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Equation of state constraints for the dense matter inside neutron stars:

The cooling tail method

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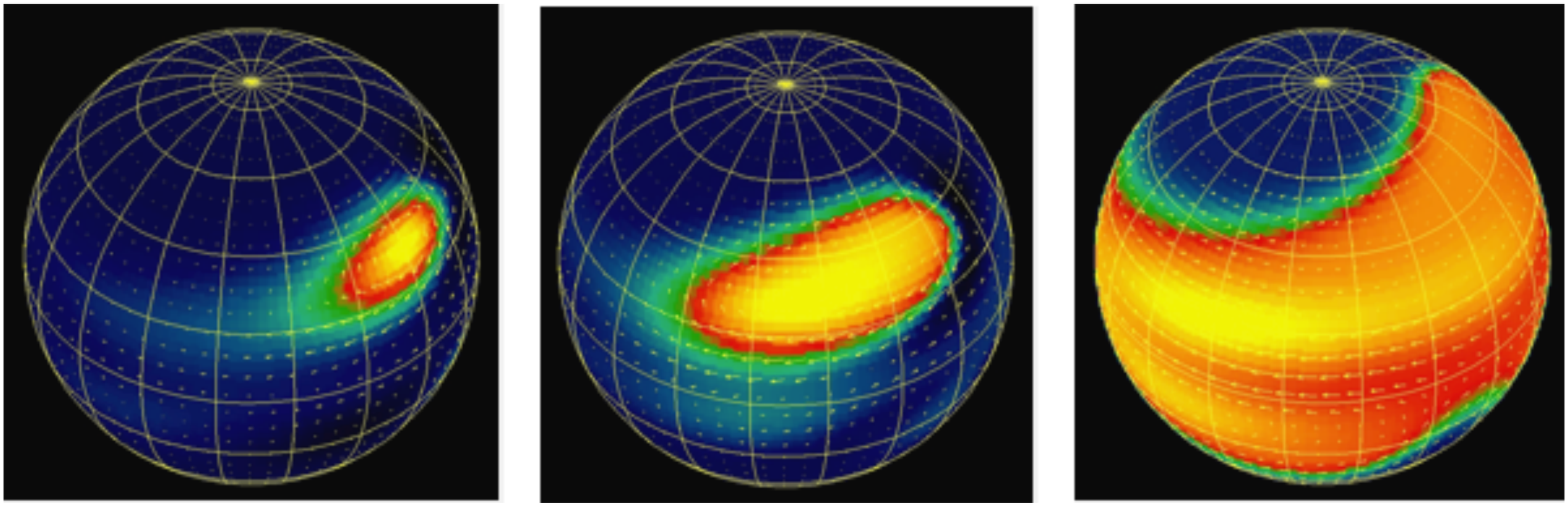
Thermal emission from the surface layers: X-ray bursts

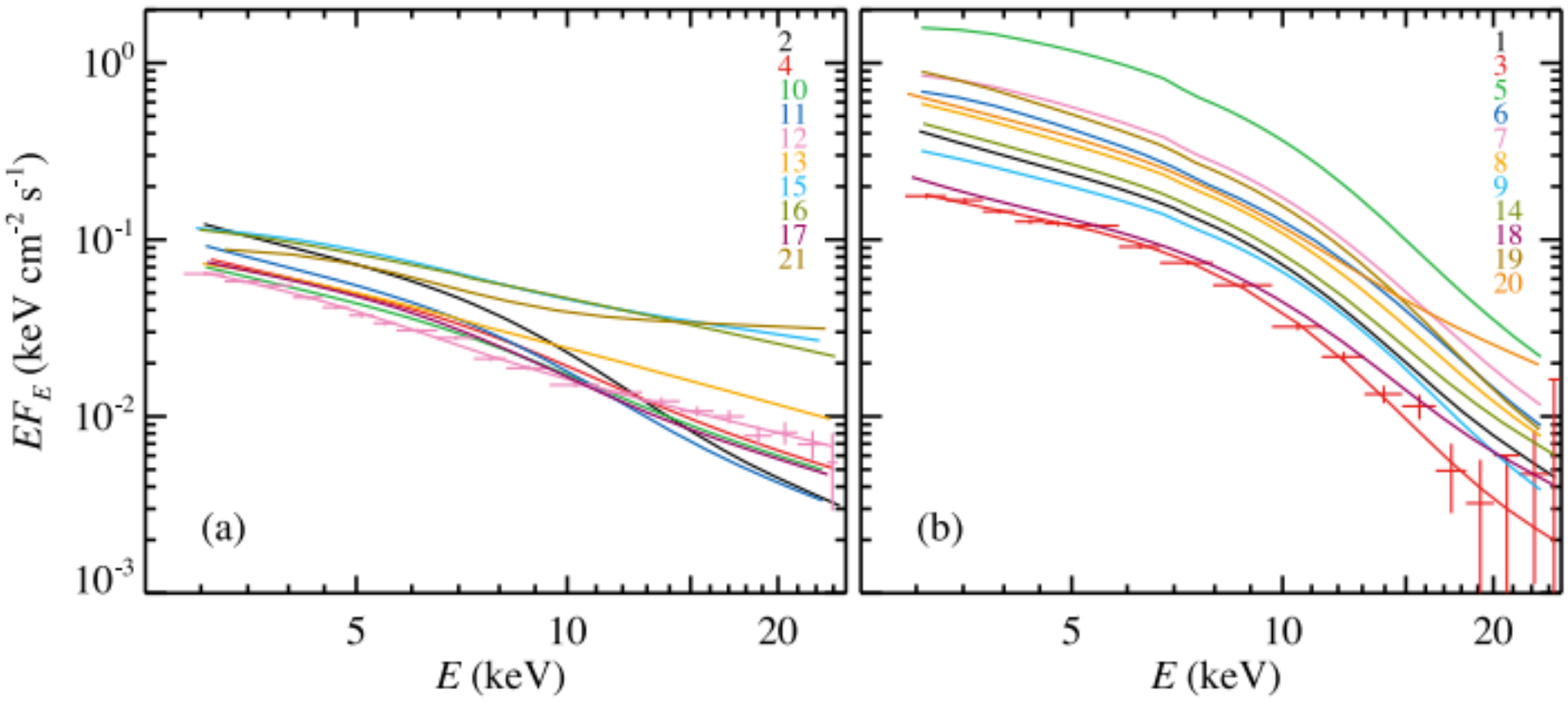


A. Spitkovsky

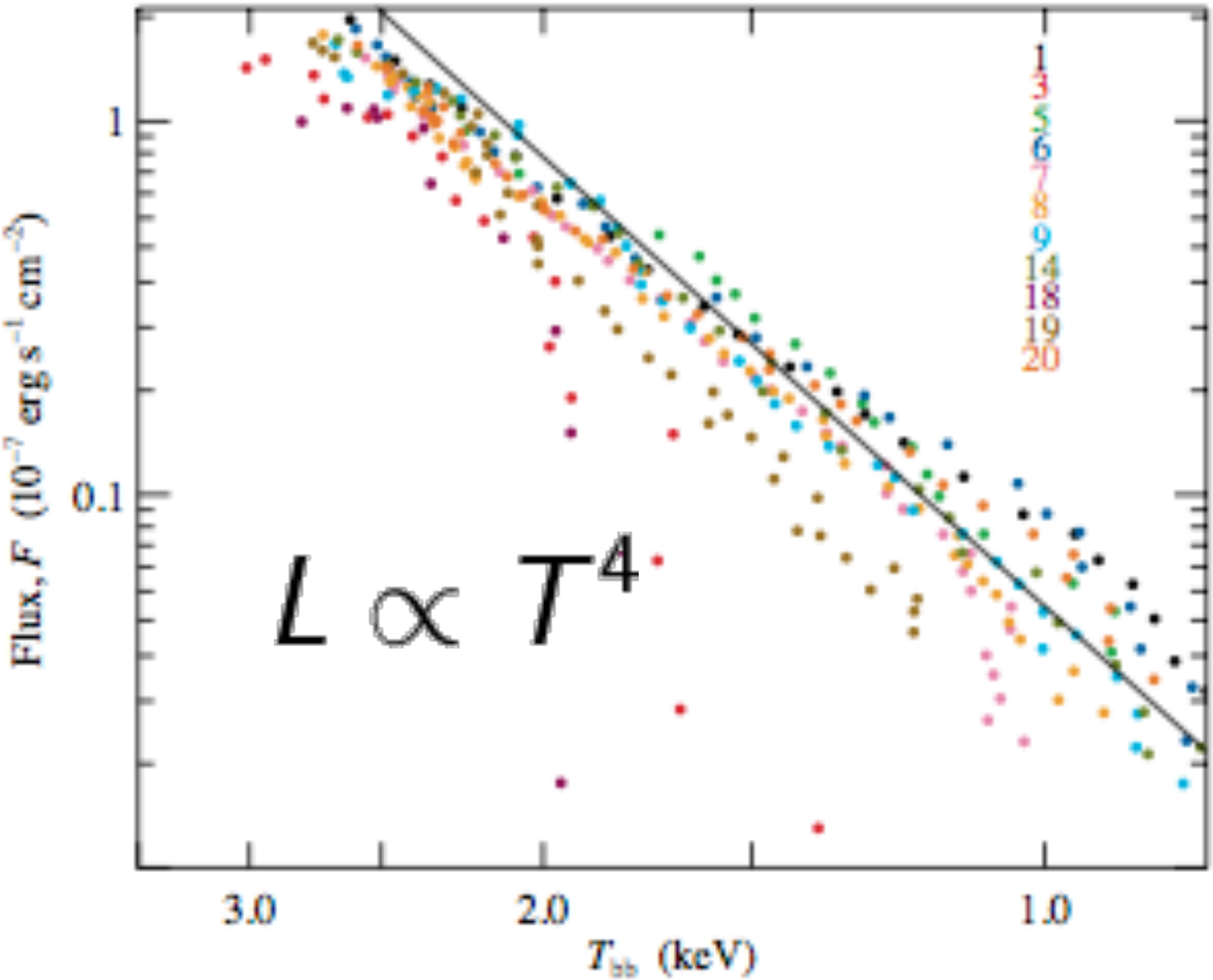
- Emission from the bursts contains a lot of information about the neutron star

