University of Leicester

Can magnetar spin-down power extended emission in some short GRBs?

B.P. Gompertz[1], P.T. O'Brien[1], G.A. Wynn[1], A. Rowlinson[2]
[1]University of Leicester
[2]University of Amsterdam

University of Leicester

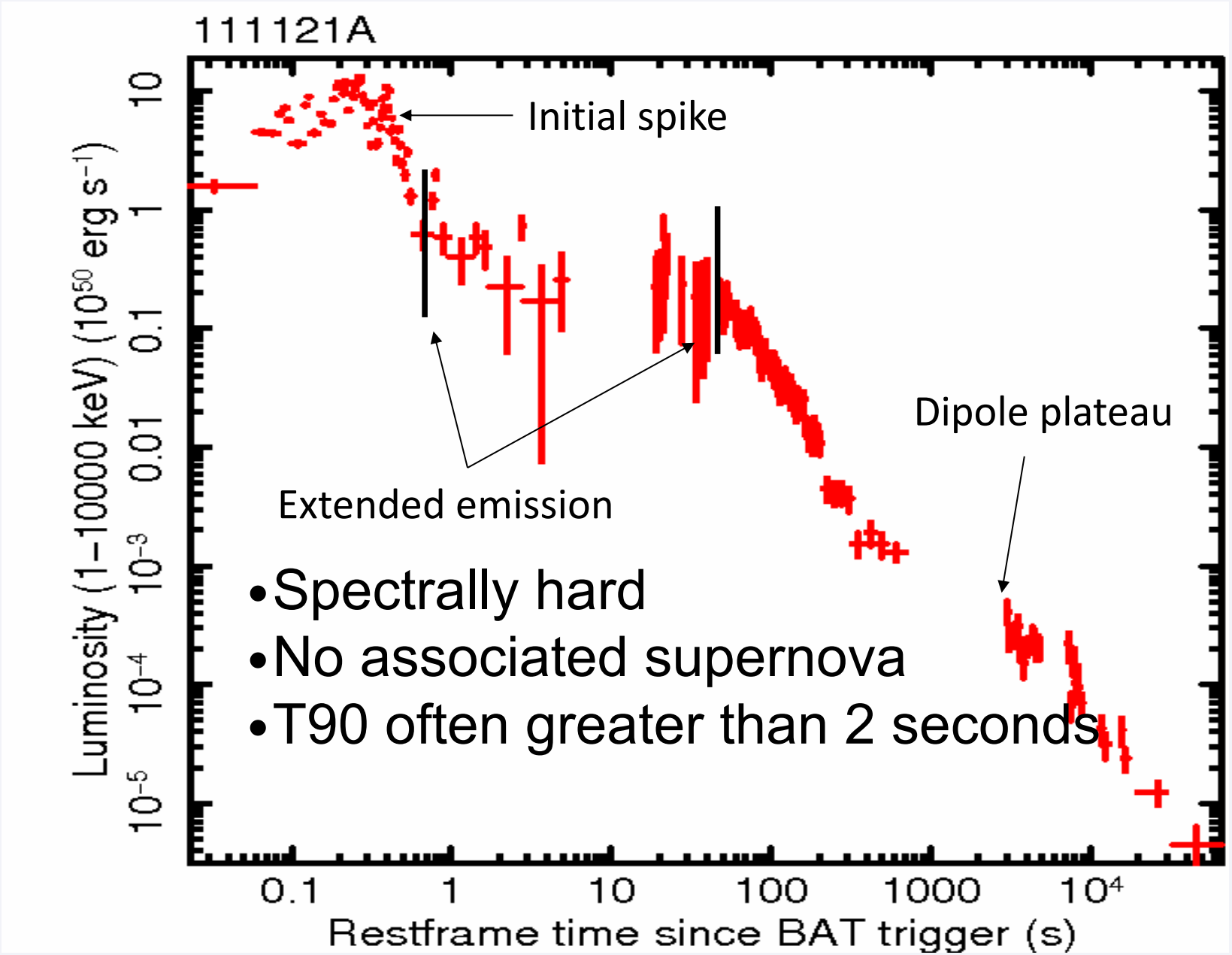
Gompertz et al. 2013: 2013MNRAS.tmp..909G
arXiv:1302.3643

Overview

- What is extended emission?
- Evidence for a common central engine
- The magnetic dipole spin-down model
- Fitting the late-time dipole plateau
- Correcting for extended emission
- Results

