CosmoGenic Backgrounds for Homestake 4850ft Level

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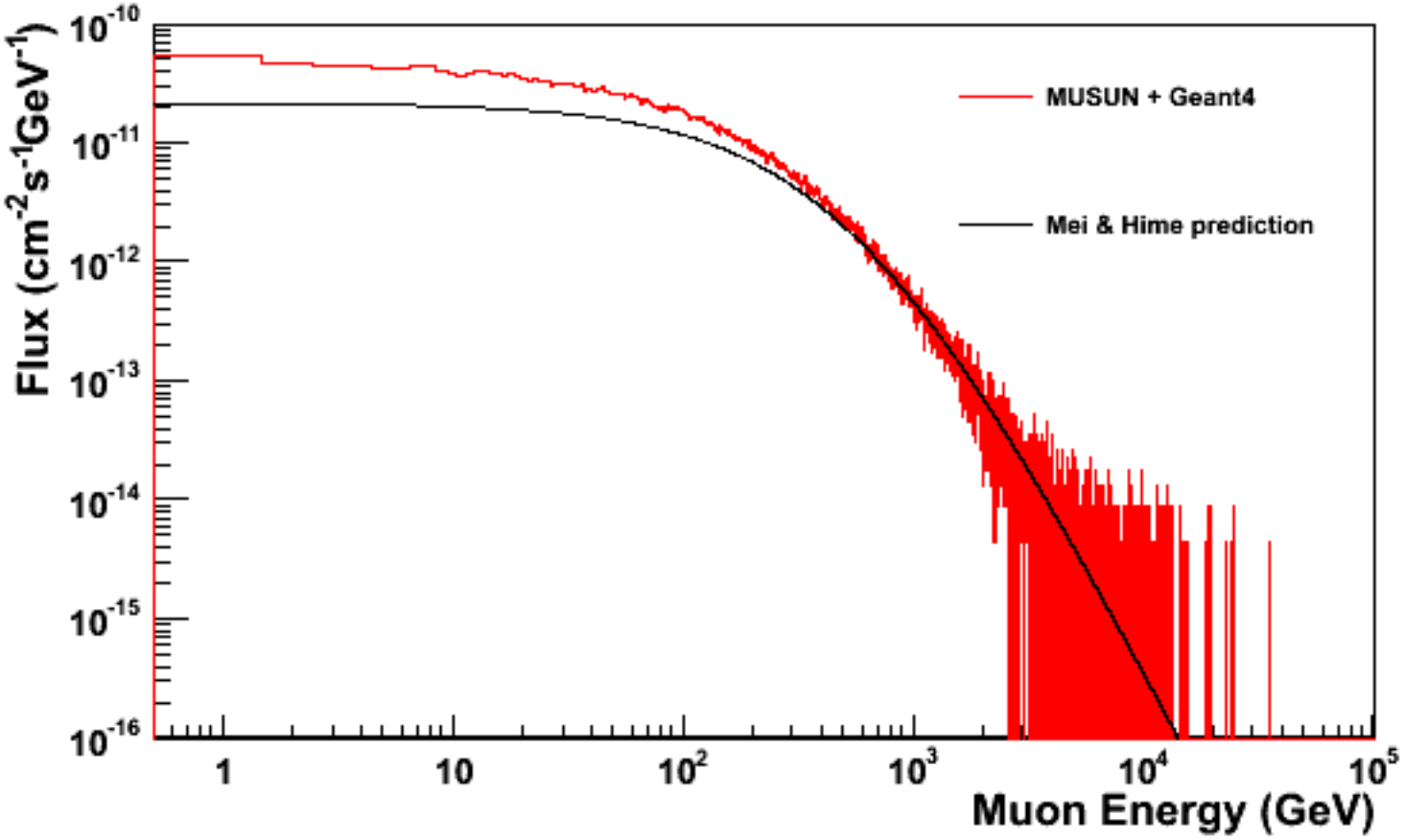
Simulation Input

- MUSUN+G4
  - MUSUN is used to get primary muon spectrum at 4850ft level which adopted Homestake mountain profile and rock composition.
  - Geant4.9.5 is used to take the MUSUN result to penetrate 7 meter rock overburden. Then secondary muon and neutron are obtained.
- Mei&Hime prediction
  - The parameterization function in Mei&Hime paper is used to calculate the muon and neutron distribution at Homestake 4850ft level.

