Observing the distant Universe with the Integral Field Unit of NIRSpec

Santiago Arribas
for the NIRSpec Team
(NIRSpec Instrument Science Team, ESA Science Operation Team)

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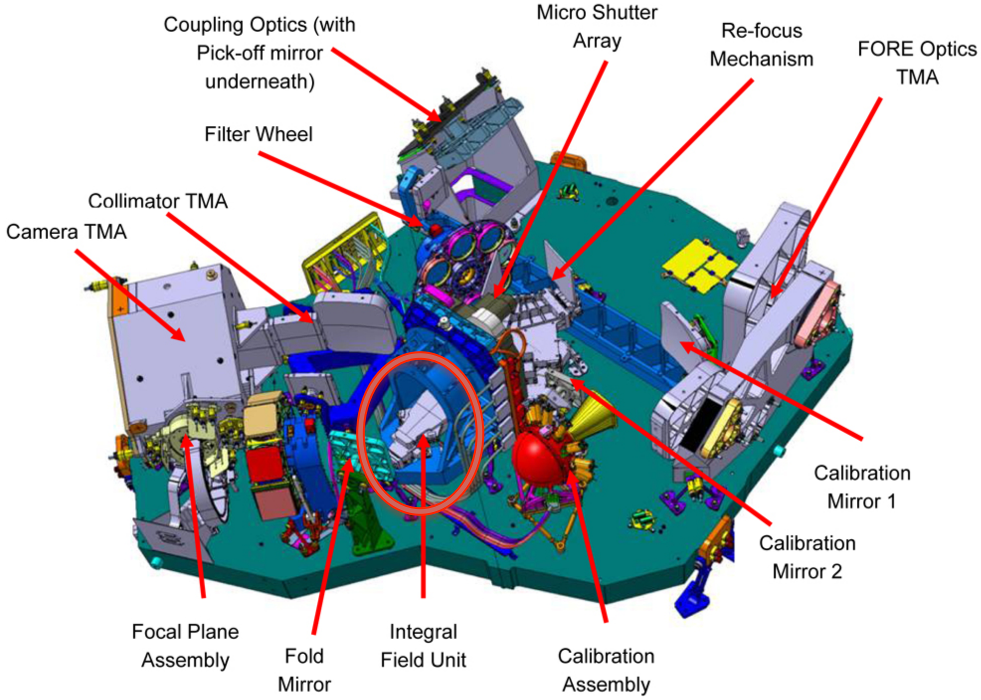
NIRSpec team	
C. Alves de Oliveira [ESA SOT]	G. Giardino [ESA SOT]
S. Arribas [IST]	P. Jakobsen [GTO team]
T. Beck [IST]	R. Maiolino [IST]
S. Birkmann [ESA SOT]	H. Moseley [IST]
T. Böker [ESA SOT]	B. Rauscher [IST]
A. Bunker [IST]	H.-W. Rix [IST]
S. Charlot [IST]	M. Sirianni [ESA SOT]
G. De Marchi [GTO team]	J. Valenti [GTO team]
B. Dorner [GTO team]	C. Willott [IST]
P. Ferruit (project scientist)	
M. Franx [IST]	

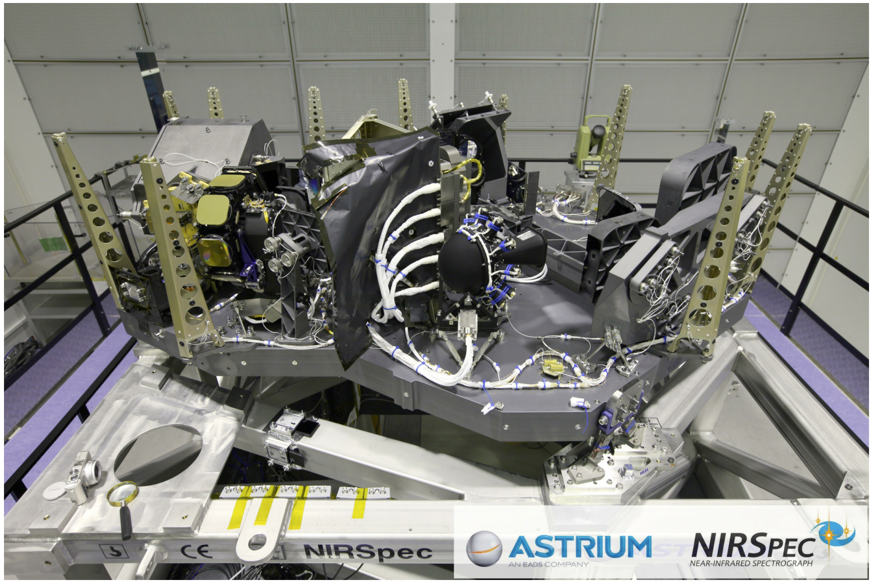
Outline

- Main characteristics NIRSpec Integral Field Unit
- Science potential @ high-z
- Goals of the GTO IFU program @ high-z
- Expected performance

NIRSpec

Developed by ESA with AIRBUS as the main contractor
NASA provided the detectors and micro-shutter arrays

