Remarks on the Mu2e Cosmic Ray Veto Counters

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Cosmic Rays→μs at Surface

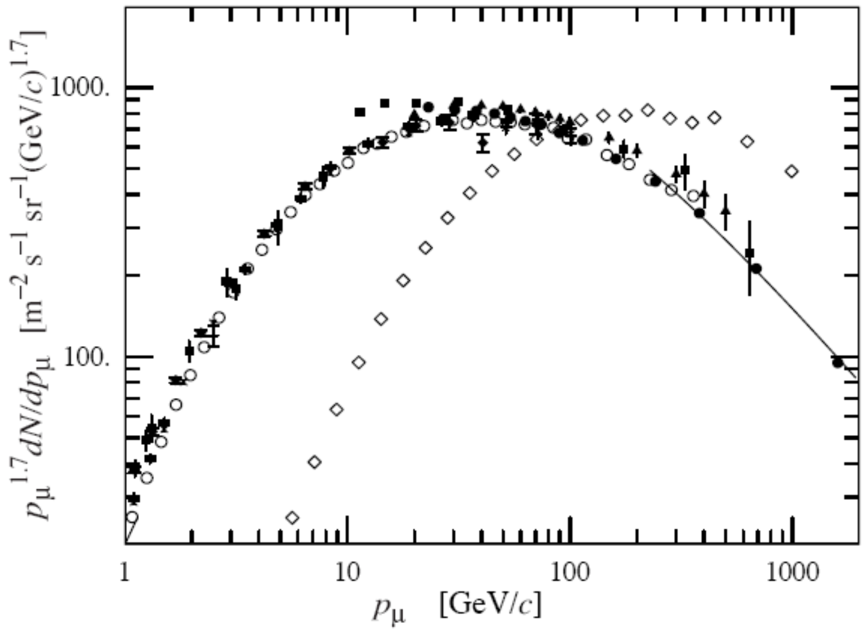


Figure 24.4: Spectrum of muons at $\theta = 0°$ (♦ [37], ■ [42], ▼ [43], ▲ [44], ×, + [39], ∘ [40] and (blakcircles) [41] and $\theta = 75°$ ◊ [45]) . The line plots the result from Eq. (24.5) for vertical showers.

Swiped from PDG article by T.K. Gaisser and T. Stanev, Phys. Lett. B., 667, (254), 2008.

$$\frac{dN_\mu}{dE_\mu d\Omega} \approx \frac{0.14\, E_\mu^{-2.7}}{\mathrm{cm}^2 \ \ \mathrm{s} \ \ \mathrm{sr} \ \ \mathrm{Ge}} \times \left\{ \frac{1}{1 + \frac{1.1 E_\mu \cos\theta}{115\,\mathrm{GeV}}} + \frac{0.054}{1 + \frac{1.1 E_\mu \cos\theta}{850\,\mathrm{GeV}}} \right\}$$

Underground…

$$-\frac{dE_\mu}{dX} = a + b\,E_\mu$$

Table 24.2: Average muon range R and energy loss parameters calculated for standard rock [53]. Range is given in km-water-equivalent, or 10^5 g cm^{-2}.

E_μ GeV	R km.w.e.	a MeV g^{-1} cm^2	$b_{\rm brems}$	$b_{\rm pair}$ 10^{-6} g^{-1} cm^2	$b_{\rm nucl}$	$\sum b_i$	$\sum b({\rm ice})$
10	0.05	2.17	0.70	0.70	0.50	1.90	1.66
100	0.41	2.44	1.10	1.53	0.41	3.04	2.51
1000	2.45	2.68	1.44	2.07	0.41	3.92	3.17
10000	6.09	2.93	1.62	2.27	0.46	4.35	3.78

