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Research Article

Four Years of Real-Time GRB Followup by BOOTES-1B (2005–2008)

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Four years of BOOTES-1B GRB follow-up history are summarised for the first time in the form of a table. The successfully followed events are described case by case. Further, the data are used to show the GRB trigger rate in Spain on a per-year basis, resulting in an estimate of 18 triggers and about 51 hours of telescope time per year for real-time triggers. These numbers grow to about 22 triggers and 77 hours per year if we include also the GRBs observable within 2 hours after the trigger.

1. Introduction

BOOTES-1B (see also [1, 2]) is an independent robotic observatory with a 30 cm aperture telescope dedicated primarily to followup of gamma-ray burst (GRBs). Since 2003, it has used RTS2 [3] as an observing system. It is located at the atmospheric sounding station (Estación de Sondeos Atmosféricos—ESAt, INTA) of El Arenosillo in Andaluca, Spain (at lat: 37°06′16′′ N, long: 06°43′58′′W). A nearby, older dome (BOOTES-1A) is used for complementary wider angle instruments (Figure 2).

We present results of our GRB follow-up programme. In a large table, we show a 4-year long follow-up log of BOOTES-1B GRBs—including all triggers available in real time which were or should have been received and processed by the system. This selected sample of GRBs is then used to provide a basic idea of how much time is needed at the telescope to observe GRB optical afterglows.

2. Robotic Telescope Configuration

The telescope is built mostly from commercially available components—a Paramount ME from Software Bisque and a D = 30 cm Schmidt-Cassegrain optical tube assembly from Meade. Over time, four distinct system configurations were used, including also two 8-inch S-C telescopes (Figure 1).

2.1. Original Meade—Stereoscopic System. The original BOOTES project idea of a new generation of robotic telescopes was very simple, BOOTES-1B would—simultaneous with an identical setup at BOOTES-2 for parallax ability—look for optical transients in an extended area of the sky with wide field cameras. Both systems would use a commercial 12-inch Meade LX-200 "robot." The wide-field cameras were considered a primary instrument, while the ability to followup with a large telescope was an option. Between 1998 and 2002 the wide-field system provided simultaneous

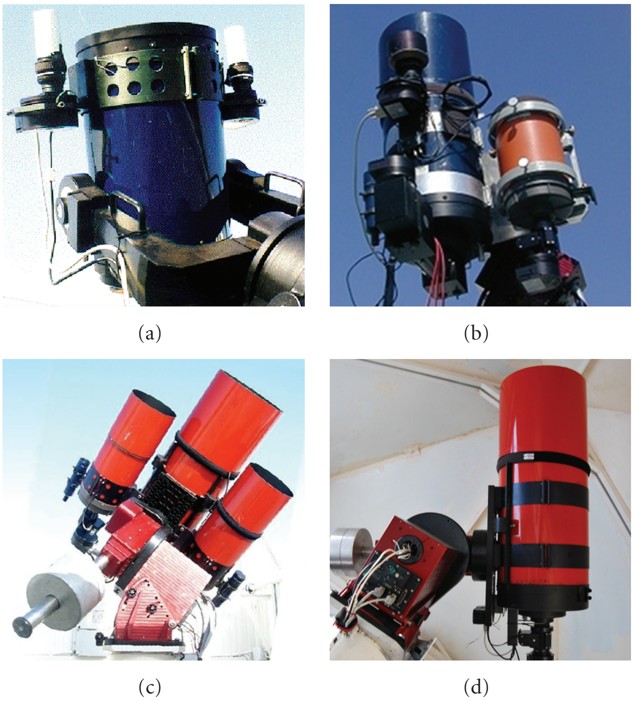


Figure 1: Four historic BOOTES-1B configurations.

Figure 2: The building of ESAt with domes of BOOTES-1A and BOOTES-1B (2002).

limits for several *CGRO*/BATSE and *BeppoSAX* GRBs, most notably the candidate afterglow for the short GRB 000313 [4]. The 30 cm telescope was successfully used to followup GRB 030329.

