

Transform our Understanding of the Baryon Cycle with High-Resolution Quasar Spectroscopy

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Team



Roland Szakacs
(ESO)



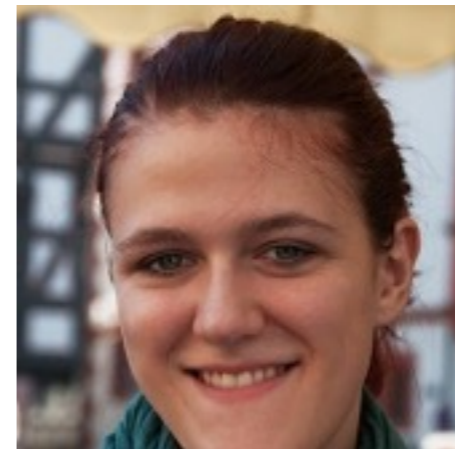
Alex Hamanowicz
(ESO/STScI)



Alejandra Fresco
(MPE)

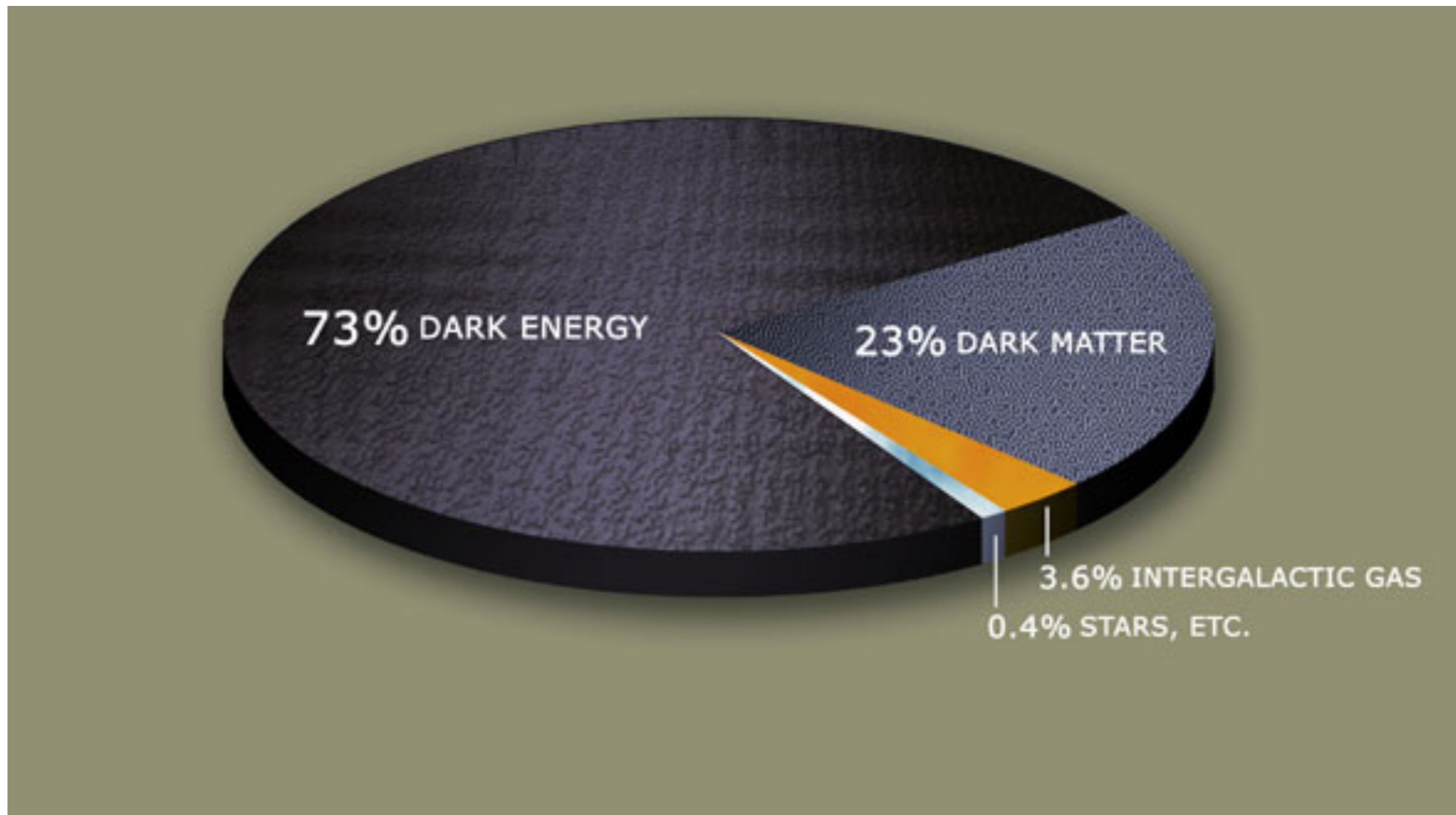


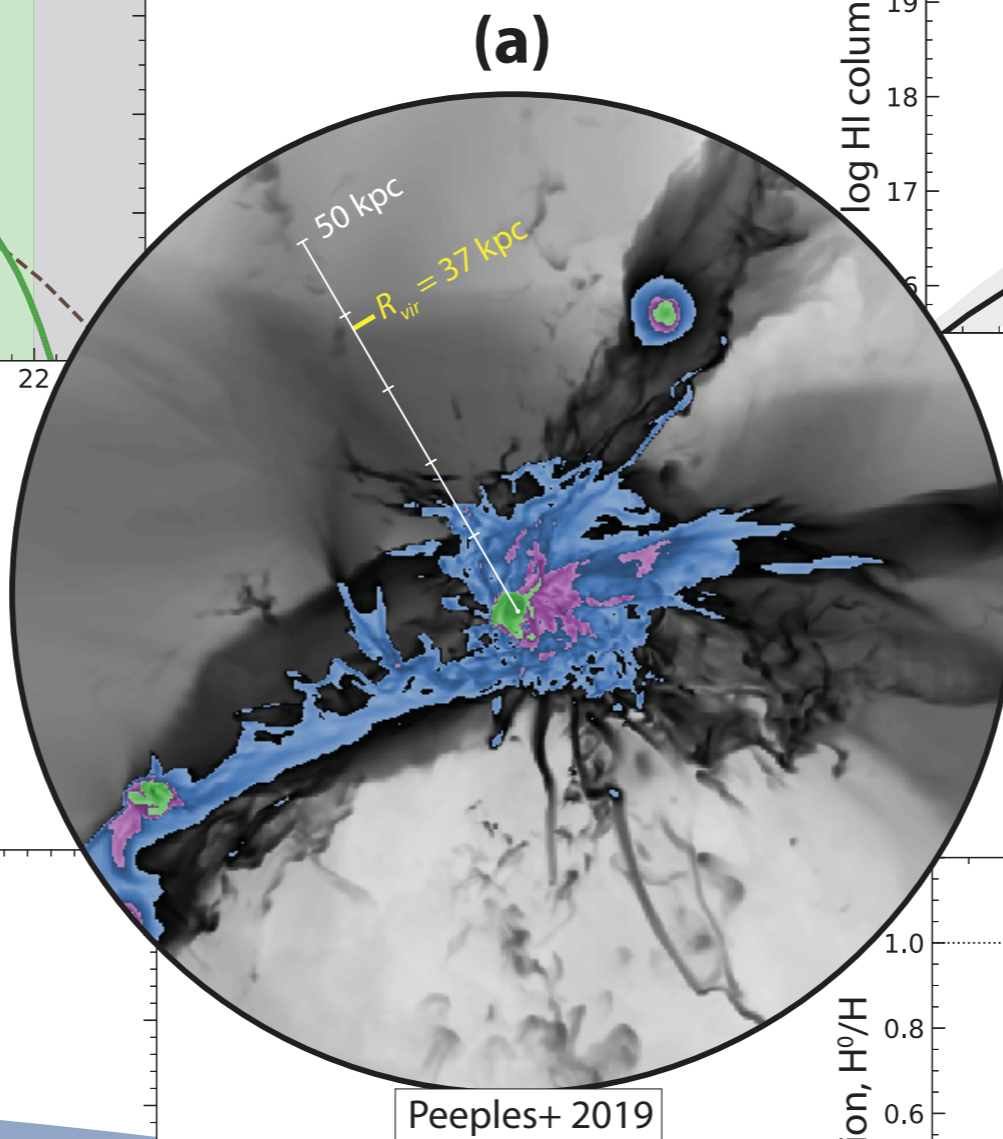
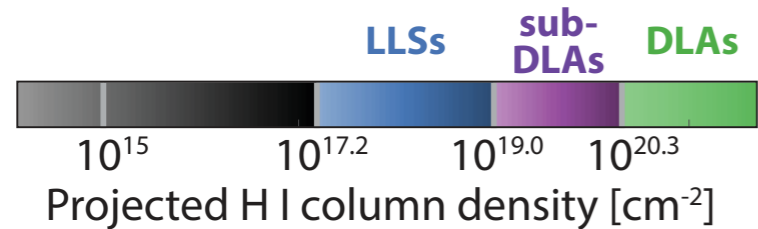
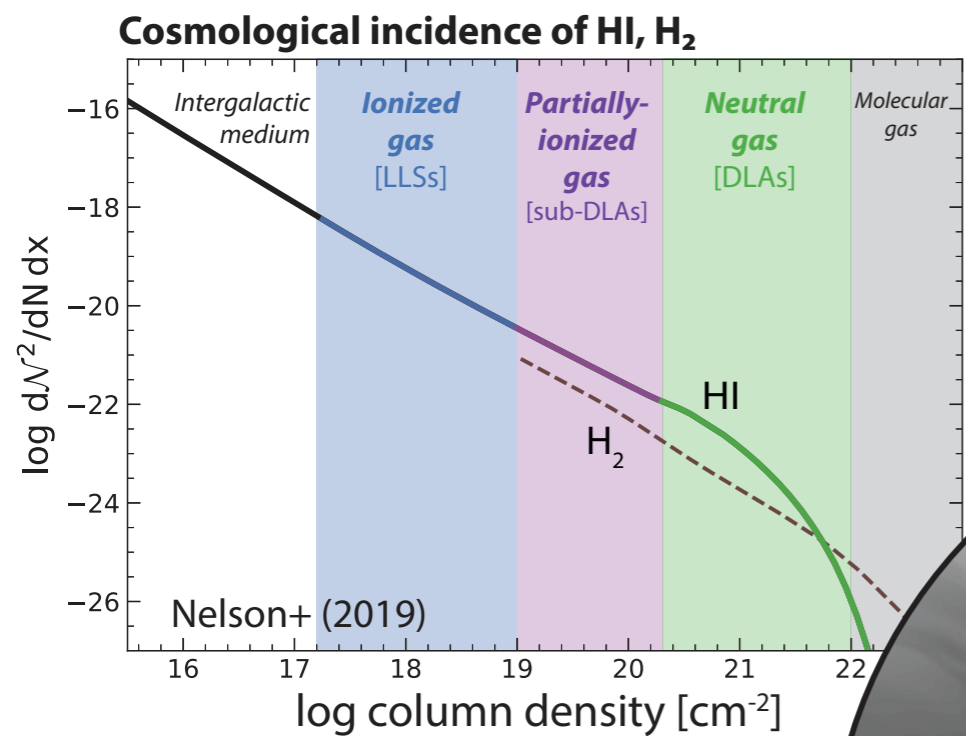
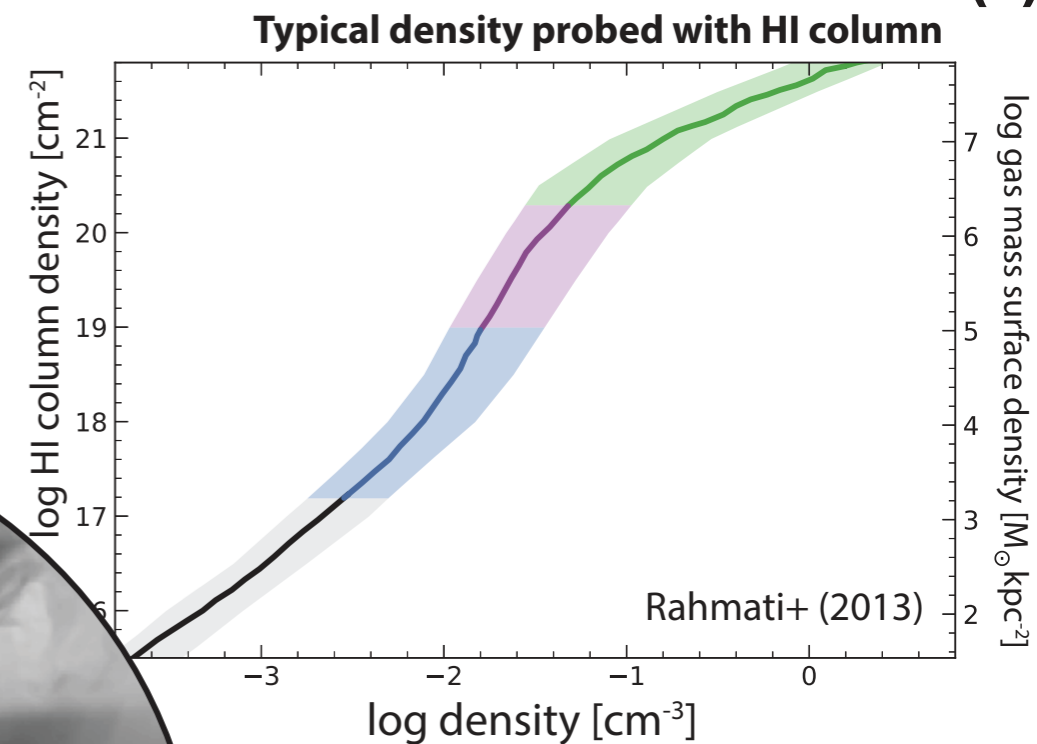
Ramona Augustin
(STScI)



