ICRC2015

Design Highlights and Status of the LHAASO Project

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on behalf of the LHAASO collaboration

2015-8-3

Outline

- Introduction
- Design of the LHAASO detectors
- Engineering arrays at YBJ
- Activities at the LHAASO site
- Summary and outlook

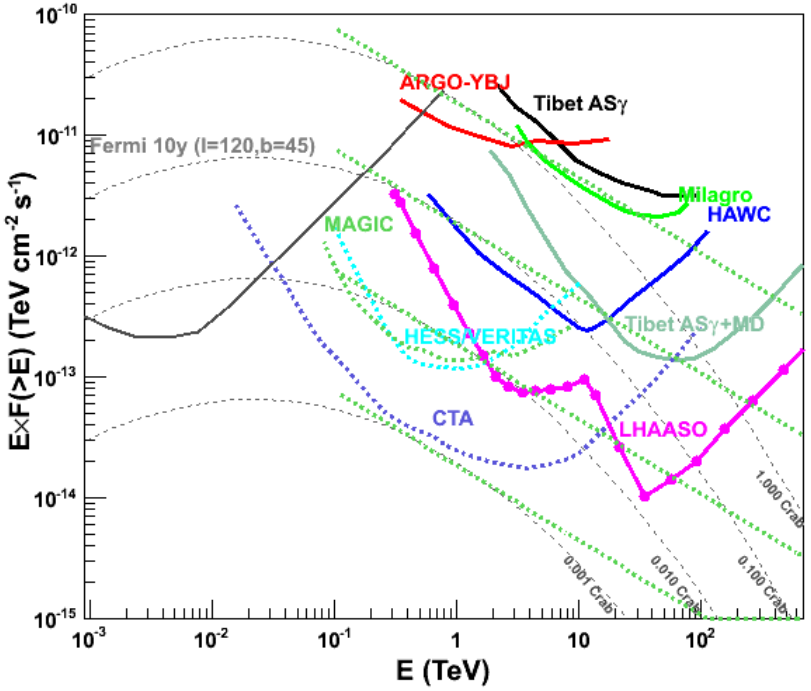
Major Scientific Goals

- **GAMMA RAY ASTRONOMY**
  - **Searching for GCR sources by measuring SED with an unprecedented sensitivity of 1% Crab unit at 50 TeV.**
  - **Searching for TeV gamma sources, especially extended and transient ones, with an unprecedented survey sensitivity of 1% Crab unit at 3TeV.**
- **COSMIC RAY PHYSICS**
  - **Energy spectra for individual compositions with energy from 10 TeV to 1 EeV, where the spectrum knees are located, by hybrid observation of showers at high altitude.**

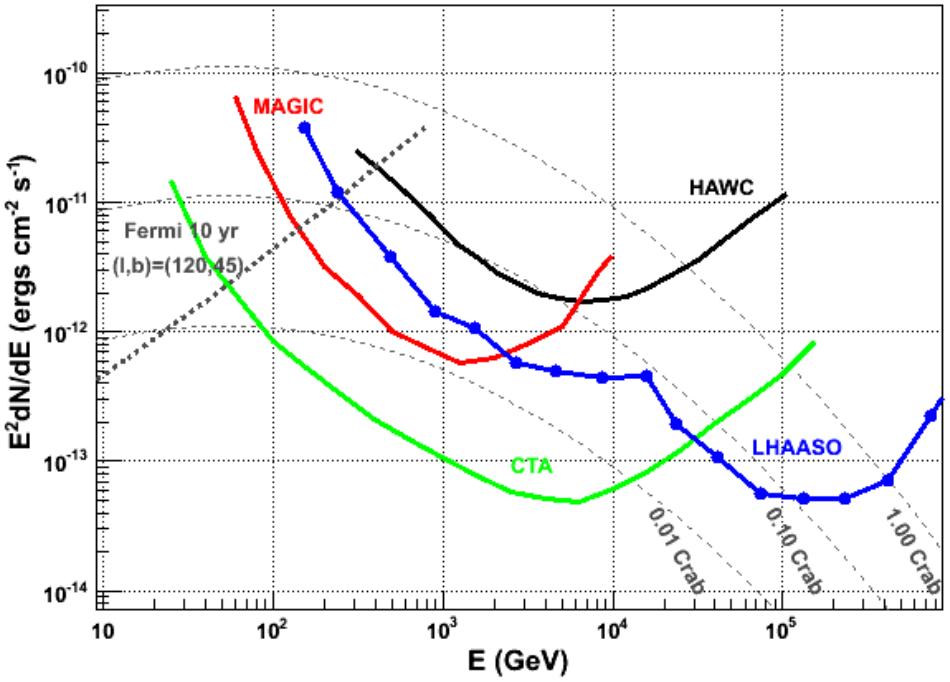
Sensitivity to gamma ray sources

- **Integral: 1% Crab unit @3TeV & 50TeV**

Integral

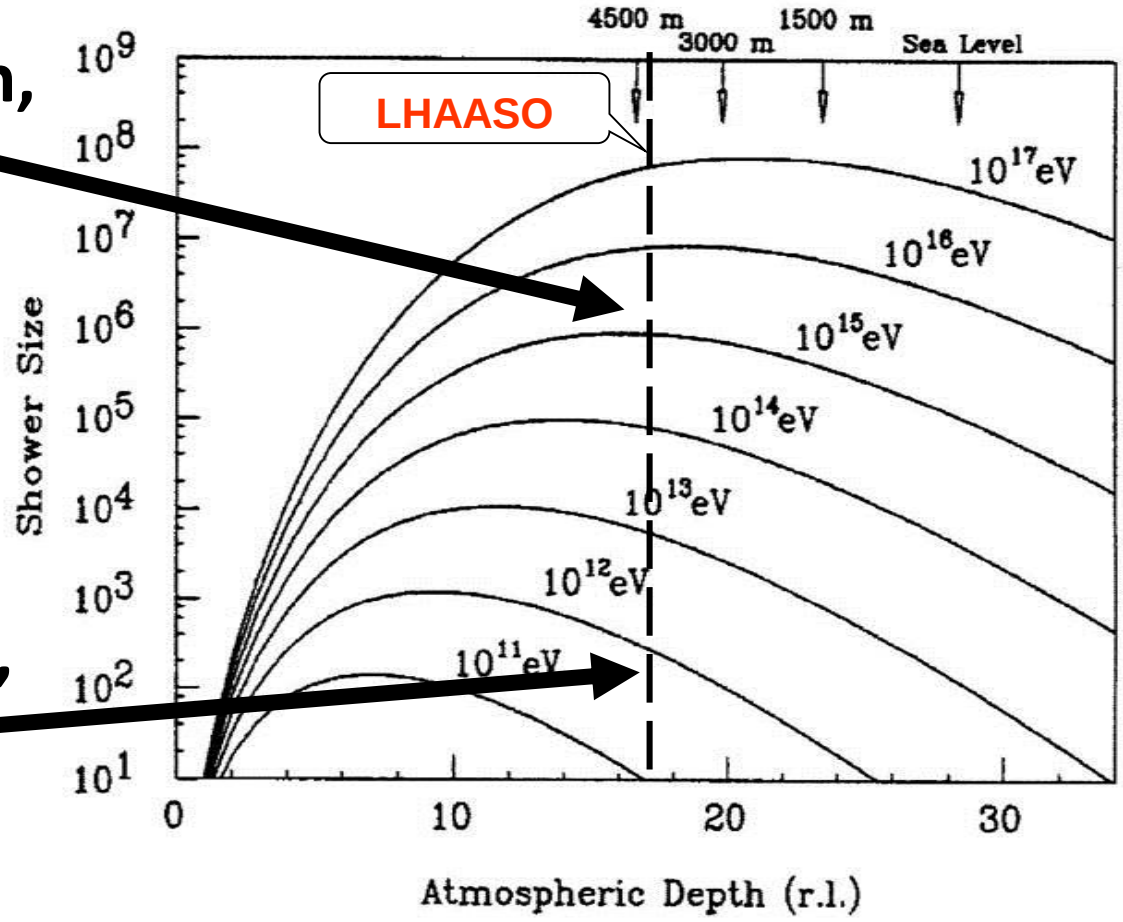


differential



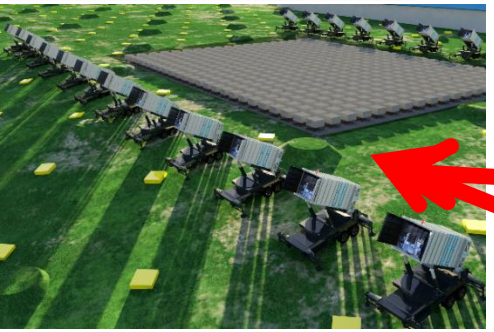
Measurement of air showers at high altitude

