

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

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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.

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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

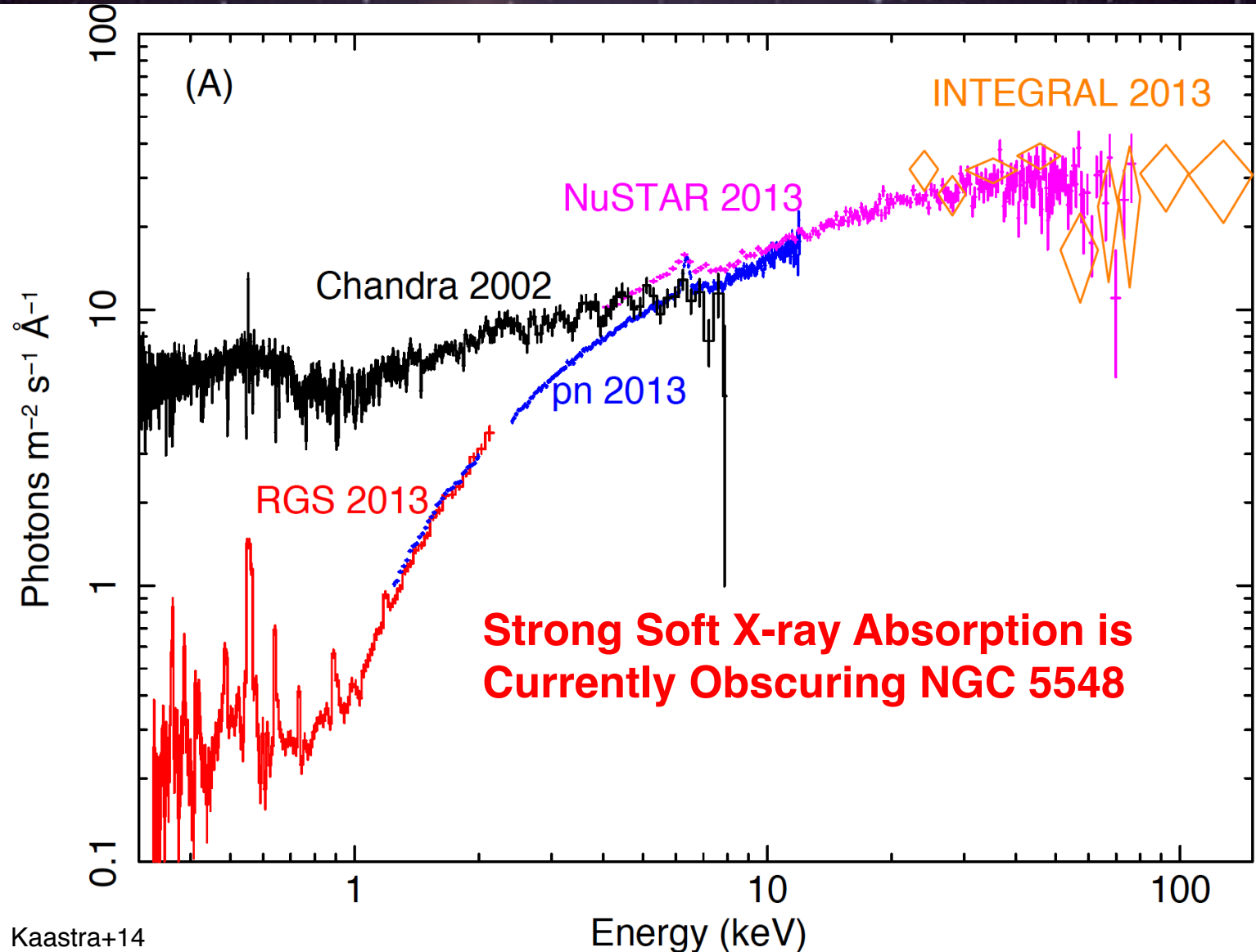
★ **Other Examples of Obscurers and their Associated Outflows**

- Mrk 335, NGC 985, NGC 4151, and NGC 3516

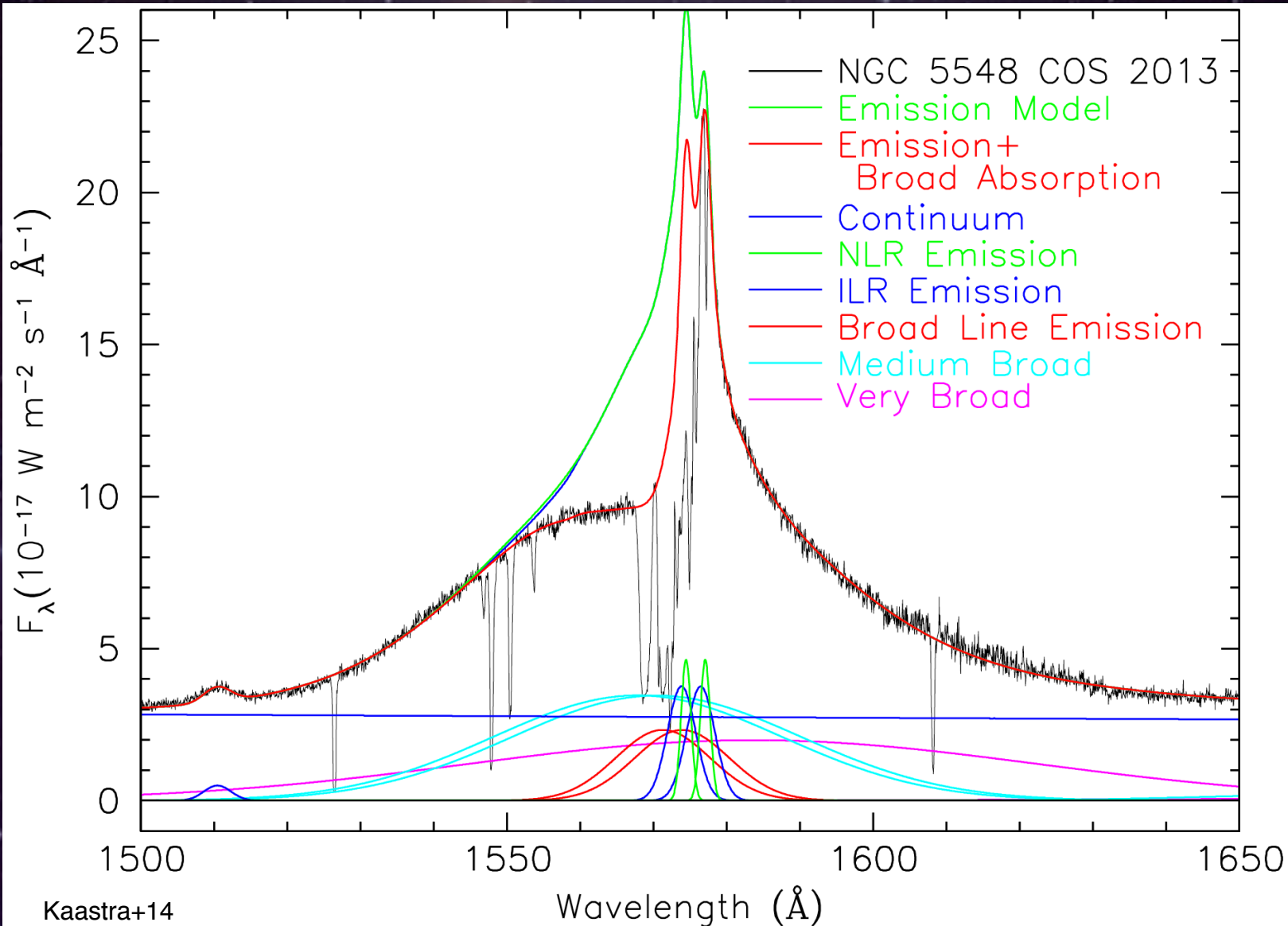
★ **Statistics of Archival Examples of Obscuring Outflows**

