Quantifying Quasar Outflows

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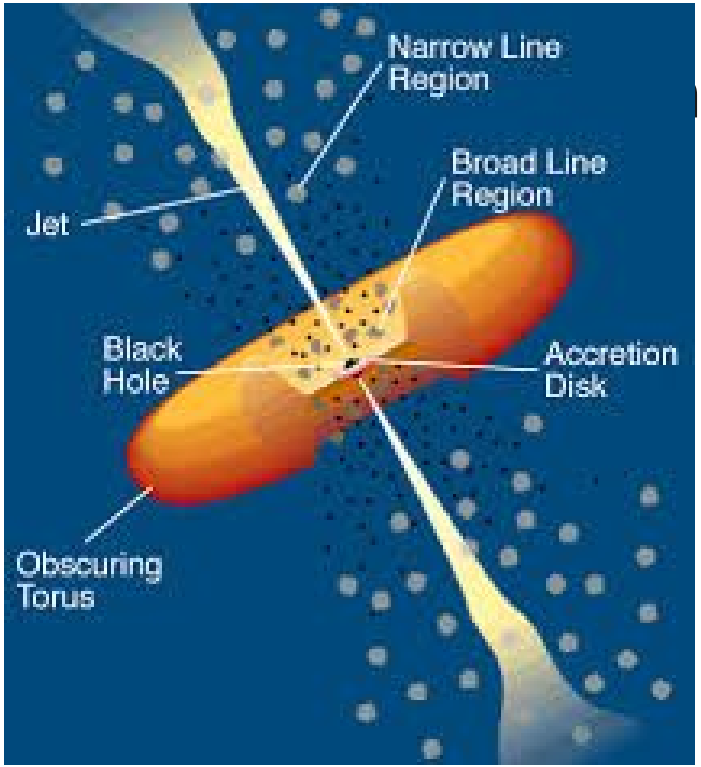
What is a Quasar?



-Gas is drawn to supermassive black hole

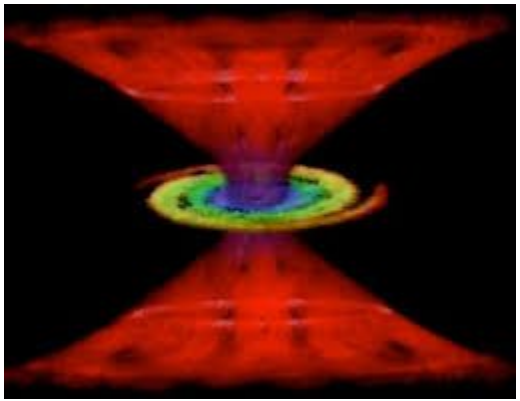
-Windy outflows of gas come off accretion disk

-Exist in center of galaxies, mass from galaxy accretes onto black hole

Why Do We Care?

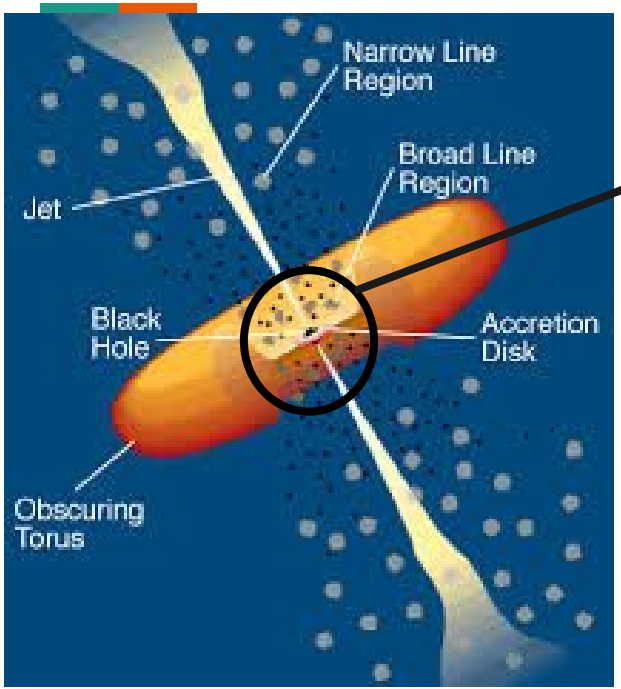
Quasar Wind Theory-Energy from quasar winds affects gas and dust throughout quasar and host galaxy

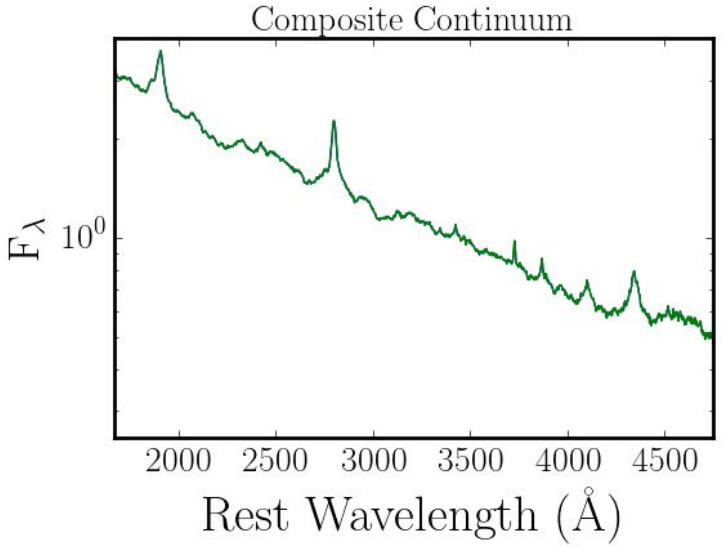
Farrah et al “anticorrelation between outflow strength and contribution from star formation to the total IR luminosity”



Ferrah et al. The Astrophysical Journal 745:178 (2012)

Quasar Continuum





-Accretion disk provides power law continuum

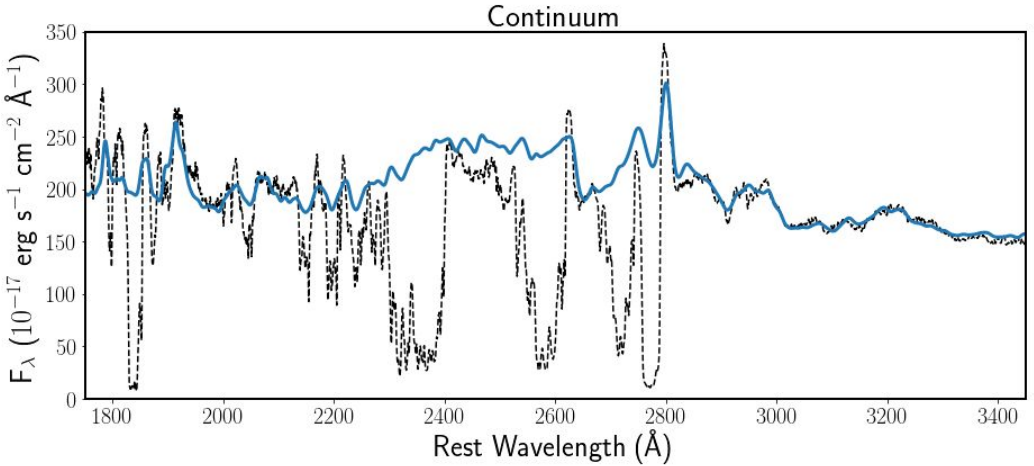
-Emission lines from clouds

Francis et al. The Astrophysical Journal 373:465 (1991)

