Variable Absorption lines from the Wind in PDS 456

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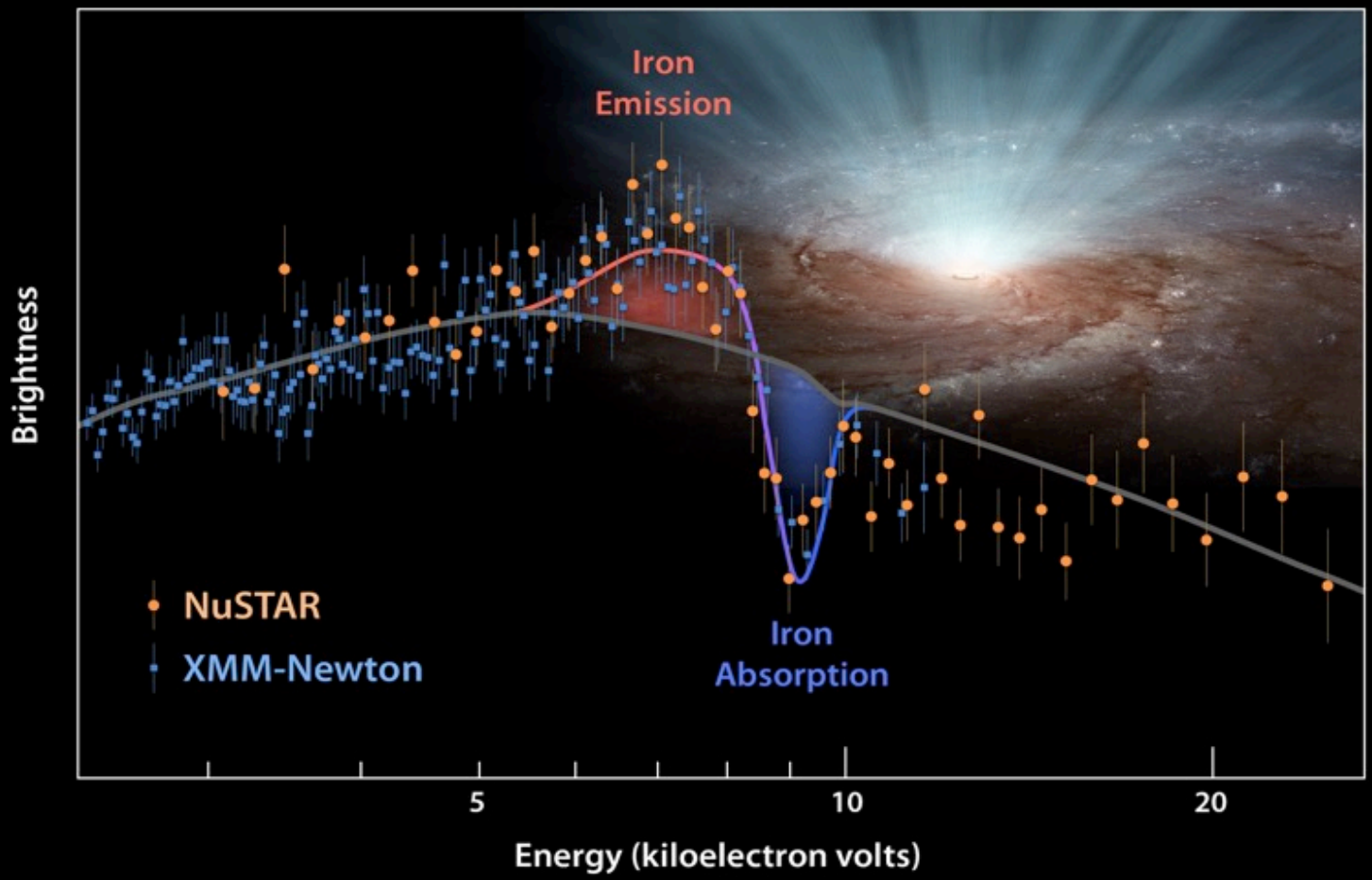
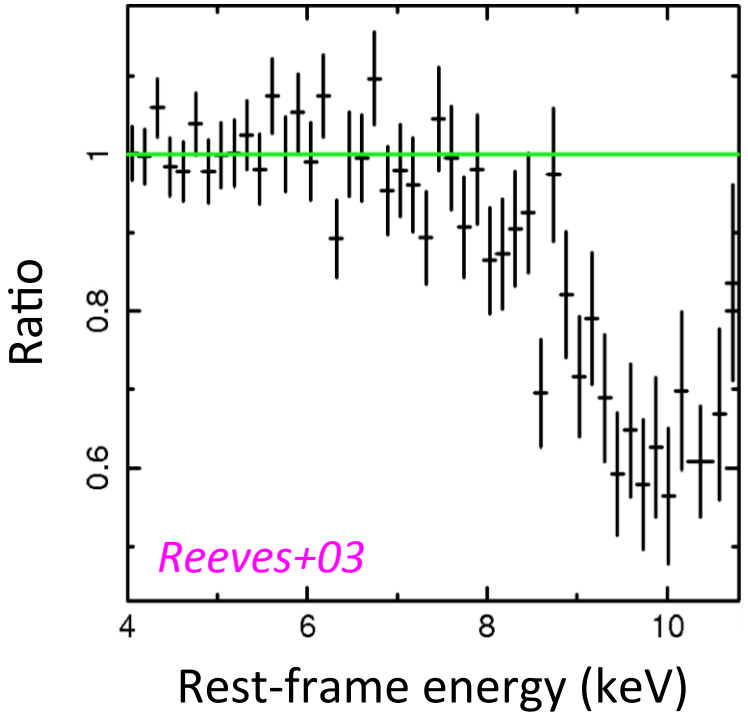
(Nardini et al. 2015, *Science;* Reeves et al., 2016*, ApJ, in press*)



