Observing the sky continuously at extreme photon energies with ALTO/CoMET

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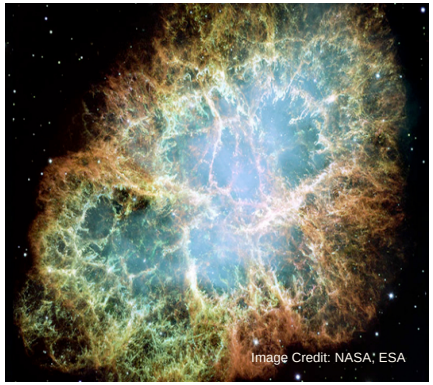
Partikledagarna - 3rd Oct 2019 - Linköping

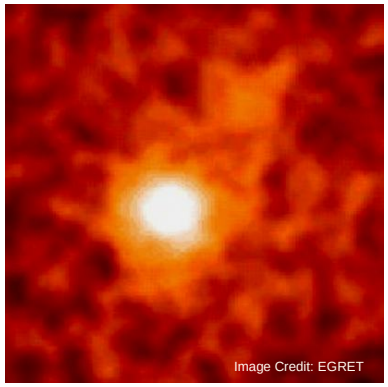
The Energetic Universe

- Very high energy photons: 100 GeV to 100 TeV.
- Unlike Cosmic rays, γ-rays travel rectilinearly in the Universe.
- Helps to understand particle acceleration in extreme environments like AGN jets, accretion disks, supernova remnant etc.,
- Also to test Lorentz-Invariance Violation and effects of axion-like particles.



Crab Nebula

Cen A



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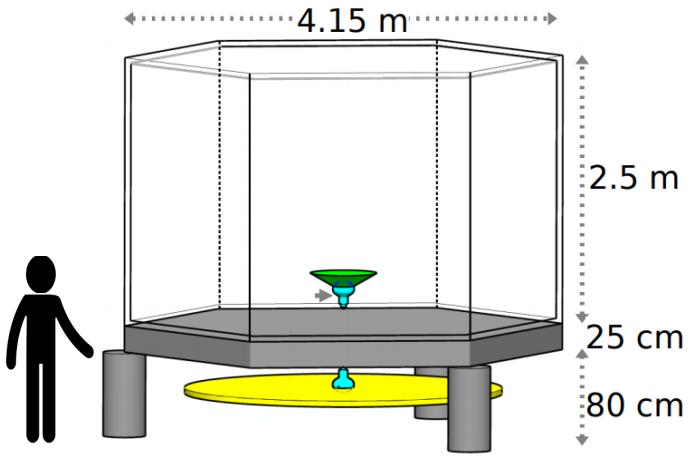
The ALTO Observatory

ALTO is a future ground-based very high energy gamma-ray observatory based on water Cherenkov technique. The key features include,

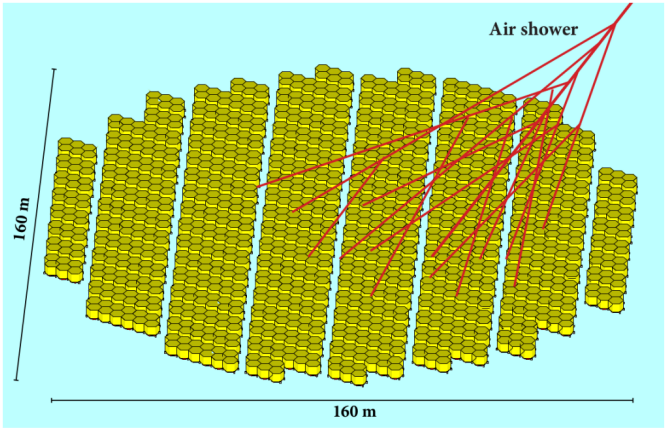
• In the Southern hemisphere	→ Daily observations of Southern sources
• Continuous Monitoring	→ Observations may be done **24h per day**
• At high altitude (> 4 km)	→ Low threshold E ≥ 200 GeV
• Wide field of view	→ ~2 steradian
• Hybrid detectors	→ Improved S/B discrimination
• Excellent timing accuracy	→ Improved ang. resolution(~ 0.1° at few TeV)
• Modular design	→ Phased construction and easy maintenance
• Simple to construct	→ Minimize human intervention at high-altitude
• Long duration experiment	→ Should operate for 30 years
• Open Observatory	→ Distribute data to the community

