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THE BOOTES-5 TELESCOPE AT SAN PEDRO MARTIR NATIONAL ASTRONOMICAL OBSERVATORY, MEXICO

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RESUMEN

BOOTES-5 es el quinto observatorio robótico de la red internacional de telescopios robóticos BOOTES (Burst Observer and Optical Transient Exploring System). Se encuentra ubicado en el Observatorio Astronómico Nacional en la sierra de San Pedro Mártir, Baja California, México. Fue inaugurado el 26 de noviembre de 2015 y se encuentra en proceso de prueba. Su principal objetivo científico es la observación y seguimiento a la brevedad posible de las contrapartes ópticas de los estallidos de rayos gama que han sido detectados desde el espacio o por otros observatorios terrestres. BOOTES-5 was named Javier Gorosabel Telescope (JGT) after Spanish astronomer Javier Gorosabel Urkia.

ABSTRACT

BOOTES-5 is the fifth robotic observatory of the international network of robotic telescopes BOOTES (Burst Observer and Optical Transient Exploring Optical System). It is located at the National Astronomical Observatory at Sierra San Pedro Martir, Baja California, Mexico. It was dedicated on November 26, 2015 and it is in the process of testing. Its main scientific objective is the observation and monitoring of the optic counterparts of gamma–ray bursts as quickly as possible once they have been detected from space or other ground–based observatories. BOOTES-5 fue nombrado Telescopio Javier Gorosabel en memoria del astrónomo español Javier Gorosabel Urkia.

Key Words: gamma rays: general — instrumentation: miscellaneous — methods: observational — telescopes

1. INTRODUCTION

The robotic telescope BOOTES-5 is the fifth telescope of the international network of robotic telescopes BOOTES for observing transient events of astronomical sources that are observed as soon as possible after they are detected by other terrestrial and space instruments (Castro-Tirado et al 2013). The BOOTES network provides automated real–time observation to detect transients such as gamma ray bursts events as well as scheduled observations. These telescopes can make an independent monitoring of the sky for the discovery of comets, meteors, asteroids, variable stars and supernovae, among others.

The BOOTES-5 project is a collaboration between the Institute of Astronomy of the National Autonomous University of Mexico (UNAM), the Institute of Astrophysics of Andalusia, and the Sungkyunkwan University in South Korea to install a completely robotic optical telescope of 60 cm in diameter at the Mexican National Astronomical Observatory at San Pedro Martir, Baja California, Mexico (OAN-SPM). BOOTES-5 opens the opportunity to make continuous observations using a coordinated operation of the telescopes network in the northern hemisphere (Hiriart 2014): BOOTES-2 in Spain, BOOTES-4 in China, and BOOTES-5 in Mexico. The BOOTES-5 observatory was unveiled and dedicated in the San Pedro Martir Observatory on November 26, 2015. BOOTES-5 was given the name Javier Gorosabel Telescope (JGT) in memory of the Spanish astronomer Javier Gorosabel Urkia.

2. OBSERVATORY'S CHARACTERISTICS

The BOOTES-5 observatory consists of the following components: a fast slewing telescope with a fast optical camera and filters; two all-sky cameras;

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Fig. 1. BOOTES-5 telescope building location at the OAN-SPM. The yellow line shows the access road to the BOOTES-5 building from the main road. Underground power lines and optic fiber follows the access road.

interior and exterior monitoring cameras; weather station; telecommunication and control computers.

Coordinates: 31 02 39 N 115 27 49 W
Altitude: 2860 meters over mean sea level
Aperture: 60 cm @ f/8
F.O.V.: 10×10 arc-min
Spatial Resolution: 0.59 arc-sec/pixel
Shutter speed: 10 frames/s.
CCD Model: Andor iXon X3 EMCCD 888 (1024 × 1024 pixels)
Filter set: g',r',i',Z,Y
Mount model: Astelco NTM-500 Mount
Maximum slewing speed: 20 degrees per second.

There are two all–sky cameras: one inside the telescope room and an exterior one. They take images every minute through a fish–eye lens. The images of these all-sky cameras are used to asses the night–sky conditions. It may also be used to detect other events such as meteors.