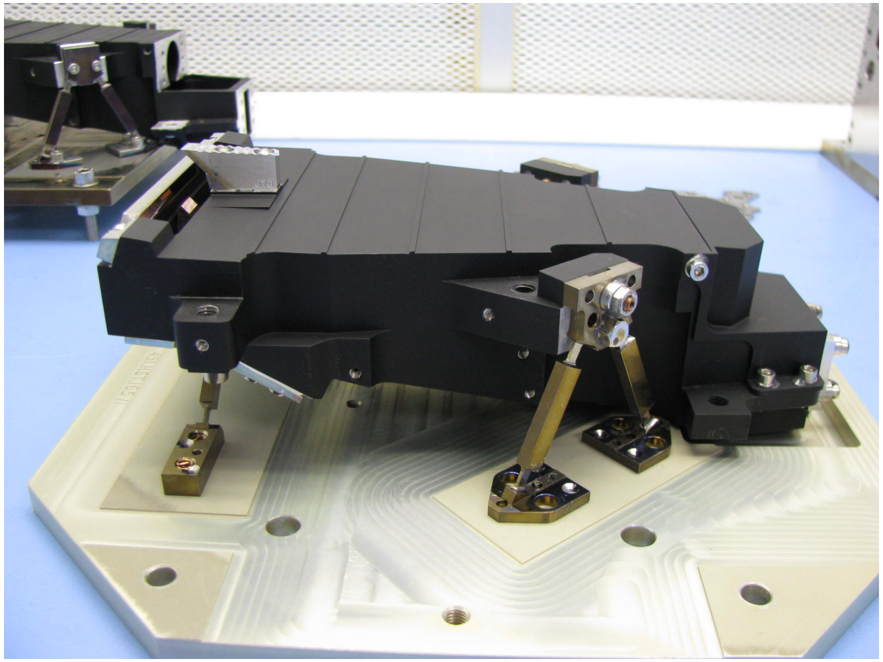


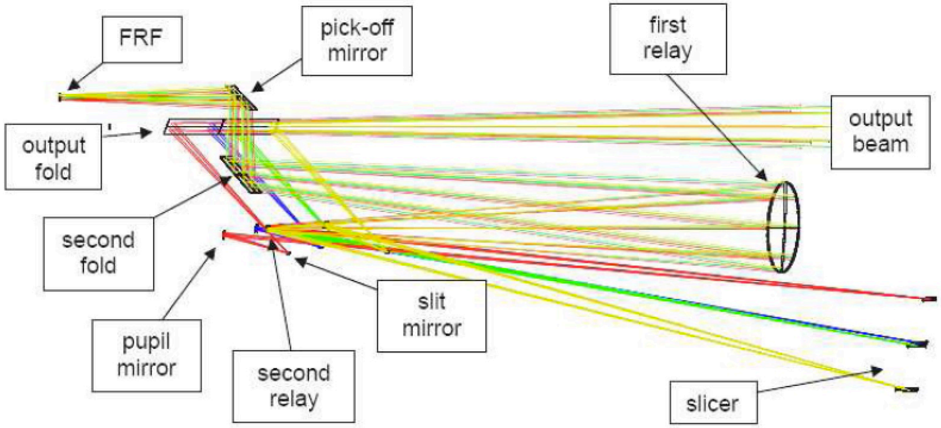


Modes of observation :

- MOS: Multi-Object Spectroscopy
- IFS: Integral Field Spectroscopy
- Slit Spectroscopy

NIRSpec Integral Field Unit





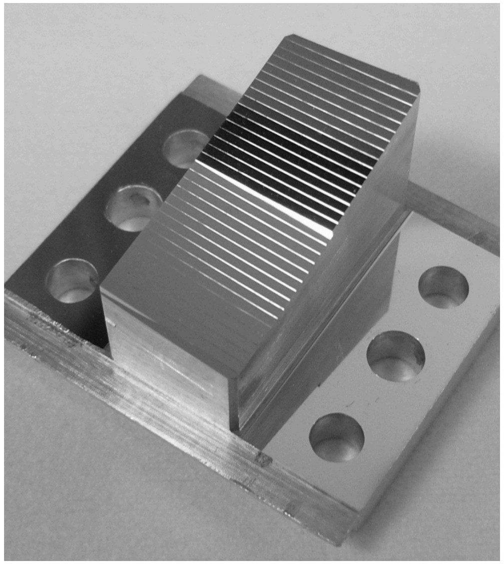


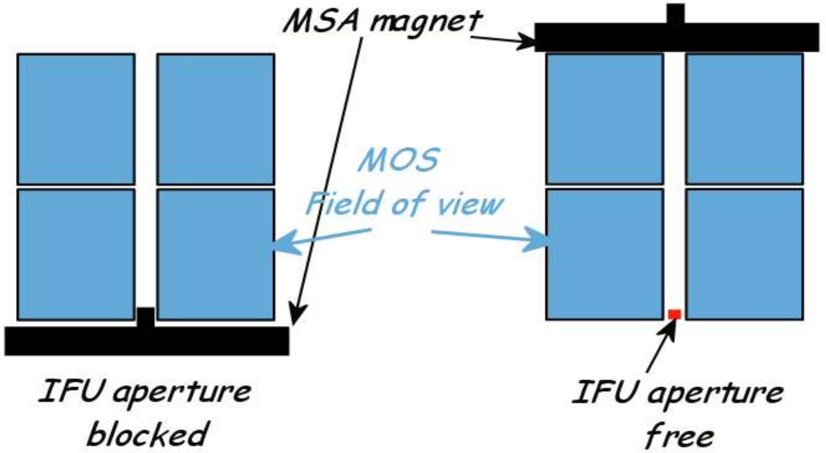
Image Slicer

- 30 mirror facets (0.8mm x 12mm)
- Unique curvature and tilt to generate a pseudo-slit at the input focal plane