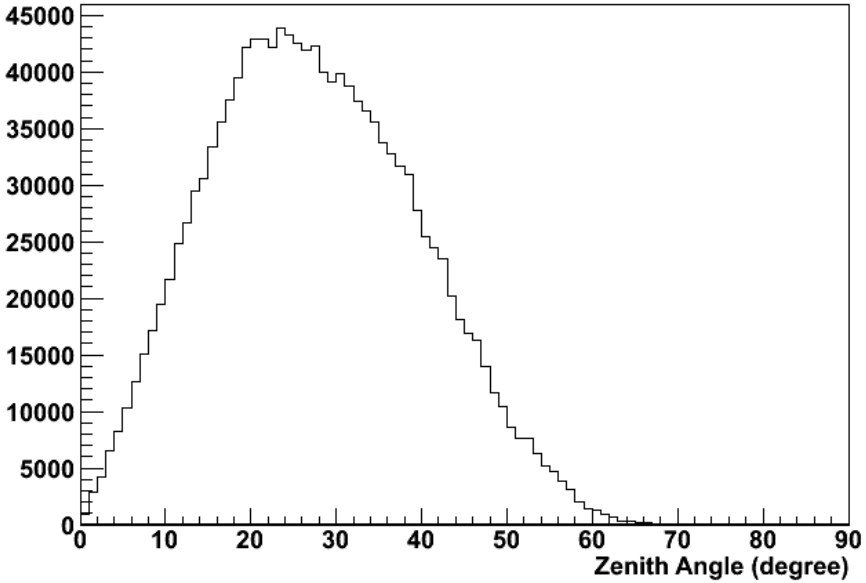
Muon flux at 4850-level

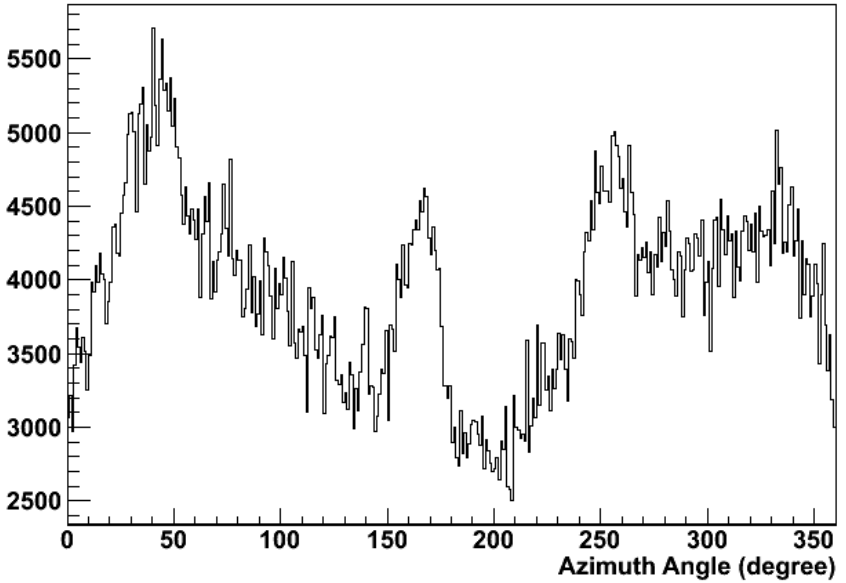


Absolute Flux:

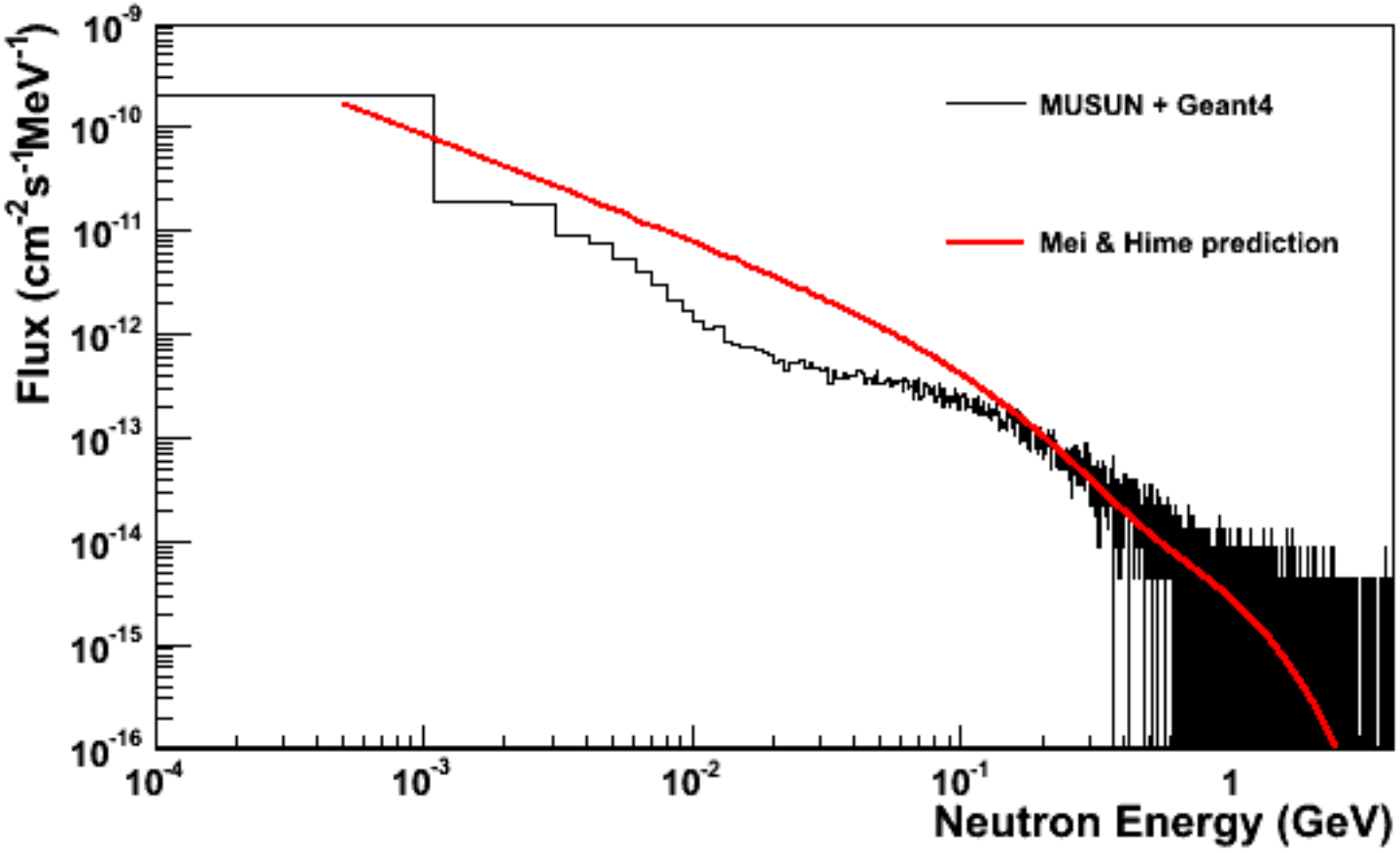
- MUSUN+G4 --- 6.46e-9cm^{-2}s^{-1}
- Mei&Hime --- 4.40e-9cm^{-2}s^{-1}