Although we made the original system able to observe, it kept having problems. It required an operator presence several times per week and, despite a notable effort, the fork mount's electronics had to be exchanged several times. Because of that, we decided to purchase another mount.

2.2. The Prototype. The new incarnation of BOOTES-1B was in preparation since mid-2002, and the first prototype was put together in November 2002 in order to follow-up *INTEGRAL* bursts. The most important change was the mount to be used—the Paramount ME from Software Bisque. The system was still carrying a wide field camera, but a shift had been made in priorities—the wide field camera performed monitoring of satellite field of view and the telescope pointed when a trigger was received. The early stage was, however, plagued with technical and organizational problems which eventually delayed the first real-time real-GRB follow-up until early 2005.

The prototype carried three instruments on a large aluminium base plate: the 30 cm telescope with a field spectrograph [5] plus an SBIG-ST8 camera, the 20 cm Meade (originally BOOTES-1A) telescope with an SBIG-ST9 camera observing in a fixed V-band filter, and an unfiltered wide-field 18 mm/1 : 2.8 with an SBIG ST-8 CCD ($43^\circ \times 29^\circ$).

BOOTES-1B was operating with this setup for about a year—on June 2004, it was dismounted and sent to the Workshop in Ondřejov for a definitive solution.

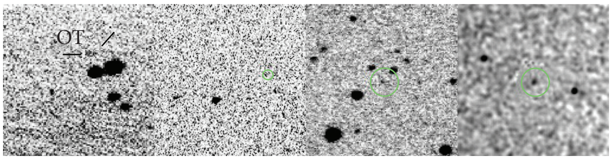
2.3. Triple Telescope. The prototype was very heavy and from the beginning had some problems. In September 2004 BOOTES-1B finally received an upgrade—together with the 30 cm telescope, there were also two 20 cm telescopes(One of them lent personally by AJCT) for direct imaging in different filters. The system was completely redesigned with many mechanical improvements and was built to be as light as possible to allow the mount working at its maximum slewing speed. In belief that the rapid dissemination and fast followup after the launch of *Swift* would lead into relatively frequent detections of bright optical counterparts, the 30 cm telescope was equipped with a field spectrograph and two 20 cm telescopes with fixed V&I-band filters. The limiting magnitude of all three instruments was $V \sim 16$ for a 60-second exposure. The wide-field cameras were moved from BOOTES-1B to BOOTES-1A.

Later, during the telescope operation, it became clear that the GRB optical transients were not as bright as had been expected and so the spectrograph on the 30 cm telescope was replaced with a direct imaging CCD with R-band filter—improving the limiting magnitude but losing the spectroscopic ability.

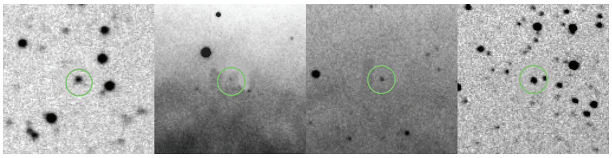
On April 23, 2006, The ESAt building was struck by lightning during a storm, destroying a major part of BOOTES-1B electronics. It took more than a year to get BOOTES-1B definitively back online.

2.4. Single 30 cm Telescope. During the lengthy reconstruction of BOOTES-1B, the follow-up strategy was reconsidered: in the interest of detecting more optical transients, the filter(s) were abandoned ($\sim 2.5\times$ or 1 magnitude gain in sensitivity). The limiting magnitude of an unfiltered 120 s exposure would be about 18.0—effectively doubling the likelihood of getting an optical transient in comparison with the R-band imaging (cf. Figure 4). Both 20 cm telescopes were dropped because of lack of suitable CCD cameras available for them. Since then, BOOTES-1B has only a single 30 cm telescope.

Any observations obtained after June 15, 2007 have been obtained without filter (W for white). We calibrate them against R-band, which, in the case of no color evolution of the optical counterpart, is expected to result in a small constant offset in magnitude.



