



GRS 1915+105 and its spectral variability from the keV to the MeV band



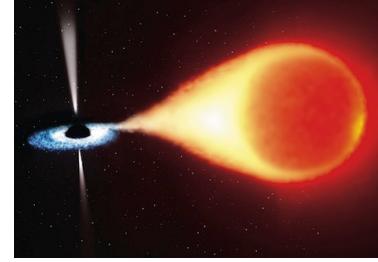
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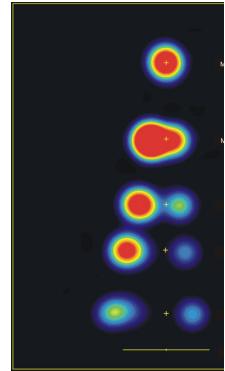
28th Texas Symposium
Genève, December 16, 2015

GRS 1915+105



What is it?

- Low Mass X-ray Binary (BH + K III) (Abubekerov+ 2006)
- $M_{BH} = 12.4^{+2.0}_{-1.8} M_{\odot}$ (Reid+ 2014).

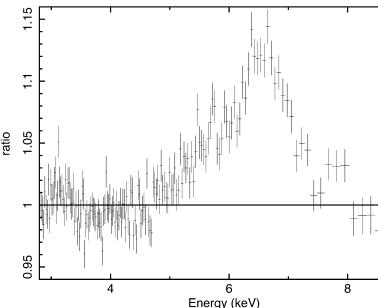


GRS 1915+105 = μ QSO with a superluminal motion of its jets

- a variable flow speed between 0.65c and 0.92c (Reid+ 2014)
- a jet inclination $\Theta = 60^\circ - 70^\circ$ (Mirabel & Rodriguez 1994).

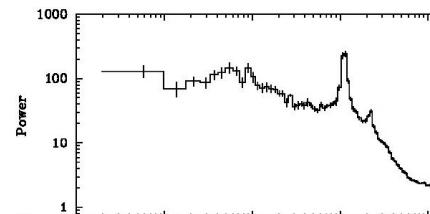
The spin parameter:

- $a/M_{BH} = 0.98^{+0.01}_{-0.01}$ (Blum+ 2009).



The object shows QPOs

- HFQPOs: 27, 34, 41, 63-71, 166 Hz (Belloni+ 2001, 2006, Strohmayer 2001, Belloni & Altamirano 2013).

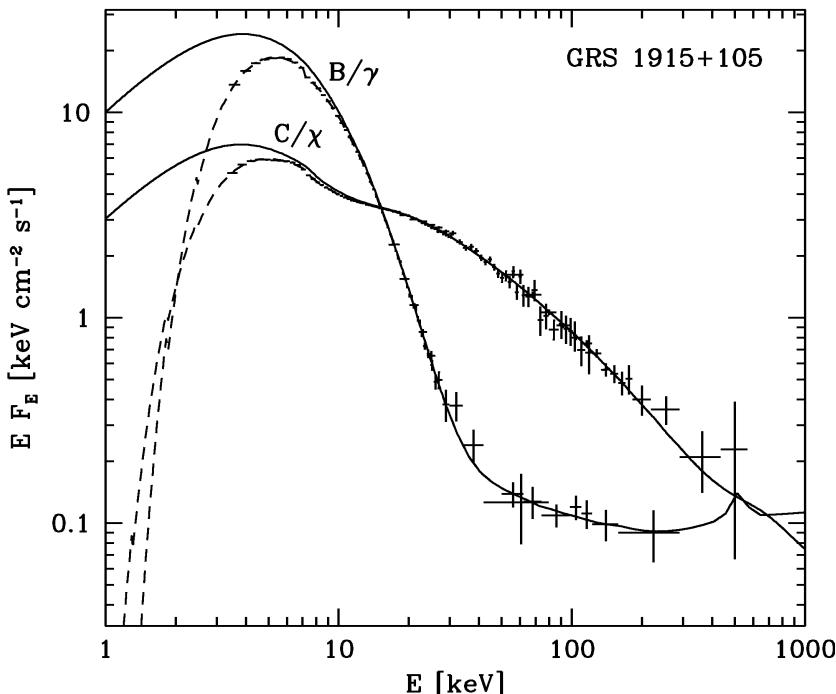


GRS 1915+105

The source shows 14 separate classes of variability of X-ray light-curves (Belloni+ 2000, Klein-Wolt+ 2002, Hannikainen+ 2005).

