# Calibrating the use of quasar Lyman-$\alpha$ emission lines as probes of reionization

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# Context

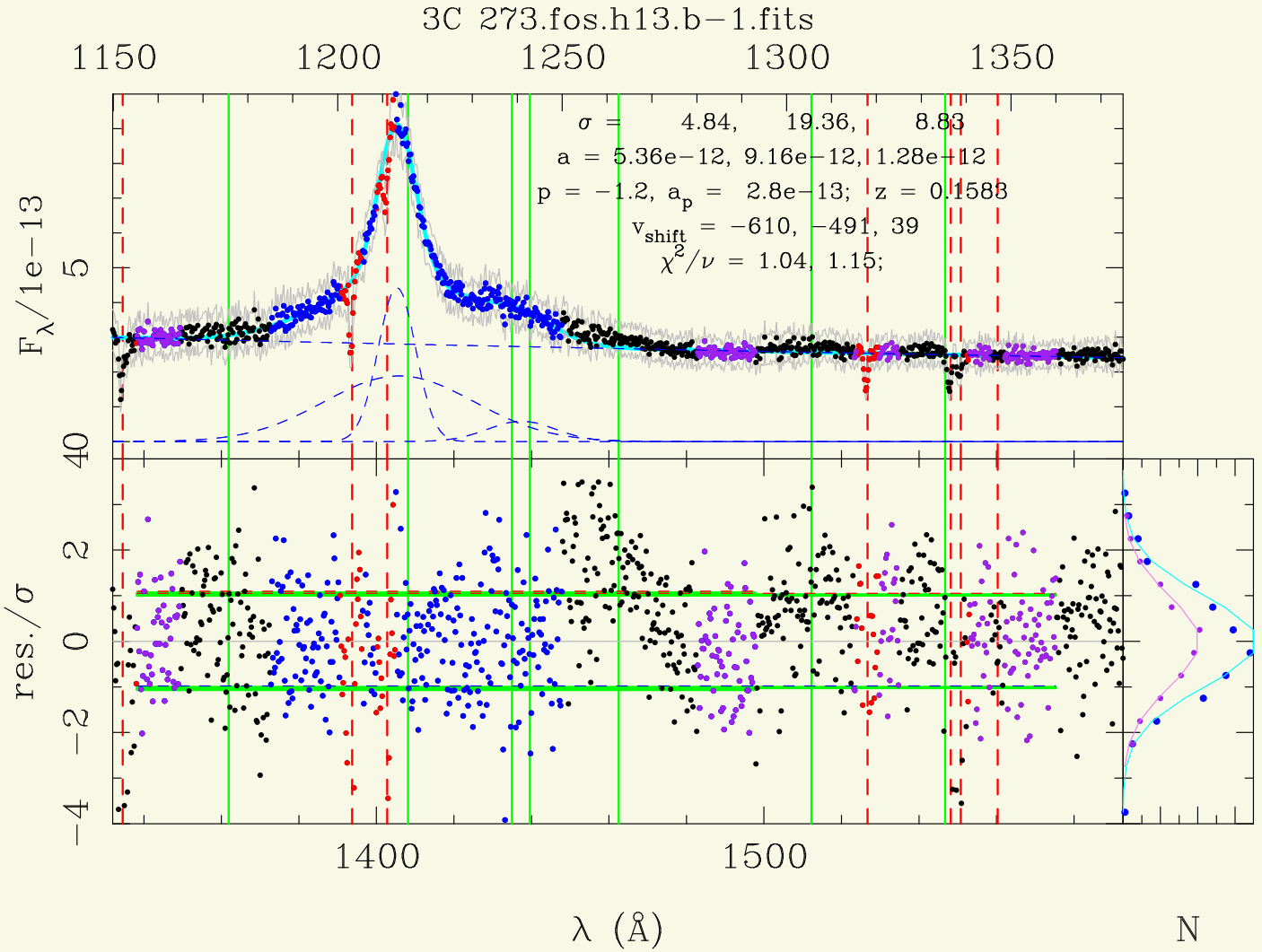
Studying this technique: inferring an IGM neutral fraction by measuring the Lyman-$\alpha$ damping wing (statistically, e.g. Mesinger and Haiman 2007) in the transmission window created by a quasar HII region.

