

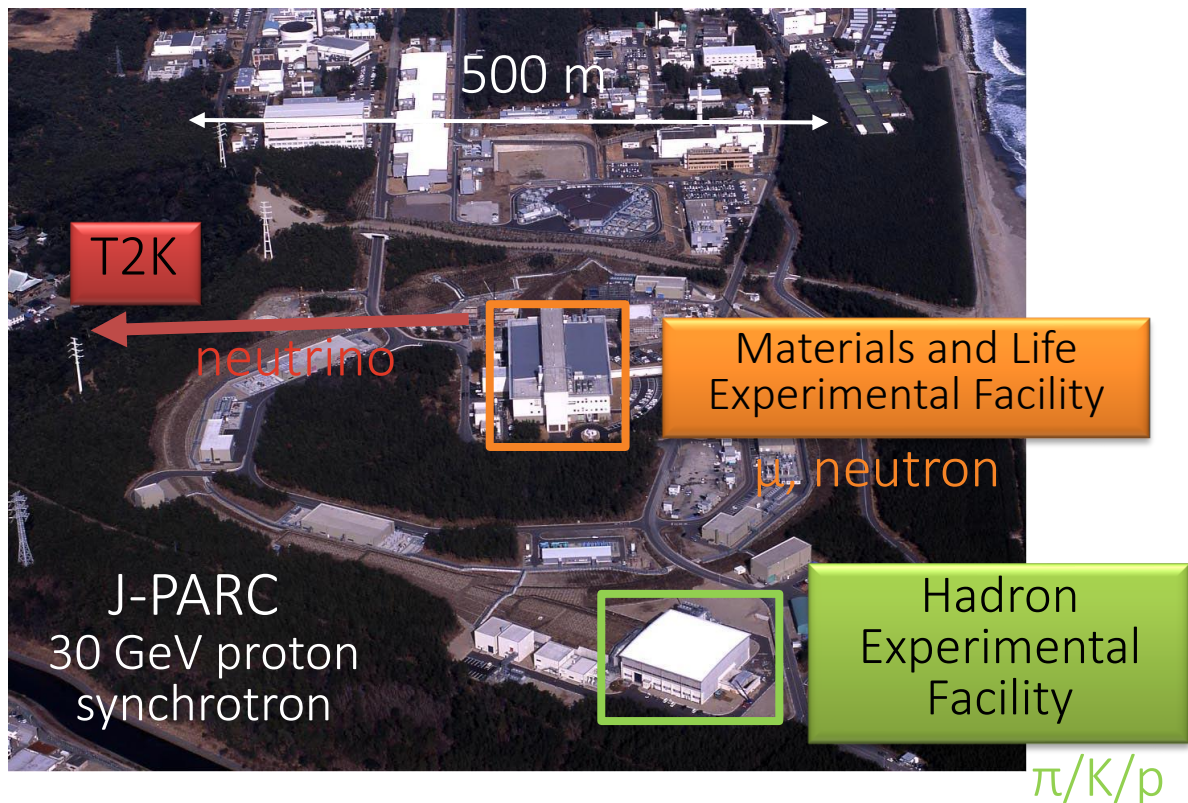
Development of MRPCs for J-PARC and muography

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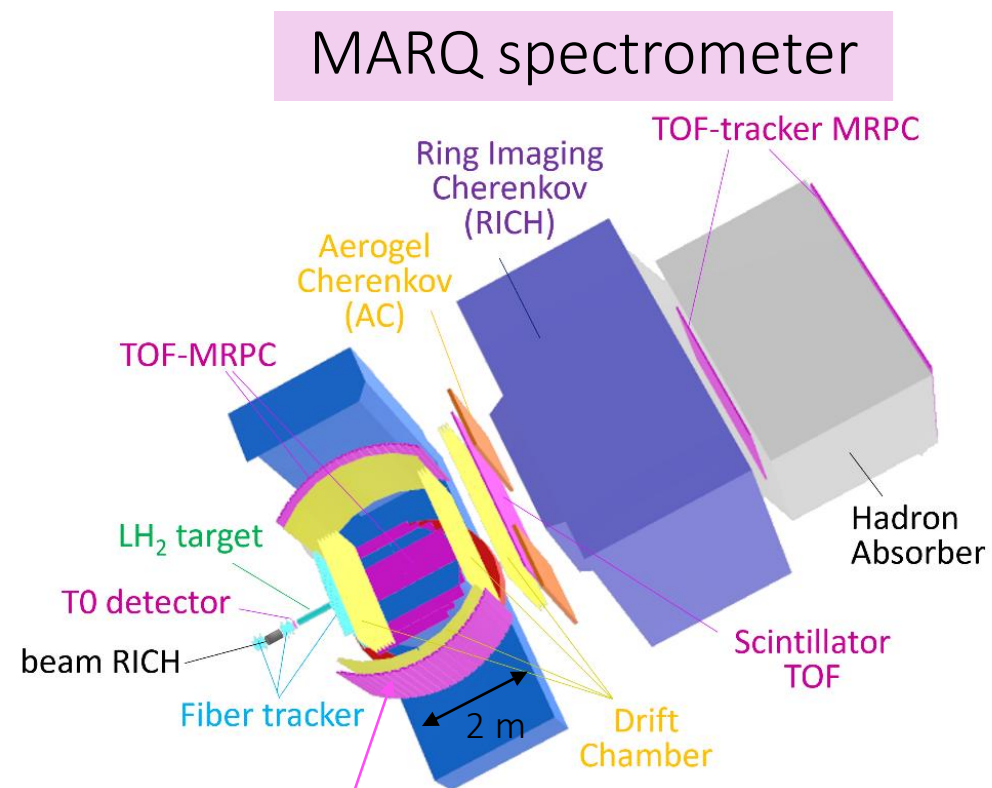
2026/9/14-18

XVIII Conference on Resistive Plate Chambers and Related Detectors (RPC2026)
Rio de Janeiro State University

J-PARC MARQ experiment



- π 20 beamline at Hadron Experimental Facility
 - New 2-20 GeV/c secondary beamline
 - First test beam extraction in 2025
 - Constructing MARQ spectrometer
 - Hadron spectroscopy
 - Nucleon structure



TOF MRPC Pole face + Wall ($\sim 11 \text{ m}^2$)

