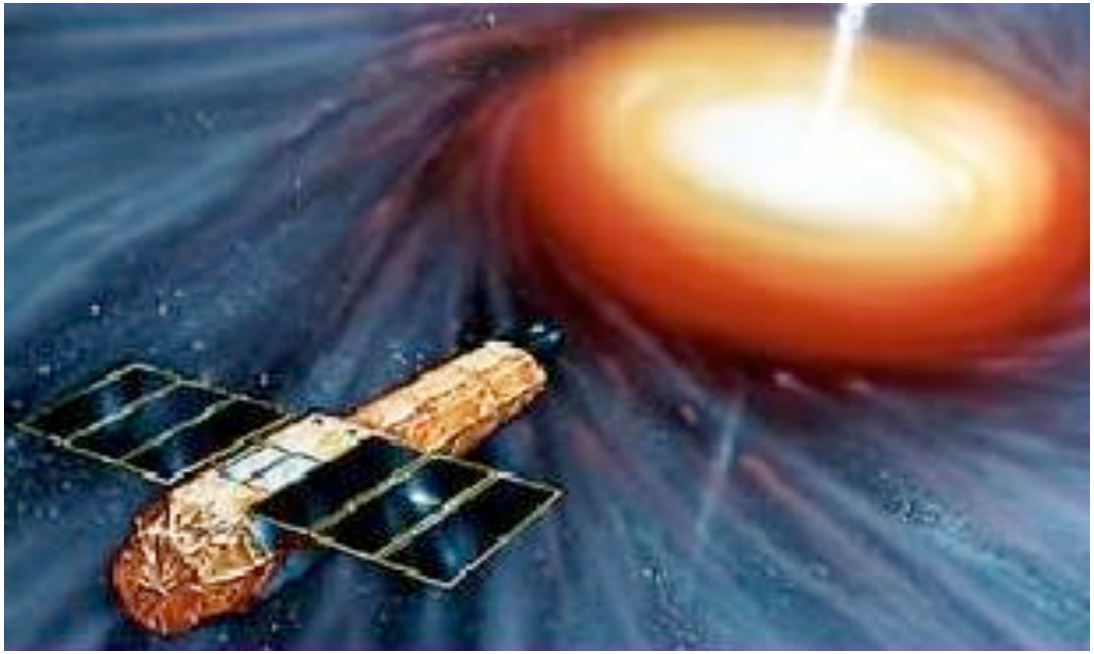
Suzaku observation of NGC 3516:

Complex absorption and the Broad & Narrow Fe K Lines



A. Markowitz, J. Reeves, P. Serlemitsos (NASA/GSFC) & the NGC 3516 Suzaku Observation Team

Observational Goals

- Use Suzaku's broad energy coverage to:

  Constrain the underlying power-law continuum

  Deconvolve broadband emitting & absorbing components

    Characterize the complex absorption

    Verify presence of broad Fe K line; constrain parameters

  Constrain Compton Reflection parameters

- Take advantage of high XIS effective area & low background in Fe K bandpass to:

  Study narrow Fe K bandpass emission features: Fe Kα & Kβ cores, Compton shoulder, 'narrow transient' features

Observation Details

NGC 3516 observed 12-15 Oct 2005 as part of SWG program

Net exposure times after screening:
Each XIS: 135 ksec
HXD-PIN: 111 ksec

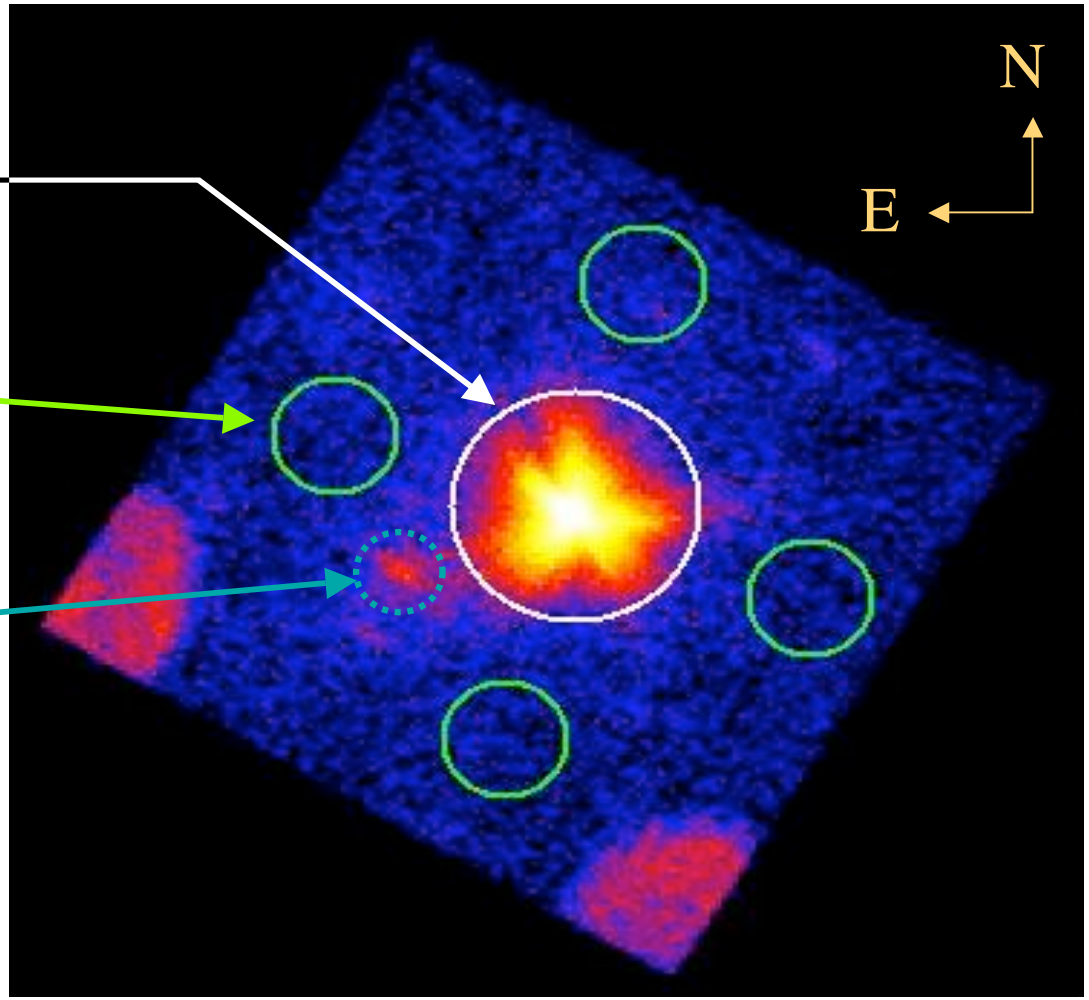
Instr.	Obsd. Flux	Source (net)	Bkgd
XIS-FI (avg) (0.4-14 keV)	3.4e-11 [cgs]	0.75 c/s	0.02 c/s
XIS-BI (0.3-10 keV)	2.4e-11 [cgs]	0.80 c/s	0.03 c/s
HXD-PIN (15-70 keV)	8.6e-11 [cgs]	0.16 c/s	0.39 c/s

XIS Extraction

Source: r=3’ circle

Bkgd: 4 x r=1.5’ circles

RX J110741.4+723235
(z=2.1 QSO)