The IFU of NIRSpec

- FOV: 3” x 3”
- Sampling: 0.1”
- 900 spaxels
- Can make use of all NIRSpec spectral configurations
  - R=100 from 0.6 to 5.3 µm
  - R=1000 and 2700 from 1.0 to 5.3 µm in 3 bands
- Entirely passive device (no moving parts)

  Shuttered by MSA magnet mechanism
- Point and shoot operations

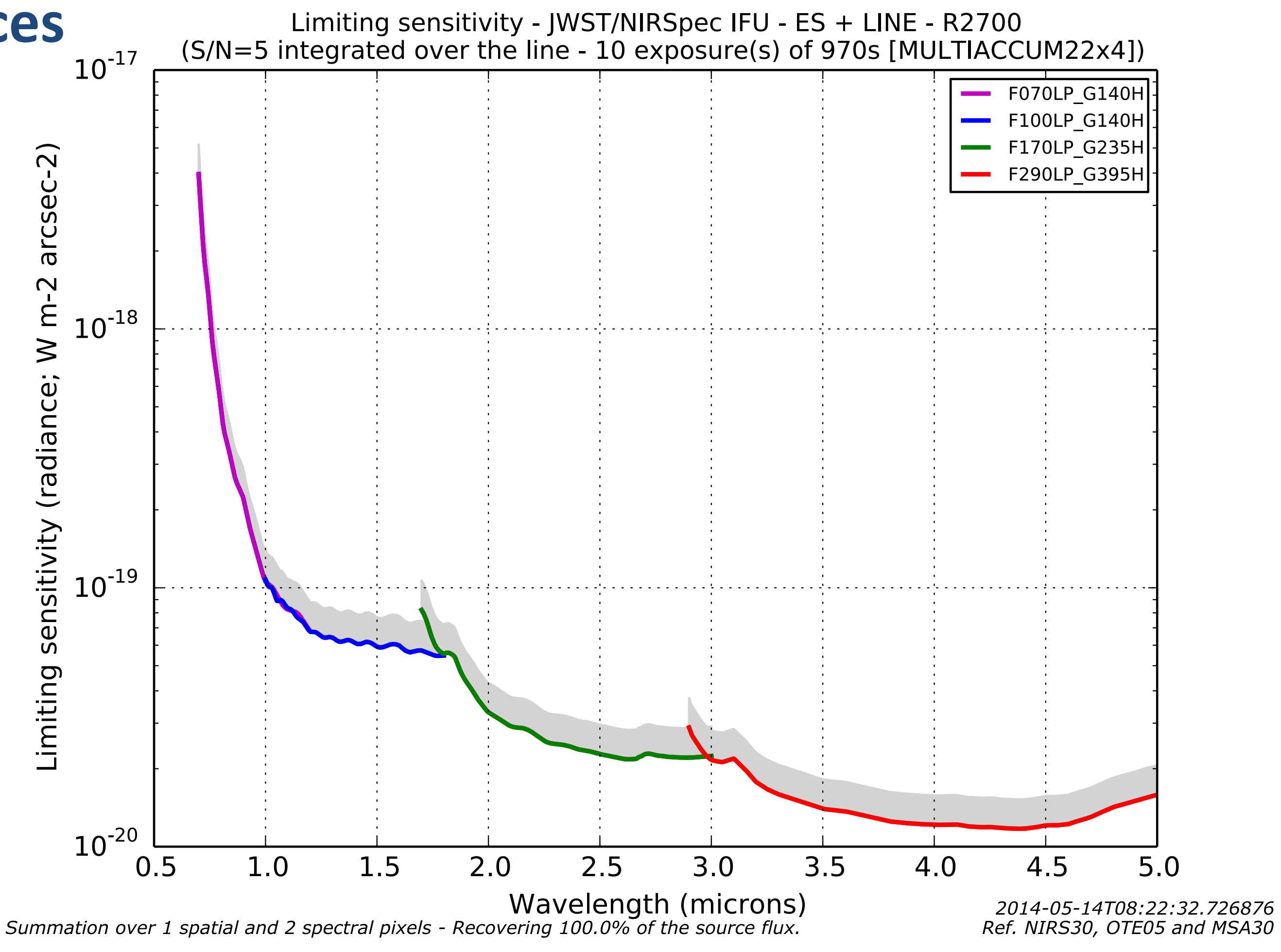


Expected Sensitivities of the NIRSpec IFU

Emission line
Extended sources

10^4 sec, S/N=5

P. Ferruit



NIRSpec –IFU @ high-z

- FOV: 3” x 3” => ~ 20 x 20 kpc^2 @ z=5
- Scale: 0.1” / spaxel => ~ 640 pc/spx @ z=5
- Δλ: 0.6-5.3mu => Hα out to z=7
  Hβ out to z=9.7

