What are we learning about binary mergers from GRBs

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GWDAW-14 Meeting
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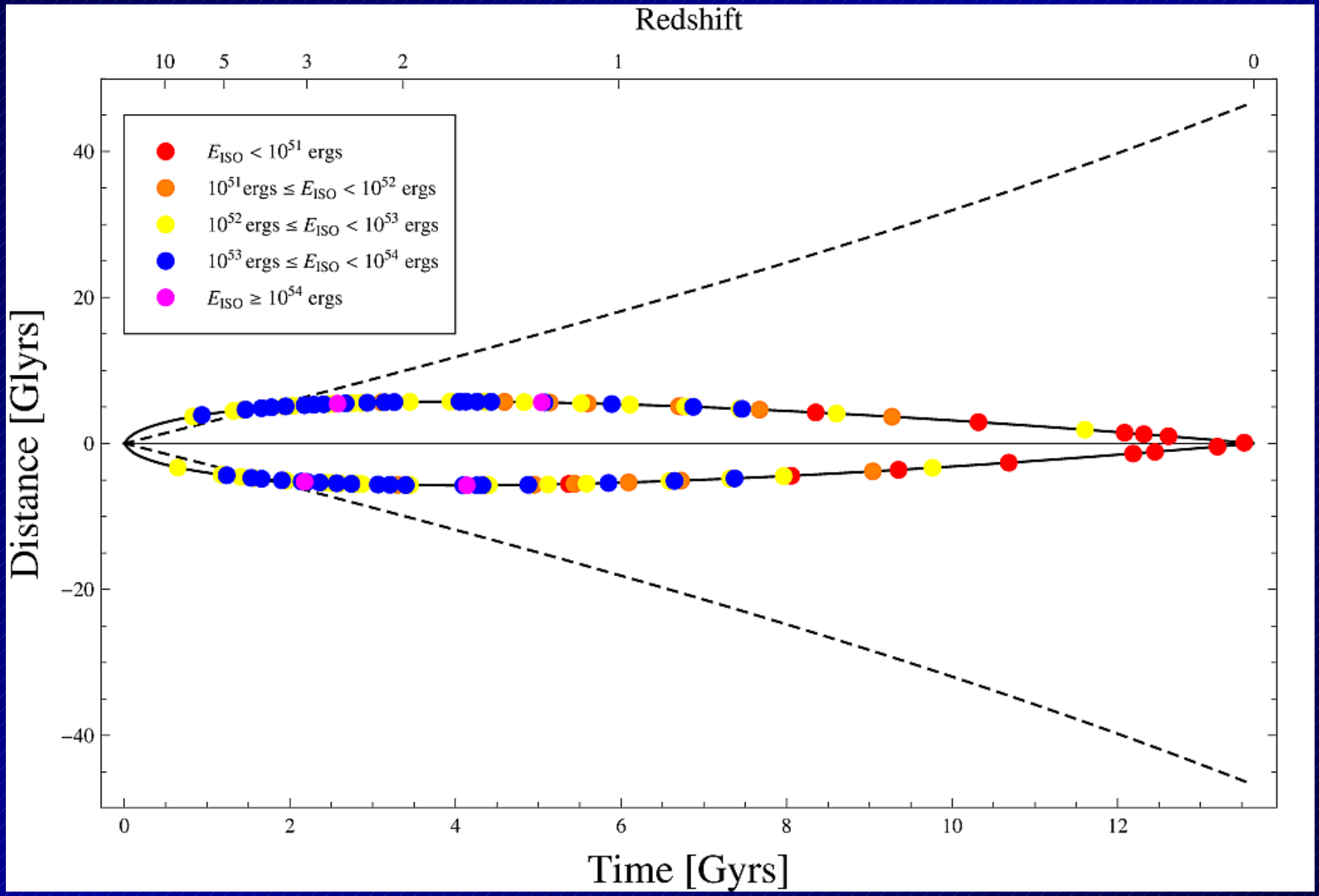
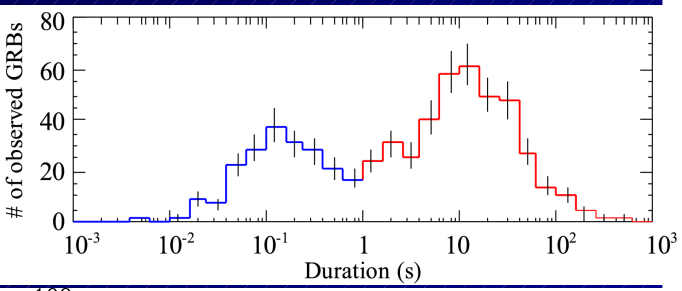
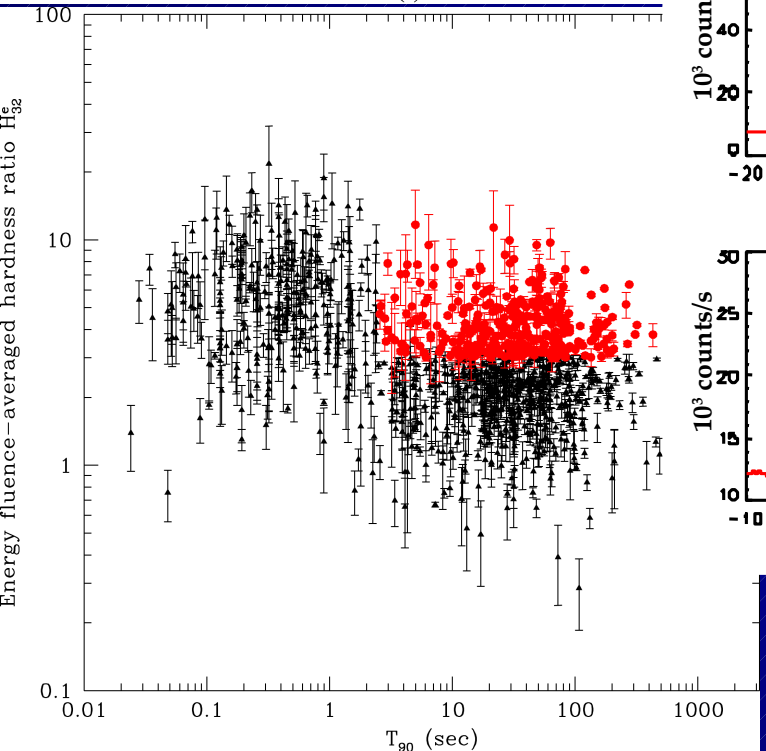
The distribution of GRBs with observed redshift in our past light cone