PDS 456: the Rosetta Stone of AGN disk winds

Most luminous radio-quiet AGN in the local Universe

$$M_B \sim -27 \qquad L_{\rm bol} \sim 10^{47}\,{\rm erg\,s^{-1}} \qquad M_{\rm BH} \sim 10^9\,M_\odot$$

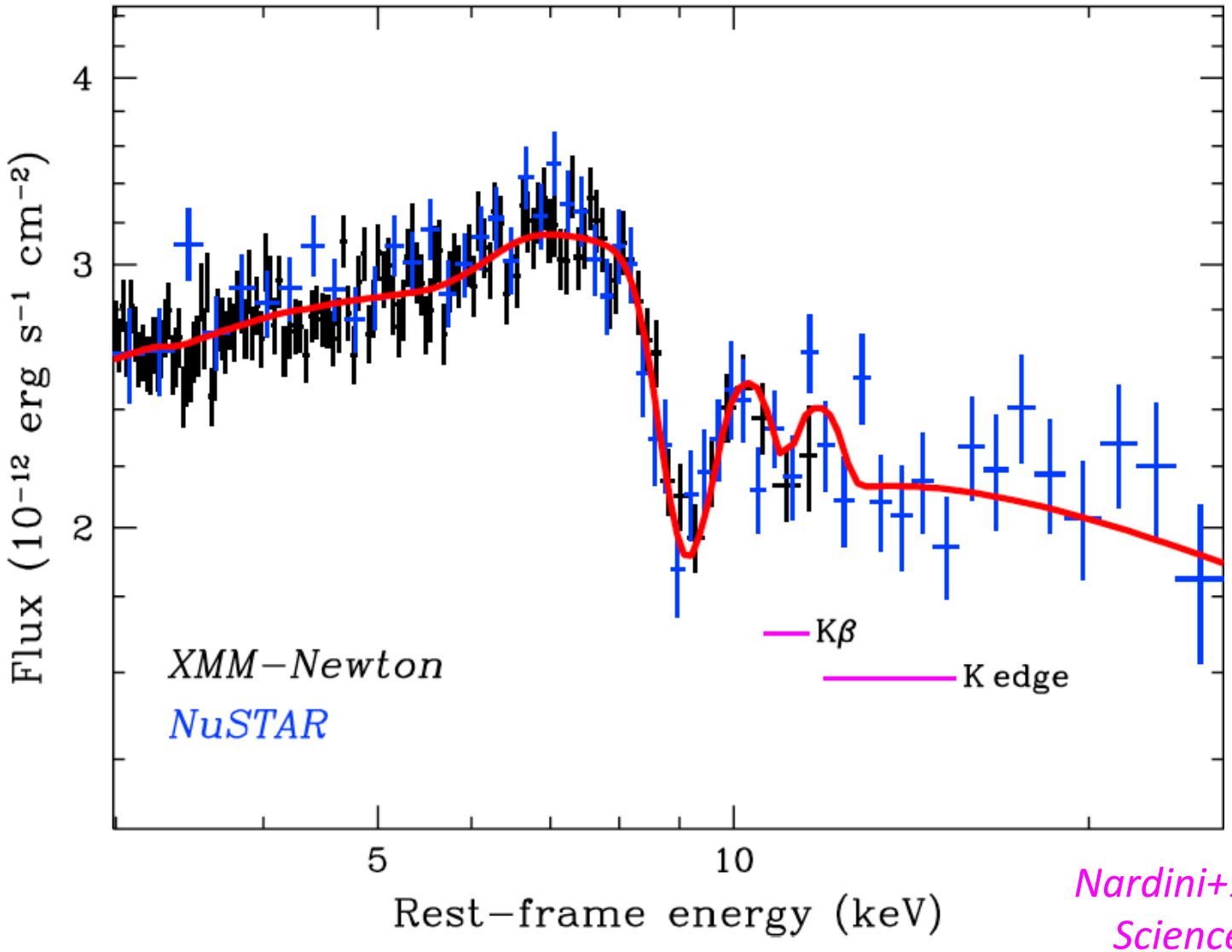


Systematic detection of a deep trough above 7 keV rest-frame: evidence for a large column of highly ionised matter outflowing at about one third of the speed of light

