Fitting fractions of the $X_{\max}$ distributions at ultra high energies

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June 29, 2021

Executive summary

We show that fitting the $X_{\max}$ distributions only with four fixed elements (p, He, N and Fe), an artificial worsening of the fit quality can be induced and the reconstructed fractions might be biased as a consequence of a high abundance of some intermediate elements (e.g. Ne/Si) not included into the fitting procedure. A more appropriate approach is to fit the observed $X_{\max}$ distributions with all possible combination of elements from a larger set of primaries (p, He, C, N, O, Ne, Si and Fe) obtaining the "best combination" of elements which best describe the data. Applying this method to the $X_{\max}$ distributions recorded by the Pierre Auger (2014) and Telescope Array (TA) (2016) Observatories the results suggest that the mass composition of UHECRs is dominated by protons and He nuclei ($> 70\%$) on the entire energy spectrum. The indirect comparison between the two data sets present a good degree of compatibility in some high energy bins around and above the *ankle* ($\lg E(\mathrm{eV}) \sim 18.7$), but worsening at lower energies.