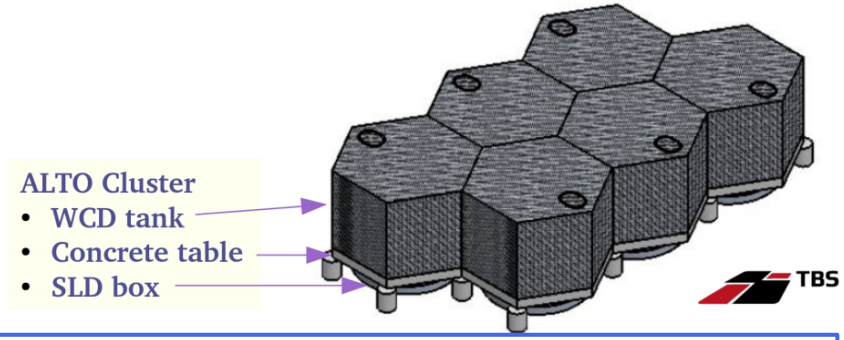
Planned ALTO Detector Design

A unit of water Cherenkov detector with Scintillator base



An array of 1242 units



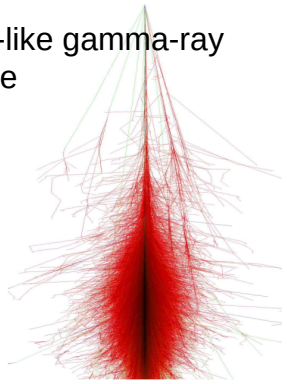


A cluster of 6 units

Summary of Monte Carlo Simulation & Analysis

Corsika – Shower Generation

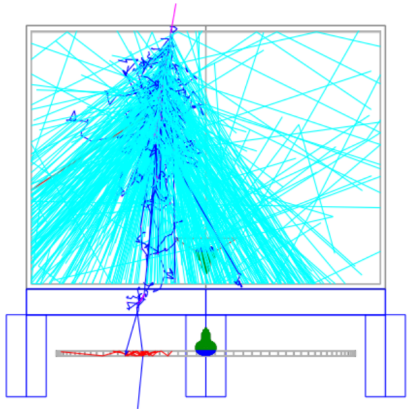
Point-like gamma-ray source



Diffuse cosmic-ray proton

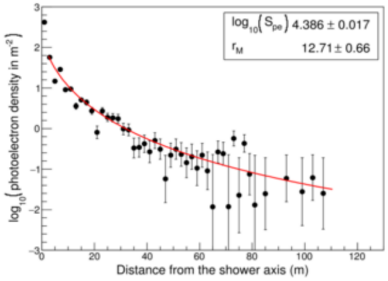
GEANT4

Detector geometry & response



Shower reconstruction

Iterative procedure between the NKG lateral-distribution fit and the particle-front timing fit.

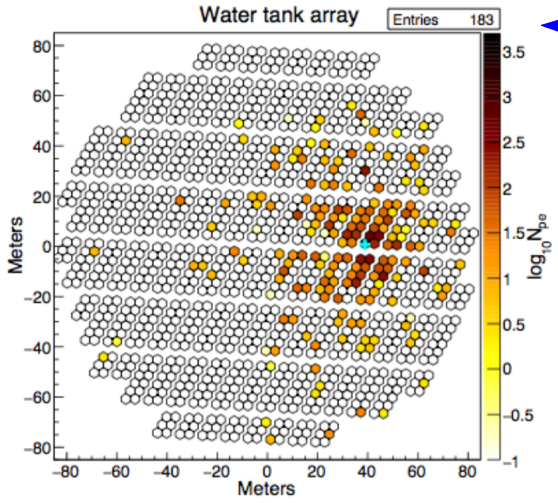


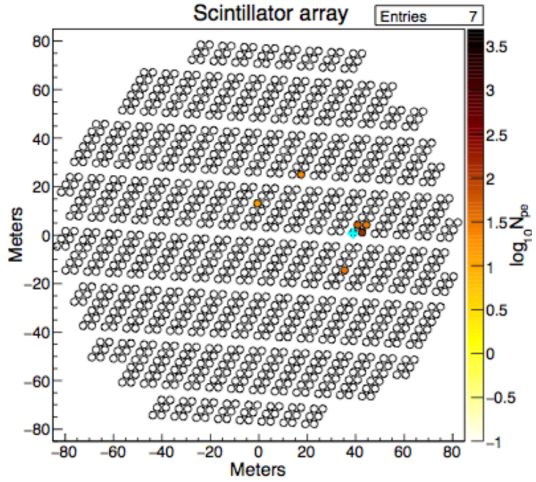
… follows **S/B background discrimination**.

