Modular Geometry and Backgrounds for Homestake Sims

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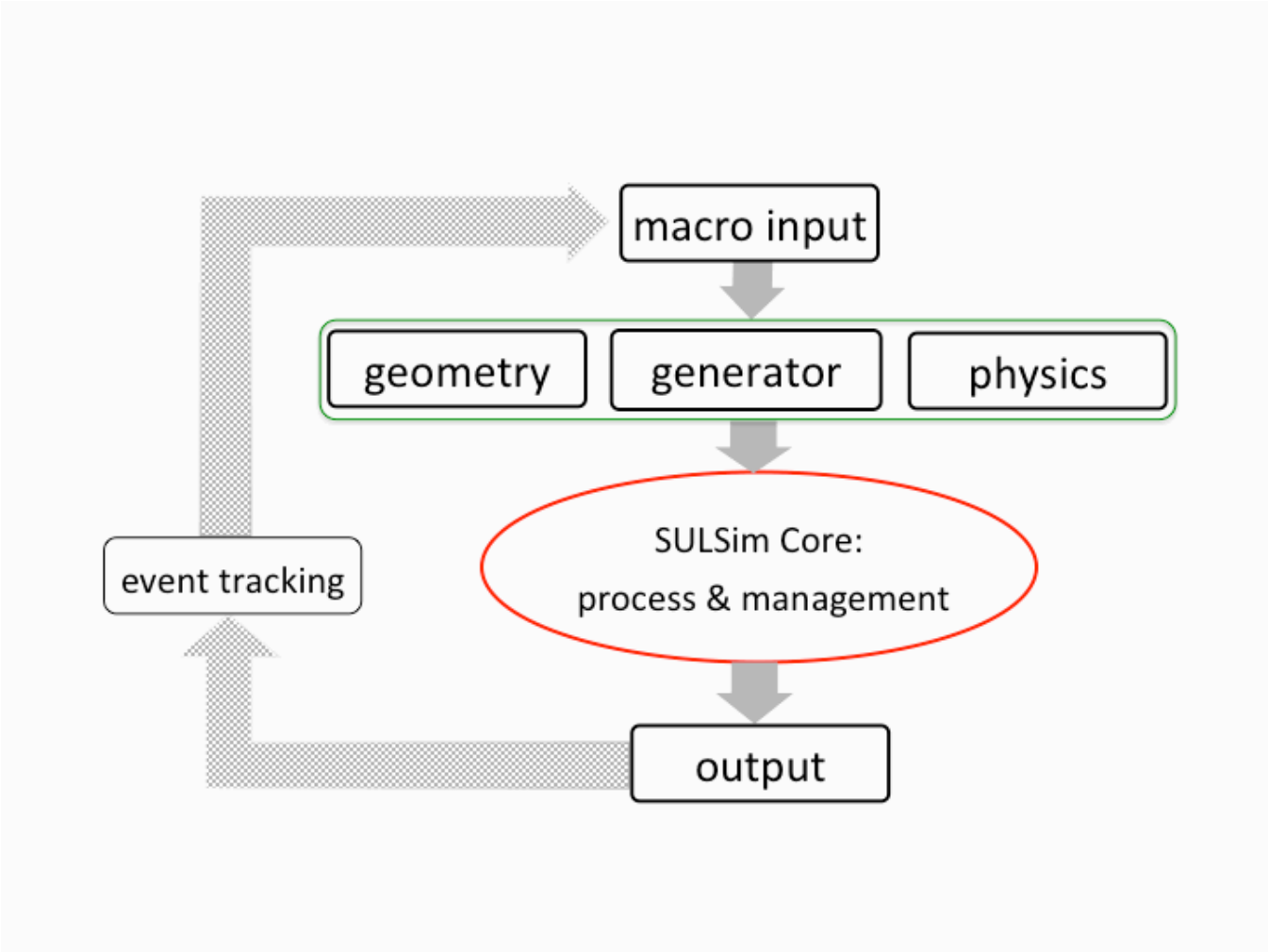
Motivations

- Incorporate all characterized Homestake background data which will be shared with all experiments.
  - Homestake external muon, gamma, neutron, radon background and rock composition have been measured at various level of depth.
  - Various geometry modules can be developed to share the results.
- Dedicated physics focusing on low energy region.
  - Rich and selectable physical models and processes.
  - Evaluated physics process and database for all relevant materials.
  - Add low energy atomic and solid state physics into Geant4.
- Retrievable output results for validation.
  - Detailed historic and event information.
  - For verification purpose, retrieve tracking information for any interested event, step by step.

