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X-RAY AFTERGLOWS OF GAMMA-RAY BURSTS

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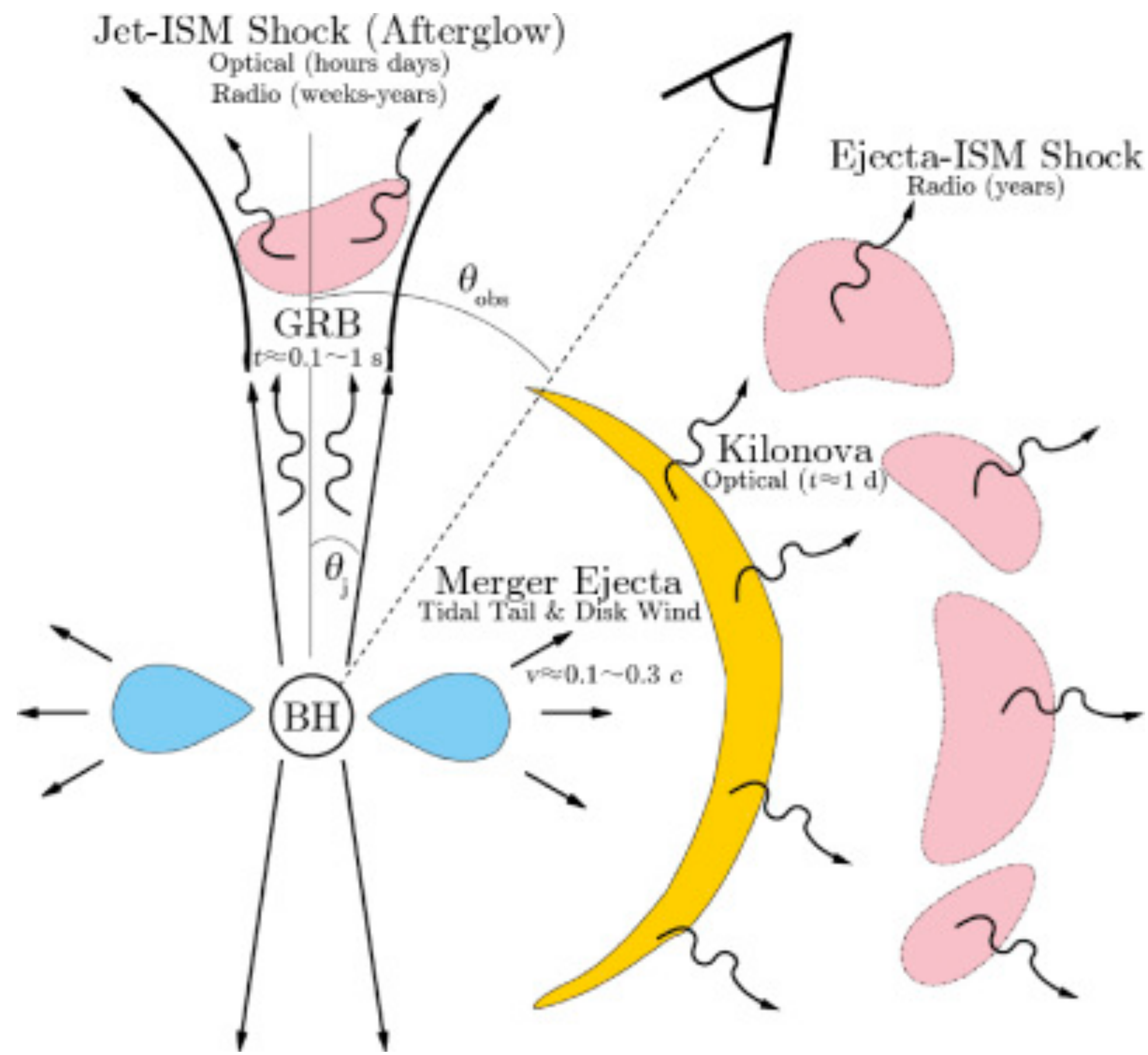
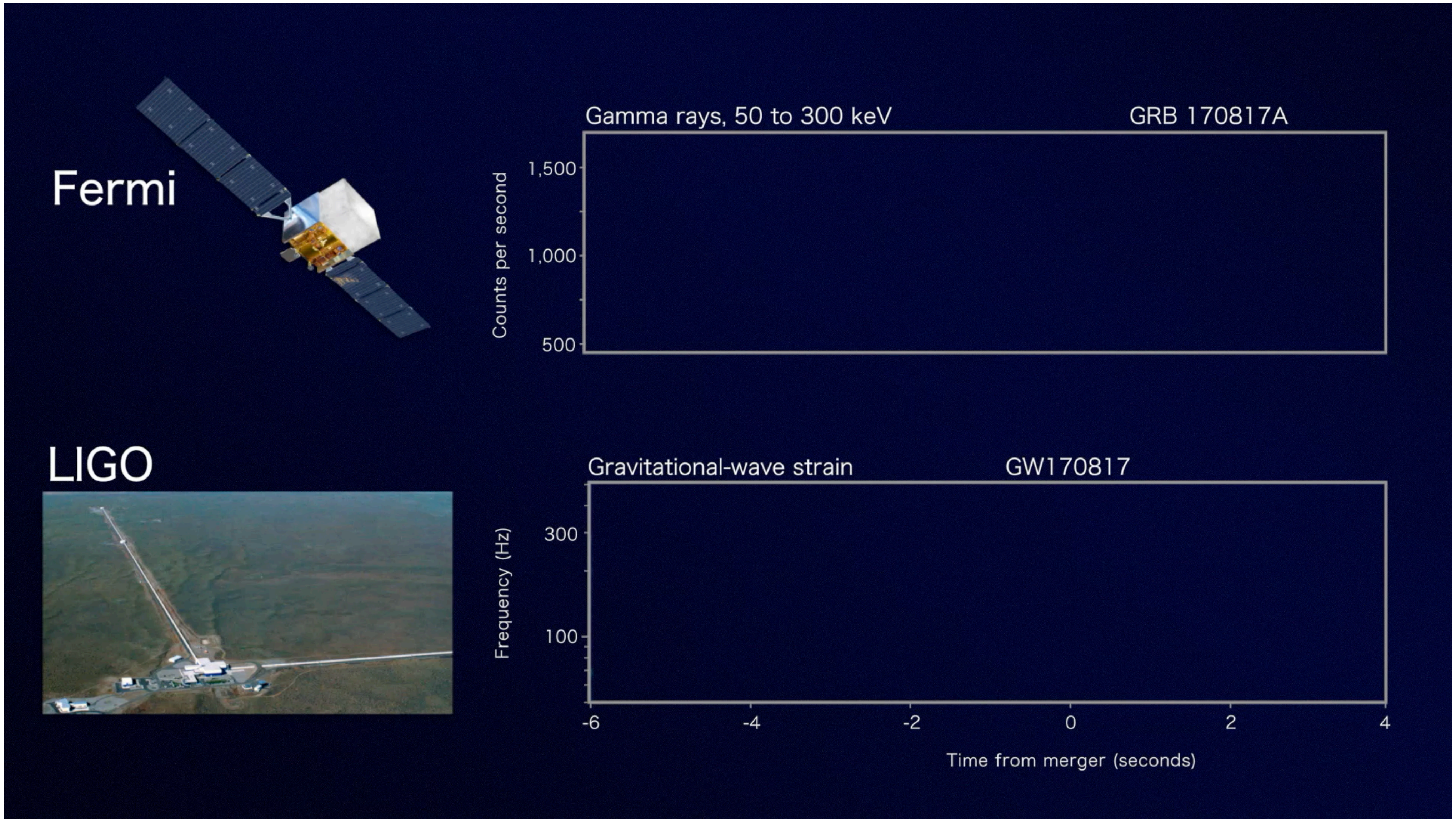
- Gamma-ray bursts often have an extended x-ray, optical, radio emission.
- Origin of this afterglow is unclear
  - External shock from a relativistic fireball.
  - Millisecond magnetar.
  - Both.