Broad Absorption Line Quasar

-Continuum and Emission for fbqs j0840

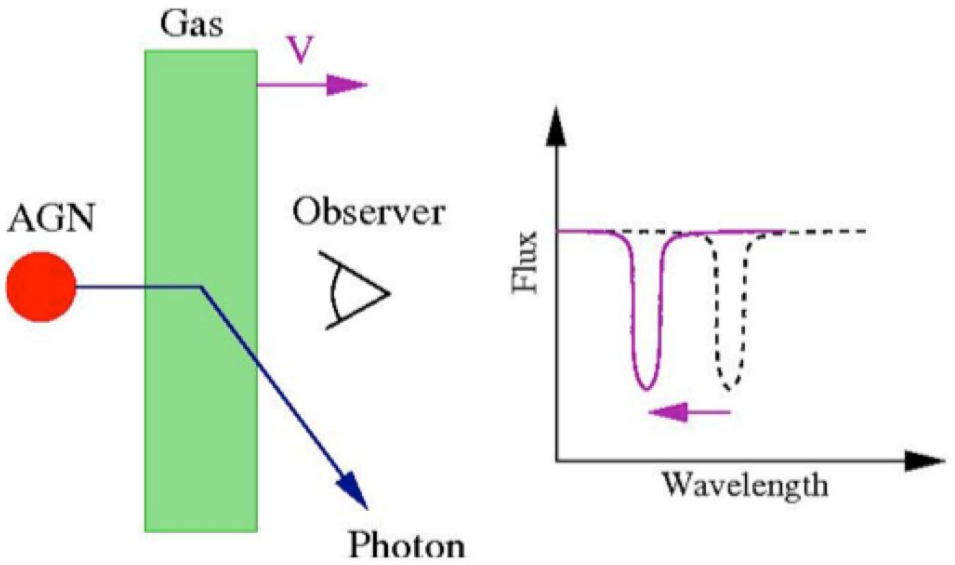
-Broad absorption line quasars make up about 20% of the quasar population



Absorption

-Light from accretion disk is absorbed by outflows

-Outflows are moving toward observer so absorption is blue-shifted by doppler effect



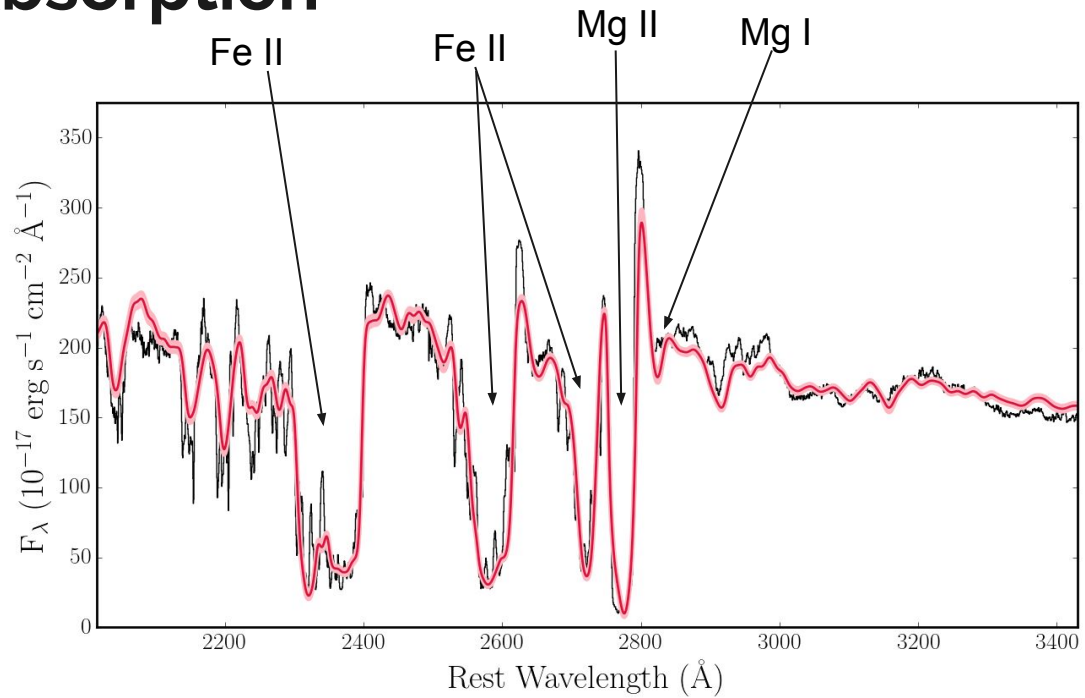
Modeling Through Absorption

-Known metals absorb photons of known wavelength

- Example: Fe+

-Observed wavelength, line depth of absorption lines are analyzed

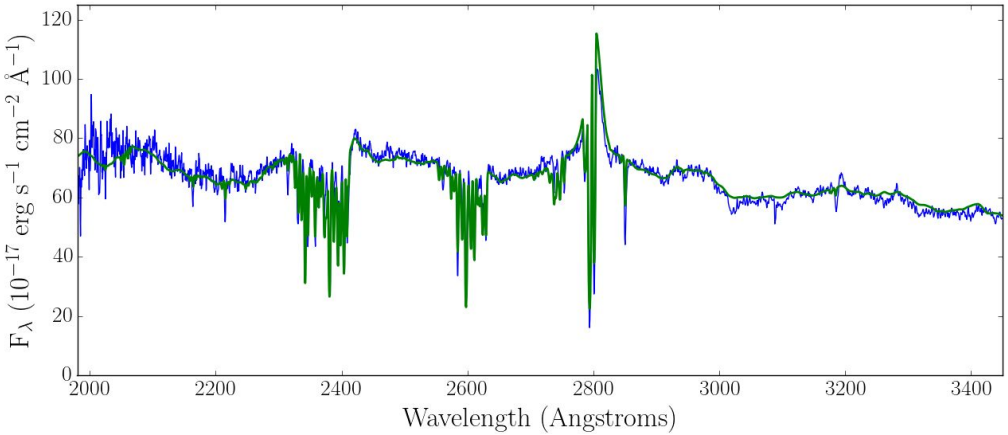
-Absorption is modeled to determine physical conditions of system

