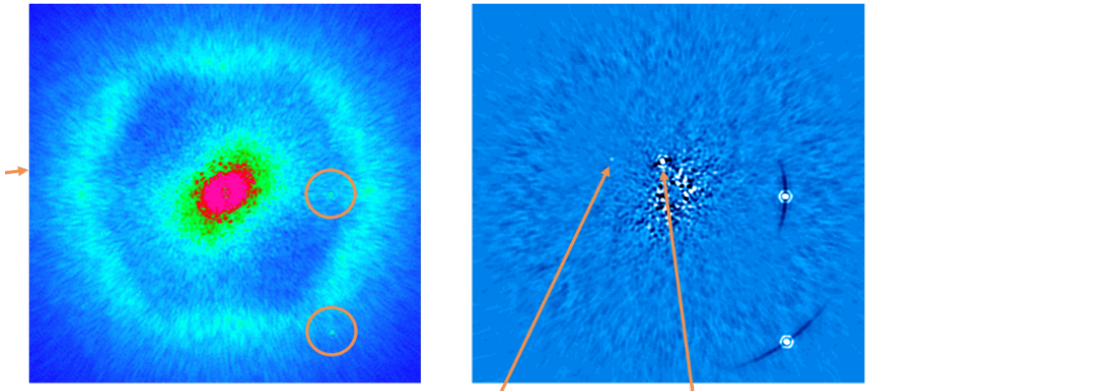


Exoplanets Detection and Characterization

METIS simulations of small planets around Alpha Cen A -



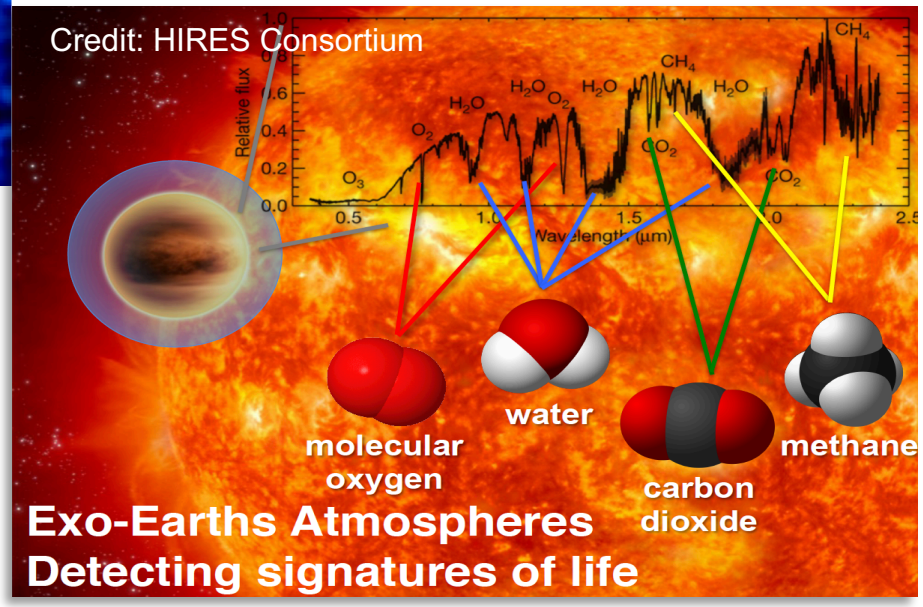
