X-shooter Science Verification Proposal

Observing the very first galaxies: the host of GRB080913

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Abstract:

We propose to observe the host galaxy of GRB080913 at a confirmed redshift of 6.7, the second most distant GRB and third most distant galaxy known-to-date. It could be possible to detect it by searching for emission lines as Ly-α and possible features of population III stars such as HeII, a long sought quest in very young high redshift galaxies. With an exposure of 4 hours, it is possible to observe an emission line with a flux greater than $\sim 1.10^{-17}$ ergs/s/cm^2 (S/N=5), which is in the range of the spectroscopically confirmed Ly-α Emitters. Such an observation will constrain the host galaxy properties and the stellar population at the origin of the very first GRBs, and will also contribute to the study of the re-ionization of the universe.

It will undoubtedly demonstrate the X-shooter capabilities by observing the most distant galaxy known-to-date observable during the Science Verification.

Scientific Case:

Searching for high redshift galaxies is one of the most active fields in observational cosmology. The most distant galaxies provide a direct probe of the early stages of galaxy formation, in addition to revealing the effects of cosmic re-ionization (see for example Fan et al. 2006). Galaxies up-to redshift 6 are now routinely found and show that star formation was initiated at significantly higher redshifts and that these galaxies are the likely sources of the re-ionization of the universe, which was already completed at this redshift. Conversely, detection of $z > 7$ galaxies is still very rare, due in large part to the complete absorption of their restframe UV emission below the Ly-α line and to the sky emission lines. However, at $z > 6.5$ the Universe is thought to be undergoing re-ionization and this may cause a further evolution of the observable properties of very distant objects with redshift, possibly more abrupt than their intrinsic evolution and dimming with age and distance.

The potential of Gamma-Ray Bursts (GRBs) as beacons to the distant universe is now widely recognized. The tremendous luminosity of both the prompt gamma-ray emission, and the X-ray and optical afterglows indicates that GRBs should be visible out to distances of $z > 10$ with present-day technology, such as *Swift* and *Fermi*. Due to their connection to the death of massive stars, long GRBs probe for example the evolution of cosmic star formation, re-ionization of the intergalactic medium and the metal enrichment history of the Universe. GRB hosts can also be used to further explore the validity of the downsizing scenario by comparing the properties of the largest sample of GRB hosts with results from galaxy spectroscopic surveys (Cimatti et al. 2002, Davis et al. 2003, Abraham et al. 2004, Coil et al. 2004, Le Fèvre et al. 2005, Fontana et al. 2004, Glazebrook et al. 2004, Papovich et al. 2006).

GRB080913, discovered by *Swift* on September 13, 2008 (Schady et al. 2008), is the second most distant GRB known to-date, with a spectroscopically redshift of $z = 6.7$ determined on the afterglow emission (Greiner et al. 2009). Its isotropic energy release is $E_{iso} \approx 7 \times 10^{52}$ erg, which is typical of the long GRB population. Compared to the properties of GRB 050904, an other GRB at $z > 6.2$, GRB 080913 has a substantially shorter duration, lower gamma-ray luminosity as well as much dimmer ($\sim$5 mag at early times) afterglow. Thus, it appears that GRBs at this early epoch show already the same large diversity as the low-z bursts.

We propose to observe for the first time the host galaxy of GRB080913[1]*, the second most distant GRB and third most distant object known-to-date*[2]! As the GRBs can trace the bulk of the star formation at $z > 3$ (Jakobsson et al. 2005, Fynbo et al. 2008) and be associated to the Population III at $z > 6$ (Bromm and Loeb 2006), we propose to detect it by searching for emission lines as Ly-α and possible features of population III stars such as HeII (see for example figure 1). It is important to note that at $z = 6.7$, detection of HeII, a long sought quest in very young high redshift galaxies (di Serego Alighieri et al. 2008, Nagao et al. 2008), could be possible, the HeII (1640 $\AA$) being ideally located at the center of the J band and detectable as well in a few hours.

