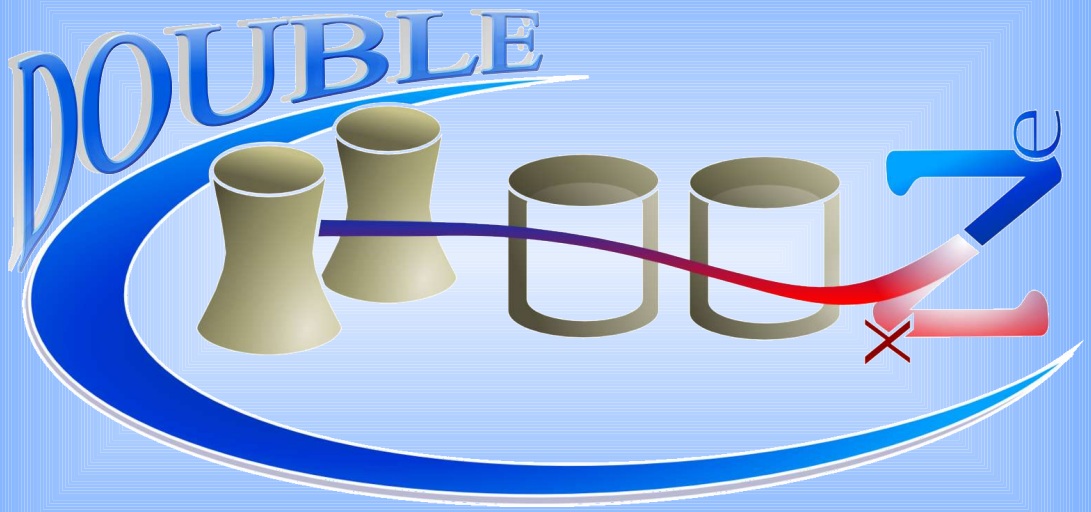
Design Development for the Outer Veto



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