Development of a high-rate-tolerant HV-switching multi-wire proportional chamber and its readout electronics for DeeMe experiment

DeeMe

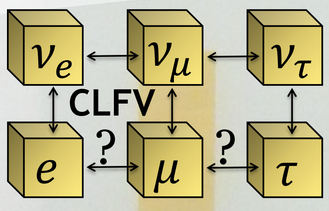
N. Teshima, M. Aoki[1], S. Mihara[2], D. Nagao[1], Y. Nakatsugawa[2], H. Natori[2], H. Nishiguchi[2], Y. Seiya, Y. Takezaki, N. D. Thong[1], N. M. Truong[1], K. Yamamoto, on behalf of the DeeMe Collaboration

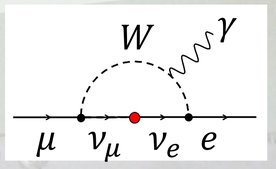
Osaka City University, Osaka University[1], KEK[2]

13th Flavor Physics and CP violation 2015 (Nagoya, Japan)

1 Motivation

Charged Lepton Flavor Violation (CLFV) processes are essentially forbidden in the Standard Model (SM) and have not been observed yet.





The BR of CLFV by the neutrino oscillation $\simeq 10^{-54}$.

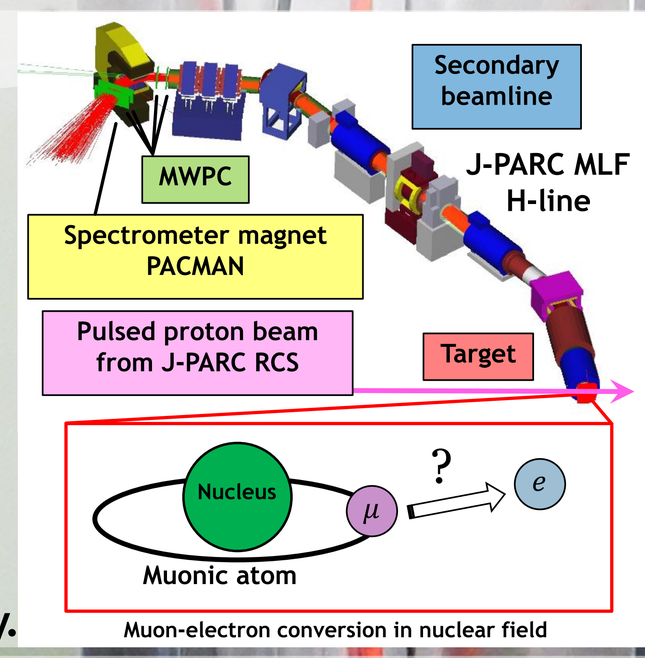
But they occur naturally in many new physics beyond the SM. Experimental observations of the CLFV provide clear evidence of new physics.

2 DeeMe experiment

is planned to search for muon-electron conversion process

$$\mu^- + (A, Z) \rightarrow e^- + (A, Z),$$

which is one of the CLFVs with a S.E.S. $\simeq 1 \times 10^{-13}$ or $\simeq 2 \times 10^{-14}$ using a graphite or silicon carbide target (for 1 MW proton beam and 2×10^7 seconds), respectively.



Muon-electron conversion in nuclear field

3 Development of a high-tolerant HV-switching MWPC

3.1 Requirements

The MWPCs are irradiated in high-rate prompt-charged particles before 105 MeV signal electrons arrives at the MWPCs.

- $\simeq 2 \times 10^8$ / pulse
- Pulse width 200 ns

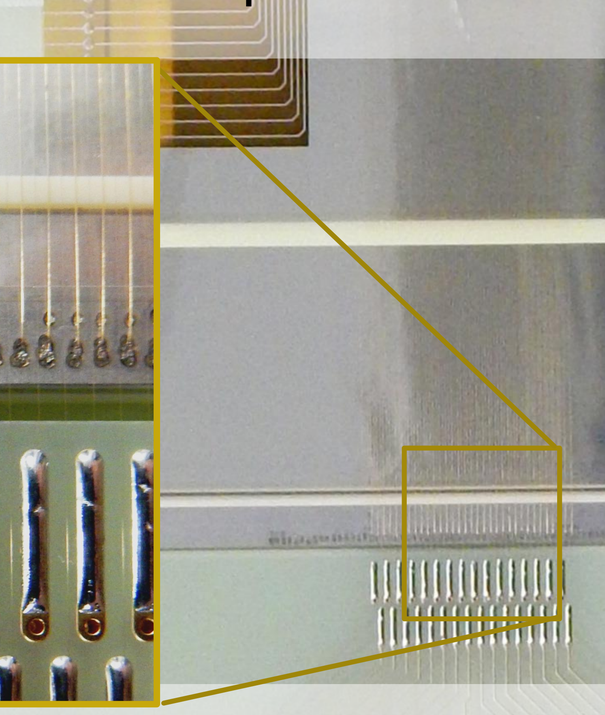
➢ The maximum instant hit rate ~70 GHz / mm^2

→ Standard design of the MWPCs will produce a huge amount of avalanche ions and be totally saturated, then blinded for a while.

The DeeMe MWPCs are required:

1) High rate tolerance
2) Ability to detect a signal electron soon after prompt burst pulses.

