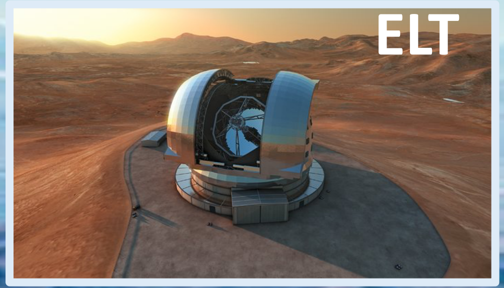
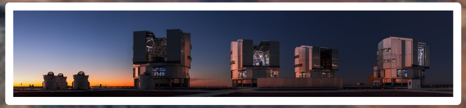


Cerro Amazones 3060m

new challenges in modern astronomy and astrophysics: the Extremely Large Telescope (ELT) project

Paranal Observatory 2635m



Livia Origlia - INAF OAS Bologna
e-mail:livia.origlia@inaf.it

OAS Days – Bologna, 17-18 December 2018

the ELT project

https://www.eso.org/public/teles-instr/elt/

the ELT telescope with a primary mirror of 39m in diameter will be the largest optical/near-IR telescope in the word, excelling in collecting power and angular resolution

milestones

- Dec 2014: ESO Council gave green light for ELT construction
- June 2016: Council approved first light in 2024

Italian participation

- ESO-member state
- Industries: ACe (dome structure), AdOptica (M4 cell)
- INAF instrument PI-ships (MAORY & HIRES)
- some participation in MICADO & MOS

the site

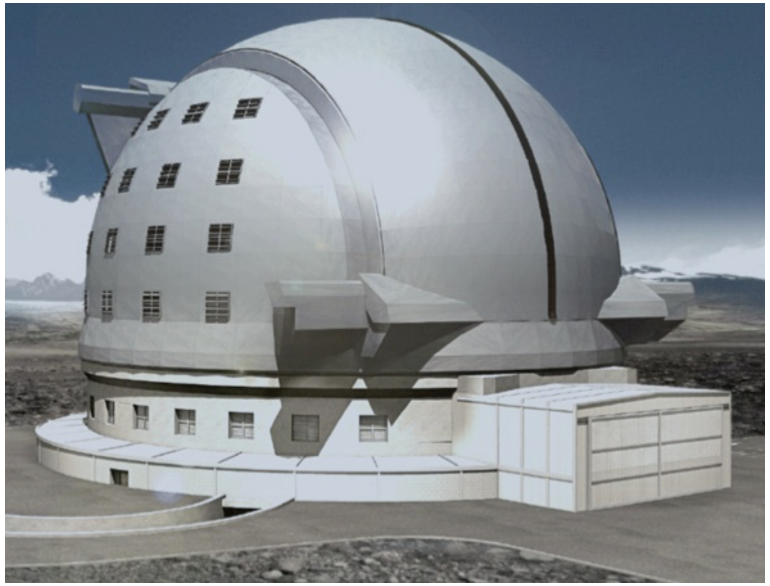
Cerro Amazones (Chile), altitude=3060m, b=-24°S, l=-70°W

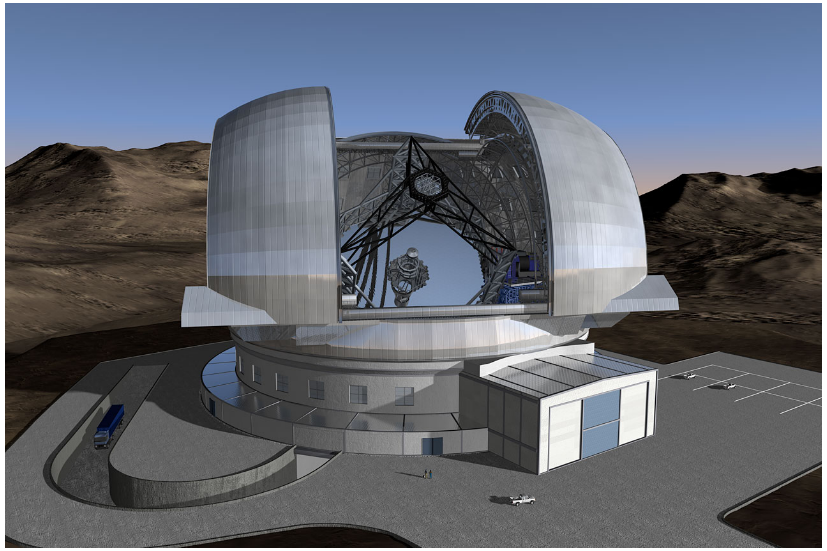
median **seeing=0.67 arcsec** at 500nm, median relative **humidity=15%,** mean wind speed =7m/s, **air temperature** between -15°C and +25°C, yearly **median nighttime =9°C**, average day/night difference =4°C

Immagini ©2018 Landsat / Copernicus,Data SIO, NOAA, U.S. Navy, NGA, GEBCO,Dati cartografici ©2018 Google 5 km

the dome

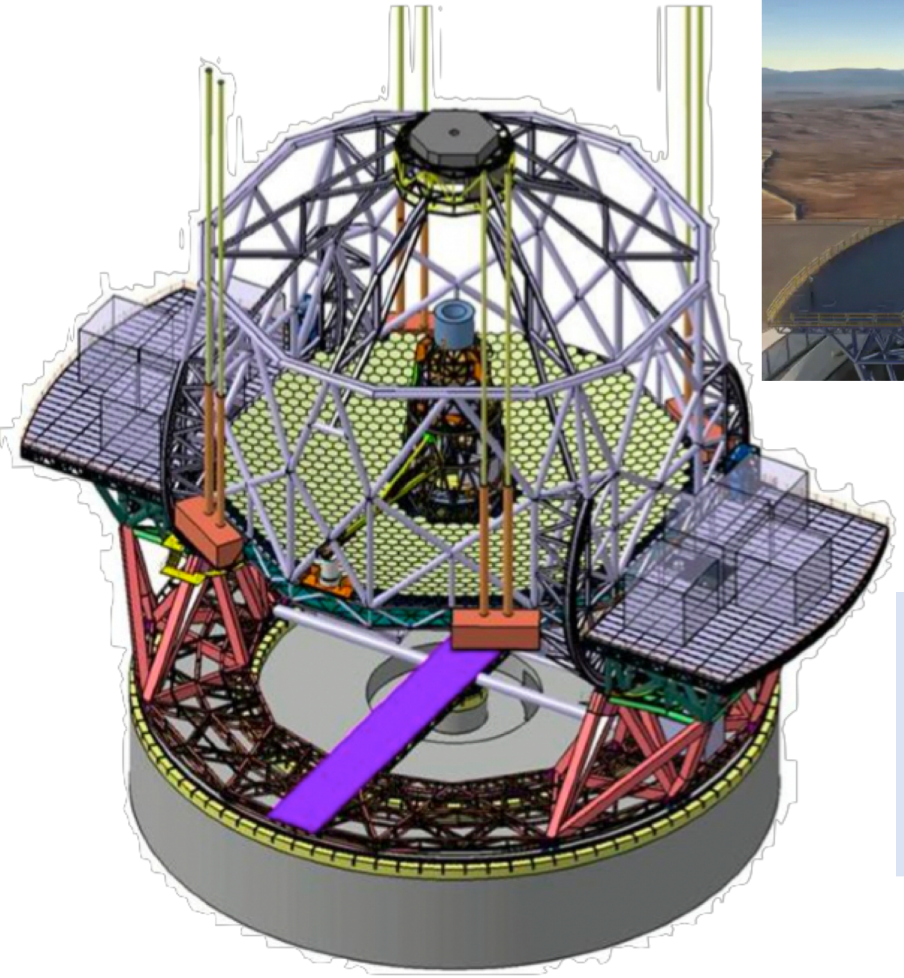
74m height, 86m diameter, single pair of sliding doors with 45.3m total width





the 39m telescope

novel 5 mirror design to include adaptive optics in the telescope, diffraction limited over the full ~10' FoV

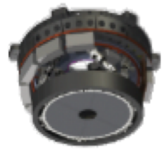


weight ~2880t
height ~62m
width ~71m

M1 Unit - 39m
Concave – Aspheric f/0.9
Segmented (798 segments of 1.4m)
Active + Segment shape Control

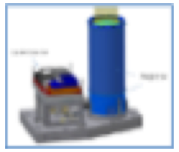
M2 Unit - 4m
Convex Aspheric f/1.1 Passive + Position Control

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



M4 Unit - 2.4m
Flat, Segmented (6 petals with 5000+ actuators each)
Adaptive + Position Control

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



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

courtesy of M. Cirasuolo, ELT Programme Scientist

instrument suite – 1st generation

imagers & spectrographs with **different spatial & spectral resolutions** in the **optical-IR range**

the ability to observe over a wide range of wavelengths from the optical to mid-infrared and in different instrumental configurations will allow scientists to exploit the telescope's size to the fullest extent

