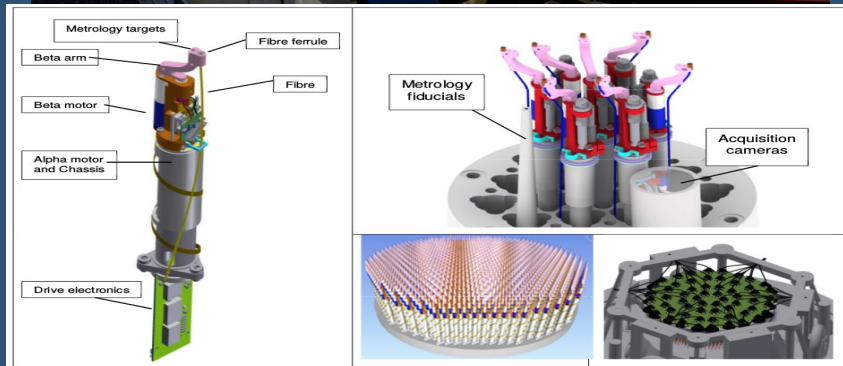


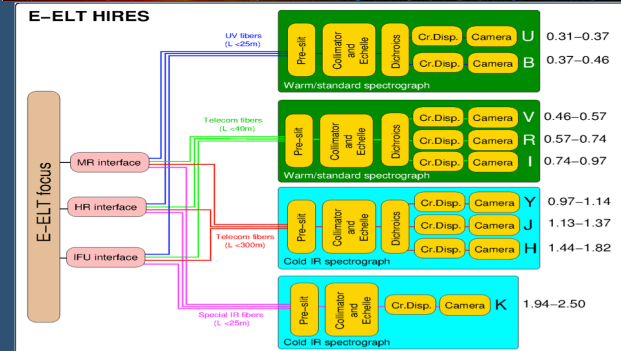
MA2 - Bologna, 15-16 June 2016

# the future of medium-high resolution IR spectroscopy

## MOONS-VLT: 2019+



## HIRES-EELT: 2027+



Livia Origlia

INAF - Osservatorio Astronomico di Bologna

[livia.origlia@oabo.inaf.it](mailto:livia.origlia@oabo.inaf.it)

# the future of medium-high resolution IR spectroscopy

## the science context of MA2

broad (**evergreen**) questions

- 1) galactic archaeology
- 2) stellar, chemical and dynamical evolution
- 3) environment/feedback
- 4) structure at large (stellar, circumstellar, galactic etc.)
- 5) stars & planetary systems

.....

## the 2020's era

Gaia, ALMA → JWST, LSST, PLATO, ELTs ...

# the future of medium-high resolution IR spectroscopy

## the instrument context

### medium resolution, multi-object spectroscopy

#### stellar populations census

chemistry & RVs of large samples of stars to trace galactic structure & archaeology in the MW, in the LG and beyond

- FLAMES (optical) at the VLT + APOGEE (IR)
- some other medium-res MOS at Keck, AAT, LBT

**future → wider fov and/or larger multiplexing**

WEAVE, 4MOST in the optical, **MOONS** in the near IR

# the future of medium-high resolution IR spectroscopy

## the instrument context

high resolution echelle spectroscopy

stellar physics & chemistry

chem abundances, MFs, activity, asteroseismology, 3D structure, winds

- HARPS-N (optical) + GIANO (IR) at the TNG
- UVES & ESPRESSO (optical) + CRIRES+ at the VLT
- other echelle at Keck, Magellan, Subaru, LBT

future → larger telescopes, ELT-class

HIRES at the EELT



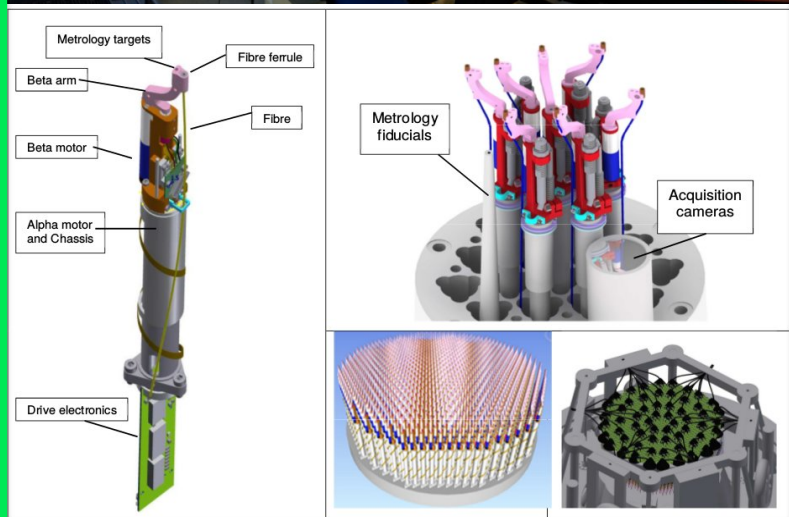
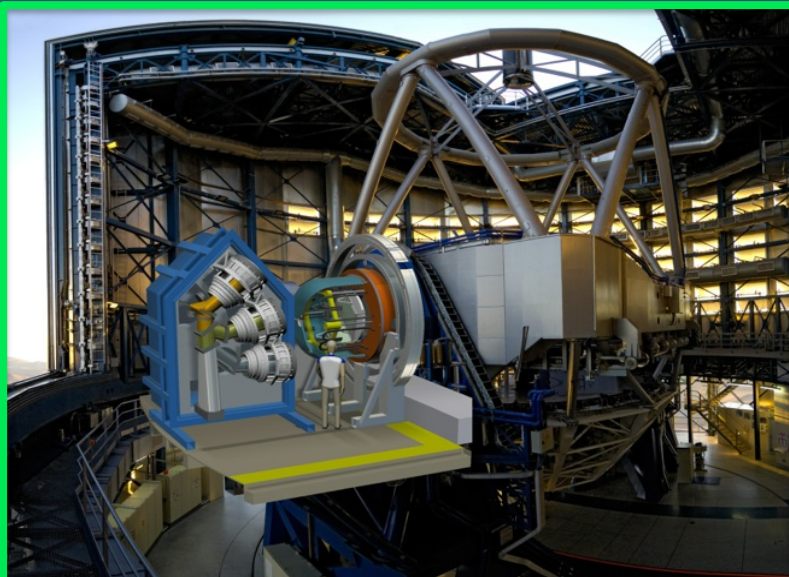
# Multi-Object Optical and Near-infrared Spectrograph for VLT



