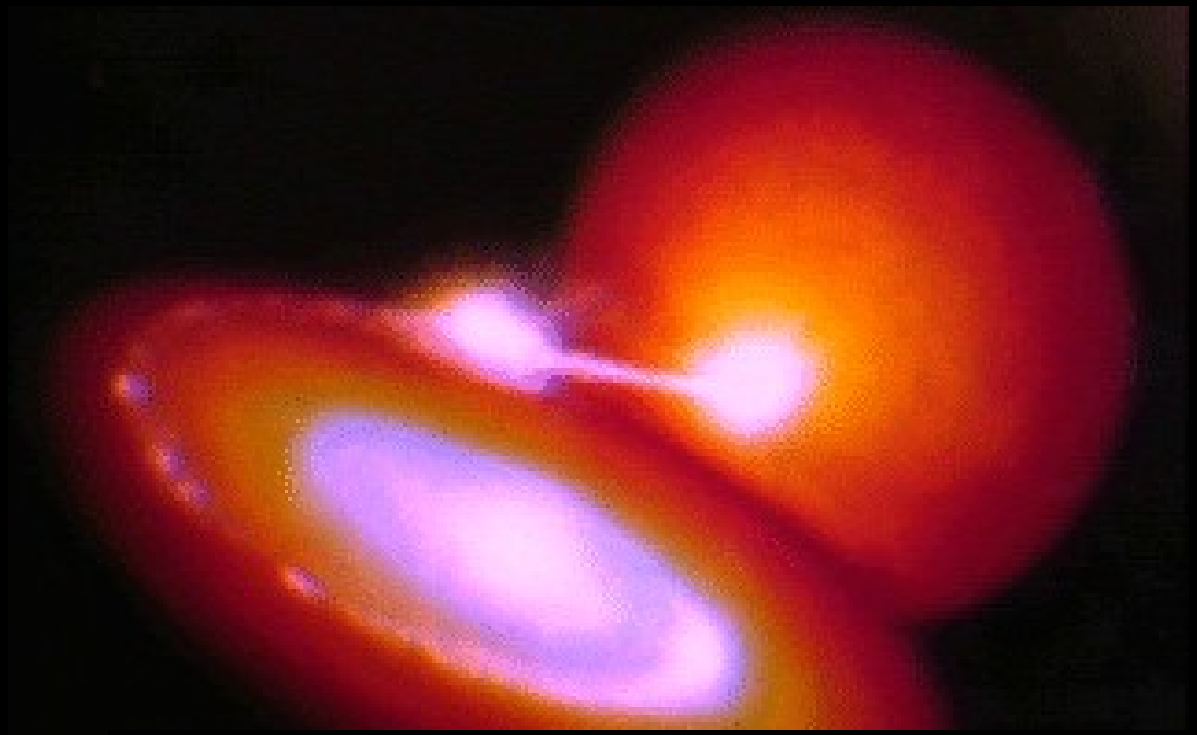
Statistical Study of Type-I X-ray Bursts in LMXB 4U 1636-53 with RXTE



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Mariano Mendez, Diego Altamirano,
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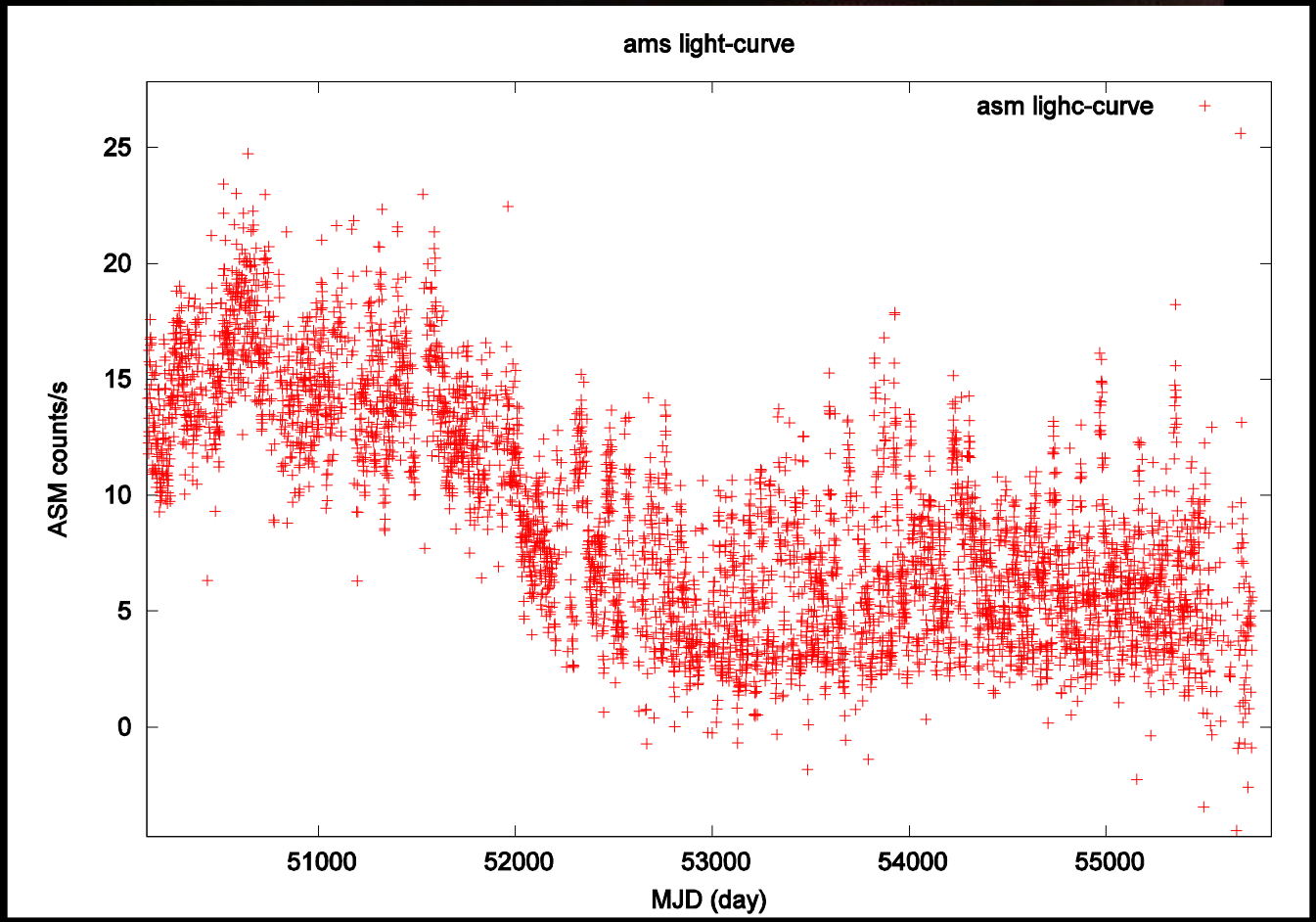
Outline

1. Motivation
2. Bursts properties in 4U 1636-53
3. The burst cooling phase
4. Summary

Why do we choose 4U 1636

More than 1300 RXTE observations from 1996 until now.



15 years ASM light-curve

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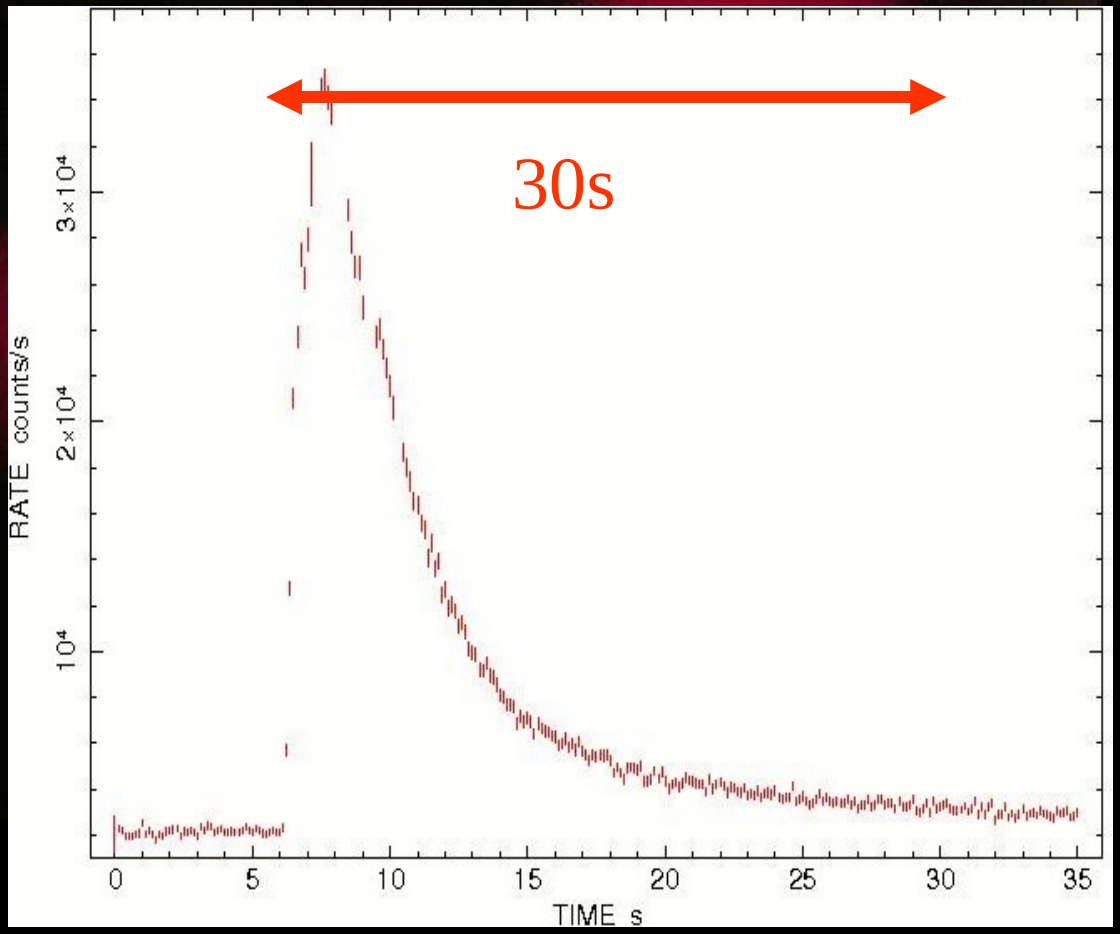
The source exhibits a wide variety of bursting behaviors



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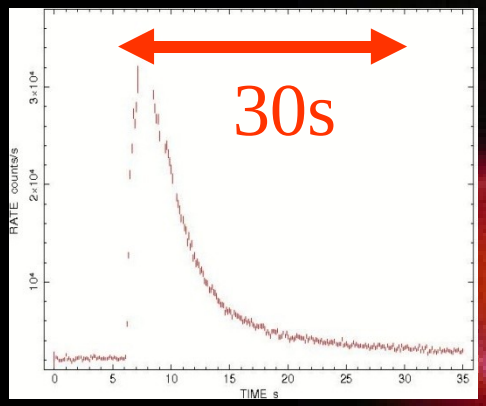