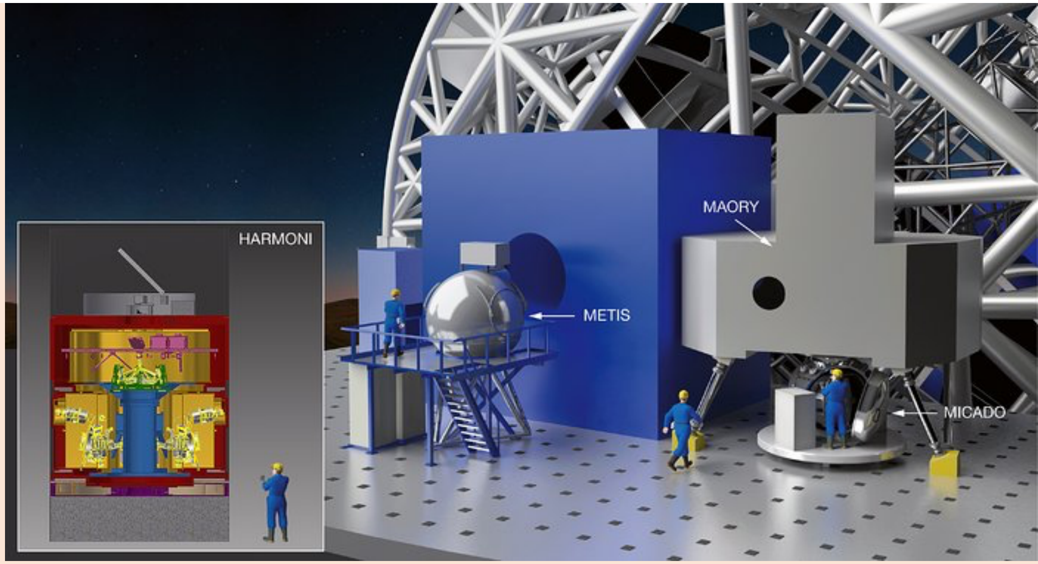
roadmap

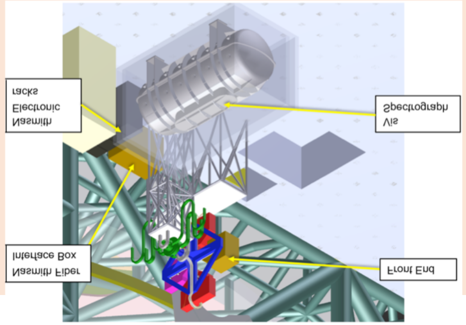
first light

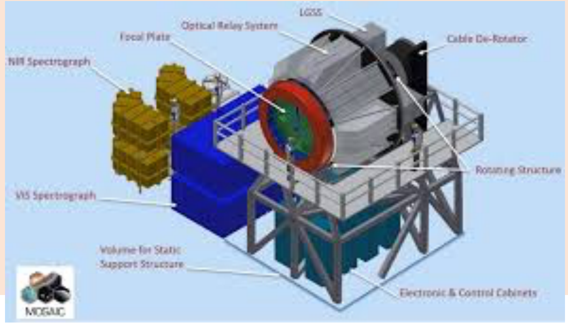
- ELT-CAM (MICADO+MAORY)
- ELT-IFU (HARMONI+LTAO)
- ELT-MIDIR (METIS)

post-first light

- high resolution spectrograph (HIRES)
- multi-object spectrograph (MOS)

