COUPP Muon Vetoing and Deep Underground Installation

PPD Review

10 December, 2008

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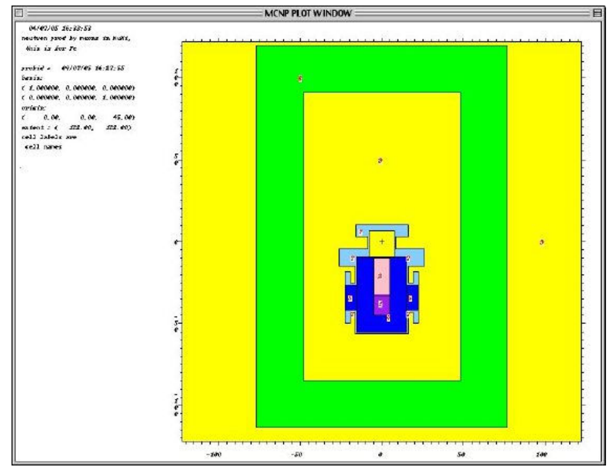
Installation Plan (Russ Rucinski)

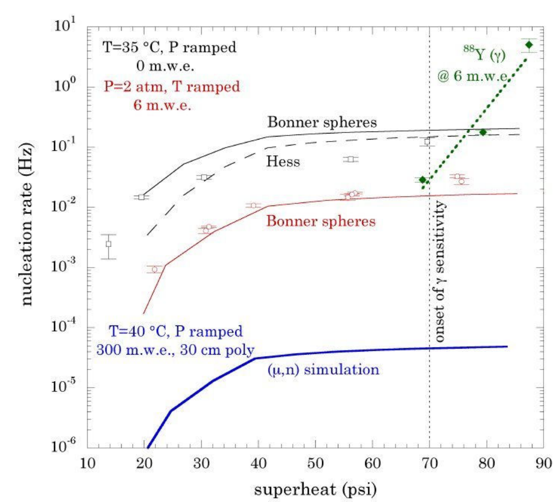
- November, 2008: Complete mechanical assembly of detector and veto tank separately.
- December, 2008: Continue planning for deep underground installation.
- January, 2009: Nest outer vessel into water tank at PAB and commission veto.
- February, 2009: Finish assembly of high purity vessel. Finalize plan for deep underground installation?
- March, 2009: Install complete detector and veto in MINOS tunnel
- April-June?, 2009: Run detector in MINOS tunnel. Construction of veto for deep underground site.
- Fall, 2009?: Move detector into new veto installation at deep site.

Prediction for cosmic muon induced bubbles

- Juan ran an MCP simulation to determine the rate of muon induced nucleations in the Minos tunnel.

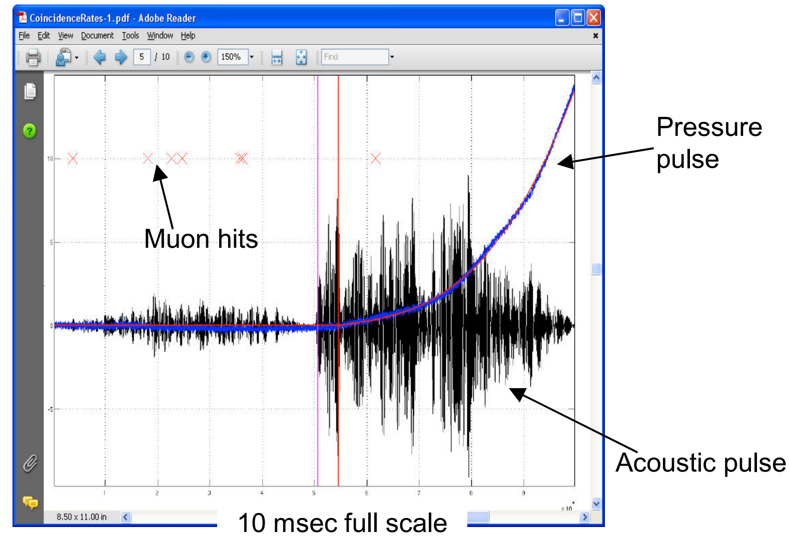
- His final prediction is ~3 x 10^{-5} Hz, or 3/day.

