MOONS

Multi-Object Optical and Near-infrared Spectrograph for the VLT

Michele Cirasuolo
on behalf of the MOONS consortium

Consortium

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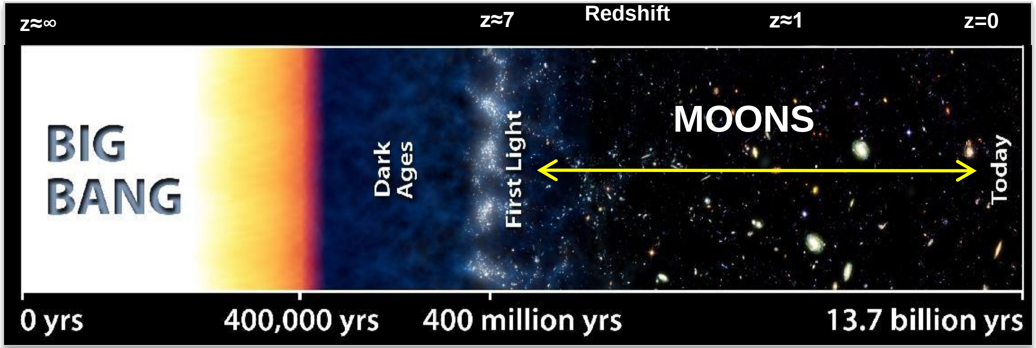
MOONS

Selected by ESO as third generation instrument for the VLT

Started construction phase in June 2014

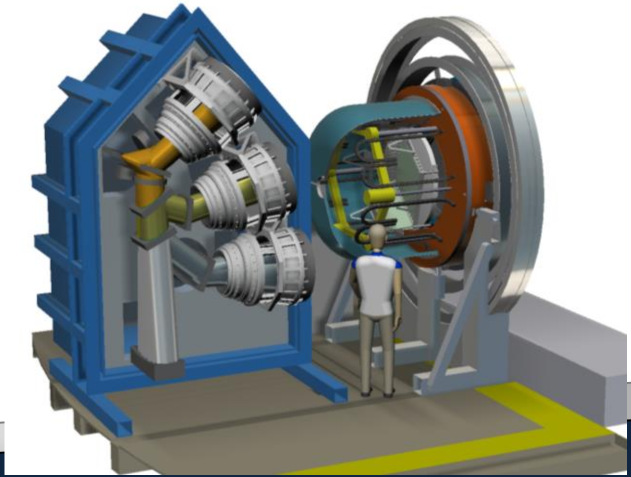
PDR in September 2015

Operational by 2019



- Highlight of science cases
  - *- Galactic Archaeology*
  - *- Galaxy Evolution*

- Current Design



MOONS in a nutshell

Field of view: 500 sq. arcmin at the 8.2m VLT

Multiplex: 1024 fibers, with the possibility to deploy them in pairs

Medium resolution:

Simultaneously 0.64μm-1.8μm

at

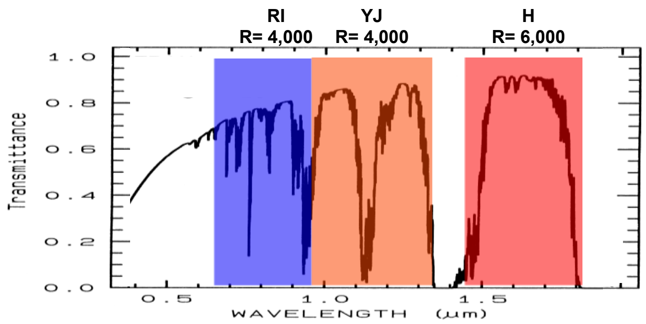
R=4,000 – 6,000

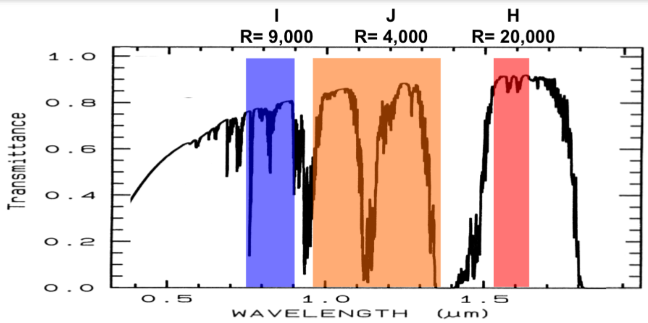
+

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=20,000





Throughput: ~ 30 %

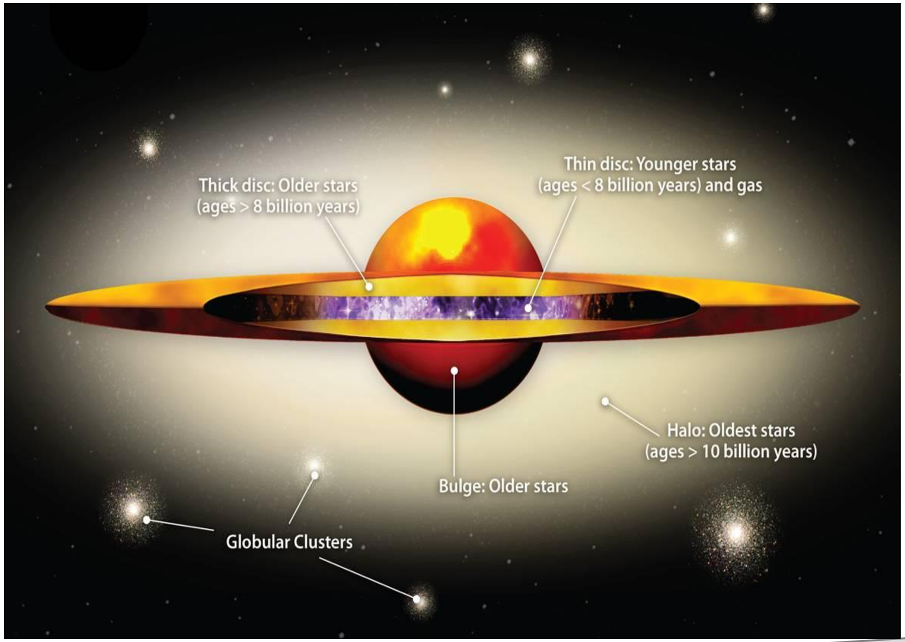
Galactic science case

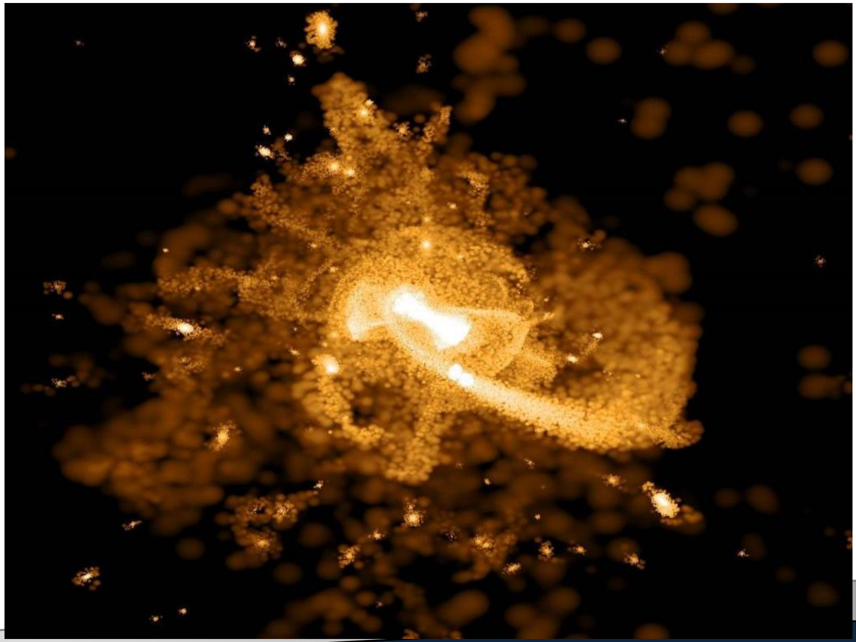
On behalf of the Galactic Science Working Group

Galactic Archaeology

The evolution of stars and galaxies remains among the key unanswered questions.

The resolved stellar populations of the Milky Way provide us with a fossil record of the chemo-dynamical and star-formation histories over many gigayears timescale.





