# Identifying Black Hole Central Engines in Gamma-Ray Bursts


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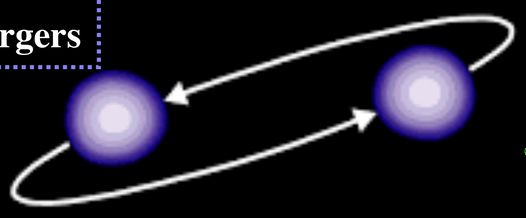
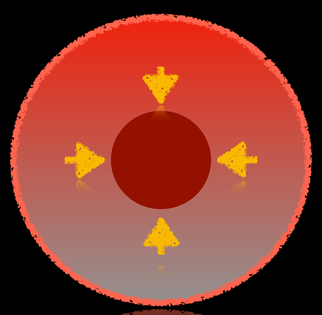
**Short GRB:**
**NS-NS/NS-BH Mergers**

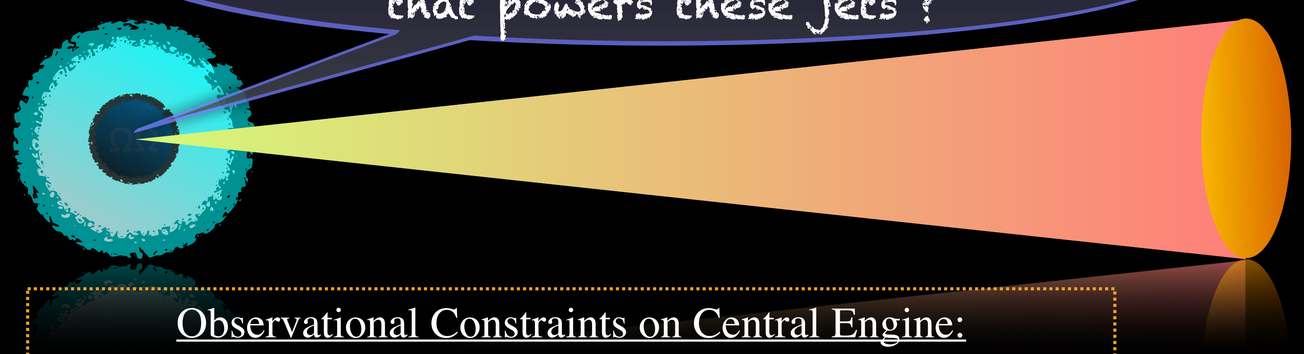


Progenitor

**Long GRB:**
**Massive star core-collapse**



What is the nature of the sources that powers these jets ?



Observational Constraints on Central Engine:

- ☑ Extremely Energetic: $10^{46}$ - $10^{55}$ erg (Isotropic equivalent)
- ☑ Milliseconds Time Variability (~100 km): Compact objects

## Possible Central Engines:

★ Black Hole

★ Magnetar

## Methods For Studying Them:

(a) X-ray afterglow light curve: Most of the features can be explained with both models, except plateau followed by steep decay.

(b) Energy Budget Criteria

### For Magnetars

Based on observed period, mass & radius; rotational energy is given by:

$$E_{\rm rot} \simeq \frac{1}{2} I \Omega^2 \approx 3 \times 10^{52} erg \left(\frac{M_{ns}}{1.5\,M_\odot}\right) \left(\frac{R_{ns}}{12\,km}\right)^2 \left(\frac{P_{ns}}{1ms}\right)^{-2}$$

This rotational energy is distributed among gravitational waves, jet energy and magnetospheric winds.

