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R&D of Residual Gas Beam Profile Monitor

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- Principle of RGBPM
- Setup for Beam Test @ K2K beam line
- Summary&Plan

Introduction

- In J-PARC Neutrino Beam Line, the intensity of proton beam is very high.

Non-destructive monitor is desirable.

- The range of Proton Beam intensity is wide.(10^{12}~10^{14}/spill)

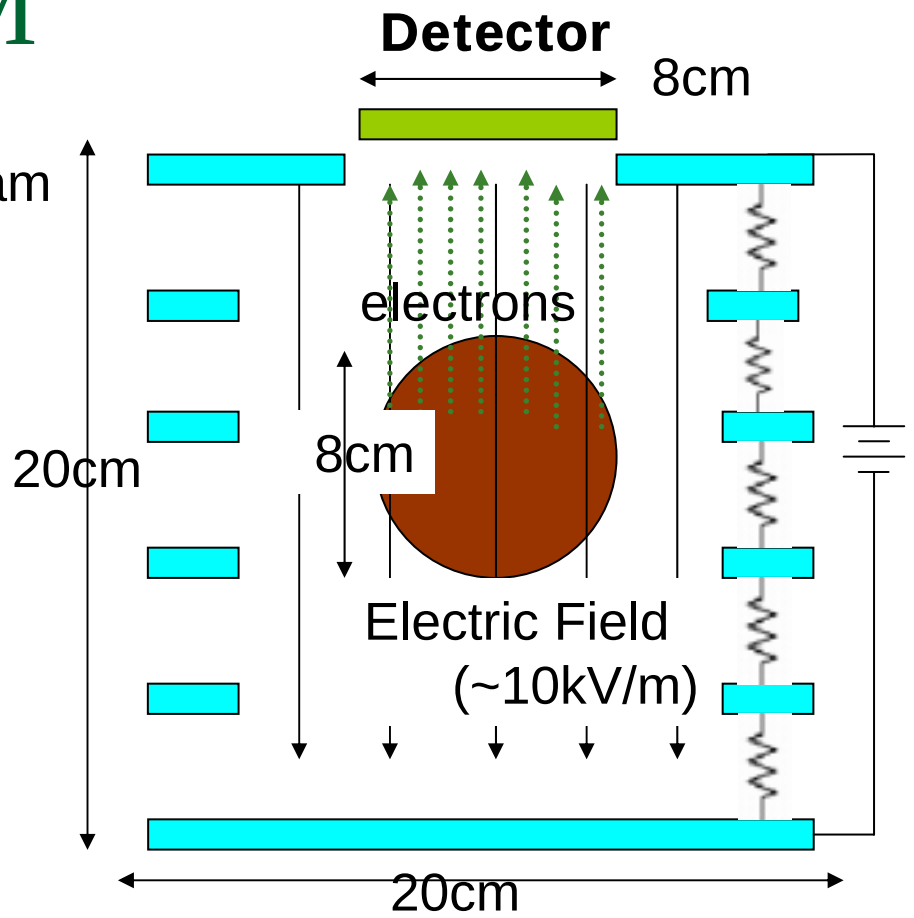
The monitor should cover the 2 orders range.

We develop the Residual Gas Beam Profile Monitor (RGBPM)

→ We plan to install the monitors in Final Focusing section to watch the beam size at the target.
(Small size beam → destroy the target)

Principle of RGBPM

- Residual gas is ionized by proton beam
- Produced electrons are collected by the Straight Electric Field.
- Collected electrons are detected by MCP (Micro Channel Plate) or EMT (Electron Multiplier Tube) equipped with the multi-anodes.



<Advantage>

- Non Destructive
- Cover the wide range of proton intensity → MCP

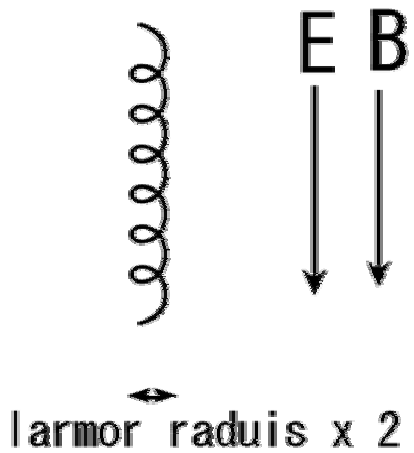
RGBPM at the J-PARC Fast-extracted beam

Fast-extracted beam ⟶ Beam line density is very high

Beam Profile cannot be kept because of the high electric field of the beam.