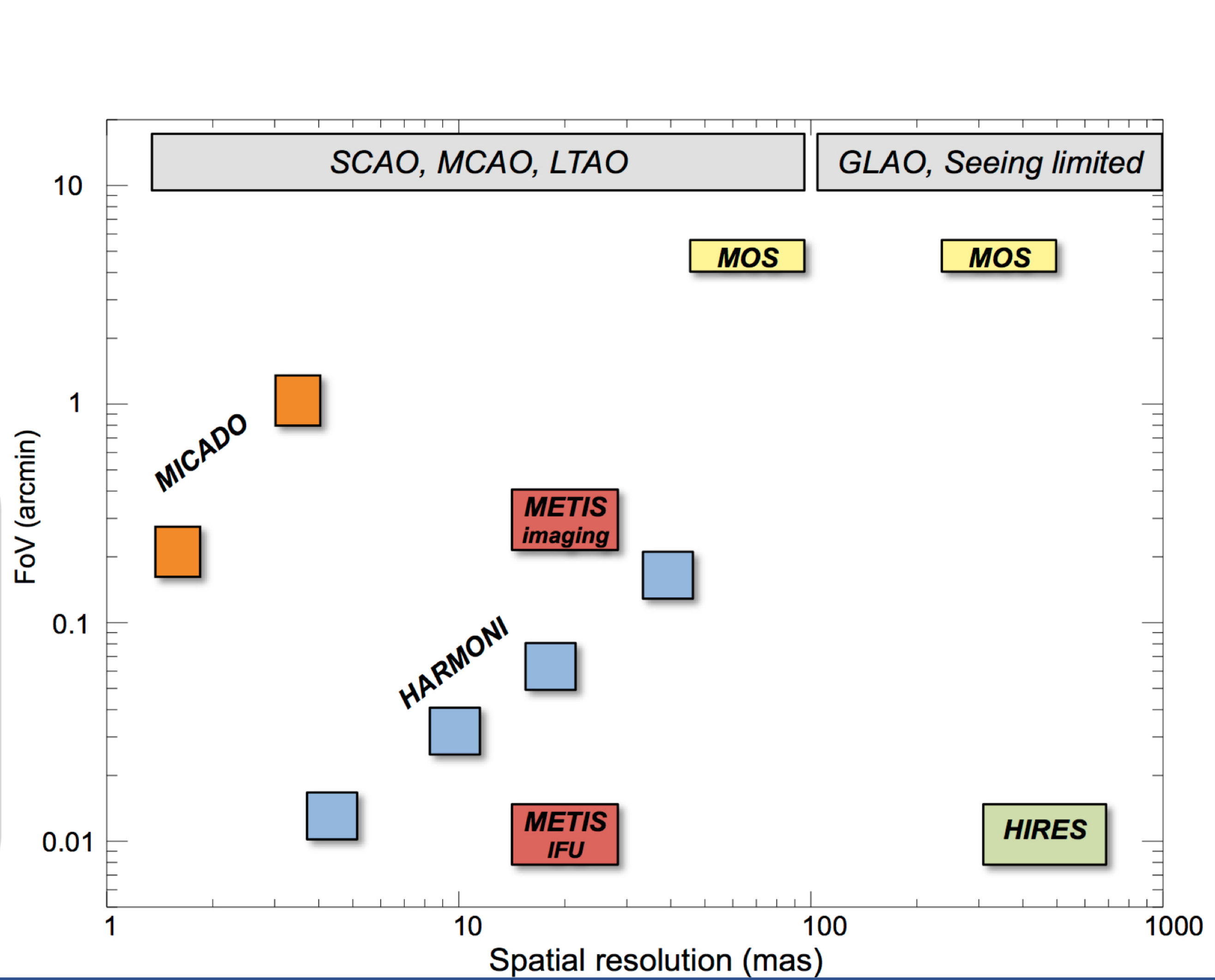


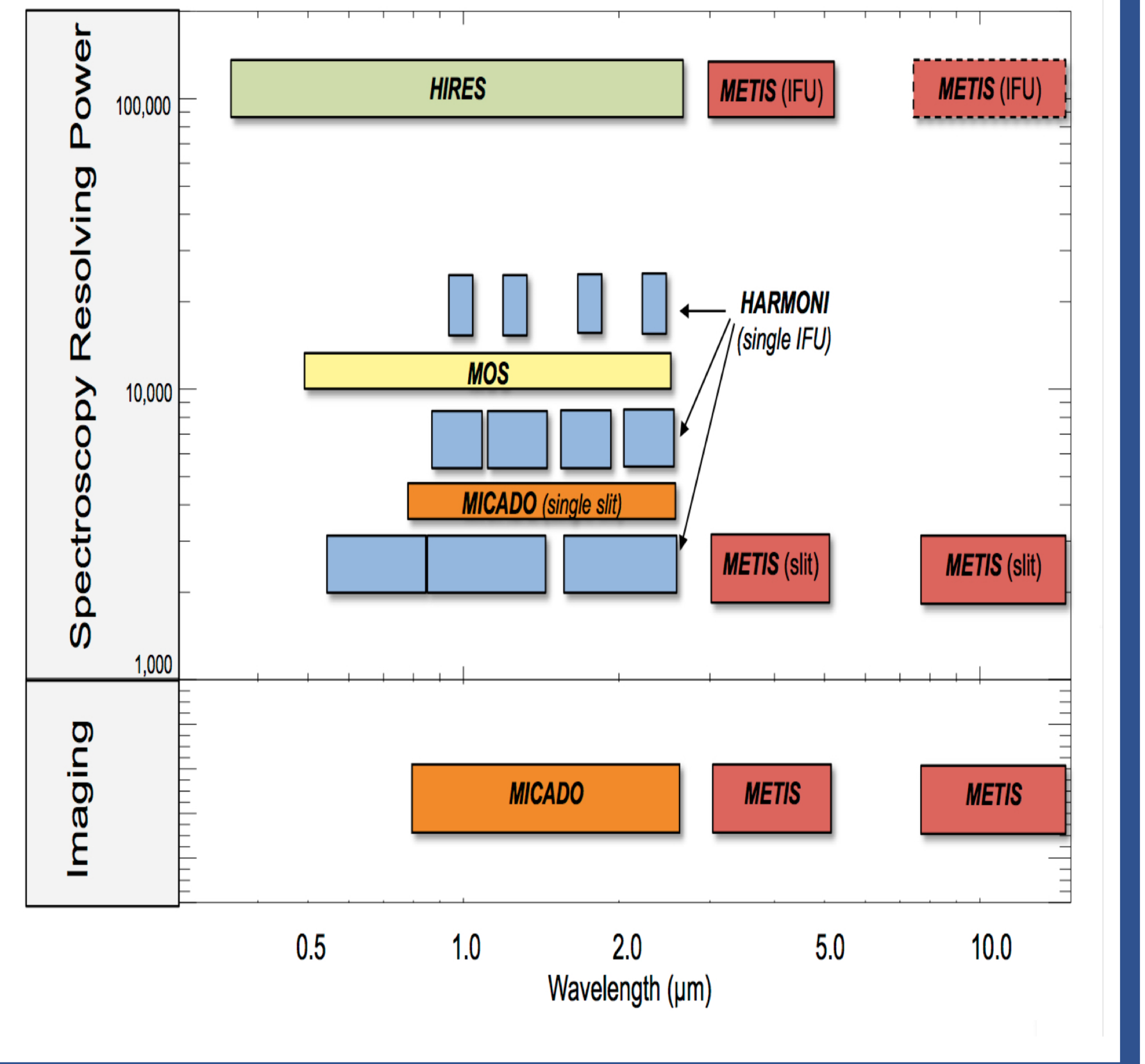




instrument suite – 1st generation

imagers & spectrographs with different spatial & spectral resolutions in the optical-IR range

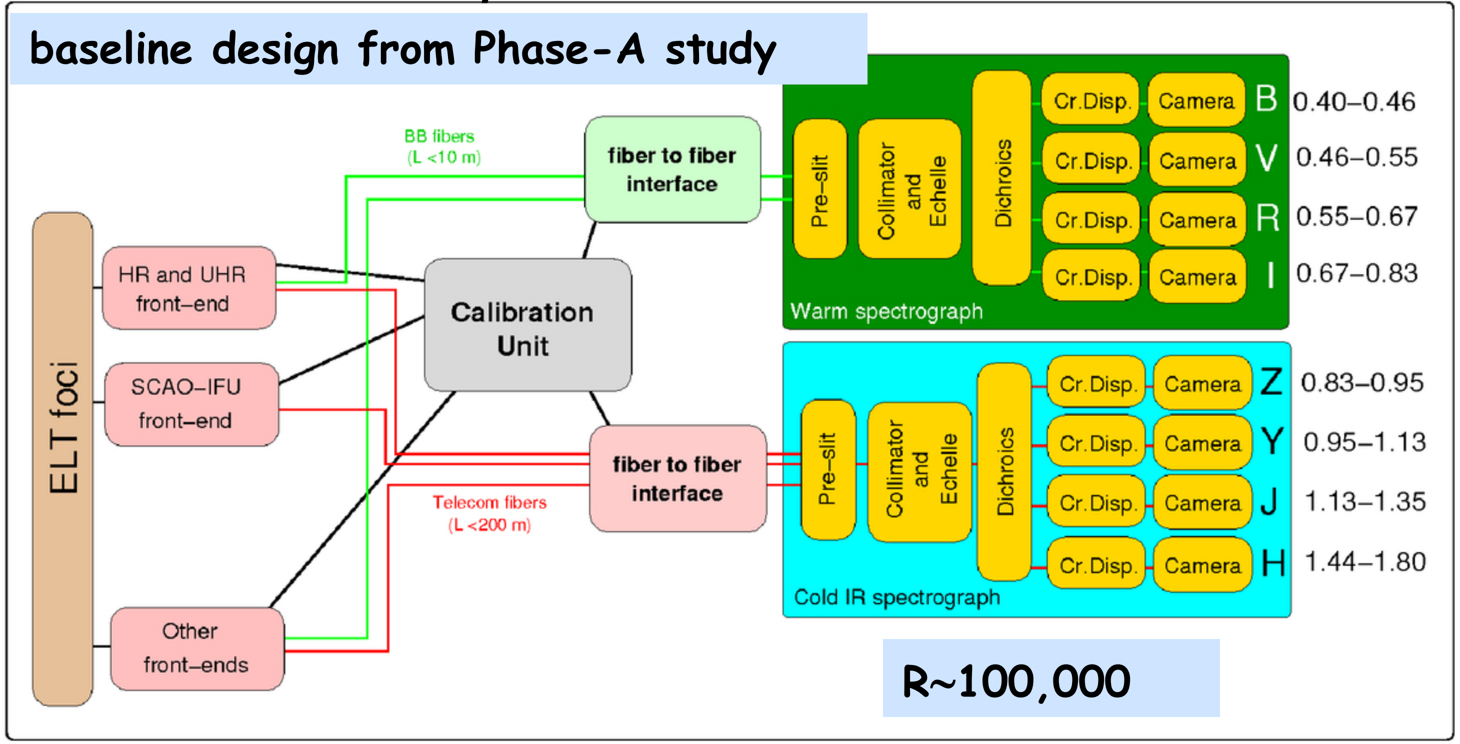




courtesy of M. Cirasuolo, ELT Programme Scientist

ELT HIRES

http://www.arcetri.astro.it/~hires/



Project Office

Principal Investigator: **Alessandro Marconi** (**I**)
Project Scientist: Roberto Maiolino (UK)
Project/ Study Manager (PM): **Luca Valenziano** (**I**), Deputies: Eric Stempels (S), Phil Parr-Burman (UK)
System Engineer (SE): **Marco Riva** (I), Deputies: Alexandre Cabral (PT), Santiago Becerril (ES), Bruno Chazelas (CH)
Software System Engineer (SSE): **Paolo Di Marcantonio** (**I**), Deputies: Tzu Chen (CHL), Manuel Monteiro (PT)
Instrument Scientist (IS): **Livia Origlia** (**I**), Deputies: Pedro Amado (ES), Michael Weber (D), Francois Bouchy (CH)

OAS people: L. Valenziano (PM), L. Origlia (IS), F. Sortino (ConfMan), D. Romano (ST)
UniBo: A. Mucciarelli (ST)

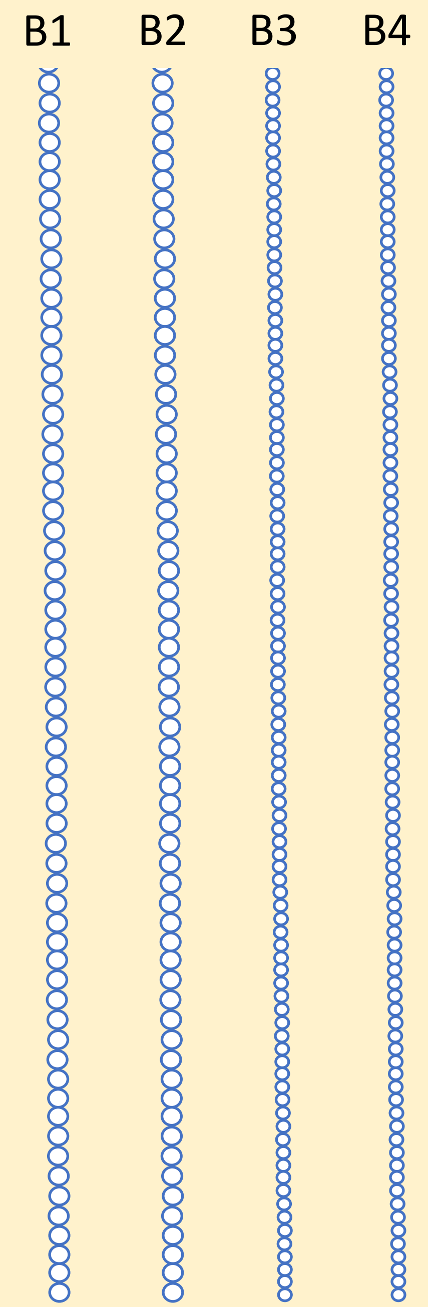
observing modes

examples of observing modes to maximize throughput

obs mode	B1	B2	B3	B4
spectral resolution	100,000	100,000	150,000	150,000
# of apertures on sky	1 (obj)	2 (obj+sky)	1 (obj)	2 (obj+sky)
# of fibers per aperture	64	30	96	46
aperture diameter on sky	1.36''	0.93''	1.11''	0.77''
simultaneous calib	no	no	no	no

