MEG II 実験の準備状況と
今後の展望

東京大学 素粒子物理国際研究センター
岩本敏幸 他MEG II コラボレーション
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JSPS Core-to-Core Program
Introduction

- Flavor physics
  - Why do we have three generations in the SM?
- charged Lepton Flavor Violation
  - FV happens in quark, neutral lepton sector
  - Why not in charged lepton sector?
- $\mu \rightarrow e\gamma$
  - Long search history since the muon has been discovered.
  - Negative results contribute to the SM formation
  - In SM + neutrino oscillation, $\text{Br}(\mu \rightarrow e\gamma) \sim 10^{-50}$
  - Many new physics scenarios predict large $\text{Br}(\mu \rightarrow e\gamma)$
**MEG II Experiment**

- MEG/MEG II experiment
  - MEG/MEG II are designed to search for such regions where new physics like SUSY-GUT, SUSY-seesaw predict
  - Real chance to discover new physics

- Start new physics search next year
  - Target sensitivity : $6 \times 10^{-14}$
  - 10 times better sensitivity with three years data taking than MEG
    - MEG sensitivity : $5.3 \times 10^{-13}$
    - MEG final results : $4.2 \times 10^{-13} \text{ @} 90\% \text{CL}$ (Eur. Phys. J. C 76(8),434(2016))

- New $\mu$-e conversion, $\mu \rightarrow 3e$ experiments will follow soon

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**History of CLFV experiments with muons**

[Graph showing history of CLFV experiments with muons]

MEG II Experiment

- Liquid Xenon γ Detector
  - Better uniformity w/ VUV-sensitive 12x12mm² SiPM
- 16aS41-7, 8 小林, 小川
- Radiative Decay Counter
  - Further reduction of radiative BG
- 16aS41-5 恩田

- Gamma-ray (γ)
- Muon (μ⁺)
- Positron (e⁺)

- COBRA SC Magnet
  - 15pS28-5 家城
- Downstream
- Upstream
- Positron Timing Counter
  - 7x10⁷/s
  - 30ps resolution w/ multiple hits
- Drift Chamber
  - Single volume He:iC4H10 small stereo cells
  - 15pS28-4 宇佐見
- x2 resolution everywhere
Current status

- All the detectors except for CDCH are constructed.
- Pilot run with partial electronics was successfully carried out in Nov.–Dec.

- Struggle with the **wire braking issue** on CDCH.
- Struggle with the **noise issue** on the readout electronics.

⇒ >2 years delay from the original (2013) schedule.

- This year all the detectors will get ready.
- Full electronics will be ready toward the end of the year.

⇒ Carry out **full engineering run**, but not physics run this year.
Current status (update from 2018 spring)

- CDCH
  - Wire breaking issue seems to be solved by humidity control, and the assembly is finished.
  - CDCH finally sent to PSI

- WaveDREAM
  - Still struggling with the noise issue, and the mass production has not started yet
  - This year we can not start engineering run due to this problem

- LXe detector
  - Light yield was saturated at the half of the maximum level

- Schedule
  - Now Mu3e beam time at the upstream side of the experimental site
  - In October, integration of all the detectors into the experimental site
  - In November - December, MEG II muon beam time is planned
CDCH

- Chamber construction work finished
  - The problem of broken wires seems to be solved by careful control of humidity
- HV supply test
  - performed before bringing the CDCH from PISA to PSI
- However, we found another problem
  - current instability of many channels observed before reaching the nominal HV
  - three most inner layers are critical
    - Drift cell at center
      - 5.8mm (inner layer)
      - -7.4 mm (outer layer)
CDCH

- Limited # electronics channels, and HV are supplied locally.
  - Drift cell instabilities have position dependence
  - Worse parallelism of end plate? ~350 μm
- Inner three layers had a worse situation
  - Smaller drift cells, lack of wire tension?
  - Wire length checked again, and 1mm longer than what was measured before
- Decide to re-open the chamber and correct the wire tension and the parallelism of the end plate
CDCH

• Making CDCH longer by 0.6mm
  - no short circuit observed

• Both endplate parallelized better
  - uniformity recovered (sector 0, 11 relative to 5, 6)

• Assembly work done again

• Shipped to PSI on 31st/July
  - He: Isobutane = 85 : 15 are supplied at PSI for the first time
  - All the HV cards became available at Mid. Aug.

