# *XMM-Newton* detection of relativistic Fe emission in the x-ray spectrum of SAX J1711.6-3808

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## SAX J1711.6-3808 some facts

X-ray transient in the Galactic Bulge serendipitously discovered by *BeppoSAX* WFC unit 1 on 2001 Feb.8.8-11.5 UT

Active in January-May 2001

Maximum $L_X$(1-200 keV) $5 \times 10^{-9}$ erg $cm^{-2}$ $s^{-1}$ (in 't Zand et al. 2002)
(25% $L_{Edd}$ for $M > 1.4\ M_{sun}$ @ Galactic Center distance)

Broad band spectrum (1-200 keV) characterized by a highly absorbed, power law cut off above 60 keV, plus a transient soft excess (in 't Zand et al. 2002)

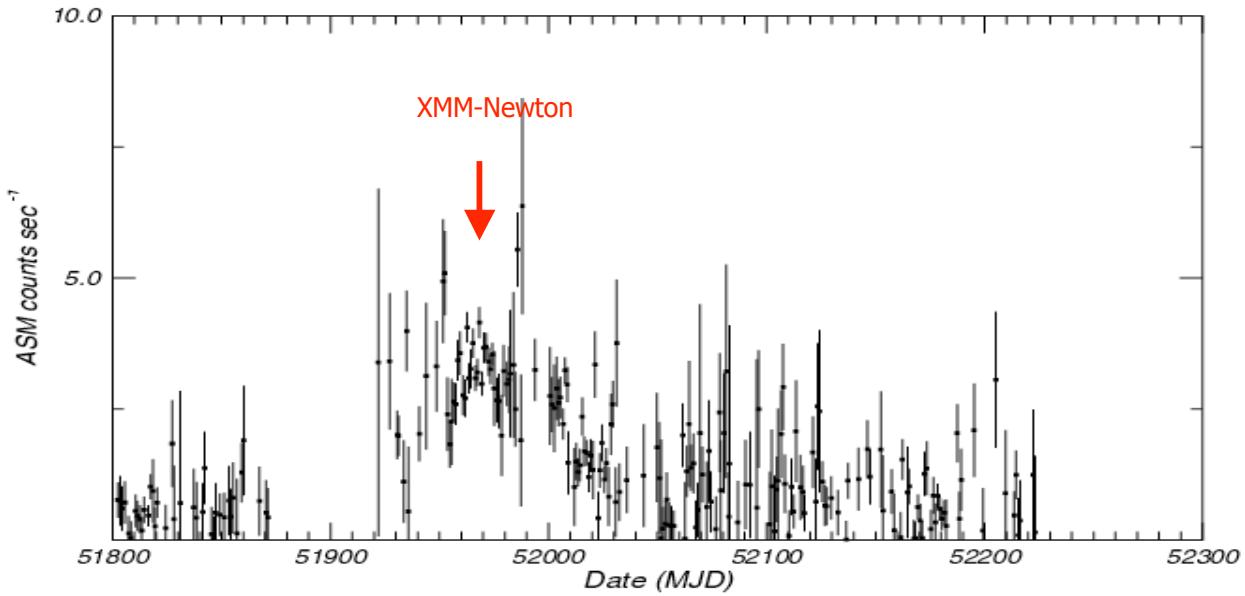
Broad emission feature at the Fe-K line complex energy (in 't Zand et al. 2002)

Spectral/timing properties well correlated, but decoupled from system X-ray luminosity (Wijnands & Miller, 2002)

Black hole candidate (lack of type-I X-ray bursts and coherent oscillations and detection of Fe emission)

