Inaugural Symposium, TCHoU, March 27, 2018

Development of TOF detector for Rare-RI ring

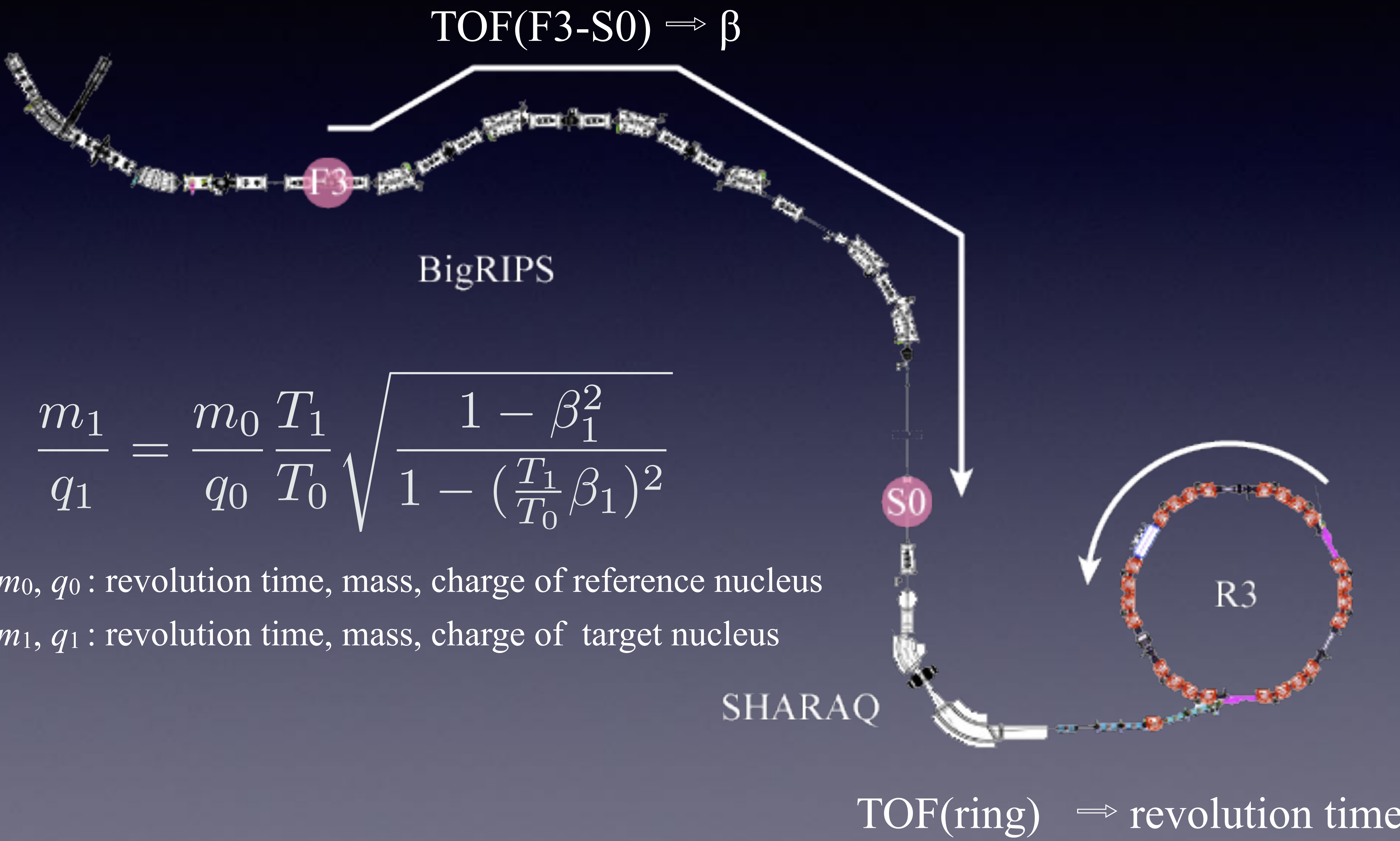
Low energy Gr.
201720248 Daiki Kamioka

contents

- Required performances for TOF detector
- Detector design
- Performance test with the heavy ion beam

Rare-RI Ring

- Development for mass measurement of short-lived RI is in progress…



$$\frac{m_1}{q_1} = \frac{m_0}{q_0}\frac{T_1}{T_0}\sqrt{\frac{1-\beta_1^2}{1-(\frac{T_1}{T_0}\beta_1)^2}}$$