MICADO simulation



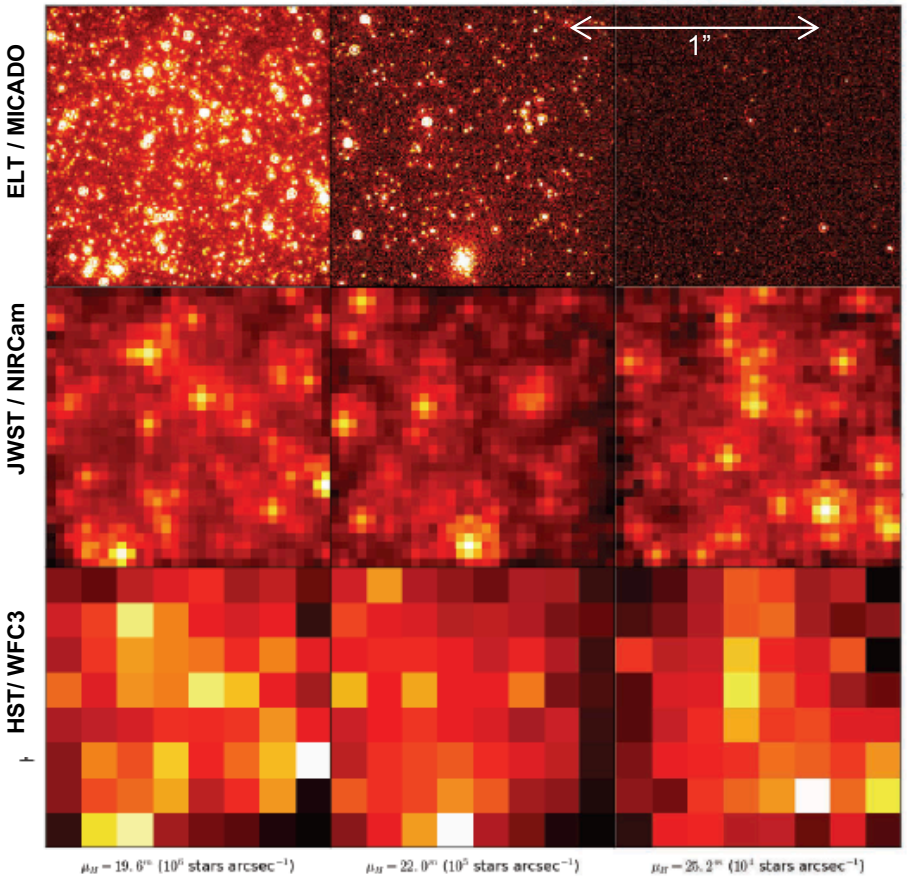
added exoplanet at 10 AU, 700 K, log(g)=4.

added exoplanet at 5 AU, 1300 K, log(g)=4.

