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Probing galaxy groups with Absorption Line Systems

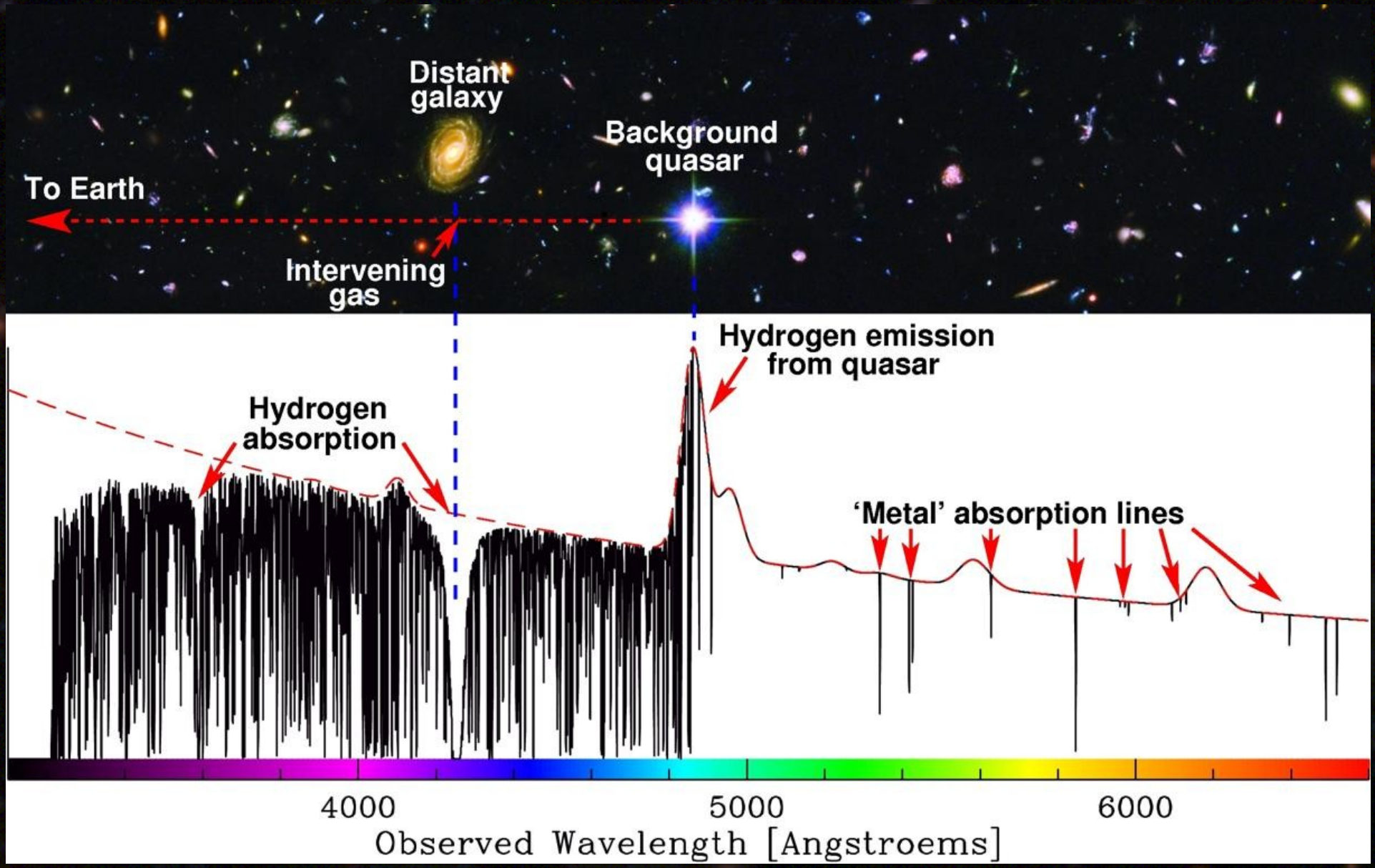
Mostly taken from arXiv:1607.03386

Rich Bielby (Durham University)

N. H. M. Crighton, M. Fumagalli, S. L. Morris, J. P. Stott, N. Tejos, S. Cantalupo

The Physics of Galaxy Groups, Paris, Dec. 2016

Sightline absorption systems



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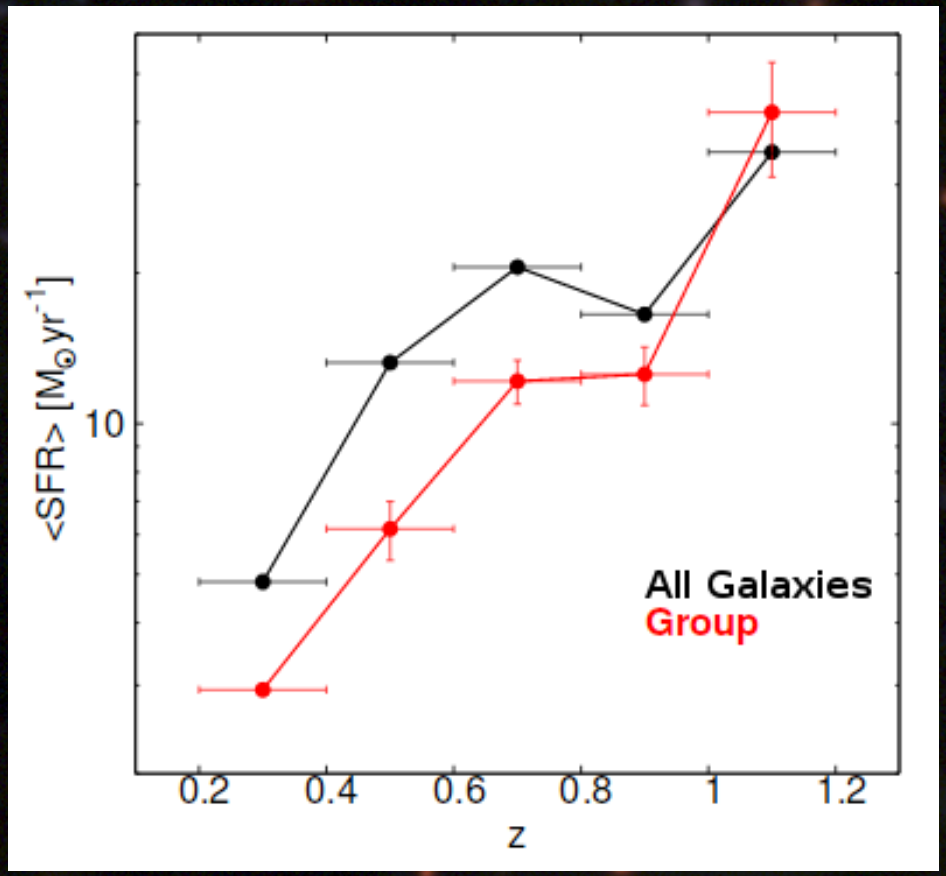
Background – Cool gas in groups

