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Comment

Comment on "Determining energy spectra for separate mass groups from EAS: the quest is still on" ☆

KASCADE Collaboration

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Abstract

In a recent publication Schatz [Astropart. Phys. (2003), this issue] argues that unambiguous results about energy distributions of primary cosmic-ray mass groups can only be obtained from measured air shower observables if their *mutual* correlations are explicitly taken into account. This statement is used to challenge preliminary results presented by the KASCADE Collaboration at the International Cosmic Ray Conference in Hamburg, 2001 [KASCADE Collaboration, 27th ICRC, Hamburg, 2001, p. 97; KASCADE Collaboration, Invited Rapporteur and Highlight Papers of

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ICRC 2001, p. 240]. In this comment it is argued that the criticism of Schatz does not apply to the aforementioned analysis of KASCADE data.

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At the International Cosmic Ray Conference (ICRC) in Hamburg, August 2001, the KASCADE Collaboration has presented preliminary results on primary cosmic ray (CR) energy distributions in the knee region for different selected mass groups [2,3]. The results are based on reconstructed electron and truncated muon number distributions of three zenith angle bins. The analysis utilises unfolding techniques taking into account primary energy and mass dependent extensive air shower (EAS) fluctuations as well as instrumental trigger and reconstruction effects, details of which are described in Ref. [2]. Each of the reconstructed energy distributions exhibits a knee like behaviour with the knee occurring clearly at higher energies for the heavier elements.

In Ref. [1] Schatz criticises the KASCADE analysis and concludes that the results of [2,3] are unreliable. Emphasizing the preliminary character of the KASCADE data analysis [2,3], we do not consider a lengthy discussion appropriate and restrict ourselves to the most important points of criticism of Ref. [1]. A detailed composition analysis of KASCADE data will be presented in a forthcoming publication.

Ref. [1] discusses the interpretation of measured $\lg N_e$ and $\lg N_\mu^{tr}$ size distributions in terms of two primary elements. To understand the problem, it is important to realize that primaries of different mass yield different values of $\lg N_\mu^{tr}$ for fixed $\lg N_e$ and vice versa. Hence, the different choices of starting values of the composition at the upper end of the displayed muon size spectrum in Fig. 7 of Ref. [1] ($\lg N_\mu^{tr} \simeq 5.2$) result in different electron size spectra in a region beyond the formerly considered range of $\lg N_e \leqslant 6.65$. In other words, the different solutions presented in that figure are linked to corresponding differences in this part of the electron spectrum. The analysis of Refs. [2,3] instead uses the full set of measured electron and muon size spectra up to $\lg N_e = 7.6$ and $\lg N_\mu^{tr} = 6.1$ including the fact that no showers were observed beyond these values (Fig. 1 in Ref. [2] does show only a subset for illustrative purposes).

It has also been concluded that the number of solutions would explode if more than two primary components would be assumed [1]. Indeed, this is obviously true when assuming one-to-one bin correlations. Considering mass and energy dependent fluctuations (which leads to the use of unfolding methods) and increasing the amount of information by including data from different zenith angles, it is possible to introduce more primary components. This can be understood in the framework of fluctuations which depend on primary energy, mass, and zenith angle (slant depth of the detector). The observed size spectra for different angular bins cannot be transformed into each other by a simple horizontal and vertical shift, see Fig. 1 of Ref. [2]. The maximum number of reconstructible primary components can be estimated from the structure and size of the response matrix used in the unfolding procedure of Refs. [2,3]. The condition number of the matrix (ratio of the largest and the smallest singular value) was found to increase appreciably only when a fifth primary component was introduced. No doubt, other combinations of elements could have been selected in Ref. [2,3] and the obtained set of spectra would have been different, but again uniquely determined by data. Also, their knee would again shift towards higher energies for the heavier elements.

Finally we want to mention that, of course, the full utilisation of the shower-to-shower correlations of electron and muon sizes is expected to increase the discrimination power of composition analyses. Analyses of this type are in progress and first results presented in [4,5] have shown to be well in line with those of Refs. [2,3].

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