Light Guide Bonding for the Dark Matter Experiment DEAP-3600

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A summary talk of my bonding work in DEAP-3600

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Outline

- 1 An introduction of DEAP-3600
- A definition of perfect bonds
- What's been prepared?
 - Single bonds
 - Multiple-bonds
 - An optimal bonding algorithm
- What's been achieved?

5 Summary

What's been achieved?

Summary

An overview of the detector



Dark matter experiment with 3600 kg liquid Argon using Pulse shape discriminations (DEAP-3600). 3/30

How to identify WIMP signals?

- Only detect scintillation light by PMTs. Output: pulse waveforms.
- Discriminate nuclear recoils from EM backgrounds.
- A definition of F_{prompt} : $F_{\text{prompt}} = \frac{\text{prompt light (200 ns)}}{\text{total light (10\mu s)}}$ PSD uses F_{prompt} combined with Energy cuts and Radial cuts



Backgrounds

- Source of βlγ events: dominated by ³⁹Ar ≈ 1 Bq/kg ⇒Removal with PSD possible up to 1000 kg of argon; ⇒Can also use argon depleted in ³⁹Ar (DAr)
- Source of neutron recoils: (α,n)+fission, μ-induced.
 ⇒Need very strict materials control, and SNOLAB depth + "Onion" layers for shielding
- Source of surface events: Rn daughters and other surface impurities

 \Rightarrow clean surfaces in-situ (resurfacer), position reconstruction, limit radon

Requirements of DEAP-3600

DEAP-3600: 1000 kg LAr, 3-year exposure < 0.2 events from each source for 10^{-46} cm² sensitivity.

What's been achieved?

Summary

Simulations of gamma backgrounds.



- Major external gamma backgrounds from PMT glass.
- Leakage in Region of Interest (RoI): [120,240] PE, and [0.7, 0.95].
- Cherenkov events to be removed by fiducial volume cuts.

Expected sensitivity

Spin-independent sensitivity:



A definition of perfect bonds

- 2.54 mm thick without bubbles in the bond;
- parallel between the stub and the LG (10% uncertainties);
- a good bulge to absorb the stress;
- pass the cryogenic test after removing the bulge.



What's been achieved?

Summary

What is the real task for light guide bonding?



Bond 255 light guides to the acrylic vessel (AV).

Single bonds

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Single bonds

R&D of the single bond

- $\downarrow\,$ Bond acrylic disks on the mock wooden board.
- ↓ Tripod systems to overcome clearance constraints on the vessel.
- \downarrow Auto-fill machine to increase the efficiency.
- ↓ Test the bond quality whether it meets the requirements.



Single bonds

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What's been achieved?

Summary

Single bonds

A bonding with the real LG.

Sample 101 (Sep. 17th, 2012)

- + Sample 101 (Sep. 17th, 2012)
 - Prior measurements.
 - + Jig installations.
 - ✤ <u>Dam tests.</u>
 - + Bond construction and filling.
 - + After bonding.
 - + What can we learn?



It works!

What's been achieved?

Summary

Single bonds

Some bond diaries in TWiki

Simple bonds using the new Tripod

- Sample 79 (Mar 9 2012, Jian and Thomas, 30% by weight polymer, 2.5% perkadox)
- Sample 80 (Mar 12 2012, Jian, Pierre and Thomas) --> Pass Cryogenic tests.
- Sample 81 (Mar 15 2012, Jian, Pierre and Thomas)
- Sample 82 (Mar 22 2012, Jian, Pierre and Thomas) --> Pass Cryogenic tests.
- Sample 83 (Apr 2 2012, Jian, Pierre and Thomas) -->Pass Cryogenic tests.
- Sample 84 (Apr 5 2012, Jian and Pierre) --> Fail in Cryogenic tests due to the bad bulge
- Sample 85 (Apr 10 2012, Jian)
- Sample 86 (Apr 11 2012, Jian)
- Sample 87 (Apr 17 2012, Jian) --> Pass Cryogenic tests.
- · Sample 88 (Apr 20 2012, Jian) --> Pass Cryogenic tests
- Sample 89 (Apr 24 2012, Jian) --> Pass Cryogenic tests.
- Sample 90 (Apr 26 2012, Jian)
- Sample 91 (May 3 2012, Jian) --> Pass Cryogenic tests
- Sample 92 (July 20 2012, Jian)
- <u>Sample 93</u> (July 24 2012, Jian)
- Sample 94 (Aug 2 2012, Jian)
- <u>Sample 95</u> (Aug 7 2012, Jian)
- · Sample 96 (Aug 9 2012, Jian)
- Sample 97 (Aug 14 2012, Jian)
- <u>Sample 99</u> (Sep 4 2012, Jian)
- Real Light Guide 1 (Sep 18 2012, Jian & Tom)
- <u>Real Light Guide 2</u> (Oct 30 2012, Aksel, Jian, Pierre & Tom)
- <u>Real Light Guide 3</u> (Nov. 26 2012, Berta, Jian, Aksel & Pierre)
- · Real Light Guide 4 (Nov. 30 2012, Jian & Richard)
- <u>Real Light Guide 5</u> (Dec. 11 2012, Berta & Richard & Jian)
- <u>Real Light Guide 6</u> (Dec. 18 2012, Jian)

