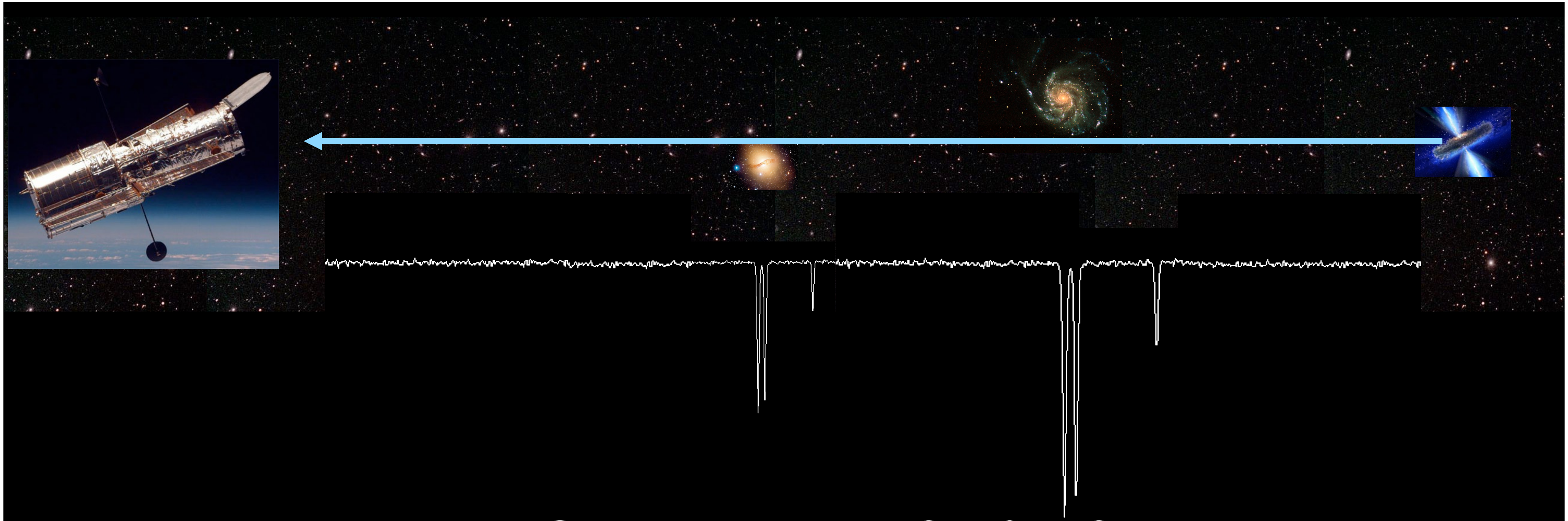
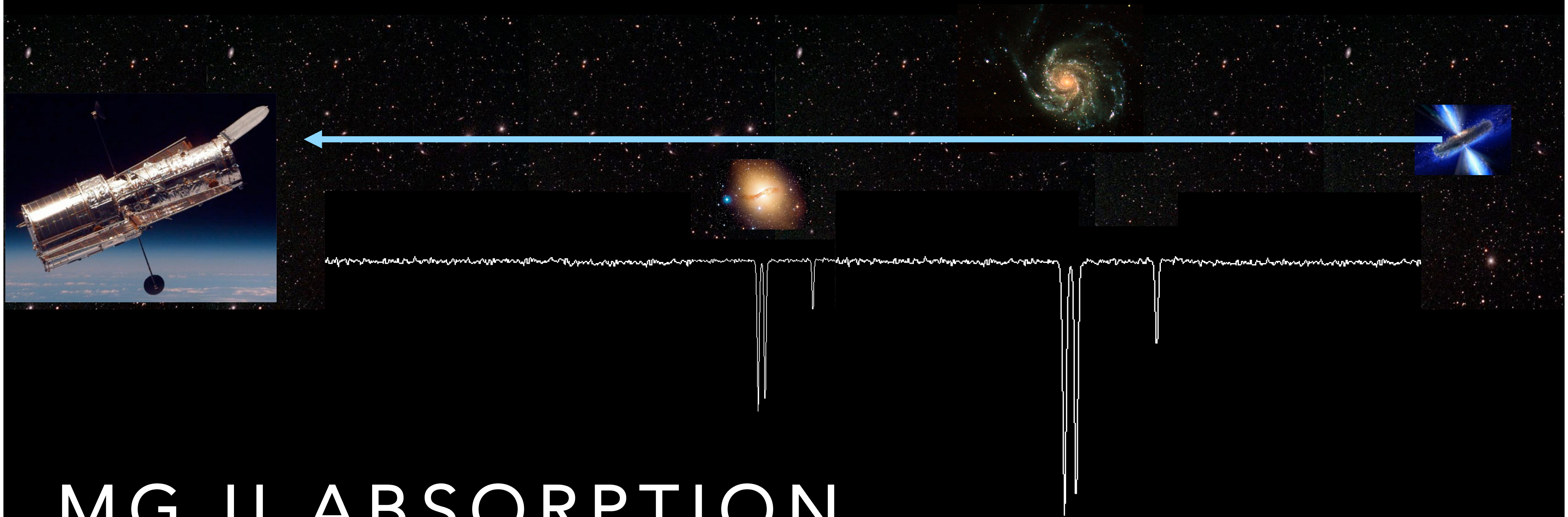


THE ENVIRONMENTS & STAR FORMING PROPERTIES OF MGII ABSORBING GALAXIES AT Z~1

Britt Lundgren
University of North Carolina Asheville

Gabe Brammer (ESA/STScI); David Wake (UNC-Asheville); John Chisholm (Geneva Observatory); Dawn Erb (UW-Milwaukee); Varsha Kulkarni (USC); Lorrie Straka (Leiden); Christy Tremonti (UW-Madison); Pieter van Dokkum (Yale); Don York (Chicago); Yusra AlSayyad (Princeton); Samantha Creech, Matthew Peek, & Nathan Kirse (UNC-Asheville)

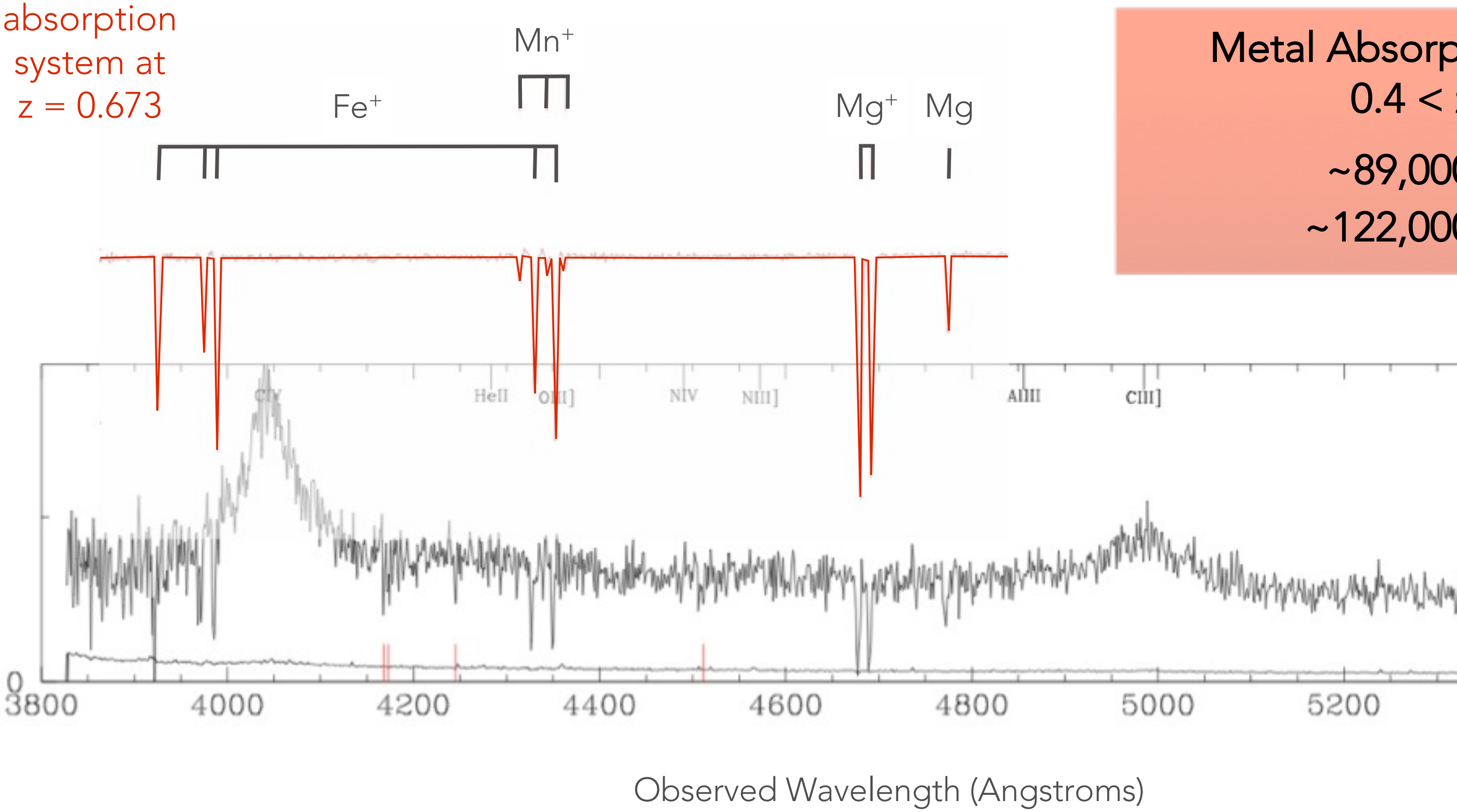


MG II ABSORPTION

- Easily identifiable UV doublet (2796, 2803 Å)
- Common in optical QSO spectra at $0.35 < z < 2$
- Arise in photo-ionized gas with T~10,000K
- Some association with DLAs (log (N_{HI}) > 19 cm^{-2})
- Associated with luminous galaxies (~0.7 L*)
- Luminosity-independent tracer of cold, enriched gas in galaxies: disk & halo processes — inflows, outflows, stripped gas, etc.,

SDSS I-IV METAL ABSORPTION DETECTION PIPELINE

York, Lundgren, Kulkarni, Alsayyad+2018, in prep



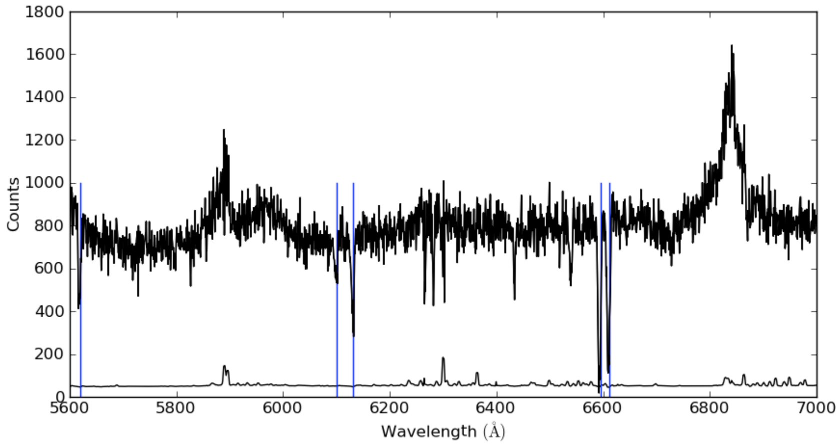
Metal Absorption Systems
0.4 < z < 4:

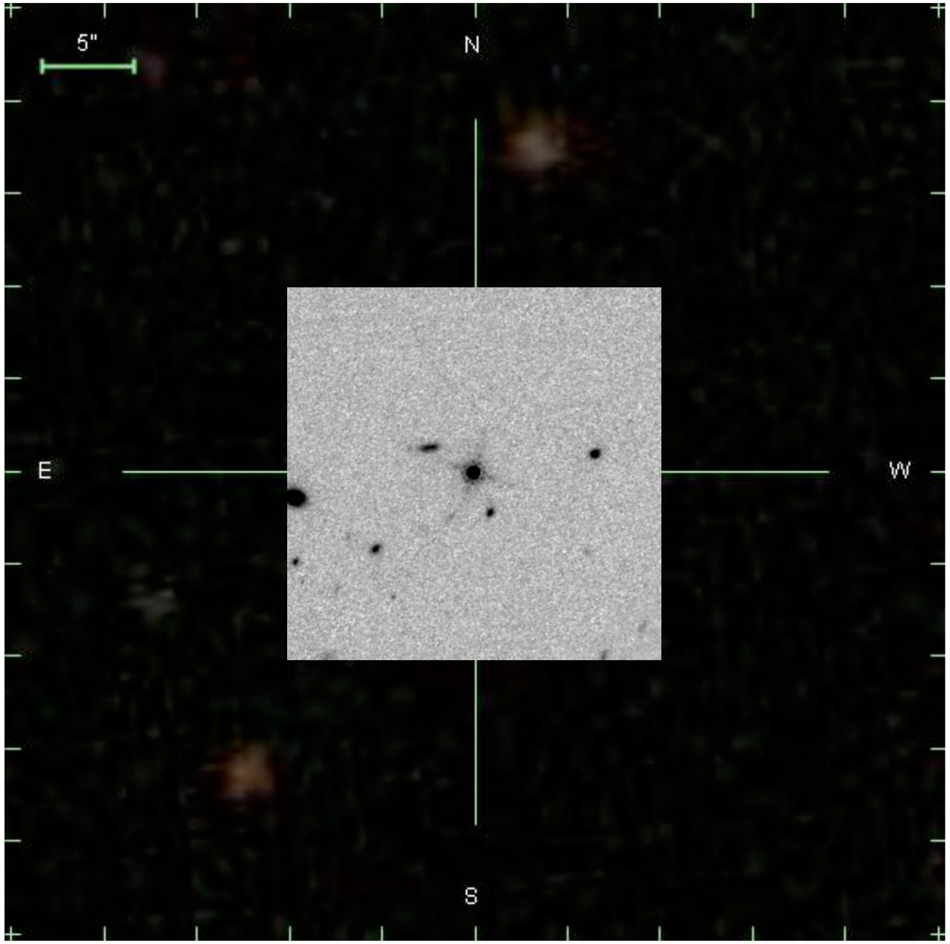
~89,000 (DR7)