Goal : $\sigma_{\text{time}} = 60 \text{ ps}$ $\pi/K/p$ PID

Rate $< 100 \text{ Hz/cm}^2$

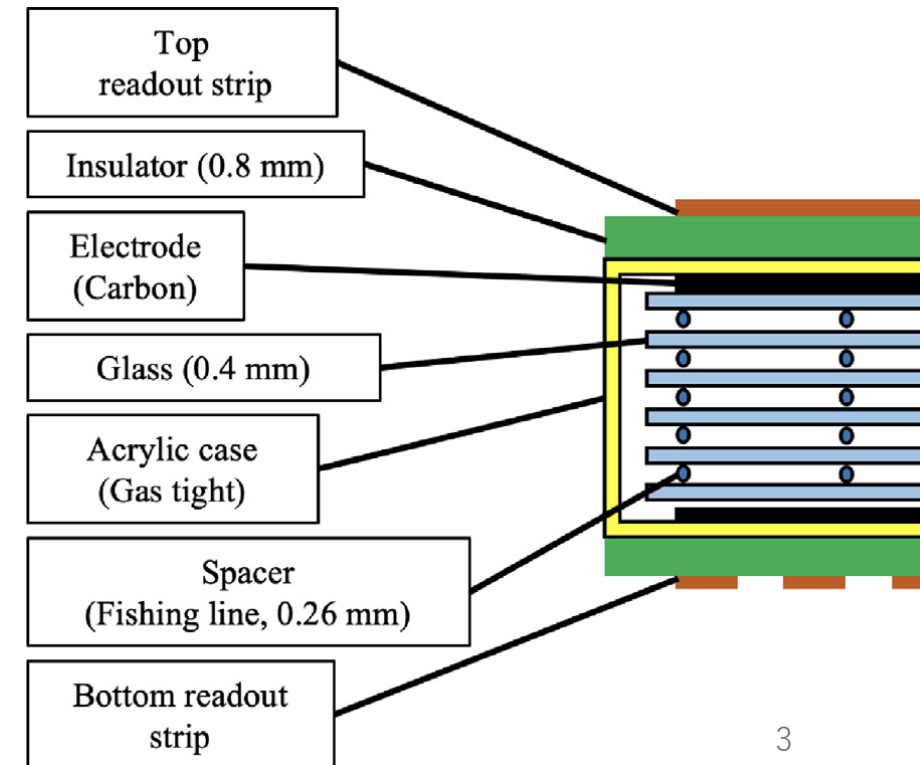
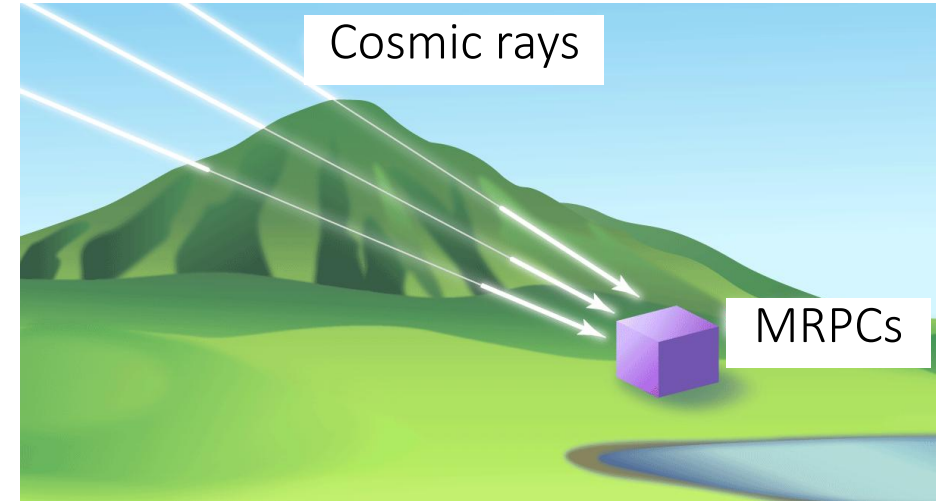
Partially share modules with the E88 experiment (H. Sako, next speaker)²

Muography

- Novel detector sensitive to both timing & position in good resolutions
- Energy selection with TOF depending on measurement target thickness

TOF-tracker MRPC

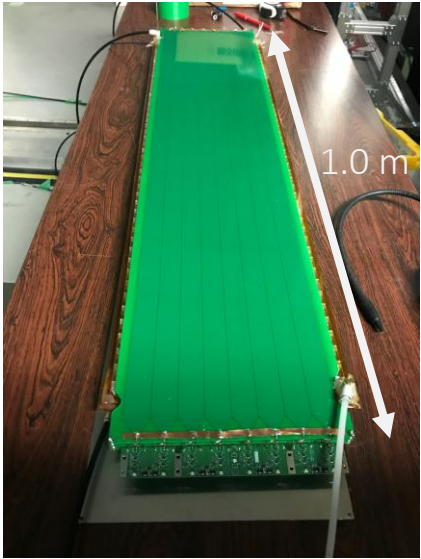
- Narrow XY readout strip pitch
- Goal
 - 1 m size
 - $\sigma_{\text{time}} = 70 \text{ ps}$
 - $\sigma_{\text{pos}} = 200 \text{ }\mu\text{m}$
 - Gas sealed (no flow)
- Need to measure narrow/small signals from narrow-width strips



Previous prototypes

TOF MRPC

[N. Tomida et al.,
NIM A 1056 \(2023\) 168581](#)

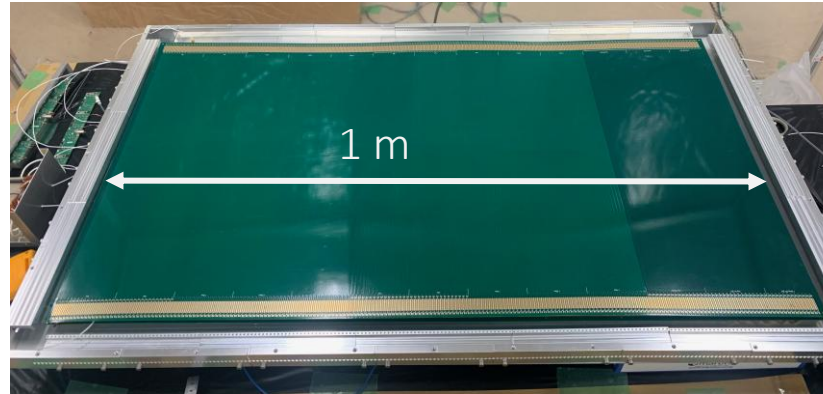


- 260 μm $\times$ 5 gap $\times$ 2
- 25 mm wide strip

$$\sigma_{\text{time}} = 60 \text{ ps}$$

Tracker MRPC

[R. Uda et al.,
NIM A 1056 \(2023\) 168580](#)
[N. Tomida et al.,
NIM A 1077 \(2025\) 170517](#)



- 5 gap $\times$ 1
- 5 mm pitch XY readout strip

$$\begin{aligned} \sigma_{\text{pos}} &= 0.77 \text{ mm} \\ \sigma_{\text{time}} &= 68 \text{ ps} \end{aligned}$$

with 50 cm strip

Common structure

- 260 μm fishing line spacer
- Gas sealed using an acrylic case
- Gas mixture (R134a:butane:SF6=90:5:5)
- FEE/DAQ

Common

- Find alternative HV electrode
- Easier production structure
- Low noise / cost FEEs

To Do

Tracker

- Gas sealed
- Improve position resolution

Contents of this talk

- New detector structure
 - Film HV electrode
 - Gas spacer
 - Gas tight
- New Front End Electronics
 - Pre-amp
 - Discriminator
- Optimized with beam/cosmic ray tests
- Detailed TOF-tracker results are reported by S.Tanaka on Sep/17