Goal: to quantify the effect of uncertainties in quasar Lyman-$\alpha$ line profile fits on the determination of the IGM neutral fraction.

Conclusion: line profile uncertainties introduce substantial but manageable scatter in the IGM neutral fraction determination, with some important caveats for low neutral fractions.

# Using the quasar HII region

The importance of the Ly-$\alpha$ line.



# Low-redshift quasar emission lines

Assembling our catalog.

## HST Instruments

FOS

HRS

STIS (forthcoming)

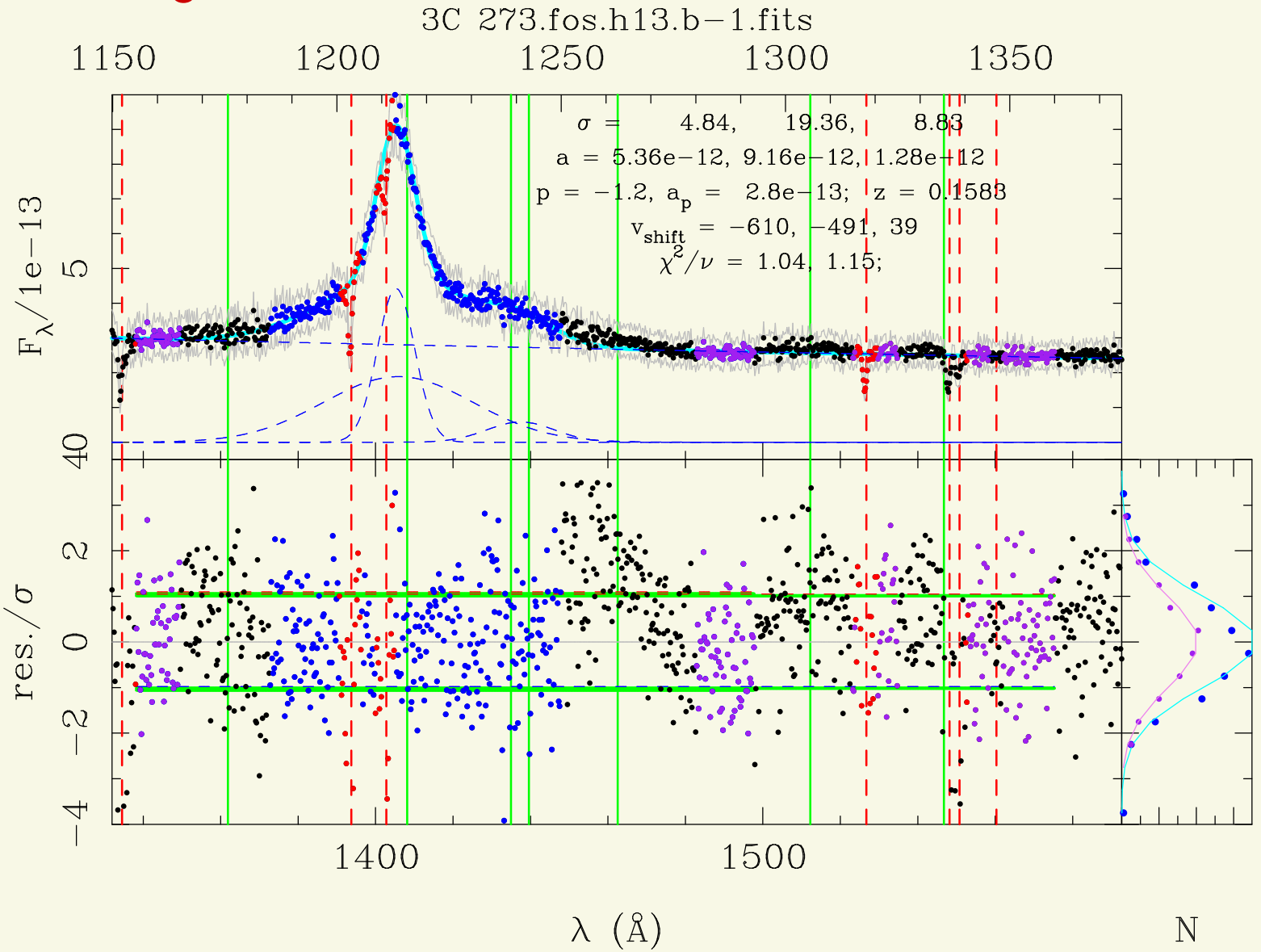
## MAST query

for observer designation of "QSO" or "quasar".