Signal over Background Discrimination

gamma-rays

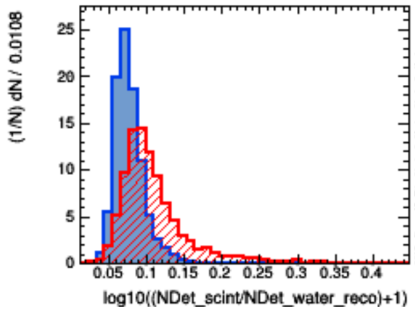
protons





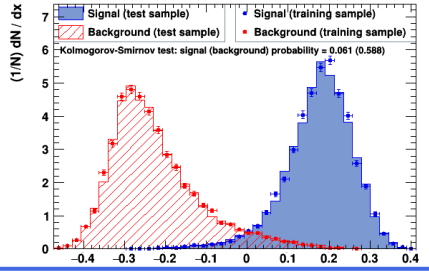
Defining variables

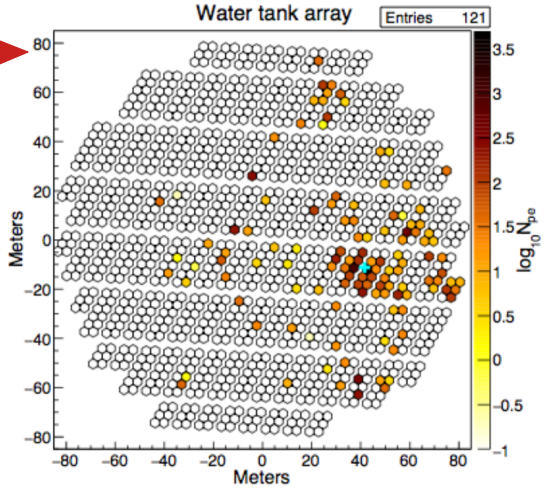
Eg., ratio of no. of water tanks hit to no. of scintillator hits.

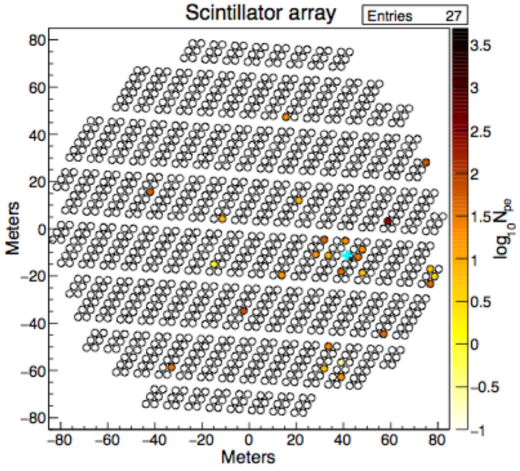


BDT Classifier output

The best variables are analyzed using Multi Variate Analysis (MVA) – Boosted Decision Trees (BDT) in four different energy bins.

