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Spectral analysis of MXB1728-34 with XMM-Newton

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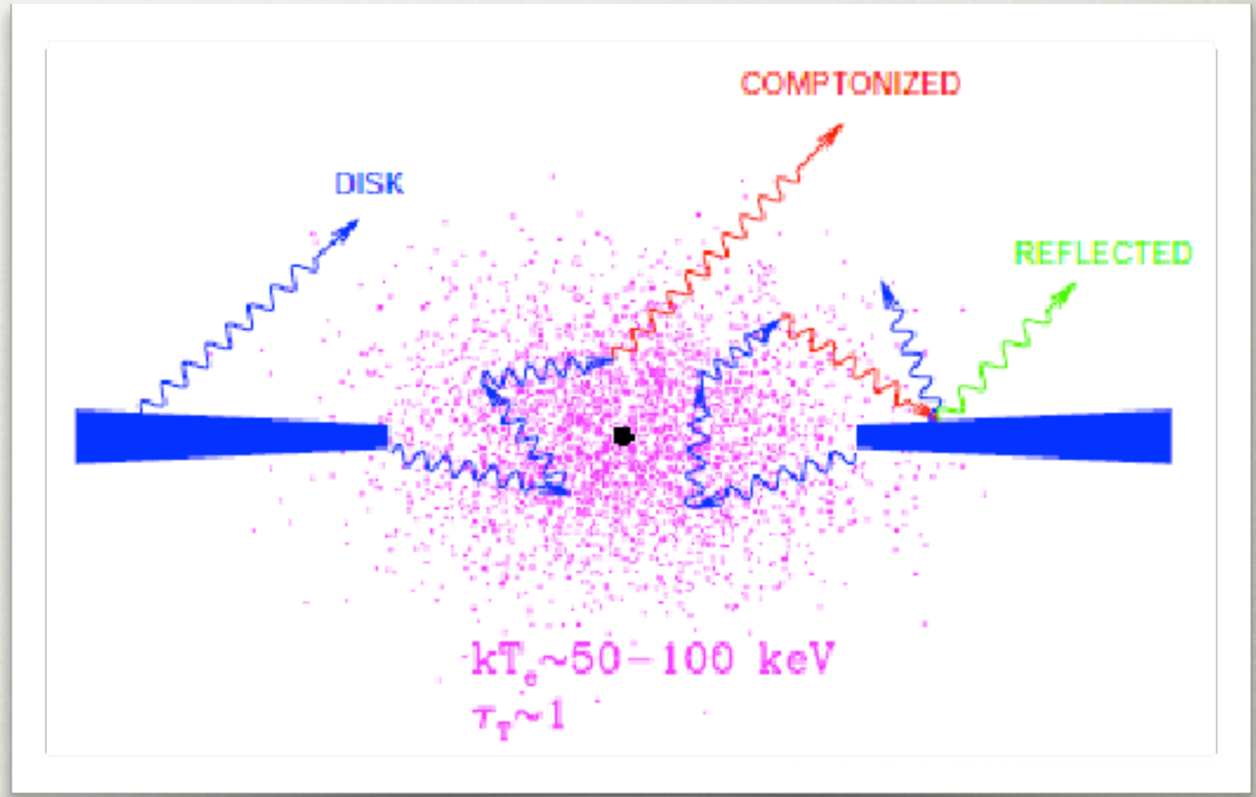
§ About the Iron Line §

- Broad iron line in the energy range 6.4 - 7.0 keV
- Could be produced from irradiation by hard X-rays of the cold matter (accretion disk)

=> reflection component



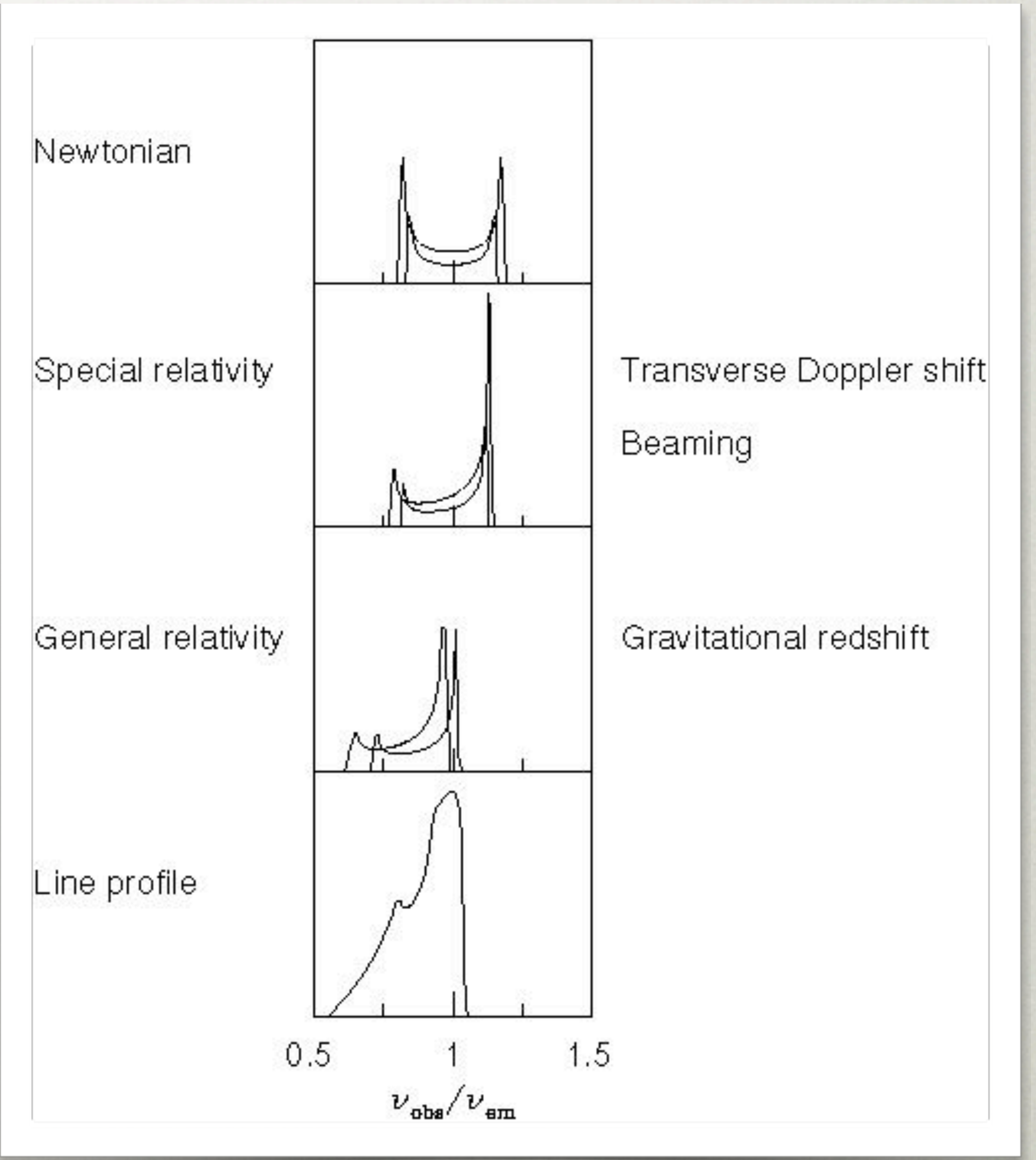
- Identified with Kalpha transition of iron at different ionization states