With an exposure of 4 hours, it could be possible to detect an emission line with a flux greater than $\sim 1.10^{-17}$ ergs/s/cm^2 (S/N=5), which is in the range of the spectroscopically confirmed Ly-α Emitters (Kashikawa et al. 2006). Due to the faintness of the host galaxy at such a redshift, it is impossible to observe its continuum in an acceptable exposure time ($Mag_J > 24.6$, Greiner et al. 2009) and the proposed strategy, with a detection probability of larger than 50% (Niino et al. 2009, Jakobsson et al. 2005), is the most reasonable one.

Theoretical and observational studies suggest that GRBs preferentially occur in low metallicity environment. The proposed observation will then constrain the host galaxy properties, by using for example the Ly-α emission as a metallicity indicator of high redshift GRB environments (Niino et al. 2009), and then the progenitor of the very first GRBs. It will also contribute to the study of the re-ionization of the universe.

We have also checked that this object is not locked by the X-shooter Guarantee Time.

This observation will be very useful for a Phd student, B. Clement, who is studying high-redshift galaxies (supervisor: J.G. Cuby).

Calibration strategy:

No specific calibration is requested. Object will be observable at the end of the night in August (dawn in July).

Our team has extensive experience with VLT instruments, some of us have worked at Paranal and have a very long experience on instruments and data reduction.

Targets and number of visibility measurements

Target	RA	DEC	Flux ergs/s/cm^2	Mode (slit/IFU)	Remarks
GRB080913	04:22:54.74	-25:07:46.2	$> 1.10^{-17}$	IFU	Observable in August

We propose to exploit an other interesting feature of X-shooter by observing the host-galaxy of GRB080913 in IFU mode, the pointing position being based on the one of the GRB prompt emission.

Time Justification:

From our direct experience with ISAAC, extrapolated to X-SHOOTER which has a better efficiency, we estimate that with a 4 hour long exposure, it would possible to detect an emission line with a flux greater than $\sim 1.10^{-17}$ ergs/s/cm^2 (S/N=5), which is in the range of the spectroscopically confirmed LAEs.

It is also clear that the spectral resolutions of X-SHOOTER is ideally adapted to provide good coverage of the UV restframe spectrum allowing in particular to search for possible emission features of population III stars such as HeII.

[1] The most distance GRB known-to-date, GRB090423 at $z = 8.2$, an obvious very promising target for X-shooter, is not observable during the Science Verification period (mainly observable between January and May). The second most distant confirmed galaxy, a LAE at $z = 6.96$,is not observable from Paranal due to its declination, $\delta = +27$.

[2] Already above the highest z for QSOs (CFHQS J2329-0301 at $z = 6.427 \pm 0.002$, Willot et al. 2007).

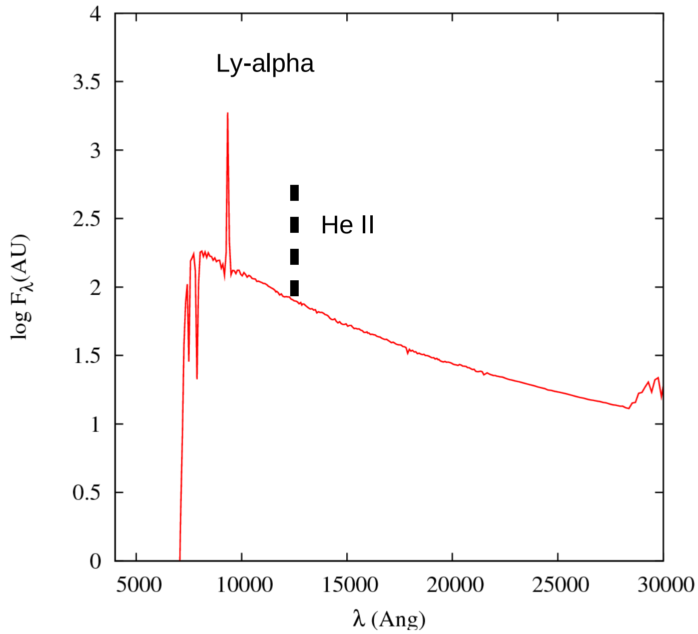

Figure 1: *Model spectral energy distributions of massive, metal-free (Population III) stars from Schaerer & Pello (2002), showing the wealth of signatures of the hard radiation field produced by these massive and hot stars. This model has been redshifted at $z = 6.7$.*