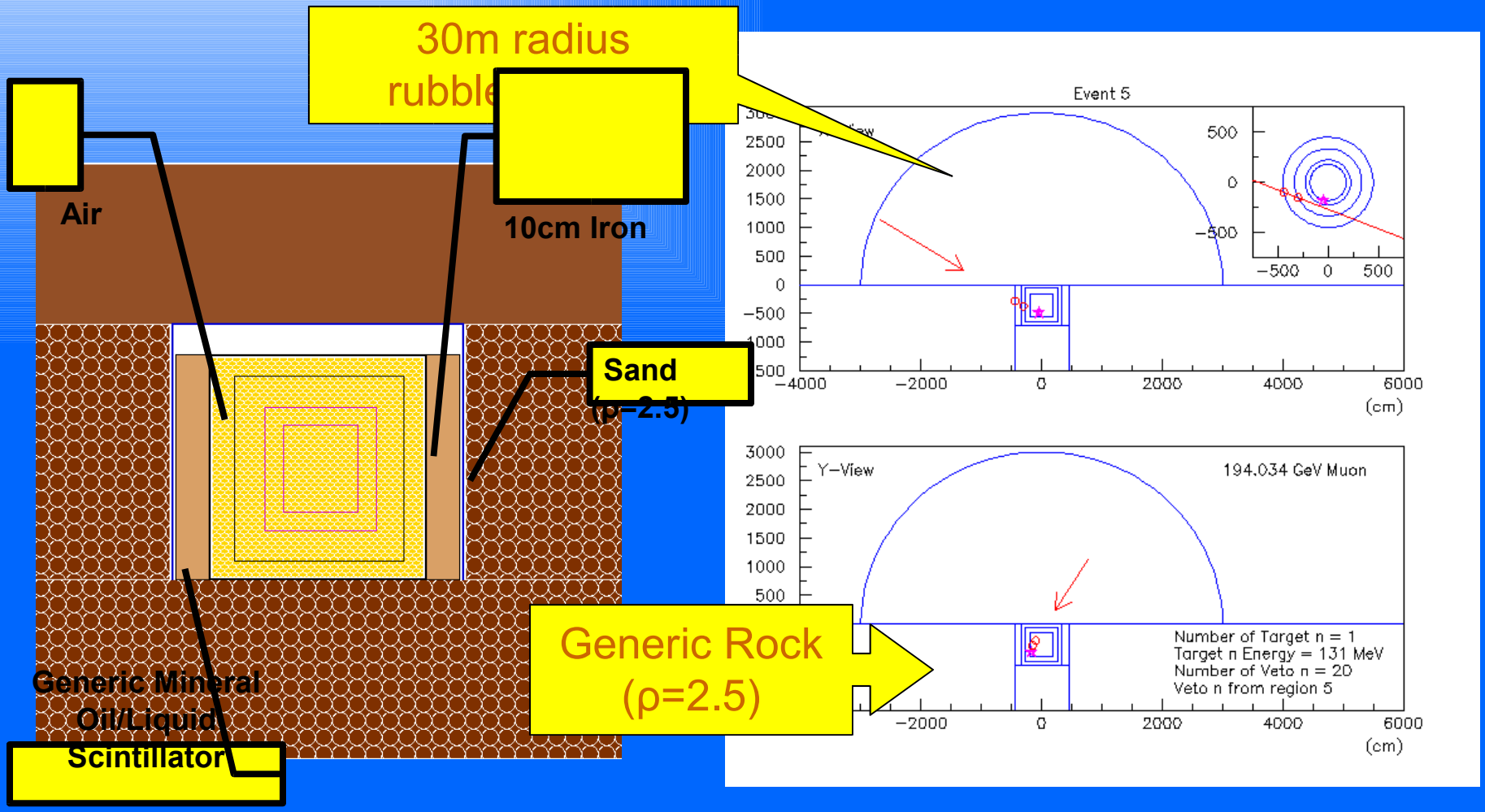
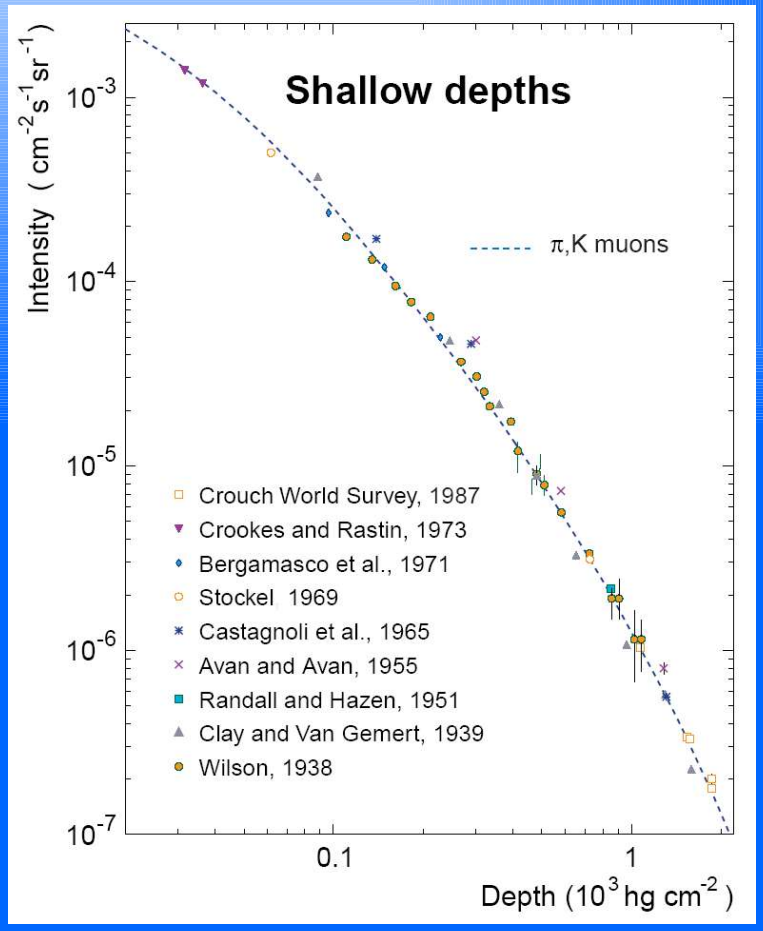
Simulated Geometry