Ideal target for studying BH winds in the Eddington-limited regime

2013/14 campaign: 5 simultaneous *XMM + NuSTAR* observations

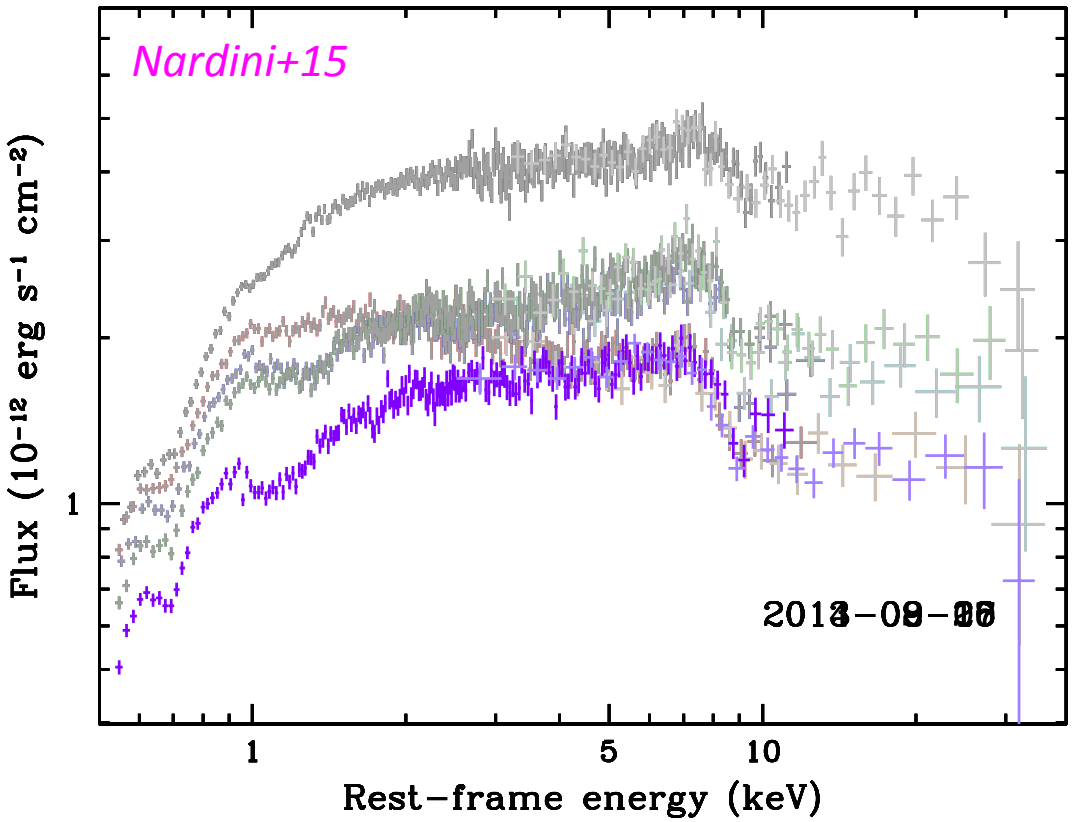
Revealing the Broad P-Cygni Iron line profile

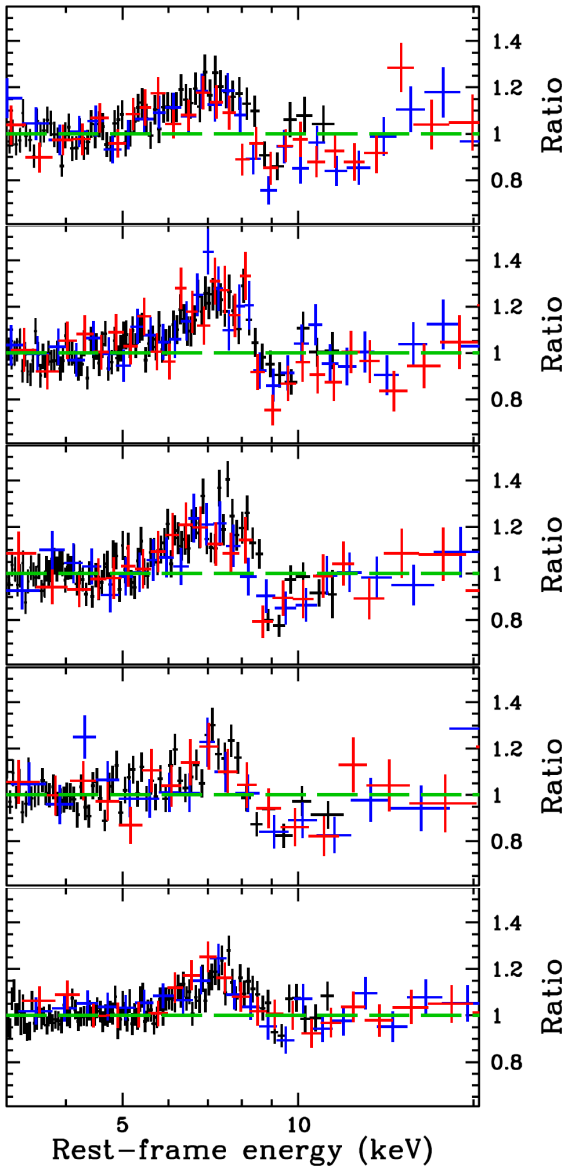


Nardini+15, Science

A persistent, wide-angle wind

P-Cygni-like profile resolved at any epoch
(aperture > 50° from FWHM)





Apparent response to continuum
changes over 7-10 days

Constraints on the Disk Wind Properties

$$\dot{M}_{\rm out} \sim \frac{\Omega}{4\pi} \times \frac{N_{\rm H}}{10^{23}\,{\rm cm}^{-2}} \times \frac{v_{\rm out}}{c} \times \frac{R_{\rm in}}{10^{15}\,{\rm cm}}\, M_\odot\,{\rm yr}^{-1}$$

All the information can now be determined from the data

The solid angle is obtained from the emitted/absorbed luminosity ratio, and the launch radius from the variability timescale

$$\dot{M}_{\rm out} \sim 10\,M_\odot\,{\rm yr}^{-1} \Rightarrow P_{\rm kin} \sim 2\times10^{46}\,{\rm erg\,s}^{-1} \sim 0.2\,L_{\rm bol}$$

