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Algorithm for Background Rejection using Image Residuals (ABRIR)

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Abstract

Identification of Cherenkov light generated by muons is a promising way to improve the background rejection of Imaging Atmospheric Cherenkov Telescopes (IACT) arrays at high energies. However, muon identification is a challenging task, for which algorithms are still being developed.

We present an algorithm in which we simply consider the presence of light outside the main shower image in IACT with large mirror area.

We show that in the case of the H.E.S.S. array, this approach results in background rejection improvements at all energies above 1 TeV, while keeping high γ-ray efficiency.

Muons

- Large numbers of muons are produced in hadronic showers.
- Very large telescopes ($\gtrsim$ 20 m) can detect muon light (ring-like images) out to large impact distances [1].
- However, only a fraction of the ring is detected when impact distance is above tens of meters,
- Here we present a simplified approach.

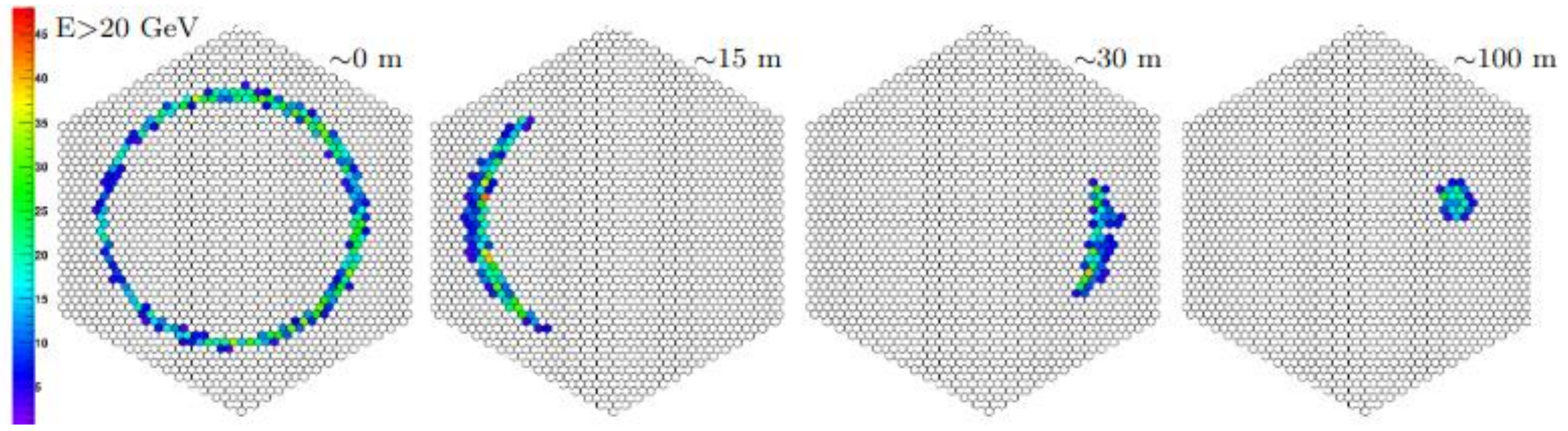

Figure 1: Example simulated muon images in a 28 m telescope at different impact distances. Simulated muons are produced at 11 km above sea level and are observed at 1835 m with a zenith angle of 20°.

Algorithm

ABRIR draws information from a large telescope, like the central dish of the H.E.S.S. array.

The algorithm is applied after the usual H.E.S.S. *stereo* reconstruction, using the four small telescopes.

The basic algorithm structure follows:

1) Identify the main shower with a template based reconstruction (ImPACT) [2].

2) Identify the light clusters thanks to the Time-Based Cleaning algorithm [3].

3) Reject those events with low reconstruction quality and clusters outside the main shower.

