An update on FMOS-COSMOS: a spectroscopic Survey of High-z Massive Galaxies and AGNs in COSMOS

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Science objectives

Understand the physical drivers of the global evolution of star formation and black hole growth in distant galaxies

A focus near the peak formation epoch (here $z \sim 1.6$)

Emission-line study to measure the following:

star formation rates
extinction
ionization
metallicity
AGN content
environment

Large near-infrared spectroscopic survey with Subaru/FMOS

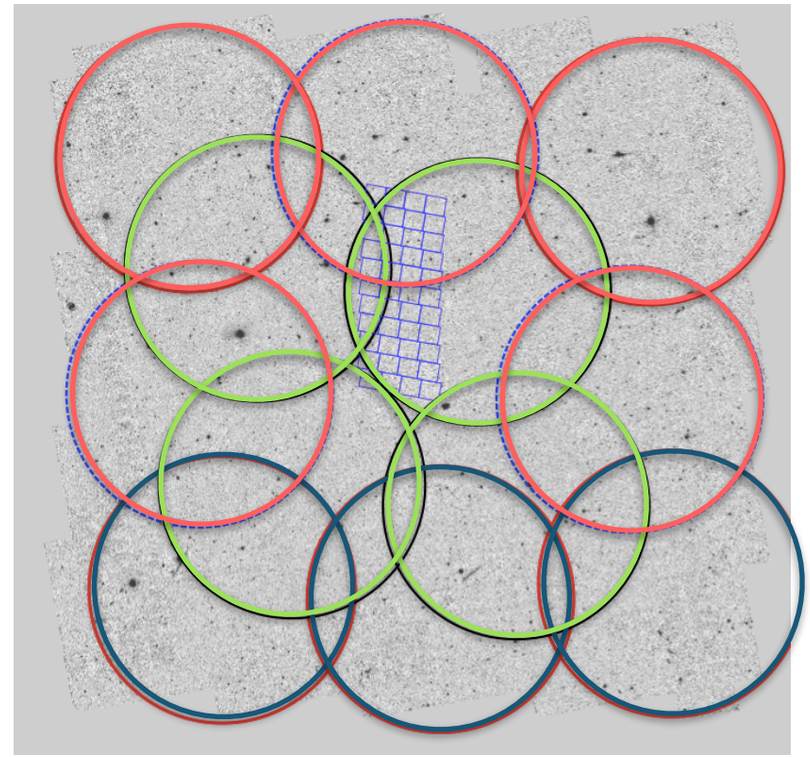
Data products

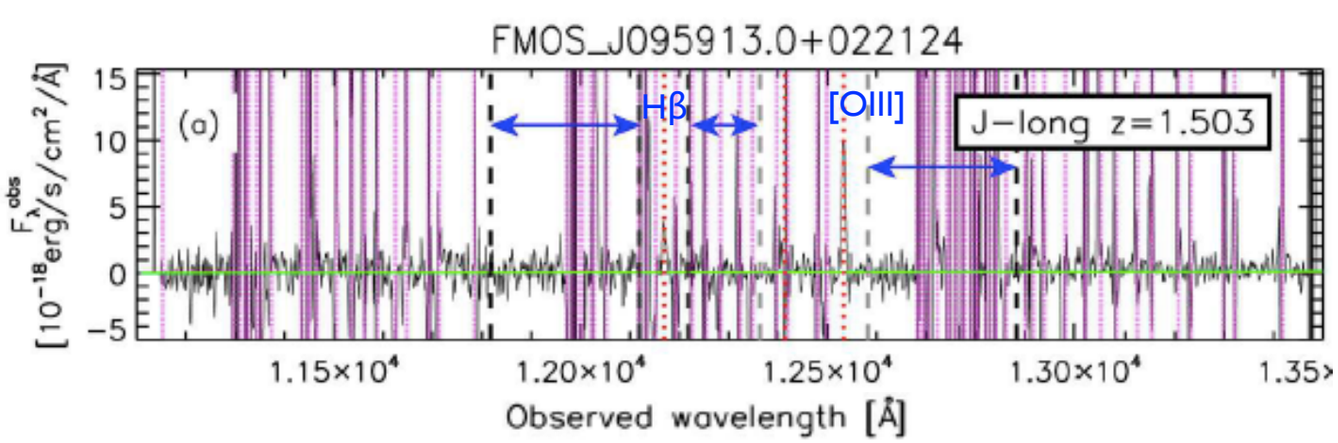
- Emission-line survey of star-forming galaxies in COSMOS
- 60 nights (2012 - 2016)
  (split between NAOJ and University of Hawaii)

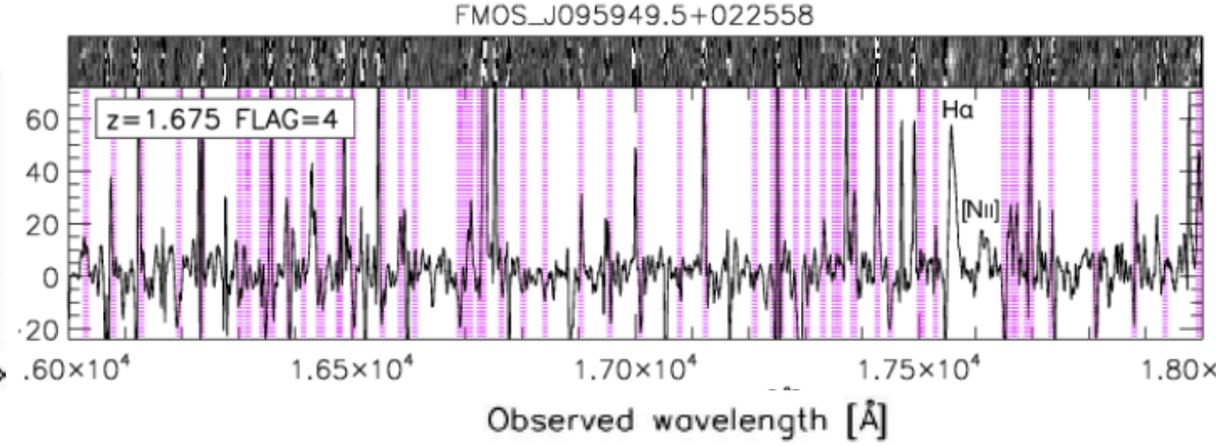
- $1.46 < z < 1.63$

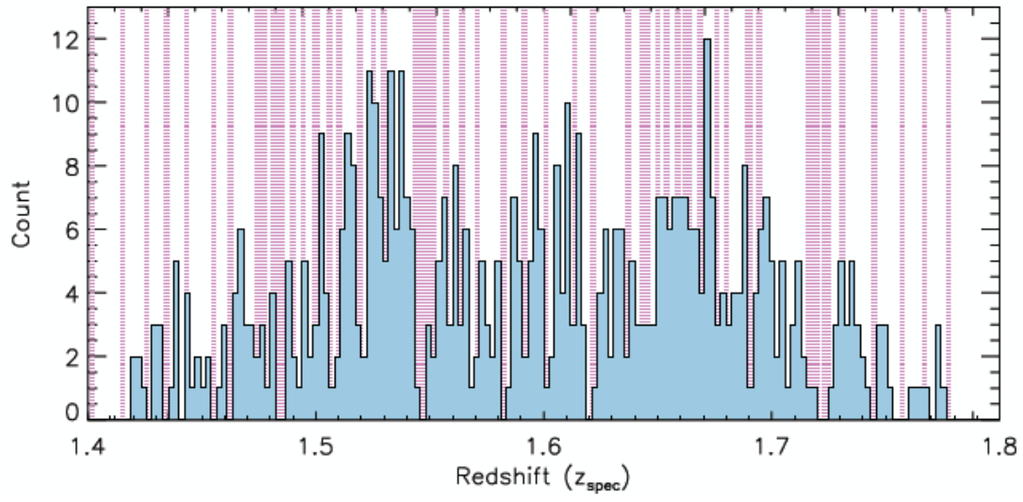
- H-long grating (1.6-1.8 μm)
  - ✳ Hα, [NII] and [SII]