§ Profile of the line §

- Broad and asymmetric :

↓

- Doppler shifts
- Relativistic beaming
- Gravitational redshifting

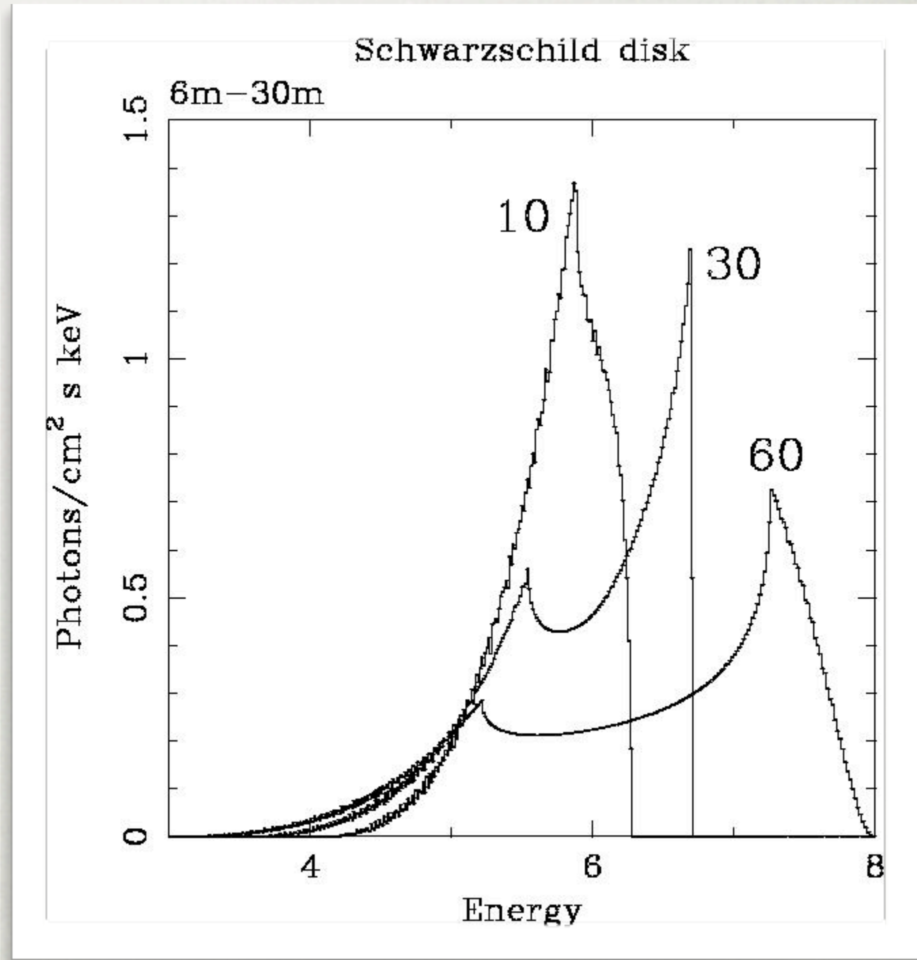


§ Useful Informations §

Determination of parameters of the accretion disk :