~122,000 (DR12)

PERSISTENT CHALLENGES

- >50,000 Mg II absorbers have been extracted to date from the SDSS I-III
- But linking the gas to the galaxies is difficult at z>0.4!
  - Requires deep, high-resolution imaging, and infrared spectroscopy





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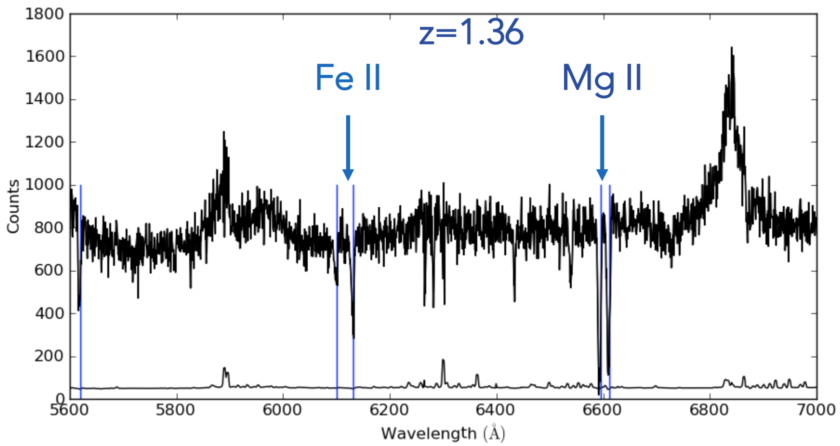
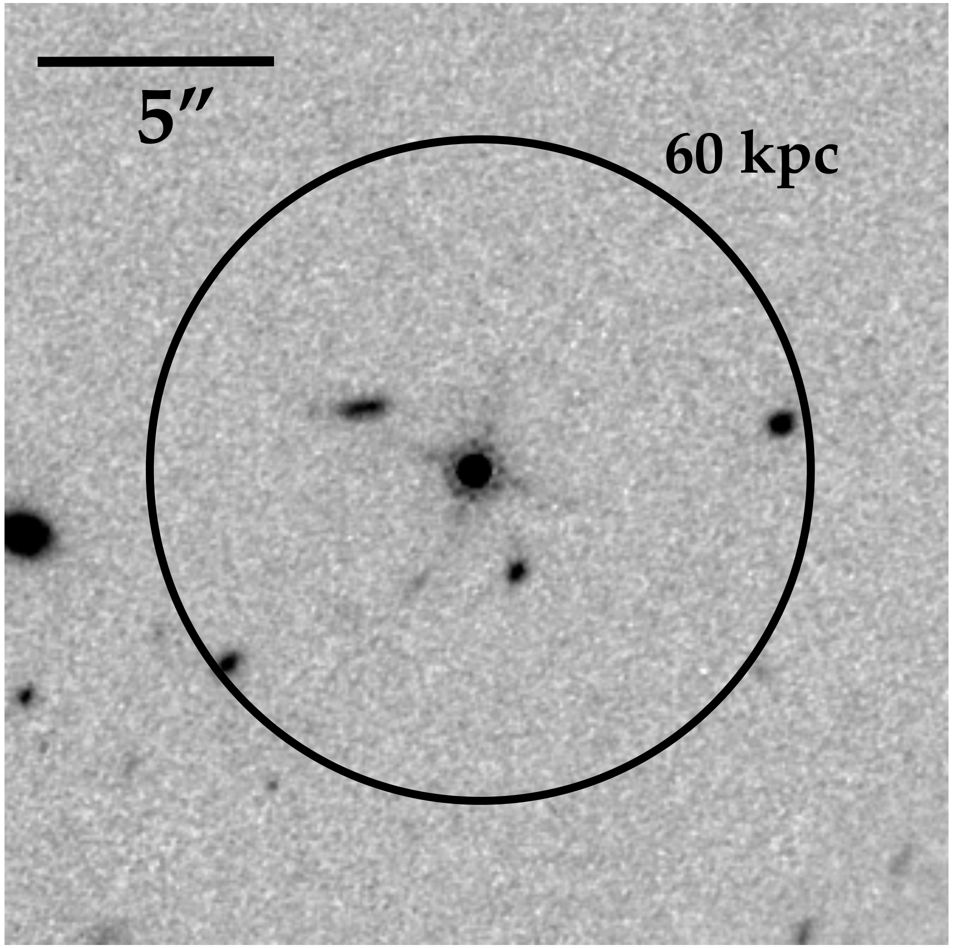


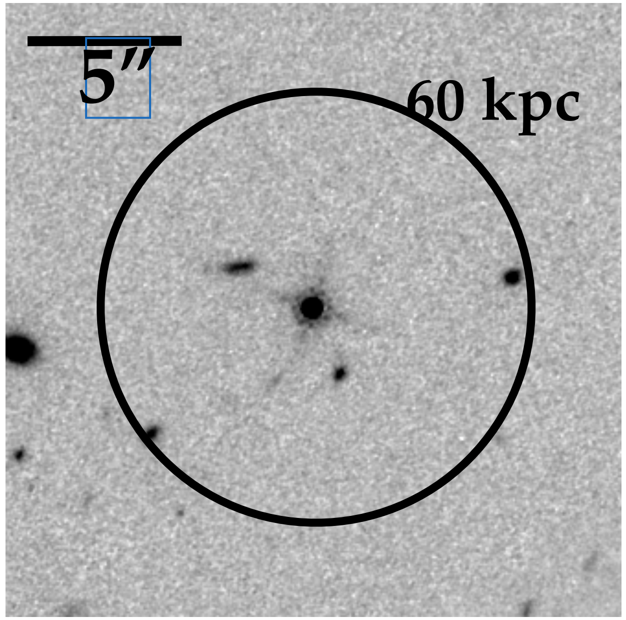


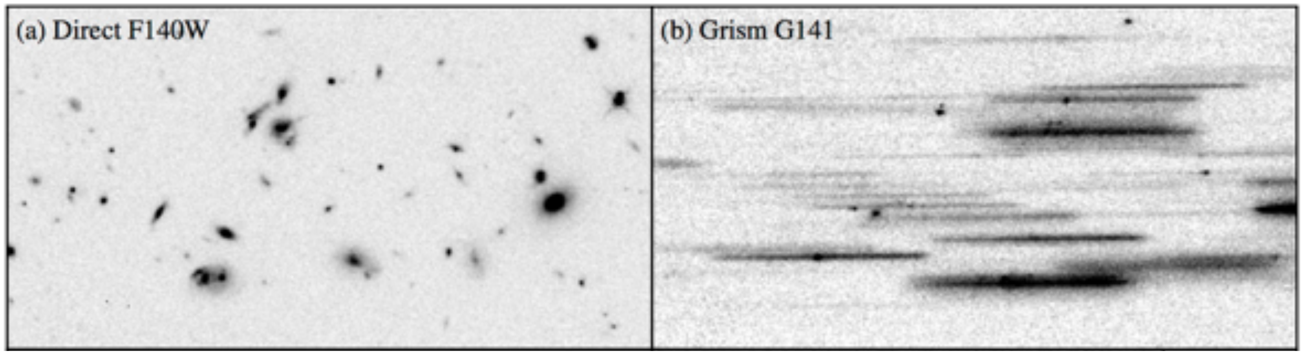
STATISTICAL STUDIES USING LARGE SAMPLES OF MGII

- **Indirect evidence at z ~ 0.6** points to correlations between strong Mg II absorbers and star-forming galaxies:
  - large-scale clustering (Bouché+ 2006; Lundgren+ 2009; Gauthier+ 2009; Lundgren+ 2011)
  - stacking (Zibetti+ 2005; York+2006; Noterdaeme & Srianand 2009; Menard+2009; Bordoloi+2011; Kacprzak+2011, 2012; Bouché+2012)
- **But still unconfirmed with direct detections**
  - Strong MgII hosts at z<0.3 not always star-forming (Chen+2010)
  - deep SINFONI searches at z = 1 (z = 2) fail to detect 34% (80)% of Mg II host galaxies (Bouché et al. 2007, 2013)

DIRECT OBSERVATIONS OF MG II HOST GALAXIES AT HIGH-Z

- Advantages of HST WFC3/IR observations for QAL science:
  - high sensitivity, resolving power (0.06” / pix)
  - large FOV for this depth, reaching impact parameters of 7-600 kpc
  - grism observations provide a highly complete galaxy redshift survey and spatially resolved spectroscopy (R=130 @ 1400 nm)

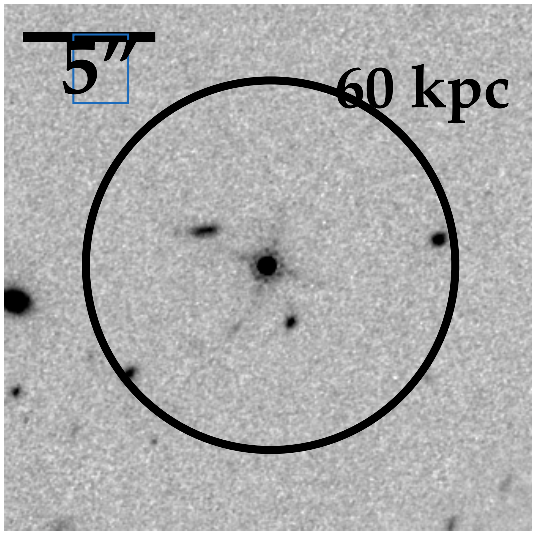


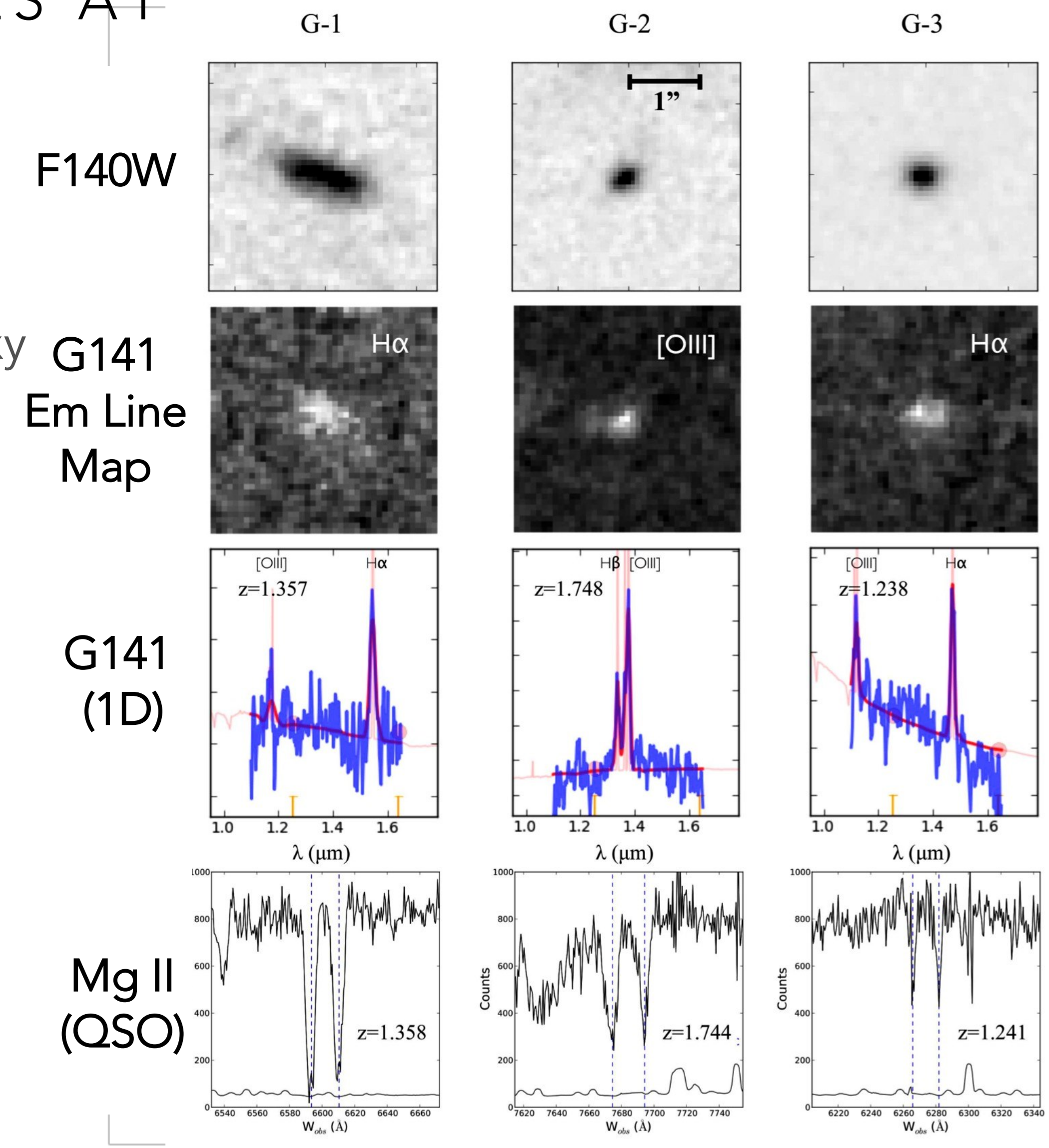


DIRECT HST OBSERVATIONS OF MG II HOST GALAXIES AT HIGH-Z

Pilot study in the 3D-HST Survey

- **Each identified Mg II absorption system** matches to an isolated galaxy at 1 < z < 2 identified with 3D-HST G141 grism observations with:
  - $\Delta z<0.004$
  - $20 < \rho$ (kpc) < 60