- J-long grating (1.11-1.35 μm)
  - ✳ Hβ, [OIII]5007









1449 redshifts
(39% success rate)

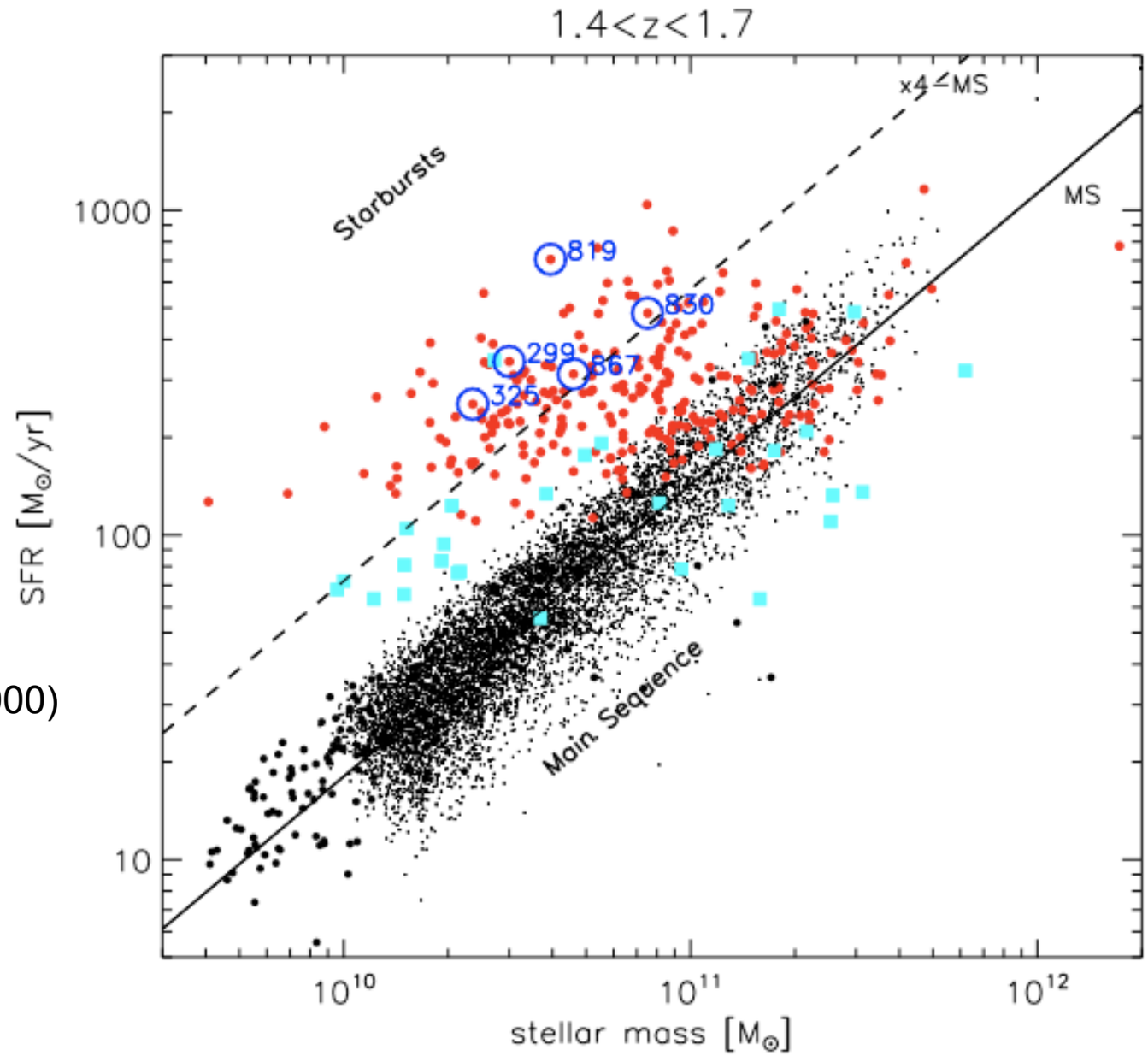
JDS et al. 2015, ApJS, 220, 12

Target selection

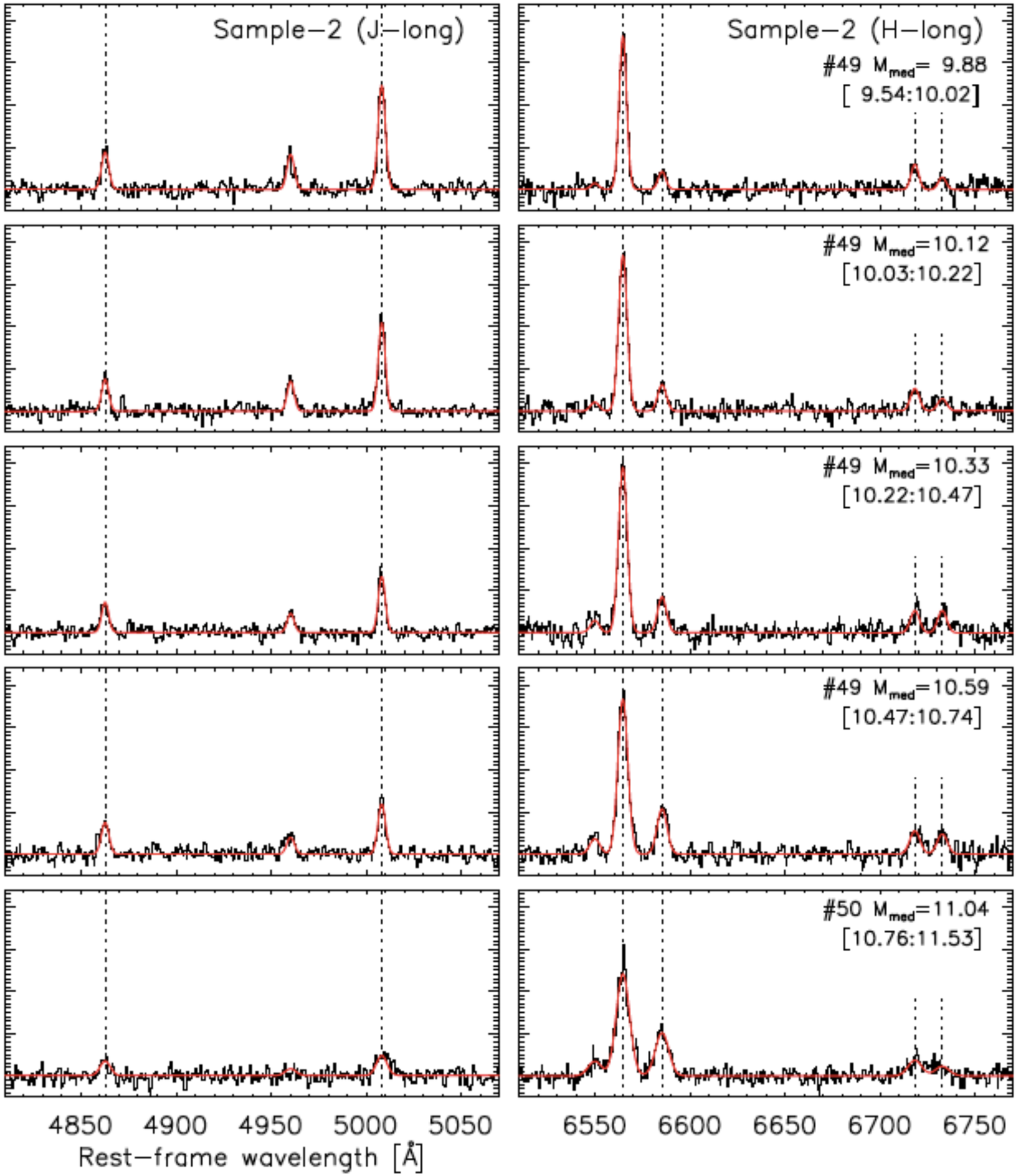
- star-forming galaxies
  - K-selected (K < 23.5)
  - $M_* > 10^{10}\ M_\odot$
  - sBzK
  - along the star-forming main sequence
  - $f_{H\alpha} > 4 \times 10^{-17}$ erg cm^{-2} s^{-1}
    - SFR: B-band
    - E(B-V): B-z color
    - $E(B-V)^{neb} = E(B-V)^{stellar}/0.44$ (Calzetti et al. 2000)