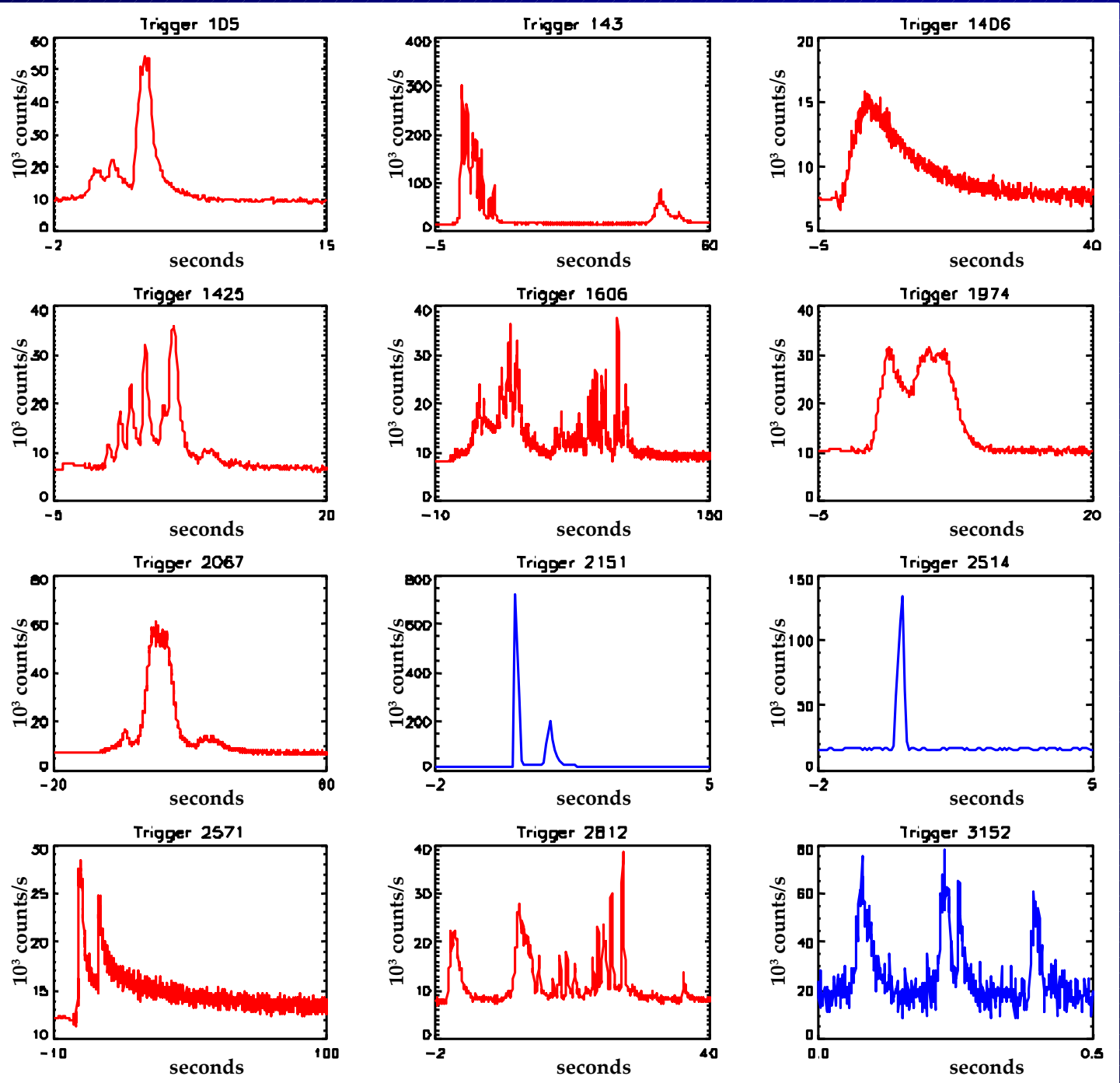


Lattanzi, Rangel Lemos (2009)