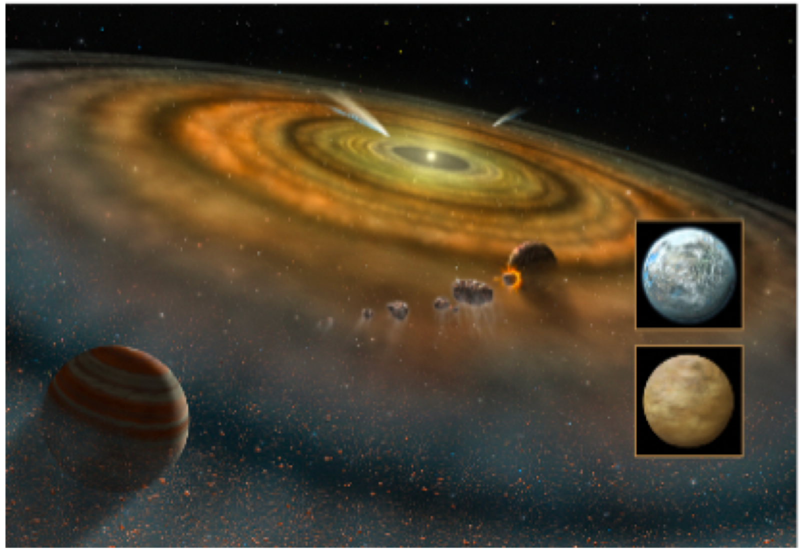
basic concepts

- **obs modes characterized by different configurations for spectral resolution and aperture on sky to fulfil the science TLRs**
- **spectral resolution defined by the sky-projected angular size of the fiber** (a)
- **aperture on sky (A) defined by the angular size of the fiber bundle** ($A = a \times \mathrm{sqrt}(N_{fibers})$)
- current optical design of each spectrometer based on cameras with a maximum slit length of 11 arcsec and a dispersion grating with a length of 1.6 meters
  - at R=100k ➔ max 64 fibers with max angular diameter of 0.170 arcsec
  - at R=150k ➔ max 96 fibers with max angular diameter of 0.113 arcsec
- **each obs mode will have dedicated fiber bundle**(s)
- different bundles will also have different fiber coupling in the fiber-to-fiber interface to optimize throughput (e.g. high efficiency telecom connectors as in APOGEE) or accuracy (e.g. double-scrambling)
- **# of bundles/obs modes ➔ tradeoff among science priority, cost & complexity**
  to be finalized in the next project phases …



from current 8-10m class telescopes to ELT-39m

Planets & Stars



Stars & Galaxies

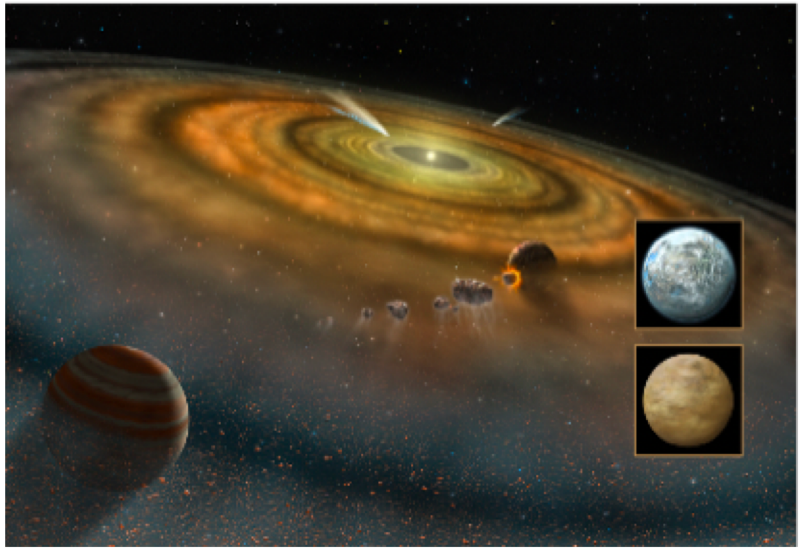
Galaxies & Cosmology

impact on performances

- 😊 spatial resolution at the diffraction limit: $\sim 1/D_{tel}$ → 4-5x <u>better</u>
- 🙁 field of view (projected area on sky): $\Omega \times A \sim const$ → $\Omega \sim 1/D^2_{tel}$ → ~20x <u>smaller</u>
- 😊 sensitivity (S/N): $\sim D_{tel}$ (seeing lim) to D^2_{tel} (diffraction lim) → 4-5x to ~20x <u>better</u>

