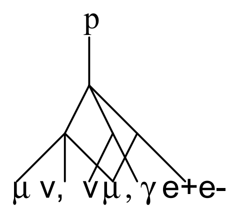
Angular Dependence of Cosmic Rays

Most cosmic rays at sea level are secondary and tertiary muons deriving from cosmic ray air showers inititated in the upper atmosphere produced by a primary proton or nucleus (eg. Fe) interacting with an atom. Electrons and gamma radiation also arrive at ground level from neutral pion decays and pair conversions.

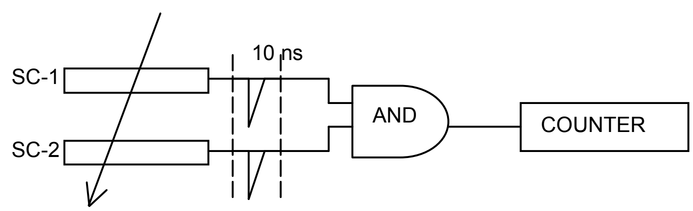
p+A -> A* $+\pi+\pi^{O}+\pi+\pi$….
-> μ ν, $\gamma\gamma$, γe+e-
Fe+A-> A*+Fe*+ $\pi+\pi^{O}+\pi+\pi$….



These cosmic rays are absorbed through greater distances in the atmosphere as the zenith angle increases. The density of the atmosphere is changing with altitude creating an overall angular distribution of cosmics at the ground level which follows a ~cos θ^N distribution with N=1-3, depending on energy. On can model the angular intensity with

$$I(\theta) = I_0 + A\cos^N \theta$$

We use a simple simple two paddle coincidence circuit to count the cosmic ray flux at ground level. The pulses from the plastic scintillators are AND'ed together and must arrive with a Δt window of 10ns which effectively eliminates all background but true cosmic ray traversals. The angular resolution $\Delta\theta$ is poor but acceptable.



1) Determine the angular resolution of the counters.

2) Record the number of cosmic ray coincidences as a function fof zenith angle for 5 -10 minute runs. Have at least 50 events when θ=90^o (horizontal) to reduce the sqrt(N) counting errors.

0	**15**	**30**	**45**	**60**	**75**	**90**	**degrees**

3) Fit $I(\theta) - I_0 = Ax^N$ where I_o=I(90^o) and x=cosθ to determine I_o, A, N along with their errors.

4) Discuss errors in the measurement.