Short and Long GRBs

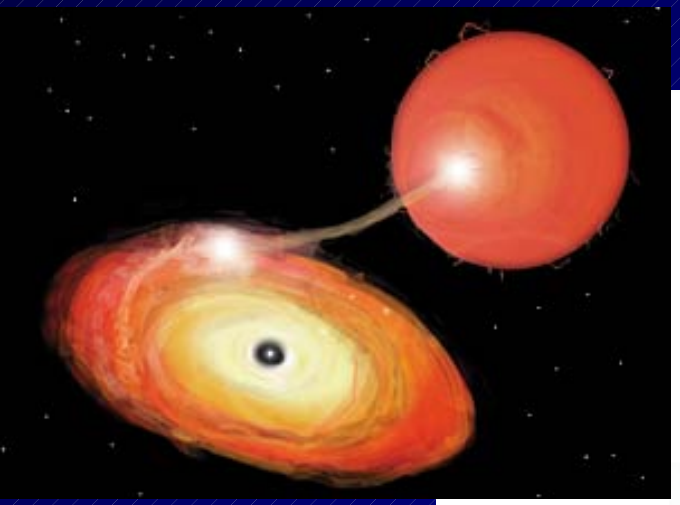




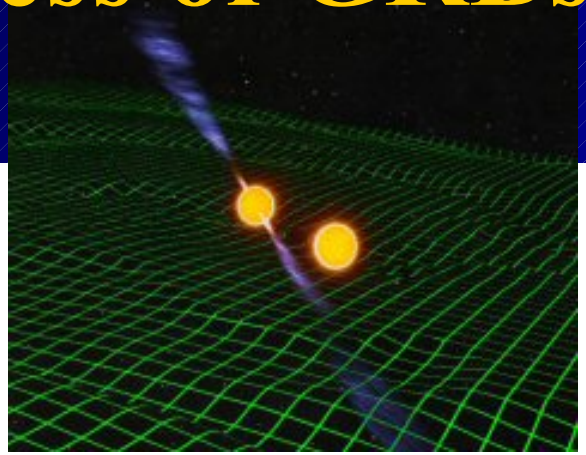


4th BATSE catalogue, Paciesas et al. (1999)

