MEG Run 2008
測定器の較正
東京大学素粒子物理国際研究センター
白雲
他 MEG コラボレーション
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• Introduction
• 2008 run
• Liquid Xenon γ-ray Detector
  - calibration
  - light yield
  - stability
MEG Experiment

- Lepton flavor violation is forbidden in the standard model (SM)
- Physics beyond the SM predict observable B.R. \(10^{-15} \text{ to } 10^{-13}\)
- Current limit is given by MEGA(1999) (B.R. \(\sim 1.2 \times 10^{-11}\))
- Backgrounds
  - Prompt: Michel decay with high energy e+ and γ.
  - Accidental: High energy e+ and γ (radiative muon decay, AIF...)
- Precise energy, time and opening angle measurement is important.
- Approved in 1999 at PSI in Switzerland
- Japan, Italy, Switzerland, Russia, and USA, \(\sim 65\) collaborators
- Explore \(\text{Br}(\mu \rightarrow e\gamma) \sim 10^{-13}\)
MEG Detector

The most intense DC muon beam at PSI in Switzerland. (1.8 mA proton current)

COBRA magnet with gradient field

Liquid xenon gamma ray detector

Plastic scintillator to measure precise time of positron

Very thin drift chamber to measure low energy positrons

Xue Bai

9/20/08
What we have been doing so far...

- Maintenance work
- Detector installation
- Evacuation, cooling, LXe transportation
- Purification
- Stability check
- Michel run
- $\pi^0$ run
- Trigger setting
- Background measurement
- MEG run
Liquid Xenon $\gamma$-ray Detector
Liquid Xenon

- High light yield (75% of NaI(Tl))
- Fast response ($t=45\text{ns}$)
- Short radiation length ($X_0=2.77\text{cm}$)
- Homogeneous
- No self-absorption of scintillation light

**Challenge**
- Low temperature ($165\text{K}$)
- VUV light
  
  - Require high purity (Resolution strongly depend on absorption length)

Purification system: $\text{H}_2\text{O}$ and $\text{O}_2$ contamination removal
Detector Concept

- Scintillation light from liquid Xenon
  - Use scintillation process only
  - High light yield, fast signal
  - Uniform over large volume

- ~3 ton (880 liters) liquid Xenon with 846 PMTs
  - Unsegmented

- Measure energy, position, timing at the same time

- Identify pileup events by light pattern, time distribution, and waveform.
Measurement Principle

- Energy
  - Sum of all PMT output charge

- Timing
  - Weighted mean of PMT time

- Position
  - Light distribution
    - Peak: position
    - Broadness: depth

Pileup Identification

- Pileup events become dominant background source as increasing beam intensity

- The detector can identify pileup events by
  - Pattern of the light distribution
  - Time difference of every PMT
  - Waveform recorded from all PMTs
Major improvements over last year

- Bad PMT channels fixed (down to 3 currently)
- HV feed-through prob. solved
Calibration and Monitoring: Various Ways

μ radiative decay

- Lower beam intensity < $10^7$
- Is necessary to reduce pile-ups
- Better $\sigma_\beta$ makes it possible to take data with higher beam intensity
- A few days ~ 1 week to get enough statistics

$\pi^0 \rightarrow \gamma \gamma$

- $\pi + p \rightarrow \pi^0 + n$
- $\pi^0 \rightarrow \gamma \gamma$ (55MeV, 83MeV)
- $\pi + p \rightarrow \gamma + n$ (129MeV)
- 10 days to scan all volume precisely
- (faster scan possible with less points)
- LH$_2$ target

Laser

- (rough) relative timing calib.
- < 2–3 ns cc

LED

- PMT Gain
- Higher V with light att.
- Can be repeated frequently

alpha

- PMT QE & Att. L
- Cold GXe
- LXe

Xenon Calibration

Proton Acc

- LiF target at COBRA center
- 17.6MeV $\gamma$
- ~daily calib.
- Can be used also for initial setup

Nickel $\gamma$ Generator

- off
- on
- Source (Cf) transferred by comp air
- 3 cm 20 cm
- 0.25 cm Nickel plate
- NaI
PMT Calibration
- Alpha-QE estimation, absorption length monitor
- LED-PMT gain, time offset

Monitoring
- Cosmic Ray, alpha, LED, Cockcroft-Walton Accelerator
- Ex. Light yield, gain stability

\( \pi^0 \) calibration
**PMT Calibration**

- Daily PMT gain calibration by multiple LEDs

- Calculating gain from statistical fluctuation of detected number of photon electrons

\[ I_{\text{sig}} = \text{Gain} \times e \times N_{\text{p.e.}} = M_{\text{ADC}} \times C \]

\[ \sigma_{N_{\text{p.e.}}}^2 = N_{\text{p.e.}} \rightarrow \sigma_{\text{ADC}}^2 = \text{Gain} \times M_{\text{ADC}} \times e / C \]
- Q.E. measurement using alpha event in LXe
- Reliable light source
- Constant light emission
- Using scintillation light from LXe
  - Same spectrum
  - Can monitor and correct LXe status

![Am source on wire](image1)

![Reconstructed α event](image2)
How to calculate QE?

- Charge fitting -
- Using gain from LED
- Comparison b/w Data and MC
- Fitting with data from multiple alpha sources in different positions
Light Yield

- Light yield increased by \% compared to last year
- Due to new filter system that removes O\(_2\)
- Long absorption length also achieved after over 100 hours of liquid phase circulation
Stability

Gain from trigger data

Gain from DRS data
Light Yield

- monitored using alpha, CW and cosmic ray data

Stable within 1~2%
Summary

- Daily calibration of LED and alpha
- Stability monitoring
- After purification, light yield increased and long absorption length achieved