湘潭大學

The absorption edge in a X-ray burst from GRS 1747-312/Terzan6

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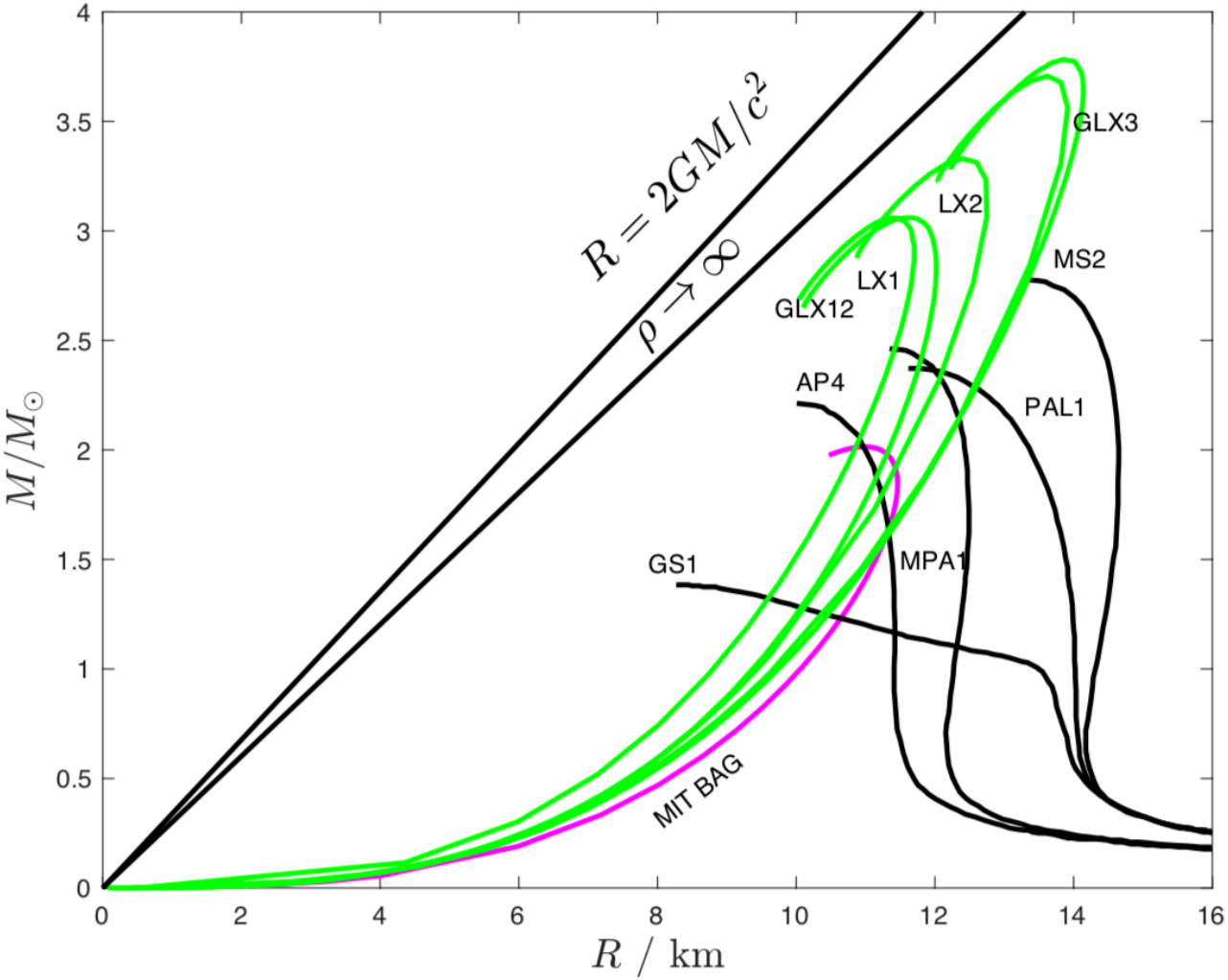
@Guangzhou, 07-06-2018

NS Equations of State



Gravity bound

Hadron star

Hybrid star

Hyperon Core

(R > 13 km)

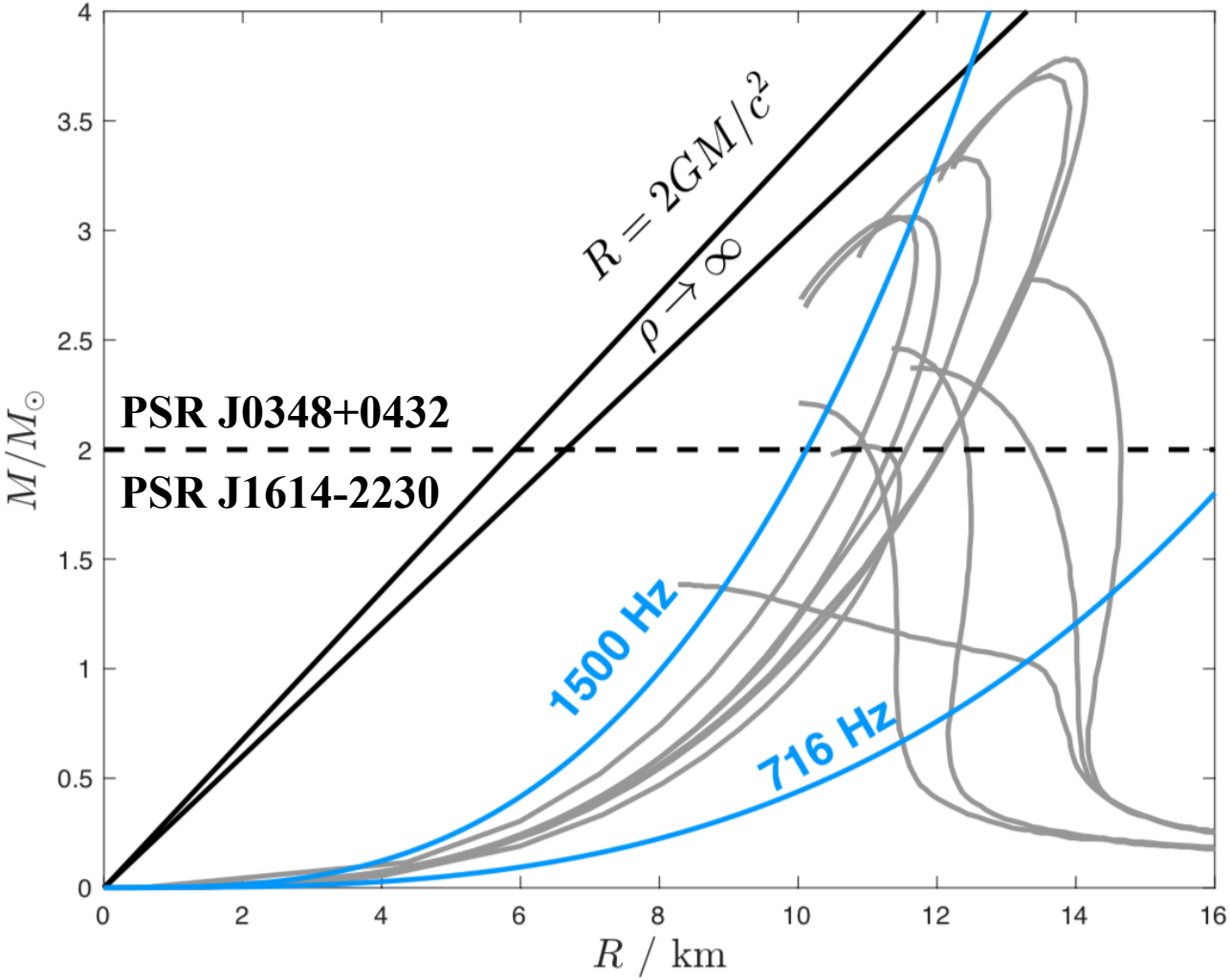
Fortin et al.(2014)