Muon Angle at 4850-level





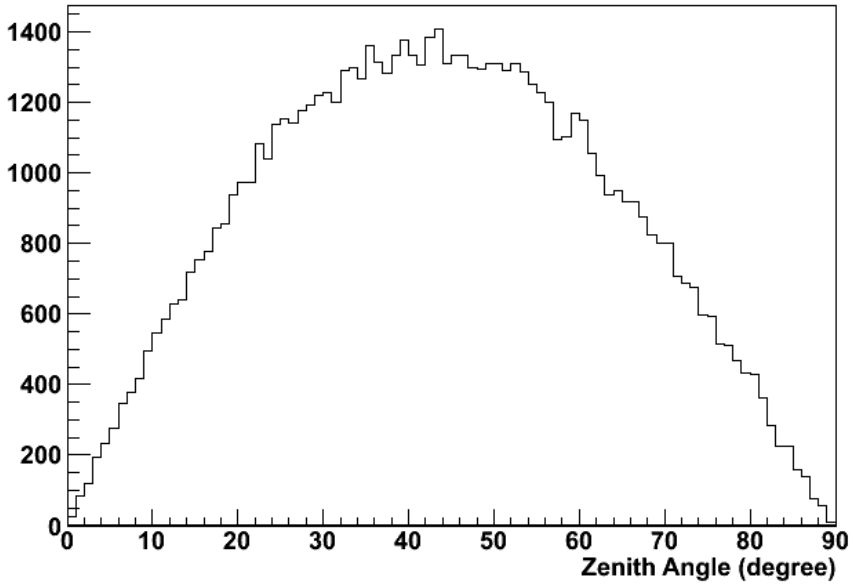
Neutron flux at 4850-level

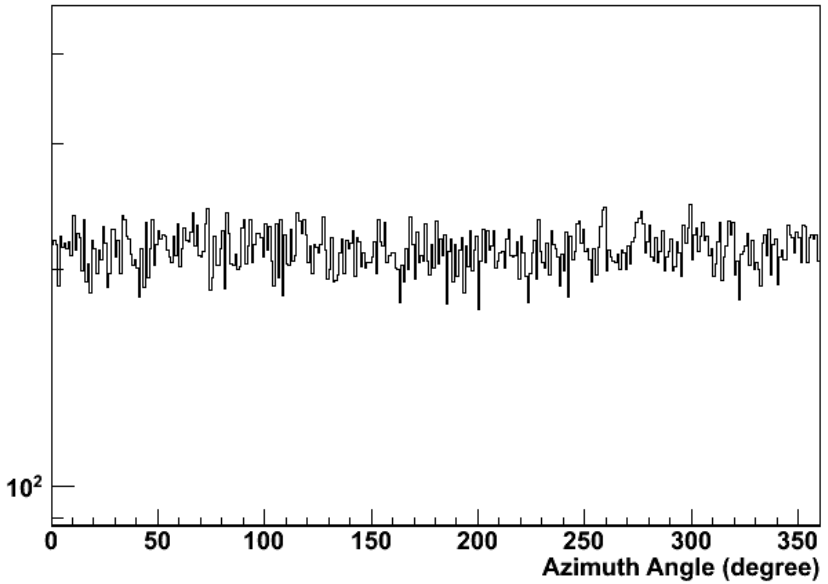


Absolute Flux:

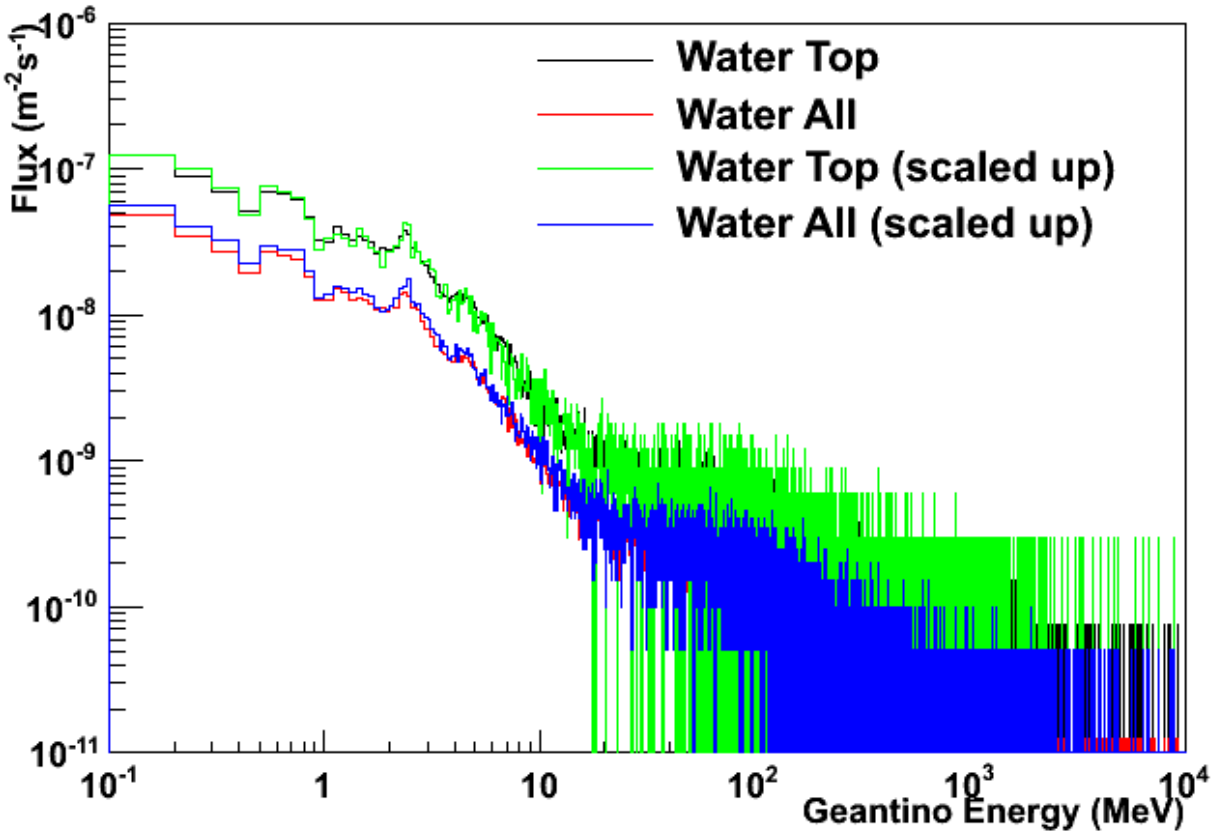
- MUSUN+G4 --- 3.41e-10cm^{-2}s^{-1}
- Mei&Hime --- 5.39e-10cm^{-2}s^{-1}