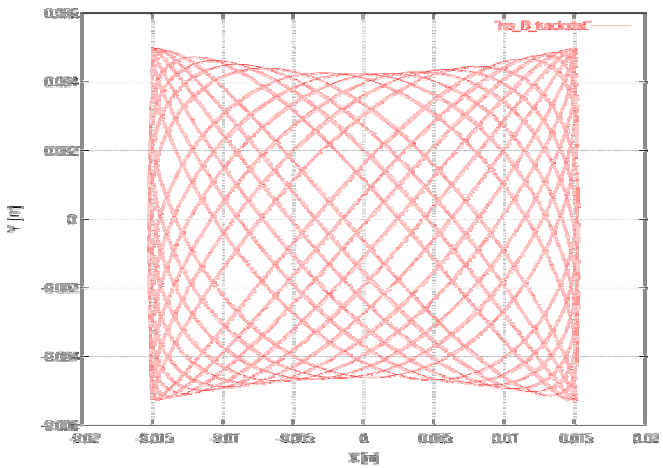
Magnetic Field parallel to the electric field is necessary to keep the profile.

⟶ To obtain ~2mm resolution at J-PARC (Fast), B>0.03T is necessary.

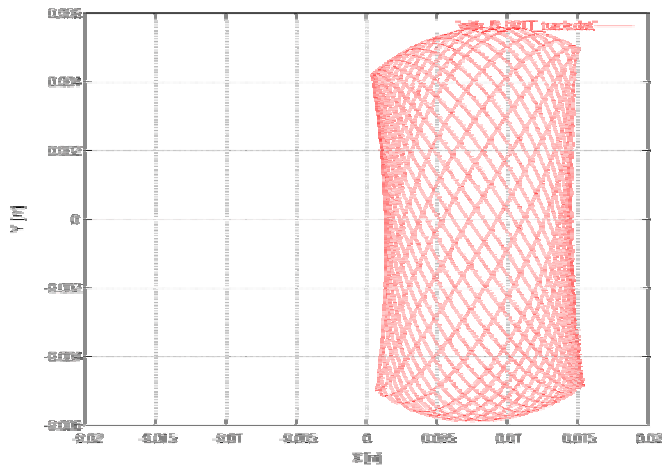


Calculated tracks of electrons in the electric field of proton beam

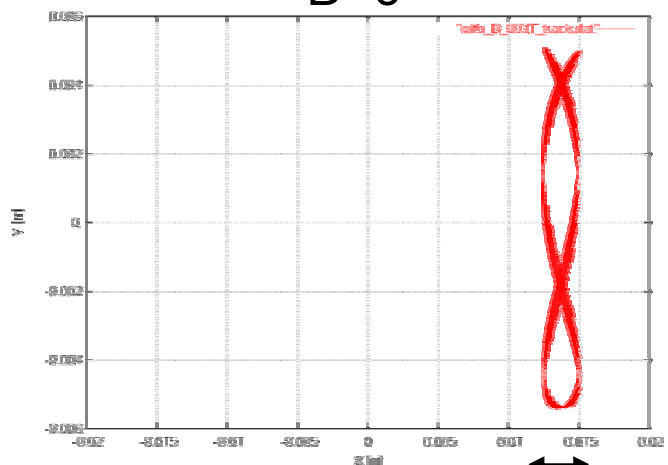
A. Kusaka



B=0

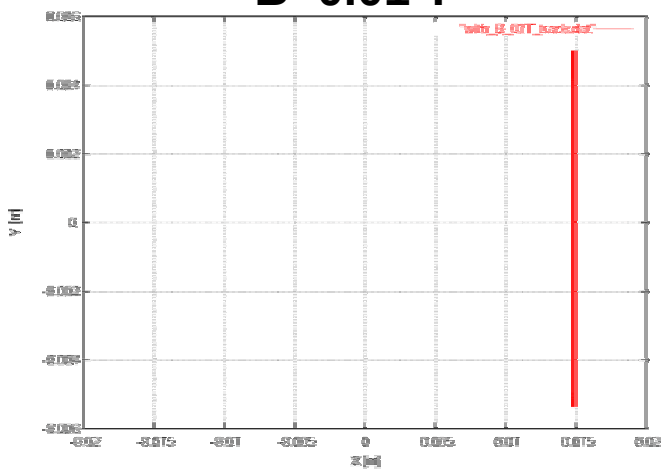


B=0.01 T



B = 0.03 T

~2mm



B = 0.1 T

Tracks during 50 ns

Start point (x.y) = (15mm,5mm)