(a)



(b)

Figure 3: GRB optical transient detections by BOOTES-1B: (a) GRB 050824, GRB 050922C, GRB 051109A, GRB 080330. (b) GRB 080413B, GRB 080430, GRB 080602B, GRB 080605.

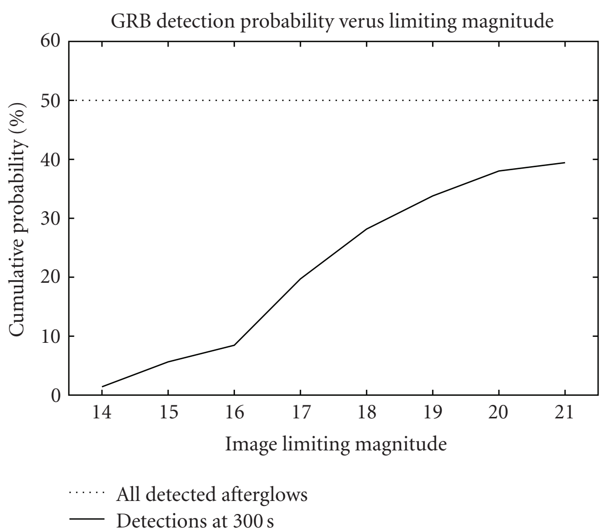


Figure 4: The graph (based on T_{300} data from Table 3) showing the likelihood of detection of an optical afterglow of a GRB as a function of the magnitude the telescope can detect (in the time interval discussed here). The dotted line delimits 50%—the ratio of GRBs in our data for which there was eventually discovered an optical transient.

3. Real-Time GRB Followup

BOOTES-1B could have received during the past 4 years (since January 2005 until December 2008) 86 GRB triggers via GCN, which could have been followed in real time or would become observable within the following two hours. Table 3 summarizes these triggers, noting, among BOOTES-1B status of the followup, also the brightness of the GRB optical counterpart if it is known. The magnitude estimation search was done with a heavy use of GRBlog [6]. Successful followups are summarized in Table 1, the detected optical transients also in Figure 3. We use these data to construct a "limiting magnitude versus likelihood of detection" graph (Figure 4).

3.1. GRB Triggers Followed by BOOTES-1B

(a) GRB 050215B. GRB was discovered by *Swift*/BAT at 02:33:43.2 UT. BOOTES received the notice, but because of a software error waited with the slew until ~22 minutes after the GRB. We coadded 600 s exposures taken by both 20 cm telescopes to obtain limits of $V > 16.5$ and $I > 15.0$ [7].

(b) GRB 050505. First image of this *Swift*-discovered GRB [8] was obtained at 23:32:30 UT, that is, 609 s after the trigger and 70 s after receiving the coordinates. No optical afterglow was detected [9].

(c) GRB 050509A. At the time of this trigger, the dome was still operating independently on the rest of the system; we obtained the first image 23 s after the GRB trigger (6 s after receiving the alert). The dome was closed due to what we consider a false trigger on the rain sensor. The first useful 10 s exposure was obtained 63.8 minutes after the burst and has a limiting magnitude of $V > 14.9$. A coadd of first 112×10 s exposures with an exposure mean time of 88.0 minutes after the GRB has a limit of $V > 18.1$.

(d) GRB 050509B. This was a *Swift*-detected short gamma-ray burst [10]. Starting 62 s after the trigger, BOOTES-1B seems to have obtained the world-first data set of this short duration GRB. However, bad luck caused that the location of the GRB on the sky coincided with the tip of a nearby antenna and its signalling light. The limiting magnitude is thus seriously degraded. The first 10-second exposure has a limiting magnitude of $V > 11.5$; a combination of the first 12×10 s exposures provides $V > 12.5$.

(e) GRB 050525A. GRB 050525A [11] was the first BOOTES-1B burst for which a detection was obtained. The telescope started the first exposure 383 s after the GRB trigger (28 s after receiving the notice). An optical afterglow with $V \simeq 15.0$ was detected.

