TeVPA2015

The Large High Altitude Air Shower Observatory

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on behalf of the LHAASO collaboration

2015-10-27

Outline

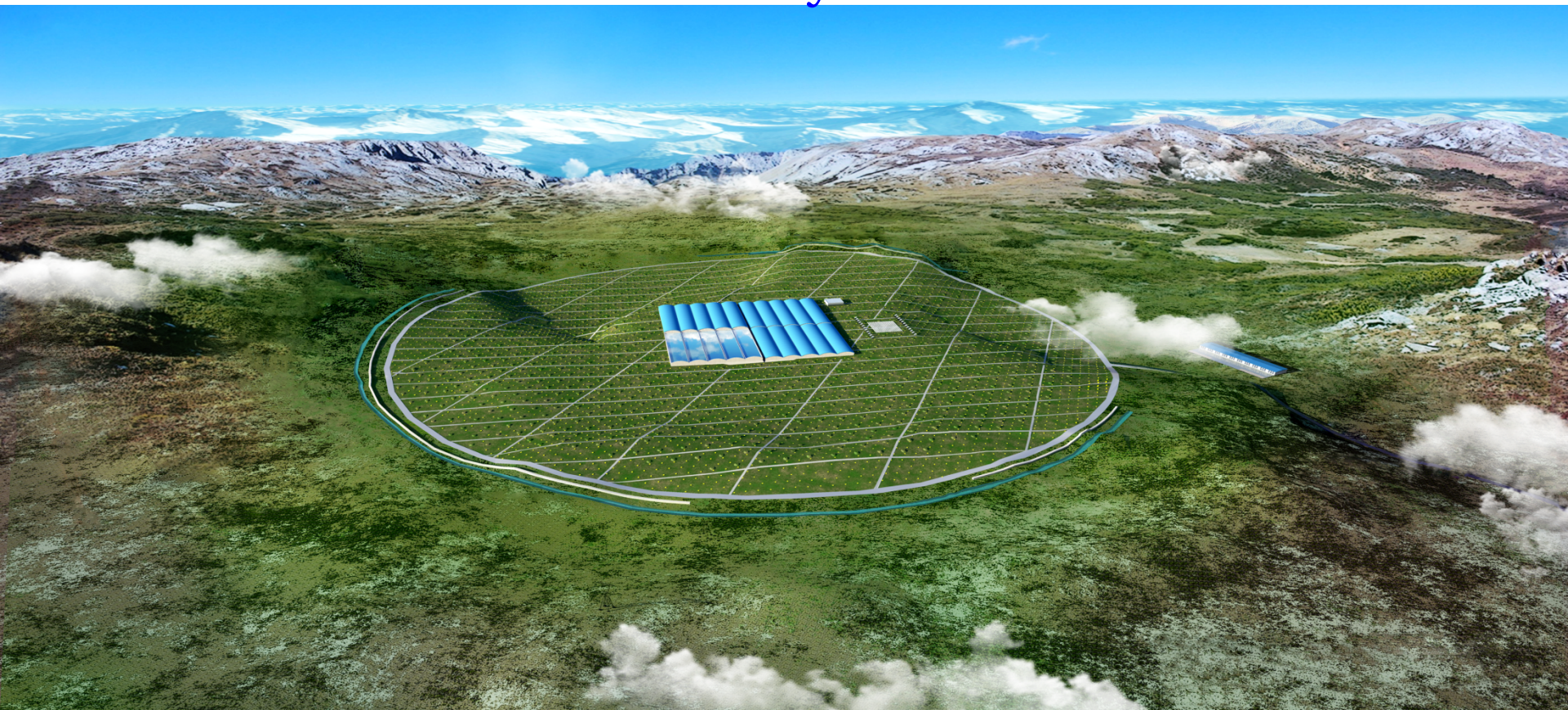
- **LHAASO: science and expectation**
- **Design of the LHAASO detectors**
- **Engineering array at YBJ**
- **Project approval status**
- **Summary**

中华人民共和国中央人民政府
www.GOV.cn
The Central People's Government of the People's Republic of China

国务院关于印发国家重大科技基础设施建设中长期规划（2012—2030年）的通知

国发〔2013〕8号

LHAASO is one of the 16 high-priority projects in the 12th Five-year Plan of China

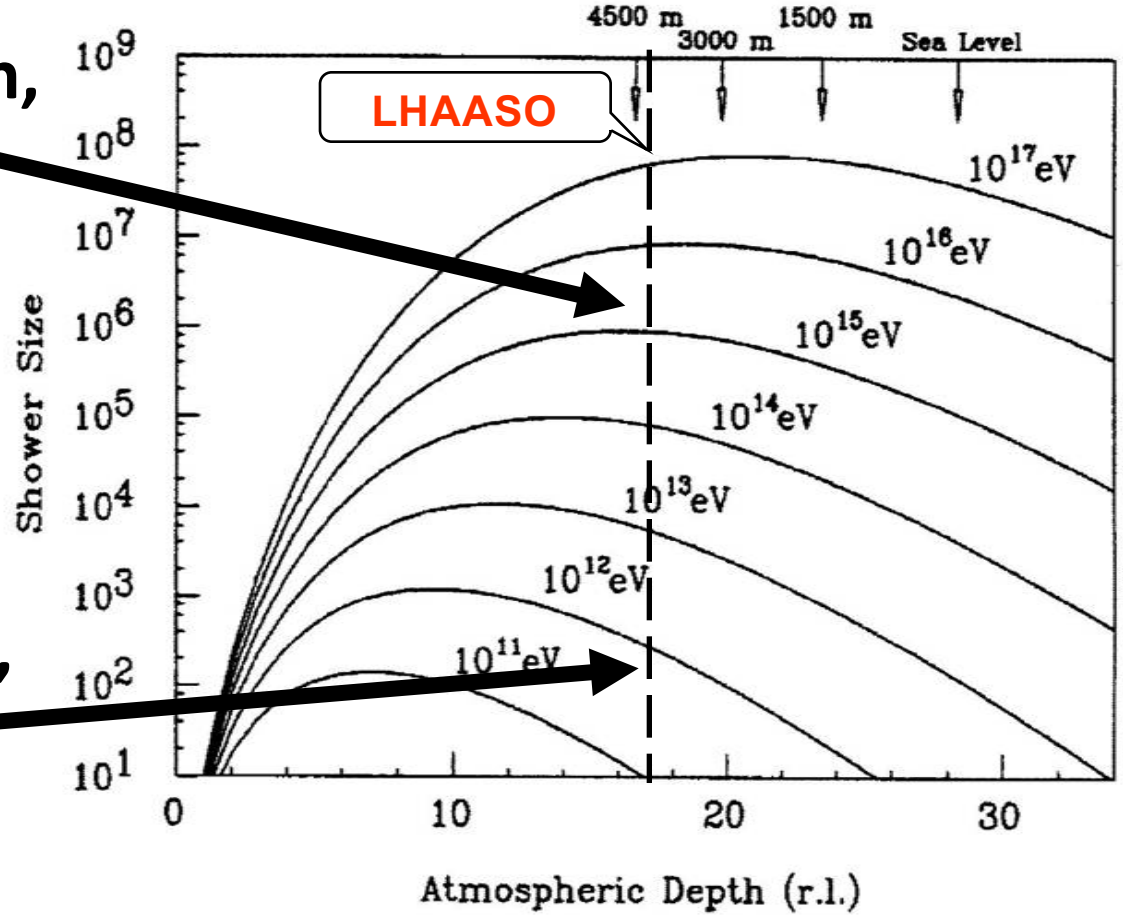


Major Scientific Goals

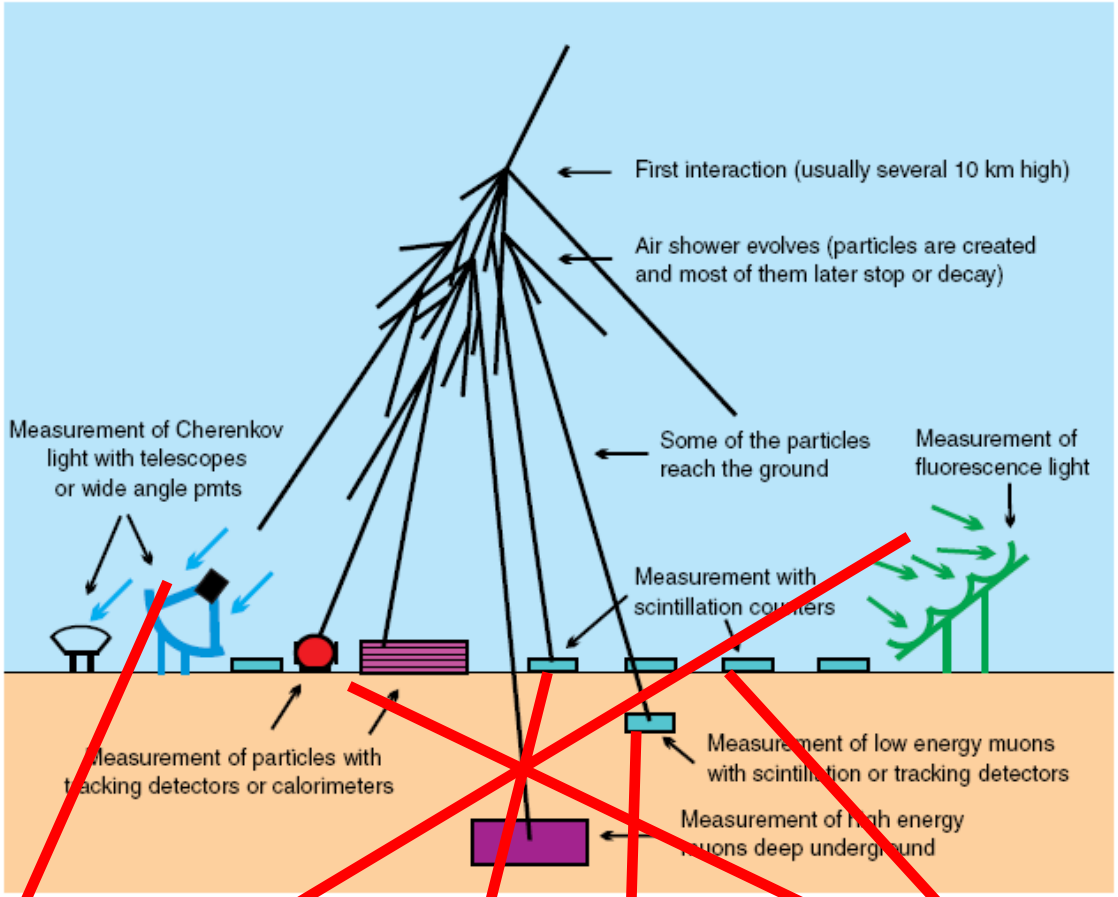
- **GAMMA RAY ASTRONOMY**
  - **Searching for GCR sources by measuring SED with an unprecedented sensitivity of 1% Crab unit at 50 TeV.**
  - **Searching for TeV gamma sources, especially extended and transient ones, with an unprecedented survey sensitivity of 1% Crab unit at 3TeV.**
- **COSMIC RAY PHYSICS**
  - **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.**

