The Circumgalactic Medium at z ~ 1 as traced by OVI

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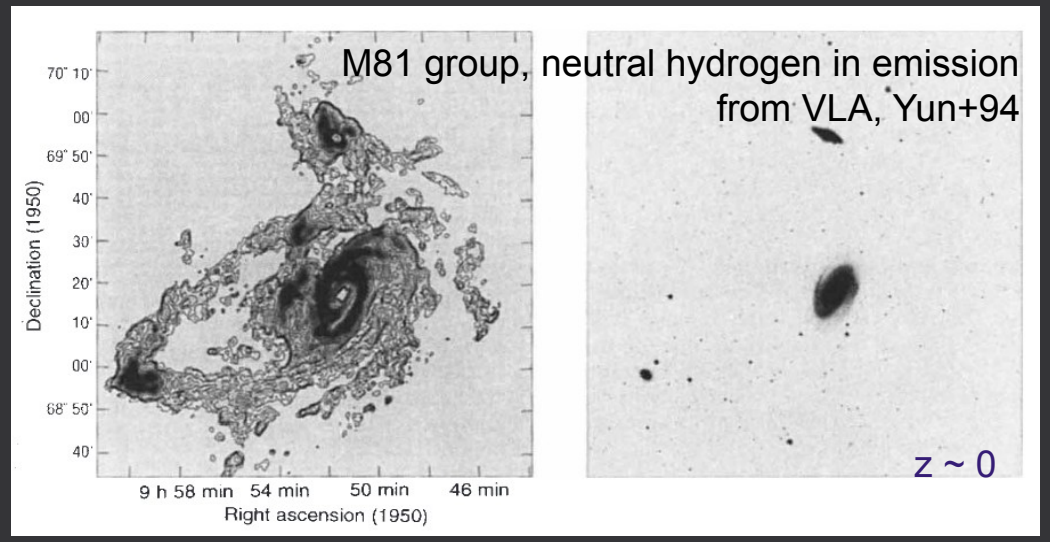
Overview

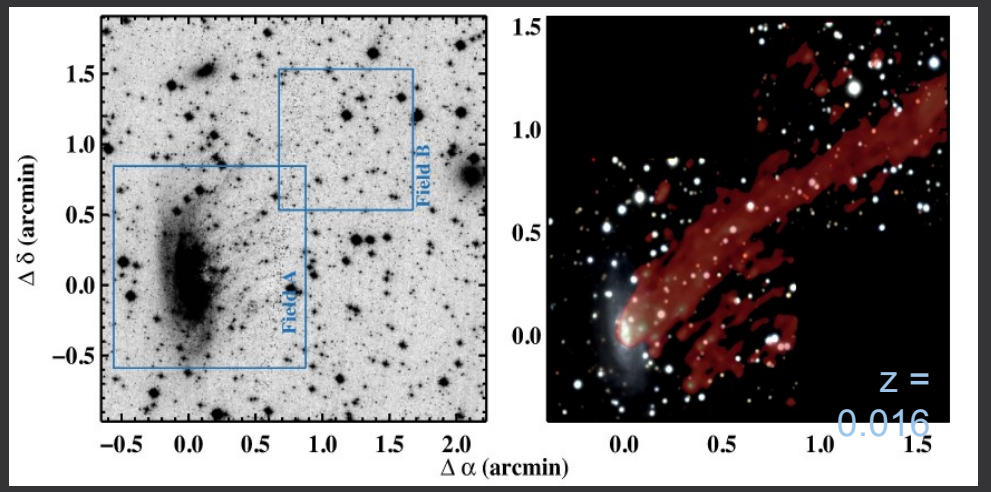
- Presenting results from the Quasar Sightline and Galaxy Evolution (QSAGE) Survey.
  - Introduction to OVI absorption as a tracer of the circum-galactic medium.
  - Overview of the QSAGE survey.
  - Results tracing the circum-galactic medium at z ~ 1 via OVI absorption.

The Circumgalactic Medium

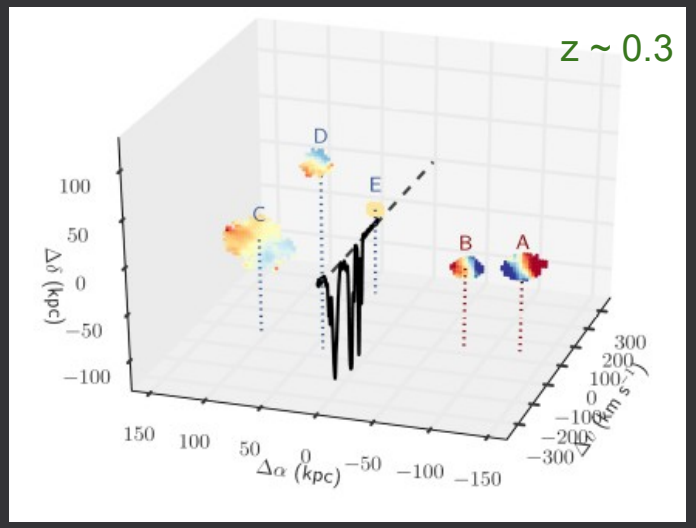
- Circum-Galactic Medium (CGM) – the interface between a galaxy and the Inter-Galactic Medium (IGM).
  - The gaseous halo surrounding a galaxy.
  - Messy & complicated mix of phases, processes.
  - Infalling material from IGM;
  - Outflows/winds powered by SN and AGN;
  - Galactic fountains combining the above two within the CGM.
  - Loose definition of physical size:
  - $1R_{vir}$, $2R_{Vir}$?

Gas structures around galaxies are complex!