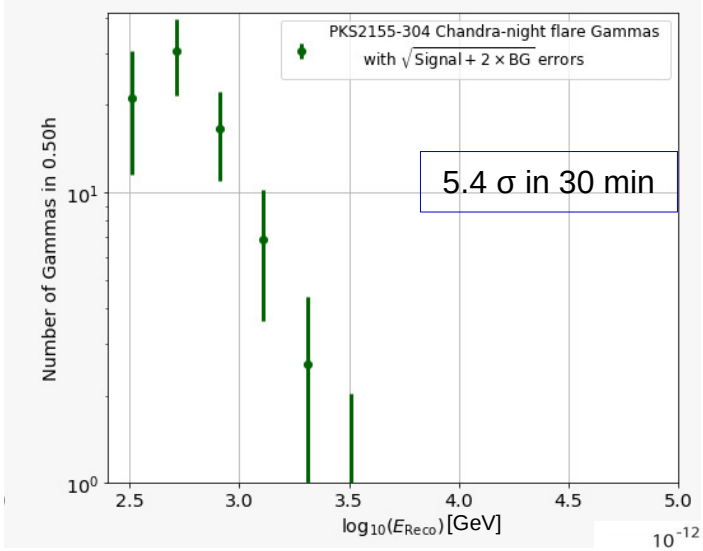




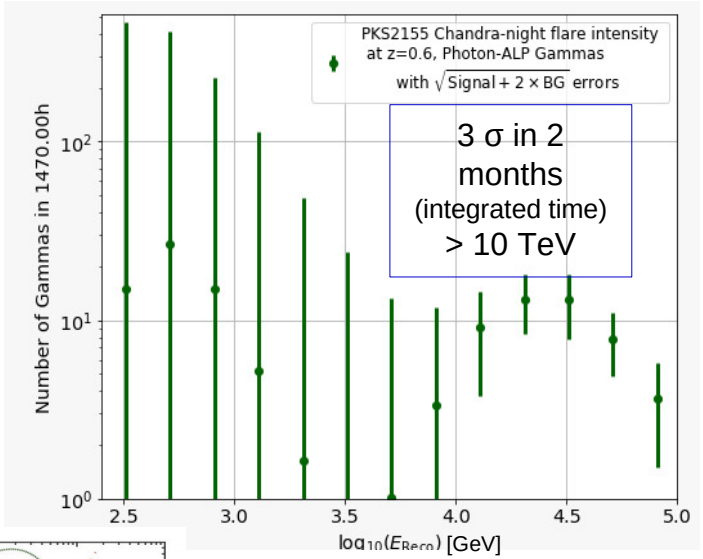


ALTO performance plots

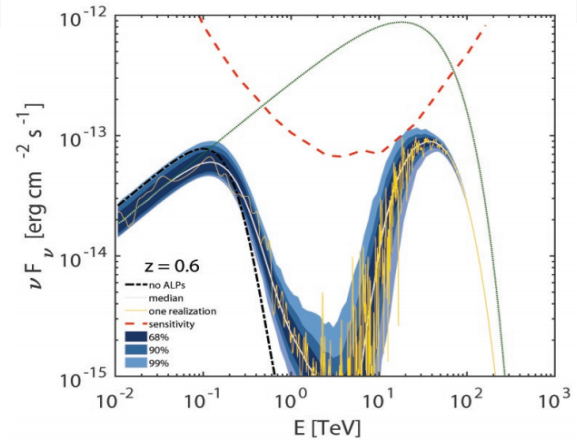