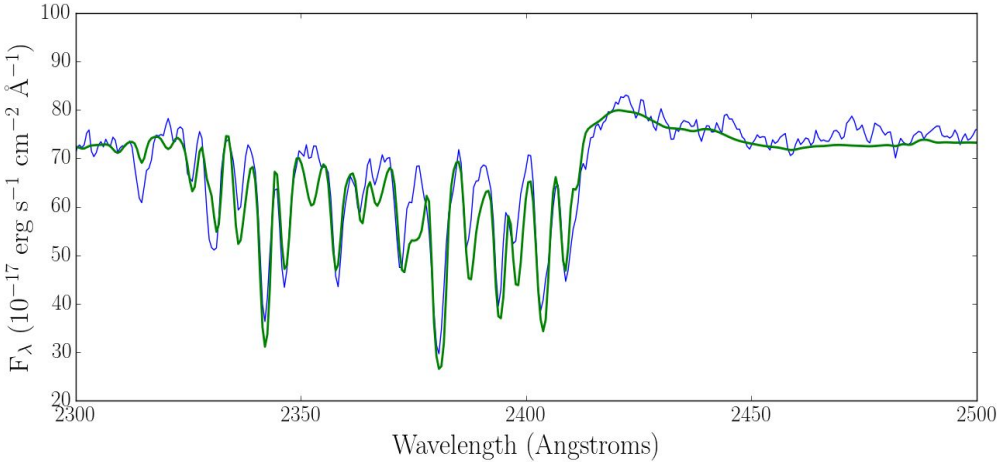


Methodology

-Rudimentary fit of quasar FBQS j083522

-Set of parameters are manually manipulated to obtain a starting point for the raw data



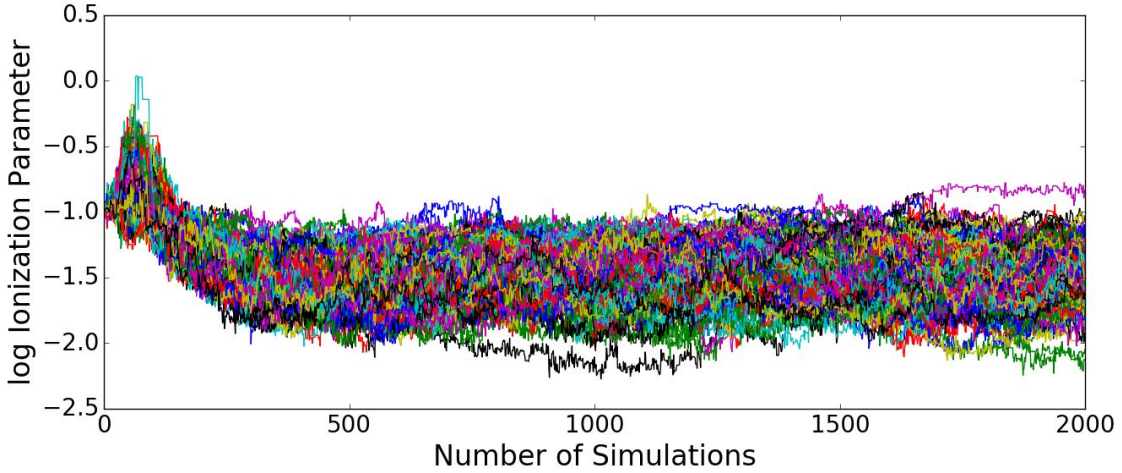


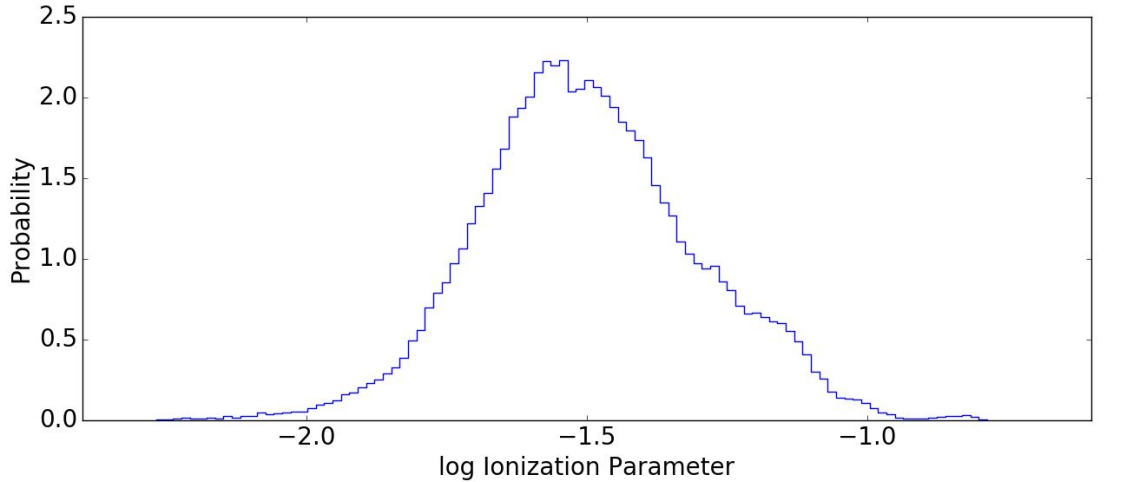
Emcee Introduction

- 300 walkers move through parameter space

-Most likely to take steps that lead to low χ^2

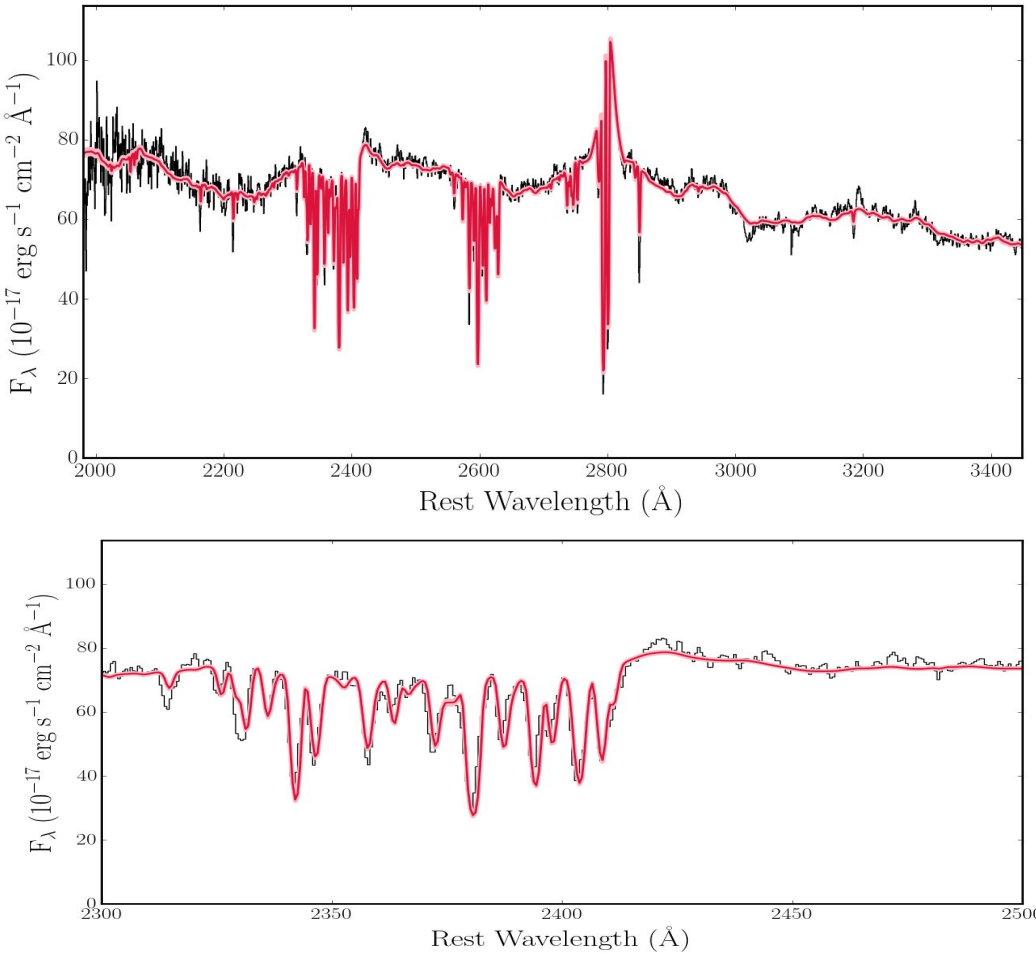
-Converges to a probability distribution because of noise and error in raw data





