LHAASO
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The study of absolute energy scale of LHAASO detectors

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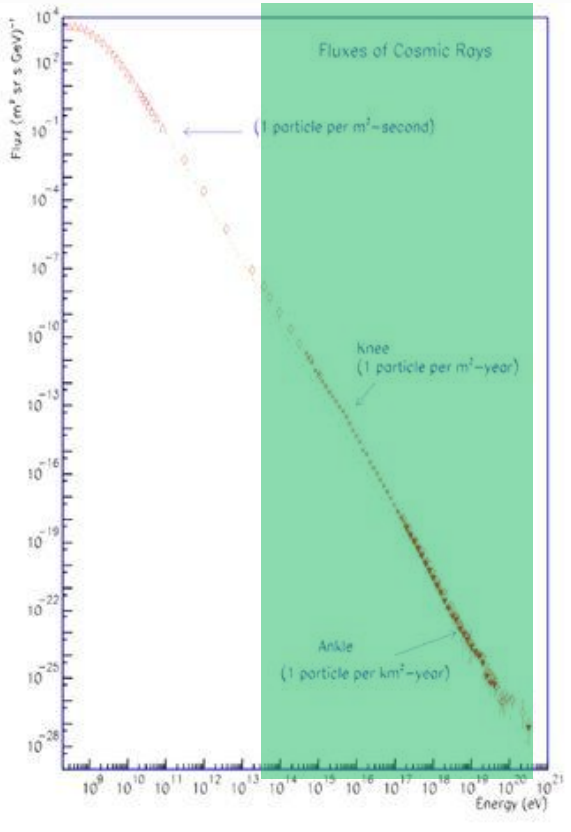
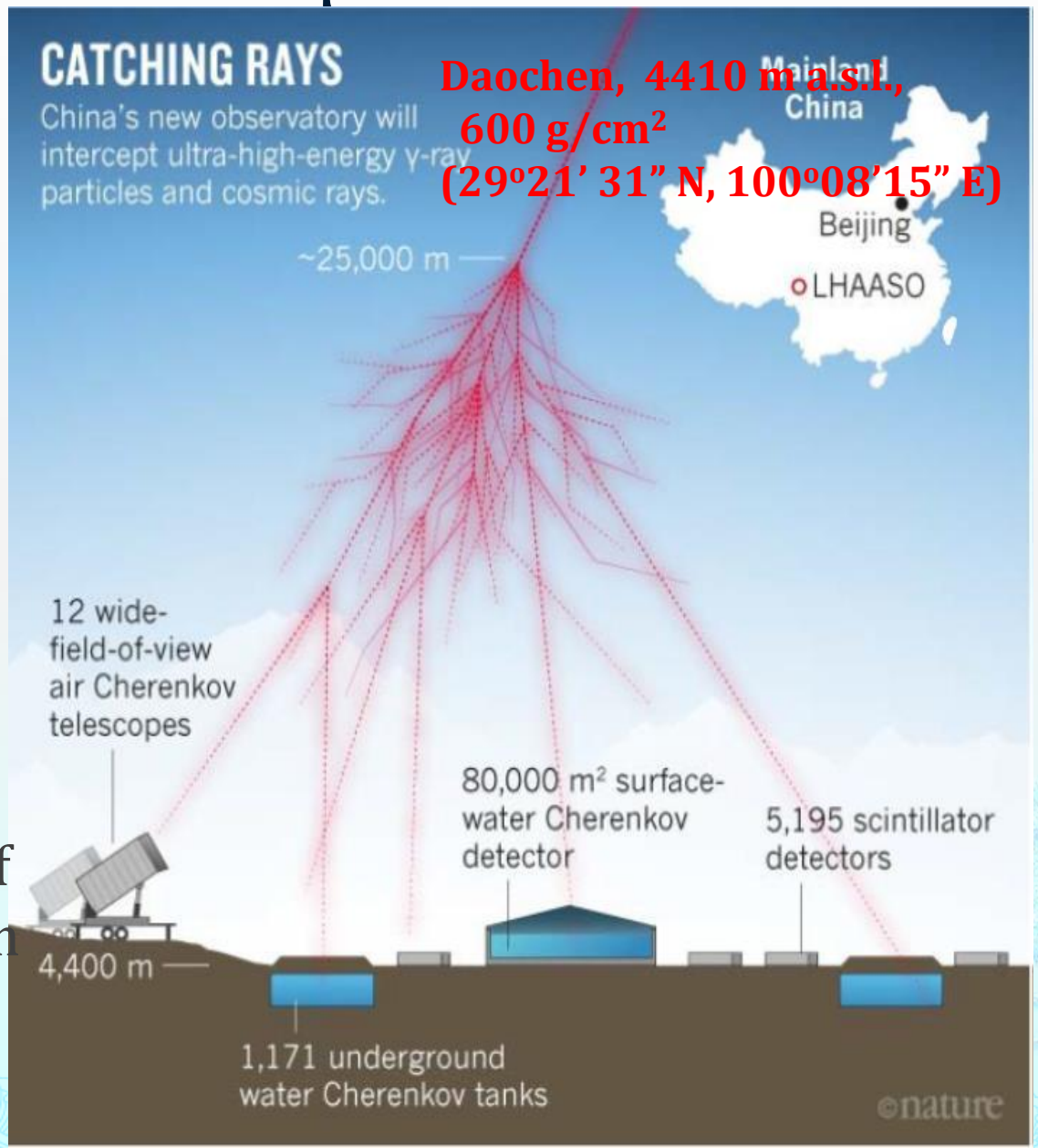
Content

