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The REM Telescope: A robotic multiwavelength facility to promptly follow up GRB afterglows(*)

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Summary. — The REM (Rapid Eye Mount) Telescope, located in la Silla Observatory Chile, is the first moderate (60 cm) aperture robotic telescope able to cover simultaneously both the visible and near-infrared (0.45–2.3 μm) wavelength range. The high-throughput Infrared Camera (REMIR) and the optical imaging spectrograph (ROSS), both equipping the REM telescope, are simultaneously fed by a dichroic and they allow to collect high-S/N data in an unprecedented large spectral range on a telescope of this size. The wide band covered, the very fast pointing capability (60 degrees in 5 seconds) and its full robotization make REM the ideal experiment for fast transients observation. The REM observatory is an example of a versatile and agile facility necessary to complement large telescopes in fields in which rapid response and/or target pre-screening are necessary. This paper describes the main characteristics and operation modes of the REM observatory and gives an overview of preliminary results obtained during the Science Verification Phase.

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PACS 95.55.Cs – Ground-based ultraviolet, optical and infrared telescopes.
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1. – Introduction

During the last decade, *Beppo*SAX observations of Gamma Ray Bursts (GRBs), and related observations by optical robotic Earth-based facilities, showed that a very fast reaction is the winning strategy to locate and study fast transient phenomena, such as GRBs [1, 2]. Following this strategy, new space-borne experiments, such as SWIFT, HETE II, INTEGRAL, AGILE, have been developed in the last years in order to be fully

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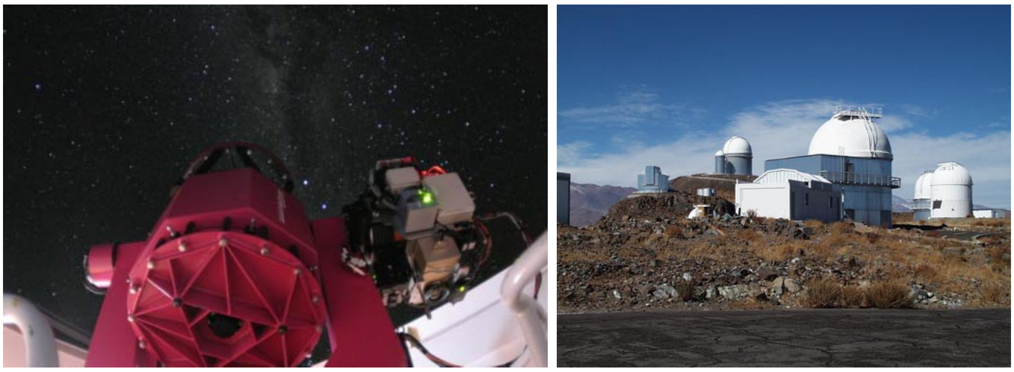

Fig. 1. – *Left panel:* The REM Telescope and instruments are pointing the sky. *Right panel:* The first building just in front is the "dome" hosting the REM Telescope. It is located at the ESO observatory of La Silla (Chile) ("Notre Dome de La Silla").

or partly dedicated to detect GRBs (or any other transient phenomena at high energies) and promptly distribute coordinates of the detected event. All these space experiments are offering now the unique opportunity to observe GRB afterglows since their very beginning when they are intrinsecally very bright and are potentially carrying out a lot of information about the physics of the burst, of the afterglow and the medium in which they go off. In such a new scenario, it has been of fundamental importance for the astronomical community to develop new automatic ground-based facilities in order to react to satellites triggers faster than a traditional "human operated" astronomical observatory. These facilities have to be versatile and agile in order to complement larger telescopes in fields in which rapid response and/or target pre-screening are necessary: a prompt detection and localization of a bright transient can also allow a prompt spectroscopic observation with a 8 m class telescope.