University of Leicester

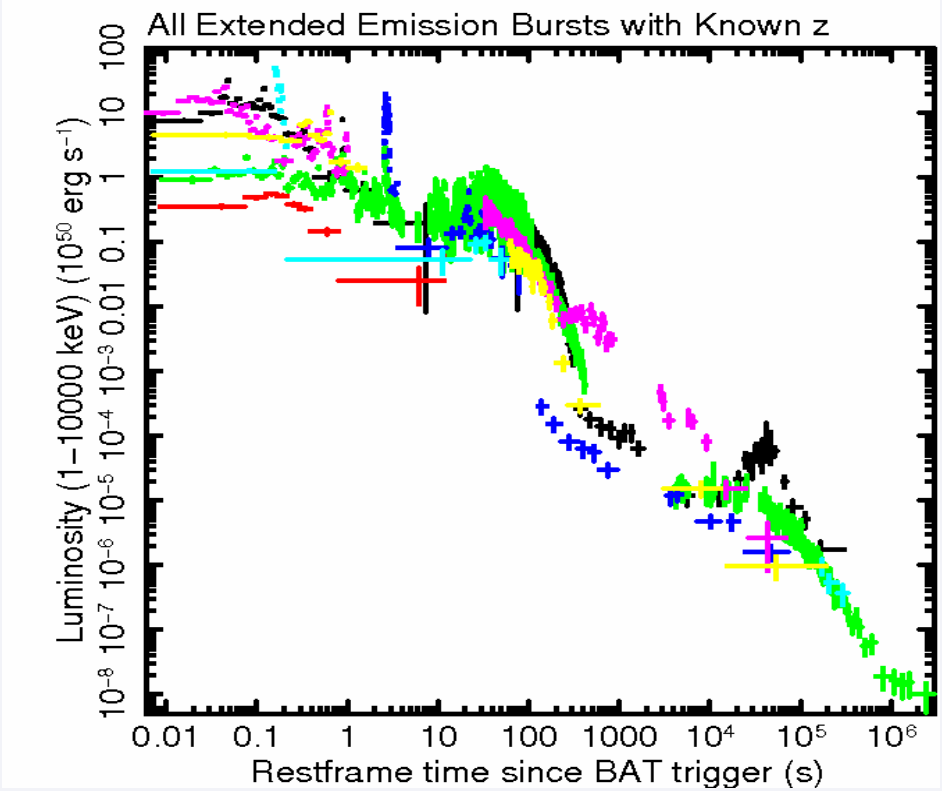
Extended emission bursts

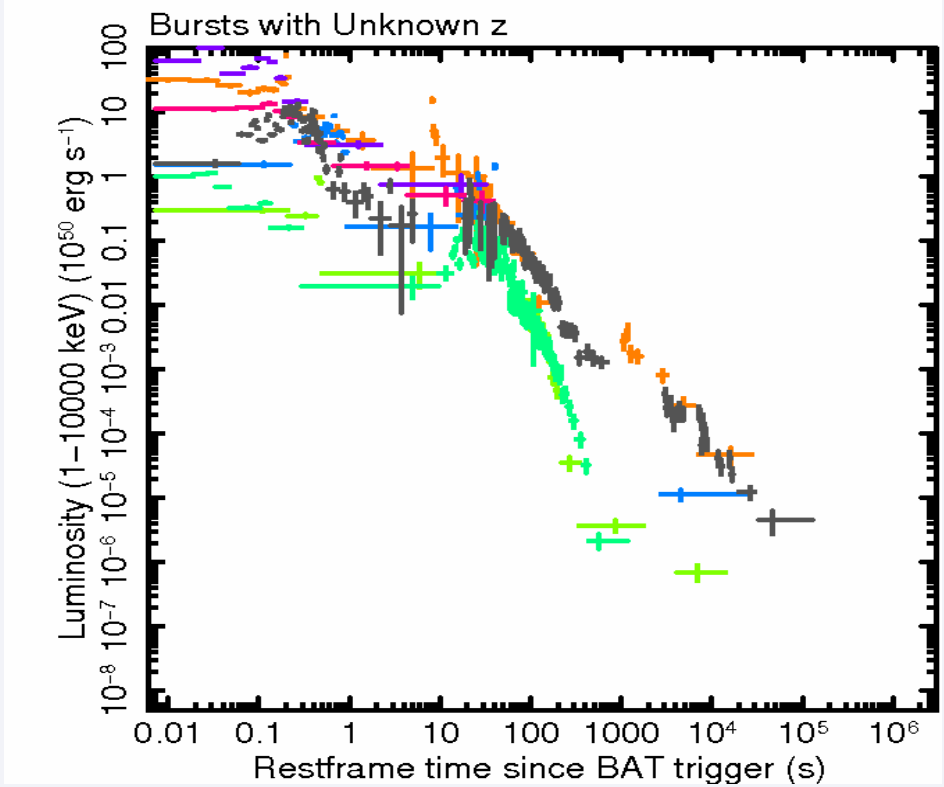


- Spectrally hard
- No associated supernova
- T90 often greater than 2 seconds

University of Leicester

A common central engine





- EE bursts show remarkable uniformity
- Suggests a common central engine
- Standard merger models struggle to reproduce the EE tail