- LHAASO Experiment
- Get the absolute energy scale by moon shadow
- Test the absolute energy scale by overlap observations with direct measurements.
- Summary

LHAASO experiments



Study the energy spectra of individual cosmic rays from 10TeV sub-EeV with a calibrated absolute energy scale



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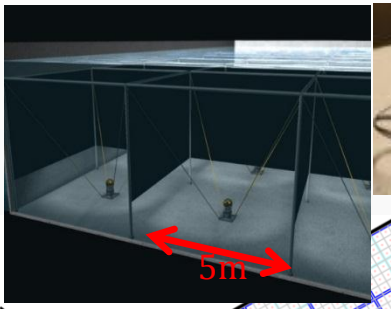
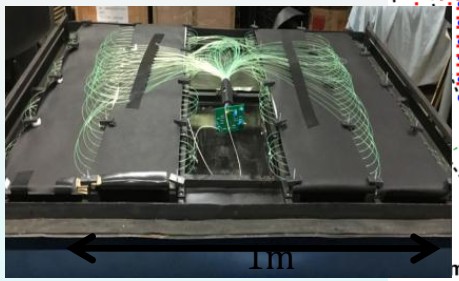
Detector Layout in LHAASO

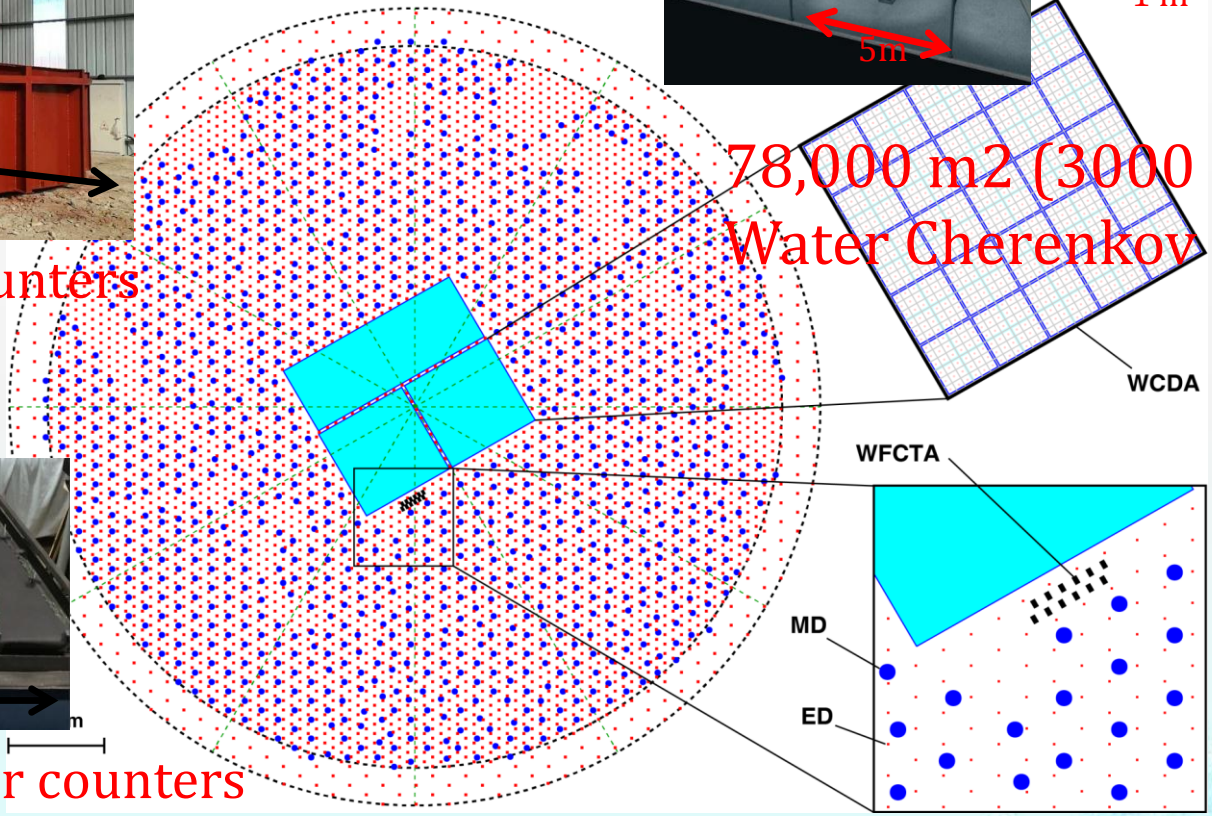
1171 muon counters
30 m spacing



78,000 m2 (3000 cells)
Water Cherenkov Detector

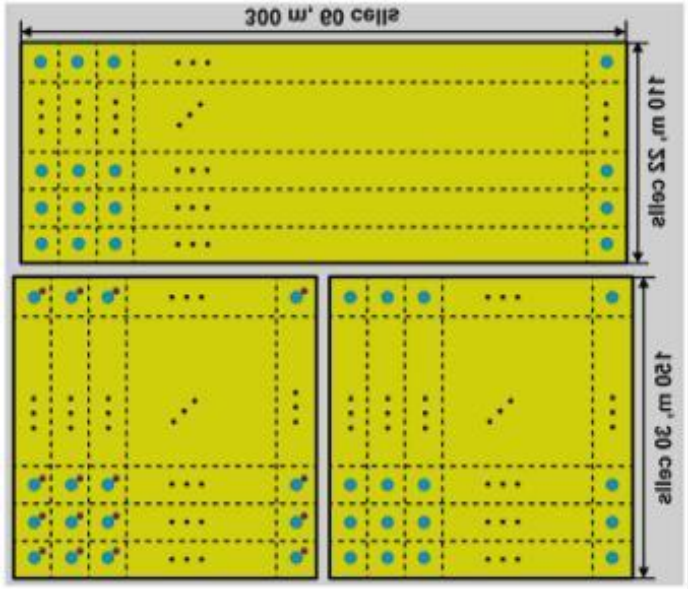


