Building a Complete Sample of *Swift* Gamma-Ray Bursts

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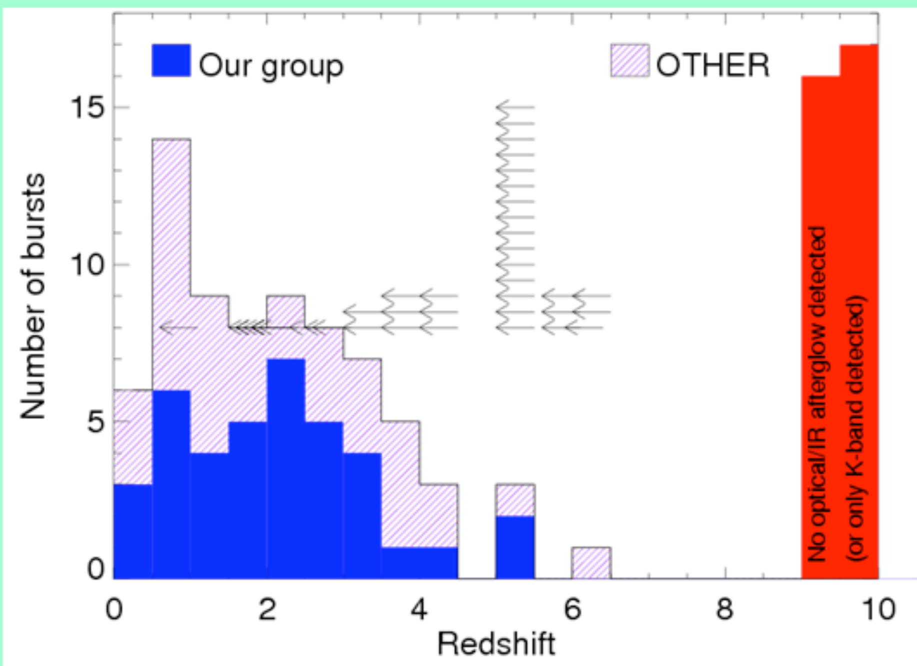
Introduction

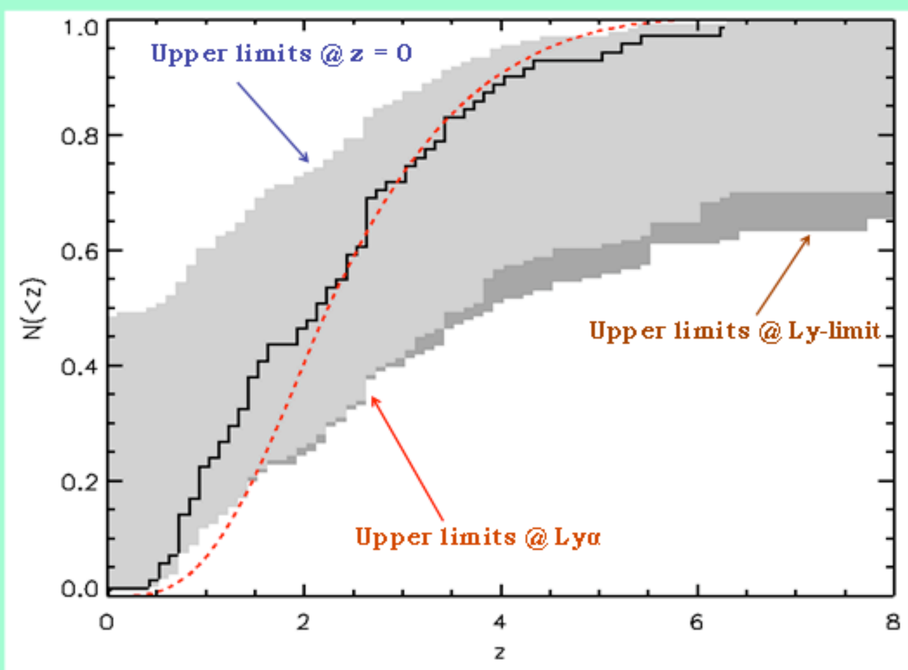
The aim is to construct a sample that is unbiased towards optically bright afterglows. We have used six simple criteria to select a sample containing bursts that have "observing conditions" favorable for redshift determination: (1) Small error circles: XRT localisation; (2) X-ray position made public within 12 hours; (3) GRB angular distance greater than 55° from the Sun; (4) Sufficiently small Galactic extinction: $A_V < 0.5$ mag; (5) Not a polar declination: $|\mathrm{dec}| < 70°$; (6) No nearby bright stars. Out of the 337 long-duration *Swift* GRBs (1 July 2008), 136 fulfil these criteria (around 40%). The redshift completeness and distribution is presented in the upper left panel below.