PKS 2155-304 at z = 0.116 in flaring state



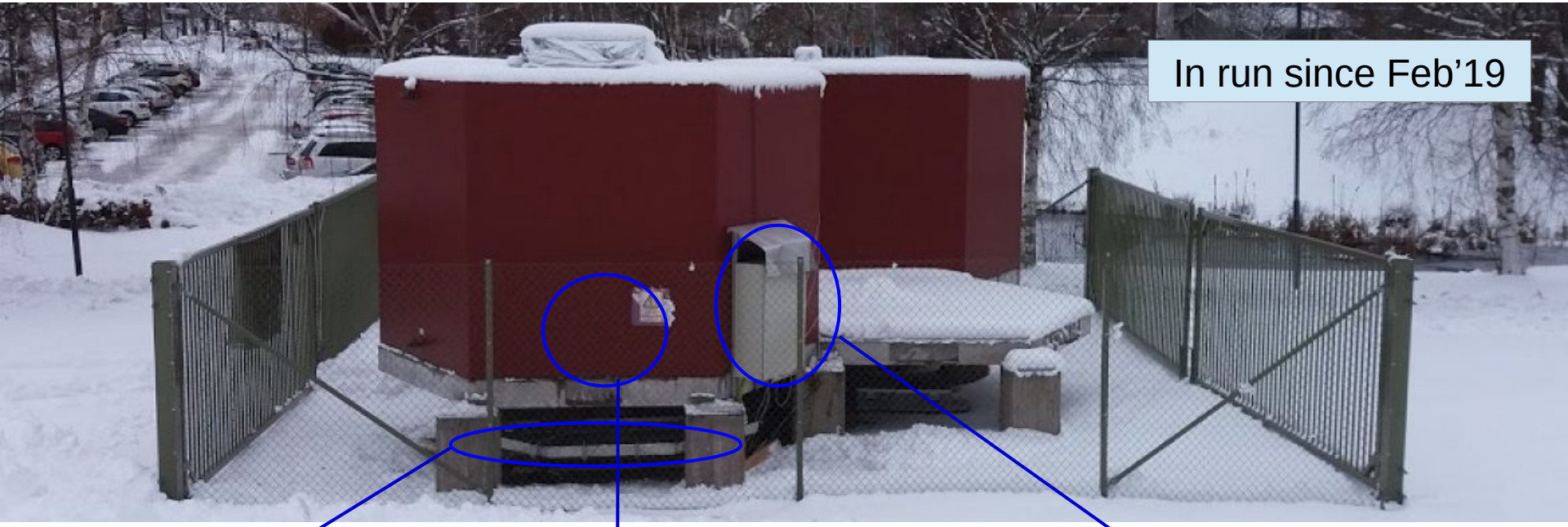
A BL Lac at z = 0.6 in flaring state viewed through galactic plane