2. – The REM Telescope and instruments

REM (Rapid Eye Mount) is a fully robotic fast-slewing 60 cm telescope located in the ESO observatory of La Silla (Chile) (see fig. 1). The telescope has been designed to be high-speed and infrared optimized. For these reasons it has a Ritchey-Chretien configuration with a 60 cm f/2.2 primary and an overall f/8 focal ratio mounted in an alt-azimuth mount providing stable Nasmyth focal stations, suitable for fast motions. At the first focal station a dichroic, working at 45 degrees in the f/8 convergent beam splits the beam to feed the two instruments REMIR and ROSS. A view of instruments is given in fig. 2. REMIR camera is a fully cryogenic NIR (0.9–2.3 μm) camera [3, 4]. The camera has a focal reducer scheme in order to reform a white pupil in a cold environment for Lyot-stop positioning. REMIR is equipped with standard filters (z', J, H, Ks) a $H2$ narrow-band filter and a grism for slit-less spectroscopy. The camera has a plate-scale of 64.4 as/mm in order to position a $9.9' \times 9.9'$ FOV on a 512×512 (18 μm pitch) HgCdTe chip of the HAWAII series produced by Rockwell. The whole camera train is mounted in a dewar and operated in a cool environment. The chip working temperature is 77 K and the optical train is kept at a temperature of about 100–120 K in order to save cooling power. The cryogenics are supported by a Stirling-Cycle cryo-pump requiring limited maintenance and no need for dewar refilling. REM Nasmyth A is also hosting the slitless

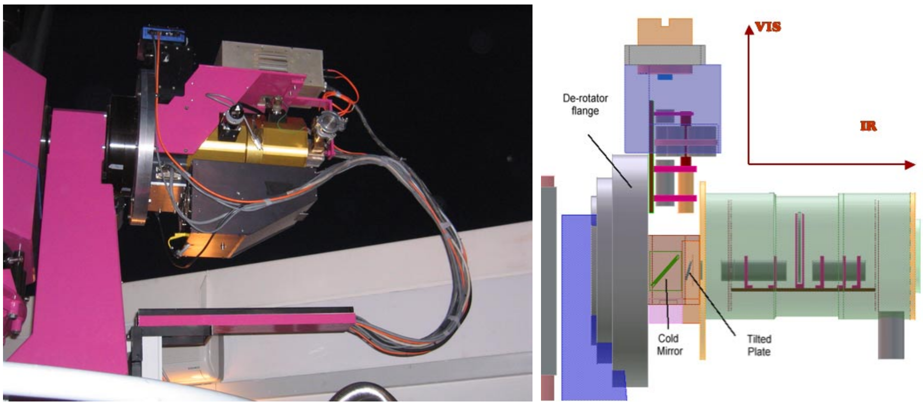

Fig. 2. – The de-rotated nasmyth focal station hosts both the instruments REM-IR and ROSS. These instruments are mounted onto the instrument flange, REM-IR along the nasmyth optical axis and ROSS orthogonal to such axis. The specific dichroic used for beam repartition has been customly designed in house and manufactured under the direct supervision of the REM technical team. A tilted plate allows to dither IR images without moving the telescope.

spectrograph ROSS [5] with an orthogonal development relative to the REMIR optical axis. The spectrograph consists of a fore-optics which images a pupil at the location of the dispersing element and re-maps the focal plane onto the detector unit. The detector plate scale ($43''$/mm) matches properly with the specifications in order to cover a $9'.54 \times 9'.54$ with a scale of $0.56''$/px. The dispersion is obtained by insertion at the pupil location of an Amici Prism 66 mm long. The prism spreads the 0.45–0.95 μm wavelength range on 60 pixels (see fig. 3). The Amici prism is accompanied by classical V, R, I imaging filters.

3. – The first year of REM observations

REM has been primarily designed to follow up the early phases of NIR/optical afterglow of gamma-ray bursts detected by dedicated satellites such as HETE-II, INTEGRAL and in particular SWIFT. The ambitious goal of the REM project is to discover and per-

