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BOOTES-3 STATUS

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RESUMEN

BOOTES-3 es el primer observatorio robótico ubicado en el hemisferio sur de la red BOOTES (Burst Observer and Optical Transient Exploring System). Fué inaugurado en febrero del 2009, y prontamente inició sus operaciones. Está ubicado cerca de Blenheim, Nueva Zelanda.
Su objetivo científico principal es la observación y seguimiento de las contrapartidas ópticas de los GRB (Estallidos de Rayos Gamma, por sus siglas en inglés), respondiendo a las alertas de manera rápida y completamente autónoma. Para esto está equipado con una montura de alta velocidad (6-10 segundos), y todo el observatorio está controlado por el software RTS-2 (Remote Telescope System 2).

ABSTRACT

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

Its 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.

Key Words: gamma-ray burst: general — instrumentation: detectors — instrumentation: miscellaneous — methods: observational — techniques: photometric — telescopes

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 has observed over 270 GRBs autonomously, and its observations have been used in 21 circulars in the GRB Circulars Network, and several peer reviewed papers, including the Nature paper on the GRB090423 with $\sim z$ 8.2.
. For a more detailed summary of the GRBs observed see Table 1.

This telescope has a very fast response time of a few seconds, 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 microlensing events, Nova Eris 2009 and other objects.

1.1. *Observatory's characteristics*

The observatory consists of two main instruments, a fast slewing telescope and an all-sky camera.
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
Filter set: Sloan: g',r',i'; UKIRT: Z,Y; Johnson: B; Dark and Clear.
Mount model: Astelco NTM-500.
Slewing speed: 20 degrees per second.

The All-sky camera takes one picture every minute with a fisheye lens and allows to see events simultaneously as they happen and other events like meteors. It also provides a visual record of the en-

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TABLE 1: BOOTES-3 response to GRBs in it's field of view during favorable weather

GRB	Publication	T-GRB	magnitude	Comments
130508A	GCN 14609 (Tello et al. 2013)	94s	> 15	
130427A	In preparation	86s	10.7	10 seconds after GCN
130315A	GCN 14312 (Tello et al. 2013)	35m	> 16.5	
130313A	GCN 14299 (Tello et al. 2013)	27m	R>15 / >8.5 allsky(t=0)	manually observed
121117A	GCN 13968(Tello et al. 2012)	13m	>16	Limited by clouds
120612A	GCN 13358(Tello et al. 2012)	3.8h	>18	Limited by sunset
120521B		81s		Rmag 17 star in the XRT position, not variable.
120521A		103s		Unfocused
120422A		55.31s		Broken automatic focuser (broken bearings)
120118A	GCN 12851(Tello et al. 2012)	3.1h	18.6	
111117A		20s	–	Overexposed due to twilight
111005A			–	Delayed by bad weather
111020A	GCN 12462(Tello et al. 2011)	1.1h	>19.5	
101011A	GCN 11343(Tello et al. 2010)	23.76h	>19	
100904A	GCN 11217(Tello et al. 2010)	5.98h	>18	High airmass ~7
100518A	GCN 10778(de Ugarte Postigo et al. 2010)	2.47h	>20.7	
100331B	GCN 10566(de Ugarte Postigo et al. 2010)	19.2h	>18.5	Through cirrus
100331A	GCN 10557(de Ugarte Postigo et al. 2010)	6.7h	17.8	
100316C	GCN 10497(Jelinek et al. 2010)	49s	>18.5	(4s from GCN)
091208B	GCN 10255(de Ugarte Postigo et al. 2009)	45s		
091111	GCN 10161(de Ugarte Postigo et al. 2009)	0	>9.3	Contemporaneous
091109	GCN 10160(Gorosabel et al. 2009)	19.5h	>19.6	Delayed by clouds
091103	GCN 10122(de Ugarte Postigo et al. 2009)	26s	19.07	
091029	GCN 10104(de Ugarte Postigo et al. 2009) Filgas et al. (2012)	6.9h	18.5	
091018	GCN 10043(de Ugarte Postigo et al. 2009)	18.2h	20	∼5h of observations
090423	Tanvir et al. (2009)	31s	>18.5	z=8.2!!! Fastest pointing. No detection due to high z
090404	GCN 9092(Yock et al. 2009)	185s	>15	high airmass
090328	GCN 9058(Allen et al. 2009)	24.8h	19.7	z=1.5

