Finding first light objects and study their physical properties with EELT-Dioramas*

**OPTIMOS-slits*

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Physics of galaxy formation

- Need to find first light objects to study them
- Establish their mean properties
- Extract representative sub-populations for detailed studies

DIORAMAS-EELT: a powerful Visible and NIR imaging & multi-slit spectrograph

Physics of galaxy formation and evolution

<u>A several steps process</u>

1. Search for objects: do they exist ? NEED TO FIND THE OBJECTS BEFORE PHYSICS !
2. Estimate the mean properties: N(z), luminosity, gas/stellar masses, SFRD, morphology, clustering, ….
   assemble representative samples w/
   ⟹ secure redshifts
3. Isolate well defined sub-populations for detailed studies, e.g. kinematics
4. Infer a scenario & compare to models / simulations
5. Infer constraints on cosmological model

~~Imaging & slit spectro~~

~~Wide field multi-λ imaging and multi-slit spectroscopy~~

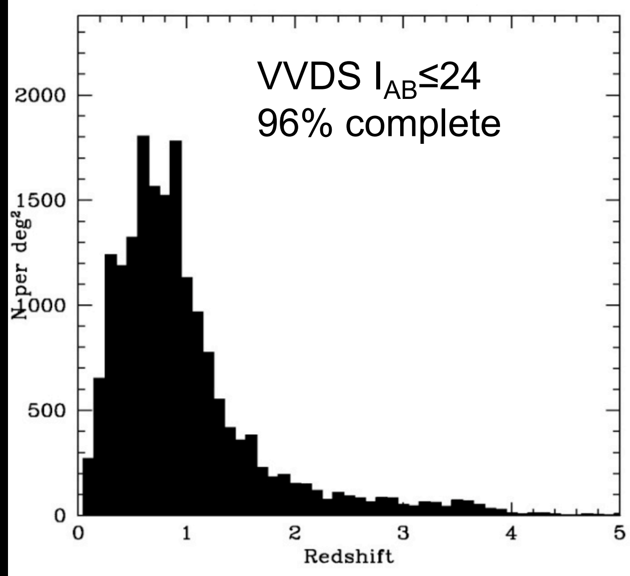
~~3D spectroscopy, HR spectroscopy, sub-mm, …~~

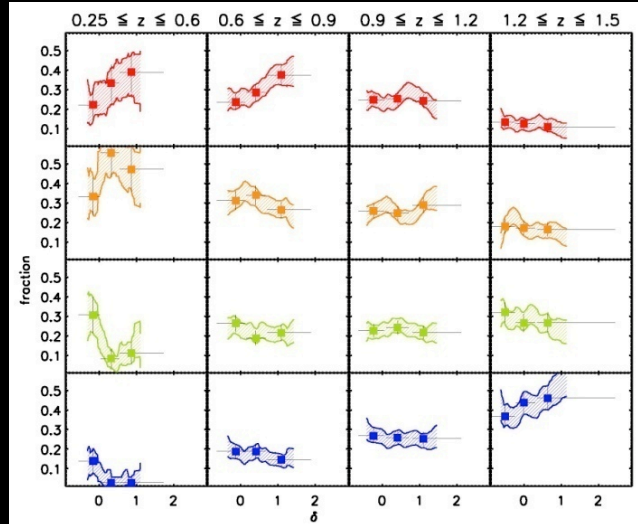
CFRS, LBG, VVDS, zCOSMOS …

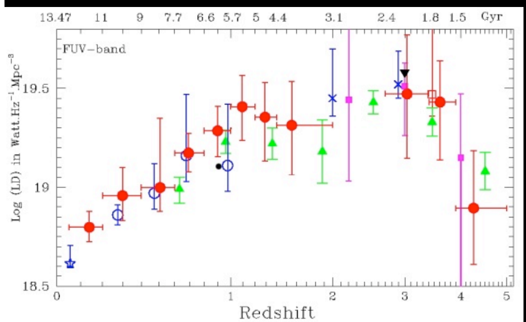
Example of VVDS

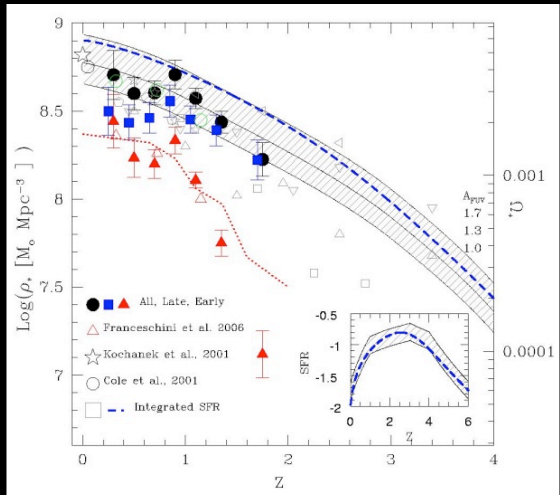
35000 galaxies with $I_{AB} \leq 22.5$, VIMOS
12000 galaxies with $I_{AB} \leq 24$, VIMOS
1000 galaxies with $I_{AB} \leq 24.75$, VIMOS
200 LAE down to 1.5×10^{-18} erg.cm^{-2}.s^{-1}, VIMOS
100 galaxies with SINFONI