Underground, cont'd

Integrating,

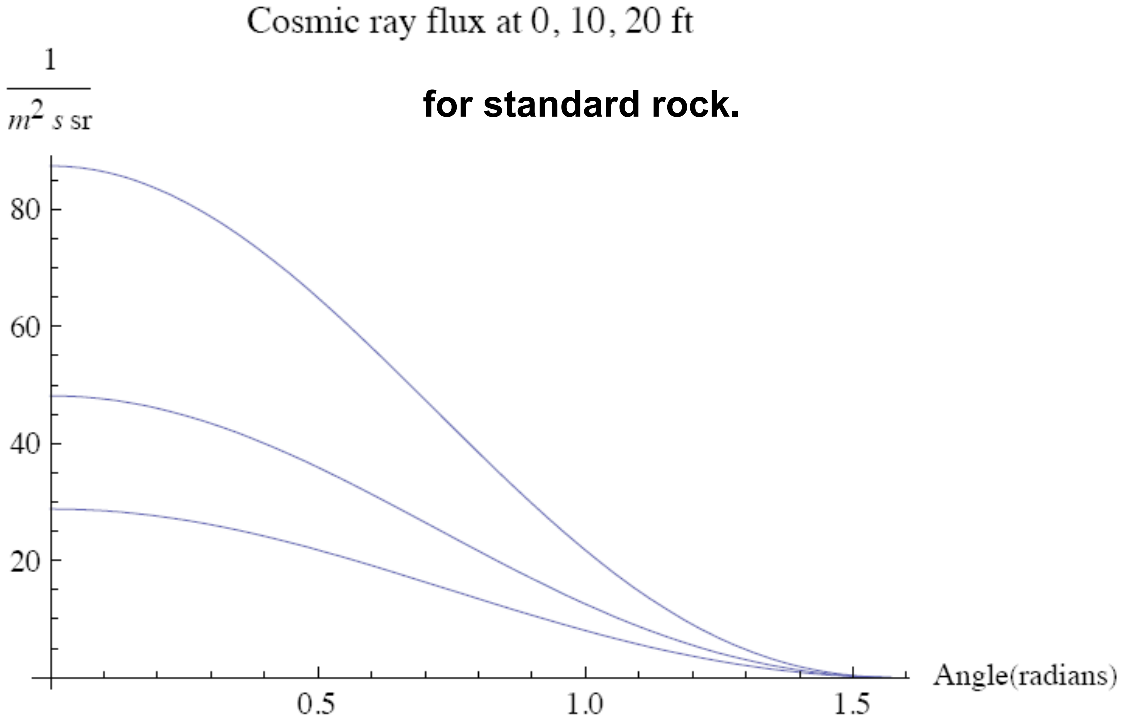
$$E_\mu = (E_{\mu,0} + \epsilon)\, e^{-bX} - \epsilon$$, **where** $$\epsilon \equiv a/b$$

and $E_{\mu,0}$ is energy of muon at production and E_μ its energy After traversing X grams of rock.

For $X \ll b^{-1} \approx 2.5$ km water equivalent, $E_{\mu,0} \approx E_\mu(X) + aX$

Underground, cont'd

Milind Diwan coded this and produced,



(This was included in our proposal)