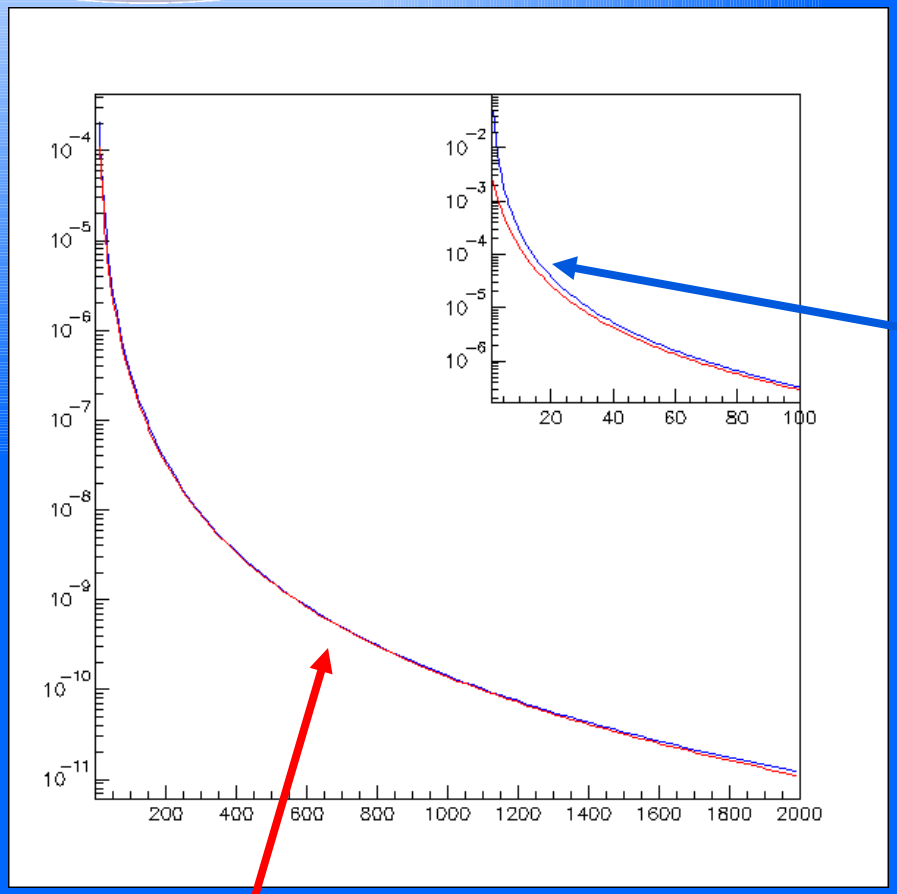
Real Muon Rates



From Bugaev et. al

- Expect ~70 Hz/m²/sr at surface
- DC-LOI assumes 11 Hz/m²/sr at 62 mwe
  - total rate of target ~300-500 Hz
- Experimental Evidence (Stocker) ~5 Hz/m²/sr
- Average absorption depth of 10 GeV muon is 50 mwe so rate of 10 GeV muons at surface is important

Surface Muon Energy



From PDG

$$I(p_\mu, \vartheta = 0°) = 0.14 p_\mu^{-2.7} \left(\frac{1}{1 + \frac{p_\mu}{115}} + \frac{0.054}{1 + \frac{p_\mu}{850}} \right)$$

From Bugaev et. al

$$I(p_\mu, \vartheta = 0°) = C p_\mu^{-\left(\gamma_0 + \gamma_1 \log(p_\mu) + \gamma_2 \log^2(p_\mu) + \gamma_3 \log^3(p_\mu)\right)}$$

Angular Dependence (Data from PDG)

$$I(p_\mu,\theta) = C\kappa^{-\left(\gamma_0+\gamma_1\log(\kappa)+\gamma_2\log^2(\kappa)+\gamma_3\log^3(\kappa)\right)}$$

