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Title	The Soft X-ray View of Ultra Fast Outflows
Authors	Reeves, J., BRAITO, Valentina, NARDINI, EMANUELE, Matzeu, G., Lobban, A., Costa, M., Pounds, K., Tombesi, Francesco, Behar, E.
Handle	http://hdl.handle.net/20.500.12386/26645

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

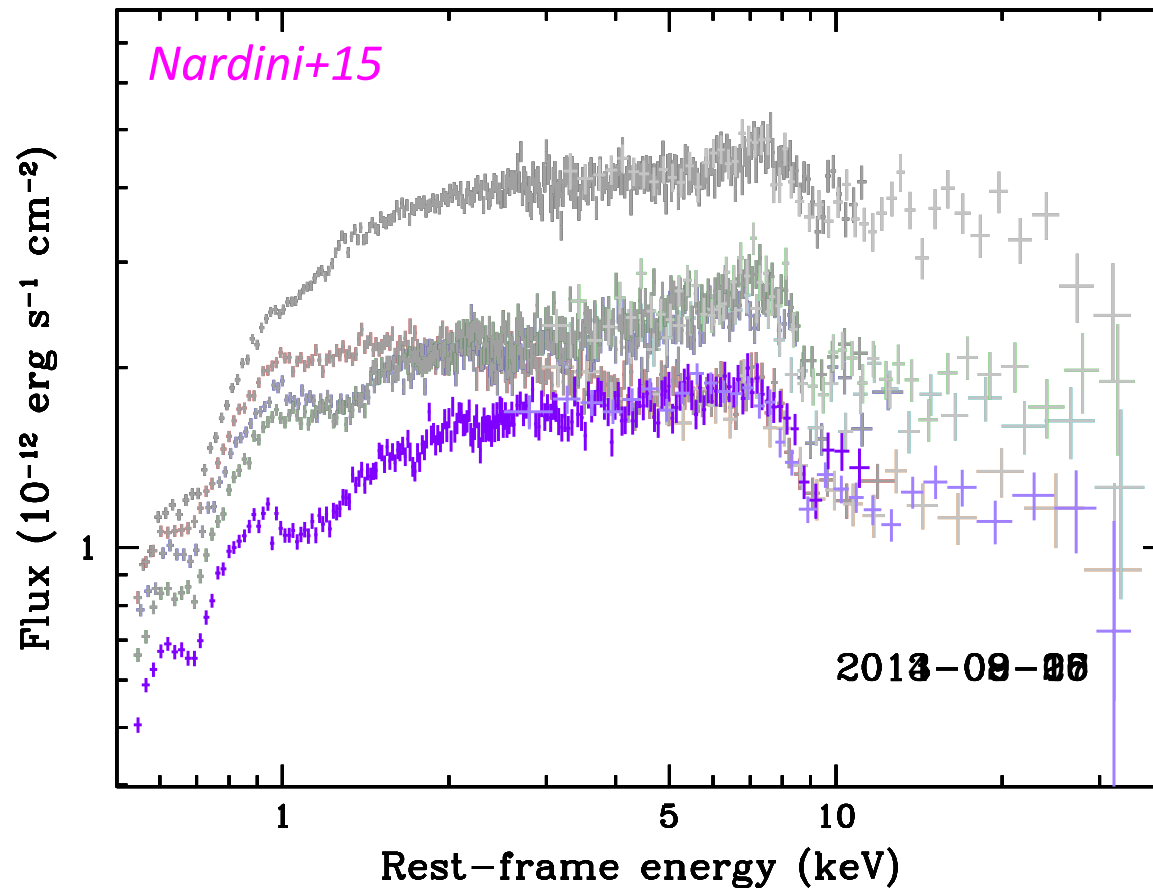
James Reeves (UMBC/Keele)

Main Collaborators:- Valentina Braito, Gabi Matzeu (Brera), Michele Costa, Andrew Lobban (Keele), Emanuele Nardini, Guido Risaliti (Arcetri), Ken Pounds (Leicester), Jane Turner (UMBC), Francesco Tombesi (UMD/GSFC)

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

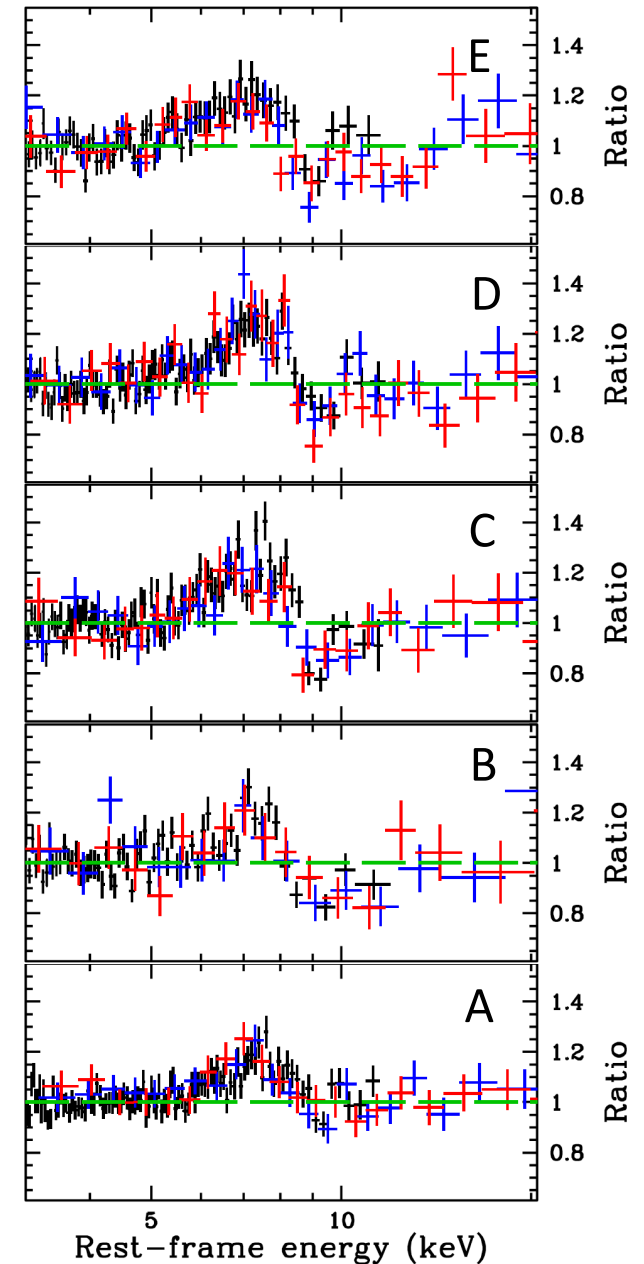
5x100ks XMM-Newton/NuSTAR observations.

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?

