Daniel Nestor (IoA)

HI Survival: the MgII View

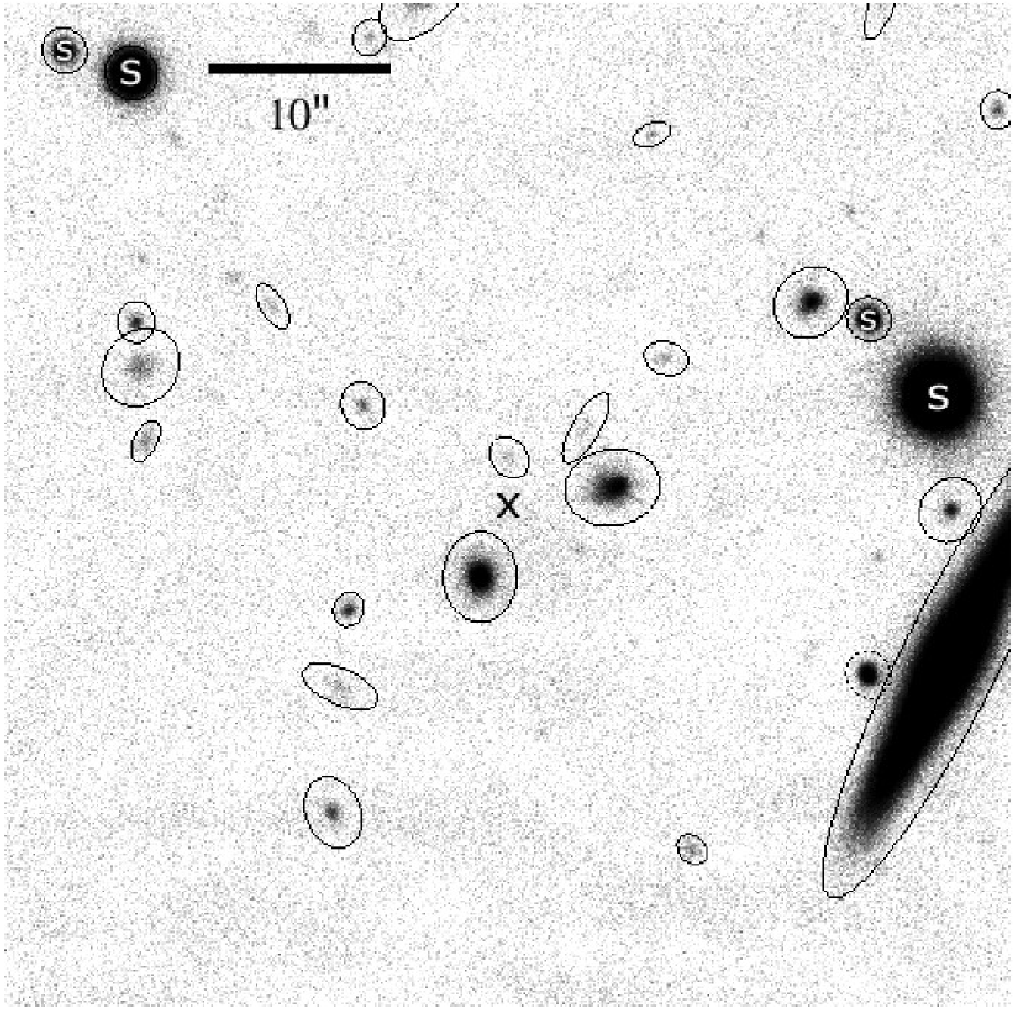
Brice Ménard (CITA)

David Turnsek, Sandhya Rao, Anna Quider (Pittsburgh)

Stefano Zibetti (MPE)

Max Pettini, Paul Hewett, Neil Trentham, Stephen Wilkins (IoA)

Gordon Richards (Drexel)



Daniel Nestor (IoA)

HI Survival: the MgII View

& Low-z DLA Galaxies...

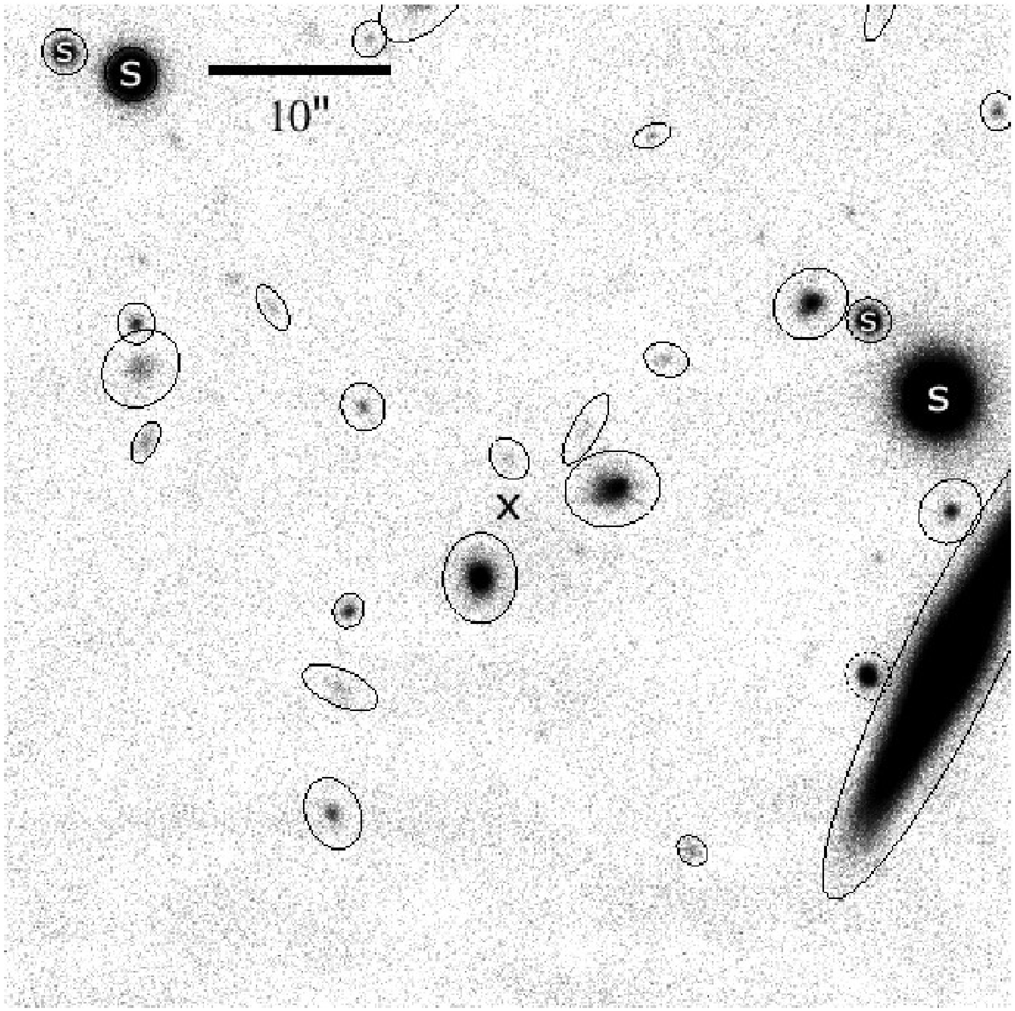
Brice Ménard (CITA)

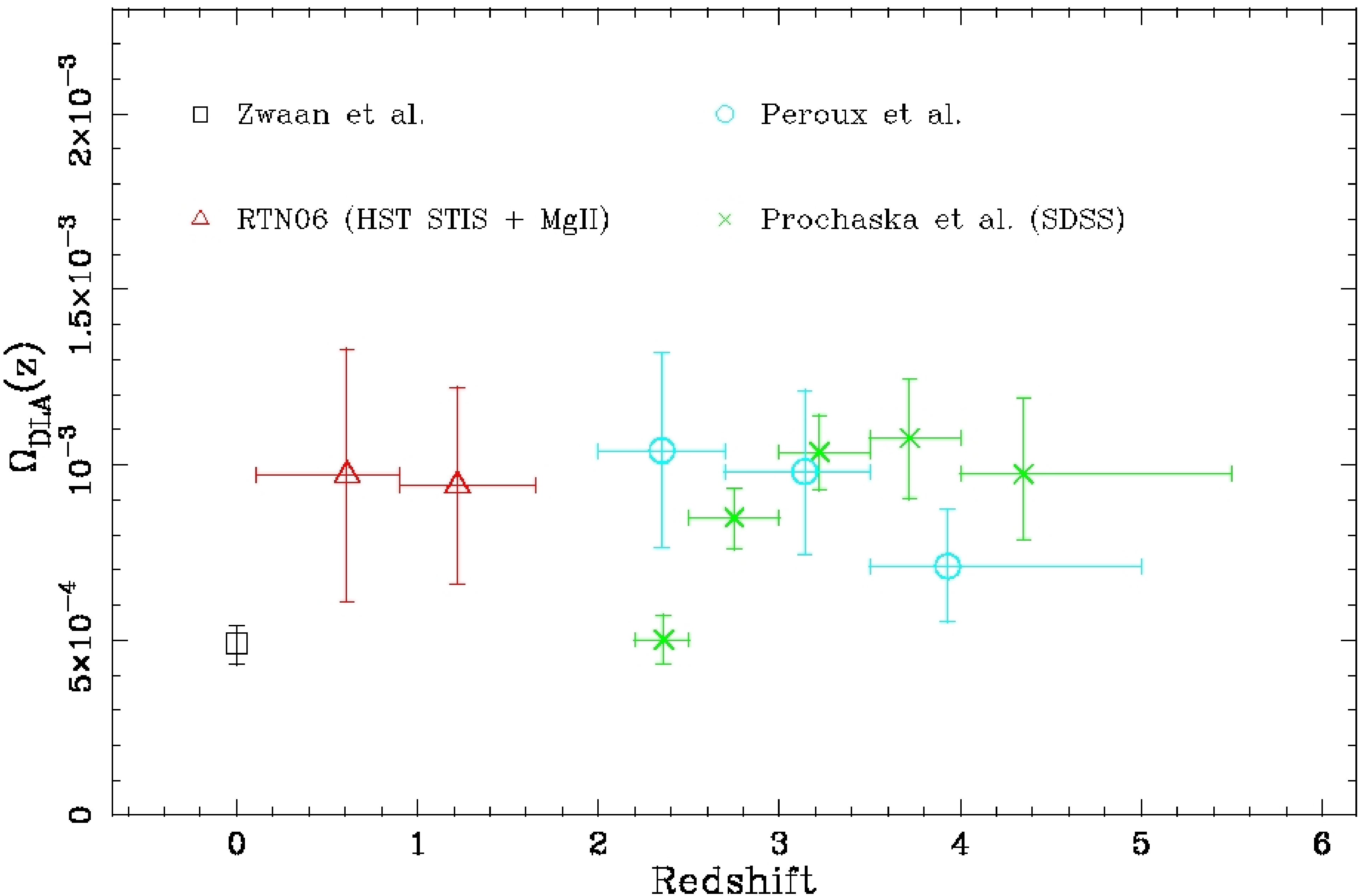
David Turnsek, **Sandhya Rao**, Anna Quider (Pittsburgh)

Max Pettini, Paul Hewett, Neil Trentham, Stephen Wilkins (IoA)

Stefano Zibetti (MPE)

Gordon Richards (Drexel)





Zwaan et al.
Peroux et al.
RTN06 (HST STIS + MgII)
Prochaska et al. (SDSS)
$\Omega_{DLA}(z)$
Redshift
0
5×10^{-4}
10^{-3}
1.5×10^{-3}
2×10^{-3}
0
1
2
3
4
5
6

Outline

- How and where do we find the H I at low-z?

  Identification; imaging.

- How much H I are we missing?

  Reddening of quasar induced by intervening Mg II systems.

- Dust properties.

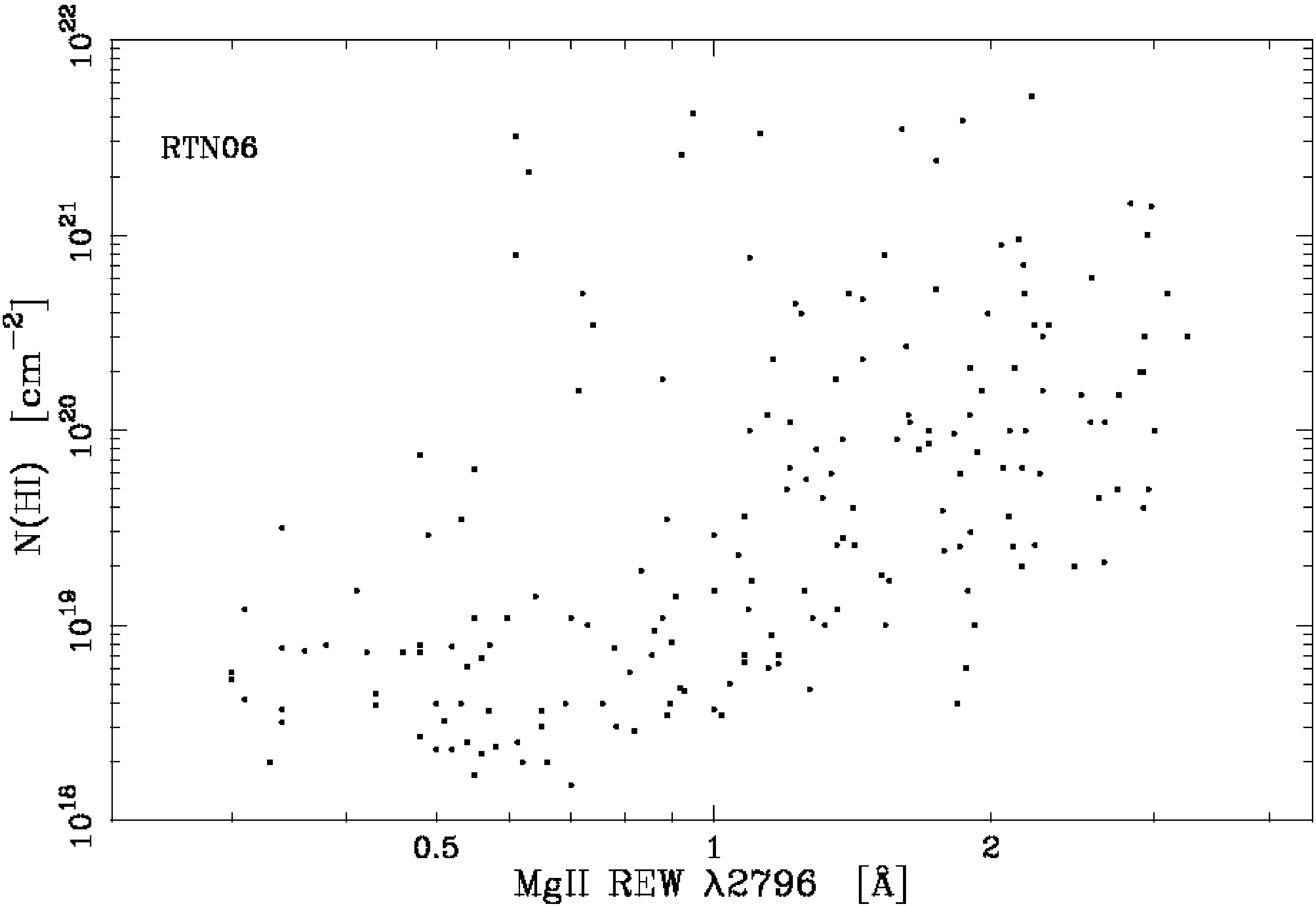
  Dust/Gas correlation with Mg II REW in DLAs and Mg II systems.

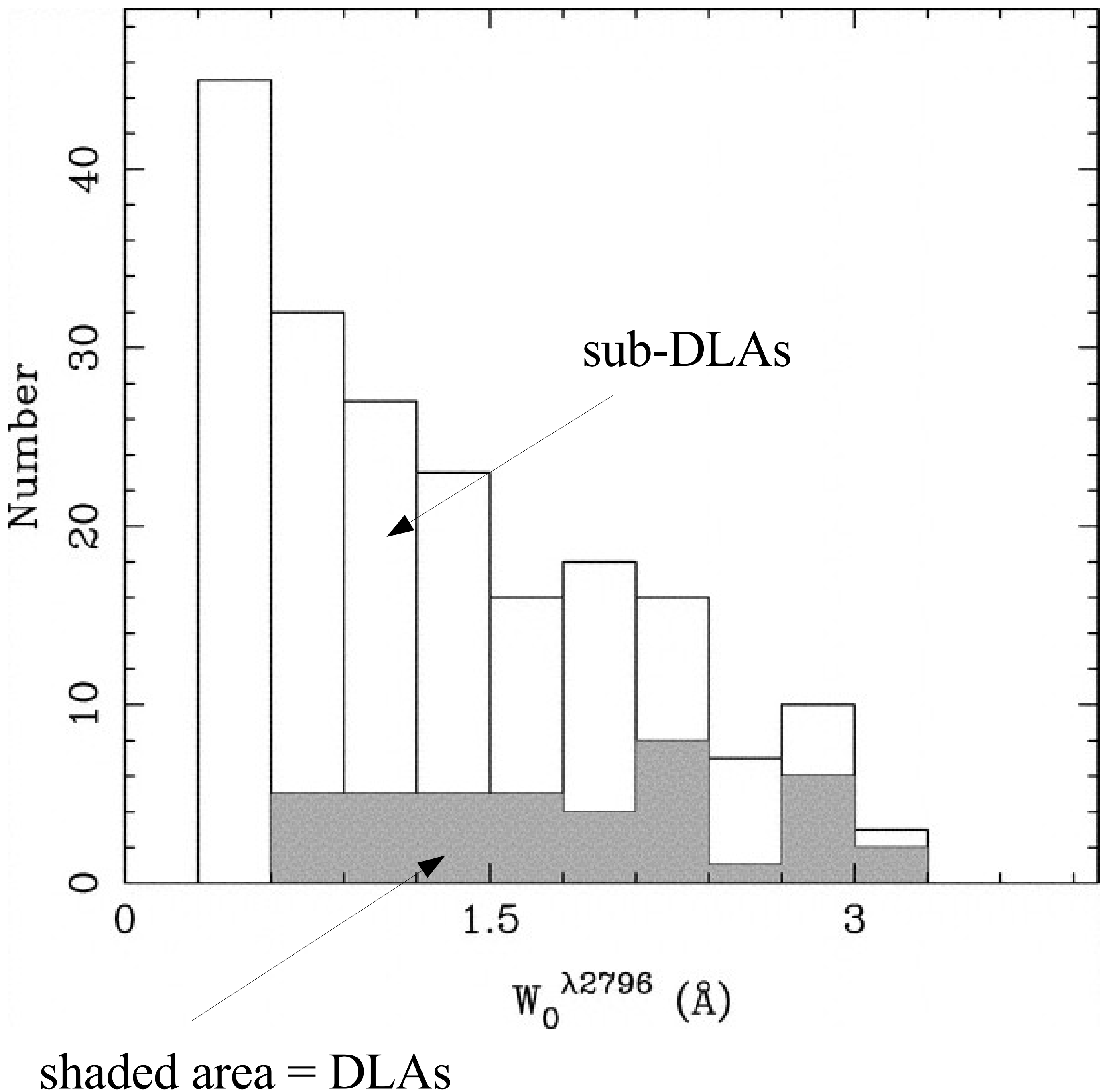
- Interpreting $\Omega_{DLA}(z)$.