Lundgren et al. 2012

HST WFC3/IR GRISM OBSERVATIONS OF THE MOST METAL-RICH QUASAR SIGHT LINES IN THE SDSS

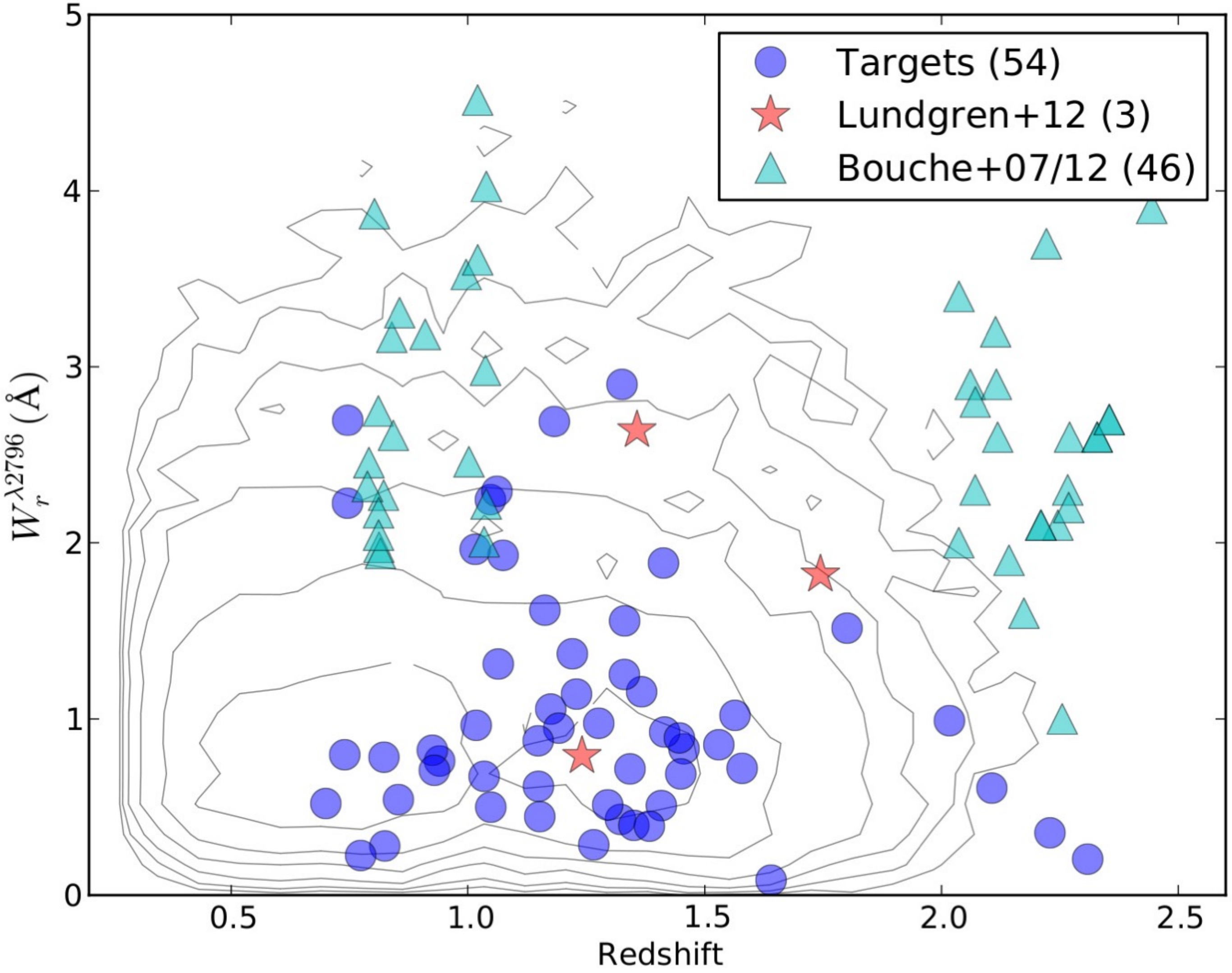
- B. Lundgren (UNC Asheville)
- David Wake (UNC Asheville)
- Gabriel Brammer (ESA/AURA; STScI)
- John Chisholm (Geneva Observatory)
- Dawn Erb (U. Wisconsin - Milwaukee)
- Varsha Kulkarni (U. South Carolina)
- Lorrie Straka (Leiden Observatory, NL)
- Christy Tremonti (U. Wisconsin)
- Pieter van Dokkum (Yale Univ.)
- Don York (U. Chicago)

HST WFC3/IR GRISM OBSERVATIONS OF THE MOST METAL-RICH QUASAR SIGHT LINES IN THE SDSS

HST Cycle 21 Program:

- 9 SDSS QSO targets (2 HST orbits / each)
  - 44 absorbers with H-alpha observable ($0.65<z<1.6$) in the G141 grism (1075-1700nm)
  - +12 absorbers with observable [O III] / H-beta
- A complete spectroscopic survey of galaxies with $b>7$kpc, $F_{140}<25.6$, SFR>1.3 $M_\odot$/yr
- Measuring impact parameters, morphologies, inclinations, SFRs, & ∑SFRs

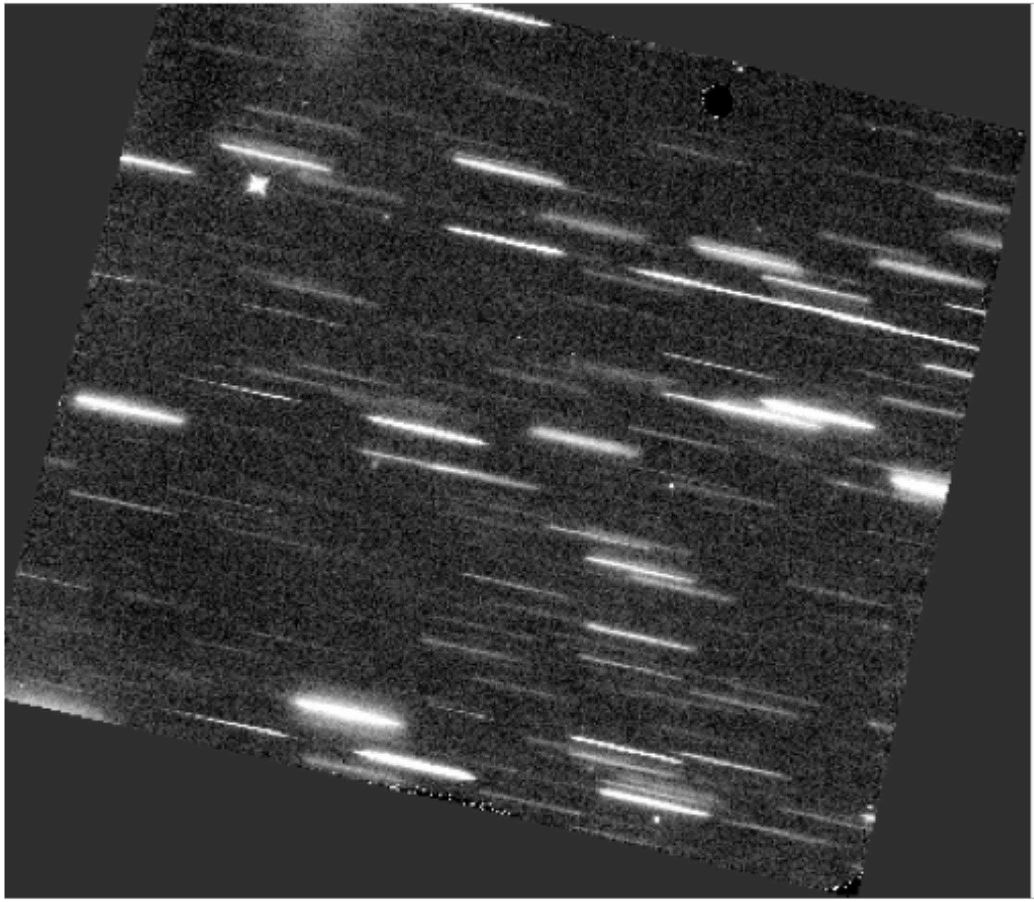
HST WFC3/IR GRISM OBSERVATIONS OF THE MOST METAL-RICH QUASAR SIGHT LINES IN THE SDSS

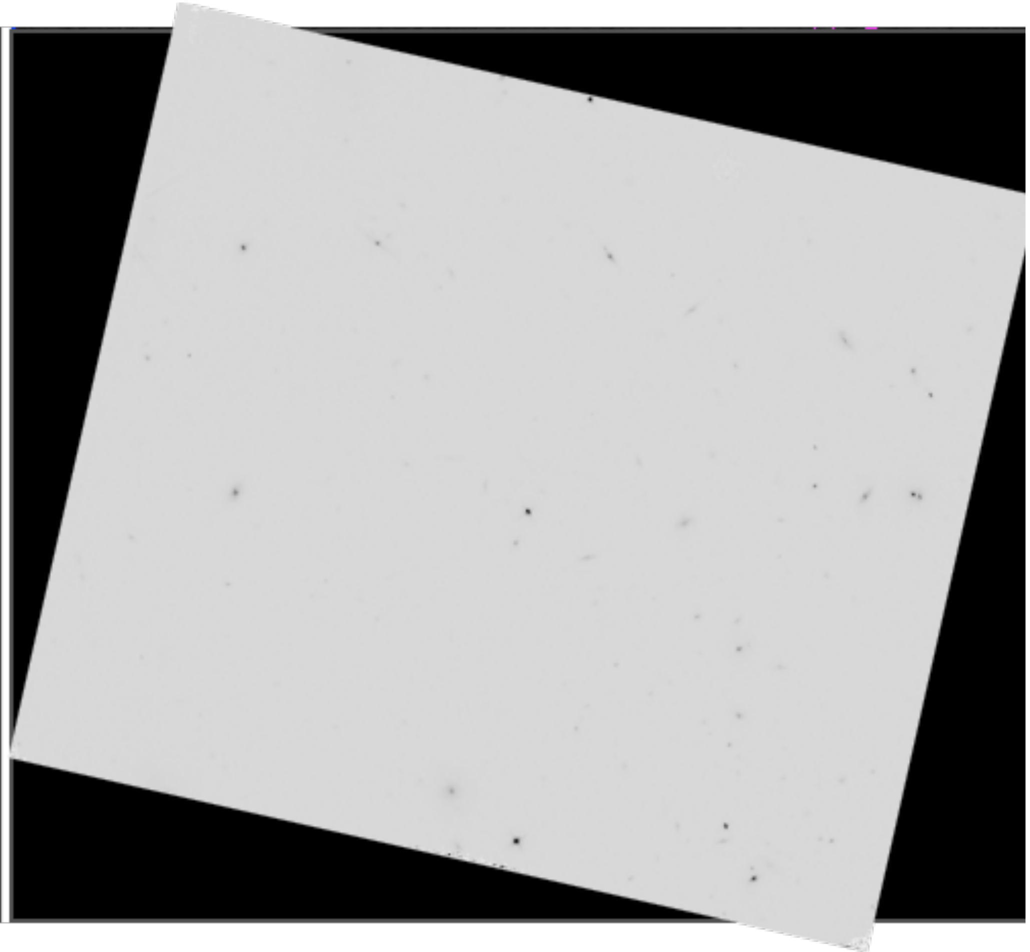


SURVEY AIMS:

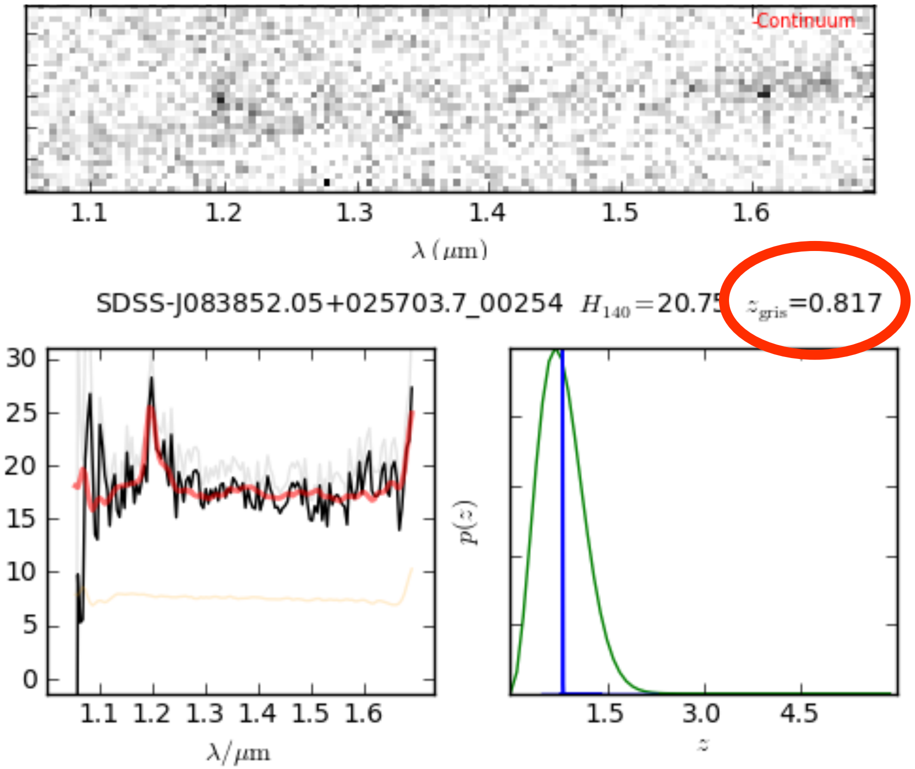
- **Determining the fraction of host galaxies that are detectable at the survey limits.**
- **Determining the distribution of host galaxy SFR and SFR surface densities** — *Are Mg+ selected galaxies always capable of launching winds?*
- **Measuring galaxy morphologies and inclinations** — I*s there evidence of azimuthal symmetry about the semi-minor (rotation) axis?*
- **Determining environmental effects** — How do the gas profiles of galaxies compare in *isolation vs. mergers*?