Measurement of air showers at high altitude

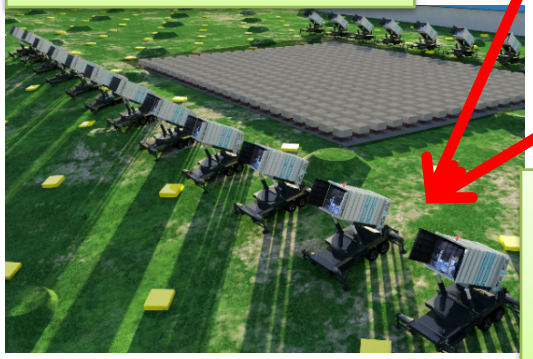
- **HE: near Xmax →lower fluctuation, better σ_E**
- **Lower E_{th} →deeper, more sources**

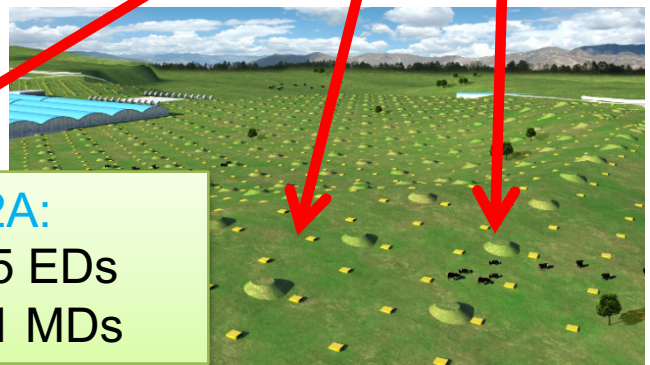


Hybrid Detection of Extensive Air Showers by LHAASO



WFCTA:
18 telescopes
1024 pixels each





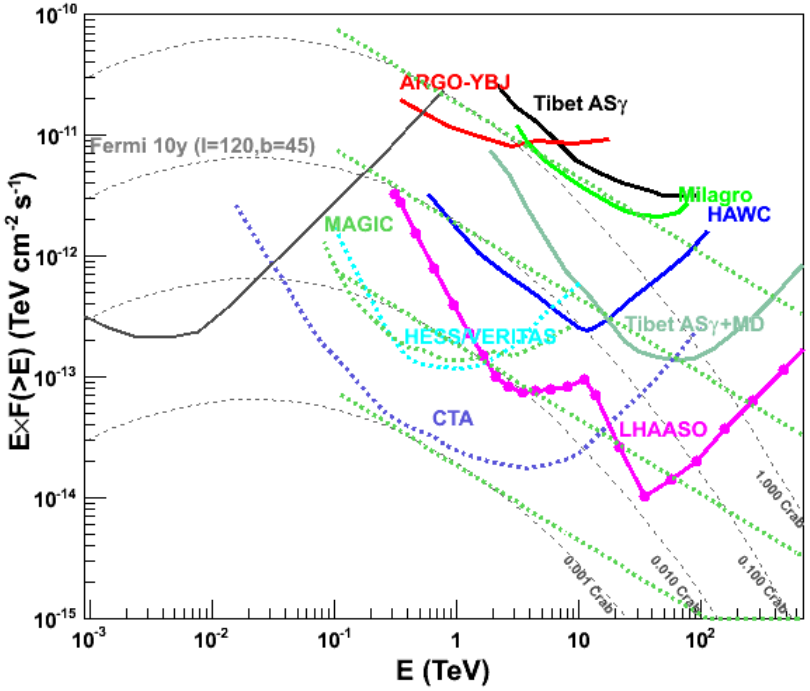
KM2A:
5195 EDs
1171 MDs

WCDA:
3000 cells

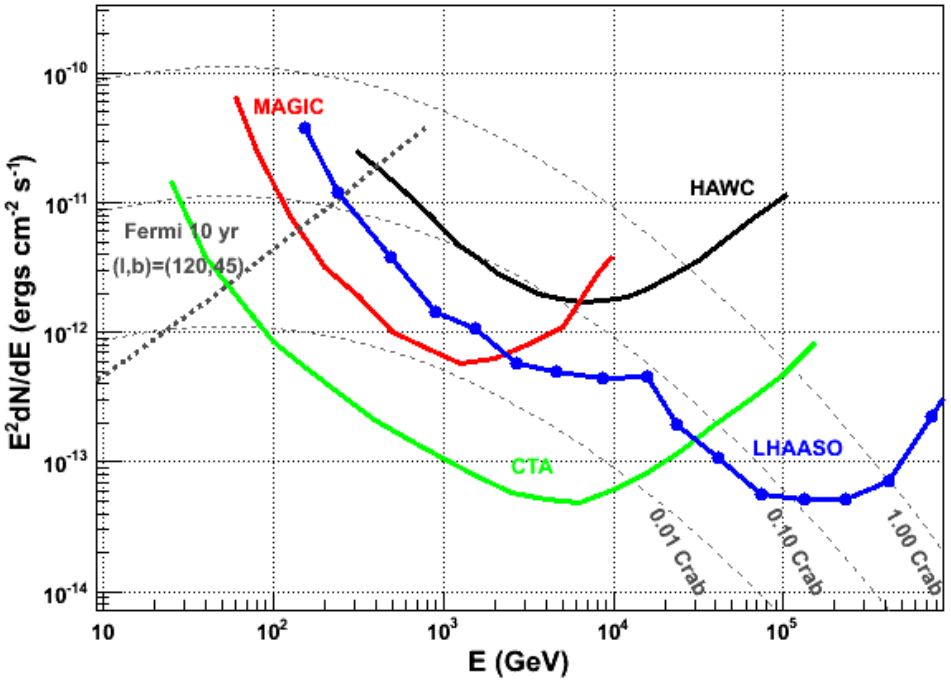