Self-bound on surface

Strangeon star

Lai & Renxin Xu (2009)

NS Equations of State



Massive NS

Low-mass NS

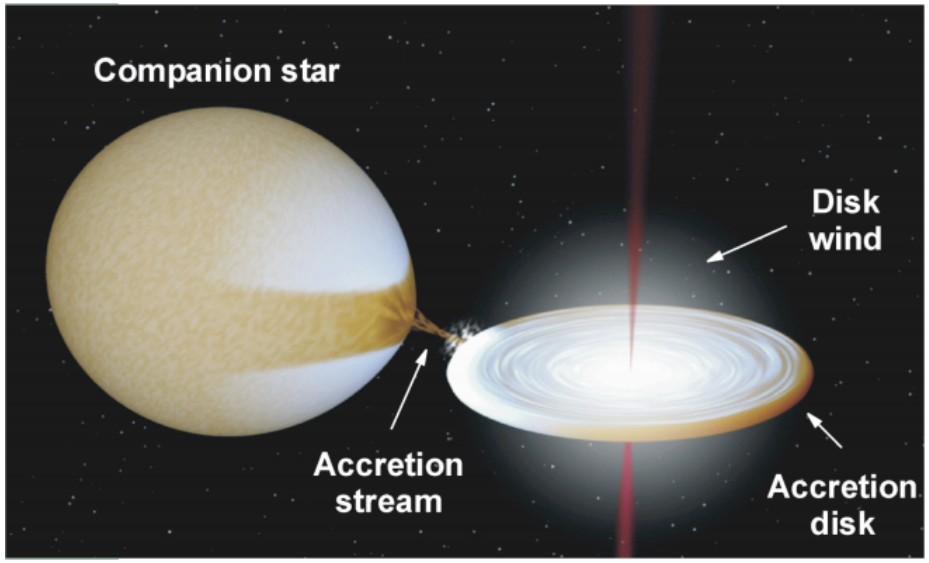
Measure M-R precisely

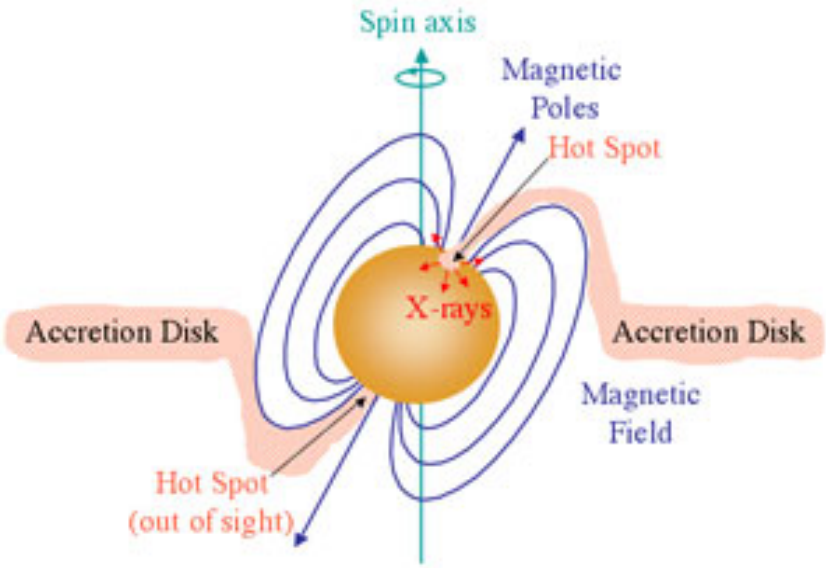
Submillisecond pulsar

Outline

- **M-R of NS**
- **The case of GRS 1747-312**
- **Conclusions**

Low-mass X-ray binary

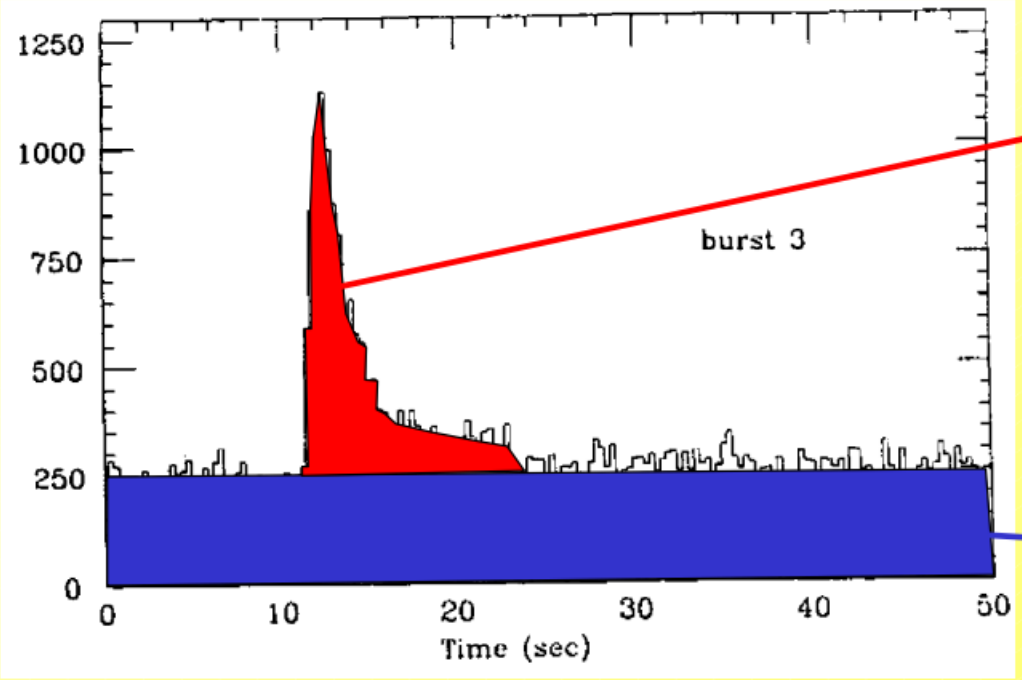




$L_X \sim 10^{36}$-10^{38} erg/s

Type I X-ray bursts

- **H burning via: CNO cycle** **6.7 MeV/u**
- **He burning via: $\alpha+\alpha+\alpha \rightarrow {}^{12}C$** **0.6 MeV/u**



Burst energy (thermonuclear energy)

Persistent flux (gravitational energy)

