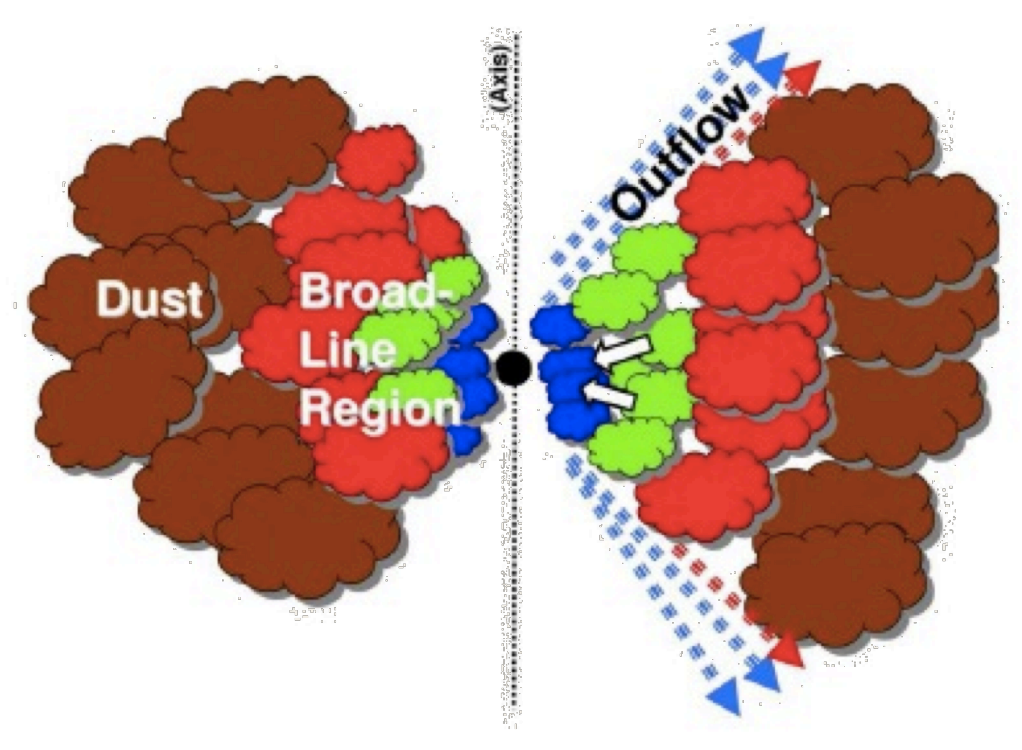
Credit: ESA/ATG medialab

Implications of Absorption Lines for the Nature of the Obscurer in NGC 5548

Maryam Dehghanian Gary Ferland

Central Structure of AGN



Gaskell 2008

Estimation of AGN's Mass

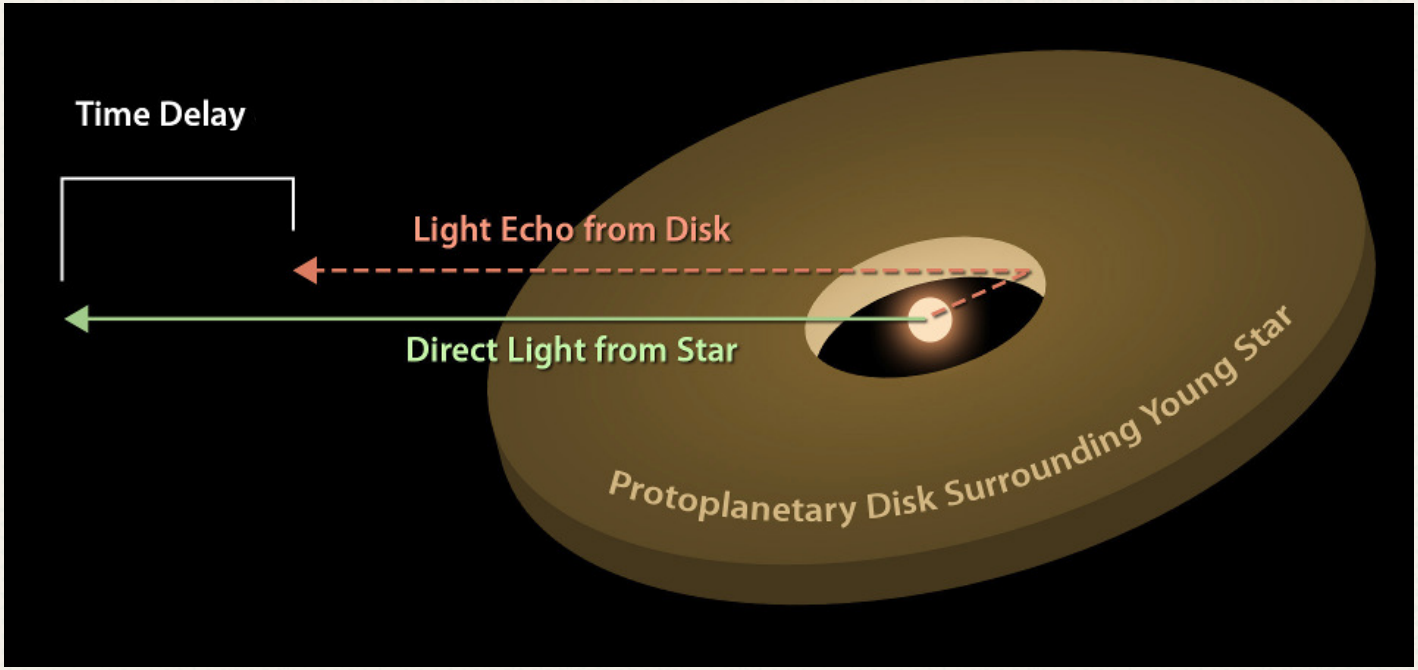
We apply the virial theorem to the broad line clouds!

$$M = rv^2/G$$!

- Two parameters needed:

1-velocity → from Doppler line broadening!

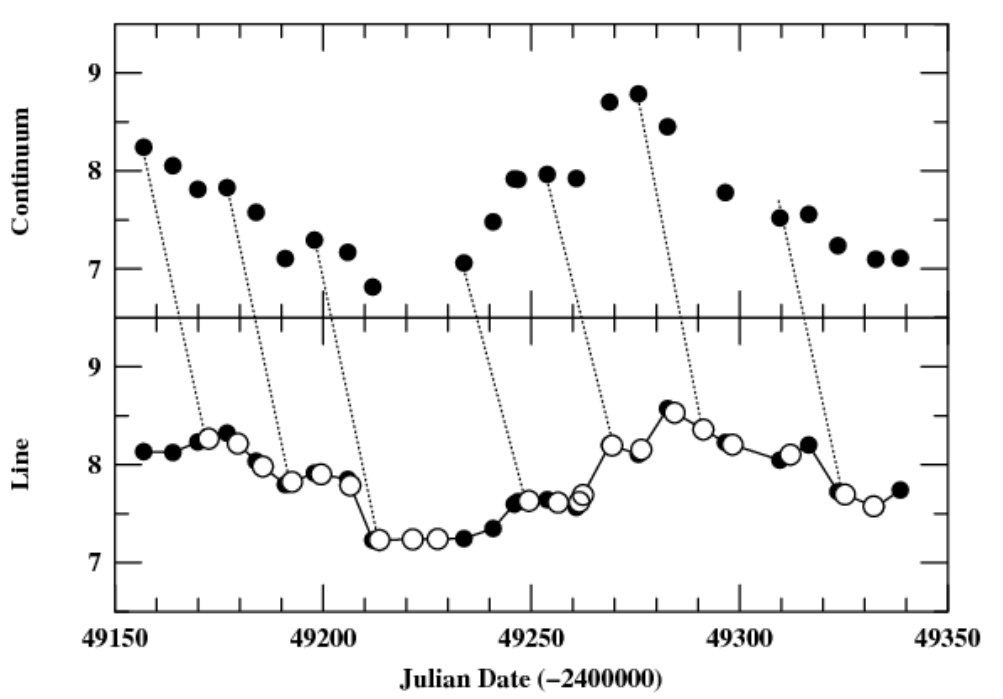
2-distance → through "Reverberation Mapping"



NASA/JPL-Caltech

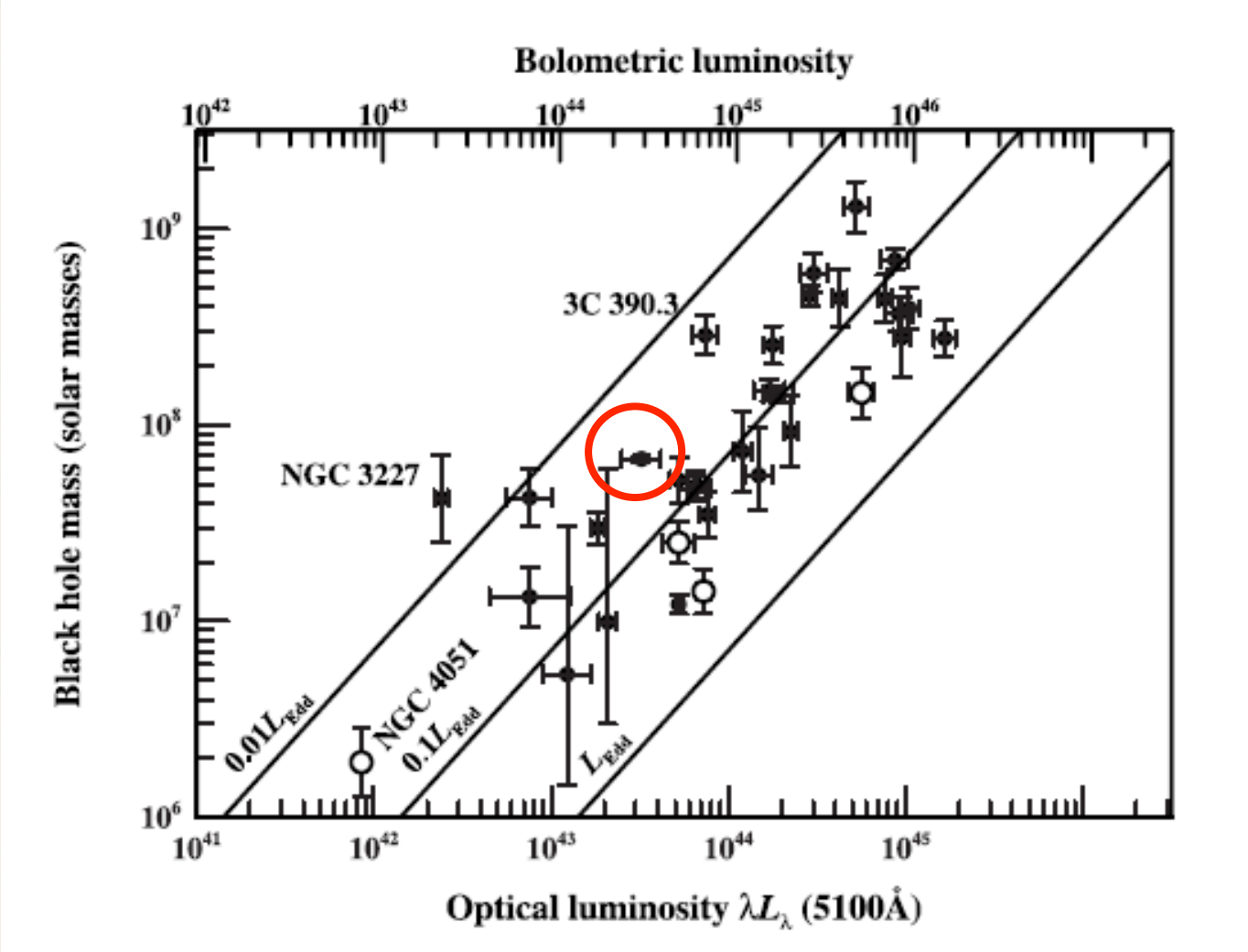
Reverberation Mapping

- Measuring the “lag” between continuum and emission-line variations
- The higher-ionization lines have smaller lags (Peterson +13)



Peterson 2001

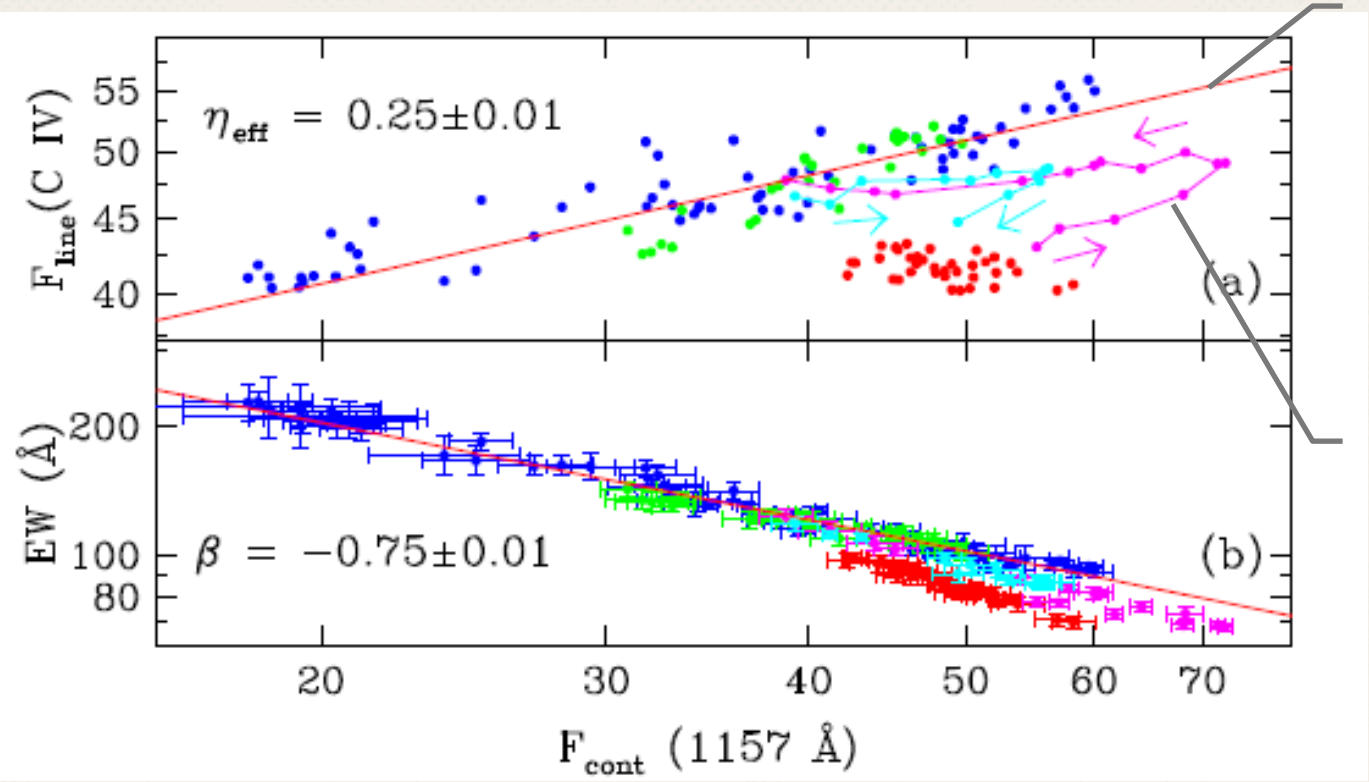
Previous results for AGN



Peterson 2004

The Holiday

Can we trust black hole mass measurement ?