- Herschel/PACs sources
  - highly obscured SF galaxies
  - above or on M-S
  - near bright stars for future IFU/AO observations

- AGNs (X-ray sources)



Rodighiero et al. 2010

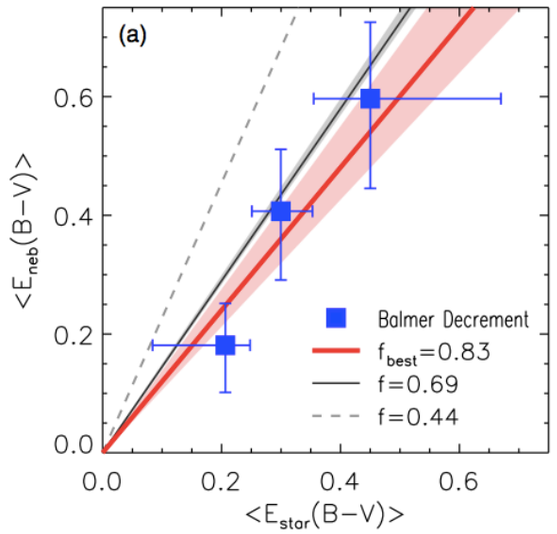

Sample−2 (J−long)
Sample−2 (H−long)
#49 M$_{med}$= 9.88
[9.54:10.02]
#49 M$_{med}$=10.12
[10.03:10.22]
#49 M$_{med}$=10.33
[10.22:10.47]
#49 M$_{med}$=10.59
[10.47:10.74]
#50 M$_{med}$=11.04
[10.76:11.53]
4850
4900
4950
5000
5050
6550
6600
6650
6700
6750
Rest−frame wavelength [Å]

Brief overview of results to date

Dust properties:

Kashino et al. 2013, ApJL

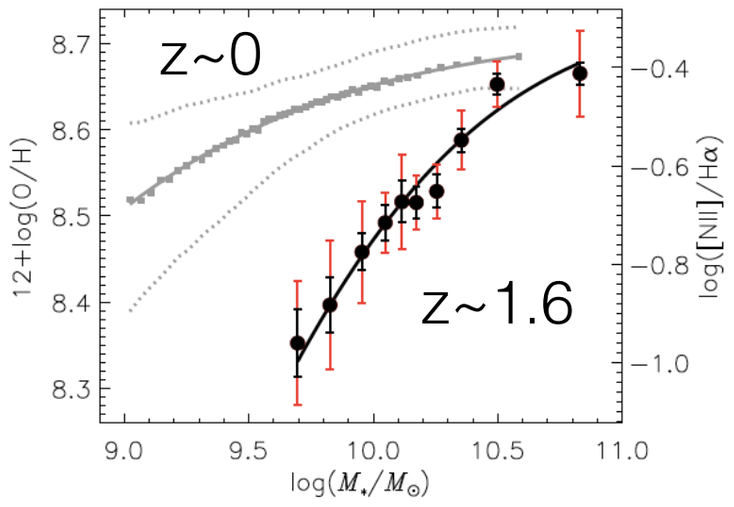
Different than local starbursts



Mass - metallicity relation:

Zahid et al. 2014a,b

Evolves with redshift
Steeper than UV-selected samples
Massive galaxies at local level of enrichment
Some evidence for an FMR



ISM conditions:

Kartaltepe et al. 2015, ApJL
Kashino et al. 2017

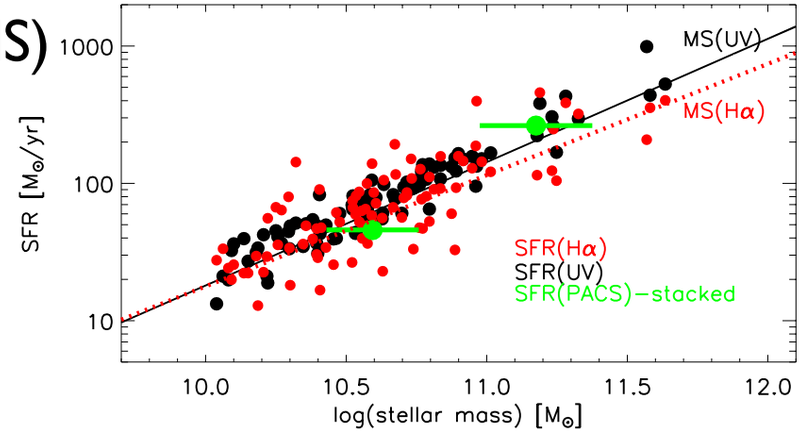
Elevated ionization state
High-z galaxies offset from local BPT relation

Star formation rates:
(corrected for dust)