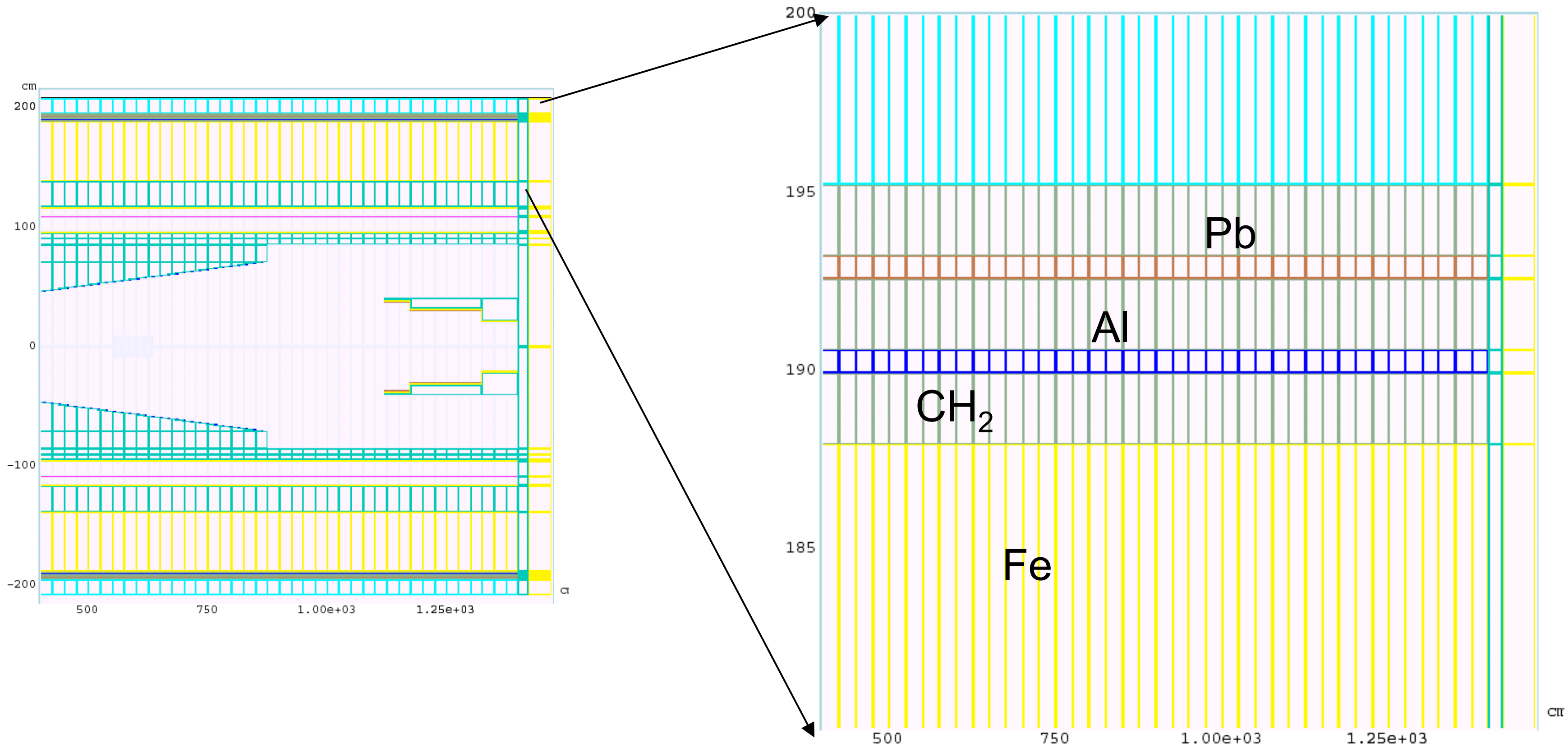
Underground, cont'd

Conclusion: we need not perform a detailed simulation of cosmic ray interactions in the upper atmosphere; we can rely on the Gaisser parameterization of muons at surface and dE/dX ≈ constant at shallow depths.