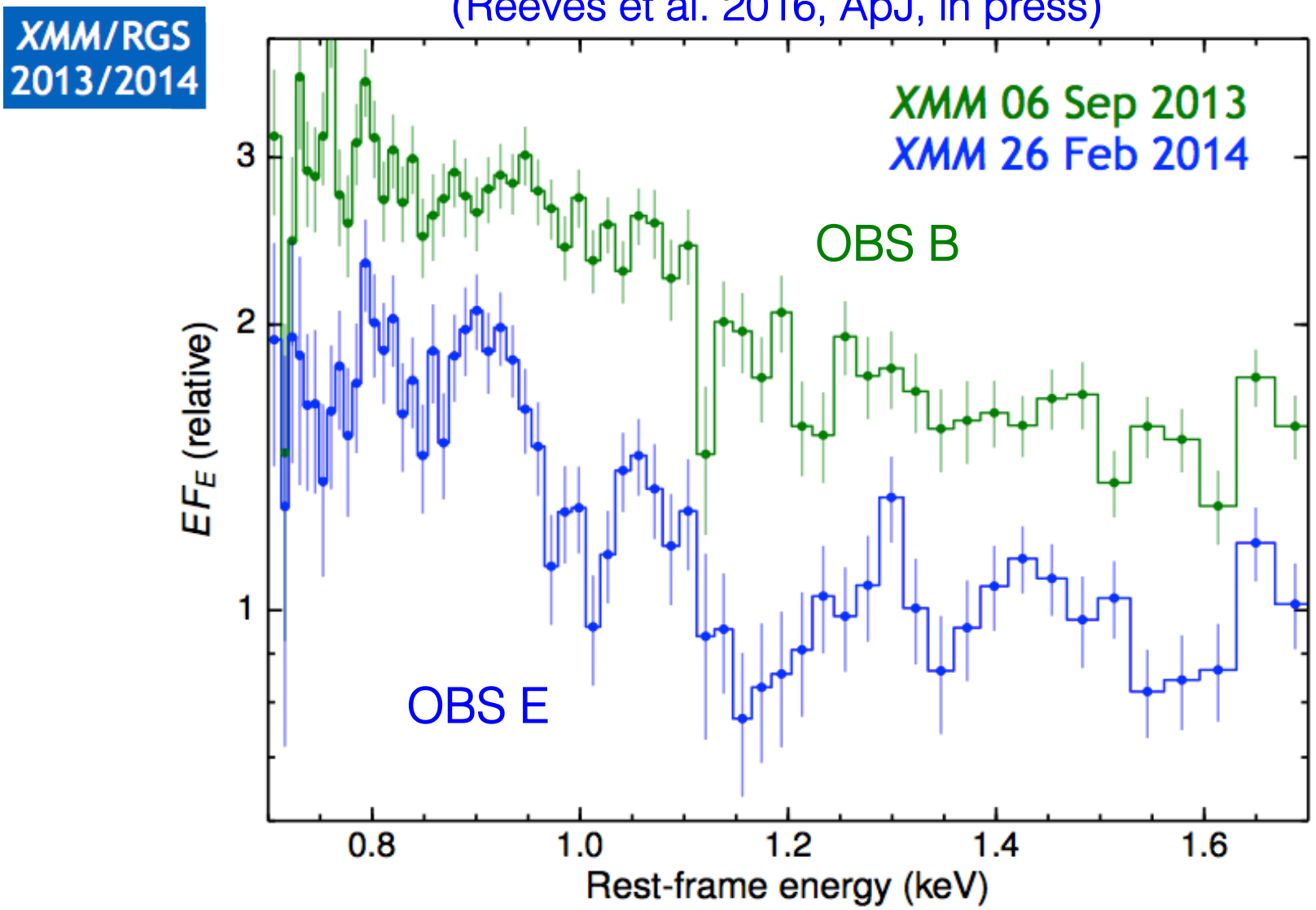
The deposition of a few % of the total radiated energy is enough to prompt significant feedback on the host galaxy *(Hopkins & Elvis 10)*.

Over a lifetime of 10^7 yr the energy released through the accretion disk wind likely exceeds the binding energy of the bulge

