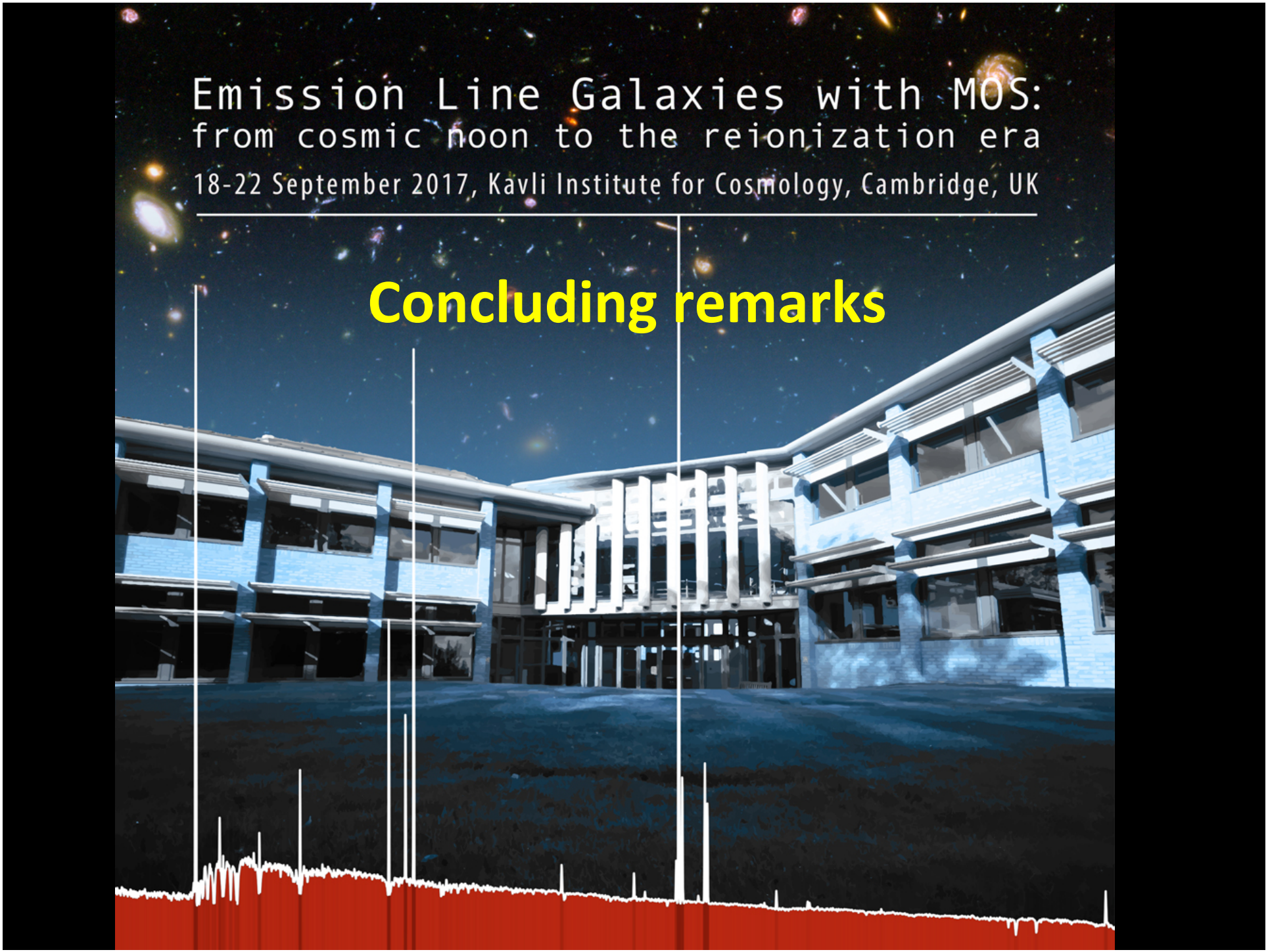
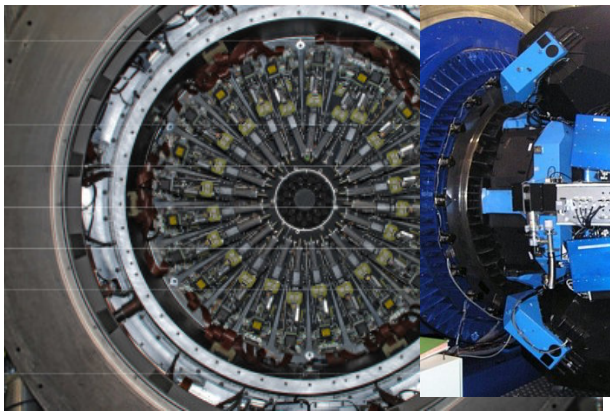
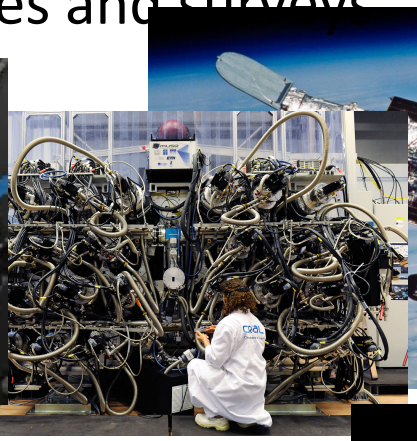
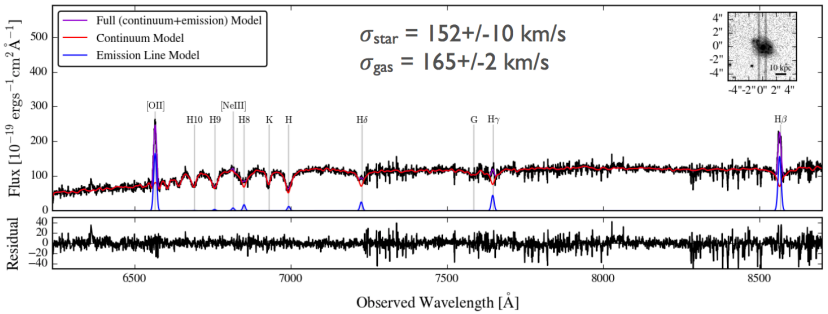
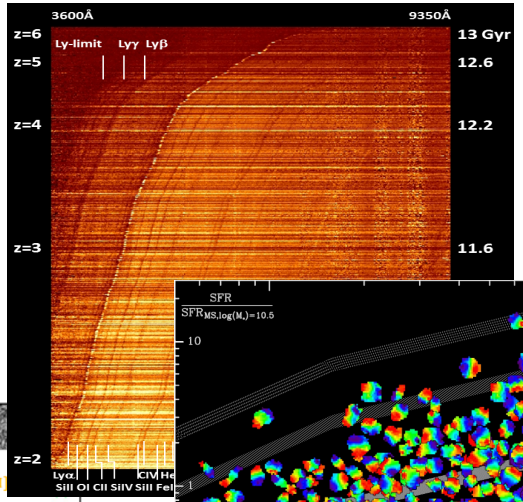

Emission Line Galaxies with MOS:
from cosmic noon to the reionization era
18-22 September 2017, Kavli Institute for Cosmology, Cambridge, UK
Concluding remarks

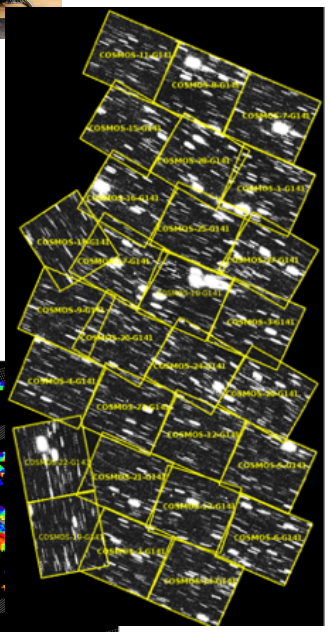
Major progress in our understanding of galaxy formation thanks to the recent generation “MOS” facilities and surveys

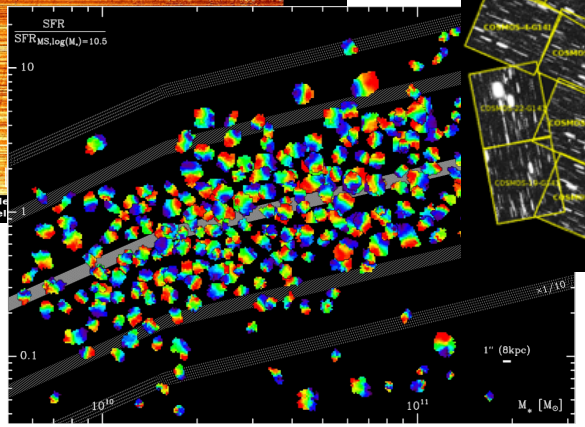


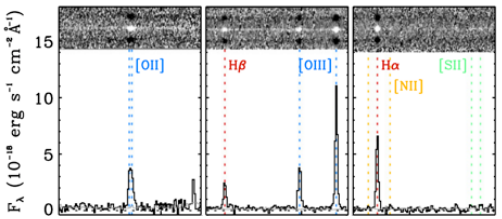


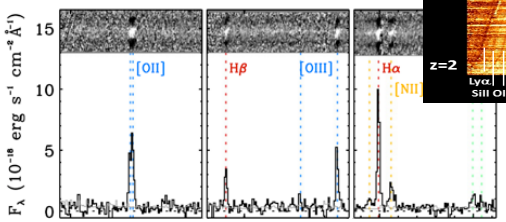












Also... many more new questions have been opened...

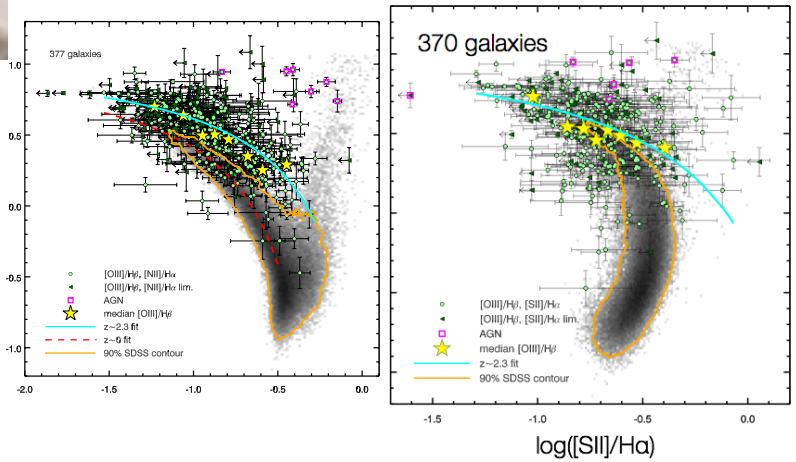
Evolution of BPT at high-z

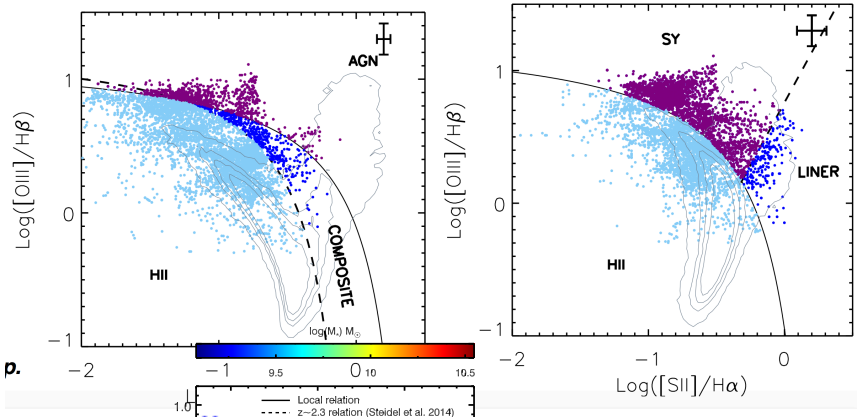
Storm, Curti
Masters, Kumari
Shapley, Sanders,
Feltre, Hirschmann, ...