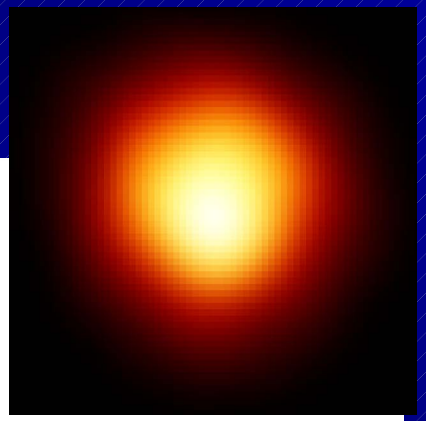
The uniqueness of GRBs



Binary X-ray sources



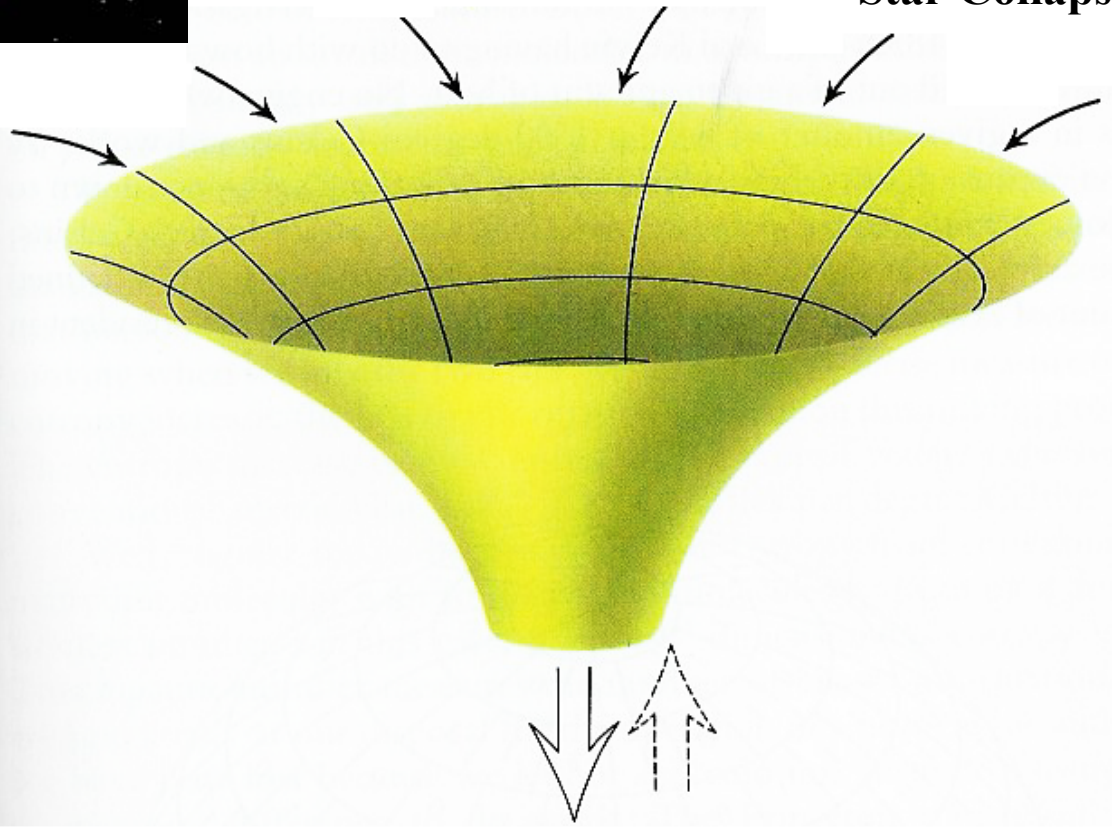
Binary Neutron Stars



Single Massive Star Collapse

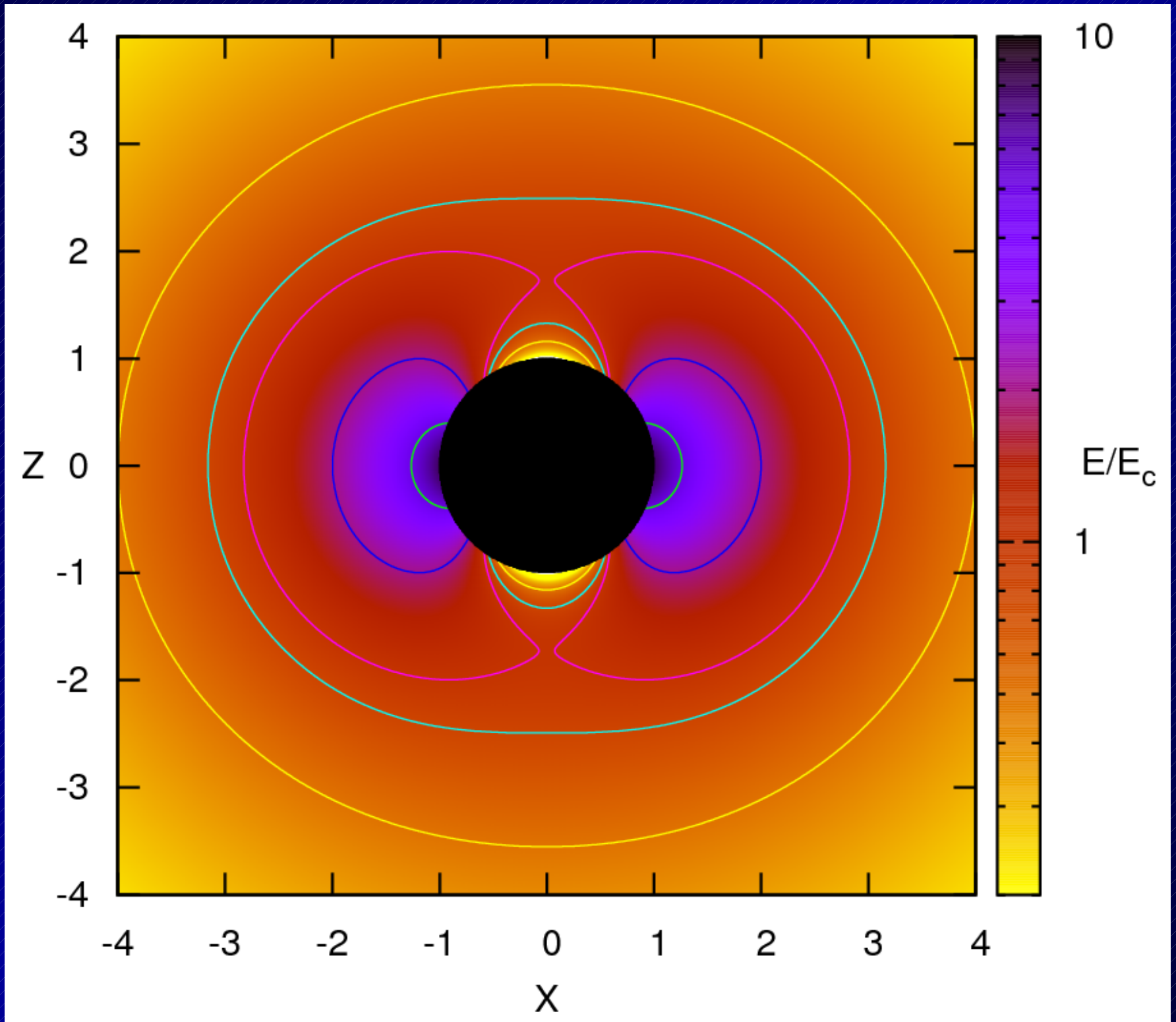
Globular Clusters, Intermediate Mass Black Holes

and the "black-holic" energy



$$E^2 = (M_{ir}c^2 + Q^2/2\rho)^2 + (Lc/\rho)^2 + p^2$$

The Dyado-torus



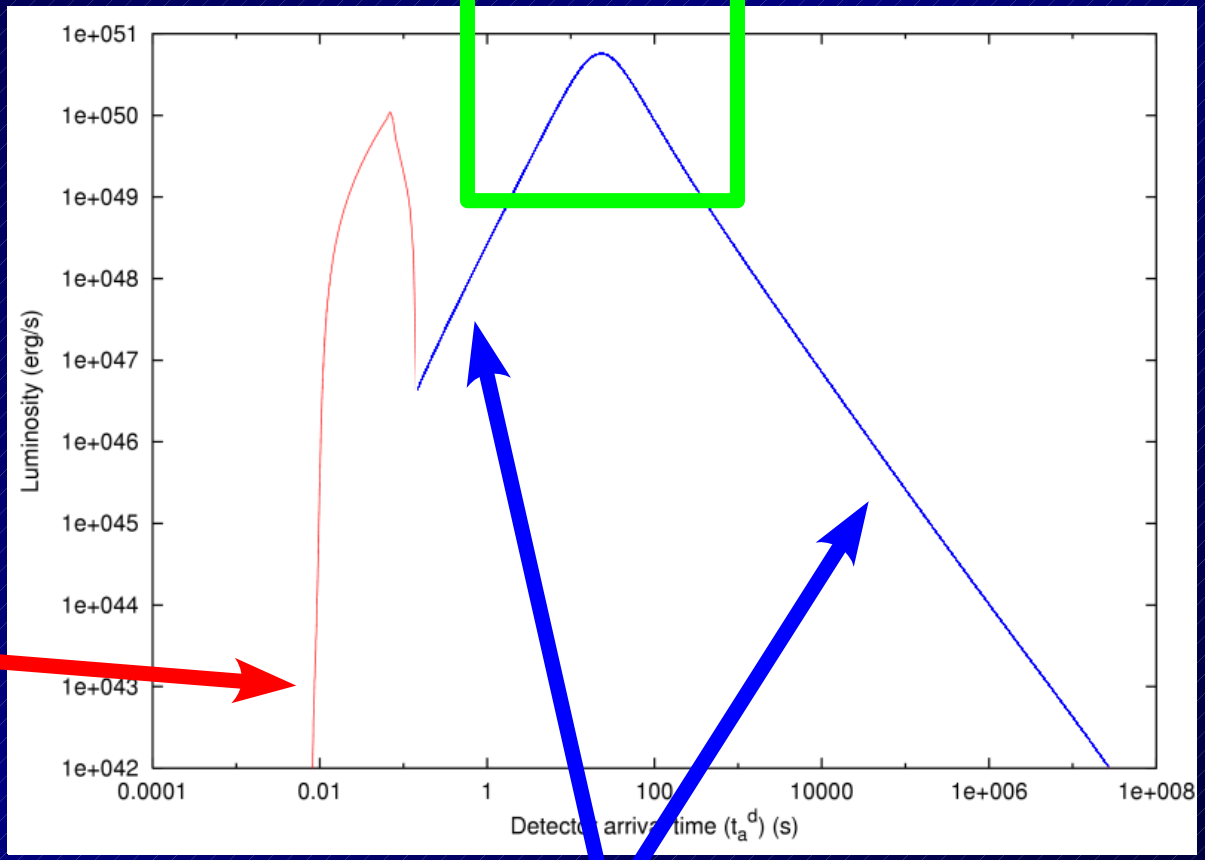
Cherubini, Geralico, Rueda, Ruffini, *PRD* 79, 124002 (2009).