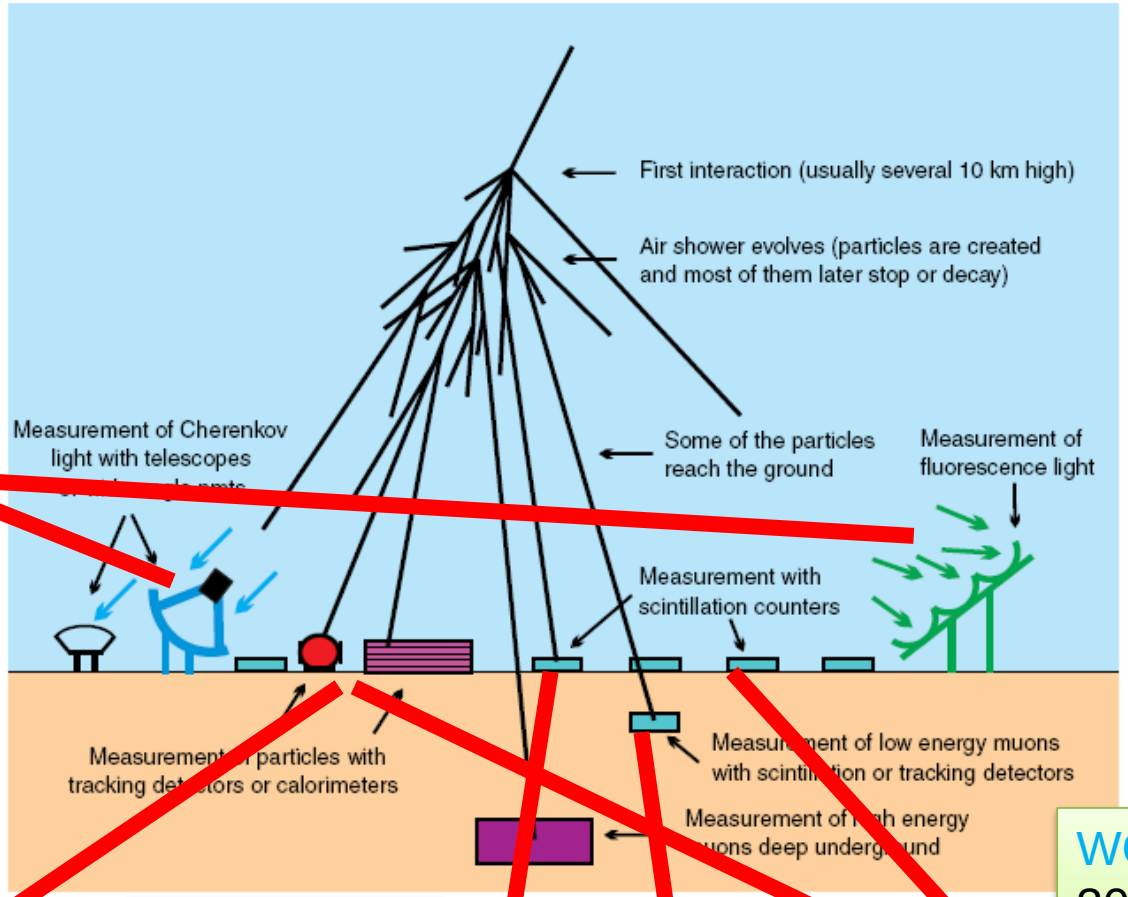
- **HE: near Xmax →lower fluctuation, better σ_E**
- **Lower E_{th} →deeper, more sources**



