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On behalf of XMASS collaboration

6th Patras Workshop on Axions, WIMPs, WISP
5-9/July/2010 Zurich University
Outline

- Kamioka Observatory
- XMASS 800 kg liquid xenon detector
  - Experimental Hall
  - Water Tank
  - Cryogenics, gas/liquid line and Emergency
  - Background
  - Detector and its Assembly
- Summary
XMASS Experiment
Multi purpose low-background experiment with LXe.

- Xenon MASSive detector for Solar neutrino (pp/\(^7\)Be)
- Xenon neutrino MASS detector (double beta decay)
- Xenon detector for Weakly Interacting MASSive Particles (DM)

IPMU, University of Tokyo: Kai Martens, J. Liu

Saga University: H. Ohsumi

Tokai University: K. Nishijima, D. Motoki

Gifu University: S. Tasaka

Waseda University: S. Suzuki

Yokohama National University: S. Nakamura, I. Murayama, K. Fujii

Miyagi University of Education: Y. Fukuda

STEL, Nagoya University: Y. Itow, K. Masuda, H. Uchida, Y. Nishitani

Kobe University: Y. Takeuchi, K. Ohtsuka

Seoul National University: Soo-Bong Kim

Sejong University: Y. D. Kim

KRISS: Y. H. Kim, M. K. Lee, K. B. Lee, J. S. Lee

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XMASS Project

100kg Prototype (FV:30kg, ~30cm)

800kg Detector (FV:100kg, 80cm)

20ton Detector (FV:10ton, ~2.5m)

R&D completed

Dark Matter 2010 start

Solar neutrino Dark Matter Future

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Sensitivity for SI case

$10^{-4}$ dru, 100 kg fiducial

XMASS 800 kg 10 days

XMASS 800 kg 1 year

(flat bg assumed)

- DATA listed top to bottom on plot
- DAMA/LIBRA 2008 3sigma, no ion channeling
- WARP 2.3L, 96.5 kg-days 55 keV threshold
- CRESST 2007 60 kg-day CaWO4
- Edelweiss II first result, 144 kg-days interleaved Ge
- ZEPLIN III (Dec 2008) result
- XENON10 2007, measured Leff from Xe cube
- CDMS: Soudan 2004-2009 Ge
- Trotta et al 2008, CMSSM Bayesian: 68% contour
- Trotta et al 2008, CMSSM Bayesian: 95% contour
- Ellis et al Theory region post-LEP benchmark points
- Baltz and Gondolo 2003
- Baltz and Gondolo, 2004, Markov Chain Monte Carlos
Why Liquid Xenon?

- High Atomic mass Xe (A~131) good for SI case (cross section $\propto A^2$)
- Odd Isotope (Nat. abun: 48%, 129,131) with large SD enhancement factors
- High atomic number (Z=54) and density ($\rho=3g/cc$): compact, flexible and large mass detector.
- High photon yield (~ 46000 UV photons/MeV at zero field)
- Easy to purify for both electro-negative and radioactive purity
  - by recirculating Xe with getter for electro-negative
  - Distillation for Kr removal
Concept of background reduction
Self-shielding

Single phase liquid Xe
Volume for shielding

Fiducial volume

23 ton all volume (d=240 cm)
20 cm wall cut
30 cm wall cut (10 ton FV)

Large self-shield effect

$g_{\gamma\gamma}$ at $10^{-10}$ GeV$^{-1}$
0.267 event/(Xe)ton/year
F. Avignone talk

Low Background region near the center of the fiducial volume

$dru = \text{event/day/kg/keV}$
γ tracking MC from external to Xenon

U-chain gamma rays

Blue: γ tracking
Pink: whole liquid xenon
Deep pink: fiducial volume

LXe
Concept of background reduction
Self-shielding

For 238U
Assumed 1.8mBq/PMT
Absorption 100cm, scattering 30cm

distance from wall
0cm ~800 kg
5cm ~540 kg
10cm ~340 kg
20cm ~100kg
Background

Background in the 100 kg fiducial volume out of 1 ton.

