Radiopurity measurement of acrylic for DEAP-3600

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DEAP-3600 dark matter experiment at SNOLAB

Operation in 2013

DEAP-3600

$\chi^{40}\text{Ar}$

scintillation photons

255 PMTs

3600 kg liquid argon

Vessel

Acrylic

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The acrylic vessel is the most critical component.
Alpha backgrounds from contaminants at surface

inherent contamination of materials

radon in air diffuses into materials
Stringent radiopurity limits for acrylic vessel

1. Vaporize 10 kg acrylic
2. Collect residue
3. Measure gammas from $^{238}\text{U}$ and $^{232}\text{Th}$ with germanium detector
4. Measure $^{210}\text{Pb}$ by counting $^{210}\text{Po}$ daughter with $\alpha$-counter

Maximum tolerable concentrations:

- $0.3 \times 10^{-12}$ g $^{238}\text{U}$ / g acrylic
- $1.3 \times 10^{-12}$ g $^{232}\text{Th}$ / g acrylic
- $1.1 \times 10^{-20}$ g $^{210}\text{Pb}$ / g acrylic

Vaporize PMMA then incinerate MMA

Vaporization: 400°C
- Suprasil boat
- Acrylic, 2 kg

Transfer section: 150°C
- Quartz tube

Incineration: 800°C
- Equations: \( C_5O_2H_8 + 6O_2 \rightarrow 5CO_2 + 4H_2O \)
- Autoignition: 435°C
- Boiling point: 100°C

Exhaust
- Water trap
Acrylic vaporization system at SNOLAB
Bubbles form on surface, colour changes from clear to yellow, block expands, liquid pools and boils, white vapour flows.
Addition of air after vaporization removes carbon residue

Excessive carbon difficult to manage during acid rinse and counting
Chemical extraction to remove residue from quartz boat

10 kg sample is 5 x 2 kg blocks in same quartz boat

Rinse boat with aqua regia (3:1 by vol. HCl and HNO₃) on heated roller at 1 rpm for 1 h
Measure $^{238}\text{U}$ and $^{232}\text{Th}$ with HPGe detectors

SNOLAB has two coaxial detectors and a well detector for low energy gamma spectroscopy.

New coaxial and well detectors are being commissioned now.
Measure $^{210}$Pb by measuring $^{210}$Po alpha decay

Allow $^{210}$Po to build up in effluent for 1 month

Spontaneous deposition of polonium on nickel

J. Environ. Radioact. 102, 415-419 (2011)

Polonium and alpha spectroscopy


new alpha counters being calibrated
Conclusions

In a direct dark matter search, background control is of utmost importance.

The DEAP-3600 acrylic vessel is the most critical detector component and has stringent limits.

We have developed an acrylic assay program based on acrylic vaporization.
DEAP collaboration

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