From FMOS to MOONS

Lessons learned from 47 Clear Subaru Nights

FMOS-COSMOS: a near-IR spectroscopic survey@Subaru

Giulia Rodighiero – University of Padova
(as part of the Team)

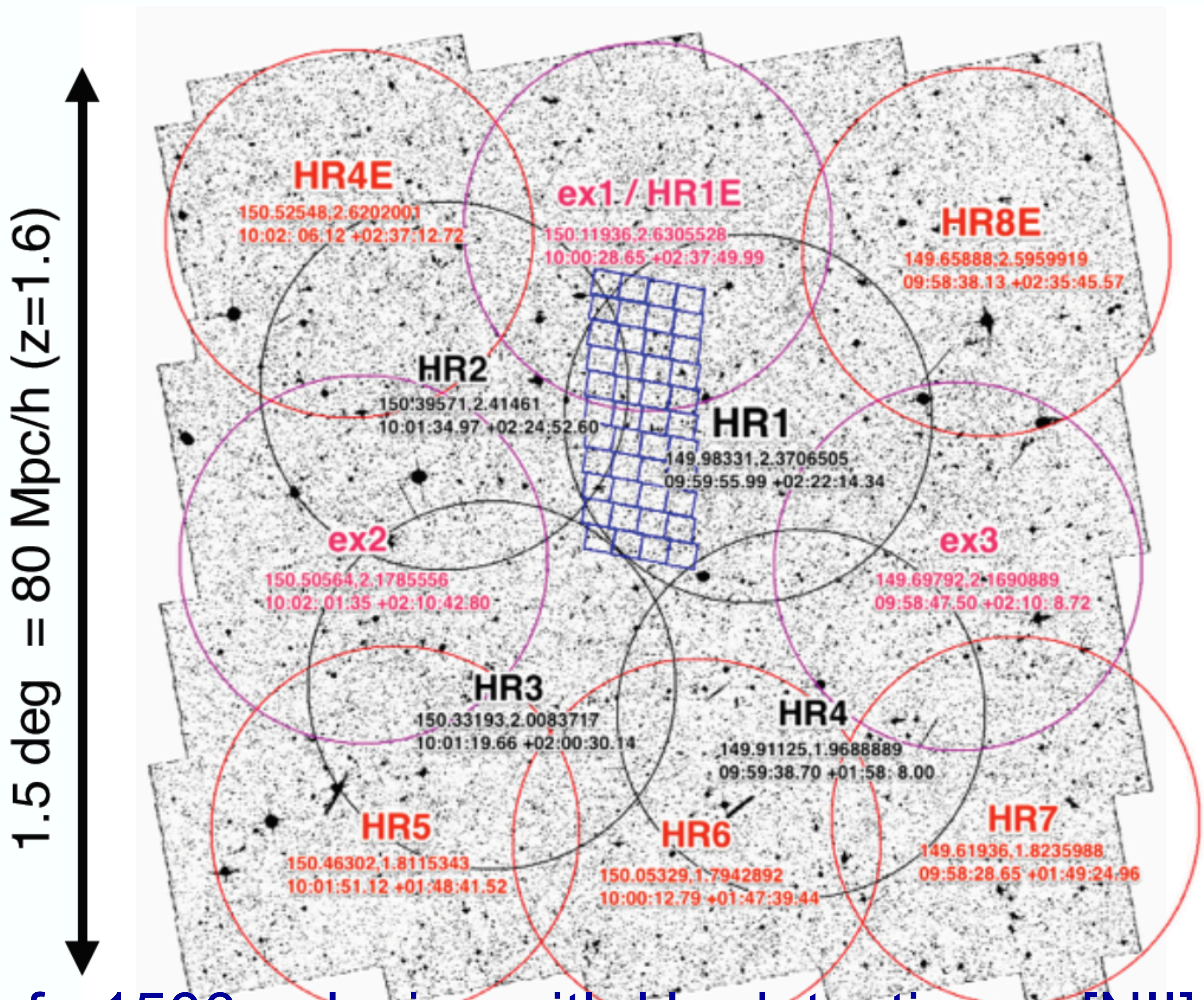
J. Silverman (PI), D. Kashino, E. Daddi, A. Renzini, C. Mancini,
A. Puglisi, N. Arimoto, D. Sanders, J. Kartaltepe, L. Kewley, J. Zahid,
et al.

The FMOS-COSMOS survey

PI:J. Silverman[Kavli IPMU], D. Sanders[Hawaii]

Period: 2012 March — 2016 April **@SUBARU**

Observed galaxies: In total, >5700 / Success rate ~30% (tentative)



Total of ~1500 galaxies with Hα detection, + [NII], [SII]

~1/3 with J-band follow up (Hβ + [OIII]), no continuum (!)

