Nuclear equation of state from observations of short γ-ray burst remnants

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Lasky, Haskell, Ravi, Howell & Coward (2014; arXiv:1311.1352)

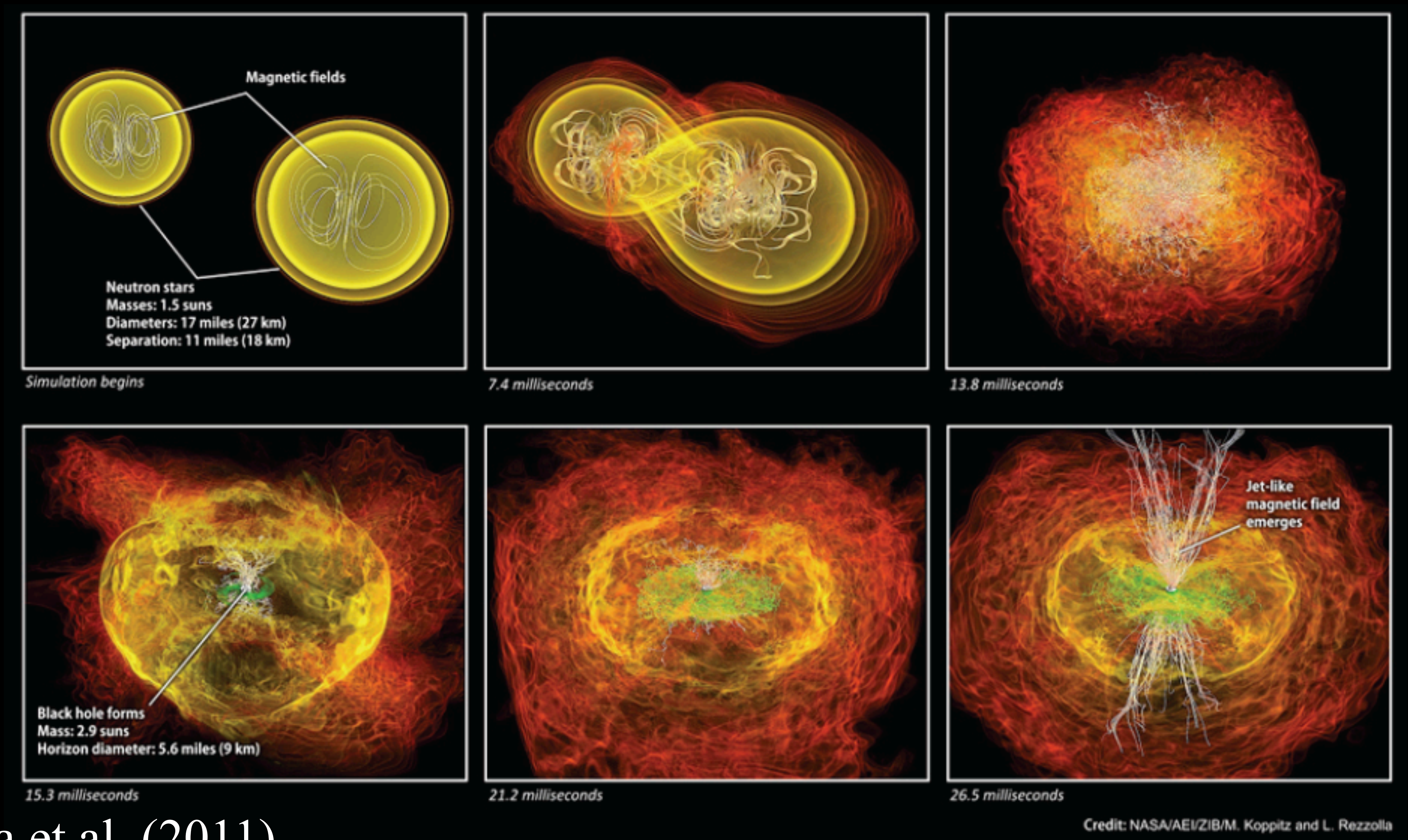
Ravi & Lasky (submitted; arXiv:1403.6327)

1) short gamma-ray burst remnants testing the EOS

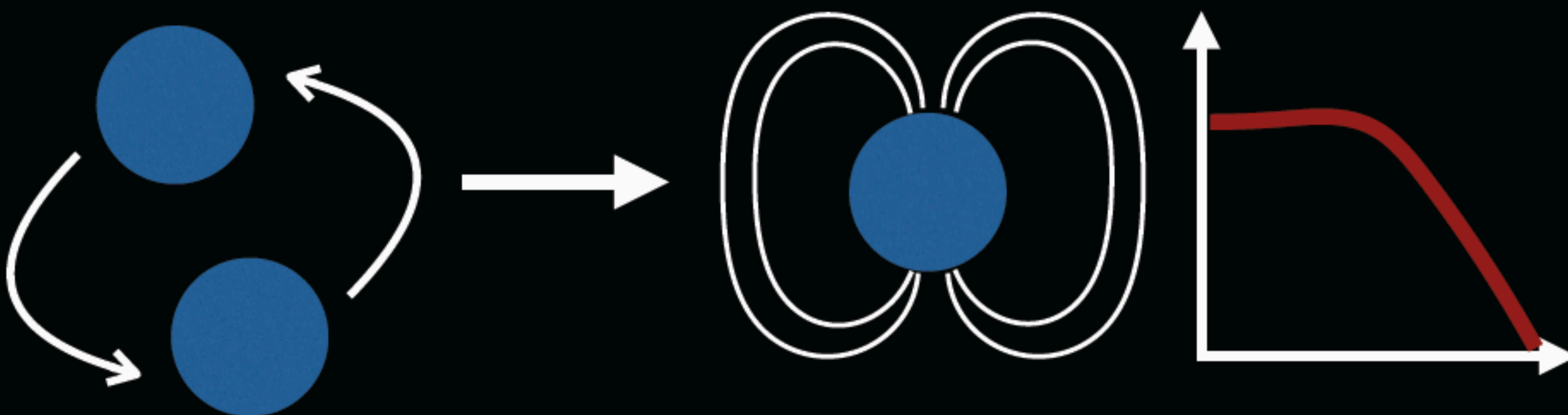
2) A timescale for gravitational collapse

a) fast radio burst progenitor models

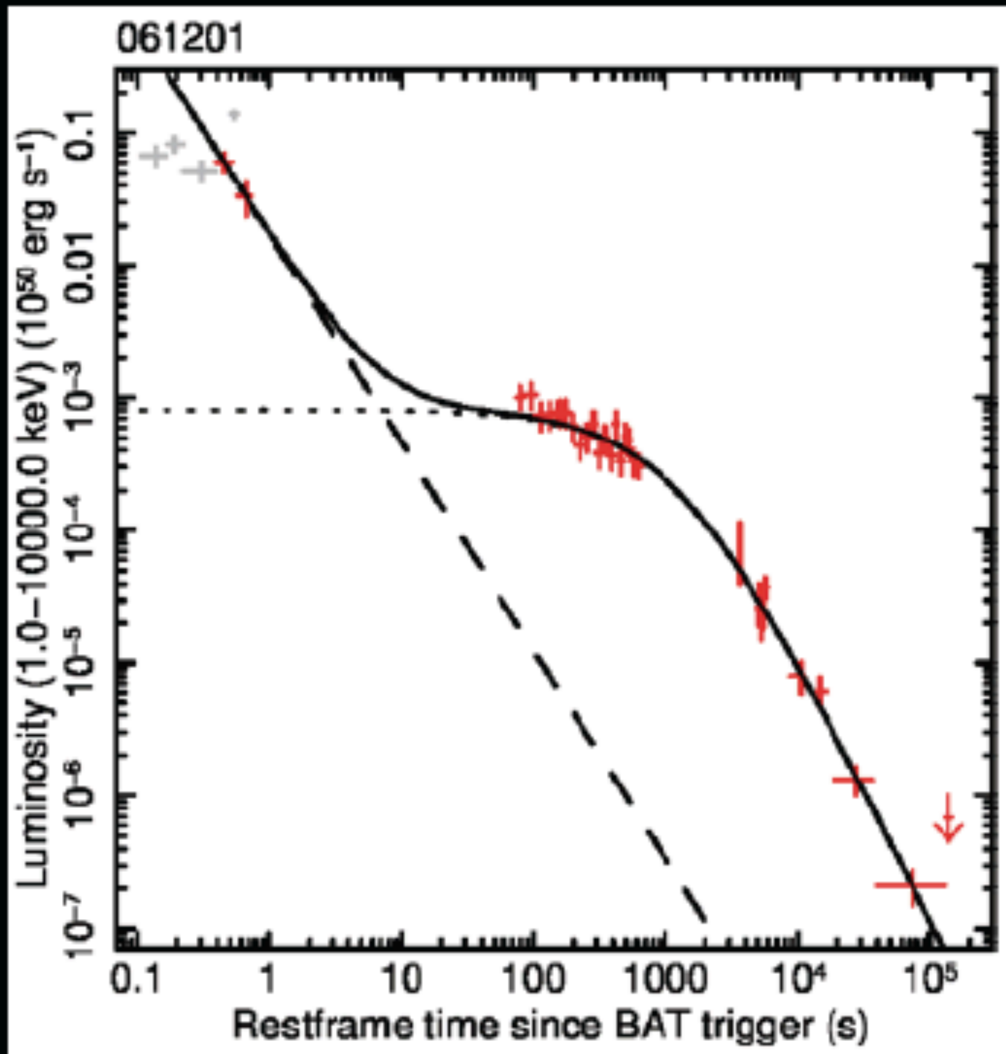
b) follow-up of short GRBs and gravitational wave bursts

