

Exploring Origin Of Ultra-Long Gamma-Ray Bursts: Lessons From GRB 221009A (The 'BOAT')

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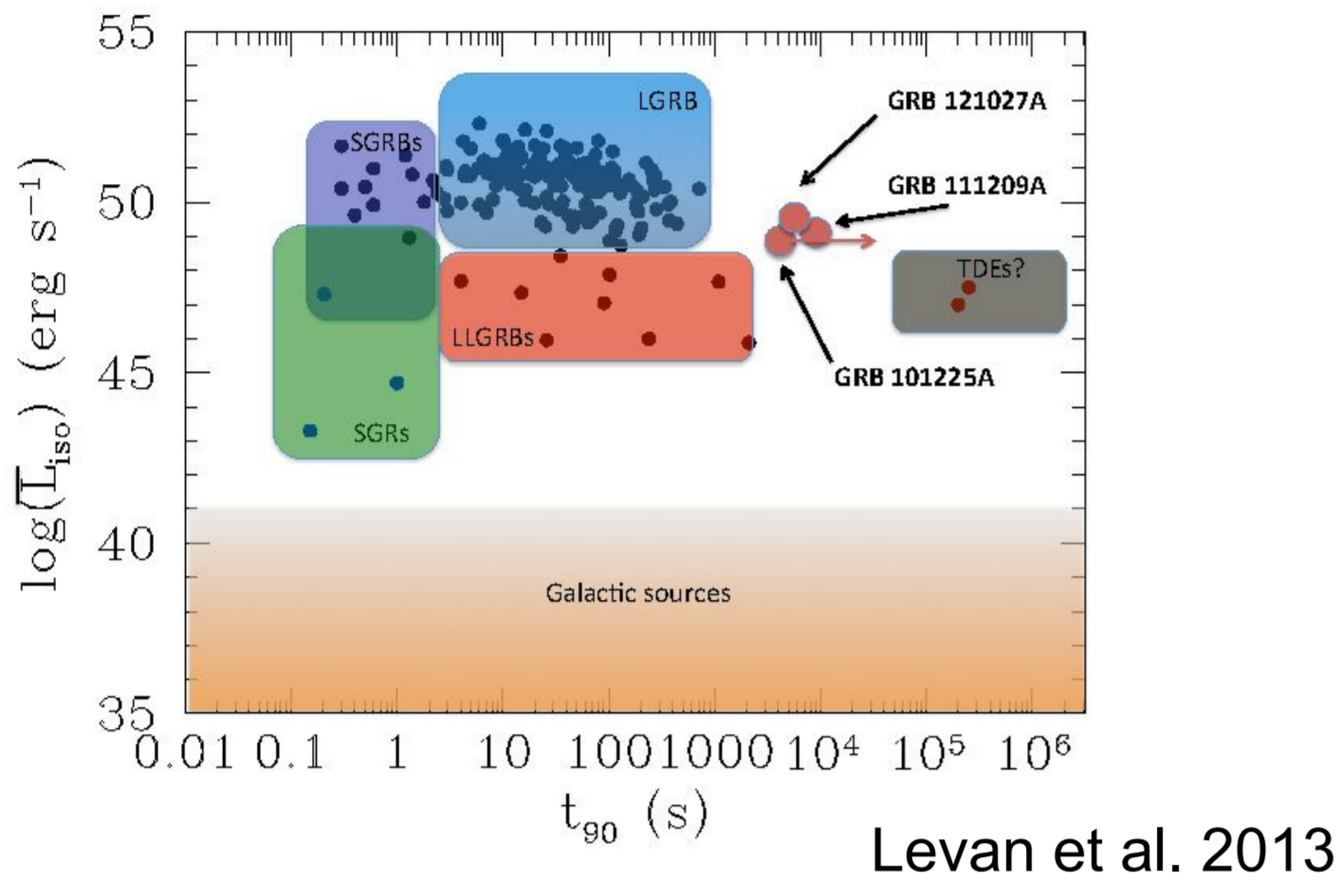
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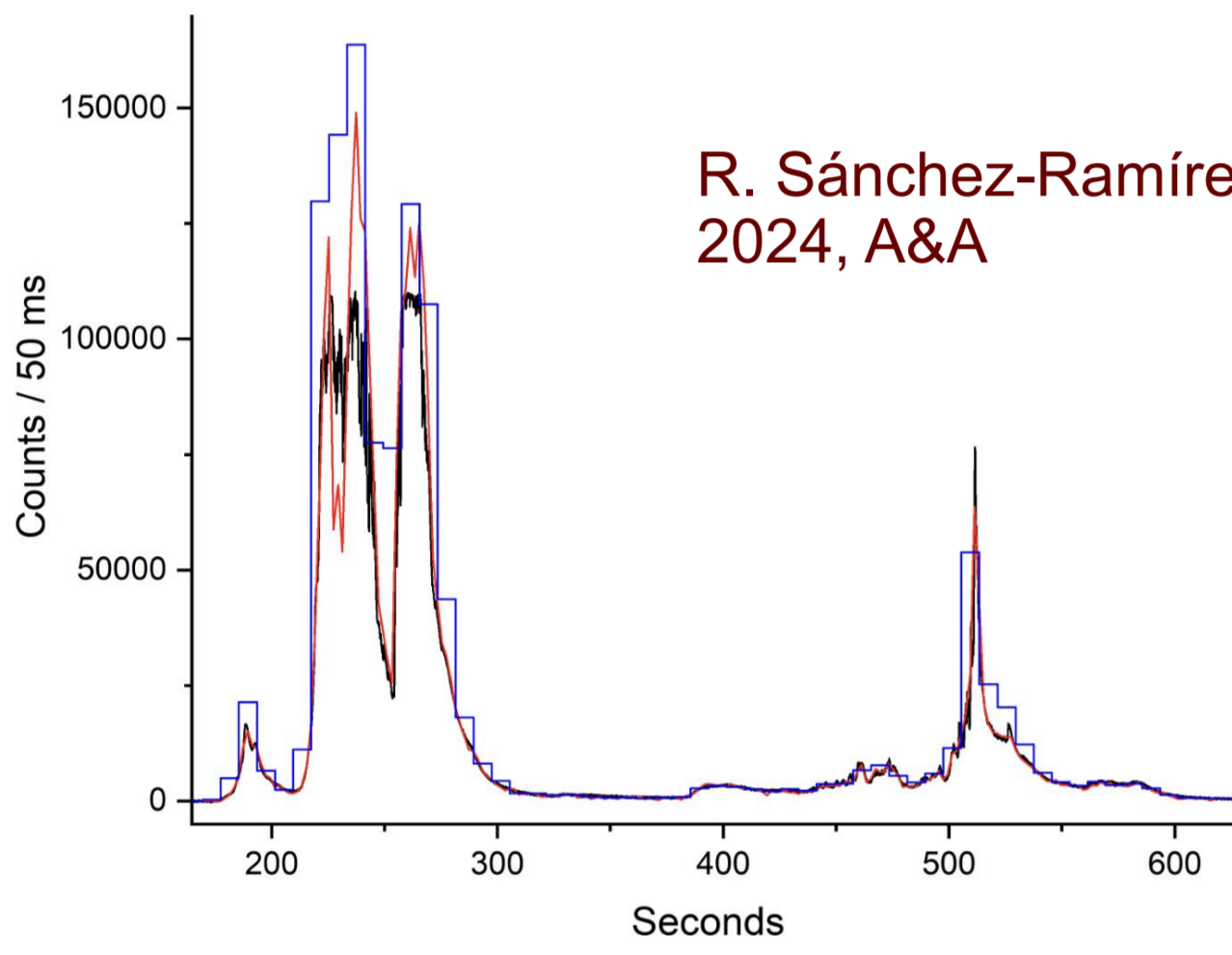
Abstract: GRB 221009A stood out as the brightest GRB detected to date, offering a remarkable opportunity to delve into the intricacies of GRB physics. In this work, we investigated the prompt emission and afterglow characteristics of this unique burst utilizing observations from several missions like Swift, Fermi, and INTEGRAL including our early photometric (prior prompt emission) and spectroscopic observations taken using various telescopes. High-energy results show an ultra-long GRB (ULGRB) nature, with a prompt emission duration exceeding 1000 s. We examined its origin (through observations and simulation in MESA) and central engine and compared it with a nearly complete sample (categorizing the sample to Bronze, Silver, and Gold based on T₉₀ duration) of Swift-detected GRBs with measured redshifts. Notably, the Gold sub-sample (a higher likelihood of being ULGRB candidates, including the "BOAT") suggests a collapsar scenario with a hyper-accreting black hole as a potential central engine. Our early optical observations during the prompt emission of GRB 221009A help to discard the presence of any bright optical emission with internal or external origin. We determine the distance to GRB 221009A through spectroscopy (taken with 10.4m GTC) of absorption and emission lines and establish the burst to be associated with a star-forming galaxy. Additionally, we conducted a comparative analysis of the properties of host galaxies associated with TeV-detected bursts including the BOAT, to acquire insights into the environments of TeV GRBs.

