Update on the cosmic muon background simulation for a 10-kg LMO prototype experiment

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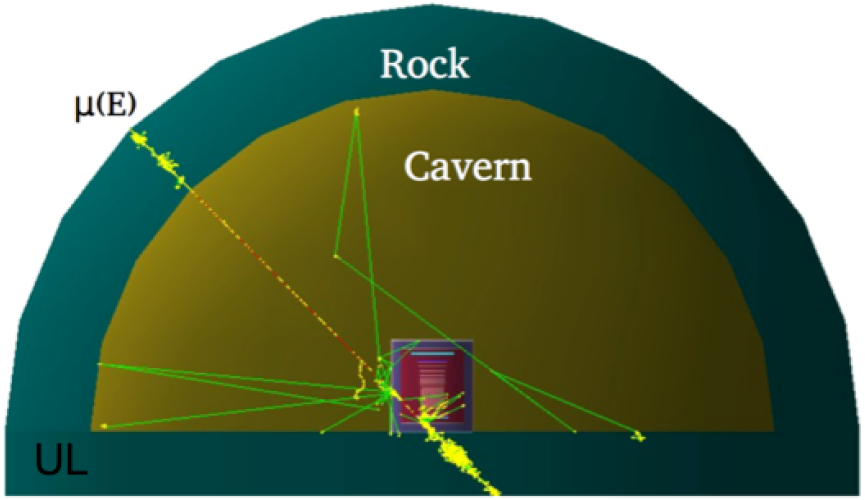
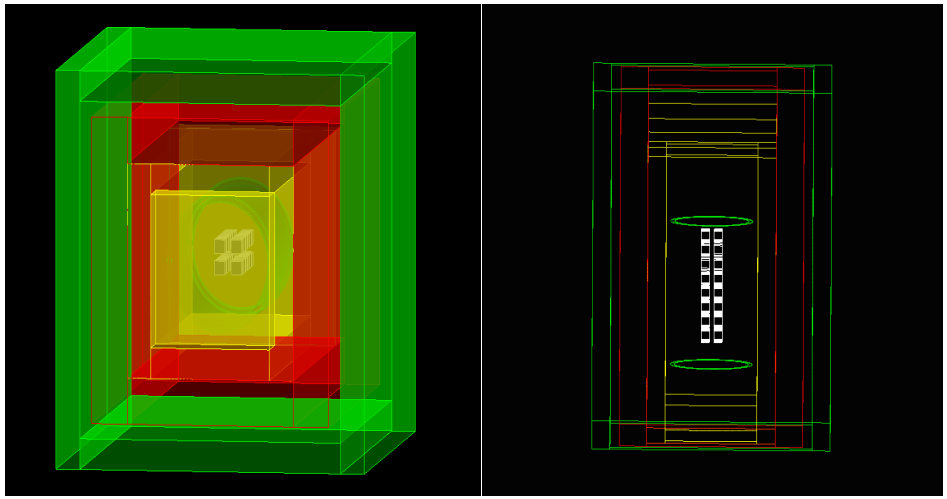
Muon background simulation

- CJPL muon spectrum simulated based on parametric formula (lack of information on the profile of Jinping mountain)
- Generation of MC muon events according to energy spectrum and spatial azimuthal distribution
- Geant4 simulation using QGSP_BERT_HP physics list (comparisons are made with livermore_EM)

G4 Setup

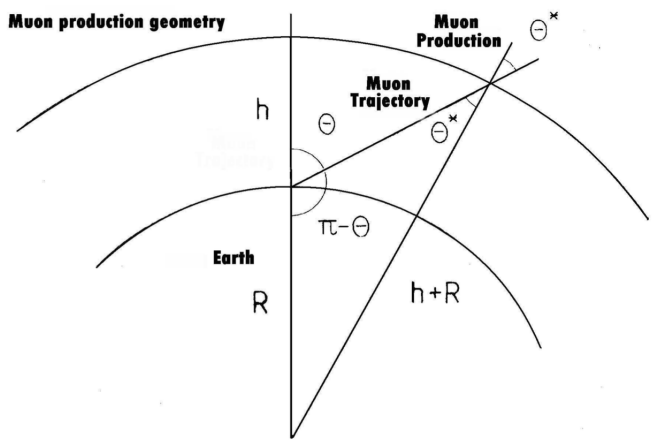




CJPL cavern radius: 6 m
Muon energy: 1-10000GeV
Crystal size: 4.5 x 4.5 x 4.5 cm^3
Crystal material: LMO
Detector: 4 x 9 array