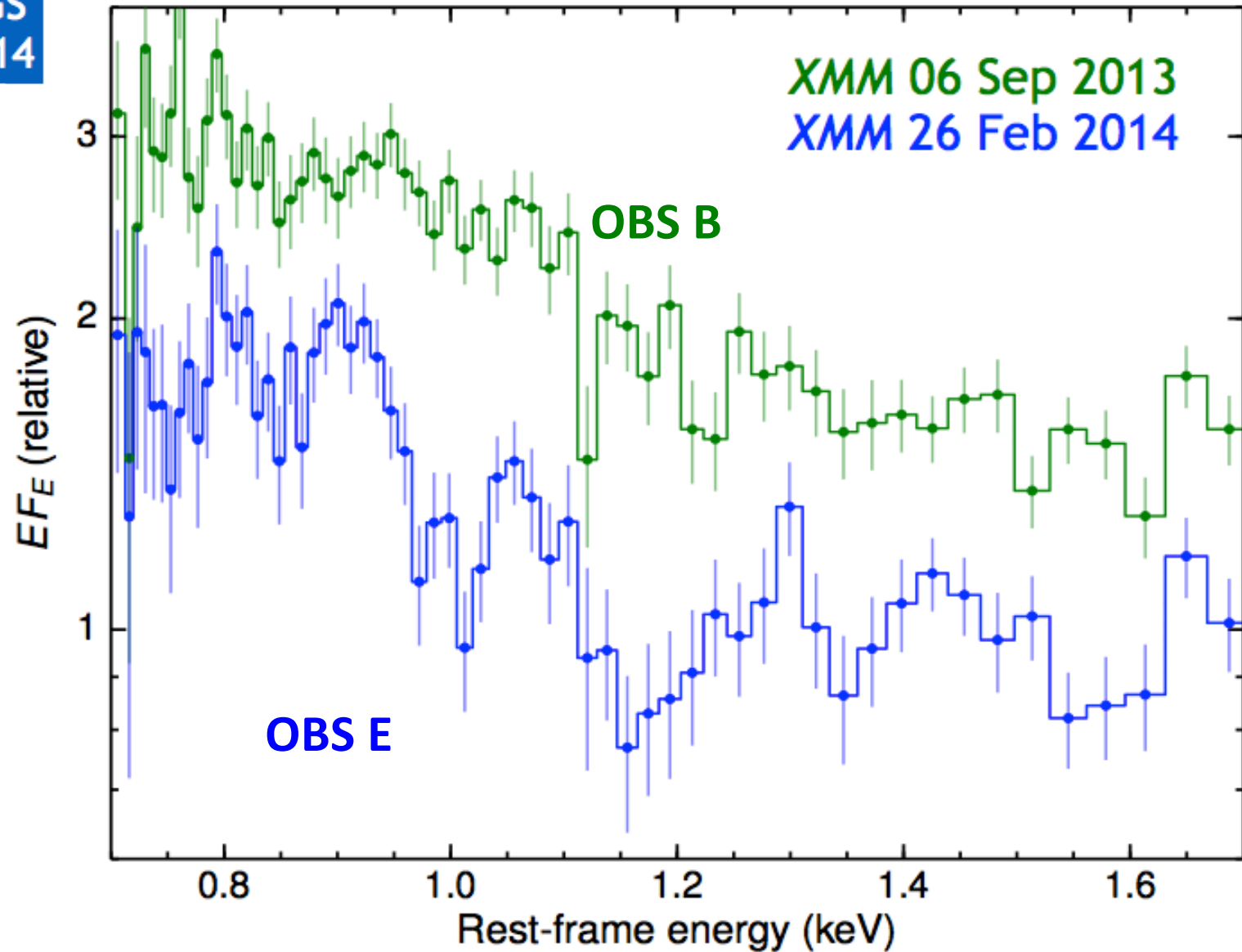
Fe K Pcygni



Broad Soft X-ray Absorption Profiles in PDS 456

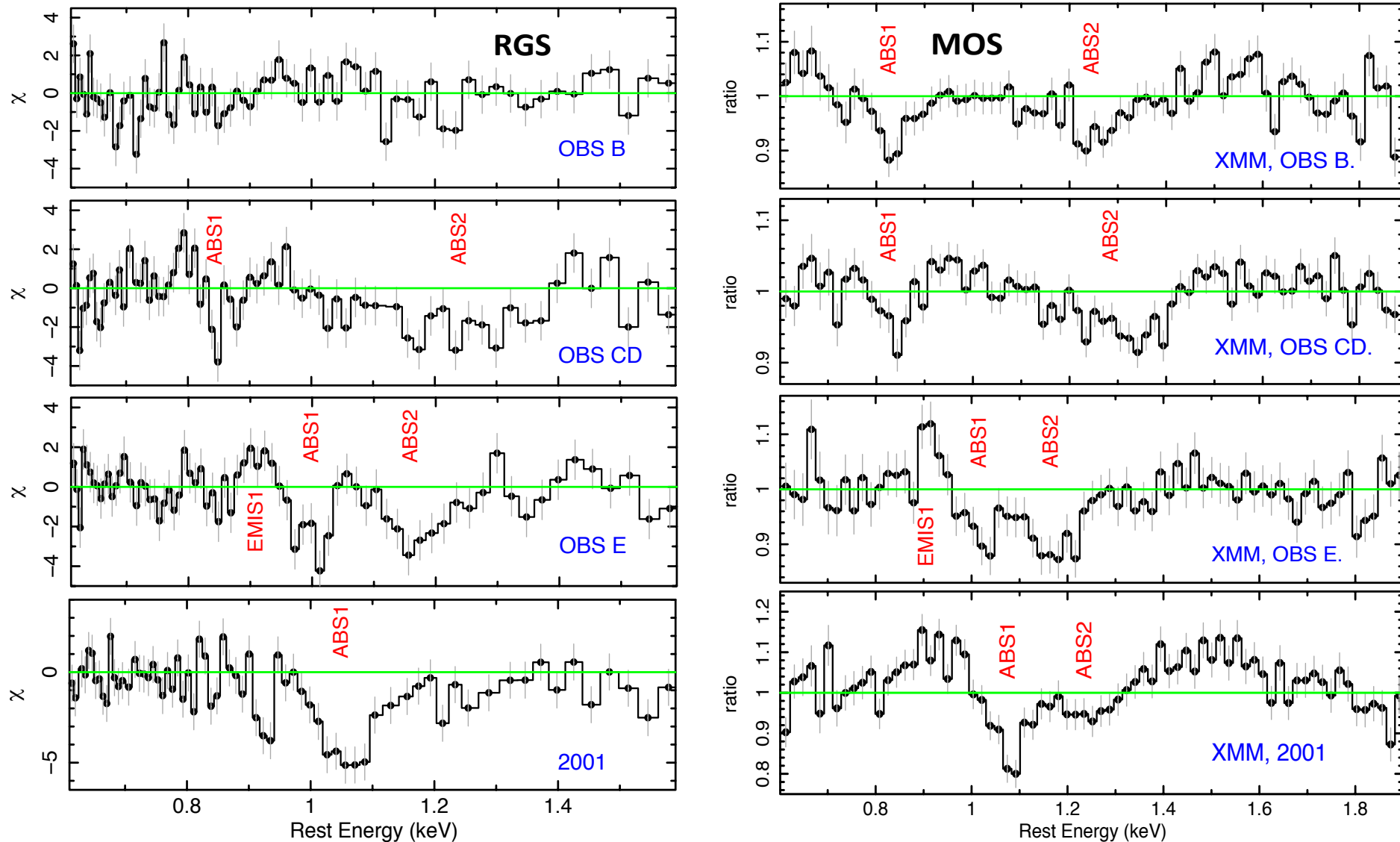
(Reeves et al. 2016, ApJ)