Closely related to the aforementioned sample, we have obtained imaging and spectroscopic data on 71 carefully selected GRB host galaxies via a VLT large programme (PI: J. Hjorth). This project has several goals, including (1) host detection through deep photometry; (2) search for red systems through nIR photometry; (3) determination of emission redshifts for GRBs without absorption redshifts; (4) search for Lyα emission for all hosts at $z > 2$. Some preliminary results are displayed in the lower left panel below along with a more detailed look at the refined XRT error radii. Although half of the data for item (3) is yet to be fully reduced, we already have five new redshifts and, surprisingly, shown several redshifts reported in the literature to be wrong.

The Redshift Distribution of *Swift* GRBs

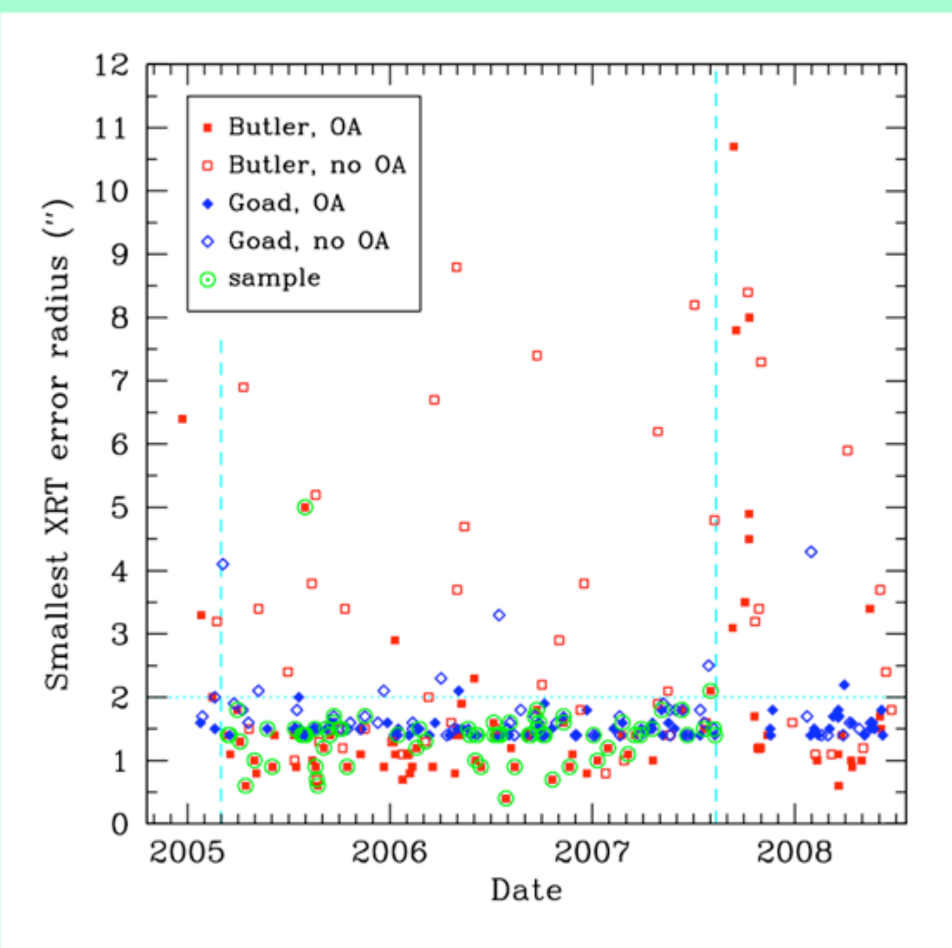
The redshift histogram of the sample is shown on the left; the redshift recovery rate is fairly high or around 53%. The mean redshift is $\langle z \rangle = 2.2$. Bursts, for which only an upper limit on the redshift could be established so far, are indicated by arrows. The red histogram on the right shows the 33 bursts for which no optical afterglow (OA) was detected and hence no redshift constraint could be inferred. A more informative plot of the redshift distribution (RD) is on the right. It is the cumulative fraction of GRBs as a function of redshift (black stepwise curve). This observed RD should be treated with caution as it is affected by important selection effects. For example, those GRBs with bright OAs are much more likely to have a redshift measured than those which have faint OAs. However, other GRBs in the sample can be used to bracket the true RD. We can simply assume that all the redshift upper limits are 0 (also GRBs without a redshift constraint). This gives us a strict lower limit on the RD. An upper limit on the distribution is obtained by placing those bursts without a measured redshift at the maximum redshift they can have. Using the Lyman-limit (dark gray area) instead of Lyα gives a stricter limit as there can be some flux leak in the Lyα forest. As a result, the true optically unbiased RD should therefore be located somewhere in the shaded area. An example of a model prediction where the GRB rate is proportional to the star formation rate is shown with a red dashed line (Gorosabel et al., 2004, A&A, 427, 87).

