Chasing Obscuring Outflows in AGN: Broad, Fast, UV and X-ray Absorption in NGC 3783 and other AGN

Gerard Kriss
STScI

Collaborators: Jelle Kaastra, Missagh Mehdipour, Nahum Arav, Ehud Behar, Massimo Cappi, P. O. Petrucci, Jacobo Ebrero, Julia Lee, Anna Lia Longinotti, Mike Crenshaw, Gisella de Rosa, Brad Peterson & many others

The Importance of Outflows in AGN

- ★ Nuclear outflows powered by AGN can provide negative feedback that quenches star formation and halts the growth of the host galaxy.
- ★ Feedback of 0.5—5% of the AGN Eddington luminosity is usually required.
- ★ Outflows are frequently seen as blue-shifted UV and X-ray absorption. Coordinated observing campaigns have determined the location and physical properties of outflows in many objects.
- ★ In low luminosity, local AGN (typically Seyfert 1s), the outflows are usually weaker than required for effective feedback, having low outflow velocities and low total column densities.
- ★ However, frequent monitoring of bright Seyfert 1s over the past two decades with HST, Chandra, and XMM-Newton has now revealed cases of transient obscuration with high velocity and high column density that may arise from the accretion disk.

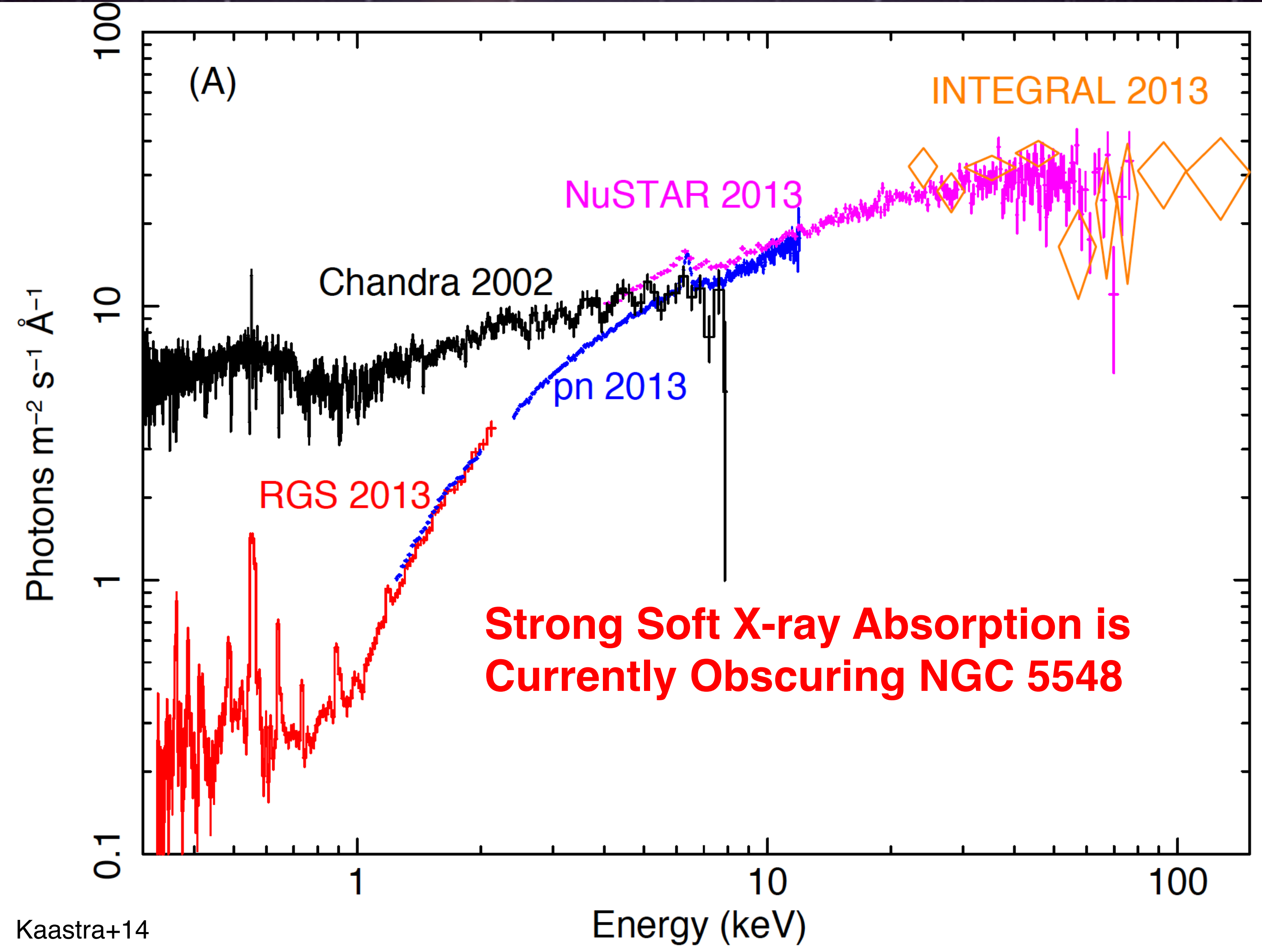
The Importance of Outflows in AGN

- Nuclear outflows powered by AGN can provide negative feedback that quenches star formation and halts the growth of the host galaxy.
- Feedback of 0.5—5% of the AGN Eddington luminosity is usually required.
- Outflows are frequently seen as blue-shifted UV and X-ray absorption. Coordinated observing campaigns have determined the location and physical properties of outflows in many objects.
- In low luminosity, local AGN (typically Seyfert 1s), the outflows are usually weaker than required for effective feedback, having low outflow velocities and low total column densities.
- However, frequent monitoring of bright Seyfert 1s over the past two decades with HST, Chandra, and XMM-Newton has now revealed cases of transient obscuration with high velocity and high column density that may arise from the accretion disk.

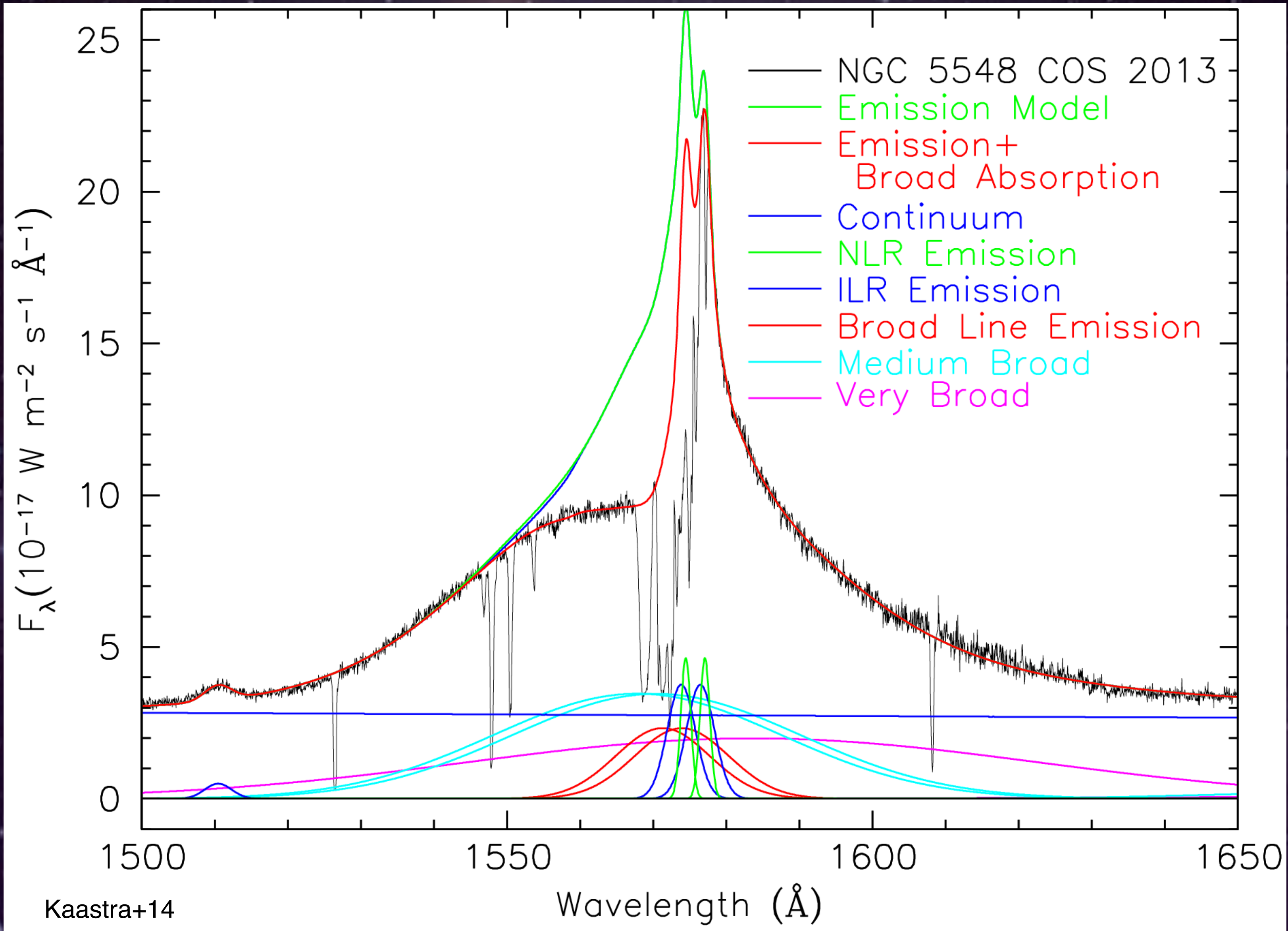
Outline for this Talk

- ★ **Discovery of Obscuring Outflows in AGN**
  - NGC 5548
- ★ **The New Obscuring Outflow in NGC 3783**
  - Modeling the UV absorption
  - Why contemporaneous UV and X-ray Observations are important
- ★ **Other Examples of Obscurers and their Associated Outflows**
  - Mrk 335, NGC 985, NGC 4151, NGC 3516
  - PG1211+143—Not an obscurer, but a UFO with a UV counterpart
- ★ **Statistics of Archival Examples of Obscuring Outflows**
- ★ **Conclusions**

