

The soft X-ray view of Ultra Fast Outflows in AGN

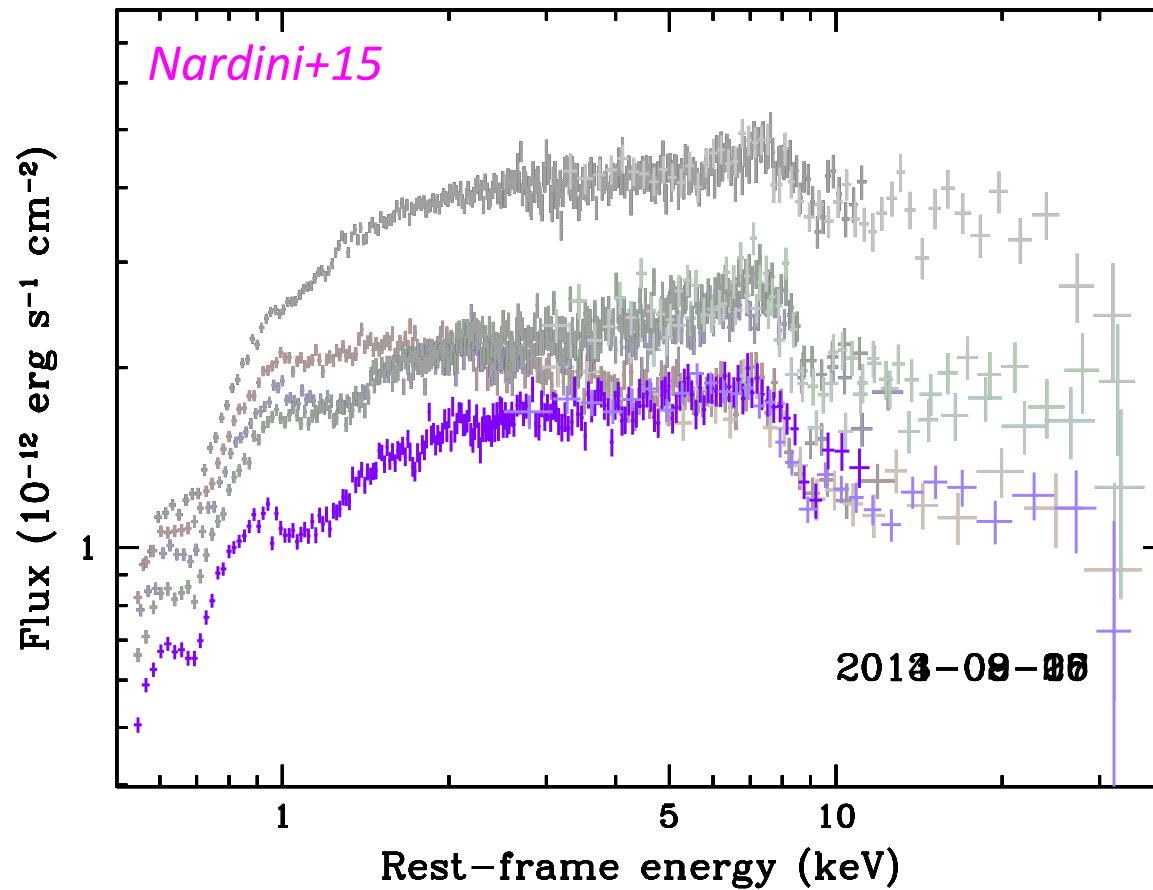
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A persistent, wide-angle wind in PDS 456 (Nardini et al. 2015, Sci)

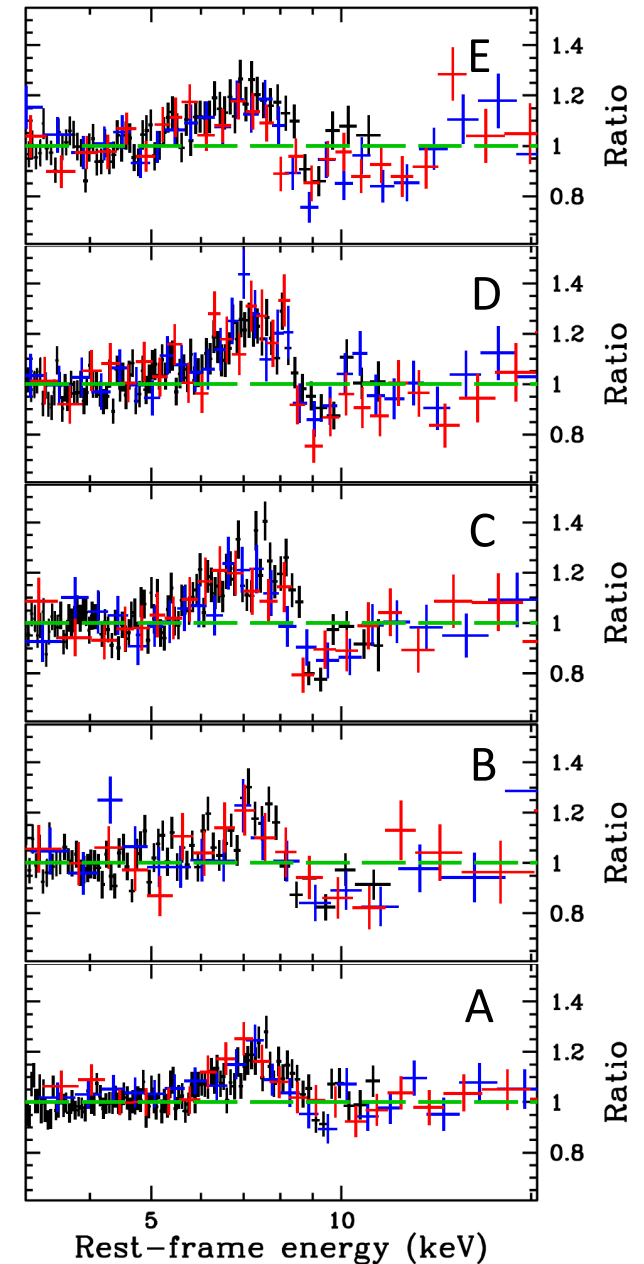
5x100ks XMM-Newton/NuSTAR observations.

Response of iron K profile to continuum variations



Is there evidence for a soft X-ray component of the fast (0.3c) wind in PDS 456?