Sensitivity to gamma ray sources

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

Integral

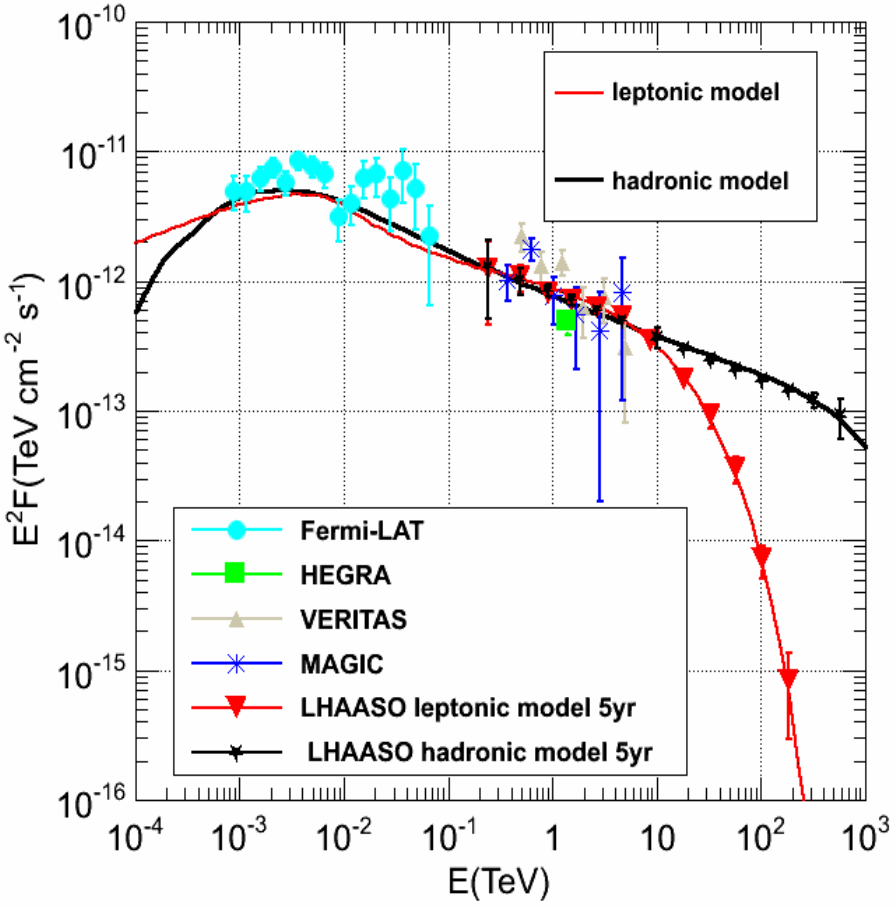


differential

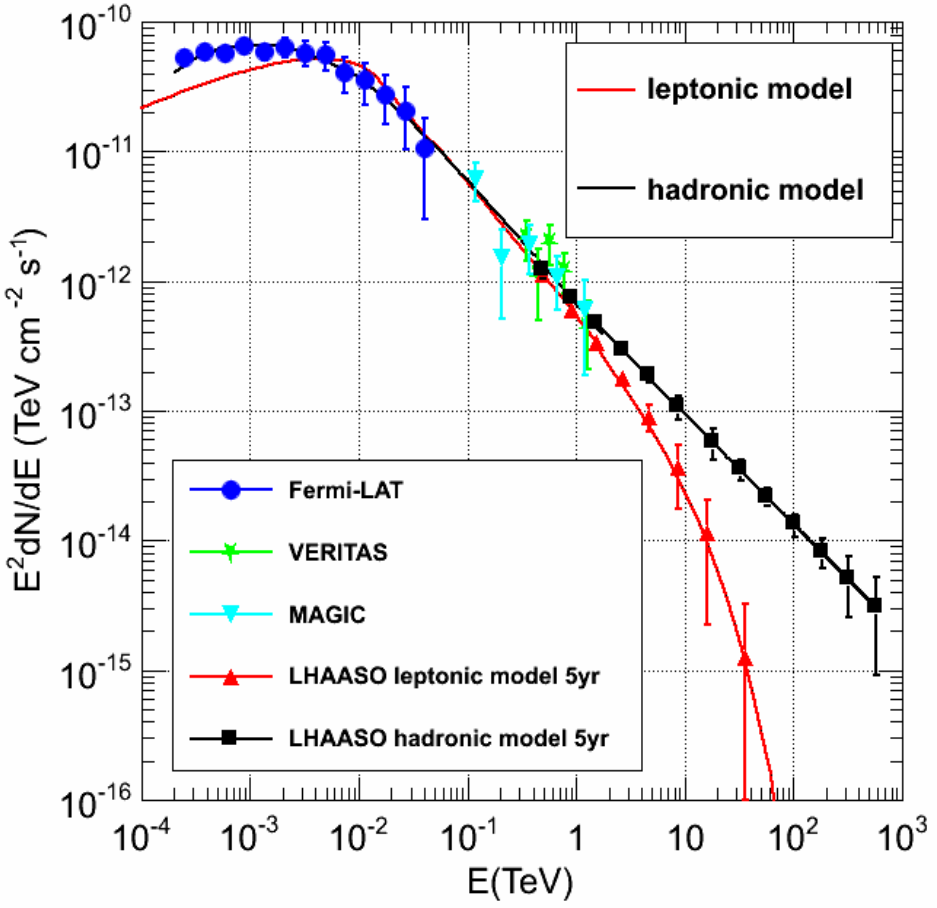


➢Hadronic vs. Leptonic

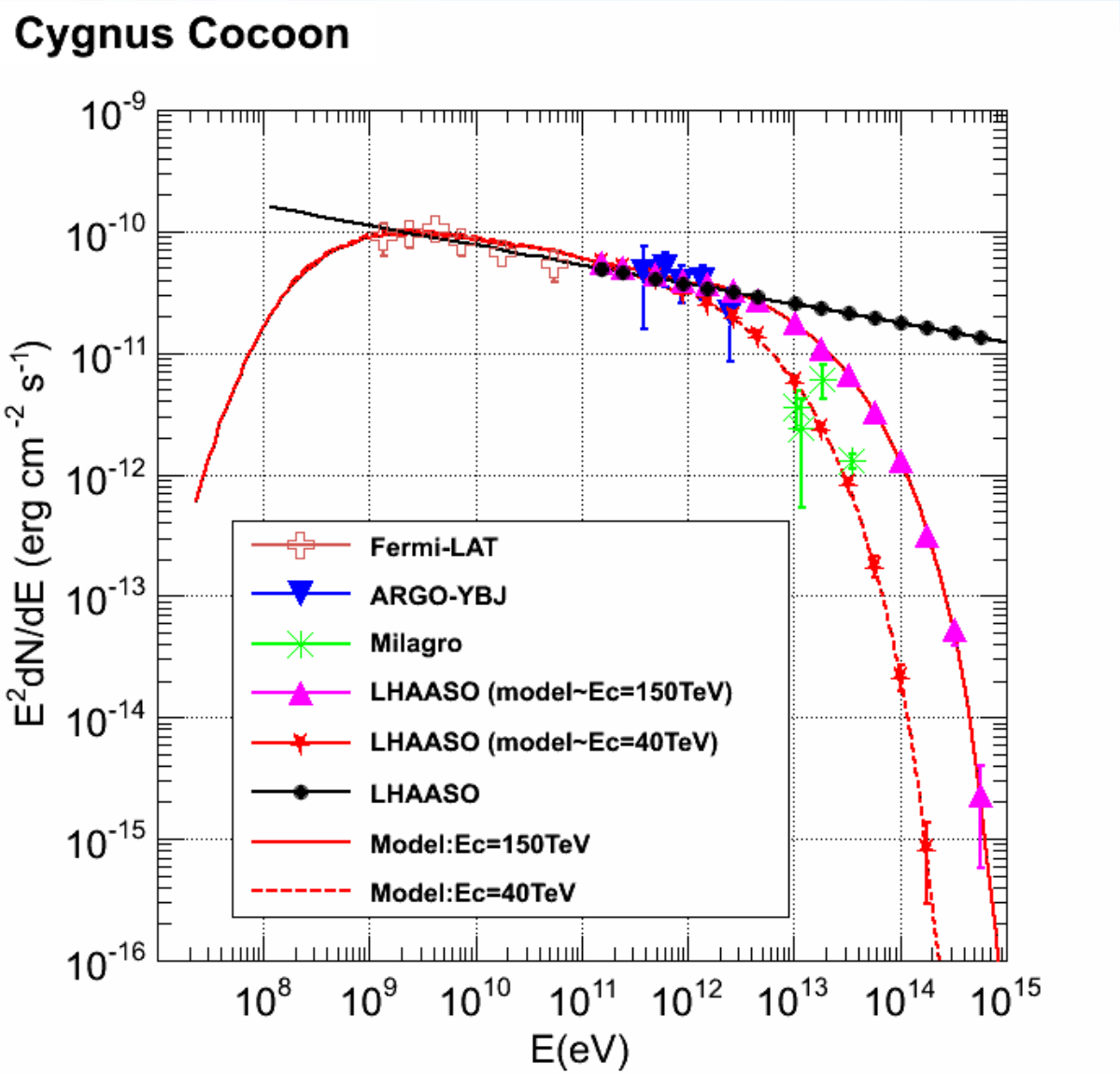
Cassionpeia A Historical SNRs



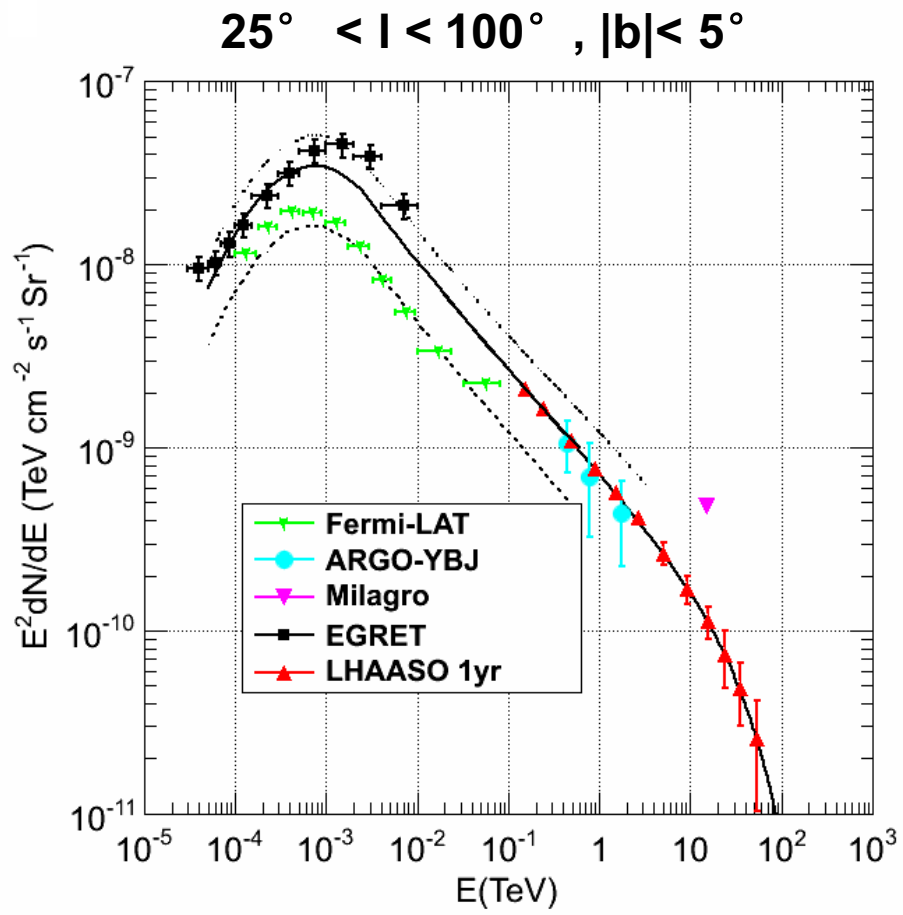
IC443 interacting with molecular clouds

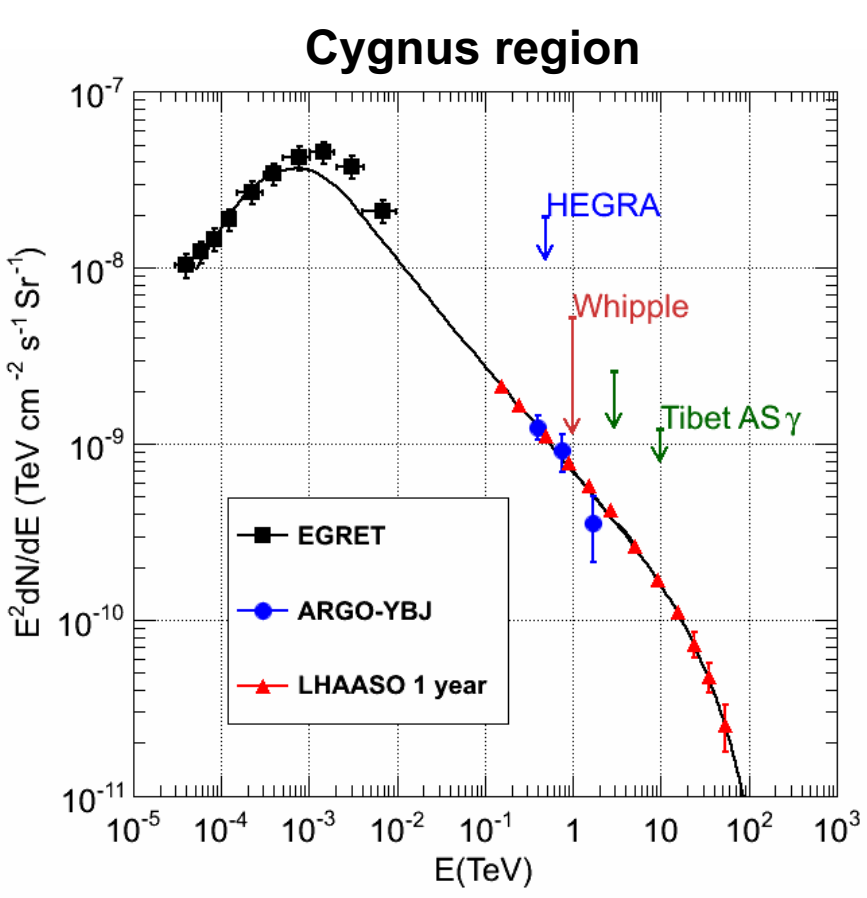


➢ Acceleration limit of GCR sources