XMM/RGS
2013/2014



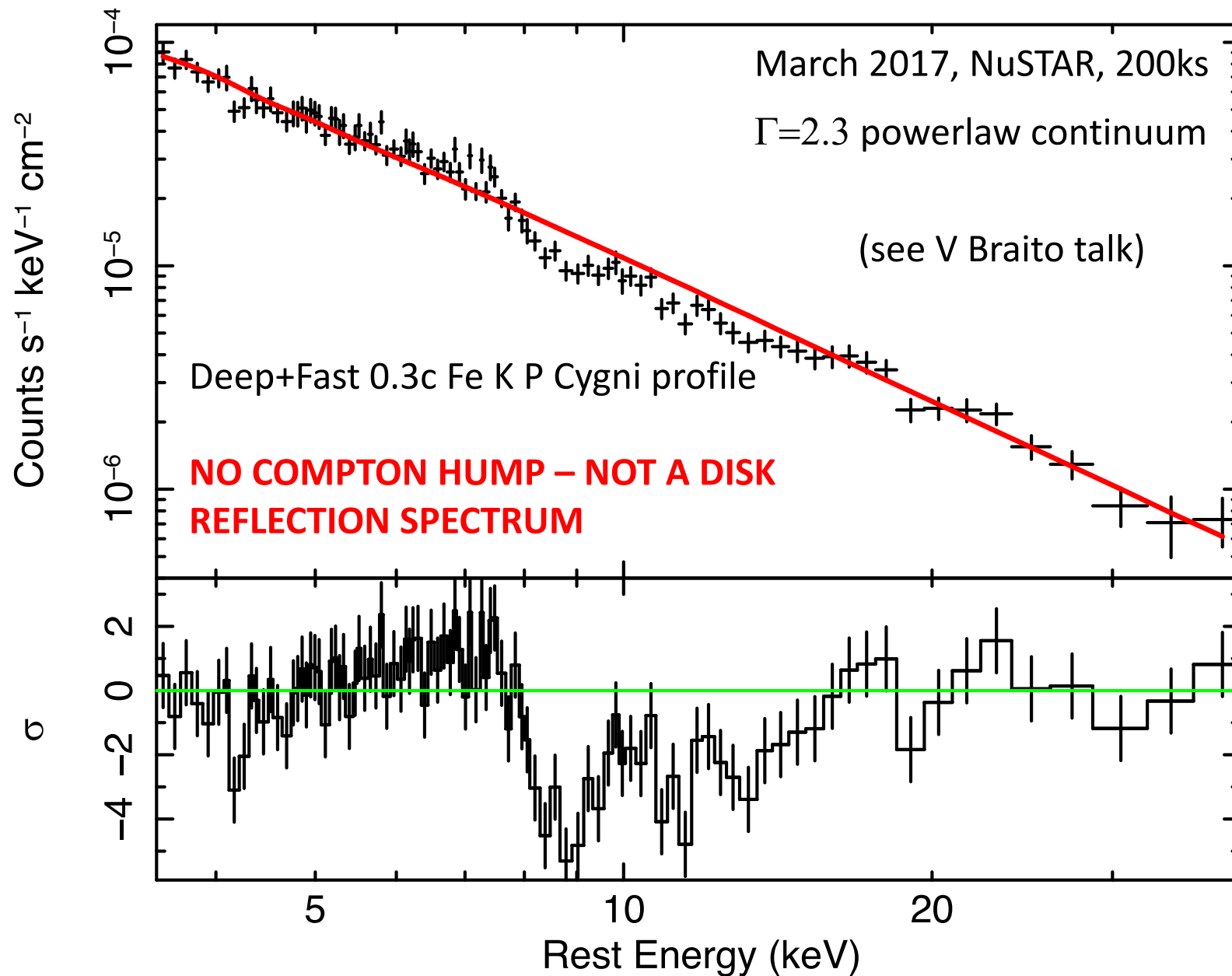
Signatures of fast (0.2c) “BAL” like profiles in soft X-rays with XMM-Newton/RGS (OBS E). Velocity widths $\sigma \approx 10000$ km/s.

Broad Soft X-ray Absorption Lines



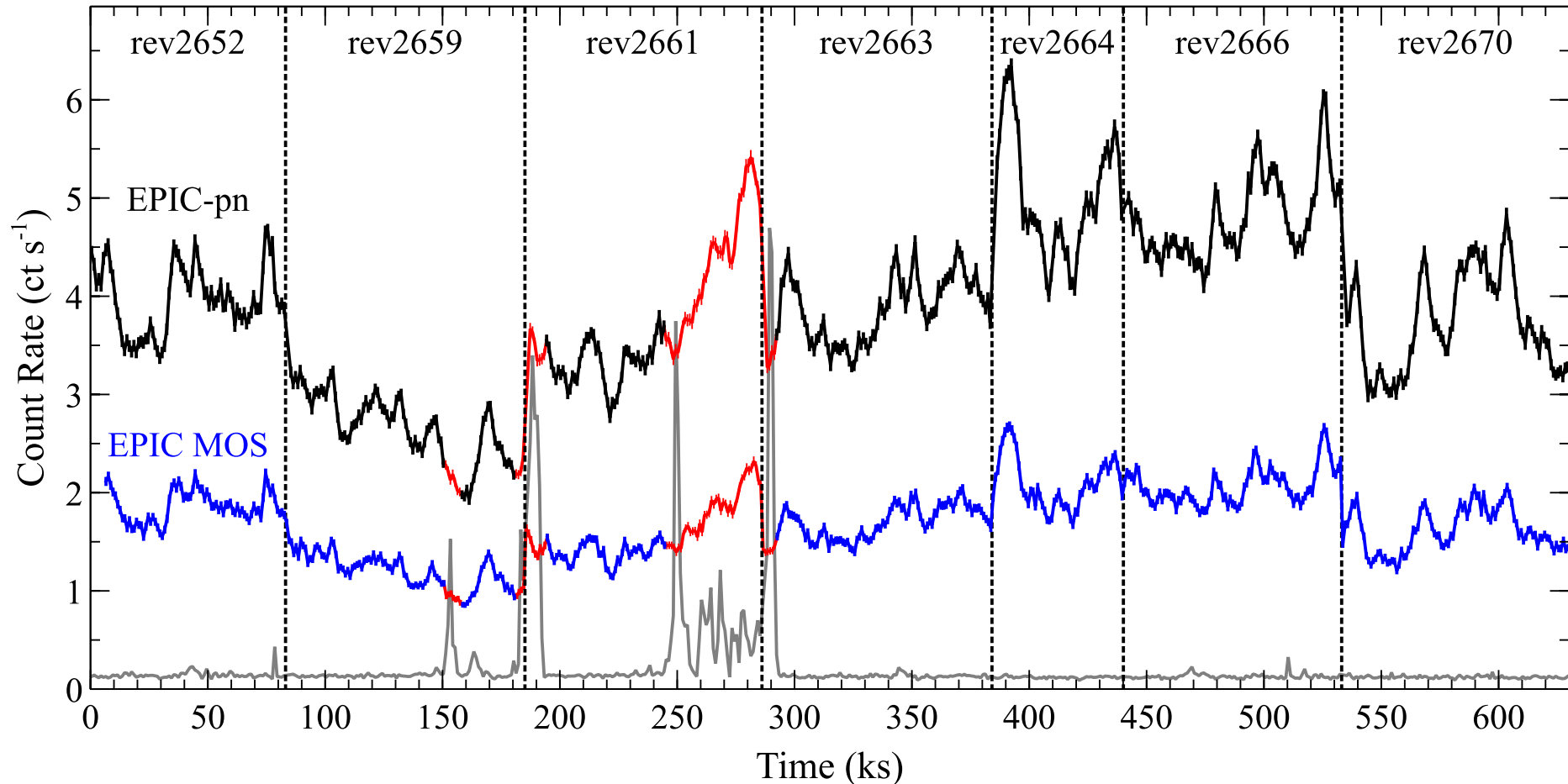
Soft X-ray absorbing gas the likely signature of an inhomogeneous wind, partially obscuring the AGN. Velocities of up to $0.2c$, $N_H \sim 10^{22} \text{ cm}^{-2}$, $\log \xi = 3.5-4$
Absorption primarily due to highly ionized Fe (Fe XX-XXIV) as well as Ne IX/X

