

# Calibration of Cangaroo II Telescope Using a Fast Blue LED Light Flasher

John R. Patterson, David L. Swaby and Neville Wild  
for the CANGAROO Collaboration<sup>1</sup>

*Department of Physics & Mathematical Physics, University of Adelaide,  
Adelaide, South Australia 5005*

**Abstract.** We describe the results obtained with a light flasher placed on a 10 metre high mound, at a distance of 1.0 km from the Cangaroo II 10 metre gamma ray telescope, giving a light pool of 7 m diameter. The flasher contains an ultrabright blue ( $\lambda=460$  nm) LED type Nichia (NSPB 510S), which has a temperature stable light output and a risetime of  $\sim 1$  ns. The flasher can be operated at 10ns and 20 ns pulse widths and rates of 30 Hz, 1000 Hz or continuously, from a battery-powered pulse generator to calibrate and test the telescope data acquisition system. The brightness can be controlled by neutral density filters or collimators. The flasher is pointed using a Ramsden eyepiece fitted with cross-hairs.

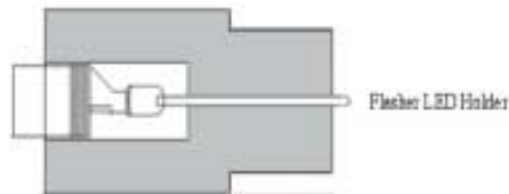
Since April 1999, the 10 metre Cangaroo II imaging atmospheric Čerenkov gamma ray telescope has operated at G-Range, Woomera, South Australia, at latitude and longitude, 31.1 °S, 136.8°E, and 165m altitude. It is fitted with a 552 pixel camera at 8 metre focal length [1]. We regularly monitor the performance of the telescope using a small portable light flasher, shown in figure 1, and set up at a distance from the telescope. We can measure the threshold energy and check the long term performance of the telescope mirrors, PMT's and light guides, as well as test the data acquisition electronics. Our technique is an independent variation of the laser method described by Frass et al [2].

## **Description of the flasher**

To simulate a Čerenkov signal, the flasher is operated at 10ns and 20 ns pulse widths and repetition rates of 30 Hz or 1000 Hz from a small battery-powered pulse generator. For a visual check, it can be also be run continuously for short periods.

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<sup>1)</sup> Institute for Cosmic Ray Research, University of Tokyo; University of Adelaide; Australian National University; Ibaraki University and Prefectural University; Institute of Space and Astronautical Science; Osaka City University; Kyoto University; Konan University; National Astronomical Observatory of Japan; Tokai University; Tokyo Institute of Technology; STE laboratory, Nagoya University; Yamagata University; Yamanashi Gakuin University; Institute of Physical and Chemical Research. See [www.physics.adelaide.edu.au/astrophysics/cangaroo.html](http://www.physics.adelaide.edu.au/astrophysics/cangaroo.html)



**FIGURE 1.** The LED flasher/telescope with the Ramsden eyepiece fitted and a previous LED holder alongside it. The fully corrected lens is 30 mm diameter and 150 mm focal length. The drawing below shows detail of the LED and fibre which improves light pool uniformity.

The maximum trigger rate of the telescope was 38 Hz. The two widths are convenient for checking saturation, gain linearity and the Time to Digital Converters (TDC's). A series of ND filters and aperture ring collimators verifies linearity. We normally run with an ND1.0 and 27mm aperture. Atmospheric scattering and absorption is  $\sim 7\%$  over the 1km path. The size of the image shown in figure 2  $\sim 0.5^\circ$ . It is due to the diameter of the fibre and a slight defocussing due to distance. Atmospheric scattering and turbulence are not significant [3].