Neutron Angle at 4850-level





A Geantino Test



Original: generated uniformly on 50m*50m sheet right above water tank 1mm
Scaled up: on 100m*100m right above water tank 1m.

LZ20ton Simulation

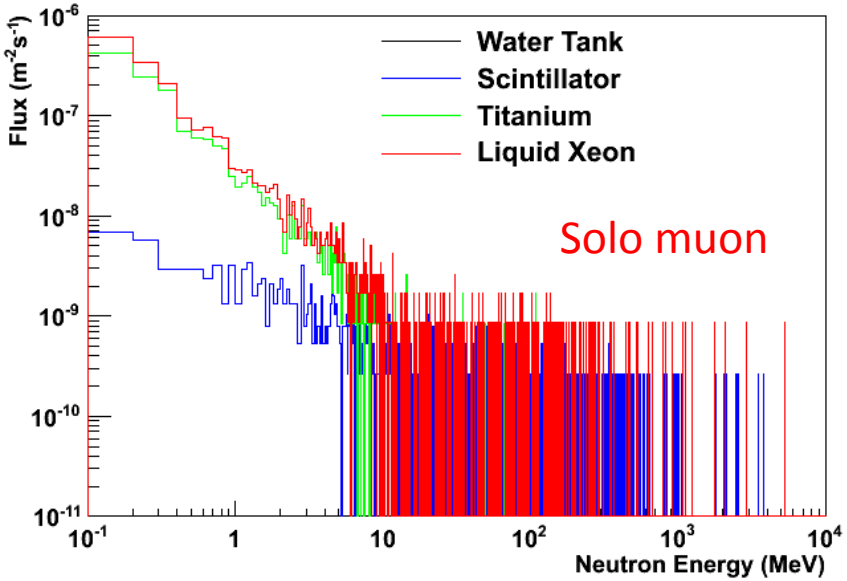
1. Solo muon as input(6.46e-9$cm^{-2}s^{-1}$):
   - Uniformly generated in a 50m*50m sheet above the water tank.
2. Solo neutron as input(3.41e-10$cm^{-2}s^{-1}$)
   - Uniformly generated in a 50m*50m sheet above the water tank.
3. Combined shower particle as input
   - Input shower information come from the MUSUN+G4.9.5 simulation while particles are collected in the boundary of 20m^3 cavern. Everything goes into the cavern is killed. The results are stored in data files for further using (to save computing time, e+/e- with energy <0.8MeV and gamma with energy <1MeV are killed because they are unlikely to create any Cherenkov lights).
   - By taking the above input files, 10cm rock is added to the wall of cavern when LZ20ton detector is positioned in the center. So that all the back scatterings can be resumed.
   - The final results are normalized to the live time of primary muons (here, 435.75days).