2017 NuSTAR observation of the wind in PDS 456



The Large XMM-Newton Programme on PG1211+143

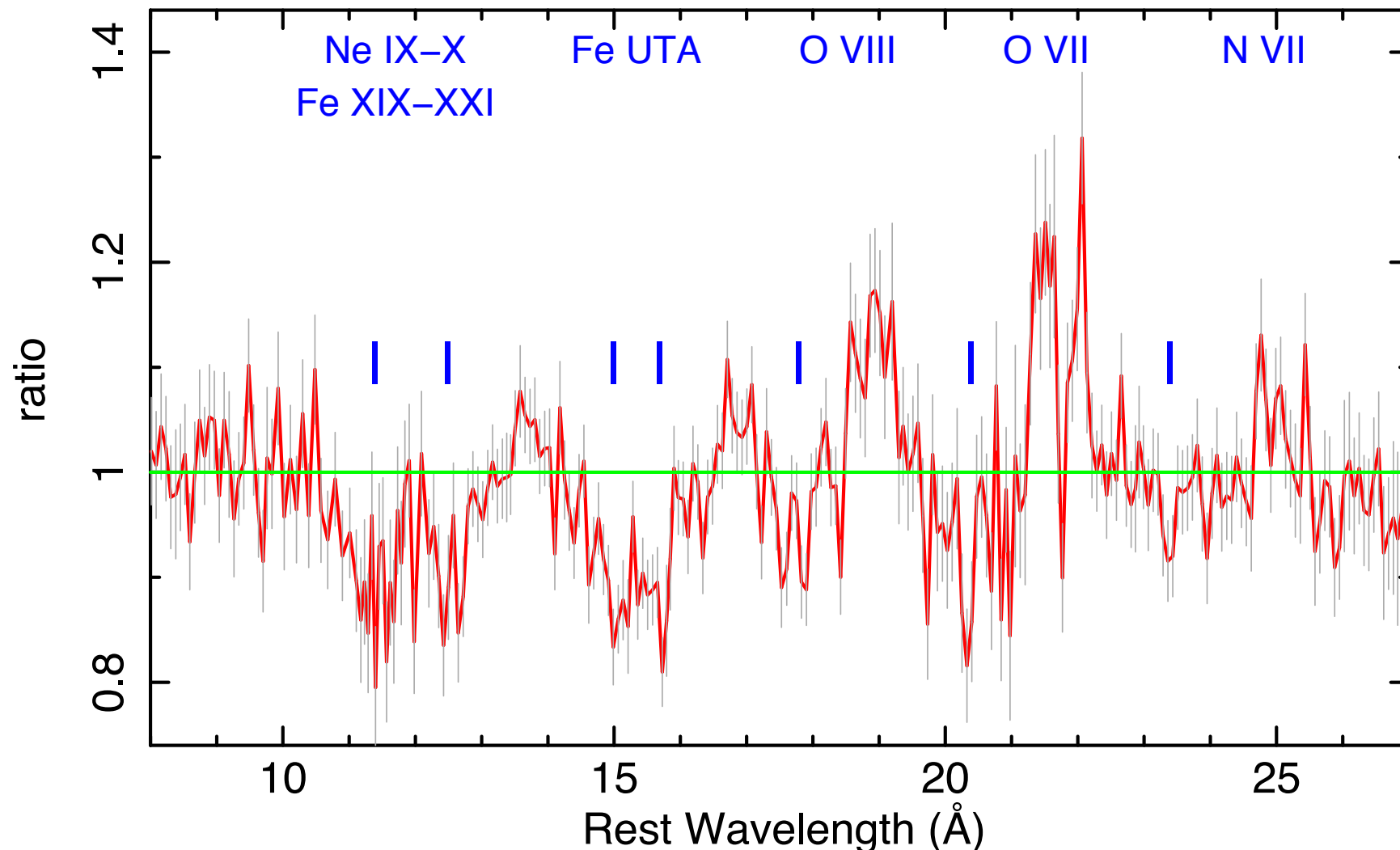
(Lobban et al. 2015, 2016; Pounds et al. 2016a, b)



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.

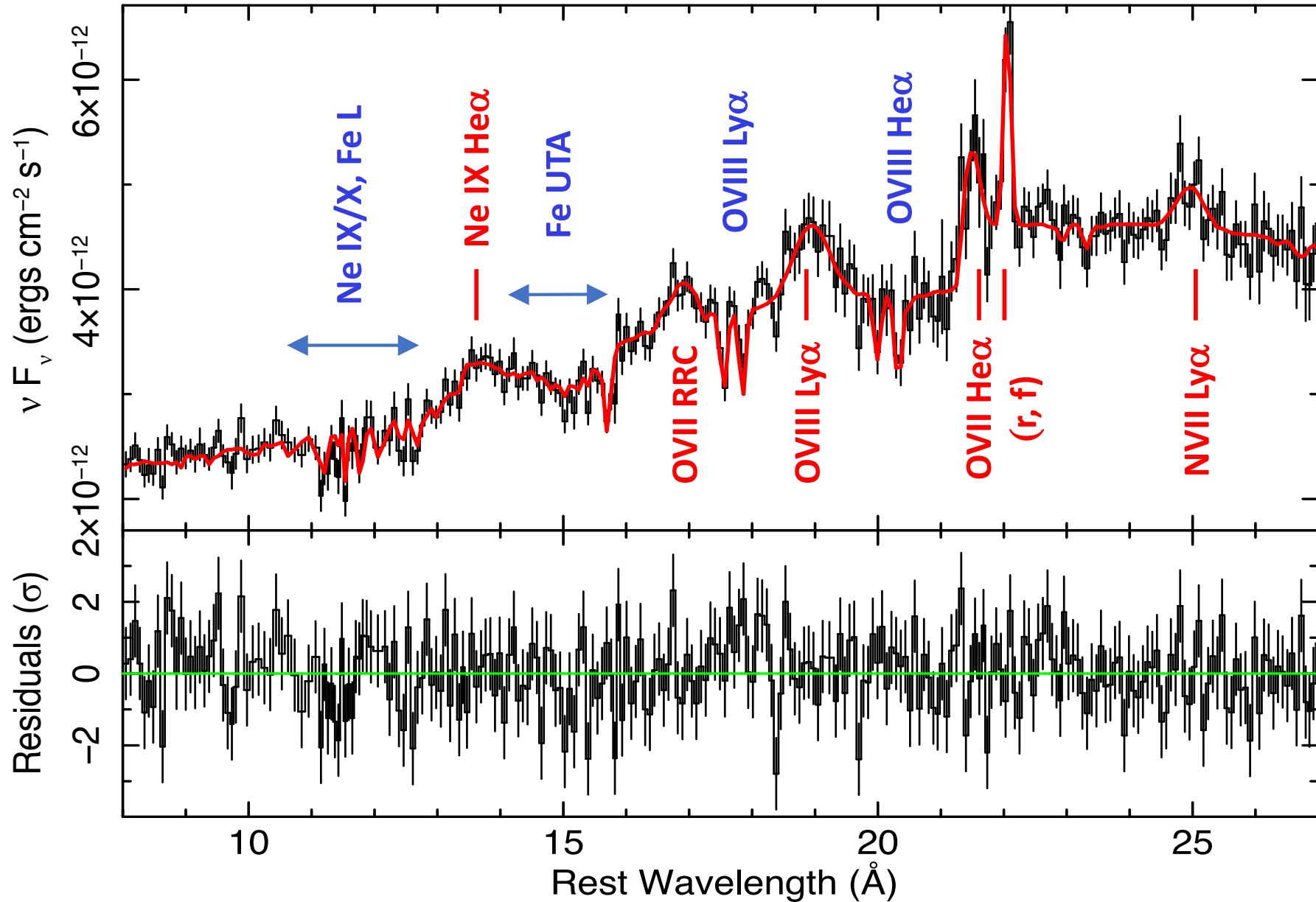
Is there evidence for the fast outflow in the soft X-ray spectrum of PG 1211? Mean RGS spectrum (June 2014, 600ks exposure)



