μ⁺ → e⁺γ 探索実験 MEG II の準備状況

(Status of the MEG II experiment searching for μ⁺ → e⁺γ)

21/March/2015

日本物理学会大70回年次大会@早稲田大学
Abstract

1. **MEG II** is upgrade of MEG experiment, searching for $\mu \rightarrow e\gamma$

2. All the detectors are now under construction

3. To carry out a ‘pre’-engineering run in 2015

4. Toward start of data taking in 2016
Next $\mu\rightarrow e\gamma$ Experiment

- Aim at sensitivity of $O(10^{-14})$
  - $\times 10$ improvement from MEG

- By exploiting the full beam power available today,
  - $\sim 10^8 \mu^+/s$ at PSI πE5

- By upgrading the MEG detector
  - Keep experimental concept
  - in short ($\sim 5$ years), at low cost

MEG II Experiment
Keep 3 keys of MEG
1. World’s most intense DC μ beam @ PSI
2. Innovative liquid xenon γ-ray detector
3. Gradient B-field e^+-spectrometer

Double beam intensity,
Double efficiency,
Suppress BG factor ~30
• Halve every resolution,
• Add new detector to identify BG
<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Start the project. Conceptual designing. Submit the proposal to PSI.</td>
</tr>
<tr>
<td>2013</td>
<td>Proposal approval.</td>
</tr>
<tr>
<td></td>
<td>R&amp;D</td>
</tr>
<tr>
<td>2014</td>
<td>Construction partially start.</td>
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<tr>
<td>2015</td>
<td>Detector construction. Detector commissioning. Pre-engineering run.</td>
</tr>
<tr>
<td>2016</td>
<td>Full engineering run. Data taking.</td>
</tr>
<tr>
<td>2017, 2018</td>
<td>2.4 x 10^{-12}</td>
</tr>
</tbody>
</table>

$k$ factor ($\times 10^{11}$): 0, 125, 250, 375, 500

MEG I
DAQ
Sensitivity

Where We Will Be

2017: Full engineering run, Data taking.
2015/Mar/21 @ JPS 70th Annual
Yusuke UCHIYAMA/ The University of Tokyo
Detector technologies

- Large-area VUV sensitive SiPM
  - for the world’s largest LXe detector. (wavelength 175 nm)
- 30 ps precision time measurement
  - with fast plastic scinti. & SiPMs
- Low mass long stereo-wire drift chamber
  - 0.0017 $X_0$ for a particle
- Compact, dense DAQ system
  - To deal with increased channels
  - Waveform digitizer & first trigger step in a same board
**LXe γ-ray detector**

- Large area VUV-MPPC development completed
  - >15% PDE achieved
  - 600 prototypes test in LXe performed
  - Final model (w/ cross-talk suppression) successfully tested.

- Final MPPCs (>4000) are about to be delivered.

Normal MPPC (3×3 mm²)

VUV MPPC (12×12 mm²)

2” LXe PMT
600 SiPMs tested in LXe
● This year, concentrate on the construction
● Assembled detector will move to the experiment site in Sep.
● Installation & commissioning in Sep-Dec.
  – Liquefaction
  – Signal test with limited readout channels
● Purification, calibration continued until summer 2016
New drift chamber

- All material procurement done.
- Wiring will be started soon.
- Full chamber will be delivered to PSI by March 2016.

- Partially wired ‘mock-up chamber’ will be delivered to PSI by July this year
  - with HV & gas system
  - for mechanical integration & operation test
Pixelated timing counter

- ~30 ps resolution demonstrated under MEG-II condition.
- 6000 SiPMs were delivered.
- Downstream system will be ready by Sep. this year.
New BG tagging detector

Radiative Decay Counter (RDC)

- Optional detector, new for MEG II
  - To actively tag BG from $\mu \rightarrow e\nu\gamma$

- Downstream detector was approved by the collaboration, giving 16% higher sensitivity
  - Construct by this summer. Production has been started.

- Need more study for the upstream detector
  - Effect on the beam transportation
  - Test it in this year’s beam commissioning.
Electronics, DAQ

- Innovative solution for Trigger & DAQ
  - Waveform digitizer, frontend circuit, HV supply, 1st level trigger on a board

- Prototype board under test
  - Frontend circuit was tested with detector signal

- First full crate (256 ch) available by Oct. this year
  - tested in the pre-engineering run

- Mass production will be started after the test

- Complete system ready by spring 2016
Goal of 2015

- Check the **mechanical integrity & functionality** of the MEG II upgrade design
- Enable design corrections & modifications well before Engineering run in 2016
- Enable beam optimization & setup of new target & test of US RDC principle
## Schedule

- **2015 Beam time granted**: 12.5 (+1.5 provisional) weeks
  - from mid. or end of Sep.

<table>
<thead>
<tr>
<th>2015 Apr</th>
<th>2016 Jan</th>
<th>Jul</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>DC mock-up to PSI</td>
<td>DC insertion test</td>
<td>DC installation</td>
</tr>
<tr>
<td>DC mock-up installation</td>
<td>Commissioning</td>
<td>US DSTC installation</td>
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<tr>
<td>7</td>
<td>4</td>
<td>9</td>
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<tr>
<td>8</td>
<td>5</td>
<td>10</td>
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<tr>
<td>9</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Beamline setup</td>
<td>Michel run</td>
<td>Microfoccal, correction, modification</td>
</tr>
<tr>
<td>1st DAQ crate</td>
<td>Accelerator shutdown</td>
<td>Beam tuning</td>
</tr>
<tr>
<td>LXe to Area</td>
<td>Complete elec.</td>
<td>Test beam, trigger</td>
</tr>
<tr>
<td>Purification, calibration</td>
<td></td>
<td>Muon data</td>
</tr>
</tbody>
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*2015/Mar/21 @ JPS 70th Annual*  
Yusuke UCHIYAMA/ The University of Tokyo
Conclusion

• A very important step for MEG II realization foreseen this year
  - All the detectors are now under construction
  - We plan to carry out a ‘pre’-engineering run in autumn–winter
    - Test mechanical integrity
    - Test all the detector signal with limited electronics
    - Carry out Michel run with a Timing Counter

• Toward data-taking started in 2016
Target system
Downstream end-cap
Paul Scherrer Institut

World’s most powerful proton beam to targets:

\[ 590 \text{ MeV} \times 2.4 \text{ mA} = 1.4 \text{ MW} \]

Proton accelerator complex

\( \pi, \mu \) production target

World’s highest intensity \( \pi \) & \( \mu \) beams

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