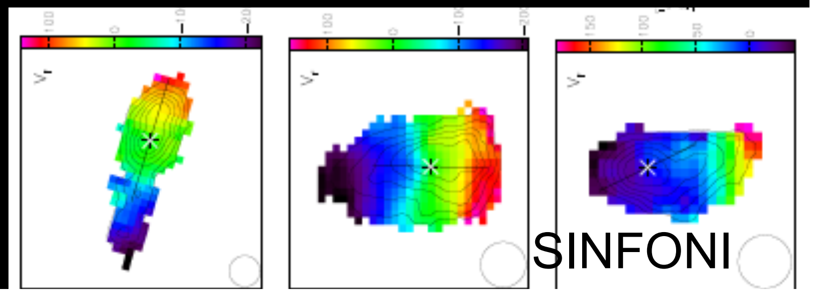
N(z), SFRD, Stellar mass density, color-density, clustering, Dark Energy,…











Finding first light objects z>6

What are we looking for ?

Sure facts

- Very faint objects AB>26.5
- Rare on the plane of the sky
- The IGM will cut their observed flux below Lyα
  - Main signatures: Ly-dropout and Lyα emission

Unsure facts:

- Take predictions with caution (see historical perspective)

Expect the unexpected…

⇒ Keep a large parameter space for instruments

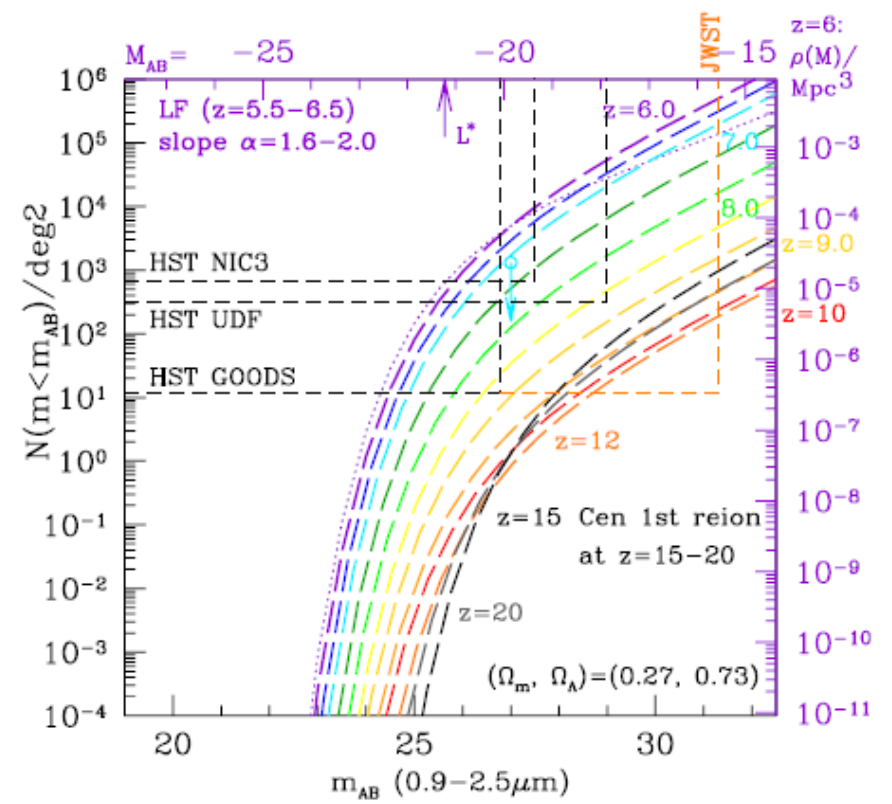
Some properties of real objects to z~6-7

Object type	Flux	Projected density	Size	UV morphology
LBG	AB~27-28	~1-10 LBG/arcmin²/dz	1-2 kpc	Compact / blobby
LAE	10^{-18} ergs/cm²/s	~1 LAE/arcmin²/dz	<5 kpc	Compact
	10^{-17} ergs/cm²/s	<0.2 LAE/arcmin²/dz	<10 kpc	Large blobs