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).

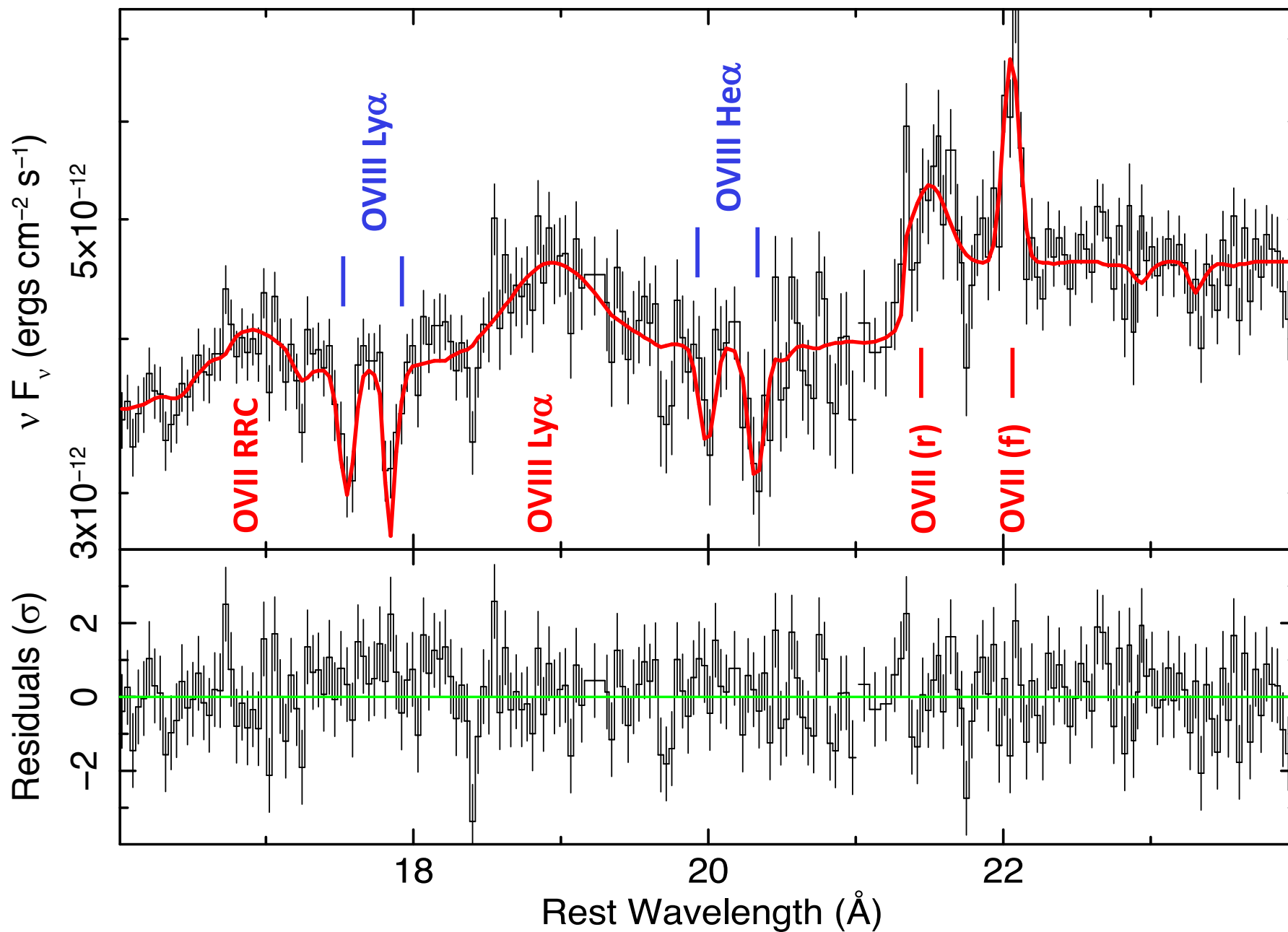
Mean RGS spectrum of PG 1211 – Best fit XSTAR model

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:- $\log \xi = 3.4 \pm 0.2$, $N_H = 1 \times 10^{22} \text{ cm}^2$, $v/c = 0.063 \pm 0.002$

