



A LED Flasher for TUNKA experiment

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Abstract: A LED flasher has been developed for TUNKA-133 EAS Cherenkov detector. A blue ultra bright InGaN LED is used as a light source in the flasher. The flasher's driver is based on a complementary pair of fast RF transistors. The light yield of the flasher is adjusted in a wide range from 0 to up to 10^9 photons per pulse. The results of studies of the flasher's amplitude and timing parameters and their stability are presented.

Introduction

The history of TUNKA EAS experiment spans more than 15 years. The experiment started in the early 1990s with a toy array TUNKA-4 [1] in the picturesque Buryatian Tunka Valley in Siberia and evolved further through TUNKA-13 [2] to TUNKA-25 [3]. The basic detecting element of all TUNKA arrays has been Quasar-370G [4-6], 37 cm hemispherical hybrid phototube. Digits in the titles of the arrays indicate the number of phototubes in the arrays. TUNKA-25 has been working successfully for a number of years and is being still runned currently, giving important information on primary cosmic rays spectrum in the energy range around the classical knee ($\sim 3 \times 10^{15}$ eV). For the time being the development of a new array is underway at full pace.

The new array christened TUNKA-133 [7,8] will consist of 133 eight inch PMTs and cover 1 km² area. The PMTs are EMI9350 from former MACRO detector at Gran Sasso. The new array will operate in the energy range of 10^{15} to 10^{18} eV, including the classical knee region, measuring elaborately the primary cosmic rays energy spectrum and mass composition. The old TUNKA-25 array will continue to operate along with the new detector.

An optical detector of the new array incorporates a light source for timing and amplitude calibration of PMT. The calibration light source is based

on ultra bright InGaN blue LED driven by a driver specially developed for this purpose.

Ultra bright InGaN LEDs

The advent of ultra bright blue LEDs based on InGaN/GaN structures at the beginning of 1990s [9, 10] opened new era in the development of nanosecond light sources for use in different fields of experimental physics: timing and amplitude calibrations of Cherenkov and scintillator detectors, fluorescent measurements, studies of fast processes kinetics etc.

Currently a plethora of ultra bright blue LEDs are available in the market. There is a wide diversion of LEDs in their intensity and timing. Extensive studies of light yield and temporal behavior of ultra bright InGaN/GaN LEDs have been done by us [11]. We have tested LED samples produced by more than 20 manufactures. Whereas light yields of one type of LEDs are more or less at the same level, LEDs light emission kinetics is subjected to much more variance. Even LEDs of one type produced by one manufacturer may differ very much by their light pulses profiles.

Finally we chose GNL-3014BC 3 mm single quantum well InGaN LED produced by G-nor Electronic Company. Its emission spectrum has a maximum at $\lambda=470$ nm. Albeit the LED's emission spectrum doesn't suite well to EMI9350 PMT's photocathode sensitivity curve, the LED

has much higher light yield than violet LEDs. Light pulses shapes of 10 GNL-3014BC LEDs are shown in fig.1. One can see that along with LEDs with slow emission components there are very fast LEDs without slow components tail at all.

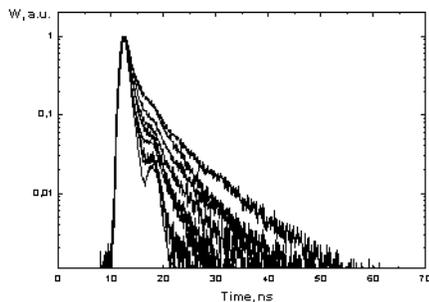


Figure 1: Light pulses shapes of GNL-3014BC LEDs produced by G-nor Electronics

We selected the fastest LEDs without slow emission components, which are capable of 1 ns width (fwhm) emission kinetics. The LED's light yield is practically the same and emission kinetics much more faster as for the famous NICHIA ultra bright blue LEDs of NSPB series. It should be noted here GNL-3014BC LEDs are extremely cheap and easily available. Among other reasons why we chose GNL-3014BC LEDs are their reliability and good temperature behavior.

LED driver

To drive ultra bright blue LEDs two types of electronic drivers are widely used. The highest level of light yield and at the same time the shortest light pulses are reached with a driver exploiting avalanche transistors to produce very short, a nanosecond or less width current pulses running through LED with amplitudes of up to 3A [12, 13]. But one should be careful with electromag-

netic cross talks working with such circuits. Another drawback arises from necessity to use several hundreds of volts power supply to feed avalanche transistors and some problems with light yield adjustment.

