The KLEVER survey

Spatially resolved excitation properties and chemical abundances in high redshift galaxies

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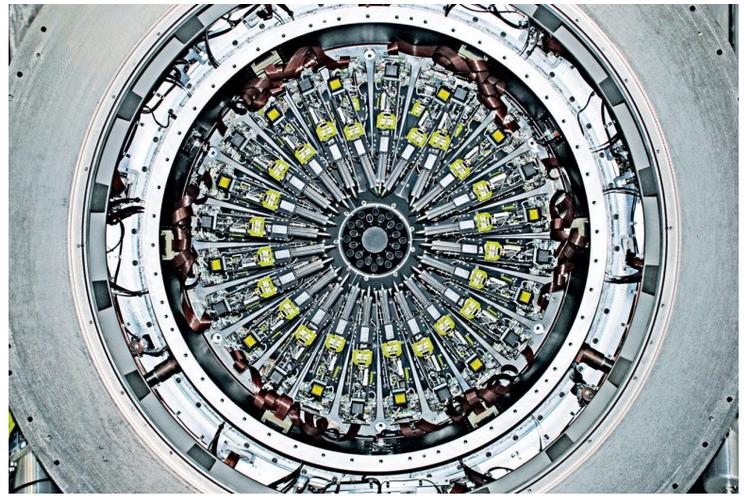
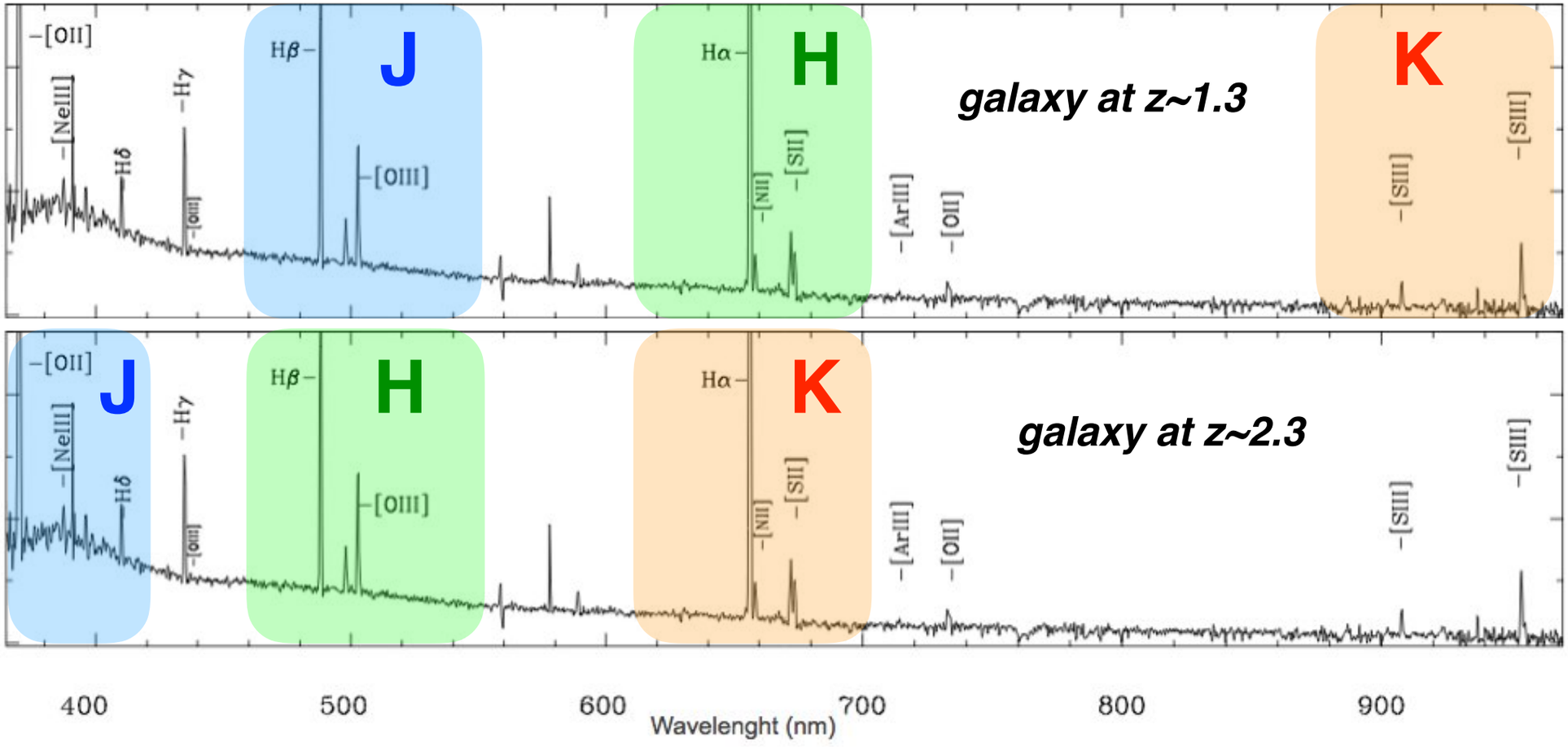
GEE5 **16/11/2017** **Firenze - Arcetri**

The KLEVER Survey

- ESO *Large Programme* to observe **~100 galaxies** at **1.2 < z < 2.5**
- Multi - Integral Field Spectroscopy with **KMOS** (24 IFU) : spatially resolved spectral information
- full NIR wavelength coverage (J, H, K band) : map the entire **set of rest-frame optical nebular diagnostics**

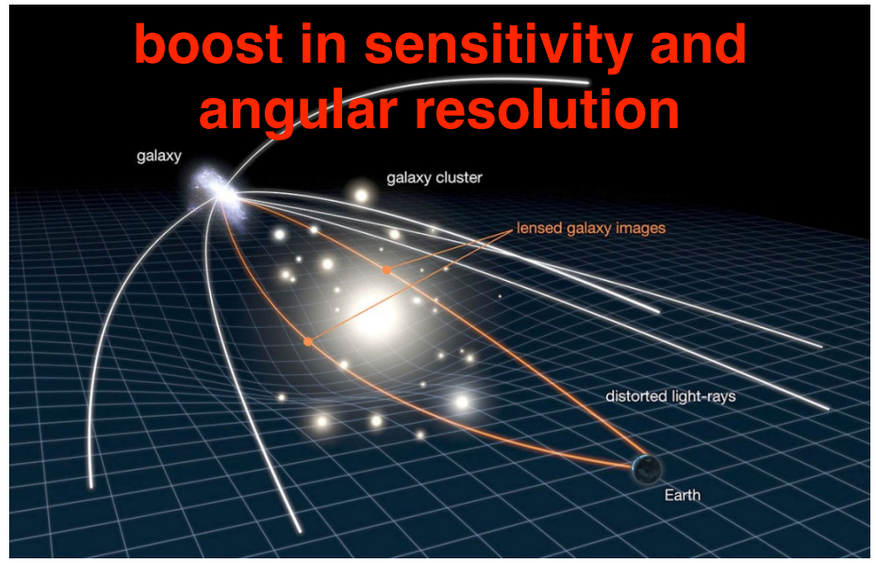


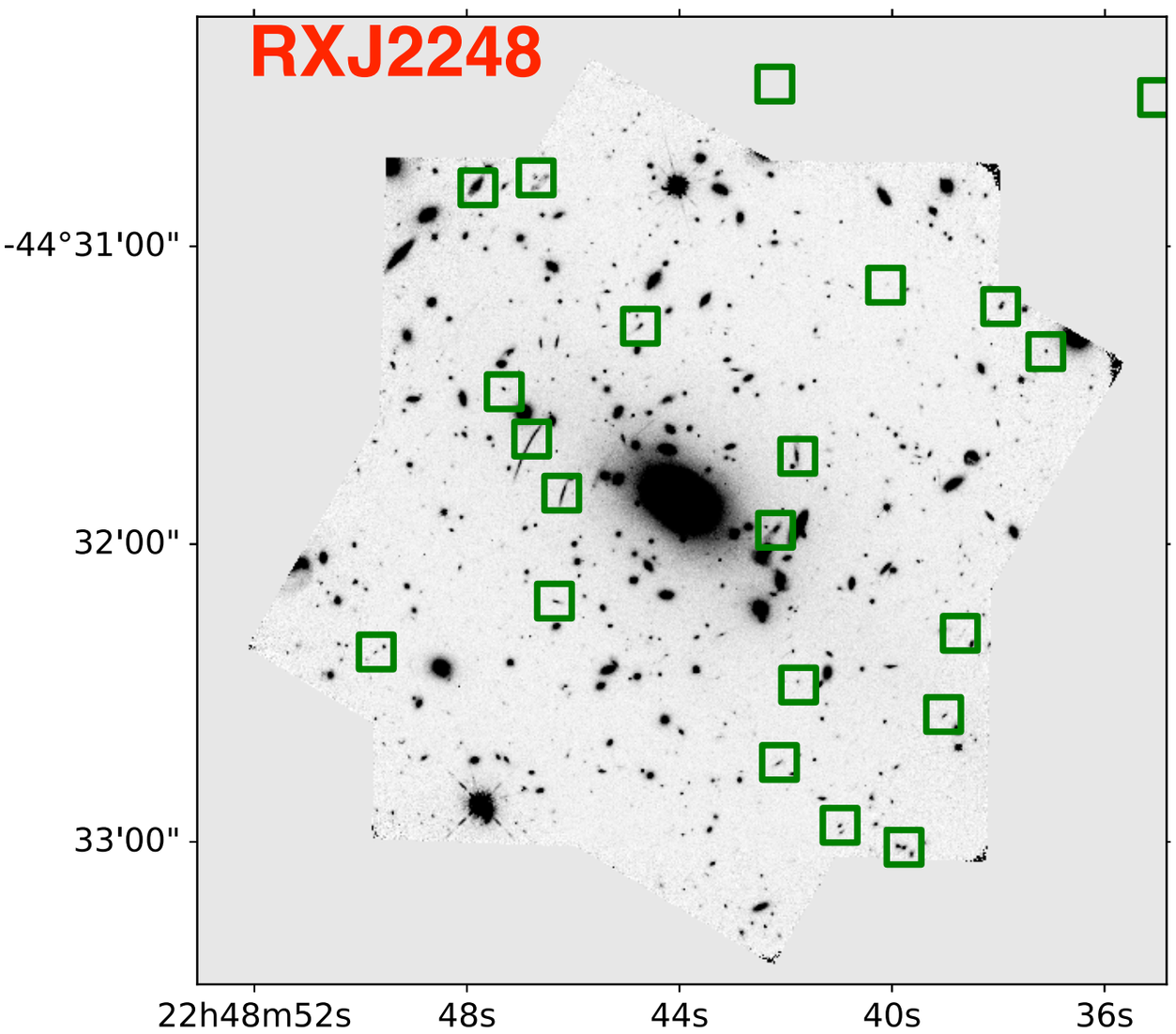


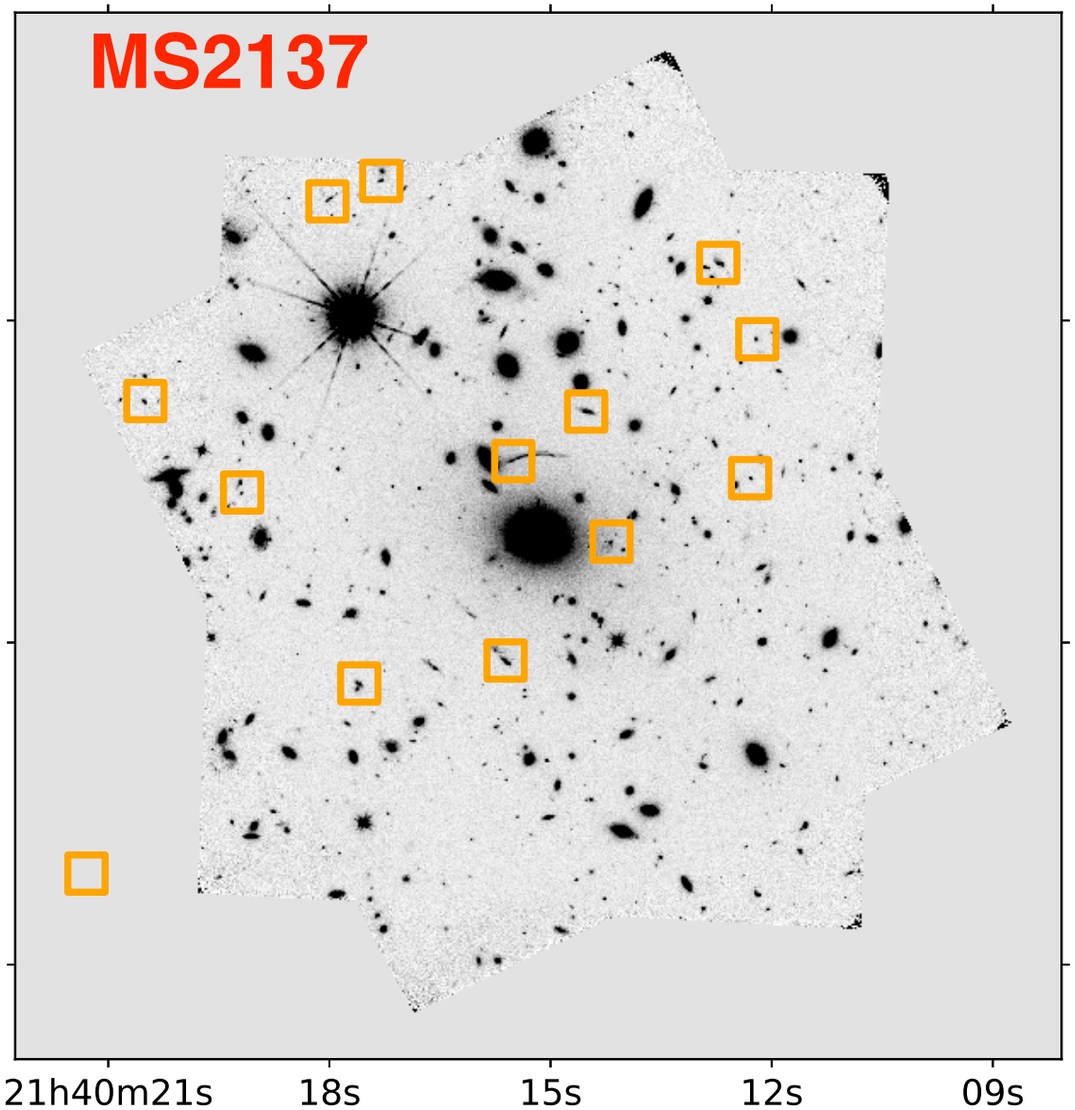
physical conditions of the ionized gas
spatially resolved **excitation properties** and **chemical abundances**