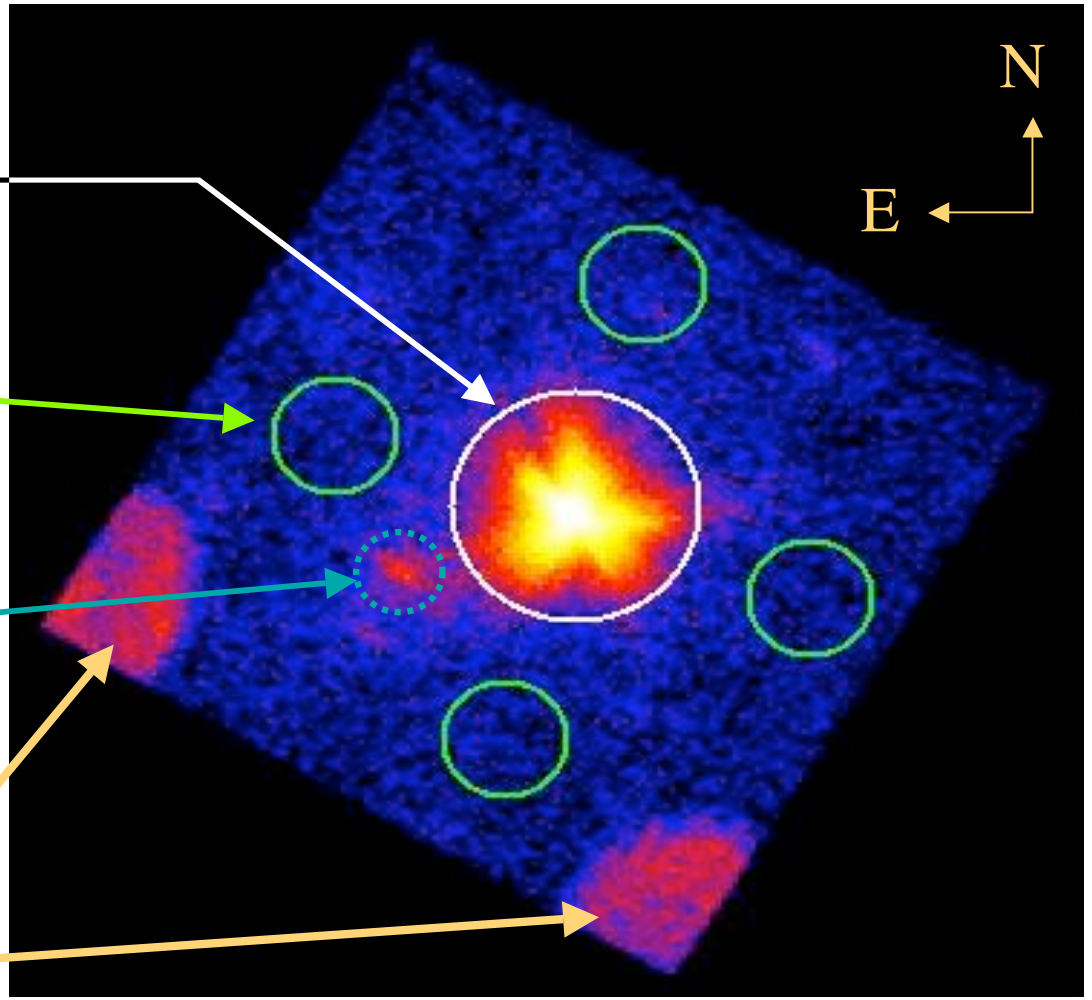
XIS Extraction

Source: r=3’ circle

Bkgd: 4 x r=1.5’ circles

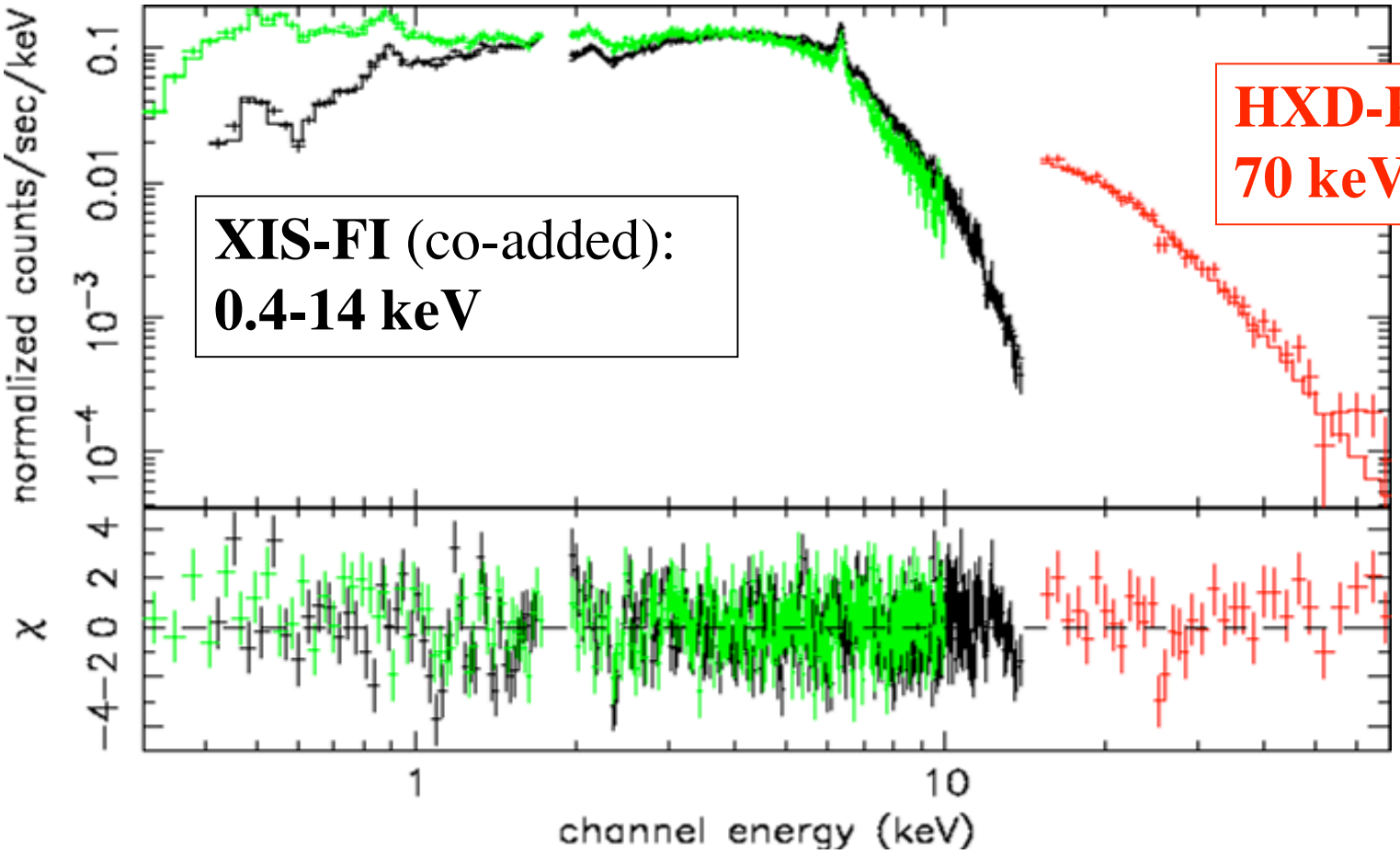
RX J110741.4+723235
(z=2.1 QSO)

^{55}Fe Cal. Sources

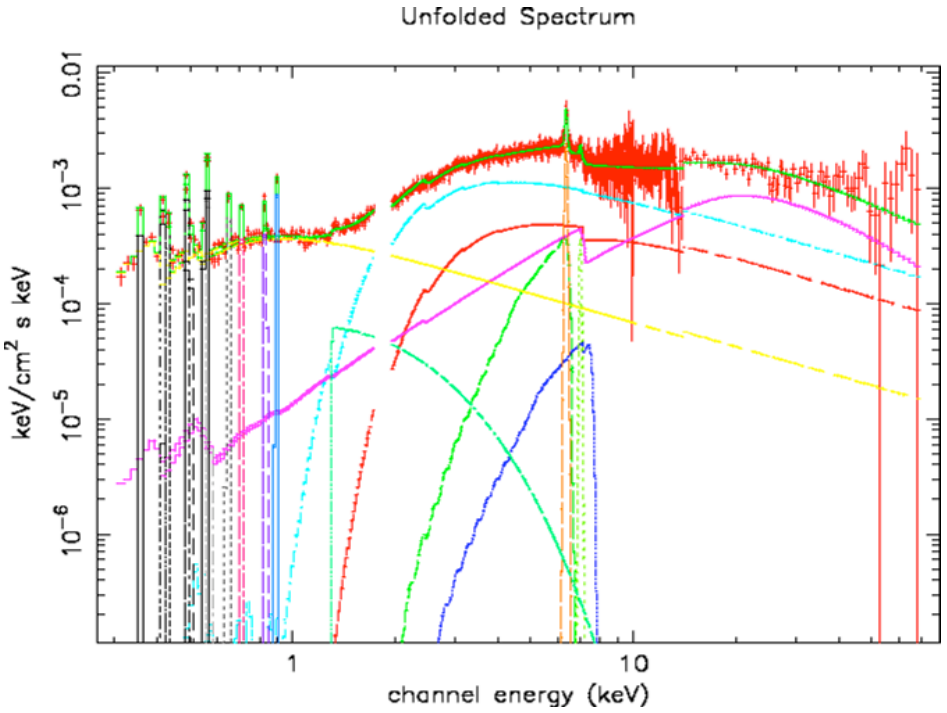


Broadband Model Fit

XIS-BI: 0.3-10 keV



Broadband Model Fit



•Similar model to Turner et al (2005) fit to 2001 XMM obsn.:

•**Power-law continuum** $\Gamma=1.84 \pm 0.02$ obscured by:

Ionized "UV" absorber, $\log\xi = -1.2 \pm 0.1$ erg cm s^{-1}
$N_H=1.92 \pm 0.02 * 10^{22}$ cm^{-2}