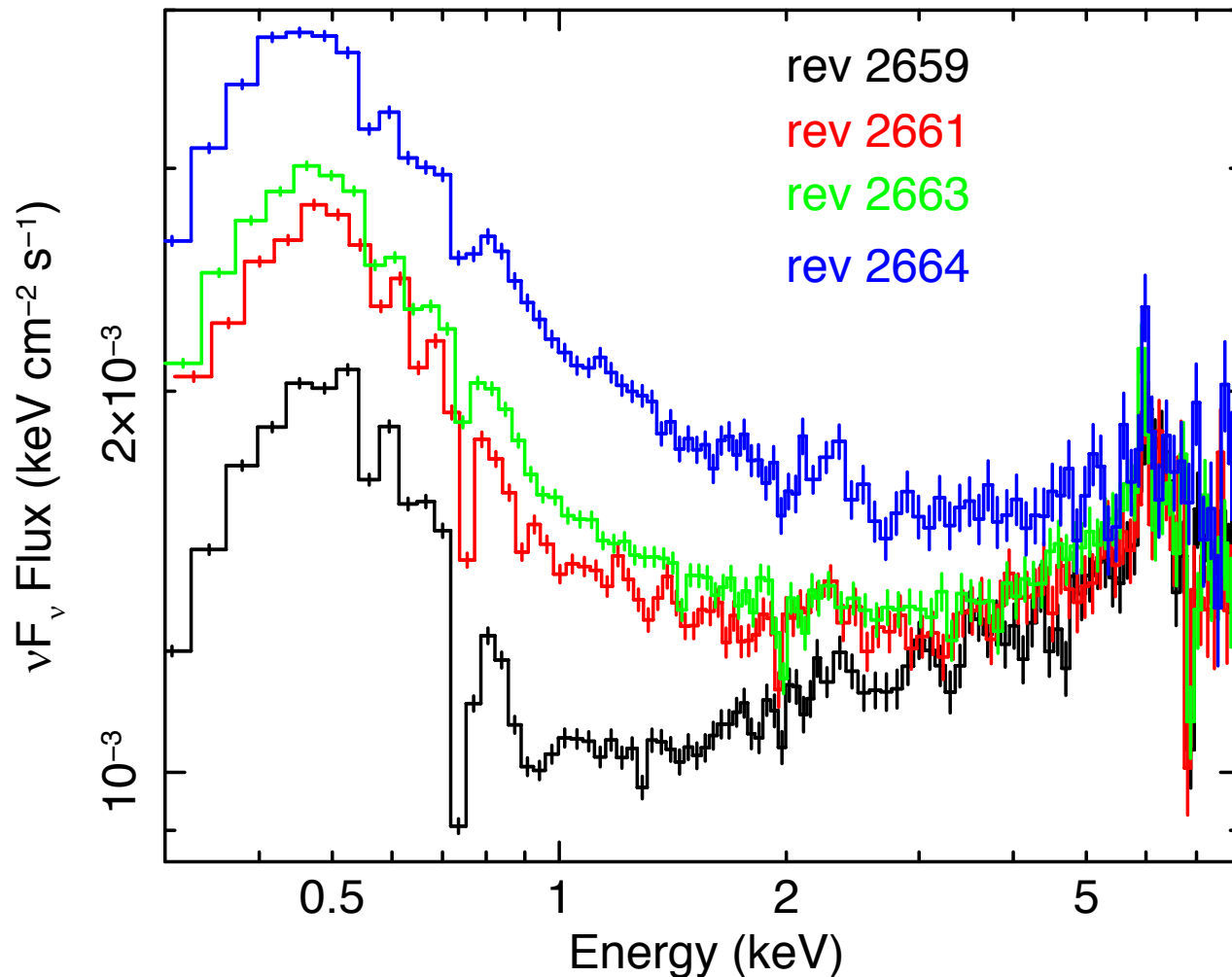


Mean RGS spectrum of PG 1211 – OVII/OVIII band

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



Rapid Variability of Ultra Fast Outflow in PG 1211+143



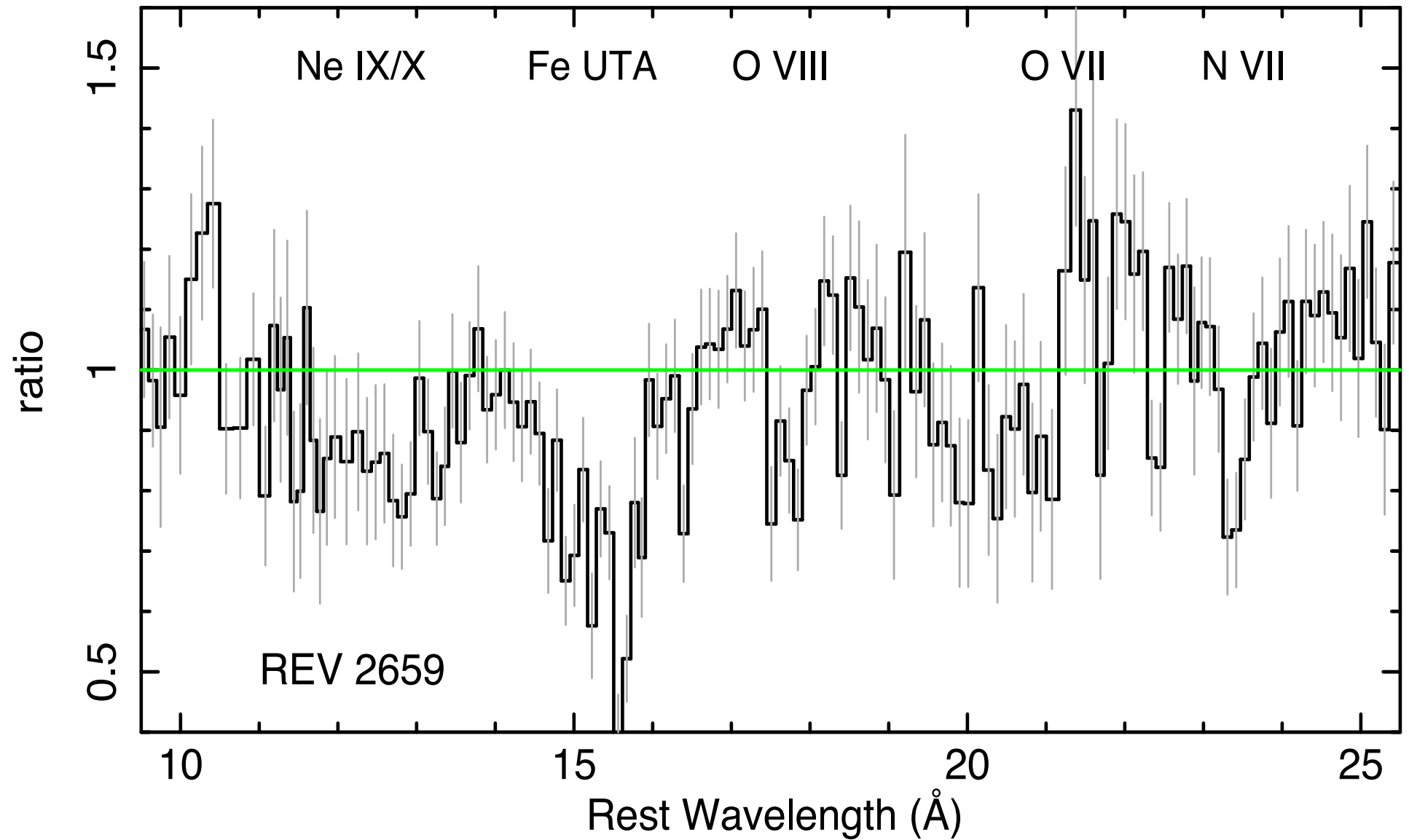
Low flux spectrum in rev 2659. Source then progressively brightens.