G. Galanti et al. 2019
ALP Model

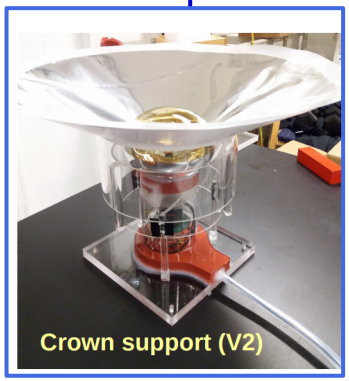


ALTO Prototype at Linnaeus University



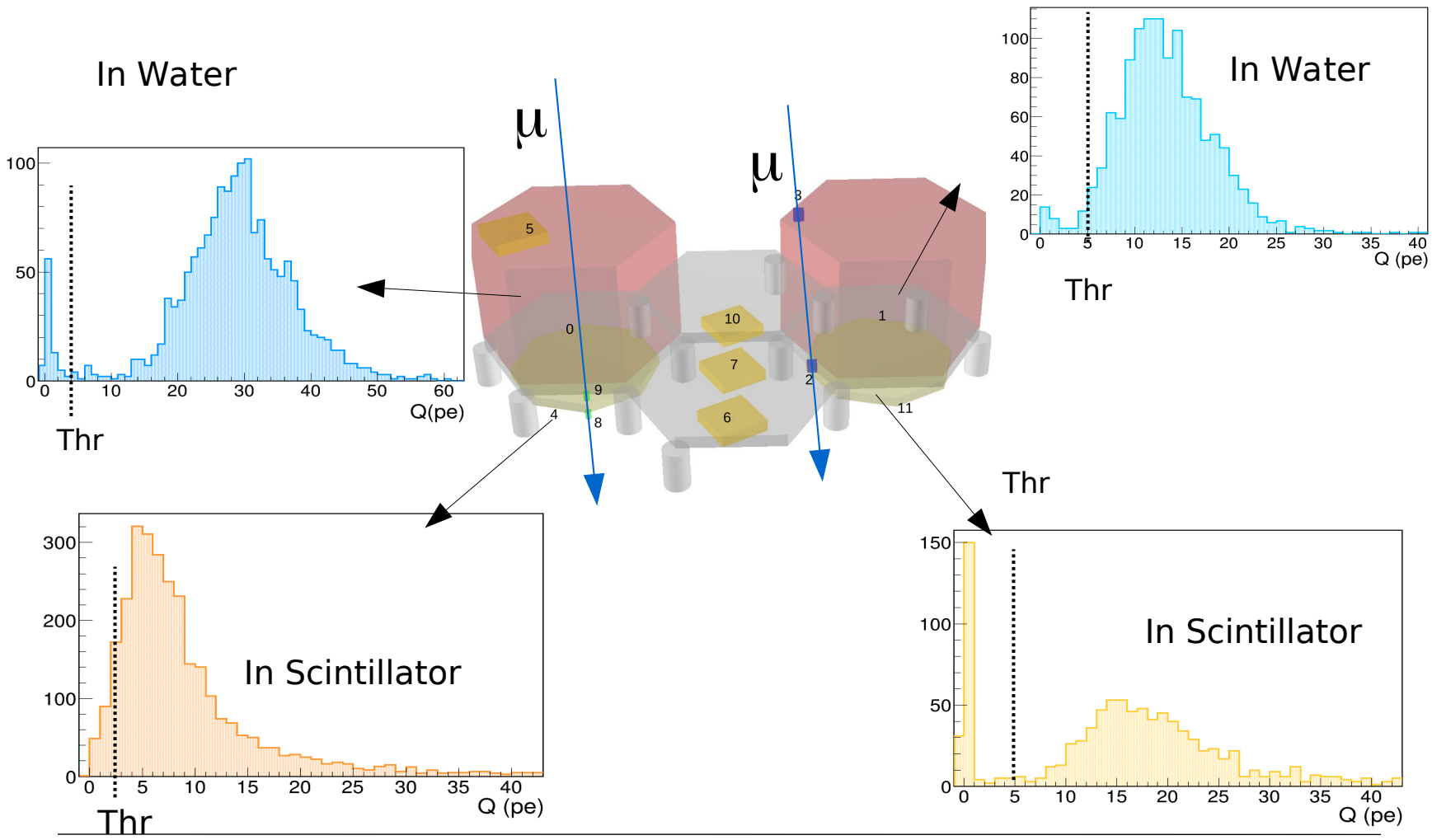
In run since Feb'19

Al scintillator tanks filled with Linear Alkylbenzene + POPOP + PPO



On site electronics

Monitoring


In Water
Thr
Q(pe)
μ
μ
In Water
Thr
Q (pe)
Thr
In Scintillator
Thr
Q (pe)
Thr
In Scintillator
Q (pe)

Future Steps of ALTO

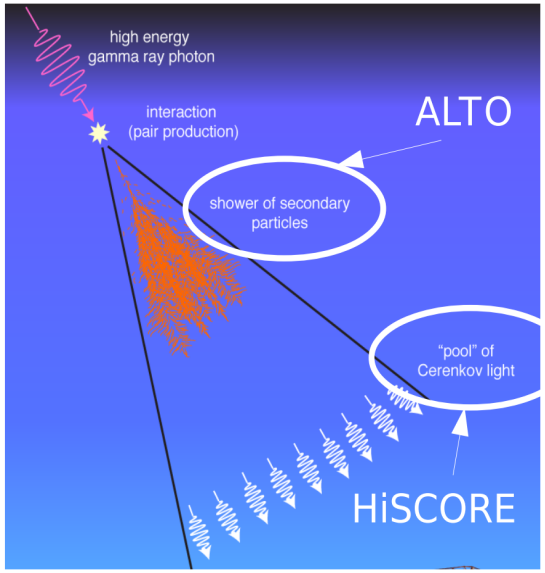
- Completion of the current simulations.
- Continuous monitoring of the prototype and installation of two new Buwa tanks – a cheaper industrial solution in steel.

- A cluster installation on site in Peru/Argentina.
- We will be happy to welcome new interested collaborators from Sweden .