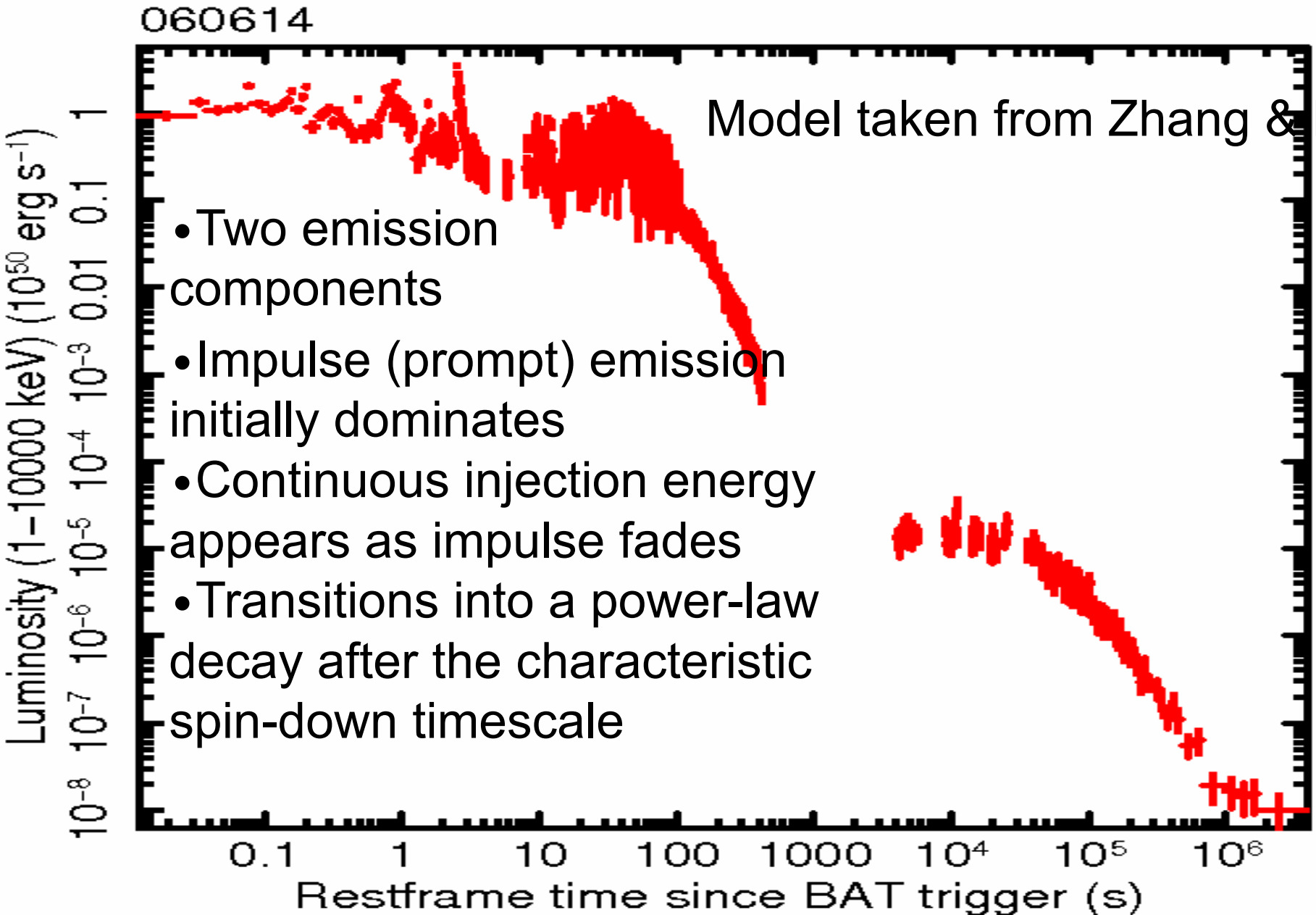
University of Leicester

The magnetar model

- Formed by merger or collapse
- Produces a compact, rapidly spinning (P ~ 1 ms) NS
- Very high (1015 G) magnetic field
- Large energy reservoir
- Variety of potential energy extraction methods
- Previous examples: Metzger et al, 2008; Bucciantini et al, 2012; Rowlinson et al, 2013