PI: M. Cirasuolo (Edinburgh → ESO), Italian co-PI: E. Oliva (Arcetri)

Consortium: UK, France, Germany, Italy, Netherlands, Portugal, Chile, Switzerland, Sweden, ESO

<http://www.roe.ac.uk/~ciras/MOONS.html>



## INAF participates with

- ~30 FTEs (spectrometer, acquisition camera, obs tools, end-to-end simul)
- Science Team

## Schedule

- ✓ Contract with ESO signed on **Sept 2014**
- ✓ Preliminary Design Review: **Oct 2015**
- Manufacturing readiness review and start procurement of long lead components: **May 2016**
- Final design review: **Dec 2016**
- Preliminary acceptance Europe: **March 2019**
- Preliminary acceptance Chile: **Sept 2019**



# MOONS science requirements and capabilities

Parameter	Specifications
Telescope	VLT
Field of View	500 arcmin <sup>2</sup>
Multiplex	1000 objects, with possibility to deploy fibre pairs (500 obj+500 sky)
Sky-projected diameter of each fibre	1.0 arcsec
Close packaging	At least two fibres within 10 arcsec
Wavelength coverage	0.65 - 1.8 $\mu$ m
Observing modes	medium resolution (MR) and high resolution (HR)

Observing Mode / Band	Spectral coverage	$R$ (at central $\lambda$ )	Comment
MR- <i>RI</i>	0.647 – 0.955 $\mu$ m	4,100	Simultaneous in MR mode
MR- <i>YJ</i>	0.934 – 1.350 $\mu$ m	4,300	
MR- <i>H</i>	1.452 – 1.800 $\mu$ m	6,600	
HR- <i>I</i>	0.765 – 0.898 $\mu$ m	9,200	Simultaneous in HR mode
MR- <i>YJ</i>	0.934 – 1.350 $\mu$ m	4,300	
HR- <i>H</i>	1.521 – 1.641 $\mu$ m	18,300	

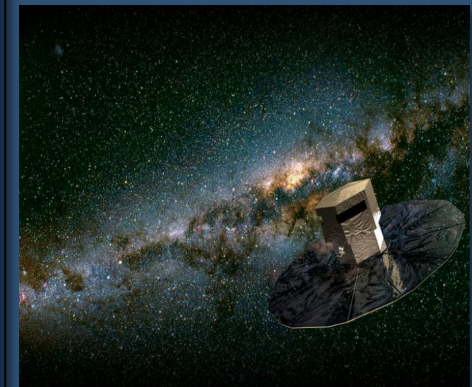


# MOONS surveys

300 nights of GTO + public/legacy surveys

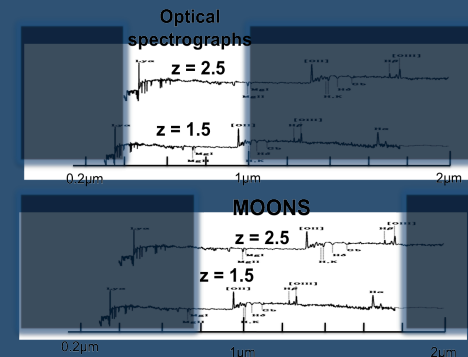
Galactic surveys  $H_{Vega} = 15.5 \rightarrow 17$   
i.e. RC in the Galaxy, RGB in the LG

- ✓ Radial velocities and detailed chemical abundances for several million stars over  $>1000$  sq. deg (GAIA, VISTA etc. follow-up)
- ✓ Best instrument to study the inner Bulge and Disk and the coolest stellar populations in the MCs & beyond
- ✓ Possibility to target star clusters and streams in the Halo and nearby galaxies



A formidable SDSS-like survey at  $z > 1$   $H_{AB} = 23.5 \rightarrow 25$

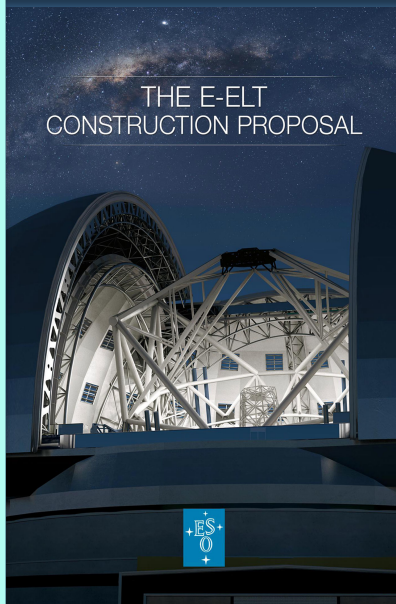
- ✓ Fundamental insights into galaxy formation and evolution over cosmic time from  $\sim 1M$  galaxies at  $z > 1$ .
- ✓ Follow-up of the very first galaxies at  $z > 7$  into the epoch of re-ionization.
- ✓ Follow-up of large-area imaging surveys: VISTA, Herschel, DES, UKIDSS, LOFAR, eRosita, Euclid etc.