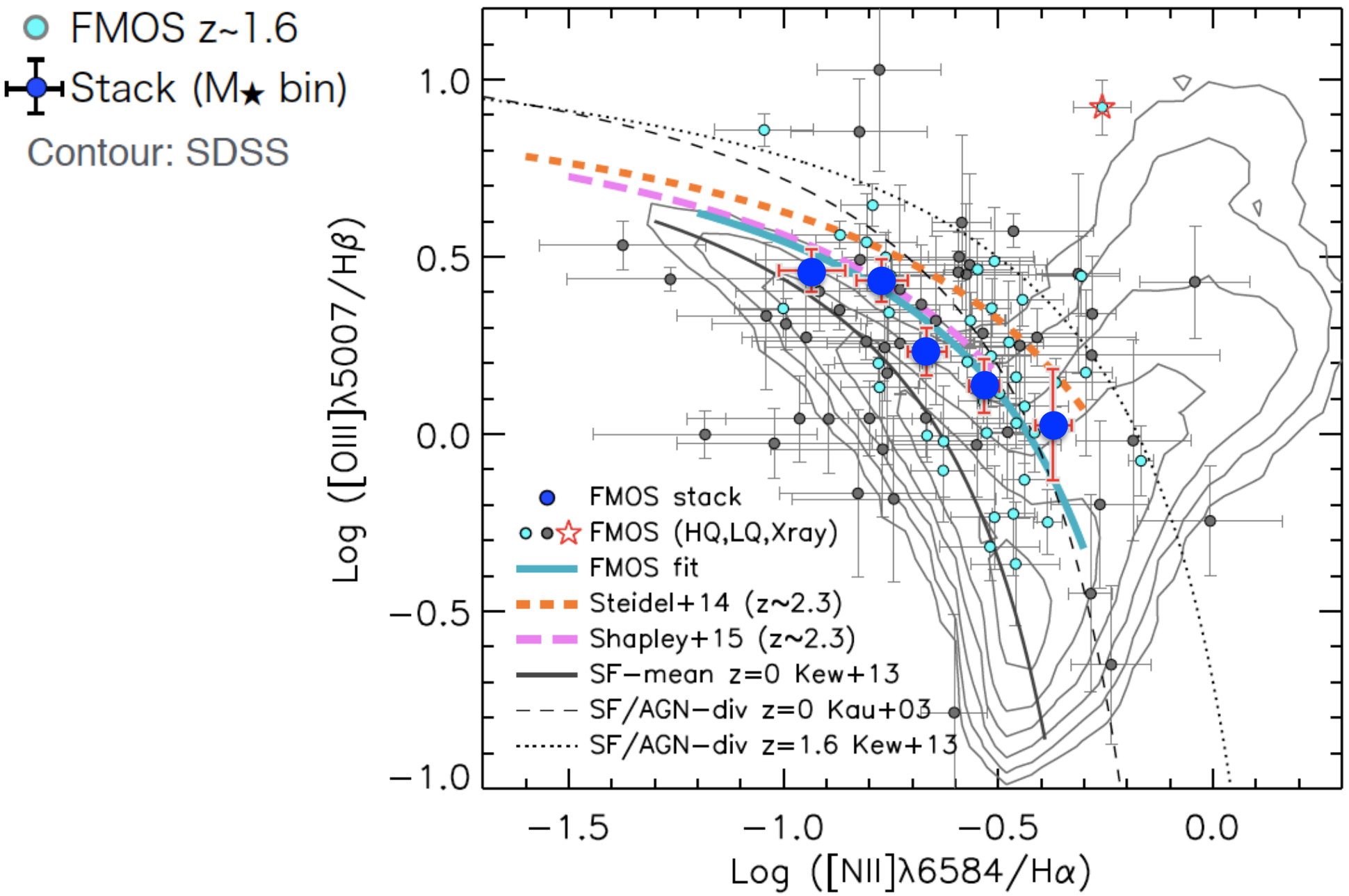
Rodighiero et al. 2014

Tight star-forming main sequence (MS)

Agreement between IR, UV and FIR SFRs for MS galaxies using local calibrations



Ionization conditions in high-z galaxies



Kashino et al. 2016; arXiv:1604.06802

Kewley et al. 2013; Masters et al. 2014; Steidel et al. 2014; Zahid et al. 2014; Shapley et al. 2015; Coil et al. 2015; Kartaltepe et al. 2015; Sanders et al. 2016

Works in progress

Clustering of Hα-emitting galaxies (Daichi Kashino)

ISM properties of starbursts (Annagrazia Puglisi)

Molecular gas content of starbursts (JDS)

Hα number counts and luminosity function (L. Tasca, O. Le Fevre)

[OII] followup of FMOS sample using Keck and VLT
(P. I. L. Kewley-ANU and S. Juneau-CEA Saclay)

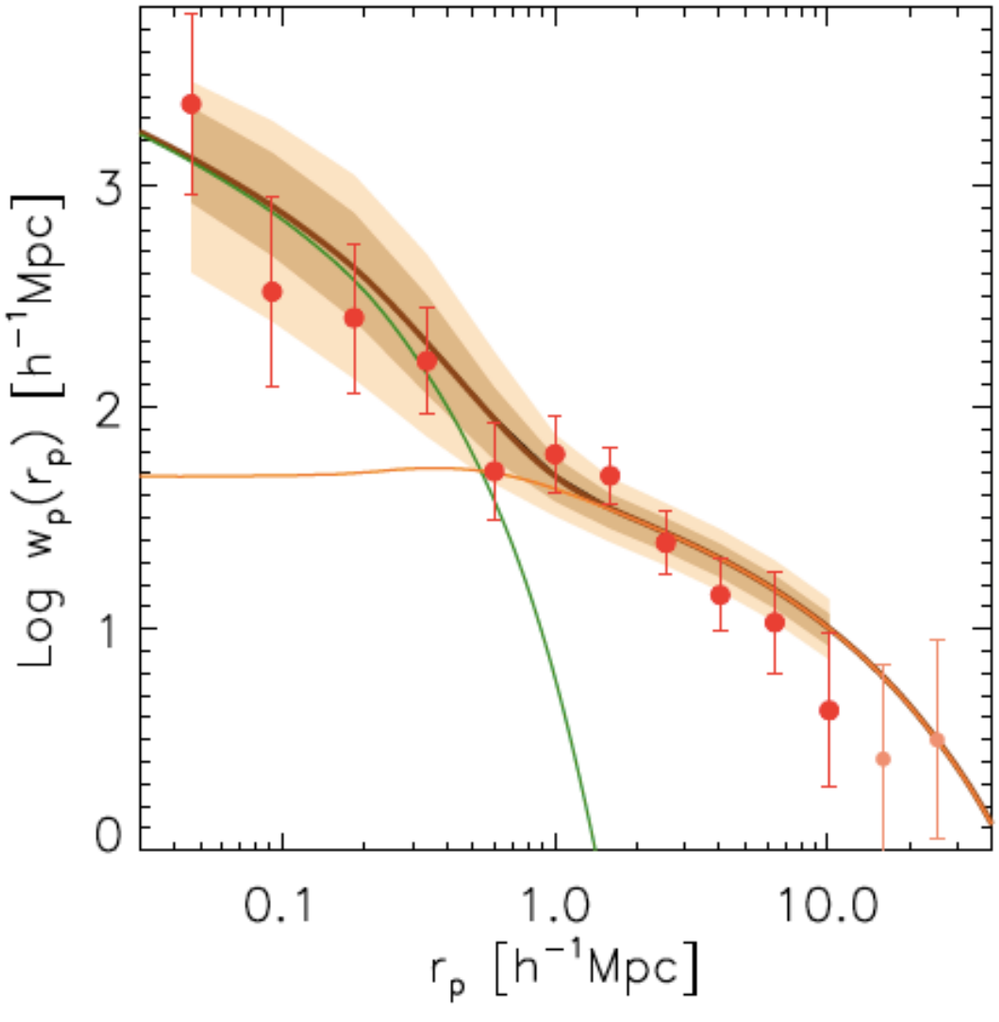
Molecular excitation of starbursts with IRAM and VLA (D. Liu, E. Daddi)

