Event rates of UHE photons cascading in the geomagnetic field at CTA-North

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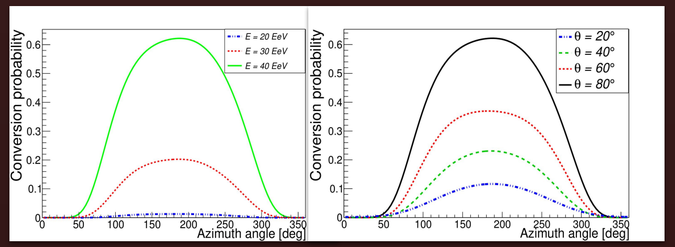
Abstract

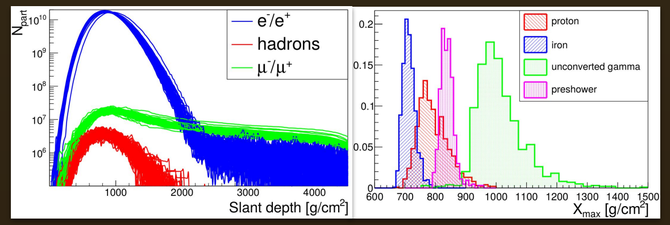
Photons in the EeV range and beyond are expected from top-down models of UHECR production and from the GZK effect. As they reach the Earth, they have a non-zero probability of converting into an electron/positron pair in the geomagnetic field and of producing an electromagnetic shower above the atmosphere. In this work, we present a new method to search for cascading UHE photons with gamma-ray telescopes based on Monte-Carlo simulations and multivariate analyses. Considering the future CTA-North experiment in La Palma, Spain, we show that such a method provides an efficient cosmic-ray background rejection with little loss of cascading UHE photon events. We also estimate that if gamma-ray bursts photon emission extends to the EeV regime, the number of expected events in 30 hours of observation time can go up to 0.17.

I - The *PRESHOWER* Effect



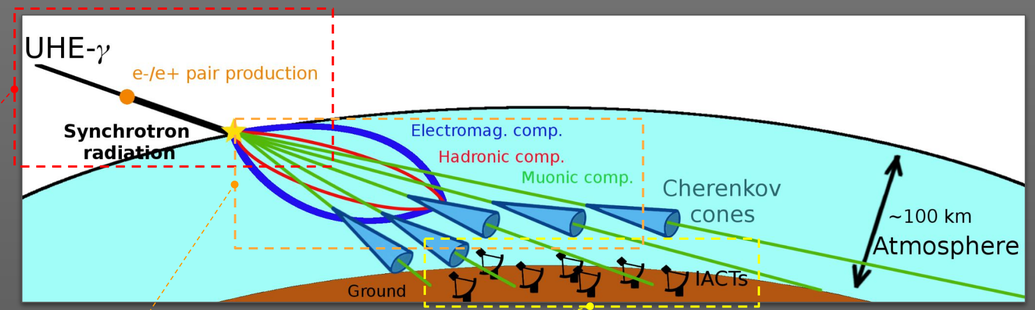
- @ CTA-North: maximum conversion for nearly-horizontal directions, in the northern direction.
- Large number of UHE particles contained within few square centimeters at the top of the atmosphere.

II - Extensive Air Showers with *CORSIKA*

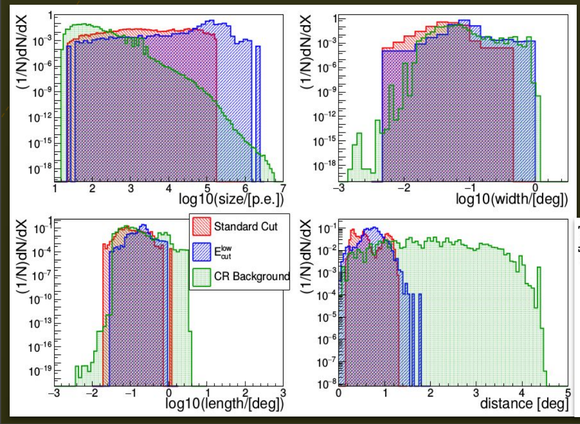


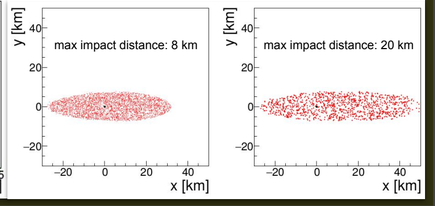
- Looking at nearly-horizontal air showers exposes the **muonic component** and a good gamma/hadron separation is retrieved at ultra-high energies.
- X_{max} of preshower events closer to X_{max} of hadronic showers, on average.

The Simulation Chain



III - CTA-North Detectors' Response with *sim_telarray*





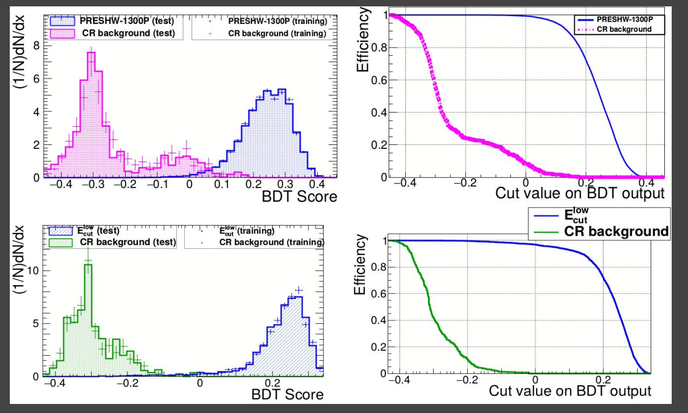
- **Hillas parameters** used to describe the images formed in the cameras.
  → High and low energy cuts tested.
- At ultra-high energy, preshower events can be detected several **tens of kilometers away from the detectors** (bottom figures).

V - Event rates from GRBs

	$\text{AUGER}_{\text{point}}$	$\langle \text{TA}_{E>31.6\,\text{EeV}} \rangle$	$\max(\text{TA}_{E>31.6\,\text{EeV}})$
$\phi_{\gamma-\text{p.}}$ (40 EeV) [$\text{km}^{-2}\text{yr}^{-1}$]	0.034	0.0073	0.019
N_{preshw} − non-transient ($R = 1$)	2.7×10^{-4}	5.7×10^{-5}	1.5×10^{-4}
$- R = 5$	1.4×10^{-3}	2.9×10^{-4}	7.6×10^{-4}
$- R = 652$	0.17	0.037	0.09

- Flux of UHE photons obtained from **upper limits** set by Auger and TA on point sources.
- *R*: boosting factor of gamma-ray emission obtained from GRB observations (R=5 for HESS', R=652 for MAGIC's) compared to non-transient mode.

IV - Preshower/CR Background separation



- Boosted decision trees provide a clear separation for both high (*top panel*) and low (*bottom panel*) energy cuts.

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