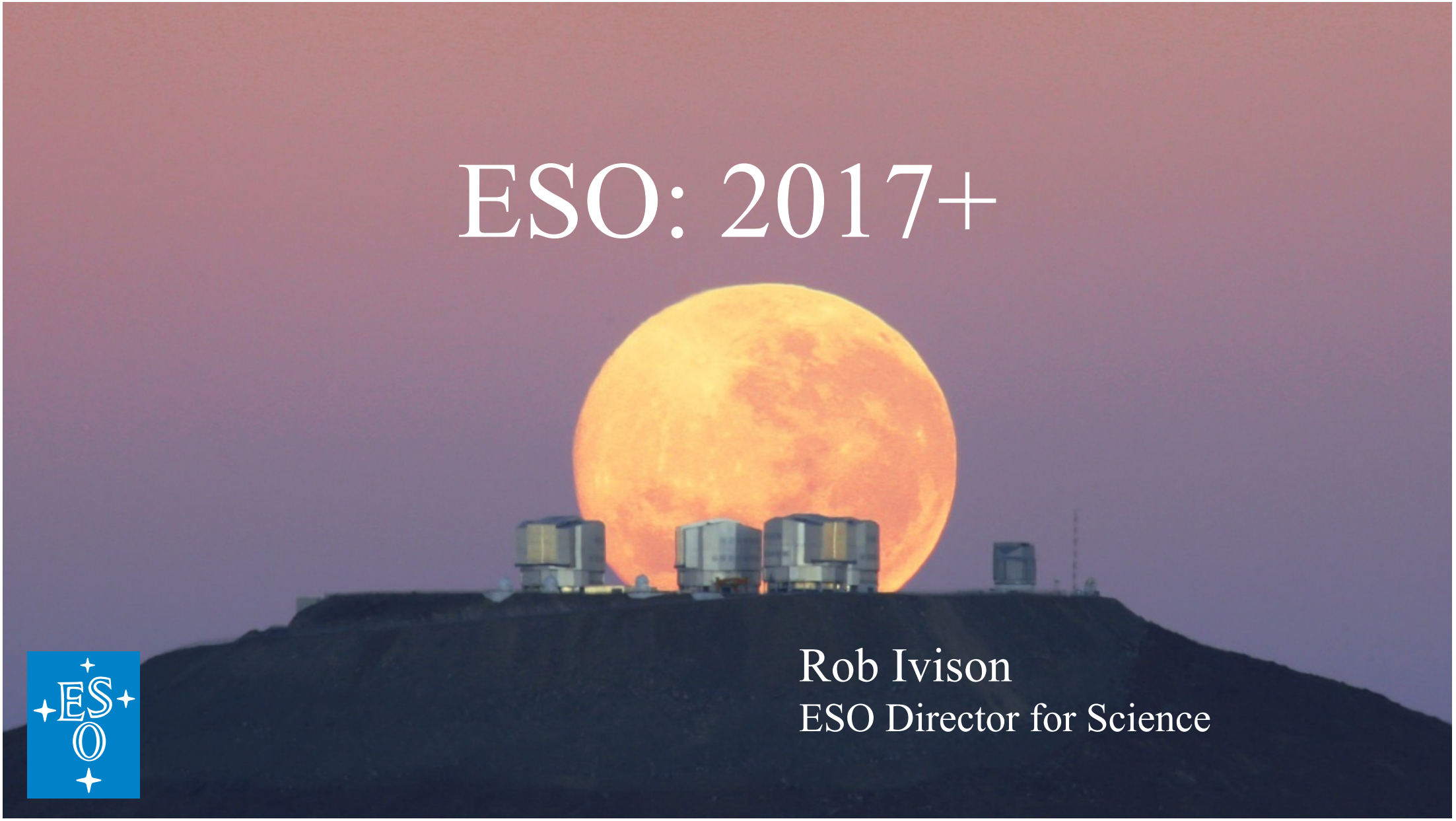
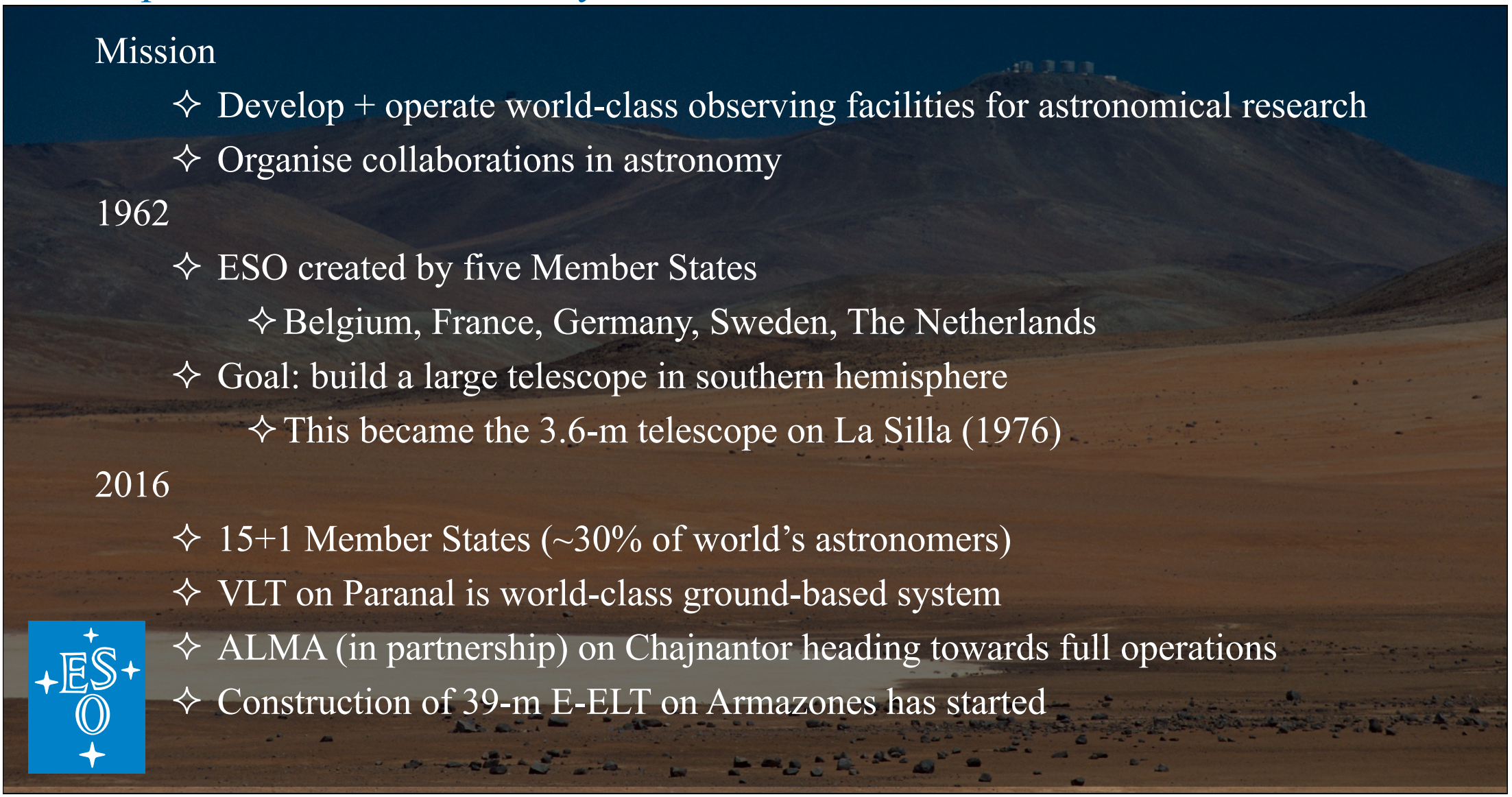
ESO: 2017+



Rob Ivison
ESO Director for Science

European Southern Observatory



Mission

- ✧ Develop + operate world-class observing facilities for astronomical research
- ✧ Organise collaborations in astronomy

1962

- ✧ ESO created by five Member States
  - ✧ Belgium, France, Germany, Sweden, The Netherlands
- ✧ Goal: build a large telescope in southern hemisphere
  - ✧ This became the 3.6-m telescope on La Silla (1976)

2016

- ✧ 15+1 Member States (~30% of world's astronomers)
- ✧ VLT on Paranal is world-class ground-based system
- ✧ ALMA (in partnership) on Chajnantor heading towards full operations
- ✧ Construction of 39-m E-ELT on Armazones has started

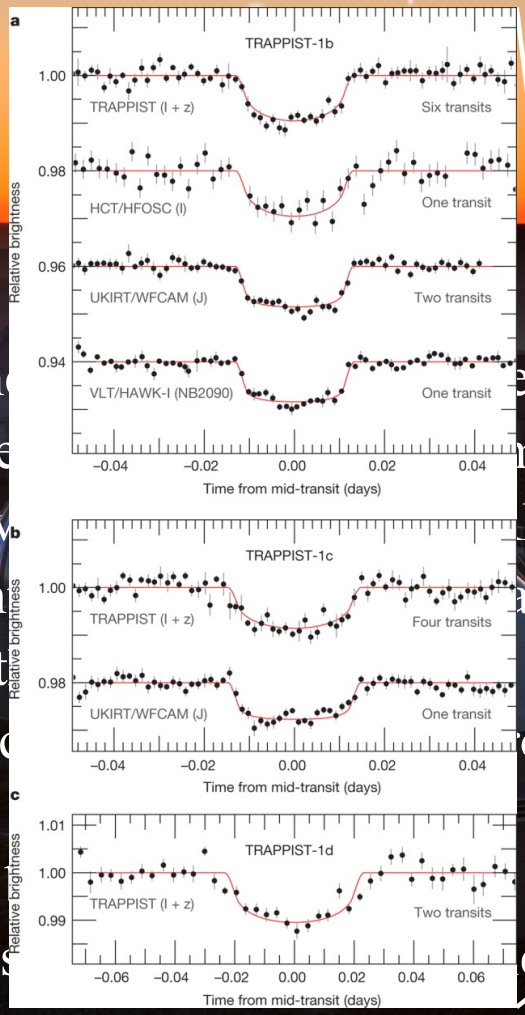
La Silla

New instrumentation

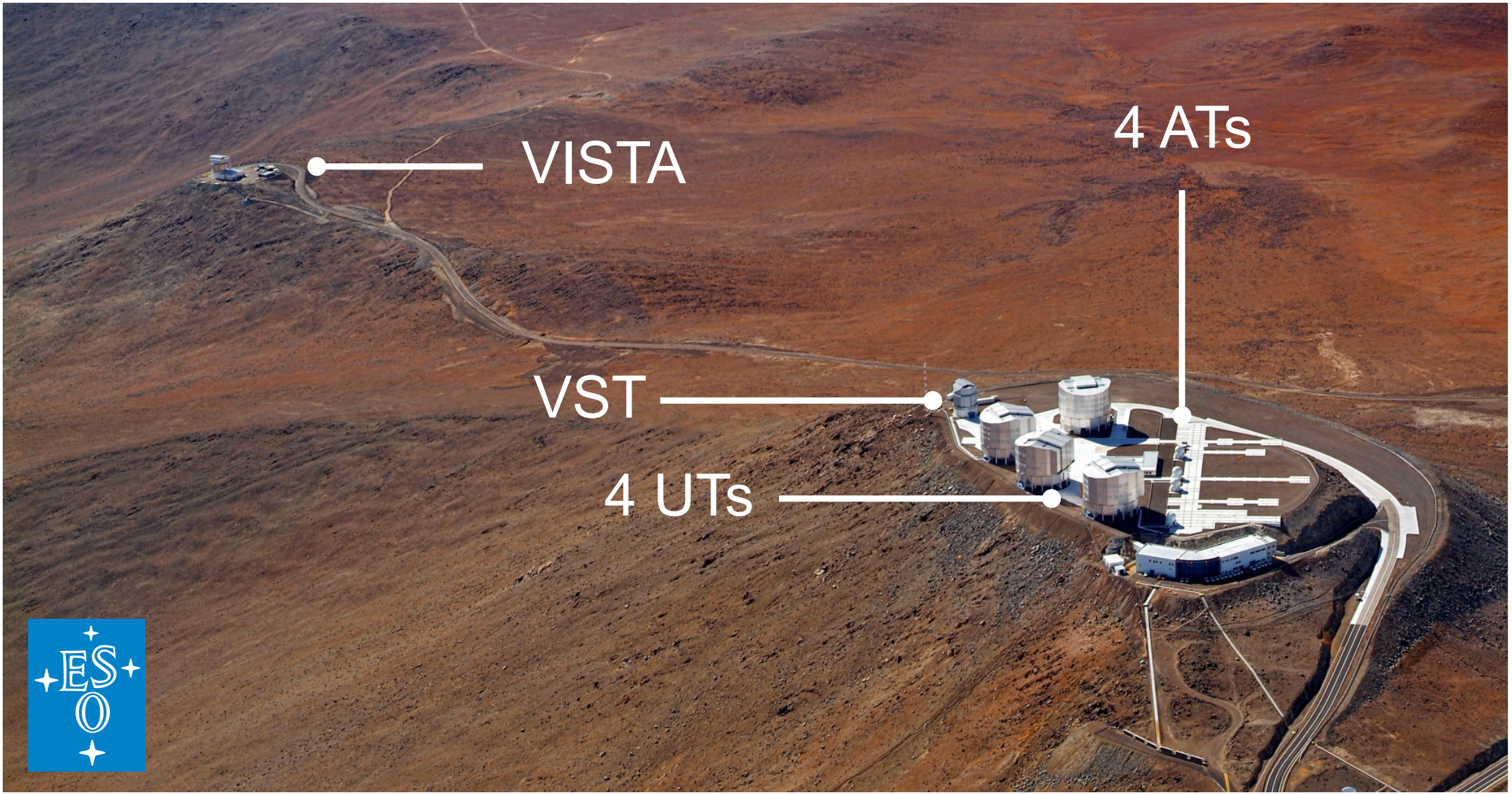
- ✧ 3.6-m strengthened furth esearch
  - ✧ HARPS laser freque m/s RVs
  - ✧ NIRPS GTO approv PS)
- ✧ NTT focused on transien a
  - ✧ SOXS selected for t
- ✧ Should ensure exciting sc o' 2025+