5195 Scintillator counters
15 m spacing

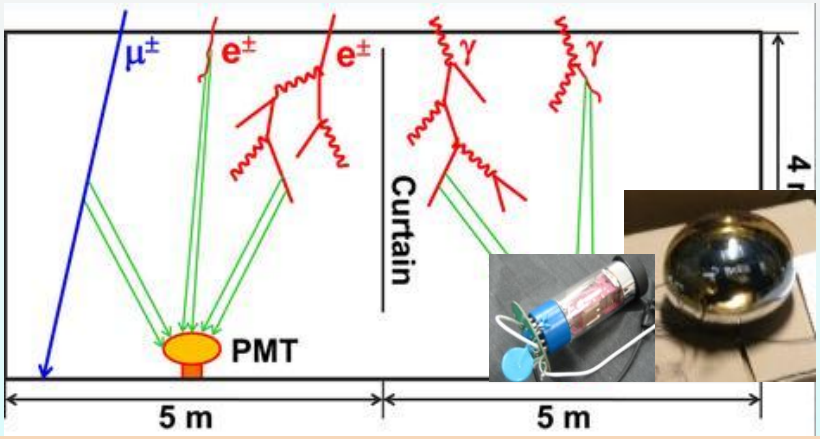


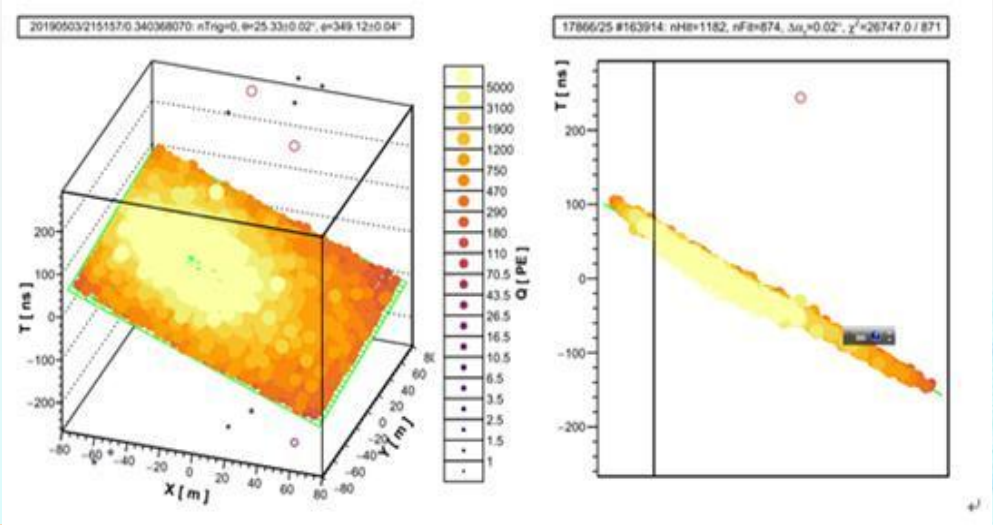
18 Wide FoV Cherenkov Telescopes

Water Cherenkov Detector Array



- Total units： 3600
- Total area 90000m2
- Time resolution: <2ns
- Two type of PMTs
  - 8 inches
  - 1inch



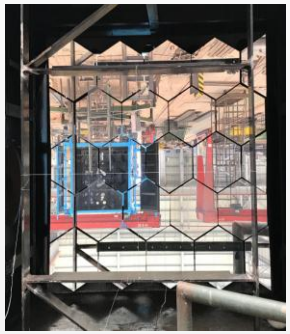


To increase the energy range 700GeV-10PeV
Information of near core

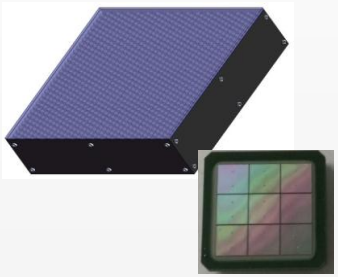
Wide FoV C-Telescope Array

Fully portable telescopes allow reconfiguring the array easily

- Movable telescope housing