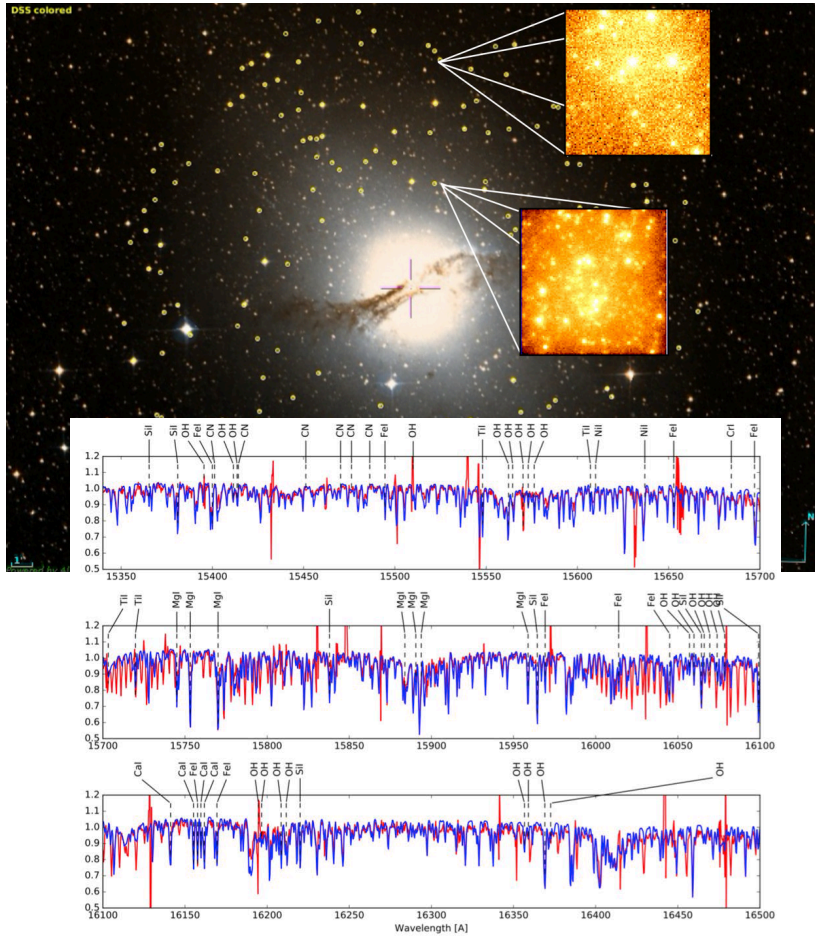
Credit: MICADO Consortium



Resolved Stellar Populations & Galactic Archaeology



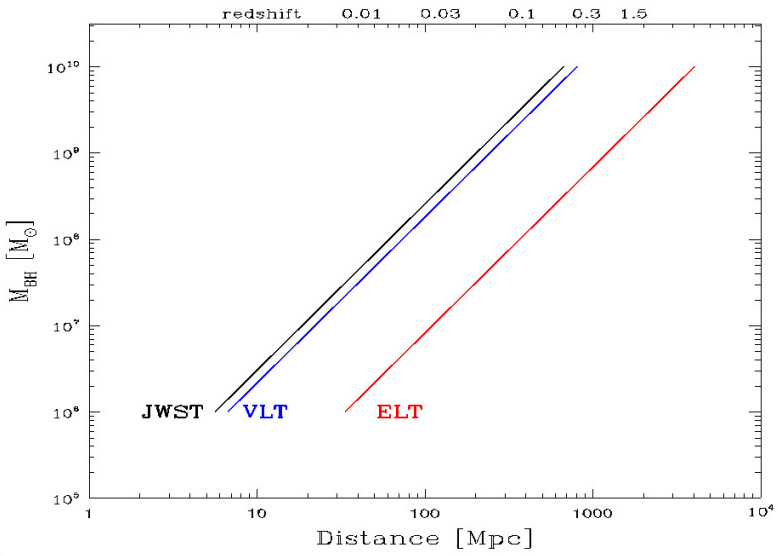
Credit: MICADO Consortium

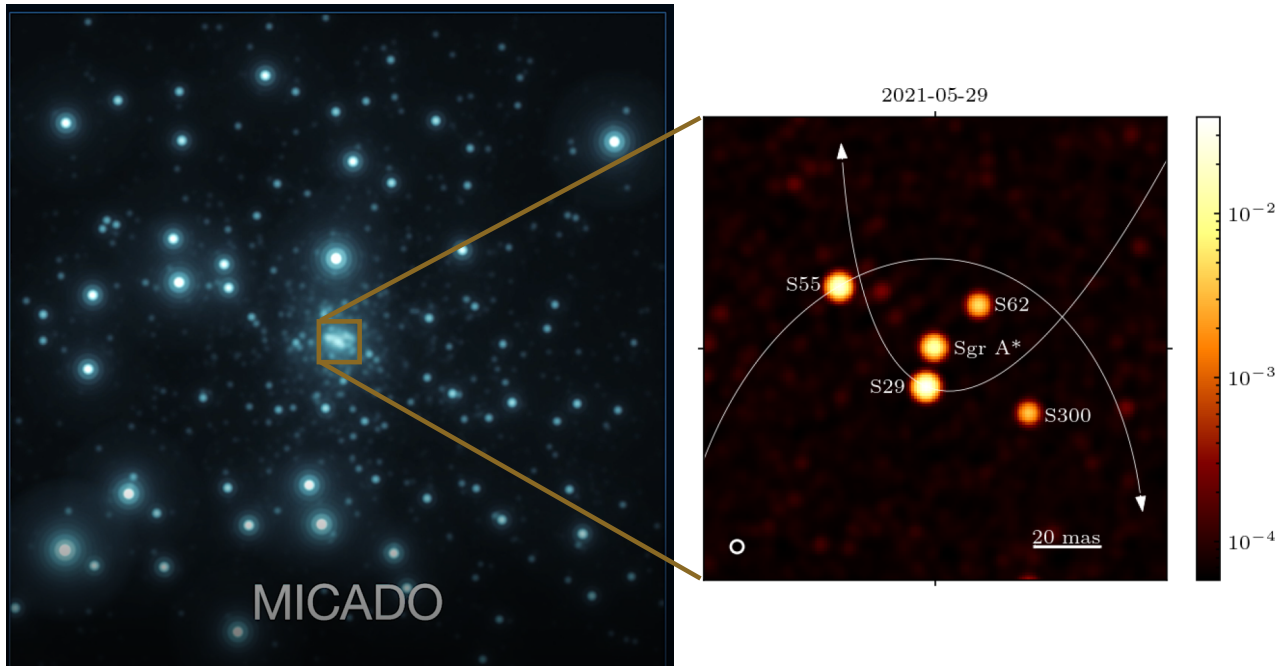


Credit: HARMONI Consortium

