Energy reconstruction method of cosmic ray for LHAASO-KM2A experiment

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Outline

- Motivation
- Introduction to the LHAASO
- Selection of observed variables （ N_e and N_μ ）
- Energy reconstruction method

Motivation

- The all-particle energy spectrum exhibits two interesting structures from 10^{14} to 10^{18} eV, the “knee” and the “second knee”. An explanation of these features is thought to be an important step in understanding the origin of the high-energy particles.

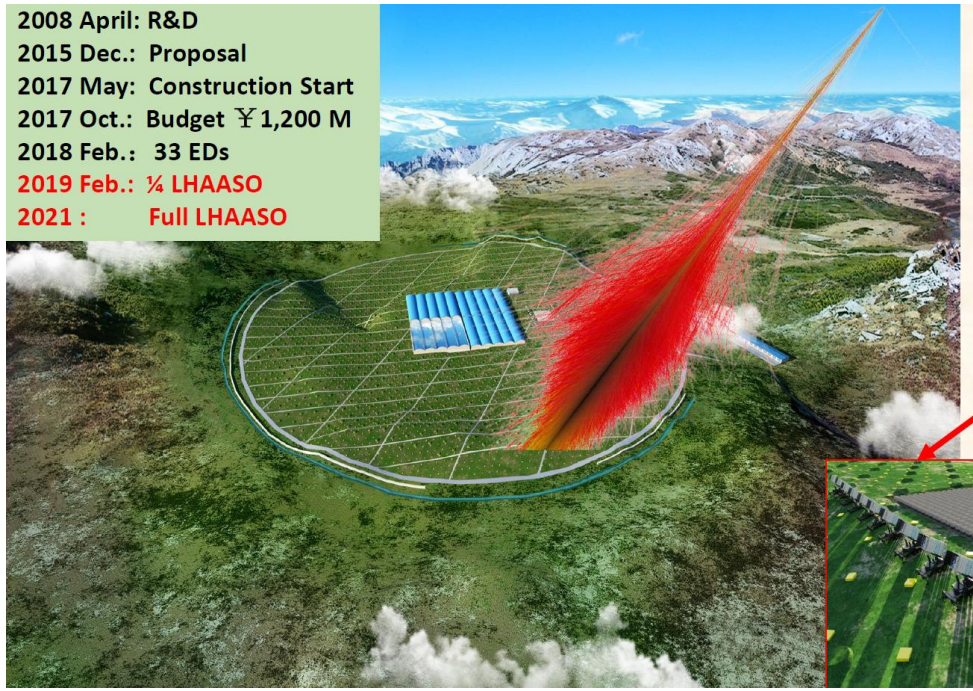
- A finite energy attained during the acceleration process
  leakage from the Galaxy

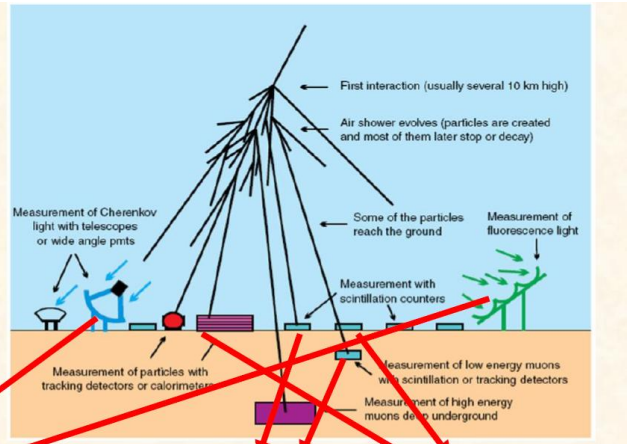
- Cosmic-ray components and hadronic interaction models

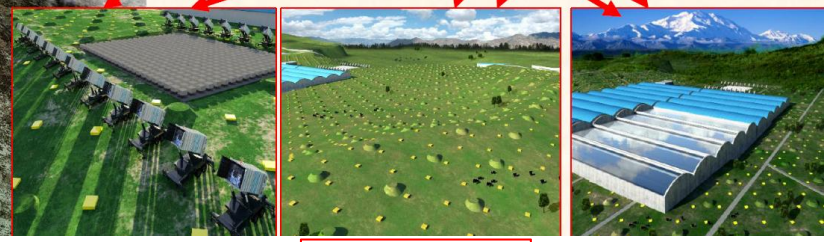
- A combination of electron and muon number is insensitive to the type of primary particle.