Partial Coverer: 35%
$N_H=1.0\pm0.1 * 10^{23}$ cm^{-2}

•**Scattered Emission:** 5% of nuclear continuum

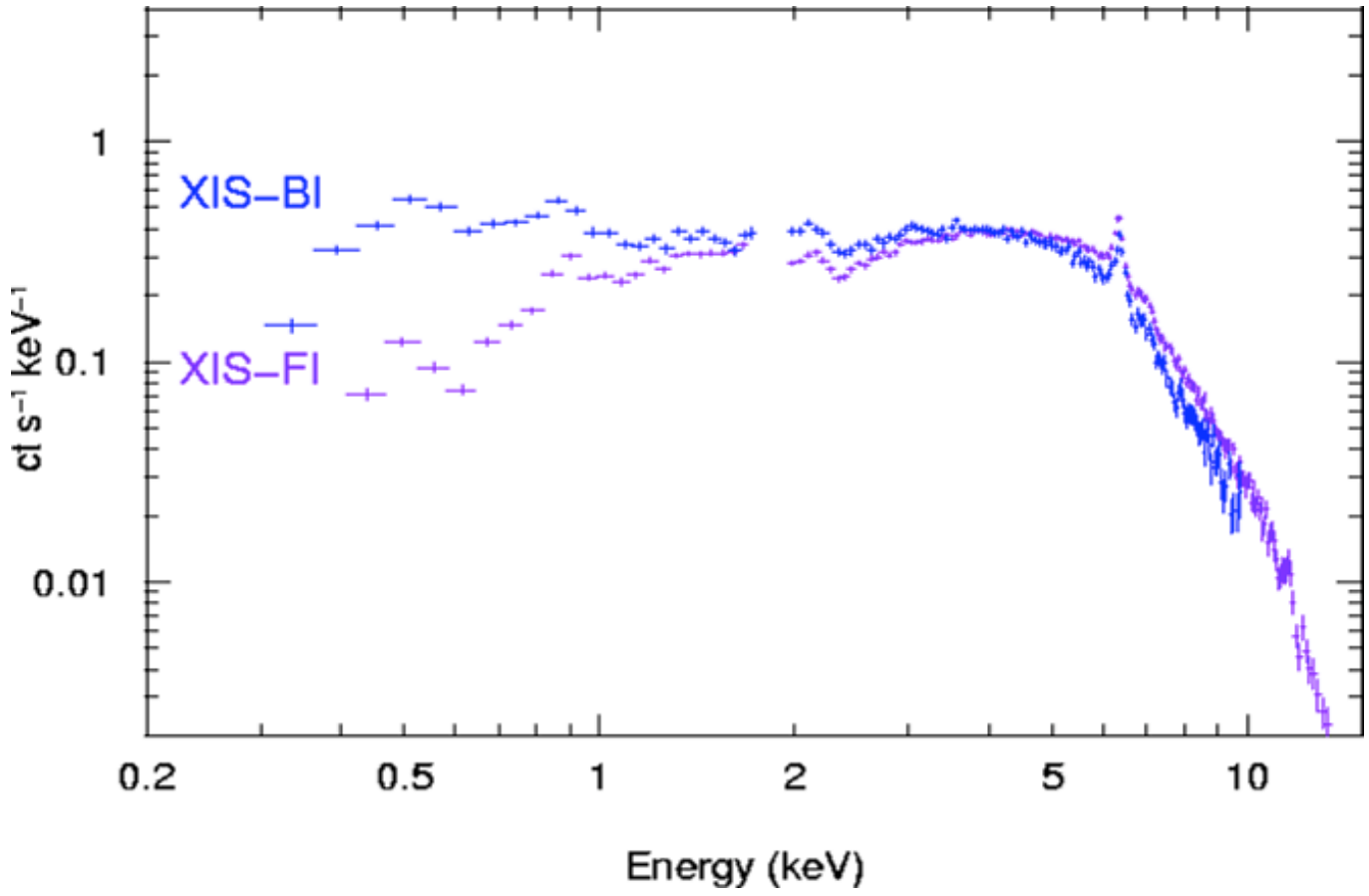
•**Soft X-ray emission lines** (see Turner et al. 2003 for RGS)

•**Broad + narrow Fe K emission lines**

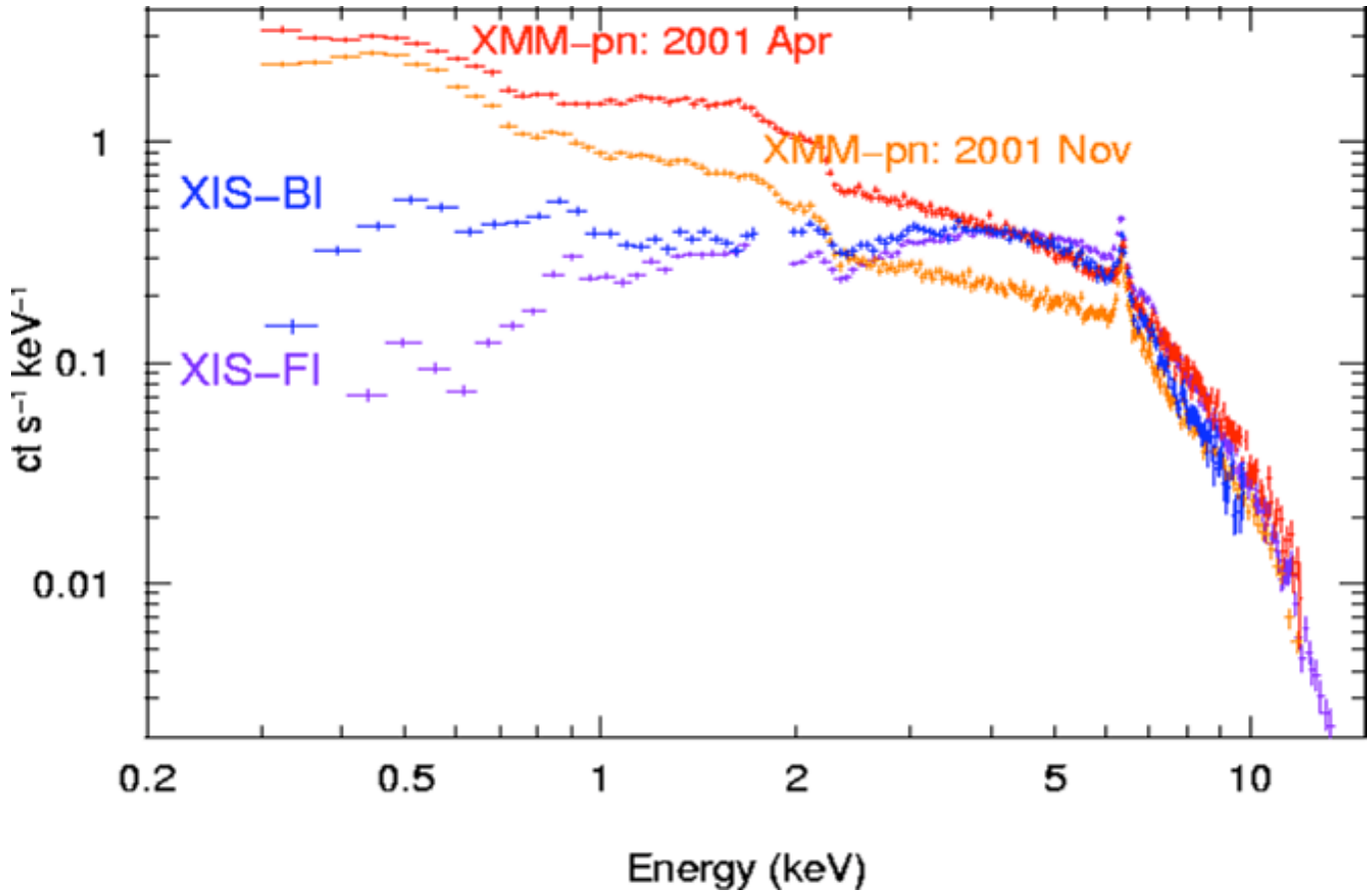
Comparison to 2001 XMM observations

	SUZAKU	**XMM-EPIC** (Turner et al. 2005)	
	10/2005	04/2001	11/2001
Observed 0.5-2.0 keV flux	**0.12e-11**	0.43e-11	0.29e-11
Absn.-corrected Nuclear Continuum flux, 2-10 keV	**2.97e-11**	2.72e-11	1.89e-11