- Many absorption line studies focus on either 'isolated' galaxies (or just pick-out nearest galaxy ignoring environment).
- But, galaxy groups are where a lot of the interesting stuff happens!
- E.g. Erfanianfar+2014
  - SFR in groups falls by ~ 0.1dex from z~1 to present day.



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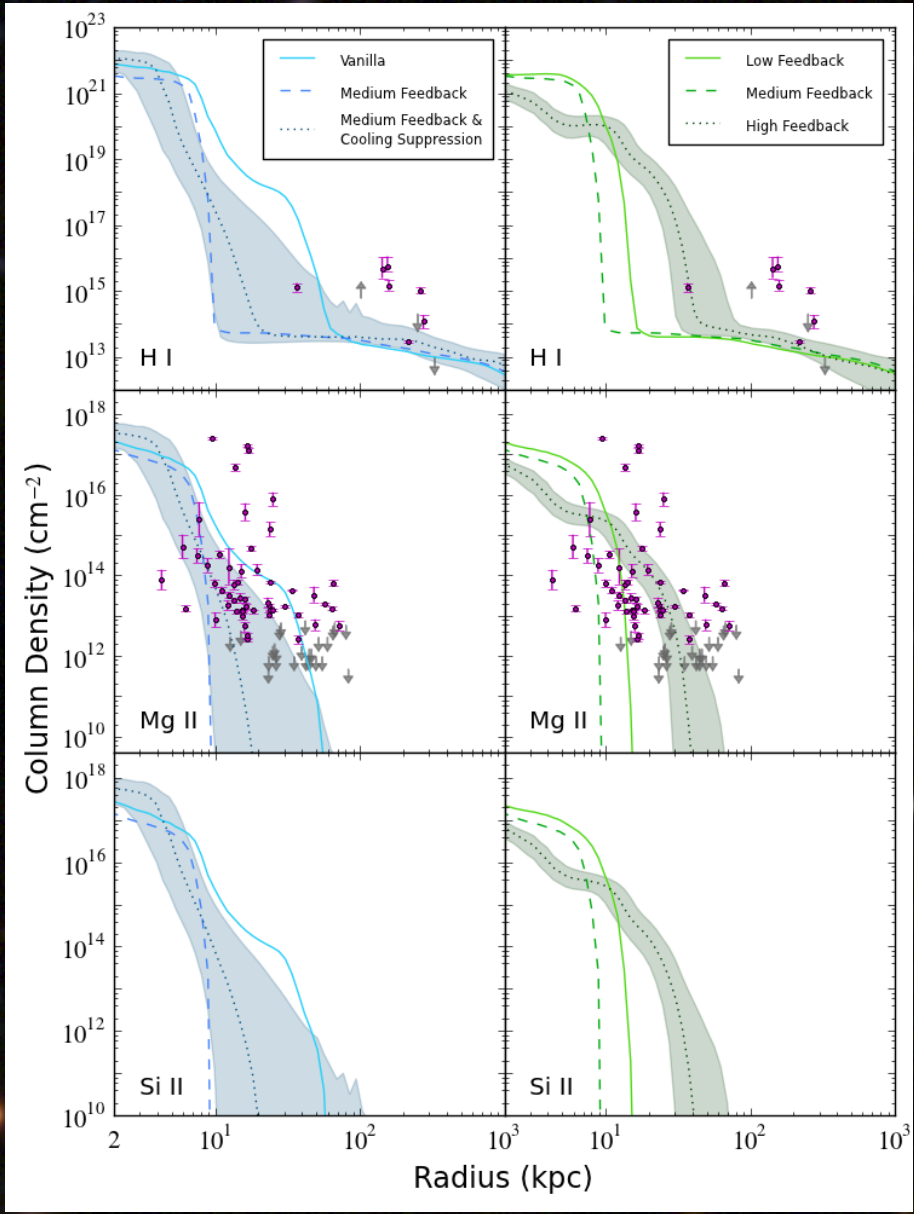
Tracing cool gas via low-ionization absorption line systems

- Tracing cool gas
  - Low ions seen in absorption in QSO sightlines
    - MgII, SiII, etc
    - T ~ 10^4 K
    - Can trace a range of gas:
      - embedded in outflows;
      - Infalling material;
      - Orbiting halo material.
- What is it good for?!
  - Hummels+12 make predictions using cosmological hydrodynamical simulations of a wide range of ionization species, illustrating predicted effects/constraints from such observations.
  - Aim to make predictions of infalling/halo material using EAGLE also.



