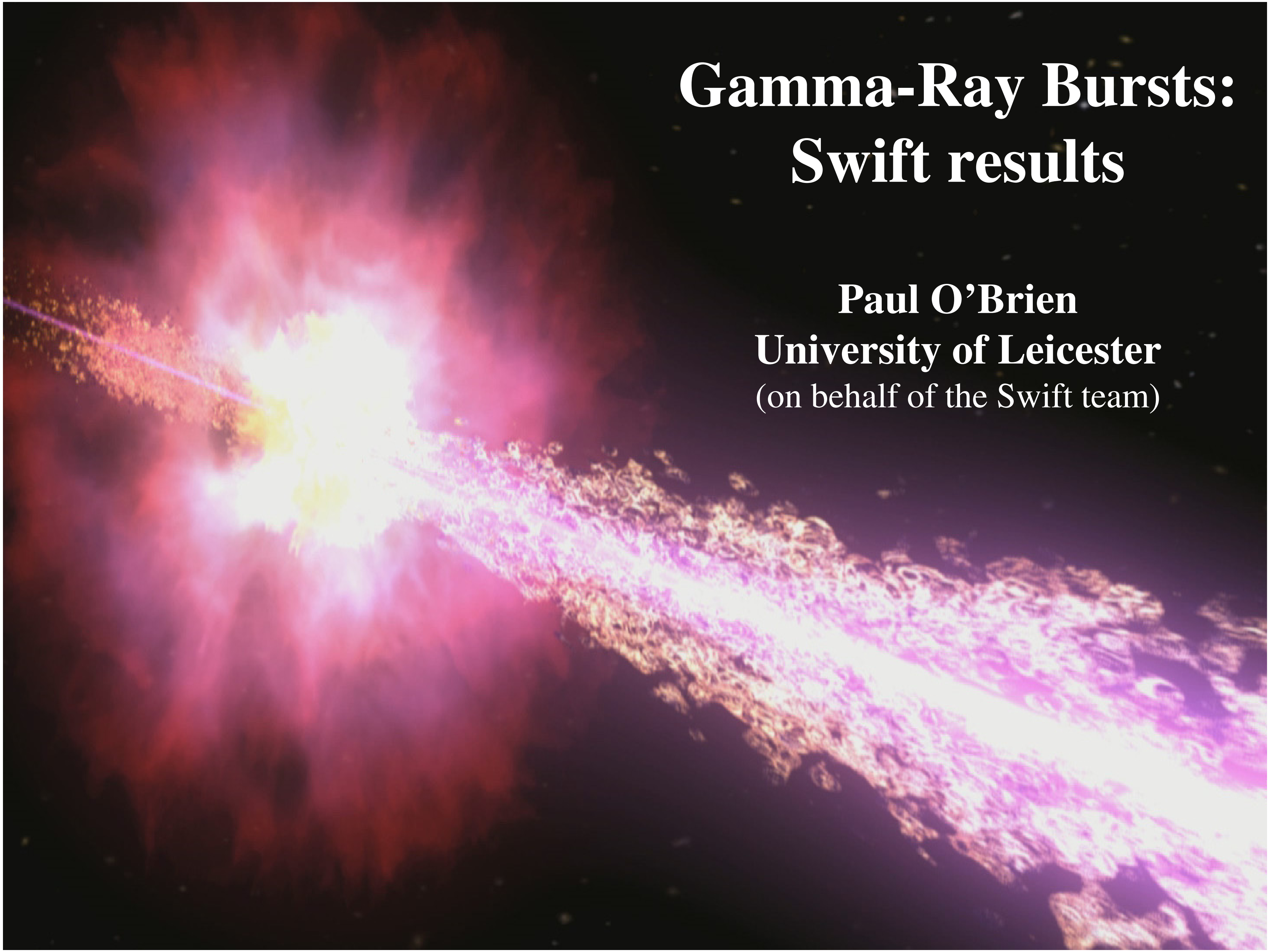
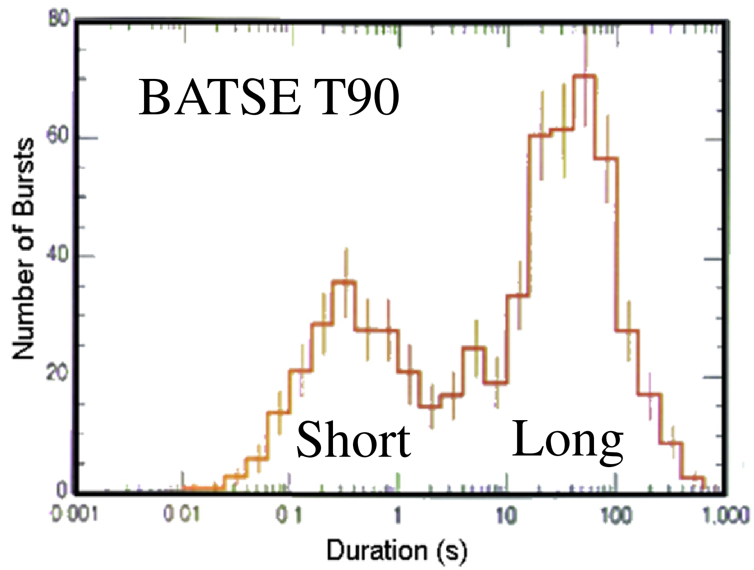
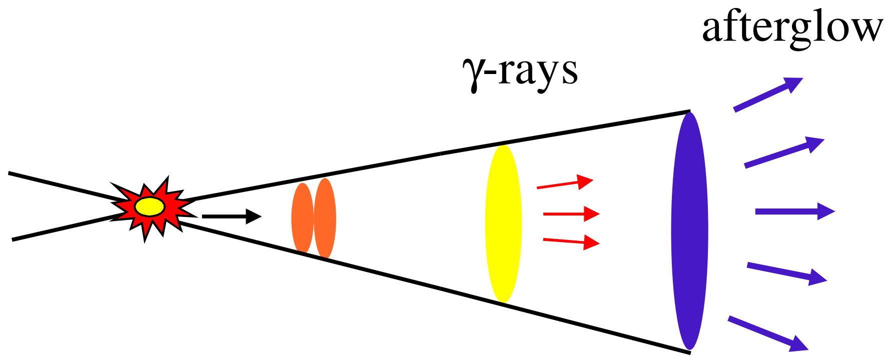


Gamma-Ray Bursts: Swift results

Paul O'Brien
University of Leicester
(on behalf of the Swift team)

Gamma-Ray Bursts





Fireball-shock Model

(Meszaros & Rees 1997)

Need Lorentz factors Γ >100

All bursts with known redshifts (several hundred) are cosmological

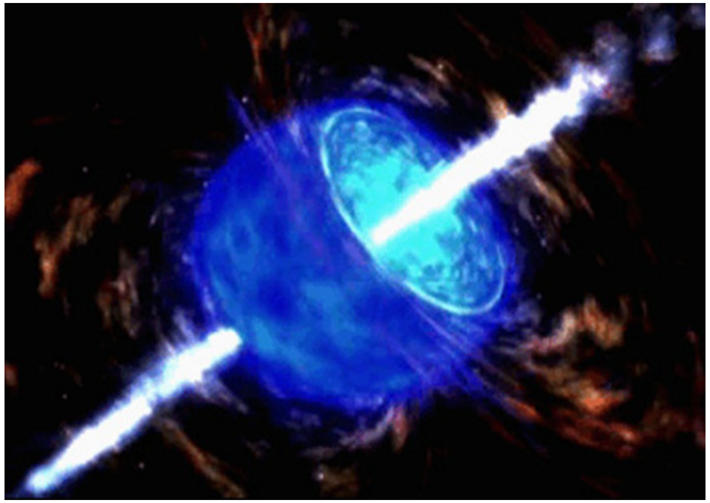
Mean observed redshift z~2.2

"Beaming-corrected" luminosities of 10^{51} to 10^{52} erg?