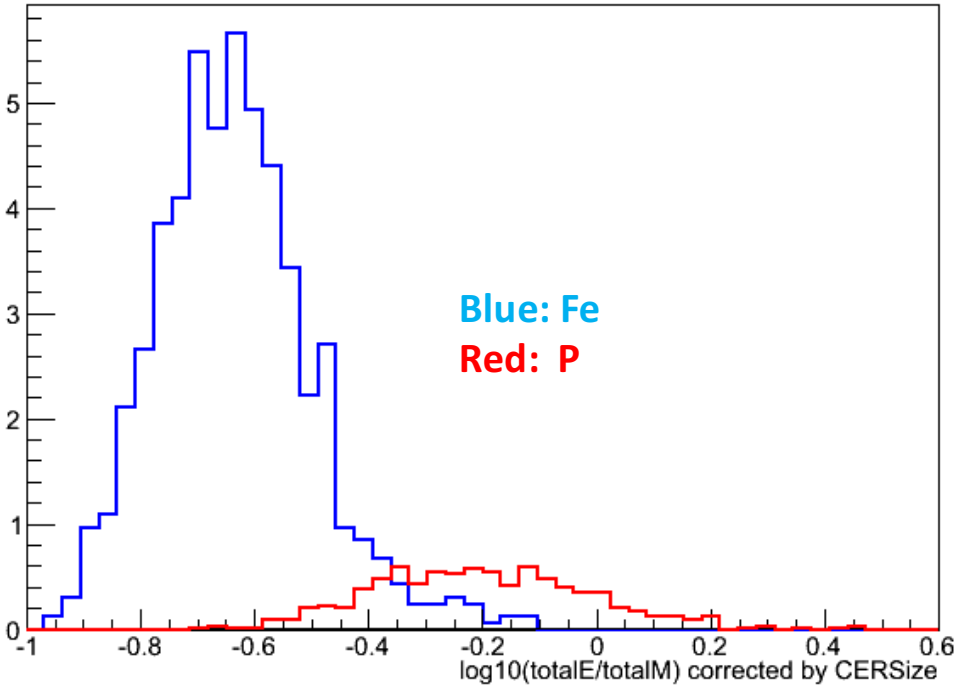


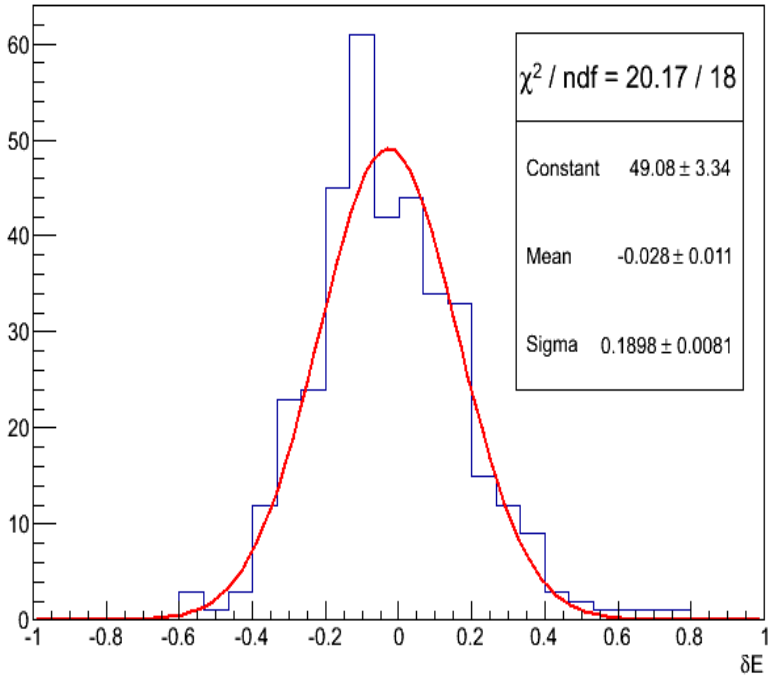
➢ GCR spectrum and density

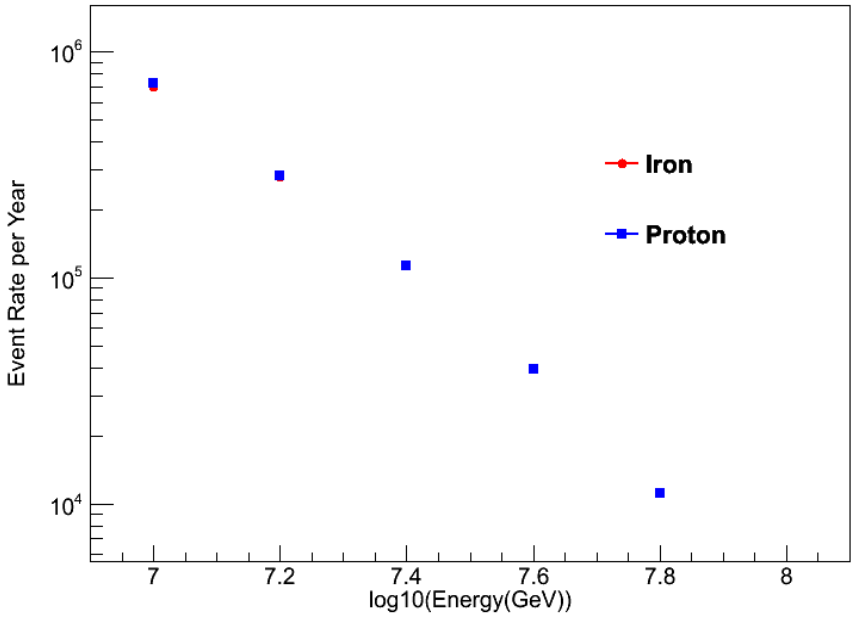




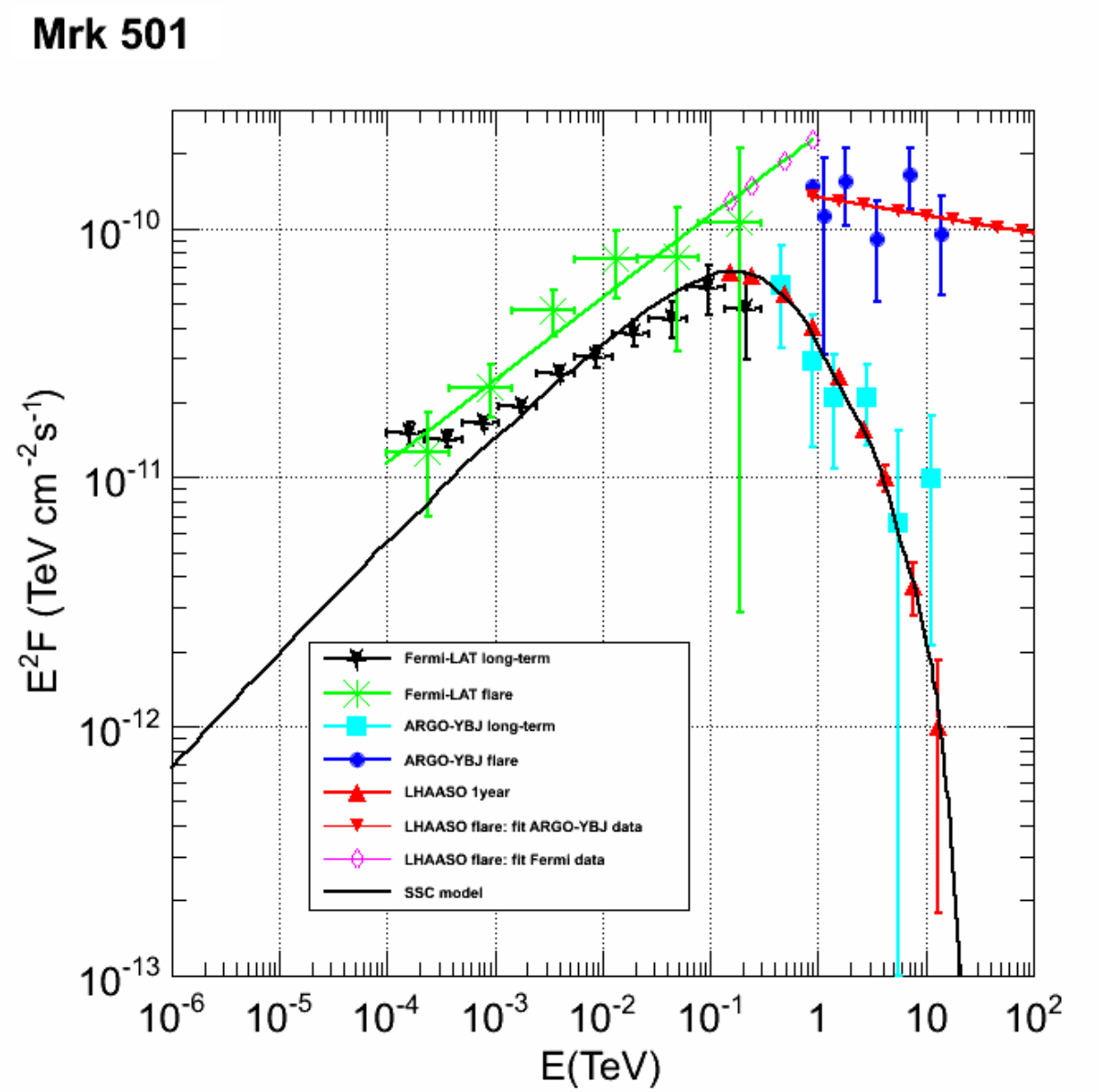
Ec=50TeV


Blue: Fe
Red: P
log10(totalE/totalM) corrected by CERSize

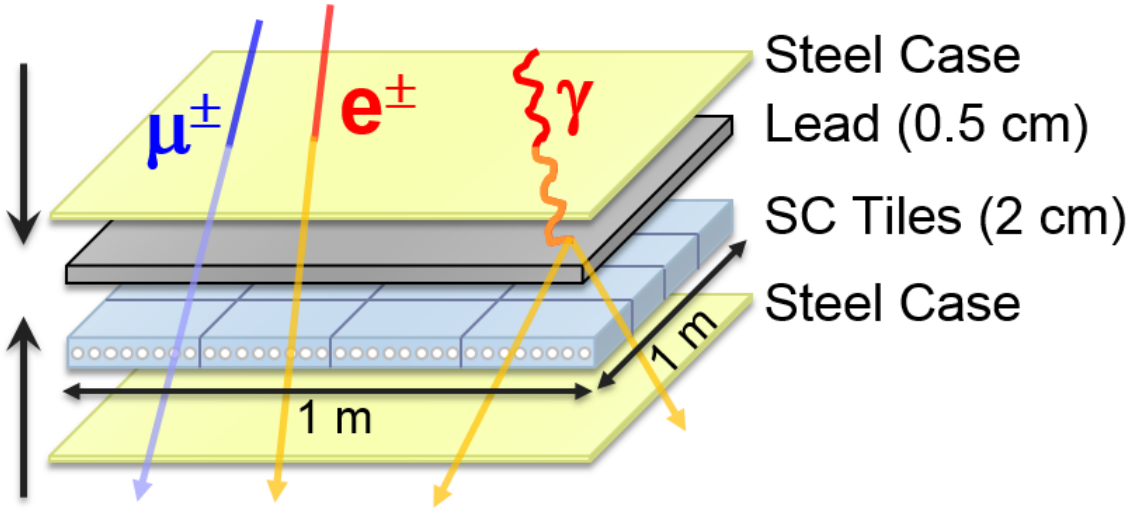

χ² / ndf = 20.17 / 18
Constant 49.08 ± 3.34
Mean -0.028 ± 0.011
Sigma 0.1898 ± 0.0081
δE


Iron
Proton
Event Rate per Year
log10(Energy(GeV))

