Commissioning of a hadron blind detector for dielectron measurement in pA reactions at J-PARC

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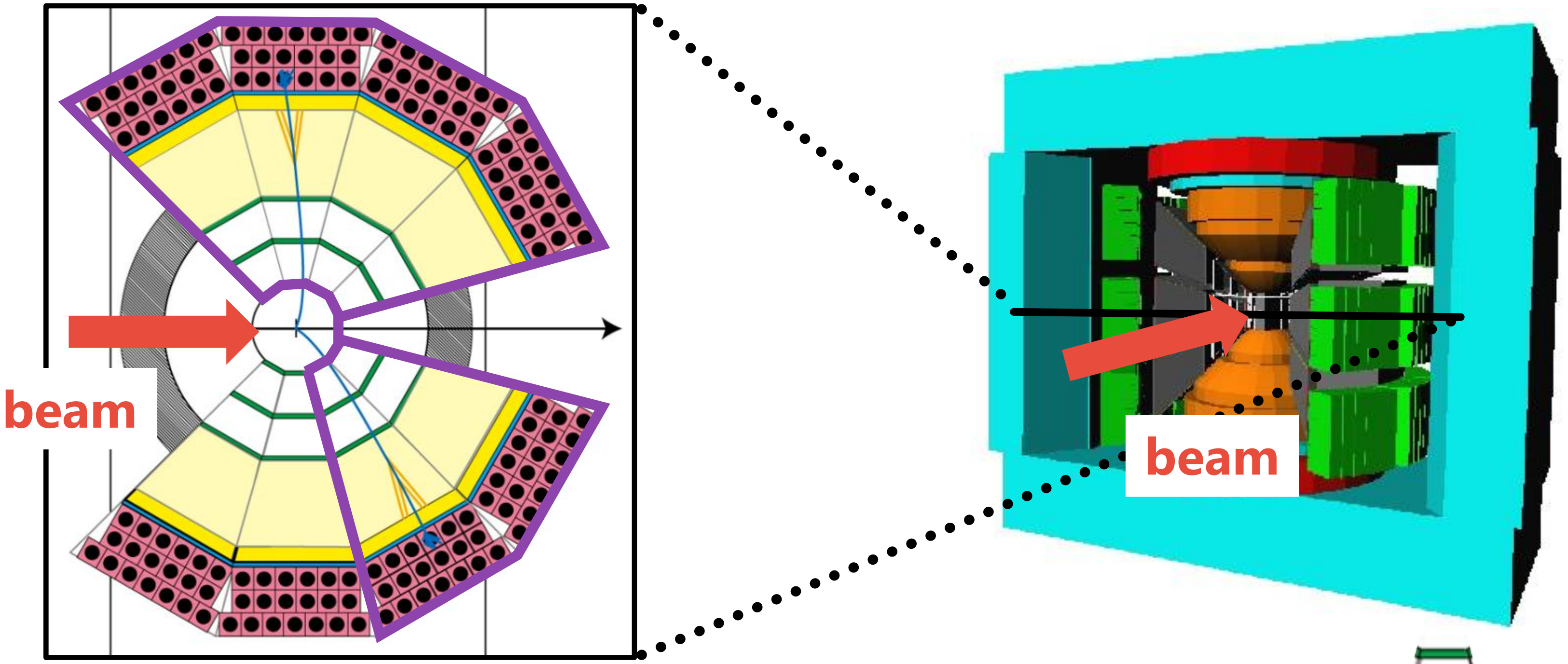
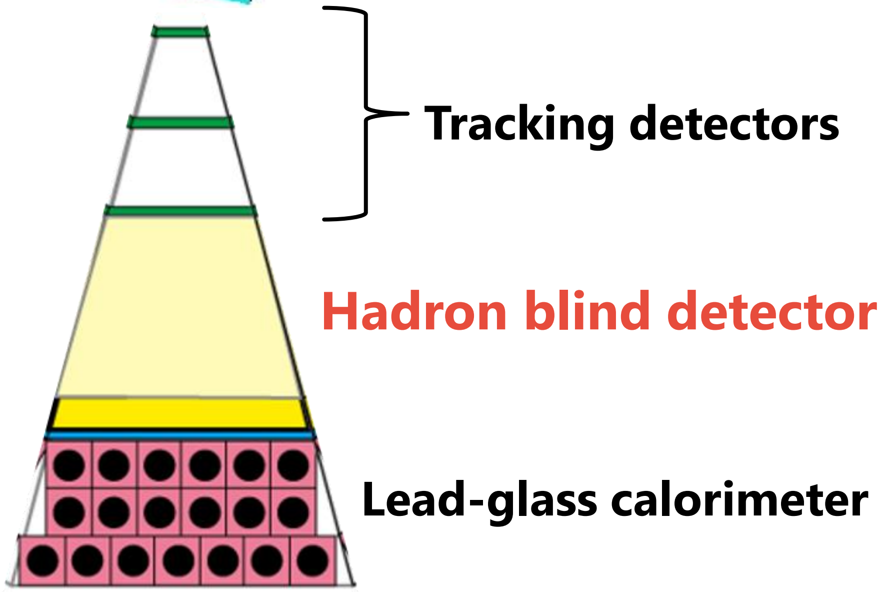
Outline

- ✓J-PARC E16 experiment
- ✓hadron blind detector (HBD)
- ✓HBD commissioning
- ✓results
- ✓conclusions and outlook

J-PARC E16 experiment



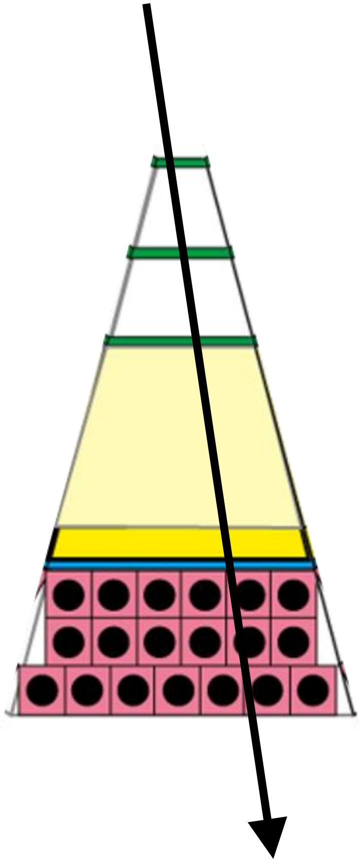
- ✓ **dielectron(e^+e^-) measurement**
  - 30 GeV p+A (fixed target), 10 MHz interaction
  - eID for up to ~3 GeV/c electrons
- ✓ **6 mod. installed for the commissioning run**
  - 26 mod. for the final design

