

ESO: current facilities and future perspectives

Rob Ivison
ESO Director for Science



Mission

- ✧ Develop + operate world-class observing facilities for astronomical research
- ✧ Organise collaborations in astronomy (ESO workshops, ESO-ESA, ESO-CERN, ...)

1962

- ✧ ESO created by five Member States: BE, FR, DE, SE, NL
- ✧ Goal: build a large telescope in southern hemisphere
 - ✧ This became the 3.6-m telescope on Cerro La Silla (1976)

2017

- ✧ 15+1 Member States (~30% of world's astronomers), may increase further
- ✧ VLT on Paranal is world-class ground-based system
- ✧ ALMA (both in partnership) on Chajnantor (+ APEX)
- ✧ ESO Fellowship and Studentship schemes
- ✧ Construction of 39-m ESO ELT on Armazones has started
- ✧ Cherenkov Telescope Array South: getting ready to sign hosting agreement



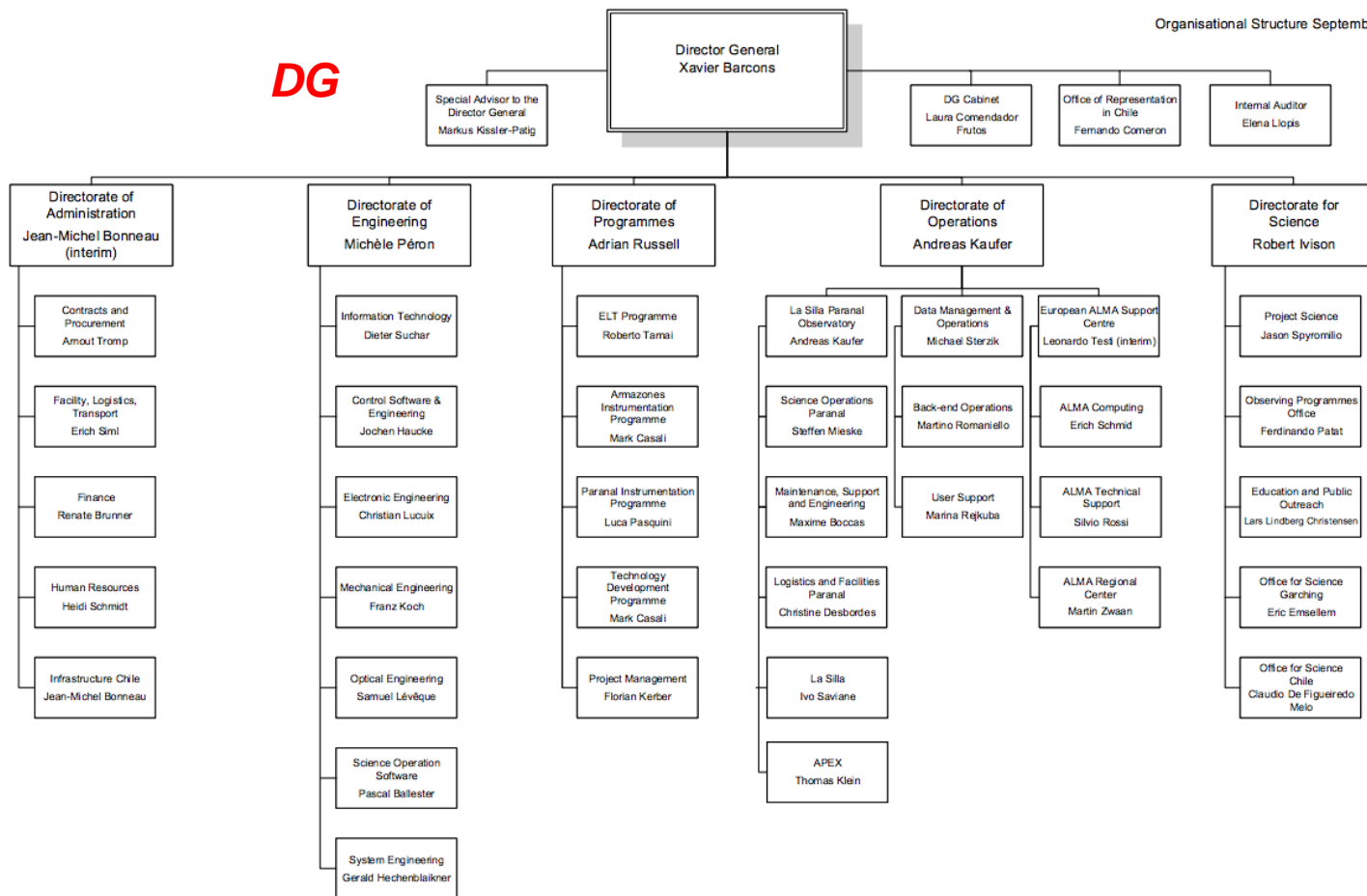
ESO organigram

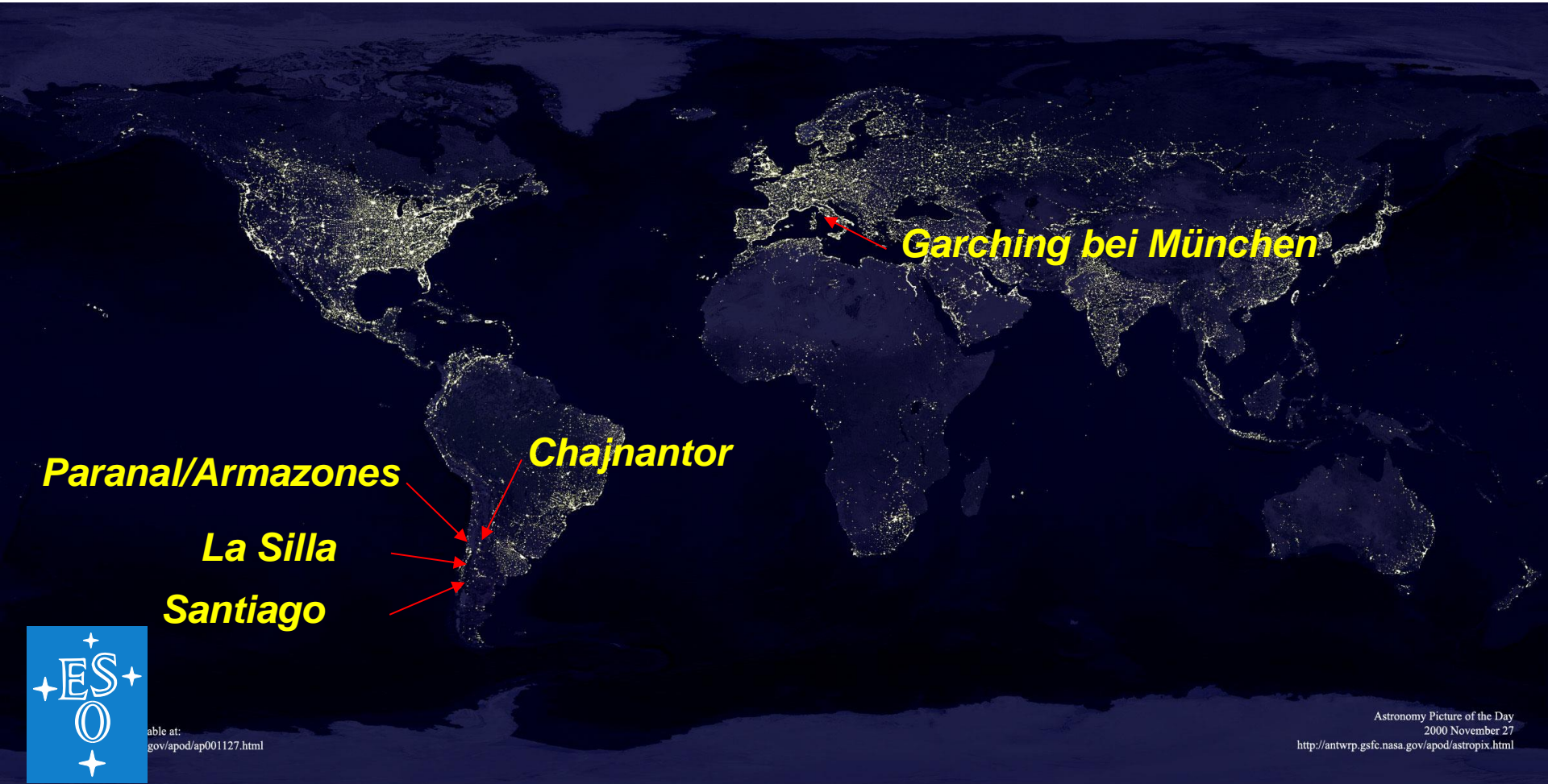
Organisational Structure September 2017

DG

Directors

Depts





ESO HQ

ESO HQ in Garching bei Munchen, Germany