from current 8-10m class telescopes to ELT-39m

Planets & Stars



Stars & Galaxies

Galaxies & Cosmology

impact on astrophysical information

from **discovery** *to* **characterization** …

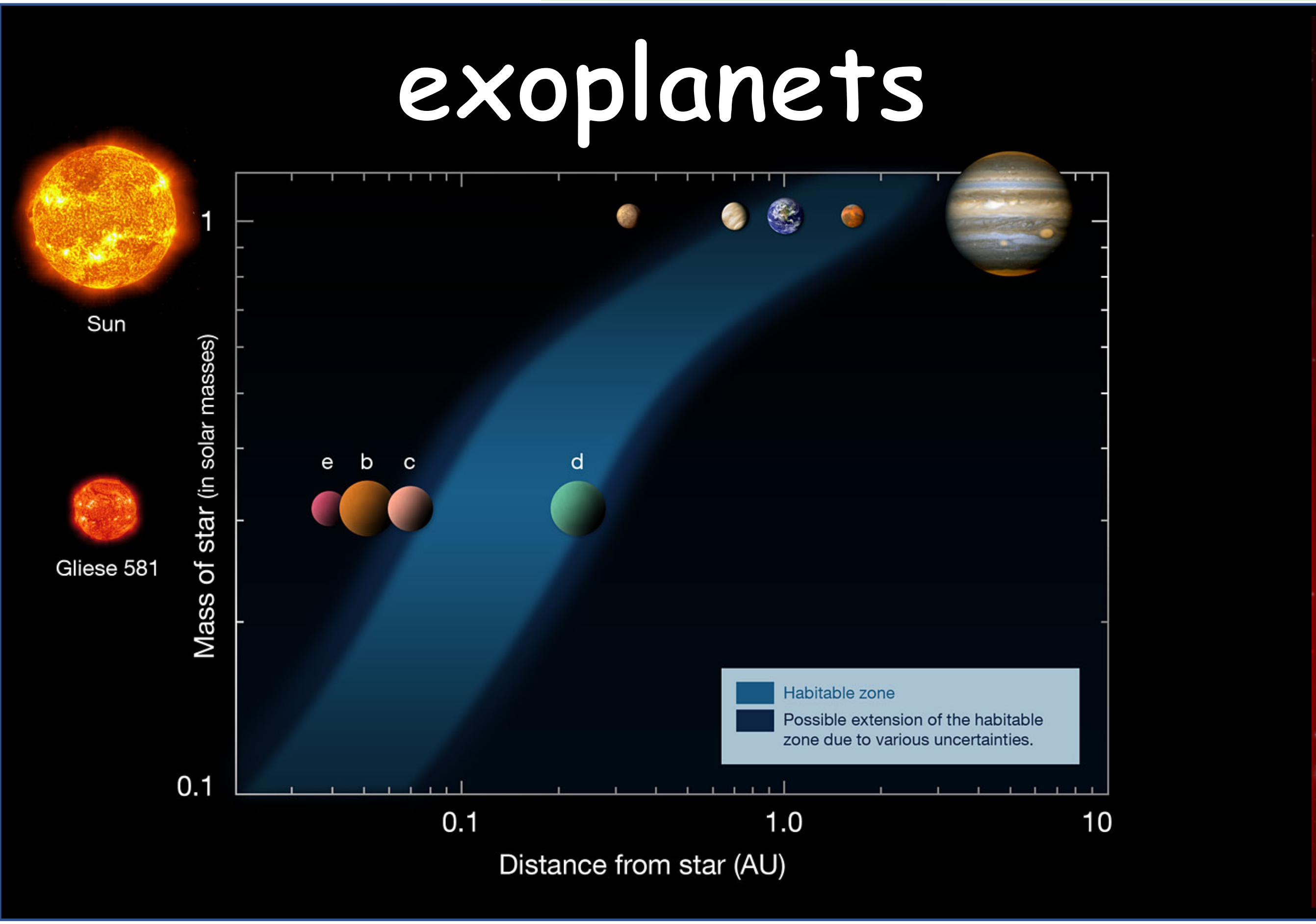
from **sketchy** *to* **detailed** …

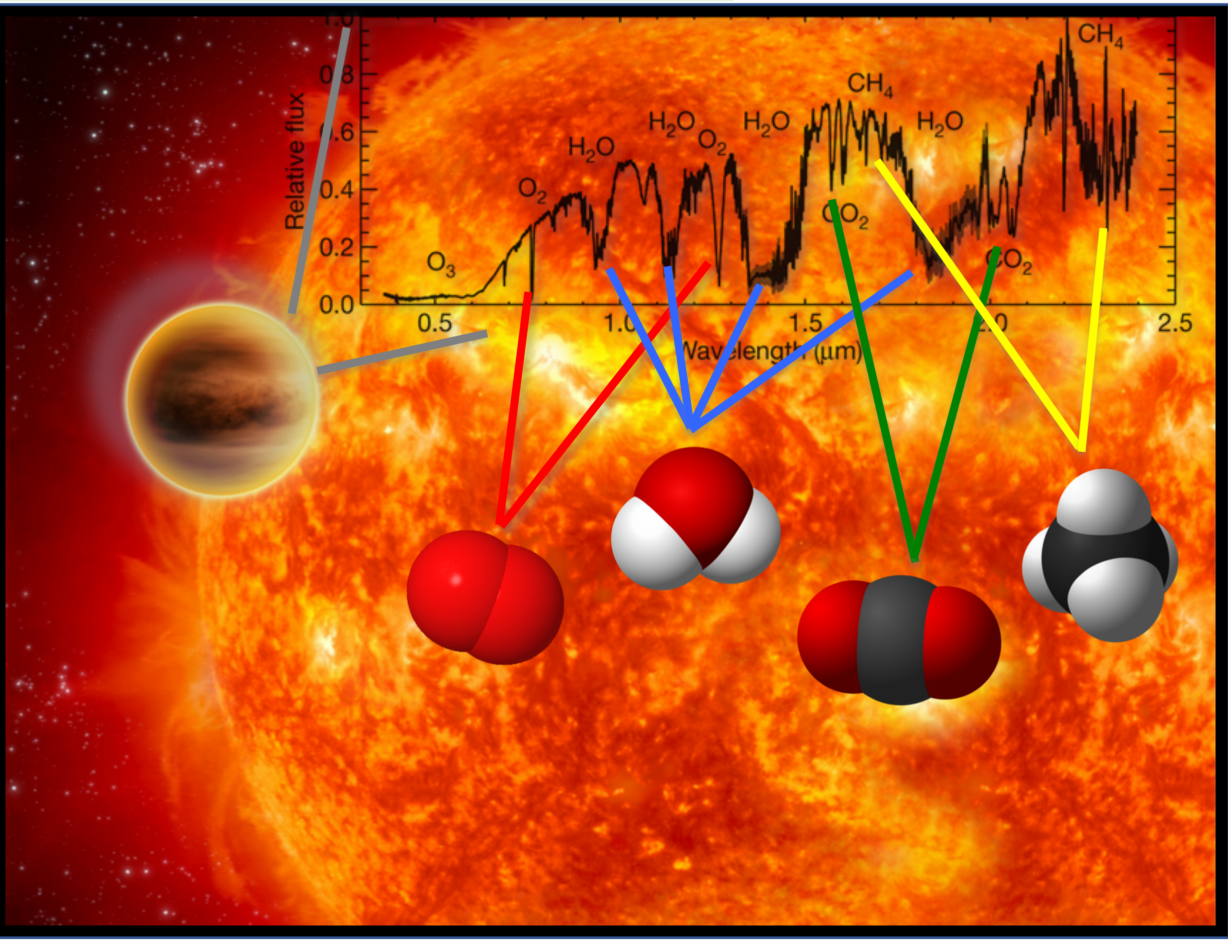
from **local** *to* **distant** …

from **below** *to* **above the threshold** …

the unknown ….

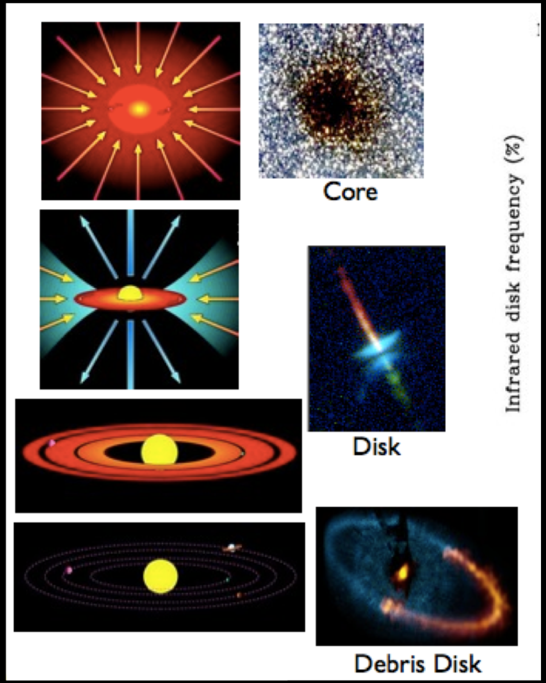
from discovery *to* characterization ...

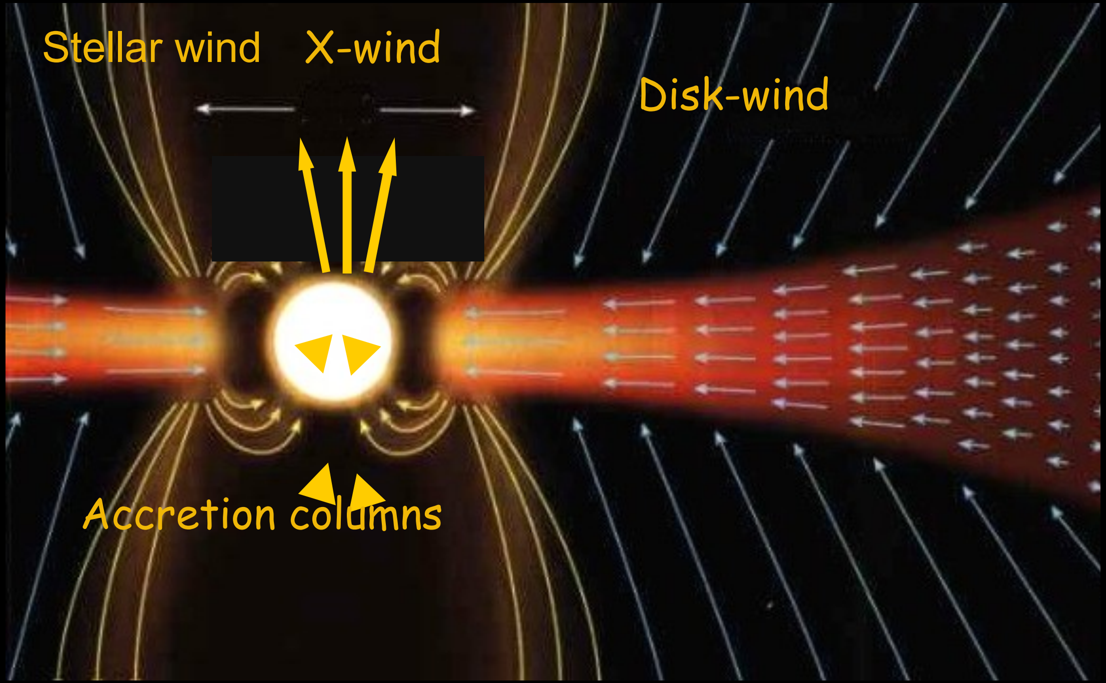


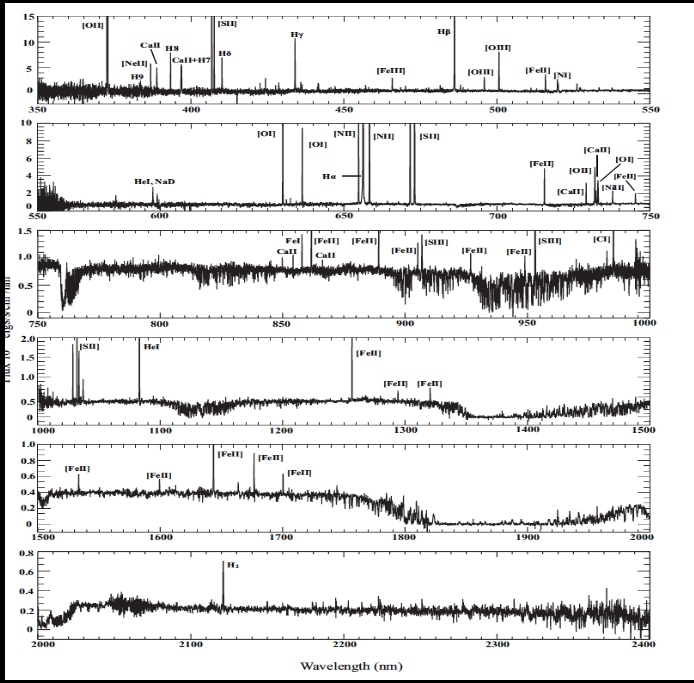


observation and characterization of **exoplanets** in habitable zones, with possible detection of **bio-signatures** in their atmosphere *from* **discovery** *to* **characterization** ...

star/disk/planet formation





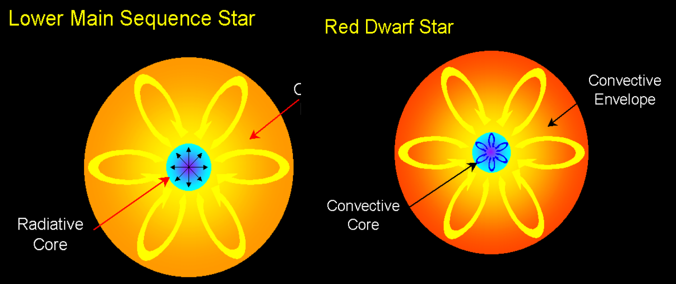


observation and characterization of **proto-planetary disks**, with possible detection of **pre-biotic molecules**