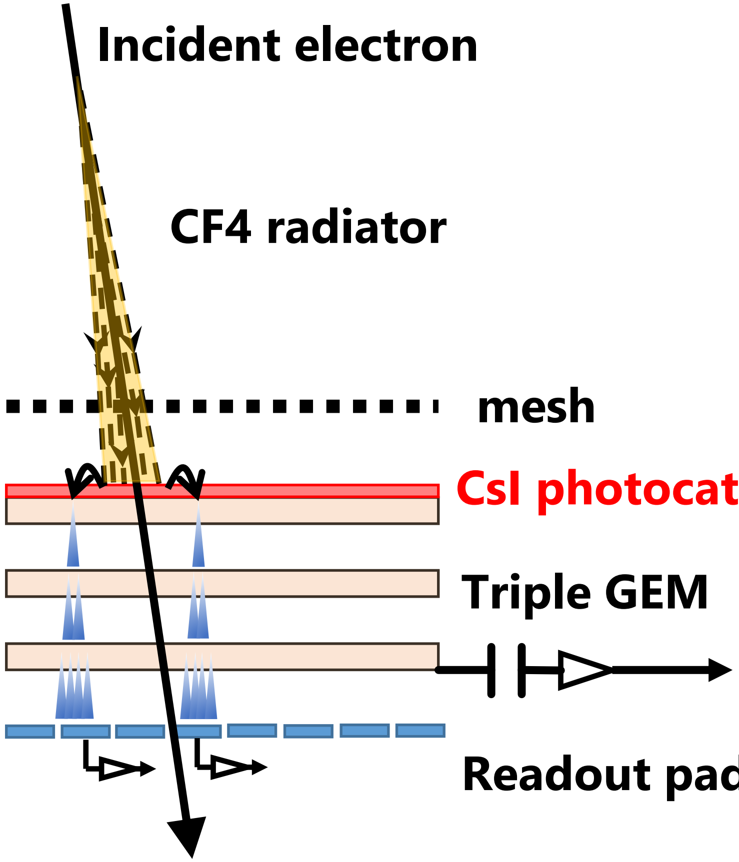


Hadron blind detector (overview)

✓windowless and mirrorless proximity focus Cherenkov detector

- originally developed by the PHENIX experiment
- utilized for eID
- Triple GEM stack + CsI photocathode
- ionized electrons swept into mesh
- pad readout+APV25 hybrid card of SRS
- ASD connected to the bottom GEM for a trigger signal





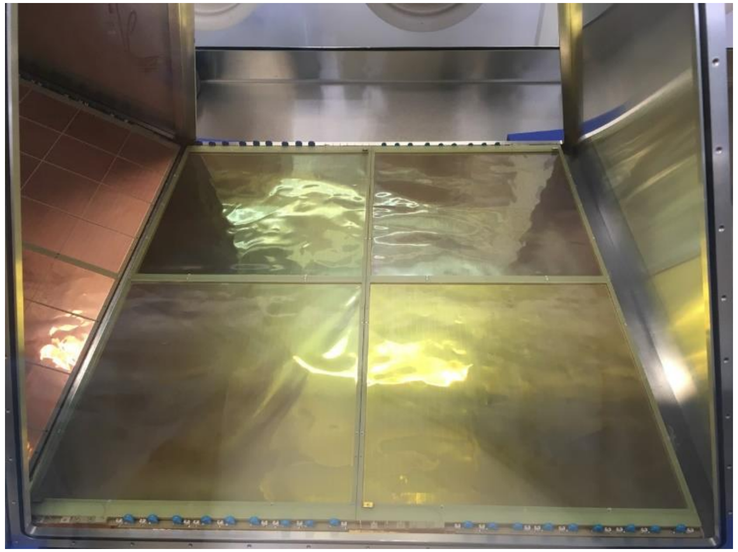
Hadron blind detector (GEM)

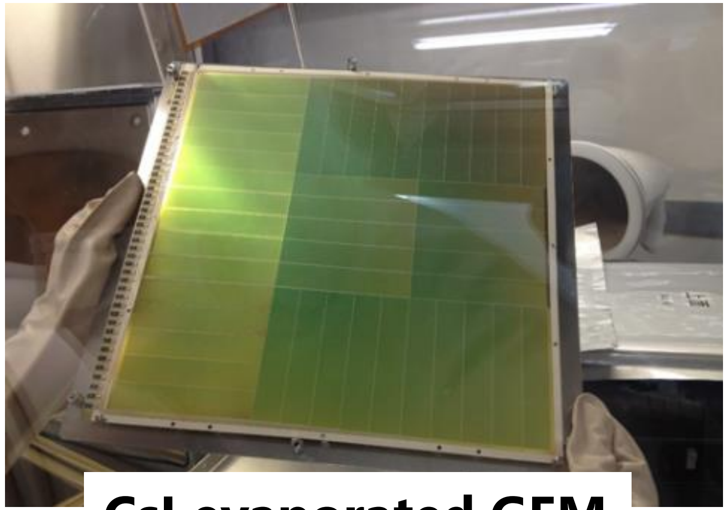
✓**30x30 cm2 GEM foils are used for the HBD**

- made by Japanese company
- 3 foils per stack, 4 stacks per module
- 6 modules = **72 foils installed for the commissioning**

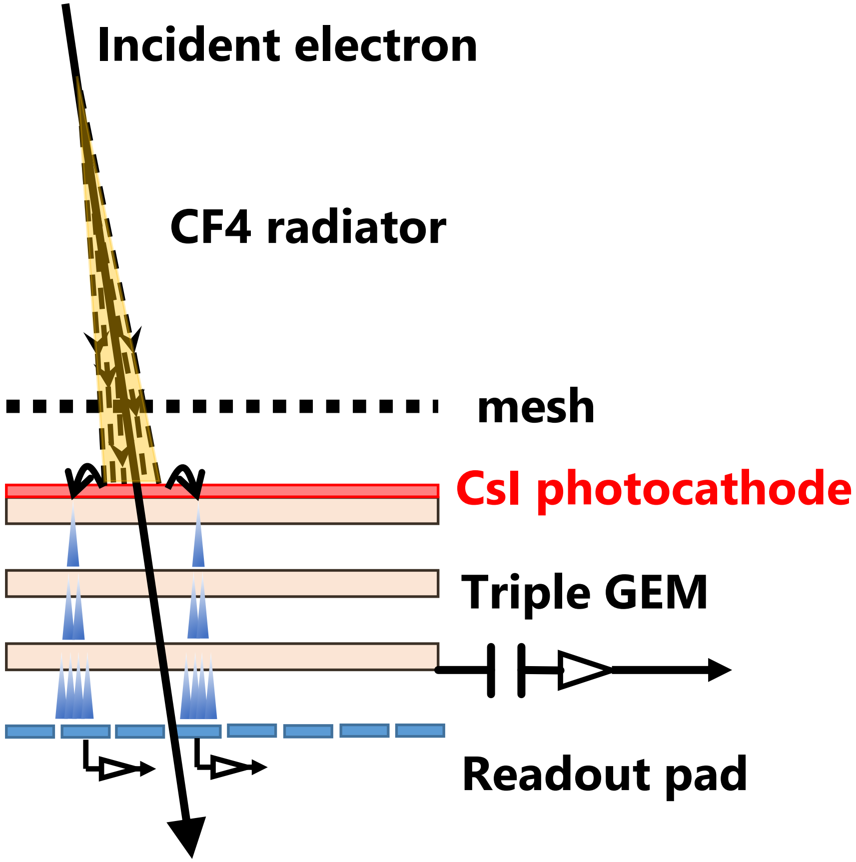
✓**CsI is evaporated on the top surface of the top GEM**