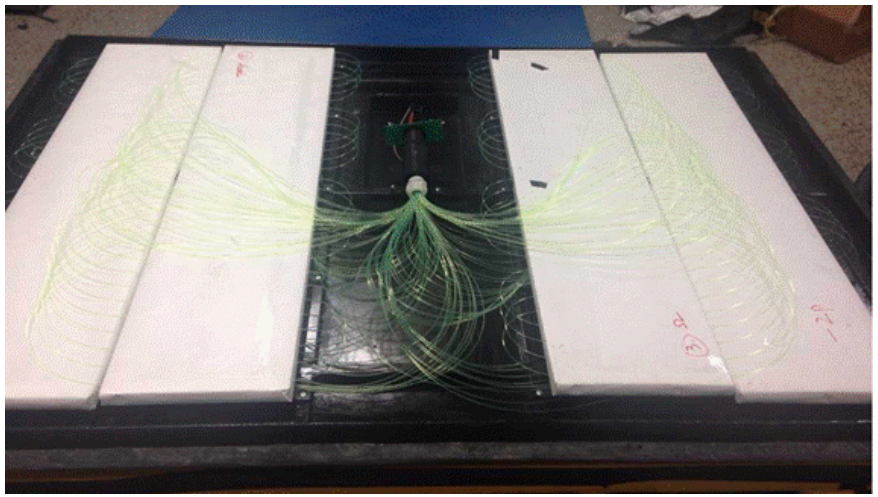
➢ Transient Phenomena



Electromagnetic Particle Detector

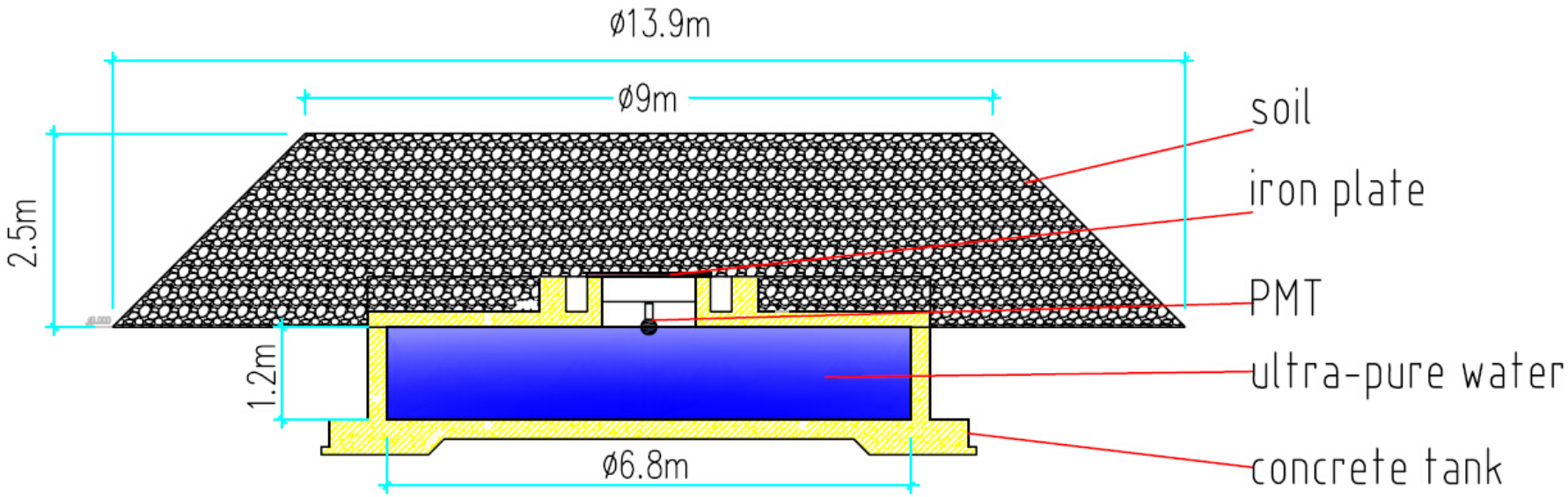


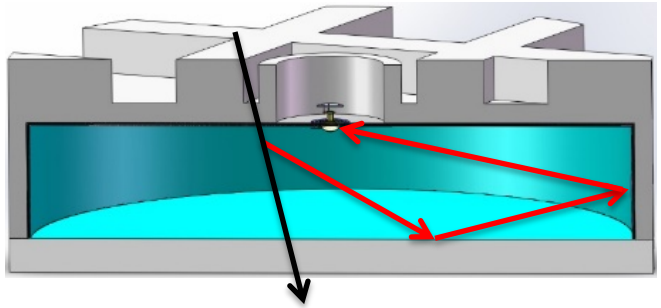
- **Uniformity for 5195 units: < 10%**
- **Stability within ±25°C: ±5%**

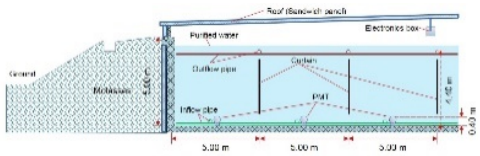


Muon Detector

- **Water Cherenkov detector underneath soil**

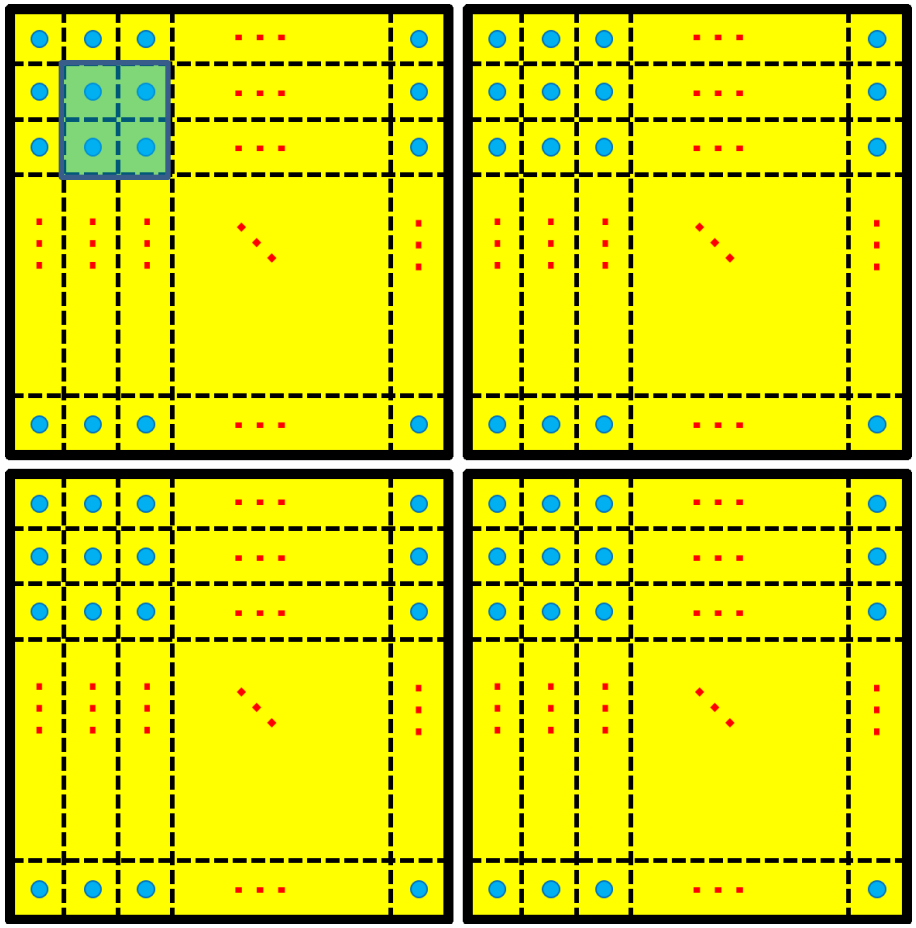


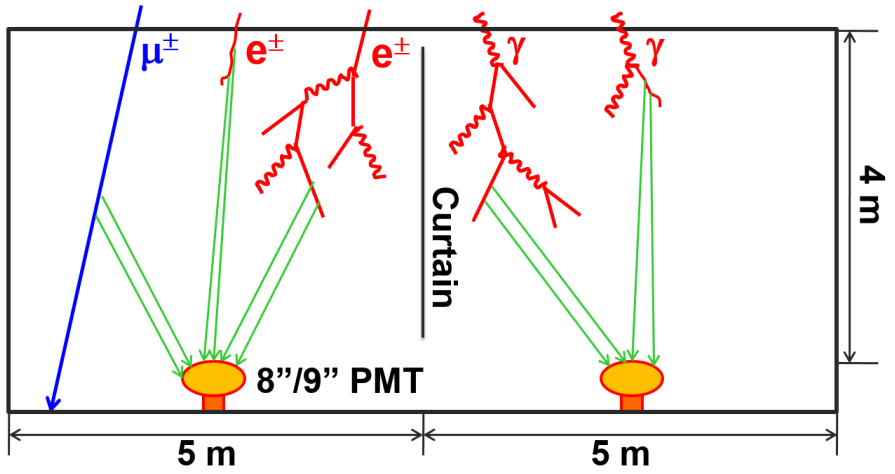


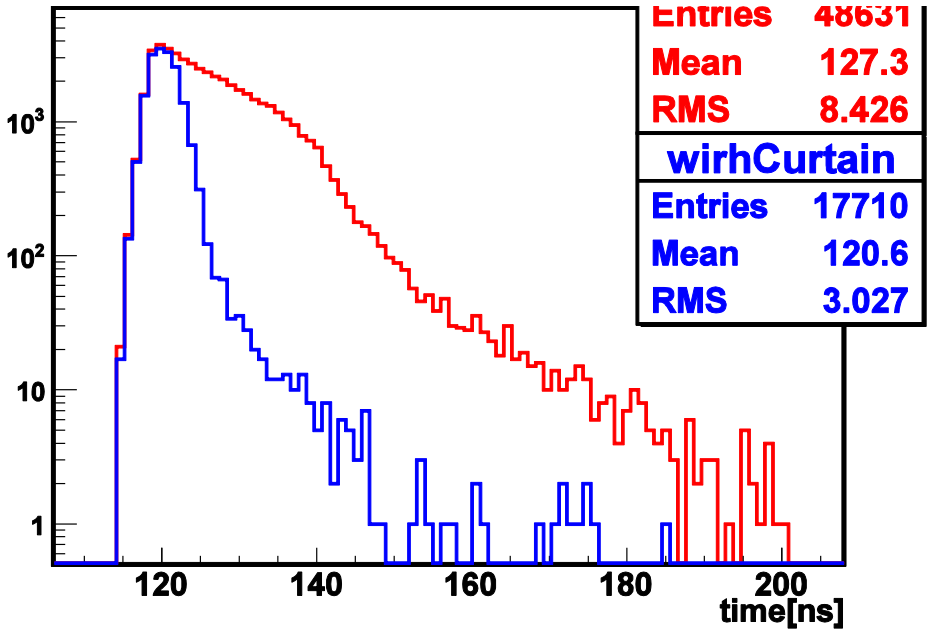


WCDA: Survey of the VHE gamma ray sky

- <1% I_{Crab} → 300m*300m

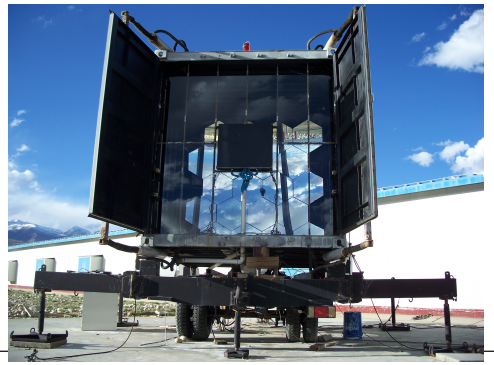


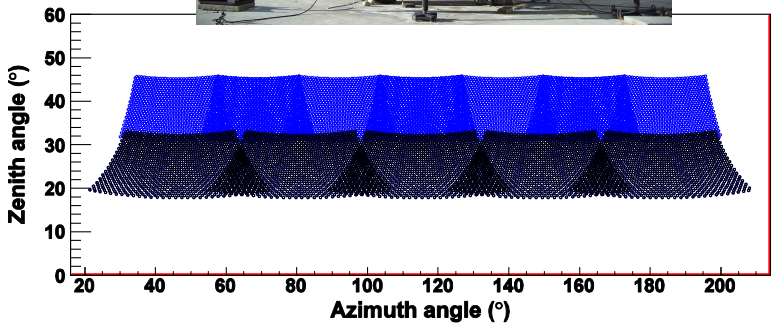


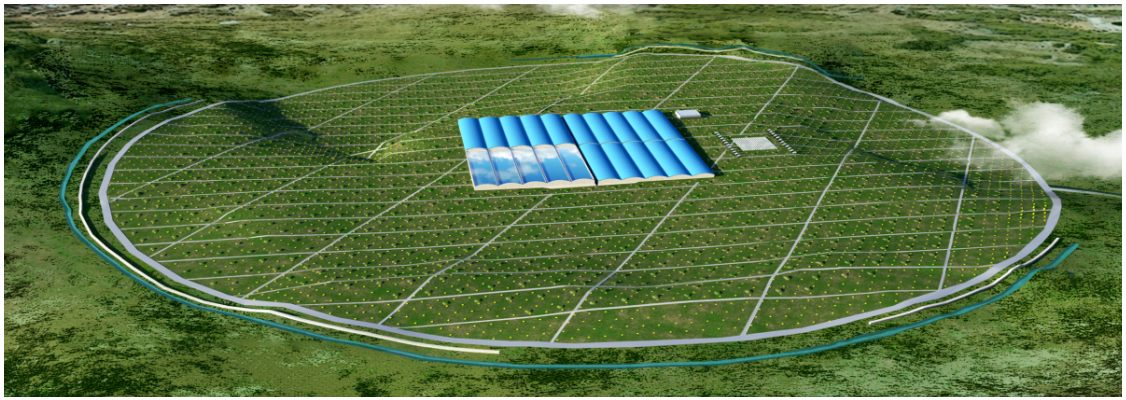


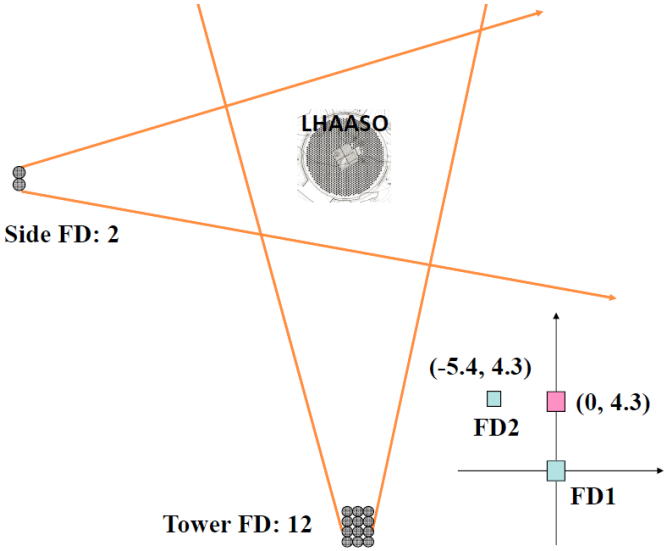
WFCTA

- 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.