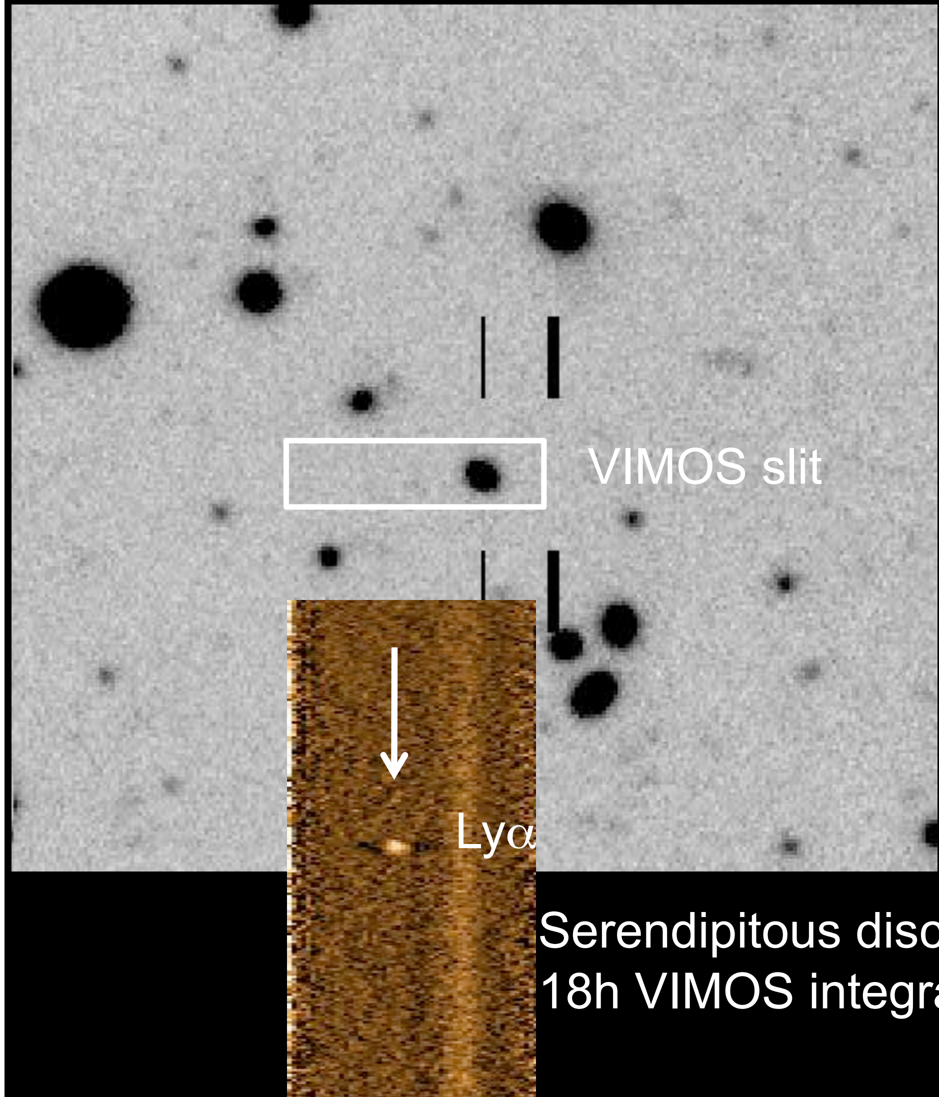
- Small <0.5 arcsec with a few (rare) bigger

- A few per arcmin²
Need area
Depth is not enough

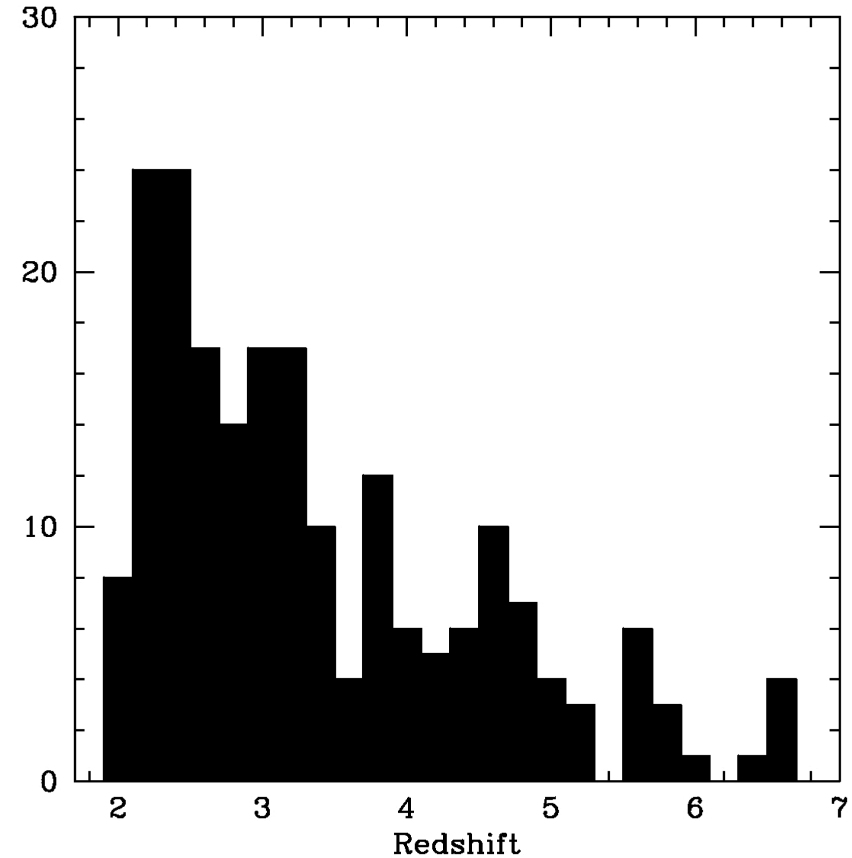
Oesch et al., 2009
Windhorst et al., 2005