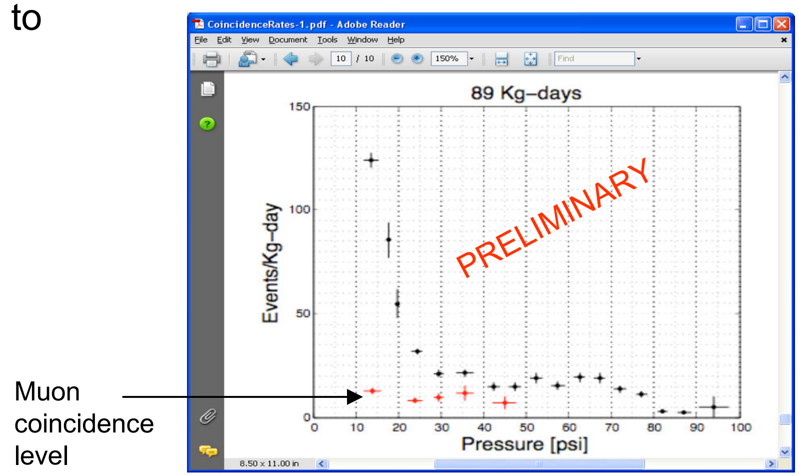




Muon veto requirement

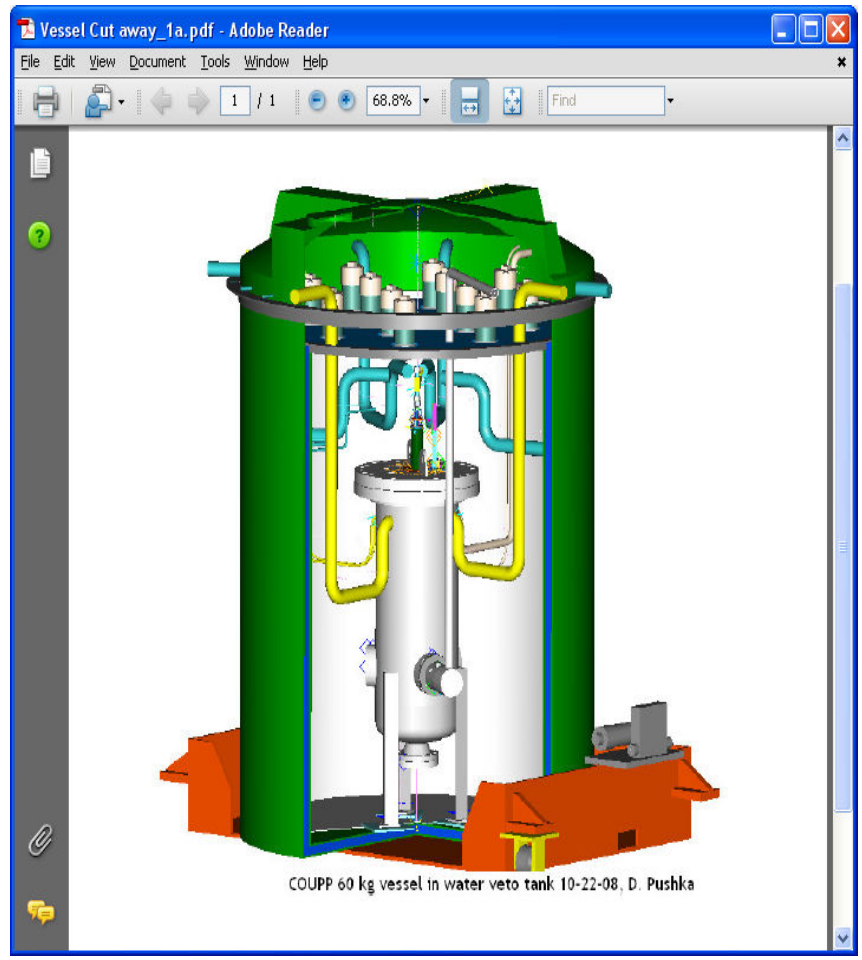
- In the MINOS tunnel, we observed about 5-10 events/kg/day in coincidence with muon veto.
- For a 60 kg x 200 day exposure, this translates to > 100K cosmic background neutrons!
  - Would need 10^{-6} inefficiency for cosmic ray veto
  - Much easier to just go deep
- At Soudan, CDMS results indicate a non-vetoed neutron background arising at the 10,000 kg-day exposure level. We would still need a cosmic ray veto.
- At SNOLAB, the cosmic ray rate is reduced to irrelevancy.
- If a muon veto is used, then the veto rate should be significantly lower than the time resolution of 10 msec (i.e. <5 Hz)