# SAX J1711.6-3808: light curve

One-day average RXTE/ASM l. curve (1.5 -12 keV) from ASM public archive



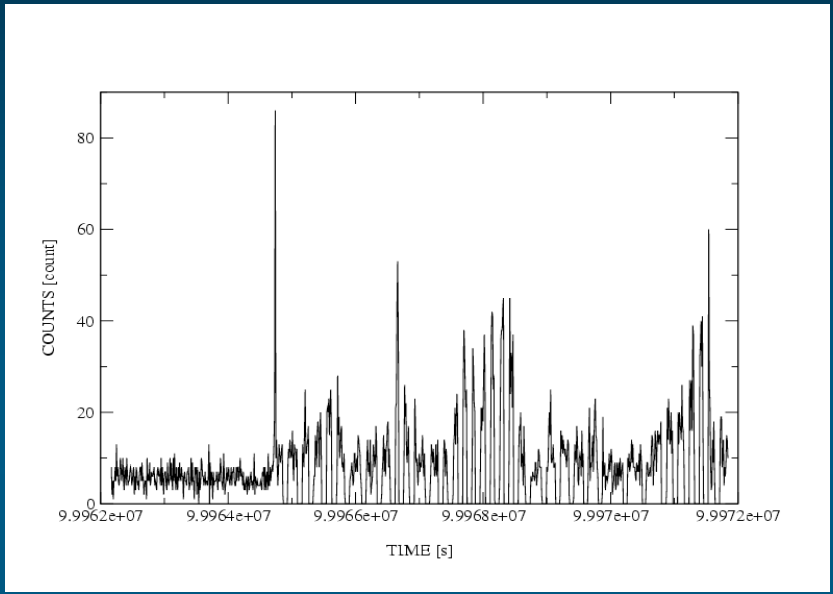
## XMM-Newton observations

SAX J1711.6-3808 observed during XMM-Newton revolution #225 (TOO-like obs)
March 2nd 2001@ 22:23:43-March 3rd 2001@ 02:06:30

- Aimed for largest detection area due to source position uncertainties (~1.2')

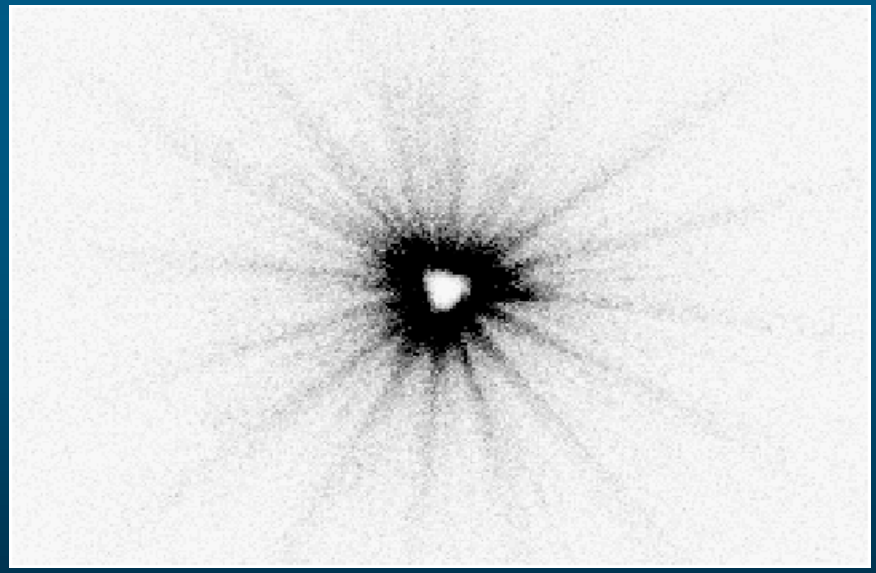
| Instrument | mode | Filter | Exp. (s) |
|---|---|---|---|
| **EPIC-pn** | Full Frame | Thin | 9748 |
| **EPIC-MOS1** | Timing | Thin | 11544 |
| **EPIC-MOS2** | Full Frame | Thin | 12394 |
| **RGS1** | Spectr | - | 12954 |
| **RGS2** | Spectr | - | 12954 |
| **OM** | Imaging | B | 4900 |
| **OM** | imaging | V | 4900 |