Changes in the X-ray Spectrum of NGC 5548

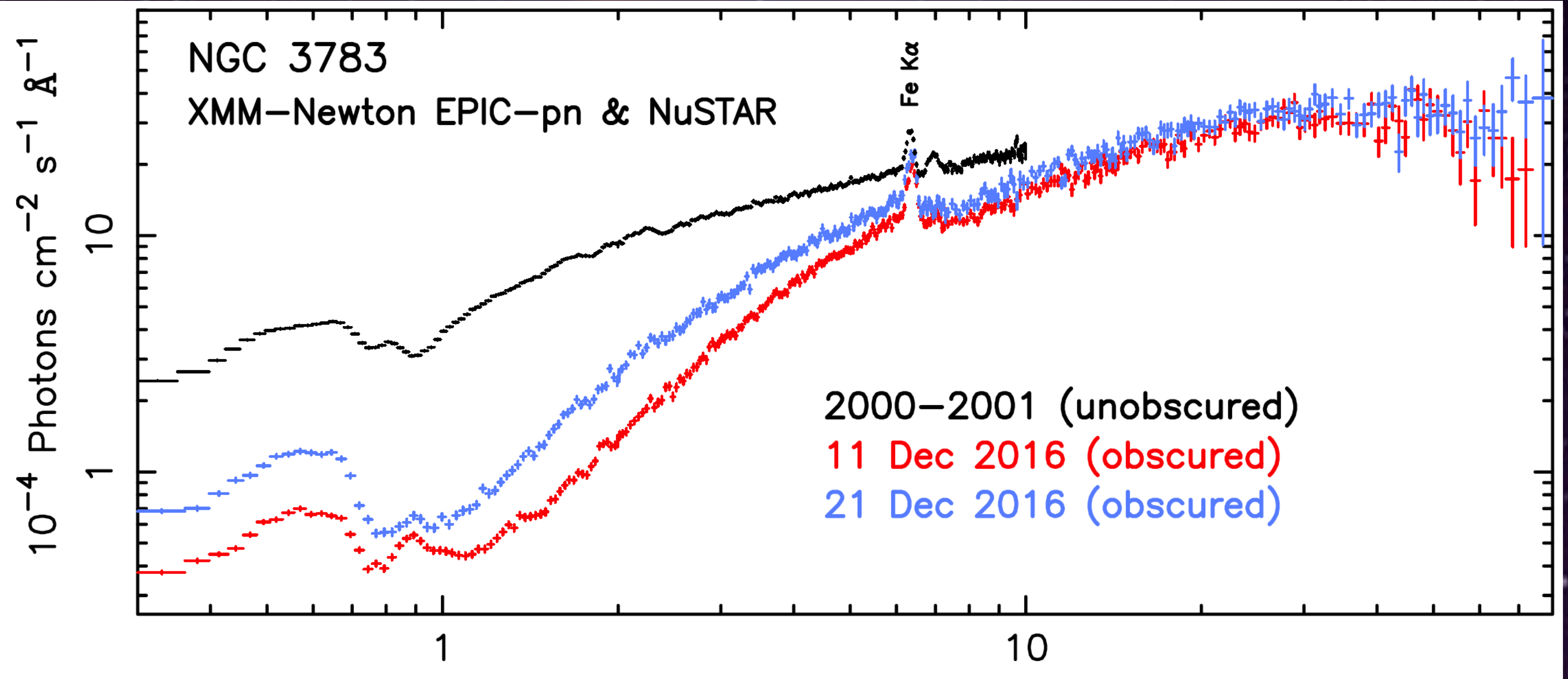


Broad C IV Absorption in NGC 5548



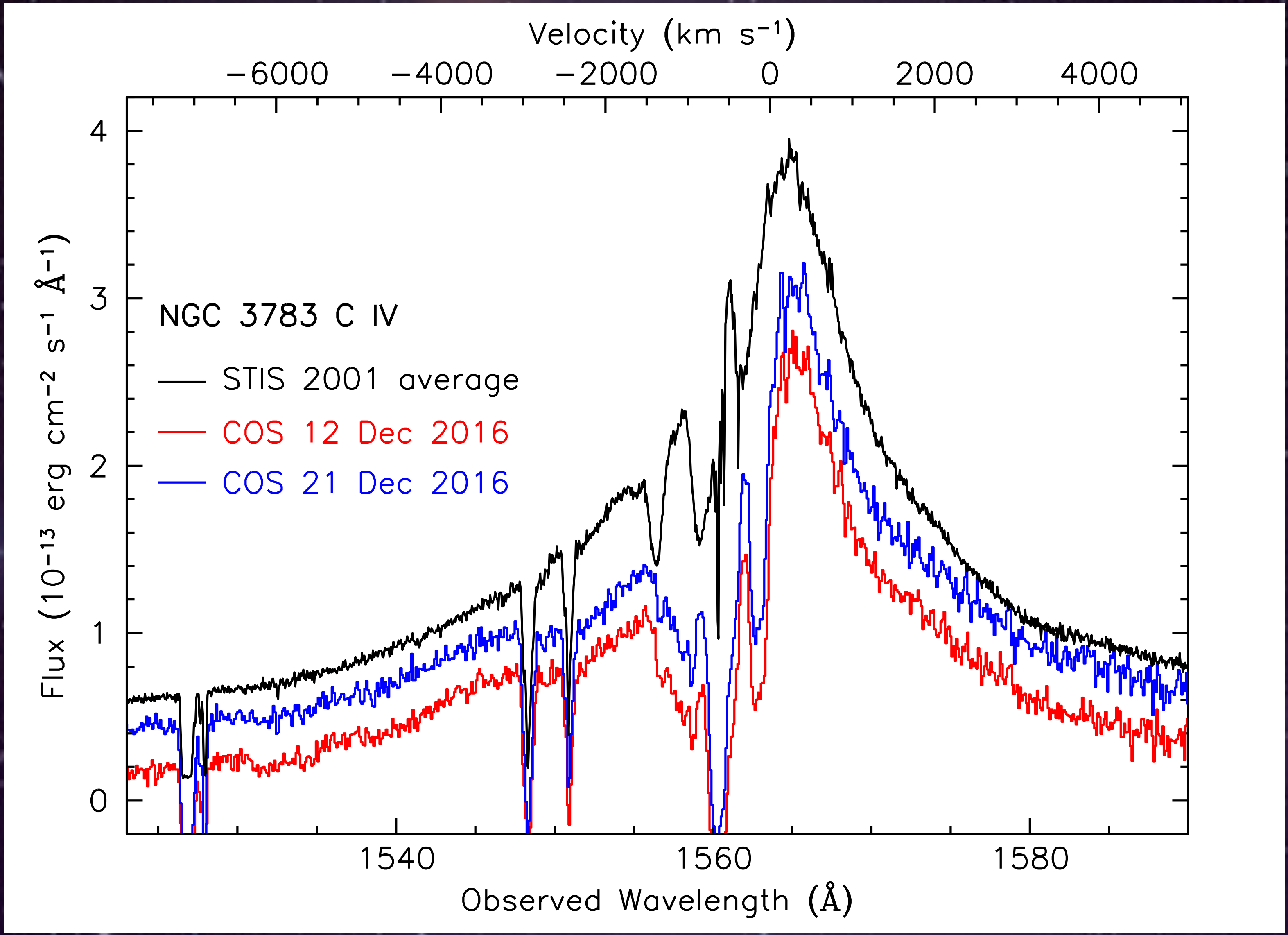
Obscuration Event in NGC 3783 in December 2016

XMM-Newton pn + NuSTAR Spectra

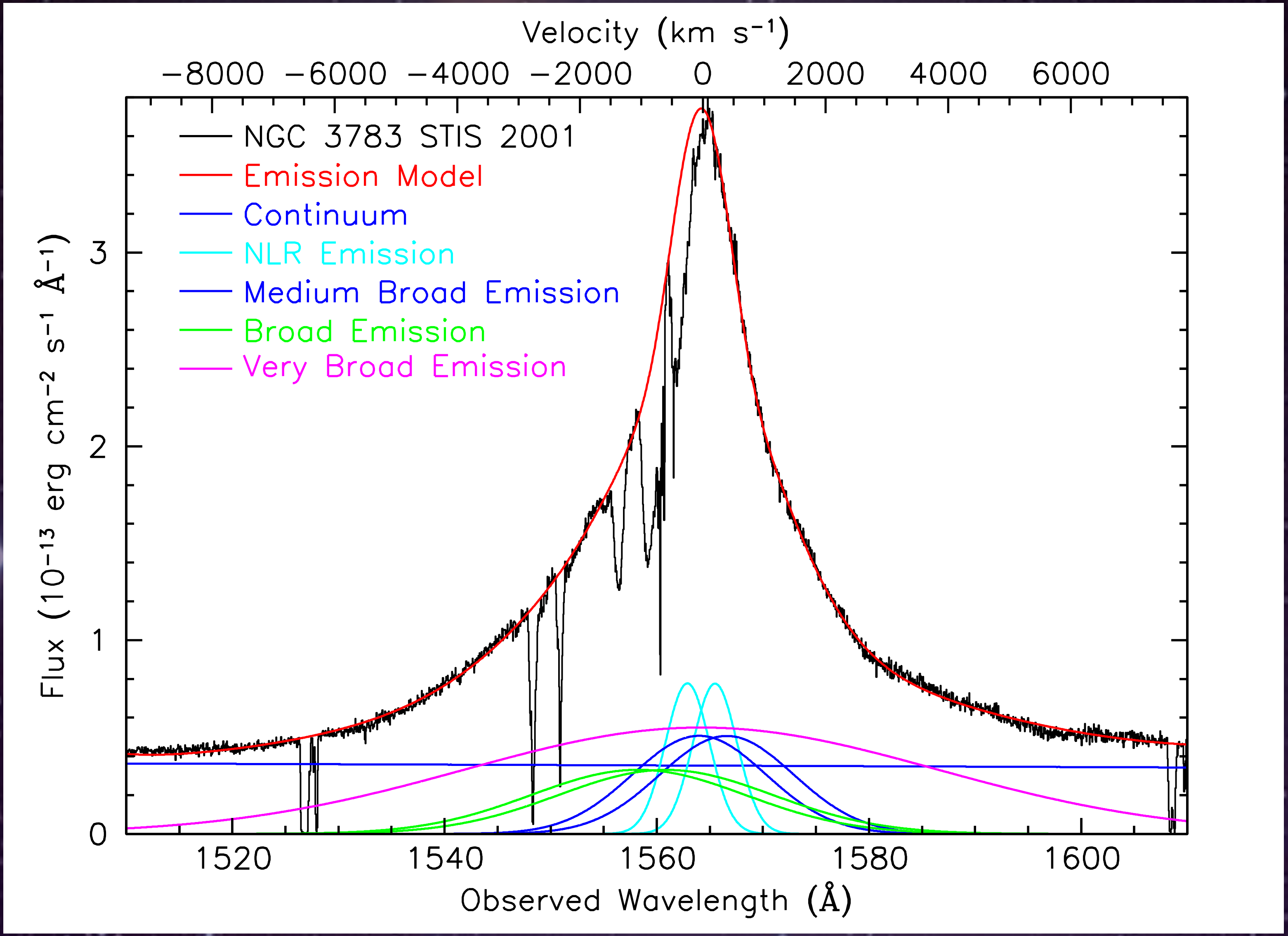


Mehdipour et al. 2017

Comparison of HST/COS C IV Profiles in NGC 3783

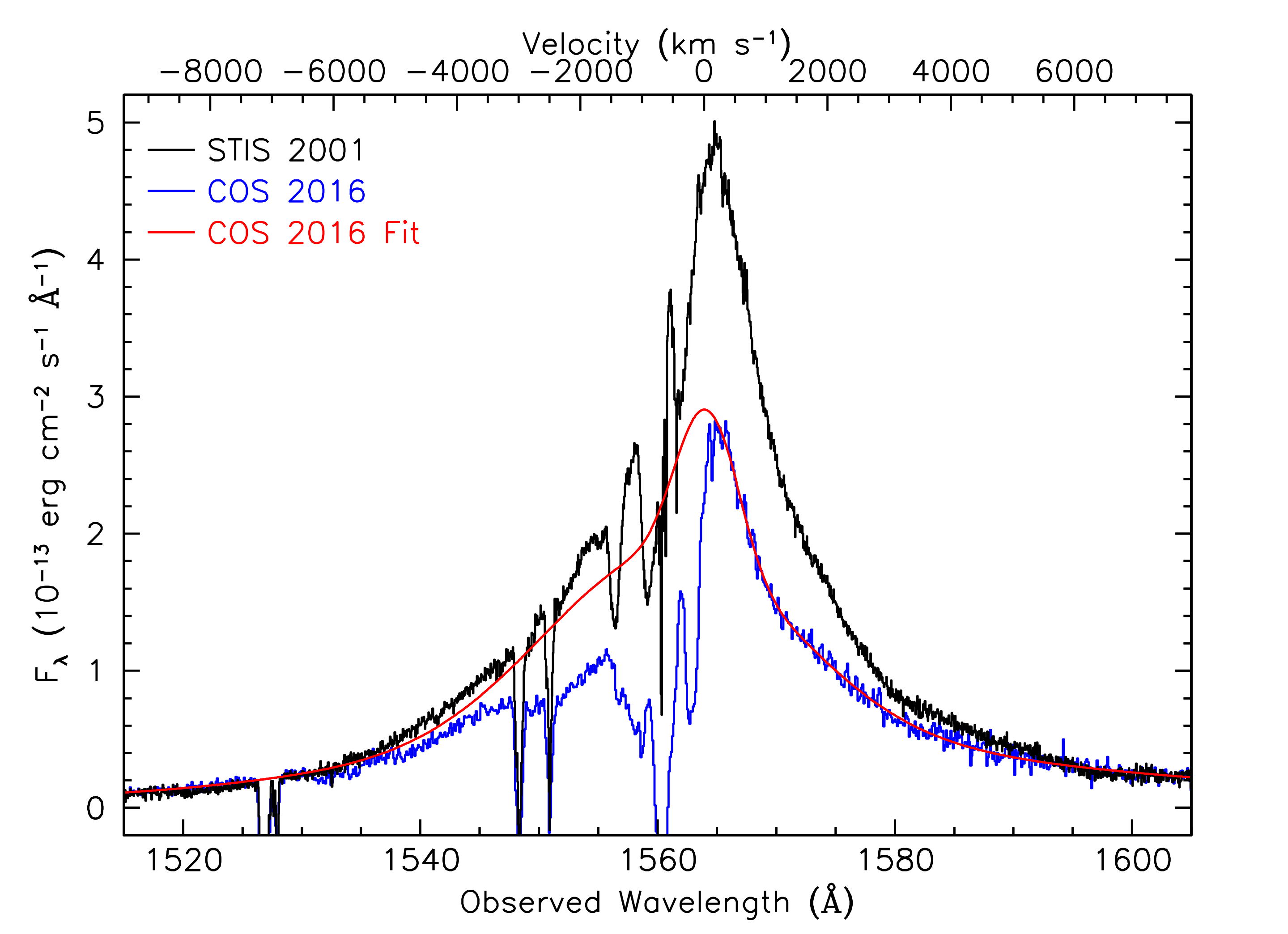


C IV Profile in NGC 3783 (STIS 2001)