They can be grouped into 3 spectral states: **A**, **B**, and **C** (Belloni+ 2000).
A & B – Soft State, C – Hard State (Reig+ 2003; Fender & Belloni 2004).

Hard part of the spectrum



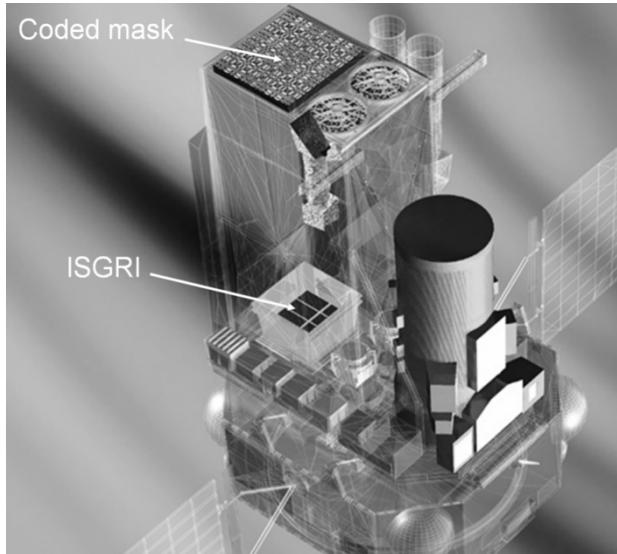
PCA+HEXTE+OSSE
(Zdziarski+ 2001)

The high energy spectrum is basically a power-law-like **without any break** as far as we observe.

There is only a few detections above 200 keV, most spectra show upper limits (Poutanen & Vurm 2009, Titarchuk+ 2009, Ueda+ 2010, Miller+ 2013, Peris+ 2015).

PICsIT

PICsIT - Pixellated Imaging Caesium Iodide Telescope.

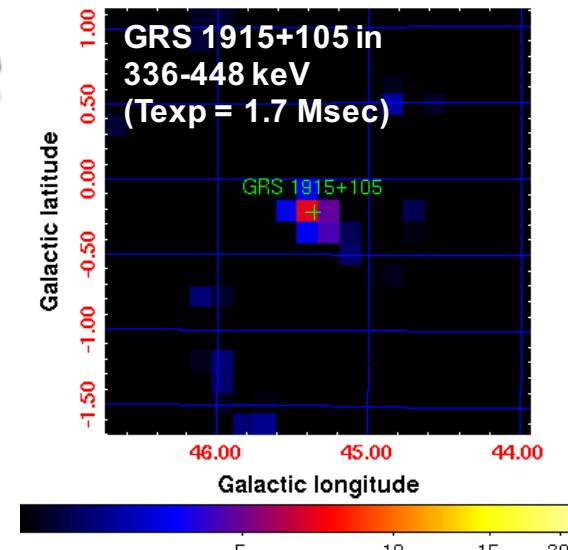


The IBIS detection unit is based on two independent solid state detector arrays, the low energy camera **ISGRI** (14 keV–195 keV) & the high energy camera **PICsIT** (200 keV–6 MeV) (Labanti+ 2003, Lebrun 2004).