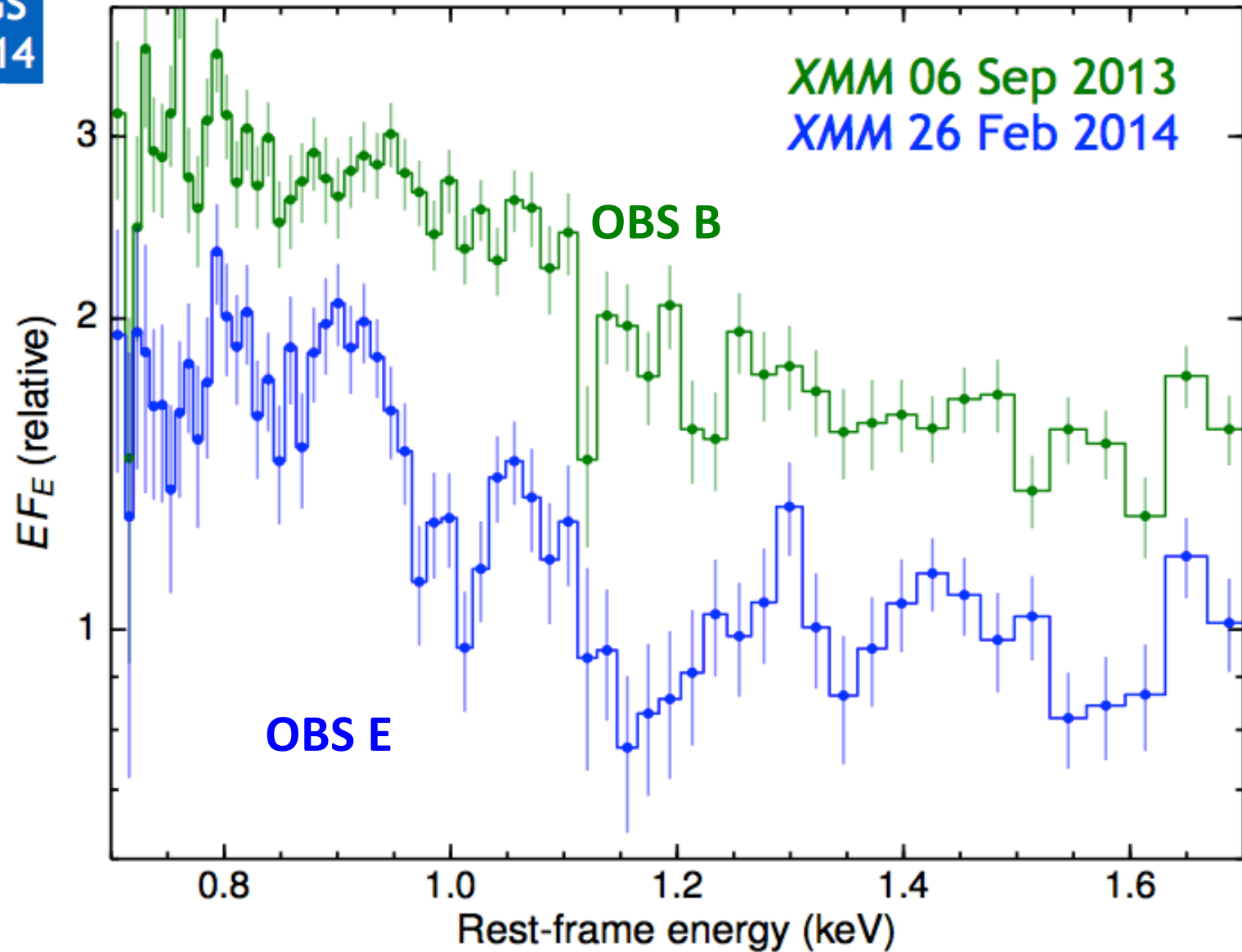
Fe K Pcygni



Broad Soft X-ray Absorption Profiles in PDS 456

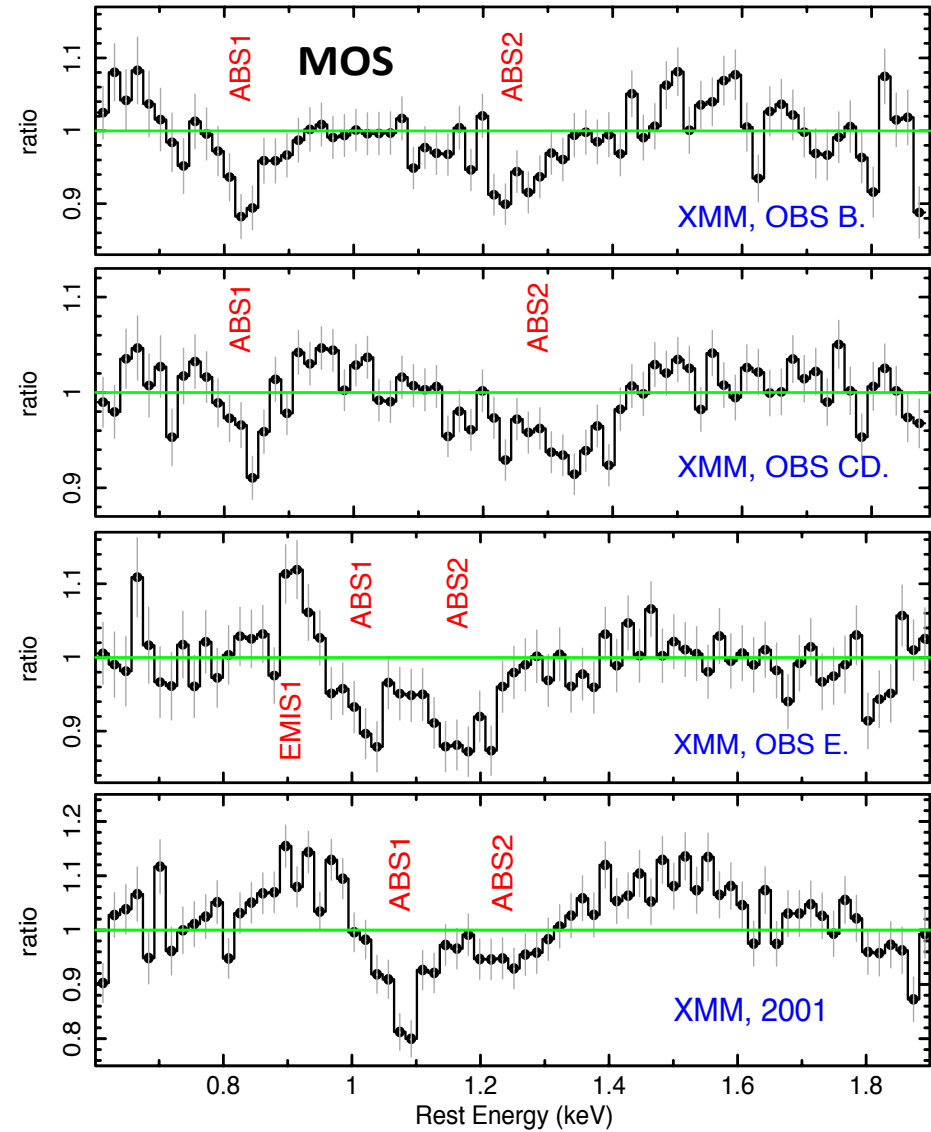
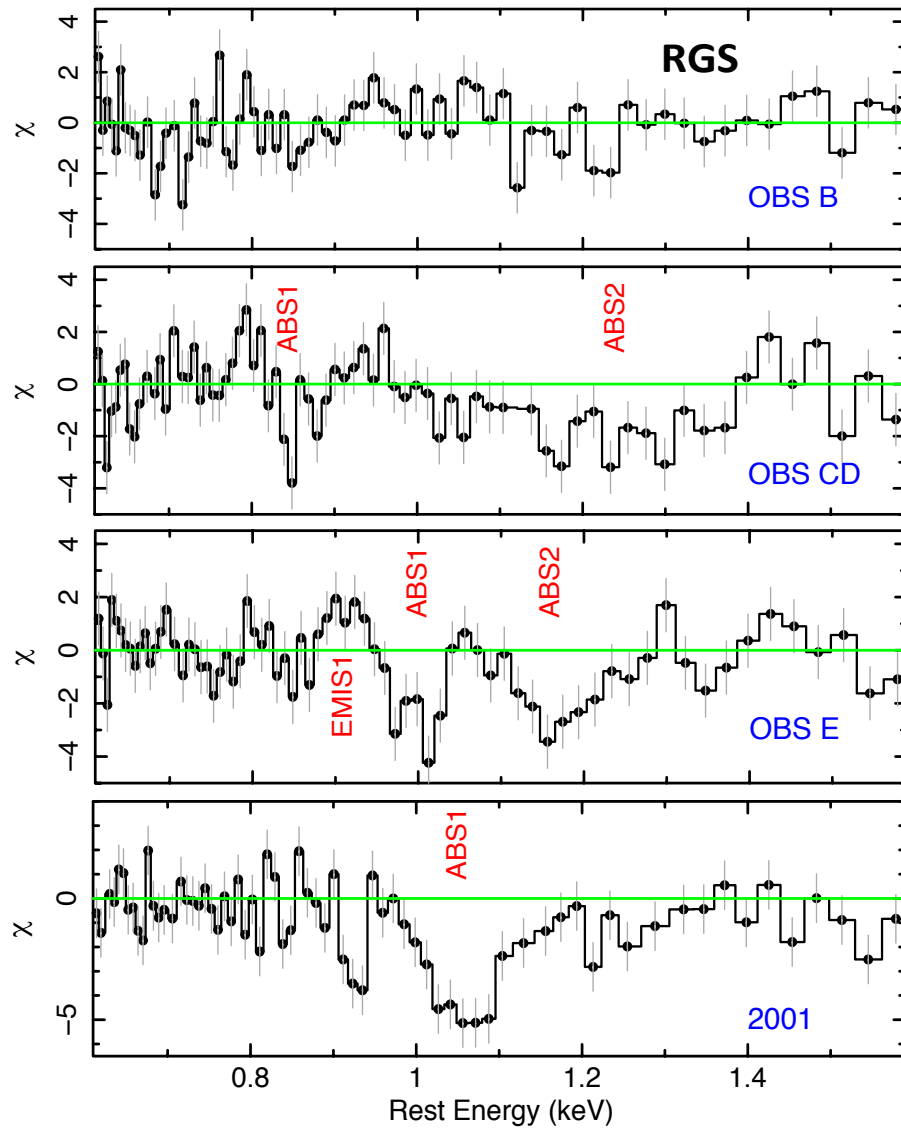
(Reeves et al. 2016, ApJ)