- evaporated by Hamamatsu





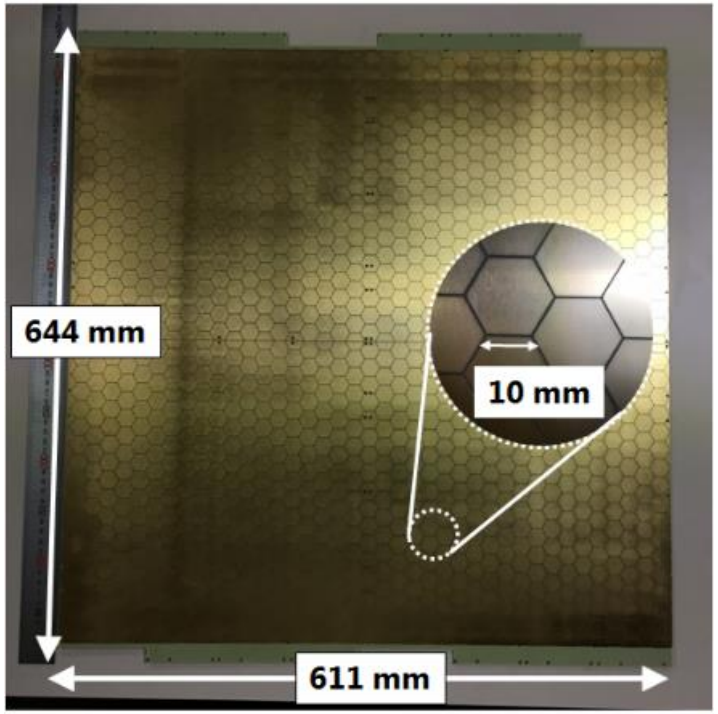
CsI evaporated GEM



Hadron blind detector (front-end)

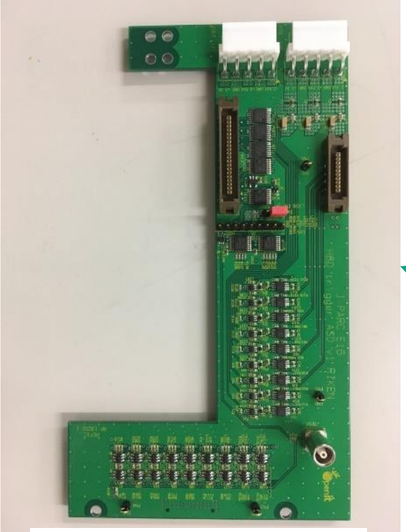
✓**two types of readouts are used for the HBD**

- pad readout with APV25 hybrid cards of SRS (1400 ch/module)
- the bottom surface of the bottom GEM with ASD **for the trigger signal (36 ch/module)**