"Canonical GRB" Bolometric luminosity

Two different phases:

P-GRB: emitted at the PEMB pulse transparency point.

(still work in progress)



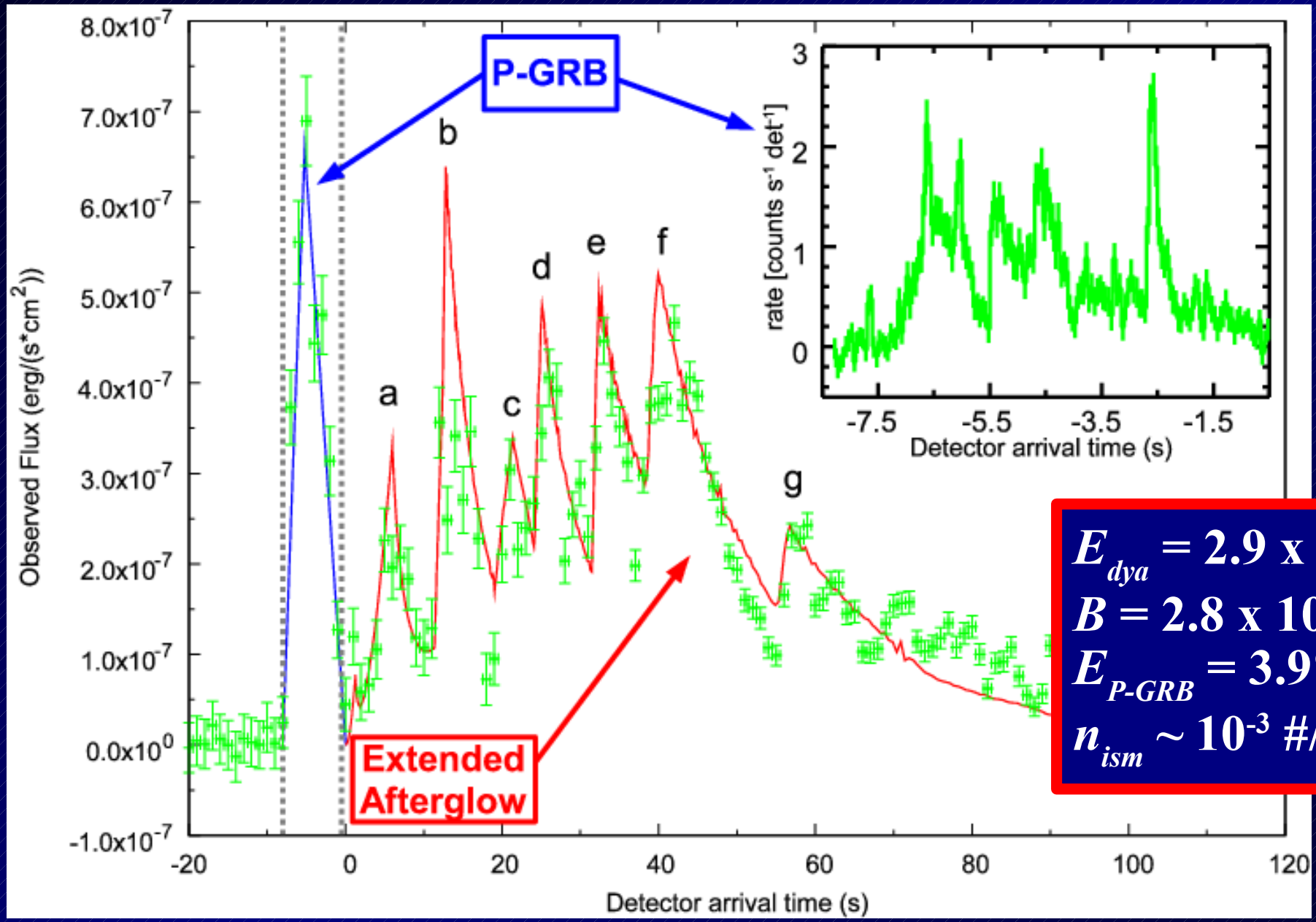
Extended Afterglow: due to the interaction between ABM pulse and ISM. Includes E-APE

$$\frac{dE_\gamma}{dt_a^d d\Omega} = \int_{EQTS\left(\hat{t}_a^d\right)} \frac{\Delta\varepsilon}{4\pi} v \cos\vartheta \, \Lambda^{-4} \frac{dt}{dt_a^d} d\Sigma$$

$$t_a^d = (1+z)\left(t - \frac{\int_0^t v(t')\,dt' + r_{ds}}{c}\cos\vartheta + \frac{r_{ds}}{c}\right)$$