Photospheric Radius Expansion bursts

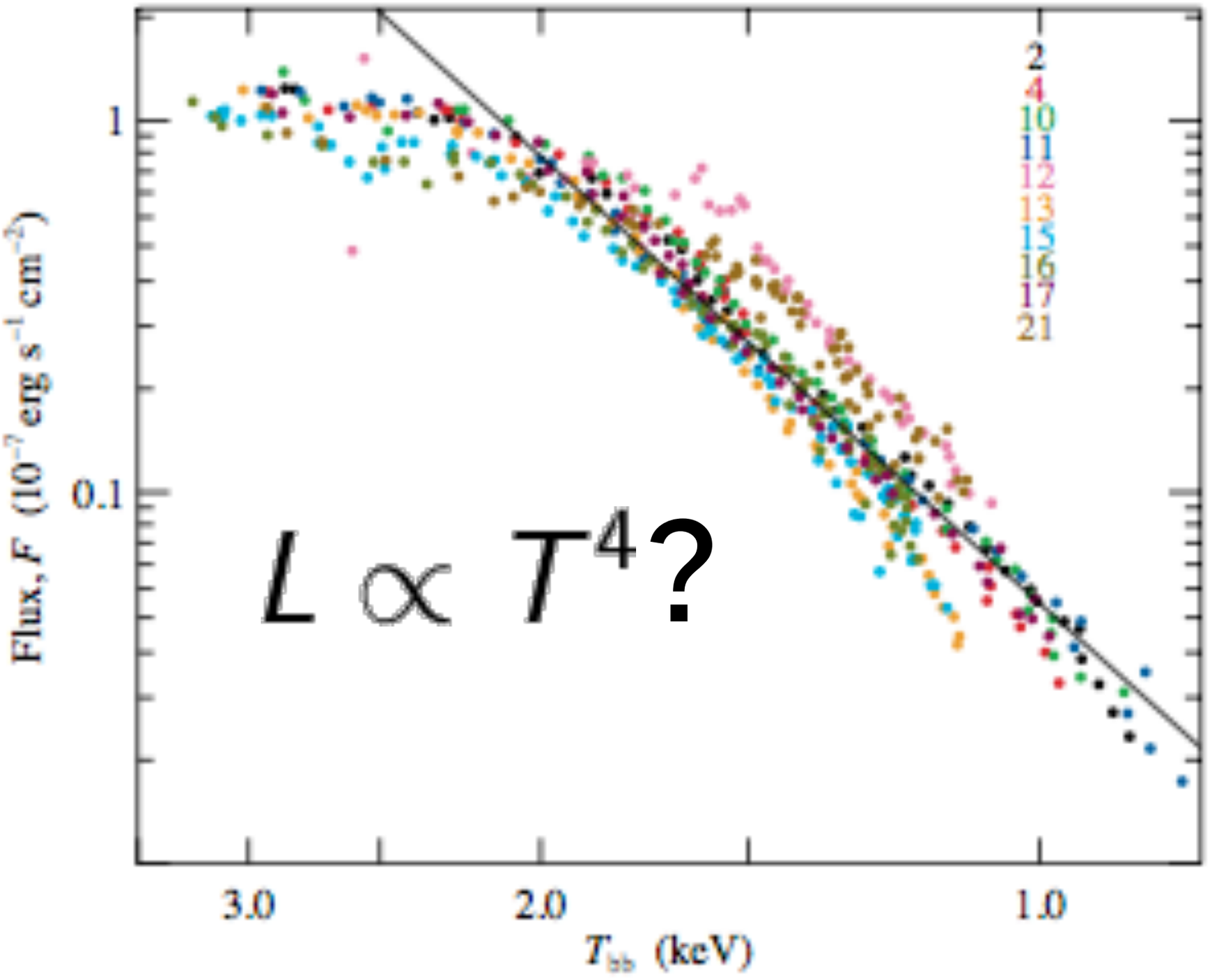
- Roughly 2 kinds of bursts
  - Hard state bursts (with low accretion)
  - Soft state bursts (with high accretion)