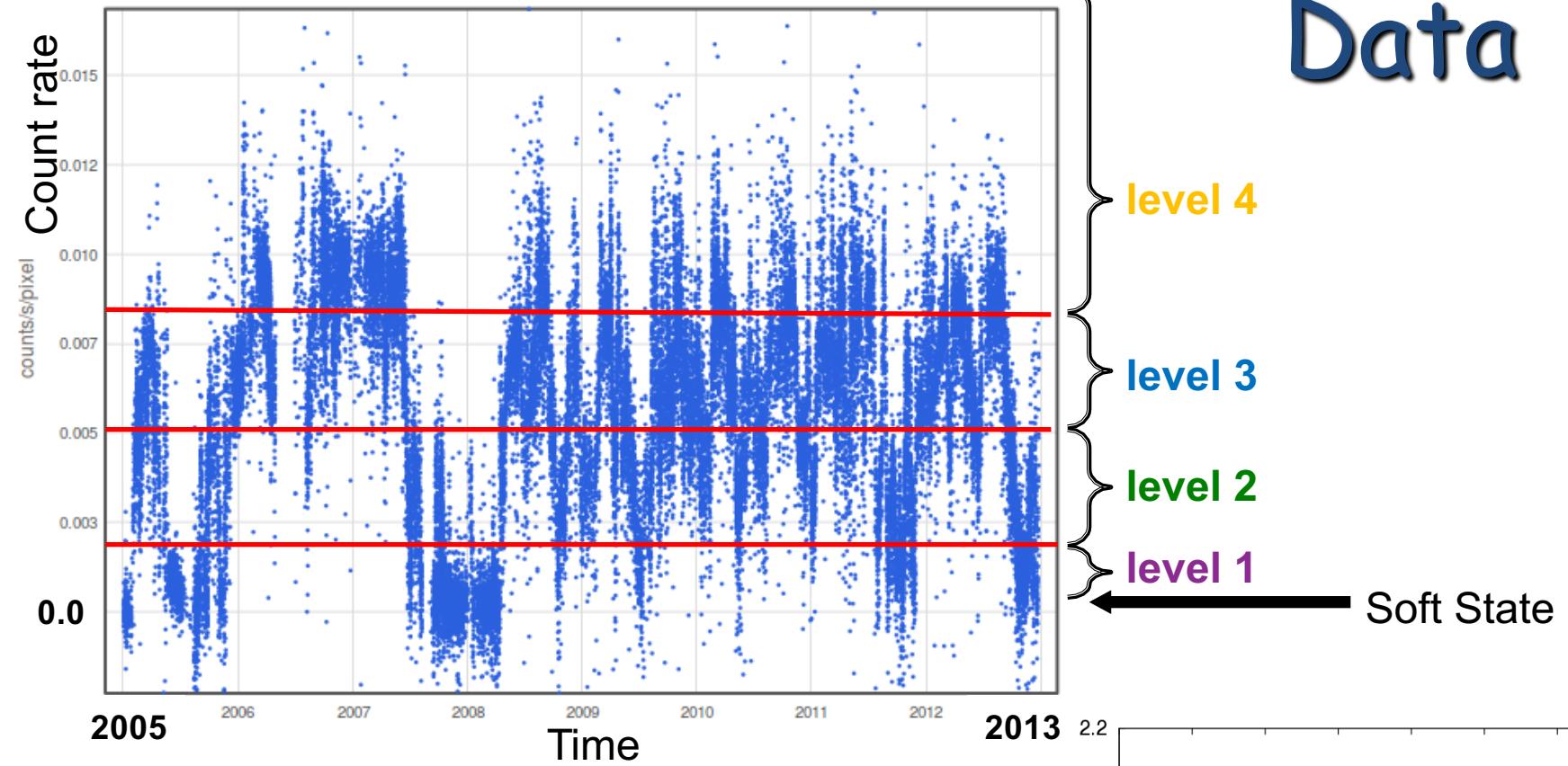
Observations

Detections were made between Jan 2005 and Dec 2012 by

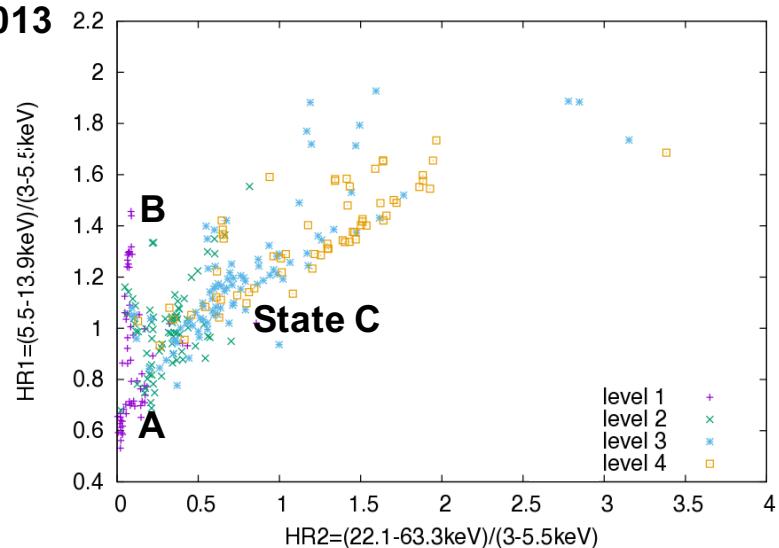
- Swift
 - BAT (14-195 keV, Tot.Exp = 14.9 Msec)
- INTEGRAL
 - JEM-X (3-20 keV, Tot.Exp = 2.2 Msec)
 - ISGRI (17.3-80 keV, Tot.Exp. = 2.7 Msec)
 - **PICsIT** (203-450 keV, Tot.Exp = 1.7 Msec)



Swift BAT (20-75 keV)

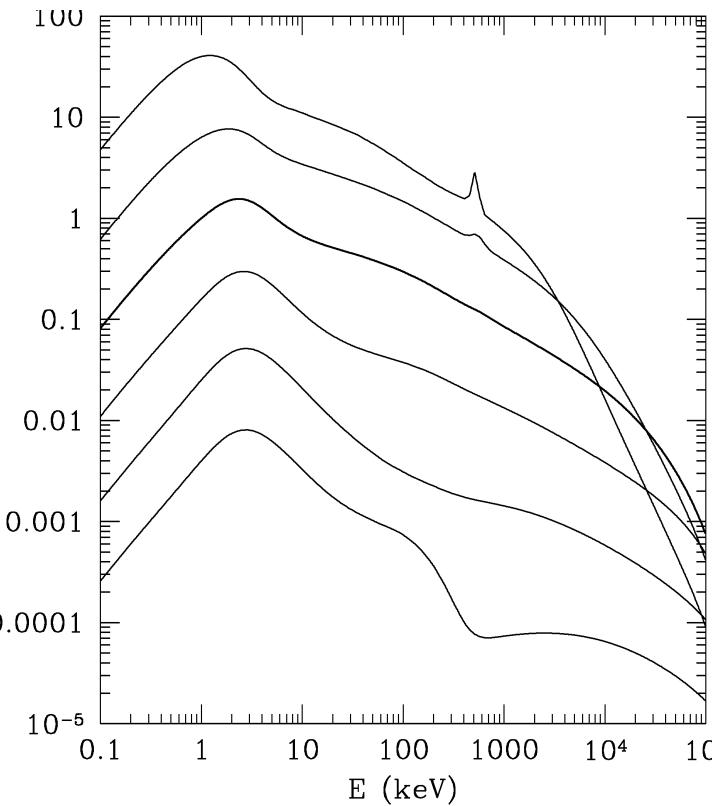


- level 4, 3 & 2 – harder to softer Hard State
- level 1 – mixture of states (Soft + Hard State)



Model

The data were fitted using the EQPAIR model (Coppi 1999, 2002).
The model fit emission of a disk, a corona and a non-thermal acceleration.



- Geometry:
- The electron distribution in corona is **thermal** at low energies and **non-thermal** at high energies. The distribution (and T_e) are computed **self-consistently** balancing cooling and heating.
- It incorporates: Compton scattering and reflection, bremsstrahlung, pair-production, annihilation, and Coulomb scattering.

Model

The input parameters are related to:

- disk (R_{in} , R_{out} , T_{in} , I_{soft} , ξ , $\Omega_{refl}/2\pi$, θ)
- plasma/corona (r , I_h , τ_p)
- non-thermal acceleration (I_{nth} , Γ_{inj} , γ_{min} , γ_{max})