Ruffini, Bianco, Chardonnet, Fraschetti, Xue, *ApJ*, 555, L113, (2001)
Ruffini, Bianco, Chardonnet, Fraschetti, Vitagliano, Xue, "Cosmology and Gravitation", AIP, (2003)

GRB060614 (Swift)



$E_{dya} = 2.9 \times 10^{51}$ erg

$B = 2.8 \times 10^{-3}$

$E_{P\text{-}GRB} = 3.9\%\ E_{dya}$

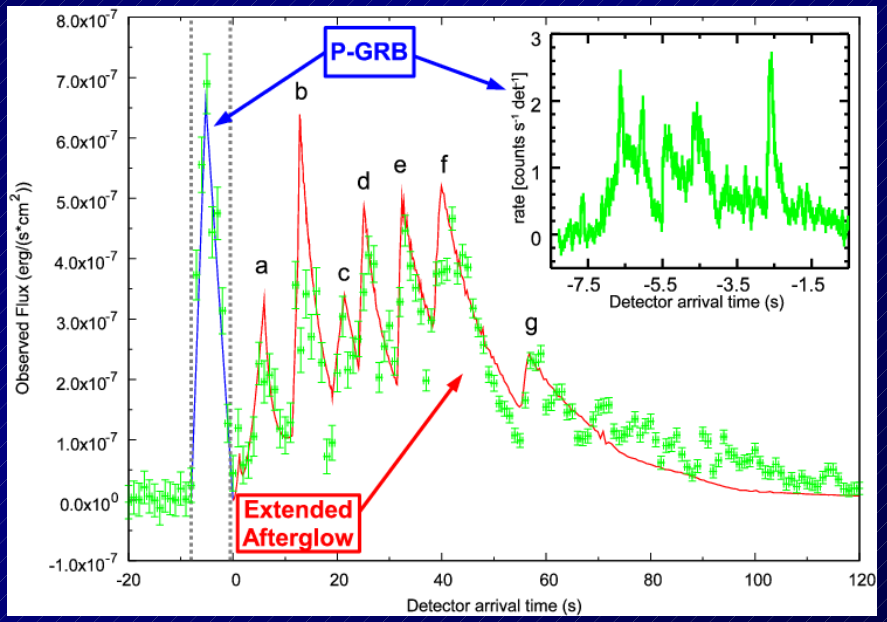
$n_{ism} \sim 10^{-3}$ #/cm^3

Caito, Bernardini, Bianco, Dainotti, Guida, Ruffini, *A&A*, 498, 501-507 (2009)

Binary mergers

Information from GRBs:

- Black hole mass
- Dyadosphere energy
- Baryon Loading
- CBM structure from the horizon to 1 ly
- Arcsec localization



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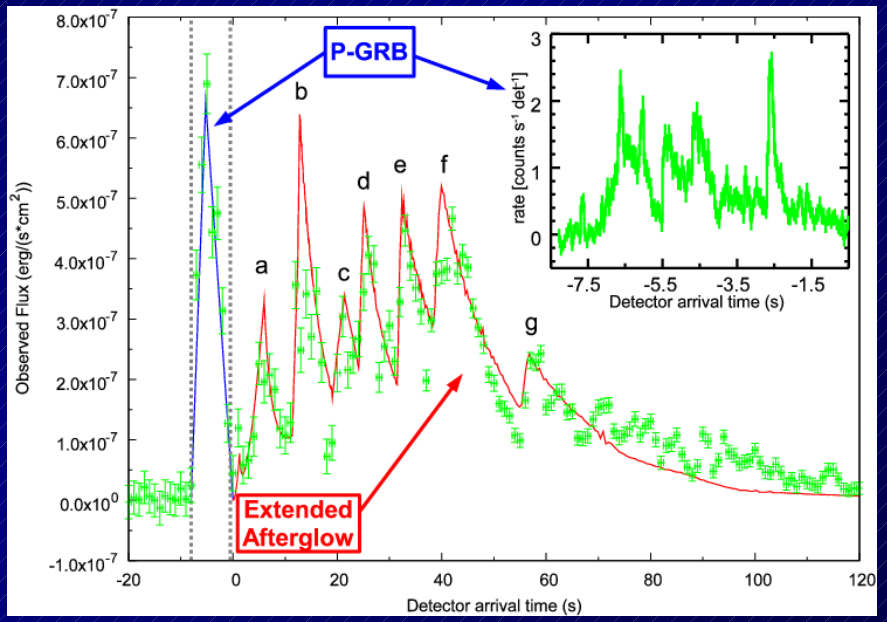
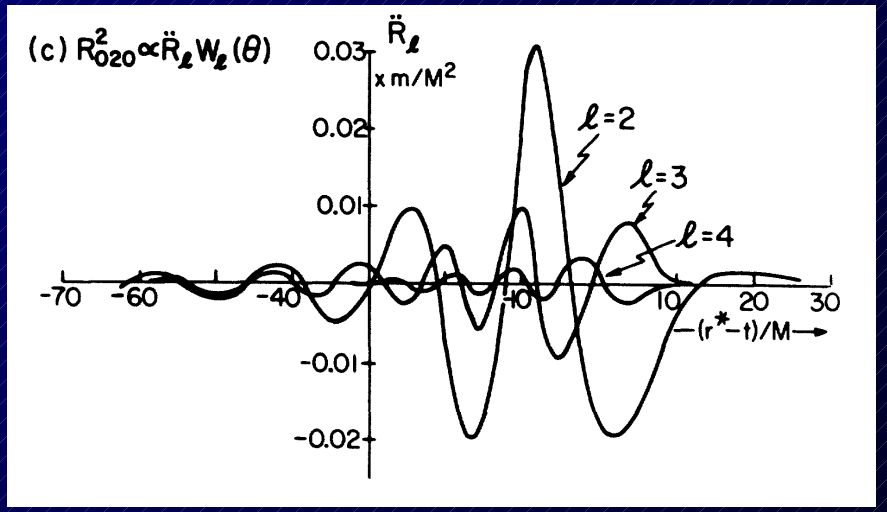