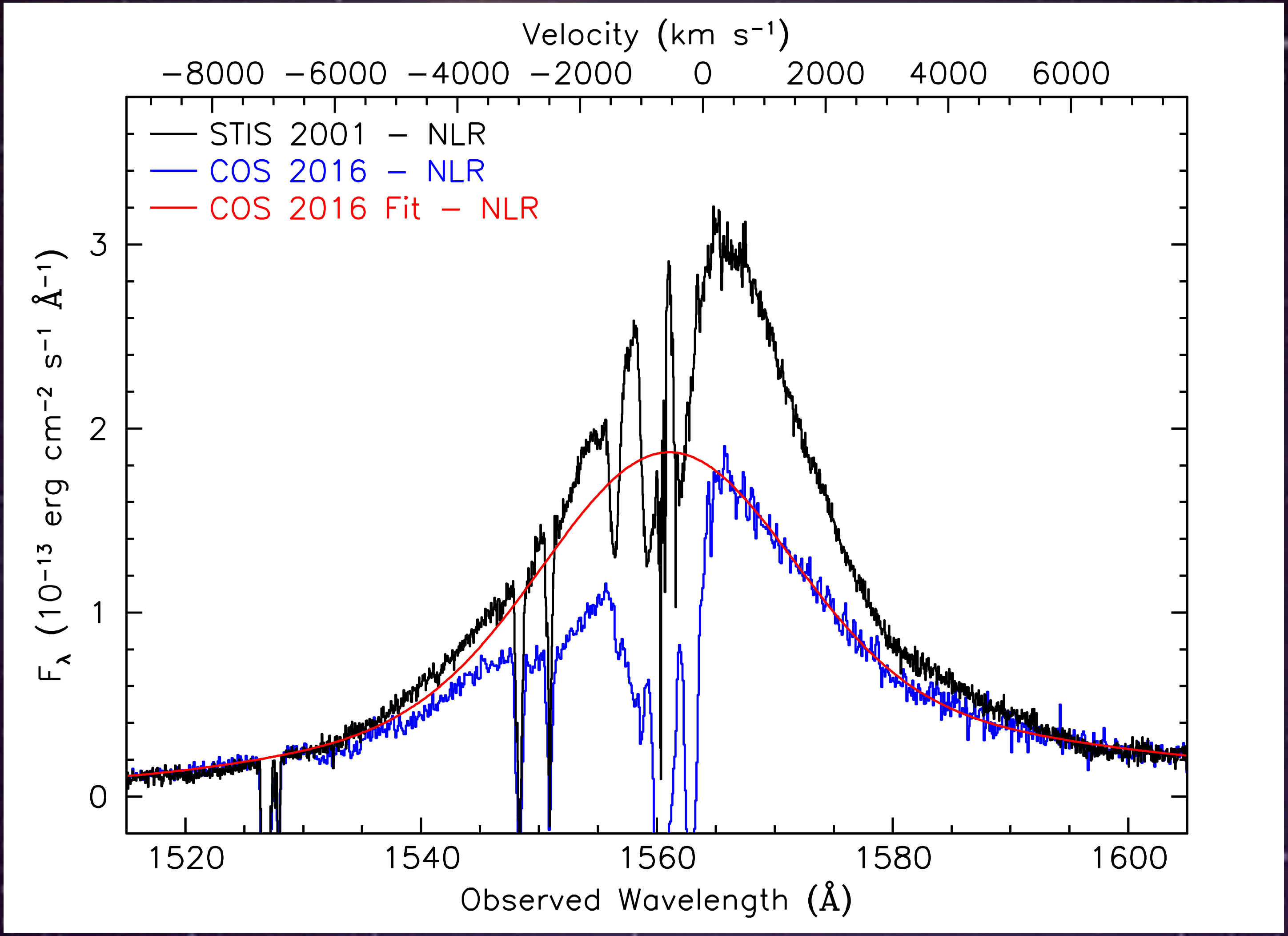
Modeling the C IV Absorption in the 2016 Spectrum

Comparison of Full STIS 2001 and COS 2016 Profiles



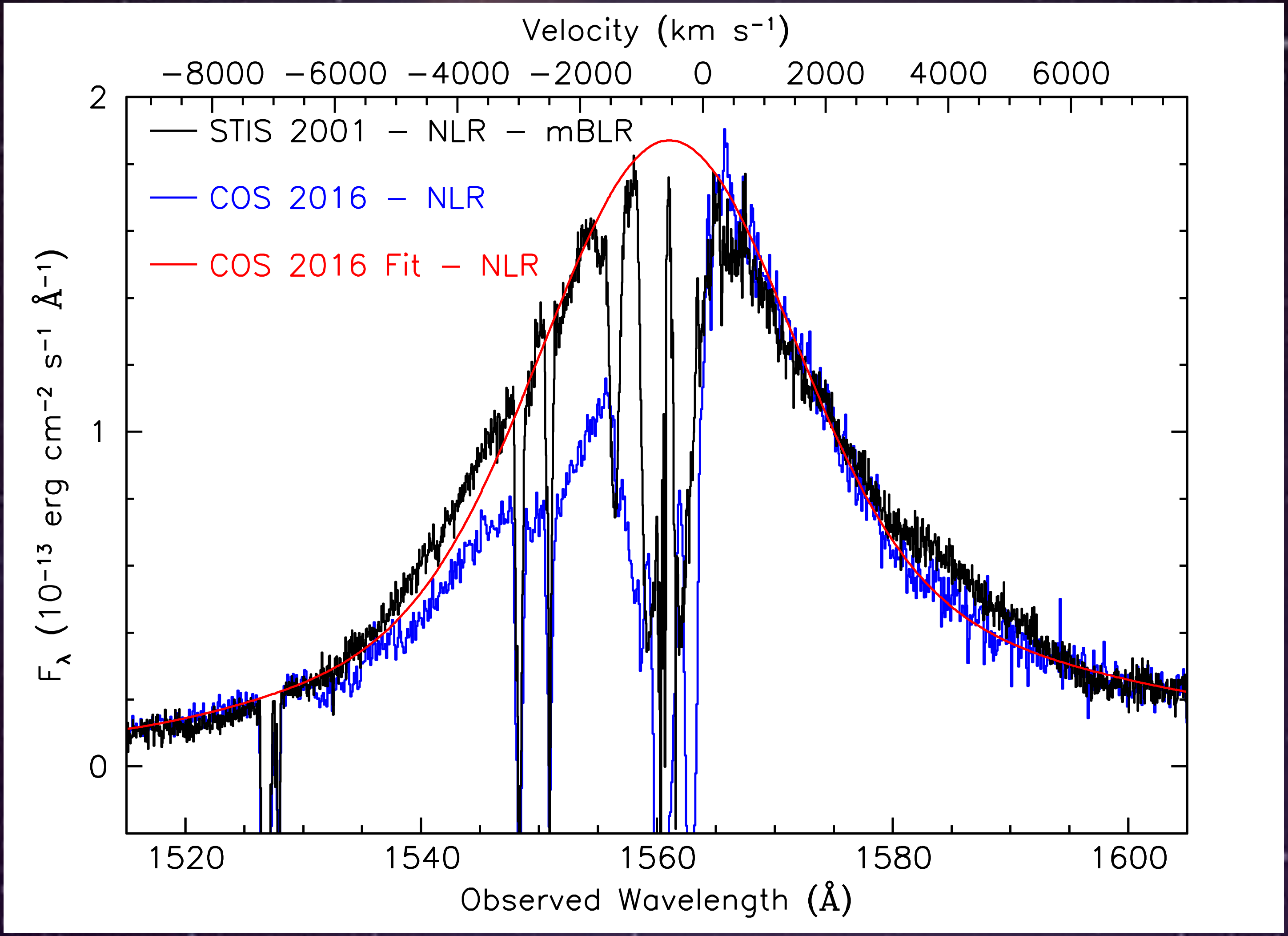
Modeling the C IV Absorption in the 2016 Spectrum

Remove the Narrow Emission Components

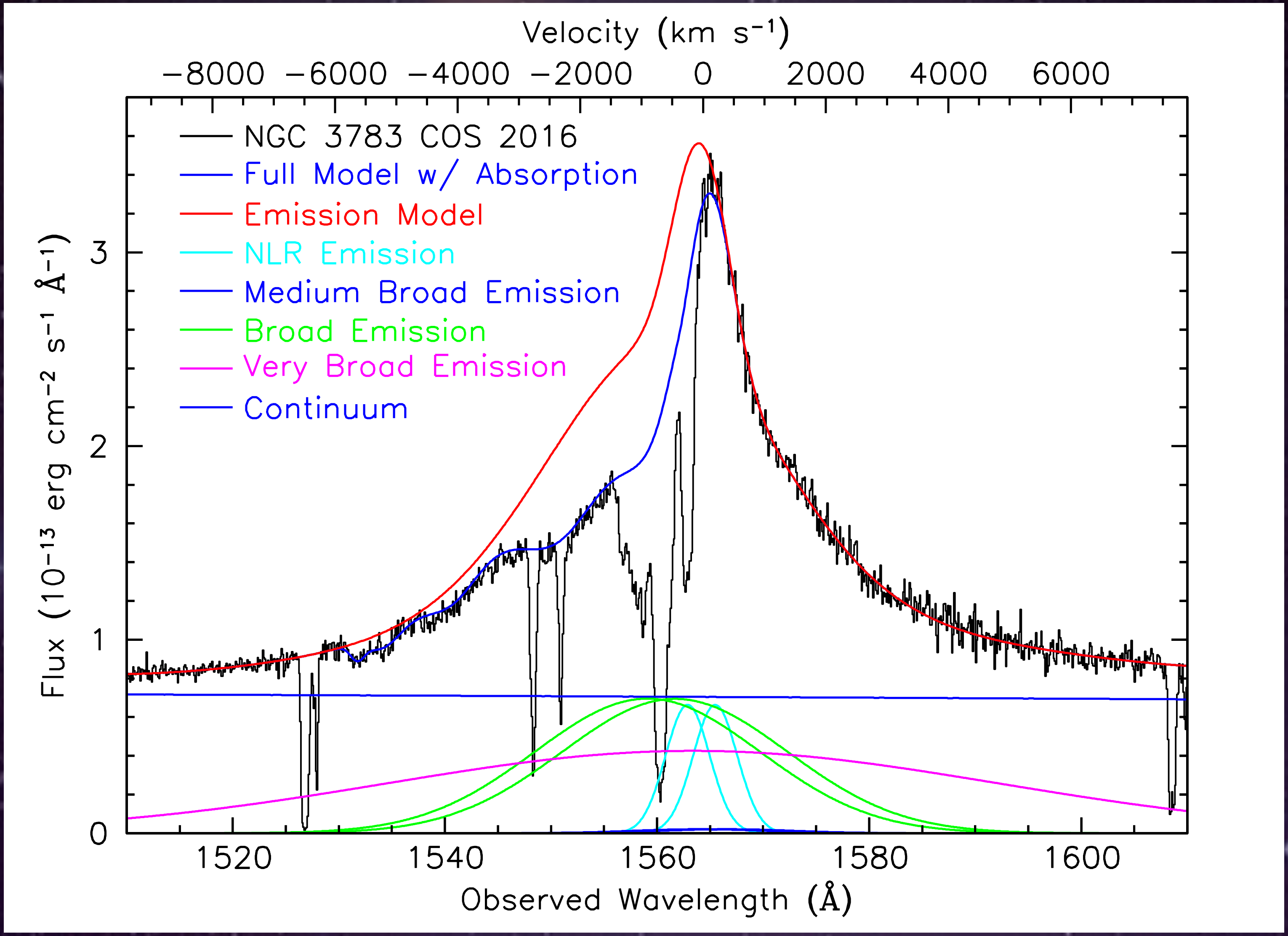


Modeling the C IV Absorption in the 2016 Spectrum

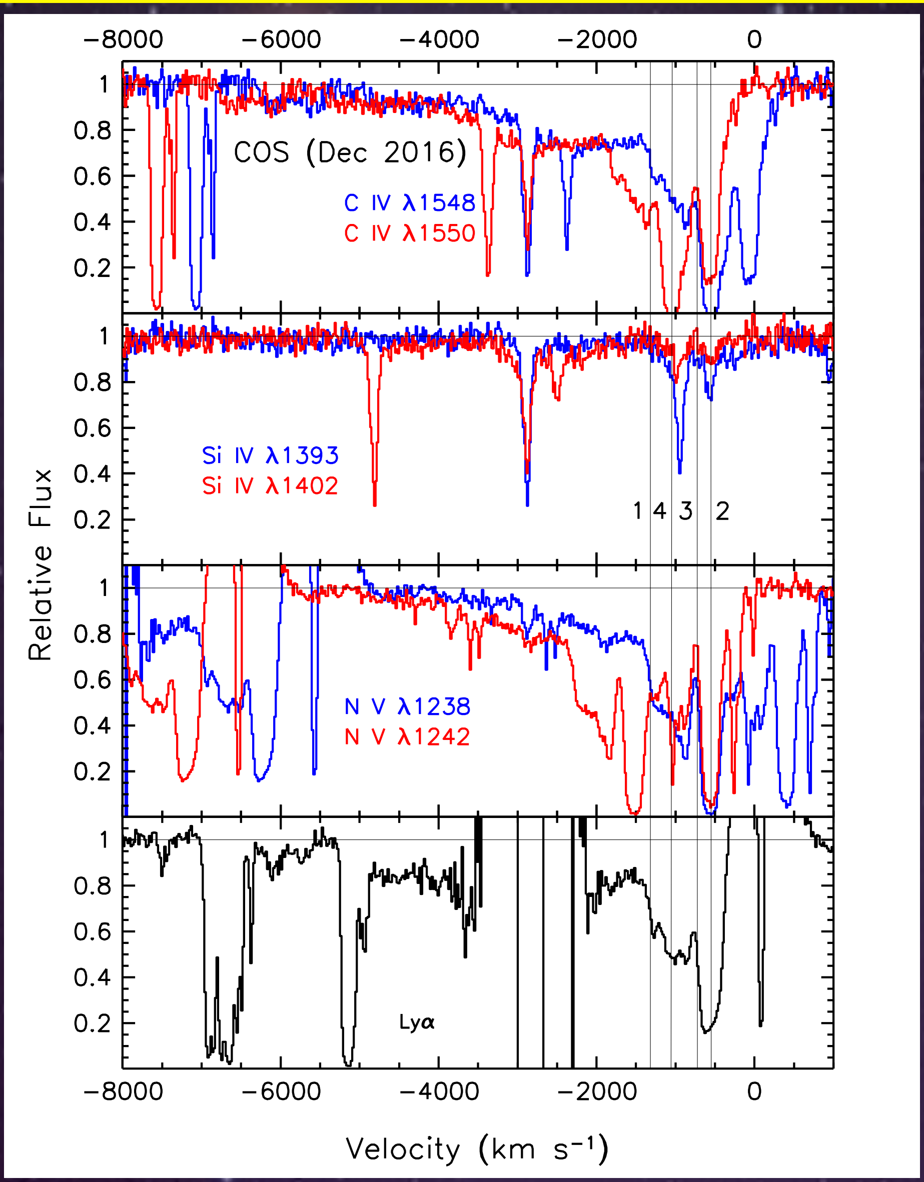
Remove the Narrow & Intermediate Emission Components