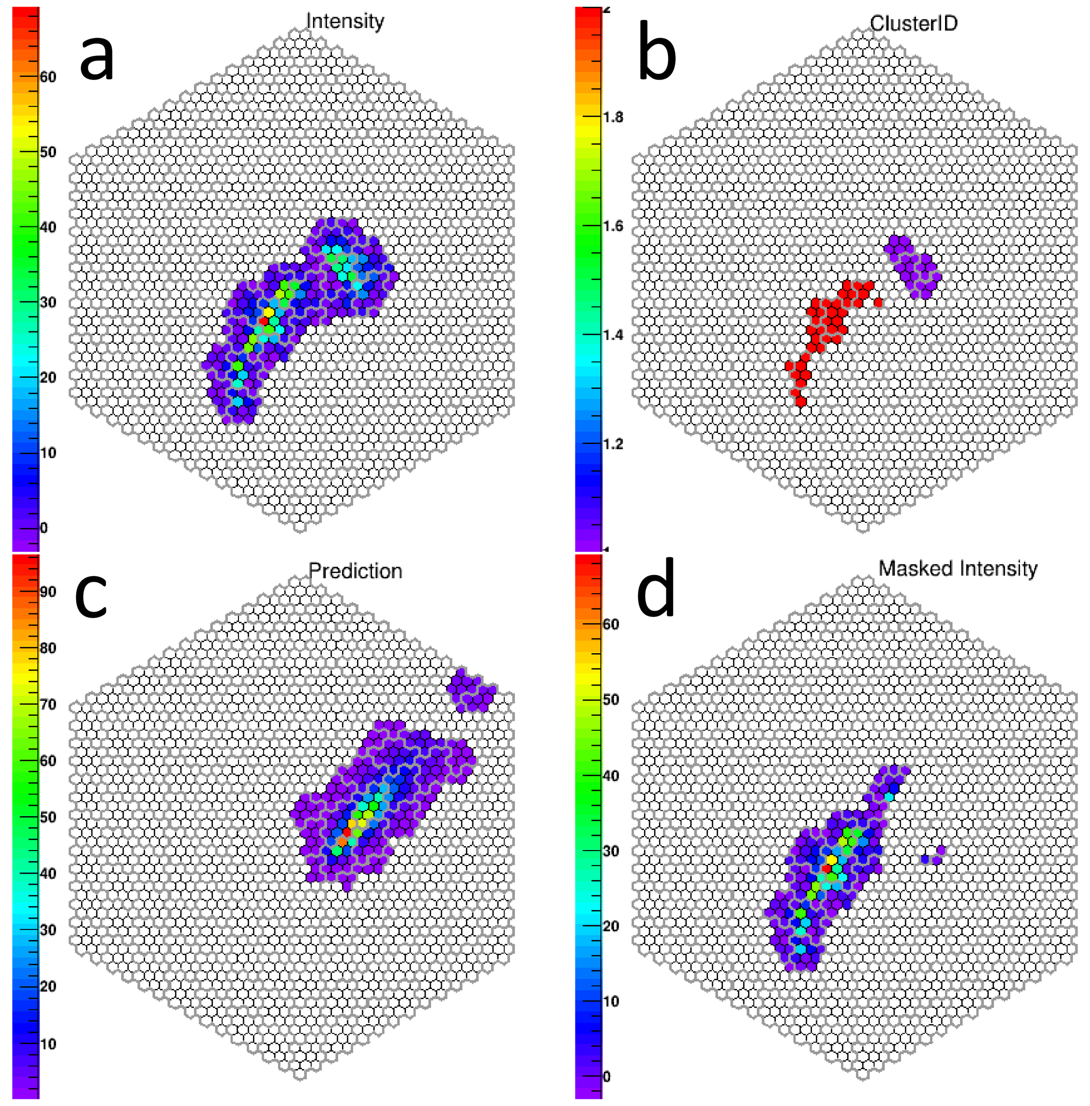

Figure 2: Large telescope image of an example background event. a) The event image intensity, b) the template image given by ImPACT, c) the cluster information given by Time-Based Cleaning algorithm and d) the masked image intensity. One can clearly see that this is unlikely a gamma-ray event.

We are currently investigating the usage of additional parameters to improve the algorithm performance, such as:

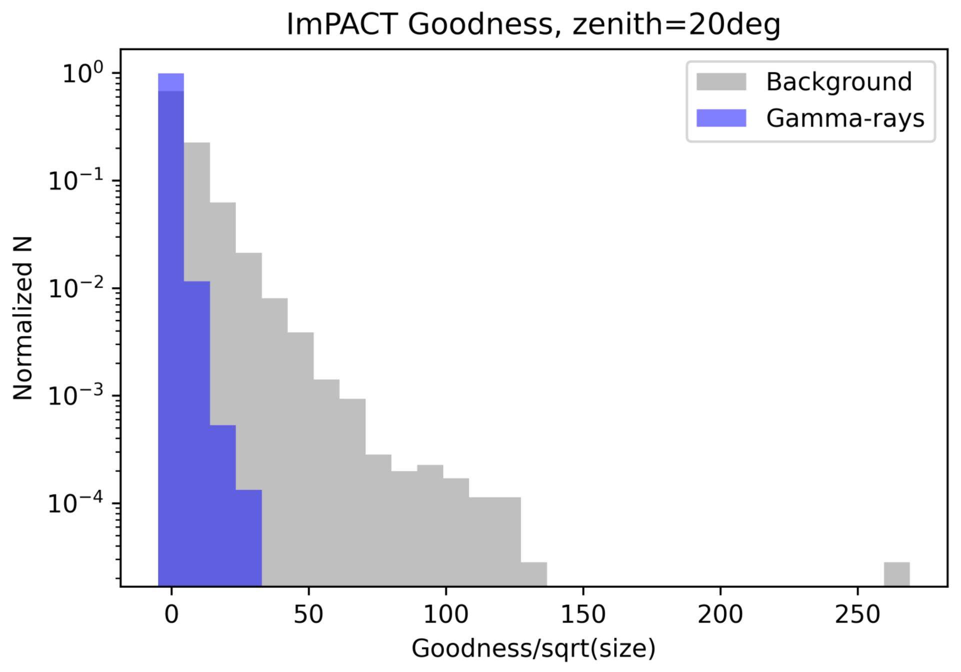

Figure 3: Distribution of the ImPACT goodness of fit for background and simulated gamma-ray events. Size in x-axis is computed as the number of pixels of the main shower image in the template.