★ **Conclusions**

Changes in the X-ray Spectrum of NGC 5548



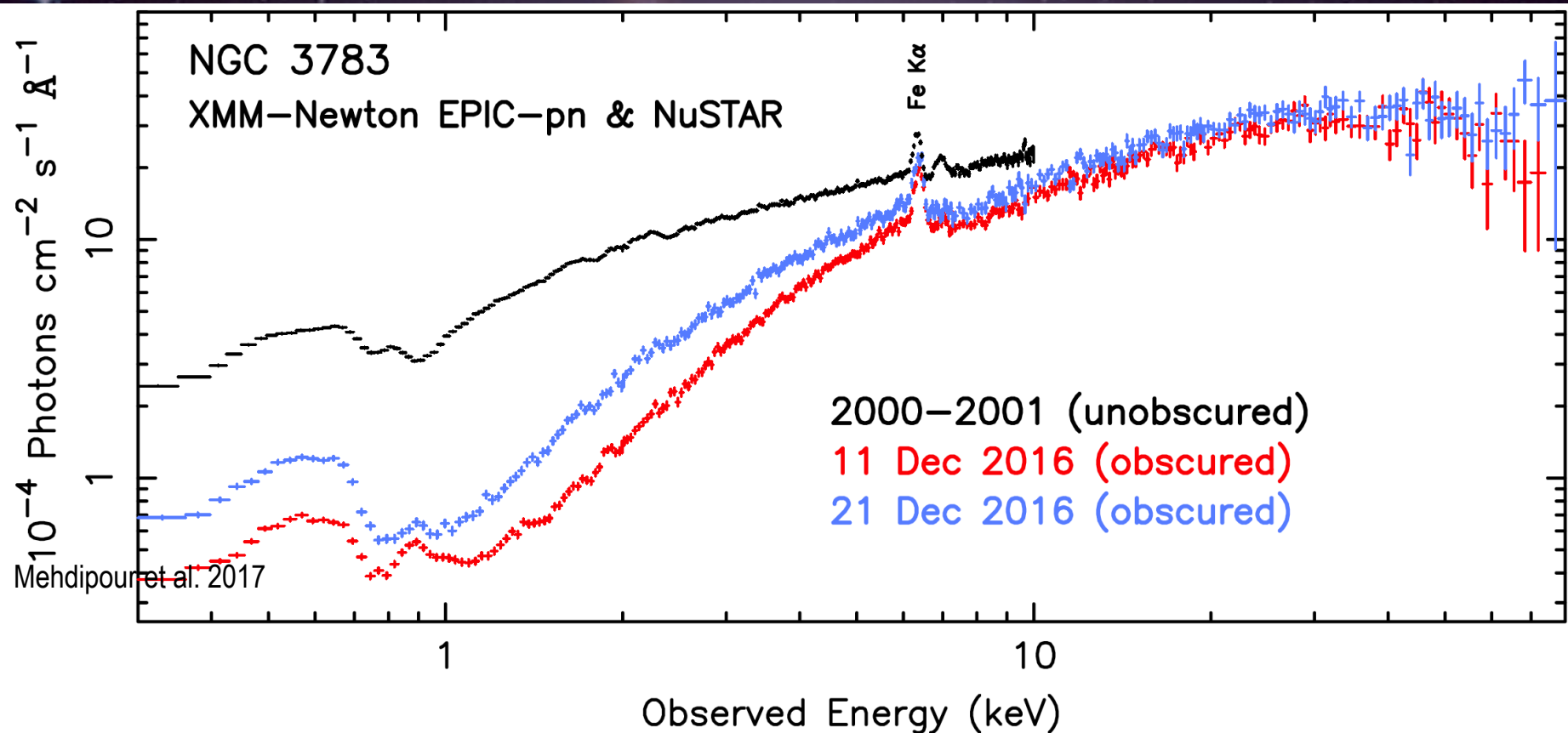
Broad C IV Absorption in NGC 5548



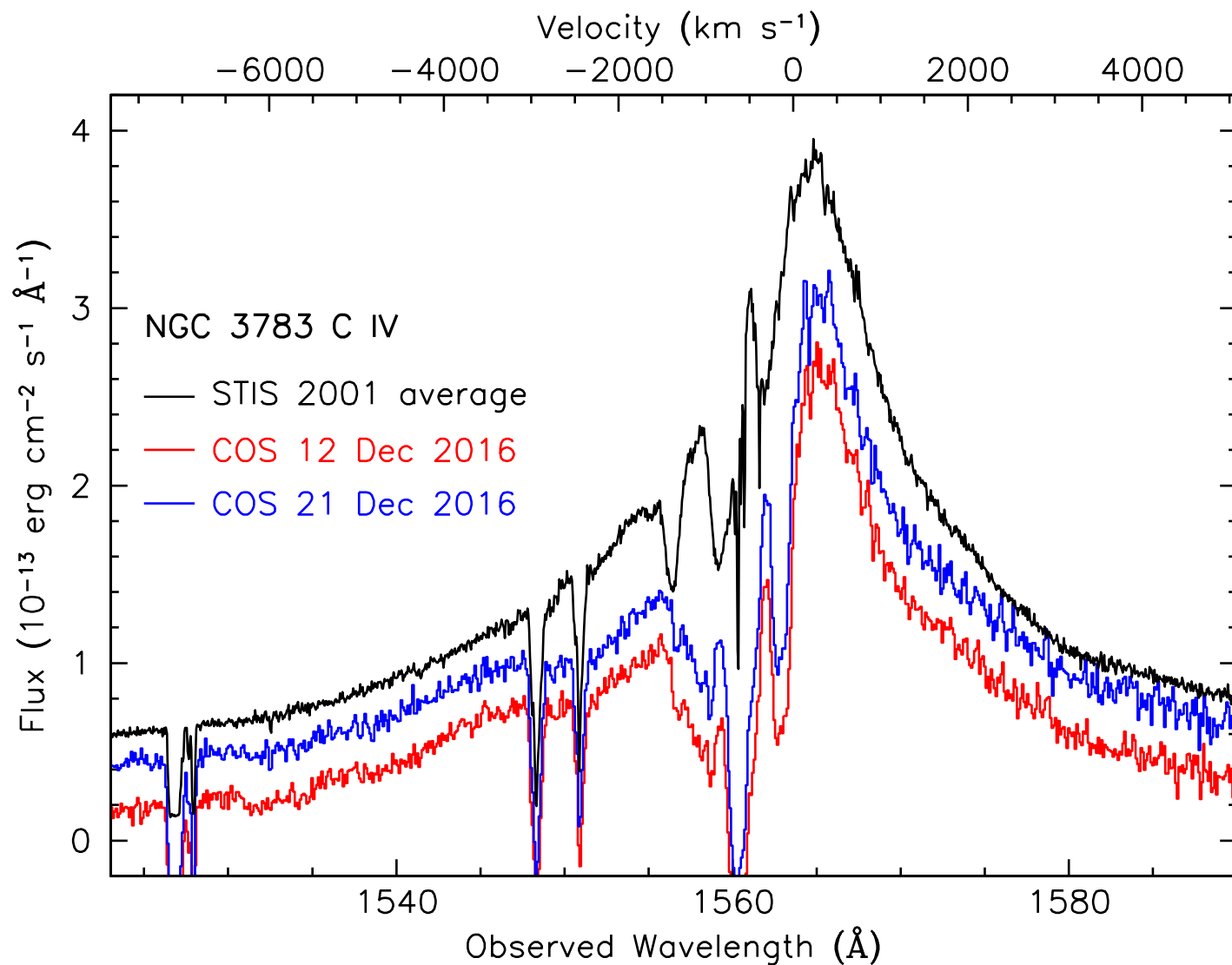
Obscuration Event in NGC 3783 in December 2016

XMM-Newton pn + NuSTAR Spectra

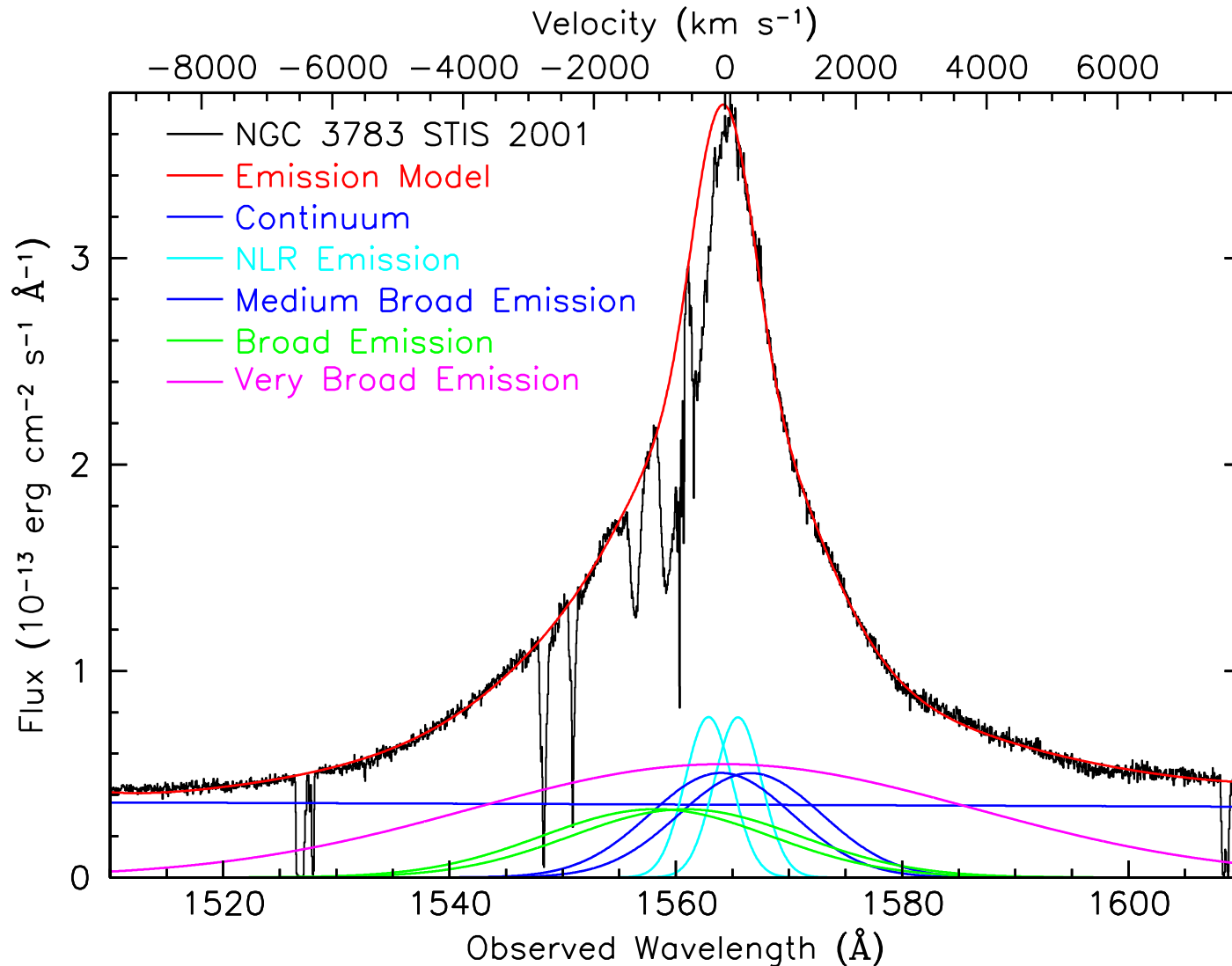
c.f. Missagh Mehdipour's talk earlier.



