GAMMA RAY BURST FOLLOW-UPS WITH BOOTES-4

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ABSTRACT. The Burst Observer and Optical Transient Exploring System (BOOTES), is a global robotic observatory network, which started in 1998 with Spanish leadership devoted to study optical emissions from gamma ray bursts (GRBs) that occur in the Universe. We present shot history and current status of BOOTES-4 telescope. Some details of 38 GRBs followed-up with BOOTES-4 are discussed.

Key words: Gamma ray burst: follow-up, optical transient

1. Introduction

The Burst Observer and Optical Transient Exploring System (BOOTES), started in 1998 as a Spanish-Czech collaboration devoted to study optical emissions from gamma ray bursts (GRBs). The first BOOTES robotic astronomical station was located at INTA's Estación de Sondeos Atmosféricos in Centro de Experimentación de El Arenosillo, a dark-sky site near Mazagón (Huelva), center owned by the Instituto Nacional de Técnica Aeroespacial (INTA). The second observing station was opened in 2001 and it is located at the Estación Experimental de La Mayora (dubbed BOOTES-2), 240 km apart. The latter is run by the Consejo Superior de Investigaciones Científicas (CSIC). In 2009 BOOTES expanded abroad, with the third station (BOOTES-3) being installed in Blenheim (South Island, New Zealand). The fourth one (BOOTES-4) has been deployed in 2011 at the Lijiang Astronomical Observatory (Yunnan, China).

2. BOOTES-4 location, instruments and science

For many astrophysical problems it is necessary that photometric and astrometric observations be carried out over a long period of time. In the case of transient events, it is especially important to have continuous monitoring for several hours or even days after the event. The successful implementation of the BOOTES project requires the installation of telescopes in varying timezones. BOOTES-4 installed at the Lijiang Astronomical Observatory, Yunnan, China (Lat: 26°41'43"N, Long: 100°01'47"E, Elev: 3231m), deliberately chosen as being at an intermediate longitude between Spain and Mexico. It was officially opened on 20 March 2012 (See Figure 1).

Figure 1: BOOTES-4 telescope

Similarly to the BOOTES-1,2,3 stations, its dome is controlled by electrical motors which are controlled automatically according to the existing weather conditions.

The BOOTES-4 station has the next instruments:

- MET Ritchey-Chrétien reflector telescope (0.6m, f/8) with very fast slewing speed (> 100 deg/s) and easy rescheduling;
- EMCCD narrow field camera (clear, Sloan u',g',r',i' and UKIRT Z and Y -band filters): 10'x10' FOV (fast readout <1s);
- All-sky camera (CASANDRA-4): 180º FOV.

Main science with BOOTES-4 station is:

- The observation of the GRB error box simultaneously to the GRB occurrence;
- The detection of optical flashes (OTs) of cosmic origin;

- The monitoring of high-energy targets in different optical, as ground-based support for the ESA's *International Gamma-Ray Laboratory (INTEGRAL);*
- The monitoring of several objects (bright AGNs/QSOs, old GRB positions, etc.).

3. GRBs with BOOTES – 4

GRBs are indeed one of the main scientific goals of BOOTES. We know that GRBs arise at cosmological distances (with mean redshift $z \sim 2.5$ and redshifts in the range ~0.01 to ~ 10), with huge isotropic equivalent radiated energy, and small timescales (in the range few ms to 10^2 s), thus implying a small emitting region. The spectrum is non-thermal and relativistic outflows ($\Gamma > 100$) are involved. A frequent assumption is that short and long GRBs (with the short ones representing 1/3 of the overall GRB population) are due to different progenitors leading to the same succession of events: formation of a compact object and ejection of a relativistic outflow which produces the (long-lasting) afterglow at other wavelengths. Main program for BOOTES-4 system is observations optical counterparts for gamma ray burst: open and monitoring OT in different filters.

GRBs observations with BOOTES-4 was started in February 2012 and continue till present days. For the period from 2012 to 2013 was 38 real-time follow-ups, with 6 detections of the OA and 32 observations with upper limit, 4 pulications (GCN circulars and other). Some examles presented on Figures 2,3,4,5.