(f) GRB 050528. We observed the errorbox [12] at 04:07:56 UT, that is, starting 71 s after the burst and 28 s after receiving the trigger in a light twilight, setting the limit to the possible GRB counterpart to $V > 13.8$ and $I > 13.0$ during the first 60 s after the beginning of our observation [13].

(g) GRB 050730. Located at 19:58:23 UT, this GRB was very low above horizon in real time; BOOTES-1B obtained few exposures starting 233.4 s after the GRB, when the system failed. The images did not provide detection of the 17.0 mag optical transient discovered by both *Swift*/UVOT [14] and 1.5 m telescope at OSN [15].

(h) GRB 050805B. This short burst was localized by *Swift* at 20:41:26 UT; BOOTES obtained first images 62.2 s after the trigger (7.2 s after receiving the trigger). No optical transient was detected. The first 10-second exposure has a limiting magnitude of $R > 16$, a combination of first five images

(exposure mean time 118 s after the GRB) has a limit of $R > 17.0$.

(i) GRB 050824. The optical afterglow of this GRB was discovered with the 1.5 m telescope at Sierra Nevada [16, 17]. BOOTES-1B was, however, the first telescope to observe this optical transient, starting 636 s after the trigger with $R \simeq 17.5$. The weather was not stable and the focus not perfect, but BOOTES-1B worked as expected. Eventually, several hours of data were obtained.

(j) GRB050904. BOOTES-1B reacted to this GRB, starting 124 s after the trigger. There was a hot pixel close to the GRB location, which made us believe we might have a detection in the R-band, which was issued in the first BOOTES-1B circular. Later, the observation revised as a limit ($R > 18.2$) which was used to compute the record redshift of this GRB [18]. The I-band camera of the 20 cm telescope, unluckily, failed.

(k) GRB 050922C. This bright burst was detected by *Swift* /BAT at 19:55:50 UT. BOOTES was not very lucky; the weather on the station was bad. Instead of a limiting magnitude of ∼17.0 for a 30-second exposure, we got 12.9. The afterglow was eventually detected with the R-band camera (at the 30 cm telescope) on few occasions between flying clouds. The first weak detection was obtained 228 s after the GRB trigger gave $R \simeq 14.5$.

(l) GRB 051109A. This is the only GRB ever detected by BOOTES-1B simultaneously in more than one filter. The first images were obtained 54.8 s after the burst in R and I bands [19].

(m) GRB 051211B. Observation of this burst started 42 s after the burst. A 30-second R-band exposure was obtained, but the camera failed after getting this image. Only useless defocused I-band images were taken with the 20 cm telescope [20].

(n) GRB 051221B. This GRB was detected by *Swift*/BAT at 20:06:48 UT [21]. BOOTES-1B slewed to the position and started obtaining images 27.8 s after receiving the alert (234.8 s after the burst). We did not find any new source in our images [22]. 30 minutes after the trigger, a faint 21 magnitude afterglow was discovered elsewhere [23].

(o) GRB 060421. BOOTES-1B reacted to this GRB within 61 s after the trigger. Images were not of a great quality, yielding a limit of $R > 14$ for the first 10-second exposure and $R > 16$ for the combination of 30 images (exposure mean time was 547 s after the trigger).

(p) GRB 061110B. The GRB was detected by *Swift*/BAT at $T_0 = 21{:}58{:}45$ UT, but the notices were delayed by 626 s because *Swift* was performing downlink. BOOTES-1B started to slew immediately after reception of the trigger, obtaining the first image 698 s after the burst (72 s after the GCN notice). When seven 60-second exposures were obtained, a communication error with the mount occurred. The communication was later restored and further 19 images were obtained starting 22:49:49 UT (0.85 hour after burst). Last image was obtained at 23:36:20 (1.62 hours after burst).

Combination of the first 7 images (limiting magnitude ∼17.2 mag each) with the exposure mean time of 938 s after the GRB trigger was found to have a magnitude limit of ∼ 18.0. Combination of 11 images obtained between 22:49:49 UT and 23:03:45 UT (lim∼16.9 mag each) yields a limit of ∼18.2 with mean time T_0+ 3452 s.