Small telescopes/robots operated

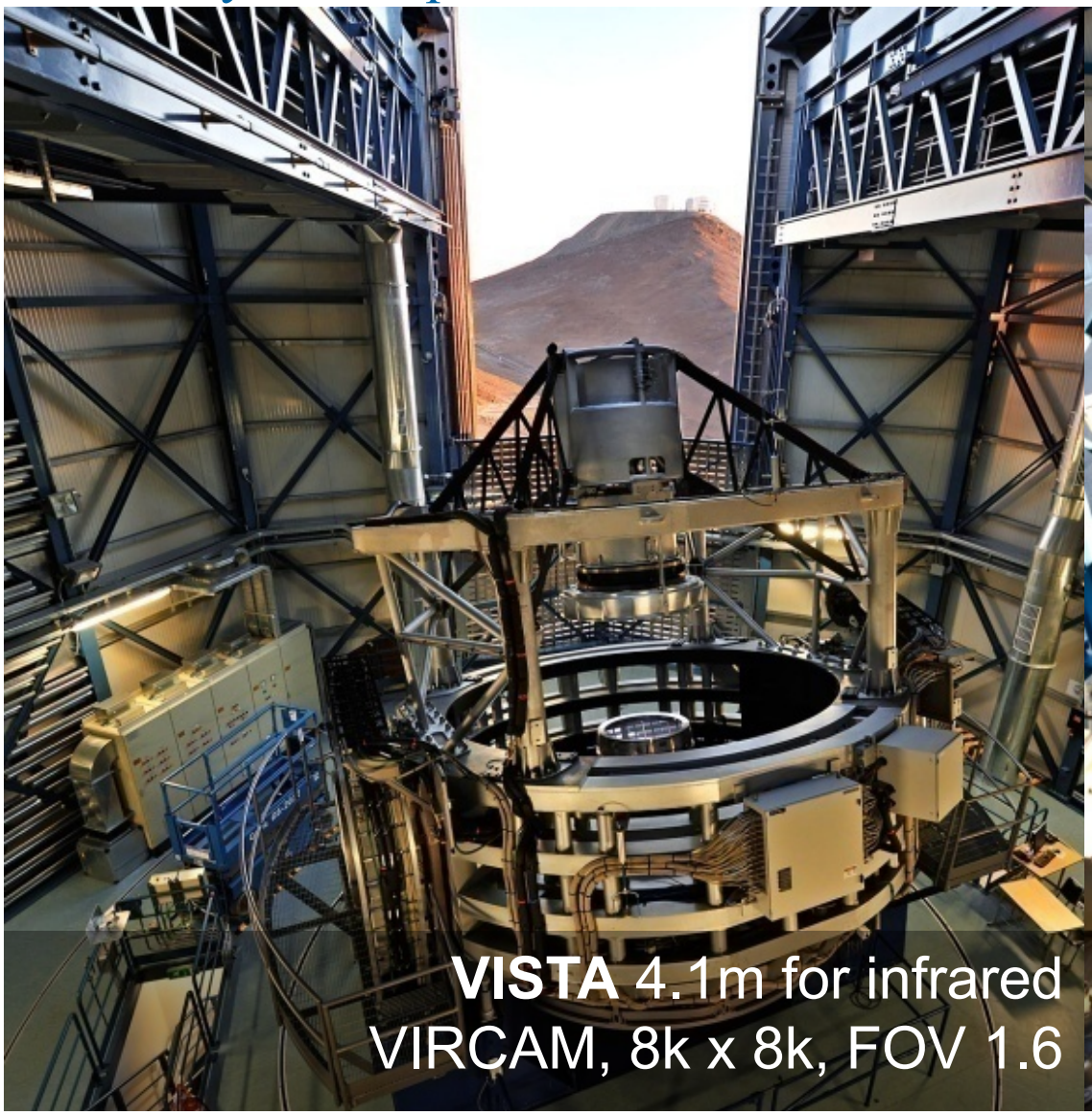
- ✧ 2.2-m MPG, 1.5-m Danis er, TRAPPIST, ExTrA, MASCARA, BlackGEM, …



Paranal



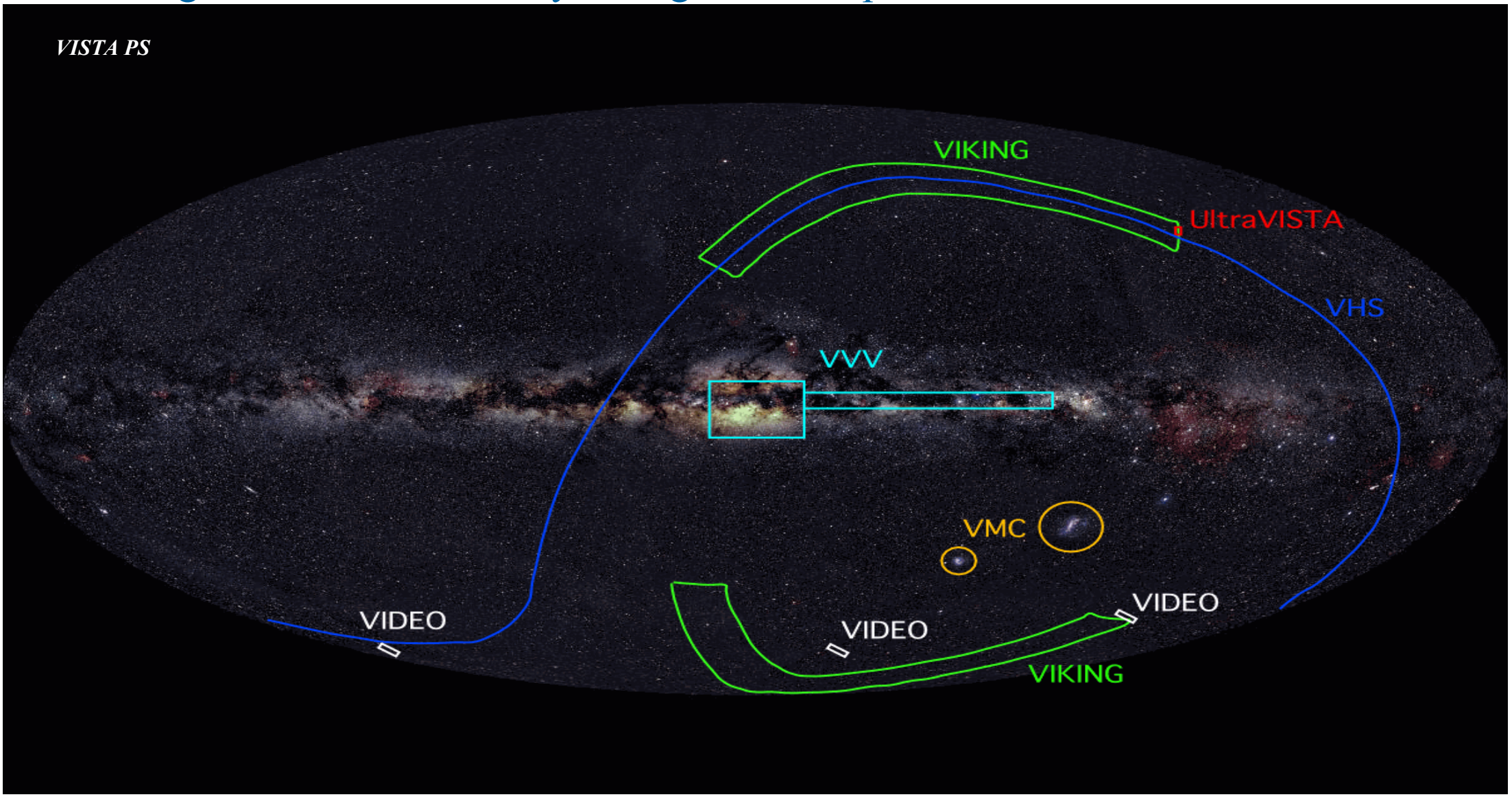
Survey telescopes



VISTA 4.1m for infrared
VIRCAM, 8k x 8k, FOV 1.6

VST 2.6m for optical
OmegaCAM, 16k x 16k, FOV 1.0

Existing VISTA Public Surveys – began 2010 April



Existing VISTA Public Surveys – began 2010 April

Survey	Science topic	Area (deg^2)	Filters	Magnitude limits	Observing time completed (hrs) to April 1st 2016
Ultra-VISTA http://home.strw.leidenuniv.nl/~ultravista/	Deep high z	1.7 deep 0.73 ultra deep	Y J H Ks NB118	25.7 25.5 25.1 24.5 26.7 26.6 26.1 25.6 26.0	1598
VHS http://www.ast.cam.ac.uk/~rgm/vhs/	Full accessible sky	17800	Y J H Ks	21.2 21.1 20.6 20.0	3730
VIDEO http://www-astro.physics.ox.ac.uk/~video	Moderately deep high z	12	Z Y J H Ks	25.7 24.6 24.5 24.0 23.5	1483
VVV http://vvvsurvey.org/	Galactic MW	560	Z Y J H Ks	21.9 21.1 20.2 18.2 18.1	2157/Completed
VIKING http://www.astro-wise.org/projects/VIKING/	Extragalactic	1500	Z Y J H Ks	23.1 22.3 22.1 21.5 21.2	2194/Completed
VMC http://star.herts.ac.uk/~mcioni/vmc/	Resolved SFH	180	Y J Ks	21.9 21.4 20.3	1529