Soft state bursts



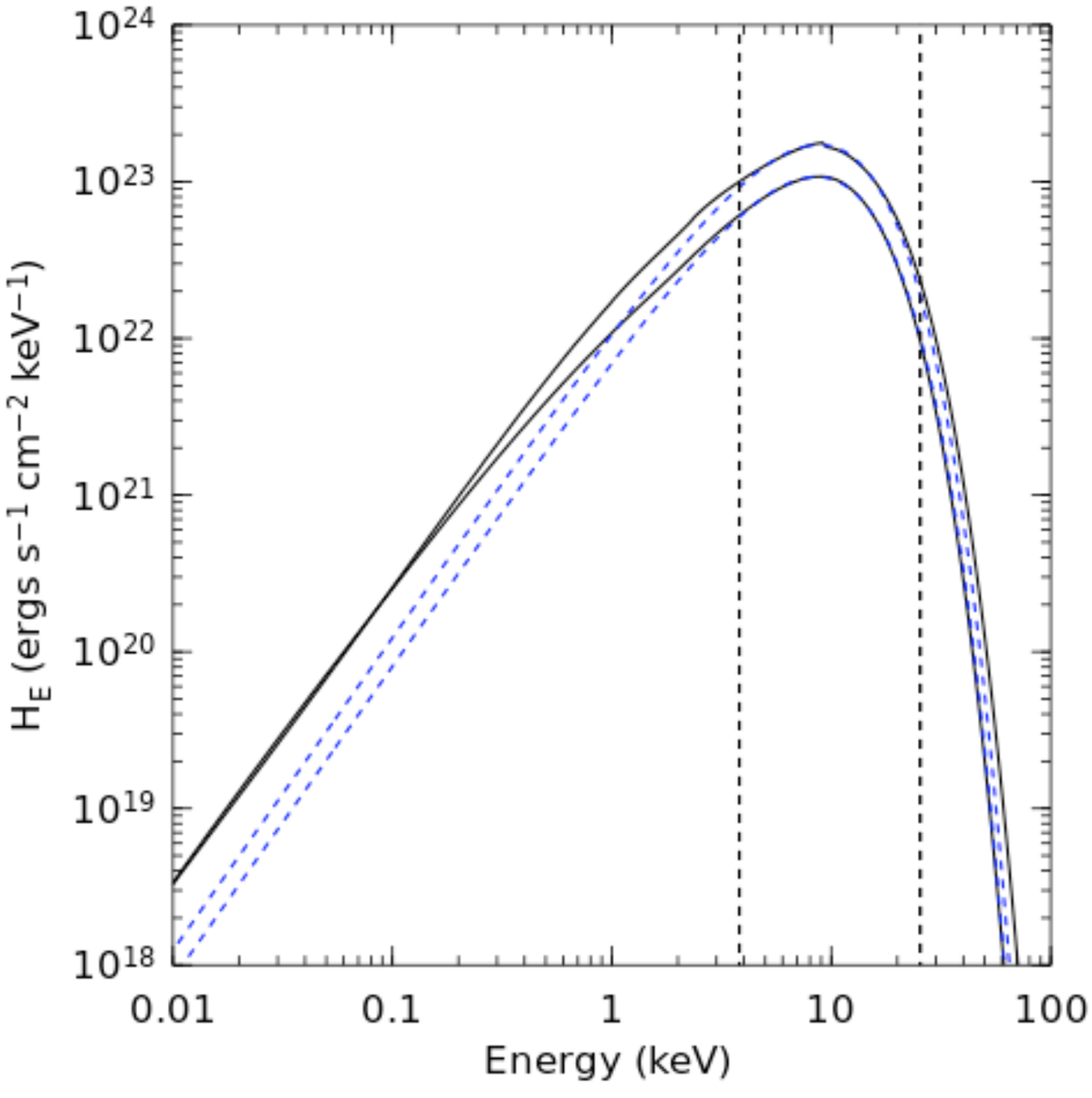
Hard state bursts



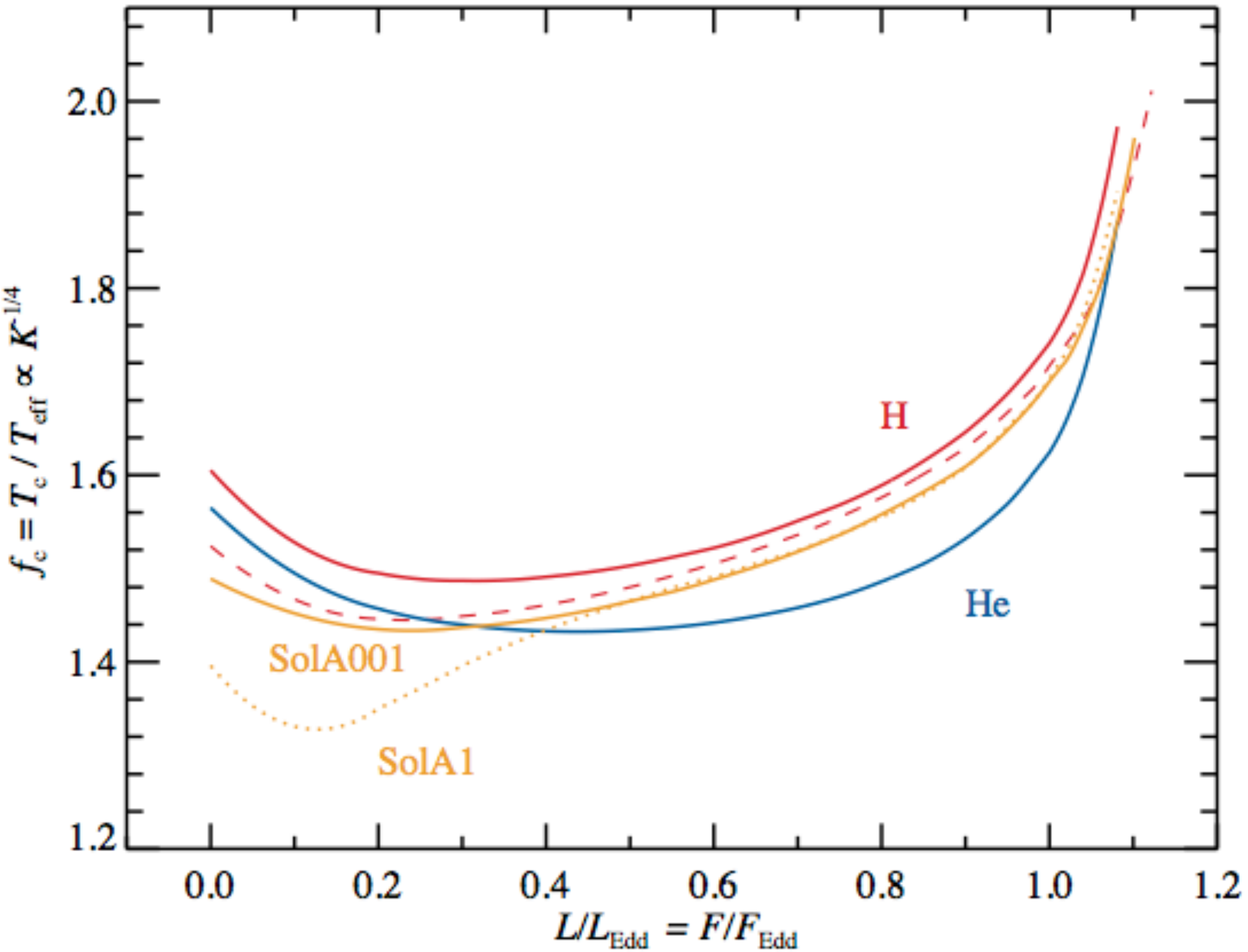
Atmosphere models: emerging spectrum

Well described by diluted black body (in range 2.5 - 25.0 keV)

$$F_{\mathrm{E}} = \frac{1}{f_{\mathrm{c}}^4} B_{\mathrm{E}}(T_{\mathrm{c}} = f_{\mathrm{c}} T_{\mathrm{eff}})$$