(q) GRB 071101. In the process of reconstruction, the 30cm telescope from BOOTES-1B was re-installed at the BOOTES-2 site in La Mayora (Málaga). This GRB was the first event successfully observed by the repaired telescope at this site. The GRB trigger [24] was at 17:53:46 UT. BOOTES started imaging 54.8 s after the burst (23.3 s after receiving the coordinates). No afterglow was detected, an unfiltered, R-band calibrated limit of $W > 17.0$ was estimated [25].

(r) GRB 071109. INTEGRAL detected this GRB at 20:36:05 UT [26]. BOOTES followed up 58.5 s after the GRB (30.9 s after receiving the alert). Because of high altitude clouds, the telescope performance was reduced, yielding an unfiltered limit of ∼13.0 in the first 10 s exposure [27].

(s) GRB 080330. This GRB [28] happened during the first day of recomissioning of BOOTES-1B after its move from BOOTES-2 site in La Mayora. The GCN client was not yet operational and at the time of the GRB we were focusing the telescope. First image was obtained 379 s after the GRB trigger and the optical afterglow was detected with magnitude ∼16.3 on the first image. A bug in the centering algorithm caused a loss of part subsequent data. Further detections were obtained starting 21 minutes after the GRB when the problem was fixed.

(t) GRB 080413A. BOOTES-1B started obtaining images of the GRB 080413A [29] starting 60.7 s after the trigger (46.3 s after reception of the alert). A $W \simeq 13.3$ magnitude optical afterglow was found [30].

(u) GRB 080430. BOOTES-1B obtained the first image of this GRB [31] 34.4 s after the trigger. An optical transient was found with a magnitude of $W \simeq 15.5$ [32].

(v) GRB 080603B. This GRB happened at BOOTES-1 site during sunset. We obtained first useful images starting one hour after the trigger. An $W \simeq 17.4$ optical transient was found.

(w) GRB 080605. GRB 080605 was observed starting 41.9 s after the trigger. A rapidly decaying optical afterglow with $W \simeq 14.8$ was found [33].

(x) GRB 081003B. *INTEGRAL* detected this GRB at 20:36:05 UT [34]. BOOTES started obtaining unfiltered images at 20:48:49 UT (41 s after the GRB trigger and 17.4 s after the GCN notice); single images have a detection limit of $W > 14$ mag. The combination of the first 32 images with an exposure mean time of 80 s after the GRB has a limit of $W > 17.6$ mag (calibrated against GSC2). Neither shows any new sources within the GRB errorbox [35].

4. Implications

4.1. Success Rate. Of the 89 triggers, 45 were processed in realtime and observed if possible; in 44 cases the system could not respond. This makes the overall failure rate quite high (50%). 29 triggers were, however, lost due to long-term failures resulting from the telescope being struck by lightning. 8 more triggers failed during the first 6 months of operation, when the system was not yet fully stable and one was lost during maintenance (and followed manually). 6 triggers out of 47 (13%) were lost unexpectedly during the 963 nights of telescope operation if we do not count the first semester of 2005.

4.2. Planning. When specifying the GRB follow-up needs, the number of nights (hours) spent observing GRBs has to be estimated. Under various follow-up strategies, we may derive different results.

Due to various instrumental effects (like a passage through the South Atlantic Anomaly) related to the satellite *Swift*, an offset from the overall triggering statistic which would depend on a geographical location could be found.

In Table 3, the fourth column has the time in hours until the first set of the event location below 10° of altitude or until the Sun rises above—15° of altitude. For nonrealtime events, this is the time the location spends on the night sky; for real-time triggers, it is the time between the trigger and the moment when the target becomes unobservable.

For a small telescope, we assume that once the GRB is real-time triggered, it is unlikely to detect it the following night (i.e., after ∼24 hours); so we assume the following simple follow-up strategy: Let the telescope observe the GRB once it becomes accessible for the first time (which is immediately for real-time triggers) and let it observe until the GRB sets or the night ends. Do not observe any further nights. Under the given assumptions, we get the following observing needs (assuming perfect weather).