Estimation of the signals

For J-PARC neutrino beam line,

- Pressure : 10^{-7}[Torr]
- Beam intensity : 3×10^{14}[/pulse]
- Ionization loss in N_2 : 1.83×10^{6}[eV・cm^2/g]
- First ionization energy of N_2 : 35[eV/pair]
- MCP gain : 10^{6}
- MCP channels : 32

→ **Estimated signals of readout = 10^{11}[electrons/ch]**

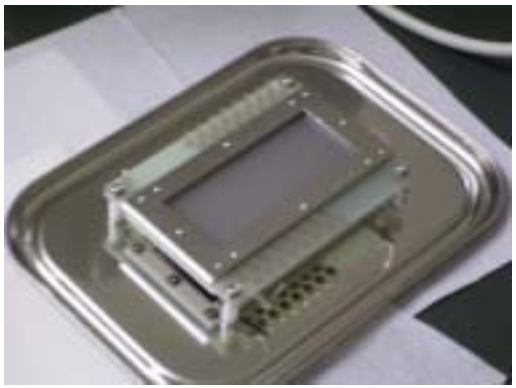
In order to check the basic detector performance, we make a prototype and install it into the K2K neutrino beam line.

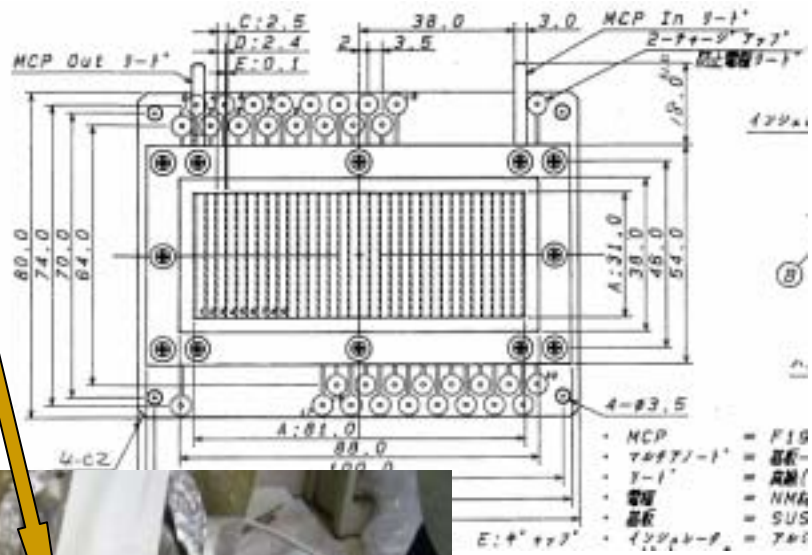
(Estimated signals for prototype at K2K beam line, 10^{10}[electrons/ch])

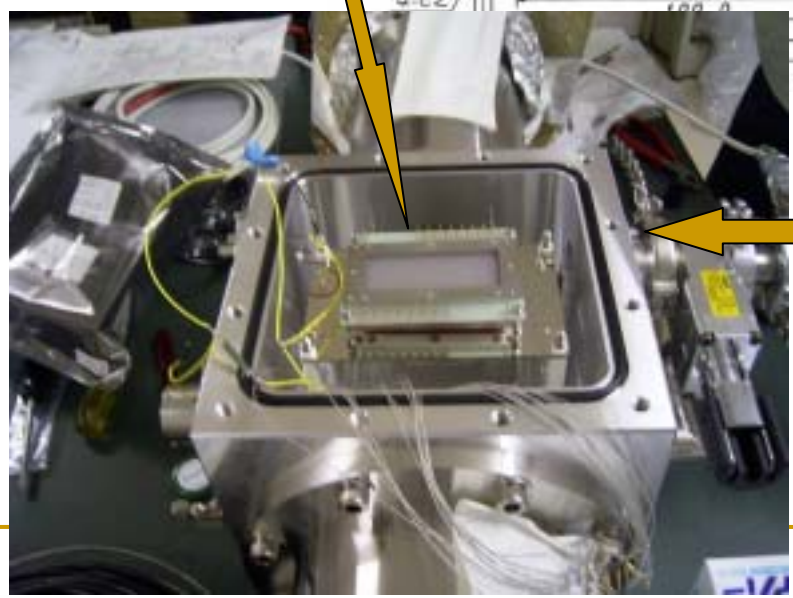
Setup of Prototype Detector

32ch multi-anode MCP(2stages)

