A new fast wind in a star forming galaxy

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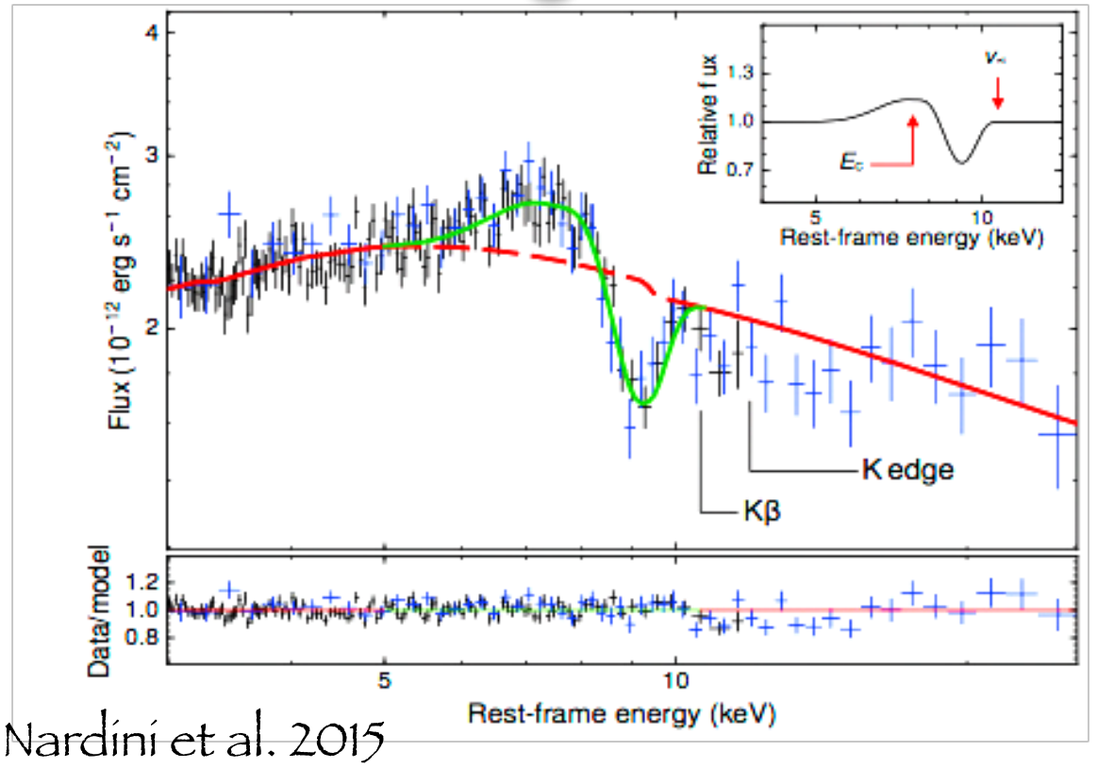
PDS456: the prototype of the UFOs



Nardini et al. 2015

2013 Campaign XMM+ NuSTAR

Persistent disk wind $v \sim 0.3c$

First accurate measure of the mass outflow rate: $P_{KIN} \sim 10^{46}$erg/s ~ 10% L_{BOL}

Signatures of the wind in the soft X-ray

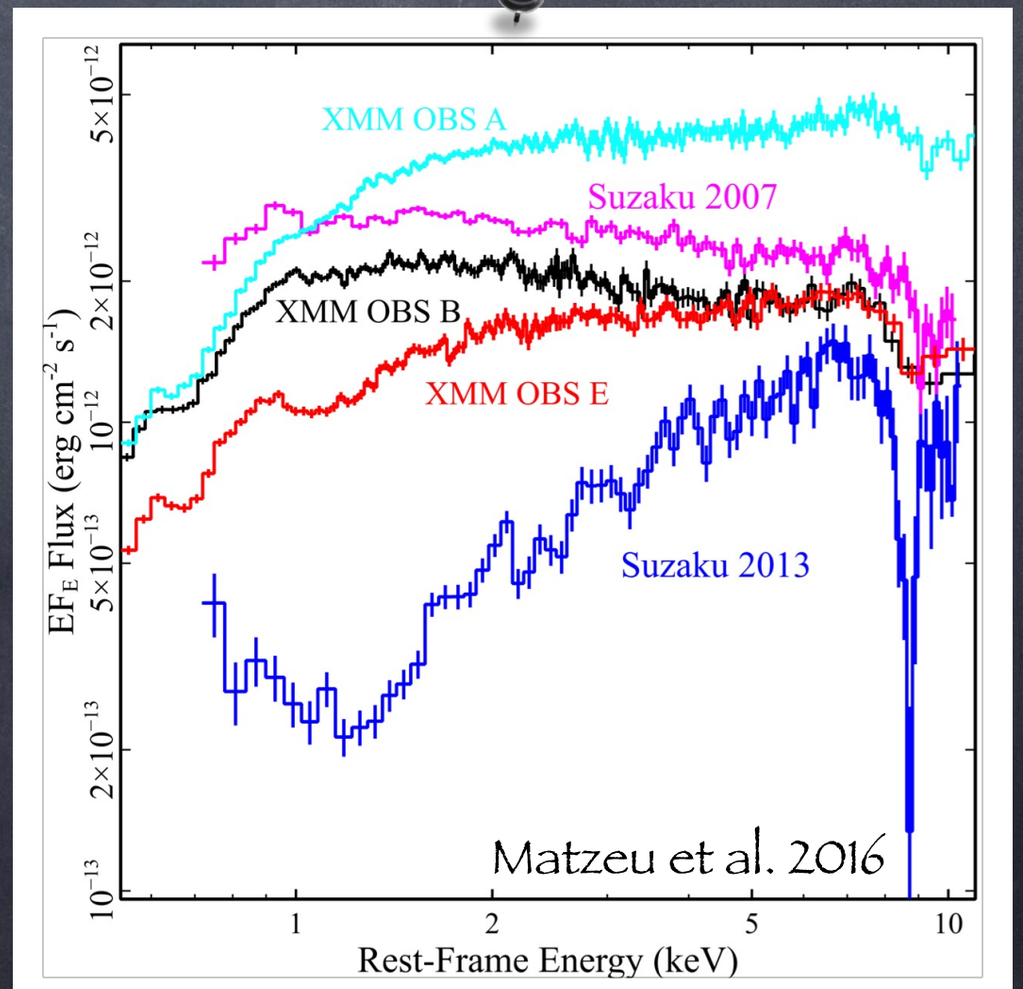
(See Reeves' talk)