(y) Real-time triggers. There have been 72 real-time triggers during the studied 4 years; during their first nights they accumulated 202 hours.

So if we allow only real-time followable triggers to be observed, we would need ∼18 triggers per year (once per 20 days) and on average 2.8 hours (max. 8.0 hours) of observing time per trigger, 50.5 hours per year. Such a program would consume about 2% of the telescope time.

(z) Extended set. In the extended set, we assume that GRBs that would become observable within 2 hours after the event would also be followed. We would need ∼22 triggers per year, each with an average length of 3.5 hours. In total we would need 78.5 hours per year, or about 3% of the telescope time. Summary of the triggering statistic cf. Table 2.

Table 1: Summary of GRBs successfully followed by BOOTES-1B.

GRB	$T_{obs} - T_{trigger}$	$T_{obs} - T_{notice}$	mag
050215B	22 min		$V > 16.5, I > 15.0$
050505	609 s	70 s	$V > 14.0$
050509A	63.8 min		$V > 18.1$
050509B	62 s	48 s	$V > 12.5$
050525A	383 s	28 s	$V \simeq 15.0$
050528	71 s	28 s	$V > 13.8, I > 13.0$
050730	233 s	172 s	$R > 16$
050824	636 s	55.8 s	$R \simeq 17.5$
050805B	62 s	17 s	$R > 16.0$
050904	124 s	43 s	$R > 18.2$
050922C	228 s	62.3 s	$R \simeq 14.5$
051109A	54.8 s	27 s	$R \simeq 16.2$
051211B	42 s	48.4 s	$I > 14.0$
051221B	234.8 s	27.8 s	$V > 13.3$
060421	61.2 s	47.6 s	$R > 16.0$
061110B	698 s	72 s	$R > 18.0$
071101	54.8 s	23.3 s	$W > 17.0$
071109	58.5 s	30.9 s	$W > 13.0$
080330	379 s		$W \simeq 16.3$
080413A	60.7 s	46.3 s	$W \simeq 13.3$
080430	34.4 s	22.1 s	$W \simeq 15.5$
080603B	60 min		$W \simeq 17.4$
080605	41.9 s	29.3 s	$W \simeq 14.8$
081003	41 s	17.4 s	$W > 14.8$

Table 2: Results of the GRB-planning statistic.

	Real time only	Up to 2 hours
triggers/year	18	22
hours/year	50.5	78.5
hours/trigger	2.8	3.5
days/trigger	20.3	16.6

4.3. Optical Afterglow Brightnesses. As a representative value of GRB optical transient brightness, important for real-time followup, we have chosen its magnitude at 300 s after the trigger. It turns out that it is not easy to find a uniform sample, and available magnitudes and limits are a mixture of different passbands, mainly V, R and unfiltered CCD magnitudes. For a general idea of how bright an OT could be this is, however, good enough. Figure 4 shows a cumulative probability of detecting an OT five minutes after the trigger with a telescope is able to detect a given magnitude. For many GRBs, the brightness at this early time is unknown, or only a limit from small telescopes has been established, so this curve is actually a slight underestimation.

TABLE 3: The Great Table of BOOTES-1B GRBs. "Target" is the RTS2 target number at BOOTES-1B. t_1 is the time delay between the GRB trigger and the possible start of observation. t_{obs} is the amount of time for which the GRB can be followed until it sets for the first time. m_{300} is the known brightness of the GRB optical transient 300 s after the event. dT is the delay of BOOTES-1B followup.