- (R: 2700 => ~ Δ V = 100 km/s)

NIRSpec – IFU at high-z

- IFU data will allow us to characterize the internal physical and kinematical structure of high-z galaxies

- IFU data (for modest samples) are highly complementary to large spectroscopic surveys based on the MSA, which will provide the integrated spectra for large samples

- We expect that the IFU will be used for follow up observations of the MSA, and of other JWST instruments

Galaxy Assembly and Early Universe NIRSpec GTO program

- MSA wedding cake survey R100, R1000 (500h)
  - Deep, 20-40 sq arcmin, 1-5µm, 45% of the time, AB=29-30, $2<z<14$
  - Medium, 100-200 sq arcmin, 1-5µm, 45% of the time, AB=27-28, $2<z<14$
  - Shallow, >400 sq arcmin, 2-5µm, 10% of the time, AB=25-26, 7000+ spectra, $2<z<4$ ($4<z<14$)

See talks by A. Bunker , and M. Franx

- IFU spectroscopy of extended objects R2700 (300h)

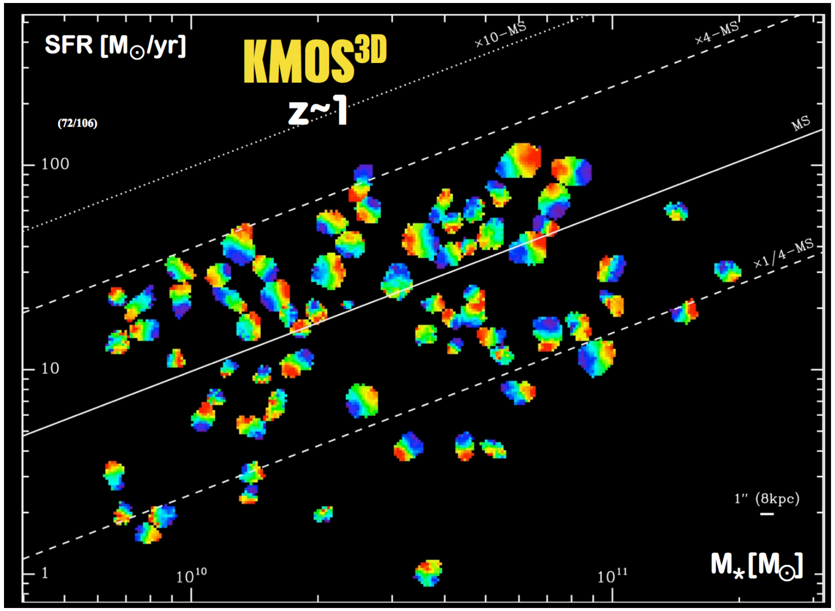
Overall Objectives of IFU GTO program @ high-z

- **Galaxy Assembly: (2.5 < z < 5+)**
  - NIRSpec/IFU will extend to higher z the IFU work done so far from the ground out to 2.5
  - Hα not accessible from the ground for z> 2.5
  - Based on representative and homogeneous samples
- **Early Universe: z> 5**
  - To characterize the most luminous and extended objects (e.g. SMGs, QSOs, HyLIRGs, LAEs)
  - Likely more heterogeneous samples

(Priorities, targets under discussion within the IST)

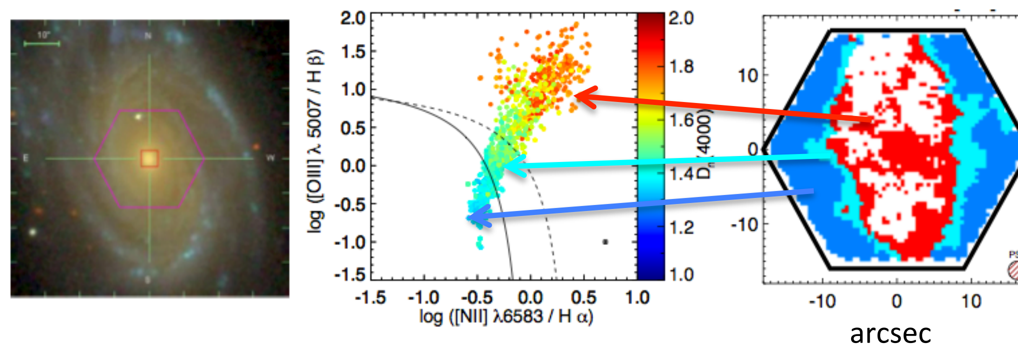
Galaxy assembly: Some of the science cases

Mapping dynamics and kinematics
for different classes of galaxies (in and out of the "main sequence", out to z~5)