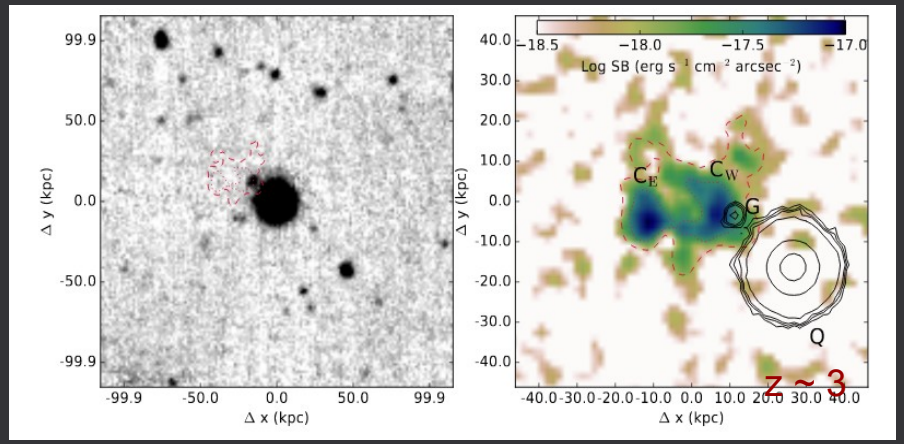




ESO137-001 (z~0.016), neutral hydrogen in emission (red = Halpha) from MUSE, Fumagalli+14

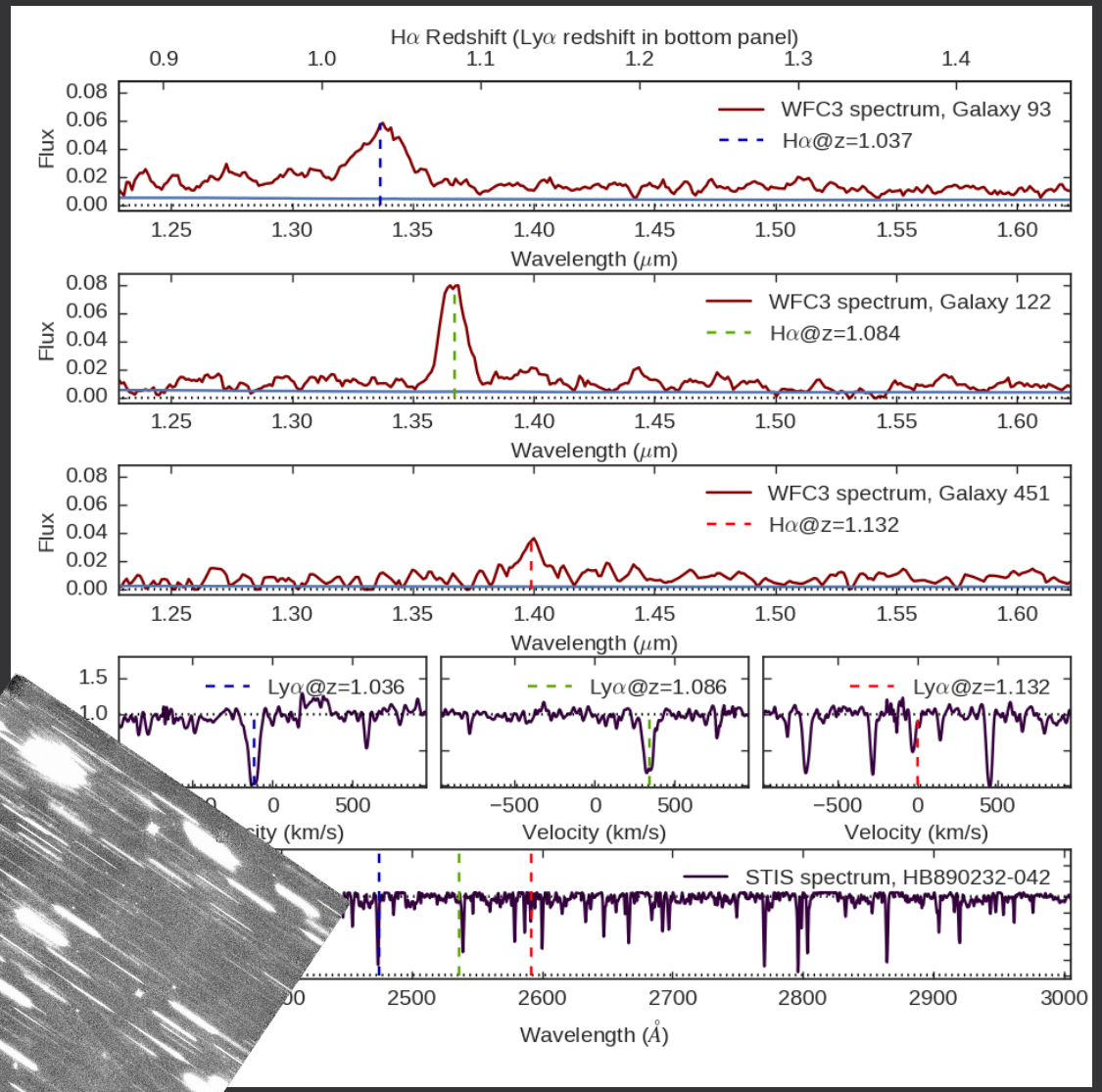


Complex and abundant cool metal absorption distribution within group environment at z=0.282, MUSE, Bielby+17b



