Direct Dark Matter Search with XMASS

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Outline

- Introduction of XMASS
- XMASS 800 kg detector
- Data Analysis
- Result of Low Mass WIMP and Solar axion search
- Summary
XMASS Experiment
Multi purpose low-background experiment with LXe.

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

Solar Axion/Neutrino

Double Beta Decay

Dark Matter
Kamioka Observatory in Japan

- 1000m under a mountain = 2700m water equiv.
- 360m above the sea
- Horizontal access
- Super-K for $\nu$ physics and other experiments in deep underground
- KamLAND (Tohoku U.)

By courtesy of Dr. Miyoki
Direct Detection Principle

WIMPs elastically scatter off nuclei in targets, producing nuclear recoils.

\[ \chi + N \rightarrow \chi + N \]

For example, assuming

- \( M_w = 100 \text{ GeV}/c^2 \), \( M_T = 100 \text{ GeV}/c^2 \), \( r = 1 \)
- WIMP velocity: \( v \sim 0.75 \times 10^{-3} = 220 \text{ km/sec} \)

\[ E_R = \frac{1}{2} M_w \beta^2 c^2 \]

\[ = 1/2 \times 100 \times \text{GeV}/c^2 \times (0.75 \times 10^{-3}) \times c^2 \]

\[ = 30 \text{ keV} \]
XMASS800kg in Kamioka

- φ10m x 10m ultra pure water shield with 20 inch x 70 PMTs for muon veto
- 642 ultra low background 2 inch PMTs
- 835 kg of LXe for sensitive volume.

<table>
<thead>
<tr>
<th>RI in PMT</th>
<th>Activity per 1PMT (mBq/)</th>
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<tbody>
<tr>
<td>238U-chain</td>
<td>0.70 +/- 0.28</td>
</tr>
<tr>
<td>232Th-chain</td>
<td>1.51 +/- 0.31</td>
</tr>
<tr>
<td>40K</td>
<td>9.10 +/- 2.15</td>
</tr>
<tr>
<td>60Co</td>
<td>2.92 +/- 0.16</td>
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Detector calibration

- Stepping motor
- Linear and rotary motion feed-through
- Source rod with a dummy source

- Hight Light Yield \(14.7\) PE/keV

- Total photo electron
- Data
- MC
- 122keV (\sim4\% rms)
- 136keV
- 59.3keV of W

- 0.21mm\(\phi\) for \(^{57}\)Co source
- 4mm\(\phi\)

- Source: Rod with a dummy source

Masaki Yamashita
Data analysis

- 835 kg x 6.7 days data
- Trigger condition: $\geq 4$ PMT hits
- Trigger efficiency obtained by WIMP MC and real data taken with low occupancy LEDs. (~80%)
- Only simple Quality and Cherenkov cuts were applied to achieve very low threshold without fiducial volume cut.
Recent Result of XMASS

Light mass WIMP

• Full volume analysis with 835 kg LXe. (without fiducial volume cut.)
• High Light Yield 14.7 PE/keV
• Eth 0.3 keVee (scaled by 122keV)

Solar Axion search

Axion is a hypothetical particle to solve the strong CP problem. Produced in the Sun and detected in the detector. XMASS is suitable to search because of a large mass and low BG.

Bremsstrahlung and Compton effect

Axio-electric effect

\( g_{\text{ae}} \)

\( g_{\text{ae}} \)

Our data

Max allowed

\( g_{\text{ae}} = \)
Solar Axion search

- Same data set as low mass WIMP search.
- No indication of signals. Bound in $g_{aee}$ vs. mass.
  - Better than any other constraint in 10-40keV.
  - Better than any other experimental constraint <1keV

*Phys. Lett B 724 (2013) 46*
*arXiv: 1212.6153*
Summary

- XMASS obtained low mass WIMP and solar axion result by using 835kg of LXe with very threshold (0.3keVee)
  - Low mass WIMP search (Phys. Lett B 719(2013)78)

and also more results are coming,
- Inelastic scattering DM search
- fiducial volume cut analysis
- Seasonal modulation for DM search

- The refurbishment of XMASS is on-going to achieve better than 1/10 lower background. => Kai Marten’s talk on July/6th 17:15
- Data taking will resume in first of autumn 2013.