LHAASO(Large High Altitude Air Shower Observatory)

2008 April: R&D
2015 Dec.: Proposal
2017 May: Construction Start
2017 Oct.: Budget ￥1,200 M
2018 Feb.: 33 EDs
2019 Feb.: ¼ LHAASO
2021 : Full LHAASO







WFCTA

KM2A
ED、MD

WCDA(WCDA++)

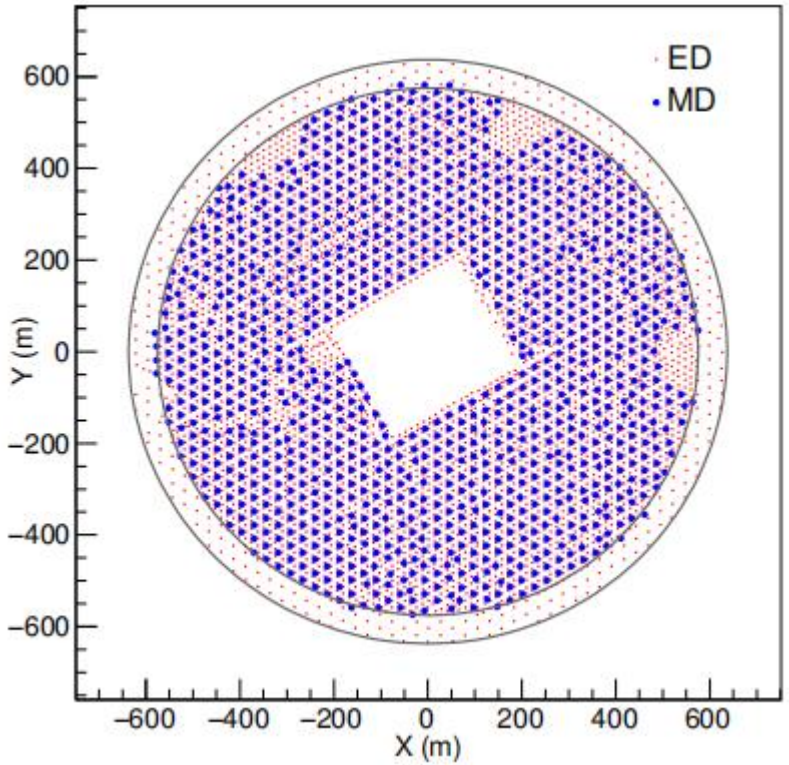
Ground-based air shower observatory under constructing at 4410 m above sea level in Daocheng,

Kilometer square array (KM2A): electromagnetic detector (ED) and muon detector (MD)

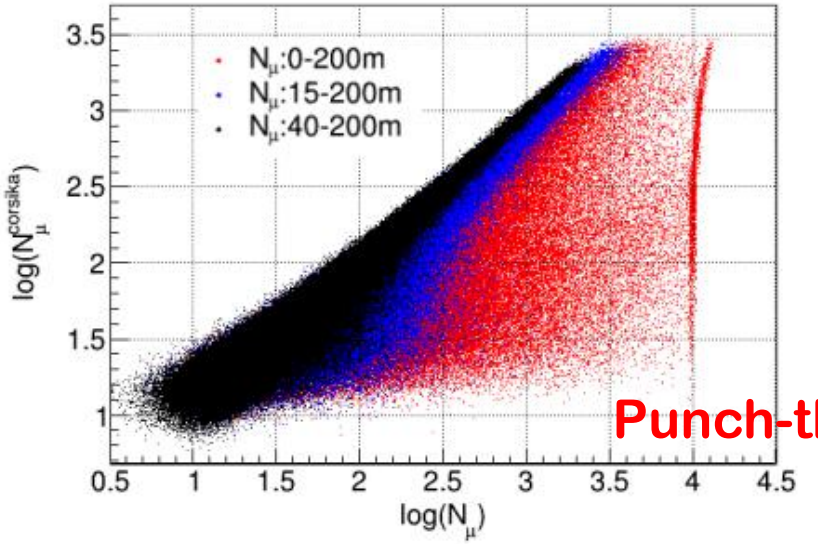
Water Cherenkov detector array (WCDA),

Wide-field-of-view Cherenkov/fluorescence telescope array (WFCTA)