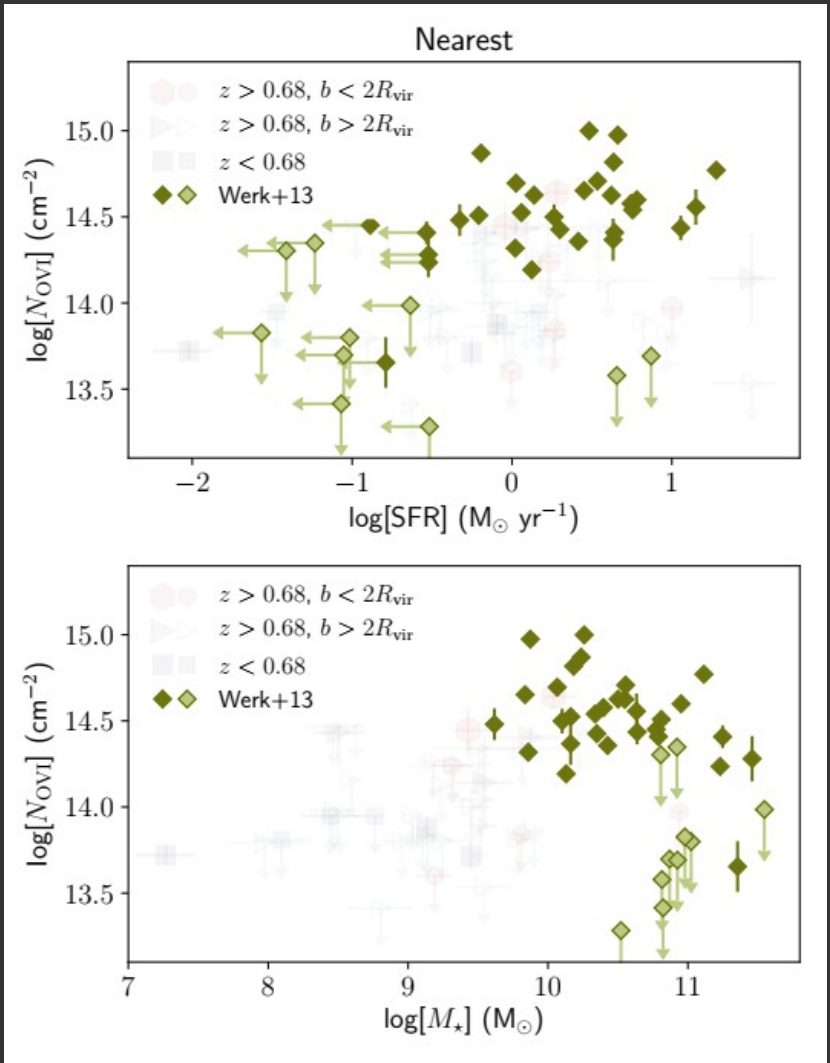
Interacting LAE pair with extended HI gas reservoir at z~3, in close proximity to a DLA, MUSE, Fumagalli+17

Quasar Sightline and Galaxy Evolution (QSAGE)



- Grism observations using WFC3/G141.
  - Spectrum for everything above flux limit for 3`x3` field of view.
  - 4 roll angles in order to remove overlapping objects + zeroth order light from individual spectra.
  - Low resolution, R=130
  - Wavelength coverage 1.1-1.6μm
  - Covers 0.7<z<1.5 with Hα, Hβ and OIII.
  - Complements 0.7<z<1.5 Lyα forest coverage provided by archival STIS/E230M data.
  - Probing CGM scales of >100 galaxies per field.
- MUSE observations of central 1'x1' in several fields.
  - 4 to be observed in ESO P103.
- Large dataset to constrain feedback and infall models at z ~ 1

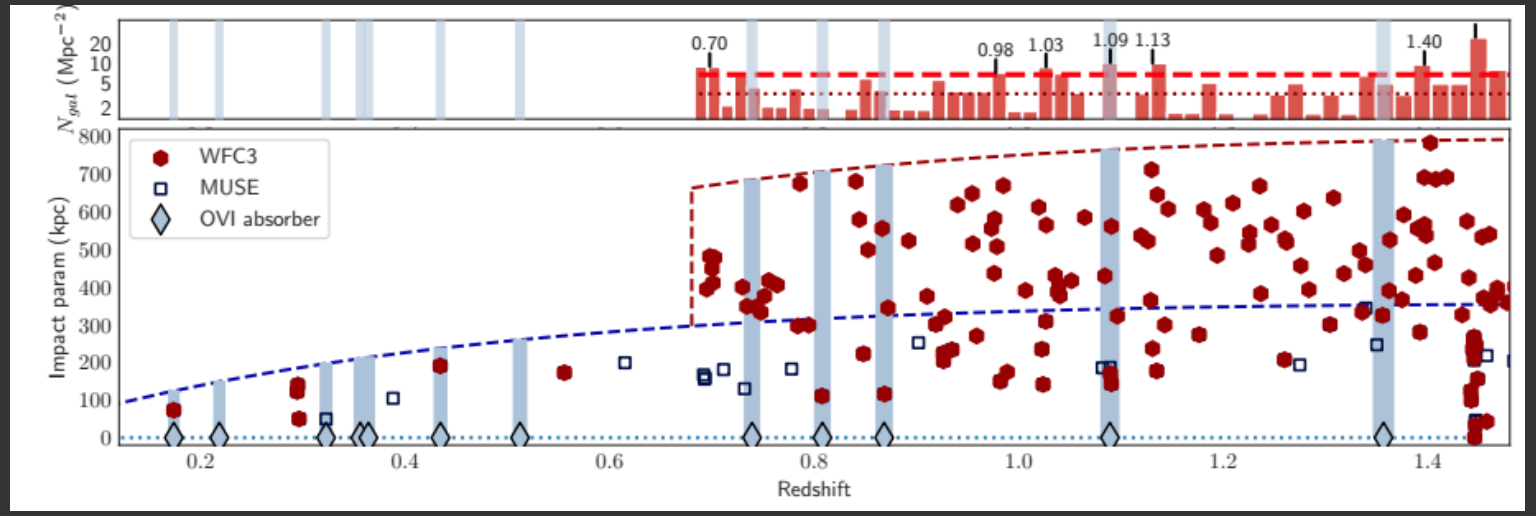
Tracing the CGM in OVI



- OVI traces ~ 10^5K gas
- Identified via wavelength ratio of doublet:
  - 1031A/1037A
  - Note: overlaps with Lya forest, so get's trickier at higher redshift.
- Absorber strength correlated with galaxy SFR in low-redshift work, e.g. Tumlinson+11, Werk+13
- Also, hint of SFR connection via orientation effects (Kacprzak+15)