Discovery of ~200 Lyα emitters 2<z<6.6

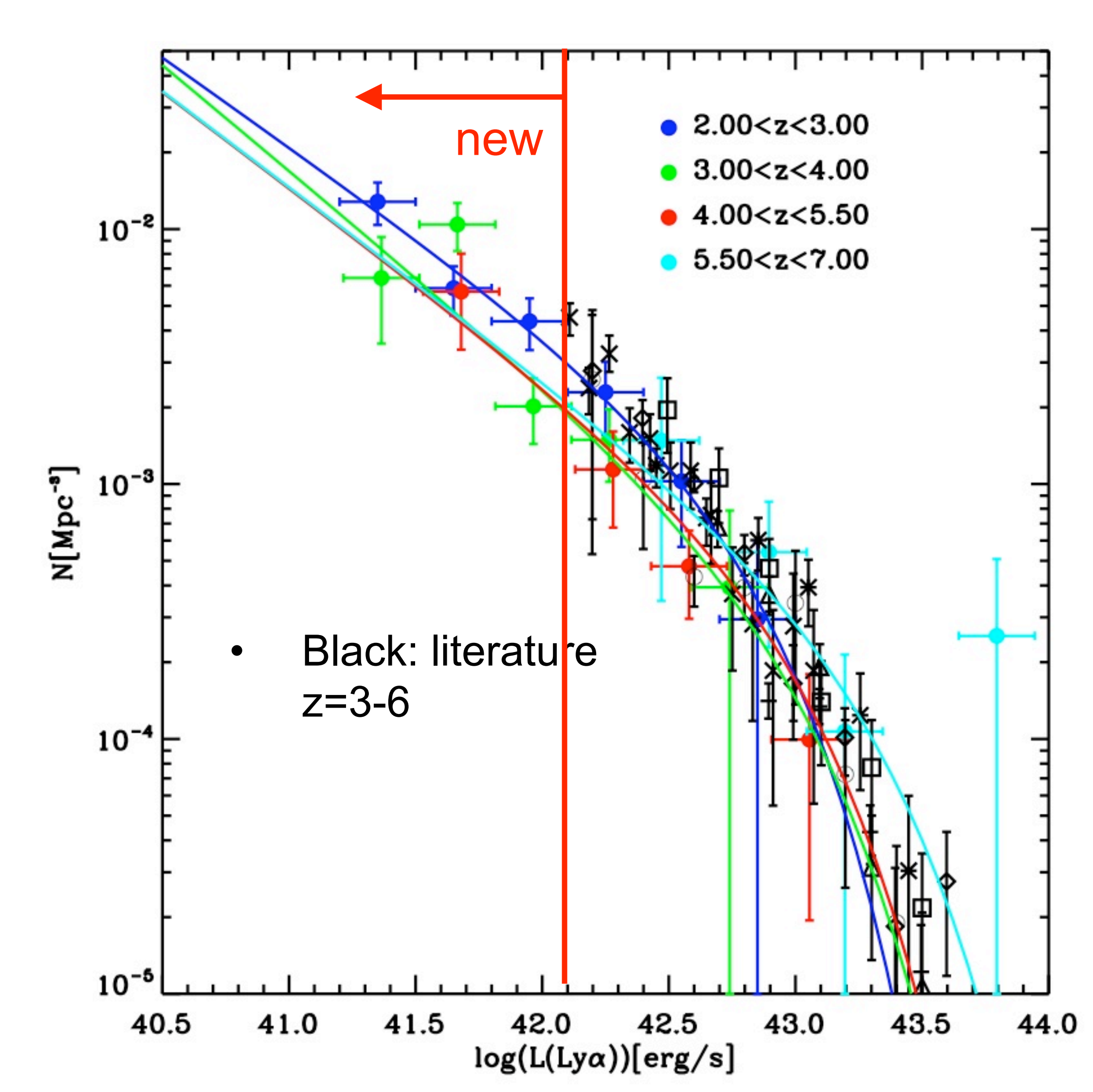


Serendipitous discovery:
18h VIMOS integrations



Cassata et al., 2010

LAE Luminosity function



we reach log(lum)=41erg/s

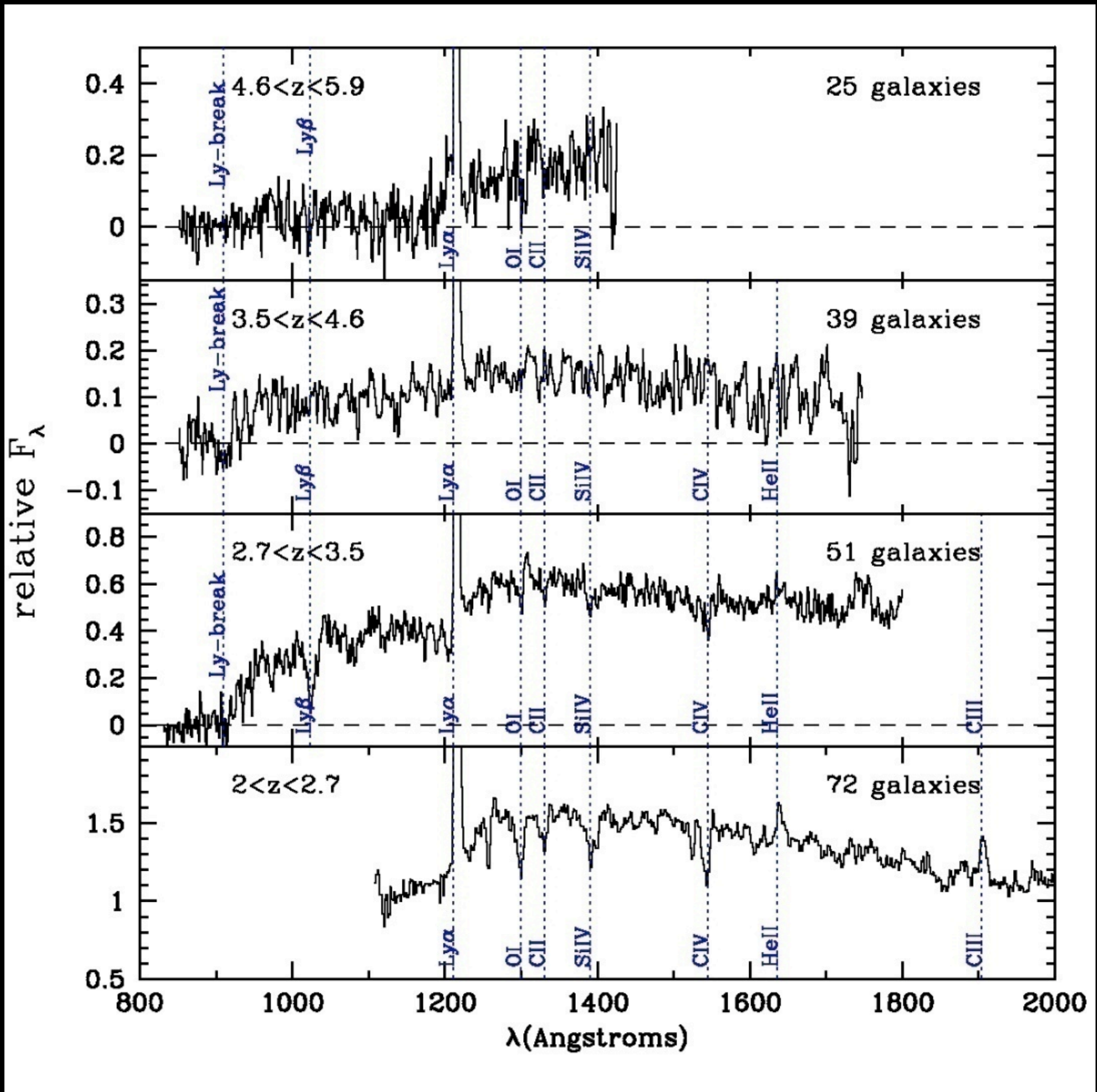
we can constrain the faint-end slope

α=1.75

Lots of faint small LAE to be found

Can be observed with EELT in ~1h

Combined spectra Lyα emitters



Lyα Flux:
$\sim 1.5 \times 10^{-18}$ erg.cm^{-2}.s^{-1}

450h of VLT	18h of EELT or JWST
700h	26h
920h	24h
1300h	48h

Finding first light objects z>6

Test case: obtain a sample of 100 z>6-7 galaxies, to z~10

- Need AB~30 ugrizYJH imaging of ~100 $arcmin^2$
- Need narrow band imaging
- Need spectroscopic redshift measurement

