Radon Control in DEAP-3600

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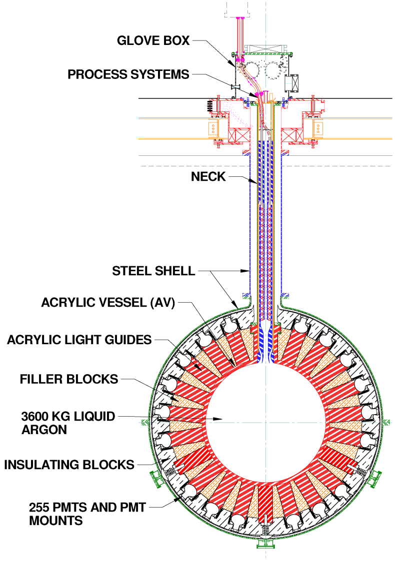
Overview

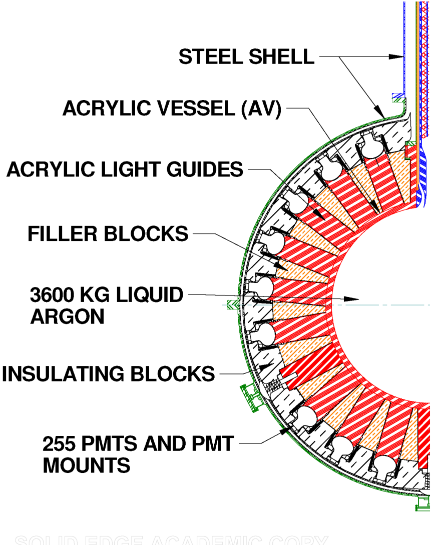
- DEAP3600
- Key components for radon control
- Treatment of Argon wetted surfaces
- Results from a Ultra-low background radon emanation system.

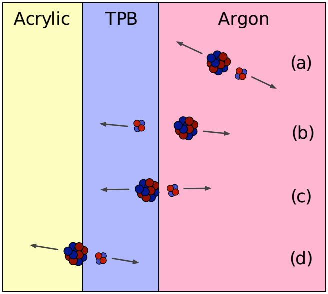
DEAP3600



- 85cm radius TPB coated acrylic sphere filled with 3600 kg of liquid Argon
- 255 PMTs mounted at the end of 8inch diameter 20inch long light guides
- Background target is 0.3 events inside the energy ROI and fiducial volume (1000 kg) in 3 years of running.
- Aggressive Radon emanation target of 5μBq for all argon wetted components.

DEAP3600





- Cases B and D are dangerous for producing low energy events which could leak into the ROI
- In case B, 28% of events leak into the ROI energy

Key Radon Control Areas

- ^{222}Rn emanation is an issue for all experiments and control is vital for meeting the targets of the DEAP experiment
  - Radon has a short 3.8 day half life
  - ^{210}Pb daughter half life is 22.2 years and thus stays in the detector.
  - Any constant ingress of radon into the detector imposes an increasing background rate though the course of the experiment.
- Internal
  - Bulk Uranium and Thorium impurities in the AV
  - Bulk Ar contamination
  - Process system components emanation
- External to AV
  - Steel Shell, welds and surface
  - Filler-block high density polyethylene and construction materials
  - AV supports
  - Neck internals

Radon Control - Material Selection

- Careful screening using gamma assay at SNOLAB to measure material suitability
- Large effort to ensure bulk acrylic for AV and light-guide is ultra pure.
  - No recycled material
  - Made from a monomer only casting process.
- Wetted process components to be stainless steel
  - Electropolished surface treatment
  - All welds specified to be non-thoriated
  - In house control of welds where possible

Radon Control - Acrylic Vessel

- Bulk acrylic is high purity, but...
- Radon daughters imbed to a depth of 50-100μm.
- Once installed acrylic vessel must be sealed from the mine air.
- Final treatment of the acrylic vessel will be to remove surface embedded radon and daughters via sanding.
  - $\rightarrow$ Up to 2mm removal.
- Resurfacer robot is under construction at Queens to perform this task.