Hybrid Detection of Extensive Air Showers by LHAASO

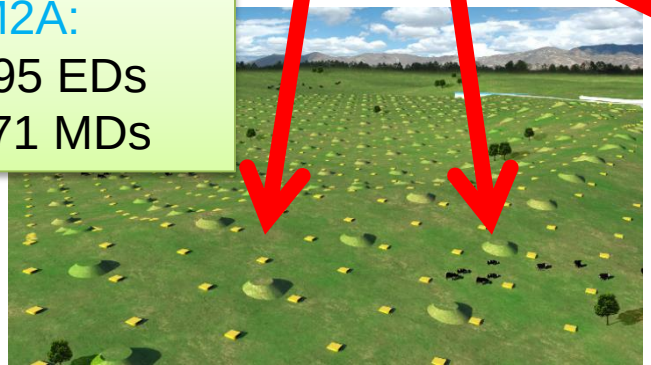
WFCTA:
12 telescopes
1024 pixels each





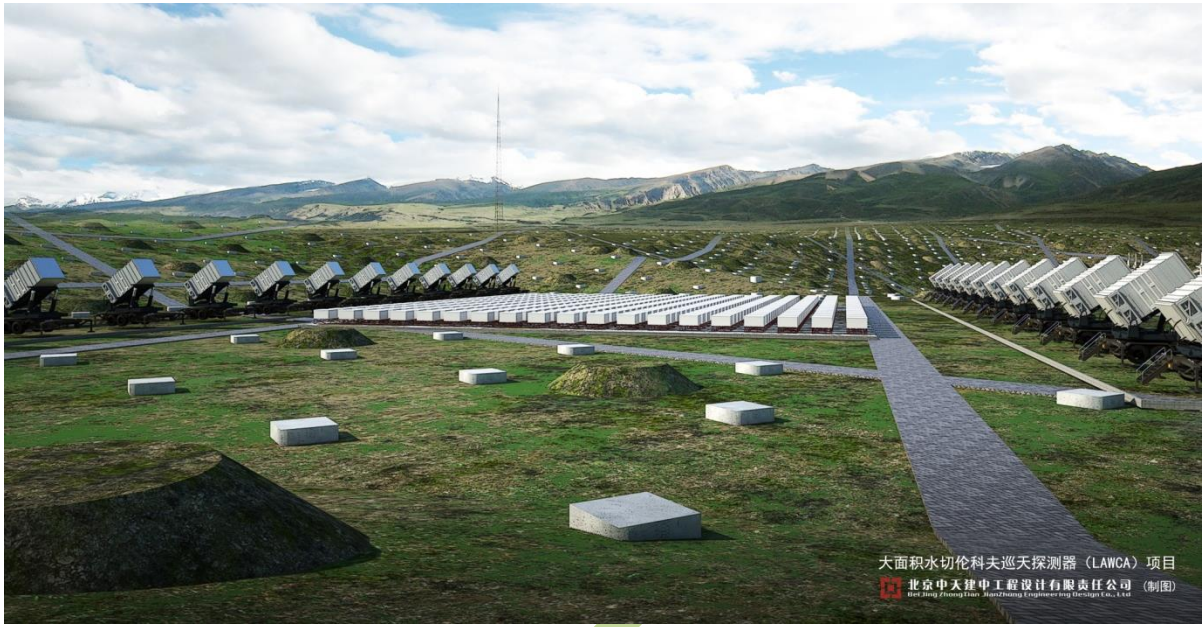
SCDA:
452 detectors

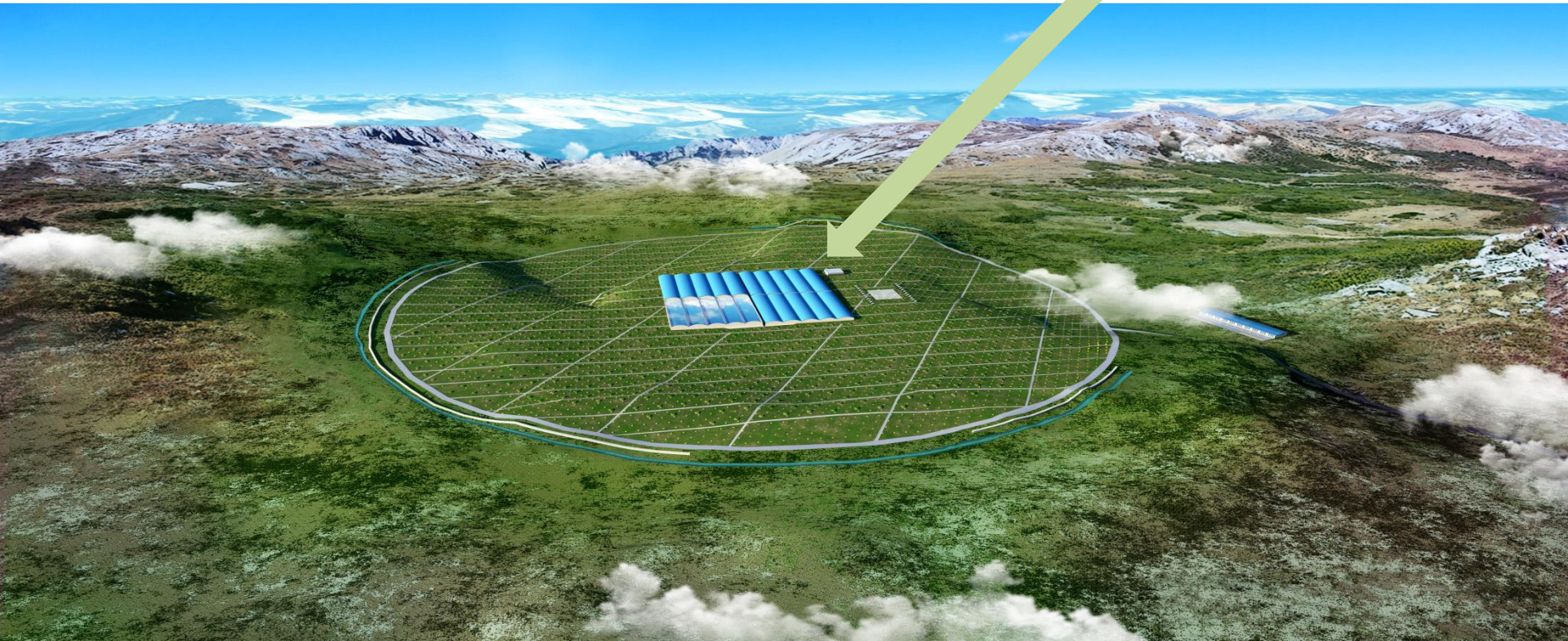
KM2A:
5195 EDs
1171 MDs



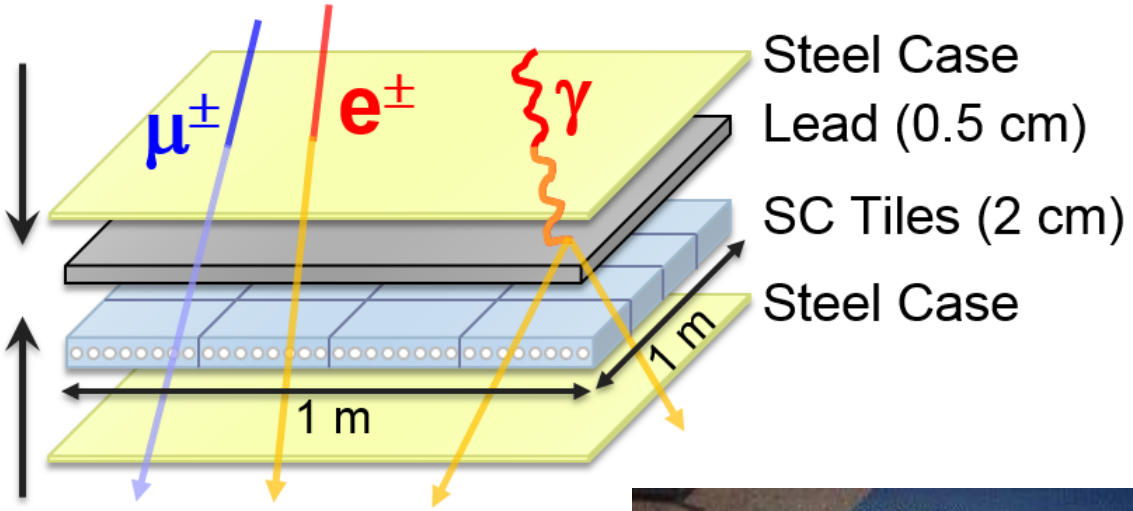
WCDA:
3000 cells

LHAASO

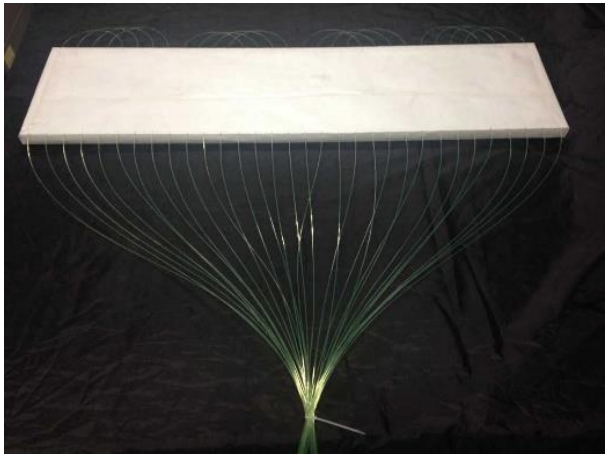

大面积水切伦科夫巡天探测器（LAWCA）项目
北京中天建中工程设计有限责任公司（制图）
BeiJing ZhongTian JianZhong Engineering Design Co., Ltd



Electromagnetic Particle Detector

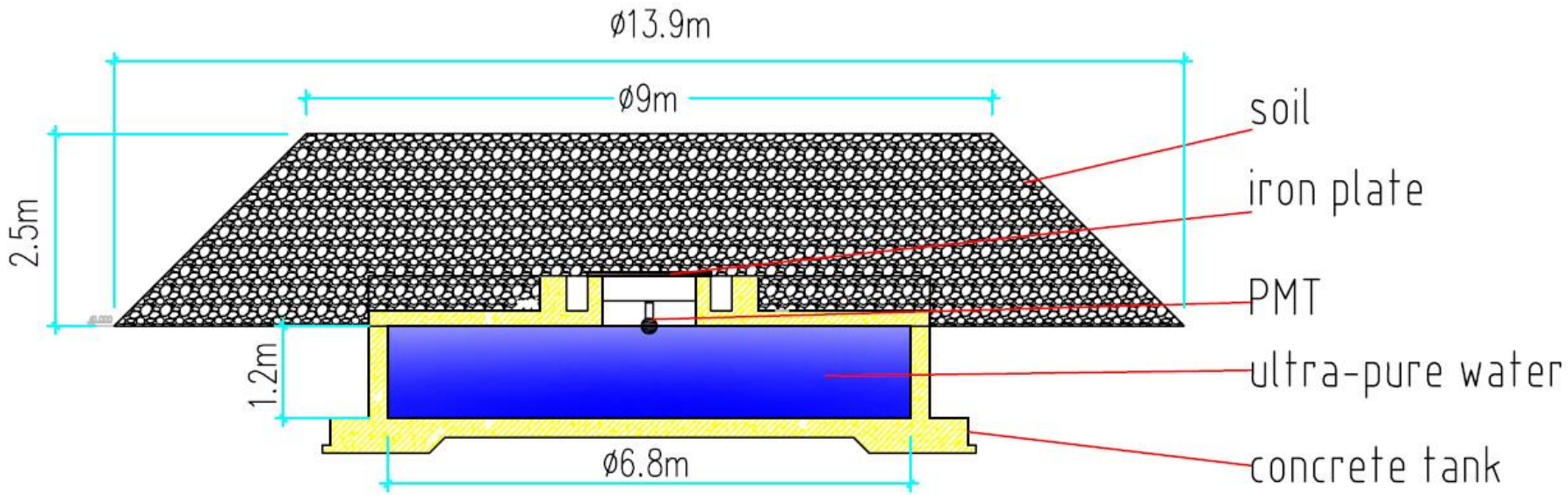


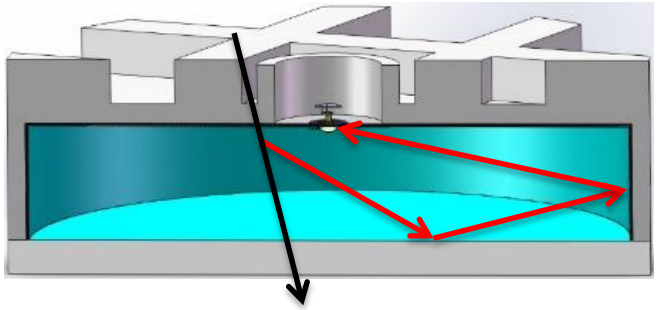
- **Uniformity for 5195 units: < 10%**
- **Stability with ±25°C: ±5%**