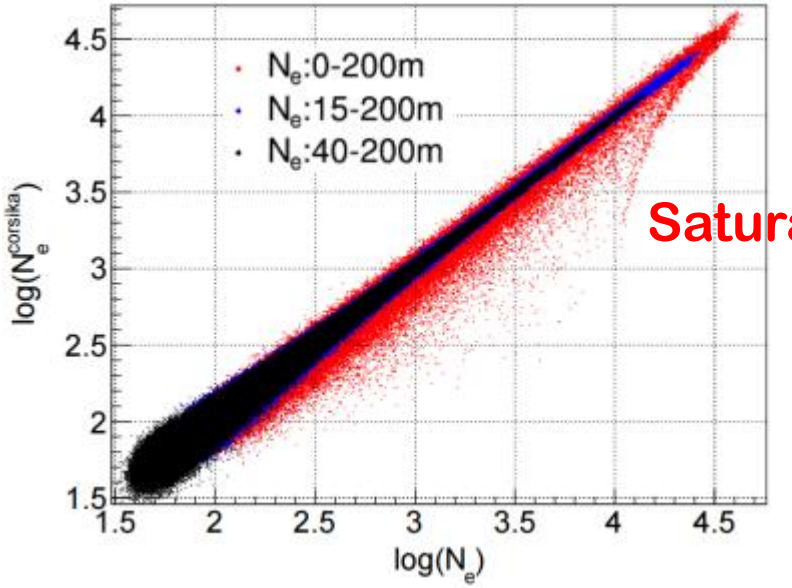
KM2A experiment



The layout of the KM2A full array



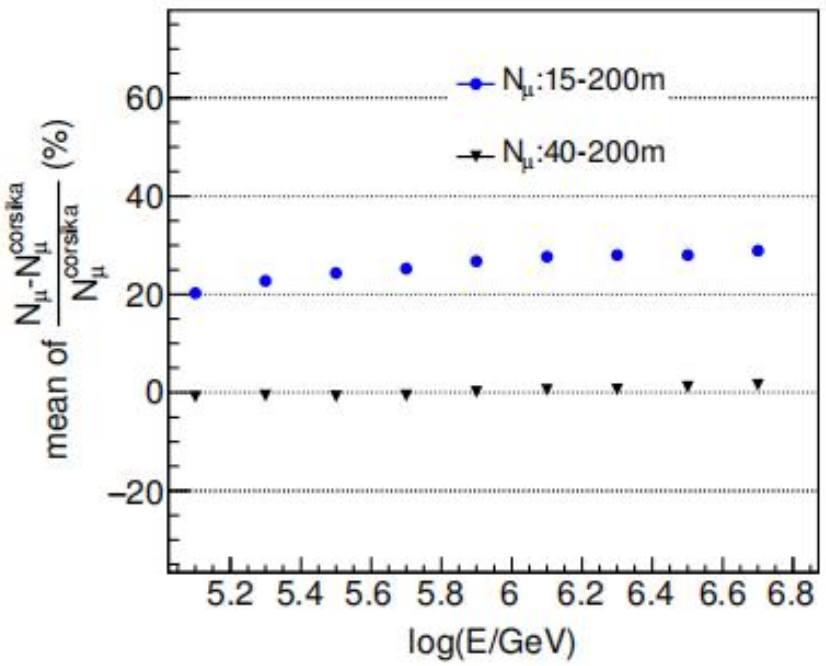
Punch-through effect

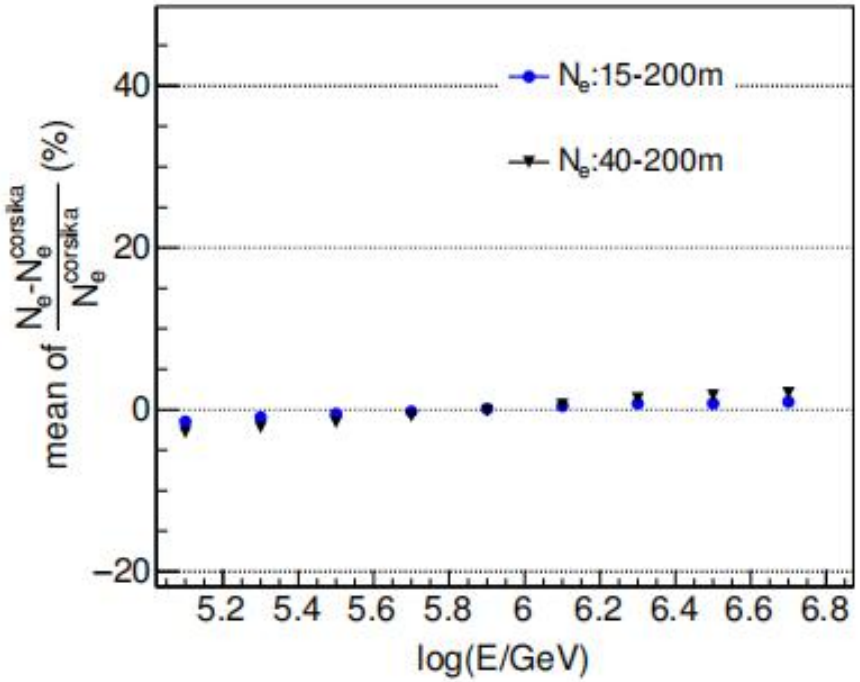


Saturation

The KM2A experiment can measure the electrons number and muon number of an air shower simultaneously with high precision for cosmic rays with energies in the knee region.