XMM/RGS
2013/2014



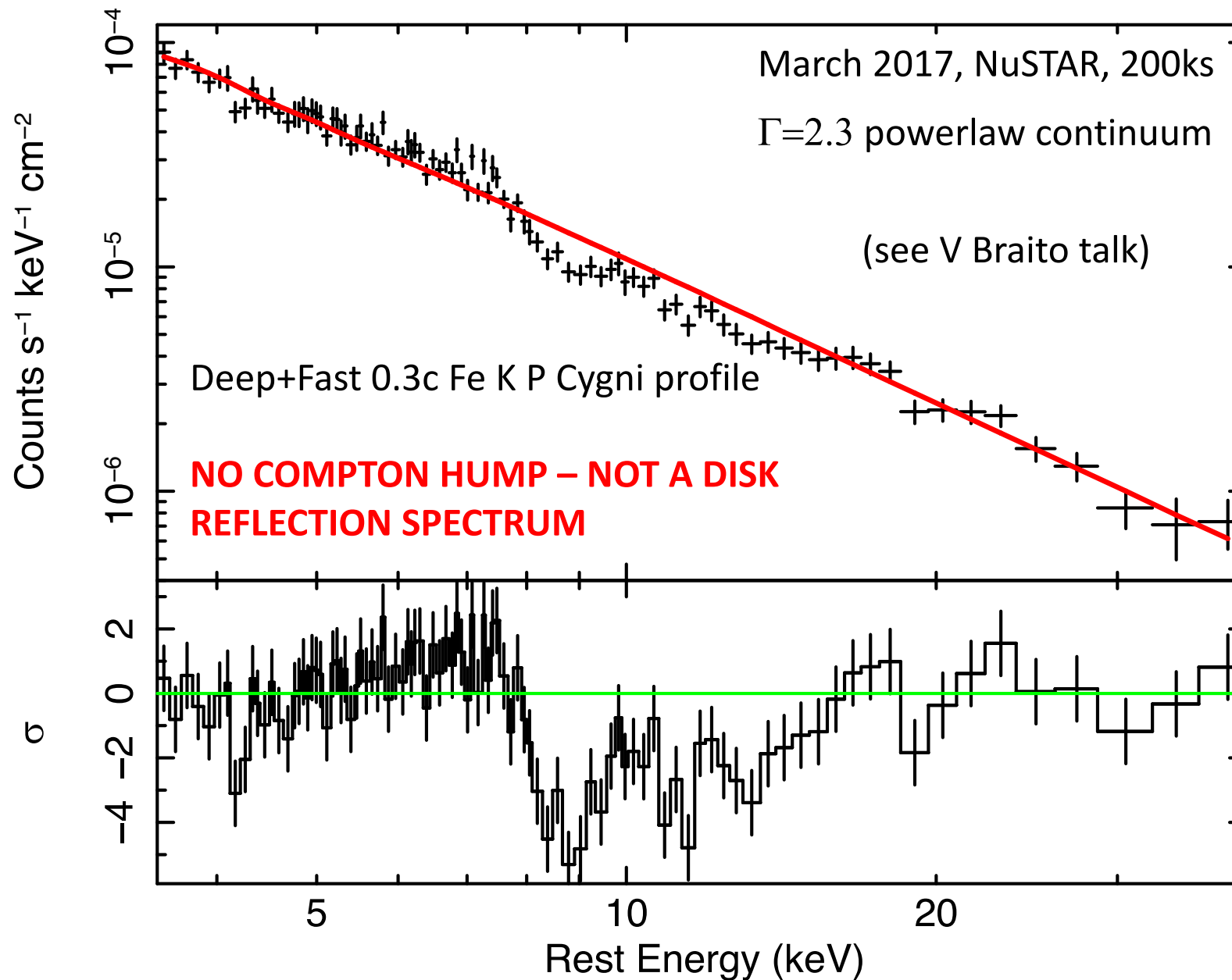
Signatures of fast ($0.2c$) “BAL” like profiles in soft X-rays with XMM-Newton/RGS (OBS E). Velocity widths $\sigma \approx 10000$ km/s.

Broad Soft X-ray Absorption Lines



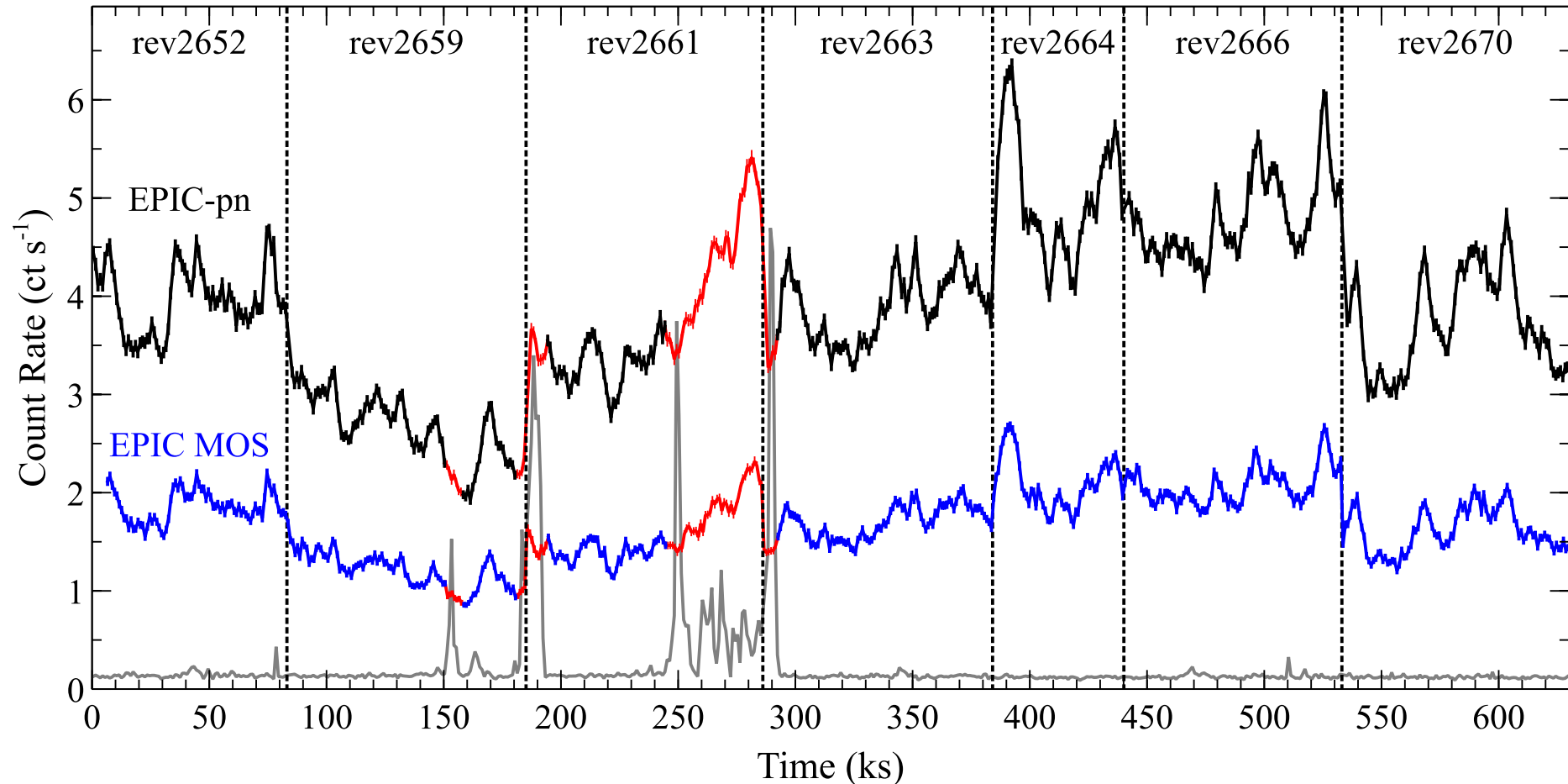
Soft X-ray absorbing gas the likely signature of an inhomogeneous wind, partially obscuring the AGN. Velocities of up to $0.2c$, $N_H \sim 10^{22} \text{ cm}^{-2}$, $\log \xi = 3.5-4$
 Absorption primarily due to highly ionized Fe (Fe XX-XXIV) as well as Ne IX/X