T_0, m_0, q_0 : revolution time, mass, charge of reference nucleus

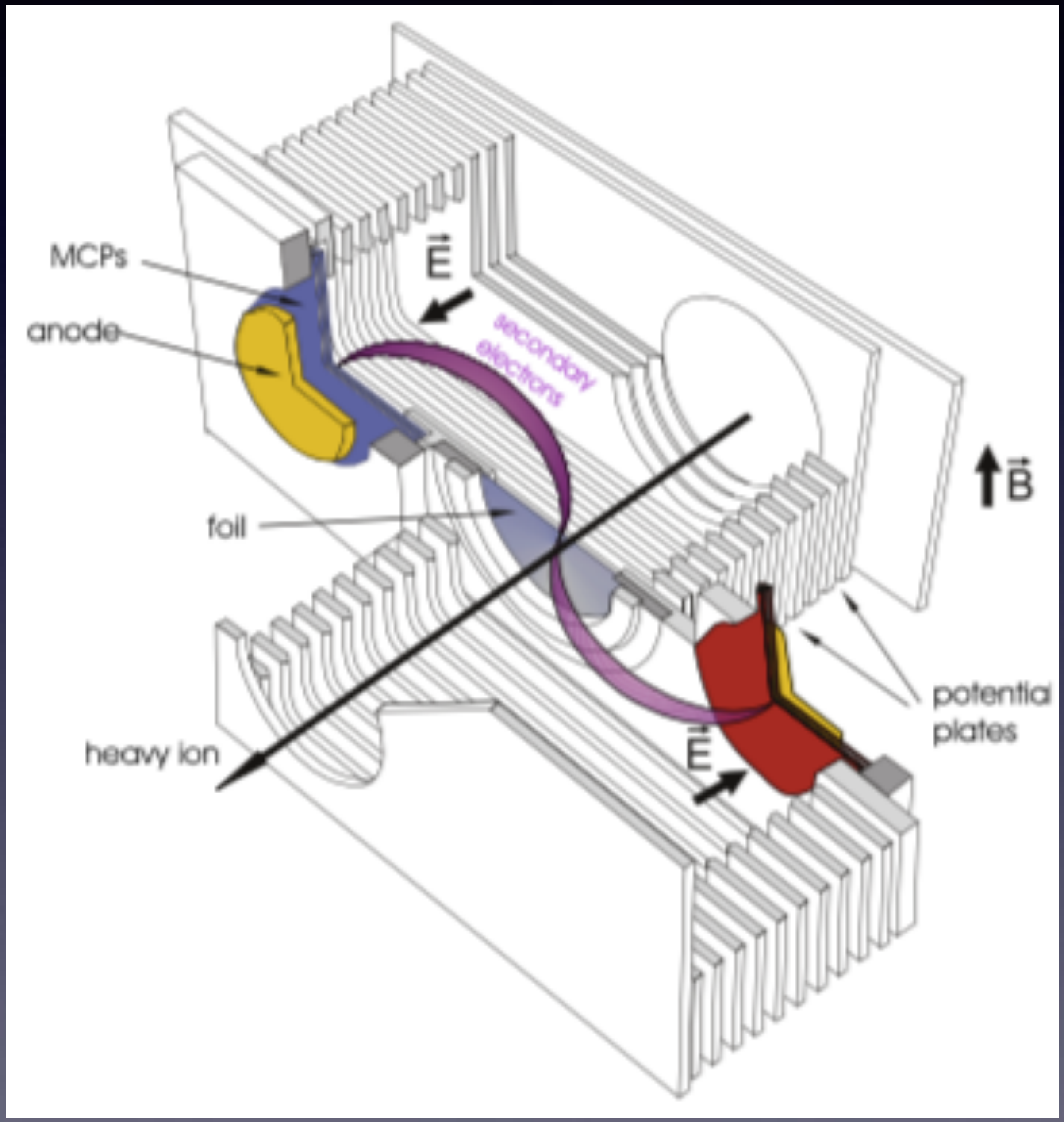
T_1, m_1, q_1 : revolution time, mass, charge of target nucleus

Required performance for TOF detector

1. **Timing resolution σ < 100 ps**
   - ▶ $\Delta(m/q)/(m/q) \sim 10^{-6}$ ➡ $\Delta\beta/\beta \sim 10^{-4}$
2. **Detection efficiency ε ~ 100 %**
   - ▶ production rate of neutron rich nuclei is few counts per day
3. **Detector should be as thin as possible**
   - ▶ the change of ion’s velocity should be less then 10^{-4}
4. **Large acceptance**
   - ▶ excepted beam size is ~ φ30 mm at focal plane