What was expected to be observed

Something completely unexpected happened

Goad+16

Emission lines went on Holiday!

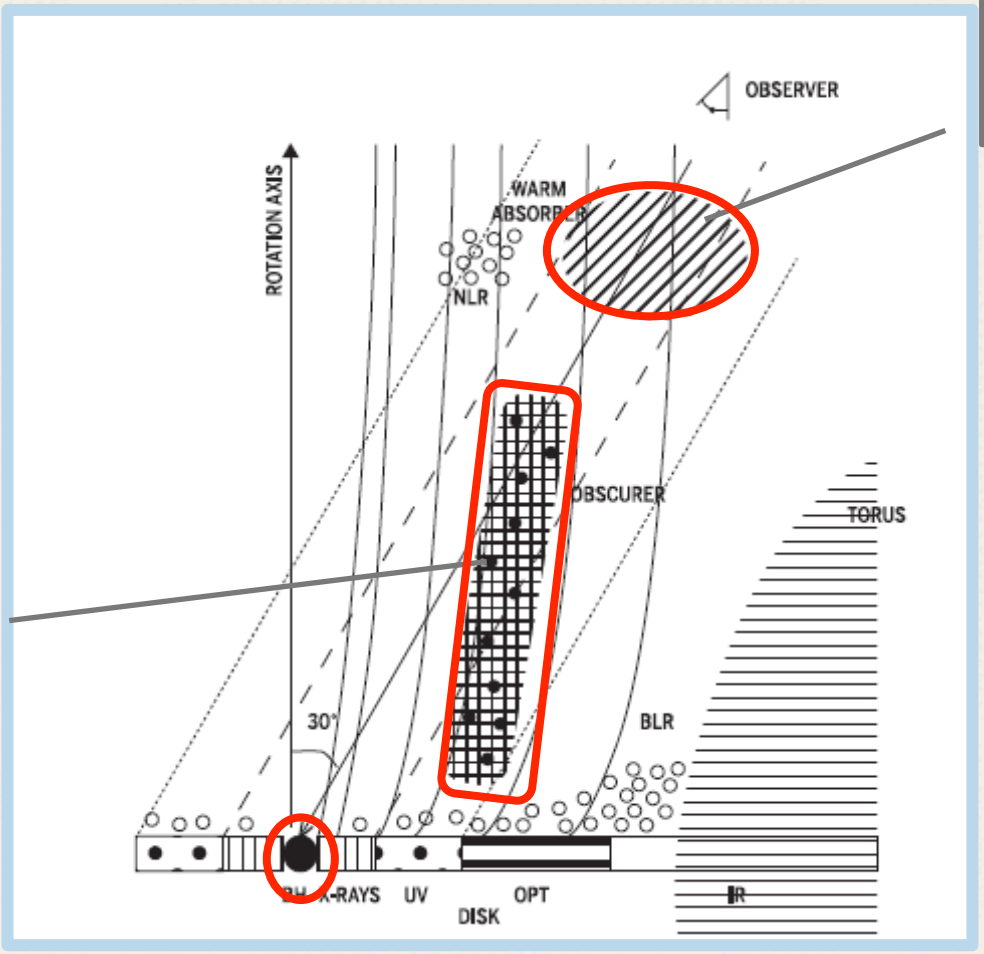
Caused by an outflowing stream of weakly ionized gas (called the obscurer), extending from the vicinity of the accretion disk to the broad-line region (Mehdipour+15)

We used absorption lines to analyze the behavior of NGC 5548: They show the anomaly and they are easier to interpret.

We predicted the ionizing SED appropriate to the HST campaign taking into account possible change in the obscurer.

The Obscurer

Outflowing component 1

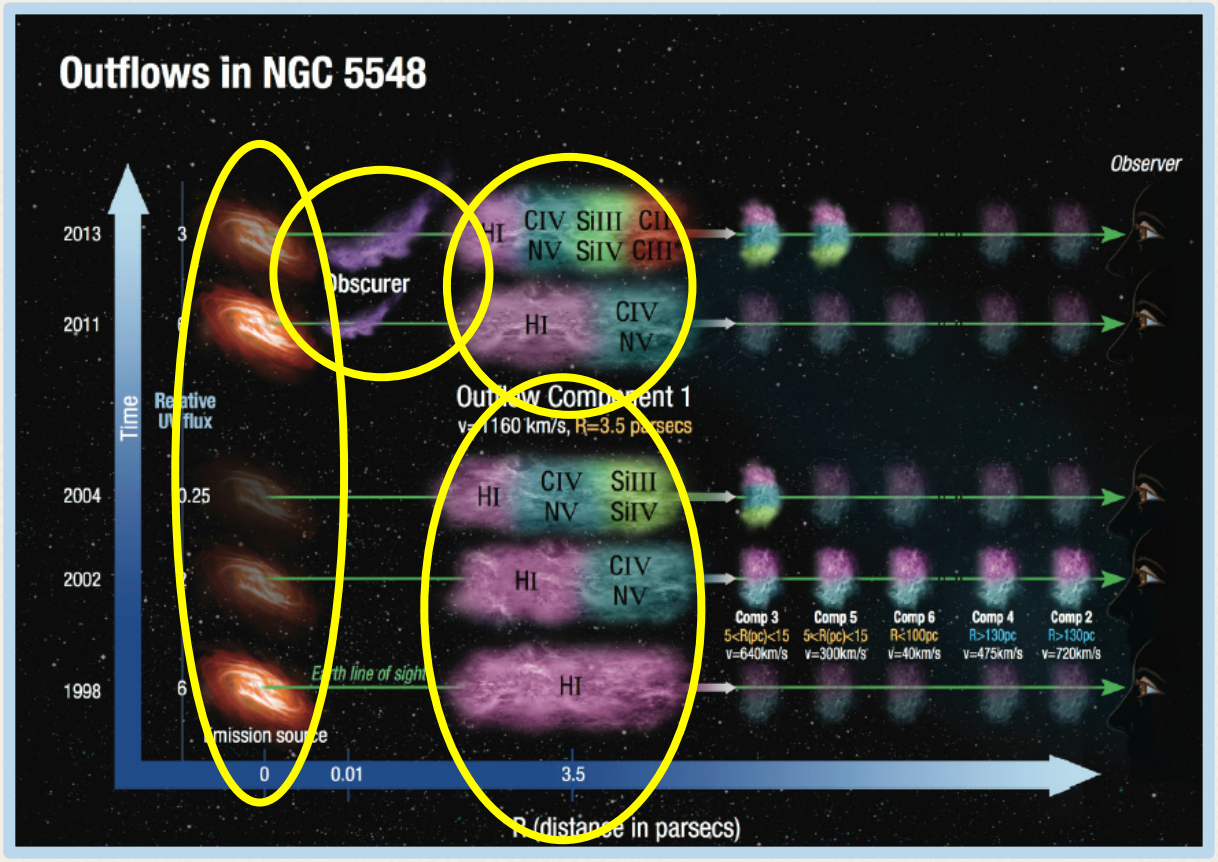


Obscurer

Kaastra+14

Outflows in NGC5548

A schematic cartoon of the outflows seen in NGC 5548. As time goes on from 1998 to 2013, you can see the behavior of the emission source. The obscurer is located at 0.01 pc from the emission source.

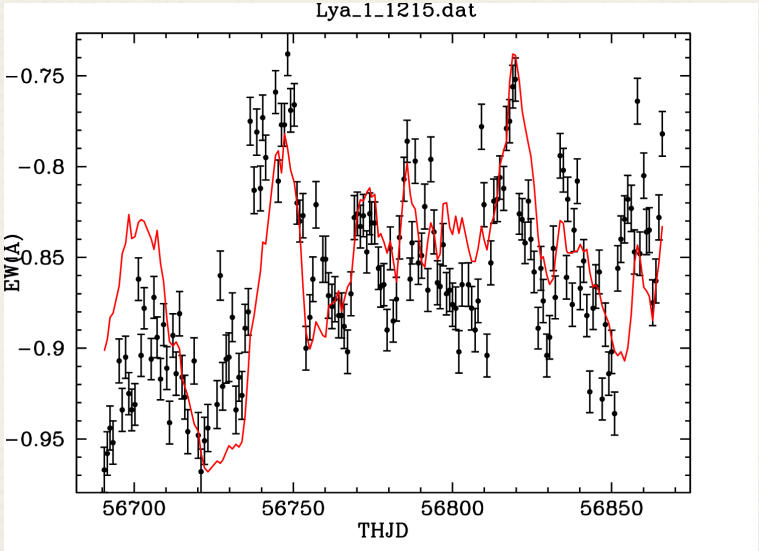


Arav+15

Correlation or Uncorrelation

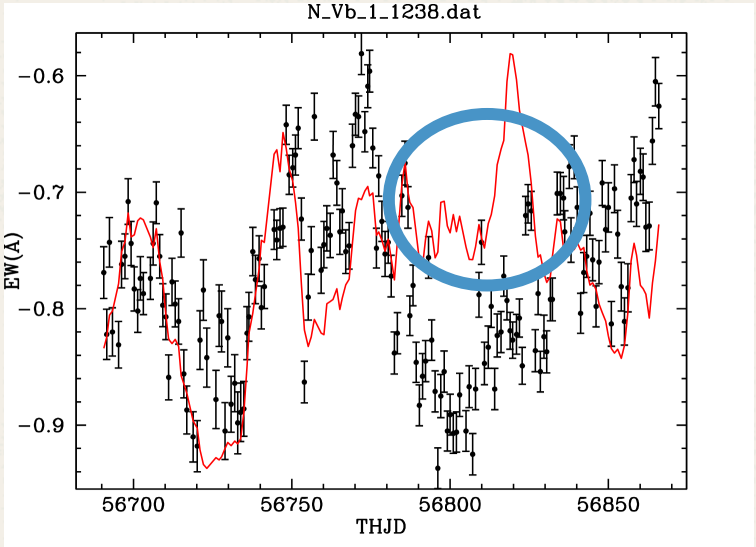
Detailed investigations showed that some of the absorption lines correlate with the UV continuum during the campaign, and some of them do not.

An example of a correlated element



Kriss+16

An example of an uncorrelated element

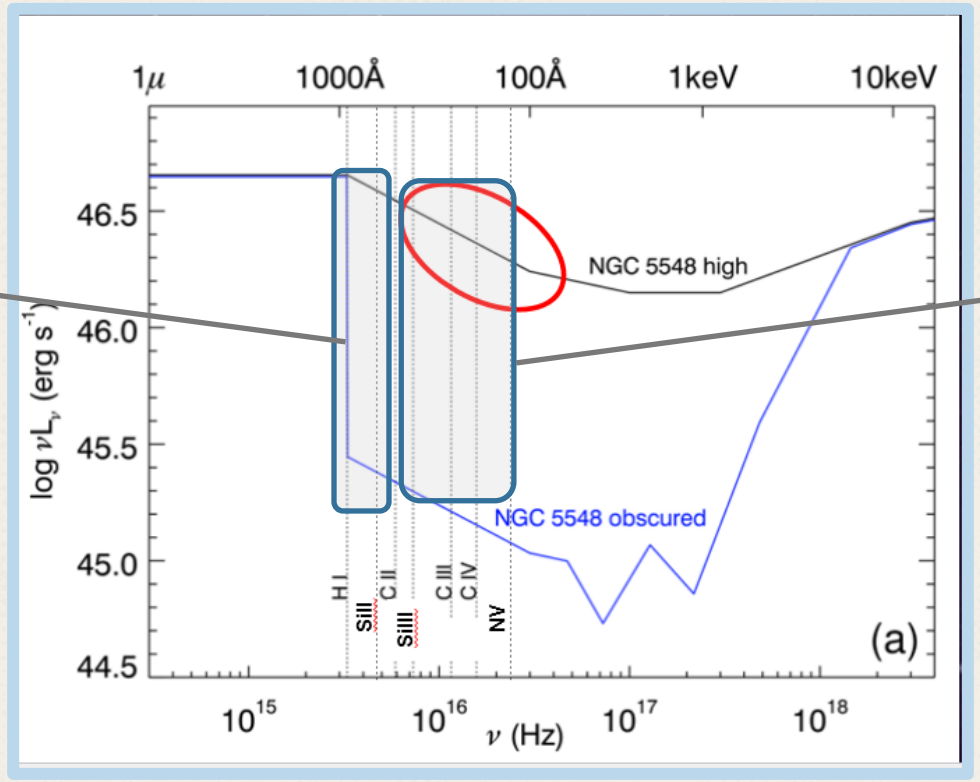


The red trend shows the HST UV continuum.