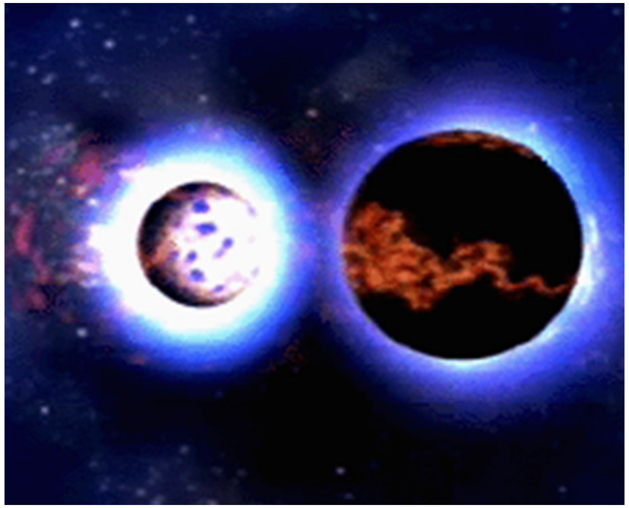
(uncertain, but if jets are very wide we are in big trouble...)

GRB progenitors

LGRB: Collapsar



SGRB: Binary Merger

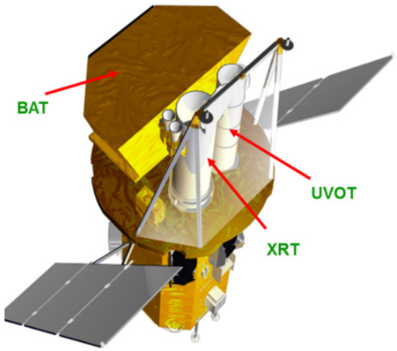


LGRB: Collapsar model – occurs in region of massive (hence recent) star formation. Several examples known of associated super/hypernova signature

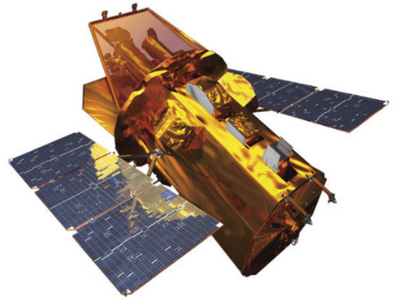
SGRB: Merger model (e.g. NS-NS) – can occur in any type of galaxy, and also off of a galaxy due to natal dynamic kick and long merger time

The “central engine” produced may be a black hole or a magnetar

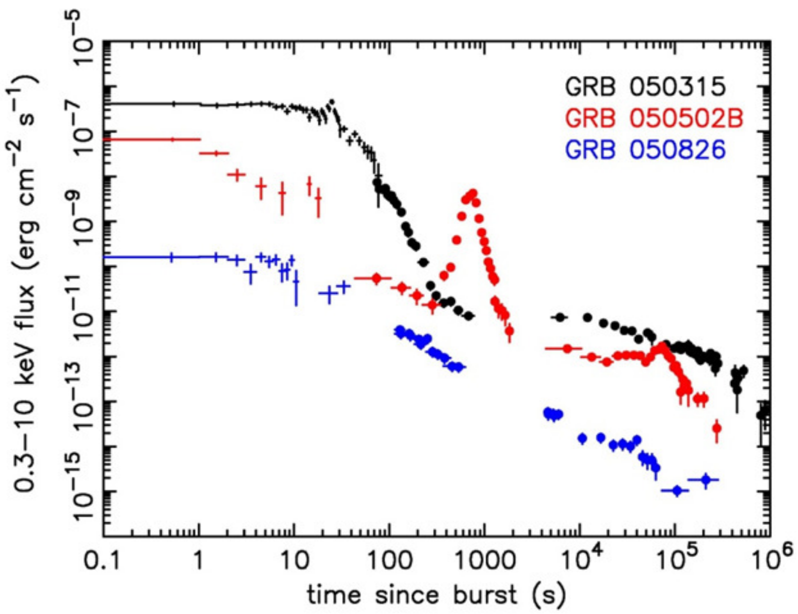
Swift statistics (at 2014 August 4)

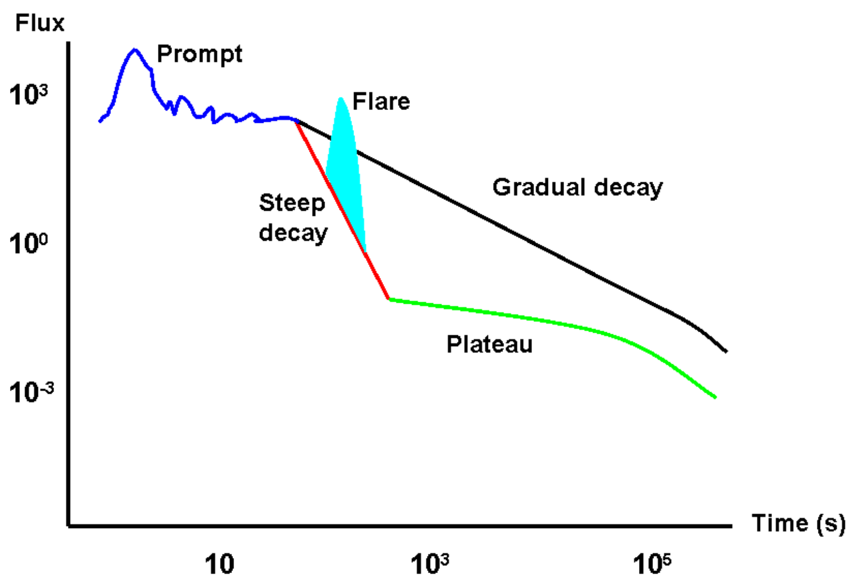


Swift GRBs	896
XRT detections	700
XRT non-detections (slew <300s)	30
UVOT detections	280
UVOT or ground detections	508
Redshift obtained	283



Swift era GRB light curves





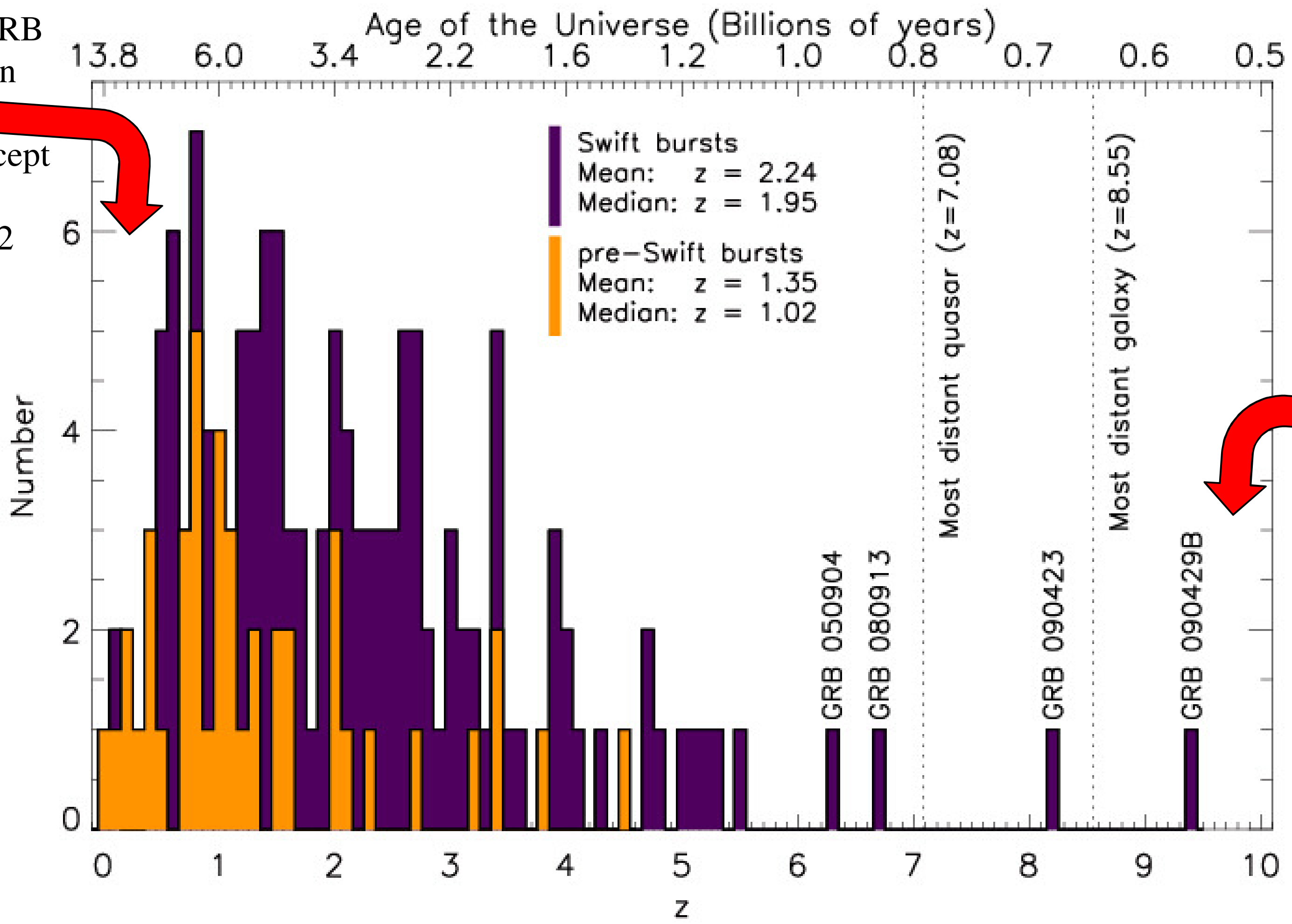
Range in shapes implies a mixture of internal and external processes (Nousek et al. (2006); O'Brien et al. (2006)…). **True for both long and short GRBs.**