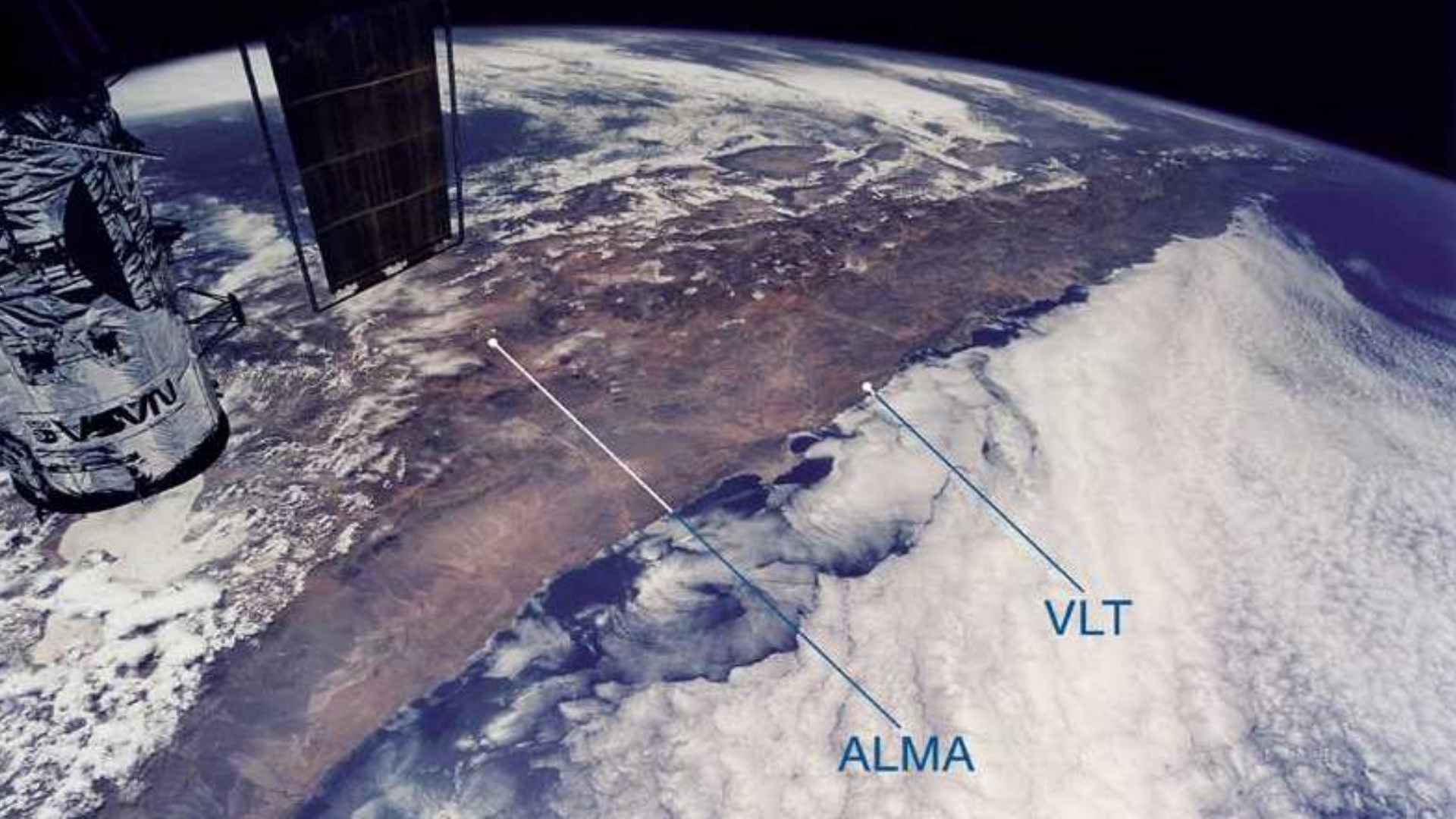


ESO HQ



Why Chile?





VLT

ALMA

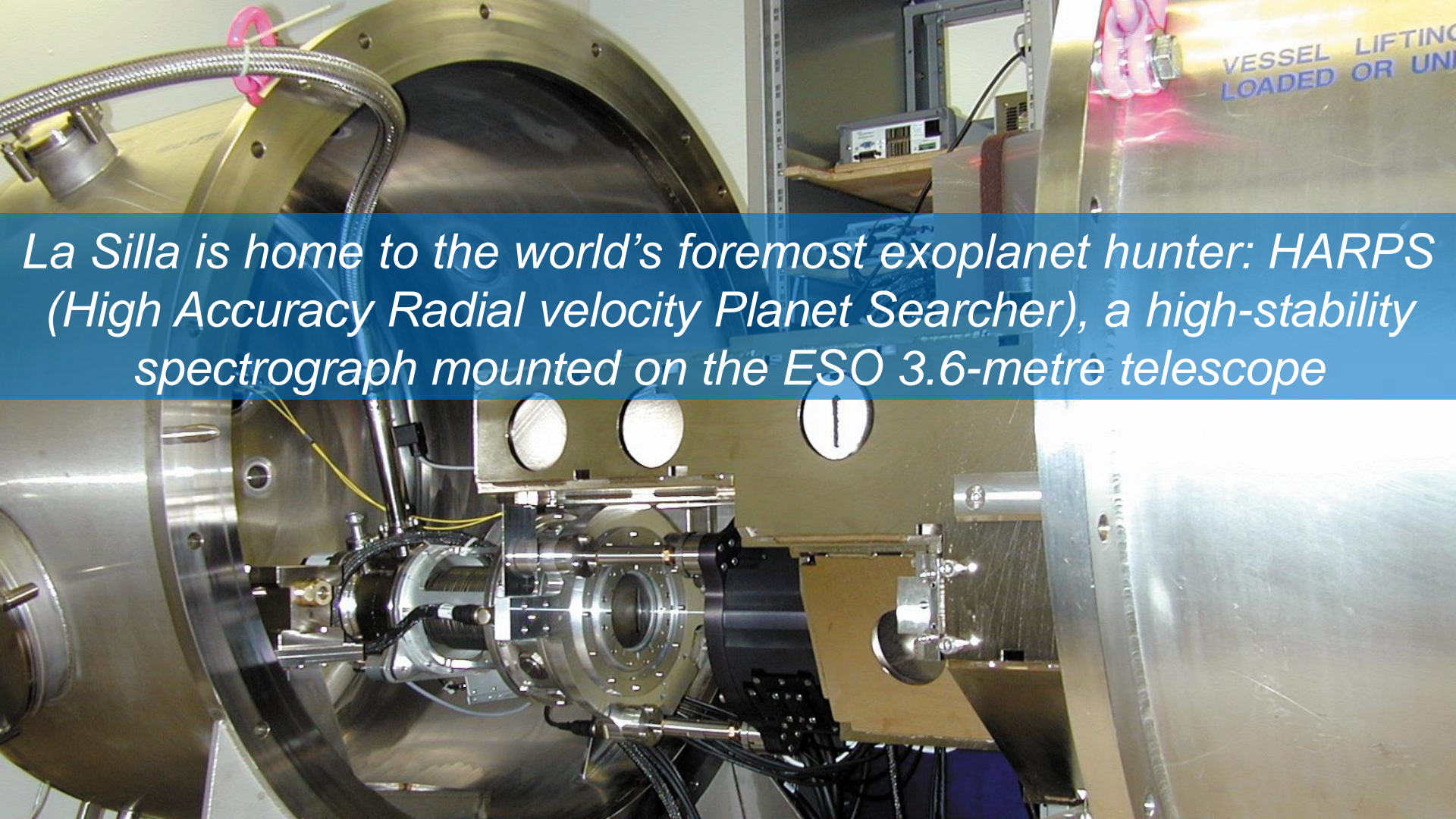
La Silla

ESO's first observatory site



La Silla has been an ESO stronghold since the 1960s. Here, ESO operates two of the most productive 4-metre-class telescopes in the world.





VESSEL LIFTING
LOADED OR UN

La Silla is home to the world's foremost exoplanet hunter: HARPS (High Accuracy Radial velocity Planet Searcher), a high-stability spectrograph mounted on the ESO 3.6-metre telescope

New instrumentation

- ✧ 3.6-m strengthened further for exoplanet (RV) research
 - ✧ HARPS laser frequency comb allows ~ 2 cm/s RVs
 - ✧ NIRPS approved (dichroic, alongside HARPS)
- ✧ NTT focused on transient follow-up in LSST era
 - ✧ SOXS selected for the NTT (also ULTRACAM)
- ✧ Should ensure exciting science from La Silla through 2025+

Small telescopes/robots operated by external consortia

- ✧ 2.2-m MPG, 1.5-m Danish, 1.2-m Leonhard Euler
- ✧ TRAPPIST (1x60cm), ExTrA (3x60cm), MASCARA, BlackGEM (3x65cm), ...