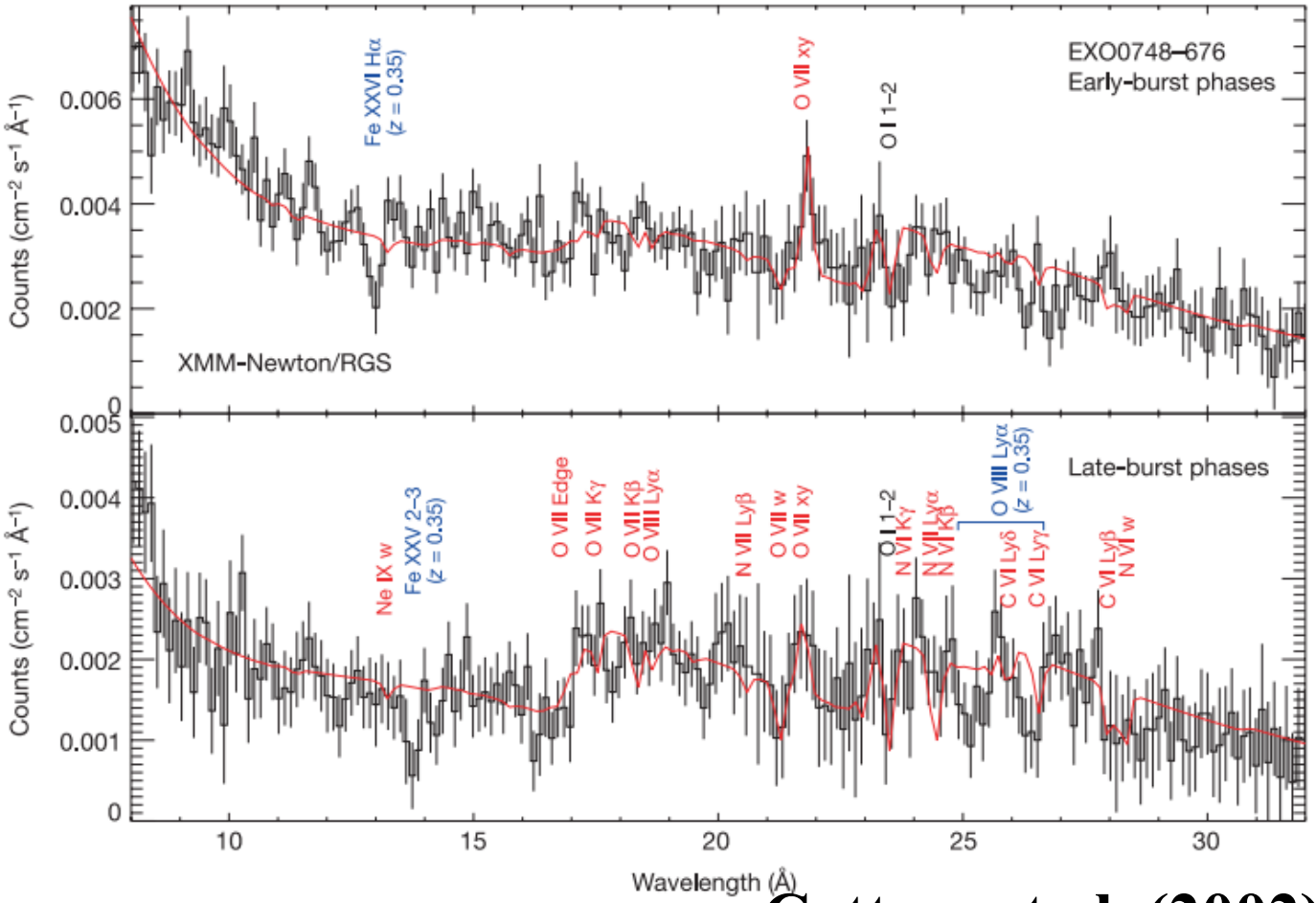
Gravitational Redshift

- **EXO 0748-676 (*XMM-Newton*/RGS)**

$$1+z(R) = (1-2GM_{\rm NS}/Rc^2)^{-1/2}$$

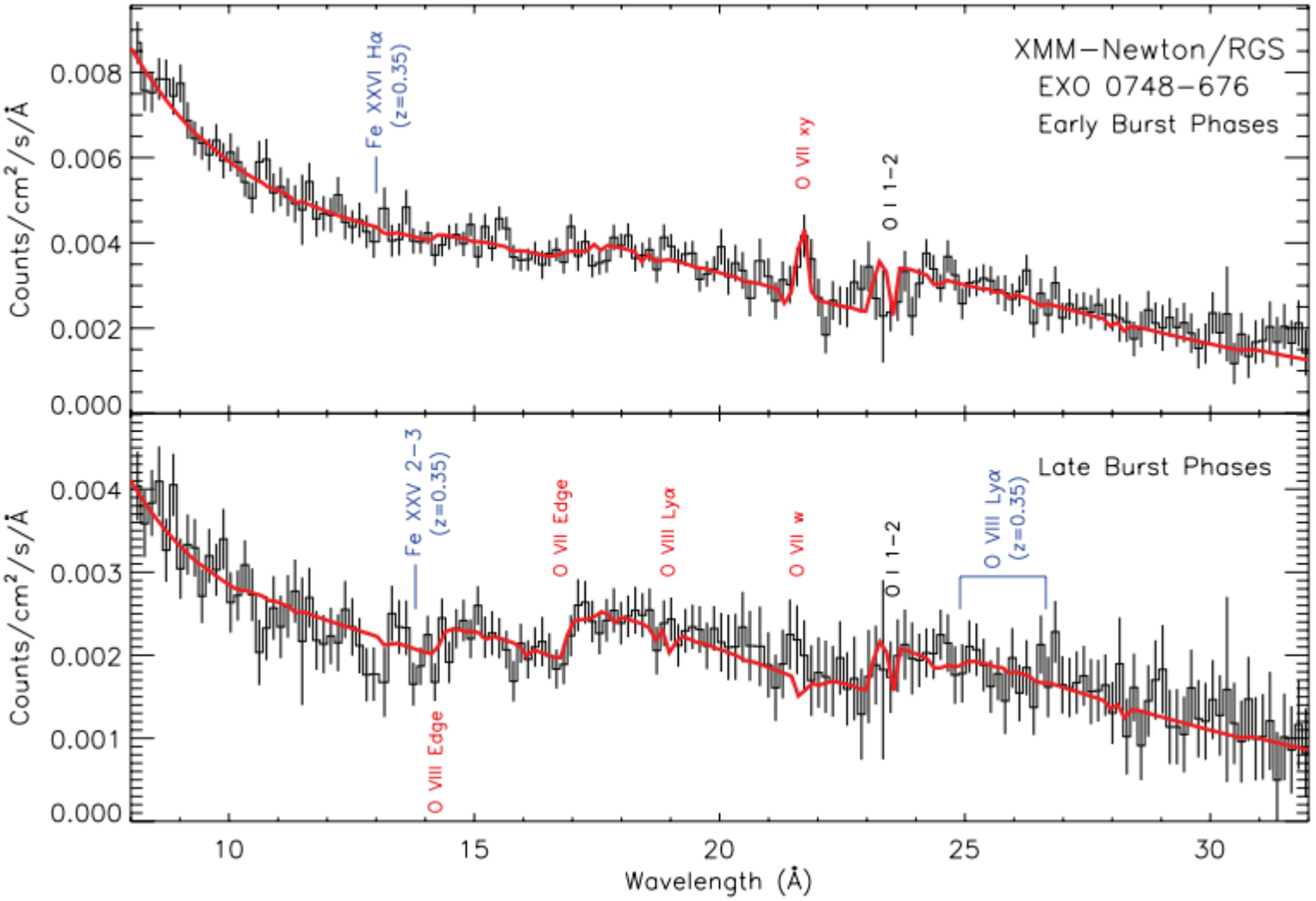
Z=0.35

Fe XXVI (Hα)
Fe XXV (He-like)
O VIII



Cottam et al. (2002)

Only once in EXO 0748-676



None detection of absorption line !

Cottam et al. (2008)