Selection of observed variables （ N_e and N_μ ）



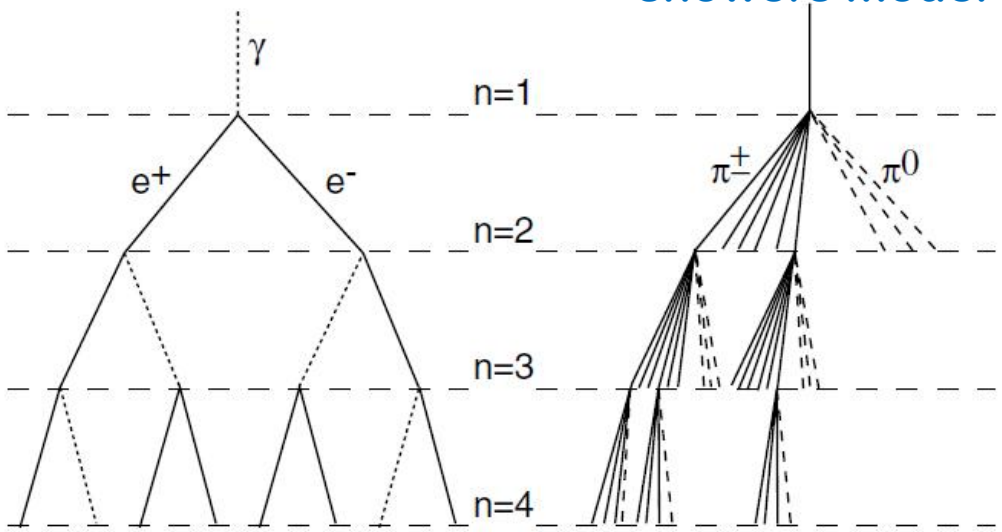


The difference between the $N_e^{corsika}(N_\mu^{corsika})$ in corsika and the reconstructed $N_e(N_\mu)$after deducting in 15 m and 40 m of the shower core

Selection of observed variables （ N_e and N_μ ）

The primary energy of cosmic ray is related to the atomic mass number *A*, the number of muons N_μ and the number of electrons N_e