  Timescale for conversion of H I into stars.

Mg II systems select both DLAs and sub-DLAs!

(abs. redshift < 1.65)



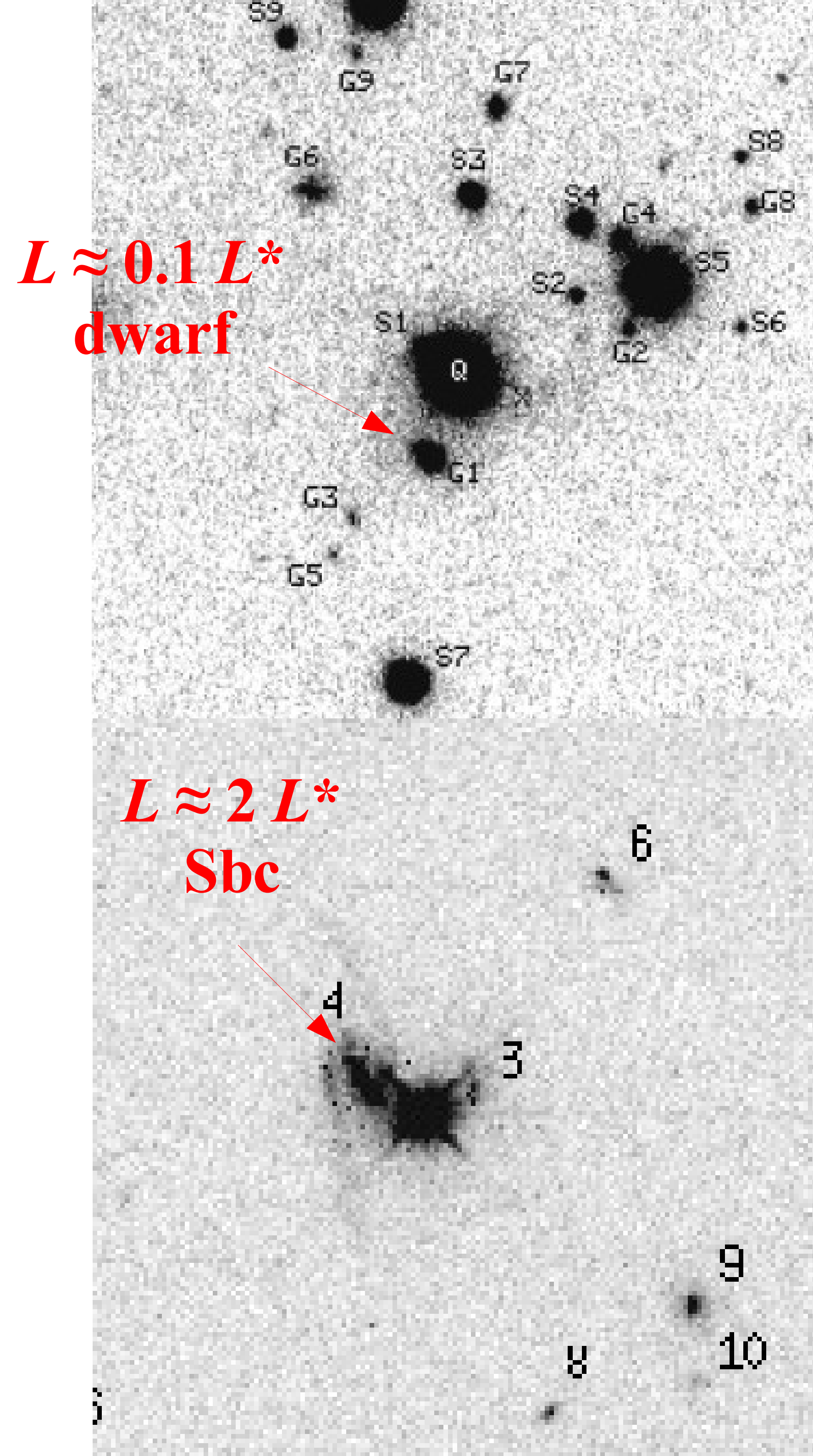


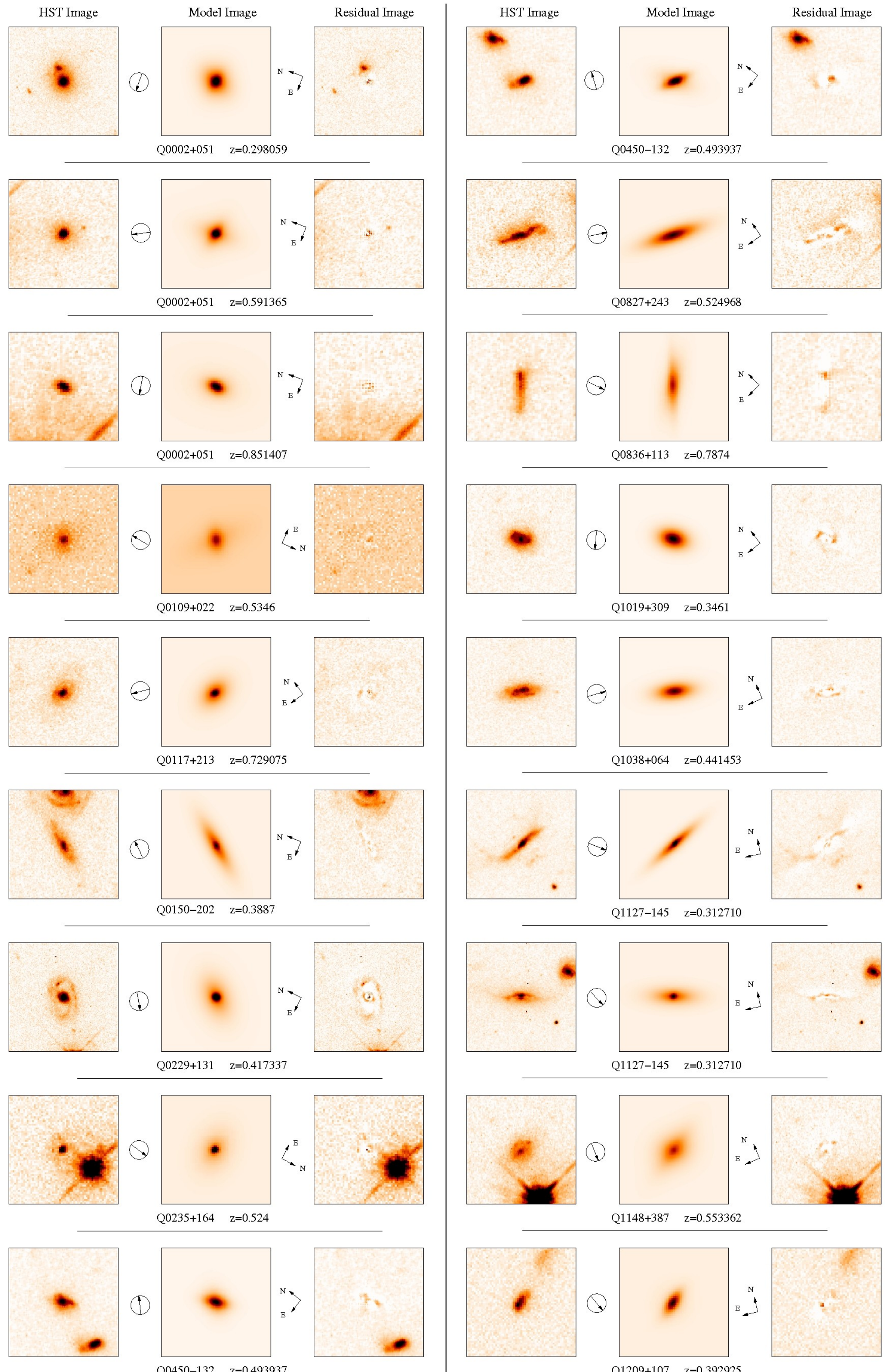
- Higher REW Mg II systems are more likely to be DLAs.
- Mg II REW also correlates with other properties; careful selection necessary to avoid biases.

DLA galaxy imaging

- DLA galaxies span a range of luminosities, morphologies and impact parameters.

- Currently, not enough identified DLA galaxies to properly compare to the field galaxy population.





Mg II galaxy imaging

From Kacprzak et al. (2007)

In 37 Mg II systems with 0.03 < REW < 2.9Å, they find no strong correlations between galaxy and absorption properties.

New (ongoing) Imaging Study:

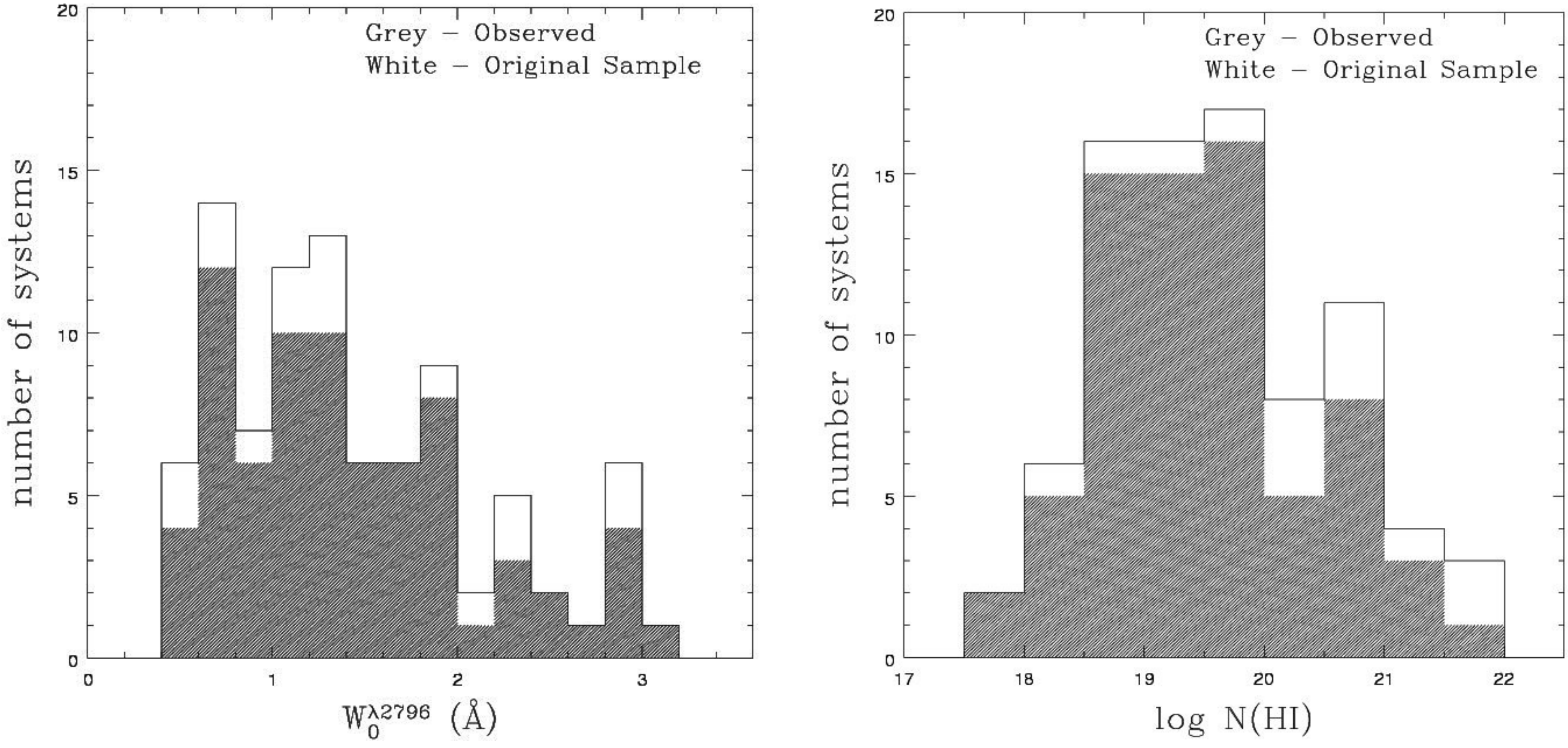
DLA and subDLA imaging sample selected from RTN2006:

MgII systems with REW(2796) ≥ 0.5 Å and N(HI) measurements from UV spectra

Redshift $z_{abs} \leq 1$.

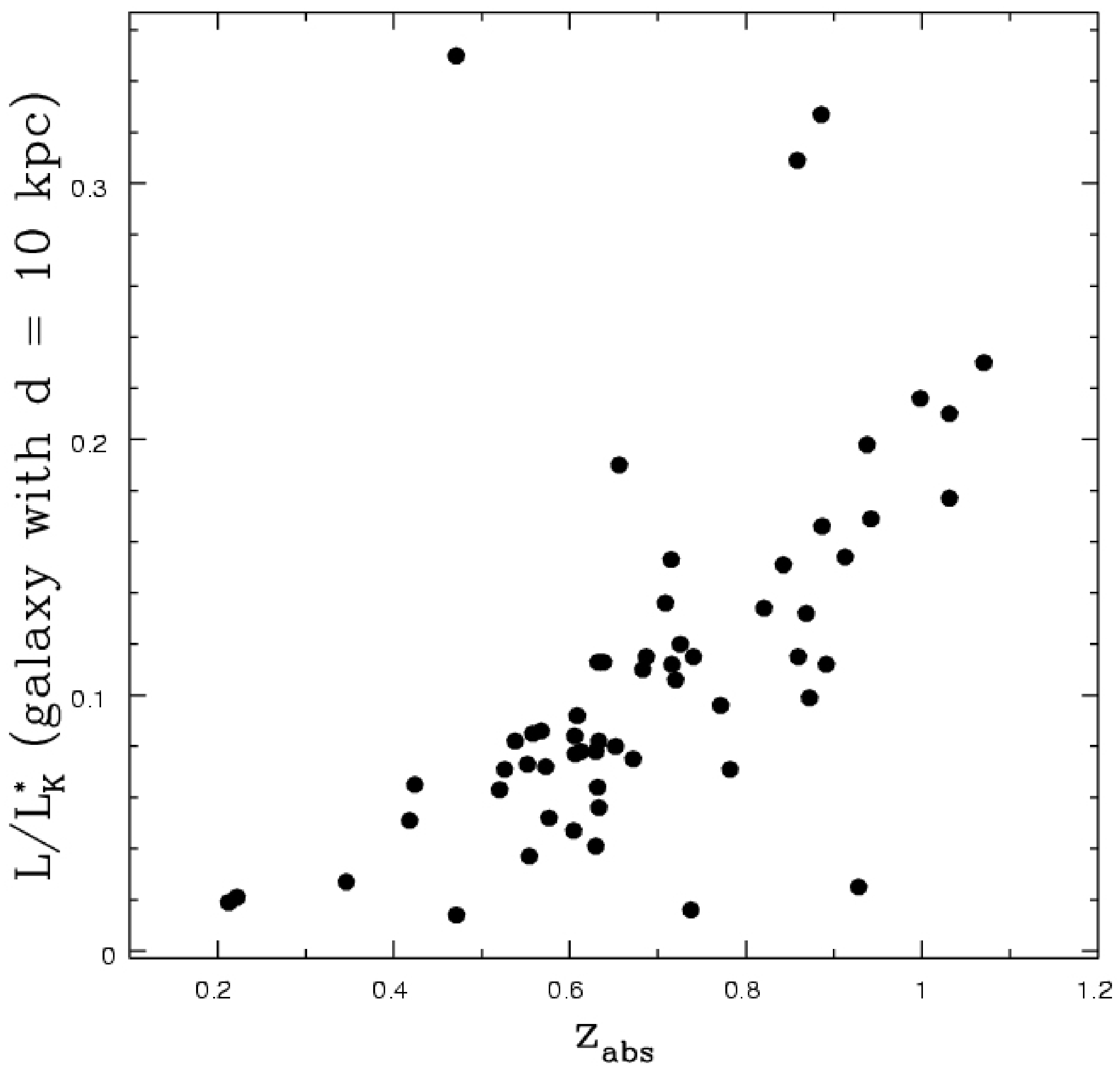
Initial sample includes 75 sightlines with 90 absorption systems; a large fraction of which was observed. Observations were carried out between 1998 and 2004 using NOAO and IRTF time as and when observing time was obtained through the TAC review process.

Distribution of observed targets as a function of REW(2796) and N(HI)



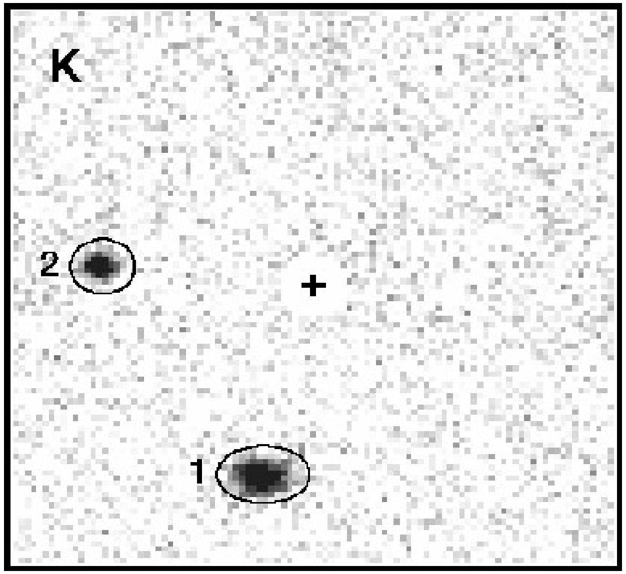
How faint were we able to go?