Galactic Archaeology

Follow-up of VISTA, Gaia and LSST imaging surveys

MOONS will provide

Medium resolution mode

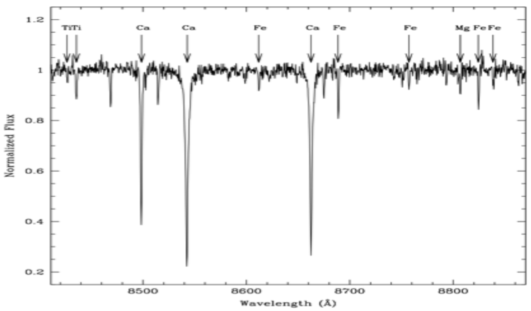
Radial velocities via
CaT @R=9,000 for I<21
+
[M/H] (via Fe,Si,Ti,Mg)
@R=4000-6000 (J+H)

High resolution mode

Detailed chemical abundances
(Si, Ca, Ti, Mg, Fe, Cr, Mn, CNO …)
@R=20,000 for H_{Vega}<15.5
+
CaT @R=9,000

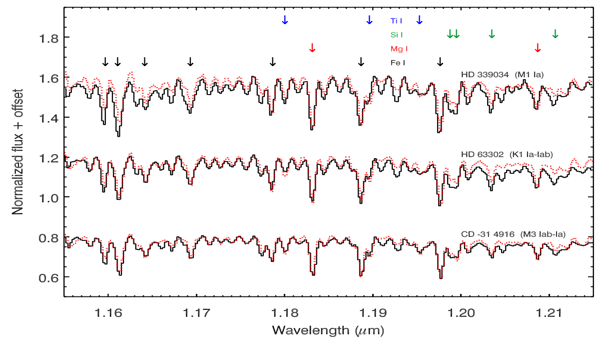
MOONS for Galactic studies

I-band
R=9,000



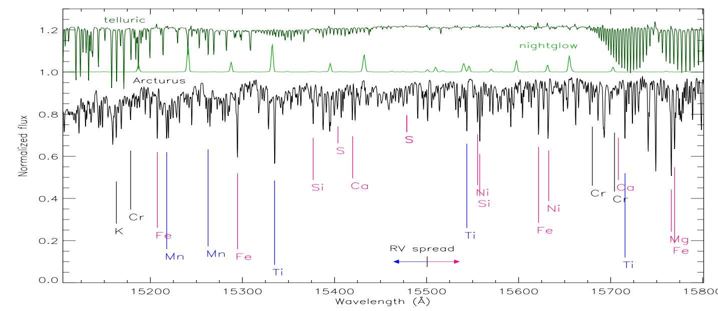
FLAMES
(multiplex = 130)

YJ-band
R=4,500



KMOS
(multiplex = 24)

H-band
R=20,000



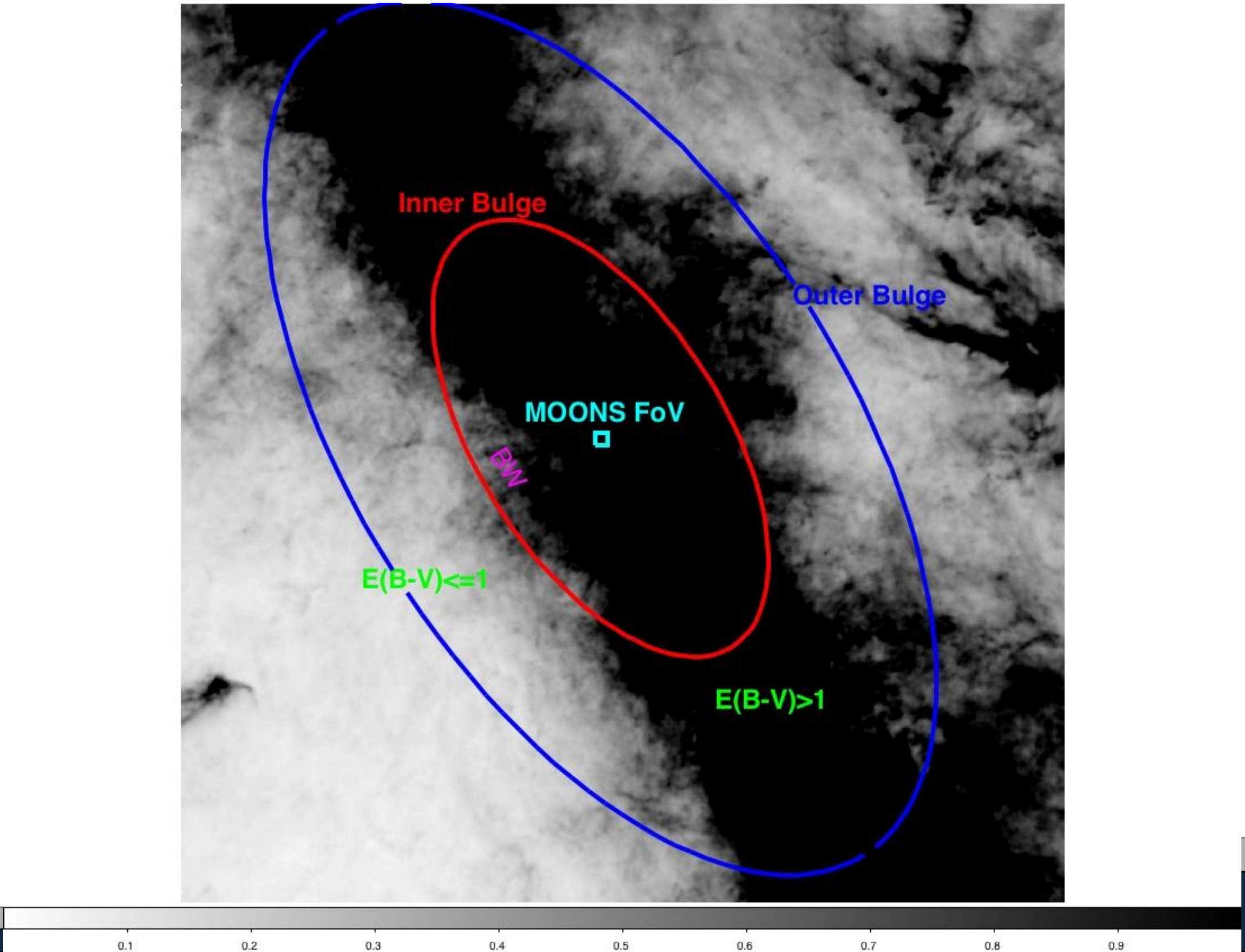
APOGEE
(multiplex = 300)

Ongoing programme led by O. Gonzalez to build a sample of stars in the inner Galaxy observed with FLAMES, KMOS and APOGEE

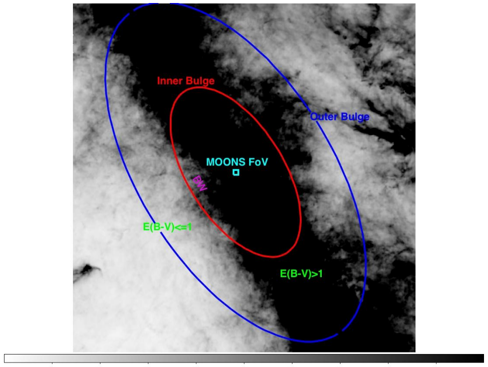
Galactic Archaeology

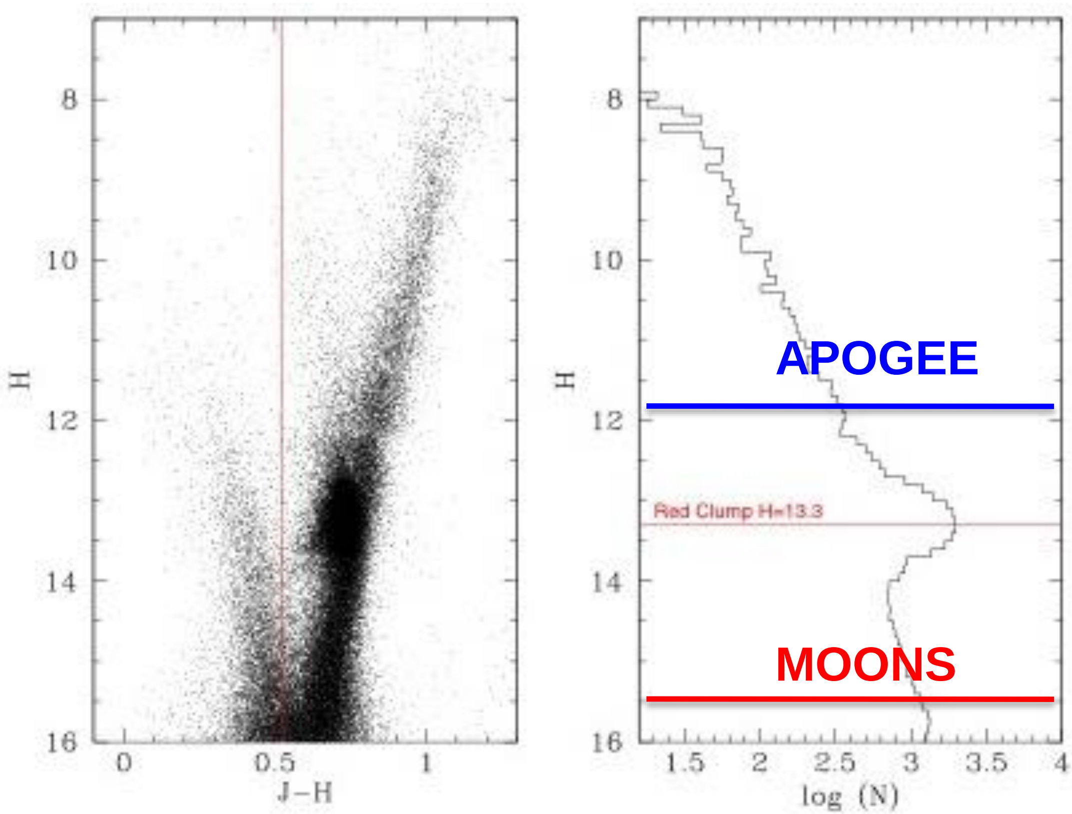
Disk and bulge

Near-IR is less sensitive to dust obscuration and combined with collective power of 8.2m VLT can reach a distance of ~12 kpc, essentially looking through the Bulge and disc.