Comparison to 2001 XMM observations

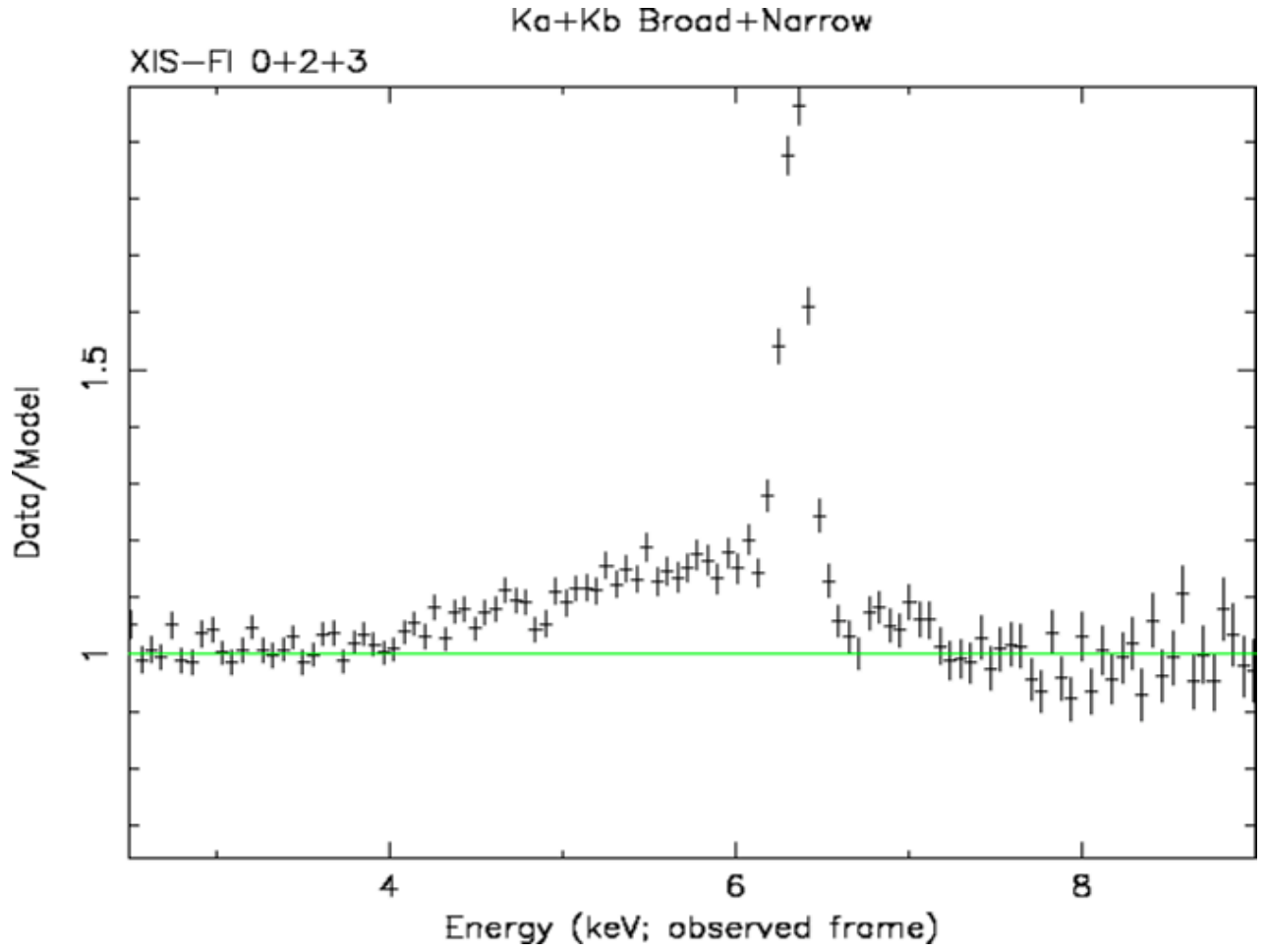


Comparison to 2001 XMM observations

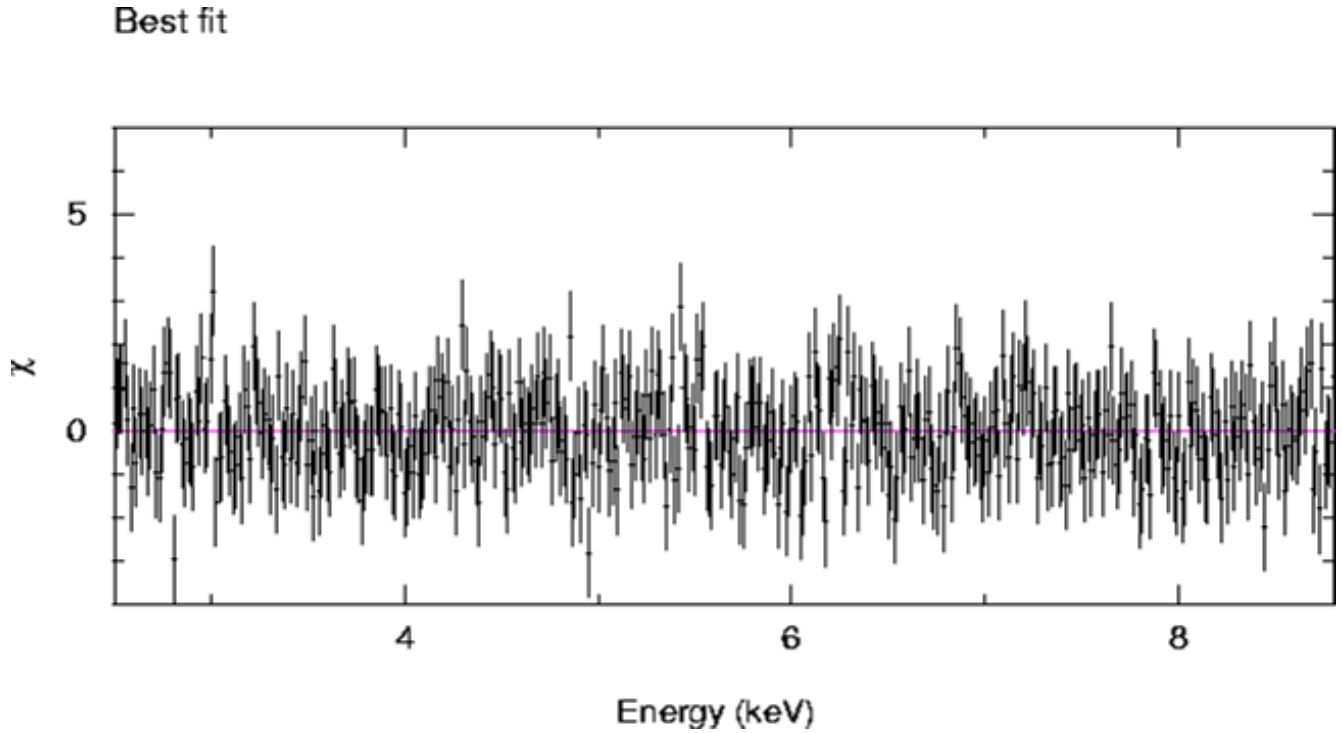


Column density of ionized material along line of sight increased by ~3 since 2001

Broad & Narrow Fe Kα+Kβ lines



Broad Fe K Diskline is Required



EW_{Ka} = 185 ± 15 eV

$I_{K\alpha}$ = 1.62 ± 0.12 e-4 ph cm^{-2} s^{-1}

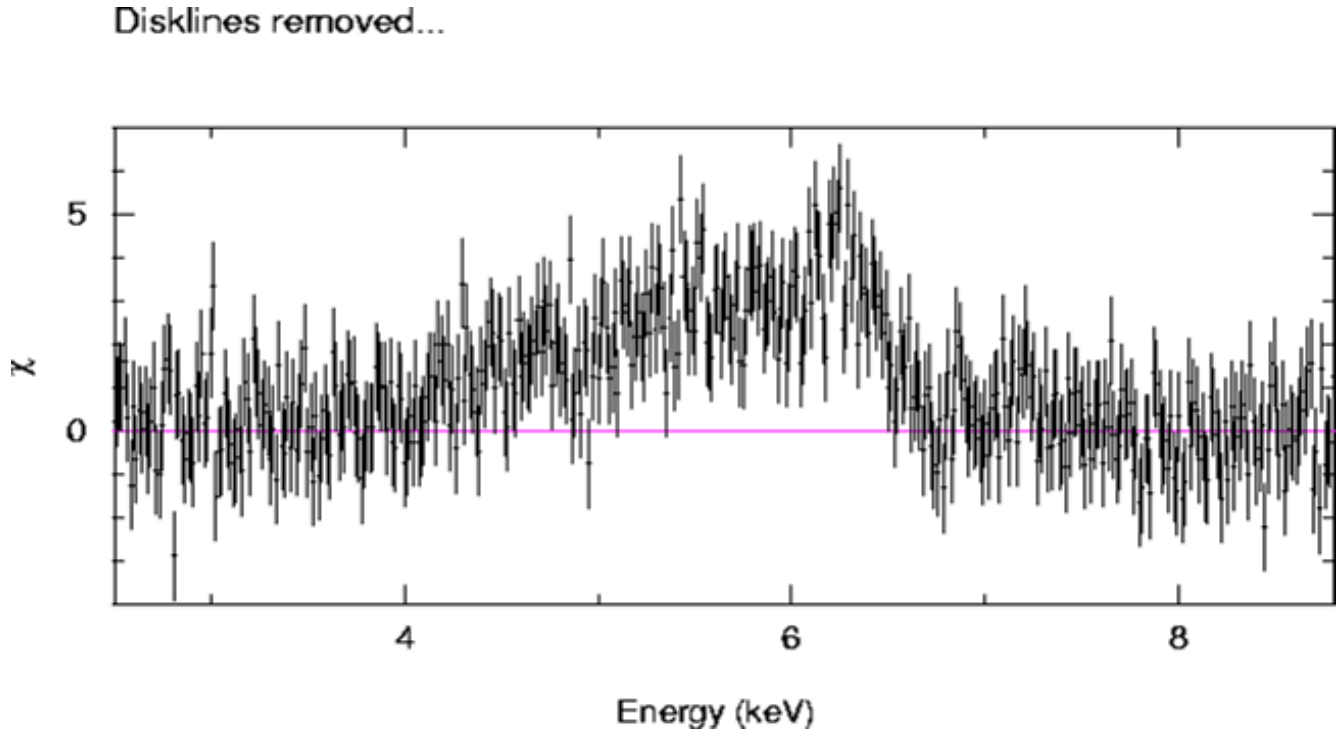
E_o Kα = 6.05 ± 0.11 keV

R_{in} = 2 ±1 R_g

R_{out} = 400 R_g (fixed)

Incl *i* = 38 ± 5°

Broad Fe K Diskline is Required



EW_{Ka} = 185 ± 15 eV

$I_{K\alpha}$ = 1.62 ± 0.12 e-4 ph cm^{-2} s^{-1}

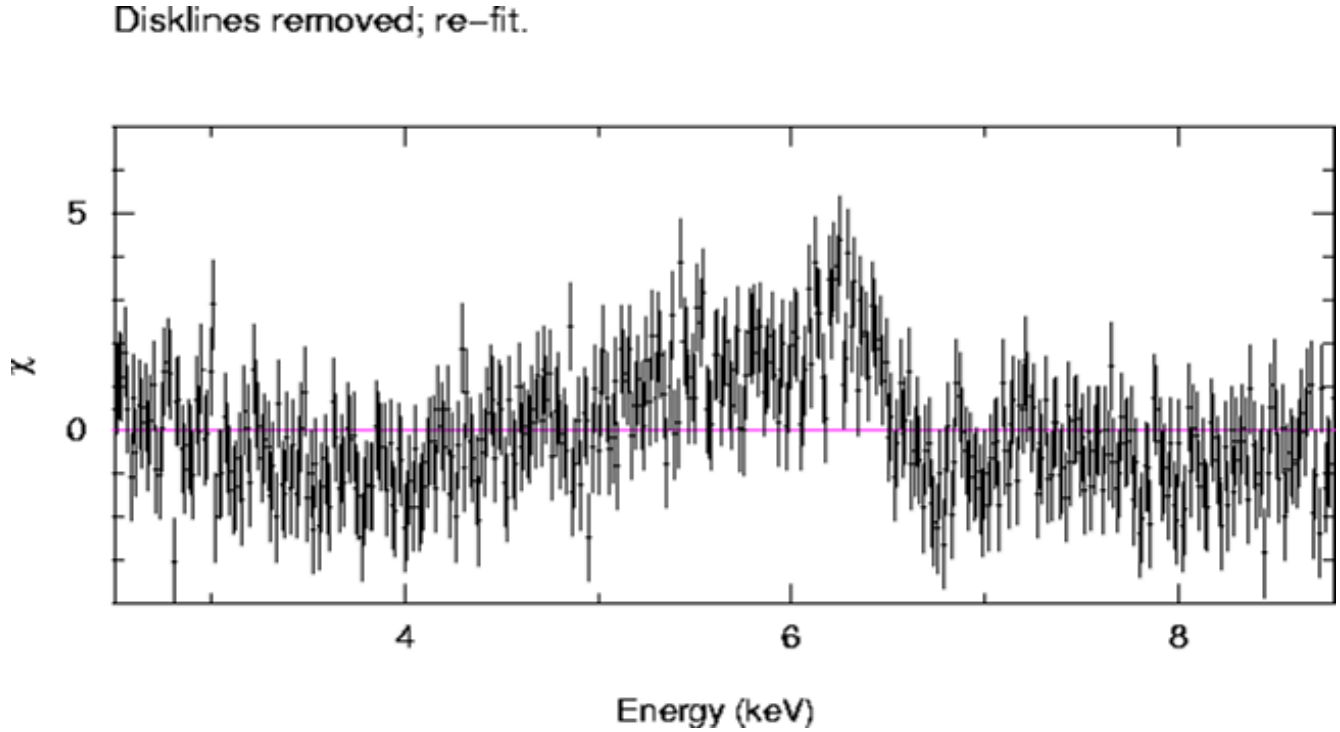
E_o Kα = 6.05 ± 0.11 keV

R_{in} = 2 ±1 R_g

R_{out} = 400 R_g (fixed)