*La Residencia was finished in 2002.
It offers ESO staff and visitors a haven away
from the harsh Atacama Desert.*





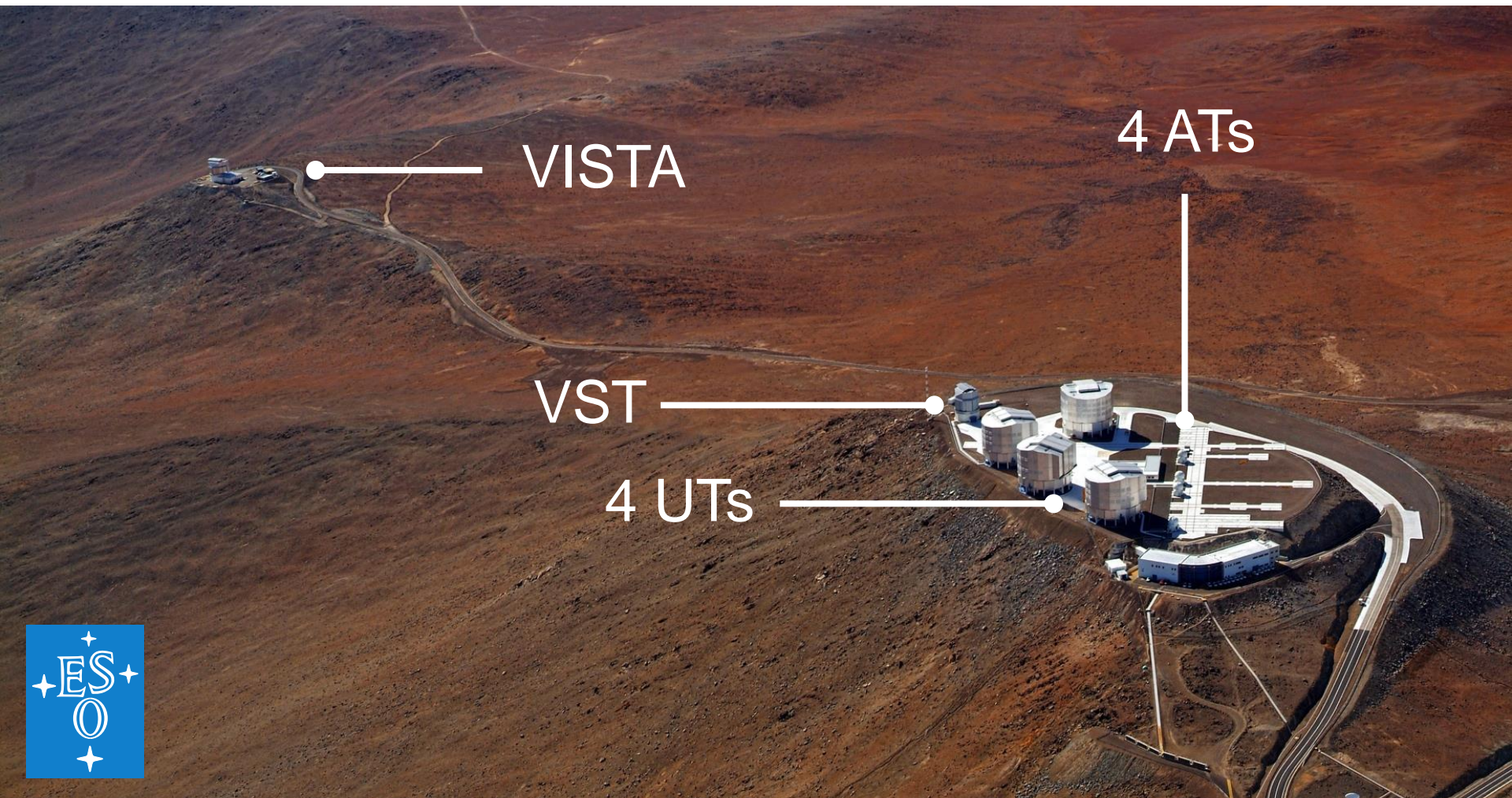


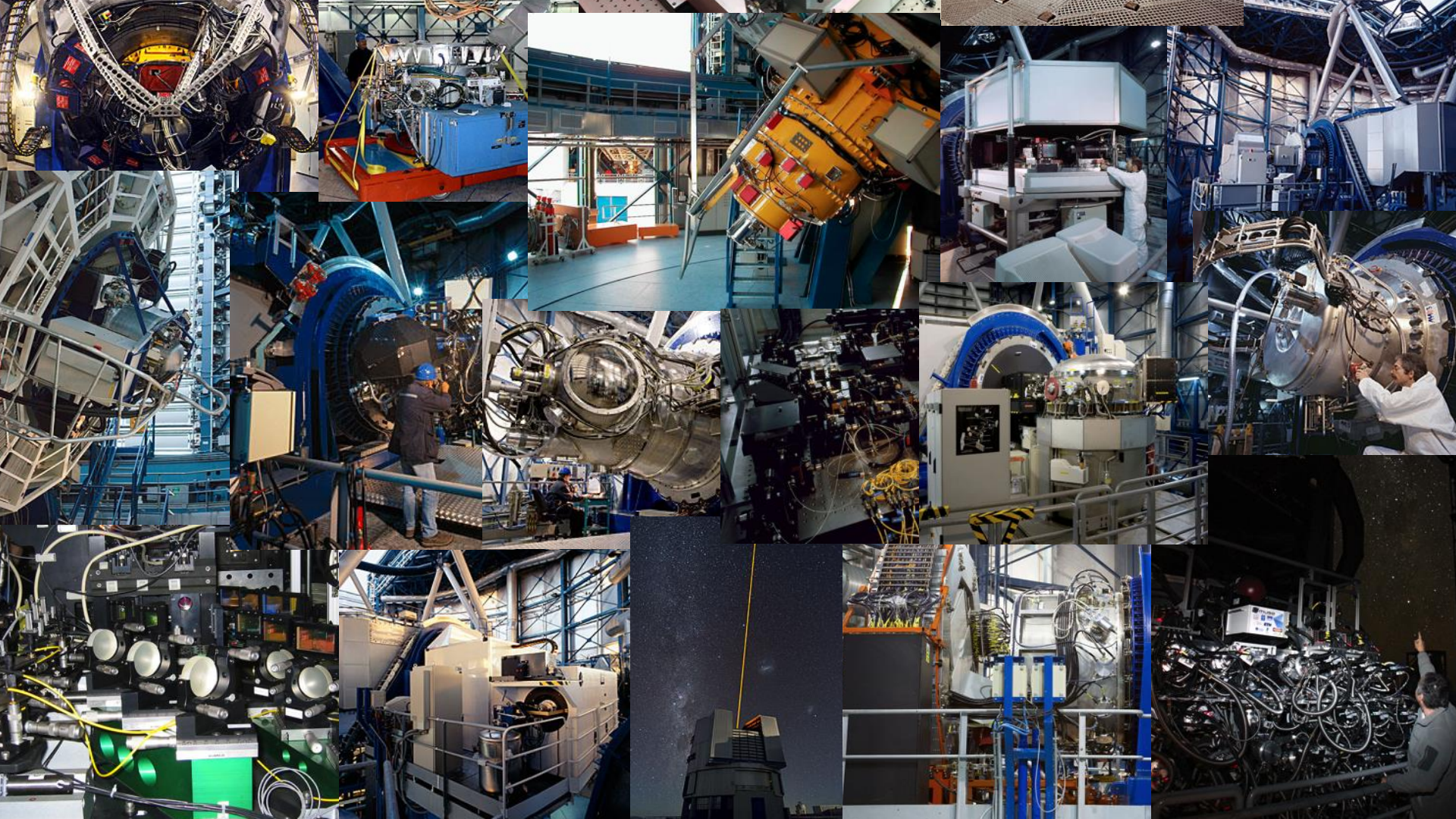
Paranal

Very Large Telescope (VLT)