Operating principle of TOF detector

- use secondary electrons emitted from a thin foil where ions pass through



Prog. Part. Nucl. Phys. 73 (2013) 84–140

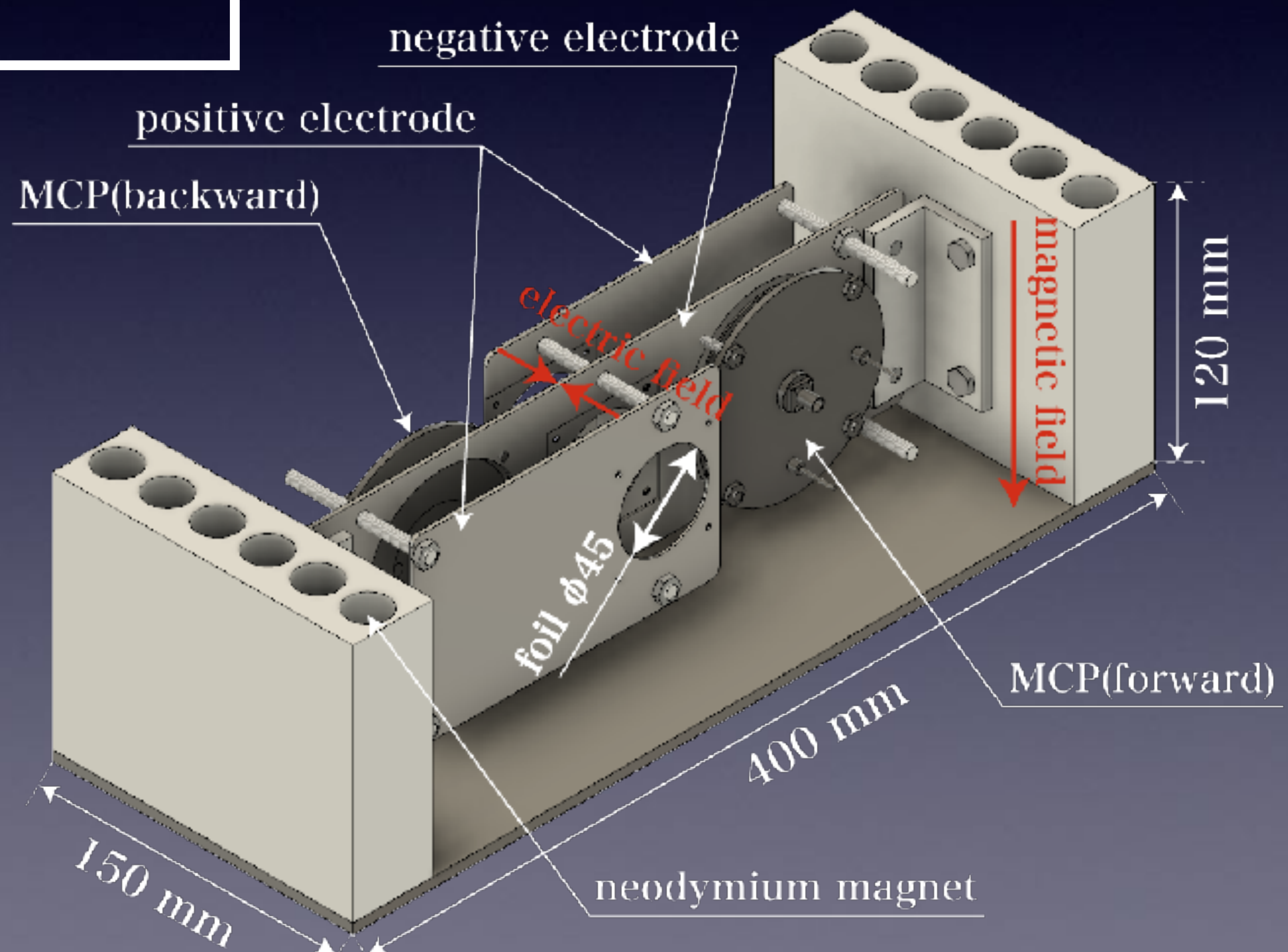
Detector design

<u>Magnetic field</u>：~150 Gauss

<u>Electric field</u>：~580 V/mm

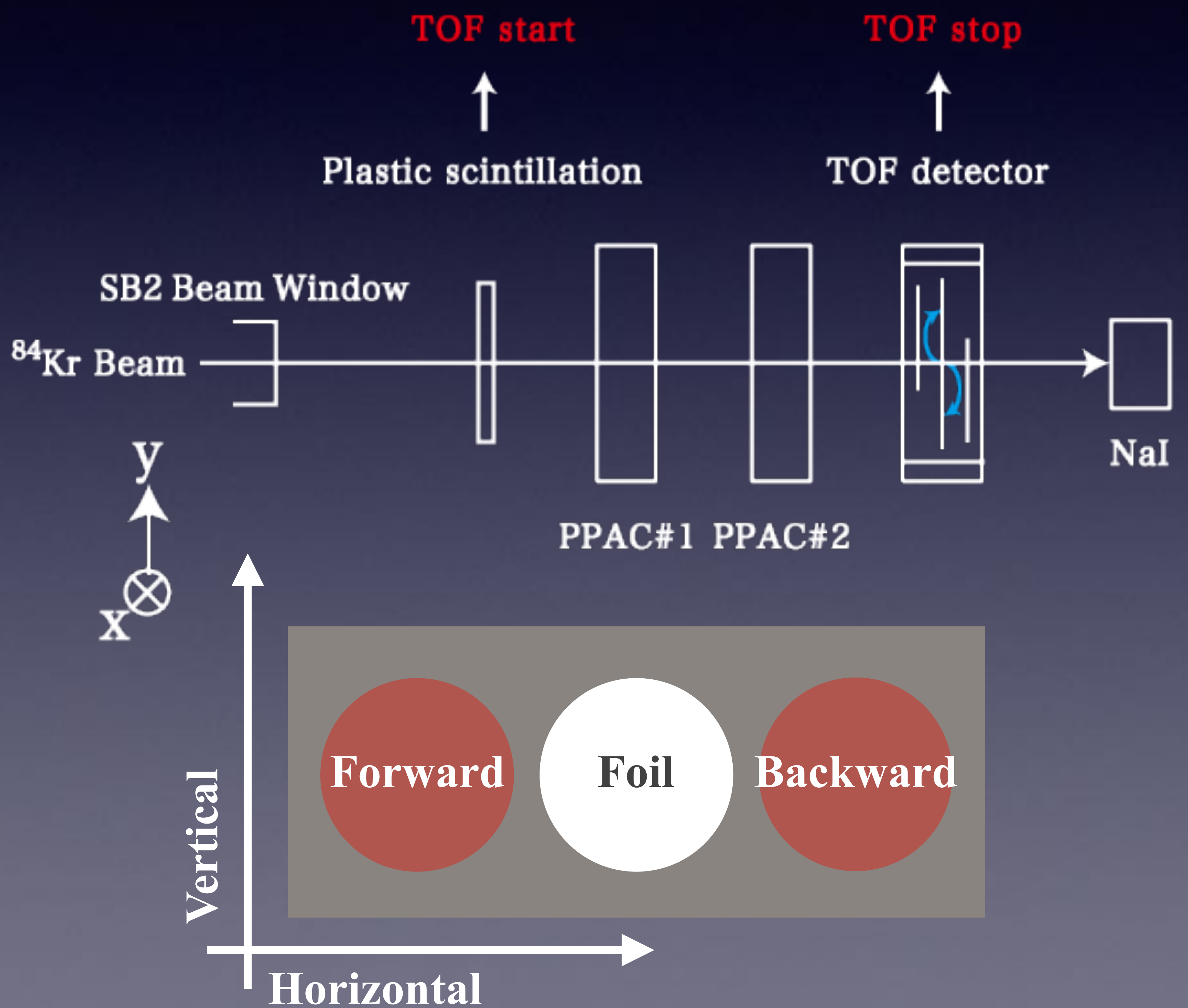
<u>Foil</u>：aluminum coated (~100 nm)
on mylar (1 μm)