Comparison of HST/COS C IV Profiles in NGC 3783

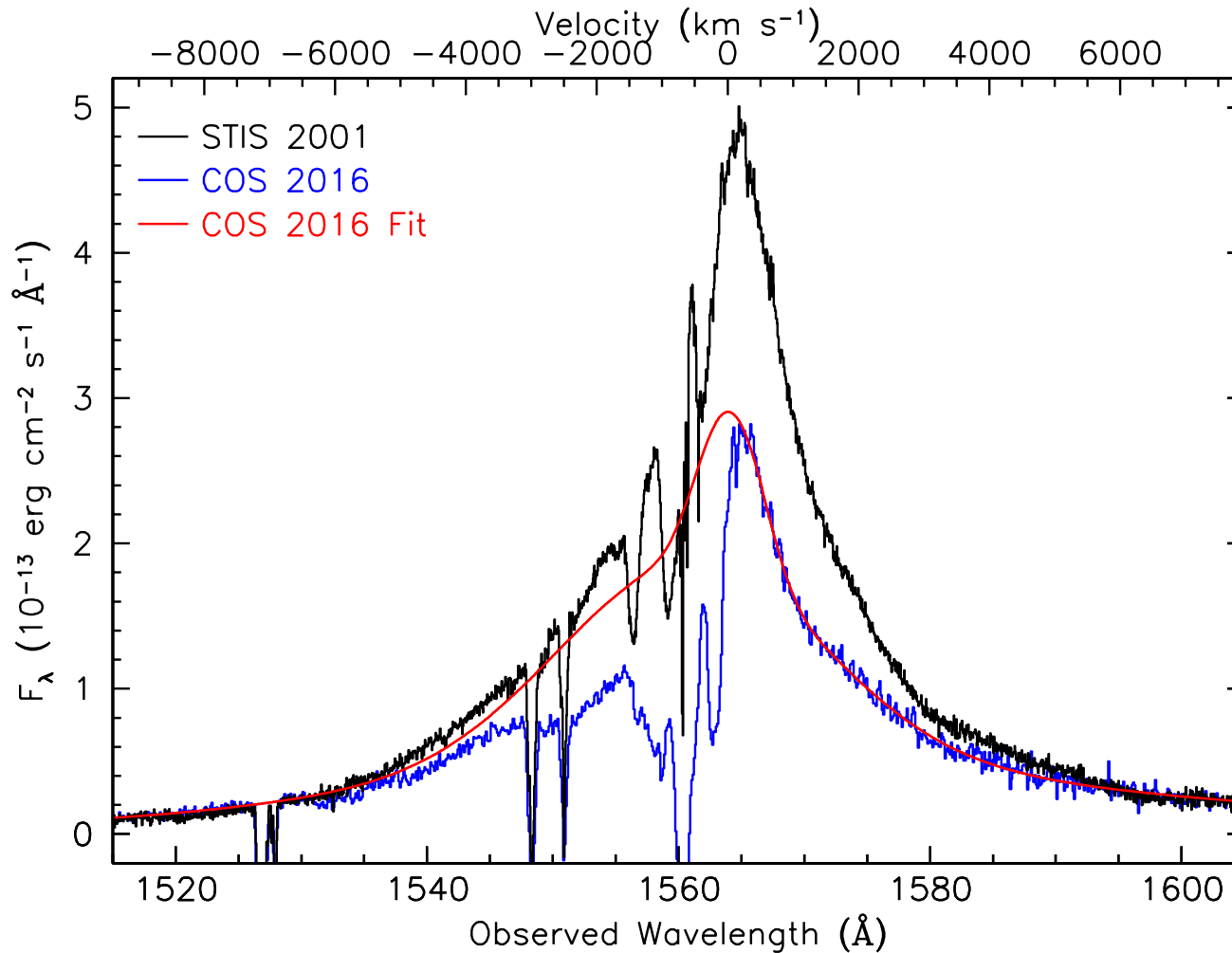


C IV Profile in NGC 3783 (STIS 2001)



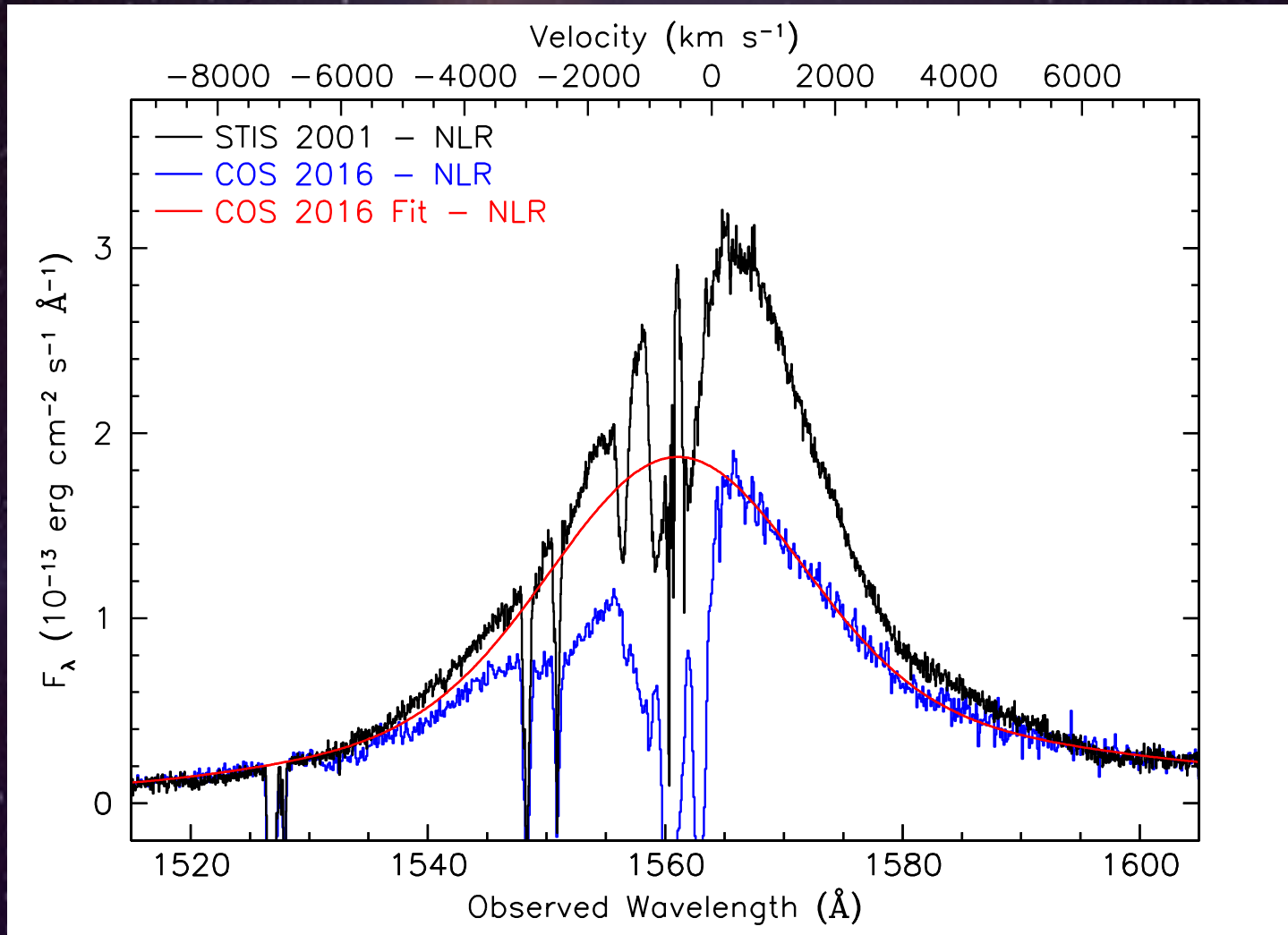
Modeling the C IV Absorption in the 2016 Spectrum

