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Estimation of the energy spectrum of cosmic ray electrons at th atmospheric depth 3.8-7.4 gm-cm $^{-2}$

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Abstract

Analytical calculations have been done to estimate the energy spectra of secondary electrons at different atmospheric depths orginated from the decay of charged and neutral pions initiated on the upper atmosphere from the primary nucleon air interactions in the energy range 4-100 GeV. The derived results are compared with the observed electron fluxes of MASS2, HEAT, magnetic spectrometer system of Golden et al., instrument using scintillating fibers of Nishimura et al., and BETS.

1 Introduction:

Muller et al. (1983) have interpreted that the containment volume of electrons includes regions beyond the disk of the galaxy, the spectrum at the acceleration cite has a power law exponent 2.65 and the time scale of containment in the galaxy is independent of the energy of the electrons. Nishimura et al. (1997)have estimated the possible contribution of nearby sources to the high energy electrons. Ptuskin and Ormes (1995) have discussed the anisotrophy of very high energy electrons based on the diffusion from local SNRs. It is very difficult to obtain the electron spectrum in the high-energy region above TeV because we need a rejection power of more than 10^4 against protons, which exceeds the limit of current emulsion technology with microscopes. To solve the problem, Nishimura et al. have reported a new type of emulsion chamber which is known as BETS.

In the present work, we have derived the flux of secondary electrons from the deacay of charged and neutral pions initiated by primary p-air collisions in the energy range 4 - 100 GeV at different atmospheric depth ranges 3.8-7.4 $gm-cm^{-2}$

2 Nuclear Physics and Kinematics:

We have adopted the modified formulation on e^- energy spectrum obtained from charged pimeson decays after Badhwar et al. (1975) along with the formulation for the evaluation of electron spectrum from the neutral pion decay after Verma (1967).

3 Result and Discussion:

The latest all particle primary nucleon spectrum in the energy range $10<E_p<10^3$ GeV which has been found to follow the form [Saha et al. 1998],

$$N(E_p)\ dE_p = AE_p^{\ -(\gamma+1)}\ dE_p \qquad (1)$$

where A = 1.52 $(m^2.sec.sr.GeV)^{-1}$ and γ = 1.65.

The CERN ISR data on the pp -> π^- X inclusive reaction cross-section can be fitted by the power law,

$$\left(x\frac{d\sigma}{dx}\right)_{\pi^-} = 23.3963\ (1-x)^{5.02}\ \text{mb} \qquad (2)$$

for 0.1<x<0.6.

The flux of electrons originated from the dacay of charged π meson at different depths of different atmosphere have been estimated in the energy range 4-100 GeV and follows the power law,

$$J_{e-} = K(m)E^{-2.65}(m^2.sec.sr.Gev)^{-1} \qquad (3)$$

for K(m) = 4.79, 7.06, 9.33 for m = 3.8, 5.6, 7.4 g/cm^2 respectively.

The estimated parametric values of Λ_i, Λ_p, Λ_γ are 70, 110, 38 in g-c ^{2} air.

The Z-factors are of values $Z_{P\pi^+}$ = 0.05631 and $Z_{P\pi^-}$ = 0.3127, respectively. The estimated Z factors from (Saha et al. 1998) for p-p collisions have also been corrected for p-air collisions after Dar (1984), multiplying by 1.147 and 1.152 for negative and positive meson production respectively. Using these parametric values, the fluxes of electrons obtained from neutral pimeson can be estimated at different atmospheric depths 3.8, 5.6, 7.4 g/cm^2 and the corresponding power law becomes,

$$J_{e^-} = T(m)E^{-2.65}(m^2.sec.sr.GeV)^{-1} \qquad (4)$$

for T(m) = 29.60, 40.87, 57.65 for m = 3.8, 5.6, 7.4 g-cm^{-2} respectively. Now, the total secondary electron spectrum is obtained by accounting the contributions from the charged and neutral piomeson decays. The corresponding derived spectra is shown in Fig.1. along with recent experimental data of different authors.

In the present investigation we have adopted the scaling hypothesis of Feynman (1969) for the estimation of meson spectrum initiated from pp collisions in the upper atmosphere. The scaling hypothesis is assumed to be valid at relativistic energy above 6 GeV. So the minimum threshold of electron energy should be above 4 GeV which is free from Albedo electrons [de Nolfo et al. (1997), Barrick et al. (1998)]. So we have compared our derived electron spectrum with measured data above 4 GeV.

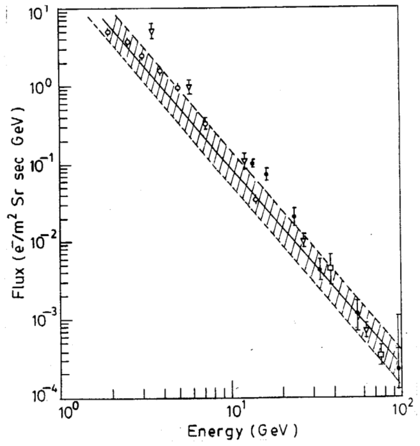

Fig.1. Derived energy spectra of secondary electrons at atmospheric depths 3.8-7.4 g-cm^{-2} initiated by p-air collision as described in the text. Broken curves represent the energy spectra at atmospheric depths 3.8 and 7.4 g-cm^{-2} and full curve is their mean spectrum. Experimental data: Box Nishimura et al. (1997), bigtriangledown bullet Torri et al. (1996), circ Golden et al. (1994), Basini et al. (1995).

4. Conclusion

The energy spectra of secondary cosmic ray electrons at atmospheric depth range 3.8-7.4 g-cm^{-2} in the spectral range 4 - 100 GeV have been calculated. The derived spectra have been found comparable with the observed results of Nishimura et al. (1997), Torri et al. (1996), Golden et al. (1994), HEAT (Basini et al. 1995), within the limits of statistical errors.

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