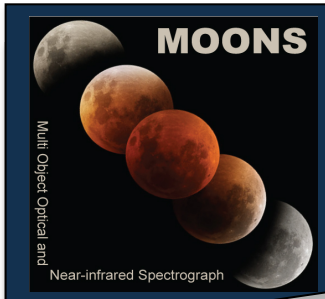


MOONS

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

Hector Flores
on behalf of the MOONS consortium

AIUC CENTRO DE ASTRO-INGENIERIA UC

CAAUL FACULDADE DE CIÊNCIAS UNIVERSIDADE DE LISBOA

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

INAF ISTITUTO NAZIONALE DI ASTROFISICA

UNIVERSITÉ DE GENÈVE FACULTÉ DES SCIENCES Département d'astronomie

l'Observatoire de Paris GEPI Galaxies Étoiles Physique et Instrumentation

ESO

UNIVERSITY OF CAMBRIDGE

Science & Technology Facilities Council
UK Astronomy Technology Centre

MOONS in a nutshell

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

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

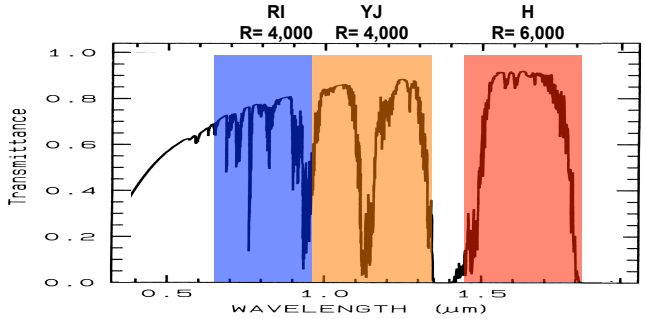
at

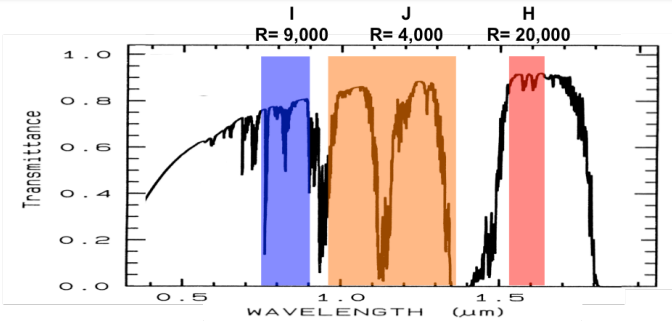
R=4,000 – 6,000

High resolution:

Simultaneously 3 bands:

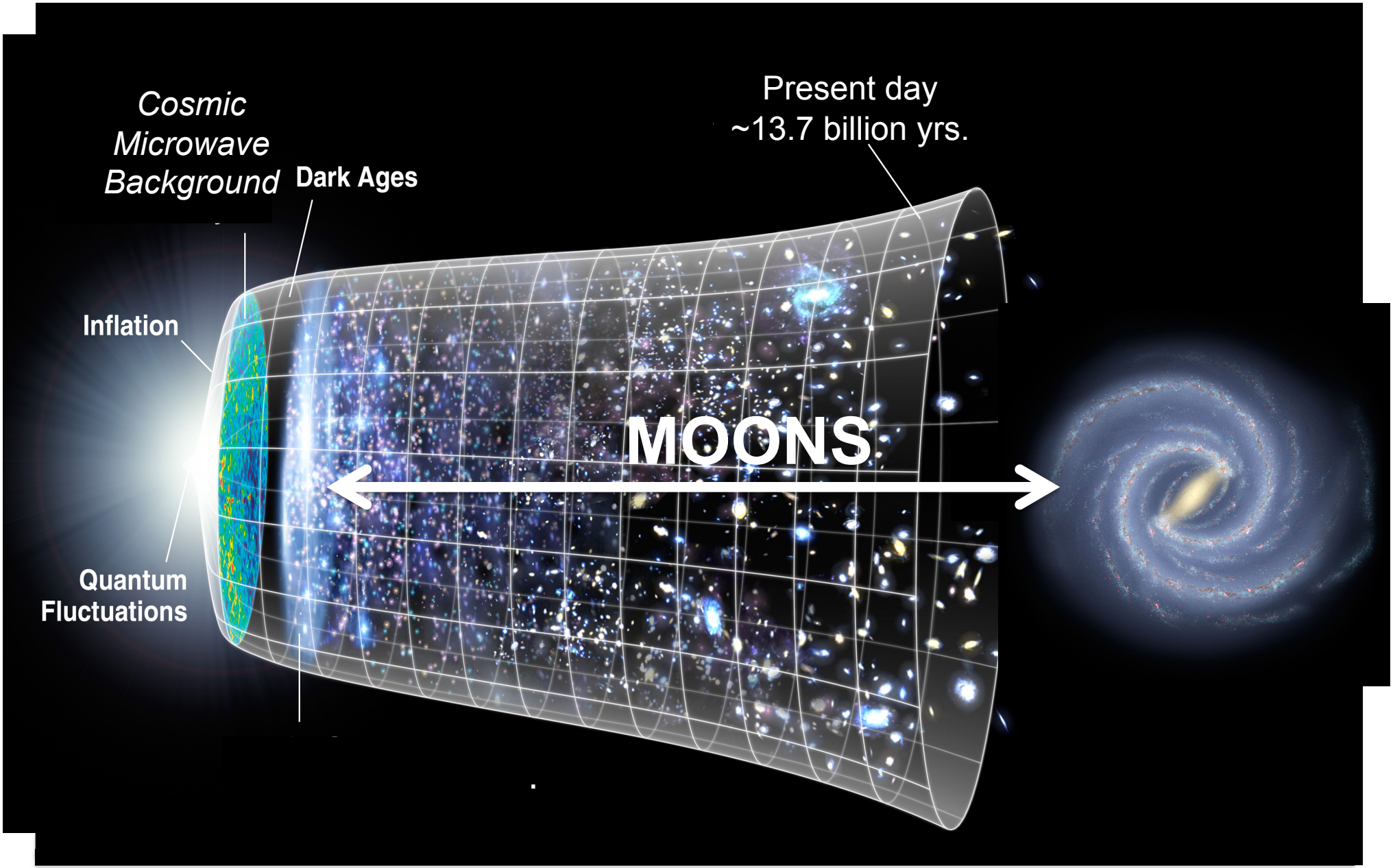
- 0.76-0.90μm at R = 9,000
- 0.95-1.35μm at R=4,000
- 1.52-1.63μm at R=20,000





Throughput: ~ 30 %

MOONS Science Cases



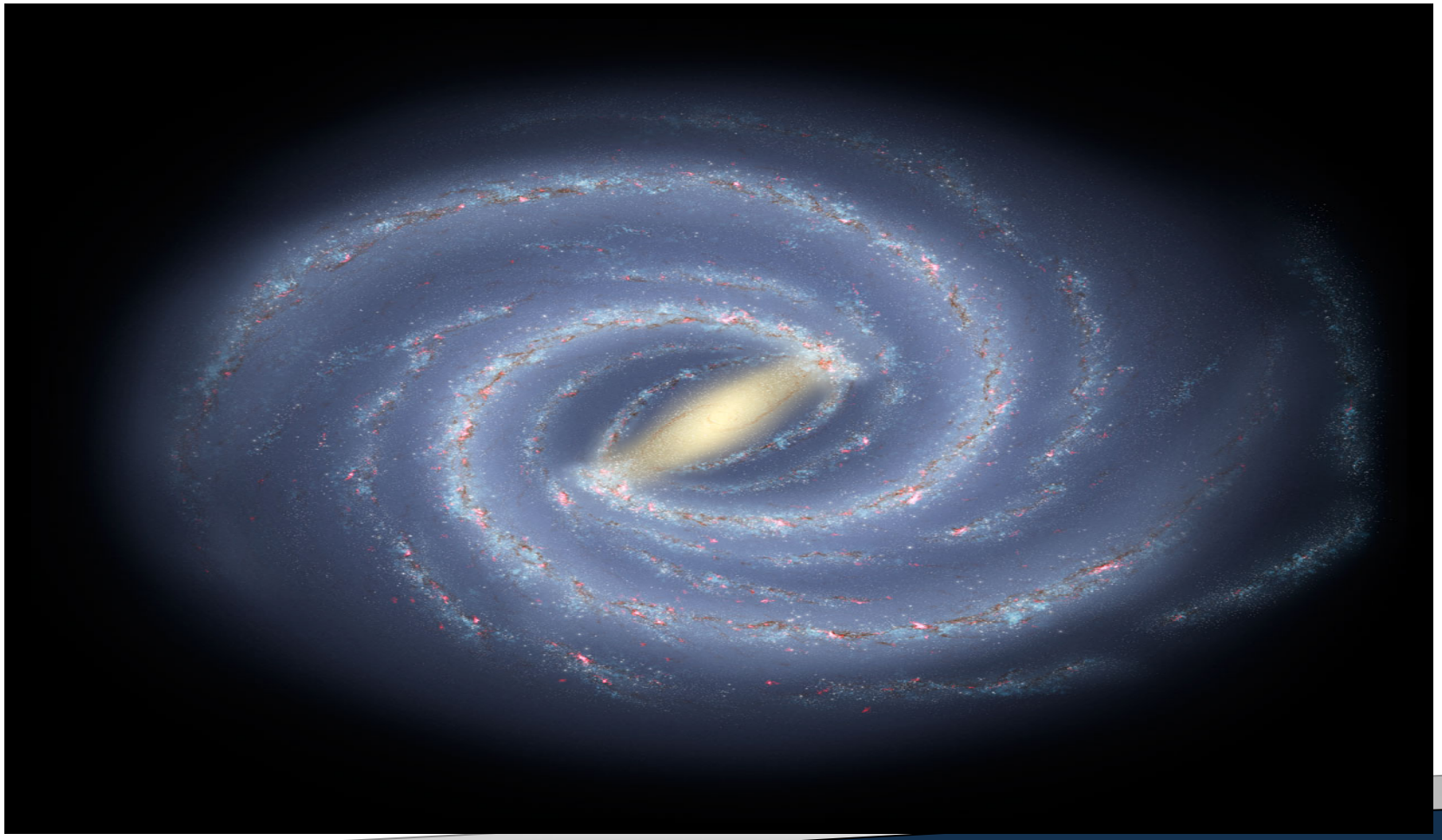
Galactic science cases

On behalf of the Galactic Science Working Group

100n

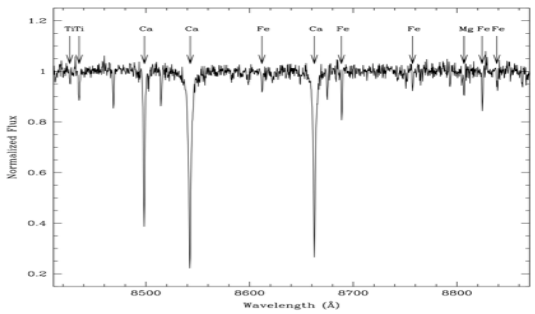
Galactic Archaeology

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.