Color-correction factor f_c



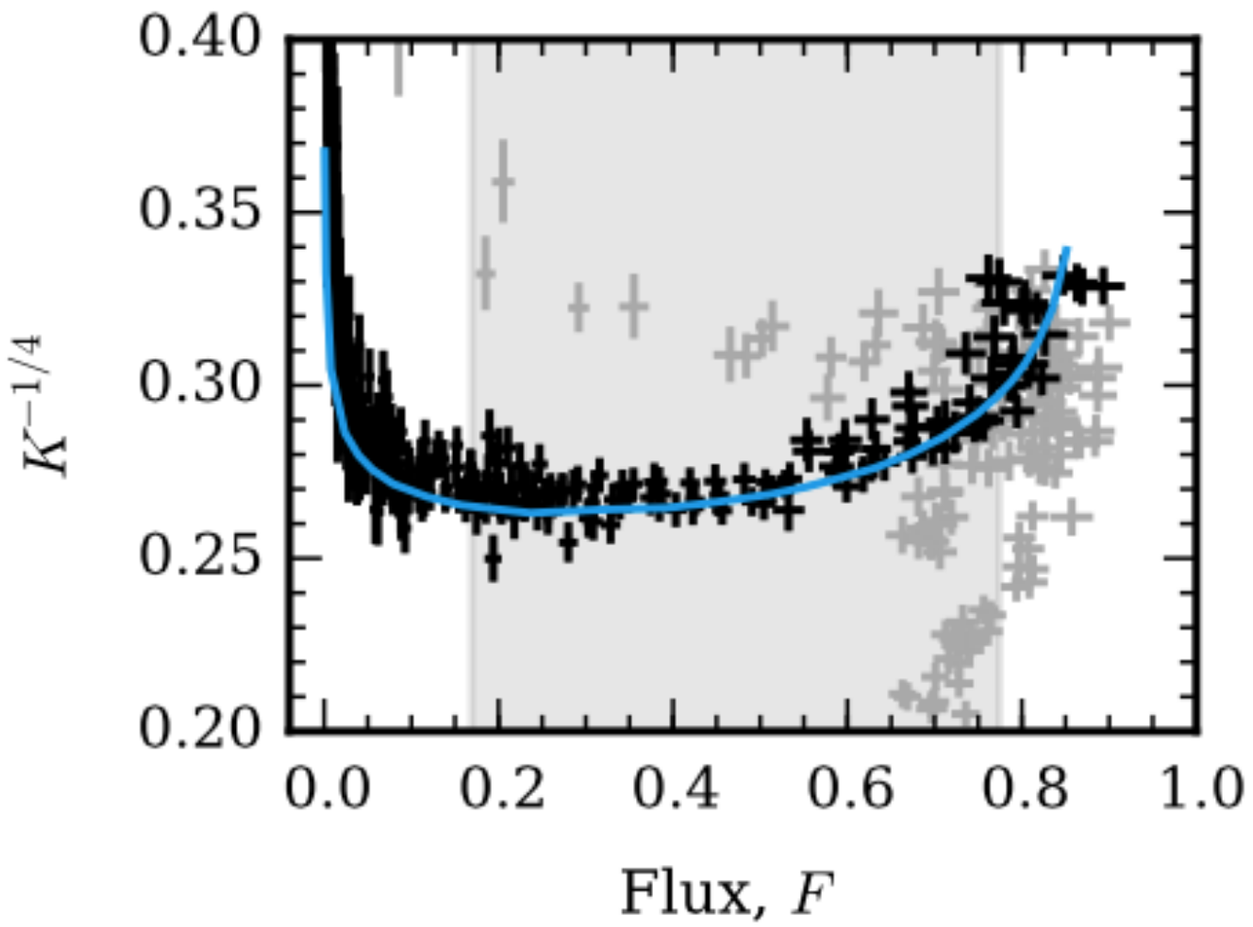
Color-correction factor f_c

- Models: $$F_E = \frac{1}{f_{\rm c}^4} B(f_{\rm c} T_{\rm eff})$$

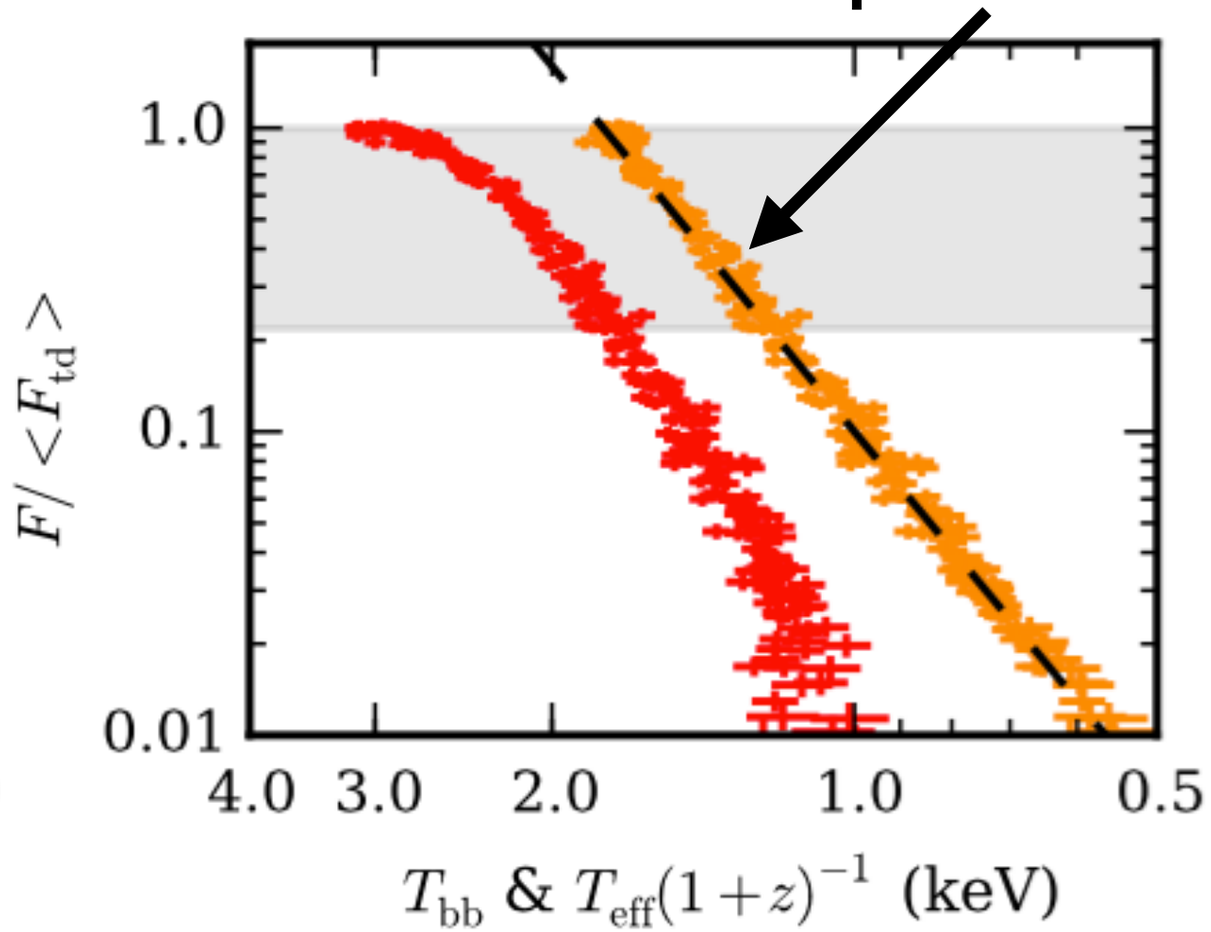
- Observations: $F_E = K_{\rm bb} B(T_{\rm bb})$

$$f_{\rm c} \propto K_{\rm bb}^{-1/4}$$
$$T_{\rm bb} \propto f_{\rm c} T_{\rm eff}$$

