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Abstract. We present an update on our ongoing effort to establish a dedicated observation program with an automated 0.6 meter telescope system that can detect GRB optical signals from 30 s to many hours after the start of the burst. The Super-LOTIS telescope has a 0.8 x 0.8° field-of-view, is sensitive to V 17 $\sim$ 19 objects, depending on the integration times, and will be placed at the Kitt Peak National Observatory. This paper presents technical aspects of this telescope and first results from initial operations at LLNL. Utilizing real-time coordinates from BATSE, BeppoSAX, XTE, IPN, HETE-2 and INTEGRAL, our LOTIS and SLOTIS systems will measure prompt GRB optical light curves that will enhance our understanding of GRBs.

INTRODUCTION

Nearly thirty years after the discovery of GRBs, x-ray, optical and radio afterglows now have been observed for a dozen of bursts during the last two years [1], [2], [3], [4]. These observations finally determined that GRBs are at cosmological distances and have established some of the GRB parameters such as energy, ambient environment and dynamics. However, there is still very little understanding of the nature of the GRB progenitors. Recent detection of a prompt optical signal [5] is inconsistent with the brightness and spectrum of the later time afterglows [6]. This amplifies our needs to measure more simultaneous optical counterparts associated with GRBs. Prompt optical activity measurements will provide clues to understanding of GRB production mechanism [7].

To search for simultaneous optical counterparts of GRBs, we are operating an automated wide field-of-view telescope at Lawrence Livermore National Laboratory (LLNL) to rapidly image GRB coordinate error boxes distributed by the Gamma-ray burst Coordinate Distribution Network (GCN) [8]. The LOTIS results are given in many papers including the one presented at this conference [9], [10], [11], [12]. In this paper, we describe our next generation prompt optical measurment experiment, Super-LOTIS, that will search for quasi-simultaneous GRB optical signals starting 30 s to many hours after the burst with a sensitivity of V 17 $\sim$ 19.

SUPER-LOTIS

The telescope is a Boller and Chivens 0.6 meter reflective telescope of f/3.5. Figure 1 shows the telescope. In order to make it dedicated and automated GRB follow-up telescope, we added computer controllable drives. These drives can point to any part of the sky within 30 s upon receipt of a GCN trigger. We also designed and fabricated a custom 4-element coma corrector to match the point spread function to the pixel scale at the corners of the imaging CCD. The sensor is a LOTIS CCD camera utilizing a Loral 442A 2048 x 2048 CCD (15 x 15 μm pixels) with LLNL built readout electronics. The CCD has thermo electric cooling (to -30°C) to minimize dark current and readout noise. Super-LOTIS has a 0.84 x 0.84° field-

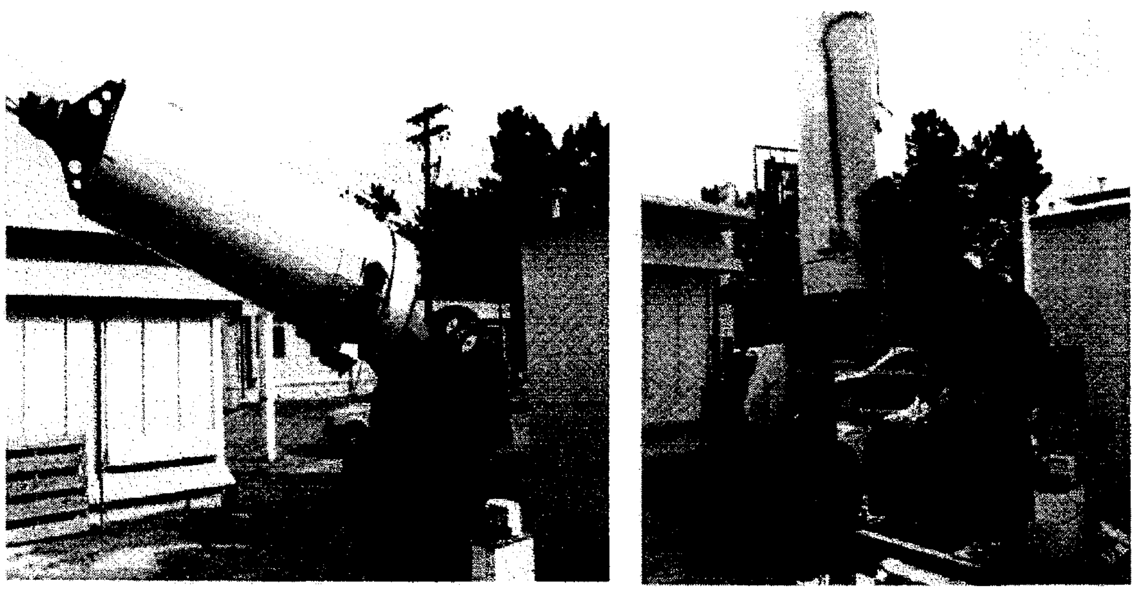

FIGURE 1. Super-LOTIS Boller and Chivens 0.6 meter reflective telescope. We converted it into a dedicated prompt GRB counterpart search telescope by adding computer controlled motors, a 2K x 2K CCD camera and an automated data acquisition system.

of-view (1.5 arcsec/pixel) sufficient for most GRB satellite triggers distributed by the GCN.