- Inner radius
- Outer radius
- Inclination of the system ⟶
- Ionization parameter :

$$\xi(r) = 4\pi F_X(r)/n(r)$$



II - MXB 1728-34

Caracteristics
Previous observations
Observation and Data reduction
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Discussion
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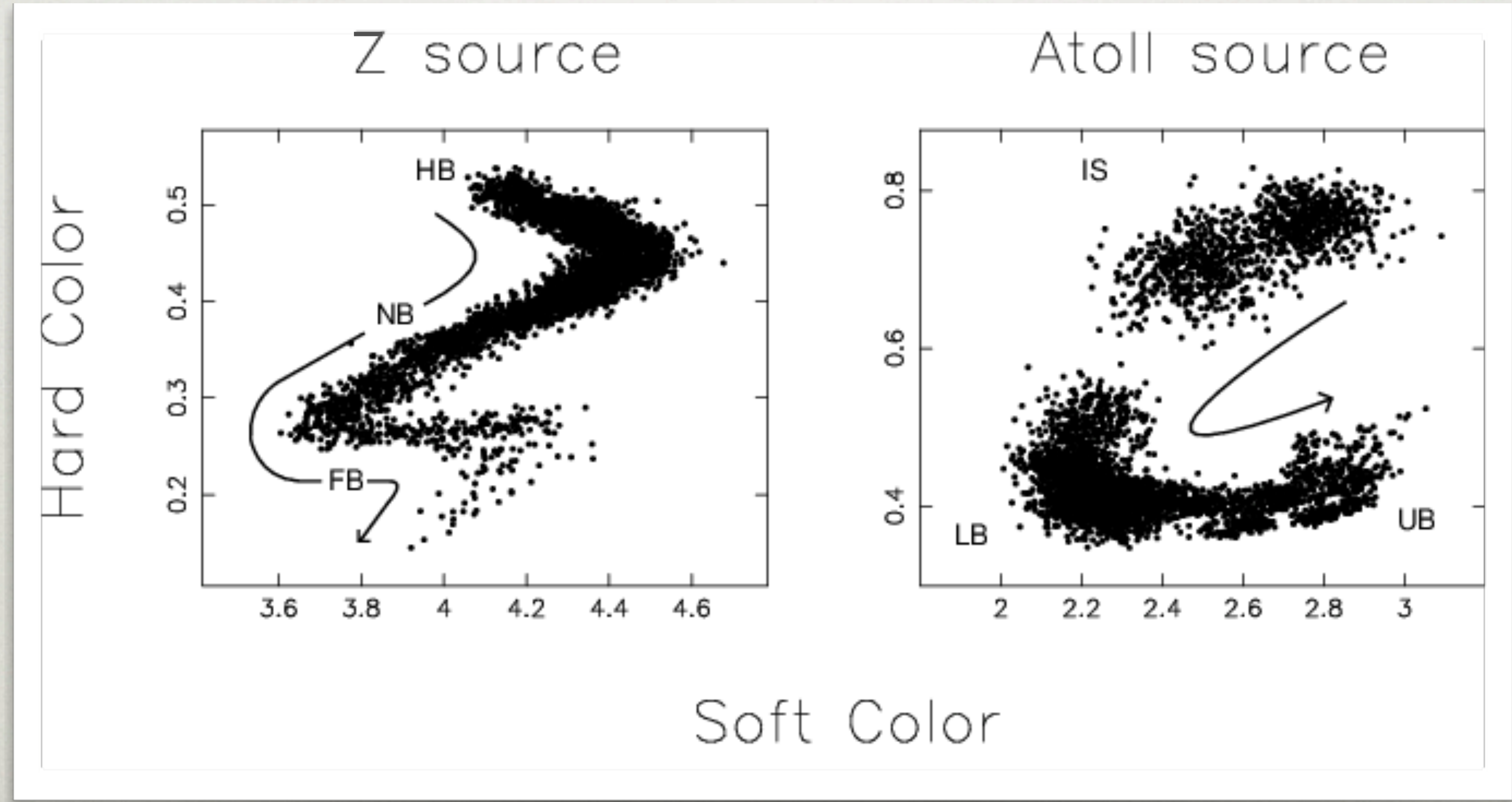
§ Caracteristics §

- LMXB containing a weakly magnetized neutron star
- Atoll class



§ Caracteristics §

- Optical counterpart unknown
- Frequent type I X-ray bursts
  => constrain the distance to the source (4.1<d< 5.1 kpc)
- Power spectrum :
  - Persistent emission : twin kHz QPOs with a frequence separation at ~350 Hz
  - During some bursts : nearly coherent oscillation at 363 Hz interpreted as the spin frequency of the NS