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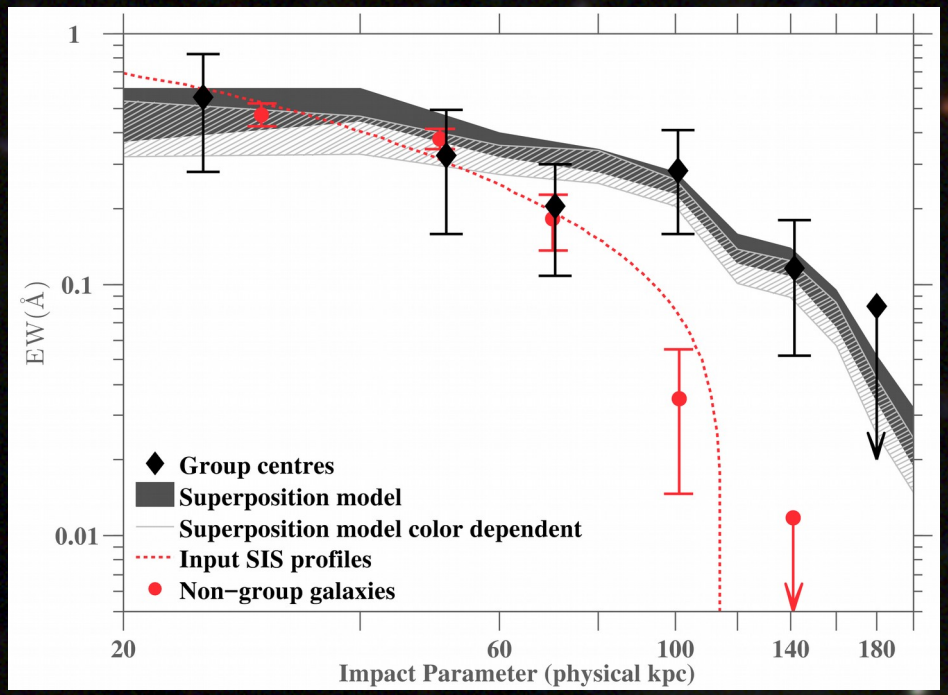
Background – Cool gas in groups

- Relatively small amount of research on absorption sightlines in the group environment.
  - Messy – difficult to disentangle associations.
- Bordoloi et al (2011):
  - Cool gas traced by MgII absorption;
  - MgII in groups more extended than around 'field' galaxies.
  - Extension potentially explained by superposition/clustering
    - i.e. Multiple individual MgII systems associated with different local galaxies.
- Can we inform/flesh out this statistical analysis with more detailed views of individual systems?



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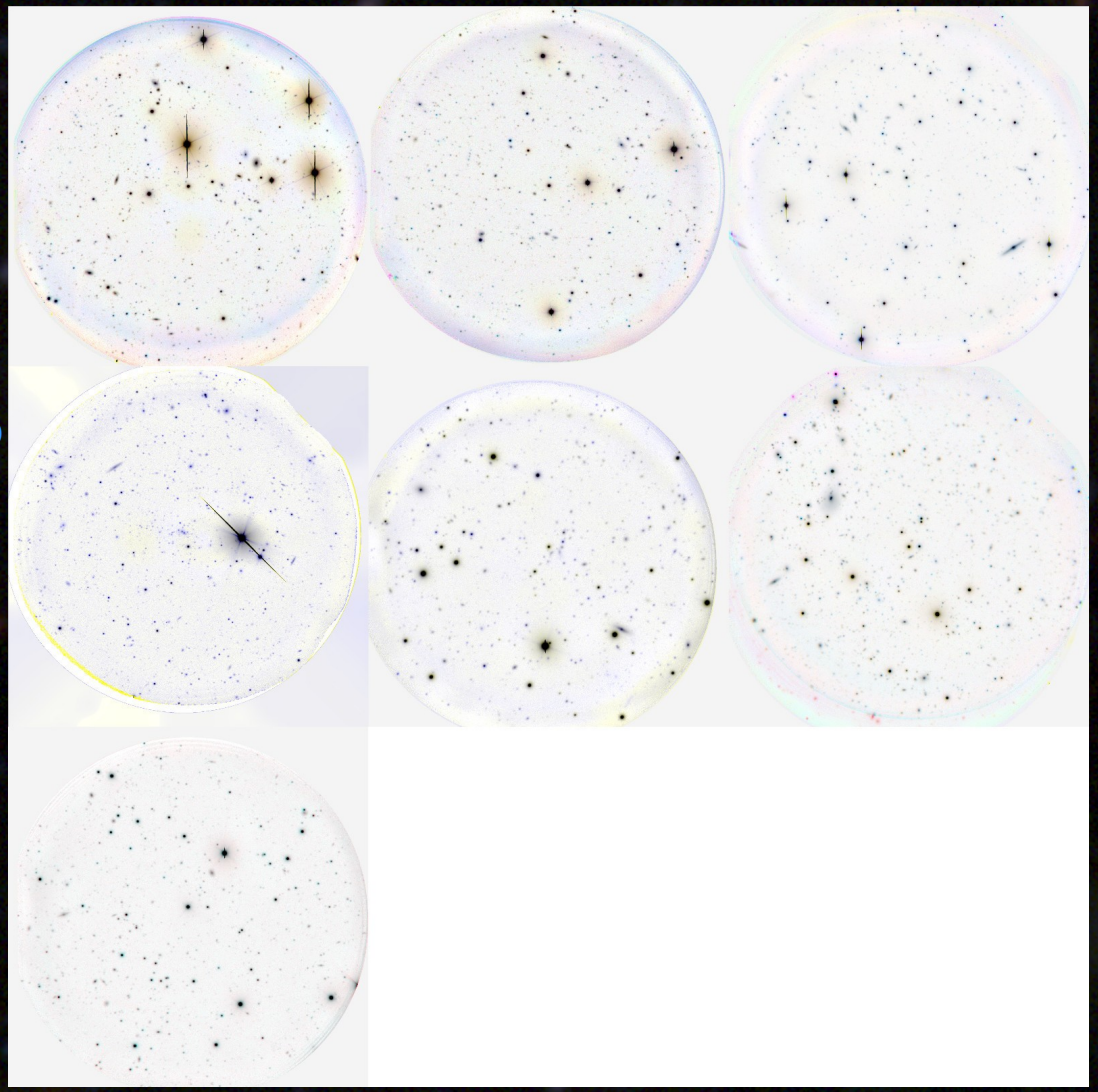
Slight aside: QSAGE

- Data presented here was partially taken in support of our large HST program:
  - QSO Sightline and Galaxy Evolution (QSAGE) survey
- Deep NIR grism data on WFC3 on 12 fields.
  - Hα coverage: 0.7<z<1.5
  - Each field 3'x3'
  - Each field centred on a bright background QSO already observed with HST-STIS.
- Developing deep datasets for each field intended to be useful for a wide range of galaxy evolution studies.
  - 7 fields observed with deep *gri* imaging with WHT-ACAM, 4 more applied for.
  - 5 fields covered with VLT-MUSE IFU observations, making plans for more.