Correlation or Uncorrelation

The correlation / uncorrelation depends on ionization potential. High ionization species, indicated by the oval, were uncorrelated with the UV while lower IP species were correlated.

Correlated species



Uncorrelated species

Kriss+16

Can Photoionization models explain the line of sight absorption?

We need the SED that filters through the obscurer and ionizes component 1.

✓ This SED depends on N(H), n(H), Z, ξ

✓ The only thing that we know for sure is the optical depth at 1 keV

C17- The 2017 version of Cloudy

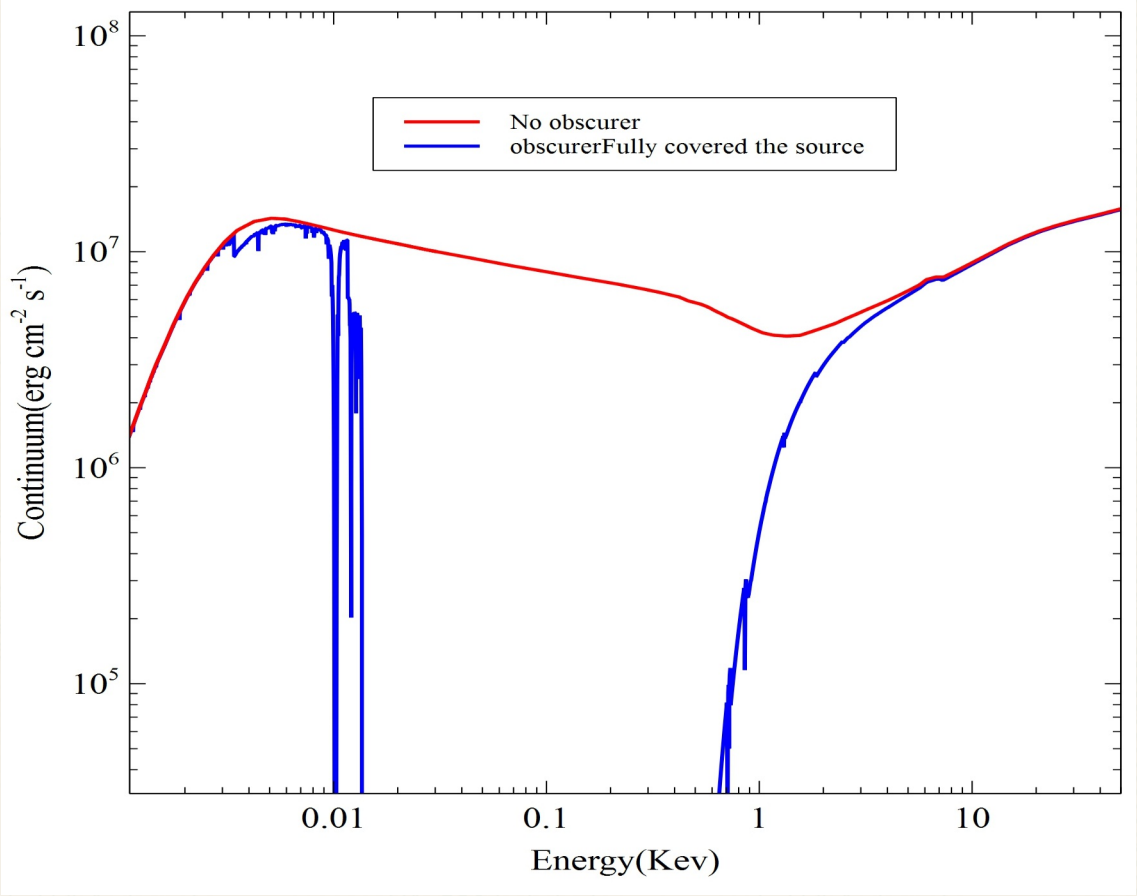
✓ Improvements described in Ferland+17

✓ Released early this year

✓ Used in all calculations presented here

Mehdipour's Model

Mehdipour+16 models suggested that obscurer blocked all SED between UV(13.6 ev) and x-ray (1 keV)



Our C17 calculations of Mehdipour`s model

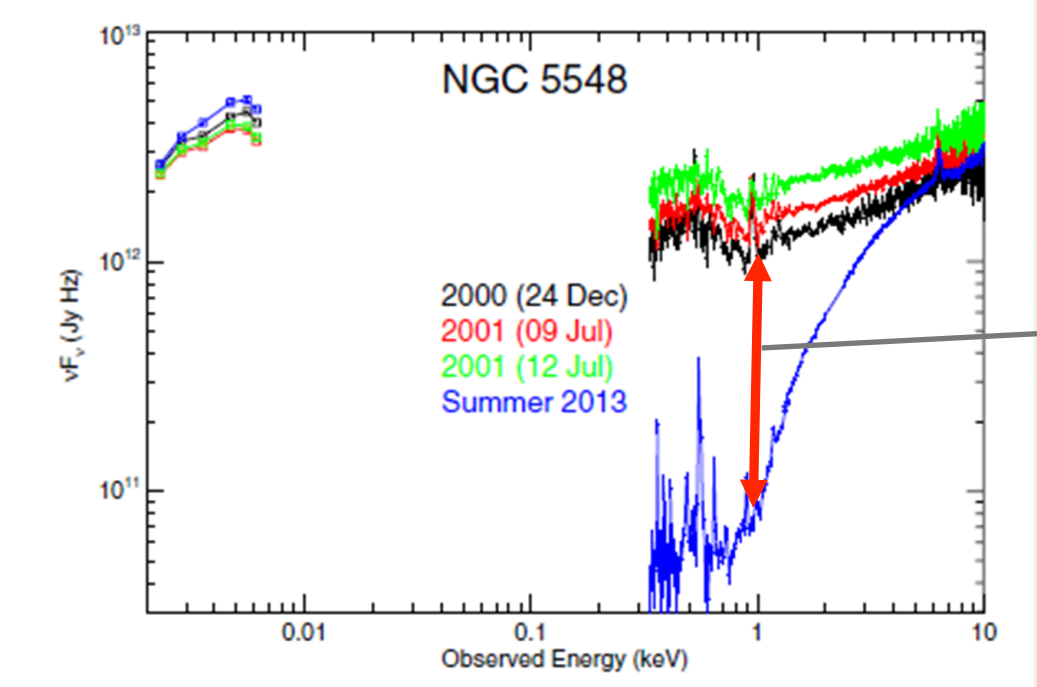
Uncertanties

We want the SED transmitted through the obscurer so we can study the outflow

We try different values for ξ, n(H) and Z to see what will happen.

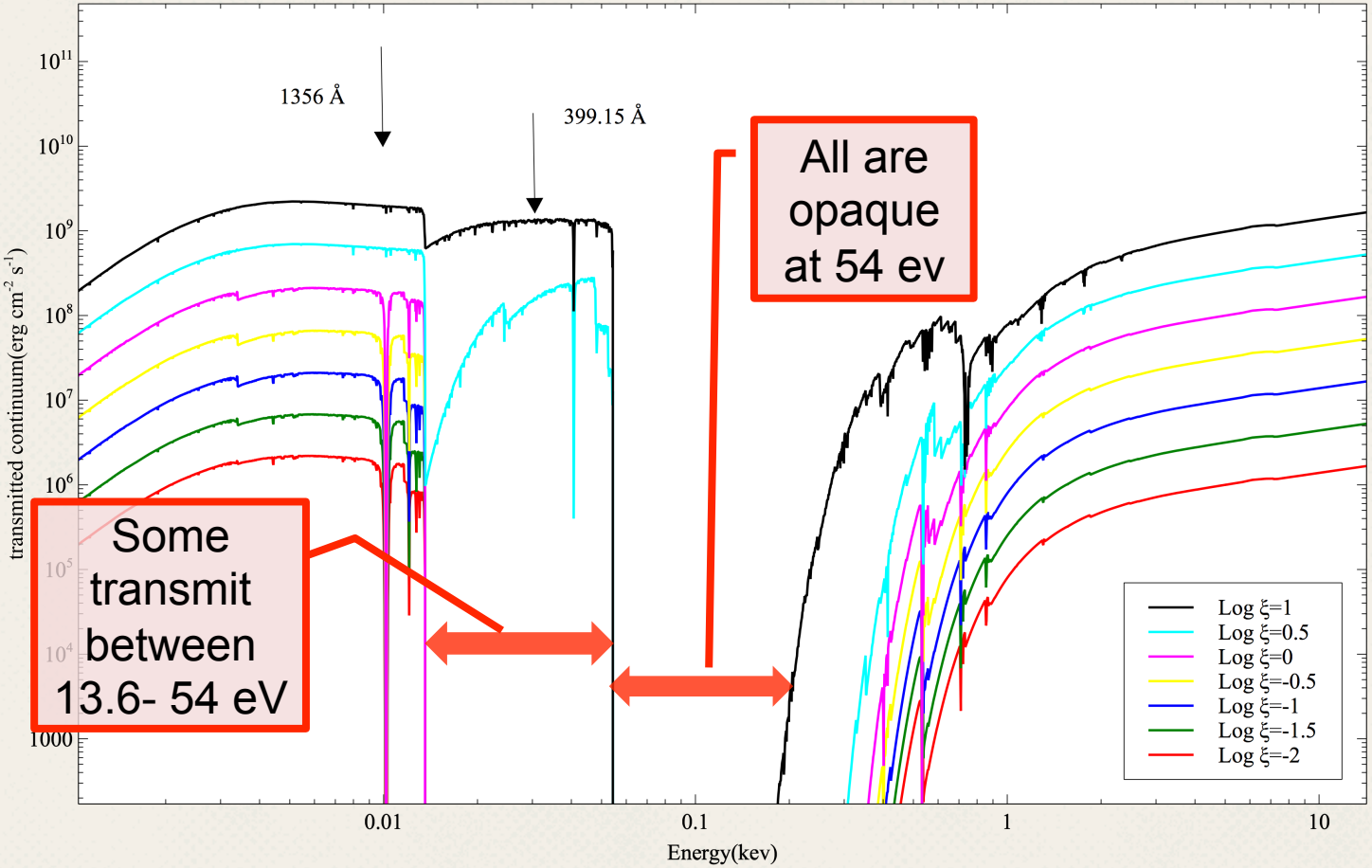
Ionization Parameter ξ

We keep the soft X-ray optical depth constant instead of column density while varying the ionization parameter.