In parallel: get z<6-7 galaxies from deep multi-wavelength imaging, observations combined with above:

- photometric redshift selection
- multi-slit observations to get key spectroscopic features for physical properties

DIORAMAS

Wide field imaging & multi-slit spectrograph for the EELT

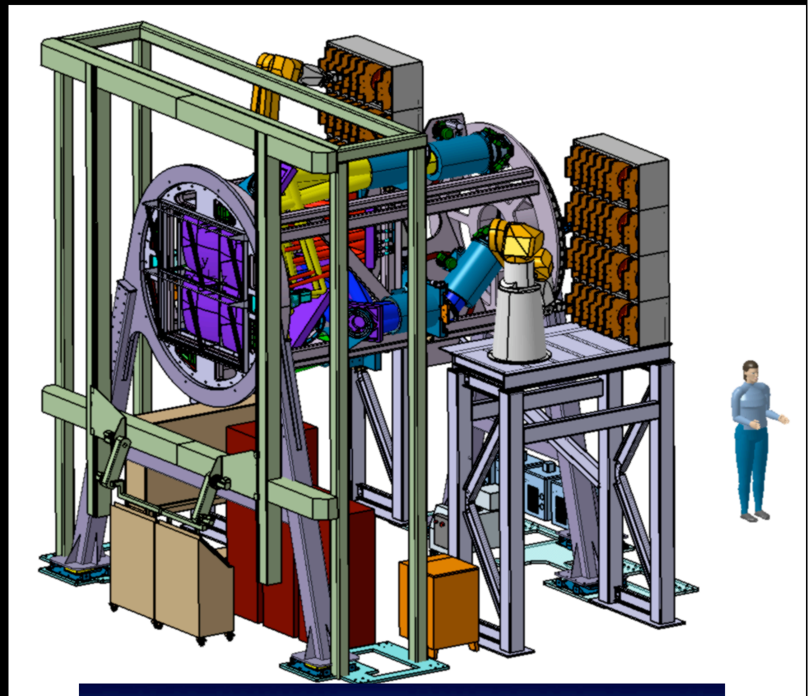
- Imaging spectrographs are the work-horses of major observatories (LRIS, GMOS, FORS, DEIMOS, VIMOS, IMACS,…)
- One single instrument for the deepest images and the deepest spectra possible with an ELT
  - Independent facility, which can supply its own targets
- Multi-slit for the most accurate sky subtraction for faint objects
- Capability to work with GLAO-corrected images
- Optional capability: Integral field unit