Introduction

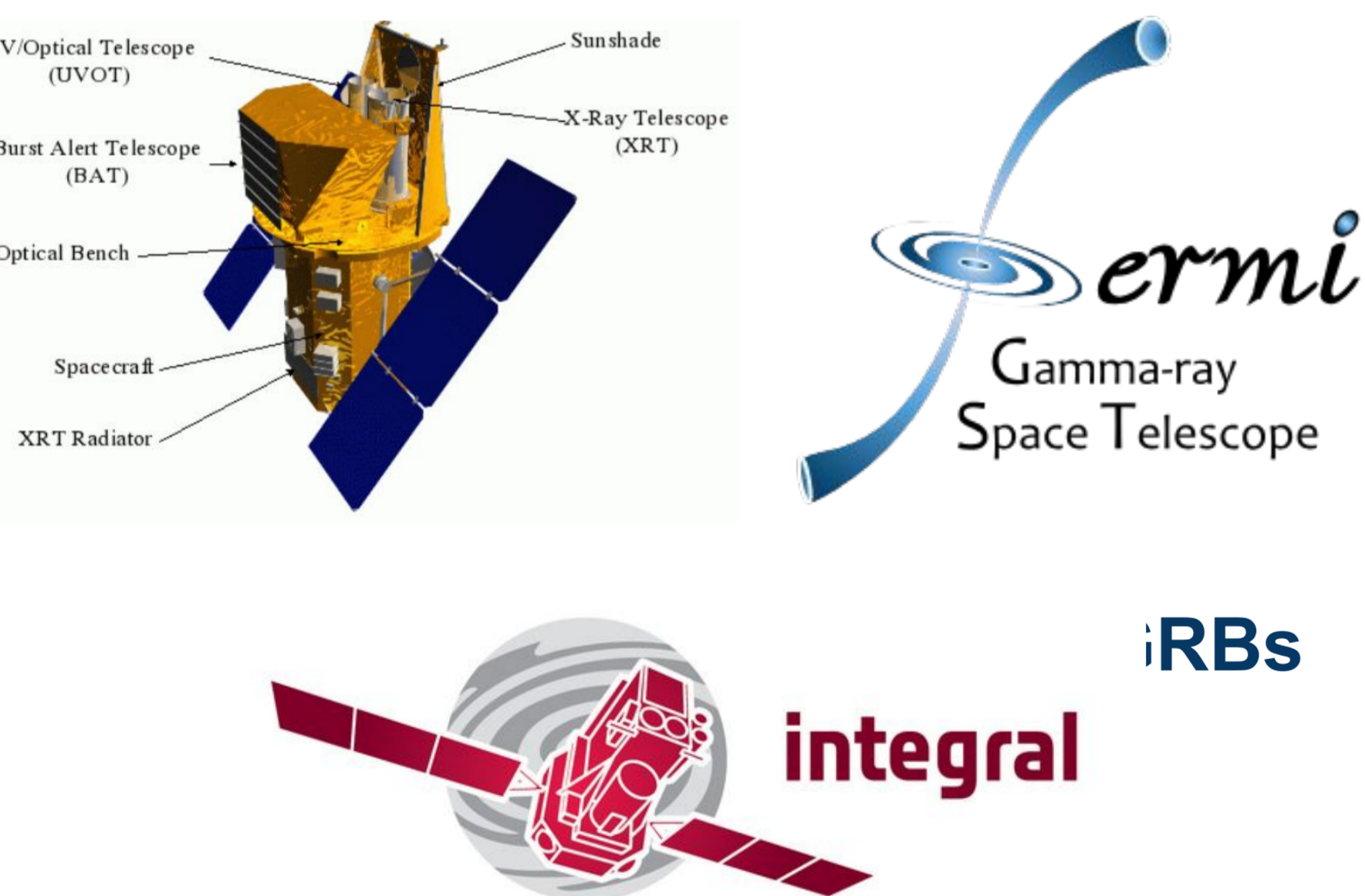
- Brightest GRB ever: GRB 221009A (the "BOAT")
- Ultra-long duration: Prompt emission > 1000 s
- First ULGRB with TeV detection (18 TeV & 250 TeV)
- Origin of ULGRBs? Progenitor & Central Engine?