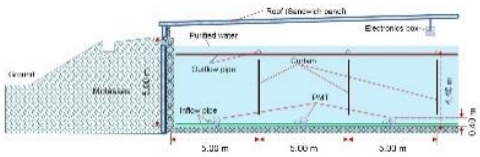


Muon Detector

- **Water Cherenkov detector underneath soil**

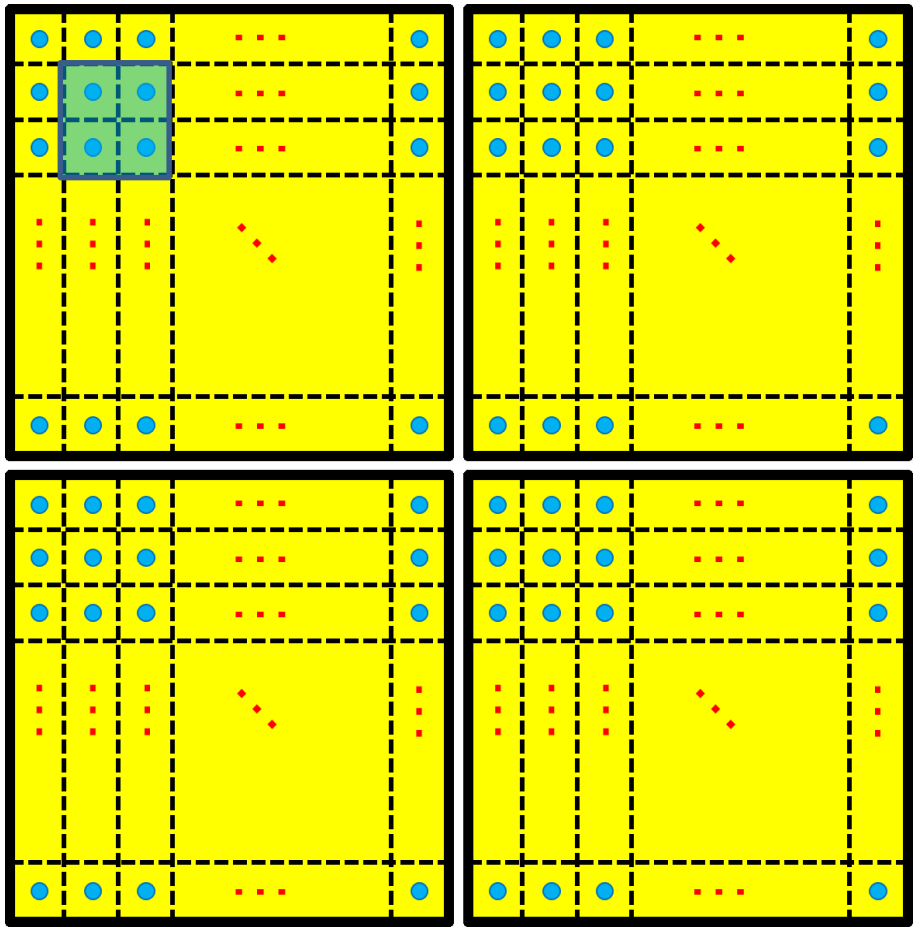


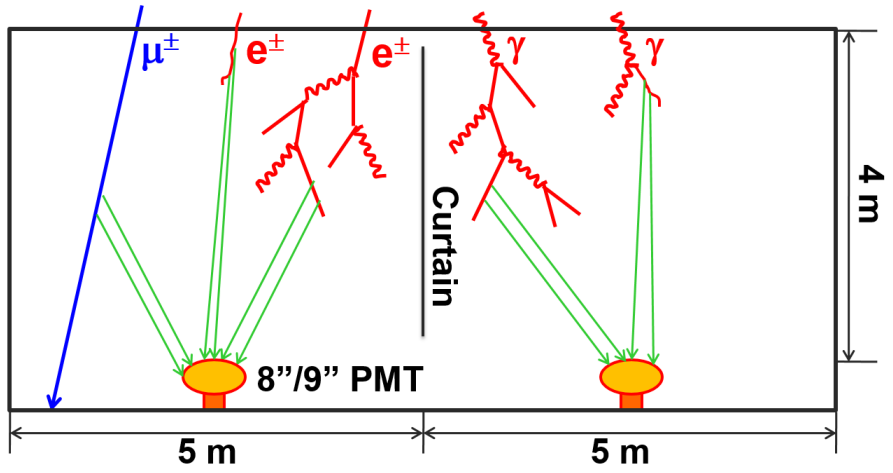


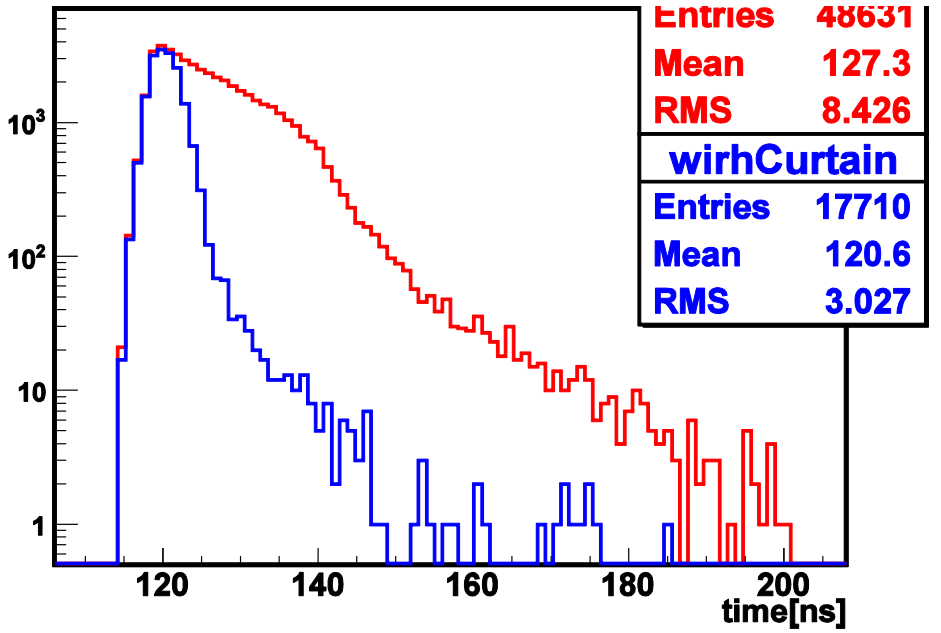


WCDA: Survey of the VHE gamma ray sky

- <1% I_{Crab} → 300m*300m

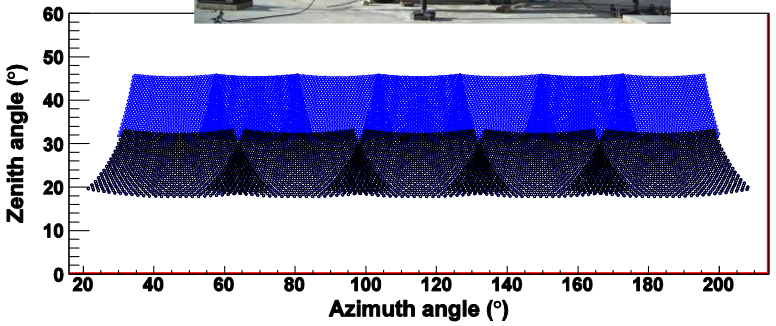


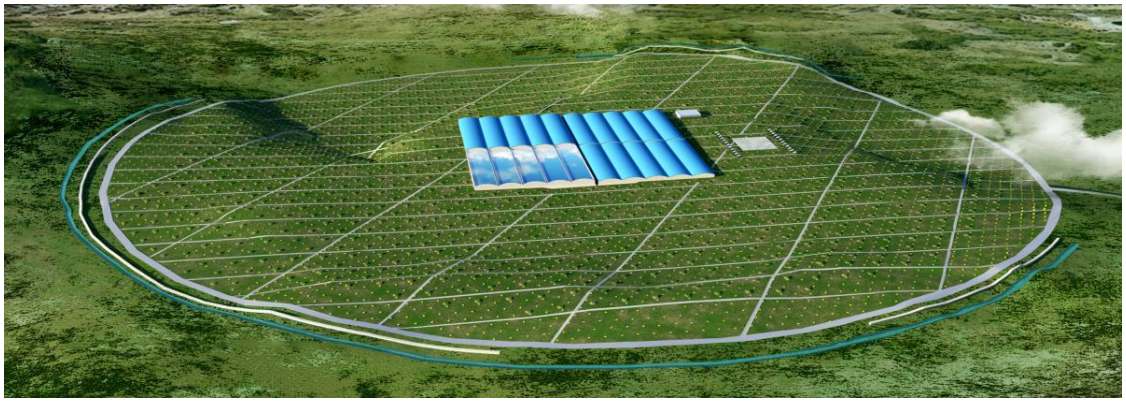


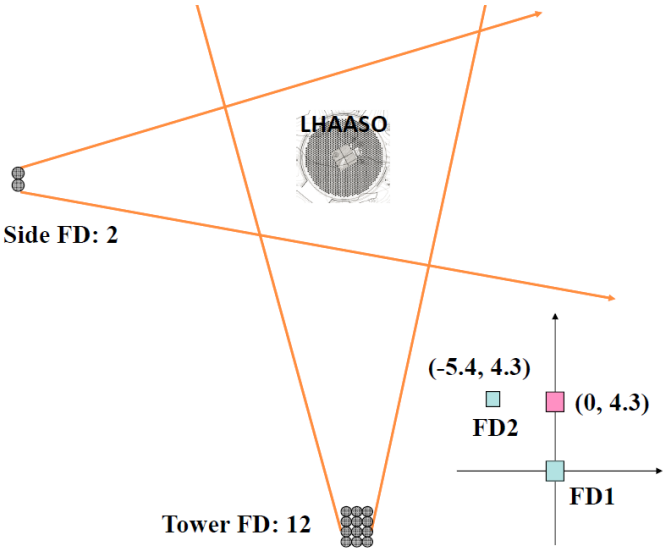


WFCTA

- 32×32 pixels, 0.5° each
- 4.7 m^2 collection area
- <10^{16} eV
- 10^{16}-10^{17} eV
- 10^{17}-10^{18} eV







LHAASO detector timing

Over 7,000 detector units
Spread around 1km^2 area

0.5° Angular resolution for shower reconstruct from *timing* of hits TOF

Synchronous timing among detectors

1000m coax cable in 30°C change, Δ delay = 15ns!

Time-stamp Synchronization

Time stamps of >7,000 nodes to be aligned <500ps (rms).

Frequency distribution & phase locking

Distribute synchronous ADC clock with <100ps skew.