2017 NuSTAR observation of the wind in PDS 456



The Large XMM-Newton Programme on PG1211+143

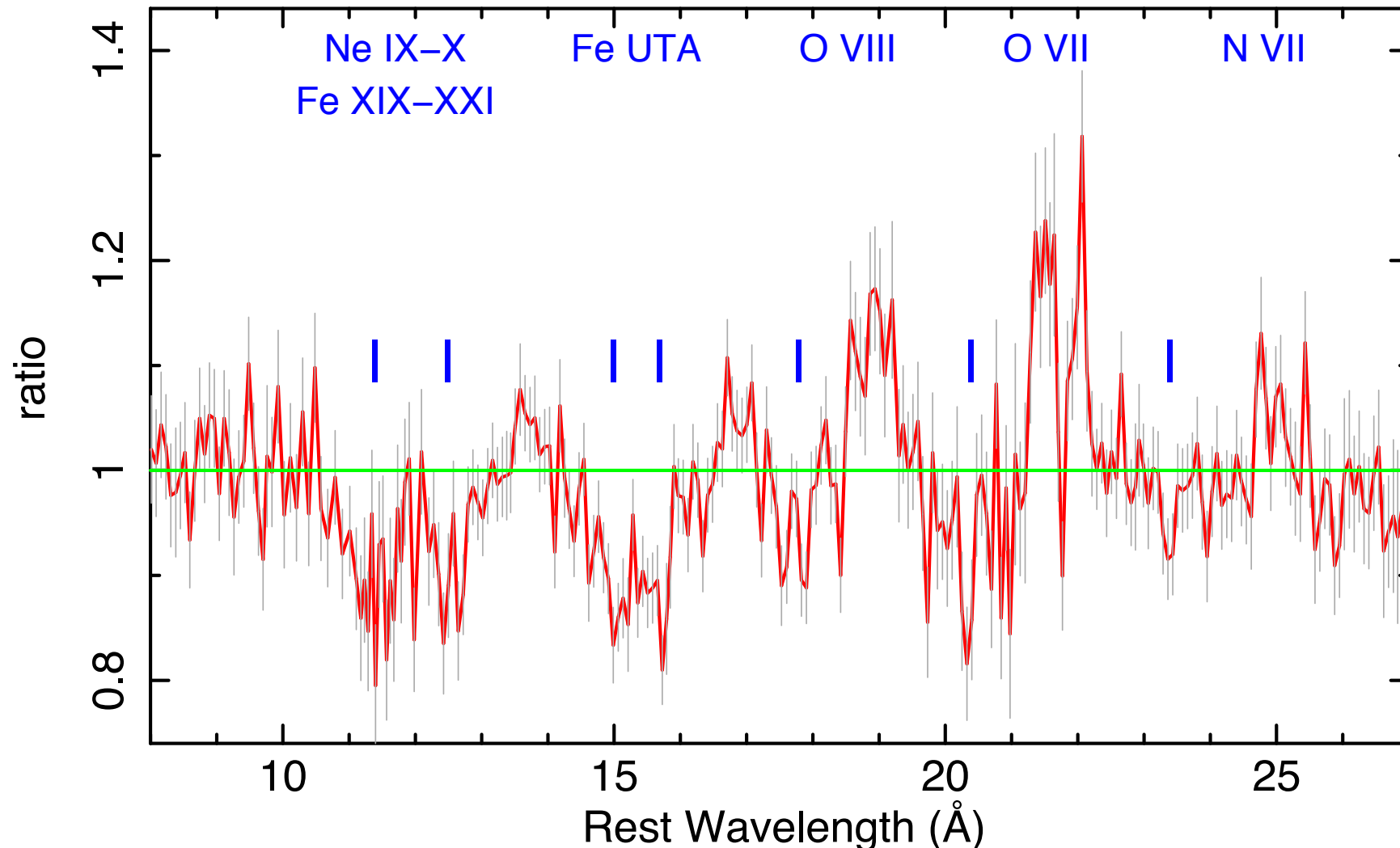
(Lobban et al. 2015, 2016; Pounds et al. 2016a, b)



PG 1211+143, luminous ($L_{\text{bol}} \sim 10^{46}$ erg/s), nearby, narrow-lined type I quasar ($z=0.0809$), the initial proto-type example of an ultra fast outflow (Pounds et al. 2003).

7 Sequences with XMM-Newton in June/July 2014. Total exposure ~ 630 ks.
Note lowest flux during rev 2659 with XMM-Newton.