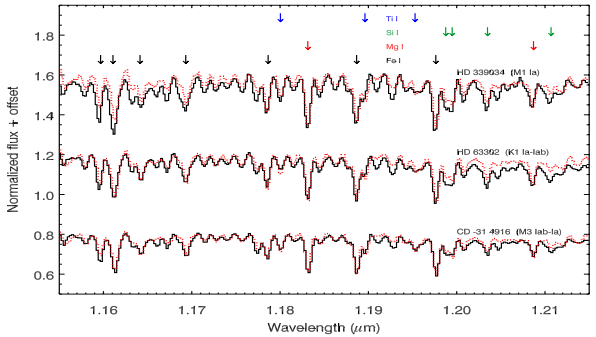
MOONS for Galactic studies

I-band
R=9,000



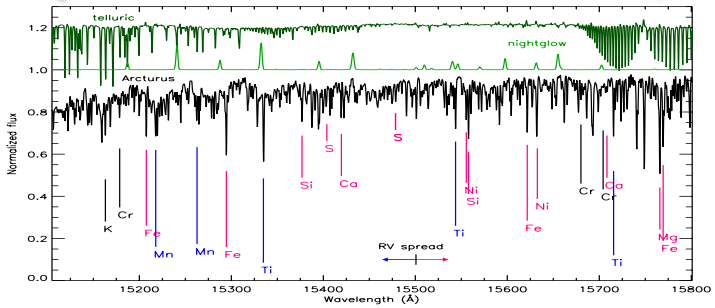
FLAMES
(multiplex = 130)

YJ-band
R=4,500



KMOS
(multiplex = 24)

H-band
R=20,000



APOGEE
(multiplex = 300)

Kinematics – Radial velocities
(<1 km/s)

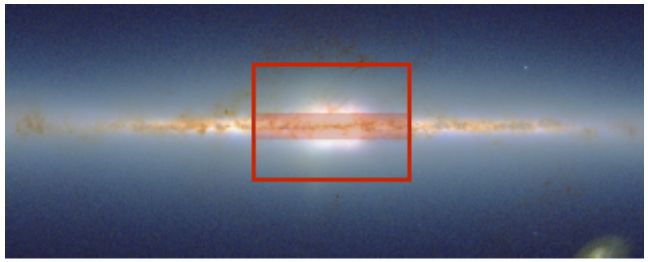
CaT @R=9,000 for I<21 + [M/H] (via Fe,Si,Ti,Mg) @R=4000-6000 (J+H)

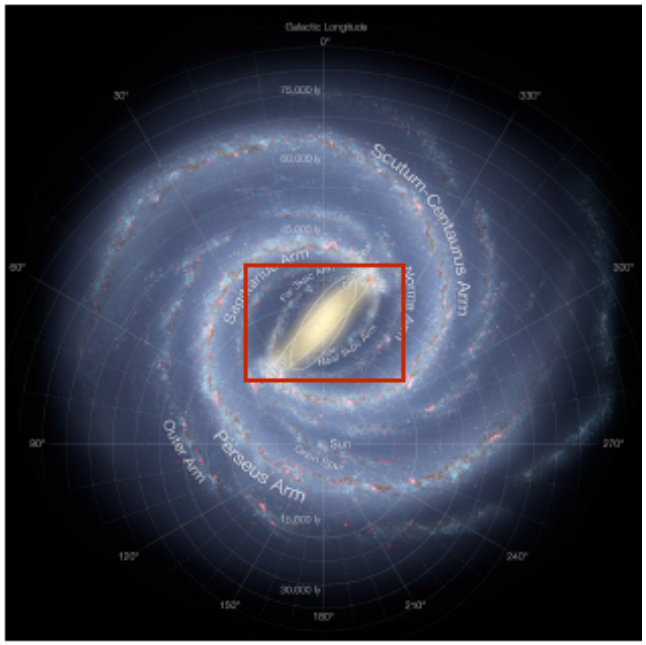
Detailed chemical abundances
(< 0.1dex)

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

Mapping the inner regions of the Galaxy

Mapping the inner regions of the Galaxy





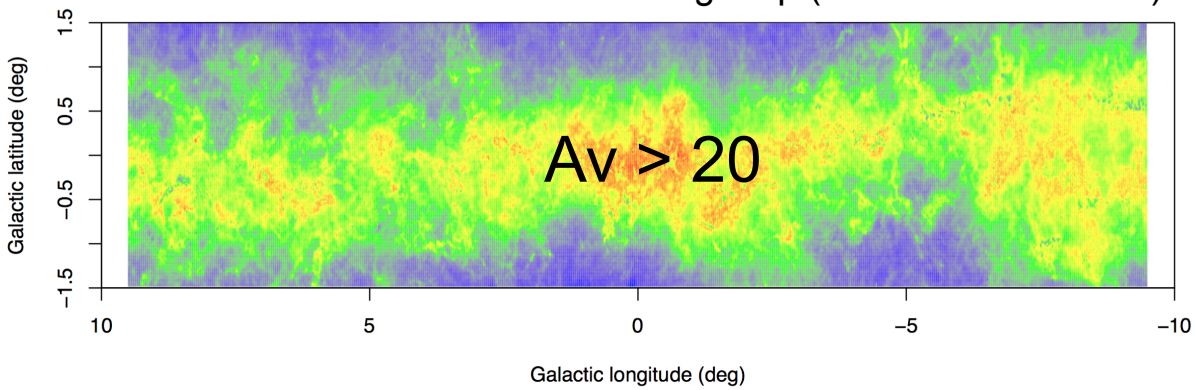
The **Bulge** is the **innermost** component of the Galaxy

The dust across the disc makes it very hard to study in the optical

It contains 1/4 of the total stellar mass and its properties are linked to the process involved in the **formation history of the Galaxy**

- **External**, violent accretion processes form old spheroids
- **Internal** processes (i.e. dynamical evolution of the disc) form bars in variable timescales

VVV reddening map (BEAM-II Gonzalez+)



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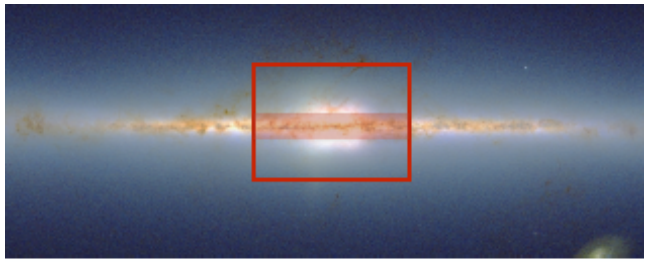

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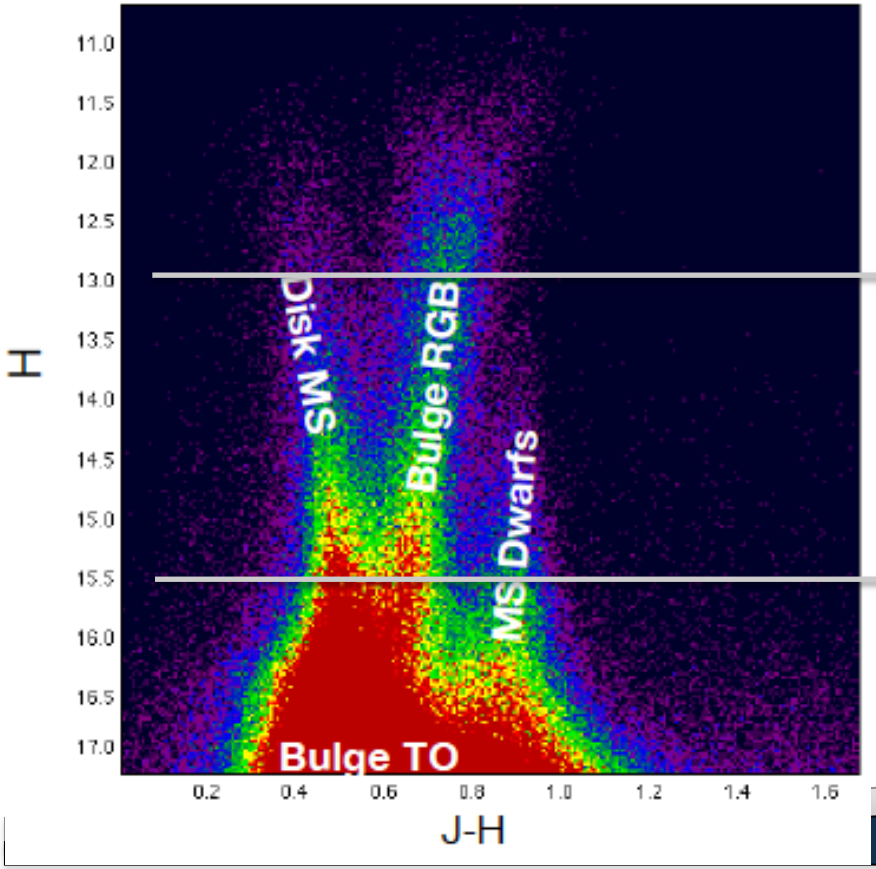
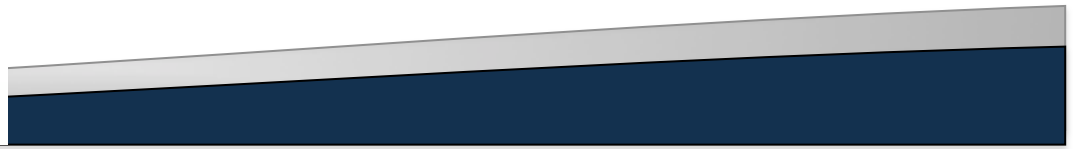
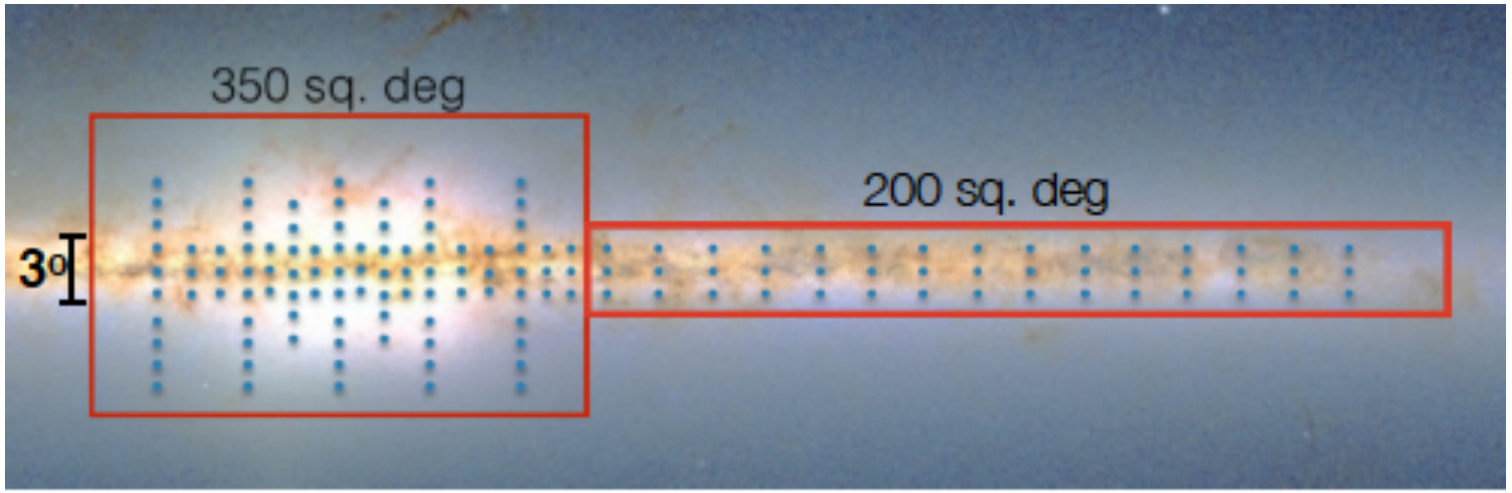


