Simulation of the Beam Commissioning Method for a Muon APF IH-DTL in the J-PARC Muon *g* − *2*/EDM Experiment

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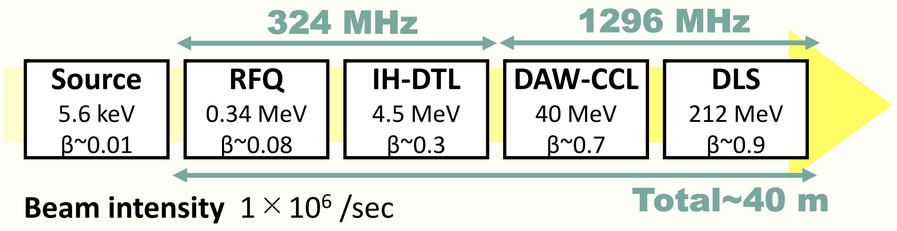
J-PARC Muon *g* − *2*/EDM Experiment

The J-PARC E34 experiment aims to measure the muon *g-2* and the EDM with a high precision by the novel method.

Low-emittance Muon Beam

The low-emittance muon beam can reduce the main systematic errors in previous research [1]. It will be achieved by re-acceleration of ultra-slow muons generated from thermal muonium production and laser dissociation.



Beam intensity 1×10^6 /sec

Transverse emittance (rms, norm.) 1.5π mm·mrad

In order to realize the low emittance beam, beam matching based on the actual profile is important.

Effect of the Beam Mismatching

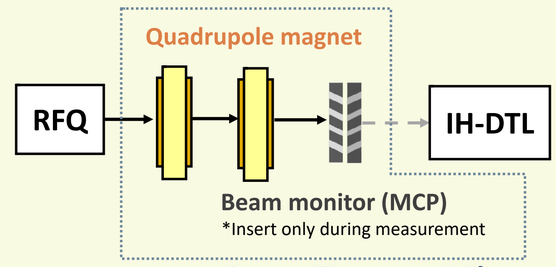
Because **Alternate Phase Focusing (= APF)** scheme is adopted in the IH, the **longitudinal beam matching is especially important** between the RFQ and the IH. Beam matching is performed by **beam adjustment in the beam transport line** which consists of beam monitor, quadrupole magnet and buncher.

Develop of the beam transport line

☑Develop the longitudinal beam profile monitor

☑Study of parameters required for design
- -Estimating beam matching conditions for IH
- -Estimating the effect of beam mismatching

☐Examination of arrangement of quadrupole magnets, beam monitors, etc.



[1] G.W. Bennett et al., Phys. Rev. D 73, 072003, (2006)

Development of the Longitudinal Beam Profile Monitor

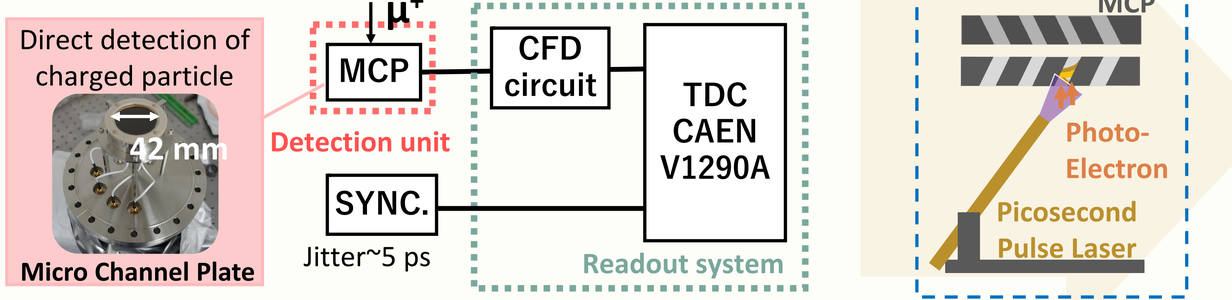
Measure muon arrival time based on reference signal from accelerator.

