TRANSFORMATION OF THE BAKER-NUNN CAMERA OF SAN FERNANDO

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We present the transformation of a Baker-Nunn Camera (BNC) for remote and robotic use with a large format CCD, and its transfer to a new site located in Catalan Pyrenees. This project is a collaboration between the Fabra Observatory (Real Academia de Ciencias y Artes de Barcelona) and the Real Observatorio de la Armada de San Fernando (ROA). Once refurbished, the 50cm f/1 camera will have a useful FOV of 5ºx5º and will be controlled via Internet. This is not a restoration of an old astronomical facility but a completely innovative refiguring of the instrument. We will modify both its mechanics and optics and will set up a new unique facility in Catalonia operating in real robotic and remote mode. Once the BNC will be operating, our scientific project considers two kinds of observing programs: a systematic observing program (QDDS) and selective observing programs. The Quick Daily Sky Survey will operate by means of TDI (Time Delay Integration) CCD observation. It will be able to cover almost the entire northern sky in 4 or 5 nights up to V=20 producing up to 25 Gb/night of data. The other specific observing programs include the discovery and tracking of solar system objects (NEOs, PHAs, main belt asteroids, comets and TNOs), the detection of extra-solar planets, the detection of novae and supernovae, the quick localization of counterparts of GRBs, the detection of dangerous space debris and, in general, any program that could benefit of the large FOV and quick reaction of the camera.

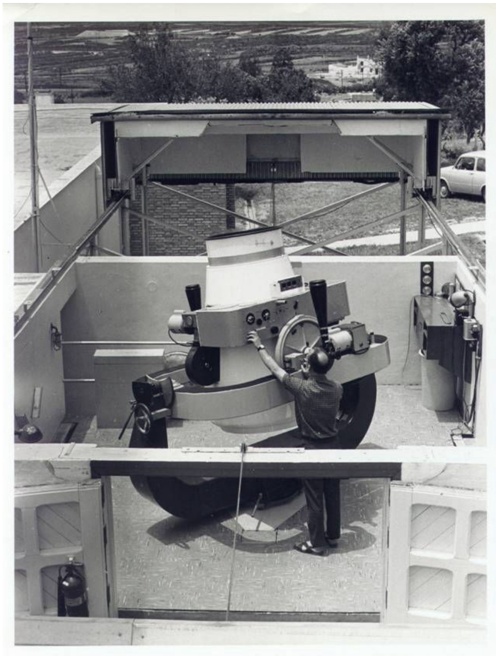
1. Introduction

The Automatic Wide Field Telescope (AWFT) project (Núñez et al., 2002) is a San Fernando-Fabra collaboration to enable a Baker-Nunn camera for remote and robotic CCD use.

The original Baker-Nunn cameras (BNC) were f/1, 50cm aperture modified Schmidt telescopes originally created by Smithsonian Institution (Henize, 1957) to photographically observe artificial satellites. The superb optical design of the camera achieved a fast response (f/1) yielding out extraordinary useful field of view (FOV) of 5ºx30º with a spot size inferior to 20 microns throughout the field. This turned BNC into an extraordinary instrument in spite of its manually altazimutal movement and the use of curved 55cm cinemascope film as detector.

One of the BNCs was installed at the Real Instituto de la Armada de San Fernando (ROA) during the 60s. Once the photographic observation of satellites was relegated, the camera was donated to ROA, where it has been maintained inactive but in excellent state of conservation. In order to transform this BNC to a proper remote and robotic use with a large format CCD, an extensive optical and mechanical transformation project

must be performed. It will operate as a quick reaction full robotic and stand alone facility observing in remote real time mode in order to follow the most appropriate scientific programs.
The experience of the ROA in the automatization of the Meridian Circles of La Palma (CAMC) and San Fernando (CMASF) operating from Argentina (Muiños et al., 2001) will guarantee the right performing of all the refurbishment stages. Besides, the nearly centenary experience of Fabra Observatory in high quality astrometic observations and the experience with the recent restoration and modernization of its own facilities ensure the right development of the project and the best scientific use of the transformed-BNC.