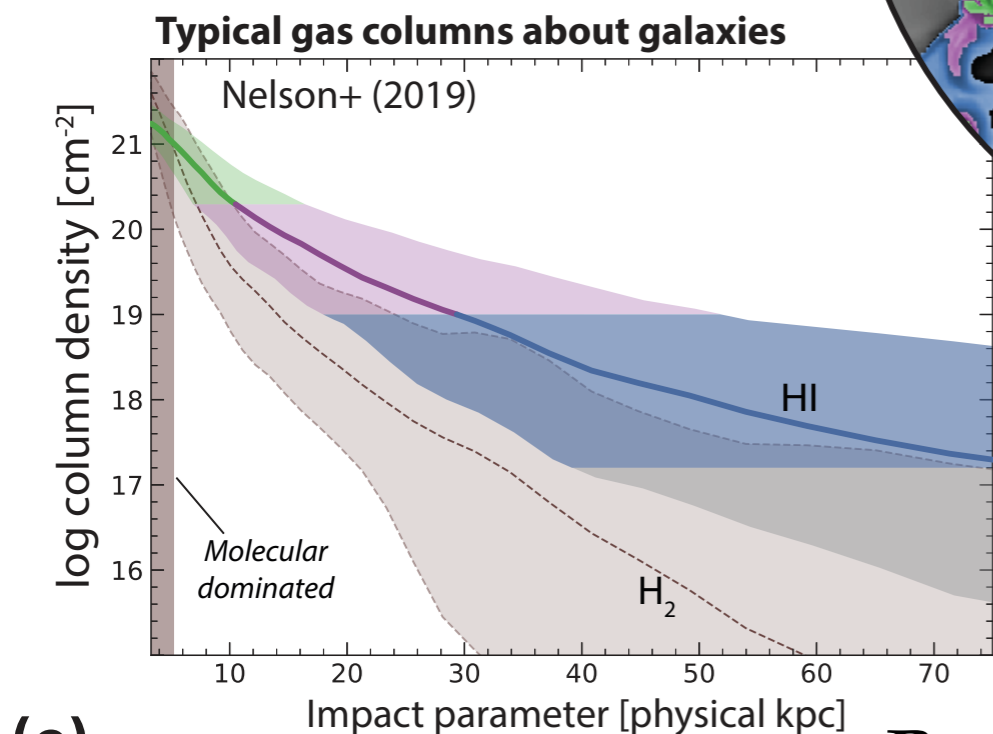
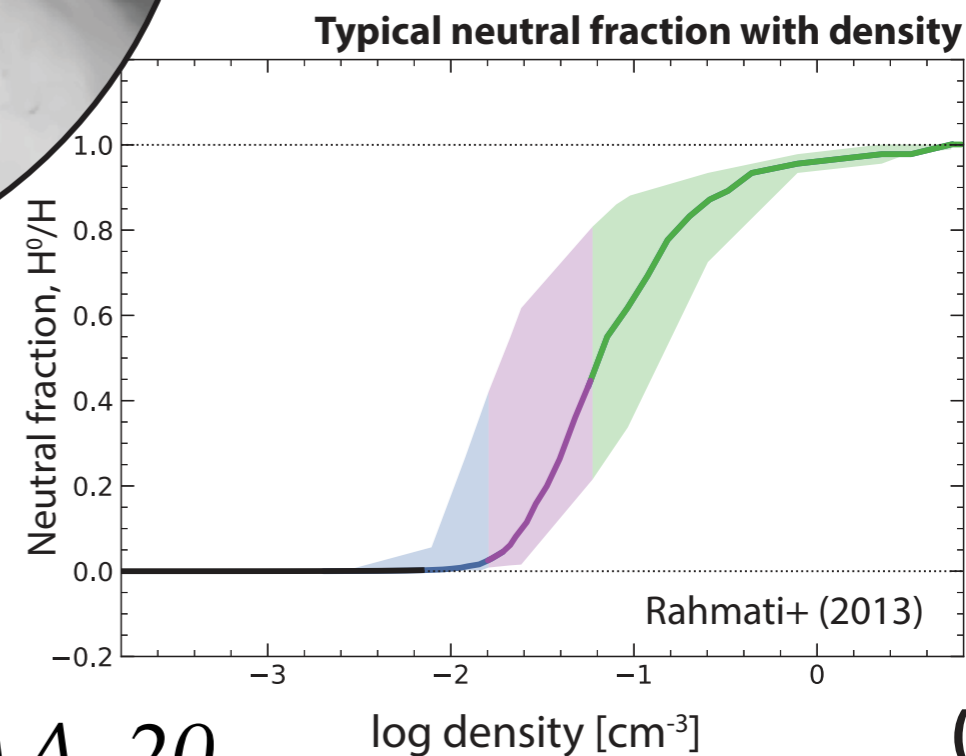
Anne Klitsch
(Dark, Copenhagen)

90% of baryons in gas



(b)**(c)**

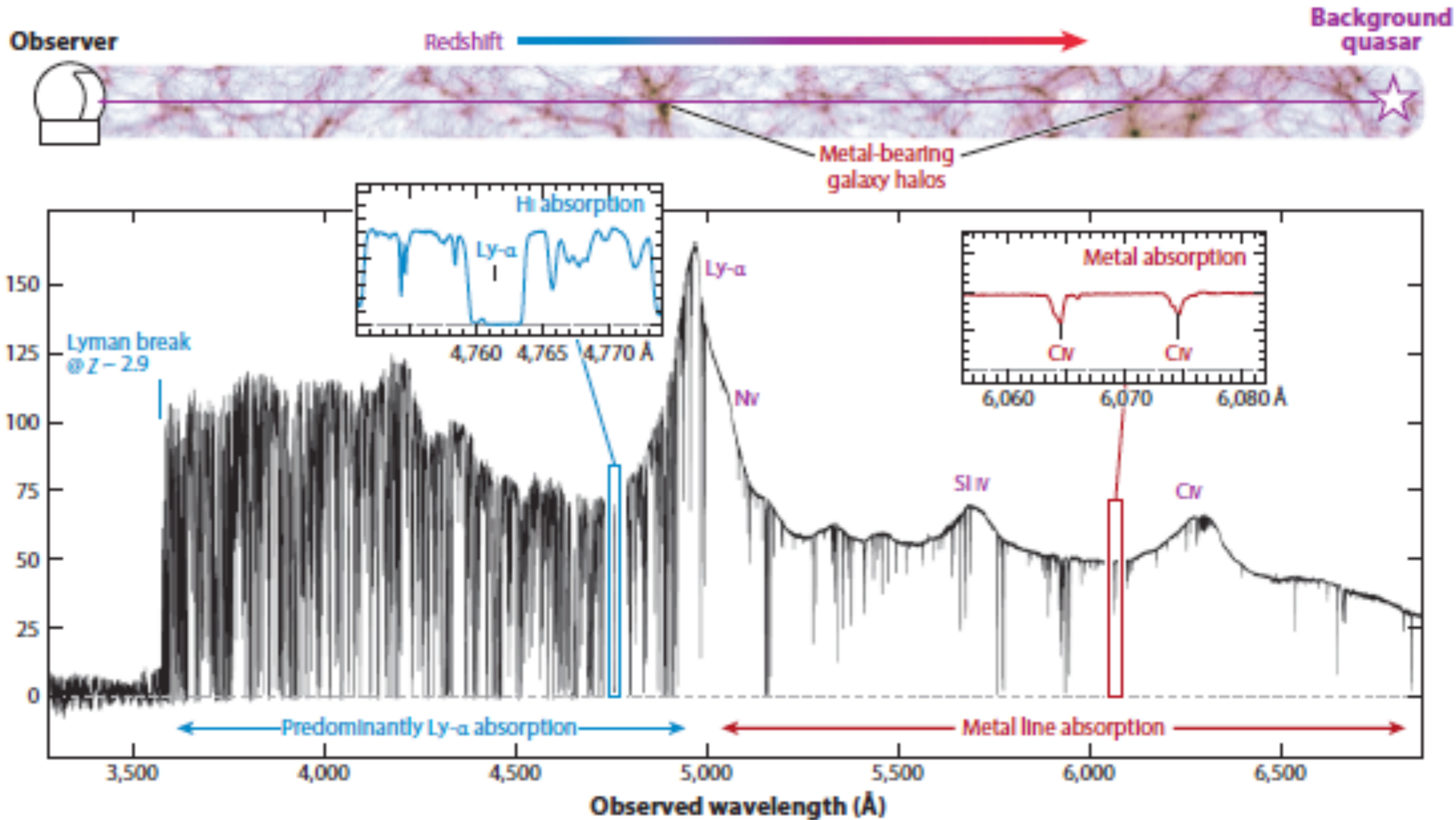
Neutral gas [DLAs]
Partially-ionized gas [sub-DLAs]
Ionized gas [LLSs]