Our data acqusition system includes custom readout electronics, a custom hardware power control unit, a weather station and a housing control unit. An extensive on-line scheduling software has been written to handle various triggers. Priority is given to the most recent trigger that has smallest error box. For example, in response to a GCN "Original" trigger, which has only a 5 s delay but a large 15° error box, the telescope begins to systematically acquire a mosaic of images covering the error box. When refined positions are received, i.e. LOCBURST, XTE, BeppoSAX, or HETE 2 triggers, the telescope moves to that region and stays at that location the rest of the night. Our scanning strategy and automation allows us to record GRB optical activity as early as 30 s.

FIRST LIGHT AND FIRST EVENT OF SUPER-LOTIS

We have completed installing the motor drivers, coma corrector, CCD camera and the data acquisition system. We imaged the night sky successfully the first time on Feb. 25, 1999.

While we were testing the on-line software Super-LOTIS obtained early time

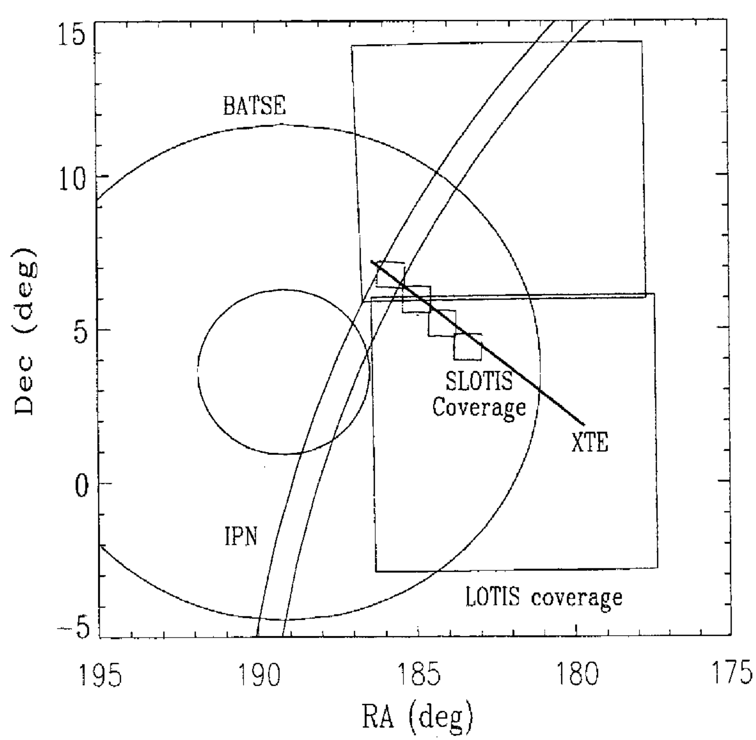

FIGURE 2. Super-LOTIS coverage of GRB990308.

observations of the error box of GRB 990308 (BATSE Trig. 7457). This event was detected and localized by the XTE/All-Sky Monitor. Super-LOTIS began a raster scan around the LOCBURST GCN coordinates 1700 s after the start of the burst. Four Super-LOTIS images (30 s integration; t=1694 s, 1809 s, 2620 s, 3923 s) covered most of the XTE/ASM error box within the BATSE 2-σ error circle.

The coverage of this event is shown in Figure 2. Here the circles represent the BATSE 1 and 3-σ errors; the arc represent the IPN error, and the thin line represent XTE observation. The large boxes represent LOTIS coverage of this event at 132 s after the burst; and the small boxes are the Super-LOTIS coverage during the raster scan. We searched for optical transient in the area where the error boxes overlap. Even though an optical afterglow for this event has been reported at 3.28 and 3.47 hr after the burst [13], Super-LOTIS detected no fading or flaring objects brighter thatn V $>$ 15.3 at 28.2 minutes. The weather condition and the usage of an uncooled prototype CCD camera at the time prevented us from reaching deeper limits.

We have shown that the Super-LOTIS is already operating and capable of responding to GRB triggers. The Super-LOTIS telescope is currently at LLNL for integration undergoing final integration. We will place it at Kitt Peak National Observatory in early 2000 and will be ready for the HETE 2 Coodinate Distribution. With the LOTIS and Super-LOTIS systems, we will be able to cover GRB optical activity from 10 s to many hours to a magnitude level of V 14 $\sim$ 19. With HETE 2 and other prompt GRB coordinate distributing satellites, we will be able to measure early time optical activity. Once we detect an optical transient, we will also be able to promptly alert other telescopes.

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