# E-ELT HIRES <http://www.arcetri.astro.it/~hires>



## EELT updates

in December 2014 ESO Council approved the construction of the 39m E-ELT in two phases, and authorized spending on Phase 1

<http://www.eso.org/sci/facilities/eelt/>  
Constructing the E-ELT, The Messenger 158, Dec 2014

### first light instruments:

MICADO(EELT-CAM)+MAORY(MCAO)  
HARMONI (EELT-IFU)+SCAO

third instrument: METIS(EELT-MIR)+SCAO



## HIRES updates

March 2015: ESO Request for Information for EELT-HIRES & EELT-MOS

July 2015: ESO call for Phase-A studies at a firm price of 150 keuro

January 2016: the HIRES Consortium selected

April 2016: Kickoff <http://www.eso.org/public/announcements/ann16017/>



# E-ELT HIRES: the Project

followed the Phase A studies of **CODEX** (PI **L. Pasquini**) & **SIMPLE** (PI **L. Origlia**) and the new E-ELT instrument roadmap

**International Consortium of 12 countries**

**Italy**, Brazil, Chile, Denmark, France, Germany, Poland, Portugal, Spain, Sweden, Switzerland, UK

**Italy has the leadership**

**PI:** A. Marconi

**Project Office:** L. Valenziano (PM), M. Riva (SE), L. Origlia (IS), P. Di Marcantonio (SW-E), E. Oliva (O-E)

**International Science Team** **Chair:** R. Maiolino

from Italy: S. Covino, G. Cresci, V. D'Odorico, R. Gratton, G. Micela, P. Molaro, A. Mucciarelli, B. Nisini, D. Romano

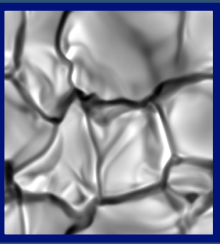
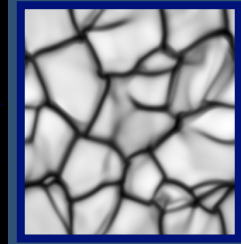
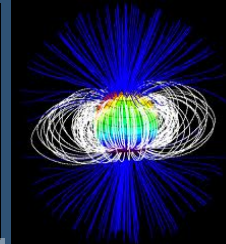
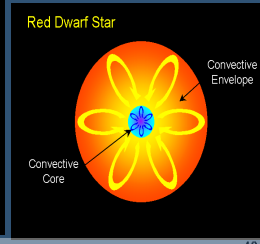
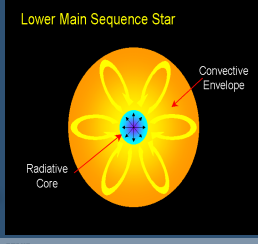
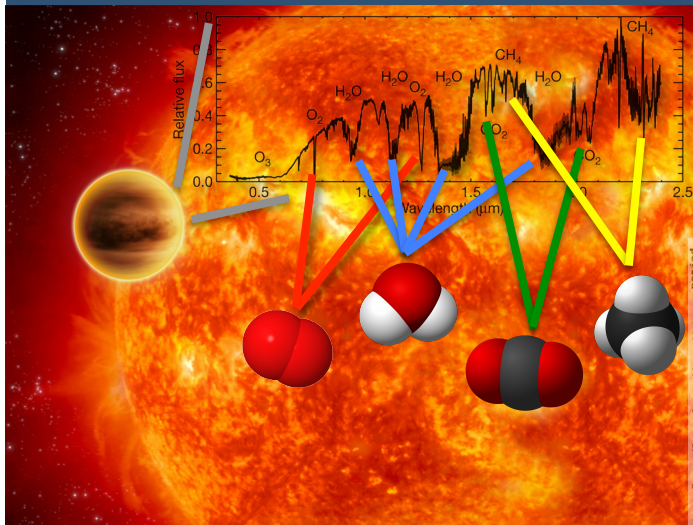
**Italian Science Team** **Chair:** S. Cristiani

in progress...