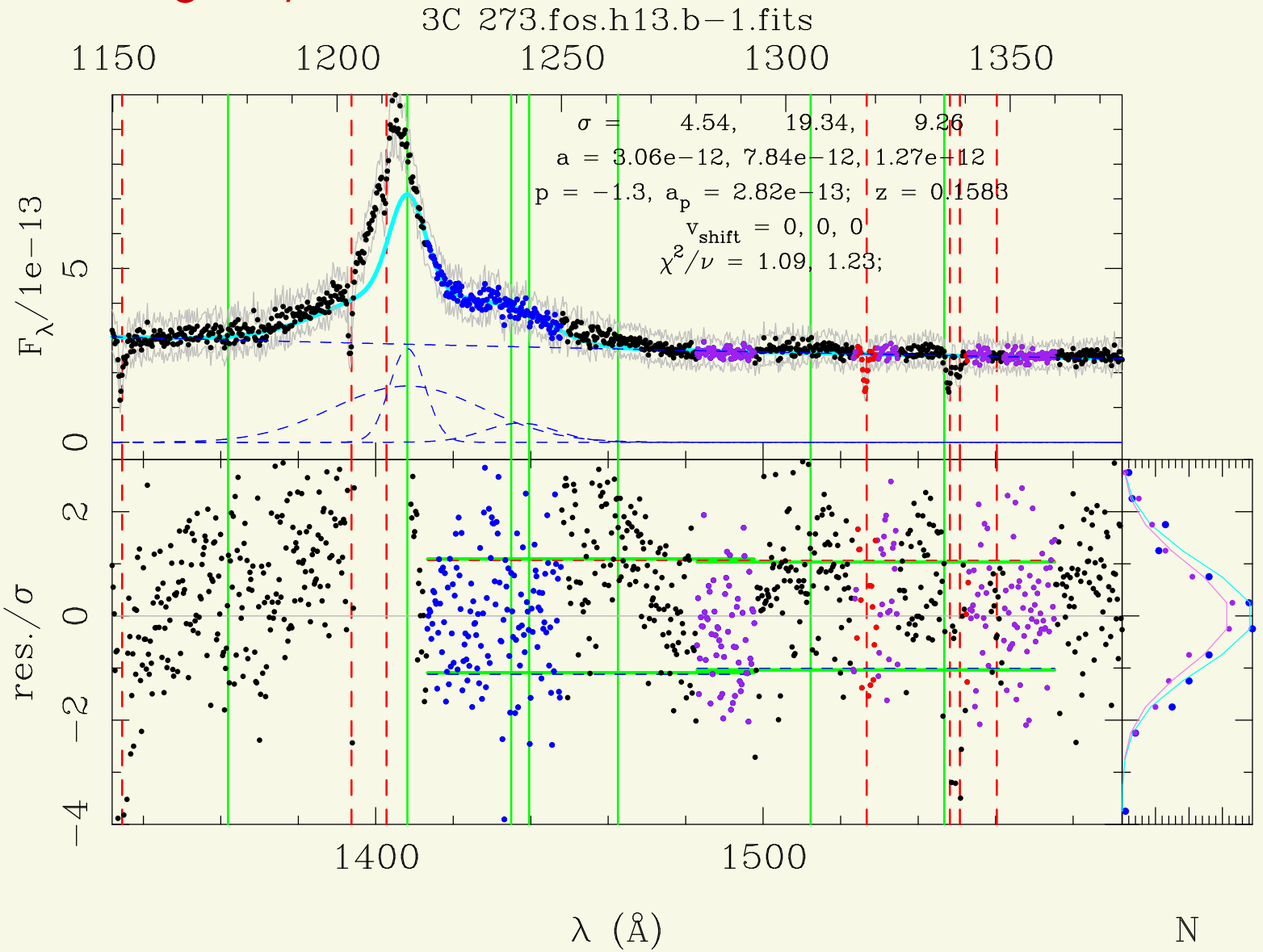
## NED redshifts

are used to determine which observations contain the Ly-$\alpha$ emission line.