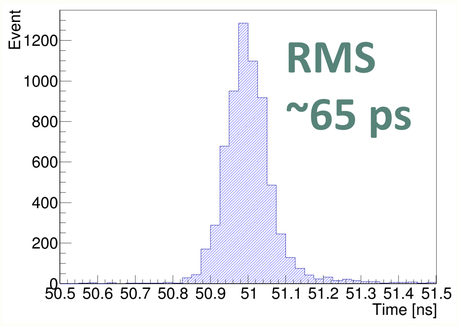
Requirements of the Beam Monitor

- **High time resolution** (better than 40 ps accuracy)
- **High sensitivity to the single muon**

⇒Using **MCP** which has high time response and sensitivity to detect a single muon.

Test Bench
…Uses photoelectrons generated by the picosecond pulse laser (σ ~ 32 ps).

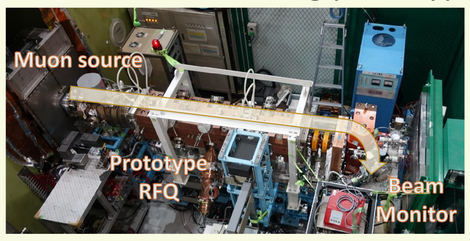




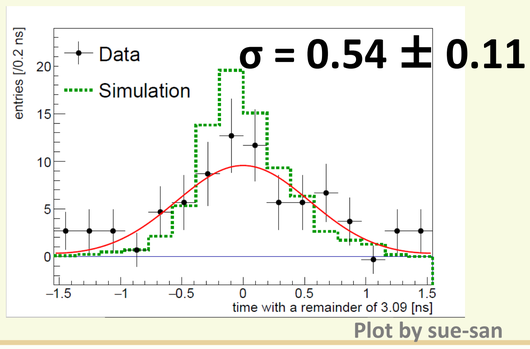
Ensures monitor resolution is better than 65ps. (including the laser width~32 ps)

Longitudinal Profile Measurement

- Measures the bunch width of Mu- accelerated to 89keV using prototype RFQ.



- The bunch width was measured by accumulating a Mu^- event.

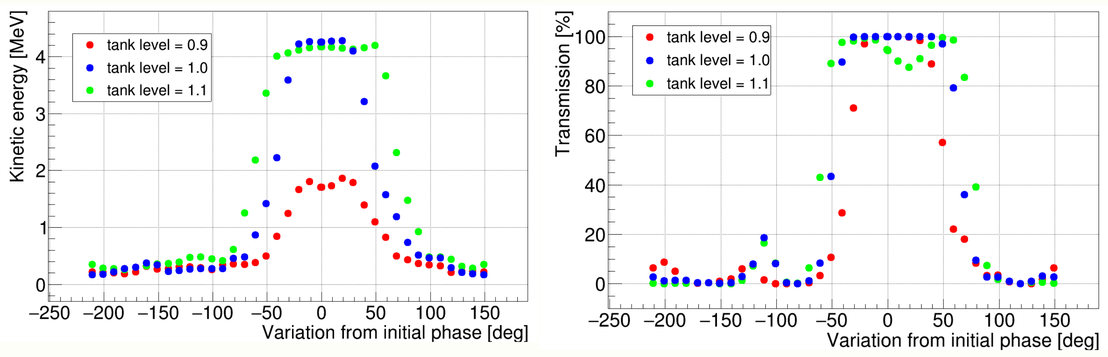


Simulation for the Beam Transport Line

In order to study the matching conditions of IH, particles were generated with a Gaussian distribution according to the Twiss parameter, and simulations were performed using the General Particle Tracer (GPT). IH electromagnetic field is estimated by finite element method (CST MW Studio).

Acceleration cavity adjustment

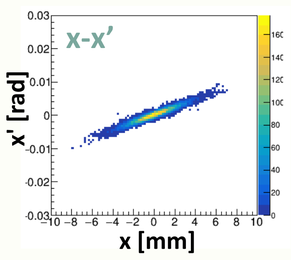
Accelerator voltage (tank level) and RF phase will be tuned by measuring the output beam energy and transmission.