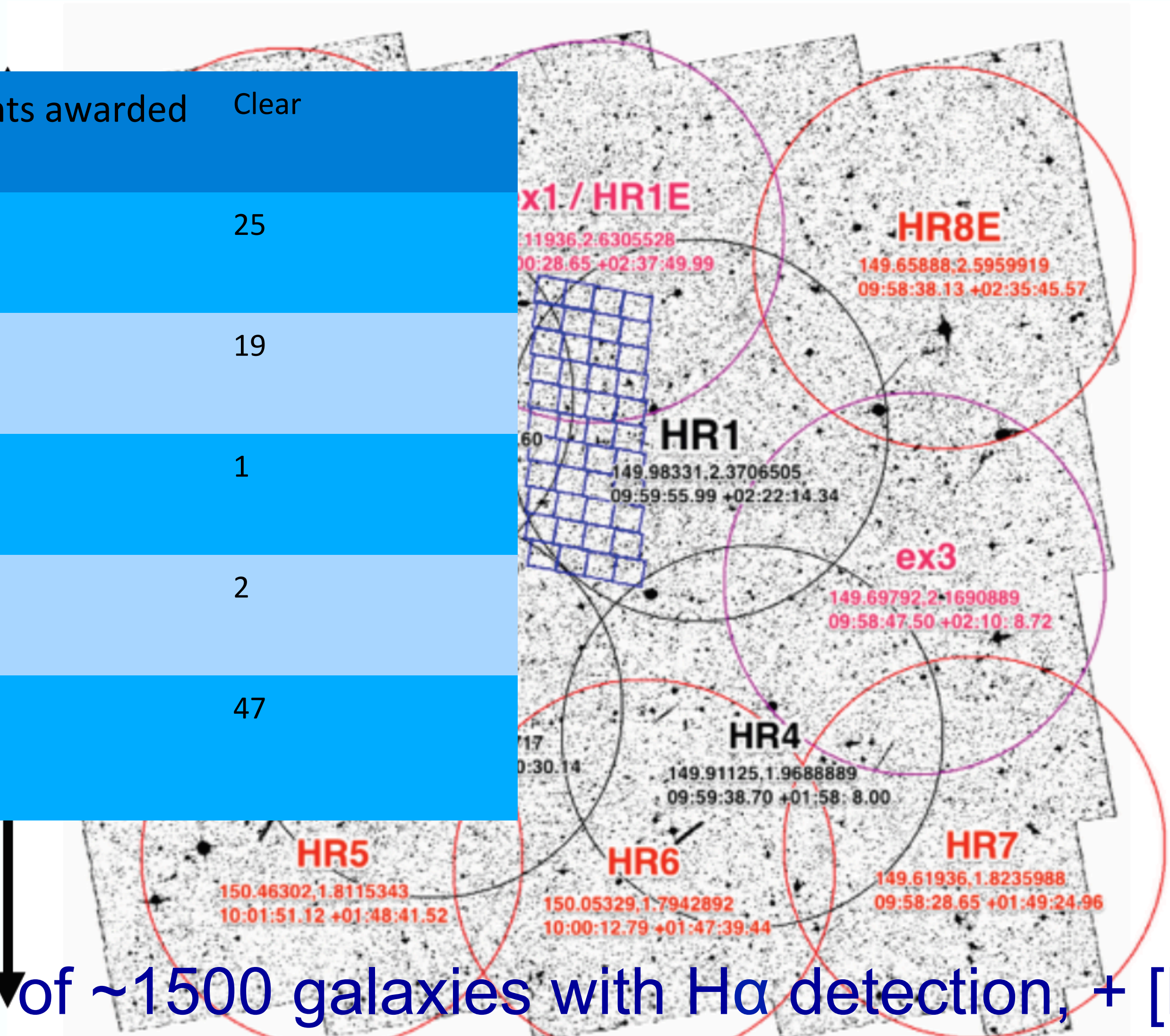
The FMOS-COSMOS survey

PI:J. Silverman[Kavli IPMU], D. Sanders[Hawaii]

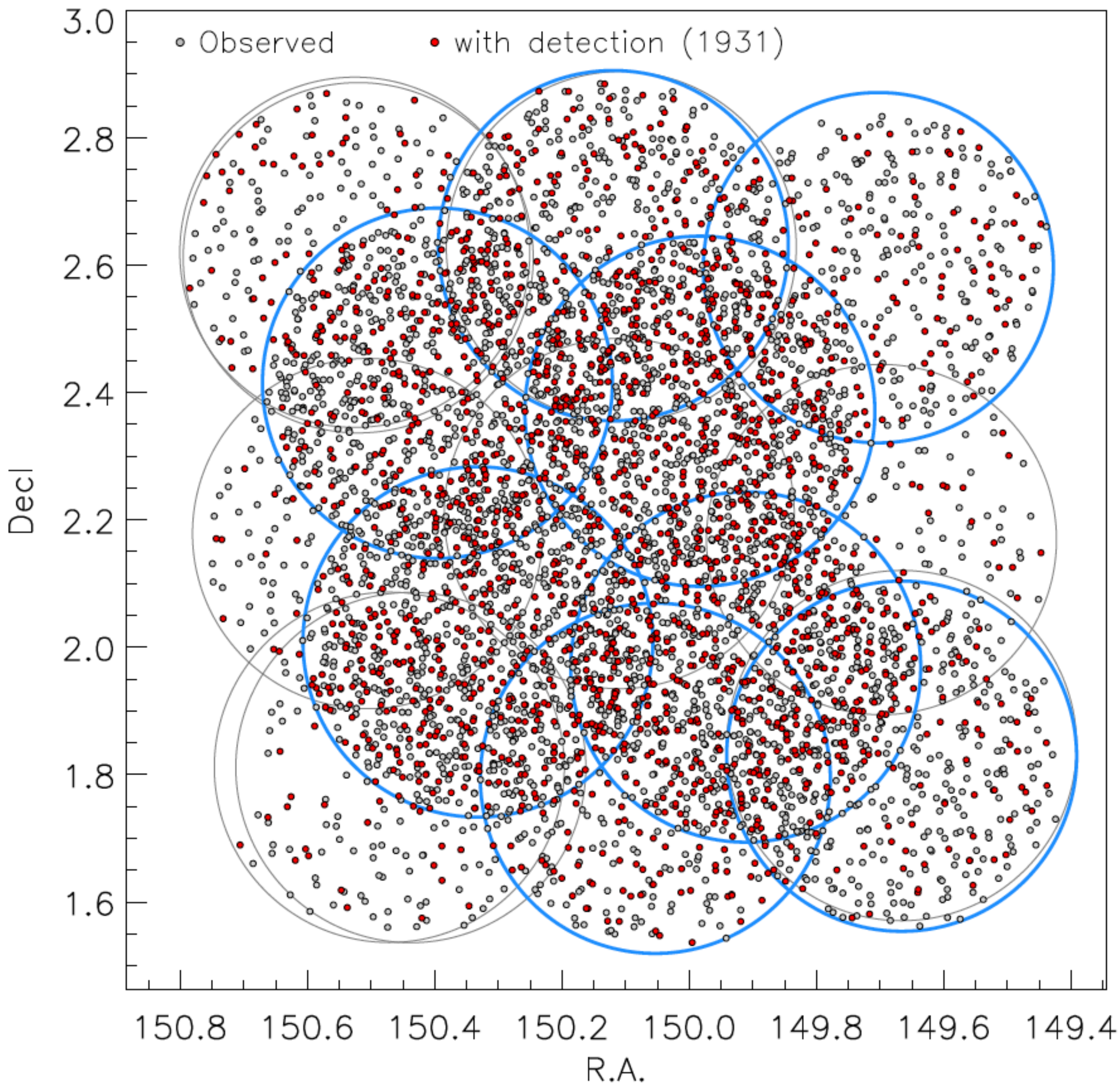
Period: 2012 March — 2016 April **@SUBARU**

Observed galaxies: In total, >5700 / Success rate ~30% (tentative)

Program	Nights awarded	Clear
Silverman	30	25
Sanders	30	19
Zahid/Kewley	8	1
Hasinger/Suh	5	2
Total:	73	47



Total of ~1500 galaxies with Hα detection, + [NII], [SII]
~1/3 with J-band follow up (Hβ + [OIII]), no continuum (!)



Observed
with detection (1931)
Decl
R.A.
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
150.8
150.6
150.4
150.2
150.0
149.8
149.6
149.4

Target selection for *z*=1.6 star-forming galaxies

For the FMOS H-long spectroscopy, we preferentially selected galaxies that satisfy the criteria listed below.

1. $K_S \leq 23.5$, a magnitude limit on the Ultra-VISTA K_S-band photometry (auto magnitude).
2. $1.46 \leq z_{\rm phot} \leq 1.72$, a range for which H$\alpha$ falls within the FMOS H-long spectral window.
3. $M_* \geq 10^{9.77}\ M_\odot$ (for a Chabrier IMF)
4. Predicted total (*not* in-fiber) Hα flux $F_{\rm H\alpha}^{\rm pred} \geq 1 \times 10^{-16}$ erg s^{-1} cm^{-2}.