C IV Profile in NGC 3783 (COS 2016)



Broad Absorption Profiles in NGC 3783



Why Contemporaneous UV Spectra are Important

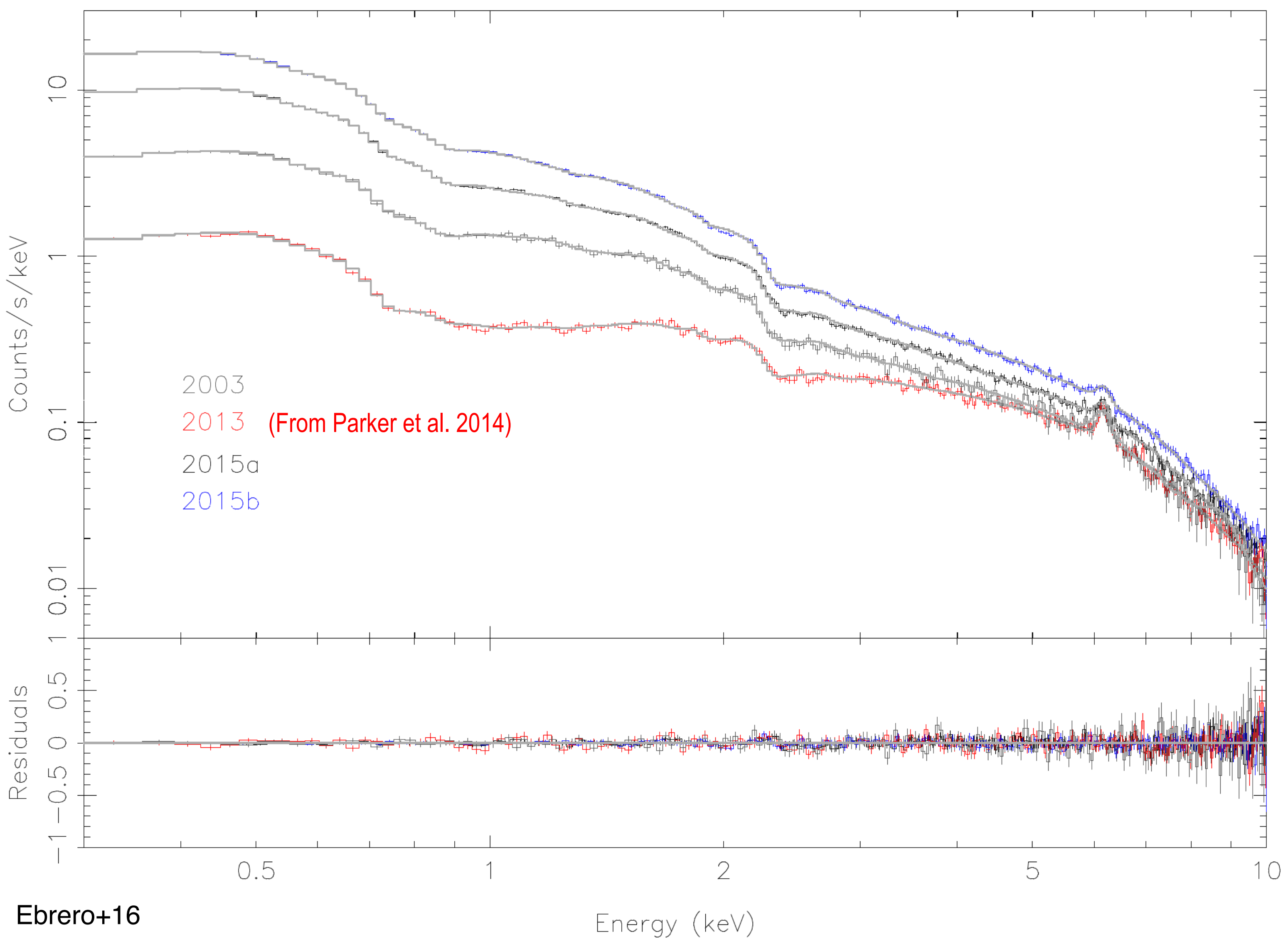
- Soft X-ray obscuration generally leaves no spectral imprint, so one cannot discern the velocity or constrain the ionization of the absorbing gas.

- Contemporaneous UV spectra supply the kinematic information that determines the velocity of the outflow and its ionization state.

- In NGC 5548, absorption from Lyα, C IV, N V, and low-ionization ions such as C II, Si II, and Si III were present. This was consistent with low-ionization, high-column density gas ($\log \xi < -1.2$).

- In NGC 3783, we see only Lyα, C IV, N V, and Si IV. Lower-ionization states are not present. Given the column density of $N_H = 1\times10^{23}$ cm^{-2}, determined from the X-ray obscuration, the ionization parameter has to be $\log \xi > 1.4$.

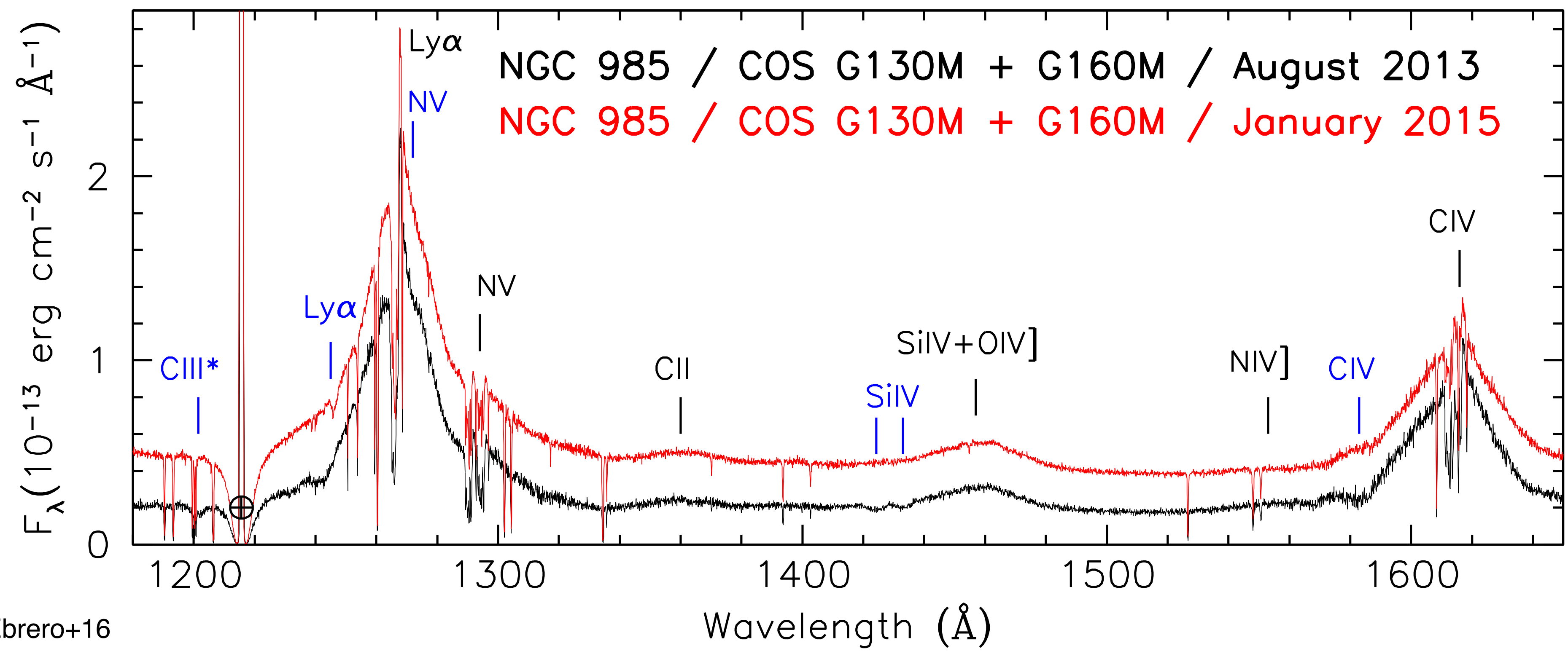
XMM-Newton PN Spectra of NGC 985 Show Variable Obscuration



Ebrero+16

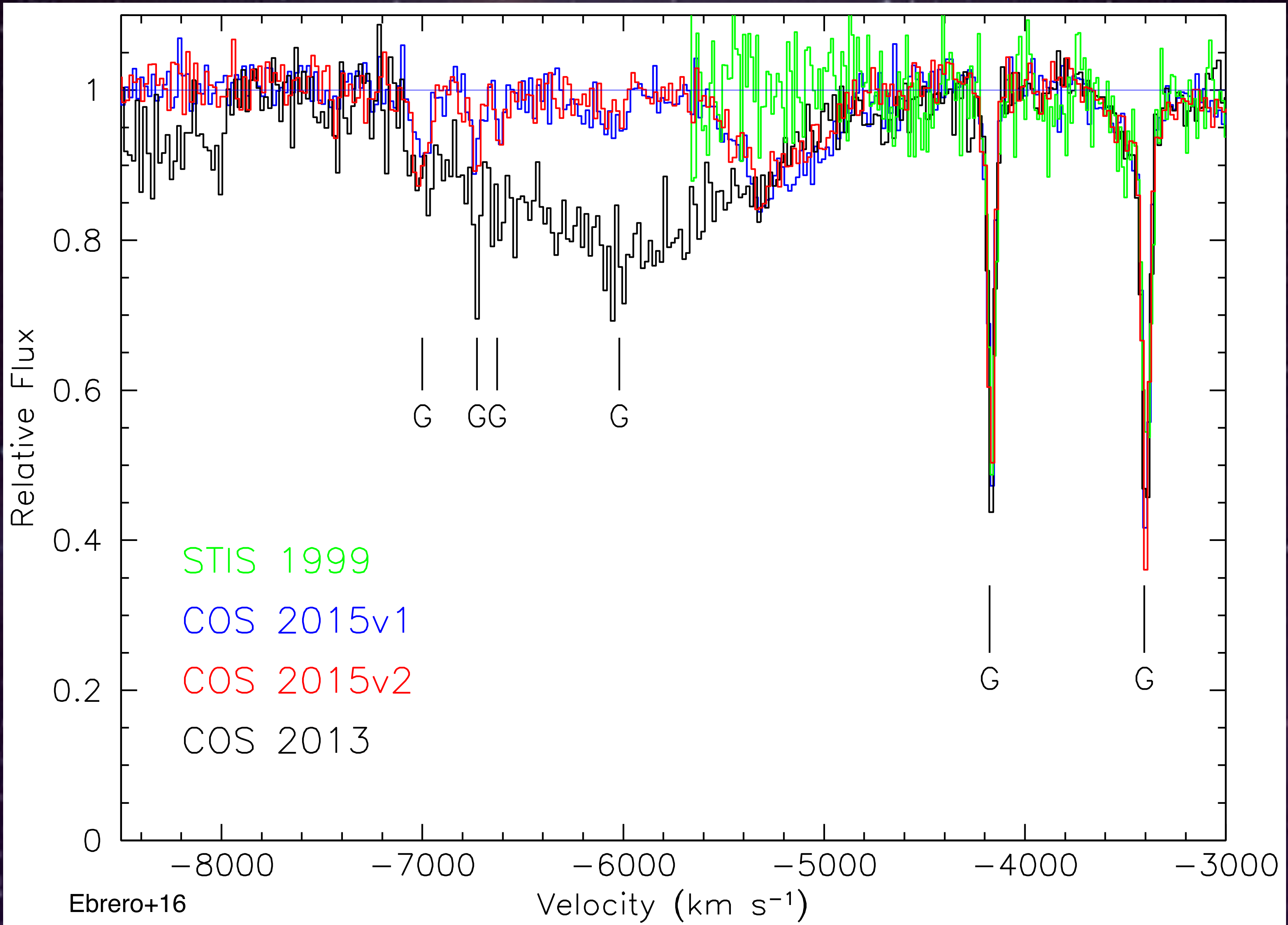
Comparison of the 2013 and 2015 COS Spectra of NGC 985

- Broad absorption appears in 2013 in C III*, Lyα, Si IV and C IV, coincident with heavy soft X-ray obscuration.
- When the obscuration diminishes in 2015, only a portion of the Lyα absorption remains visible.