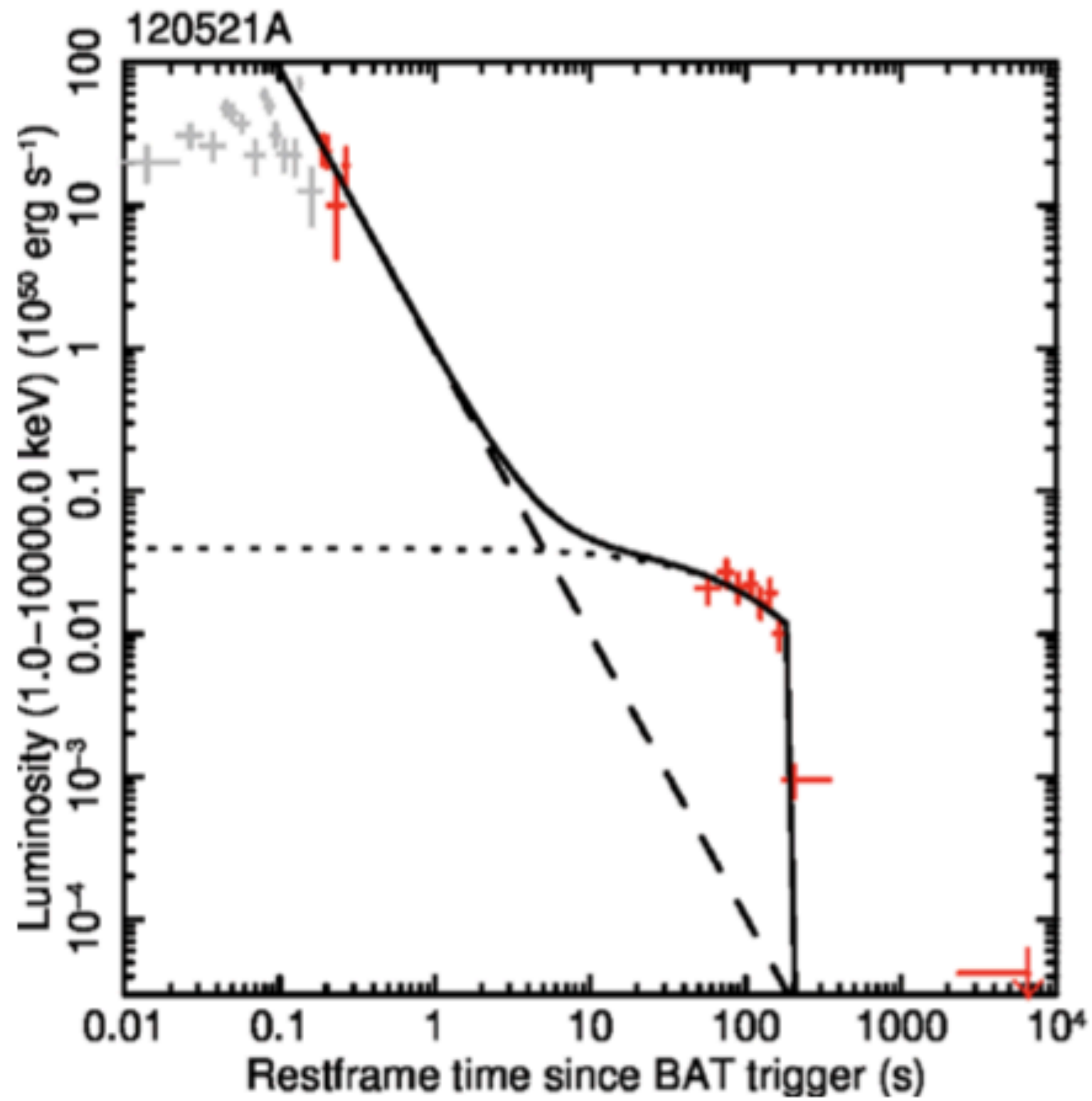


Schematic from Metzger and Berger (2012)

