



DEAP-3600 backgrounds

Bei Cai Queen's University

Dark Matter Experiment with Liquid Argon using Pulse-Shape Discrimination

Aug 28-29, 2010

SNOLAB LRT workshop

1





β/γ backgrounds

• ³⁹Ar is the most dominant β/γ backgrounds

$$^{40}Ar + n \rightarrow ^{39}Ar + 2n$$

- ³⁹*Ar* → ³⁹*K* + $β^-$ + $\overline{ν}$ • Expect ~10⁹ events in 3 years within WIMP energy ROI (60, 120) keVr
- Pulse-shape discrimination from DEAP-1 shows promise
- Working with Princeton to get depleted argon (>20 times depletion)



Bei Cai, Queen's University

covered with TPB wavelength shifter



Neutron backgrounds from (α , n) reactions

- Rock (1.11 ppm ²³⁸U and 5.56 ppm ²³²Th)
 - 4400 n/m²/day at SNOLAB
 - Water shielding
- PMT glass (0.1 ppm U and Th)
 - 2x10⁵ n/y
 - Attenuated and absorbed by acrylic light guides
- Acrylic (9.6 ppt U and 16.8 ppt Th)

– ~74 n/y

- Clean material and limit from Rn exposure

• Target: < 0.2 neutron leakage in 3 years

Neutron shielding efficiency

- Evaluated by Monte-Carlo simulations
- (α, n) spectrum as input to our GEANT4 based simulation package
- Neutrons are generated in isotropic directions at interested detector volume
- We then look for neutron leakage in liquid argon

All meet our background requirements

Radon exposure

- Radon diffusion and implantation
- Long-lived ²¹⁰Pb atoms produce alpha and neutron backgrounds
- Need to make sure acrylic beads are stored in "radon-tight" bags
- 1/8-inch diameter beads, 1 month of exposure in room air

→ 10⁻²⁰ g/g ²¹⁰Pb from radon diffusion (0.03 mBq/kg)



Surface contamination: alpha backgrounds

Alphas may lose most of their energies in acrylic, scintillate in either TPB or LAr or both, and produce signals in WIMP ROI

DEAP-3600 surface profile



Surface backgrounds

- Alphas from acrylic surface (U and Th) layer produces ~0.4 WIMP-like events in 3 years in fiducial volume
- No estimate for ²¹⁰Pb yet (10⁻²⁰ g/g upper limit)
- Possibilities to reduce backgrounds
 - Remove radon-exposed dirty surface with resurfacer
 - Acrylic purification and coating on inner surface
 - Data analysis in DEAP-3600: PMT hit pattern with large signals when PMTs are directly in front of an alpha
 - Alpha pulse-shape discrimination



Paper submitted for publication

Time [ns]



Background rates in DEAP-1 (120-240 pe)

Date	Background Rate (in WIMP ROI)	Configuration	Improvements for this rate
April 2006	20 mBq	First run (Queen's)	Careful design with input from materials assays (Ge γ couting)
August 2007	7 mBq	Water shield (Queen's)	Water shielding, some care in surface exposure (< a few days in lab air)
January 2008	2 mBq	Moved to SNOLAB	6000 m.w.e. shielding
August 2008	400 μBq	Clean v1 chamber at SNOLAB	Glove box preparation of inner chamber (reduce Rn adsorption/implantation on surfaces)
March 2009	150 μBq	<i>Clean v</i> 2 chamber at SNOLAB	Sandpaper assay/selection, improved purging, PTFE instead of BC-620 reflector (from Rn emanation measurements), Rn diffusion mitigation, UP water in glove box, documented procedures; Rn Trap@SNOLAB for filling.
March 2010	~130 µBq	Clean v3 chamber at SNOLAB	Acrylic monomer purification for coating chamber. TPB purification.

Expect no change if backgrounds are from 222Rn in target chamber

From Mark Boulay

Extrapolating surface backgrounds from DEAP-1 to DEAP-3600

r=45 cm, 550 kg 3000 r=35 cm r=55 cm r=85 cm (acrylic vessel) 1000 kg 3600 kg 250 kg backgrounds scaled with 0.16 18 748 case (DEAP -1 bkd rate surface area scaled to surface area) $(650 \mu Bq/m^2)$ 0.004 0.4 17 1000 radon atoms case 2 in target (130 µBq) events in 500 fiducial volume (DEAP-1 bkd rate) (3 years) 00 20 40 60 80 100 120 140 Fit radius (cm) Current surface background rates from DEAP-1 would allow 250 kg 16 "background-free" in DEAP-3600 (4x10⁻⁴⁶ cm² sensitivity)

From Mark Boulav

Summary

- β/γ backgrounds in DEAP-3600 can be distinguished with PSD
- DEAP-3600 has taken great caution in detector design on neutron shielding
- Various possibilities to reduce surface alphas and have demonstrated good handle on them in DEAP-1
- With current backgrounds in DEAP-1, DEAP-3600 has a 4x10⁻⁴⁶ cm² sensitivity

DEAP/CLEAN Collaborators

University of Alberta

B. Beltran, P. Gorel, A. Hallin, S. Liu, C. Ng, K.S. Olsen, J. Soukup

Boston University

D. Gastler, E. Kearns

Carleton University M. Bowcock, K. Graham, P. Gravelle, C. Oullet

Harvard University

J. Doyle

Los Alamos National Laboratory

R. Bourque, V.M. Gehman, J. Griego, R. Henning-A. Hime, F. Lopez, J. Oertel, K. Rielage, L. Yeomans, Rodriguez, S. Seibert, D. Steele

Massachusetts Institute of Technology

L. Feng, J.A. Formaggio, S. Jaditz, J. Kelsey, J. Monroe, K. Palladino

National Institute Standards and Technology TRIUMF K. Coakley

University of New Mexico

M. Bodmer, F. Giuliani, M. Gold, D. Loomba, J. Matthews, W.H. Lippincott, D.N. McKinsey, J.A. Nikkel, Y. Shin P. Palni

University of North Carolina/TUNL

M. Akashi-Ronguest, R. Henning

University of Pennsylvania

T. Caldwell, J.R. Klein, A. Mastbaum, G.D. Orebi Gann

Queen's University

M. Boulay, B. Cai, M. Chen, S. Florian, R. Gagnon, V. Golovko, P. Harvey, M. Kuzniak, J. Lidgard, A. McDonald, T. Noble, P. Pasuthip, C. Pollman, W. Rau, P. Skensved, T. Sonley, M. Ward

SNOLAB Institute

M. Batygov, F.A. Duncan, I. Lawson, O. Li, P. Liimatainen, K. McFarlane, T. O'Malley, E. Vazquez-Jauregi

University of South Dakota V. Guiseppe, D.-M. Mei, G. Perumpilly, C. Zhang

Syracuse University M.S. Kos, R.W. Schnee, B. Wang

P.-A. Amaudruz, A. Muir, F. Retiere

Yale University

DEAP-3600 Acrylic Vessel Resurfacer (Florian, Queen's Eng.)





resurfacer sanding head (R. Gagnon, Queen's)

Mechanical resurfacer removes surface contamination in inert environment.

Debris is flushed and removed with ultrapure water.

Resurfacer components are lowemanation materials (for Radon-load)

Finalizing drawing package for resurfacer component construction

Background rates in DEAP-1 versus time