$$\kappa = p_\mu \cos\theta$$

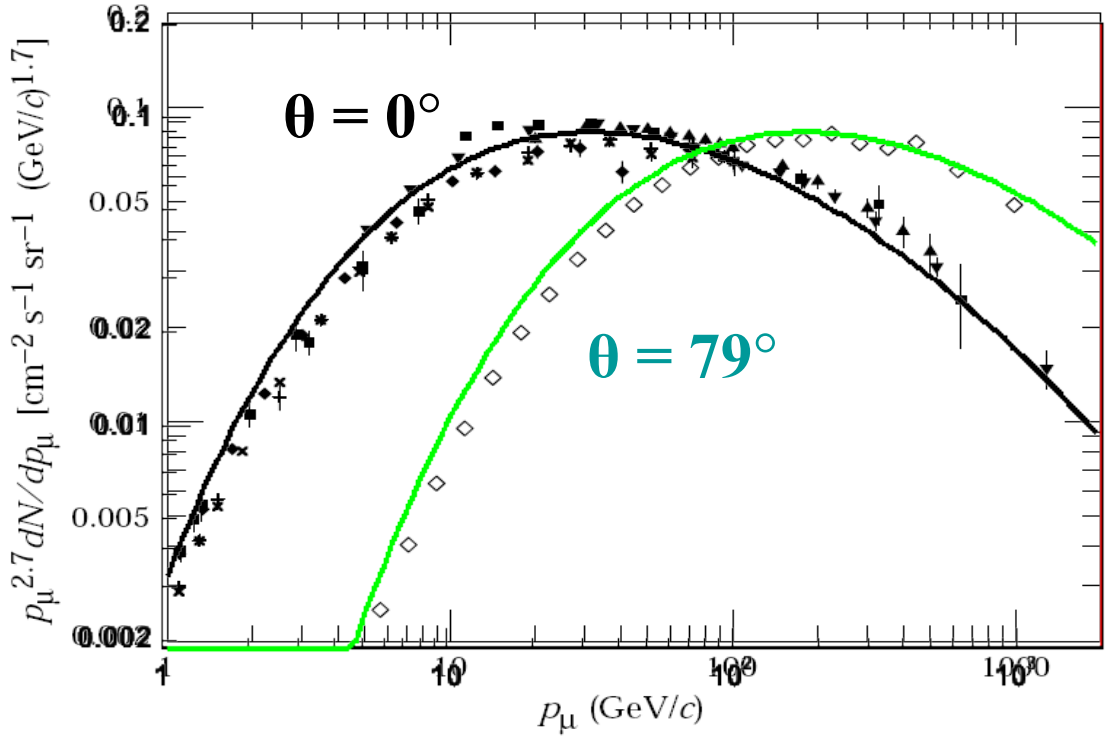
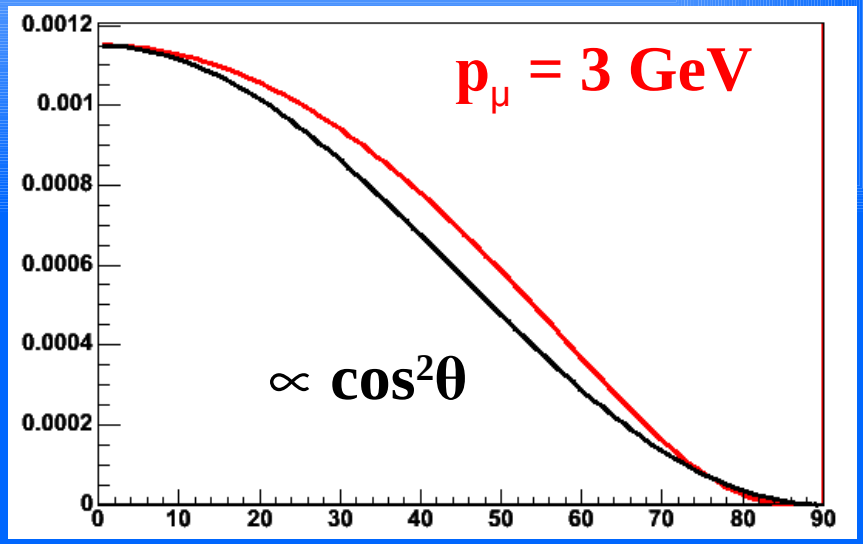