- Fast decay and flares appear internal – central engine dominated?
- Slow decays and late plateau external – afterglow dominated?

All of these phenomena are potential sources of VHE

GRB redshifts

No Swift GRB found within A-LIGO volume, except perhaps GRB130822

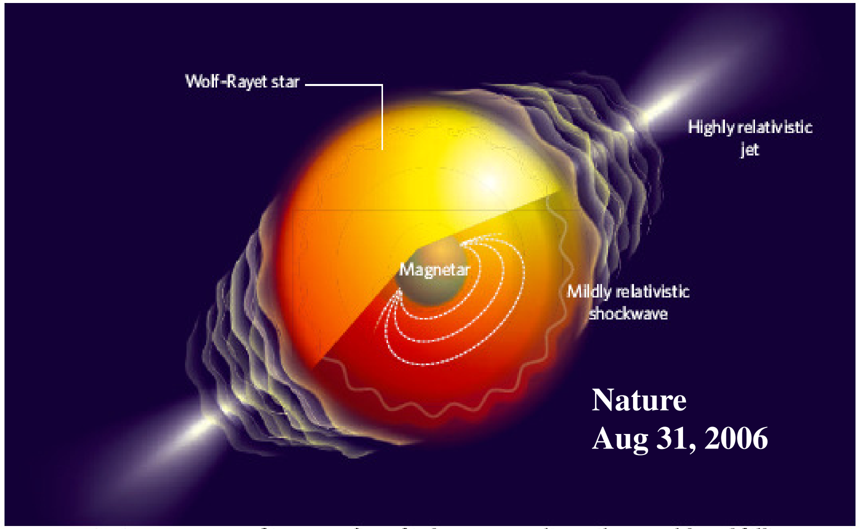


How far back can we detect GRBs?

Pali Jakobsson (2011)
http://raunvis.hi.is/~pja/GRBsample.html

GRB 060218 : low luminosity GRB

(Campana et al. 2006)