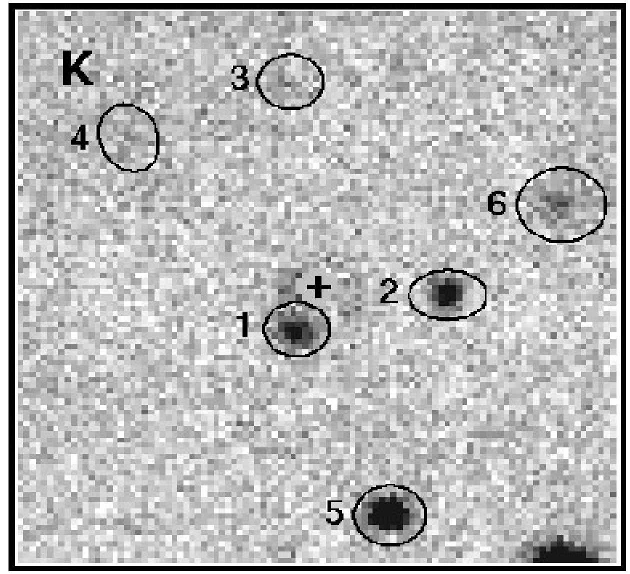
Limiting surface brightness can be used to determine the luminosity of the faintest detectable galaxy, that is, for eg. 10 kpc in diameter:

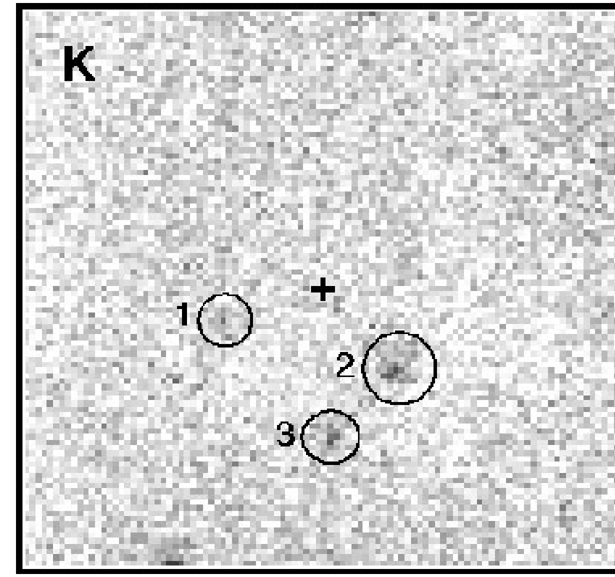


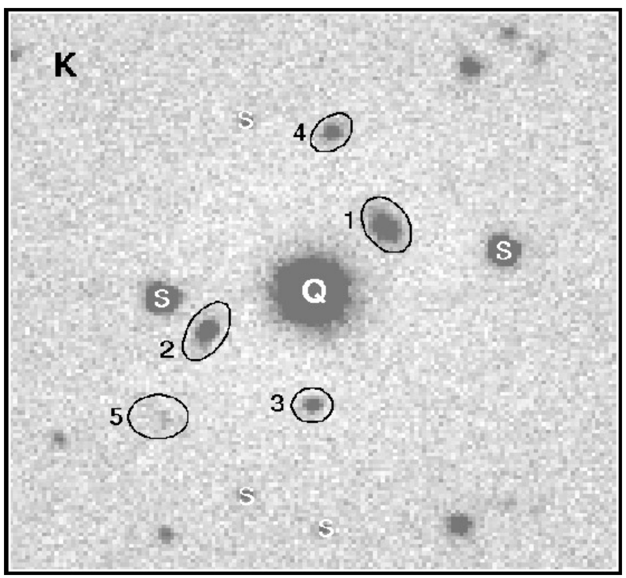
Outliers are SPEX data – guider camera on IRTF – not very sensitive

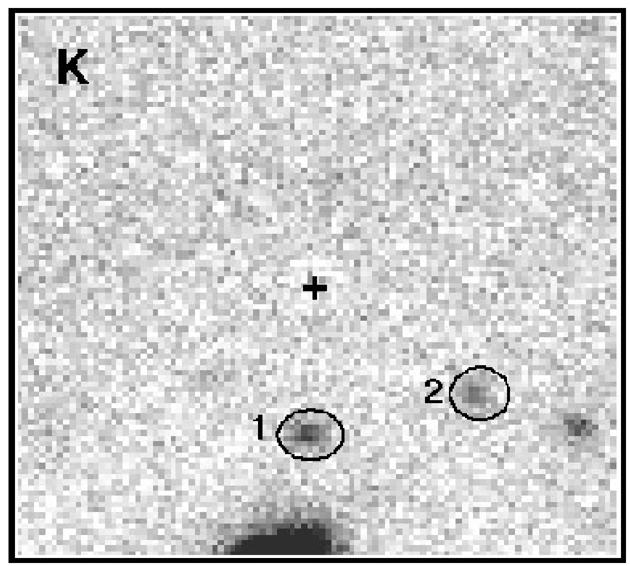
We can detect at least a 0.1L* galaxy up to z=0.6





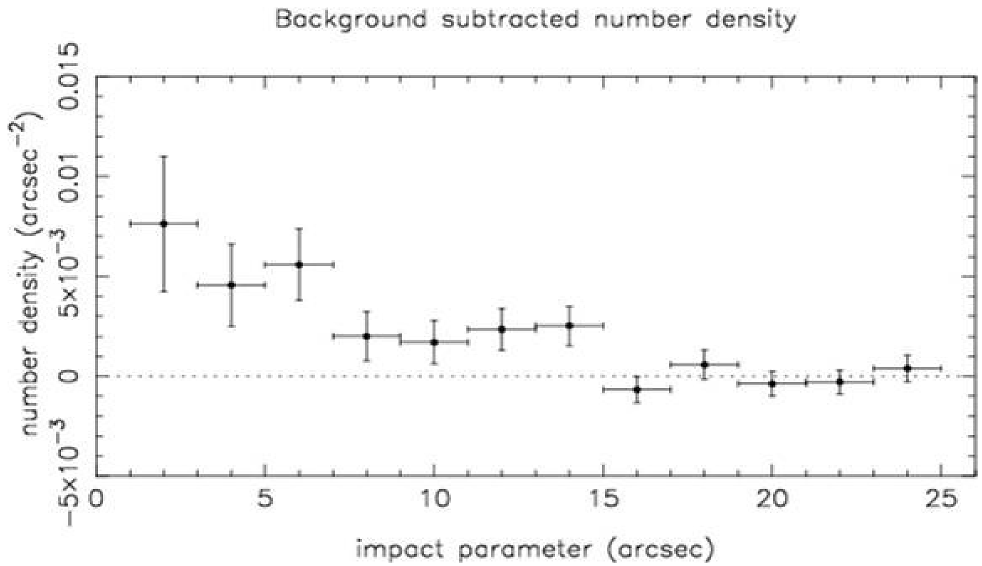






Criterion for object detection: 5 contiguous pixels 2σ above background.

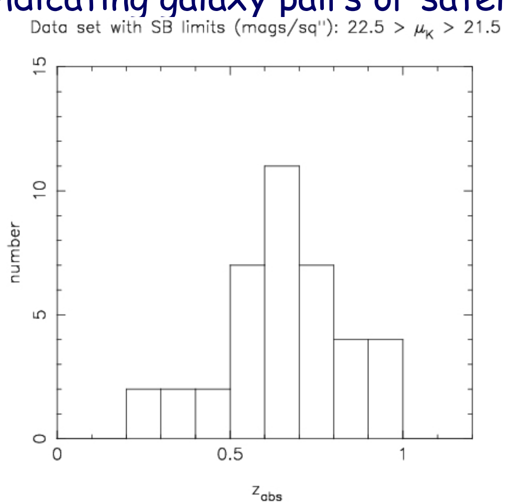
Example images: 30" x 30". Quasar PSF residuals, if any, are masked. Objects are labeled in order of increasing distance from quasar.

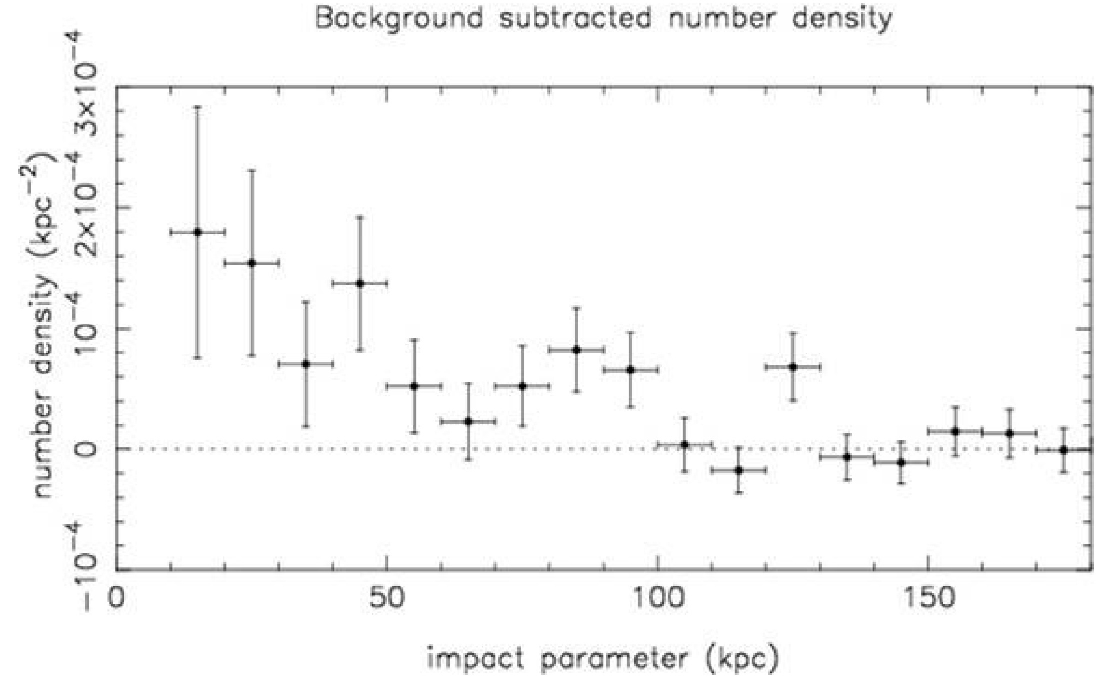


All K band data with 3σ surface brightness limits between 21.5 and 22.5.

For 0.5 < z < 0.8:

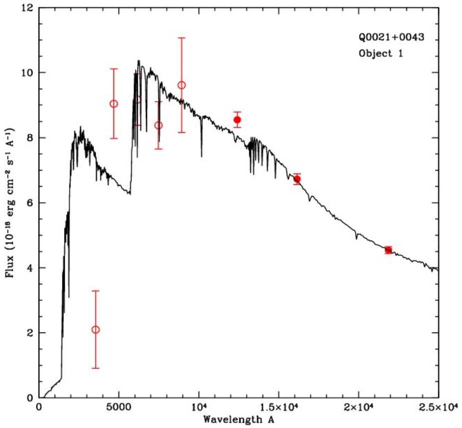
An excess of galaxies is seen at impact parameters less than ≈ 50 kpc. Unclear if the small peak at 80 kpc is real – indicating galaxy pairs or satellites?

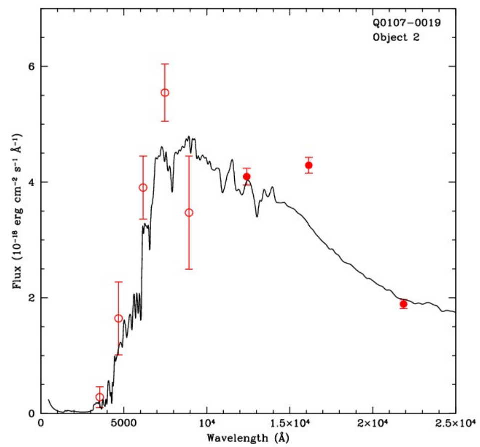


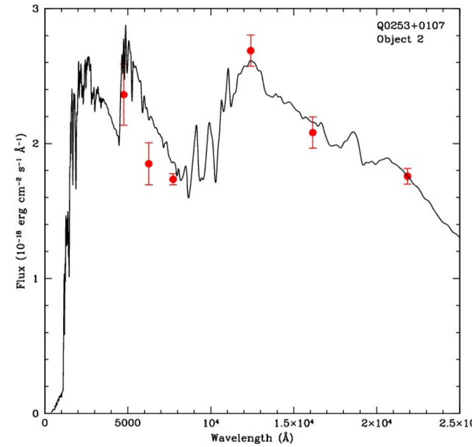


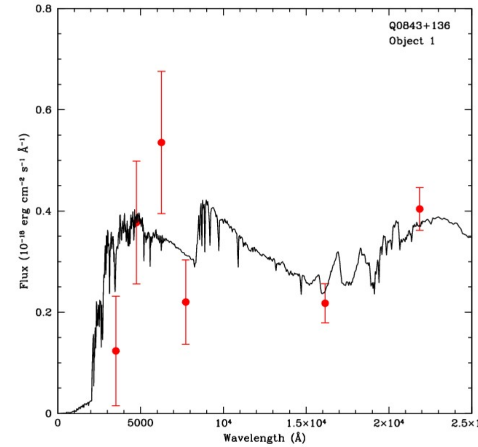
Point at 130 kpc is most likely discrepant

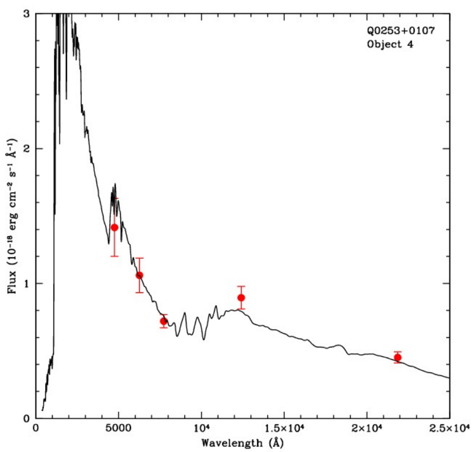
Example photometric redshift fits to our (solid pts) and SDSS (open) data.

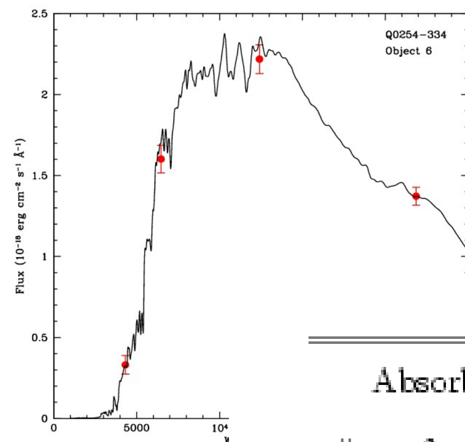










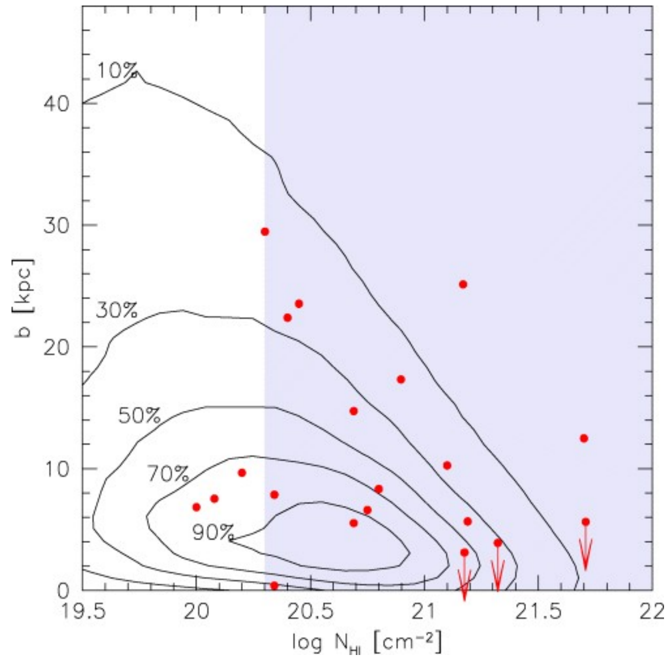


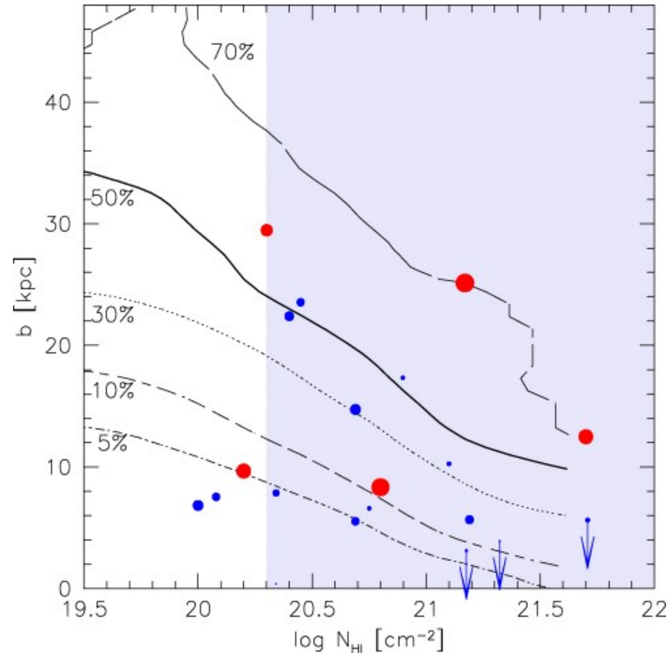
40% of the systems have a candidate absorber galaxy identified with photo-z; the rest are tentatively 'proximity' identifications.

Absorber			Model				
#	θ	b	Age	τ	$E(B-V)$	Z	$z_{phot} \pm \sigma_{z_{phot}}$
	″	kpc	Gyr				
1	5.2	34.7	0.1000	12.0000	0.5000	0.0500	1.238±0.288
8	10.1	68.0	0.5000	1.0000	0.2000	0.0200	0.443±0.281
11	13.7	91.9	0.5000	0.1000	0.0000	0.0500	0.798±0.125
				SFR	dust	metallicity	

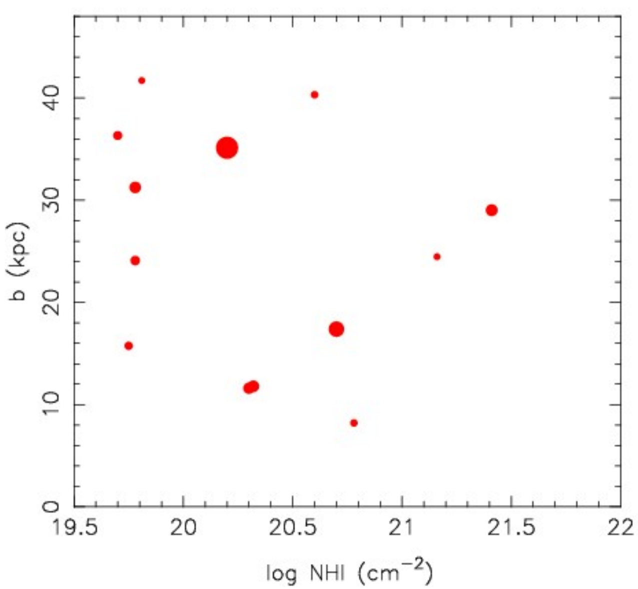
Example information for one field.