# BUT:




*High background...*

*Pile-up...*



# SO: effective exposure times significantly diminised....

| Instrument | mode | Filter | Exp. (s) | | Eff.Exp. (s) |
|---|---|---|---|---|---|
| **EPIC-pn** | Full Frame | Thin | 9748 | High background | 2416 |
| **EPIC-MOS1** | Timing | Thin | 11544 | Out of scwin | - |
| **EPIC-MOS2** | Full Frame | Thin | 12394 | Piled-up | - |
| **RGS1** | Spectr | - | 12954 | High background | 7573 |
| **RGS2** | Spectr | - | 12954 | High background | 7425 |
| **OM** | Imaging | B | 4900 | Out of main scwin | 980 |
| **OM** | imaging | V | 4900 | Out of main scwin | 980 |

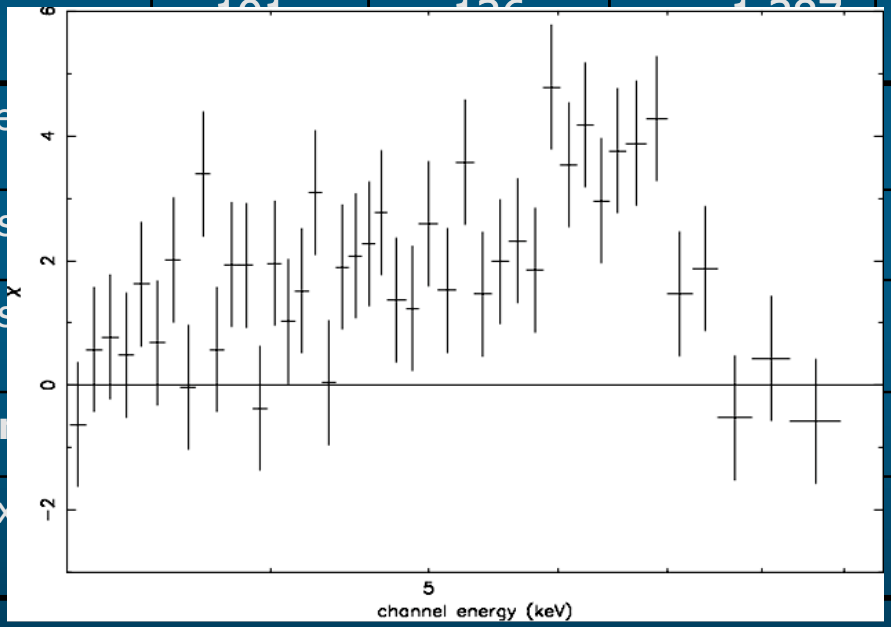
## EPIC-pn data reduction and spectrum extraction

- **Standard data reduction using XMM-Newton SAS V6.0**
- **Special treatment to minimize pile-up effects on our data:**
  - * Excision of psf core ($R_{inn}$ ~16 ") ~20 % of the psf still valid for analysis
    BUT: ***Count rate 15.44 counts/sec***
  - * Only pattern 0 events are considered
  - * Response matrices adequate for source off-axis position
  - * Ancilliary response matrices apropiate for spectrum in annulus
- **Data analyzed with XSPEC version 11.3.0**