Flow Chart of AARMSim



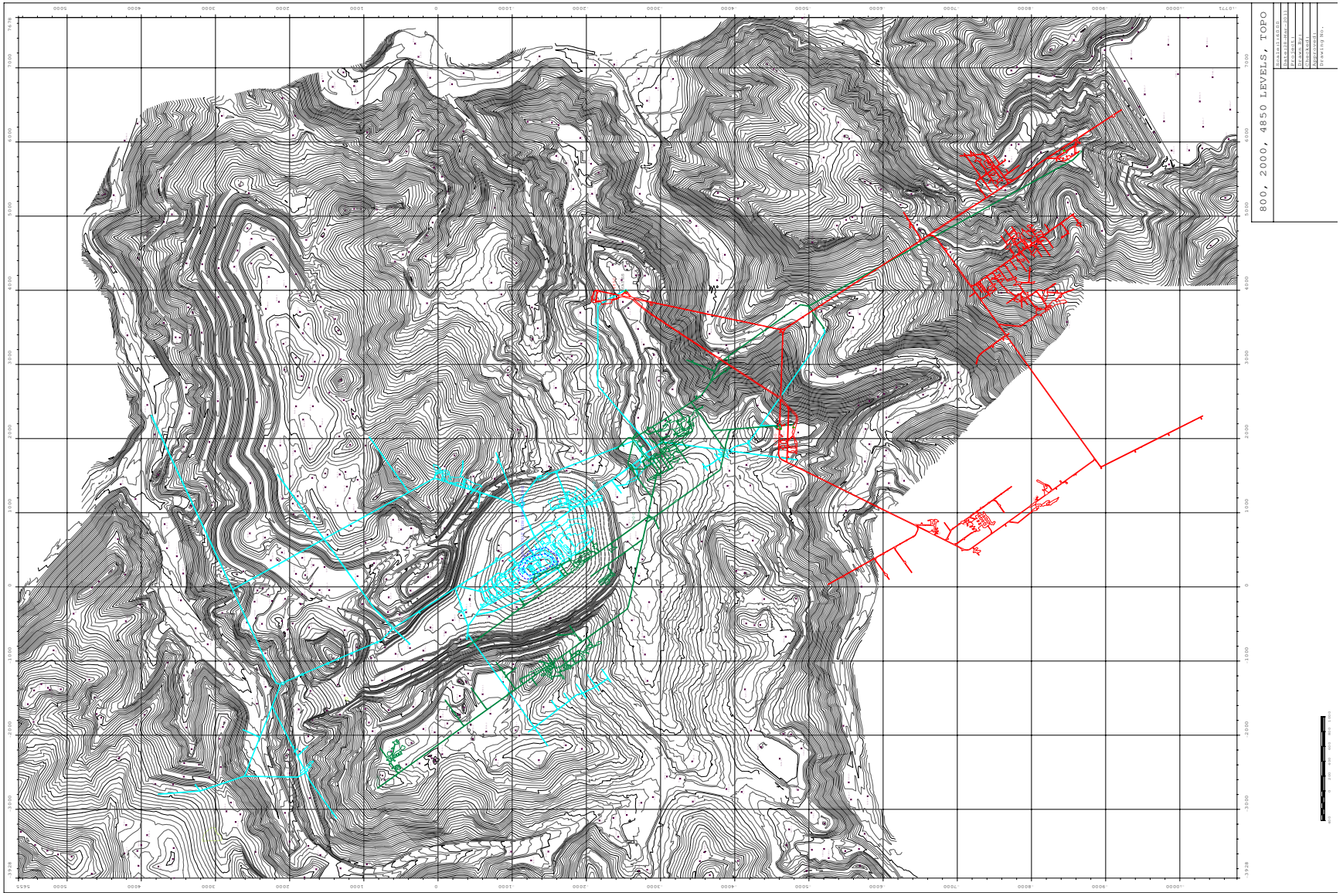
Package Status

- Package takes Geant4.9.4 as its working base.
- The basic structures are finished and initialized to SVN repository(http://svn.csci.usd.edu/AARM).
- The package is divided to six sub-systems for group development. It will be released for public using early next year.
- Detailed database for Davis Cavern is under construction.

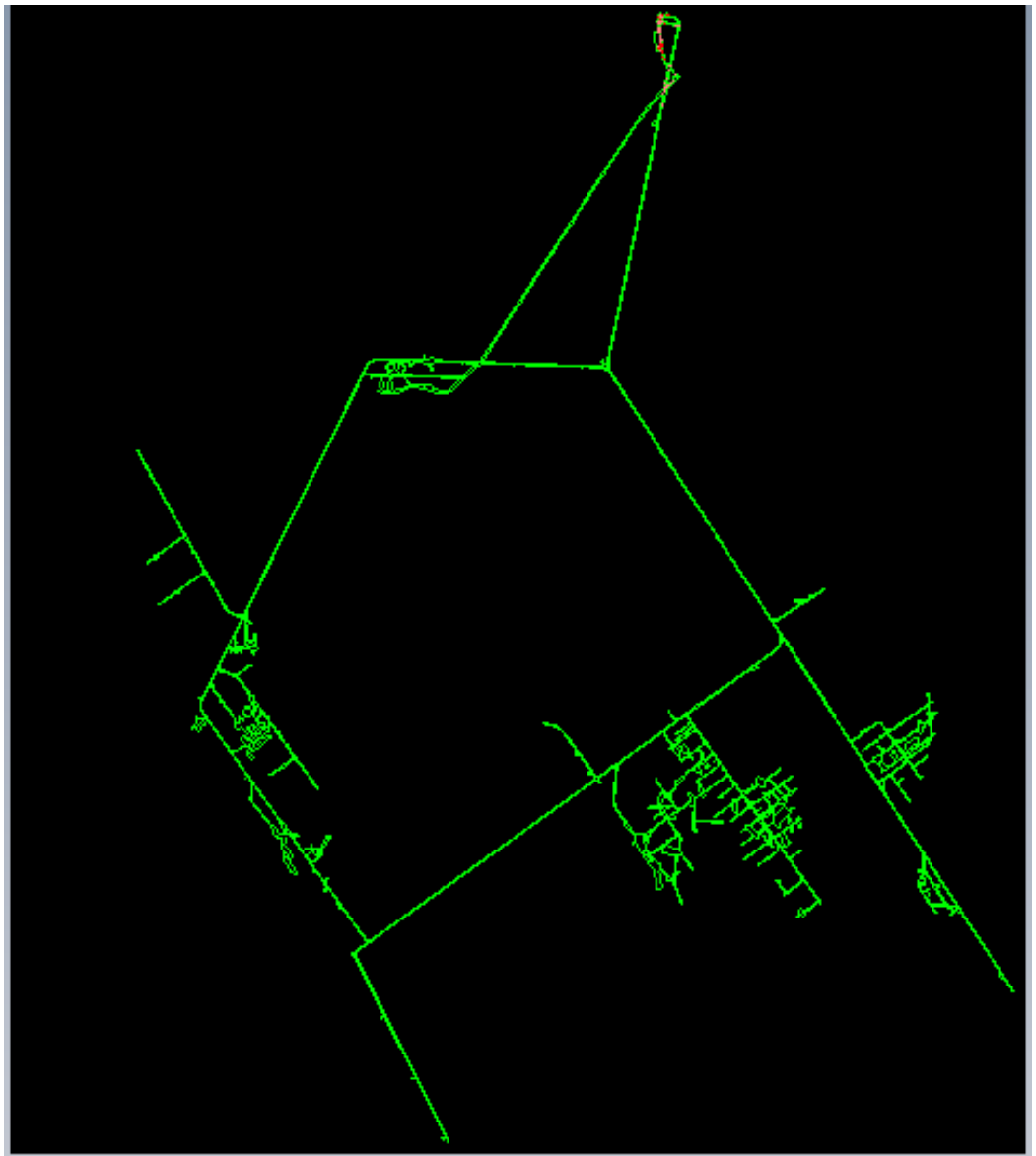
Database for Backgrounds

- Two important backgrounds:
  - ✓Cosmogenic:
    - ➢ cosmic-ray muons
    - ➢ spallation neutrons & gamma-ray
  - ✓Radiogenic:
    - ➢ (a, n) neutrons
    - ➢ radioactive gamma-ray
    - ➢ radon