From Zwaan: on the left – probability contours of b_NHI space at z=0. Dots are known low-z (sub)DLAs. On the right is probability that host galaxy is brighter than L*.



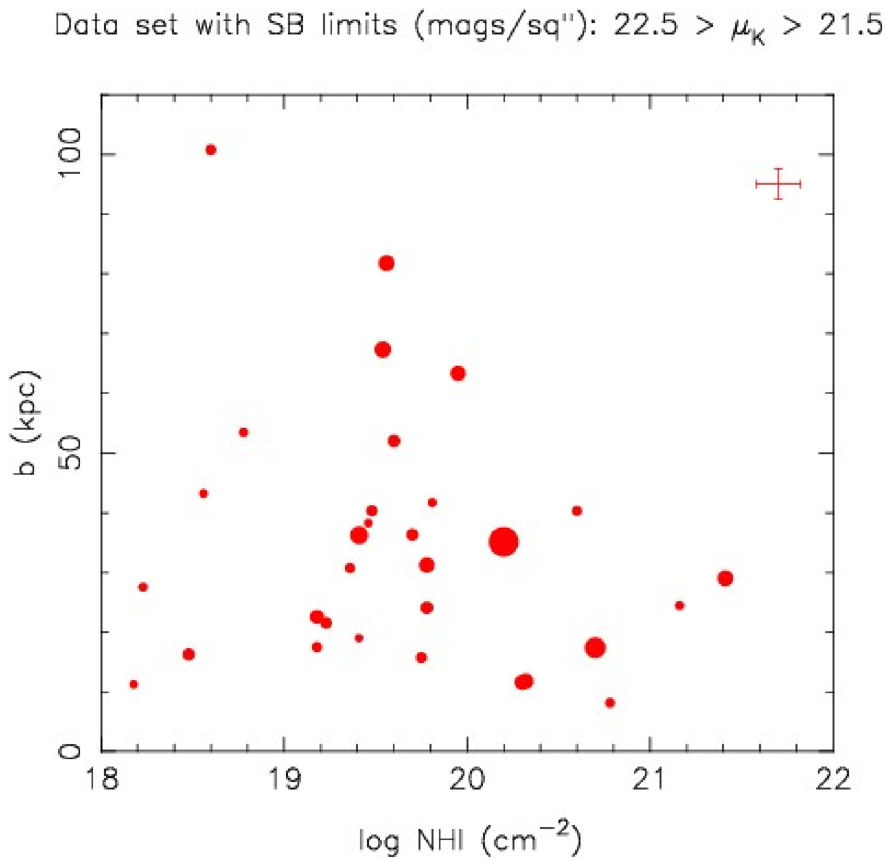


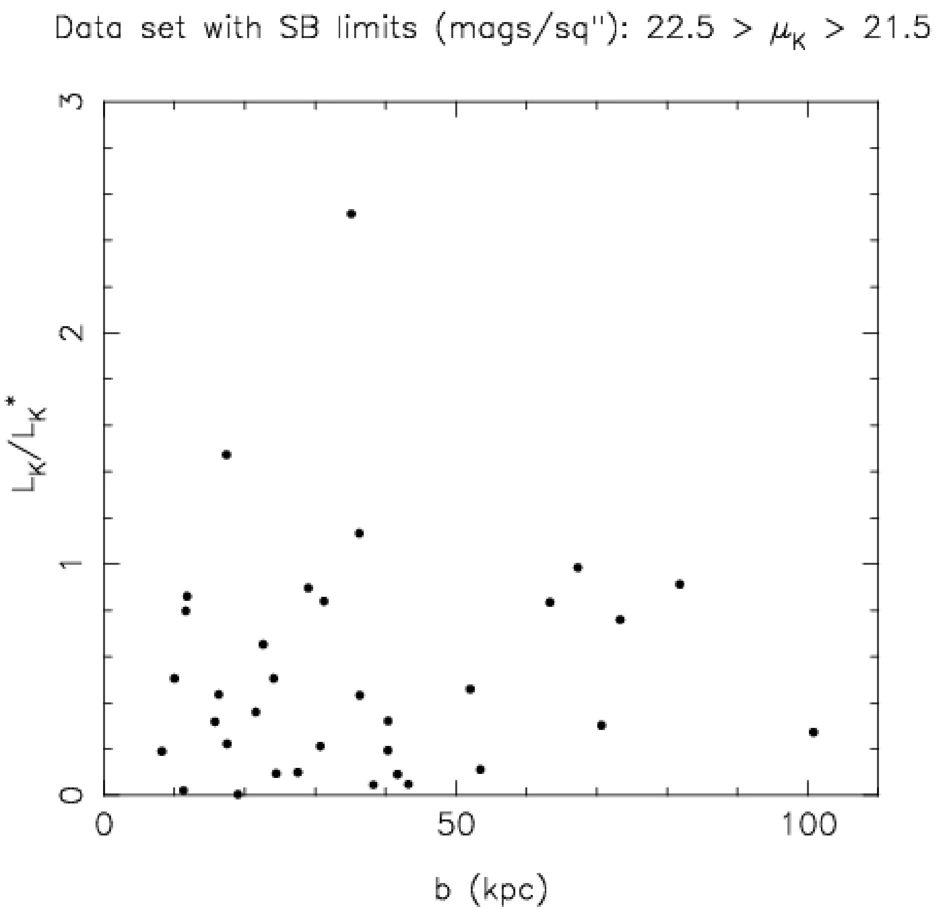
Data set with SB limits (mags/sq"): 22.5 > μ_K > 21.5



Our sample in overlapping NHI, b plane.

N(HI) – impact parameter distribution





Galaxies with *b < 50 kpc* can be considered bonafide absorber candidates.

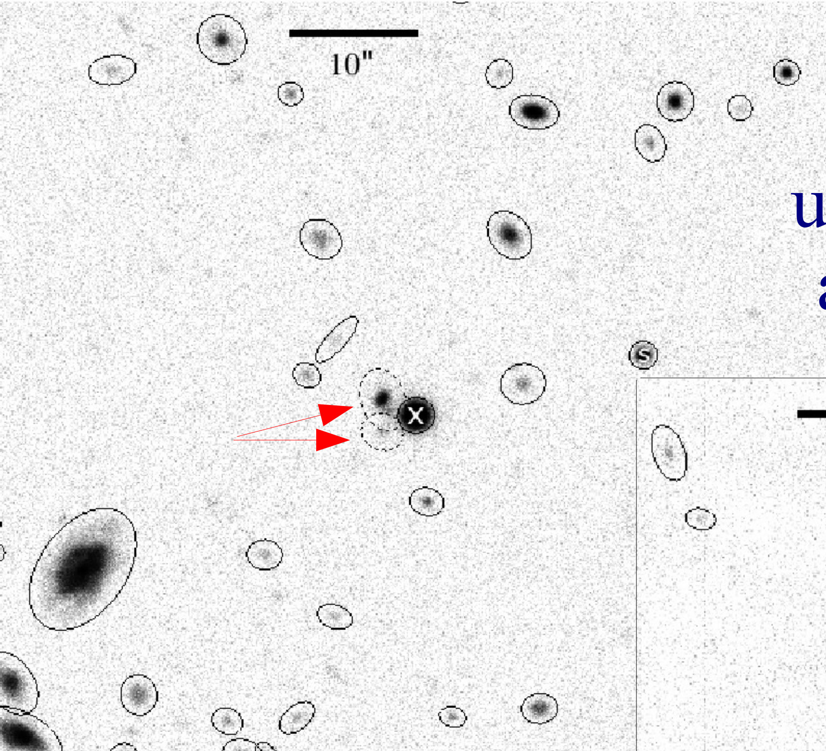
Size of dots is luminosity dependent

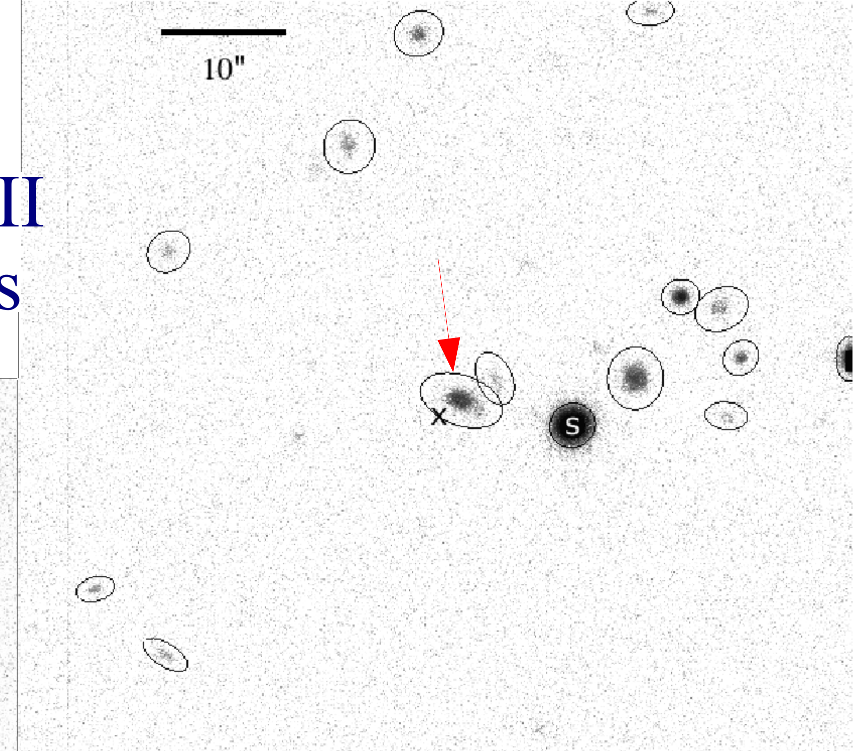
Also imaging "ultra-strong" MgII absorbers

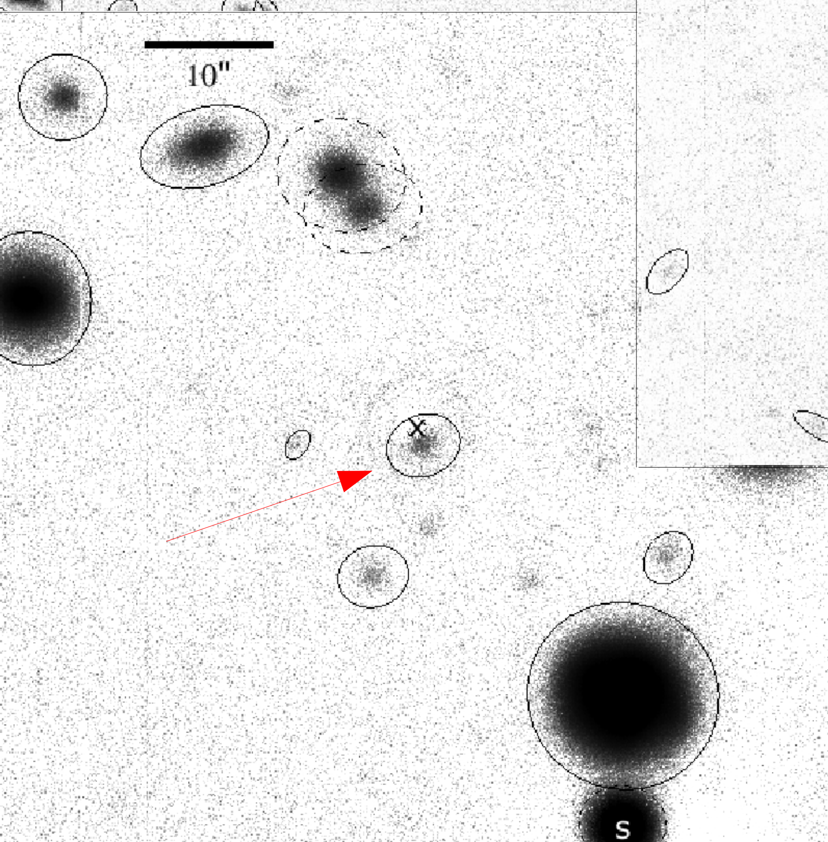
(Defined to have REW > 3Å)

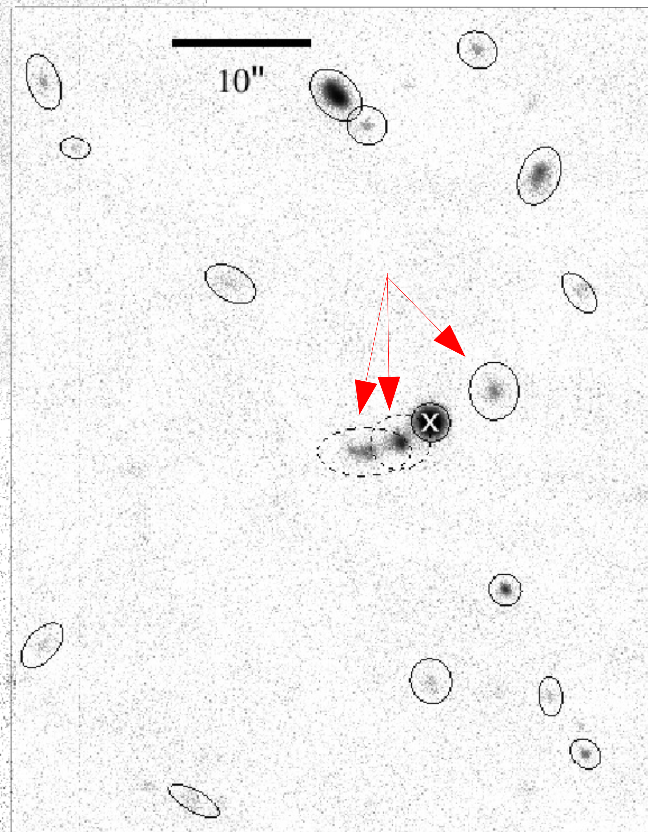
- 13 fields analyzed (see Nestor et al., 2006)
- Images of 23 more fields already obtained
- ...more on the way.

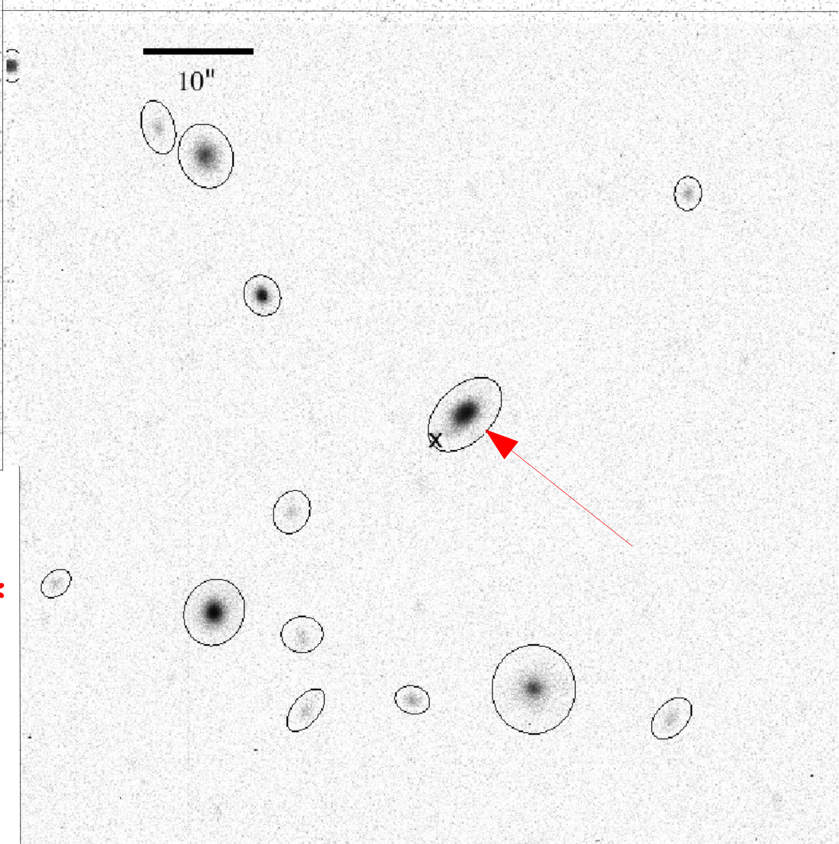
“Normal” ultra-strong Mg II absorbing fields





