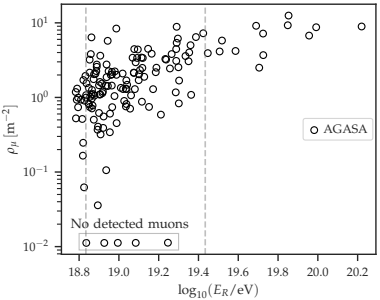
Muon deficit in simulations of air showers inferred from AGASA data

Flavia Gesualdi[a,b]*, Daniel Supanitsky[a], Alberto Etchegoyen[a]

[a] Insituto de Tecnologías en Detección y Astropartículas (CNEA, CONICET, UNSAM), San Martín, Buenos Aires, Argentina
[b] Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany
* flavia.gesualdi@iteda.cnea.gov.ar

UNSAM
UNIVERSIDAD NACIONAL DE SAN MARTÍN

Data



Data extracted from Ref. [1].
Energy is rescaled to a cross-calibrated energy scale [2].

Simulations

p He N Fe	+	EPOS-LHC QGSJetII-04 Sibyll2.3c

Simulation library described in Ref. [3].

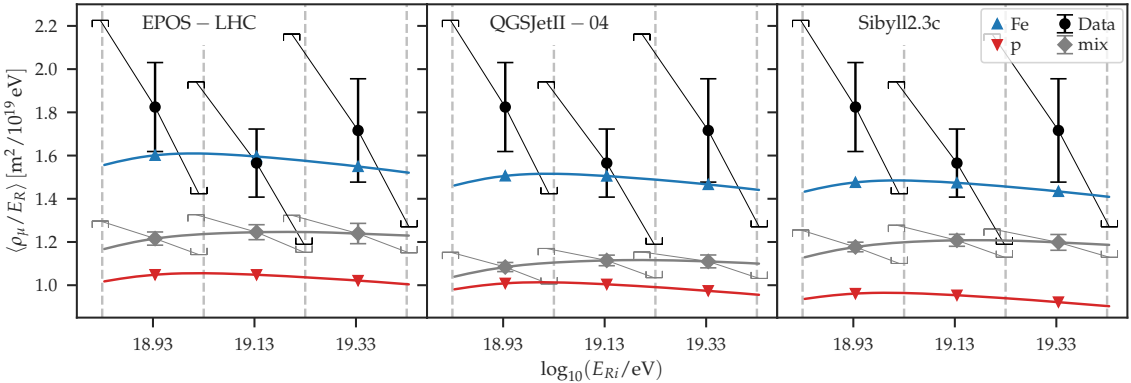
Mixed composition

$$\langle \widetilde{\rho}_{\mu,\mathrm{mix}} \rangle(E) = \sum_{\mathrm{A}} f_{\mathrm{A}}(E) \cdot \langle \widetilde{\rho}_{\mu,\mathrm{A}} \rangle(E),$$

where $f_{\mathrm{A}}(E)$ are the mass fractions from the Pierre Auger fits to $X_{\max}$ distributions [4].

We analytically compute the energy reconstruction and binning effects $\rightarrow \langle \rho_\mu / E_R \rangle$ is 11 % to 22 % smaller.

Results

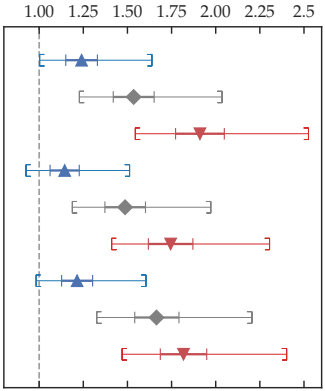


AGASA data vs. {p, mix, Fe}. Bin width $\Delta \log_{10}(E_R/\mathrm{eV}) = 0.2$.
The AGASA data are compatible with a heavier composition.

Results

$$F_{\{\mathrm{p,\,mix,\,Fe}\}} = \frac{\langle \rho_{\mu,\mathrm{data}}/E_R \rangle}{\langle \rho_{\mu,\{\mathrm{p,\,mix,\,Fe}\}}/E_R \rangle}, \text{ where } 18.83 \leq \log_{10}(E_R/\mathrm{eV}) \leq 19.46.$$

		$F \pm (\mathrm{stat}) \pm (\mathrm{syst})$
Sibyll2.3c	Fe	$1.24 \pm 0.09 \pm^{0.40}_{0.24}$
	Mixed	$1.54 \pm 0.12 \pm^{0.50}_{0.31}$
	p	$1.91 \pm 0.14 \pm^{0.61}_{0.37}$
EPOS - LHC	Fe	$1.14 \pm 0.08 \pm^{0.37}_{0.22}$
	Mixed	$1.49 \pm 0.12 \pm^{0.49}_{0.30}$
	p	$1.74 \pm 0.13 \pm^{0.56}_{0.33}$
QGSJetII - 04	Fe	$1.21 \pm 0.09 \pm^{0.39}_{0.23}$
	Mixed	$1.66 \pm 0.13 \pm^{0.54}_{0.34}$
	p	$1.82 \pm 0.13 \pm^{0.58}_{0.35}$



F_{mix} does not overlap with 1.

↓

AGASA data constitute further evidence of a muon deficit at the highest energies.

References I

[1] K. Shinozaki and M. Teshima, Nucl. Phys. B (Proc. Suppl.) **136**, 18 (2004).

[2] D. Ivanov for the Pierre Auger Collaboration and the Telescope Array Collaboration, PoS (ICRC2017) 498 (2018).

[3] F. Gesualdi, A. D. Supanitsky, and A. Etchegoyen, Phys. Rev. D **101**, 083025 (2020).

[4] J. Bellido for the Pierre Auger Collaboration, PoS (ICRC2017), 301 (2018).