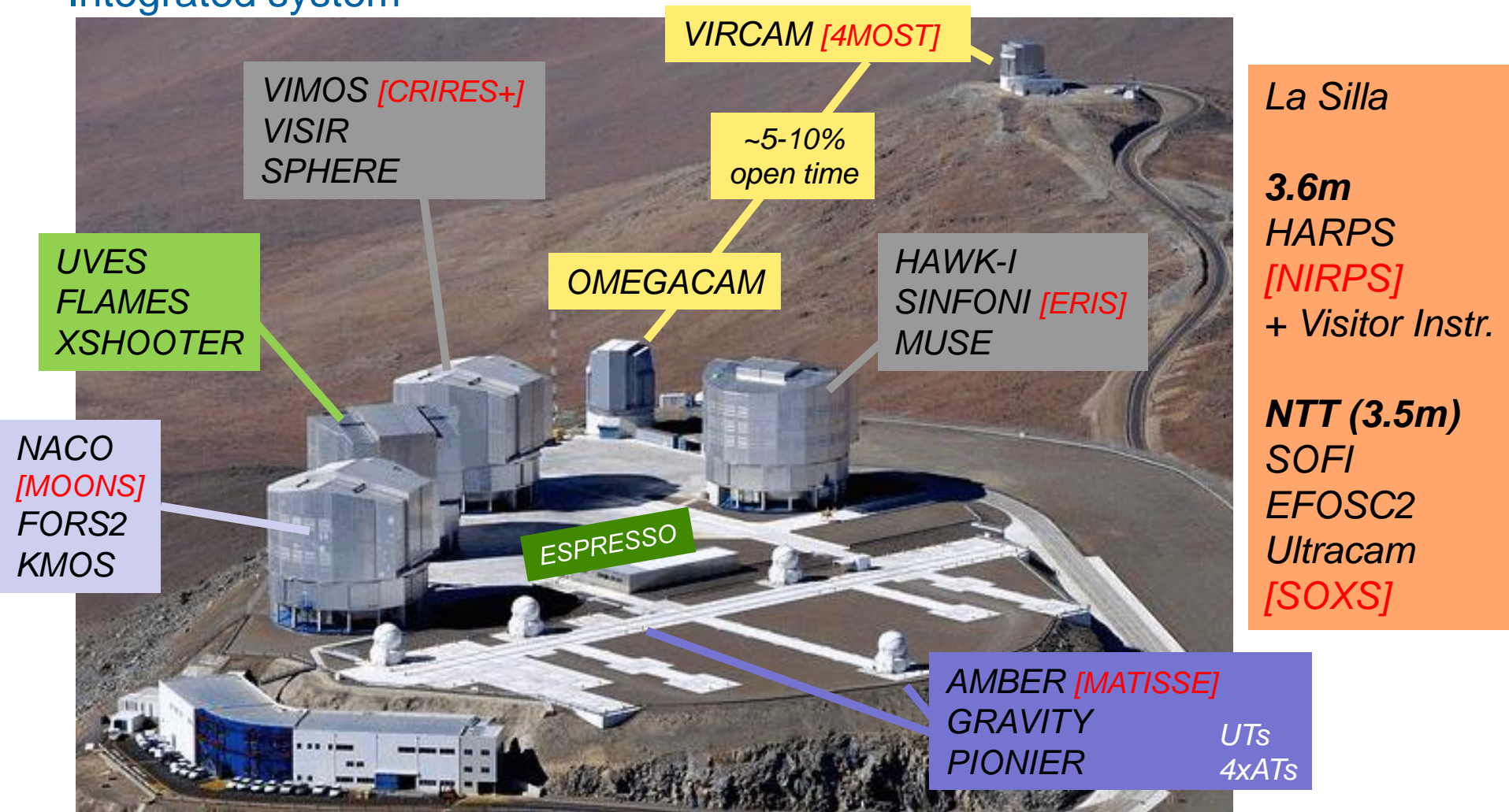


Antu, Kueyen, Melipal, and Yepun





Integrated system




Instruments overview

Paranal Instruments Summary Table

Instrument	Spectral Coverage	Observing Mode	Spectral Resolution	Multiplex	Note
KMOS	near-IR 0.8 - 2.5 μm	multi-object integral field spectroscopy (24 arms)	1800 - 4000	yes	24-arms Integral Field Spectroscopy; 2.8x2.8", 0.2" sampling IFU over a 7.2' field;
FLAMES	optical 370 - 950 nm	multi-fibre echelle,integral field spectroscopy	6000 - 47000	yes	132 Medusa fibres; 15 deployable IFUs, one large IFU; GIRAFFE: single echelle order; 8 fibres to UVES
X-SHOOTER	UV-optical-NIR 300 - 2500 nm	echelle, slit and integral field spectroscopy	~5000-17000	no	full spectral coverage with one pointing; slit + IFU; RRM
UVES	optical 300 - 1100 nm	echelle, image slicer, slit spectroscopy	up to 80,000 (blue arm) / 110,000 (red arm)	no	long slit capability in single order; iodine cell; RRM

La Silla Instruments Summary Table

Instrument	Spectral Coverage	Observing Mode	Spectral Resolution	Multiplex	Note
HARPS	optical 378-691nm	echelle, polarimetry	120,000	no	2 fibres, high accuracy; 2 fibers, high efficiency
EFOSC-2	optical 350 - 1100nm	imaging, spectroscopy, polarimetry, coronagraphy	~1000	yes	imaging and spectroscopic polarimetry
SOFI	near-IR 1-2.5 μm	imaging, spectroscopy	600-2200	no	-
 ULTRACAM	optical: u',g',r' or u',g',i' or u',g',z'	3-channel, high-speed CCD camera	-	no	frame rate up to 300Hz; field-of-view of 6 arcmin

Survey telescopes



New VISTA Public Imaging Surveys – began 2017

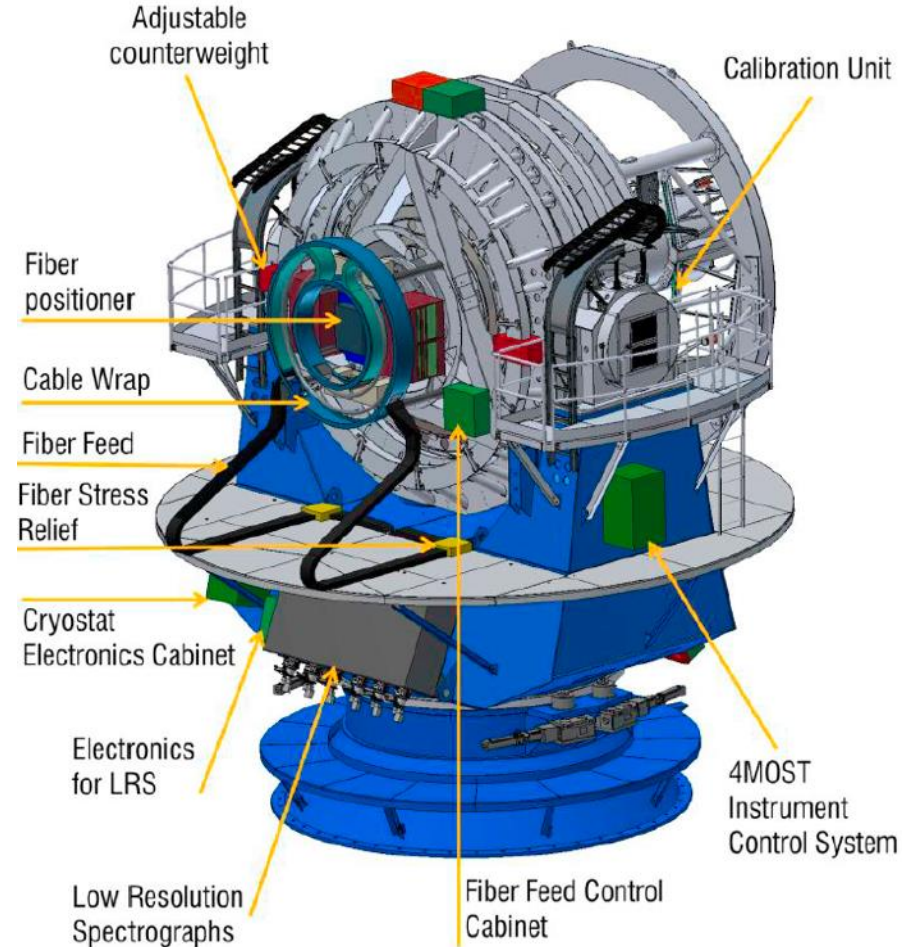
Survey name P.I.	Short Title	Filters	Time (hrs)	Area (deg²)
GW; Tanvir	Kilonova counterparts to Gravitational wave sources	Y J Ks	420	(10)
UltraVISTA; Dunlop	Completing the legacy of UltraVISTA	J H Ks	756	0.75
VVVX; Minniti	Extending VVV to higher Gal lat.	J H Ks	1900	1700
VEILS; Banerji	VISTA Extragalactic 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
- 7 proposals selected by PSP, approved by OPC, then by DG

4MOST

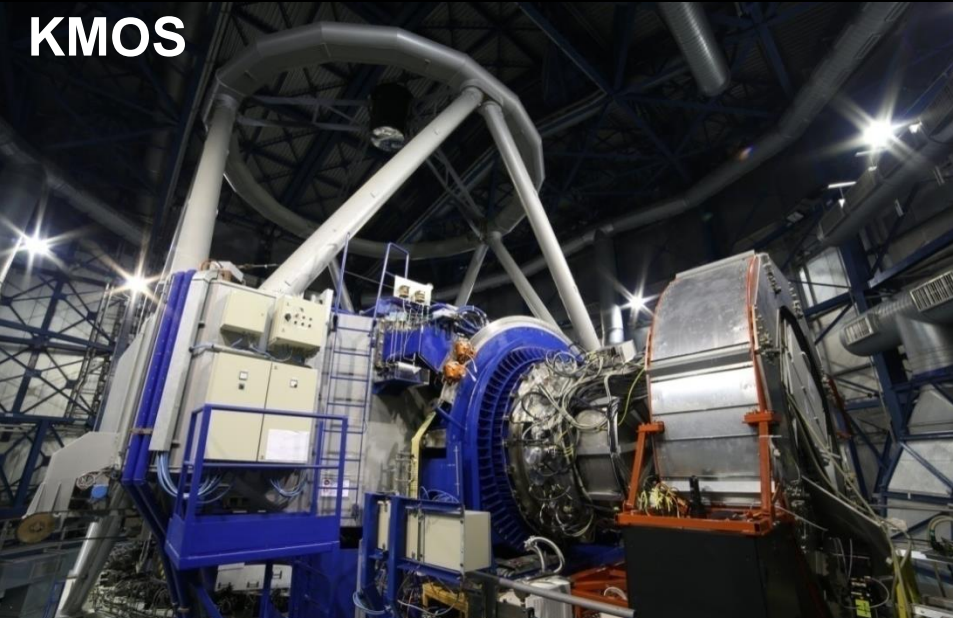
- PI Roelof de Jong – AIP
- World-class fibre-fed MOS
 - Cassegrain focus of VISTA
 - large field of view ($> 4 \text{ deg}^2$)
 - spectral resolutions (LRM: $R > 5,000$, HRM: $R > 18,000$) for both Galactic and extragalactic applications
 - high multiplex (> 700 LRM, > 700 HRM)
 - 1500 fibres, goal 2200
 - broad coverage in LRM (400-885 nm)
 - 393-435, 521-571, 610-675 nm in HRM
- PAC 2022