Shield	Thickness	Height
Lateral Copper	120mm	1200mm
Lateral Lead	100mm	1500mm
Lateral PE	150mm	1500mm
Top Copper	120mm	120mm
DR Vessels (3x)	2mm	600mm

Parameterization of the muon spectrum

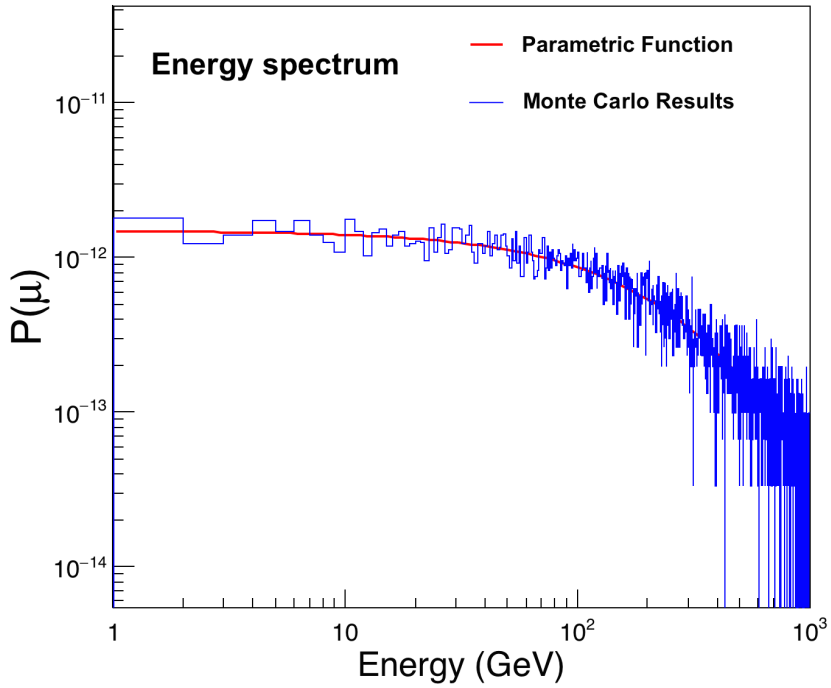


Parameterization of Muon energy distribution at sea-level

$$\frac{dI_\mu}{dE_\mu} = 0.14\left[\frac{E_\mu}{GeV}\left(1+\frac{3.64GeV}{E_\mu(\cos\theta^*)^{1.29}}\right)\right]^{-2.7} \times\left[\frac{1}{1+\frac{1.1E_\mu\cos\theta^*}{115GeV}}+\frac{0.054}{1+\frac{1.1E_\mu\cos\theta^*}{850GeV}}\right]$$

arxiv: 1509.06176v1

Muon energy spectrum in CJPL



Muon spectrum UL parameterization
(b=0.4,γ_μ=3.77,ε_μ=693 GeV)

$$\frac{dN}{dE_\mu} = Ae^{-bh(\gamma_\mu-1)}\cdot(E_\mu+\epsilon_\mu(1-e^{-bh}))^{-\gamma_\mu}$$

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Parameterization of the muon spectrum

Cosmic muon flux in underground lab：

$$I_{\text{tot}} = \int \sin(\theta) d\theta \int d\phi I(h(\theta, \phi)) G(h, \theta),$$

Differential flux of cosmic muons based on semi-sphere approximation (h0 is the thickness of rock in equivalent water unit km.w.e)

$$I_{\text{th}}(h, \theta) = (I_1 e^{(-h_0/\lambda_1)} + I_2 e^{(-h_0/\lambda_2)}) \sec(\theta).$$

$$I_1 = (8.60 \pm 0.53) \times 10^{-6} \text{sec}^{-1}\,\text{cm}^{-2}\,\text{sr}^{-1}$$

$$I_2 = (0.44 \pm 0.06) \times 10^{-6} \text{sec}^{-1}\,\text{cm}^{-2}\,\text{sr}^{-1}$$

$$\lambda_1 = 0.45 \pm 0.01 \text{ km.w.e.} \quad \lambda_2 = 0.87 \pm 0.02 \text{ km.w.e.}$$