Type I X-ray bursts

Photospheric Radius Expansion

Expansion->Contraction->Cooling

$$L \sim R^2 T^4$$

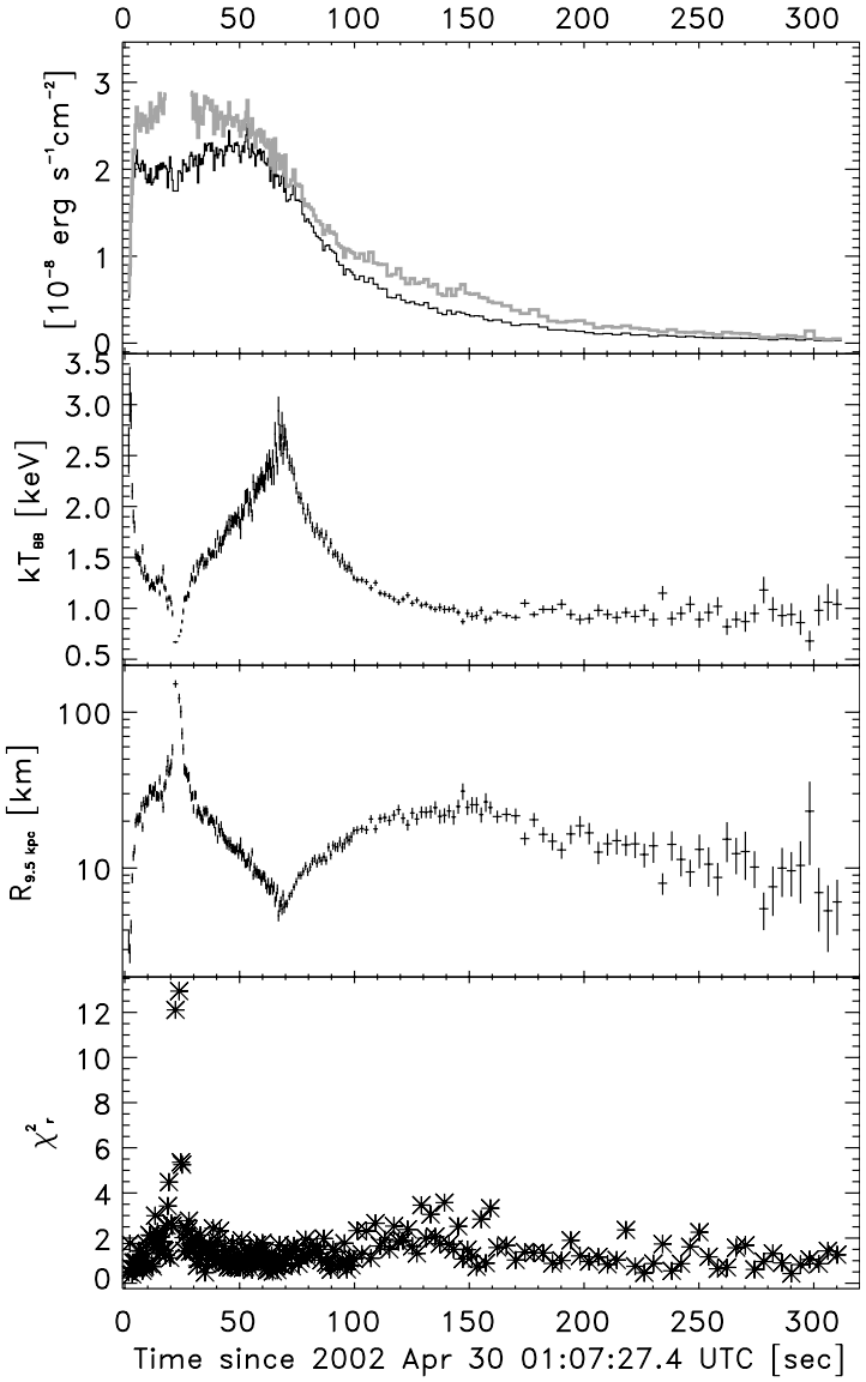
$$L_{\mathrm{Edd}} = \frac{4\pi GMc}{\kappa_{\mathrm{e}}}(1+z)$$

at the touchdown

$$K = \frac{R^2}{D^2 f_{\mathrm{c}}^4}\left(1 - \frac{2GM}{Rc^2}\right)^{-1}$$

during the cooling tail

GRS 1747-312, in't Zand 2003



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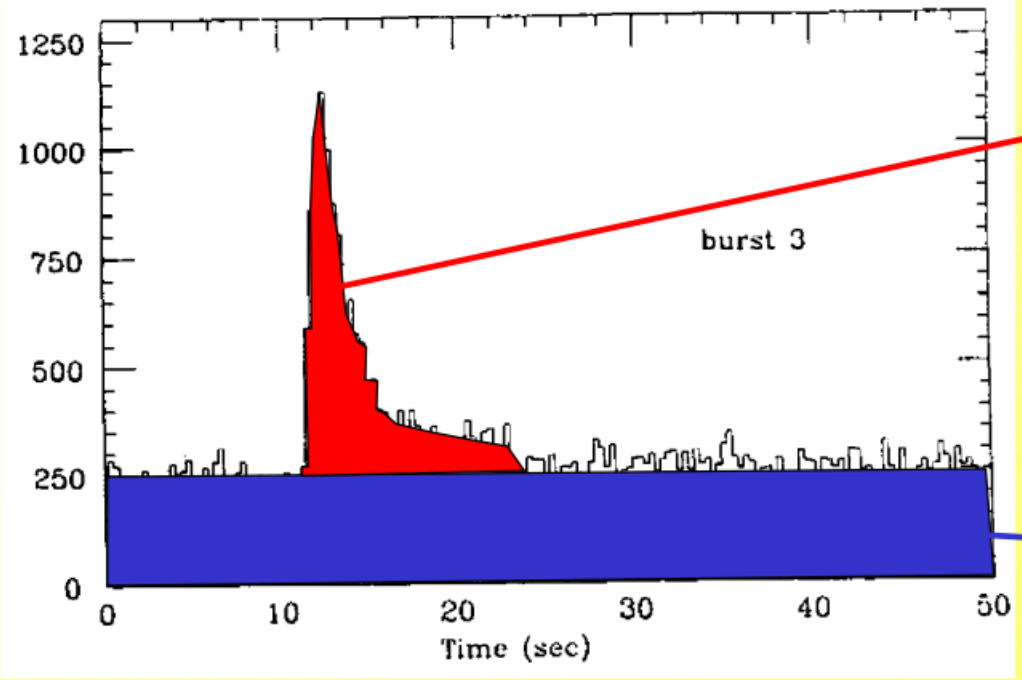


Burst energy (thermonuclear energy)

Persistent flux (gravitational energy)

Type I X-ray bursts

- **Reflection from Inner Accretion Disk**

Ballantyne & Strohmayer 2004; Keek et al. (2017)