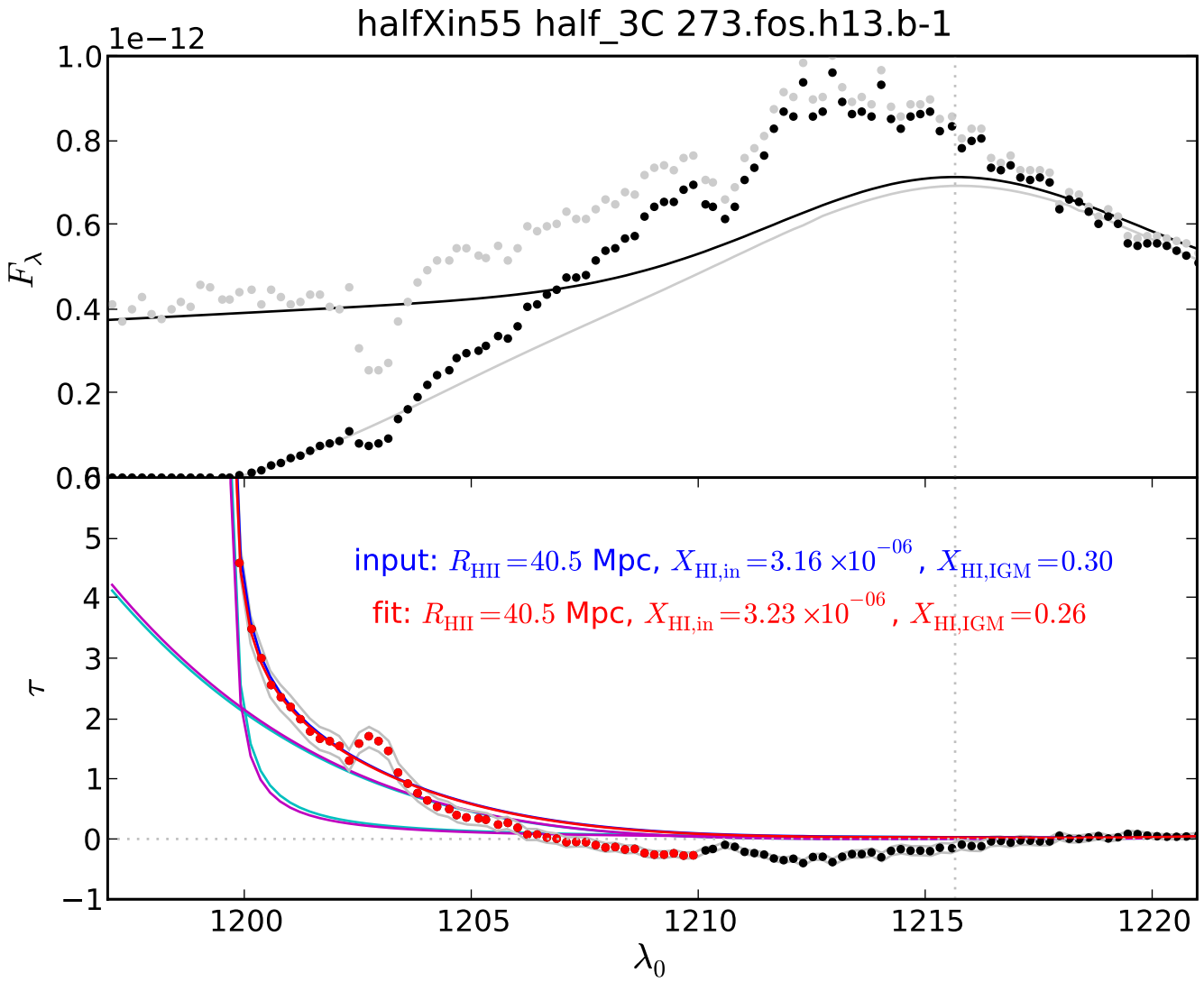
# Modeling the line



# Red-wing-only