Extremely variable

week/month time scales

✓Variability is both intrinsic and due to absorption

✓The partial coverer is an inhomogeneous zone of the wind with v ~0.1-0.2c



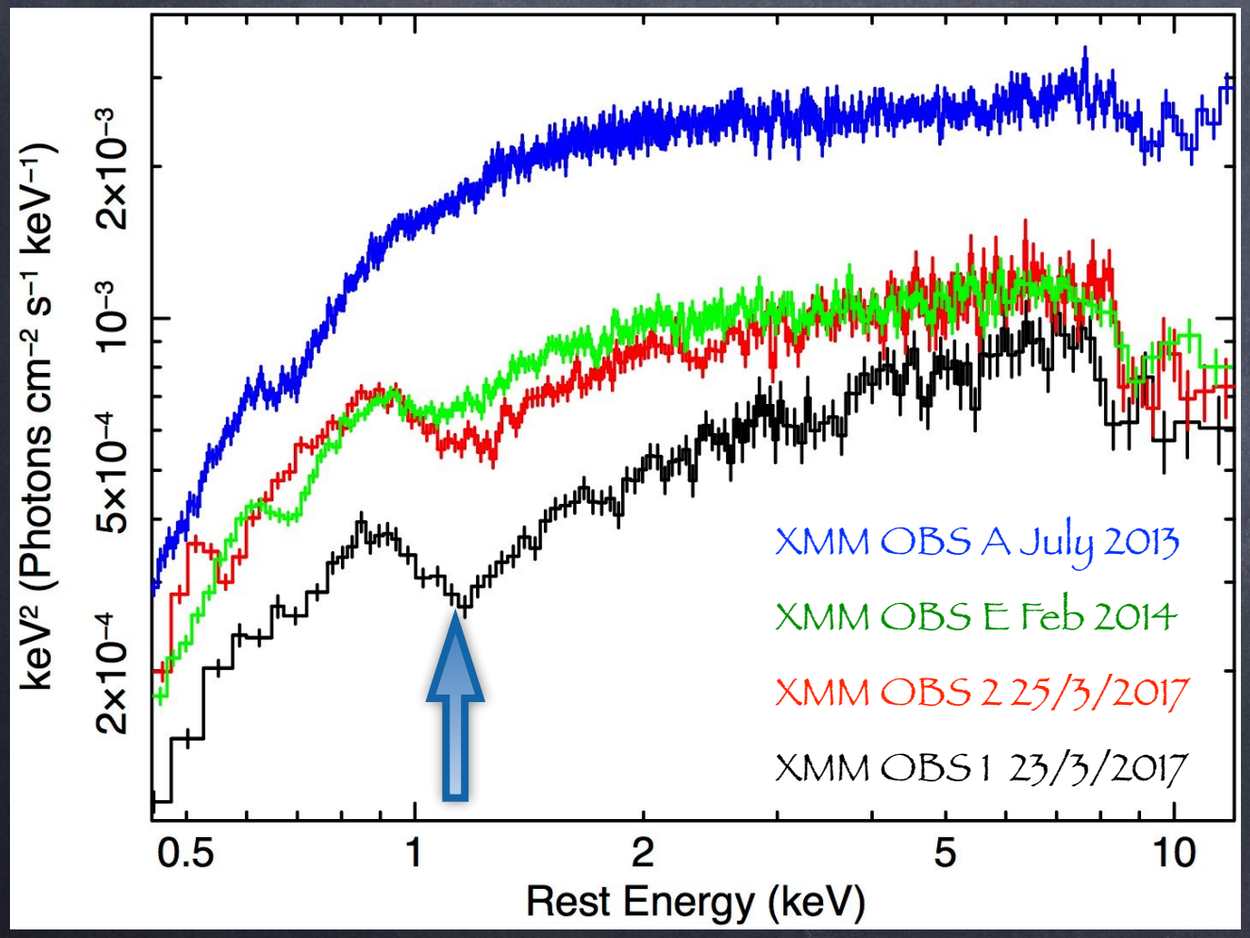
Another state of PDS456

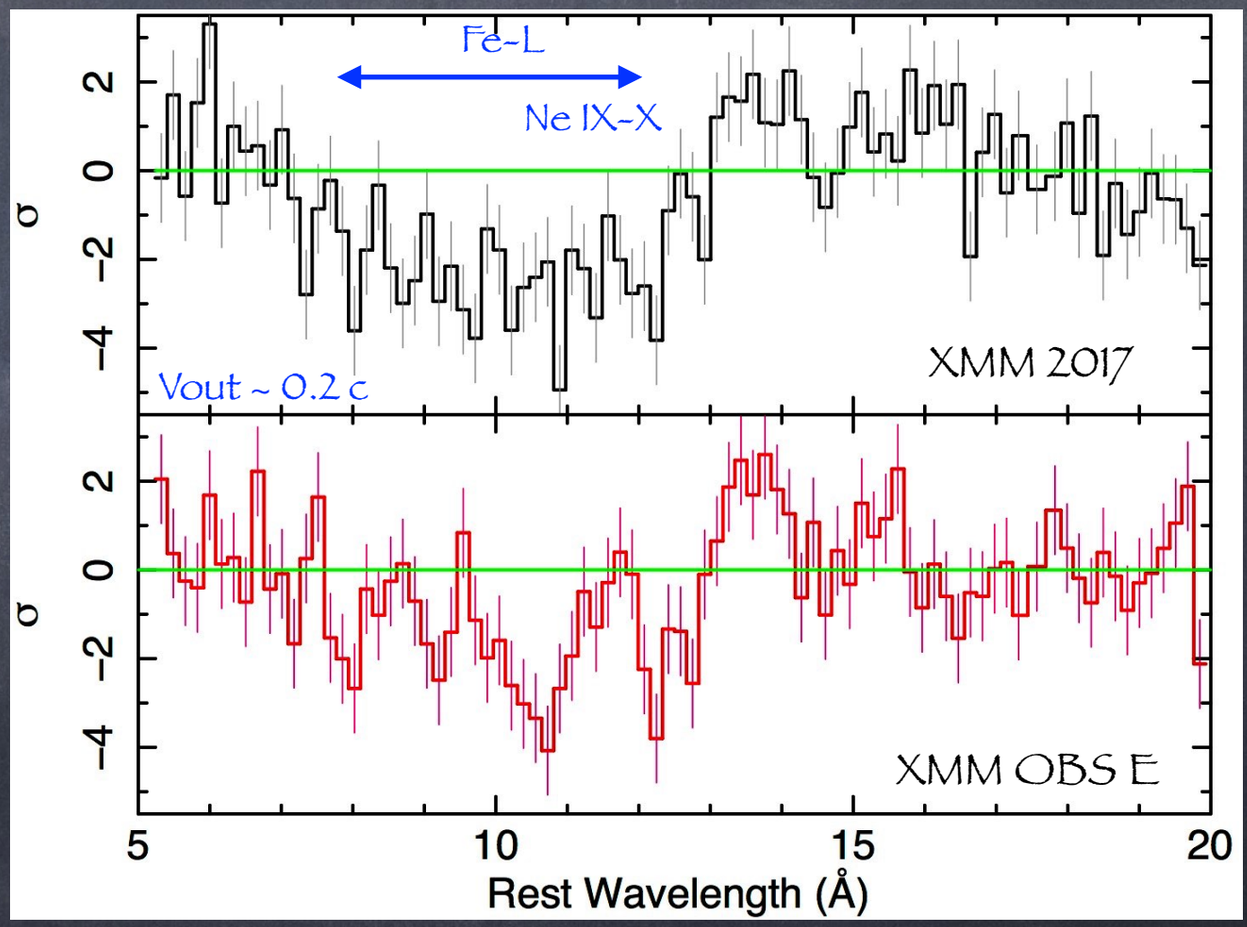
2017 Campaign: 2 XMM 90 ksec observations + NuSTAR

PDS 456 was caught in two new obscured states

But not as obscured as the Suzaku 2013 states (see Matzeu's talk)

