Cherenkov & Imaging Detectors - Tutorial

ESIPAP 2022

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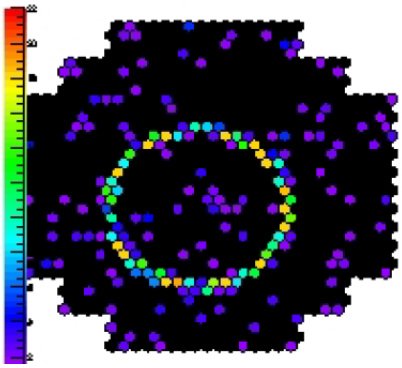
3rd of February 2022

1 Calibrating an IACT using single muons



Imaging Atmospheric Cherenkov Telescopes used for VHE gamma-ray astronomy consist of a large spherical mirror with a multi-pixel camera at its focal plan. The PMT used at each pixel need to be precisely and continuously monitored (efficiency, gain). This is done by checking the Cherenkov light yield produced by high energy muons that intersect the mirror surface. Each pixel of the camera covers an fixed angular size of the sky around the axis of the telescope. The 4 smaller H.E.S.S telescopes have mirrors with $\approx$ 12 m in diameter and pixels overlook a 0.16×0.16 degree-square portion of the sky. There are 960 identical pixels per camera and thus the field of view of the telescope is $\approx$ 25 degree-square. The telescope acts as a 2D Fourier transform, mapping angles α, ψ to a given position (pixel) on the focal plane, where α is the angle of the light ray with respect to the telescope axis and ψ the angle in the transverse plane with respect to some arbitrary reference.
We well neglect absorption or scattering of Cherenkov photons in the atmosphere as well as scattering or energy loss by the muon along its path. Useful data can be found at the end.

1. Show that the Cherenkov light emitted by a high energy muon (multi GeV) parallel to the telescope axis will map to a ring of illuminated pixels, and that this ring will be centered on the camera center and its radius will be ≈ 9 pixels.

2. Find the total path-length along which the muon emits Cherenkov light that is reflected back to the camera.

3. What is the photon yield received by each pixel of the ring.

Useful data:
Index of refraction of air (at STP conditions i.e. sea level) $n_{\text{air}} \approx 1. + 3 \times 10^{-4}$
Muon mass: 105 MeV/c^2
You may use $N_\gamma = 370 Z^2 \sin^2(\theta_C)$ photons.eV^{-1}.cm^{-1} and assume that the spectral sensitivity of the PMTs is about 1 eV.