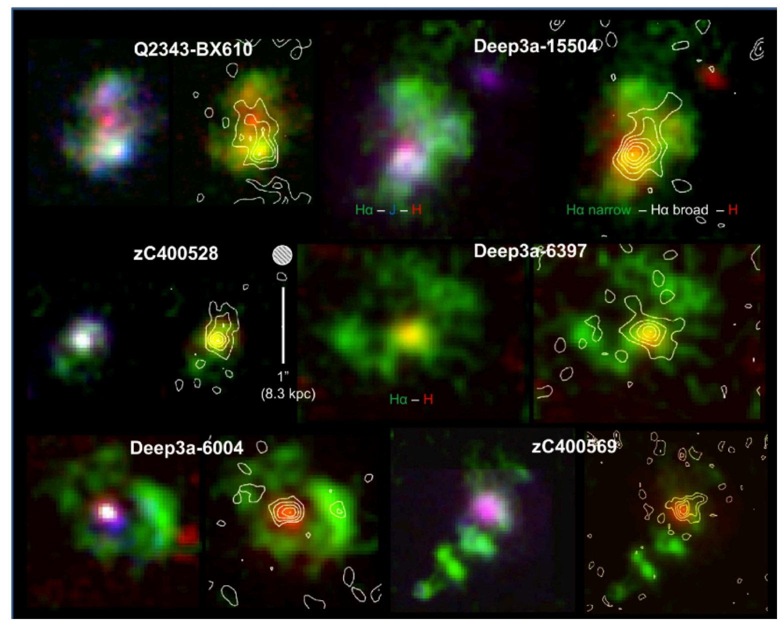
Wisnioski+15

Mapping stellar populations
and BPT diagnostics out to z~5



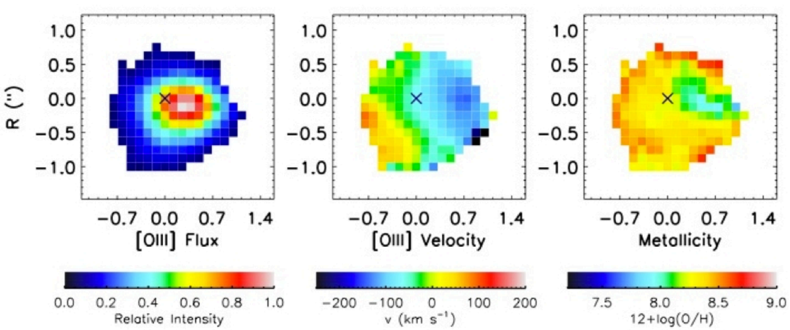
Belfiore+14 (local)

SF distribution and outflow properties out to z~5



Forster-Scheiber+14 (SINS z~2)

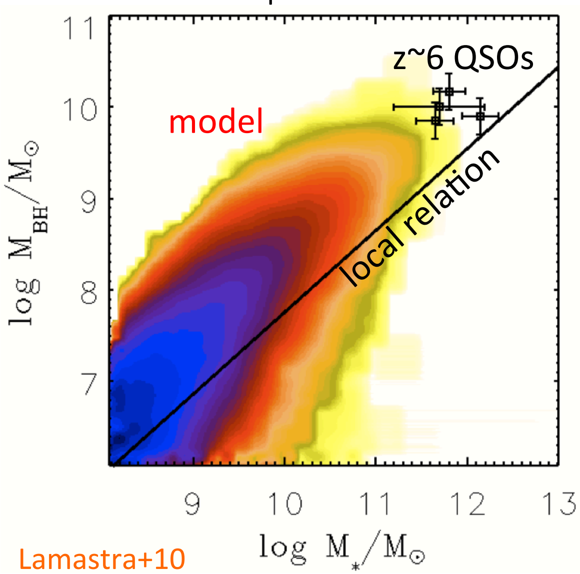
Evolution of metallicity gradients from z=2.5 to z~5



Cresci+10
(AMAZE, z~3)

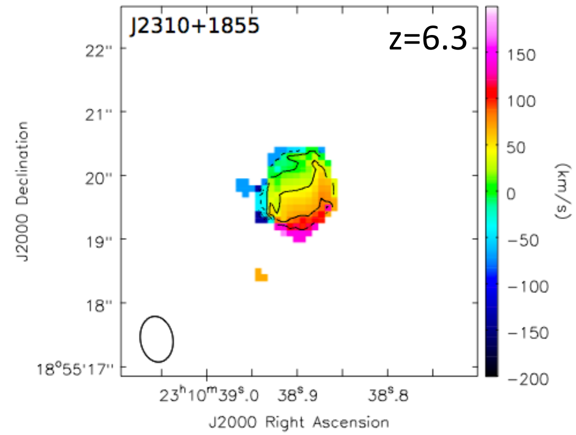
Early Universe: Some of the science cases

Evolution of the M_{BH*}-M_{sph} relation



Lamastra+10

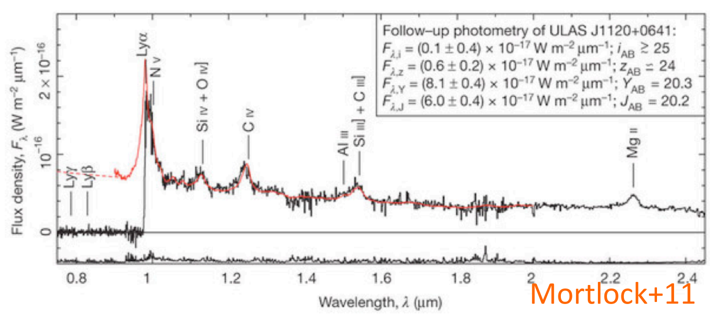
Dynamical and stellar masses of z~6-7 galaxies