**(e)**

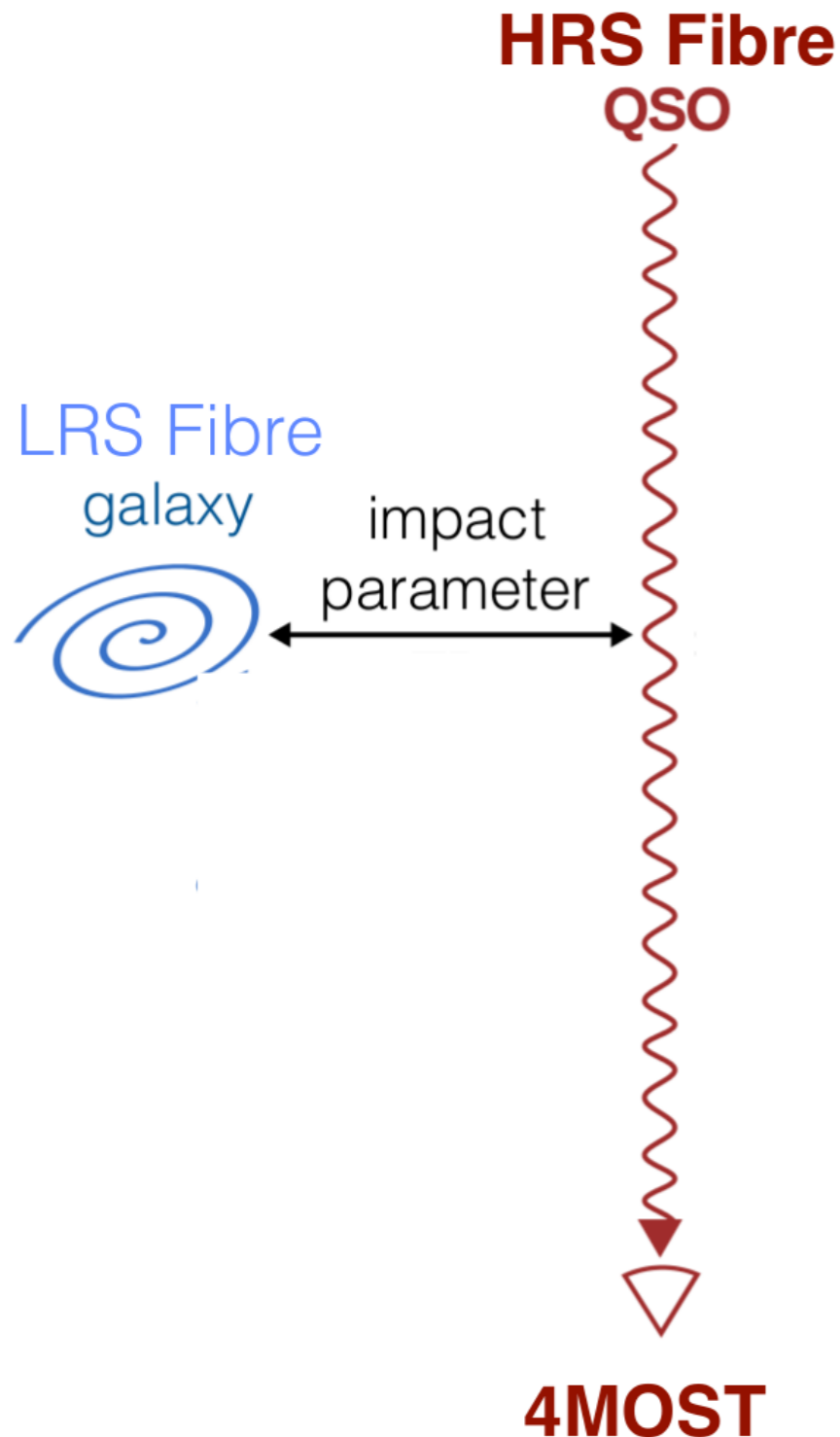
Peroux & Howk, ARAA, 20

(d)