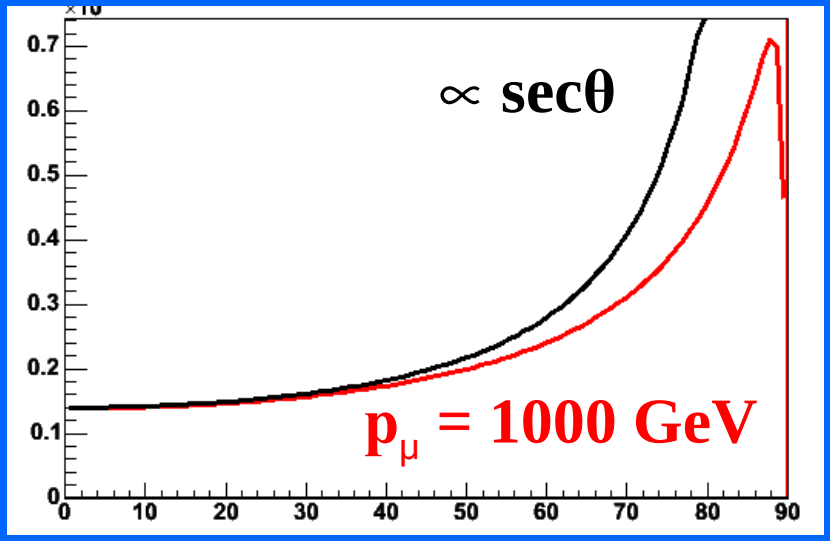
Figure 24.4: Spectrum of muons at $\theta = 0°$ (♦ [24], ■ [29], ▼ [30], ▲ [31], × and + [26], and $\theta = 75°$ ◊ [32]).

Angular Distributions

Surface Muon Flux from modified Bugaev formula



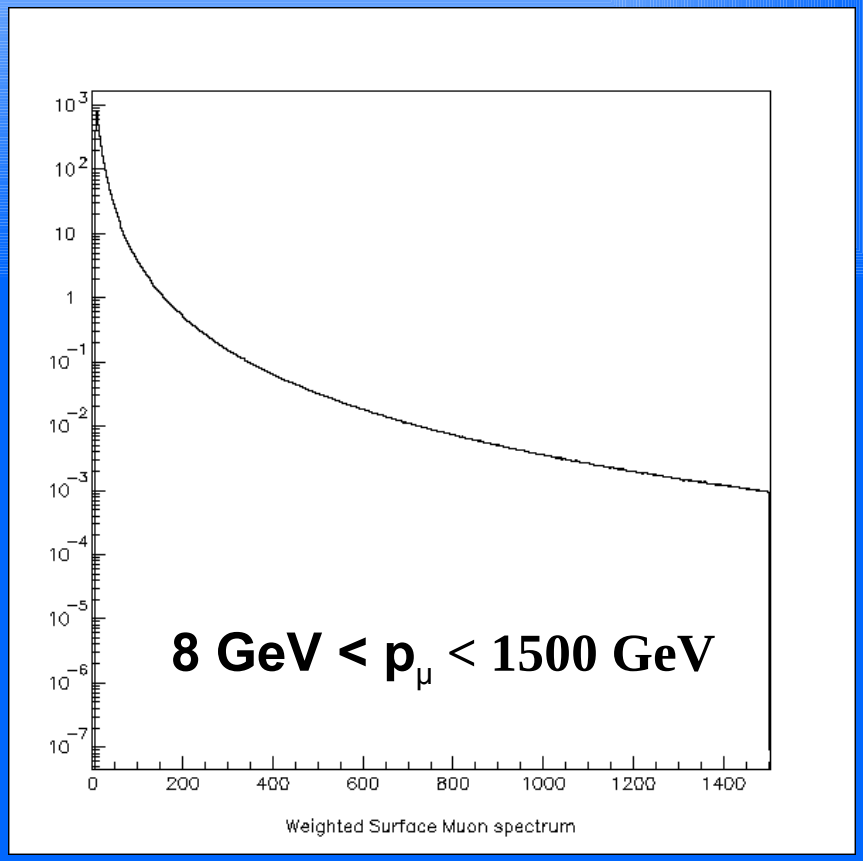
Zenith Angle (°)