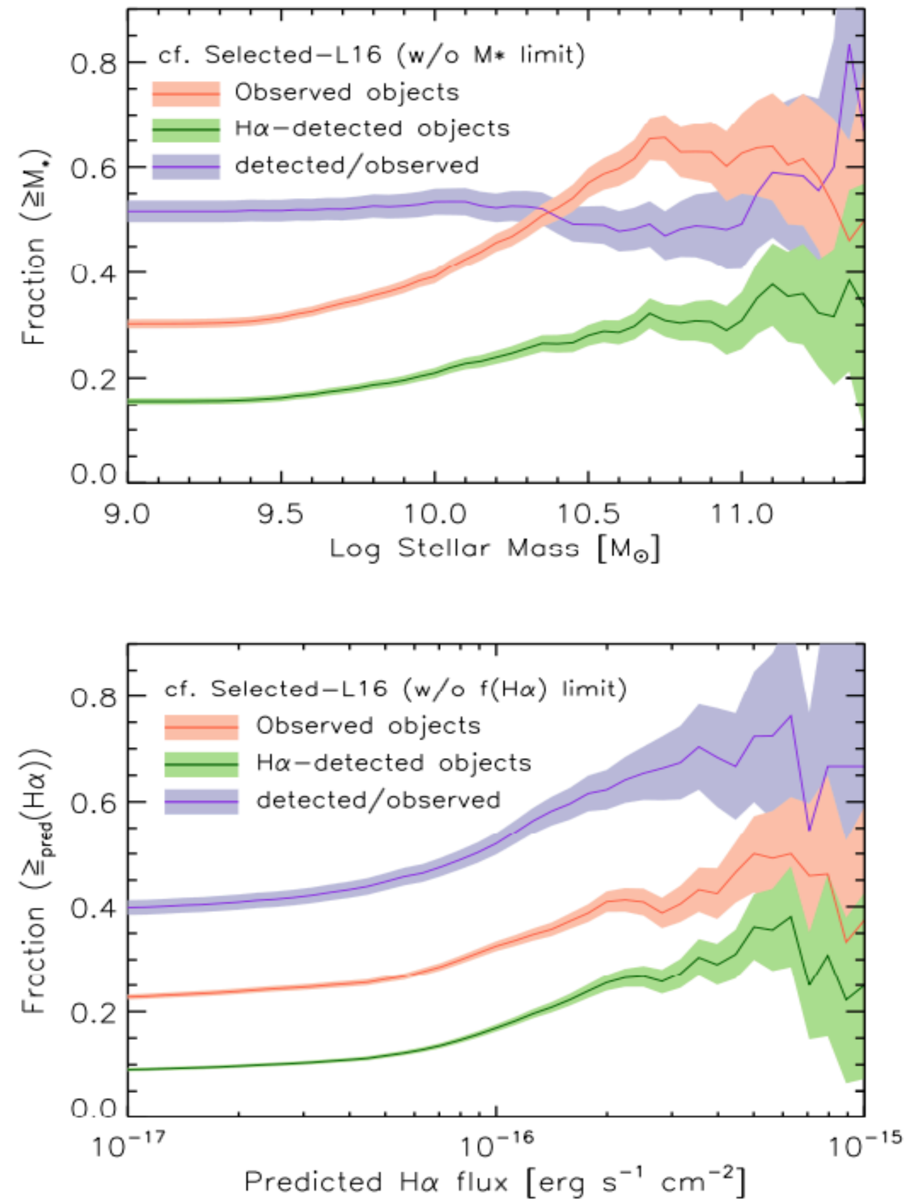
+

A sample of 200 IR luminous Herschel + Spitzer sources at 1.4<z<1.7

FMOS-COSMOS Success Rate on z~1.6 SF Galaxies

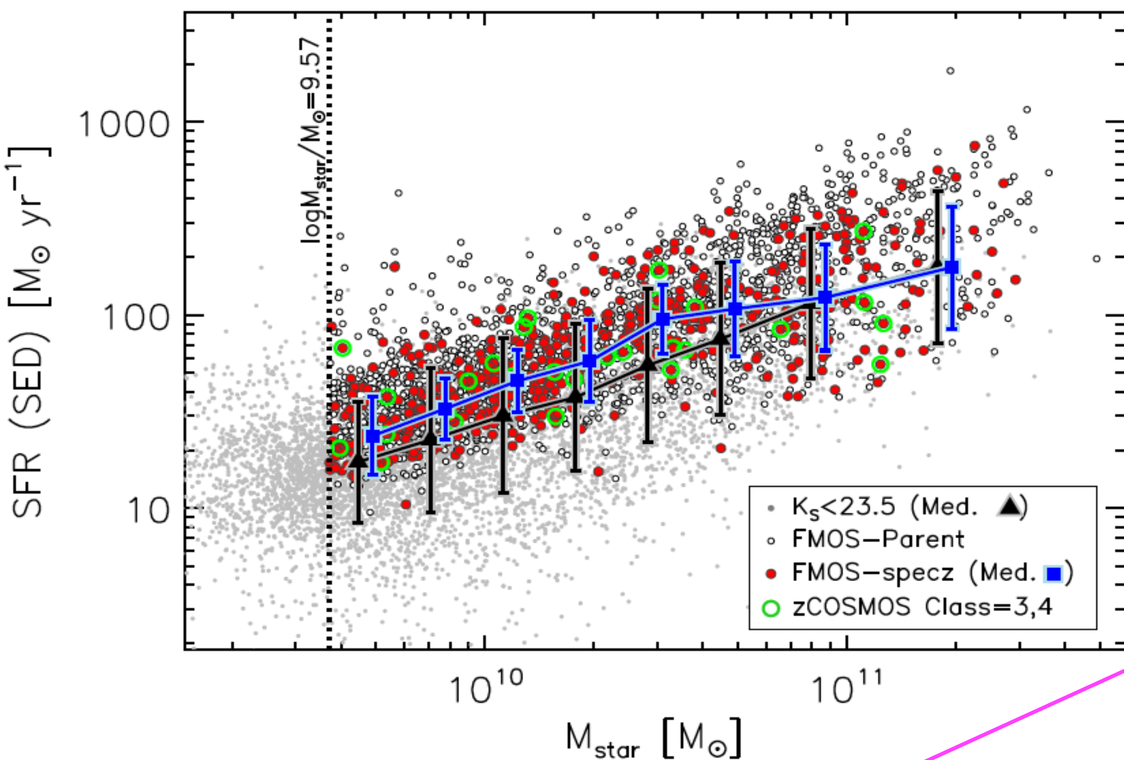
The FMOS-COSMOS success rate (=Hα detected/observed) was ~50%
Some 30% of Hα lines were blocked by the OH suppression mask or fell in the gap between the J and H bands. So, apart from this, the actual success rate was ~70%.

