

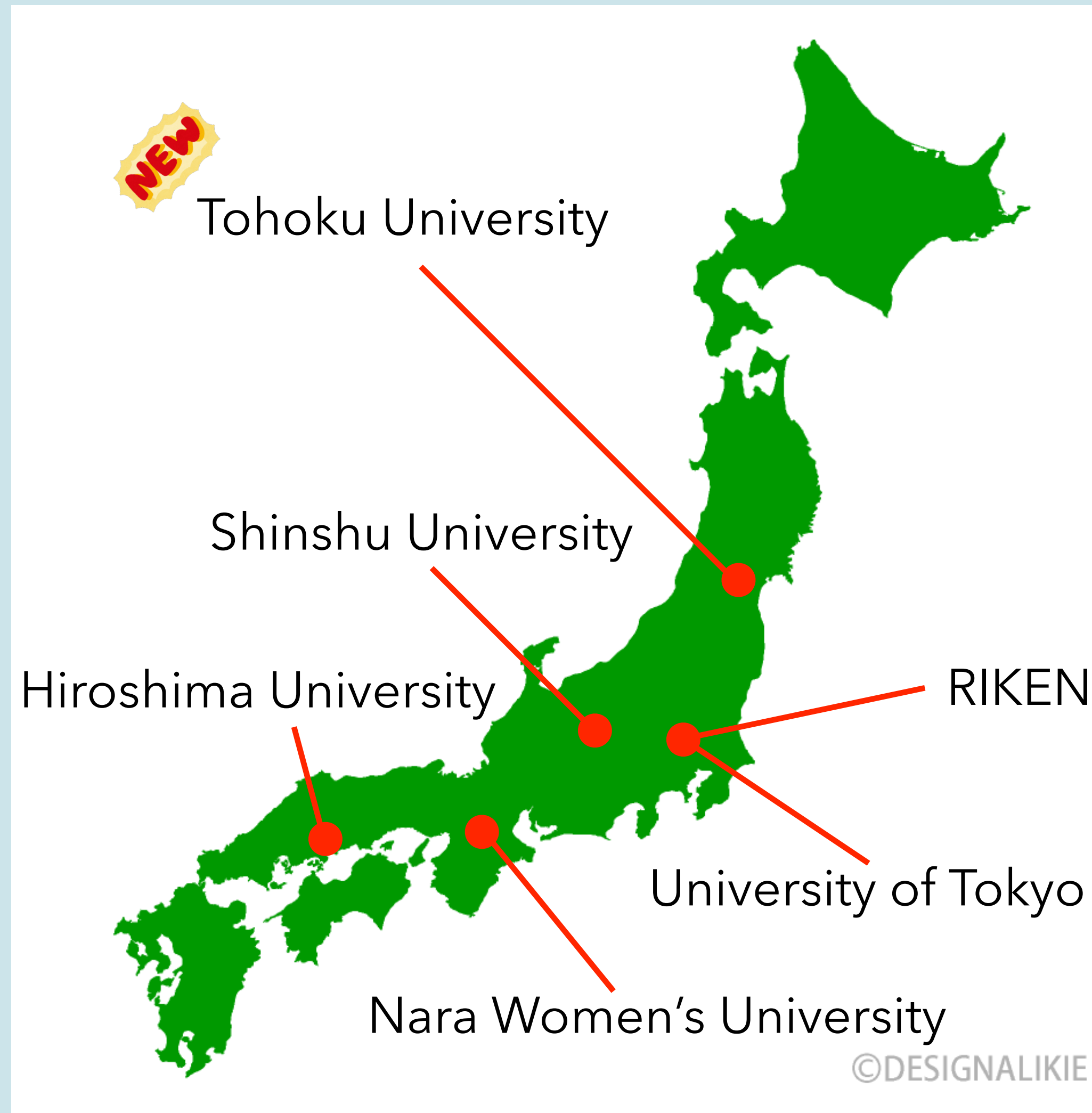
# Summary

## TOF-Japan ~~meeting~~ activities

*Satoshi Yano (Hiroshima University)*

*TIC meeting on 11/11/2024*

# Organization of TOF-Japan

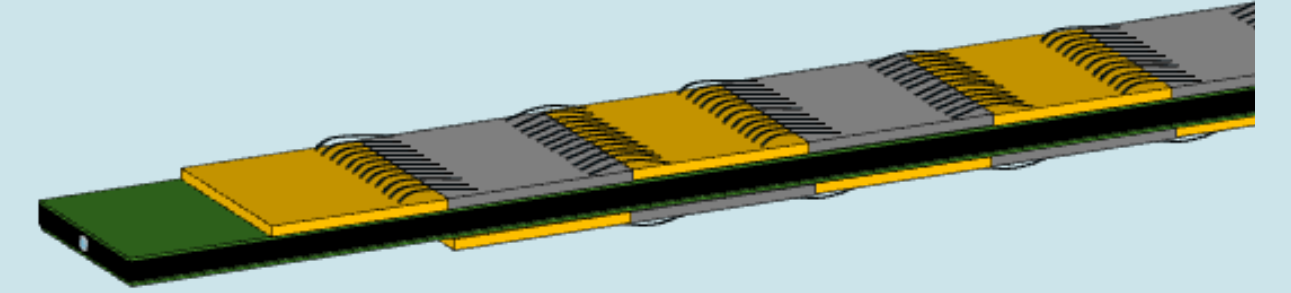


- The Japanese community has committed to the AC-LGAD TOF project
  - Especially, we focus on the BTOF part
- Recently, Tohoku University has participated in the project officially
- The institutes are working on,
  - Simulation (background & material budget)
  - Long FPC design
  - Sensor R&D
  - Assembling & Construction
- TOF-Japan meeting ([link](#)) is held every Wednesday (10:00JST → 20:00EST)



# Summary: Assembly & Resource

- Construction has begun on a new building to house TOF's development and assembling room
  - The building is scheduled to be completed by the end of 2025
- There is one 100 m<sup>2</sup> 1,000 ~ 10,000 class clean room that we can use for BTOF
  - Wire bonding machine, probe station, laser system and other equipment will be installed here
- We are discussing whether to build another site at RIKEN
  - The site will be used not only by BTOF but also by ZDC activities
- We requested a large amount of budget for our government to succeed in the ePIC project
  - BTOF is one of the main projects in the plan (\$10M order)
  - The official conclusion will be public this December



Japan to Join Electron-Ion Collider Accelerator Construction Project; Potential Boost for Quantum Computer Technology



The Education, Culture, Sports, Science and Technology Ministry building in Tokyo

The Yomiuri Shimbun  
© 15:47 JST, May 15, 2024

Japan will participate in a U.S. project to build a large electron-ion collider (EIC), a particle accelerator capable of observing the world at the level of one trillionth of a millimeter, it has been learned.

The EIC is expected to shed new light on the physical laws governing the subatomic world and contribute to the practical application of advanced technologies such as quantum computers.

The Education, Culture, Sports, Science and Technology Ministry plans to announce soon its intention to participate in the plan, with the goal of starting operations in 2032.

The state-of-the-art EIC accelerator, a circular experimental facility about 3.8 kilometers in circumference, will be built by Brookhaven National Laboratory (BNL) in New York, part of the U.S. Department of Energy.