Final Result

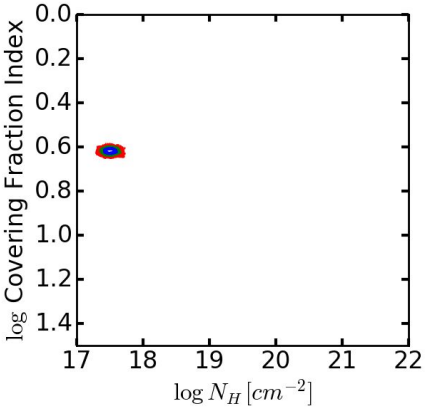
-Final fit and post processing probability distributions

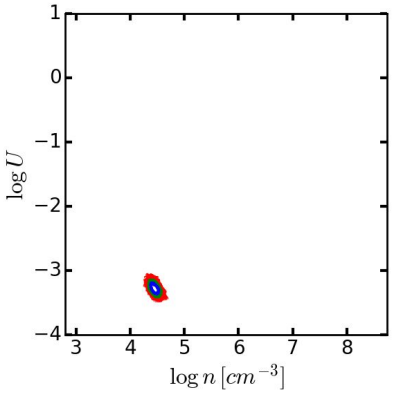


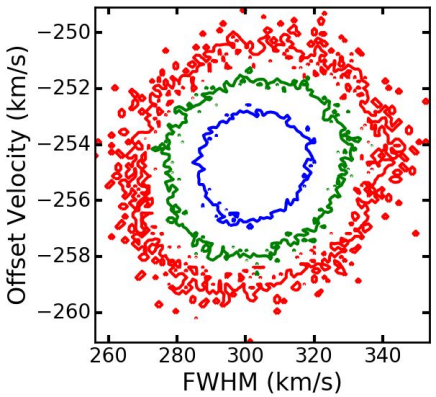
Final Result

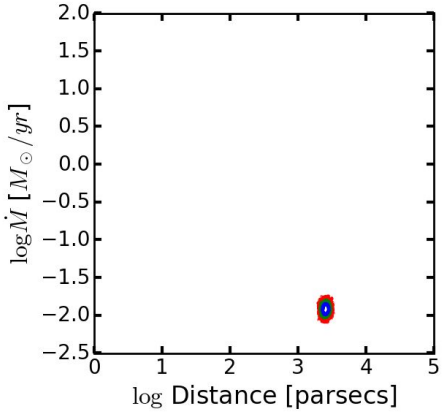
-Probability distributions for absorption values are determined

-Accretion rate and distance from central engine is determined based on absorption parameters