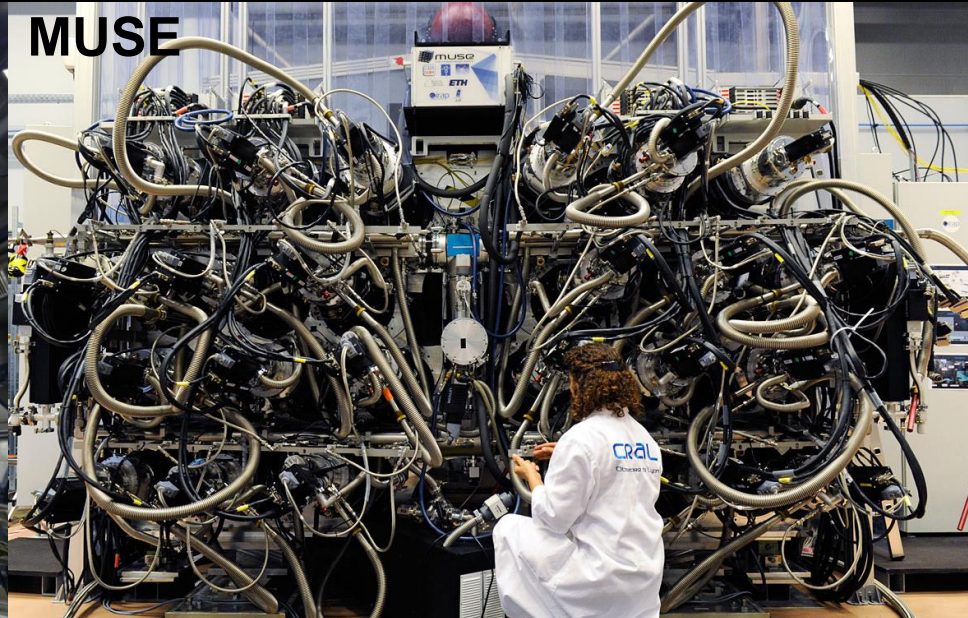
Partnership with ESO Community

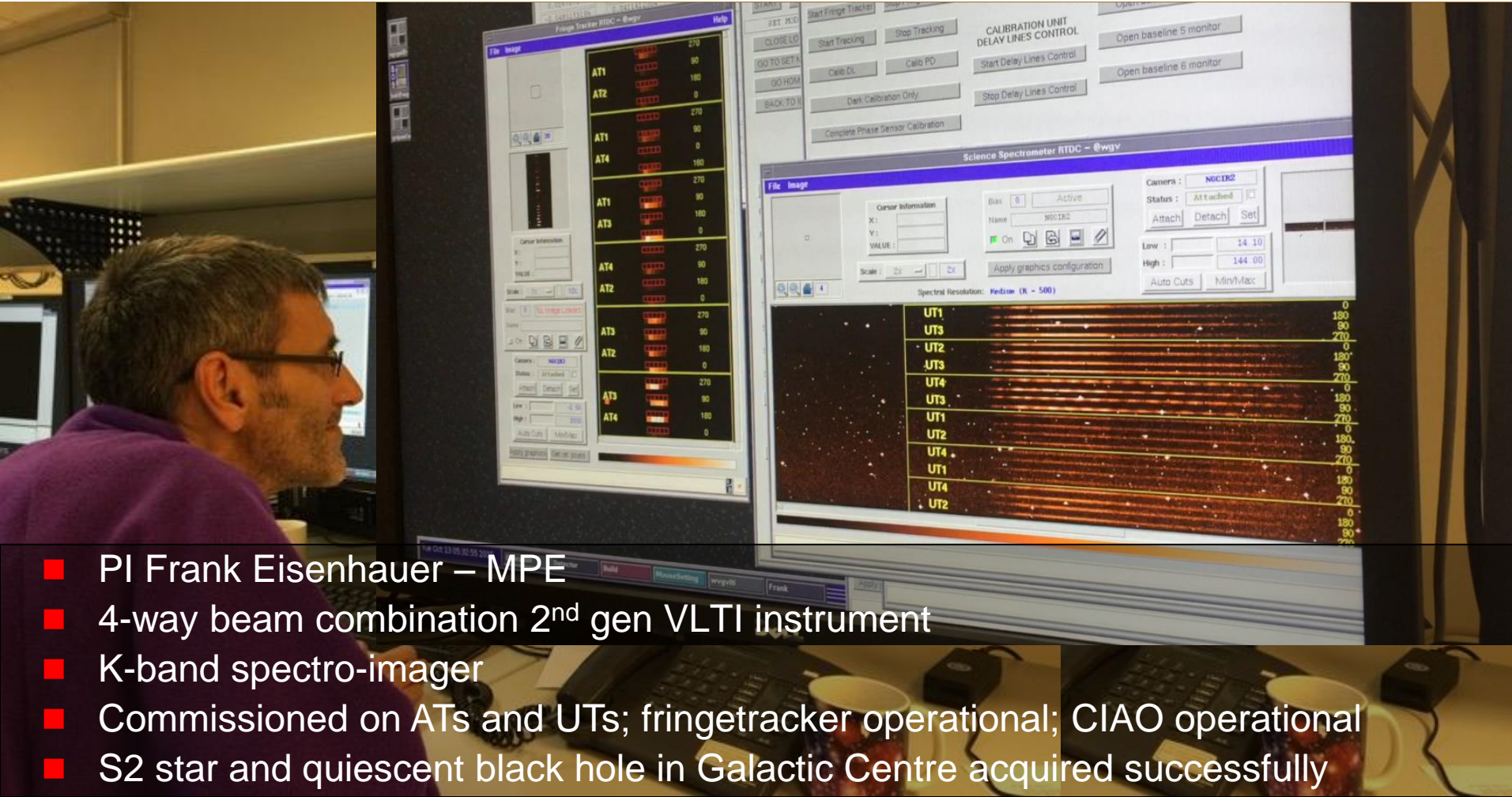
- ❖ Most instruments built by *consortia of institutes*
 - ESO pays hardware (~1/3rd of total cost)
 - Consortia provide FTEs; compensated in Guaranteed Time
 - Typically ~250 nights of GTO per instrument
- ❖ Infrastructure upgrades mostly carried out by ESO
 - Interferometer, adaptive optics facility, combined focus

KMOS



MUSE

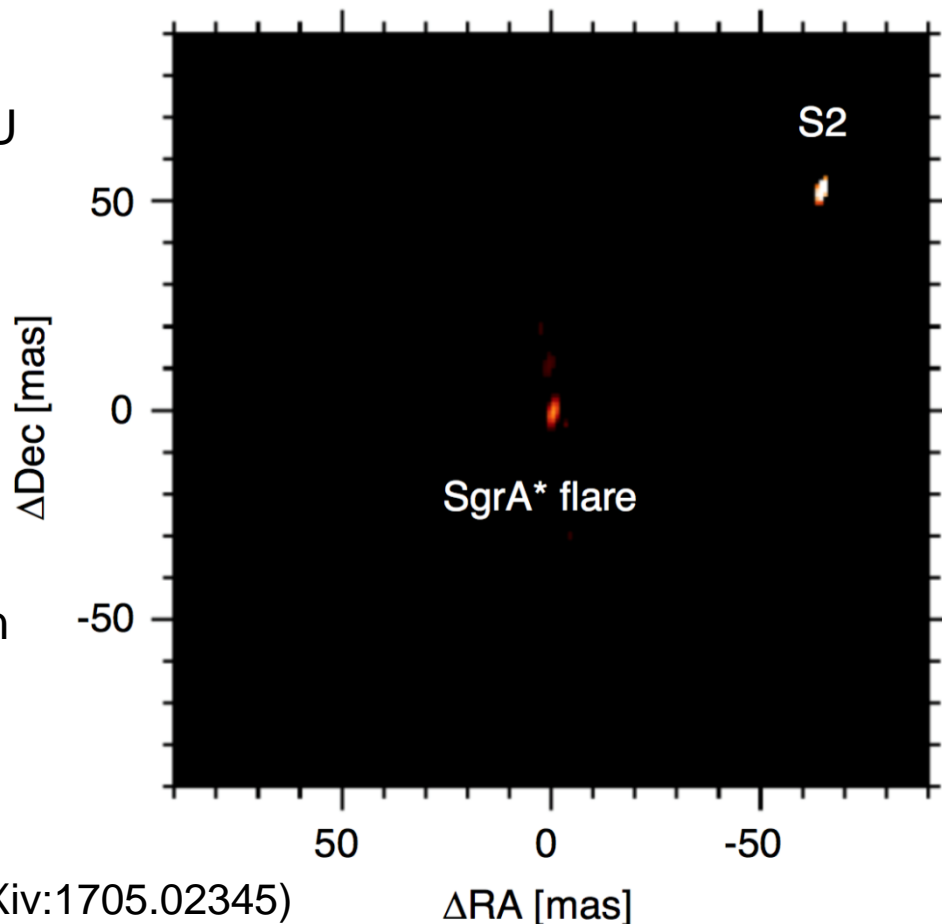




- PI Frank Eisenhauer – MPE
- 4-way beam combination 2nd gen VLTI instrument
- K-band spectro-imager
- Commissioned on ATs and UTs; fringe tracker operational; CIAO operational
- S2 star and quiescent black hole in Galactic Centre acquired successfully