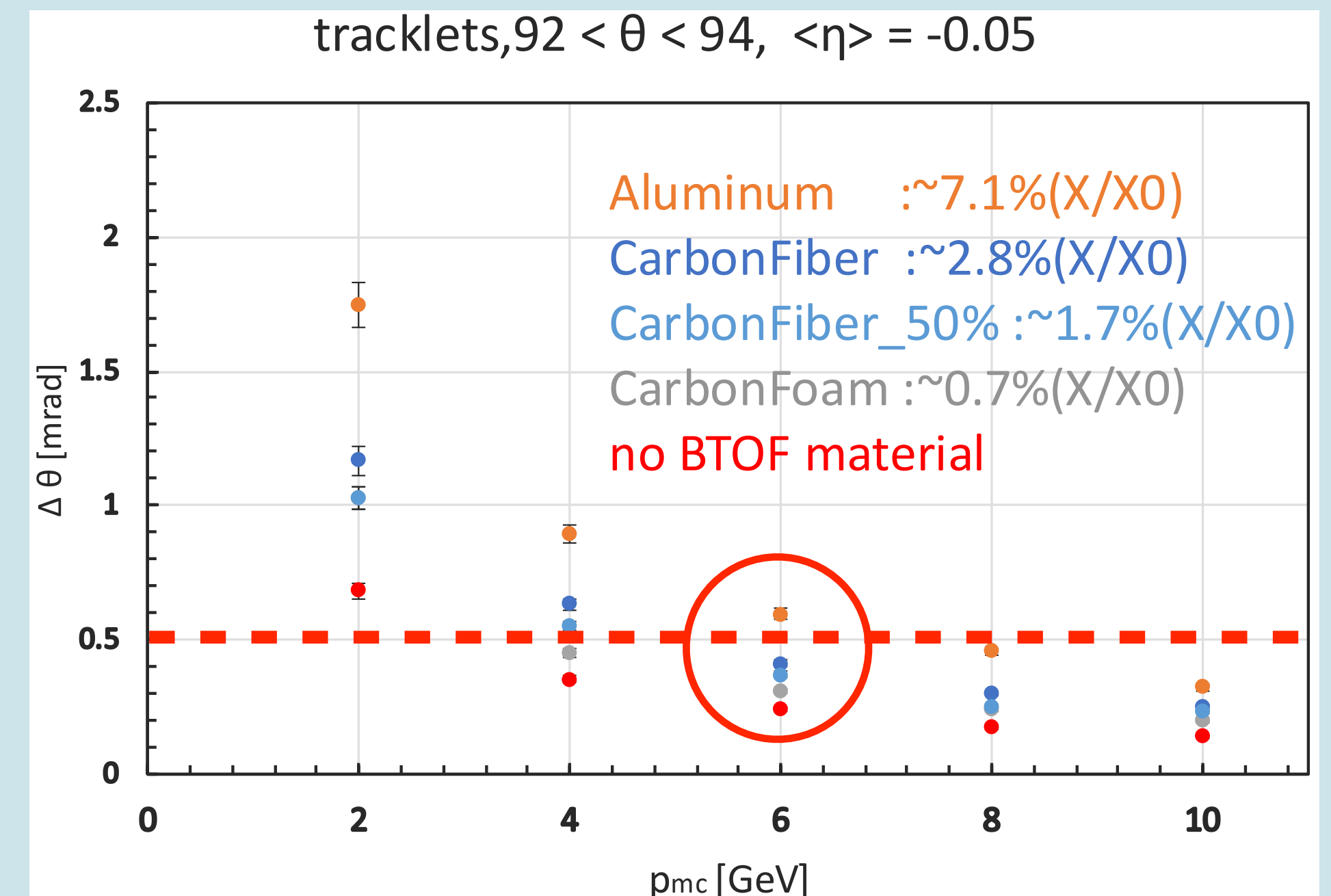
BNL plans to replace the existing accelerator in the basement of the building. Construction is scheduled to begin in 2026, with operations beginning in 2032.

[News link \(English\)](#)



# Summary: Simulation

- Shunichiro Muraoka (Hiroshima University) is studying the BTOF material budget effects on the other detectors
- The total material budget of  $\sim 1\%$  is requested by hpDIRC and BEMCal, so long ( $>1.3$  m) and low material budget FPC has to be developed
  - Making such FPC is as difficult as making a sensor with high timing and spatial resolution
- However, no studies clarify how much BTOF material budgeting is acceptable
  - If this constraint could be relaxed, it would greatly increase design options
  - Full simulation (EICRecon) is used to clarify the point
  - The angle resolution of the reconstructed track is used to evaluate the hpDIRC PID performance
  - The requested value is 0.5 mrad @ 6 GeV/c
- The material budget of **2.8%** is still below the required angle resolution (this result is work-in-progress)
- By varying the material budget, the electron detection performance is being estimated as well



# Summary: Electronic

- Takashi Hachiya (NWU) is working on the FPC design
  - FPC design is still difficult despite relaxed conditions
  - The first one is designed with ETROC2
- We visited HAYASHI-REPIC CO. Ltd. to discuss how to cooperate with the AC-LGAD TOF project
  - The company made the long & low material FPC of sPHENIX
  - The mass production of the ATLAS Strip tracker for the upgrade is ongoing
- The FPC design depends on the ASIC design, so enhancement of the ASIC development environment is essential
  - We plan to push the development strongly because every component is connected to the ASIC
  - Currently, we don't have any ASIC to test the readout chain and assess the performance
  - We have a sense of urgency in the development of ASICs
  - As soon as we get the budget, we would like to establish a cooperative relationship with eRD109 and proceed with the development