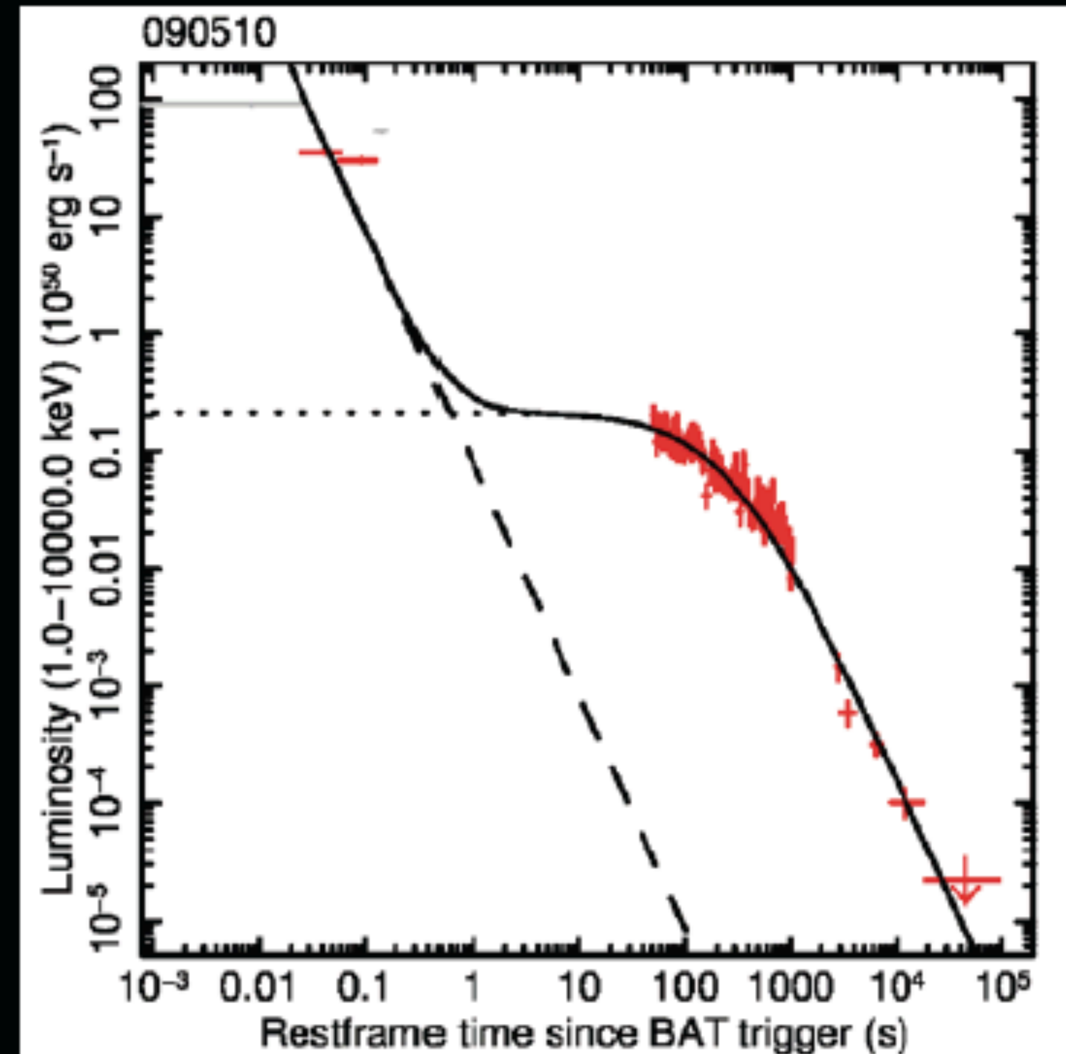


Rezzolla et al. (2011)



Rowlinson et al. (2013)



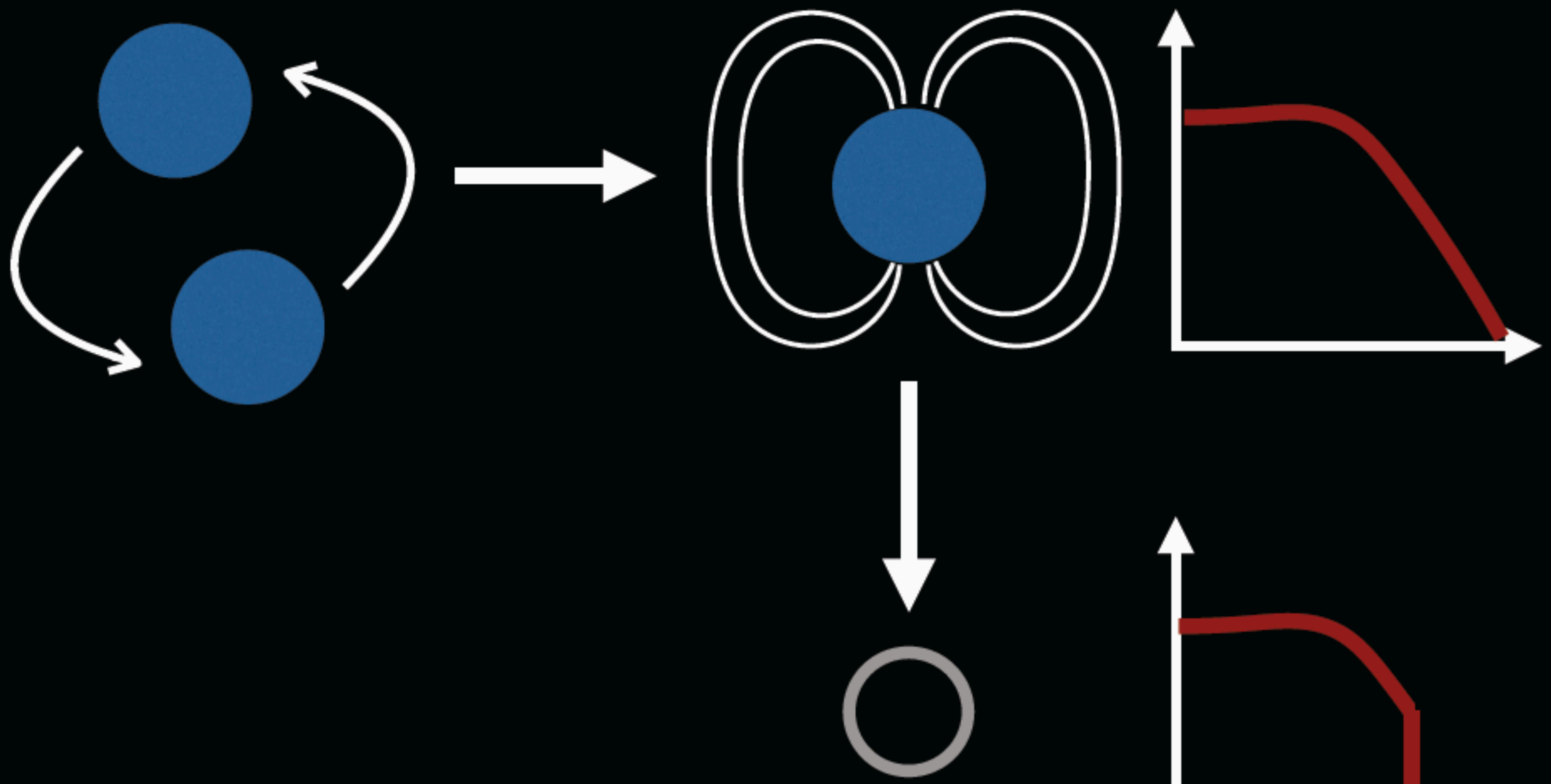


$$B_p^2 \sim \frac{I^2}{R^6 L_0 T_{\rm em}} \qquad P_0^2 \sim \frac{I}{L_0 T_{\rm em}}$$