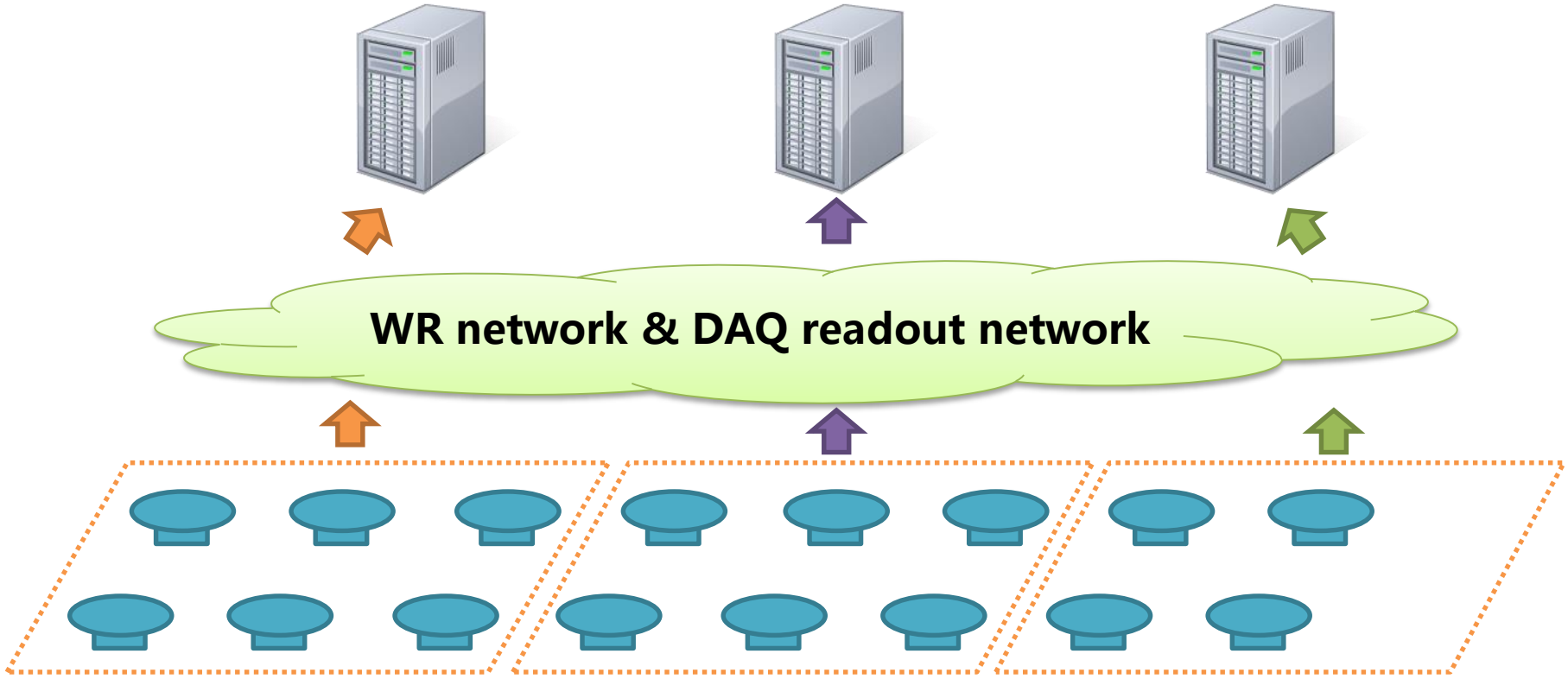
Traceability & Real-time calibration

Timing delay compensation due to environmental perturbation in hardware in real time.

“Triggerless” DAQ

---hybrid measurement of shower

- **Triggering, building, (re-construction) and storage by online computers**

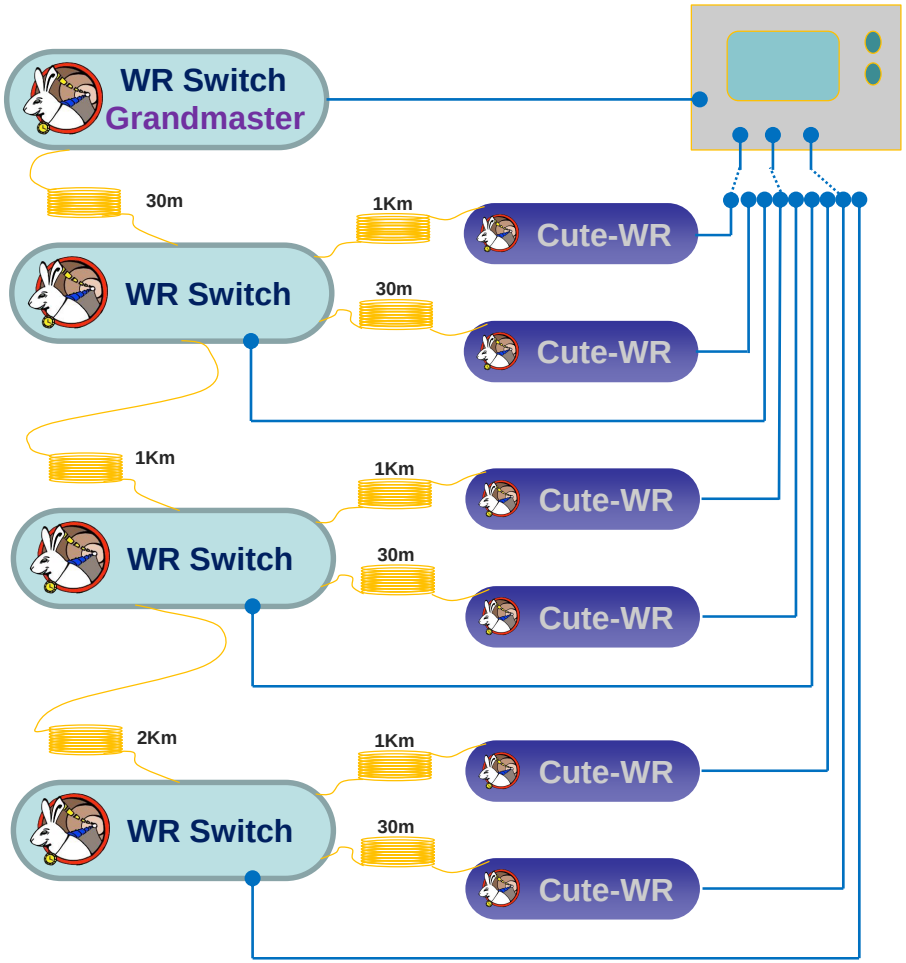


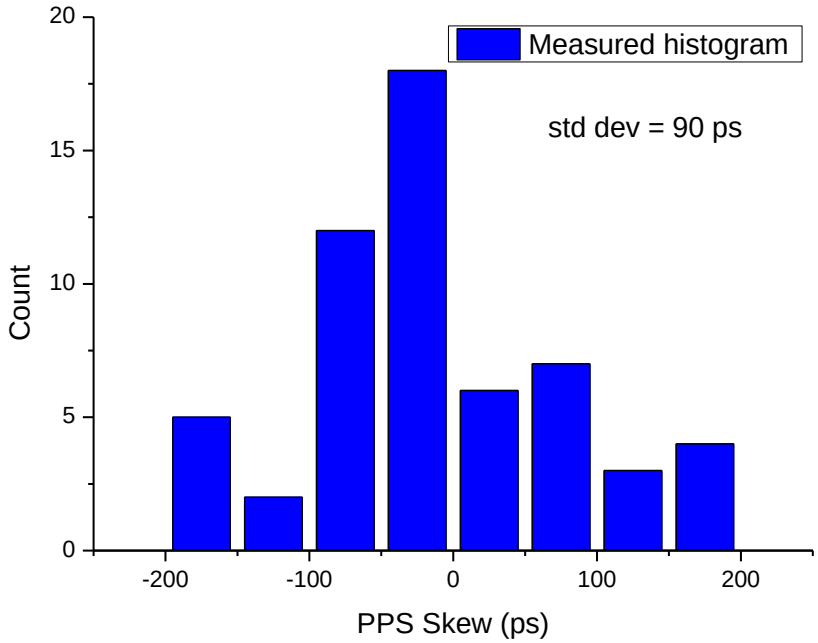
Engineering Array @ YBJ

- **~1% of LHAASO**
  - **42 EDs, 2 MDs, 9-unit WCDA, 2 telescopes, 100 shower core detectors.**
- **Fully implementing the LHAASO designs, including White-Rabbit-based clock distribution, “triggerless” DAQ, etc**
- **Has been in operation for more than 2 years.**