Incl *i* = 38 ± 5°

Broad Fe K Diskline is Required



EW_{Ka} = 185 ± 15 eV

$I_{K\alpha}$ = 1.62 ± 0.12 e-4 ph cm^{-2} s^{-1}

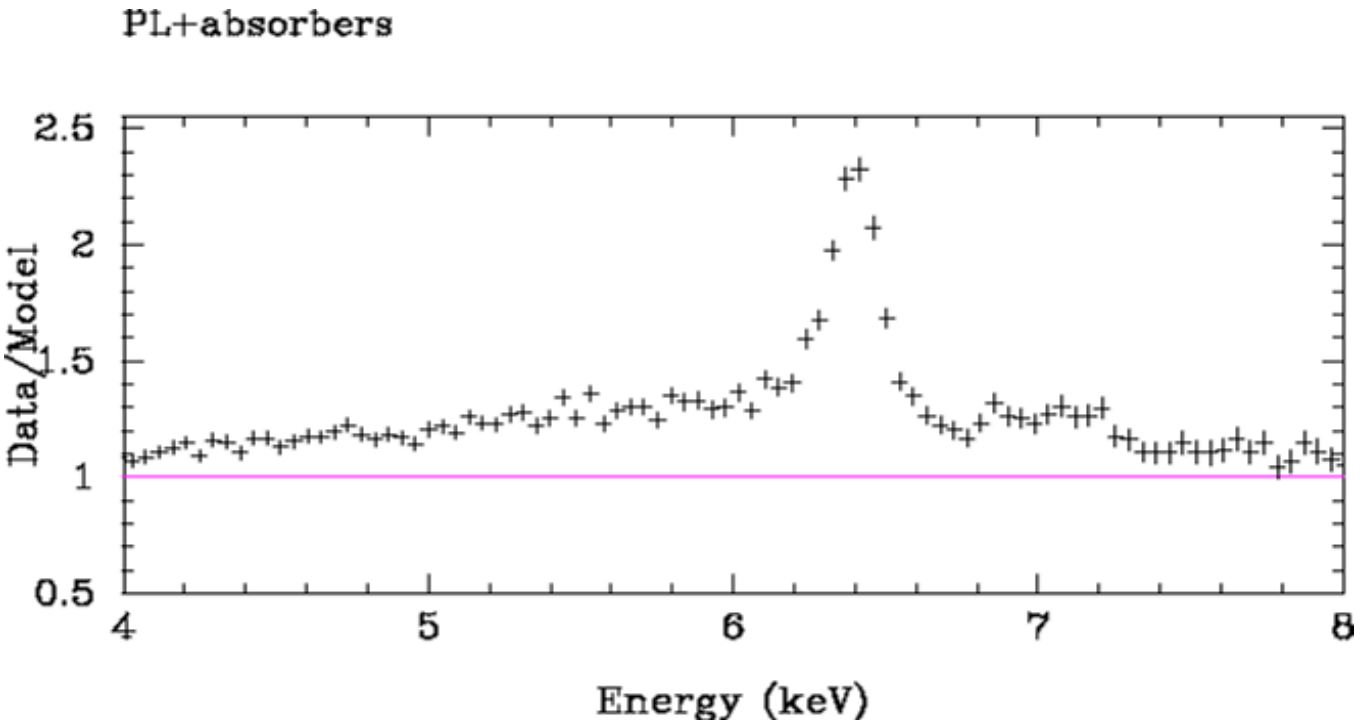
E_o Kα = 6.05 ± 0.11 keV

R_{in} = 2 ±1 R_g

R_{out} = 400 R_g (fixed)