Wang+13

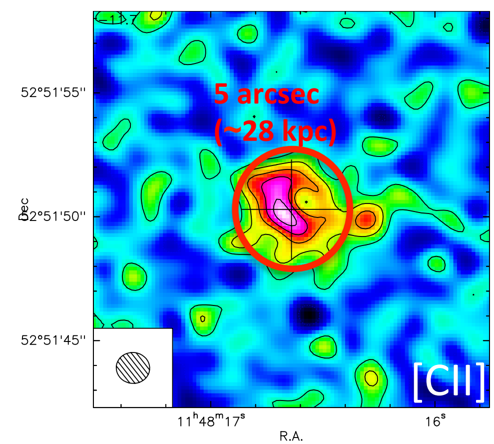
ALMA Cycle 0 @ 0.7′′

Mapping the early chemical enrichment and stellar population in primordial SMGs and quasar hosts



Mortlock+11

Extended gas in the halo at z>6



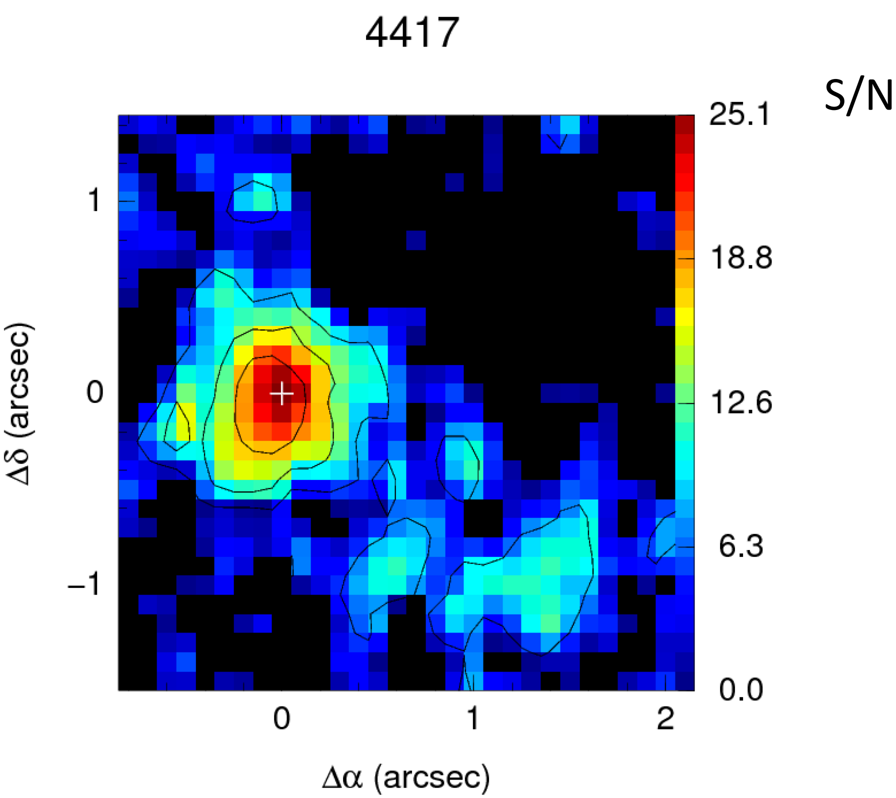
Cicone+15

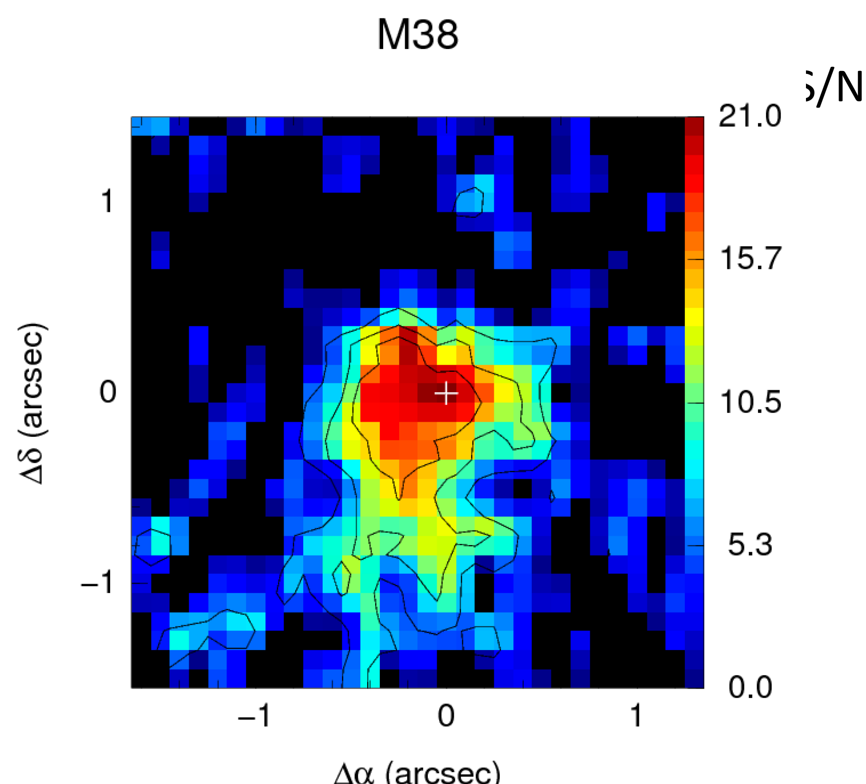
Expected performance

Expected performance: Predicted Hα S/N maps of LBGs @ z= 3-4