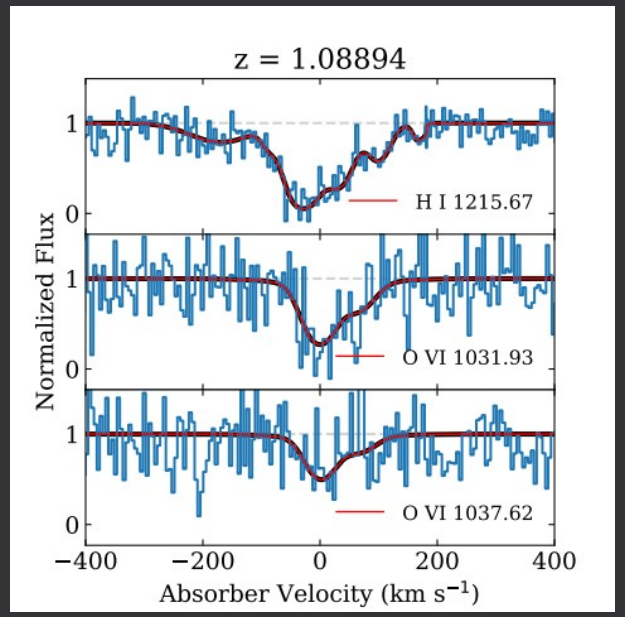
Analysis of first field (HB890232-042)

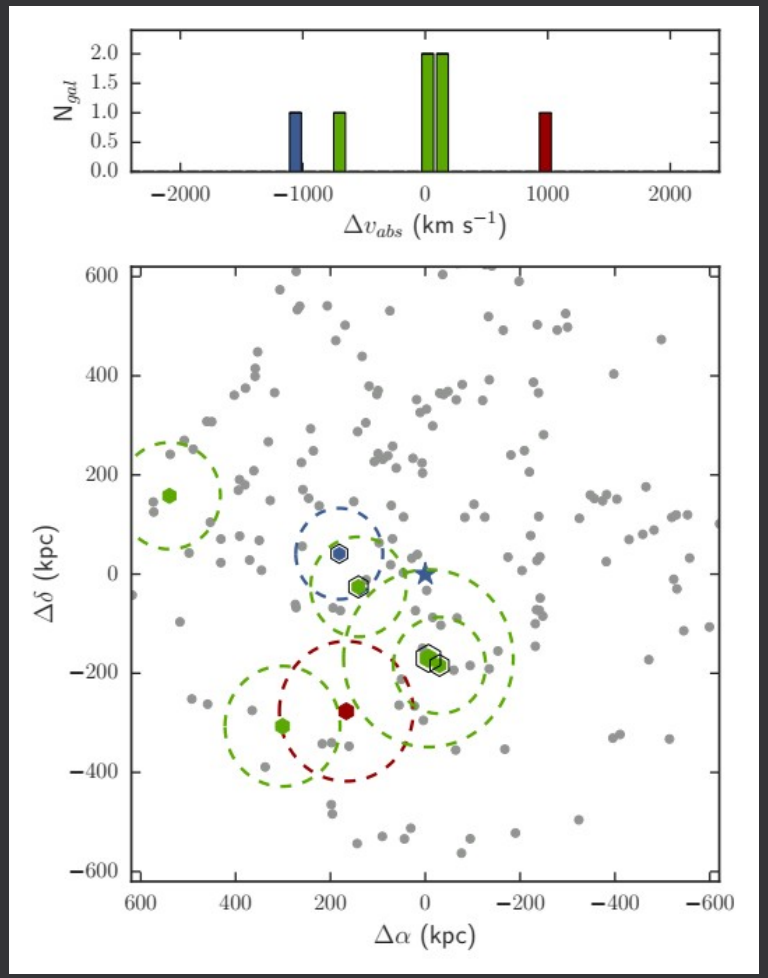
- HST-WFC3 grism data supported by VLT-MUSE data at smaller scales.
  - VLT-MUSE check of grism redshift accuracy: ~ 600 km/s.
- Large over-density co-incident with the bright QSO at z=1.44.
  - Early indication from line ratios suggest widespread AGN activity in the QSO group members (Stott et al. In Prep).