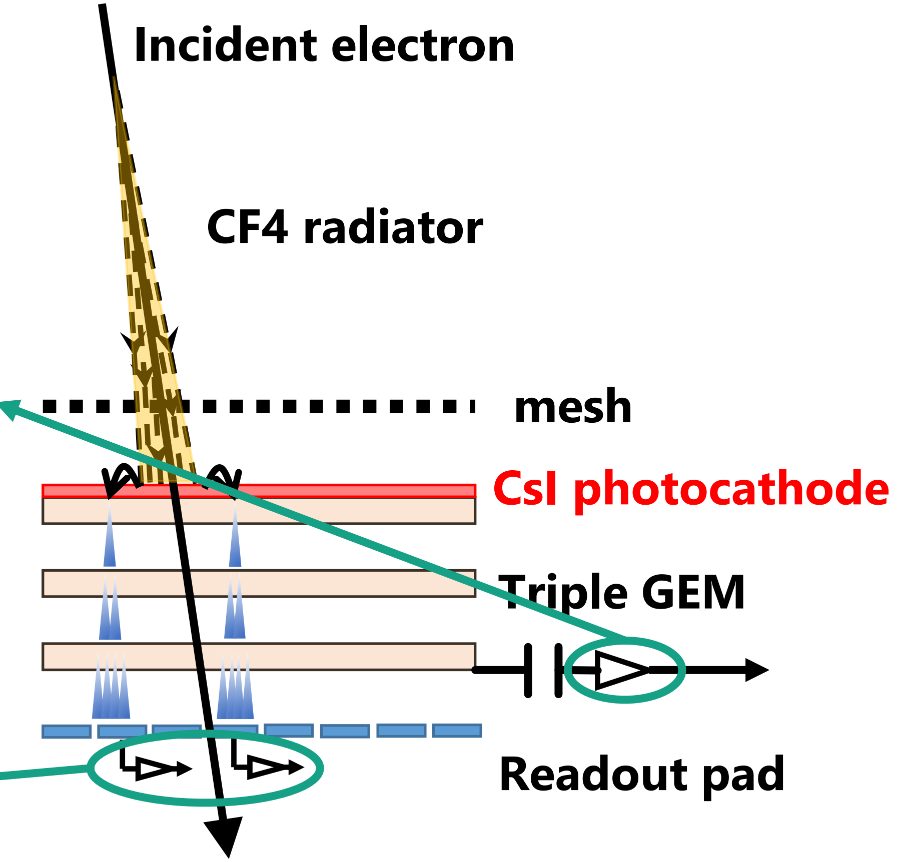


pad readout board

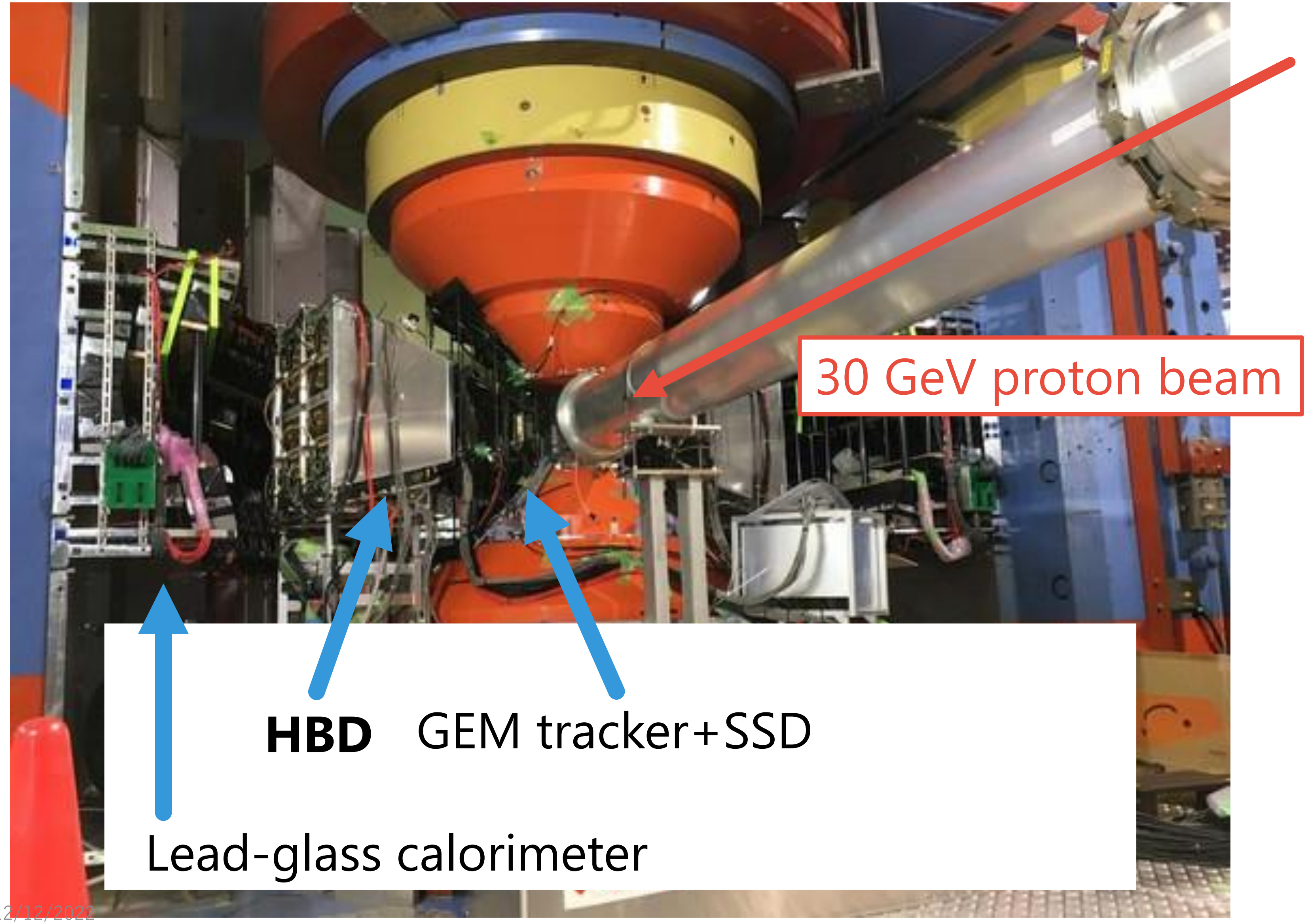
APV25 hybrid card



trigger ASD



Spectrometer commissioning



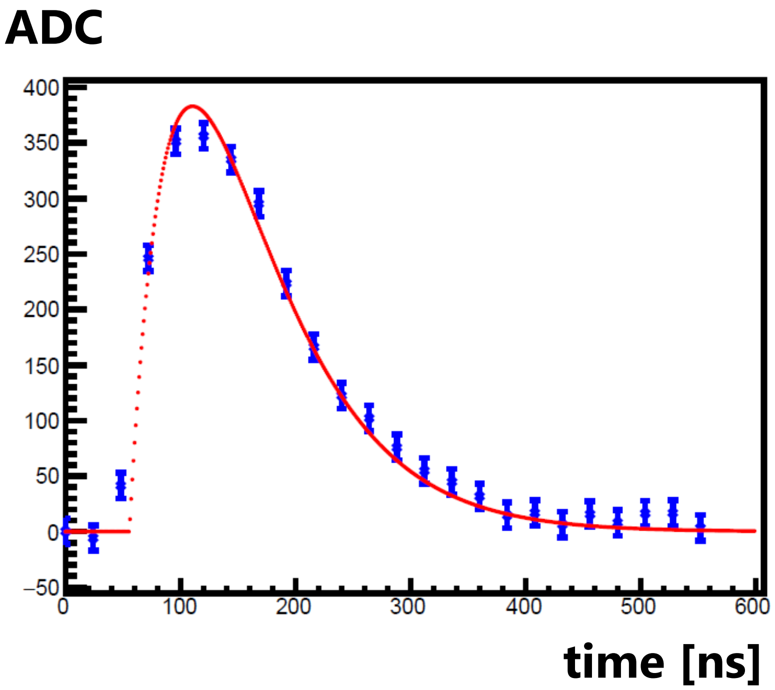
Analysis (waveform)

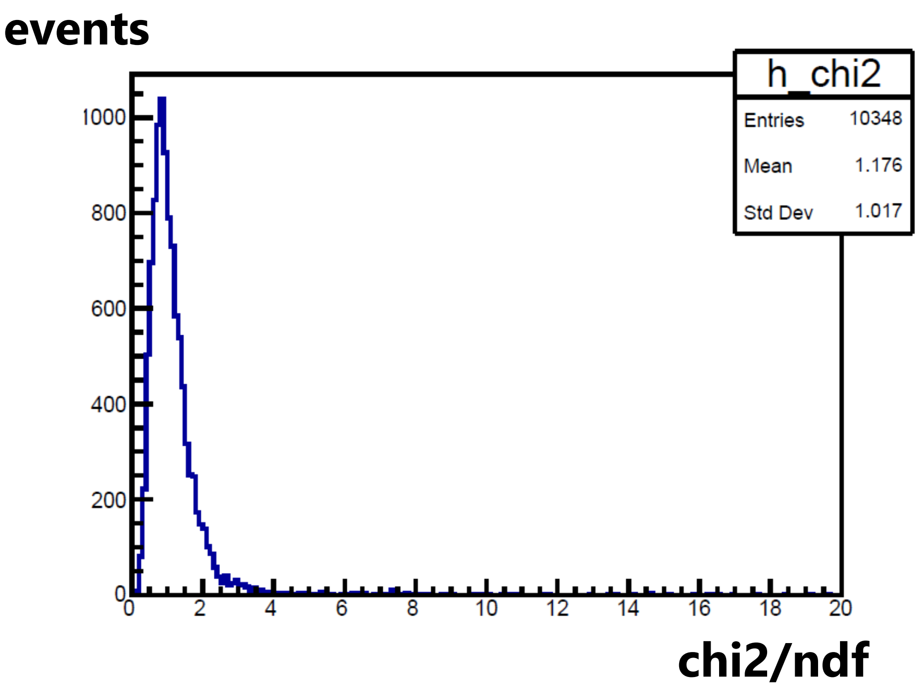
✓**signals are samples with 41.67 MHz (24 ns/cycle)**

- with APV25 hybrid card of SRS

✓**fitting w/ a function based on apv25 circuit constants**

- a waveform template obtained with a test pulse does not reproduce well





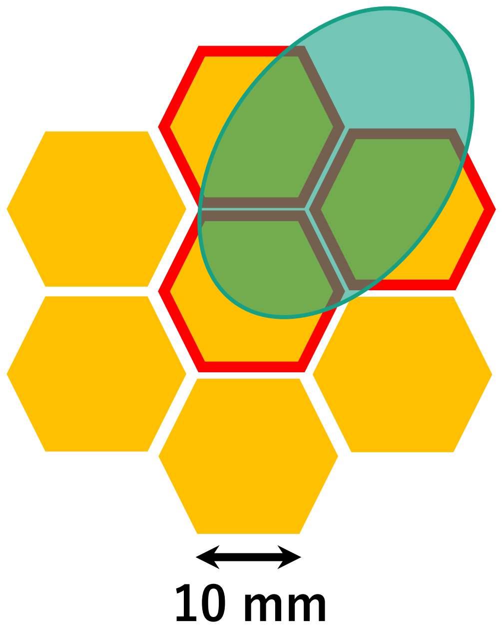
Analysis (clustering)