80mm



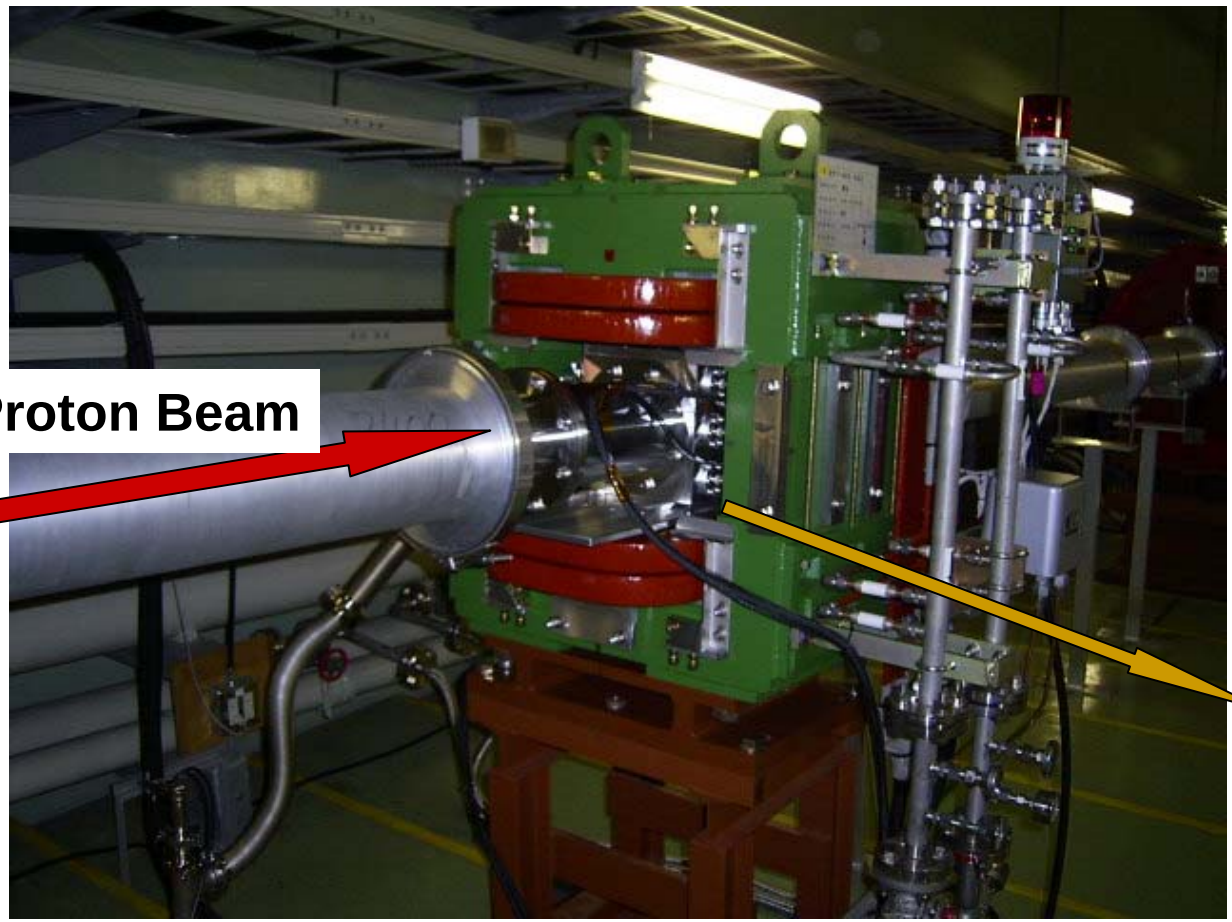




Vacuum chamber
(~5e-06[Torr])

Installation Prototype Detector

@K2K neutrino beam line



Installation in the steering magnet.

B=0~0.5[T]

<Read out>
Oscilloscope
or
FASTBUS ADC

Wave form measured by Oscilloscope

MCP-HV 0.95[kV]

27ch

15ch

6ch

MCP channels

MCP-HV 1.0[kV]

Magnet 0.03T
Electric Field 2kV/20cm

- 9 bunch signals which synchronize with the beam
- Change the MCP-HV → MCP gain is also changed

Summary & Future Plan

For J-PARC Fast-extracted proton beam, we consider to use RGBPM for the profile monitor.

→ To measure the beam profile, **Magnet field (B>0.03T)** is necessary!

In order to check the basic performance of RGBPM, we made a prototype and install it to the K2K neutrino beam line.

→ Basic detector performance has been studied.

In the future,

- Continue detail studies using K2K beam.
- Consider the calibration scheme : using the beam or UV lump?