APOGEE-II in 4 hrs

MOONS in 1 hr



MOONS Inner Galaxy Survey



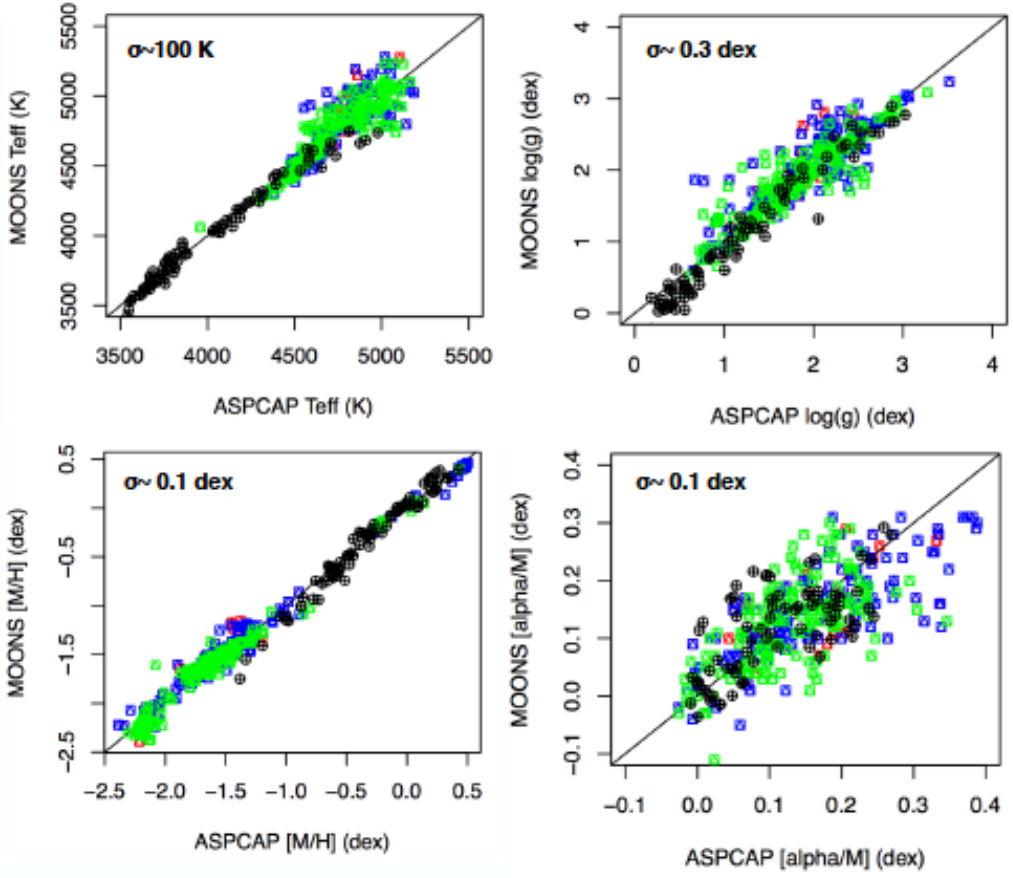
MOONS Inner Galaxy survey + low latitude disc

>10^6 stars in 550 sq. deg (S/N>50)

- **Chemo-dynamics of inner bulge and disc:**
  - Is there a distinct large-scale inner bulge structure?
    - *Inner/nuclear bar* (Alard+01, Nishiyama+05, Gonzalez+11)
    - *Metal-poor central spheroid* (Schultheis+15)
    - *kpc-scale nuclear stellar disc* (Debattista+15)
  - Nuclear bulge characterisation (inner 0.5 deg / 200 pc) (Launhardt+02)
  - Galactic disc - bar transition (Bono+15)
  - Complete the global/detailed view of a B/P bulge (Gonzalez+16, Zoccali+14)

Calibration

H-band only

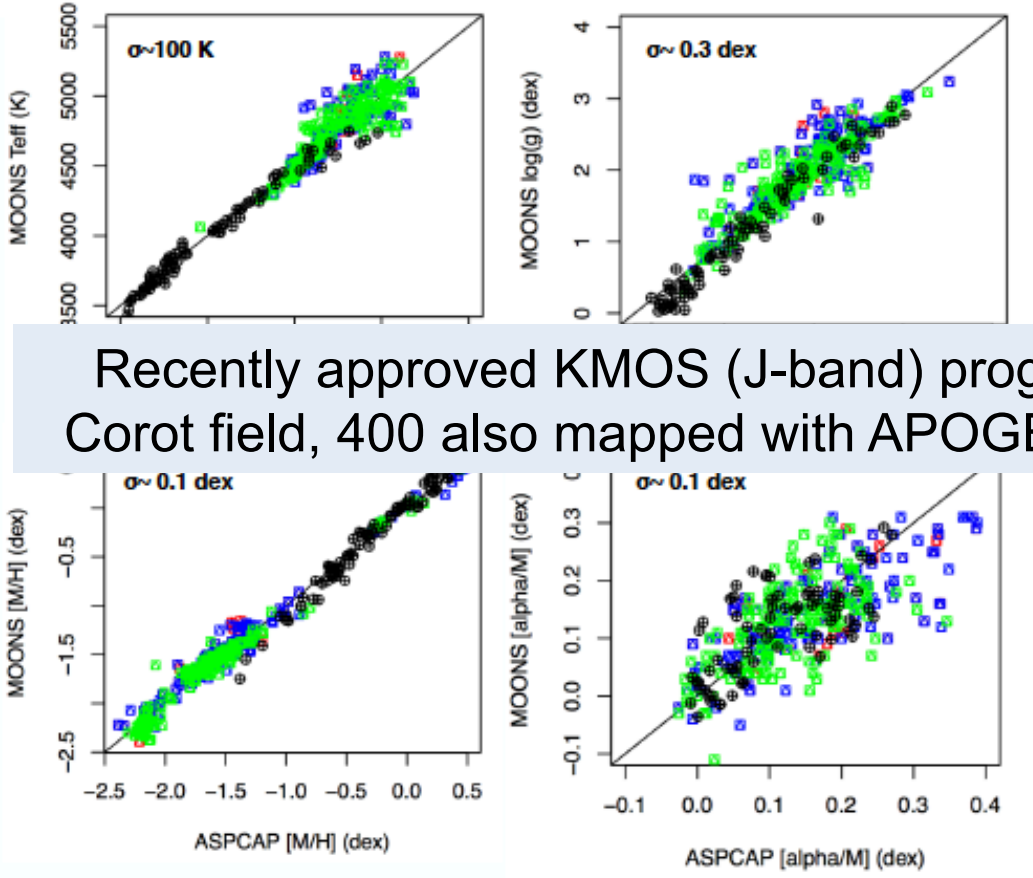


By Oscar Gonzalez

H-band tests with The Cannon
- R 18,000 - 20,000
- Reduced wavelength range

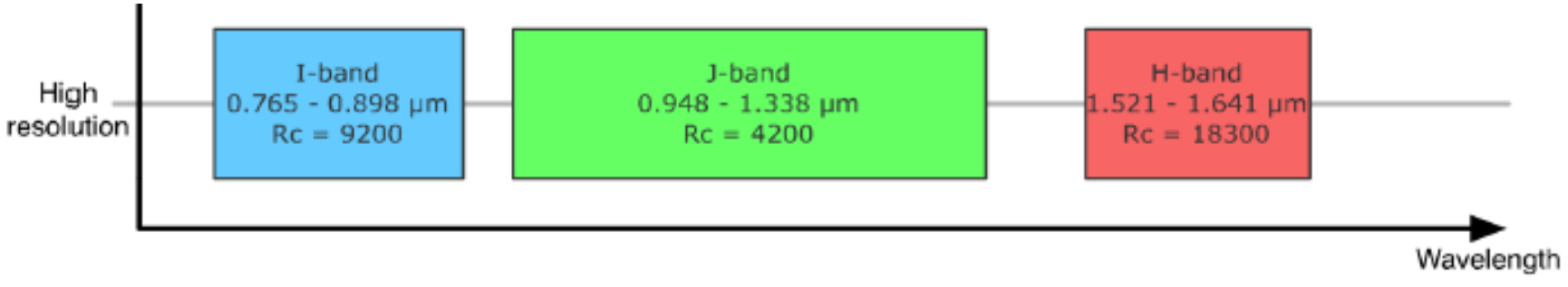
Calibration

All bands



Recently approved KMOS (J-band) programme to obtain 1,700 giants in Corot field, 400 also mapped with APOGEE (H-band) and GALAH (optical)