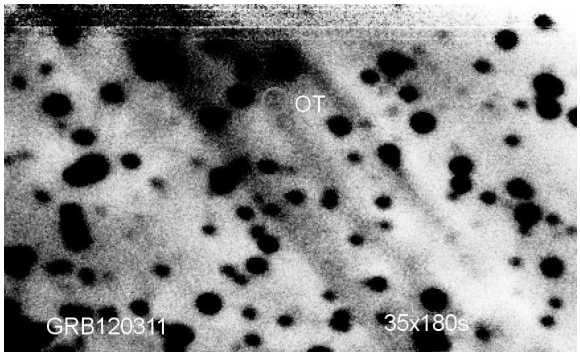

Figure 2: GRB 120311A - optical transient in the SWIFT XRT error box obtained with BOOTES-4 telescope in 13.66 hours after the burst. On the picture 35 coadded unfiltered images taken with 180s exposure each.

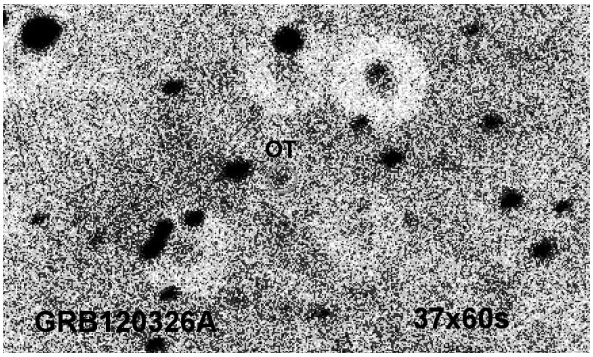

Figure 3: GRB 120326A. The observations started 10.7 hours after the GRB trigger. On the picture 37 coadded images taken with 60s exposure each.

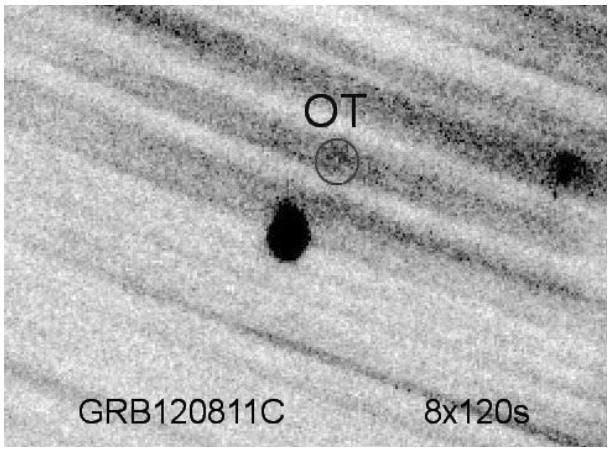

Figure 4: GRB 120811C. The observations started 34 min. after the GRB trigger with bad weather condition. On the picture 8 coadded unfiltered images taken with 120s exposure each. The afterglow was detected in the combined image with magnitude as 19.1 ± 0.3

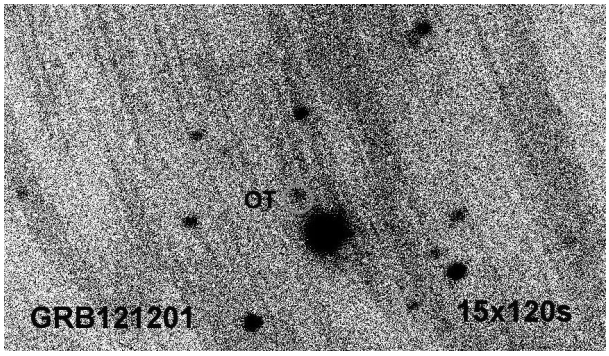

Figure 5**:** The GRB 121201A. The observations started 3 sec. after the GRB trigger. On the picture 15 coadded unfiltered images taken with 120s exposure each. The afterglow was detected in the combined image.

4. Conclusion

Multiwavelength observations (photometry, spectroscopy, polarimetry) are ideal to better understand the GRB diversity. As on Oct. 1 2013, the number of GRBs followed-up at the BOOTES-4 stations is 38, with 6 optical counterpart detections and 32 upper limits reported (the rest being too crowd fields or unusable due to dew, low airmass, unfocused images,...), altogether leading to 4 publications.

Installing the remaining BOOTES stations will help in continuous monitoring for some celestial sources, building more precise light curve for the targets. More detailed information about the BOOTES network can be seen in *http://bootes.iaa.es*.