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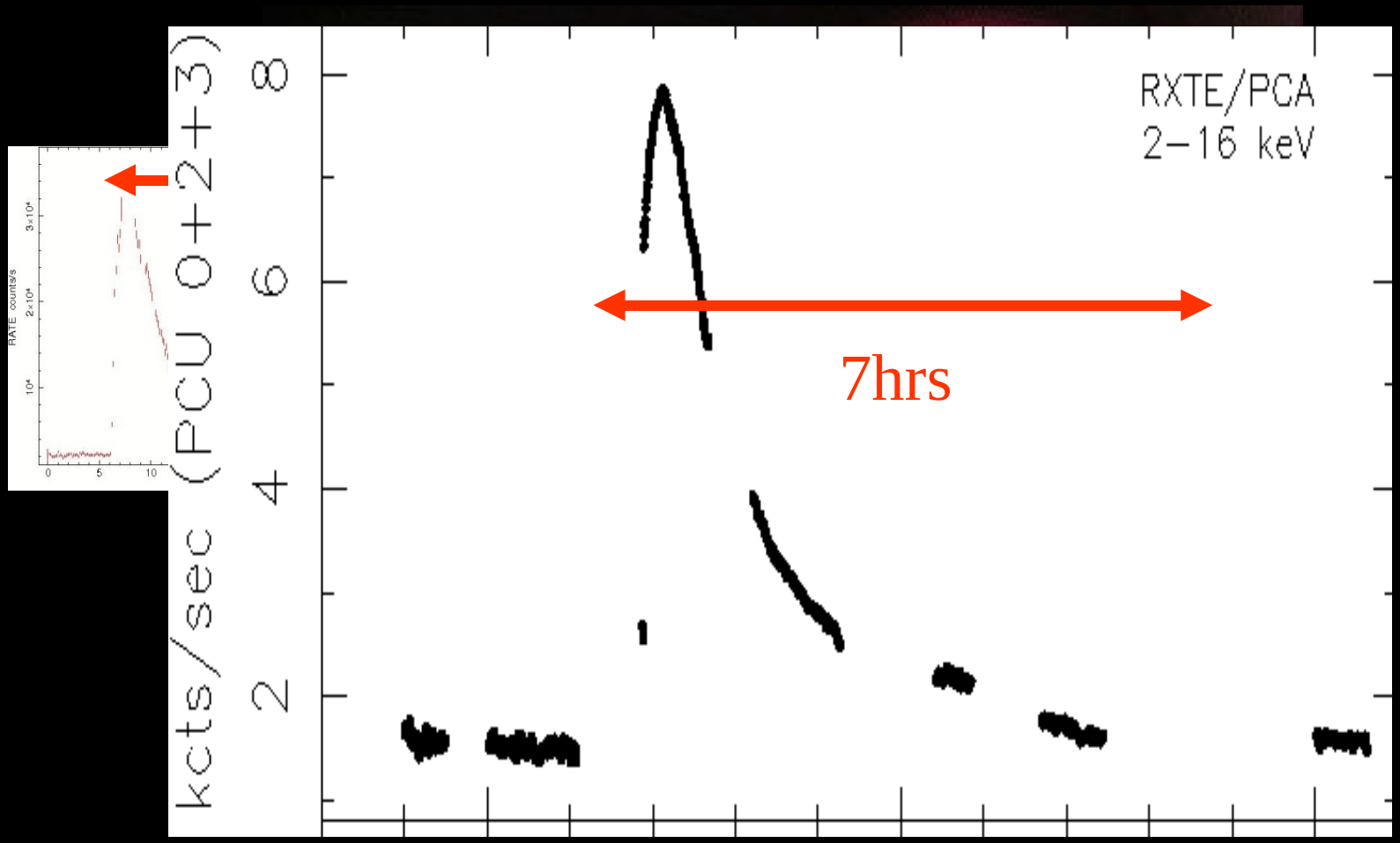

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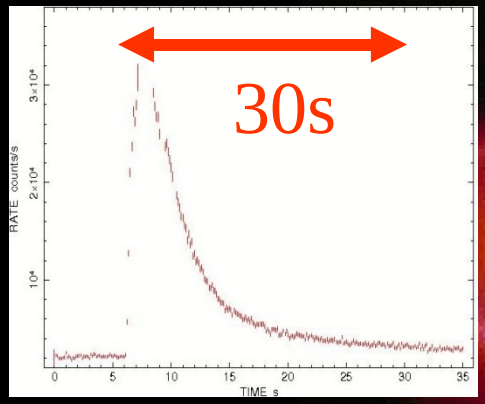

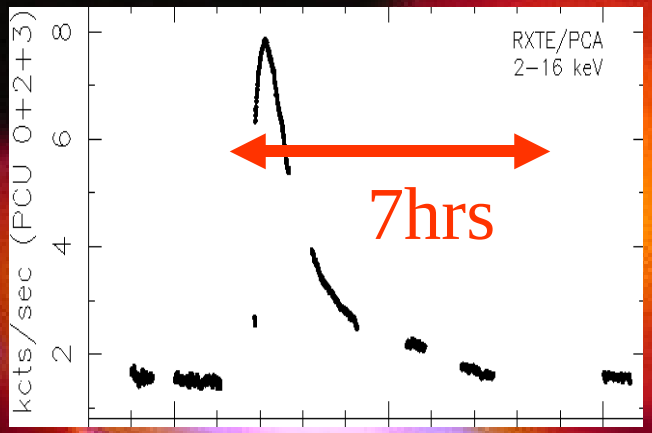

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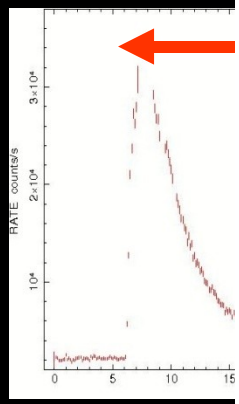

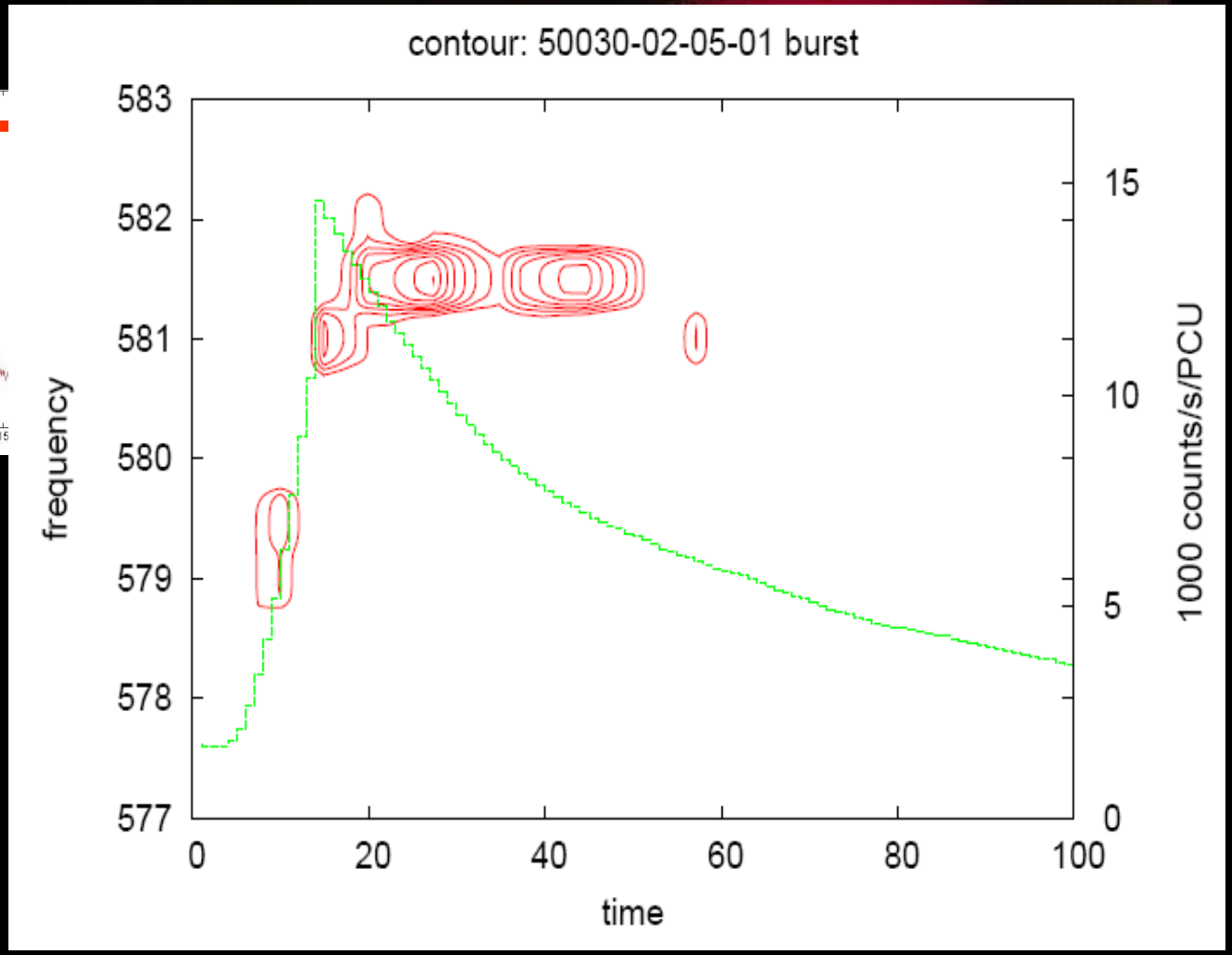

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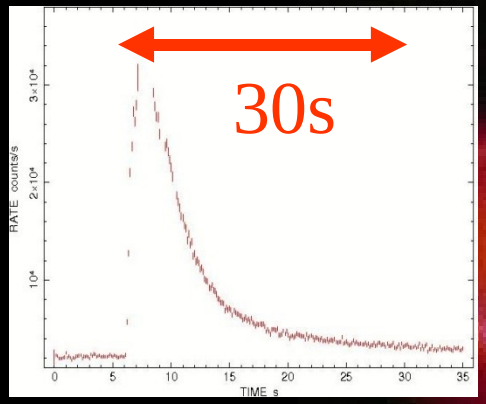