✓**the side length of a hexagonal pad is 10 mm and it is smaller than the circular image of the Cherenkov photons**

- circular image is φ34 mm when incident angle is 0 degree under the zero magnetic field

✓**the neighboring fired pads are defined to belong to the same cluster**

- a fired pad is defined to have a greater signal than 4σ of electric noise



cluster charge:
sum of charge of fired pads in a given cluster

cluster size:
the number of fired pads in a given cluster

Gain calibration

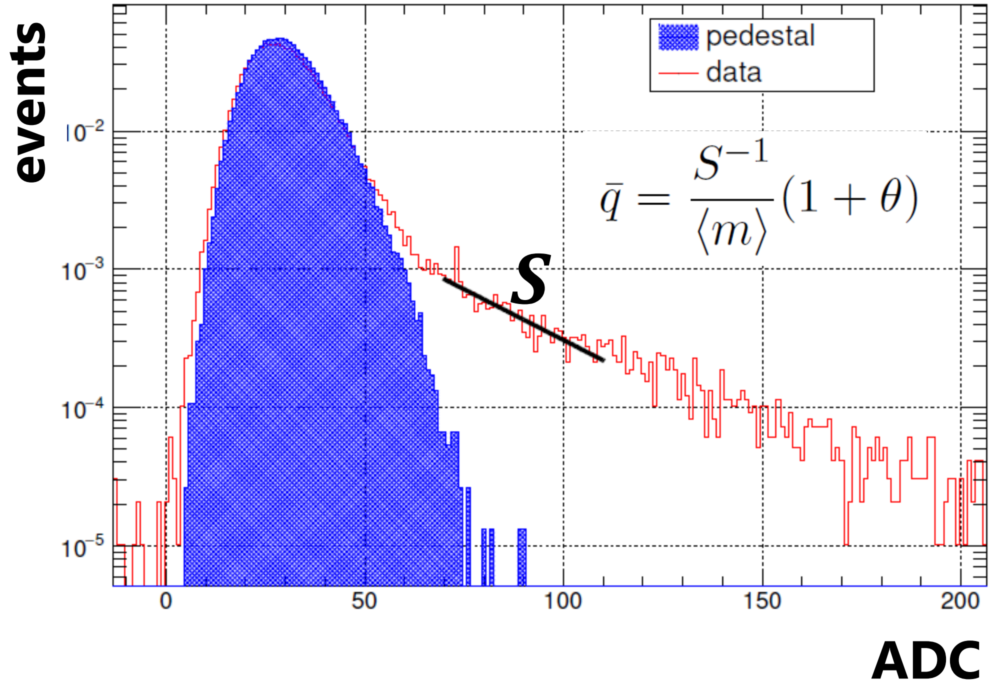
✓**gas gain of a triple GEM stack is measured with scintillation photons induced by incident charged tracks**

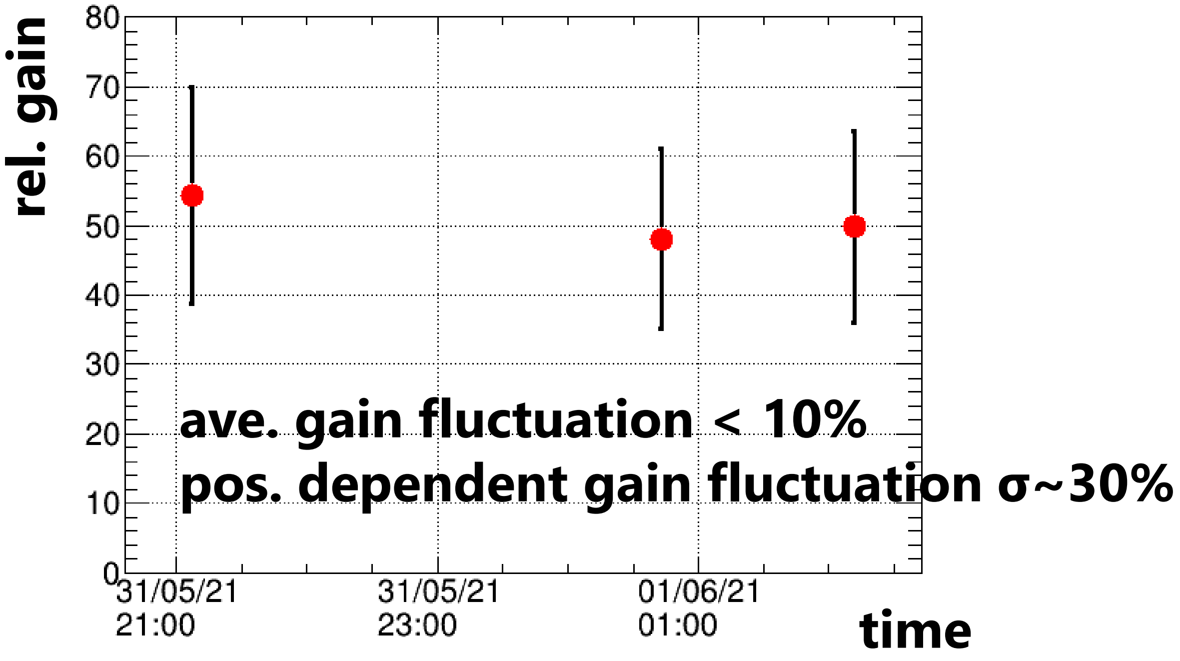
- radiator and working gas of CF4 is a good scintillator