Object	Target	t_1[h]	t_{obs}[h]	m_{300}[mag]	dT	observation status
050128	—	+0.0	1.8	—	—	No link to GCN
050208	—	+0.0	4.2	—	—	No link to GCN
050215B	5064	+0.4	10.0	$\gtrsim 16^\dagger$ [36]	22 m	V, I limits [7]
050306	5075	+0.2	1.8	>16 [37]	86 s	w/roof closed
050416B	5109	+0.0	2.8	—	—	grbd failure
050421	5112	+0.0	0.2	>18.4 [38]	—	hw problems
050502A	—	+0.0	1.8	16.3 [39]	—	grbd failure
050505	5123	+0.0	2.2	—†	609 s	clouds, V, I limits
050509A	5129	+0.0	2.2	>18.2 [40]	23 s	hw problems, later limit
050509B	5130	+0.0	0.0	>20.8 [41]	62 s	OK, $V > 12.5$, antenna hit!
050520	—	+0.0	3.6	>16.6	—	GCN connection lost
050525A	5136	+0.0	3.6	14.7 [42]	383 s	OK, V-band lightcurve
050714A	1037	+0.0	3.6	—†	10 m	manually, later limit
050730	50008	+1.2	1.6	17.4 [14]	1 h 40 m	limits
050805B	50015	+0.2	7.2	—	62 s	Limits
050824	50032	+0.0	5.2	17.5 [17]	636 s	detection [17]
050904	50055	+0.0	2.8	—†	124 s	R-band limit [18]
050922C	50090	+0.0	6.2	15.5 [43]	228 s	detections between clouds
051109A	50126	+0.0	1.4	16.8	54.8 s	detection in R,I
051111	—	+0.0	4.6	14.9 [44]	—	GCN connection lost
051211A	50144	+0.0	3.2	—†	—	CCD failure
051211B	50146	+0.0	4.8	>14.0	50 s	OK, limits [20]
051221B	50151	+0.0	3.8	>18.2 [45]	235 s	OK, limits [22]
051227	50155	+1.6	10.6	>19.2 [46]	59 m	bad weather
060111A	50162	+0.0	2.0	>18.3 [47]	296 s	during maintenance, limit
060121	—	+0.0	7.8	—†	—	telescope OFF
060123	50171	+0.0	7.6	—	—	bad weather
060130	50173	+0.0	1.2	—	—	bad weather
060203	—	+0.0	6.2	—	—	bad weather+no GCN
060204C	—	+0.0	9.6	>18.7 [48]	—	bad weather+no GCN
060206	—	+0.0	1.4	16.5 [49]	—	GCN connection lost
060219	50185	+1.0	6.0	>18.6 [50]	—	bad weather
060319	50190	+0.0	4.4	$>19^\dagger$ [51]	—	bad weather
060418	50207	+0.0	1.4	14.2 [52]	—	bad weather
060421	50208	+0.0	3.8	>16.8 [53]	61.2 s	Limit
060424	—	+0.0	0.0	—†	—	hw failure
060502A	—	+0.0	1.0	18.7 [54]	—	hw failure
060507	—	+0.0	2.0	$>15.5^\dagger$ [55]	—	hw failure
060512	—	+0.0	4.6	17.15 [56]	—	hw failure
060515	—	+0.0	1.4	>16.2 [57]	—	hw failure
060522	—	+0.0	1.6	19.65 [58]	—	hw failure
060602A	—	+0.0	1.2	$>15^\dagger$ [59]	—	hw failure
060602B	—	+0.0	3.6	—	—	hw failure
060712	—	+0.2	3.0	>14.5 [60]	—	hw failure
060814	—	+0.0	0.8	>17.4 [61]	—	hw failure
060825	—	+0.0	1.4	>18.3 [62]	—	hw failure
060901	—	+1.6	5.2	—†	—	hw failure
060904A	—	+0.0	0.2	>19.5 [63]	—	hw failure
060904B	—	+0.0	2.2	~17 [64, 65]	—	hw failure

Table 3: Continued.