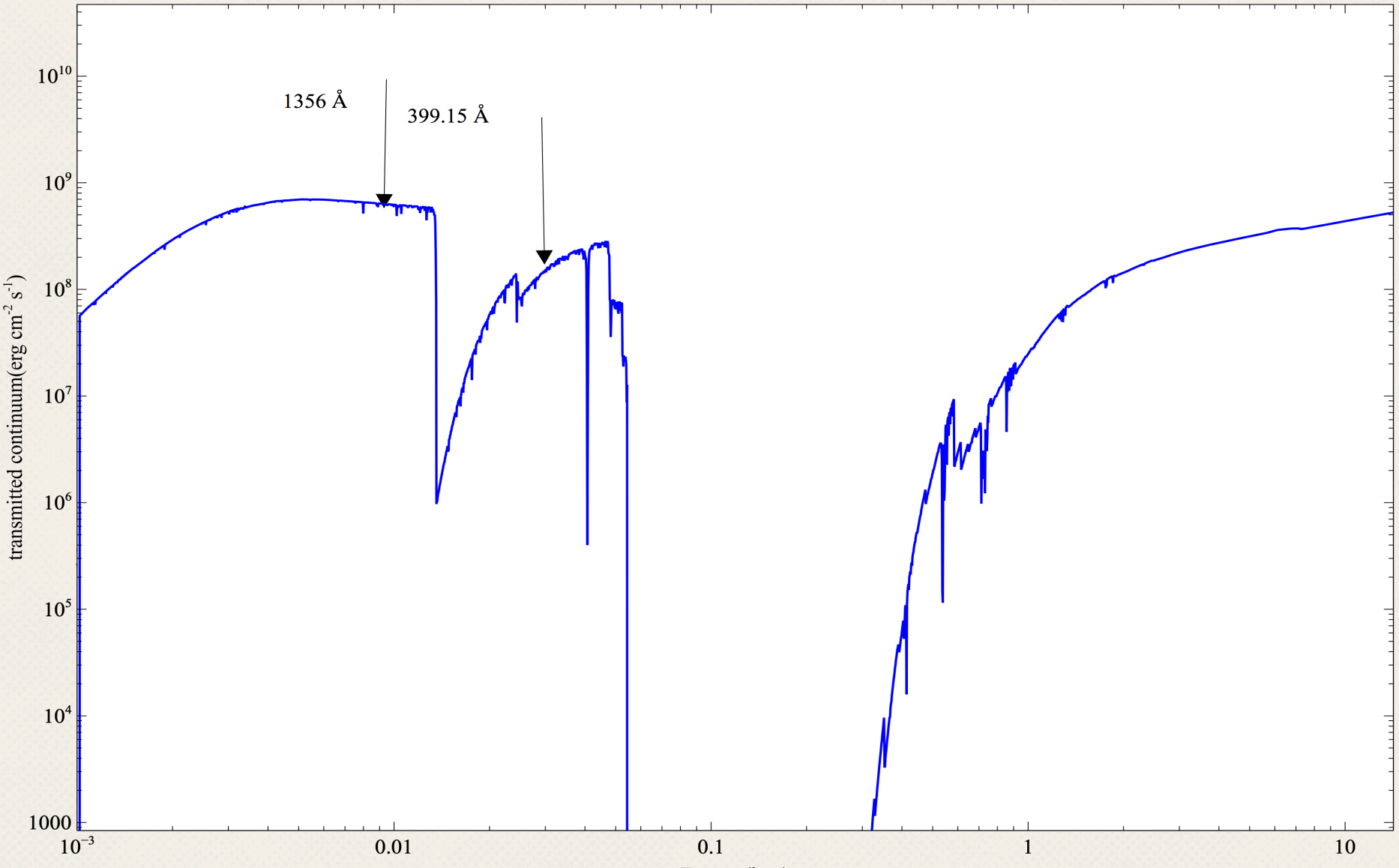
Mehdipour+15

The Obscurer SED is Very Sensitive to ξ

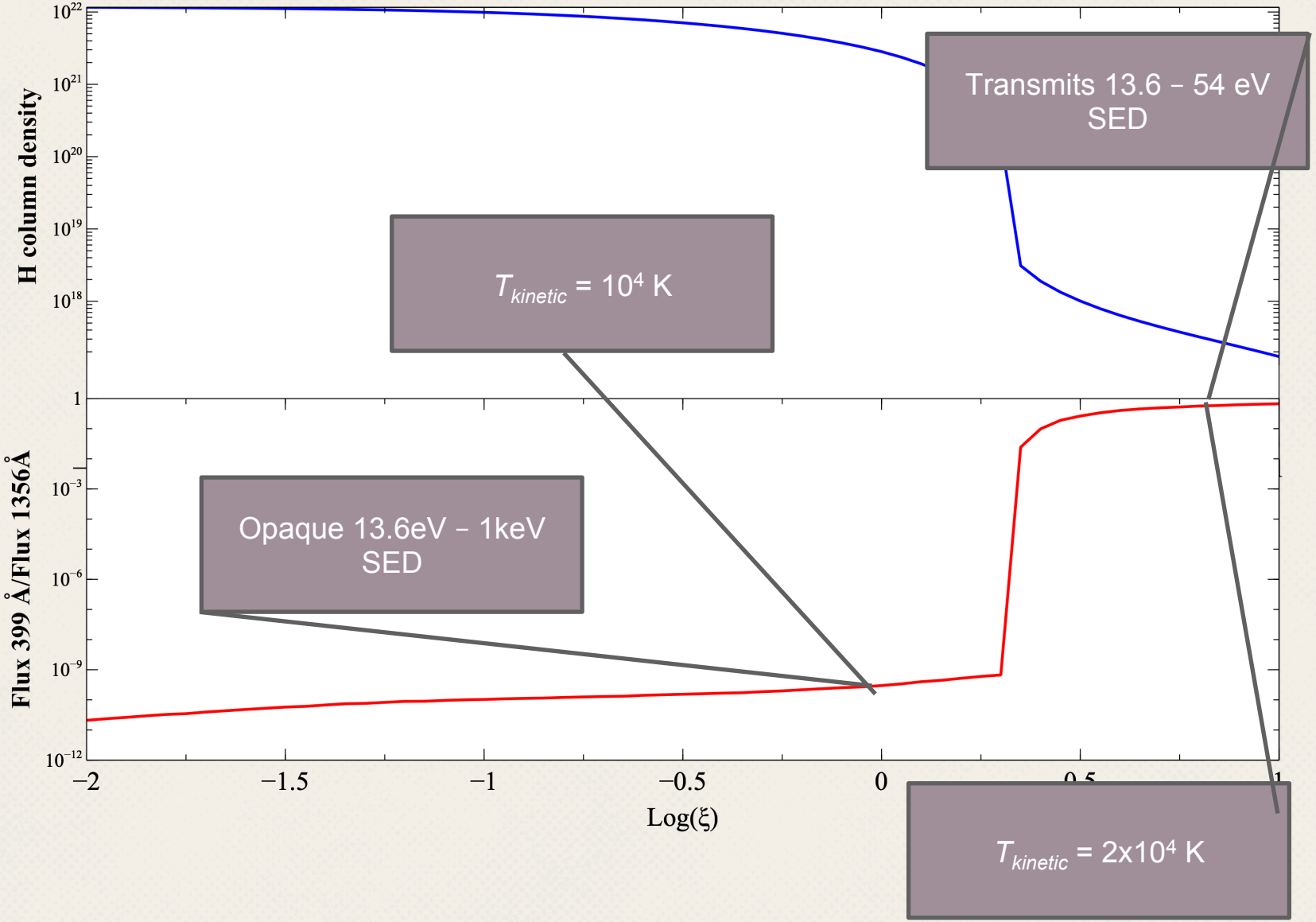


We measure the continuum at the two indicated points and vary the ionization parameter while keeping the soft X-ray extinction constant.