• Now HV conditioning in progress outside the detector hut
  - Up to now, ~1000V are achieved (working condition will be ~1500V)

• Beg. October installation into the MEG II experimental site if everything is ok
TC

- Full counters were tested under muon beam, and expected performance was confirmed (~30ps)
- Radiation damage can be mitigated by low temperature operation
  - 30% time resolution deterioration at 100μA at 30°C becomes 5% at 10°C
- Cooling test performed at open space
  - 20°C was already achieved
  - Water chiller system plus cooled dry air
  - Cool down test down to 10°C will be done in the detector hut with air conditioning system
LXe detector

• Last year
  • light yield reached 90% of expected by gaseous/liquid purification
  • After some readout PMTs are modified, it changed to 70% of expected

• This year
  • Started detector operation in June
  • unexpectedly the light yield is saturated at 50% of expected
  • Molecular sieves have some problem? Replacement work in progress
MPPC position survey

- X-ray measurement again this year
  - Measure MPPC positions in LXe directly
  - Absolute MPPC position comparison with more lead strips
    - last year, ~1mm discrepancy was observed
    - Stability of MPPC position after thermal cycle

- Waveform data are taken
  - last year only event rate (scaler) was used.
  - Online trigger can veto cosmic ray events
    - S/N improved from 1 to 5

- Results
  - No significant displacement from the thermal cycle
  - Again, the laser survey and the lead strip data show discrepancy. Careful checks are in progress.
Noise

• High/low frequency coherent noises are observed for both PMT and MPPC

• High frequency noise
  • mainly coming from waveform digitizer
  • Related to 80MHz system clock
  • Try to remove the high frequency noise by offline analysis

• Low frequency noise
  • dominant source for charge estimation
  • Still limited number of channels, but already 1% contribution to charge RMS

• Energy resolution will be checked by CW Li 17.6MeV γ monochromatic calibration
RDC

- **Downstream RDC**
  - In 2017 RDC + LXe data taking was performed, and radiative muon decay events are successfully observed
  - Data analysis and the comparison with MC in progress

- **Upstream RDC**
  - Considering the possibilities to use silicon sensor, RPC etc.

LXe Event Display

DCH mockup

\[ T_{RDC} - T_{LXe} \ (data) \]

\[ N_{RMD\_detected} \]

BG Rate
**WaveDAQ**

- **New DAQ/Trigger system**
  - Waveform digitizer, amplifier, SiPM voltage supply, trigger are integrated in a card
  - 6 crates (=1500ch.) are now available for test

- **Noise study from hardware point of view**
  - Test of common mode choke: mainly to remove high frequency noise

- **Baseline slope**
  - Drop caused by temperature dependent leakage current in DRS
  - Cells at right are read out later → more time for leakage → slope
  - Need to keep the temperature constant

- **Next year mass production for all ch.**
## Prospects 2018

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<th>Sep</th>
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<td>Purification and Calibration</td>
<td>CW + Muons</td>
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<td>CW</td>
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<td>Camera</td>
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<tr>
<td>CDCH</td>
<td>Gas System + HV Test + Conditioning</td>
<td>Install inside Cobra</td>
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### Key Points
- **CDCH Preparation**
- **Detector Integration**
- **Beam Tuning**
- **Muon beam LXe + TC + CDCH + RDC**
Summary

• All the MEG II detectors are finally at PSI, and will be installed into the experimental site in October.

• Muon beam time is scheduled with all the detectors and limited number of readout electronics in November-December.

• Next year after the mass production of the readout electronics, engineering run and physics run will be started.
Sum of # of p.e. of PMTs from an alpha source

LXe purification

MEG I nominal level
~10%

gXe purification
~30%

gXe purification

07/23 08/22 09/21 10/21 11/20

07/23 08/22 09/21 10/21 11/20 11/8 11/20

• Beam time in 2018 for MEG II is allocated as requested (by Stefan)
## HIPA operation

### Betrieb Protonen-Anlagen 2018-2020

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- **Umbau**
- **Betrieb**

Klaus Kirch, PSI

Stand: 20.09.2017
Pileup analysis

Reconstructed E_y Spectrum (BG y)
Positron analysis
Target preparation