The observatory system is managed by RTS2, the second version of the *Remote Telescope System* software (Kubánek 2010; Kubánek et al. 2004) which can be controlled through a terminal accessible by SSH, or by a Web Interface. The weather conditions are automatically determined by rain, wind, humidity from which the control system determines when to open or close automatically the dome.

2.1. *The Building*

The BOOTES-5 telescope enclosure is a two floor building constructed of metallic structure covered with sandwich panel. Access to the second floor is through stairs located at the East side of the building where the access door to the second floor is located.

The building walls are oriented at an angle close to the 45° from the prevailing wind direction that comes from SW (Michel et al. 2003).

The building has a dome that opens on the second floor that allows to the telescope to operate in open air condition. The dome has two halves. One of the halves overlaps the other. The overlapping halve is upwind from the prevailing wind direction.

Figure 1 shows the location of the telescope building at San Pedro Martir Observatory. The BOOTES-5 building is located 80 meters to the NW from the 2.1-m telescope building in a hill called, for historical reasons, the Caltech's hill. This hill is at least 60 meters above the surrounding ground level and allows to have an almost un-obstructed view of the horizon in 360 degrees. However, to the East the dome of the 2.1-m telescope building emerges 10 degrees above the horizon in a width of about 15 degrees.

Underground electric power lines and fiber optic cable were installed to the BOOTES–5 building to provide power and communication services from the 2.1–m telescope building. A total power of 75 KVA, 120 V, 60 Hz, triple phase is provided at the site. Inside the building there are four circuits: UPS-A, UPS-B, utilities, and lighting. UPS-A and UPS-B are single 3kVA UPS systems: the first one for telescope and dome, and the second one for computers and science instruments. Utility circuit include electric wall sockets. The lighting circuit is for illumination on the two floors. The building struc-

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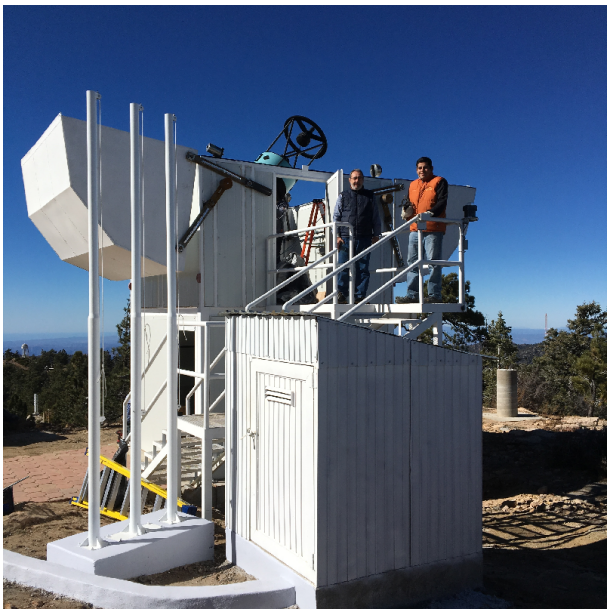

Fig. 2. East view of the BOOTES-5 astronomical station at OAN-SPM showing a fully–opened enclosure.

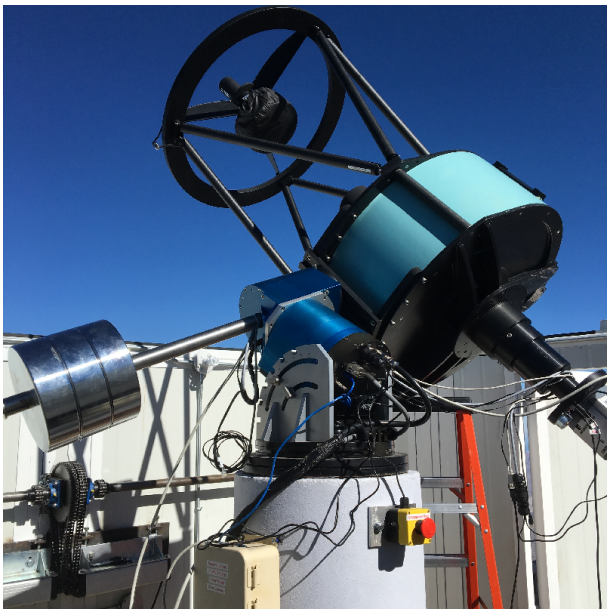

Fig. 3. BOOTES-5 telescope optical tube and mount at the second floor of the building. At the background, in the bottom left, can be seen part of the motors and gears to open the North half segment of the dome.

ture is electrically grounded. A lightning rod a few meters away from the building protects the building and equipment. Isolation of the electric power lines between the BOOTES-5 building and the 2.1–m telescope building is provided through isolation transformers. Lightning arrestors are located at both ends of the electric line.