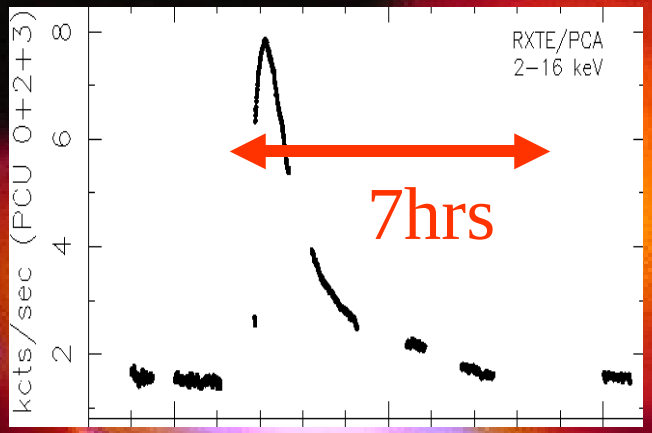

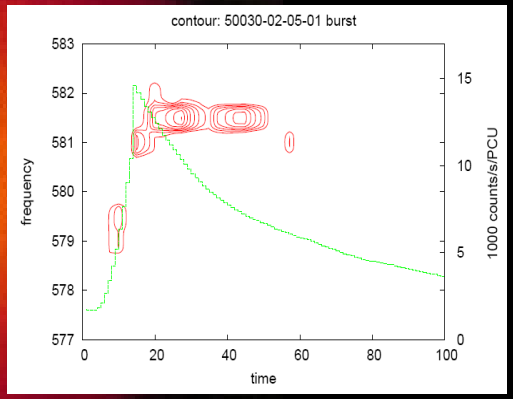

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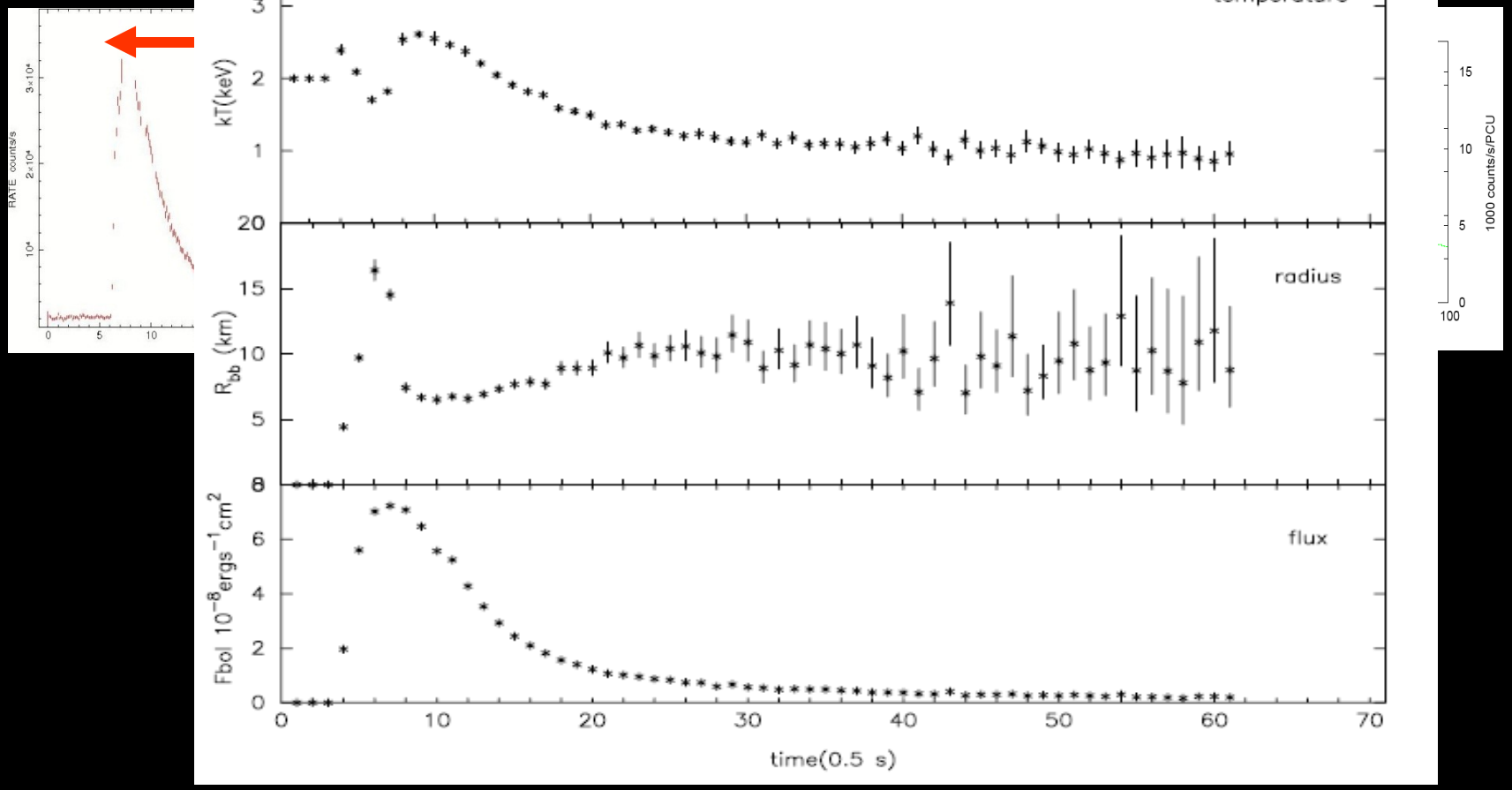

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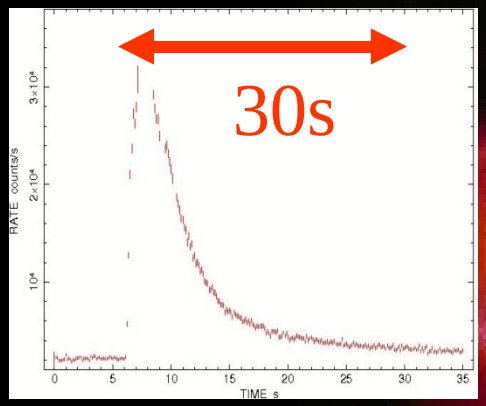

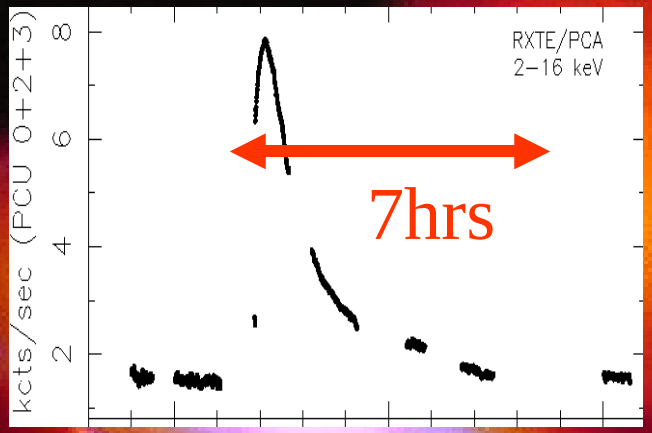

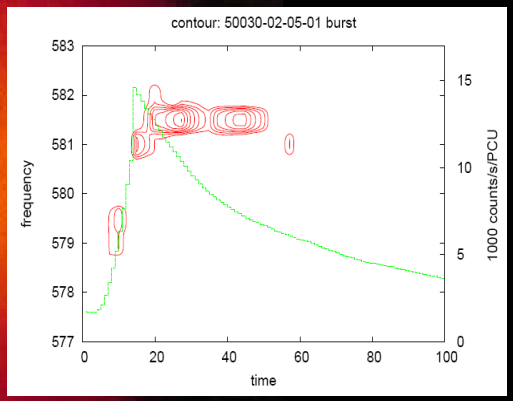

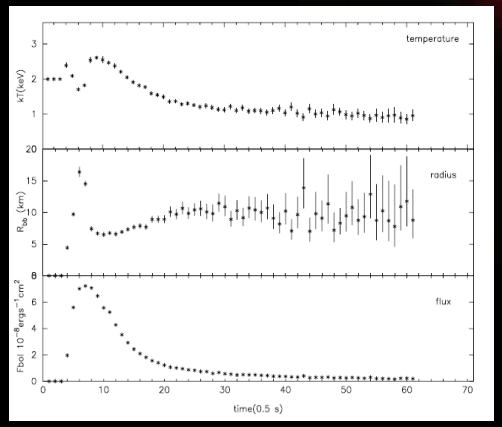

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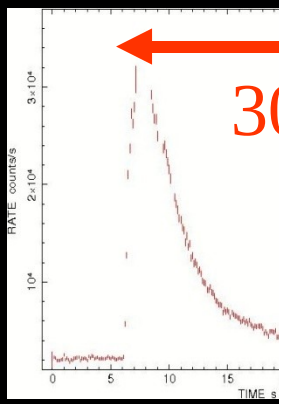

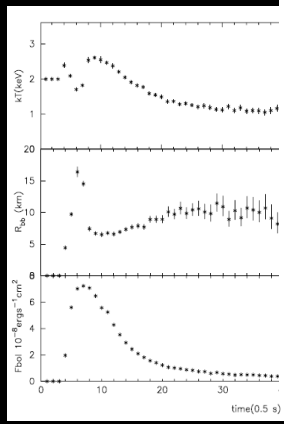

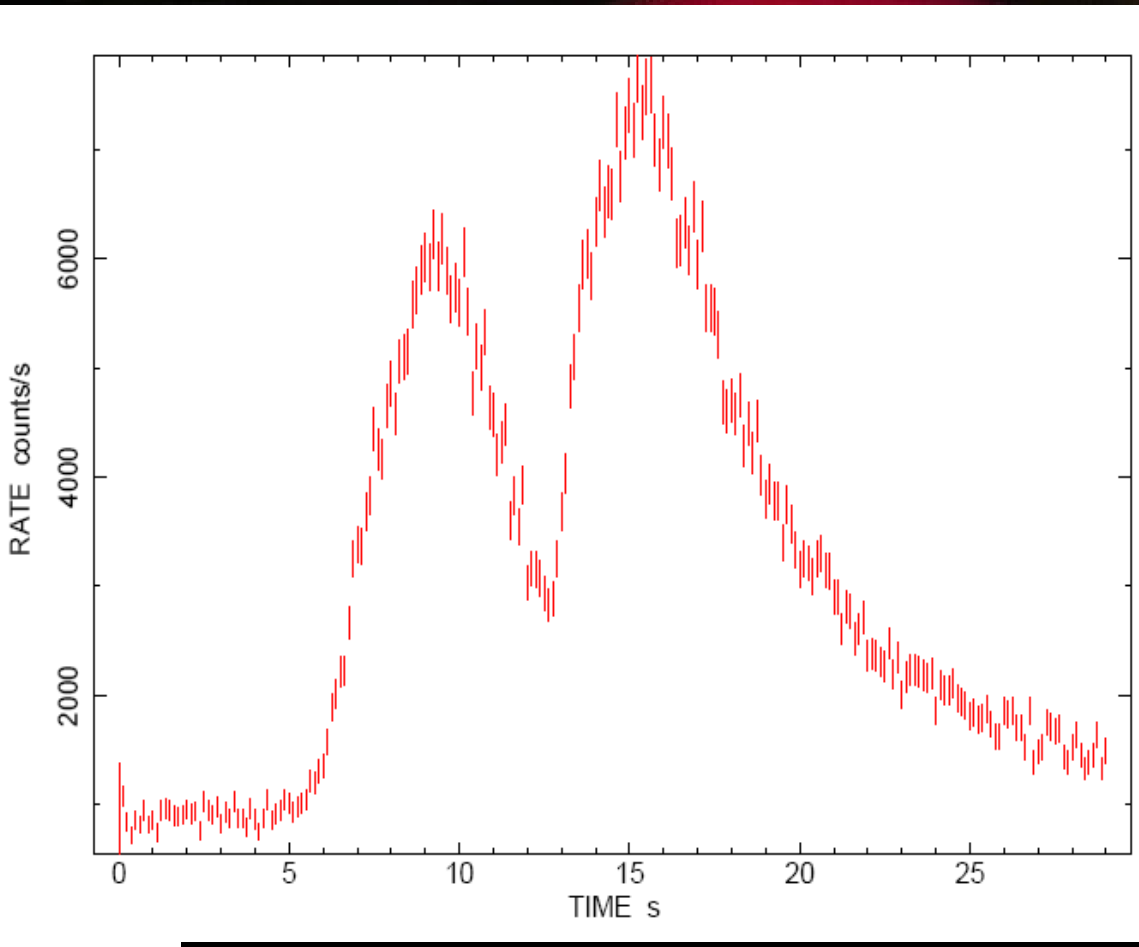

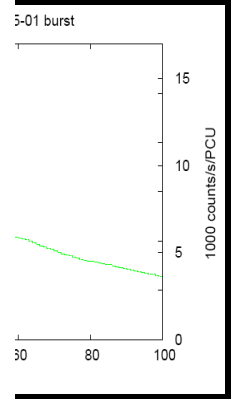

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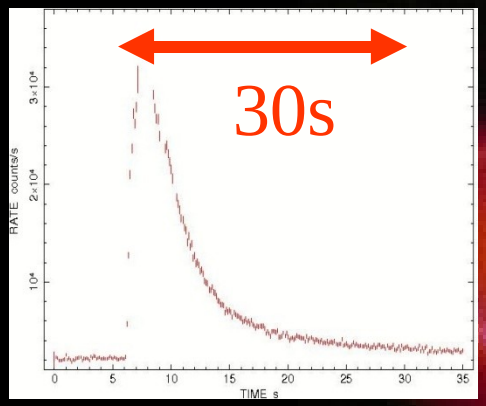