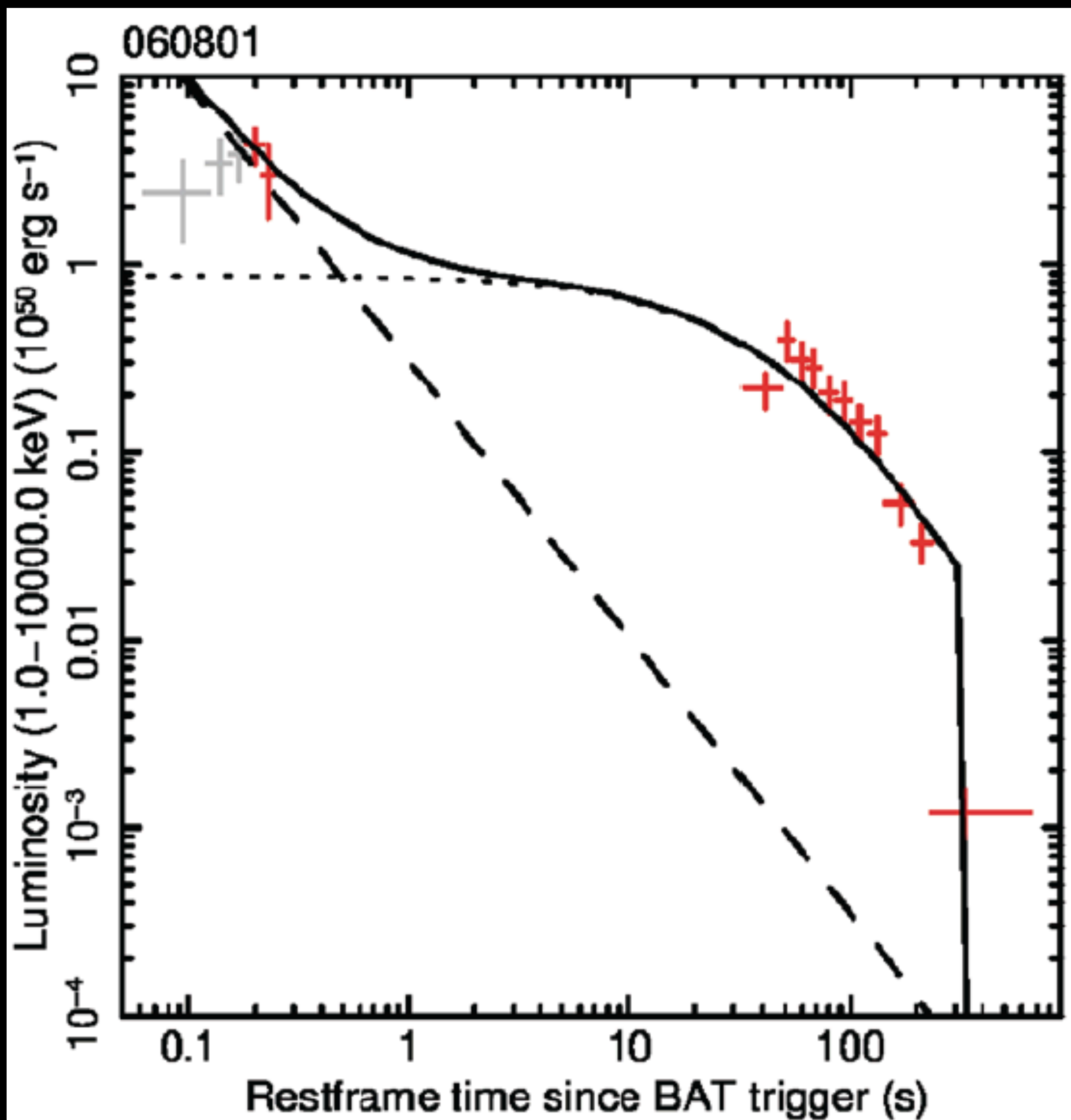
L_0 - plateau luminosity

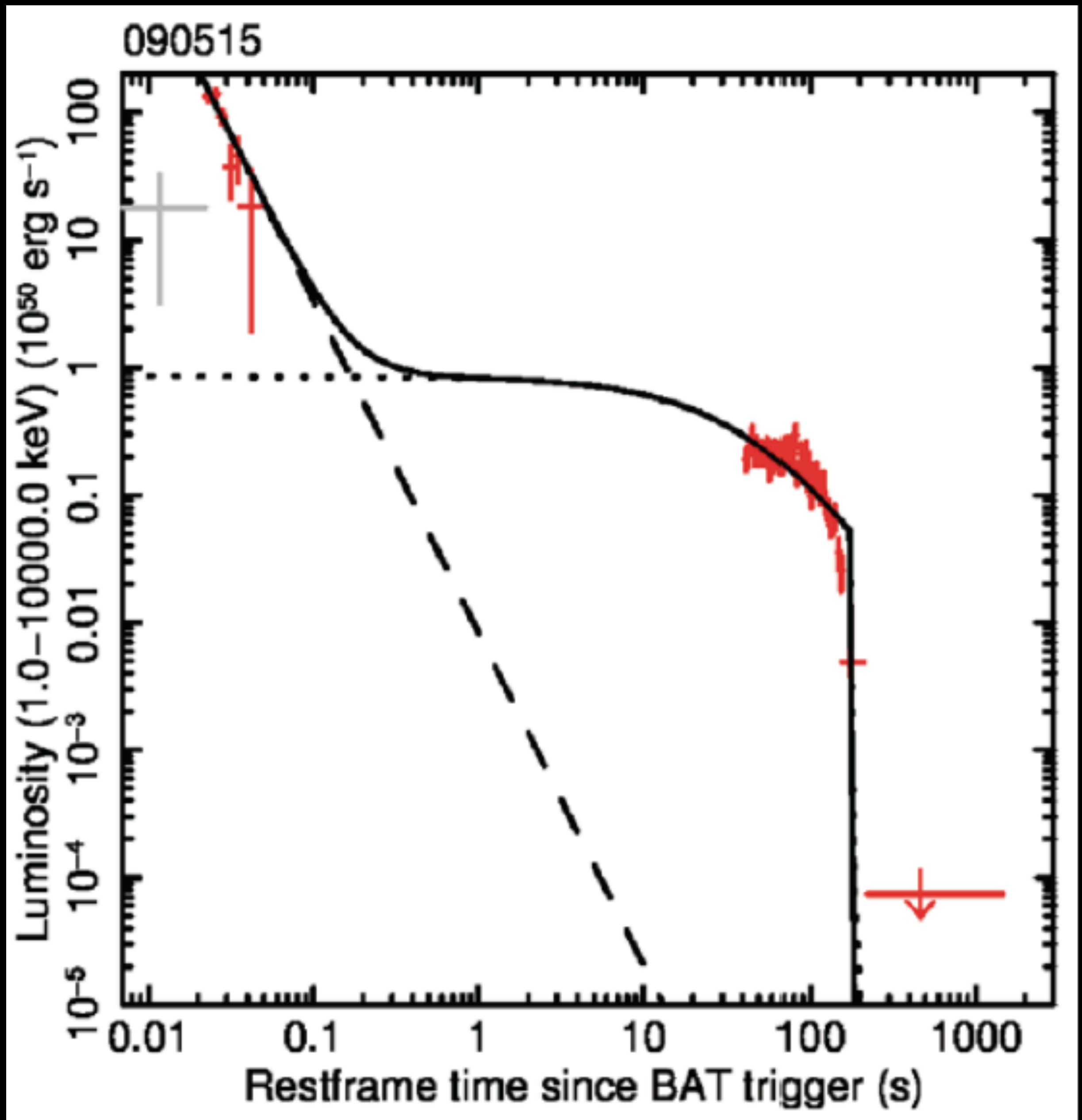
$T_{\rm em}$ - plateau duration

Zhang & Mészáros (2001)



Rowlinson et al. (2013)

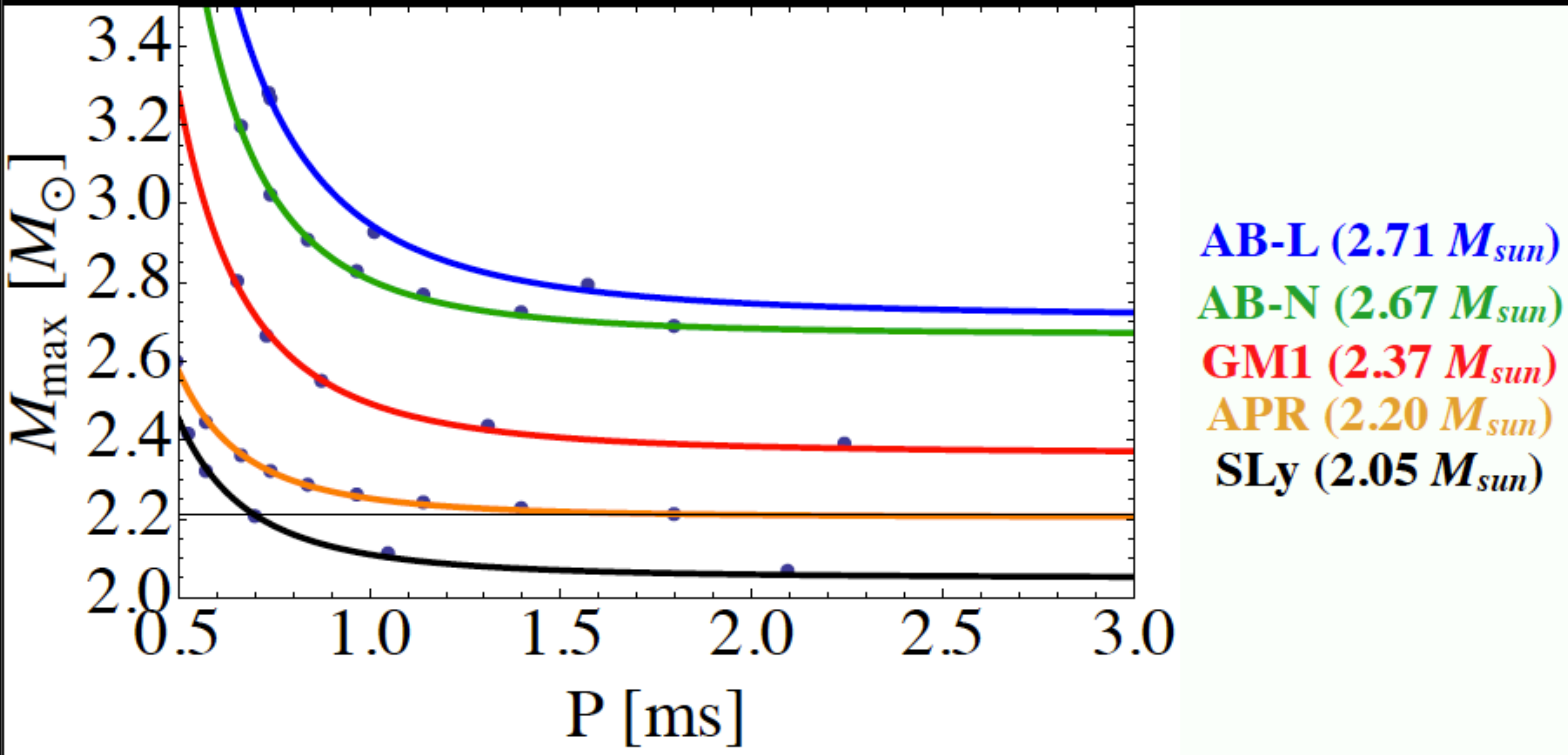




$t_{collapse}$ $t_{collapse}$

GRB	z	p_0 [ms]	B_p [10^{15} G]	$t_{\rm col}$ [s]
060801	1.13	$1.95^{+0.15}_{-0.13}$	$11.24^{+1.93}_{-1.78}$	326
070724A	0.46	$1.80^{+1.04}_{-0.38}$	$28.72^{+1.42}_{-1.29}$	90
080905A	0.122	$9.80^{+0.78}_{-0.77}$	$39.26^{+10.24}_{-12.16}$	274
101219A	0.718	$0.95^{+0.05}_{-0.05}$	$2.81^{+0.47}_{-0.39}$	138