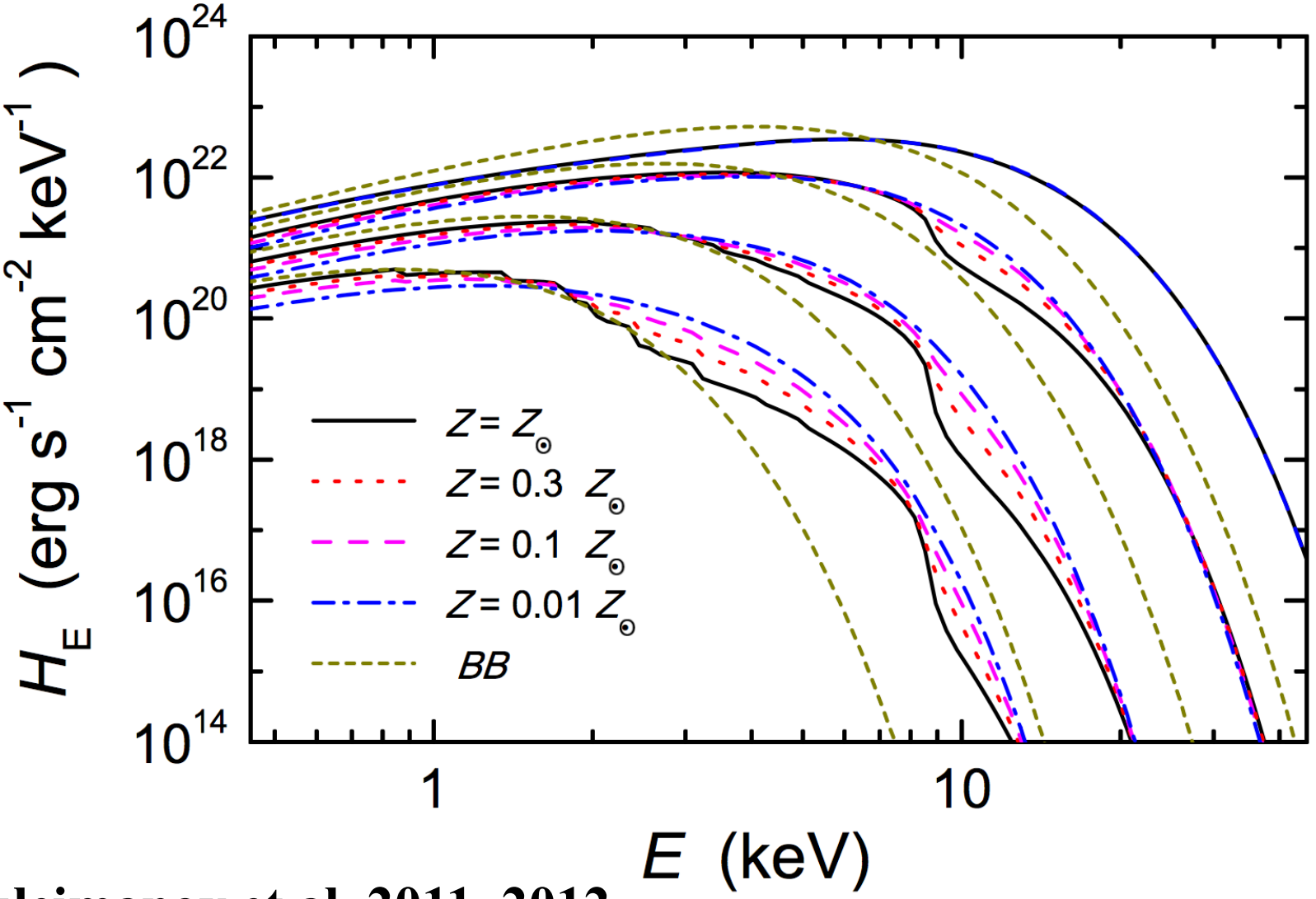
- **Blocked by Outer Accretion Disk**

Galloway et al. (2008)

- **Enhanced Persistent Emission**

Poynting-Robertson effect, in't Zand et al. (2013)