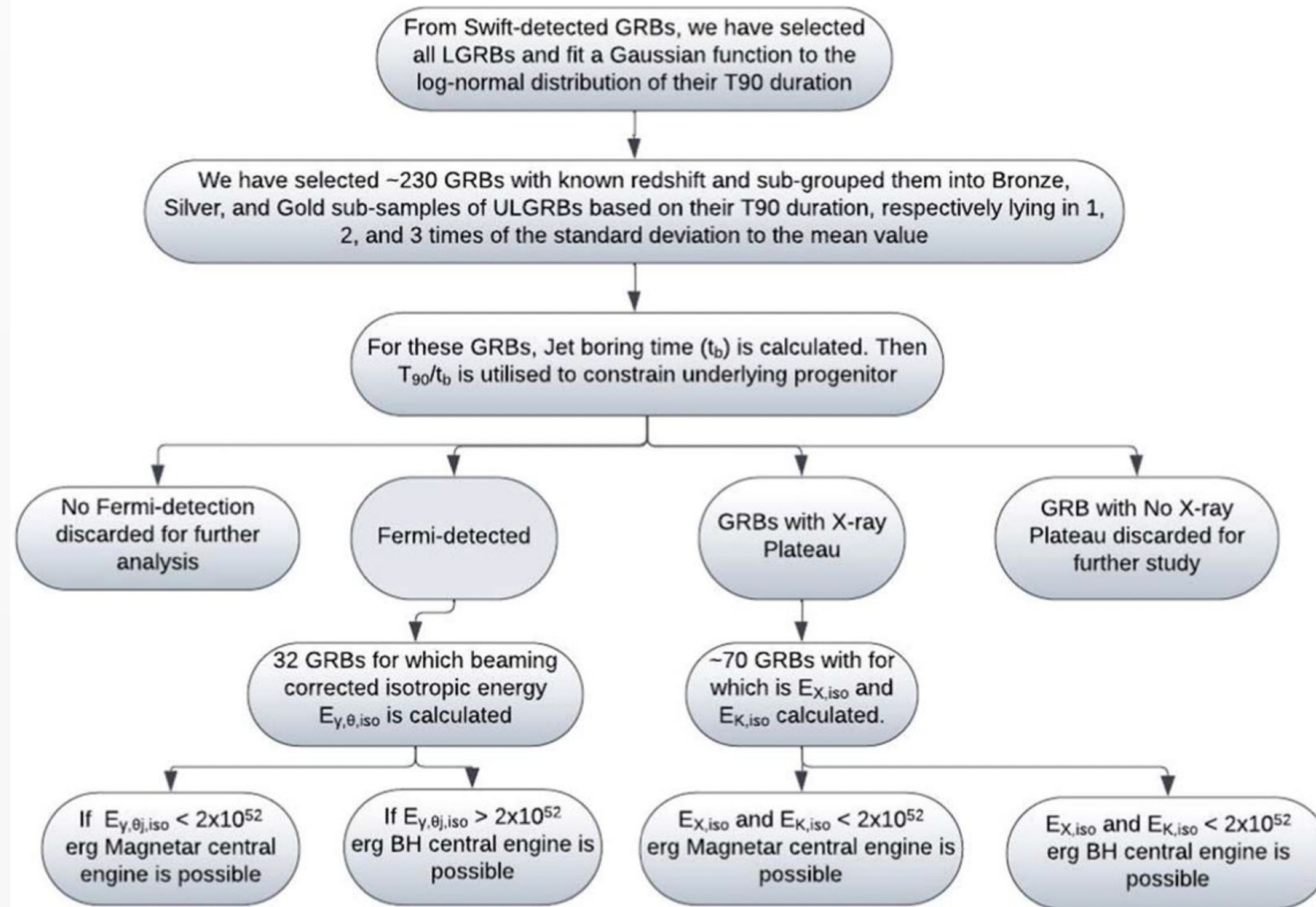
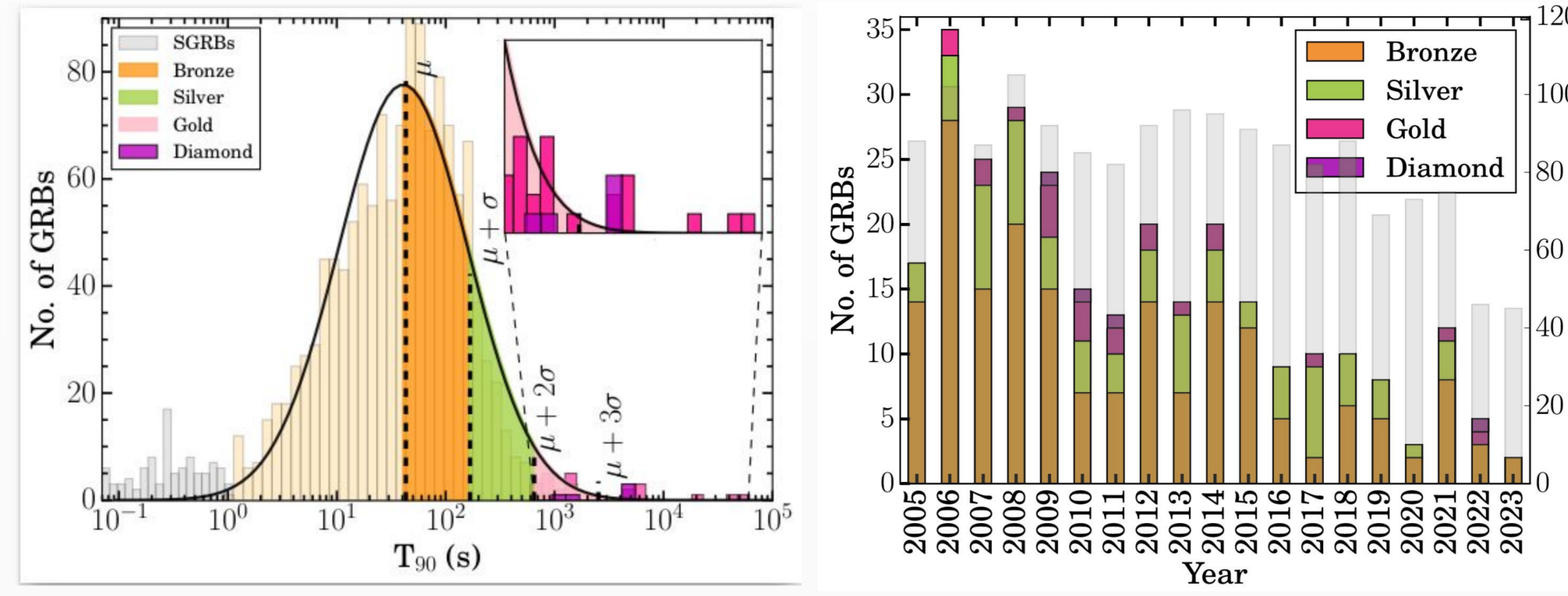
GRB 221009A as ULGRB