Mountain Profile of Homestake



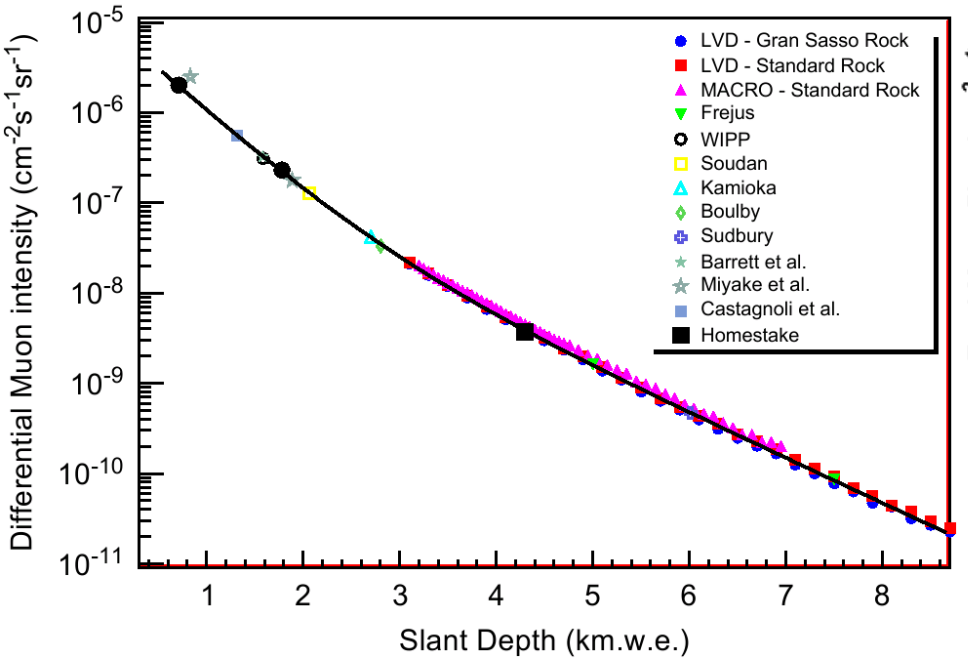
4850ft level of Homestake

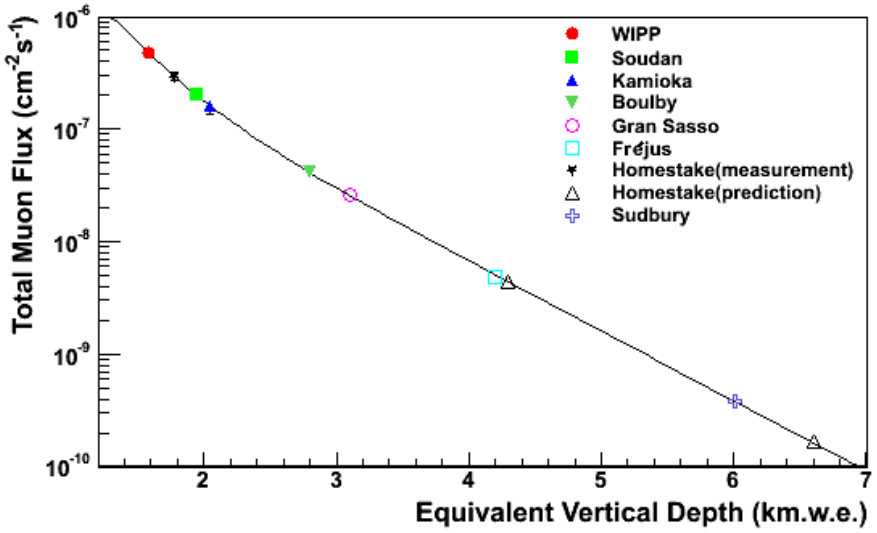


Rock Component (Sample 278-2)	Composition (% weight)
SiO_2	43.7
TiO_2	1.22
Al_2O_3	13.6
FeO	12.7
MnO	0.13
MgO	7.0
CaO	7.9
Na_2O	2.87
K_2O	0.21
P_2O_5	0.07
H_2O	10.7
$^{232}Th(\alpha, n)$ Yield	0.34/g/ppm/y
$^{238}U(\alpha, n)$ Yield	0.86/g/ppm/y