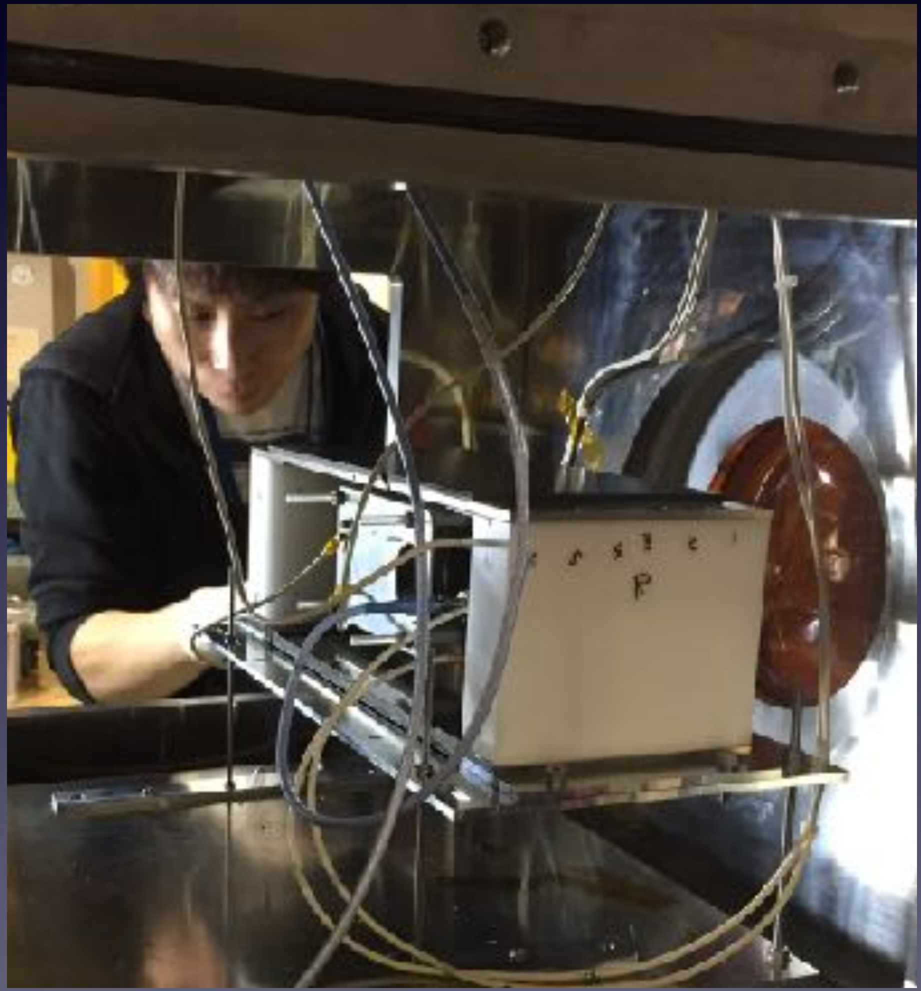
<u>Effective area</u>：~φ40 mm



Experimental setup

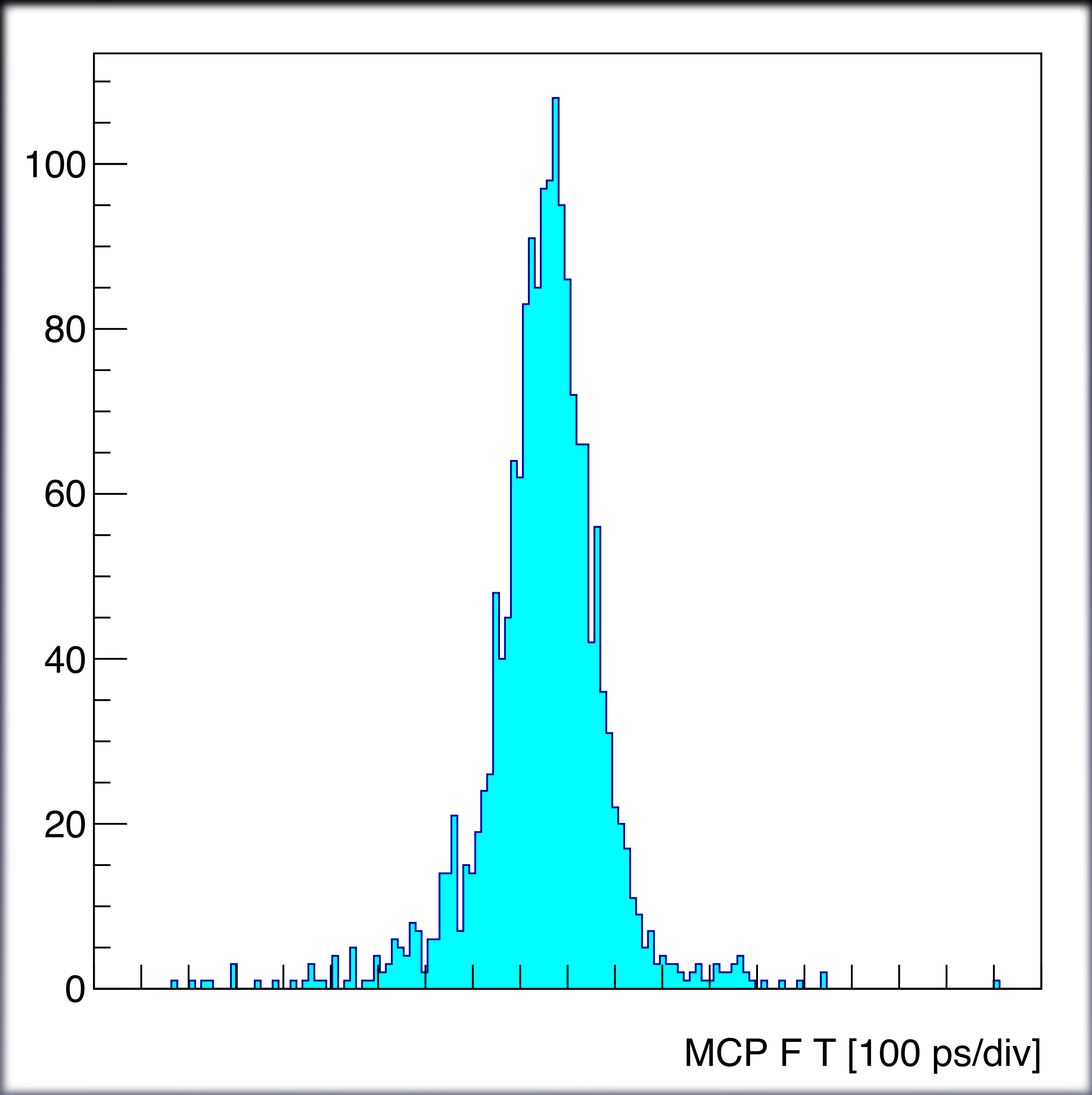
$^{84}Kr^{36+}$ of 200 MeV/nucleon
@ HIMAC(Heavy Ion Medical Accelerator in Chiba) in NIRS