§ Previous observations §

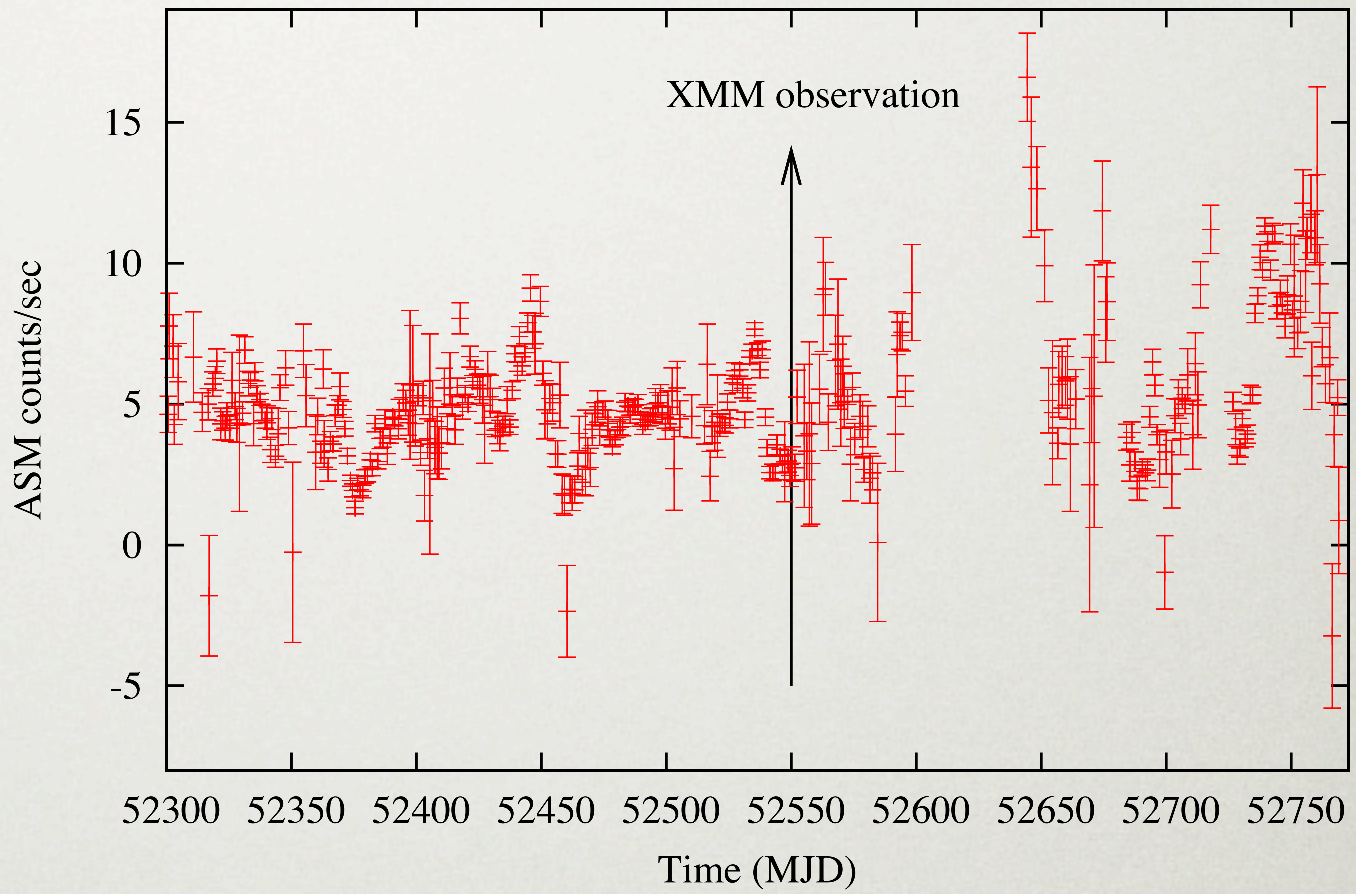
Reference	Satellite	E range (keV)	State source	Spectral param	Iron line
Grindlay et Hertz 1981	Einstein	1-20		thermal bremsstr. kT=18 keV	no
White et al. 1986	EXOSAT	2-16		bb + compt kT_e=7.8 keV	6.7 keV
Claret et al. 1994	SIGMA	30-200		thermal bremsstr. kT=38 keV	-
Narita et al. 2000	ASCA	1-10		compt kT_e=5.9 keV, t=7.8	6.4 keV, sig=1.3
Di Salvo et al. 2000	BeppoSAX	0.1-100	Soft State	bb + compt kT_e=10 keV, t=5	6.7 keV, sig=0.5
Piraino et al. 2006	BeppoSAX + RXTE	0.3-50	Soft State	bb + compt kT_e=3 keV, t=11	6.7 keV, sig=0.3
D'Aì et al. 2006	Chandra + RXTE	1.2-35	quite Hard State	bb + compt kT_e=7.4 keV, t=6.2	2 abs edges
Falanga et al. 2006	INTEGRAL	3-200	trans Int/Hard to Soft State	bb + compt HS: kT_e=35 keV, t=0.5 SS: kT_e=3 keV, t=5	no

§ Observation And Data reduction §

- Observed by XMM-Newton on 2002 October 3rd
- Observing time of 28 ks
- EPIC-pn, MOS1, MOS2, RGS1, RGS2
- OM not active

RXTE/ASM LIGHTCURVE :