Both showing signatures of the wind at the Fe -K band and in the soft X-ray





OBS 1: clearly shows the imprint of the soft zone of the wind at 1 keV

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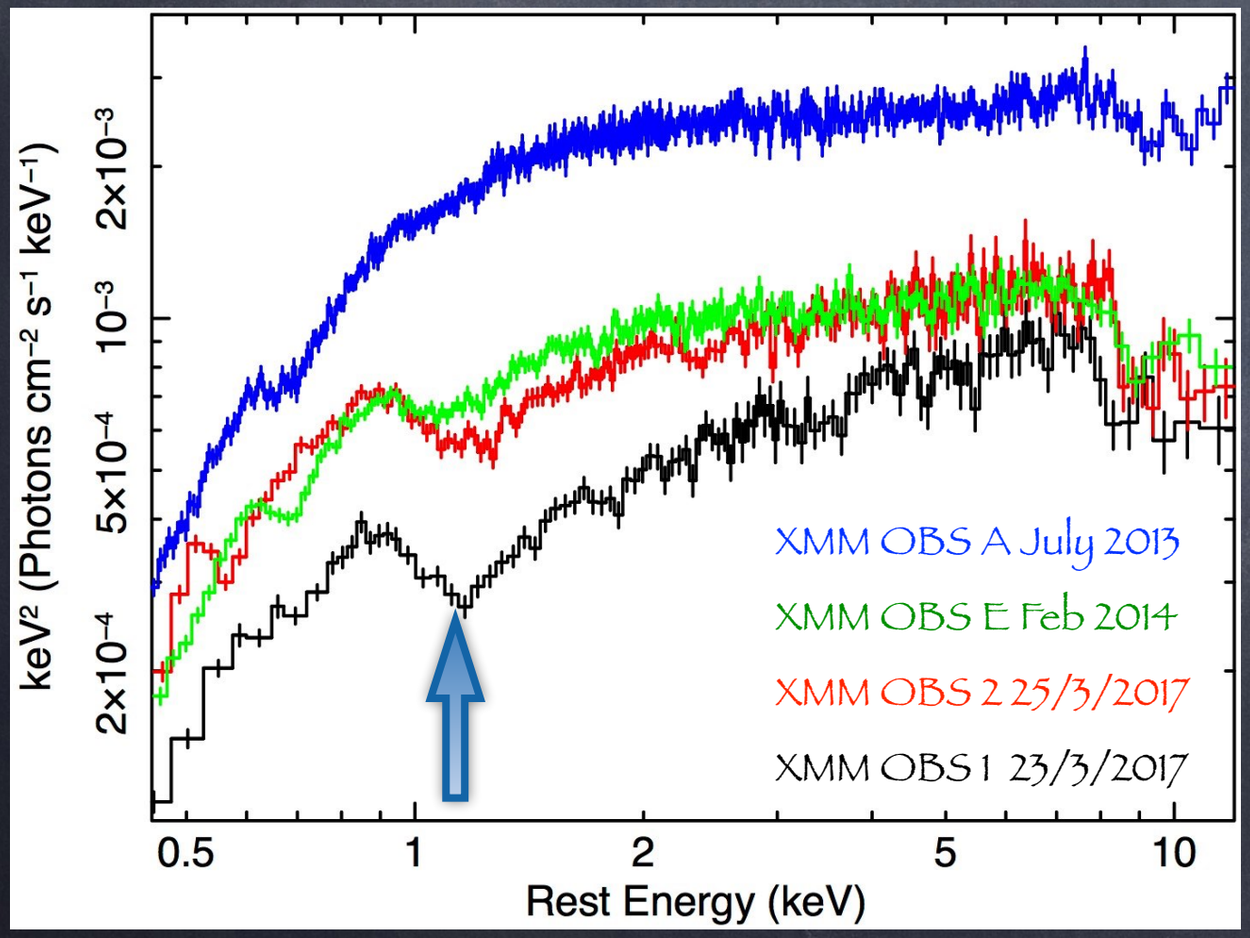
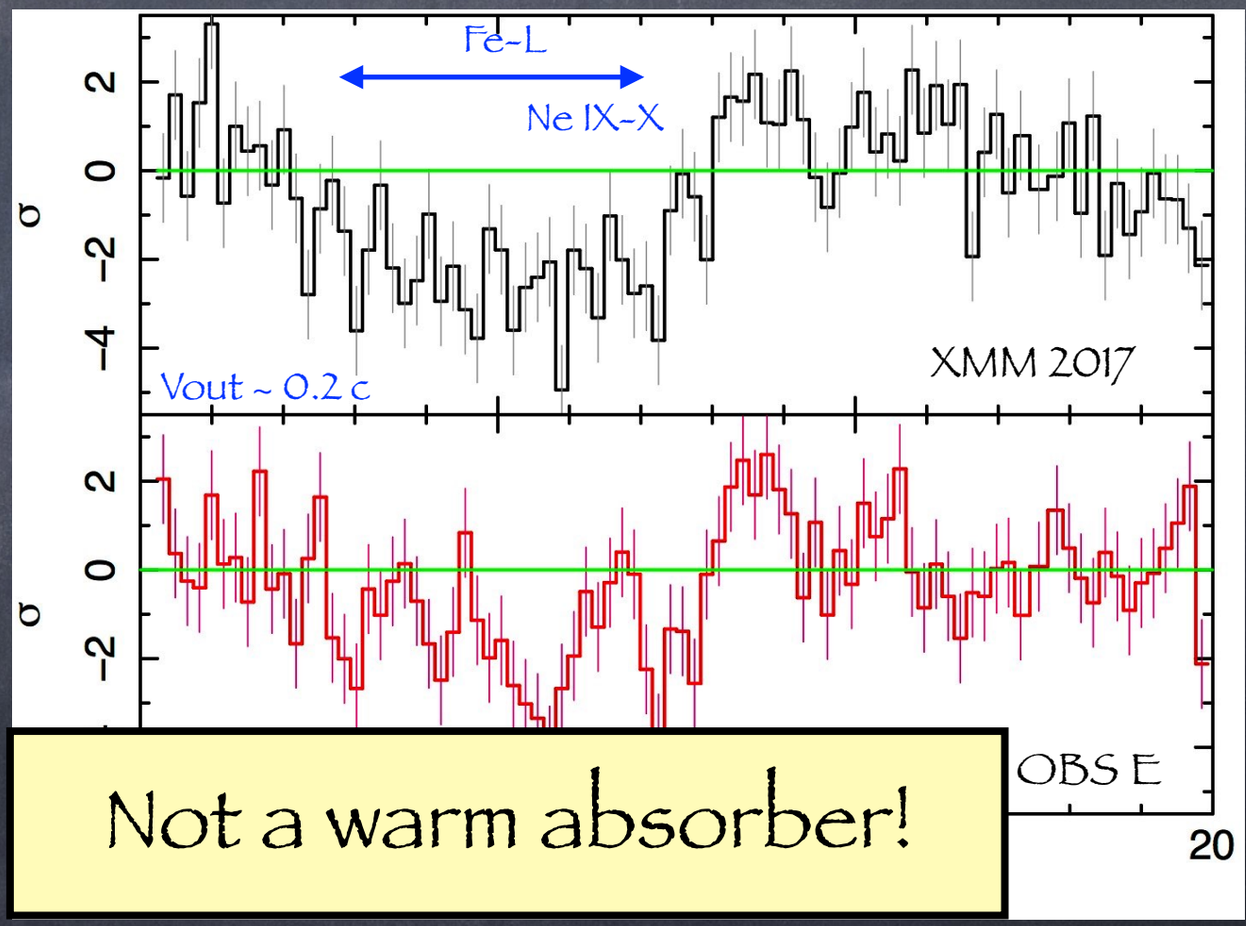


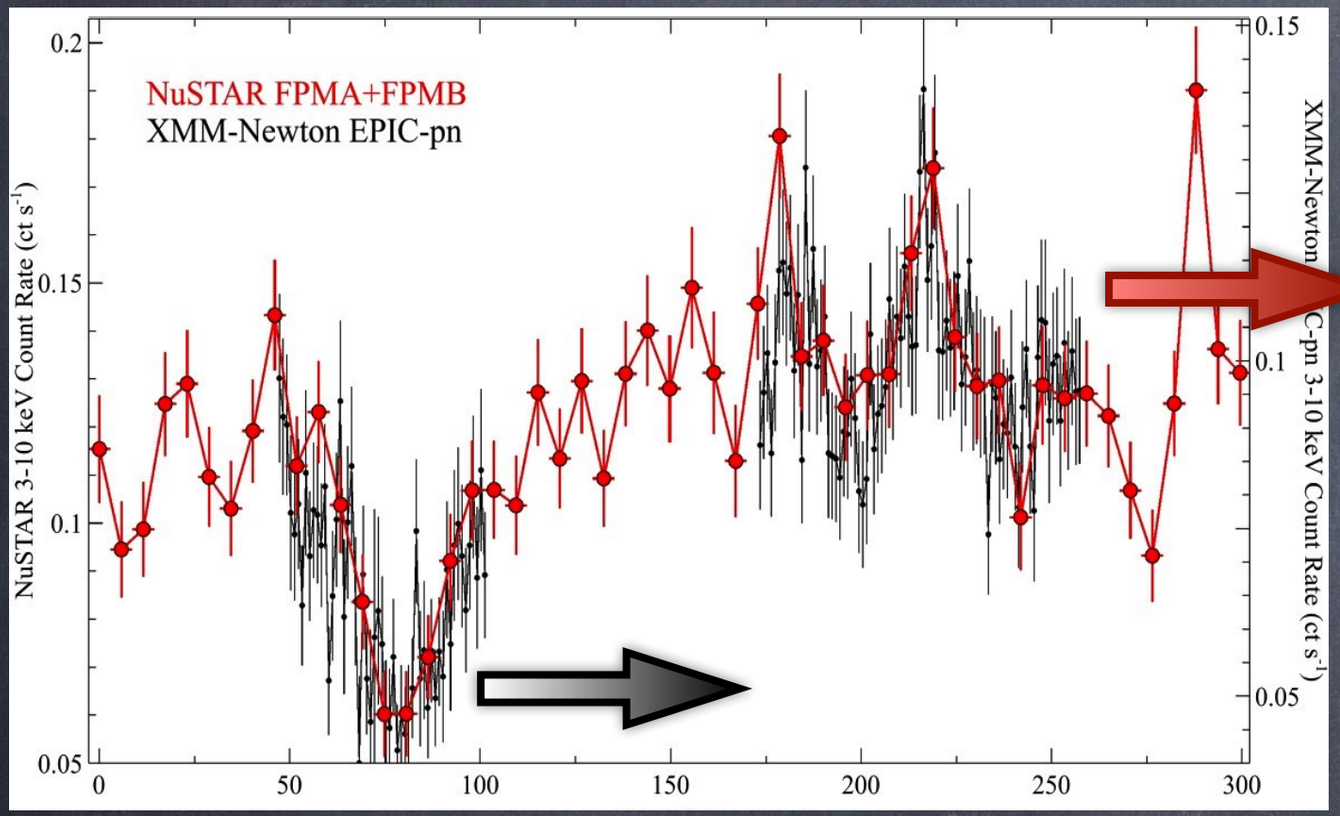


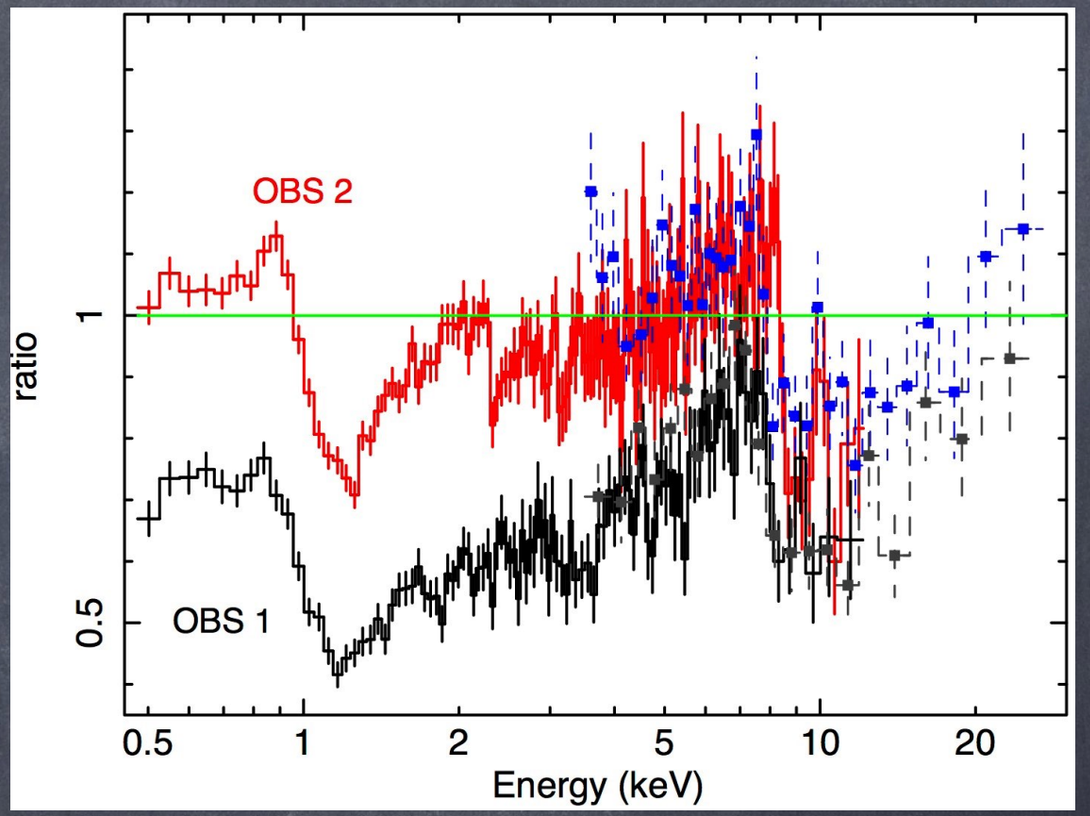
Not a warm absorber!