Rotation supporting extra mass

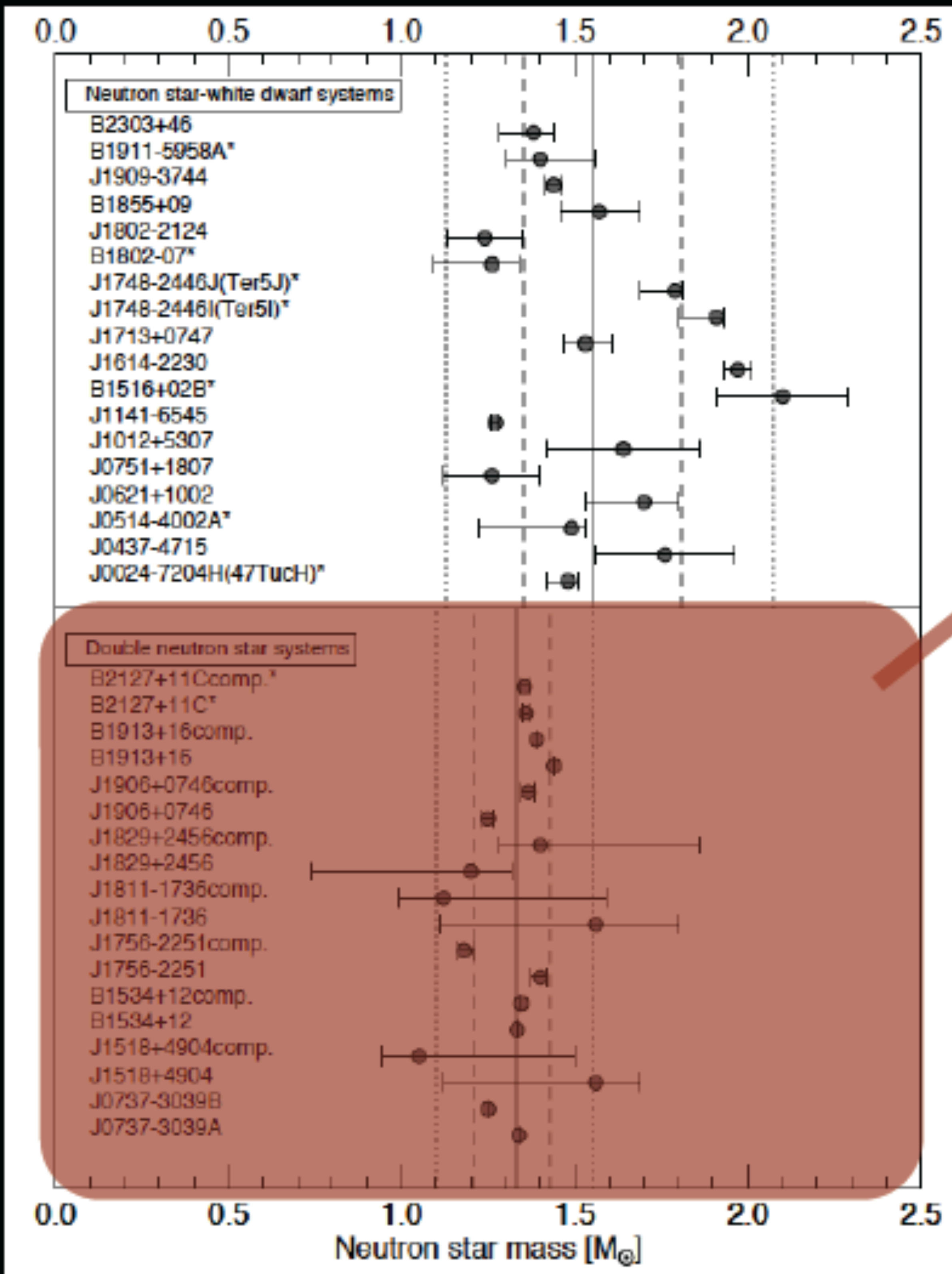


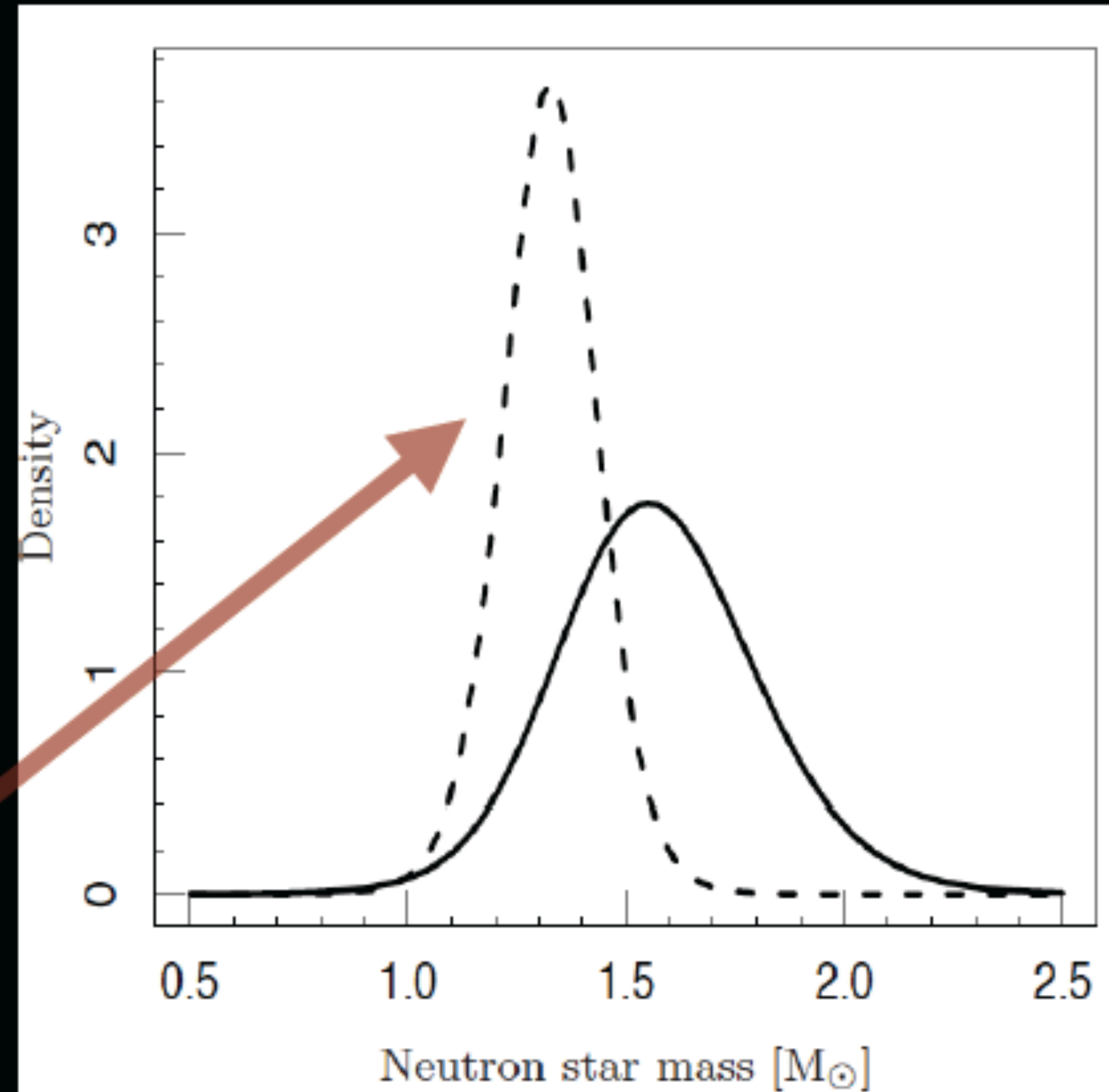
✓ ✓ ✓ ☐ ?

$t_{\mathrm{col}}\left(B_p,\, p_0,\, M,\, \mathrm{EOS}\right)$

Lasky et al. (2014)

Kiziltan et al. (2013)