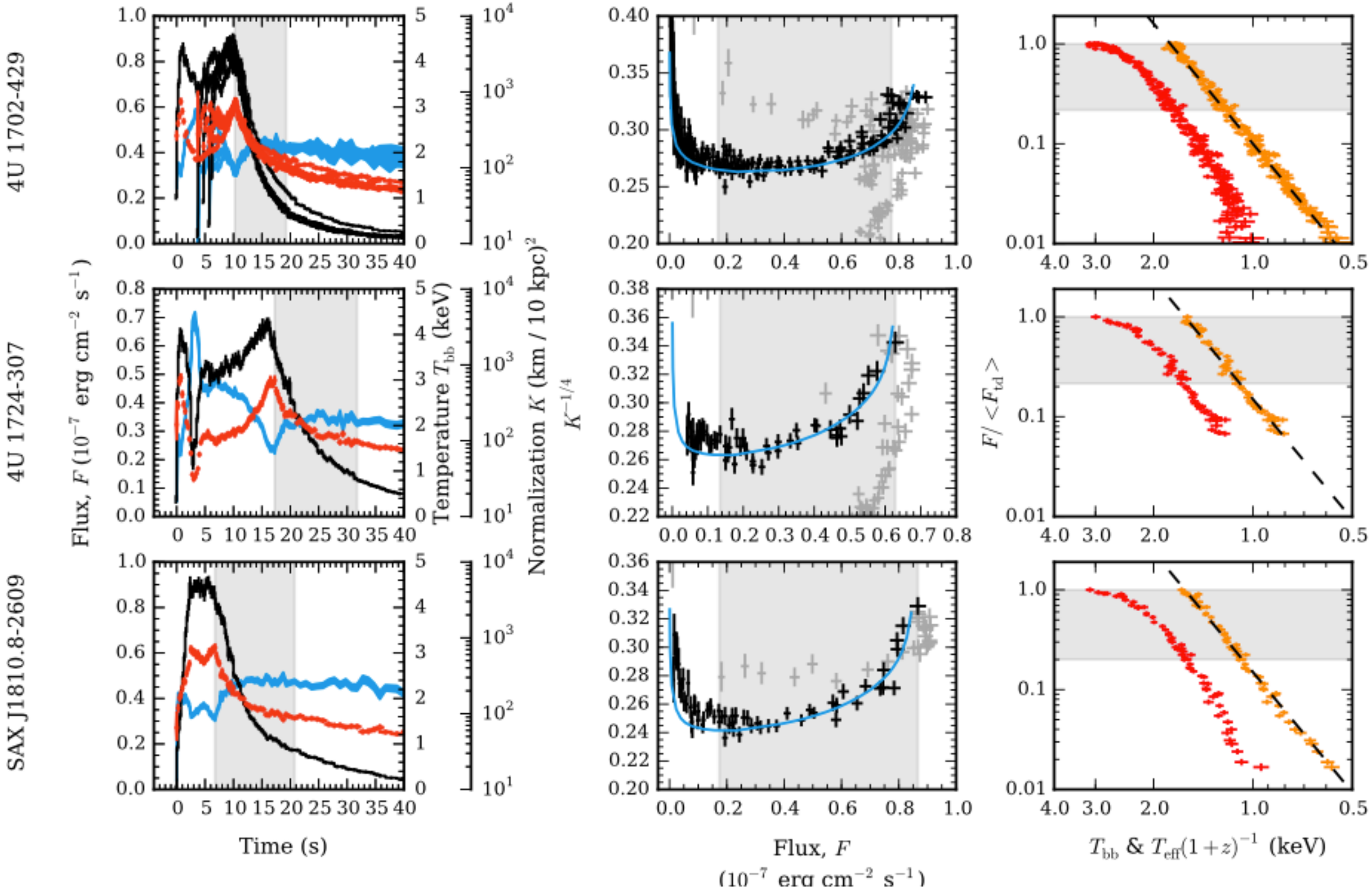
Observations with hard state bursts



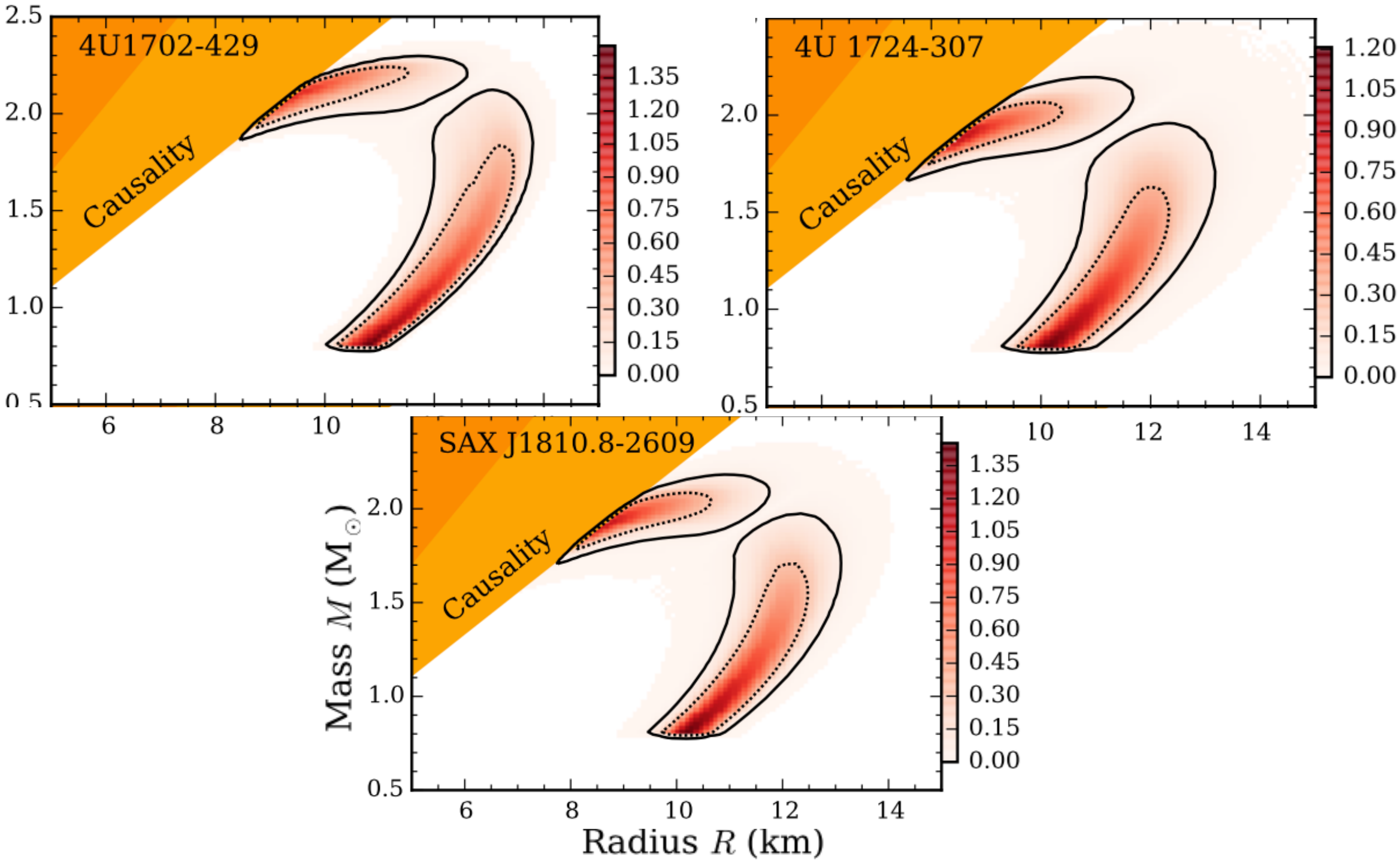
Color corrected temperature



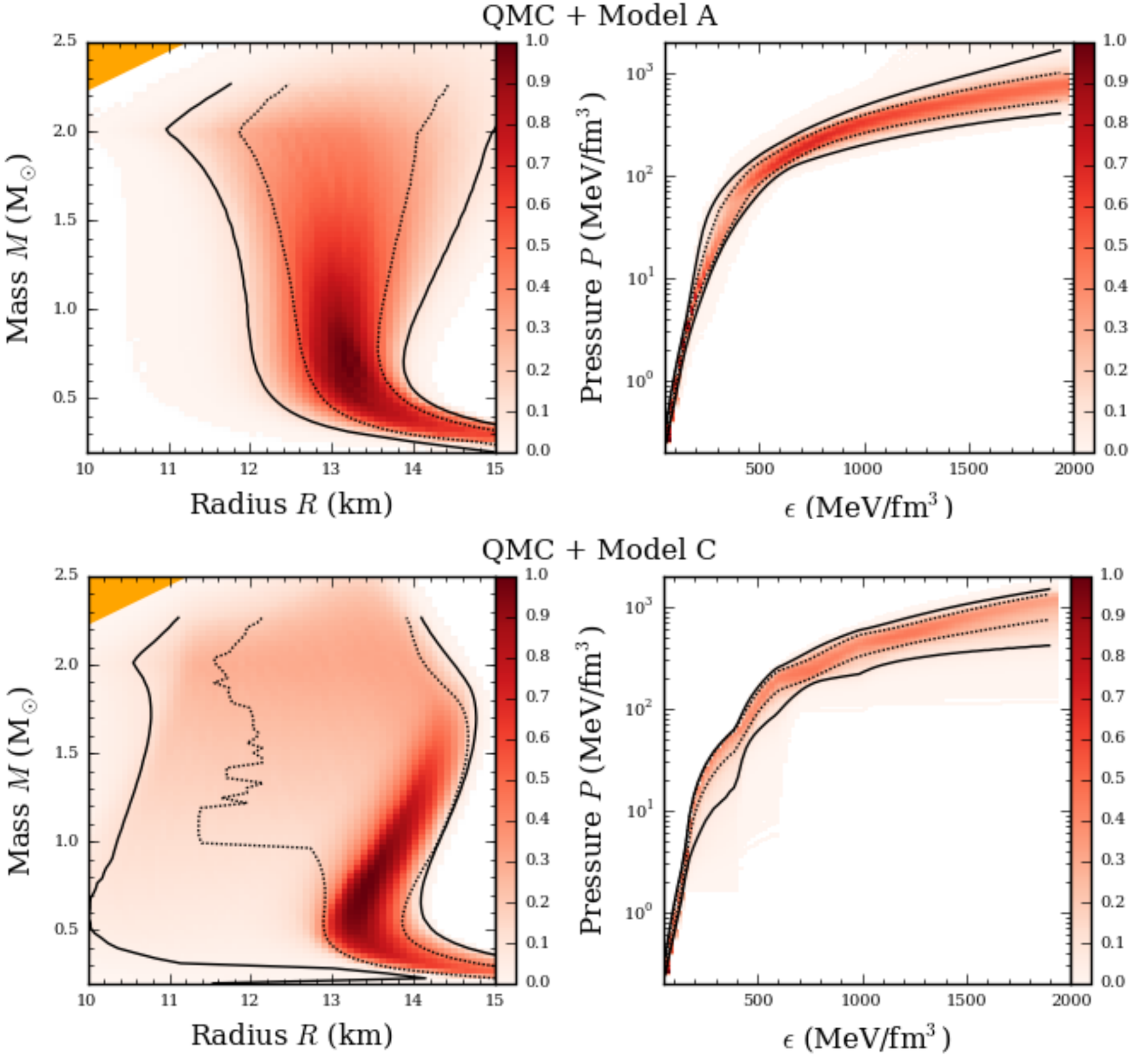
Observations with hard state bursts



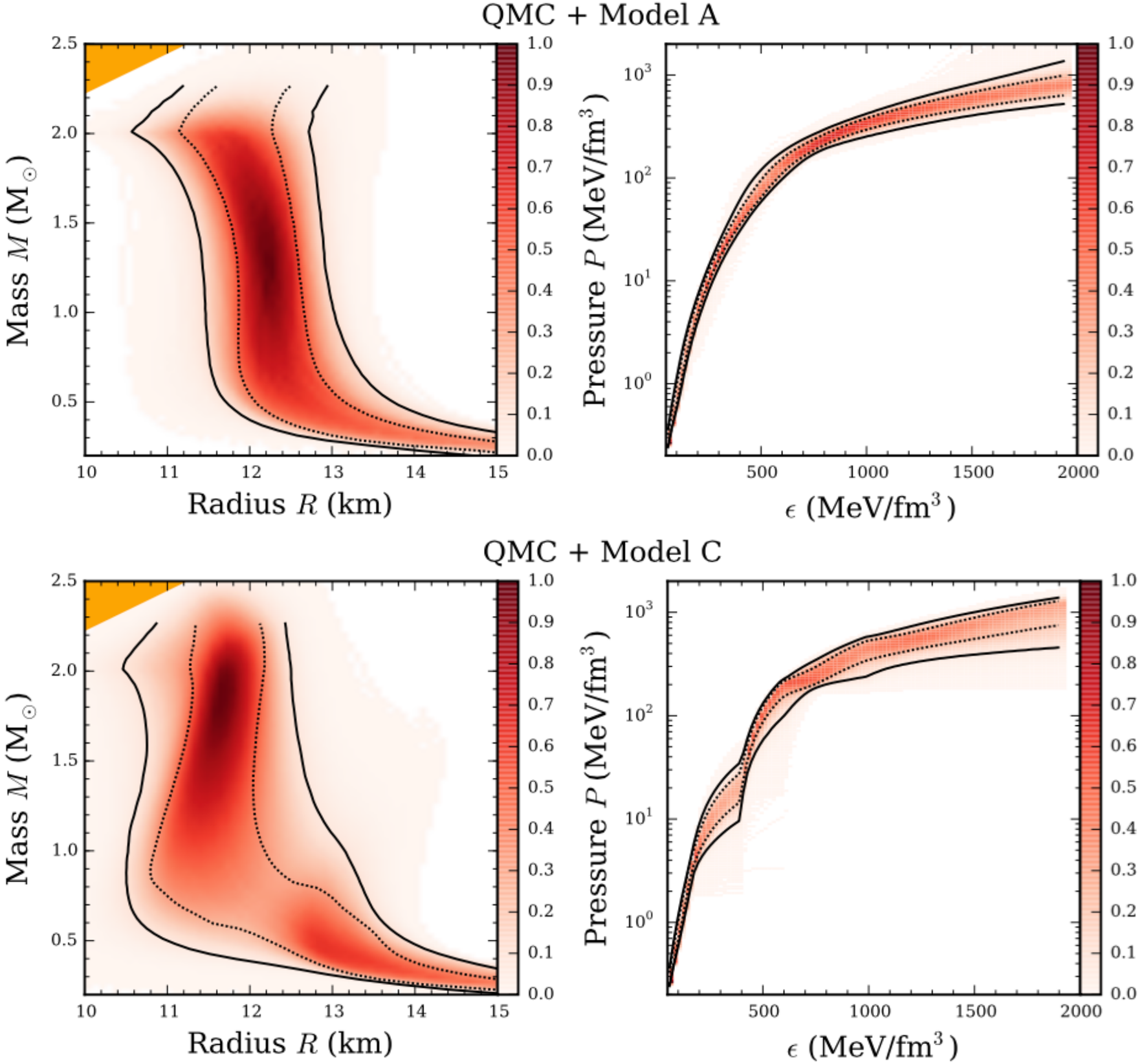
Mass and radius constraints from hard state bursts