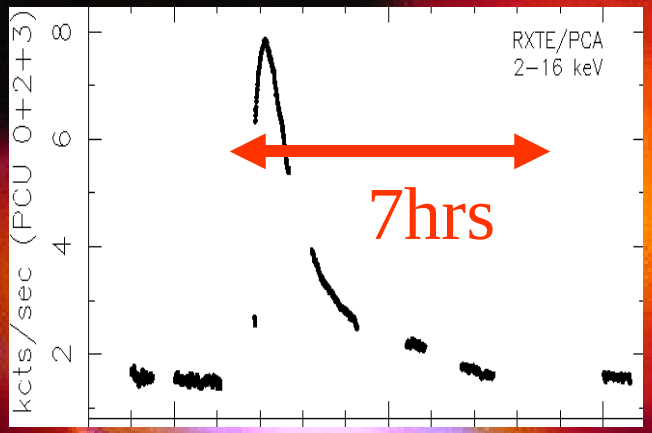

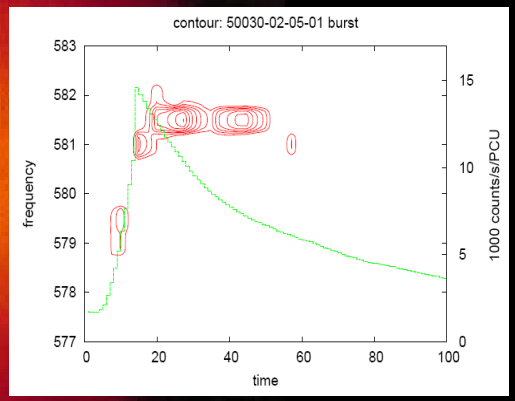

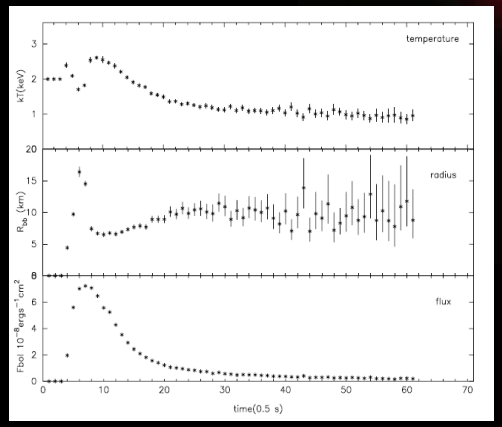

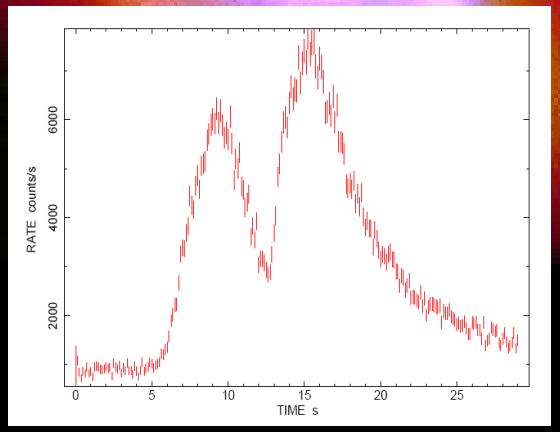

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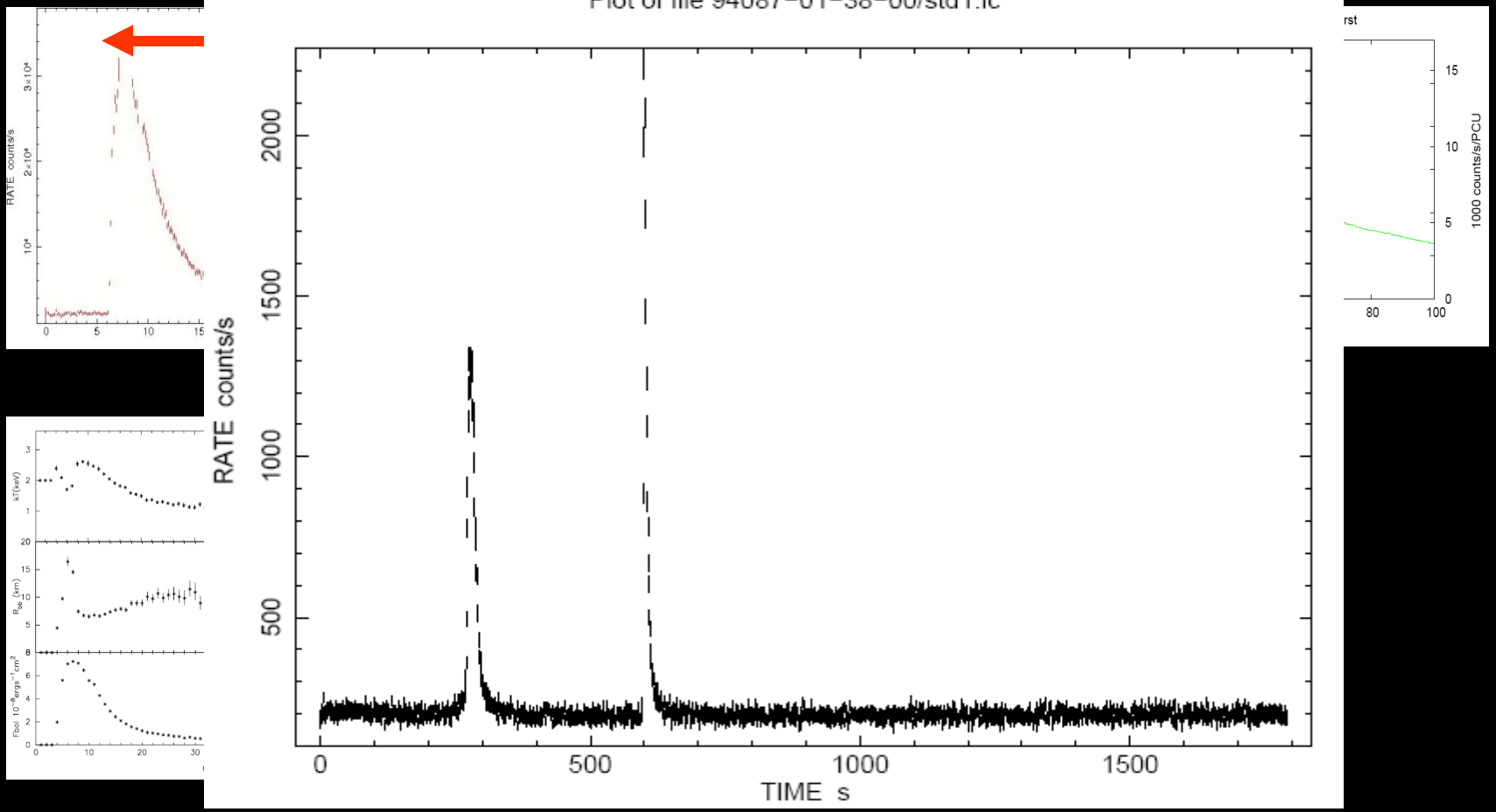

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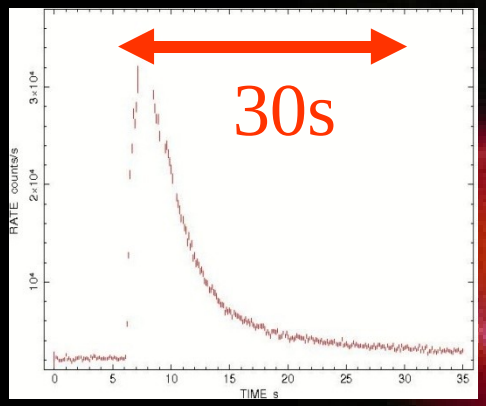
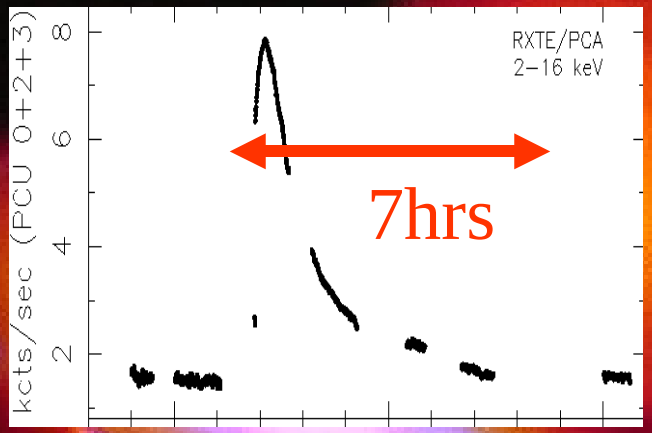
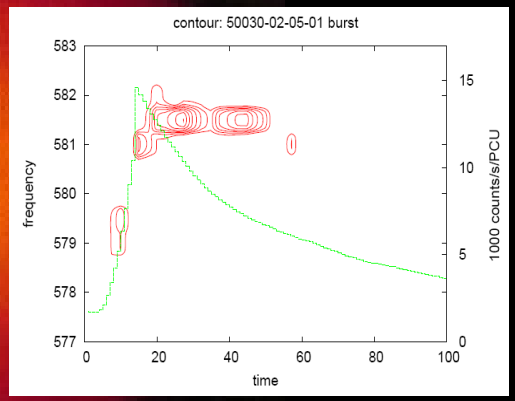
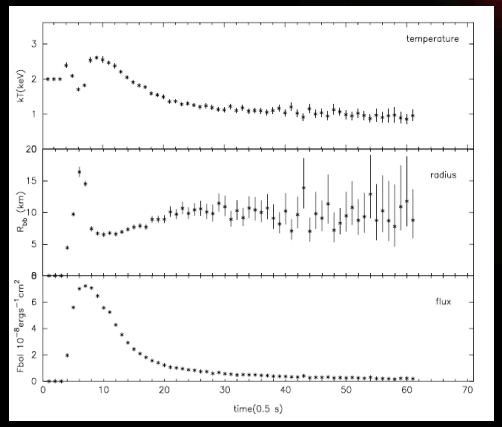
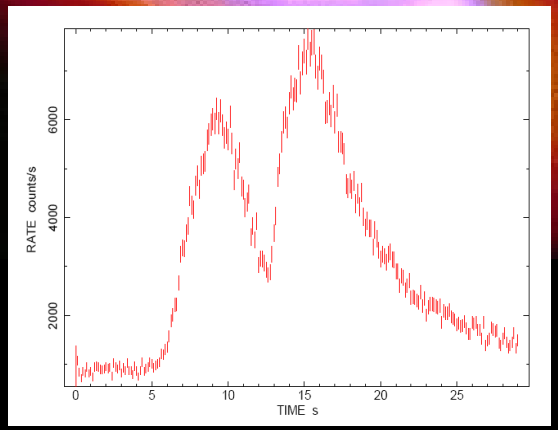
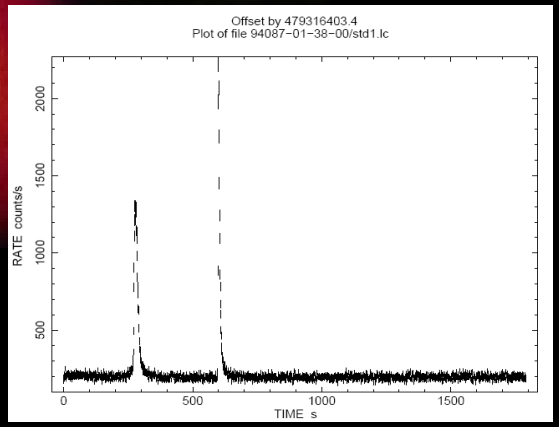