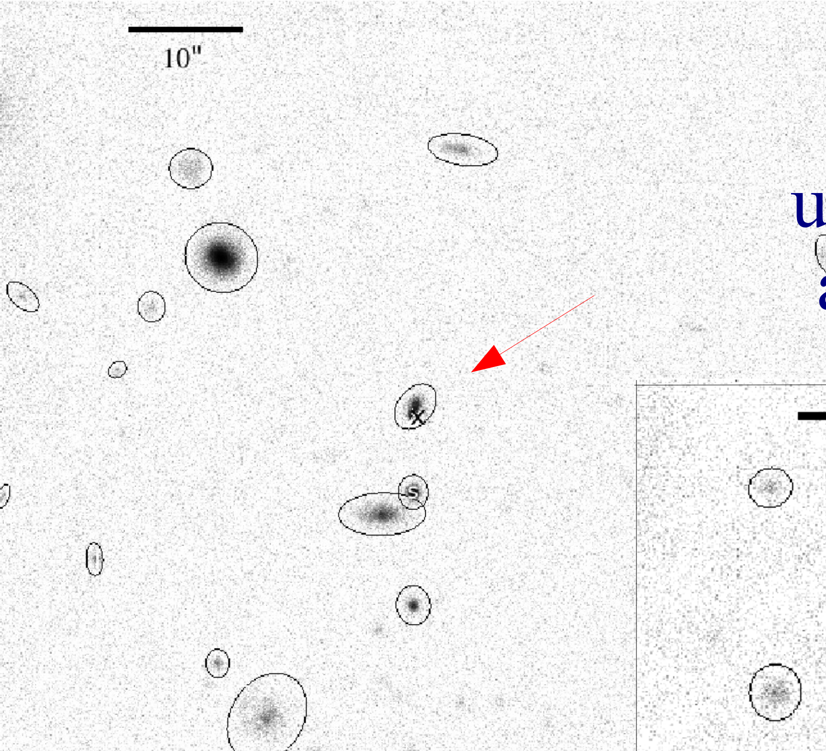


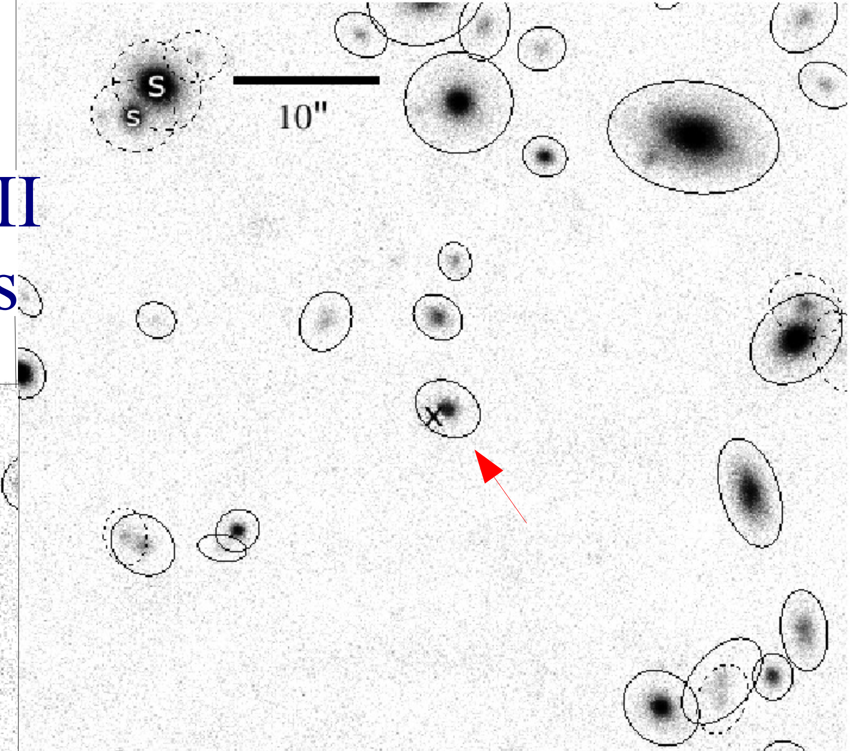


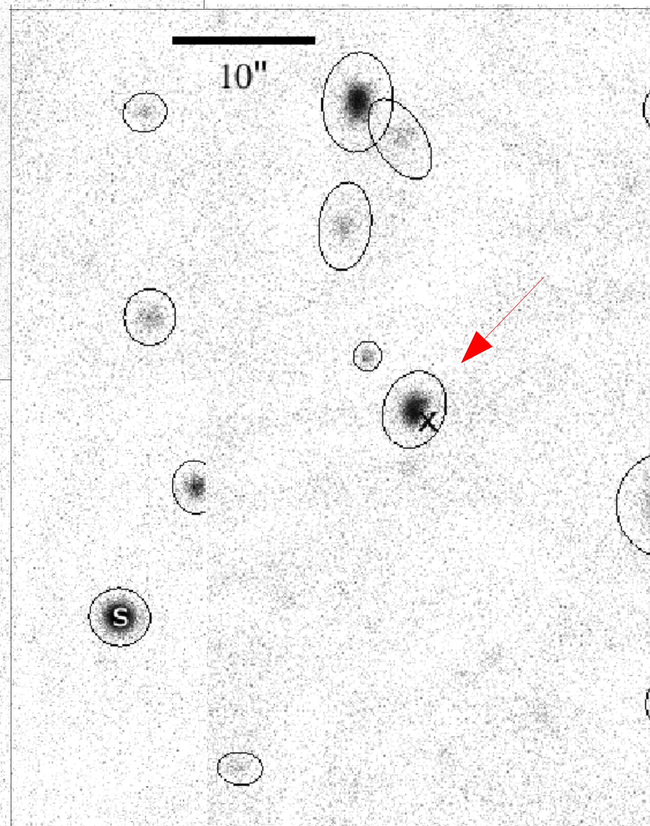


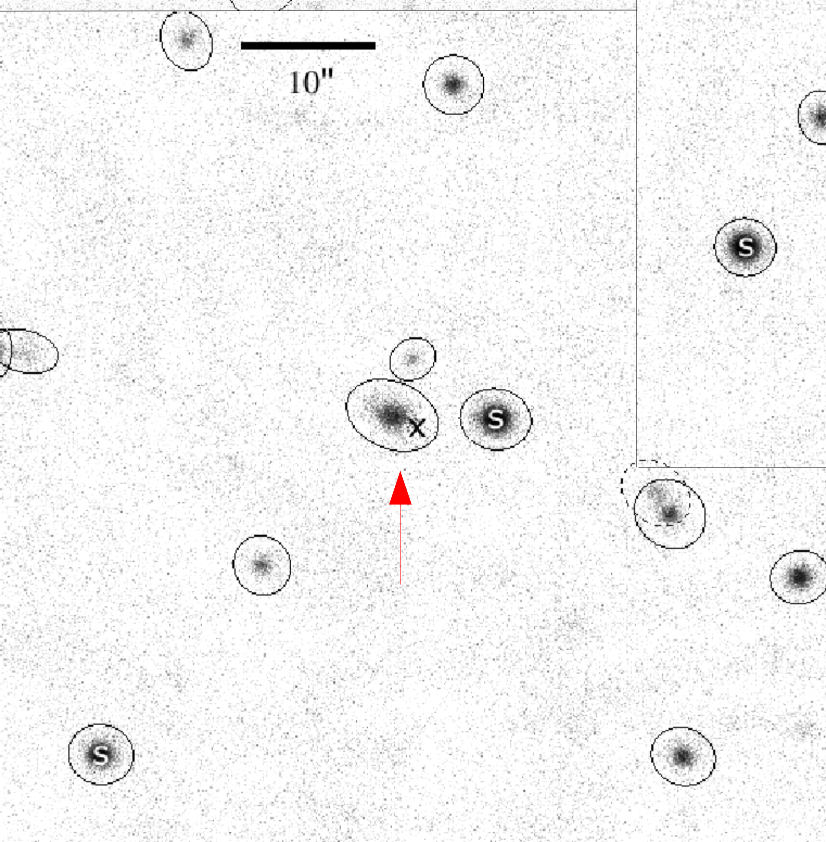
$L \sim 0.5 - 3.5\, L^*$

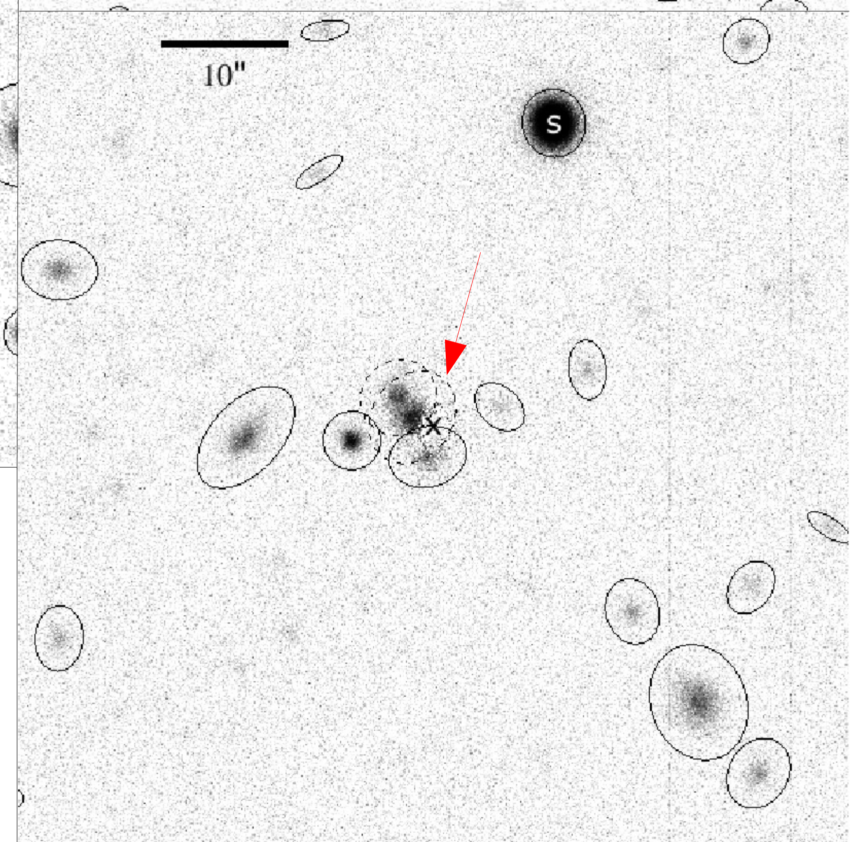
“Overlap” ultra-strong Mg II absorbing fields





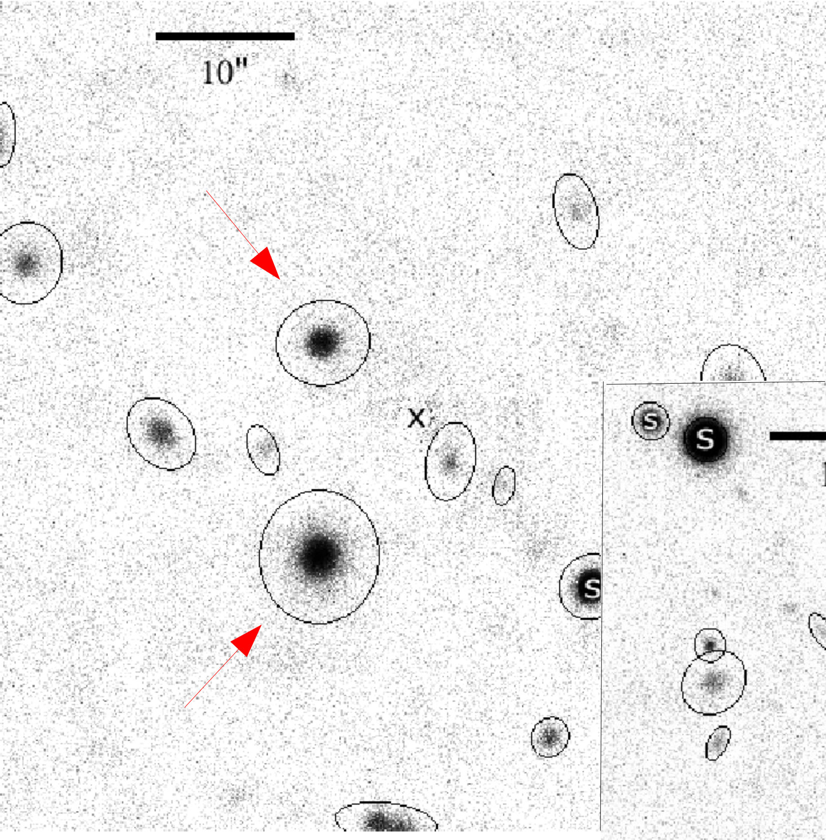


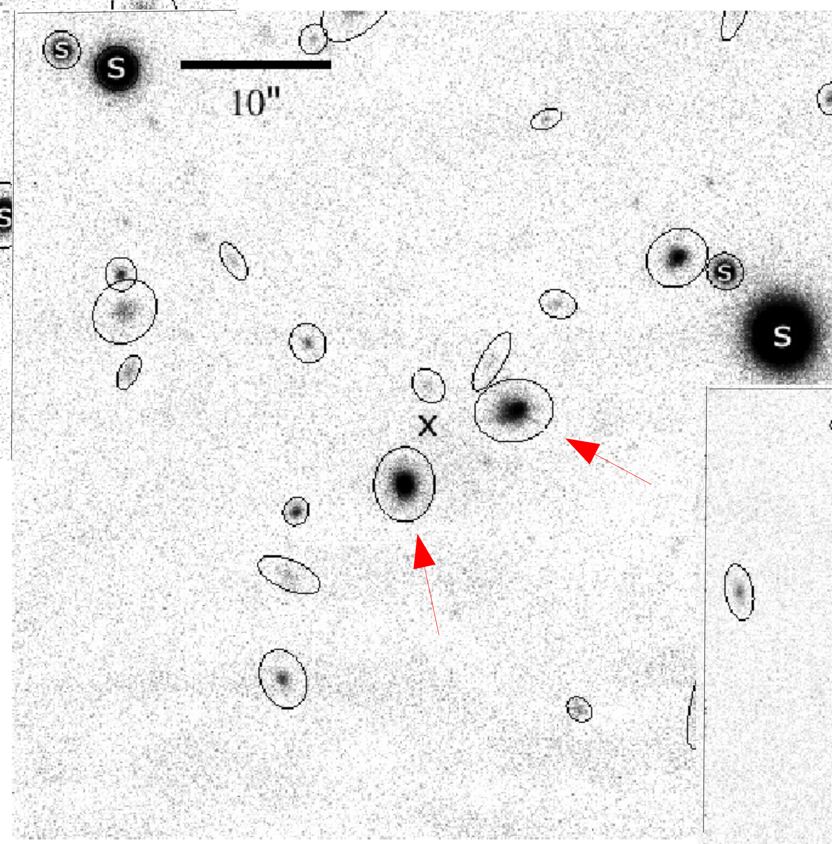


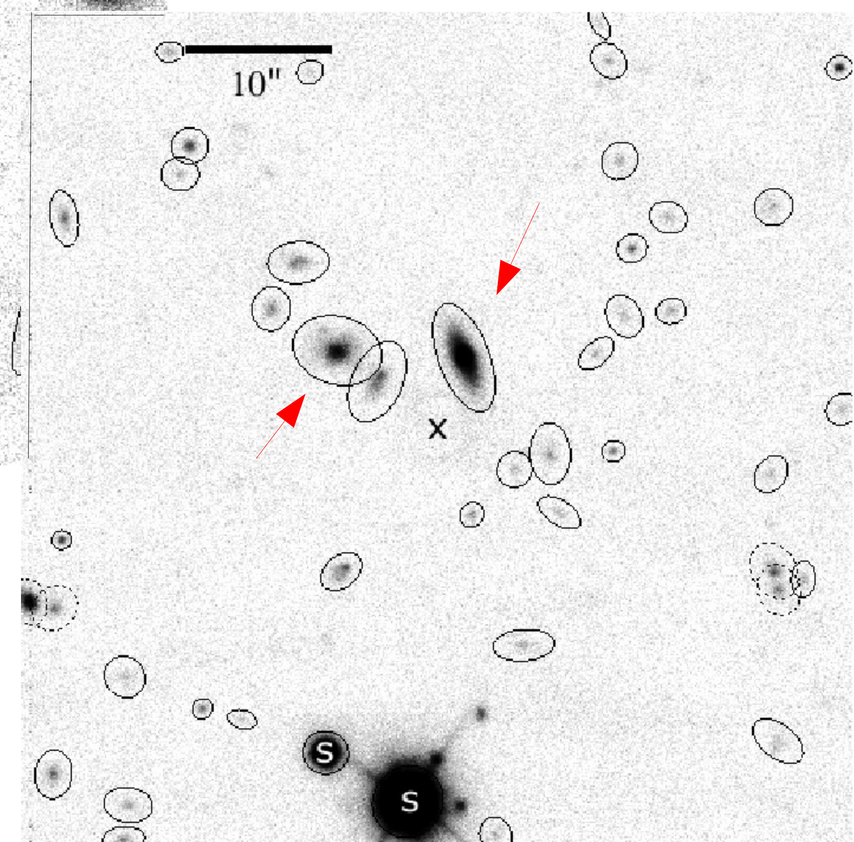


$L \sim 2\,L^{*}$

“Bright” ultra-strong Mg II absorbing galaxy fields







$L \sim 5 - 12\, L^*$

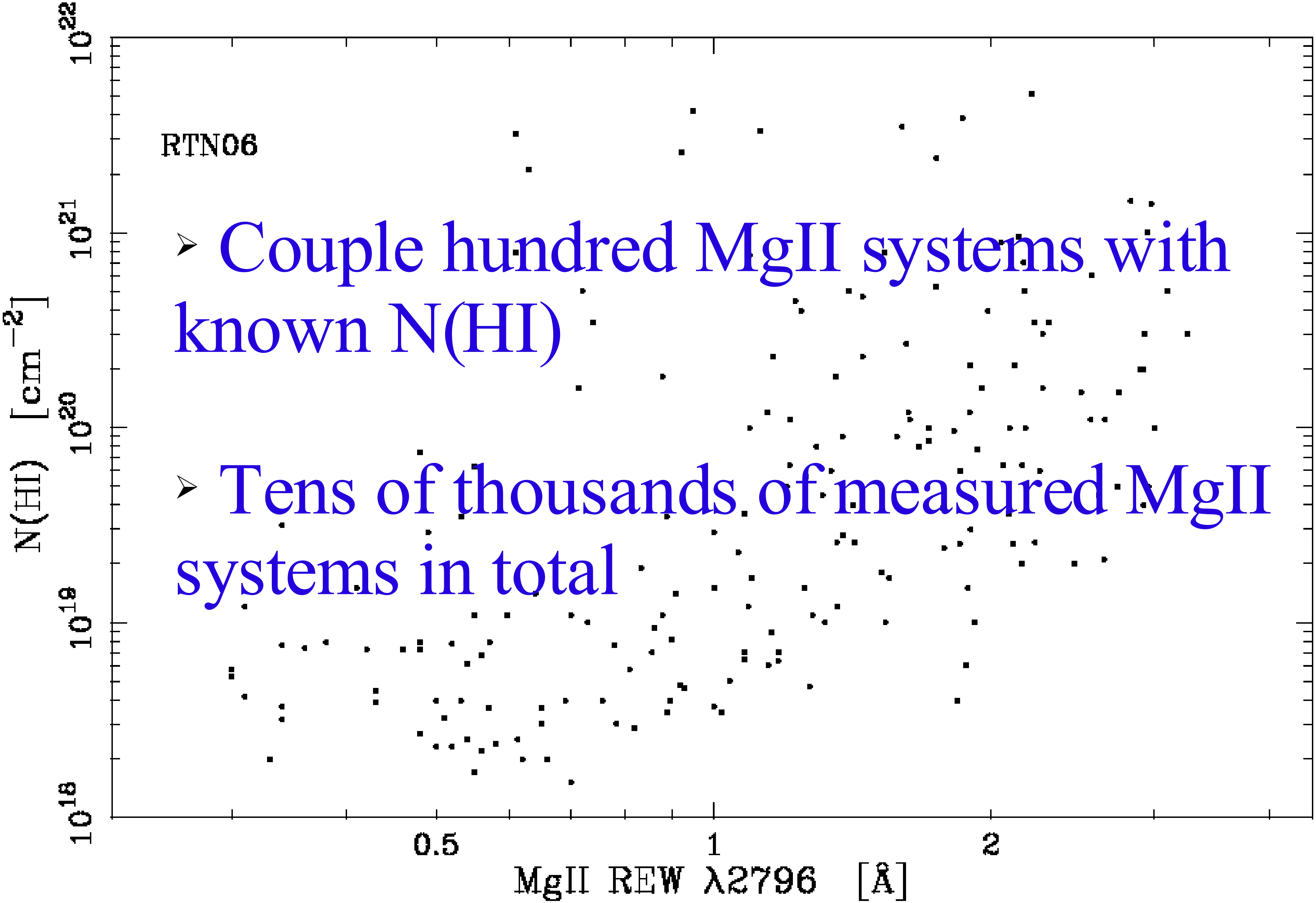
Conclusion #1:

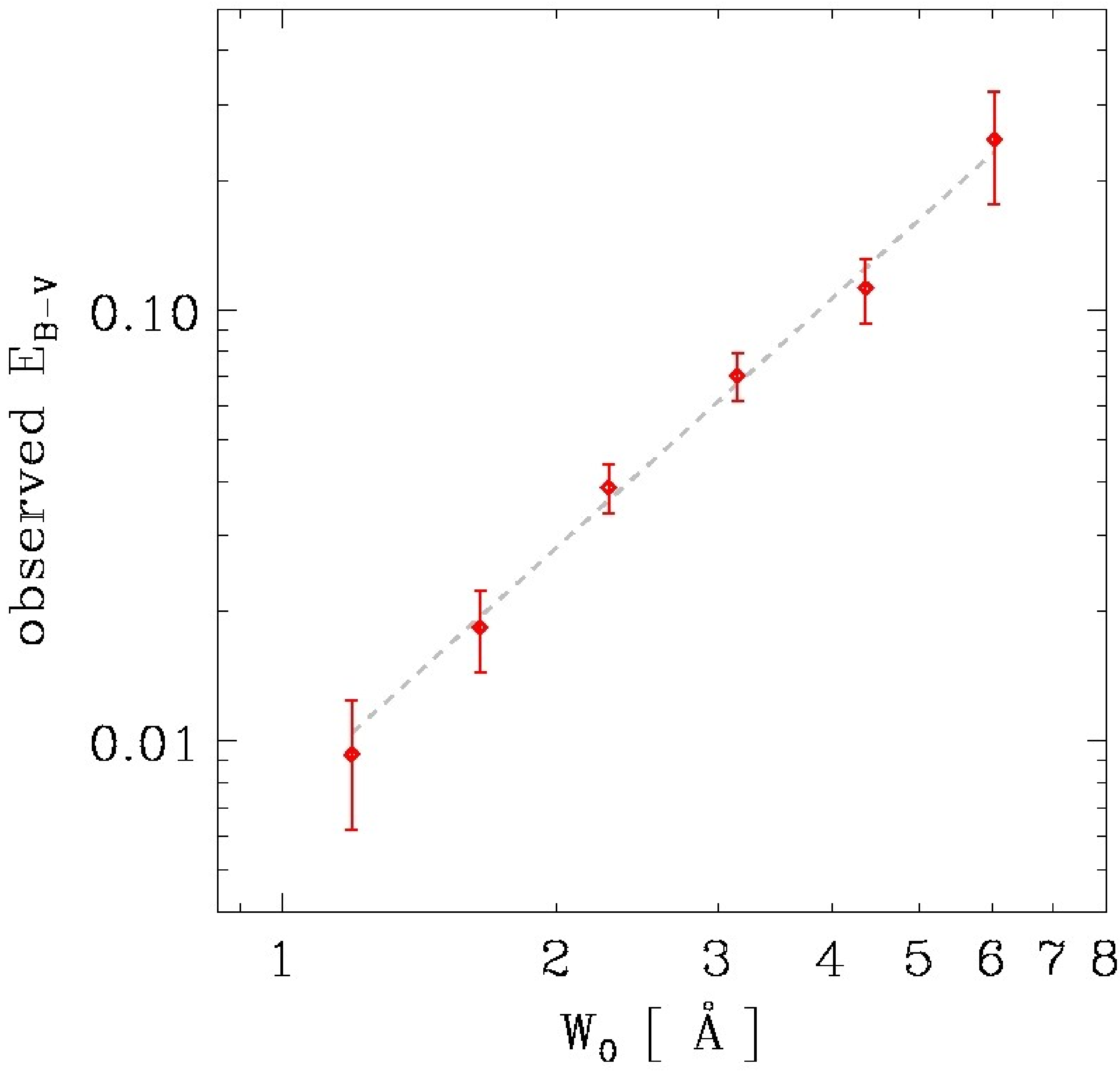
We have obtained imaging datasets:

- Covering a large baseline in MgII REW
- Multiband imaging covering a large baseline in N(HI)

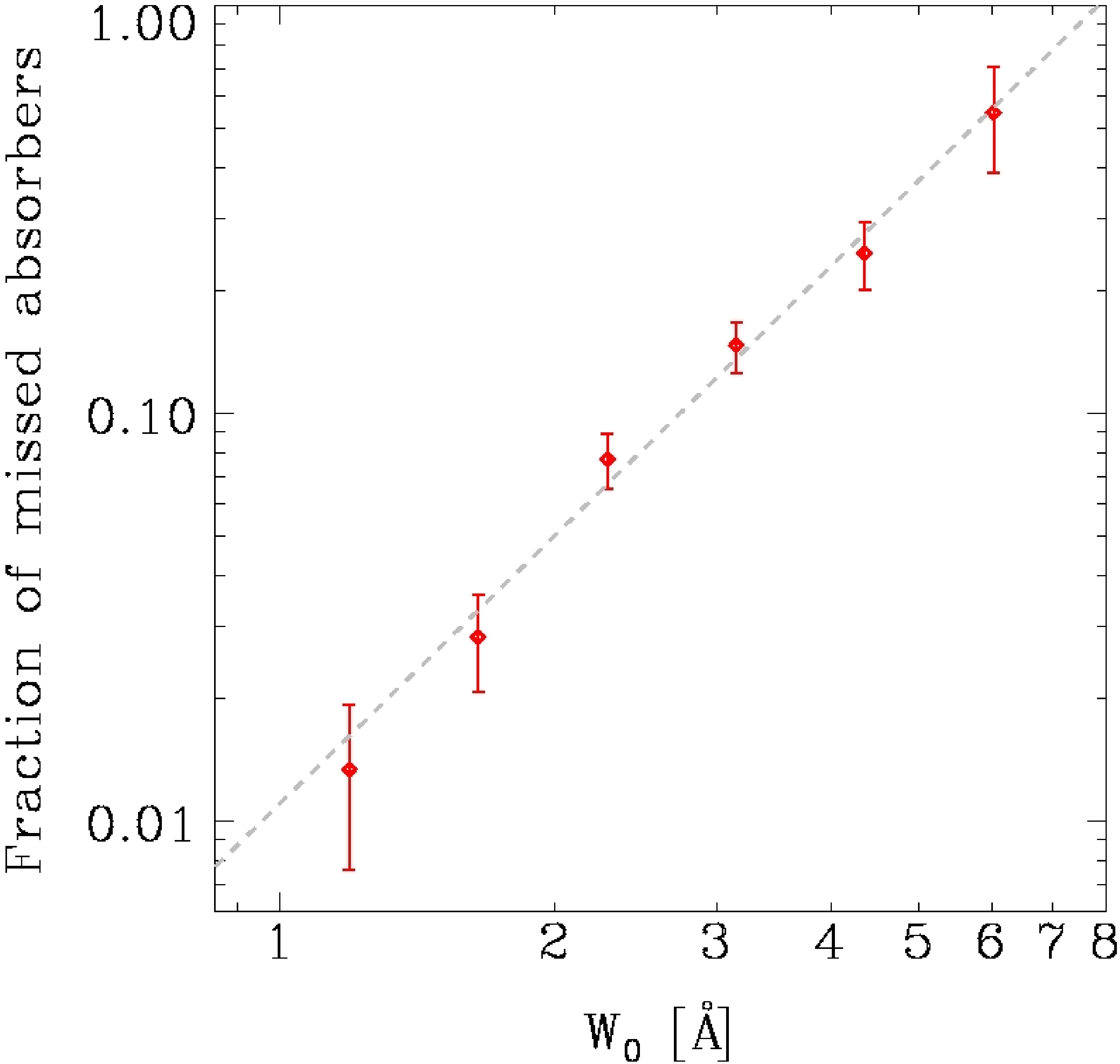
...look for results this fall/winter.

- Couple hundred MgII systems with known N(HI)
- Tens of thousands of measured MgII systems in total

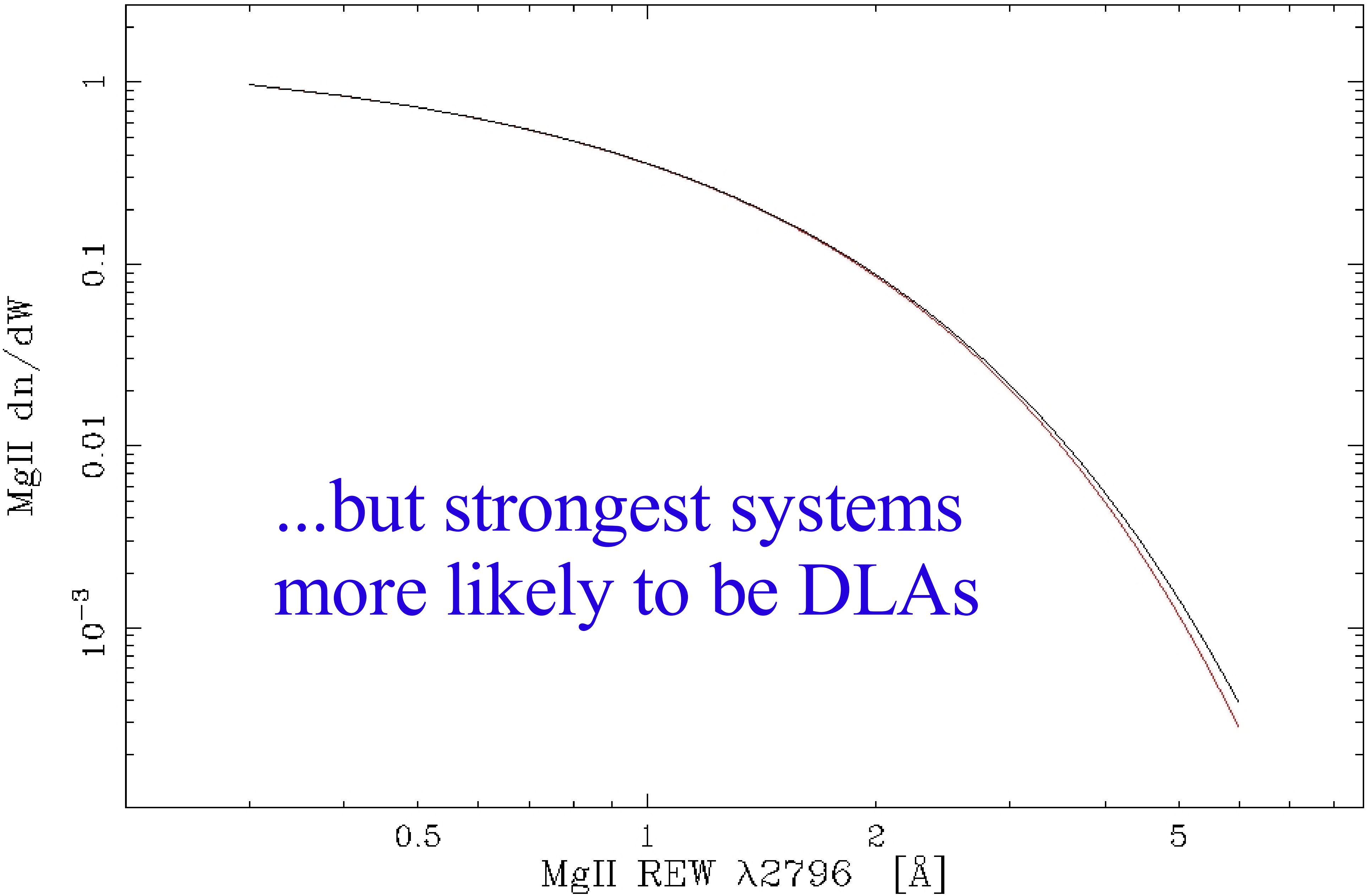




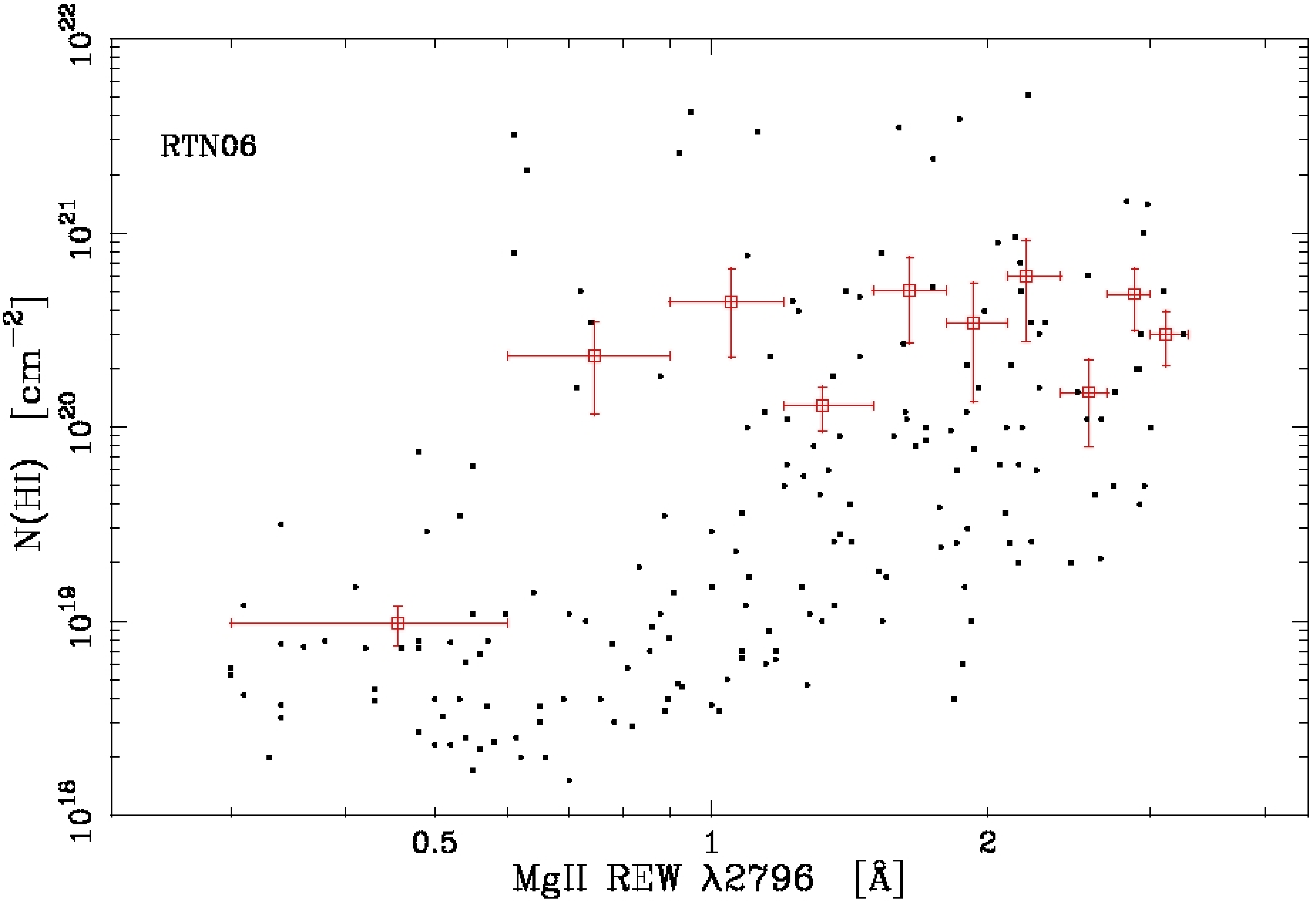
- Individual systems will exhibit a range of $E_{B\text{-}V}$ values
- $\langle E_{B\text{-}V} \rangle$ good measure of reddening signal



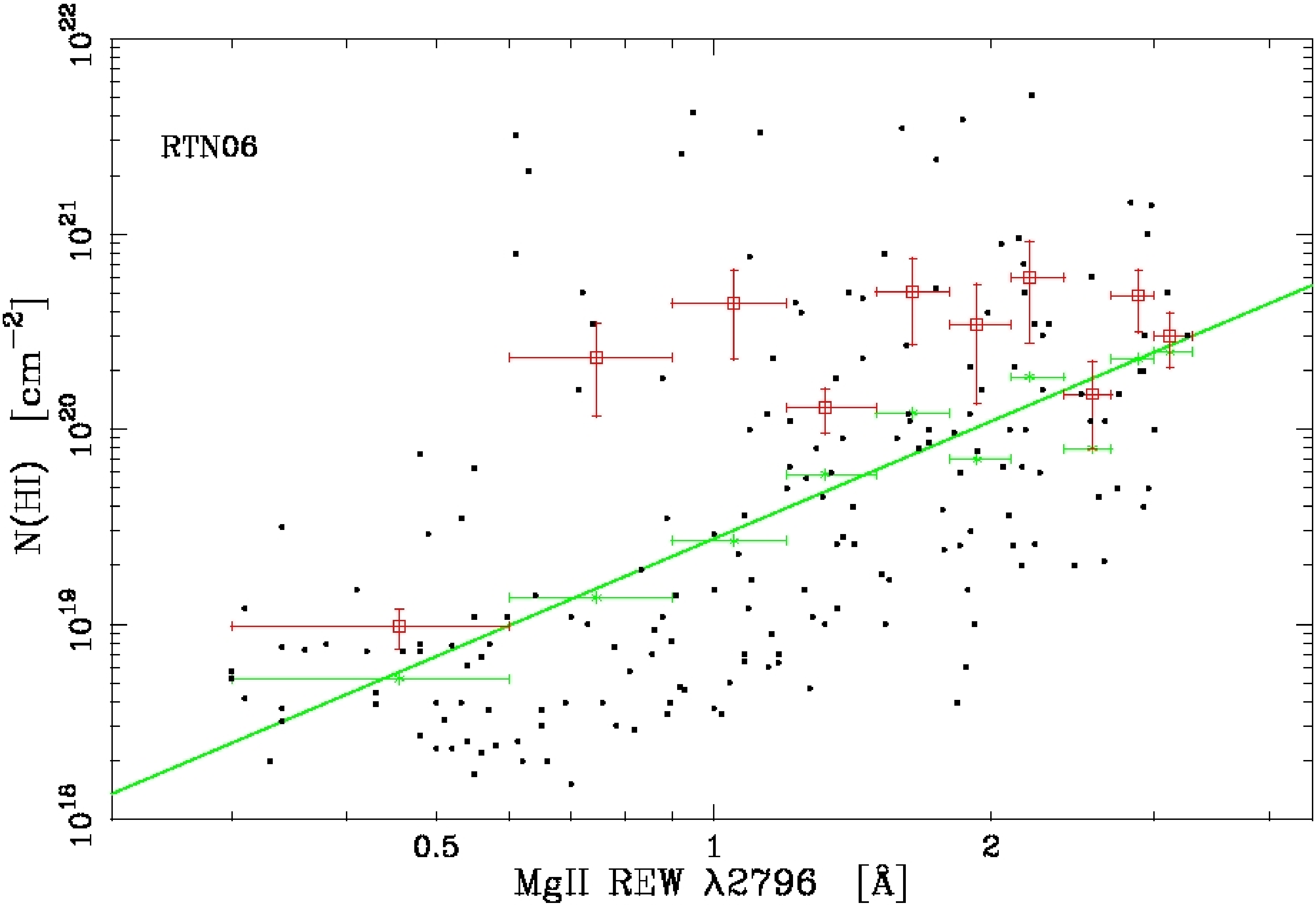
- Few $W_0 \lesssim 2$Å systems missed
- Significant fraction of $W_0 \gtrsim 3$ Å missed, but...
- ...strongest systems also the rarest