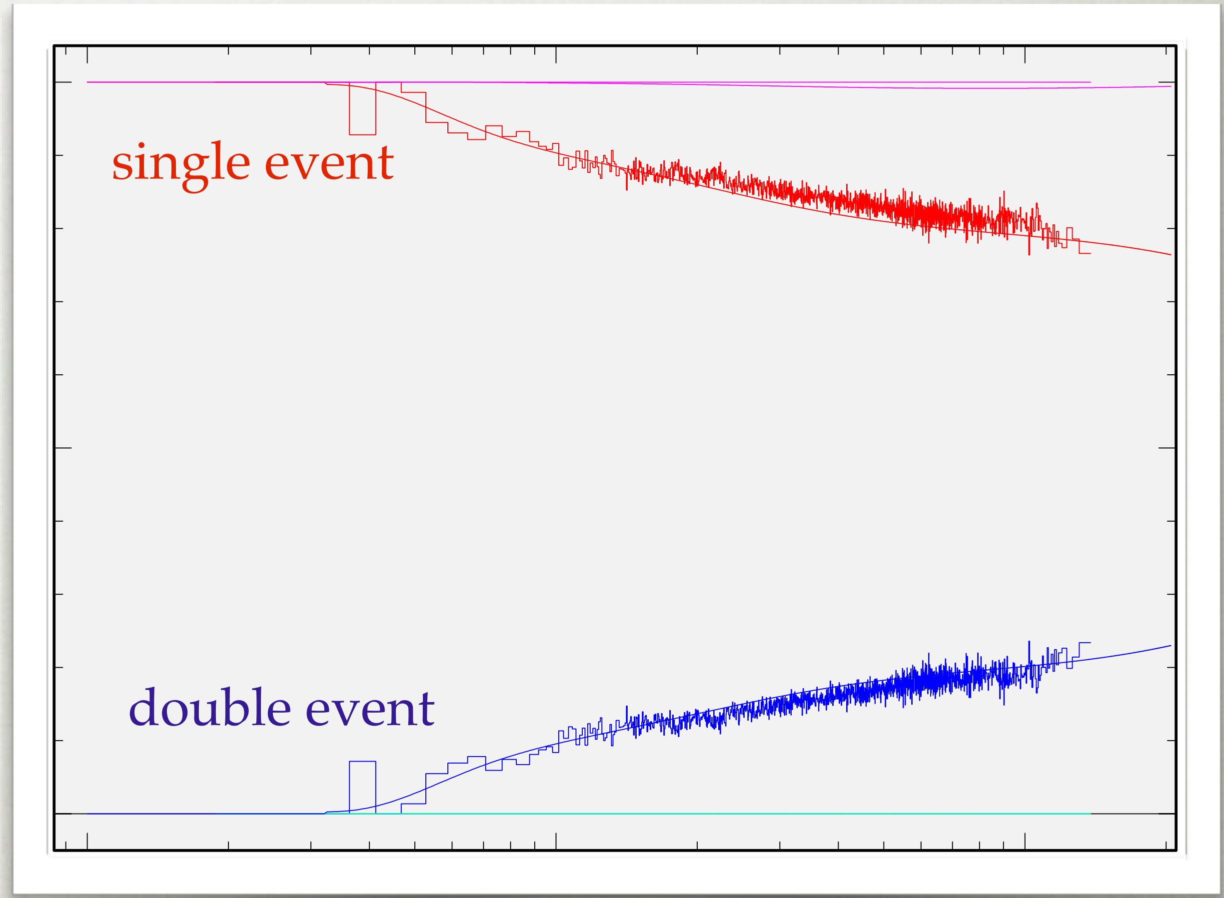
- 1.5-12 keV energy range
- Average count rate :
  3 counts/s



Not activity period while the XMM-Newton observation

Data reduction with SAS :

- EPIC-pn and MOS => Timing Mode
- No contamination from the background solar flares (lightcurve in 10-12 keV)
- Pile-up did not affect the data
  count rate : 110 counts/s << 800 counts/s