- Rotating from 0° to 90° in elevation



- 5 m^2 spherical aluminized mirror
- Reflectivity of 85%



- 32×32 SiPM array
- FoV of 16°×16°
- 0.5° pixel
- 1-4000 PE nonlinearity less than 5%

- 4×4 20μm SiPM sub-cluster
- 50 MHz FADC
- Temperature-compensation power supply
- T-stamp from WR network

- Aluminized Winston cones
- Cut-off angle 30° with efficiency of 93%
- Filter transmission of 92% in 310－550 nm

with full-moon duty cycle >30% above 100 TeV

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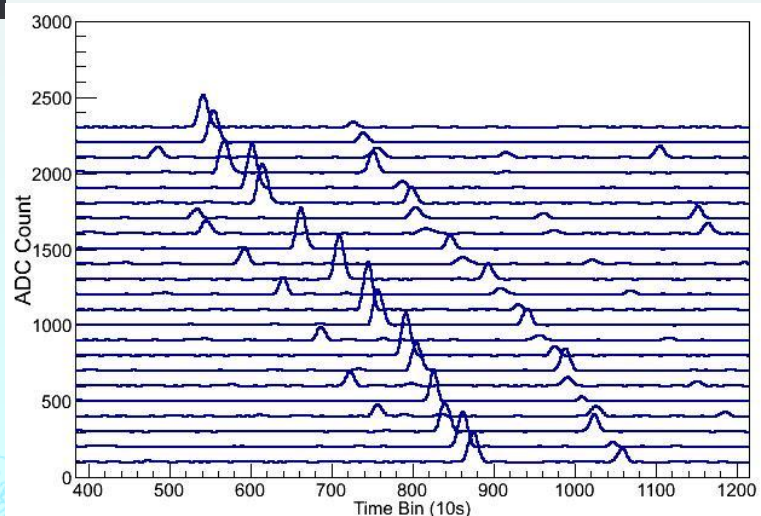
26th April, the first LHAASO detectors was put into operation