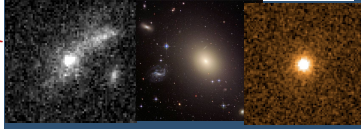
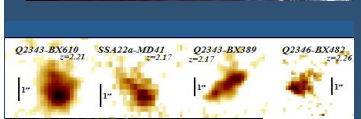
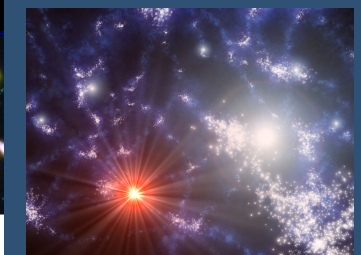
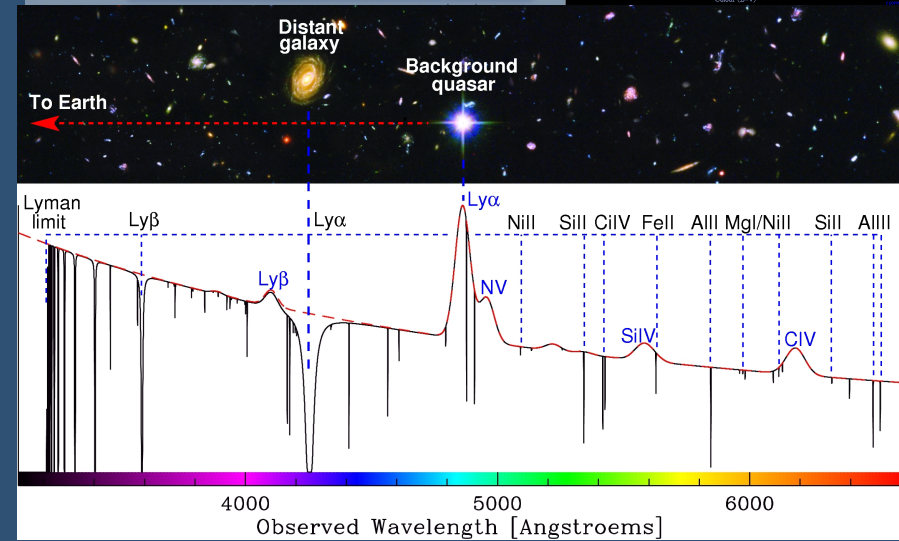
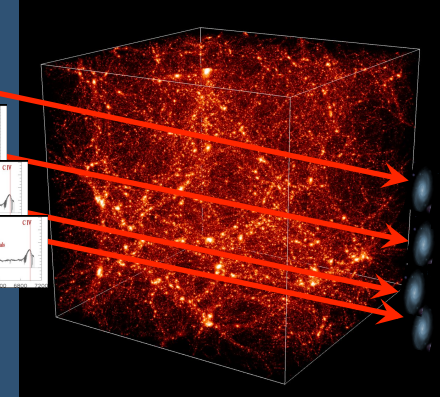
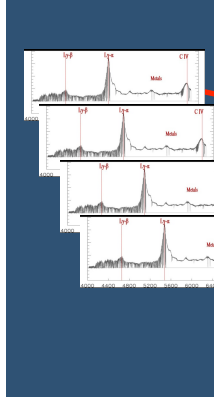
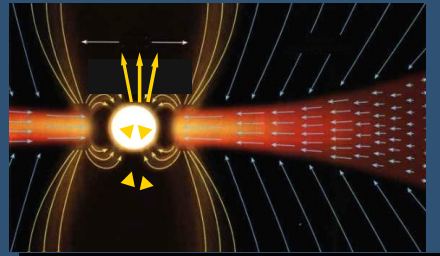
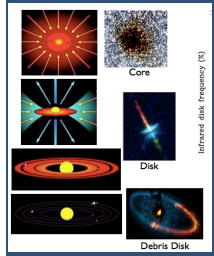
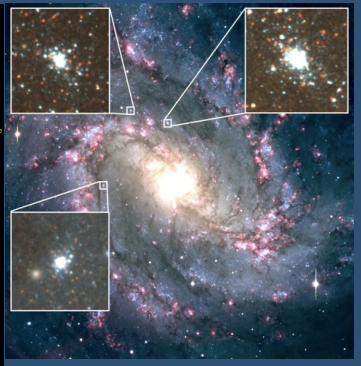
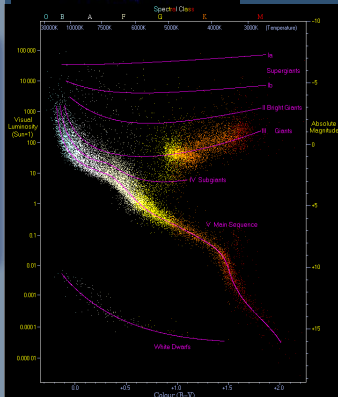




# E-ELT HIRES: science cases



group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
I	IIa	IIb	IIIa	IIIb	IVa	IVb	Va	Vb	VIa	VIb	VIIa	VIIb	VIIIa	VIIIb	IX	X	XI	XII		
1	H	He											B	C	N	O	F	Ne		
2	Li	Be											Al	Si	P	S	Cl	Ar		
3			K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
4			Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
5			Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
6																				
7			Fr	Ra	Ac	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***







# E-ELT HIRES: science cases

HIRES white paper: <http://arxiv.org/abs/1310.316v2>

RfI-Annex 2: Science Case by ESO+PST

- solar system
- exo-planet characterization
- star formation & proto-planetary disks
- stellar physics
- stellar populations & Galactic archaeology
- pristine intergalactic medium & cosmic web
- galaxy evolution
- massive black-holes
- cosmology & fundamental constants
- ...
- the unknown





# E-ELT HIRES: science cases

HIRES white paper: <http://arxiv.org/abs/1310.316v2>

RfI-Annex 2: Science Case by ESO+PST

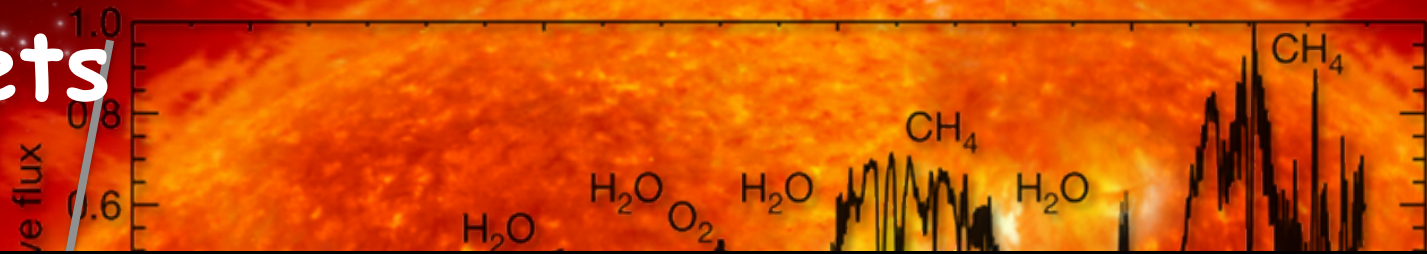
## main Science TLRs (work in progress)