The KLEVER Survey

- **lensed galaxies** from HST CLASH & FRONTIER FIELDS clusters (**KMOS**)
- few **strongly lensed galaxies** (**SINFONI** - Pilot)
- unlensed from GOODS-S and COSMOS (KMOS)

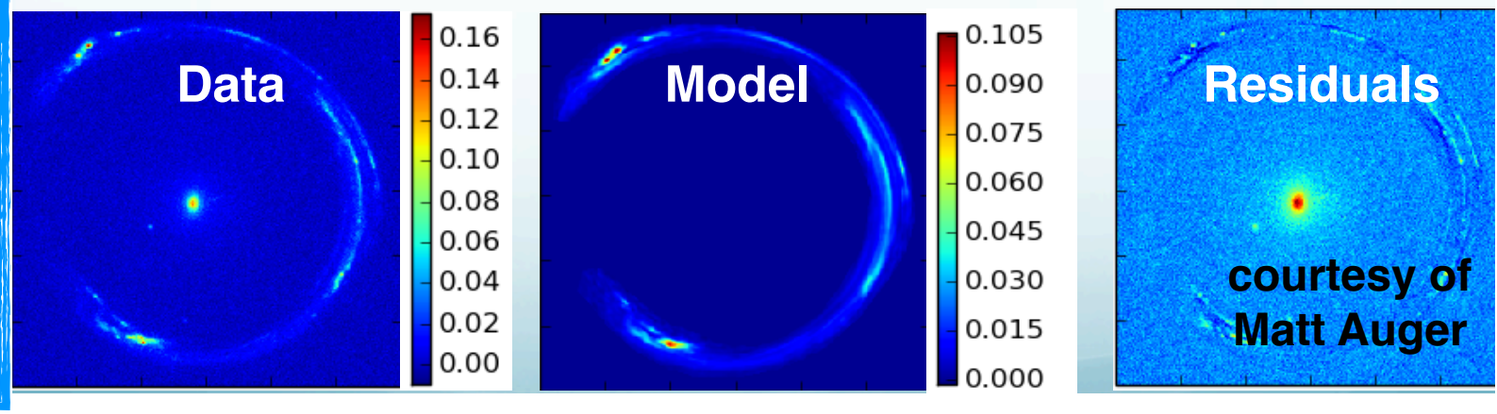


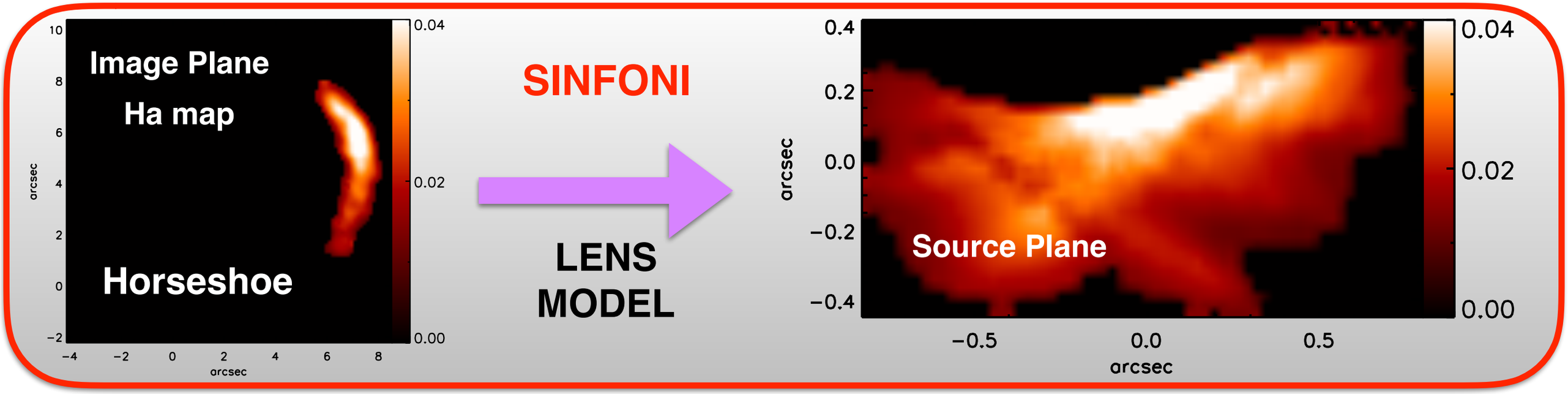


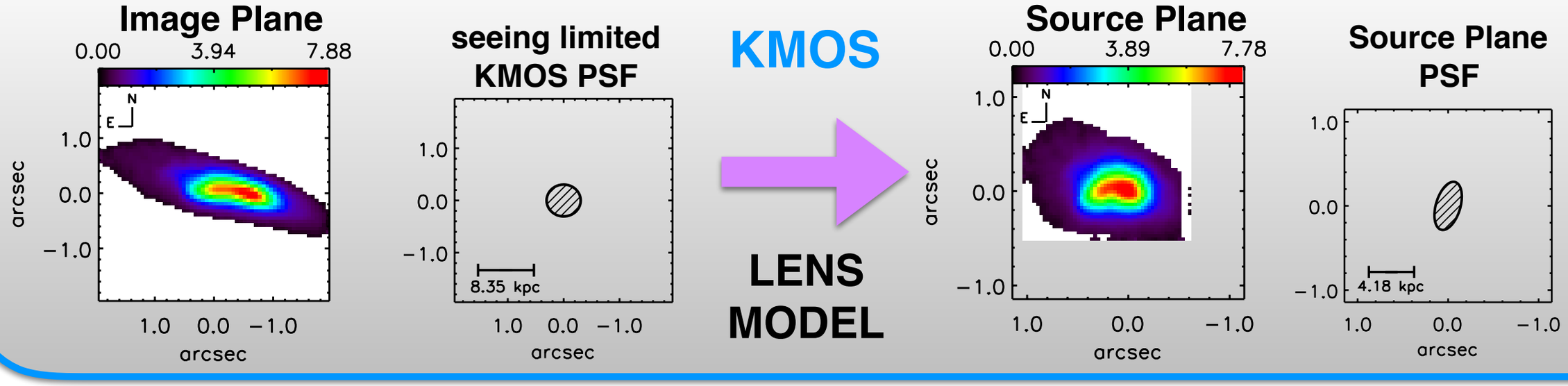


Modeling and Analysis

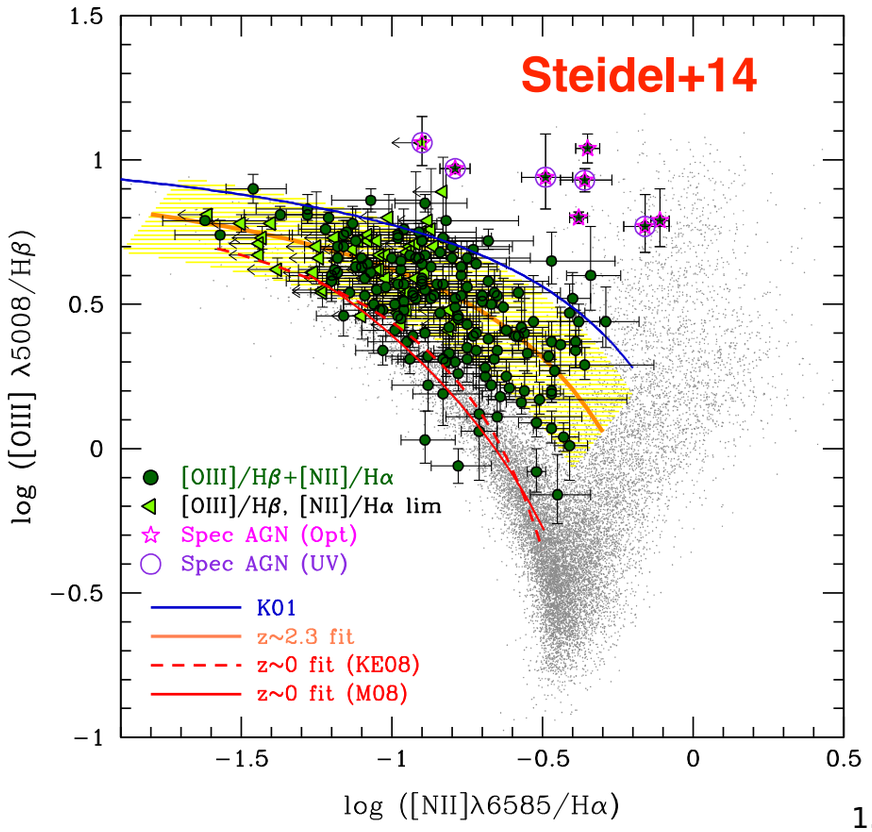
- emission line fitting on image plane
- surface brightness maps reconstructed in the Source Plane
- typical **resolution ~ 1.5 Kpc**
- typical **magnification μ ~ 1.2 - 2.5**







BPT Diagrams at high redshift



? higher density harder radiation field ionization parameter nitrogen enrichment ?

Newman+14, Masters+14,16, Steidel+14, Shapley+15, Hayashi+15, Zahid+14, Kashino+16, Strom+17 ...