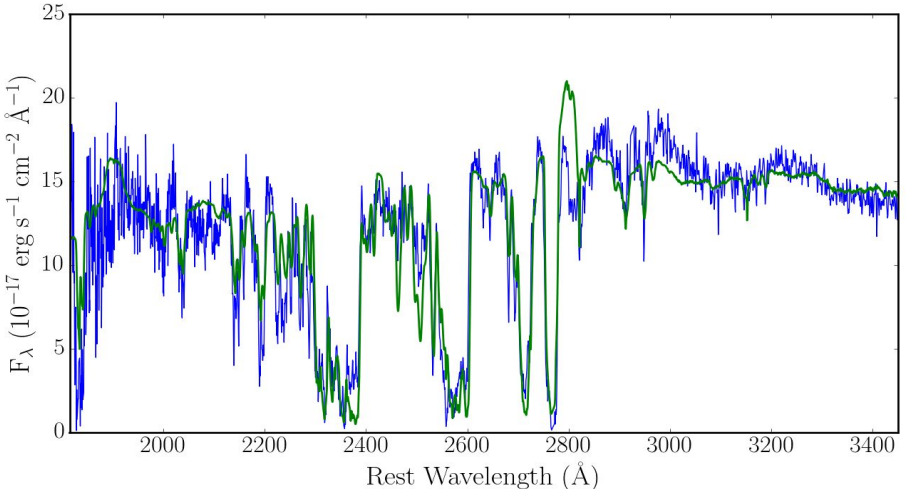


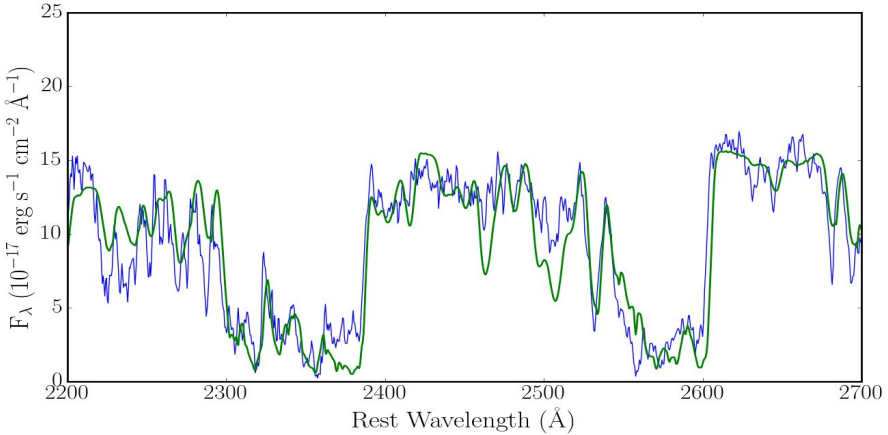


More Difficult Object

-Quasar sdss j102036

-Initial fit using 22 parameters

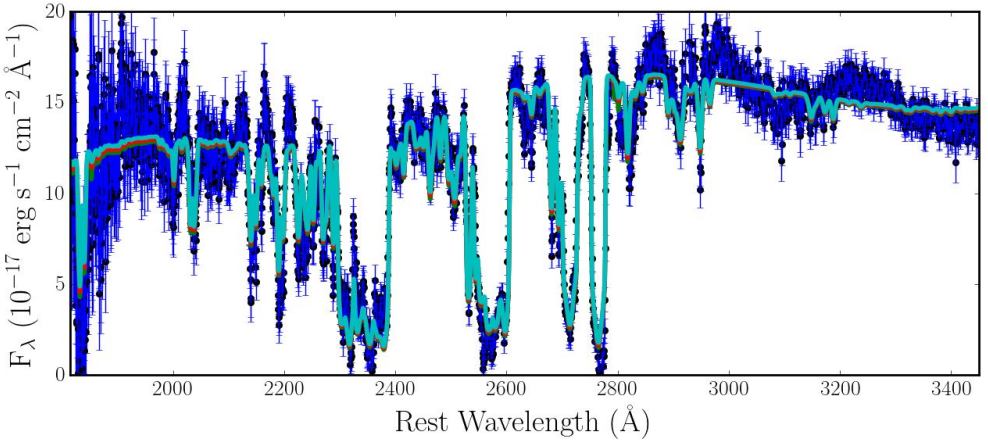


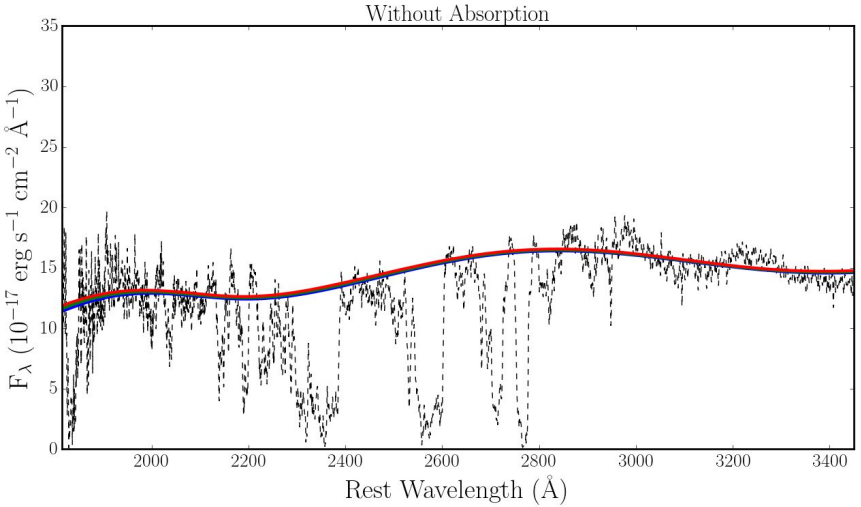


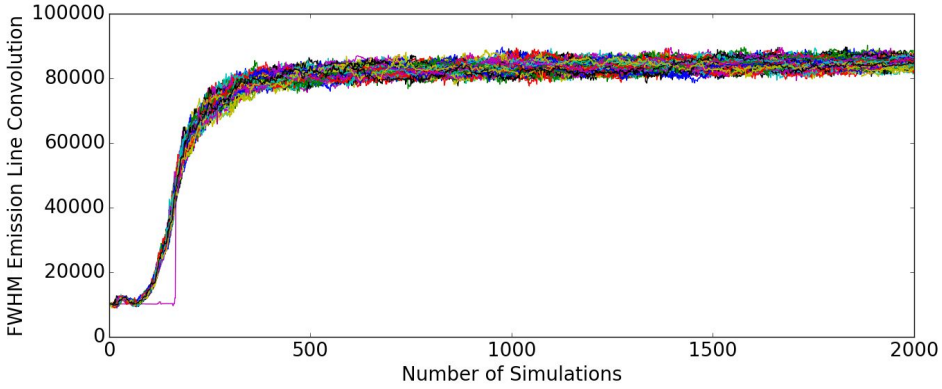
Results of first run

-Continuum does not match quasar continuum

-Full width half max value is too large to be physical for quasar emission





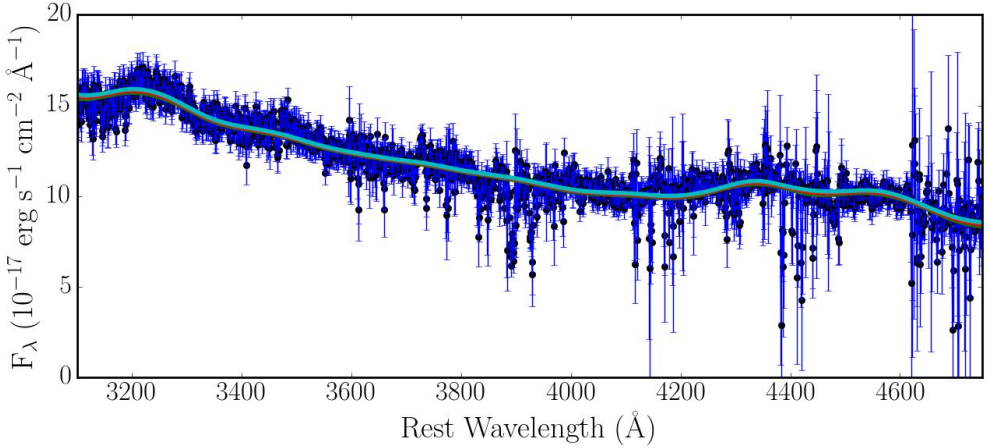


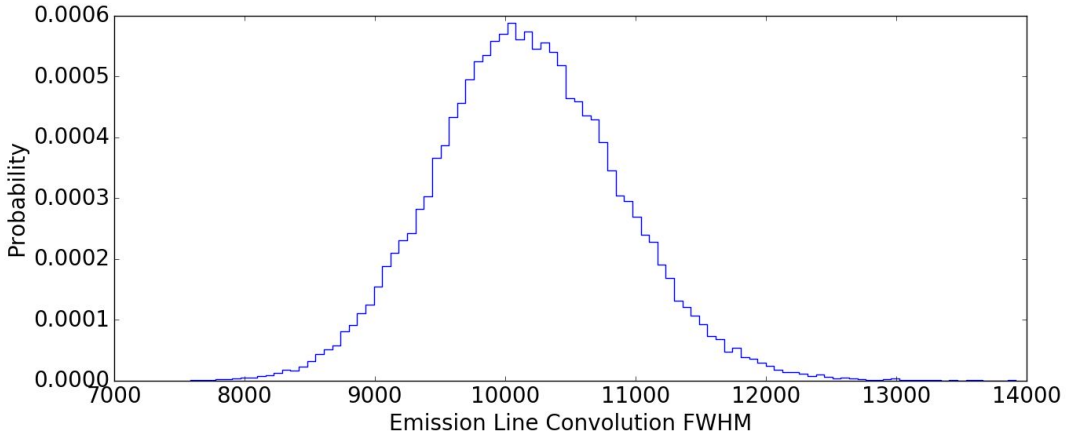
Using Long Wavelength to Constrain FWHM