Information from GWs:

- Information on the progenitor system
- A trigger for GRBs

However, big unknown on the electrodynamic structure of neutron stars



GRB 080916C (Fermi)

Our fit gives:

$E_{dya} = 8.4 \times 10^{54}$ erg

$B = 3.0 \times 10^{-4}$

$E_{P\text{-}GRB} = 6.2\%\ E_{dya}$

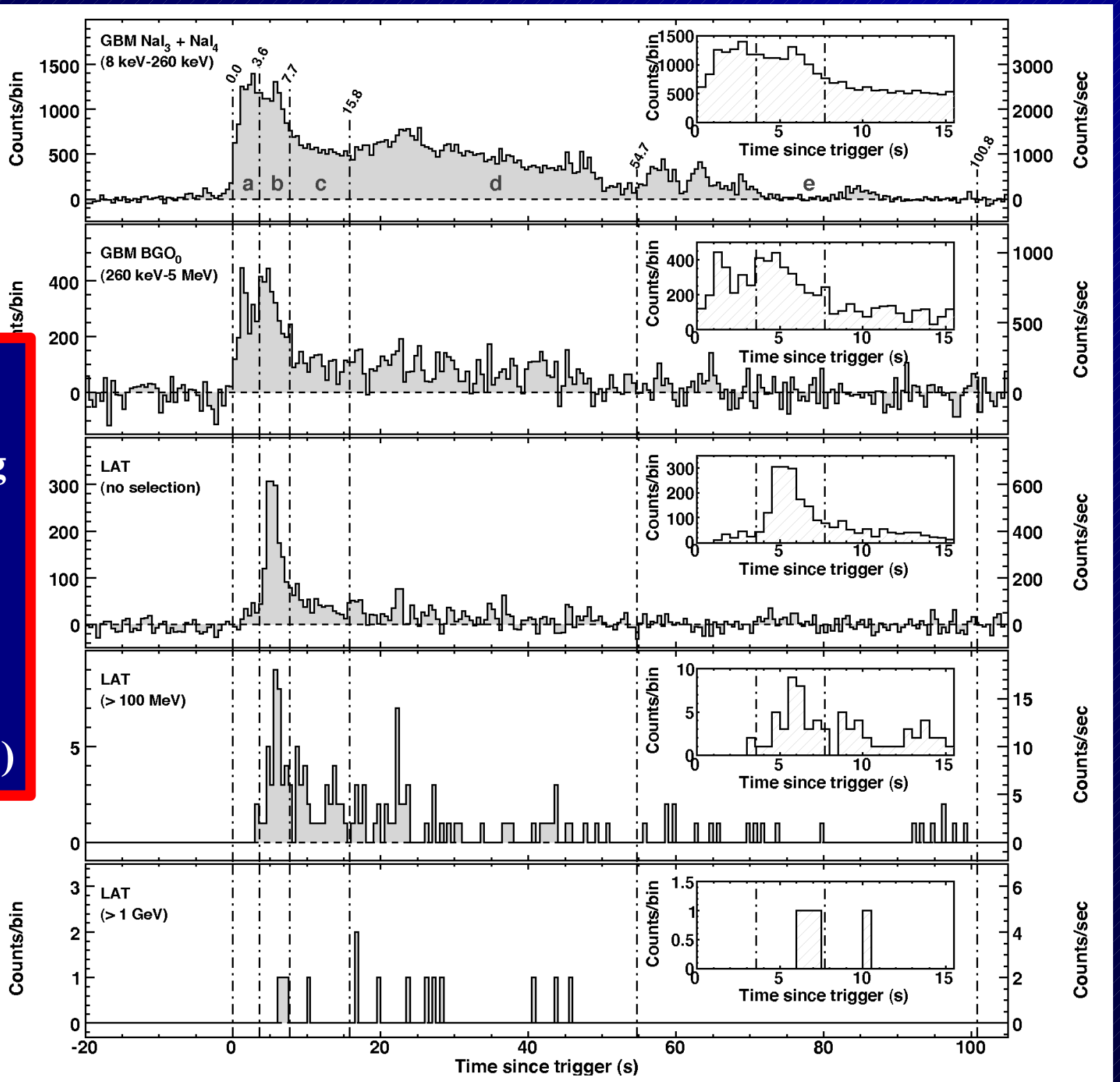
$\gamma \sim 3000$

$n_{ism} \sim 10^{-1}$ #/cm^3

(L. Izzo et al.)