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

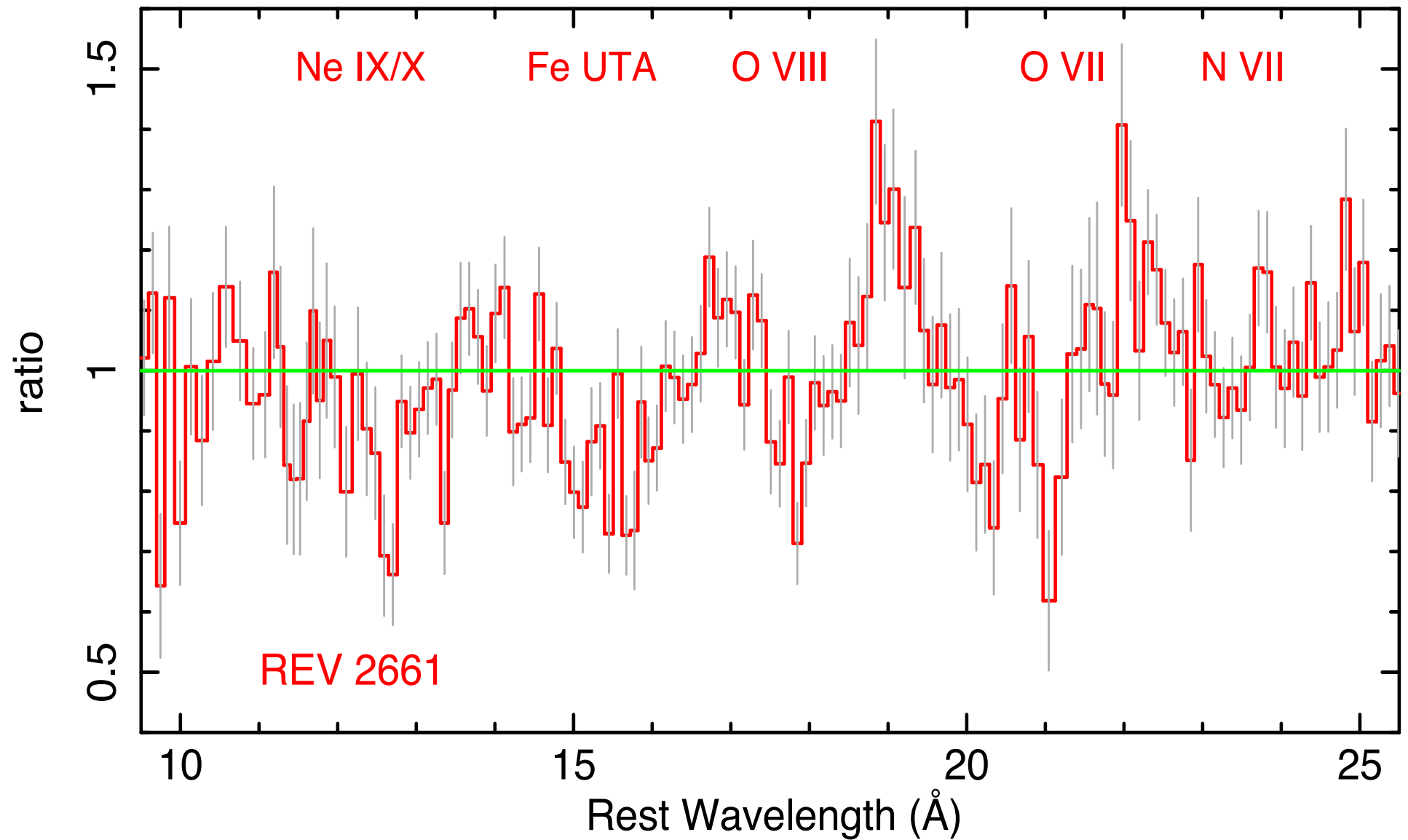
PG 1211 undergoes absorption event during rev 2659, increasing in lower ionization absorption.

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.

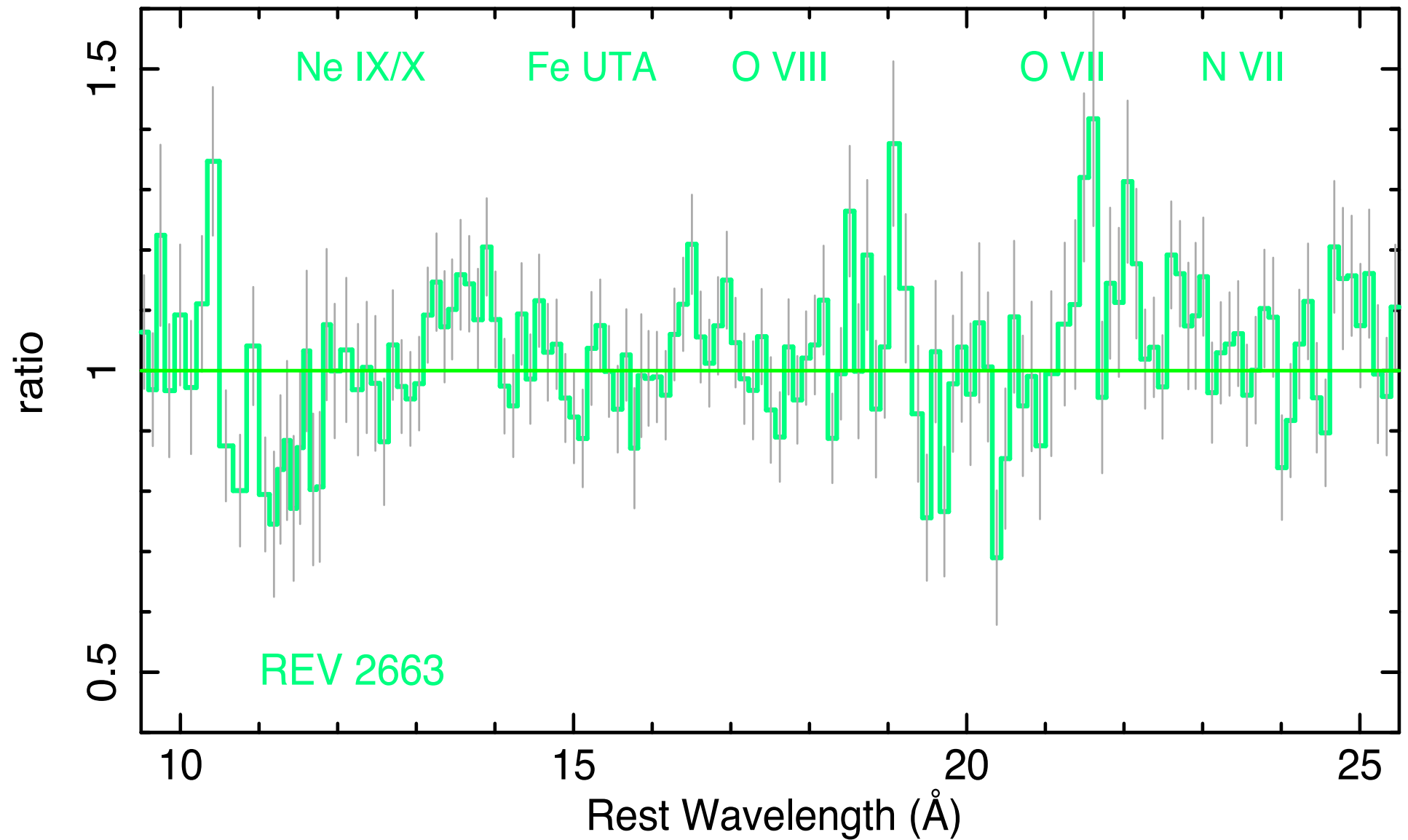
Variability of PG 1211 wind seen in RGS spectrum