HST WFC3/IR GRISM OBSERVATIONS OF THE MOST METAL-RICH QUASAR SIGHT LINES IN THE SDSS

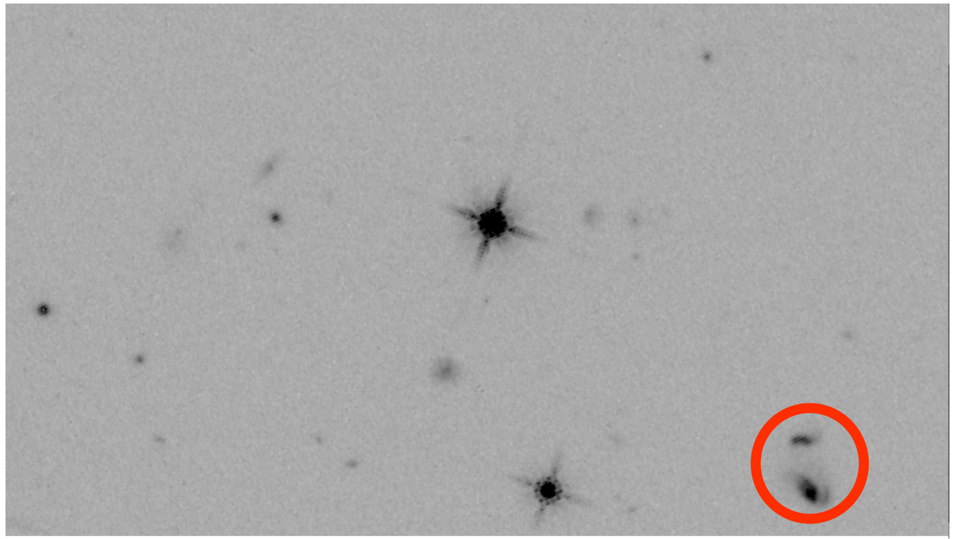




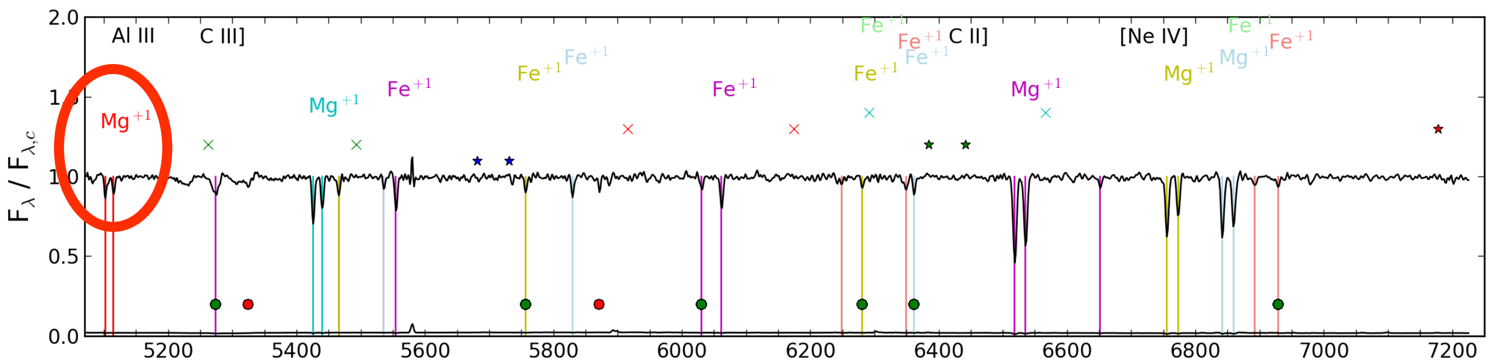
HST IR Grism Spectrum



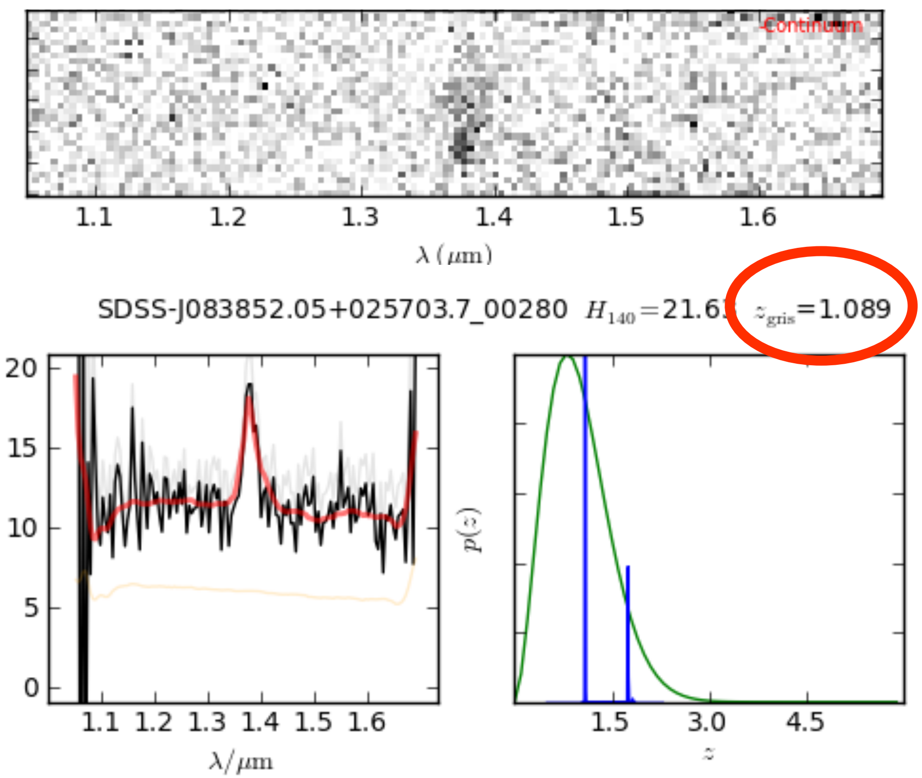
HST IR Direct Image



SDSS Optical Quasar Spectrum



HST IR Grism Spectrum



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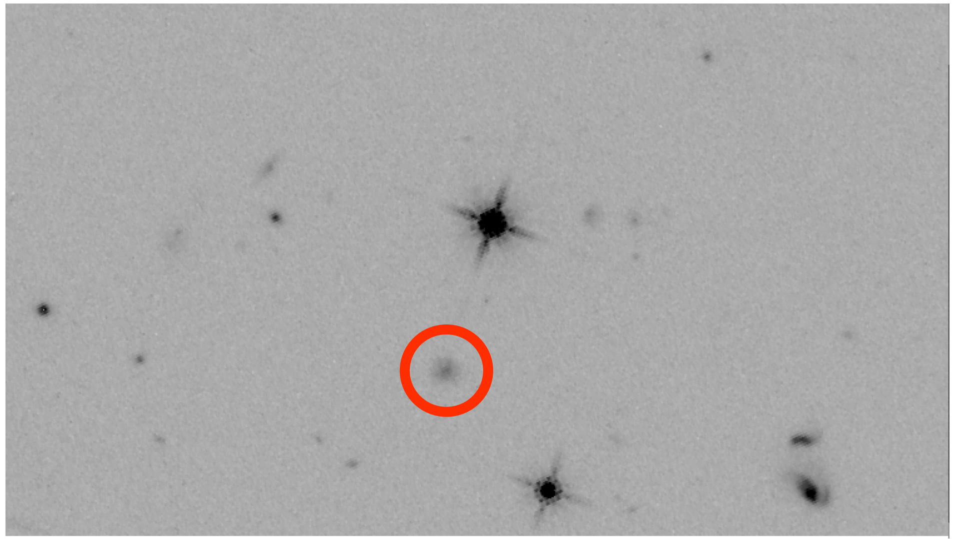
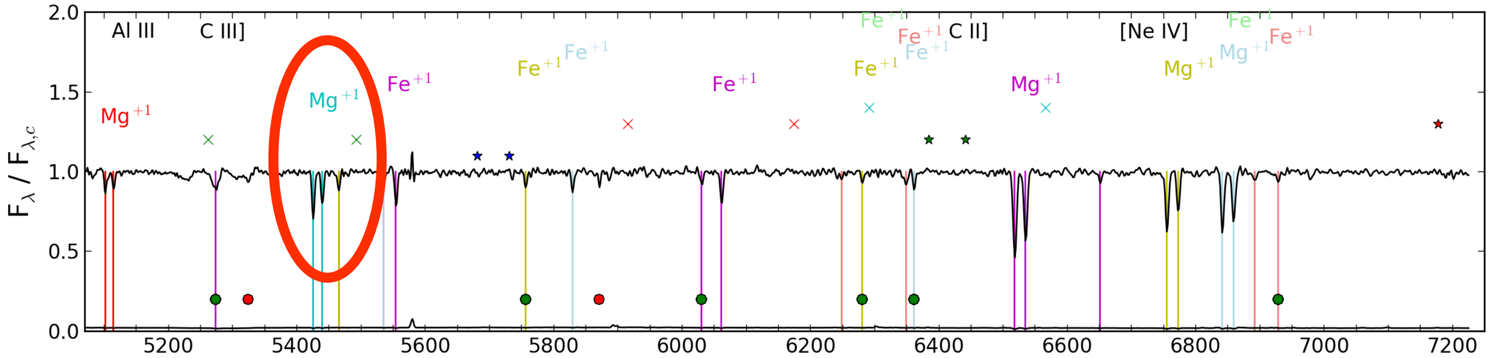


SDSS Optical Quasar Spectrum



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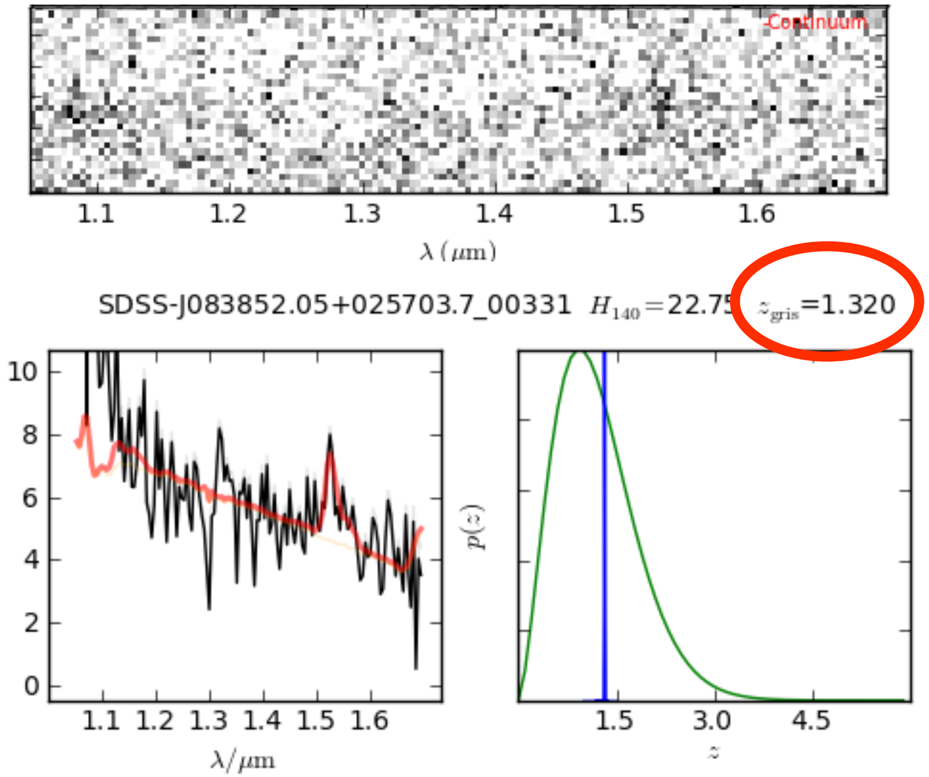

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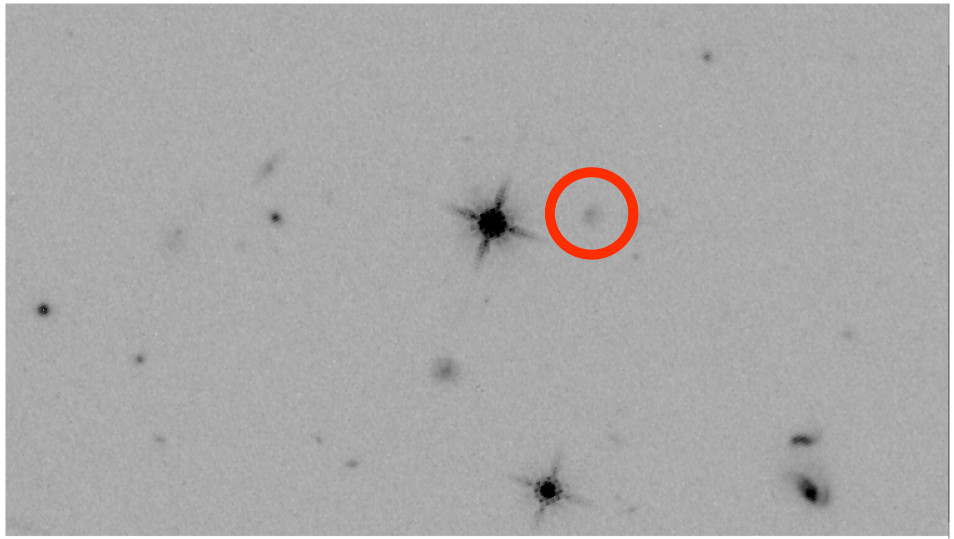
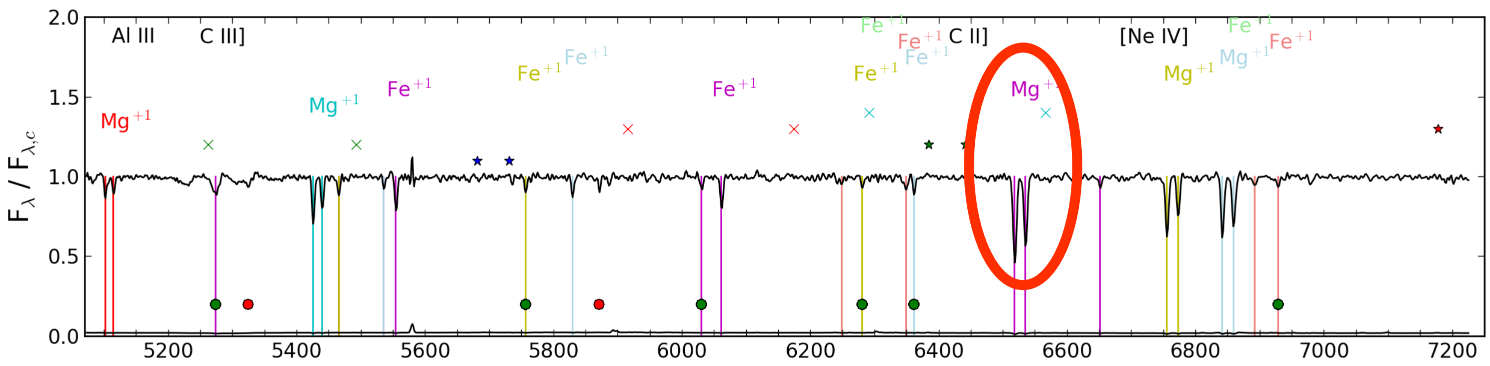
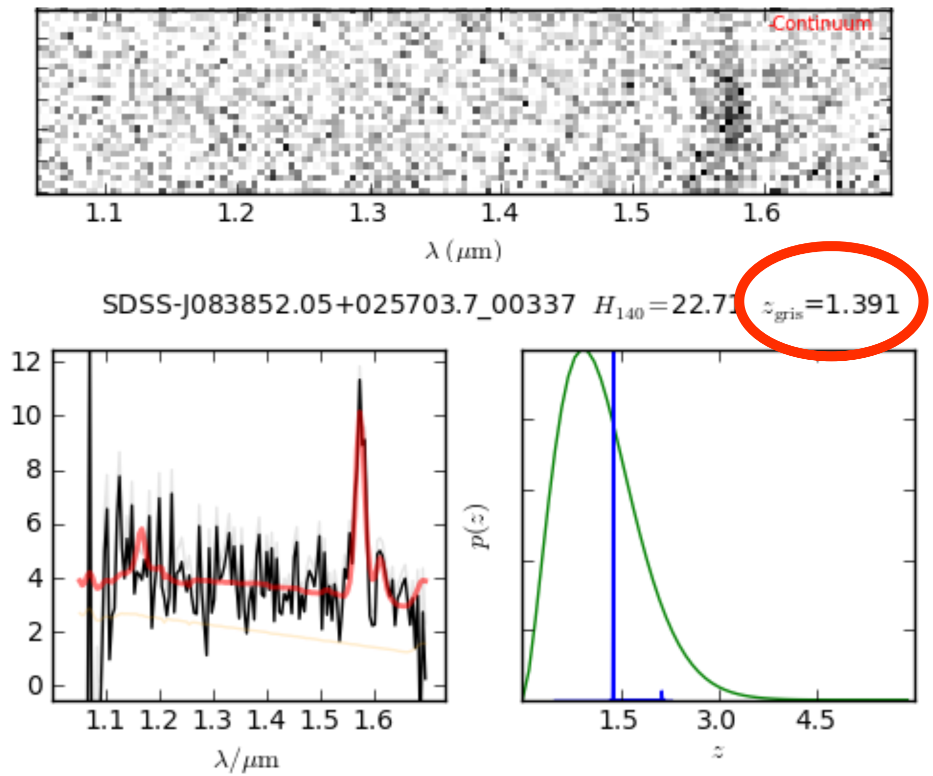


