New Instruments for VLT and La Silla

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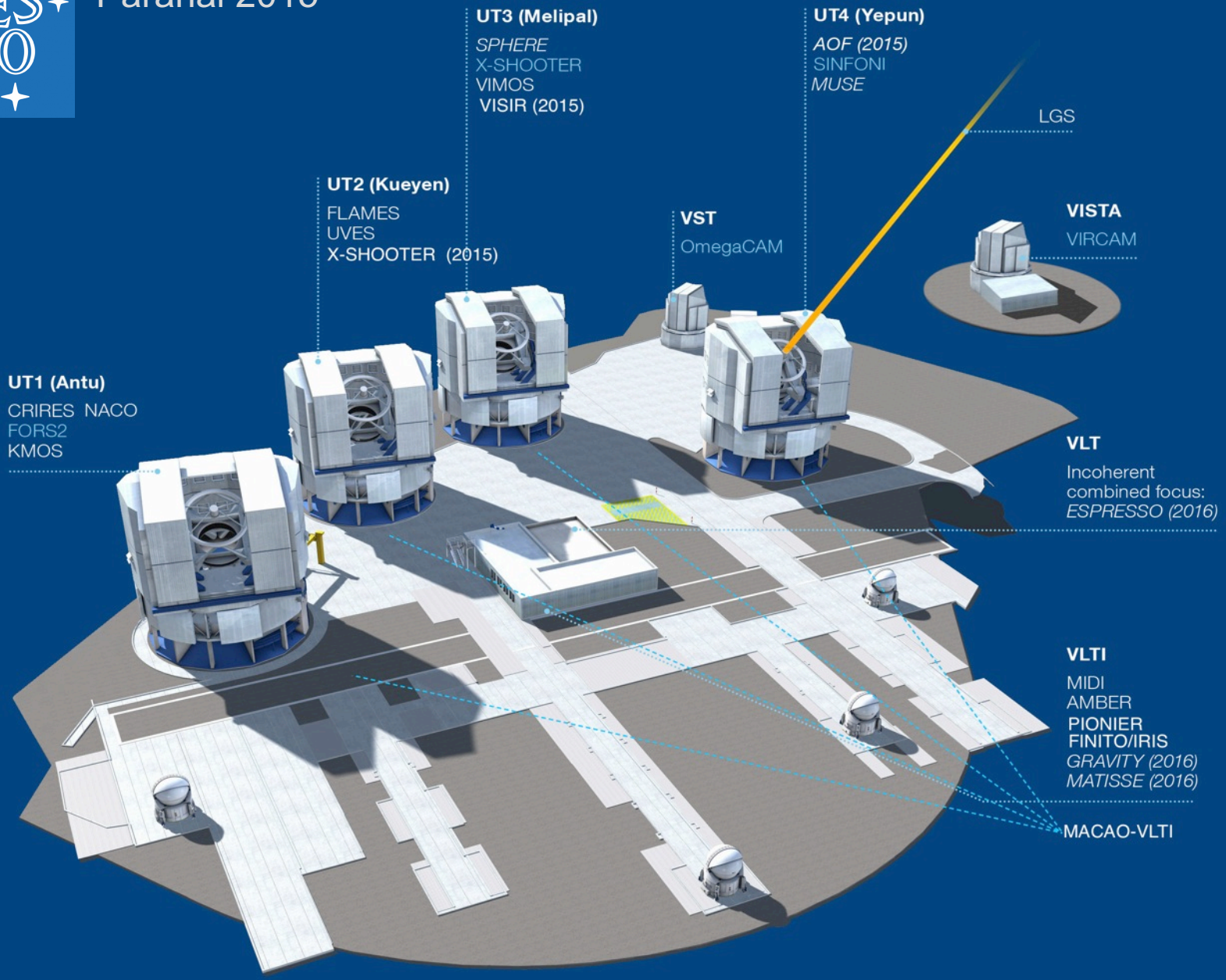
The three modes of the VLT

Incoherent combined focus (ESPRESSO)

Coherent combined focus Interferometry (PIONIER, GRAVITY, MATISSE)

Individual use of the unit telescopes (Cassegrain and Nasmyth foci)

Paranal 2015



La Silla Paranal Vision

- Maintain VLT in world-leading position for another 10-15 years by continued upgrades
- Exploit unique capabilities of the VLTI