By Oscar Gonzalez

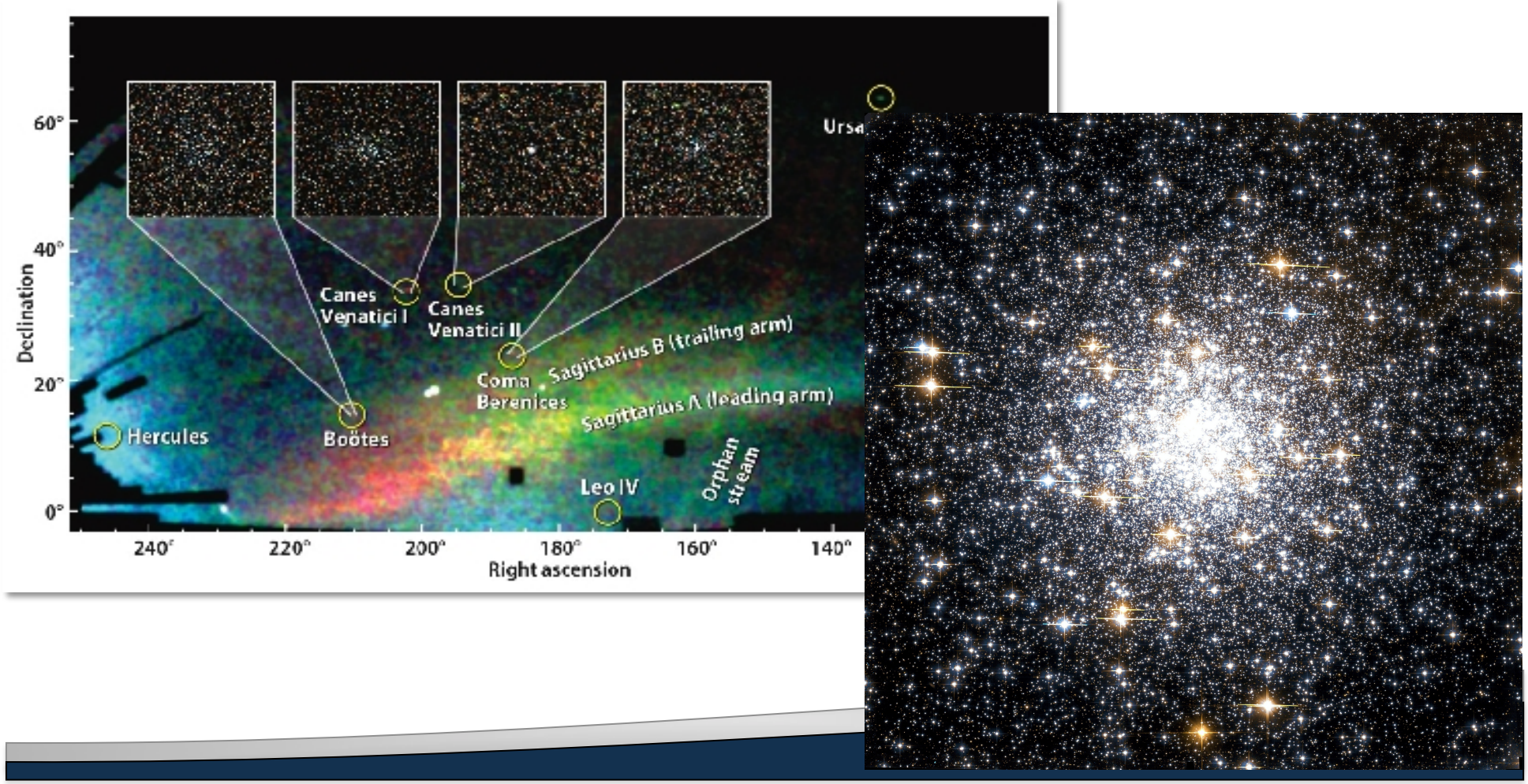


Galactic Archaeology

Disk and Bulge

Streams in the Halo field and clusters

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



Galactic Archaeology

Disk and Bulge

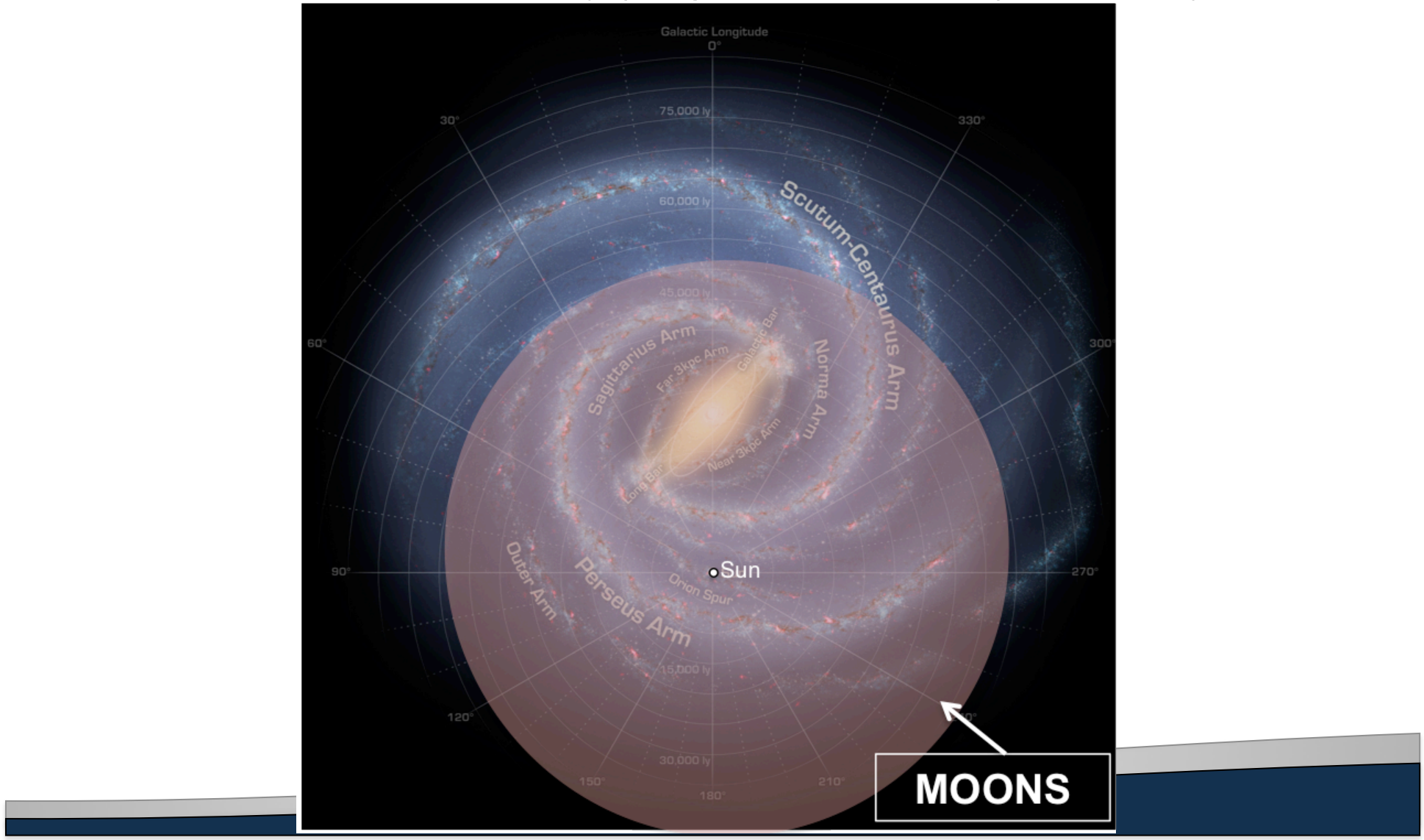
Streams in the Halo field and clusters

Resolved stellar population in external galaxies

Magellanic clouds, Nearby galaxies

Galactic Archaeology

MOONS will deliver chemo-dynamical measurements across all the main components of our Galaxy (Bulge, Disk, Streams) … and beyond.



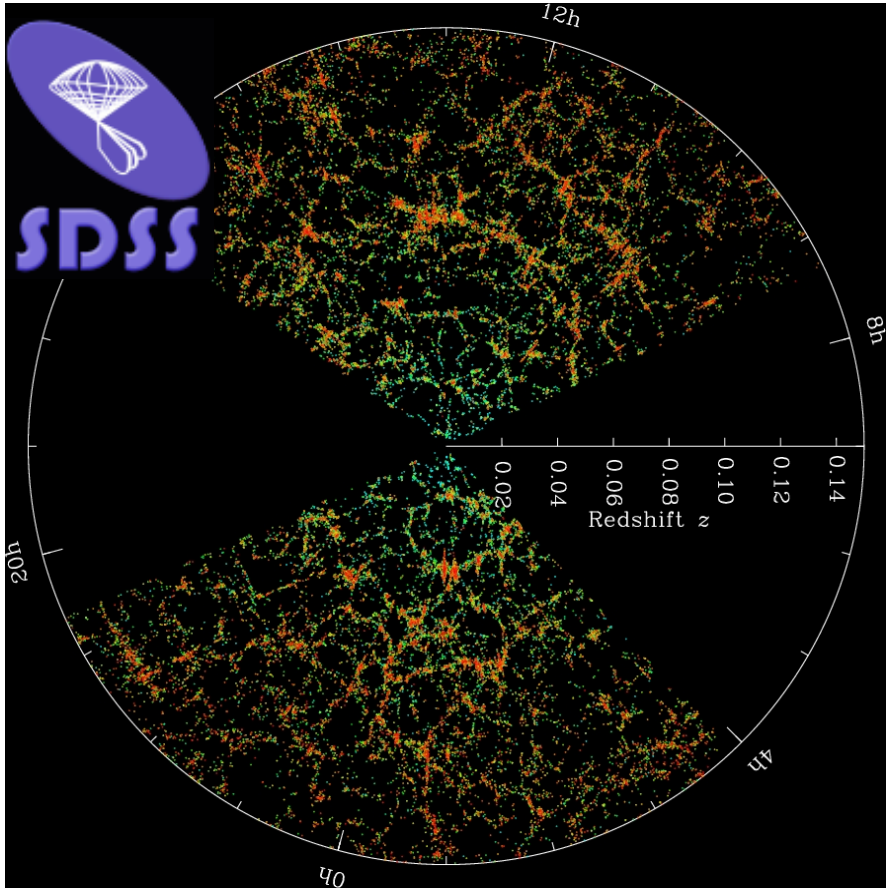
Extragalactic science case

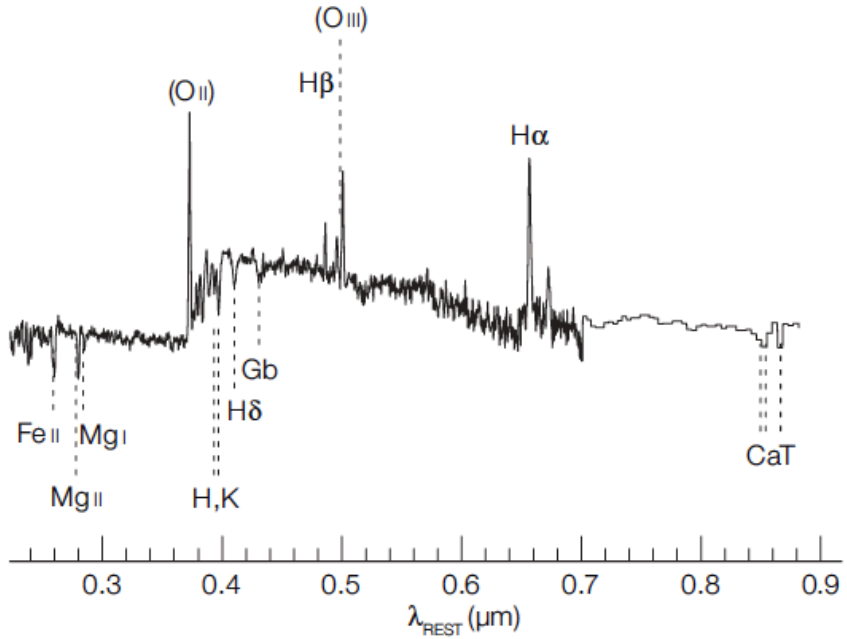
On behalf of the Extragalactic Science Working Group