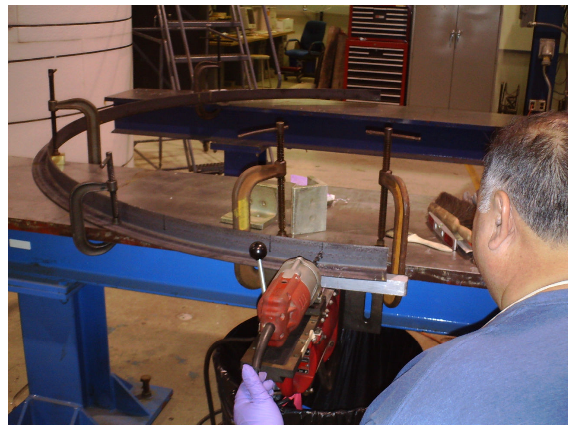
Solution in MINOS tunnel

- We decided to go with the cheapest solution that would maximize our shielding and muon veto coverage – namely a monolithic polyethylene 4000 gallon water tank with Tyvek liner that would act as shielding, a muon Cerenkov detector, and a heat bath.
- Dave Pushka is in charge of construction and has created a 3d model. →
- In tandem with this approach, we are also developing a set of scintillating oil veto tanks that surrounds our 4 kg chamber.
- If we decide to use such a water tank at a deep site, then it would have to be designed in pieces to fit down the mine shaft.
- If we install at SNOLAB, there probably are no issues with muon vetoing, and we can either proceed with this option or consider simple stackable water cubes or polyethylene shielding if a water tank is too cumbersome. The director of SNOLAB has indicated he could help with this project.

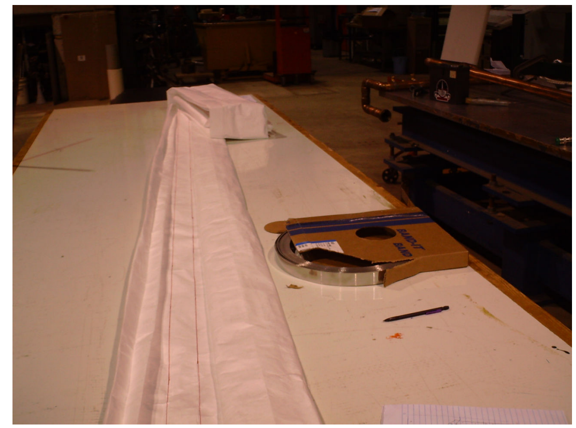


Status of veto tanks

Inner tank is insulated. Outer tank top ready to be cut. Nesting of tanks will soon follow.



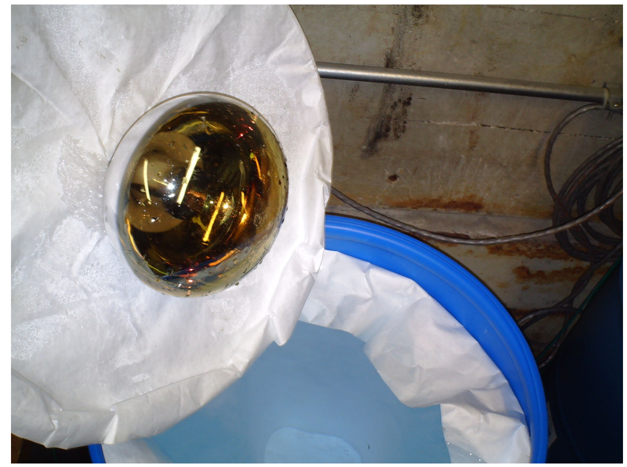
Stabilizer ring for inner tank is near completion



Tyvek liner has had pockets sewn into it, to accommodate steel bands that press Tyvek against walls of tank.