✓**exponential curve at low amplitudes attributed to scintillation photons**

- gas gain distribution follows the Polya distribution

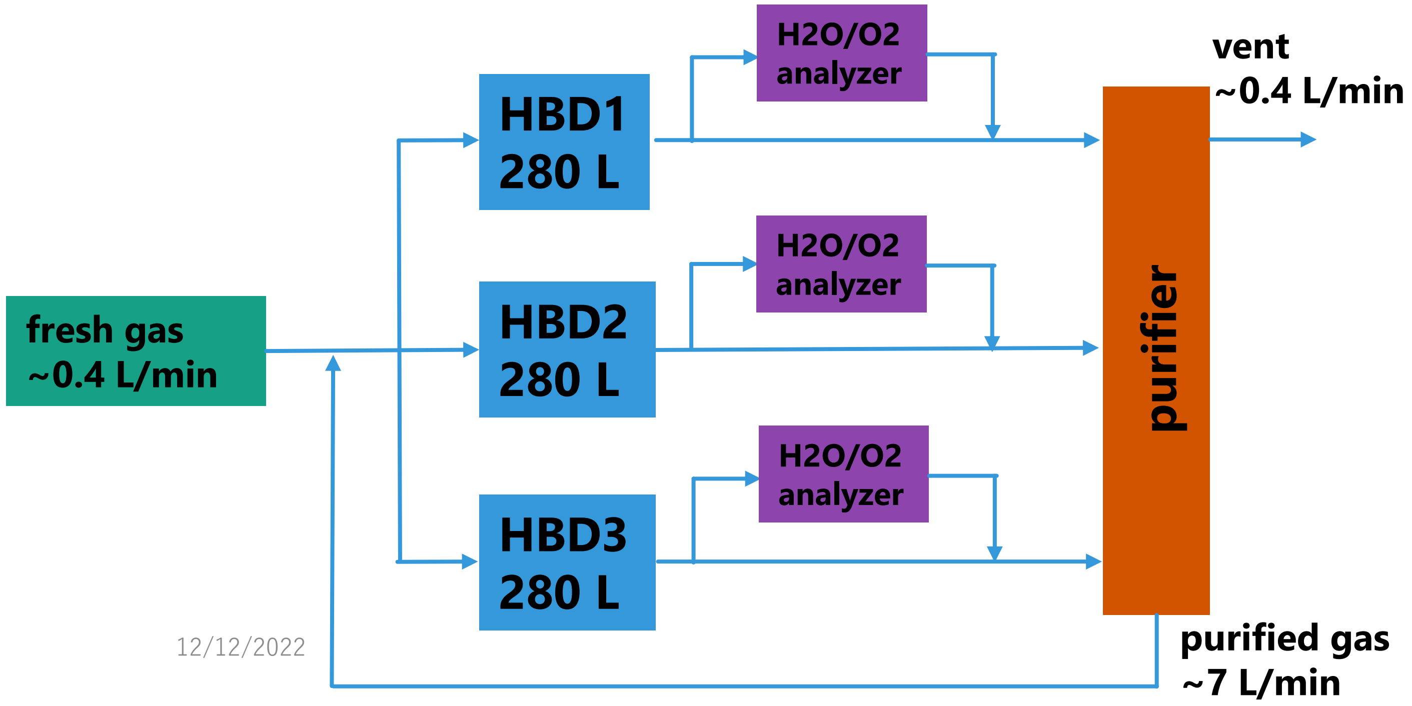
$$P(q) = C\frac{(1+\theta)^{(1+\theta)}}{\Gamma(1+\theta)}\left(\frac{q}{\bar{q}}\right)^{\theta}\exp\left[-(1+\theta)\frac{q}{\bar{q}}\right]$$

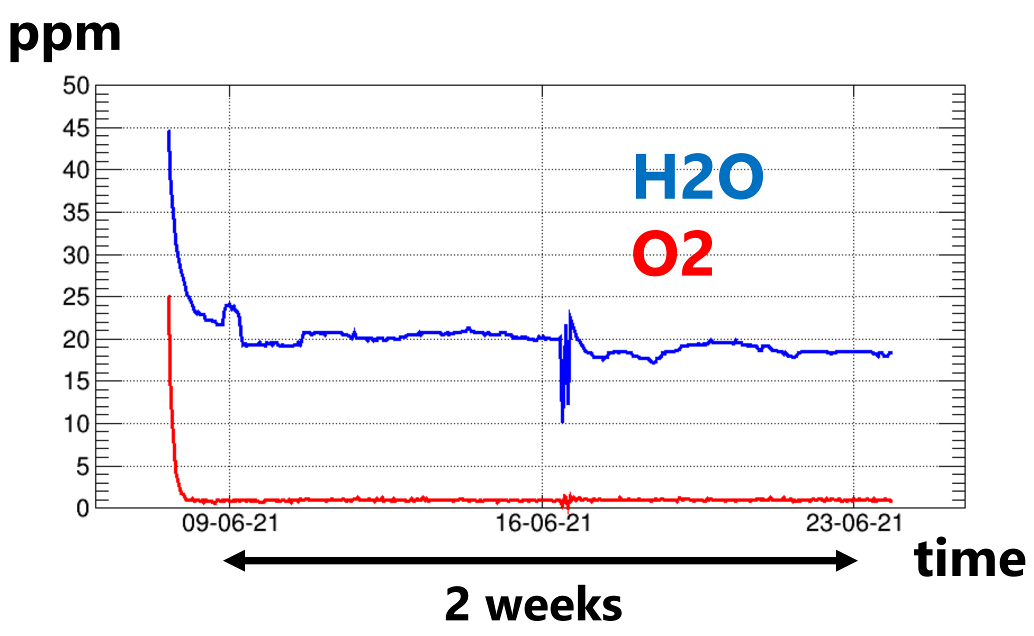




Gas system

- ✓a recirculating gas system is implemented to reduce gas consumption and running costs
- ✓photon wavelength of interest ranges VUV region (100—200 nm)
- ✓kept H_2O and O_2 reasonably low over 2 weeks
  - less than 5% loss of photoelectron