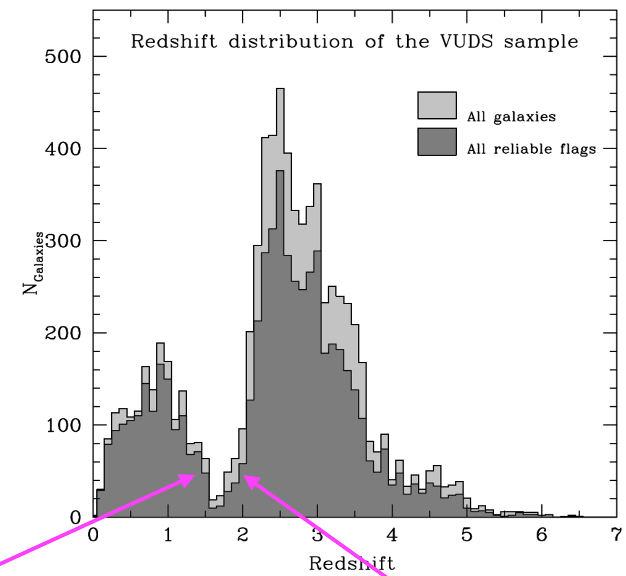
Morale: even if MOONS will be ~30x better than FMOS (in terms of total grasp), OH glow and atmospheric transmission may prevent MOONS from reaching a success rate well above ~80%, though R=4000 should help.



Kashino et al. (arxiv:1812.01529)

FMOS-COSMOS in a Nutshell

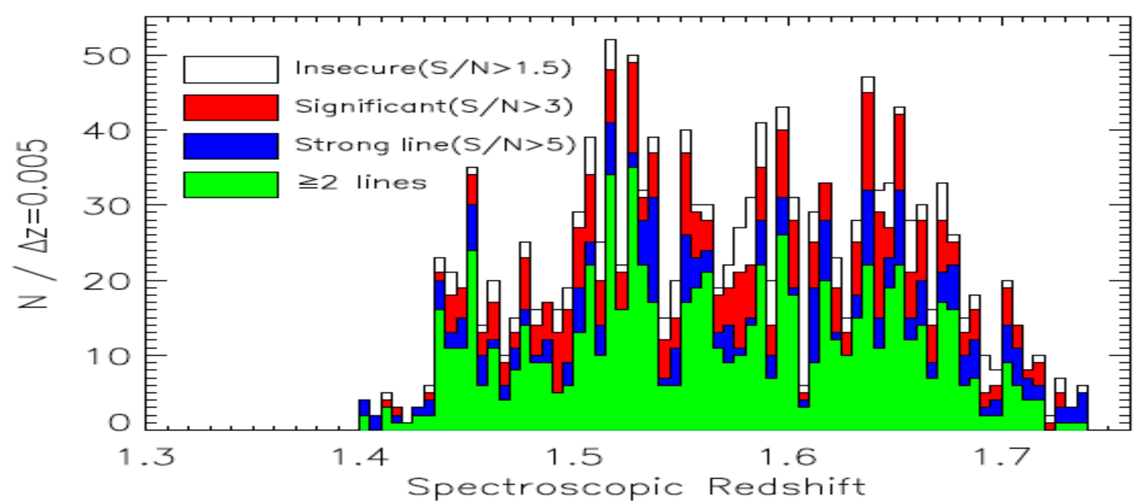




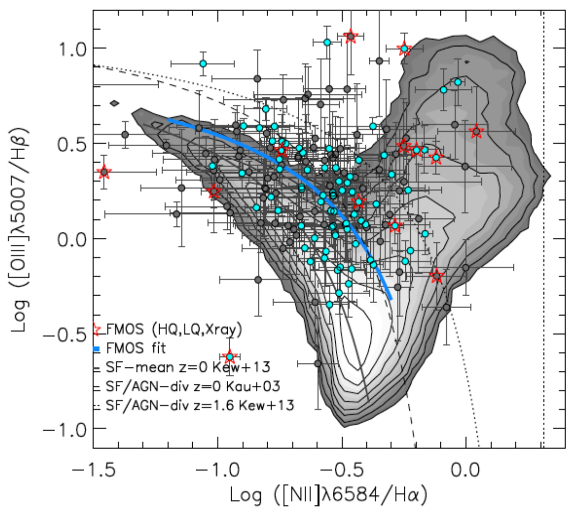
Filling the desert

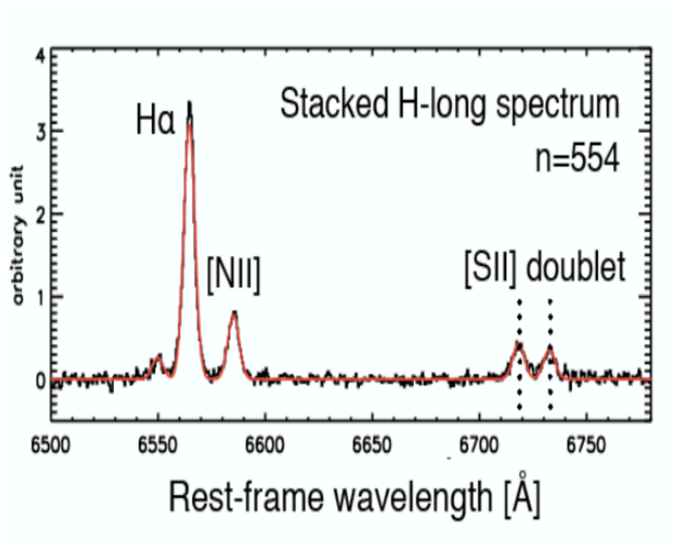
~30% of the photons die
on the OH suppressor mask

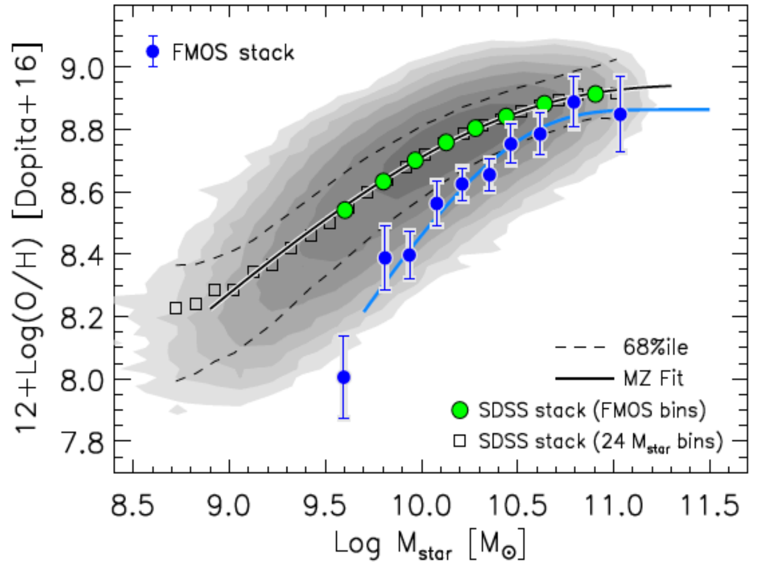
Resolution R ~ 3000
Integration time: 5h or more
400 fibers (200 targets, 200 sky, nodding)
Max throughput ~7%