Comparison of Full STIS 2001 and COS 2016 Profiles



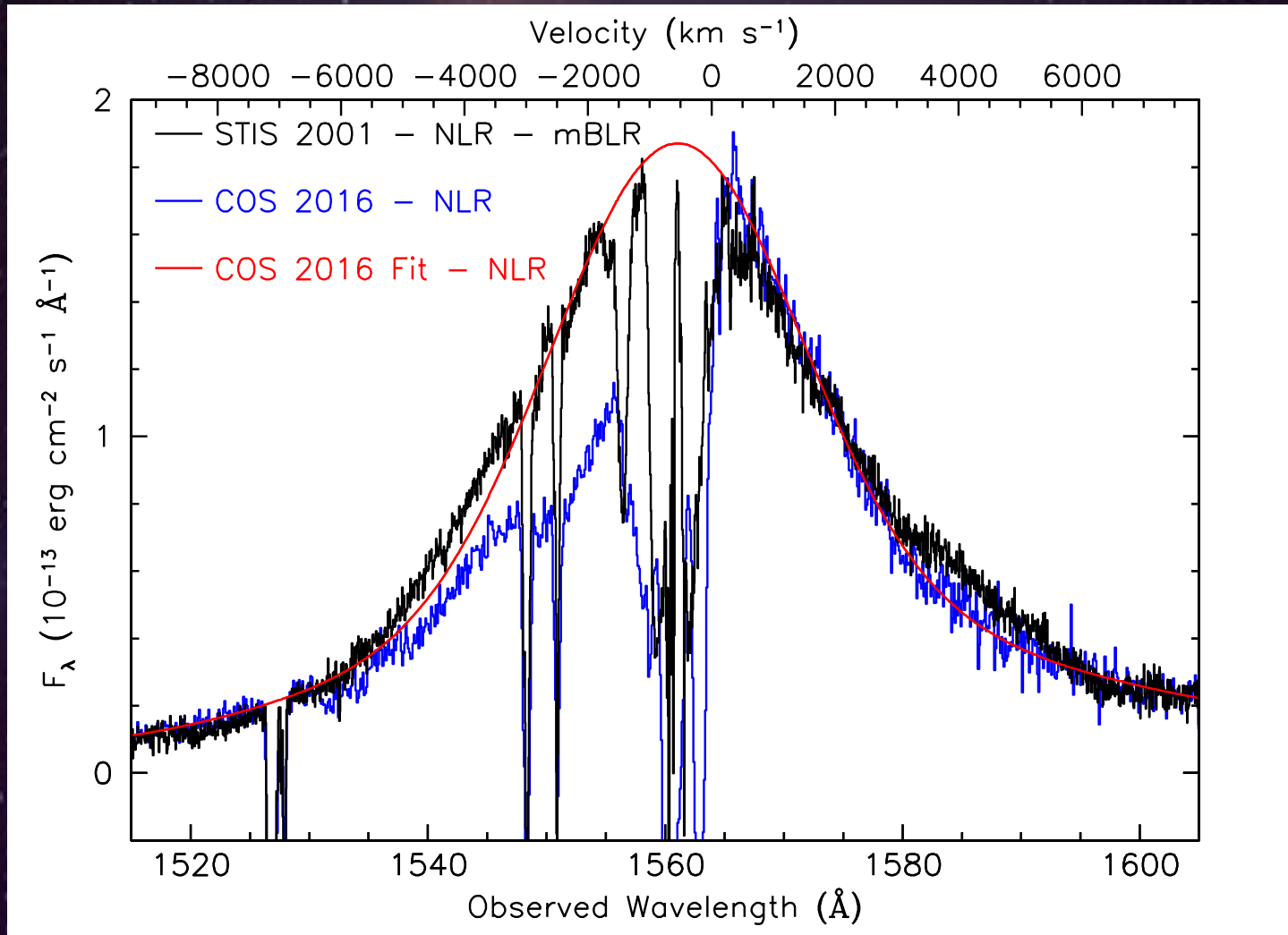
Modeling the C IV Absorption in the 2016 Spectrum