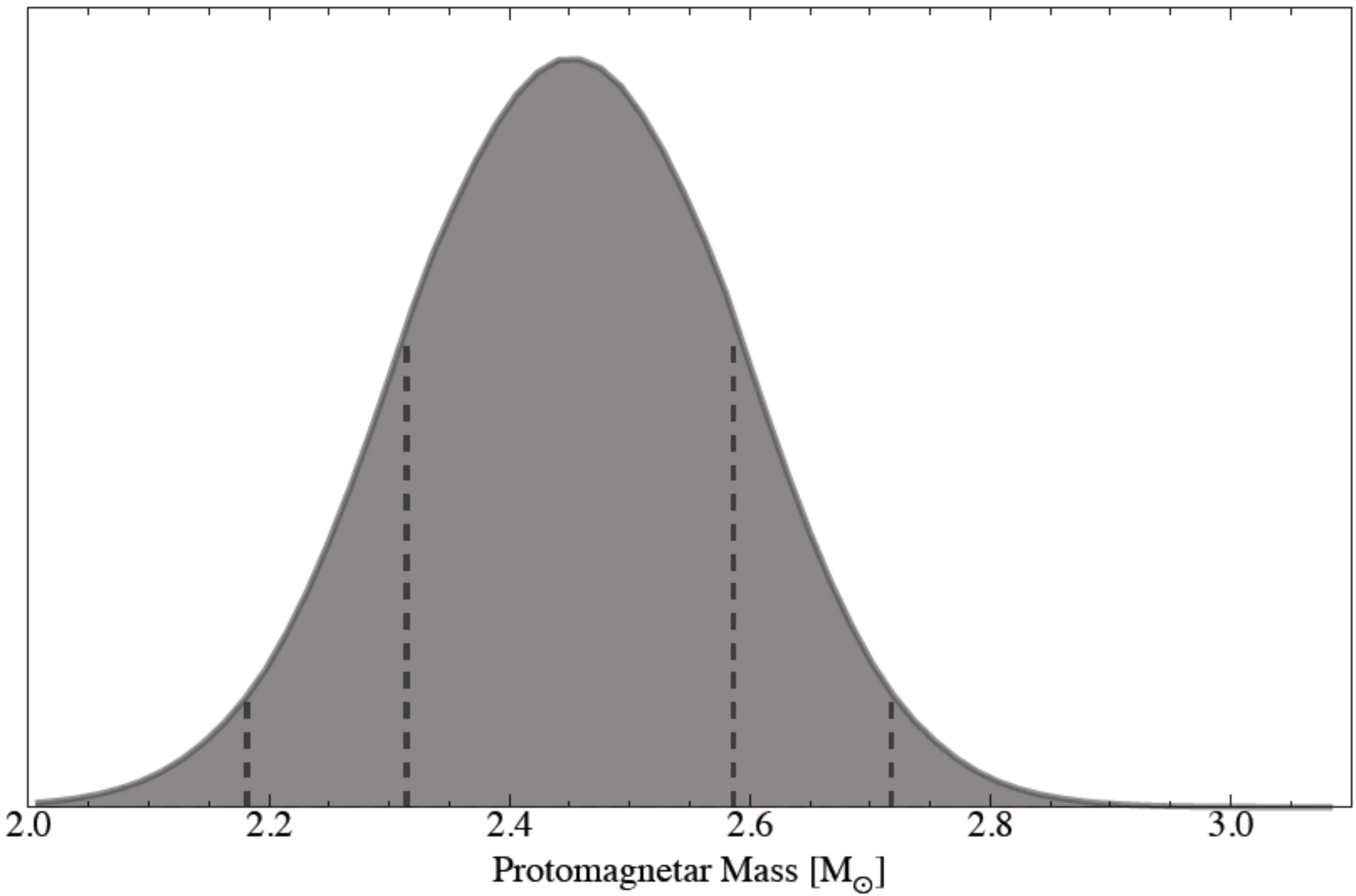




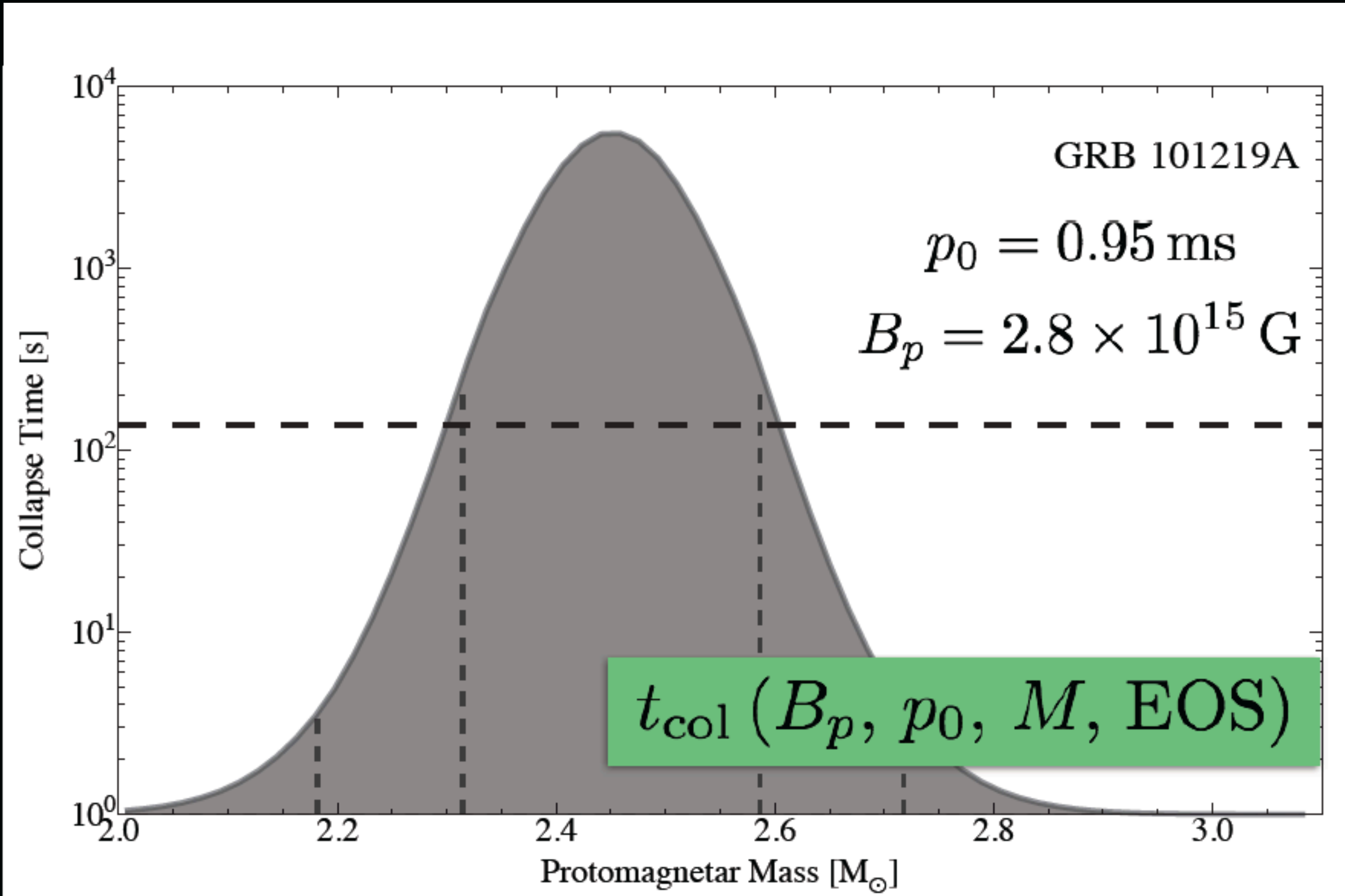
$$M = 1.32^{+0.11}_{-0.11} M_\odot$$

Rest mass conservation

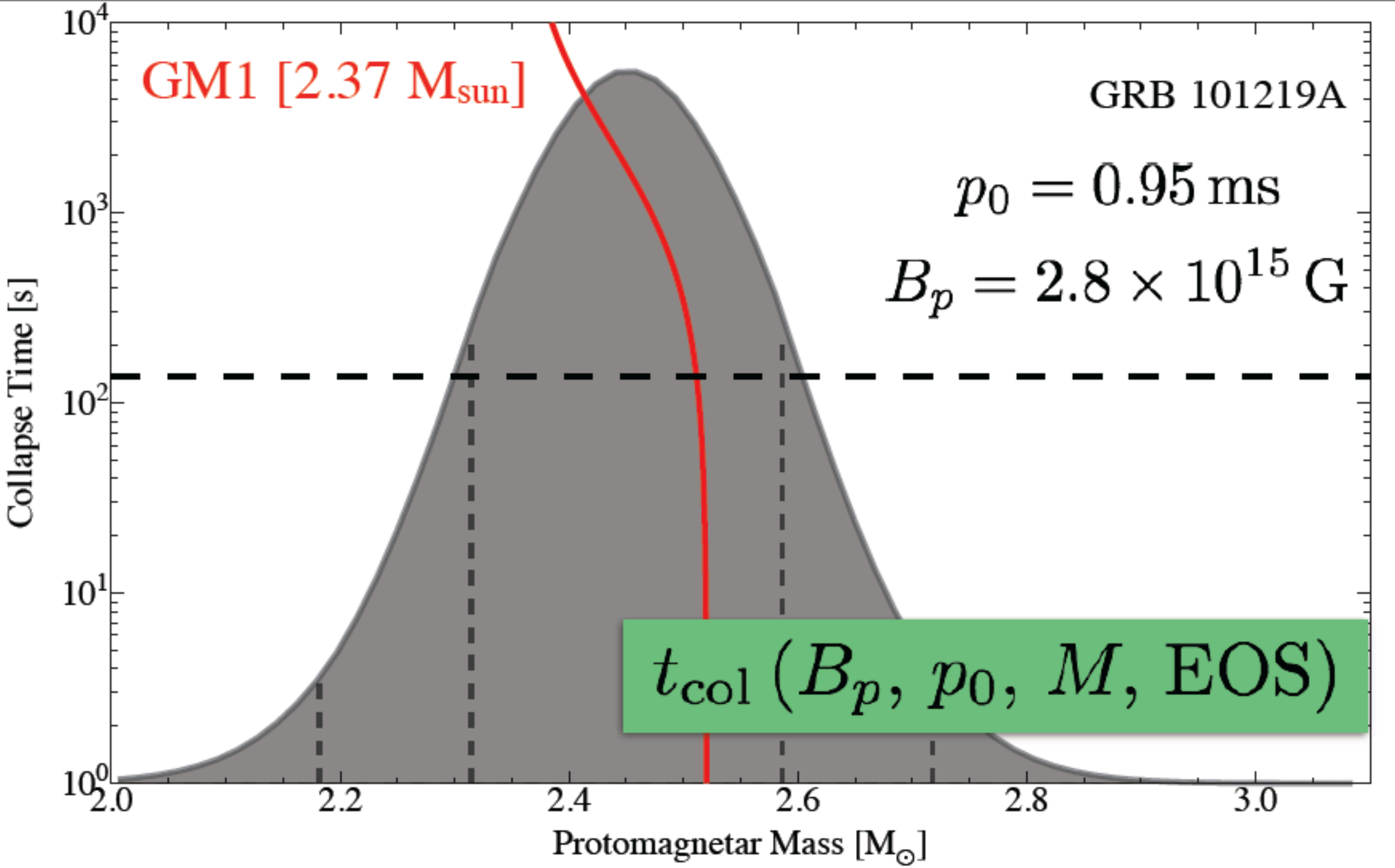
$$M_p = 2.46^{+0.13}_{-0.15} M_\odot$$



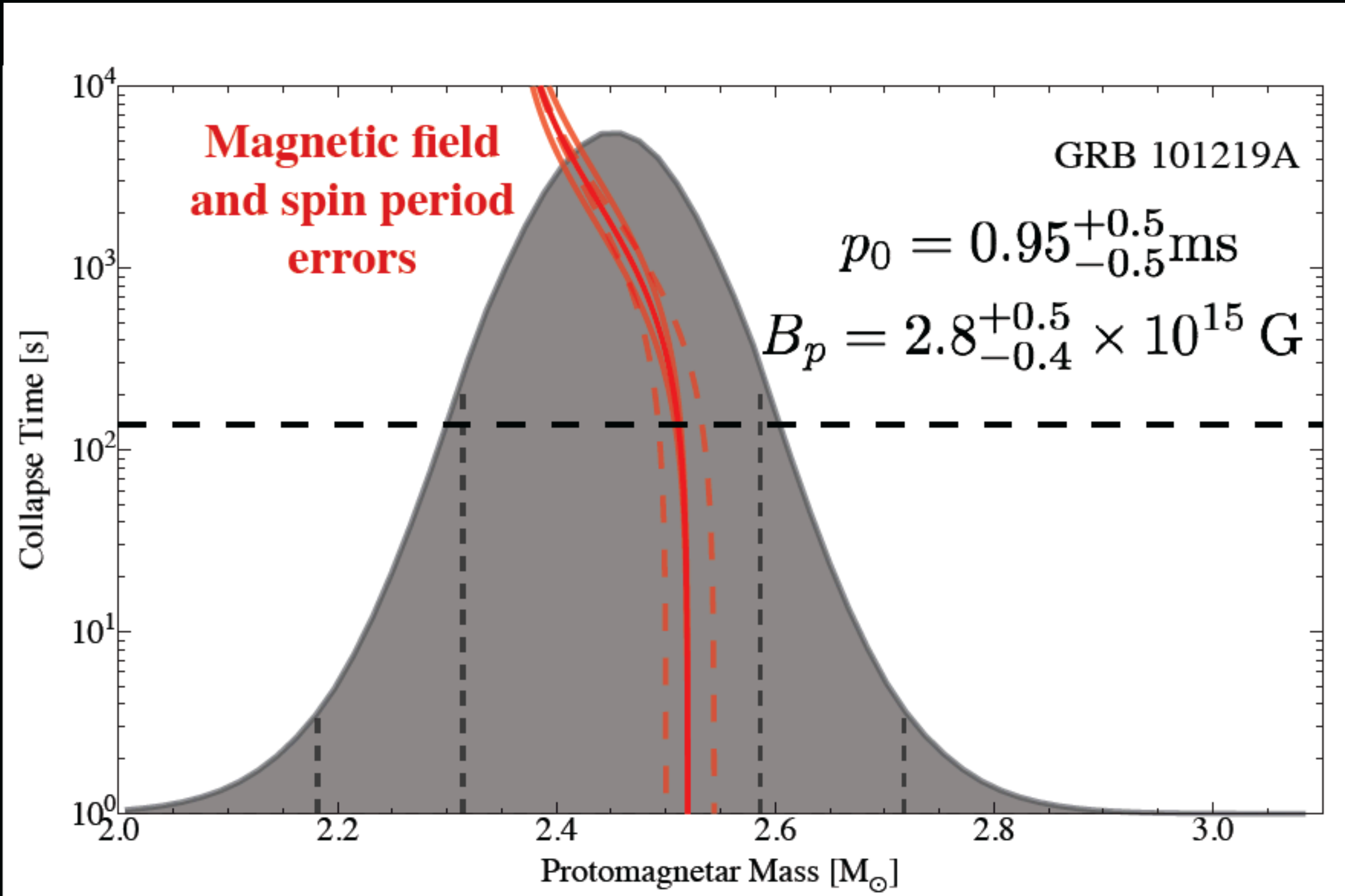
Lasky et al. (2014)