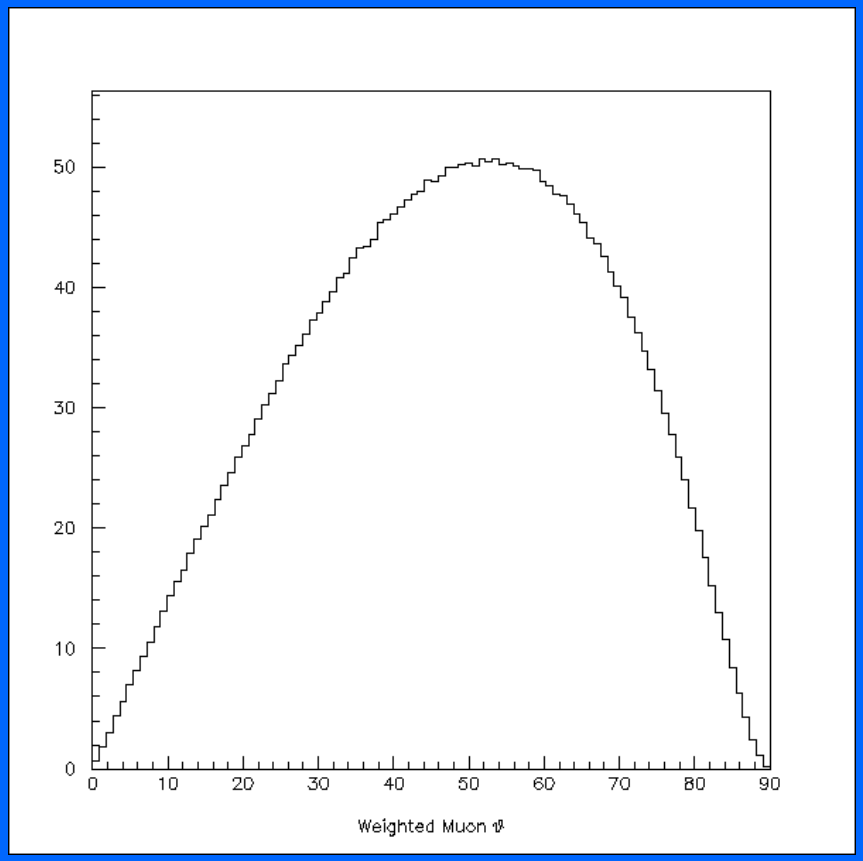
Zenith Angle (°)

Actual Generated Distributions

Muon Momentum



Muon Zenith Angle



Rates at the Detector

Detected Muon Rates	
Outer Veto	2750 Hz
Inner Veto	2132 Hz
Target + GC	1021 Hz
Rate of Neutrons in Target + GC	
Total	0.6431 Hz
Excluding Target Muon	0.2728 Hz
Excluding Inner Veto	0.0196 Hz
Excluding Outer Veto	0.0008 Hz