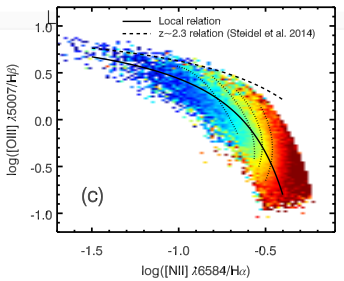
Why?

- N/O
- Ionization parameter
- Harder spectra (low-Z+binaries)
- Pressure/density
- Shocks
- AGNs
- DIG

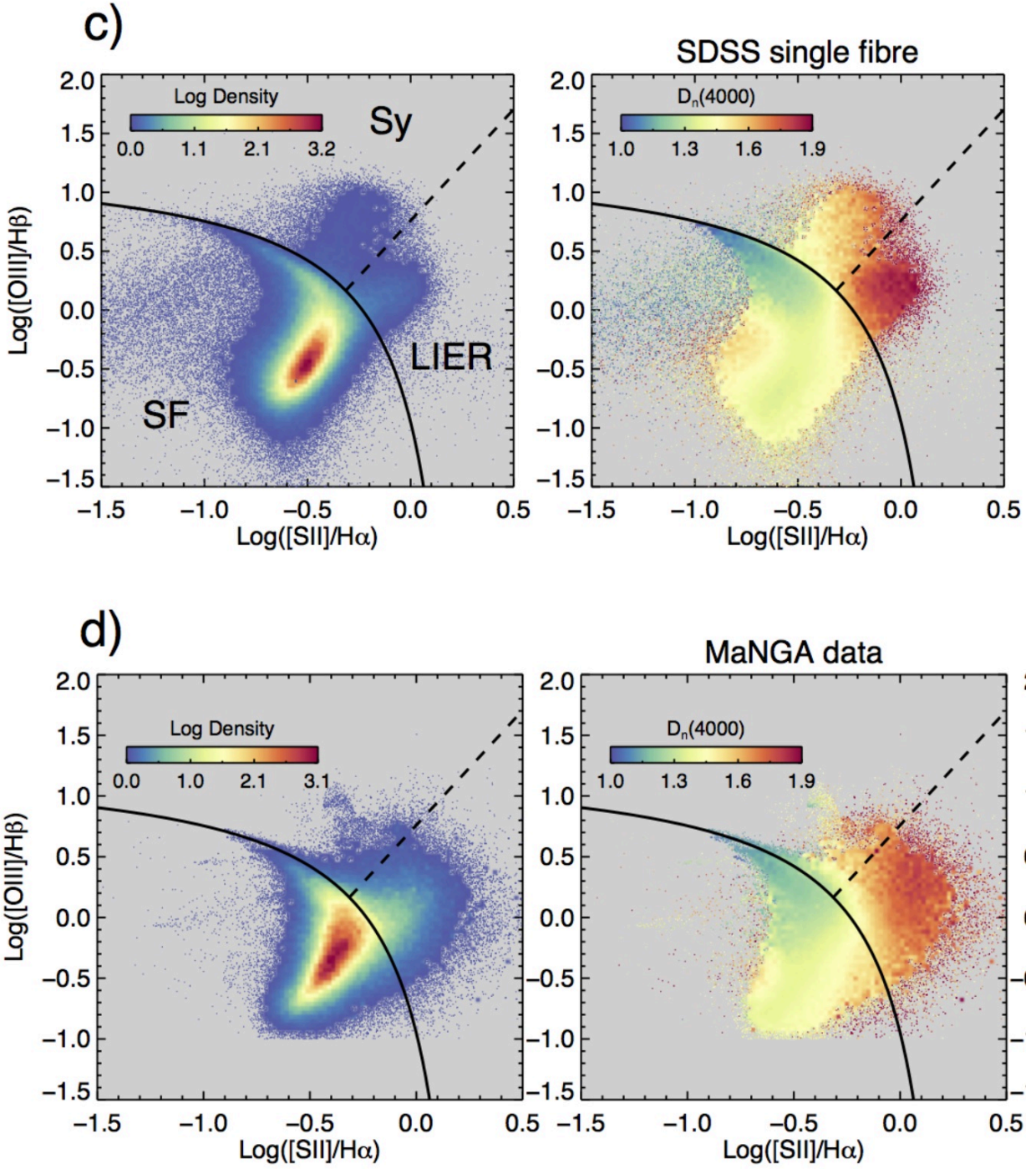
... very likely
not a single origin:
different effects play
different roles in
different galaxies







Additional warning:
be also aware
of aperture effects



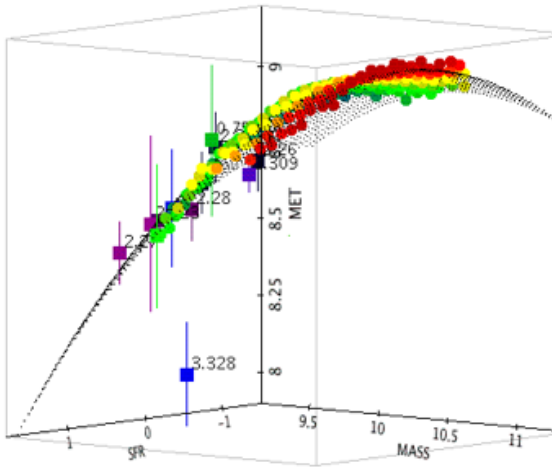
(Belfiore+16)

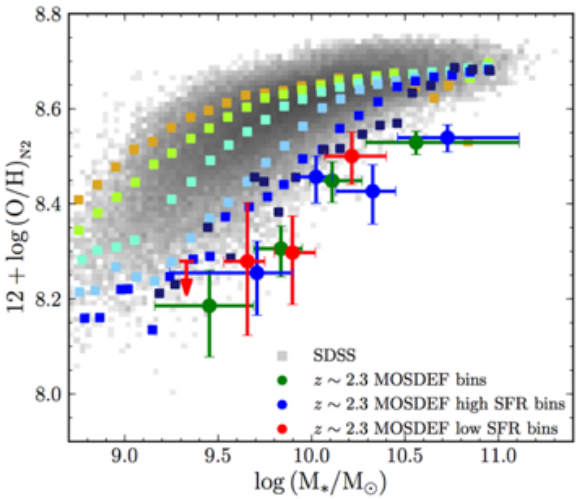
Evolution of the ISM properties, Mass-Metallicity relation and of the FMR: a Tower of Babel?

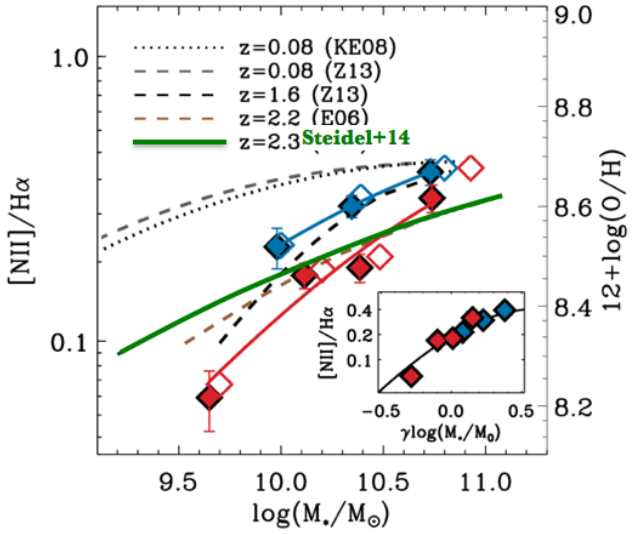
Different dignostics
Different calibrations
Different assumptions
Different approaches
Different samples
Neglect/account environment

→ Different results

Mannucci, Sanders
Vilchez, Calabro', Sanchez-Almeida
Shapley, Siana, Puglisi







Evolution of the ISM properties, Mass-Metallicity relation and of the FMR: a Tower of Babel?

Different dignostics
Different calibrations
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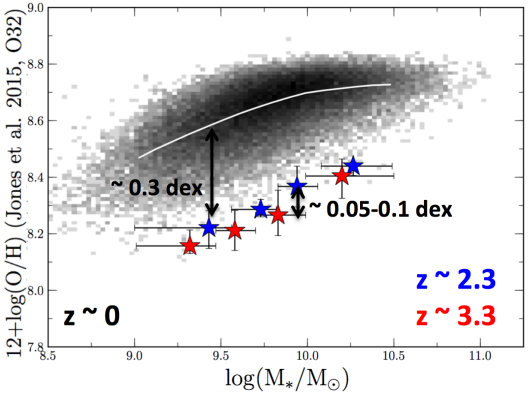
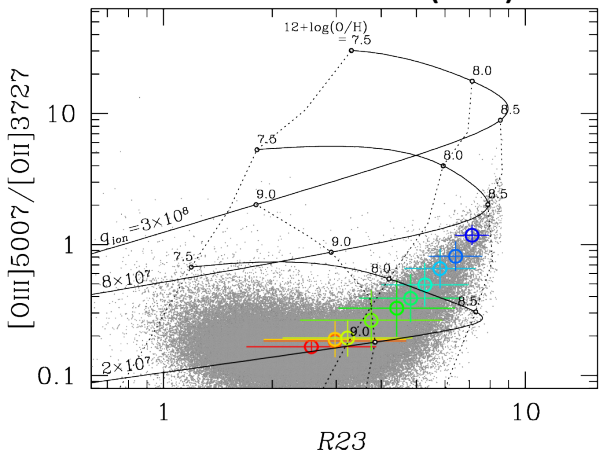
[OIII]/[OII]

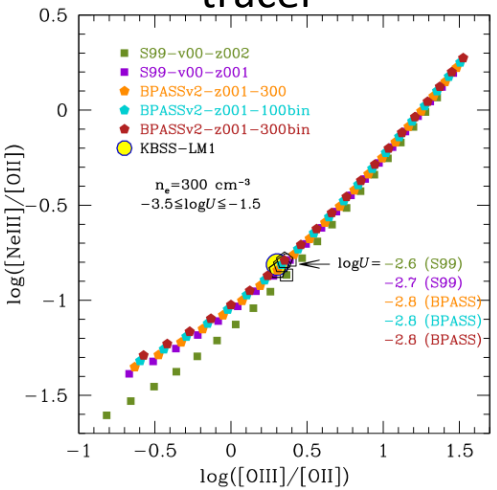
Metallicity tracer



Both metallicity and ionization parameter dependence
... but used to trace f(esc)



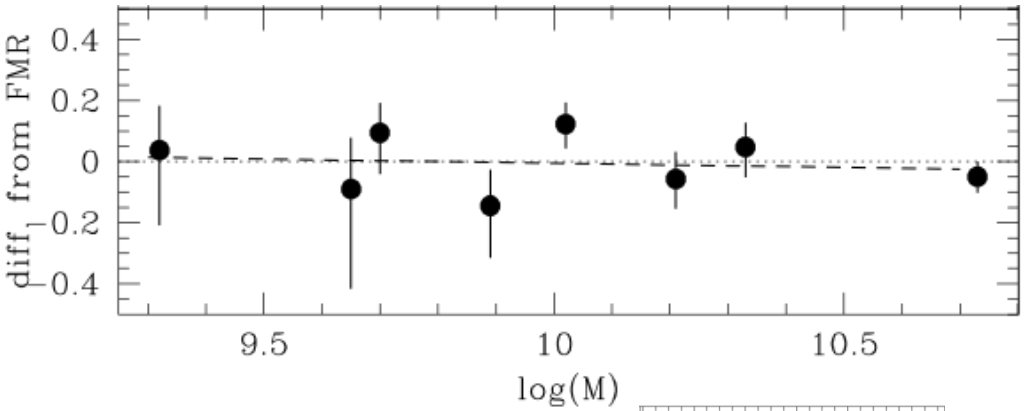
Ionization parameter tracer



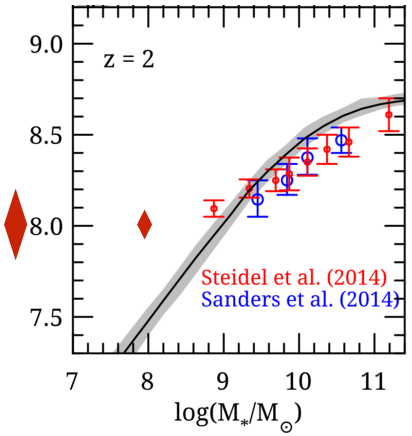
Evolution of the ISM properties, Mass-Metallicity relation and of the FMR: a Tower of Babel?