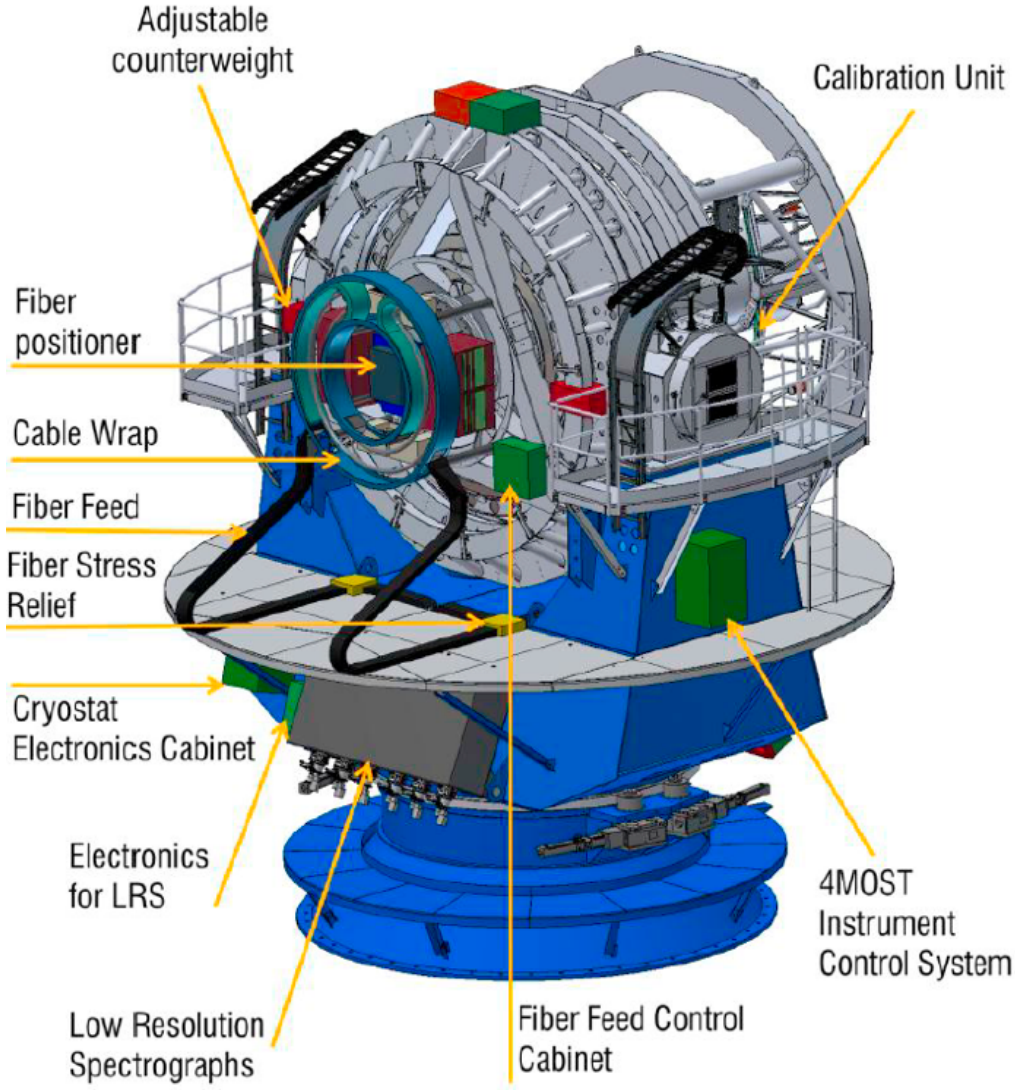
New VISTA Public Surveys – to begin 2017 April

Survey name P.I.	Short Title	Filters	Time (hrs)	Area (deg^2)
GW; Tanvir	Kilonova counterparts to Gravitational wave sources	Y J Ks	420	(10)
UltraVISTA; Dunlop	Completing the legacy of UltraVISTA	J H Ks	756	0.75
VVVX; Minniti	Extending VVV to higher Gal lat.	J H Ks	1900	1700
VEILS; Banerji	VISTA Extragalactic Infrared Survey	J Ks	1180	12
CAV; Nonino	Clusters at VIRCAM	Y J Ks	560	72
VISIONS; Alves	VISTA star formation atlas	J H Ks	553	70.5
SHARKS; Oteo	Southern Herschel-Atlas Regions K-band survey	Ks	1200	300

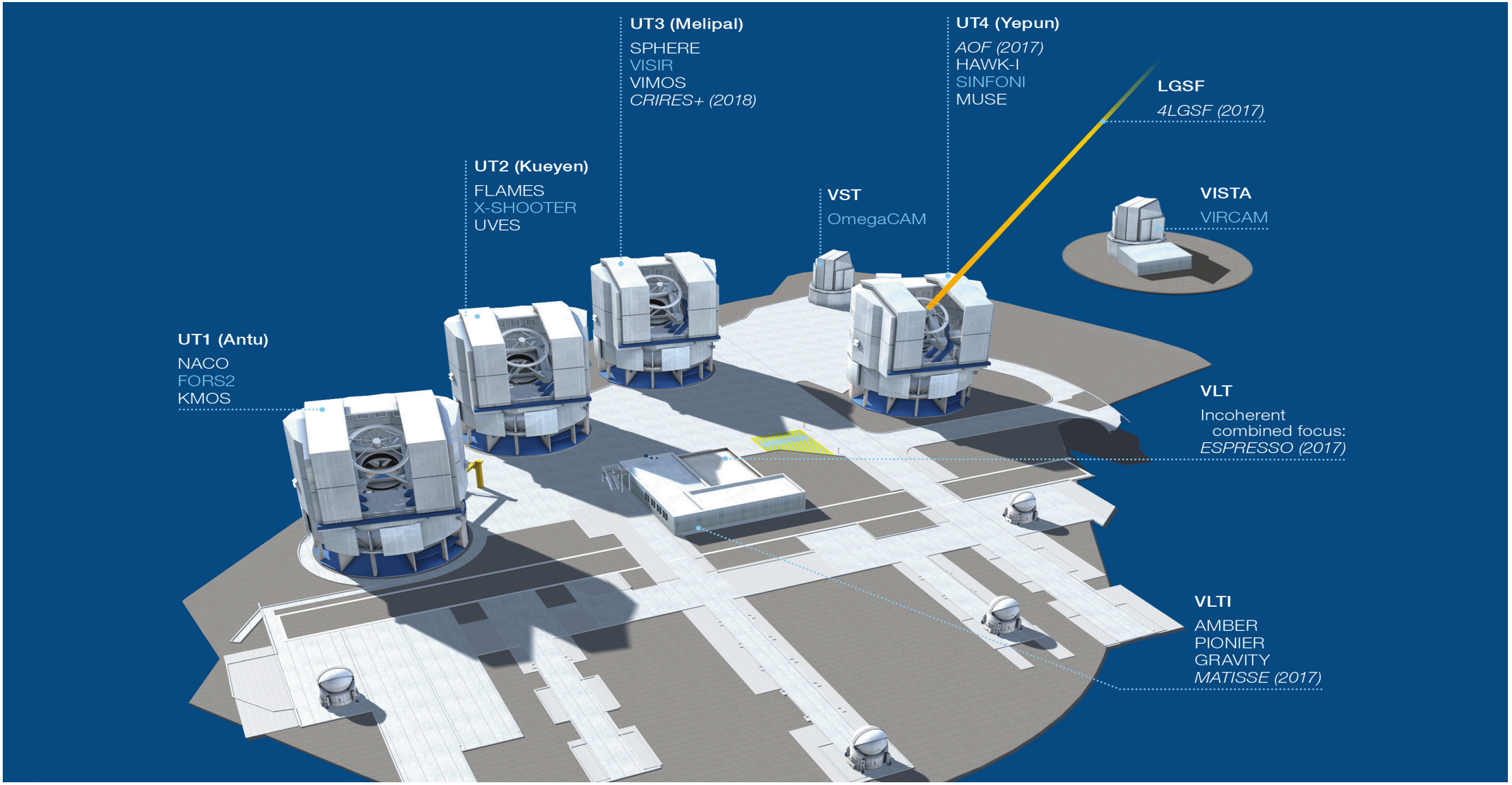
- Second cycle of VISTA surveys; ESO Call in 2015
- 13 LoI submitted by community, oversubscription >2x
- 7 proposals selected by PSP, approved by OPC, then by DG

4MOST

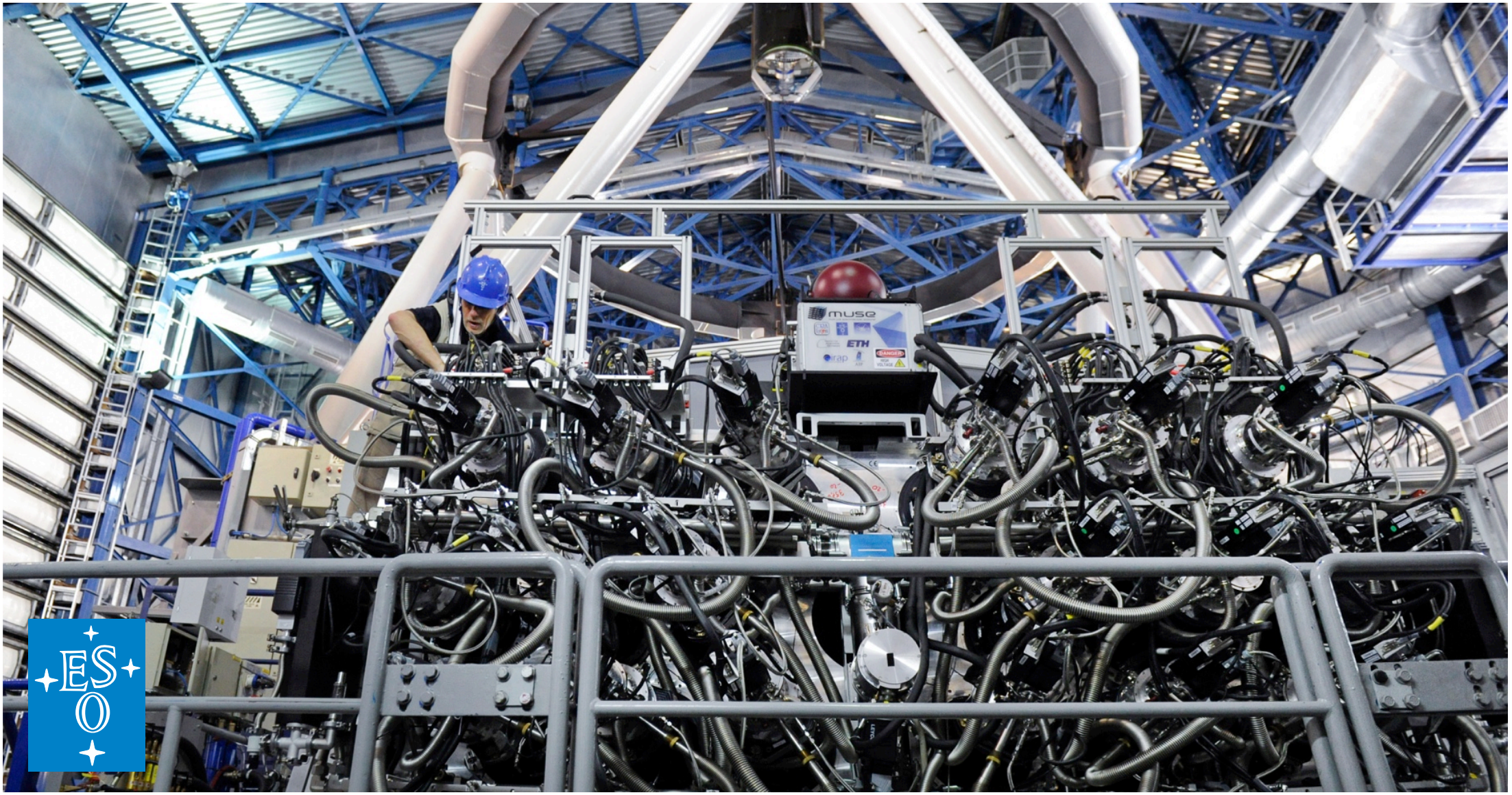
- PI Roelof de Jong – AIP
- World-class fibre-fed MOS
  - Cassegrain focus of VISTA
  - large field of view (> 4 deg^2)
  - spectral resolutions (LRM: R>5,000, HRM: R>18,000) for both Galactic and extragalactic applications
  - high multiplex (>700 LRM, >700 HRM)
    - 1500 fibres, goal 2200
  - broad coverage in LRM (400-885 nm)
  - 393-435, 521-571, 610-675 nm in HRM
- PAC 2021