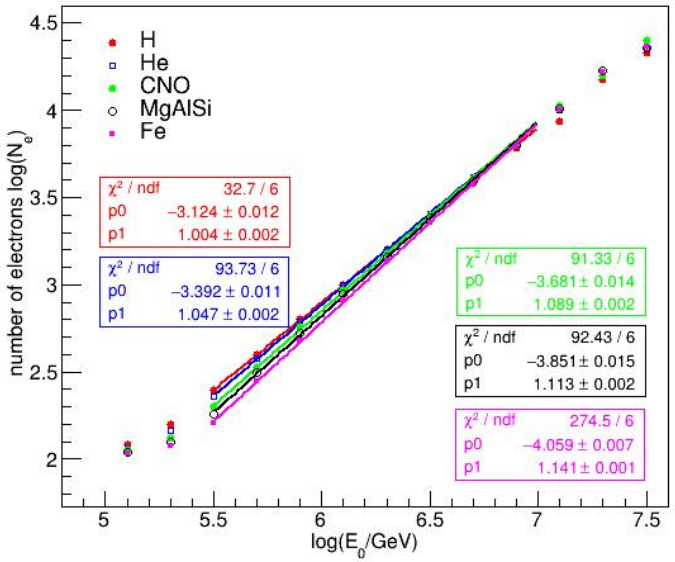
Heitler's EM model

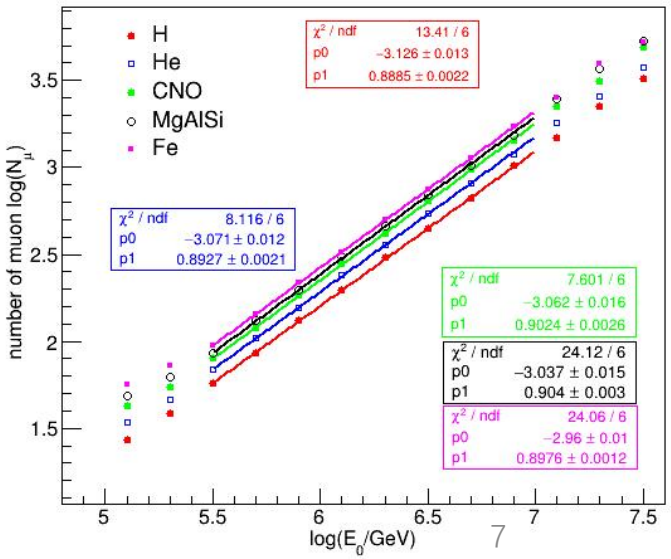


Matthews's hadronic showers model

$$N_\mu = \left(\frac{E_0}{E_c^\pi}\right)^\beta A^{1-\beta} \approx 1.69 \times 10^4 \cdot A^{0.10} \left(\frac{E_0}{1\ \mathrm{PeV}}\right)^{0.90}.$$

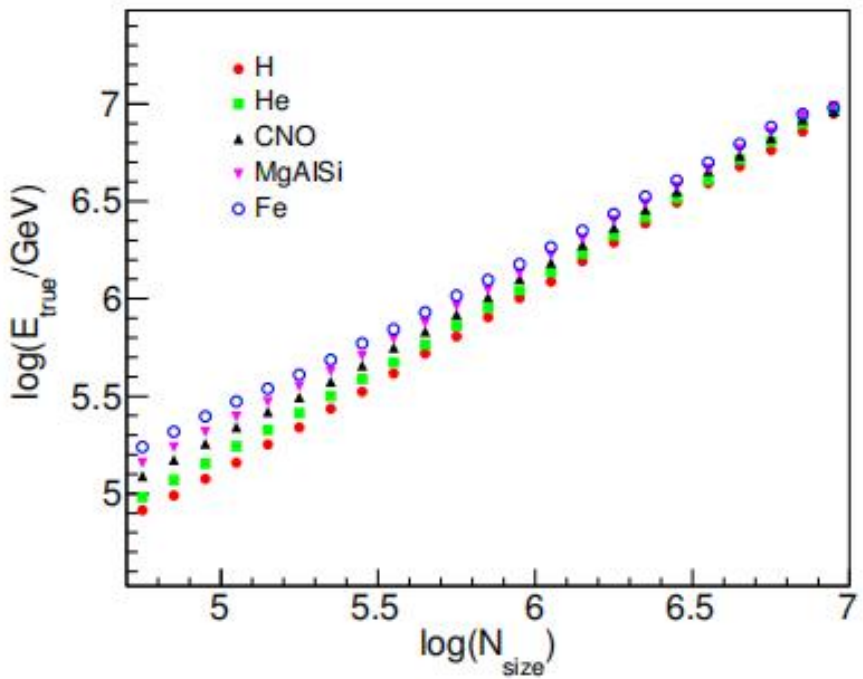
$$N_e \approx 5.95 \times 10^5 \cdot A^{-0.046} \left(\frac{E_0}{1\ \mathrm{PeV}}\right)^{1.046}$$