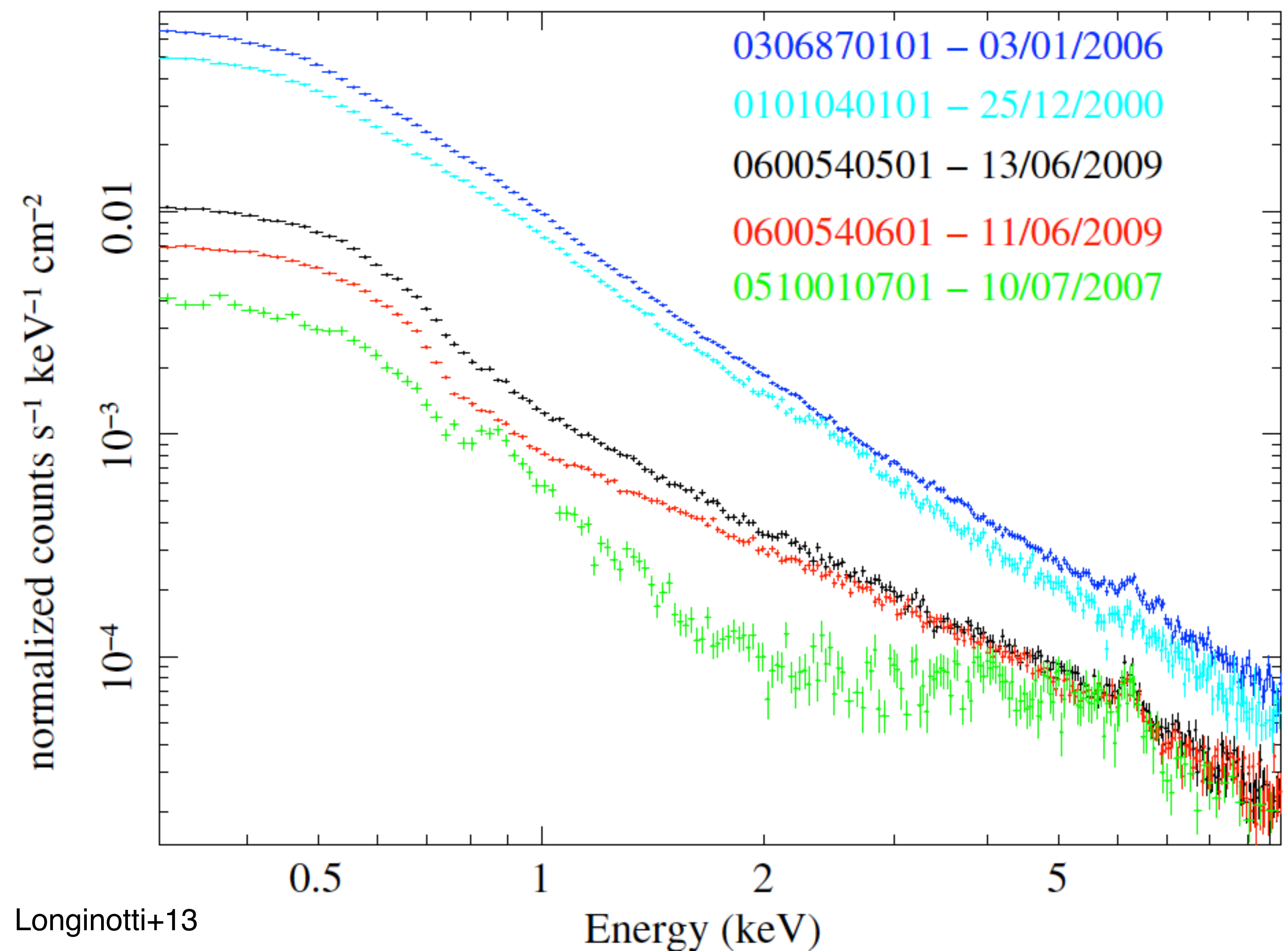
Ebrero+16

Comparison of Lyα Absorption in Archival HST Spectra of NGC 985



Ebrero+16

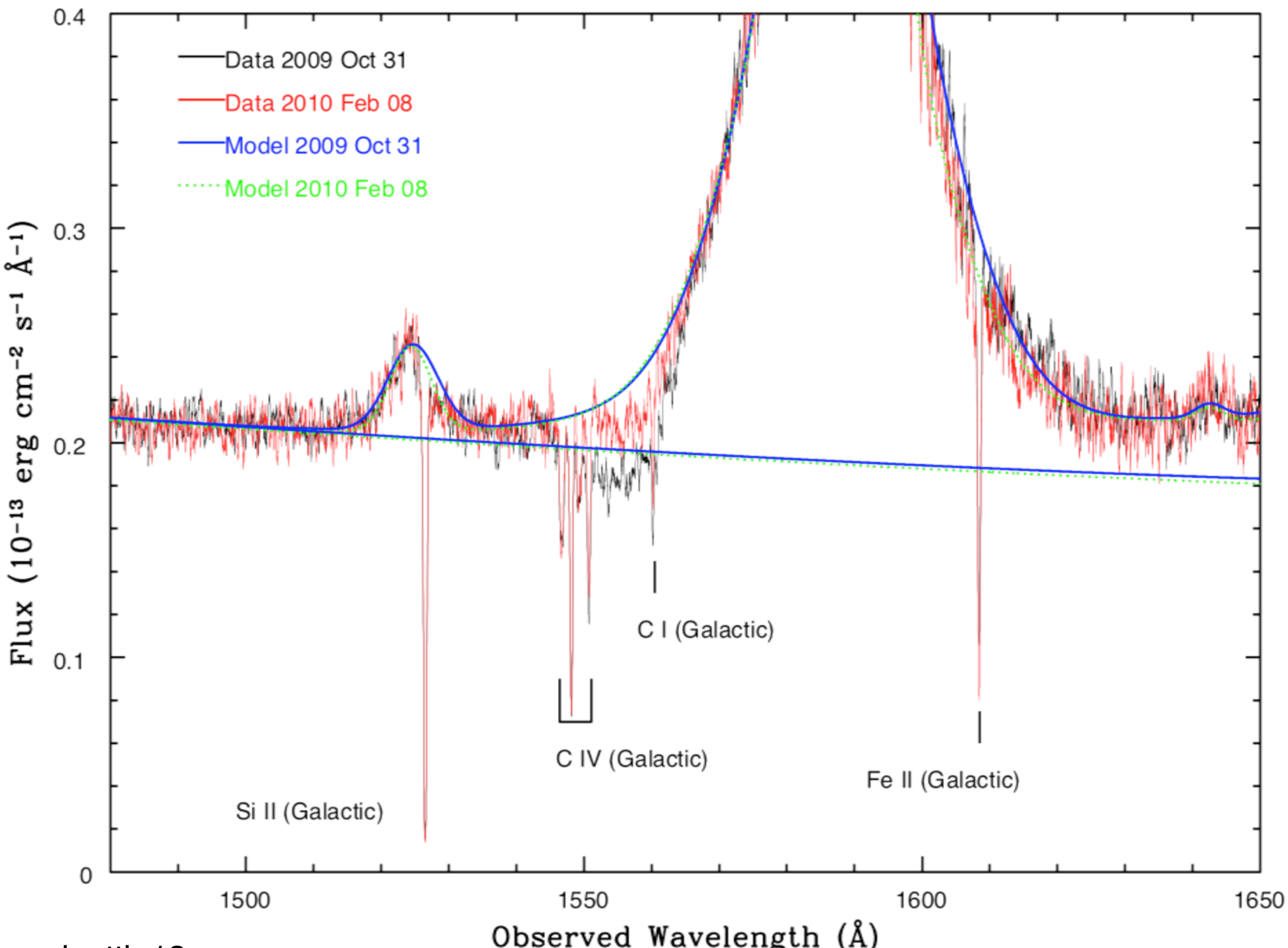
X-ray Absorption in Mrk 335



Longinotti+13

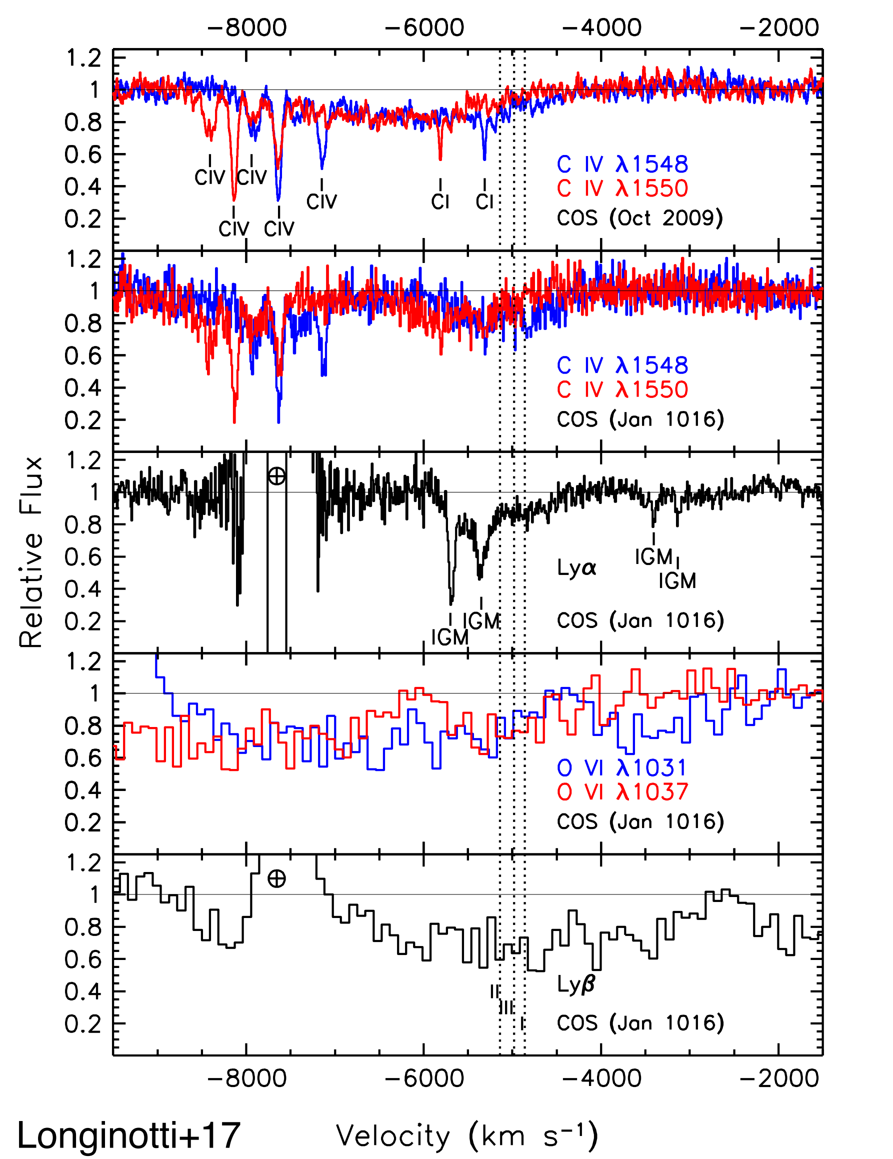
Broad C IV Absorption in Mrk 335

(X-ray obscuration occurred in June 2009)



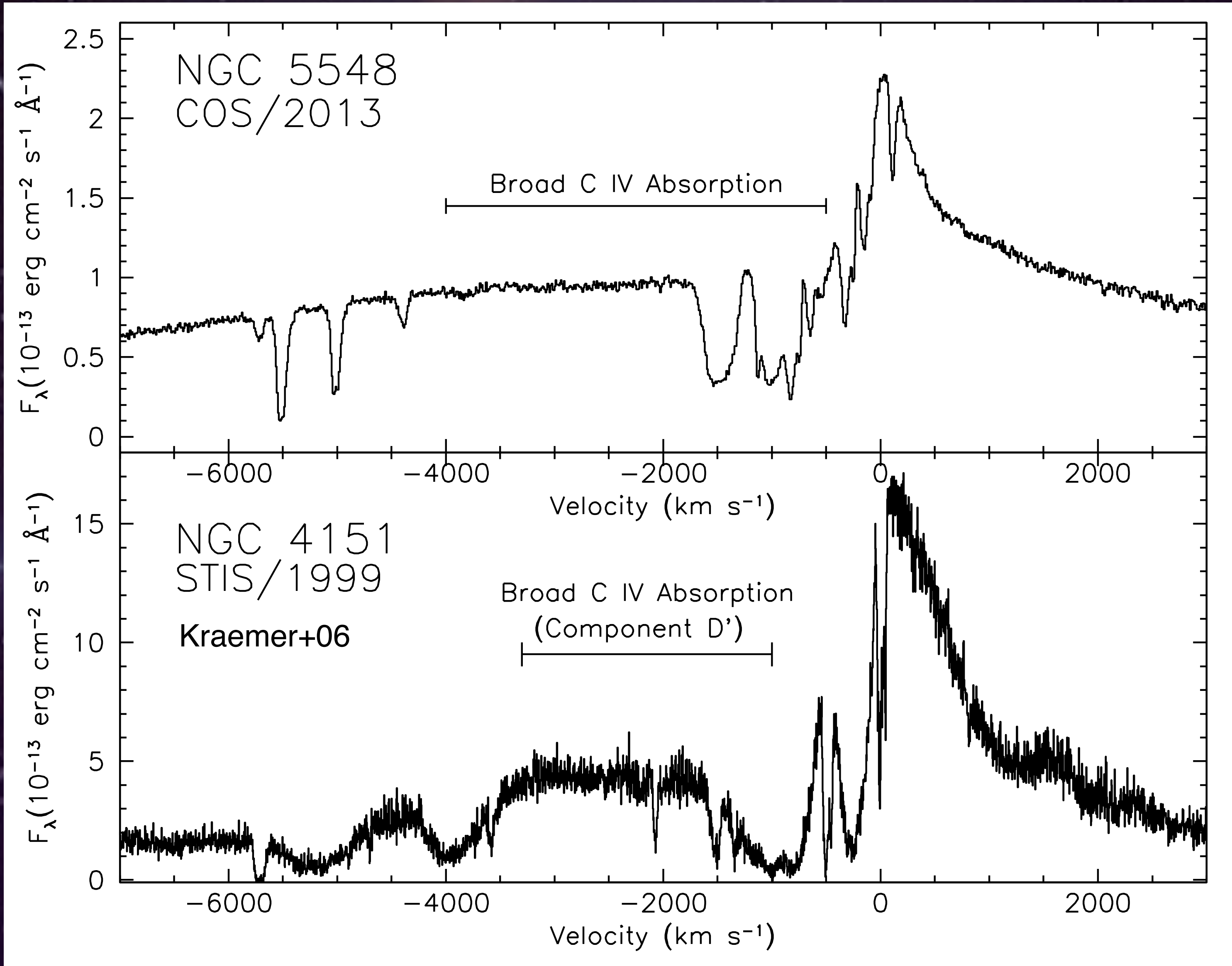
Longinotti+13

Broad Lyα, Lyβ, C IV, and O VI in Mrk 335 from a triggered XMM+HST observation in January 2016