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Performance

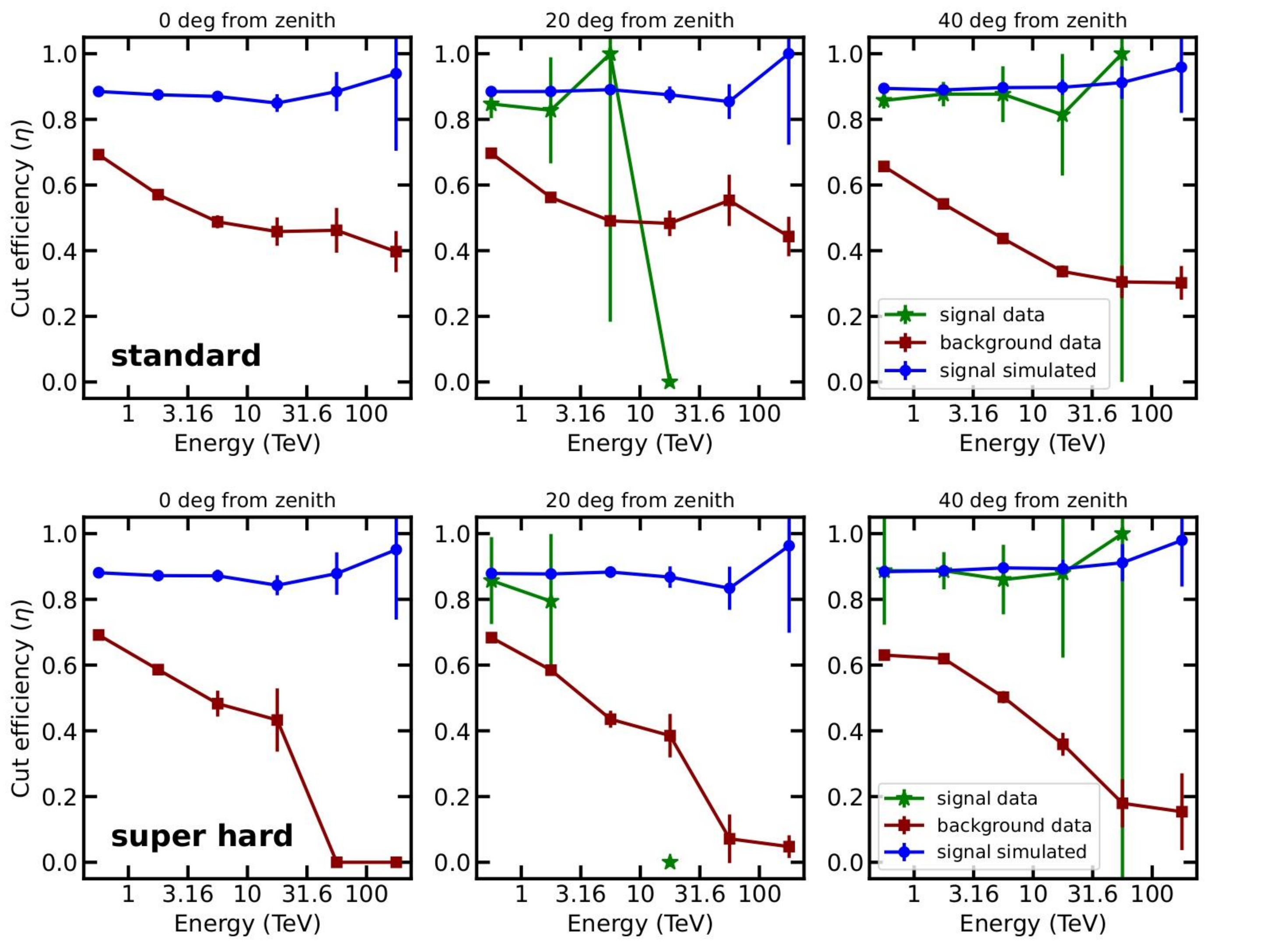

Figure 4: Fraction of events kept by the ABRIR cut applied after the H.E.S.S. *standard* cuts (upper plots) and *super hard* cuts (bottom plots) for simulated gamma-rays (blue), background data from off-runs (red) and events taken from a radius of 0.2° from bright gamma-ray sources (green). H.E.S.S. standard cuts only require images to have a total intensity >60 photoelectrons (p.e.), while the *super hard* cuts require a 200 p.e. minimum.

Conclusions & Next Steps

The performance of ABRIR shows promising results at high energies above 1 TeV (paper in preparation).

Next steps will be:
- Standardise the use of ABRIR in the H.E.S.S. Analysis Package (HAP).
- Apply ABRIR algorithm to analyse high energy sources, e.g. the Galactic Centre.

References

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[3] M. Shayduk & C. Consortium. ICRC, volume 33, 3000 (2013).