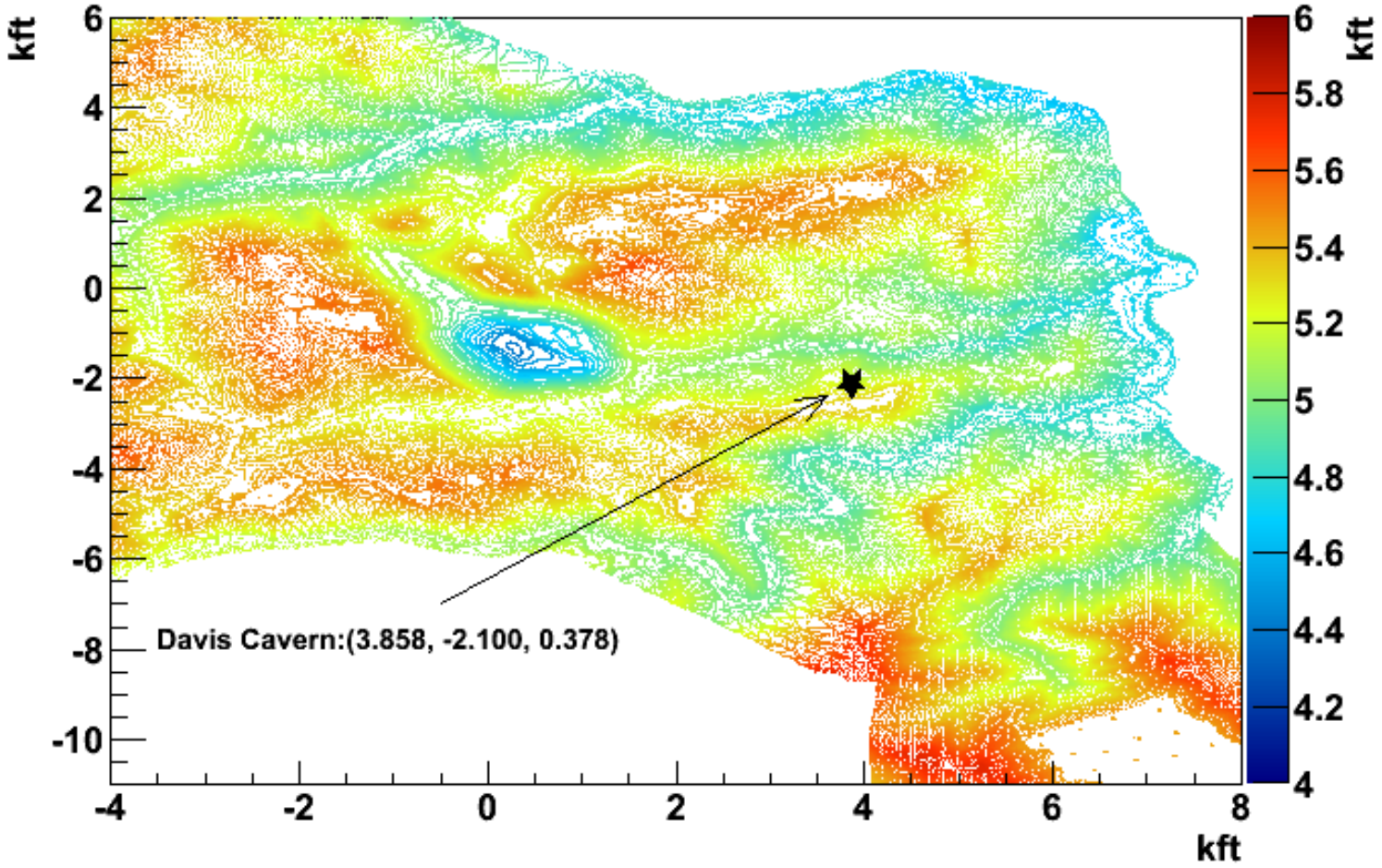
Muon flux at 4850-level of Homestake

- The nearly vertical cosmic ray muon flux was measured at surface, 800ft, 2000ft level of Homestake mine (NIMA 638(2011)63-66).
- The muon flux at 4850ft and 7400ft level are predicted using the depth-intensity-relation in Ref PRD 73(2006)05304 and calibrated to measured results at 800ft and 2000ft level.