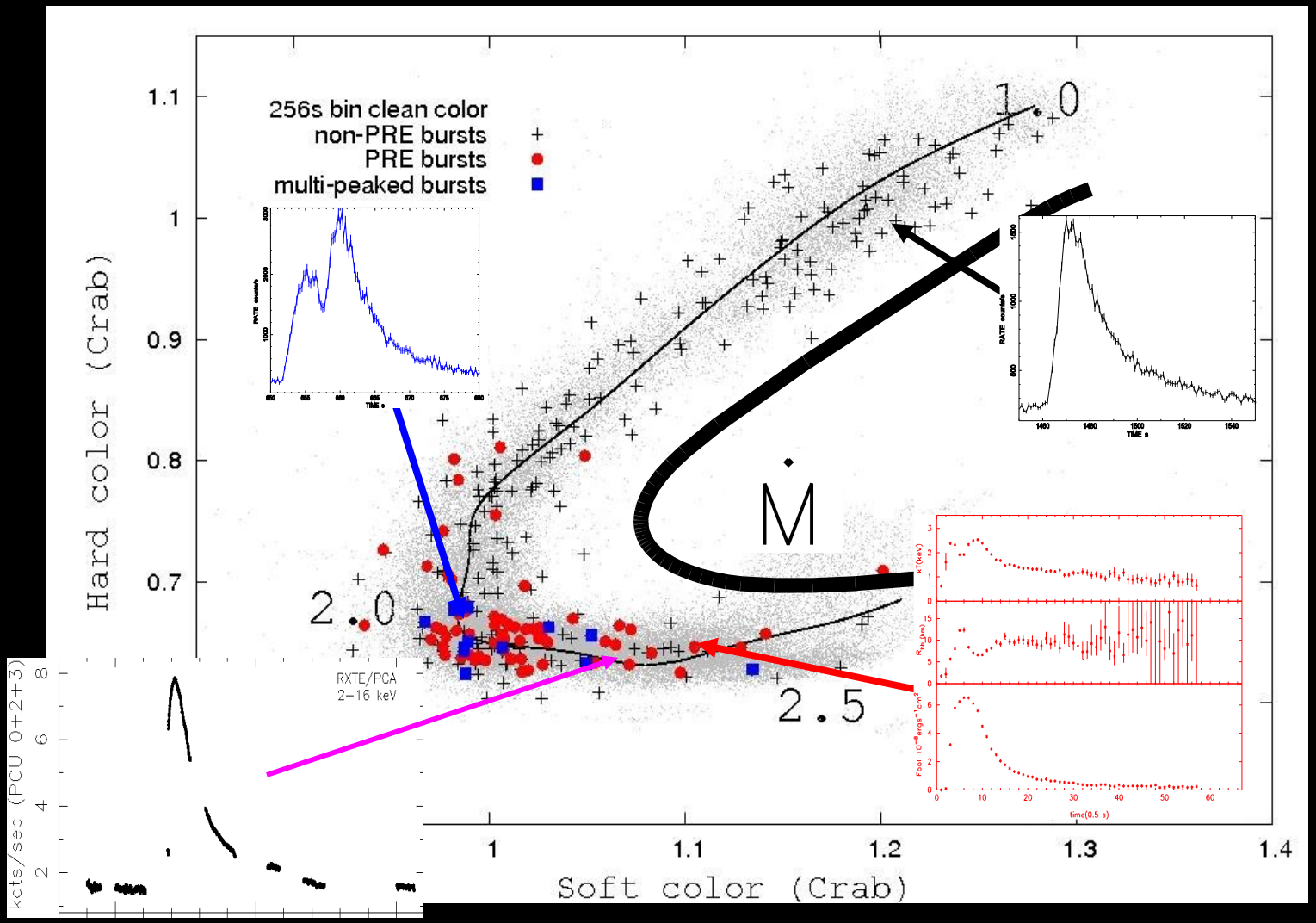








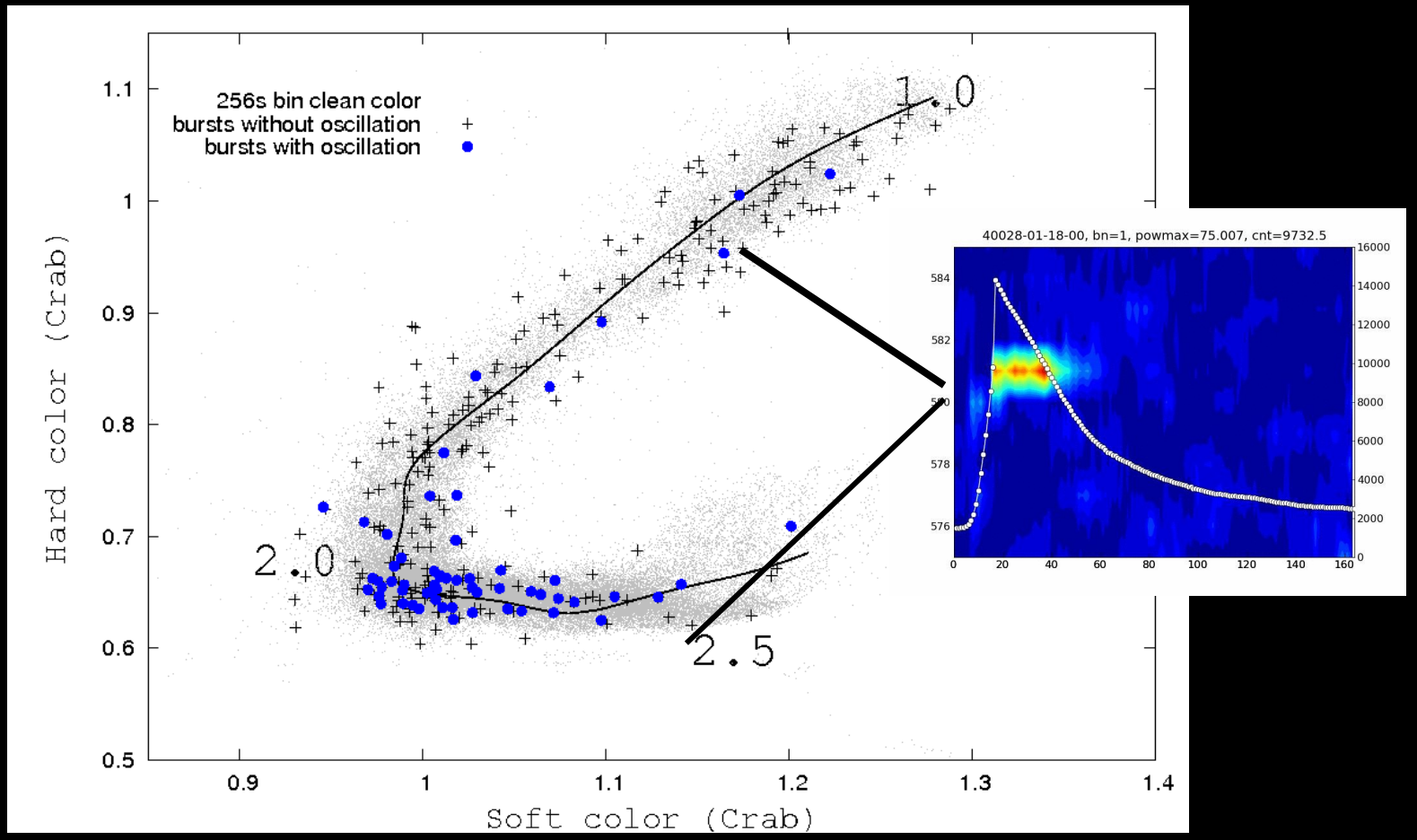
Bursts along Color-color Diagram



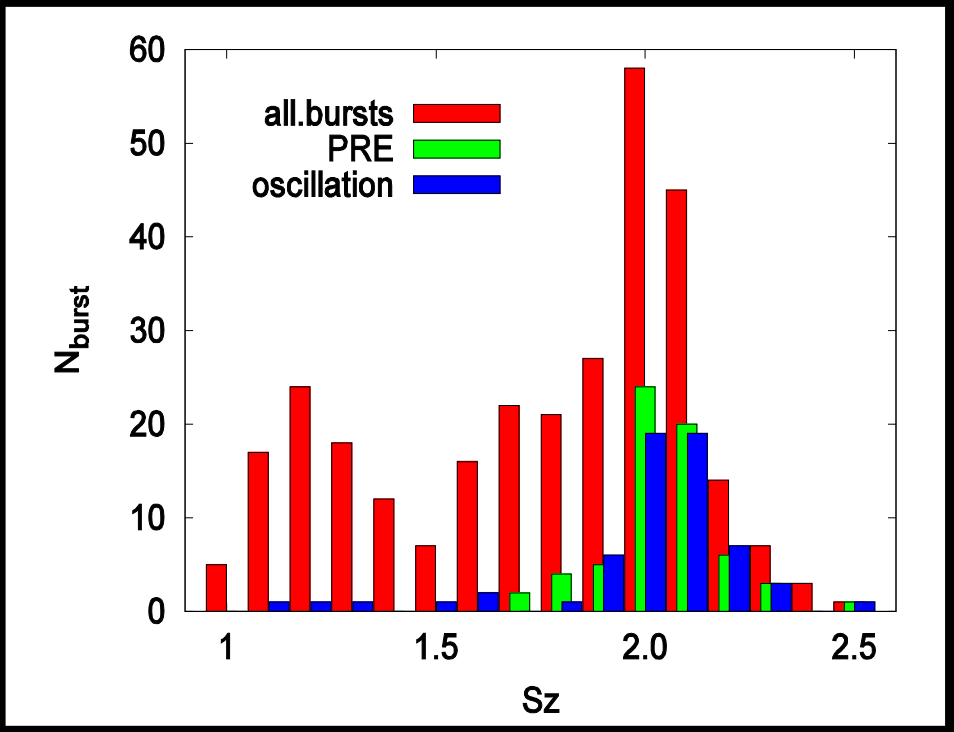
The coordinate Sz is thought to be

a monotonic function of mass accretion rate.

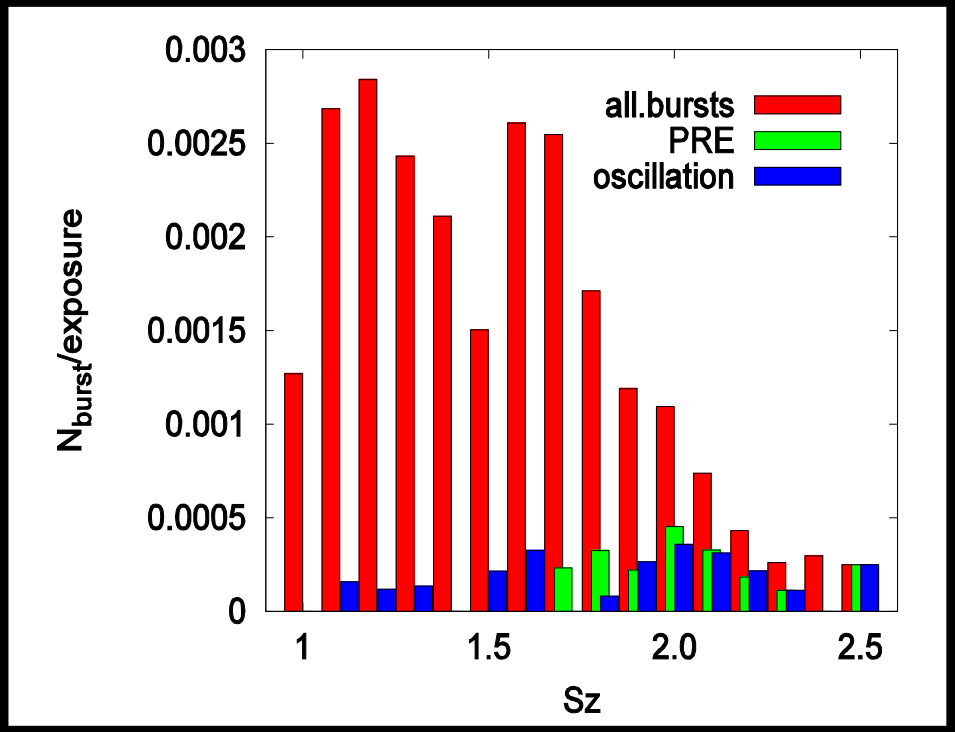
Bursts with/without oscillations along Color-color Diagram