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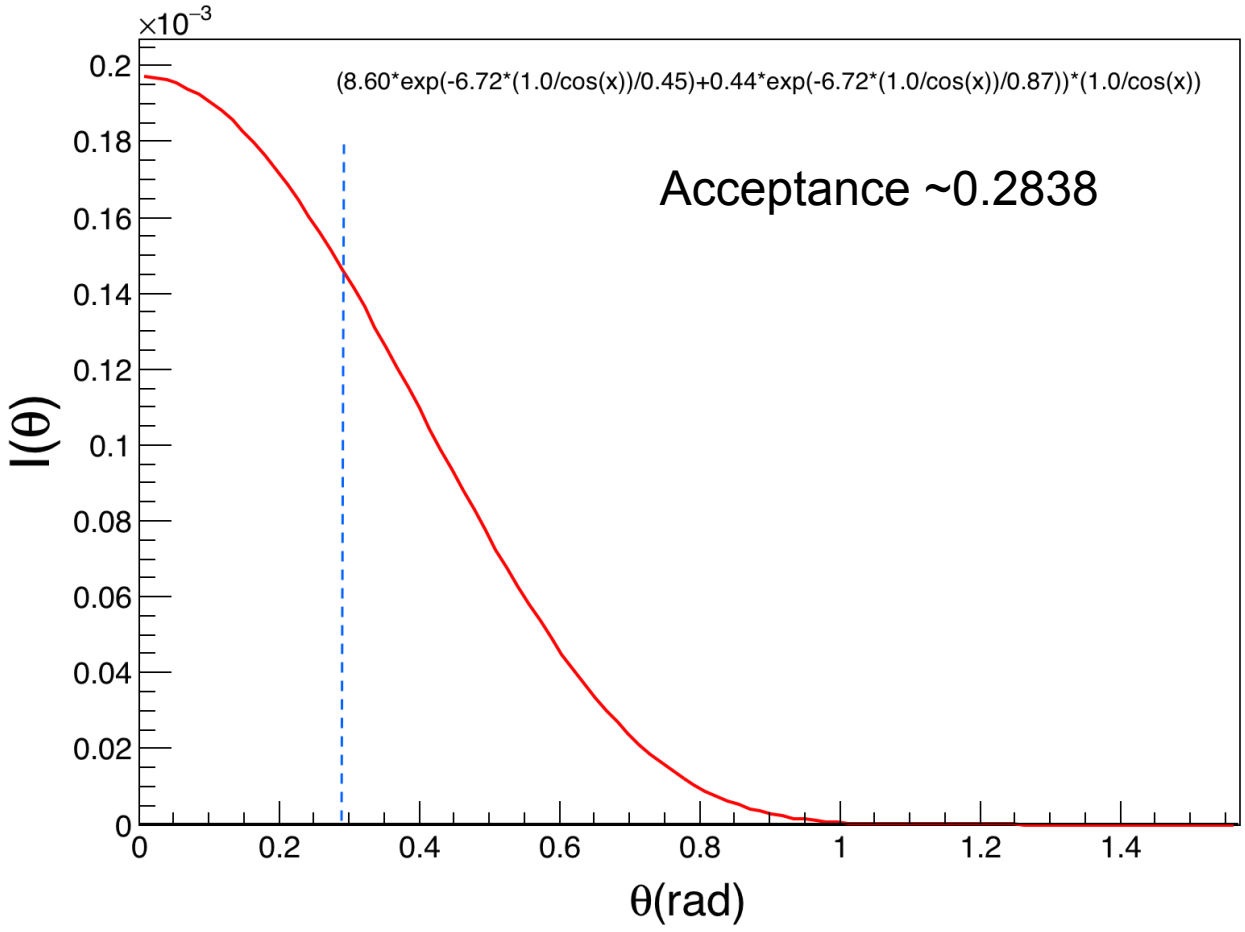
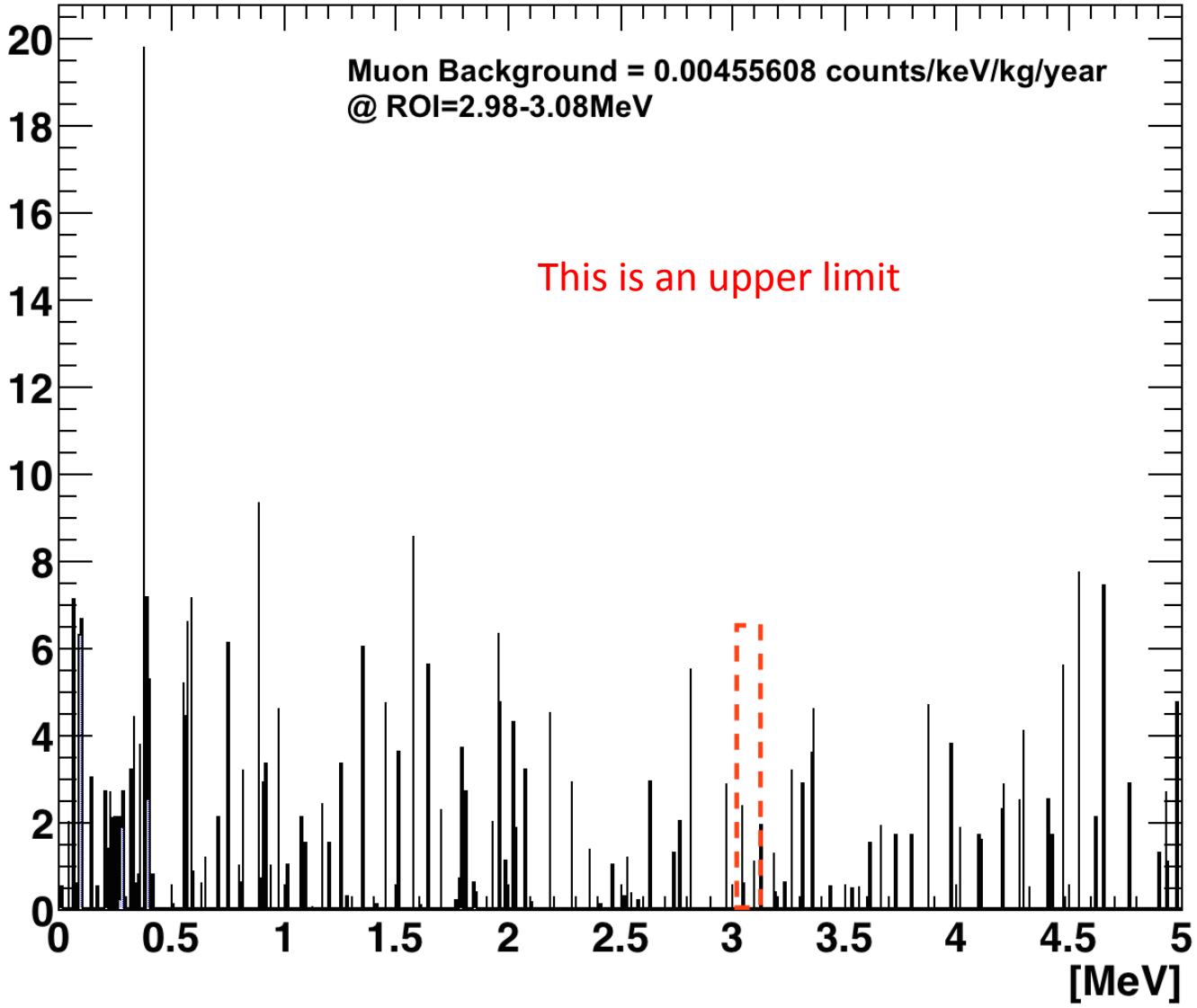
Parameterization of the muon spectrum



Direct cosmic muon background contribution



Discussion

- Considerable muon BG contribution
- Muon induced BG (cosmogenic radioactive isotopes) need to be studied particularly
- Finalized the study by including the gamma/ neutron results