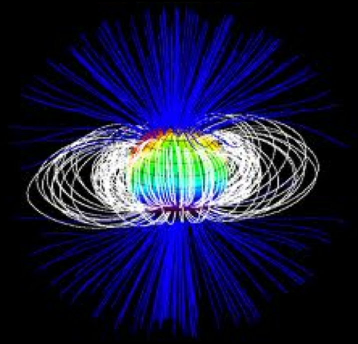
from **sketchy** *to* **detailed** …

stellar physics

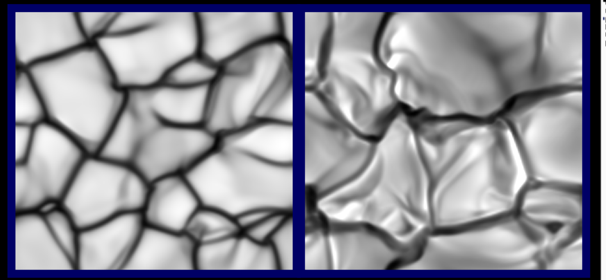
asteroseismology



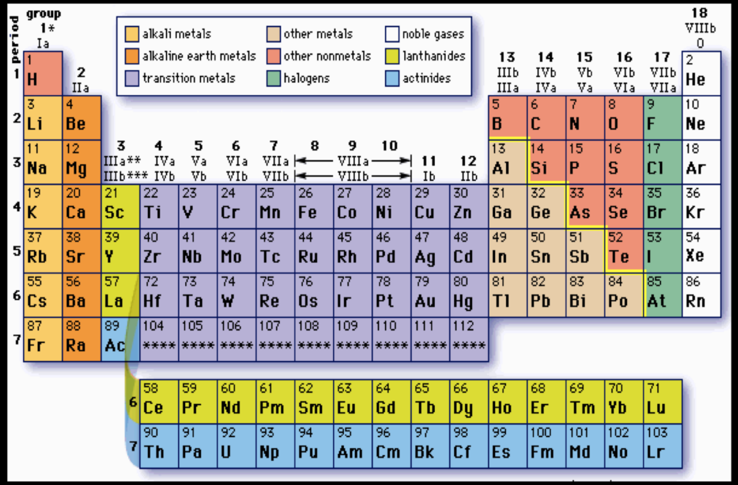
magnetic fields



granulation



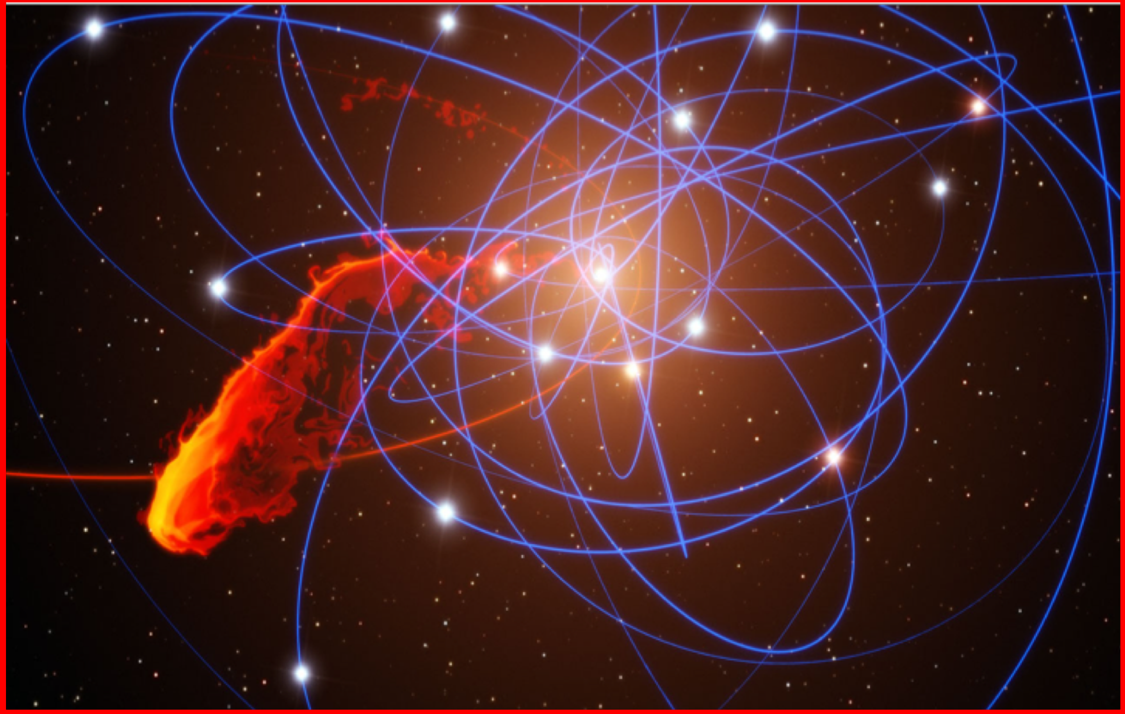
chemical abundances

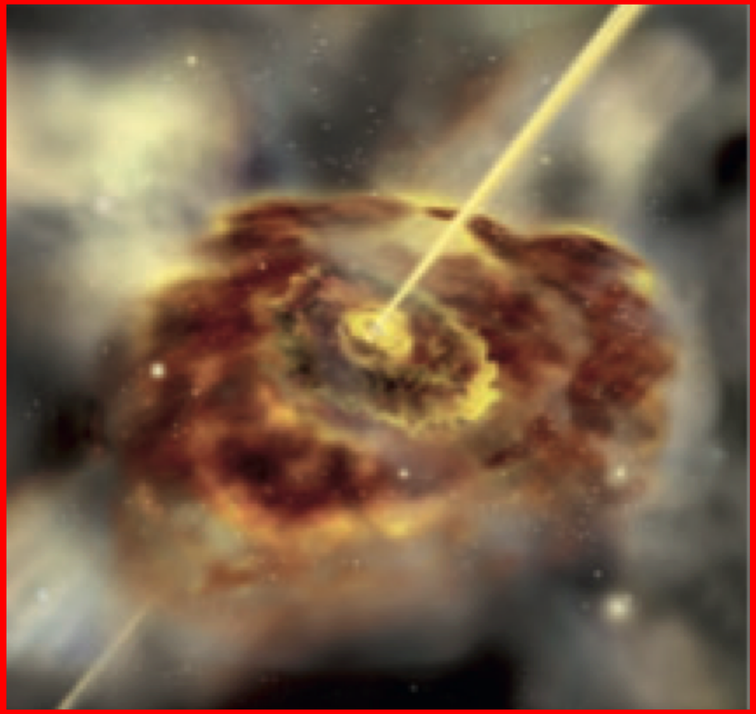


stars: 3D structure, asteroseismology, accurate surface parameters, activity, mixing, diffusion, yields & nucleosynthesis **across the full space of parameters**

from **sketchy** *to* **detailed** ...