fits

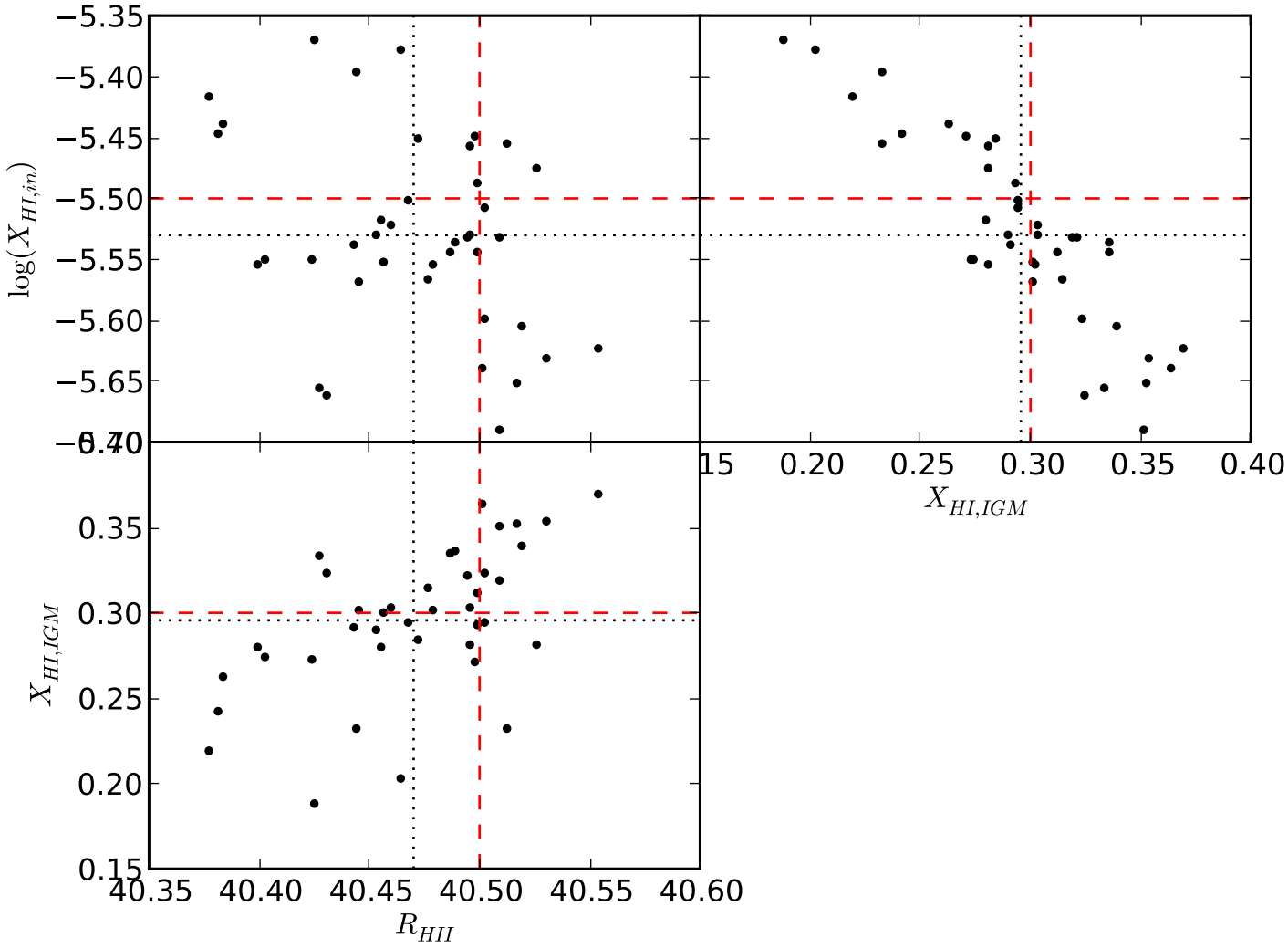


# Optical depth fits