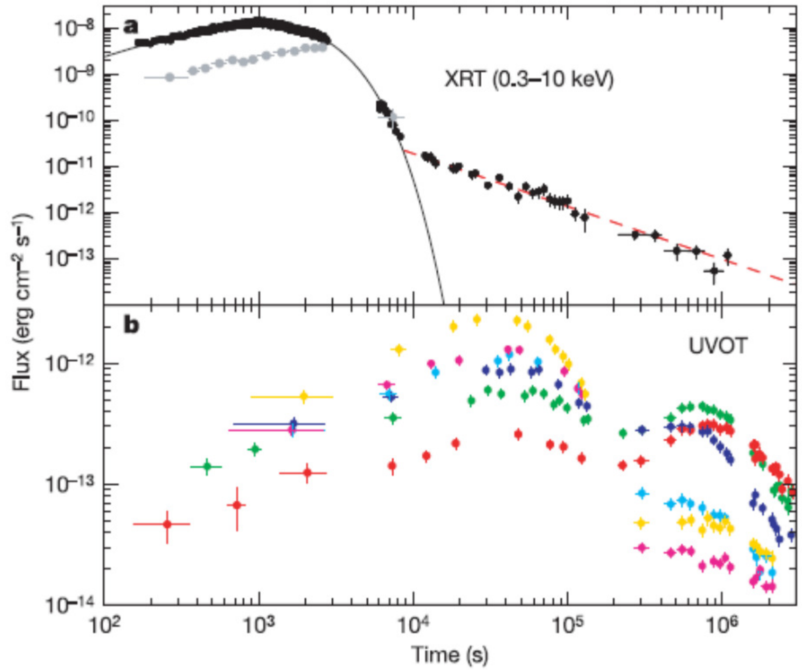


Very long GRB T90 ~35 minutes

z = 0.033 d = 145 Mpc

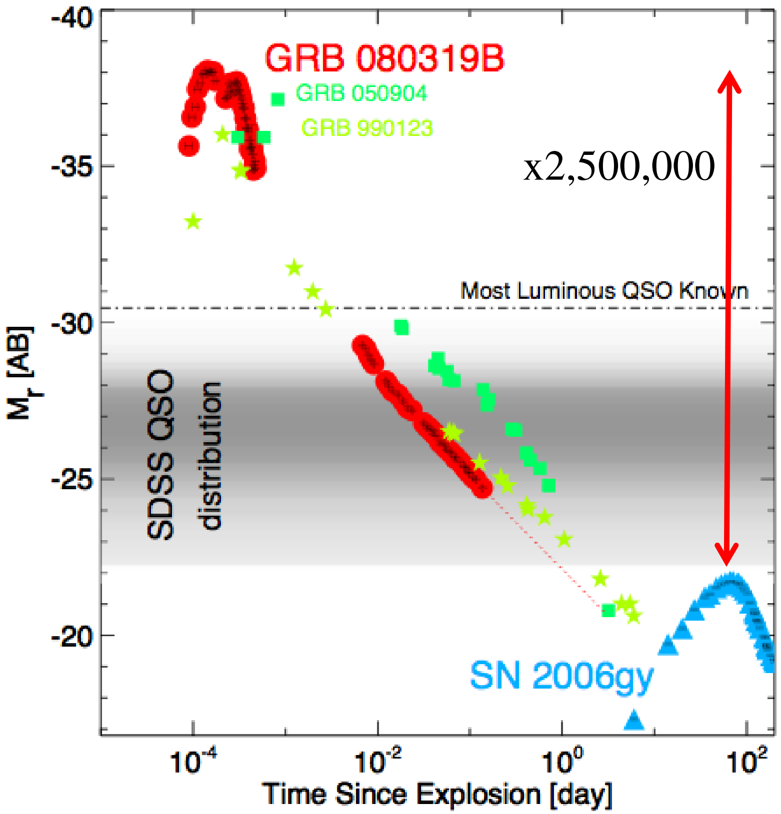
SN 2006aj Type Ib/c

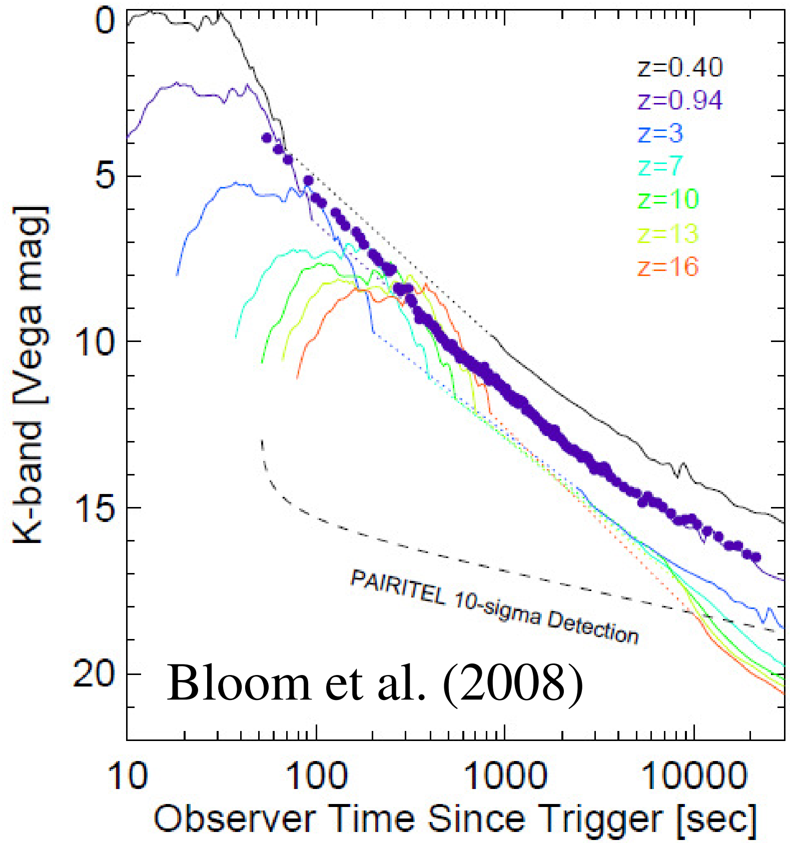
- E_{iso} = few x 10^{49} erg cm^{-2}
- Thermal X-ray spectrum, perhaps due to shock break-out through wind?
- Wolf Rayet progenitor (no H or He)
- Could this burst have a magnetar central engine?
- May be a significant number of such sources, below the BAT detection threshold



GRB080319B; z=0.935

"The naked-eye Burst" (Racusin et al. 2008)

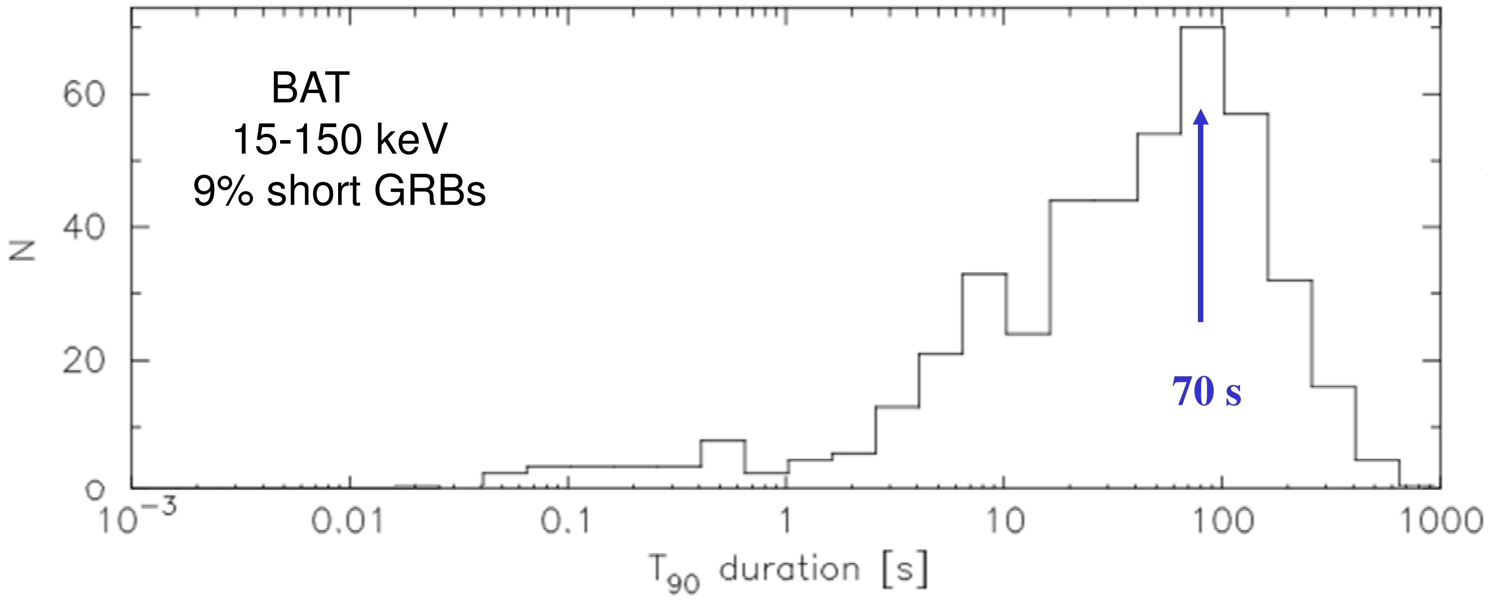




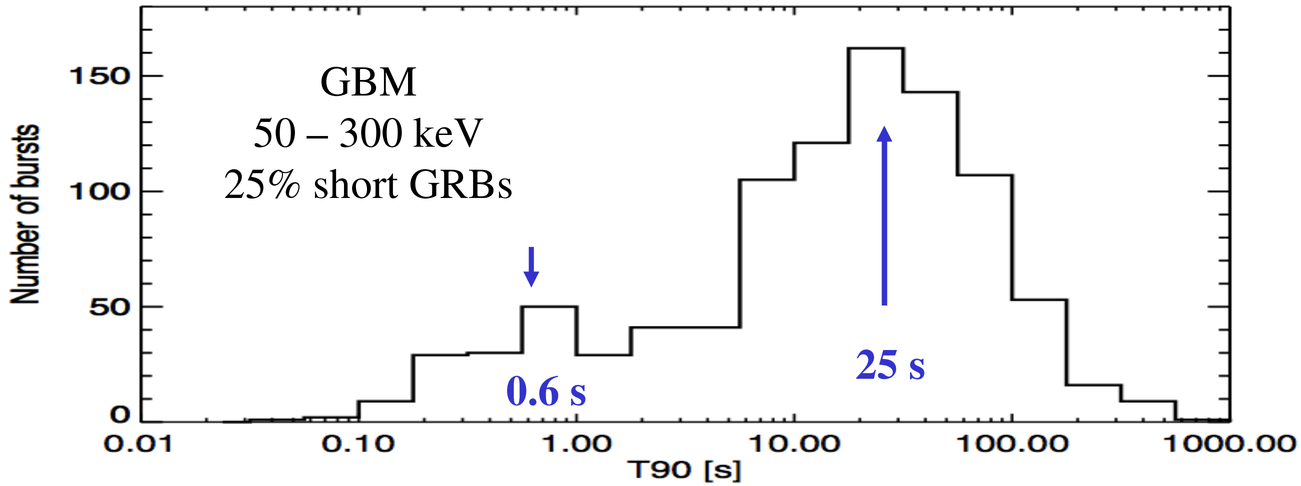
Such bursts can be seen to very high z in both IR and X-ray (re-ionisation era targets for JWST, E-ELT, Athena…)

Finding high-z GRBs is a major science driver for future facilities (e.g. SVOM)