FMOS-COSMOS in a Nutshell







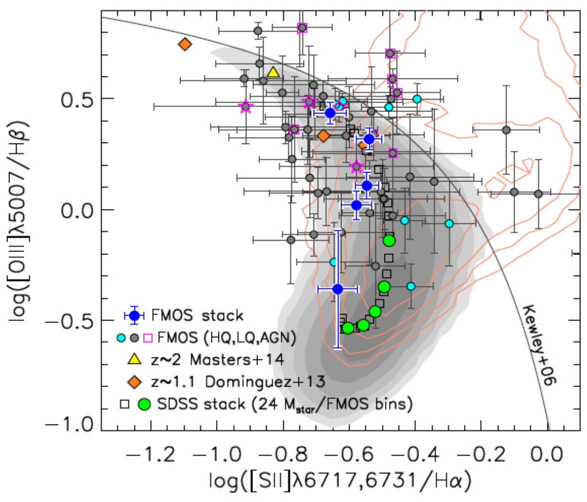


Figure 9. S2-BPT

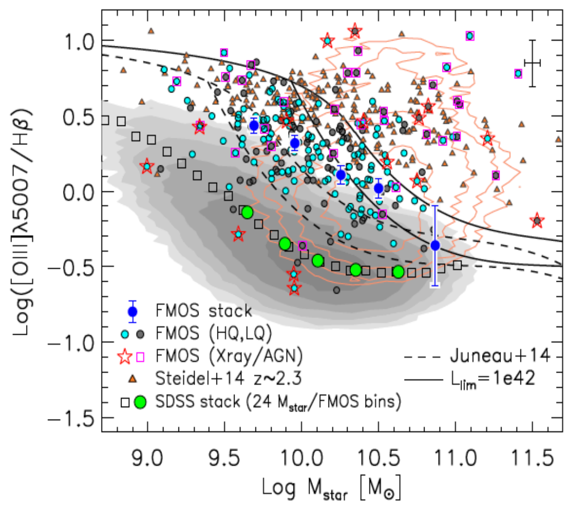


Figure 6. Mass excitation diagram.

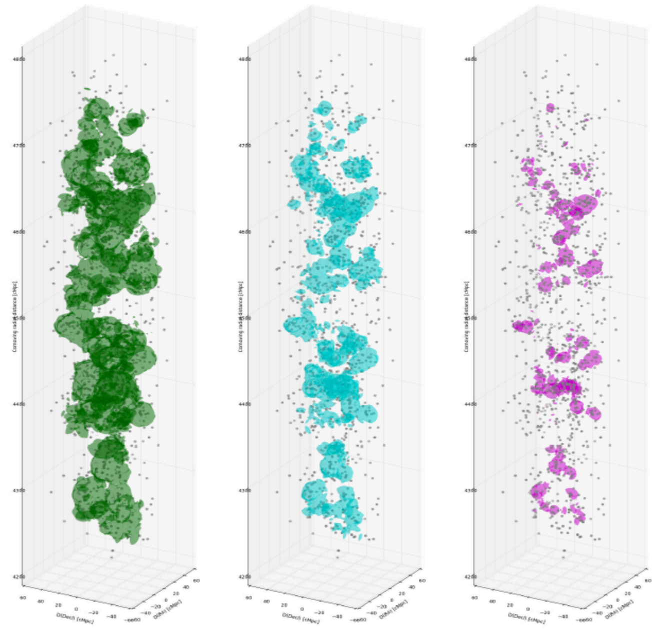
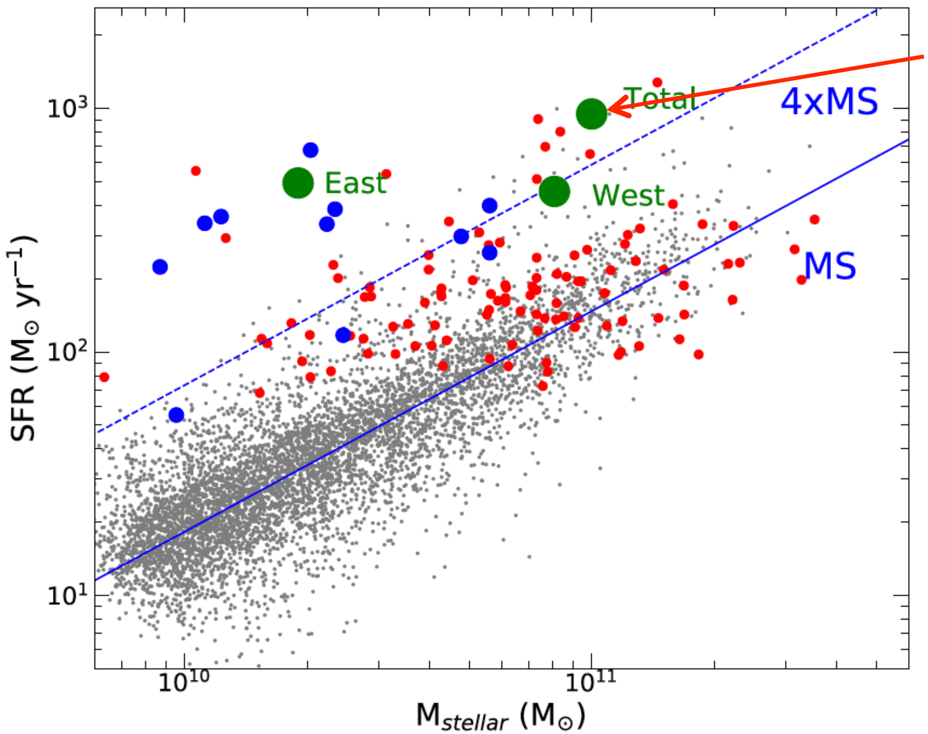


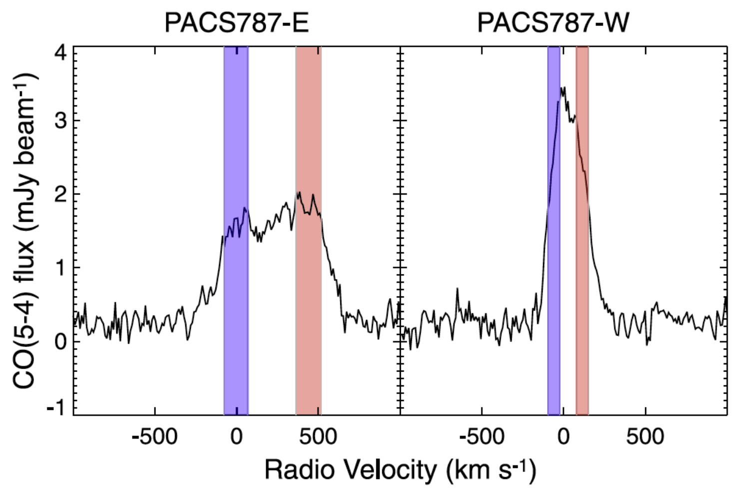
Figure 3. Reconstructed galaxy density map.