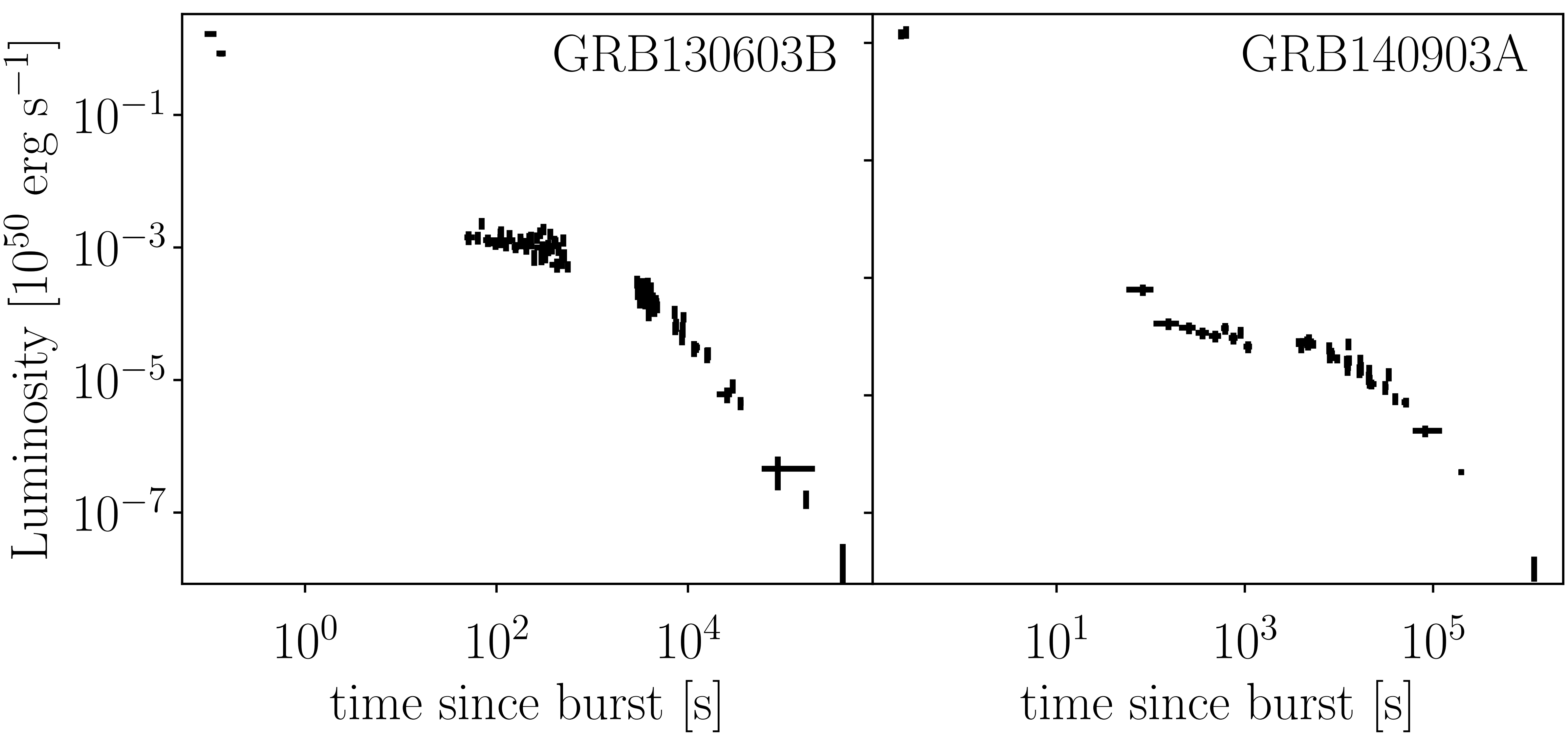


- What was the ultimate fate of the post-merger remnant of GW170817? We don't know (See Paul Lasky's talk)…

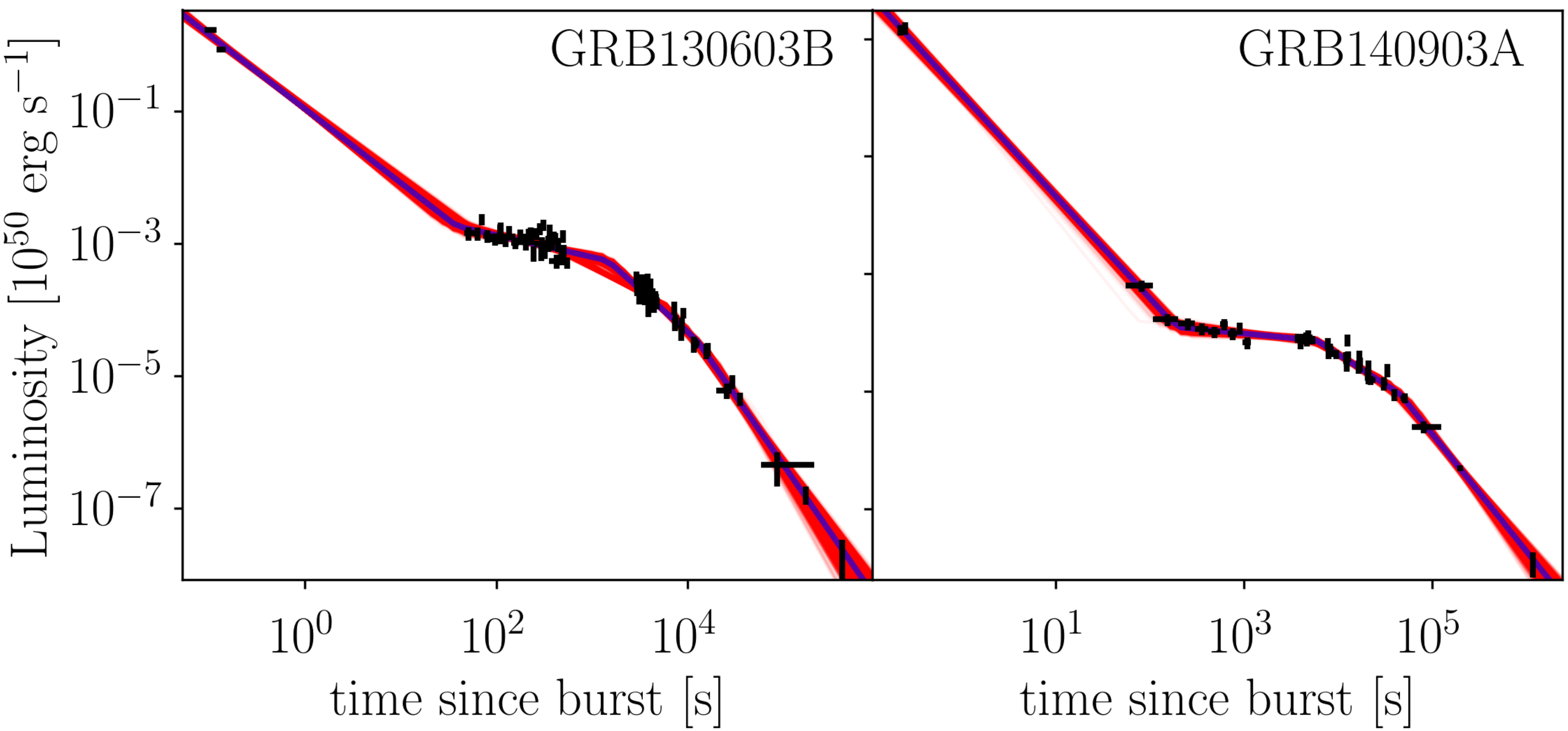
- X-ray afterglows of gamma-ray bursts offers great insight into the fate of post-merger remnants.
- Unfortunately, quite often, the answer is not as clear cut - Bayesian model selection can help here!