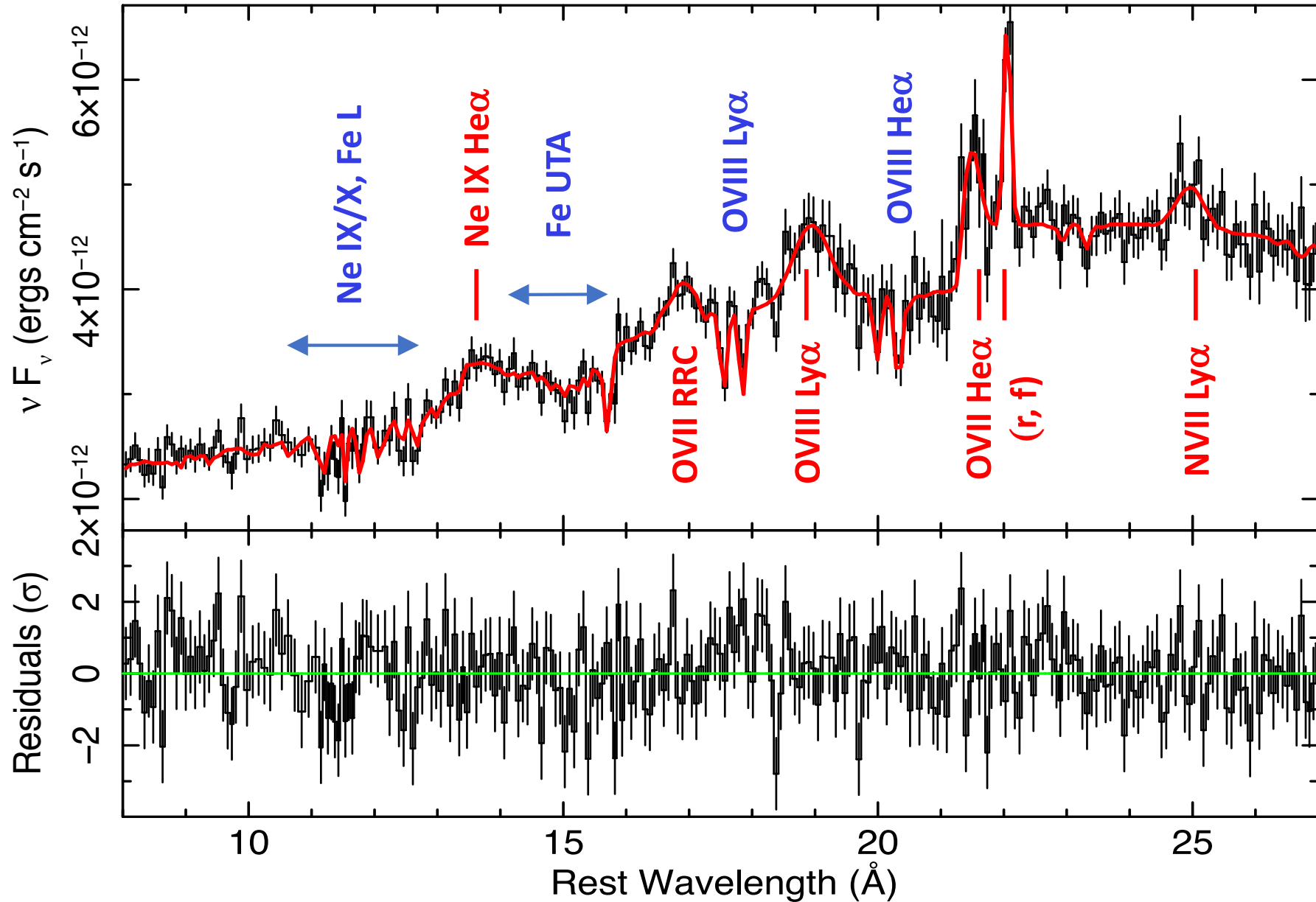
Is there evidence for the fast outflow in the soft X-ray spectrum of PG 1211? Mean RGS spectrum (June 2014, 600ks exposure)



Blue-shifted absorption profiles revealed in deep RGS exposure of PG 1211+143, e.g. from N, O, Ne, Fe. Systematic velocity shift of 0.06-0.07c. Note position of low ionization UTA component and strong emission (OVII/OVIII).

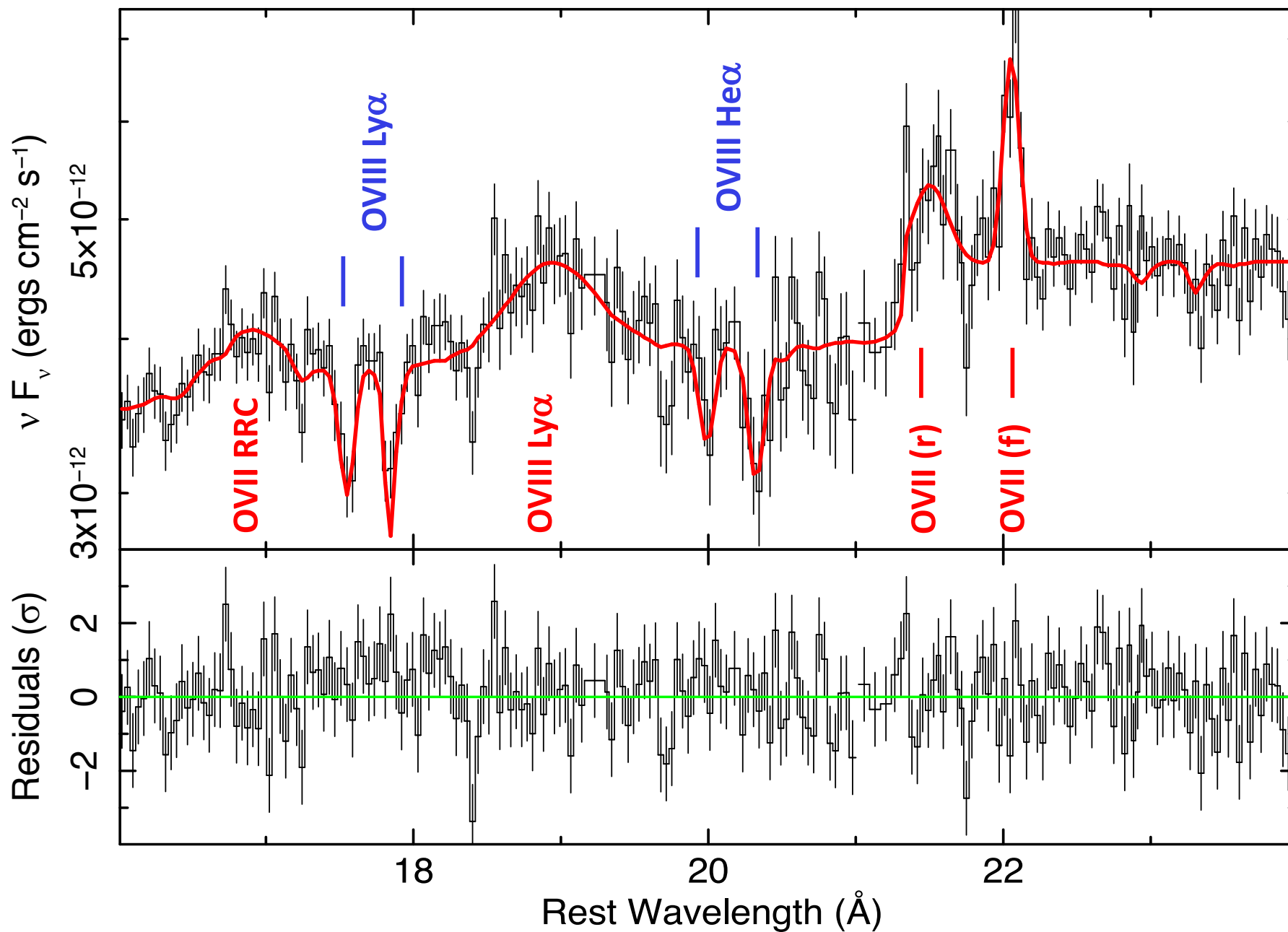
Mean RGS spectrum of PG 1211 – Best fit XSTAR model

Two main zones. Low ionization:- $\log \xi = 1.8 \pm 0.2$, $N_H = 4 \times 10^{20} \text{ cm}^2$, $v/c = 0.064 \pm 0.002$
High ionization:- $\log \xi = 3.4 \pm 0.2$, $N_H = 1 \times 10^{22} \text{ cm}^2$, $v/c = 0.063 \pm 0.002$