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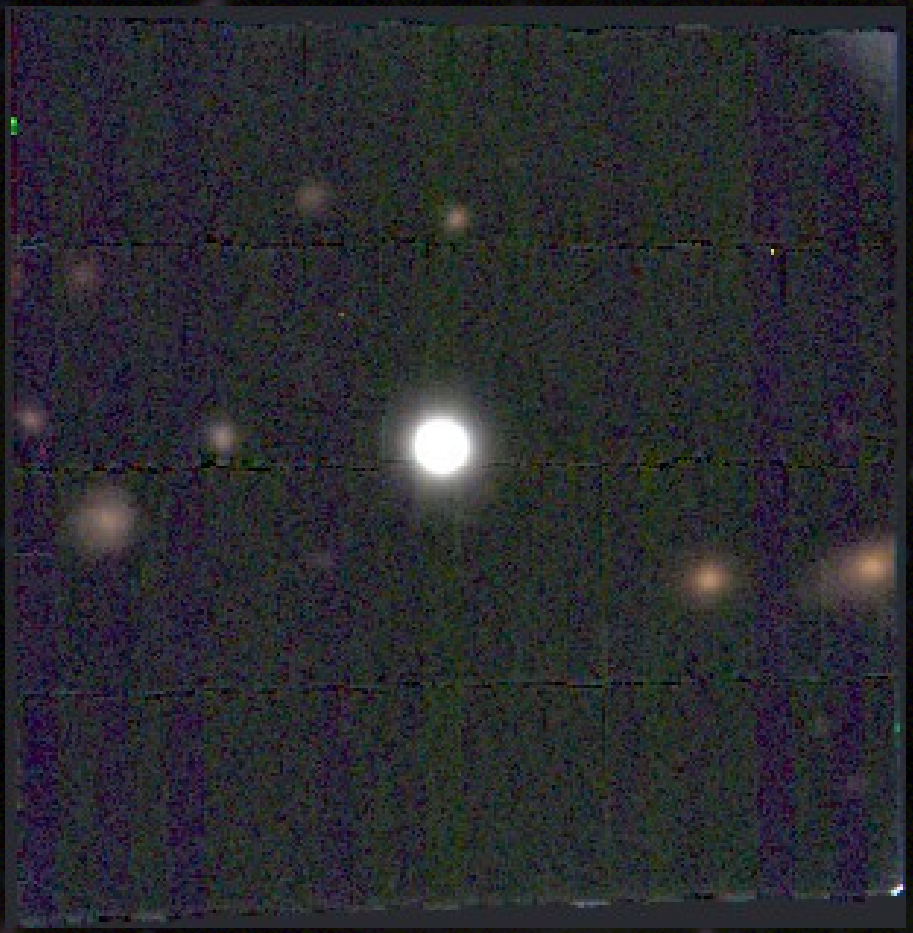
MUSE observations of HE0515-4414

- 25 mins integration with MUSE (out of 240mins requested) centred on the QSO HE0515-4414 (z=1.7).
- 5 galaxies detected at z = 0.282-0.283.
  - Spread around the background quasar position all within 200 kpc.



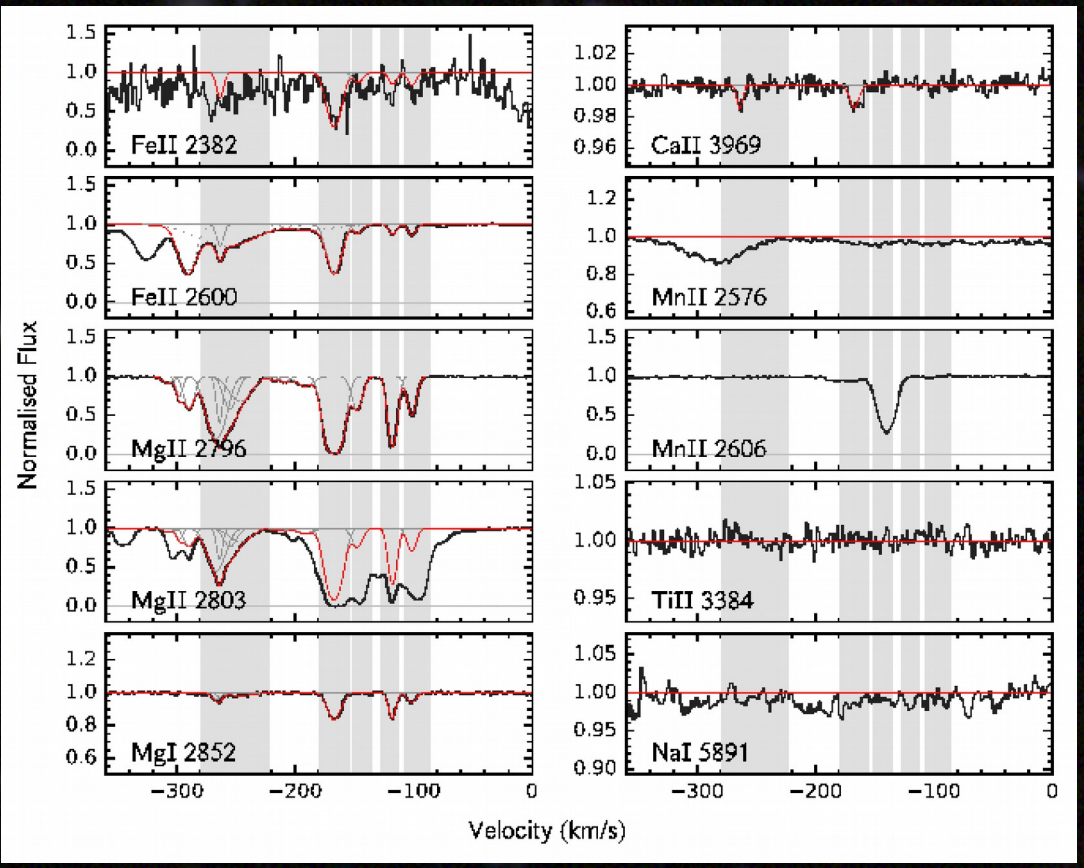
OB Details

OB 1115738 (Raw) - (Reduced) | 03:02:24 > 03:52:38 | 00:50:14 | SERVICE Mode | F:See|THN Loss |

Instrument	MUSE
Name	WFM QSO B0515-4414 OB_1
Target	QSO B0515-4414
PI	Rich Bielby
Run	094.B-0304(A)
Container	-
Public Comments	06 Feb 03:52 : Done out of constraints as no OBs for the conditions was found. THN conditions FLI=0.99 FWHM~0.9"
Weather	ACD

Constraint	Fulfilled	Requested
Seeing	No	0.6
Sky Transparency	No	CLEAR
Airmass	Yes	2.8
FLI	No	0.4
Moon Distance	No	90

Absorption line systems co-incident with z = 0.28 galaxy group



- Co-incident with galaxy group, we find multiple low-ionization species:
  - FeII, MgII, CaII.