$$E_{\rm wind} \sim 10^{61}\,{\rm erg} \sim 3\times M_{\rm bulge}\,\sigma^2$$

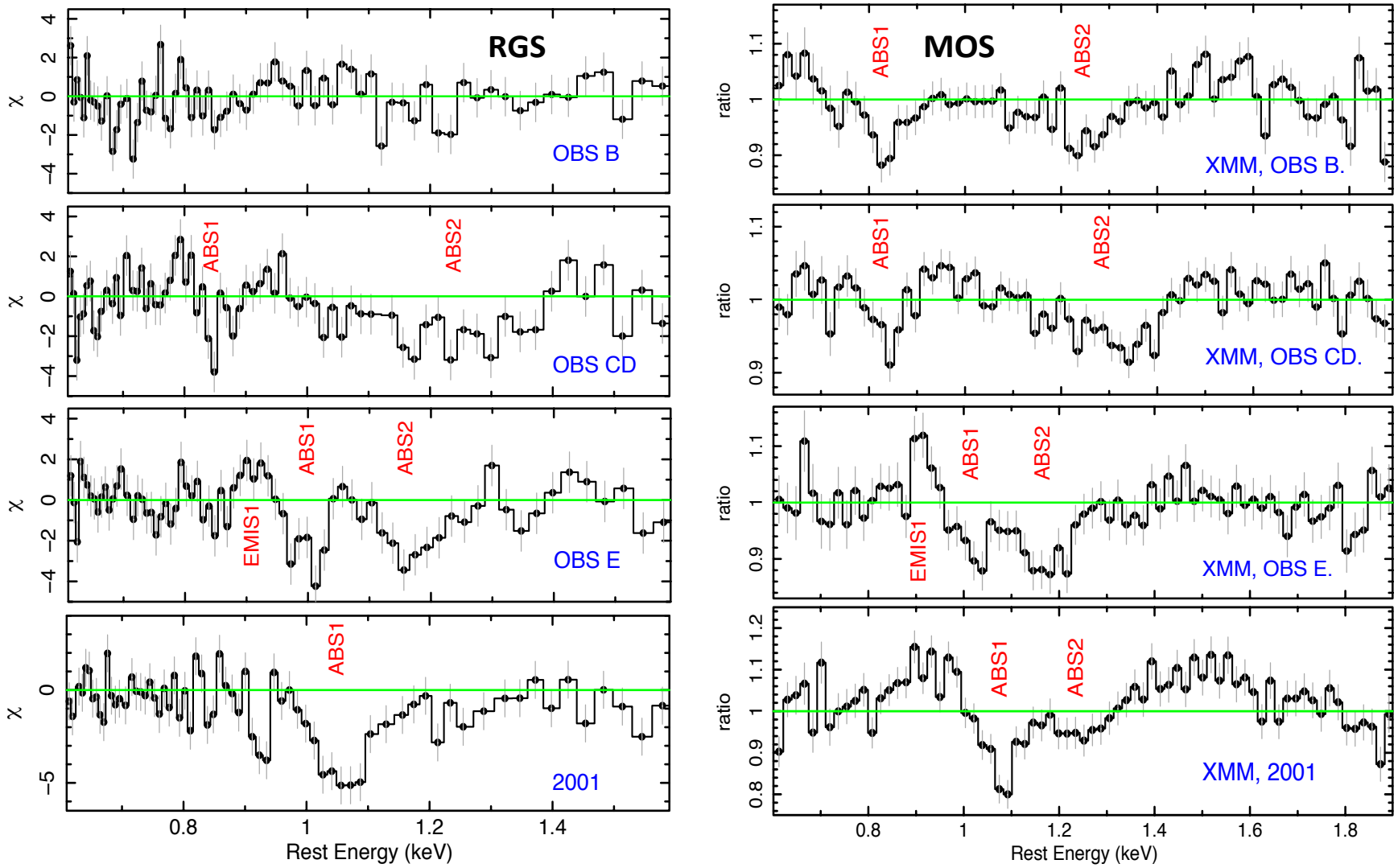
Broad Soft X-ray Absorption Profiles in PDS 456

(Reeves et al. 2016, ApJ, in press)



Signatures of fast (0.15c) "BAL" like profiles in soft X-rays with XMM-Newton/RGS. Velocity widths $\sigma \approx 10000$ km/s.