OBS 1: clearly shows the imprint of the soft zone of the wind at 1 keV

PDS456: an eclipsing event of the UFO

NuSTAR and XMM light curves reveal that during OBS1 we caught PDS456 during a possible occultation event





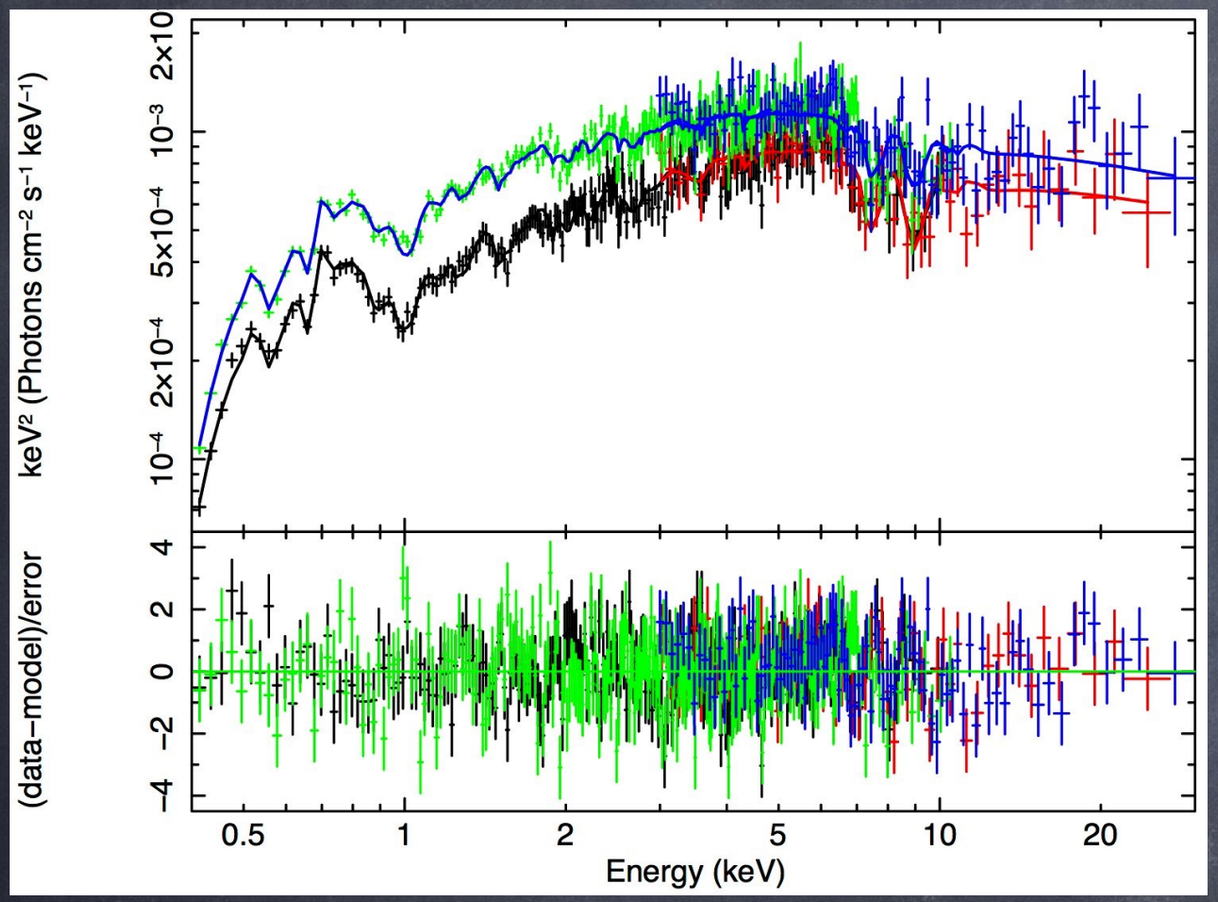
✓Ratio to the baseline continuum model shows that both the soft absorption trough and the Fe-K feature are stronger in OBS 1

✓The continuum emerging above 10 keV is almost at the same level

Variability: inhomogeneity of the wind + weak variations of the continuum

Revealing the wind structure

Same structures of the soft X-ray absorber seen in the past RGS observations (see Reeves's talk)



Now we have more constraints thanks to the occultation event

Both zones varies on a time scale as short as 90 ksec

✦$\Delta N_{H\ soft} \sim 10^{22}$ cm^{-2} & $\Delta N_{H\ Fe\text{-}K} \sim 10^{23}$ cm^{-2}

Short time scales: we are probably seeing filaments of the wind with

✦ $\Delta R \sim$ few x 10^{14} -10^{15} cm or ~10Rg

✦@ $R \sim 10^{17}$-10^{18} cm

✦ $n_e \sim 10^{7}$ -10^{8} cm^{-3}

BUT how unique is PDS456?

A new PDS 456?

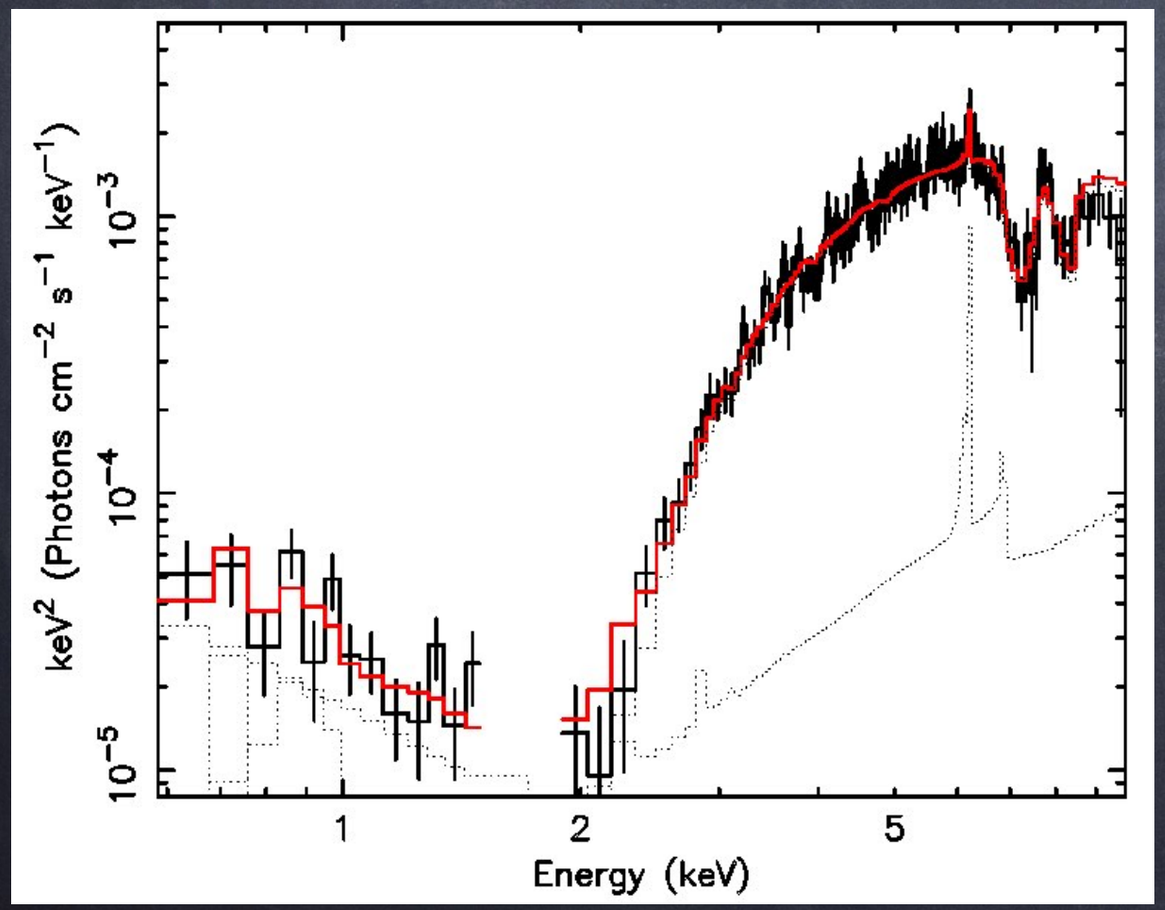
Smaller system than PDS456: $M_{BH} \sim 7 \times 10^7 M_{SUN}$ & $L_{BOL} \sim 10^{45}$ erg/s