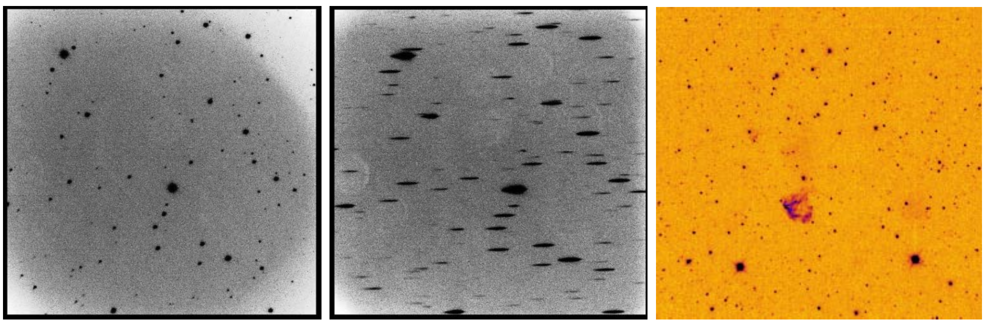

Fig. 3. – *Left and mid panels:* The same field observed by ROSS with R filter and Amici Prism. Amici prism spreads the 0.45-0.95 μm wavelength range on 60 pixels. *Right panel:* REMIR H band observaions of the plerion around SGR0526 showing the good quality of infrared images.

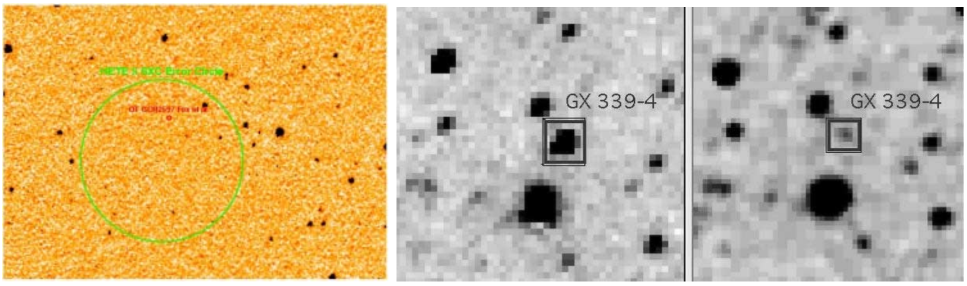

Fig. 4. – *Left panel:* REMIR H band observation of GRB 040511 performed 12 hours after the burst, due to late time observation only an upper limit could be derived. Overimposed there is the HETE II error circle and the Optical Transient position. *Mid and right panels:* The galactic black-hole candidate GX 334-9 observed by REM in Ks band during a high state compared with an archive image (from 2MASS) in the same band.

mit the study of the the most distant astronomical sources ever observed so far. Such a goal is related to the detection and observation of early afterglows of GRBs triggered in almost real time by SWIFT or other space-born experiments. Roughly a half of the observed GRBs do not show any optical afterglow. At least for a part of them it could be that Ly-α absorption dumps all the light at optical wavelengths because they explode in high-z galaxies. Ly-α absorption falls in the REM Infrared Arm wavelength range for sources with red-shift between 8 and 15. A burst in this z-range can be detected by REM if it is bright enough ($K < 15.5$), a figure expected for this kind of event if observed promptly. REM is able to provide positions, to a few tenth of one arcsecond, in a time-scale of tens of second allowing one to observe the transient with larger area telescopes when it is still very bright. During 2004, REM observed many GRBs detected by both HETE-II and INTEGRAL. Unfortunately, in all cases events happened during La Silla daytime so the fully automatic reaction was not tested and only upper limits on the afterglow emission could be derived. SWIFT (launched on November 20, 2004) is now providing more triggers (about 100/y) and in the first months of 2005 we had the possibility to observe a couple of GRB fields in less then 30 s.

As all other robotic facilities dedicated to GRB science, for considerable amount of time REM remains idle in the sense that it does not have any GRB transient to point to. During such idle phase REM serves the community as a fast pointing NIR imager particularly suitable for multi-frequency monitoring of highly variable and transient sources. Among the obvious applications of REM idle time we find AGN and variable stars multi-frequency monitoring. Some Key-programs of interest for the REM-team have been identified and the related preparatory work has been initiated. During 2004 REM has been used in association with INTEGRAL to monitor galactic black-hole candidates or low- and high-mass X-ray binaries, flaring stars, variable stars, star-forming regions and Blazars monitoring (fig 4).

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