Galactic Archaeology





Inner galaxy
Bulge and Disc

- **IR obs crucial because of reddening**
- **red clump crucial to trace sub-structures**

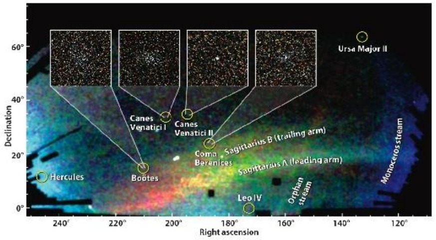
Galactic Archaeology

Disk and Bulge

Near-IR is less sensitive to dust obscuration and combined with collective power of 8.2m VLT can reach a distance of ~12 kpc, essentially looking through the whole Bulge and Disc.

Streams in the Halo field and clusters

Photometrically selected with Gaia, SDSS, Pan-STARRS, VISTA, UKIDSS, LSST etc.



Resolved stellar population in external galaxies

Magellanic clouds, Nearby galaxies, follow-up of VISTA and UKIDSS

Galactic Archaeology

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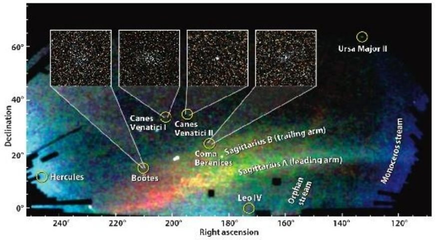
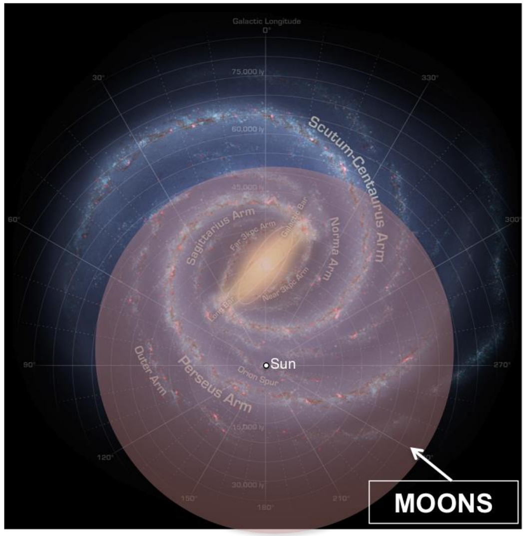


Resolved stellar population in external galaxies

Magellanic clouds, Nearby galaxies, follow-up of VISTA and UKID

Radial velocities and detailed chemical abundances for **several million stars** over **>500 sq. deg**.



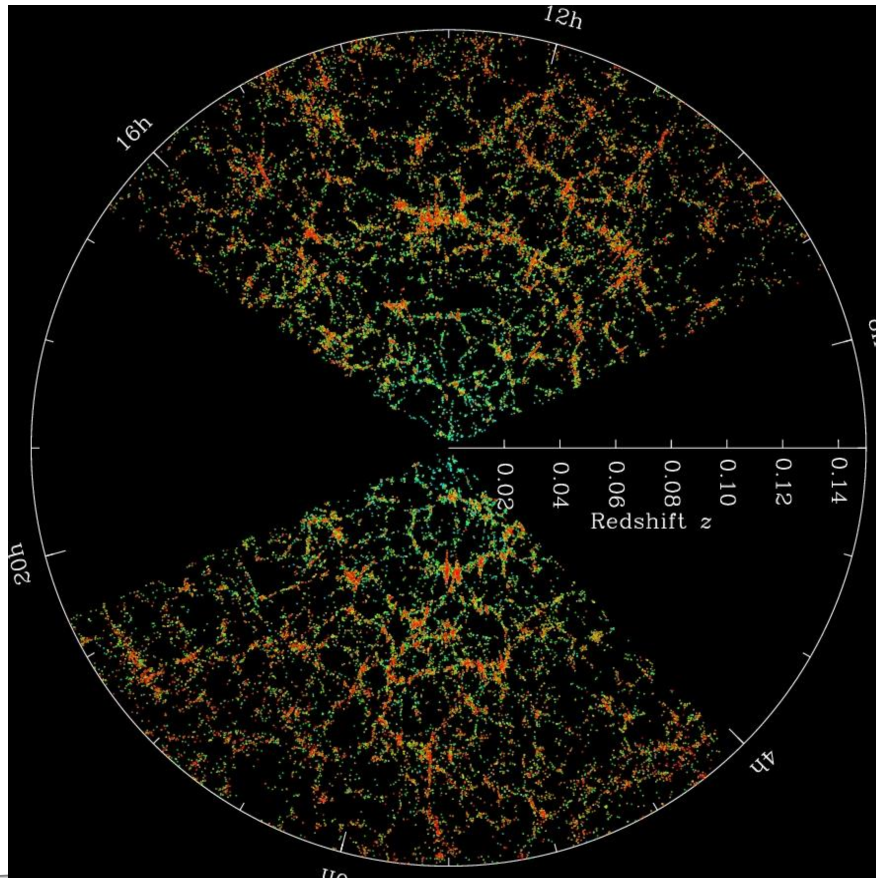
Chemistry and dynamics for all components of the Milky Way (Bulge, Disc and Halo)

Extragalactic science case

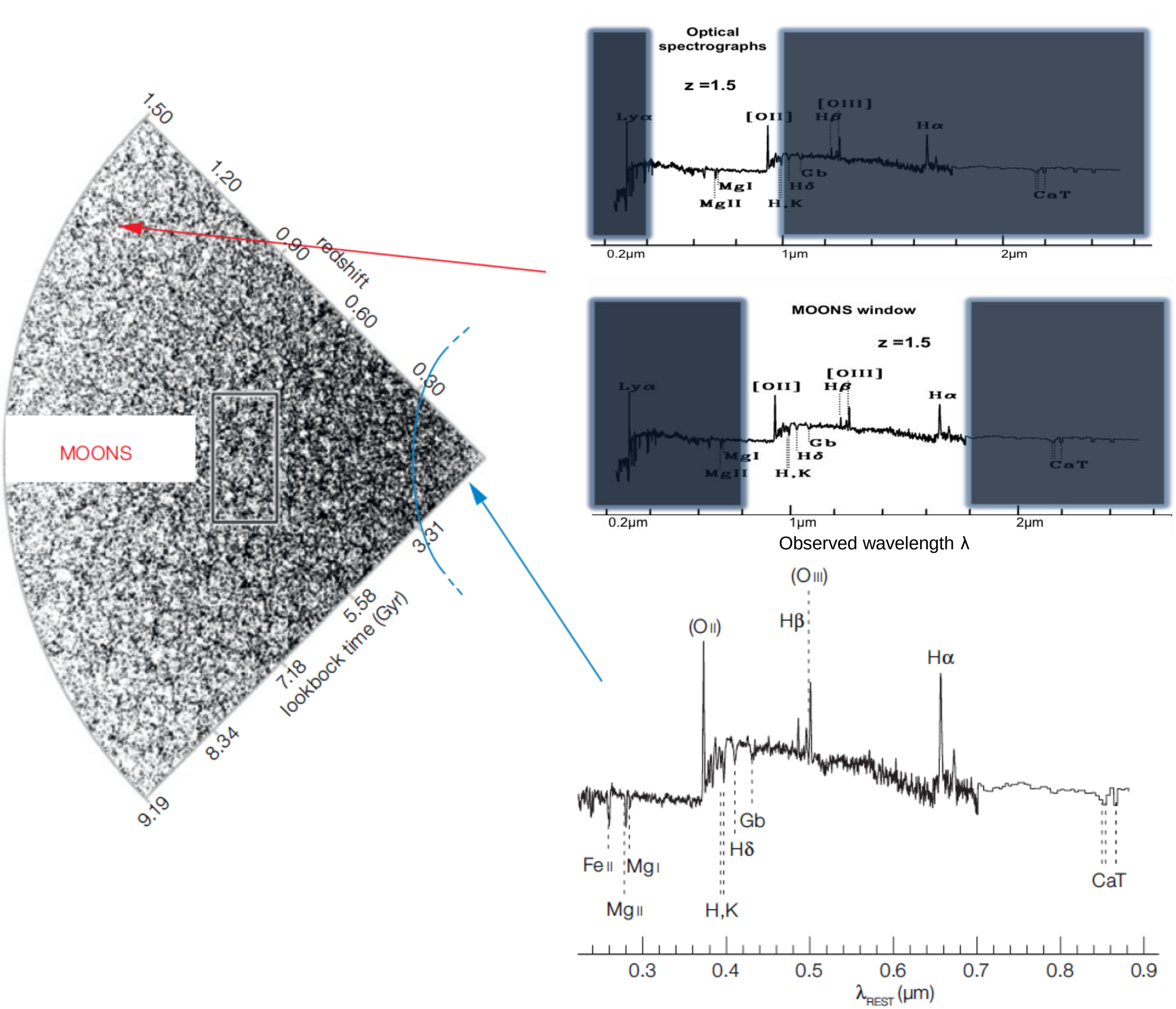
On behalf of the Extragalactic Science Working Group

Sloan Digital Sky Survey (SDSS)

In the local Universe the SDSS has been extremely successful due to both size and spectral quality.