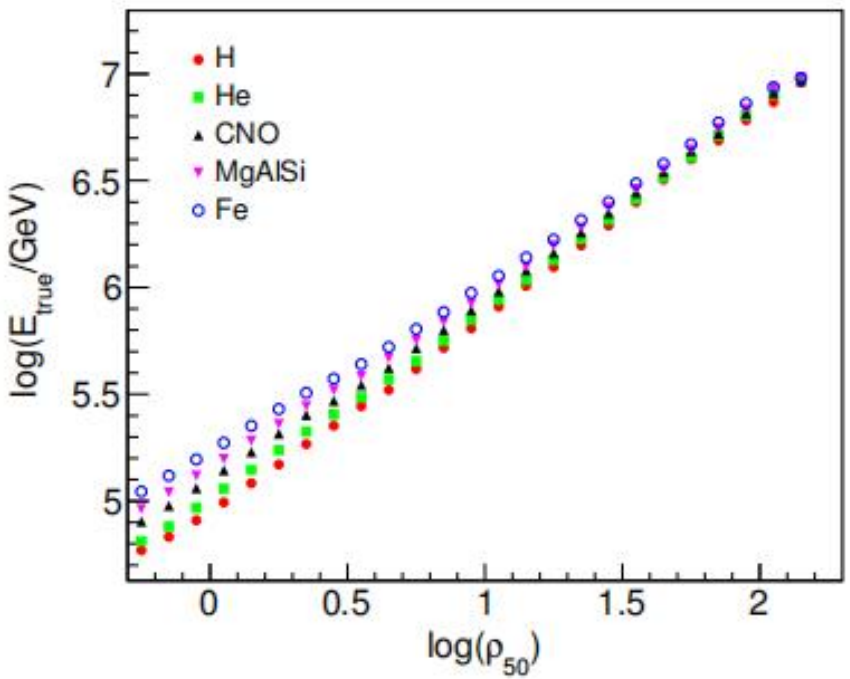




Energy determination

Other quantity to reconstruct energy





Tibet-III air-shower array estimated the cosmic ray primary energy by the shower size N_{size}

The particle density at r = 50 m (denoted as ρ_{50}) evaluated using the lateral distribution function is used to estimate the γ-ray energy