Bursts distributions along S_z

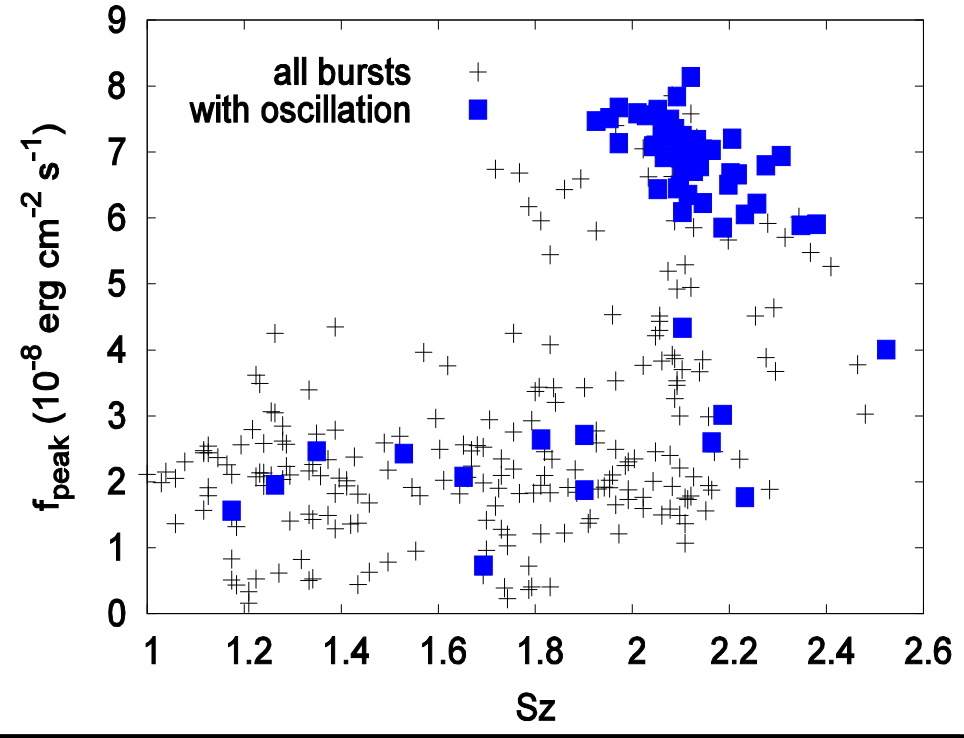


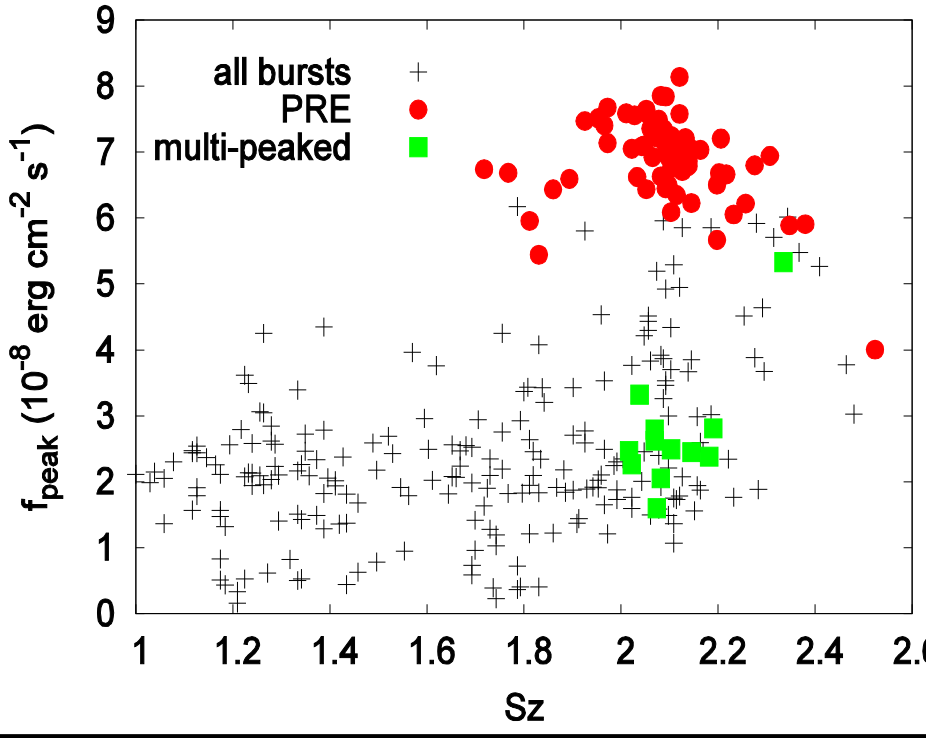
Number of bursts as a function of Sz



normalized by the total exposure at each position on the CD

Peak flux along S_z

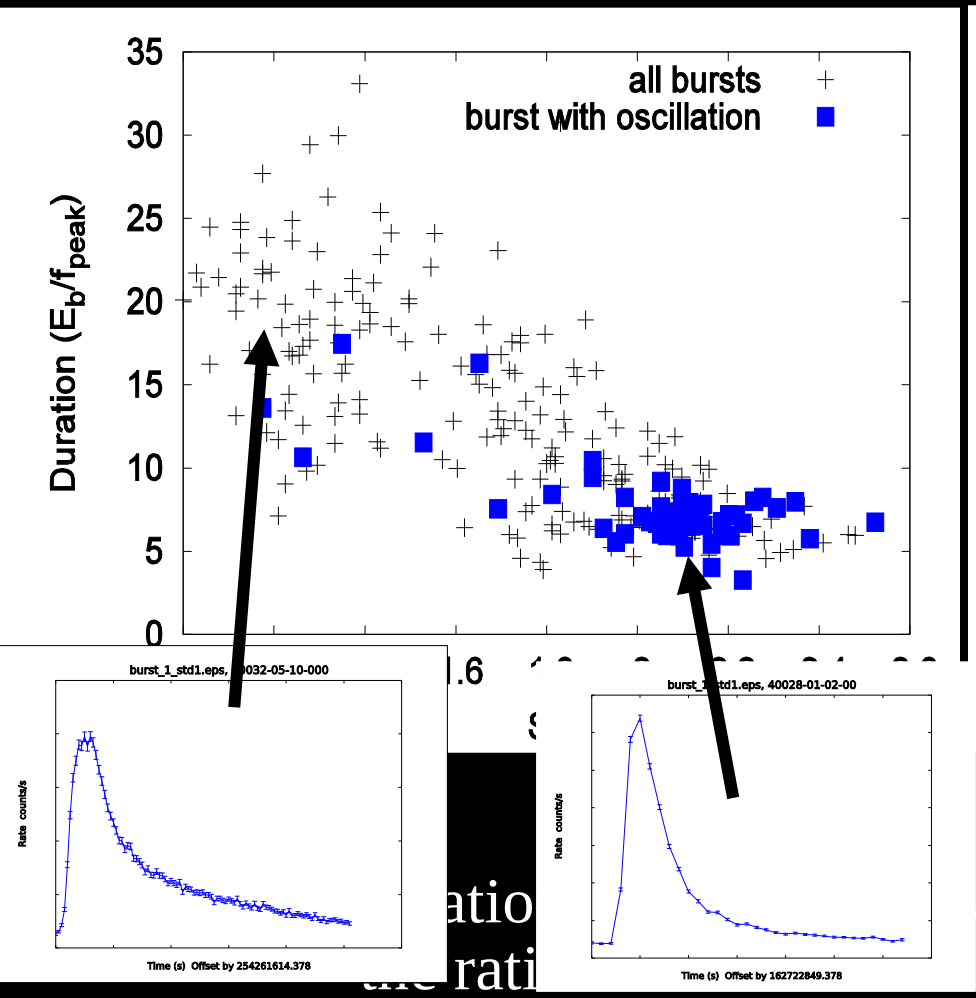


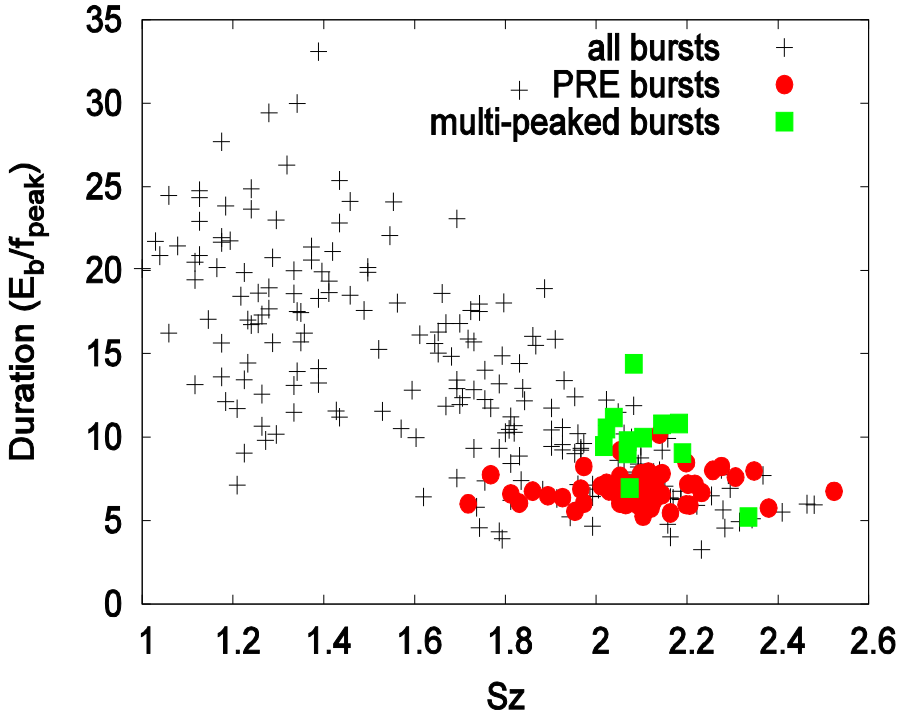


Burst with oscillations

PRE bursts

Bursts duration along S_z



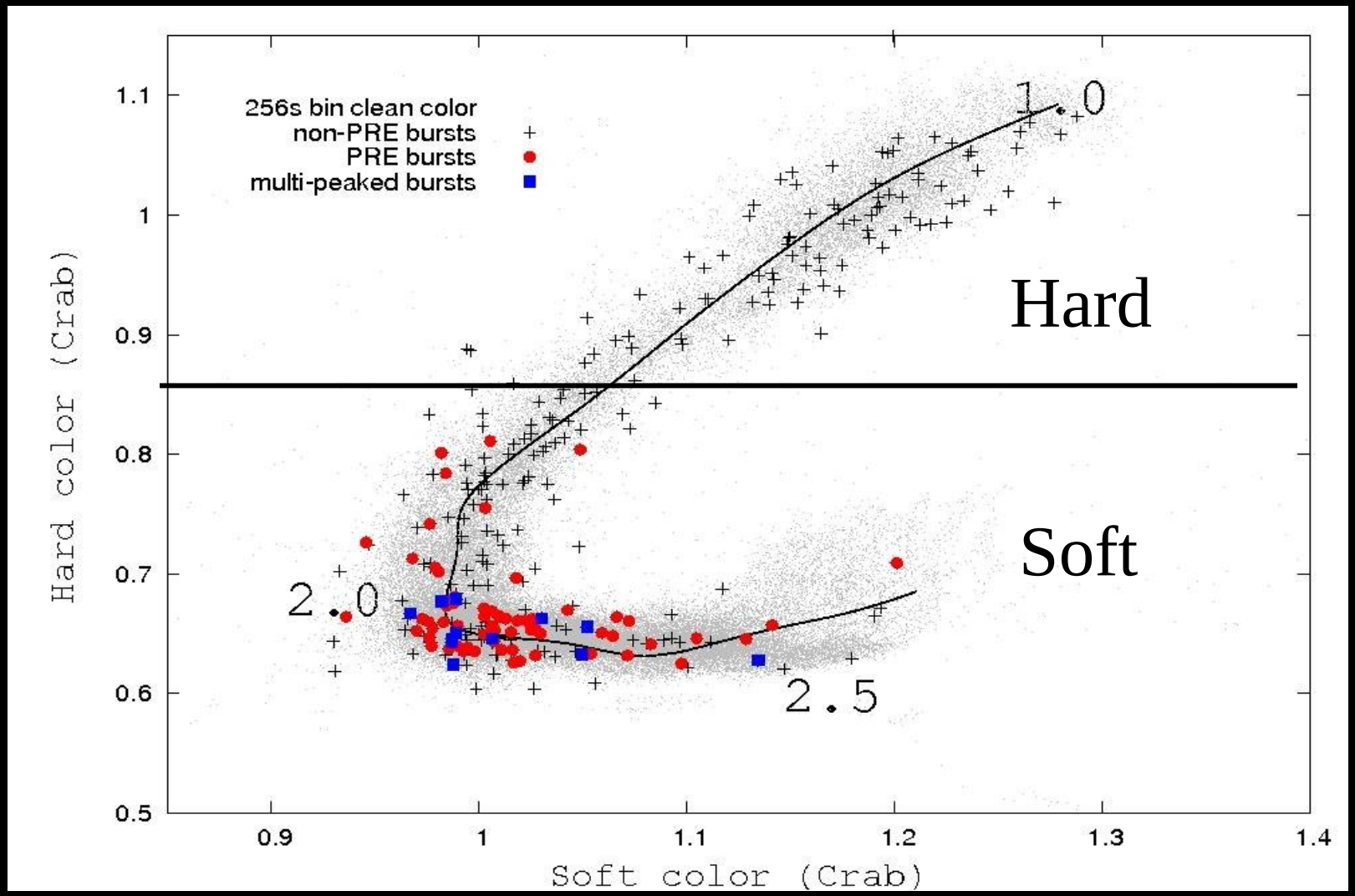


atio a function of Sz, defined as
rati of the bursts divided
