



Dark-matter Experiment using Argon Pulse Shape Discrimination

Chris Ouellet - Carleton University, on Behalf of the DEAP Collaboration

Overview

- DEAP-3600 construction is nearly complete
- DEAP-1 prototype phase data analysis is complete and papers written (TBA Journal of Astroparticle physics)
- Argon scintillation
- Pulse shape discrimination
- Backgrounds and radiopurity
- Construction status
- Anticipated sensitivity region

Ar Scintillation



Ar*+ Ar
$$\longrightarrow$$
 Ar₂* \longrightarrow 2Ar + y
Ar++ Ar \longrightarrow Ar₂++ e⁻ \rightarrow Ar₂* \longrightarrow 2Ar + y



- Decay times of singlet and triplet states **do not** depend on density of excited species along the track, linear energy transfer (LET)
- Intensity ratios of singlets to triplets **do** depend on (LET)
- Easily purified, inexpensive, accessible liquid temperature 87 K, very large detector mass possible
- 8 pe/keV light yield
- 128 nm molecular spectrum not absorbed by bulk Ar
- 128 nm light is deep UV, needs to be wavelength shifted for PMT detection

Pulse Shape Discrimination



DEAP-1 Detector Stability



 Average light yield of 2.81
 +/- 0.1 Photoelectrons/keV (systematic uncertainty not shown)

Triplet component lifetime 1.46 +/- 0.06 µs

SNOLAB Subury Ontario Canada







- 3600 kg 1000 kg fiducial single phase liquid Ar
- 85 cm radius inner sphere
- 255 8 inch PMTs (warm) Hamamatsu R5912 HQE (32% QE, 75% coverage)
- 50 cm light-guides (neutron shielding from glass, thermal insulation for PMTs)
- Interior has only argon and wavelength shifter
- Filler blocks for neutron shielding
- Entirely surrounded by 8 m water shield

Detector Backgrounds

- Background rate goal in sensitive region is ~0.1/tonne/year
- Fast neutrons from (α,n) activity in acrylic, TPB, PMT glass, steel shell and surrounding rock
- Cosmic ray induced neutrons
- β from ³⁹Ar and other β and γ emitters
- Radon gas and its daughters

Background Mitigation Strategy

- SNOIab 6000 mwe overburden and active muon veto
- 8 m water shielding surrounding steel shell
- Selection of materials for:
 - Low U and Th content (acrylic)
 - Neutron absorption (light guides, filler blocks)
 - High reflectivity to enhance PSD
 - Reduced emanation (process systems <5µBq of ²²²Rn)
- SEAS getter and cold radon-trap filtration of Ar
- Specific construction steps against Radon daughters
- Potential move to depleted Ar factor of x10 β reduction over natural Ar (1 Bq/kg)







- Extensive and enormous effort
- Acrylic, polymethal-meth-acrylate, sourced, counted in-situ and followed through every step from distillation to thermoforming pure MMA monomer sheets (Thai MMA)
- Electropolishing of metal surfaces including interior of the steel shell to reduce radon emanation
- Seamless tubing and where unavoidable welds in process system performed with non-thoriated TIG welding to reduce radon emanation
- Developed vaporization system for acrylic assays, ultra low background emanation chamber to qualify process systems materials and cleaning methods



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vic vaporization system on surface at SNOLAB
 Seamle unavoid perform welding
 Develop

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- Pervasive gas, in higher concentration underground than surface (100 vs 10 Bq/m³)
- Can diffuse into materials, particularly acrylic (~100 µm depth)
- Daughter product Polonium of particular concern, plates out on metal and TPB
- Po major portion of DEAP prototype low energy background
- Control of lab air exposure of inner surface of AV
- Re-surfacing inner surface of AV before TPB deposition (1mm removal)
- ²¹⁰Po and Pb controlled to10⁻²⁰g/g



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Queen's University

Thermoforming Acrylic Vessel



RPT Colorado



Acrylic Vessel Machining



University of Alberta

Neck Acrylic Bonding



RPT SNOLAB



Light Guide Bonding



Final Machining



Cleanroom Installation



Reflectors, Filler Block and PMT Installation



Infrastructure - Steel Shell





Additional Infrastructure



Outlook

- Detector lifted into final location (this week!)
- Cabling, instrumentation and final crosschecks
- Process systems and cooling coil commissioning
- Shield tank water systems commissioning
- Re-surfacing and TPB deposition
- First calibrations and cool-down within months

Anticipated Sensitivity Region



- Conservative effective resolution of 10 cm (predict x2 with better max likelihood fitter analysis)
- Attenuation length of at least 4 m
- 15keVee threshold (approx. 60 keV recoil energy), 3-yr exposure

DEAP Collaboration

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