- **Water Cherenkov detector array with 900 detection units, 22500m2**
- **Two Wide FOV Cherenkov telescopes**
- **180 Scintillator detectors**
- **180 Muon detectors**

The whole picture of LHAASO on 26th April

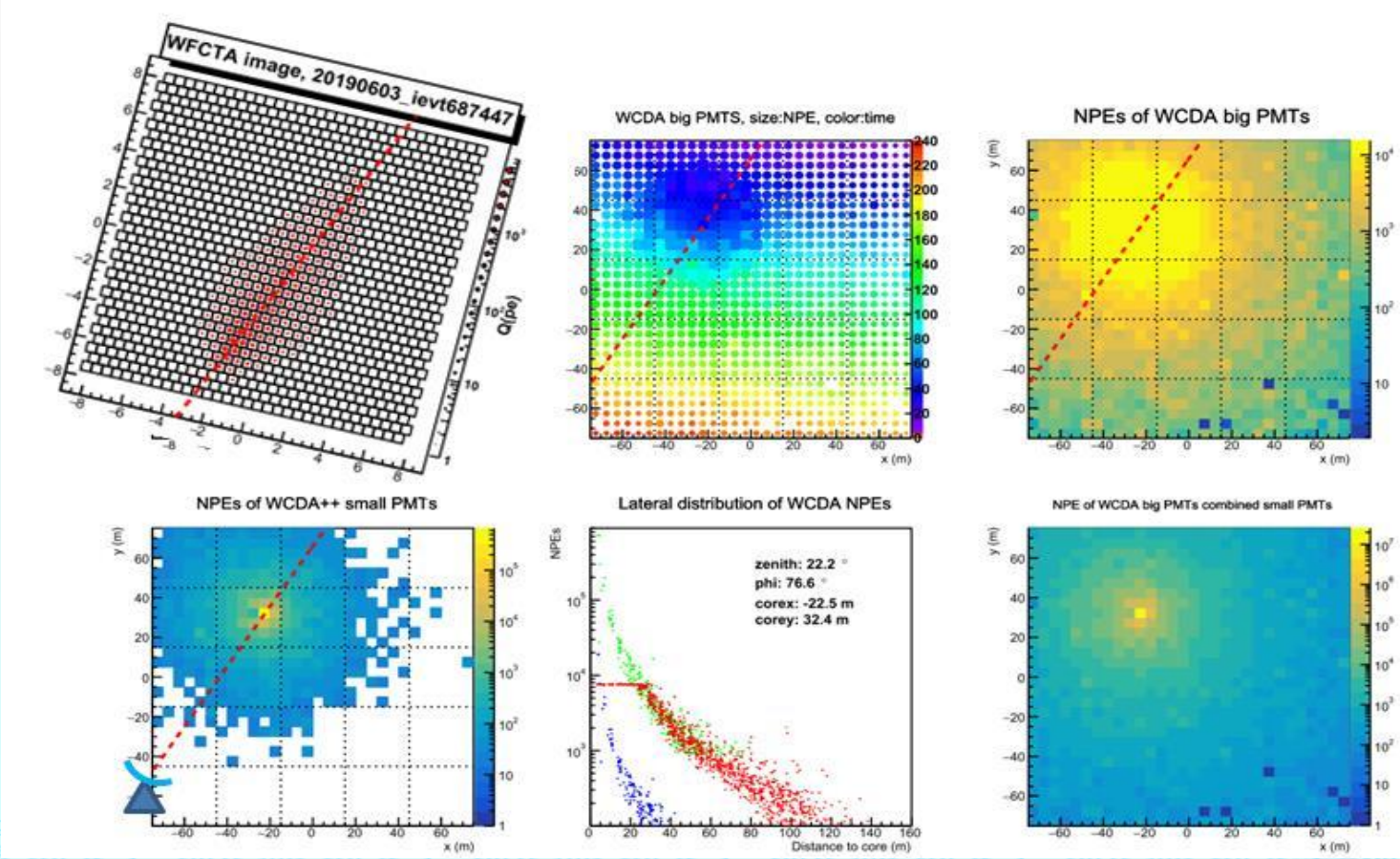
Hybrid observation of WCDA and WFCTA

The WFCTA is pointed to zenith to reduce the energy threshold



A hybrid event observed by WCDA, WCDA++ and WFCTA

left to right and upper to lower) Air Cherenkov image, water Cherenkov timing map, number of photo-electrons (Npe) map by 8” PMT array, same by 1.5” PMT array, matching of lateral distributions of Npe by two arrays , combined water Cherenkov map of Npe