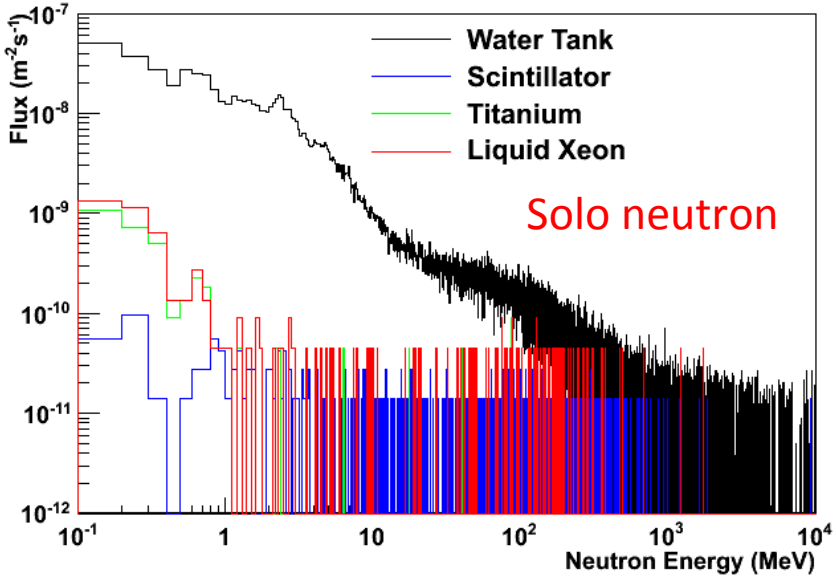
Results

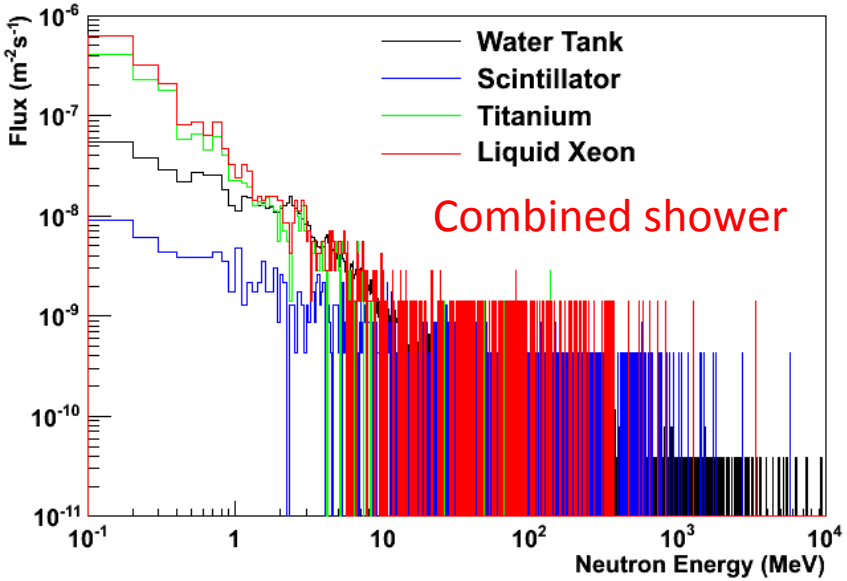
	Solo muon	Solo neutron	Combined shower
Mu_wat_top(/m2/s)	6.46e-5	-	6.46e-5
Mu_wat_all(/m2/s)	1.84e-5	-	1.85e-5
Neu_wat_top (>100keV /m2/s)	-	2.91e-6	1.55e-6
Neu_wat_all (>100keV /m2/s)	-	1.13e-6	1.08e-6
Neu_Xe_all (>100keV /m2/s)	2.38e-6	1.00e-8	2.40e-6
At least one NR/s (5 keV_r<E<25 keV_r)	1.32e-5	2.56e-9	1.31e-5
Single NR/s	<1.62e-8	<8.52e-10	<2.73e-8

Short of statistics…

Comparison







Neutrons cross the the outer boundary (out-->in) of the water tank, scintillator, titanium and liquid Xe volume.

Summary

- Neutrons in Xenon are mostly produced by muons crossing the detect shielding materials.
- Shower information must provided as input(instead of using solo muon & neutron separately) in order to give a reasonable estimation for the number of single NR(the shower will dramatically increase the veto rates).
- A proposal for cosmogenic simulation:
  1. Primary muons(generated in a big sheet or other shape depending on MUSUN output) cross ~7meter rock to get all secondaries.
     - ✓ Normalize to the live time of primaries.
     - ✓ The shape of cavern can be a cube or sphere. All particles enter into the cavern should be killed. Only collect the shower information on the cavern boundary(store in binary files).
  2. Specific simulations by placing your detect in the cavern
     - ✓ Taken the input shower information files and put some rock around the cavern so that back scatterings can be resumed.
     - ✓ The results can be normalized to the live time of primaries.