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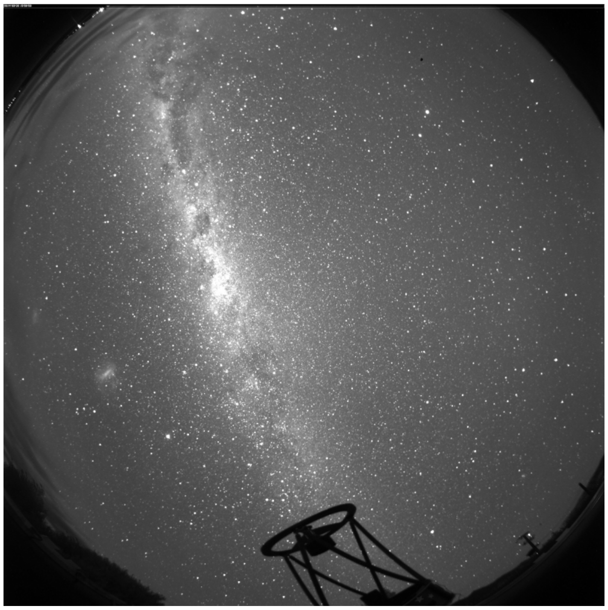

Fig. 1. Image taken with the all-sky camera at the BOOTES-3 Observatory

vironmental conditions. For an example image see Figure 1.1

The complete observatory is managed by the RTS-2 system (Kubánek et al. 2004) which can be controlled through a terminal accessible by SSH, or by a Web Interface currently in beta state of development. The weather conditions are autonomously determined by rain, wind, humidity and an IR cloud sensor by which the system determines when to open or close automatically.

2. TROUBLESHOOTING

One of the main benefits of attending a conference in instrumentation is the possibility to get to know the challenges other groups have encountered and most importantly, how they overcame them, and to avoid repeating mistakes or wasting time looking for solutions.

With that in mind, this work intends to briefly mention several issues the BOOTES-3 observatory has encountered and their resolution.

2.1. *Focuser*

Starting April 2012, our focuser, the Optec TCF-S3, broke some of its bearings. Replacement was sent by the manufacturer and when replaced the bearings were broken again. The complete focuser was shipped back to the manufacturer and it was determined that the shaft was misaligned. So a new focuser was sent in its place. This problem spanned 3 months.

2.2. *Dew*

The quality of the images was also deteriorated by dew frequently forming on the mirror. Two solutions were tested, a cloth tube to cover the telescope's length and a heating system for the mirror. However, the cloth acted as a sail with the wind and deteriorated pointing, and the heat jacket systematically worsened the focus possibly due to a rather thin mirror loosing its precise curvature.

So both solutions were discarded and the observatory is still vulnerable to the effects of dew.

2.3. *Mount*

The mount was a somewhat difficult problem to address since problem only arose sporadically and there was doubt on whether the problem was in RTS2, balancing or the mount itself. Sometimes it would start wobbling, stop tracking completely and in some cases it could not move from the parking position. After many tests it was finally fixed by the Tau-Tec people changing some motor parameters, and changing the parking position. However this last part was a kludge since the reason why certain parking positions are forbidden is unknown. Finally, there seems to be an RTS2 bug that clears errors by the hundreds per second which makes it difficult to diagnose the problems and is probably unsafe.

2.4. *Dome*

We came across the problem of the dome sporadically not closing one of the halves remotely, leaving the telescope exposed. To avoid damage to the telescope the operations have been halted and it has been decided to redesign it to include some counterweights to reduce the load on the motors.

As of writing these proceedings the problem was fixed by the addition of counterweights, and the closing and opening (or end of line) sensors also gave some issues. These will be replaced by non-mechanical parts.

3. FUTURE WORK

By the time these proceedings are prepared the autofocusing routine mentioned in the talk has been implemented successfully. It consists of a Python routine developed by Markus Wildi which should be included in the RTS2 SVN repository.

There are plans to dispose of the infrared cloud detector which requires constant calibration and will give false positives. This will be replaced by a star counting algorithm for weather-proof camera.

In the future we would also like to make the most of the telescope's time with new science. For example, the all sky images will be processed for autonomous detection of meteors and fireballs.

With the web-interface being implemented we also expect more microlensing events to be observed, as well as transits and other transients.

And with the integration to GLORIA network the telescope should be open for citizen science.

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