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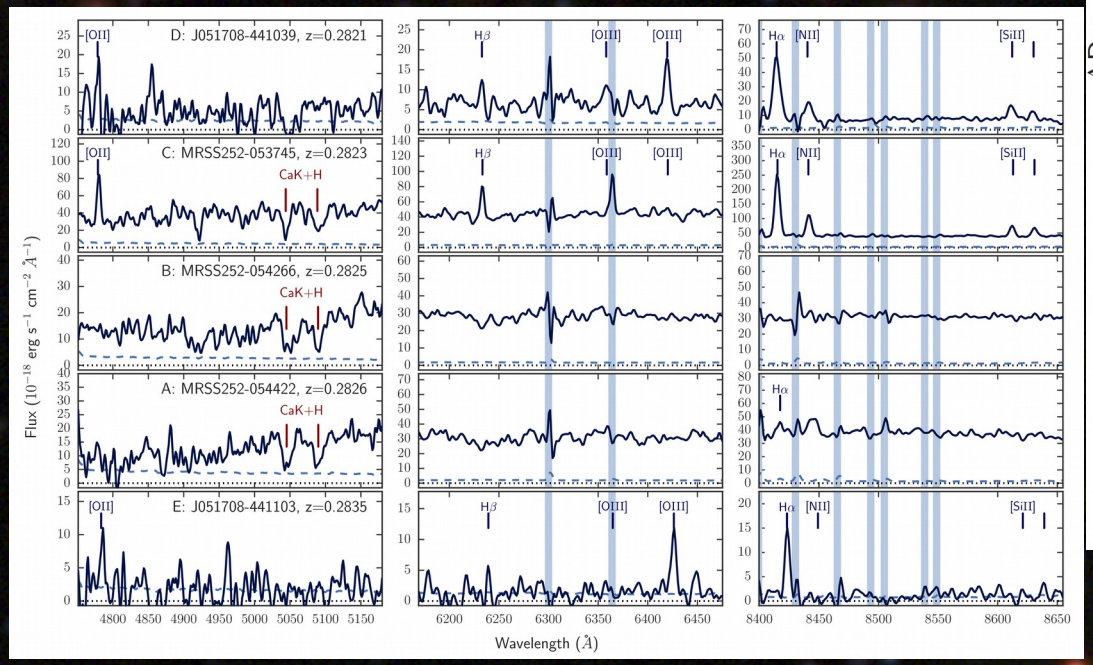
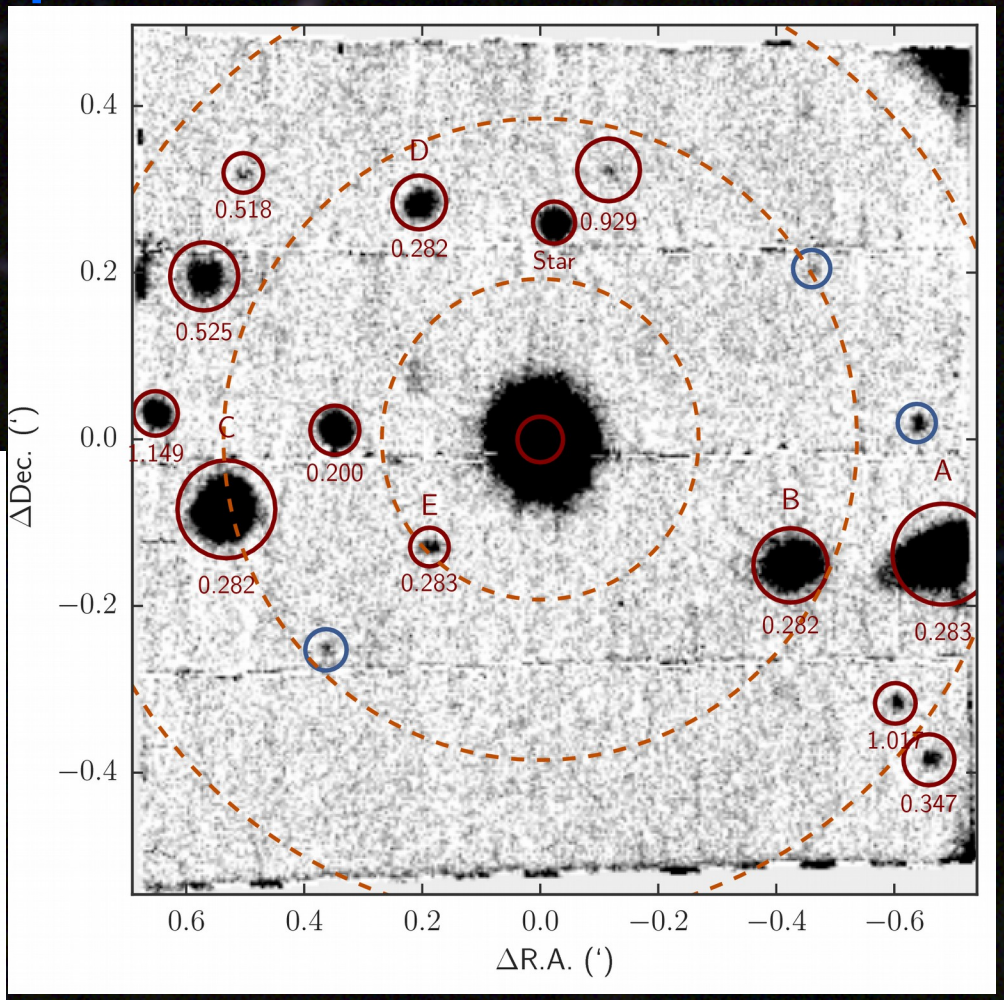
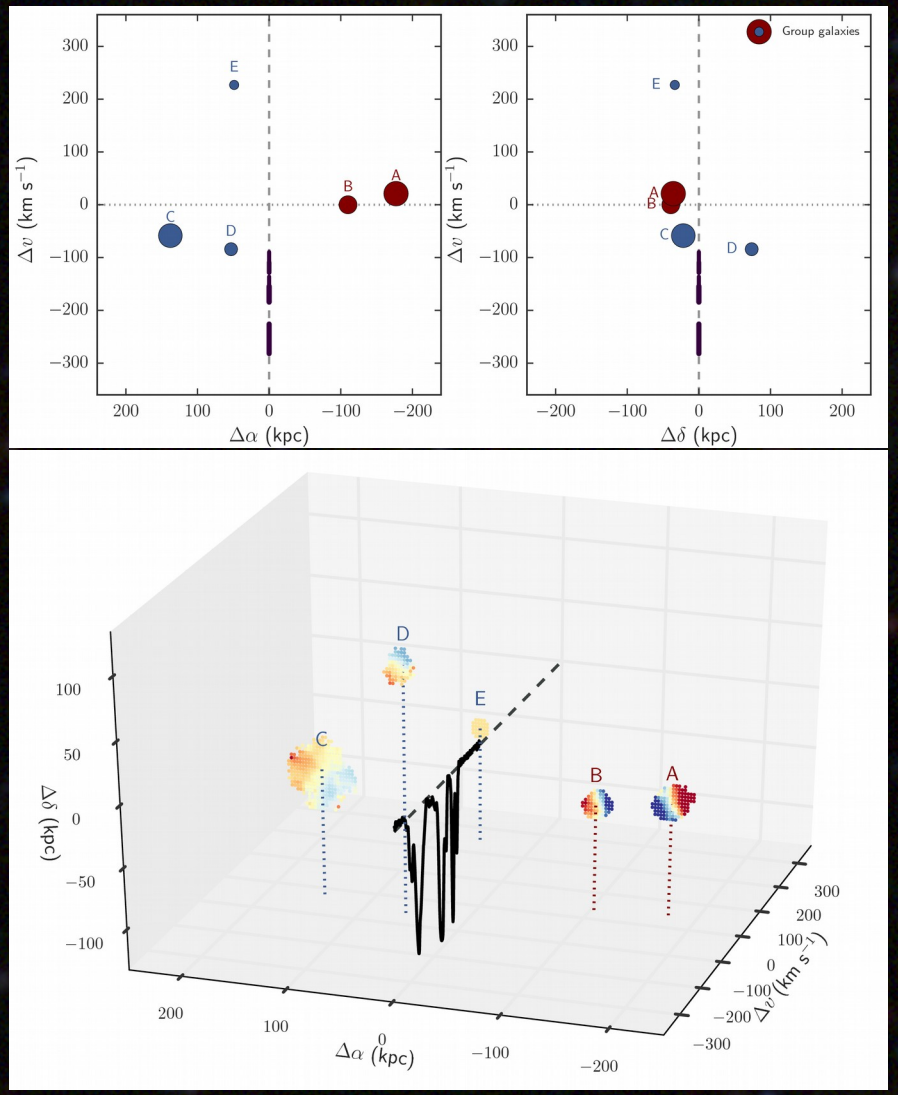
Gas structures within and around galaxy groups