GRAVITY observes Sgr A* at Galactic Centre

- Sgr A* at $\sim 8\text{kpc}$, so $180\text{mas} = 22.5\text{AU}$
- Flares detected at $K \sim 15$
- S2 and Sgr A* unresolved ($< 2\text{ mas}$)
- Astrometry: $< 1\text{ mas}$
- Gal. Centre observed every month
- Peribothron expected 2018
- Goal: measure relativistic effects on orbit of S2, in particular effects of spin of the black hole (Kerr metric)



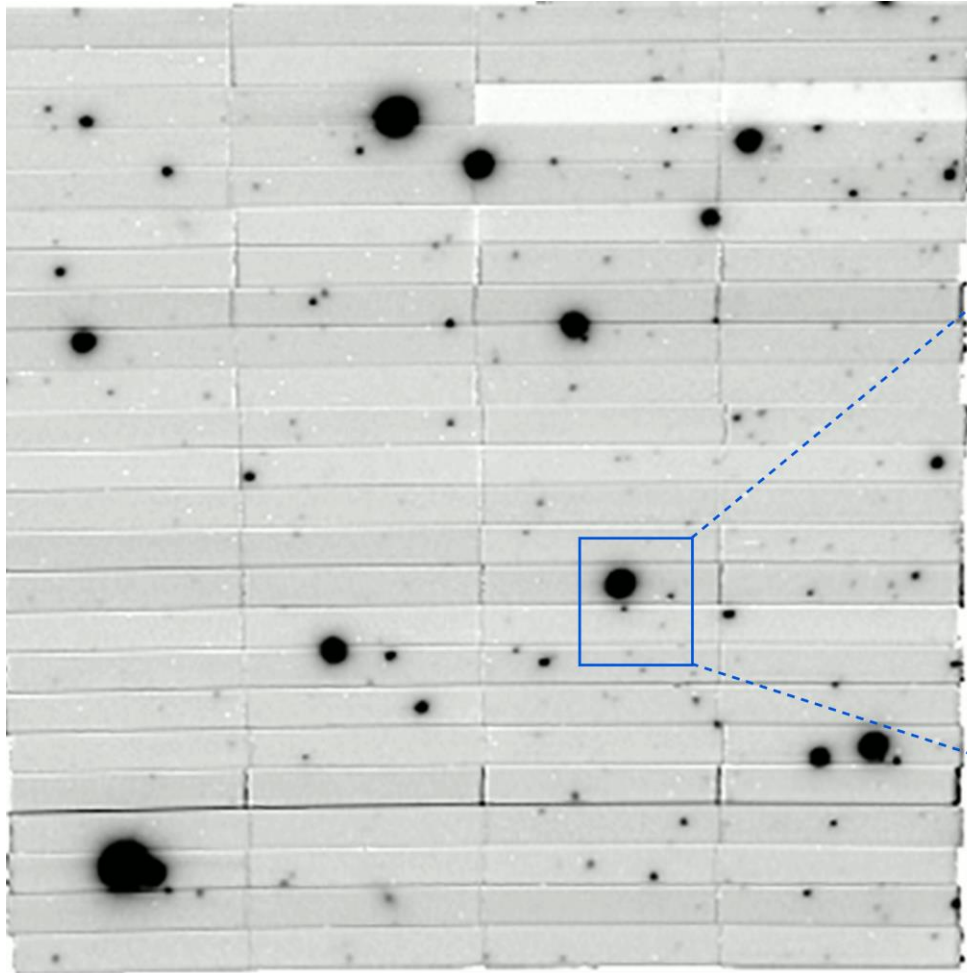
Eisenhauer+2017 in press (arXiv:1705.02345)



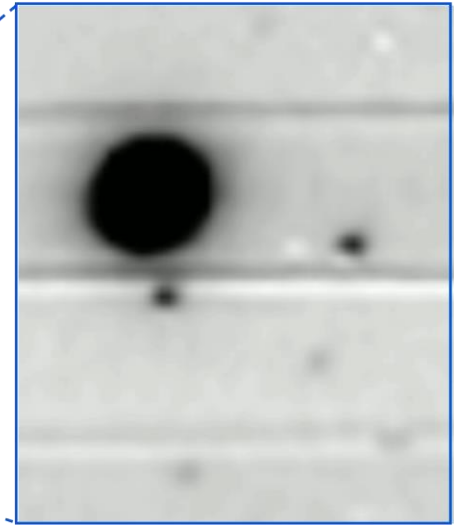


- Upgrade UT4 with an Adaptive Secondary mirror (1170 actuators) and Four 25W Sodium Laser Guide Stars
- GALACSI – feeds MUSE
 - Two fields of view: 1 arcmin for Ground Layer AO
 - x2 in encircled energy at 750nm
 - 7.5" FOV for Laser Tomography AO
 - moderate Strehl ratio in the visible (>5% @ 650 nm) on-axis
- GRAAL – feeds HAWK-I
 - GLAO: x2 in encircled energy at K over the 7.5 arcmin FoV
- PAC 2017-8

MUSE+AOFGALACSI GLAO



Stellar field in vicinity of
globular cluster, NGC5694,
with and without AO



2017 June 16
<http://muse-vlt.eu/blog/>



ESPRESSO - Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic

- 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
 - $R=120\text{k}-220\text{k}$
 - 4UT $R=60\text{k}$
- First light expected 2017 November
- PAC 2018



■ PI Artie Hatzes –Tautenburg

- 1-5 microns spectral coverage, $R \sim 20k-100k$
- Cross-disperser + new detectors will enlarge wavelength coverage by $\sim 10\times$, cover a full IR filter simultaneously
- Gas cells will provide few m/s RV precision
- Polarimetric capabilities
- Refurbished AO system

■ PAC 2018

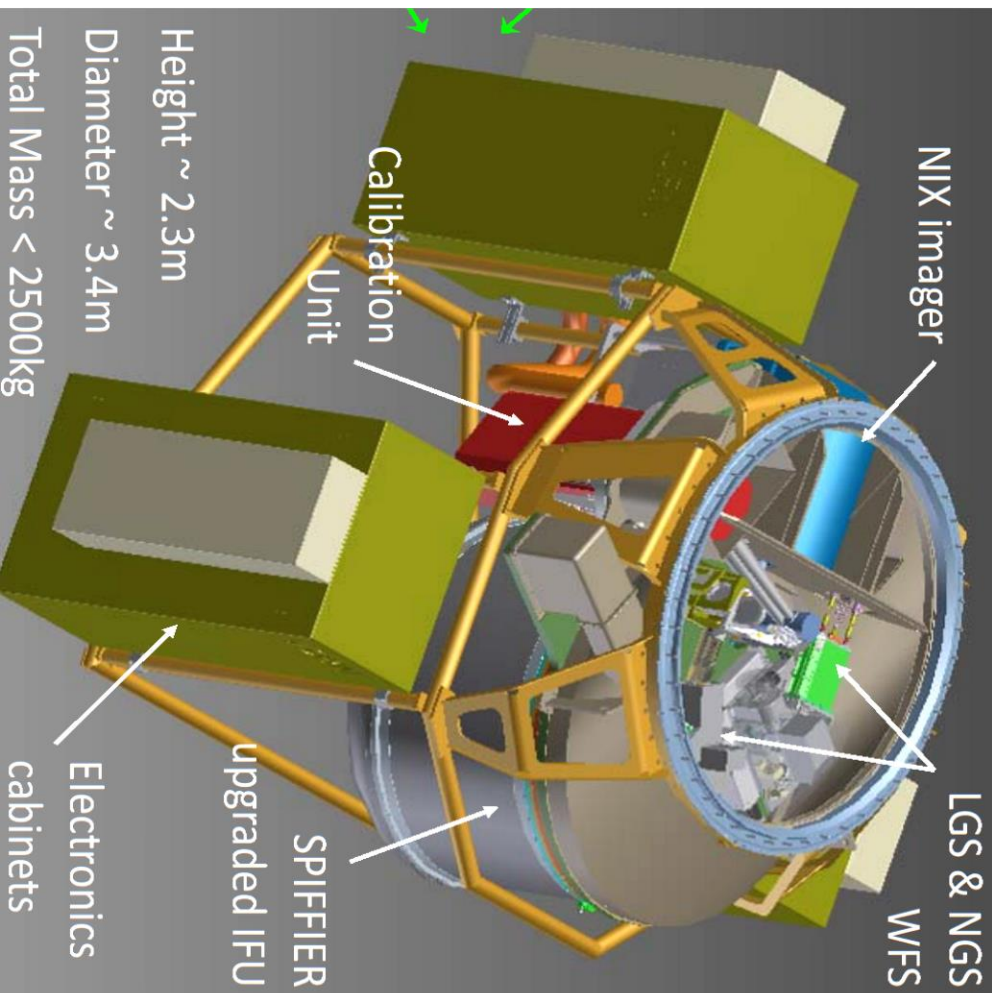
MATISSE - Multi-Aperture mid-Infrared SpectroSopic Experiment

■ PI Bruno Lopez – OCA (Nice)