Rowlinson et al. (2013)


GRB130603B
GRB140903A
Luminosity [10^{50} erg s^{-1}]
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{0}
10^{2}
10^{4}
time since burst [s]
10^{1}
10^{3}
10^{5}
time since burst [s]

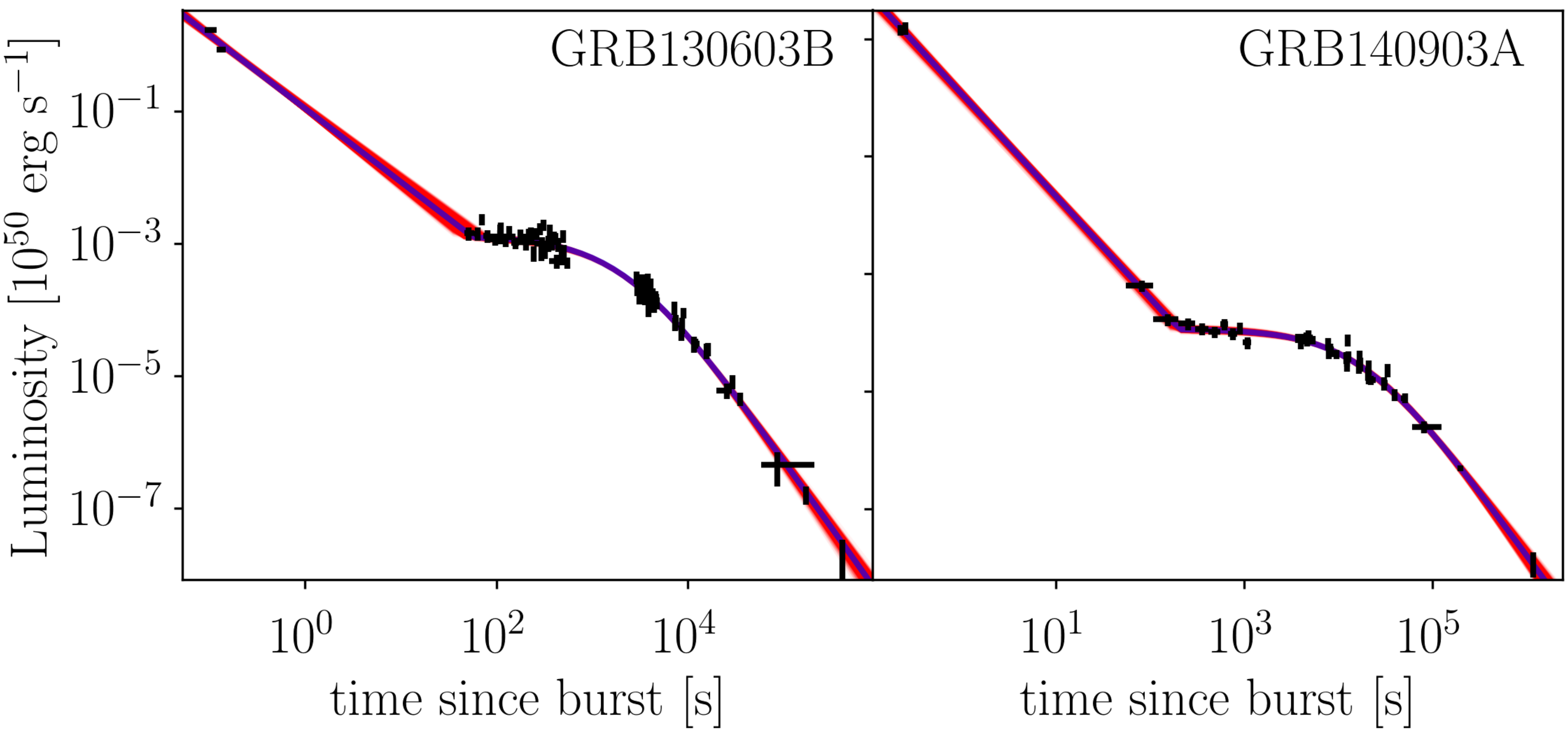
Fireball



