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CONTINUOUS MONITORING USING BOOTES WORLDWIDE NETWORK

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RESUMEN

Se presentan los avances en la instalación del quinto telescopio de la red mundial de telescopios robóticos BOOTES. Este telescopio, denominado BOOTES–5, se instalará en el Observatorio Astronómico Nacional en la sierra San Pedro Mártir, en Baja California, México. La operación coordinada de este telescopio con los de la red BOOTES operando en China y España permitirá un monitoreo continuo de fuentes astronómicas.

ABSTRACT

It is presented the progress on the installation of the fifth telescope of the BOOTES worldwide network of robotic telescopes. The telescope, called BOOTES–5, is planned to be installed at Observatorio Astronómico Nacional at sierra San Pedro Mártir, Baja California, Mexico. Coordinated operation of this telescope with observatories of the BOOTES network operating already at China and Spain will allow to astronomers a continuous monitoring of astronomical targets.

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

1. INTRODUCTION

The Burst Observer and Optical Transient Exploring System (BOOTES) is an international network of astronomical robotic observatories with sites in Southern Spain, New Zealand, and China. These observatories have a 0.6–m diameter robotic telescopes with an EMCCD camera at their Cassegrain focus, and a set of filters (g', r', i', Z, and Y). The main goal of the network is to observe as quickly as possible transient events after they have been detected.

Specially, the BOOTES network provides an automated real time observing response to the detection of events of Gamma Ray Burst (GRB). It uses wide field cameras (WFC), ultra wide field cameras (UWFC), and narrow field cameras (NFC) attached to small robotic telescopes. To study GRBs, it is of the most importance to perform prompt optical follow up observations, after they are detected at high energies.

The scientific objectives of the BOOTES networks include:

- Simultaneous and quasi simultaneous observations of GRB.
- Detection of optical flashes.
- Continuous all–Sky monitoring down to 10th mag.
- Monitoring of different types of variable objects (galactic or extragalactic) down to 20th mag in order to search for optical variability.
- Discovery of comets, meteors, asteroids, variable stars, novae, and supernovae.

Recently, the Instituto de Astronomia from Universidad Nacional Autonoma de Mexico (IA-UNAM) has been invited to participate at the BOOTES network by installing a new BOOTES telescope at Observatorio Astronomico Nacional en la sierra de San Pedro Martir, Baja California, Mexico (OAN-SPM). This new telescope, BOOTES–5, will have a 0.6-m diameter telescope and a mount from ASTELCO company. It will have a Cassegrain focus with an IXON camera and a set of filters (R, g, r, Z, and Y).

2. CONTINUOUS OBSERVATION USING BOOTES NETWORK

Table 1 shows the locations of the BOOTES telescopes at the network including the new proposed site for BOOTES–5 at Mexico. All but one of the sites, BOOTES–3, are located at the northern hemisphere.

2.1. *Latitude of BOOTES Sites*

The latitude of the northern hemisphere sites of the BOOTES network is within +26.7 to +37.1 degrees. The average latitude of the BOOTES telescope international network for the northern hemisphere, including the planned BOOTES–5, is

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TABLE 1

BOOTES SITES

Site	Name	Lat	Long	Elev
BOOTES-1	El Arenosillo Spain	37.0995 N	6.73747 W	30
BOOTES-2	Estación Experimental de La Mayora, Spain	36.7569N	4.04273 W	50
BOOTES-3	Blenheim, New Zealand	41.4913S	173.8395E	500
BOOTES-4	Lijang, China	26.6952N	115.7879E	2690
BOOTES-5	San Pedro Mártir, México	31.0442N	115.4636W	2890

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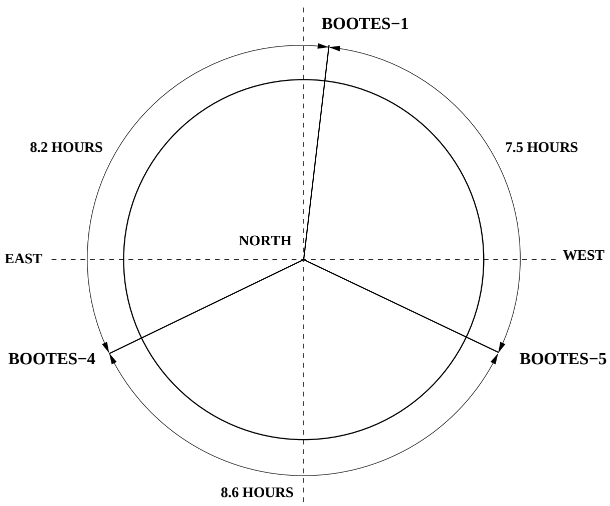

Fig. 1. Longitude separation between telescopes at the BOOTES–1, –4, & –5. The time separation between adjacent sites is shown.

(32.9±4.3) degrees. The closest site to this average latitude is BOOTES–5 that is away only 1.8 degrees. With a telescope that can reach the horizon, the declination of the sky covered by BOOTES–5 will go from -60.0 to 90.0 degrees. The rest of the northern telescopes will have almost the same coverage.

