

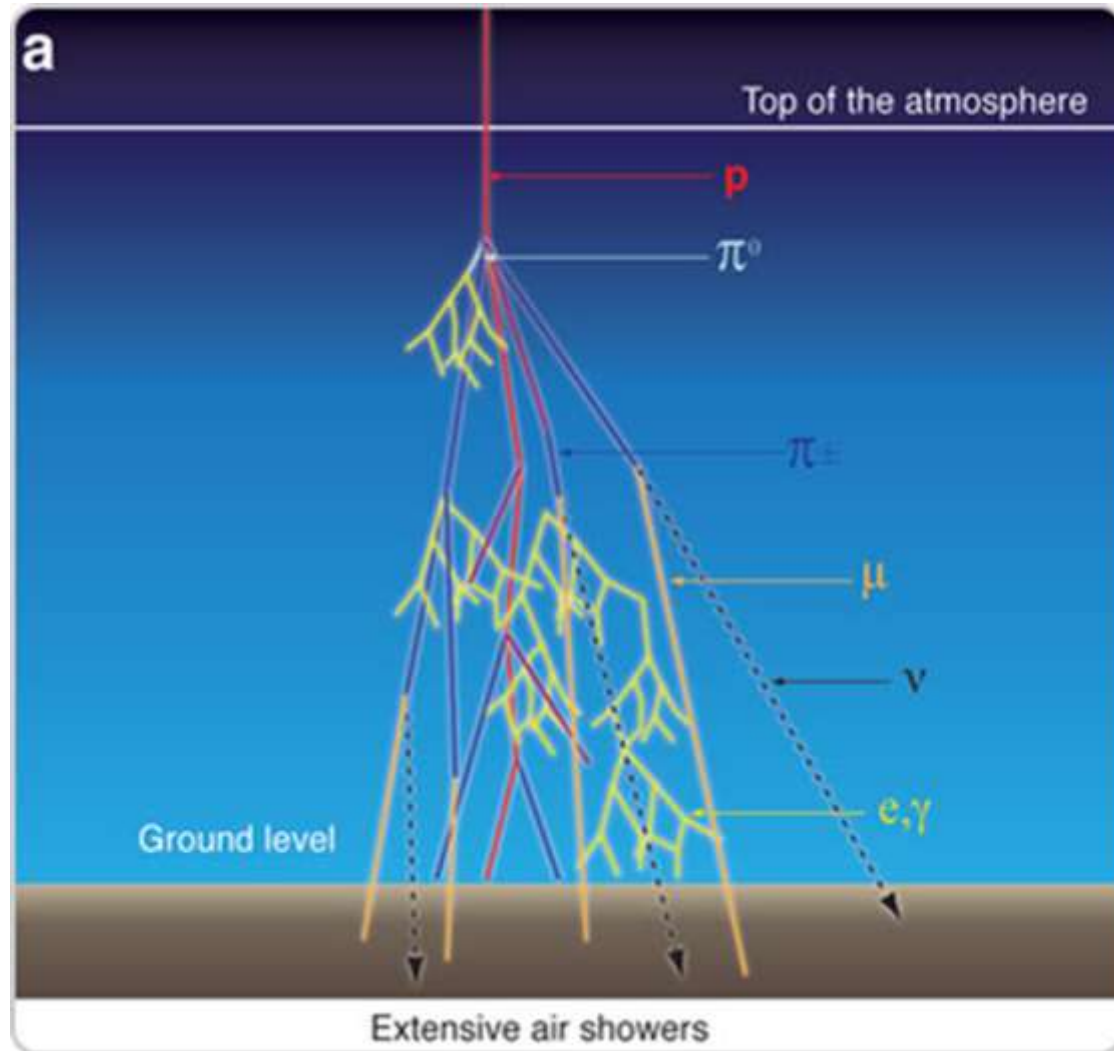


Estimation of the composition of the primary cosmic ray particles by measurements of the cosmic ray muon component

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Introduction



- Interaction of cosmic rays in the atmosphere to produce secondary particles.

- $p + nucleus \rightarrow \pi^\pm + \pi^0 + x$ (1)

- $\pi^0 \rightarrow \gamma + \gamma$ (2)

- $\pi^\pm \rightarrow \mu^\pm + \nu_\mu (\bar{\nu}_\mu)$ (3)

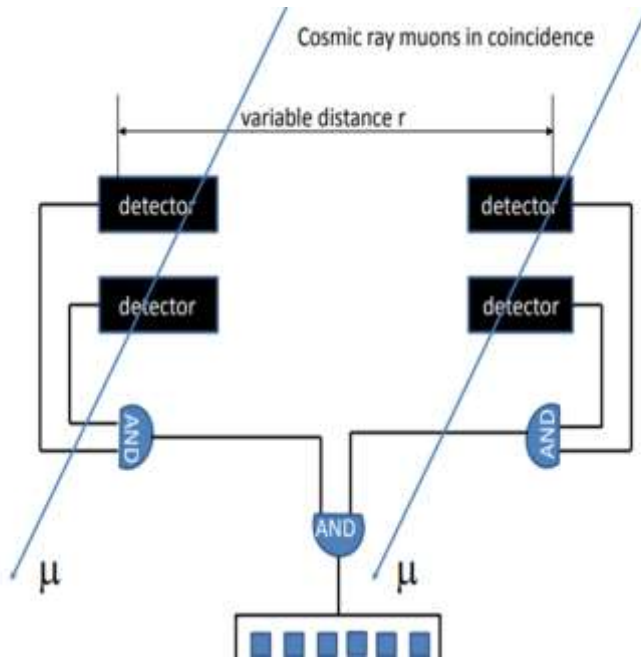
- $K^\pm \rightarrow \mu^\pm + \nu_\mu (\bar{\nu}_\mu)$ (4)

