Gamma Ray Reconstruction with Liquid Xenon Calorimeter for the MEG Experiment

Yusuke UCHIYAMA, Univ. of Tokyo/ICEPP (Japan), MEG Collaboration

The MEG experiment[1] searches for the lepton-flavor violating muon decay (μ−→e−γ) by selecting opening angle ~180° to achieve such a good sensitivity. A new type of γ-ray detector using liquid xenon (LXe) is built up. For this new detector, we developed dedicated reconstruction algorithms which can extract the performance of the LXe as much as possible.

### Signal & backgrounds

- **Signal**
  - Clear 2-body decay
  - 52.8 MeV
  - Back-to-back
  - Time coincidence
- **Backgrounds**
  - Radiative muon decay
  - Accidental overlap

### Liquid xenon γ-ray detector

We use 850l liquid xenon as a scintillator. The scintillation light is detected by 846 PMTs surrounding the active volume of LXe. LXe properties enable us to measure the energy, timing and position of incident γ-ray at the same time with required resolution.

![Properties of LXe as scintillator](image)

### Waveform analysis

All PMT outputs are digitized with fast waveform digitizer[2] at 1.6 GHz. We can extract not only charge and timing but also information on pile-up events.

![Waveform analysis](image)

### Pile-up identification

- Time distribution (O(1ns))
- Light distribution (>15cm)
- Waveform analysis

### π⁰ calibration run 2008

- **We took calibration run with π⁰ beam**
  - 55 MeV and 83 MeV monochromatic γ from π⁰ decay by selecting opening angle ~180°
  - Tag back-to-back γs with NaI detector
  - Full scan over the acceptance
  - August (full) and December (short)
  - Calibration, check performance, obtain response

### Reconstruction & performance

- **Position**
  - Fit light distribution by solid angle
  - Only use PMTs in limited region to minimize shower fluctuation
  - Solid angle of each PMT is calculated numerically
  - Performance check with collimator run

#### Timing

- Reconstruct hit time with each PMT
  - \( T = T_{\text{PMT}} - T_{\text{baseline}} - \sigma_{\text{delay}}(\eta) \)
  - \( d \): distance b/w hit point and the PMT
  - \( \eta \): incident angle to the PMT
  - Minimize variance of PMT times
  - Typically ~150 PMTs are used
  - Filtering bad \( \chi^2 \) channel (reject pileup)
  - Performance check by the difference b/w tagging counter
  - Minimize spread by tagging counter and beam size

#### Energy

- Sum up all PMT outputs
  - Precise PMT calibration (gain, QE)
  - Photocathode coverage factor
  - Correct position dependence
  - Alternative algorithms
  - Optimize weights
  - Fit PMT charges

<table>
<thead>
<tr>
<th>Summary of performances with new algorithms (preliminary)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal</strong></td>
</tr>
<tr>
<td>Energy</td>
</tr>
<tr>
<td>Timing</td>
</tr>
<tr>
<td>Position</td>
</tr>
</tbody>
</table>

- Mean value. Depending on position
- *Improving with LXe purity

---