MOONS: a SDSS-like machine probing the peak of galaxy and black hole formation



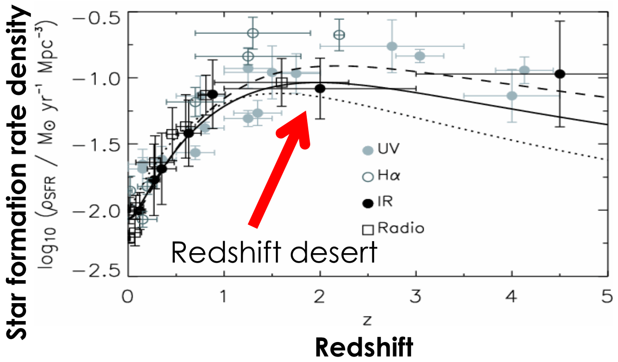
Optical spectrographs z=1.5

MOONS z = 1.5

SDSS at z=0.1

Extra Galactic Science Case

SDSS-like survey
1M galaxies at z>1 across the peak of star-formation and black hole accretion, up to the very first galaxies at z>7-8



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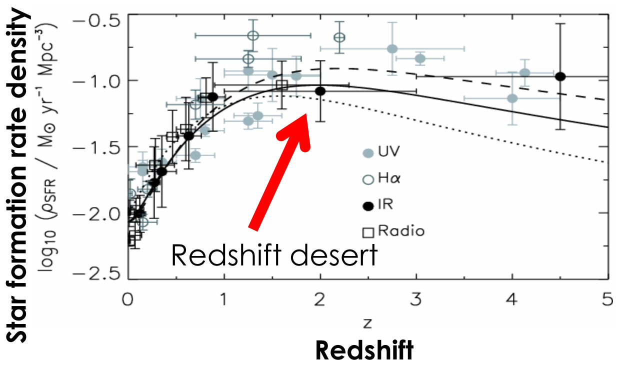
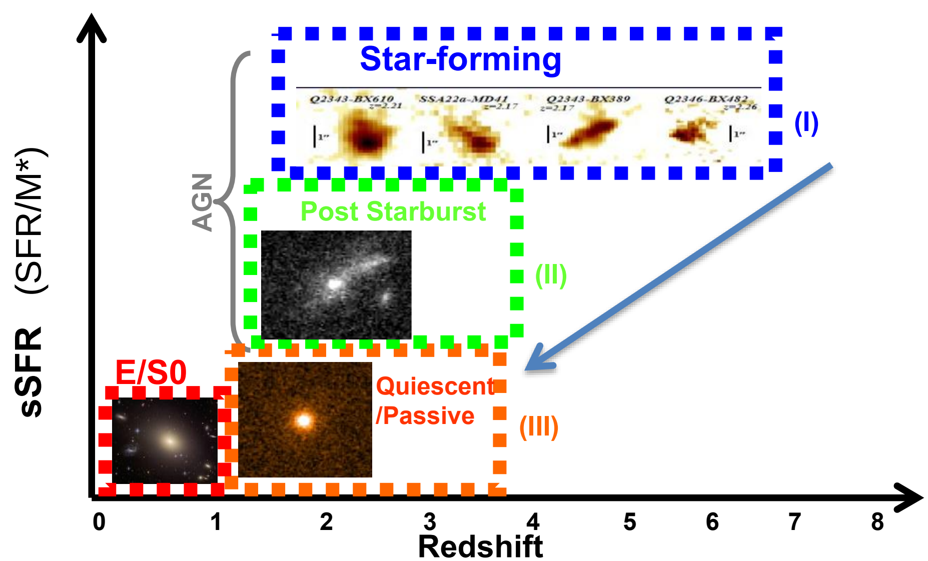


Galaxy Evolution: Diagnostics for passive and star-forming galaxies

- *Metallicity (R_{23},N_2)*
- *SFR (Hα, Hβ, [OII])*
- *AGN power (BPT)*
- *Dust extinction (Hα/Hβ)*
- *Galaxy mass (σ_v)*
- *BH mass (BLR)*



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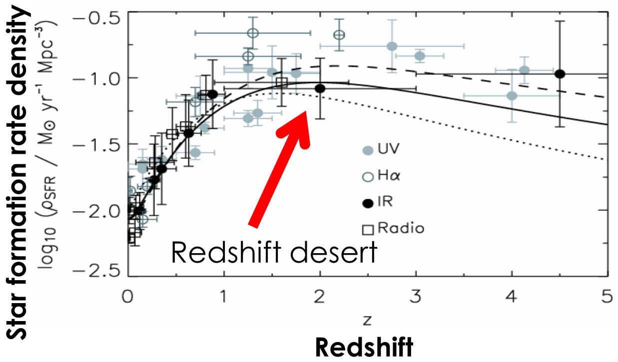

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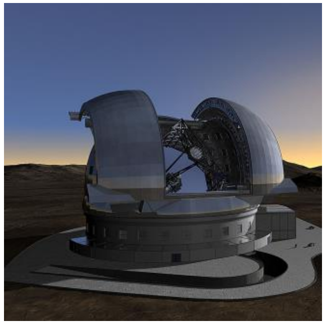
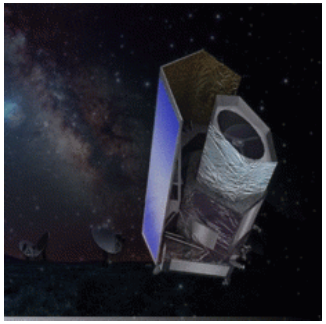
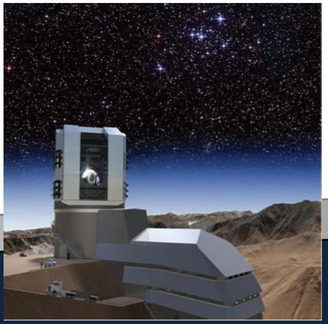
- ***Galaxy mass (σ_v)***
- ***BH mass (BLR)***

✓Follow-up of large-area imaging surveys: VISTA, Herschel, DES, UKIDSS, eRosita, etc.