University of Leicester

Dipole spin-down

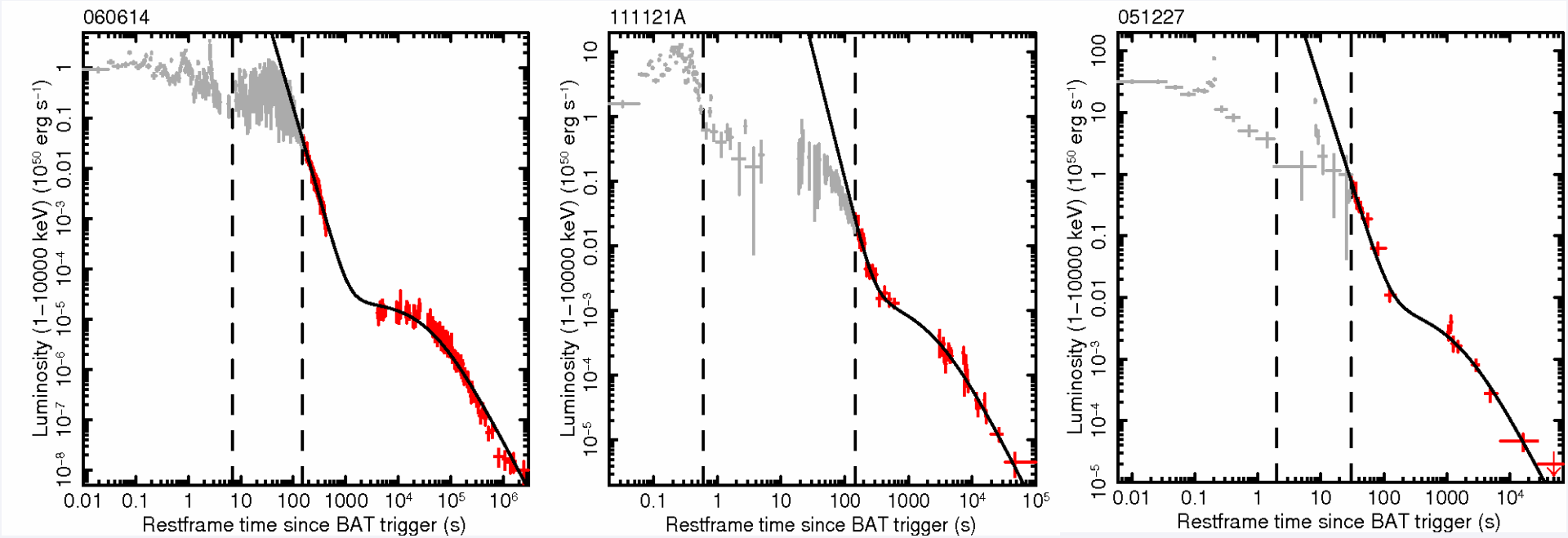


University of Leicester

Fitting

$$T_{em,3} = 2.05(I_{45} B_{p,15}^{-2} P_{0,-3}^{2} R_{6}^{-6})$$

$$L_{0,49} \sim (B_{p,15}^{2} P_{0,-3}^{-4} R_{6}^{6})$$



University of Leicester

Correcting for EE

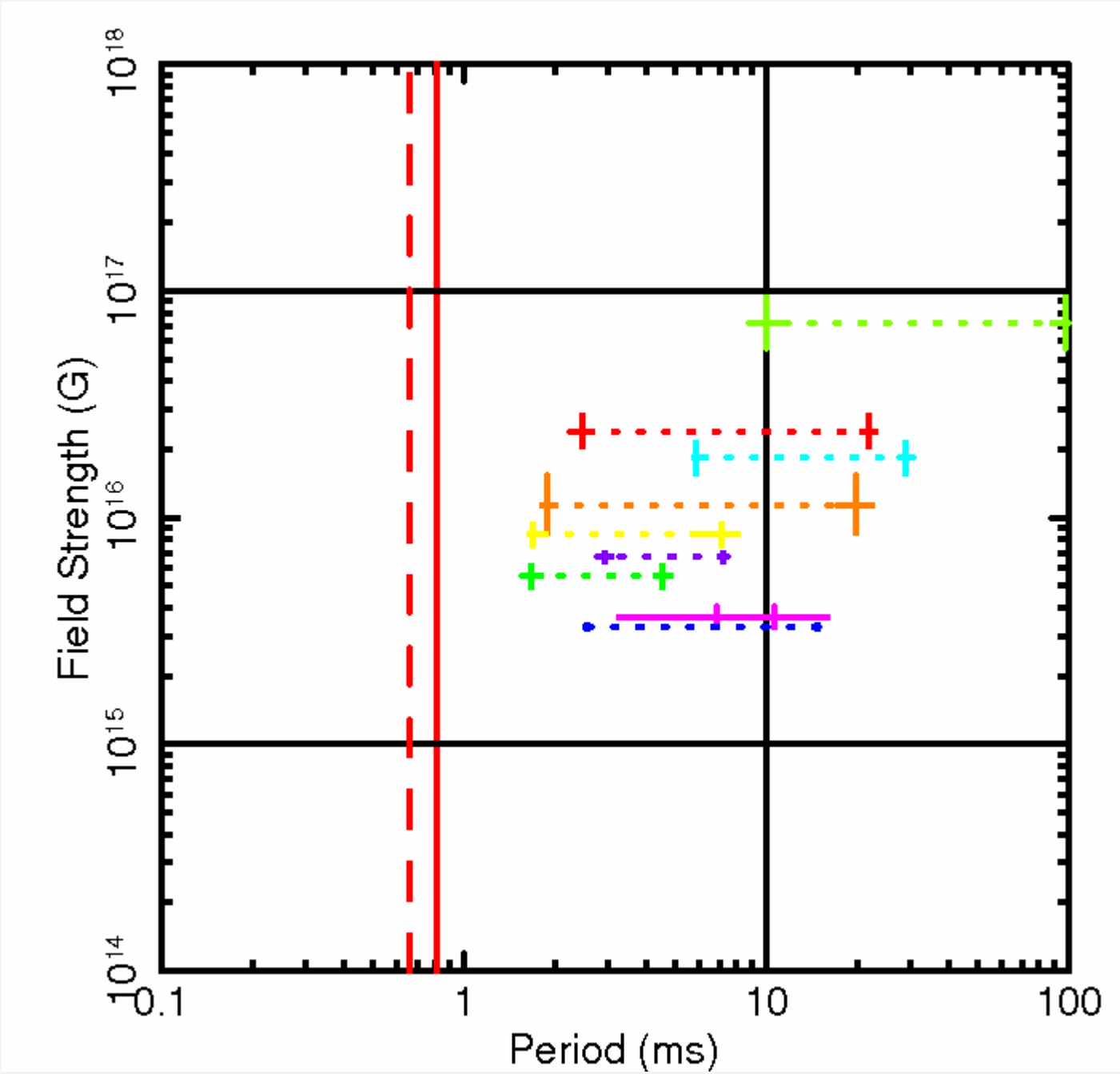
- Derived value for P0 is affected by EE
- Assume EE is entirely due to magnetar spin down
- Assume magnetic field constant
- Area under curve during EE is total energy release

$$\Delta E = 2\pi^2 I(P_i^{-2} - P_0^{-2})$$

University of Leicester

Results

- RHS: post EE (P0) from fitting
- LHS: corrected for EE (Pi)