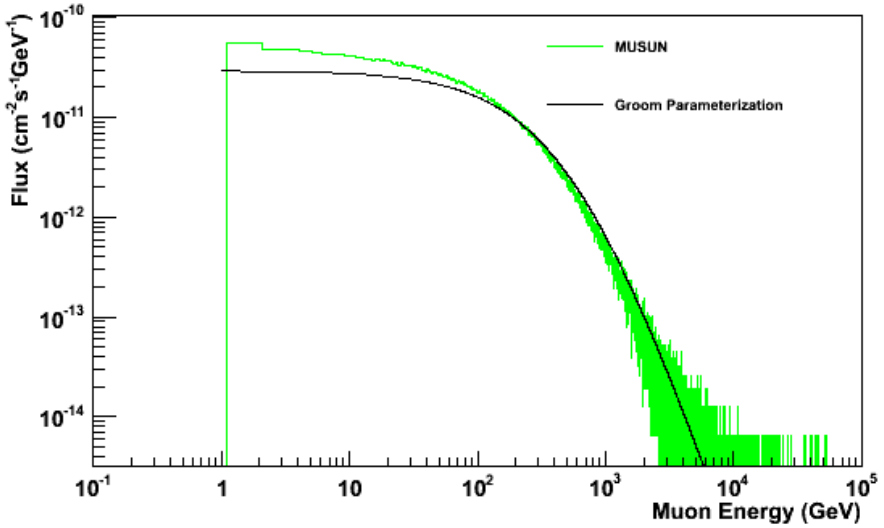


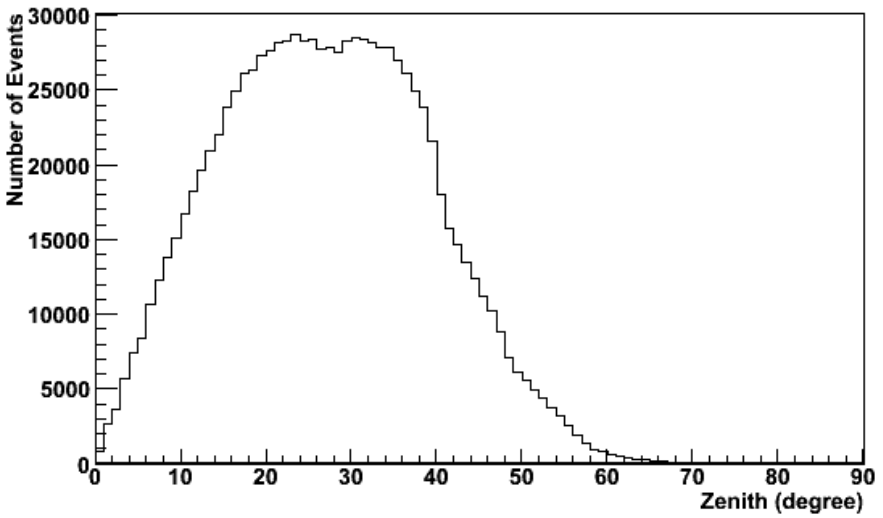


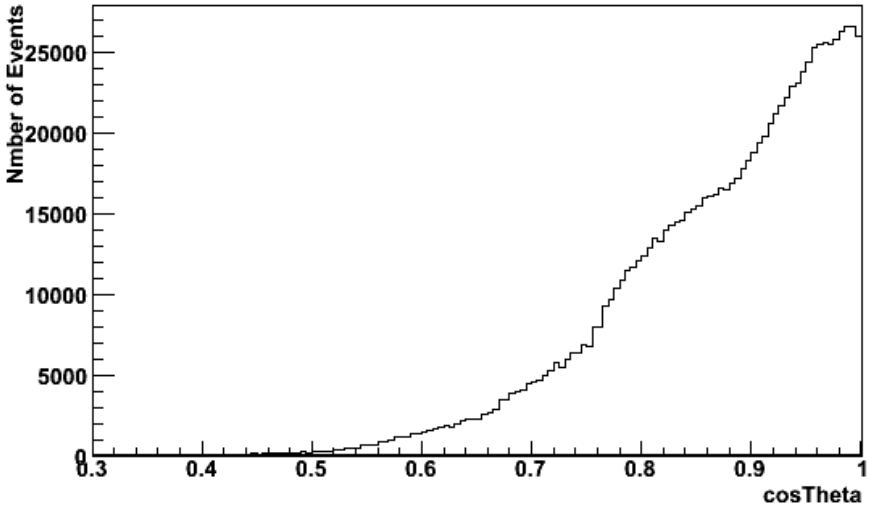
Simulation effort

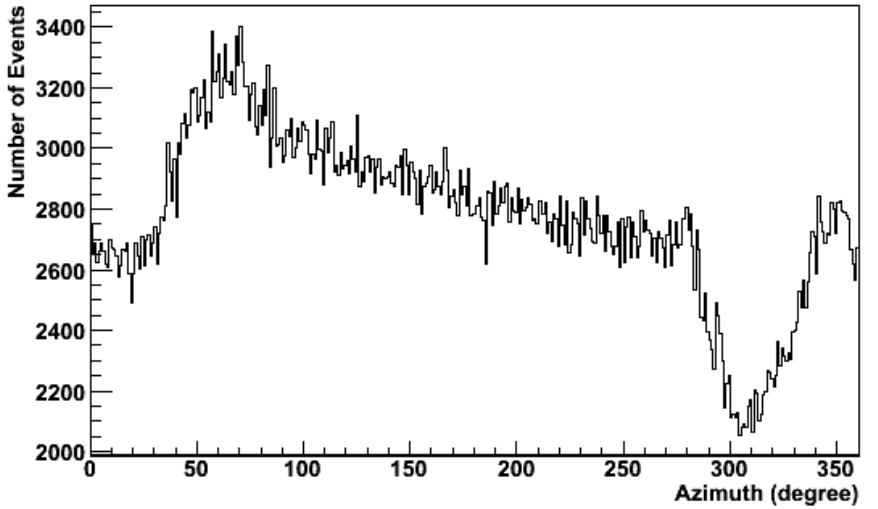


Muon flux at 4850-level(MUSUN)

