Gamma-ray Screeners and Overall thoughts for discussion

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Very Low background techniques

1. **Ge spectroscopy: gamma-ray emitting nuclides**
2. **Rn emission assay: ^{226}Ra, ^{228}Th**
3. **Neutron activation analysis: primordial parents**
4. **Liquid scintillator counting: α and β emitting nuclides**
5. **Mass spectroscopy (ICPMS, AMS): primordial parents**
6. **Alpha spectroscopy: α emitting nuclides**
7. **Beta cage: beta emitting nuclides?**

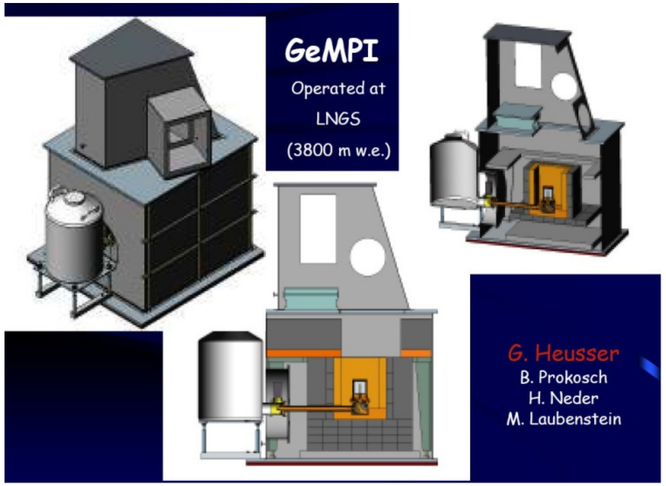
Sensitivities

1. **Ge spectroscopy: Gamma-ray emitting nuclides 10 – 100 uBq/kg**
2. **Rn emission assay: ^{226}Ra, ^{228}Th 0.1-10 uBq/kg**
3. **Neutron activation analysis: primordial parents 0.01 uBq/kg**
4. **Liquid scintillator counting: α and β emitting nuclides 1 mBq/kg**
5. **Mass spectroscopy (ICPMS, AMS): primordial parents 1-100 uBq/kg**
6. **Alpha spectroscopy: α emitting nuclides 1 mBq/kg**
7. **Beta Cage: beta emitting nuclides ?**

Phase-Approached Gamma-ray screeners

1. Sub-ppb or 1 mBq/kg:
   a. Detector: $50-60 K depending on the energy resolution
   b. Cryostat: very low background $10 K
   c. Inner shield: OFHC copper $150/brick with 2"x4"x8", $20 K
   d. Outer shield without water shielded room: lead: $100/ brick with 2"x4"x8, $40K
   e. Rn exclusion box: $3K
   f. DAQ: $35K
   g. LN auto: $25K
   h. Office: $10K
   i. Total: $868 K without water shielded room
   j. Total: $628K with water shielded room

Ultra-low sensitivity



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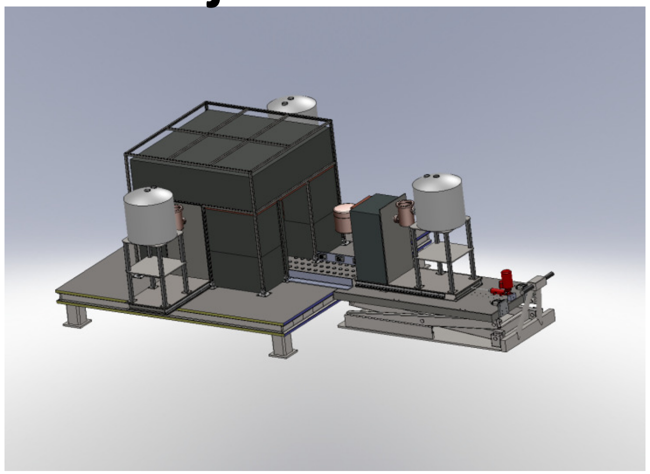

1. **GeMPI: ~10-100 uBq/kg**
   or ~1-10 ppt
2. **GeMPII: ~10 uBq/kg**
   ~1 ppt?
3. **GeMPIII:?**

1. **~0.01 ppt, the inner-most shield must be electroformed copper Produced underground**
2. **~40 cm lead outer shield**
3. **Multiple detectors with PSD**
4. **~30 cm Poly shield outside plus veto**

What we do for ultra-low screeners?

1. **GeMPI type screeners with ppt level sensitivity or better**
2. **Neutron shield is needed**
3. **Inner shield must be very pure copper (electroformed copper is the best)**
4. **Outer shield must be very pure lead**
5. **Cost analysis**
   a. **Without water shield room: $3.5 M (detector: $200K)**
   b. **With water shield room: $1.5 M**
   c. **Difference: clean room, engineering, outer shield, neutron shield for 4 individual detectors**

Water shield room in needed

1. **Neutron shield is needed for ultra-low screeners including gamma-ray and Alpha/beta screeners**
   a. H-M experiment: 0.05 cnts/keV/kg/year in the ROI were removed by adding 10 cm poly. It is about 40% of the total background budget
   b. IGEX: 40 cm poly, 40% of events in the ROI were vetoed
   c. Neutrons are needed to be shielded from the detectors
2. **With a water shielded room, it makes shielding design, engineering, and operation more convenient**
3. **It is easier to purify water down to sub-ppt level but it is difficult to find lead with purity at a level of sub-ppt (can be in ppt level, a few Bq/kg of ^{210}Pb is often presented in lead). Even tough, it is expensive any way.**
4. **Save about $2.24 M for gamma-ray screeners along for individual shielding for gamma-rays and neutrons**

Suggestions

1. Leave immersion tank outside the water shielded room to save the space and money for the water shield room. Only gamma-ray screeners and alpha/beta screeners are inside the water shielded room. This way, the water shielded room can be built within a few million dollars
2. Immersion tank will be built in a class 1000 clean room with radon reduced air (<1 mBq) and active water shield and veto. This way is cheaper and easier to engineering. The cost would be about 1 million dollars (my first order guess)
   a. measuring radiopurity for ultra-pure water for LBNE
   b. measuring intrinsic radio-purity for germanium detectors
   c. whole body counting for large objects, which can not be counted accurately with any type of screeners. For example: large PMTs for proton decay and dark matter searches
3. The total equipment budget can be controlled within $10 M for FAARM