BEX

- Cable design (prototype)
  - Dimension (L x W): 120 x 5 cm<sup>2</sup>
  - 4 layers (signal, 2xGND, PWR):  $X = 0.8\% X_0$ 
    - Cu : 12um thick per layer + 30 um Cu plating on surface
  - Lines : 124 lines (Line and space : 130 & 130 um)
  - $Z_{diff}$  : 100Ω by strip line structure
    - Signal layer is sandwiched by GND layers
  - Liquid Crystal Polymer (LCP) as substrate
    - Less signal loss due to low di-electric constant &  $\tan(\delta)$
    - Thick LCP available for  $Z_{diff}$  : 100um

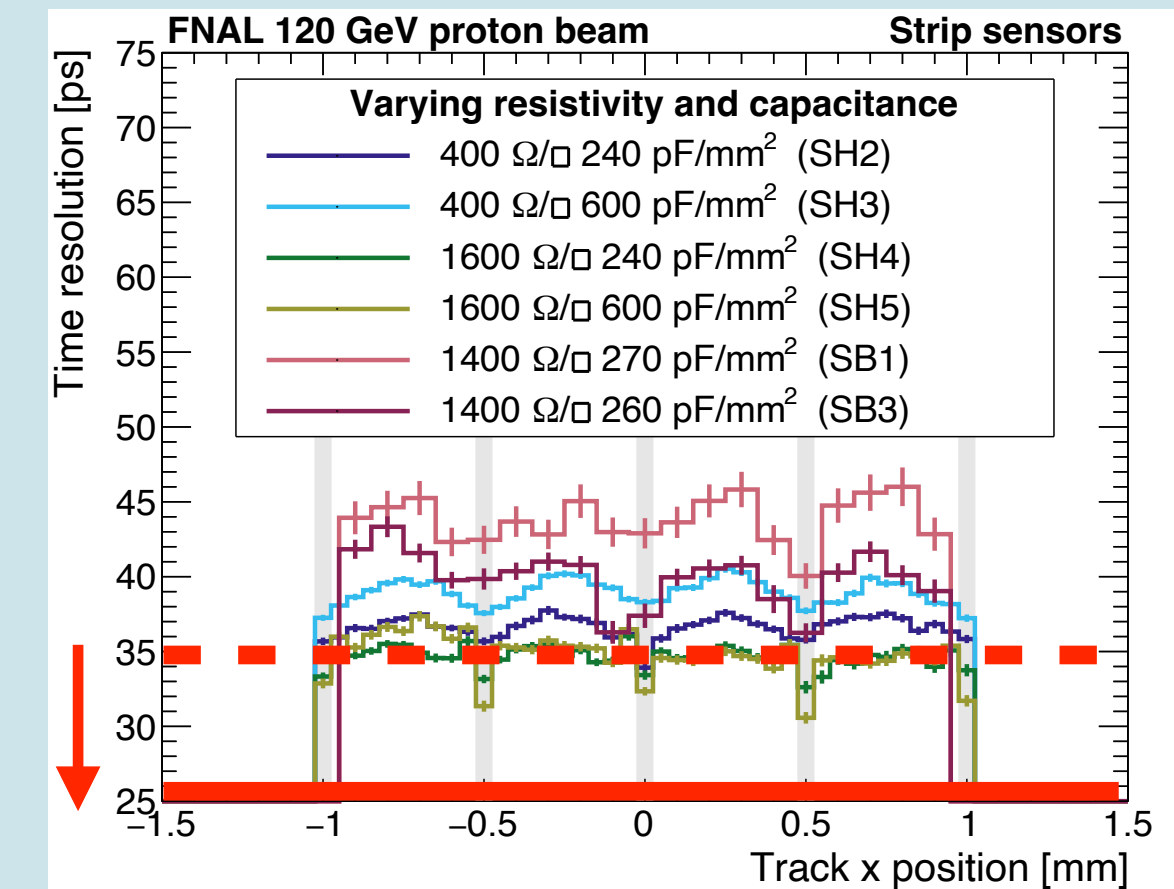
4 layers laminated by the adhesive sheet