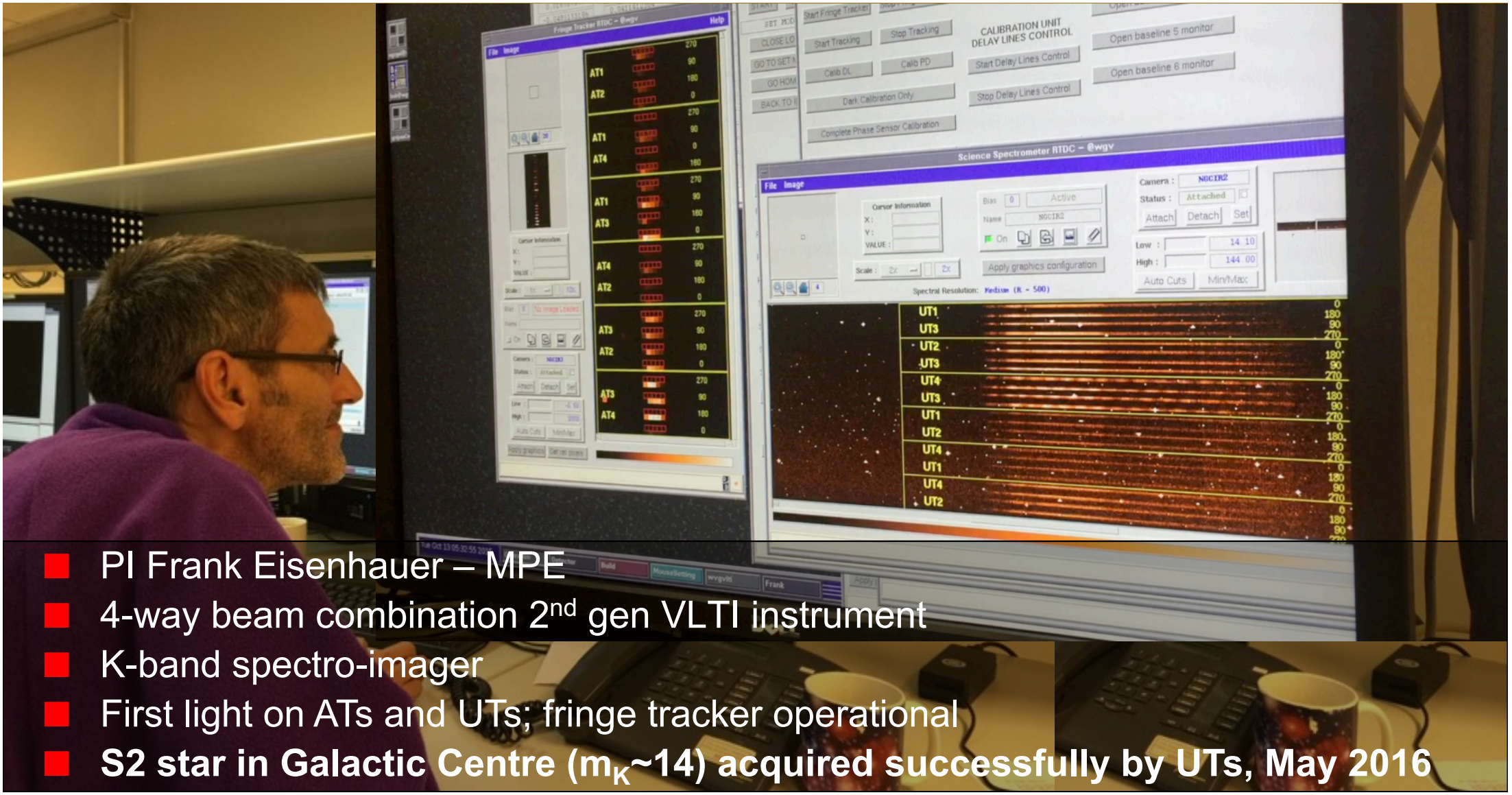
Integrated system



MUSE



GRAVITY

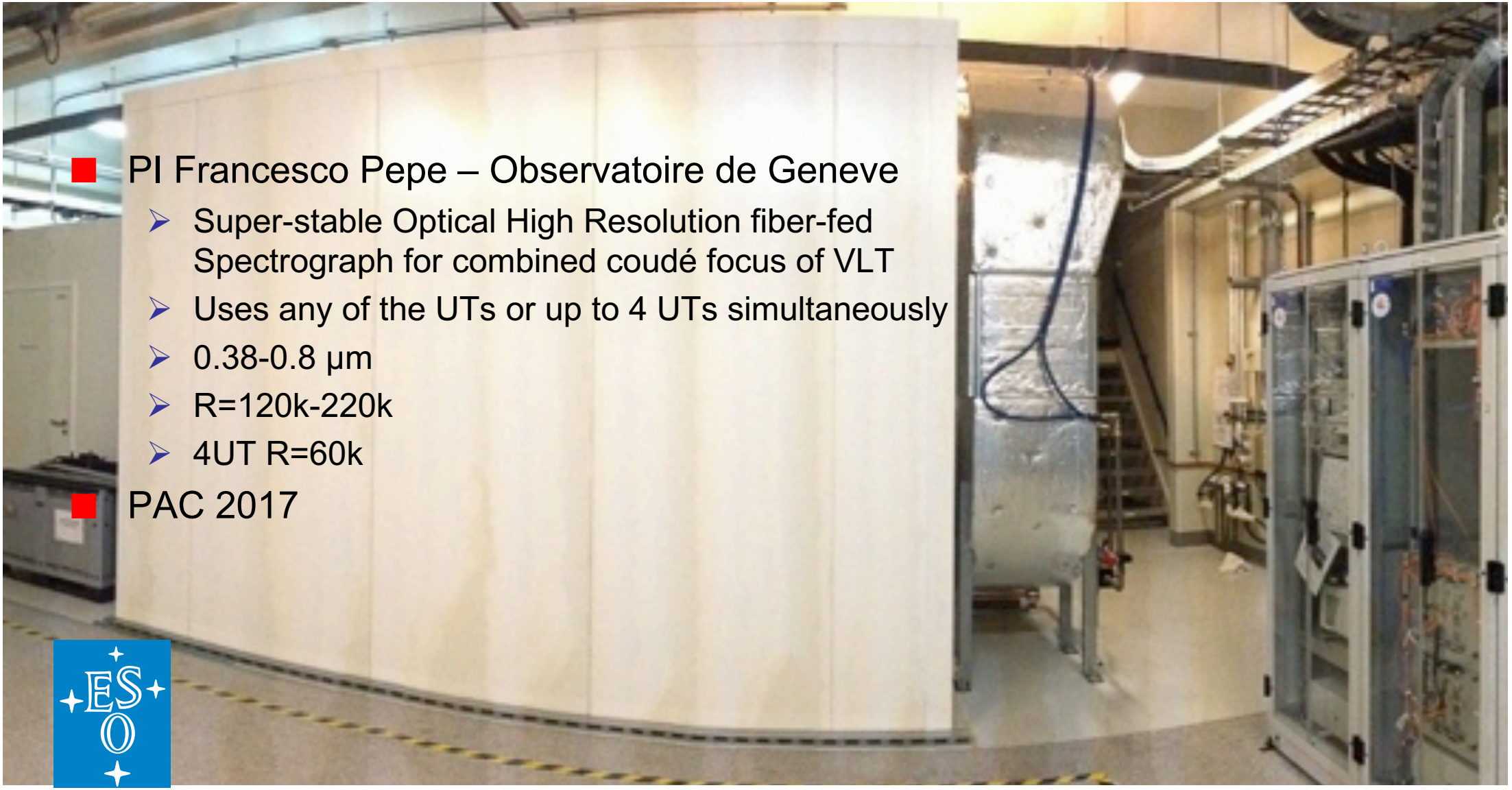


- PI Frank Eisenhauer – MPE
- 4-way beam combination 2nd gen VLTI instrument
- K-band spectro-imager
- First light on ATs and UTs; fringe tracker operational
- **S2 star in Galactic Centre (m_K~14) acquired successfully by UTs, May 2016**

AOF

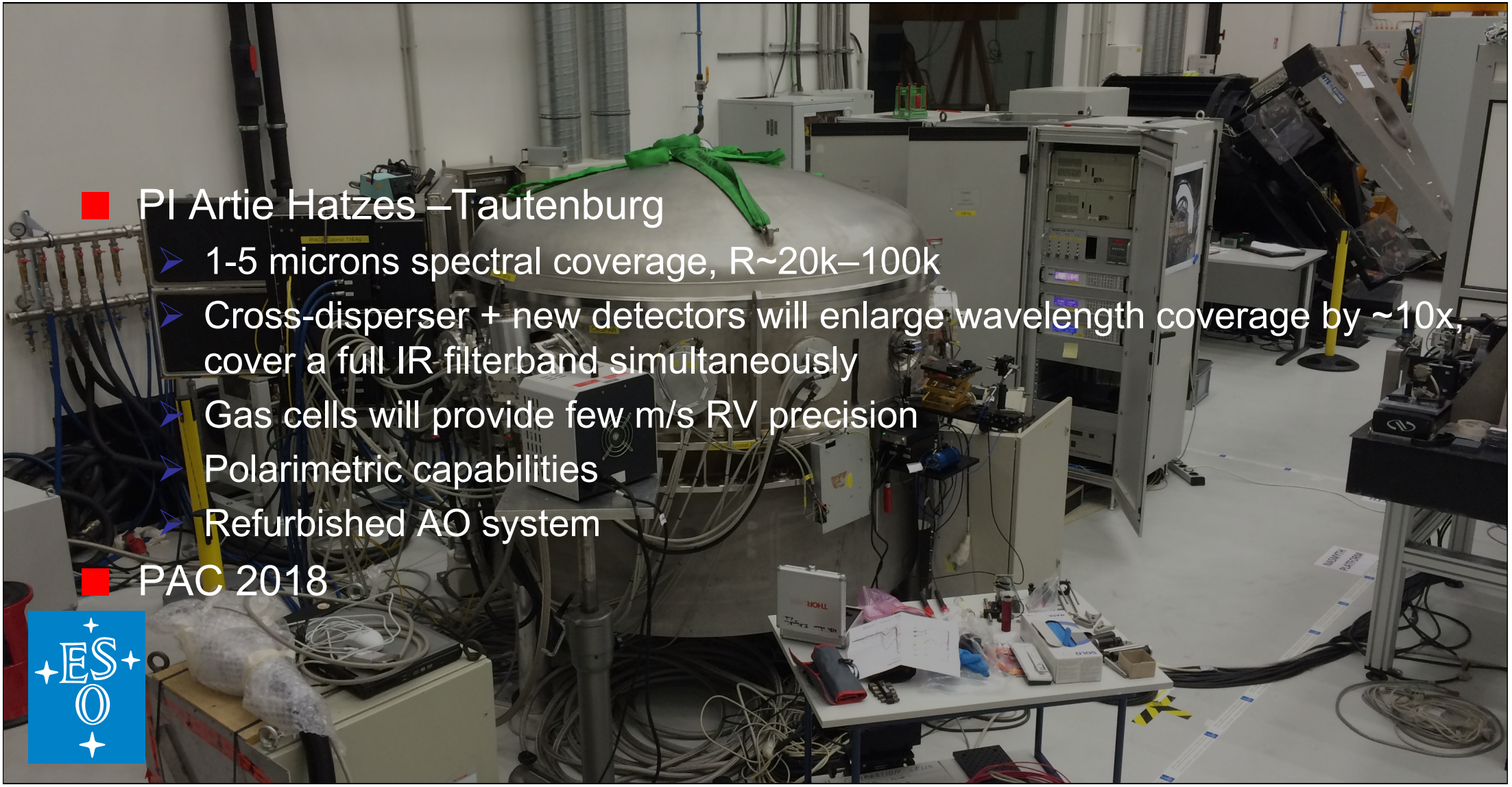
- Upgrade UT4 with an Adaptive Secondary mirror (1170 actuators) & Four Laser Guide Stars
- GALACSI – feeds MUSE
  - Two fields of view: 1 arcmin for Ground Layer AO
    - gain of 2 in ensquared energy at 750nm
  - 7.5” FOV for Laser Tomography AO
    - moderate Strehl ratio in the visible (>5% @ 650 nm) on-axis
- GRAAL – feeds HAWK-I
  - GLAO: x2 in ensquared energy at K over the 7.5 arcmin FoV
- PAC 2017-8