200n

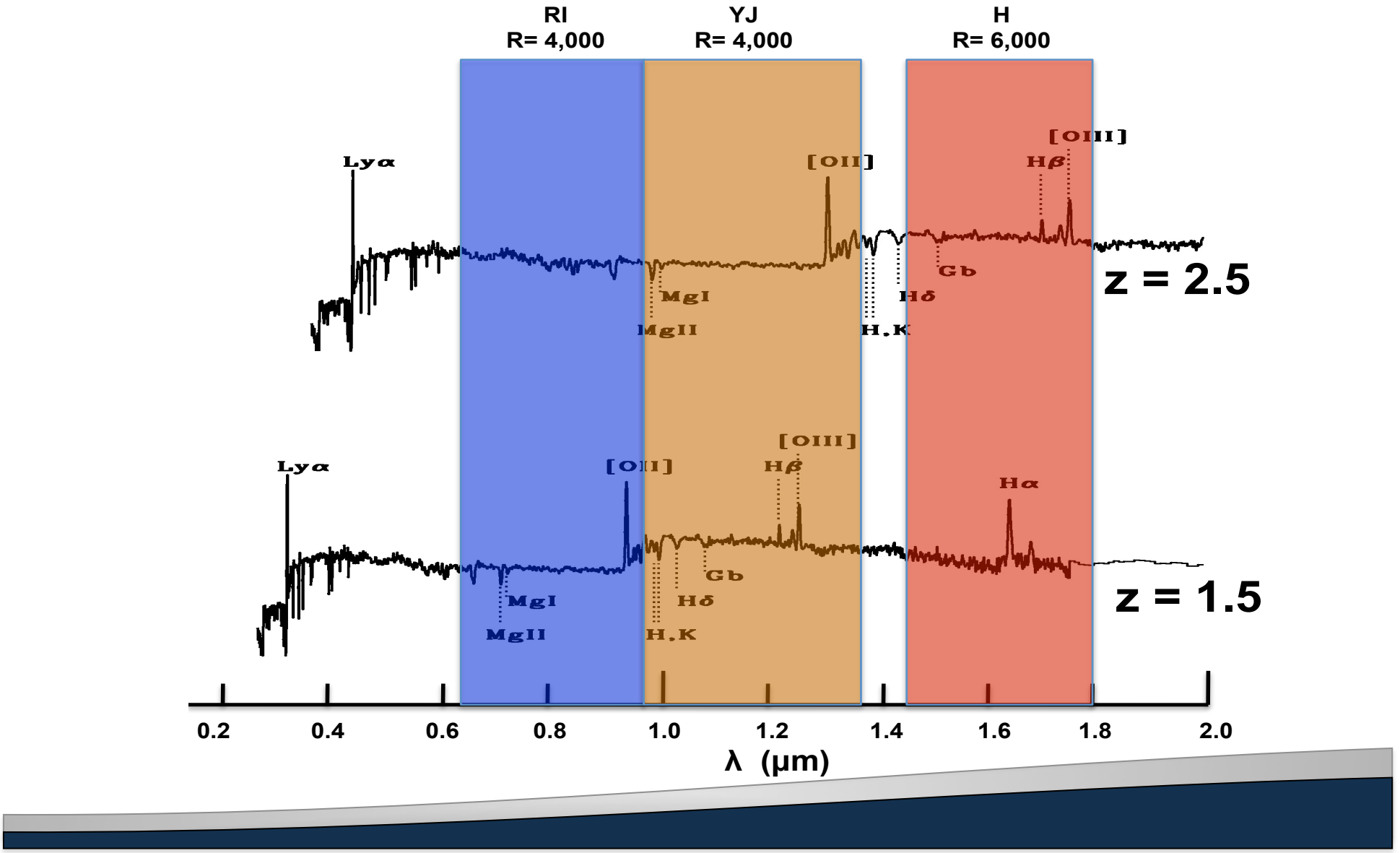
Sloan Digital Sky Survey (SDSS)

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



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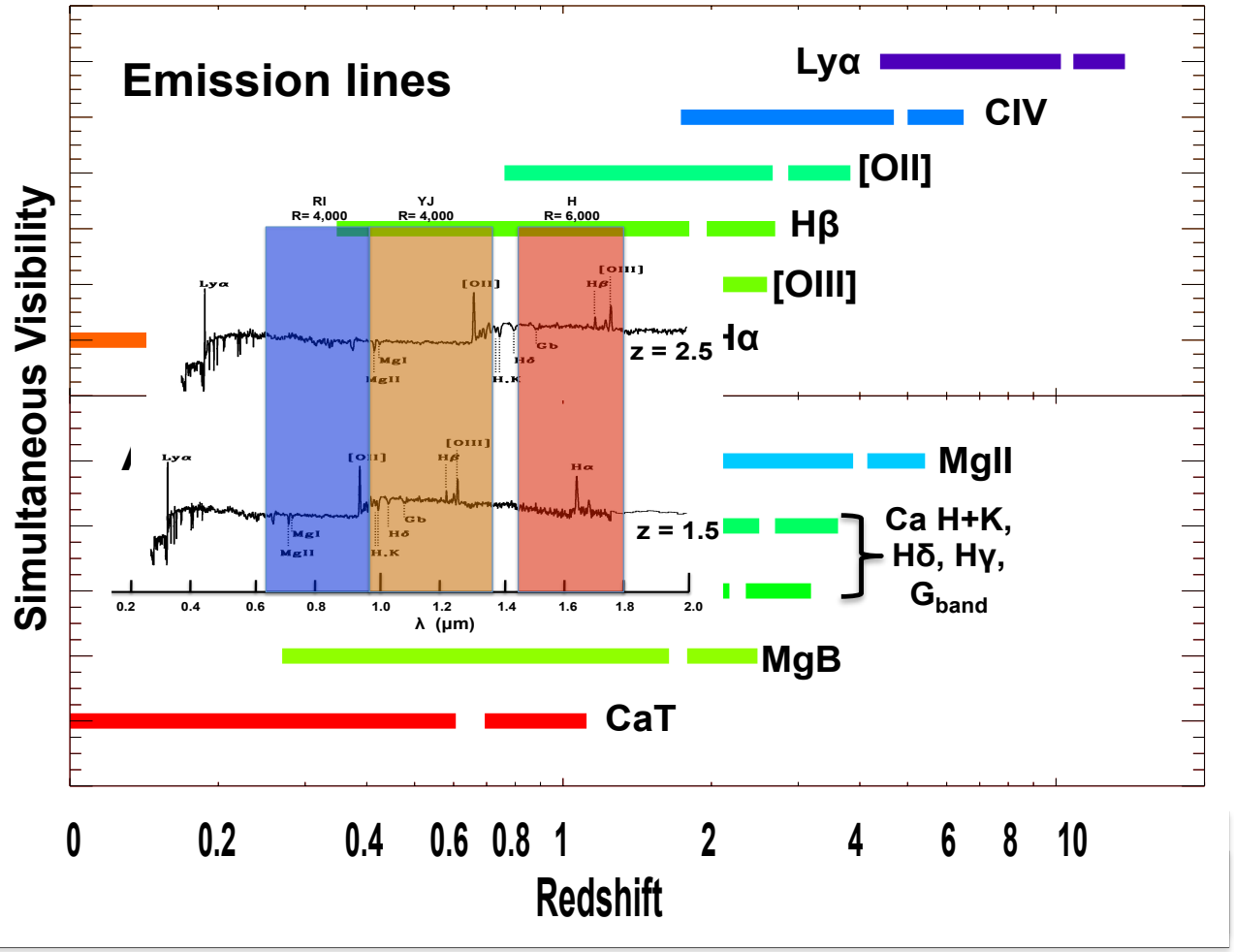
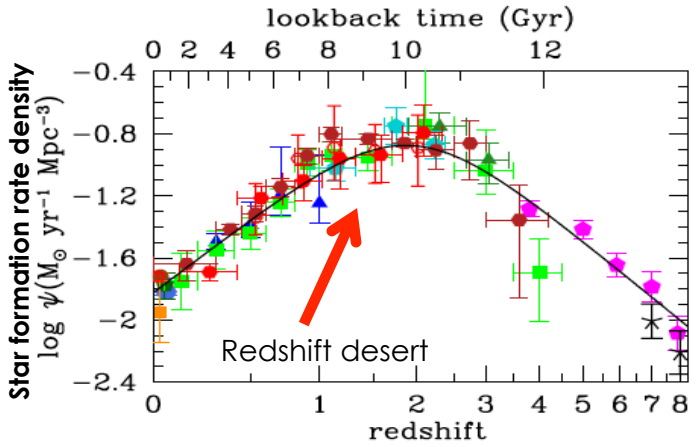


Extra Galactic Science Case

SDSS-like survey
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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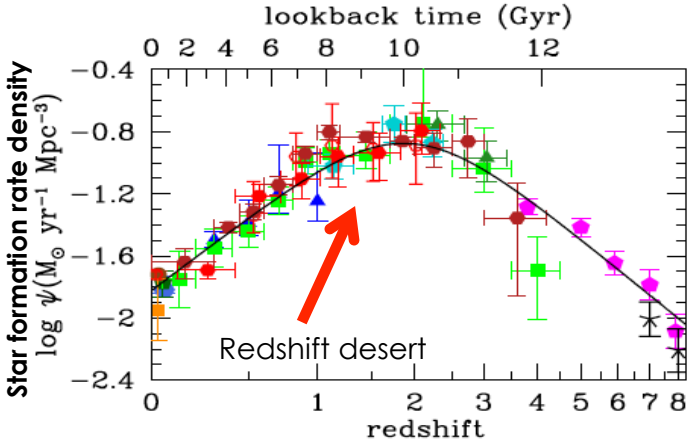

Diagnostics for passive and star-forming galaxies

- ***Metallicity (R_{23},N_2, stellar indices)***
- ***SFR (Hα, Hβ, [OII])***
- ***Stellar populations***
- ***Galaxy transformation (quenching) mechanisms***
- ***AGN power (BPT)***
- ***Dust extinction (Hα/Hβ)***
- ***Galaxy mass (σ_v)***
- ***BH mass (BLR)***
- ***Dependence on environment (large scale structures)***

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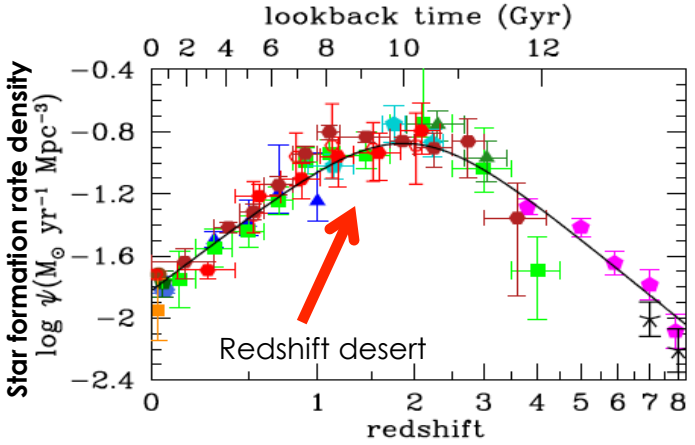

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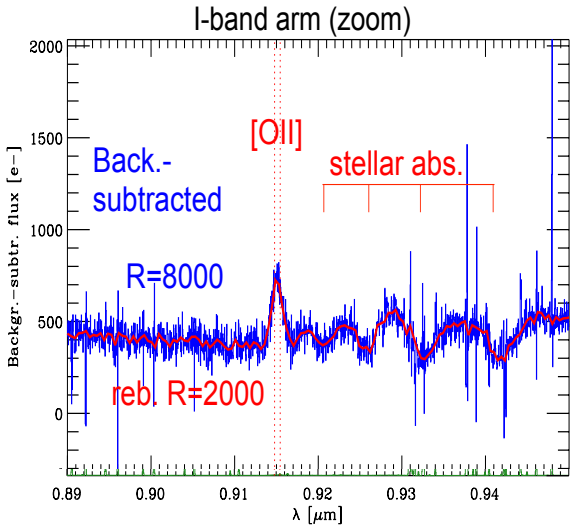