-Wavelength range for this object extends beyond normal range for fitting

-Long wavelength range has little to no absorption

-Fit emission spectrum in long wavelength range to constrain full width half max

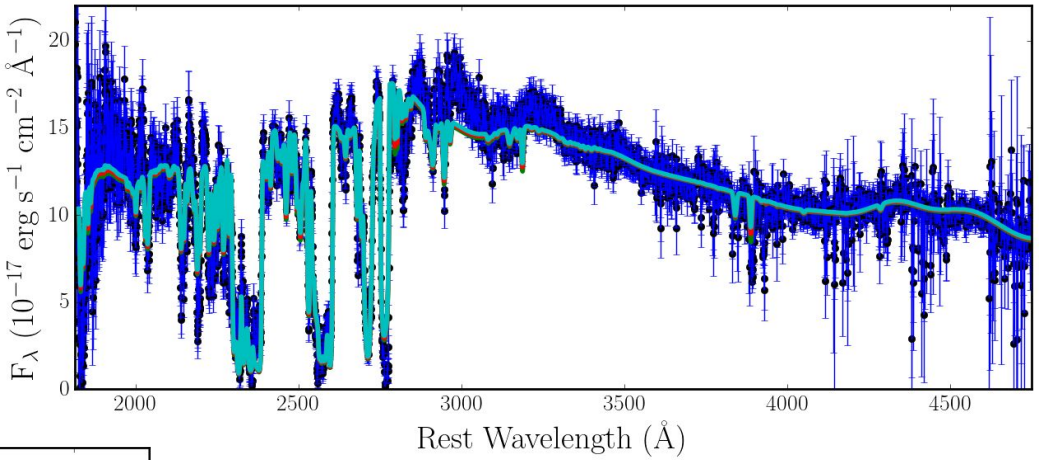


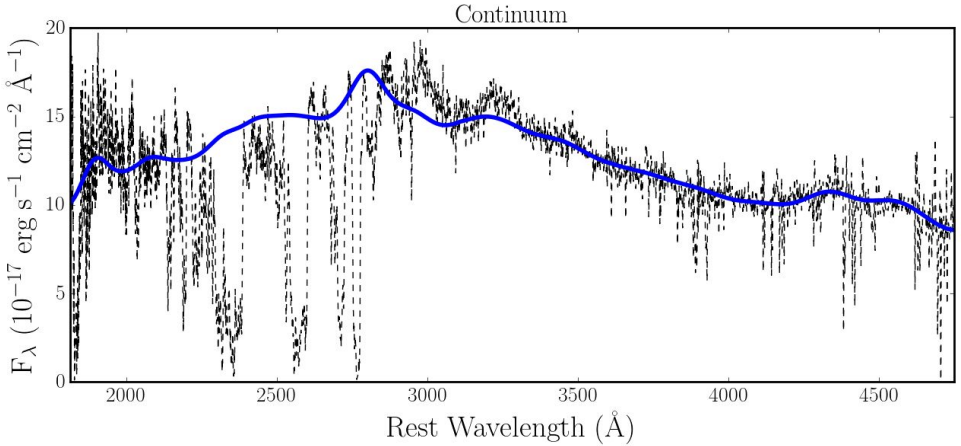


Final Results

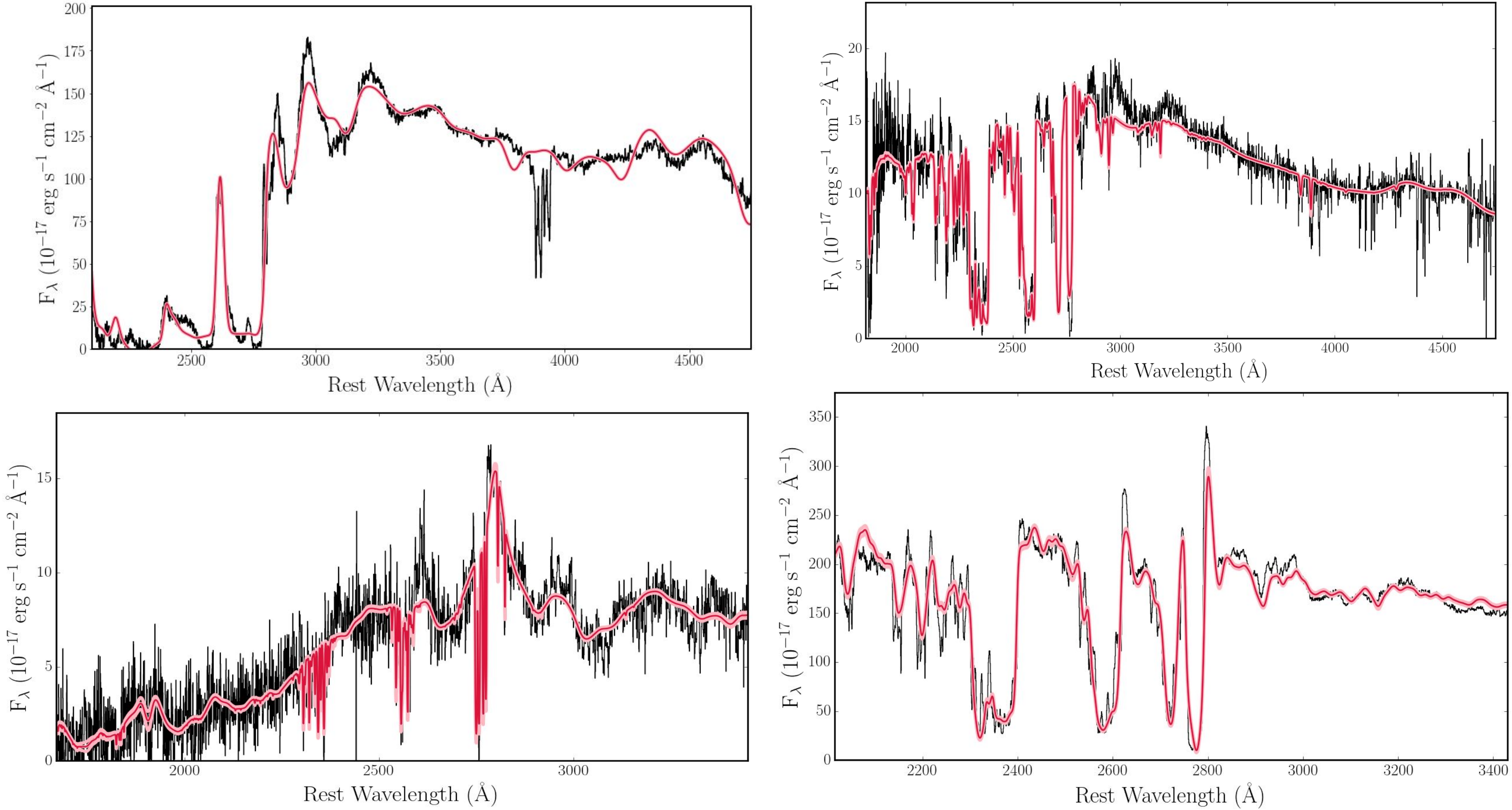
-Fit data in normal wavelength range

-Constrain FWHM to value determined from long wavelength run





Different Morphologies



Results of Broad Survey

-20 objects fully analyzed

-5 objects with significant absorption from 2 different outflow components