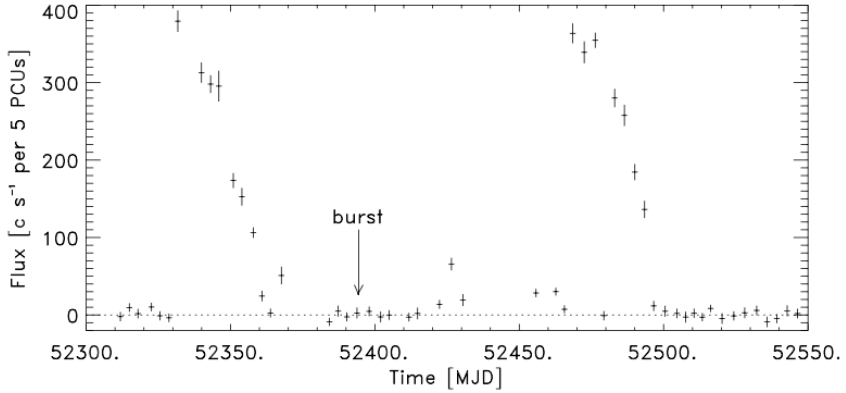
X-ray burst spectra

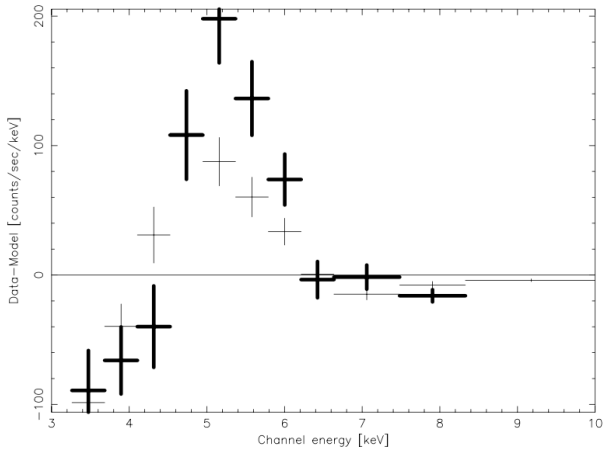


Suleimanov et al. 2011, 2012

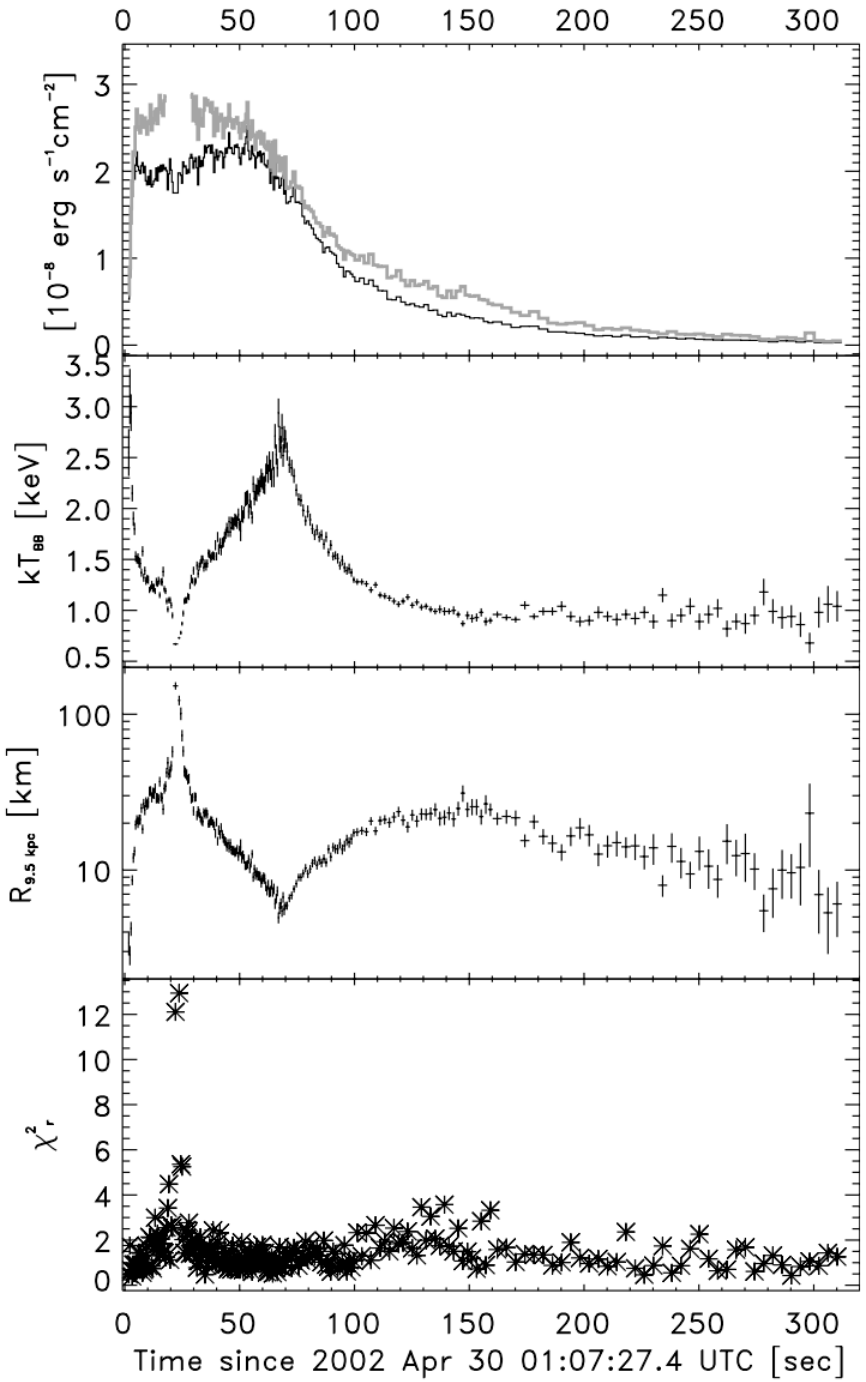
GRS 1747-312

Fast Expansion & Slow Expansion Features in Burst Spectrum

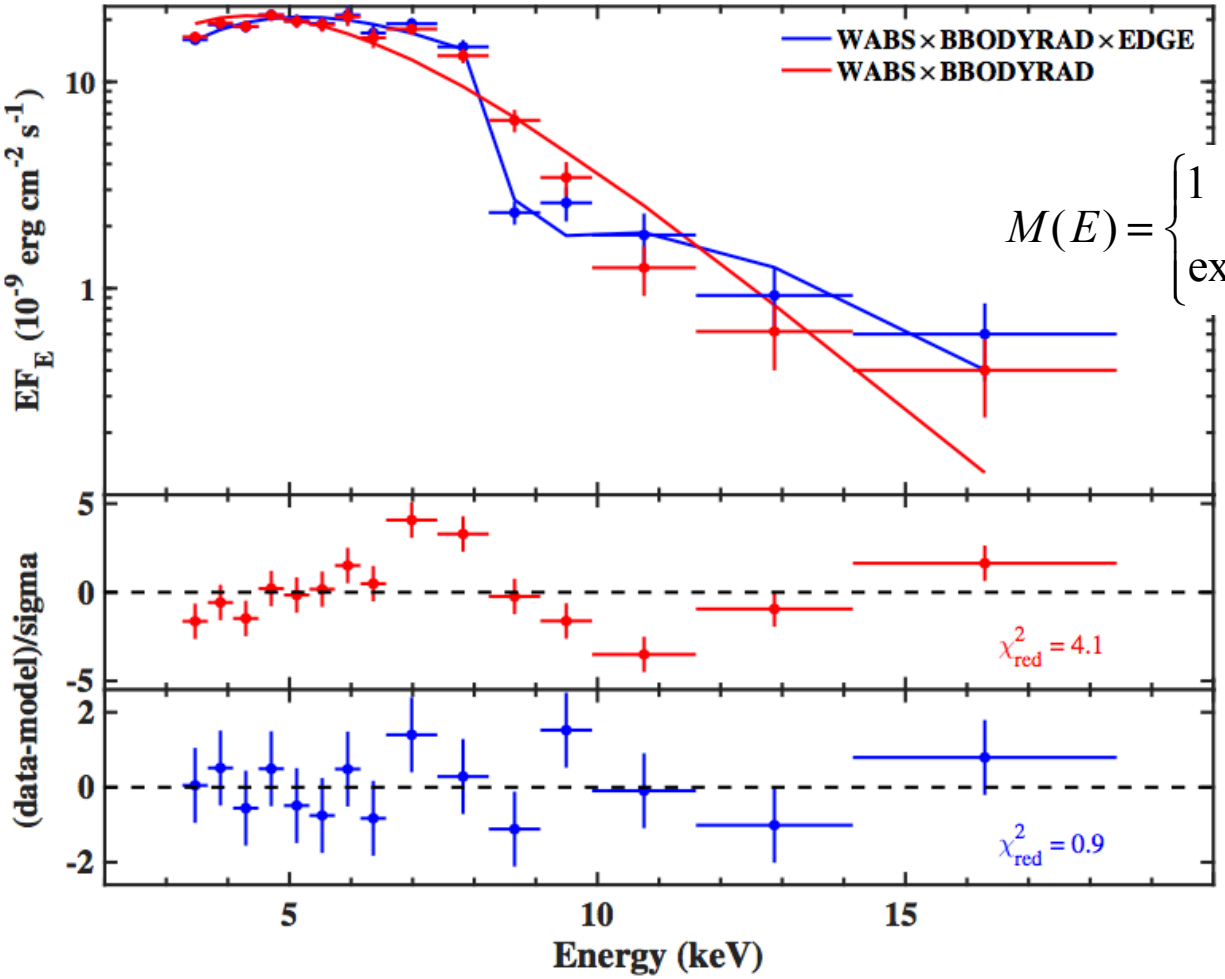