Remove the Narrow Emission Components

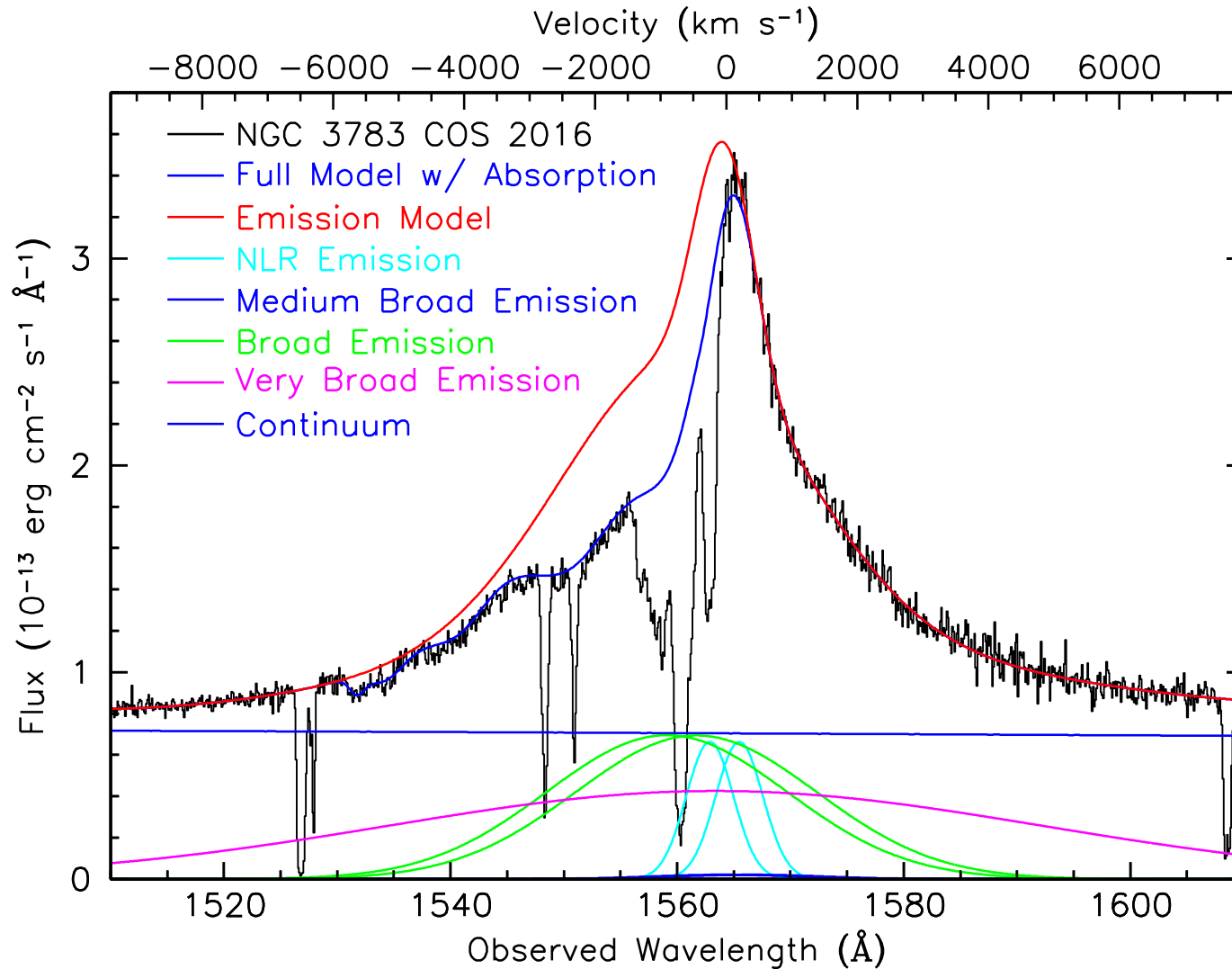


Modeling the C IV Absorption in the 2016 Spectrum

Remove the Narrow & Intermediate Emission Components



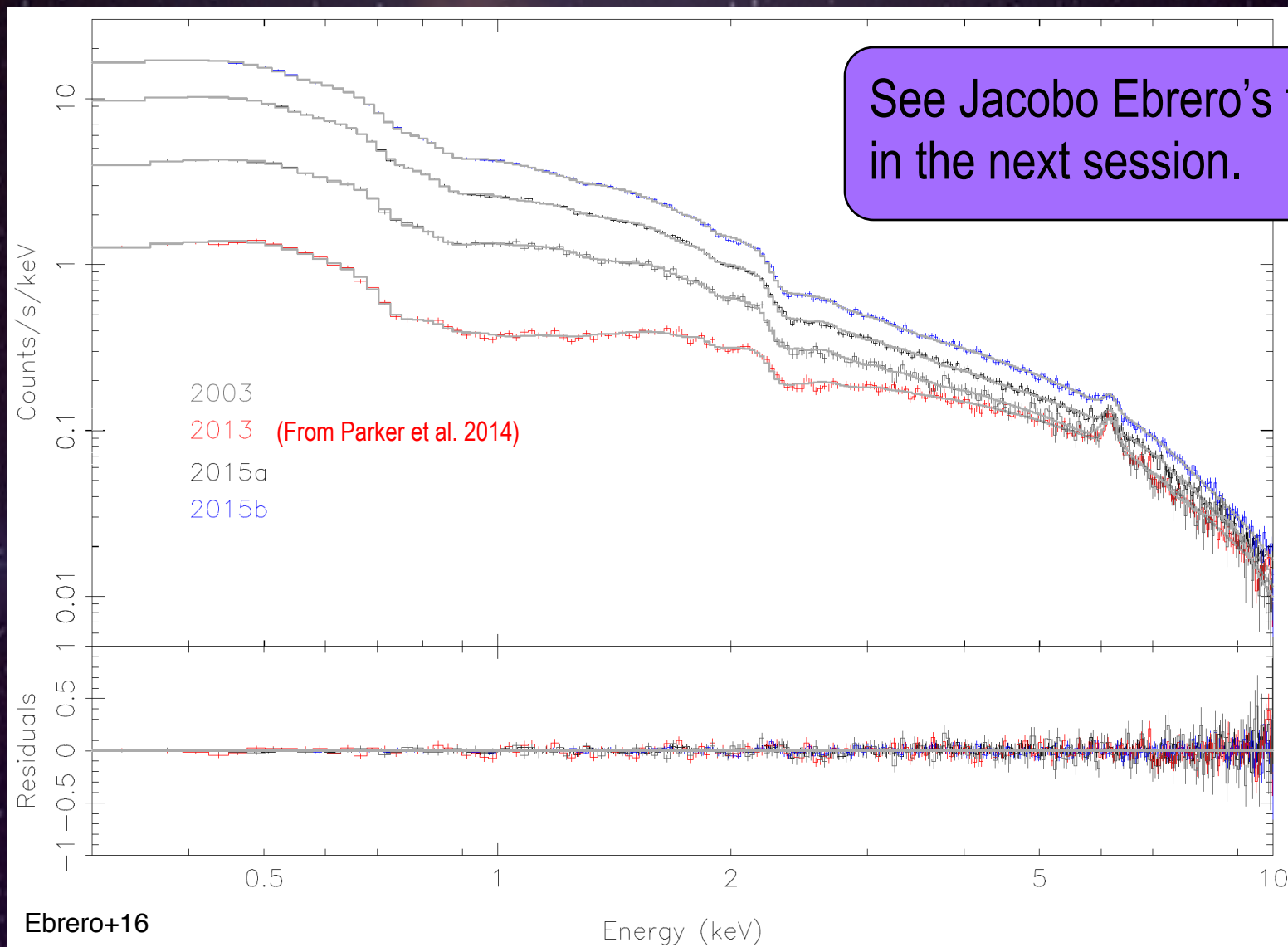
C IV Profile in NGC 3783 (COS 2016)



Why Contemporaneous UV Spectra are Important

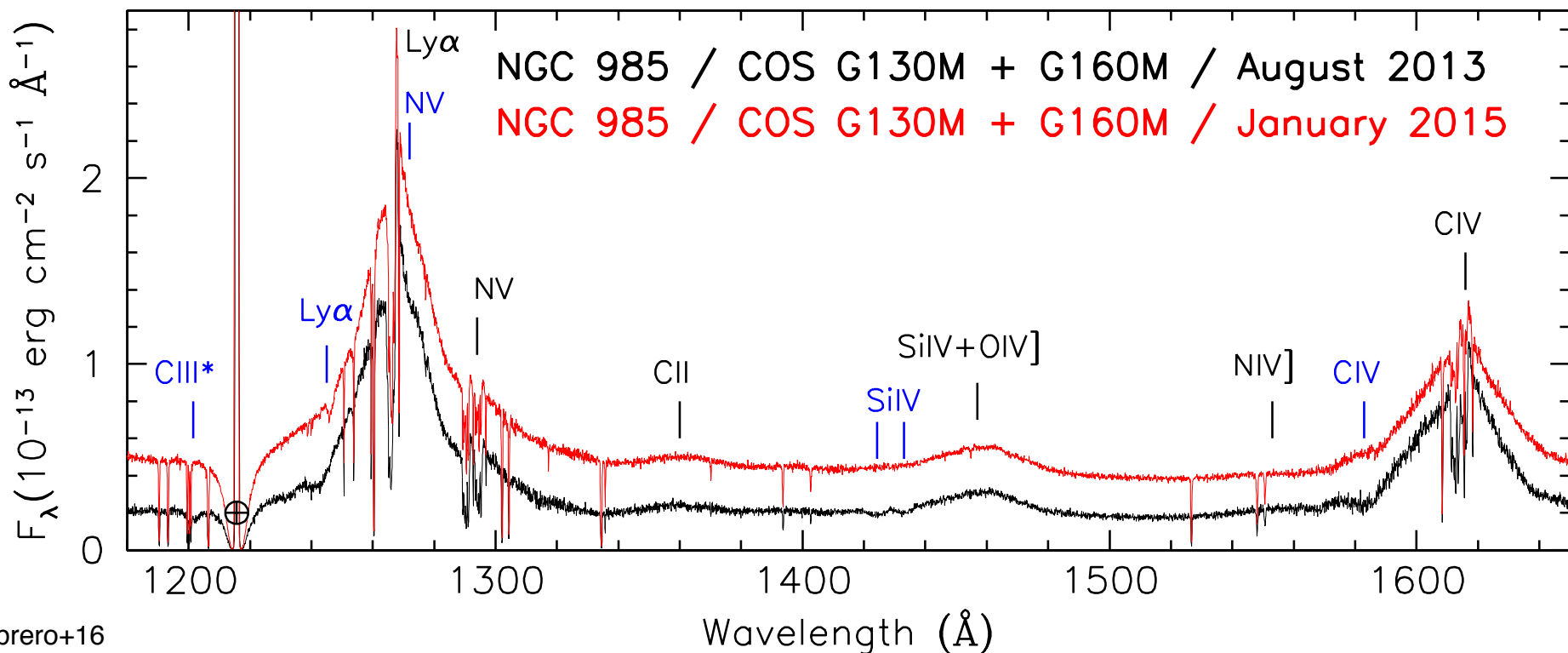
- ★ Soft X-ray obscuration generally leaves no spectral imprint, so one cannot discern the velocity or constrain the ionization of the absorbing gas.
- ★ Contemporaneous UV spectra supply the kinematic information that determines the velocity of the outflow and its ionization state.
- ★ In NGC 5548, absorption from Ly α , 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 ($\log \xi < 0.0$).
- ★ In NGC 3783, we see only Ly α , C IV, N V, and Si IV. Lower-ionization states are not present. Given the column density of $N_{\text{H}}=1\times 10^{23} \text{ cm}^{-2}$, 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