- RGS => Standard spectroscopy mode

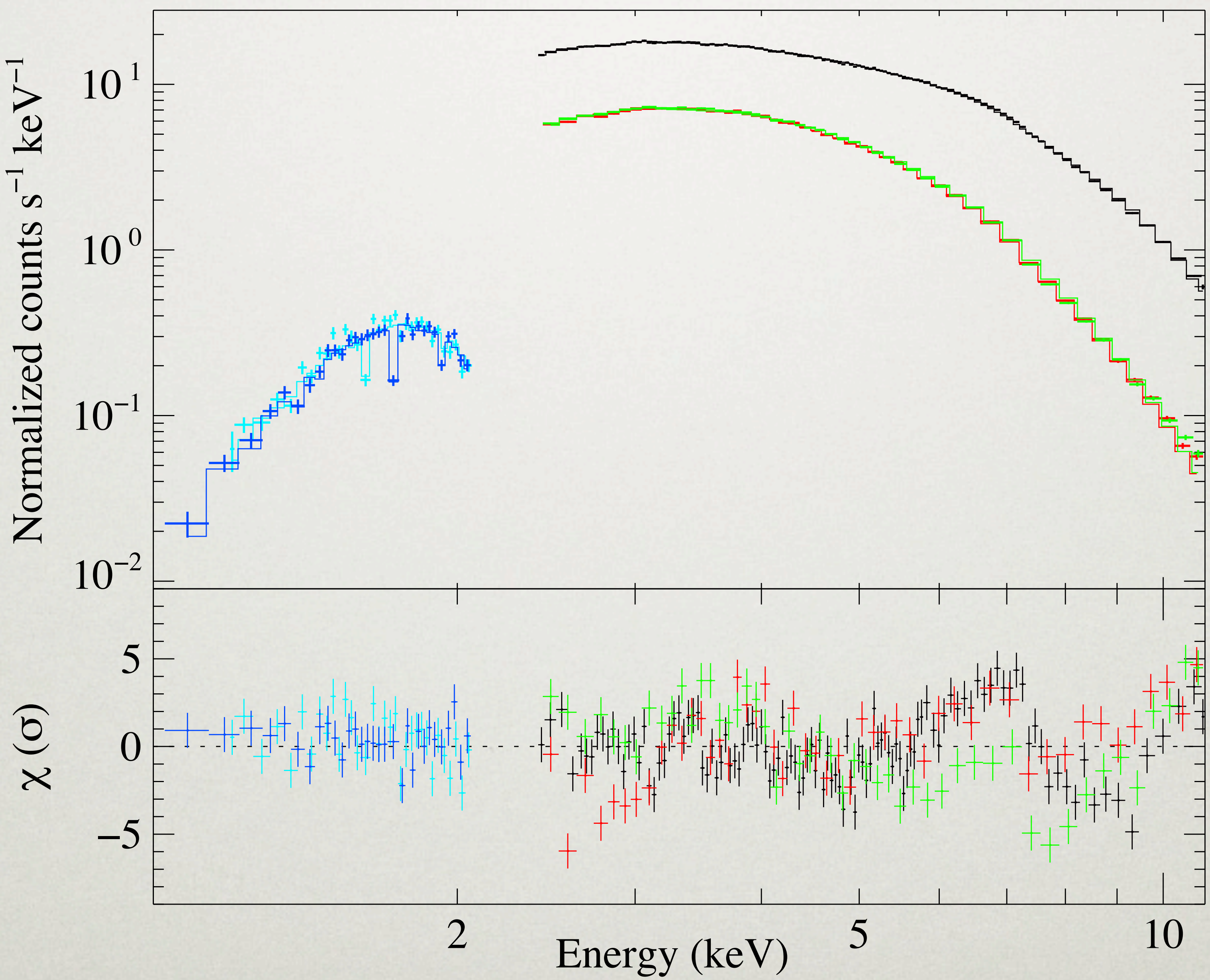
§ Spectral analysis §

- Data fitted with Xspec
- Simultaneous fit from all the 5 instruments
- Considering the best calibration ranges of the detectors :
  - EPIC-pn and MOS data in 2.4 - 11 keV
  - RGS between 1-2 keV
- Continuum :
  - Thermal Comptonized component : ***compTT*** modified at low energy by the interstellar photoelectric absorption modelled by ***phabs***.
  - Addition of a blackbody not statistically significant

Best fitting parameters of the continuum emission :

Parameter	**Value**
N_{H} ($\times 10^{22} cm^{-2}$)	2.4 ± 0.1
kT_{seed} (keV)	0.59 ± 0.02
kT_{e} (keV)	2.74 ± 0.04
τ	16.5 ± 0.2
Norm	9.54 ± 0.02
Flux 2.0−10.0 keV (pn)	8.06
Flux 2.0−10.0 keV (MOS)	8.17 (MOS1) - 8.07 (MOS2)
Flux 1.0−2.0 keV (RGS)	0.186 (RGS1) - 0.185 (RGS2)
Total χ^2 (d.o.f.)	1732 (903)

Data have been rebinned for graphical purposes



Different models to fit the excess in the residuals between 5.5-8 keV

- 1) Gaussian line at 6.6 keV
- 2) Diskline profile
- 3) Relativistically distorted line : Relline
- 4) Two absorption edges *(D'Aì et al. 2006)*
- 5) Reflection model : Reflion

Component	Parameter	Model 1: Gaussian	Model 2: Diskline	Model 3: Relline	Model 4: Two edges	Model 5: Reflection
edge	E edge (keV)	-	-	-	7.5 ± 0.1	-
edge	τ ($\times 10^{-2}$)	-	-	-	6 ± 1	-
edge	E edge (keV)	-	-	-	$8.49^{+0.09}_{-0.07}$	-
edge	τ ($\times 10^{-2}$)	-	-	-	6 ± 1	-
phabs	N_{H} ($\times 10^{22} cm^{-2}$)	2.2 ± 0.1	2.2 ± 0.1	2.2 ± 0.1	2.4 ± 0.1	2.7 ± 0.1
compTT	kT_{seed} (keV)	0.69 ± 0.02	$0.69^{+0.01}_{-0.02}$	0.68 ± 0.02	0.62 ± 0.02	-
compTT	kT_{e} (keV)	3.2 ± 0.1	3.3 ± 0.1	3.3 ± 0.1	3.1 ± 0.1	-
compTT	τ	$14.1^{+0.4}_{-0.5}$	$13.9^{+0.5}_{-0.3}$	$14.0^{+0.4}_{-0.2}$	15.2 ± 0.3	-
compTT	Norm ($\times 10^{-2}$)	7.6 ± 0.3	7.4 ± 0.3	$7.5^{+0.3}_{-0.4}$	8.3 ± 0.3	-
nthComp	Γ	-	-	-	-	$1.84^{+0.04}_{-0.01}$
nthComp	kT_{e} (keV)	-	-	-	-	$4.9^{+1.4}_{-0.7}$
nthComp	kT_{bb} (keV)	-	-	-	-	$0.71^{+0.03}_{-0.01}$
nthComp	Norm ($\times 10^{-2}$)	-	-	-	-	4.9 ± 0.2
Gauss	E (keV)	6.57 ± 0.05	-	-	-	-
Gauss	σ (keV)	0.6 (frozen)	-	-	-	-
Gauss	Norm ($\times 10^{-4}$)	8.8 ± 1	-	-	-	-
diskline	E (keV)	-	$6.45^{+0.05}_{-0.07}$	-	-	-
diskline	Betor	-	$(-2.8)^{+0.2}_{-0.3}$	-	-	-
diskline	R_{in} (GM/c^2)	-	18^{+3}_{-6}	-	-	-
diskline	R_{out} (GM/c^2)	-	1000 (frozen)	-	-	-
diskline	i (°)	-	60 (frozen)	-	-	-
relline	E (keV)	-	-	6.43 ± 0.07	-	-
relline	Index 1	-	-	$2.8^{+0.2}_{-0.1}$	-	-
relline	i (°)	-	-	60 (frozen)	-	-
relline	R_{in} (GM/c^2)	-	-	19^{+3}_{-4}	-	-
relline	R_{out} (GM/c^2)	-	-	1000 (frozen)	-	-
rdblur	Betor	-	-	-	-	-2.7 (frozen)
rdblur	R_{in} (GM/c^2)	-	-	-	-	20^{+29}_{-6}
rdblur	R_{out} (GM/c^2)	-	-	-	-	1000 (frozen)
rdblur	i (°)	-	-	-	-	> 44
reflion	Fe/Solar	-	-	-	-	1 (frozen)
reflion	Γ	-	-	-	-	$1.84^{+0.04}_{-0.01}$
reflion	ξ	-	-	-	-	660 (frozen)
reflion	Norm ($\times 10^{-6}$)	-	-	-	-	$2.2^{+0.5}_{-0.4}$
	Total χ^2 (d.o.f.)	1489 (901)	1463 (899)	1464 (899)	1519 (899)	1463 (900)