BAT vs. Fermi/GBM durations



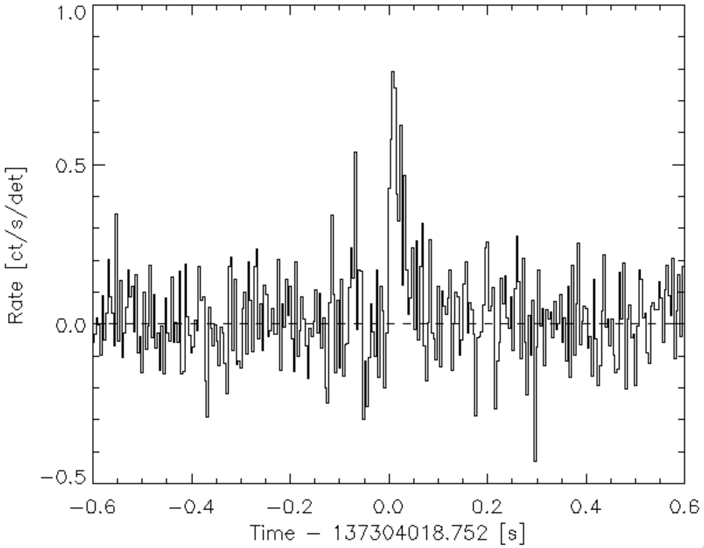
Sakamoto+ 10



Kienlin+ 14

First Swift short GRB 050509B

Gehrels, Sarazin, O'Brien et al. (2005)



BAT

- 30 ms duration
- spectrum is medium hard
- very weak, $2\mathrm{x}10^{-8}$ erg/cm^2

Spacecraft slew in 52 sec

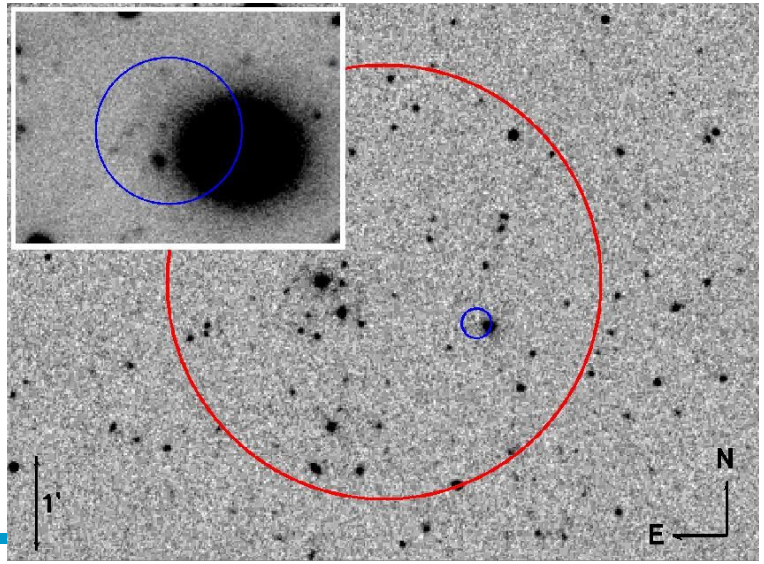
XRT

- faint source, fading
- 11 cnts = $1\mathrm{x}10^{-12}$ erg/cm^2/s

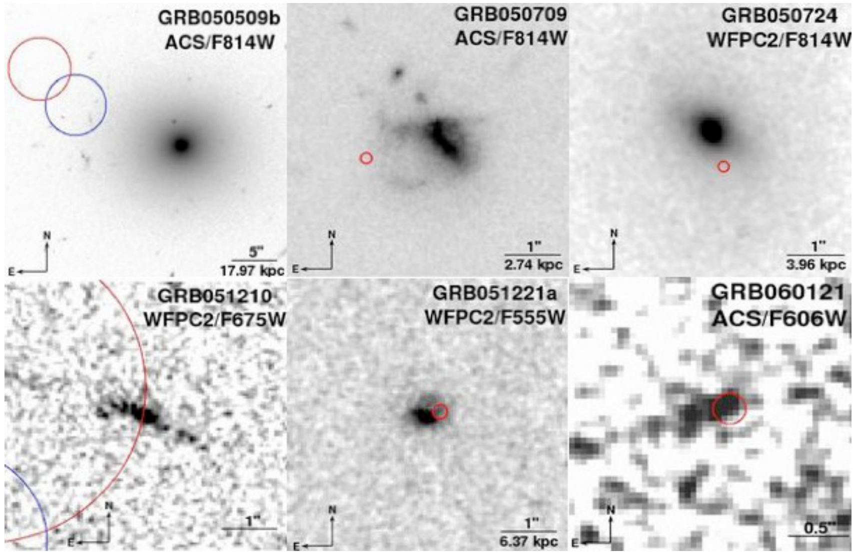
Proposed host:

- cD Elliptical
- K = 14.1
- L = 3 L*
- z = 0.225
- SFR < 0.2 M_O yr^{-1}

VLT image
Hjorth et al.



Short GRB host galaxies

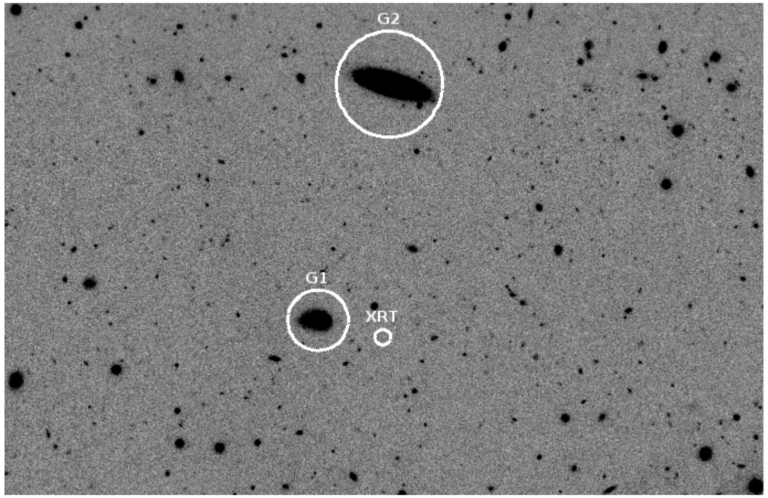


Fong, Berger & Fox (2010)

- Range of stellar populations in host galaxies:
  - some exclusively ancient
  - some actively star forming
  - some have a mixture
- Most SGRBs are offset from host galaxy – how to assign host?

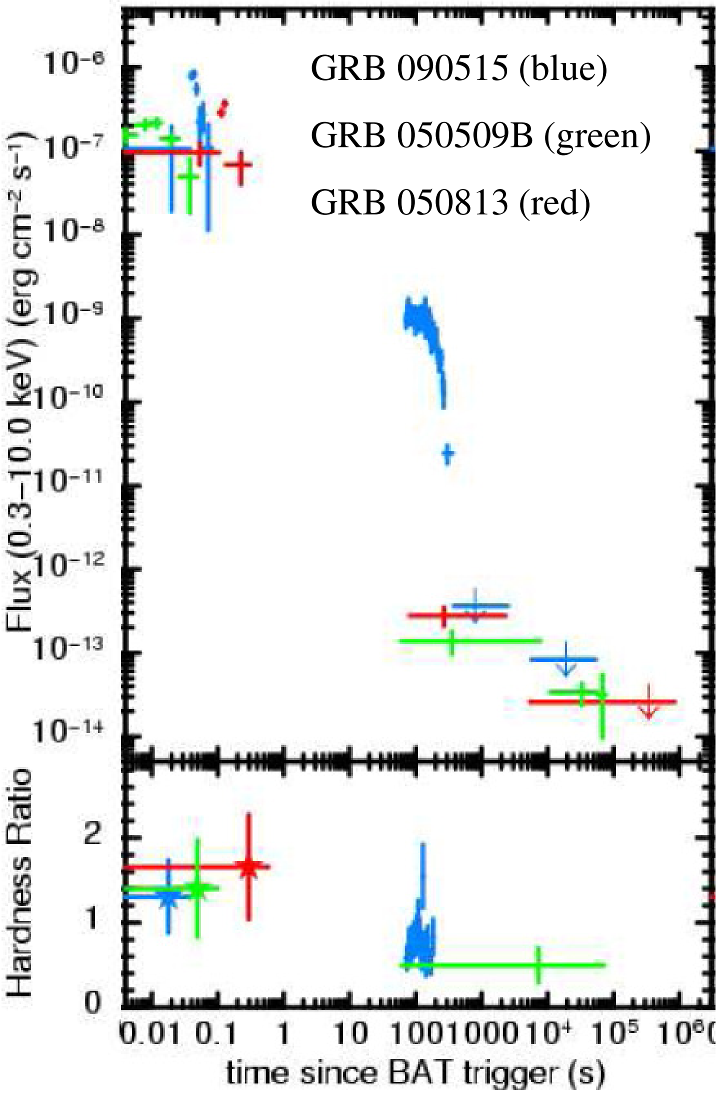
Short GRB 130822A
Wiersema et al. (GCN15178)