**spectral range:** as blue as practical to K, simultaneous highly desirable for complete line diagnostics & redshift

**observing modes** → **spectral resolution(s) & multiplexing**

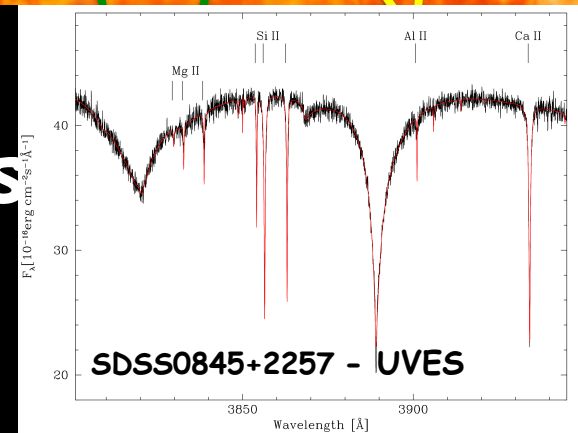
- $R \geq 100k$  single-obj → exo-planets & chemical evol (stars, IGM)
- $R \sim 10k$  +10 obj → stellar pops, galaxy evolution, IGM tomography
- $R \sim 100k$  + IFU/MOS at  $\sim DL$  (IR) → CS disks, dense fields

exo-planets



transit spectroscopy  
characterization of rocky planet atmospheres  
signature of life

metal polluted old white dwarfs  
& planet debris



oxygen

carbon  
dioxide



# stellar physics

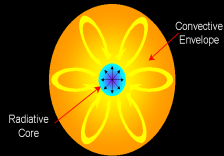
asteroseismology

magnetic fields

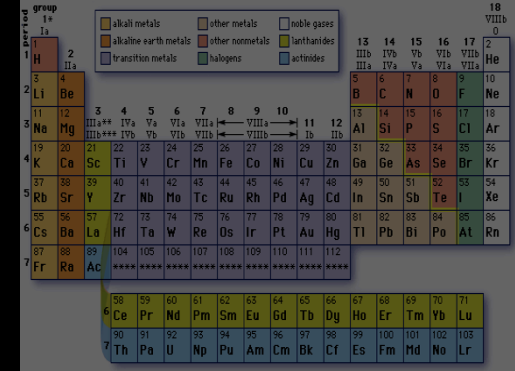
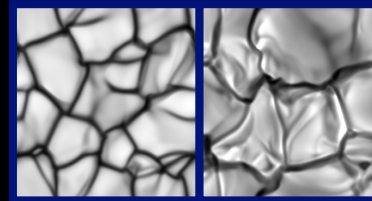
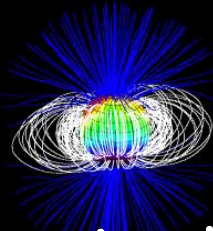
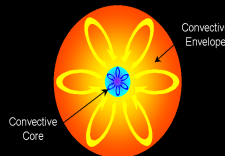
granulation

chemical abundances

Lower Main Sequence Star

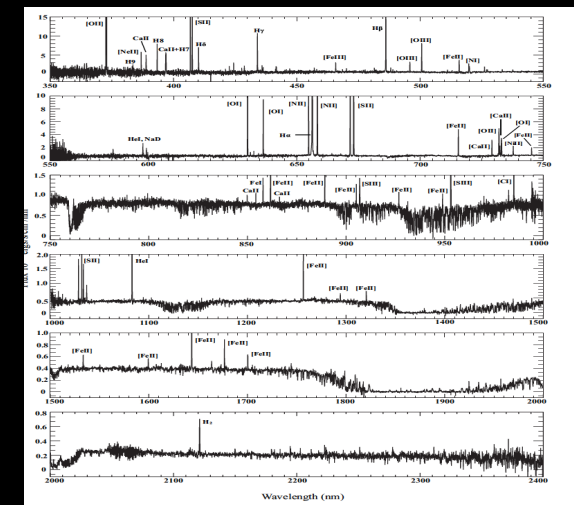
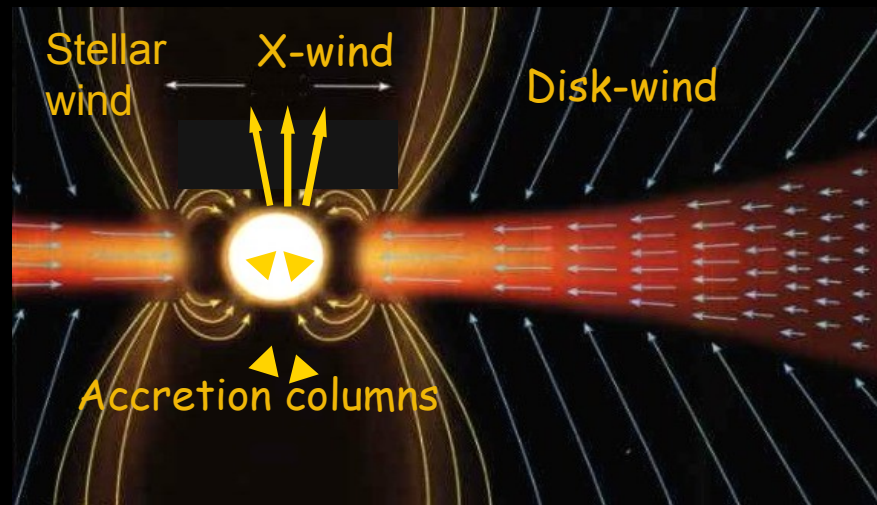
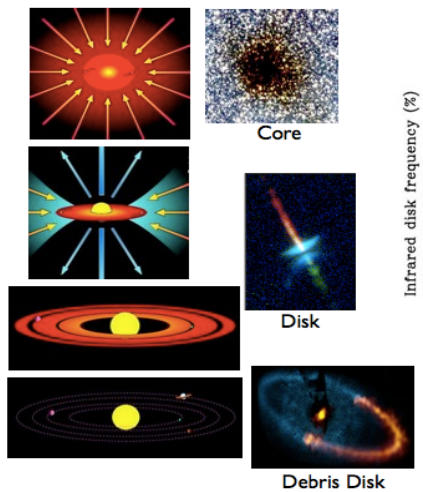


