Absolute calibration of Atmospheric Cherenkov Telescopes with Rayleigh Scattered LASER light

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Abstract

The amplitude of atmospheric Rayleigh scattering off a calibrated LASER pulse can be precisely calculated once viewing angle, local temperature and pressure are known [2]. When other forms of scattering can be neglected, Rayleigh scattering can be compared to the signal amplitude recorded by a telescope and used for its absolute calibration.

VERITAS

✐ The VERITAS [1] project consists in a 160m across array of 4 telescopes under construction on Kitt-Peak in Southern Arizona. Each telescope is a 12m Davis-Cotton reflector f/D=1 with a 499 0.15° photomultiplier tube camera covering a 3.6° field of view.

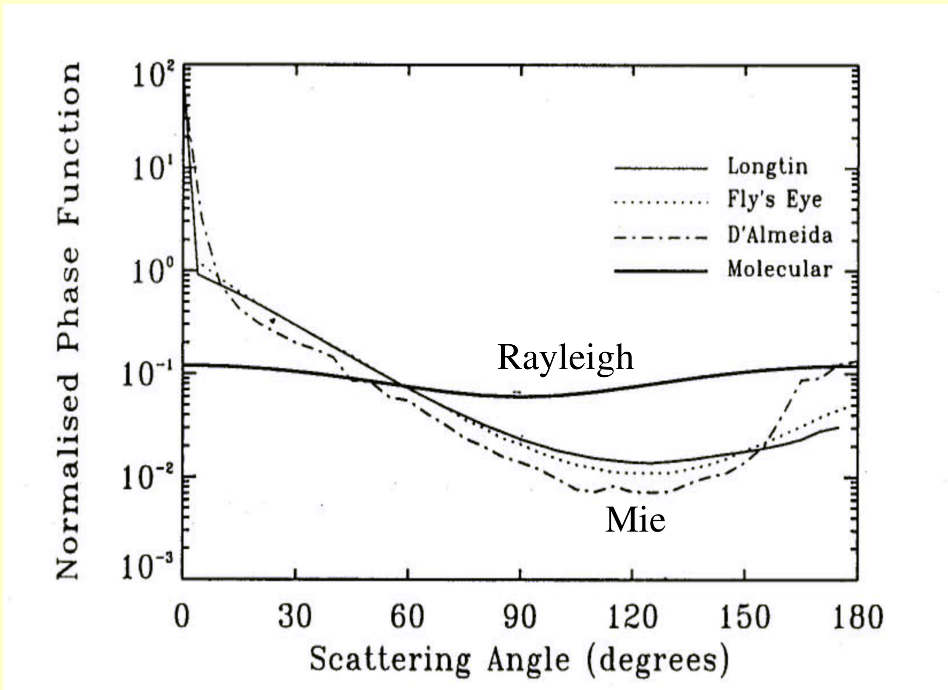
✐ Photomultiplier tube signals are digitized at a 500MHz rate. The FADC system has a memory depth of 64 microseconds, providing plenty of time for constructing the array trigger even for low elevations.

✐ This also gives enough time to record the Rayleigh scattered light from a fast LASER pulse seen at large angle from a distance of a few kilometers.

