Multi-messenger Astrophysics Master Class:

Gamma Rays

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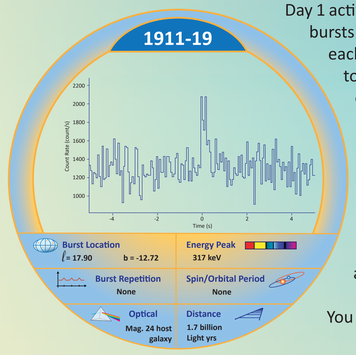
GW170817
"Golden Binary"

As part of the international gravitational wave collaboration for education and public outreach (IGrav), Fermi communications and outreach is supporting the development of the gamma-ray content for a *Multi-Messenger Astrophysics Master Class*. The Master Class is being created for use in high schools, and represents how scientists work together using different types of data to make sense out of astrophysical phenomena. The event that inspired the class is GRB170817A (GW170817), the *Golden Binary* neutron star merger observed by more than 70 ground and space-based instruments on August 17, 2017.

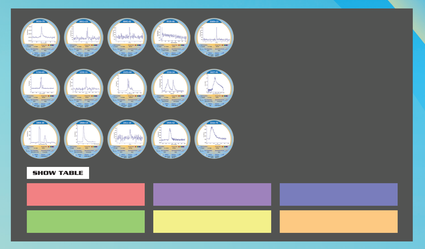
Along with the gamma-ray activities that use Fermi GBM data, activities are being developed by IGrav members for other messengers including: gravitational waves, x-ray and radio data, and visible light data.

The students will be divided into teams: each team will study one type of messenger for the first two days. On the final day, all the data will be combined to reveal the big picture, and to measure the Hubble constant.

Day 1

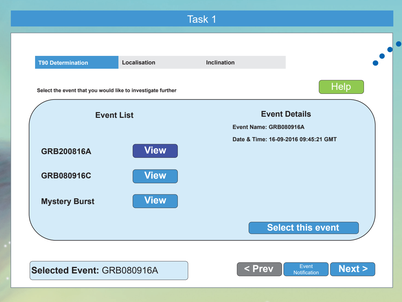


Day 1 activities train the students to classify different types of gamma-ray bursts based on common physical characteristics. Students examine each burst and decide how to sort them in differently colored boxes. The data table is then color-coded to match their selections. When all bursts have been sorted, students learn that they should have identified three different types of bursts: long, short and SGRs.

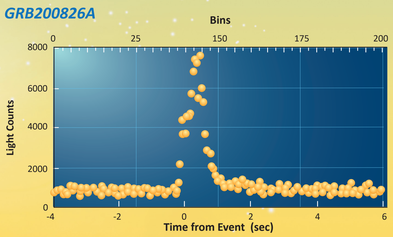


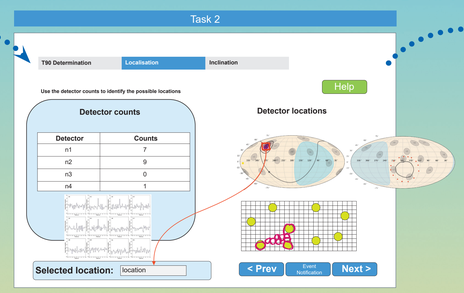
You can play this Gamma-ray Burst Game through the Discover link at *http://afh.sonoma.edu*

Day 2

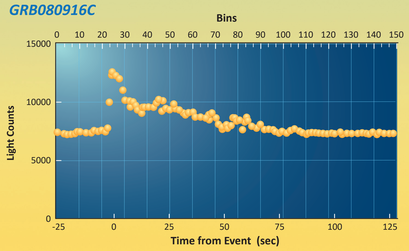


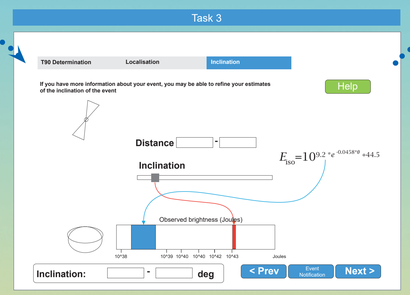
On Day 2, students analyze three candidate bursts to determine T90. The mystery burst is then studied further in subsequent activities.



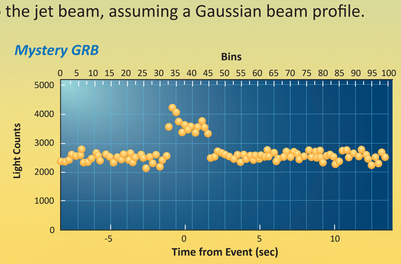


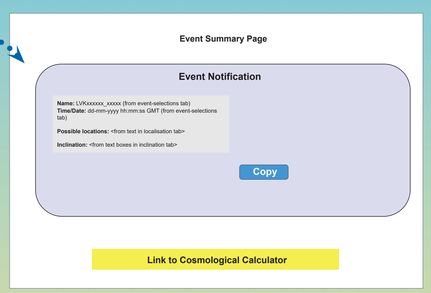
The GBM position for the mystery burst is determined by examining count rates in different detectors. The rough position is then sent to the other teams.





The observed flux from the burst is much lower than expected based on the distance to the GRB which was provided by the GW team. The difference is explained by viewing the gamma–ray jet off axis. A slider bar tool allows the students to estimate the inclination angle to the jet beam, assuming a Gaussian beam profile.





Final results are communicated to the other teams and are used as inputs to the Day 3 activity. Day 3 focuses on determining the Hubble constant and other parameters of cosmological interest.

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