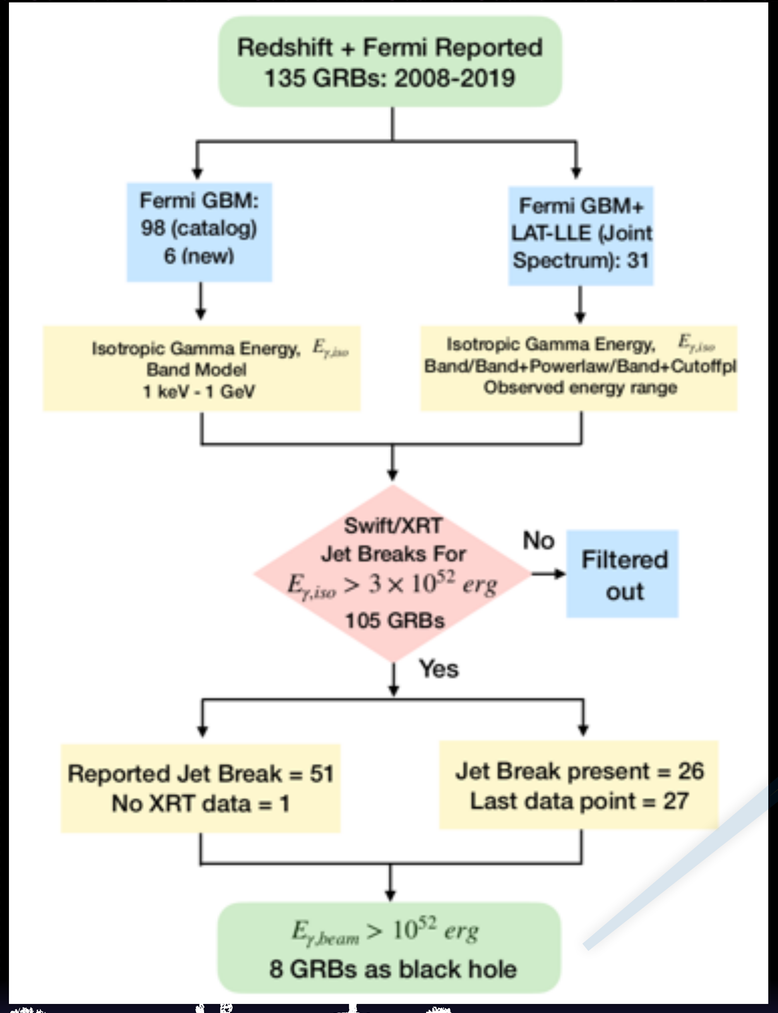
Using equipartition of energy, "Maximum extractable energy ~ $10^{52}$ erg".

Rotational energy → powers the jet.

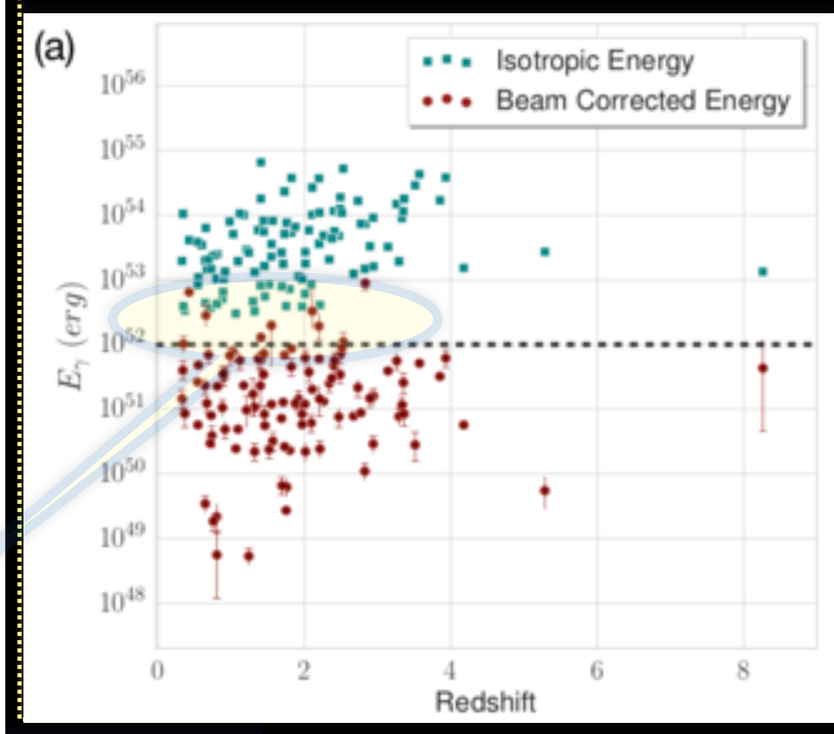
## Energy Estimation:

(a) Redshift + Prompt Spectra

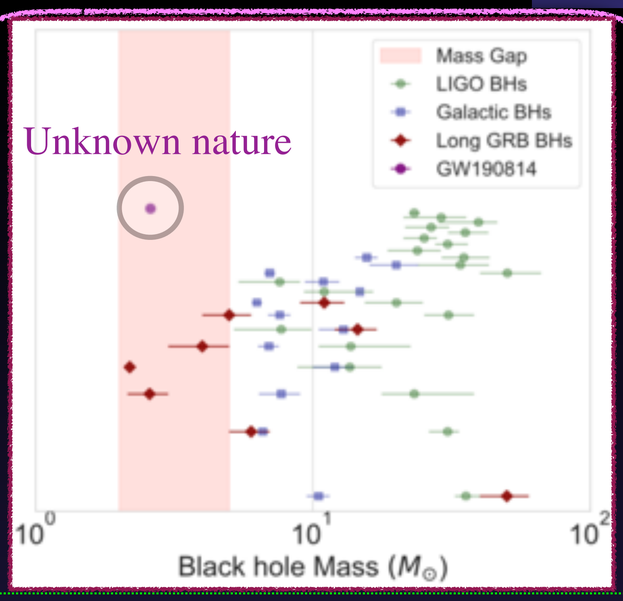
(b) Jet opening angle




- Isotropic equivalent energy of 105 GRBs is exceeding magnetar energy budget.
- After beam correction, 8 GRBs are black hole candidates.




## Results & Summary



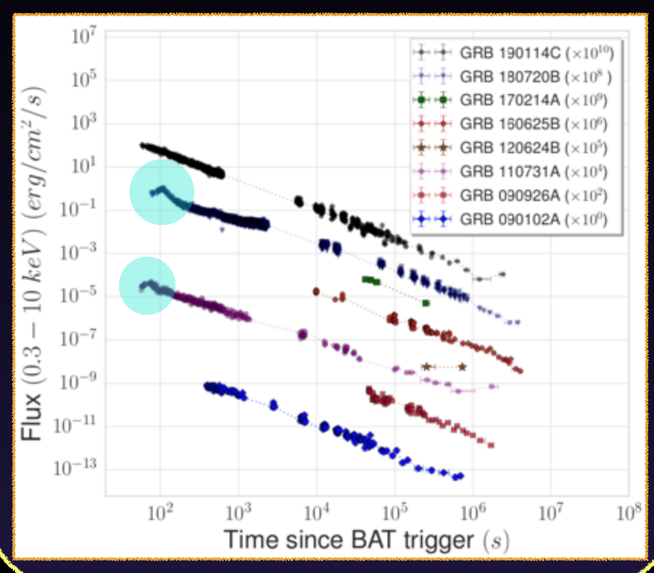

Assuming, Blandford Znajek (BZ) mechanism

$\eta$ Erot ≈ $E_{\gamma,beam}$

Mass ranges between ~ 2-60 solar masses

## XRT Afterglow Light curves

Observe X-ray flares, Multiple breaks




Using limits on energetics,

we identify 8 black hole central engines.

- ❖ Except one, most of the bursts are LAT detected, hence, sub-GeV loud.
- ❖ In the case of the core-collapse of a massive star, masses of BH formed range from a few to tens of solar mass. We find the BH produced in these catastrophic events may lie in the mass gap region.
- ❖ In the XRT afterglow; we observe flares and multiple breaks.
- ❖ No plateau is observed for these cases, which is generally associated with magnetar central engine.


***References:***

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