Absorption in background quasars



Absorption lines are powerful

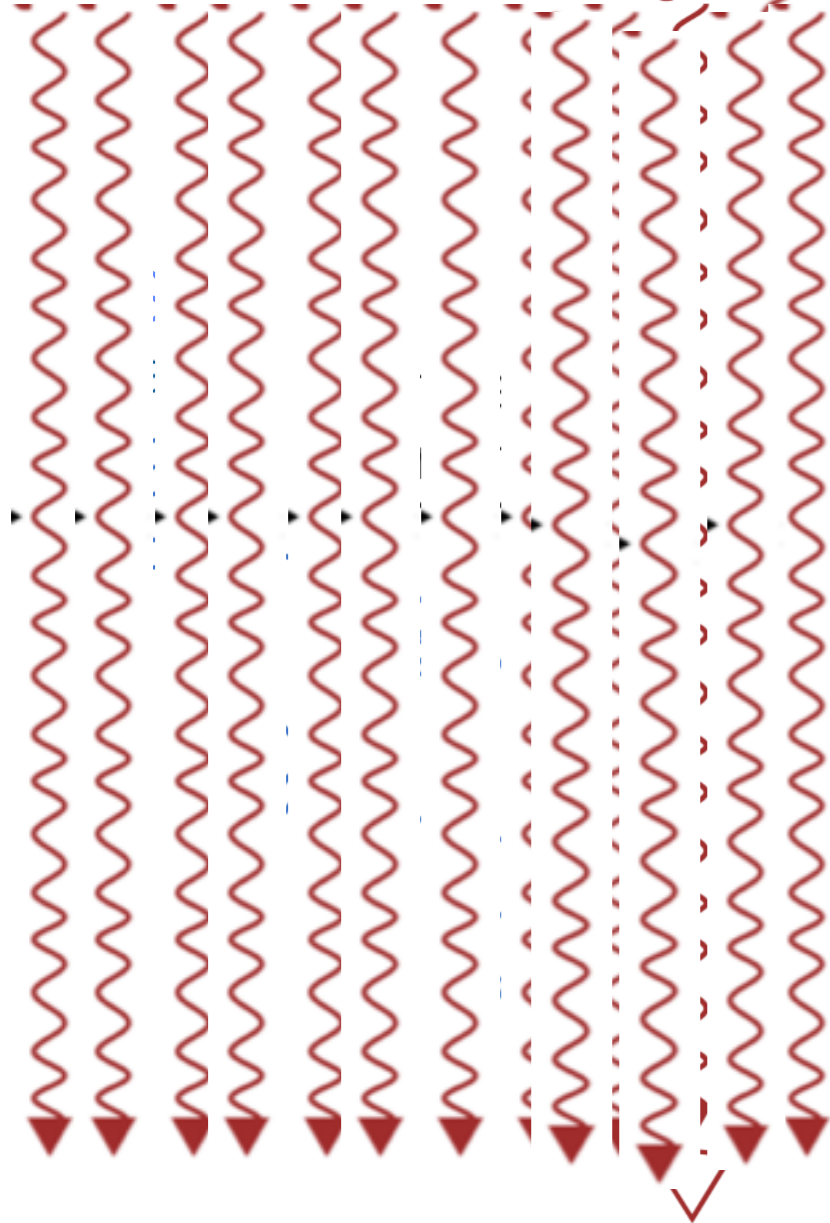


1. direct measure of density, temperature, metallicity
2. reach low-density gas
3. sensitivity is redshift independent

Absorption lines are powerful

HRS Fibre

QSO



4MOST

1. direct measure of density, temperature, metallicity
2. reach low-density gas
3. sensitivity is redshift independent
4. probing many sightlines provides mean physical properties

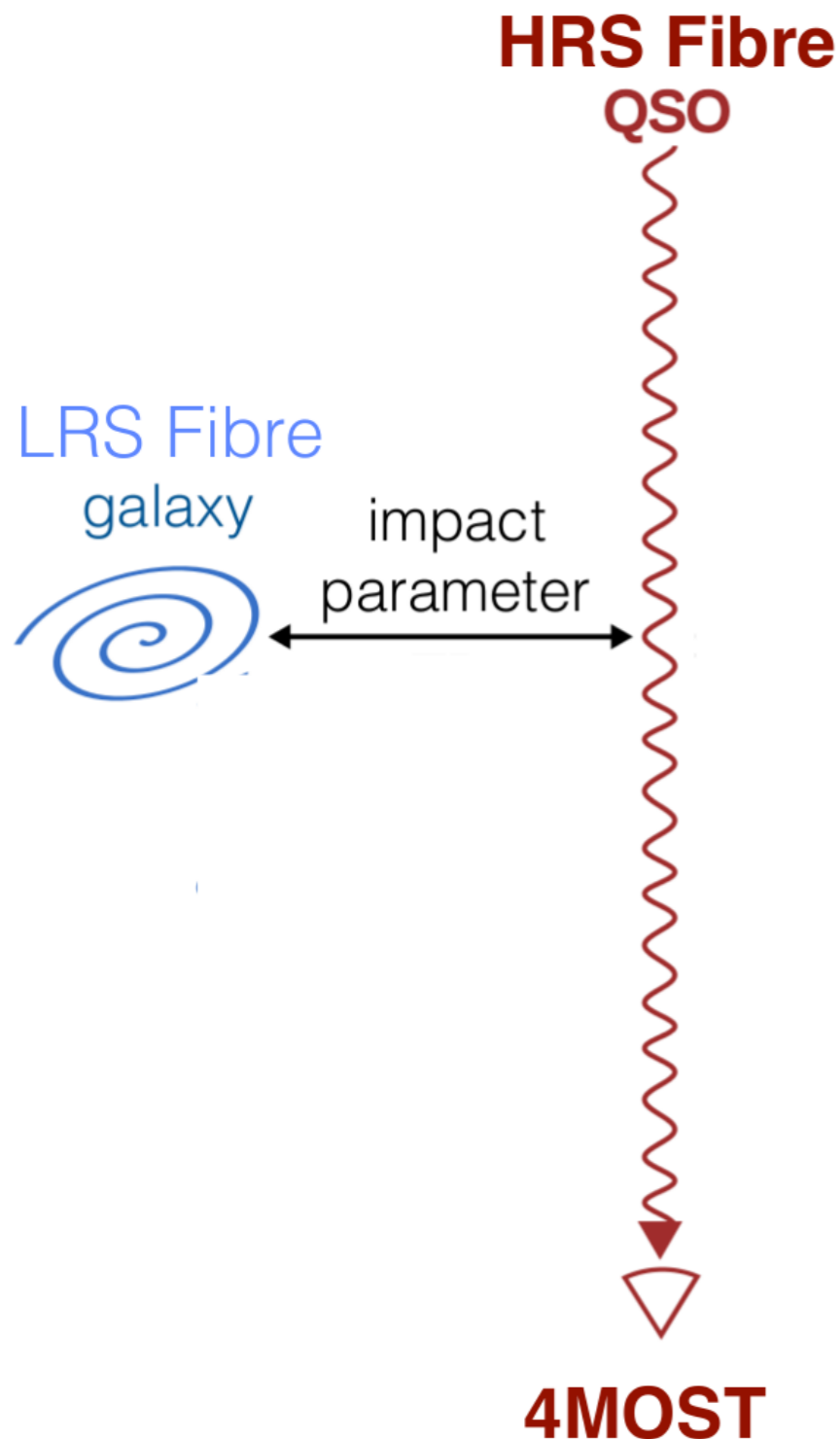
In a nutshell: 770,000 quasar spectra

- ◆ 755,000 $z > 1.04$ quasars with HRS
=> 232,000 MgII to x-correlate with 1 million galaxies
- ◆ 15,000 $z > 2.58$ quasars with HRS
=> 1,500 strong Ly α absorbers tracing the neutral phase of the gas and its metal content

Key Goal I:

What is the role of CGM gas in
galaxy evolution?