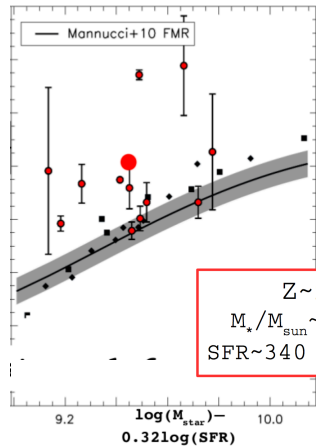
Different dignostics
Different calibrations
Different assumptions
Different approaches
Different samples
Neglect/account environment

Attempt to homogenize low-z and high-z
Mannucci



Yet, see Siana's dwarf high metallicity targets... as well as Puglisi's

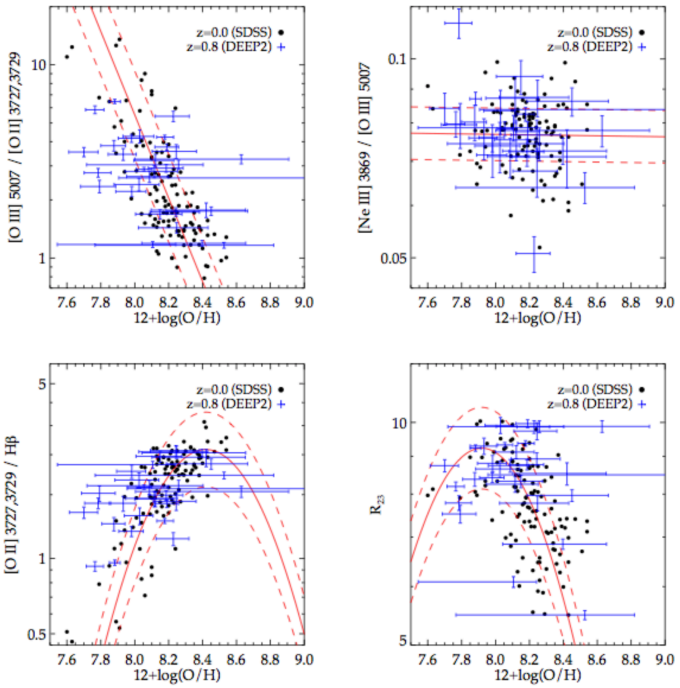




Can the metallicity strong line diagnostics be applied at high-z?

Jones
Shapley
Calabro'

Te – Direct metallicity calibrations/checks at high-z

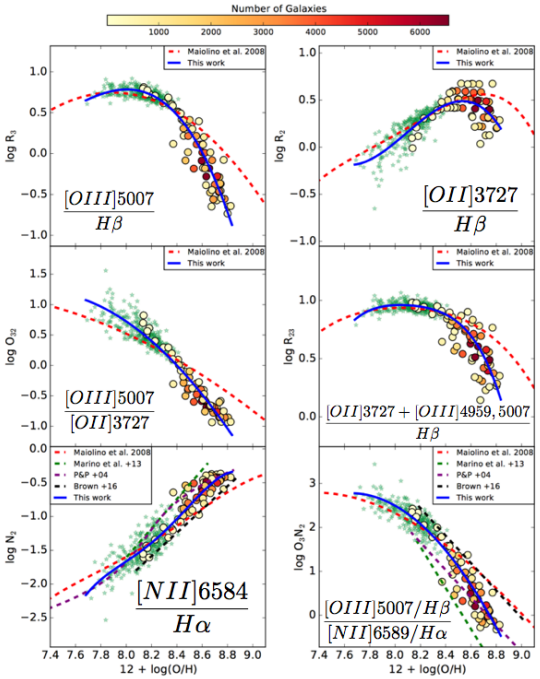


At z~1 is ~ok

But still low statistics (and mostly at intermediate-z)

Need to recalibrate strong-line diagnostics at high-z

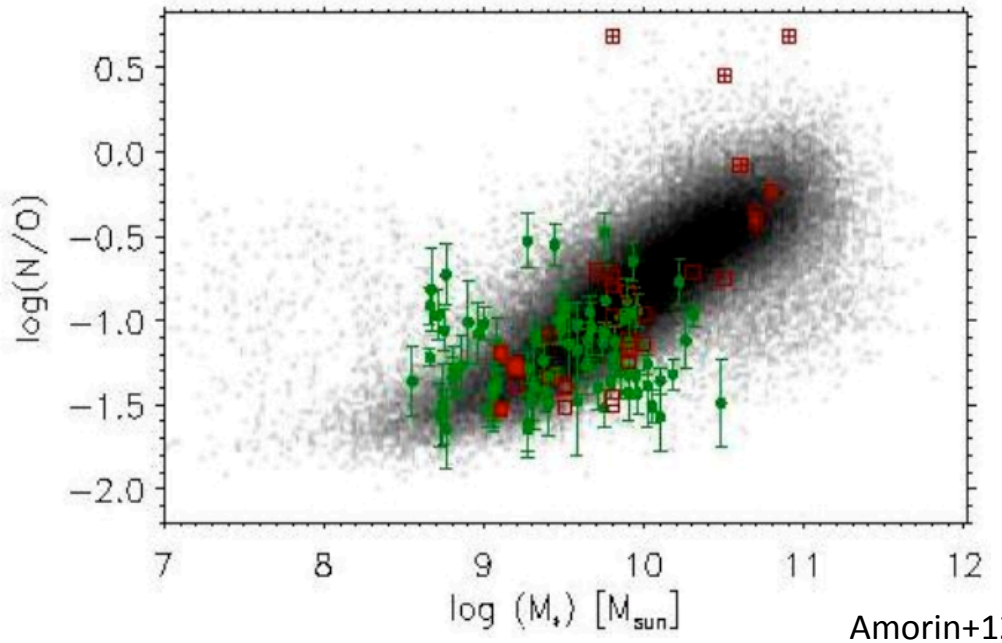
Curti+17



z=0 → high-z (JWST/ELT)

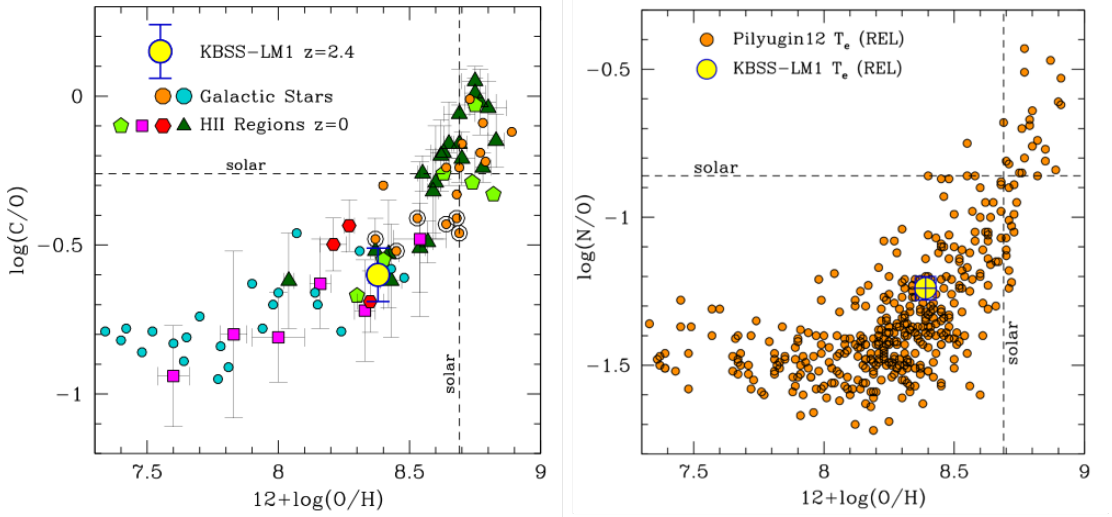
Metals abundance ratios (esp. secondary elements)
-> much more stable tracers of galaxy evolutionary stage

Perez-Montero
Masters
Shapley
Strom



Amorin+12

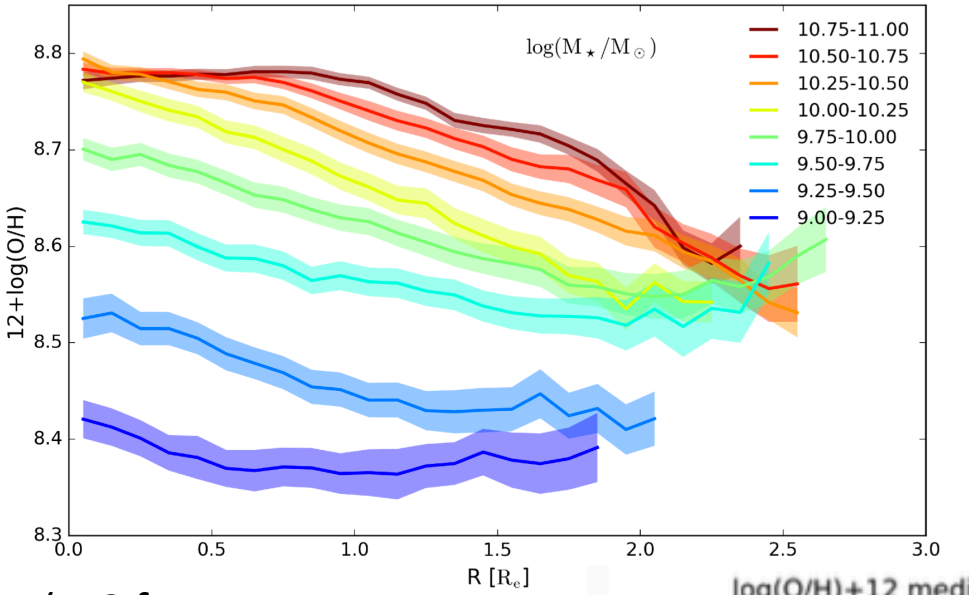
Metallicity sensitive
to inflow/outflows



Steidel+12

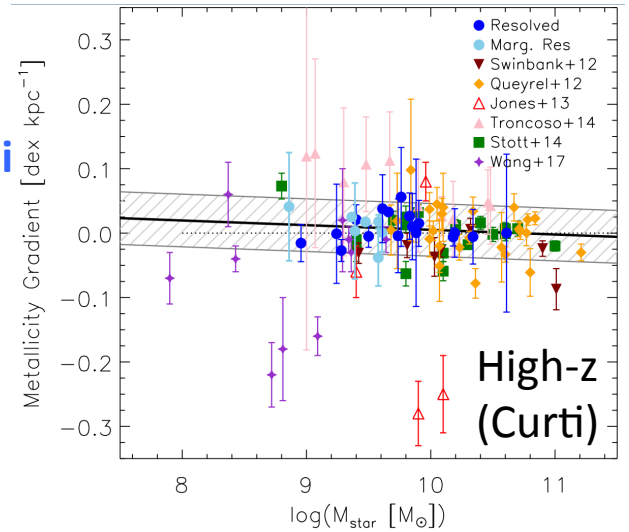
Metallicity gradients at high-z

Major progress, but still f
ar from achieving the statistics
and clear-cut results obtained locally