GRS 1747-312, in't Zand 2003

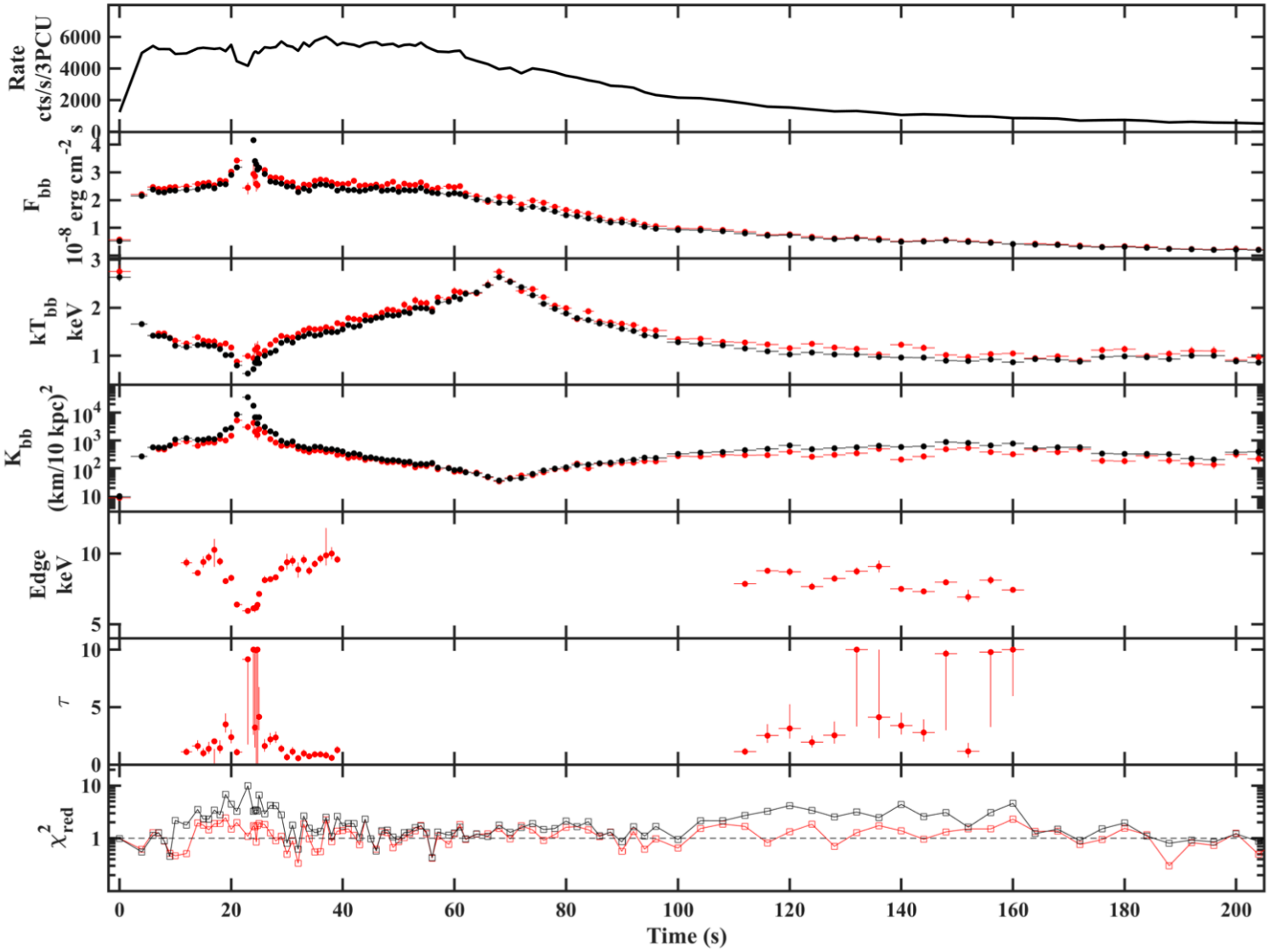


Absorption Edge

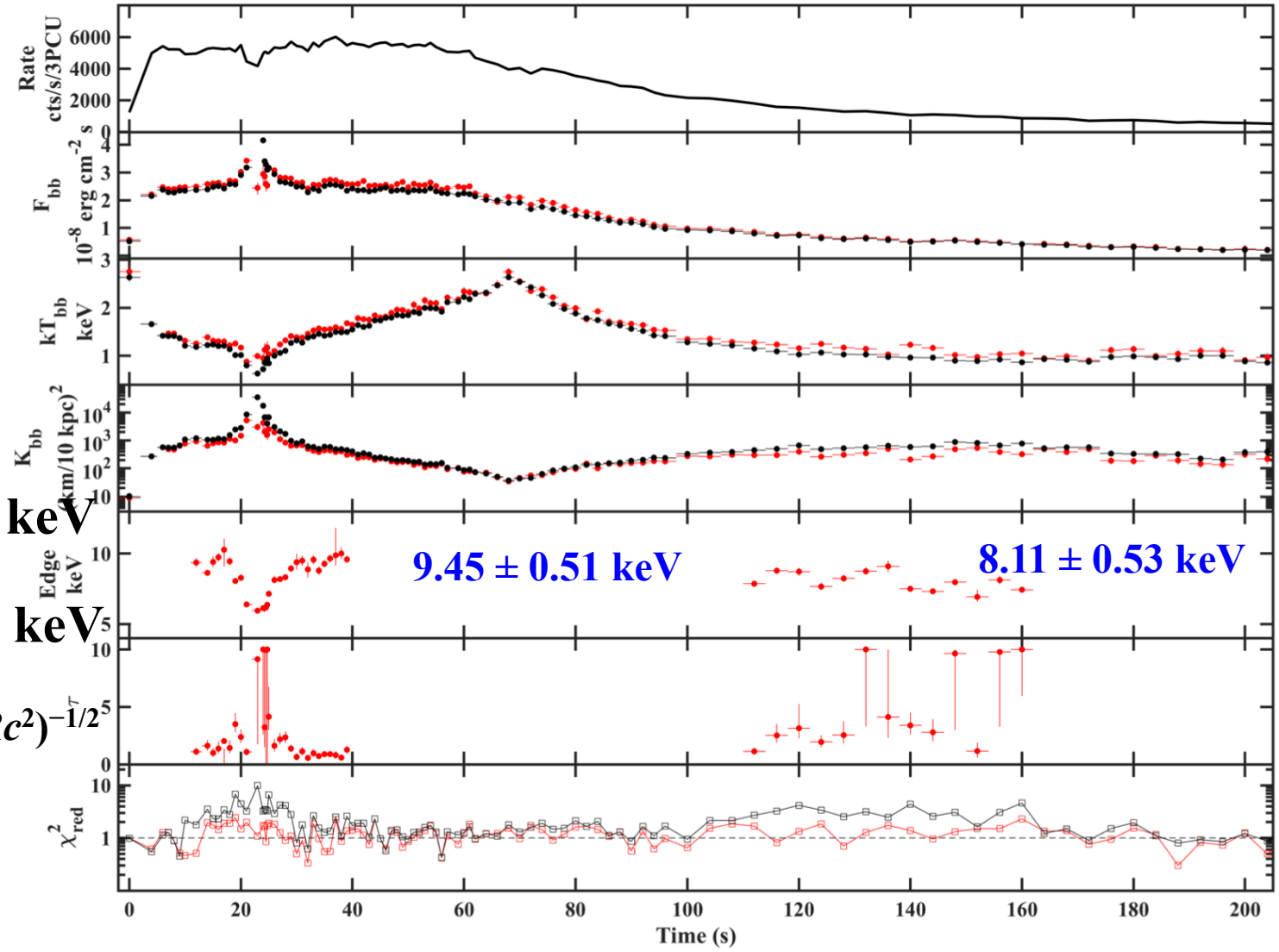


$$M(E) = \begin{cases} 1 & E < E_{\text{Edge}} \\ \exp[-\tau(E / E_{\text{Edge}})^{-3}], & E \geq E_{\text{Edge}} \end{cases}$$