Assumptions:
- Flux (Hα), from SED fitting and Hβ
- Hα distribution=[OIII] distribution (Troncoso+14)
- Caveat: Flux distribution (seeing limited) → with NIRSpec-IFU, clumpier

R2700,
t_{exp}= 3h



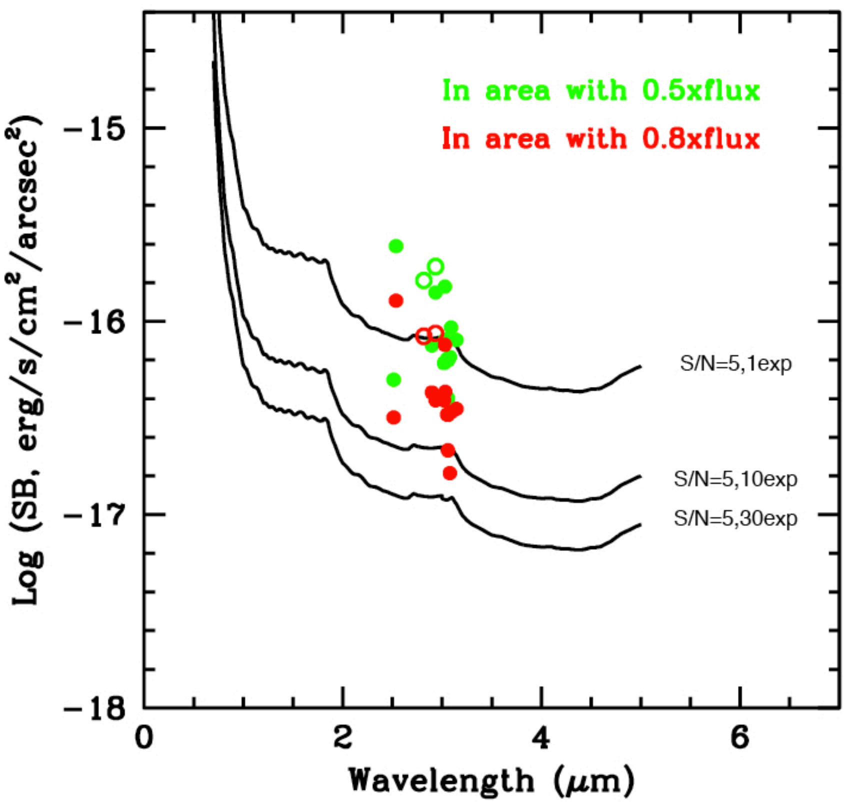


Expected performance: LBG @ z=3-4

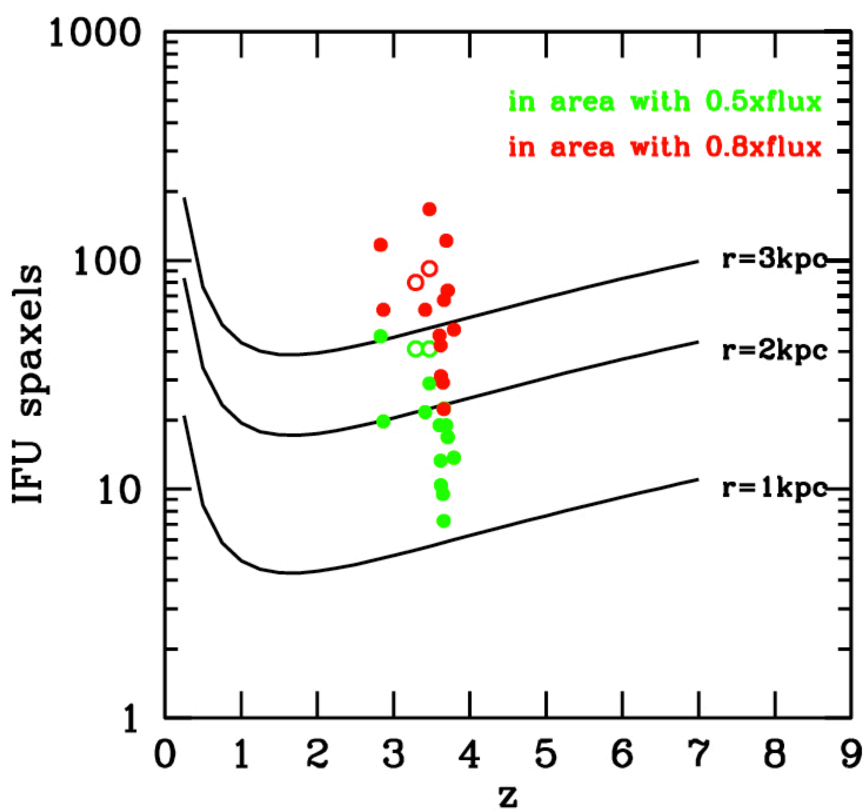
LBGs @ z= 3 – 4 from Castellano+14

Hα

Sensitivity (R=2700)