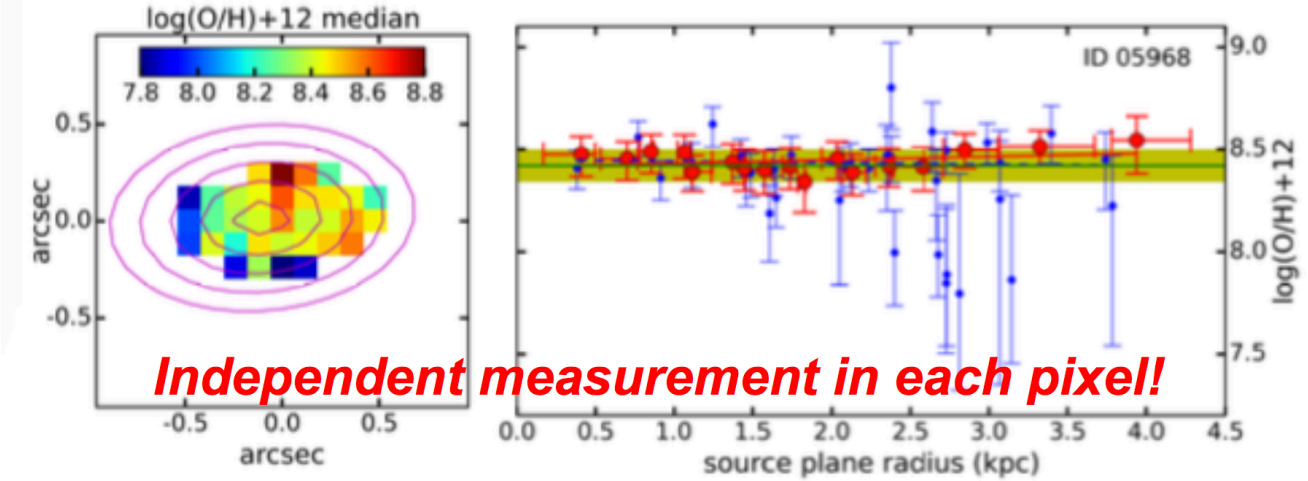
(z=0 from Manga, Belfiore+17)

Jones
Curti
Mannucci
Ferrara



Yet, main issue is that
high-z galaxies are simply "messy"
in terms of metallicity structure
... do not get fixated in trying
to extract radial, azimuthally
averaged gradients...

(all of this convolved
with diagnostic
uncertainties)



Modelling nebular lines and stellar spectra

Feltre
Gomes
Vidal-Garcia
Wilkins
Ferrara
Hirschmann
Curtis-Lake

Beagle
FADO
Mega
HCm
…

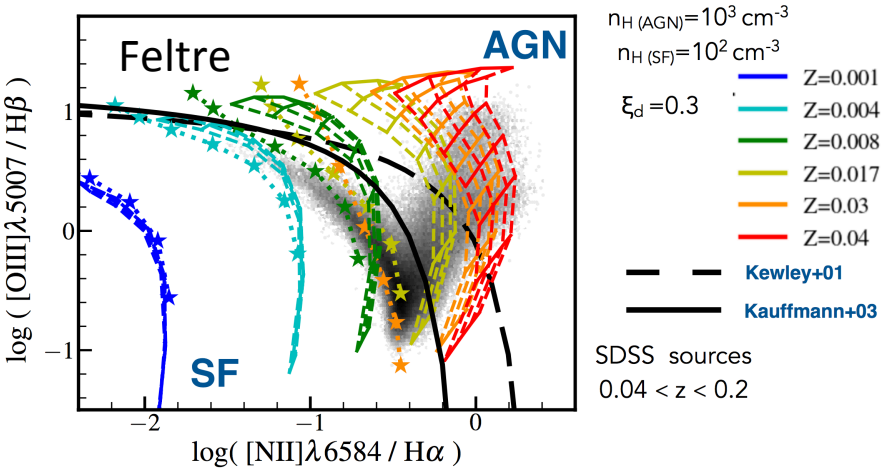
Combined with cosmological simulations

- Impressive progress!
- Key new insights!

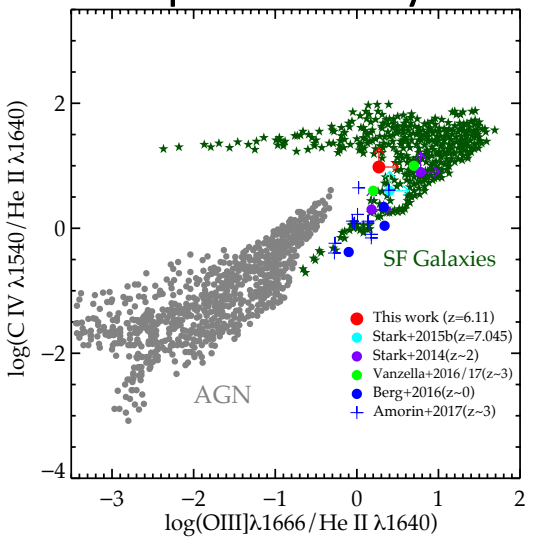
- Next step:
  Check consistency with other direct diagnostics?
  (e.g. Te for metallicities, X-ray for AGNs, ...)

Important warning
- degeneracies especially at high-z

Need to expand to a broader range of diagnostics & combine with photometry



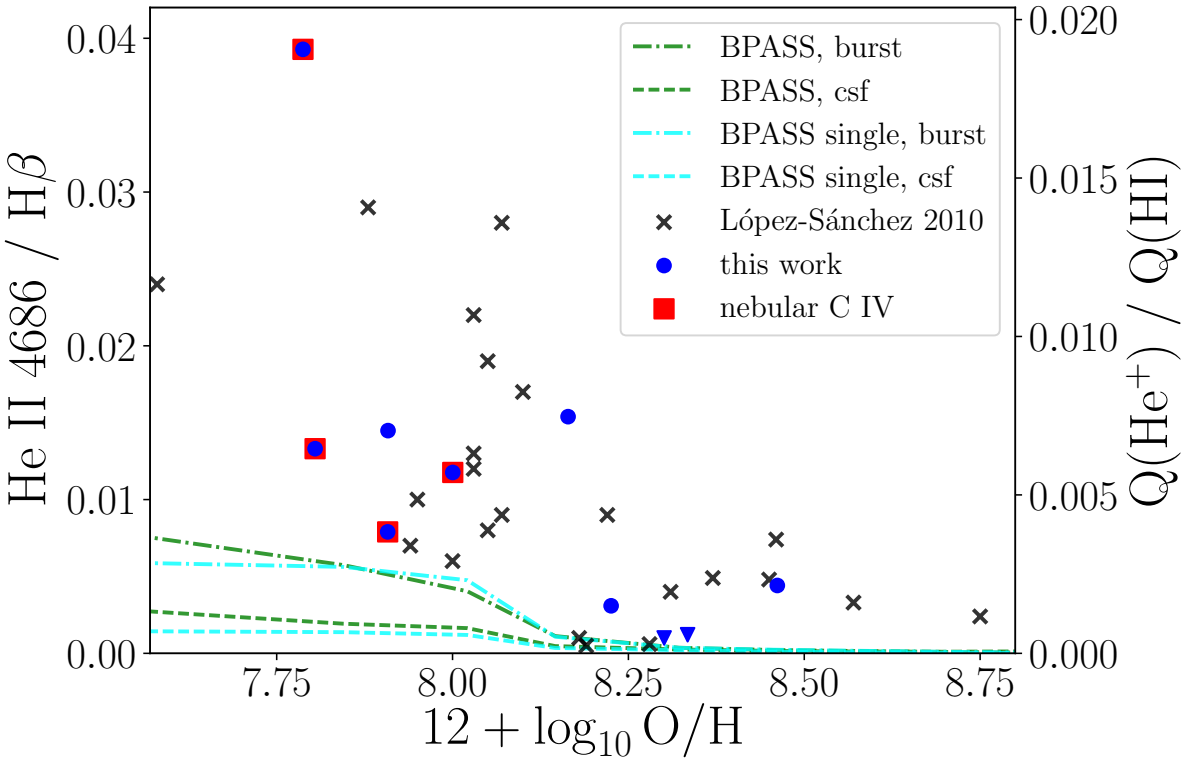
Stark
Pentericci
Maseda
Curtis-Lake



Limits of current models...

Stark

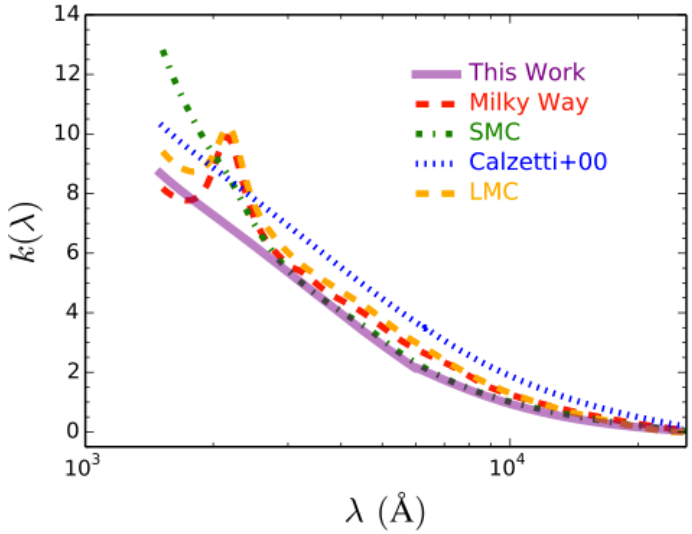
Senchyna+17



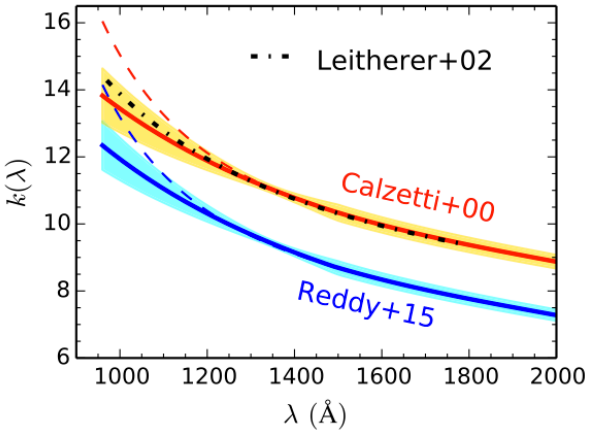
Interesting new physics?