Muon Rate at Target

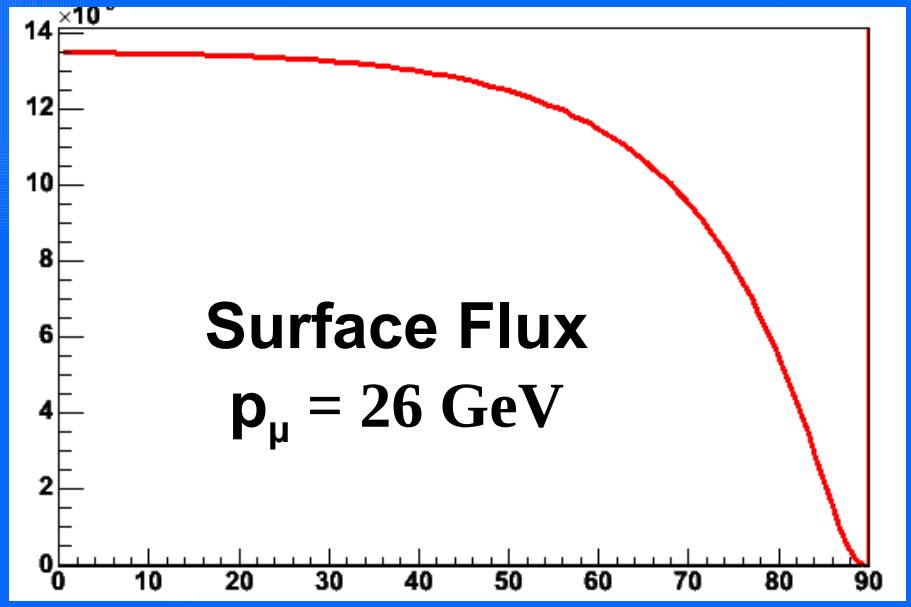
For 60 mwe, surface E > 12 GeV

<E> ~ 26 GeV

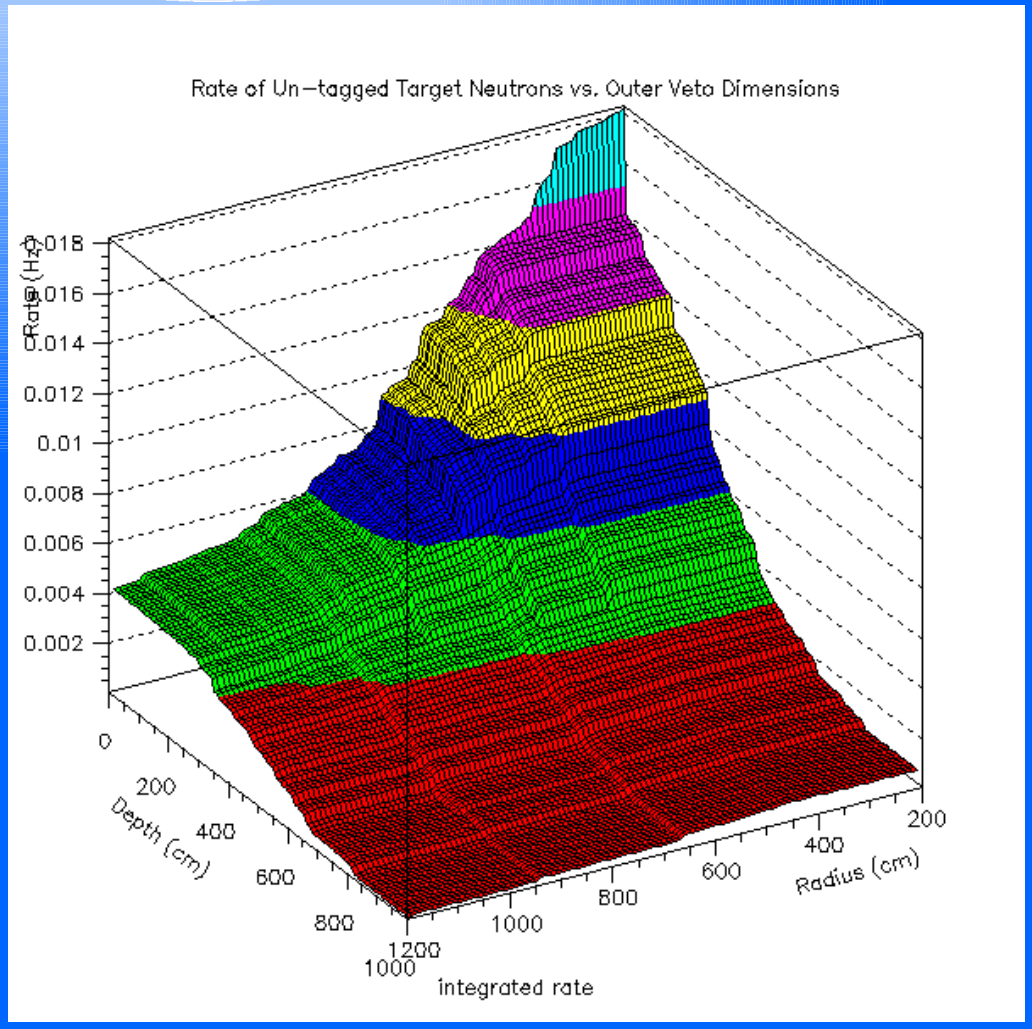
$$\int d\Omega \approx 2\pi$$

I_v~5 Hz m^{-2} sr^{-1}

$\Rightarrow$ >30 Hz m^{-2}



Optimizing the Outer Veto Design



Total Rate of neutrons entering the gamma catcher from outside

- Can improve rejection by using larger top
- Most of the rejection from the sides is contained within the first 4m