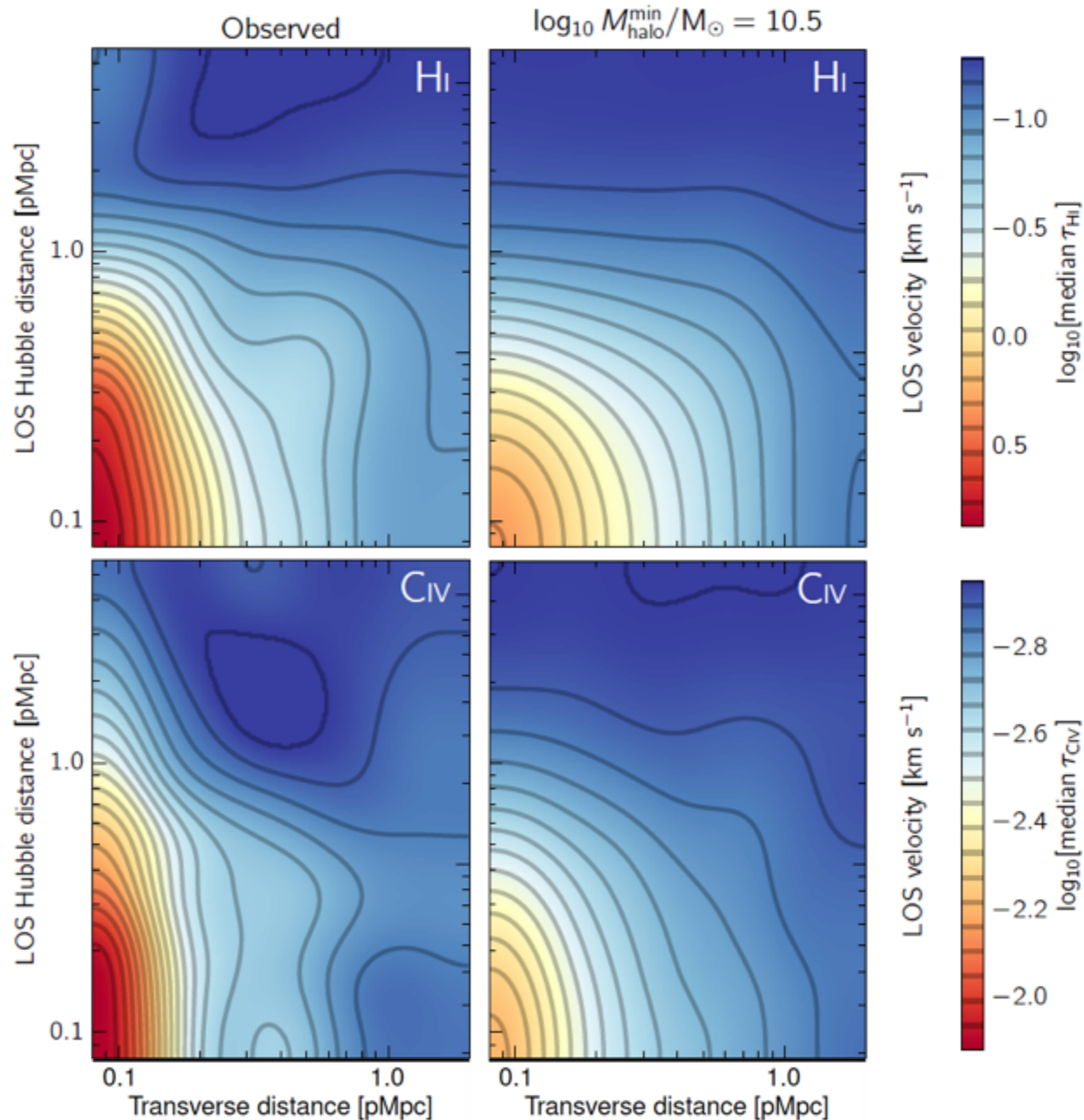
X-correlates HRS abs with LRS galaxies



1. piggy-back on consortium surveys
 - . WAVES Deep
 - . CRS Luminous Red Galaxies
 - . CRS Emission Lines Galaxies
 - . AGNs
 - . Groups & Clusters
2. add further scientific value to extragalactic survey

Metal-absorbers/galaxy pairs

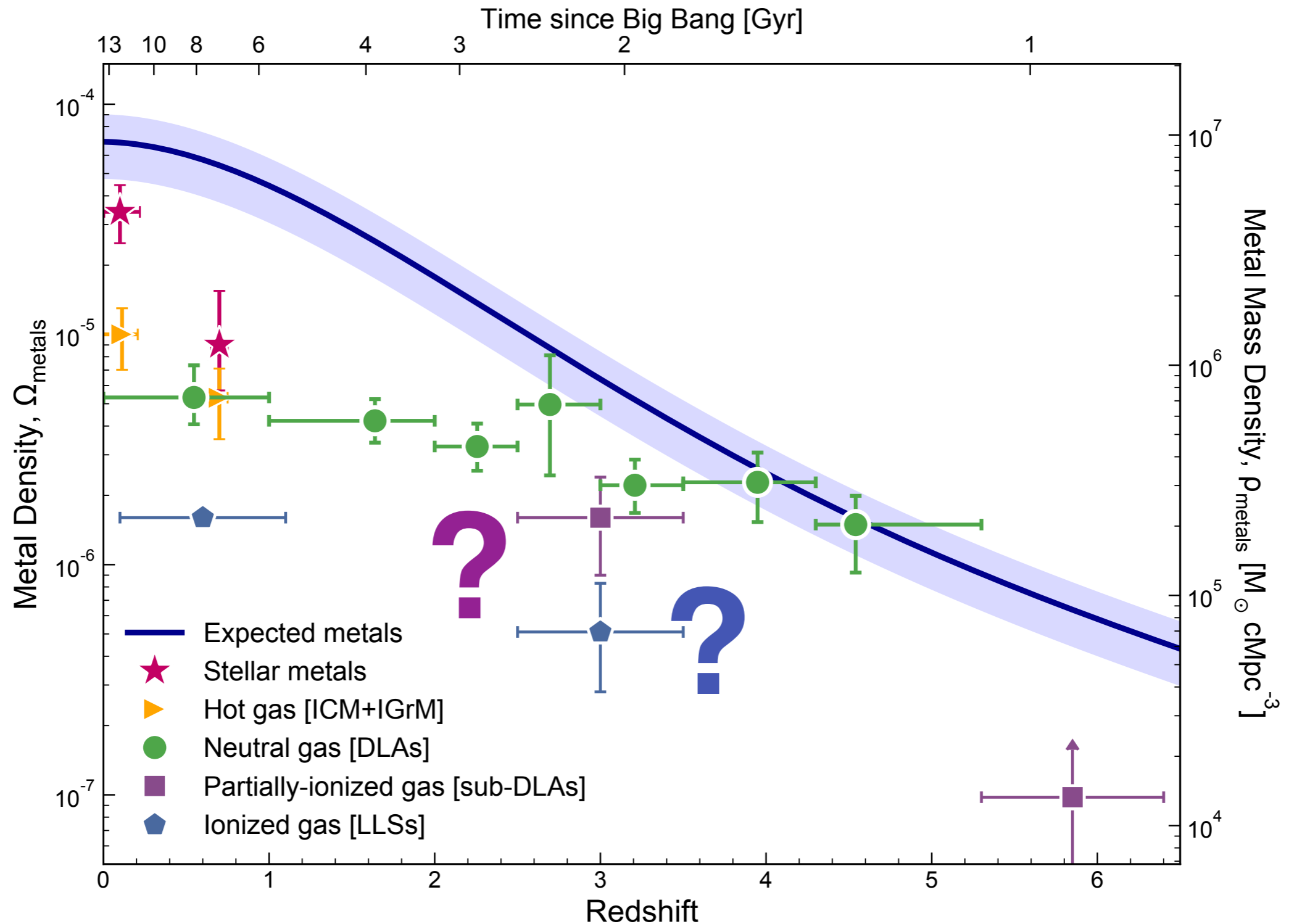
Turner+14



Key Goal II:

Can we solve the “missing
metals problem”?