- VLT/4 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's fringe tracker

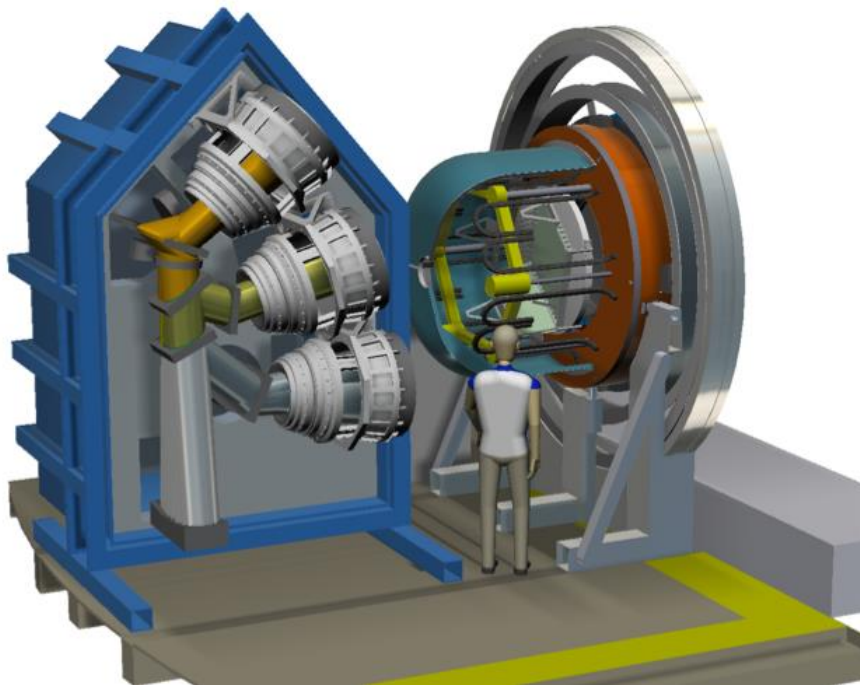
■ PAC 2019

ERIS



- PI Ric Davies – MPE
- SPIFFI Integral field spectroscopy
 - FoV 0.8", 3.2", 8"
 - $R \sim 3000$ and 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 2020

MOONS - Multi-Object Optical and Near-infrared Spectrograph

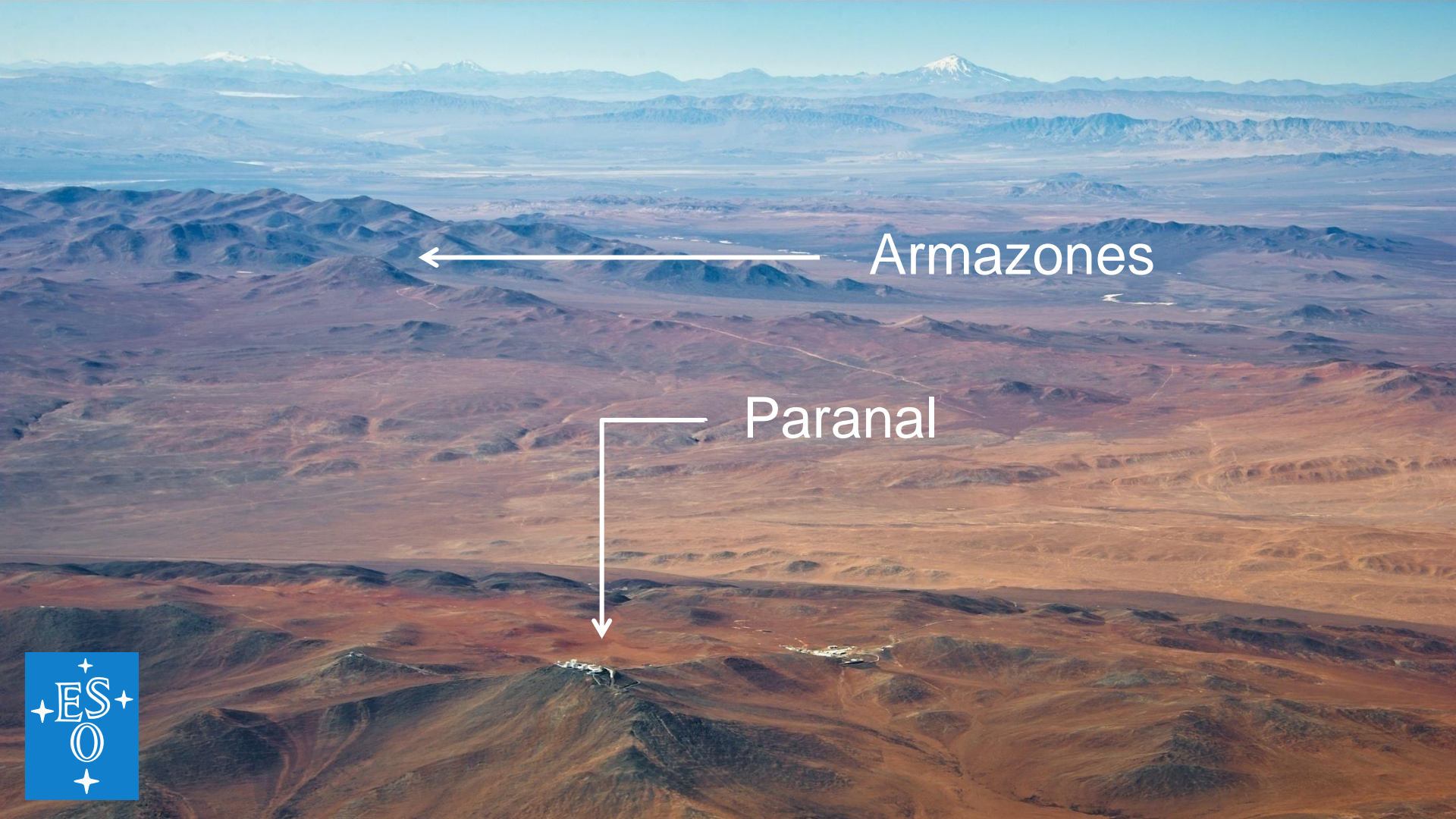


■ PI Michele Cirasuolo

- Field of view: 500 sq. arcmin at 8.2m VLT
- 1024 fibers with possibility to deploy them in pairs
- Medium resolution:
 - Simultaneously $0.64\mu\text{m}$ - $1.8\mu\text{m}$
 - $R=4,100$ – $6,600$
- High resolution:
 - Simultaneously 3 bands:
 - 0.76 - $0.90\mu\text{m}$ at $R = 9,200$
 - 0.95 - $1.35\mu\text{m}$ at $R=4,300$
 - 1.52 - $1.63\mu\text{m}$ at $R=18,300$

■ PAC 2021





Armazones

Paranal







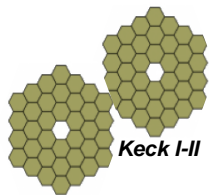
HST 2.4m
(in space)

Larger collecting area than all major
observatories put together!