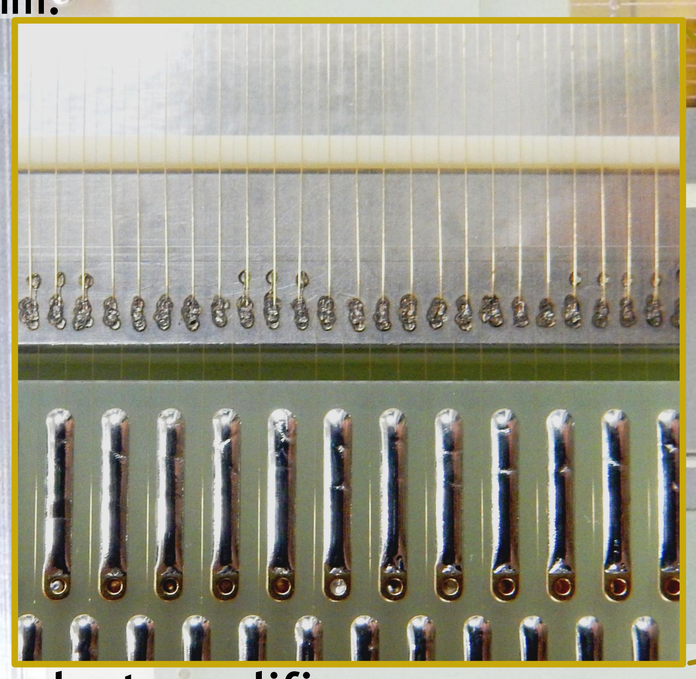
To achieve them, we develop a technique, HV switching on potential wires, which controls the avalanche gas gain.



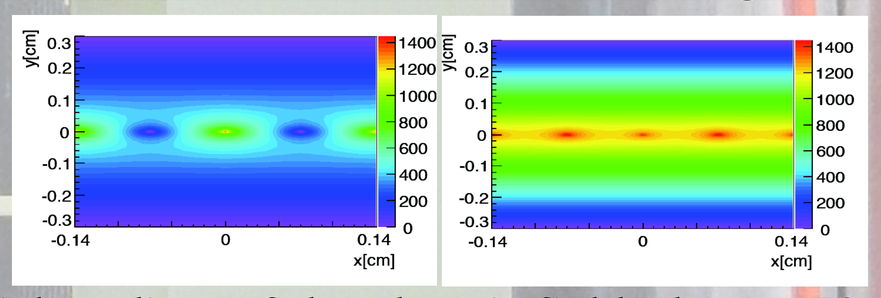
The expected signal waveform of DeeMe experiment

3.2 Construction

Anode wires and potential wires are tighten up alternately.
The distance between an anode wire and a potential wire is 0.7 mm.



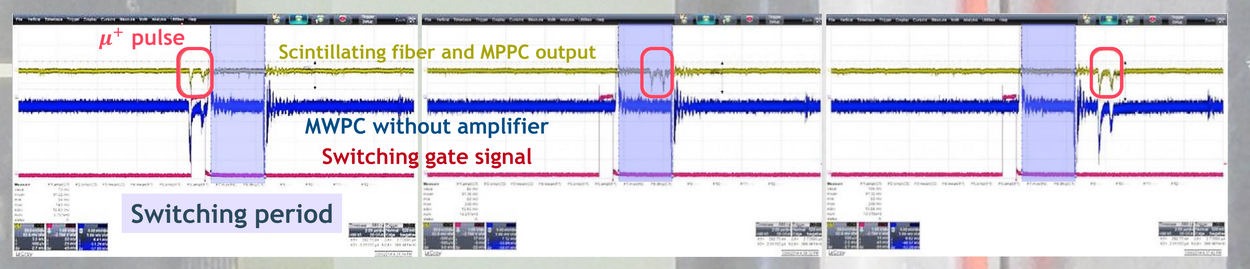
3.3 Electric field calculation. HV switching effect



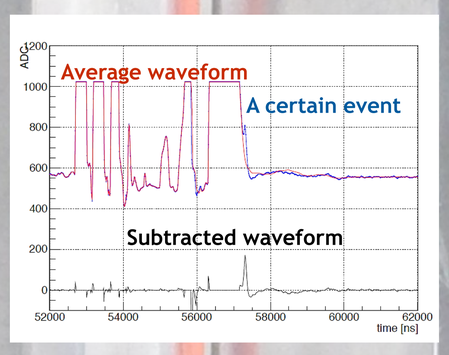
Potential gradient of the electric field when 1450 V is applied across potential wires (right) is smaller than that when 0 V is applied (left).

3.4 Test beam experiment of the prototypes

The HV switching technique successfully suppressed gas gain during the switching period.



The prototype detects a delayed single electron after a burst pulse (the intensity in the DeeMe experiment condition).



3.5 The final design

- Readout by Cathode strips.
- 90 channels 3 mm width in the X direction.
- 16 channels 5×3 mm width in the Y direction.
- The active region area 250×200 mm^2.
- 3 mm between a wire and a cathode strip.

4 Readout amplifier

We developed the readout electronics for the DeeMe experiment.

- Pole-zero cancellation circuit to cancel long tail by slow ions movement in the detector.
- Large current tolerance by the prompt burst pulse or HV switching.

5 Summary

- High-rate-tolerant MWPCs with a novel technique, HV switching on the potential wires, are being used in the DeeMe experiment.
- After the test beam experiment of the prototype, two of the final design MWPCs were constructed.
- We will get ready to begin our experiment soon after J-PARC MLF H-line construction in 2015-2016.