Red Dwarf Star



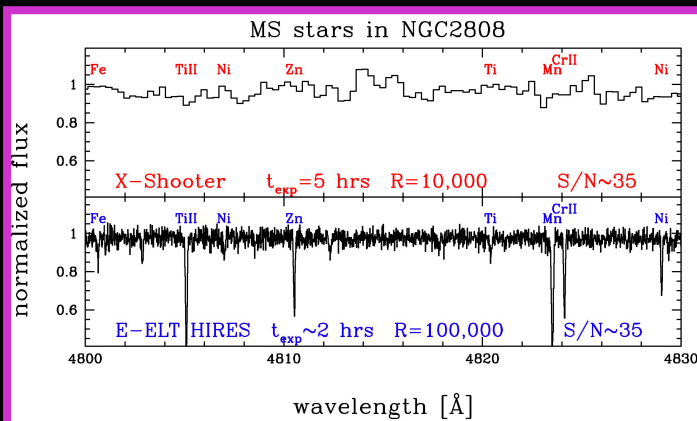
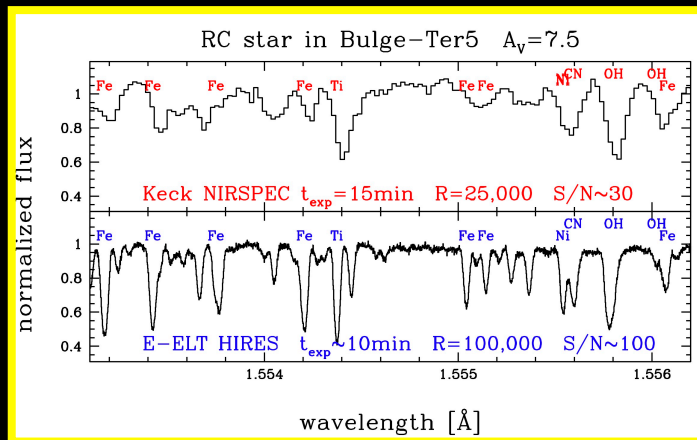
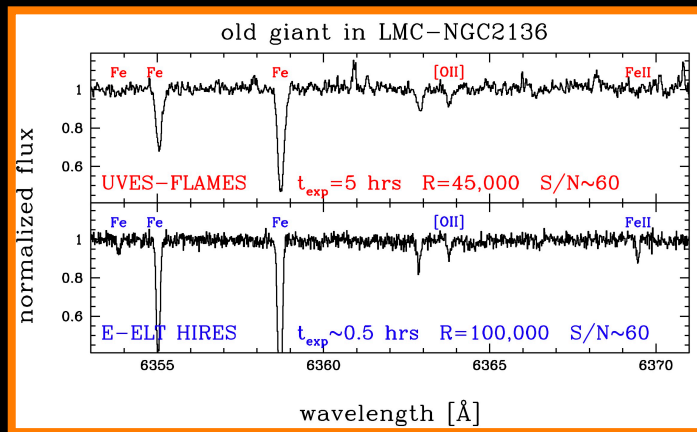
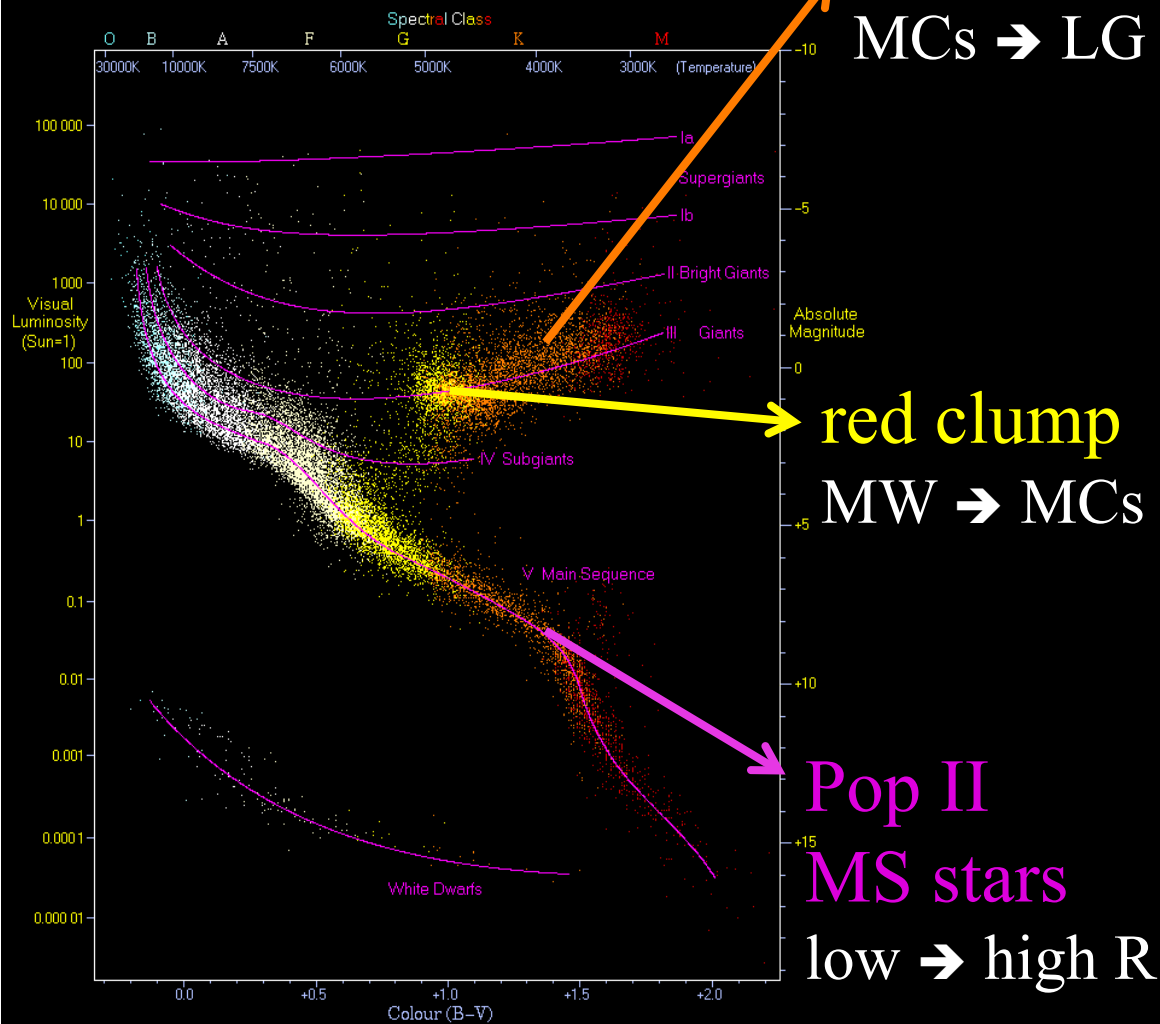
3D structure, asteroseismology, magnetic fields, activity, mixing, diffusion, yields & nucleosynthesis in cool stars and/or in new environments