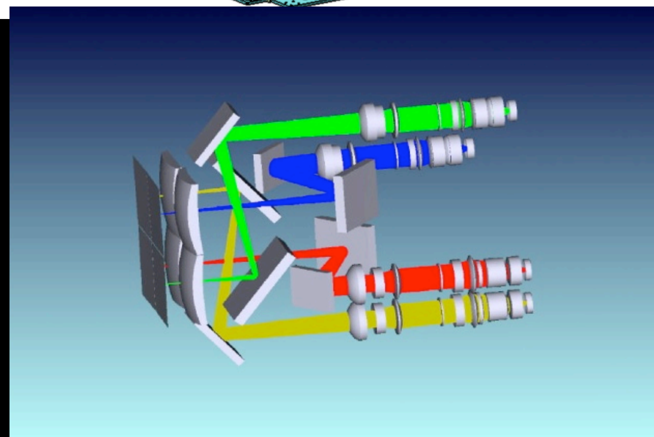
DIORAMAS @ EELT = FORS+VIMOS+HAWKI+KMOS @ VLT

A powerful imaging-MOS which can also do surveys

Innovative and robust concept

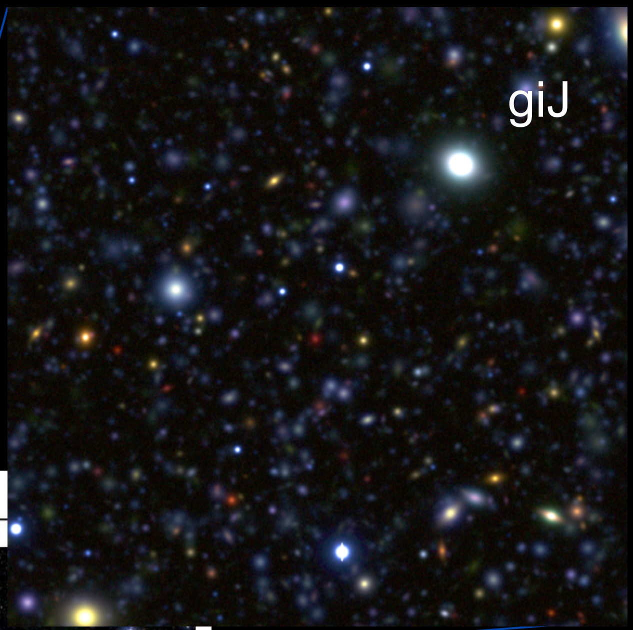
- Wide field up to 44 arcmin², use seeing limited or GLAO-corrected images, 0.05 arcsec/pix
  - 2 Visible and 2 NIR quadrants, with 0.6-1μm overlap
- Imaging and MOS (slits) from 0.37 to 1.6 μm
  - IFU possible
- Superb optical design and compact mechanical layout
- Opto-mechanical systems using industry standards, no R&D required
- Low risk