# Spectral analysis:

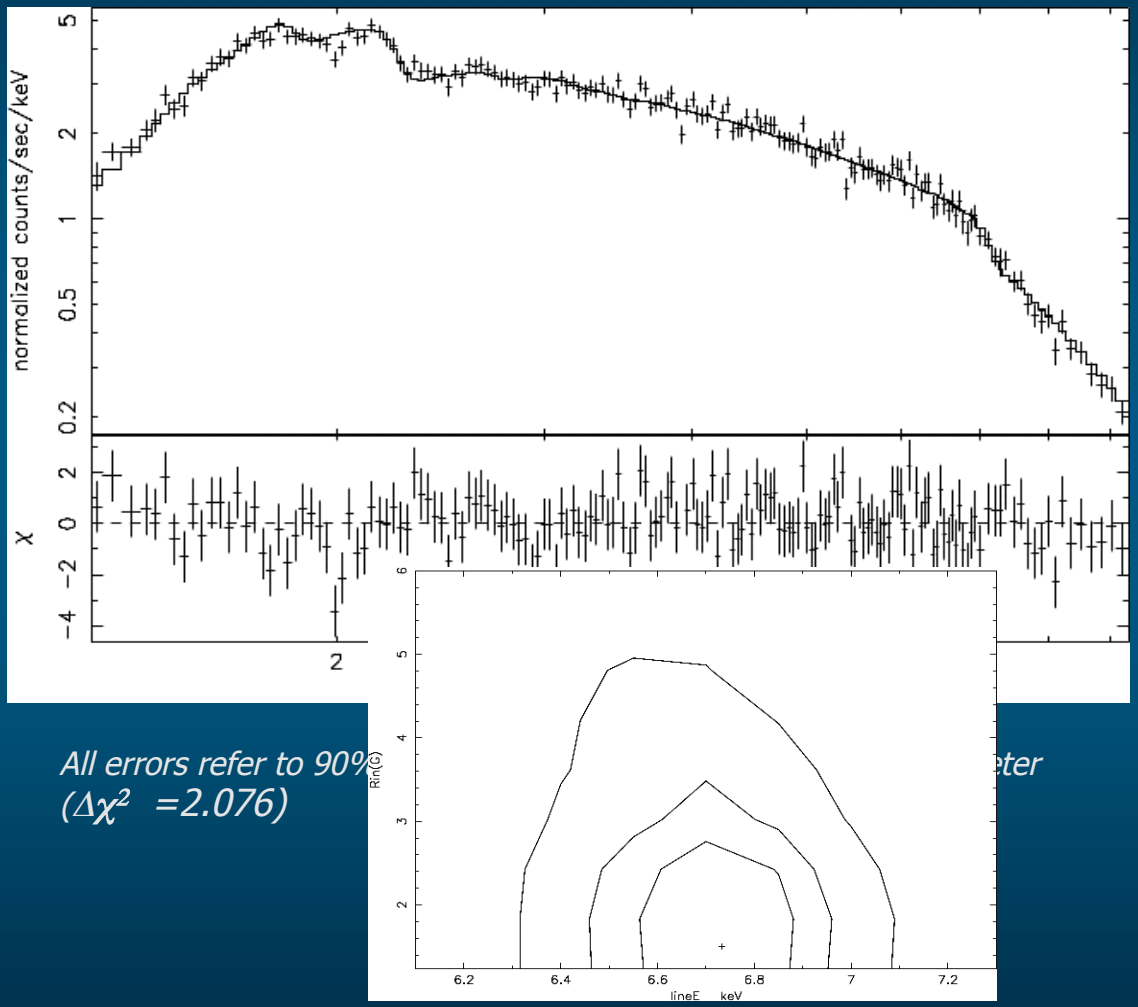
- Spectrum highly absorbed below ~1keV $N_H$ ($2.44*10^{22}$ $cm^{-2}$)

| Model | $\chi^2$ | d.o.f. | $\chi^2$ /d.o.f. | Null hypothesys probability |
|---|---|---|---|---|
| Phabs x pow | | | | 1.1201E-4 |
| Phabs x pow x smedge | | | | 9.92E-2 |
| Phabs x ( pow + gauss | | | | 0.233E-2 |
| Phabs x ( pow + gauss smedge | | | | 0.169 |
| **Phabs x (pow + laor** | | | | **0.290** |
| Phabs x (pow + laor) x smedge | | | | 0.126 |