black holes

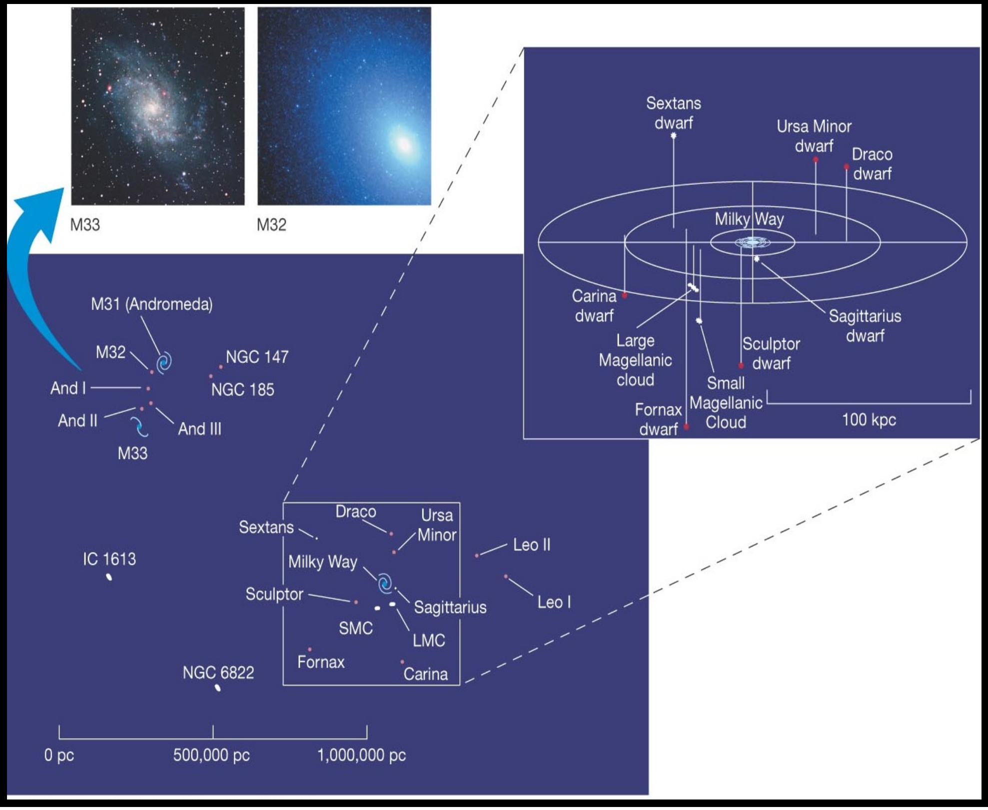


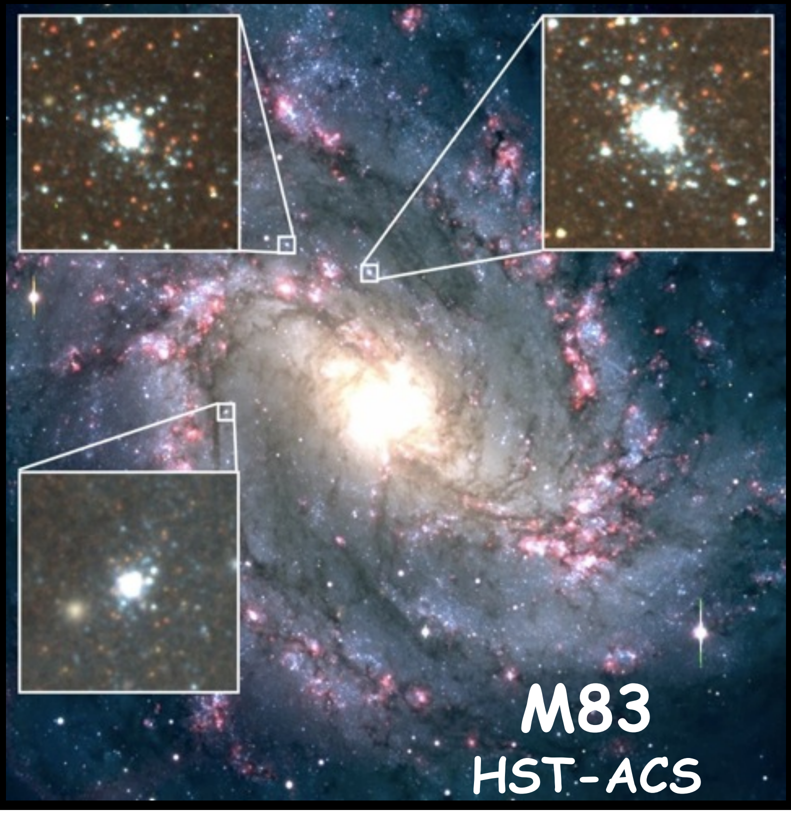


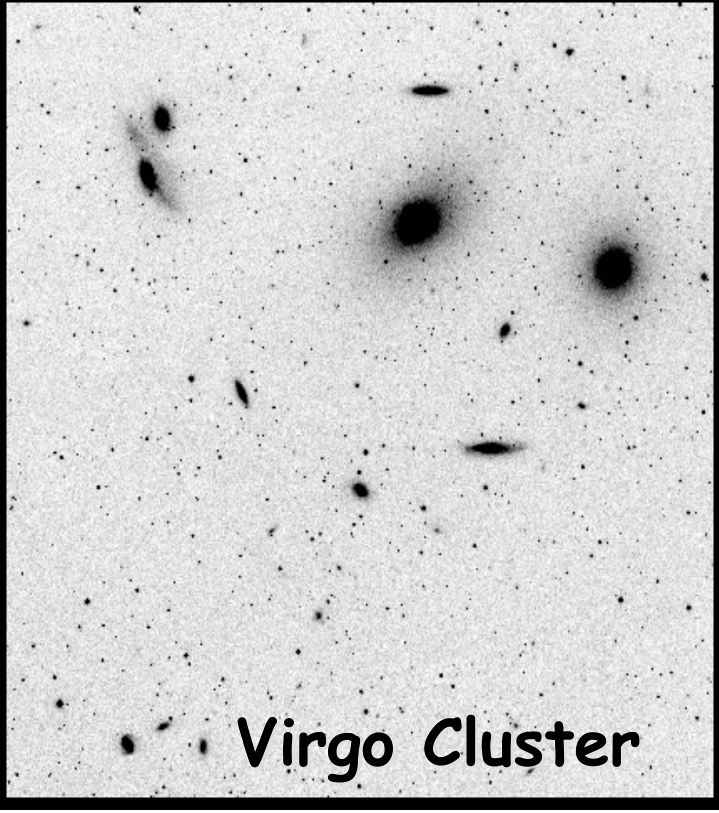
demography: from stellar to intermediate to super-massive

detailed mapping: motions of gas and stars around them *from* **local** *to* **distant** …

stellar archaeology



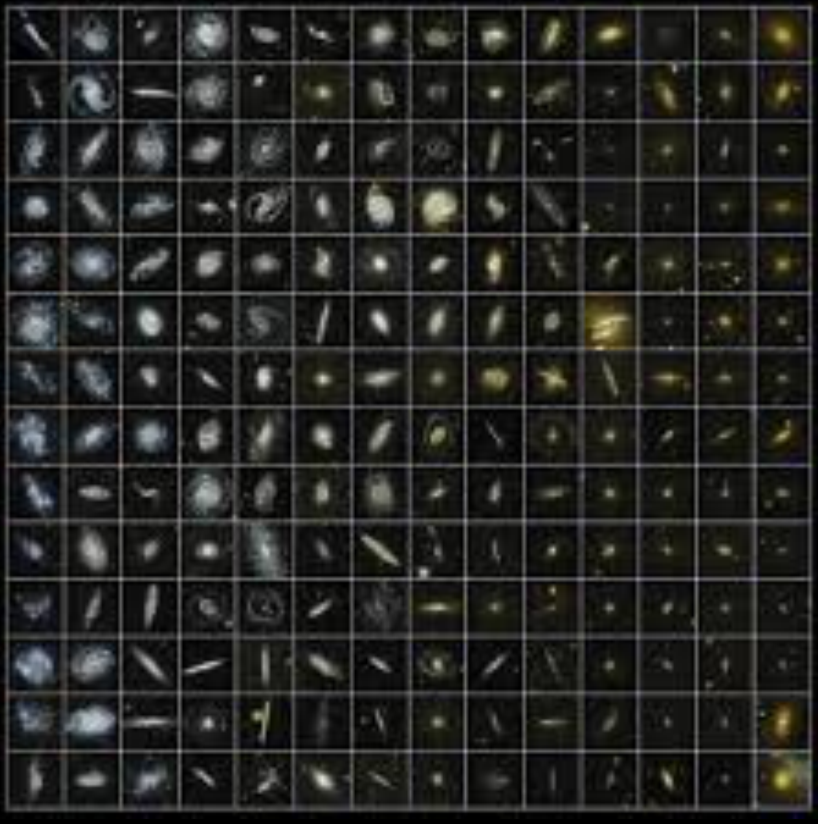


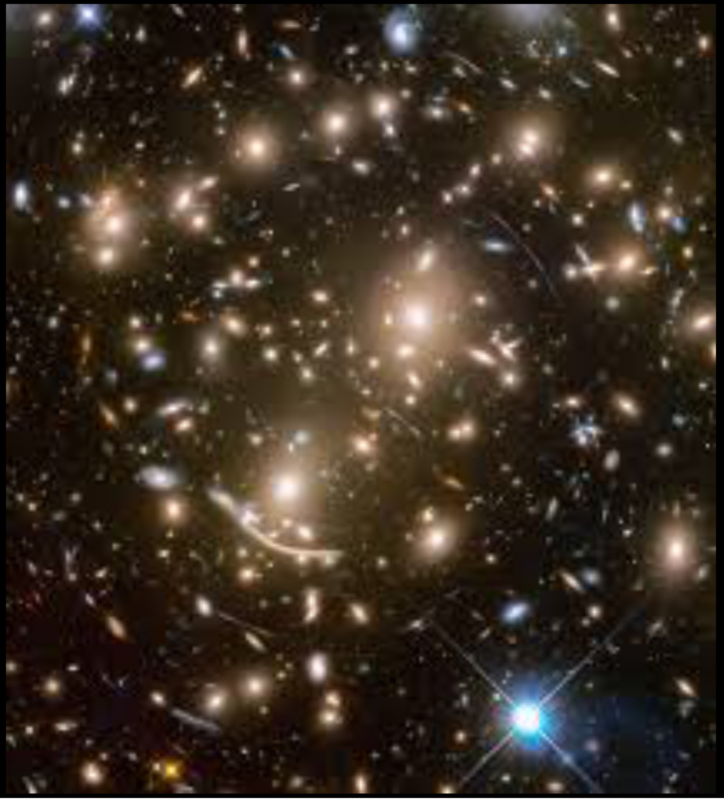


accurate ages, kinematics and chemistry of **stellar populations**
in the Local Group and beyond

from **local** *to* **distant** ...