Where are the metals in the universe?



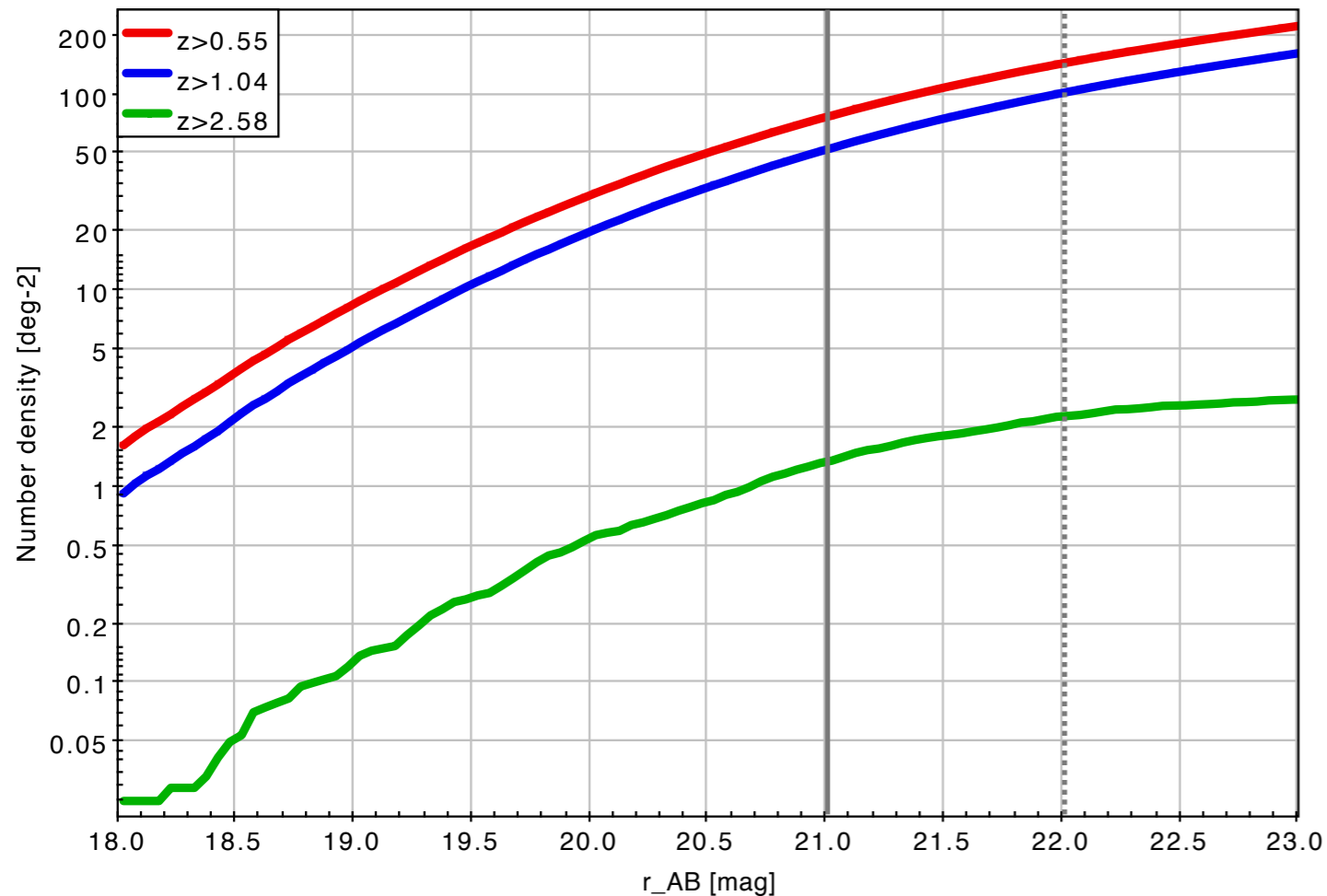
$$\rho_{\star}(z) = (1 - R) \int_0^{t(z)} \psi(z) \frac{dz}{dt} dt.$$

Two of many topics

1. WHIM tracers in stacked spectra
2. 3d tomography
3. fine structure constant using emission lines
4. IGM: temperature, 1d power spectrum
5. HeII reionisation
6. discover new bright lensed quasars & quasar pairs
7. effect of dust bias
8. broad emission lines in AGN

