

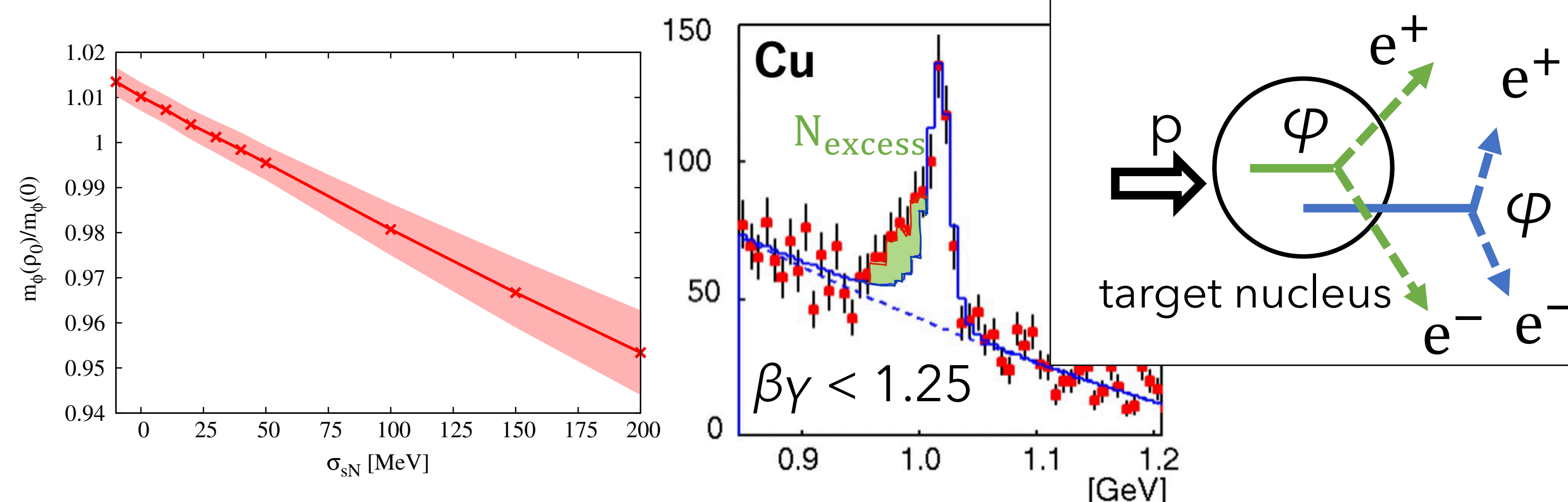
# Measurement of the mass spectrum of vector mesons in nuclei at J-PARC.

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## Physics Motivation

- Investigating the mass of the  $\phi$  meson at finite density is pivotal for grasping the QCD vacuum description.
- The KEK-PS E325 Experiment observed a 3% mass reduction of slow  $\phi$  mesons in Cu, however, more statistics is needed.



Peak positions of the  $\phi$  meson at density  $\rho_0$  as a function of  $\sigma_{sN}$

Gubler and Ohtani, Phys. Rev. D. 90 (2014) 094992

Result of KEK-PS E325.

Change of mass spectrum is observed.

R. Muto et al., Phys. Rev. Lett. 98(2007) 042581

## J-PARC E16 Experiment

Systematic study of the spectrum of phi meson change in nuclei.