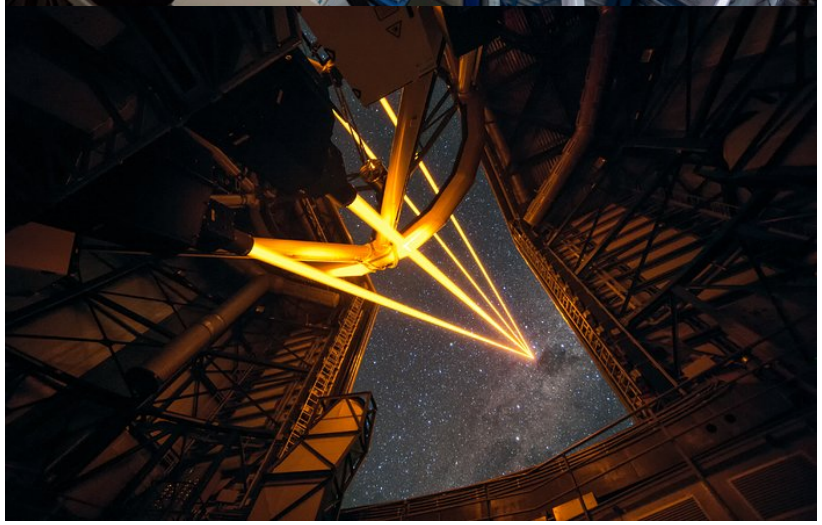
- The programme includes ESO 3.6m and 3.5m NTT telescopes at La Silla, 4m VISTA at Paranal.

Paranal Facilities

- VLT
  - Instrumentation operating, in assembly and planned
    - Covers the available optical infrared wavelengths 300nm to 20µm
    - Angular resolution from seeing limit to 50 µ-arcseconds
    - FORS2, UVES, FLAMES, NACO, SINFONI, VISIR, HAWK-I, X-Shooter, laser guide star facility, KMOS, MUSE, SPHERE, Adaptive Optics Facility, ESPRESSO, CRIRES+, ERIS, MOONS
- VLTI
  - PIONIER, GRAVITY, MATISSE
- VISTA
  - VIRCAM, 4MOST
- VST
  - ΩCam

Adaptive Optics Facility (AOF)

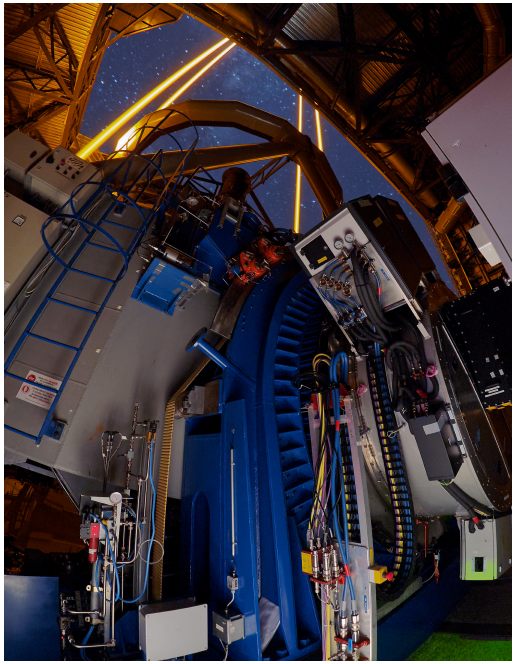
- 4 Laser Guide Star Facility (4LGSF)
- Deformable secondary mirror
- GALACSI+MUSE Wide-Field Mode (WFM)
  - Optical ground-layer adaptive optics correction
  - FoV 60”x60”
- GRAAL+HAWK-I
  - Near-infrared ground-layer adaptive optics correction
  - FoV 7’x7’
- GALACSI+MUSE Narrow-Field Mode (NFM)
  - Optical laser tomography
  - FoV 7.5”x7.5”



Four Lasers

Adaptive Optics Facility

- GALACSI MUSE WFM offered
  - GLAO to feed the MUSE Wide-Field Mode:
    - seeing enhancer in 1x1 arcmin^2 FoV @ 750nm
    - 4 LGSs located ≈1 arcmin from the optical axis
    - No optics inserted in the MUSE scientific FoV
- GRAAL + HAWK-I offered
  - GLAO to feed HAWK-I camera
    - seeing enhancer in 7x7 arcmin^2 FoV @ 0.9 to 2.2μm
    - 4 LGS located outside the FoV
- GALACSI MUSE NFW commissioning
  - laser tomography adaptive optics (LTAO)
    - full correction (goal 10% Strehl ratio) in 7.5x7.5 arcsec^2 @ 650nm
    - 4 LGS located ≈ 8 arcsec from optical axis