The flasher contains an ultrabright blue ( $\lambda=460$  nm) LED type Nichia (NSPB 510S), which has a light output approximately independent of temperature over a range from  $\sim 5-25^\circ$ , and a risetime of  $\sim 1$  ns. The LED has a double emitter giving a non-uniform light pool. By drilling a small hole in the LED lens, and gluing in a 1 mm diameter plastic fibre, about 15 mm long, we obtained a more uniform light pool, with a reduced intensity. The flasher is fitted with horizontal and vertical screw adjustments, which enable it to be accurately pointed at night by illuminating the telescope with a floodlight. An eyepiece, fitted with cross-hairs, replaces the LED holder. The light pool is 7m diameter at 1km.

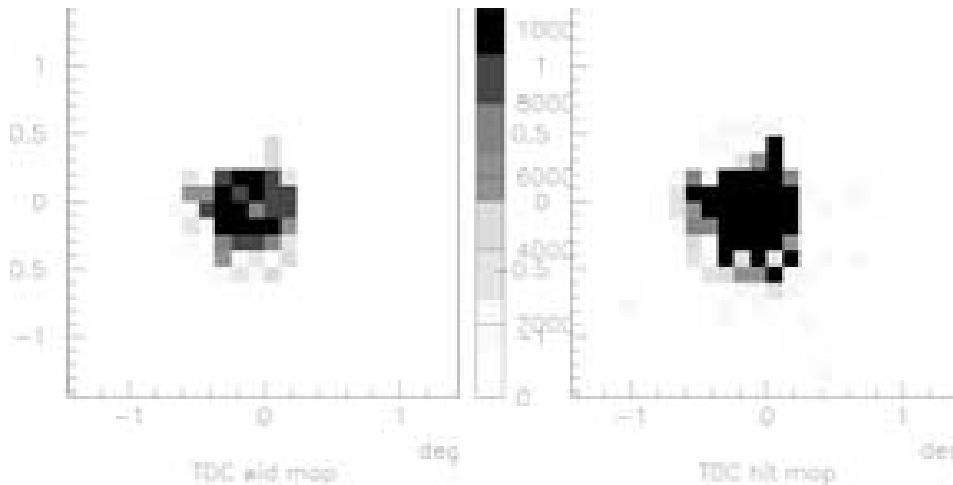
The electronic circuit shown in fig 3 is housed in a die-cast metal box, draws only a few  $\mu\text{A}$ . It maintains a stable light pulse output over many nights, separate

9 V batteries being used for the pulse and continuous modes. The pulser battery is screwdriver-adjusted each month to supply 6.00 V for the LED. The free running multivibrator consists of four CMOS 74C04 gates. The rate is controlled by a switchable 15 nF capacitor in the feedback, while the pulse width is set by a second switch and 442 $\Omega$  resistance pair. The output is sharpened and buffered by three 74AC14 gates in parallel to provide increased drive. Their output is AC coupled by three 0.1 F capacitors, in a low inductance combination, to the cable and blue LED.

