Keck Observations of 153 Gamma-Ray Burst Host Galaxies

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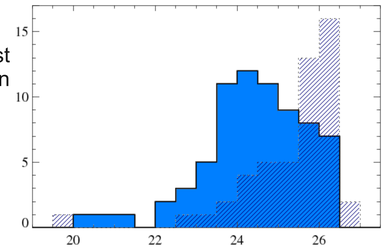
The Keck GRB Host Project

Thanks to Swift, the rate of GRB localizations has greatly outstripped the availability of observational resources to follow all (or even just most) fields at late times. Even so, this profusion of targets also permits the construction of very large host samples, even for relatively rare sub-classes of burst. Since 2005, we have been actively observing GRB host galaxies under a number of different programs at Keck Observatory, which we are uniting and releasing to the public as a single data set. Here I describe the combined project and summarize observations compiled and reduced to date.

Imaging Observations

The majority of project time has been spent on imaging and host identification. We have currently imaged **149** different GRB fields (Figure 1) to and detected host galaxies (or likely host candidates) consistent with available afterglow positions in **88** of these cases. Multiple filters (usually g+R or g+I) are available for the large majority (135) of these fields.

Figure 2 (right) - Apparent *R*-band host magnitude distribution (after foreground extinction correction) of the sample. The hashed histogram shows upper limits.



Spectroscopic Observations

Host redshift measurements in the Swift era have been challenging, since the redshift distribution peaks well above z>1.5, where all emission lines except Ly-α are shifted into the NIR. Nevertheless, we have attempted spectroscopy on **46** of our targets, resulting in **21** successful redshift measurements (14 of these were previously unknown before our observations). Four of these redshifts are due to Ly-α detections, with the rest mostly from [OII].

Luminosities

We detect host galaxies ranging from subluminous dwarfs up to (and often exceeding) L* across the entire range in redshifts, from the current universe to z~4. While our sample is not uniformly selected and cannot directly constrain the GRB host luminosity function, it is clear that GRBs can and do form in quite luminous galaxies at all redshifts.

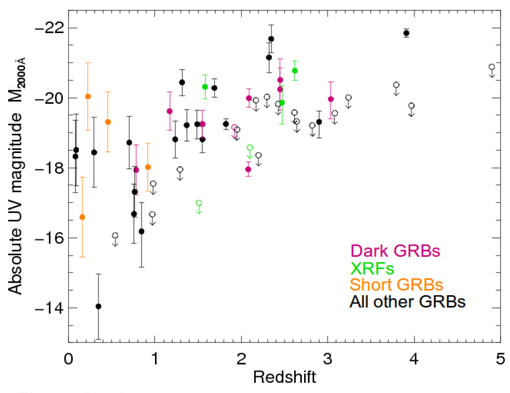


Figure 3 (above) - UV absolute magnitudes of GRB hosts of known *z* detected in our sample, color-coded by event class.

Colors

At z>1, our g+R/I observations measure the host's rest-frame UV spectral index β_{UV} (where $F_\lambda = \lambda^{\beta_{UV}}$), a probe of extinction in star-forming galaxies. Our sample shows a wide range of β_{UV}, from -2 to 2.5. Nearly all events with β_{UV}> 1 are dark. We do not find any hosts with β_{UV} < -2.5, which would be indicative of an unusual stellar populations.

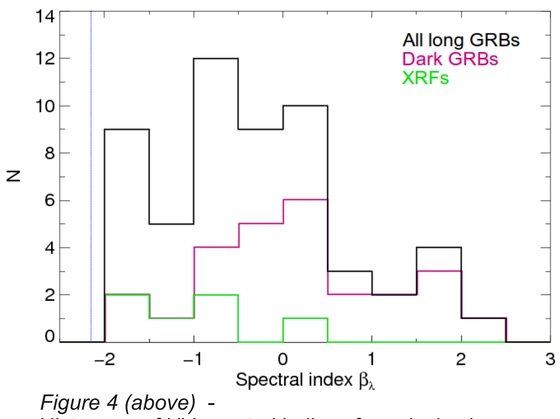


Figure 4 (above) - Histogram of UV spectral indices for galaxies in our sample (events with known z<1 are affected by the Balmer break and excluded.)