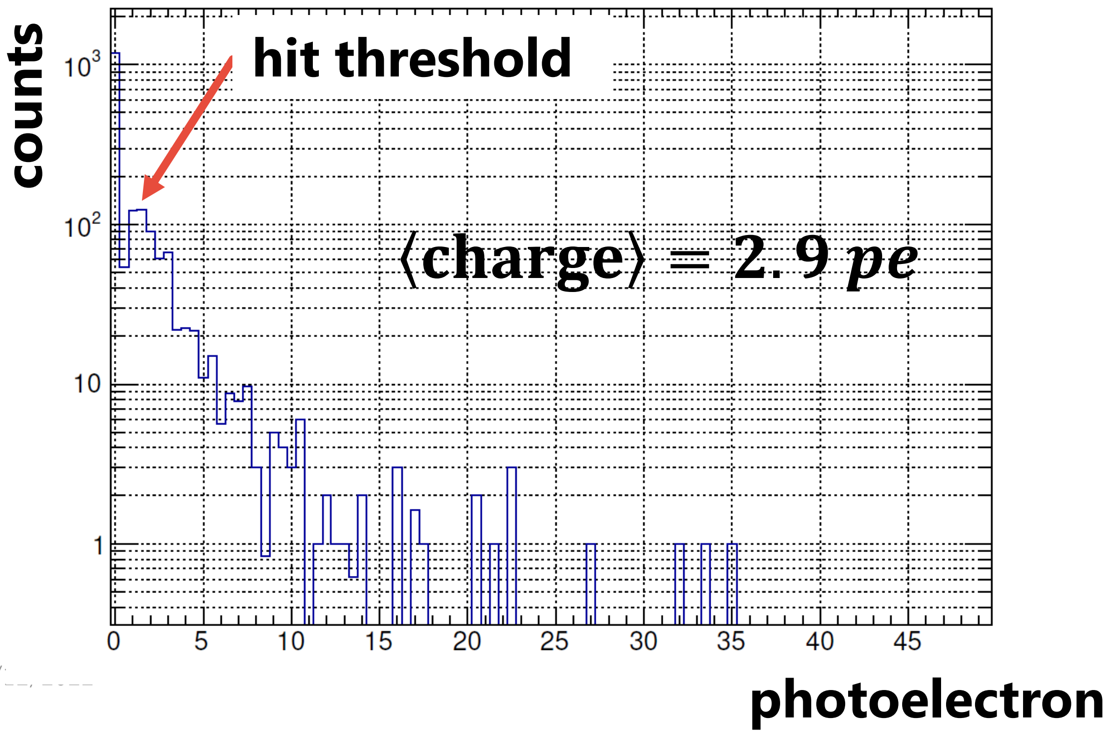


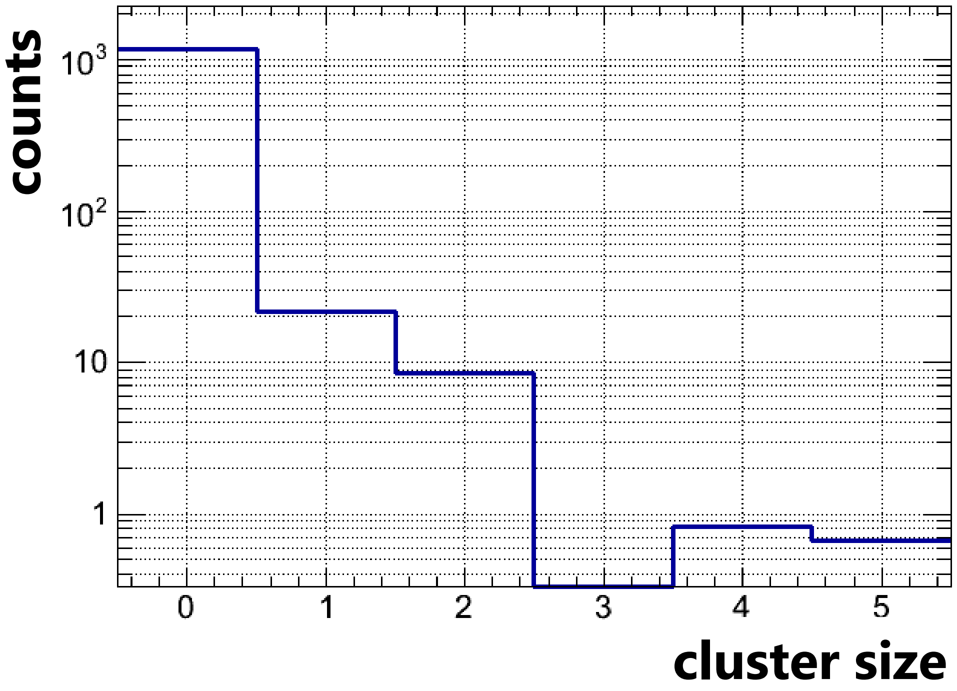
HBD response to pion

✓**search for a HBD signal around the projected position of a track**

- tracking with SSD and GEM trackers in front of the HBD
- pion ID with lead-glass calorimeter behind the HBD

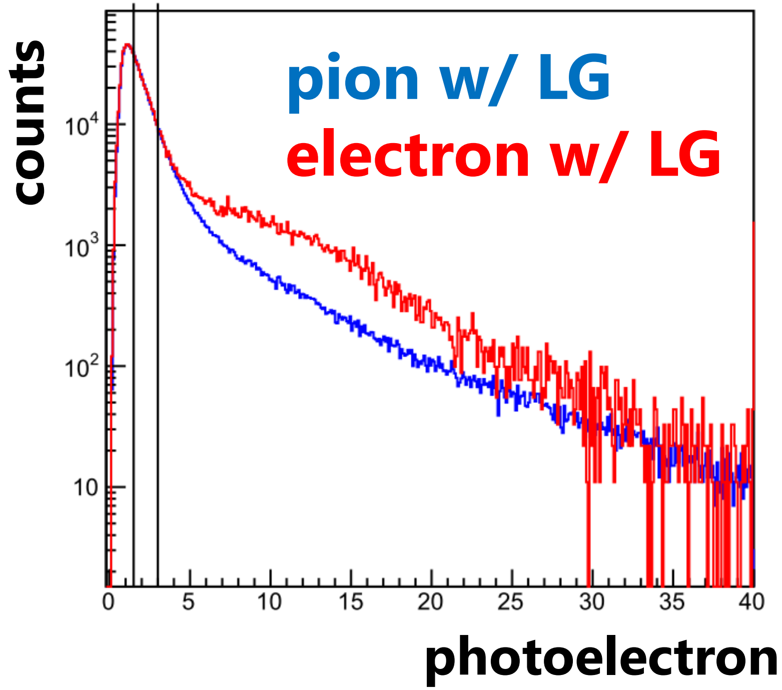
✓**ave. charge and cluster size are both consistent with the expected result**

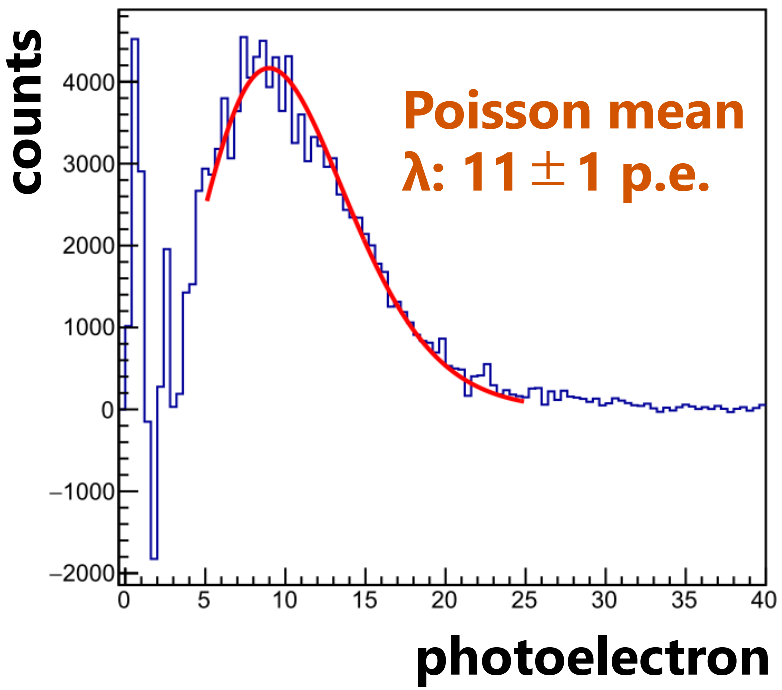


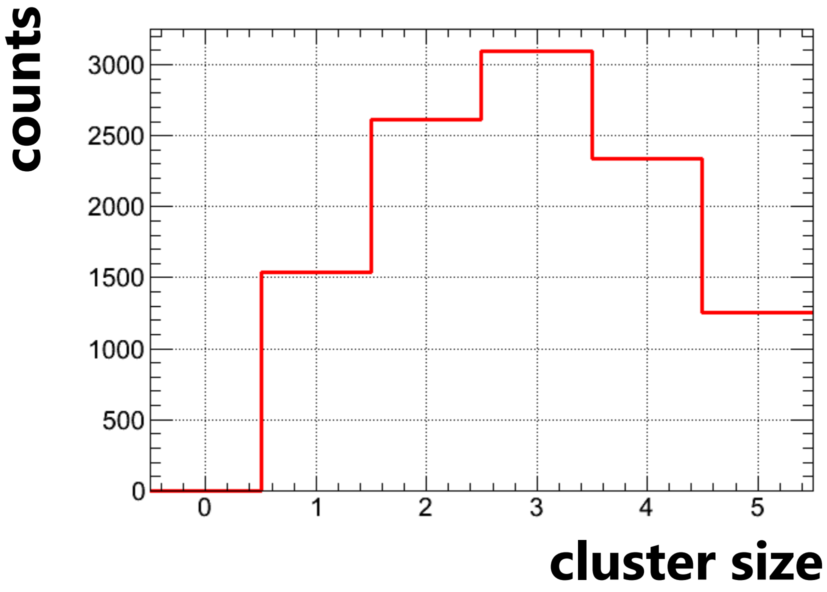


HBD response to electron

- ✓Lead-glass calorimeter is used for eID and position matching
- ✓we observed 11 ± 1 p.e.
- ✓expected performance is 11 + 1 p.e. and consistent with the observed result
- ✓an electron candidate leaves a multiple-pads hit