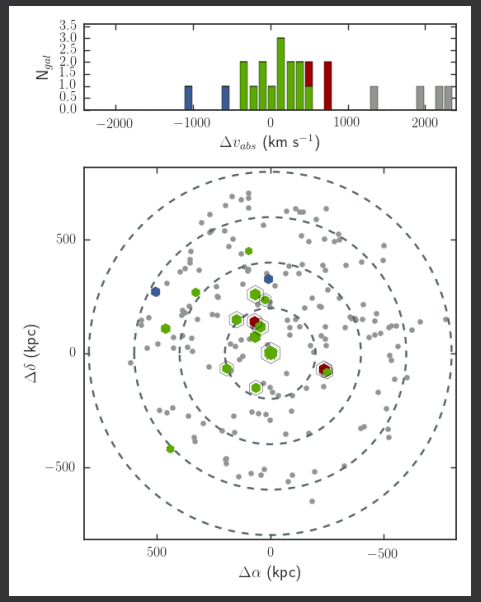
Galaxy Group Environments

- Low mass group coincident with strong OVI absorption, z~1.089
  -

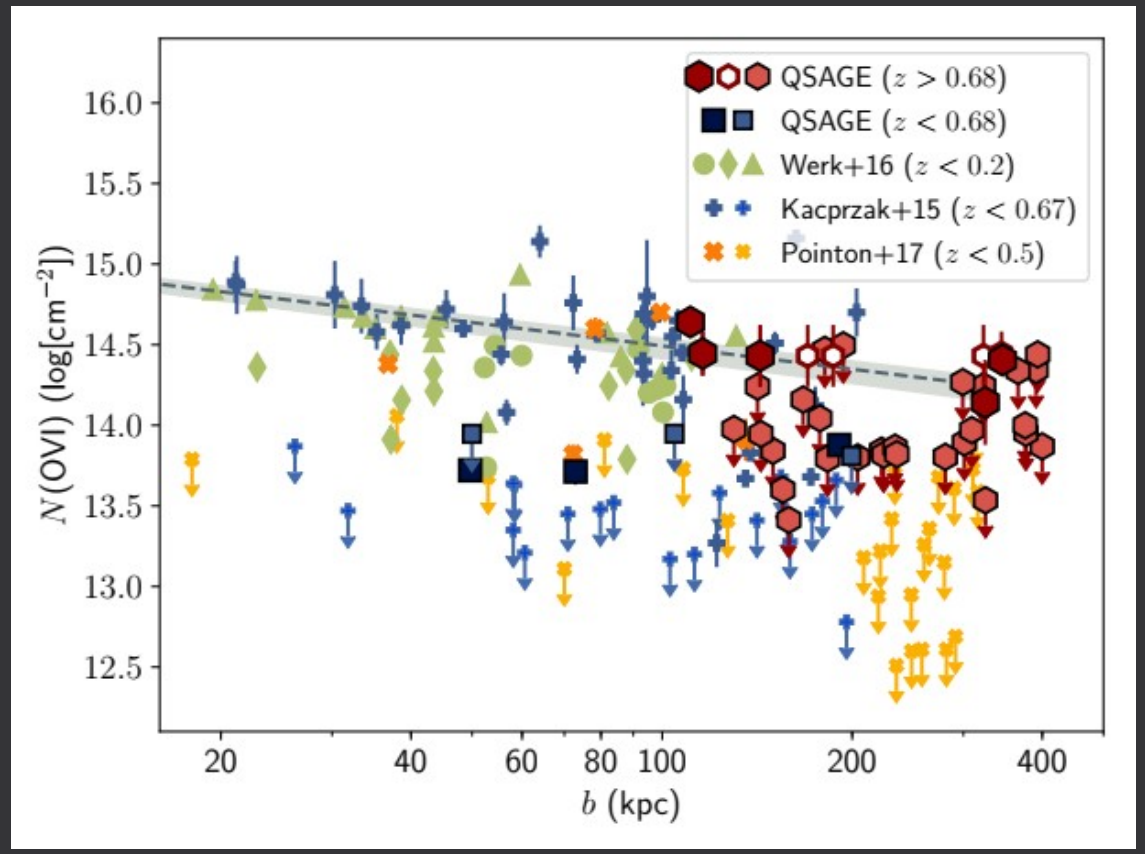




- Large galaxy group also found at QSO redshift.
  - Initial analysis suggests enhanced AGN activity among group members.



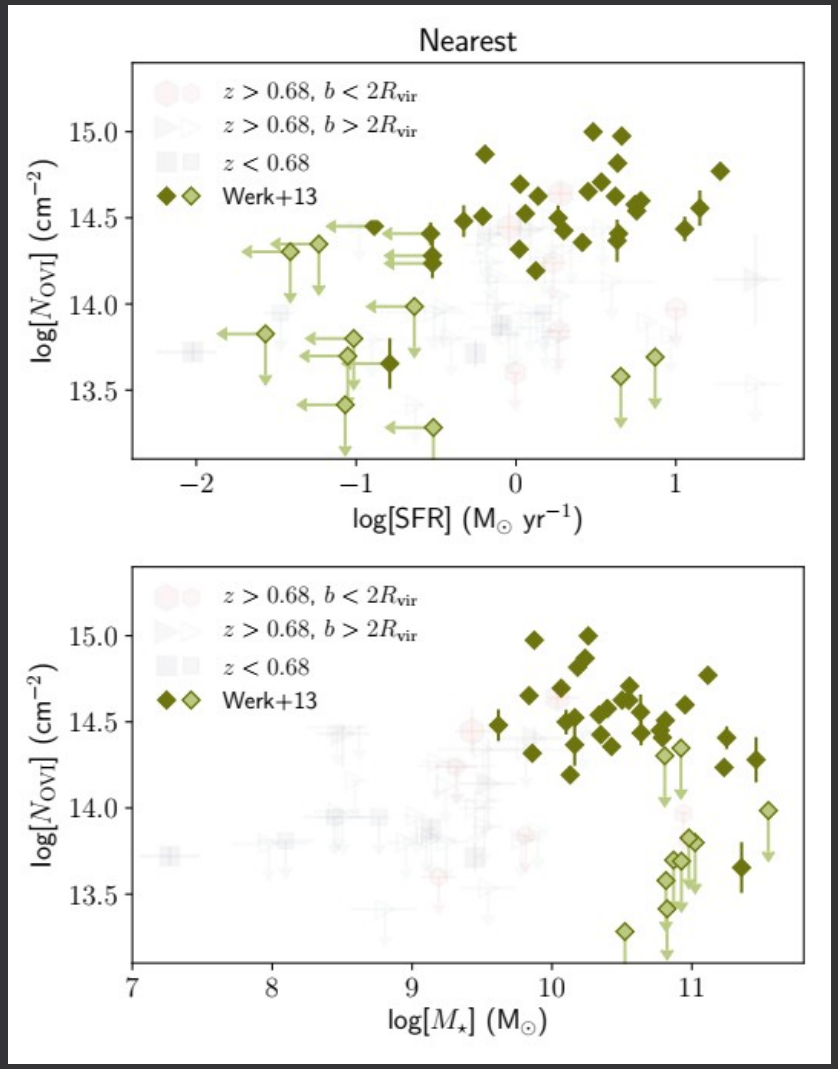
OVI absorption systems around z~1 galaxies



- Results at z~1 build on picture formed from previous surveys at z<0.5.
  - OVI seen up to large scales, i.e. ~ 350 kpc, from nearest detected galaxy.
  - Large scatter in level of OVI absorption detected around the galaxy population.