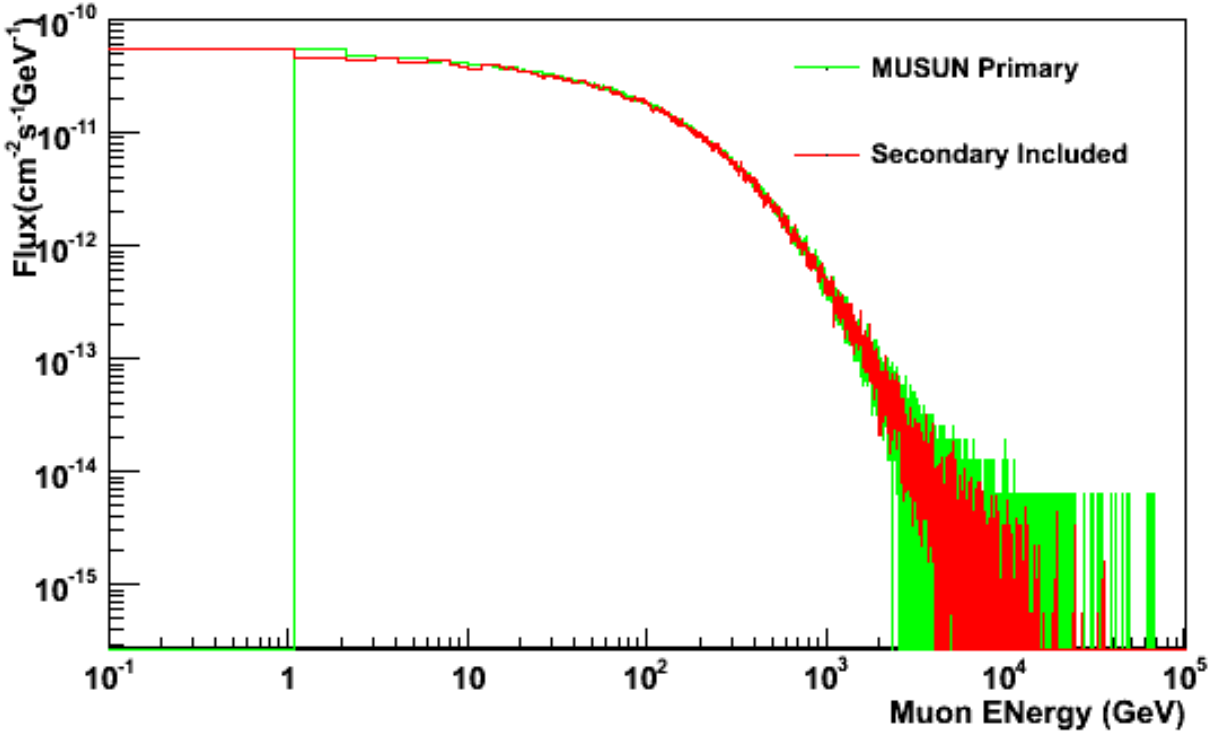






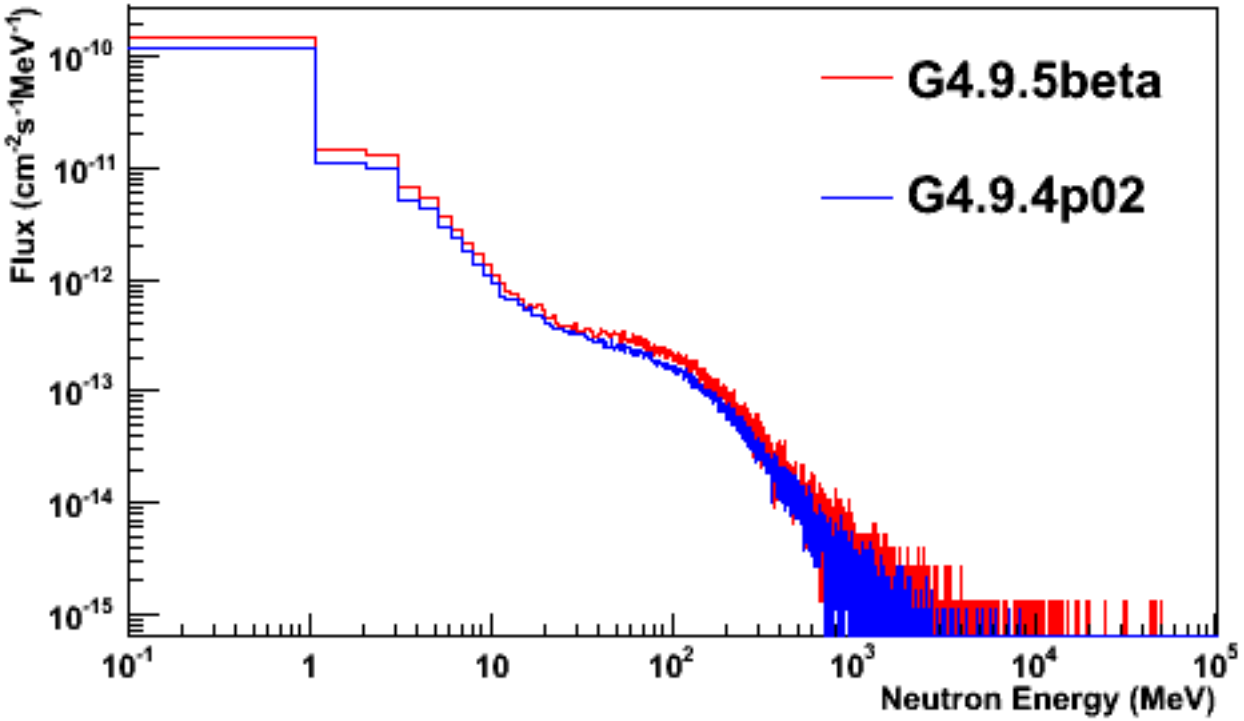


Muon Flux at 4850-level(Geant4)



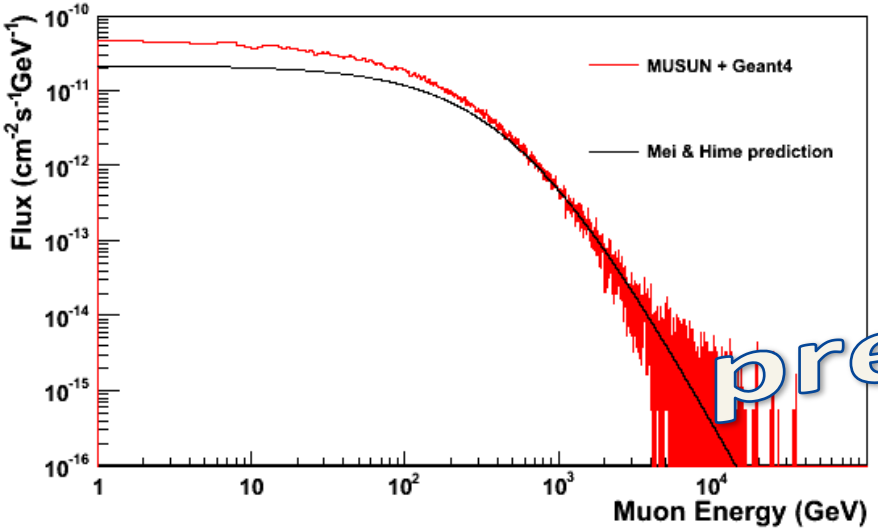
- Rock sample from Davis cavern.
- 20m*20m*20m cavern with 7m rock coverage.
- Input muon spectrum from MUSUN-DUSEL-4850(6.46e-9cm^{-2}s^{-1}).

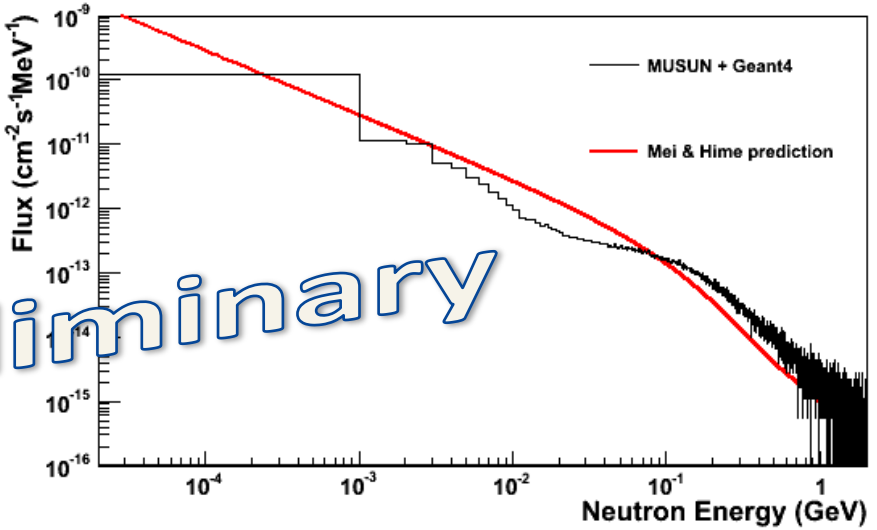
Neutron Flux at 4850-level(Geant4)



- Total muon flux 6.46e-9cm^{-2}s^{-1}.
- Total neutron flux 1.65e-10cm^{-2}s^{-1}(G4.9.4p02).
- Total neutron flux 1.89e-10cm^{-2}s^{-1}(G4.9.5beta).

