





Measurements of the cosmic ray all-particle and light component energy spectra, between 10¹⁴ and 10¹⁶ eV, with ARGO-YBJ

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Outline

- → The ARGO-YBJ (analog) detector
- → The particle lateral distribution seen by ARGO-YBJ
- → Event energy reconstruction
- ➔ The all-particle energy spectrum measured with ARGO-YBJ

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DEL **Salent**

→ p+He selection and light component energy spectrum with ARGO-YBJ











- Made of a single-layer of Resistive Plate Chambers (RPCs).
- → A system for the RPC analog charge readout implemented throgh large pads (big pads), each covering half a chamber, extending the detector sensivity from about 10¹⁴ eV up to more than 10¹⁶ eV.
- → Different gain scales (G0,... G7) used to cover a wide range in particle density, up to 10⁵ particles/m²
- → Data taking in full configuration from november 2007 to february 2013

High space/time granularity

- + Full coverage
- + High altitude (4300m a.s.l.)

detailed study on the EAS space/time structure with unique capabilities

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Particle lateral distribution

LDF: Lateral **D**istribution **F**unction of charged particles at ground

- Access the LDF down to shower core without saturation
- Fitted to a simplified NKG-like function:

$$\rho'_{NKG} = A \cdot \left(\frac{r}{r_0}\right)^{s'-2} \cdot \left(1 + \frac{r}{r_0}\right)^{s'-4.5}$$



The shape parameter s':

- decreases when N_{p8} (i.e. shower size) increases for a given primary
 - \rightarrow observation of younger (deeper showers)
- Increases going from proton to iron, for a given $N_{_{\rm D8}}$

The measurement of both N_{p8} and s' has two implications:

- help constraining the shower age
- $\boldsymbol{\textbf{\scriptsize \rightarrow}}$ give information on the primary particle nature

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Big Pads (analog) →clear

identification of the shower core

ARGO-YBJ (154 CL) - Event 242653

ARGO-YBJ (154 CL) + Event 242653

Strips (digital) \rightarrow

saturation at high multiplicity

ARGO-YBJ (154 CL) - Event 242653



Energy reconstruction



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All particle spectrum

Quasi-vertical events ($\theta < 15^{\circ}$)

- Two different gain scales (blue dots G1, red dots G4) are plotted.
- The parametrizations provided by Horandel (blue line) and Gaisser-Stanev-Tilav (red line) for comparison.
 - Consistent picture with models and previous measurements
 - Nice overlap with the two gain scales (different data,...)
 - Suggest spectral index of -2.6 below 1 PeV and smaller at larger energies



The p+He spectrum

He

Fe



- Gradual change of the slope starting around 500 TeV : proton knee ?!!

-New hints for SN acceleration and galactic CR propagation models

-Agreement with another ARGO-YBJ independet analysis

- Overlap with direct measurements at low energy



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reliminary

protons

CNO

-MC simulated

CNO group, Fe

-Magenta line:

select a p+He

ARGO-YBJ data

s' vs Np8 Fe