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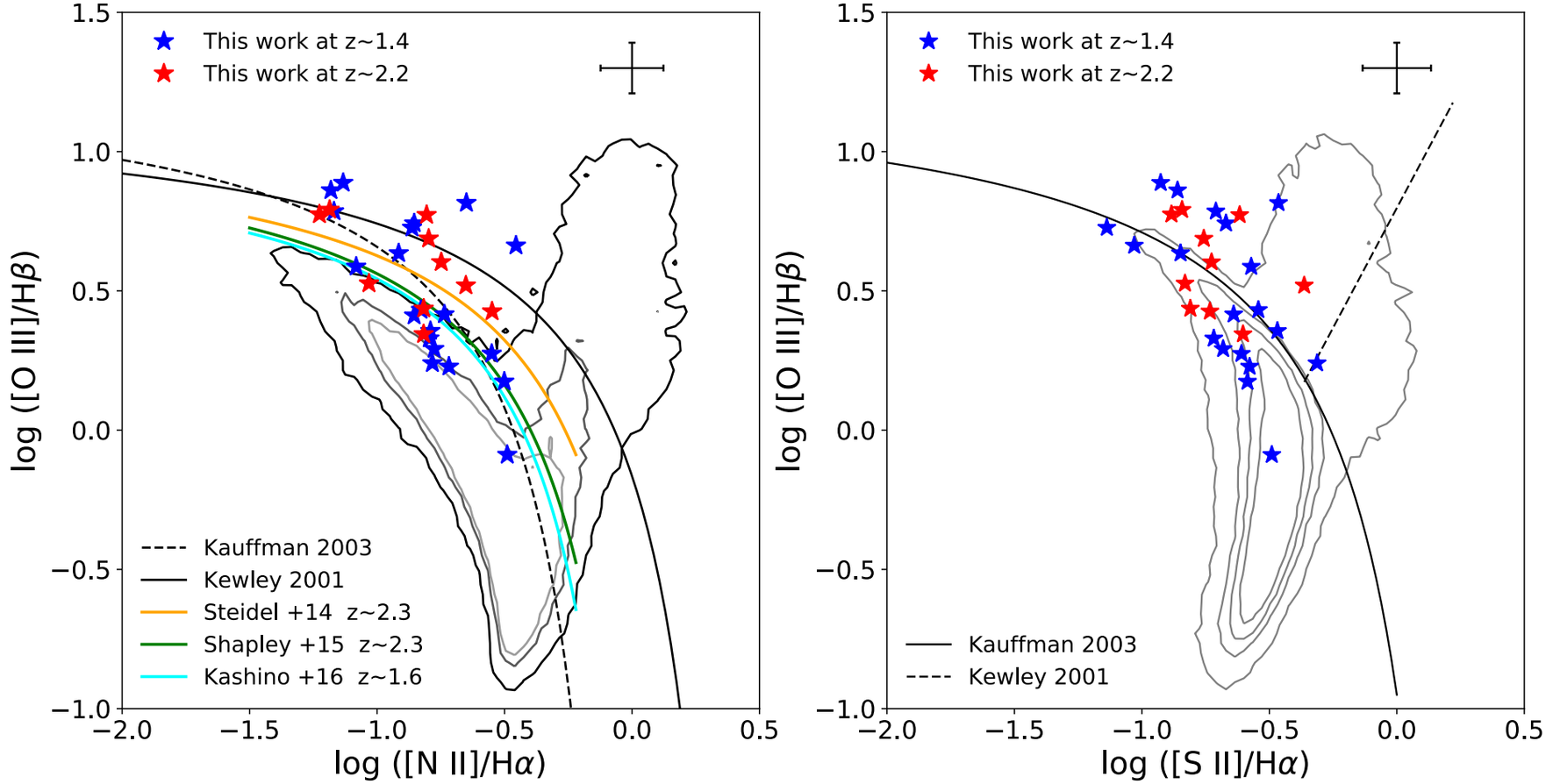
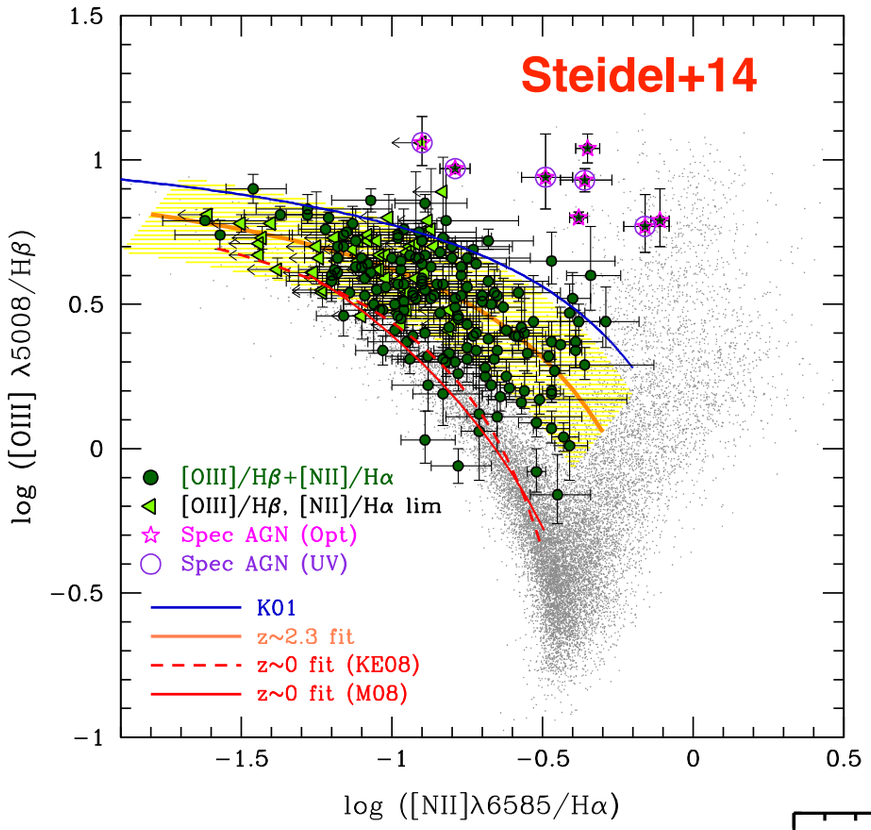


Williams, MC et al, in prep.

BPT Diagrams at high redshift



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Newman+14, Masters+14,16, Steidel+14, Shapley+15, Hayashi+15, Zahid+14, Kashino+16, Strom+17 ...

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investigate the origins of this offset in a spatially resolved manner

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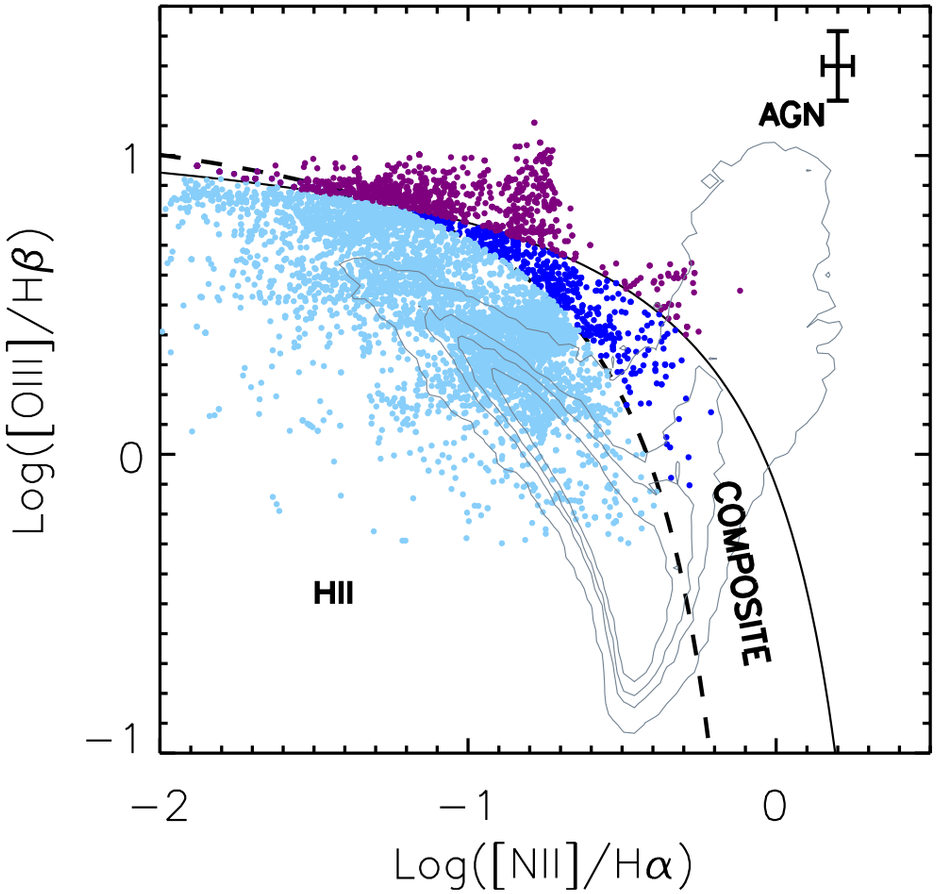
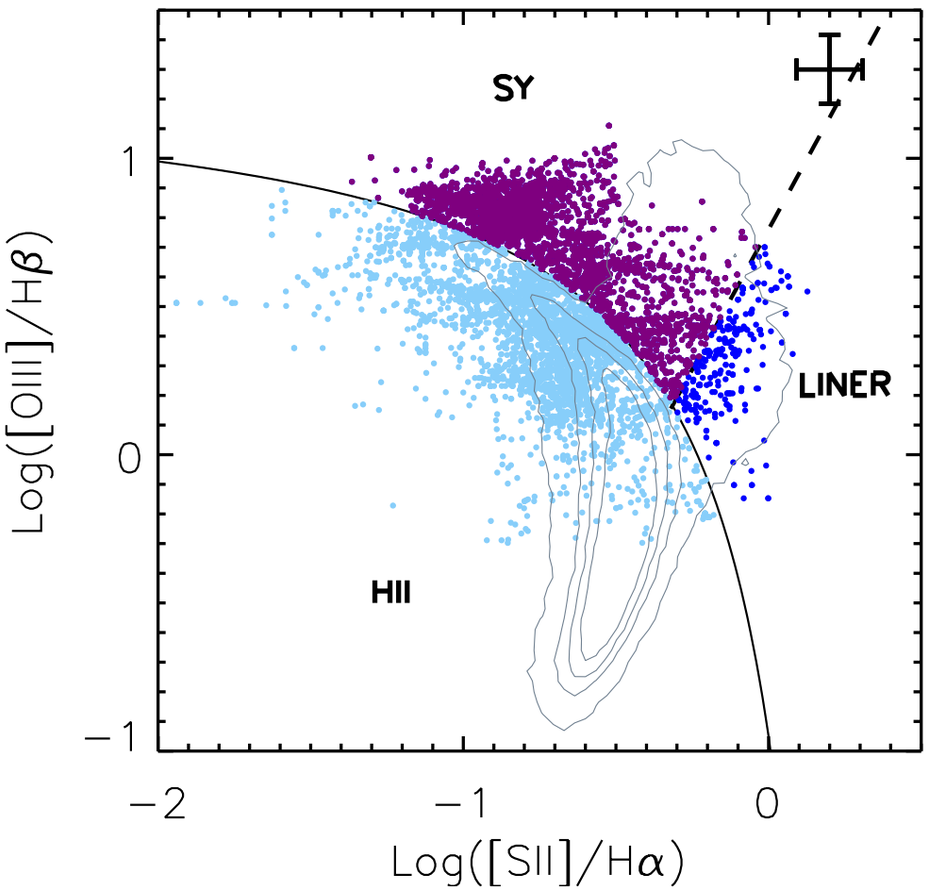
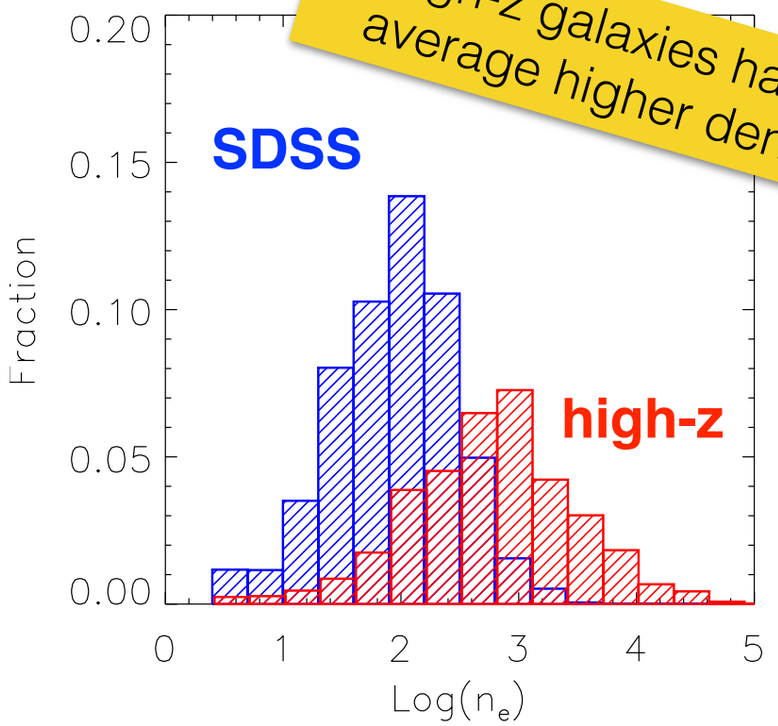