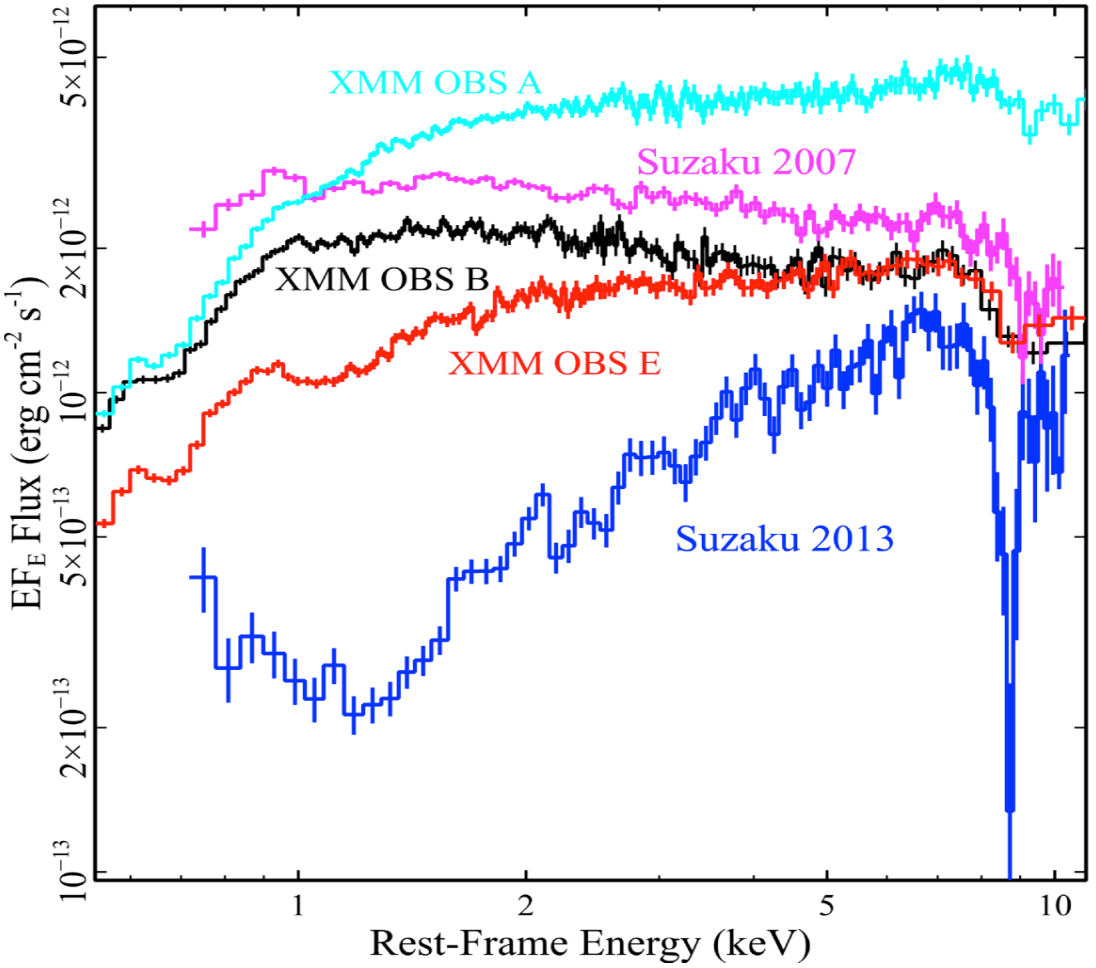
Broad Soft X-ray Absorption Lines



Soft X-ray absorbing gas the likely signature of an inhomogeneous wind, partially obscuring the AGN. Velocities of up to 0.1c.

Absorption primarily due to highly ionized Fe (Fe XX-XXIV) as well as NeIX/X

One year in the life of PDS 456



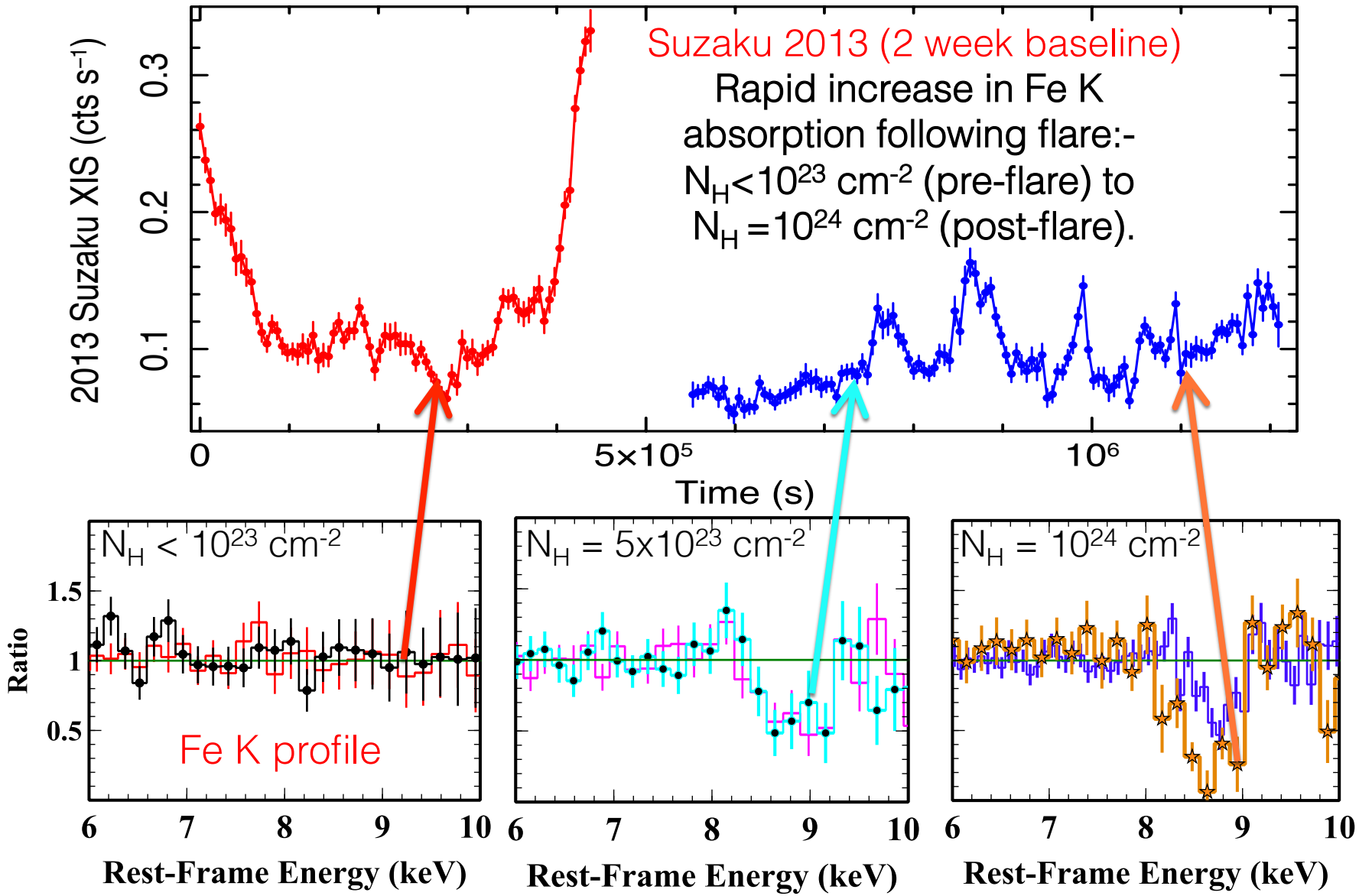
Spectral variability of PDS 456, from March 2013 (Suzaku) to August 2013 (XMM OBS A/B) to March 2014 (XMM OBS E).

