Geometry and Backgrounds for a FAARM/DUSEL Simulation Framework

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February 25, 2011

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FAARM Facility

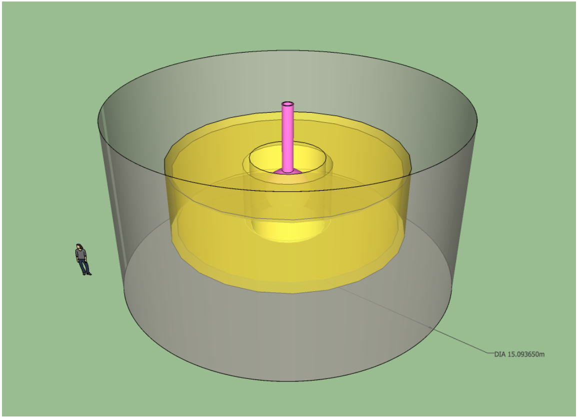

Figure: **F**acility for the **A**cquesition and **A**ssay of **R**adioactive **M**aterials.

FAARM Modular Geometry

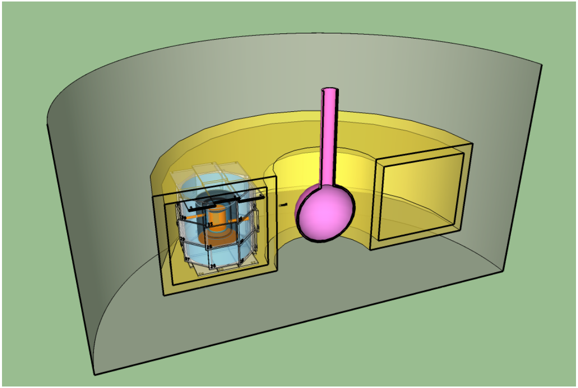

Figure: An example of modular geometry (CDMS Soudan) in the FAARM. One should include Geant4 geometry from CDMS directly. CDMS model due to M. Fritts

Geometry and Community

Geometry

- Our geometry is important to have properly included in the mine
- General simulations can be done based on mine properties
- Materials are included individually Stainless, Acrylic (PMMA), Poly, Rock

Community

- Since simulations are very important for FAARM, place effort into framework (Chao)
- Useable by (eventually) all low background groups
- Tie in materials (radioactive and not) database for code stability

FAARM Framing Materials

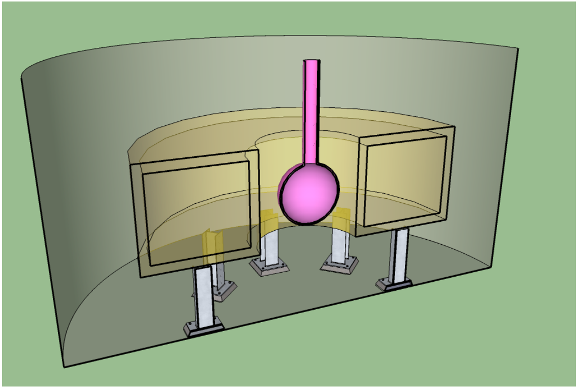

Figure: An example of support structure which should have the contamination quantified.

One Contaminant, Codified

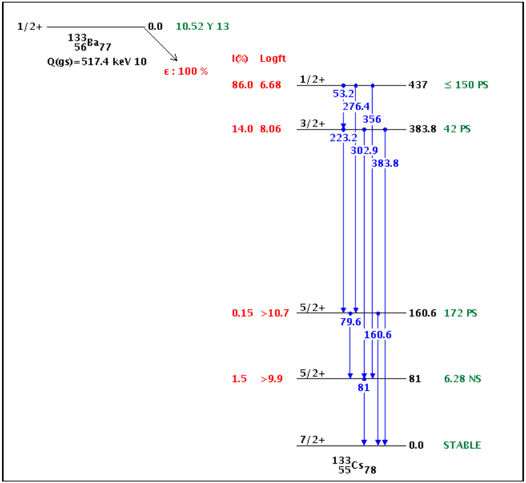

Figure: ^{133}Ba decay scheme.