Galaxy G1, z= 0.154 (proj. dist. = 58 kpc)
Galaxy G2, z = 0.045 (proj. dist. = 72 kpc)



GRB 090515

(Rowlinson, O'Brien et al. 2010)

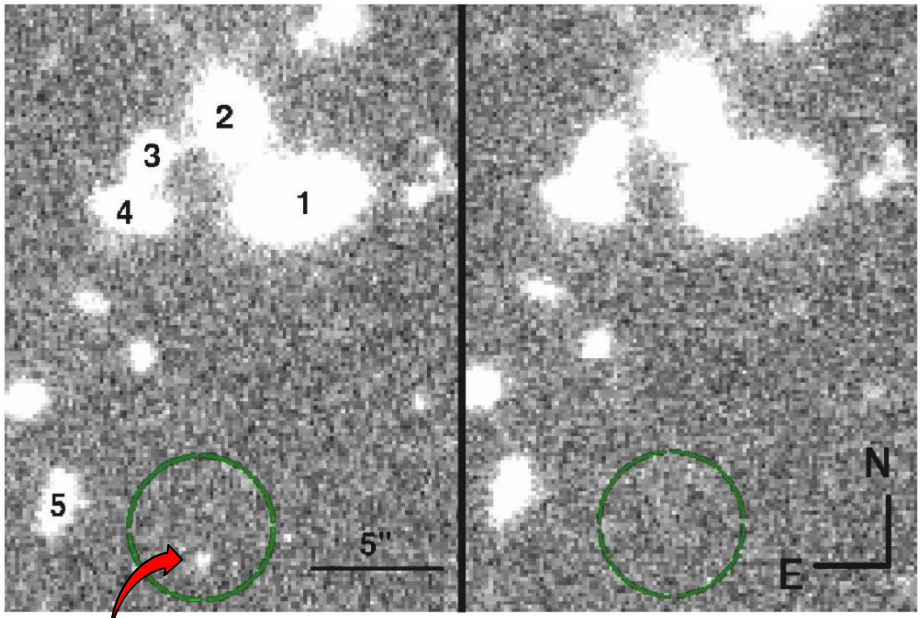


T90 = 0.036s

Fluence = $2\mathrm{x}10^{-8}$ erg s^{-1} (15-150 keV)

Highest short GRB X-ray flux at100s

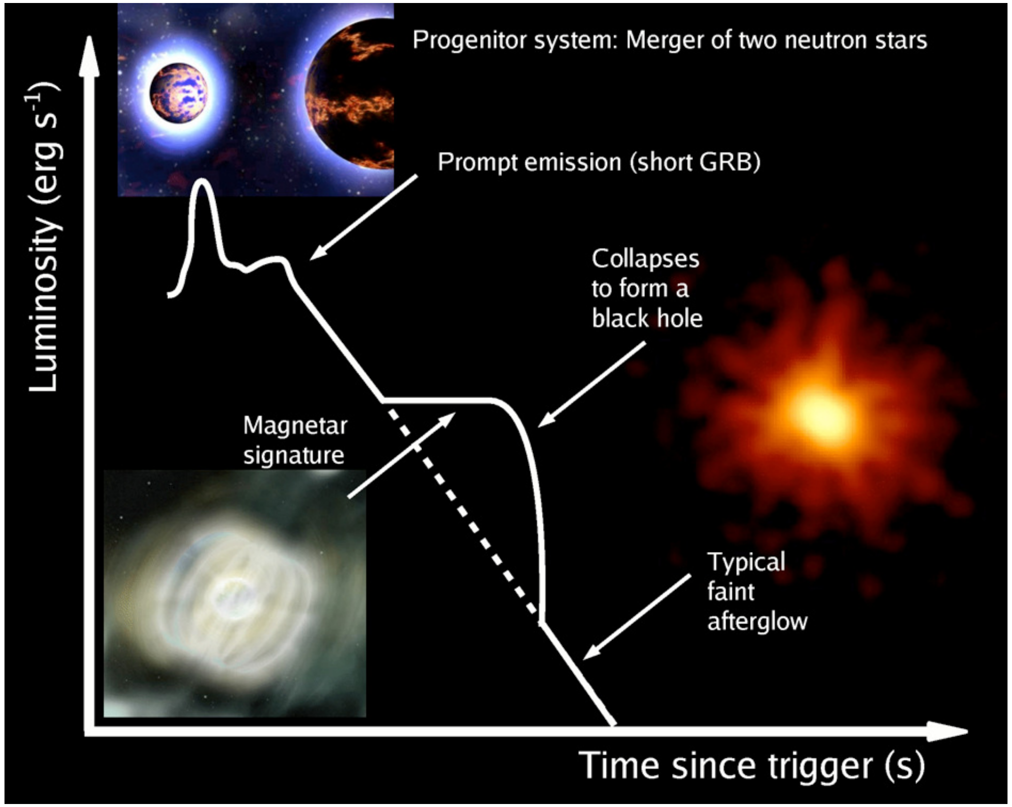
Very unusual given low γ-ray fluence

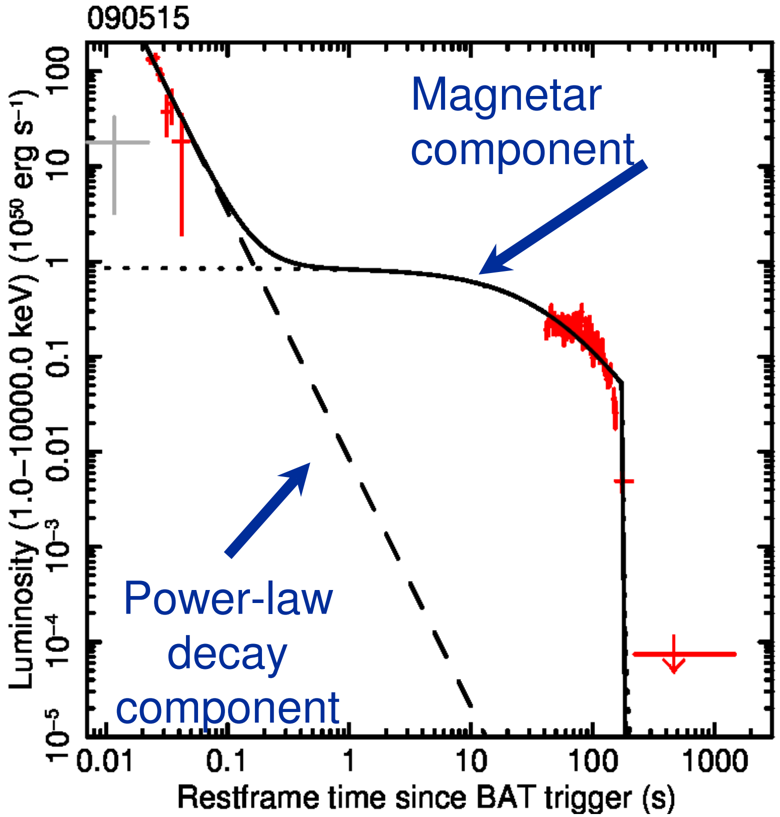


Gemini-N, r-band at 6300s

See a (fading) r=26.4 source

SGRB magnetar concept





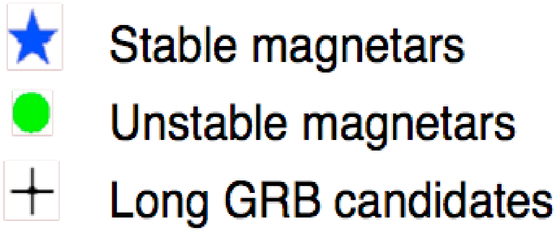
Expect a relation between the pulsar initial spin period (P_0), dipole field strength (B_p), luminosity (L) and the characteristic timescale (T_{em}) for spin-down:

$$\mathbf{L \propto B_p^{\,2} / P_0^{\,4} \quad \text{and } T_{em} \propto P_0^{\,2} / B_p^{\,2}}$$