PRE of GRS 1747-312



PRE of GRS 1747-312

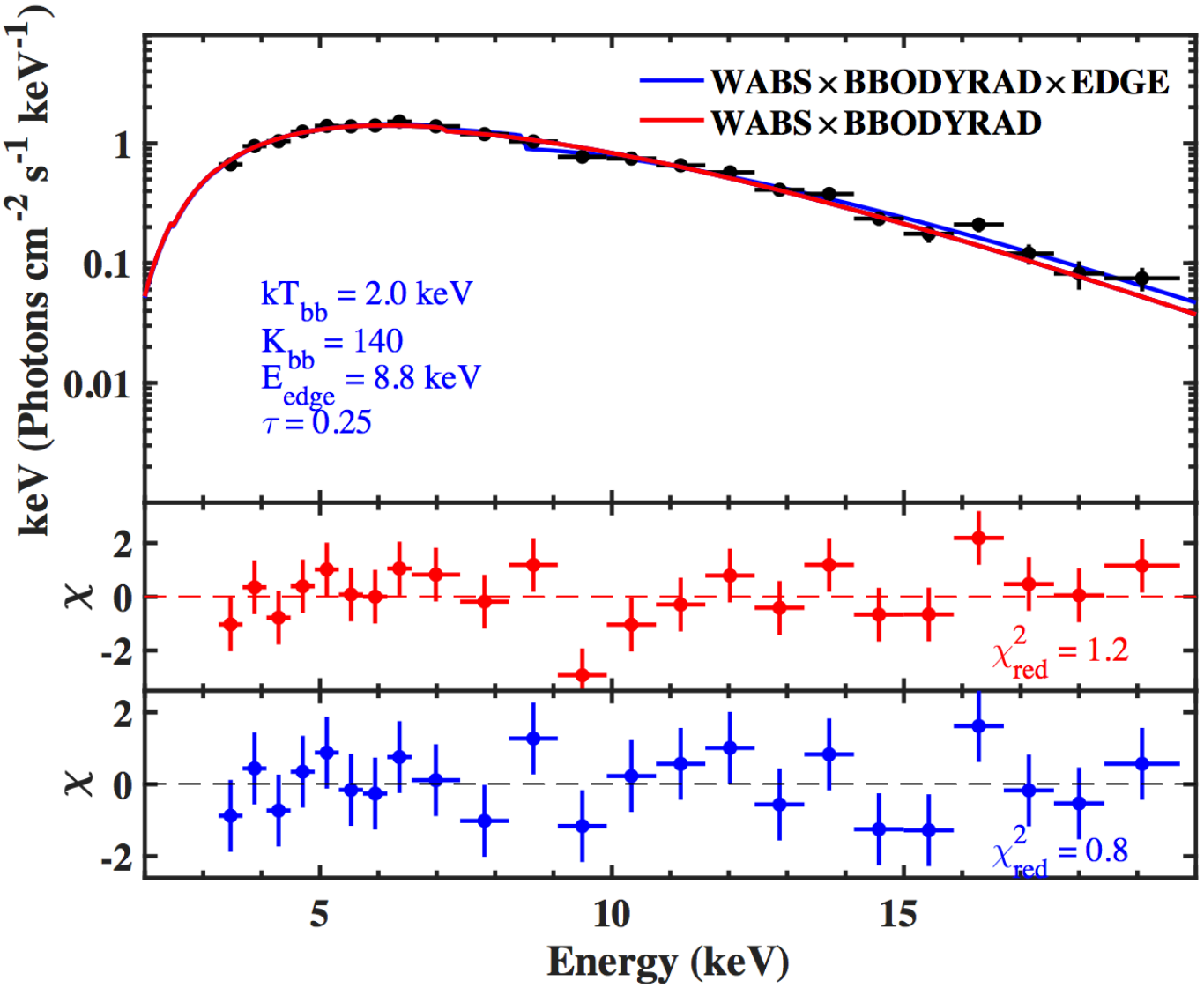


$E_{\text{Ni H-like}} \sim 10.8$ keV

$E_{\text{Fe H-like}} \sim 9.28$ keV

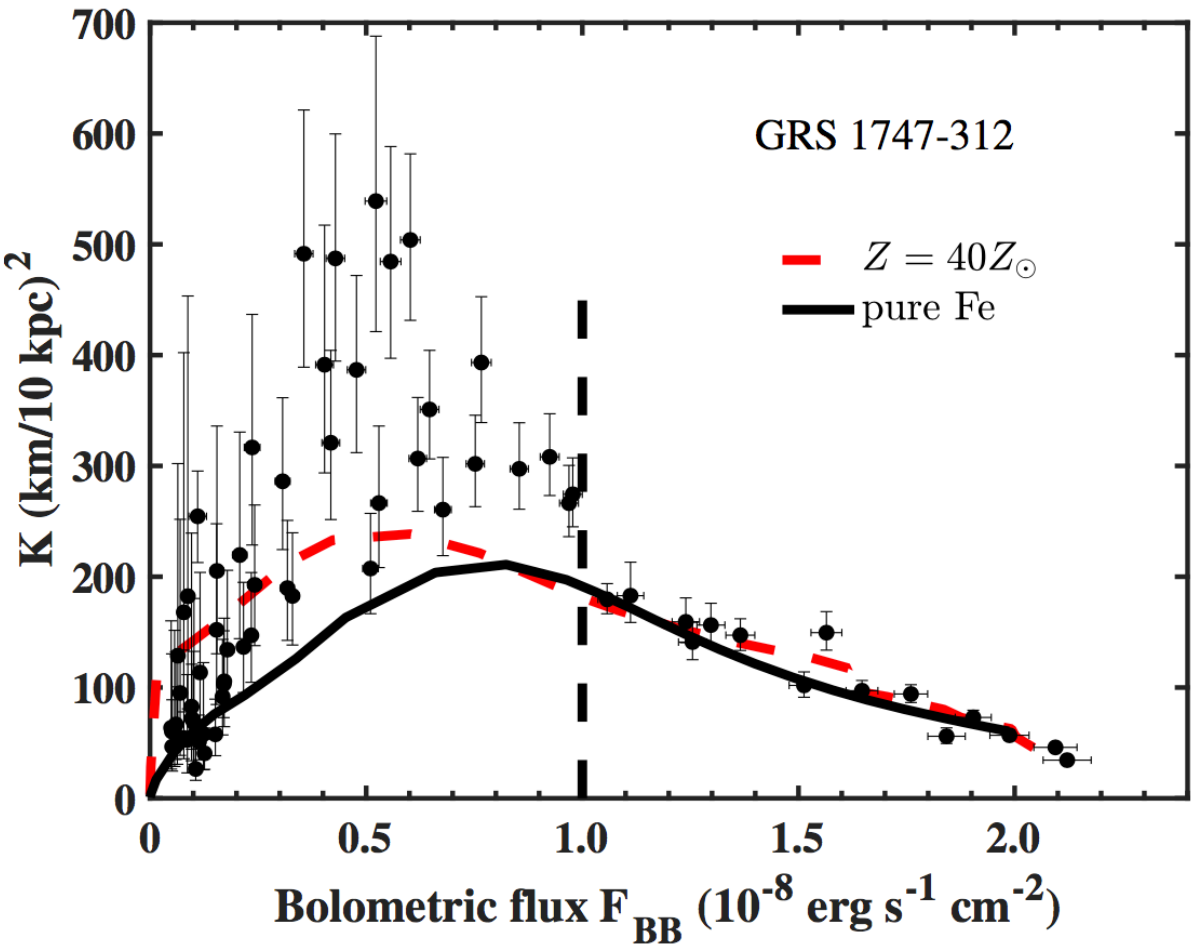
$1 + z = (1 - 2GM/Rc^2)^{-1/2}$
=1.34 or 1.15

Simulation

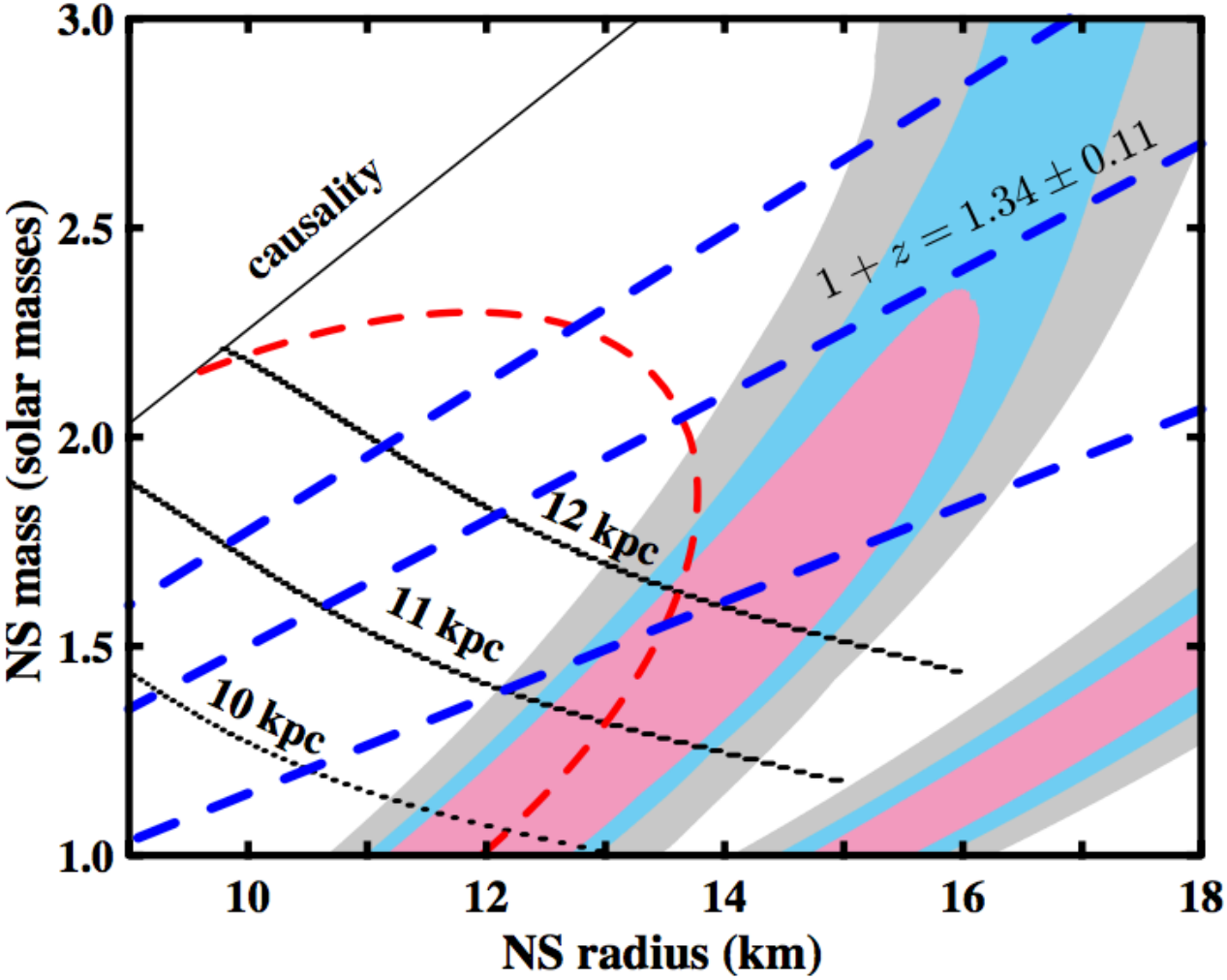

WABS × BBODYRAD × EDGE
WABS × BBODYRAD
kT_bb = 2.0 keV
K_bb = 140
E_edge = 8.8 keV
τ = 0.25
χ²_red = 1.2
χ²_red = 0.8
keV (Photons cm⁻² s⁻¹ keV⁻¹)
Energy (keV)
χ

Cooling tail

$$K = \frac{R^2}{D^2 f_c^4}\left(1 - \frac{2GM}{Rc^2}\right)^{-1}$$



The *M-R* of GRS 1747-312



Li et al. 2018 apj submitted

Conclusions

- **GRS 1747-312**
  - Edges
  - Gravitational Redshift
  - M-R of NS
- **Future**
  - eXTP,…