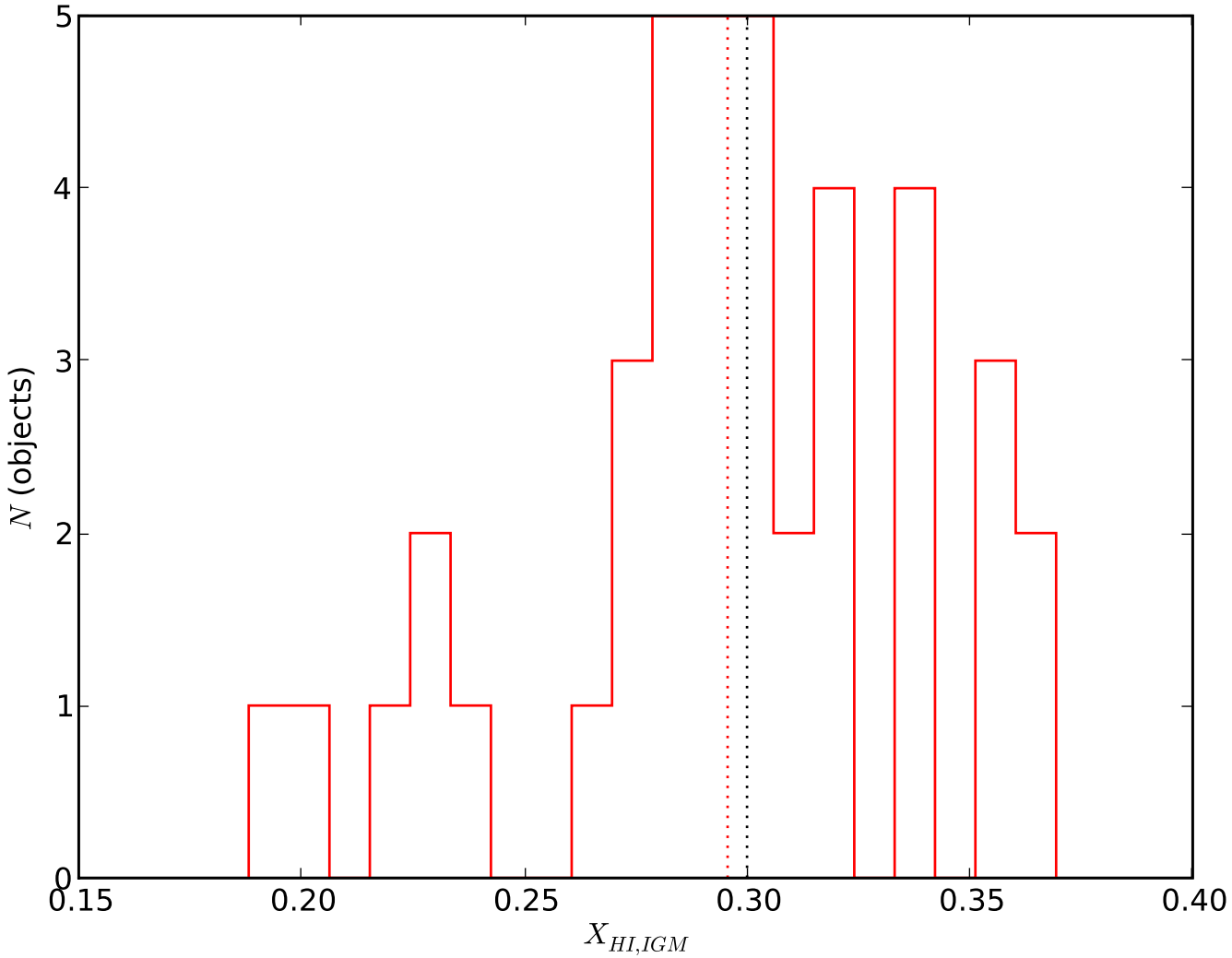
# Recovered optical depth fit parameters

