Bootes 3: first two years of GRB follow-ups in New Zealand

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Abstract. BOOTES-3 is the first robotic observatory located in the southern hemisphere of the BOOTES (Burst Observer and Optical Transient Exploring System) network. It was inaugurated in February of 2009, beginning its operations promptly after. It's located nearby Blenheim, New Zealand.

The main scientific objective is observation and follow-up of the optical counterparts of GRBs (Gamma Ray Bursts), responding to an alert in a quick and completely autonomous manner. For this it is equipped with a high-speed pointing mount (6-10 seconds), and the whole observatory is controlled by the RTS-2 (Remote Telescope System 2) software. Being at Spain’s antipode, this observatory complements the coverage of the Spanish BOOTES telescopes.

Keywords: BOOTES – Robotic telescope – GRB – afterglow

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1. The Yock-Allen telescope

Inaugurated February 27, 2009, in New Zealand, Bootes-3 has provided the possibility to complement the visible sky of the Bootes network both in declination and in time, allowing the observation of events that happen during Spain’s daytime and objects too far south in Spain’s sky. Bootes-3’s observations have been used in 15 circulars in the GRB Circulars Network, and several peer reviewed papers, including the Nature paper on the GRB 090423 with \( \sim z = 8.2 \) (Tanvir et al. 2009).

Table 1. Bootes-3 response to GRBs in it’s field of view during good weather.

<table>
<thead>
<tr>
<th>GRB</th>
<th>Publication</th>
<th>T-GRB</th>
<th>Detecting spacecraft</th>
<th>magnitude</th>
<th>Comments</th>
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<tbody>
<tr>
<td>101011A</td>
<td>GCN 11343</td>
<td>23.76h</td>
<td>Swift</td>
<td>&gt;19</td>
<td></td>
</tr>
<tr>
<td>100904A</td>
<td>GCN 11217</td>
<td>5.98h</td>
<td>Swift</td>
<td>&gt;18</td>
<td>High airmass ( \sim 7 )</td>
</tr>
<tr>
<td>100518A</td>
<td>GCN 10778</td>
<td>2.47h</td>
<td>INTEGRAL</td>
<td>&gt;20.7</td>
<td></td>
</tr>
<tr>
<td>100331B</td>
<td>GCN 10566</td>
<td>19.2h</td>
<td>AGILE</td>
<td>&gt;18.5</td>
<td>Through cirrus</td>
</tr>
<tr>
<td>100331A</td>
<td>GCN 10557</td>
<td>6.7h</td>
<td>INTEGRAL</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>100316C</td>
<td>GCN 10497</td>
<td>49s</td>
<td>Swift</td>
<td>&gt;18.5</td>
<td>(4s from GCN)</td>
</tr>
<tr>
<td>091208B</td>
<td>GCN 10255</td>
<td>45s</td>
<td>Swift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>091111</td>
<td>GCN 10161</td>
<td>0</td>
<td>INTEGRAL</td>
<td>&gt;9.3</td>
<td>Contemporaneous</td>
</tr>
<tr>
<td>091109</td>
<td>GCN 10160</td>
<td>19.5h</td>
<td>INTEGRAL</td>
<td>&gt;19.6</td>
<td>Delayed by clouds</td>
</tr>
<tr>
<td>091103</td>
<td>GCN 10122</td>
<td>26s</td>
<td>Swift</td>
<td>19.07</td>
<td></td>
</tr>
<tr>
<td>091029</td>
<td>GCN 10104</td>
<td>6.9h</td>
<td>Swift</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>091018</td>
<td>GCN 10043</td>
<td>18.2h</td>
<td>Swift</td>
<td>20</td>
<td>(-5h of observations)</td>
</tr>
<tr>
<td>090423</td>
<td>Tanvir et al. 2009</td>
<td>31s</td>
<td>Swift</td>
<td>&gt;18.5</td>
<td>( z=8.2!! )</td>
</tr>
<tr>
<td>090404</td>
<td>GCN 9092</td>
<td>185s</td>
<td>Swift</td>
<td>&gt;15</td>
<td>High airmass</td>
</tr>
<tr>
<td>090328</td>
<td>GCN 9058</td>
<td>24.8h</td>
<td>Fermi</td>
<td>19.7</td>
<td>( z=1.5 )</td>
</tr>
</tbody>
</table>

This telescope has a very fast response time of a few seconds (Kubánek et al. 2004), the bulk of the delay being caused by the GCN network and poor weather conditions. Besides the follow up of GRBs, Bootes-3 has also provided observations for micro-lensing events, Nova Eris 2009 and other objects.

1.1 Telescope characteristics

Coordinates: S 41°29’28.72” E 173°50’21.03”
Altitude: 27 m.a.s.l.
Aperture: 60-cm
F.O.V.: 9.52’ x 9.52’
Spatial Resolution: 0.558”
Shutter speed: 10 f.p.s.
CCD model: Andor iXon X3 EMCCD 888
Mount model: Astelco NTM-500.
Slewing speed: 20 degrees per second.
Figure 1. Image from the all sky monitor at Bootes 3 station.

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References

Allen B., Yock P., de Ugarte Postigo A. et al., 2009, GCN Circ. 9058
de Ugarte Postigo A., Castro-Tirado A. J., Gorosabel J. et al., 2010, GCN Circ. 10778
de Ugarte Postigo A., Castro-Tirado A. J., Gorosabel J. et al., 2010, GCN Circ. 10566
de Ugarte Postigo A., Castro-Tirado A. J., Gorosabel J. et al., 2010, GCN Circ. 10557
de Ugarte Postigo A., Castro-Tirado A. J., Gorosabel J. et al., 2010, GCN Circ. 10255
de Ugarte Postigo A., Gorosabel J., Castro-Tirado A. J. et al., 2010, GCN Circ. 10161
de Ugarte Postigo A., Gorosabel J., D’Avanzo P. et al., 2010, GCN Circ. 10104
de Ugarte Postigo A., Jelinek M., Castro-Tirado A. J. et al., 2010, GCN Circ. 10222
Gorosabel J., de Ugarte Postigo A., Castro-Tirado A. J. et al., 2010, GCN Circ. 10160
Kubánek P., Jelinek M., French J. et al., Advanced software and control for astronomy, SPIE, 7019
Tello J. C., Jelinek M., Castro-Tirado A. J. et al., 2010, GCN Circ. 11343
Tello J. C., Gorosabel J., Castro-Tirado A. J. et al., 2010, GCN Circ. 11217
Yock P., Allen B., de Ugarte Postigo A. et al., 2009, GCN Circ. 9092