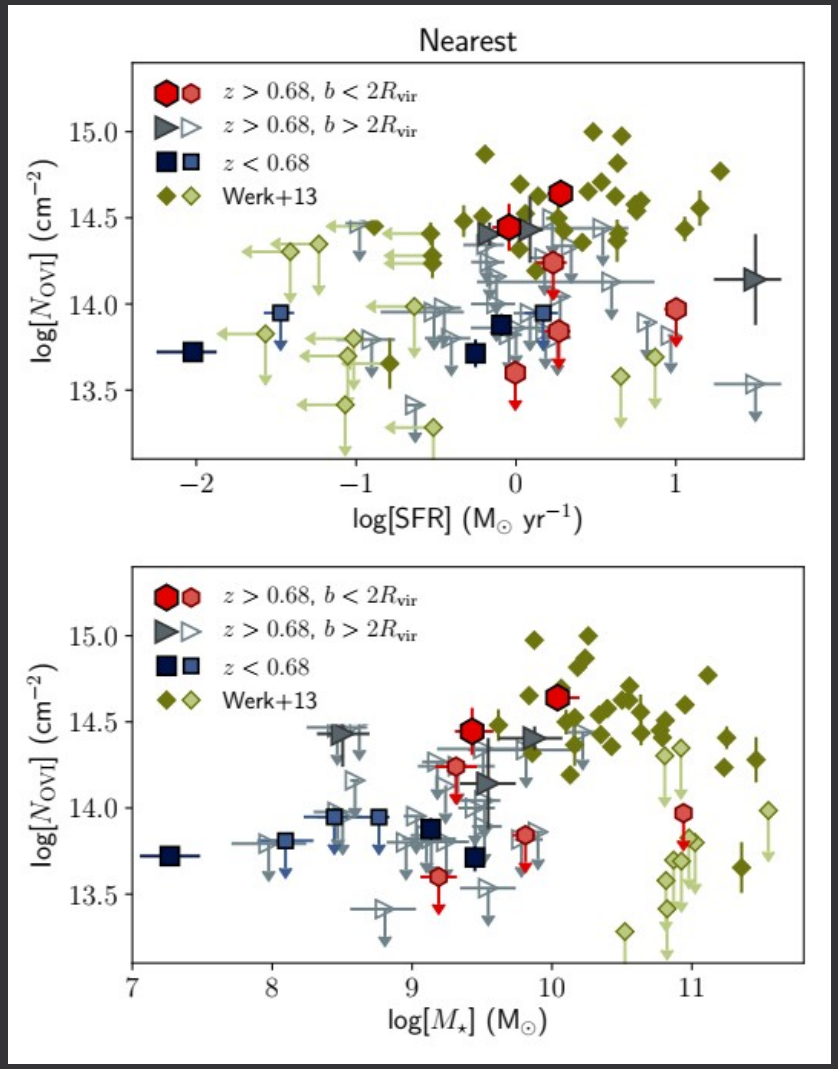
OVI absorption – Galaxy properties

- COS-Halos shows correlation of OVI absorber strength with galaxy SFR (Tumlinson+11, Werk+13).
- OVI absorption primarily detected in the proximity (<R_{vir}) of star-forming galaxies.



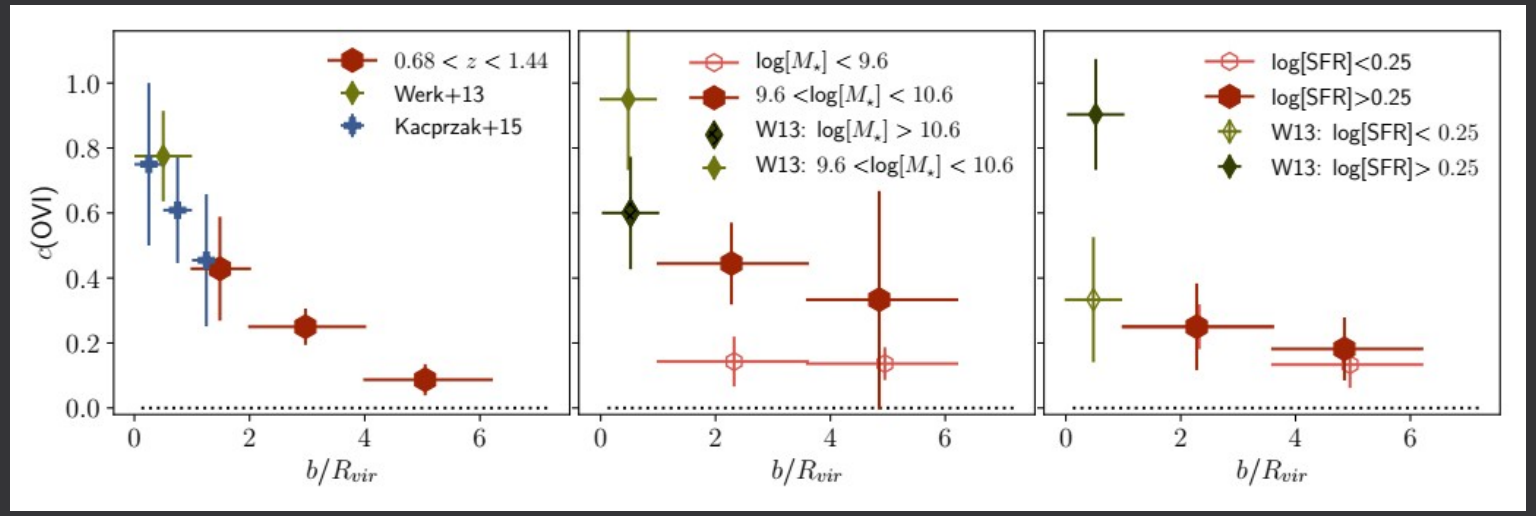
OVI absorption – Galaxy properties

- COS-Halos shows correlation of OVI absorber strength with galaxy SFR (Tumlinson+11, Werk+13).
  - OVI absorption primarily detected in the proximity (<R_{vir}) of star-forming galaxies.
- QSAGE data provides a complementary dataset in parameter space, in particular probing to lower mass systems.
  - Correlation with SFR less clear.
  - Potential indication of OVI absorbers to have a preferred mass-scale of galaxies (c.f. Oppenheimer+).