Get the absolute energy scale by moon shadow

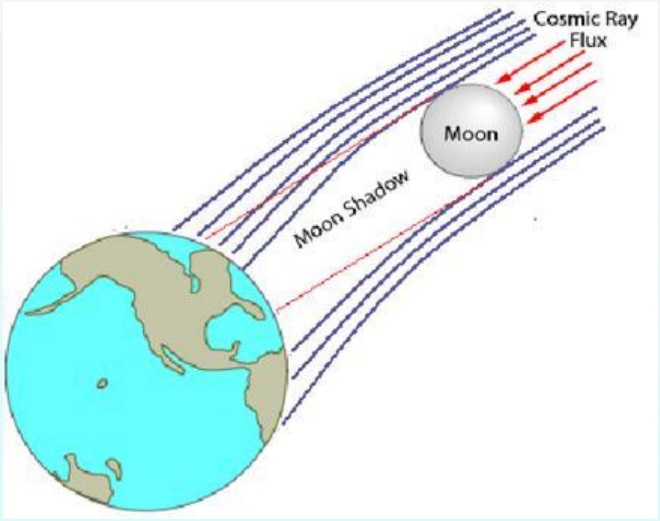
- By a natural magnetic spectrometer
  - The magnetic field between the Earth and the moon
  - The offset of the moon shadow is energy related

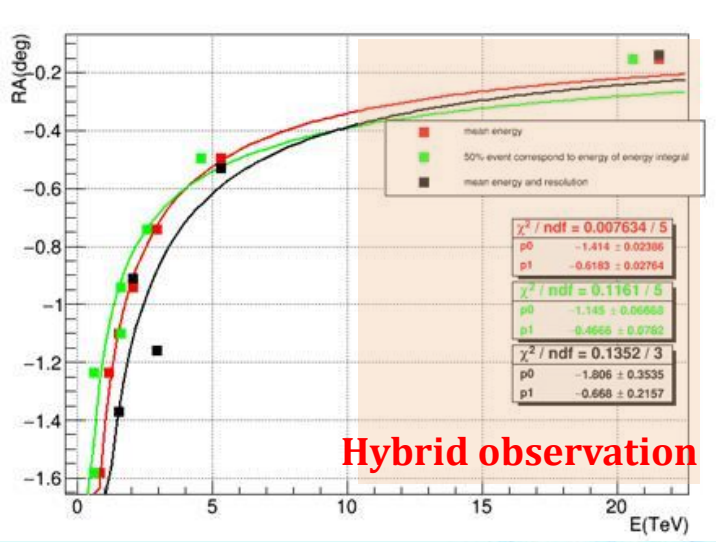
Get the off set of the moon shdaow

Get the energy scale of the WCDA

Transfer the energy scale by hybrid observation

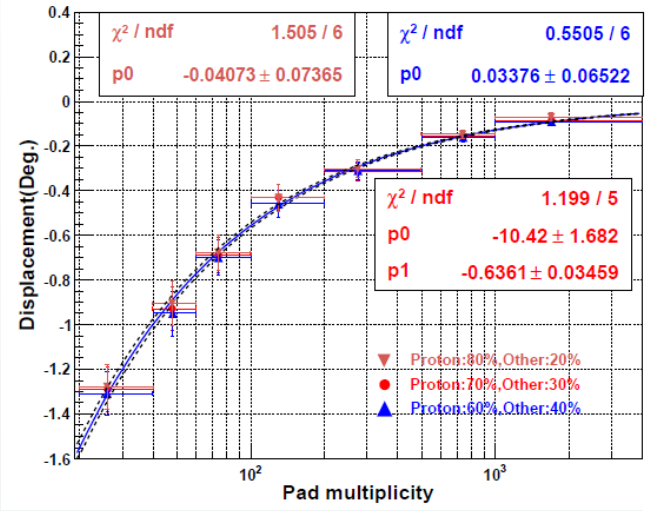
Get the energy scale of the small PMT and WFCTA