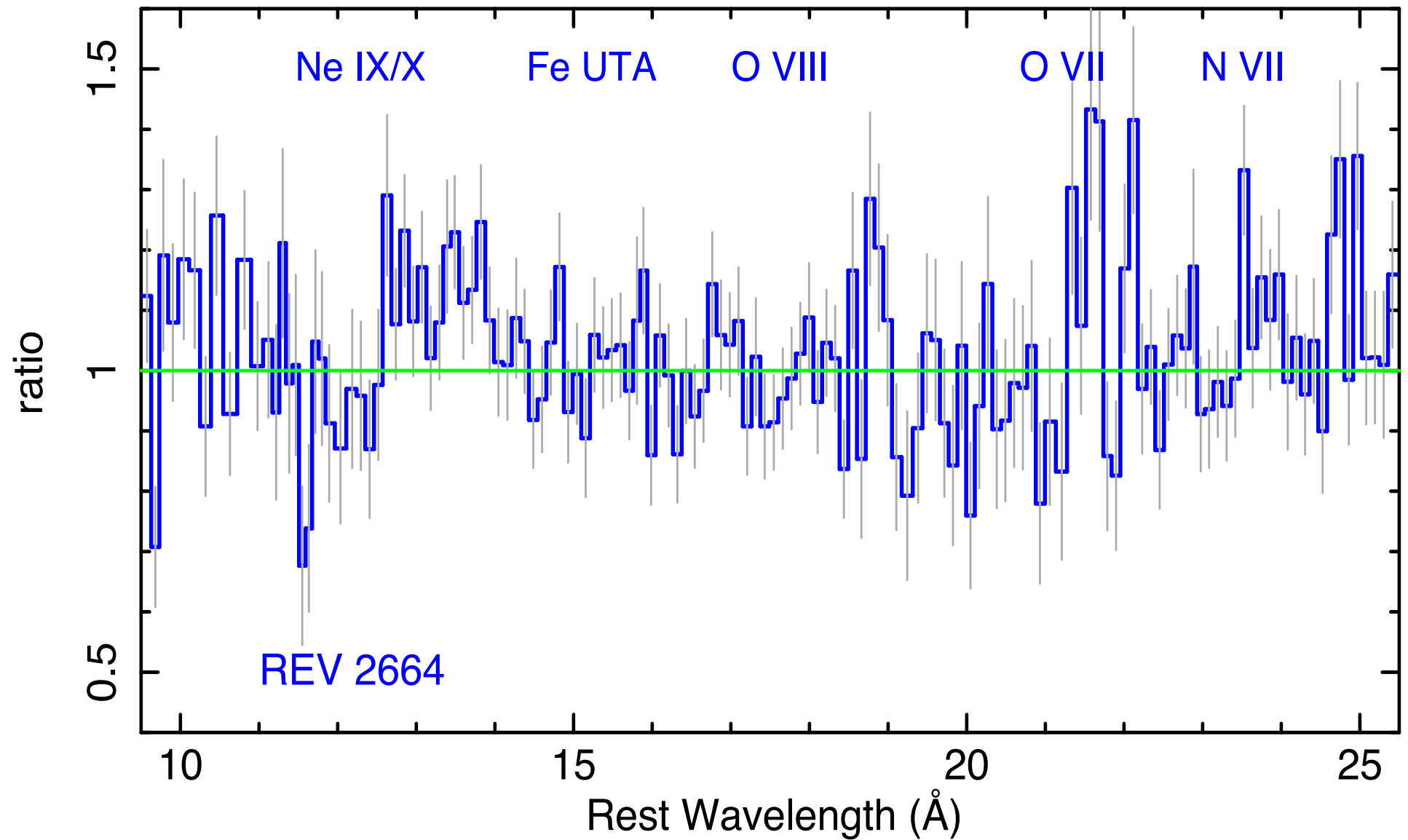
Variability of PG 1211 wind seen in RGS spectrum



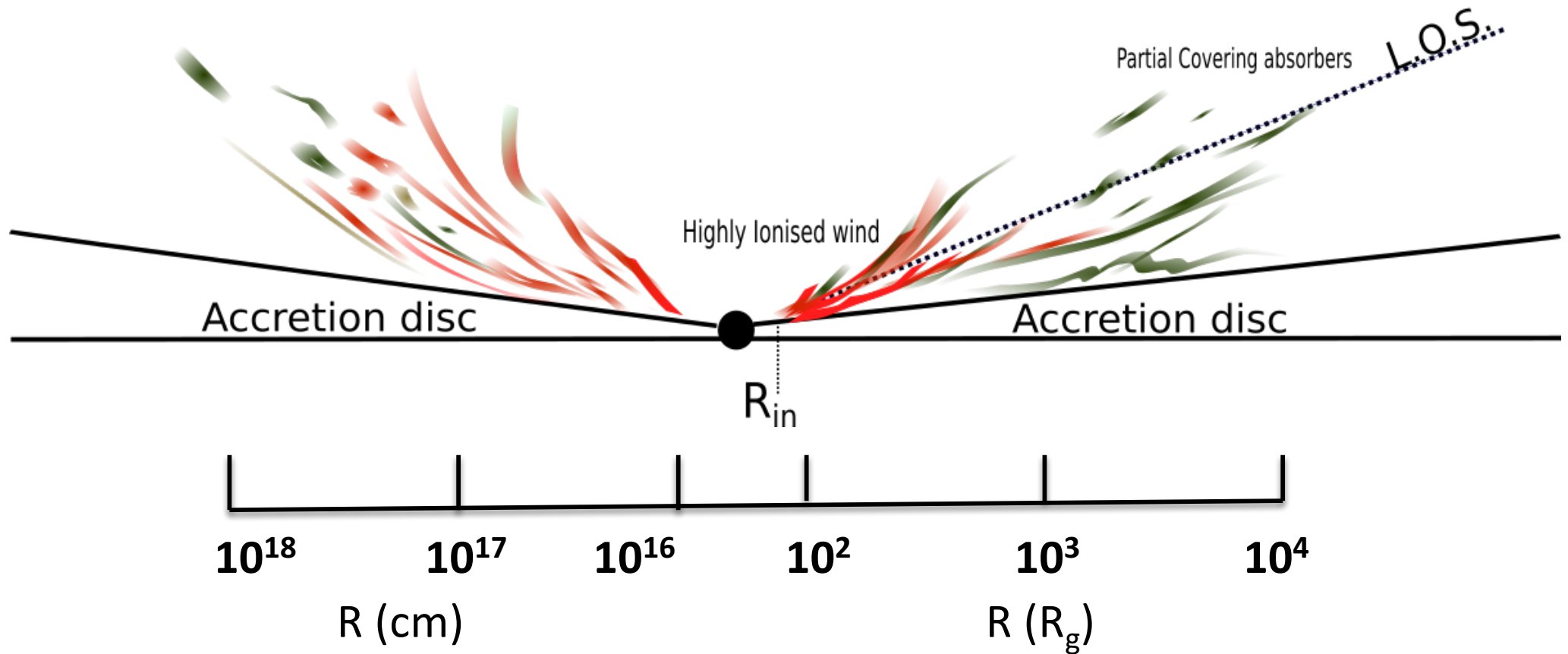
Variability of PG 1211 wind seen in RGS spectrum



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.