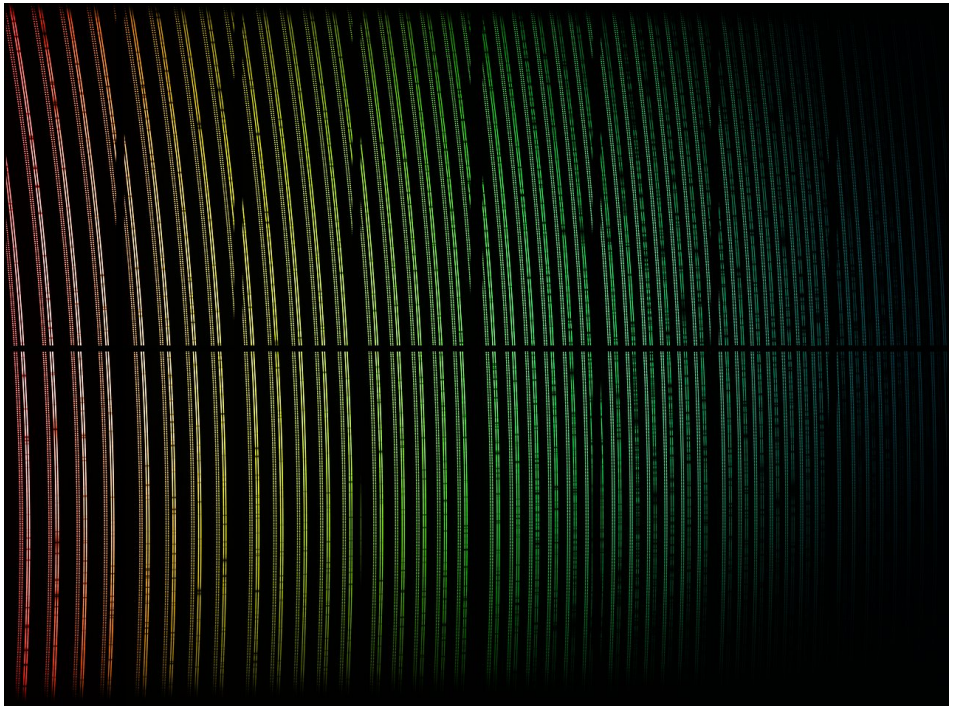


Planned new VLT/I instruments

- GRAVITY – highest angular resolution in K-band
- ESPRESSO – extremely stable high-resolution spectrograph
- Matisse – mid-infrared interferometry instrument
- ERIS – new NIR AO imager (NACO replacement)
  - includes SINFONI upgrade
- MOONS – high multiplex NIR spectroscopy
- 4MOST (VISTA) – high multiplex optical spectroscopy
- FORS2 upgrade – maintain instrument operational
- CUBES – UV high-resolution spectroscopy
- New AO instrument – optical AO imager and spectrograph

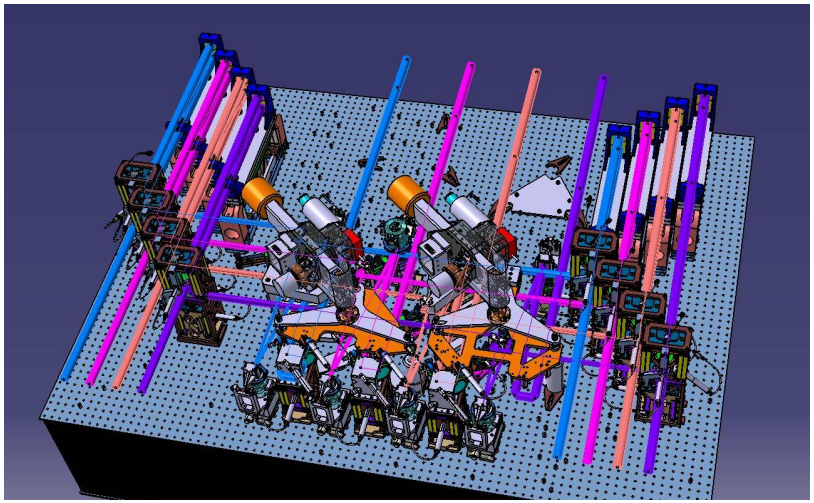
ESPRESSO

- The Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations
  - ESPRESSO is a super-stable optical high-resolution fibre-fed spectrograph for the combined coudé focus of the VLT
  - Uses any of the UTs or up to 4 UTs simultaneously
  - 0.38-0.8 μm
  - R=120k-220k
  - 4UT R=60k
  - V_{rad}~10 cm/s
- In commissioning