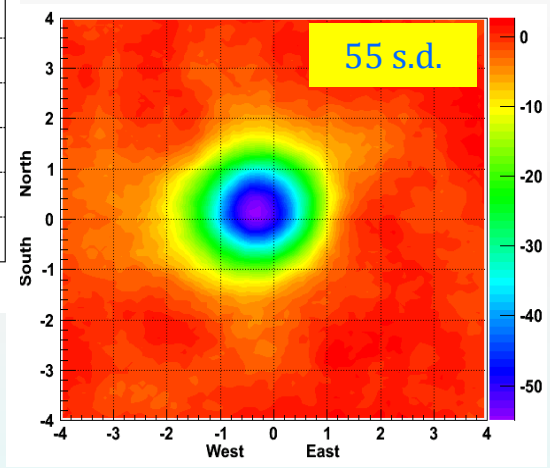


Energy scale in experiment

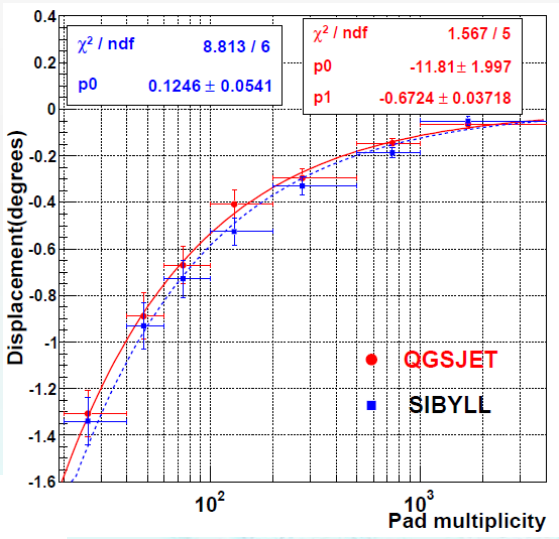
ARGO-YBJ : Moon Shadow displacement



$$N \approx 21 \cdot (E_{TeV}/Z)^{1.5}$$



1 – 30 (TeV/Z)



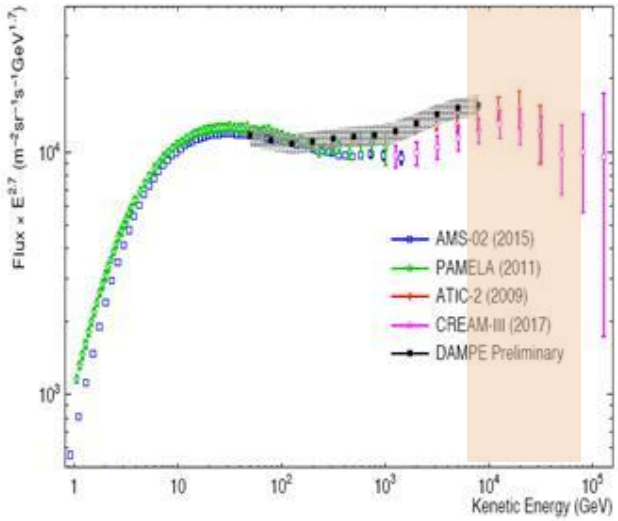
The energy scale uncertainty: smaller than 13%:

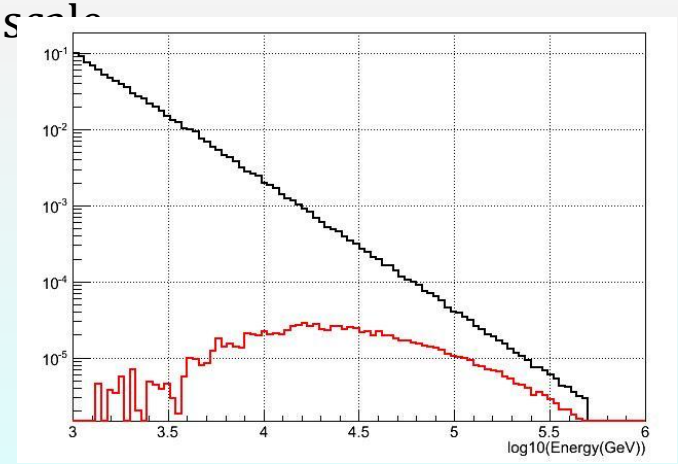
- the assumed primary CR chemical composition (7%)
- the uncertainties of different hadronic models (6%)

statistical uncertainty (8%)