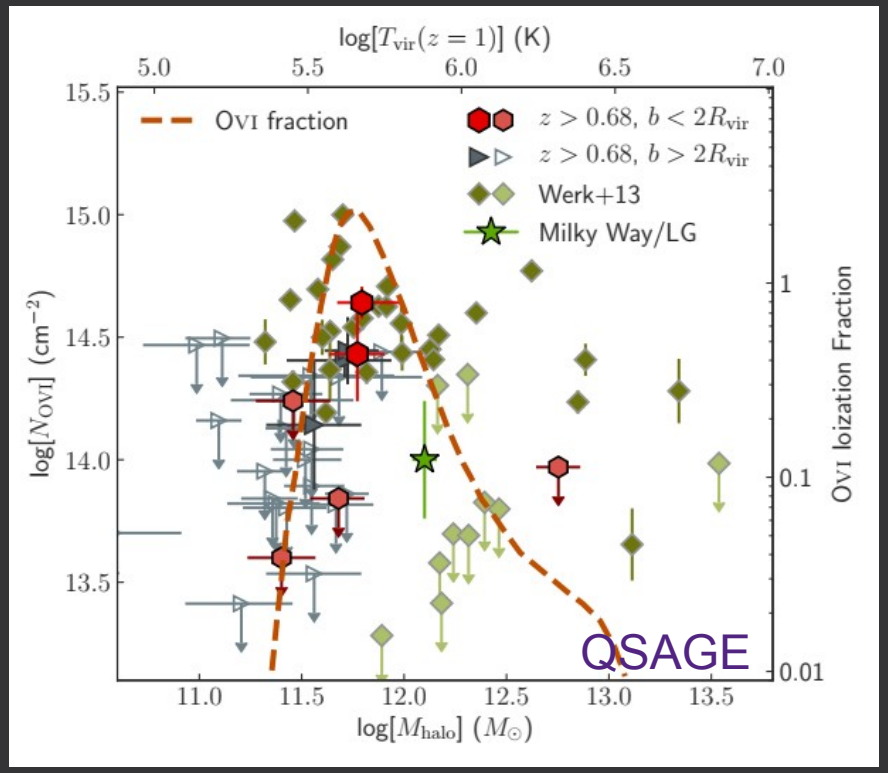
Covering fractions of OVI at z~1

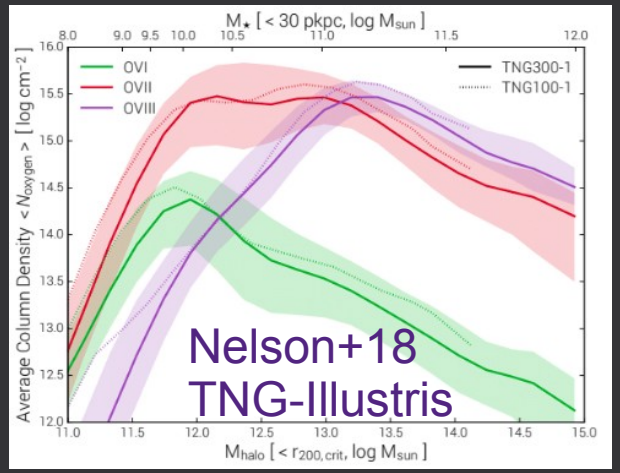
- QSAGE covers large field of view in terms of estimated.
- Agreement/overlap with small-scale low-redshift work (e.g. Werk+13, Kacprzak+15).
  - After taking evolution in R_{vir} into account.
- Covering fractions at large scales again show hint of preference for ~10^{10} Msun galaxies.
- But no evidence of any SFR correlation at these large scales.