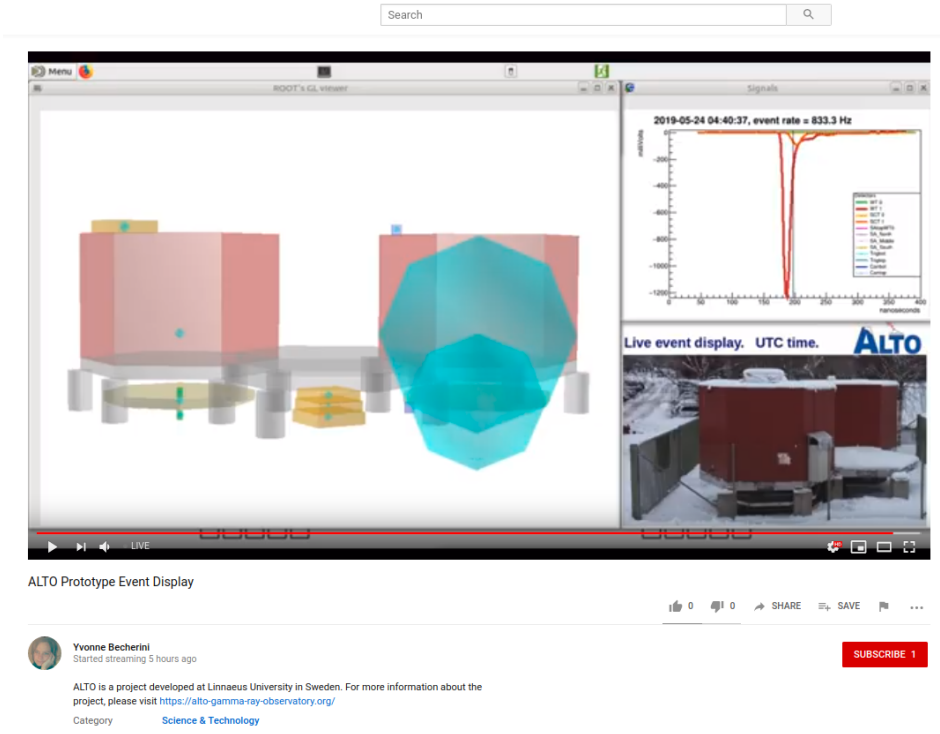
Future Steps of ALTO - CoMET

Idea: enhance the sensitivity of ALTO during darkness with HiSCORE.

- First observations with ALTO and mini-HiSCORE stations at Linnaeus University this autumn during darkness, beginning from the end of October.
- Weather Station installed on top of a tank for monitoring the sky quality
- First simulations of CoMET on the ALTO full array to start this autumn.



Live Event Display in YouTube



Live Stream Link

Follow our blog in, alto-gamma-ray-observatory.org for future updates.

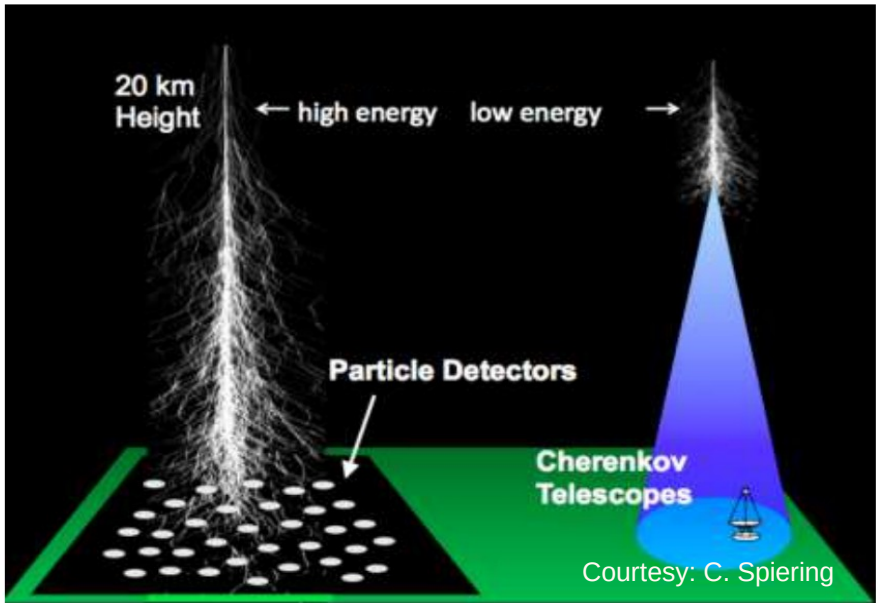
Thank you for your attention

BACKUP SLIDES

Backup slide: VHE Gamma-ray Astronomy

VHE γ-rays in Atmosphere

- Pair production and Bremsstrahlung radiation generates cascade of e^+, e^- and γ-rays leads to air shower.