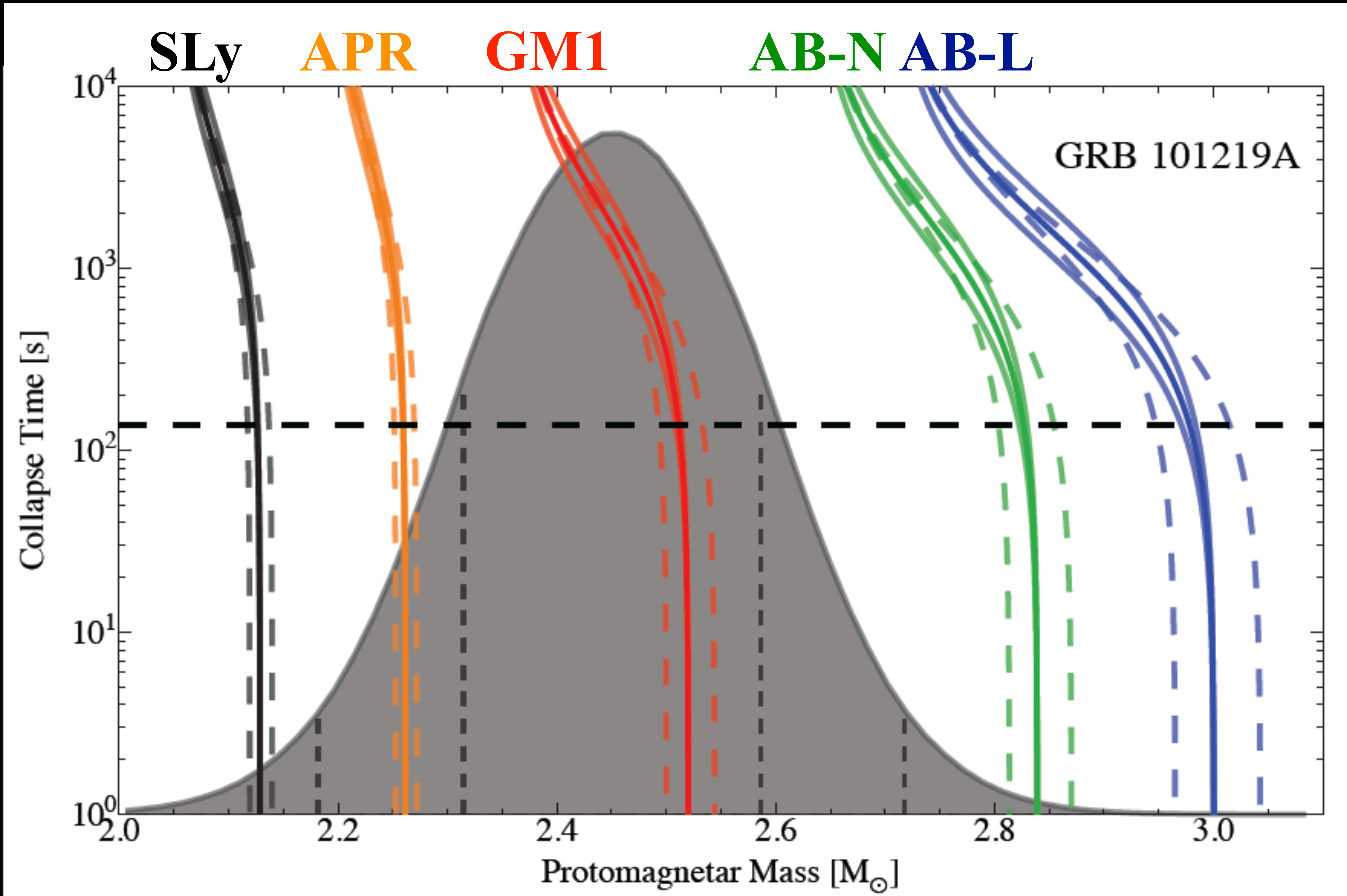
Lasky et al. (2014)



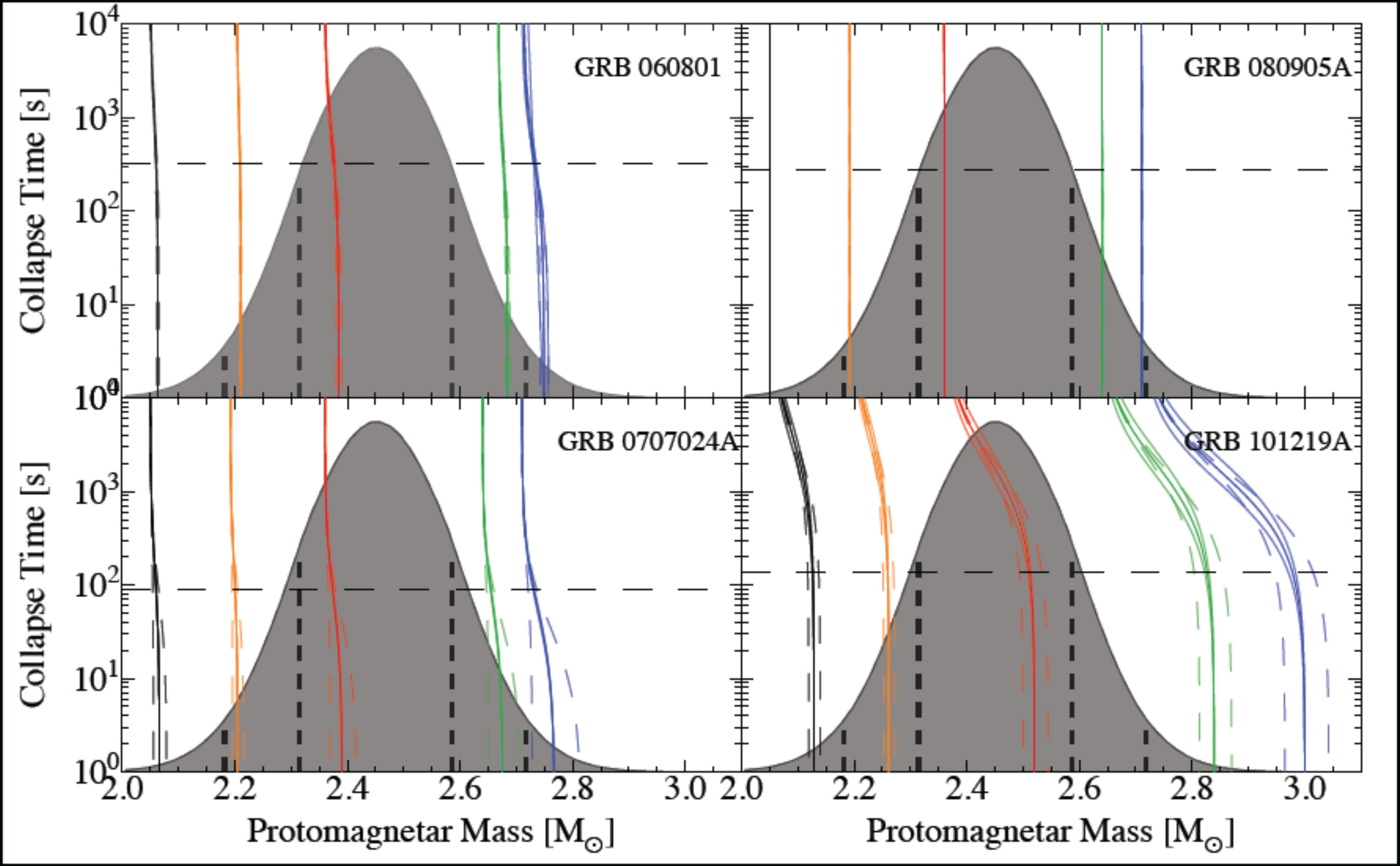
Lasky et al. (2014)



Lasky et al. (2014)

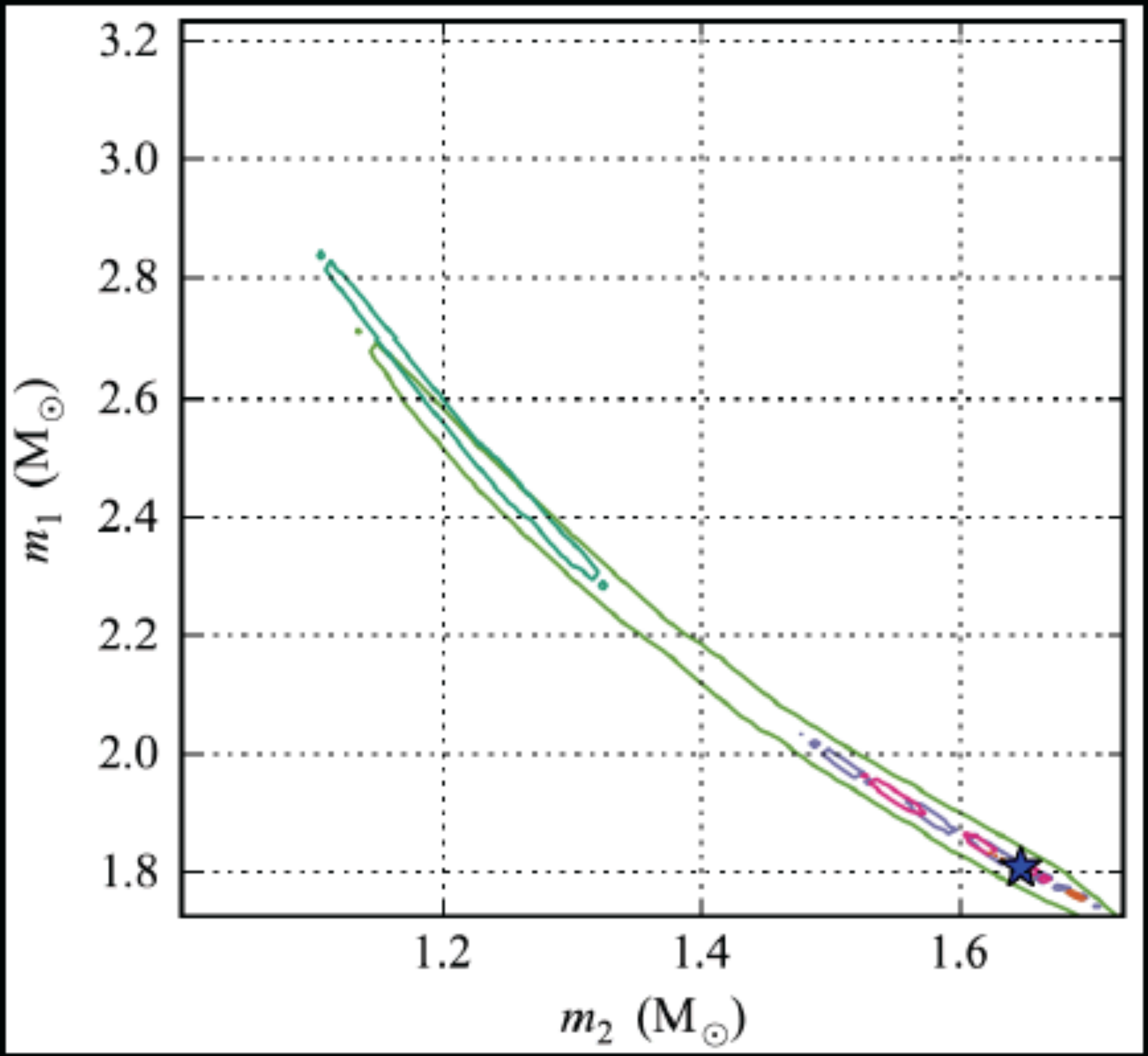


Lasky et al. (2014)