MATISSE

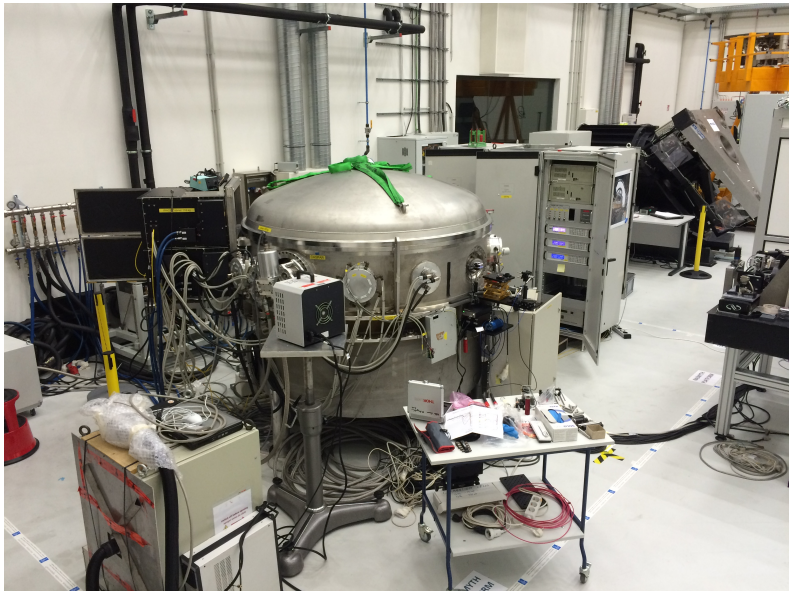
- MATISSE
  (Multi-Aperture mid-Infrared SpectroScopic Experiment)
  - VLTI four-telescope L, M and N-band imager
  - Multi-axial beam combination, closure phase imaging
  - Spectral resolutions between R=30 and 5000
  - Operating with UTs and ATs
  - Will use GRAVITY as a fringe tracker



- In commissioning

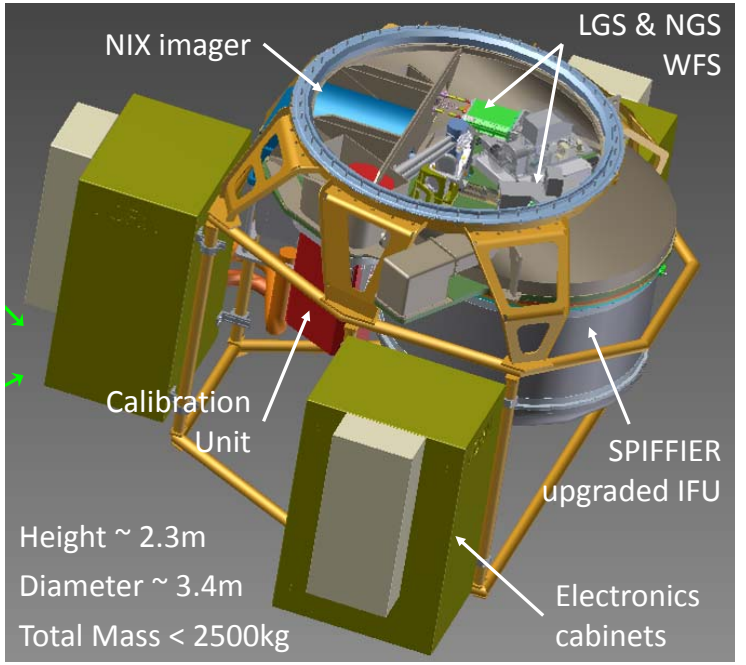
CRIRES upgrade

- CRIRES Upgrade project
  - 1-5 microns spectral coverage, R~20k–100k
  - Cross-disperser + new detectors will enlarge simultaneous wavelength coverage by ~10 times, will cover simultaneously one IR band
  - Gas cells will provide few m/s radial velocity precision
  - Polarimetric capabilities
  - Refurbished AO system
- Offered in 2019