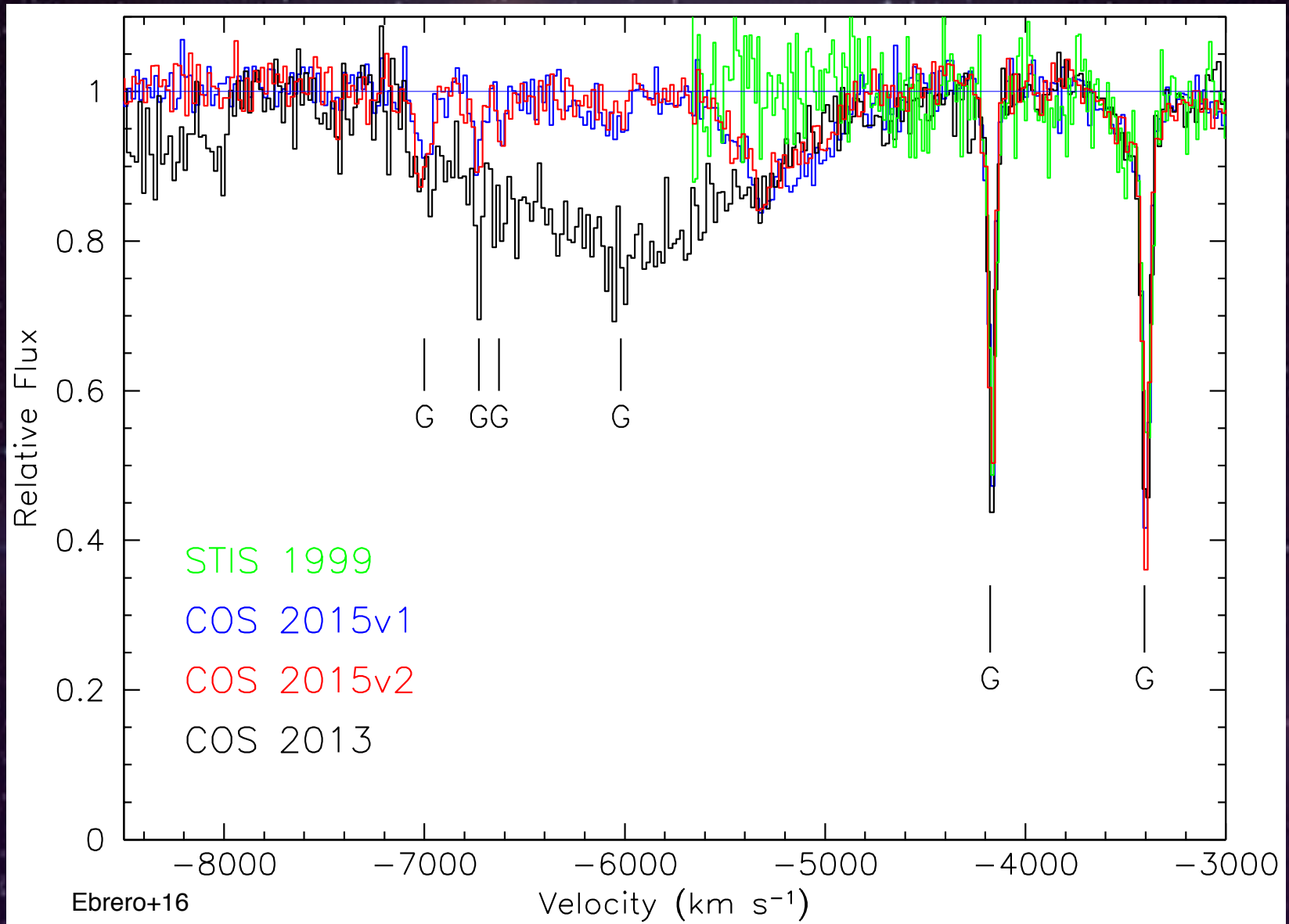


Comparison of the 2013 and 2015 COS Spectra of NGC 985

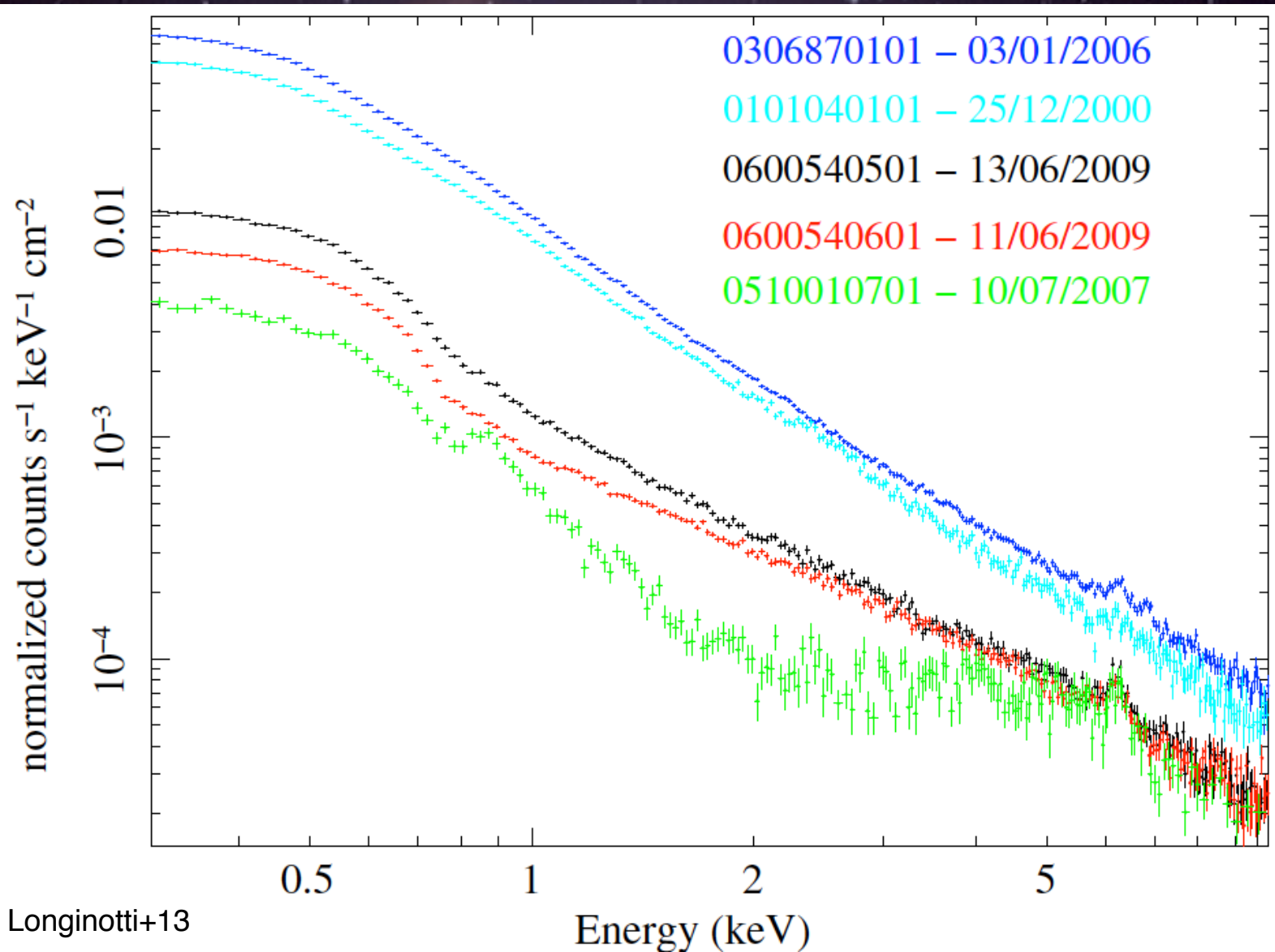
- Broad absorption appears in 2013 in C III*, Ly α , Si IV and C IV, coincident with heavy soft X-ray obscuration.
- When the obscuration diminishes in 2015, only a portion of the Ly α absorption remains visible.



