A Novel Alternative to UV-Lasers Used in Flat-Fielding VHE γ-ray Telescopes

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Abstract

Preliminary tests of an alternative calibration system for the H.E.S.S. telescope array show that it is possible to replace the currently operating UV-Lasers device with an optical LED apparatus. Together with complementary optics, it is able to simulate the Cherenkov flashes, while at the same time illuminating the whole of the telescope's camera uniformly. The device in question is capable of driving a fixed number of specifically chosen LEDs to produce frequent flashes of very short duration similar to the Cherenkov emission generated by electromagnetic cascades. The design of the system continues to be refined. We describe the components and the operation of the device as developed so far.

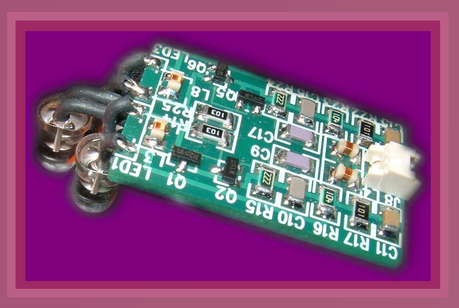
A new flat-fielding system was installed on the second H.E.S.S. telescope in spring 2003. It is located at the centre of the dish, 15m away from the camera.

The advantages over the UV-Laser, installed on the first telescope, are:

- The 40× faster pulse repetition rate
- The shorter pulse duration (see Specifications Table)
- The significant reduction of maintenance costs, and
- The long-term stability, which arises from the simpler and more compact design.

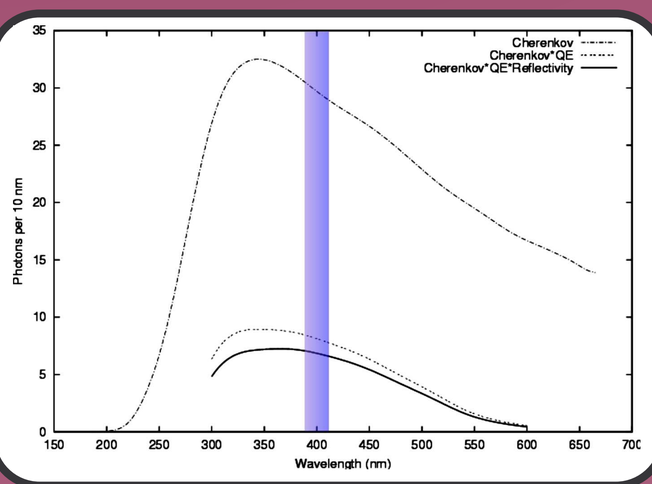
Device Specifications

Maximum Trigger Rate	1 kHz
Pulse FWHM	5 ns
Pulse Rise Time	2.5 ns
Short term Temporal Stability (jitter)	<0.5 ns
Long term Temporal Stability (drift rate)	<0.25 ns/y
Intensity Stability	<5% RMS
Photon Flux per Pulse at 15 m distance	250 ph cm^{-2}



The LED pulser, designed at Sheffield University, is the 'heart' of our flat-fielding system. For our specific purposes, we have integrated three pulsers into the flat-fielding circuit (see picture).

Each pulser can drive compatible LEDs to produce frequent pulses, whose properties remain adequately constant over long periods of time. A list of tested LEDs is presented in the table below.