# star/disk/planet formation



# stellar evolution

8-10m telescopes → EELT-HIRES



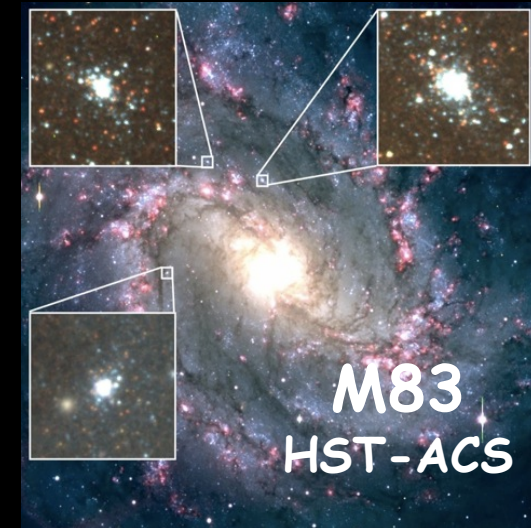
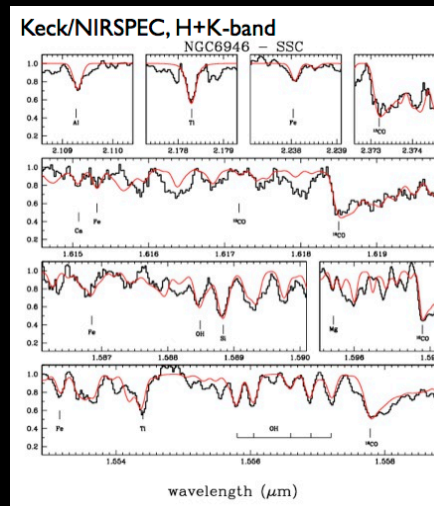
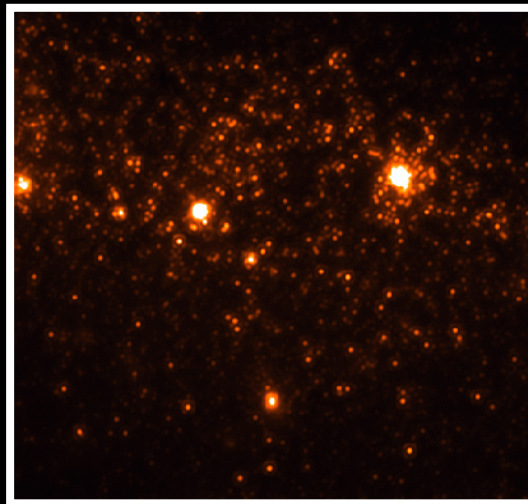
# extra-galactic star clusters