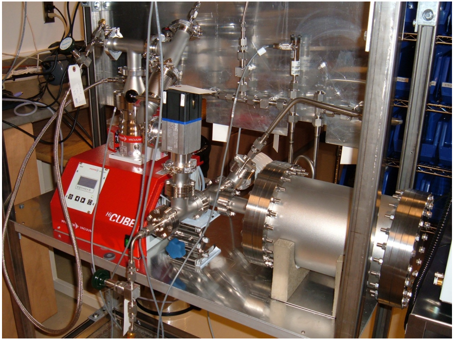
Exposure during commissioning

- During commissioning the acrylic vessel will be exposed to the resurfacer robot, Glove box and a TPB evaporation source.
- Each component must meet strict targets Radon emanation rates
- Important not to re-contaminate the acrylic surface while attempting to clean

Component	Target Rn emanation rate	Exposure time
SNOLAB Air	—	$\sim$ 6minutes
Resurfacer	2.2mBq	1 month
Glovebox	10mBq	1 Week
TPB applicator	10mBq	1 Week

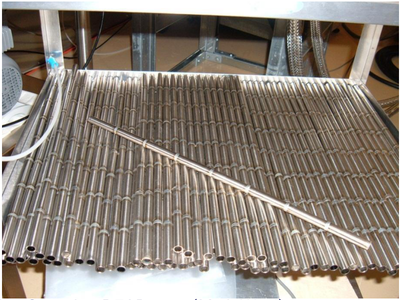
Radon Control - Process Systems

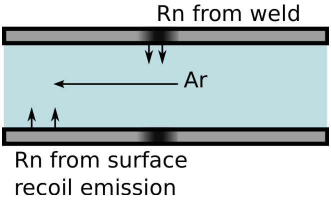
- Process systems tasked to purify and liquify the argon and do so without emanating more than 5μBq Radon into the Argon.
- Ultra low background Radon emanation chamber constructed to qualify materials and cleaning methods.



- Focus of this system has been to test cleaning procedures for stainless steel

Radon emanation from TIG welds





- Electrode material has been assayed for ^{238}U and ^{232}Th and selected for cleanliness
- Emanation from bulk steel and welds into Argon
- Surface of weld and surrounding is more porous
- Experimentally determine the contributions

Process System Cleaning

- Ultrasonic cleaning in UPW and detergent
  $\rightarrow$ Remove large contaminants, dust, oil
- Citric acid passivation
  - 10% by weight citric acid in UPW
  - Sample submerged at $60\circ$C for 30 minutes
  - Ultrasonic clean in UPW

  $\rightarrow$ Removal of top surface and reformation of a clean chromium oxide layer.

Emanation results

Sample	Emanation
Chamber Background	4.39 ± 1.85 Rn / day
	$109 \pm 46 \mu Bq/m^2$
1/2 inch electropolished Stainless tube	$92 \pm 30 \mu Bq/m^2$
Ultrasonic cleaning only	$1.8 \pm 0.6 \mu Bq/m$*
550 welds on 38m of Stainless steel tube	$192 \pm 43 \mu Bq/m^2$
550 welds only	$100 \pm 52 \mu Bq$
	$2.3 \pm 1.1 \mu Bq/m$**
383 welds on 24m of Stainless steel tube	$129 \pm 27 \mu Bq/m^2$
383 welds only	$38 \pm 40 \mu Bq$
	$1.2 \pm 1.3 \mu Bq/m$
550 passivated welds	$87 \pm 21 \mu Bq/m^2$

*Conservative for internal surface

**internal surface only

Conclusions

- Passivation appears to reduce emanation to similar levels as bulk stainless steel
- Analysis of residue left behind in the citric acid show Iron was being removed from the surface
- A new chromium oxide layer was formed
- Surface finish of the tube is brushed on the outside, electropolished on the inside
  - Smoother surfaces typically emanate less
  - Welding is from outside, inside weld surface could be cleaner.
  - Results given are thus conservative
- Inside weld surface condition/surface area is not yet known