14. COSMIC RAY FLUXES

The fluxes of particles of different types depend at the $\sim 10\%$ level on the latitude, their energy, and the conditions of measurement. Some typical sea-level values [1] for charged particles are given below:

I_v flux per unit solid angle per unit horizontal area about vertical direction

$\equiv j(\theta = 0, \phi)[\theta =$ zenith angle, $\phi =$ azimuthal angle$]$;

J_1 total flux crossing unit horizontal area from above

$$\equiv \int_{\theta \le \pi/2} j(\theta, \phi)\, \cos\theta\, d\Omega \; [d\Omega = \sin\theta\, d\theta\, d\phi] \; ;$$

J_2 total flux from above (impinging on a sphere of unit cross-sectional area)

$$\equiv \int_{\theta \le \pi/2} j(\theta, \phi)\, d\Omega \; .$$

	Total Intensity	Hard Component	Soft Component
I_v	1.1×10^2	0.8×10^2	0.3×10^2 m^{-2} s^{-1} sterad^{-1}
J_1	1.8×10^2	1.3×10^2	0.5×10^2 m^{-2} s^{-1}
J_2	2.4×10^2	1.7×10^2	0.7×10^2 m^{-2} s^{-1}

Very approximately, about 75% of all particles at sea level are penetrating, and are muons (the dominant portion of the hard component at sea level). The sea-level vertical flux ratio for protons to muons (both charges together) is about 3.5% at 1 GeV/c, decreasing to about 0.5% at 10 GeV/c.

The muon flux at sea level has a mean energy of 2 GeV and a differential spectrum falling as E^{-2}, steepening smoothly to $E^{-3.6}$ above a few TeV. The angular distribution is $\cos^2\theta$, changing to secθ at energies above a TeV, where θ is the zenith angle at production. The $\pm$ charge ratio is 1.25–1.30. The mean energy of muons originating in the atmosphere is roughly 300 GeV at slant depths $\gtrsim$ a few hundred meters. Beyond slant depths of $\sim$ 10 km water-equivalent, the muons are due primarily to in-the-earth neutrino interactions (roughly 1/8 interaction ton^{-1} year^{-1} for $E_\nu > 300$ MeV, $\sim$ constant throughout the earth) [2]. Muons from this source arrive with a mean energy of 20 GeV, and have a flux of 2×10^{-9} m^{-2} s^{-1} sterad^{-1} in the vertical direction and about twice that in the horizontal [3], down at least as far as the deepest mines.

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References:

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2. J.G. Learned, F. Reines, and A. Soni, Phys. Rev. Lett. **43**, 907 (1979).
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