Figure(1). Baker-Nunn at ROA when it was still on active service.

2. Refurbishment project.

Through a simple optical modification for adapting the camera for the use with CCD, we will achieve an useful FOV of 5ºx5º. This provides us with a unique instrument to perform precise systematic observations of large sky areas in a reduced amount of time and to a relatively high limiting magnitude. Moreover, the camera and all other instruments involved in the observatory will be modified for operating as a totally automatic robotic and remote facility controlled via Internet.
The refurbishment project consists in the following phases:

- Mechanical modification and remote telescope control.

Conversion of original mount to equatorial, installation of new servo drive for RA and DEC axes, positional absolute encoders, multi-axe closed-loop controller and a GPS card must be implemented. These modifications are now being held at the military facilities in San Fernando.

- Optical modification.

CCD adaptation implementing a 4kx4k-9μm front-illuminated CCD with optional filters will be held. To maximize the useful FOV maintaining the low magnitude of aberrations we should modify certain optical parameters and add a field flattener 3-element corrector. A new precise optical design is currently being studied to achieve the best performance.

- Software adaptation for telescope control system.

Adaptation and/or creation of software appropriate for our specific instrument and operating mode for both telescope working and observatory control. Own telescope movement, guidance and pointing software is available to be adapted to the new requirements in San Fernando. Dome, weather station and other observatory parts controlled by software are chosen to work with known available TCS.

- Building and observatory elements transformation.

Remodeling of the building, including dome, weather station and microwave telemetry and data link system installation at the chosen site can be done only at summer time because of high mountain climate.

Nowadays, there are two similar projects involving BNCs transformations. One of them, the Australian Automated Patrol Telescope project (Carter et al.), has already accomplished successfully those objectives. The other, held at the Rothney Observatory (Canada) is currently in the late stages of refurbishment project.

Figure(2). Mechanical transformation of the Baker-Nunn camera is being held in San Fernando, where they have consolidated experience with astronomic instruments.

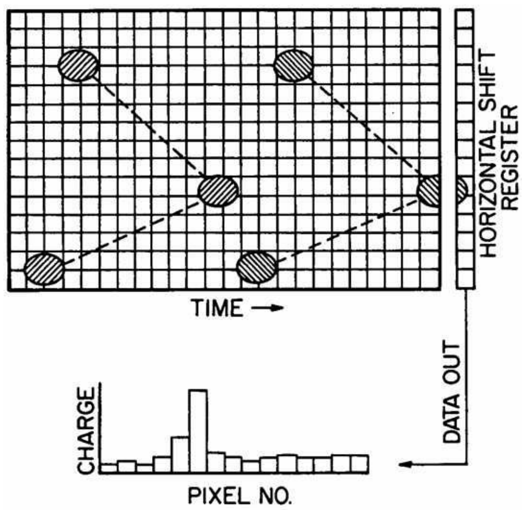
3. Scientific project

For such a fast response high FOV instrument we must consider two different kind of observing programs to be developed. First, an ingenious survey capable of optimize the BNC performance which has been chosen to be the Quick Daily Sky survey (QDSS). And besides, other specific observational programs of diverse nature related to different areas of astronomical and astrophysical interest.

Nevertheless, this division may not be always so clear since some specific programs could take advantage of the QDSS mode not only using its resulting data, but also enabling several real time data processing tasks and other possible interactions such as programmed automatic launch alarm systems.

3.1 Quick Daily Sky Survey (QDSS)

The systematic observing program would operate by means of TDI (Time Delay Integration) CCD observation. This scanning technique consists in covering sky areas following celestial meridians towards the pole while the CCD charge is transferred at the same rate that the telescope is slewed. With the planned modified BNC FOV, would be allowed to cover daily up to 25% of the sky between declinations -30<d<+70 up to more than V=20 mag.
Given the aperture of the BNC, a integration time of 2 minutes, the scale, and considering a CCD detector with moderate-high quantum efficiency (70%) offered by a typical commercial CCD camera, we estimate the limiting magnitude of the QDSS of at least V=20 mag. In this range there are many astronomical and astrophysical fields of research that could benefit from the obtained data.