Future efforts: AGNs, ALMA followup, focus on most massive galaxies

Galaxy-DM halo connection

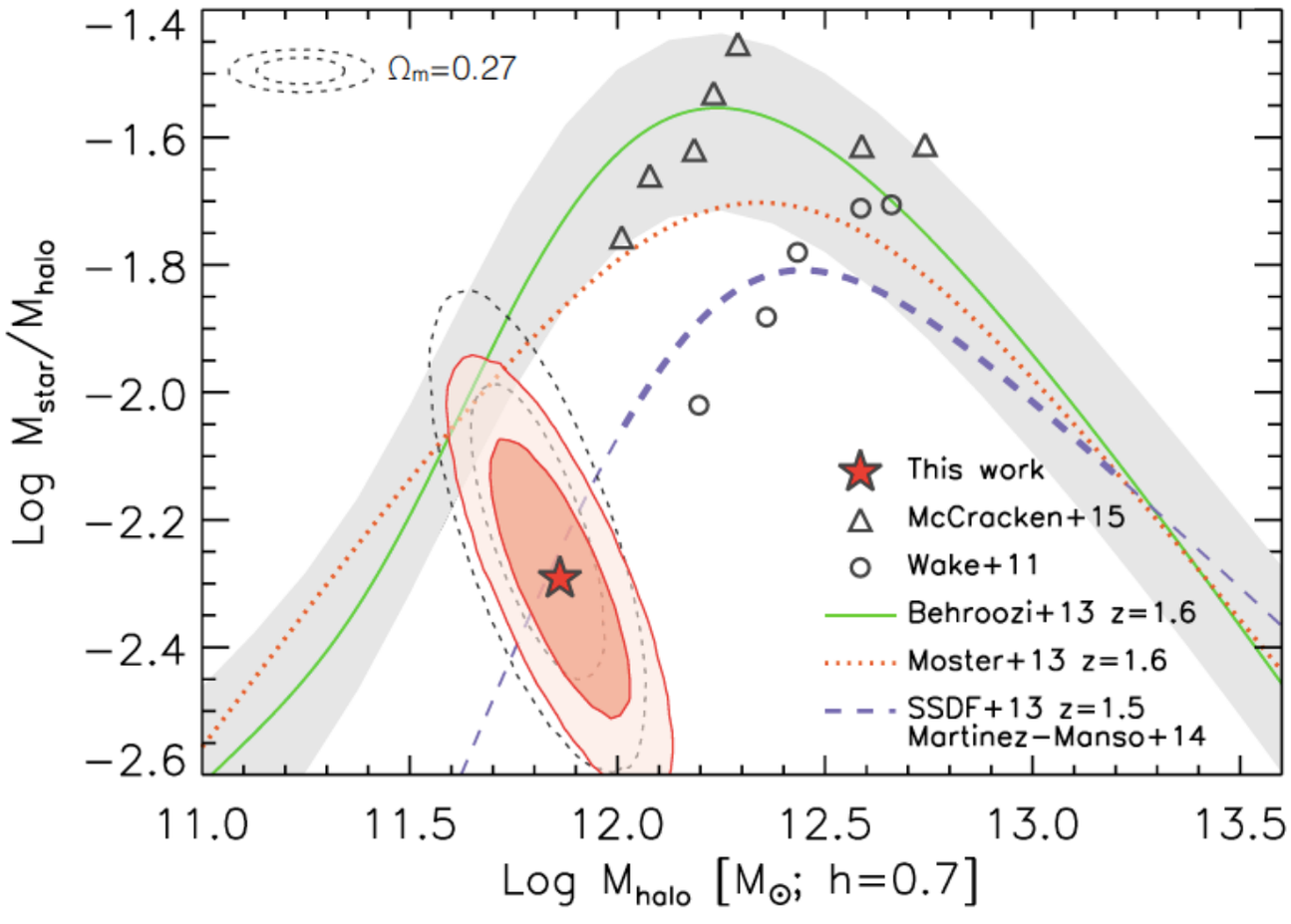
Kashino et al. submitted soon

- Correlation function with **500 z_{spec}'s**
- HOD modeling
  - Significant **one-halo** term
  - Effective constraints on the HOD parameters



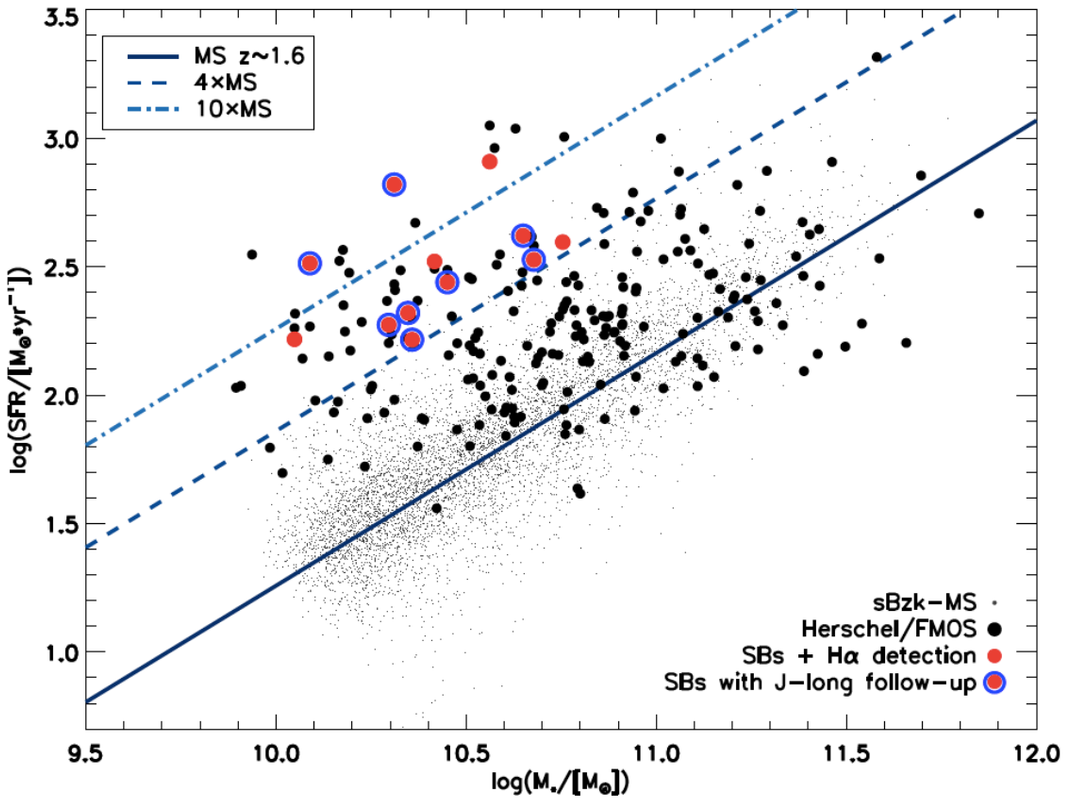
- On average, SF galaxies at z~1.6 ($M_\star > 10^{9.8} M_\odot$) **live in a few × 10^{12} $M_\odot$/h haloes.**