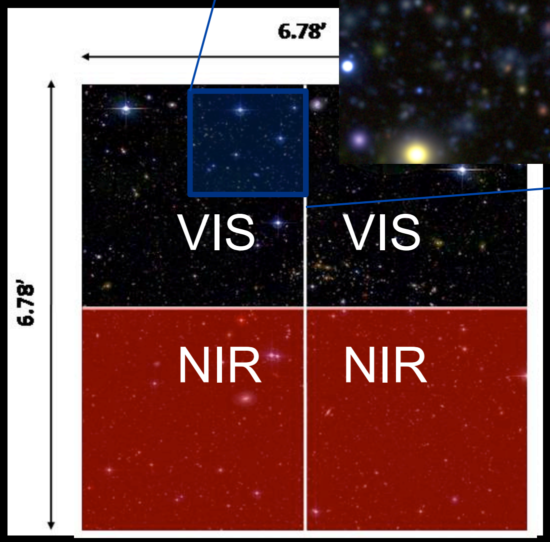




Wide field, multi-mode

Imaging

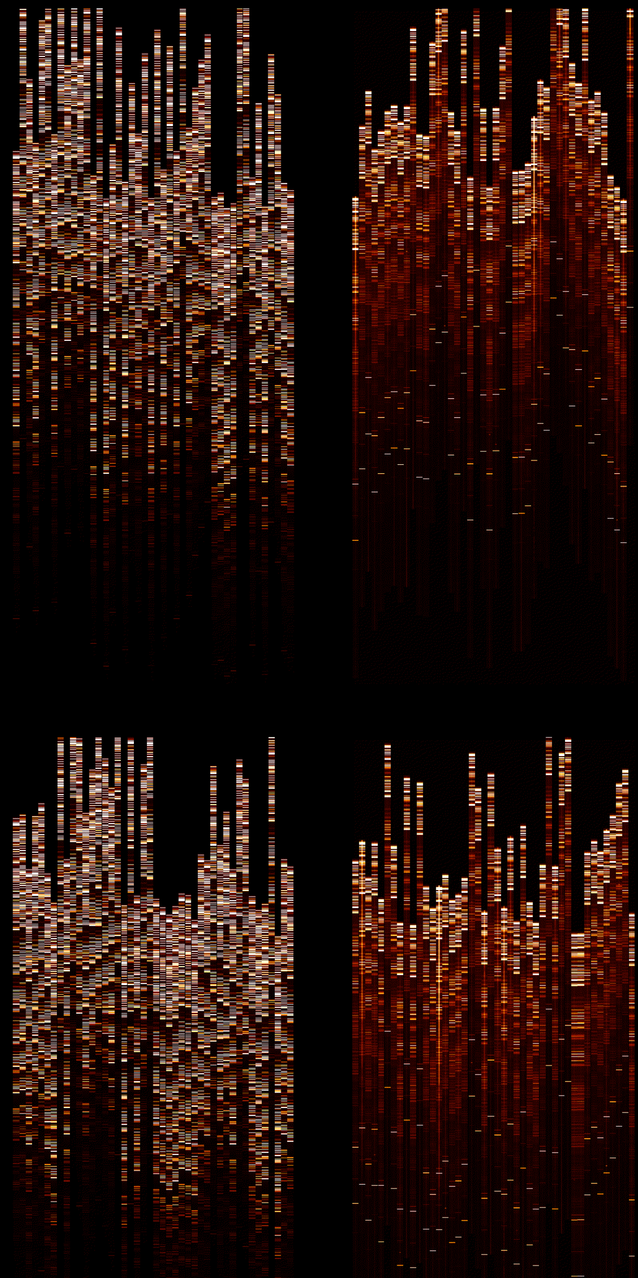




>30,000 sources in 7'x7' to r_{AB}=29.8

JWST-NIRCAM

JWST-NIRSPEC



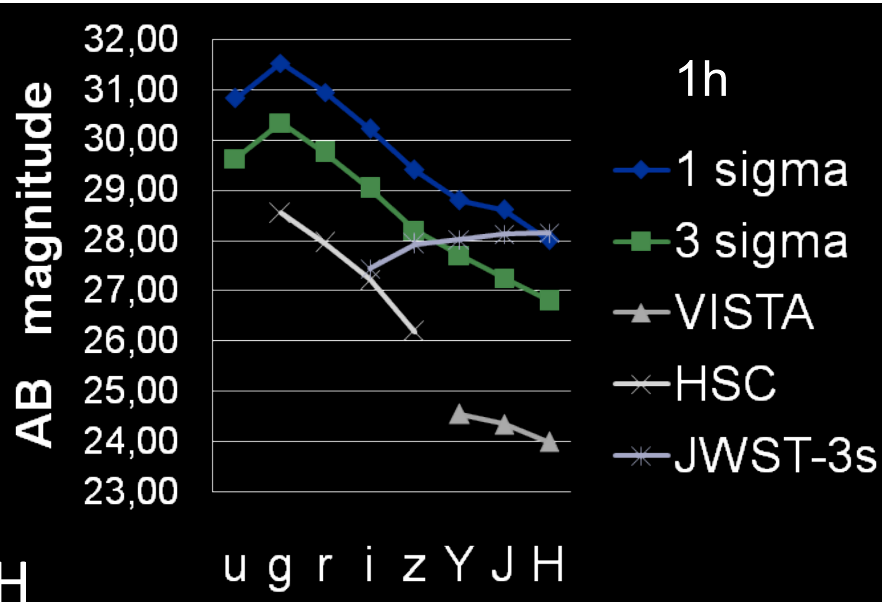
Multi-slit R~300, 480 slits

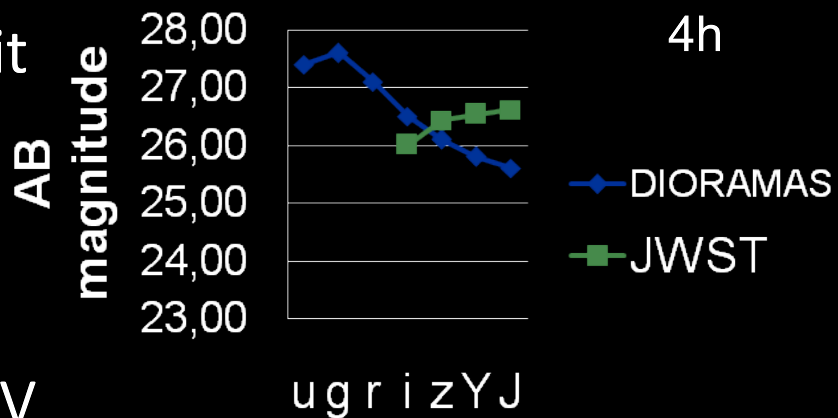
Multi-slit R~3000, 160 slits

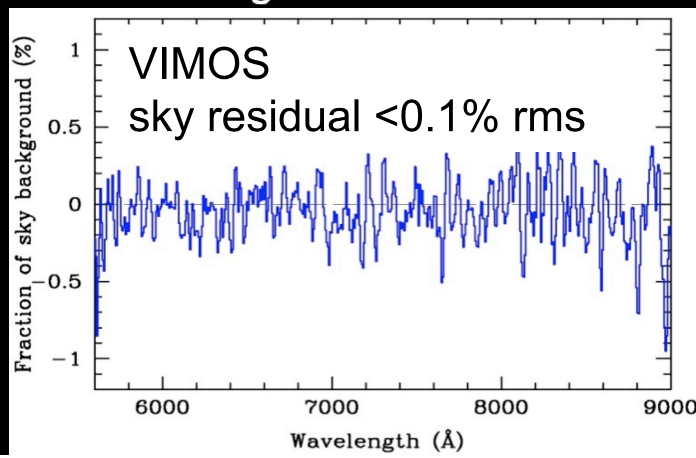
High level of performances

- Excellent image quality and high throughput (~70%)
- Extremely deep imaging from u' to H
- High multiplex: 160 slits in HR, 480 slit in LR, 0.37 to 1.6µm
- Limiting magnitude (4h): AB~29 in imaging, AB~26.5 in MOS
- GLAO: from 0.7 to 0.4 arcsec over FOV

Gain @1µm compared to JWST-NIRSPEC: x5 multiplex, x2.5-5 the FOV, at equivalent depth/unit time