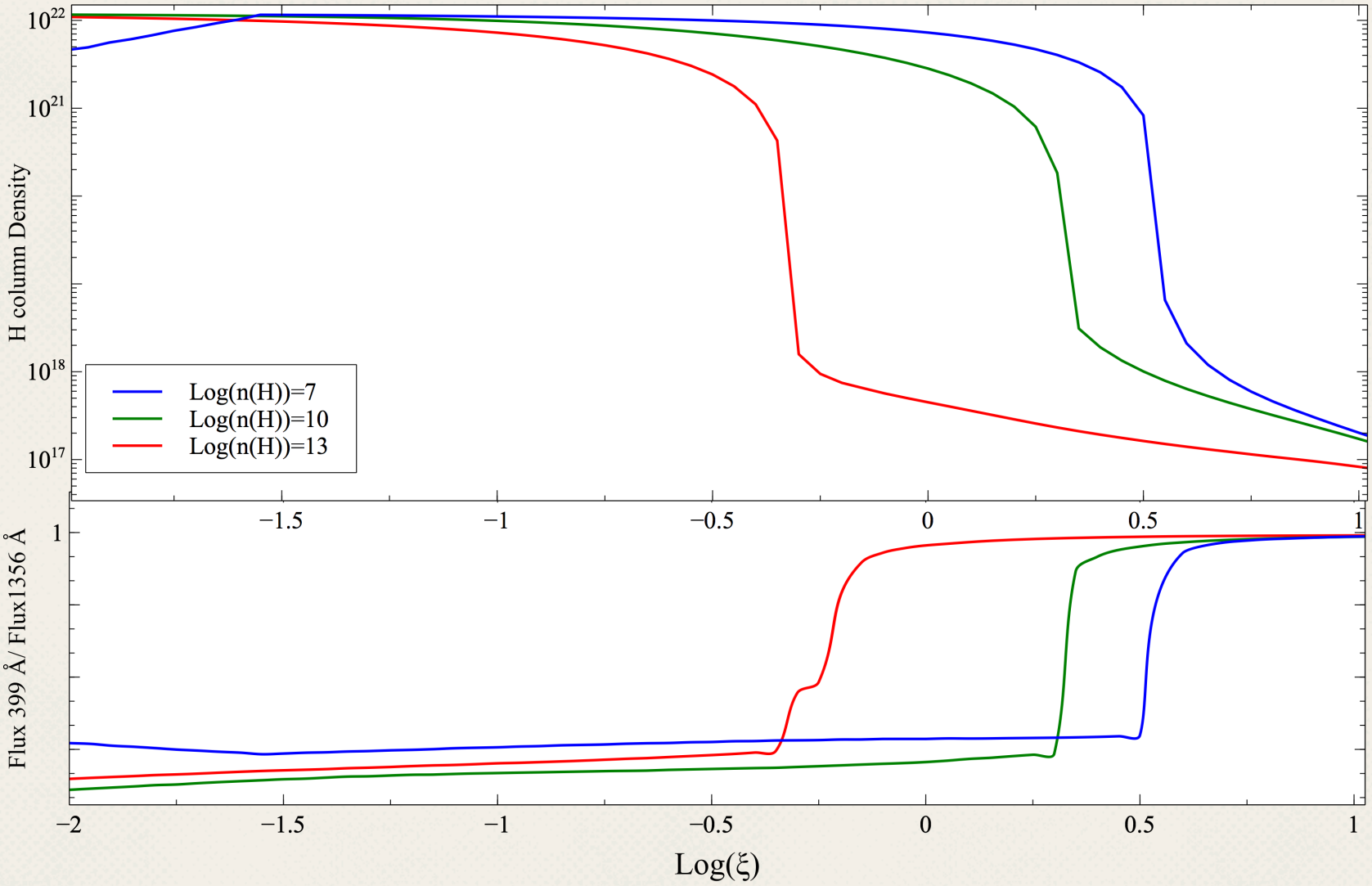
Changes in the ξ



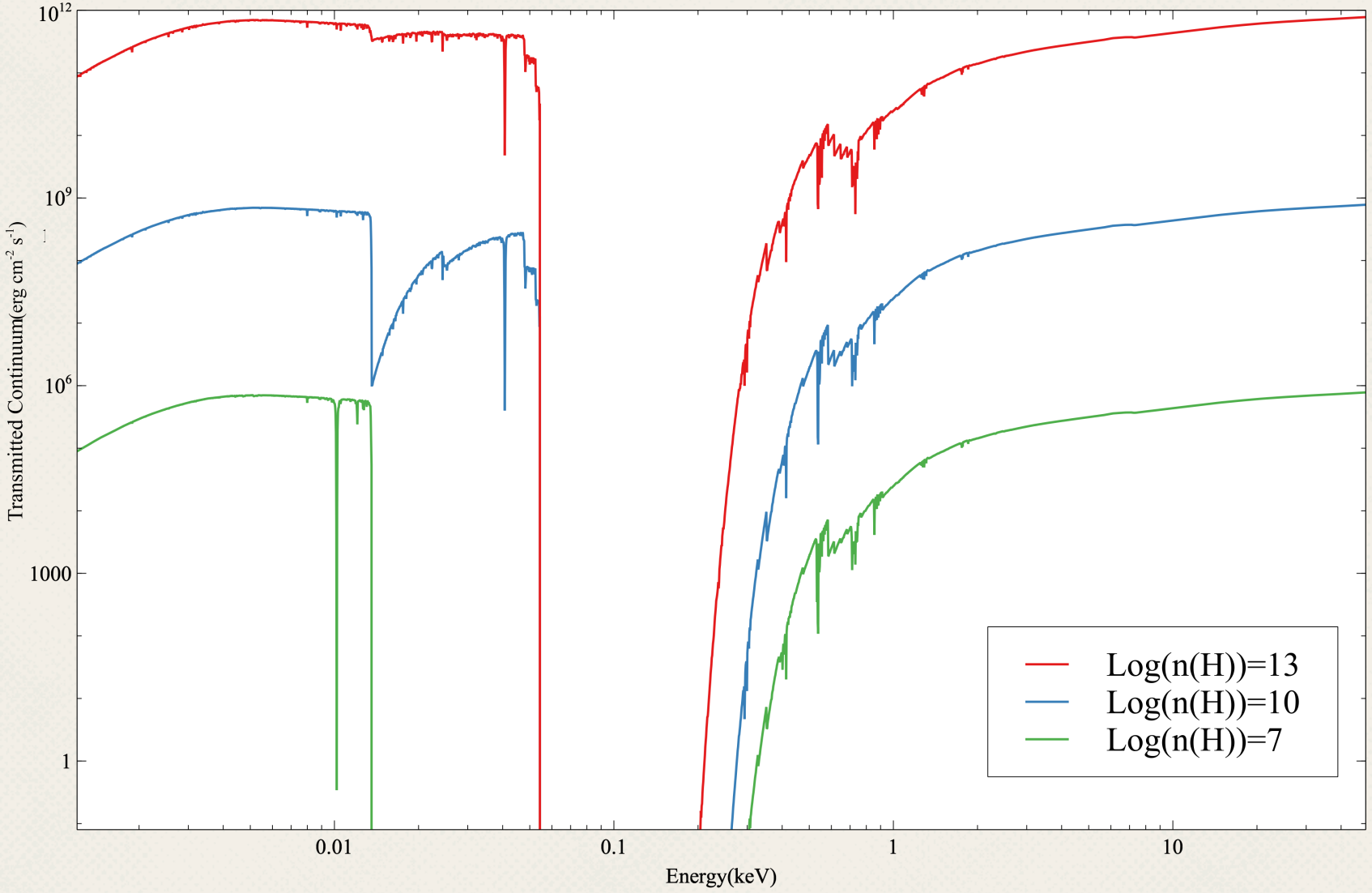
Changes in the ξ



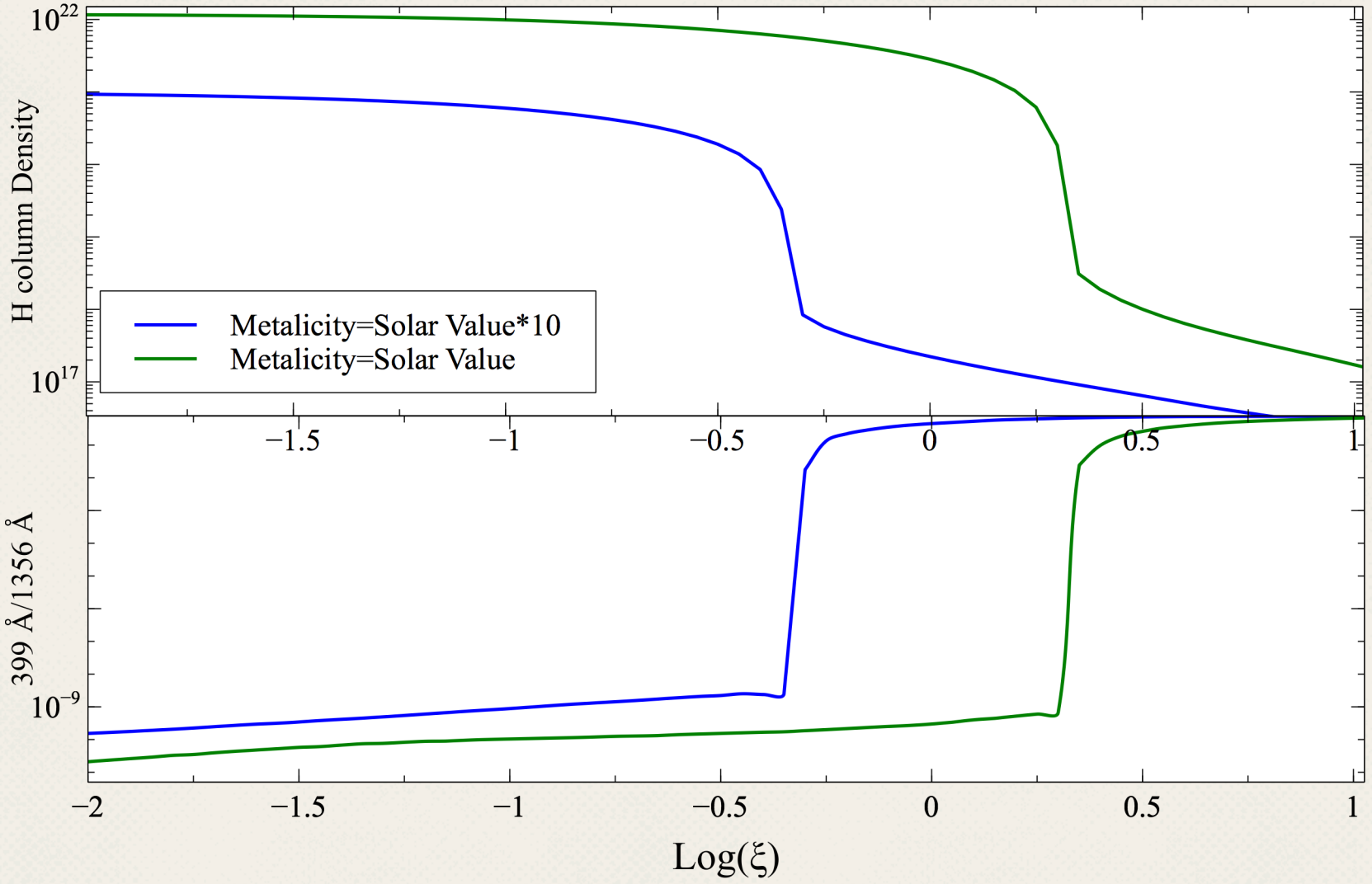
Obscurer SED is Sensitive to Hydrogen Density



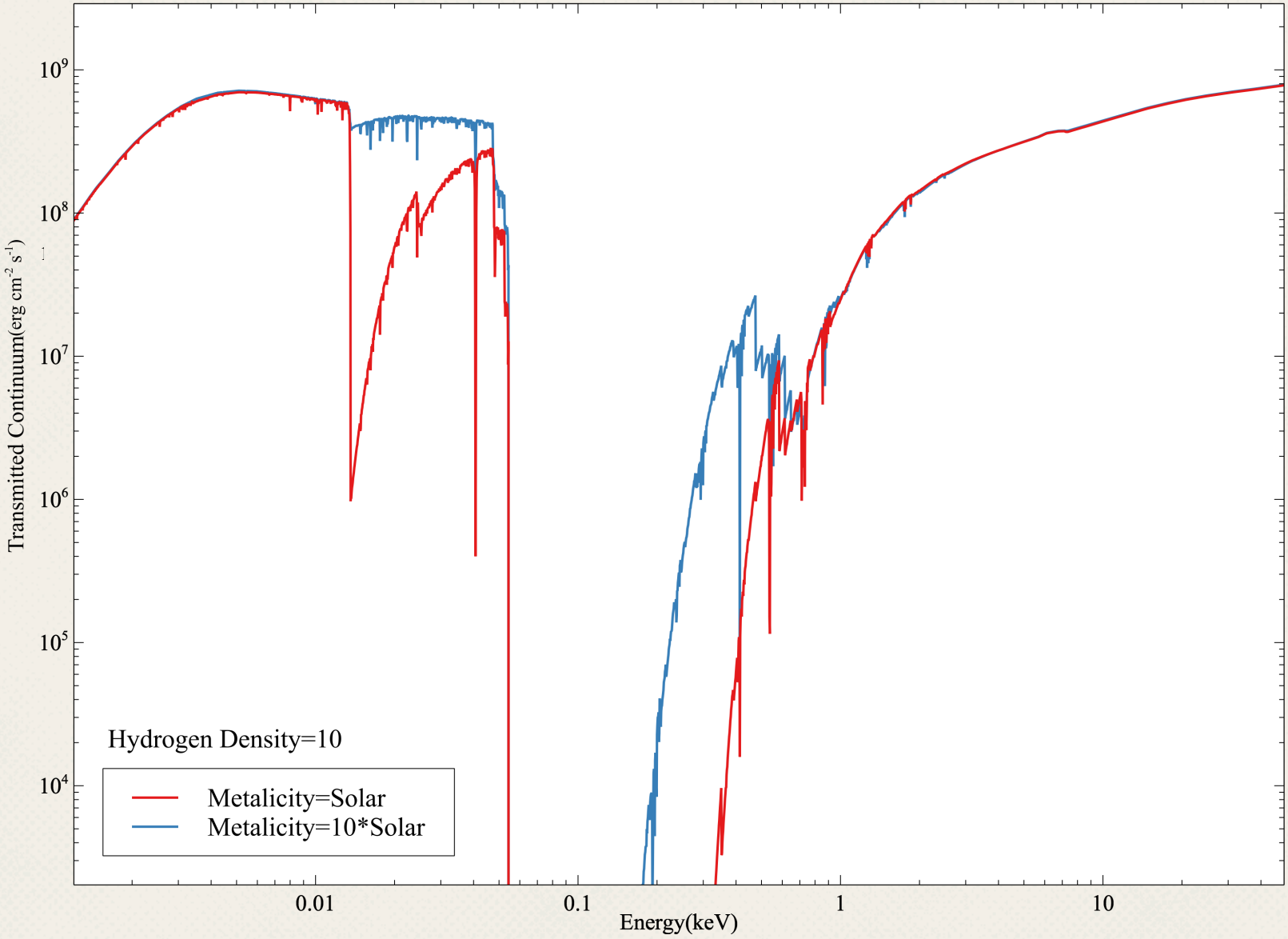
SEDs for Different Hydrogen Densities($\mathbf{Log(\xi)=0.5}$)



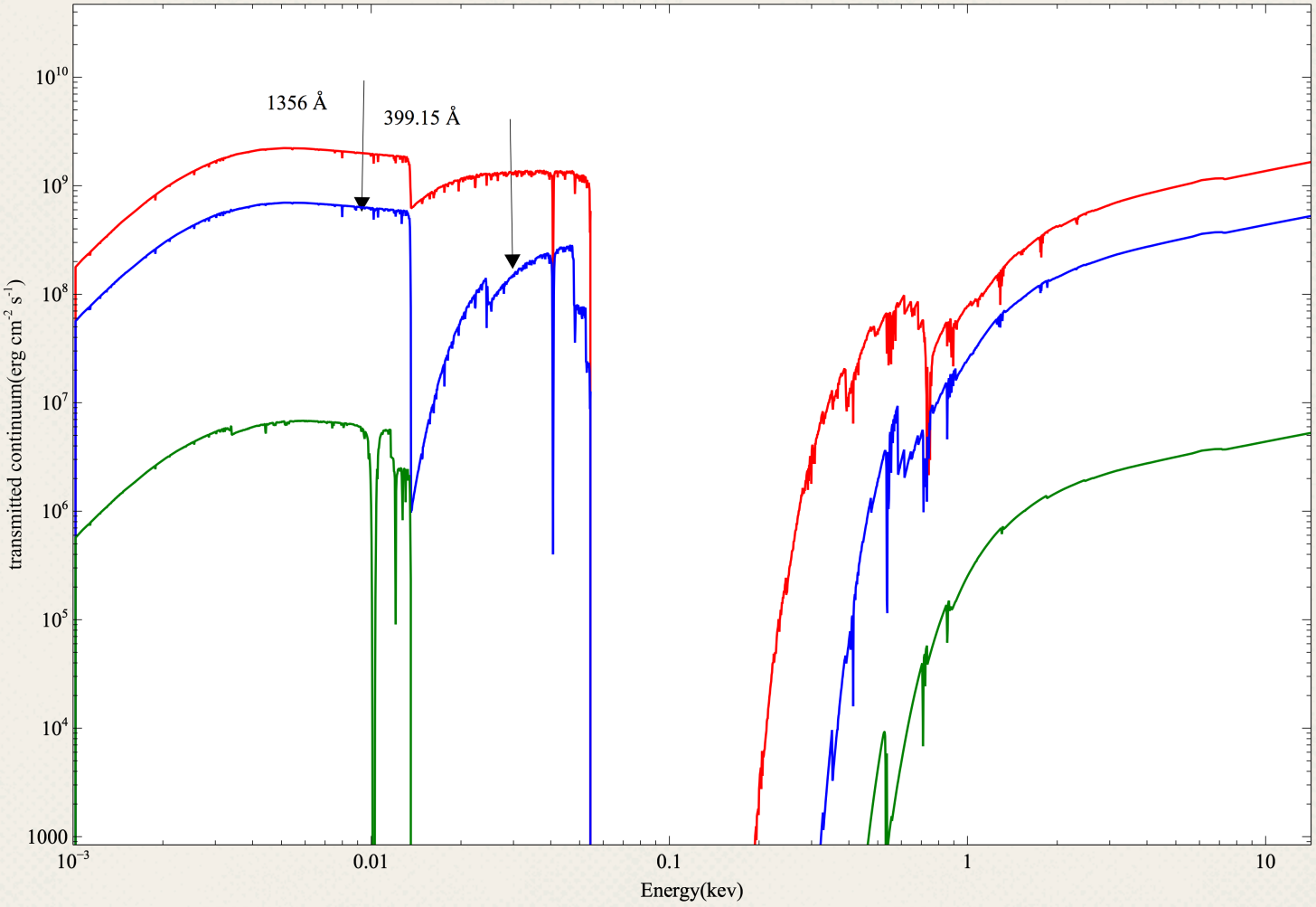
Obscurer SED is Sensitive to the Metallicity (Z) ($\mathbf{Log(\xi)=0.5}$)



SEDs for Different Metallicity



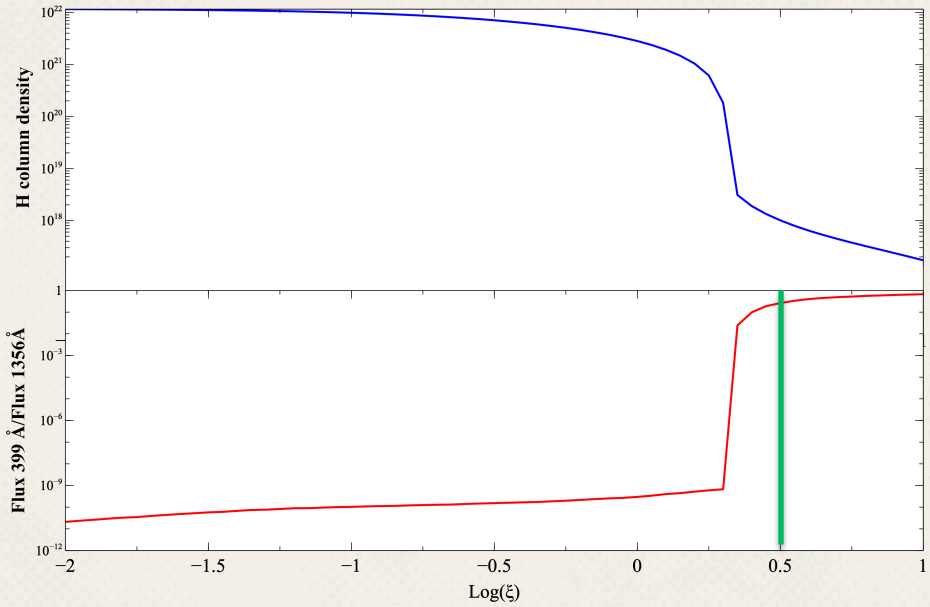
We Have Three Types of SED

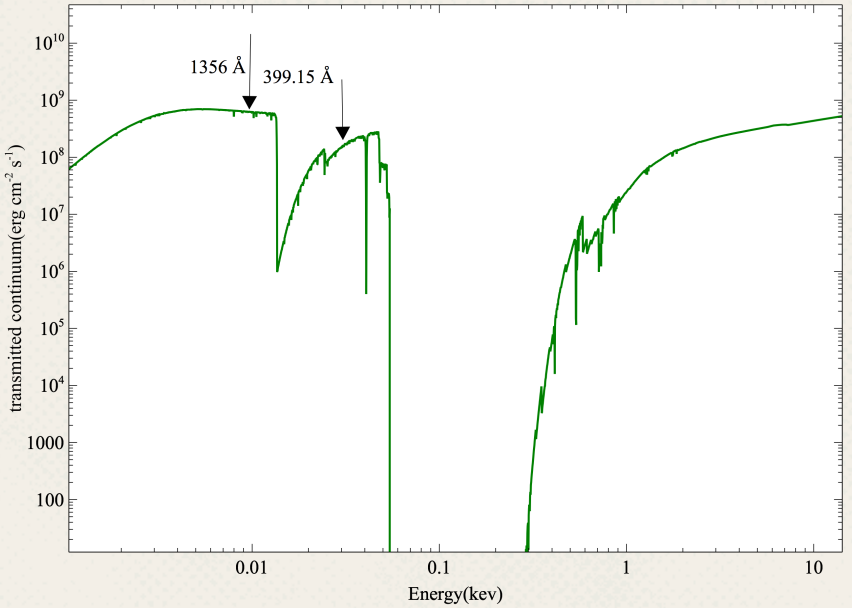


Can changes in the covering factor account for the non-correlated lines?