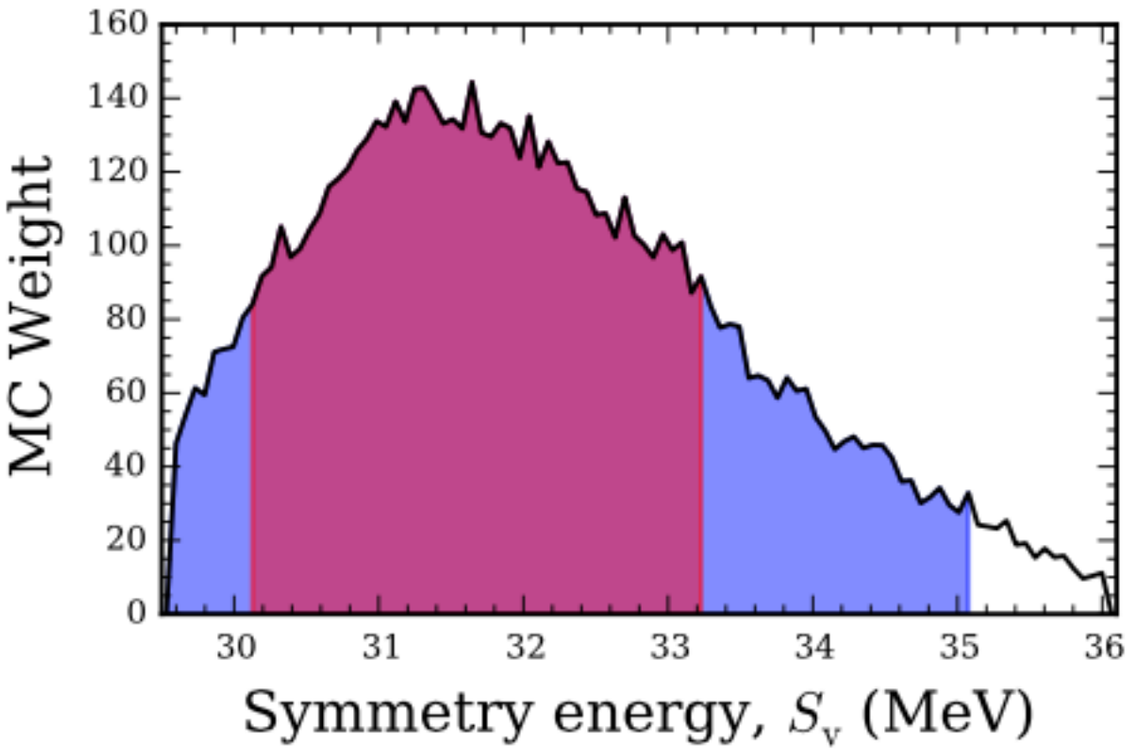
Parameterized EoS

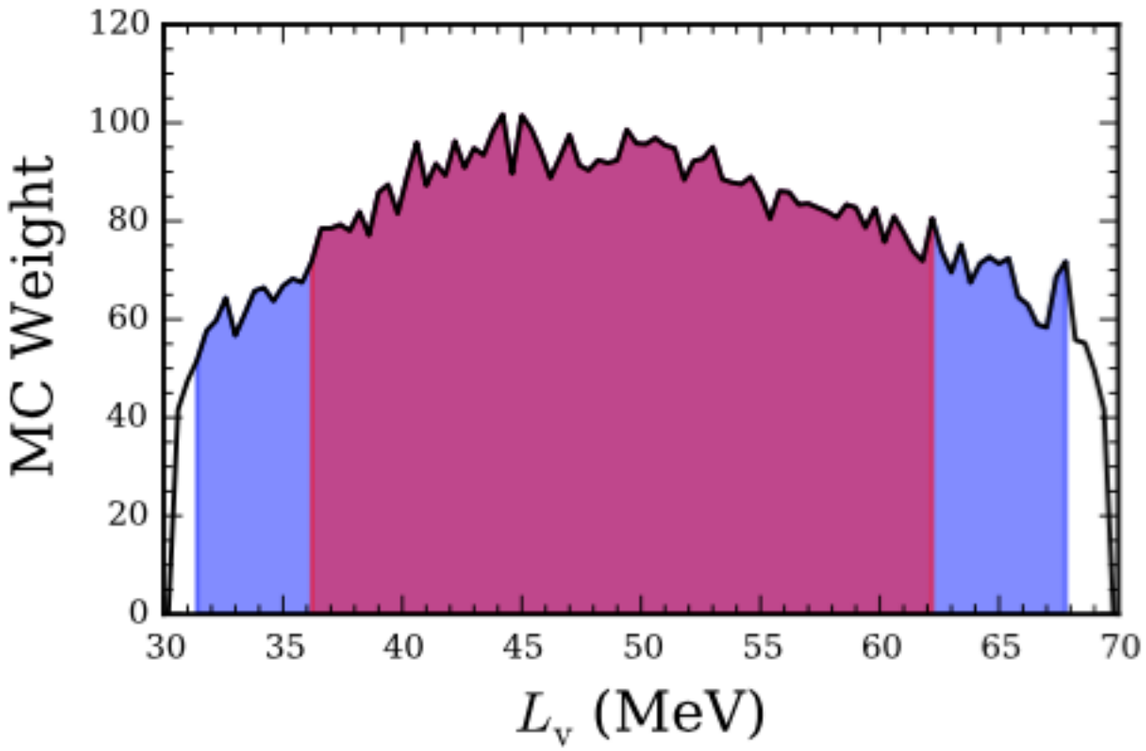


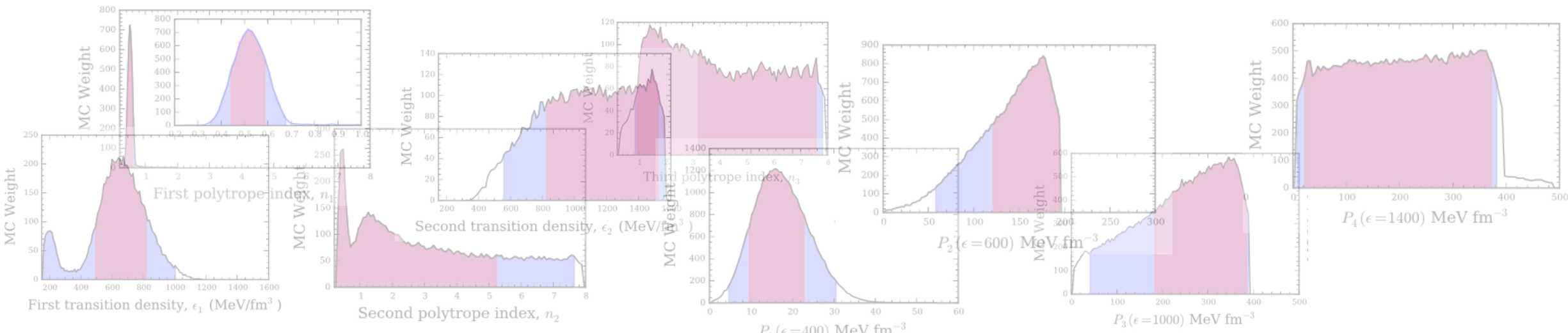
Parameterized EoS from the data