-1 object with significant absorption from 3 different outflow components

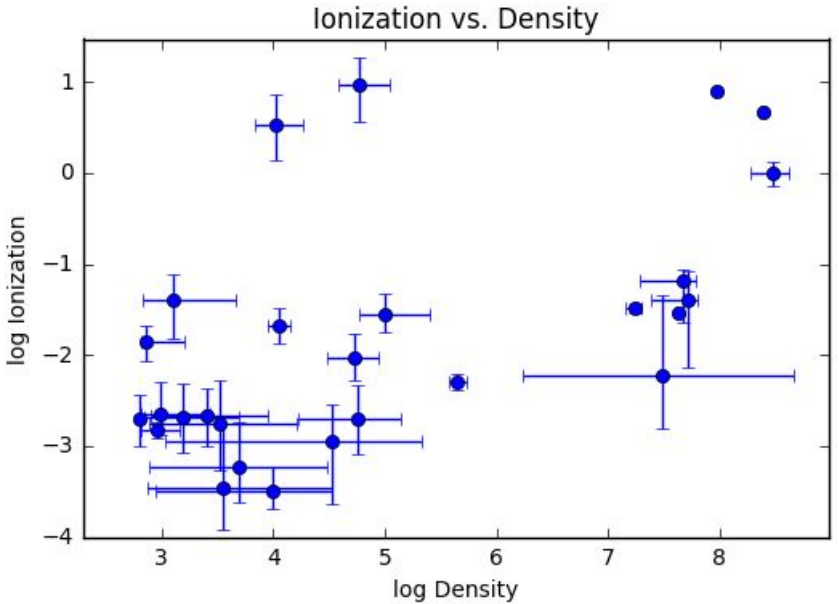
-Total of 27 absorption components analyzed for broad survey

Results

$U=Q/(4\pi ncr^2)$

-No obvious correlation between ionization and density

-Can not assume constant radius

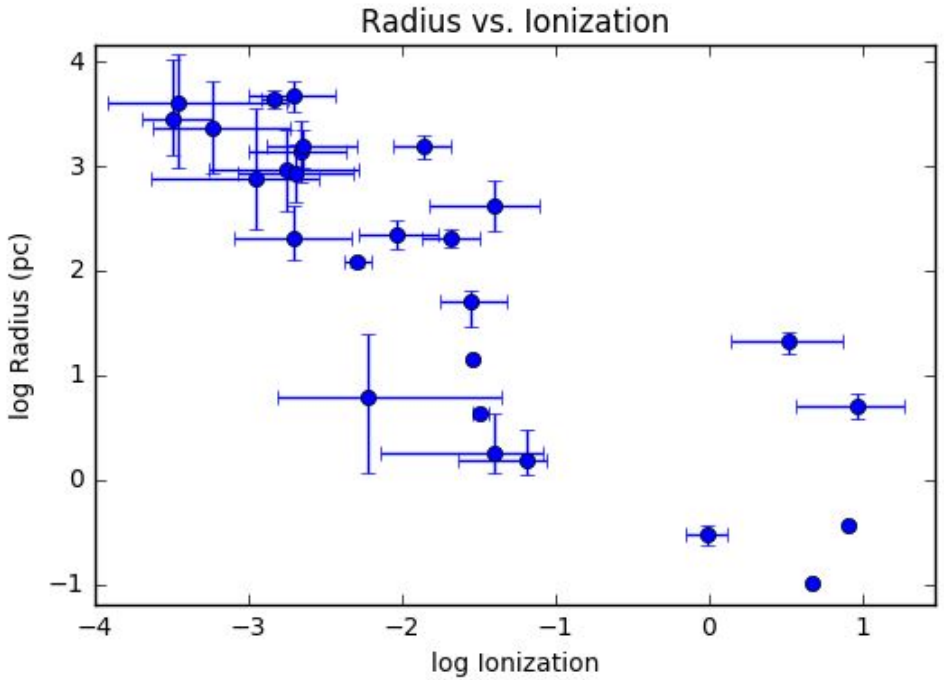


Results

$U=Q/(4\pi ncr^2)$

-If we assume constant density, expect slope of -½

-Can not assume constant density



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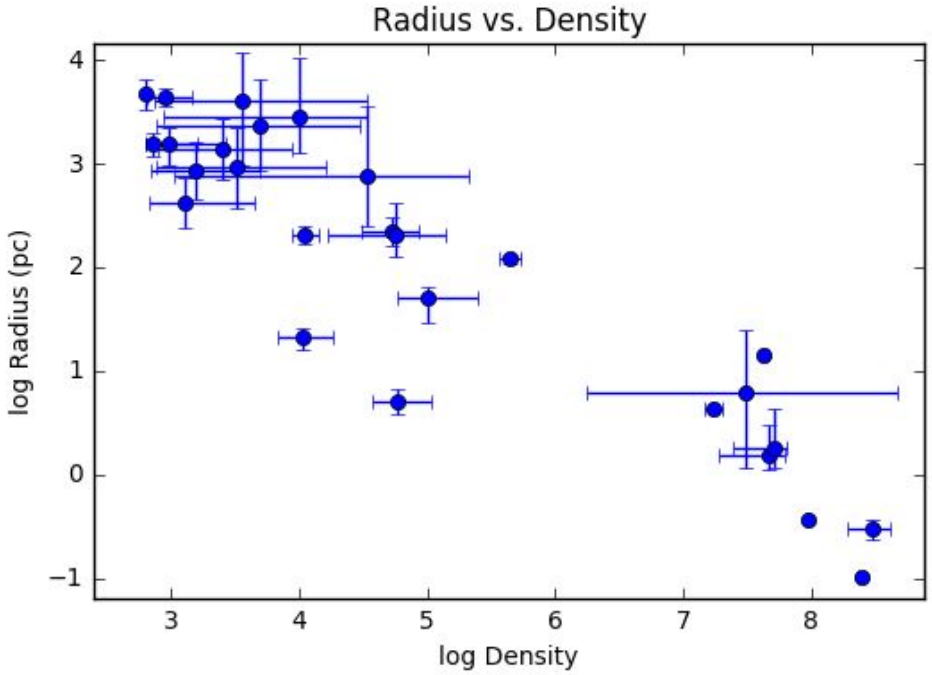
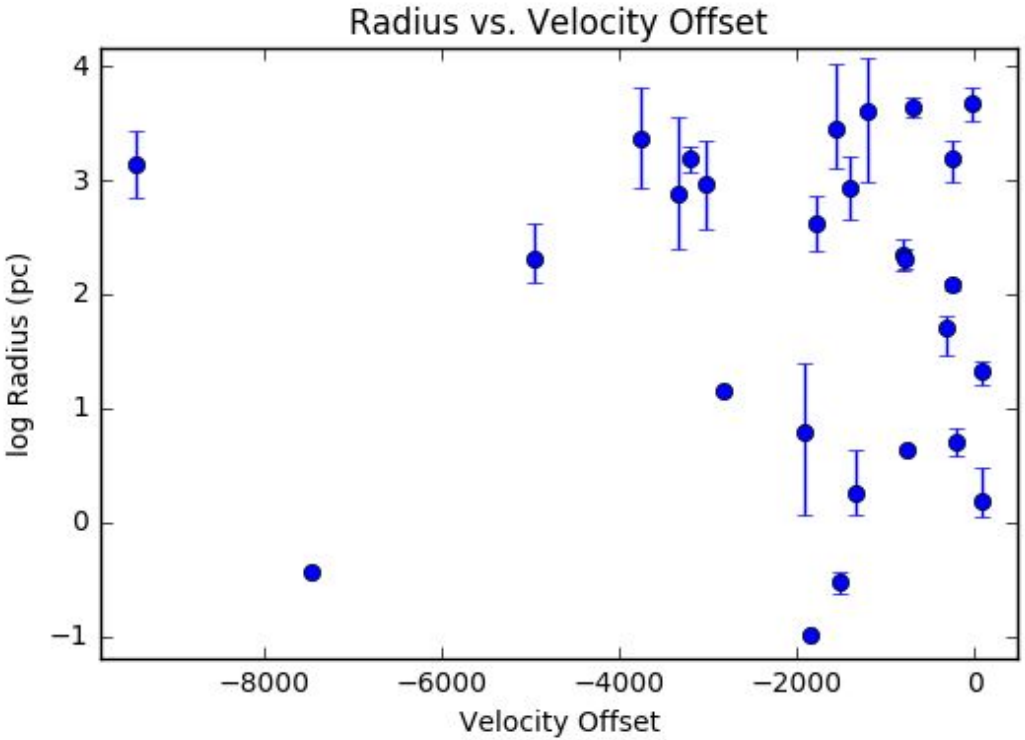