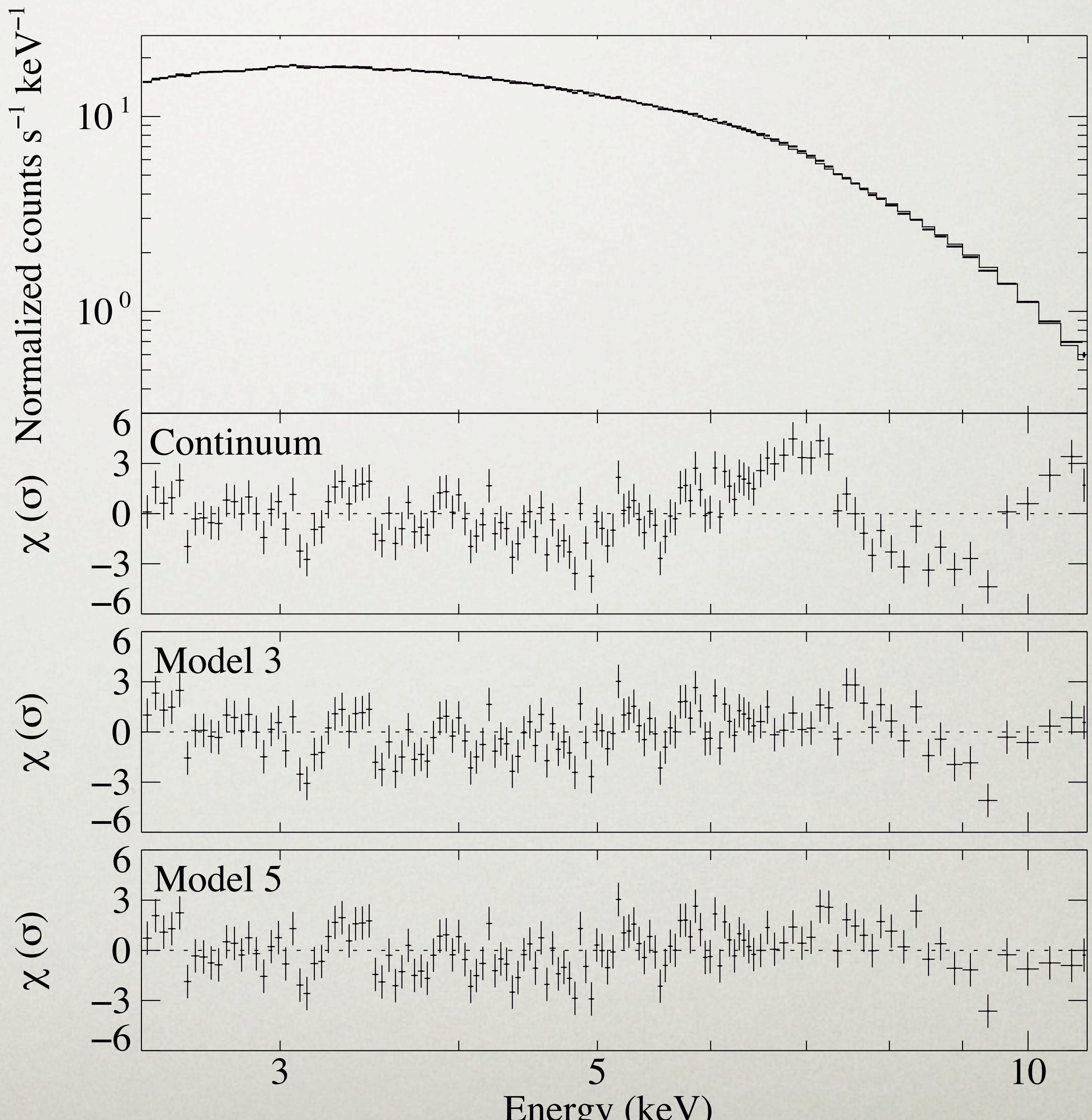
Comparison of the residuals

Relline

χ^2 (d.o.f.) = 1464 (899)

Reflion

χ^2 (d.o.f.) = 1463 (900)



§ Discussion §

- Best fit continuum model consists of an absorbed Comptonized component => inverse Compton scattering
- Evident residuals at 6-8 keV
- Fitted equally well fitted by either a relativistic line (diskline or relline) or a self-consistent relativistic reflection model

Diskline profile

- Line centroid energy at 6.45 keV compatible with a fluorescent Kalpha transition from mildly ionized iron
- Rin : 12-21 Rg
- Line profile broad and possibly asymmetric
  => Doppler and relativistic effects in the inner part of the accretion disk
  => coherent with disk-reflection scenario

Self consistent relativistic reflection model

- Reflection model + Relativistic smearing (broad line)