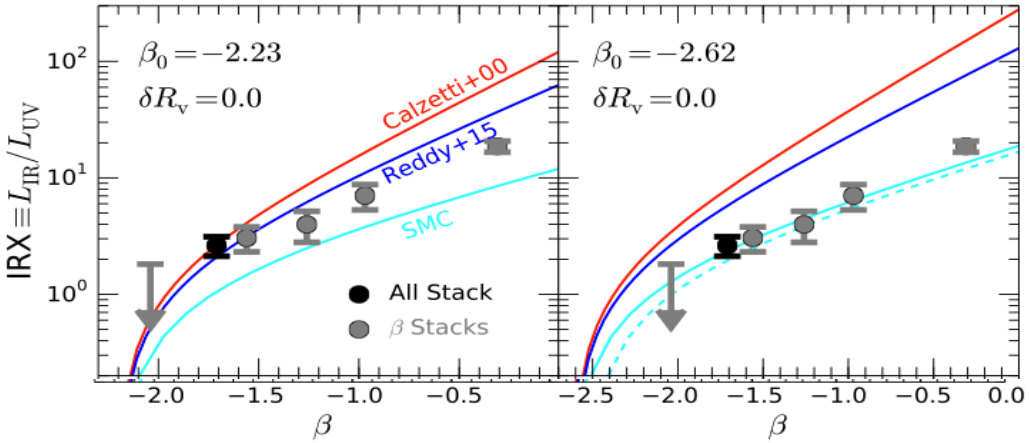
Dust extinction
Dust attenuation curves
Stellar/nebular relative attenuation

Reddy
Siana
Ferrara



- Different from local
- New recipes for stellar/nebular dust correction
- New insights on the relative distribution of dust and stars
- New insights on the dust properties and stellar population





Next step -> exploit Paschen and Brackett lines

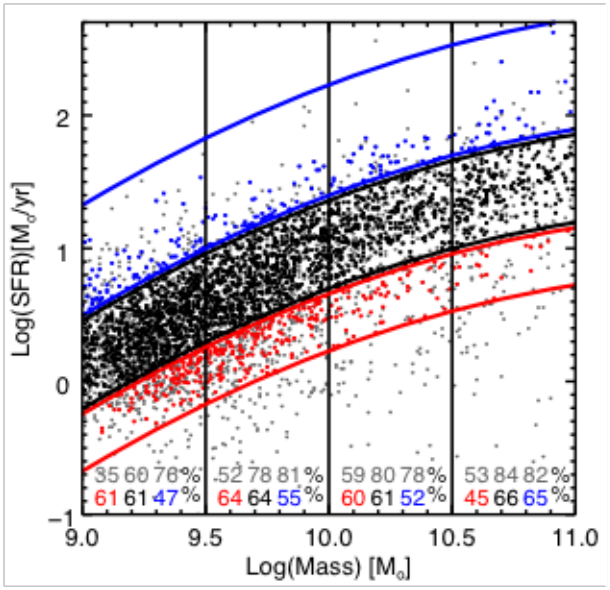
Momcheva

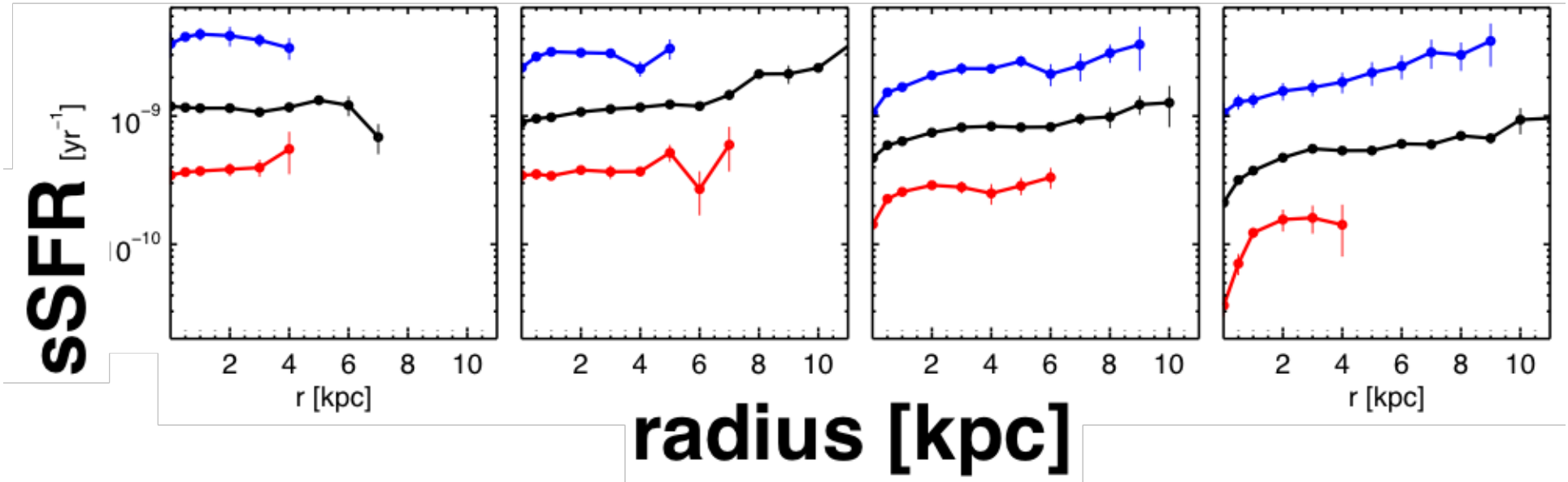
Where do stars form?

Where star formation is suppressed

- Look at stacks on, above and below the star-forming sequence
- Elevated (suppressed) at all radii above (below) the SF sequence
  - e.g., no evidence for central starbursts

Nelson et al., 2015

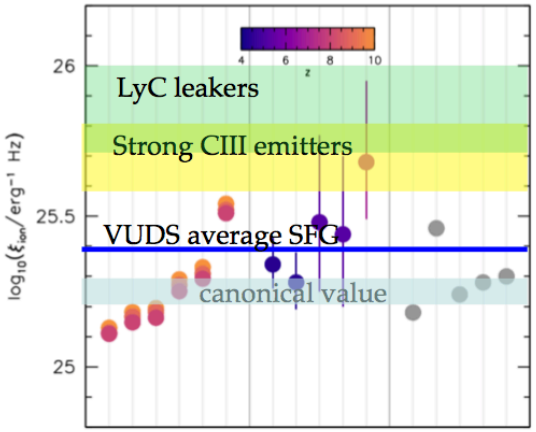


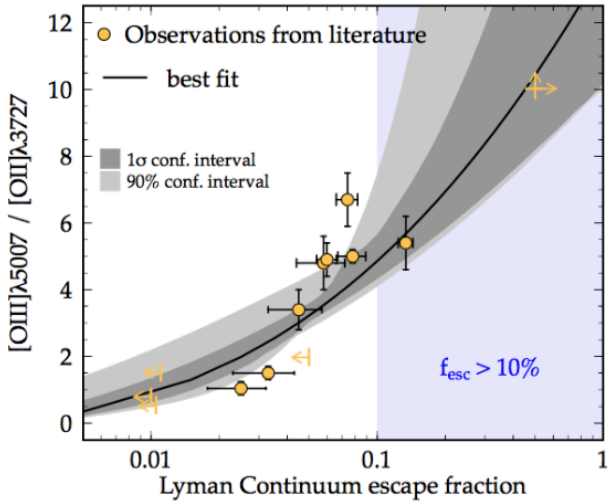


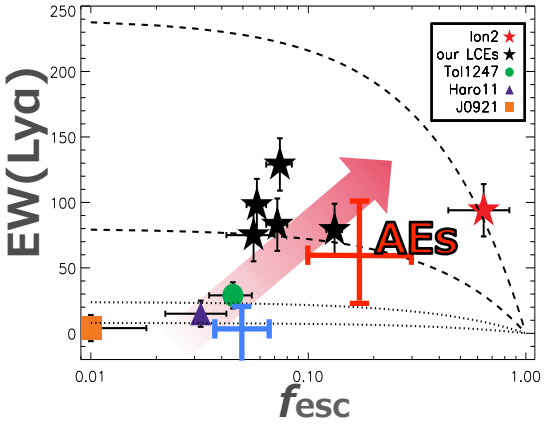
f_{esc}(ion), ξ_{ion}, f_{esc}(Lyα) and reionization sources

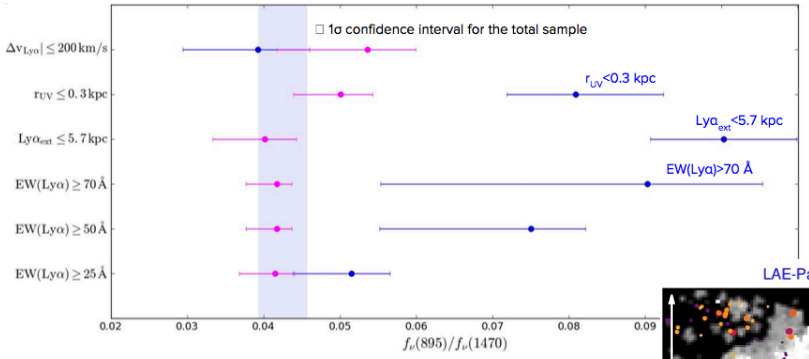
A lot of progress being made despite the technical difficultie

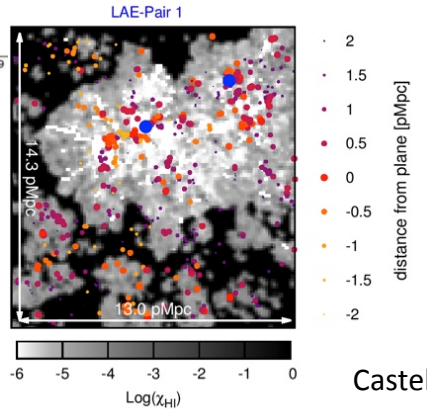
Schaerer
Reddy
Stark
Nakajima
Marchi
Fletcher
Sobral
Matthee
Maseda
Castellano
Bowler











Connection between reionization and overdensities

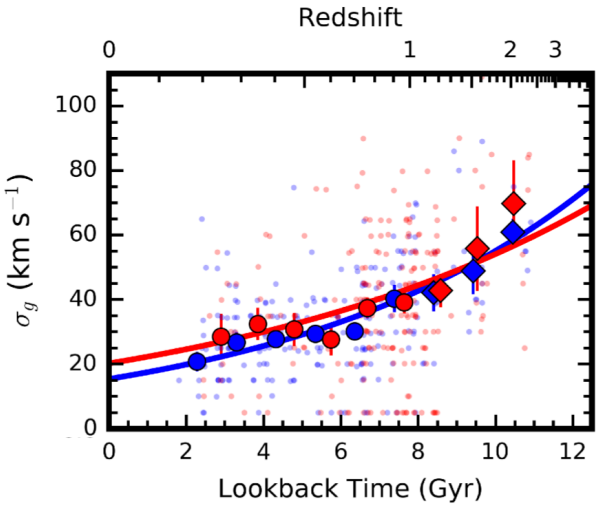
Castellano+16

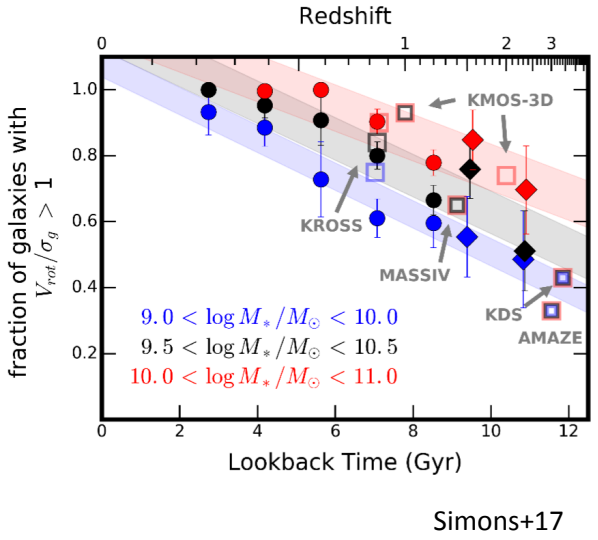
Kinematics

Gas Kinematics
(star forming galaxies):