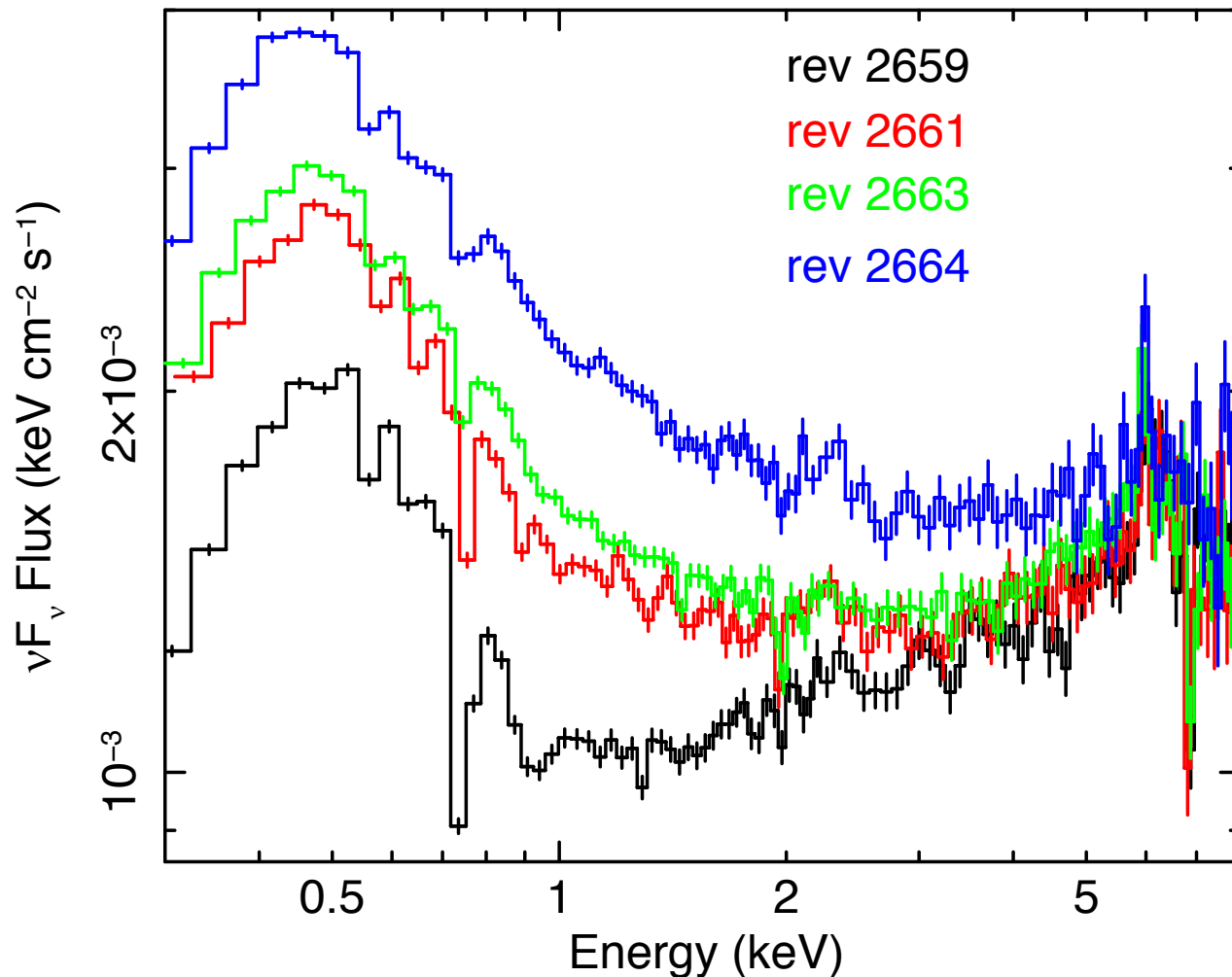


Mean RGS spectrum of PG 1211 – OVII/OVIII band

Broad (FWHM 10000 km/s) OVII/OVIII emission lines and blueshifted absorption profiles



Rapid Variability of Ultra Fast Outflow in PG 1211+143



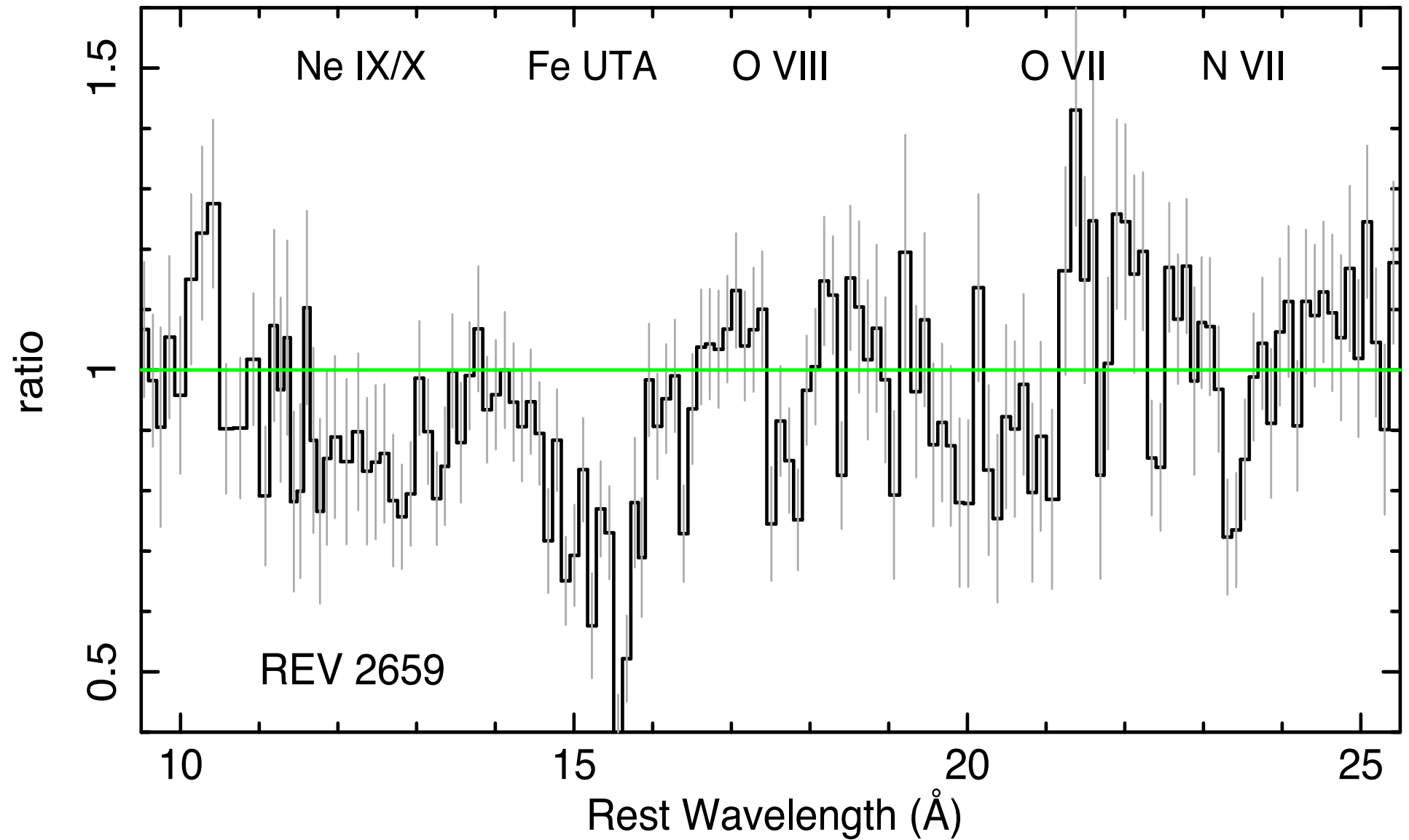
Low flux spectrum in rev 2659. Source then progressively brightens.

Soft X-ray absorption is rapidly variable (within 2 orbits), decreasing with increasing flux.