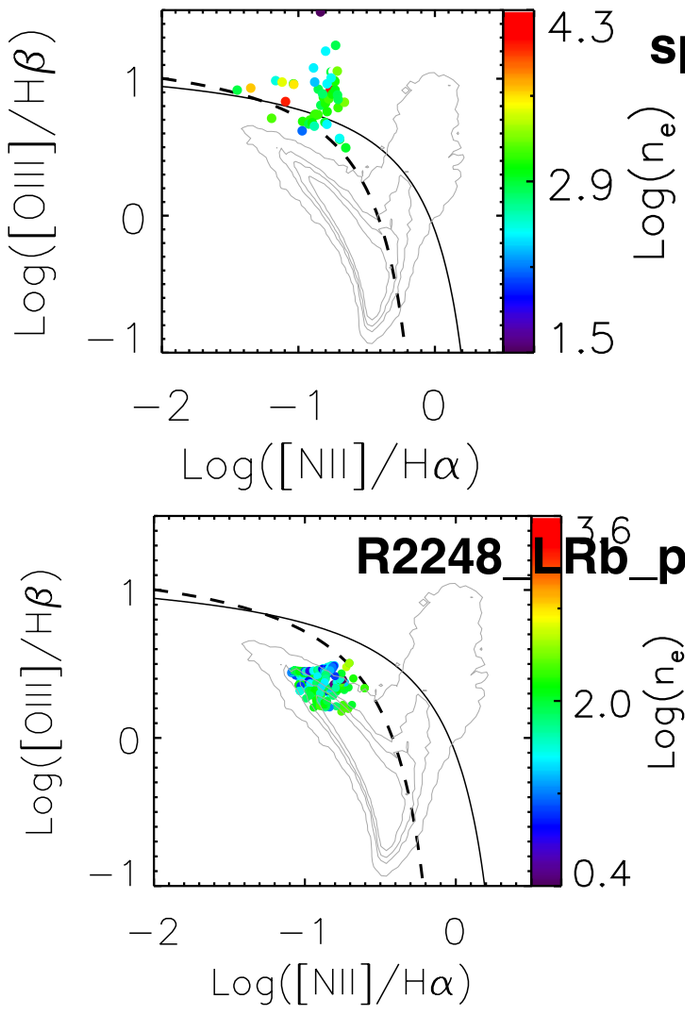


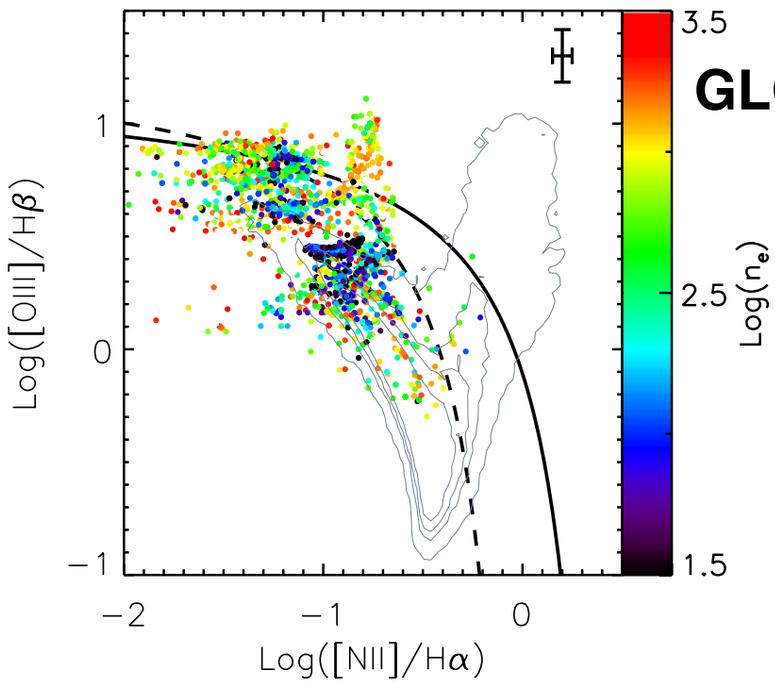
BPTs - Electron Density (Ne)

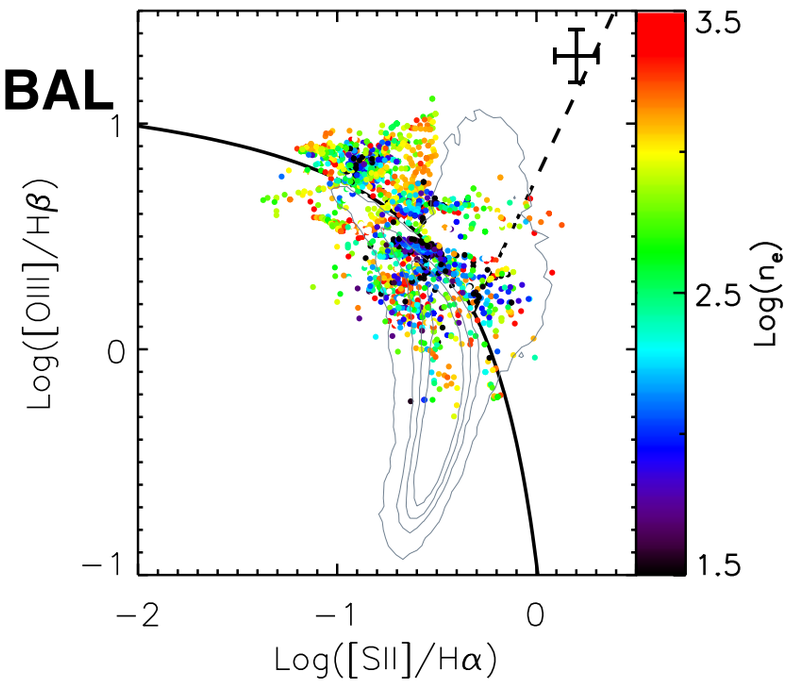
from **[S II]6717/6731**

high-z galaxies have on average higher densities









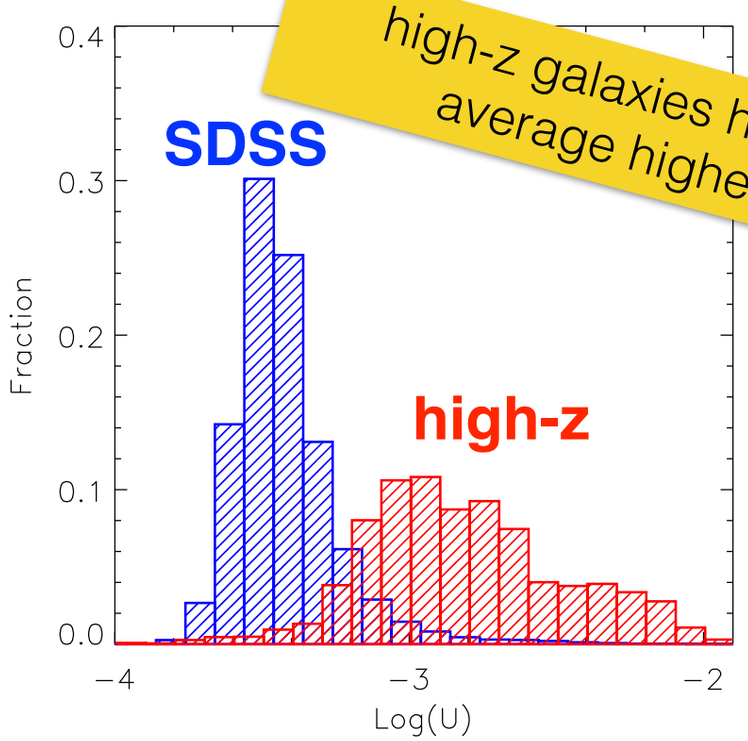
- no clear correlation between enhanced density and BPT offsets

Williams, MC et al, in prep.

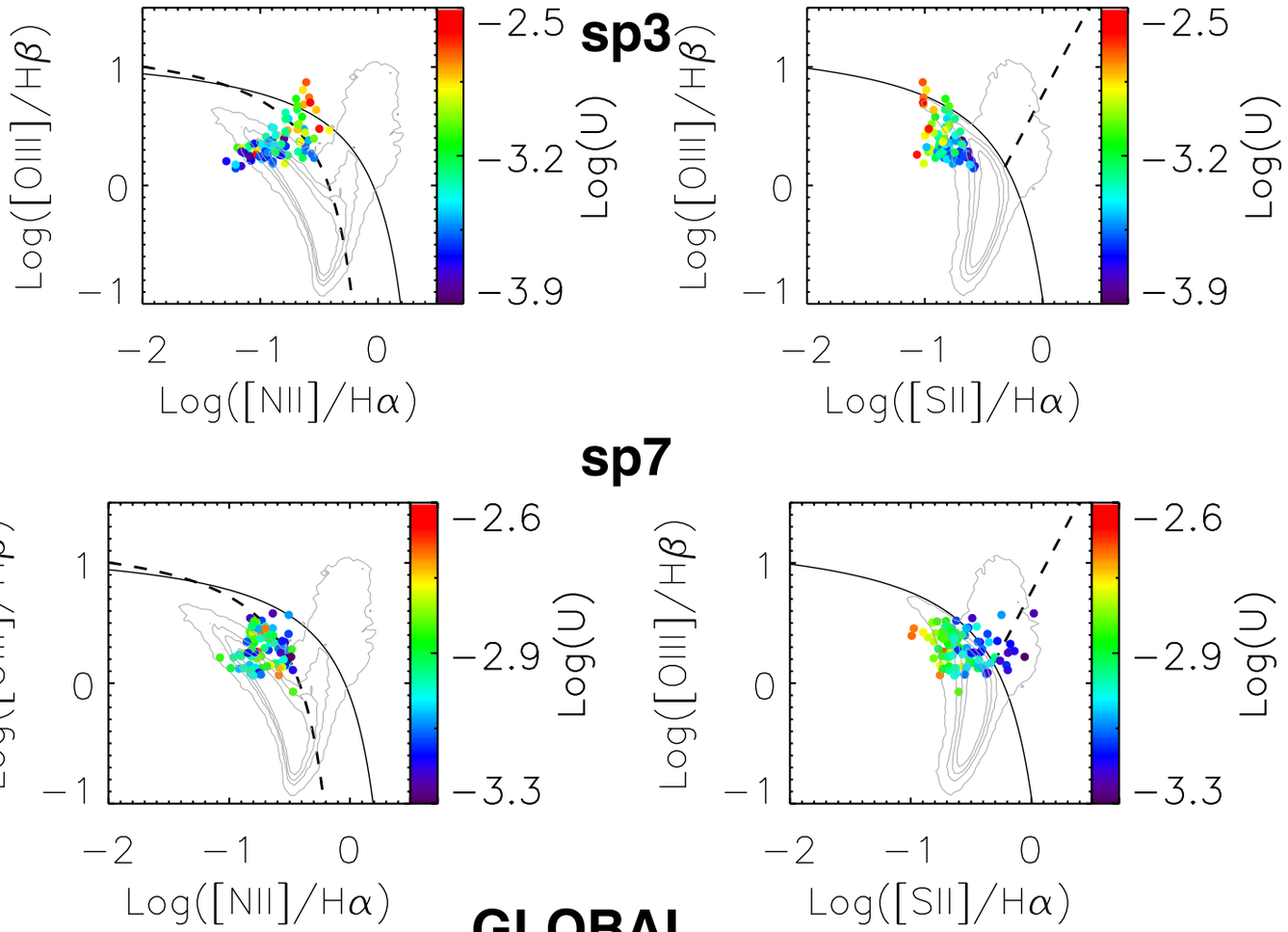
BPTs - Ionization Parameter (U)

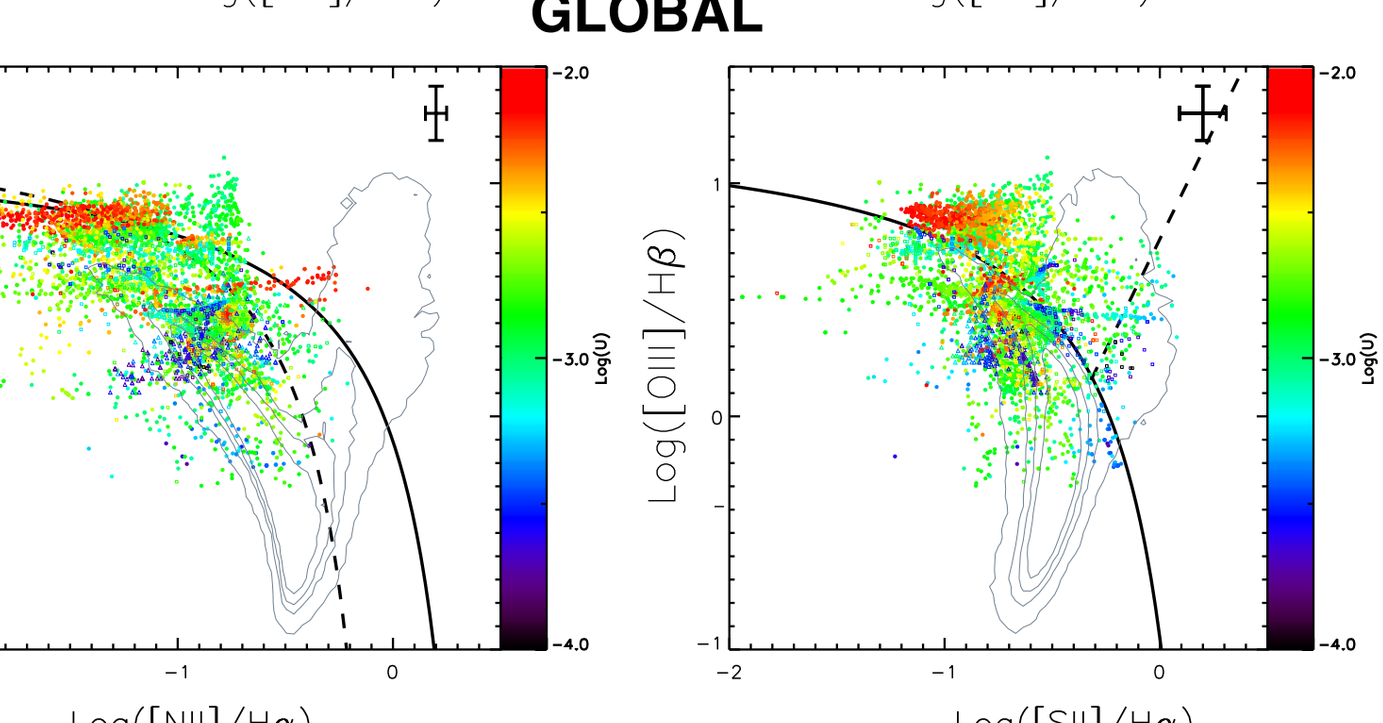
from **[S III]9530/[S II]6717,6731**
or **[OIII]5007/[O II]3727**

high-z galaxies have on average higher U



- in some galaxies U is correlated with the deviation in BPT line ratios, but it's not always the case
- as a general trend large [O III]/Hß can be ascribed to high U values
- many spaxels in SF-region with high U as well