HV electrode

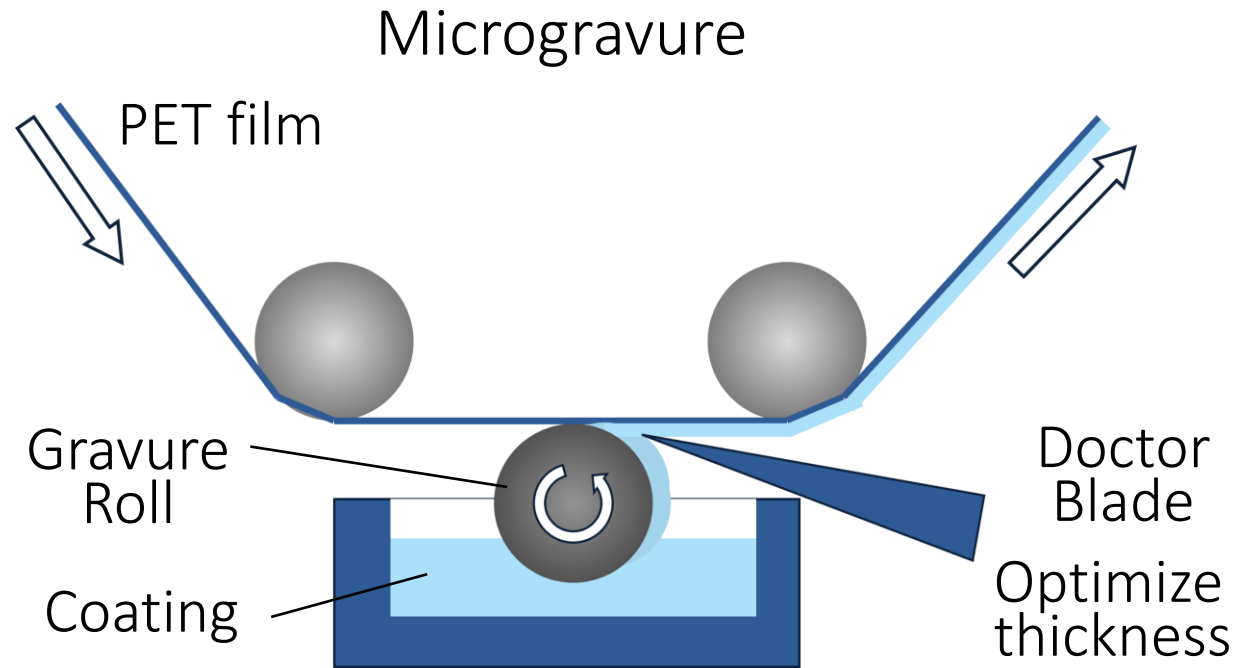
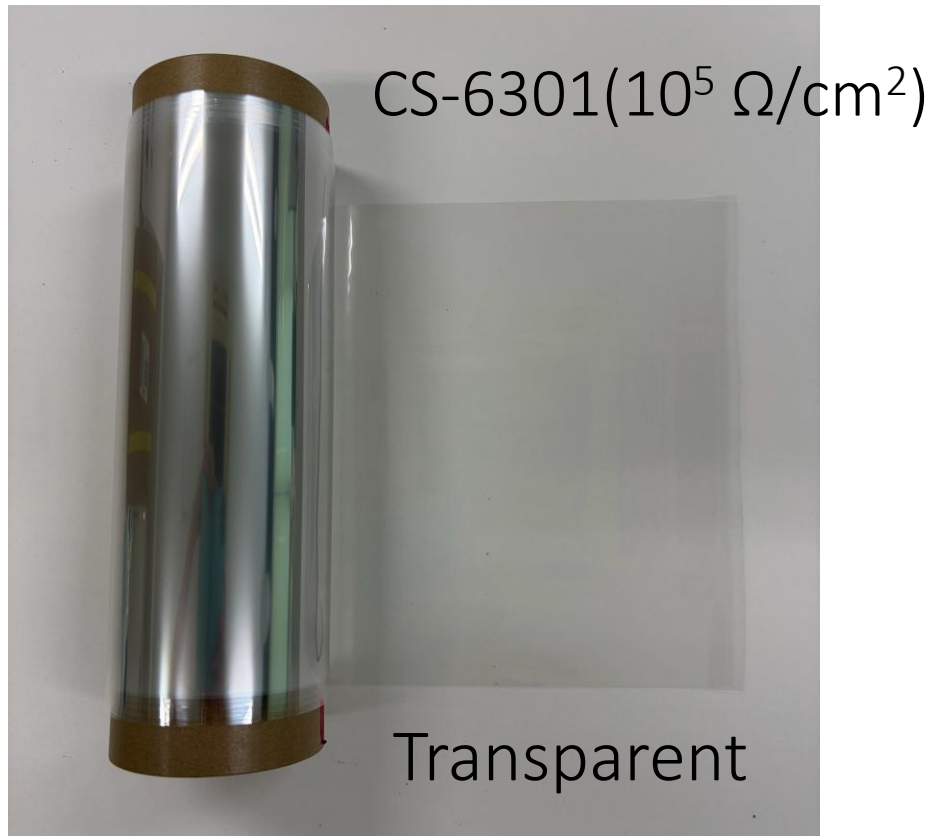
- Carbon tape (EEEC T-9188) used for MRPCs in Japan → Discontinued
- Alternatives tested

Product	Company	Coating	Material	Performance	
Air-Opaque	Badger	Hand spray / Bar coating	Glass	No signal	Used in LIP
Graphit 33	Contact Chemie	Roll	Film	Good	Used in Lyon Import prohibit
SEPLEGYDA	Shinetsu polymer	Bar coating	Film	No signal	Conductive polymer
KP-8348-1	Kansai polymer	Hand spray	Glass	Good	Fluoropolymer-base conductive coating
KP-K2929-1				Good	
CS-6301	Colcoat	Hand spray	Glass	Fair	Nanocarbon dispersed polysiloxane
		Microgravure	Film	Good	
CS-5302		Microgravure	Film	Good	

- Adopt CS-6301/5302 with microgravure coating on film

HV electrode – CS6301/5302

- Microgravure coating on film
 - Lower cost, easier handling compared with coating on glasses
 - Arbitrary resistivity by changing thickness of coating : 10^4 - $10^8 \Omega/\text{cm}^2$
- Stability operated for several month



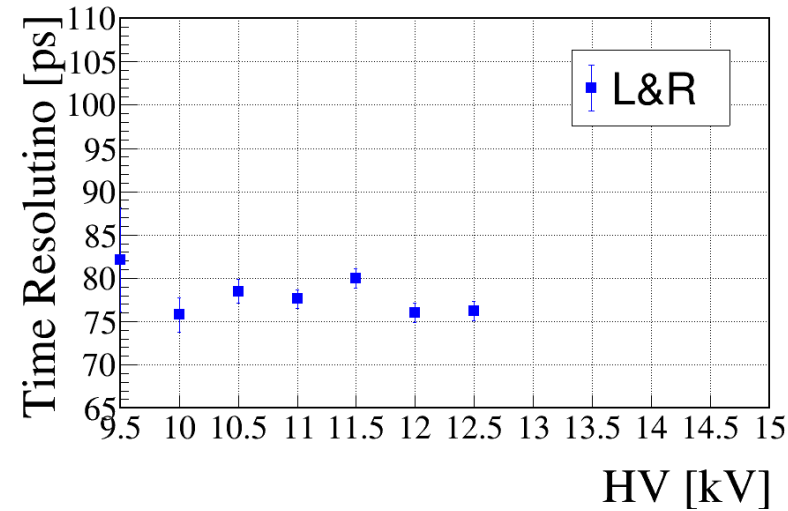
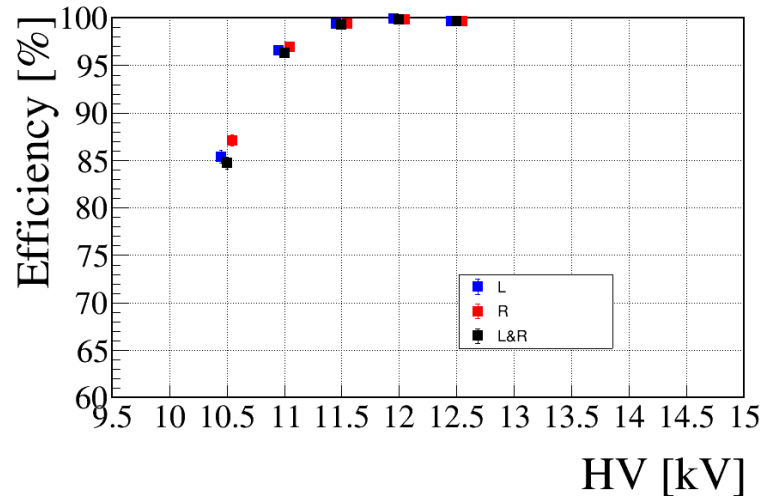
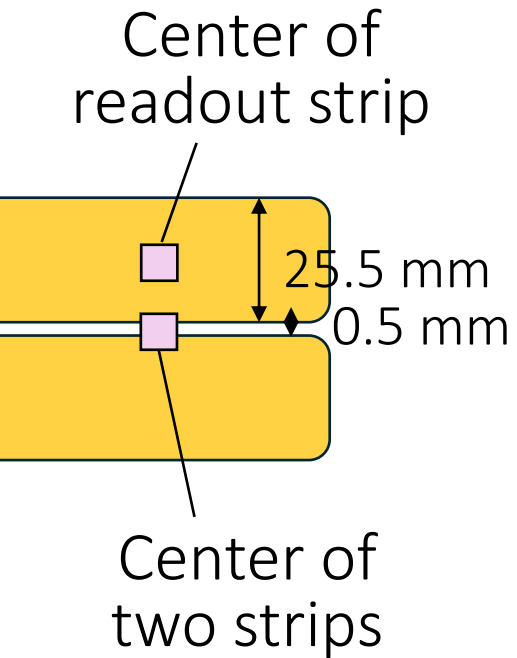
<https://www.yasuseiki.co.jp/uniqueness/microg/>

