Expected performance of the ALTO particle detector array designed for 200 GeV - 50 TeV gamma-ray astronomy

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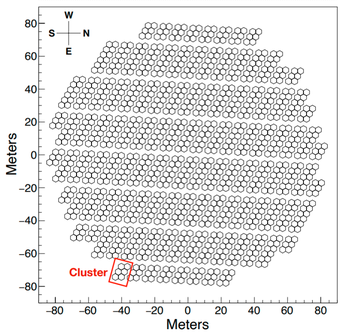
The CoMET R&D project

Science goal: Extra-galactic gamma-ray astronomy

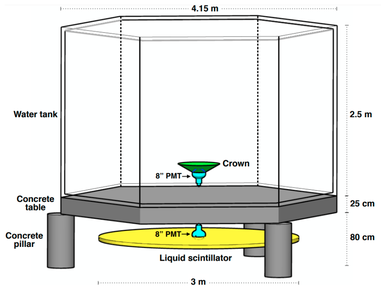
- The **Co**smic **M**ultiperspective **E**vent **T**racker (CoMET) R&D project focuses on the ground-based detection of very-high-energy (VHE) gamma rays from 200 GeV to 50 TeV
- The future observatory is planned to be established at an altitude of ~5 km a.s.l. and it has a wide FoV of ~2 sr
- The proposed design consists of,
  - an array of particle detectors (ALTO) to detect extensive air showers
  - atmospheric **C**hereknov **Li**ght **C**ollectors (CLiC)

The ALTO particle detector array for day and night observation

Array of 1242 detector units



A single detector unit



- A detector unit consists of,
  - a water Cherenkov detector filled with ~25 m^3 water
  - a liquid scintillator detector filled with ~250 L of LAB+PPO+POPOP

CLiC detectors to enhance the performance during darkness

- CLiC detectors aim to provide independent information by detecting the atmospheric Cherenkov photons during darkness

See the contribution by **Gašper Kukec Mezek** at this conference [1]

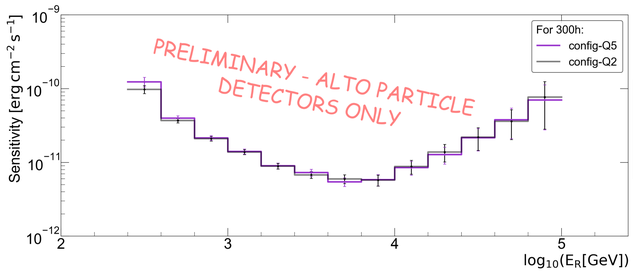
- By combining the CLiC detectors with ALTO in the simulation studies, we noticed the improvements in background suppression, angular and energy resolution

Expected performance of the ALTO particle detectors

The workflow of the simulation studies

CORSIKA air shower simulation → GEANT4 detector simulation → Shower parameters recontruction → The SEMLA analysis [2] → Sensitivity calculation

- CORSIKA air shower simulation: Point-like γ-ray at 18° zenith angle & diffuse protons
- GEANT4 detector simulation: The PMT response generation
- Shower parameters recontruction: The NKG and hyperbolic shower-front fit; analysis configuration: Q5, Q2 defined
- The SEMLA analysis [2]: Golden event selection and energy reconstruction



Expected spectral response for point-like VHE gamma-ray sources

VHE gamma-ray source	Approximate time to reach a 5-σ detection for config-Q2
GRB 180720B *	~ 38 seconds
PKS 2155-304 flare	~ 24 minutes
GRB 190114C	~ 31 minutes
Crab Nebula	~ 17 hours
PG 1553+113 flare	~ 21 days
PKS 2155-304 quiescent	~ 33 days

*** Extrapolated to the time of Gamma-ray Burst (GRB) alert**

Acknowledgements: https://alto-gamma-ray-observatory.org/acknowledgements/

The ALTO prototype at LnU, Sweden

The ALTO prototype consists of,
- two detector units
- several small independent scintillator detectors for monitoring the detector units
- slow-control and DAQ systems

Summary & Conclusions

From the proposed particle detector array design and based on the simulation studies, we learnt that

- ALTO could resolve a point gamma-ray source to ~0.8° at 300 GeV and this improves to ~0.15° at 20 TeV
- ALTO would be able to detect extra-galactic transients such as GRBs in timescale of seconds and thus it can act as a transient alert-system

The study concludes that the ALTO particle detector array is promising for the purpose of extra-galactic VHE gamma-ray astronomy.

Additionally, the prototype activities are providing various technical experiences which enable us to develop the full ALTO particle detector array for the final deployment.

References

[1] Gašper Kukec Mezek et al.,The CoMET multiperspective event tracker for wide field-of-view gamma-ray astronomy, at this conference

[2] M. Senniappan et al.,Signal extraction in atmospheric shower arrays designed for 200 GeV − 50TeV γ-ray astronomy, accepted by JINST [astro-ph.IM/2105.06728]