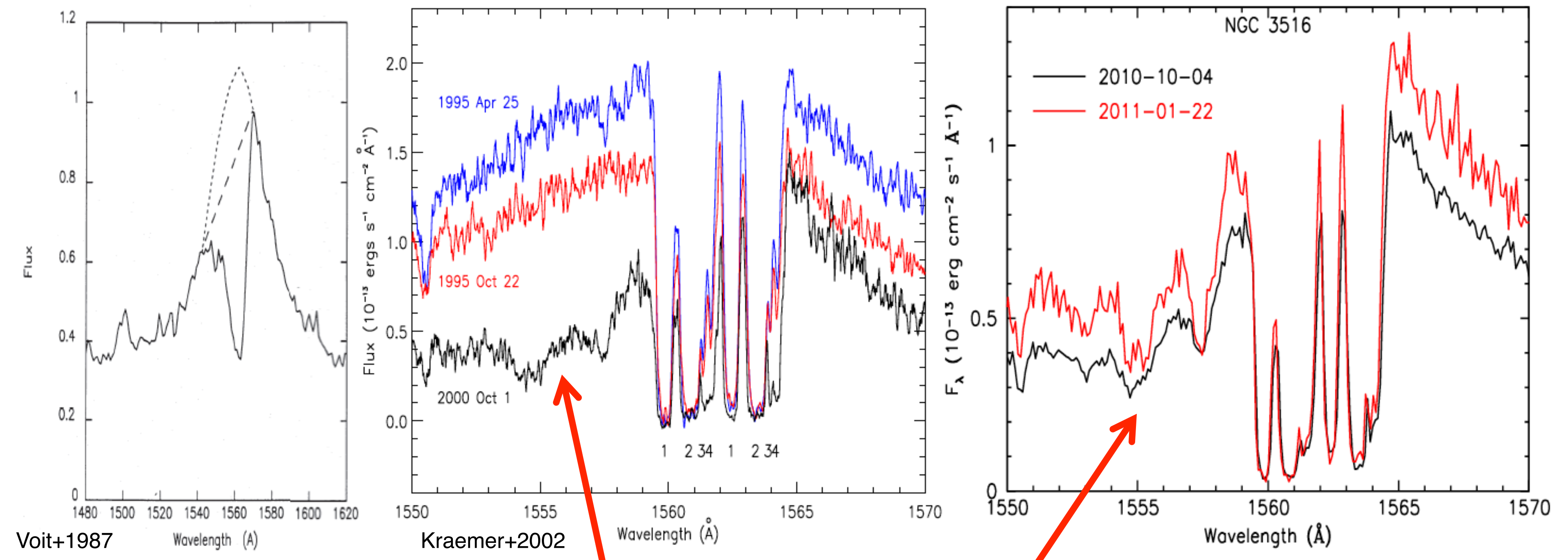
Longinotti+17

Broad C IV Absorption in NGC 5548 is Similar to NGC 4151



Broad, Variable Absorption in NGC 3516

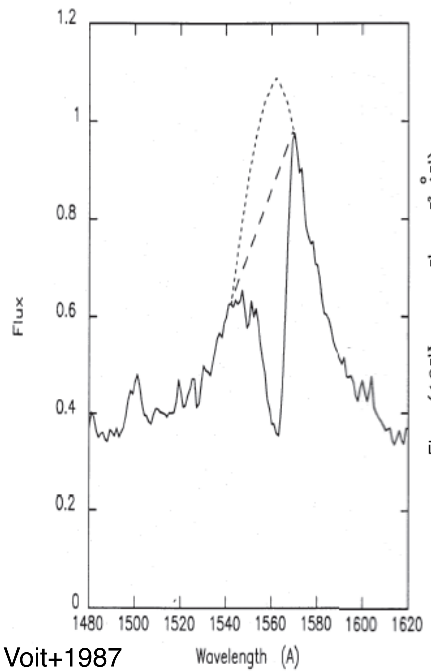
IUE 1987 GHRS 1995 and STIS 2000 COS 2010 & 2011



Broad absorption comes and goes

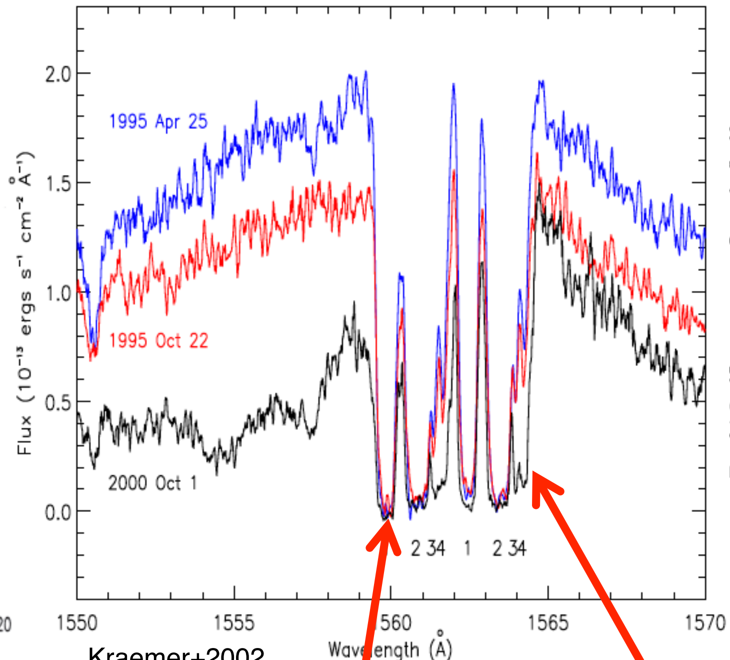
Broad, Variable Absorption in NGC 3516

IUE 1987



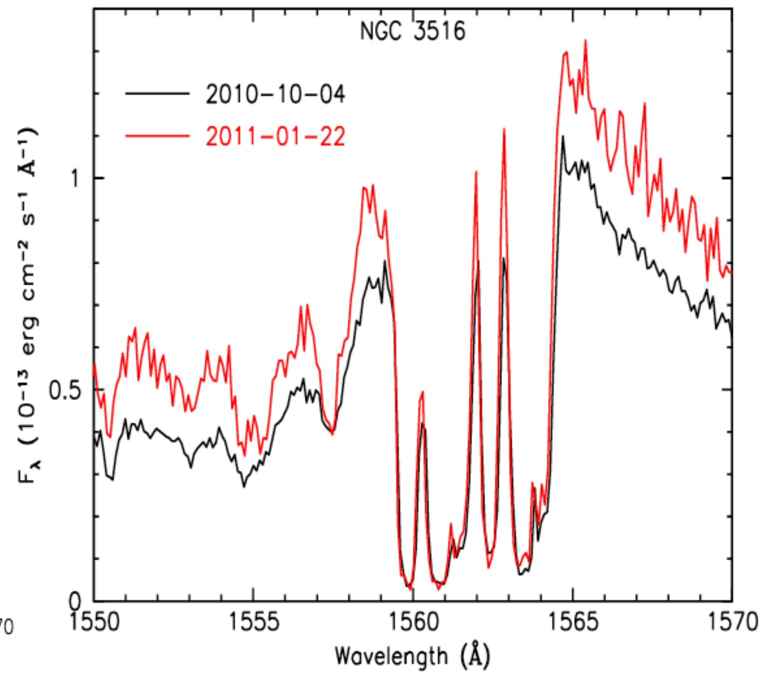
Voit+1987

GHRS 1995 and STIS 2000



Kraemer+2002

COS 2010 & 2011



Narrow absorption is always present, but optically thin lines get deeper during obscuring events.

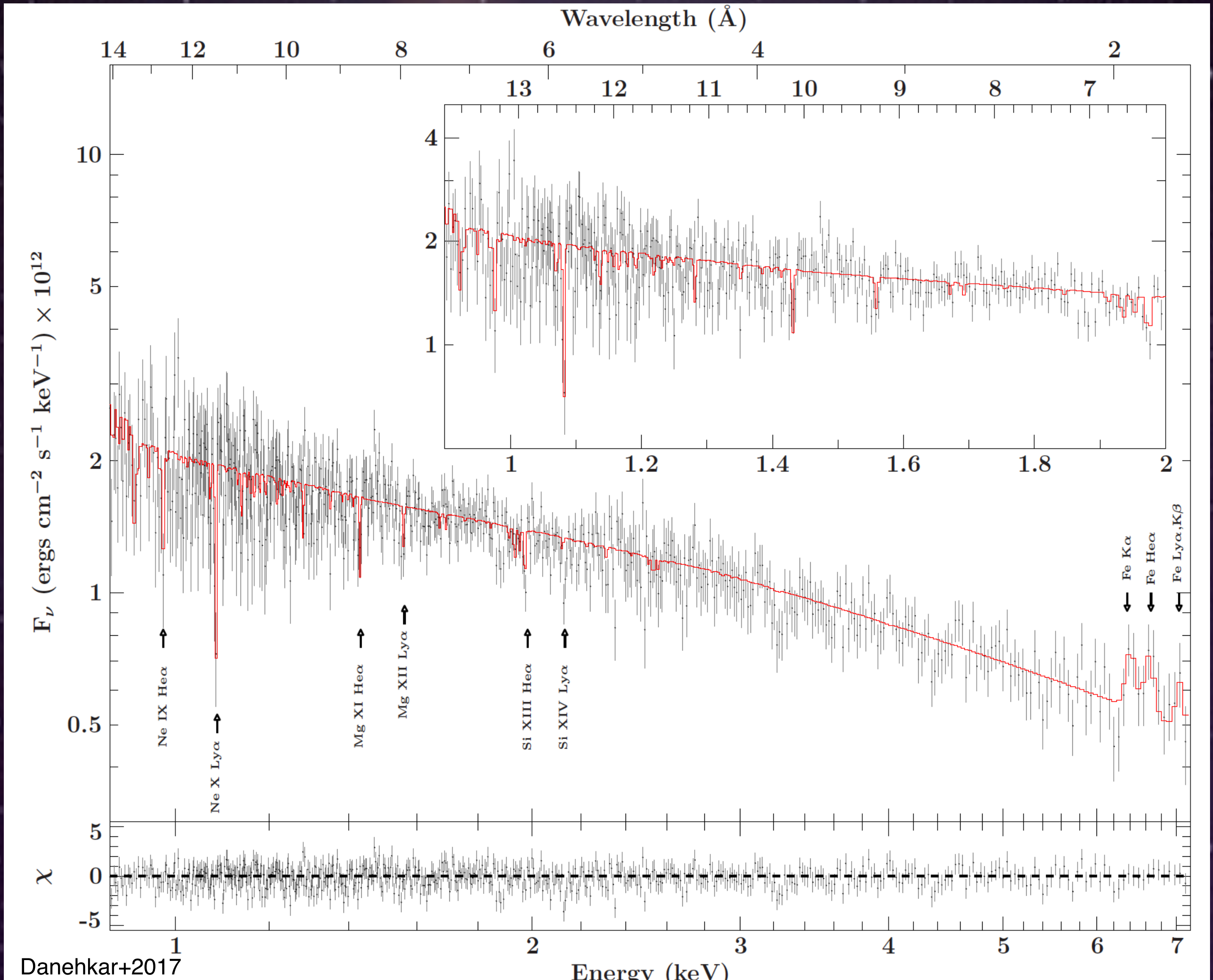
How Common is Broad, Fast UV Absorption?