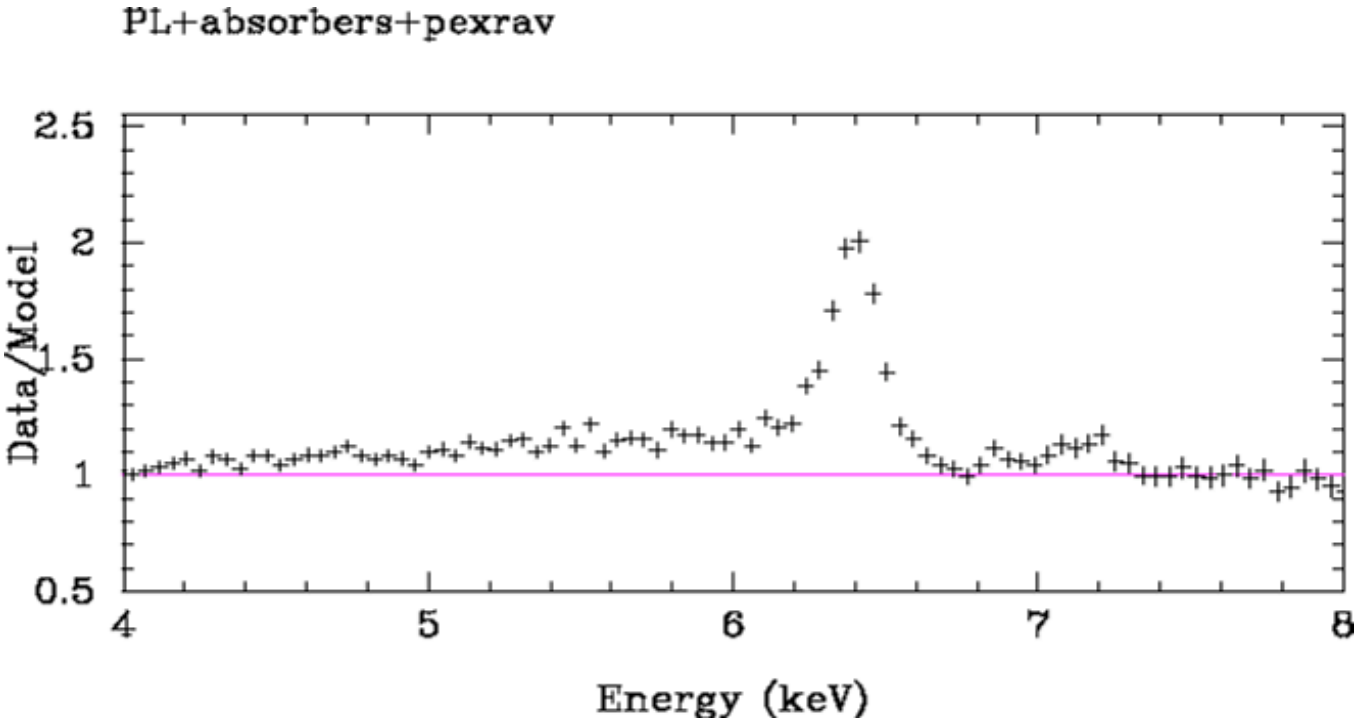
Incl *i* = 38 ± 5°

Fe K Band

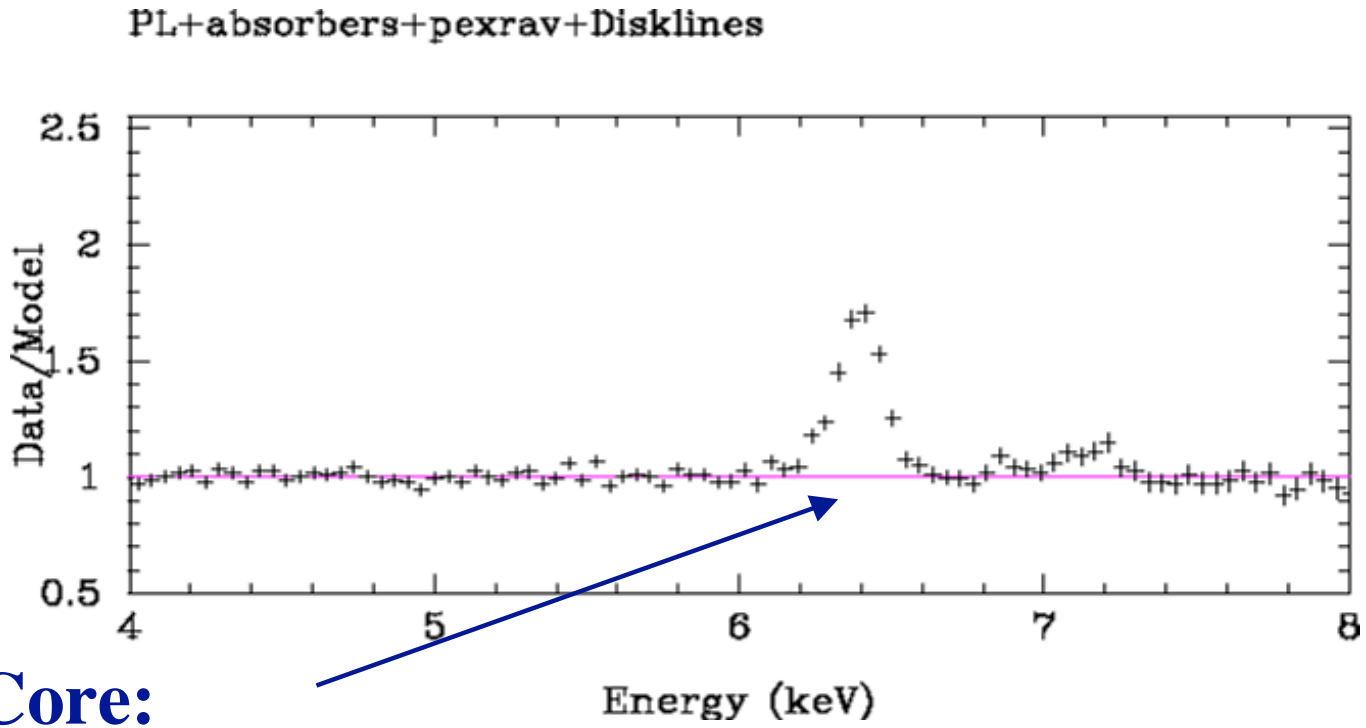


(Residuals to models fit to XIS-FI spectrum)

Fe K Band



Fe K Band

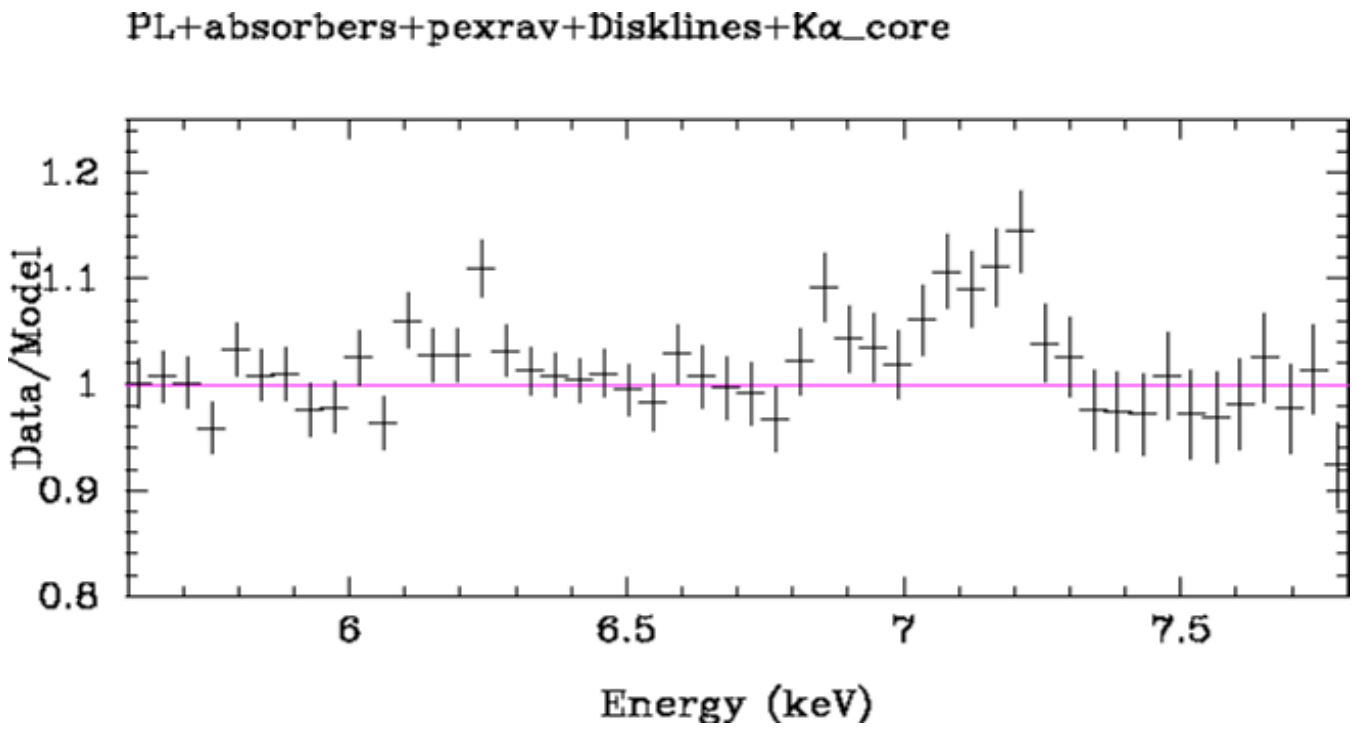


Fe Kα Core:

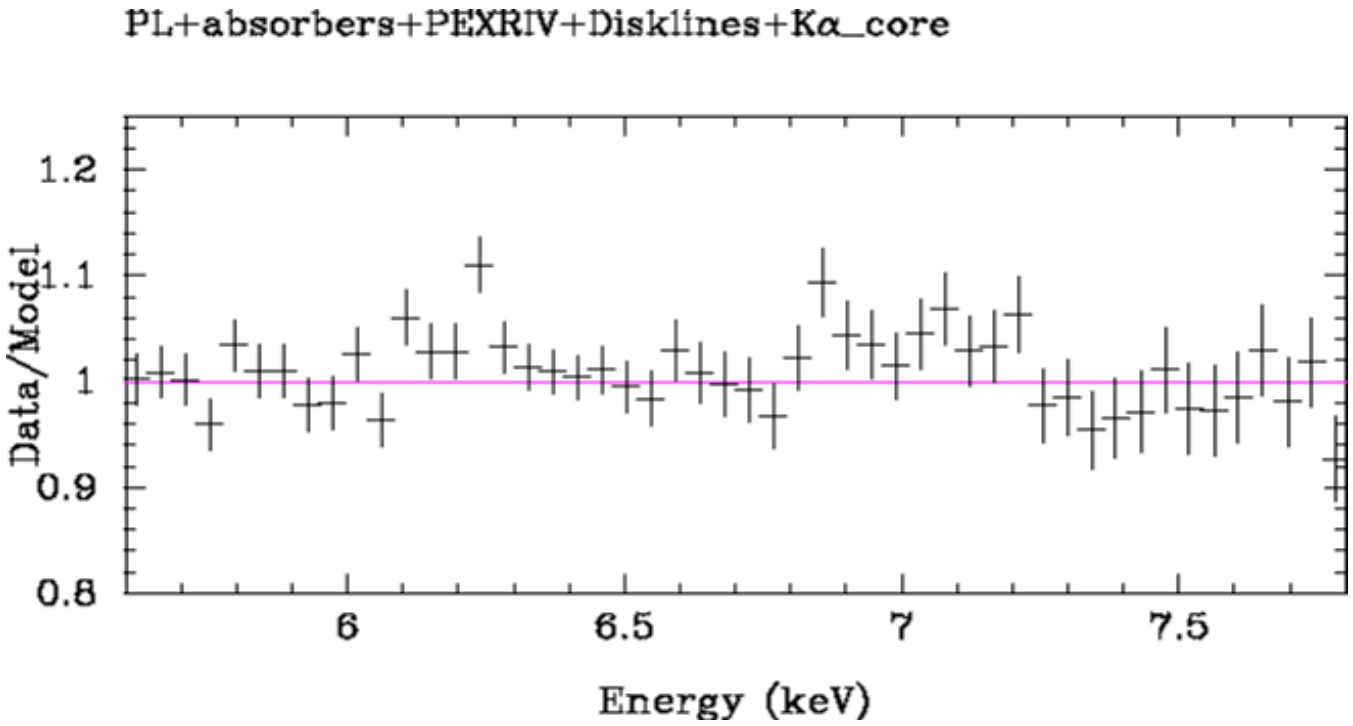
$E_o = 6.404 \pm 0.006$ keV

EW = 46 ± 2 eV

Fe K Band


PL+absorbers+pexrav+Disklines+Kα_core
Data/Model
1.2
1.1
1
0.9
0.8
6
6.5
7
7.5
Energy (keV)