HV electrode tests

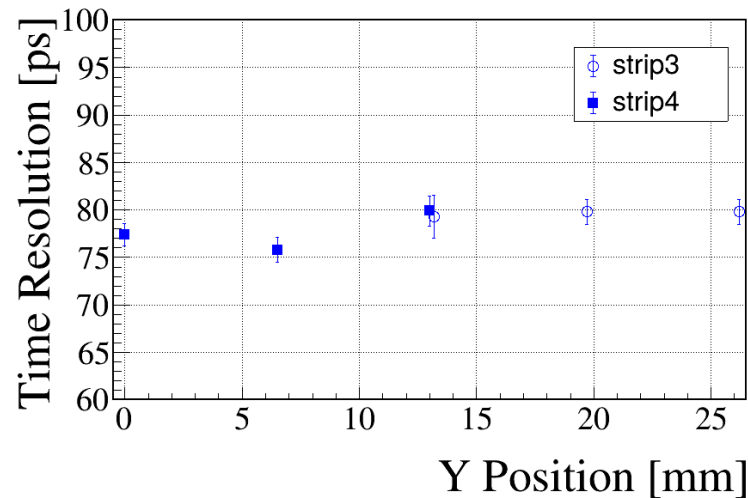
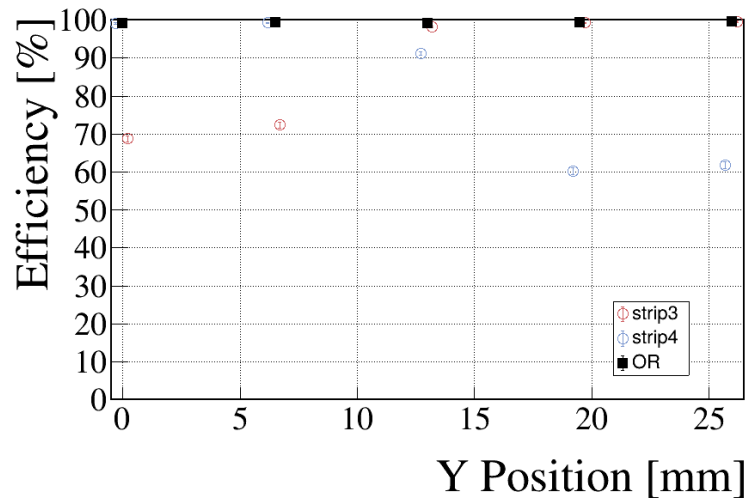
- Time resolution & efficiency were examined using beam for all candidate electrodes

CS-5302

- 1 m long TOF MRPC



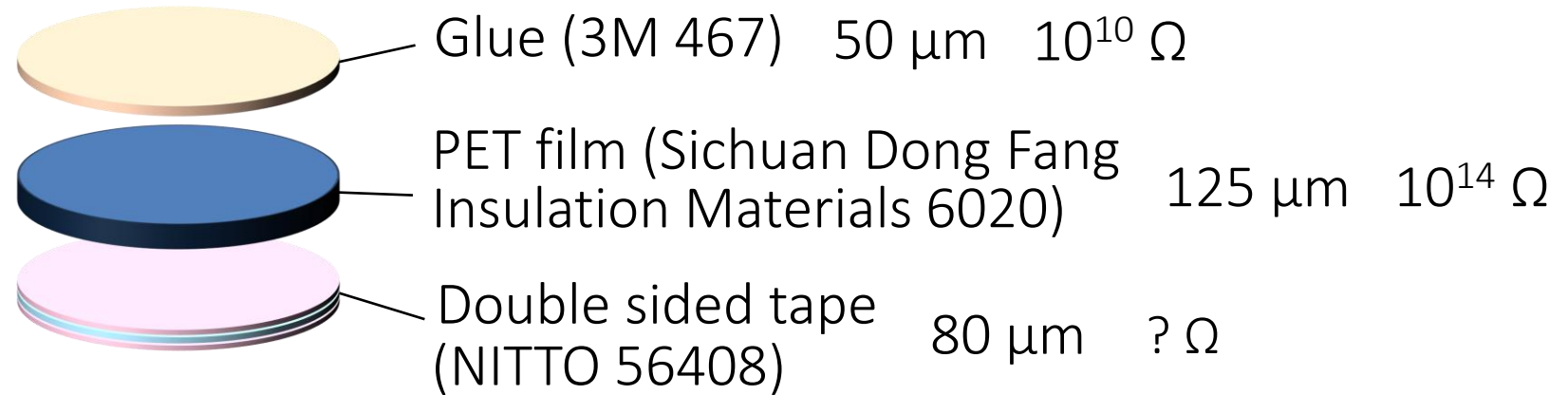
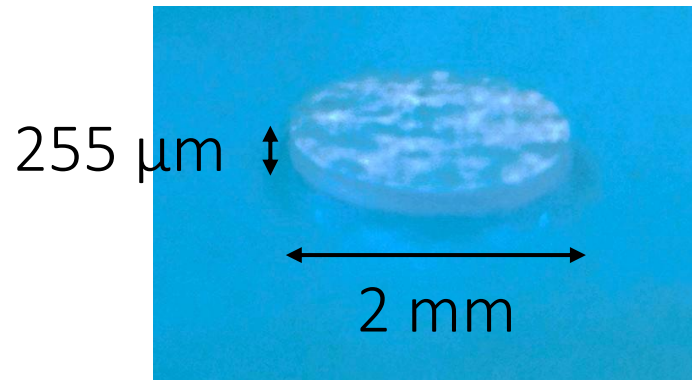
Scanned also along readout strip