• External
  • gamma
  • neutron

• Detector material
  • PMT+Base (2 inch)
  • U/Th/^{40}K/^{60}Co
    
    \(0.7/1.5/<5.1/2.9\) mBq/PMT

• Internal
  • ^{85}Kr
    • <1 ppt Kr required
    • 3 ppt is achieved
  • U/Th(Rn)
    • <10\(^{-14}\) g/g required
    • U/Th 9±6/<23 x 10\(^{-14}\) g/g

Water Shield

<10\(^{-4}\) dru

Distillation Tower

MS, Charcoal

goal <10\(^{-14}\) g/g

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## PMT

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2000</th>
<th>2002</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Prototype</td>
<td>R8778</td>
<td>R10789</td>
</tr>
<tr>
<td>Material:Body</td>
<td>glass</td>
<td>Kovar</td>
<td>Kovar</td>
</tr>
<tr>
<td>QE</td>
<td>25%</td>
<td>25%</td>
<td><strong>27-39%</strong></td>
</tr>
<tr>
<td>RI:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U [mBq/PMT]</td>
<td>50</td>
<td>18±2</td>
<td>0.7 +/- 0.28</td>
</tr>
<tr>
<td>Th [mBq/PMT]</td>
<td>13</td>
<td>6.9±1.3</td>
<td>1.5 +/- 0.31</td>
</tr>
<tr>
<td>(^{40})K [mBq/PMT]</td>
<td>610</td>
<td>140±20</td>
<td>&lt;5.1</td>
</tr>
<tr>
<td>(^{60})Co [mBq/PMT]</td>
<td>&lt;1.8</td>
<td>5.5±0.9</td>
<td>2.9 +/- 0.16</td>
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</tbody>
</table>

### XMASS PMT HISTORY

- **Prototype:** R8778
- **Material:** Kovar
- **QE:** 25%
- **RI:**
  - **U [mBq/PMT]:** 50
  - **Th [mBq/PMT]:** 13
  - \(^{40}\)K [mBq/PMT]: 610
  - \(^{60}\)Co [mBq/PMT]: <1.8

### e.g. \(^{40}\)K case

- **4000 Bq/Human**
- **15 Bq/香蕉**
Water Tank

10m

70 PMTs (20 inch) to detect Cerenkov Light (same as SK)
Active shield for muon induced events
Passive shield for $\gamma$ and neutron from Rock
Experimental Hall

- Water Tank
- Distillation Tower
- LXe Tank
- Xenon Buffer Tank
- Entrance (clean room)

Rn: ~ 1mBq/m$^3$
5ton/hour

Water purification system
Distillation to reduce krypton in Xe (2003)

A distillation system was made and tested. System specification:
- Process speed: 0.6kg Xe/hour
- Collection efficiency: > 99%
- Kr concentration after process: < 1/1000

<table>
<thead>
<tr>
<th>Boiling point (@1 atm)</th>
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<tbody>
<tr>
<td>Xe</td>
</tr>
<tr>
<td>Kr</td>
</tr>
</tbody>
</table>

178±2K in tower

Original Xe:
~3 x 10^{-9} Kr

2cmφ

13 stage of

Lower temp.

~3m

Higher temp.

~1%

Off gas Xe:
330±100 x 10^{-9} Kr

Purified Xe:
(3.3±1.1) x 10^{-12} Kr

Astroparticle Physics 31(2009), 290

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Distillation Tower (Upgrade)

- 5kg/hour production
- ~8 days for 1 ton
- >$10^5$ Kr reduction (goal < 1 ppt)

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2009</th>
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<tbody>
<tr>
<td>Height</td>
<td>3 m</td>
<td>4 m</td>
</tr>
<tr>
<td>production [kg/hr]</td>
<td>0.6</td>
<td>5</td>
</tr>
<tr>
<td>Kr Reduction</td>
<td>$1/10^3$</td>
<td>$1/10^5$</td>
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</table>
800 kg Detector

- The detector will be attached to SUS frame.
- Diameter of the PMT holder is $\Phi 1113$.
Clean Room in Water Tank

Stage for the assembly of detector

3.7m
4.0m
3.0m

写真update

Rn level in the air \( \sim 10\text{mBq/m}^3 \)
Design of 800 kg Detector

- Hexagonal PMT
- Hamamatsu
- R10789
- QE 28-39%

- 60 triangle in total
- about 10PMT/triangle×60
- Total: 642 PMTs
- Photo coverage: 62%

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642 PMTs
PMT Holder

OFHC Filler

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Summary

- XMASS 800 kg detector is under constructing at Kamioka. The goal is to reach a few x $10^{-45}\text{cm}^2$ for spin independent case.
- PMT assembly was completed and the detector vessel will be delivered in the end of July and the installation will be finished in August.
- The WIMP search run will be started in this year 2010 after the commissioning run.