ESPRESSO - Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations



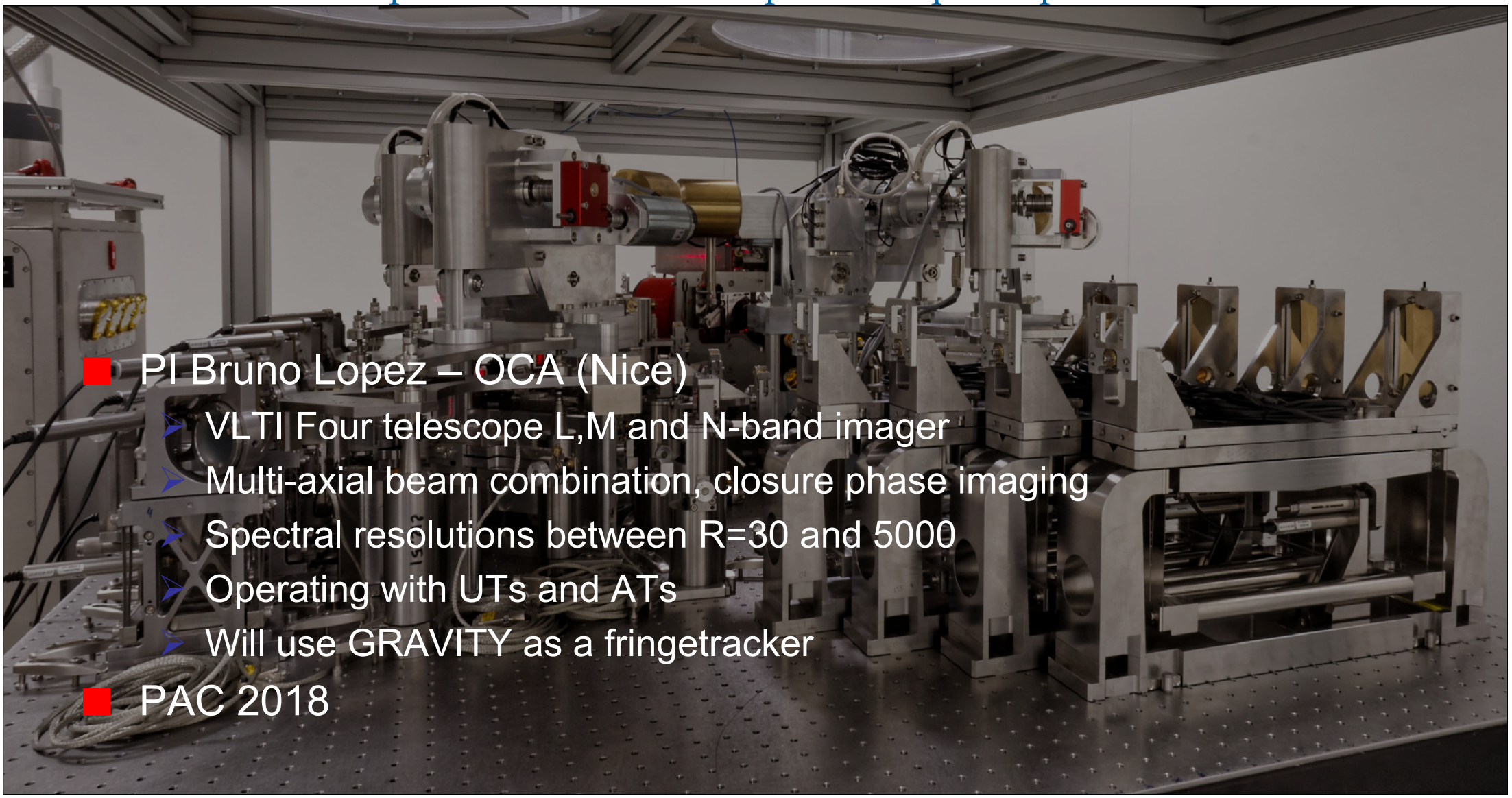
- PI Francesco Pepe – Observatoire de Geneve
  - Super-stable Optical High Resolution fiber-fed Spectrograph for combined coudé focus of VLT
  - Uses any of the UTs or up to 4 UTs simultaneously
  - 0.38-0.8 μm
  - R=120k-220k
  - 4UT R=60k
- PAC 2017

CRIRES+



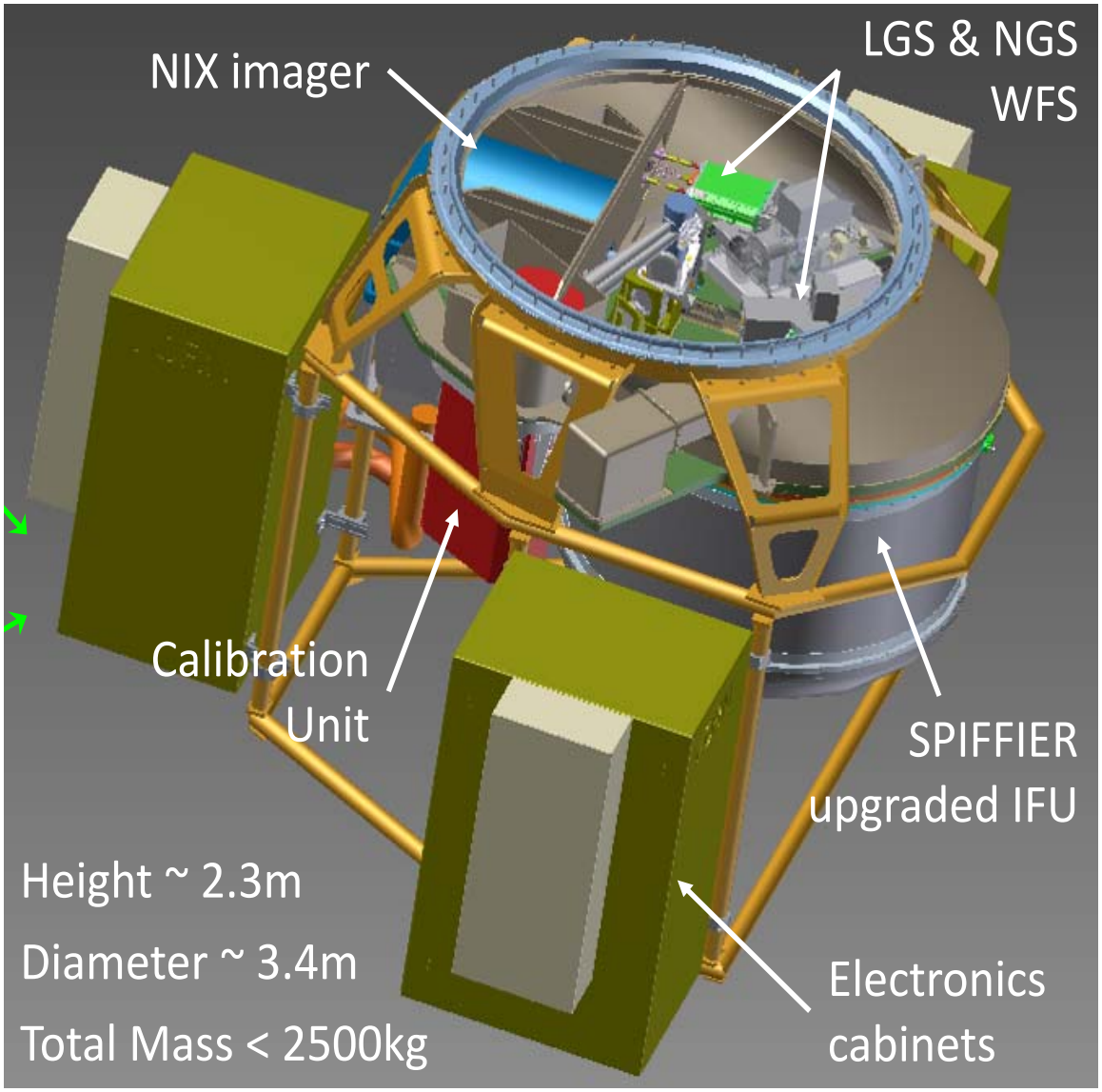
- PI Artie Hatzes –Tautenburg
  - 1-5 microns spectral coverage, R~20k–100k
  - Cross-disperser + new detectors will enlarge wavelength coverage by ~10x, cover a full IR filterband simultaneously
  - Gas cells will provide few m/s RV precision
  - Polarimetric capabilities
  - Refurbished AO system
- PAC 2018

MATISSE - Multi-Aperture mid-Infrared SpectroScopic Experiment



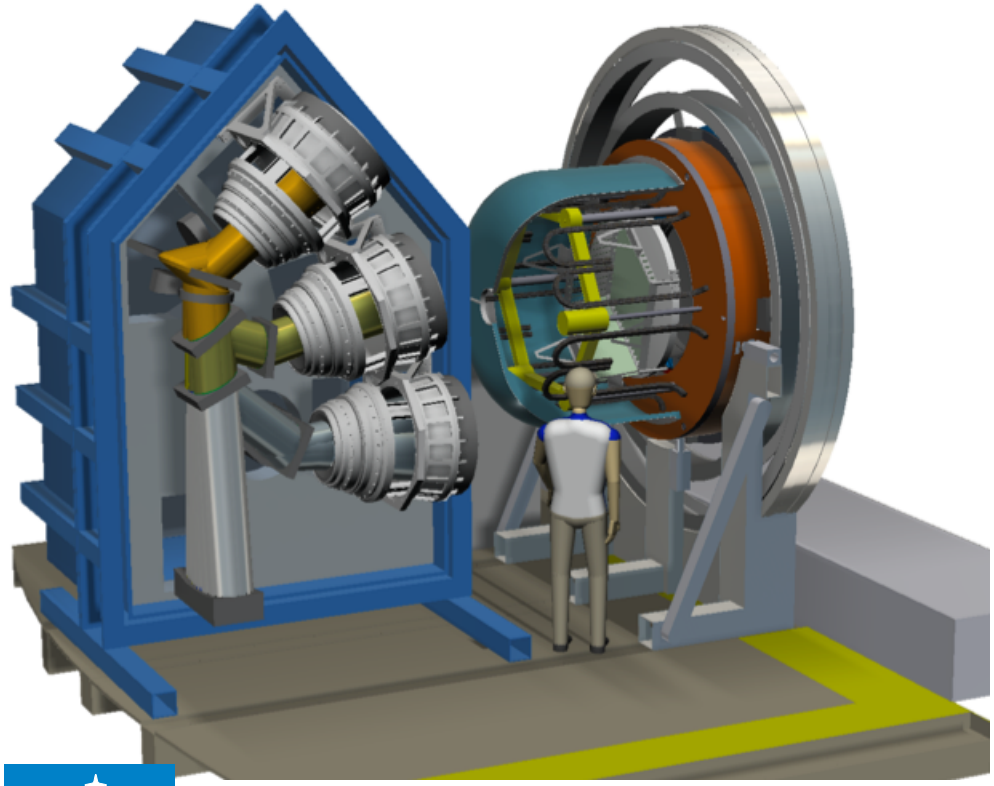
- PI Bruno Lopez – OCA (Nice)
  - VLTI Four telescope L,M and N-band imager
  - Multi-axial beam combination, closure phase imaging
  - Spectral resolutions between R=30 and 5000
  - Operating with UTs and ATs
  - Will use GRAVITY as a fringetracker
- PAC 2018

