MEG液体キセノン検出器の性能とμ粒子崩壊事象の測定

東大素粒子センター 澤田 龍 他 MEG コラボレーション

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Outline

-Muon data in 2007
-Toward physics analysis
-Prospect of 2008
 Operated from 15 to 17/Dec.

Collected ~ 630k \(\mu \rightarrow e\gamma\) trigger, in 29 hours in real time.

About \(2 \times 10^{12}\) muon stops on the target, during live time of trigger. (acceptance and efficiency is not taken into account.)

Rates in agreement with expectations

- **Trigger 0**: \(~ 4\) Hz (@ 40 MeV threshold) \(\mu \rightarrow e\gamma\) trigger
- **1**: \(~ 6\) Hz (@ 35 MeV threshold) loose energy
- **2**: \(~ 20\) Hz (only up/down e\(^+\)\(\gamma\) correlation) loose angle
- **3**: \(~ 10\) Hz (DT = 20 ns) loose time
- **4**: \(~\) (no e-g correlation, DT = 20 ns) radiative decay
- **5**: \(~\) (no e-g correlation, DT = 40 ns) radiative decay, wide time
Trigger efficiency can be obtained by comparing event rate of $\mu \rightarrow e\gamma$ trigger and loose condition triggers.

Example:

Event rate comparison with various gamma energy thresholds

** This plot was made from calorimeter-self-trigger runs (not in $\mu \rightarrow e\gamma$ runs). Threshold is different from $\mu \rightarrow e\gamma$ runs.
\( \gamma - e^+ \) opening angle and time distribution

Distribution of all pairs of \( \gamma \) and positron, in \( \mu \rightarrow e\gamma \) trigger events.

Unfortunately, center of trigger was not at 0 in 2007.
Very preliminary

Analysis was done with preliminary reconstructions.
No pileup rejection of calorimeter.
No positron track selection.

\[ E_\gamma, E_{e+}, T_{e\gamma}, \theta_{e\gamma} \]

Reconstruction result with preliminary analyses.
No background events in 2 sigma region.

No selection with angle and time

\[ 3\sigma \text{ region} \]

\[ 2\sigma \text{ region} \]
Maximum likelihood analysis is being prepared

\[ L(s, s') = \prod P(x_i) = \prod (sS(x_i) + s'S'(x_i) + (N-s-s')B(x_i))/N \]

- **L**: likelihood function
- **x_i**: observables
- **N**: total number of events in analysis box
- **s**: number of signals
- **s'**: number of radiative decays (RD)
- **S(x_i)**: probability density function (p.d.f.) of signal
- **S'(x_i)**: p.d.f. of RD
- **B(x_i)**: p.d.f. of accidental background

Points are **how to define likelihood function** and **how to obtain p.d.f.**
Signal PDF

\[ S(x) = S_1(T_{e\gamma})S_2(\theta_{e\gamma})S_3(E_e)S_4(E_{\gamma})S_5(d)S_6(v) \]

- \( T_{e\gamma} \): Time
- \( \theta_{e\gamma} \): Angle
- \( E_e \): Energy
- \( E_{\gamma} \): First conversion depth in calorimeter
- \( d \): Vertex
- \( v \): Pion data
- \( e^+ \): Electron data
- \( \gamma \): Gamma data

Graphs show distributions for:
- \( E_{\gamma} \) vs. Time [MeV]
- Vertex [cm]
- \( E_{e^+} \) vs. Time [MeV]
- \( \gamma \) position [cm]
- Time [nsec]
- \( e^+ \) angle [rad]

Data sources:
- Pion data
- Michel data

JPS 63rd meeting, 23/Mar/2008, Kinki university, R. Sawada
Background PDF

Accidental background

Distribution can be obtained from “off-timing” data.

\[ B(x_i) = B_1(T_{e\gamma})B_2(\theta_{e\gamma})B_3(E_e)B_4(E_{\gamma})B_5(d)B_6(v) \]

Opening angle

\[ S'(x_i) = S'_1(T_{e\gamma})S'_2(\theta_{e\gamma}, E_e, E_{\gamma})S'_5(d)S'_6(v) \]

Radiative decay

From MC

- Pion data for \( \gamma \)
- Michel data for \( e^+ \)

\[ \sigma_{\text{region}} \]

- Time distribution can be obtained from “off-timing” data.

\[ \text{Accidental background} \]

\[ \text{Radiative decay} \]
Prospects in 2008 (calorimeter)

- Improvement of electronics
  - New version of waveform digitizer (DRS4), with better linearity and stability.
  - Noise study.

- Better PMT calibration
  - Number of alpha sources will be increased for better estimation of Q.E.
  - LED is modified for better estimation of gain. (Increased light attenuation)
  - More LEDs were installed for better estimation of time offset.

- Xenon purification
  - New purifier will be installed (removes water and oxygen).
  - Number of photoelectrons could be doubled?
Plan 2008

Detector install
XEC purification
CW setup & DAQ
Detector debugging
Beam test
$\pi^0$ calibration
Physics run
(DRS upgrade)

Apr  | June  | Aug  | Oct  | Dec
---   |---    |---   |---   |---
Detector install
XEC purification
CW setup & DAQ
Detector debugging
Beam test
$\pi^0$ calibration
Physics run
(DRS upgrade)

5 months DAQ for physics result in 2008
DRS upgrade is scheduled during DAQ
### Prospect of 2008 run

<table>
<thead>
<tr>
<th>Parameter</th>
<th>*MEGA (1999)</th>
<th>MEG 2008 prospects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma Energy (%)</td>
<td>3.3-5.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Positron Energy (%)</td>
<td>0.93-1.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Gamma Position (cm)</td>
<td>15.6</td>
<td>9.0</td>
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<tr>
<td>Positron Angle (mrad)</td>
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<td>17</td>
</tr>
<tr>
<td>Gamma Time (nsec)</td>
<td>1.6</td>
<td>0.15</td>
</tr>
<tr>
<td>Positron Time (nsec)</td>
<td></td>
<td>0.12</td>
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<tr>
<td>Acceptance</td>
<td></td>
<td>9%</td>
</tr>
<tr>
<td>Gamma efficiency (%)</td>
<td>0.3 %</td>
<td>&gt;40%</td>
</tr>
<tr>
<td>Positron efficiency (%)</td>
<td></td>
<td>65%</td>
</tr>
<tr>
<td>Muon rate ($10^8$/sec)</td>
<td>2.5 (Pulse, 6-7% duty)</td>
<td>0.3 (DC)</td>
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<tr>
<td>Running Time (week)</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Single Event Sens ($10^{-13}$)</td>
<td>23</td>
<td>2.2</td>
</tr>
<tr>
<td>Accidental Rate ($10^{-13}$)</td>
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<td>1.0</td>
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<tr>
<td>#Accidental Events</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>90% CL Limit ($10^{-13}$)</td>
<td>120</td>
<td>6.9</td>
</tr>
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Muon rate: 2.5 (Pulse, 6-7% duty), 0.3 (DC)

1 week is defined to be $4\times10^5$ sec

Summary

• 2007 run
  • All the components of the MEG experiment were constructed.
  • Various kinds of data for studying sub-detectors were taken.
  • Trigger system was developed for $\mu \rightarrow e\gamma$ trigger.

• Present
  • Development of reconstruction and physics analysis are being done in parallel.
  • Improvements of hardware is also being done.

• 2008 run
  • We will be ready to restart data taking in June-July.
  • Hopefully, new limit of $\mu \rightarrow e\gamma$ branching ratio from this year’s data.