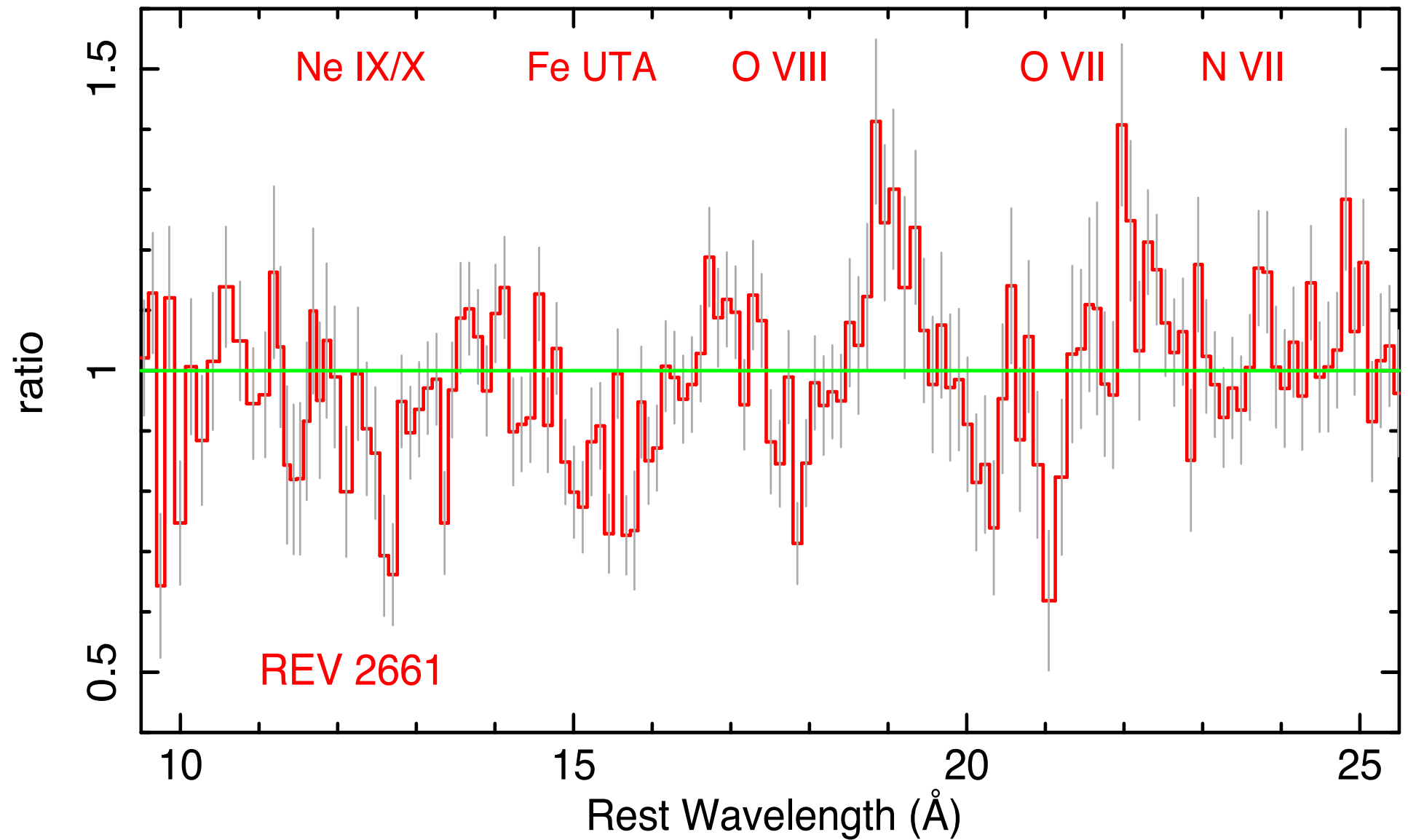
PG 1211 undergoes absorption event during rev 2659, increasing in lower ionization absorption.

Soft X-ray absorber not a conventional warm absorber. Fast ($0.07c$) and rapidly variable on timescales of < 1 week. Implies absorber is compact, on scales of $10s R_s$, likely part of clumpy disk wind.

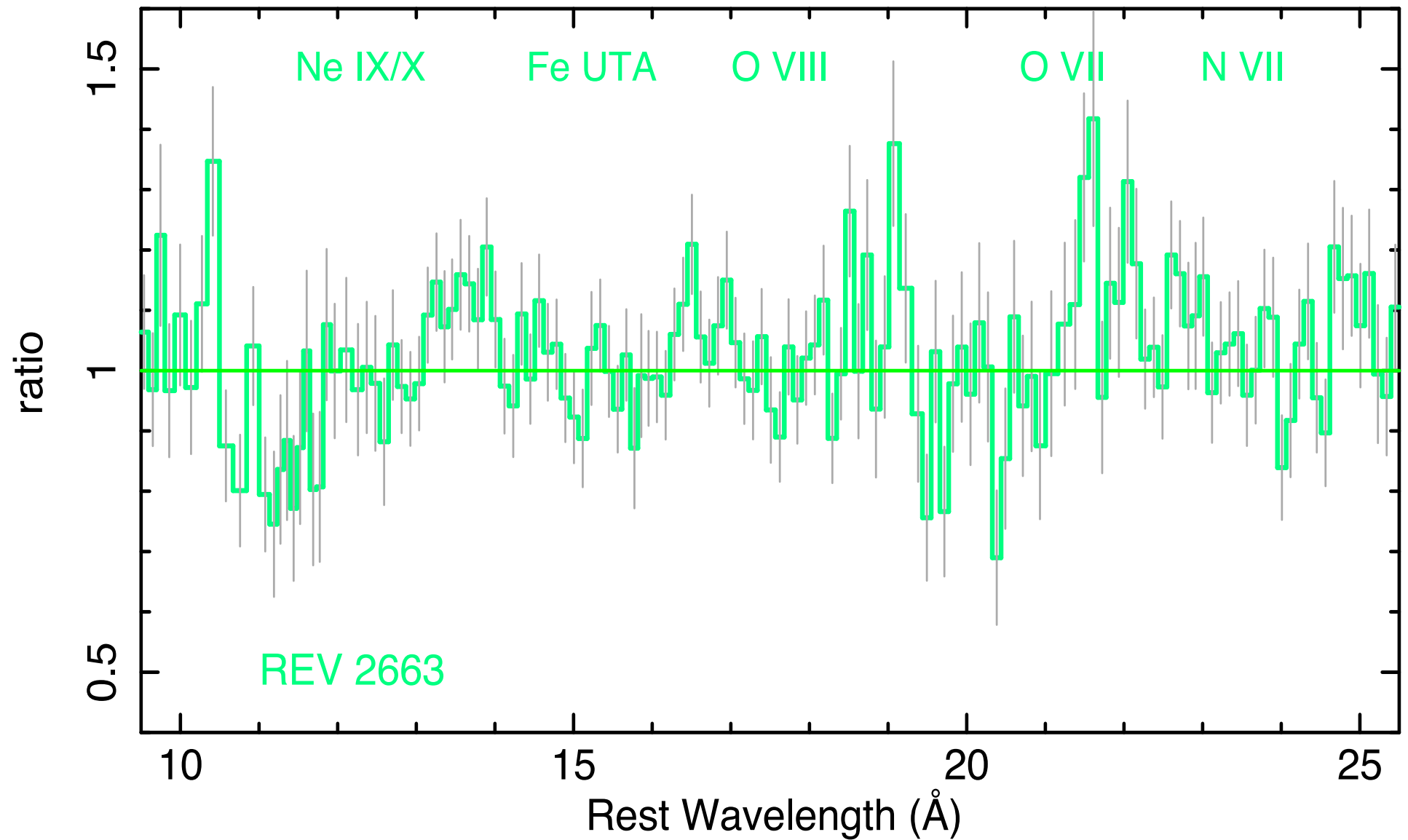
Variability of PG 1211 wind seen in RGS spectrum