One of the Models:

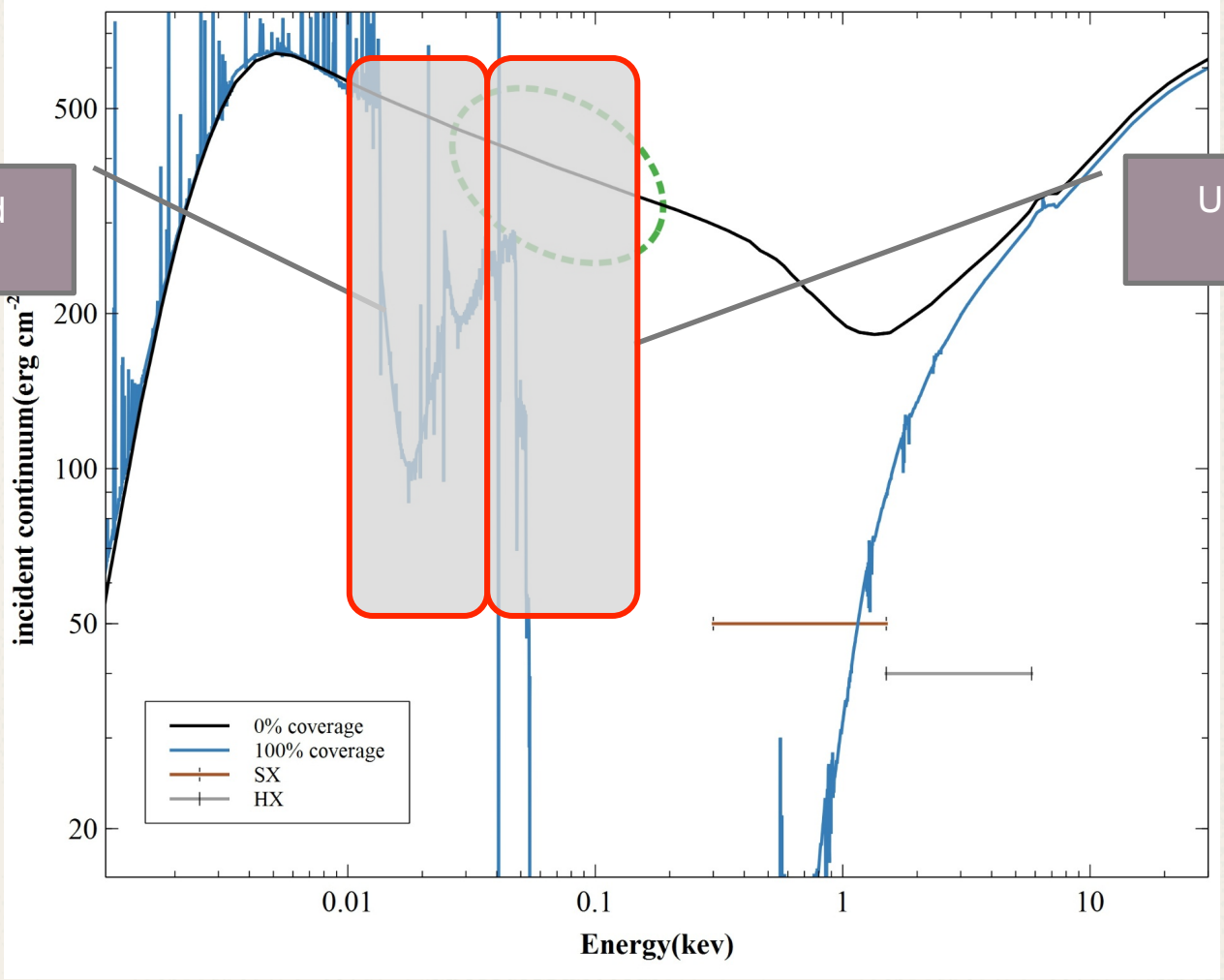
Let's focus on ξ=0.5 to examine how changes in covering factor change the absorption lines





Mehdipour's Model Using the Log(ξ)=0.5

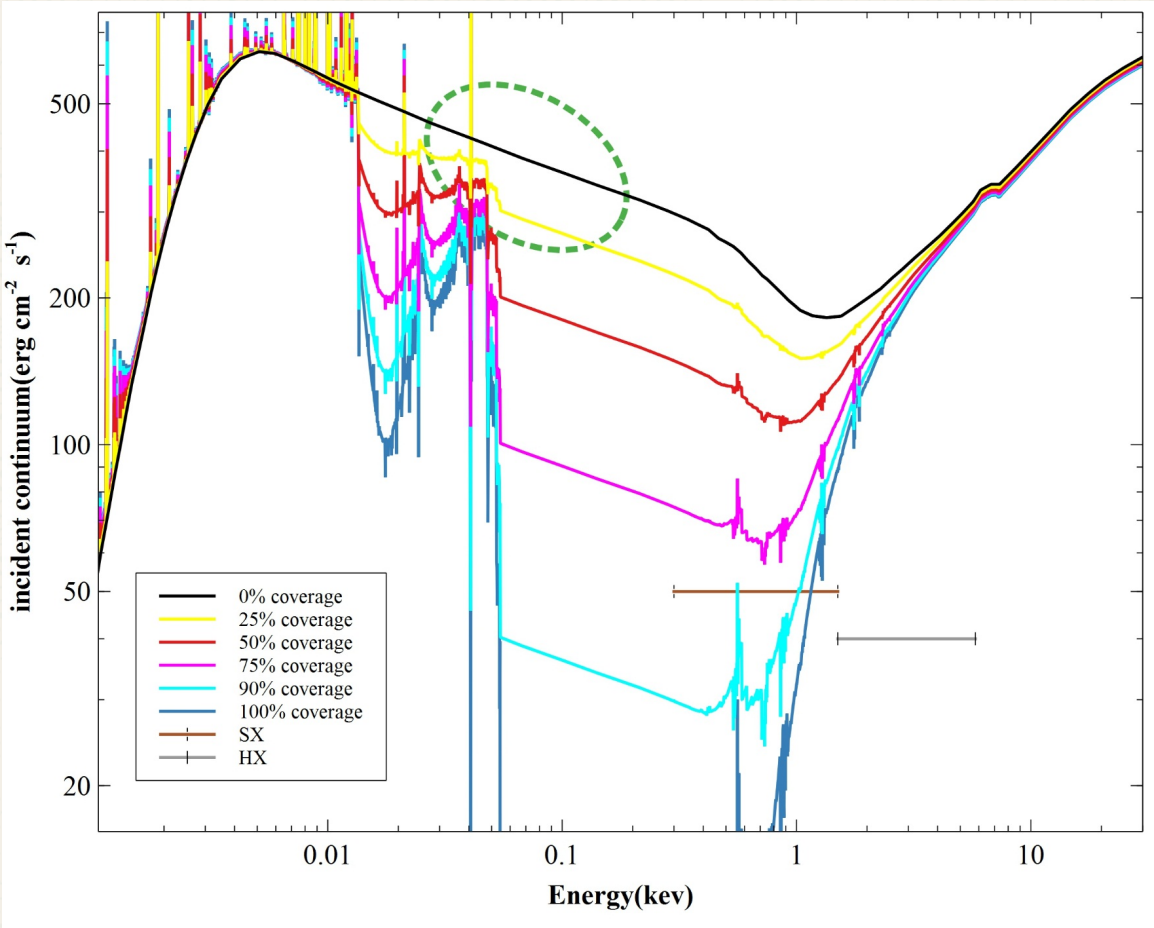
Correlated species



Uncorrelated species

The Covering Factor

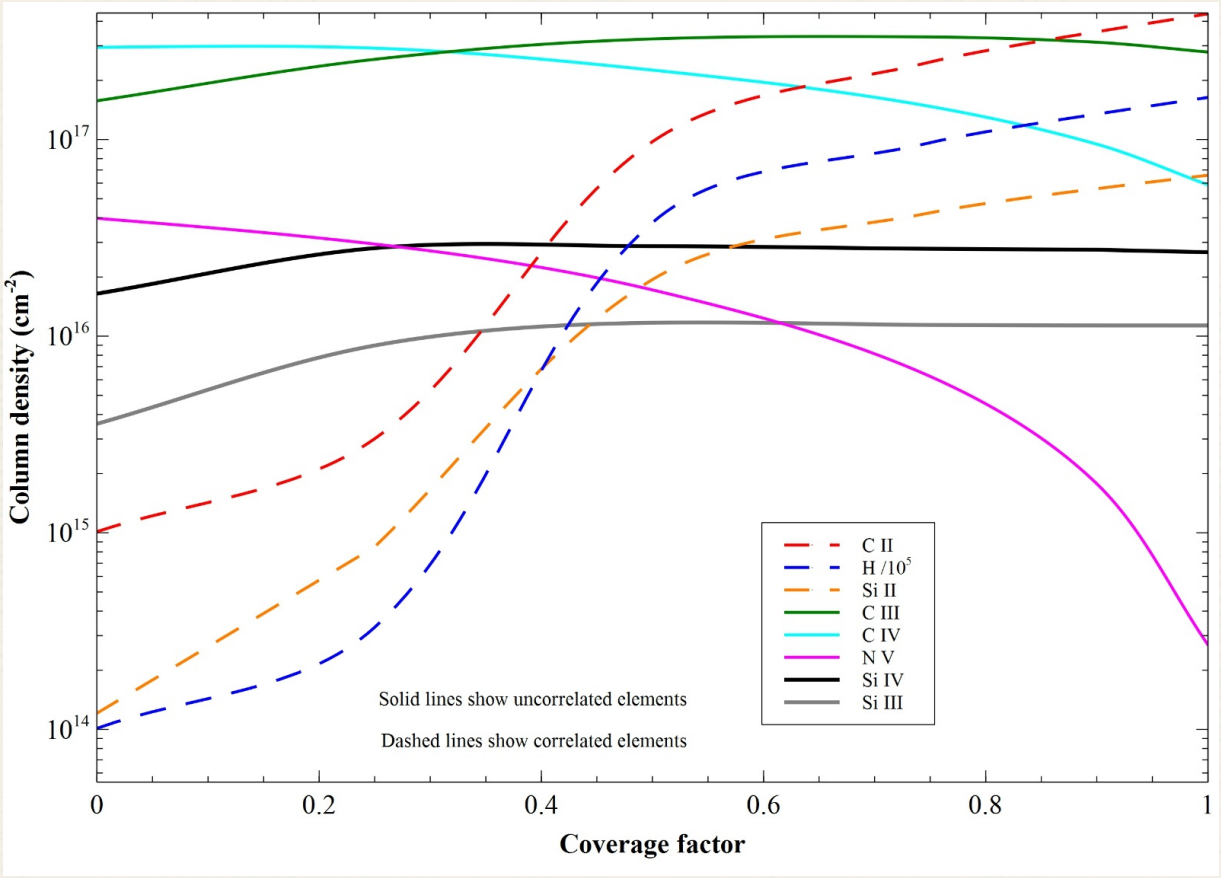
In these six models, $\nu F(\nu)$ in the HST UV is kept constant and the obscurer covering factor changes.