10x flux increase at 1 keV from Mar 2013 to Aug 2013.
Column decreases by $\Delta N_H > 10^{23}$ cm^{-2}

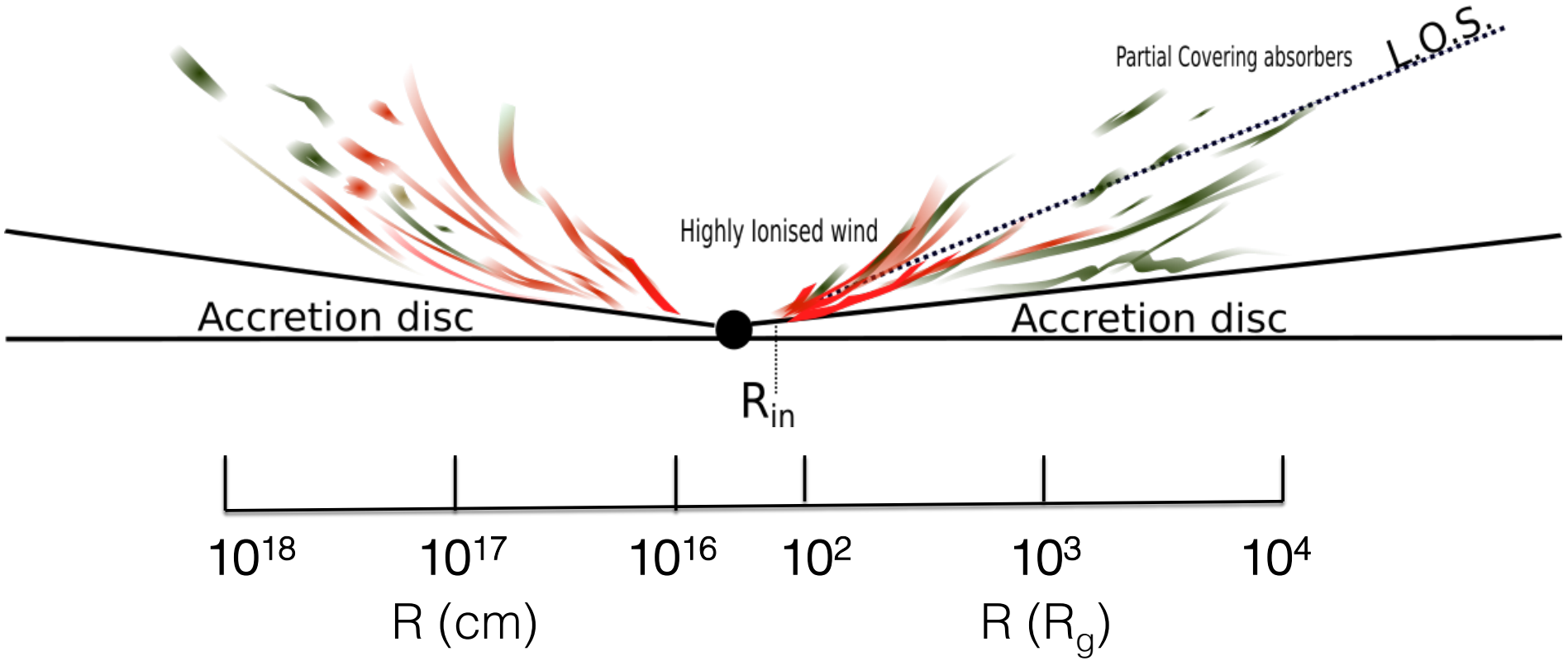
Factor x2 decrease in flux from Sept 2013 to Feb 2014.
Soft X-ray absorption profiles emerge as flux drops

Drastic (x10) absorption variability over months timescales.
Increase in absorption opacity likely linked to emergence of soft X-ray broad absorption profiles – partial covering in clumpy wind?
Iron K absorber also stronger during low flux episodes.

Rapid Absorption Line Variability (Matzeu et al. 2016)