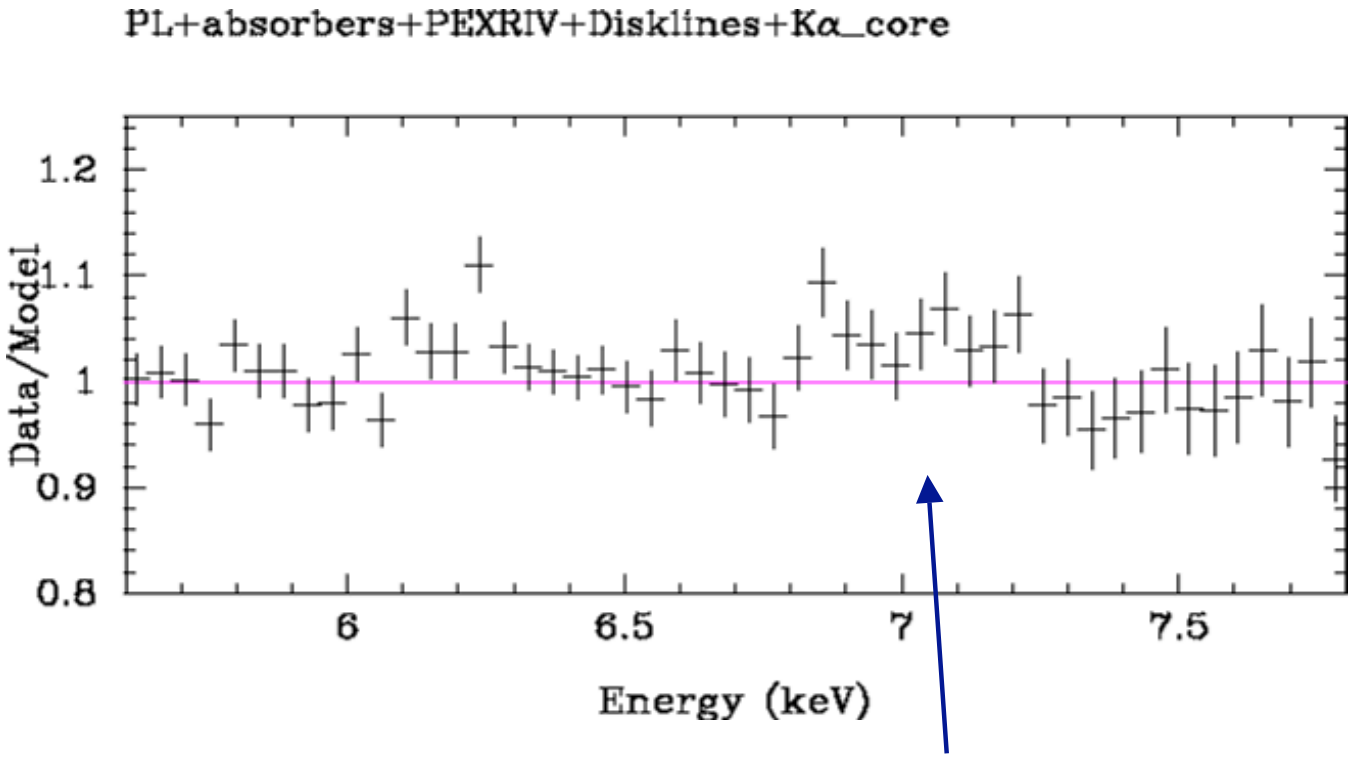
Fe K Band



Ionized Reflector?: Fe K edge at 7.32 ± 0.06 keV

$\xi = 0.054^{+0.028}_{-0.047}$ erg cm s^{-1}

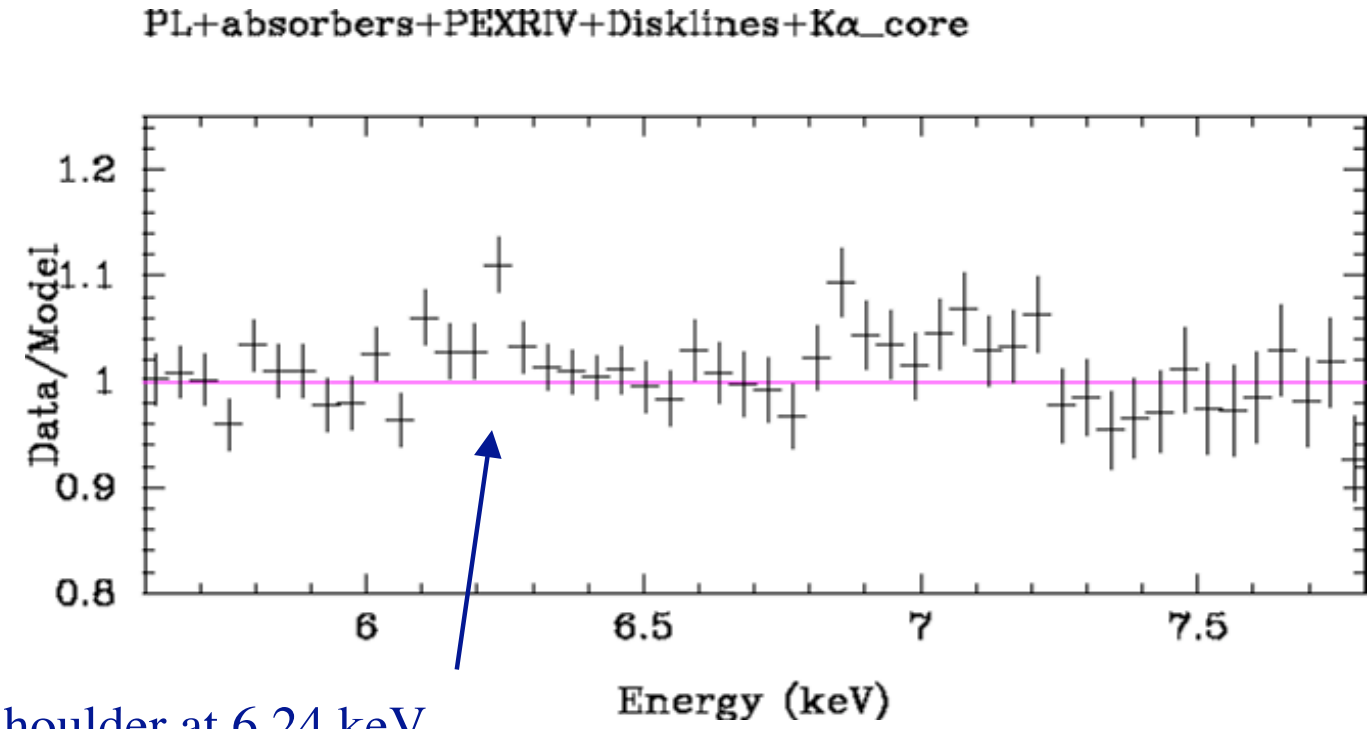
Fe K Band



Narrow Kβ line added at 7.06 keV

Significant at 98% in F-test

Fe K Band

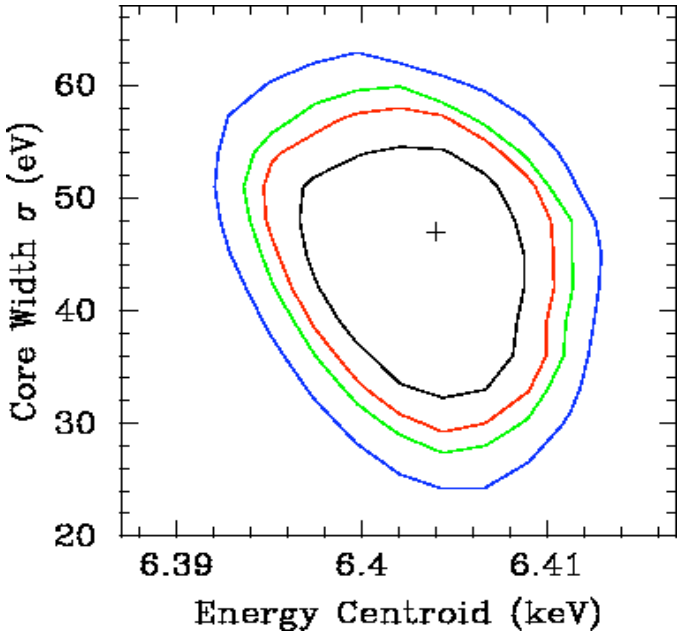


Compton Shoulder at 6.24 keV

Significant at >99.9% in F-test

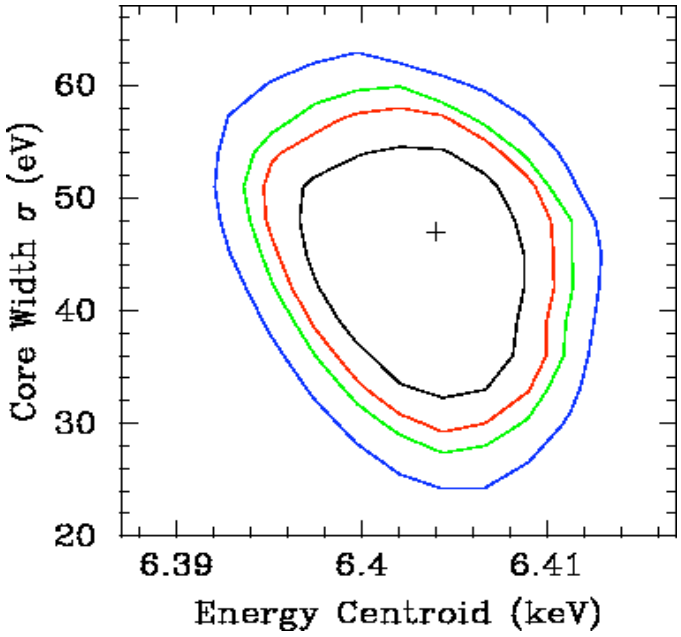
$EQW_{CS} = 1.8 \pm 1.1$ eV … $EQW_{CS}/EQW_{core} = 0.04 \pm 0.03$