SDSS Optical Quasar Spectrum

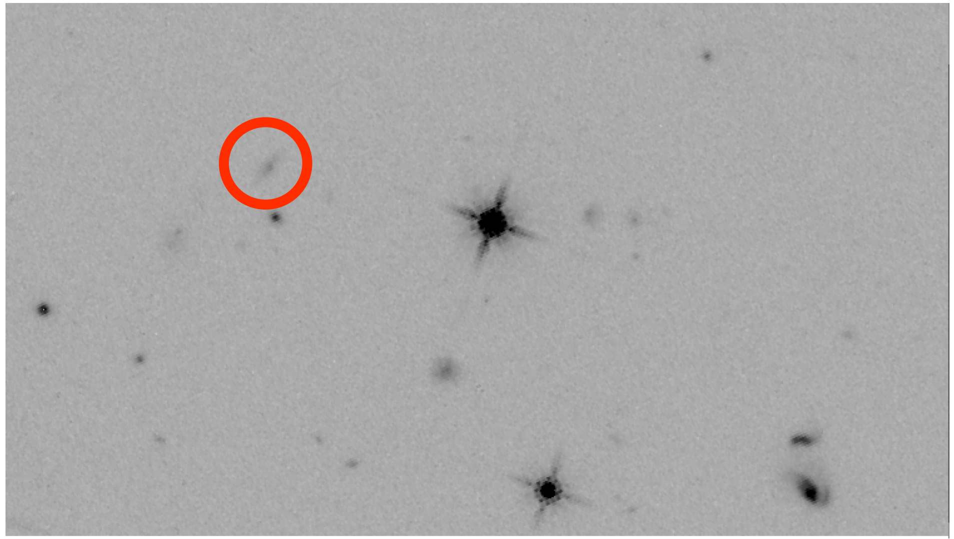


HST IR Grism Spectrum

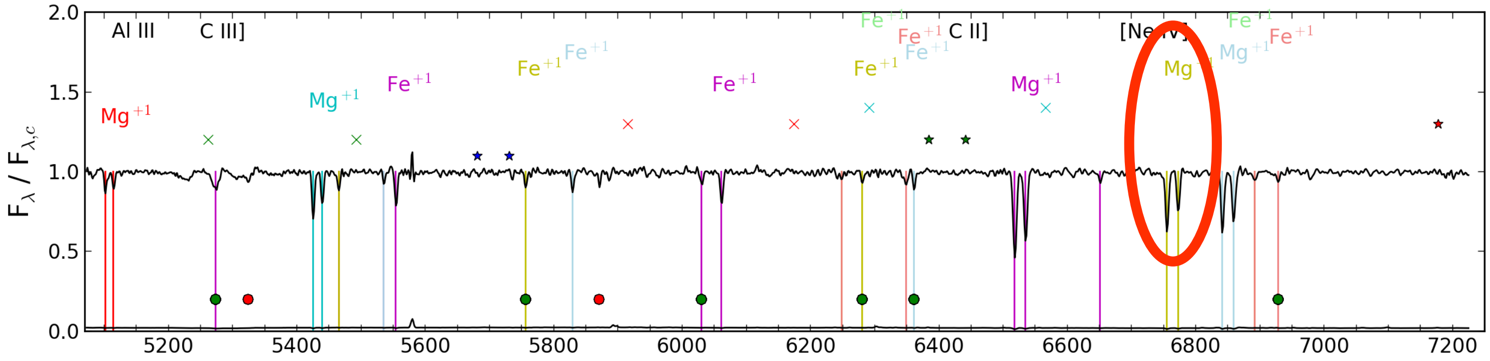


λ/μm

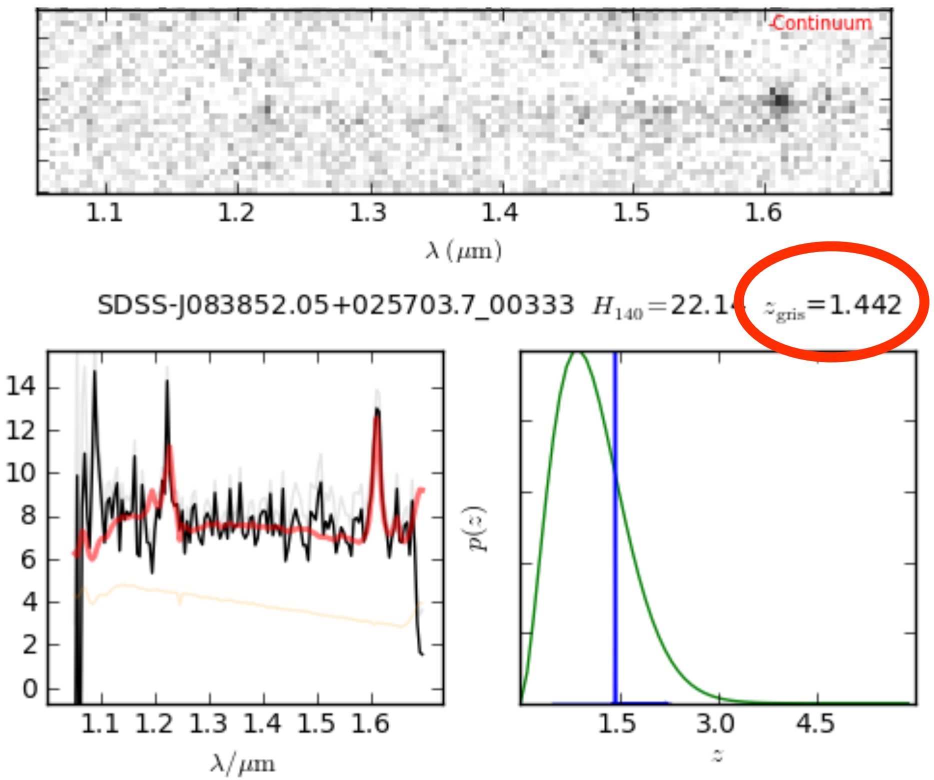
HST IR Direct Image



SDSS Optical Quasar Spectrum

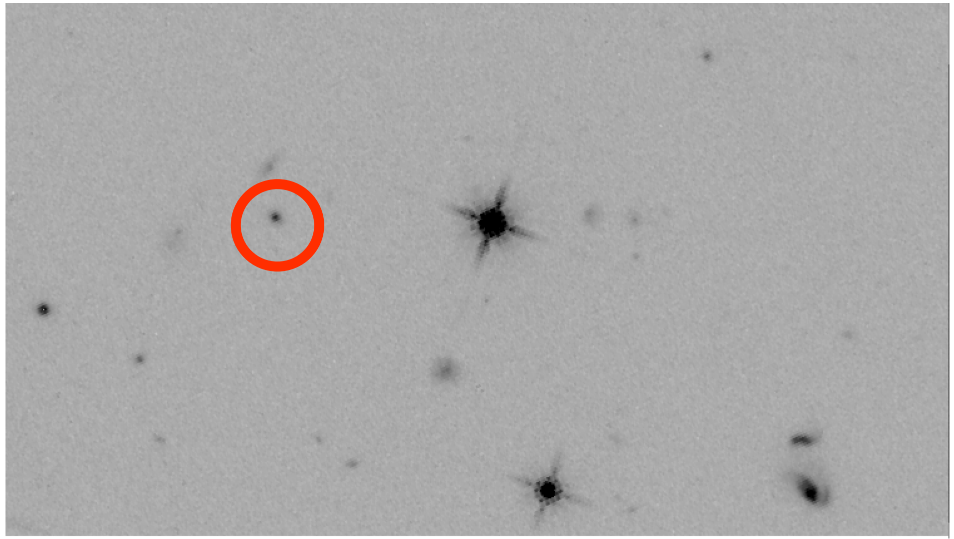


HST IR Grism Spectrum

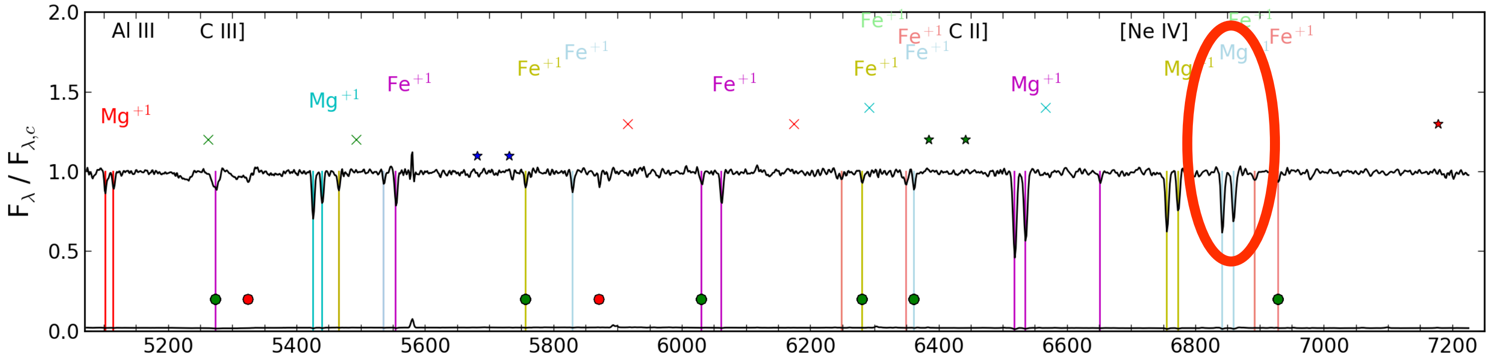


λ/μm

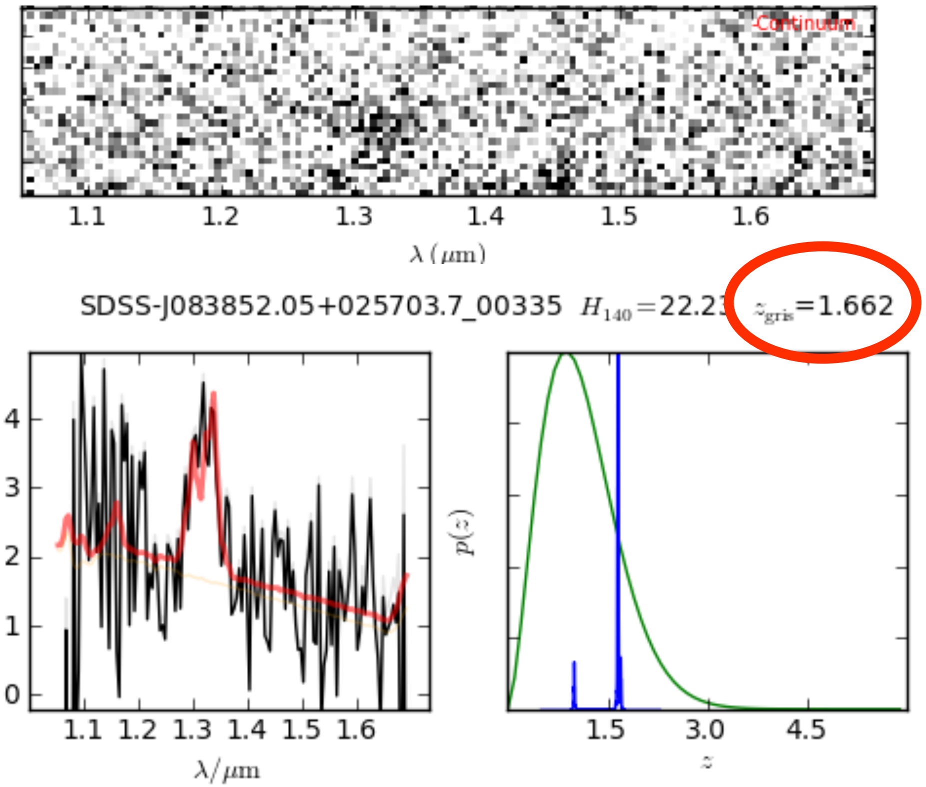
HST IR Direct Image



SDSS Optical Quasar Spectrum



HST IR Grism Spectrum