$$L = A_1 t^{\alpha_1} + A_2 t^{\alpha_2} + ... + A_n t^{\alpha_n}$$

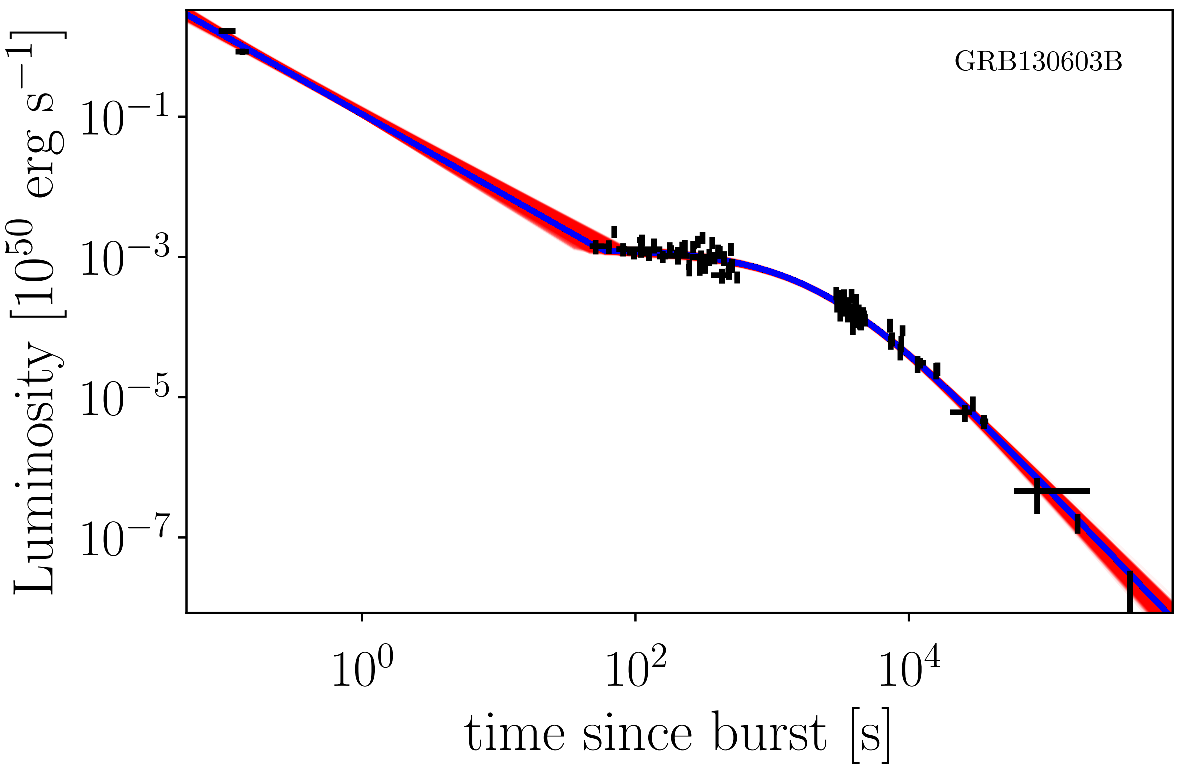
 Sarin et al. (2019)

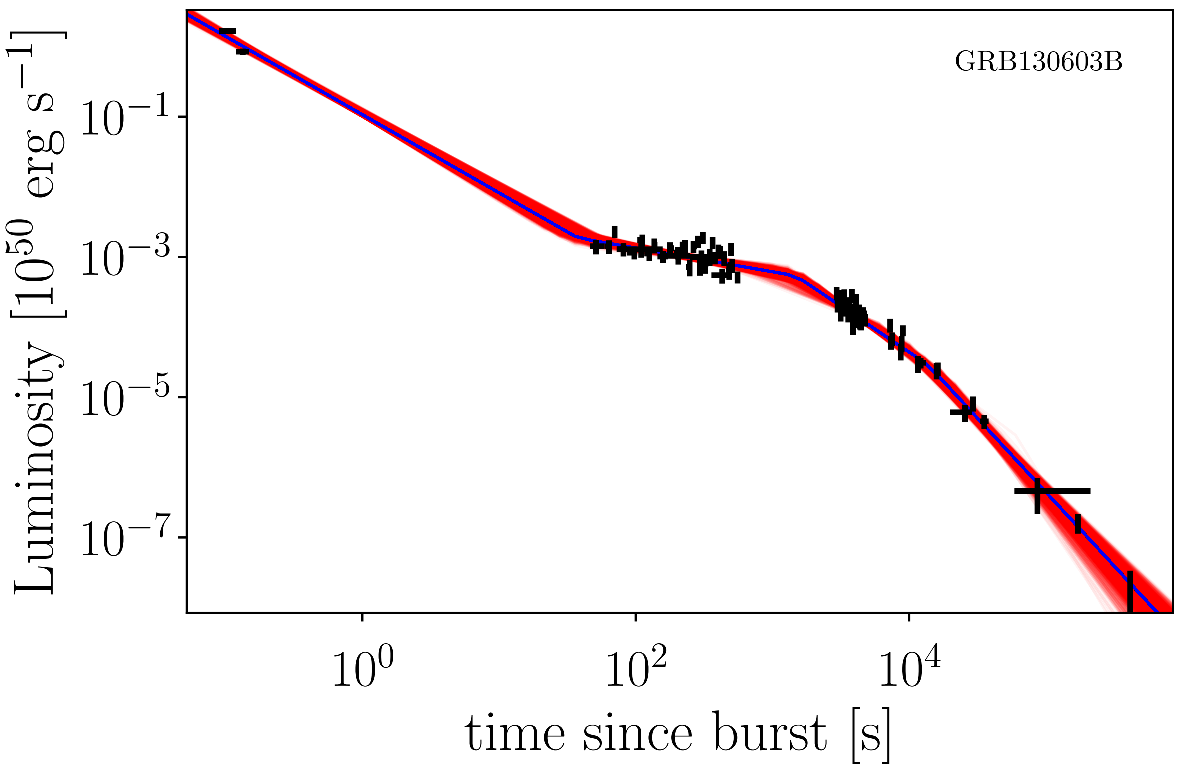
Magnetar



$$L = A_1 t^{\alpha_1} + A_2 \left(1 + \frac{t}{\tau}\right)^{\frac{1+n}{1-n}}$$

- So what is the better model?