One Contaminant, Codified

```
int CDMS_ParticleSource::GenerateBa133Decay(G4PrimaryVertex* vert)
{
  G4double rndm,rndm2,rndm3,rndm4,rndm5;
  G4int numberOfGamma = 0;

  particle = particleTable->FindParticle("gamma"); SetParticleDefinition(particle);

  rndm = G4UniformRand();
  if (rndm<=0.86)
    goto decay1;
  else
    goto decay2;

 decay1: rndm2 = G4UniformRand();
  if(rndm2>=0 && rndm2<=0.7165) {
particle_energy = 356.02*keV; numberOfGamma +=1; CreatePrimaryParticle(vert);
goto decay4;}
  else if(rndm2>0.7165 && rndm2<=0.7348) {
goto decay4;}
  else if (rndm2>0.7348 && rndm2<=0.8175) {
particle_energy = 276.40*keV; numberOfGamma +=1; CreatePrimaryParticle(vert);
goto decay3;}
  else if (rndm2>0.8175 && rndm2<=0.8222) {
goto decay3;}
  else if (rndm2>0.8222 && rndm2<=0.8476) {
particle_energy = 53.16*keV; numberOfGamma +=1; CreatePrimaryParticle(vert);
goto decay2;}
  else if (rndm2>0.8476 && rndm2<=1.0) {
goto decay2;}
```

Contamination of α

The (α, n) process

$$\alpha + A \rightarrow n + A'$$

- particles come from radioactive decay and slow down
- eventually capture with various nuclei and relese Q-value of energy

These are dangerous

- Need to understand contamination in detail to know how many α are generated

Cosmic Secondaries

Muons propagate

- maximum π population at 15 km
- π lifetime: 2.6 $\times 10^{-8}$ s
- μ lifetime: 2.2 $\times 10^{-6}$ s
- $\mu^{\pm}$ and ν survive and dominate spectrum at sea level
- $\mu^{\pm}$ have suppressed radiative energy loss and electroweak interactions only

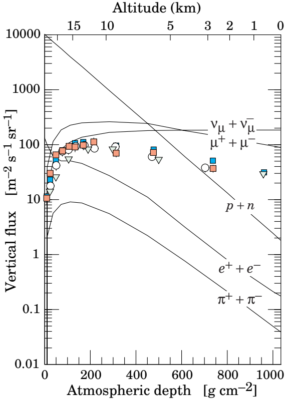

Figure: PDG, J. Phys. G **37**, 075021 (2010).

Muons Interact in Dense Rock

Muons very distinct

- passing through a detector results in a reliable 2 MeV/cm
- most all of energy is imparted to electrons (not nuclei)
- rare for hard nuclear scattering but large energies emerge
- these can easily be vetoed in sensitive dark matter and neutrino experiments

So why worry about muons?

- spallation is a problem

$$\mu^{\pm} + A \to \mu^{\pm} + A' + X$$

- X are hadronic products, including neutrons and A' can be radioactive

Difficulties

Problems, directions

- though a lot is known about transport and interactions of materials in matter this requires:
  1. computing time
  2. information of hadronic cross sections over wide ranges of energy
- Geant4 should be extensively checked in this region
- **data** is always important but how compare?

FAARM Cosmogenic Spectra

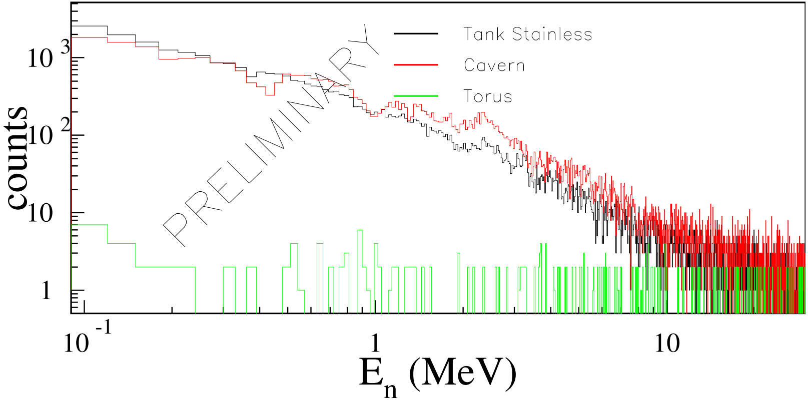

Figure: Moderation of FAARM cosmogenic neutrons by 2.3 m water shield.

Directions for Geometry

Geometry

- Get FAARM geometry and physics in a state that can feed back to engineering
- Include other geometry into FAARM by modular methods
- Gather basic materials data to store, like stainless steel, rock etc.
- Beginnings of geometry super-class, capability to store and use meta-data
- Read data from contamination database which has various data specific to a counted material (tomorrows discussion)

Directions for Backgrounds

Backgrounds

- Confirm the correctness of (α, n) in Geant4, kinematics
- How detailed are Geant4 decay schemes?
- Decay chains read from an online database (like http://nndc.bnl.gov), angular dist. studied where needed
- Study physical cross sections in detail (especially in cosmogenics case)
- Gather statistics for general FAARM/DUSEL installation and hold in standard format