Test detector

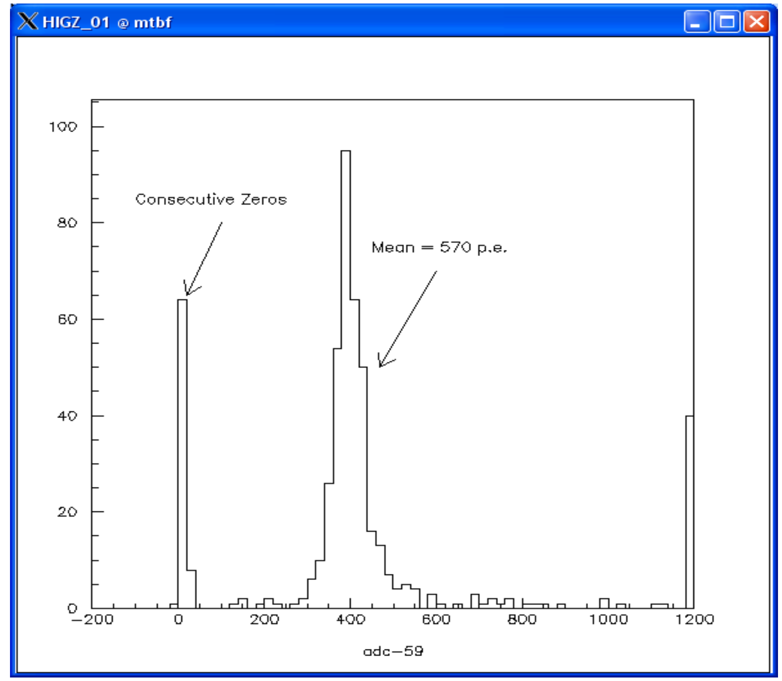
A small drum of distilled water with a Tyvek liner was used for cosmic ray tests. Trigger scintillators on top and bottom.