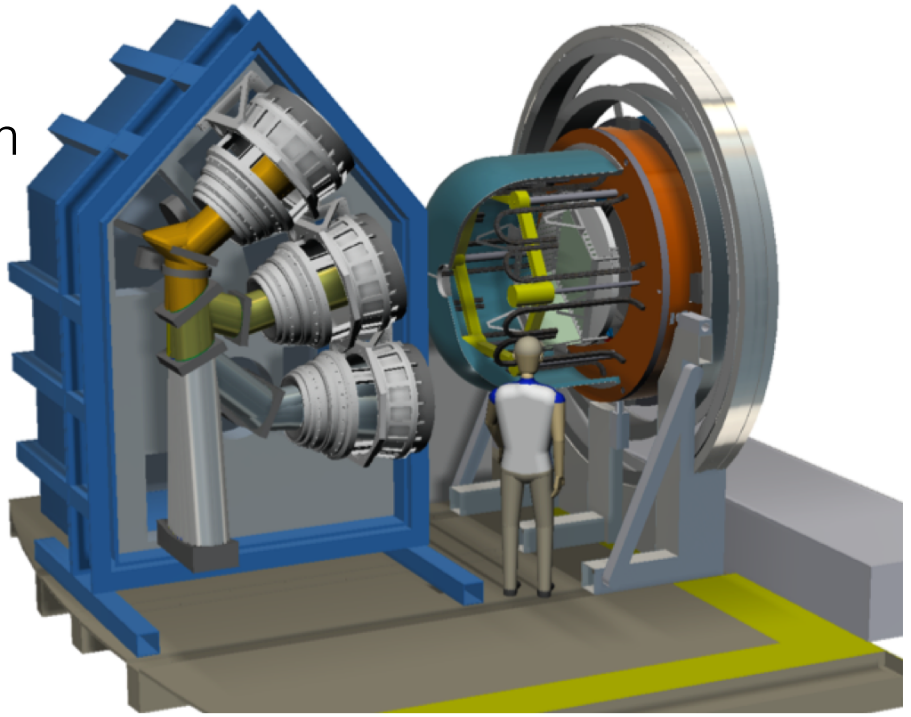
ERIS

- SPIFFI Integral field spectroscopy
  - FoV 0.8”, 3.2”, 8”; R~3000 & 8000; J-K bands
- NIX (camera)
  - J-K narrow/broad bands; 13/27 mas pix (26”/55” FoV)
  - L-M broad bands; 27 mas 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
- Offered after 2020



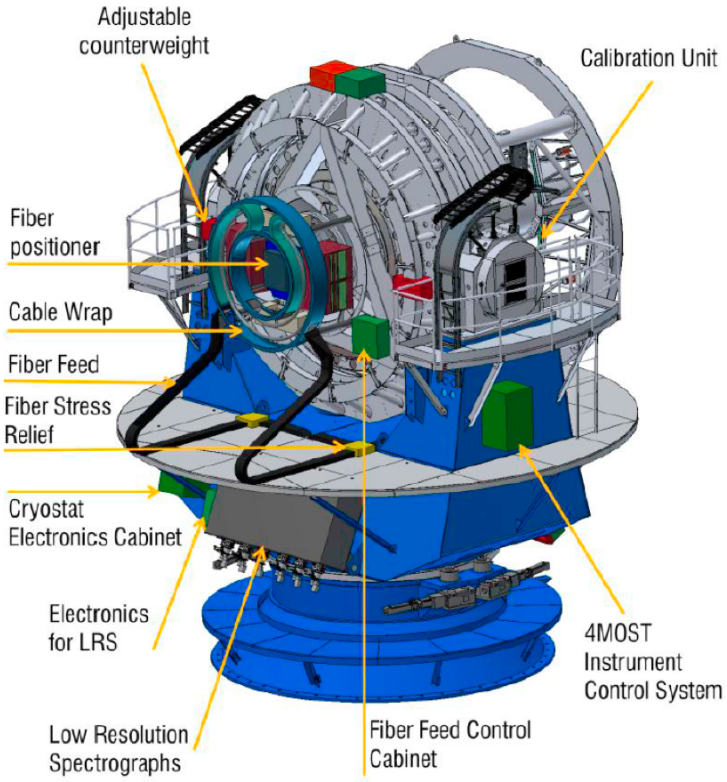
MOONS

- Multi-Object Optical and Near-infrared Spectrograph
  - Field of view: 500 arcmin^2 at the 8.2m VLT
  - Multiplex: 1024 fibers with the 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 = 9000
    - 0.95-1.35μm at R=4000
    - 1.52-1.63μm at R=20000
- Offered after 2020