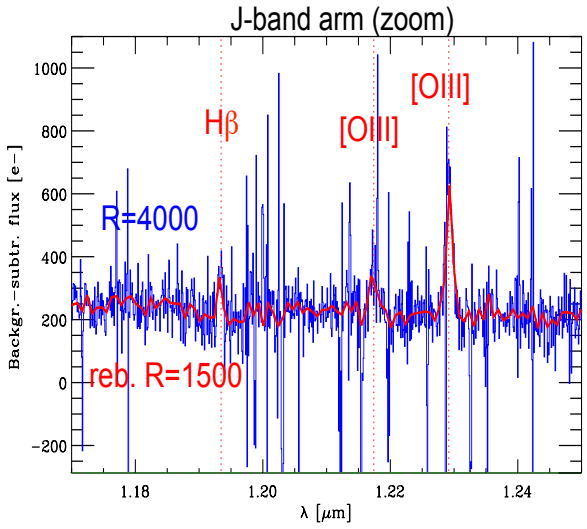

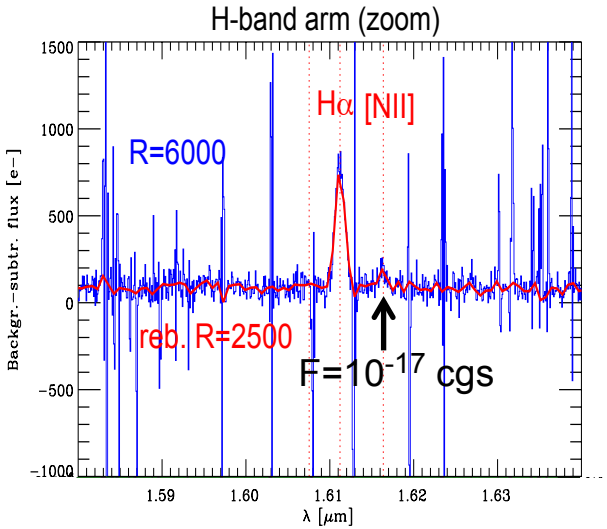

z=1.45, H_{AB}=22.7, 1hr

Extra Galactic Science Case

SDSS-like survey
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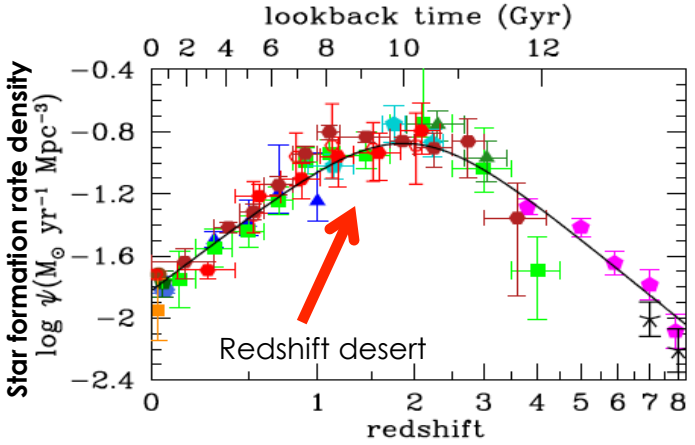

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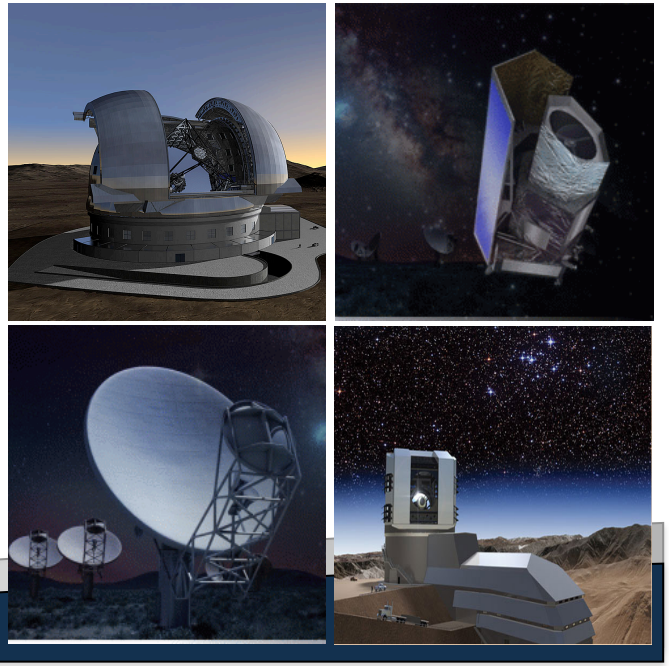


✓Follow-up of large-area imaging surveys: VISTA, Herschel, DES, UKIDSS, eRosita, etc.

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

MOONS Extragalactic Surveys

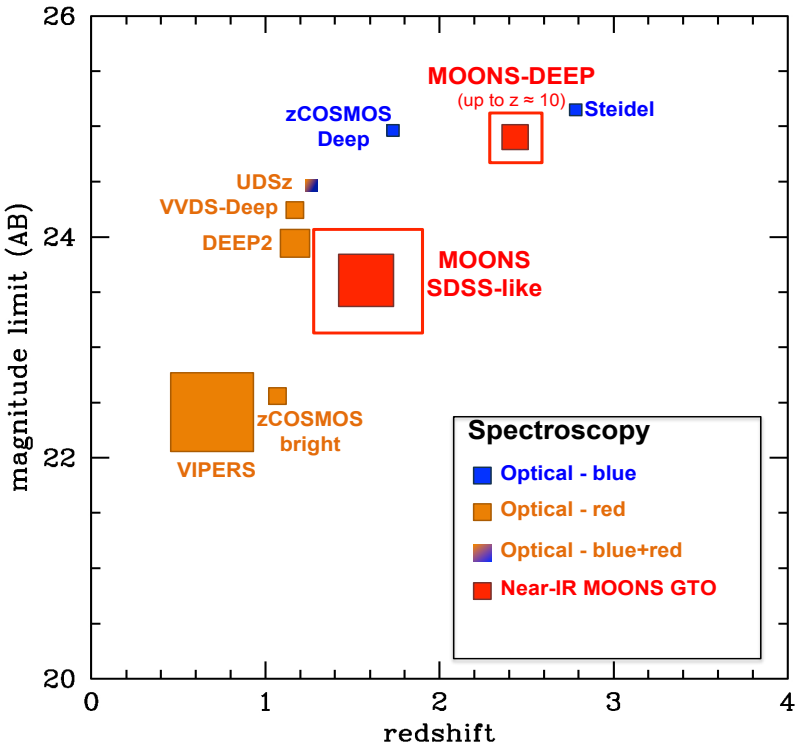
SDSS-like + Deep Surveys

Physical, Chemical and Environmental properties for
~1M galaxies at 0.8 < z < 10

Optimised observation strategy:

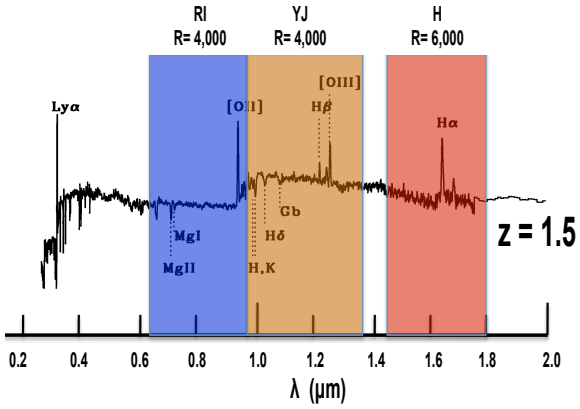
$H_{AB} < 23.5$ 1-8hr over 30sq. deg.

$23 < H_{AB} < 25$ 8-40hr over 5-6sq. deg.



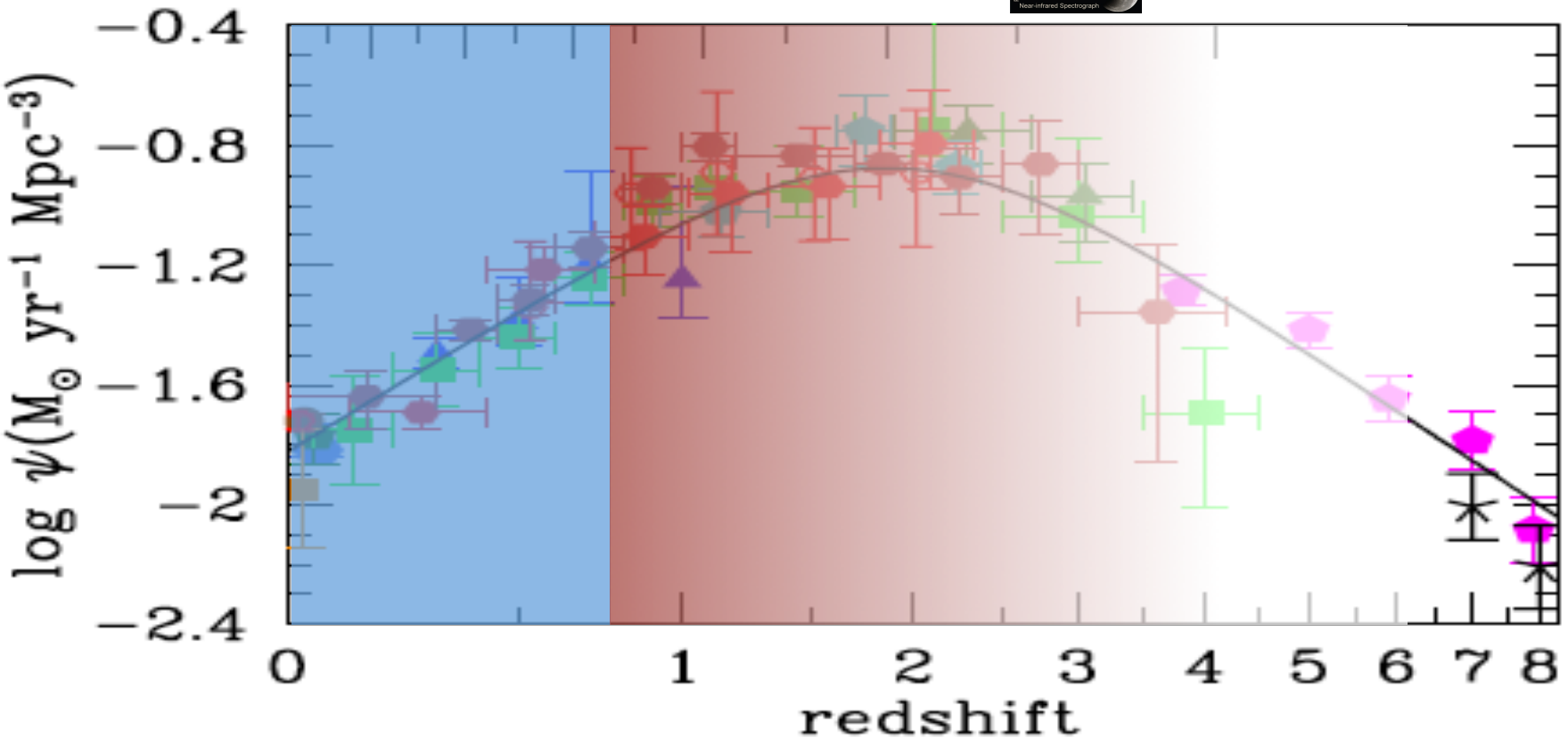
$M \sim 10^9\ M_\odot$ and $SFR < 1\ M_\odot/yr$ at z~1-2
with multiple lines diagnostics to measure:
SFR, Metallicity, Ionisation state, AGN, Dust, Environment, etc …