Multiple bonds by the auto-fill machine

- · An inventory of 10 simultaneous bonds (Nov 21 2012, Jian)
- <u>The full checklist of bonding</u> (Nov 30 2012, Jian)
- The inventory of bonding staff to be shipped to SNOLAB (Mar 25, 2013, Jian)

Multiple-bonds





- 2 A definition of perfect bonds
- What's been prepared?
 Single bonds
 - Multiple-bonds
 - An optimal bonding algorithm
- What's been achieved?

5 Summary

What's been achieved?

Summary

Multiple-bonds

Multiple-bond board

Mount the multiple-bond boards and test multiple bonds.



What's been achieved?

Summary

Multiple-bonds

Review of bonding tools





What's been achieved?

Summary

Multiple-bonds

A bonding with 7 real LGs.



An optimal bonding algorithm





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An optimal bonding algorithm

Motivations

- 255 LGs to be bonded on a spherical vessel.
- $\pm 10^{\circ}$ allowed to be tilted on the AV rotator.
- Maximal effeciency: 10 bonds/day.
- Limited clearance left for tripod installations and alignments.
- Find the minimal working days? ≈How to win a chess-board game with 255 grids?



A definition of perfect bonds

What's been prepared?

An optimal bonding algorithm

Possibilities for each stub including constraints



- ♣-the target stub.
- \star -the reference point on AV rotator.
- * -stubs allowed to be bonded on the same day.
- ♦ -stubs not allowed to be bonded with the target stub on the same day.



An introduction of DEAP-3600

A definition of perfect bonds

What's been prepared?

What's been achieved?

Summary

An optimal bonding algorithm

Gedanken experiments in Autodesk Inventor



- In the 10th round of bonding, we found that there was a stub close to the AV tail which could not be bonded.
- Upgrade of tripod design to overcome the barrier.

What's been achieved?

Summary

An optimal bonding algorithm

An adjustment of glue ratio

Problem:

- We did all the R&D work with the MMA and PMMA from PolySCI. Ratio: 70% v.s 30%.
- The AV was fabricated by RPT and we had to use their recipe.
- The same ratio of MMA and PMMA was applied but got higher viscosity.
- The higher viscosity significantly slows the glue injection.

Solution:

- Try different ratios of MMA and PMMA from RPT: 30%, 29%, 28%, 27%, · · · .
- Reach 20% until the viscosity matches.
- Do bond tests and accept the adjustment of the new glue recipe.

What's been achieved?

Summary

Going underground in SNOLAB



What's been achieved?

Summary

On-site work



Help machining, sanding, polishing!

What's been achieved?

Summary

On-site work



Help annealing AV after machining, sanding, polishing!

What's been achieved?

Summary

Bonding light guides to the AV



Work hard to bond 255 light guides to the AV.

What's been achieved?

Summary

Bonding light guides to the AV



Sorry to miss other bonders. Rare chance to catch all in double shifts!

What's been achieved?

Summary

The shining AV



Complete bonding to get a shining and beautiful AV for DEAP-3600!

Summary

- Put hands on real detector constructions within 2 years.
- A successful R&D of acrylic bonding tests done in the local lab.
- The real bonding work underground in SNOLAB is good.
- The AV bonding was complete on Nov. 15th, 2013.
- Many thanks to all bonders and SNOLAB for on-site support.
- Other on-site installations continue.
- Hopefully start taking data next summer to present good results!