Chapter 7

Discussion

7.1 Summary and discussion

The problem of origin of the knee in the cosmic ray energy spectrum is a difficult one to explain or even understand. It is widely believe that the knee in the energy spectrum is an inscription of either cosmic ray sources or acceleration mechanism or propagation characteristics and hence proper understanding of this interesting spectral feature may shed light on the long standing problem of cosmic ray origin.

In the present thesis work we first examine critically the existence of the knee in the primary energy spectrum. The knee feature in the primary energy spectrum is inferred mainly from the size (total number of particles) spectrum of electrons in cosmic ray EAS. It is also expected from theoretical consideration that the knee feature also should reveal from EAS muon size spectrum. We, therefore, have checked whether the knee in the primary energy spectrum is revealed consistently from both electron size and muon size spectra by analysing results obtained by EAS-TOP and KASCADE experiments. The interpretation of the EAS results in terms of primary cosmic rays requires Monte Carlo simulation study of EAS that relies on the high energy particle interaction models. Since our knowledge of particle interactions is somewhat uncertain at high energies as the accelerator data for relevant target-projectile combinations covering the whole kinematic region are not yet available, we first compare the simulated atmospheric proton and antiproton spectra obtained with different low energy hadronic interaction models with those measured by BESS experiment at high altitude. We found that out of the different models used, UrQMD describes the overall experimental data better.

At higher energies QGSJET -1c is found to describe the LHC data, at least major features such as pseudo-rapidity distribution, transverse momentum distribution, cross-section and multiplicity, reasonably well. Hence we choose combination of these two interaction models, QGSJET and UrQMD, as input in our Monte Carlo simulation study of EAS.

It was found from the present analysis that the EAS-TOP observations on total charged particle and muon spectra consistently infer a knee in the primary energy spectrum provided the primary is pure unchanging iron whereas no consistent primary spectrum emerges from simultaneous use of the KASCADE observed total charged particle and muon spectra. However, it has been noted from the analysis that the derivation of the size spectrum from observed data is a quite complex issue, particularly owing to the uncertainty in primary mass composition. The simultaneous use of the measured EAS total charged particle and muon size spectra to infer the primary energy spectrum requires a careful and experiment specific analysis.

Finally a model of knee has been proposed in which the steepening of the spectrum beyond the knee is explained in terms of the mass distribution of the progenitor of the cosmic ray source. The proposed speculative model can account for all the major observed features of cosmic rays without invoking any fine tuning to match flux or spectra at any energy point. A prediction of the proposed model is that the mass composition of primary cosmic rays should remain almost the same below and above the knee energy which is consistent what we found from EAS-TOP data after simultaneous use of the measured EAS total charged particle and muon size spectra to infer the primary energy spectrum. Such a prediction about primary mass composition is quite different from most of the prevailing models of the knee, and thereby can be discriminated from future precise experimental measurements of the primary composition. Other observational consequences, if any, of the proposed models will be investigated in future.