The Galactic Centre and Super-massive Black Holes

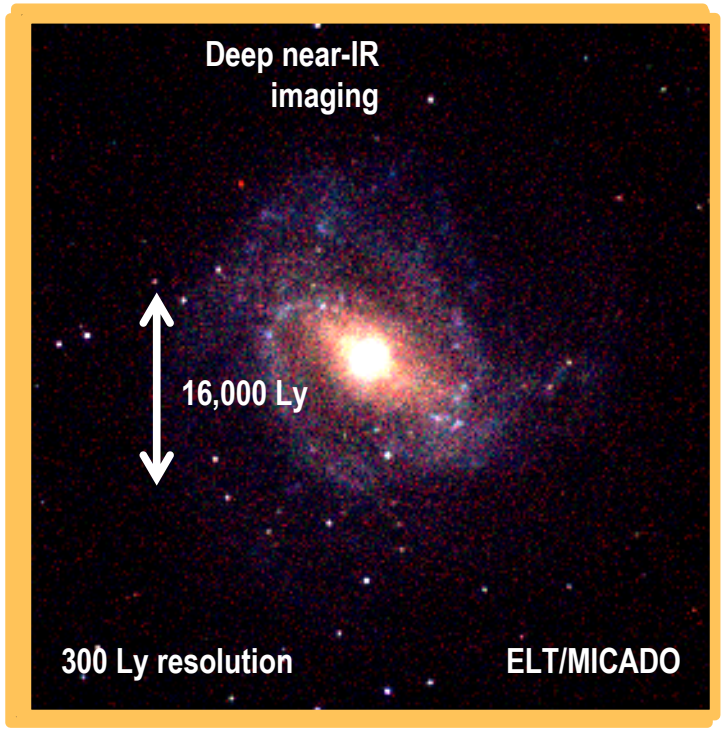
- ELT enables astrometry at <50 μarcsec.
- Trace stars at ~100 R_S around the BH in Galactic Centre
- Orbital velocities ~ 0.1c.
- Test post-Newtonian effects of SR and GR.
- SF in extreme environments.