Result

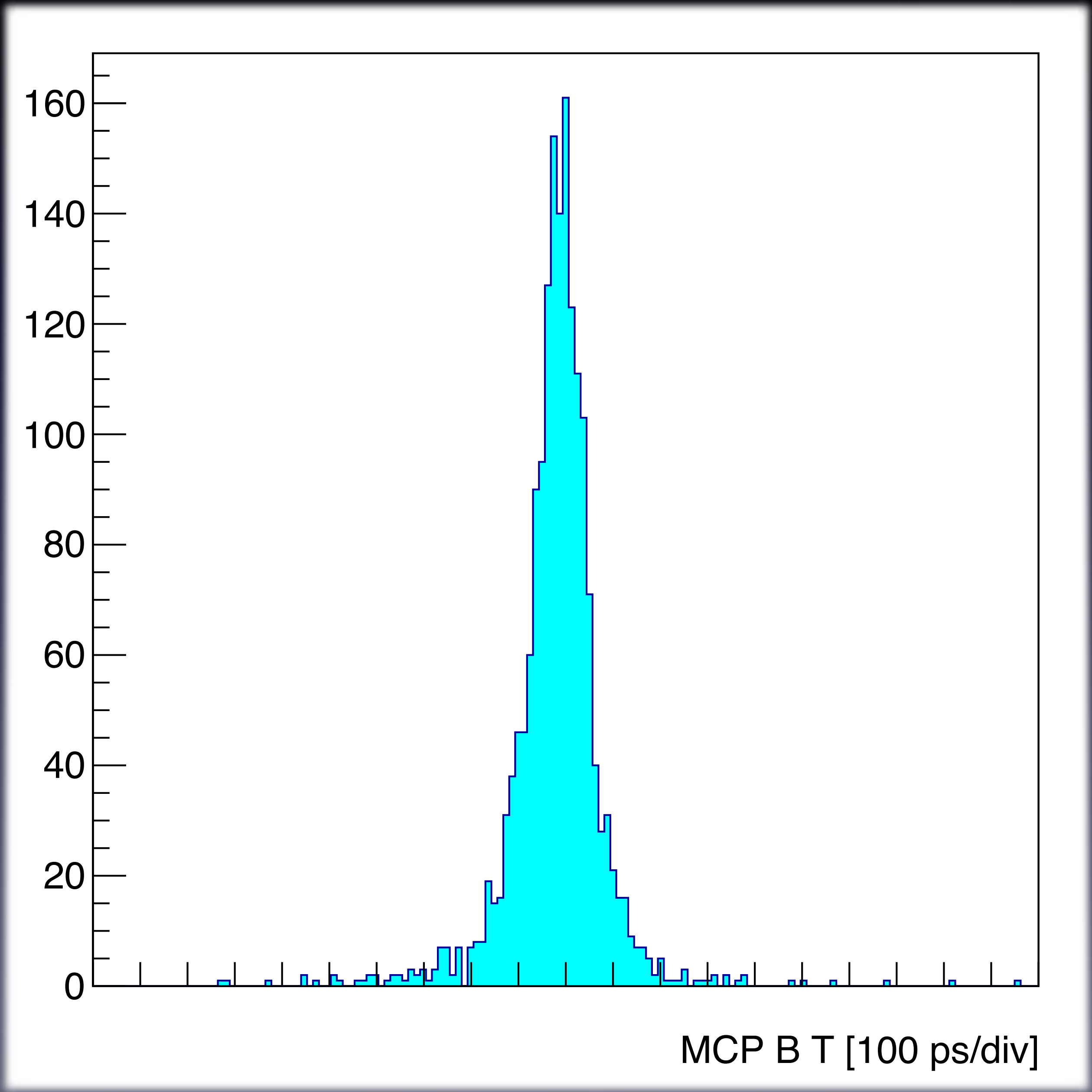
Forward



$$\varepsilon_{\rm F} = 98(7)\,\%$$

$$\sigma_{\rm F} = 86(3)\,\rm ps$$

Backward

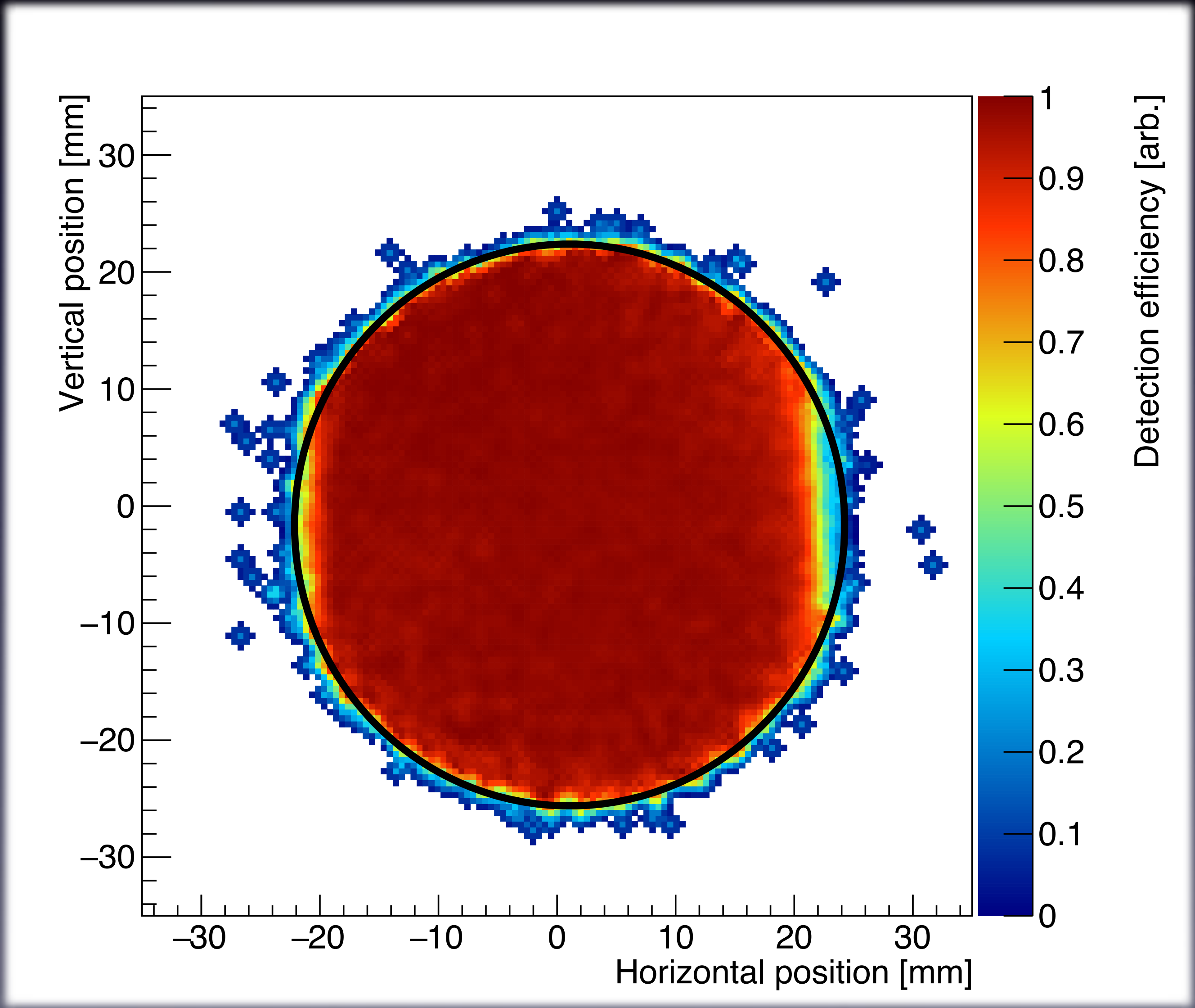


$$\varepsilon_{\rm B} = 96(7)\,\%$$

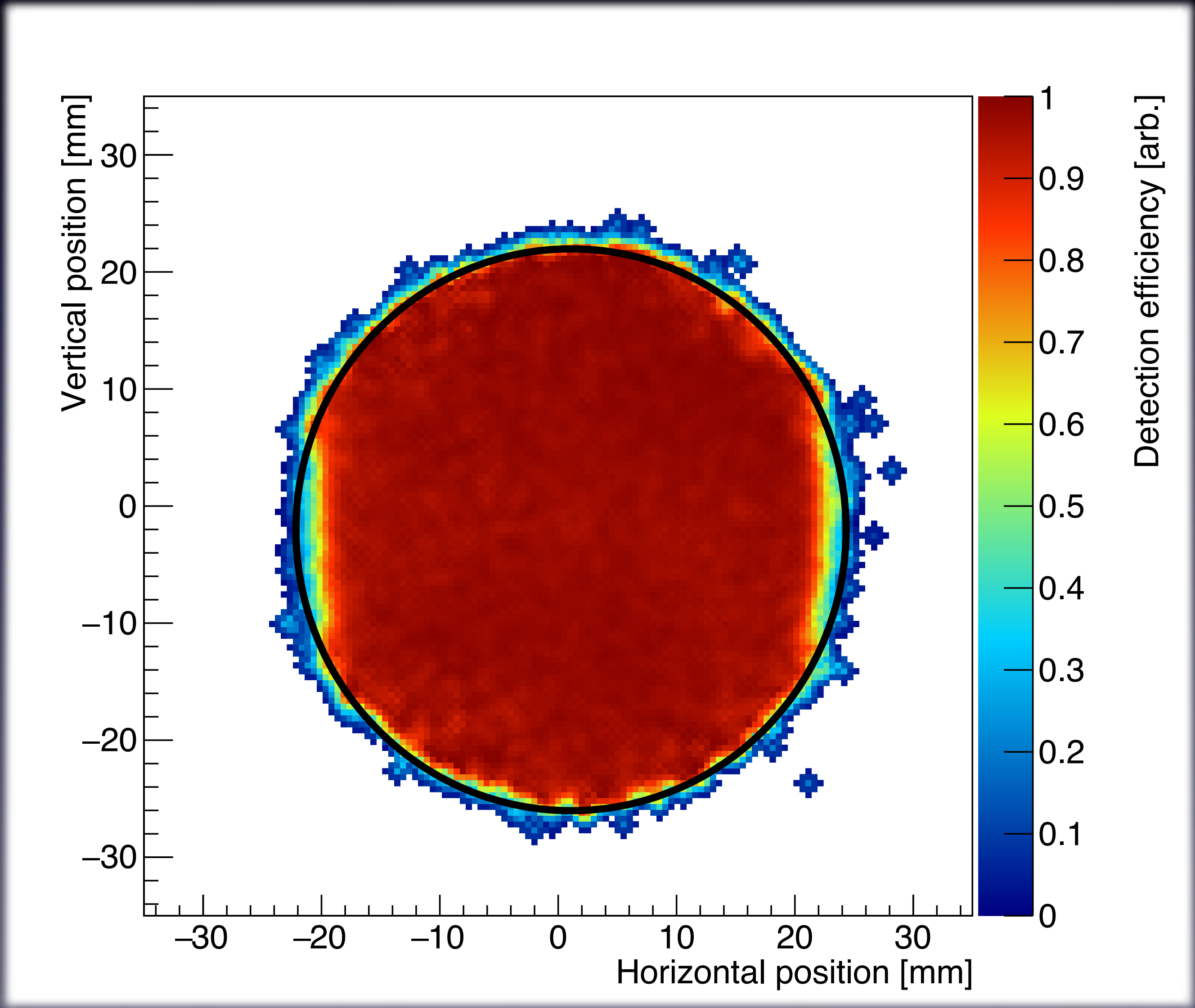
$$\sigma_{\rm B} = 53(2)\,\rm ps$$