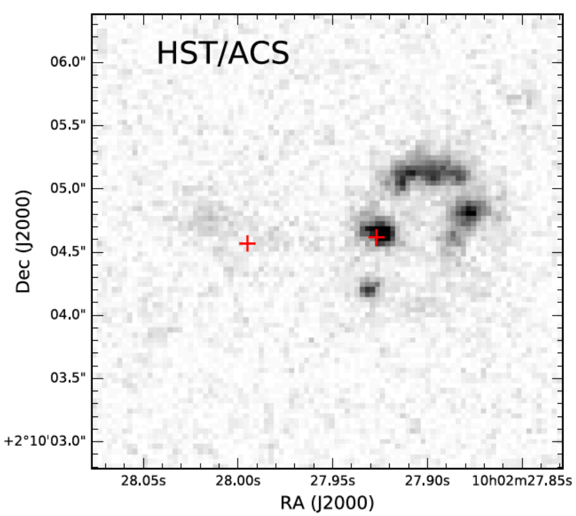
Concurrent Starbursts in Molecular Gas Disks within a Pair of Colliding Galaxies at $z = 1.52$ (Silverman+18)

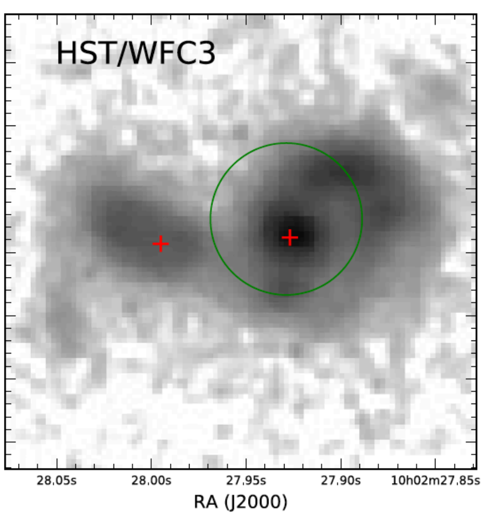


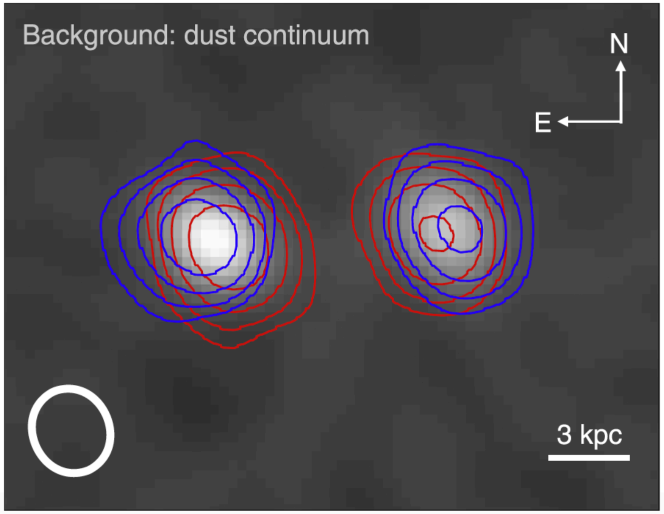
Herschel starburst followed-up with FMOS

ALMA CO(5-4)









Some Useful Experience of NIR-MOS with the Subaru Telescope

Aperture correction for z~1.6 SF galaxies in the 1.2 arcsec fibers as from the FMOS-COSMOS Survey

(PI J. Silverman)

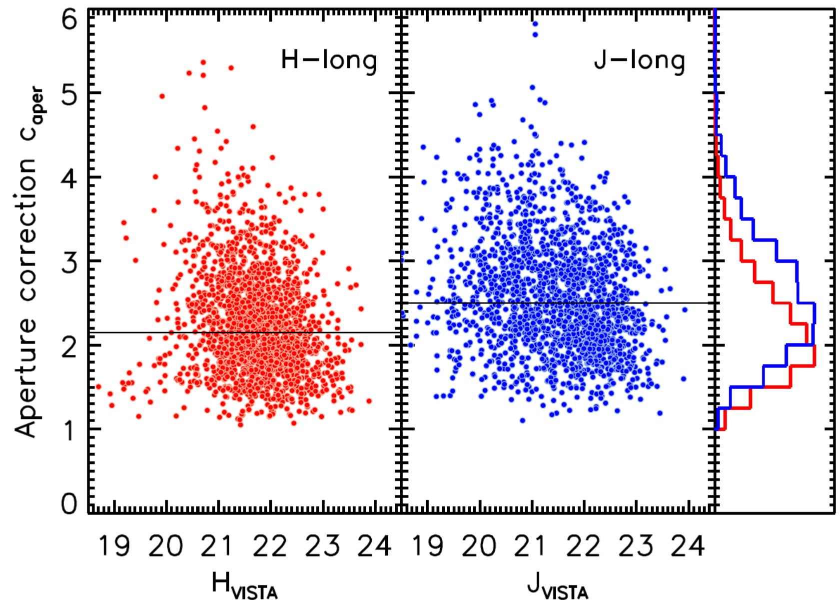


Figure 8. Derived aperture correction factors c_{aper} as a function of the reference H or J magnitudes (Laigle et al. 2016). The horizontal solid lines mark the median values. Histograms show the distribution of c_{aper}, separately for the H- (red) and J-long (blue) bands.

Figure 8 shows the derived aperture correction factors as a function of the reference magnitude, separately for the H and J bands. We excluded insecure estimates of aperture correction, which includes cases where the blending or contamination from other objects are significant. The aperture correction factors range from ~ 1.2 to ~ 4.5, and the median values are 2.1 and 2.5 for the H and J band, respectively. This small offset between the two bands is due to the fact that seeing is worse for shorter wavelengths under the same condition. Note

Morale: median loss: 3/4 of a magnitude (!)