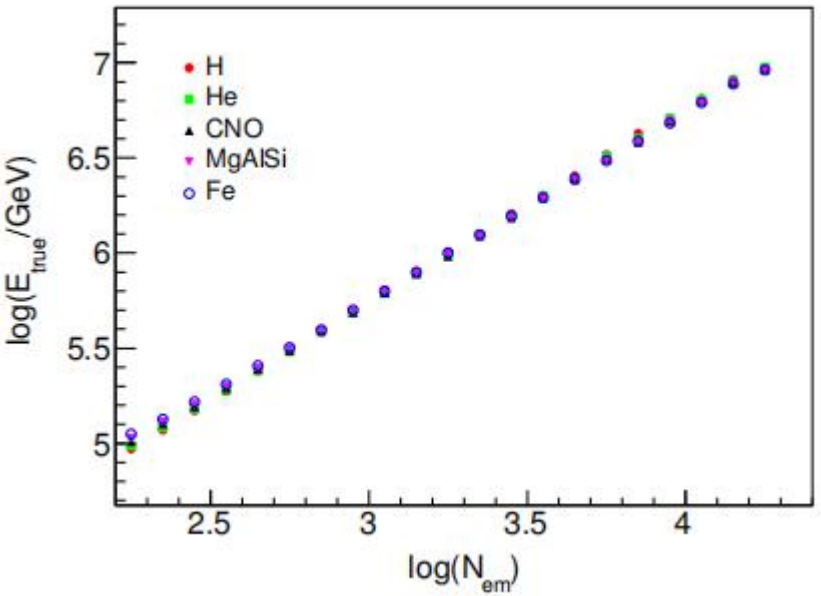
Energy determination

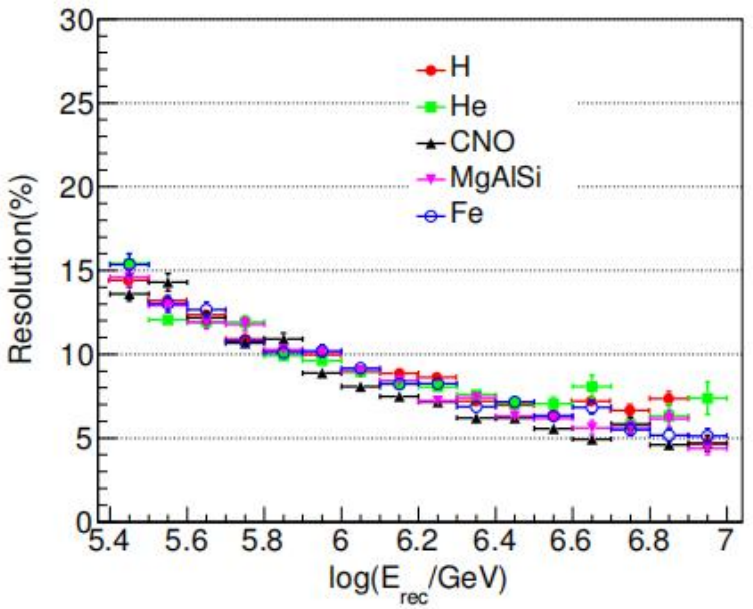
As Heitler's EM model and Matthews's hadronic showers model introduced that the primary energy is finally divided between pions and electromagnetic particles in subshowers.

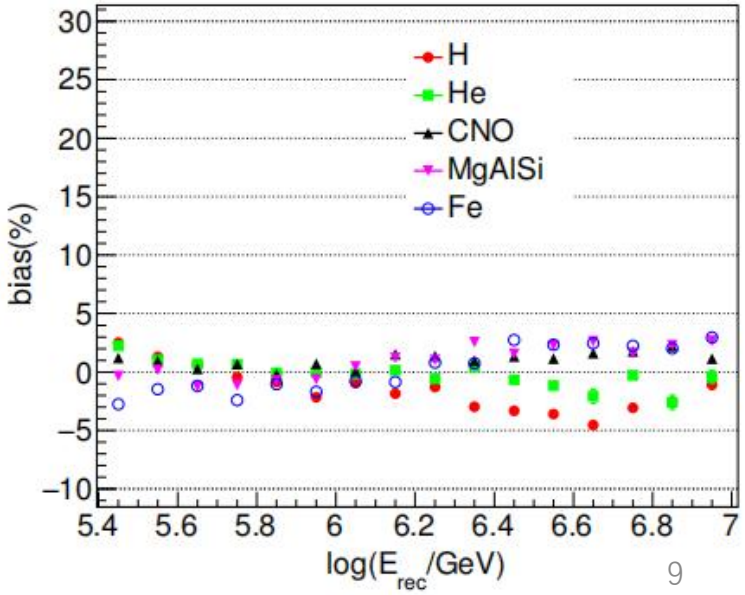
$$E_0 = E_e + E_h$$

one combined variable to reconstruct the cosmic ray energy weakly dependent on the components

$$N_{em} = N_e + 2.7 * N_\mu$$







Summary

- ✓ A combination of electron and muon number which will be shown to be insensitive to the type of primary particle.
- ✓ The cosmic ray all-particle energy spectrum between 10^{14} to 10^{17} eV using LHAASO-KM2A full array.

Thanks