- Eff > 99%
- $\sigma_{\text{time}} < 80$ ps

Gas spacer

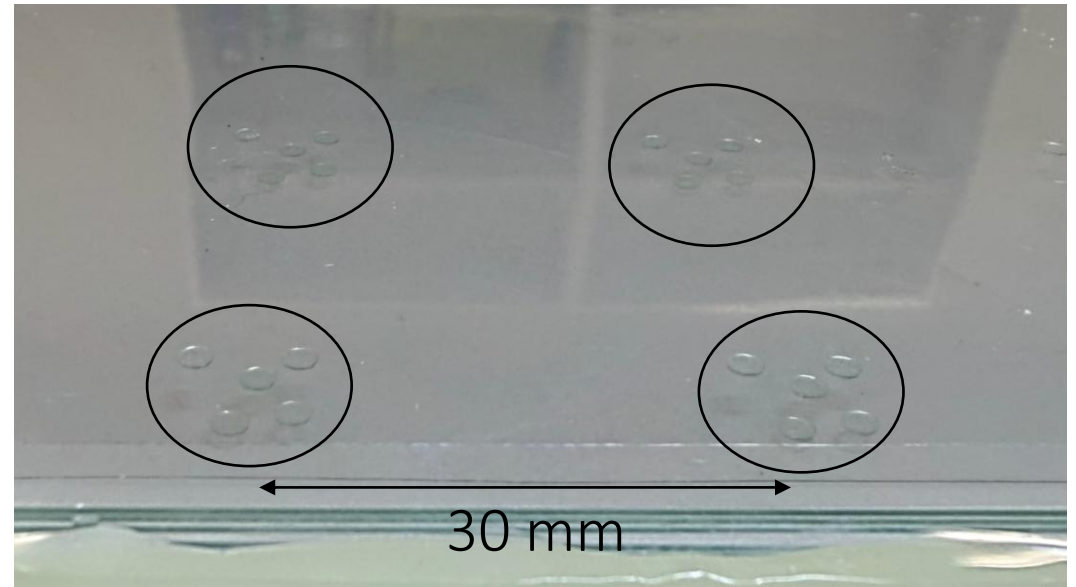
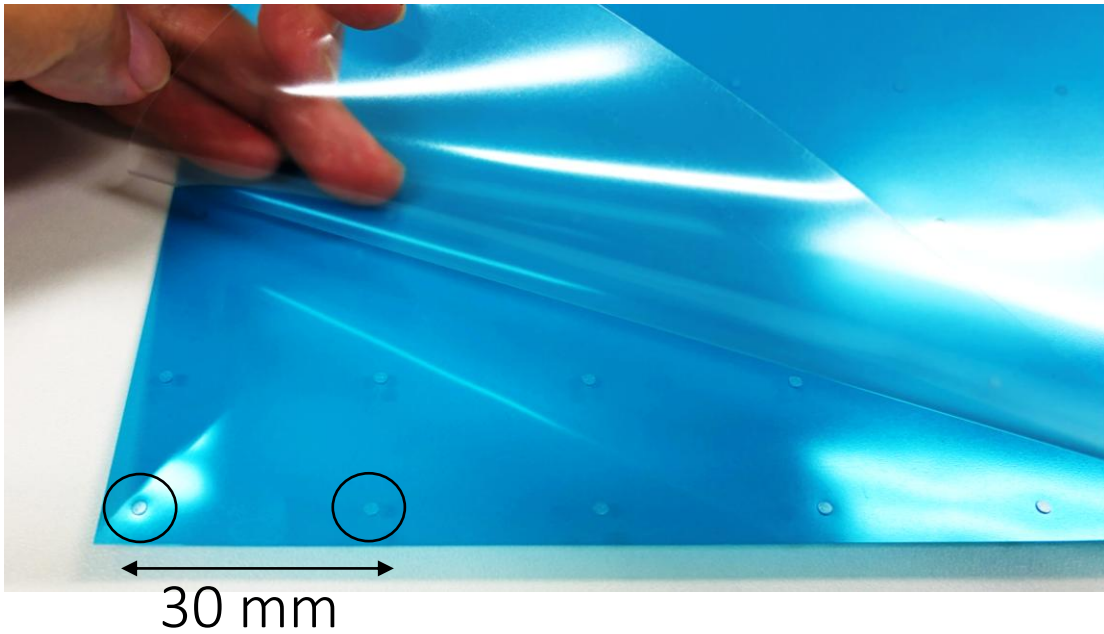
- Cylindrical spacer



- By Panel group in Taiwan
 - Can be customized
 - Material : Teflon, mylar, Kapton
 - Thickness : 0.07-1.5 mm
 - Diameter > 1.0 mm
 - Interval > 1.0 mm
- Stably operated for a few month under HV
- Weak against temperature ?
 - Discharge sound from spacers stored in room temperature ~40°C
 - Test different glue/double sided tape