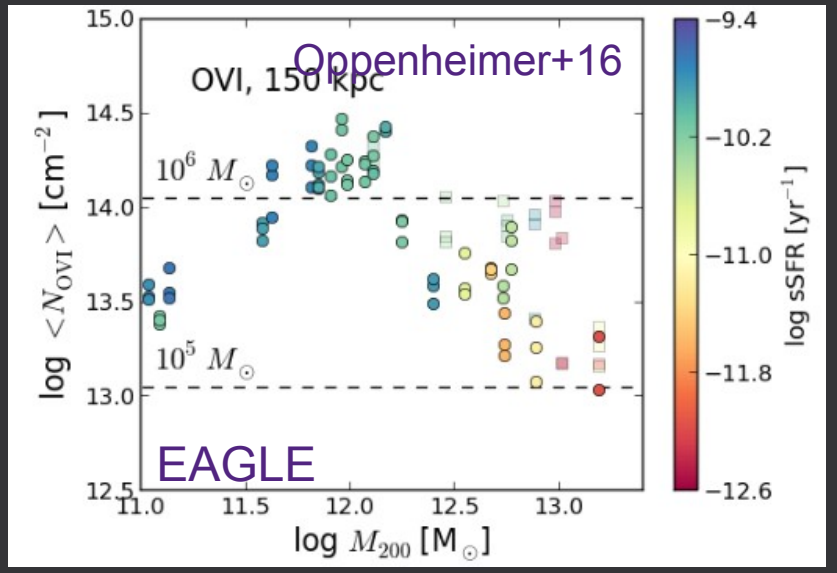


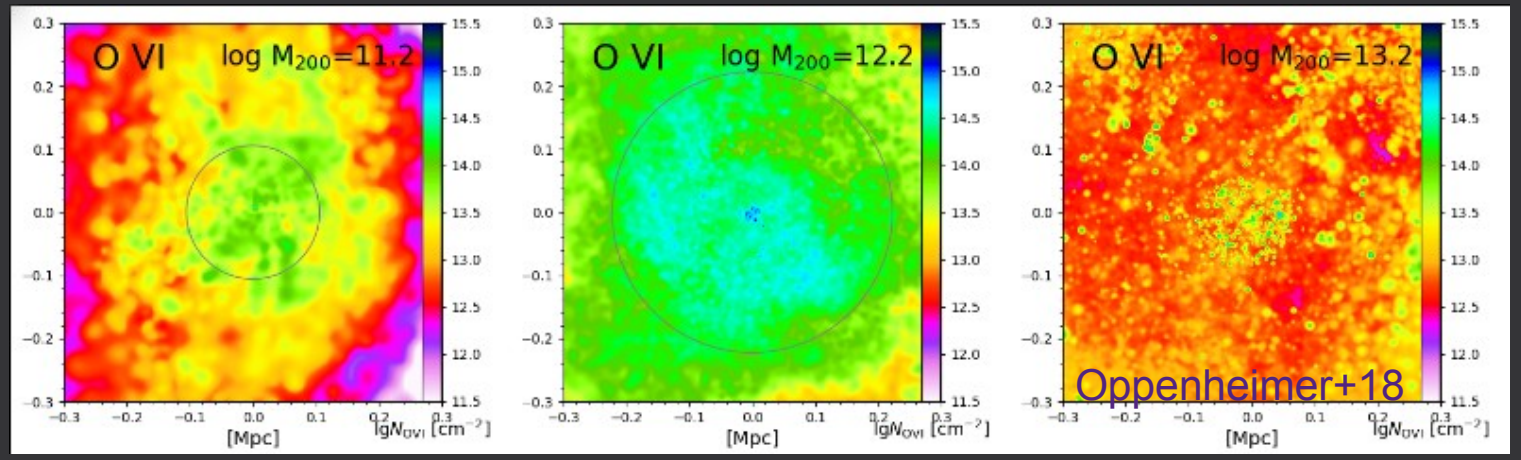
Comparison to Hydro-Sims

- Taking estimated halo mass of absorber host halos:
  - Hint of OVI tracing temperature of host halo – i.e. diffuse collisionally ionized gas.
  - c.f. Oppenheimer et al (2016, 2018)
  - Also Nelson et al. (2018) - Illustris



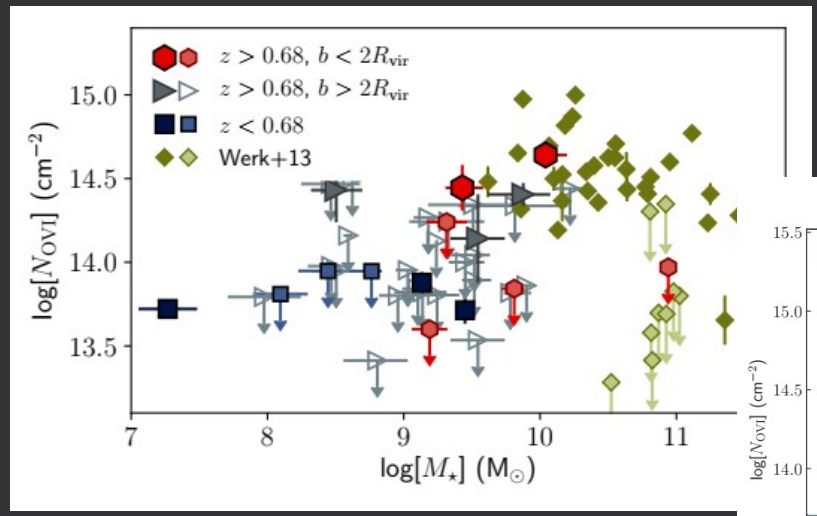


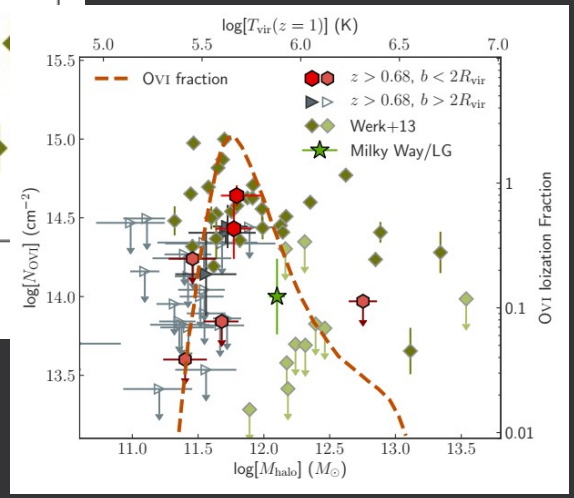




Conclusions and Summary

- First of 12 fields presented in Bielby et al. (2019).
- Background QSO @ z=1.44
- Large over-density co-incident with QSO, with signs of group member AGN activity (see Stott et al., In Prep).





- Analysis of OVI at z ~ 0.7-1.5.
- OVI absorption seen at up to ~ 350 kpc from nearest detected galaxy.
- OVI system detected in association a small mass galaxy group @ z=1.08.
- Tentative indication of OVI absorbers preferentially being located in close proximity to ~$10^{10}M_{sol}$ galaxies (~$10^{12}M_{sol}$ halos).