4MOST

- 4MOST will be a world-class facility for fiber-fed multi-object spectroscopy
  - 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 (1600 in LRM, 800 in HRM)
  - broad wavelength coverage in LRM (400-885 nm)
  - broad wavelength coverage in HRM (393-435 nm and 521-571 nm, 610-675 nm)
  - implementation at the Cassegrain focus of the VISTA telescope
- Offered after 2022



Visible Adaptive Optics Instrument

- Discussed in two ad-hoc workshops, in consultation with LSP & STC (STC-568, STC-581)
- Most attractive concept: VISIBLE MCAO
  - Call for Phase A studies to be issued soon
    - Science cases
    - Top Level Requirements
    - Strawman Concept (for costing and feasibility) (AO Concept)
    - Management plan
- Maintain optical imaging at the level of HST into the next decades
- Strong synergies with ELT

Visible Adaptive Optics Instrument

- Optical camera with
  - ~7 mas per pixel
  - 30 arcsec diameter FoV
  - Focus on VRI but also UBz sensitivity
- IFU Spectroscopy
  - ~3x3 arcsec^2 FoV
  - 20-40 mas spaxels
  - Spec. res. at R~5000
- Adaptive Optics
  - Diffraction limited in V-band (AOF + 2 more DMs)
  - Strehl ratio >10% in V-band
  - 4 or 5 Lasers
  - Near IR WFS