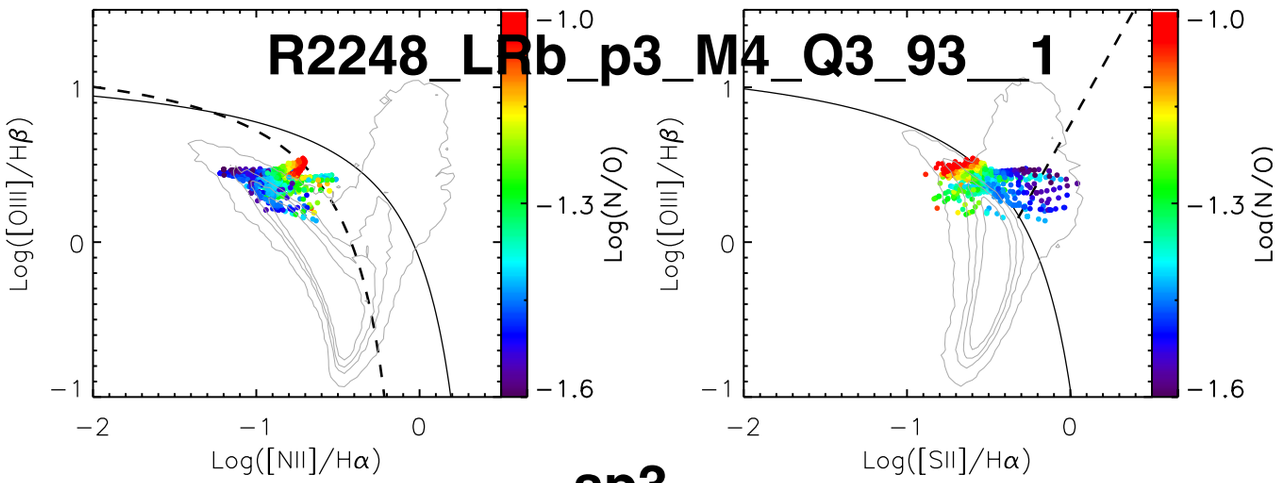


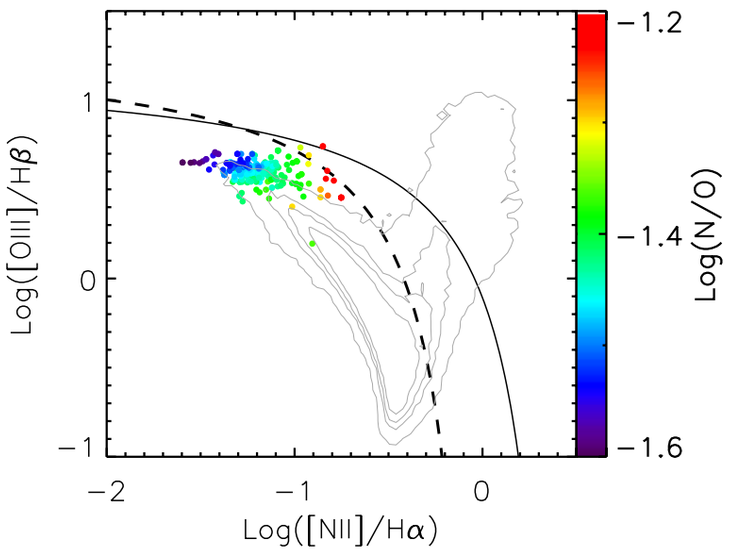


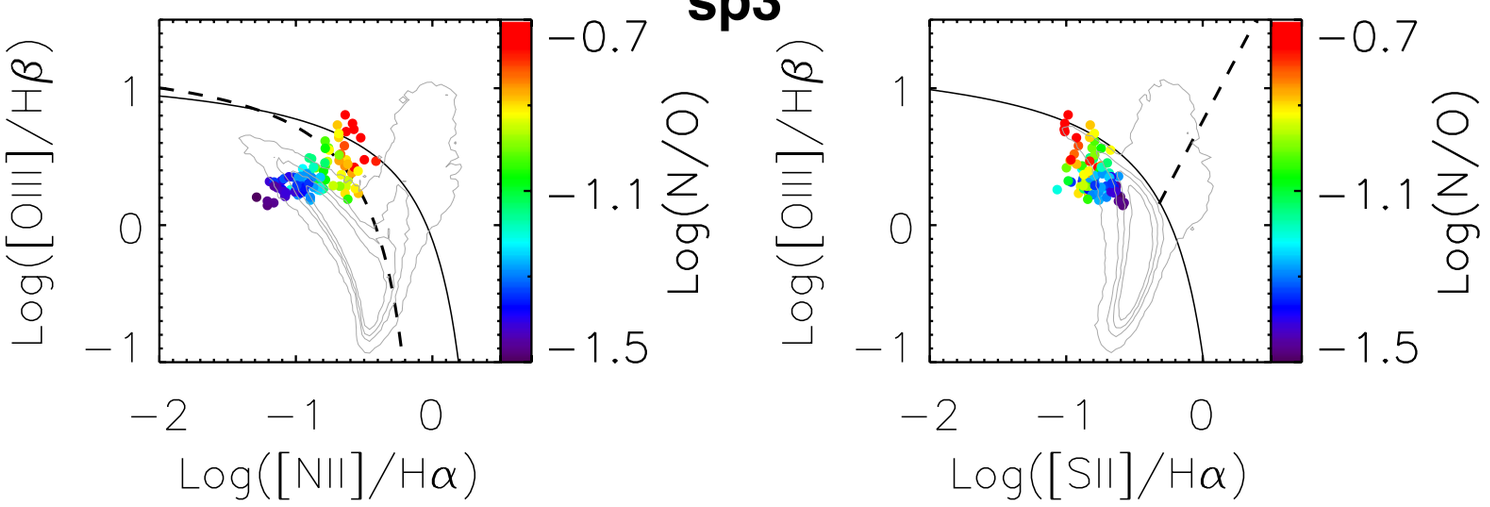
N/O abundance

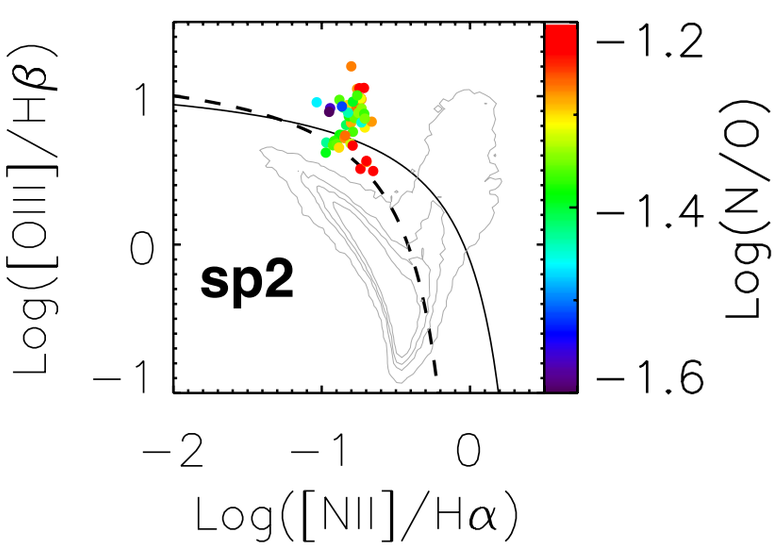
from **[NII]/[OII]**
or **[NII]/[SII]**

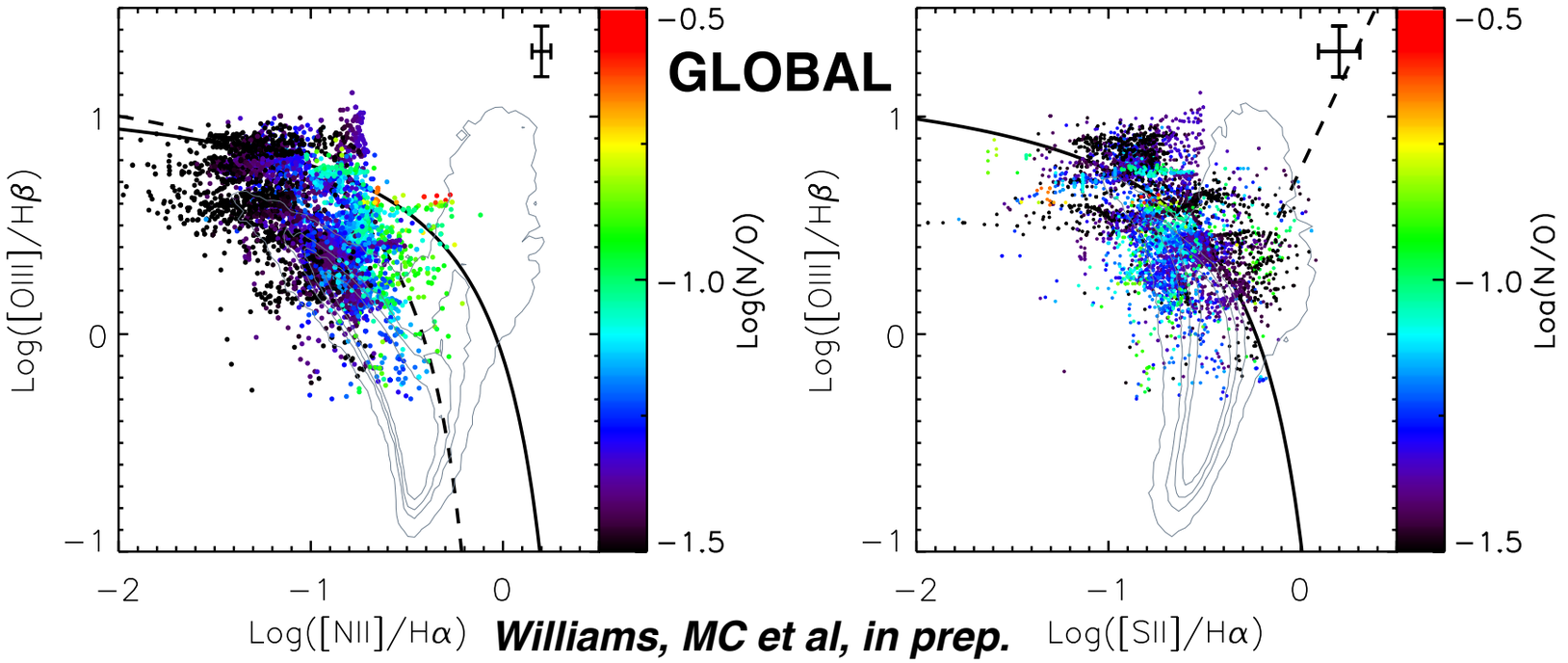
- N/O correlates well with the most deviating spaxels in the [NII]-BPT
- no clear trend in [S II] BPT