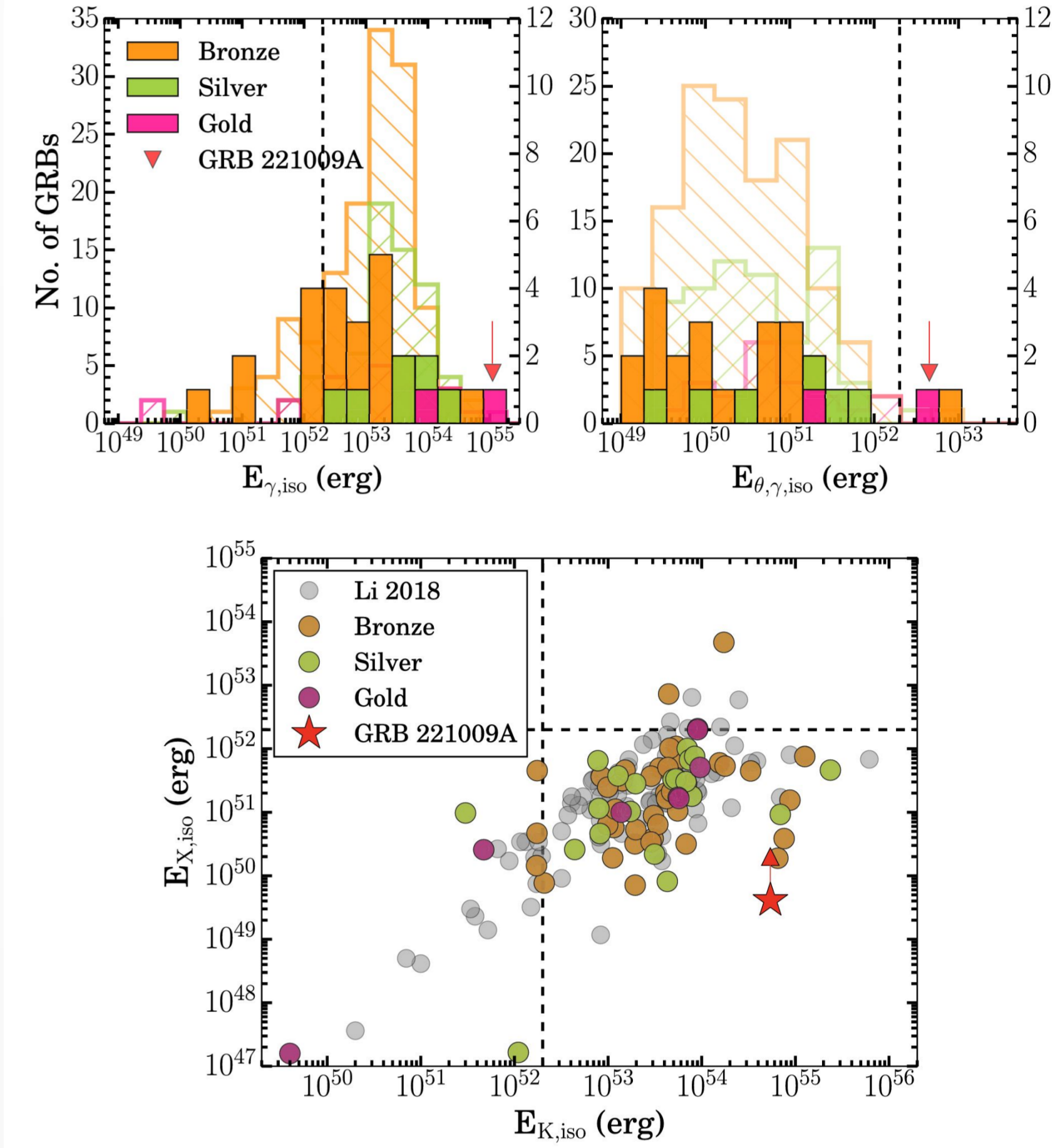
GRB 221009A was an extraordinary event: Observations