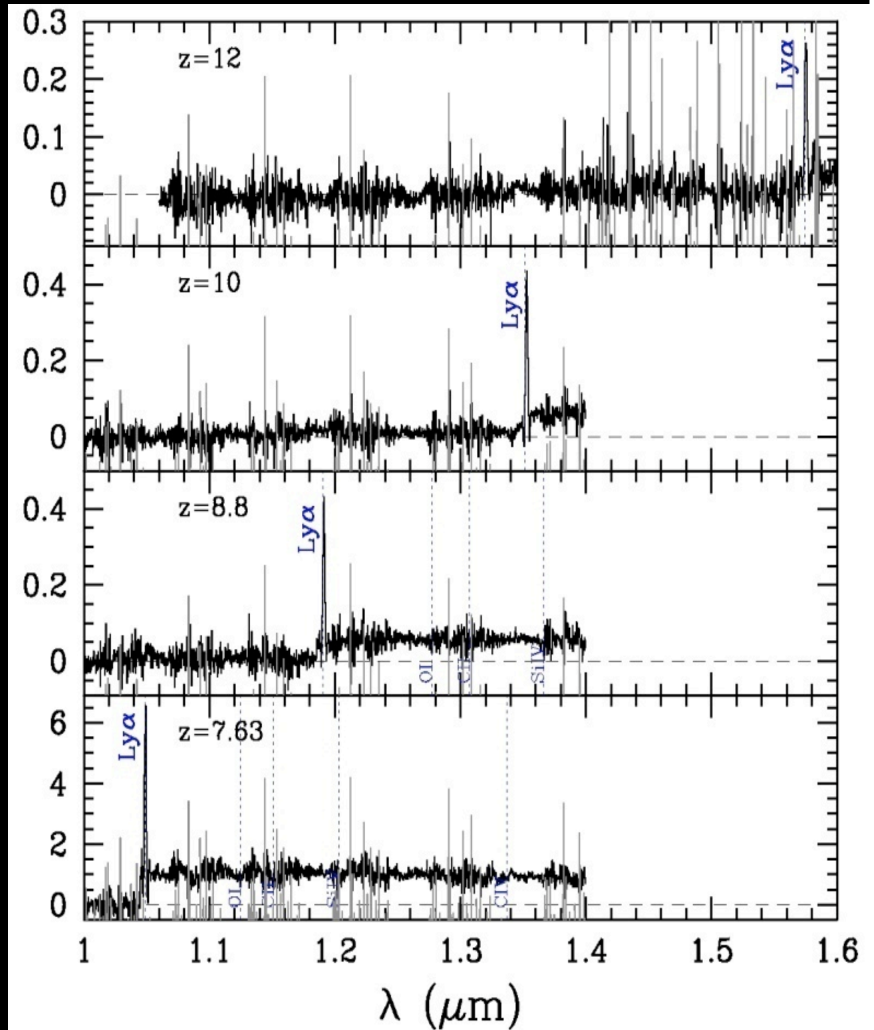




Example of a 'first light' science program with DIORAMAS

Combine first light study of ~100 galaxies z>7 with galaxy assembly 1<z<6 on 10000 galaxies

- 88 arcmin², 2 DIORAMAS pointings
- ugrizYJH GLAO imaging, AB~30, 20h per pointing: 40h
- NB imaging z~8.8: 2x5h
- R~300 GLAO MOS, AB~27.5, 10x2h masks per pointing: 40h
- IFU (optional), 4 gal per pointing, 25 pointings, 100h



Summary

- Avoid blindness to see the light: science requires deep & wide field imaging capabilities on the EELT
- The study of galaxy formation and evolution requires wide field MOS-slits, up to 1.6μm
- DIORAMAS@EELT offers high performance imaging and multi-slit spectro: A powerful first light instrument