✓ Strong synergies: Euclid, SKA, LSST and E-ELT

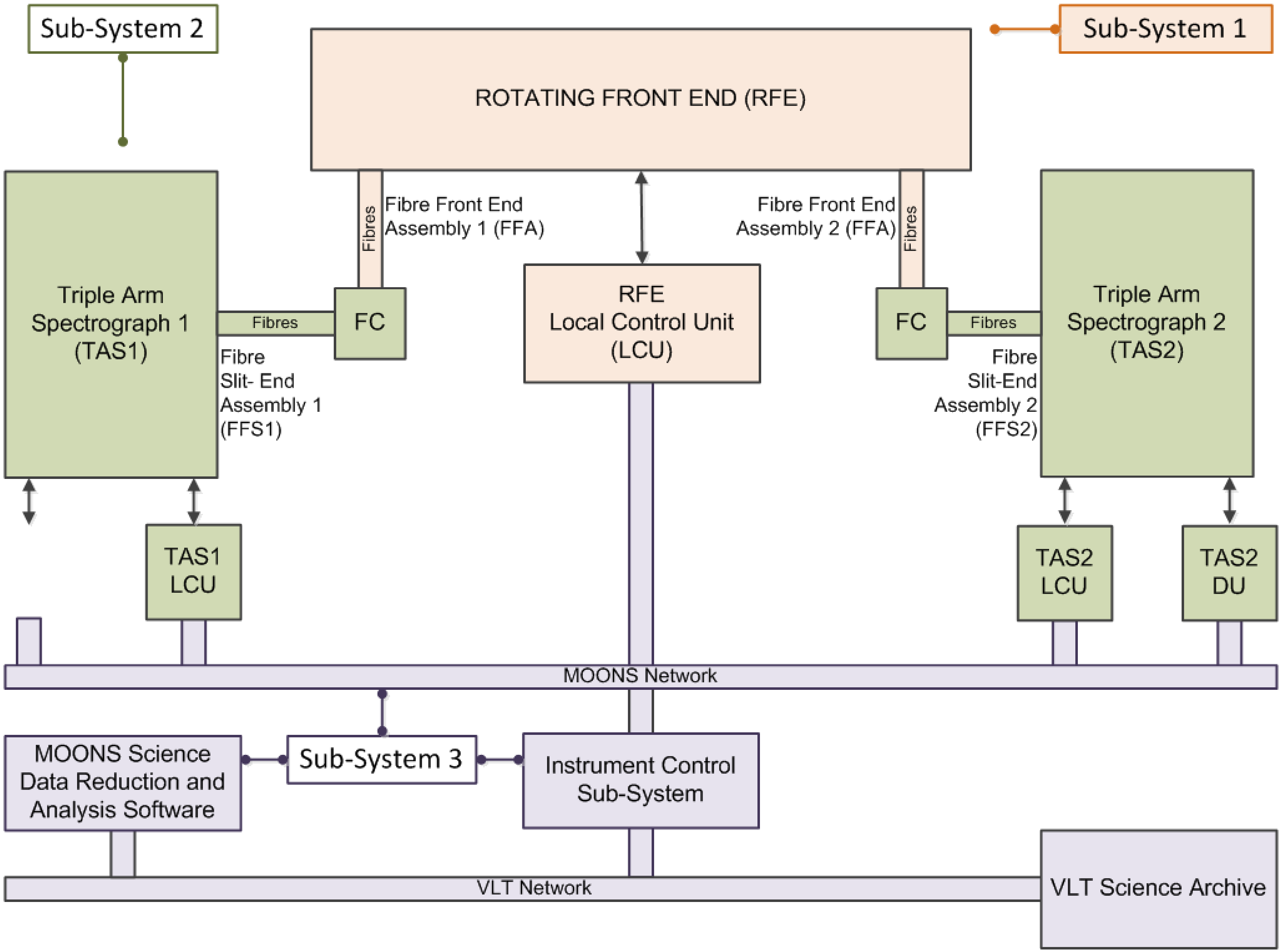






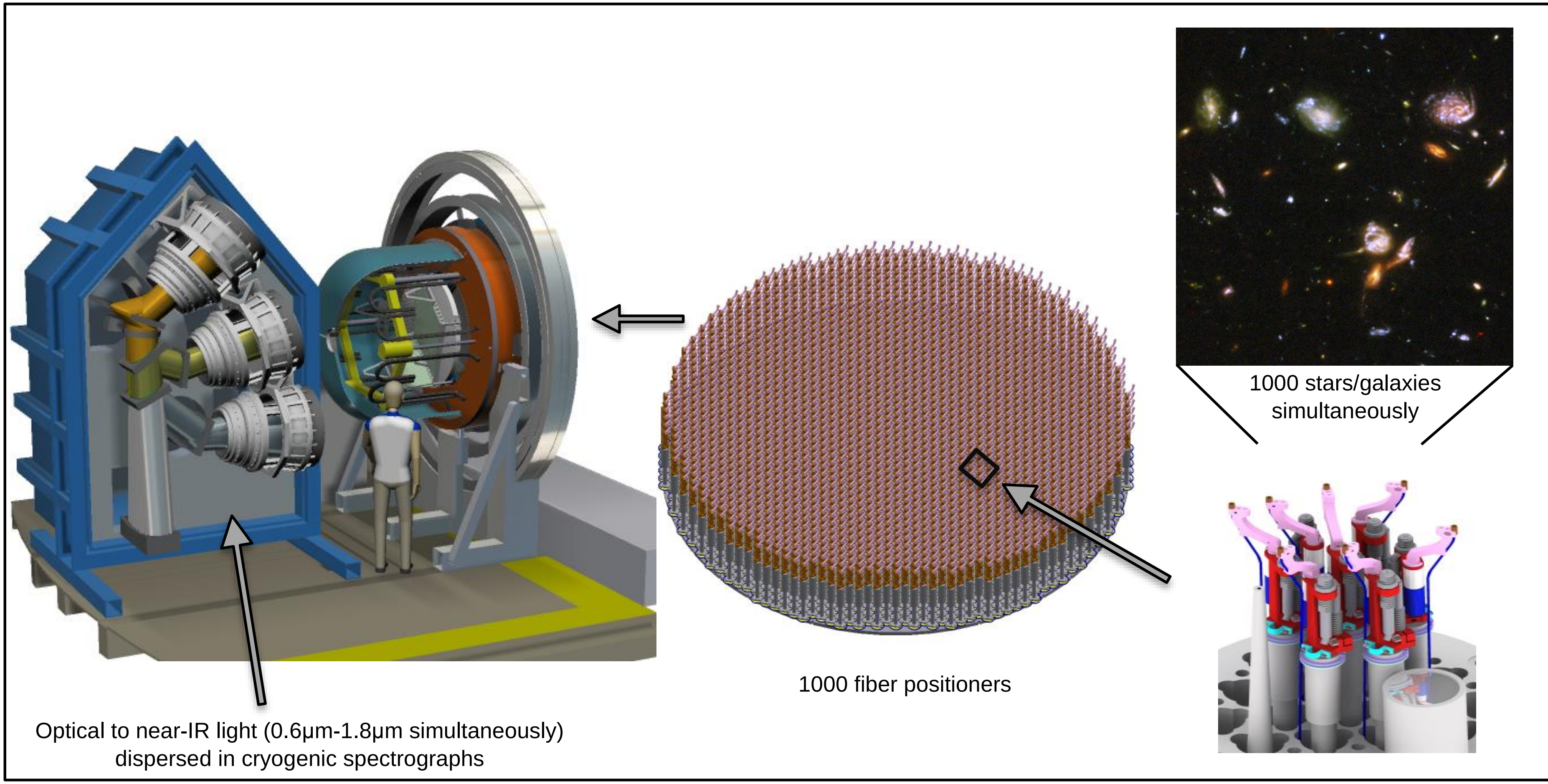
MOONS basic layout

System Overview

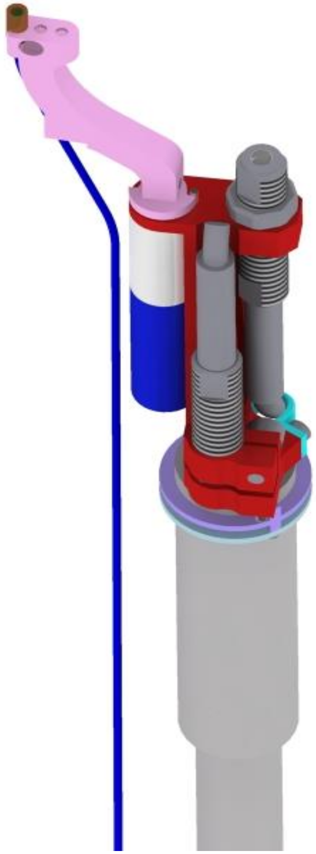


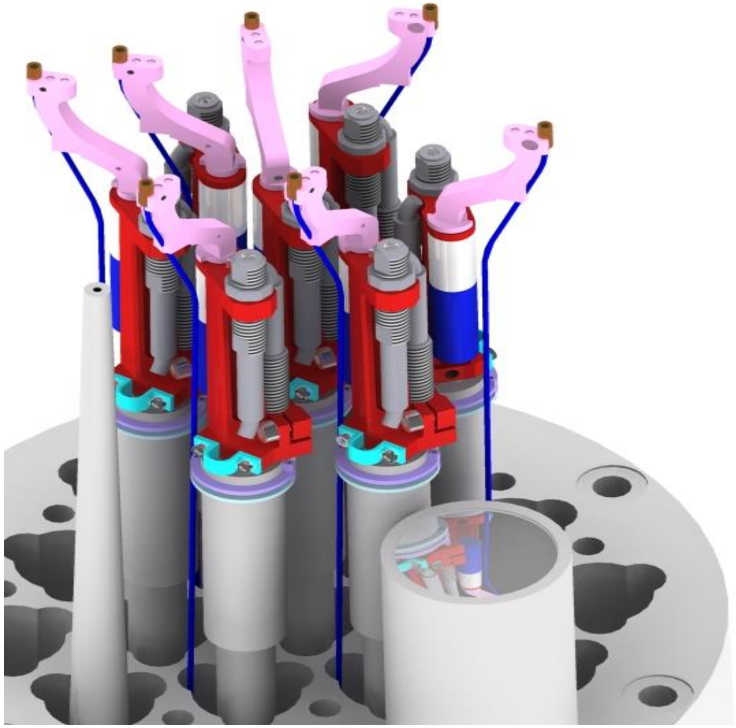
See H. Schnetler et al, SPIE 9150-23

System Overview