- By using MUSE, we may now zoom in on individual systems, discerning the details hidden within the broad trends.





Overview of the group kinematics



- Detailed kinematics derived for 4 of 5 group members to inform on relationship between galaxies and gas.
- Is the absorbing gas tracing…
  - outflows;
  - co-rotating halo gas/superposition of multiple galaxy halos;
  - intra-galactic medium?

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Nature of the absorbing gas

- Outflowing
  - Absorber is blue-shifted by ~ 250-500 km/s from SF galaxy redshifts.
  - Nearest galaxy is SF, but only ~0.10±01M_{solar}/yr
    - too low to power outflow to 50 kpc?
  - Two further SF galaxies at distances of 80 kpc, unlikely to power ouflow at that distance given relatively low SFRs (<3M_{solar}/yr).
- Co-rotating material
  - Accreting material co-rotating with a single galaxy (e.g. Steidel+02, Churchil+05)?
  - Much higher EW than predicted for any of the individual galaxies based on observational studies by e.g. Chen+10.
  - Kinematically, it is difficult to explain velocity offset in all cases except assumed brightest group galaxy.
- Intra-group medium
  - All galaxies are well within R_{vir} of sightline: is it physically realistic to think of five distinct halos?
  - The ALS kinematics are consistent with the rotation of the brightest group galaxy.
  - Sightline lies at ~ 0.3-0.4x estimated virial radius of the group.

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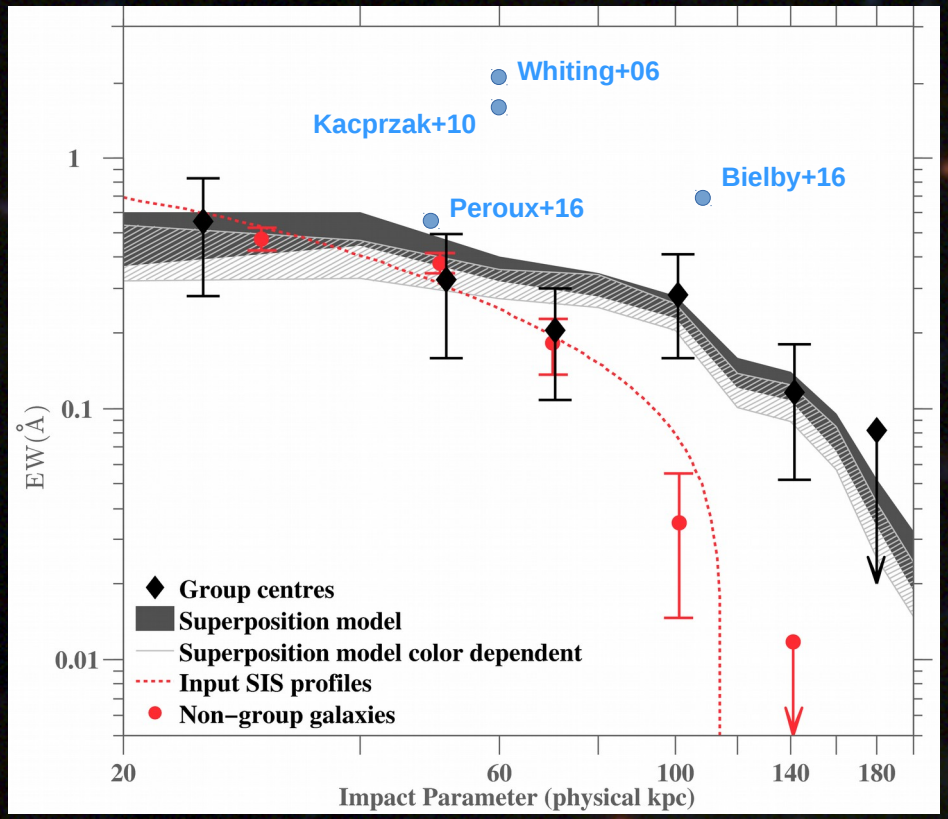
Combining detailed sightlines