SGRB magnetar results

(Rowlinson, O'Brien et al. 2013)

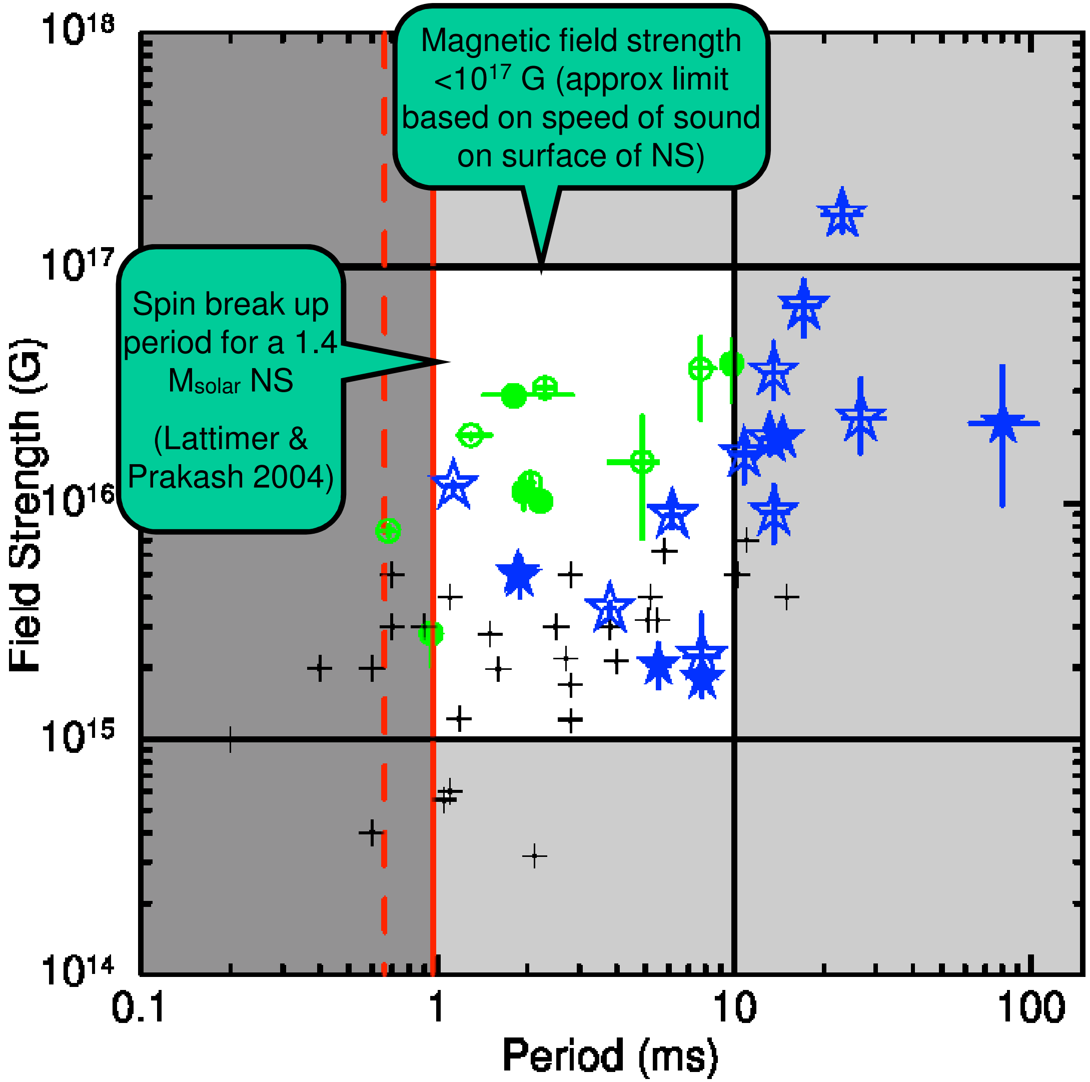
University of Leicester



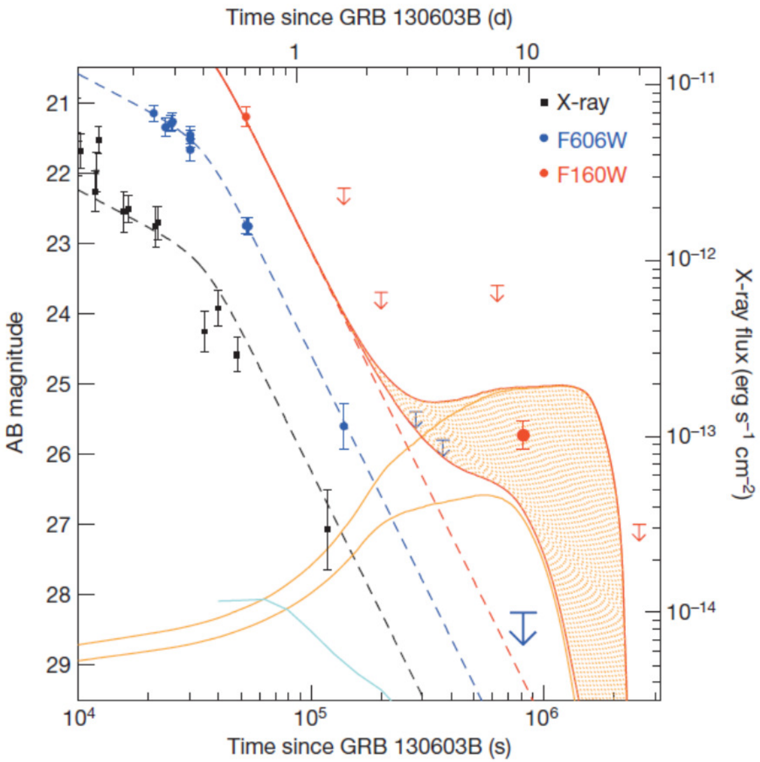
- Open symbols: SGRBs using mean sample z

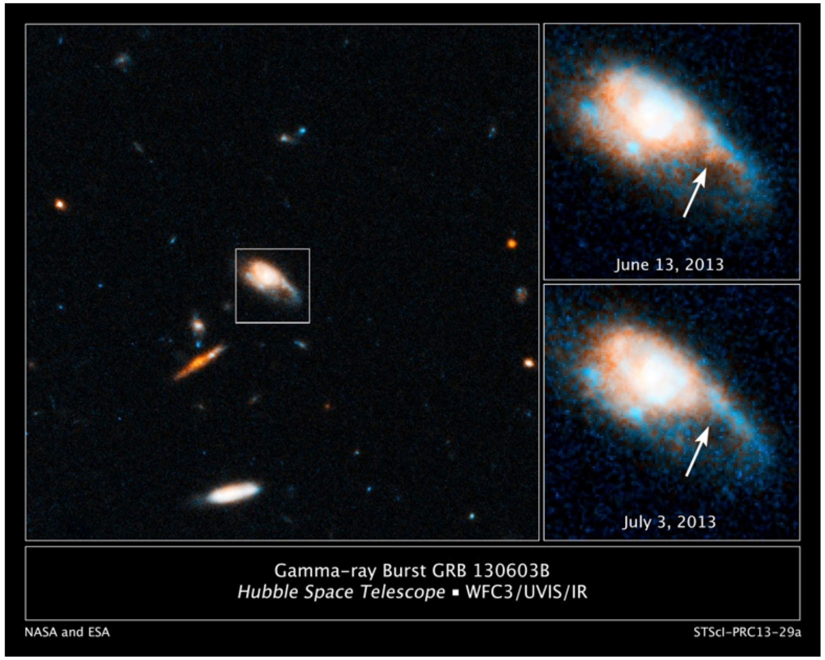
Not clear if such strong magnetar B fields or long lifetimes can occur?

Can test using GW data – expect two signals if a double-stage collapse



GRB 130603B, z=0.356
Kilonova Discovery?