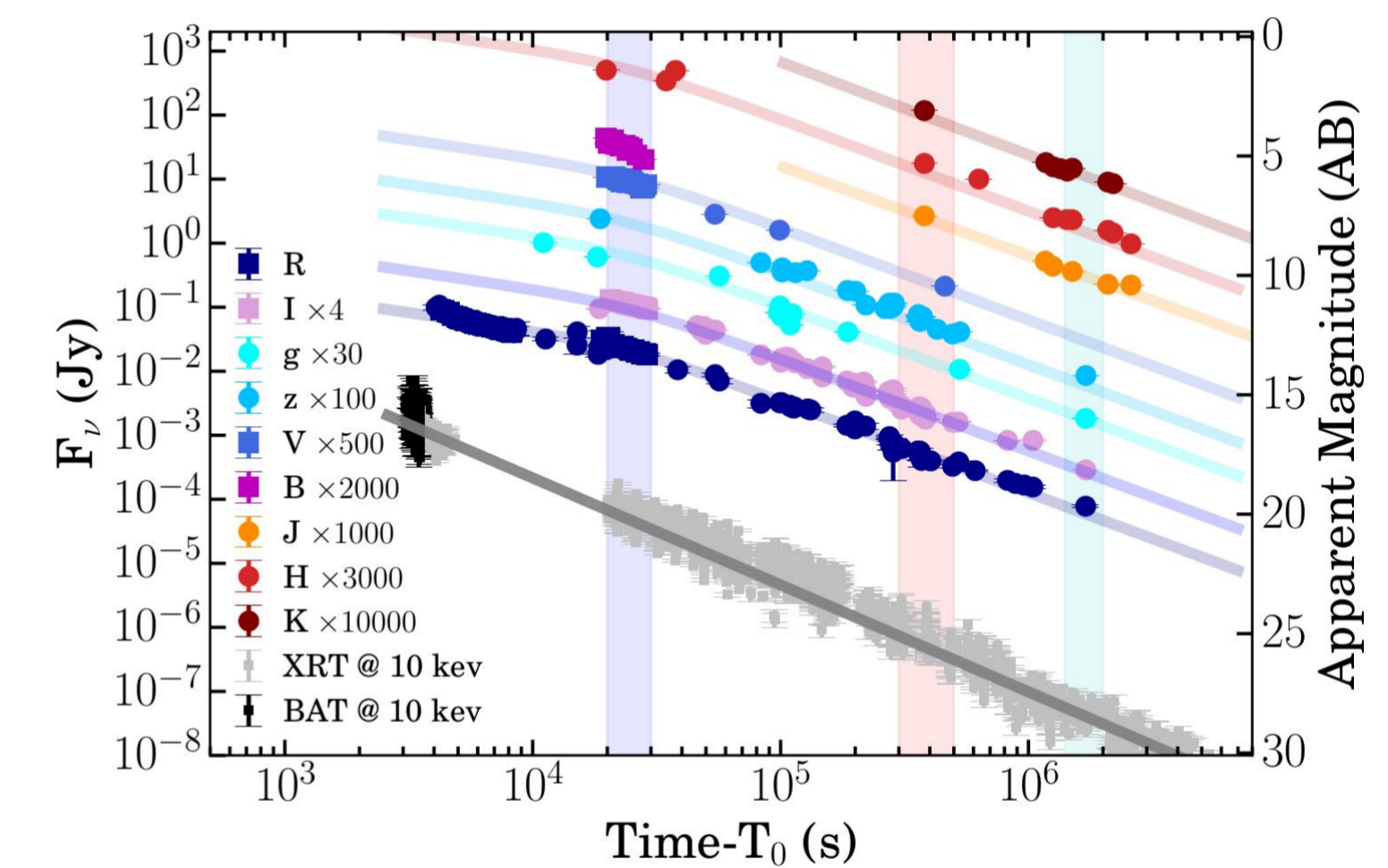
Sample distribution & Methodology



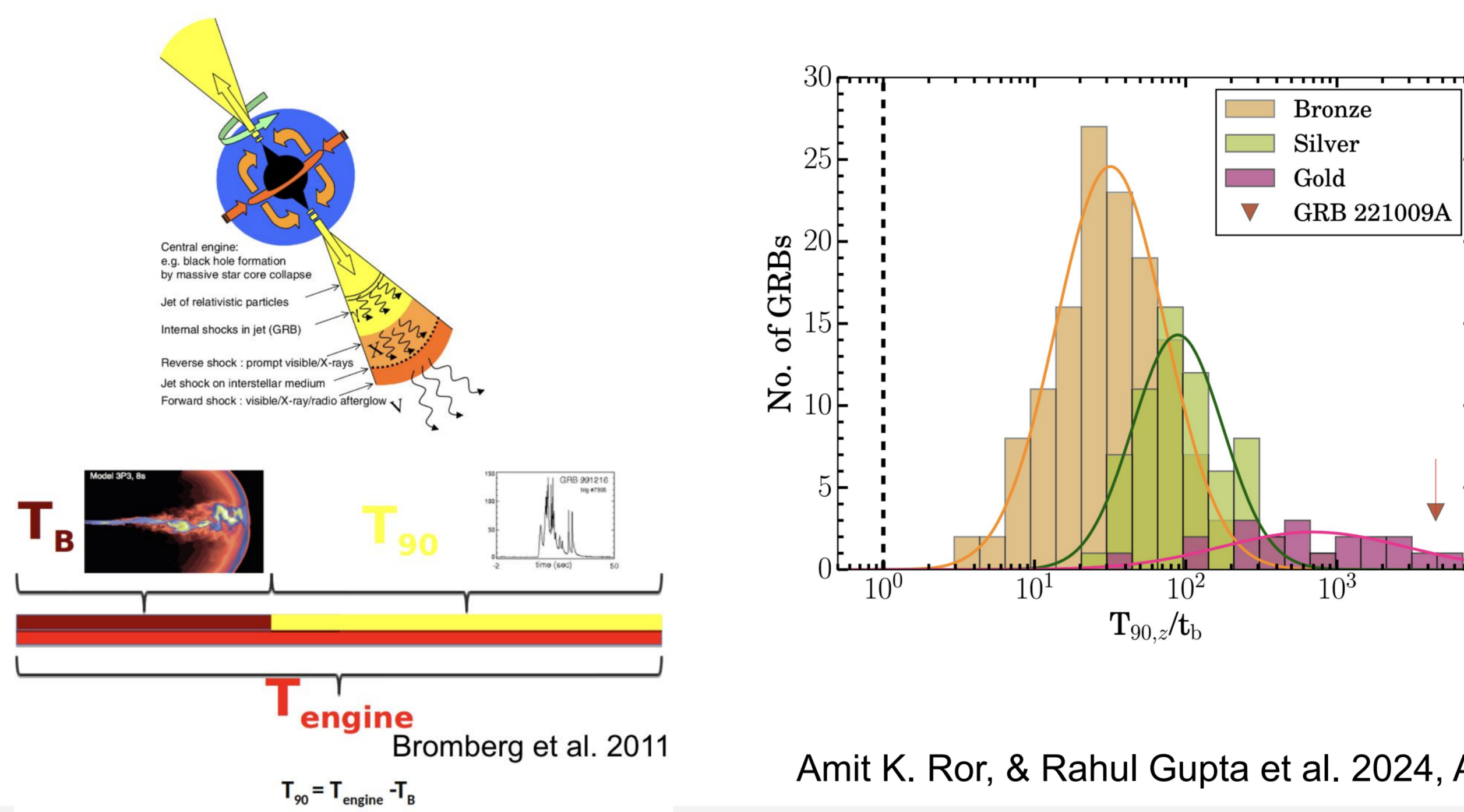
Exploring Origin of Ultra-Long GRBs: Central Engine