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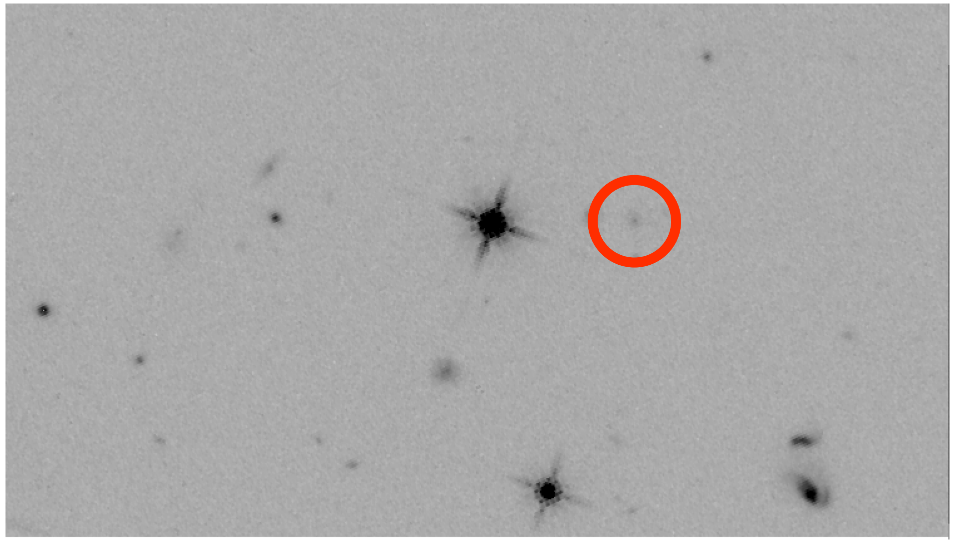
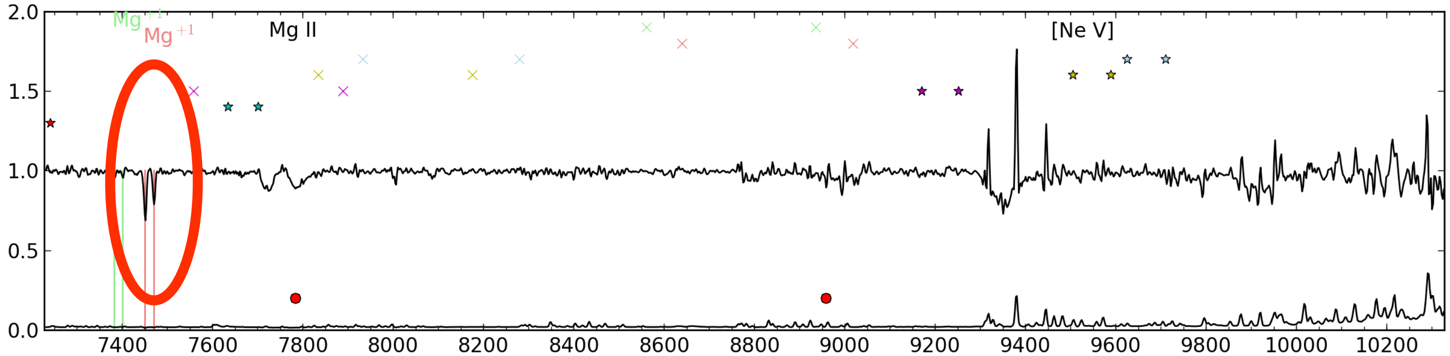
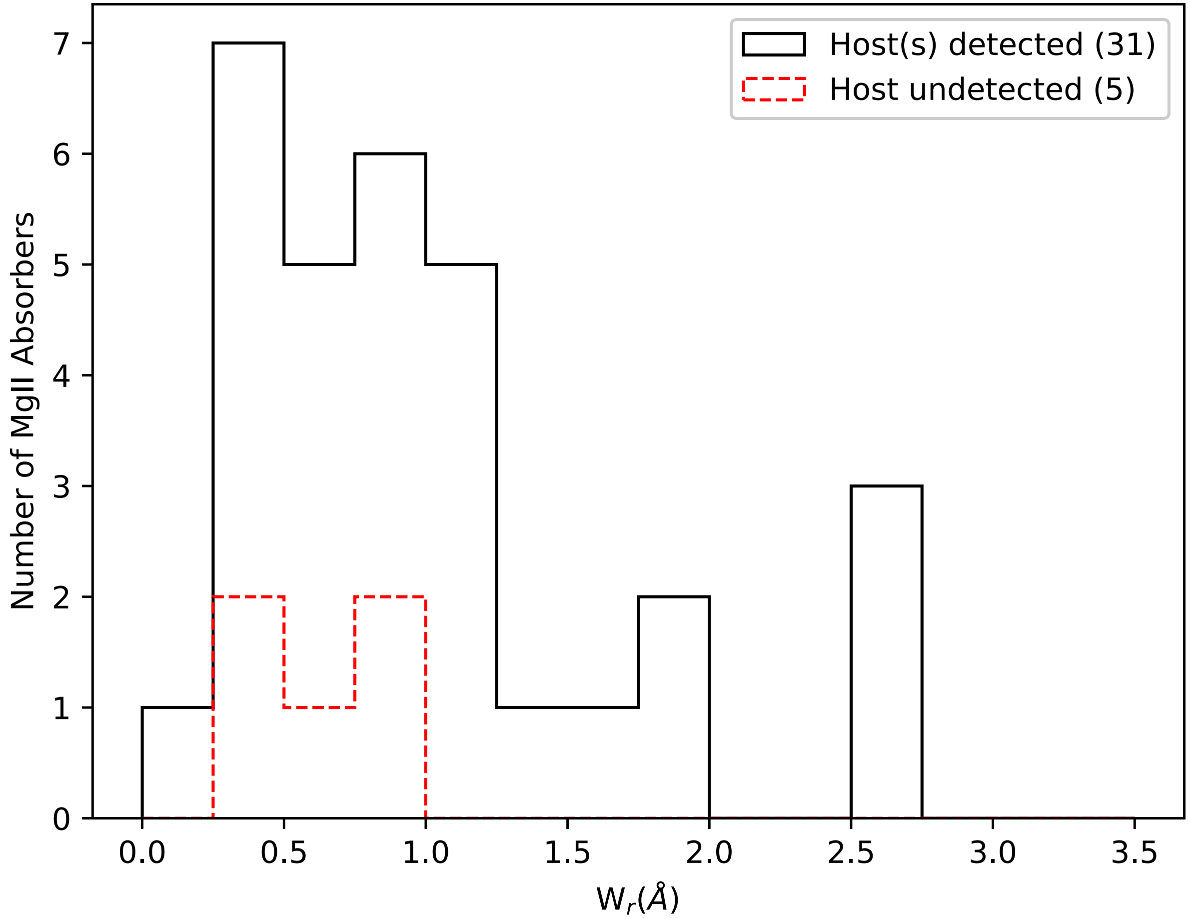


SDSS Optical Quasar Spectrum



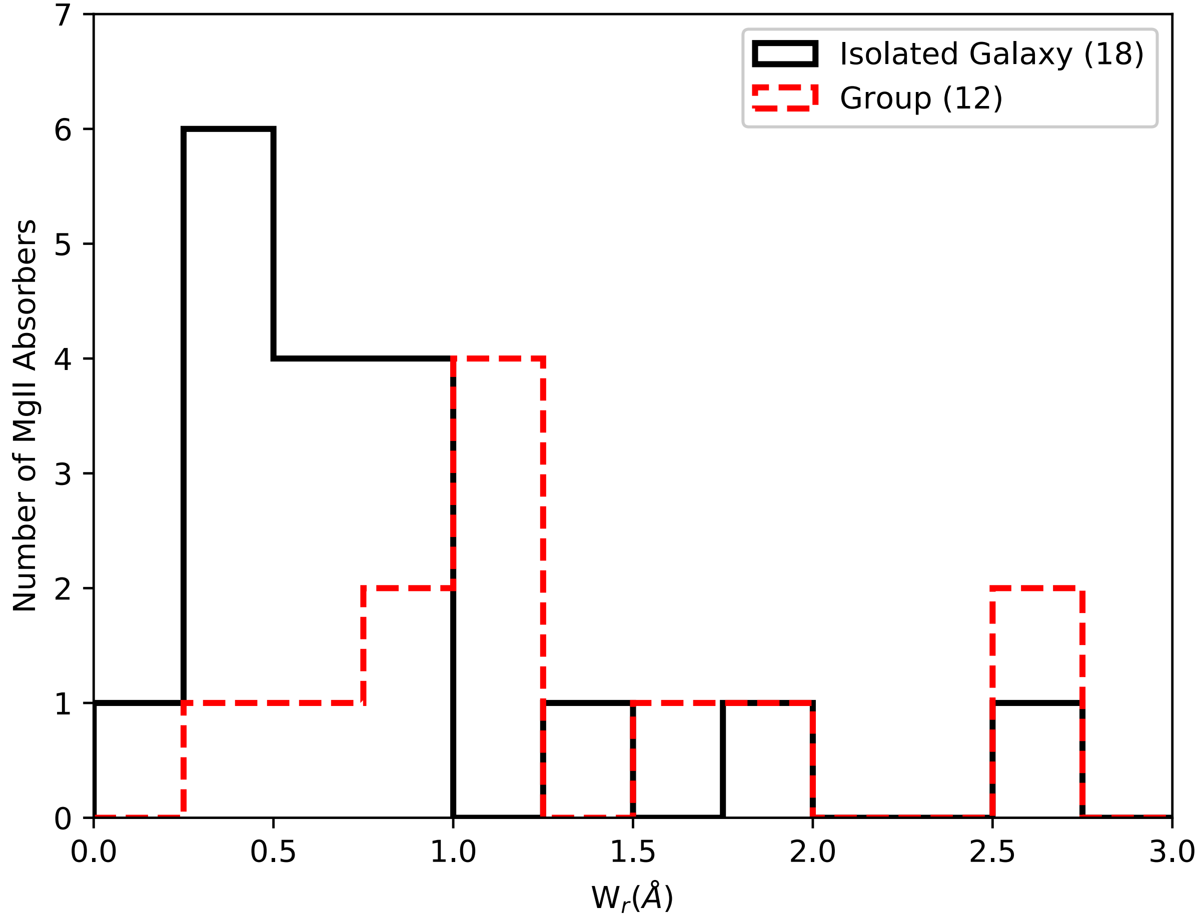
FIRST RESULTS (LUNDGREN+2018 IN PREP)

- An unprecedented detection rate for high-z Mg II-selected galaxies: 31/36 (86%) of 0.65<z<1.6 MgII absorbers matched to a galaxy within 150kpc and <Δz>/z < 0.01

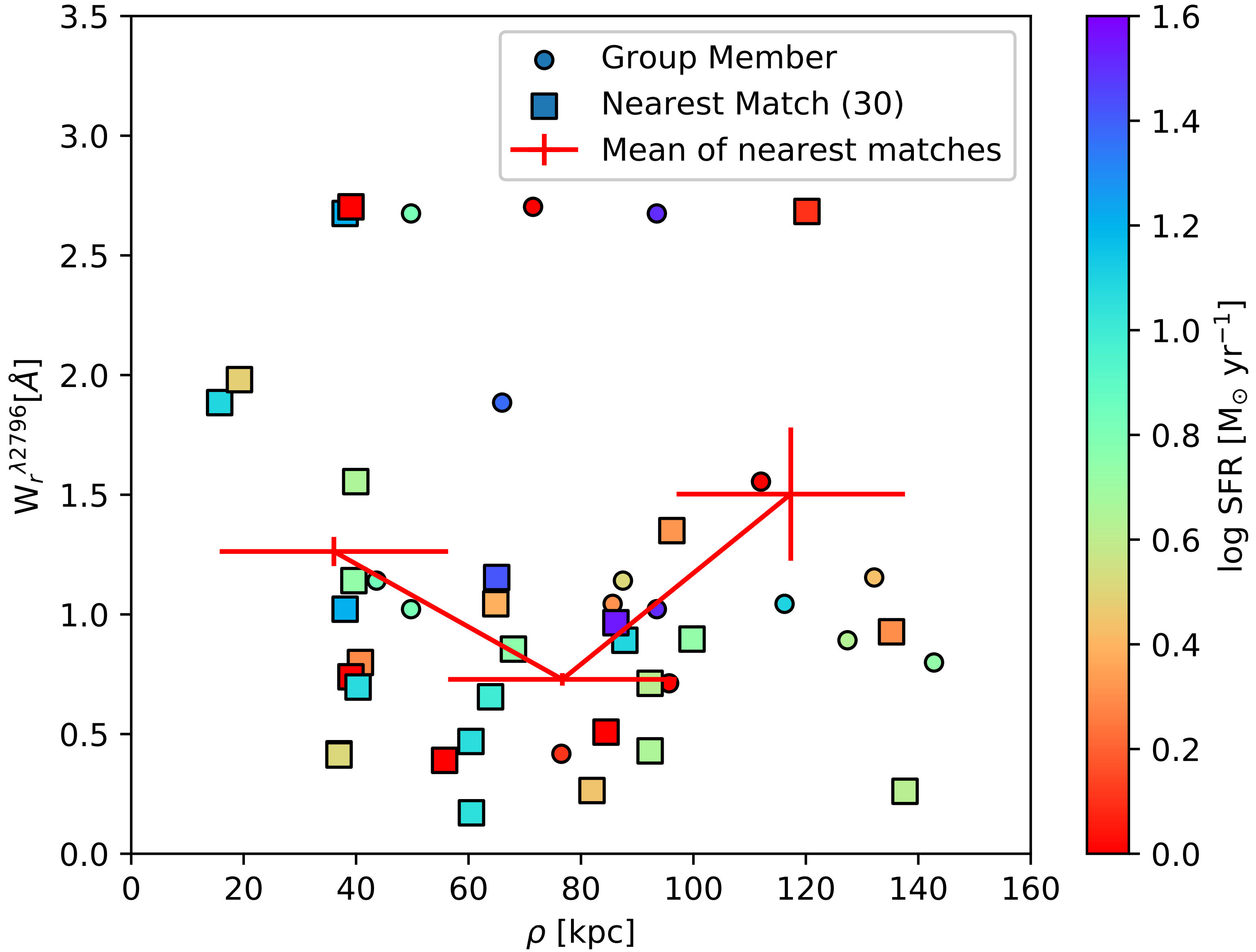


FIRST RESULTS (LUNDGREN+2018 IN PREP)