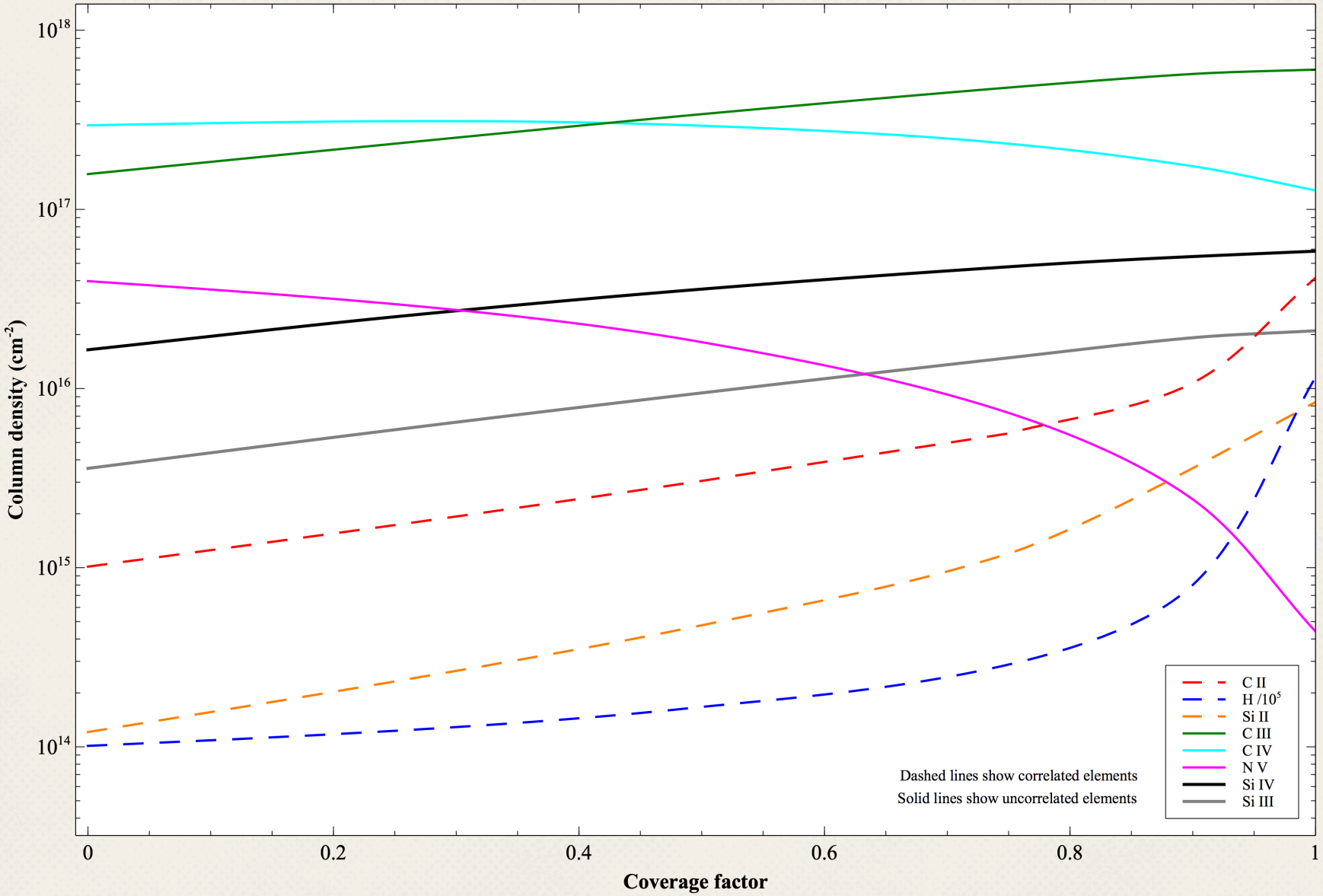
Outflow`s Column Density

Dashed lines show the three species which were highly correlated during the campaign.

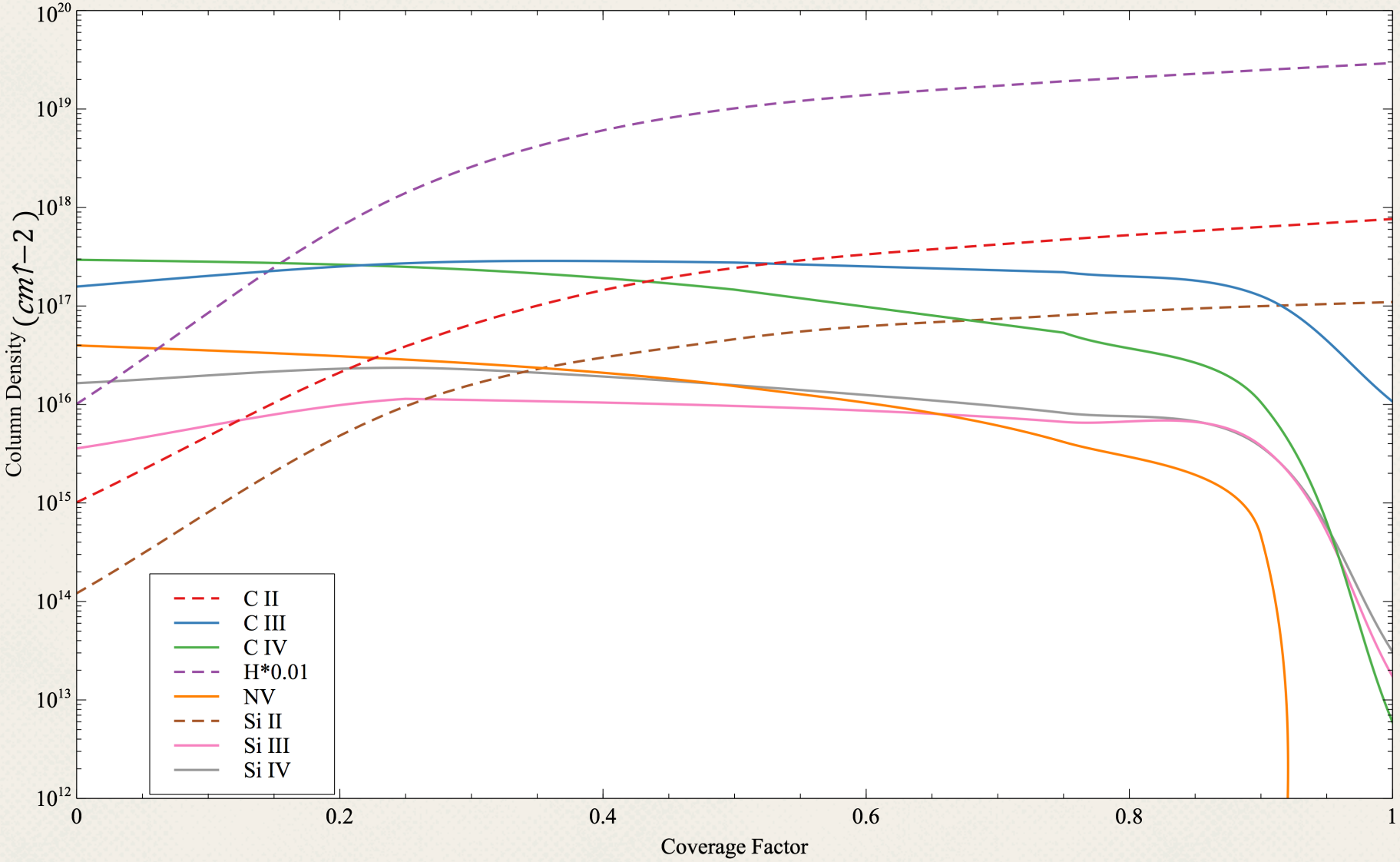
Changes in the obscurer covering factor can NOT reproduce the correlated / uncorrelated changes.