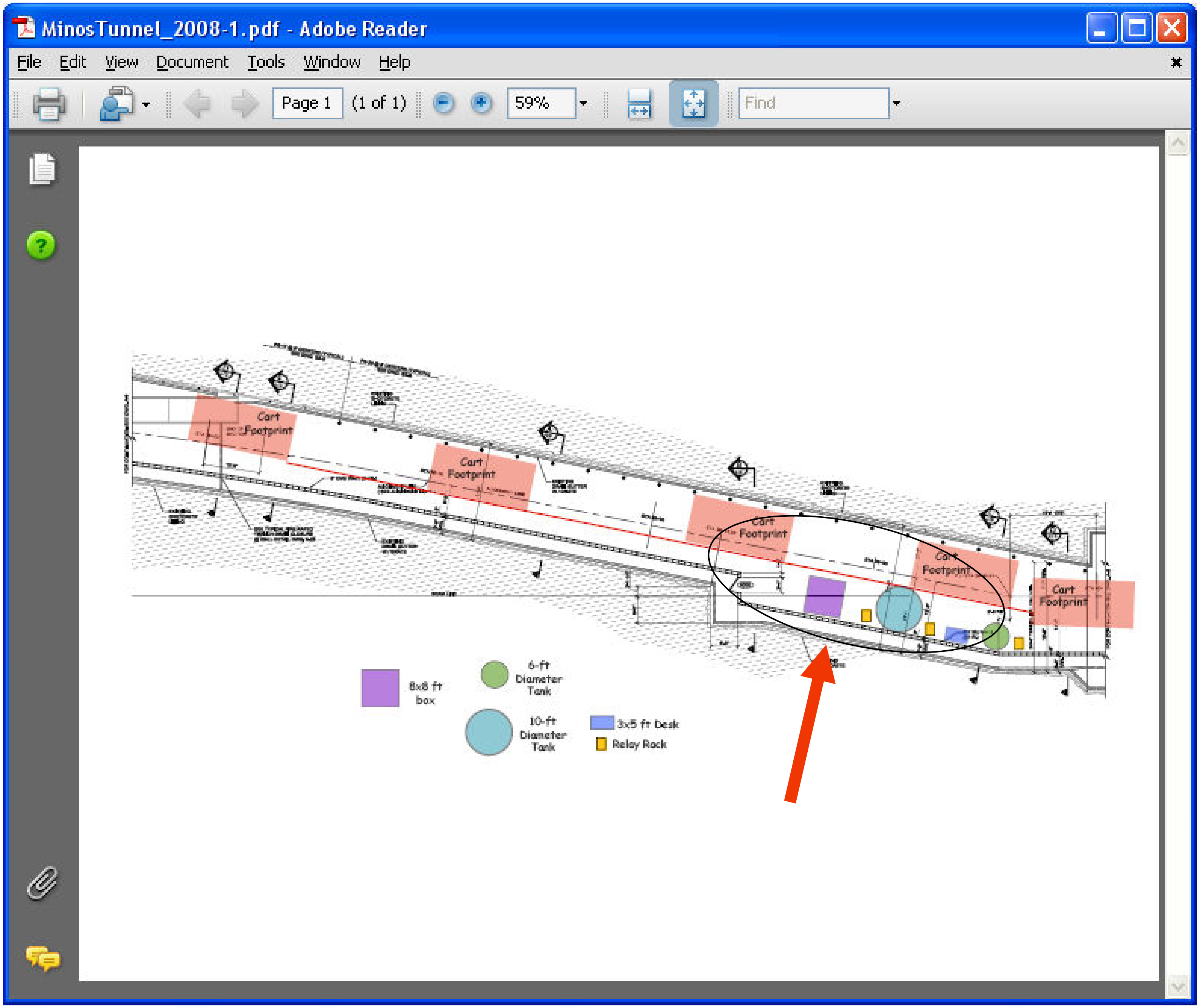
Tyvek liner has been sitting in water for 6 months, with no degradation.

Light yield results

- In this tank, we have a path length in water of 70 cm, which should give about 14,000 visible photons.
- Geometrical acceptance of phototube is $(8/20)^2 = 0.16$
- Assume Q.E. of tube to be .25
- Guess that reflectivity of Tyvek gives .80 efficiency:
  - Prediction is about 450 photons
  - Observation is about 560 photons (2 Volt signals at nominal gain)
- In large tank, geometrical acceptance for each tube is reduced by factor of 25, so we should see ~30 p.e. for unobstructed tracks of 1 meter length.
- Noise level of dark adapted tube at 5 p.e. threshold is 25 Hz, which should increase by a factor of 10 at 40 degrees C.