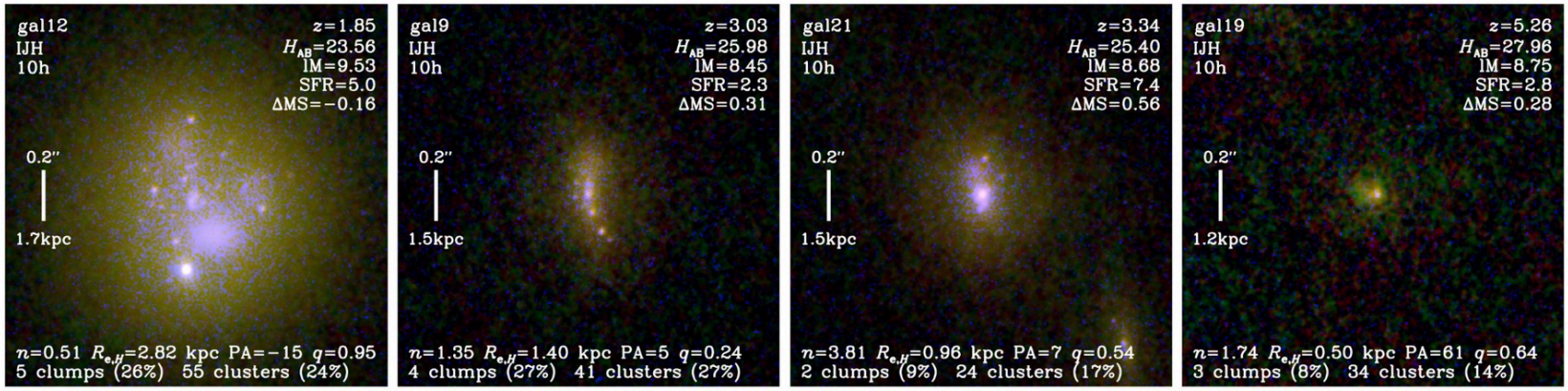
Credit: MICADO

Resolving Distant Galaxies on 100 Parsec Scales



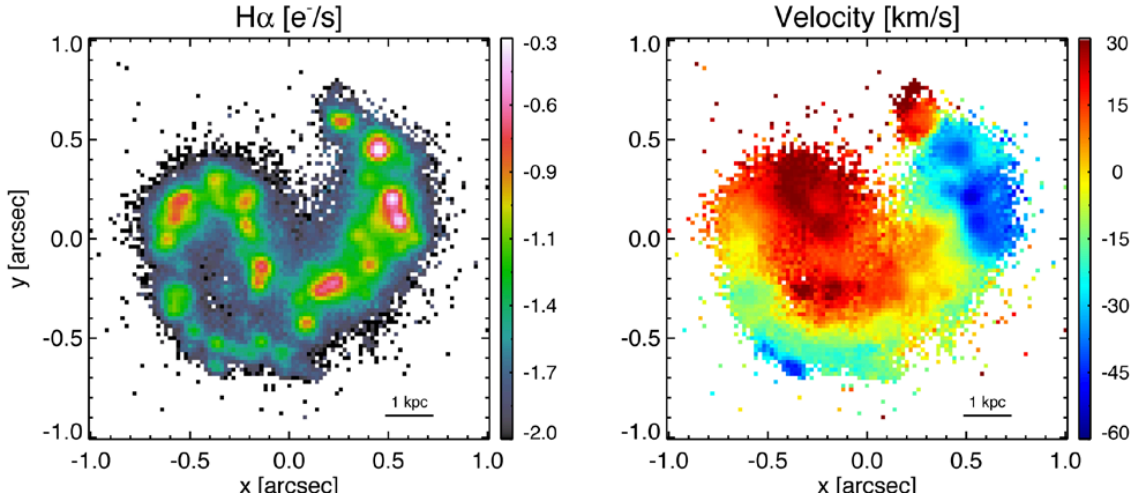
Credit: N. Förster Schreiber and
MICADO Consortium