- Higher velocity dispersion
  at high-z

- Lower V_{rot}/σ at high-z





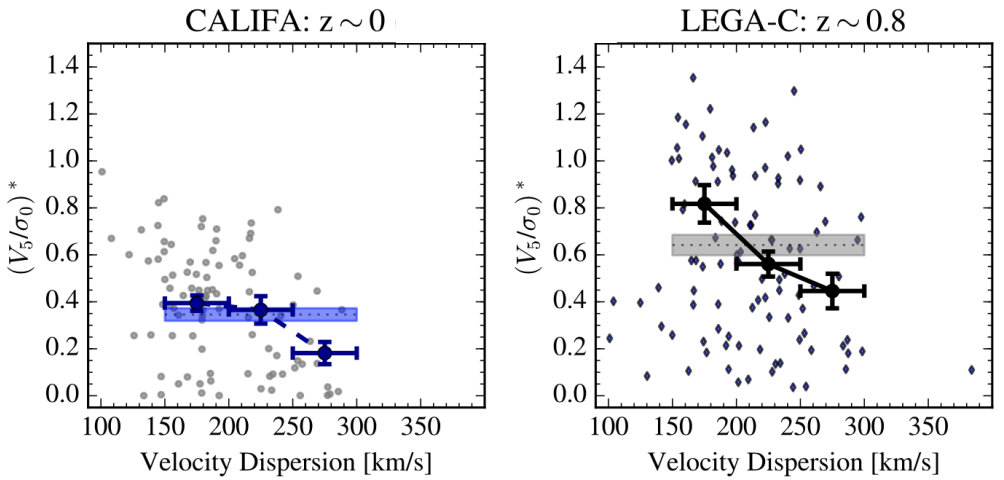
Simons+17

Übler
Kassin
Turner
Tiley
Tran
Patricio
Straatman
van der Wel

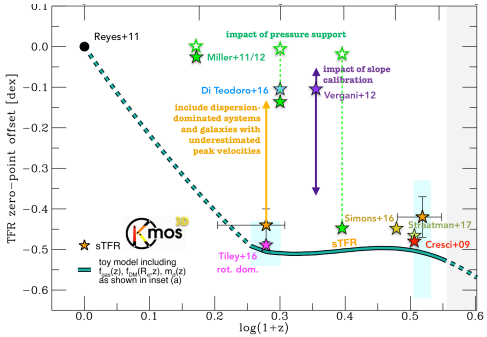
(Progenitor bias fully under control?)

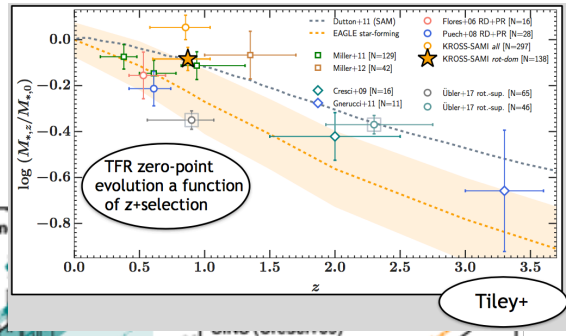
Stellar Kinematics:

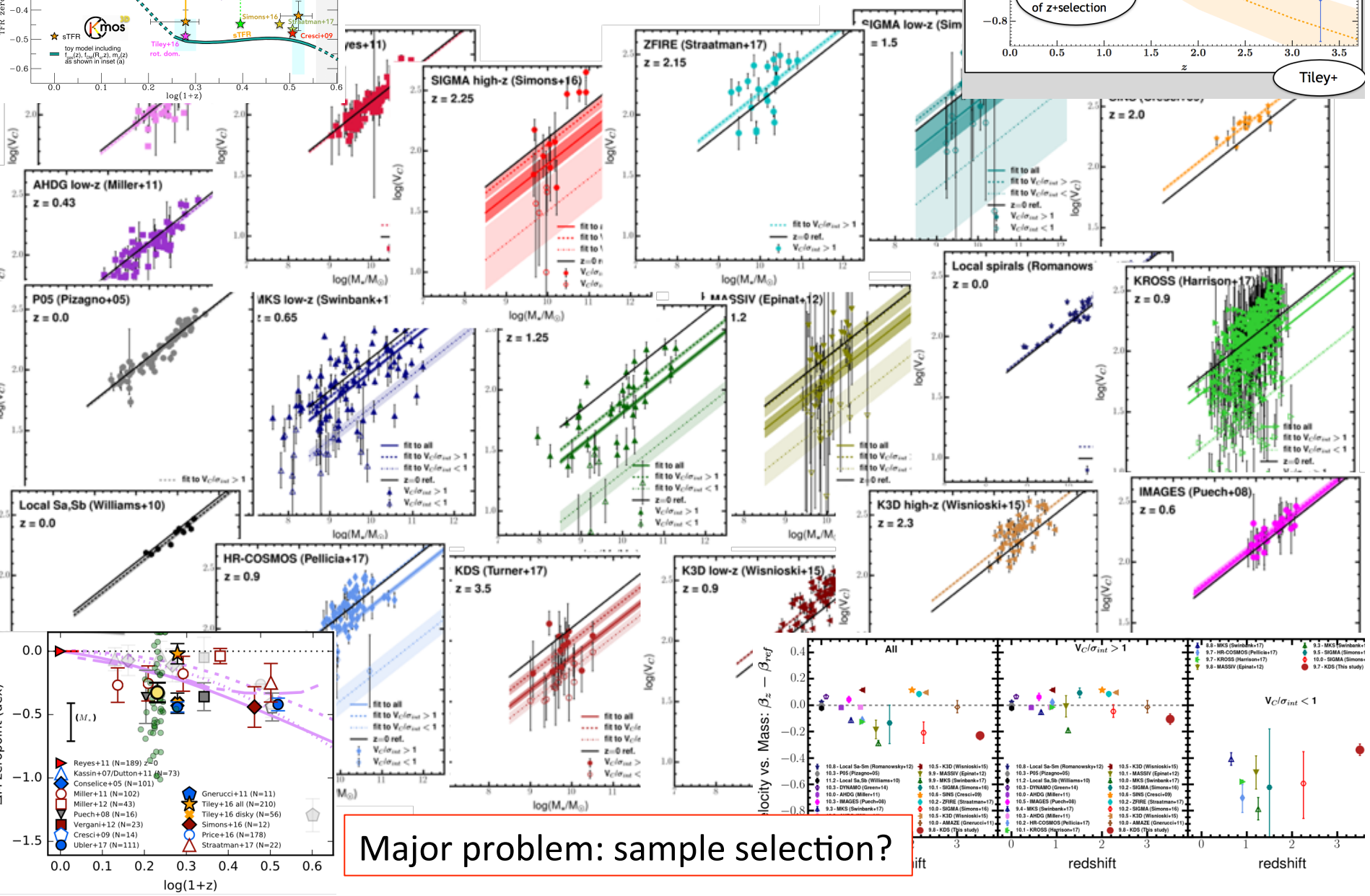
-> probing (also)
passive galaxies



Evolution of the Tully-Fisher relation?...



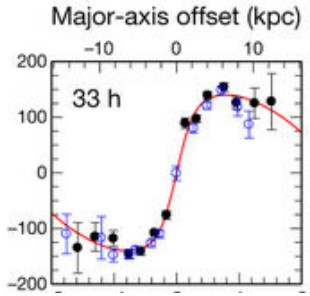




Major problem: sample selection?

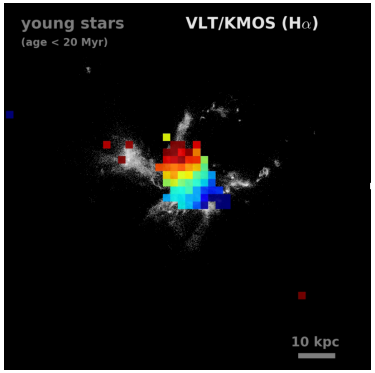
Some of the kinematic studies warnings:

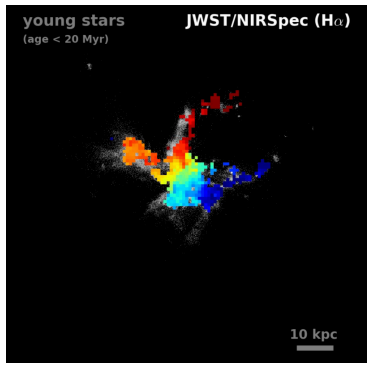
- Constraining dark matter content
  -> need to reach larger radii
  (JWST, ELT, SKA2)



Ubler+17
Genzel+17

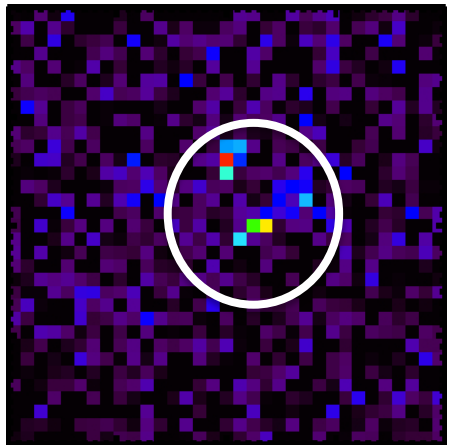
- Angular resolution
  (JWST, ELT)





Courtesy
S. Kassin

- Non-uniniform gas distribution
  (van der Wel)

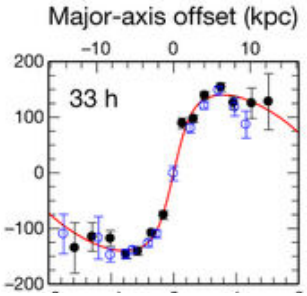


HST V-band

Williams+14

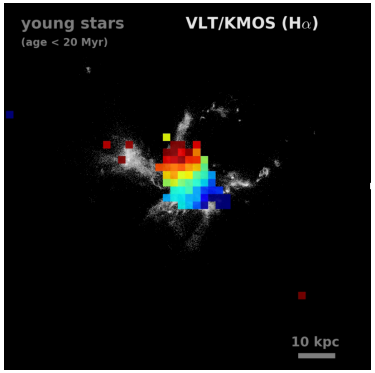
Some of the kinematic studies warnings:

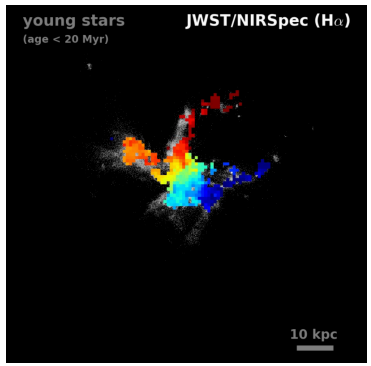
- Constraining dark matter content
  -> need to reach larger radii
  (JWST, ELT, SKA2)



Ubler+17
Genzel+17

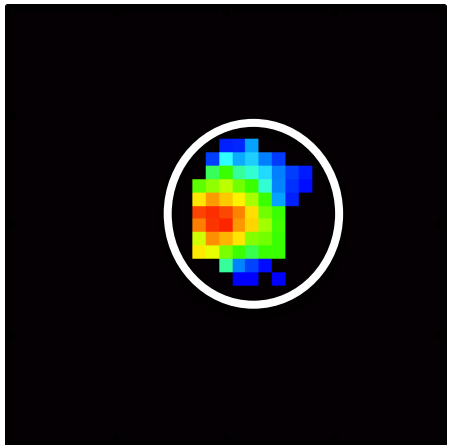
- Angular resolution
  (JWST, ELT)





Courtesy
S. Kassin

- Non-uniniform gas distribution
  (van der Wel)



Hα (SINFONI)

Williams+14

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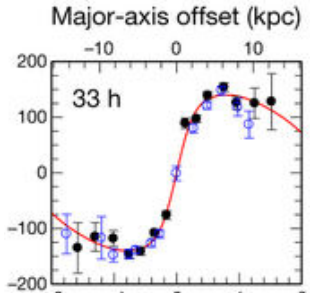
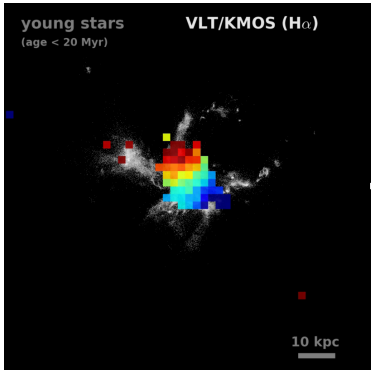
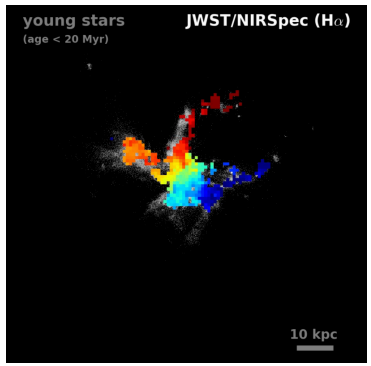