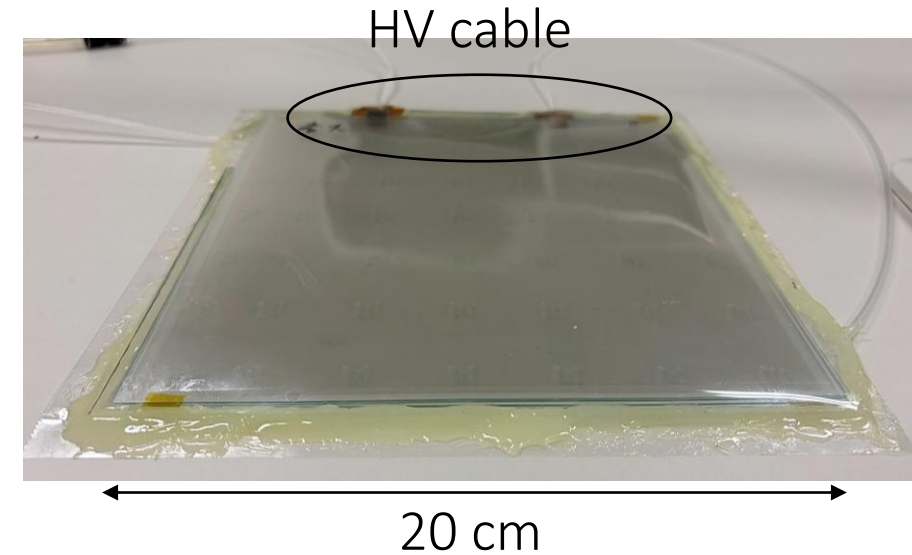
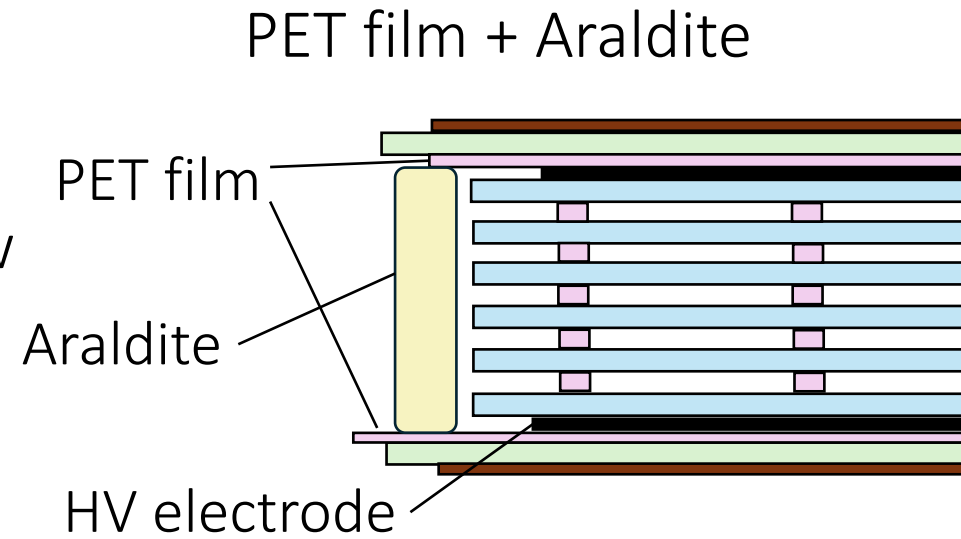
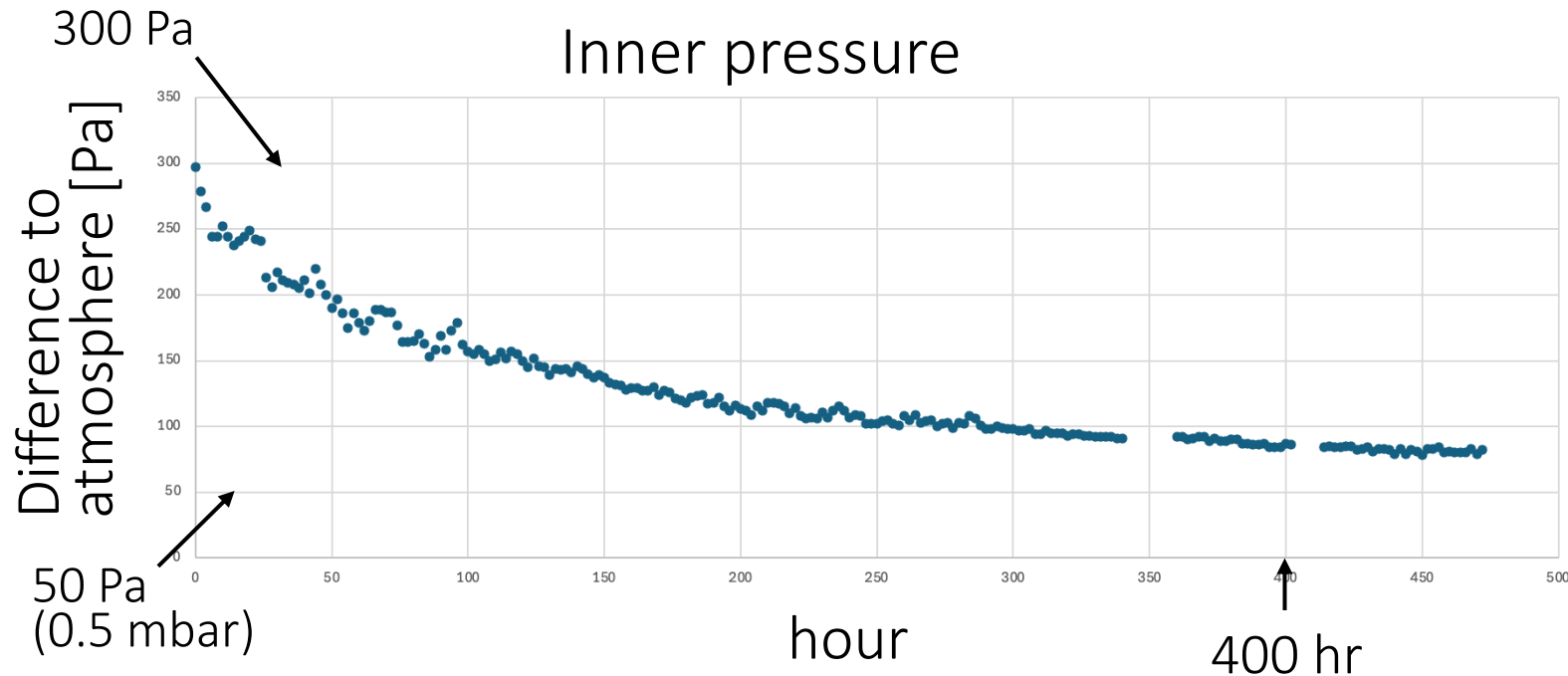
Cylindrical spacer

- Double-sided adhesive → Easy glass stacking
- Need to press with an appropriate pressure to keep proper thickness
- Different spacer position gap by gap to avoid strong electric field around spacers
(and dead space)



Gas tight

- Previous : acrylic case → expensive
- Current : PET Film + Araldite (glue)
 - Good enough for circulating gas
 - A lot of glueing work needed to use with no gas flow
 - HV electrode inside the gas volume
→ Easy leak around HV cable

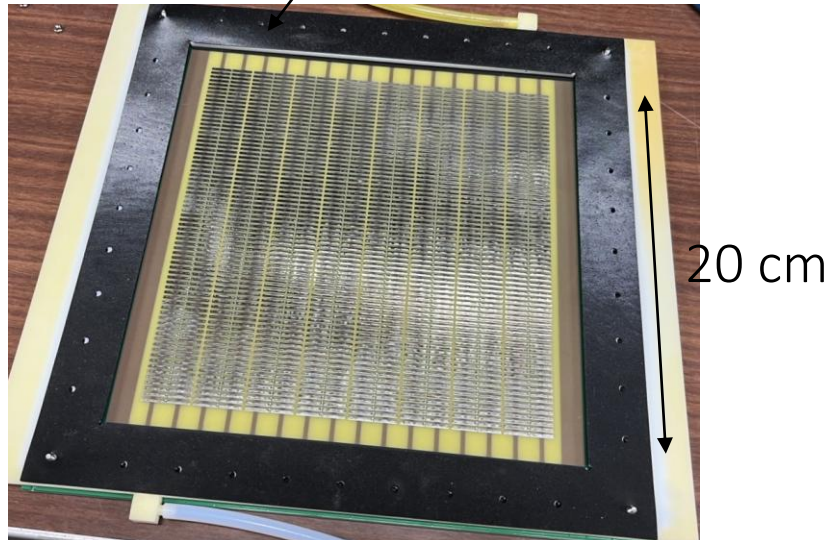


Gas tight

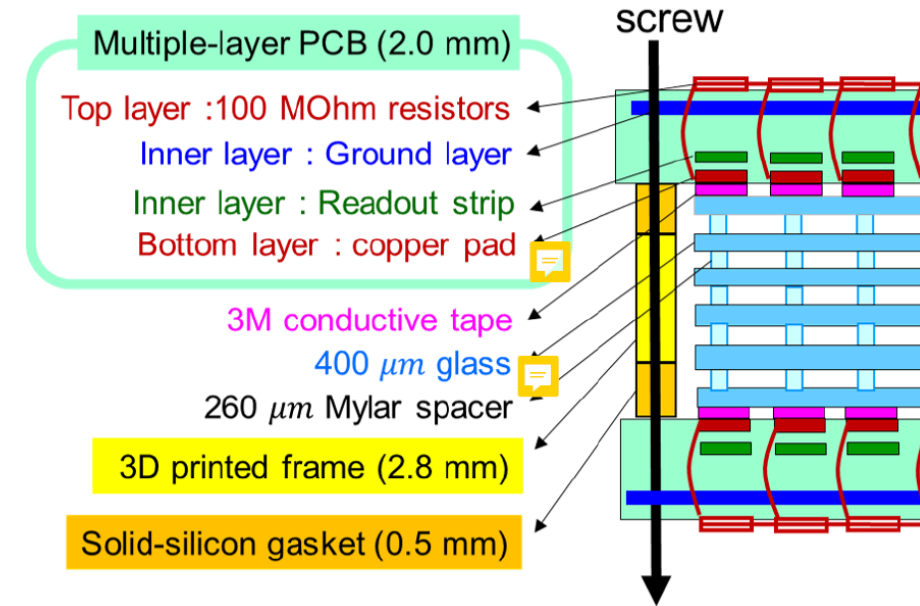
- Also tested : Silicon gasket
 - Good enough for circulating gas
 - Significant leak for no gas flow use
- Next : Spacer + Araldite
 - Reduce Araldite coverage
 - HV electrode outside of gas sealed