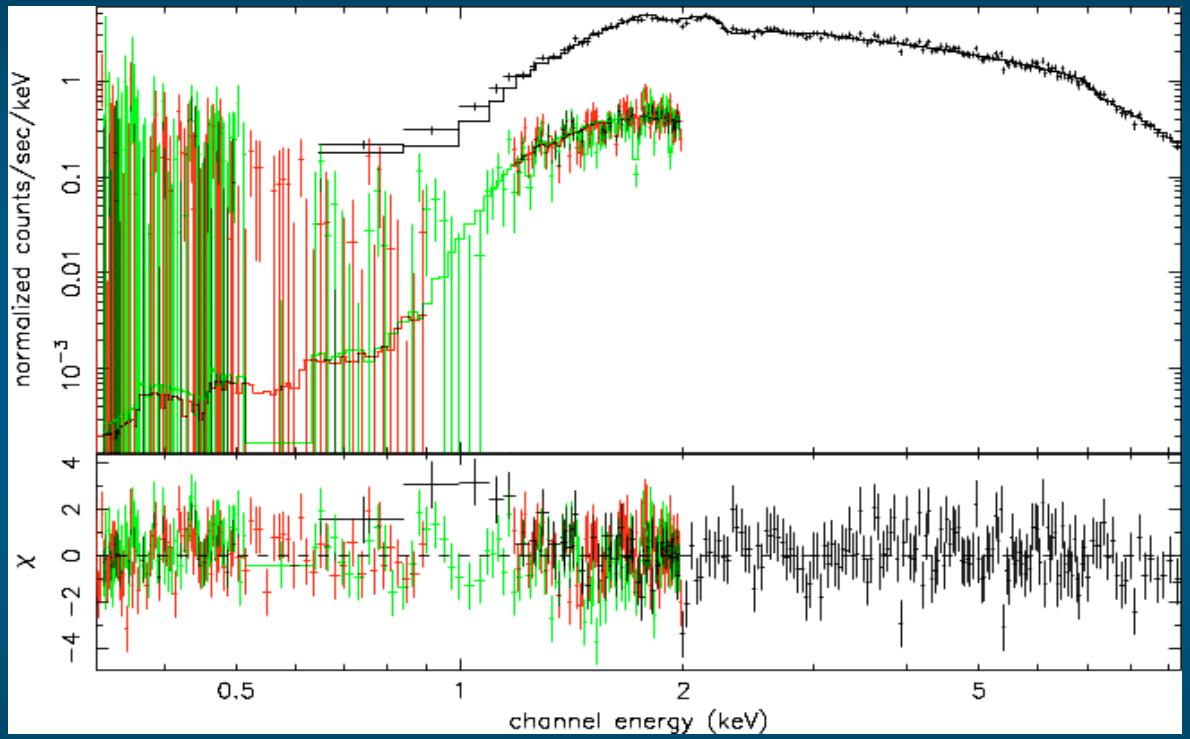
# Best fit parameters

| Fit Parameter | Best fit value |
|---|---|
| $N_H$ ($10^{22}$ cm$^{-2}$) | $2.44^{+0.07}_{-0.08}$ |
| $\Gamma$ | $1.64^{+0.04}_{-0.04}$ |
| Norm (phot/eV/cm$^2$/s @ 1 keV) | $0.20^{+0.01}_{-0.01}$ |
| E(Fe; keV) | $6.7^{+0.02}_{-0.02}$ |
| $R_{in}$ (Fe; $R_g = GM/c^2$) | $1.5^{+1.3}_{-0.3}$ |
| inclination (Fe; deg) | $31^{+4}_{-6}$ |
| Fe flux (x$10^{-3}$) (phot/cm$^2$/s in line) | $4.2^{+0.9}_{-0.9}$ |
| EW (eV) | 486 |
| $\chi^2_\nu$ | 1.064 (134 d.o.f.) |
| Null hyp. probability | 0.29 |




*All errors refer to 90% ($\Delta\chi^2$ =2.076)*

But: is there a disk close to the compact object???
Join fits with RGS




No clue….

# Conclusions

After (a painful) analysis XMM-Newton spectrum of SAX J1711.6-3808 was extracted.

The continuum of the source is highly absorbed and well described by a power law.

We have detected evidences of Fe K-$\alpha$ emission at an energy ~ 6.7 keV, probably due to FeXXV. The line is red-wards skewed, suggesting a Kerr black hole.

BUT: Where is the line originated??

- Is there a cool disk not detectable from our data?
Note that, recently, cool disks in low state have been detected, for example in GX 339-4 during the rising phase of the 2004 outburst (Miller et al 2006), in SWIFT 1753.5-0127 during the decay phase of the 2005-2006 outburst (Miller et al. 2006).

- If not, is the line broadened by Compton processes?

- Or (more exotic) is the origin of the line in a recessing ring of gas orbiting the black hole? (Schnittman et al. 2006)