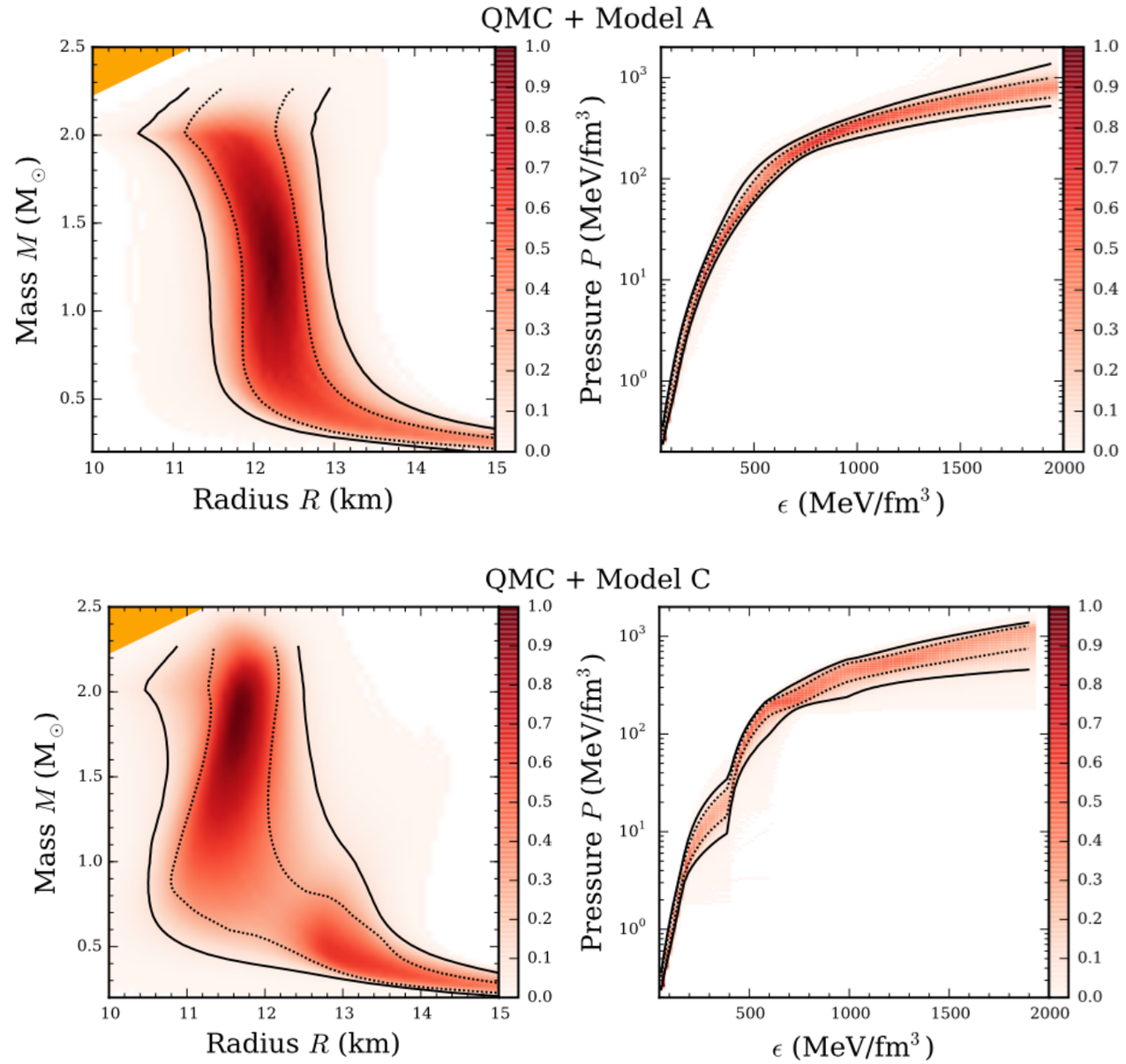
Parameterized astrophysical EoS: A probe for nuclear parameters



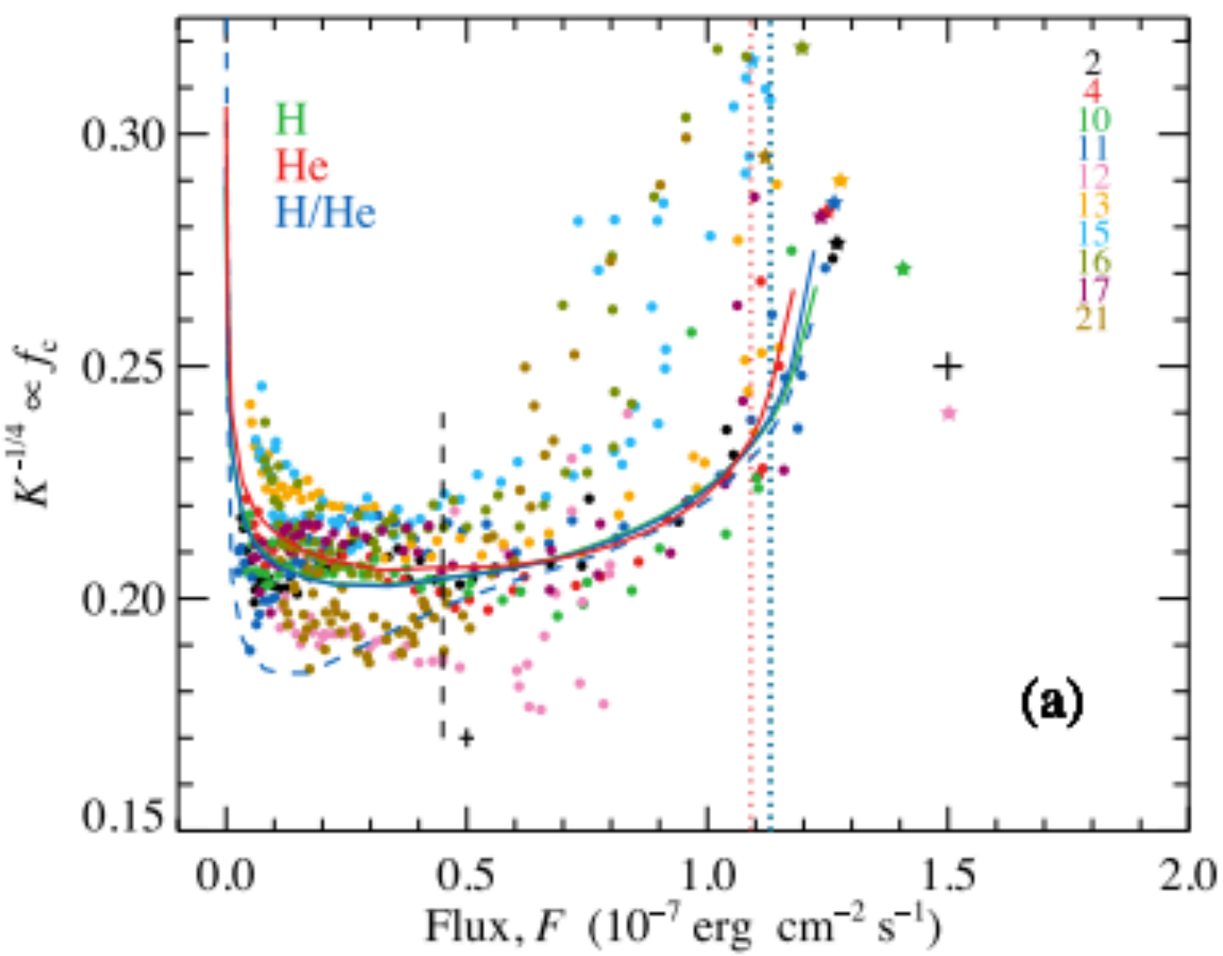


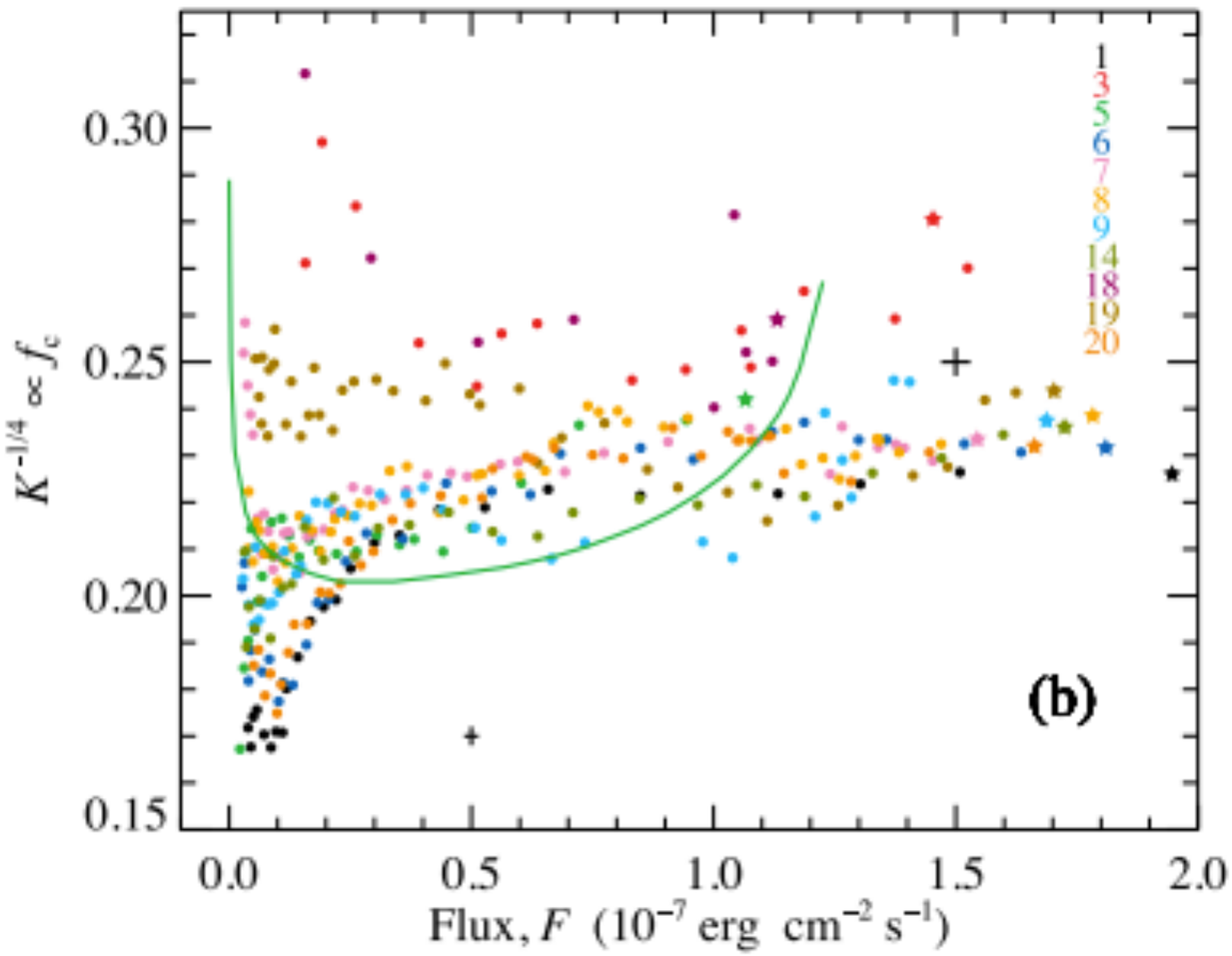


Thanks!