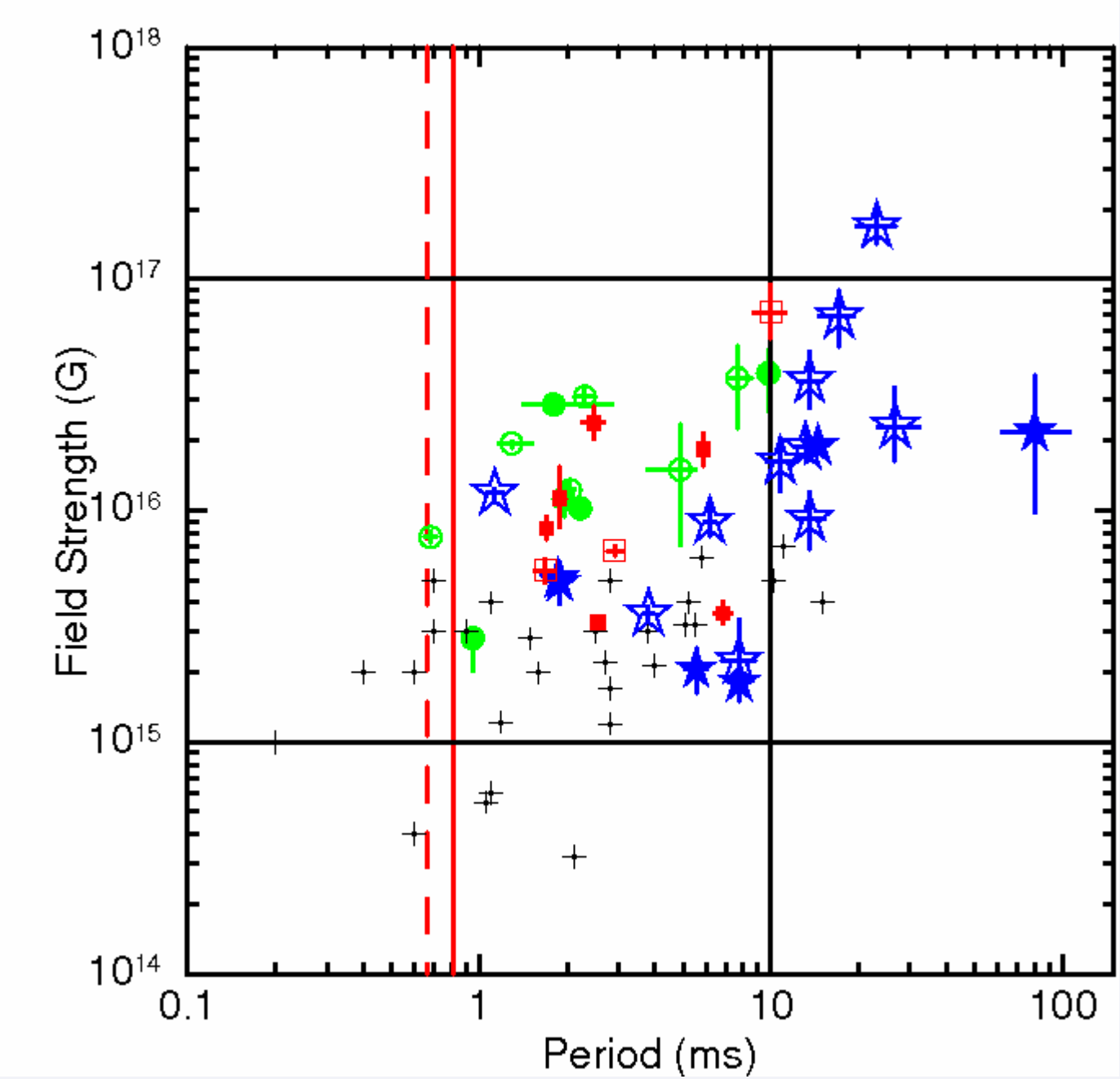


University of Leicester

Wider GRB context

SGRBs (Green, blue):
Rowlinson et al. 2013

LGRBs (Black):
Lyons et al. 2010;
Dall'Osso et al. 2011;
Bernardini et al. 2012



University of Leicester

Summary

- Results are consistent with EE being powered by a spinning-down magnetar
- Derived values for P and B are consistent with those theorised for magnetar birth
- EE population shares properties most in common with unstable magnetar SGRBs
- Similarities in P and B suggest EE arises from a different formation mechanism or environment

Gompertz et al. 2013: 2013MNRAS.tmp..909G

References

- Bernardini et al. 2012, MSAIS, 21, 226
- Bucciantini et al. 2012, MNRAS, 419, 1537
- Dall'Osso et al. 2011, A&A, 526, A121
- D'Avanzo et al. 2009, A&A, 498, 711
- Lattimer & Prakash, 2004, Sci, 304, 536
- Lyons et al. 2010, MNRAS, 402, 705
- Metzger et al. 2008, MNRAS, 385, 1455
- Rowlinson et al. 2013, MNRAS, 608
- Thompson 2007, RmxAC, 27, 80
- Usov 1992, Nature, 357, 472
- Zhang & Mészáros, 2001, ApJ, 552, 35