X-shooter Science Verification Proposal

Title: Target-of-opportunity observations of gamma-ray burst afterglows

Investigators	Institute	EMAIL
Johan P. U. Fynbo	Dark Cosmology Centre, NBI, Copenhagen, DK	jfynbo@dark-cosmology.dk
Lise Christensen	ESO, Garching, ESO	lichrist@eso.org
Stefano Covino	INAF/Brera, I	stefano.covino@brera.inaf.it
Hector Flores	Paris Observatory, F	hector.flores@obspm.fr
Jens Hjorth	Dark Cosmology Centre, NBI, Copenhagen, DK	jens@dark-cosmology.dk
Ralph A. M. J. Wijers	Sterrenkundig Instituut, Amsterdam, NL	R.A.M.J.Wijers@uva.nl

Abstract:

Gamma-ray burst (GRB) afterglow spectroscopy is one of the main science drivers behind the X-shooter spectrograph. We here propose to carry out target-of-opportunity observations of GRB afterglows that are observable during science verification. ESO has been leading the follow-up work on GRB afterglows leading to a range of major breakthroughs based on ESO data. X-shooter allows us to make the next leap ahead and these proposed observations during science verification will help the community finding the optimal observing strategy. The proposed observations will also allow harvesting early science results such as determination of metallicities, molecular content, and extinction curves for GRB sightlines. This proposal is sent on behalf of the GTO GRB/ToO collaboration.

Scientific Case:

A decade ago, very little was known about GRB progenitors and their environments. Now, mainly thanks to the study of optical/near-infrared afterglows, with the VLT at the forefront, we have learnt that: GRBs are cosmological - the current record holders are GRB 090423 at $z \approx 8.2$ (Olivares et al. 2009, GCN 9215; Tanvir et al. 2009, GCN9219; Fernandez-Soto et al. 2009 GCN 9222;) and GRB 080913 at $z = 6.7$ (Greiner et al. 2009, ApJ, 693, 1610), and their afterglows outshine every other known object in the Universe, both in the optical/near-infrared (e.g. Racusin et al. 2008, Nature, 455, 183) and in the X-rays (Watson et al. 2006, ApJ, 637, L69). Long GRB hosts are generally blue, low mass, starbursting galaxies (e.g. Christensen et al. 2004, A&A, 425, 913; Fruchter et al. 2006, Nature, 441, 463; Margutti et al. 2007, A&A, 474, 815) with metallicities ranging from 1/100 solar to solar, and with very high HI gas column densities (Jakobsson et al. 2006, A&A, 460, L13; Savaglio et al. 2009, ApJ, 691, 182). Several long GRB afterglows have a spectroscopically confirmed supernova (SN) component (e.g. Galama et al. 1998, Nature, 395, 670; Hjorth et al. 2003, Nature, 423, 847), providing evidence that they are linked to the core collapse of a massive star (Woosley 1993, ApJ, 405, 273). However, two recent long-duration bursts surprisingly show no evidence for SN emission down to very deep limits suggesting a new phenomenological type of massive stellar death (Fynbo et al. 2006, Nature, 444, 1047; Della Valle et al. 2006, Nature, 444, 1050). Short GRB afterglows were first identified only a few years ago (Hjorth et al. 2005, Nature, 437, 859) in nearby galaxies of various morphological types (Berger, 2009, ApJ, 690, 231). On average, short GRB afterglows are fainter than the long GRB afterglows, although they also seem to share most of the physical properties of the long bursts (Lee & Ramirez-Ruiz 2007, New J Phys, 9, 17).

Despite the impressive progress during the last 10 years there are shortcomings. Most afterglows are too faint for high resolution spectroscopy so here we have so far only been able to secure low resolution spectroscopy. This is excellent for measuring redshifts and doing spectrophotometry, but it is typically not possible to measure precise abundances or to detect molecular lines. Also, with 1st generation VLT instruments the wavelength coverage is of course much more limited than with X-shooter. Hence, for a number of bursts we have in the past obtained featureless spectra with neither absorption nor emission lines in the observed range.

X-shooter is built with spetroscopy of GRB afterglows as one of its main science drivers. With its wide wavelength coverage and high efficiency it will allow us to secure high quality data covering the full UV to near-IR range in a single shot in the short time available before the afterglows have faded away. Its resolution is high enough to allow measurements of abundances, its wavelength coverage is the best that can be done from the ground so we can detect the crucial HI and metal lines over a much wide redshift range than previously. Its near-IR coverage will allow us to get spectra of very high redshift and dust-obscured afterglows.

We here propose to observe GRB afterglows during science verification. Our goal is twofold: first we wish to get more experience using X-shooter on these targets, especially on how to optimize exposure times and binnings for getting the best data over the full spectral range. Second, we want to start securing the X-shooter data on GRB afterglows as early as possible.

Calibration strategy:

Calibration should be standard.

Targets and number of visibility measurements

Target	**RA**	**DEC**	**V** mag	**Mode** (slit/IFU)	**Remarks**
GRB1	20 11 11	-11 11 11	11.1	slit	First priority
GRB2	21 11 11	-11 11 11	11.1	slit	First priority
GRB3	22 11 11	-11 11 11	11.1	slit	First priority

Time Justification:

With the acquisition camera (covering 1.5×1.5 arcmin^2) we will first image the XRT error circle (typically 3–6 arcsec radius) down to first $R = 24$ and if no source is detected to $z = 23$ (5σ). This requires about 150 s in each band. This is not necessary if an optical afterglow position is already available from other observers. If a counterpart is detected (either by the night astronomer or by our team), follow-up spectroscopy is performed with exposure time depending on the afterglow brightness: if $R < 18$ we will observe for 20 min. If $18 < R < 20$ we will observe for 2×20 min. If $20 < R < 21$ we will observe for 4×20 min. If $R > 21$ we will observe for 3×1 hr. We plan to bin the detector 1×2 in the UV and visible arms to reduce the impact of read-out noise.