- $\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$ (5)

- $\mu^- \rightarrow e^- + \nu_\mu + \bar{\nu}_e$ (6)

π^0, π = pions ν = neutrinos N = Neutron μ = Muons e^+ = Positron P = Proton γ = Gamma ray e^- = electron

Methodology



- In this work the following instrumentation was be used, Power supply, Detectors Nuclear Instrument Module and Personal computer for Monte Carlo simulations and data analysis.
- Monte Carlo Simulations using CORSIKA (Cosmic Ray Simulation for KASCADE Grande Experiment)
 - i) Choose the high energies for hadronic interactions. EPOS LHC(used in this work)
 - ii) Choose the low energies for hadronic interactions. GHEISHA(used in this work)
 - iii) Choose the detector orientation Horizontal flat orientation(used in this work)
 - iv) Specify the particle its ID and its percentage composition.

Estimation of the elemental composition of primary cosmic ray particles

$$f(x) = Par(1).fp + Par(2).fHe + Par(3).fFe \quad (8)$$

The sum of parameterization obtained for P, He, and Fe after simulating using EPOS LHC were fitted to the measured two-fold coincidences.

where Element(i) represents the contribution in % for proton, helium, and iron.

$$Element(i) = E(i) = \frac{Par(i)}{\sum Par(i)} \times 100\% \quad (9)$$

$$\sigma_{Ei} = \sqrt{\sum_{j=1,3} \left(\frac{\partial E_i}{\partial Par(j)} \cdot \sigma_{Par(j)} \right)^2} \quad (10)$$

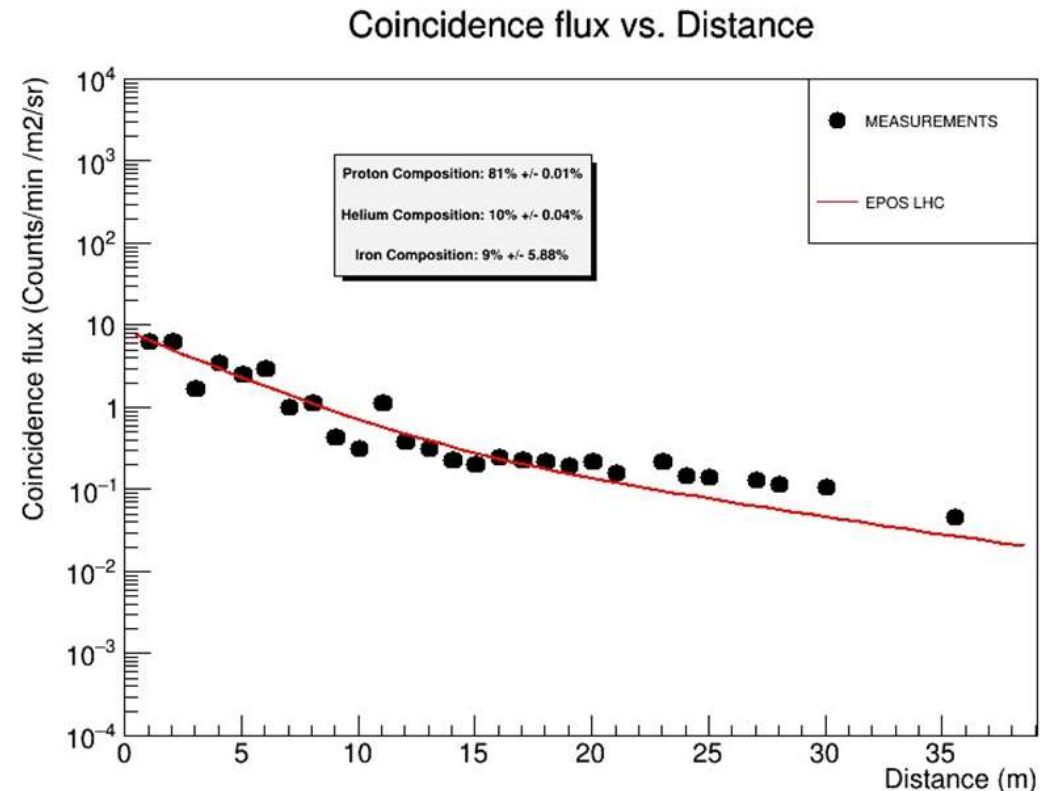
The errors of the parameters par(j) are computed by the MINUIT fitting function.

Results and Discussion

- Below are the parameters obtained after fitting the NKG function to each particle respectively.

ELEMENT	a	b	c	R_0
PROTON	0.6828 ± 0.0001	-0.9995 ± 0.0001	0.0005 ± 0.0002	0.9644 ± 0.0002
HELIUM	0.0573 ± 0.0027	-1.1724 ± 0.0243	-0.2724 ± 0.0358	1.6419 ± 0.0817
IRON	0.0020 ± 0.0002	-1.0931 ± 0.0112	-0.4246 ± 0.0595	14.4102 ± 1.6336

- This is where we have the graph, Fitted Primary Composition (EPOS LHC model): Proton: $81 \pm 0.01\%$ Helium: $10 \pm 0.04\%$ Iron (heavier): $9 \pm 5.88\%$
- Comparison: VENUS model (Tcaciuc 2006): 77% Proton, 23% Iron
- This work favors light composition (proton + helium dominant)



Conclusion

- Muon flux from simulation agrees well with experimental data.
- Primary cosmic ray composition is dominated by light nuclei
- EPOS LHC model successfully accounts for proton, helium, and iron components.

Recommendation

- Use other hadronic models (like QGSJET-II-04) to further enhance the knowledge on the primary cosmic ray composition.
- Increase number of detectors and extend measurements for better lateral distribution data.