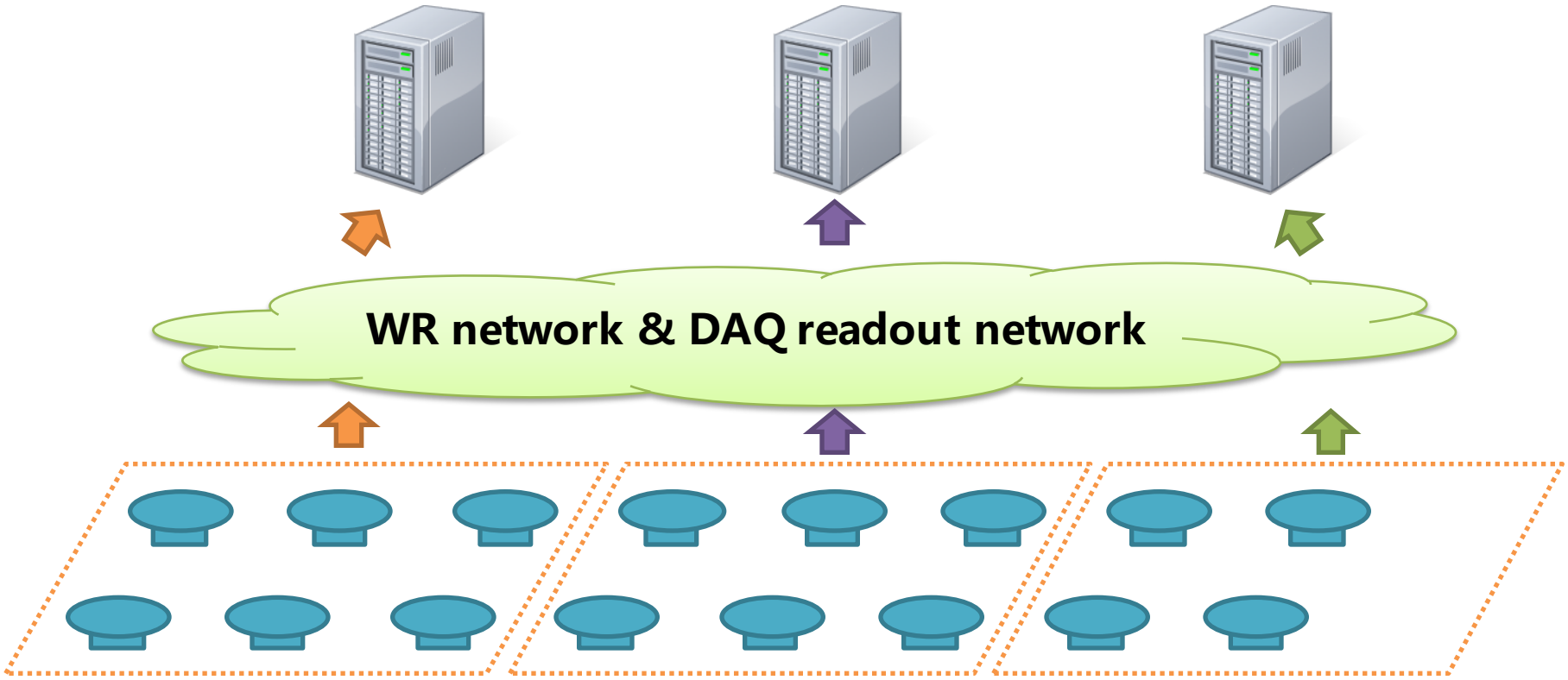
Traceability & Real-time calibration

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

“Triggerless” DAQ

---hybrid measurement of showers

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

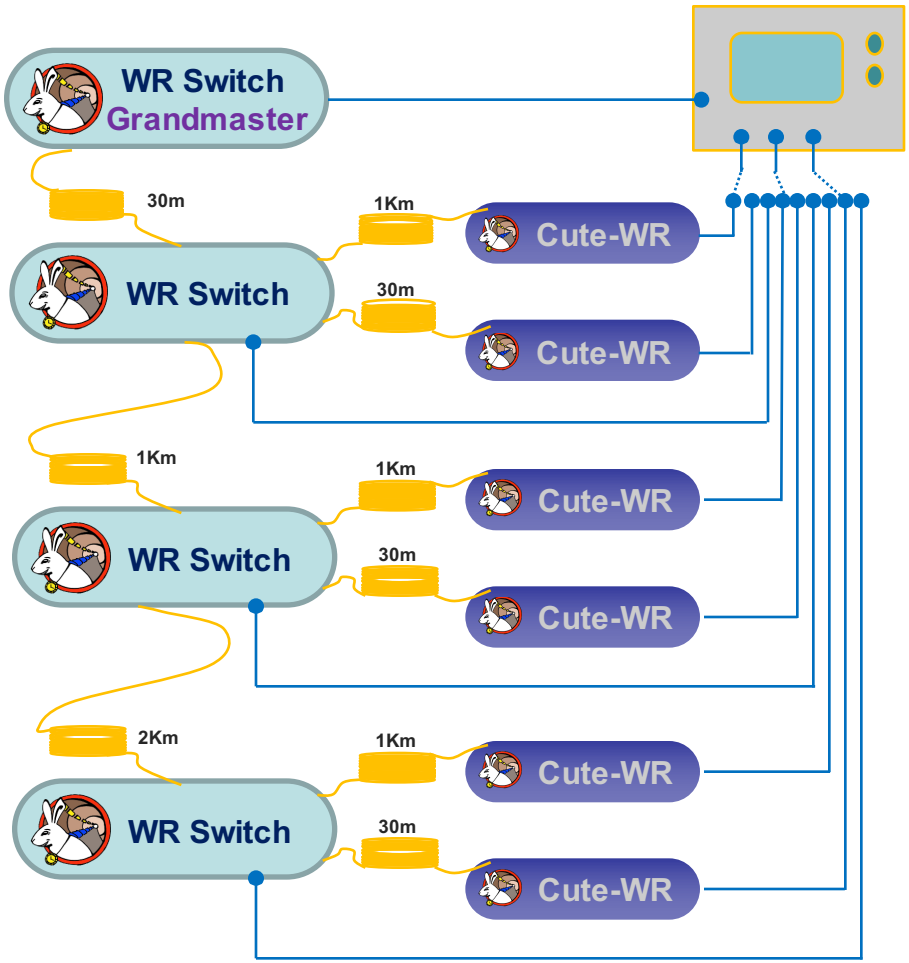


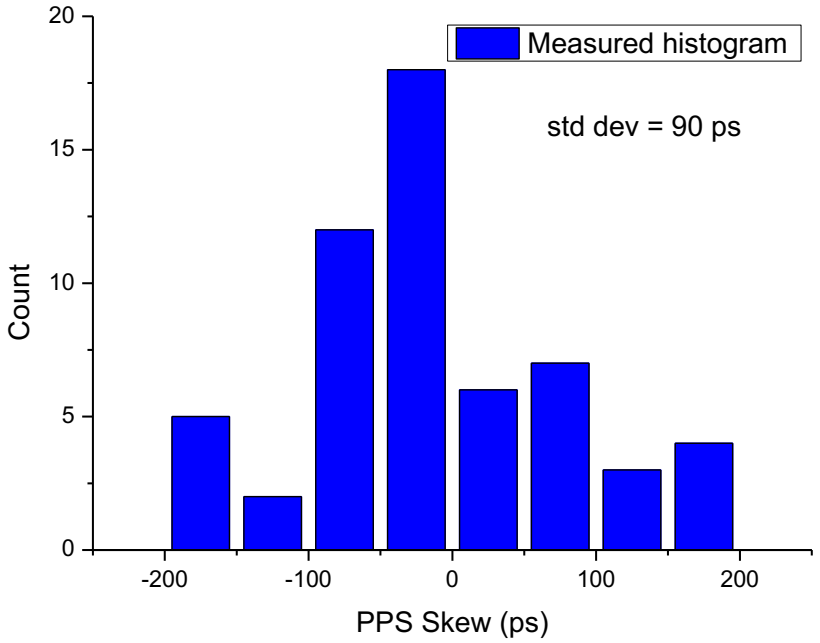
Engineering Array @ YBJ

- **~1% of LHAASO**
  - **42 EDs, 2 MDs, 9-unit WCDA, 2 telescopes**
- **Fully implementing the LHAASO designs, including WR-based clock distribution, "triggerless" DAQ, etc**
- **Has been in operation for more than 2 years.**