Figure(3). Diagram of TDI operating mode. Once the CCD is oriented in N-S direction, the telescope moves covering sky areas following celestial meridians towards the pole while CCD charge is transferred at the same rate. TDI allows a wide coverage of declination with an improved magnitude limit (it depends on the readout rate chosen) with an easy synchrony to work.

3.2 Specific observing programs

Apart from the systematic programs as QDSS, BNC will be able to operate specific programs of diverse nature. Extraordinary large FOV and quick reaction in remote-robotic mode enables modified BNC to work in observational programs such as:

- Discovering and tracking of NEOs, PHAs, MBOs, comets, KBOs and TNOs.
  A complete census of these objects is demanding for accurate calibration of Earth-collision probabilities (NEOs, PHAs) and of present models of solar system origin, composition and evolution (MBOs, comets, KBOs, TNOs).
  Observation and tracking of comets and asteroids has been developed at Fabra and San Fernando Observatories for more than a century. BNC technical specifications will be ideal to enforce this activity since the extraordinary large

FOV besides the ability of working within a wide range of temporal resolution will greatly increase the probability of detection and discovery.

- Detection of extrasolar planets.
  Photometric transit technique applied over a large FOV is likely to bring positive detections since it greatly increases the number of measured stars and, consequently, the probability of spotting transit

- Detection and monitoring of optical transient events such as gamma ray bursts (GRBs), supernovae (SNs) and novae.
  Again, the BNC large FOV combined with its planned fast slewing response will permit to point the GRB afterglow few tens of seconds after satellite alarm has been given.

- General and temporal high-resolution CCD photometry in scanning mode.
  The use of the filters added to the modified BNC during scanning modes (both QDSS and non-QDSS scanning) will permit to cover large areas of sky within a wide range of time resolution in selected wavelength range.

- Discovery and tracking of space debris (0.1m-1m).
  A complete orbit catalog and tracking of these objects is demanding, since they can put in danger current or future space missions.

4. Data flow and processing

BNC operations will generate a large amount of data to be transmitted, processed and archived. The proper flow, processing, analysis, archiving and retrieval of such huge amount of data will be another challenge of this project. For instance, only QDSS data would produce up to 12 Gb/night.
Managing of this amount of data for real time remote operations require a fast data flow. In our project, it will be trough microwave technology from the high mountain top site chosen to the Catalan universities fast speed network.
Specifically, the processing and following use of the data would go through the following steps:

1. Immediate and in situ processing.
   Basic image handling, automatic search for minor bodies (NEOs, MBOs, TNOs,..), supernovae (SNs), novae, gamma-ray bursts (GRBs), extrasolar planets… or programmed automatic launch alarm systems.
2. Short term processing.
   Includes not only data transfer, storing and archiving and the usual knowledge discovery through traditional data processing, but also other more sophisticated digital processing techniques of reconstruction, fusion,…
3. Mid and long term processing.
   Besides the storage of raw data, all the developed data should be passing through an efficient image compression system and be available in some kind of permanent archiving with access from some international astronomical databases coordinated group.

5. Site

In order to take advantage of the BNC specifications, this should be moved to a site with very good astronomical conditions. The definitive site is still under study but probably it will be at Catalan Pyrenees.

6. Conclusions

Automatic Wide Field Telescope (AWFT) has been presented and described as the project of transformation a BNC into a fast high FOV remote and robotic CCD stand-alone facility operated through internet, its placement at a new location and the following use of the instrument for scientific purposes.
Finally, we must remark that this project does not have a character of restoration of an old facility to equip it with the new instrumentation, but it consists in a completely innovative refiguring of the instrument for achieving such special specifications for a successful developing of the relevant scientific tasks described.

7. Acknowledgements

Partial funding provided by grants AyA2001-3092, AyA2001-4114-E and AyA2002-11251-E from the Spanish ministry of Science and Technology.

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