- nuclear size dependence
- mesons' momentum dependence

### Experimental Challenges

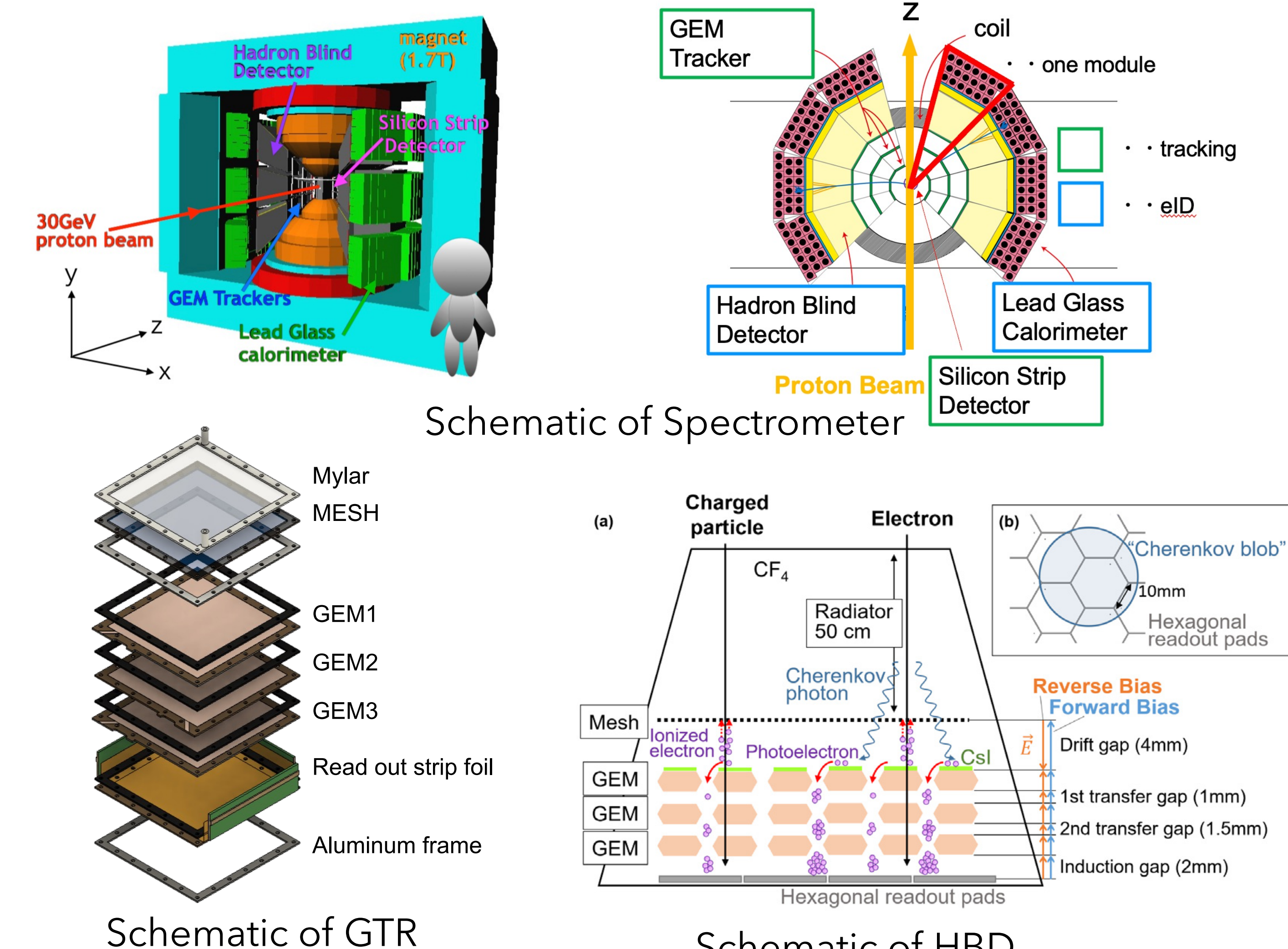
- Branching ratio of  $\phi \rightarrow e^+ + e^- \sim 3 \times 10^{-4}$  is small.
- Thin target ( $0.5\% X_0$ ) is needed to suppress the trigger background and radiative tail.

### Our Approachs

- 30 GeV primary proton beam at J-PARC ( $1 \times 10^{10}$  protons/spill).
- Horizontal  $\pm 15^\circ \sim \pm 135^\circ$ , vertical  $\pm 45^\circ$  is covered.
- Using  $\text{CH}_2$ , C, Cu, Pb targets.

### Detectors Design Values

- Tracking : 5.8 MeV mass resolution for slow meson ( $\beta\gamma < 1.25$ )  $\cong 100 \mu\text{m}$  position resolution.
- Electron Identification : 99.97% pion rejection.
- High-rate capability :  $\sim 10^7$  Hz interaction rate.



Schematic of Spectrometer

Schematic of GTR

Schematic of HBD

Schematic of LG

## Detector Commissioning Run

Detector commissioning Run was performed in 2020-2023.

### Tracking Performance

- Satisfactory** as shown in the table. However, there is still room for improvement. Calibration is ongoing.