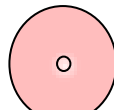
Altitude, m

4000

2000

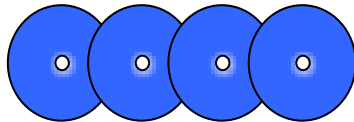


Keck I-II

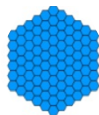


Subaru

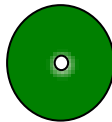
Gemini N



VLTs



HET



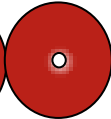
Gemini S



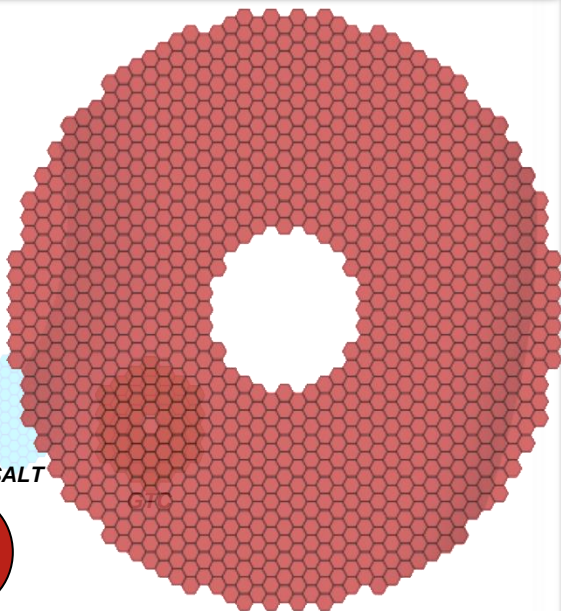
Magellan



LBT



SALT



ESO ELT
39m

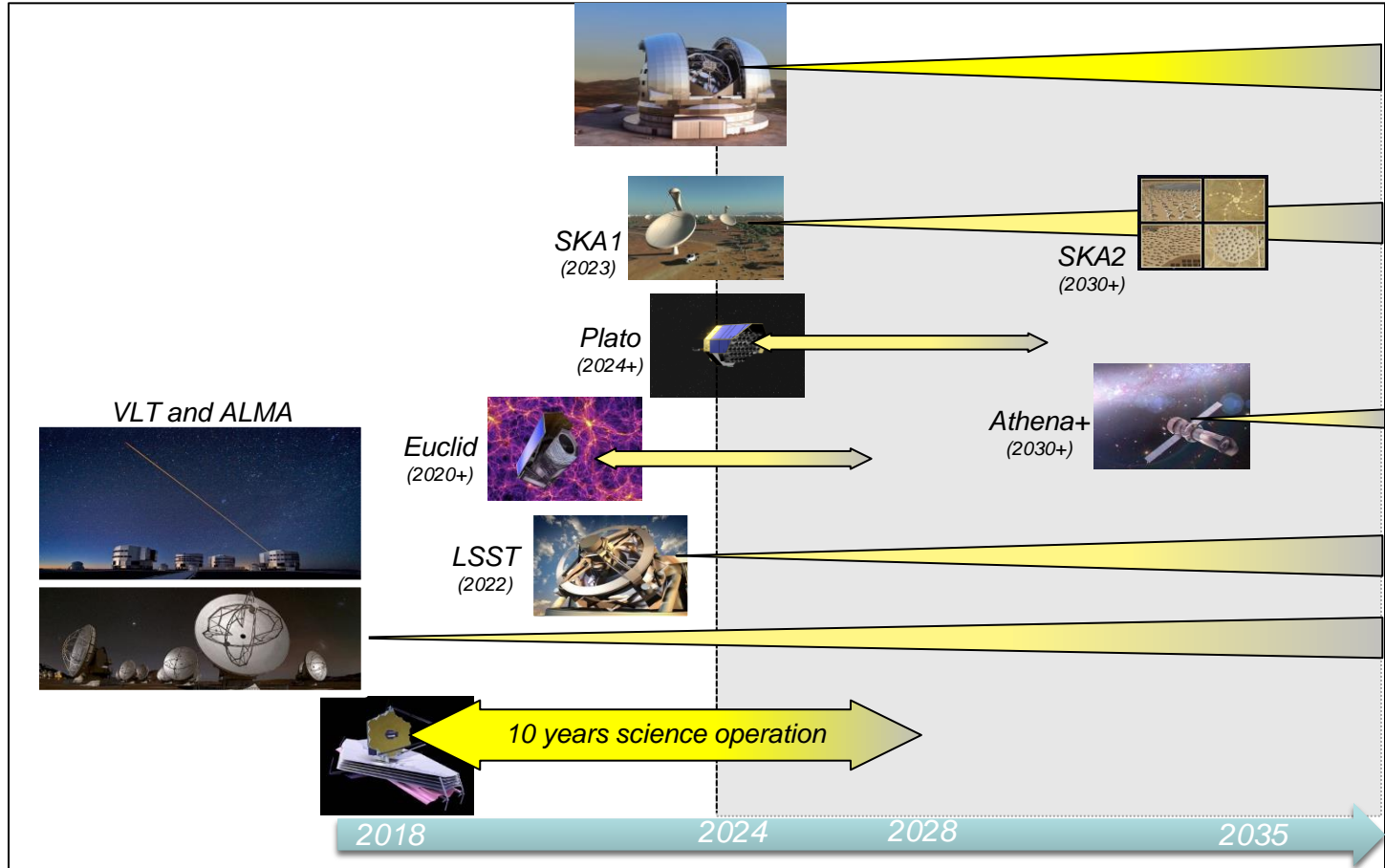
1990

2000

2010

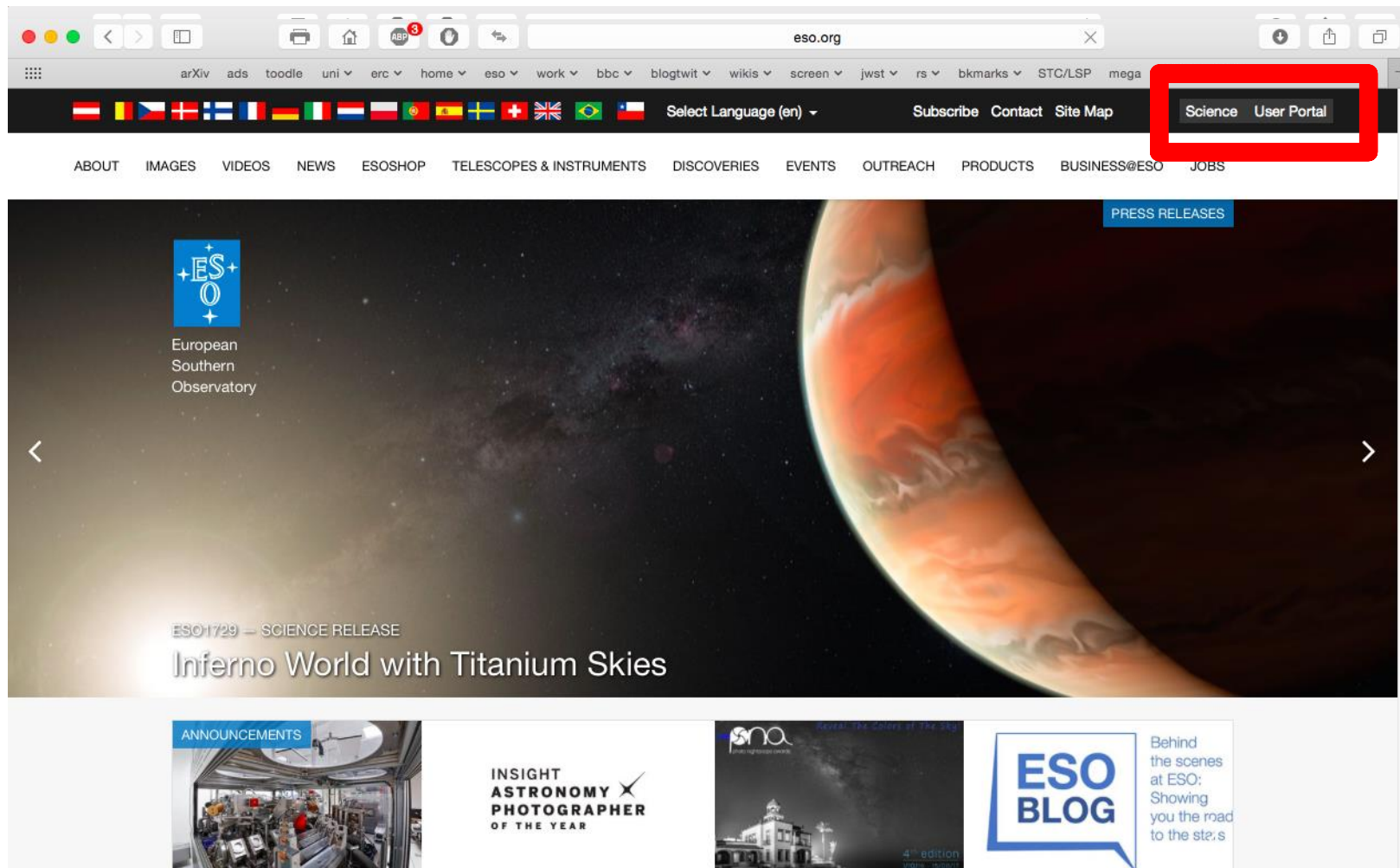
2020

ESO ELT synergies





Your entry to ESO



The screenshot shows the ESO.org website. The browser's address bar displays 'eso.org'. A red rectangular box highlights the 'Science' and 'User Portal' links in the top right navigation bar. Below this bar is a row of flags and a 'Select Language (en)' dropdown. The main navigation menu includes links for ABOUT, IMAGES, VIDEOS, NEWS, ESOSHOP, TELESCOPES & INSTRUMENTS, DISCOVERIES, EVENTS, OUTREACH, PRODUCTS, BUSINESS@ESO, and JOBS. The main banner features the ESO logo and the text 'European Southern Observatory' on the left, and a large image of a planet's horizon with the text 'Inferno World with Titanium Skies' and 'ESO1729 - SCIENCE RELEASE' on the right. A 'PRESS RELEASES' button is in the top right corner of the banner. At the bottom, there are four sections: 'ANNOUNCEMENTS' with an image of a telescope interior, 'INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR', 'ESO BLOG' with an image of a building at night, and a text box titled 'Behind the scenes at ESO: Showing you the road to the stars'.

eso.org

arXiv ads toodile uni erc home eso work bbc blogwit wikis screen jwst rs bkmrks STC/LSP mega

Select Language (en) Subscribe Contact Site Map **Science User Portal**

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European Southern Observatory

ESO1729 - SCIENCE RELEASE

Inferno World with Titanium Skies

ANNOUNCEMENTS

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

ESO BLOG

Behind the scenes at ESO: Showing you the road to the stars

ESO Science Newsletter

- Regular electronic newsletter with latest information, e.g.
 - Call for Proposals, Period 101 – deadline September 28
 - **ESO Fellowships (Germany or Chile) – deadline October 15**
 - **ESO Studentship Programme – deadlines May 15, Nov 15**
 - **Engineering & Technical Research Fellowship Programme – deadline October 15**
 - **ESO Visitor programme** (e.g. Prof. Geraint Lewis, 2018)
 - Release of “Phase 3 datasets” from ESO Data Archive Facility
 - “Science Verification” with newly commissioned instruments

Distribution

The distribution list for the *ESO Science Newsletter* remains the same as for the previous Enews: all holders of an ESO User Portal account who opted for the subscription will receive the *ESO Science Newsletter* regularly. New users can subscribe via the **User Portal**.



*APEX: a collaboration between the Max-Planck-Institute
for Radio Astronomy (MPIfR), the Onsala Space
Observatory (OSO) and ESO*



Welcome