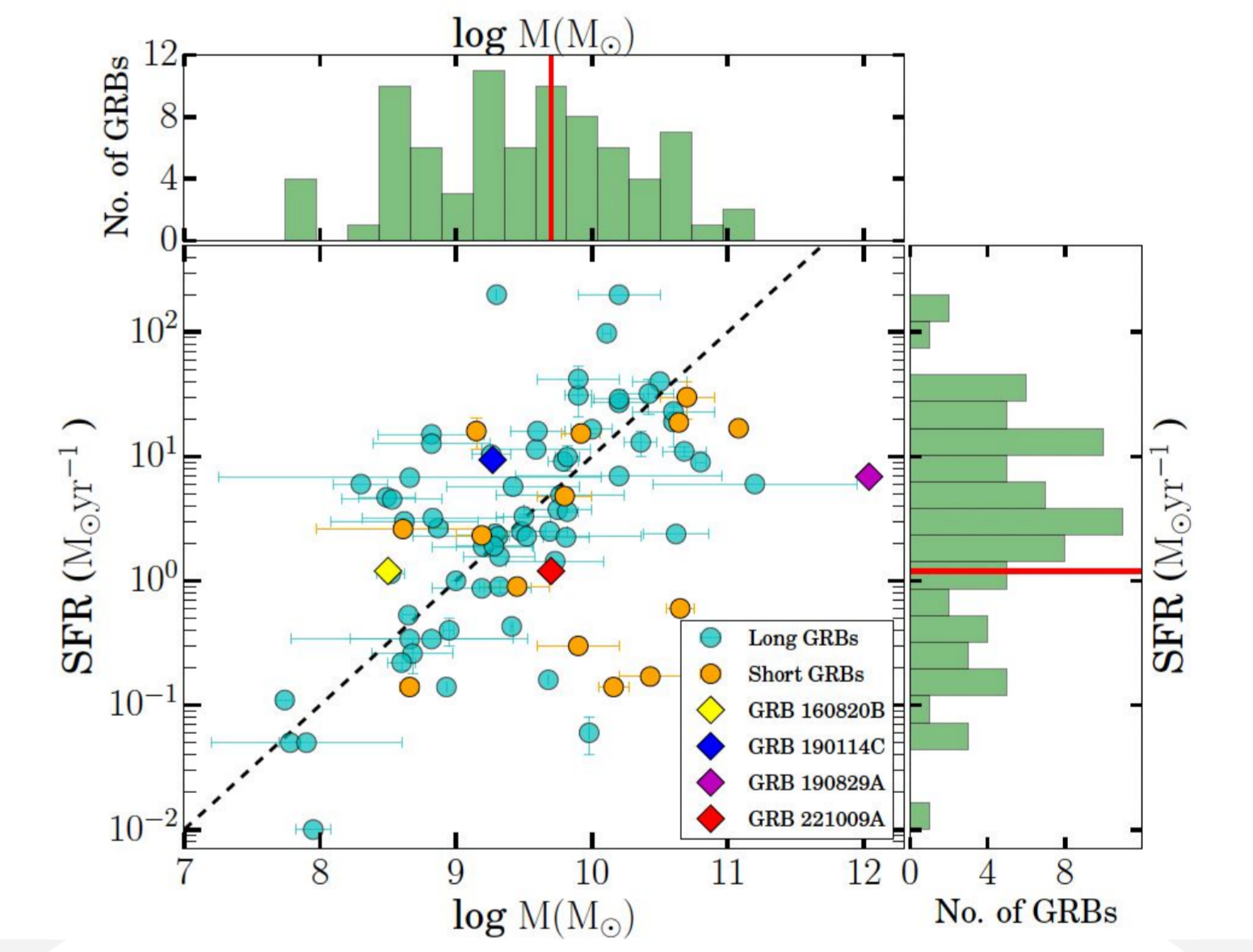
Afterglow properties of GRB 221009A



ULGRBs: Collapsar origin



Host galaxy properties of GRB 221009A

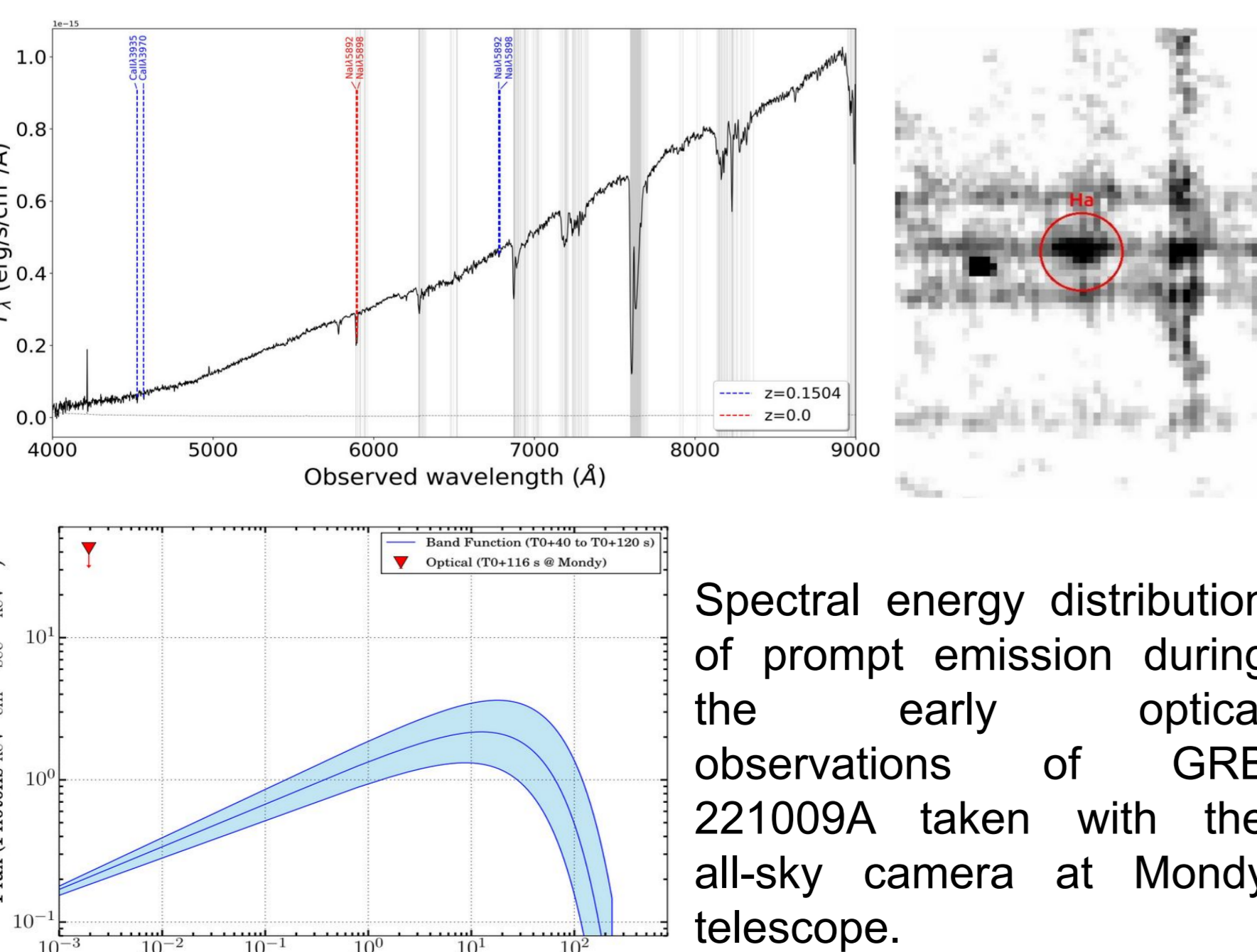


Conclusion

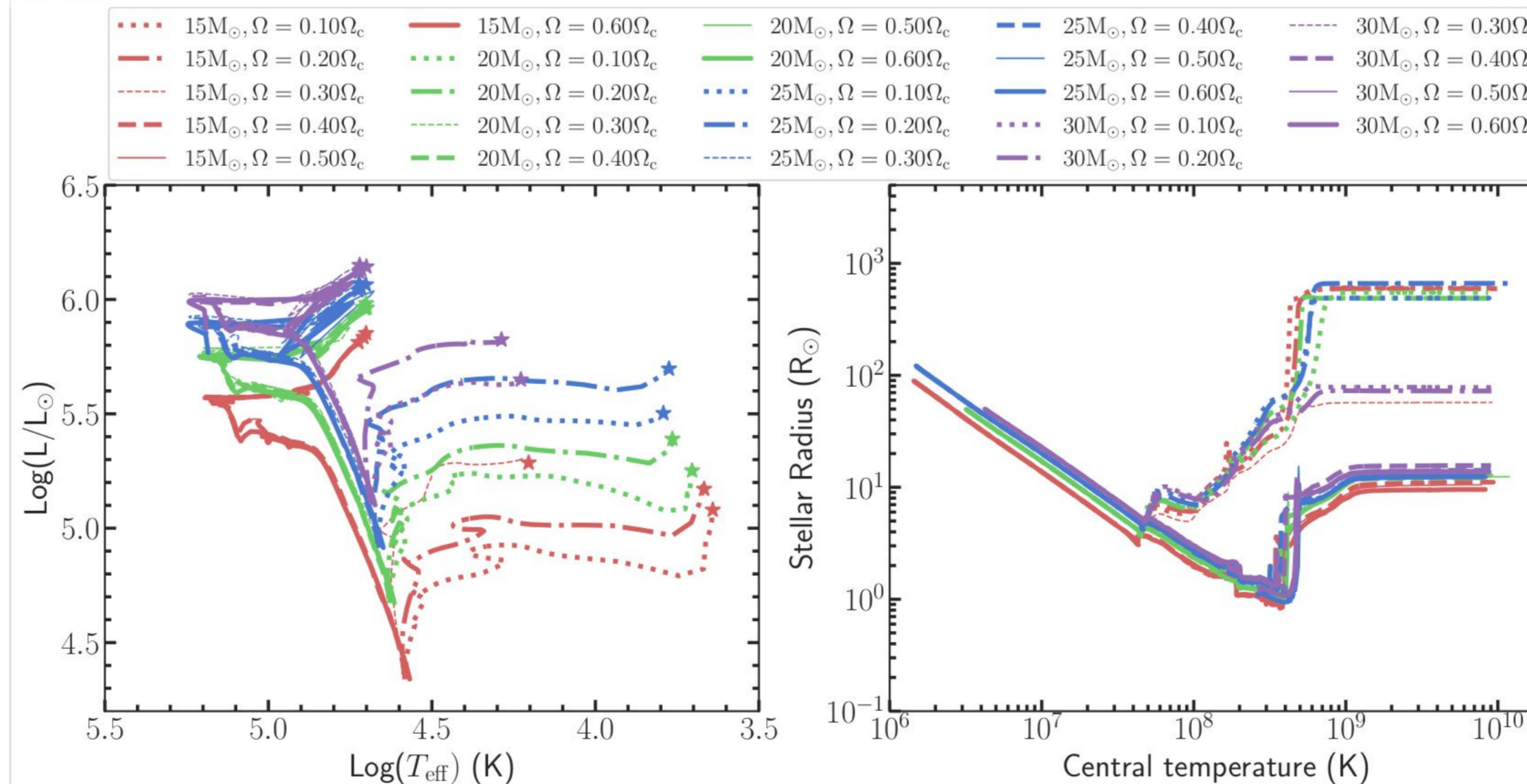
- The BOAT was an extraordinary and rare event.
- We shed light on the origin of ULGRBs (including the BOAT) utilizing observations and simulations.
- MESA simulation suggest the low metallicity, moderate rotating massive star (BSG) as a progenitor of ULGRBs.
- A hyper accreting black hole is constrained as a potential central engine candidate for our gold samples, and only a few GRBs favor a magnetar.
- Utilizing our earliest GTC spectroscopic observations, we determined the redshift of GRB 221009A to be z = 0.1504.
- GRBs present a fascinating view of ultra fast jets that demands coordinated attention of all state-of-the-art facilities.