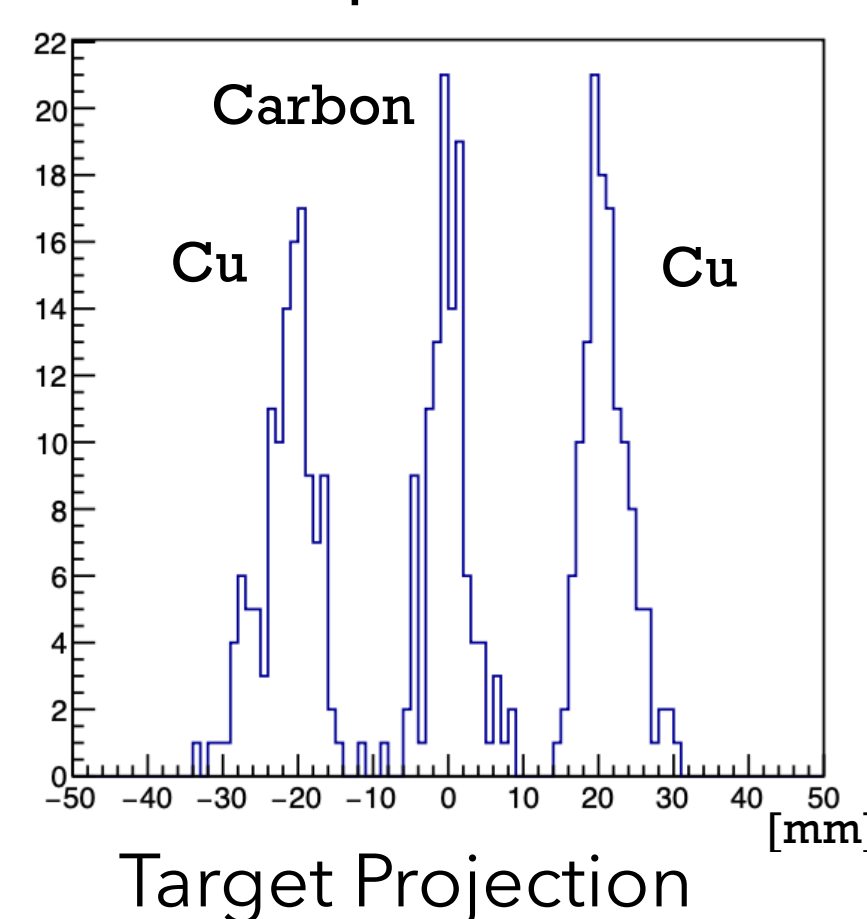


Table : Resolution of Each GTR

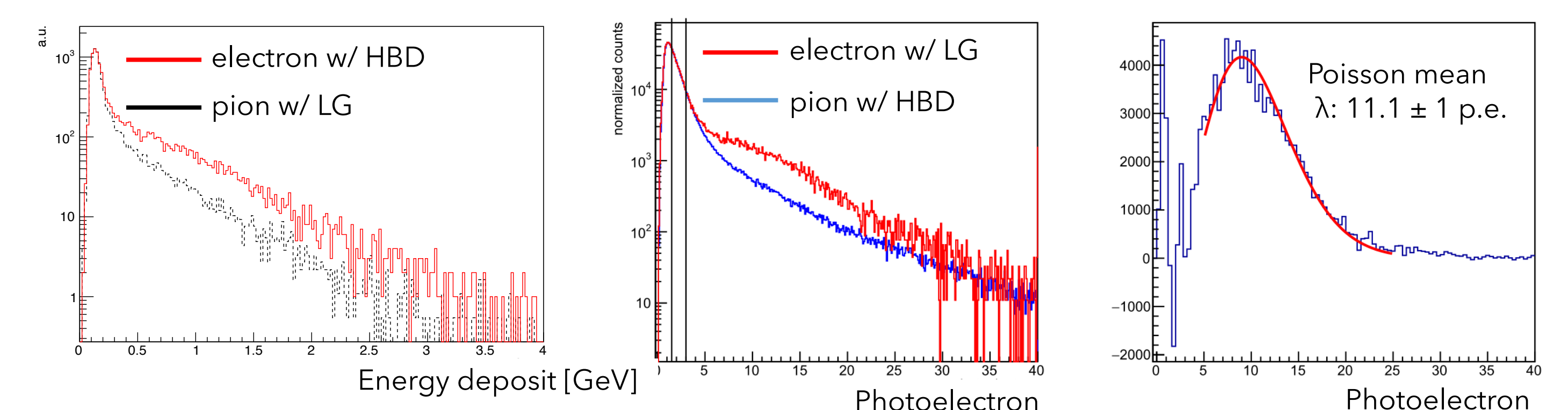
	X [ $\mu\text{m}$ ]	Y [ $\mu\text{m}$ ]
GTR100	<b>236 <math>\pm</math> 42</b>	414 $\pm$ 81
GTR200	<b>230 <math>\pm</math> 52</b>	464 $\pm$ 116
GTR300	<b>235 <math>\pm</math> 54</b>	477 $\pm$ 65

### Electron Identification Performance

- Achieved required values** as shown in the table.