ERIS

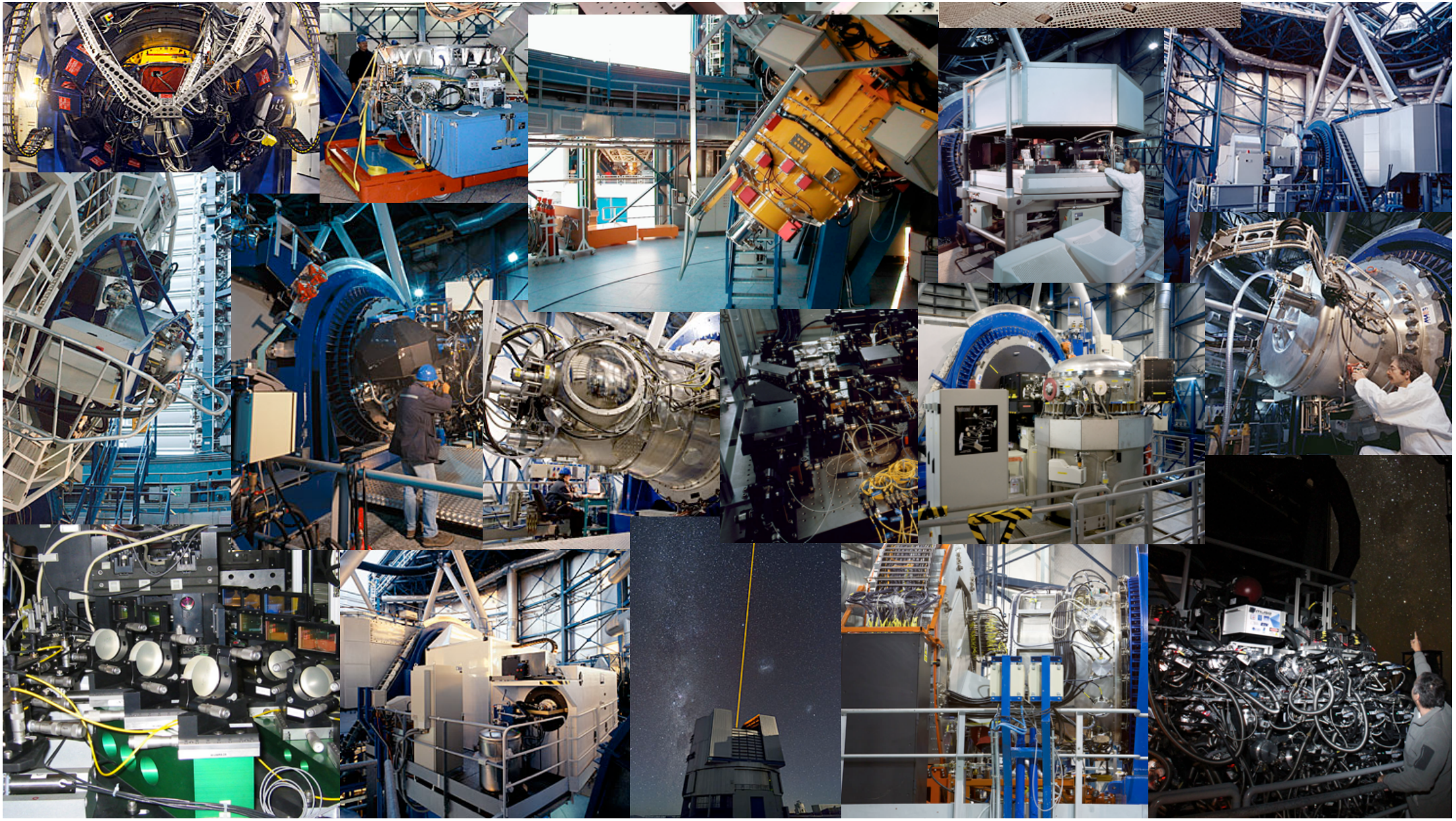


- PI Ric Davies – MPE
- SPIFFI Integral field spectroscopy
  - FoV 0.8”, 3.2”, 8”
  - R~3000 & 8000; J-K bands
- NIX
  - J-K narrow/broad bands;
  - 13/27 mas pix (26”/55” FoV)
  - L-M broadbands; 27mas pix (55” FoV)
- High-contrast imaging
  - Pupil plane coronagraph (L-M)
  - Focal plan coronagraph (L-M)*
  - Sparse aperture Masking (J-M)
- long slit spectroscopy*
  - R=500, LM band simultaneously
- PAC 2021

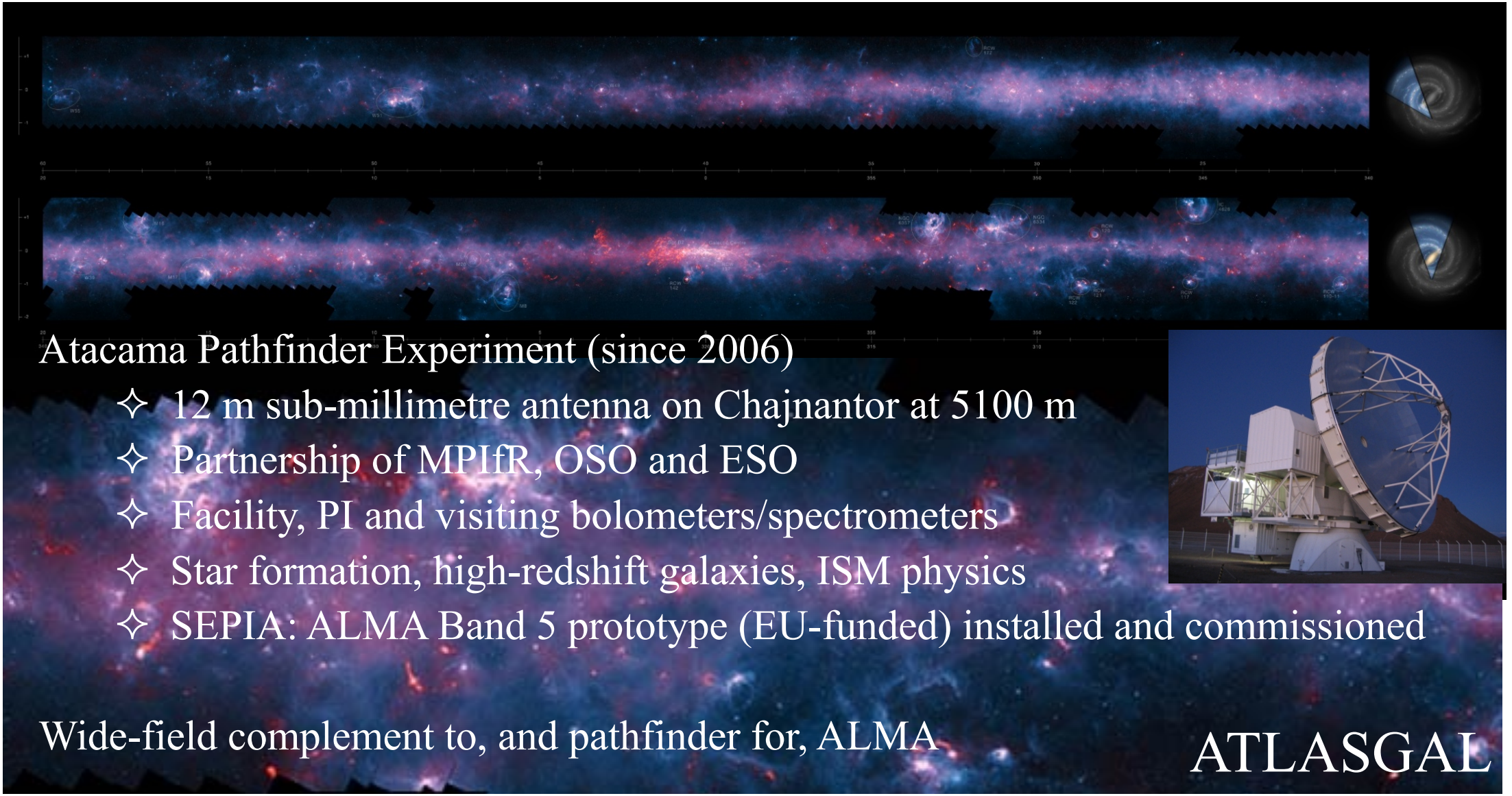
MOONS - Multi-Object Optical and Near-infrared Spectrograph



- PI Michele Cirasuolo
  - Field of view: 500 sq. arcmin at 8.2m VLT
  - 1024 fibers with possibility to deploy them in pairs
  - Medium resolution:
    - Simultaneously 0.64μm-1.8μm
    - R=4000–6000
  - High resolution:
    - Simultaneously 3 bands:
    - 0.76-0.90μm at R = 9,000
    - 0.95-1.35μm at R=4,000
    - 1.52-1.63μm at R=20,0
- PAC 2020



APEX



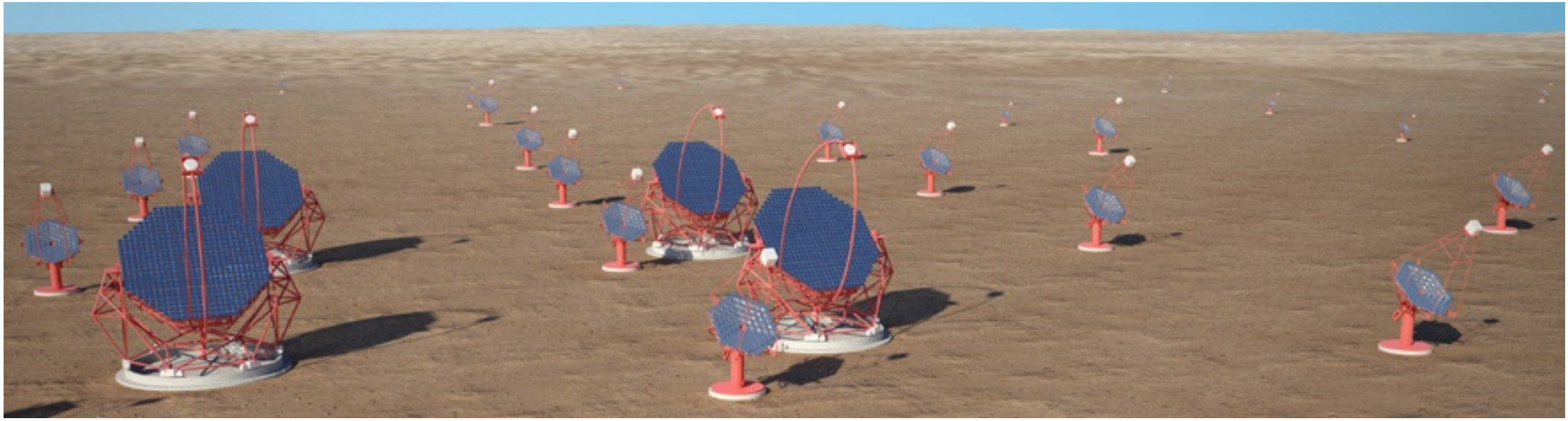
Atacama Pathfinder Experiment (since 2006)

- ✧ 12 m sub-millimetre antenna on Chajnantor at 5100 m
- ✧ Partnership of MPIfR, OSO and ESO
- ✧ Facility, PI and visiting bolometers/spectrometers
- ✧ Star formation, high-redshift galaxies, ISM physics
- ✧ SEPIA: ALMA Band 5 prototype (EU-funded) installed and commissioned

Wide-field complement to, and pathfinder for, ALMA

ATLASGAL

Cherenkov Telescope Array (CTA)



- Array of simple but fairly large optical telescopes
  - Measure Cherenkov flashes in Earth's atmosphere from interaction with very high energy photons from objects in the Universe, with ~0.1 degree angular accuracy
  - Follow-up to HESS, MAGIC, VERITAS experiments
  - Approximately 1000 objects expected, many Galactic
    - Transition from experiment to observatory

E-ELT

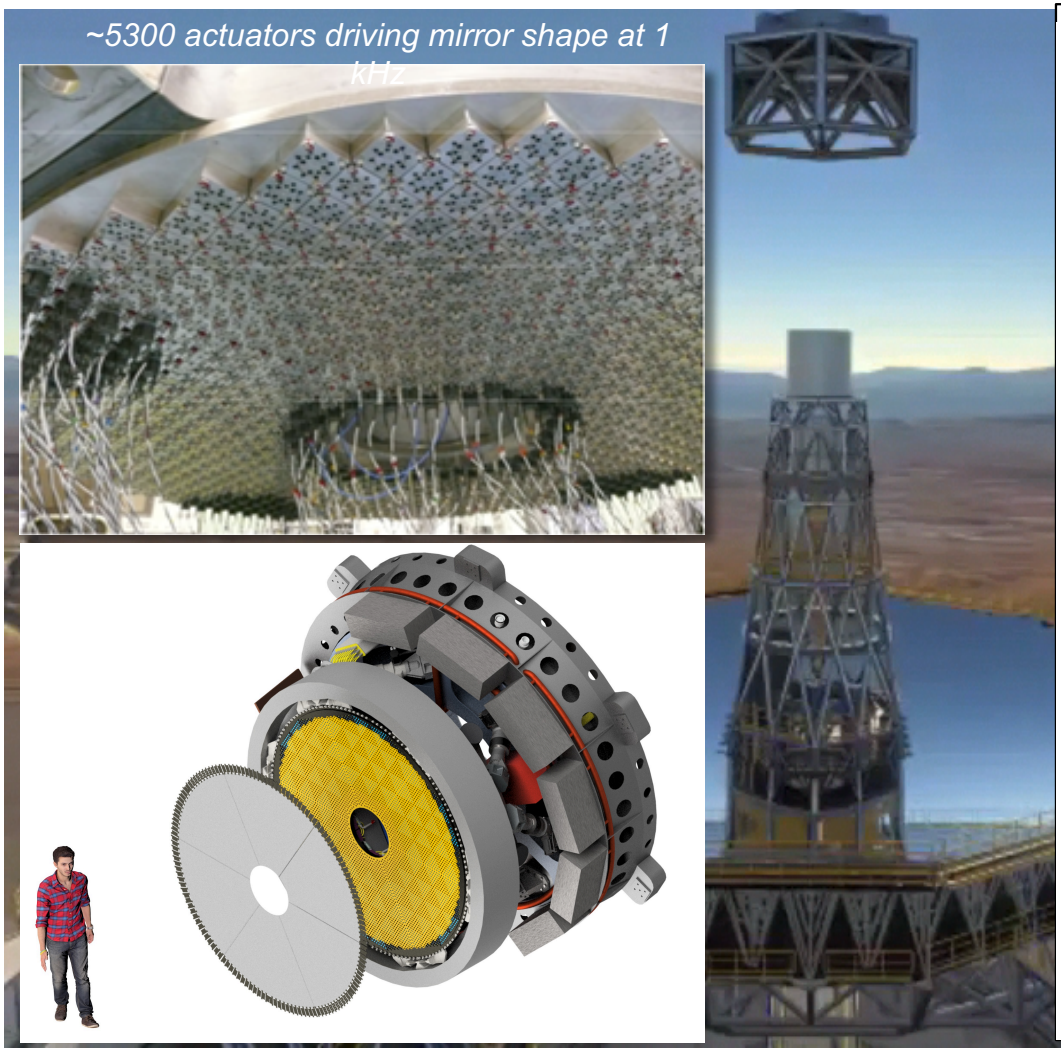
Largest optical/infrared telescope in the world

- ✧ 39-m segmented primary mirror: transformational step
- ✧ On Armazones, as integral part of the Paranal system

Construction on-track for first light in 2024

- ✧ Maximises synergy with JWST et al.