Results

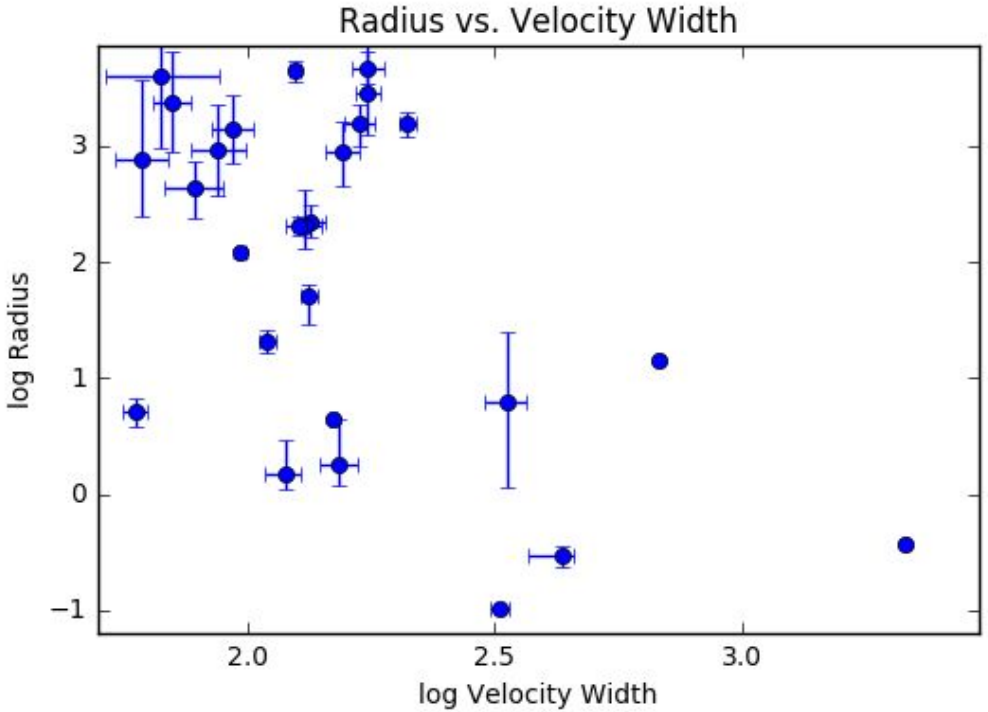
-It has been theorized that outflows may accelerate or deccelerate after they leave the central engine

-This does not seem to be supported by our data



Results

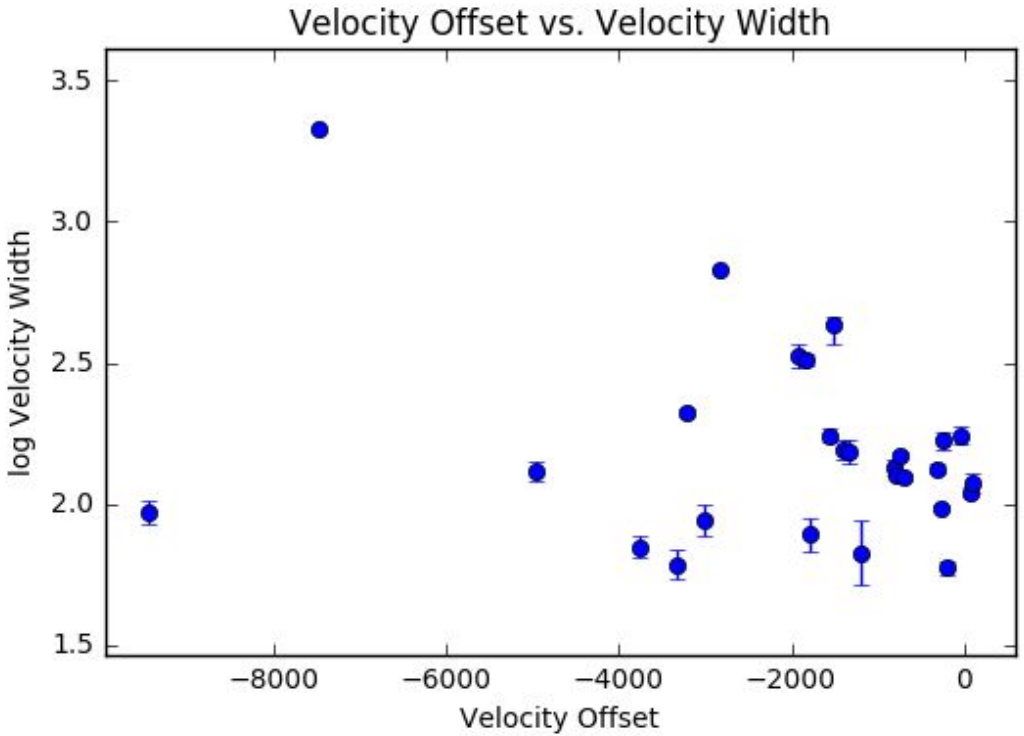
-Correlation between velocity width and radius



Results

-If all outflows started at zero velocity, expect correlation between offset and width

-No correlation



Summary

-Modelled 20 objects using similar method

-Determined characteristics of windy outflows

-Analyzed results from a broad survey of quasars

-Found potential interesting correlations between ionization, density and radius as well as velocity width and radius

-Further analysis of correlations may produce important results