Model	χ^2 (d.o.f.)
Reflion	1555/901
Reflion + Rdblur	1466/899

=> Relativistic distorsions are required

- Inner radius consistent with that found using a diskline profile or a relativistic line, uncertainties higher : Rin = 13-43 Rg
- Considering a NS with M= 1.4 Msol, Rin = 25-100 Km
  => disk truncated quite far from the NS surface
- i > 44° => in agreement with the fact that the source does not show any dips in its lightcurve (i < 60°)

Two absorption edges

- Edges detected at 7.5 and 8.5 keV
  => May be interpreted as moderately and highly ionized iron
  => Results compared to D'Ai et al. (2006) : 7.1 and 9 keV
- Fit not so good as with the previous models :

Model	χ^2 (d.o.f.)
2 abs edges	1519/899
Rel emission line	1464/899
Reflection	1463/900

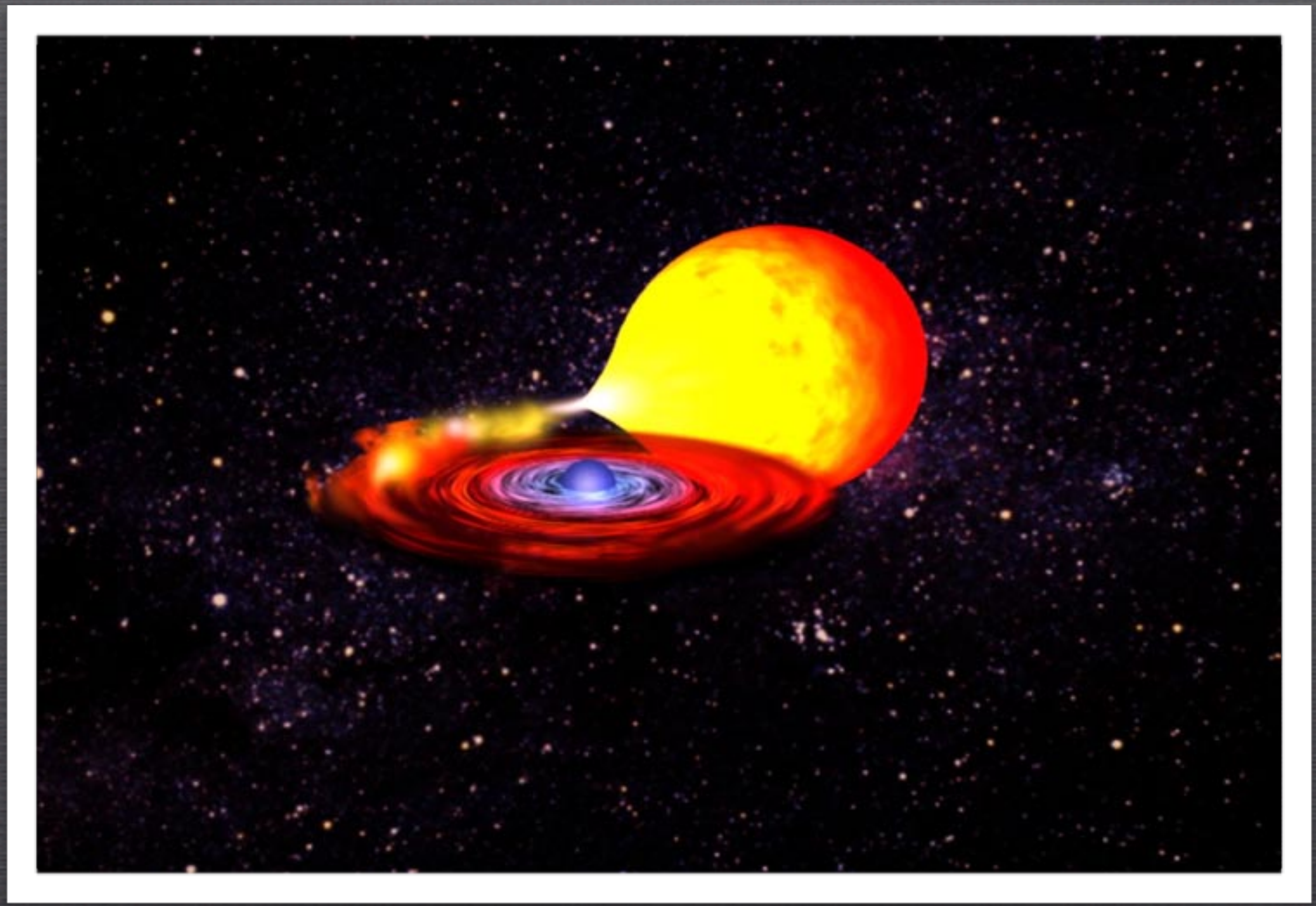
- We favor the interpretation of iron features as a broad emission line

About the blackbody component

- Usually required => accretion disk
- Not significantly detected => relatively low X-ray luminosity during the observation
- Component to weak to be detected => in agreement with the previous results
- disk truncated far from the NS

§ Comparison with 4U 1705-44 §

- D'Aì et al. (2010) : 4U 1705-44 -> source in hard state
- ASM count rate = 5 counts/s
- Broad line at ~6.4 keV => iron line in low ionization state
- 3 models : soft component (bb or multicolored disk emission)
  + reflection model (gaussian or refbb+rdblur)
  + Comptonized component
- Very soft disk emission, 20 Rg < Rin < 90 Rg
  => disk truncated at large distance from the compact object
- Line instrinsically broad, not asymmetric (low statistic & rel effects reduced if disk truncated at a large dist from the NS)
- Hot corona with high kTe and low optical depth around the NS



Thank you !