Position dependence of detection efficiency

Forward



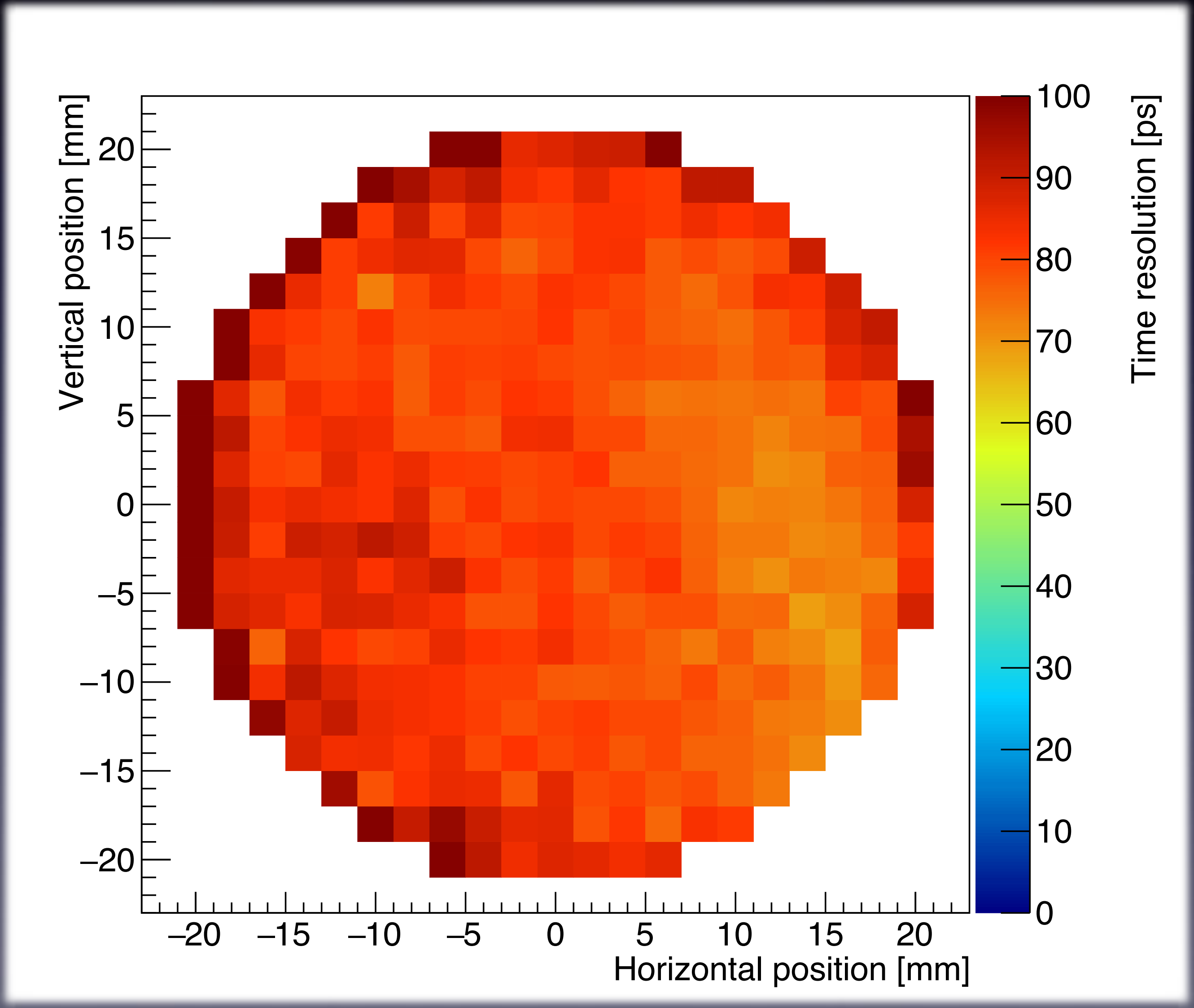
Backward



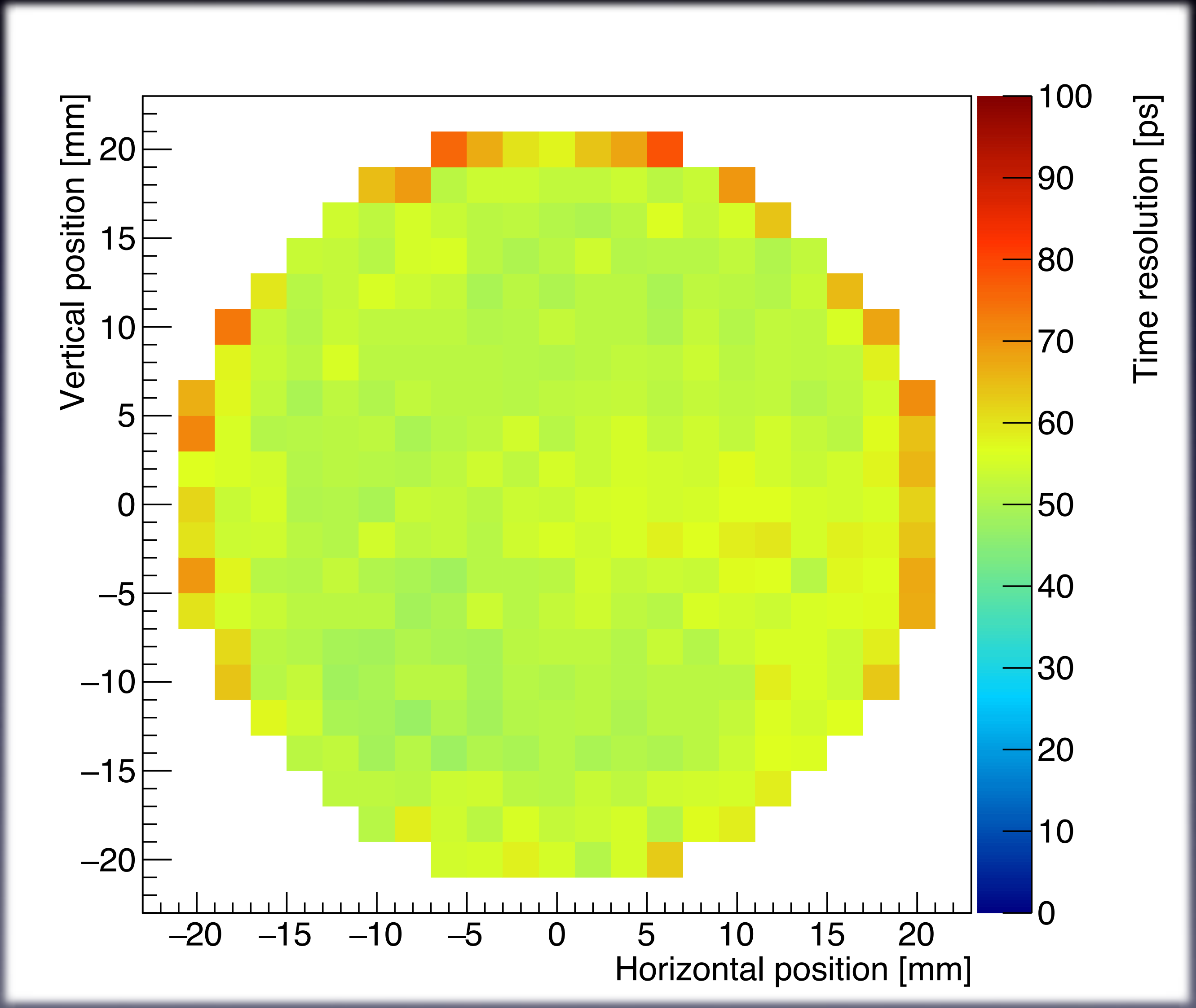
- Almost 100 % in the whole region of the foil

Position dependence of timing resolution

Forward



Backward



- Large beam position dependence is not seen in timing resolution.

Summary

- We are developing the TOF detector which measures both **velocity and revolution time** in R3. The detector uses **secondary electrons** emitted from a thin foil where ions pass through.
- We use **aluminum (~100 nm) coated on mylar (1 μm)** for a thin foil .
- The timing resolution achieved **less than 100 ps**, the maximum detection efficiency recorded **98 %** and both forward and backward electrons were detected with high efficiency in **the whole region of the foil**.
- Large beam position dependence is not seen in detection efficiency and timing resolution.