WR performance

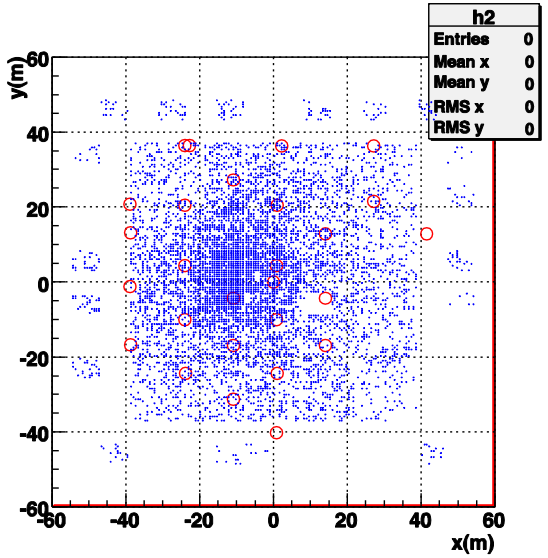


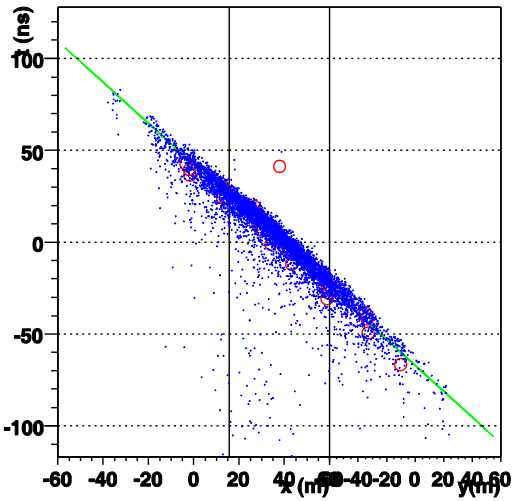


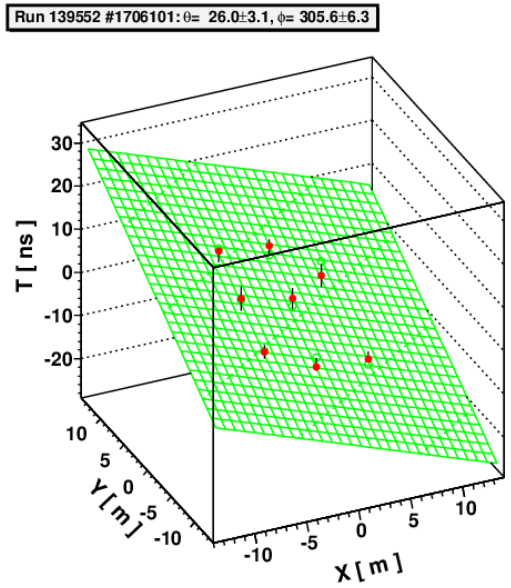
Cascade topology

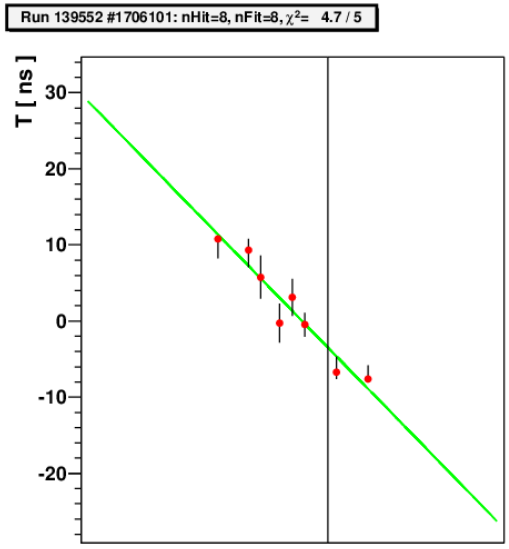
WR CERN: 1ns

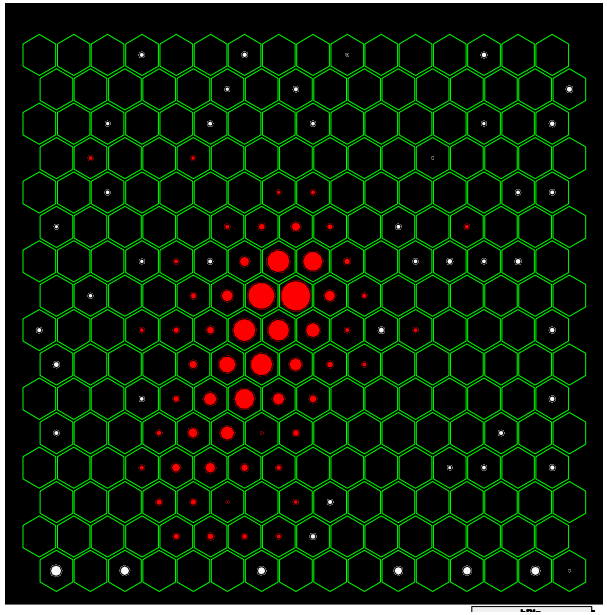
Example Showers





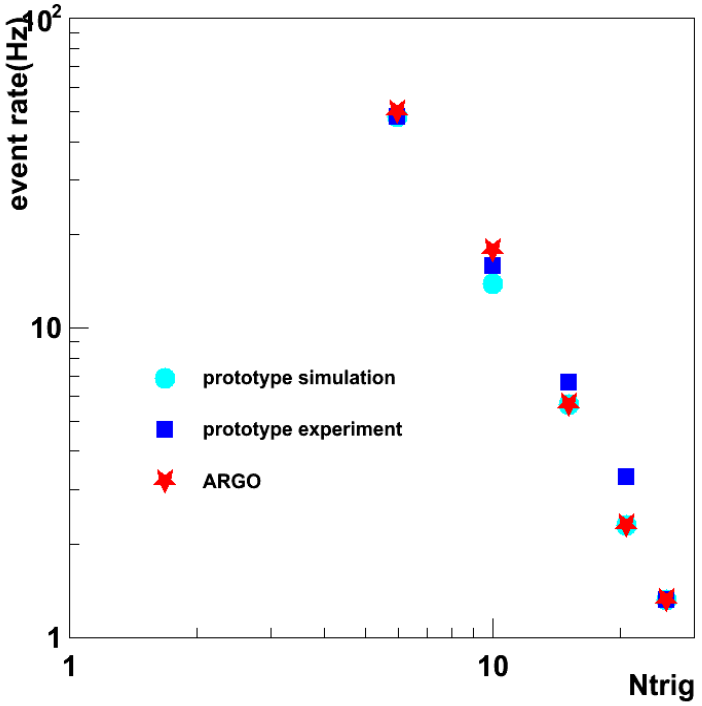


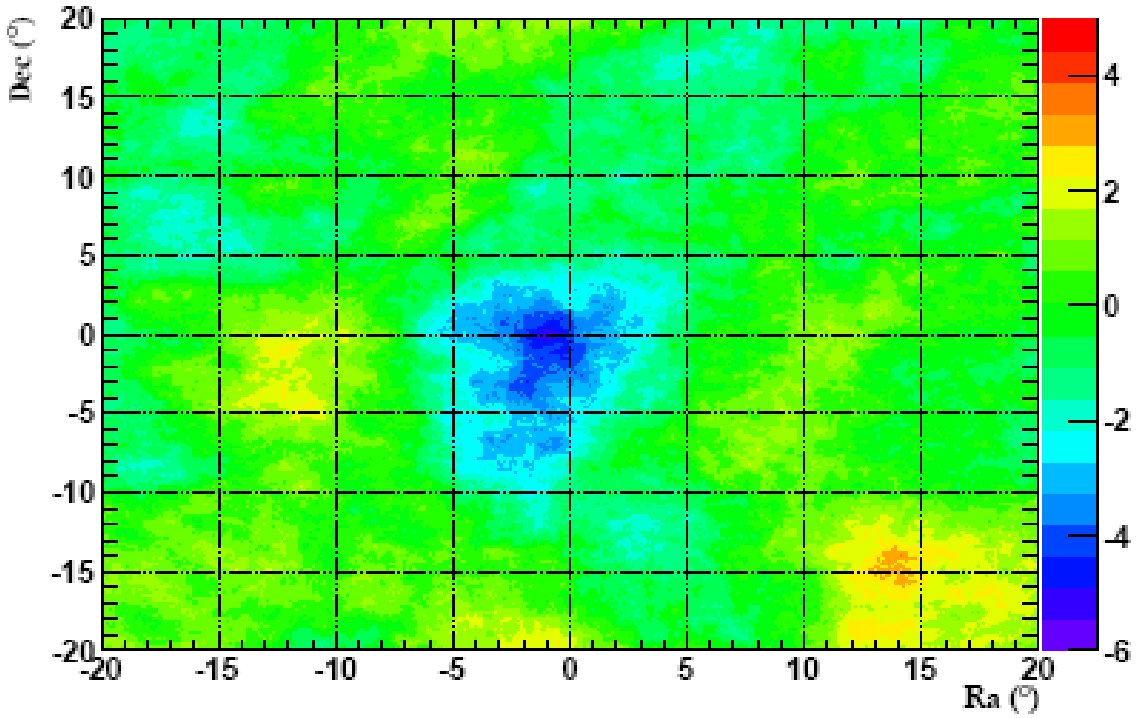




Event Rate and Moon Shadow

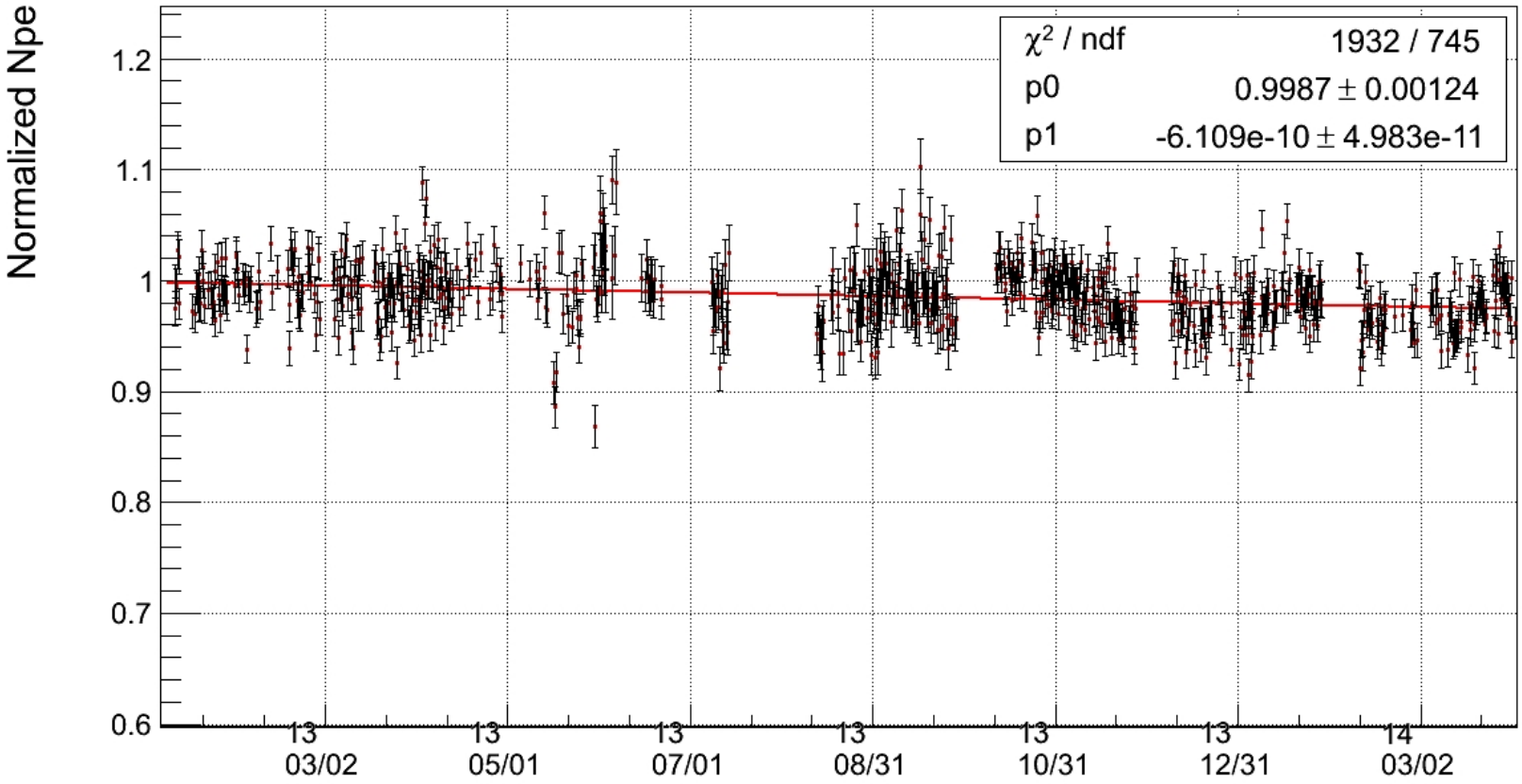
- Event rate agrees with MC and ARGO-YBJ
- Observed moon shadow by 5.8σ in 2 years.