chemistry & dynamical mass from integrated spectroscopy

8-10m → a few Mpc

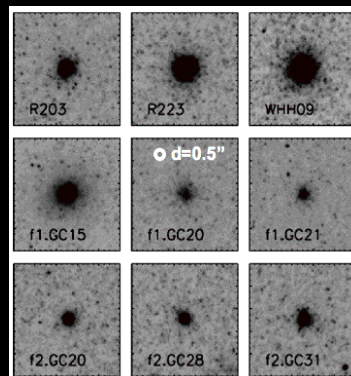
EELT → 20 Mpc

young  
super  
star  
clusters

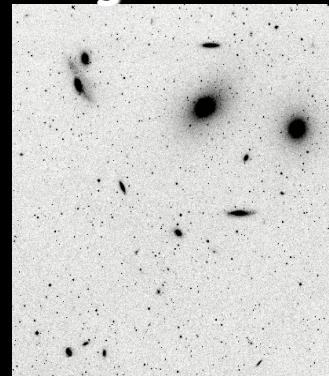


M83  
HST-ACS

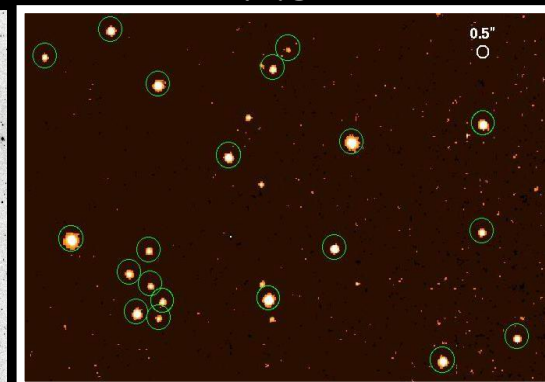
Centaurus



Virgo Cluster



M87

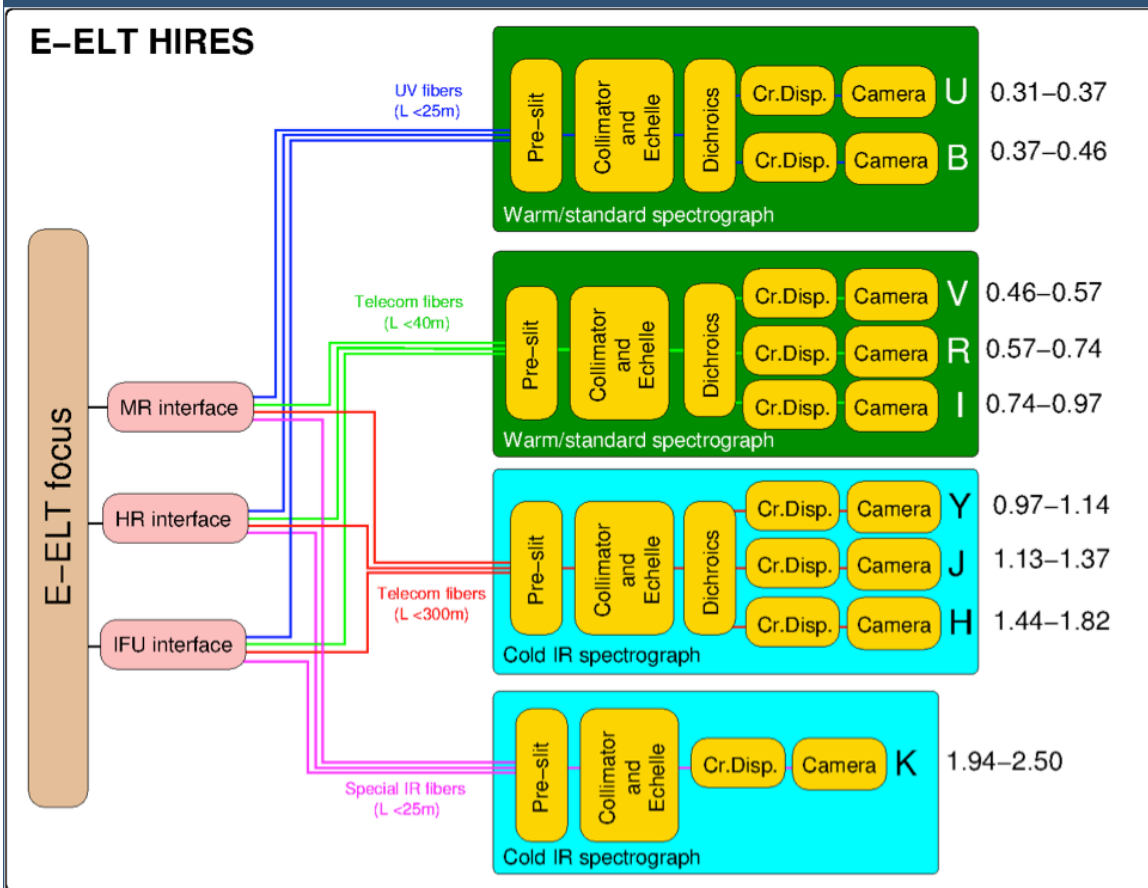


old  
star  
clusters





# E-ELT HIRES: a modular concept



independent **fiber-fed** modules (i.e. spectrometers) optimized over specific spectral ranges (UB, VRIZ, YJH, K or BVRI, ZYJH, K)

different observing modes are obtained using different and independent groups of fibers feeding each spectrometer, no changes inside the spectrometers

modules and observing modes may be added or removed following a trade-off study between scientific priorities & tech/cost constraints