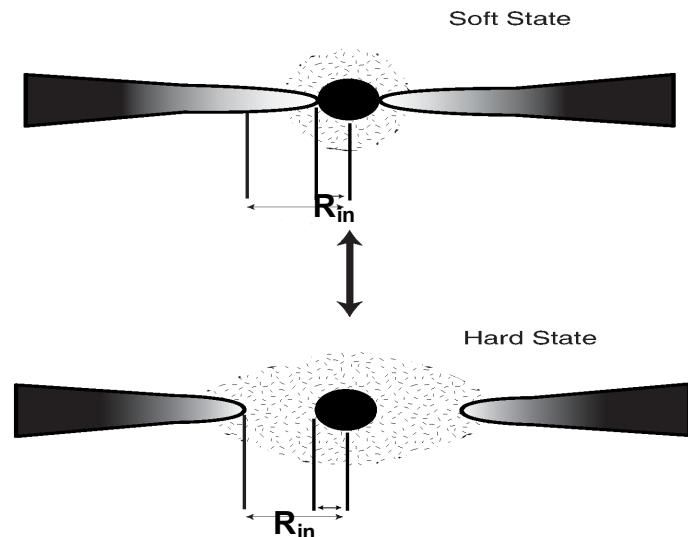
$$I_x \stackrel{\text{def}}{=} \frac{L_x}{R} \frac{\sigma_T}{m_e c^3}$$

$$I_h \stackrel{\text{def}}{=} I_{th} + I_{nth}$$

$$N_{e, nth} \propto \gamma^{-(\Gamma_{inj}+1)}$$

where e.g.

- I_{soft} – compactness par. related to luminosity of soft photons entering the plasma,
- I_h – the power supplied to the electrons,
- I_{th} – heating of the thermal part of electron distribution,
- I_{nth} – corresponds to the electron acceleration.



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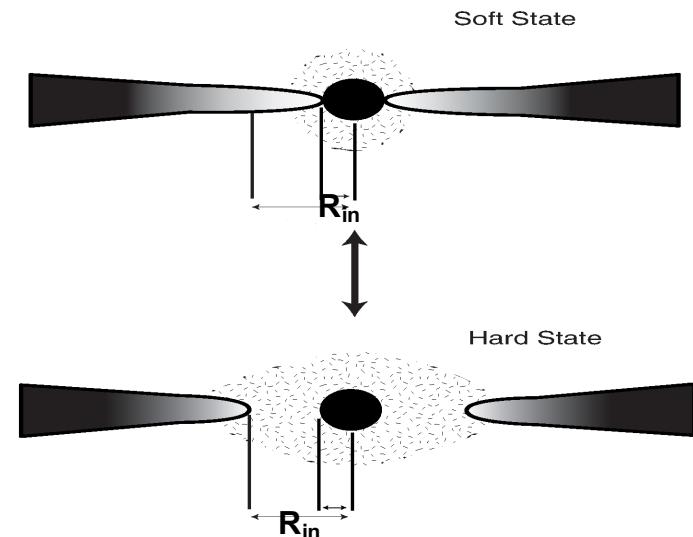
green col. \rightarrow free parameters

We assume following Poutanen & Coppi (1998):