Magnetar Model

4-component fireball model

 Sarin et al. (2019)

	Bayes Factor
GRB130603B	~ 30
GRB140903A	~ 1700

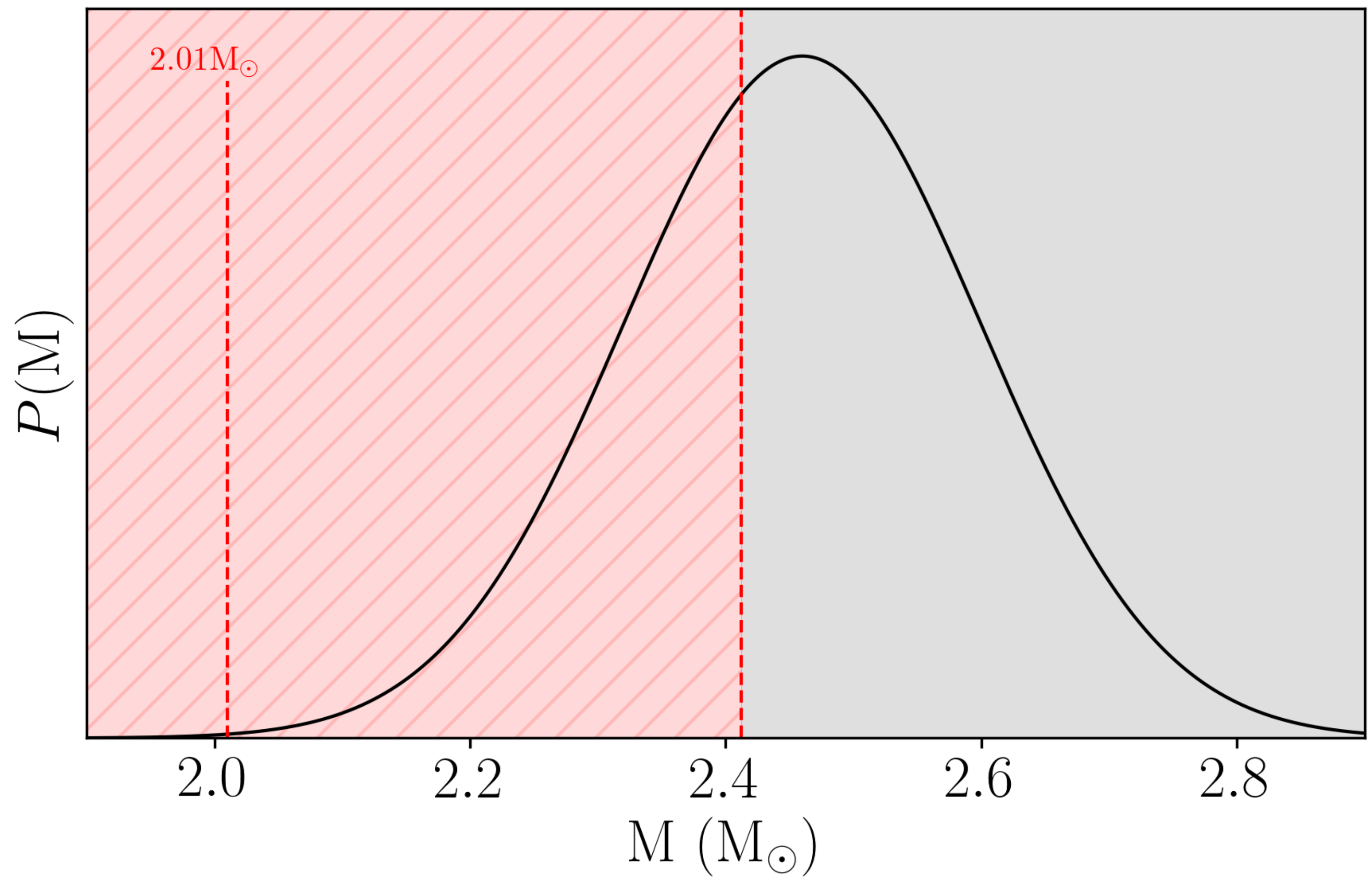
- GRB140903A: magnetar model is ~1700 times more likely than the most likely fireball, assuming both hypotheses are equally likely…