Comparison of Ly α Absorption in Archival HST Spectra of NGC 985

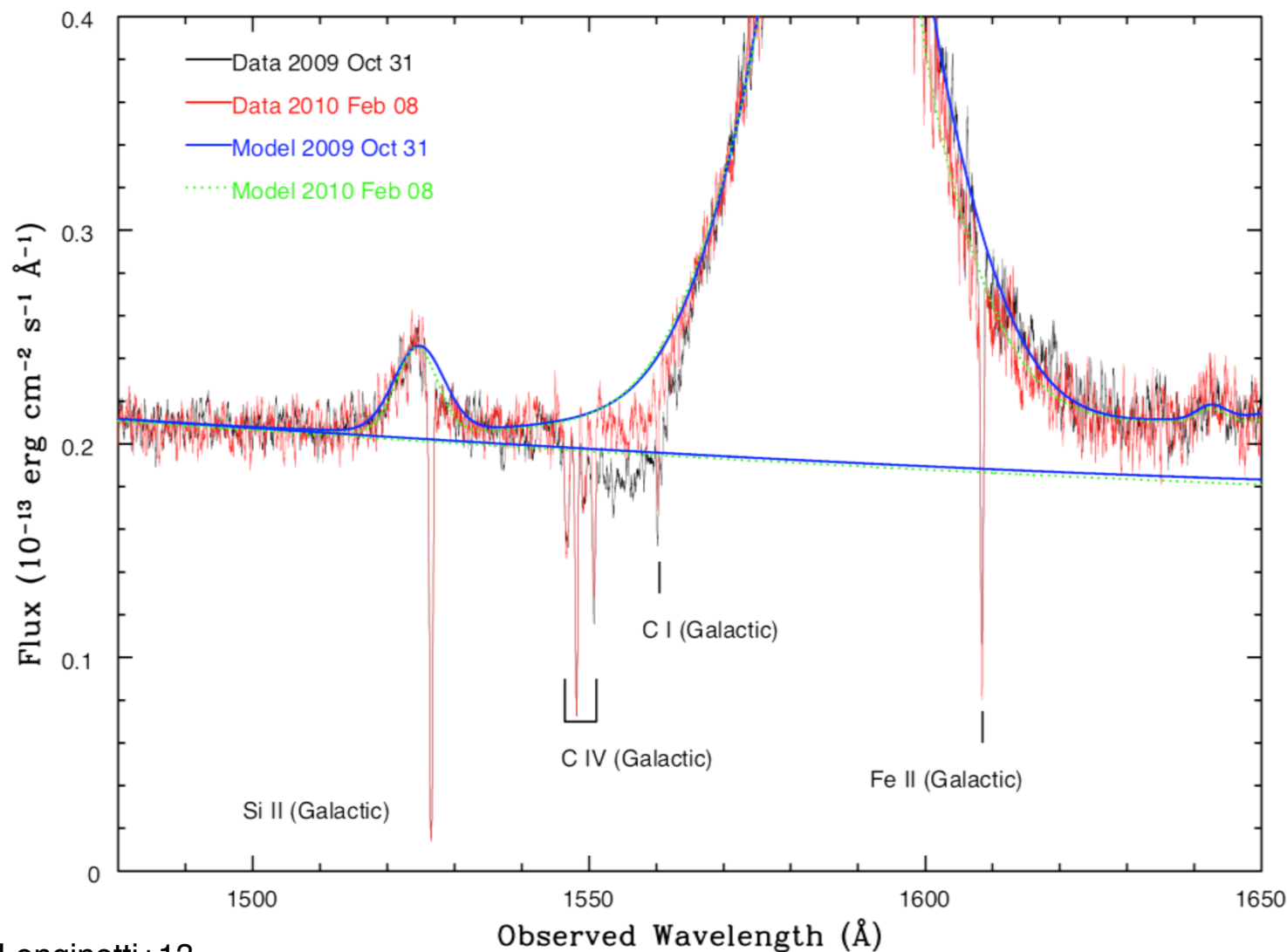


X-ray Absorption in Mrk 335

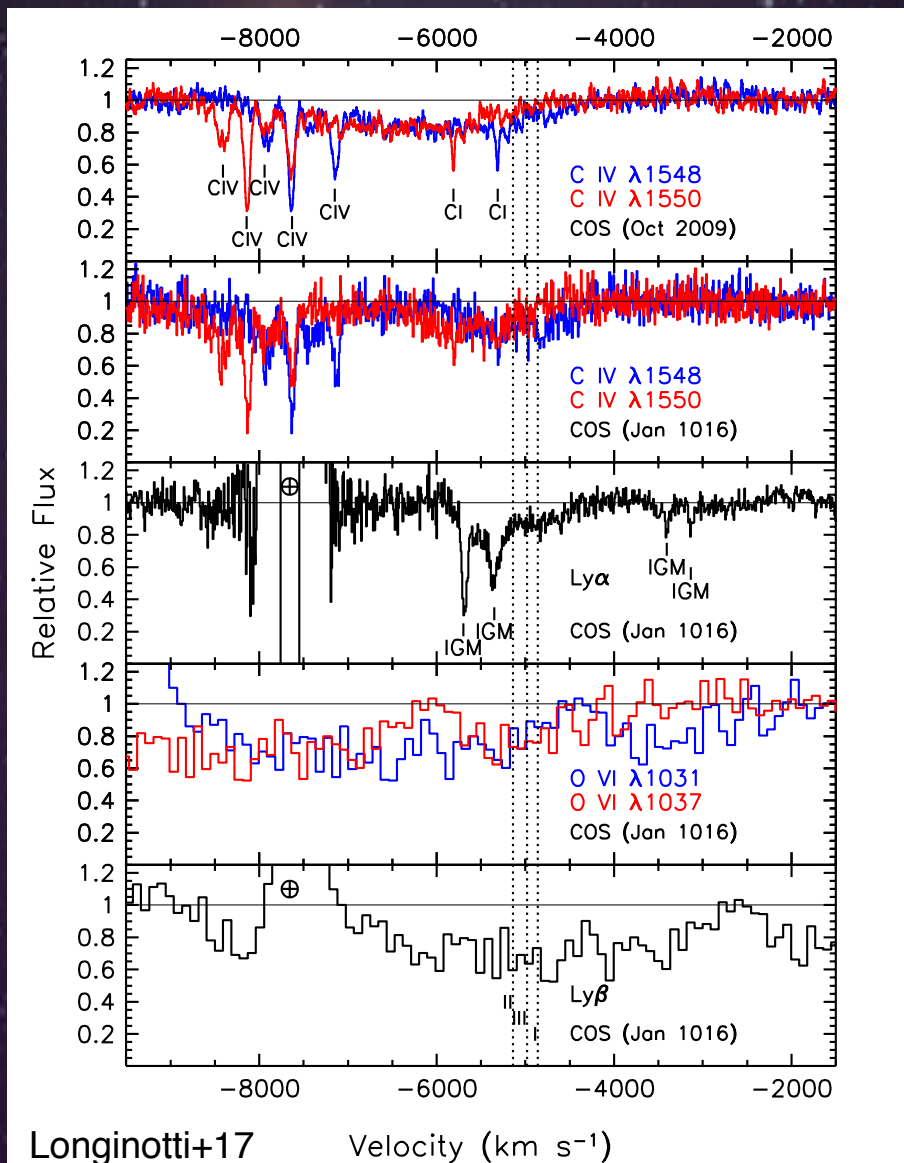


Broad C IV Absorption in Mrk 335

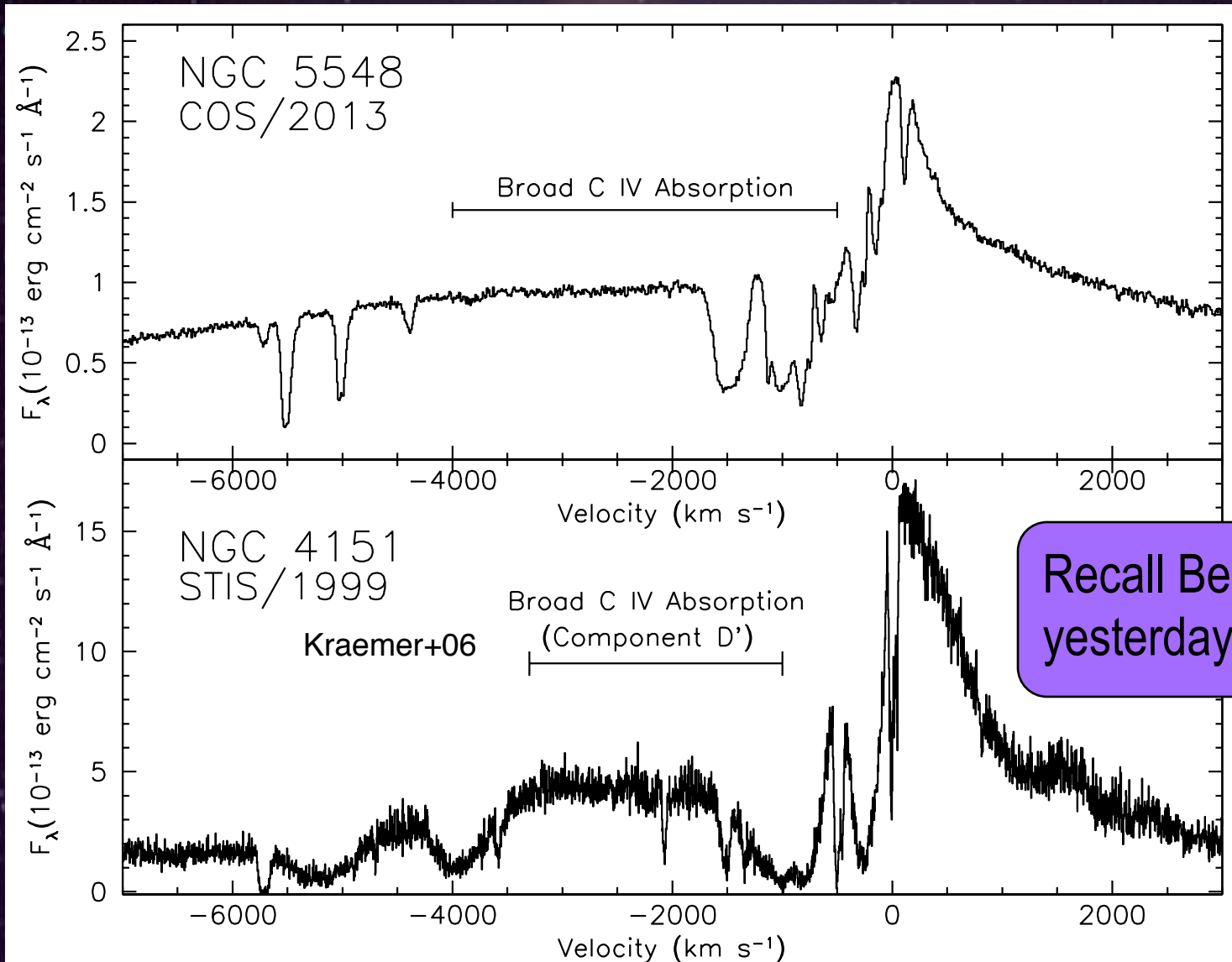
(X-ray obscuration occurred in June 2009)



Broad Ly α , Ly β , C IV, and O VI in Mrk 335 from a triggered XMM+HST observation in January 2016