Spatial Extension



CR7: The brightest LAE in COSMOS (z=6.6)

NIRSpec/IFU FoV

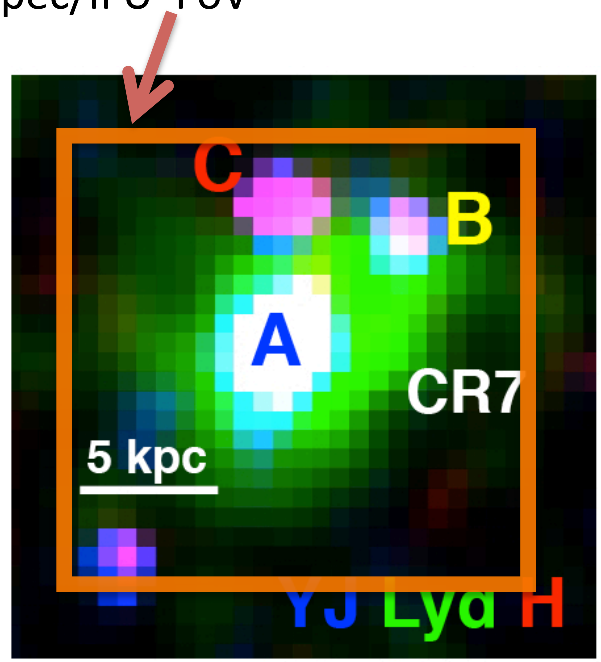


FIG. 7.— A false colour composite of CR7 by using NB921/Suprime-cam imaging (Lyα) and two *HST*/WFC3 filters: F110W (YJ) and F160W (H). This shows that while component A is the one that dominates the Lyα emission and the rest-frame UV light, the (likely) scattered Lyα emission seems to extend all the way to B and part of C, likely indicating a significant amount of gas in the system. Note that the reddest (in rest-frame UV) clump is C, with B having a more intermediate colour and with A being very blue in the rest-frame UV.

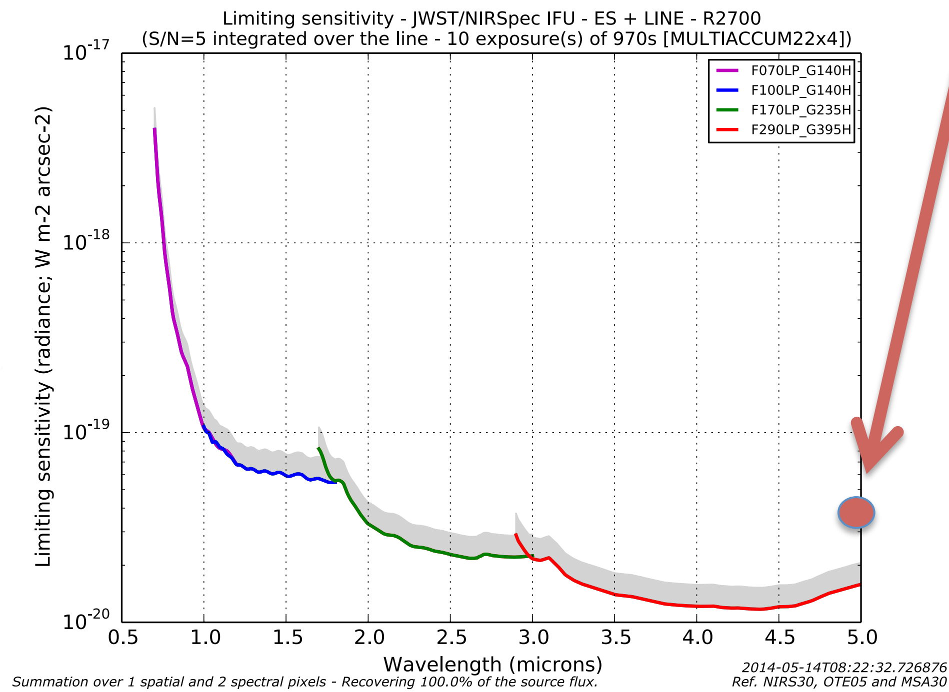
Sobral et al. 2015

L (Lyα) = 8.5 e+43 erg/s

Assuming
- Lya/Ha = 8.7
- A dominant in Lyα
- r (A) = 2.5 kpc

SB (Ha) = 3 e-20 watt/m/”^2

Hα
R2700
In 2.7h
S/N ~ 10 (for <SB> in A)
Unresolved (Hα) line



Summary

- The Integral Field Unit of NIRSpec is a very powerful tool for studying Galaxy Assembly, and for characterizing the most extended and luminous objects in the early Universe

- It is highly complementary to the NIRSpec MSA mode, and to other JWST instruments