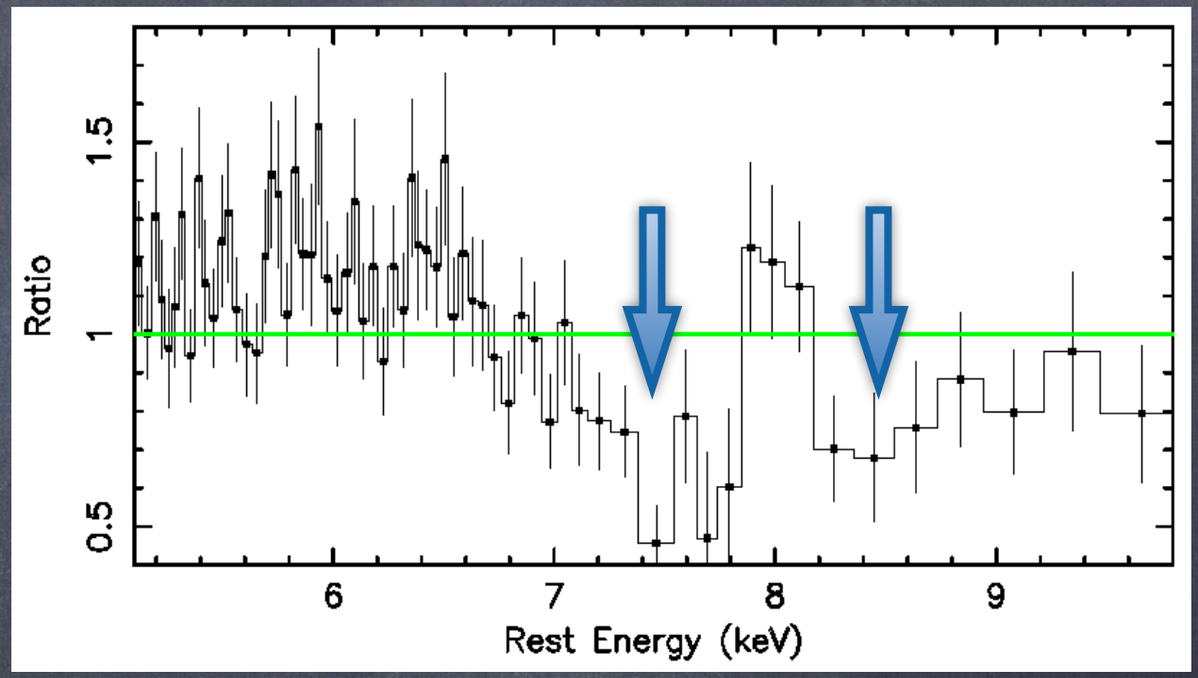
$L_X \sim 10^{43}$ erg/s ; $F_X \sim 3 \times 10^{-12}$ cgs

MCG03-58-007 is LIRG ($L_{FIR}=1.7 \times 10^{11} L_{SUN}$) with a SFR ~ 10 M_{SUN}/yr

