MEG 実験用 LXe Scintillation detector の
$\pi^{-}p \rightarrow \pi^{0}n$ を用いたビームテスト：I

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R&D status on the Large Prototype Liquid Xenon detector

2001
construction, cooling & liquefaction test @ KEK

2002
R&D on a xenon purification system
60 MeV electron beam test @ KSR

2003
Beam test @ TERAS (Laser Compton gamma)
shipping from KEK to PSI
beam test @ PSI, using γ from the π0 decay
Beam test @ PSI
\[ \gamma \text{ from } \pi^0 \text{ decay} \]

- Elementary process
- \( \pi^- p \to \pi^0 n \)
- \( \pi^0 \to \gamma \gamma \)

Angular selection
- Opening angle = \( q \)
- \( E_\gamma \)

Energy (MeV)

54.9 MeV \[ 82.9 \text{ MeV} \]

1.3 MeV for \( q > 170^\circ \)

0.3 MeV for \( q > 175^\circ \)
**Experimental Setup**

### Beam
- $\pi^-$ beam from piE1 beamline
- Carbon degrader to degrade momentum
- Plastic scintillator to define the beam

### Target
- Liquid Hydrogen cooled with a GM-refrigerator

### Opposite $\tau$ tagging detector
- NaI crystals array detector
- Angular selection $\sim$ 5 degree
Hydrogen Target

- Liquid H2 cooled with a GM-refrigerator
- Temperature control
- Target cell
  - 0.5mm (t) Al
  - 40mm (d) x 100mm
  - 125cc liquid H2
- Kapton foil window
- Pion entrance
- Gamma exit
Nal detector

- 8x8 Nal crystals array
- 6.3cm x 6.3cm x 40.6cm
- Located 110cm from the target
- HV calibration by cosmic ray

Energy resolution
- 7.0% (55MeV), 6.5% (83MeV), 6.1% (129MeV)

Position resolution
- 2.7cm (x), 1.6cm (y)
Timing counter

- 2 counters with lead
- 5cm x 5cm x 1cm : BC404
- Hamamatsu R5505
- 6mm$^t$ lead plate (γ converter)

Efficiency
- ~40% (for 83MeV γ)

Timing resolution
- 60 psec (sigma)

Pion stopping distribution in the target must be considered in subtraction
Schedule of the beam test

- 25/Sep. : Evacuation started
- 27/Sep.~ : Beam tuning
- 29/Sep.~01/Oct. : Pre-cooling
- 02/Oct.~05/Oct. : Liquefaction of xenon
- 05/Oct.~ : Electronics setup
- 05/Oct.~ : Purification started
- 06/Oct.~ : Test DAQ start
- 15/Oct. : First pi0 event
- 06/Dec.~07/Dec. : Recovery
- 07/Dec. : Cold xenon gas data for PMT calibration

Xenon preparation

Electronics and trigger

DAQ ~ 7weeks
Typical event (online display)

**run6648-26110**
Xenon Qsum = 38515 ph
Nal sum = 100 MeV

**run6628-1885**
Xenon Qsum = 53150 ph
Nal sum = 54 MeV

*Sigma2 = 39.4*
*Nfpmu(0.5) = 3.4*
*x average = 0.3 cm*
*y average = -1.5 cm*

*Sigma2 = 70.6*
*Nfpmu(0.5) = 8.6*
*x average = -0.0 cm*
*y average = -0.9 cm*

Xenon: 55 MeV
Nal: 83 MeV

Xenon: 83 MeV
Nal: 55 MeV
$\pi^0$ events example
Energy spectrum example

**raw spectrum**

<table>
<thead>
<tr>
<th>htemp</th>
<th>Entries</th>
<th>Mean</th>
<th>RMS</th>
<th>$\chi^2$/ndf</th>
<th>Peak</th>
<th>Transition</th>
<th>Height</th>
<th>Sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>267283</td>
<td>2.15x+04</td>
<td>1.56x+04</td>
<td>48.5/4</td>
<td>3.38x+04 ± 25</td>
<td>335.2 ± 17.2</td>
<td>1.05x+04 ± 73</td>
<td>1048 ± 21.9</td>
</tr>
</tbody>
</table>

**after event selection**
(Nal: 83 MeV)
Neutron background

- Most probably caused by beam-related neutrons
- Corresponding to 1.5E6 p.e./sec
- Not due to bleeder current shortage but due to photocathode saturation because we observed the same effect even with lower PMT gain

**Thermal neutron in Xe**
- Absorption length ~ 3 cm
- Capture close to calorimeter walls
- Multi $\gamma$, $\Sigma E(\gamma) = 9.3$ MeV
Analysis and Results

NEXT PRESENTATION
Plans in 2004

- Liquid phase purification test
- Neutron background measurement
- Magnetic field effect check
- Final detector construction
  - cryostat design renewal
  - Refrigerator will be assembled and delivered soon
Appendix

Additional transparencies
MEG experiment

Search experiment for $\mu \rightarrow e\gamma$

- “$\mu \rightarrow e\nu\nu$” ~ 100% (Normal $\mu$ decay in SM)
- “$\mu \rightarrow e\gamma$” violates Lepton Flavor Conservation
- SUSY-GUT models predict higher branching $\text{Br}(\mu \rightarrow e\gamma) = 10^{-11} \sim 10^{-15}$
- Sensitive to physics beyond the SM!!

New experiment with a sensitivity of $\text{Br} : 10^{-13} \sim 10^{-14}$ planned at Paul Scherrer Institut (PSI)
**Features**

- The most intense DC muon beam @ PSI
- Liquid Xenon photon detector
- Positron spectrometer with gradient magnet field
- Thin superconducting magnet
- Thin drift chamber and timing counter for positron tracking
- Engineering run will start in 2004,5
- Physics run will start in early 2006
MEG Experiment Collaboration
4 countries
10 institutions

ICEPP, University of Tokyo
KEK
Waseda University
Paul Scherrer Institut
ETH-Zurich

INFN & Genova University
INFN & Lecce University
INFN & Pavia University
Budker Institute
Liquid Xenon Photon detector

Features
- High light yield (75% of NaI)
- Good resolutions
- Fast signal (4.2nsec decay time)
- Reduce pileups
- Liquid (good uniformity)
- No need segmentation

Design
- Active volume of LXe ~ 800L
- 800 PMTs immersed in LXe
Large Prototype LXe detector

70 Litter active volume (120 L LXe in use)
228 PMTs
Total system check in a realistic operation
Purification system for Xenon
Performance test
NaI detector calibration

- High voltage value for each PMT is adjusted by using cosmic ray events
- Pedestal subtraction and gain correction are done in the offline analysis
- Energy and vertex reconstruction are performed by using corrected charge information
NaI energy estimation

- Search for the NaI crystal with maximum charge
- Charge sum in the surrounding NaI’s
- The calibration parameter is determined by using 129 MeV gamma data (and MIP peak)
Nal vertex reconstruction

- Search for the Nal crystal with maximum charge
- Fit the charge distribution of the raw or column (8 Nals in each) that include Nal with maximum charge using Gaussian