Development of ultra-low material RPC for background identification in MEG II experiment

Atsushi Oya¹, Kei Ieki¹, Atsuhiko Ochi², Rina Onda¹, Wataru Ootani¹ University of Tokyo¹, Kobe University²

Abstract: An ultra-low material Resistive Plate Chamber (RPC) is being developed to suppress γ-ray background in MEG II experiment. It is required to detect low energy positrons associated with radiative muon decays, which is a major source of γ-ray background, under a harsh environment with a high intensity muon beam passing through it. The sensitivity of the experiment is expected to improve by 10% with this detector. R&D studies of this detector are presented.

Chapter 3

MEG II experiment

MEG II, an upgraded experiment from MEG will search for BSM via lepton flavor violating muon decay μ → eγ with 6×10⁻¹⁴ branching fraction sensitivity [1], which improves the sensitivity of the MEG experiment by one order of magnitude.

MEG II signal

- 180° relative angle for e and γ
- Same emission timing of e and γ
- Both of e and γ have 52.8 MeV energy

Background identification detectors: Detectors to suppress background γ from RMD

RMD events emitting ~52.8 MeV photon is accompanied by 1-5 MeV positron. By detecting this positron, RMD is identified.

Motivation of our study

- The aim of this study is to develop the upstream background identification detector, improving the sensitivity by 10%.

Difficulty of upstream detector

- Must be operated under high intensity muon beam (21 MeV/c, 100 MHz in total, 4 MHz/cm² at the center, 60 week data taking) passing through the detector.
  1. Low material budget (<0.1% of X₀) so as not to degrade the beam.
  2. Radiation hardness and rate capability.

Resistive Plate Chamber (RPC)

A hopeful candidate of the upstream detector is Resistive Plate Chamber with electrodes based on Diamond Like Carbon (DLC).

- RPC: Electric field is applied between two resistive electrodes
  - Ionizations from charged particles produce avalanches in the gas gap
- Electrodes made of DLC sputtered Kapton film
  - DLC has mixed structure of sp² bond and sp³ bond of carbon
  - The advantages of DLC:
    1. Low material budget.
    2. Adjustable surface resistivity.
    3. Readout pad is implemented at the top and the bottom of the detector.
    4. Pillars to control gas gap distance.

- MEG II design
  - ~4 layers (at maximum) to satisfy the requirement of low material

Resistance plate made of DLC film

Medial 

Pulse height spectra

Detection efficiency

- Measured using 590β ray

- Measured with +40dB amplifier

Timing resolution

- Measured using 590β ray

- Measured with +40dB amplifier

Summary and conclusion

- In order to further improve the experimental sensitivity of the MEG II, we are developing RPC for the background identification detector based on DLC sputtering technology.
- The measured performance looks promising, but still needs further design optimization to meet the requirements.

References:

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Contact: Atsushi Oya, atsushi@icepp.s.u-tokyo.ac.jp