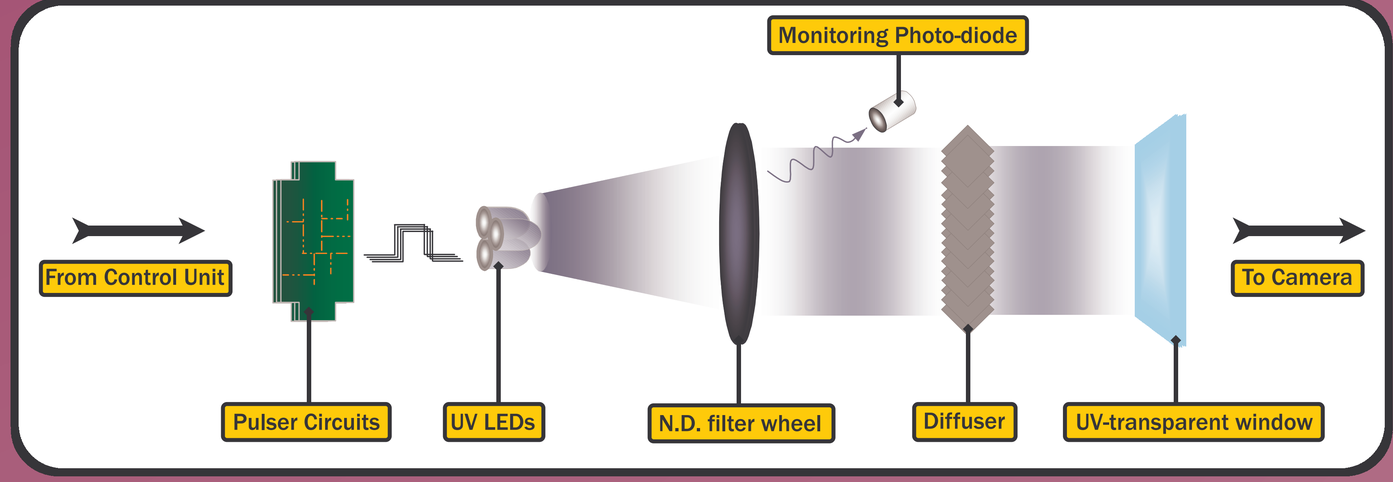
The **Cherenkov spectrum** (see above) for 1 TeV γ-rays at the Gamsberg Plateau in Namibia.

– · – The **dash-dotted** line represents the spectrum as it was derived from MOCCA simulations.

· · · · The **dotted line** represents the simulated spectrum, with the PMT's quantum efficiency included.

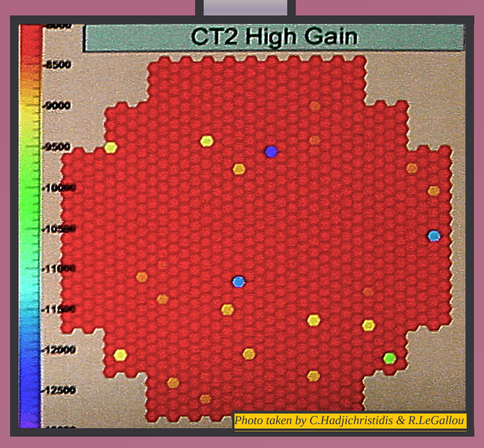
—— The **solid line** represents the simulated spectrum, with both the PMT's quantum efficiency and the mirror's reflectivity included.

We have included a shaded band, which corresponds to the bandwidth (390–410 nm) of the LED currently in use (HUVL400-520).



Our main concern about the LED flat-fielding system was to have a uniformly covered camera, which would allow us to calibrate the PMTs with better accuracy. Additionally, the light beam would have to be bright enough to trigger the PMTs from a distance of 15 m.

The first tests were successful, as both these requirements were met, resulting in a high and uniform illumination of the camera's PMTs. This is illustrated in the picture below, where it is apparent that the majority of the camera's pixels are 'hot', while a few 'broken' pixels are also present (blue).



LED	Peak λ (nm)	Relative Intensity (%)
NSHU550E	370	0.5
RLT370-10	370	0.5
380D30	380	4
E1L5M - 4POA2 - 01	385	5
LC503MUV1 - 30Q	390	91
HUUV5102L	393	85
HUVL400 - 520	400	85
GB333UV1C/L1	400	91
B5437- CVD	405	**100**
HUUV5101L	410	80
383UBC	430	0.7
HLMP-CB15	480	46
HUBL - 5101L	470	57
HUBG - 5102L	480	25
383 - 2UBGC	502	25

References

1. Chadwick, P.M. et al. 2001, Flat-fielding of H.E.S.S. phase I, Proc. 27th Int. Cosmic Ray Conf., 2919
2. McMillan, J.E. 2001, Using the Sheffield Pulser, private communication
3. McMillan, J.E. on behalf of the ANTARES Collaboration 2001, Calibration Systems for the ANTARES Neutrino Telescope, Proc. 27th Int. Cosmic Ray Conf., 1287

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