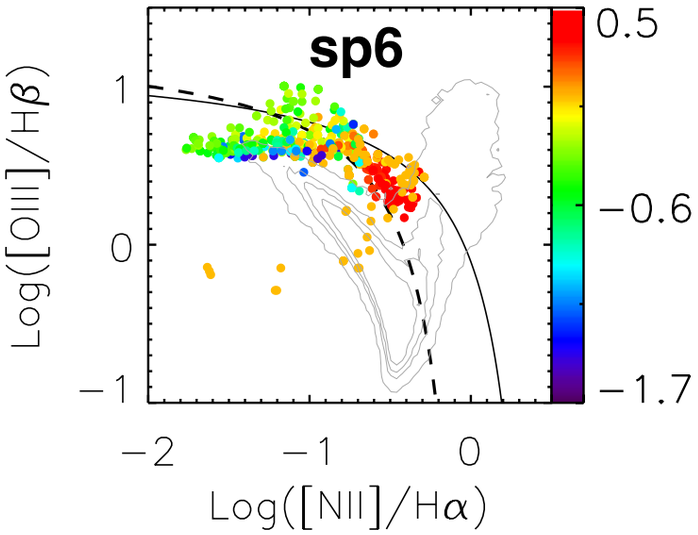


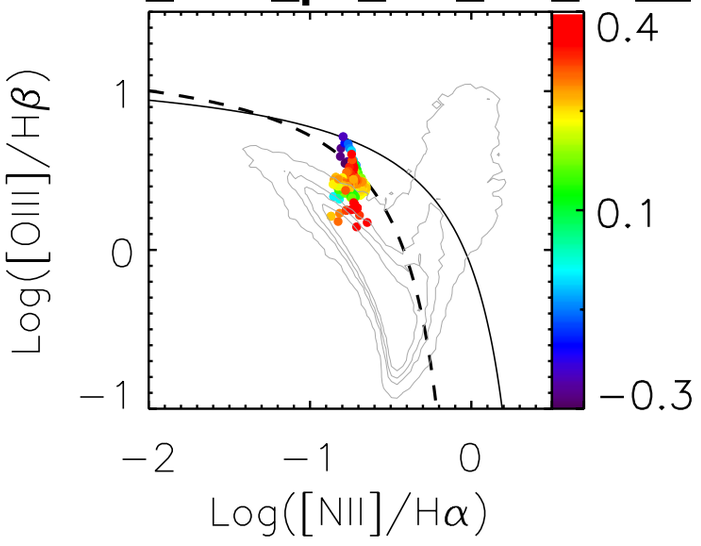


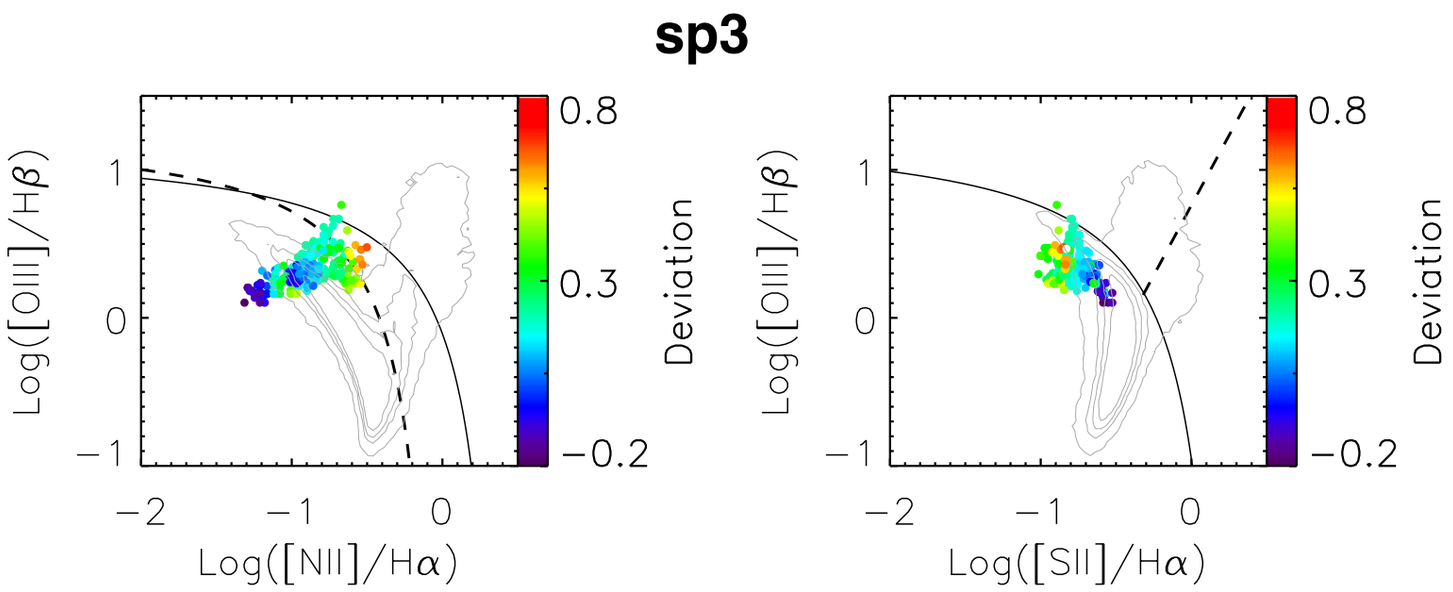
Williams, MC et al, in prep.

N/O abundance

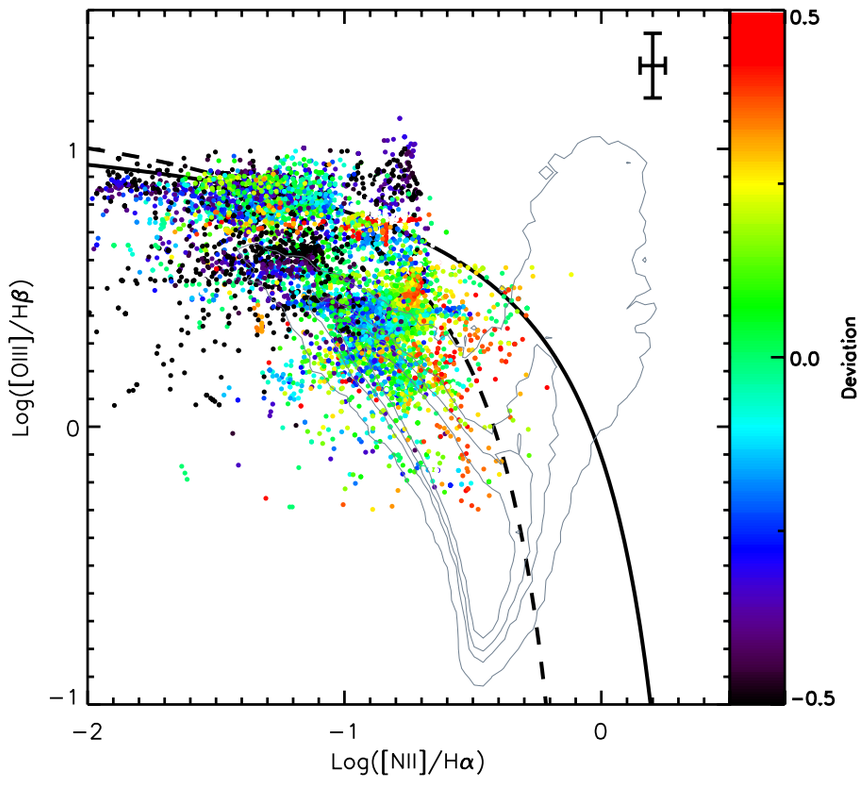
- N/O correlates locally with O/H above ~1/4 Z_sun
- BPT offset as a function of deviations from local O/H vs N/O relation

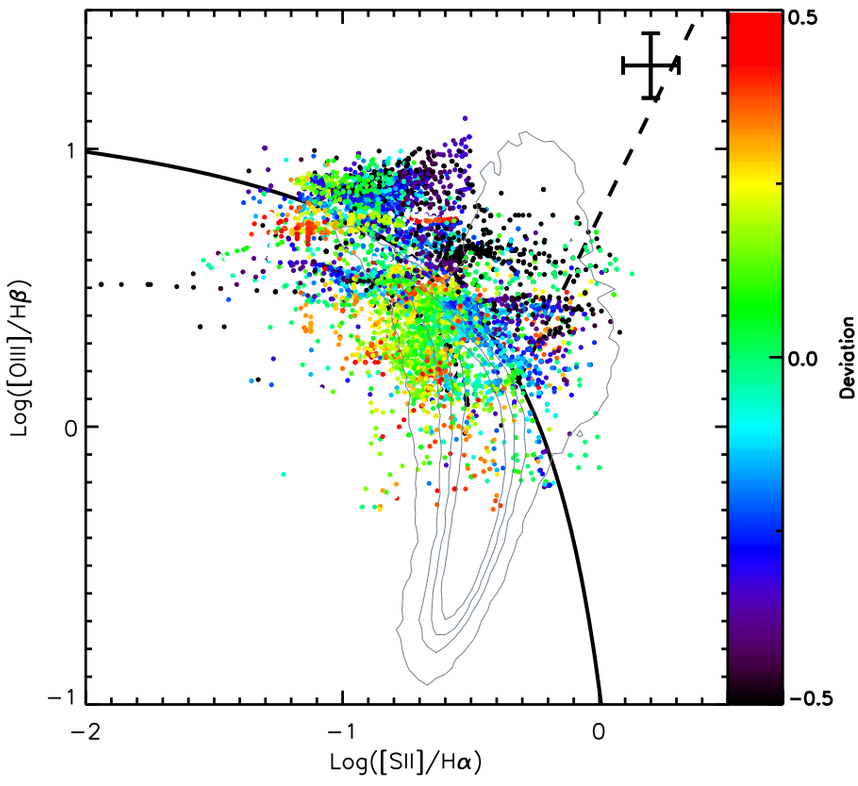






GLOBAL





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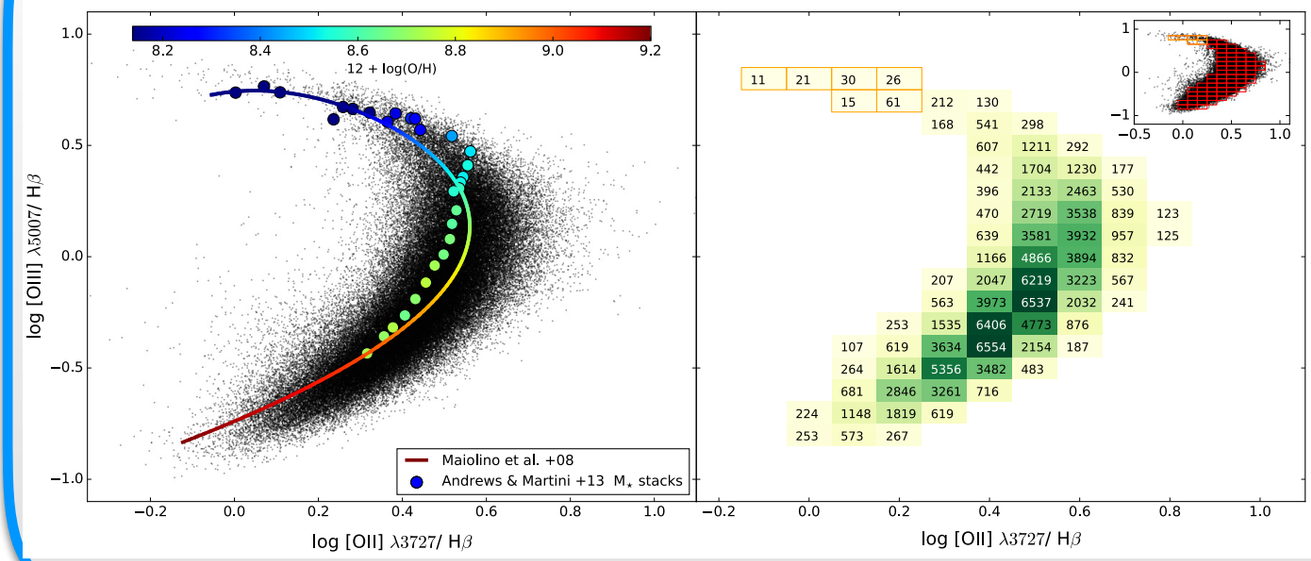
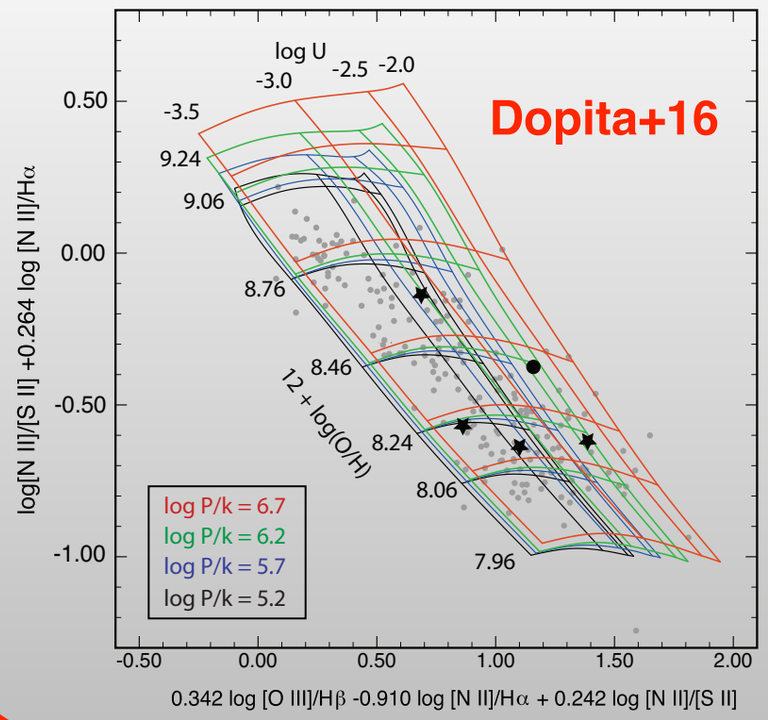
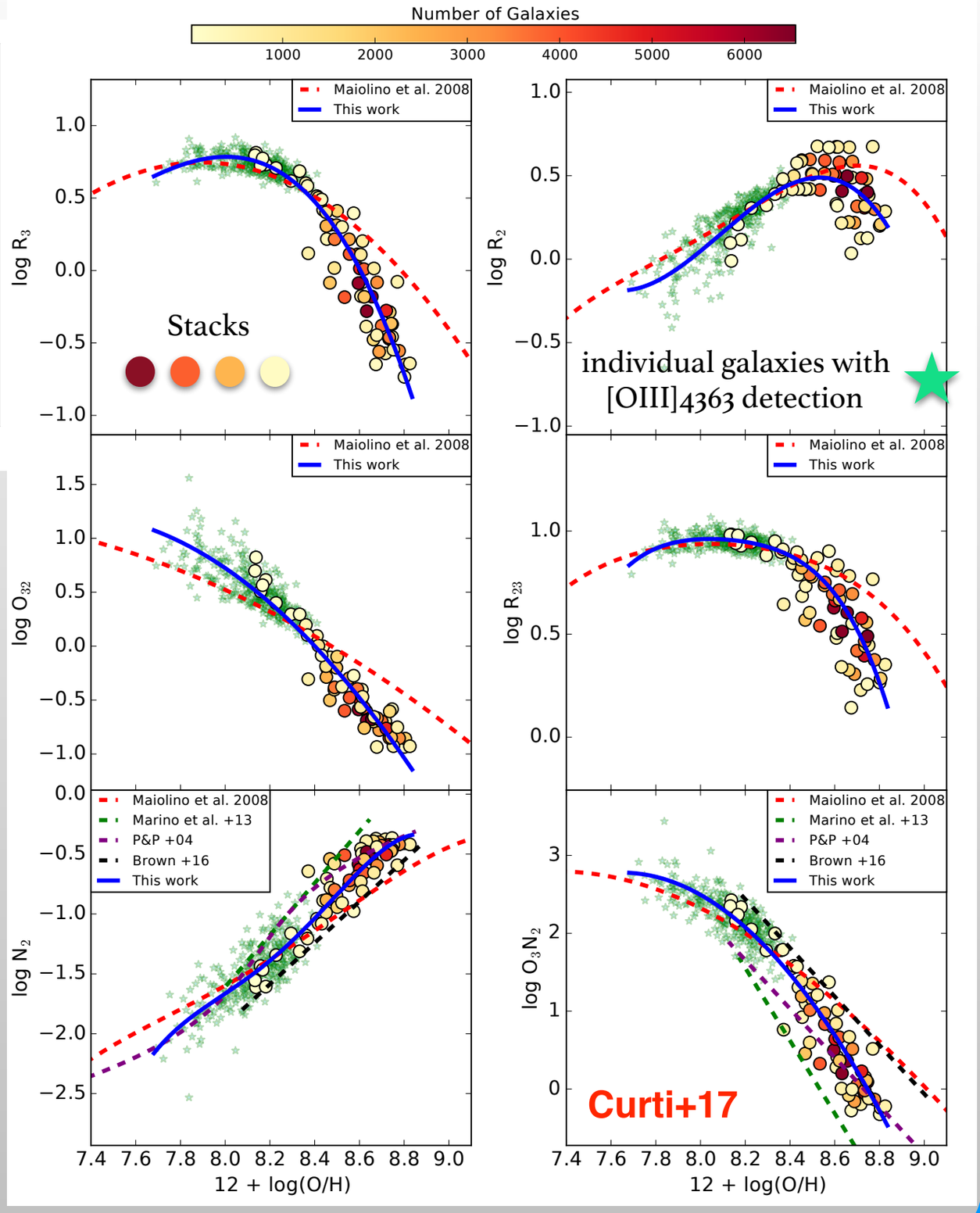
Gas-phase metallicity