- **Search MAST (Mikulski Archive for Space Telescopes) for sensitive observations of bright Type 1 AGN.**

- **Start with a list of bright AGN based on over 20 years of IUE observations, the Ultraviolet Light Curve Database for AGN (Dunn et al. 2006):**
  - 25 Type 1 AGN with median brightness > 2×10^{-14} erg cm^{-2} s^{-1} Å^{-1}

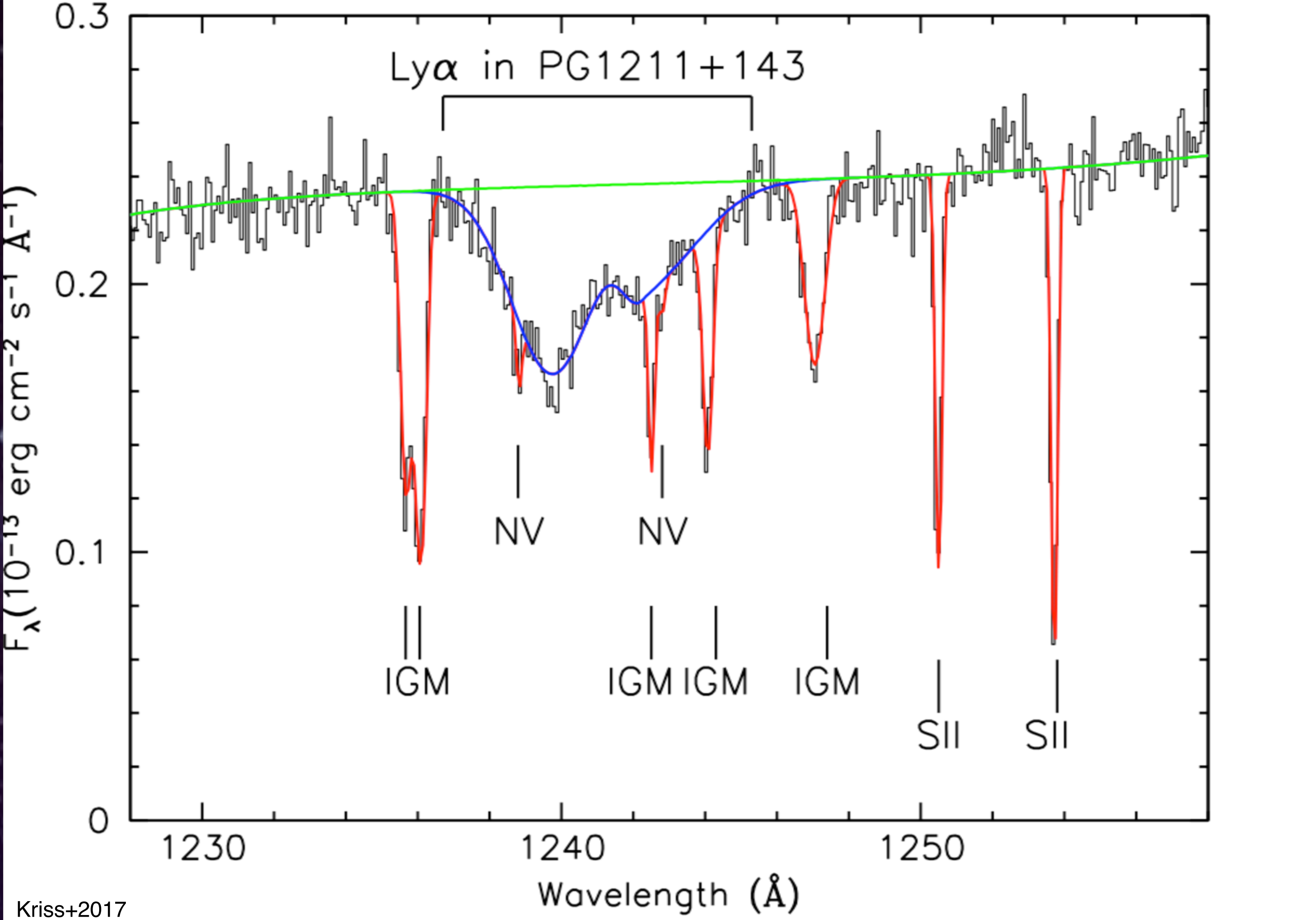
- **Of these 25 AGN:**
  - 21 have high S/N HST observations using either STIS or COS over the past 20 years.
  - 6 exhibit broad (>1000 km s^{-1}), fast (>1000 km s^{-1}) blue-shifted absorption features.
  - In 6 cases these features persist for months to years, but are not always present.

X-ray outflow in PG1211+143 confirmed by Ne X, Mg XII, and Si XIII at z=-0.056c (Danehkar+2017, Chandra HETGS, April 2015, 390 ks)



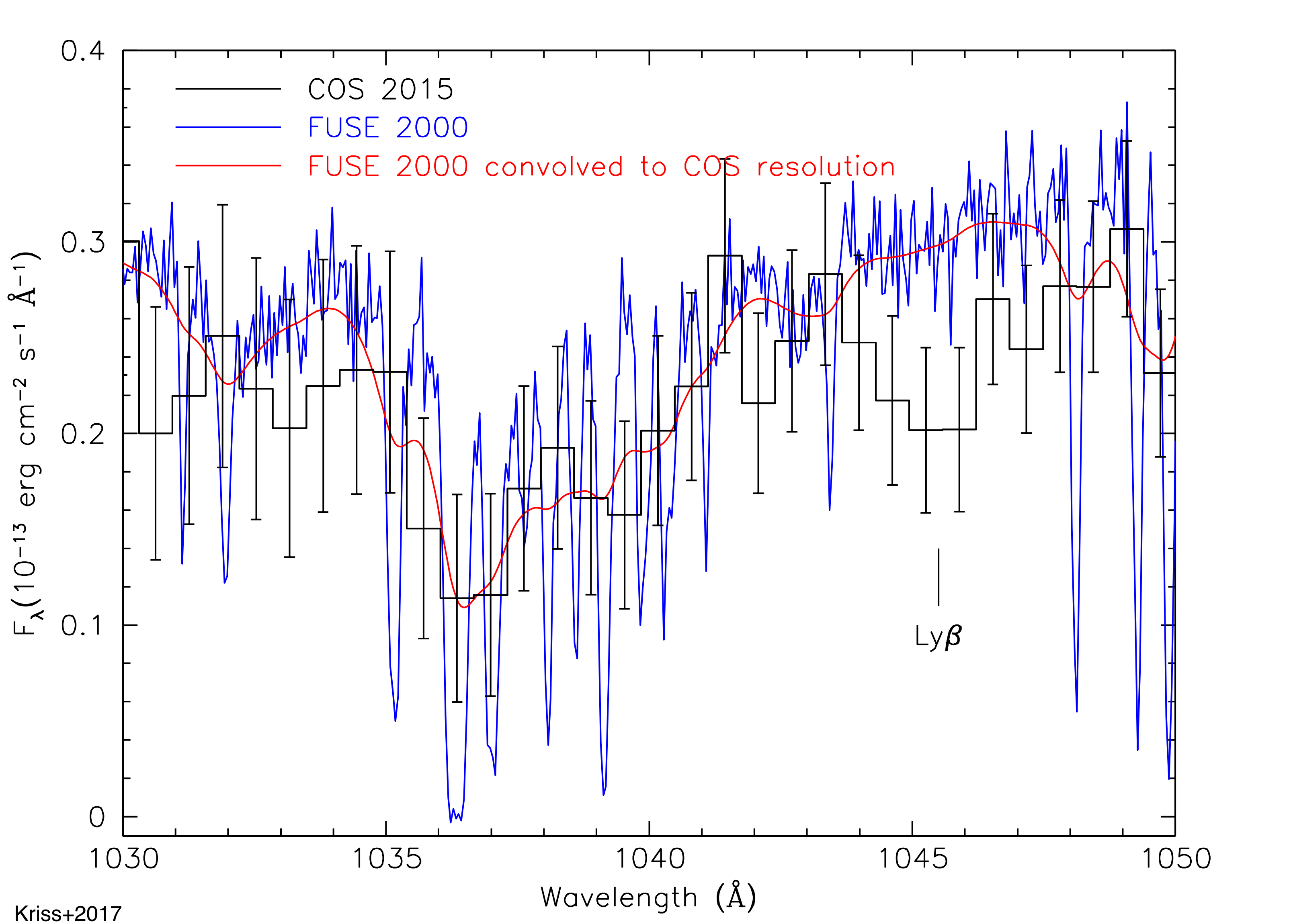
Danehkar+2017

Lyα Absorption in PG1211+143 at v=−0.0565c



Kriss+2017

Lyβ Absorption in PG1211+143 at v=–0.0565c



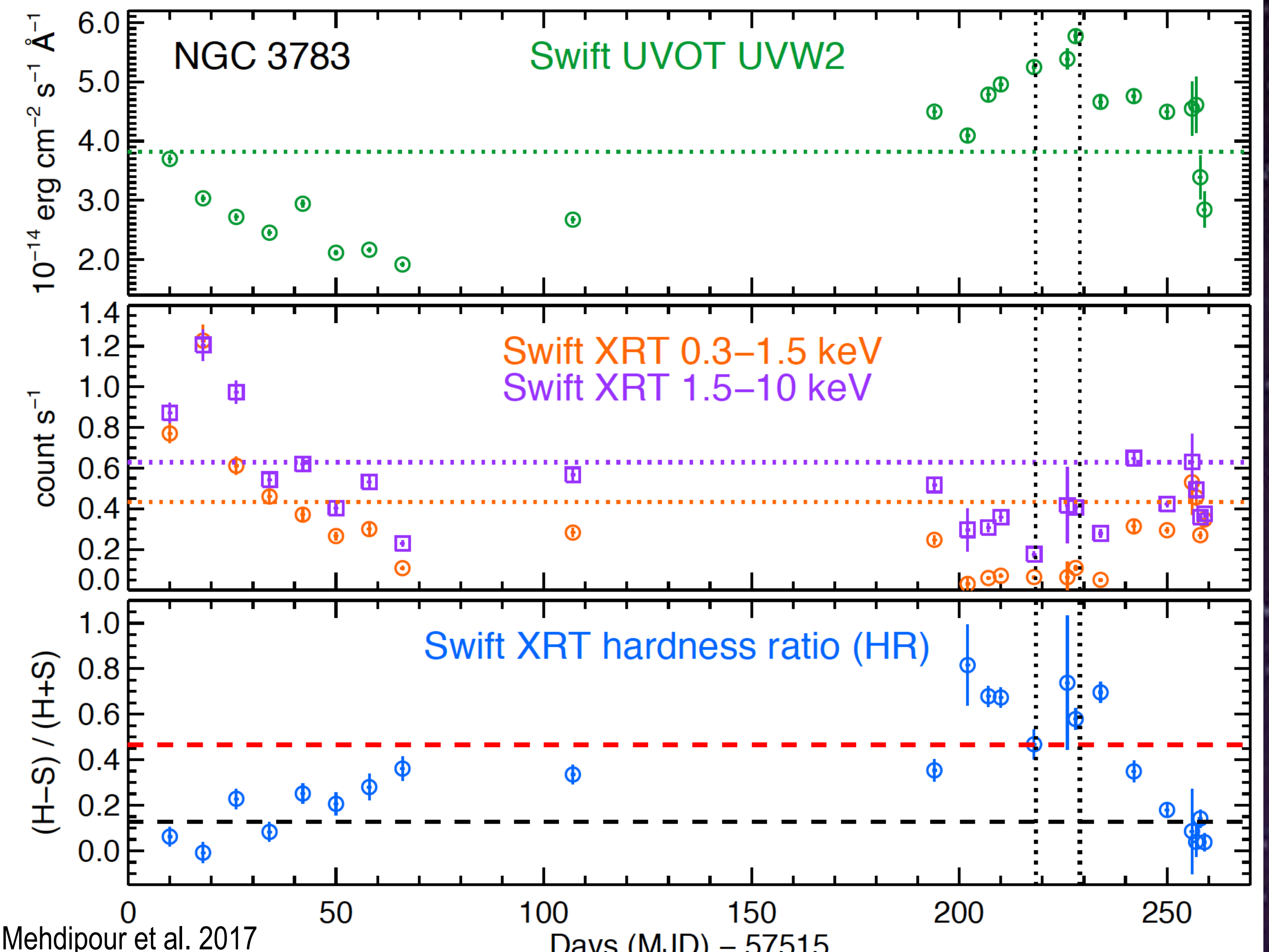
Kriss+2017

Summary

- ★ Coordinated observing campaigns on bright Seyfert 1s with HST, XMM-Newton and Chandra have determined the location and physical properties of outflows in many objects.
- ★ These coordinated observing campaigns are also revealing episodes of strong soft X-ray obscuration.
- ★ Frequently, this strong soft X-ray obscuration is associated with broad, high-velocity UV absorption lines.
- ★ We now have *four* recent examples: Mrk 335 (Longinotti et al. 2013), NGC 5548 (Kaastra et al. 2014), NGC 985 (Ebrero et al. 2016), and NGC 3783 (Mehdipour et al. 2017).
- ★ These outflows are much stronger than the typical associated narrow UV absorption lines and X-ray warm absorbers, and may arise in an accretion disk wind.