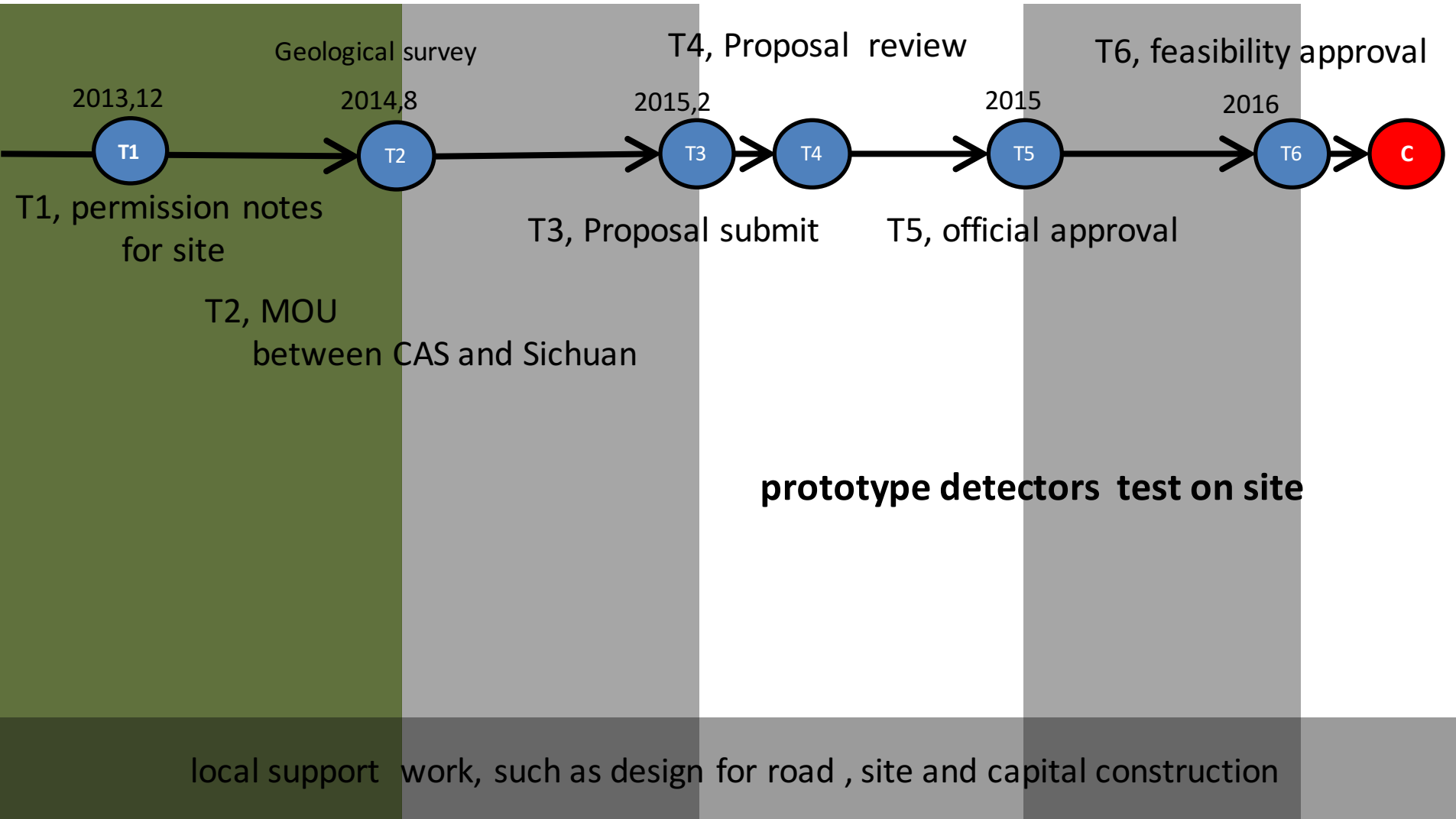
Long-term Stability

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



LHAASO: project approval

Project proposal→Feasibility Report→Technical Design Report →Construction Drawing→Commencement Report



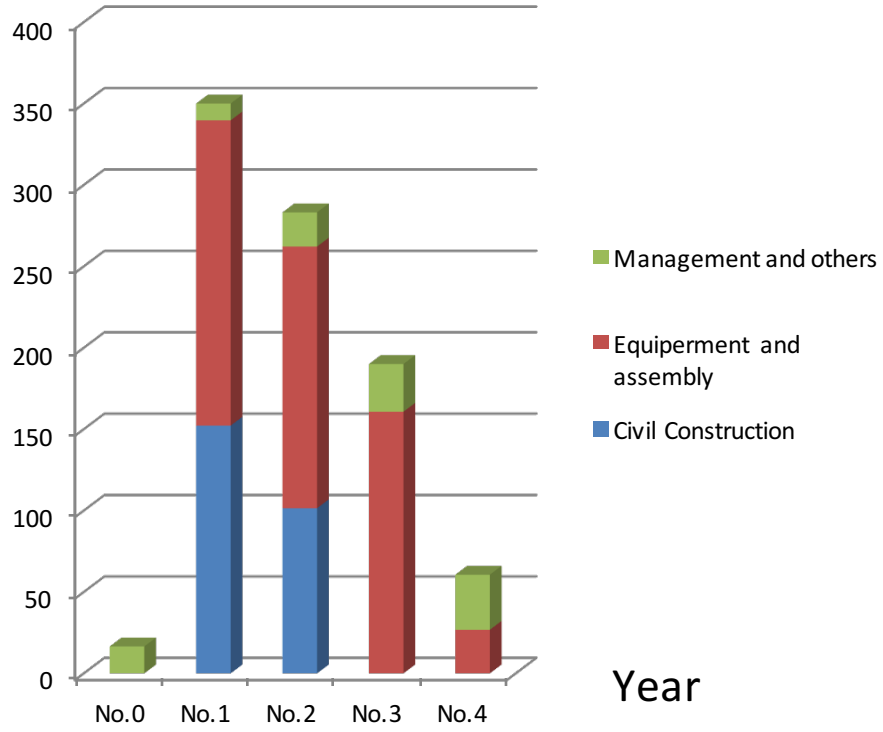
Total Budget: 1,200 M

Project: 900 M (NDRC)

- Detector and assembly， test， partial operation， etc.

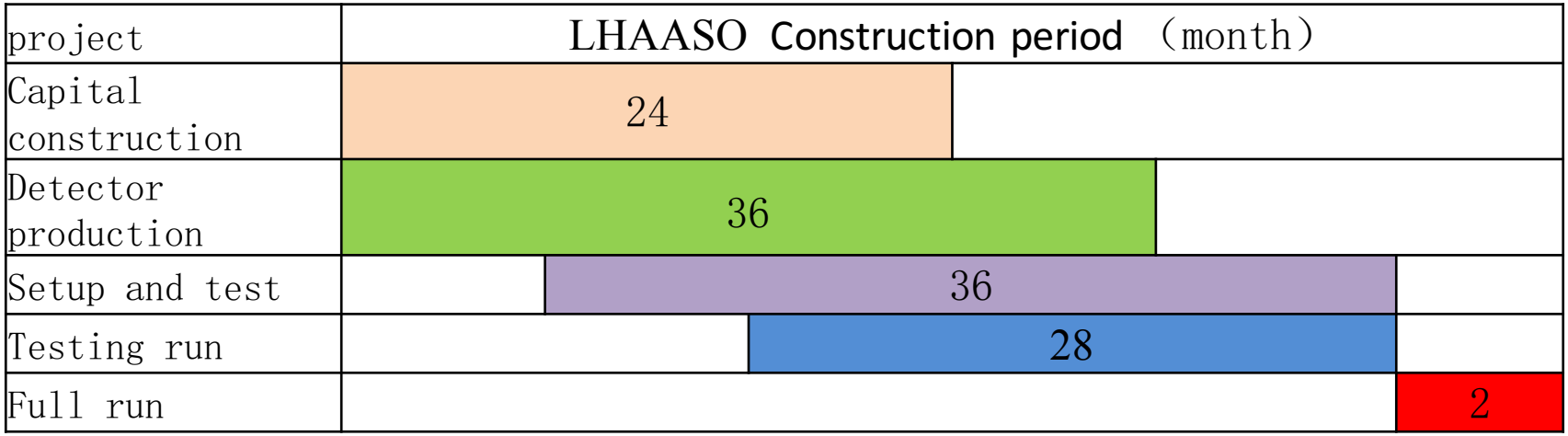
Local Matching: 300 M (Sichuan Province)

- Land, power, road, civil construction, etc.



- Local funding:
  - 100 M (2015)
  - 150 M (2016)
  - 50 M (2017)
- Operation money:
  - 1.2 M (2^{nd})
  - 4.8 M (3^{rd})
  - 6 M (4^{th})

LHAASO Construction Schedule



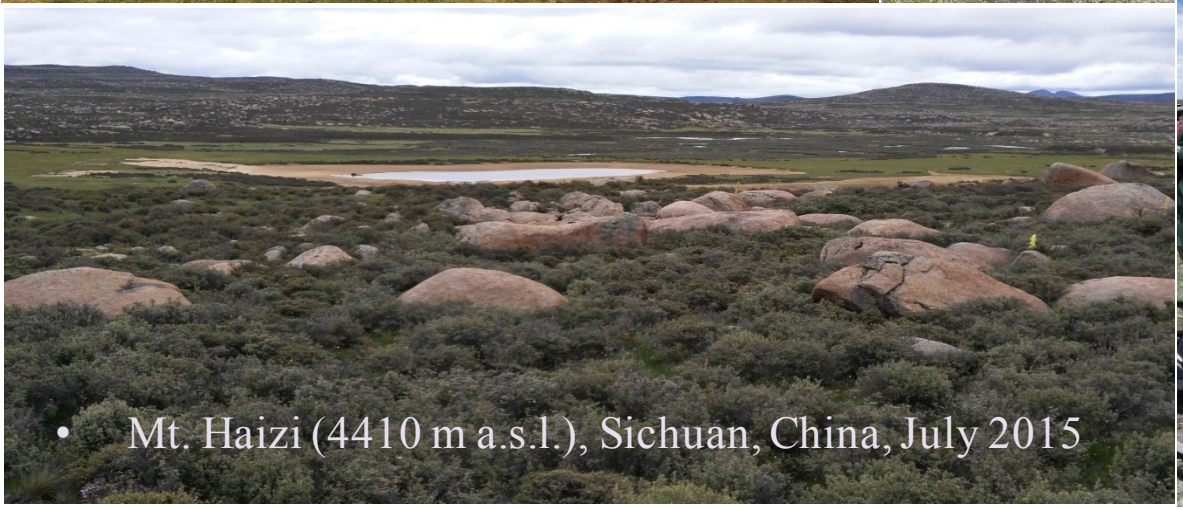
Duration: 4 years

Different detectors will go parallel

¼ will be finished and start to take data in 2 years

Activities @LHAASO site

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



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**
- **The official approval of LHAASO is coming soon**