The Wind Structure

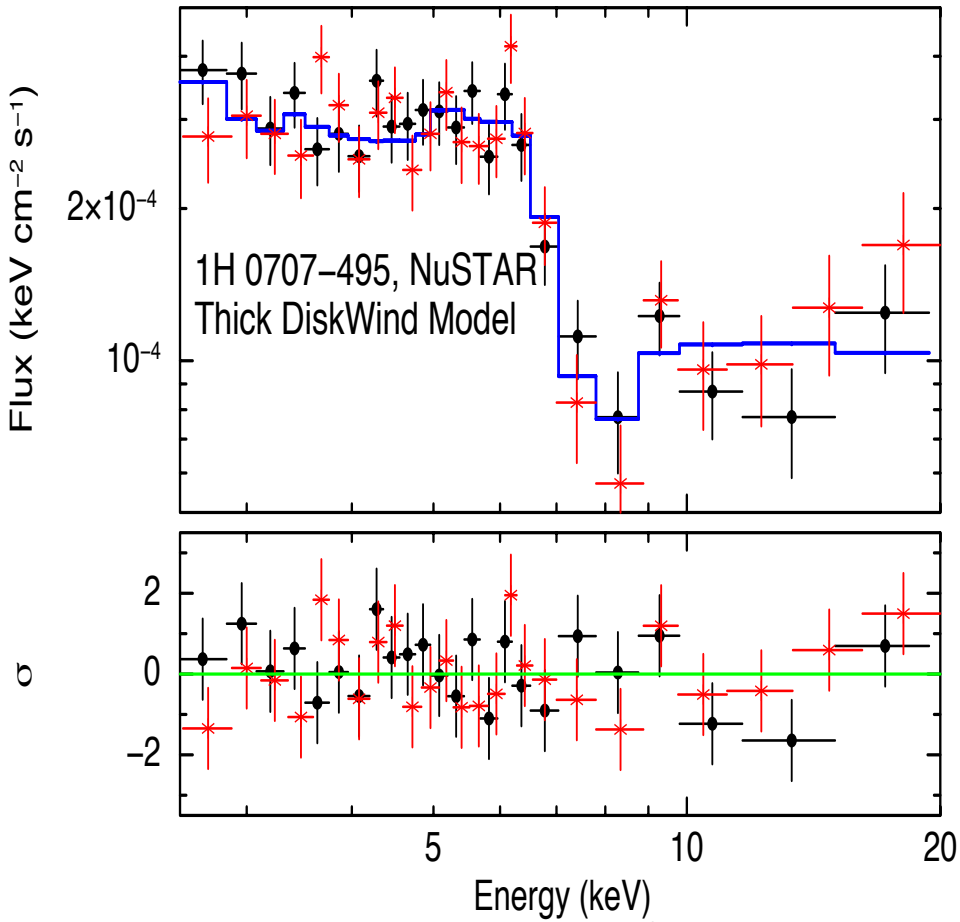


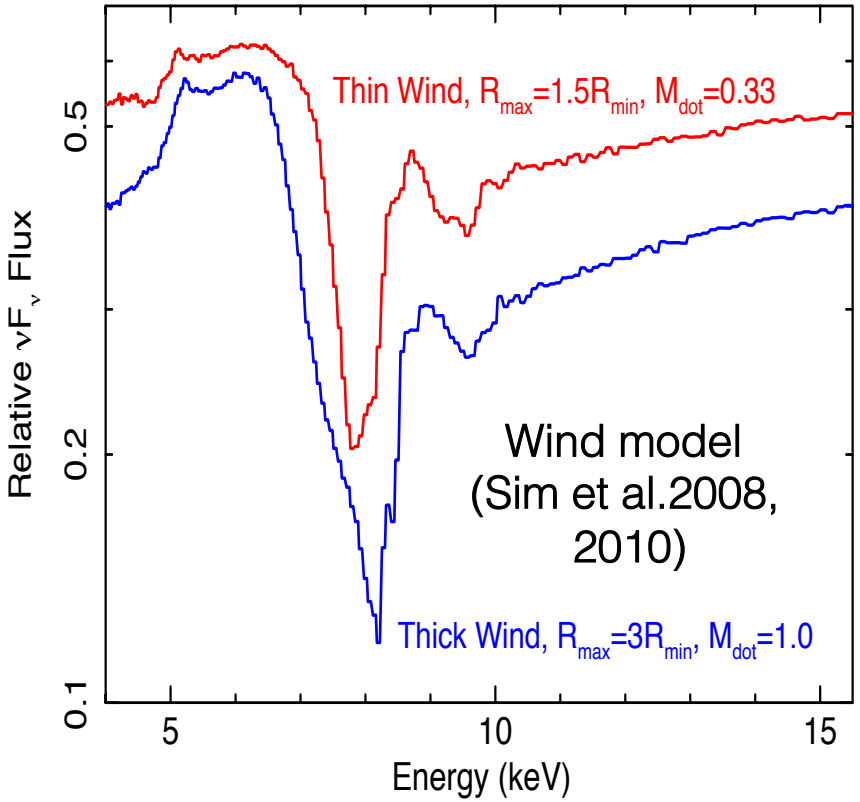
Innermost highly ionized wind launched from within 100 Rg of black hole – ultra fast iron K absorption (0.3c).

Inhomogeneous soft X-ray absorber $R \approx 10^{17}$-10^{18} cm, $n_e \approx 10^{7}$-10^{8} cm^{-3}, with thickness $\Delta R \approx 10^{15}$ cm. Filling factor $f \approx 10^{-3}$.

UV BLR emission (absorption) profiles $R \approx 10^{18}$ cm

An extreme disk wind in the NLS1, 1H 0707-495?





Extension of disk-wind model (Sim et al. 2008, 2010) to the extreme NLS1,1H 0707-495. Can account for strong (tau>1) drop at iron K with a fast, Eddington limited wind profile. No need for highly relativistic iron K reflection. Solar abundances of Fe only. See also Hagino talk!

Summary

★ PDS 456 is an exceptionally luminous QSO in the local Universe, yet representative of an accreting SMBH during the peak of the quasar era.

★ The new XMM + NuSTAR campaign revealed a broad P Cygni profile at iron K and allowed a direct measure of the mass-loss rate and energetics of an accretion disk wind, whose mechanical power is largely consistent with the requirements of feedback models.

★ A fast component of the soft X-ray absorber has now been discovered, with BAL like absorption profiles emerging in the RGS data, with typical velocities of 0.1-0.2c

★ The data point to a clumpy, inhomogeneous outflow, with the soft X-ray absorber representing filaments which form further out along the wind, on scale that are consistent with the inner BLR.

★ Is PDS 456 an X-ray equivalent of a BAL quasar?