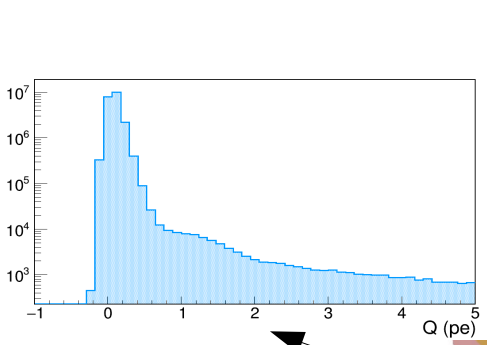


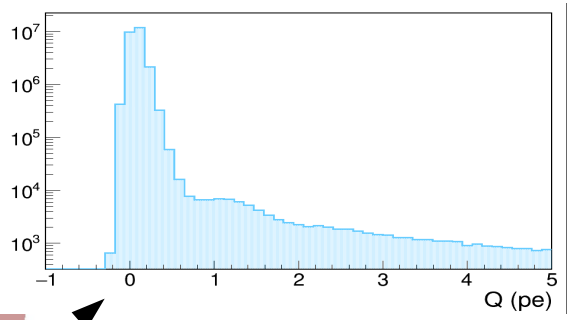
Ground based observation

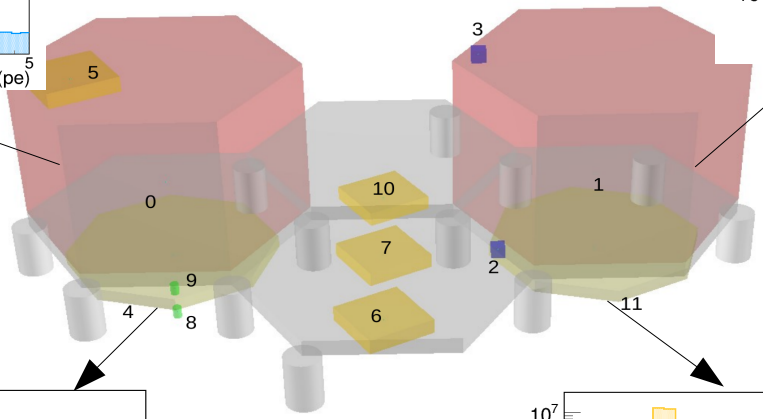
- Air Cherenkov Telescopes – H.E.S.S., MAGIC, VERITAS
- Particle Detectors – ALTO, LHAASO, HAWC

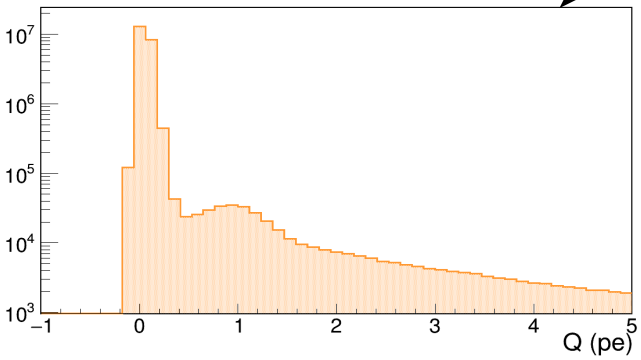
Back up slide: Charge in data

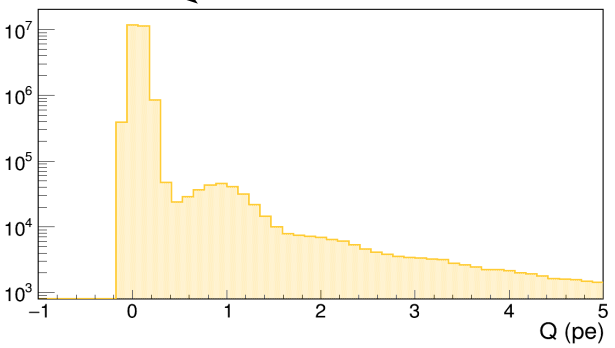
Distributions obtained when triggers originate from other channels



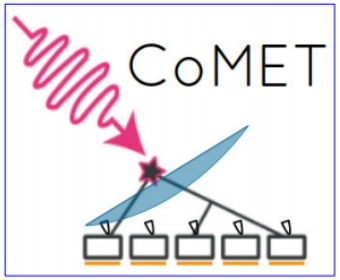








Backup slide: ALTO/CoMET



Cosmic Multiperspective Event Tracker

Among all the advantages of particle detection in gamma-ray astronomy, there are also some limits:
– The position of the shower maximum is difficult to reconstruct,
– Limited angular resolution in the low energy range.

Our new investigation channel:
– During darkness, couple the detection of the particles in the shower with the detection of Cherenkov light in the atmosphere.