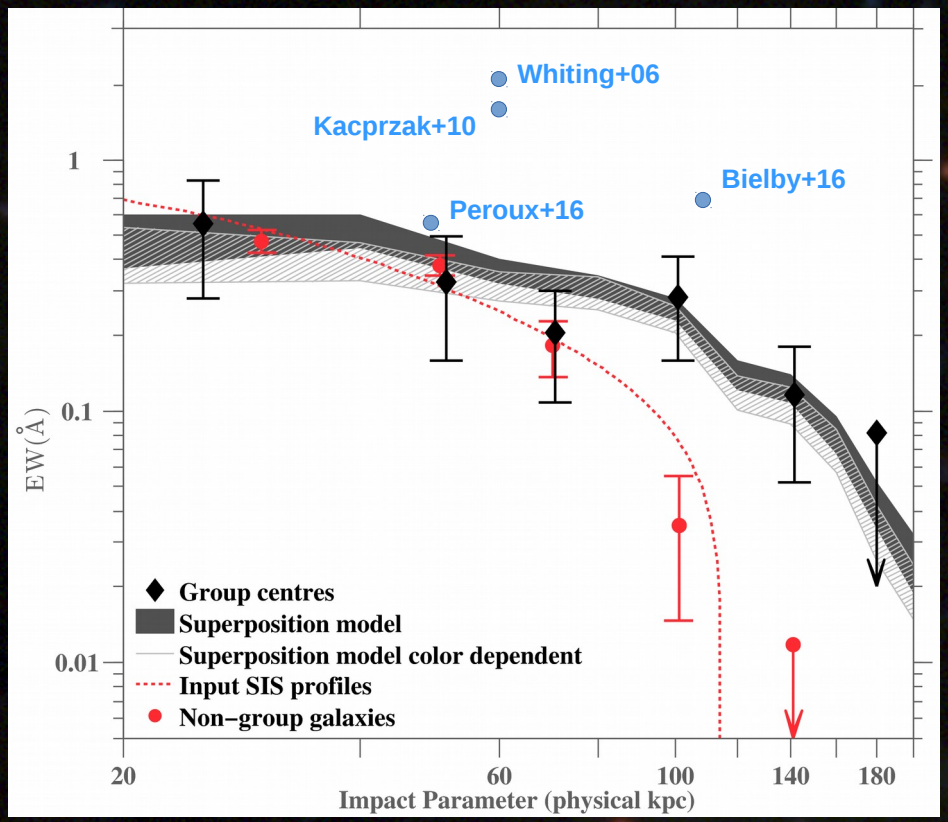
- Well studied individual systems alongside the averaged results of Bordoloi et al. (2011)
  - If we take the 5 galaxies around our sightline, the predicted EW based on Bordoloi+11 model is:
    - EW = 0.56±0.10 Å
    - compared to 0.73±0.02 Å measured.
  - Individual systems generally high outliers in terms of MgII EW.
  - i.e. not particularly representative of the whole (and don't necessarily fit the superposition model of Bordoloi et al).



Sightline	Absorber redshift	Impact: Group centre	Impact: Nearest galaxy	MgII EW
HE0515-4414 (B16)	0.283	110 kpc	49 kpc	0.72±0.02Å
PKS2126-158 (W06)	0.666	60 kpc	26 kpc	2.2±0.2Å
Q1127-145 (K10)	0.312	60 kpc	18 kpc	1.77±0.01Å
HB892128-123 (P16)	0.431	50 kpc	50 kpc	0.58±0.07Å

Combining detailed sightlines

- Each of the four studies conclude that the cool gas is most likely intra-group gas.
  - e.g. stripped material.
- Absorber-galaxy properties are generally concluded to be inconsistent with outflows in all four studies.



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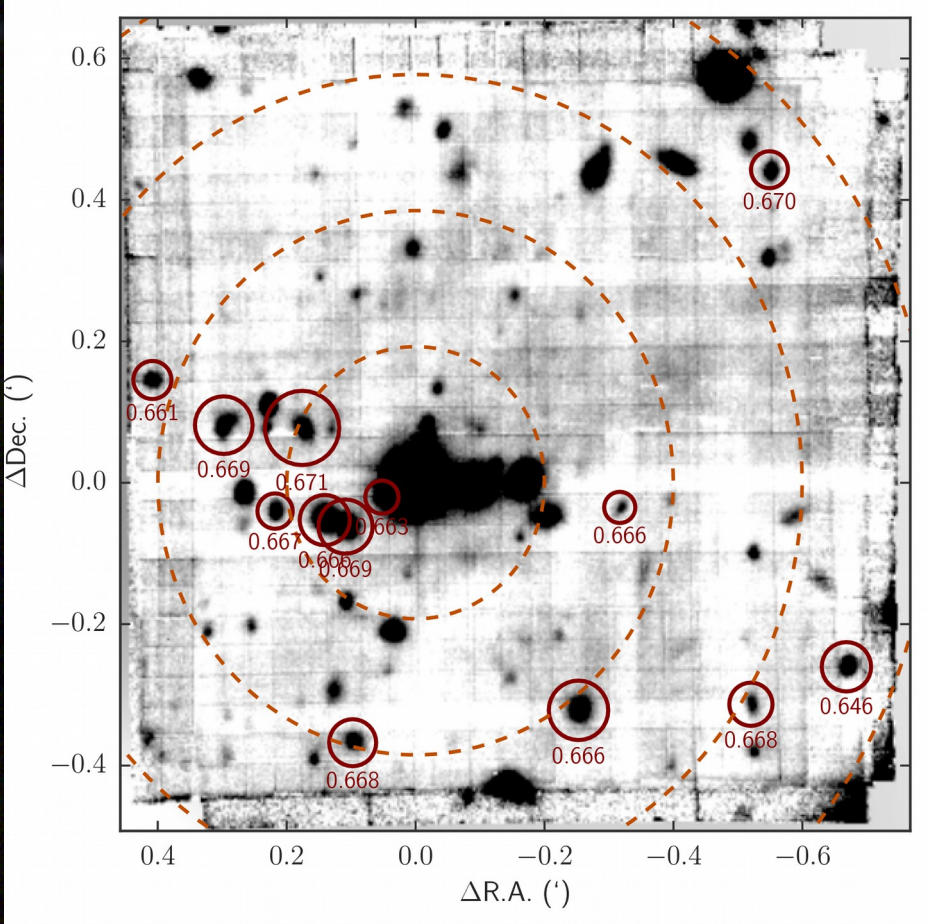
Update on PKS2126-158 sightline