WR performance

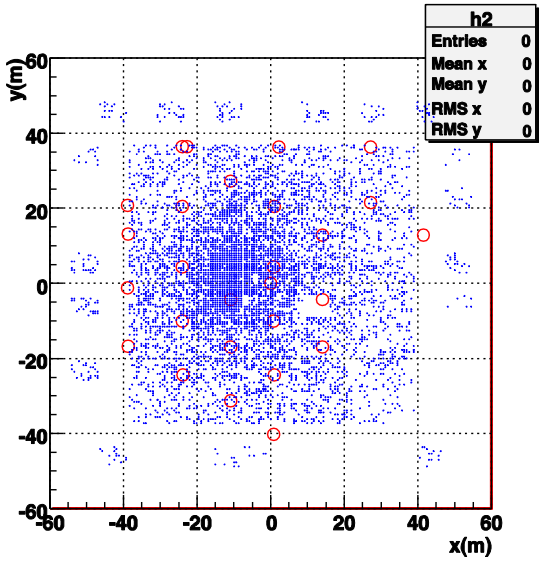


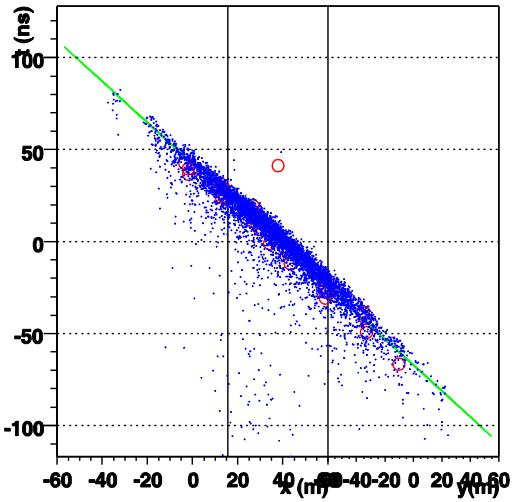


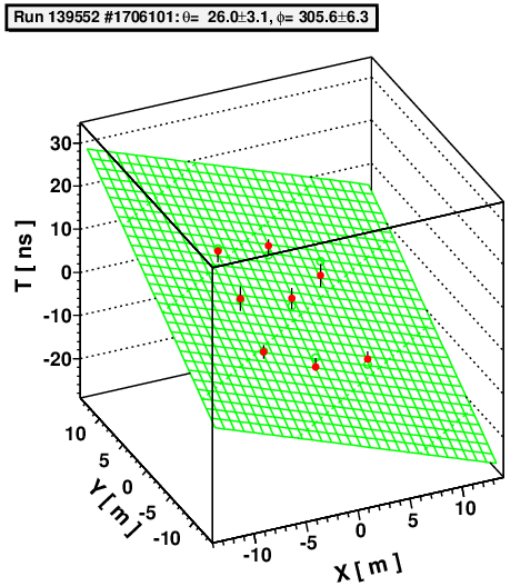
Cascade topology

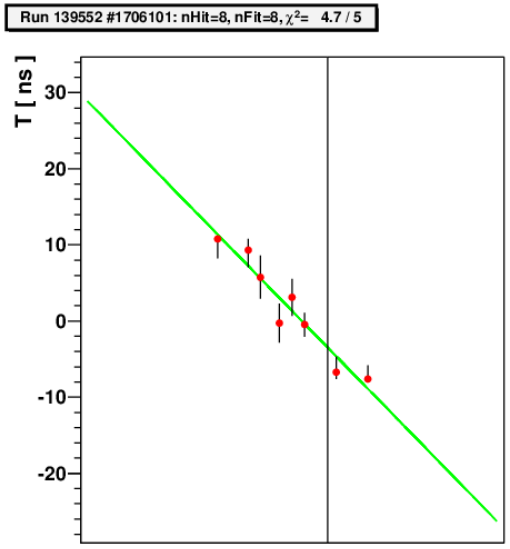
WR CERN: 1ns

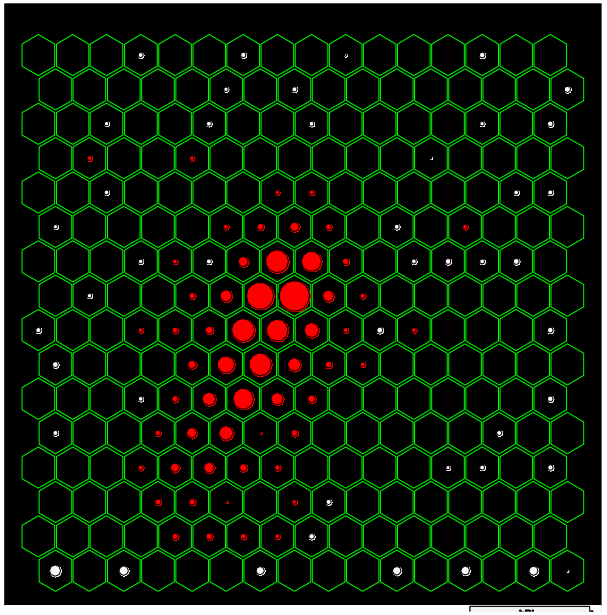
Example Showers





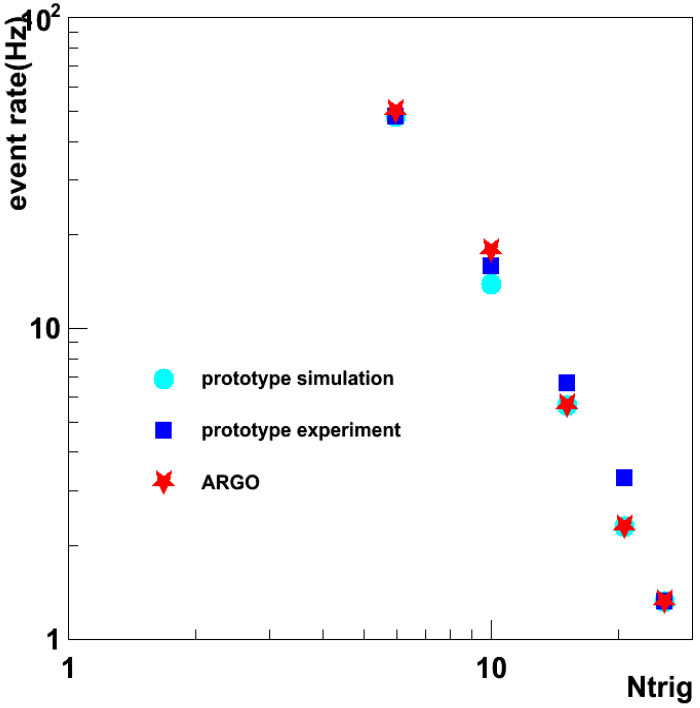


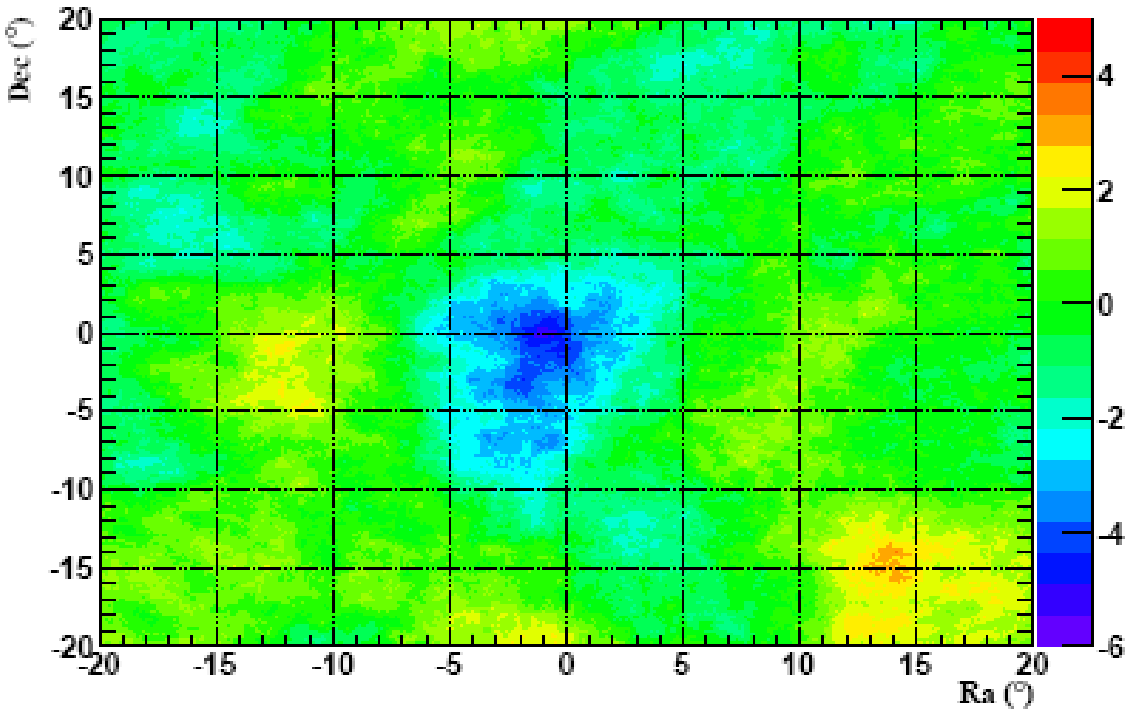




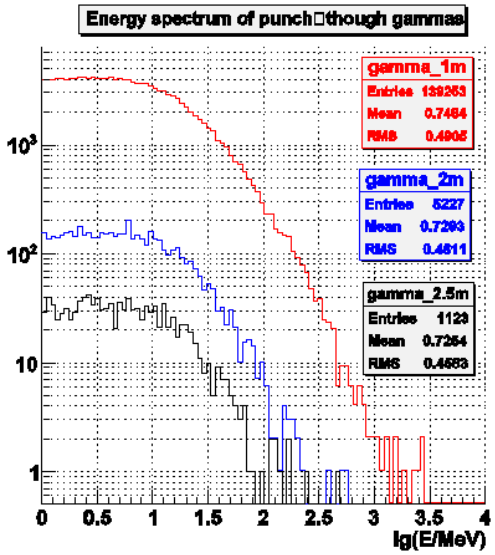
Event Rate and Moon Shadow

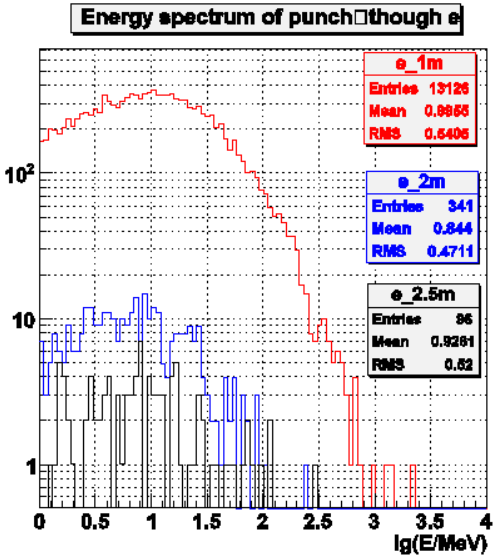
- Event rate agrees with MC and ARGO-YBJ
- Observed moon shadow by 5.8σ in 2 years.

