MEG II実験液体キセノン検出器のインストール及びセンサー試験

→ 次のトークで

東大素セ 家城 佳、
他 MEG II コラボレーション
**μ → eγ search**

Observation of lepton flavor violation (LFV) decay $\mu \rightarrow e\gamma$

Evidence of new physics!

e.g. $\mu \rightarrow e\gamma$ with SUSY

New generation LFV experiments can explore the region predicted by BSM

![Graph showing mu LFV upper limit history](image)
MEG II

$\mu^+ + \gamma$ beam @ PSI ~$7 \times 10^7 \mu/s$

Radiative decay counter (BG identification)

Upgrades from MEG:
- x2 beam rate
- x2 detector resolution and efficiency
- x10 sensitivity (4x$10^{-14}$)

900ℓ LXe $\gamma$ detector

e$^+$ drift chamber + timing counter in gradient B-field
LXe detector

- Measures the energy, position, and timing of $\gamma$-rays.
- Readout: 2" PMTs $\times$ 668 + 12mm MPPCs $\times$ 4092 → Granular & uniform coverage → x2 resolution improvement expected from MEG
  - Energy resolution $\sim$1%
  - Position resolution $\sim$2.5mm

PMTs on this surface are replaced with MPPC

1 m

2 inches

12 mm
Final stage of construction

- Cabling
- Closing the lid
- Closing the flanges

last JPS (Mar2017)
Installation & pipe connection

Installation

Pipe connection

LXe transfer tube

μ

GM refrigerator (new)
Filling LXe to the detector

1. Liquefaction (GXe storage tanks → 1000l LXe tank)
2. Vacuum evacuation of the detector (to ~2x10⁻³ Pa)
3. Pre-cooling of the detector (~175K)
4. LXe transfer from 1000l tank to the detector
LXe transfer

View from a USB camera installed inside the detector
Position monitoring

MPPC position was scanned with laser after installation↓

However, inner cryostat deforms by heat shrink and LXe load.

→ Monitor the movement by position sensors

inner cryostat (filled with LXe)

outer cryostat

vacuum

TE connectivity
SM1

wire pull out length is measured

wire position sensors are attached to the outer cryostat.
3 sensors are installed at 4 different positions.

Moved mostly during the pre-cooling due to heat shrink. Result was roughly consistent with what we expect ($\sim 1.6 \times 10^{-3} \text{mm/m/K}$ heat shrink to bottom direction).

Cryostat is fixed at the bottom middle.
X-ray survey

Another method for position check:
Measure MPPC signal from the X-rays.

$^{57}$Co source + collimator

Position of the stage is measured by laser and monitored by laser and bubble level + camera.

moving stage & rotator

X-ray (124, 132 keV)
X-ray survey

Scan was performed in two directions in 1mm step. X-ray spot size ~ 2 mm x 30 mm

Example of X-ray signal at one MPPC

Event rate increase was successfully observed around X-ray irradiated region. Analysis is ongoing.
LXe monitoring & control

We built a slow control system using special modules (SCS2000) developed at PSI

SCS2000 can:
- readout the sensors (bias & ADC)
- automatically or manually adjust the cooling power (refrigerators and LN₂) by firmware
- allow users to monitor & control via internet
LXe monitoring & control

Normal (stable) operation:
Temperature & pressure is maintained by adjusting electric heater power.

Emergency or special operation:
Open LN$_2$ valves for additional cooling

Firmware of SCS2000 does the control automatically.
- Heater power adjustment (PI control)
- LN$_2$ valve open at high temp. or high pres.
- Issue an alarm in case of emergency
LXe monitoring & control

Overall system is monitored & controlled from web browser.
Purification

Purity of Xe affects the scintillation (light yield, attenuation, pulse shape)

Two types of purifications are ongoing in parallel for ~2 months.

- Gas phase (getter)
  Slow (GXe ~35 l/min)
  Removes H$_2$O, O$_2$, CO, CO$_2$, N$_2$, H$_2$ …
- Liquid phase (molecular sieve)
  Fast (LXe ~40 l/hour)
  Removes H$_2$O
Purification and detector stability

- Xe purity is improving (light yield increased ~10 times over 2 month.) Currently the light yield is ~85% of what we achieved in MEG.
- Temperature and pressure are sometimes unstable due to LXe purification pump trouble and due to heat income in LXe purification line.
  → Once we finish purification, the detector will be more stable.

Pressure variation (1 week)

Temperature variation (1 week)

0.001MPa

0.04 deg

pump trouble
• Construction & installation are finished!
• LXe operation started. Purification is ongoing.
• MPPC & PMTs are being tested → Next talk (S. Ogawa)
  with limited amount of DAQ channels available now (~1000ch)
• Detector monitoring is started → Next next talk (N. Matsuzawa)
• Pilot run will start in the end of 2017, followed by the engineering
  run and physics run in 2018.
Summary

- LXe detector is successfully installed.
- Position of the detector is measured by wire sensors and X-ray.
- Slow control system is built. Purification is ongoing. (so far achieved ~85% of light yield in MEG)
- Commissioning of MPPC & PMTs is also ongoing.
- Monitoring of the detector is started.