- 4 hrs MUSE data.
  - Detect 13x z~0.66 galaxies.
  - 8 galaxies reported by Whiting+06, all Early Type.
    - But missed closest group member at 25kpc, which is star-forming.



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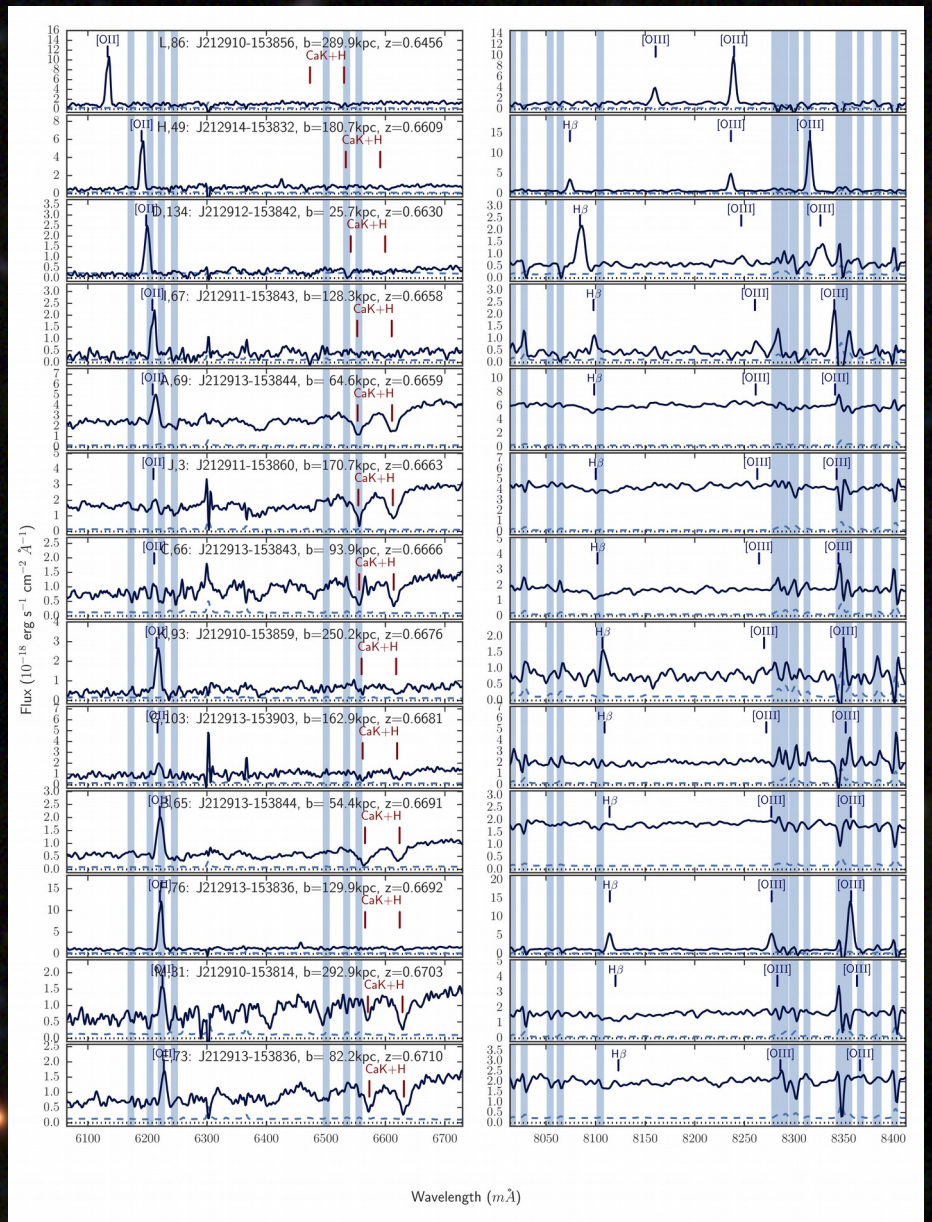
Update on PKS2126-158 sightline

- 4 hrs MUSE data.
  - Detect 13x z~0.66 galaxies.
  - 8 galaxies reported by Whiting+06, all Early Type.
    - But missed closest group member at 25kpc, which is star-forming.
- Applying Bordoloi+10 superimposed MgII absorber model:
  - EW_{pred} = 1.4±0.1 Å
  - Compared to EW_{pred} = 2.2±0.2 Å
- Not calculated galaxy kinematics for full analysis yet.
- To Be Continued….



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Summary

- MUSE can provide invaluable insights into the environment of absorption line systems associated with galaxy groups.
  - Blind surveys of galaxy population
  - Galaxy kinematics
- Cool gas (traced by MgII, FeII etc.) detected in galaxy group environments.
  - Surmised to be intra-group medium/group halo material.
  - Ultimately, using simulations (e.g. EAGLE), the distribution of metals in the group environment can feed our understanding of the declining SFRs in group galaxies.

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What Matter(s) Around Galaxies

Resolving the physics of the Circumgalactic Medium

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Wider group environment