Beware of it **before** using MOONS' ETC

From Kashino et al. (arxiv:1812.01529)

MOONS vs its FMOS Pathfinder

Parameter	Specifications
Telescope	VLT
Field of View	500 $arcmin^2$
Multiplex	1000 objects, with possibility to deploy fibre pairs (500 obj+500 sky)
Sky-projected diameter of each fibre	1.05 arcsec
Close packaging	At least two fibres within 10 arcsec
Observing modes	medium resolution (MR) and high resolution (HR)
Simultaneous λ-coverage in MR	0.64μm - 1.8μm
Resolving power in MR	R ~ 4,000 – 6,000
Simultaneous λ-coverage in HR	[0.76μm – 0.9μm] + [1.177μm – 1.268μm] + [1.521μm – 1.635μm]
Resolving power in HR	R~9,000 R~20,000 R~20,000

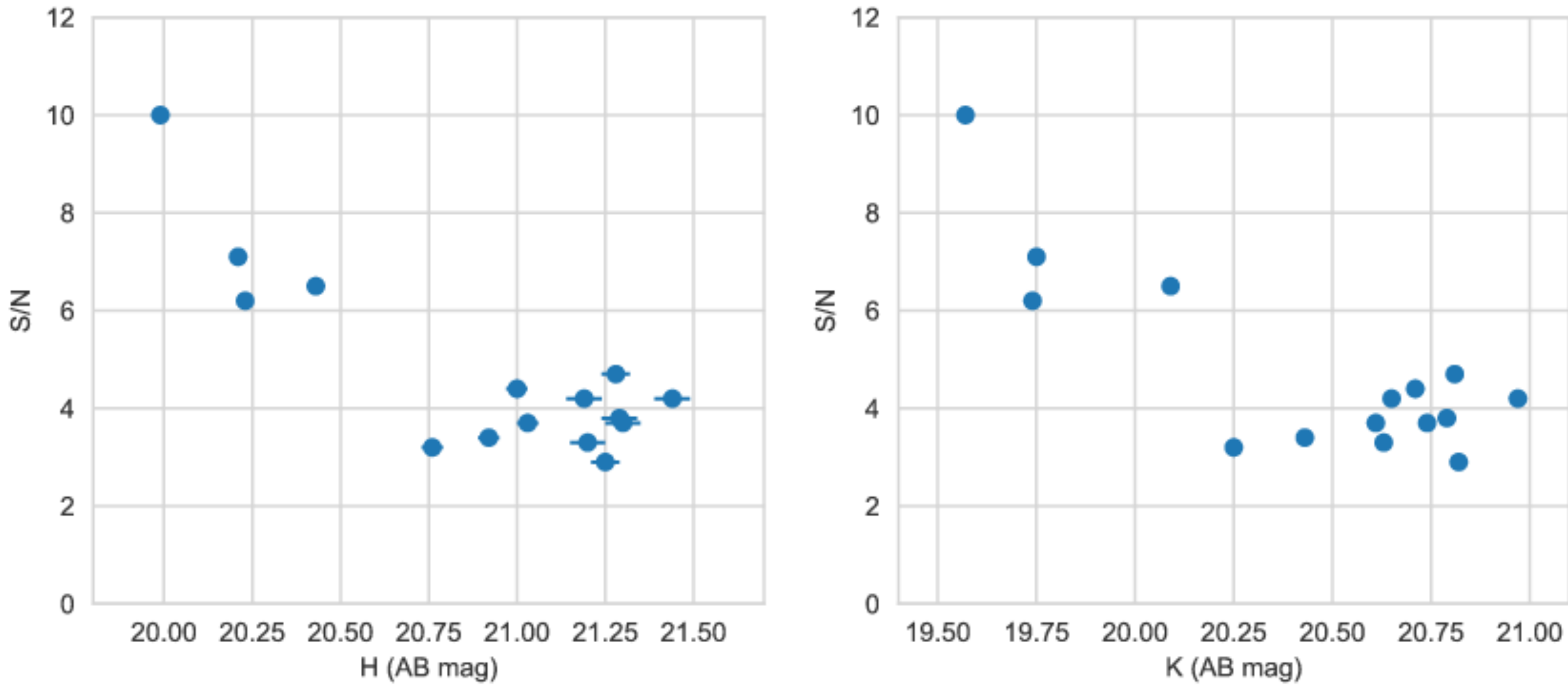
Grasp: mutiplex x throughput x spectral coverage
2.4 x 4 x 3 =~30 times FMOS!

x another factor of ~1.2 for twice the resolution = ~36 x FMOS!!

So, 200 MOONS GTO nights = ~7,000 FMOS Nights

Passive Galaxies at z~1.6 with MOIRCS@Subaru

- S/N per angstrom with ~8h integration with MOIRCS w/ R=500



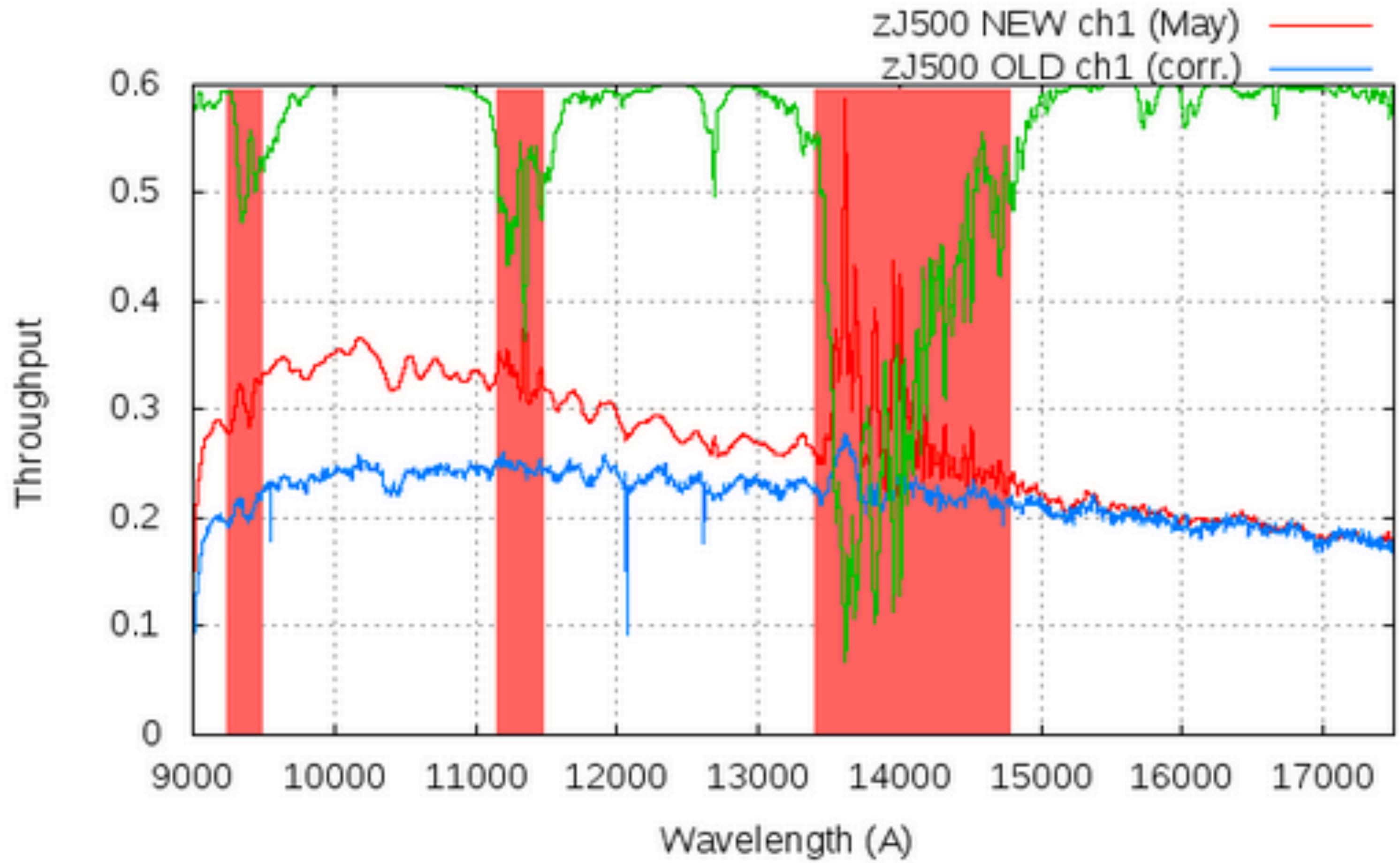
Morale: NO REDSHIFTS for passive galaxies Fainter than H_AB > 21.5