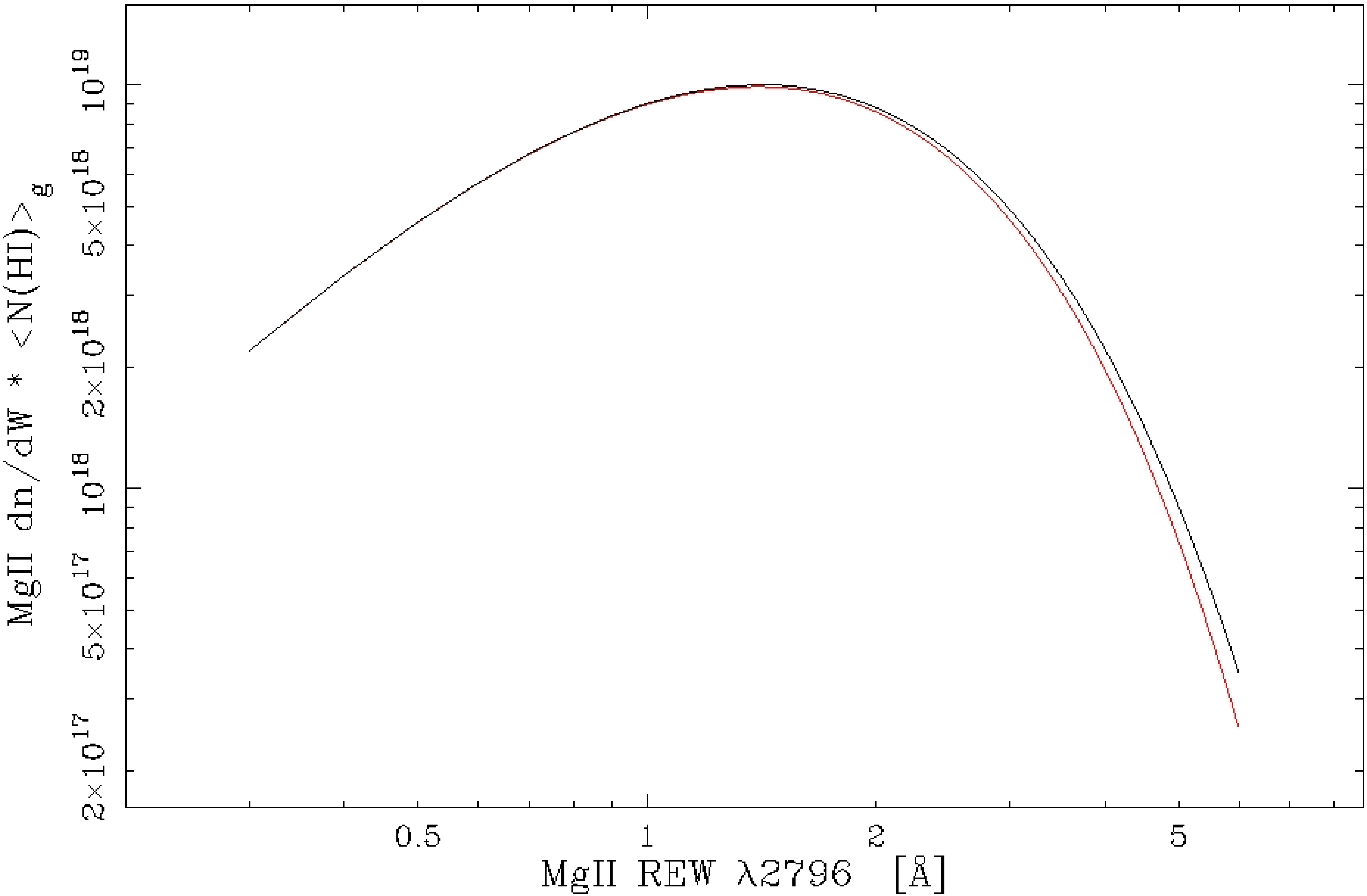
...but strongest systems
more likely to be DLAs
MgII dn/dW
1
0.1
0.01
10^{-3}
0.5
1
2
5
MgII REW λ2796 [Å]



RTN06
N(HI) [cm⁻²]
MgII REW λ2796 [Å]
10^22
10^21
10^20
10^19
10^18
0.5
1
2



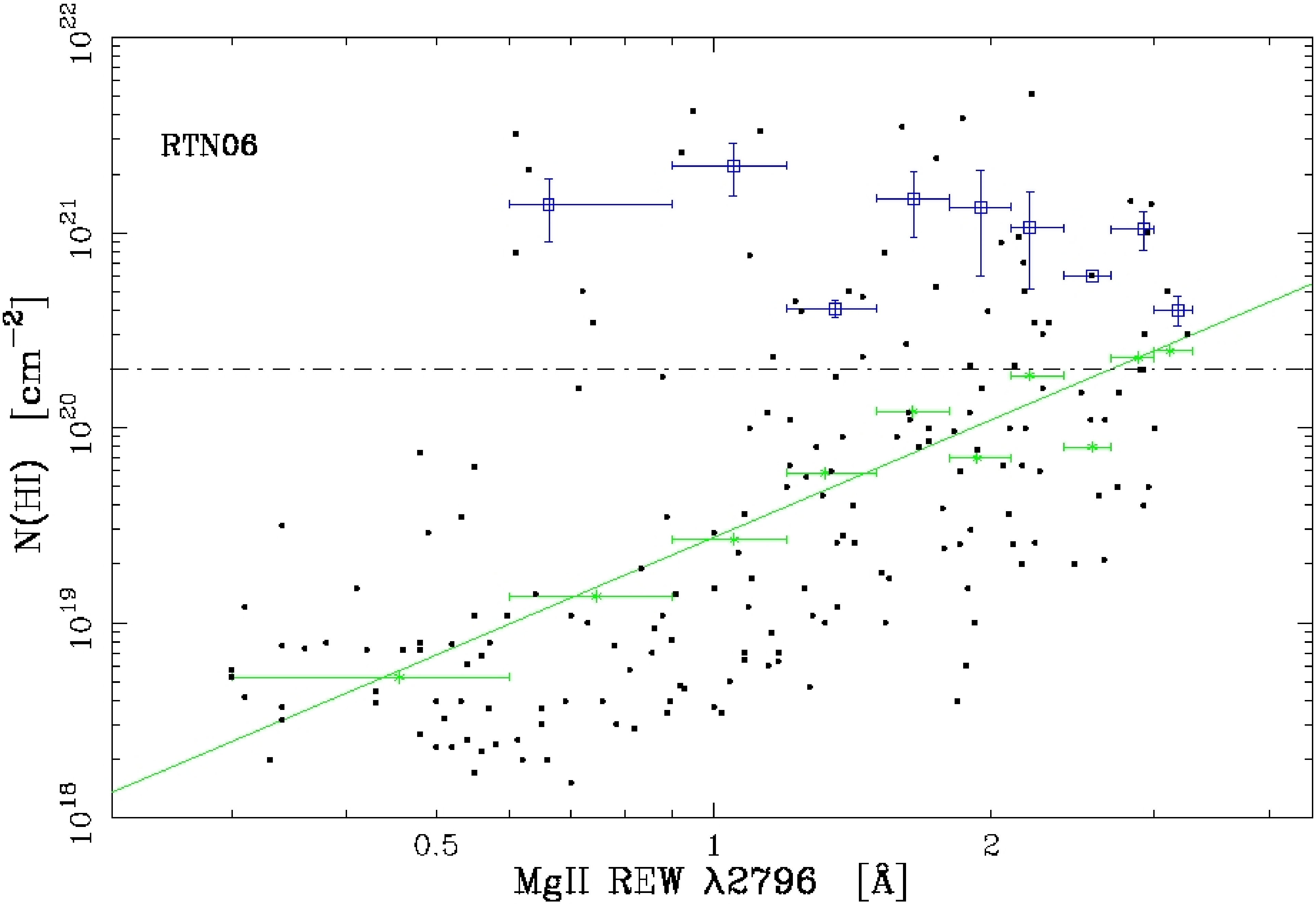
RTN06
N(HI) [cm^{-2}]
10^{18}
10^{19}
10^{20}
10^{21}
10^{22}
0.5
1
2
MgII REW λ2796 [Å]

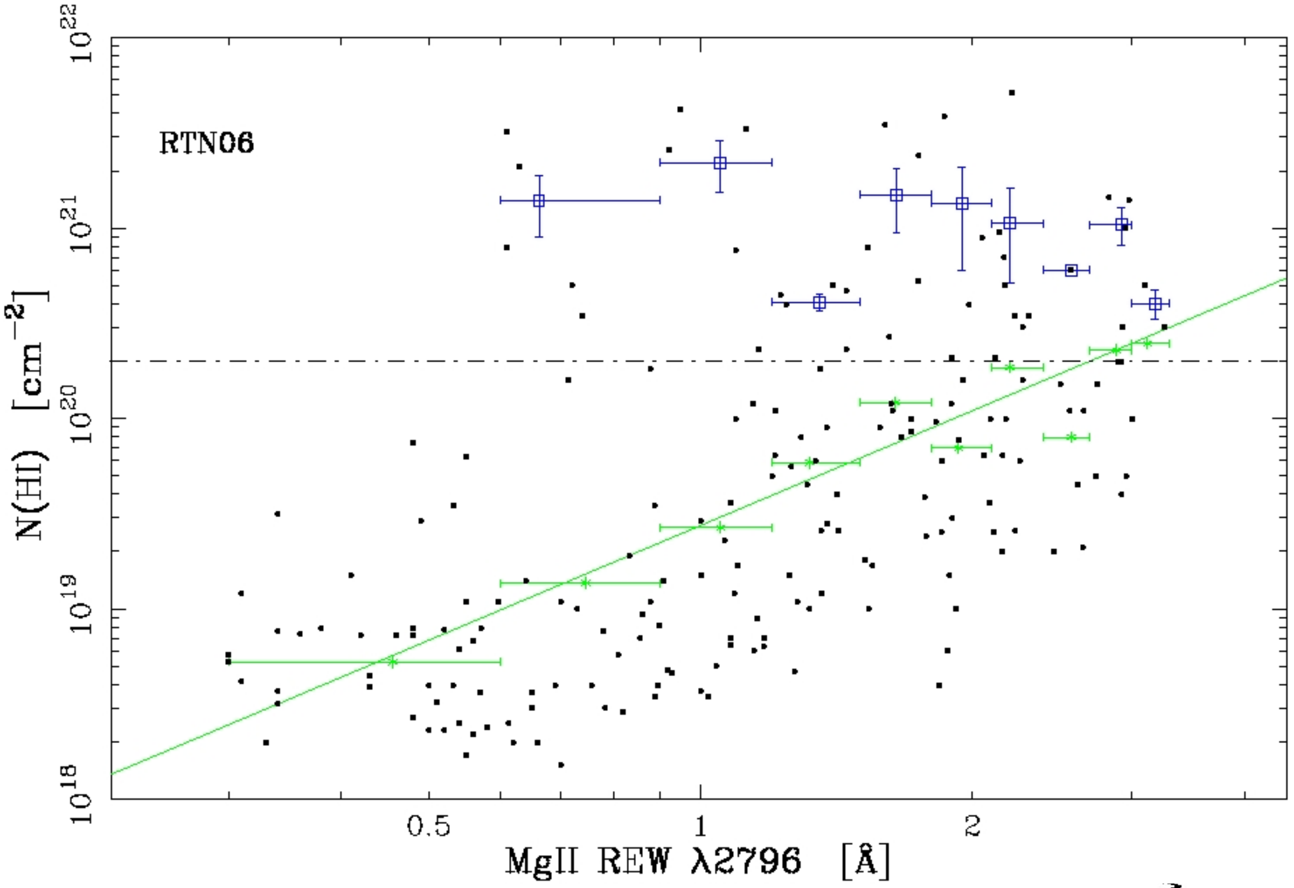


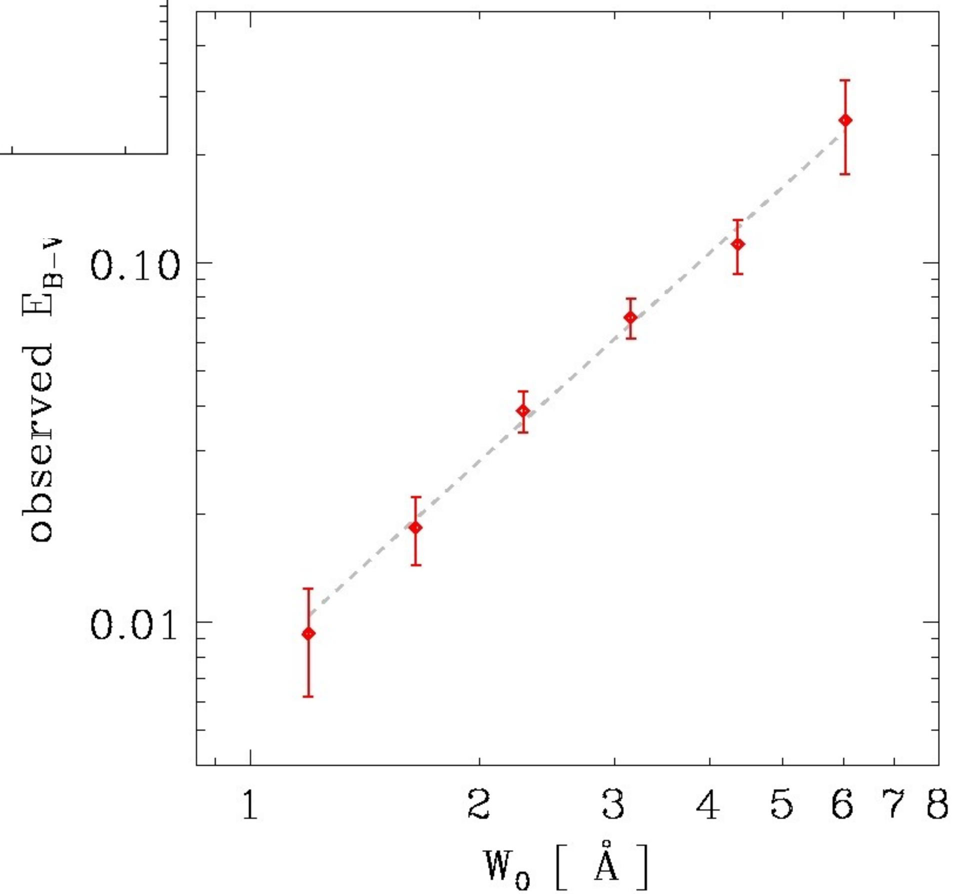
MgII dn/dW * <N(HI)>g
10^19
5×10^18
2×10^18
10^18
5×10^17
2×10^17
0.5
1
2
5
MgII REW λ2796 [Å]

Conclusion #2:

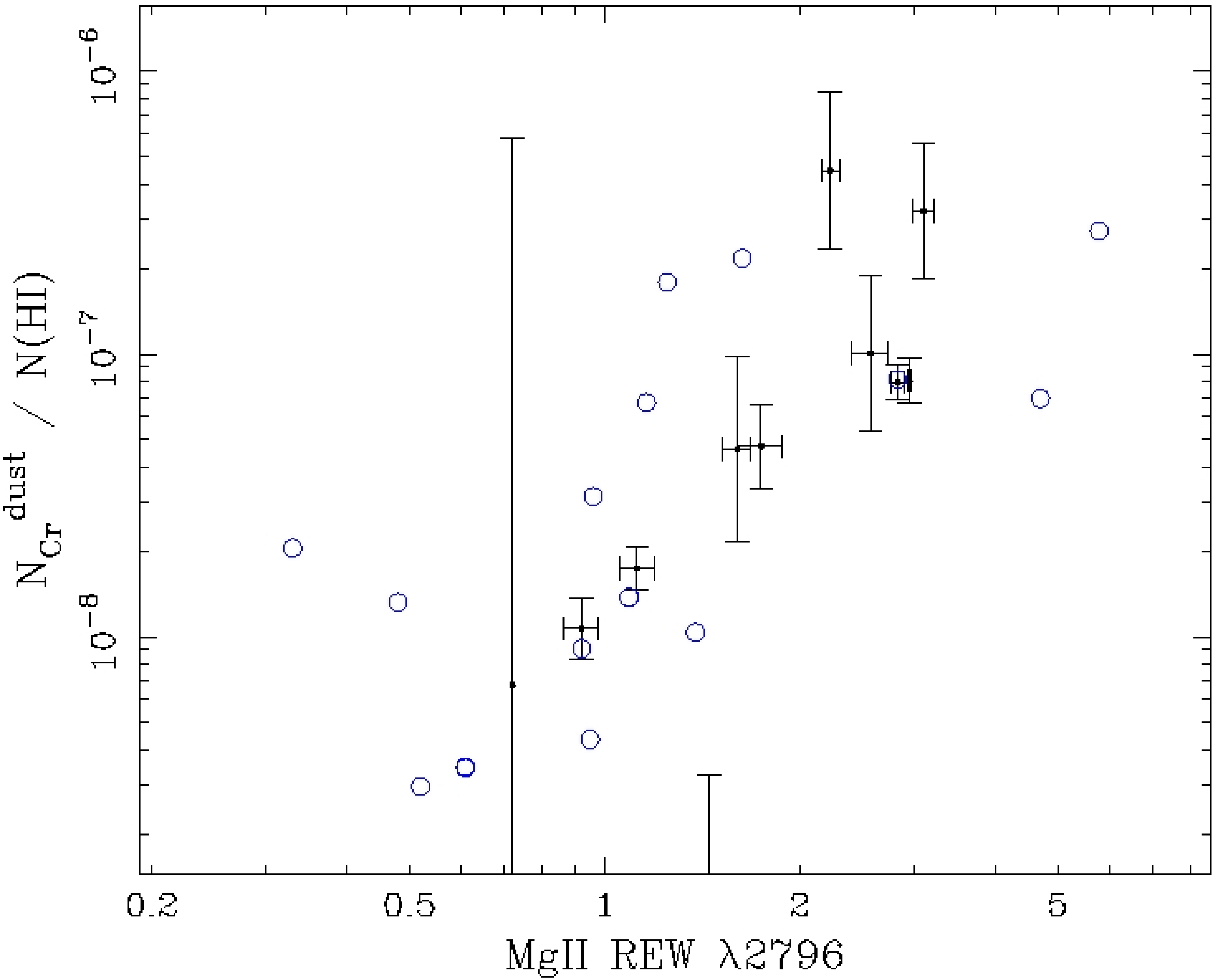
We are probably not missing much (~1% to ~4%) H I due to reddening of the background QSOs by Mg II absorbers.