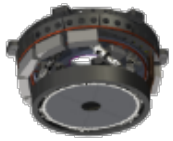
E-ELT Optomechanics



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

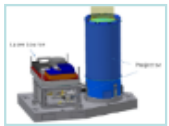
M2 Unit
4-m
Convex Aspheric f/1.1
Passive + Position Control

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

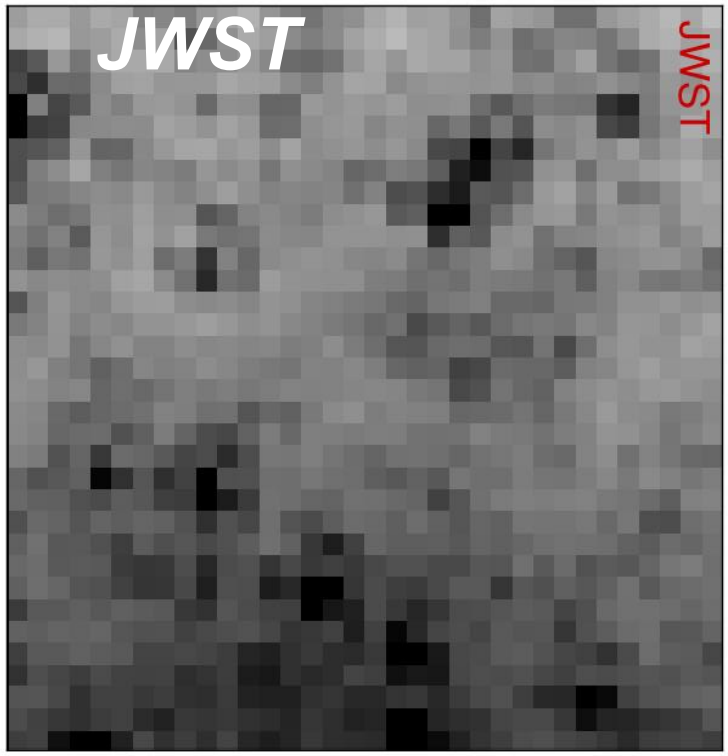


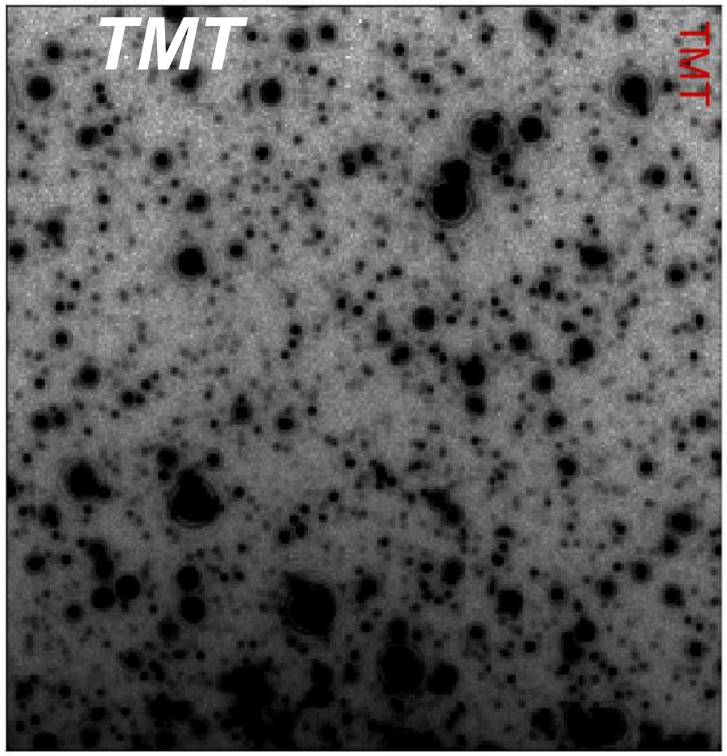
LGSU
(Laser Guide Star Units)
Laser Sources + Laser Beacons shaping and emitting

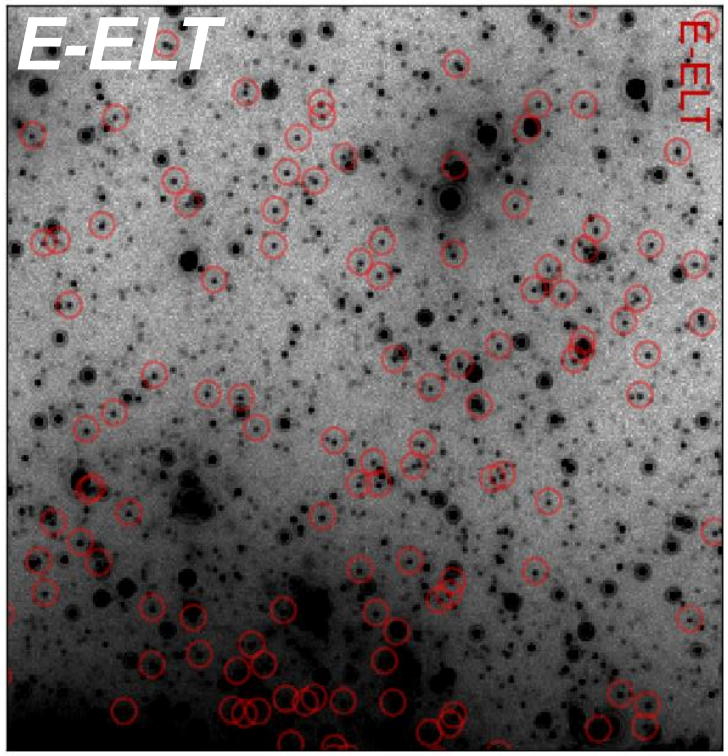
E-ELT Science

Planets & Stars

Stars & Galaxies







Gullieuszik et al 2014.

E-ELT

Recent contract awards

- ✧ M4 shell and unit
- ✧ MAORY, MICADO, HARMONI, METIS
- ✧ Dome and main structure

Instrumentation roadmap

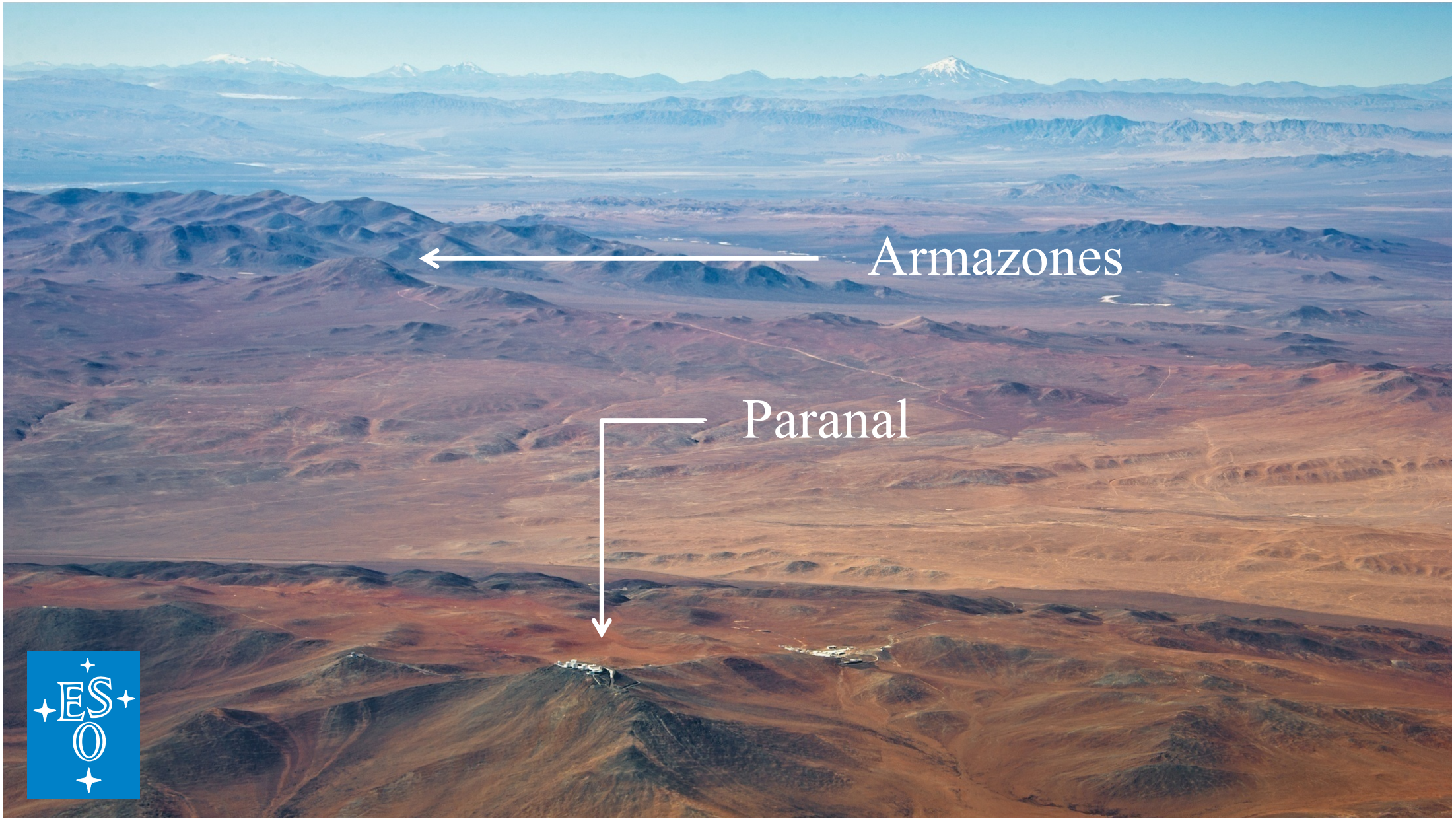
- ✧ Phase A studies: MOS & HIRES
- ✧ ELT-6: Specs to be defined later
- ✧ EPICS: After further technology development