- **Te-based calibrations**



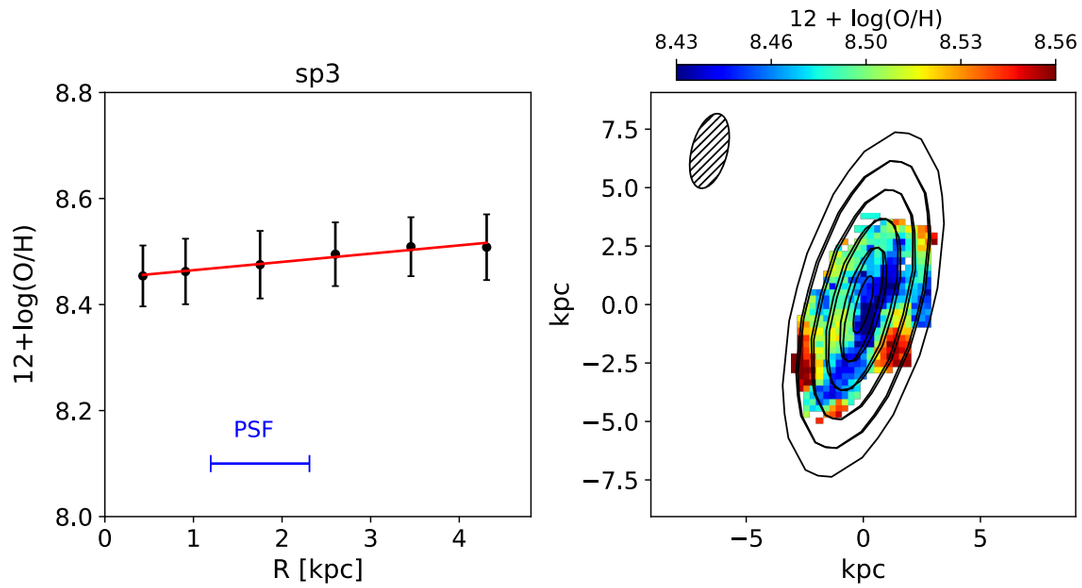
- **grids of photoionization models**

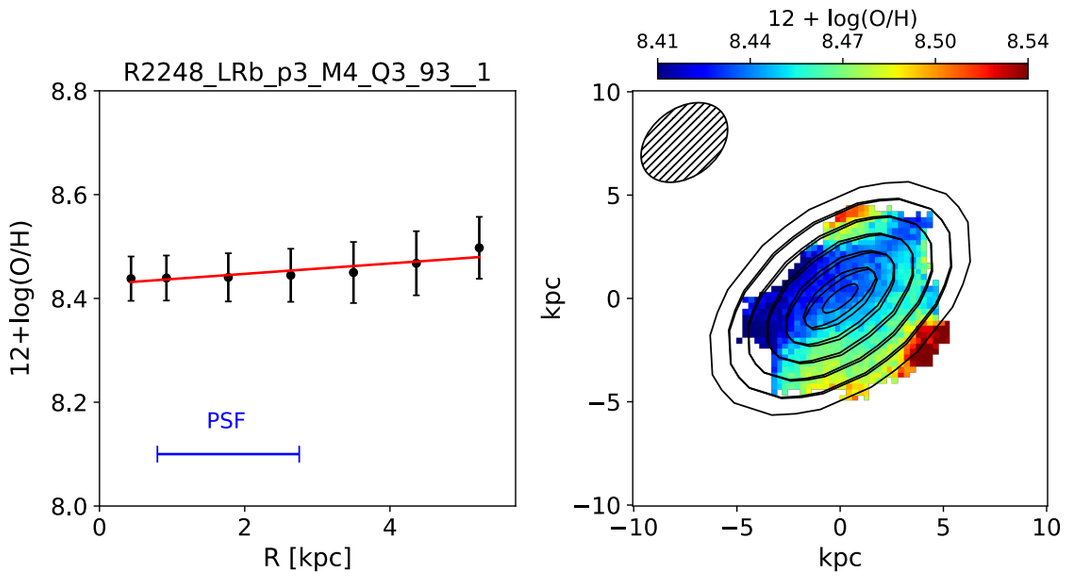


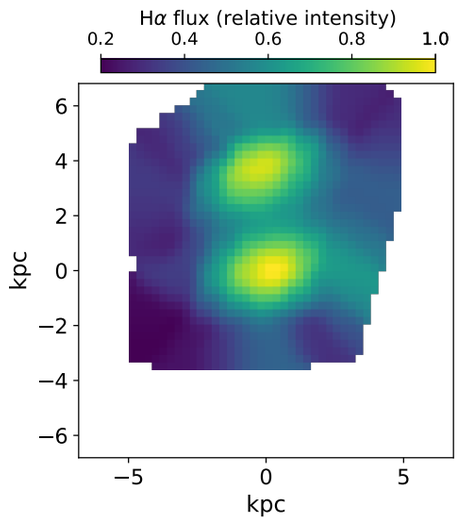


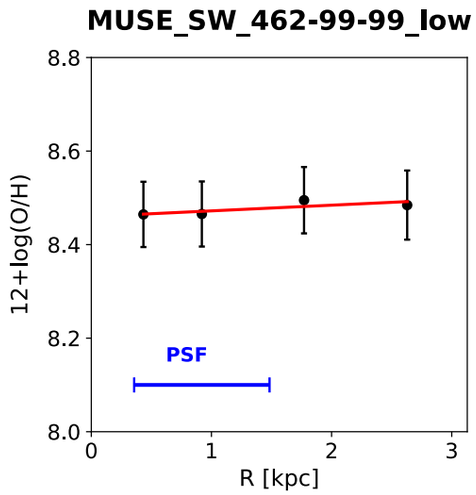
Metallicity Maps & Gradients

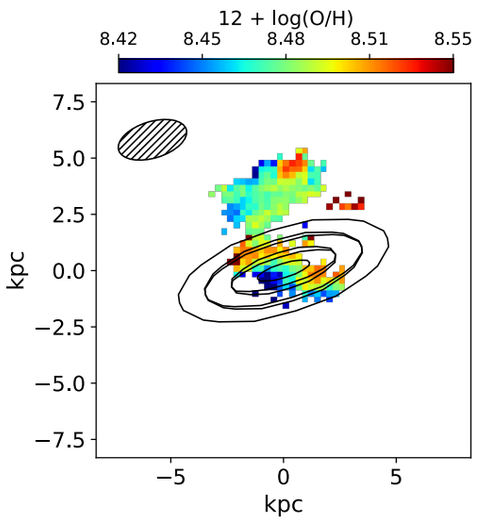
- metallicity maps sometimes **irregular**
- gradients from average metallicity in elliptical apertures (Source Plane PSF)
- Resolved if sampled at least 2 linear PSFs
- **radial** metallicity gradients generally **flat**
- a few examples of **inverted** gradients