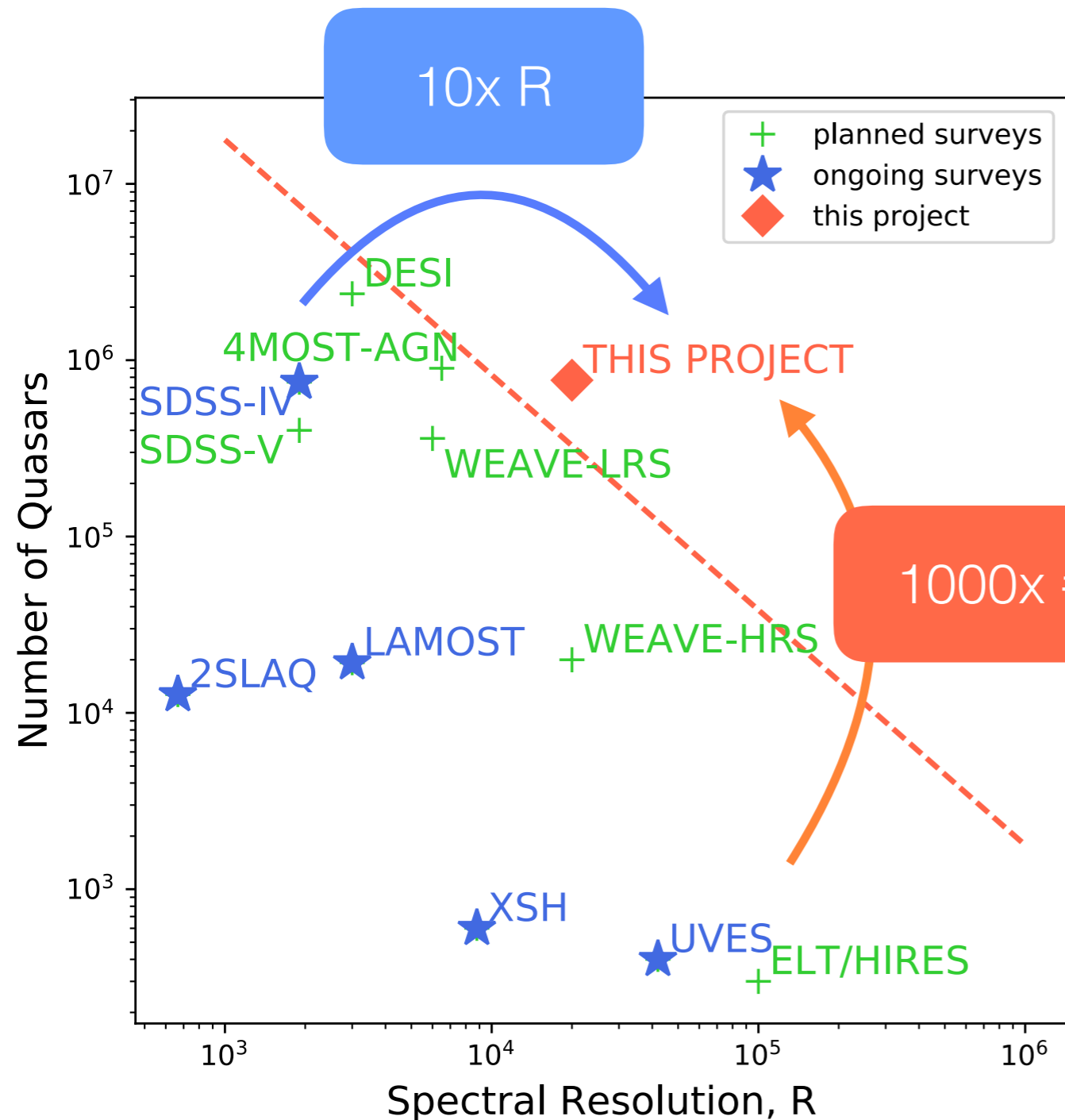
Survey Metrics

Target Selection



- ◆ X-ray (eROSITA), optical, variability selection
[Andrea Merloni, Johan Comparat]
- ◆ spectro-z (SDSS-V) or photo-z (WISE, GALEX, DES, LSST / Rubin Obs.)
[Mara Salvato]
- ◆ area $\sim 10\text{k deg}^2$

Why so many quasars?



1. ambitious project: 1600k F.H.

2. long-lasting legacy

3. unique project:

◆ **1000x more high-resolution quasar spectra at >2x XSH resolution**

◆ **SDSS at 10x the spectral resolution**

Data Processing

- ◆ HRS quasars spectra will be processed by L1 [Mike Irwin]
- ◆ L2 for high-resolution quasars to be developed [Luke Davies]: redshift, continuum fit, emission lines, absorption lines, EW etc
- ◆ Machine learning pivotal to analysis of absorption lines properties in these large samples

FoM

- ◆ CGM (low- z): area overlap with other extragalactic surveys to maximise # abs / gal pairs
- ◆ Metal Census (high- z): total # of targets, SNR=1-20
- ◆ No constraints on continuity, cadence or completeness
- ◆ Optimise HRS fibres allocation in dark time

=> easy to schedule!

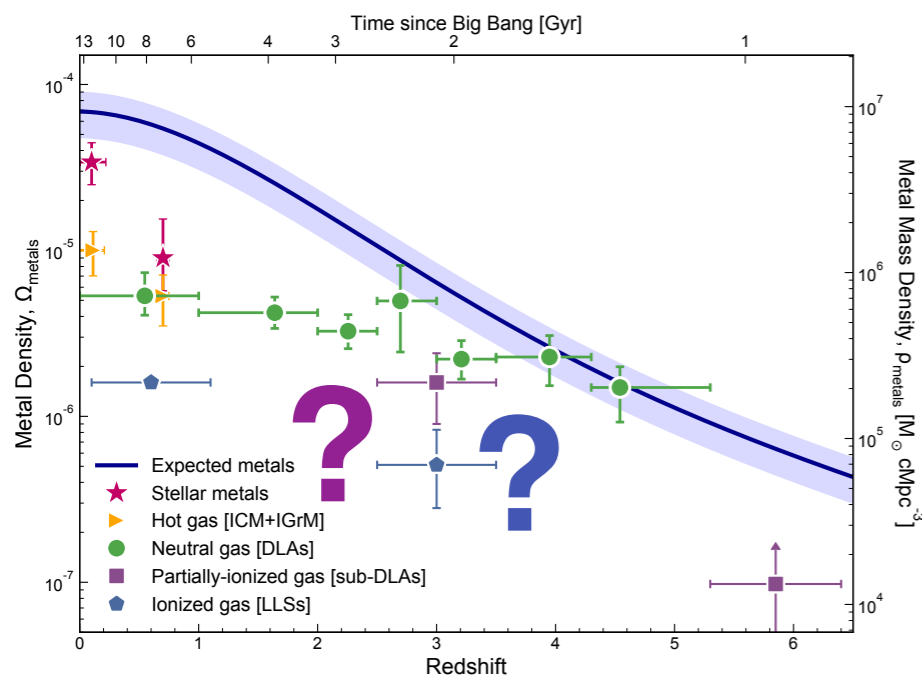


Operations

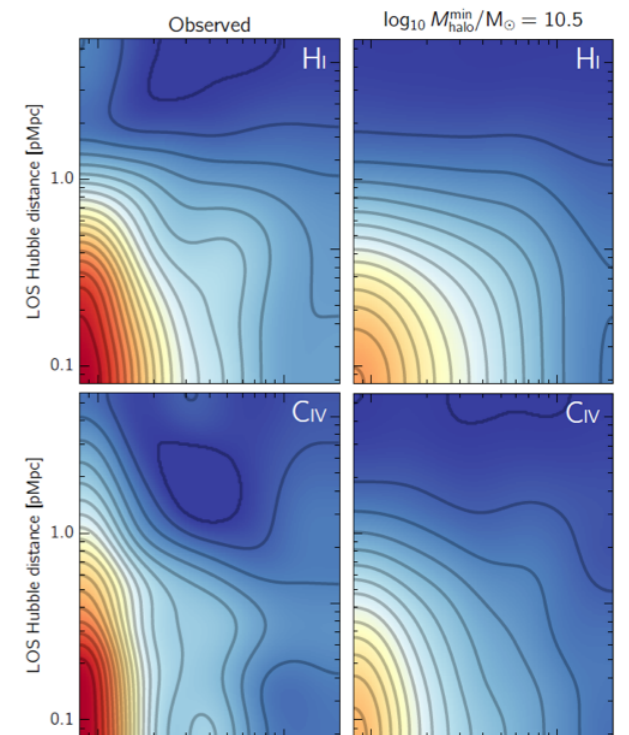
- ◆ coordination with consortium / other community proposals is **key** to this project
- ◆ community projects which are interested are welcome to contact us

Take home Messages

- ◆ 232,000 quasar absorbers to correlate with 1 Million galaxies \Rightarrow **transform our understanding of the baryon cycle**



- ◆ 1000x more high-resolution quasar spectra or SDSS at 10x the spectral resolution \Rightarrow **solve the “missing metals problem”**



- ◆ Long-lasting legacy survey, add scientific value to extragalactic surveys, optimise HRS allocation in dark time \Rightarrow **no competition with other facilities**