One significant issue:
Several times overnight, there were a series of 10-20 events with zero pulse height. I suspect HV problems.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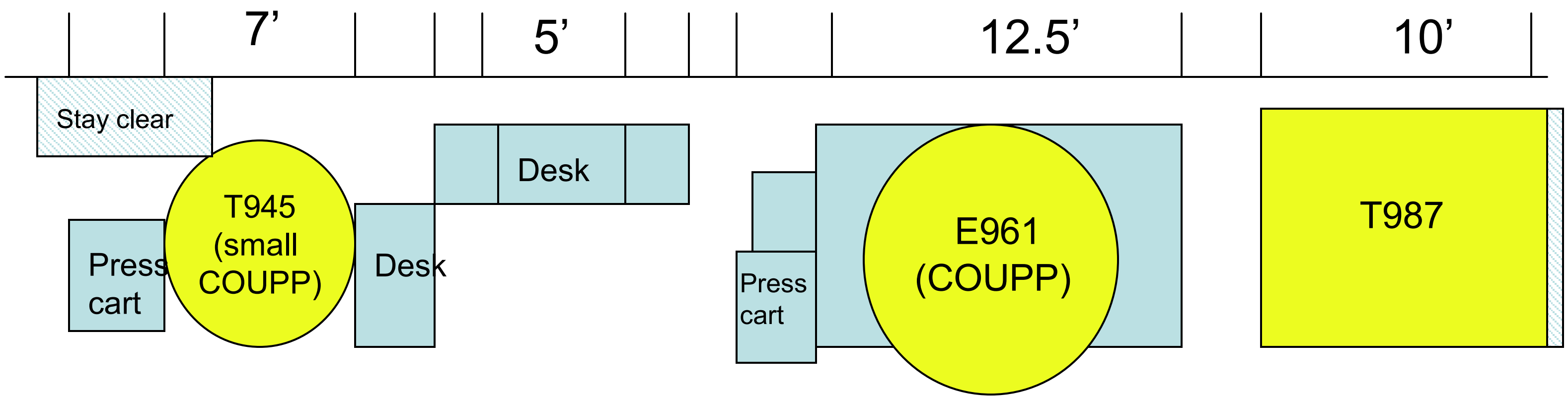
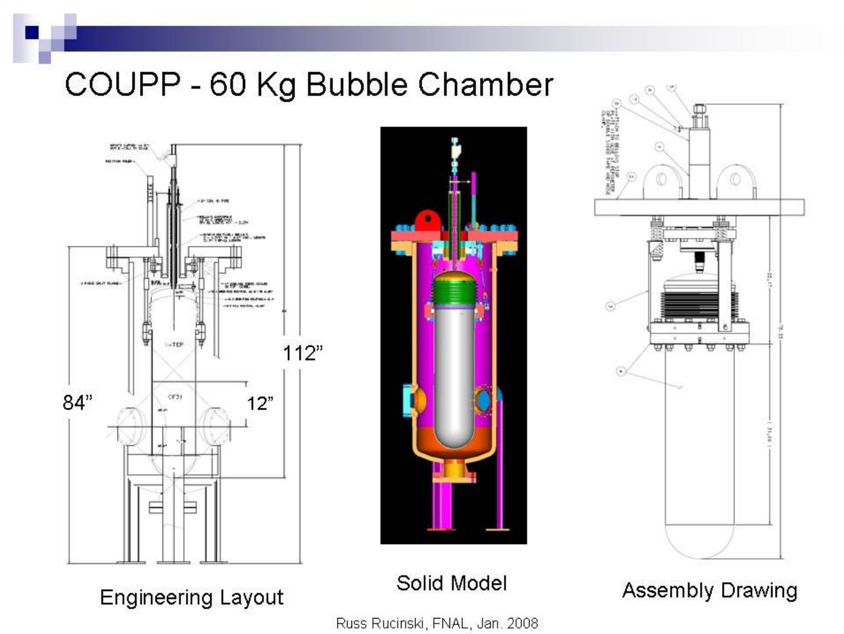


Proposed underground installation has been reviewed by Cat James and presented at the NUMI underground installation meeting

Assembly requirements

- Three significant installation steps:
  - Cleaning of inner vessel. (performed at A0 accelerator RF clean room at Fermilab)
  - Assembly of clear vessel with flange and bellows. Requires significant clean room conditions (class 10 clean room in lab 3 at Fermilab)
  - Insertion of vessel assembly (at PAB at Fermilab)
- Obviously it is not necessary to consolidate these steps in a single location, but it is desirable.
- Probably want to have the insertion stage be at the experimental location. This requires a minimum of about 15-16 foot hook height.



Infrastructure requirements

- Vertical height requirement >17’
- Room to remove shielding from around detector. This could be another water tank where we pump water from the experiment’s tank, or just space to move polyethylene shielding if we decide to go that route.
- Ideally, a source of very clean water, with state-of-the-art radiopurity
- Power: < 10 kW of 115V AC.
- Computing: very desirable to have easy offsite access
- Accessibility: easy access to site and underground when needed.

  - SNOLAB would be preferable because of its depth, clean room facilities and pure water supply.
  - SOUDAN is certainly workable, but would have higher background levels and require more effort from Fermilab.

Some highlights of SNOLAB tour

Adequate detector space

Purified water facility

Very low background Ge

Offices, conferencing

Dedicated clean room

Radon counting facility