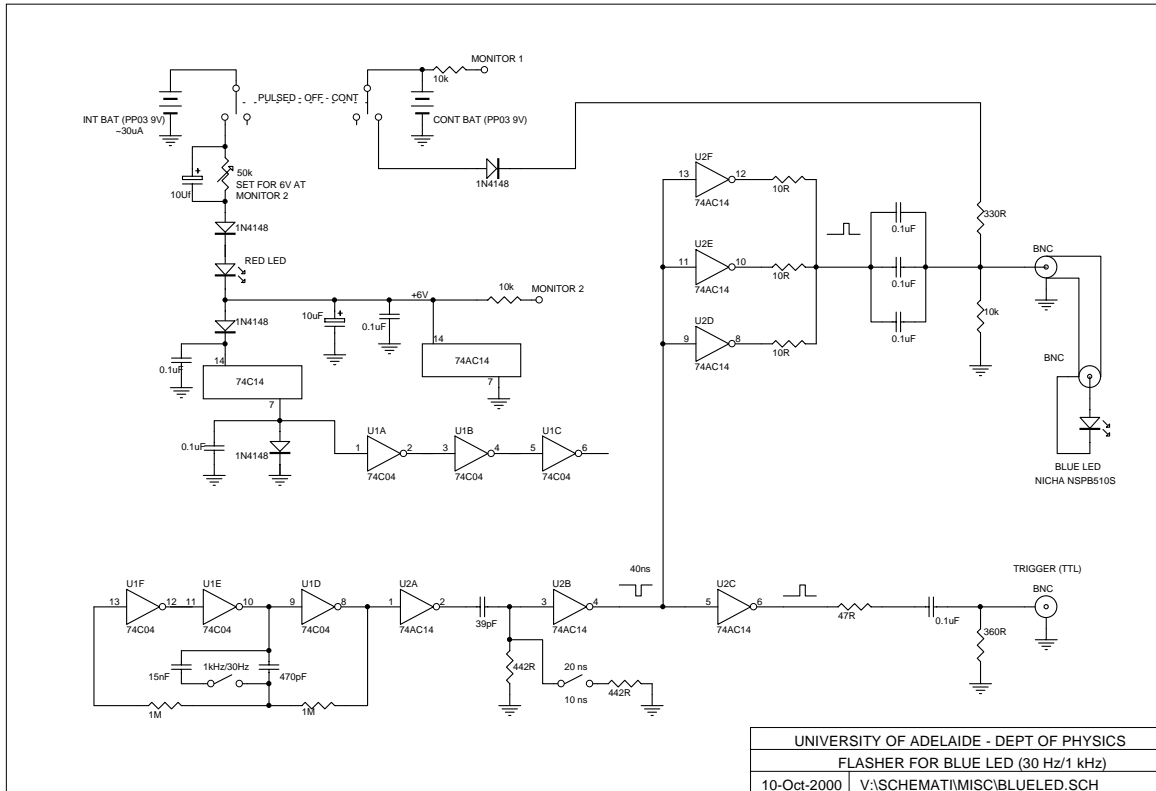
### Laboratory Calibration and Energy Threshold

We measured the light output attenuated by the 1.0ND filter in equivalent photo-electrons by two methods. (i) using a Hamamatsu R4124UV camera tube, we measured the anode currents corresponding to 10 ns and 20 ns pulses at 1000 Hz by means of the millivolt drops across a 10,000 $\Omega$  resistor. The anode currents at several high voltages were divided by the nominal gains to give a roughly constant cathode current,  $\sim 3.0 \times 10^{-12}$  A. Then, dividing by 1000Hz and the electron charge, we obtained a flasher output of  $\sim 2,750$  pe  $\pm 10\%$  for the 10 ns pulses. (ii) A second method involved a Philips XP2262 single photo-electron phototube. We compared the ND3 attenuated flasher to the single photo-electron peak using a multichannel analyzer and found a similar result.

The energy threshold was calibrated by pointing the telescope to the vertical and measuring the shower cut-off on the ADCs, relative to the flasher peak. This gave a threshold of  $240 \pm 20$  photo-electrons. From simulations at 320 GeV [4], for 10 m telescope with 70% mirror reflectivity, we expect 160 pe. Correcting this by a mirror coverage factor of 74%, we get 118 p.e. Assuming linearity and 7% loss, we then estimate our threshold to be 600 GeV  $\pm 15\%$ . The light guides, mirror aberration and camera efficiency are already included.



**FIGURE 2.** Camera images of the flasher. Pixels, each  $0.12^\circ$ , on the left are for brightness; those on the right show fairly uniform TDC start times.



**FIGURE 3.** This electronic circuit is designed to draw minimum power and maintain a stable light output. The selectable pulse rates are 30 Hz or 1000 Hz, and the pulse widths are 10 or 20 ns. The rectangle blocks are expanded at bottom left and mid right.

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2. Frass, A., et al, *Astropart. Phys.* 8, 91-99 (1999).
3. Dowling, J. A. & Livingston, P. M. *J. Opt. Soc. of America*, **63**, 846 (1973).
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