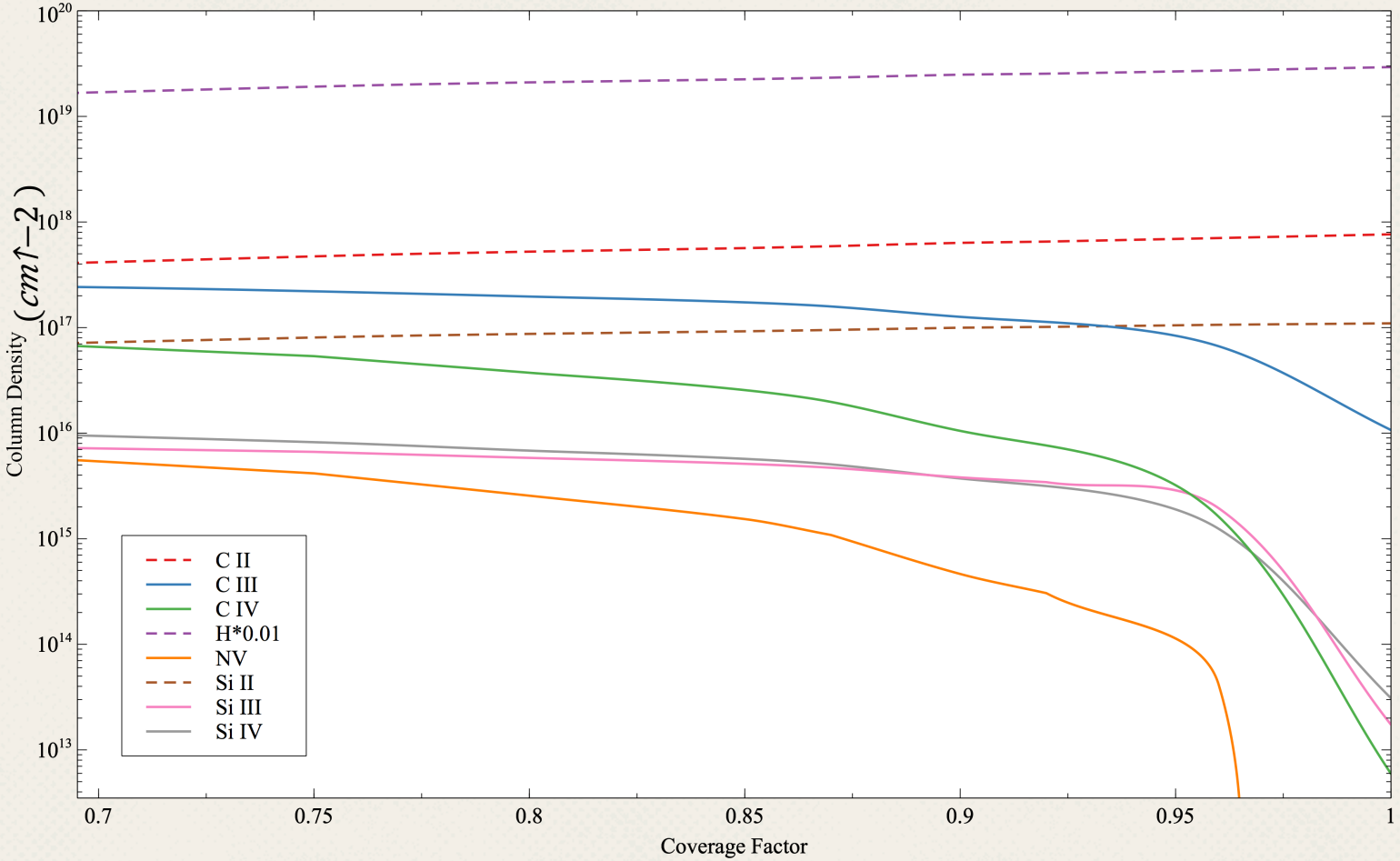
Outflow`s Column Density



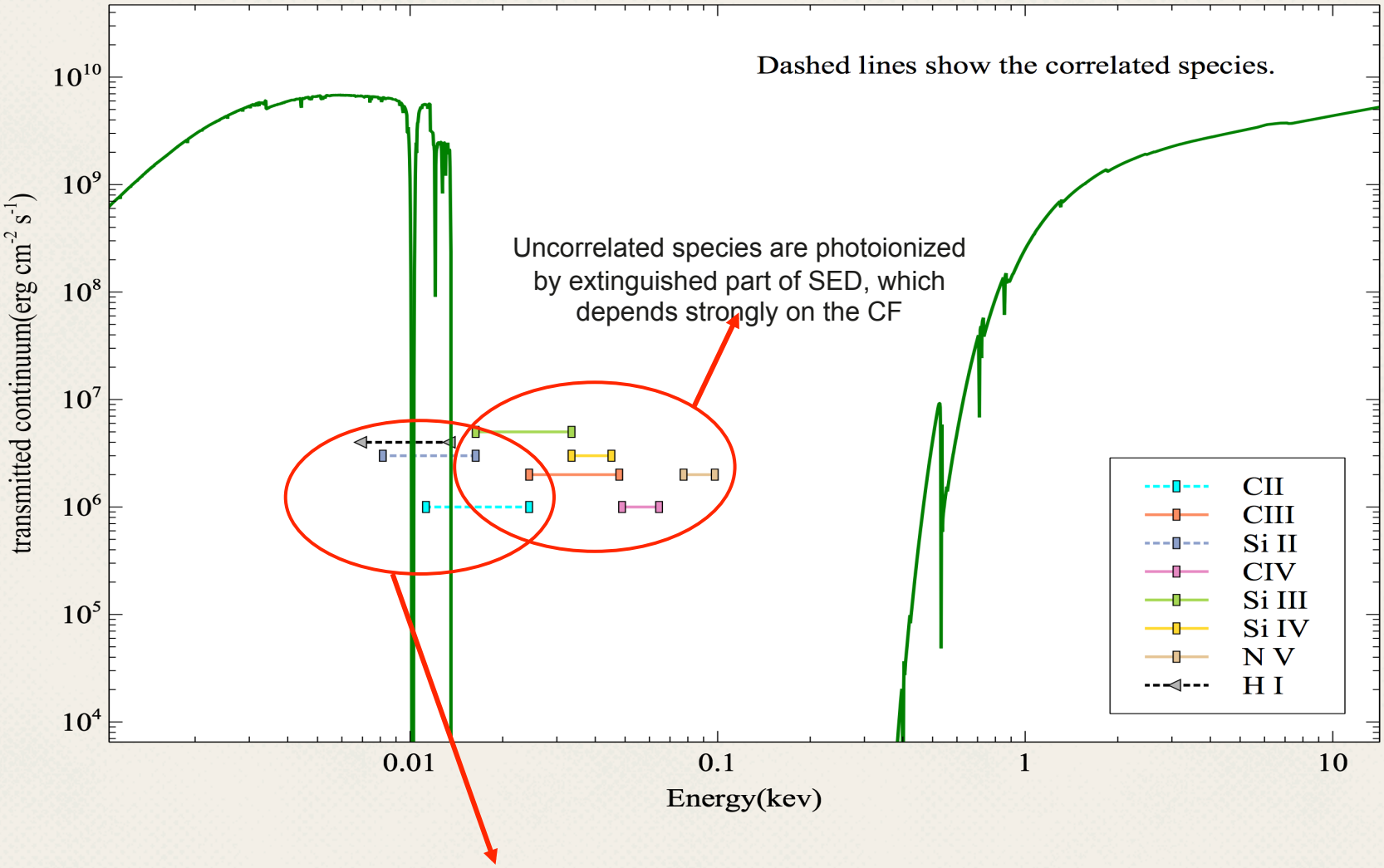
Outflow`s Column Density



The Coverage Factor is 86%

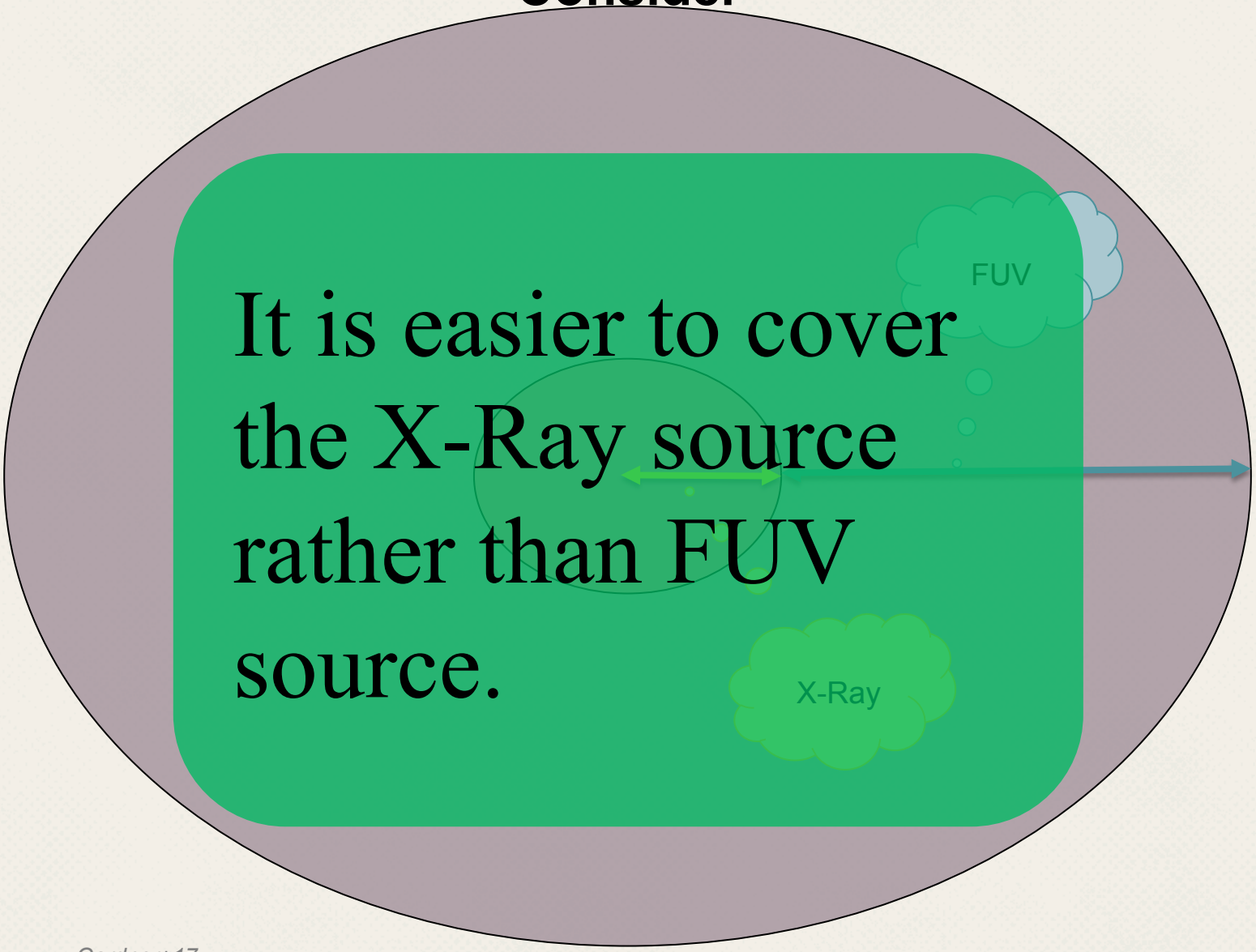


Mehdipour`s Model



Correlated species are photoionized by the HST continuum longward of 912 *A*

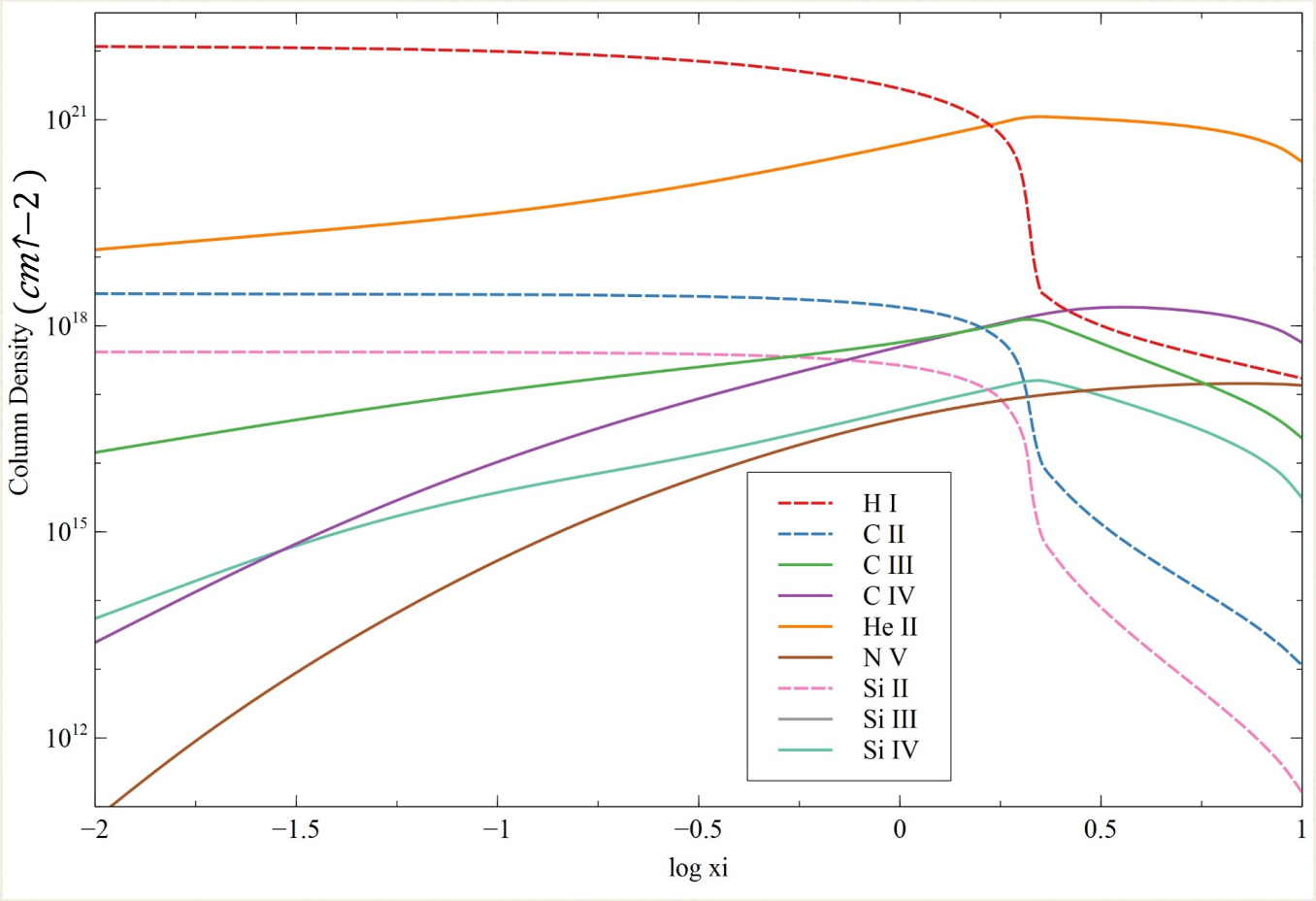
Another Uncertainty to Consider



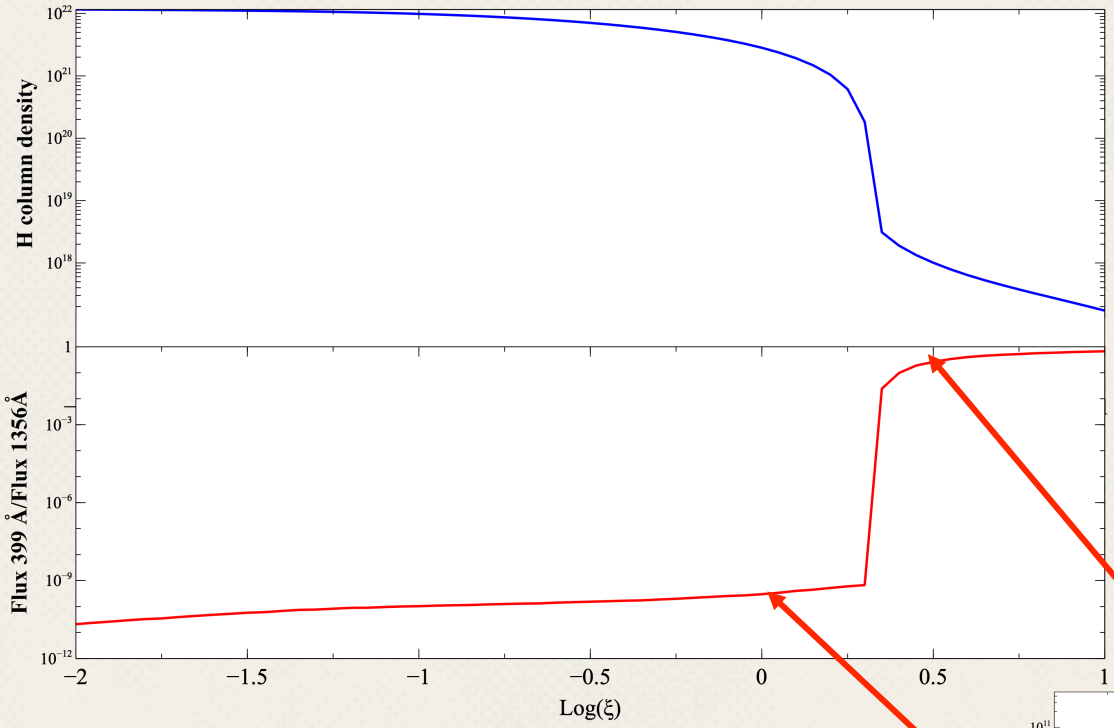
Gardner+17

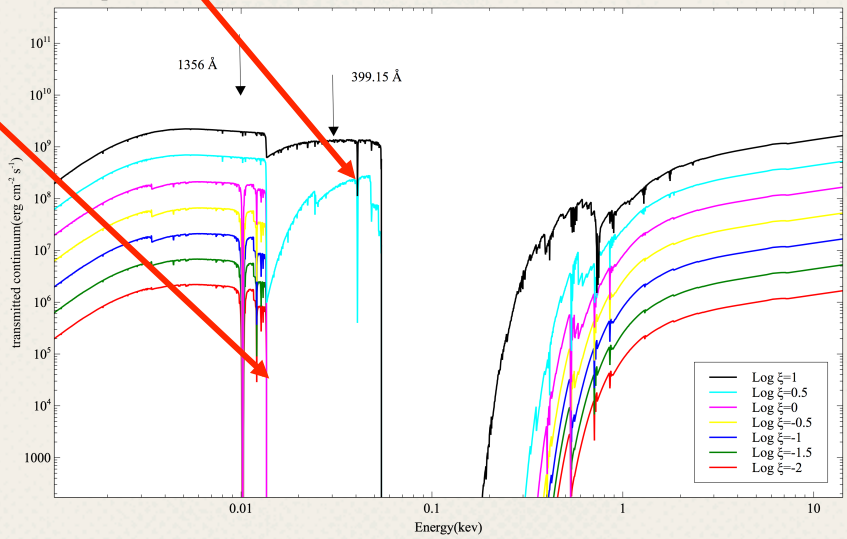
Future Work

Obscurer's Column Density



The Holiday???





- Small change in luminosity and ionization parameter results in *many* dex change in XUV continuum
- This would produce unexpectedly large changes in emission lines

Conclusions

Changes in absorption column densities exist in a way that lower ionization species correlate with the HST continuum and higher ionization species are uncorrelated.

During the HST campaign the obscurer covering factor can change. This produces very large changes in the XUV SED, and more modest changes in the soft X-Ray SED.

As a result, low ionization species are mainly affected by changes in the luminosity while high ionization-potential species are also affected by changes in the obscurer covering factor.

- In Mehdipour’s standard model, the SED is blocked between UV and X-Ray. Using this model, we predicted absorption line correlation/ uncorrelation similar to that observed.

- In all of the models the behavior of N V is predicted to be different from other uncorrelated species. The reason is that it has the highest ionization potential.

- We propose to investigate the effects of the partial transmission on the emission lines and the BLR holiday.

Thank you!