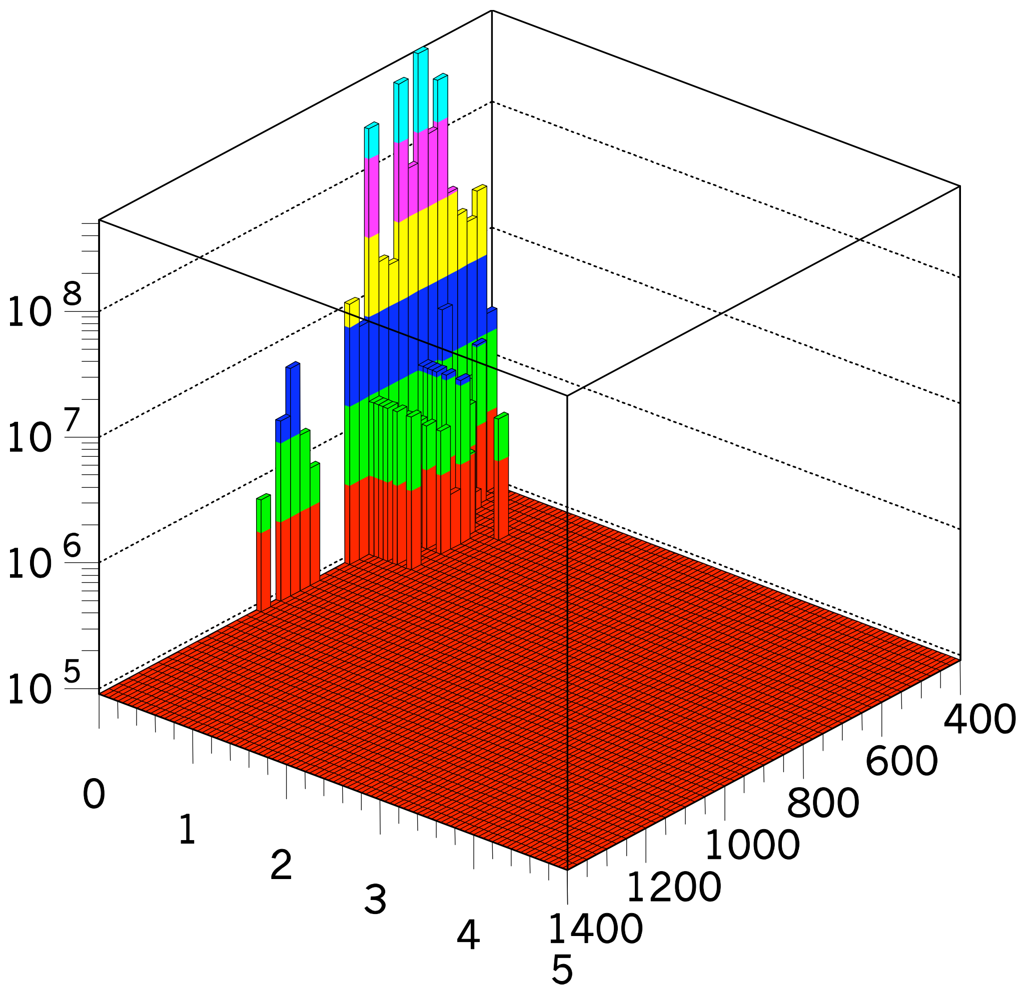
But

Backgounds in the Veto Counters

A MARS model:

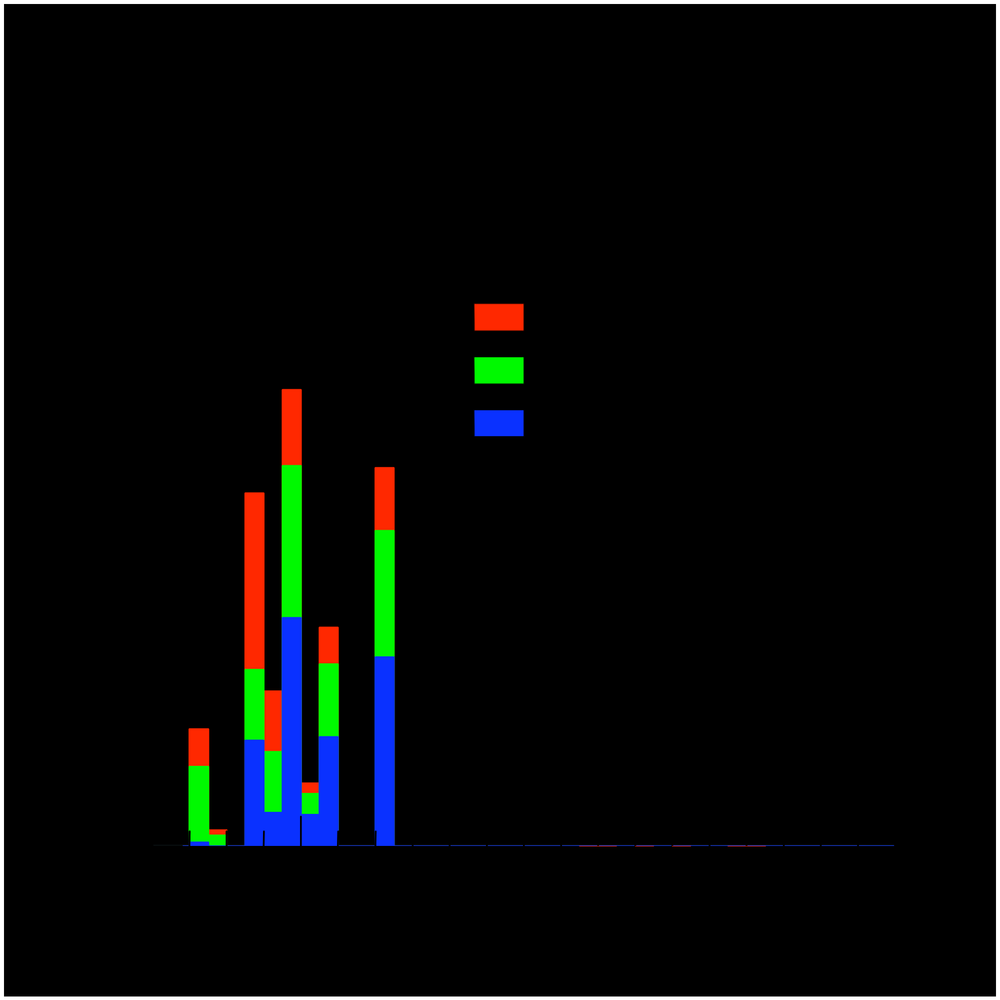


Backgrounds, cont'd.



E vs. Z in Inner CRV For 2.5 x 10^{11} incident μ^-

Backgrounds, cont'd.



Neutrons could present a background problem.

Conclusions:

Thermal neutrons from muon stopping target could present a background problem in Cosmic Ray Veto Counters. Ambient background from Production Target not yet been simulated and could introduce additional background.

Test Cosmic Ray Veto Counter efficiency in region of high thermal neutron flux