Comparison with Mei&Hime Prediction

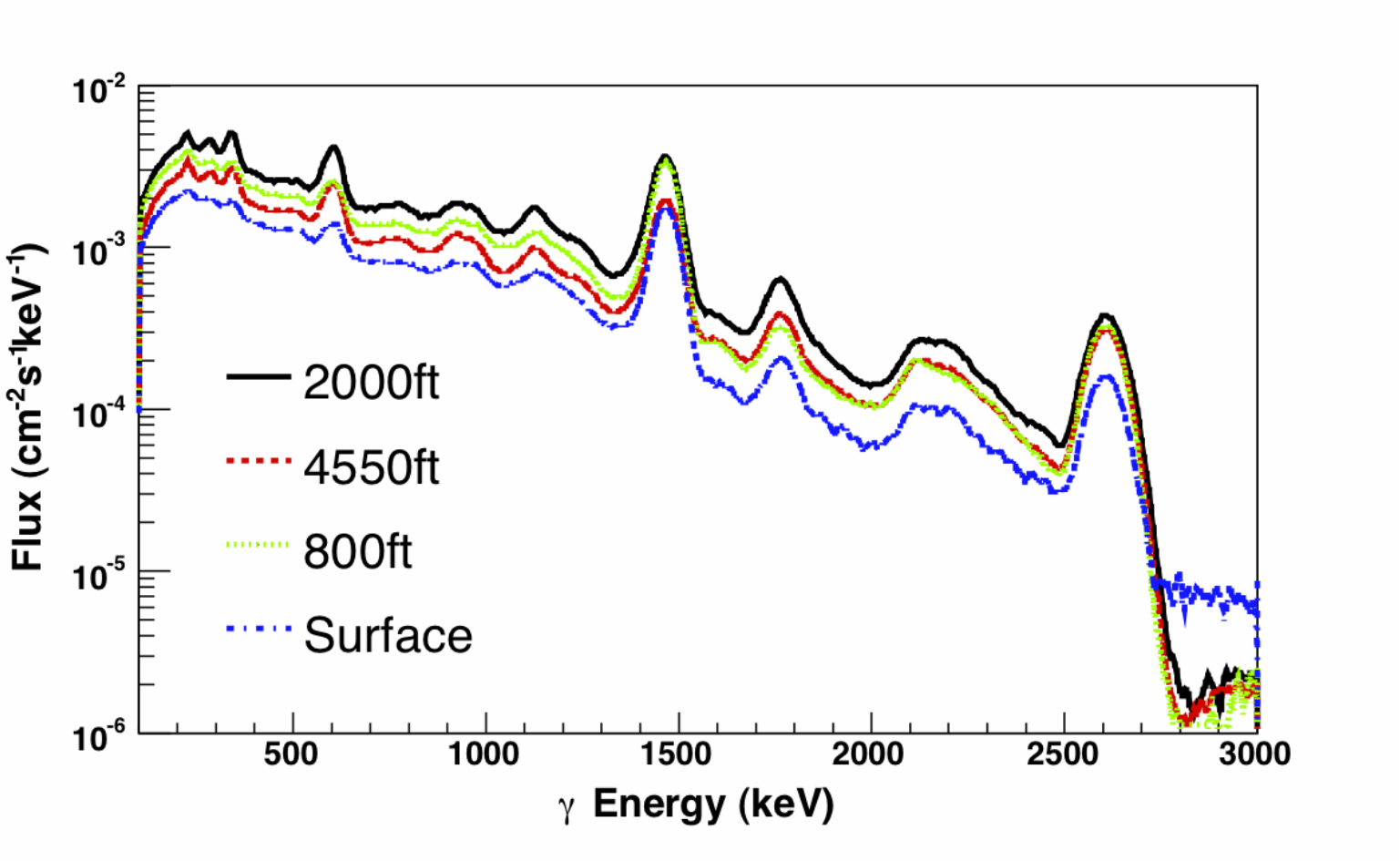




preliminary

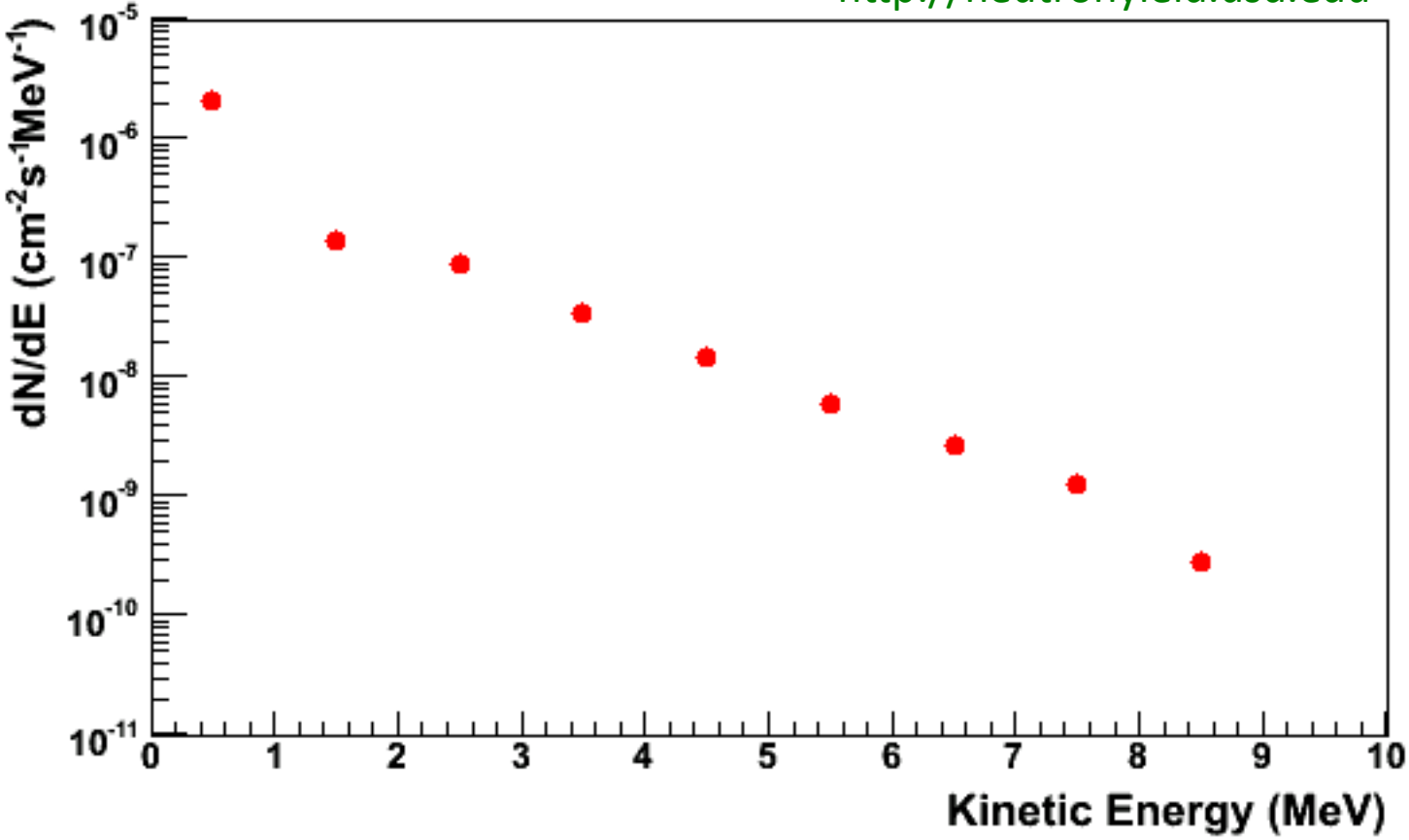
- MUSUN+G4: muon flux 6.46e-9cm^{-2}s^{-1}; neutron flux 1.65e-10cm^{-2}s^{-1}.
- Mei&Hime : muon flux 4.4e-9cm^{-2}s^{-1}; neutron flux 5.39e-10cm^{-2}s^{-1}.