- 40% of Mg II absorbers with $0.65<z<1.6$ are matched to more than one galaxy within 150 kpc and with $\langle\Delta z\rangle/z < 0.01$
- Mg II EW appears to correlate with environment

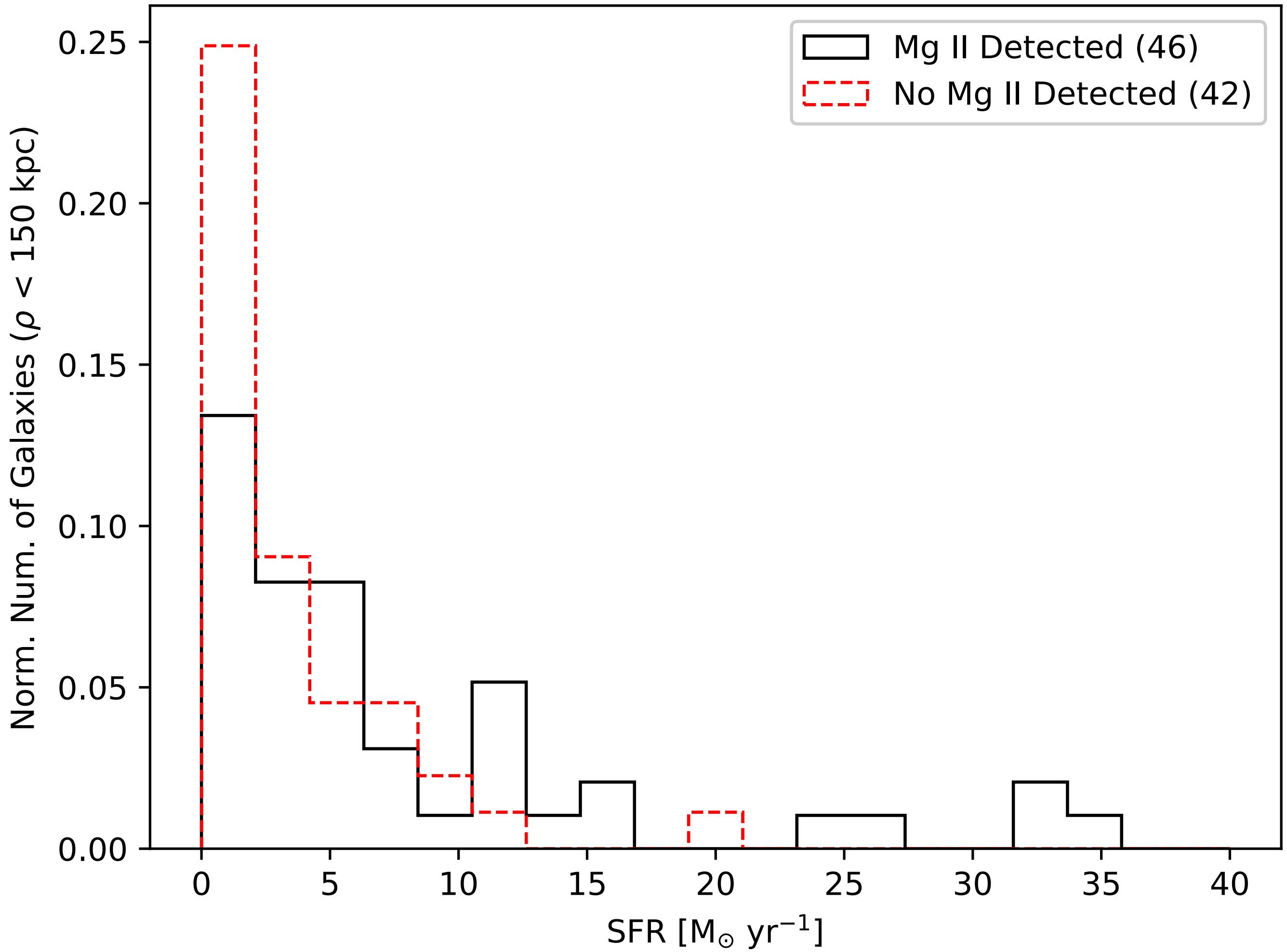


FIRST RESULTS (LUNDGREN+2018 IN PREP)



FIRST RESULTS (LUNDGREN+2018 IN PREP)

- Galaxies with Mg II absorption have <u>significantly *higher SFRs*</u> than those without (KS p-value <1%)



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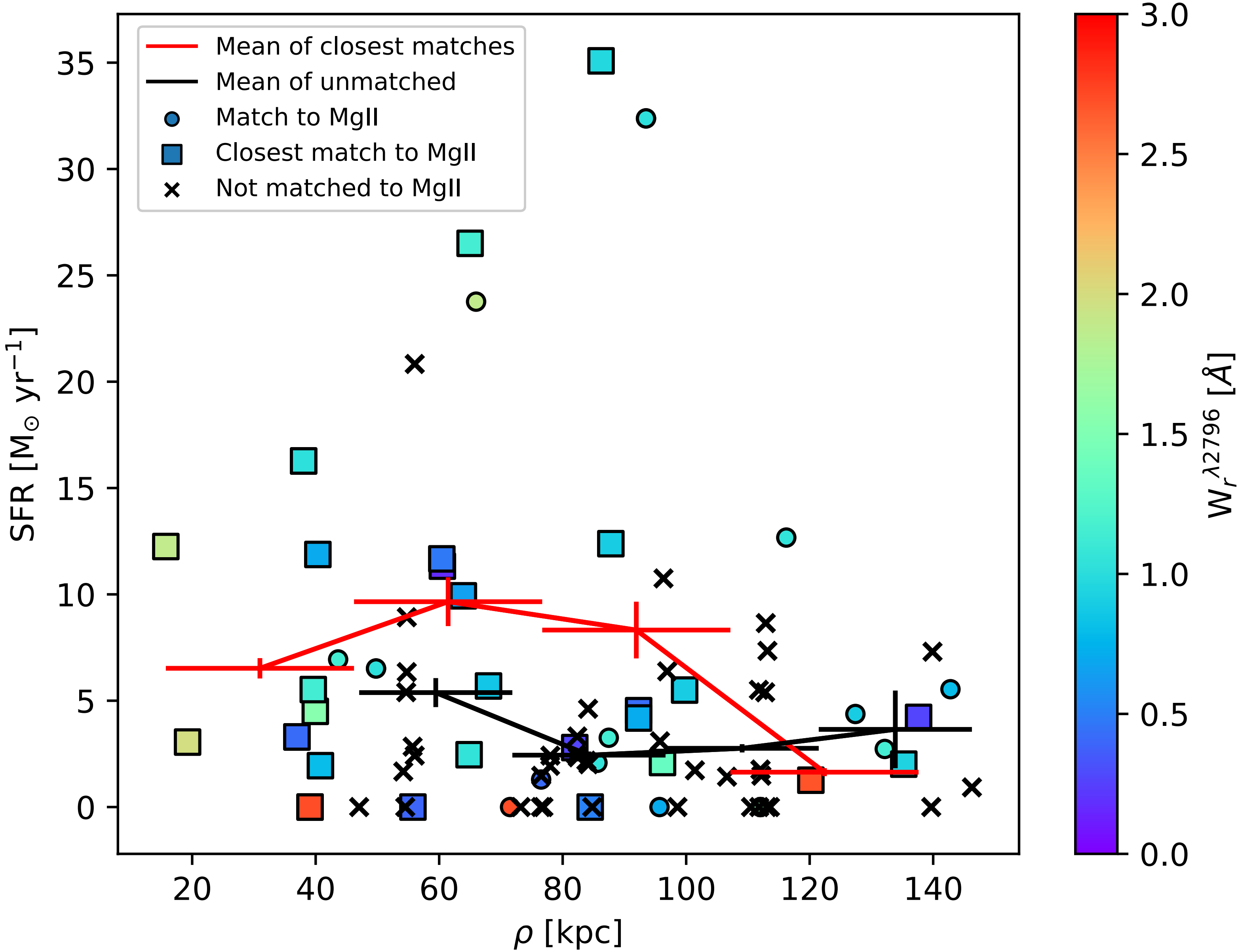
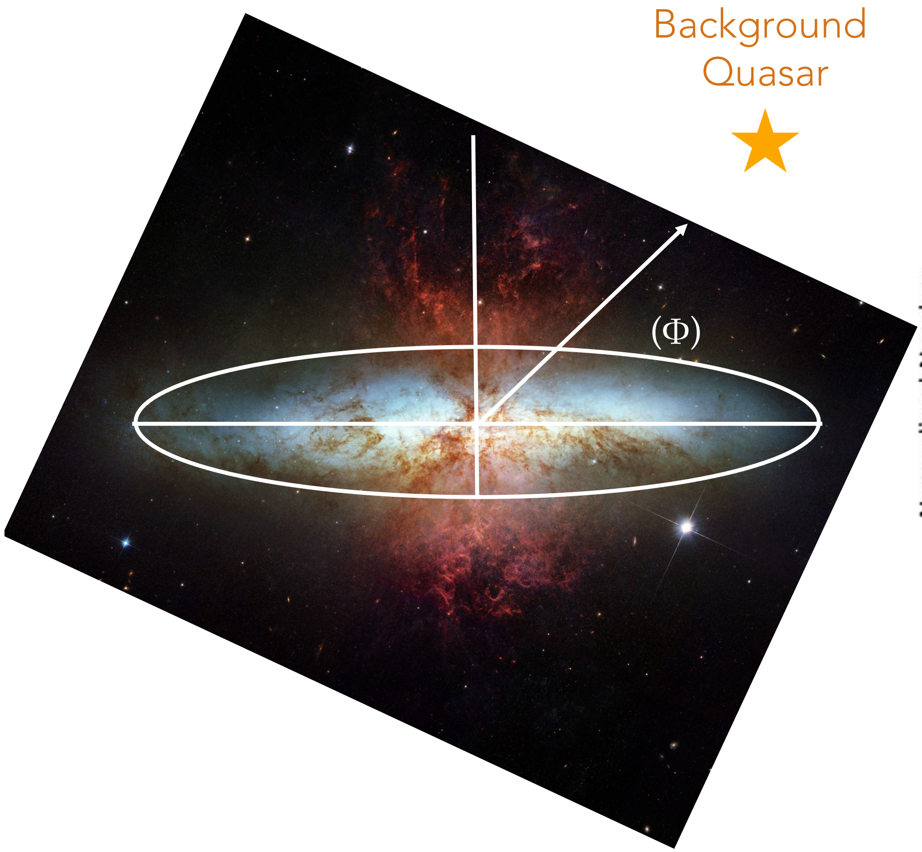
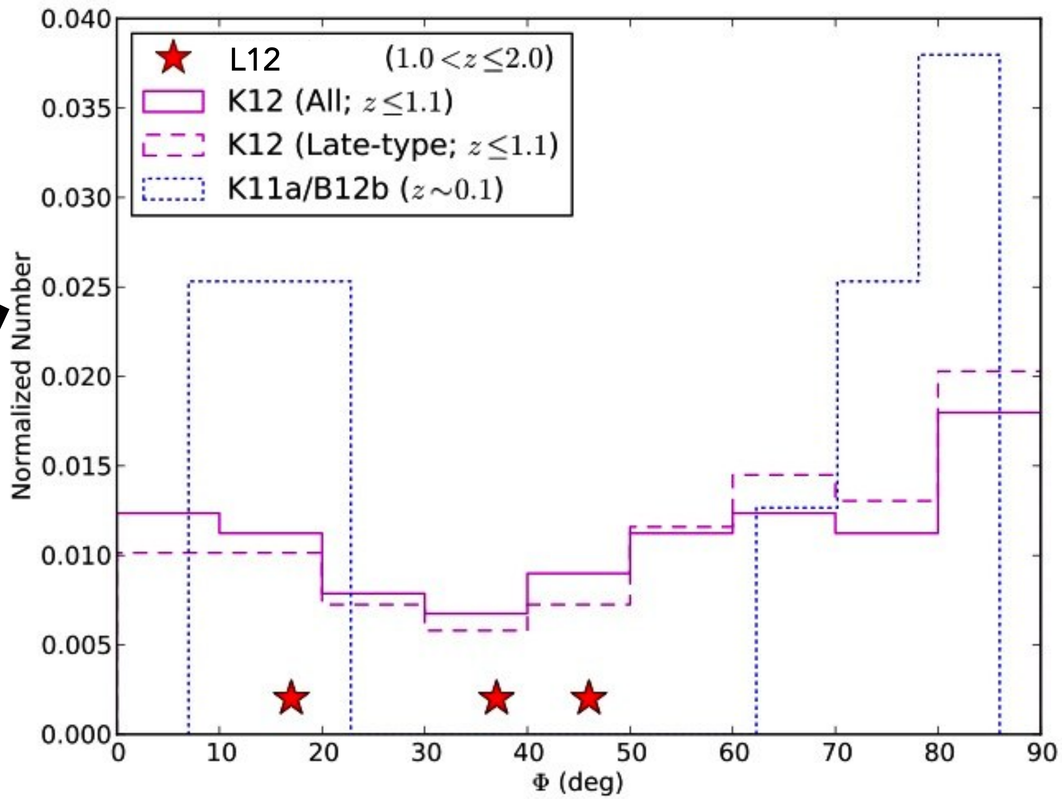


EVOLVING? AZIMUTHAL DISTRIBUTION OF MG II AROUND GALAXIES

- An evolving azimuthal distribution of Mg II around star forming galaxies from z~2?
- Consistent with an increasing collimation of outflows with time (Law et al. 2012)