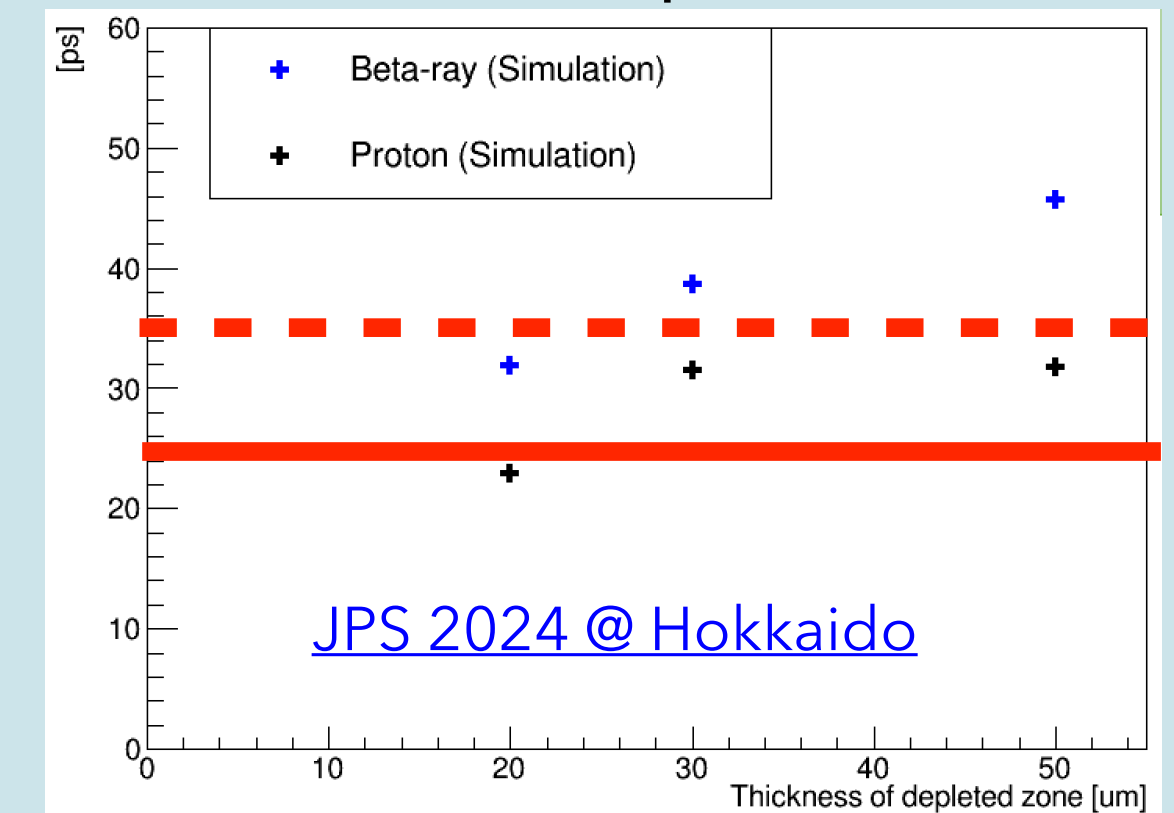


# Summary: AC-LGAD Sensor

- Hiroshima University has built the AC-LGAD sensor R&D test bench
  - 90Sr radiation source is used for the fast sensor test of timing & positioning resolution
  - IR laser system will be installed in 2025
  - Hiroshima University has participated in eRD112 member from FY25
- We are planning to test higher-timing resolution sensors
  - **$\sigma_{\text{Sensor}} = 25\text{ps}$  is necessary** when  $\sigma_{\text{ASIC}} = 20\text{ps}$  and  $\sigma_{\text{T0}} = 15\text{ps}$  are assumed ( $\sigma_{\text{total}}^2 = \sigma_{\text{sensor}}^2 + \sigma_{\text{ASIC}}^2 + \sigma_{\text{T0}}^2$ )
  - Thicker sensor has better timing resolution ( $\leq 20\mu\text{m}$ ?)
  - We will contact HPK to ask if they can manufacture such a thickness sensor
  - We want to build a mutually complementary relationship with eRD112



## Performance prediction



# Summary

- The ePIC Japanese team is working on AC-LGAD BTOF
  - We have the weekly meeting on Wednesday
- Full MC simulation with EICRecon is used to recalculate the really necessary material budget requirements
- We are designing long and low-material FPC
  - This is very important not only to TOF but also to other detectors and very very very challenging items to realize TOF
  - We are preparing to promote ASIC development with ASIC development team
- We would like to promote AC-LGAD sensor development with both sides complementing with eRD112