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"π of the Sky" - automated search for fast optical transients over the whole sky

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1. Novel approach to search for fast OT

Recently, a lot of interest in fast optical transients (OT) was stimulated by prompt observations of Gamma Ray Burst afterglows (Akerloff 1999, Paczynski 2001). A search is usually performed with small robotic telescopes of short focal lengths ($\leq$500mm), guided by satellite signals towards a given position in the sky (Feder 2002). Unfortunately, the delay of satellite triggers and the inertia of the device itself reduces the chance for a prompt observation of GRB optical counterparts. In order to overcome those drawbacks we propose a different approach.

Static design with optics covering almost the full hemisphere eliminates mechanical inertia. Self-triggering and buffer memory enables storing the data prior to a satellite alert, which can be used later as a confirmation. As a consequence, the data flow is very high and must be processed in real time. Fast and efficient recognition and selection of interesting events is done with multi-level trigger techniques.

2. Design and working prototype

The designed apparatus consists of two sets of 16 fixed CCD cameras covering almost the whole visible sky. Parallax and coincidence measurements of the two sets eliminates background from human artifacts and cosmic rays. One camera with lenses of f=50mm and aperture d=f/1.4 covers field of view $35^o \times 35^o$. It contains a CCD with 2000×2000 pixels of 15μm, cooled by Peltier modules. The electronics designed for fast readout of 2 MHz / pixel reads the entire chip in 2 s with 16-bit ADC. Clocking and control is realized with programmable logic (FPGA) making the system flexible. On board RAM enables reading the previous frame while the next one is under exposure. Communication with a PC is performed by Cypress FX2 processor with USB 2.0 interface. The processor software and FPGA configuration can be upgraded remotely via USB. Special attention was given to a shutter design. Assuming 5 s exposures all night for a couple of years, it must sustain over 10^7 cycles.

Two custom build prototype cameras have been recently installed at the ASAS site at the Las Campanas Observatory. They meet the specification and exhibit a readout noise of $\sim$16e$^-$, well below the sky background. The cameras are installed on a robotic mount reaching any point in the sky in less than 1 min. In a normal run it follows the HETE satellite field of view. The data are taken continuously with 5 or 10 s exposures and analysed on-line in search for fast transients up to 10^m. A 25cm telescope of ASAS can be used to follow up selected events. The system can also react to other satellite alerts from the GCN network. In parallel, photometric analysis of the data is performed to study variable stars, asteroids etc. up to 12^m.

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