From Onodera et all. (2012, 2015)

Note: MOIRCS is a multislit MOS

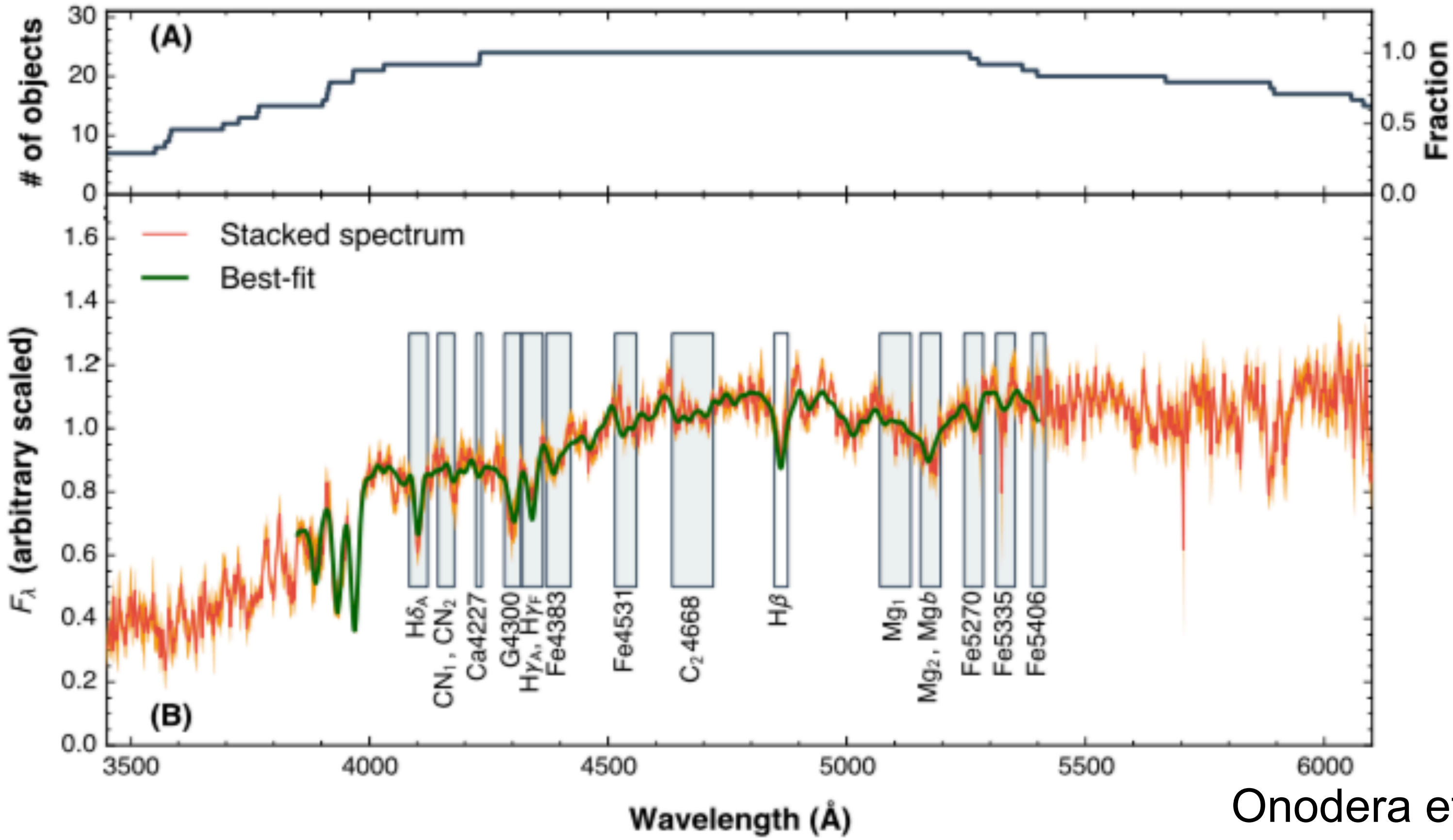
MOIRCS' Throughput

- Peak throughput with R=500 is ~30%, comparable to MOONS



Stacking 25 z~1.6 Passive Galaxies

- Equivalent to 200h integration on objects brighter than H_AB=21.5



Onodera et al (2015)

Figure 2. Composite rest-frame optical spectrum of the 24 quenched galaxies at $z \sim 1.6$. (A): the number (left axis) and fraction (right axis) of spectra that have been stacked at each wavelength. (B): the stacked spectrum and associated 1σ error (orange solid line and filled region, respectively). The green solid line shows the best-fit combination of stellar spectra (Sánchez-Blázquez et al. 2006b), using pPXF (Cappellari & Emsellem 2004). The rectangles show the wavelength ranges used to measure the Lick indices of the stacked spectrum, though the Hβ index is not used in our stellar population analysis.

Morale: absorption-line science (ages, metallicities, α-elements) basically on stacks (!)

From FMOS to MOONS
Lessons learned from 47 Clear Subaru Nights
FMOS-COSMOS: a near-IR spectroscopic survey@Subaru

- Start filling the redshift desert $1.4<z<1.8$
- Getting ISM metallicities from emission lines
- Physics of the ISM via BPT, [SII] and the like
- Compare MS Outliers (starbursts) to MS “Liers”
- LSS, Groups, density map + zCOSMOS
- ALMA Follow-up
- MOONS Pathfinder