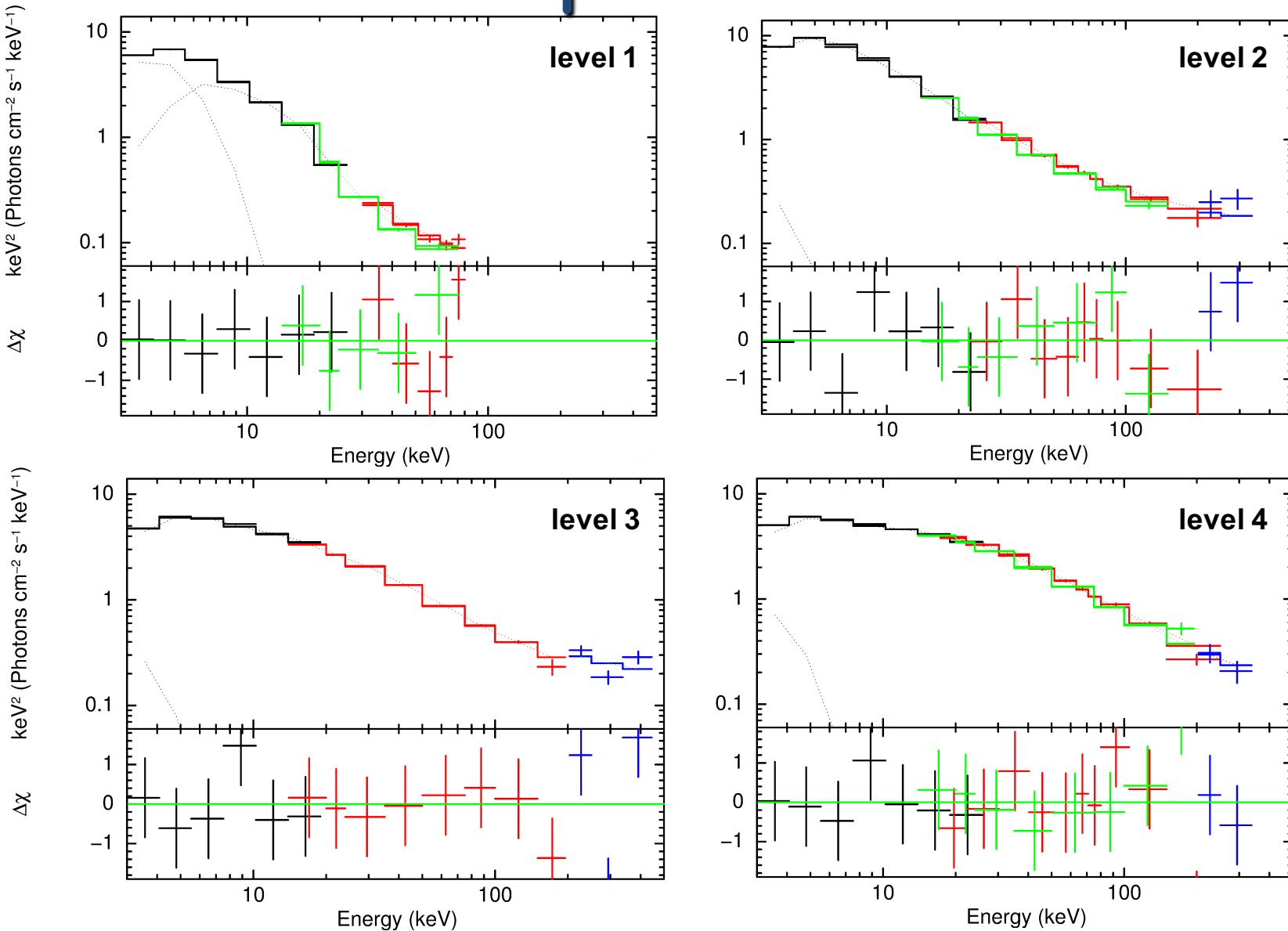
- temperature of the soft photons: $T_{\text{in}} \propto R_{\text{in}}^{-0.75}$
- soft luminosity: $L_{\text{soft}} \propto 1/R_{\text{in}}$ ($\Leftarrow L_{\text{soft}} \sim \int \sigma_{SB} T^4 2\pi r dr$)
- optical depth: $\tau_p \propto R_{\text{in}}$ ($\Leftarrow \tau_p = \sigma_T n \ell$)

We also fix:

- $R_{\text{out}} = 10^5 r_g$
- $\xi = 100 \text{ erg cm s}^{-1}$
- $\theta = 70^\circ$
- $r = 80\% R_{\text{in}}$
- $\gamma_{\min} = 1.3, \gamma_{\max} = 1000$