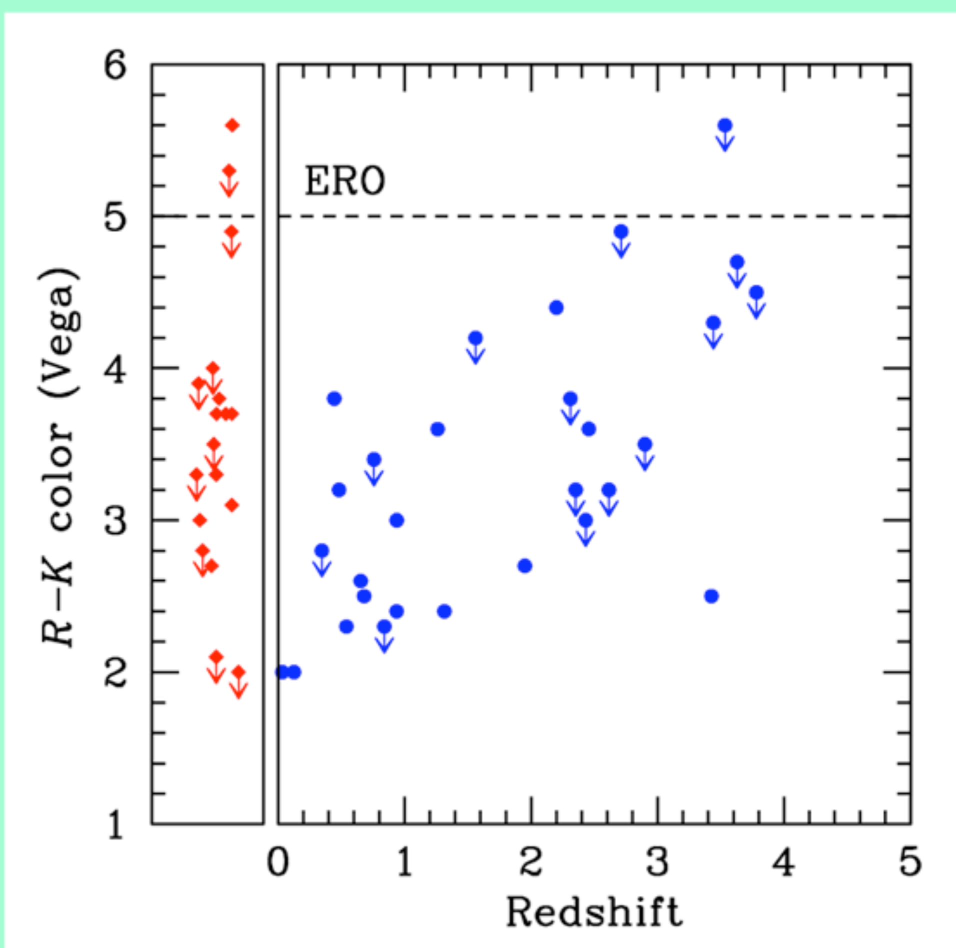




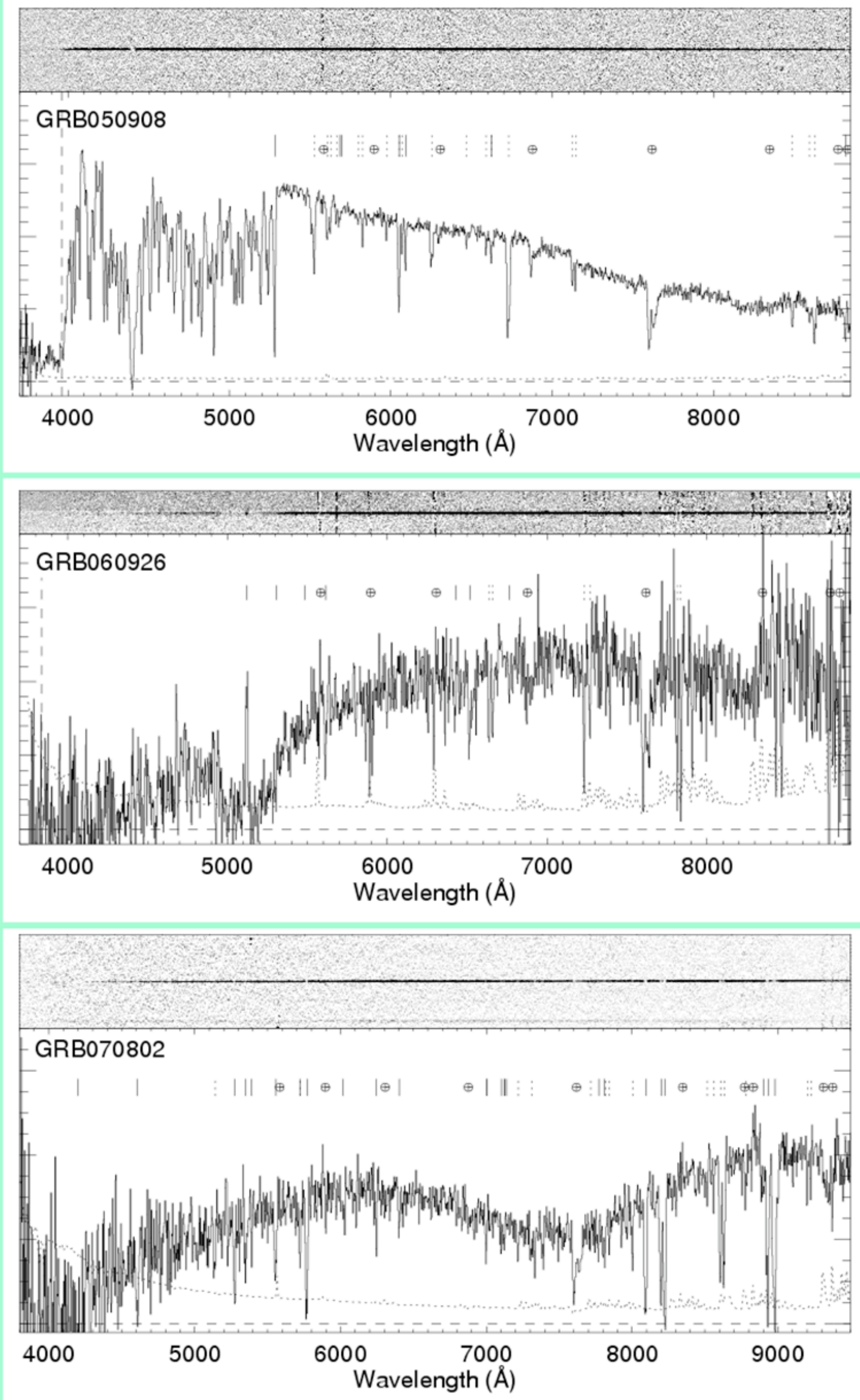
Fundamental Properties of GRB-Selected Galaxies: A *Swift*/VLT Legacy Survey

The aim of the large programme has been to characterize the host galaxies of homogeneously selected sub-sample of *Swift* GRBs. In addition to the criteria listed in the Introduction, the error radius has to be smaller than 2 arcsec; the position may come from the optical afterglow, the Butler (2006, AJ, 133, 1027) table or the UVOT-enhanced position (Goad et al., 2007, A&A, 476, 1401). The smaller radius of the latter two is displayed in the figure on the left for all *Swift* long-duration bursts. The sample is circled in green and includes bursts between 1 March 2005 and 10 August 2007. The figure on the right shows the R-K colours of galaxies in the sample as a function of redshift. The diamonds in the left panel represent objects with, as yet, no measured redshift. Only one extremely red object (ERO, R-K > 5) is visible in the sample. The results of the photometry along with the definition of the sample will be published in Hjorth, Malesani, et al.





A Few Spectroscopic "Byproducts"



The redshift is not the only important number or result obtained from low-resolution spectra of optical afterglows.

Top: GRB 050908 at $z = 3.34$. A direct detection of Lyman continuum photons (left of the vertical dashed line) allows the measurement of the escape fraction of ionizing radiation (see e.g. Chen et al., ApJ, 667, L125).

Middle: GRB 060926 at $z = 3.20$ displays both one of the largest DLAs ever detected with $\log(N_H/\mathrm{cm}^{-2}) = 22.6$ and a strong Lyα emission in the DLA trough. The latter is redshifted by 400 km/s compared to the redshift inferred from the metal lines.

Bottom: GRB 070802 at $z = 2.45$. A broad absorption bump peaking around 7500 Å is clearly apparent. The spectrum is well fitted with a power-law spectrum and an extinction curve containing the 2175 Å extinction bump, known from our Galaxy and the LMC. This is one of the very few detection of the 2175 Å bump for any sightline outside the Local Group (see also Krűhler et al., arXiv:0805.2824).

These three spectra along with more than 40 other VLT and NOT spectra will be published later this year in ApJ (Fynbo, Jakobsson, et al.)