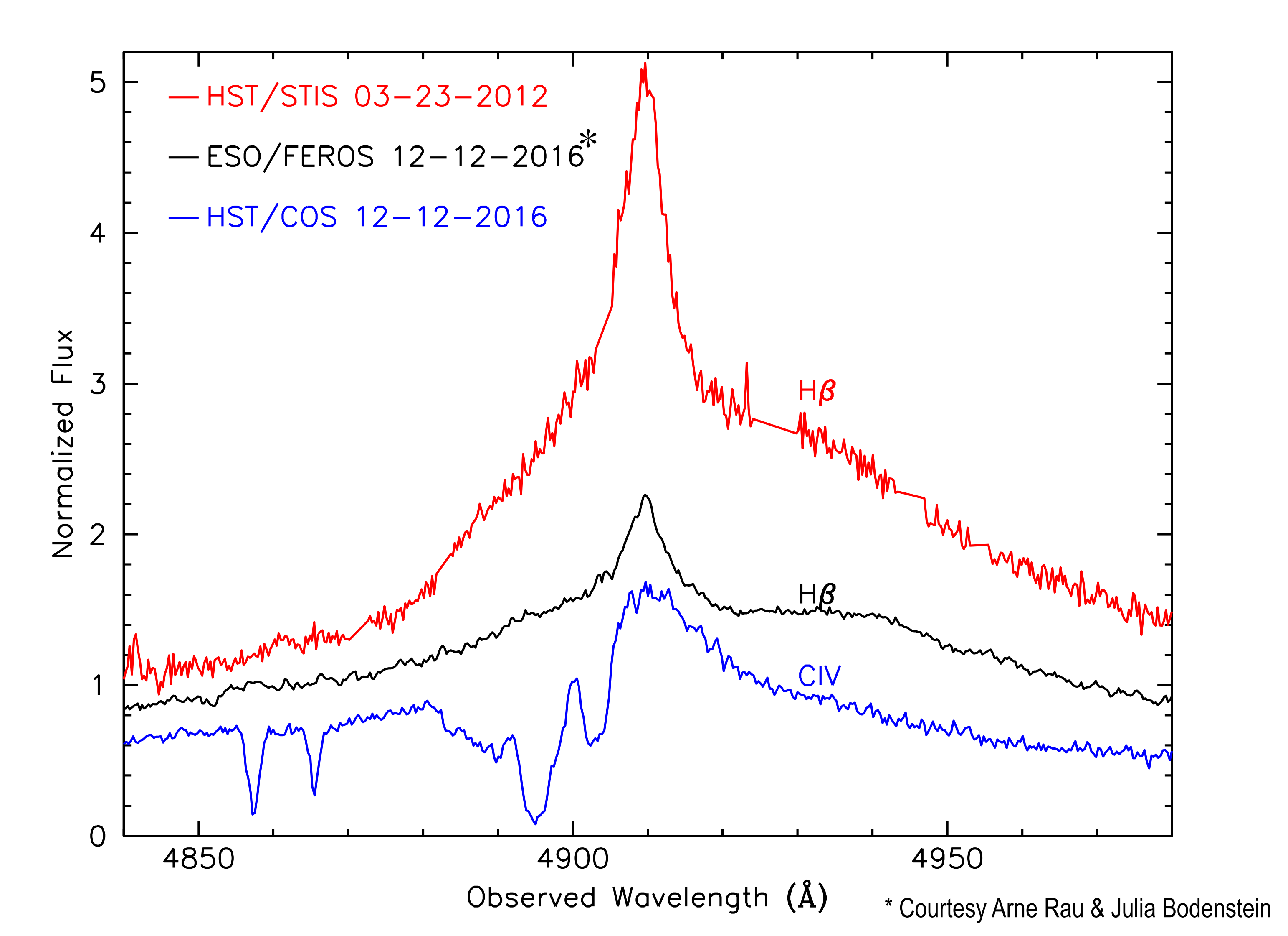
Backup Slides

Obscuration Event in NGC 3783 in December 2016
Swift Trigger on Hardness Ratio

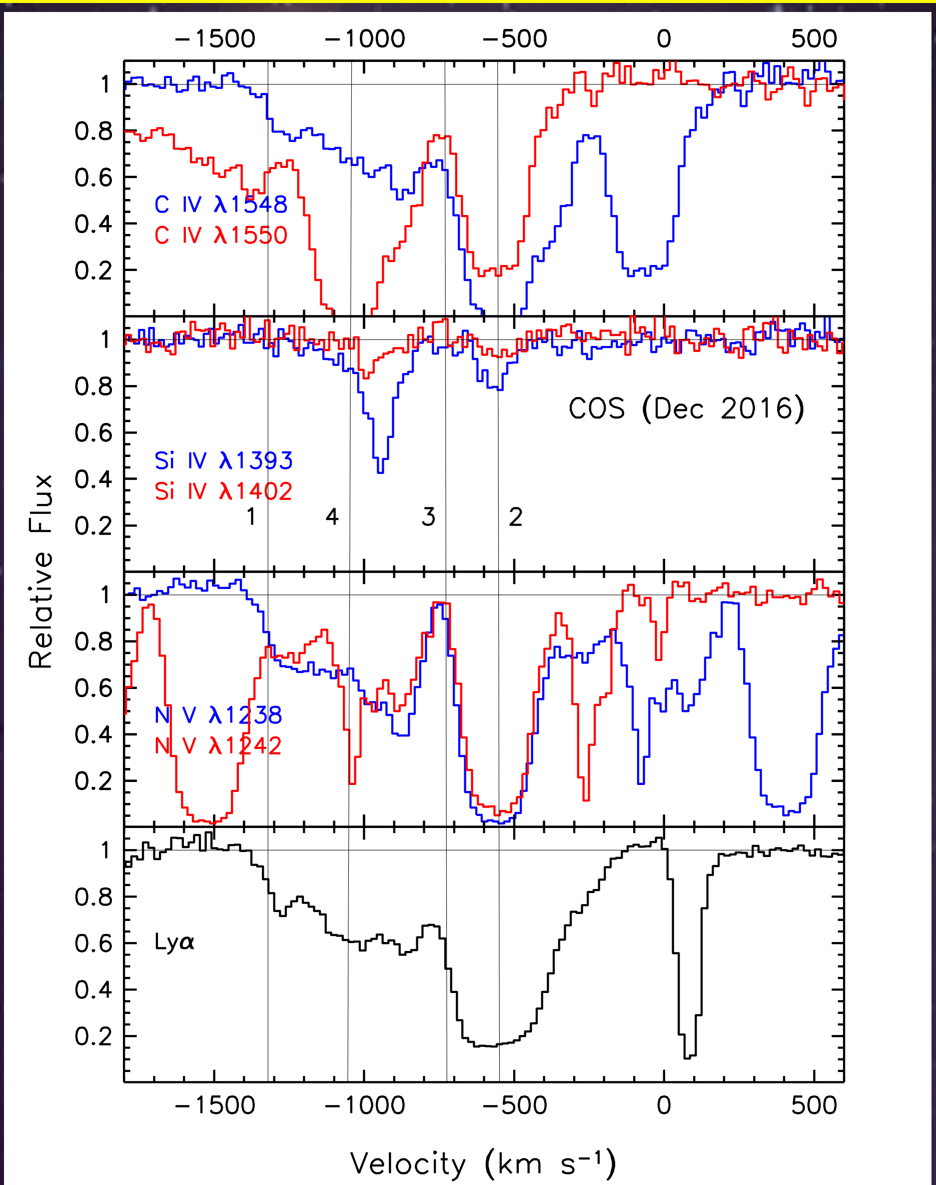


Mehdipour et al. 2017

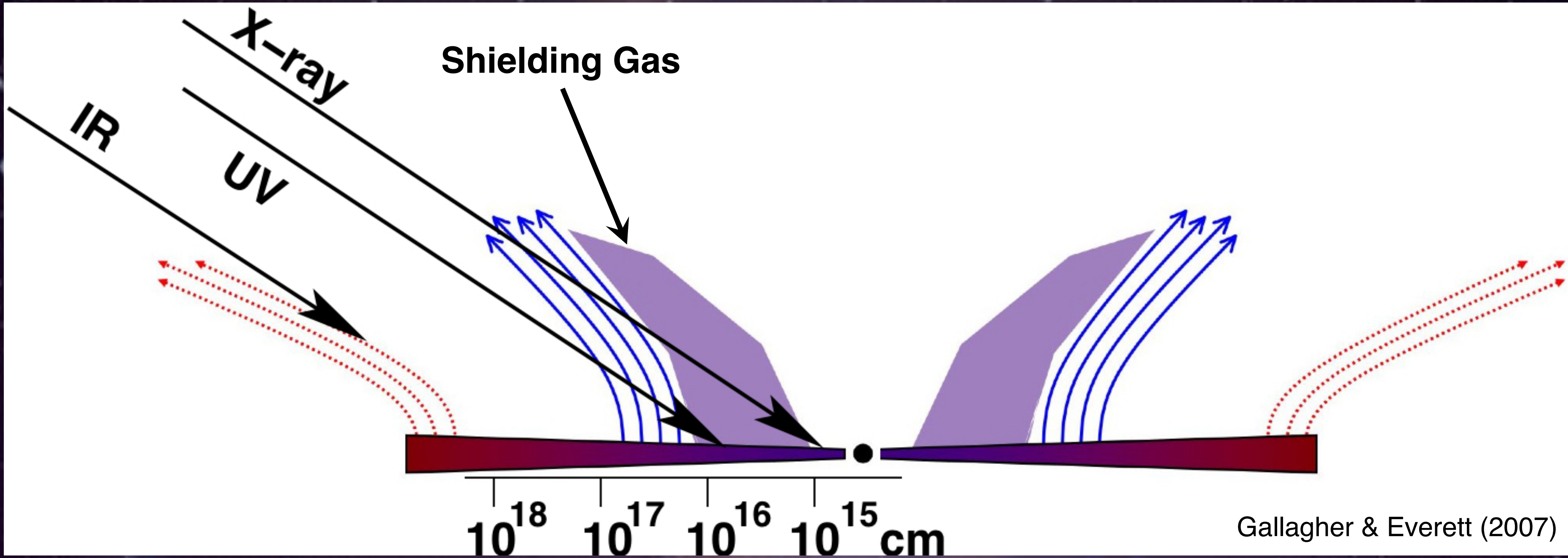
Hβ Profiles in NGC 3783 compared to C IV



The Narrow Absorption Lines in NGC 3783

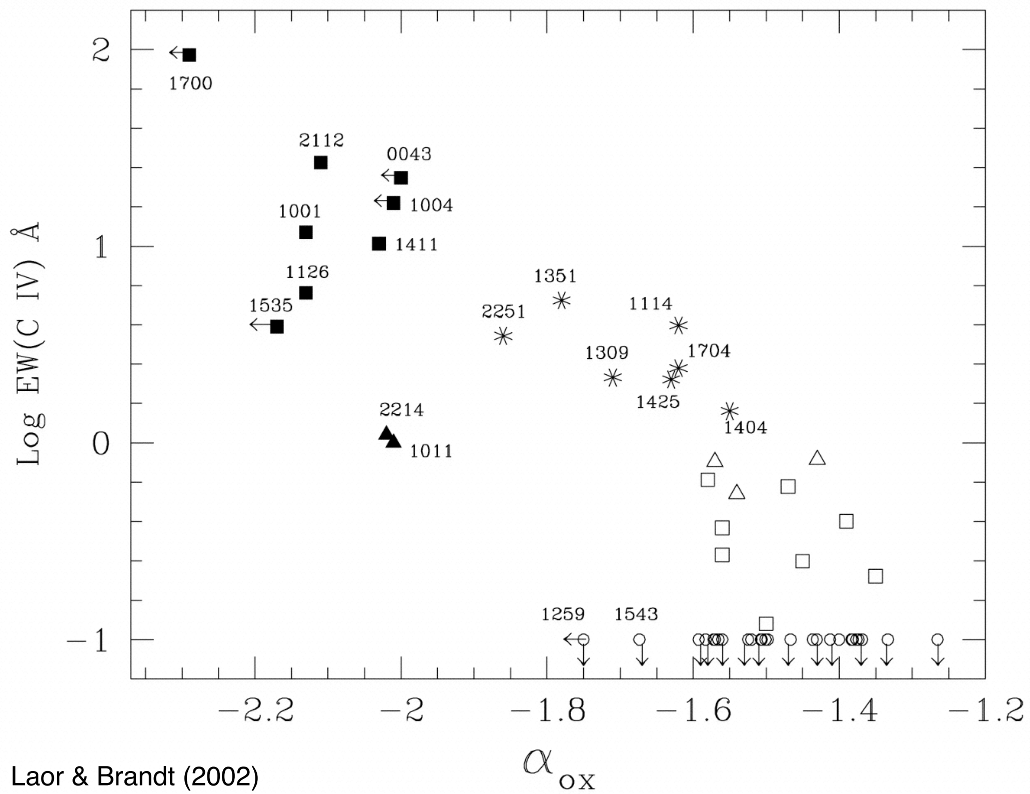


Are these examples of accretion disk winds?

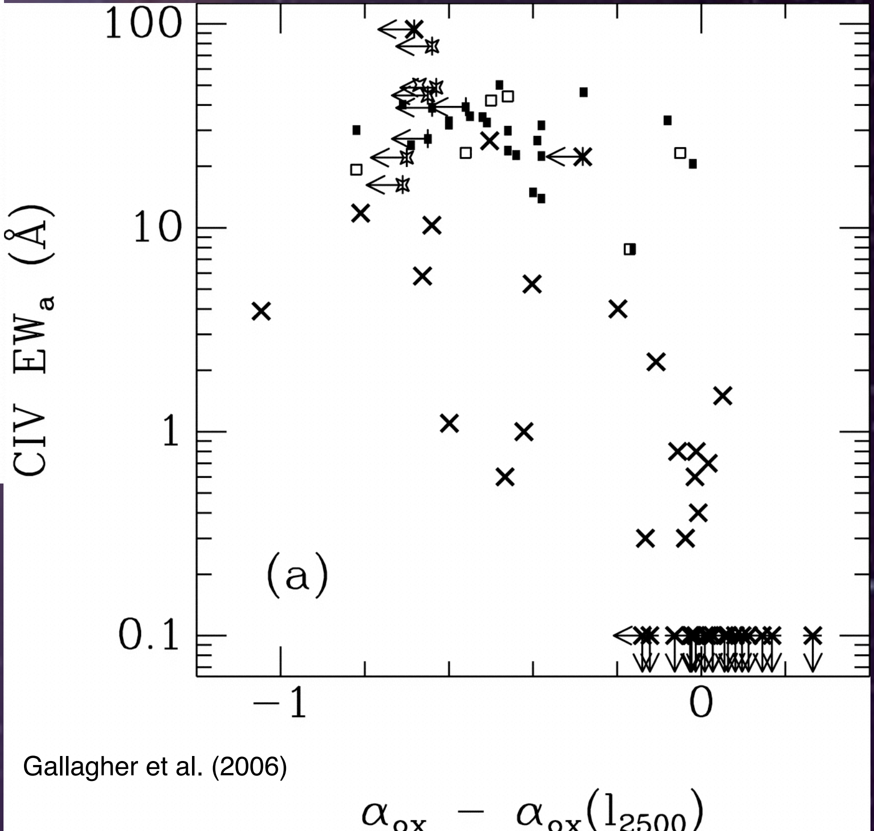


- ★ BALQSOs are X-ray faint, so spectra are low S/N. Data are consistent with heavy X-ray absorption, but they also could be intrinsically faint (Gallagher et al. 2008).
- ★ Heavy X-ray absorption plus broad UV absorption in these Seyferts could be the long-sought “shielding gas” of disk-wind models for BALQSO outflows.

BAL QSOs Show Strong X-ray Absorption



Laor & Brandt (2002)



Gallagher et al. (2006)