RTN06
N(HI) [cm^{-2}]
10^{22}
10^{21}
10^{20}
10^{19}
10^{18}
0.5
1
2
MgII REW λ2796 [Å]


RTN06
N(HI) [cm^{-2}]
MgII REW λ2796 [Å]
0.5
1
2


observed E_{B-V}
0.10
0.01
1
2
3
4
5
6
7
8
W_0 [Å]

DLAs only



Conclusion #3:

For strong Mg II absorbers in general:

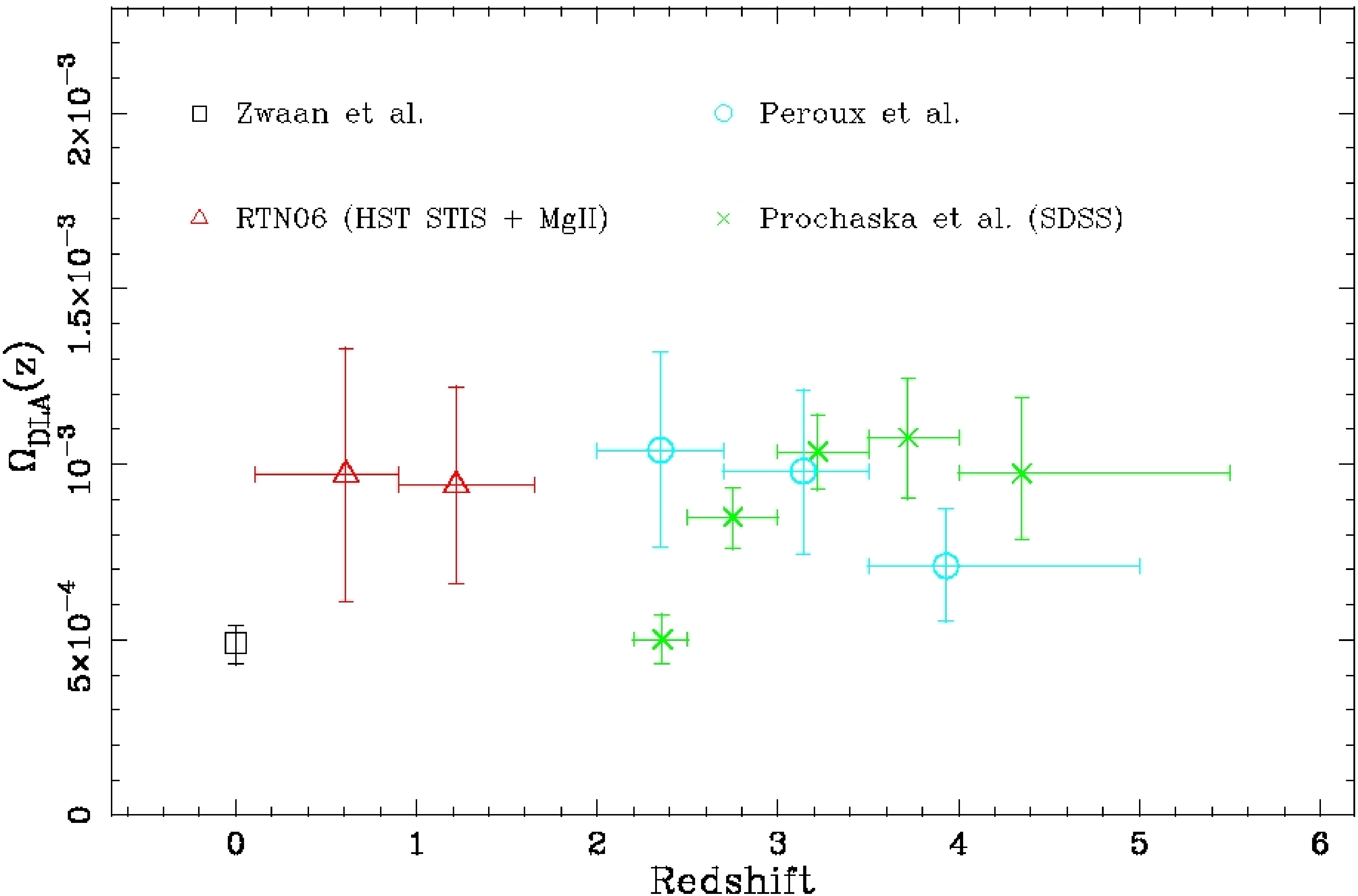
(i) REW and dust/gas are **uncorrelated**

but

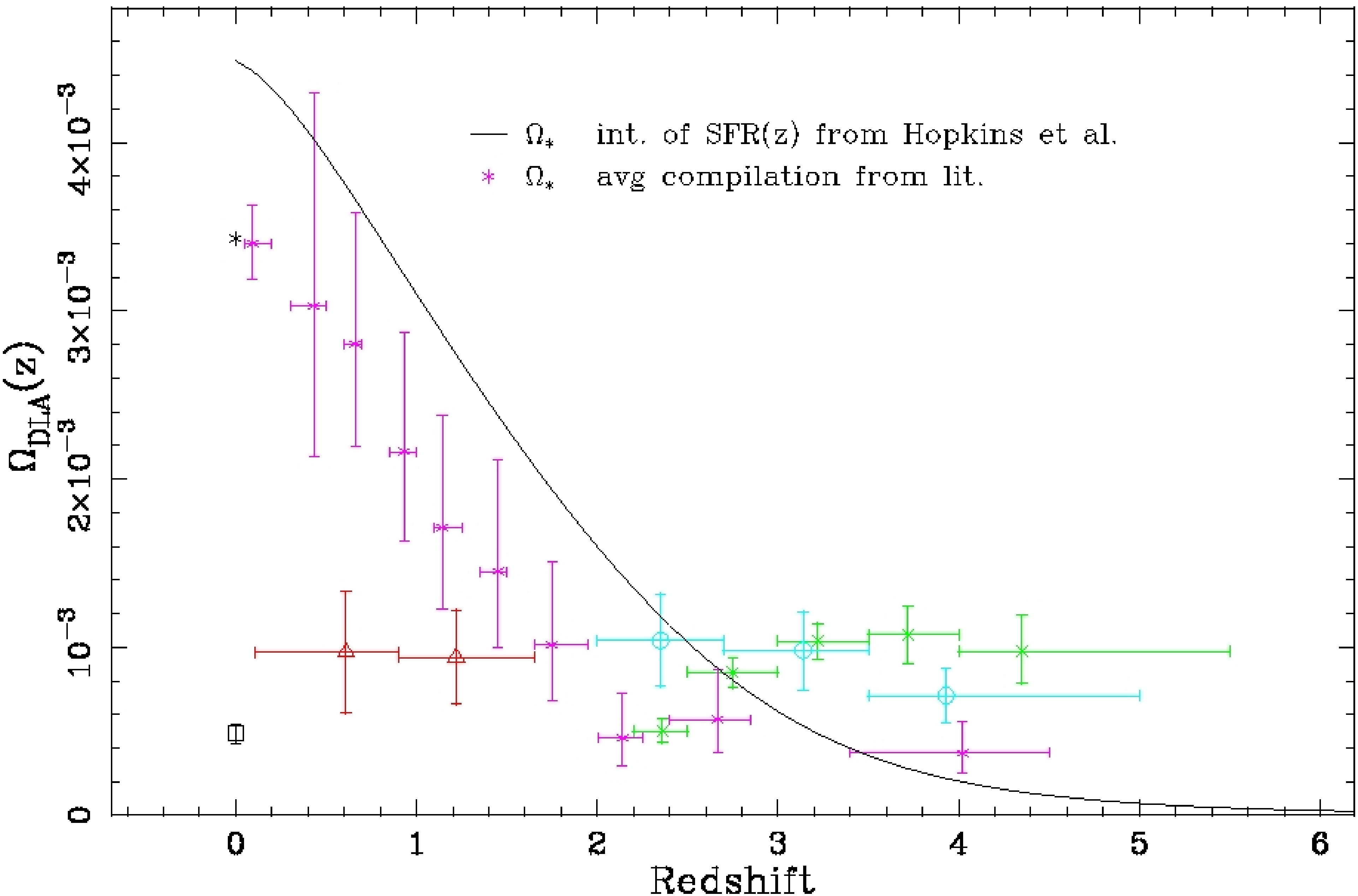
(ii) REW and $\langle b \rangle$ **anti-correlate**

$\Rightarrow$ ejected and/or outflowing gas.

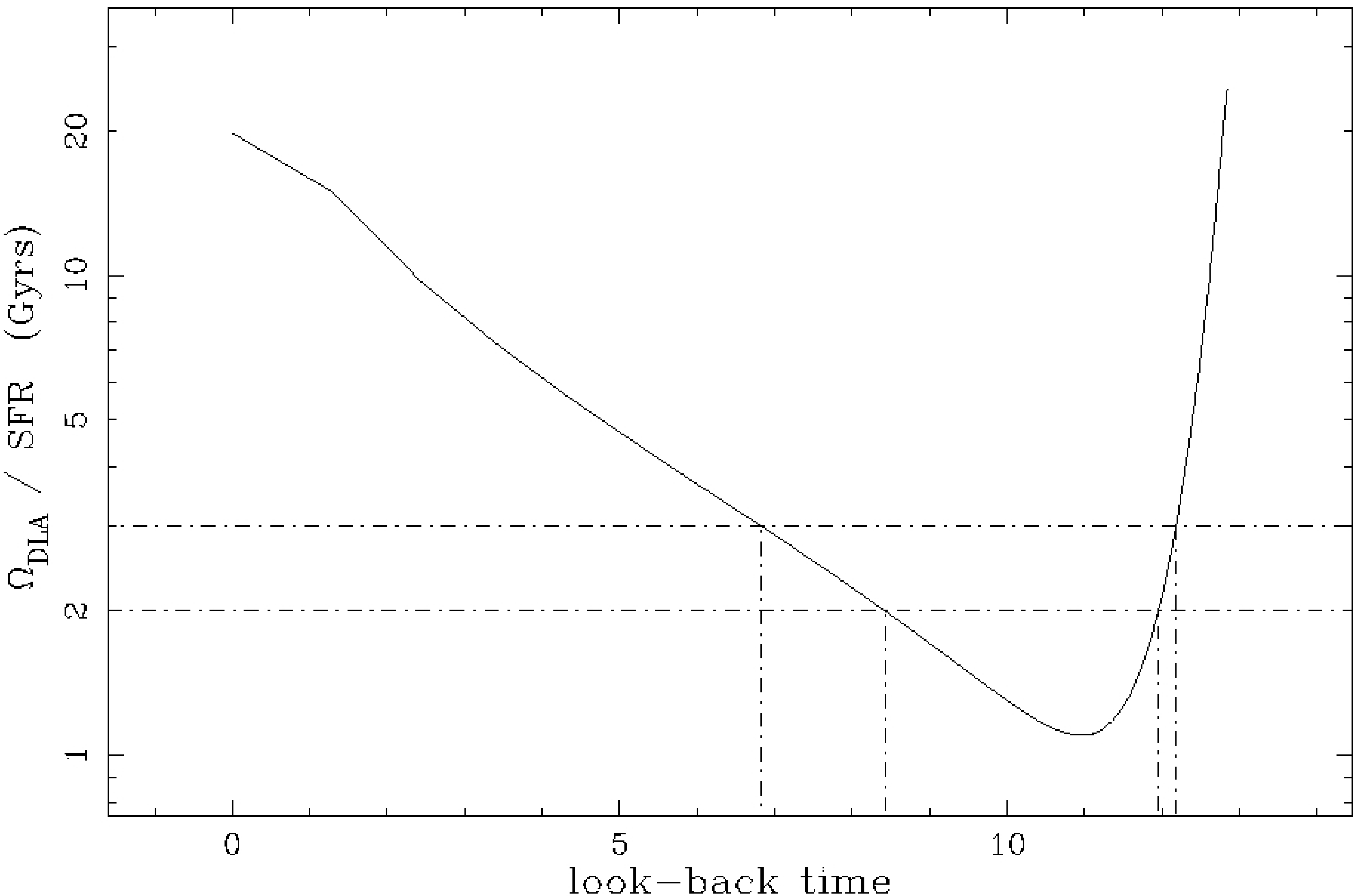
However, this is **not the case** for DLAs.



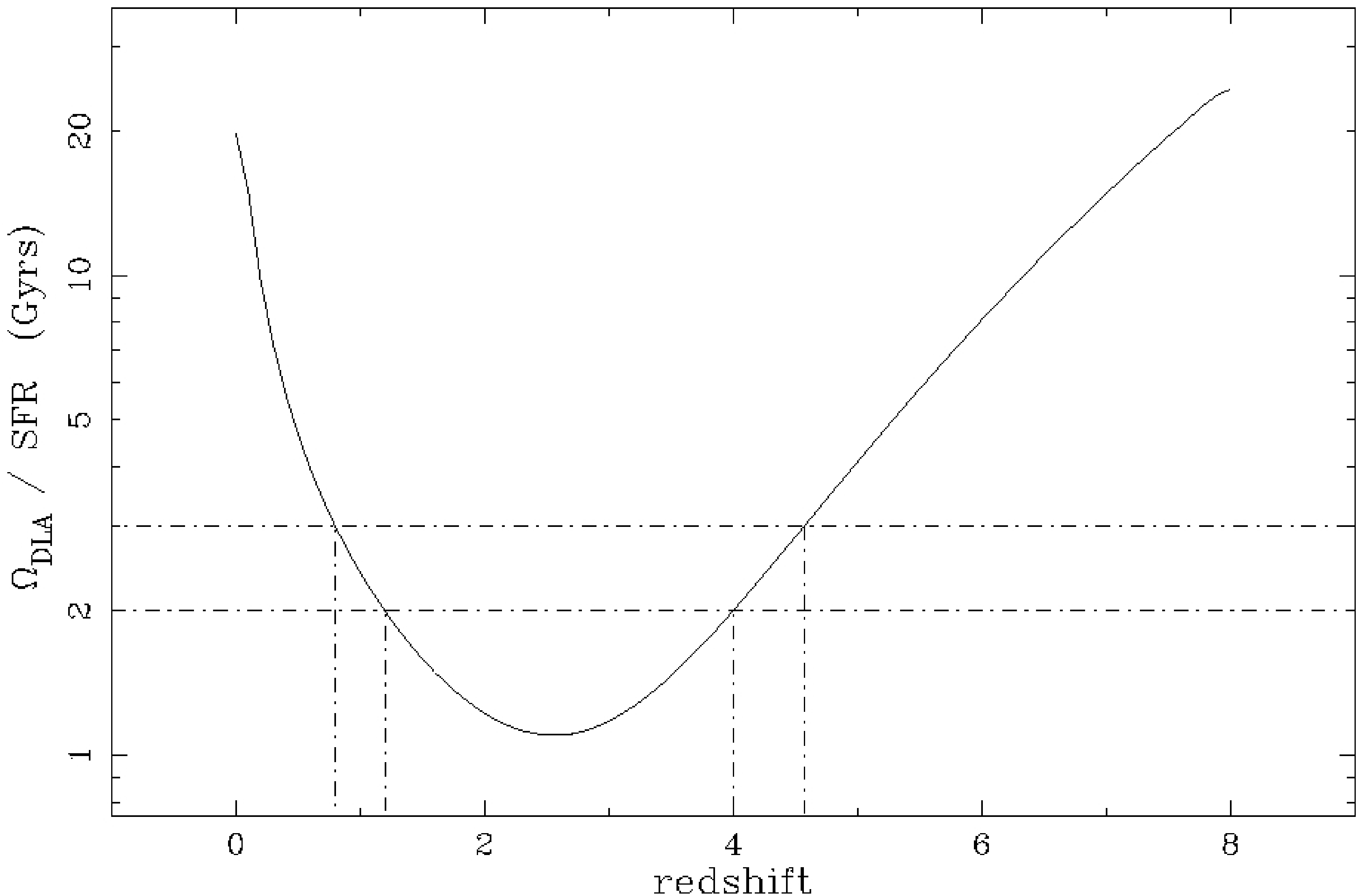
Zwaan et al.
Peroux et al.
RTN06 (HST STIS + MgII)
Prochaska et al. (SDSS)
$\Omega_{DLA}(z)$
0
5×10^{-4}
10^{-3}
1.5×10^{-3}
2×10^{-3}
0
1
2
3
4
5
6
Redshift



$\Omega_{DLA}(z)$
0
10^{-3}
2×10^{-3}
3×10^{-3}
4×10^{-3}
0
1
2
3
4
5
6
Redshift
Ω_* int. of SFR(z) from Hopkins et al.
Ω_* avg compilation from lit.



20
10
5
2
1
0
5
10
Ω_{DLA} / SFR (Gyrs)
look−back time



Ω_{DLA} / SFR (Gyrs)
20
10
5
2
1
0
2
4
6
8
redshift

Conclusion #4:

The small values of $\tau(z)_{HI\rightarrow stars}$ imply that either:

- H I in individual halos doesn't survive long:

the global SFR at any epoch is **determined by** the overall rate at which H II is converted to H I

or

- H I in individual halos does survive long:

gas traced by Ω_{DLA} has little to do with the bulk of the star formation density at $0.5 \lesssim z \lesssim 5$

Summary

- We're developing large absorber-galaxy catalogs across color-space over a large baseline in N(H I) and Mg II REW
- Very little (~1% - 4%) of N(H I) is being missed in DLA surveys do to reddening/extinction by the absorbers.
- Many Mg II absorbers may harbor significant quantities of gas that has been removed from the luminous regions of galaxies.
- The H I in DLAs may not be the reservoir for the bulk of the star formation seen in the Madau plot.
- *Grazie mille* to the organizers!!!