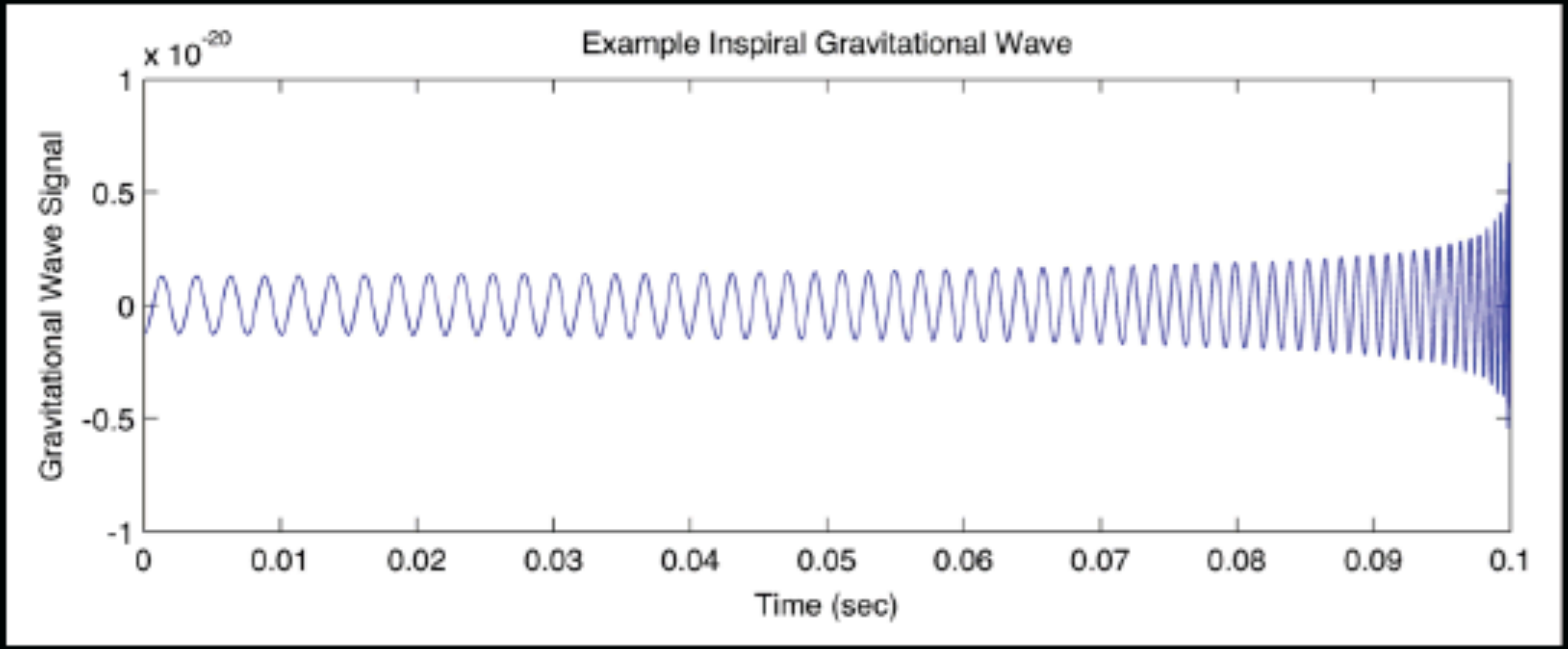


Lasky et al. (2014)

Gravitational Waves

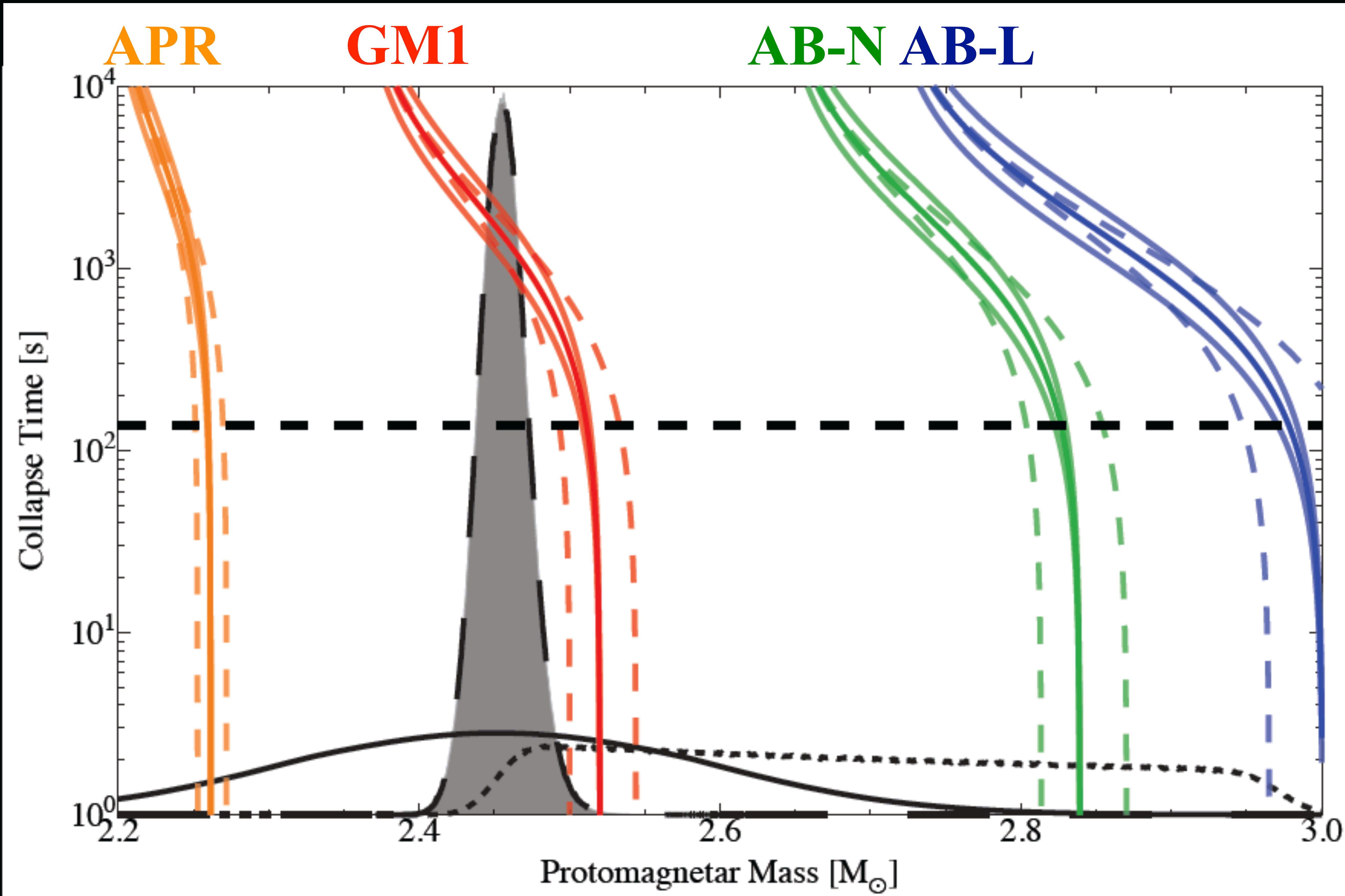


Aasi et al. (2013)



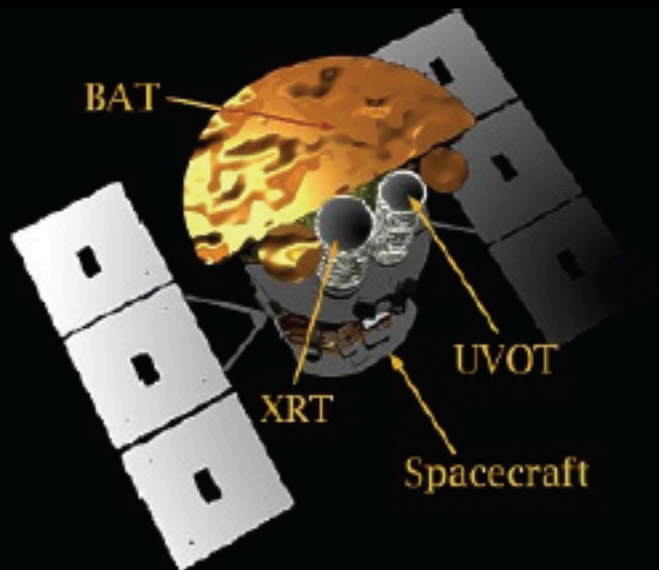
$$\mathcal{M} = \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{-1/5}}$$

$$\eta = \frac{m_1 m_2}{(m_1 + m_2)^2}$$



Lasky et al. (2014)

How many will we see?



+

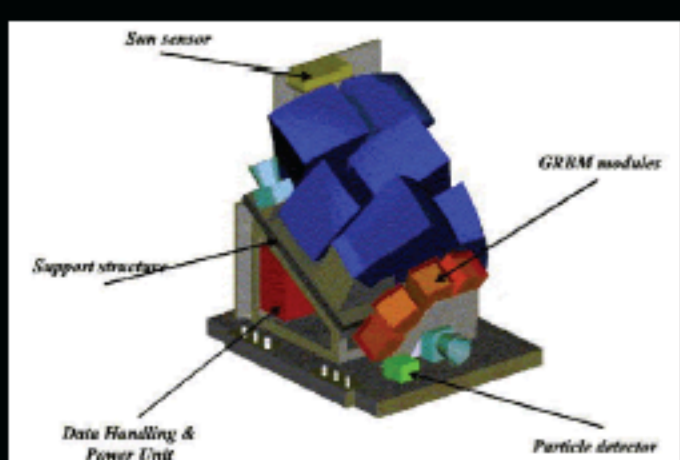
$\approx 0.2\ \mathrm{yr}^{-1}$

BATSE-XRT

+

$\approx 0.4\ \mathrm{yr}^{-1}$

Space-based multi-band astronomical Variable Object Monitor (SVOM)