Communication up to 1 GBps is available at the site through fiber optics. Inside the building wireless connection is provided for troubleshooting.

BOOTES–5 has its own weather station mounted on a metallic tower at 14m away from the building in the SW direction and above ∼6m above the ground. At this tower, an external camera pointing to the building is also mounted at the weather station mounting tower.

There are two all-sky cameras: one internal (located inside the dome) and one external (located at the stairs handrail). At the same handrail of the stairs a rain detector is located. This rain detector interfaces directly to the dome control unit to validate the open/closure status of the dome.

2.2. *The Dome*

The dome consists of two halves that open/close in clam shell fashion under the action of electric motors. The dome is located on the second floor, at 4.9m above ground level. The enclosure has a footprint of 3.3m×3.3m that holds the two dome halves. The two halves were especially designed to be completely open thus allowing the telescope to have access to any part of the sky as soon as possible. Figure 2 shows a view of the telescope building with a fully–opened dome.

BOTES-5 uses two electric motors in tandem configuration to open each leaf of the dome. Each motor has a torque of 450 N-m. Each leaf of the dome has a weight of about ∼100 kg and it is balanced by inside and outside counterweights.

The motors rotate each leave through a central axis located at North and South walls of the building. Motors can be activated manually or through automatic control with a computer.

2.3. *Telescope & Mount*

Figure 3 shows the BOOTES–5 telescope optical tube and mount at the OAN–SPM. The Astelco mount MNT-500 provides high-speed positioning, high–accuracy pointing, and below arc–second precision tracking. From the fabricant specifications, the mount can achieve speeds up to 30∘/s and accelerations up to 10° depending on the optic tube and equipment installed at it. The pointing accuracy is less than 5 arcmin without pointing model and less than 5 arcsec rms with pointing model. Tracking accuracies are less than 2 arcmin per hour without pointing model and less than 1 arcsec per hour with pointing model (Astelco 2014). The mount has air–pressure brakes. The control electronic interfaces is fully TCI2 complaint and optionally can use the TPL2 network interface.

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Fig. 4. BOOTES-5 Rack. From top to bottom are located: NTM-500 mount controller computer; server; backup server; keyboard and monitor (shutdown); UPS-A; UPS-B; and American–European voltage converter.

The mount operates in a temperature range between -20°C to +40° well appropriated for the temperatures registered at OAN–SPM (Michel et al. 2003). The power consumption is less than 400 W in all the telescope operation conditions. The control unit of the telescope mount is installed in the first floor of the telescope building protected from sun light, water, humidity, and temperatures below 0°C. The control units connects to the mount through a 10m cable set that rises to the second floor through the concrete pillar.

The BOOTES-5 telescope has a 60–cm aperture in Ritchey–Chretien design at f/8 beam. The telescope optic tube has an ultra-light carbon–fiber st Russ with an overall weight of about 70 kg that allows the telescope mount to achieve fast slewing speeds and accelerations to reach any part of the sky in less than 8 seconds.

2.4. *Control and communication equipment*

Computer and communication equipment is located in 24U metallic rack in the first floor of the building (see Figure 4). Telescope control units and dome units are powered by a UPS while a second UPS is used for the scientific and communication equipments. A voltage converter from American to European voltage is necessary to operate the NTM-500 mount control unit.

3. CONCLUSION

By the time these proceedings are prepared BOOTES-5 is being under test. Full operation of the telescope is expected by the first semester of 2016. BOOTES-5 opens the possibility of continuous monitoring of stellar objects using similar instruments at the astronomical stations of the network located in China and Spain.

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