Dangerously closed to absolute upper limit ~10^{55} ergs

Abdo et al. (2008)



The pursuit and plunge scenario

$$E_{grav} \sim \frac{Mc^2}{d} \qquad R \sim d\frac{GM}{c^2}$$

$$\langle \rho \rangle \sim 1.86^2 \frac{m_n}{\frac{4}{3}\pi d^3 \left(\frac{\hbar}{m_n c}\right)^3 \left(\frac{M}{M_\odot}\right)^2}$$

$$\langle \rho \rangle > \rho_{nucl} \sim \frac{m_n}{\frac{4}{3}\pi \left(\frac{\hbar}{m_\pi c}\right)^3}$$

$$\frac{M}{M_\odot} < 1.86 \frac{1}{d^{\frac{3}{2}}} \left(\frac{m_n}{m_\pi}\right)^{\frac{3}{2}}$$

⇒ $E < 1.1 \times 10^{55}$ ergs

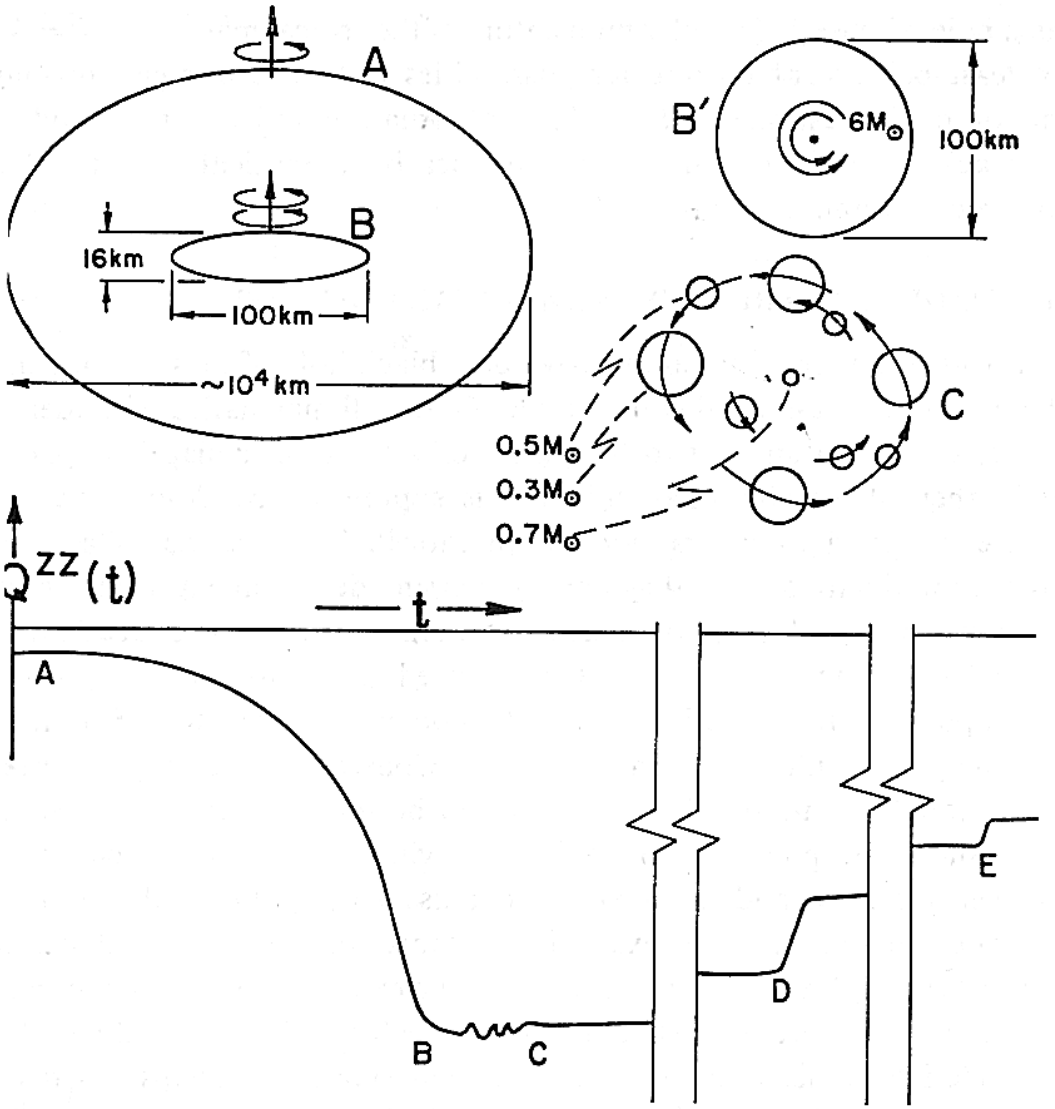


Figure 33 A rotating star with dense core A collapses to a pancake neutron star B; it fragments C; the fragments lose energy in periodic and splash gravitational radiation and recombine. The lower curve gives a schematic representation of the quadrupole moment as a function of time. Between B and C impulse radiation is created in the act of fragmentation not adequately described by the one indicated component of the quadrupole moment tensor. Between C and D multiply periodic radiation is given out until at D two fragments have lost enough angular momentum so that they combine with a splash of gravitational radiation; similarly at *E*, etc.

GRB progenitors

Underluminous "long" GRBs associated with SNe Ib/c	→ Induced gravitational collapse in a binary system
"Disguised" short GRBs	→ Merging of a binary system in the halo of its host galaxy
Traditional high-luminosity "long" and "genuine" short GRBs	→ *Likely* merging of a binary system near its birthplace
Highly energetic "long" GRBs (above 10^{54} ergs)	→ *Likely* collapse of a massive core around $10 M_{\odot}$

Caito, Bernardini, Bianco, Dainotti, Guida, Ruffini, *A&A*, 498, 501 (2009)