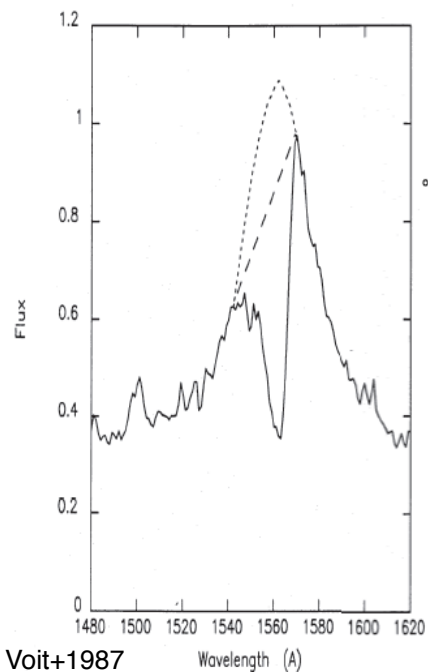
Broad C IV Absorption in NGC 5548 is Similar to NGC 4151



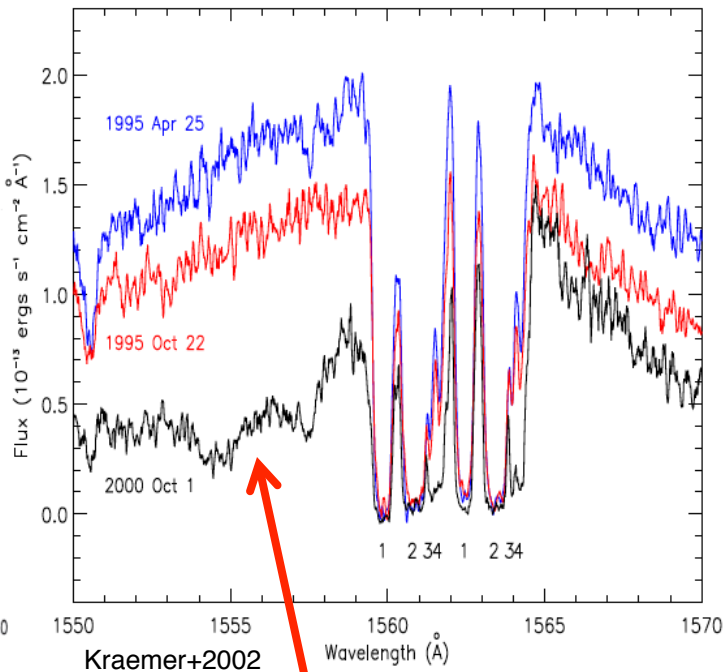
Recall Beuchert's talk yesterday afternoon.

Broad, Variable Absorption in NGC 3516

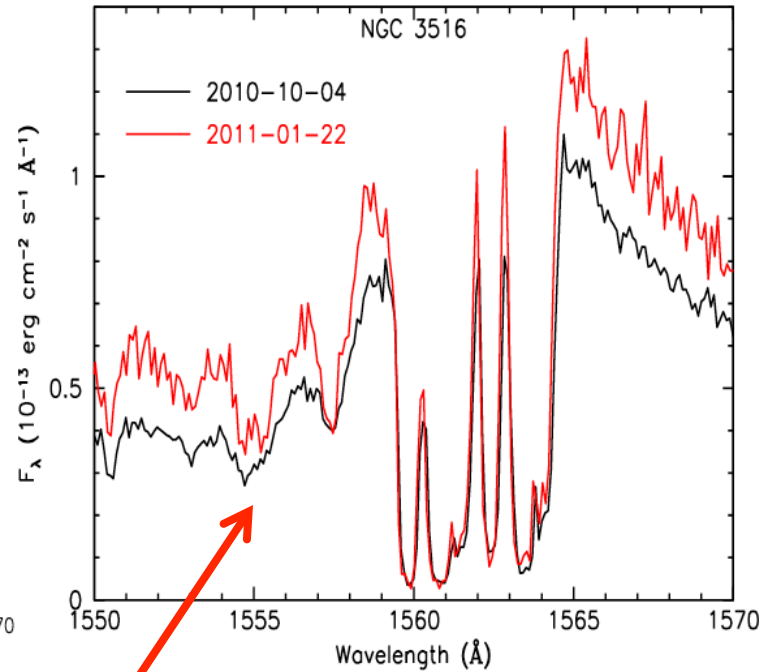
IUE 1987



GHRS 1995 and STIS 2000



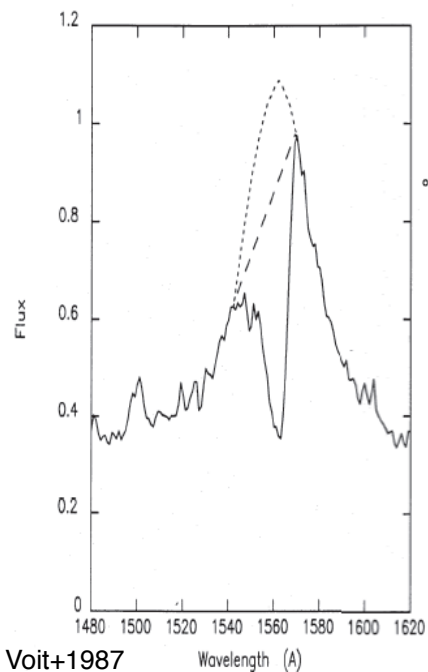
COS 2010 & 2011



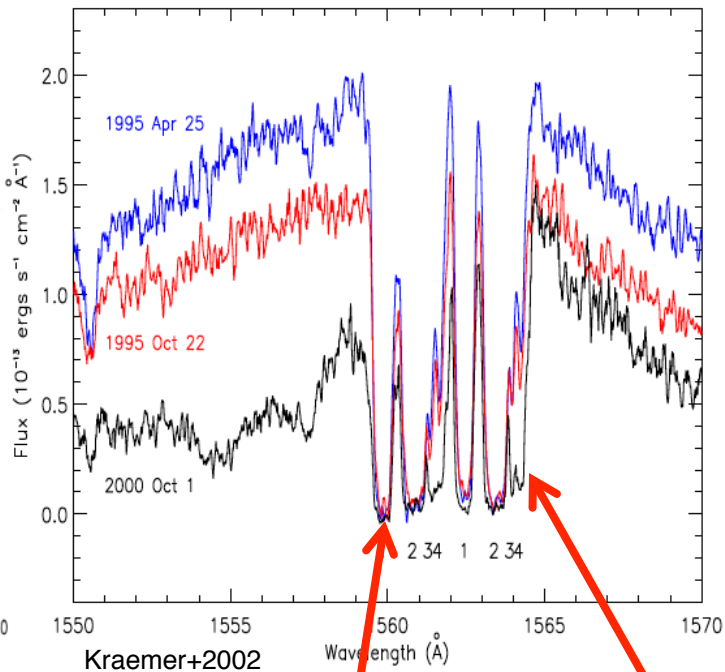
Broad absorption
comes and goes

Broad, Variable Absorption in NGC 3516

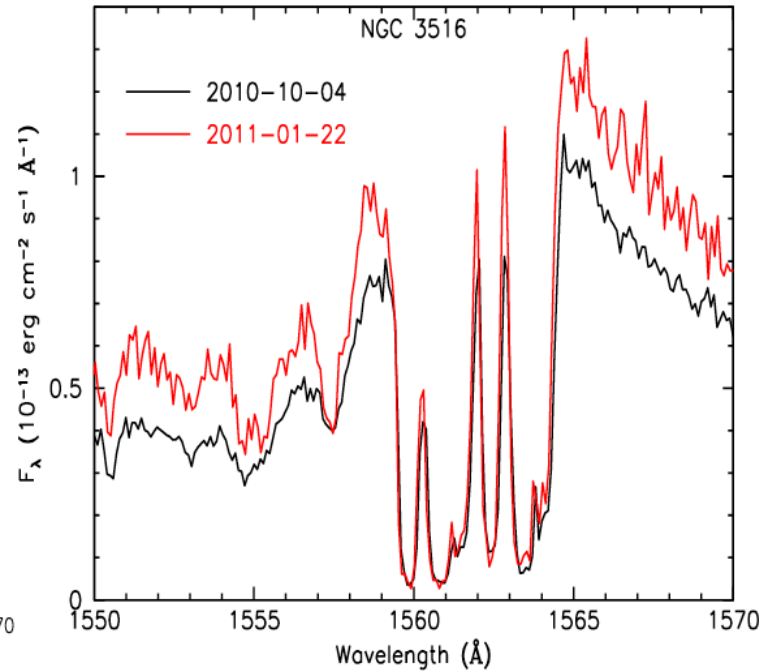
IUE 1987



GHRS 1995 and STIS 2000



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 $> 2 \times 10^{-14} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ \AA}^{-1}$
- ★ **Of these 25 AGN:**
 - 21 have high S/N HST observations using either STIS or COS over the past 20 years.
 - 6 exhibit broad ($> 1000 \text{ km s}^{-1}$), fast ($> 1000 \text{ km s}^{-1}$) blue-shifted absorption features.
 - In 6 cases these features persist for months to years, but are not always present.

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.