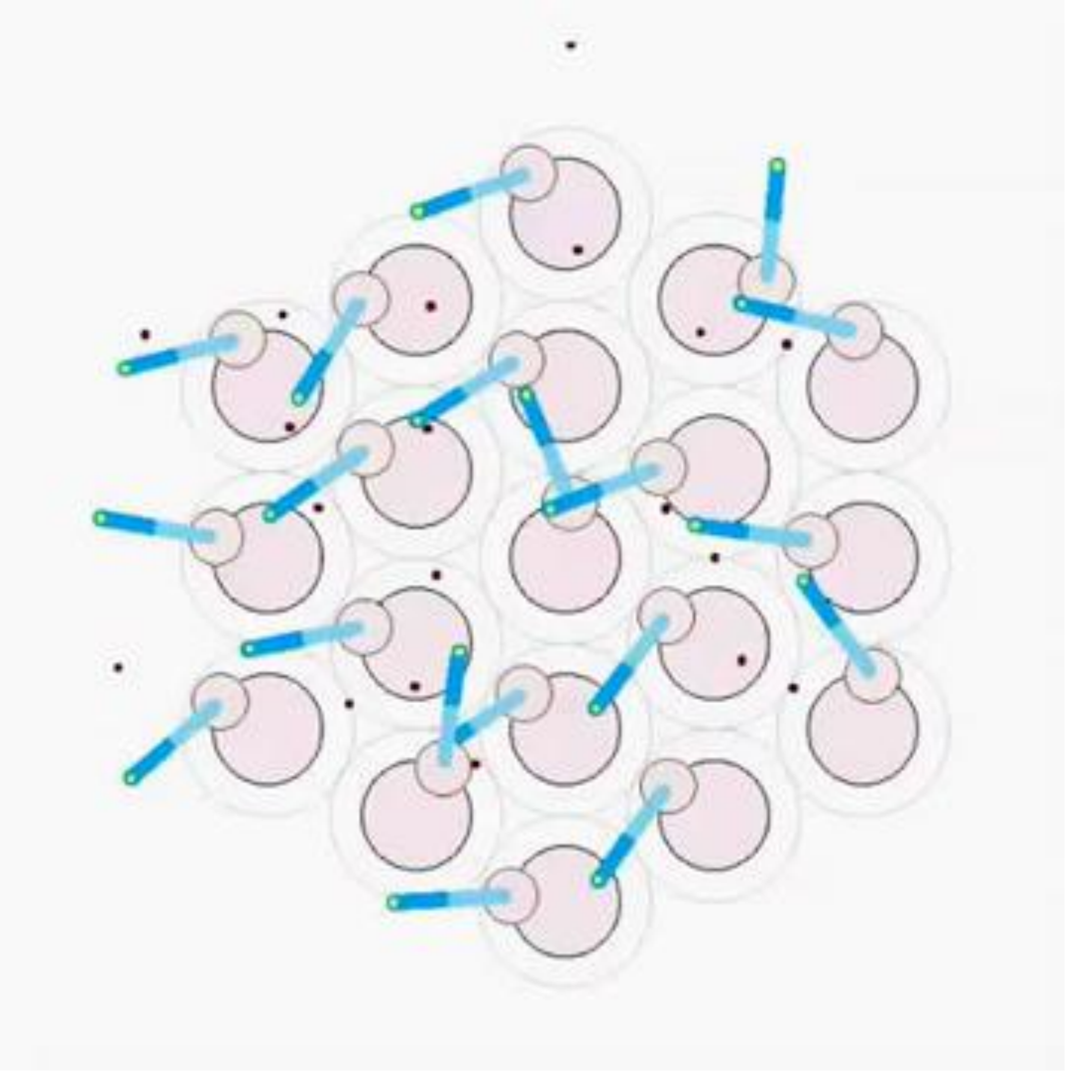
Fiber positioner
micro-mechanical pick-off system





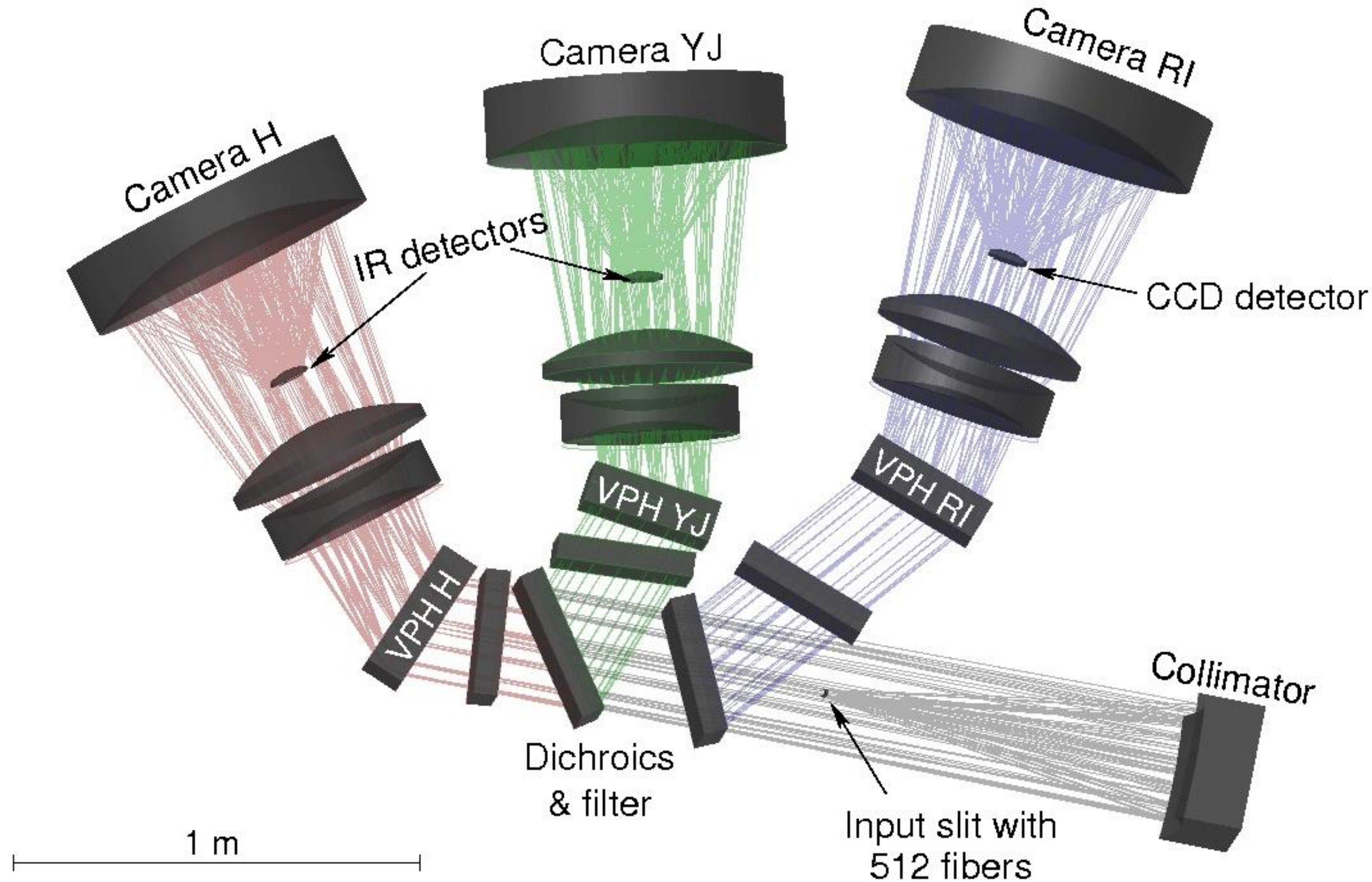
- ✓ Large overlap between positioners
- ✓ Possibility to pair all fibers for optimal sky subtraction
- ✓ Both motors with encoders and anti-backlash
- ✓ Fast reconfiguration time (< 1min)