Construction philosophy

- ✧ 'VLT model' of consortia working closely with ESO
- ✧ GTO policy: Cou-1543

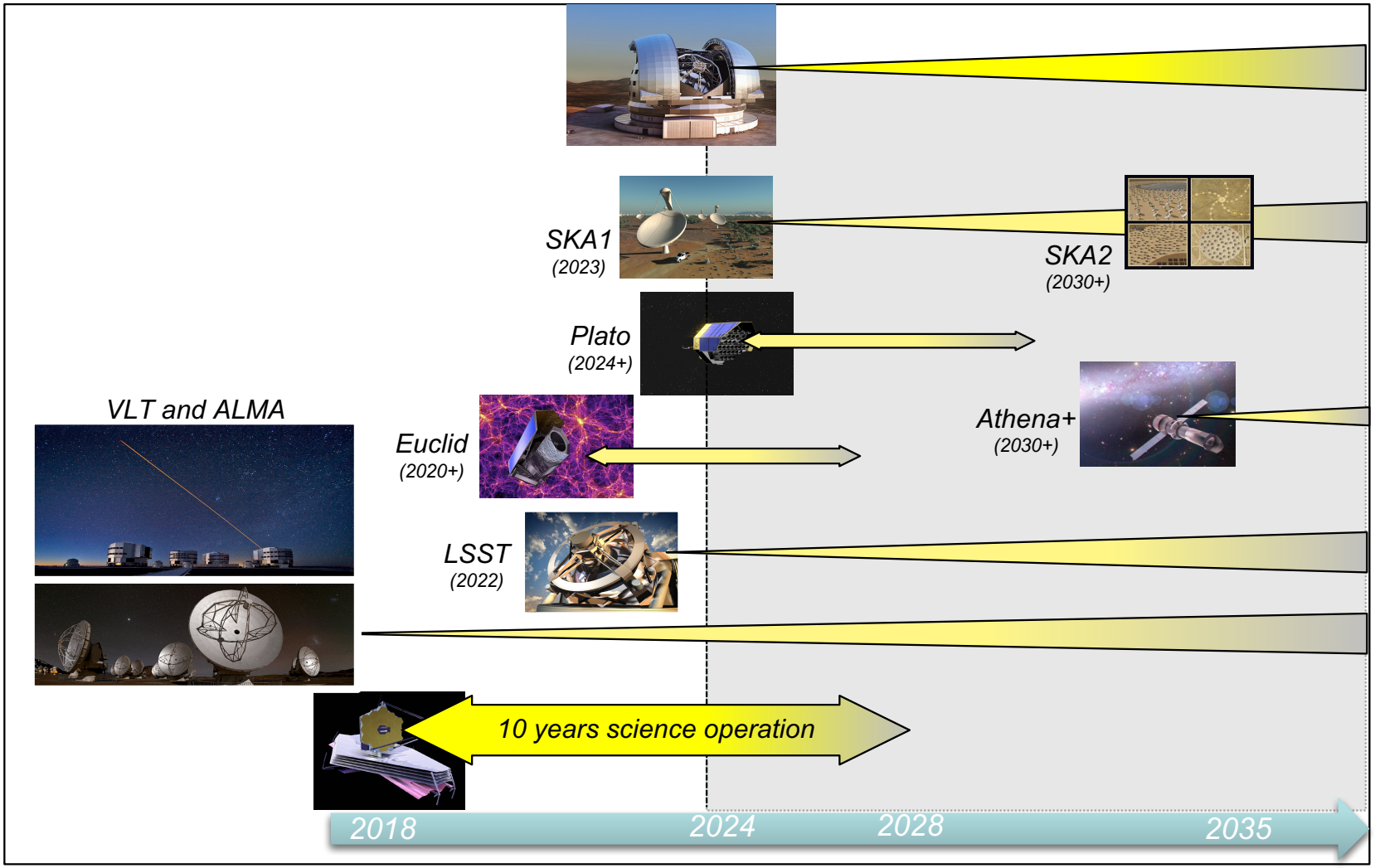
  Max 15% of E-ELT observing time for GTO to consortia

  65 nights per instrument, spread over 4-8 years

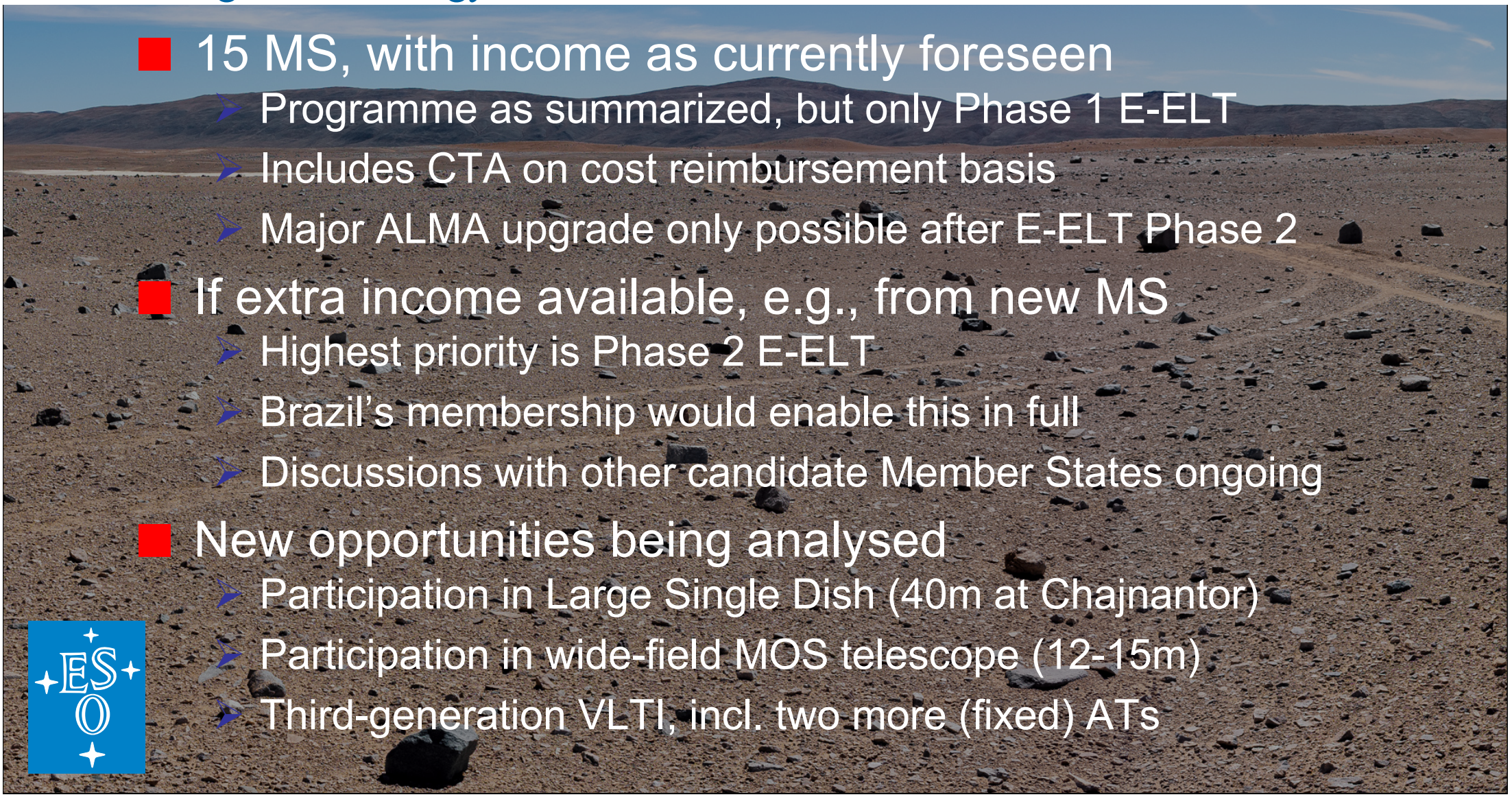

Armazones
Paranal


ESO

E-ELT synergies

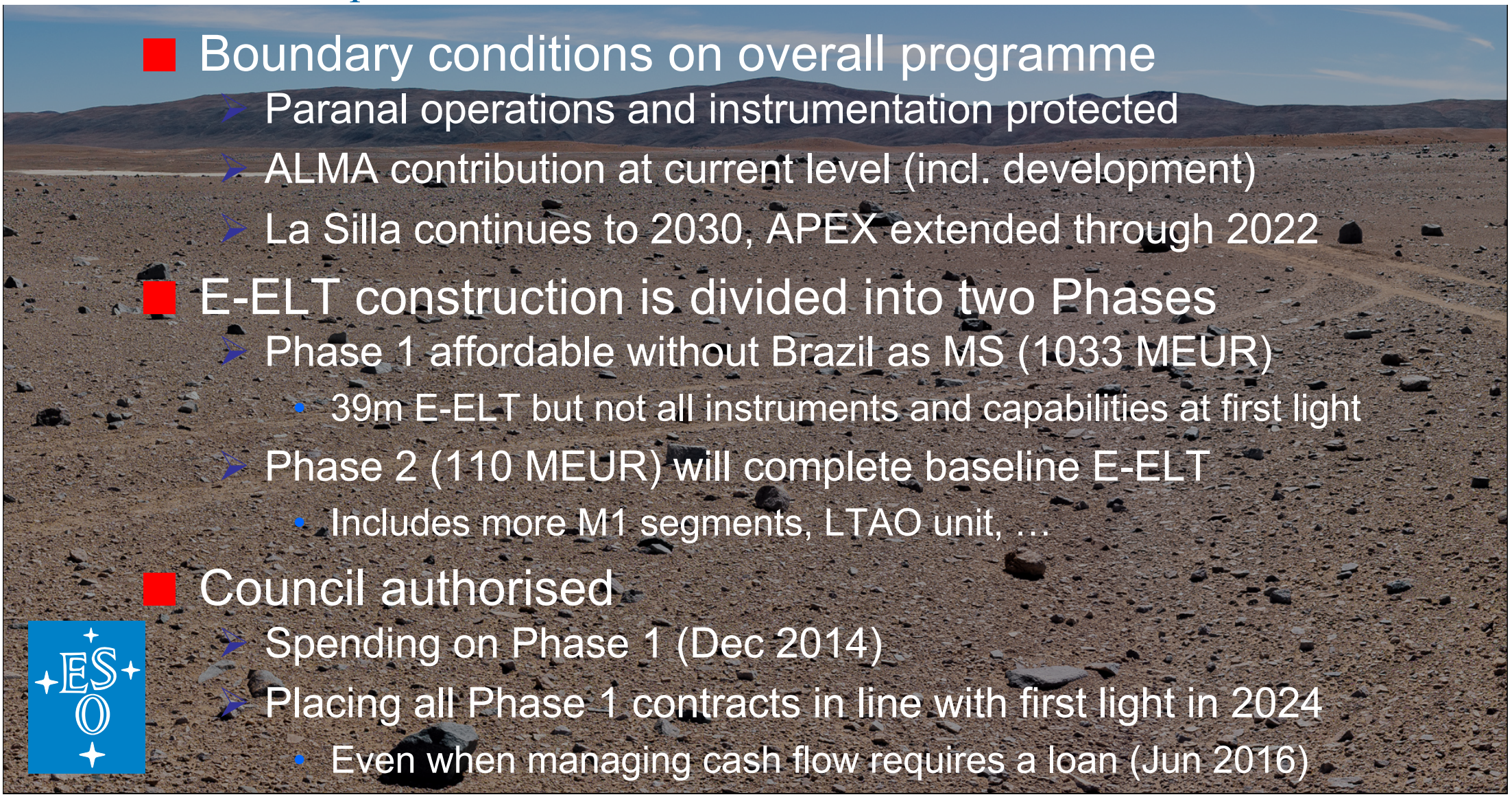


ESO Long-Term Strategy



- 15 MS, with income as currently foreseen
  - Programme as summarized, but only Phase 1 E-ELT
  - Includes CTA on cost reimbursement basis
  - Major ALMA upgrade only possible after E-ELT Phase 2
- If extra income available, e.g., from new MS
  - Highest priority is Phase 2 E-ELT
  - Brazil's membership would enable this in full
  - Discussions with other candidate Member States ongoing
- New opportunities being analysed
  - Participation in Large Single Dish (40m at Chajnantor)
  - Participation in wide-field MOS telescope (12-15m)
  - Third-generation VLTI, incl. two more (fixed) ATs

ESO Financial aspects



- Boundary conditions on overall programme
  - Paranal operations and instrumentation protected
  - ALMA contribution at current level (incl. development)
  - La Silla continues to 2030, APEX extended through 2022
- E-ELT construction is divided into two Phases
  - Phase 1 affordable without Brazil as MS (1033 MEUR)
    - 39m E-ELT but not all instruments and capabilities at first light
  - Phase 2 (110 MEUR) will complete baseline E-ELT
    - Includes more M1 segments, LTAO unit, …
- Council authorised
  - Spending on Phase 1 (Dec 2014)
  - Placing all Phase 1 contracts in line with first light in 2024
    - Even when managing cash flow requires a loan (Jun 2016)