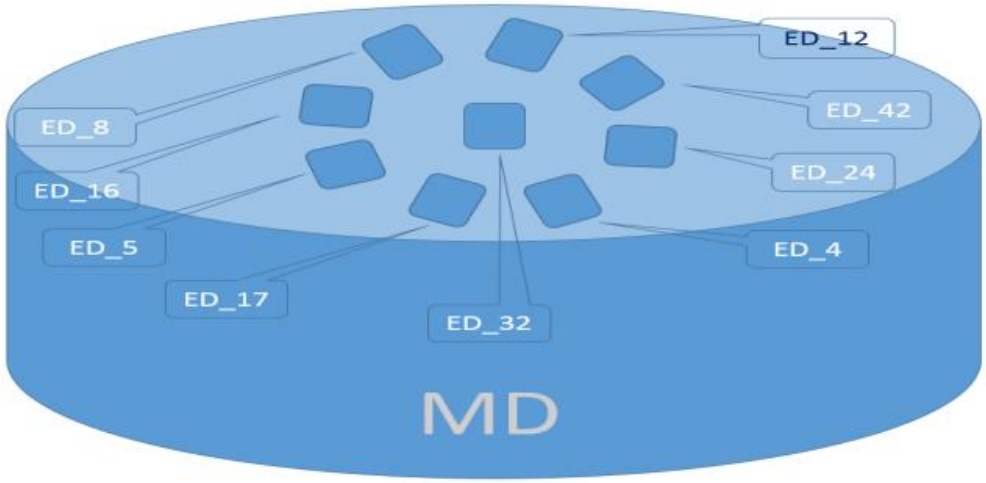


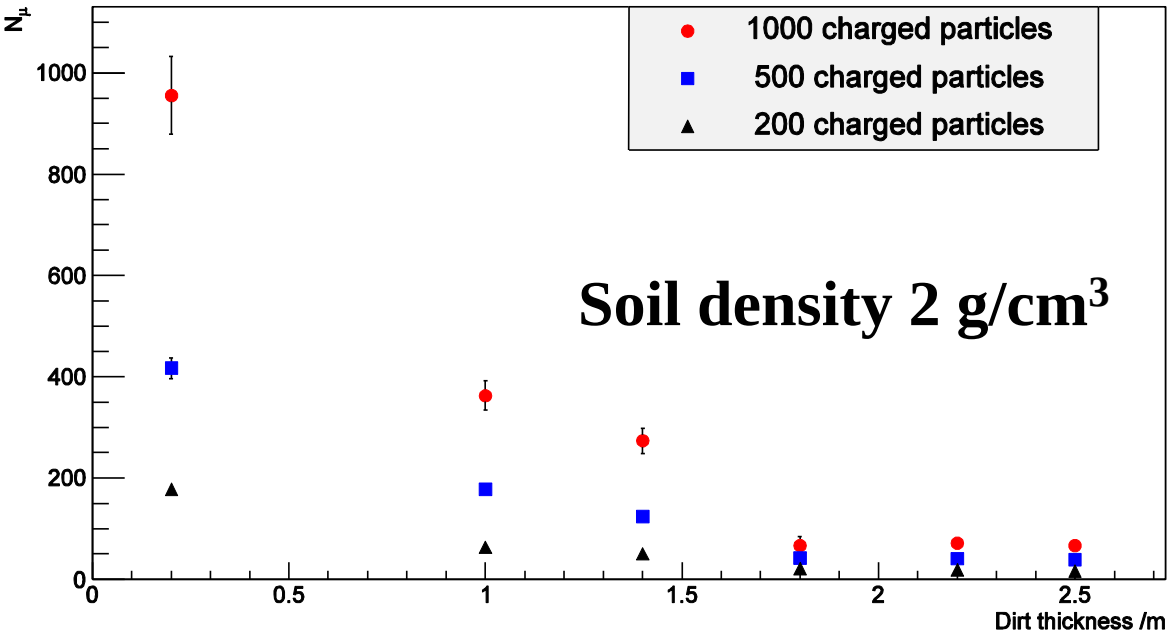


N_μ purity > 97%



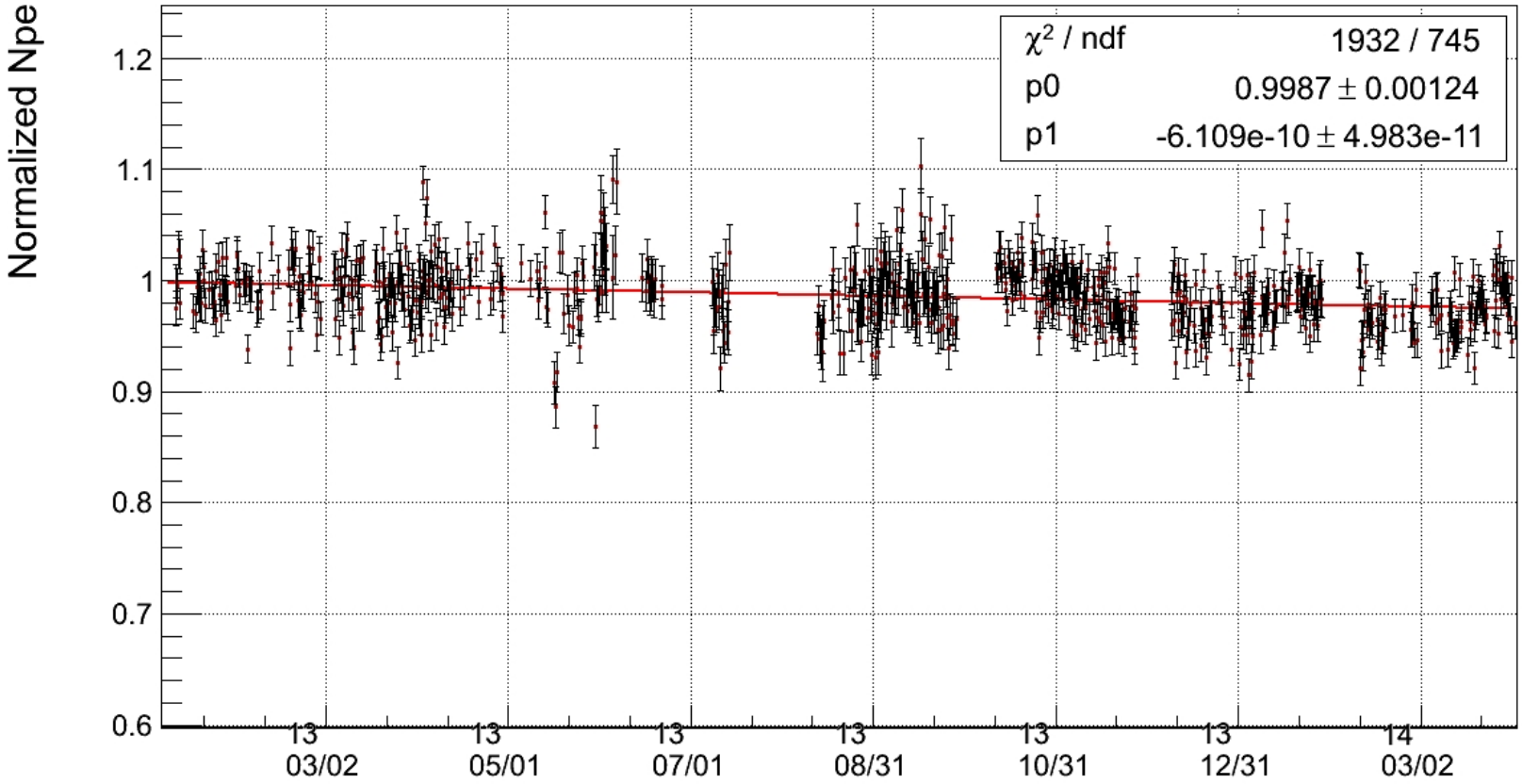




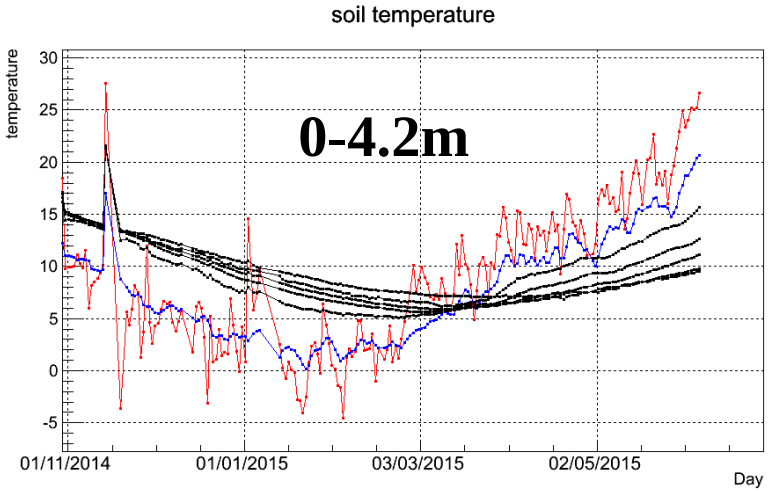


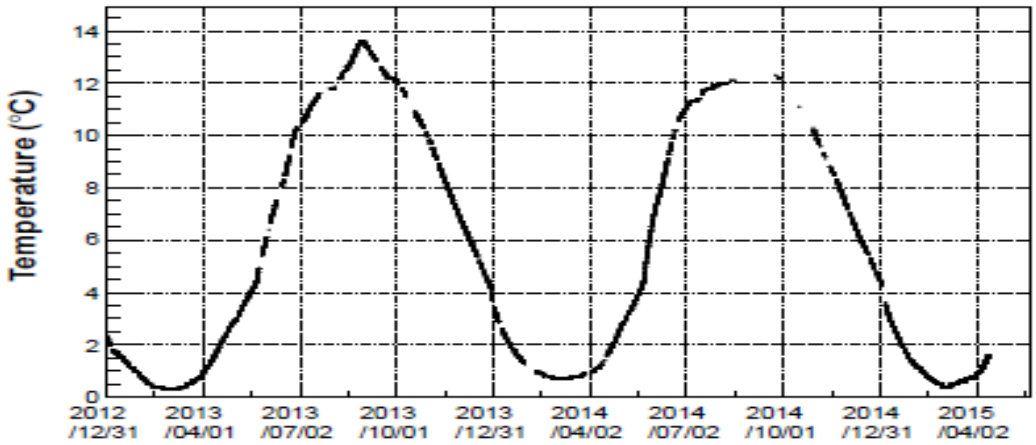
Long-term Stability

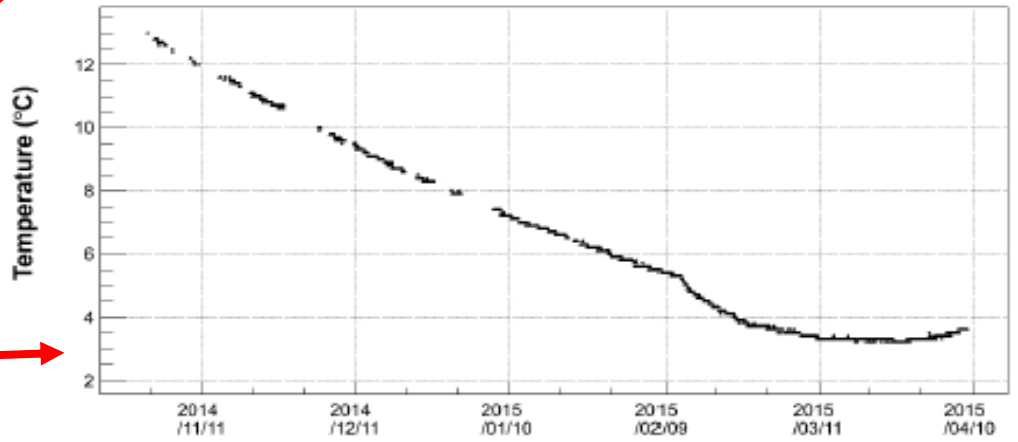
- **2%/year→17.8% in 10 years if the signal attenuates exponentially**



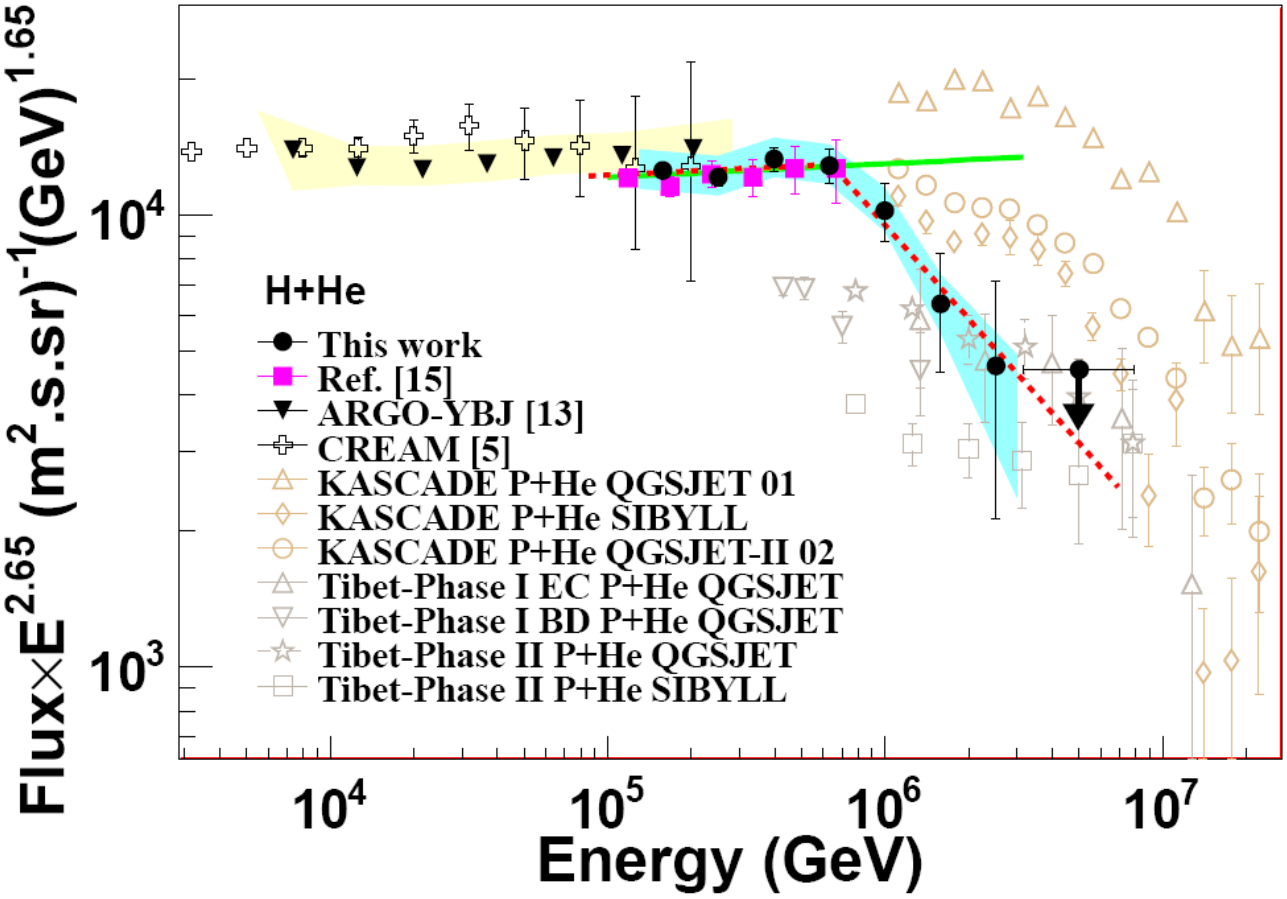
MD Water Temperature







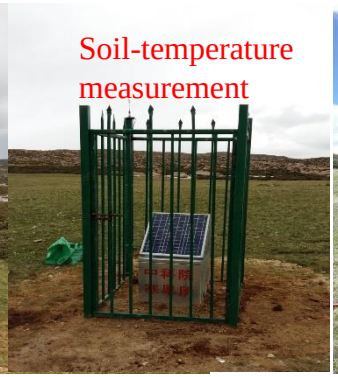
P+He Spectrum by WFCTA prototype and ARGO-YBJ



Activities @LHAASO site

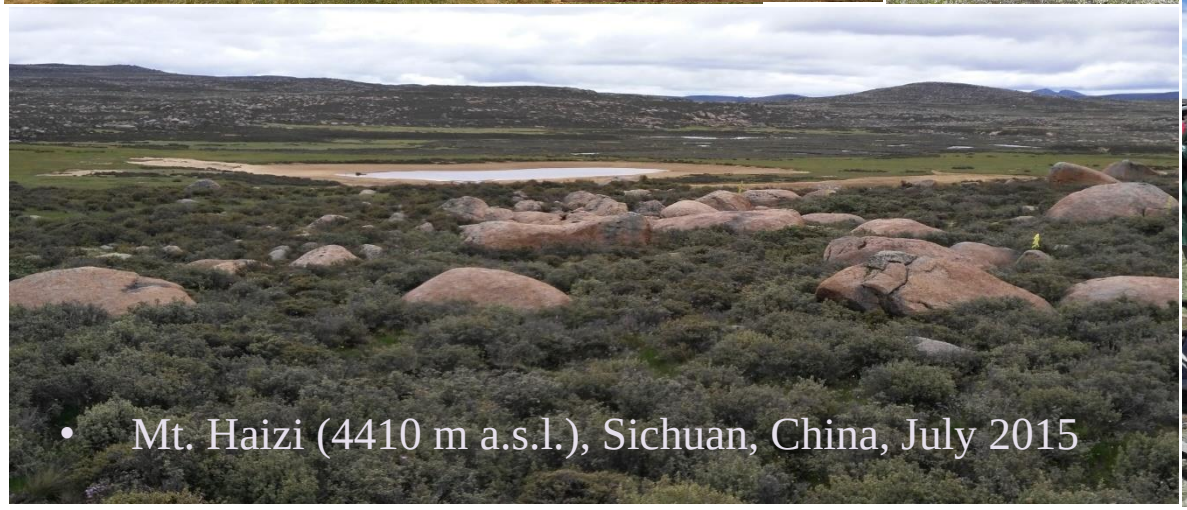
- **Mt. Haizi (4410 m a.s.l.), Sichuan, China**
- **10 km from Yading Airport.**


Meteo-station


Soil-temperature measurement


MD sites


Site boundary survey


- Mt. Haizi (4410 m a.s.l.), Sichuan, China, July 2015


Deep geo-survey, July 2015

Summary and outlook

- **The LHAASO is designed to fulfill the physical goals in gamma ray astronomy and cosmic ray physics**
- **Prototype arrays of ~1% LHAASO have been in operation at YBJ for more than 2 years**
- **LHAASO infrastructure construction has started at Mt. Haizi, Sichuan, China**
- **The official approval on LHAASO was drafted, waiting the chief of funding agency to sign on it**
- **The detector deployment will start by the end of next year**