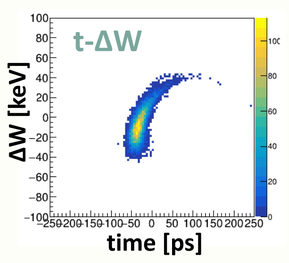


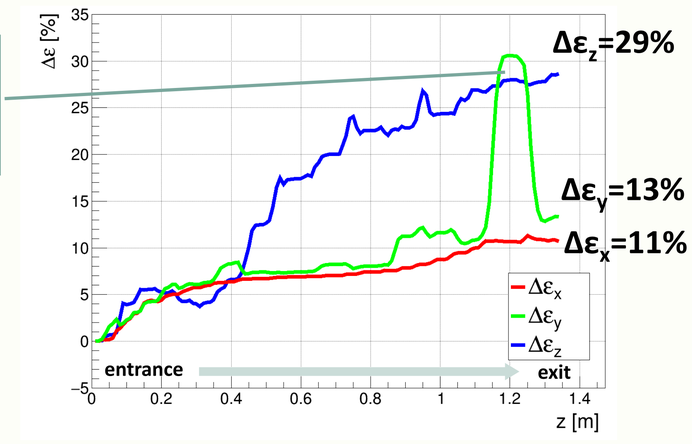
Estimating Beam Matching Conditions for IH

Twiss parameters of the incident beam were adjusted so that the output beam emittance is minimized.

Increase of ε_y at z ~1.2 m is caused by **extra electric and magnetic fields due to the structure of the IH**.







Estimating the Effect of Beam Mismatching

- **Longitudinal direction**

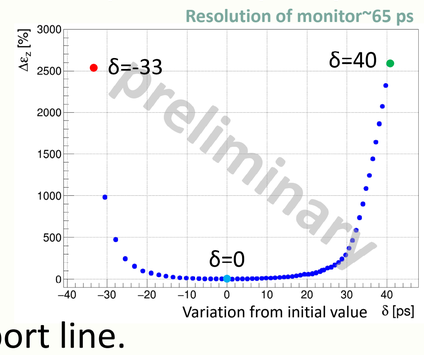
…Up to **27000% increase** in emittance in the z direction in the range of -41 ps <δ <65 ps. Up to **2600% increase** in the range of -33 ps <δ <40 ps.

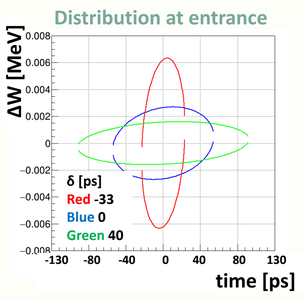
⇒ The effect of mismatch in the longitudinal direction is serious.

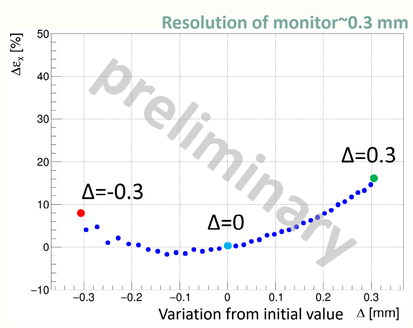
- **Horizontal direction**

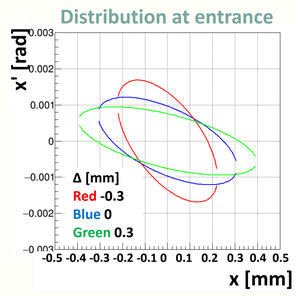
…In -0.3 mm <Δ <0.3 mm, emittance increase is **less than 16%**.

⇒ The effect of the mismatch in the transverse direction is small and within the required value range.









Obtained the parameters necessary for designing the beam transport line.

Plan to re-evaluate after the beam transport line design, and improvement of the monitor is under consideration.

Summary

In order to realize a low emittance beam, we are developing the beam transport line between the RFQ and the IH.

☑We improved the evaluation accuracy of the beam monitor with high time resolution. The result of evaluation measurement is **65 ps in RMS**.

☑We studied the matching conditions for the IH and the effect of mismatch on the resolution of the beam monitor.

⇒We could obtain the parameters used as a guideline for the transportation line design, so that **we will start to design** based on it. We are also considering improving the performance of monitors.

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