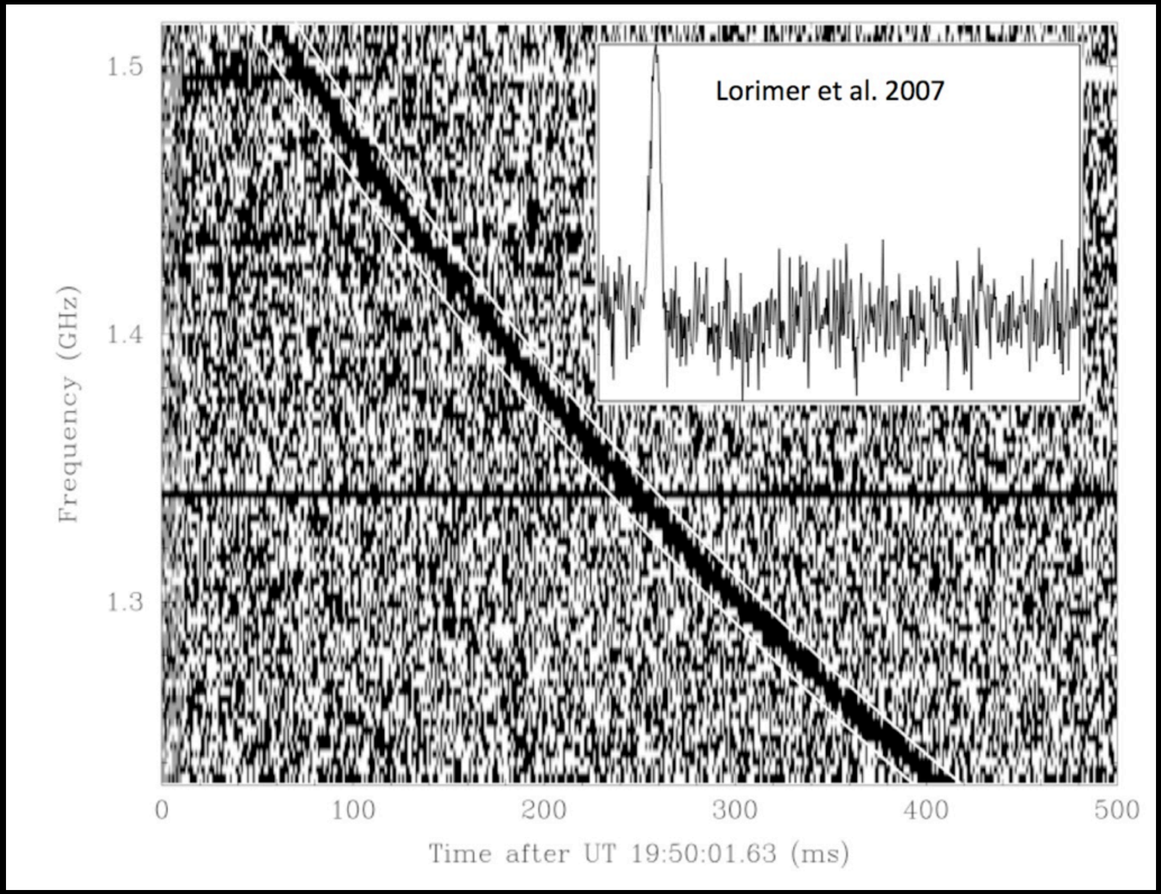


+

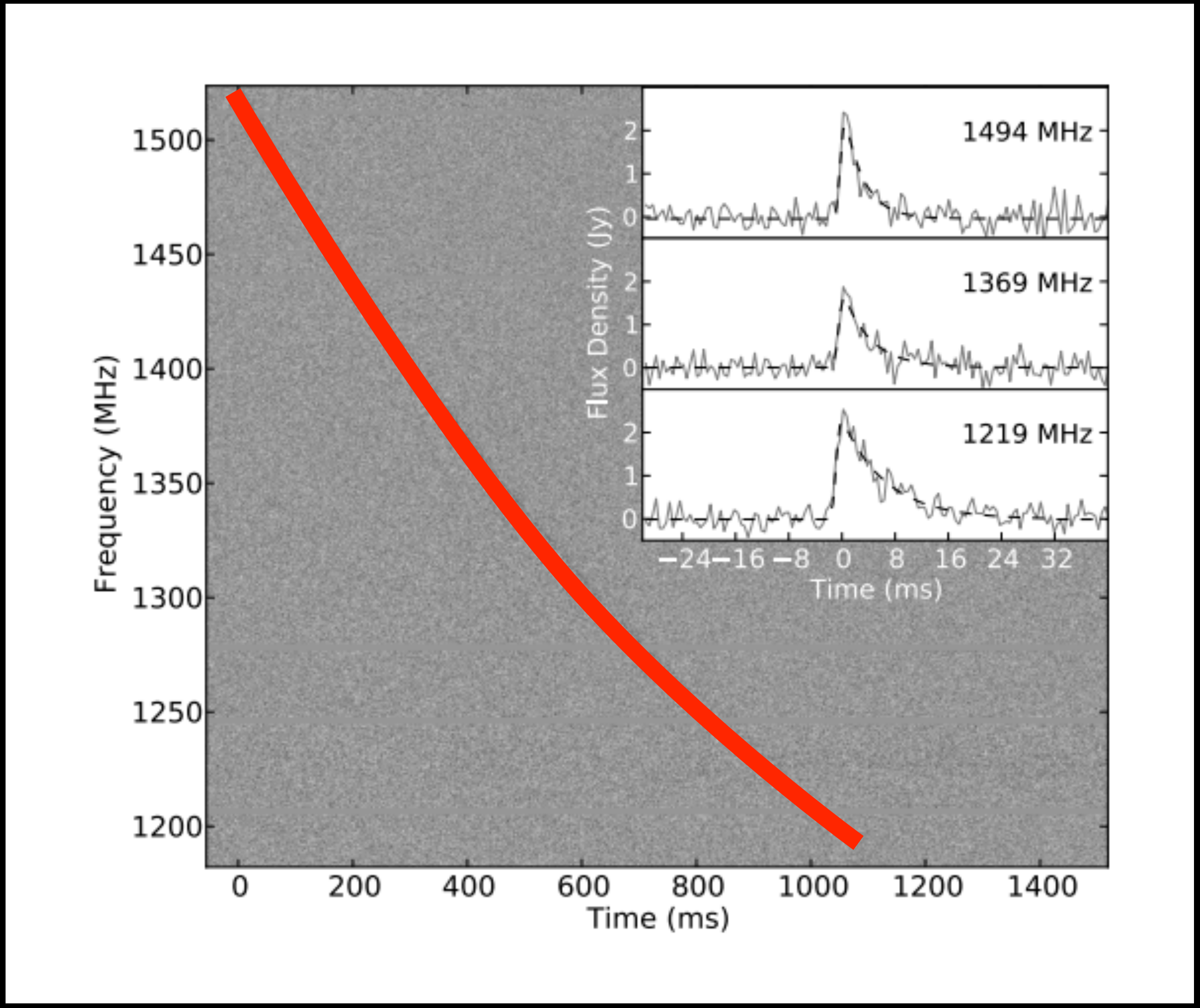
$\approx 1\ \mathrm{yr}^{-1}$

ISS-Lobster

Fast Radio Bursts



Lorimer et al. (2007)
Thornton et al. (2013)



Intense, millisecond duration bursts of radio waves

high dispersion measure and scattering tales consistent with cosmological origin

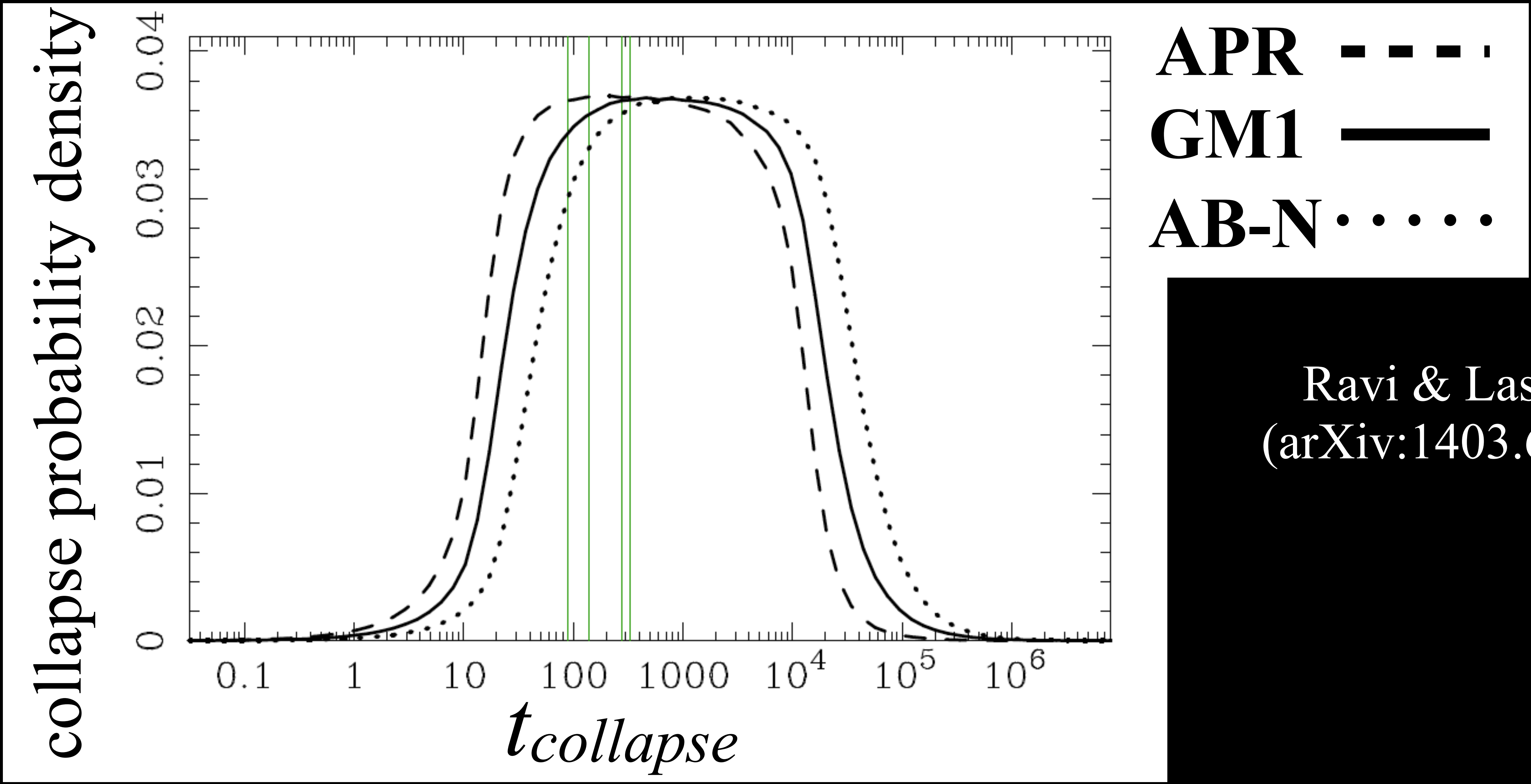
Fast Radio Bursts

Numerous models:

magnetar hyperflares (Popov & Postnov 2013)
binary white dwarf mergers (Kashiyama et al. 2013)
binary neutron star mergers (Totani et al. 2013)
stellar flares (Loeb et al. 2014)
blitzars (Falcke & Rezzolla 2014)

collapse of supramassive
neutron star!!

(see Zhang (2014) *The GRB/FRB connection...*)



Ravi & Lasky (arXiv:1403.6327)

supramassive NSs from binary NS mergers collapse within 4.4×10^4 s (95 % confidence)

➡ not the progenitors of Blitzars

➡ a natural timescale for X-ray -- radio follow-up of SGRBs and gravitational wave triggers

Summary

The formation of black holes may have recently been observed in x-ray observations

0) this is really cool!

1) this is a nuclear physics experiment

   a) gravitational wave observations will help

Lasky et al. (2014; arXiv:1311.1352)

2) this provides a natural timescale for gravitational collapse of supramassive NSs

   a) constrain progenitor models for fast radio bursts

   b) timescale for high-time resolution x-ray -- radio follow-up of short GRBs and gravitational wave triggers

Ravi & Lasky (2014; arXiv:1403.6327)