（別紙様式２）

フォトンサイエンス国際卓越大学院プログラム（XPS）
光科学特別実習　報告書

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Background of the research activity

Currently, the Standard Model of particle physics is considered to be the most successful theory, explaining a wide range of phenomena from those found in accelerator experiments to those found in astrophysical observations. On the other hand, there are puzzles and anomalies yet to be understood, implying the existence of a more extensive law of nature. Thus, the upcoming researches should focus on such additional law. Among them, a high expectation is put on the MEG II experiment, designed to search for charged lepton flavor violating $\mu \rightarrow e\gamma$ decay at the world's best sensitivity in the coming years. This experiment will offer powerful tools to explore new physics signatures, especially on the matter sector of the Standard Model. Thus, we would gain better understandings of the aforementioned puzzles such as the matter-antimatter asymmetry of the universe, and some latest experimental results on neutrino physics.

Since the suppression of background gamma-ray plays an essential role in the MEG II experiment, dedicated detectors will be installed to identify a fraction of them(Fig.1). These detectors target the low energy positrons originating from the radiative muon decay ($\mu \rightarrow e\nu\nu\gamma$), enabling us to identify the background gamma from this deday. These detectors will be installed into the upstream and downstream positions of the muon stopping target. The downstream part has already been developed, whereas the upstream one is still under study with some technological difficulty.

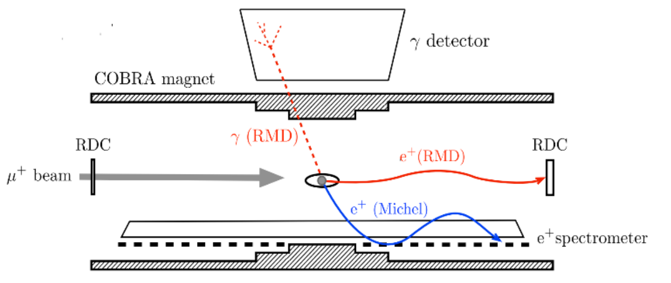

Fig.1　Detectors for background gamma identification[1]. They are called "RDC" in this figure.

The upstream detector development is challenging because the 28 MeV/c muon beam must pass through the detector. Accordingly, the followings are required;

1. the material budget of as low as 0.1% radiation length, letting muon pass through the detector,
2. 4 MHz/cm^2 level of rate capability against the 28 MeV/c muon, which is the muon rate at the center,
3. radiation hardness to operate the detector under that environment for years,
4. < 1ns timing resolution and > 90% detection efficiency for 1 – 5 MeV positron for RMD gamma identification.

The Resistive Plate Chamber (RPC) is a candidate detector technology, and its performance is measured using beta-ray coming from ^{90}Sr. The result is promising so far with the satisfactory results on the last two requirements, except it has not been operated under the muon beam environment. The top priority at this stage is to measure the RPC response to the muon beam and demonstrate the first two of the requirement list.

The activity and the achievement

I stayed in Paul Scherrer Institute (PSI) Switzerland for two months from the last week of October 2020. As the MEG II experiment will exploit the 28 MeV/c muon beam at PSI, its use is the ideal choice for the RPC's response measurement to the muon beam. In the series of measurements, the prototype RPC detector (Fig.2) is placed on the muon beamline (Fig.3) and irradiated with the muon beam in the following two different ways;

1. RPC is irradiated with muon beam with kHz/cm^2 level intensity, intending to see the detector's response without being affected by its rate capability
2. RPC is exposed to the high-intensity muon beam with ~1 MHz/cm^2 rate at the center. It is intended to be a

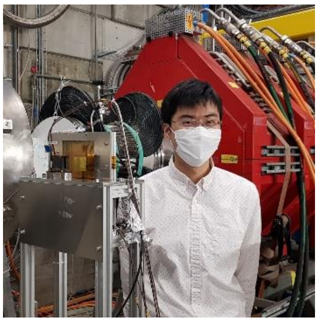

Fig.2 Detector and the author standing beside it

Fig.3 Detector placed on the beamline

measurement that lets us project the performance in detecting the RMD positrons under the situation where the high rate muon beam passes through the RPC.

Concerning the first measurement using the lower intensity beam, we succeeded in measuring the RPC's response to the beam muon, which turned out to be different from that to beta-ray from ^{90}Sr; we will publish the detail soon. This result means the requirement on its material budget is completely satisfied, and as far as I am aware, this is the first RPC letting highly ionizing particles to pass through.

In the measurement using the high-intensity beam, we investigated the performance in detecting positrons originating from $\mu \rightarrow e \nu \nu$ decay, which are the reasonable alternatives of the RMD positrons as the minimum ionizing particles (MIP). As we anticipated from Ref[2], the performance degradation was observed for MIP particle detection. The RPC's performance agrees with our understanding, considering the difference in the condition between our measurement and Ref[2]. Though the prototype detector's rate capability is still insufficient due to its incomplete design, this result will lead us to develop a detector that fulfills the whole demand for the upstream background gamma identification detector.

During this stay, I also contributed to the data taking dedicated to the performance evaluation for the other detector systems of the MEG II experiment. As the 24hour local detector monitoring is necessary during the data taking period, it was challenging performing the series of measurements while soundly protecting ourselves from the infection. Though we faced this difficulty for the first time, the data taking has successfully been completed this year by minimizing the local peoples' burden of detector monitoring. As the recent harsh situation is expected to continue for the moment, this year's successful experience is meaningful, helping us keep the experiment from being decelerated while adhering to the infection prevention measures for the coming MEG II experimental periods.

References

[1] Baldini, A.M., Baracchini, E., Bemporad, C. et al. The design of the MEG II experiment. Eur. Phys. J. C 78, 380 (2018)

[2] G. Aielli *et al*. Improving the RPC rate capability. *JINST* 11 P07014 (2016)