by the peak flux of the bursts.

Summary 1

- All the PRE bursts are located at high S_z
- Multi-peaked bursts only appear at high S_z
- Bursts with oscillation everywhere on CD
- Burst duration correlated with S_z
- Bimodal peak flux distribution.

Cooling phase of Type-I X-ray Bursts in 4U 1636-53



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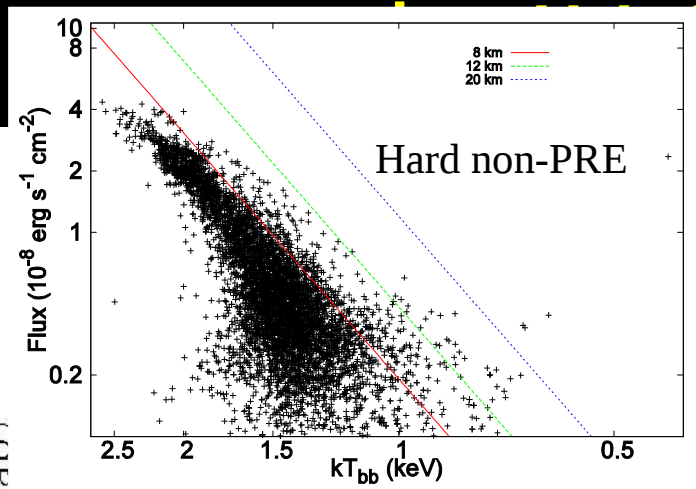
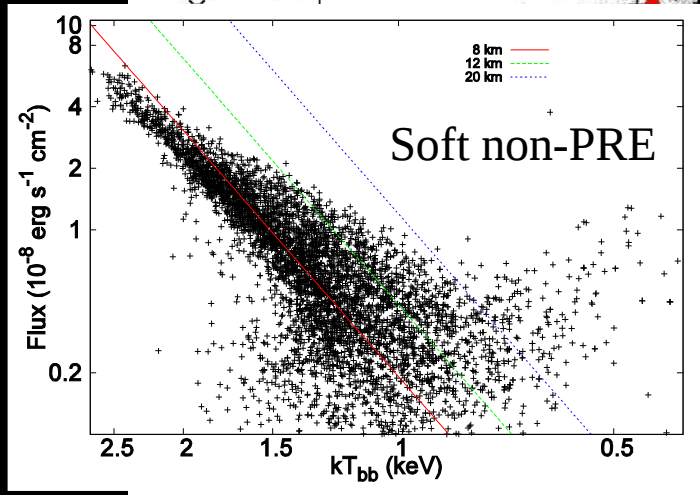
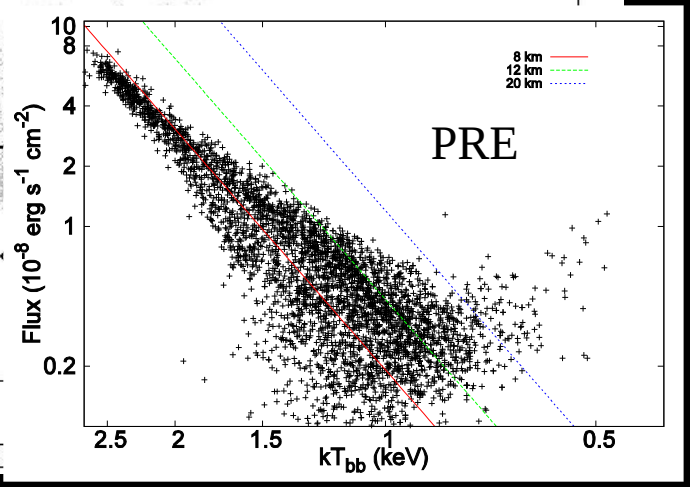
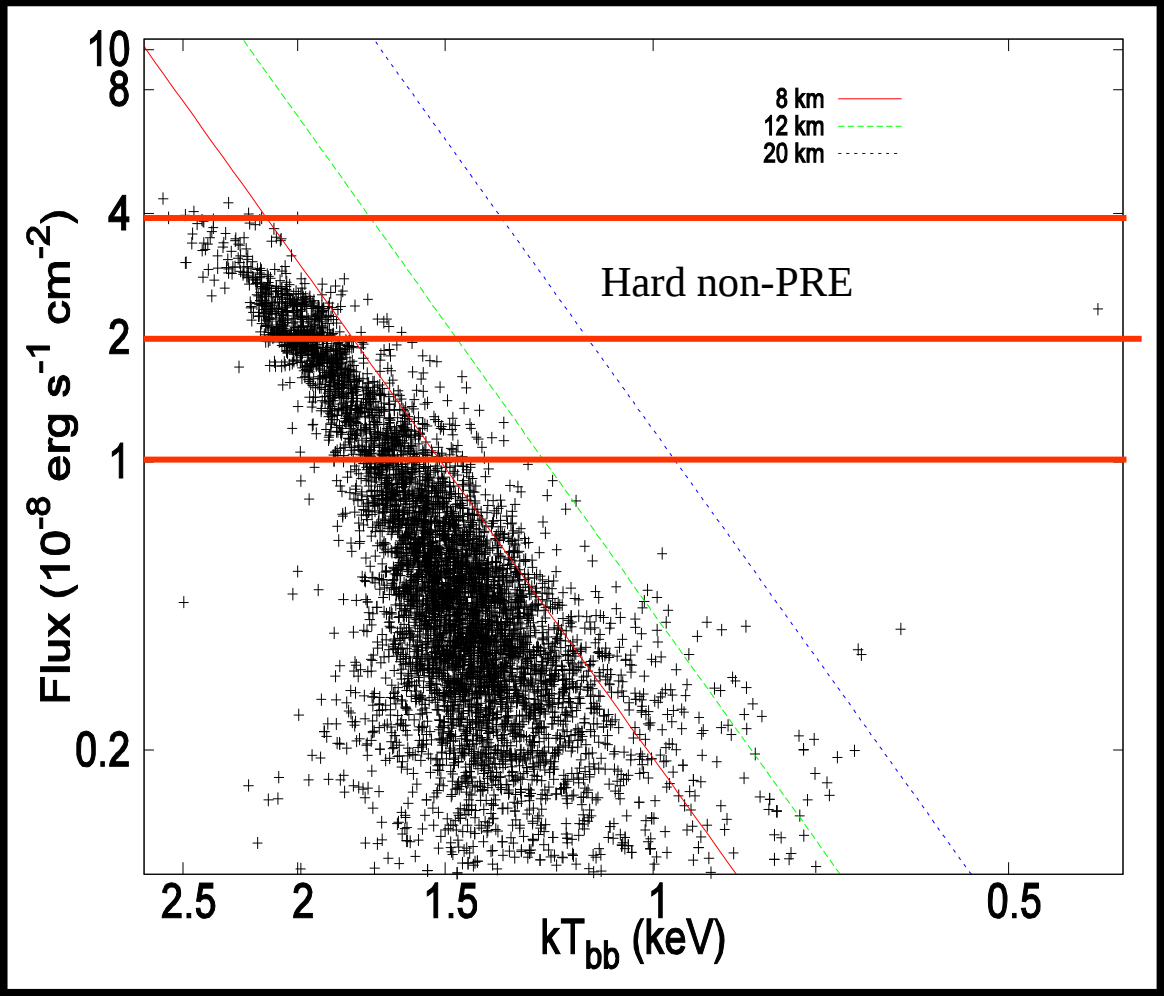