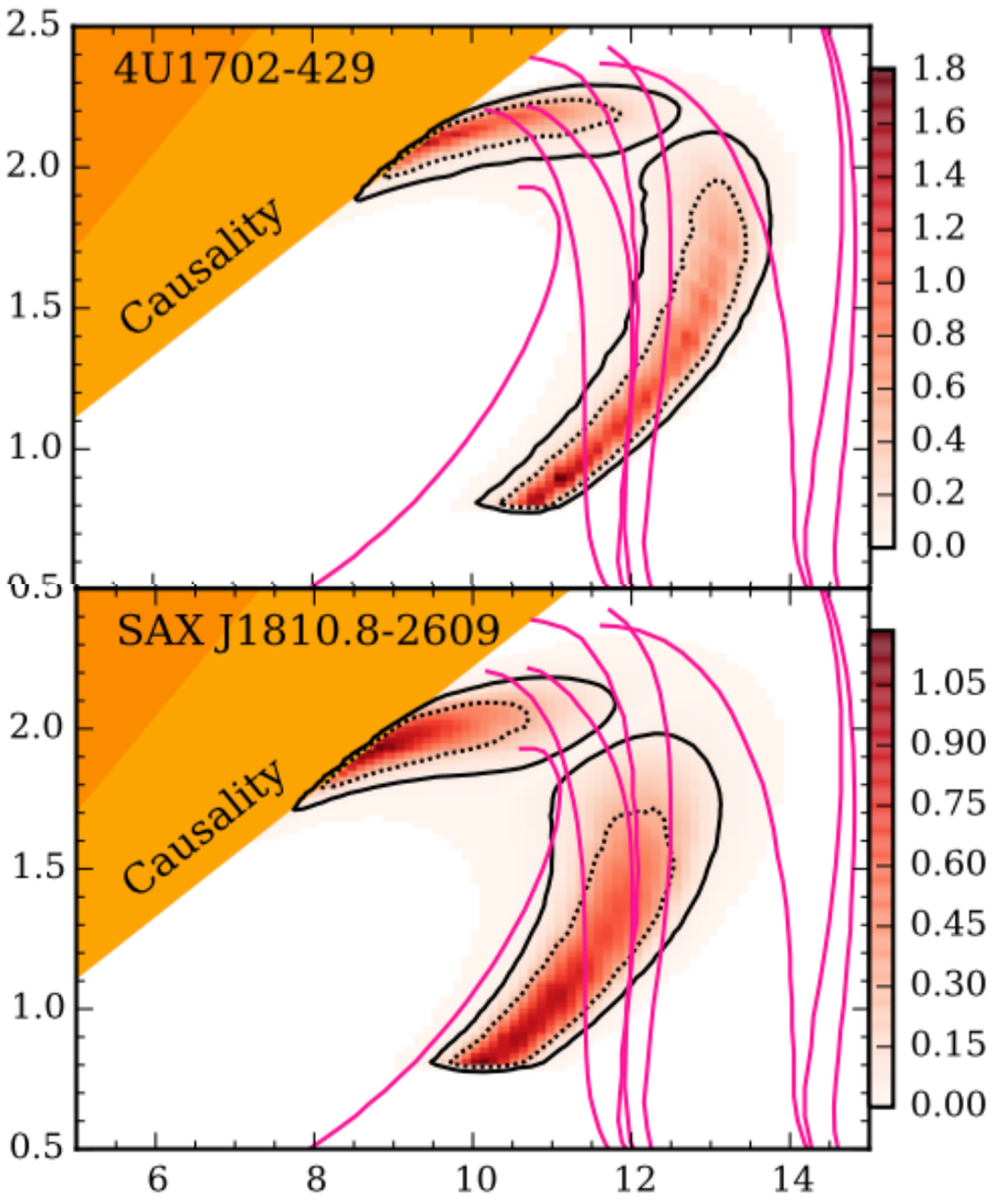

QMC + Model A
Mass M ($M_\odot$)
Radius R (km)
Pressure P (MeV/fm^3)
ϵ (MeV/fm^3)
QMC + Model C
Mass M ($M_\odot$)
Radius R (km)
Pressure P (MeV/fm^3)
ϵ (MeV/fm^3)

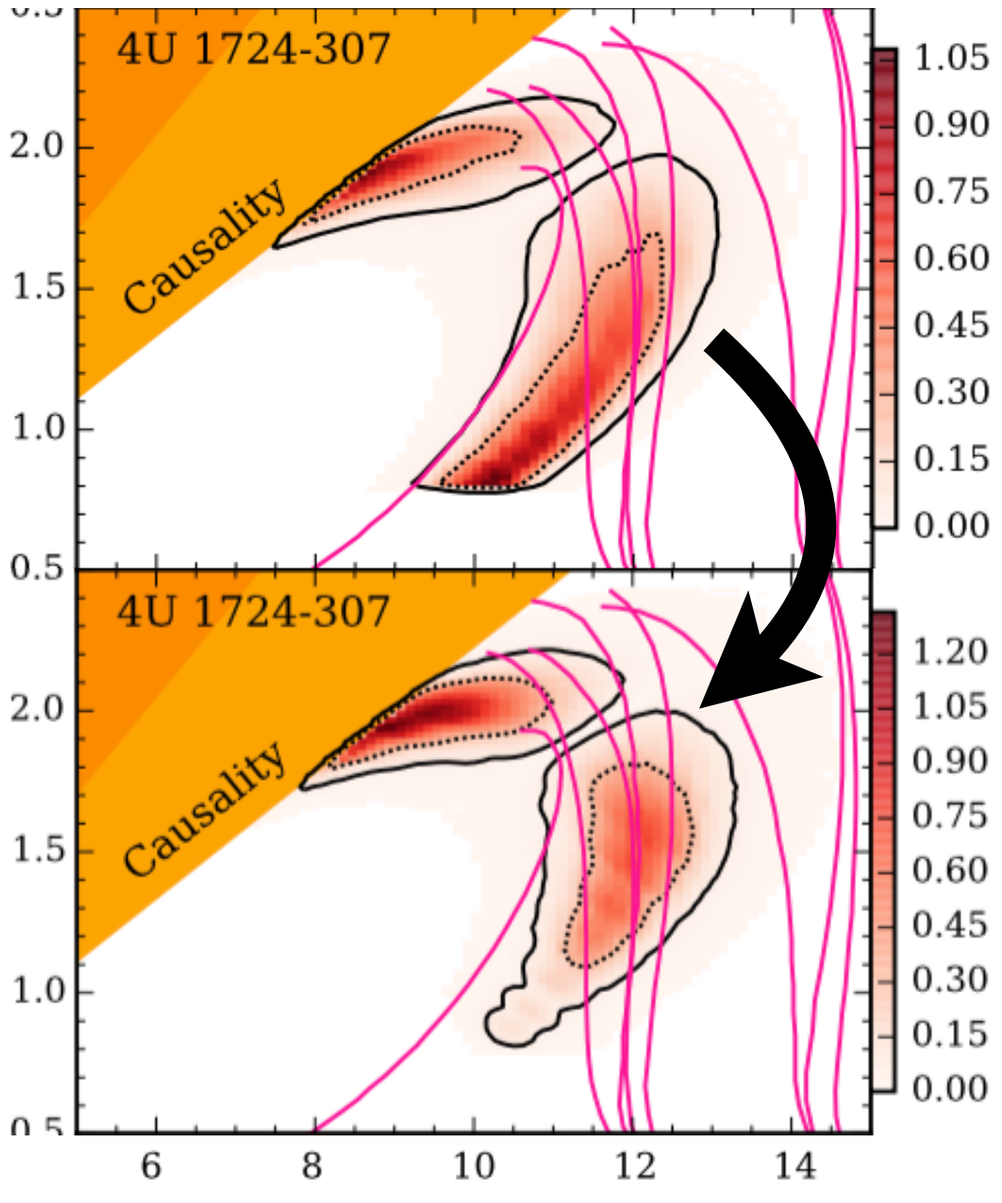
Soft vs. hard state bursts





Effect of distance: Uninformative priors





No information of distance

Boxcar distance prior from 5.3 to 7.7 kpc