Radioactive Gamma-ray

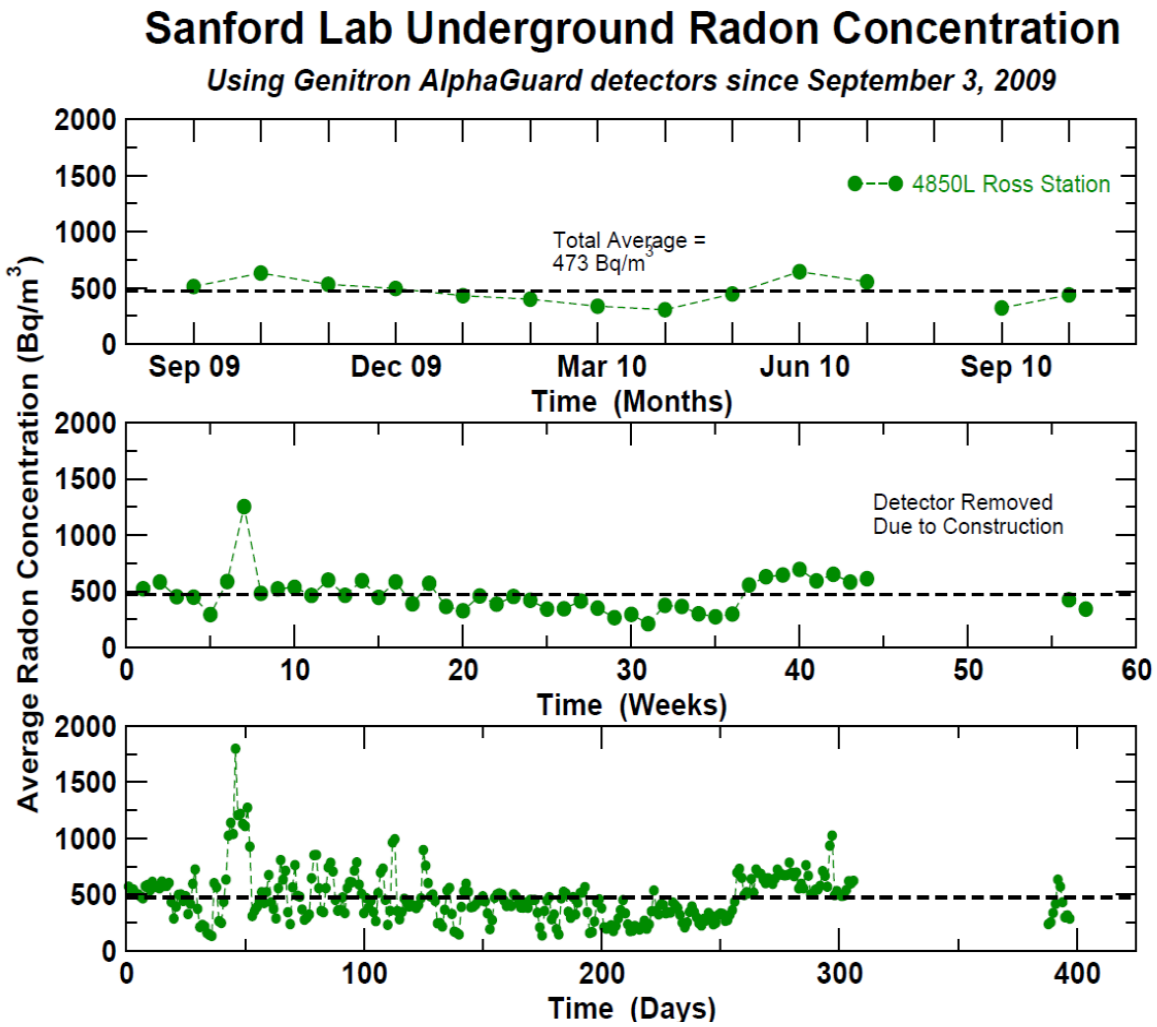


(a, n) neutrons

http://neutronyield.usd.edu



Radon


Sanford Lab Underground Radon Concentration
Using Genitron AlphaGuard detectors since September 3, 2009
Average Radon Concentration (Bq/m3)
4850L Ross Station
Total Average = 473 Bq/m3
Sep 09
Dec 09
Mar 10
Jun 10
Sep 10
Time (Months)
Detector Removed Due to Construction
Time (Weeks)
Time (Days)

Summary

- An Integrated simulation package is under construction to serve the coming experiments in Homestake mine. Focusing on low energy physics, the processes and the associated database will be validated element by element.
- External backgrounds for the mine have been collected. A dedicated database for Davis cavern will be completed and serving the community.