- The correct metric for model selection is the Odds.
- Prior odds describe our prior belief of the likelihood of one hypothesis over another

$$\mathcal{O}^A_B = \frac{\mathcal{Z}_\mathcal{A}}{\mathcal{Z}_\mathcal{B}} \times \frac{\Pi_A}{\Pi_B}$$

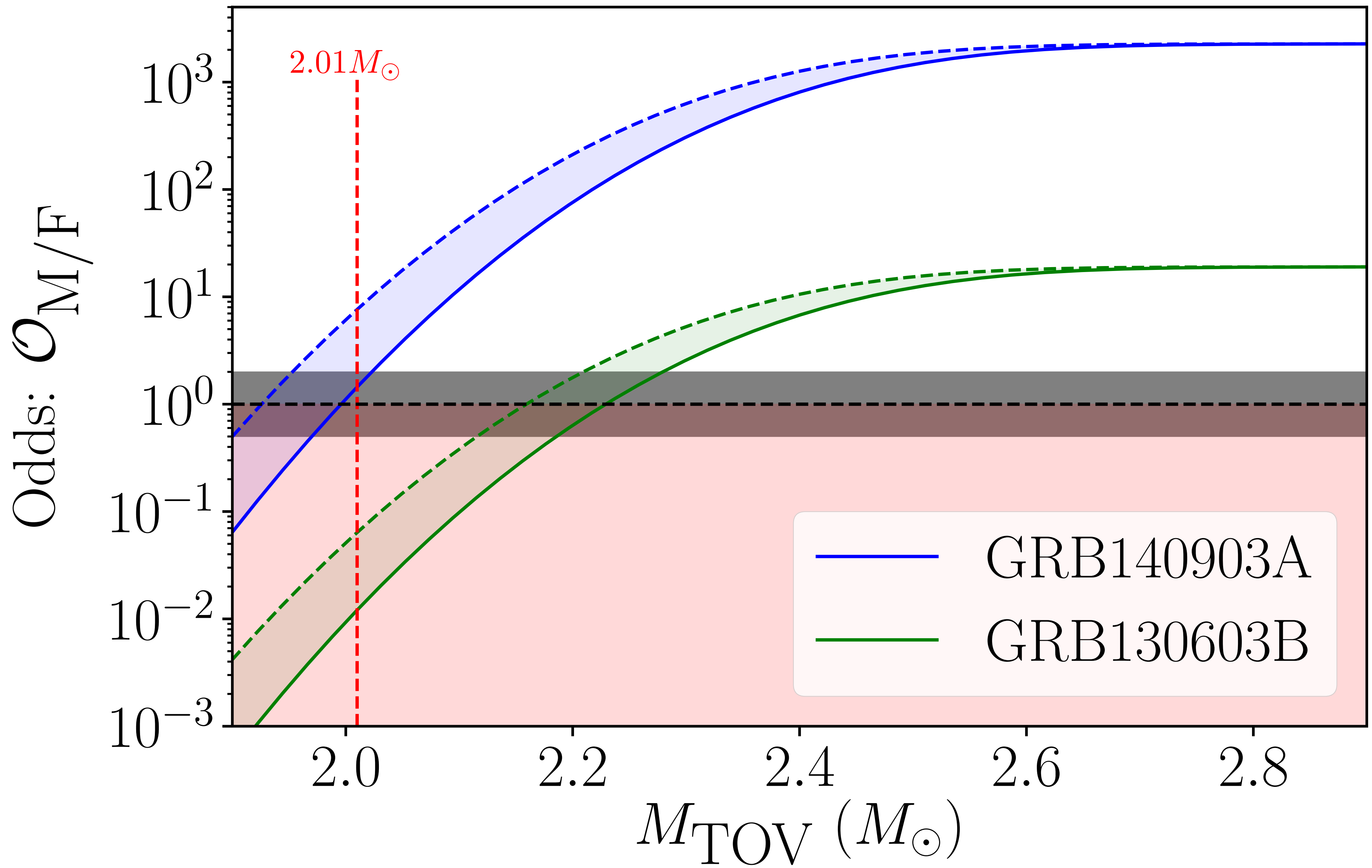
Sarin et al. (2019)

- Magnetar model requires the formation of a long-lived neutron star.
- Can inform our prior odds by using the neutron star mass distribution of Kiziltan et al. (2013) and the post-merger mass distribution of Lasky et al. (2014)



$$\frac{\Pi_M}{\Pi_F} = \int_0^{\mathrm{M_{TOV}}} P(\mathrm{M})\, d\mathrm{M}$$

Sarin et al. (2019)



- Model selection becomes dependent on the unknown nuclear equation of state.
- GRB140903A favours the magnetar model for all possible equation of states.

- Knowing the ultimate of binary neutron star post-merger remnants is incredibly informative, particularly towards the equation of state.
- Model selection on X-ray afterglows can help answer the question but it is not conclusive without a known equation of state.
- Magnetar model is preferred over the fireball model for all equation of states for GRB140903A. Implying a long lived neutron star remnant, which will spin down and emit gravitational waves (Sarin et al. 2018)