galaxy formation and evolution

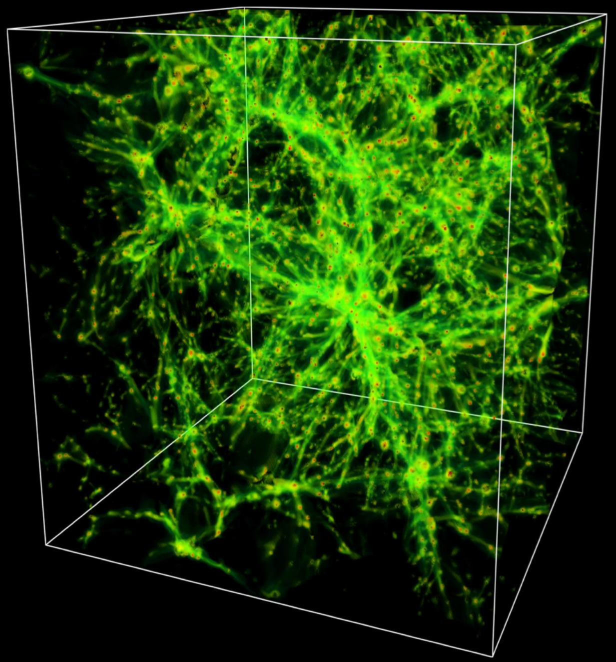


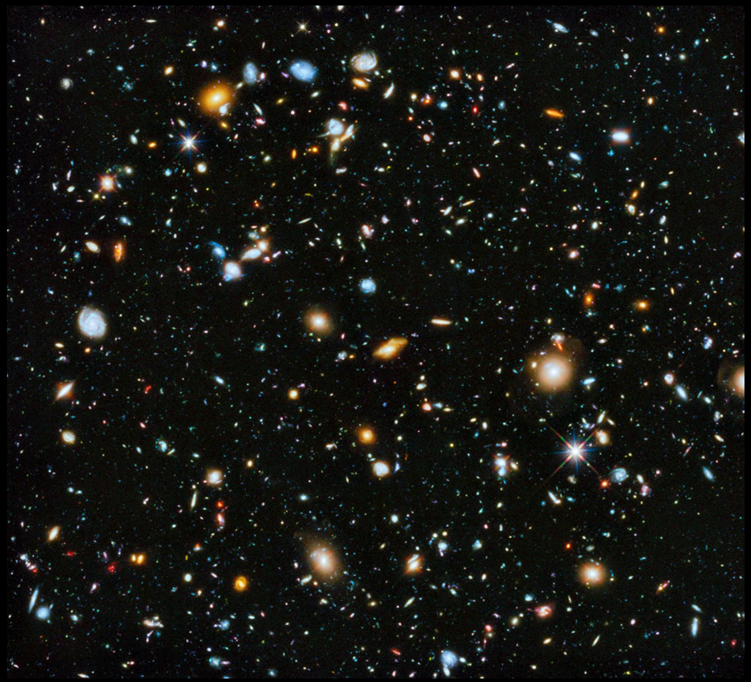


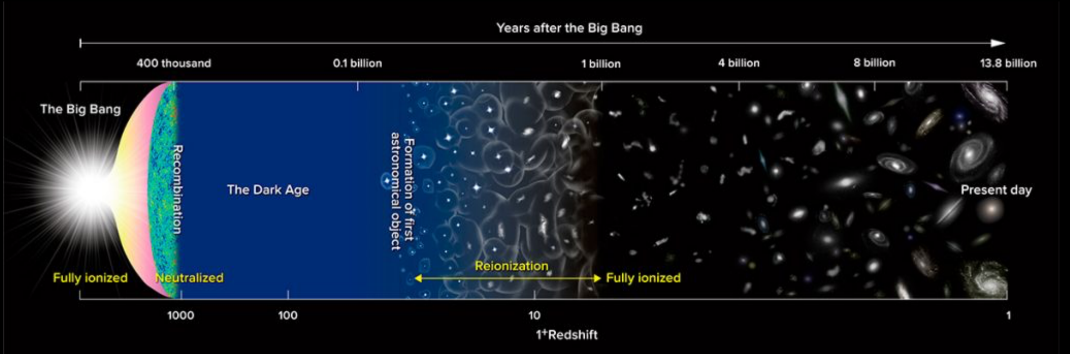
galaxies: structure, dynamics & chemical enrichment at **high redshift**

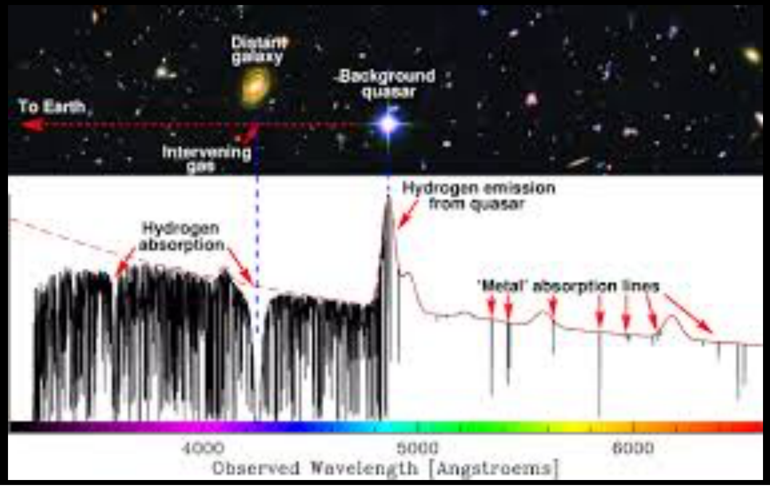
from **below** *to* **above the threshold …**

cosmology







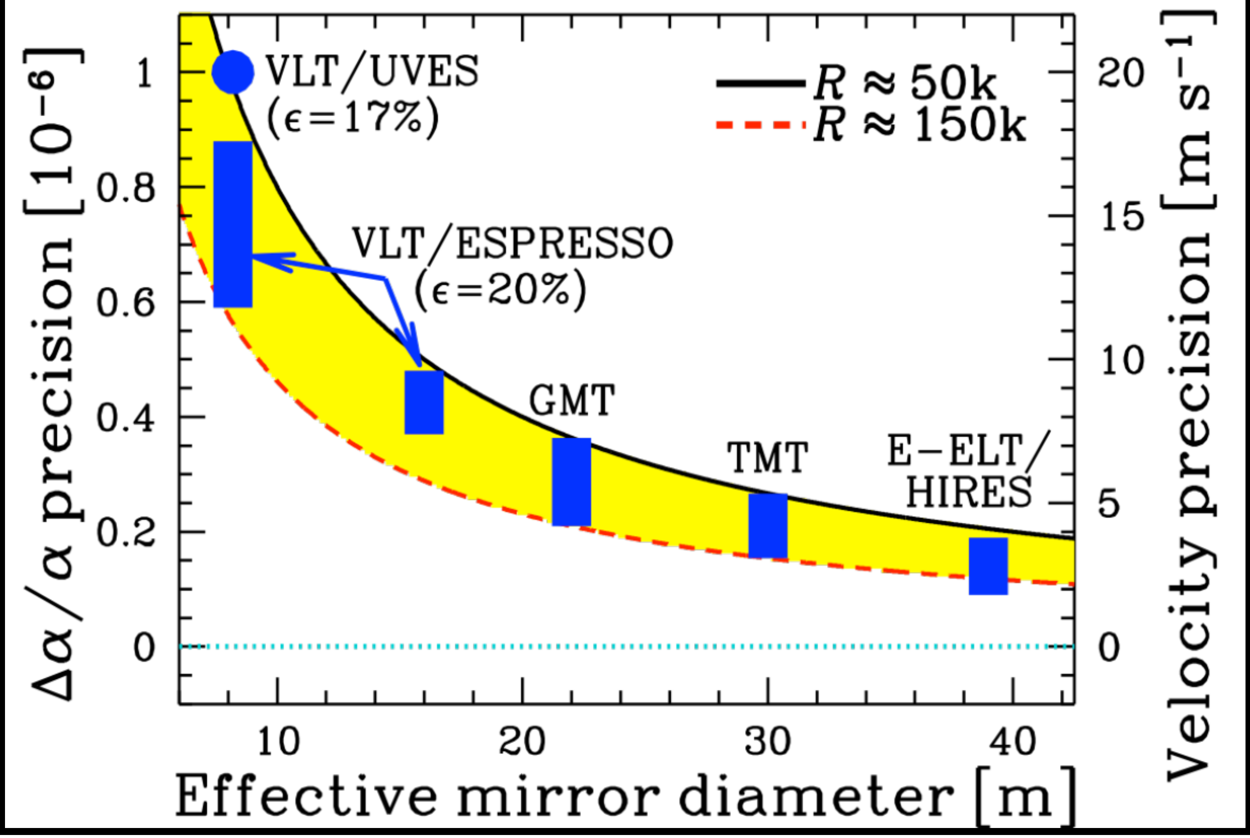


Inter Galactic Medium: detailed chemistry & tomography

Sandage test: measuring the expansion rate of the Universe by adopting a model-independent approach → **redshift drift**

from **below** *to* **above the threshold …**

fundamental constants



fine structure constant (α) **and proton-electron mass ratio** (μ)

are they really constant?

cosmological searches have the enormous advantage of exploring possible variations over 12 Gyr time-scales and 15 Gpc spatial scales