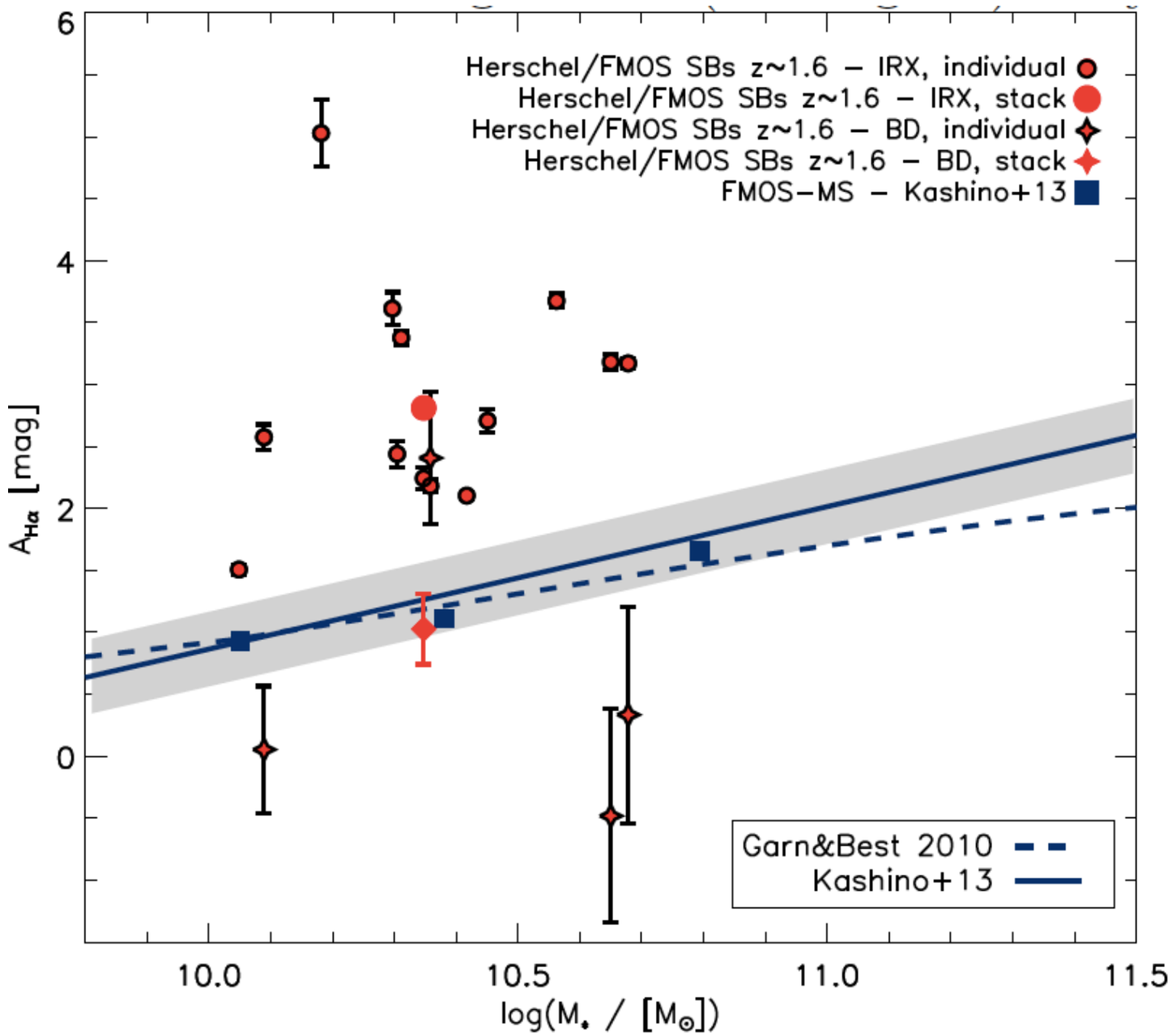
Stellar-to-halo mass ratio



ISM extinction and metallicity of starbursts at z ~ 1.6

Annagrazia Puglisi, Giulia Rodighiero (University of Padova)

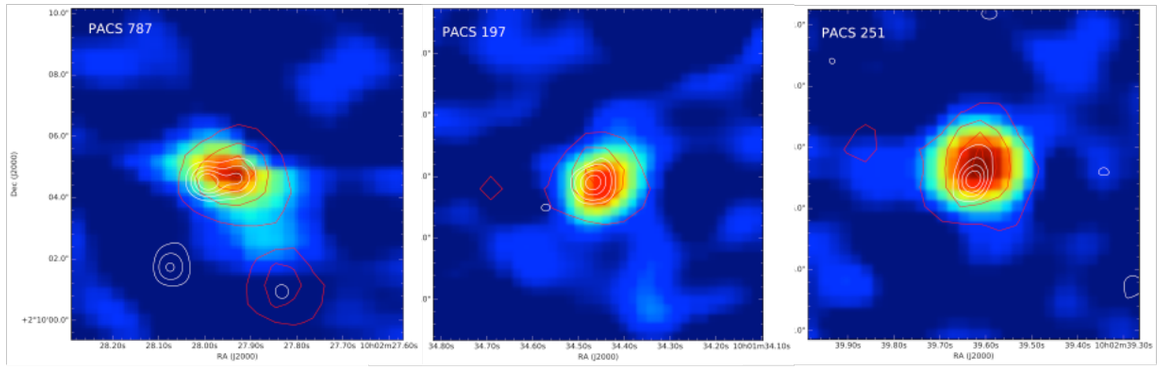


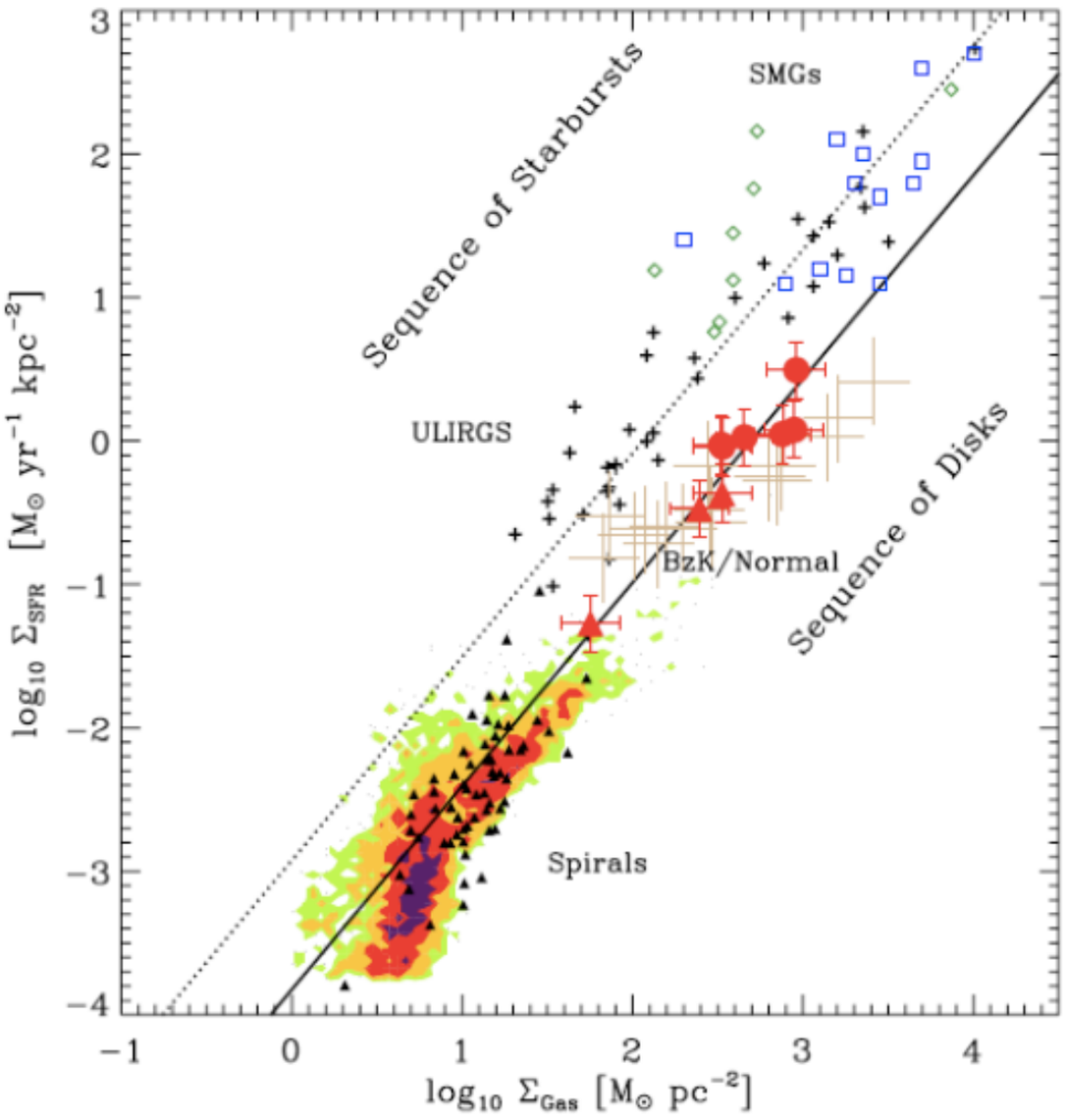


$L_{IR}/L_{H\alpha}$ (obs)