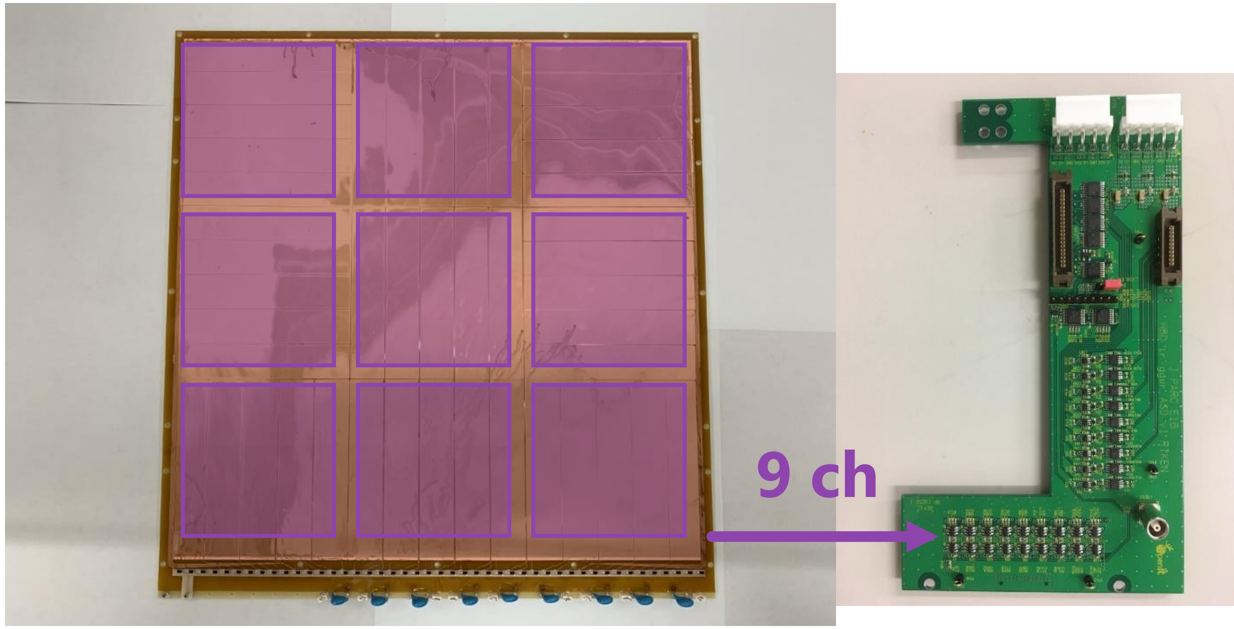


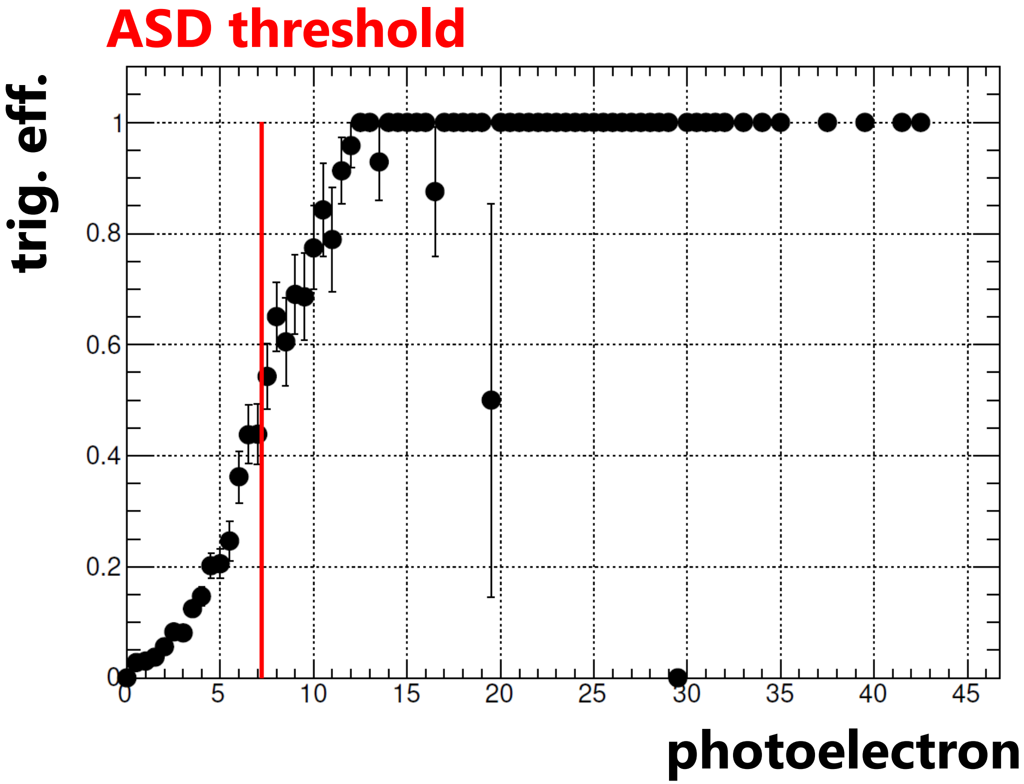
✓**HBD issues a trigger signal via ASD connected to the bottom surface of the bottom GEM**

- 30x30 cm2 GEM foil segmented into 9 trigger-tiles

✓**due to noise, a very shallow curve around the threshold is observed**

- detector capacitance of each segment is ~5 nF





Electron detection efficiency and pion rejection power

✓**electron detection efficiency and pion rejection power at both the trigger level and the offline level are evaluated**

- At the trigger level, only a charge threshold is applied in an ASD board
- At the offline level, a threshold for charge cluster size is applied as well as trigger level condition

✓**pion rejection power at the trigger level is worse than we had expected due to noise of ASD**

- noise control
- DAQ upgrade

	eID efficiency observed/expected	**pion rejection power observed/expected**
trigger level	0.63±0.03/0.68	0.043±0.005/0.02
offline level	0.61±0.04/0.63	0.009±0.002/0.006

Conclusions and outlook

- ✓ **we performed commissioning runs for the J-PARC E16 spectrometer which was design to measure dielectron spectrum**
- ✓ **Hadron blind detector is utilized for eID and works**
  - expected response to electrons and pions
  - recirculating gas system
- ✓ **ASD board for a trigger signal is so noisy that pion contamination increases**
- ✓ **noise control by grounding and DAQ upgrade are on-going for the next beam time**