Considerably deeper if only interested in determining the redshift



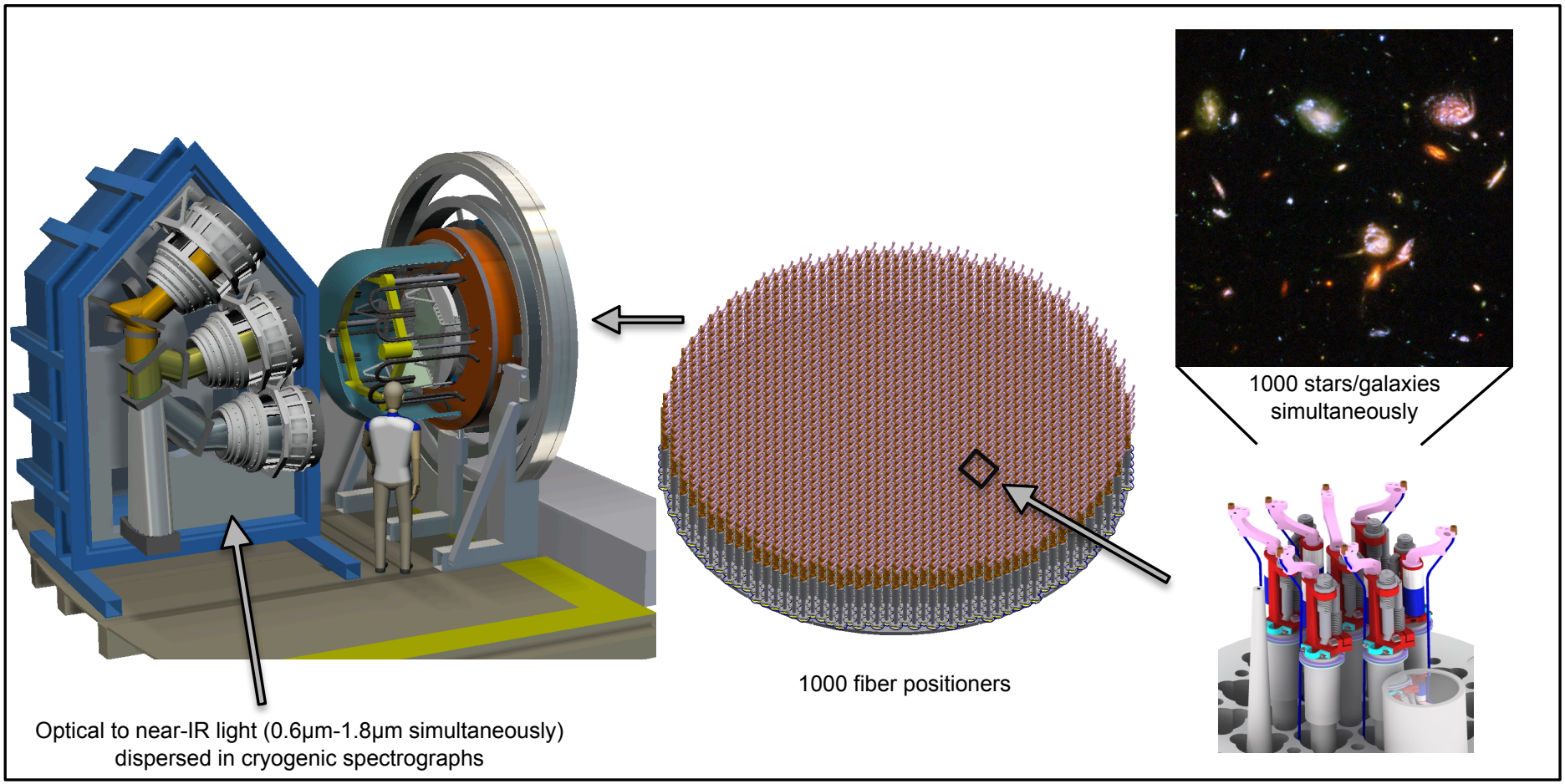
Synergies MOONS

Visible
WAVE
4MOST
8m tel

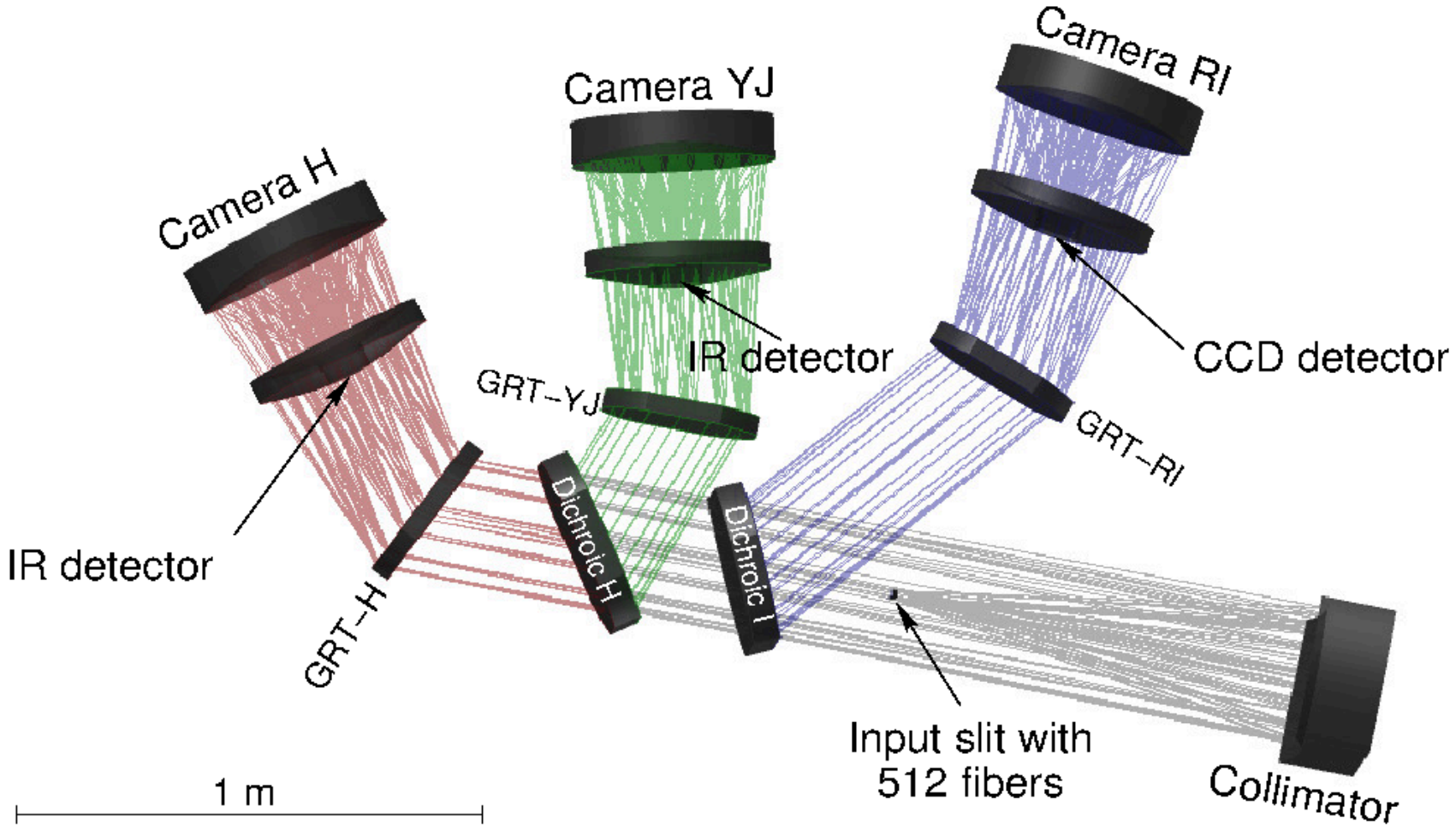


MOONS basic layout

System Overview

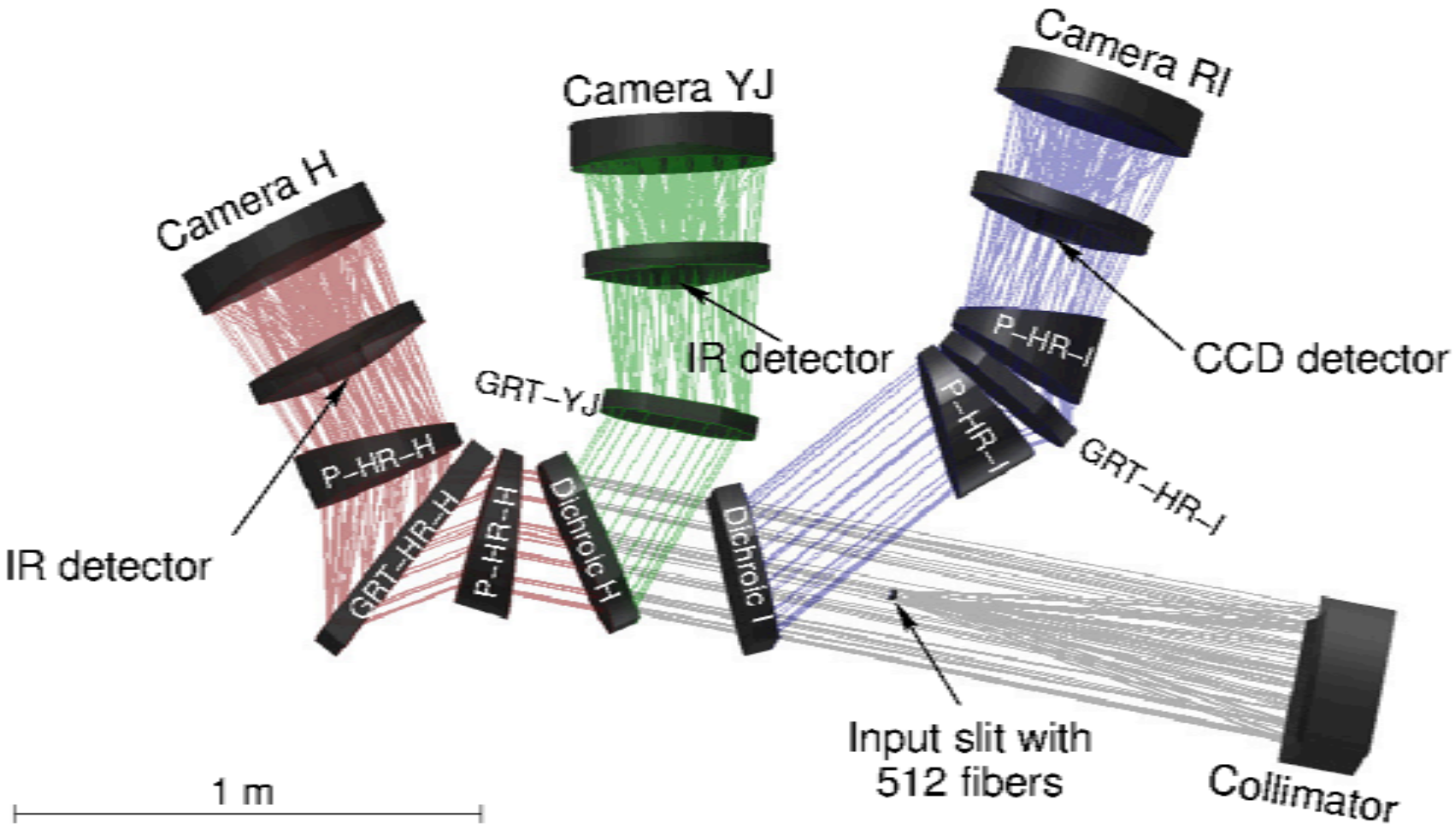


Spectrograph optical design



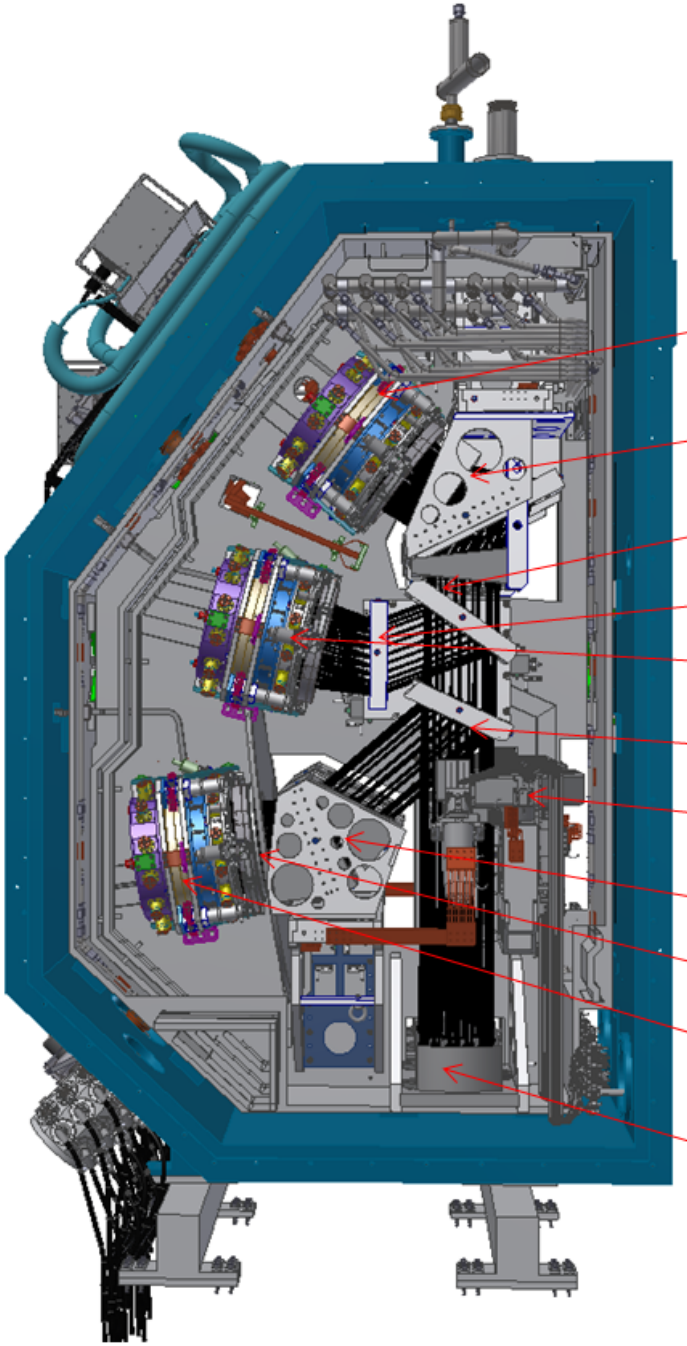
See E. Oliva et al, SPIE 9147-337

Spectrograph optical design



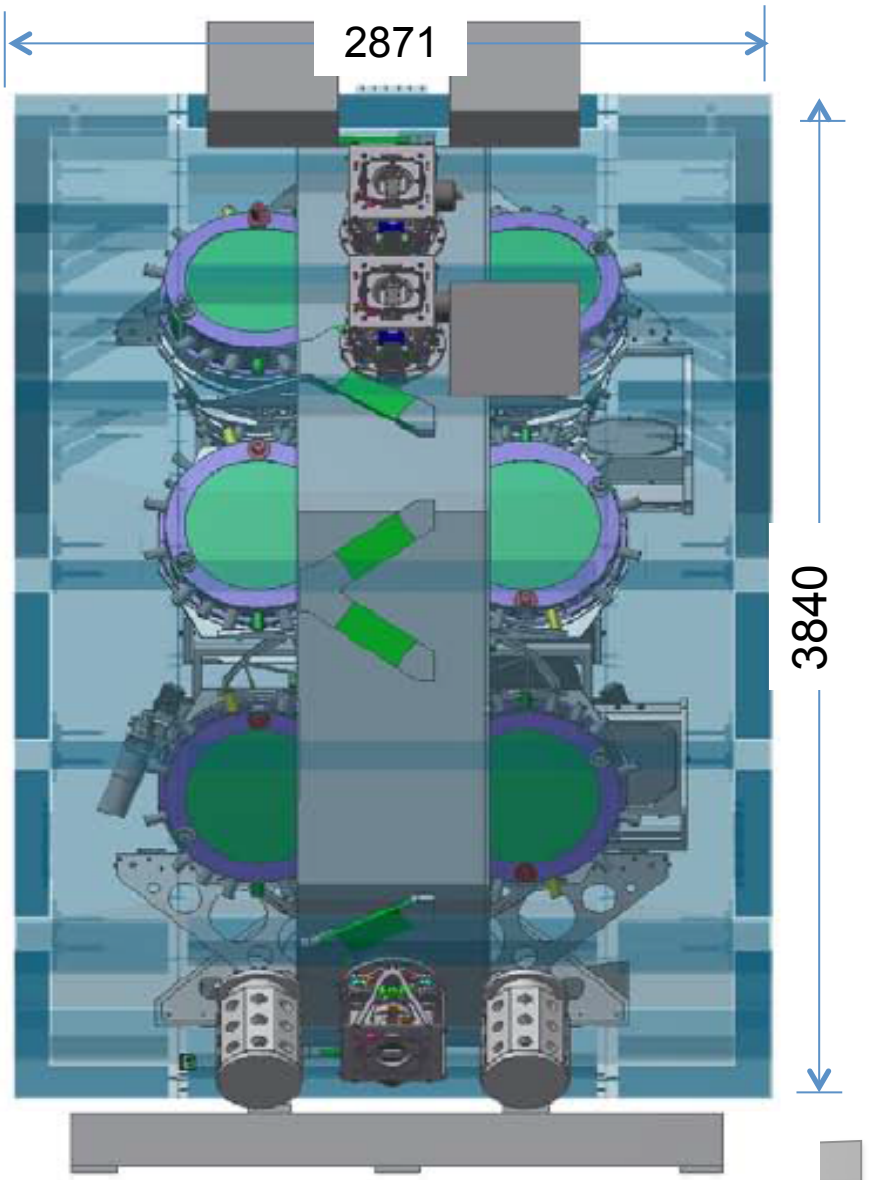
See E. Oliva et al, SPIE 9147-337

Cryostat



Spectrometer 1

- H camera
- H disperser
- YJ dichroic
- YJ disperser
- YJ camera
- RI dichroic