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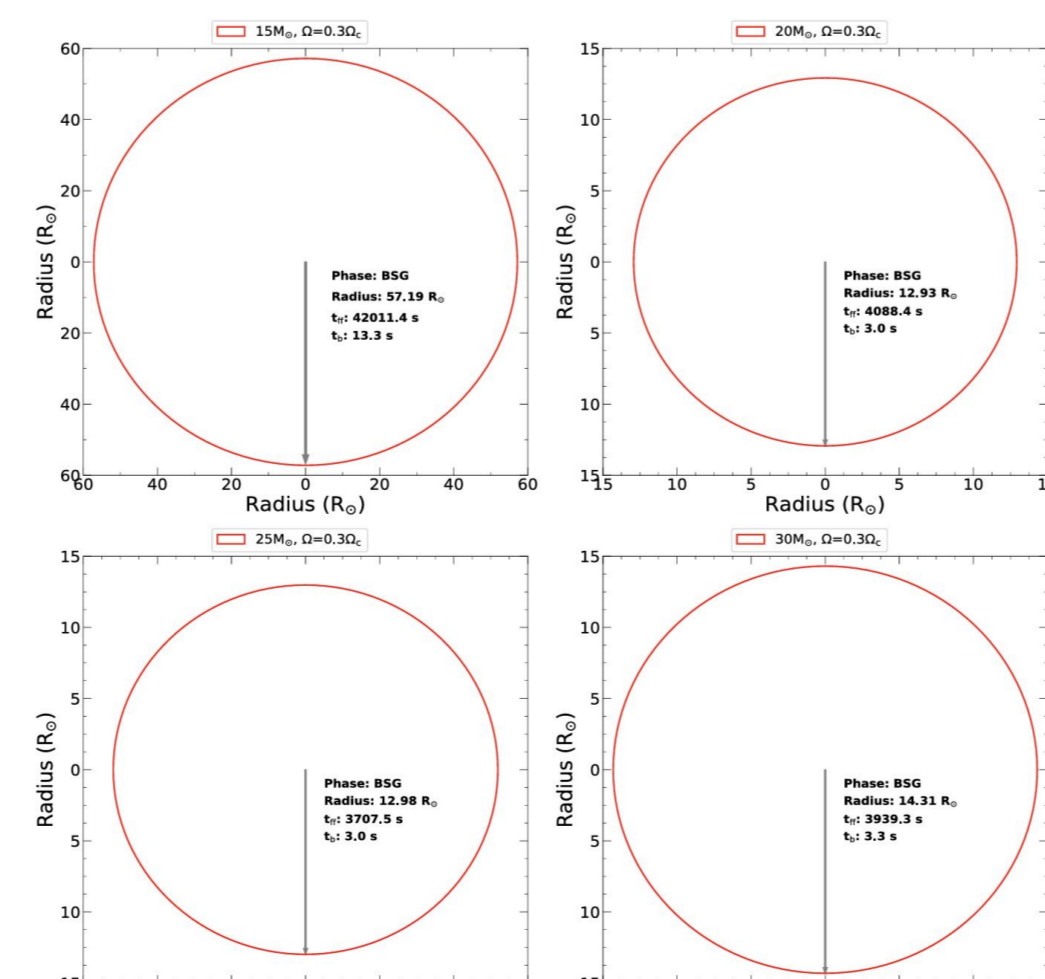
Early photometric and spectroscopic observations of GRB 221009A



MESA Simulation of ULGRBs Progenitors



BSG as Possible Progenitors of ULGRBs?



References: Starling et al. 2011; Thöne et al. 2011; Bromberg et al. (2011, 2013); Virgili et al. 2013; Gendre et al. 2013, 2019; Levan et al. 2014, 2015, 2023; Evans et al. 2014; Boër et al. 2015; Greiner et al. 2015; Cucchiara et al. 2015; Perna et al. 2018; Aguilera-Dena et al. 2018; Wet et al. 2023; Lesage et al. 2023; O'Connor et al. 2023; Kann et al. 2023; Laskar et al. 2023; Shrestha et al. 2018, 2023; Williams et al. 2023; Song & Liu 2023; Ror et al. 2024., and R. Sánchez-Ramírez et al. 2024, A&A

Thank you!