kT distribution at different flux level



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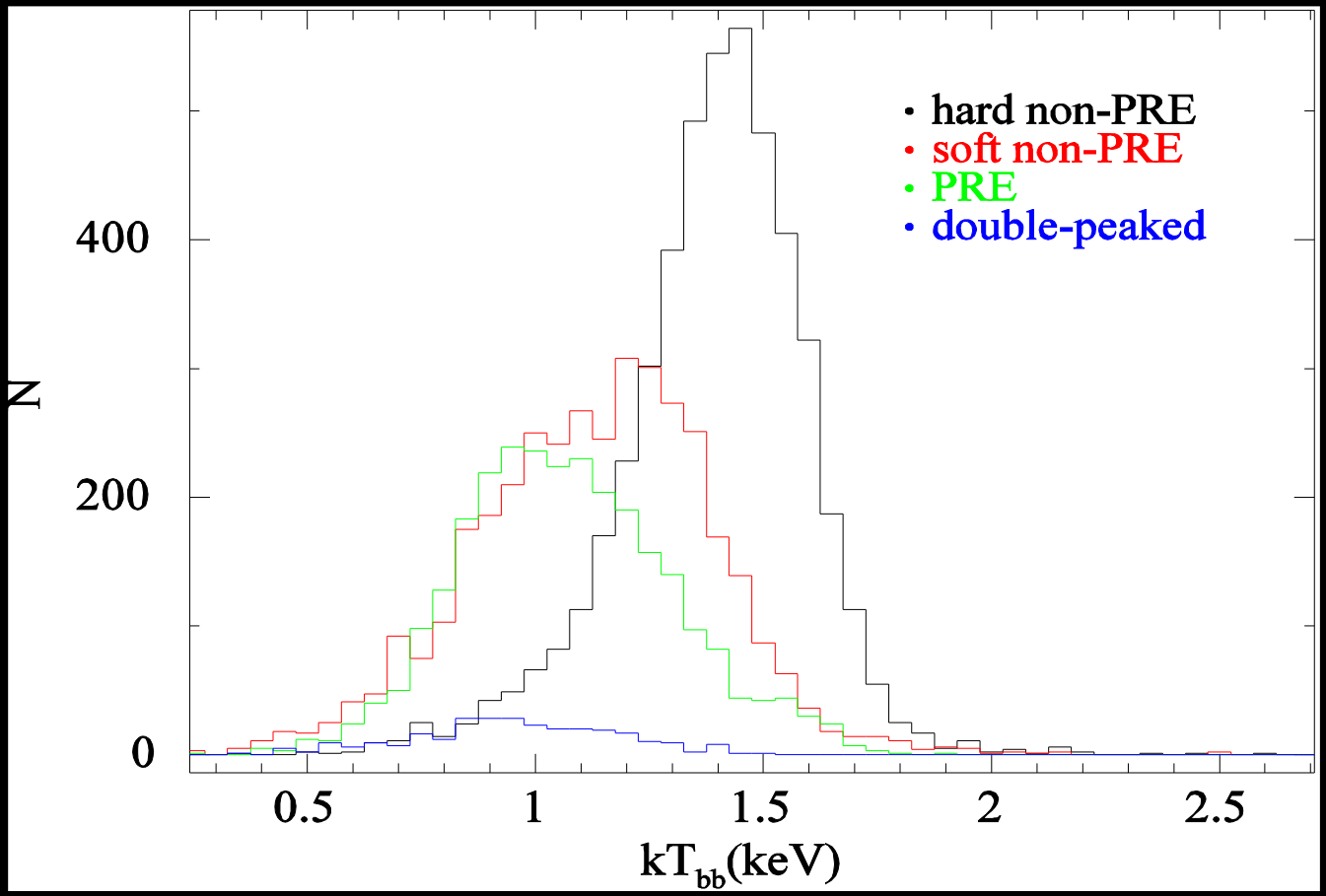
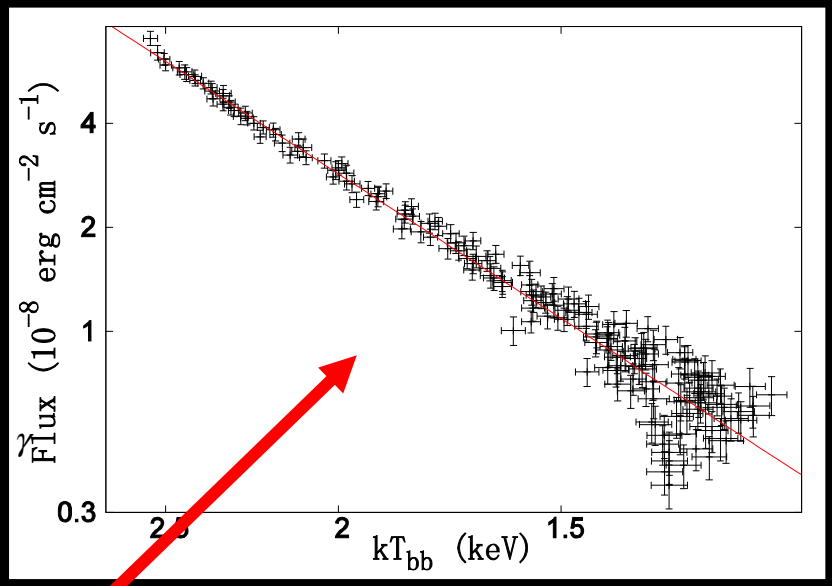


0-1.0×10−8 erg cm−2 s−1

Fitting the flux-temperature relation

Fitting with a power-law in different type bursts and different flux band.

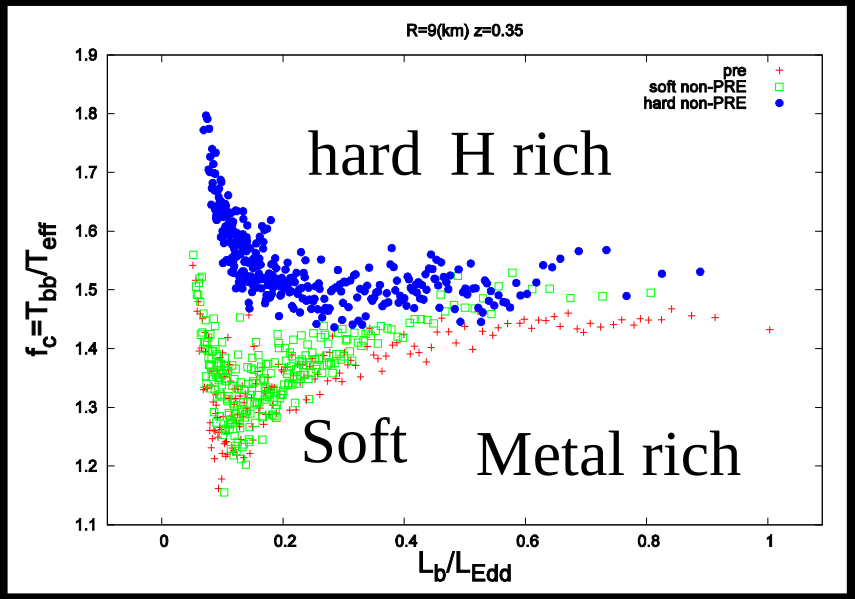
$$F_{\rm b} = \alpha T_{\rm bb}^{\gamma},$$



Flux range 10 ergcm s	all		Flux > 1.0		Flux > 2.0	
		γ		γ		γ
PRE	3.35	0.03	3.22	0.06	3.24	0.11
Soft non-PRE	3.23	0.04	2.91	0.06	2.96	0.13
Hard non-PRE	4.48	0.06	3.58	0.12	3.09	0.31

Color correction factor

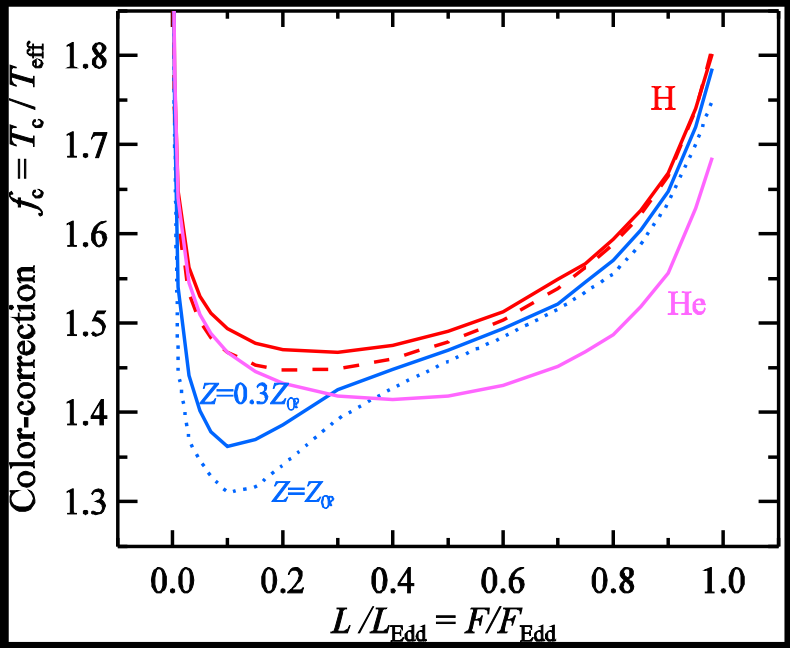
data



Zhang et al. 2011

$$f_{\rm c} = \sqrt{\frac{R_\infty}{d\sqrt{\frac{F}{\sigma T_{\rm bb}^4}}}} = \sqrt{\frac{R(1+z)}{d\sqrt{\frac{F}{\sigma T_{\rm bb}^4}}}},$$

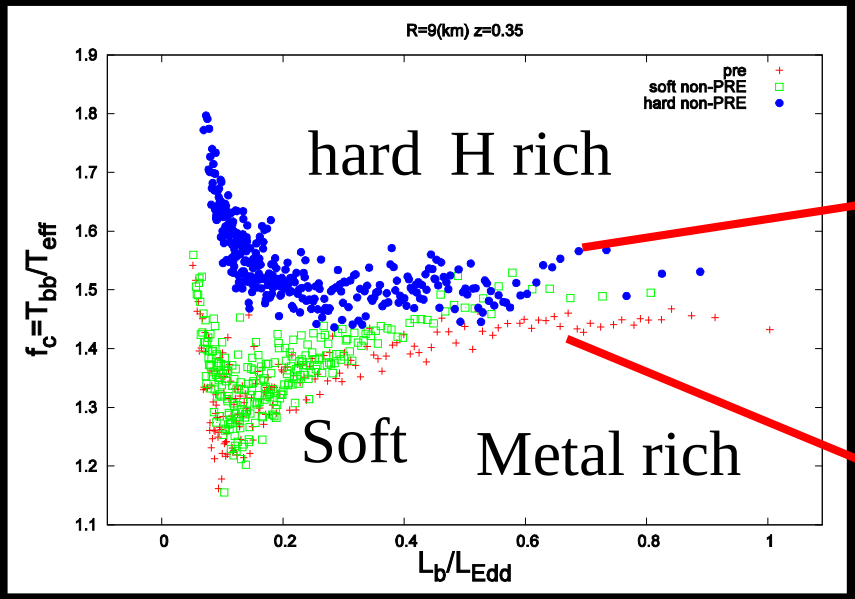
R=9 km, z= 0.35
and d=6.0 kpc

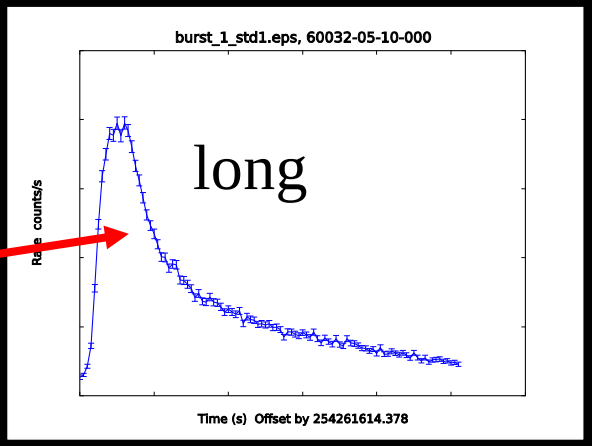


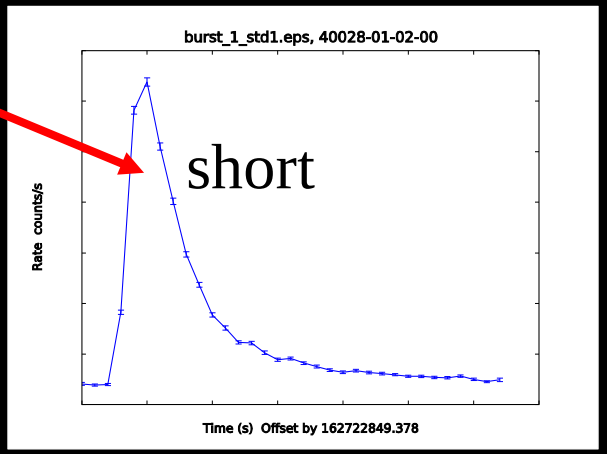
Suleimanov et al. 2010

Color correction factor

data







Zhang et al. 2011

$$f_c = \sqrt{\frac{R_\infty}{d\sqrt{\frac{F}{\sigma T_{bb}^4}}}} = \sqrt{\frac{R(1+z)}{d\sqrt{\frac{F}{\sigma T_{bb}^4}}}},$$

R=9 km, z= 0.35
and d=6.0 kpc

Summary 2

- Bursts in 4U 1636-53 don't follow $F_b \sim T_{bb}^4$
- The average $F_b \sim T_{bb}$ relation is different in for PRE , hard non-PRE and soft non-PRE bursts.
- The temperature distribution at different flux levels is significantly different for different type bursts.
- Hard non-PRE bursts ignite in a hydrogen-rich atmosphere, soft non-PRE and PRE bursts ignite in a metal-rich atmosphere.
- Metal abundance in the NS atmosphere decrease as the bursts decay.