The Distant Universe



Credit: MICADO Consortium

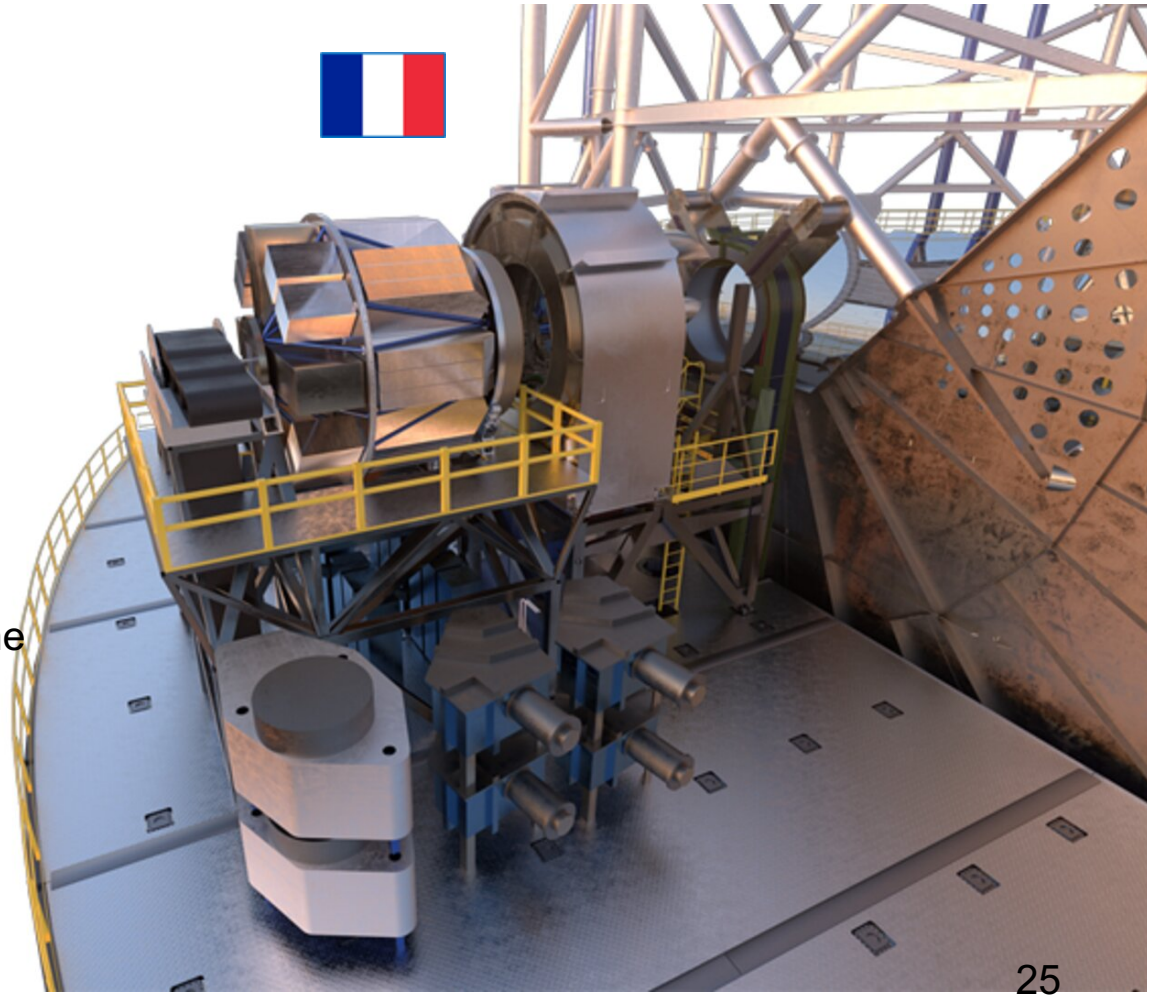
Dynamics and physics from spatially resolved spectroscopy