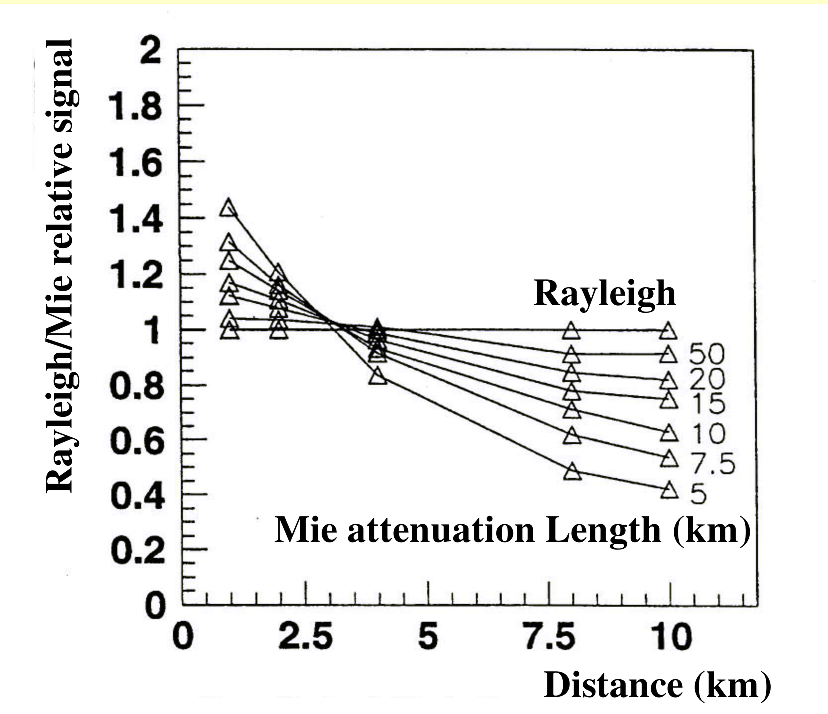
Absolute calibration

✐ Calibration technique using Rayleigh scattered light from a pulsed LASER was originally developed for atmospheric fluorescence detectors of Ultra High Energy Cosmic Rays [3].

✐ In this technique, a pulsed LASER is shot at zenith and is observed sideways with the telescope to be calibrated under scattering angles close to 90° where Mie scattering contribution is close to minimum.



From: [5] C. R. Wilkinson 1998

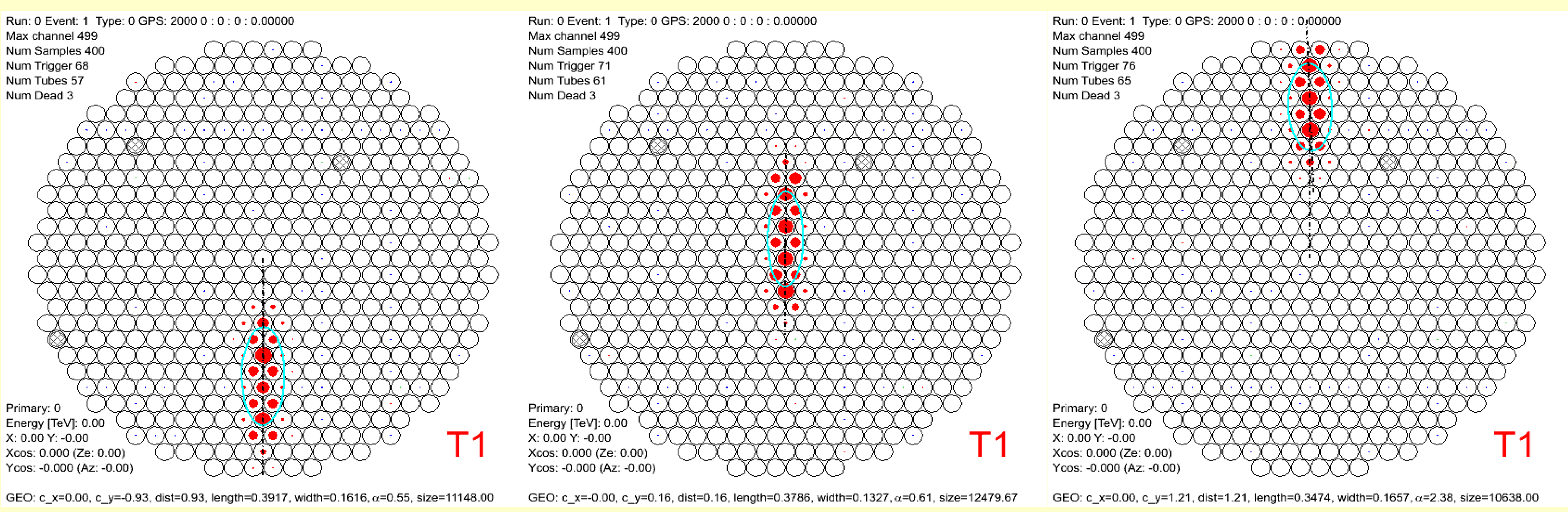


From: [4] L.R. Wiencke 1999

✐ The distance of the LASER from the telescope should be set to approximately 3 km in order for the Mie scattering contribution to be compensated by the Mie attenuation from the LASER to the telescope [4].

✐ Fluctuations from night to night result from the residual Mie scattering. This systematic limitation can be further reduced by studying distance dependence.

✐ We have simulated a 4 ns 3 micro-Joule nitrogen laser (337 nm) seen from a distance of 4 kilometers by one of the VERITAS telescopes under an angle of 90°. The three pictures correspond to consecutive 100ns exposures that could be recorded with a VERITAS telescope camera. The length of the image corresponds to the distance traveled by the pulse during 100ns. The width of the image results from the relatively small distance to the LASER for which the telescope is not in focus.