Suzaku revealed deep abs.
structure at 7.5 keV & 8.5 keV

$EW_{7.5keV} \sim 300$ eV





Disk Wind properties: 2 zones

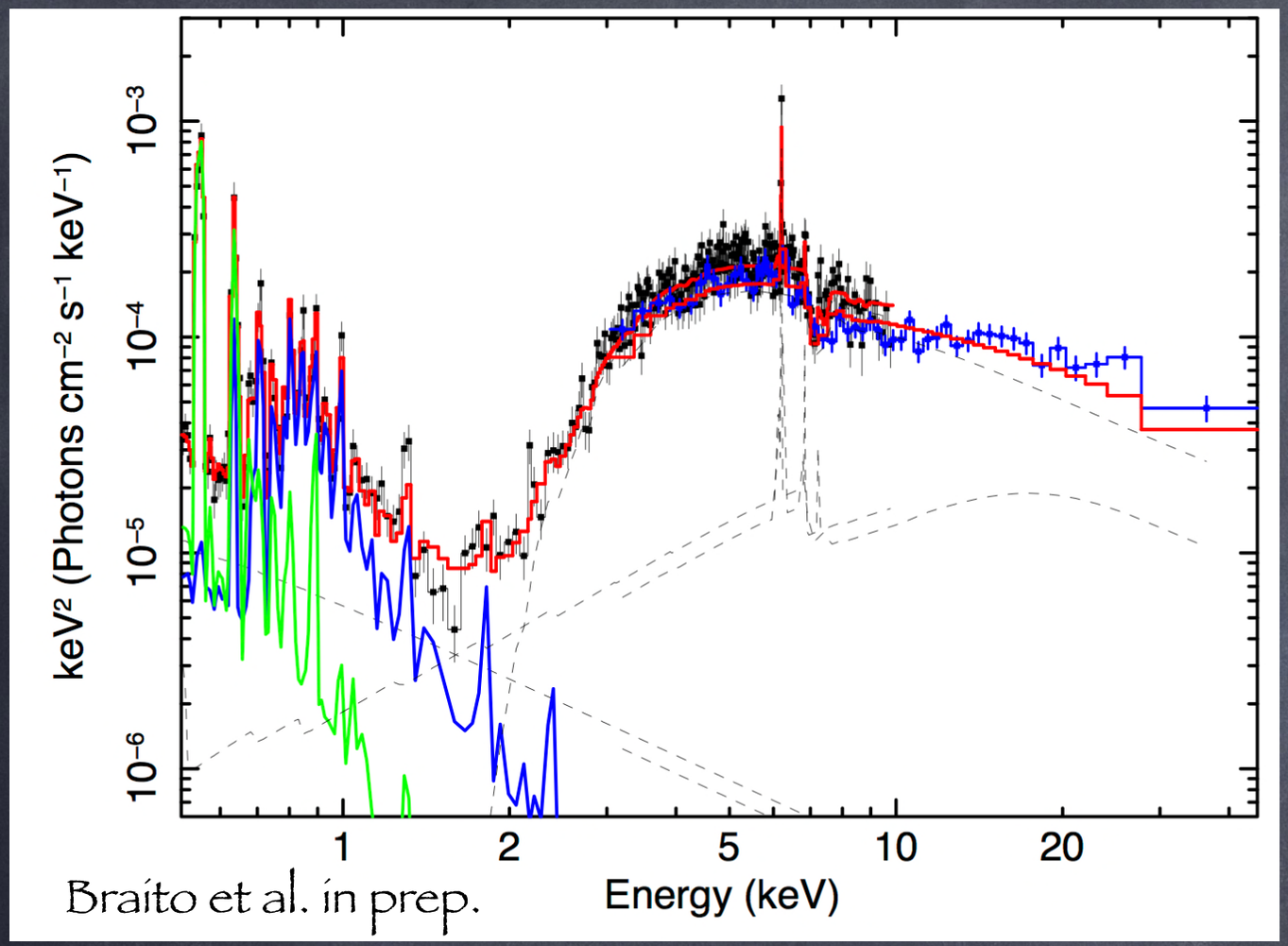
$\log \xi \sim 5$ erg cm s^{-1}

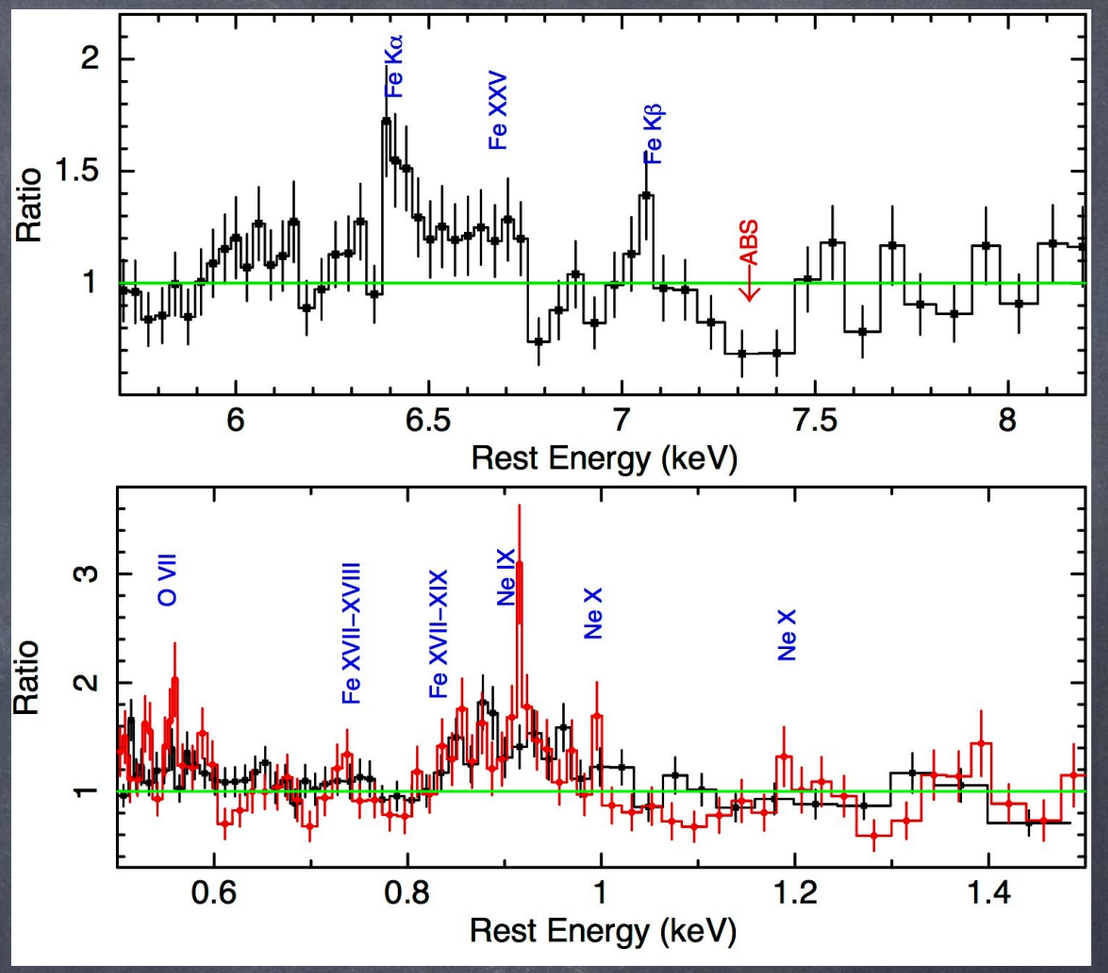
both with $N_H \sim 7\text{-}8 \times 10^{23}$ cm^{-2}

$v_{out} \sim 0.07c$ & $0.2c$

$L_{KIN} \sim 10^{43}\text{-}10^{44}$ erg/s

The XMM-NuSTAR long look

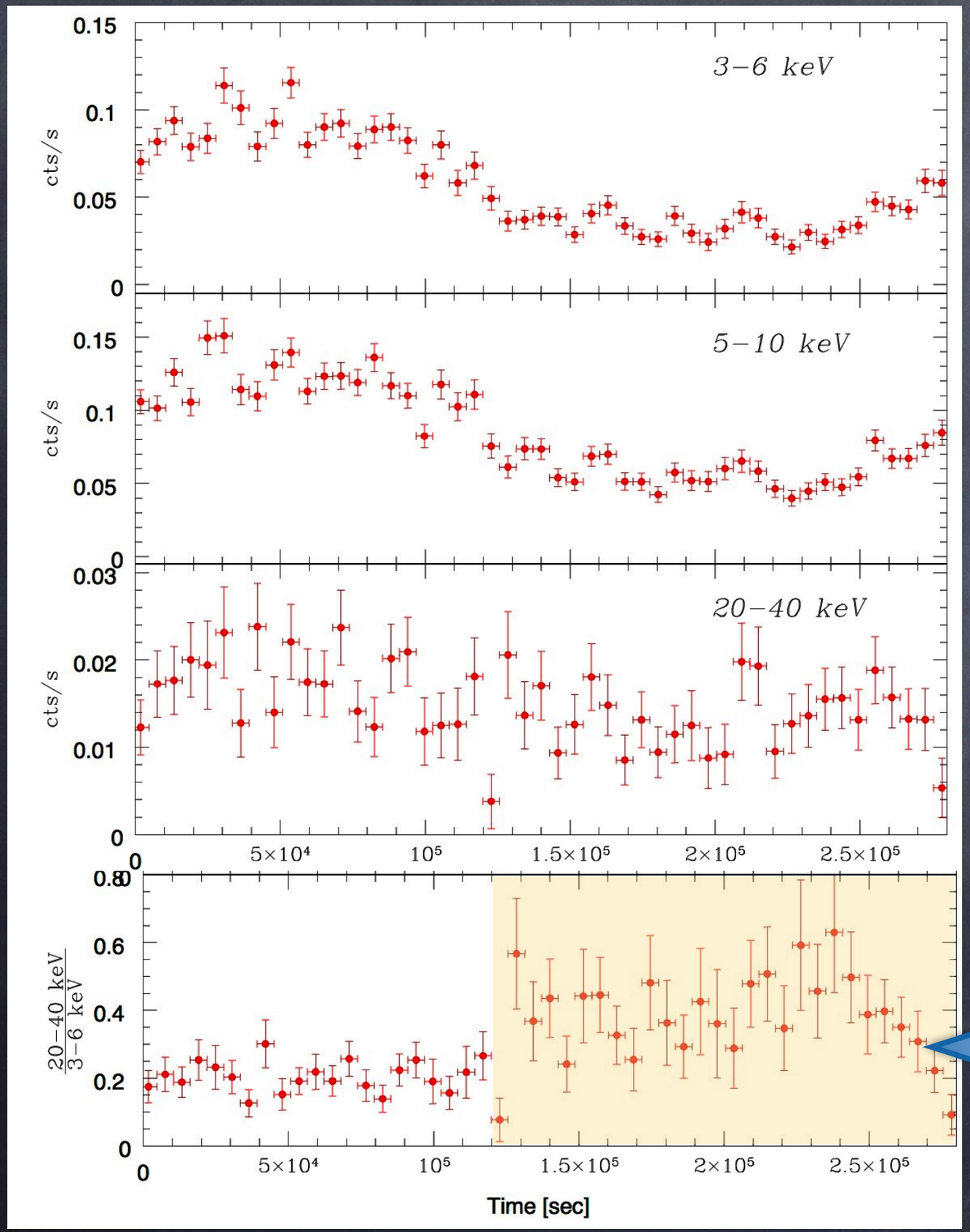




XMM-NuSTAR observation confirms ultra-fast wind with $P_{KIN} \sim 10^{43}$ erg/s.
Although the abs. feature is weaker: EW ≈ 75 eV ($N_H \sim 2 \times 10^{23}$ cm^{-2}).
Soft X-ray extremely rich in emission lines: stronger SFR or AGN lines?

Awarded a Chandra 60 ks obs. to investigate the diffuse emission

The occultation event



NuSTAR light curves reveal a possible occultation event at around 120 ksec.

Flux decreases in both the 3-6 keV & the 5-10 keV band but not in the 20-40 keV

Unfortunately at this point we had almost no XMM coverage (~10 ksec)

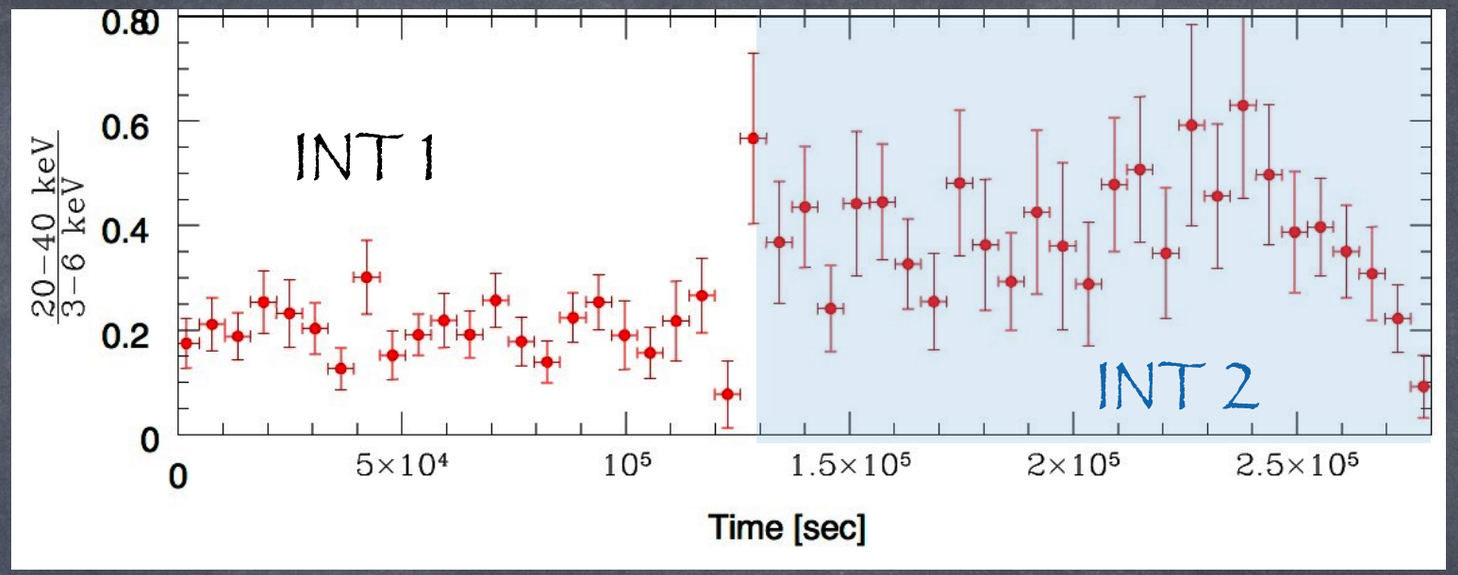
HR shows a clear spectral change.