$X_{\mathrm{HI,IGM}} = 0.3$



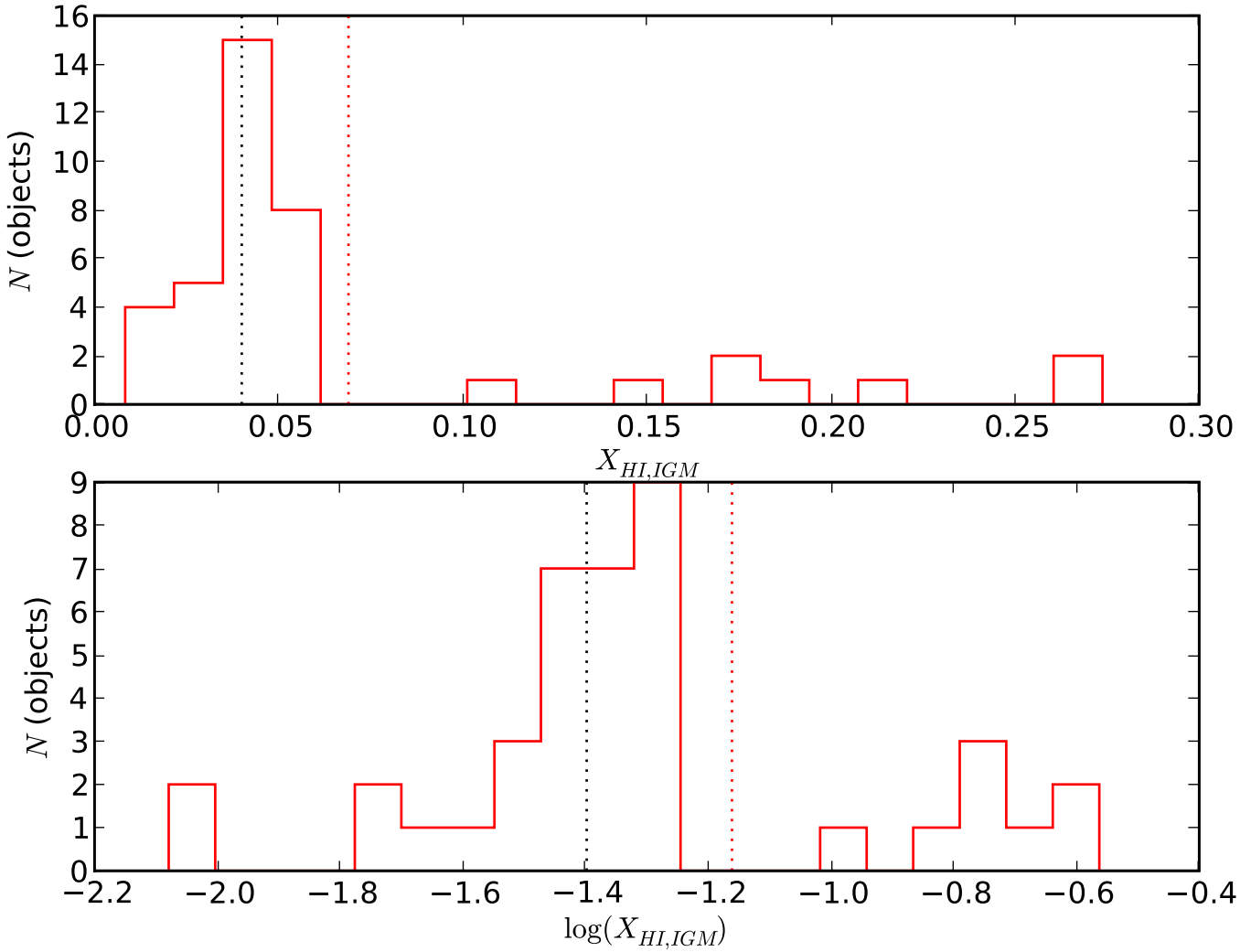
# Recovered IGM neutral fraction values

$X_{\rm HI,IGM} = 0.3$



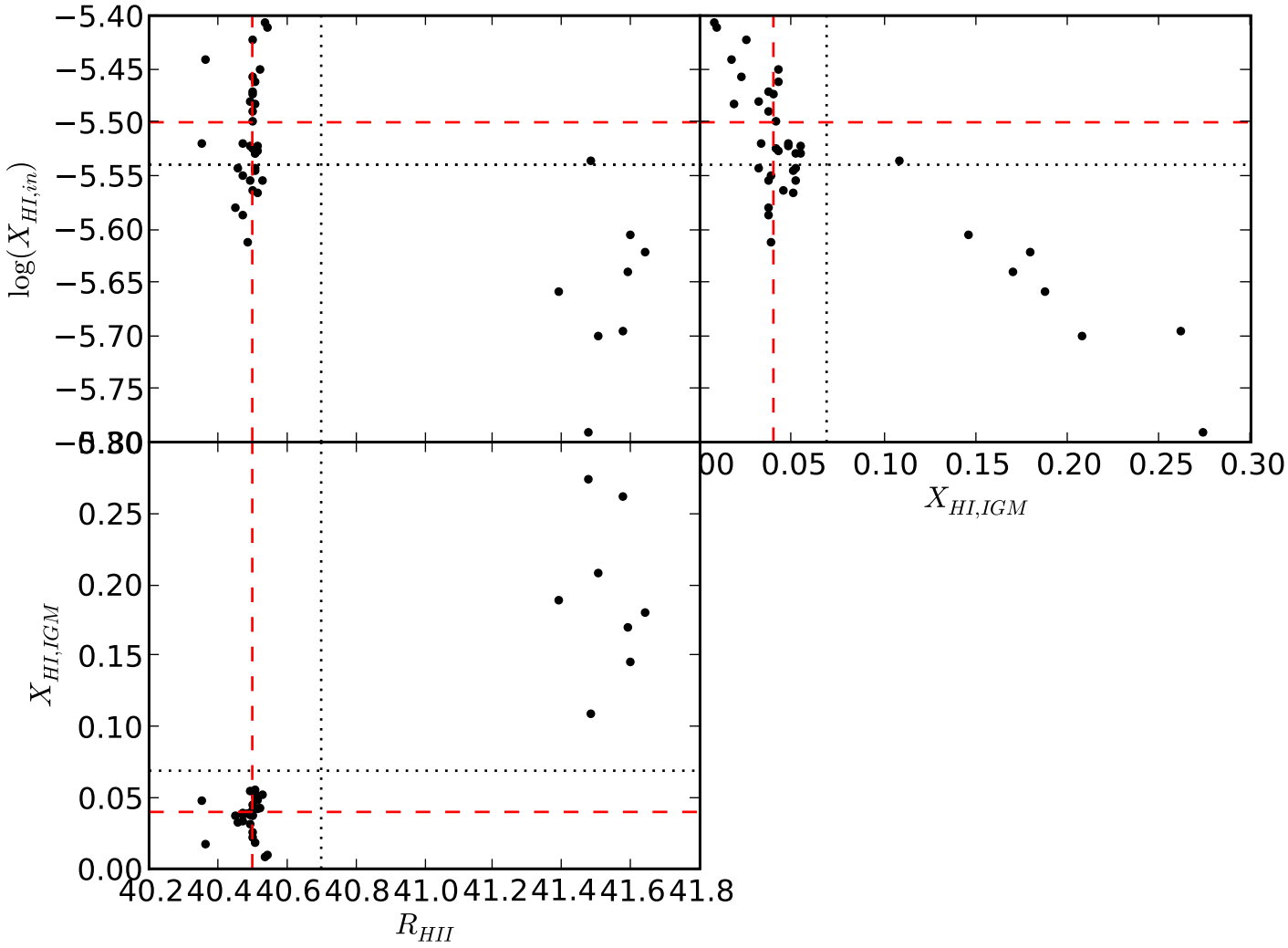
# Recovered IGM neutral fraction values

$X_{\rm HI,IGM} = 0.04$



# Recovered optical depth fit parameters

$X_{\mathrm{HI,IGM}} = 0.04$



# Future directions

We will:

simulate realistic high-$z$ spectra (including density fluctuations) and neutral fraction measurement procedures,

investigate correlations between line profile parameters and luminosity and look for trends with redshift,

explore improved line-profile models, perhaps including constraints from correlations between line components or other lines.

# Summary

We are assembling a catalog of spectra of low-redshift quasar Lyman-alpha emission line profiles.

Line profile fitting uncertainties affect the measurement of the IGM neutral fraction from the damping wing.

For $X_{\rm HI,IGM} \sim 0.3$
the scatter induced by line-profile uncertainties $\sim 25\%$.

For $X_{\rm HI,IGM} \sim 0.04$
the scatter induced by line-profile uncertainties $\sim 0.2$ dex,
but with some very large overestimates.

# Acknowledgments

Andrei Mesinger
Josh Schroeder
David Schiminovich

Multimission Archive at the Space Telescope Science Institute (MAST)
NASA/IPAC Extragalactic Database (NED)

The Perl Data Language (PDL)
levmar
SciPy + NumPy
OpenOpt