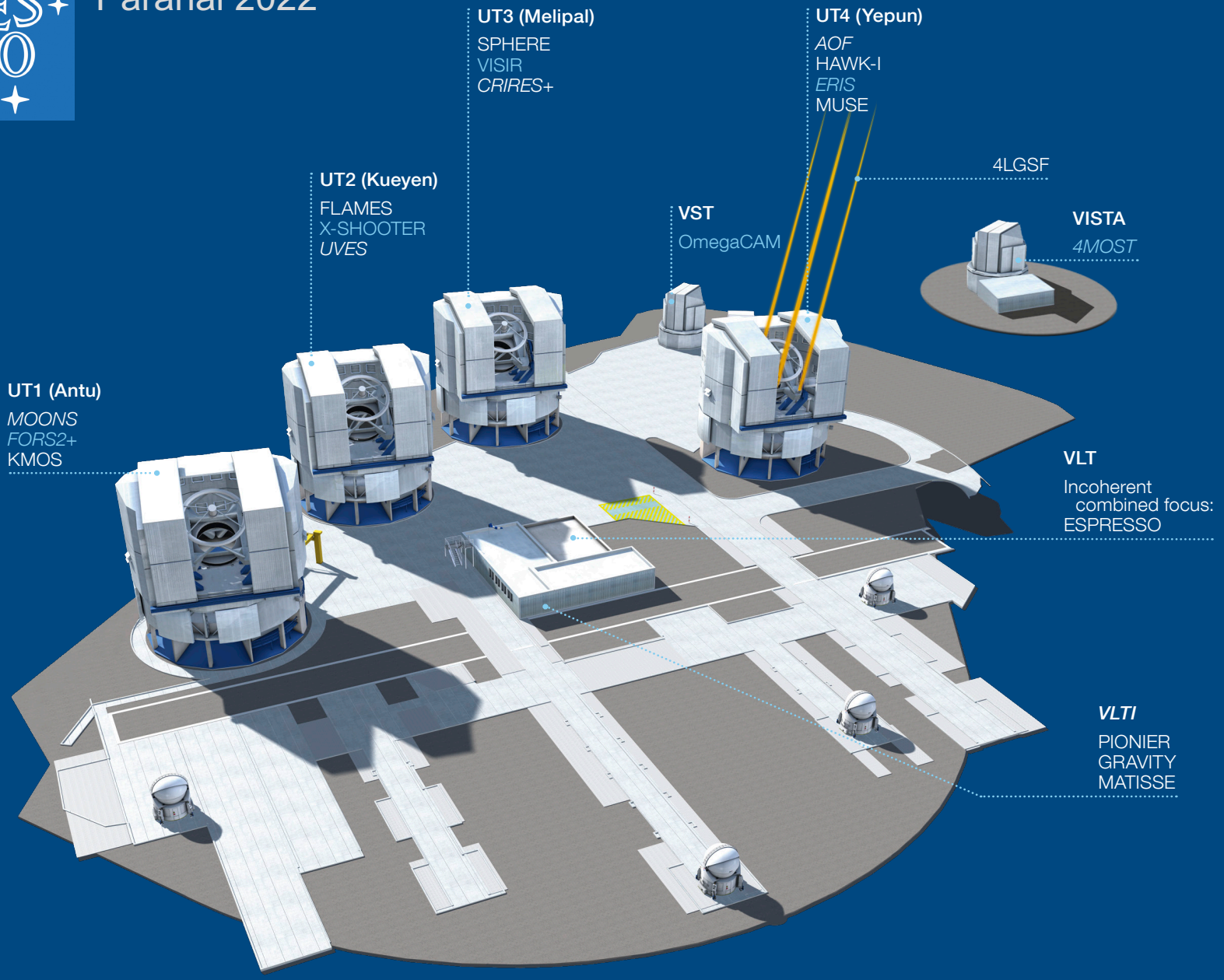
FORS2 Upgrade

- FORS to remain available for another 2 decades
  - 15+ years life and new controllers require new electronics and control SW
  - Decommissioning of VIMOS makes the case for a blue MOS at VLT (FORS MXU)
- Requested for a long time
  - New CCD to avoid blue-red camera exchange
    - Maximize operations efficiency
- Start in 2018

UV Spectrograph

- UV spectroscopy (310-380nm)
  - Stellar and extragalactic science cases
    - dedicated workshop in 2013
  - Complementarity/synergies with ELT
  - Phase A review Sep 2012: Simple, moderate size project
- Planning started

Paranal 2022



OIR Future Strategies

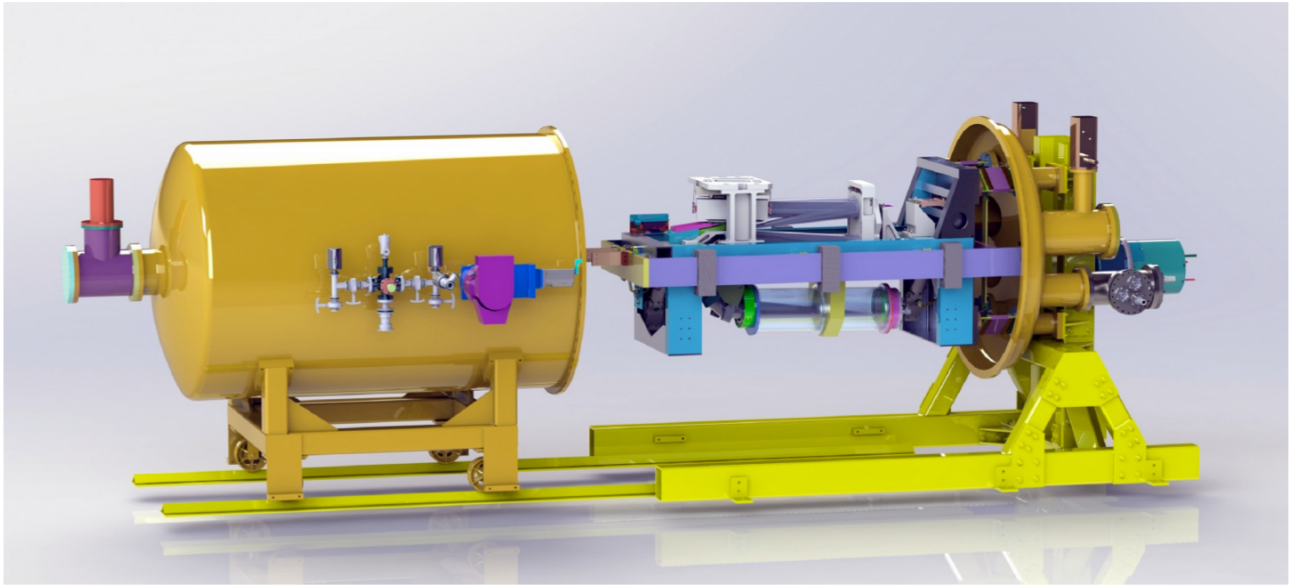
- Flexibility
  - Astrophysics covers many topics and techniques
  - Completeness of instrumentation
  - Reaction to interesting new events, object and topics
- Coordination
  - Instrumentations programmes at different facilities
    - either through a large pool or through collaboration between observatories
  - Planning between ground and space
  - Time allocation between observatories
- Operations
  - inbuilt flexibility
  - archive → open distribution of data