Object	Target	t_1 [h]	t_{obs} [h]	m_{300} [mag]	dT	observation status
060929	50212	+0.0	1.2	>17.0 [66]	—	bad weather
061019	50220	+0.0	1.0	>14.8† [67]	—	bad weather
061110B	50228	+0.0	2.2	> 17.8† [68]	11 m 38 s	>18.1 OK
061217	50240	+0.0	2.6	>19.2 [69]	—	mount failure
061218	50242	+0.0	2.0	>18.6 [70]	—	mount failure
061222B	50245	+0.0	0.6	18.0 [71]	—	mount failure
070103	50246	+0.0	2.8	>19.6 [72]	—	mount failure
070129	50253	+0.0	0.4	>19.2† [73]	—	mount failure
070219	—	+0.0	4.8	>20.0 [74]	—	mount failure
070220	50258	+0.0	1.2	>19.6 [75]	—	mount failure
070223	50259	+0.0	4.6	>21.4† [76]	—	mount failure
070224	50260	+1.4	8.0	>20.1† [77]	—	mount failure
070406	50277	+0.0	4.0	—	—	mount failure
070411	—	+0.0	3.2	~18.3 [78]	—	mount failure
070412	—	+0.0	3.2	>20.7 [79]	—	mount failure
070429A	50286	+1.6	1.0	>18.0 [80]	—	mount failure
070531	—	+0.0	1.4	>19.9 [81]	—	mount failure
070610	—	+0.4	6.2	~19 [82]	—	mount failure
070704	—	+1.4	6.2	>21.2 [83]	—	manually disabled
070714A	50010	+0.0	1.0	—†	52 s	bad weather
071025	50033	+0.0	0.4	17.3 [84]	—	bad weather
071101	50038	+1.0	10.6	>19.7 [85]	56 s	limit [25]
071109	50040	+0.0	1.0	>15.5 [86]	59 s	thick cirrus, limit [27]
071112C	50044	+0.4	11.0	17.5 [87]	64 s	bad weather
080320	50076	+0.0	0.6	>20 [88]	—	bad weather
080330	50079	+0.0	1.2	16.8 [89]	400 s	manual, detection
080413A	50082	+0.0	1.6	15.0	60.7 s	detection [29]
080430	50090	+0.8	7.4	17.5	34 s	detection [31, 32]
080517	50098	+0.0	2.4	>18.5 [90]	3 h 22 m	weather delay
080603B	50113	+1.6	6.4	16.5 [91]	1 h 15 m	detection
080605	50115	+0.0	3.8	17.9 [92]	43 s	detection [33]
080727C	—	+0.0	4.8	>19.9 [93]	—	dome failure
080903	—	+0.0	4.4	19.2 [94]	—	dome failure
081001	50159	+0.0	1.4	—	—	bad weather
081003B	50167	+0.0	3.6	>17.6 [35]	41 s	OK, limit [35]
081126	50181	+0.0	4.0	>18.0 [95]	—	bad weather
081128A	50184	+1.2	9.8	20.9 [96]	—	bad weather
081210	50188	+0.0	8.0	19.9 [97]	45 m	weather delay, out of focus
081228	50195	+0.0	2.0	19.8 [98]	—	bad weather
081230	50197	+0.0	3.2	19.1 [99]	—	bad weather

† denotes discovered optical counterparts where there are not enough data to estimate the brightness 300 s after the GRB.

For example BOOTES-1B, which could detect mag ~ 18 at an unfiltered 60 s exposure, may detect an OT in about one third of the GRB triggers.

5. Conclusions

We have shown in a small historical retrospective the evolution of the telescope of BOOTES-1B, as it developed from the wide-field survey telescope to a dedicated GRB follow-up telescope.

Four years of BOOTES-1B GRB follow-up history are summarised for the first time transparently in the form of a table, which includes not only the observation status of BOOTES-1B, but also the time for which the object could have been observed, and a magnitude (or a limit) of the GRB optical afterglow 5 minutes after the trigger found in the literature. Every existing GRB trigger which was, or could have been observed by BOOTES-1B within 2 hours after the trigger is included. Twenty four successfully followed events are described case by case in a separate chapter. Many of these are published for the first time.

The data collected are also used to show the GRB trigger rate in Spain. By simply counting the triggers and the days during which they were collected, we estimate 18 triggers and about 50.5 hours of telescope time per year for real-time triggers. These numbers grow to about 22 triggers and 78.5 hours per year if we include also the GRBs observable within 2 hours after the trigger. We also derive the likelihood of the optical afterglow detection five minutes after the GRB trigger depending on the limiting magnitude of the telescope.

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