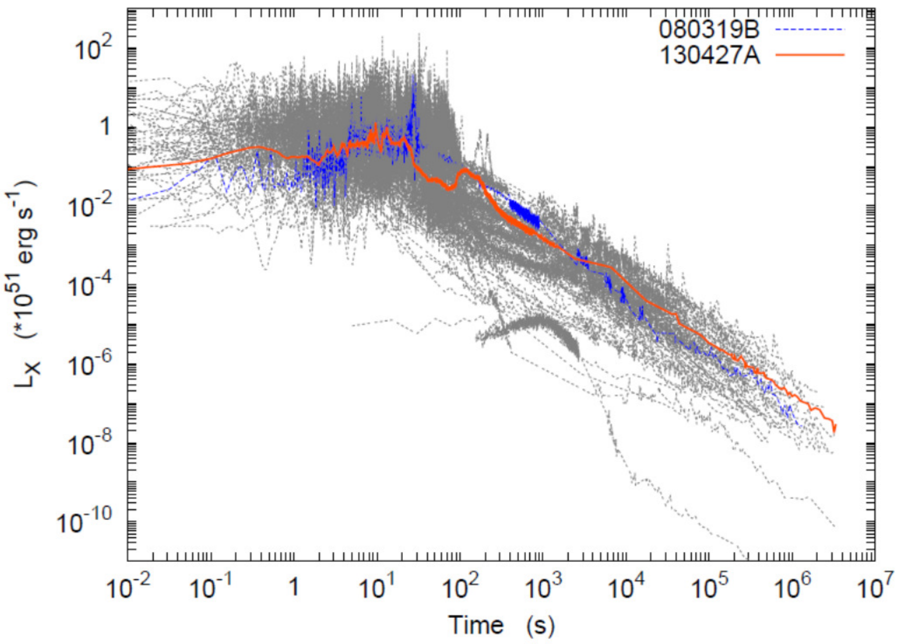
Tanvir et al. (2013); Berger et al. (2013)

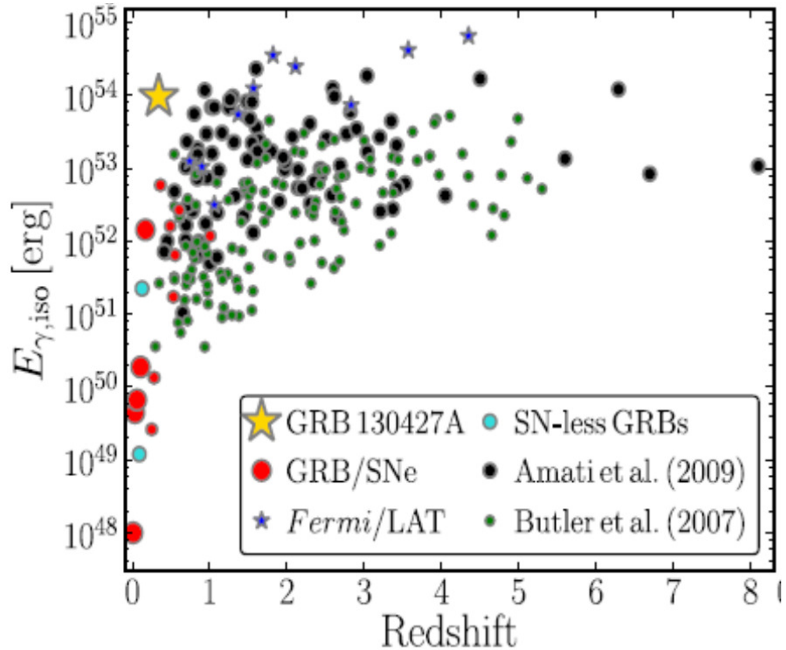
Implications:

1) Evidence that short duration GRBs are the result of the merger of two extremely dense neutron stars.
2) Provides a counterpart to gravitational wave events.

Very bright GRB 130427A

(Masalli et al (2013); Ackerman et al. (2013) etc.)



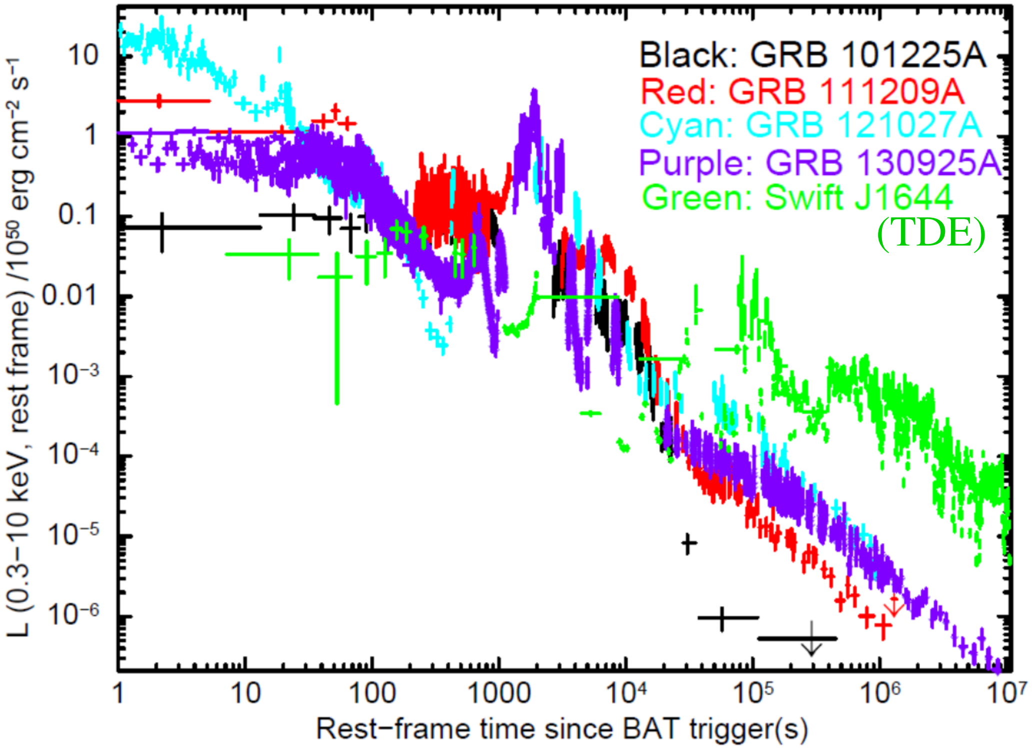


Brightest in flux and one of the most luminous GRBs found by Swift. A highly energetic GRB and a highly energetic SNe (Xu et al. 2013).

The origin of the multi-wavelength emission is unclear (see other talks) – likely mixture of forward+reverse shocks

Very long GRBs/transients

(Levan et al., 2013; Evams et al. 2014)



Swift has found a small number of VERY long transients, with T_{90} >2000s.

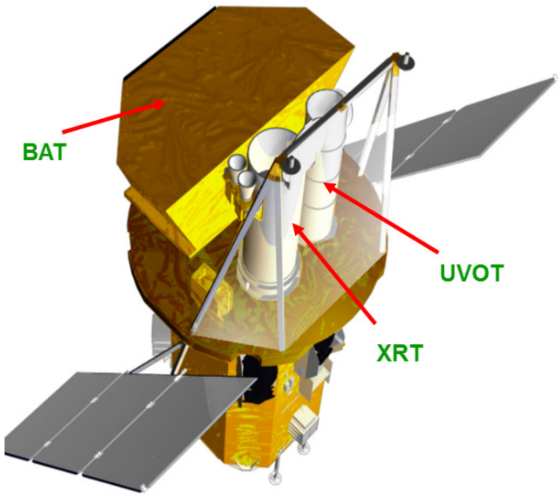
Origin unclear, but probably GRBs which require a different progenitor.

To study these (and others) we need to consider wide-field X-ray facilities.

Future of Swift …and party invite

Swift can operate for another 10+ years (funding/failure permitting). No significant degradation of performance to date.

Top in NASA 2014 Senior Review. Funded until 2016+



http://www.brera.inaf.it/Swift10/Welcome.html