Another type of driver is so called "Kapustinsky's driver". In 1985 J.S.Kapustinsky and his colleagues published their famous scheme of an inexpensive compact nanosecond LED pulser [14]. Since that time the pulser has become particularly popular in astroparticle physics experiments where it's widely used for time and amplitude calibrations: in high energy neutrino telescopes like NT-200 in Lake Baikal [15] and ANTARES in the Mediterranean Sea [16], the imaging atmospheric Cherenkov telescope H.E.S.S. [17], the extremely high energy cosmic detector AUGER [18] etc. The popularity resulted from the pulser's high performance, simplicity, convenience, and robustness.

We have developed our LED driver following Kapustinsky's basic scheme. The driver is based on fast discharge of a capacitor via a complementary pair of fast RF transistors. An electrical scheme of the driver is shown in fig.2.

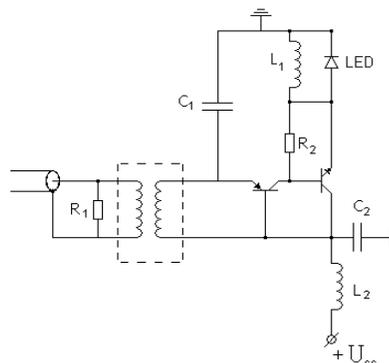


Figure 2: LED driver for TUNKA experiment

The driver is remotely operated from cluster's electronics [19] via ~85 m coaxial cable. To avoid stray ground potential floating the driver's circuit is completely isolated from cluster's electronics by a transformer. The driver is built on 35 mm × 35 mm PCB board. All details of the driver are of shelf and rather cheap. The photo of the driver is presented in fig.3.

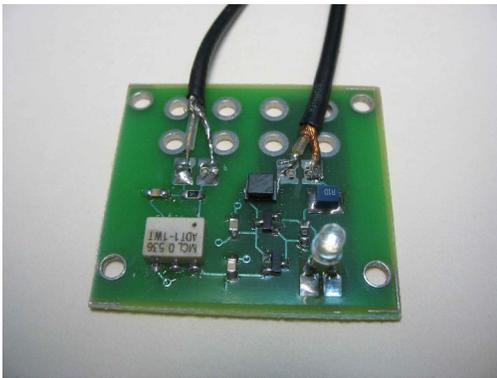


Figure 3: Photo of the driver

One definite advantage of the pulser is the possibility to adjust quite easily the light pulse intensity of LEDs by varying the power supply voltage U_{cc} . The latter is adjusted in the range of 0-12V. The light yield of the driver changes in very wide range, up to almost more than 10^9 photons per pulse at $U_{cc} = 12V$. It's interesting that at $U_{cc} = 12V$ single light pulses from the driver are seen by just naked eye. The light pulse width ranges from 2 ns (fwhm) at lowest value of U_{cc} at which the driver light pulses start to be registered by PMT to ~7 ns (fwhm) at $U_{cc} = 12V$.

We measured the long-term stability of the driver's parameters. The light yield of the driver and its light pulses width didn't practically

change even after 10^{10} total pulses of driver at highest U_{cc} (fig.4). The light yield stability is better than 1%.

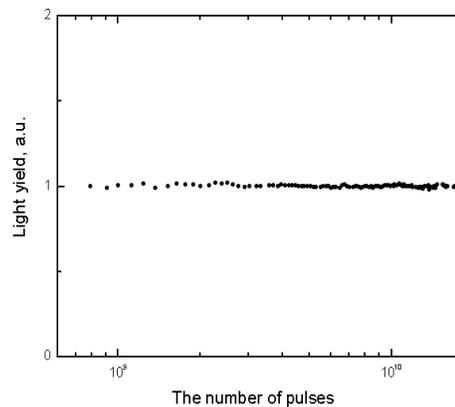


Figure 4: Long-term stability of the driver's light yield.

The dependence of the driver's light yield on temperature in the range of ~50°C is shown in fig.5. The measured temperature coefficient in this range is 0.15-0.2%/°C. As for the driver's light pulses width there is no any notable changes. However, in reality Tunka Valley presents temperature changes in substantially wider range, so it's necessary to study further the driver's parameters temperature dependence

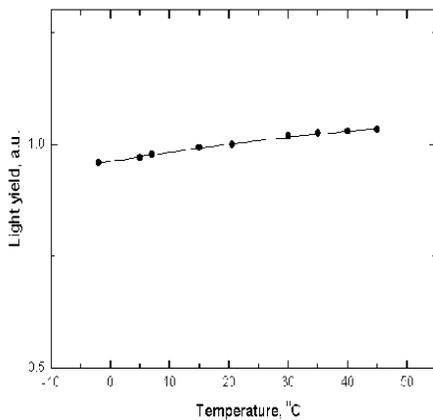


Figure 5: Temperature dependence of the driver's light yield

Conclusion

The LED driver developed for TUNKA EAS experiment demonstrates good performances. The operation of the first cluster of the TUNKA-133 array proves the driver's reliability and robustness.

Acknowledgements

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