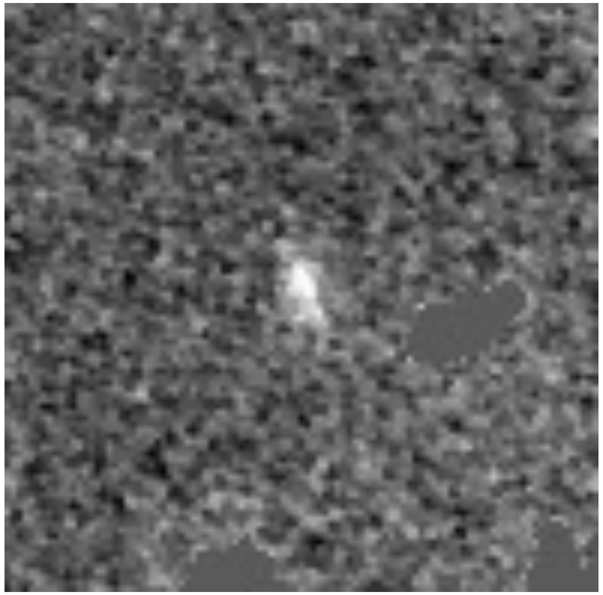


Kacprzak+2011a,2012; Bouche+2012b; Lundgren+2012

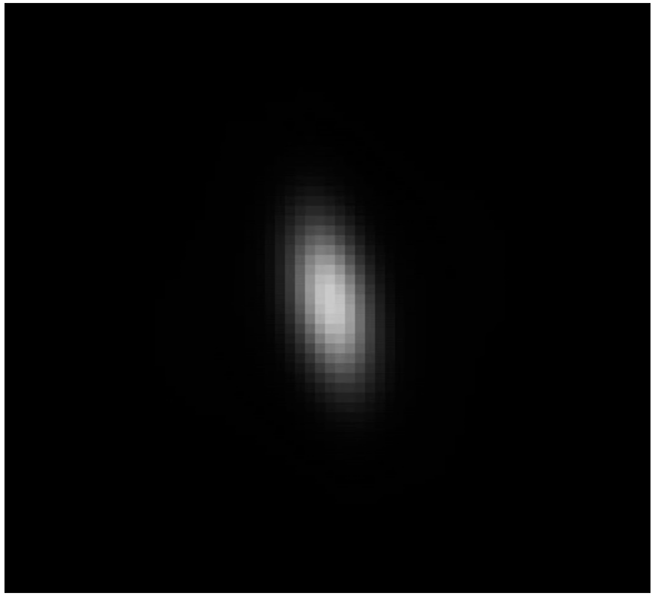
INCLINATION OF MGII-ABSORBING GALAXIES RELATIVE TO THE QSO

UNCA undergraduates Nathan Kirse & Samantha Creech

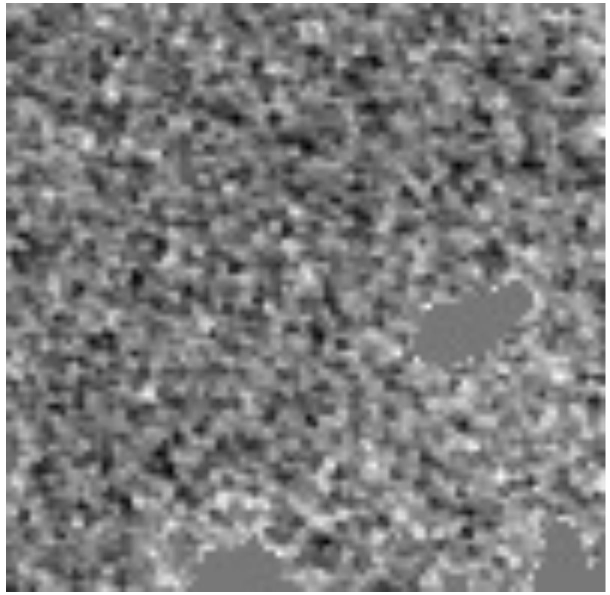
F140W Image



Galfit model

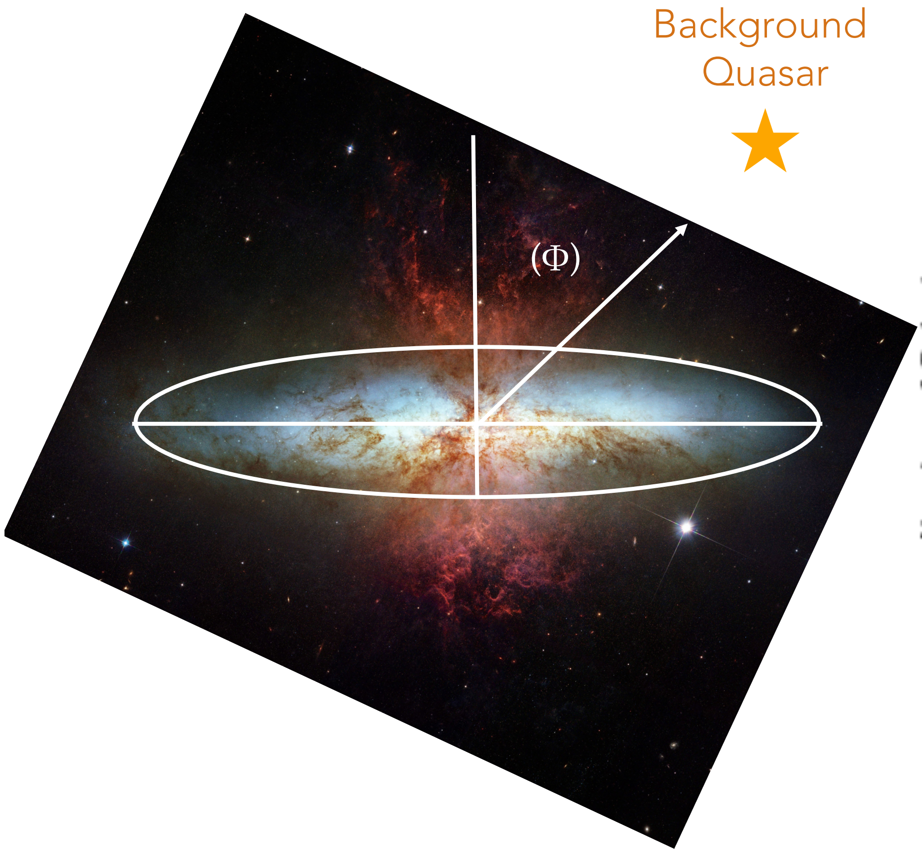


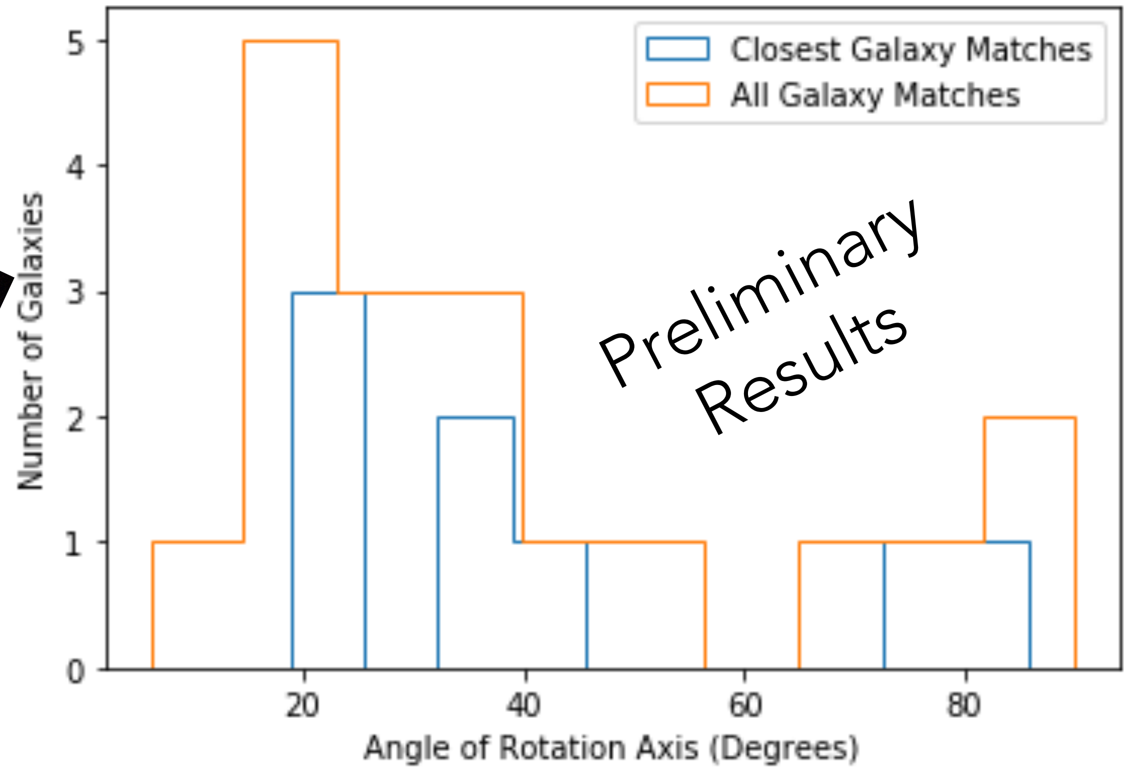
Residual



INCLINATION OF MGII-ABSORBING GALAXIES RELATIVE TO THE QSO

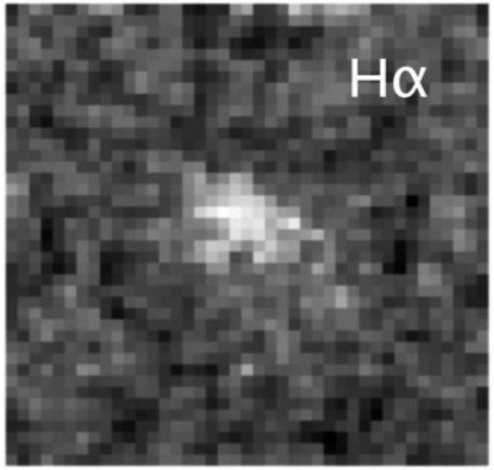
UNCA undergraduate Samantha Creech

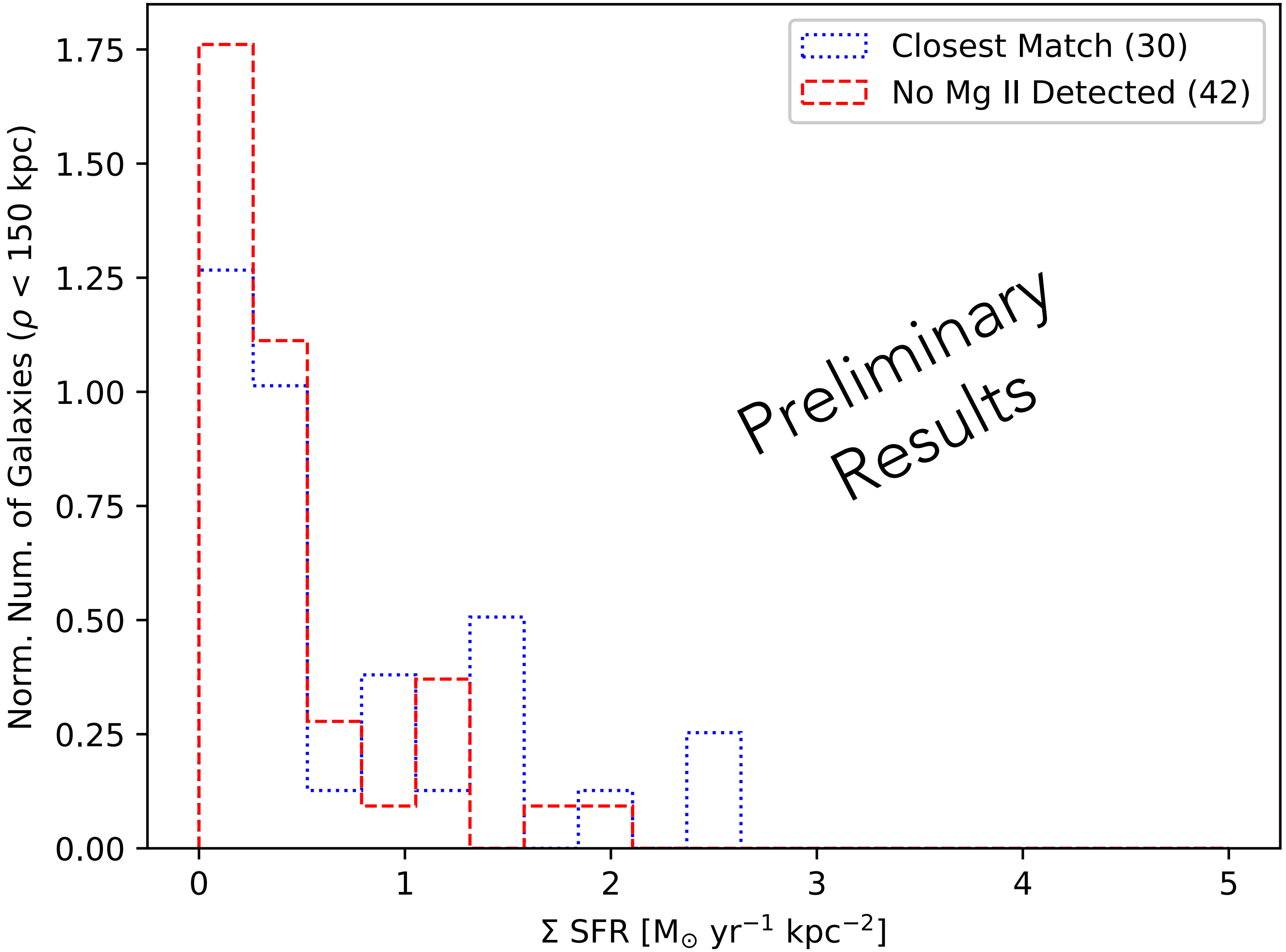




STAR FORMATION RATE SURFACE DENSITIES

UNCA undergraduate Matthew Peek





SUMMARY

18-orbit HST Cycle 21 WFC3/IR grism program to survey 56 Mg II host galaxies in the 9 most metal-rich SDSS quasar sight lines:

- ~90% detection rate in 8/9 fields
- All galaxies within 45kpc of a quasar sightline (13/13) exhibit MgII absorption
- Compared to other galaxies in the fields, Mg II absorbing galaxies have significantly higher SFRs
- 40% of Mg II absorbers match in redshift to multiple galaxies within 150 kpc
- Mg II equivalent width may correlate with environment
- Early results indicate a strong angular correlation of MgII absorption along the rotation axis of galaxies, suggestive of outflows.
- **More results to come! (SFR surface densities, SFR spatial distributions)**