Ubler+17
Genzel+17

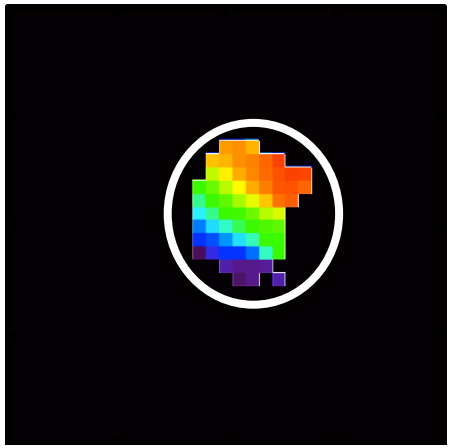
- Angular resolution
  (JWST, ELT)





Courtesy
S. Kassin

- Non-uniniform gas distribution
  (van der Wel)



V_{gas} (SINFONI)

Williams+14

Some of the kinematic studies warnings:

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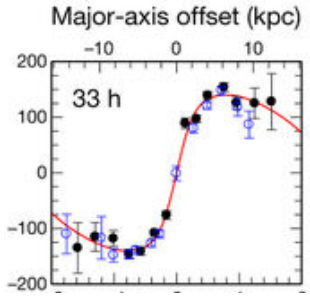
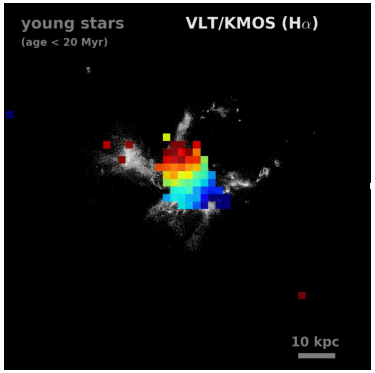
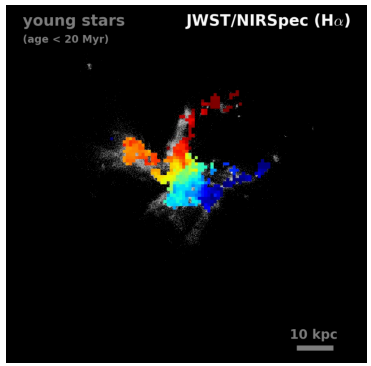
  (JWST, ELT, SKA2)



Ubler+17
Genzel+17

- Angular resolution
  (JWST, ELT)





Courtesy
S. Kassin

- Non-uniniform gas distribution
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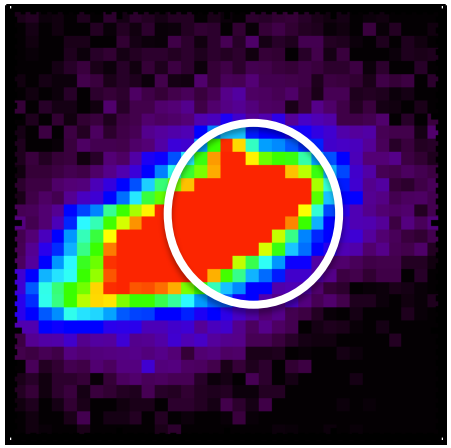
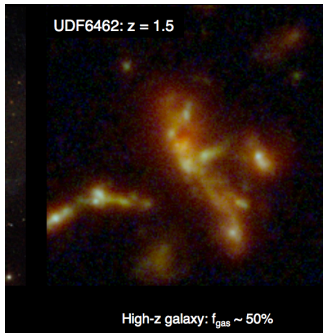


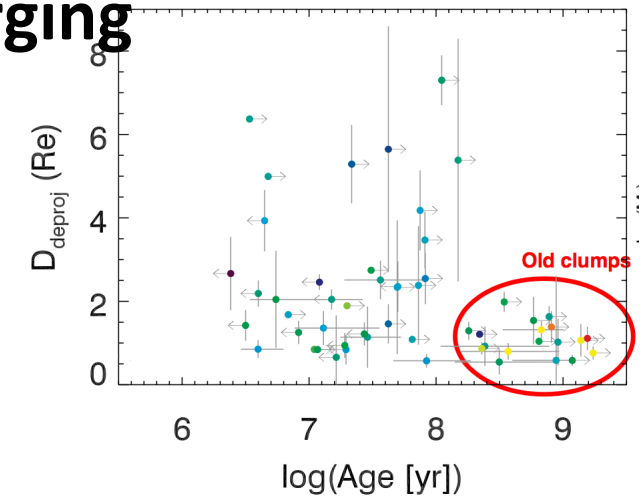
HST H-band

Williams+14

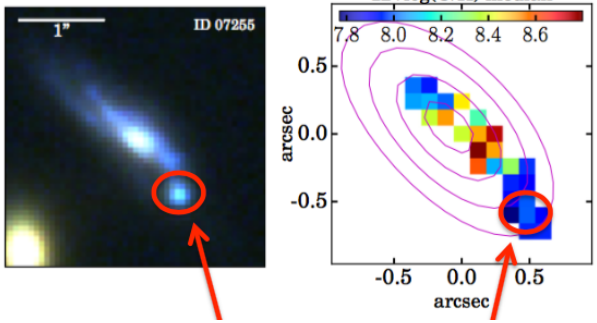
Clumps (in-situ/ex-situ) and role of merging

Clumps: evidence for both
- in-situ formation (instabilities)
  and long survival times
- accreted clumps (minor merger)

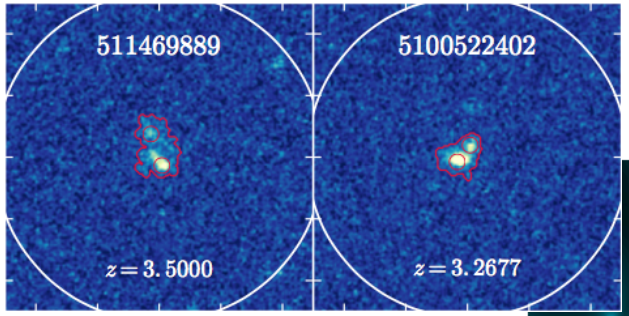


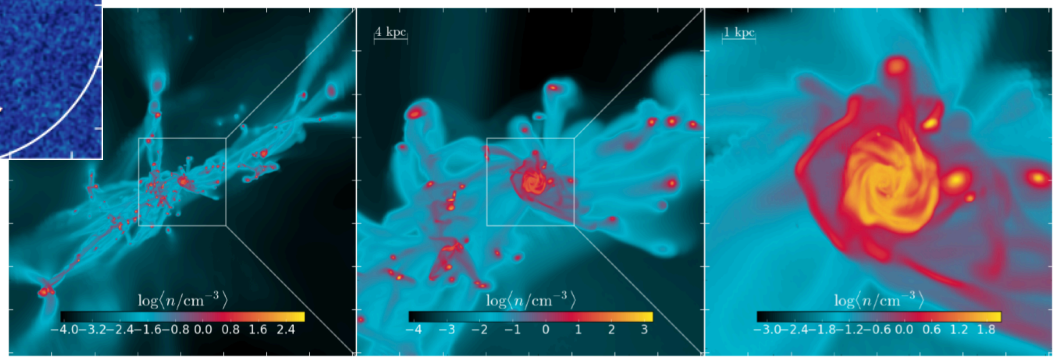


Merger scenario vs “smooth” accretion...
really alternative scenarios?
(accreting flows are clumpy and form stars
along the stream)