At the end the HR slowly decreases back to almost the initial value

A fast variable absorber?

20-40 keV band:- the primary PL& reflected components

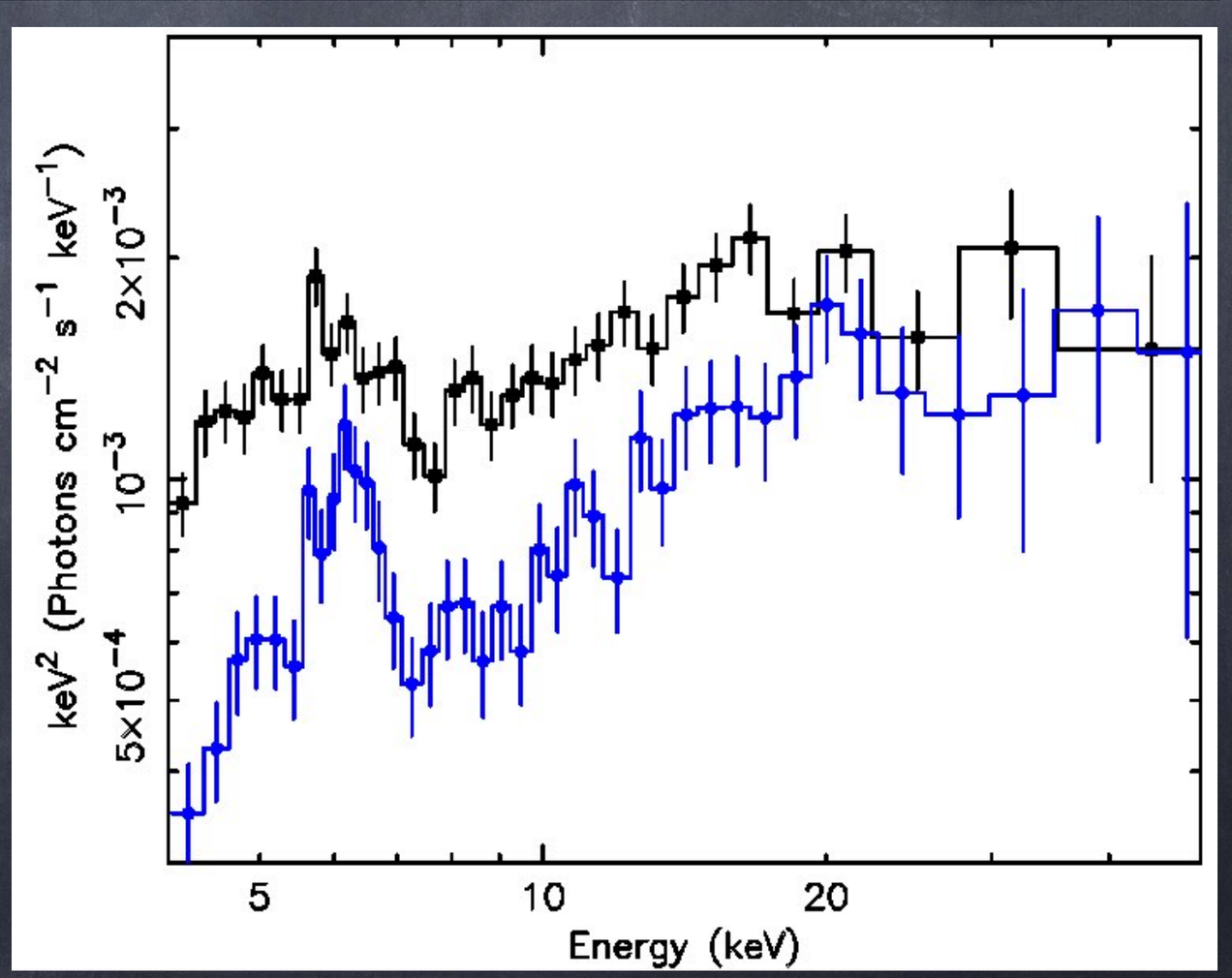
3-6 keV band:- carries the imprint of the N_H~10^{23} cm^{-2} absorber



Clear variations of the N_H

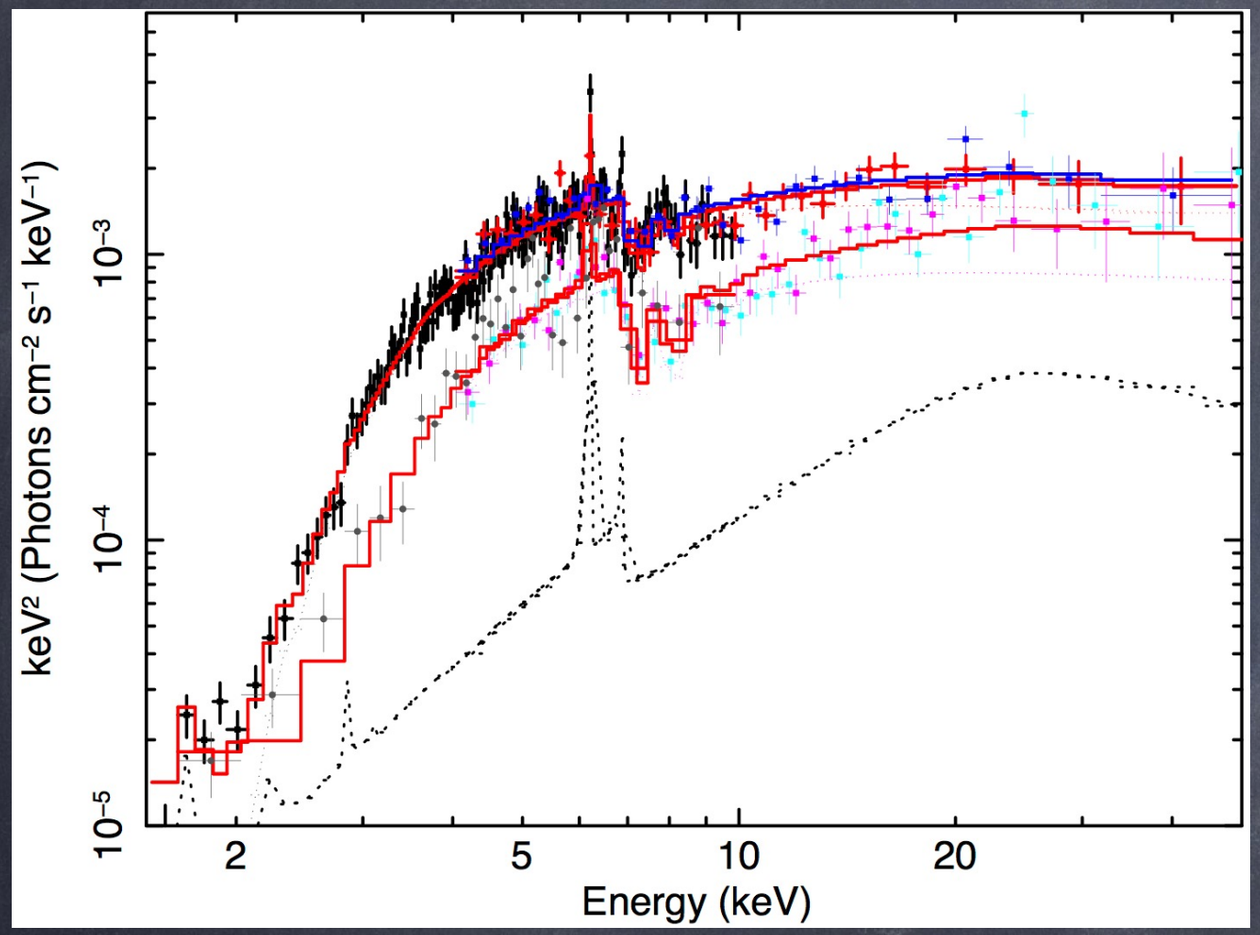
INT2 reminiscent of a highly obscured AGN.

Highly curved & strong Fe emission line



What about the fast wind ?