- Inlet slits
- RI disperser
- RI shutter
- RI camera
- Collimator



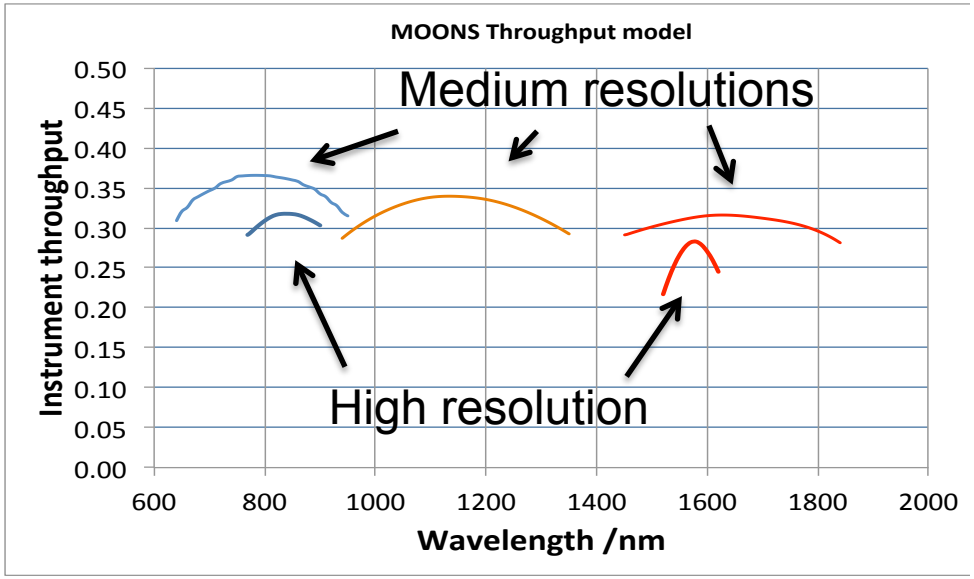
Expected performances

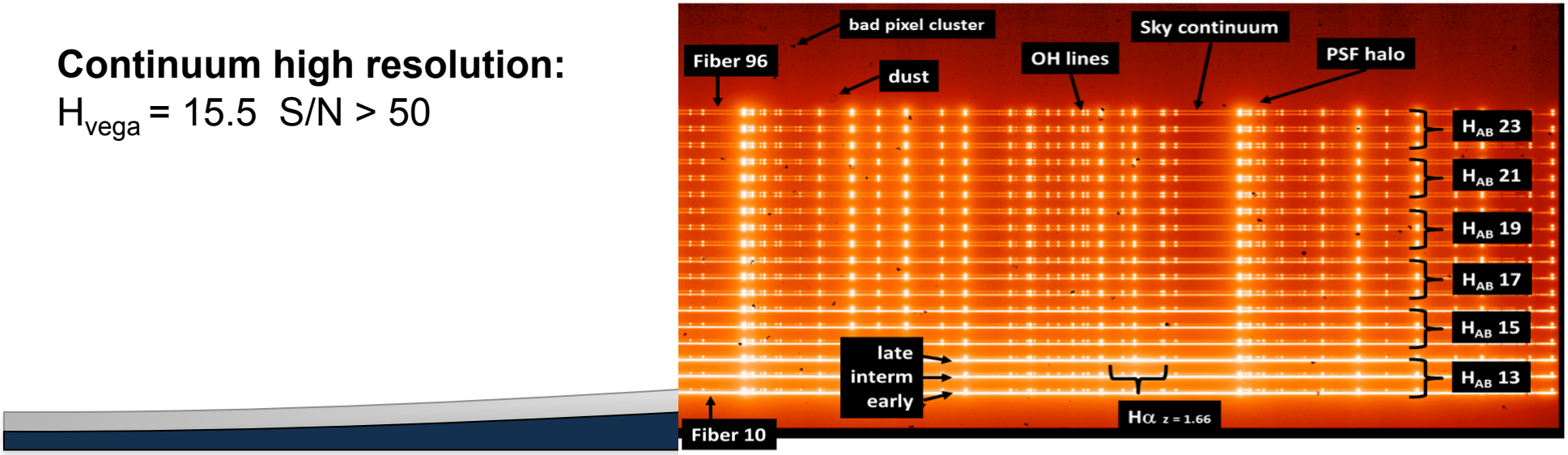
Sensitivities in **1hr** integration:

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 > 50





MOONS timeline

- ☑ *October 2015: Preliminary Design Review*
- ☑ *June 2016: started procurement of Teledyne H4RG near-IR detectors*
- ☑ *October 2016: Long lead items (Optics) Final Design Review*
- *Early 2017: Final Design Review*
- *mid 2019: Preliminary Acceptance Europe*
- *End 2019 - Early 2020: Start of science operations*