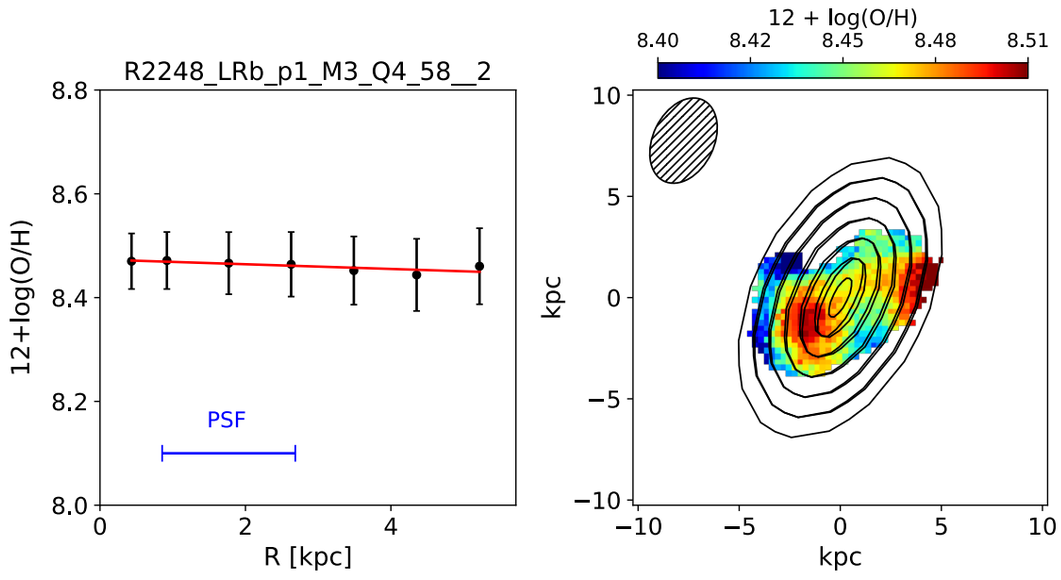


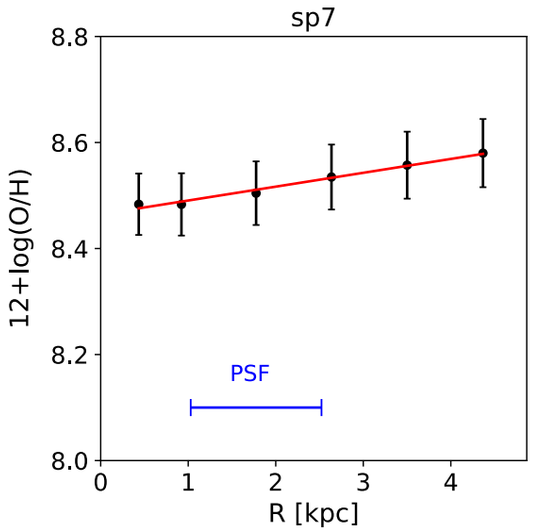


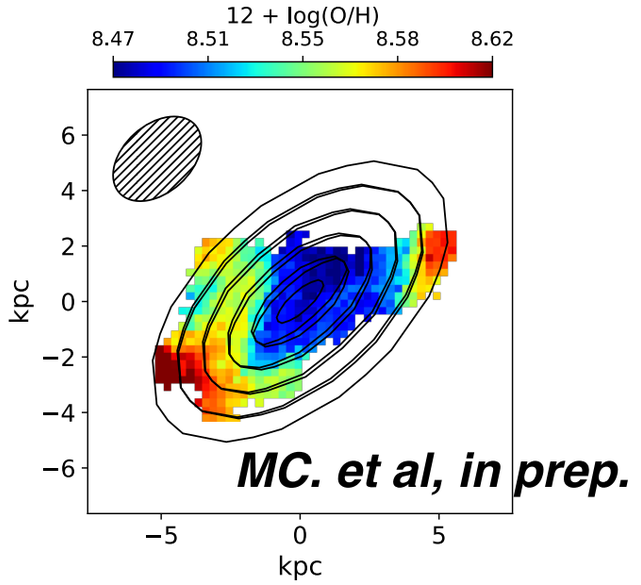






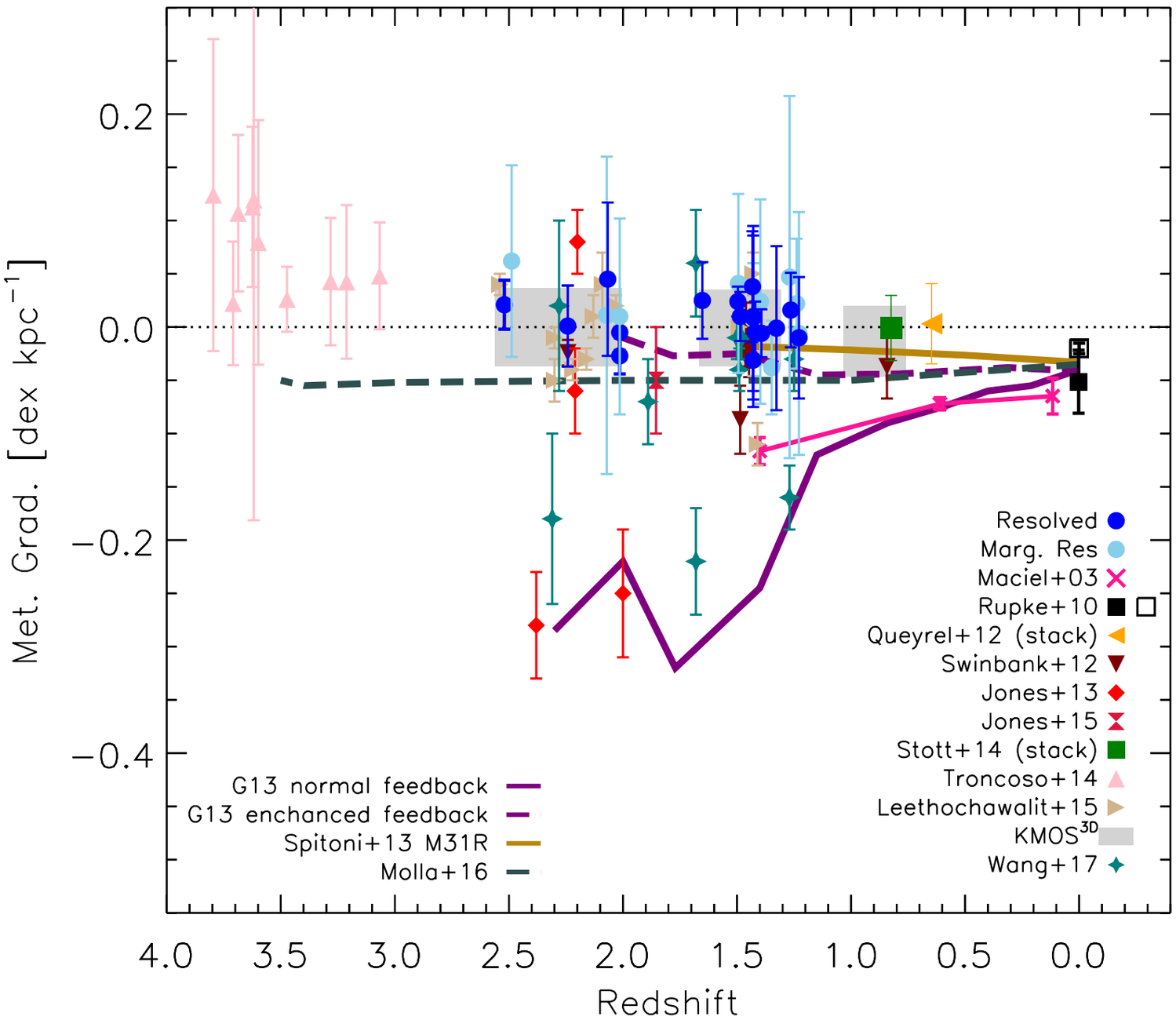






Evolution of Metallicity Gradients

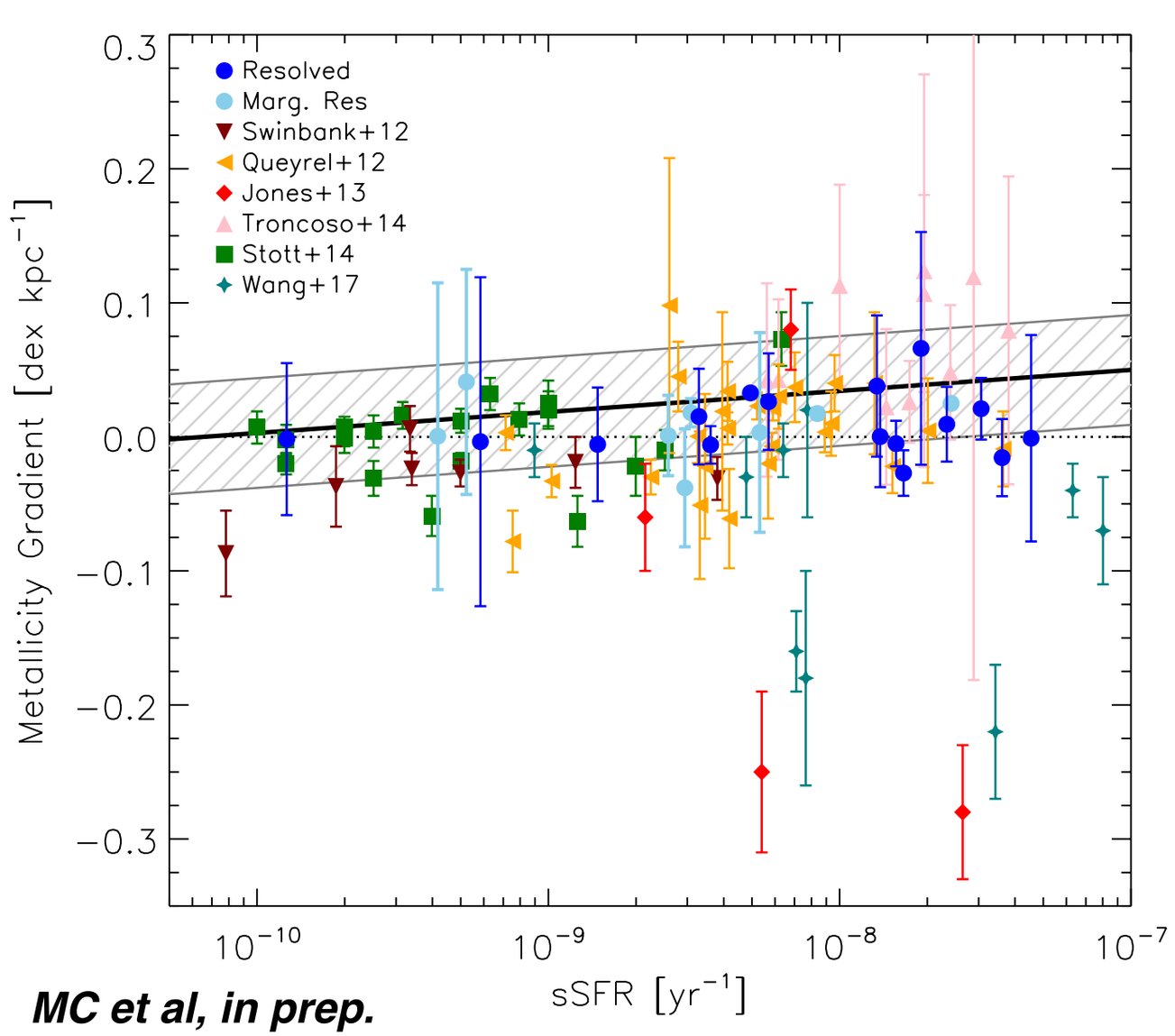
- **flat radial gradients** at z~1.2-2.5 with mild cosmic evolution
- enhanced feedback, efficient mixing processes
- CEMs: inside-out + no gas flows prescriptions also ~fit
- **irregular maps - beware of azimuthally averaged gradients at high-z**

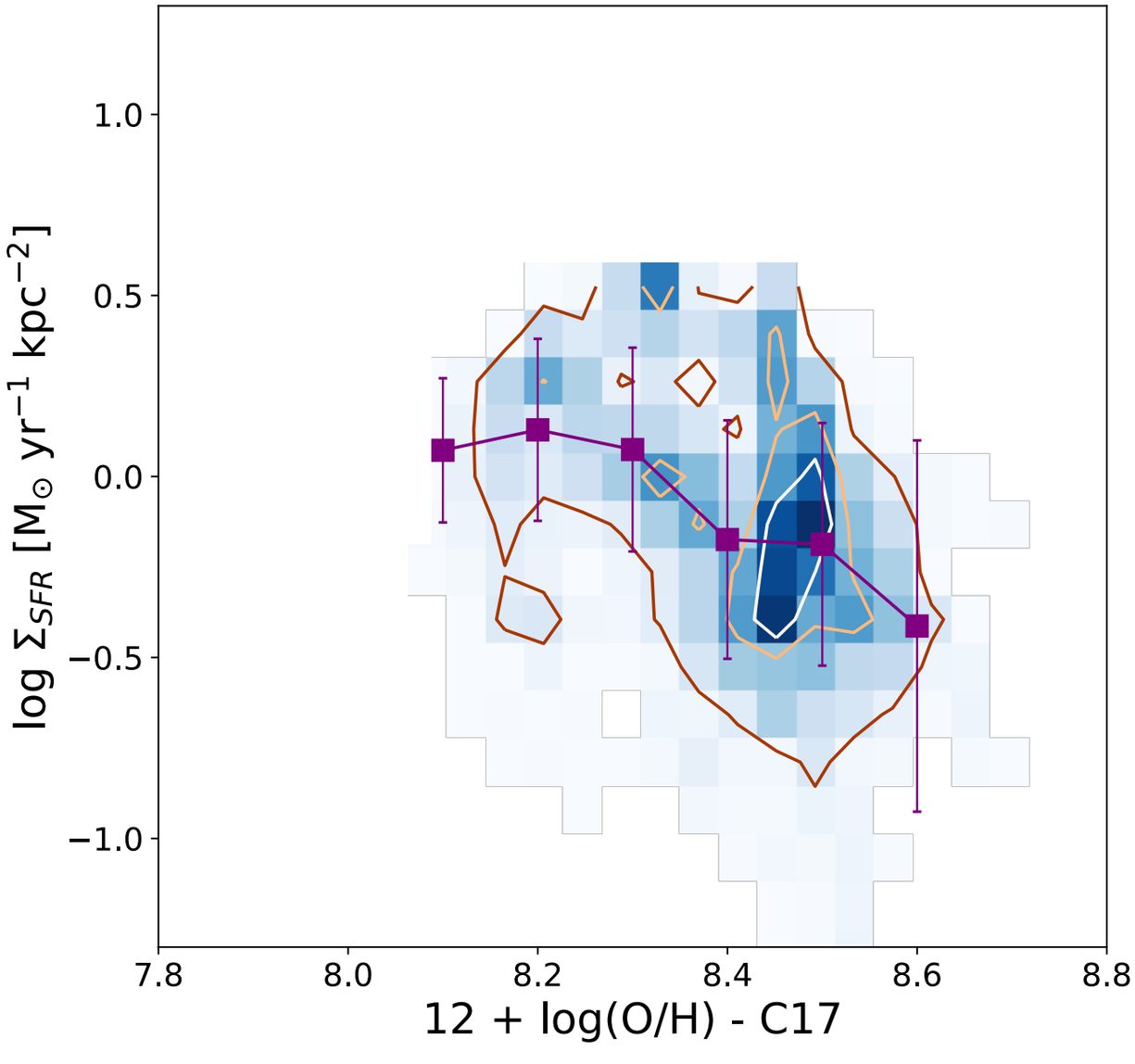


MC et al, in prep.

Metallicity Gradients Relations

- mild trend with sSFR: high sSFR galaxies with flatter/positive gradients (Stott+14)
- **low metallicity spaxels** are characterized on average by **higher ∑SFR** values, thus by a **higher gas fraction**
- local infall of gas diluting the metal content and triggering SF (weaker than in Troncoso+14, z~3.4)





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Summary

- first observations from **KLEVER** ~30 lensed galaxies analyzed so far
- **spatially resolved BPT** diagrams at **1.2 < z < 2.5**
- high-z galaxies with higher electron densities but no strong correlation with offsets in BPTs
- increase in ionization parameter drives the evolution in line ratios for some, but not all, galaxies
- N/O: nitrogen enriched regions deviates towards high [NII]/Ha
  (in particular the most deviating from local N/O vs O/H relation)
- **BPT offsets** arise from the **combination of different effects** whose relative contribution can **change from galaxy to galaxy**
- **metallicity maps** : often **chaotic** and **irregular**
- **radial metallicity gradients** consistent with being **flat** between 1.2 < z < 2.5
- log(O/H) vs $\sum_{SFR}$ correlation on spaxel basis: local infall of diluting gas

stay tuned for more results soon !