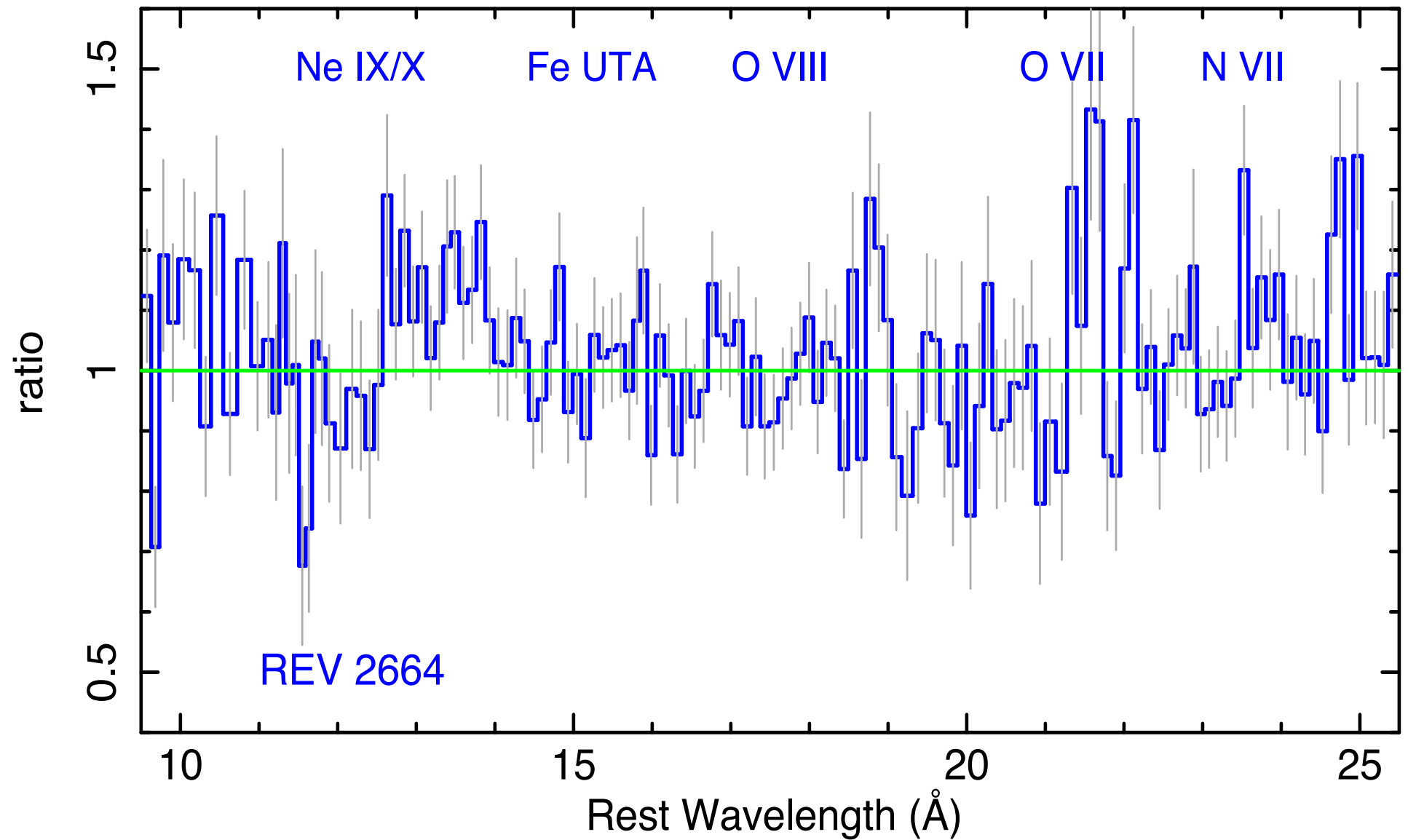
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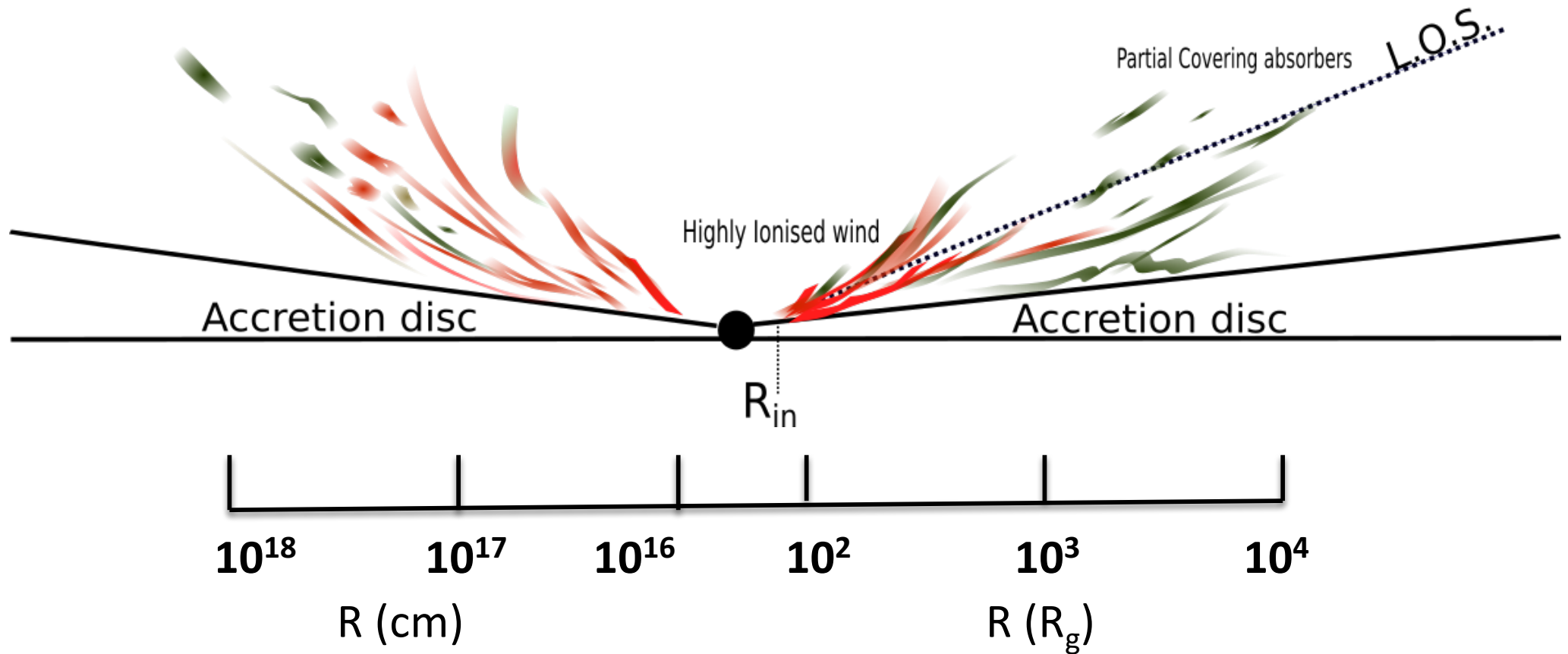
Variability of PG 1211 wind seen in RGS spectrum



Variability of PG 1211 wind seen in RGS spectrum



The Wind Structure



Innermost highly ionized wind launched from within $100 R_g$ (10^{16} cm) of black hole – ultra fast iron K absorption ($0.1-0.3c$).

Inhomogeneous soft X-ray absorber $R \approx 10^{17}-10^{18}$ cm, $n_e \approx 10^7-10^8$ cm $^{-3}$, with thickness $\Delta R \approx 10^{14-15}$ cm. Filling factor $f \approx 10^{-3}$.

UV BLR emission (absorption) – high velocity CIV in UV.