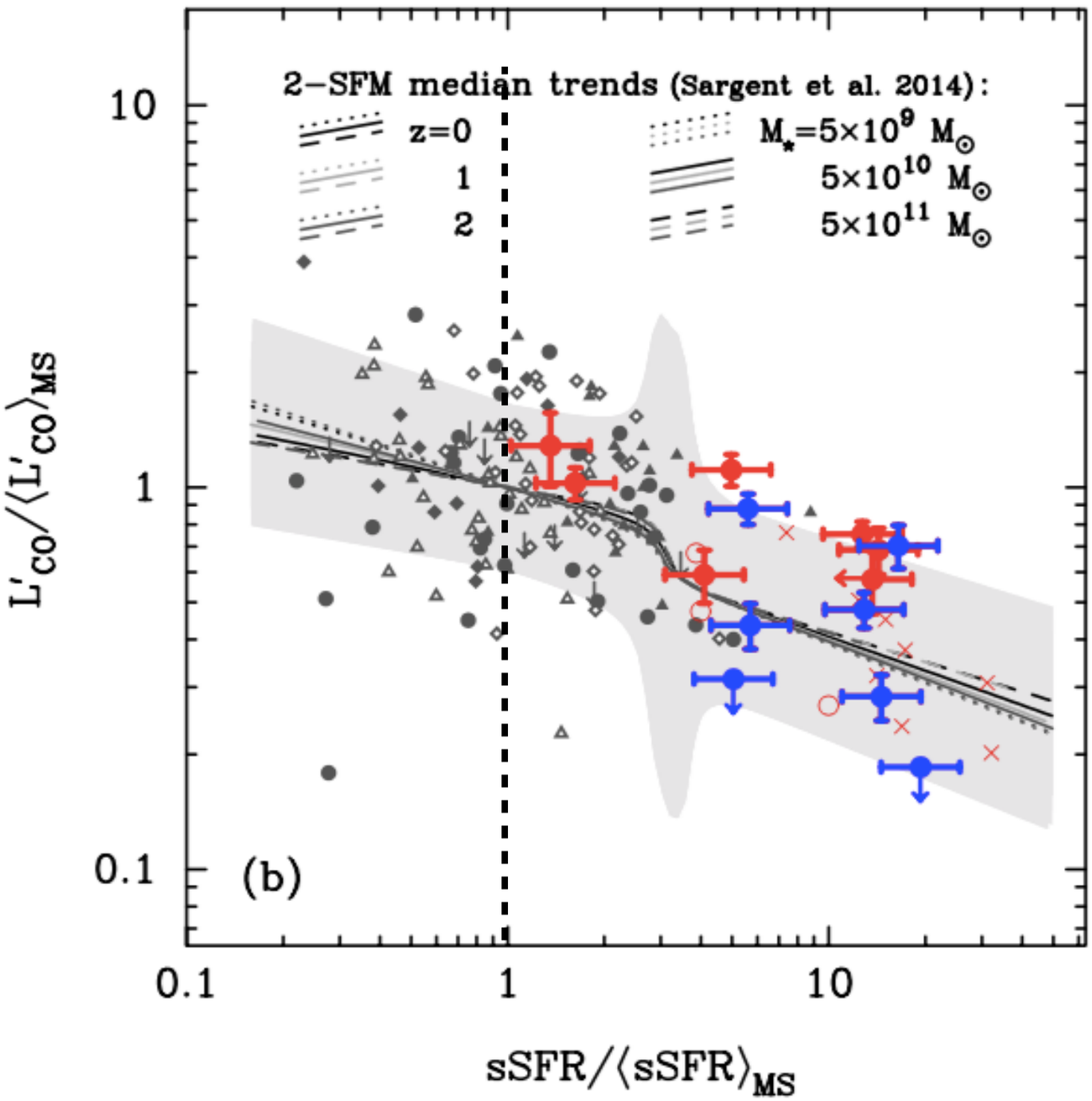
ALMA CO 2-1 study of starbursts at z ~ 1.6

(Cycle 1 + 3)





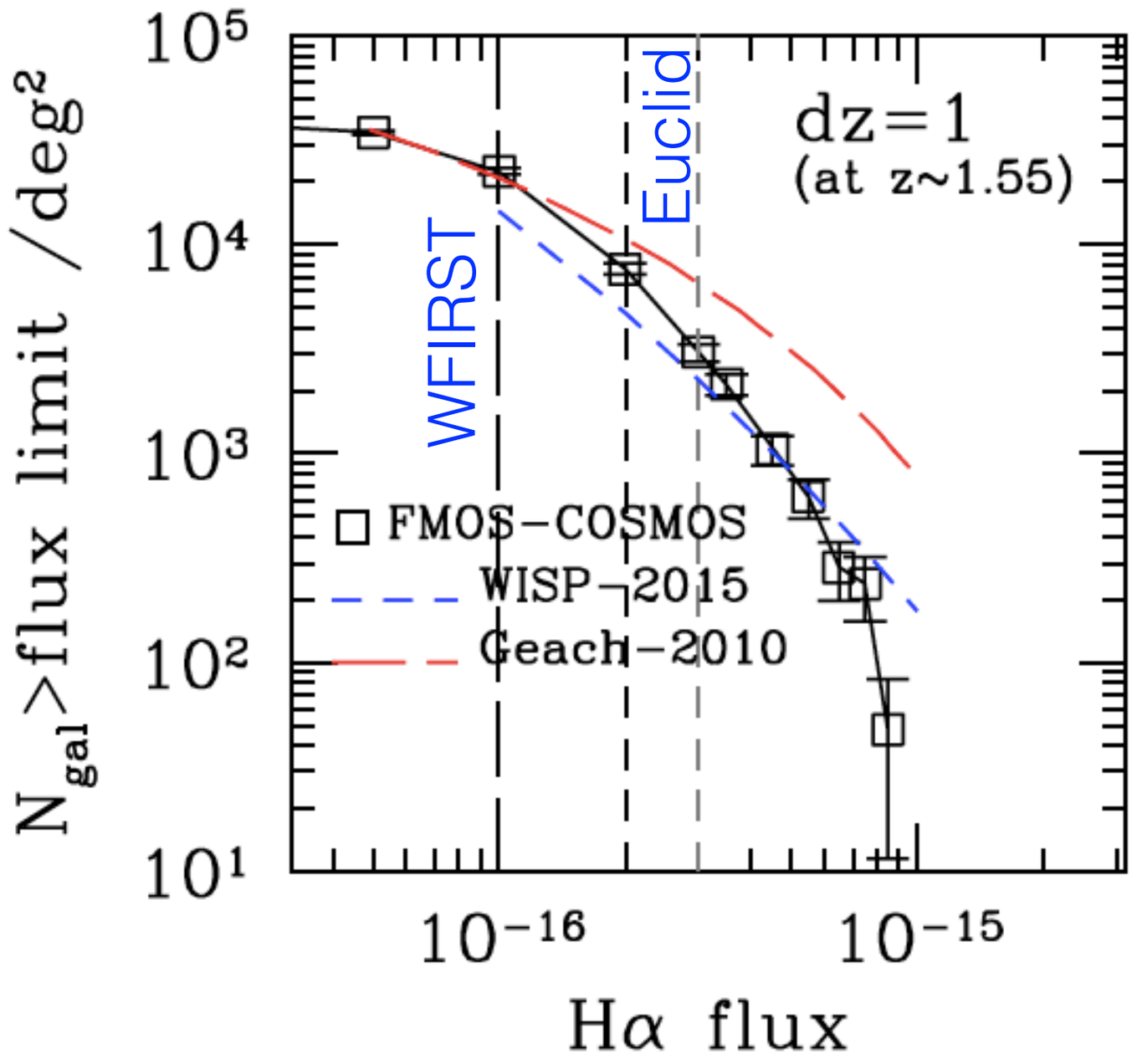
Daddi et al. 2010; Genzel et al. 2010



JDS, Daddi et al. 2015 (ApJL), 2016 (in prep)