La Silla beyond 2020

- Dedicate large telescopes to specific science topics
  - 3.6m telescope: exo-planets, radial velocity studies
    - HARPS; NIRPS
  - NTT: transient sky
    - EFOSC2, SOFI, (ULTRACAM); SOXS
- Hosted telescopes
  - in operation
    - 2.2m MPG
    - 1.54m Danish
    - 1.2m Euler
    - REM
    - TAROT-S
    - TRAPPIST
    - ESO 1m
  - upcoming
    - ExTra (2017)
    - MASCARA (2017)
    - TBT (2018)
    - BlackGEM (2018)

NIRPS

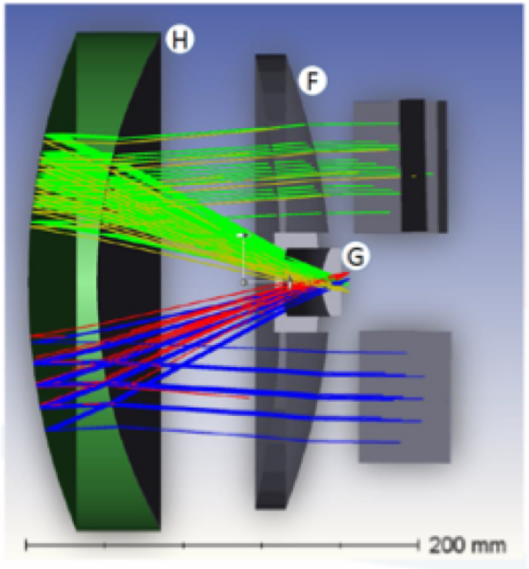
- NIRPS @ 3.6m : High Accuracy NIR Spectrograph
  - NIR (970-1800 nm)
  - High Resolution: R>80000
  - AO-Assisted
  - Simultaneous observations with HARPS
  - $v_{rad} < 1\, m/\mathrm{sec}$



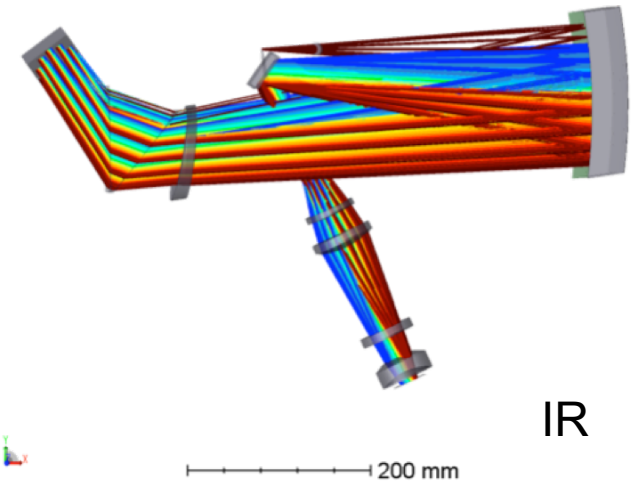
SOXS

- SOXS @ NTT
  - Broad-band spectrograph, 350nm through 2.0μm
  - *R* ~ 4,500 (3,500–6,000)
  - Two arms (UV-VIS + NIR)
  - S/N ~ 10 spectrum, 1-hr exposure at *R* ~ 20
  - Acquisition camera (3'x3') to perform photometry in *ugrizY*

Vis



IR



Near Future

- April 2018
  - VIMOS Decommissioning
  - ESPRESSO 1UT offered
  - GRAVITY Astrometry offered (partial support)
- 2019
  - ESPRESSO 4UT offered
  - MATISSE UT & AT offered
  - MUSE NFM offered
  - CRIRES offered
- 2020
  - NIRPS offered
  - ERIS
  - MOONS