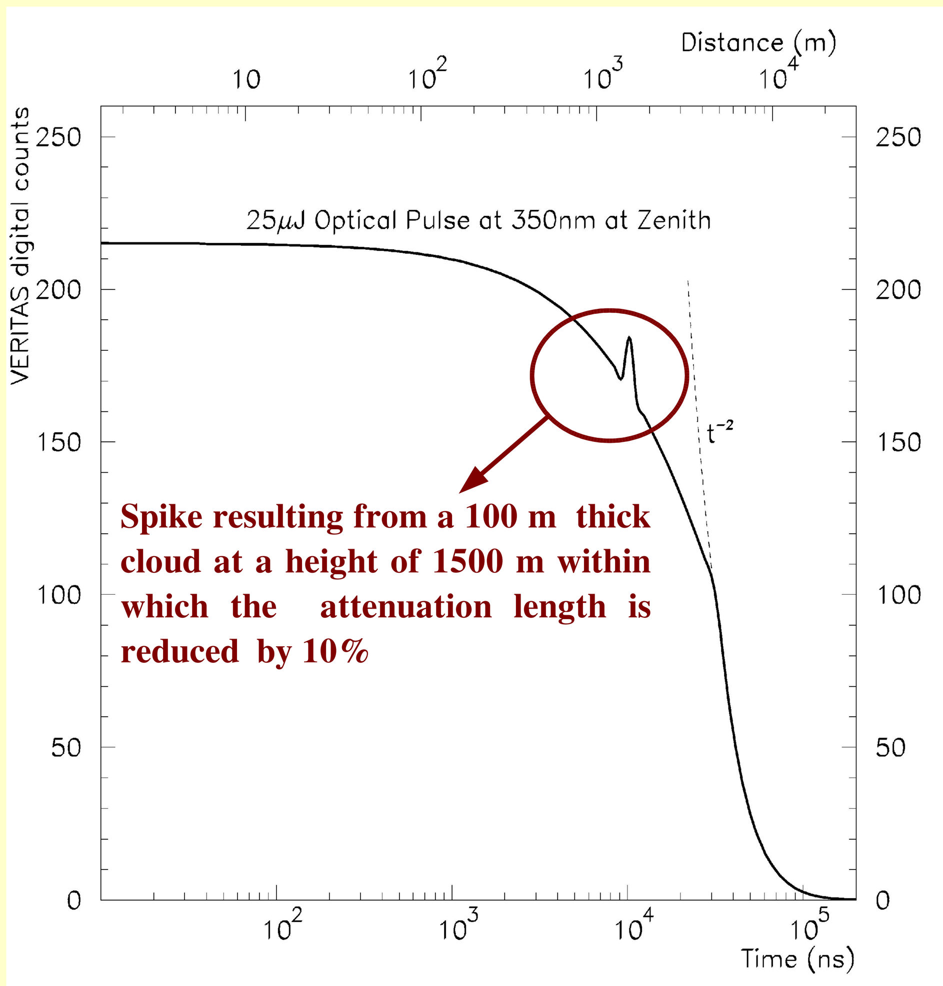


✐ **First real measurements with the VERITAS telescope 1 should be obtained in May 2005.**

LIDAR application

✐ It is also possible to observe the back-scattered light with the LASER next to the telescope. The VERITAS telescope would then be used as a LIDAR receiver.

✐ The pulse becomes focused only when reaching distances of more than 4000 m. Until then, the back scattered light collected by the telescope is spread over a number of pixels that decreases as the pulse gets further. Therefore the large size of the telescope effectively reduces the dynamic range required from the electronics.



✐ The graph indicates the expected signal from a LASER pulse at zenith in the central pixel.

✐ The electronics AC coupling was not taken into account for this calculation. This will complicate the analysis and tests have to be done but this system should permit to signal the presence of clouds, provide a measurement of there altitude and permit some monitoring of atmospheric conditions.

[1] Weekes T. C., et al., 2002, Astropart. Phys. 17 221

[2] Bucholtz A., 1995, Applied Optics, 34, 15, 2765

[3] Roberts, M.D., et al., http://www.auger.org/admin/GAP_Notes/GAP2003/GAP2003_010.pdf

[4] Wiencke, L.R., et al., 1999, NIM, A428, 593

[5] Wilkinson, C. R., May 1998, PhD Thesis, Ppt. Of Physics and Mathematical Physics, Univ. of Adelaide

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