Increase in star-formation efficiency with distance above the MS

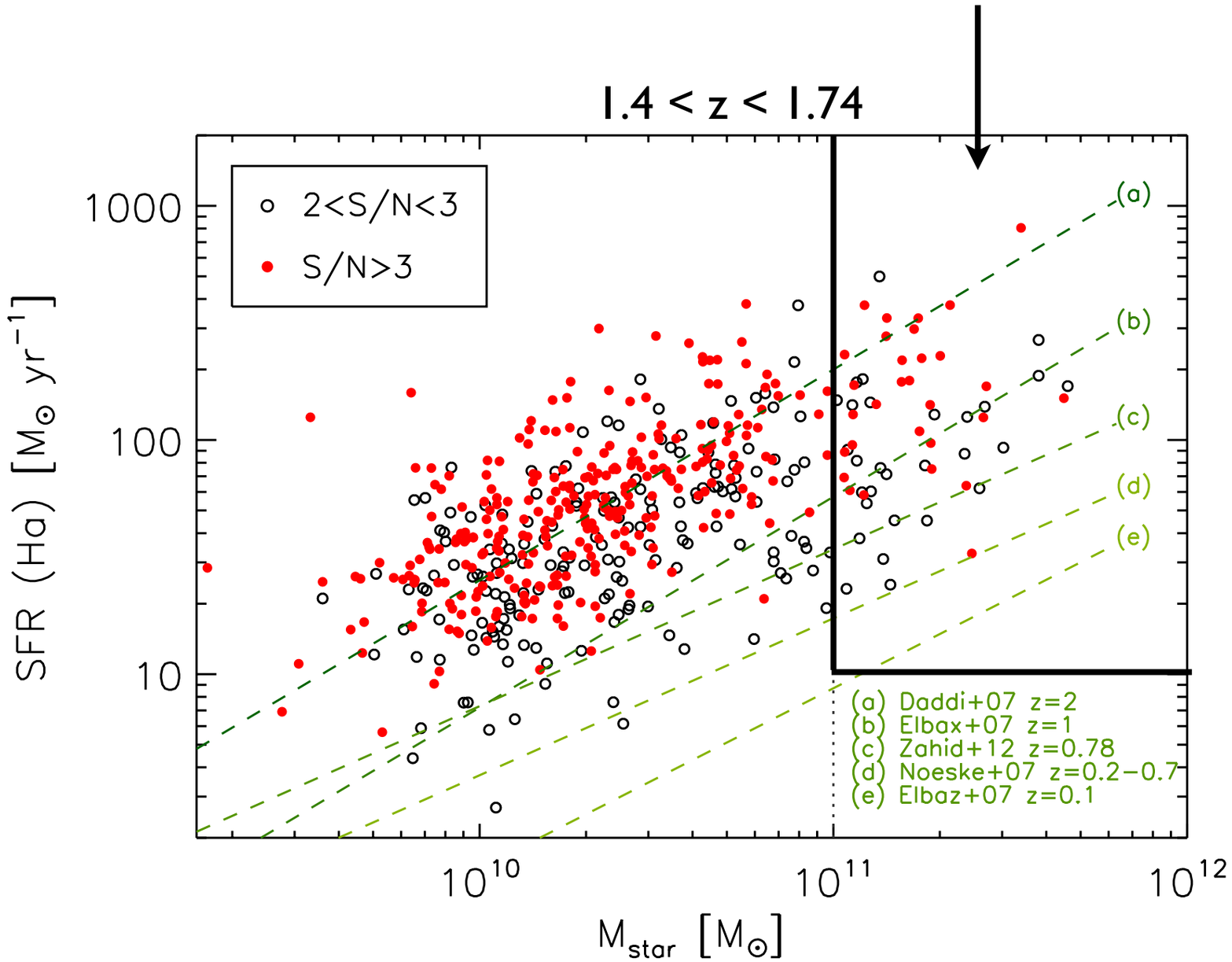
Implications on cosmology experiments at high-z (BAO, redshift space distortions)



Tasca, JDS, Le Fevre et al. in prep

FMOS-COSMOS Intensive Program I1+III:
Rare key populations - Massive galaxies and AGN

Lack of massive galaxies at z > 1 in all NIR samples



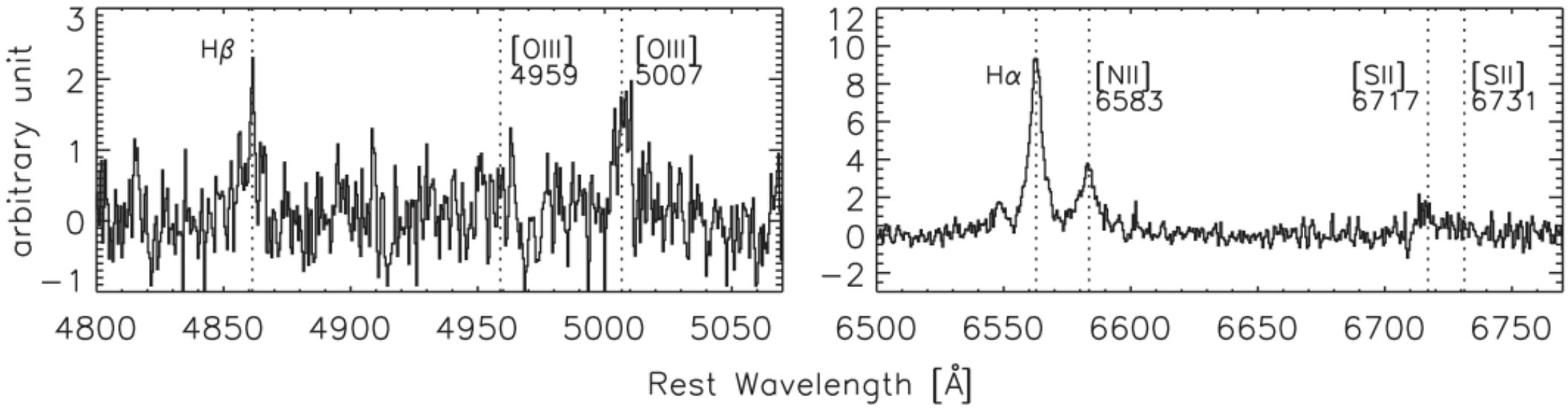
Acquired over 100 massive ($M > 10^{11}\ M_\odot$) galaxies at $z \sim 1.6$

FMOS-COSMOS Intensive Program II+III:
Rare key populations - Massive galaxies and AGN

J-long followup (1.1.-1.35 μm; Hβ, [OIII]5007)
of galaxies with positive Hα detections

- Improve the number of individual Hβ and [OIII]5007 detections
- Higher S/N detection with average line strengths

Stack of 25 (J-long) and 68 (H-long) massive (log Mstellar > 11) galaxies



Final remarks

- FMOS spectroscopy fills a void in the wide spectroscopic redshift coverage of COSMOS, a key extragalactic survey field and an HSC Ultradeep field

- FMOS spectroscopy is improving photo-z estimation for HSC surveys and target selection for cosmology experiments with PFS

- All high-level data are released to the public

- Flux calibrated 1D spectra in fits format (object + error spectra)

- Redshift catalogs

- Line flux measurements

Data release from the first intensive program has been accomplished
http://member.ipmu.jp/fmos-cosmos/FMOS-COSMOS.html
(includes catalogs, 1D and 2D science grade spectra)