2.2. *Longitude of North BOOTES Sites*

Figure 1 shows the location of the sites of BOOTES–1, –4, and –5 as seen from the north pole. It can be notice the separation of between a pair of sites is about 8 hours. Therefore, is possible to make a continuous monitoring using the northern telescopes of the network if the darkness last for more than eight ours at each site.

2.3. *Night Length at the BOOTES Sites*

The length of a night varies along the year, and depends upon the latitude of a site. Because of the eccentricity of Earth's orbit, the sun is north of the equator for almost 4 days more than half the year. For this reason, the duration of the average night at a given latitude in the northern hemisphere is less than the length of the average night at the same latitude in the southern hemisphere by a few minutes. Nevertheless, for the given northern sites of the BOOTES network, a continuous monitoring will be possible if the length of the shortest night at each of the sites is longer than 8.6 hours, the time separation between the BOOTES–5 and BOOTES-4 sites.

Table 2 shows the longest and the shortest length of darkness for each of the northern sites of the BOOTES network. The table presents, the total time that the entire sun is below the horizon. These values were obtained from calculations from the US Naval Observatory[2]. The longest night for each site happens around the Winter solstice and the shortest during the Summer solstice. In any of the BOOTES places the shortest length of darkness is longer than the longest time separation between adjacent sites, so a continuous monitoring, if weather allows it, is possible.

3. SAN PEDRO MARTIR OBSERVATORY PRIMER

The Observatorio Astronómico Nacional of Mexico (OAN) was dedicated on 1878. It is one of the oldest scientific research institution in Mexico. In 1929, when the National University of Mexico got its autonomy (becoming the National Autonomous University of Mexico or UNAM), the OAN passed to be administrated by UNAM. On 1942 the OAN moved to the state of Puebla in central Mexico and finished its part on the *Cart du Ciel* international project. On 1970 OAN moved to San Pedro Martir sierra (hereafter OAN–SPM) looking for darker skies and better astronomical weather.

The OAN–SPM has three telescopes:

- 2.1–m telescope: operates for low– and median–resolution optical spectroscopy.

[2] http://aa.usno.navy.mil/data/docs/Dur_OneYear.php

TABLE 2

DURATION OF DARKNESS ON THE BOOTES SITES FOR 2014

Site	Longest Night [Hours]	Shortest Night [Hours]
BOOTES-1	14.4 (Dec. 16–27)	09.3 (June 18–24)
BOOTES-4	13.6 (Dec. 19–24)	10.2 (June 16–25)
BOOTES-5	13:9 (Dec. 16–27)	09.9 (June 15–27)

- 1.5–m telescope: robotic operation (RATIR) imaging in the near infrared and visible regions.
- 0.84–m telescope: Semi-robotic for broadband imaging and optical polarimetry.

3.1. *Astronomical Weather*

Since 2000, the OAN–SPM has hosted several site survey for different projects: Advanced Technology Solar Telescope (2001), Large Survey Synoptic Telescope (2003), Thirty Meter Telescope (2005), & Cherenkov Telescope Array (2012–to the present). All these surveys have settle down the astronomical weather characteristics of the site:

- Yearly average photometric nights: 60% (cloud cover <10%) 219 nights
- Yearly average spectroscopic nights: 82% (cloud cover<20%) 292 nights
- Mean seeing value: 0.67 arc-sec (IAUNAM Michel et al. 2003) 0.78 arc–sec (TMT survey Shöeck et al. 2009).Cross calibration to ESO–Robodimm, & TMT Site survey dimm (Núñez et al. 2007).
- Sky Brightness: sky: V=21.5 mag/arcsec^2, R=20.7 mag/arcsec^2. Bortle Scale = 4 Zodiacal light seen on best nights. Milky way shows much dark lane structure with beginnings of faint bulge into Ophiuchus. M33

3.2. *Human resources and Infrastructure*

Facilities at the OAN–SPM include guest house, machine shop, electronic lab, liquid nitrogen plant, an aluminizing chamber of 2.4–m, power generators, Internet radio link, etc.

Observatory staff at the site is available 24/7. Technical staff includes one electronic, one mechanic technician, and one optician (half time); two telescope operators. The support staff includes cooks, janitors, drivers, etc.

The Observatory is located at a National Park, so before applying for any construction permit we need to elaborate a study of environmental impact. The study has been made and we have now all the permits from the Mexican Environmental Agency to proceed with the construction of the telescope building. County permits for constructing the building have also been granted.

For a more detailed primer for the San Pedro Mártir Observatory see López & Gutiérrez (2003).

4. CONCLUSIONS

BOOTES–5 at San Pedro Martir Observatory (SPM) will be a key element for continuous observations of astronomical targets from the northern hemisphere using the BOOTES worldwide robotic telescope network.

The excellent astronomical weather SPM plus the technical support available at any time increases the possibility of continuous observing using the BOOTES worldwide network.

Construction and environmental permits have been granted for the installation of BOOTES–5 at SPM. The ASTELCO telescope mount, the control console, and the voltage converter are already at SPM. We expect to start construction as soon as possible or when weather permits it.

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