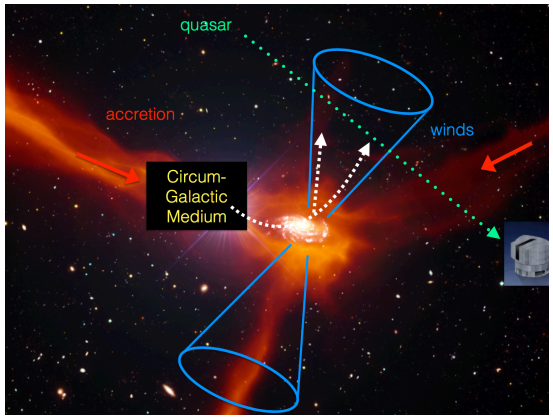
Zanella
Jones
Tasca
Dave’
Ferrara

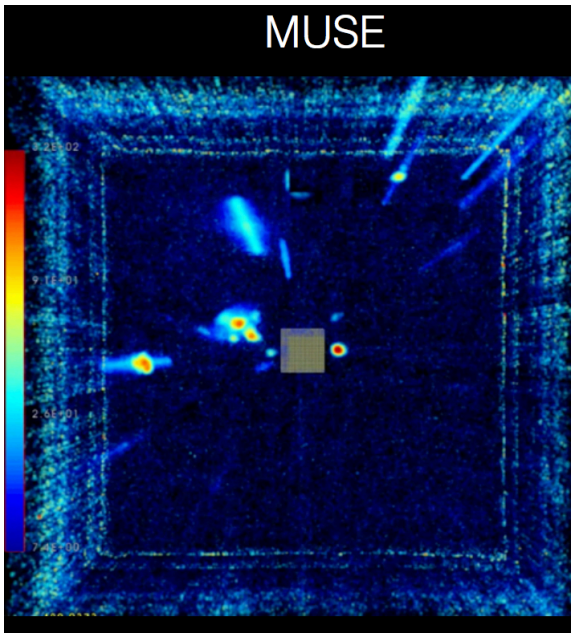


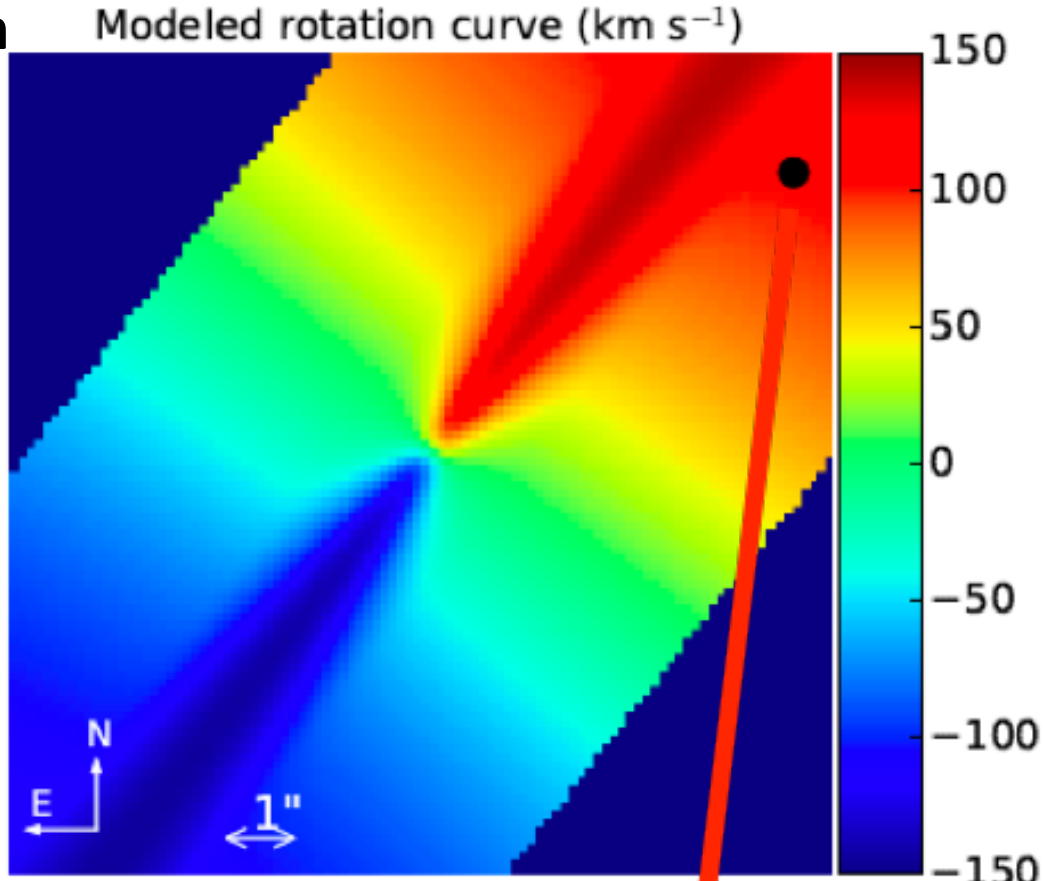


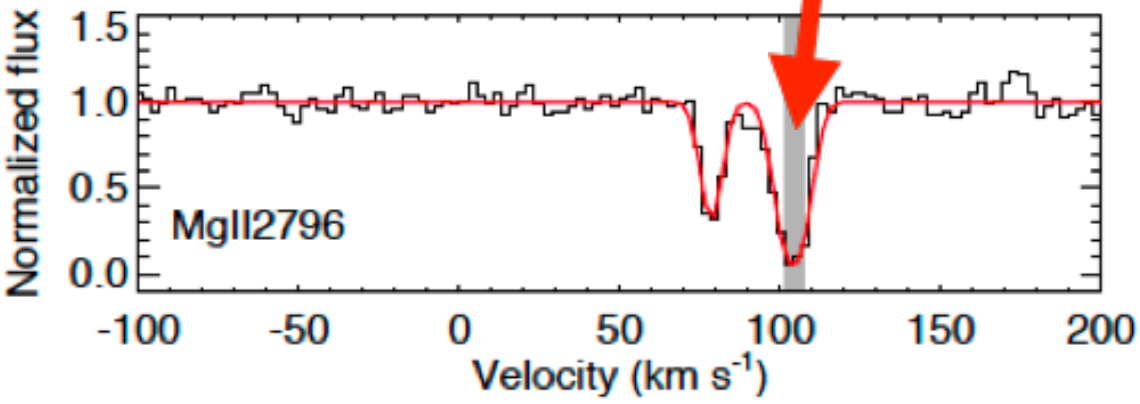
Probing cold flow accretion with 3D wide field spectroscopy

Peroux



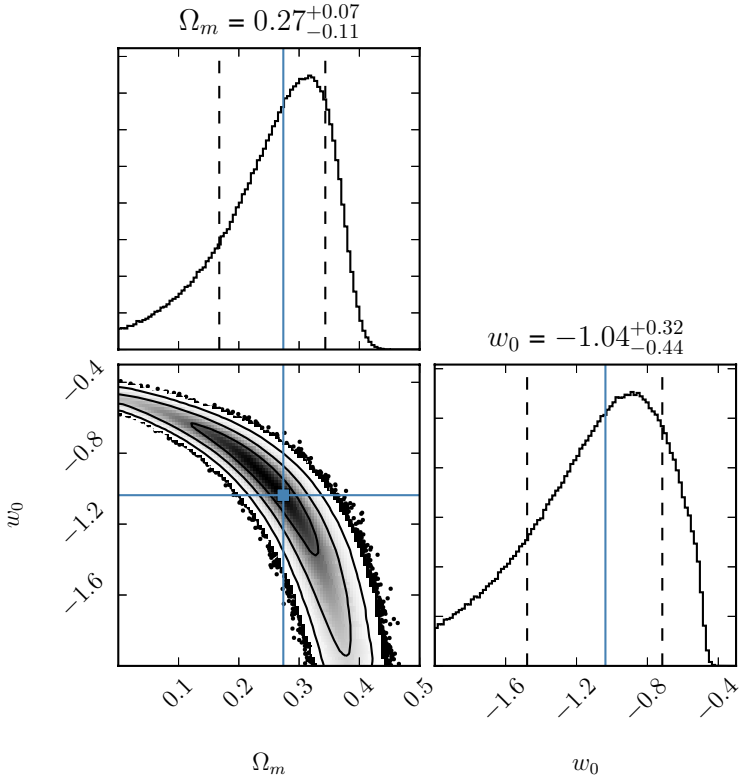






Great prospects for “tomography” (Hammer)

Cosmological constraints using high-z HIIG

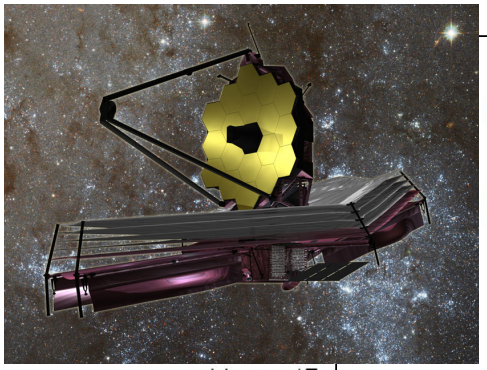


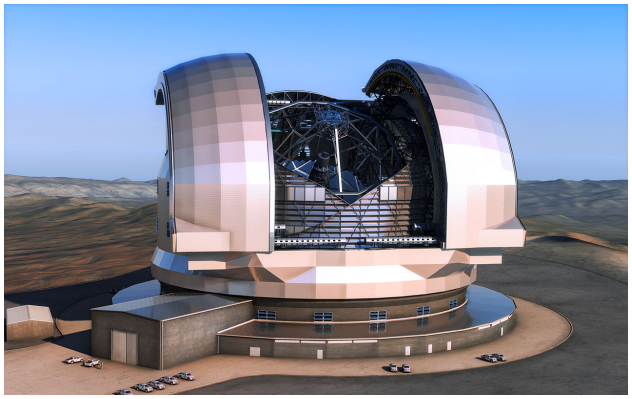
Terlevich

Constraints on IMF

“Any change in the slope of the IMF between z ~ 0 and z ~ 2.5 has to be less than ~0.06 at 1-**σ** level.”

Next generation facilities: a sudden big leap in discovery space

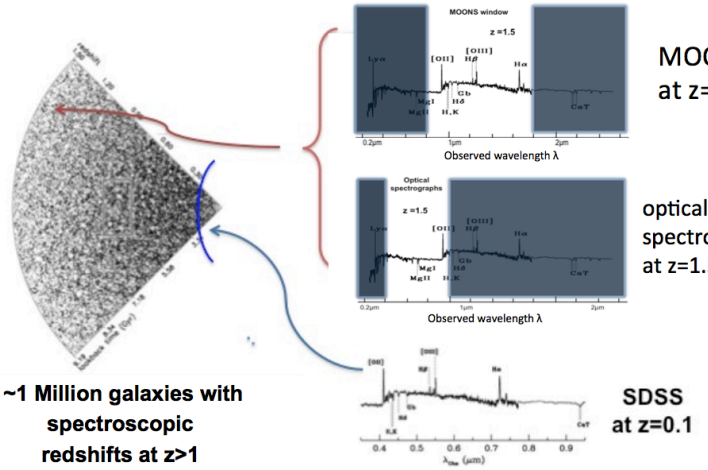


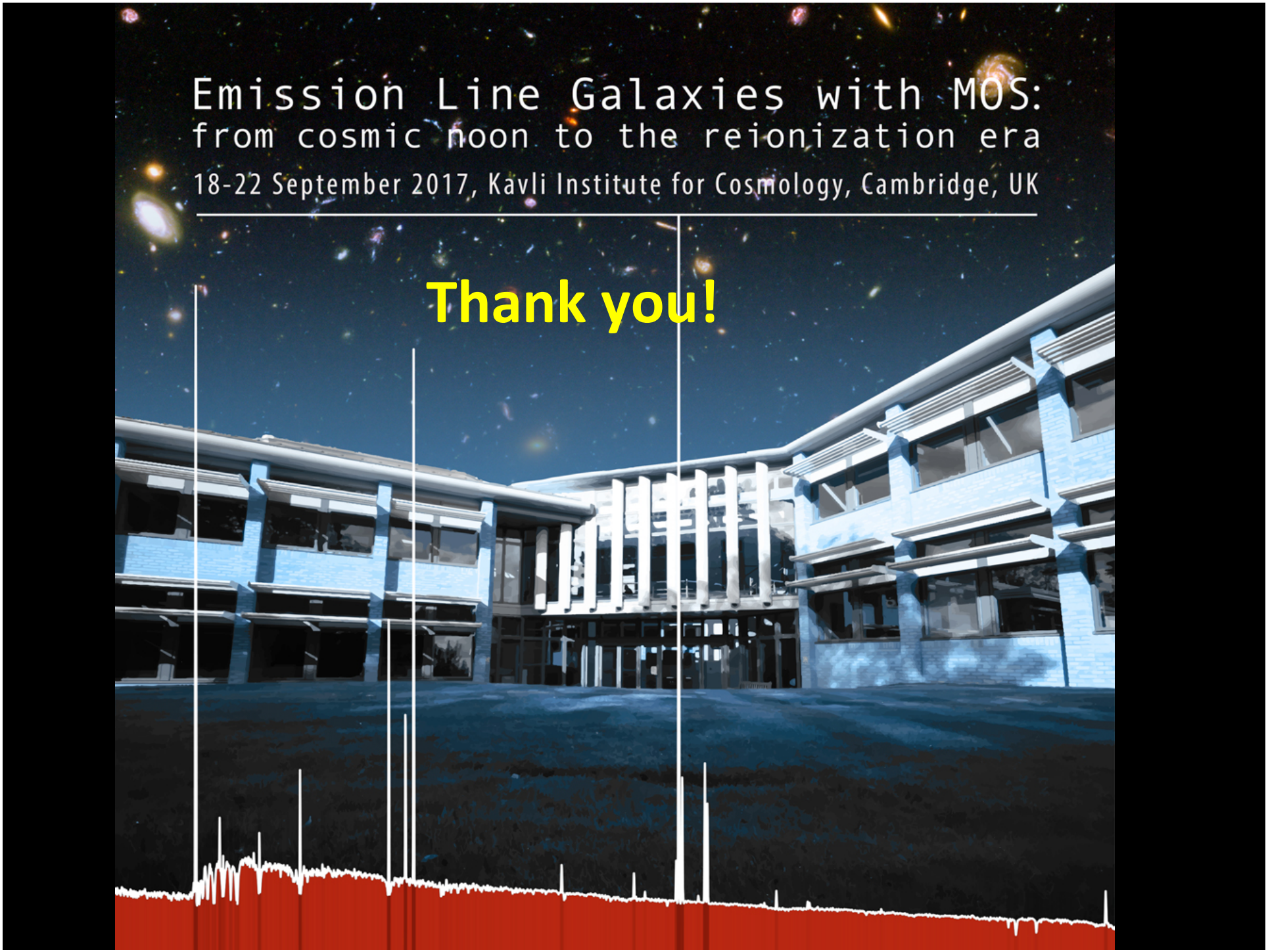


Equivalent to suddenly passing from Galileo's telescope to VLT

ELT/TMT: Will couple Sensitivity with angular resolution (Kassin)

DESI, 4MOST, WAVE, PFS, MOONS, Euclid, WFIRST: "SDSS-like" surveys at high-z




Emission Line Galaxies with MOS:
from cosmic noon to the reionization era
18-22 September 2017, Kavli Institute for Cosmology, Cambridge, UK
Thank you!