Redshift Distribution

Combination of our catalog with the P60 afterglow sample has enabled us to achieve 80% redshift completeness (100% for z>5) providing strong constraints on the intrinsic Swift long GRB redshift distribution. In particular, a large population of high-z events (more than a few percent) is ruled out.

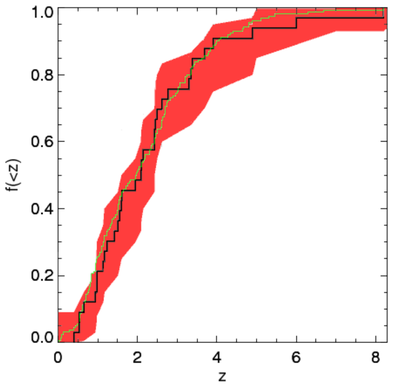
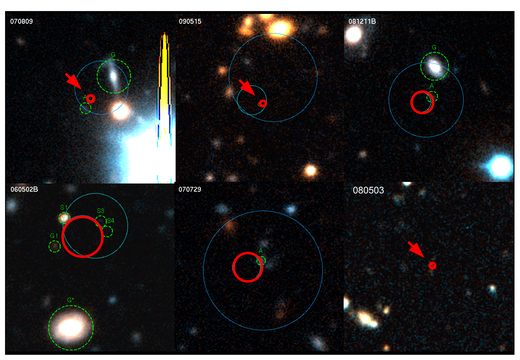


Figure 5 (above) - The observed cumulative redshift distribution of the P60 sample (black) and the inferred intrinsic distribution of *Swift* GRBs (red; 80% confidence).

Short GRBs

About half of all short GRBs imaged by our program do not have any natural host candidate within the best-available afterglow error circle (Figure 6), even though though those events which do have clear host associations usually have low redshifts and luminous hosts. Unless the host population is strongly bimodal, this supports a scenario in which a significant fraction of short GRBs are ejected from their host galaxies.



X-Ray Flashes

XRFs are GRBs with soft prompt-emission spectra (E_{peak} <~ 30 keV). Their hosts appear to be star-forming galaxies typical of other long GRBs. One possible exception is XRF 060428B, localized to the outskirts of an elliptical at z=0.35 (Figure 7) - but this may be a chance association or even a lensed event in a background galaxy.

Figure 6 (left) – Examples of possible "hostless" short bursts with no galaxy consistent with the best-available optical or X-ray error circle.

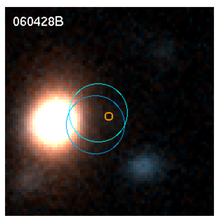


Figure 7 (top right) – Keck imaging of the field of XRF060428B, an X-ray flash with a faint optical afterglow localized to the outskirts of a red and (mostly) dead galaxy at z=0.35. A faint, blue source also underlies this position, however.

Data Availability

A partial release of program data is now available at lyra.berkeley.edu/hosts. The current release includes imaging and host photometry in one filter, as well as labeled thumbnail snapshots. Additional releases, including the final calibrated imaging catalog and all spectroscopy, will follow later in the year.

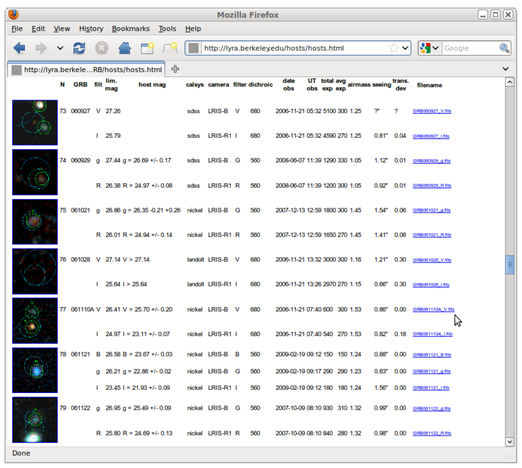


Figure 8 (right) – Screenshot of the beta version of our host catalog and data access page.

Figure 1 (right) - 6x6 arcsec false-color thumbnails of imaging of all fields.