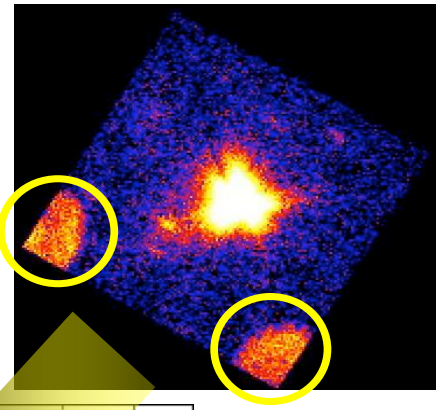
Fe Kα Core Properties



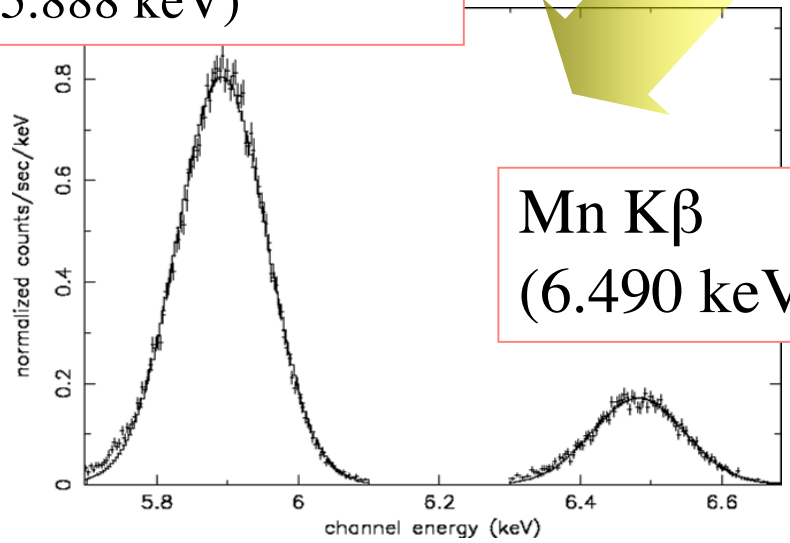
- σ(measured) = 47 ± 11 eV

Fe Kα Core Properties





Mn $K\alpha_{1\ \&\ 2}$ (5.899 keV & 5.888 keV)

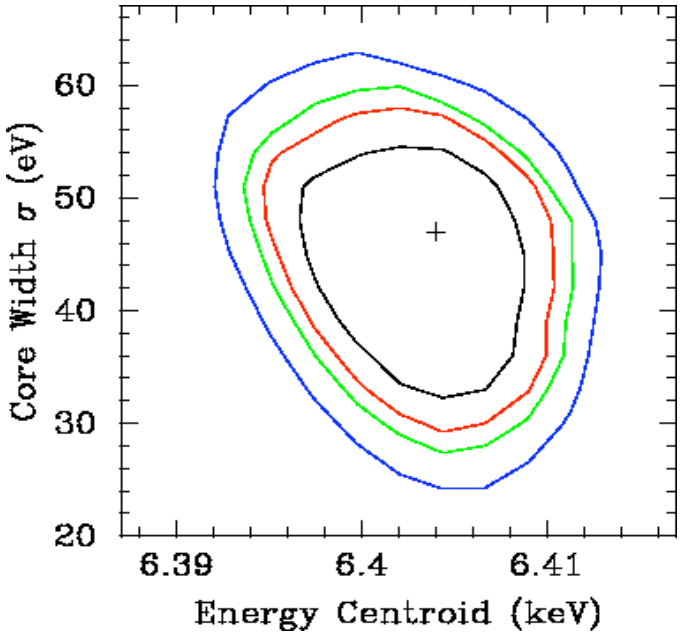


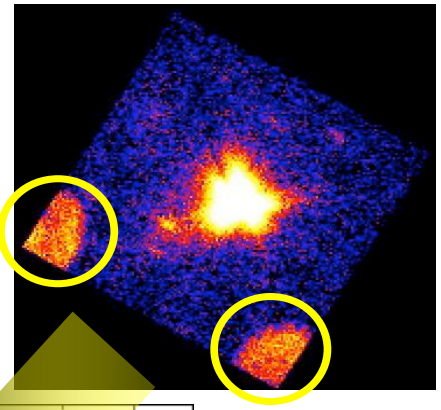
Mn Kβ (6.490 keV)

σ_{cal} = 30 ± 1 eV: Fe Core is resolved!

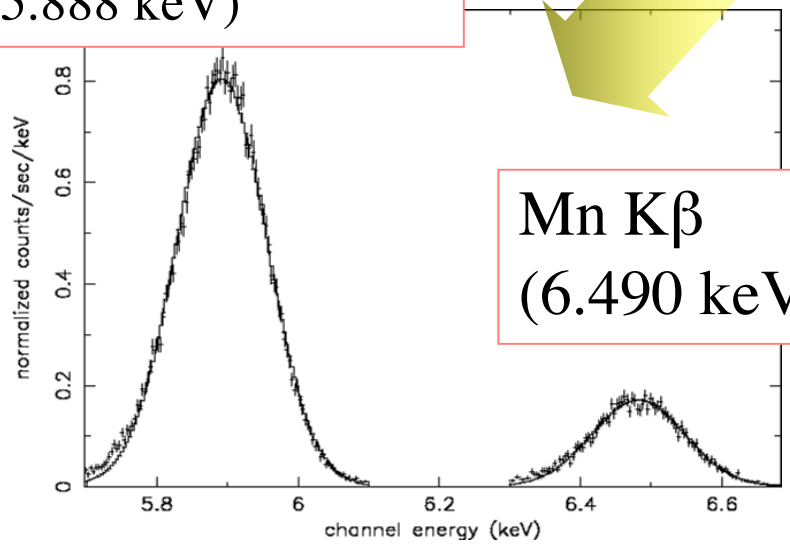
- σ(measured) = 47 ± 11 eV

Fe Kα Core Properties





Mn $K\alpha_{1\ \&\ 2}$ (5.899 keV & 5.888 keV)

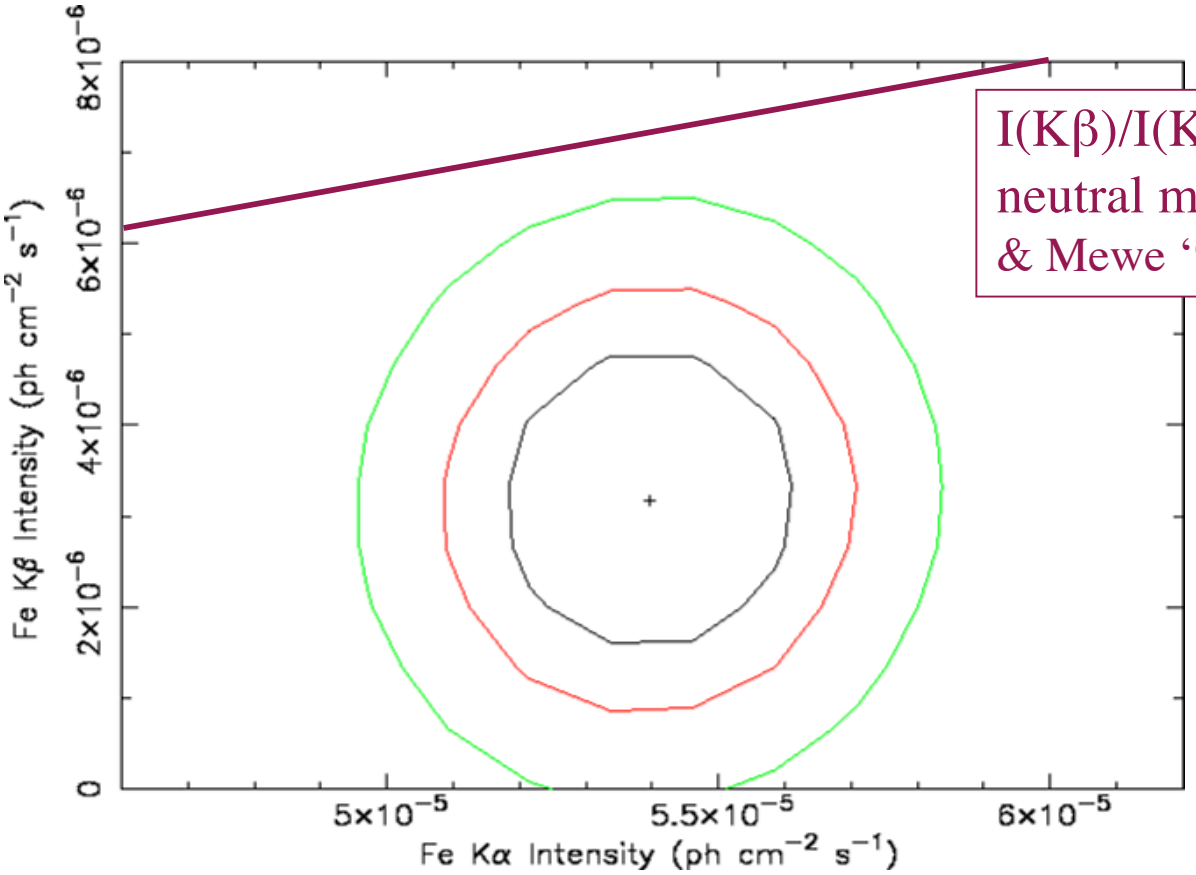


Mn Kβ (6.490 keV)

σ_{cal} = 30 ± 1 eV: Fe Core is resolved!

- σ(measured) = 47 ± 11 eV → σ (intrinsic) = 36^{+14}_{-18} eV
- **FWHM velocity = 3800^{+1500}_{-1900} km s^{-1}** ***(BLR velocities)***
- Consistent with Chandra HETGS value (Yaqoob & Padmanabhan 2004)

Fe Kα/Kβ Core Intensities



I(Kβ)/I(Kα) = 0.134 for neutral material (Kaastra & Mewe '93)

Non-neutral origin? Or maybe there's a bit of narrow absorption from Fe XXVI present blending with the Kβ. Will investigate further….

Conclusions

•Suzaku has successfully disentangled broad Fe line & absorbing components in spectrum of NGC 3516

• Similar model fit to the 2001 XMM spectra: full-covering ionized absorption + partial covering (35%) absorber

•Ionized absorbing column is ~3x higher than in 2001; $F_{0.5\text{-}2.0}$ is ~2-3x weaker

•Scattered power-law emission (5% of nuclear continuum)

•Broad Fe K diskline (EW = 185 eV) is required in the Suzaku fit

•7.32 keV edge: evidence for ionized reflector?

•Fe Kα core is resolved: intrinsic FWHM velocity ~3800 km s^{-1} (consistent with BLR velocities)

•Detect Fe Kβ line and a Compton Shoulder at high significance