Path analysis and anti-collision



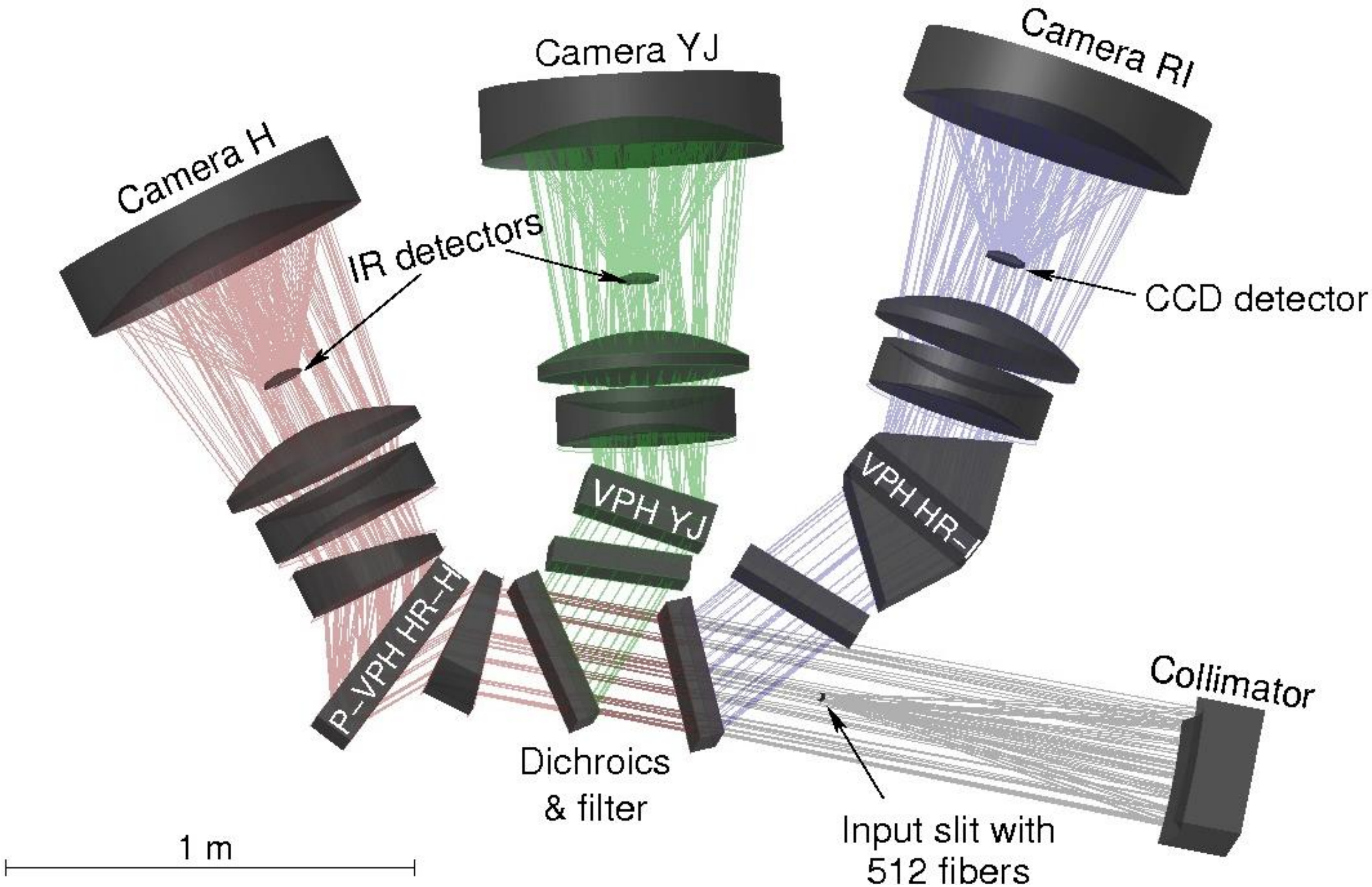
See L. Makarem et al, SPIE 9152-24

Spectrograph optical design



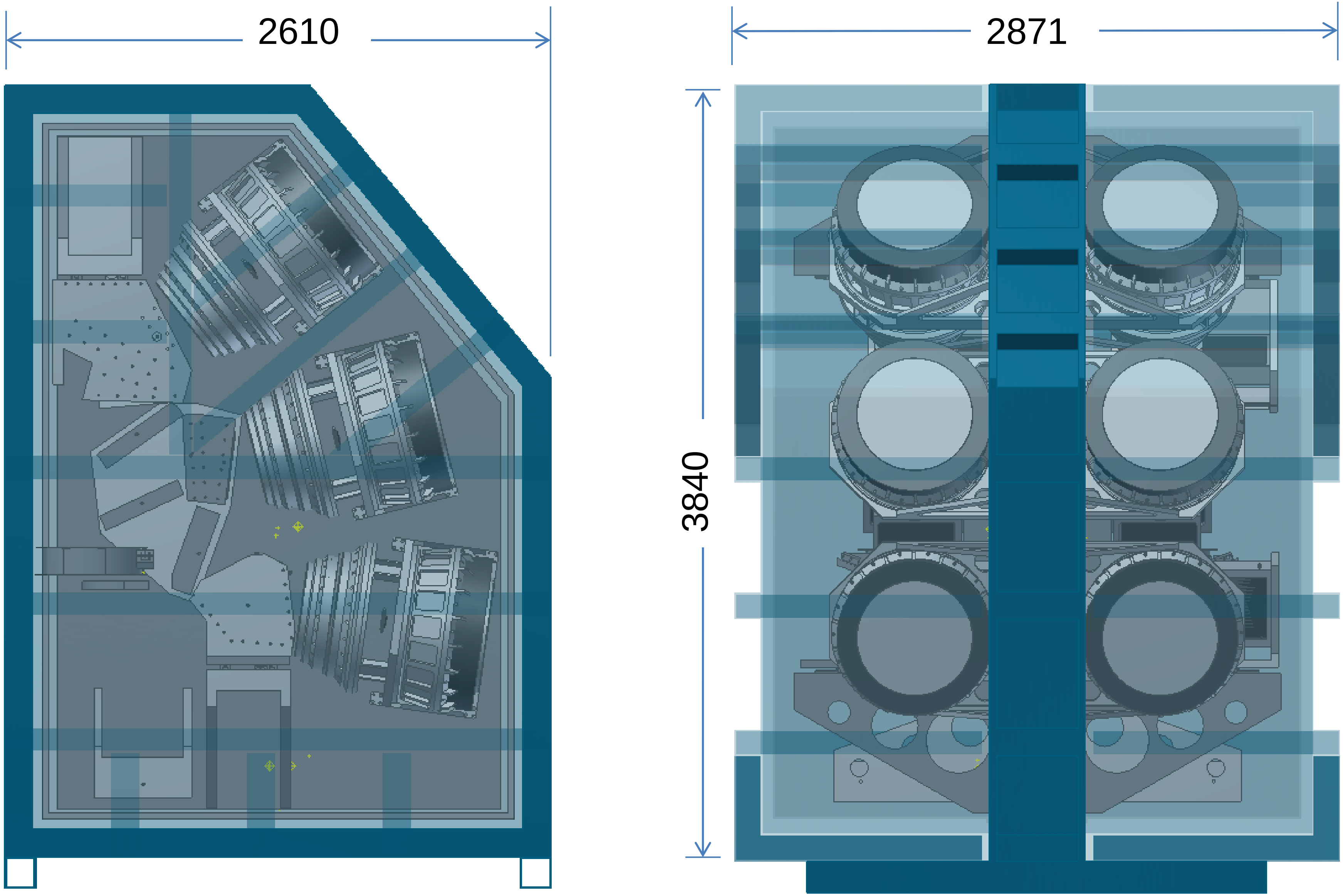
See E. Oliva et al, SPIE 9147-337

Spectrograph optical design

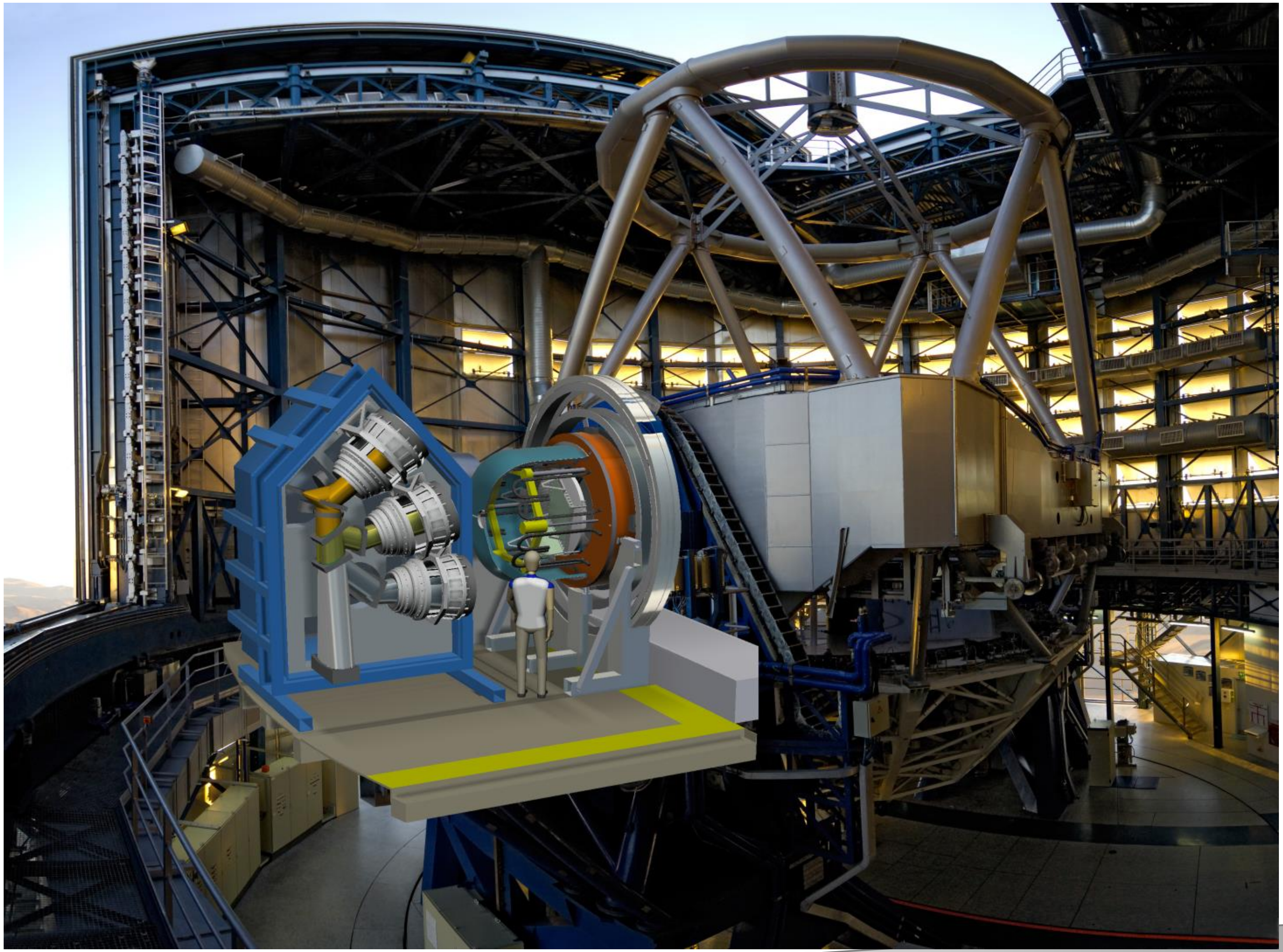


See E. Oliva et al, SPIE 9147-337

Cryostat



MOONS on Nasmyth



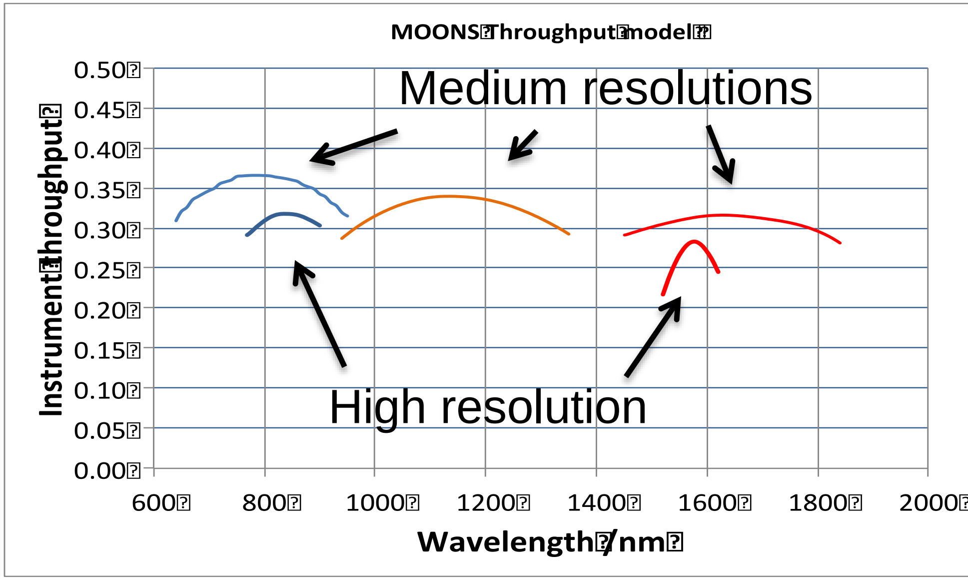
Expected performances

Sensitivities in 1hr integration:

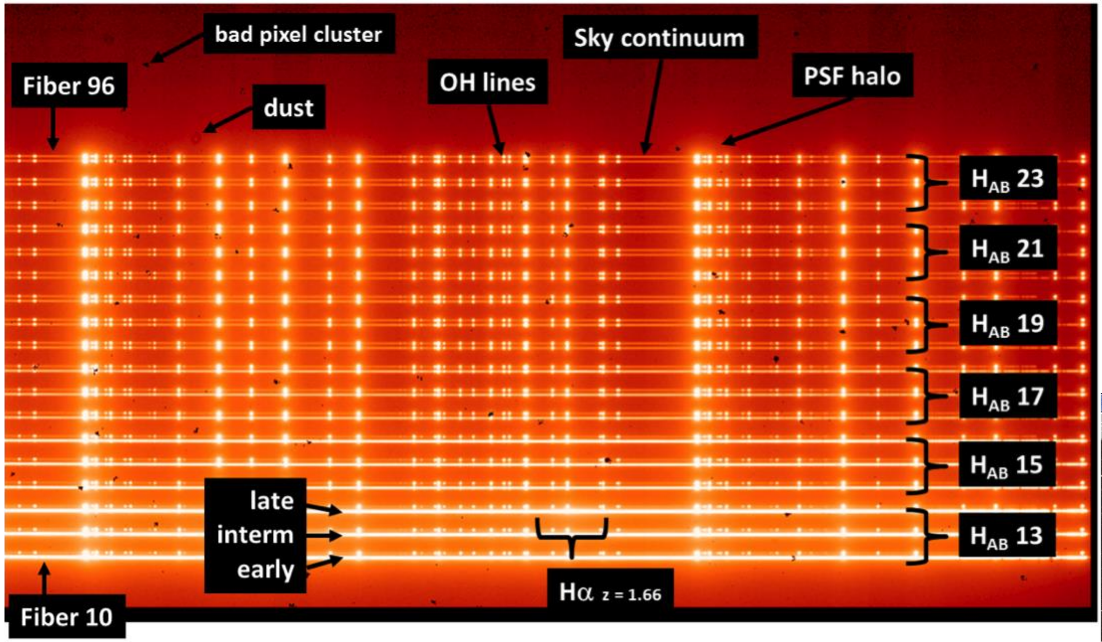
Emission lines:
2 x 10^{-17} erg/s/cm^2 (5σ)

Continuum:
AB = 22.7 (5σ) with the spectrum rebinned, after sky subtraction, to an effective resolution of R=1,000

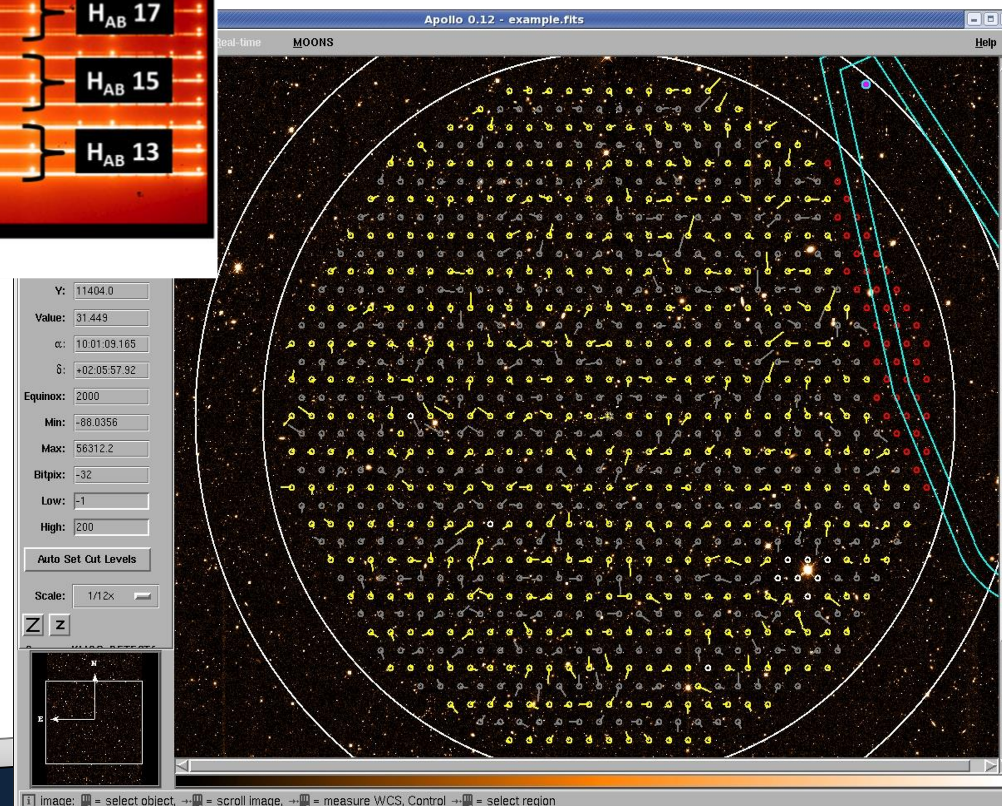
Continuum high resolution:
H_{vega} = 15.5 S/N > 30



Advanced end-to-end simulator and Observation preparation tool



See G. Li Causi et al, SPIE 9147-229



Summary

MOONS is the long-awaited near-IR MOS for the VLT

Construction phase started in June 2014

Operational by 2019

Field of view	500 sq. arcmin
Multiplex	1000 fibres
Low resolution mode	R = 4,000-6000 λ = 0.64μm – 1.8μm simultaneously
High resolution mode	R>9,000 for CaT + R=4,000 in YJ-band + R=20,000 in H band
Throughput	> 30 %

Main science cases:

Galactic Archaeology:

✓ Radial velocities and detailed chemical abundances for **several million stars** over **>500 sq. deg** in our own Galaxy.

Galaxy evolution:

✓ Formidable **SDSS-type survey for >1M galaxies at z>1**. Unique insight into the effect of environment, chemical and physical evolution, nature of Dark Matter.

Synergies:

✓ Essential follow-up of large-area imaging surveys: Gaia, VISTA, Herschel, DES, UKIDSS, LOFAR, eRosita, Euclid, LSST, SKA