# Construction of GEM tracker for J-PARC E16 Run-1†

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The GEM tracker (GTR)[1] has been constructed for the first physics run (Run-1) of the J-PARC E16 experiment,[2,3] scheduled for 2025. The GTR was designed to withstand a high counting rate of up to 5 kHz/mm$^2$ and to minimize the material budget to suppress the gamma conversion and the radiative energy loss of the electrons. This report details the structure and construction process of the GTR.

The schematic plan view of the E16 spectrometer is shown on the left side of Fig. 1. The experimental target is located at the center of the spectrometer magnet, surrounded horizontally by eight detector modules. Each GTR module consists of three GEM chambers of different sizes forming the three tracking layers. The dimensions and location of each chamber are 100 × 100 mm$^2$, 200 × 200 mm$^2$, 300 × 300 mm$^2$, and approximately 200 mm, 400 mm, and 600 mm in radius from the center, respectively. The total angle coverage of the eight modules for the target is ±15° to ±112° horizontally and ±13.9° vertically.

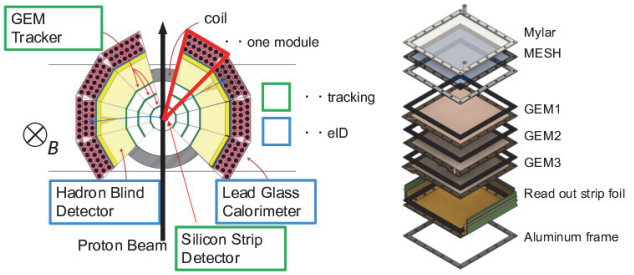


Fig. 1. Left: Schematic plan view of the E16 spectrometer. Right: Schematic view of a GEM chamber. Adapted from the paper.†

The schematic view of a GEM chamber is shown on the right side of Fig. 1. Each chamber features a drift electrode (mesh) at the top, just below the Mylar window. Three GEM foils and a two-dimensional readout strip foil are stacked under the drift region. This structure is consistent across the different sizes of chambers. The amplification gas used is Ar : $CO_2$ (70 : 30). The total thickness of the three chambers is less than 1% $X_0$ (radiation length).

Before assembling each GEM chamber, unit test of the GEM foils was performed. The discharge rate and leakage current between the top and bottom of a GEM foil were measured by applying 600 V in the $N_2$ gas. The selection criteria were less than 30 discharges-/100 cm$^2$/hour and 1 nA/100 cm$^2$, respectively. The rate and current decrease over time, typically taking 24 hours to meet the criteria. During the construction of the eight modules, 157 GEM foils were tested, as shown in Table 1.

Table 1. Summary of tested GEM foils.

| size | OK | bad | total | yield |
|---|---|---|---|---|
| 100×100 | 33 | 26 | 59 | 56% |
| 200×200 | 28 | 21 | 49 | 57% |
| 300×300 | 36 | 13 | 49 | 73% |
| total | 97 | 60 | 157 | 62% |

Each chamber was assembled in a class 1000 clean room using the GEM foils that passed the above test. A set of three different-sized of chambers, forming a module, were attached to a CFRP frame to keep the relative positions of the chambers within a module. Each module underwent testing to check the gain and cable assignments. The gain of each chamber was measured using the signals produced by a 5.9 keV X-ray source, $^{55}$Fe. The operation voltages were adjusted to achieve a gain of 6000 or more. Previous test experiments confirmed that a gain of 6000 is sufficient to meet the required position resolution of 100 $\mu$m. A typical gain curve is shown in Fig. 2.

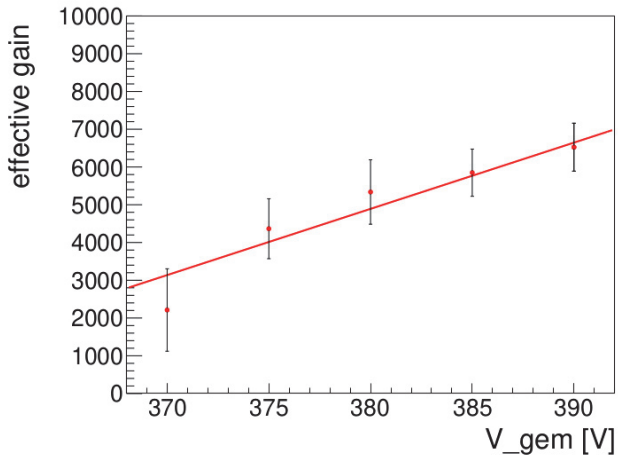


Fig. 2. Typical gain curve of a GEM chamber. Adapted from the paper.†

In conclusion, we have successfully constructed the GTR. We tested 157 GEM foils and selected the best ones to assemble the 24 GEM chambers that compose the eight modules of the GTR. The commissioning run of the E16 spectrometer is currently underway.

References

1) T. N. Murakami, RIKEN Accel. Prog. Rep. **54**, 108 (2021).
2) S. Yokkaichi, in this report.
3) K. Aoki *et al.*, Few-Body Syst. **64**, 63 (2023).

† Condensed from the article in Nucl. Instrum. Methods Phys. Res. A **1058**, 168817 (2024)

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DOI:10.34448/RIKEN.APR.57-106