A variation in the N_H of the disk wind can explain the spectral variability



Similarly to the Suzaku observation we need 2 zones

$\log \xi \sim 4$ erg cm s^{-1} & $N_H \sim 1\text{-}2 \times 10^{23}$ cm^{-2}

$v_{out} = 0.07c$ & $0.14c$

For both the zones N_H increases to

$N_H = 4\text{-}5 \times 10^{23}$ cm^{-2}

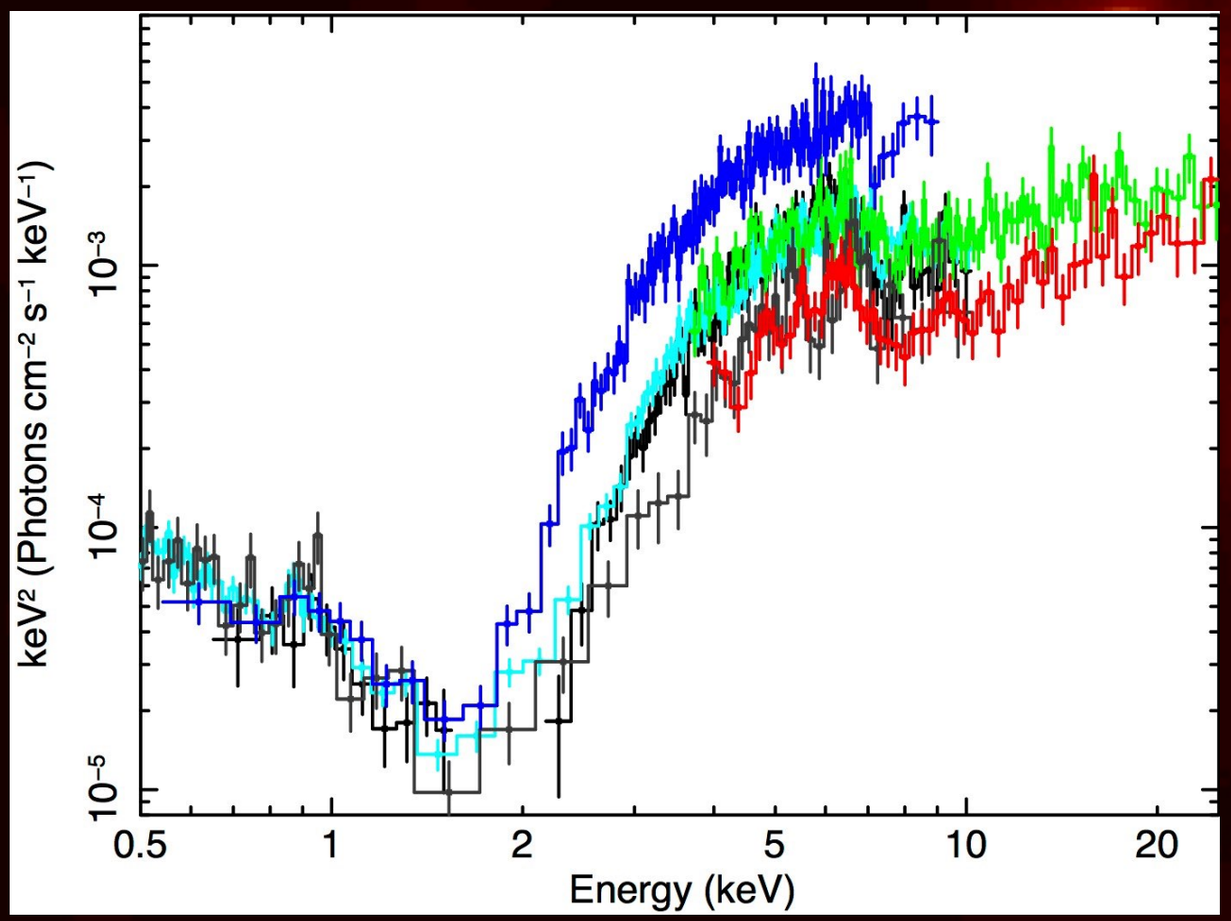
- ξ and v_{out}: disk wind launched from $100R_G$ with $L_{KIN} \sim 5 \times 10^{43}$ erg/s
- Variability in ~100 ksec $\Rightarrow \Delta R \sim$ few $\times 10^{14}$ cm or few $\times 10 R_g$ & $n_e \sim 10^9$ cm^{-3}

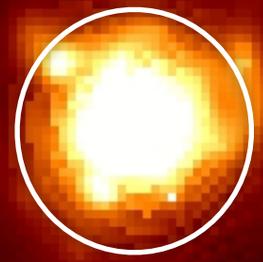
A new fast wind and star forming galaxy

Chandra observation:

Most of the X-ray emission from the central 2”

Soft X-ray emission lines from the extended
NLR gas photoionized by the AGN.





MCG03 varied again
It is now brighter

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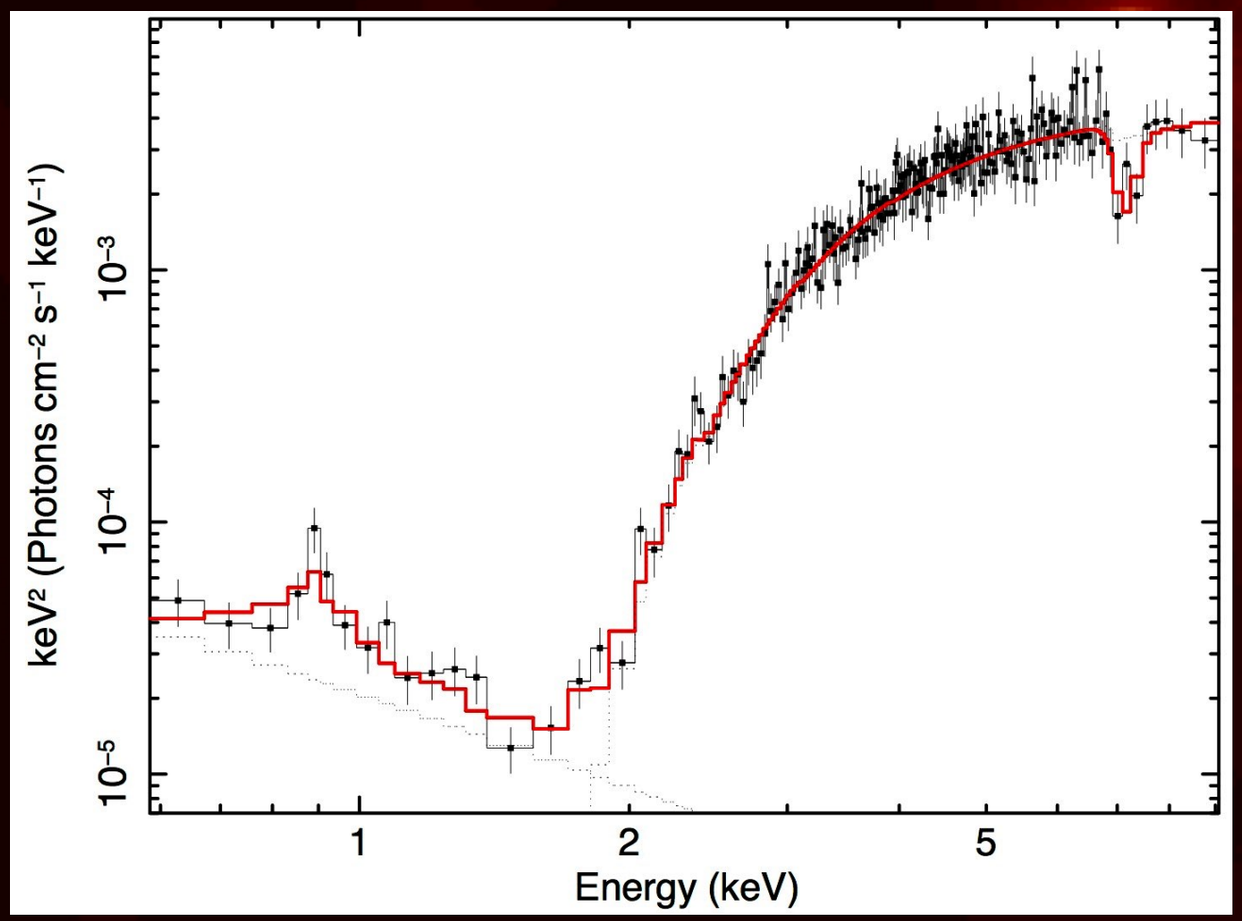

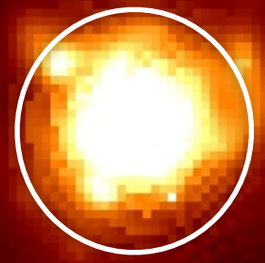

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The absorption feature is confirmed @ E ~ 7.4 keV with EW ~ 200 eV

Summary

- The occultation events that we have witnessed in these XMM+NuSTAR observations of PDS456 and MCG03 could be due to clumps/filaments of their disk winds

- This disk wind in MCG03 is a scaled down version of the one in PDS456 with a typical kinetic power of $L_{KIN} \sim 5 \times 10^{43}$ erg/s corresponding to ~ $5\% L_{BOL}$

- The system is now smaller and less luminous than PDS456 and IRASF11119+3257 (Tombesi et al. 2015) & Mrk 231 (Feruglio et al. 2015) where the most powerful winds have been detected.

ALMA observations awarded for both MCG03 (PI Severgnini) and PDS456 (PI Piconcelli) to look for the signatures of the kpc-scale molecular outflow