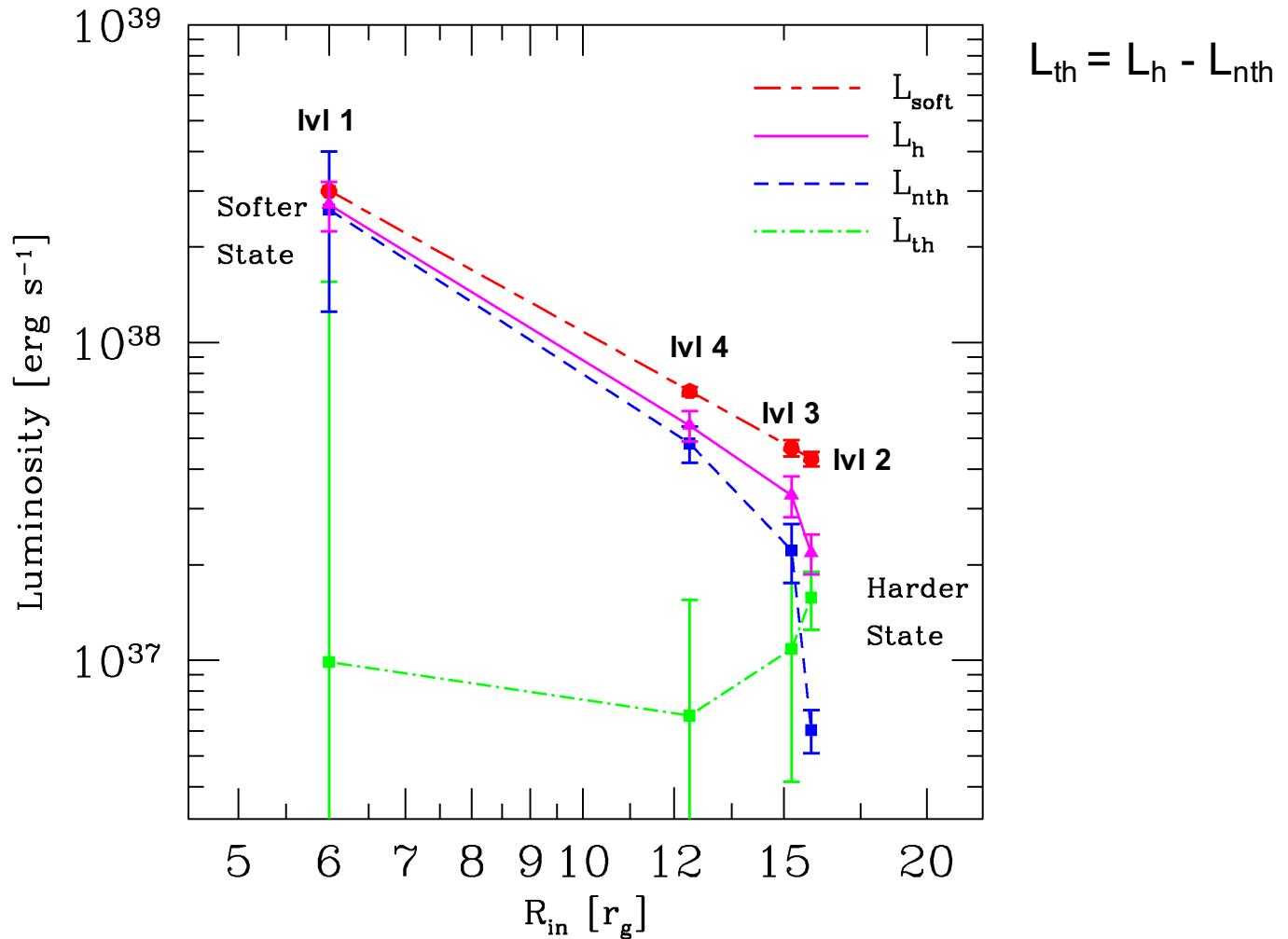


Spectra



Results from spectral fits

$$L_{\text{GRS Edd}} = 1.7 \times 10^{39} \text{ erg}$$



Discussion/Conclusions

- **L_{nth} varies during state transitions.** When R_{in} decreases, L_{nth} and $L_{\text{nth}} / L_{\text{soft}}$ increase. Non-thermal electrons/pairs acceleration becomes more efficient. Perhaps the jet is much stronger for small R_{in} .
- L_{th} is not varying that much with R_{in} (**L_{th} could be constant**). The heating of the thermal electrons does not seem to vary with the geometry.
- **The MeV band**, at the edge between the thermal and non-thermal domains, provides the information required **to understand how** non-thermal particle are accelerated around BH and how jets are launched. The ESA M5 proposal **AstroGam** ($E \sim 0.3\text{-}100$ MeV) should increase the sensitivity by a factor of 10.