Credit: HARMONI Consortium

MOSAIC

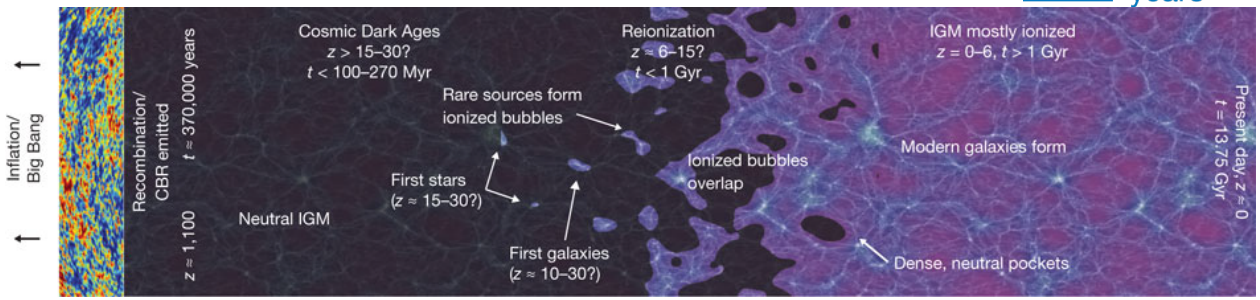
- Driving science requirements
  - First light galaxies
  - Inventory of matter
  - Mass assembly of galaxies
  - Resolved stellar population beyond the local group
- Technical Requirement specifications
  - **MOS**: a high multiplex mode (100-200 objects) covering both the VIS and NIR, both at low (R~5,000) and medium (R~20,000) spectral resolution
  - **mIFU**: a multi IFU mode (8-10 objects) covering the NIR channel in both low and medium spectral resolution
  - Parallel observations between VIS and NIR
  - GLAO

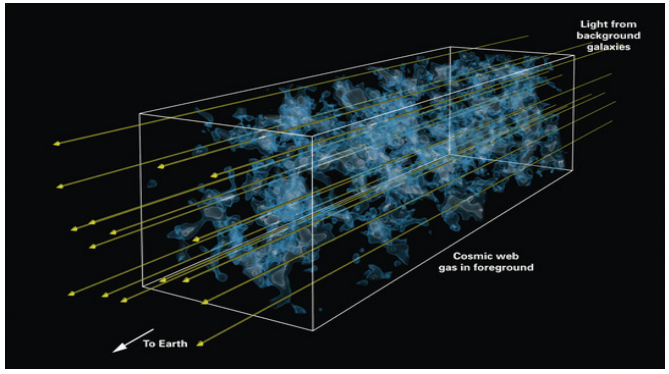


Science with MOSAIC

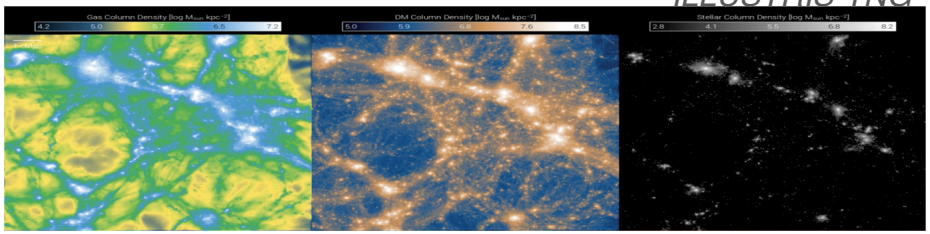
Dimensioning science cases:

- SC1. First light galaxies
- SC2. Inventory of matter
- SC3. Mass assembly of galaxies
- SC4. Resolved stellar population
- SC5. Galaxy archaeology
- SC6. Transients and multi-messenger

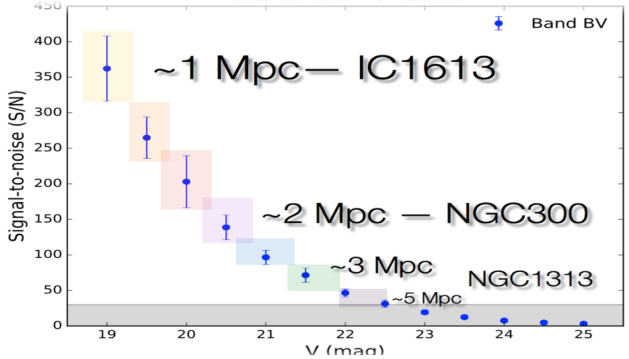




ILLUSTRIS-TNG



GAS DARK MATTER
STARS



Thank you!

Linda Tacconi

ESO Council President

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What have been the keys(s) to ESO's success?

- Strong and steady governance – funding agencies and astronomers work together in Council
- Striving for consensus
- Programmatic and financial stability
- Engagement with the community at all levels
- Partnership with MS institutes and scientists in instrument development
- Data archive – maximizing science output
- Collective power – greater than the sum of its parts