Table : Performance of HBD and LG

	Pion Rejection power observed / expected [%]	Electron detection efficiency observed / expected [%]
HBD	<b>(99.1 <math>\pm</math> 0.2)</b> / 99.4	<b>(61 <math>\pm</math> 4)</b> / 63
LG	<b>(95.2 <math>\pm</math> 0.1)</b> / 95	<b>(79 <math>\pm</math> 17)</b> / 90



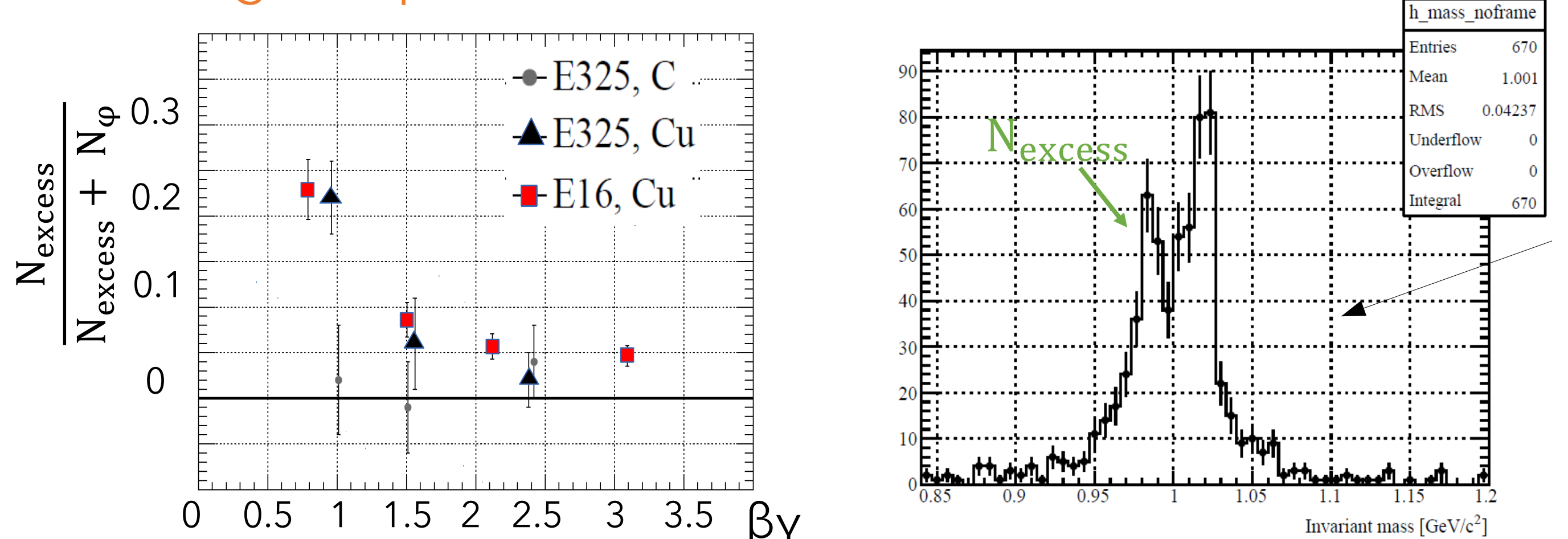
Left : Measured energy deposit with LG for electron and pion selected by HBD.  
Middle: Measured Pulse-height distribution of HBD.

Right : Difference of two histograms on the middle panel.  $11.1 \pm 0.1$  p.e. is consistent with expected performance.

S. Nakasuga et al., in: Proc. 16th VCI. 1041 (2022) 167335  
Koki Kanno, 7th MPGD. Weizmann Institute of Science, Rehovot, Israel (2023)

## Expected Results

- Examine  **$\beta\gamma$  dependence** of excess ratio.
  - Only slow/Cu  $\phi$  is significant in E325.
  - All bins for Cu will be significant in E16 Run1 (2023-)
- Pb target will be installed in Run2 (After 2024).
  - Clear separated peak will be seen.
  - Target dependence** can be investigated



Excess ratio in Run1.

Expected mass spectrum using Pb target in Run2.

## Summary

- The J-PARC E16 experiment has been launched to investigate the mass modification of vector mesons in nuclei.
- Detector commissioning run was performed in 2020-2023 and achieved required performances.
- Examinations of  $\beta\gamma$ /targets dependences of excess ratio and mass spectrum will be conducted.