[M.-L. Chu et al.,
NIM A 1077 \(2025\) 170768](#)

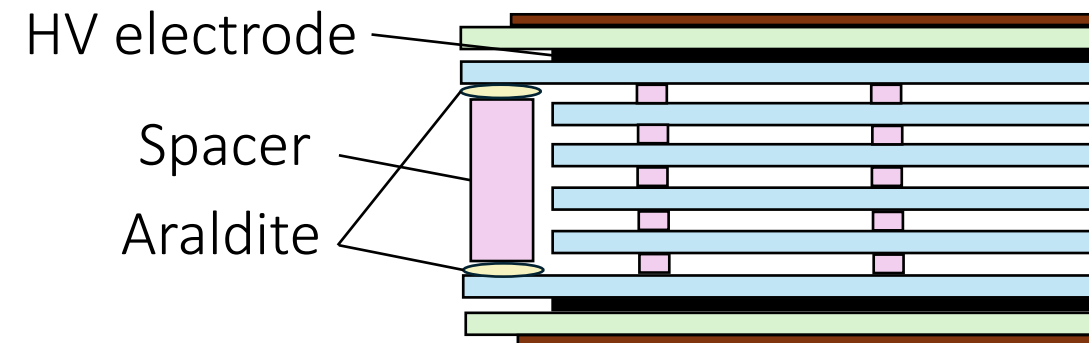
Silicon gasket



Silicon gasket



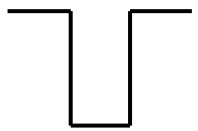
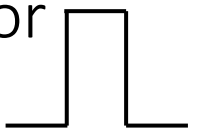
Next : Spacer + Araldite



FEEs

- Pre-amp, discriminator : conventional (non-ASIC) electronics
- DAQ : Streaming DAQ
- TDC : FPGA HR-TDC with AMANEQ mother board ($\sigma_{\text{TDC}} \sim 20$ ps)
- Charge measurement : Time-Over-Threshold (TOT) with HR-TDC

⇒ HR-TDC Firmware updated to deal with MRPC narrow signals

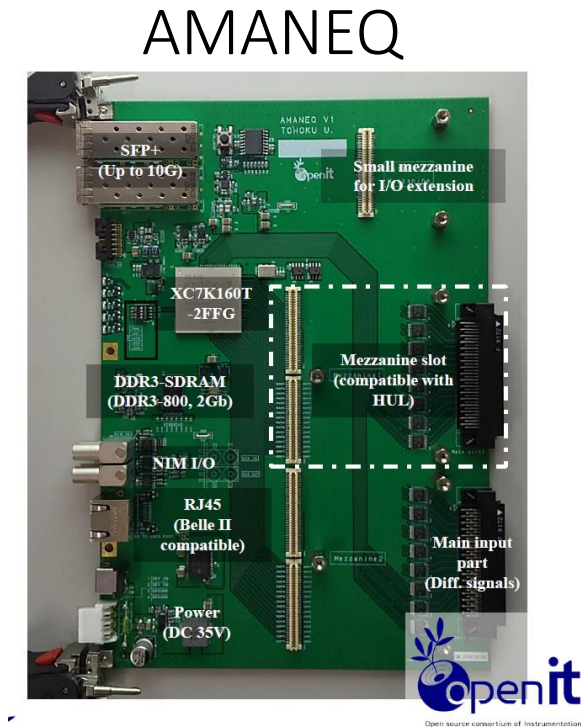
⇒ Minimum TOT : ~ 1.0 ns for  ~ 2.0 ns for 
because of offset in HR-TDC

Leading Trailing Trailing Leading

- Requirement

- Pre-amp : High gain, low noise
- Discriminator : TOT, Stretch of small narrow signals of the tracker MRPC
- Work for both polarity of tracker

[N. Tomida et al.,
NIM A 1056 \(2023\) 168581](#)



Pre-amp

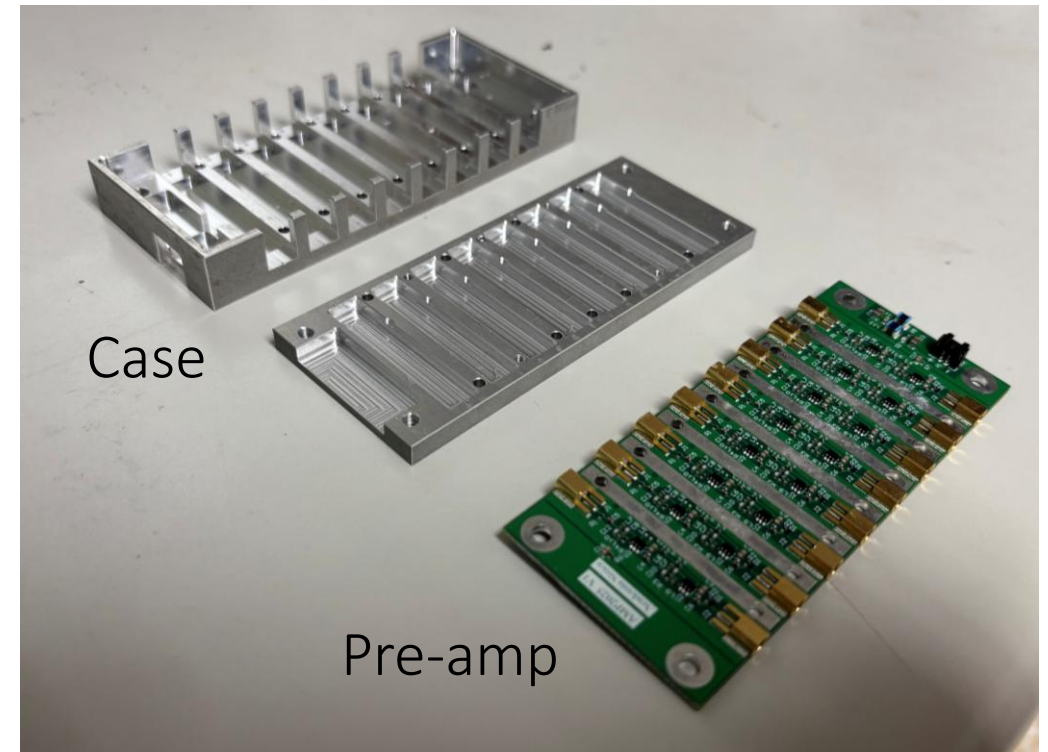
- Chip selection
 - Original : BGA2866 + BGA2869 (NXP) : Gain ~ 550
 $\Rightarrow$ discontinued in 2026
 - New : SMA3107 + SMA3109 (Onsemi)
: Gain 1/2.5 of original amp
Beam test $\Rightarrow$ Not enough efficiency

Use original chips

- Noise suppression
 - Change connector U.FL $\rightarrow$ MMCX
 - Partitioned channel by channel with ground

