

# Search for lepton flavor violating decay of muon in MEG experiments

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on behalf of the MEG Collaboration

# Charged lepton flavor violation

- Standard Model.
  Flavor violation can happen in quark & neutrino sector.
   Charged Lepton Flavor Violation (CLFV) prohibited.
   Beyond Standard Model.
   CLFV is predicted at a detectable branching ratio in some BSM models (SUSY-GUT, SUSY-Seesaw, etc...)
- Experimental search of  $\mu \rightarrow e\gamma$ 
  - Expected to be Br( $\mu \rightarrow e\gamma$ ) = 10<sup>-12</sup> 10<sup>-14</sup> in BSM.
  - Best limit before MEG: 1.2 x 10<sup>-11</sup> @90%C.L. give by MEGA (1999)

#### MEG searches for $\mu \rightarrow e\gamma$ down to O(10<sup>-14</sup>)



Ũ0

μ

 $e_R$ 

 $\mu \rightarrow e\gamma$  search



Intense DC muon beam & good detector resolutions are the keys to search for  $\mu \rightarrow e\gamma$ .

# MEG experiment

- MEG experiment was carried out in 2009-2013.
  - World's most intense DC beam at PSI (Switzerland).
  - Positron spectrometer
    - Gradient magnetic field + segmented low-mass drift chamber + scintillation timing counter.
  - LXe γ-ray detector
- $\rightarrow$  MEG result with full data set:



# MEG II experiment

### MEG II : Upgrade of MEG experiment

- Muon beam intensity : x2 ( $3x10^7 \rightarrow 7x10^7 \mu/s$ )
- Detection efficiency : x2
- All detector resolutions : x1/2

"The design of the MEG II experiment", Eur. Phys. J. C (2018) 78:38 Improve sensitivity by one order of magnitude



# Cylindrical drift chamber

- Tracking (momentum, emission angle, vertex reconstruction) of 53MeV e<sup>+</sup>
- Unique volume cylindrical drift chamber
  - Low-mass to reduce multiple scattering
  - More # of hits per track for better tracking precision
    - : ~20 (MEG)  $\rightarrow$  ~60 (MEG II)
  - Reduced material on positron track before hitting timing counter.
    - : x2 e<sup>+</sup> efficiency from MEG



# Pixelated timing counter



# LXe γ-ray detector

- Position, energy, timing measurement of 53MeV γ.
- LXe scintillation light read out by photo-sensors.
- Eγ resolution in MEG was limited by non-uniformity of readout.
- 216 PMTs on the γ-entrance face are replaced with 4092 MPPCs.
  - Better granularity & uniformity
    - → Better position
      & energy resolution.
  - VUV-sensitive MPPC newly developed with HPK.





### Current status



### Current status



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### Prospects

Engineering run of MEG II will be done in 2019, followed by physics DAQ.

 Expected sensitivity of MEG II : 6 × 10<sup>-14</sup> (3 years DAQ)

PDF parameters	MEG	MEG II
$E_{e^+}$ (keV)	380	130
$\theta_{e^+}$ (mrad)	9.4	5.3
$\phi_{e^+}$ (mrad)	8.7	3.7
$z_{e^+}/y_{e^+}$ (mm) core	2.4/1.2	1.6/0.7
$E_{\gamma}(\%) \ (w > 2 \ \text{cm})/(w < 2 \ \text{cm})$	2.4/1.7	1.1/1.0
$u_{\gamma}, v_{\gamma}, w_{\gamma} \text{ (mm)}$	5/5/6	2.6/2.2/5
$t_{e^+\gamma}$ (ps)	122	84
Efficiency (%)		
Trigger	≈ 99	≈ 99
Photon	63	69
$e^+$ (tracking × matching)	30	70



# Summary

- MEG experiment searches for  $\mu \rightarrow e\gamma$ .
  - Lepton flavor violating decay of muon.
  - Promising BSM search.
- MEG final result : Br( $\mu \rightarrow e\gamma$ ) < 4.2 x 10<sup>-13</sup> at 90% C.L.
- Preparation of MEG II is going on.
  - Completed construction of all detectors.
  - Engineering run from 2019.
    - $\rightarrow$  Sensitivity 6x10<sup>-14</sup> within 3 years DAQ, once physics run starts.

# Backup

# VUV-sensitive large area MPPC

MPPC for MEG II LXe detector has been developed in collaboration with Hamamatsu Photonics K.K.

#### VUV-sensitive (PDE (λ=175nm) > 15% )

- Scintillation light of Xe is in VUV range
- Realized by removing the protection layer of resin, optimizing optical matching b/w LXe and sensor surface, and thinning contact layer.

#### Large sensitive area (12 × 12 mm<sup>2</sup>)

- To keep the number of readout channels manageable.
- Discrete array of four 6 × 6 mm<sup>2</sup> chips
- Four chips connected in series at readout PCB to reduce long time constant.

#### Hamamatsu S10943-4372





# LXe γ-ray detector

- Detector commissioning is ongoing.
  - Sensor calibration & alignment, Xe purification, etc...
- γ-ray from SM muon decay was successfully observed.





### Radiative Decay Counter / Readout electronics

#### **Radiative Decay Counter**

Detect low energy e<sup>+</sup>, associated with BG γ.



### **Readout electronics**

- Integrated trigger and DAQ system designed for MEG II.
- System demonstrator successfully tested.
- $\rightarrow$  Start mass production soon.