Energy spectrum @100 TeV

- The energy scale of space detectors can be calibrated b enery accelerators
- The space experiments can measure the cosmic ray energy spectrum below 100TeV very well
- Proton spectrum becomes soft after 10TeV
- The structure can be used to test the energy scale



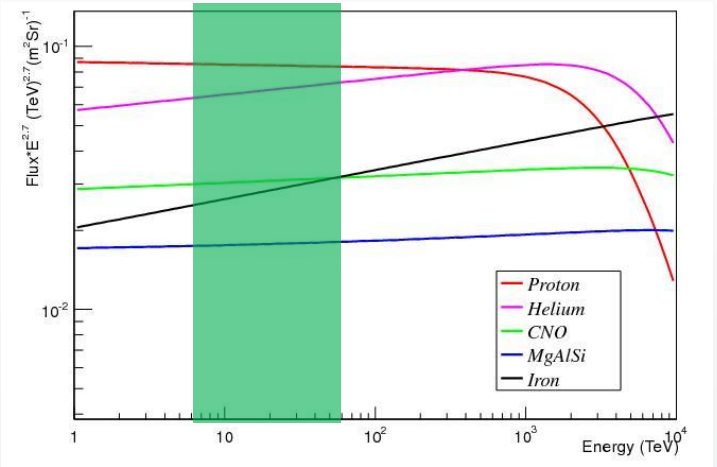


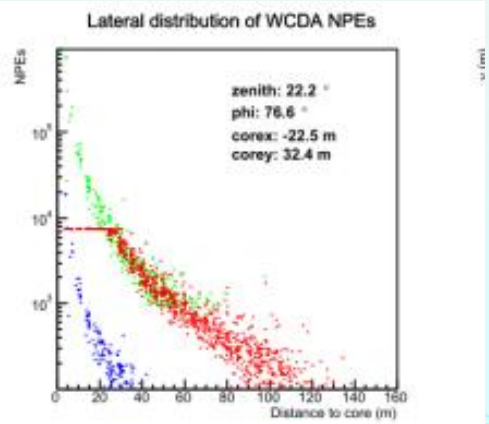
WFCTA is pointed to the zenith to reduce its energy threshold .

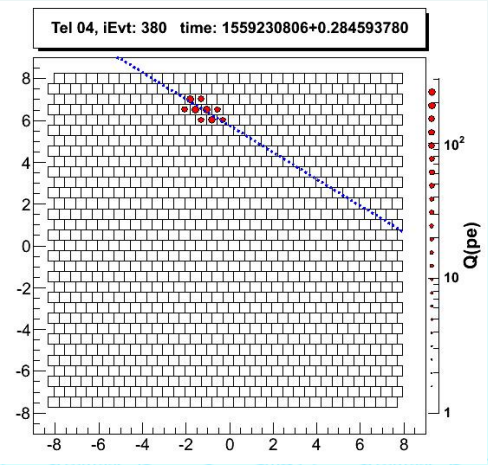
The energy threshold is about 15TeV with single threshold 45pe and at least 5 pixel after image cleaning

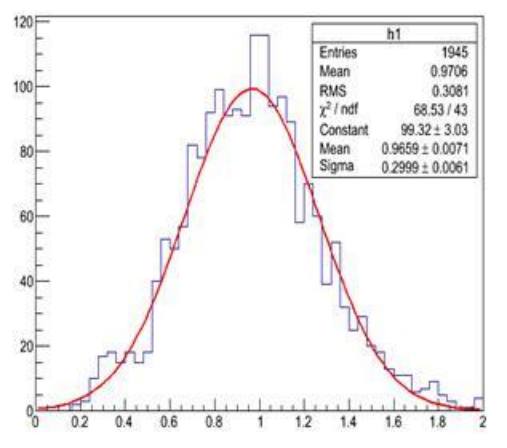
The energy spectrum @ 10TeV

- In the energy range, the proton and helium is dominated
- The purity can reach up to 95% of proton and helium
- Information of near core observed by WCDA
- Hillas, Xmax
- The energy resolution at 10 TeV is about 30%









Summary

- By moon shadow the absolute energy scale of LHAASO-WCDA can be obtained
- The energy the scale can be transferred to the LHAASO-WFCTA
- The energy scale can be tested by structure of spectrum at 10TeV
- LHAASO can measure the energy spectrum with a calibrated energy scale

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Thanks