Very low noise level achieved

[N. Tomida et al.,
NIM A 1056 \(2023\) 168581](#)



Discriminator

- Original
 - ADCMP573BCPZ (~ \$ 20/chip) [N. Tomida et al., JINST 9, C10008 \(2014\)](#)
 - Common threshold for 8 channels

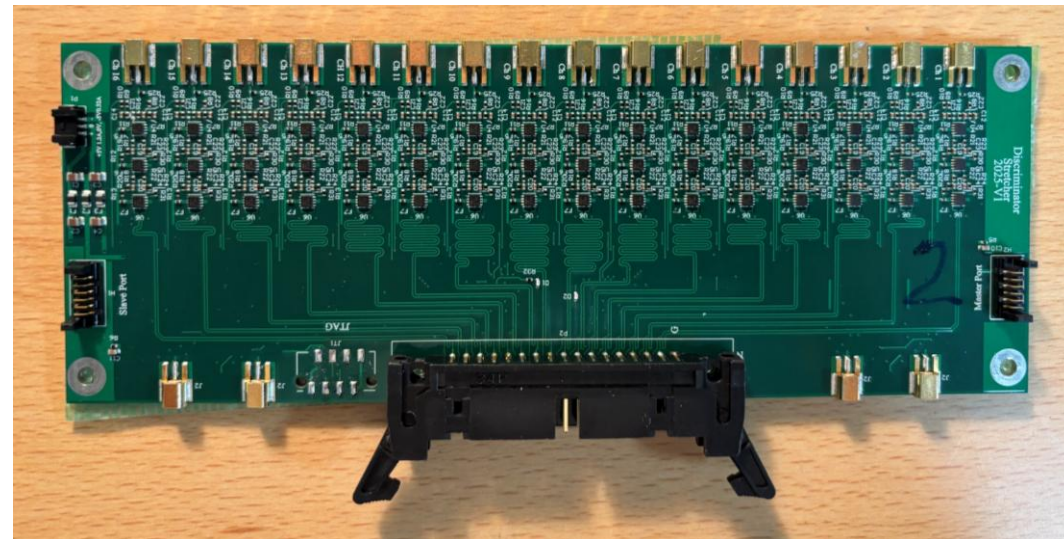
- New
 - TLV3801 (~ \$ 7/chip)
 - Channel by channel threshold control
 - 1 ns stretch of TOT
 - Unfavored polarity for HR-TDC

Good enough performance for TOF

Low efficiency for narrow signals of tracker ?

- Next
 - Polarity change
 - 3 ns stretch of TOT
- ⇒ Beam test in 2026/Nov

New discriminator



Summary

- TOF and TOF-tracker MRPC for J-PARC and muography
- Common development of detector structure / FEEs
- HV electrode : selection completed, arbitrary resistivity, film coating
- Cylindrical gas spacer : working well, need to examine temperature effect
- Gas sealed : test improved chamber for no gas flow usage
- Pre-amp : design completed, mass production started
- Discriminator : new board beam test on 2026/Nov

Acknowledgement



2026: DRD1 Early Career Scientist Award



Prof. Natsuki Tomida (ex aequo)

for her outstanding scientific contributions to the development of large-area multi-gap resistive plate chambers, combining innovative detector concepts with successful implementation in international experimental programs, and for demonstrated leadership in detector R&D, international collaborations, and the training of the next generation of experimental physicists.



Dr. Alessandro Rocchi (ex aequo)

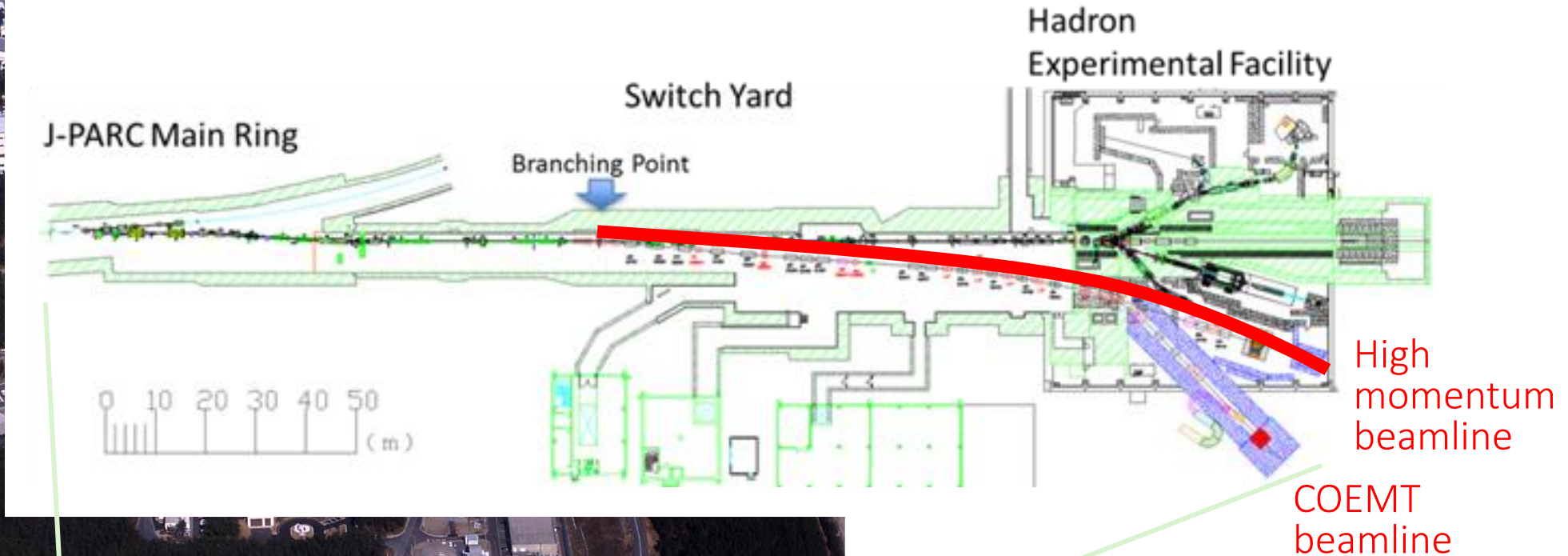
for his outstanding scientific contributions to the advancement of gaseous detector technologies through exceptional innovation in detector design and experimental R&D, and for pioneering the development of novel RPC concepts with broad potential for future particle physics applications.



- The first awards both from RPC
- Thanks to RPC community/friends/conferences
- Communications at RPC conferences helped me grow since I was a master student

Backup

Experiments at the new high momentum beamline



- 30 GeV primary beam
 - 2020 first delivery
 - 2025 first physics run
- 2-20 GeV/c secondary beam ($\pi/K/p/\mu$)
 - 2025 first delivery

Physics program @ J-PARC high momentum beamline

Primary beam

- Meson mass modification in nuclei

- $\phi \rightarrow KK$ (E88)

- Pentaquark search

- $\pi^- p \rightarrow \phi n$ (E95)

Secondary beam

E16 spectrometer (for e^+e^-) +
Multigap RPC (K^+K^- TOF ID)

MARQ spectrometer
(Multigap RPC for PID)

Secondary beam

- Hadron structure

- Charmed baryon spectroscopy
- Ξ ($s=-2$) baryon spectroscopy

- Exotic hadrons

- High isospin dibaryon search
- Pentaquark search

- Nucleon structure

- Measurement of 3D parton distributions
- Color Transparency

- Elementary cross sections

- Λp scattering cross section
- Hadronic cross sections for neutrino experiments

