Mass production and performance of large area Micromegas\DMM detectors

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Abstract: To meet the performance demands of various experiments, the development of high-performance, large-area Micromegas detectors and their mass production have become crucial technical challenges to address. This report will present the advancements in Micromegas manufacturing technology utilizing the thermal bonding method. In recent years, we have successfully produced large-area Micromegas detectors with sensitive areas of 400 × 400 mm^2 and 600 × 600 mm^2, and completed the production of a batch of detectors for cosmic ray track detection by implementing quality control methods such as material selection, condition control, and high-voltage aging. Test results demonstrate a position resolution of approximately 130 μm and a detection efficiency exceeding 95%. Furthermore, several large-area, high-performance double layer mesh Micromegas (DMM) detectors have been fabricated successfully. Preliminary test results show gas gain higher than 10^5 and the IBF ratio < 0.03%, indicating promising application potential in the future.

Introduction

- The thermal bonding method
- Mass production and optimization
- The Multi-layer tracker system for muography
- The DMM detectors and performance
- Conclusions

Thermal Bonding Method（TBM)

The thermal bonding method is a highly promising and competitive technoloty for Micromegas detectors, developed by the MPGD team at the University of Science and Technology of China.

Fig. 1 the thermal bonding method of the Micromegas detector

We have developed a high-stability, high-performance, large-area manufacturing process for Micromegas detectors. This technique offers advantages such as non-etching, environmentally friendly operation, simplicity, and cost-effectiveness. As shown in the illustration on the left, the primary TBM process involves using a rolling machine to bond the stretched stainless-steel mesh onto the PCB to create the avalanche gap of the Micromegas detector. The fundamental performance characteristics of the Micromegas detectors based on the TBM process are detailed in [1][2].

Mass Production and Improvement

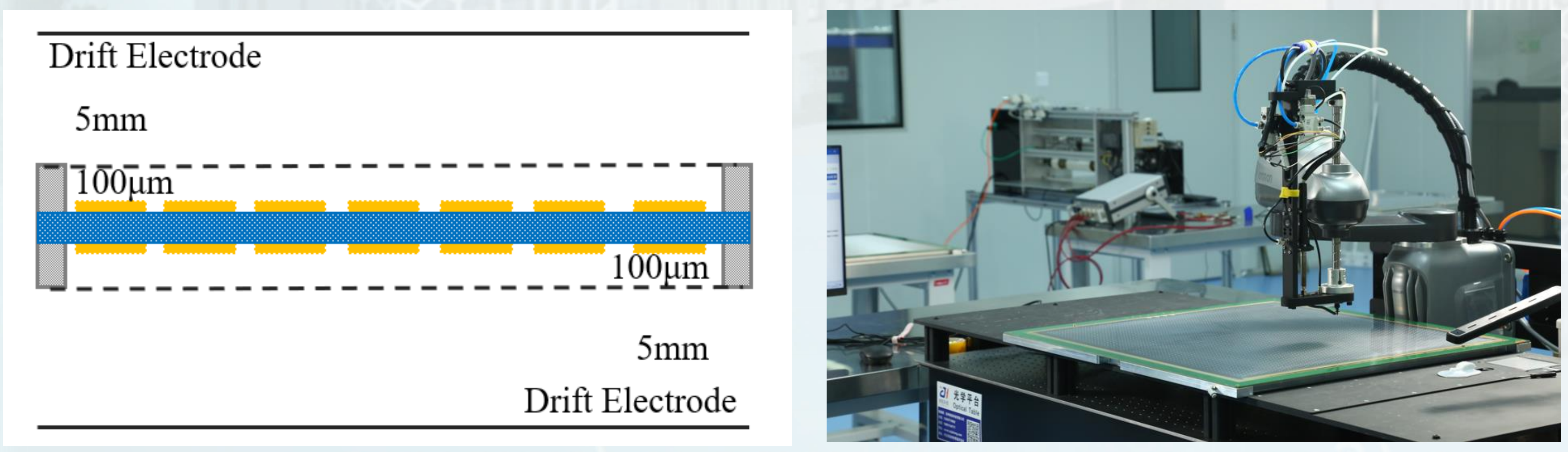


Fig. 2 the "**back-to-back**" design and the automatic process improvement

In order to improve the stability of large area Micromegas detectors, we have adopted a "**back-to-back**" structure, distributing the readout strips in the X and Y directions on the upper and lower surfaces of the readout PCB, and constructing identical avalanche and drift regions on both surfaces. This "**back-to-back**" structure allows independent avalanche amplification in the X and Y directions on the each side of the detector, increasing the signal-noise ratio, thereby lowering voltage requirements and improving detector stability.

In terms of batch production processes, an automated robotic arm replaces manual process to place the spacers, as shows in Fig. 2, improving production efficiency while enhancing process stability, laying a solid foundation for the batch production of high-performance, large area Micromegas detectors.

Conclusion

- A "**back-to-back**" structure designed, automated robotic arm and laser cutter are introduce to improve the batch production process.
- Several different sizes standard muongraphy platforms are built.
- Successfully fabricating a large-area double-mesh Micromegas detector with low IBF ratio of ~0.05%.

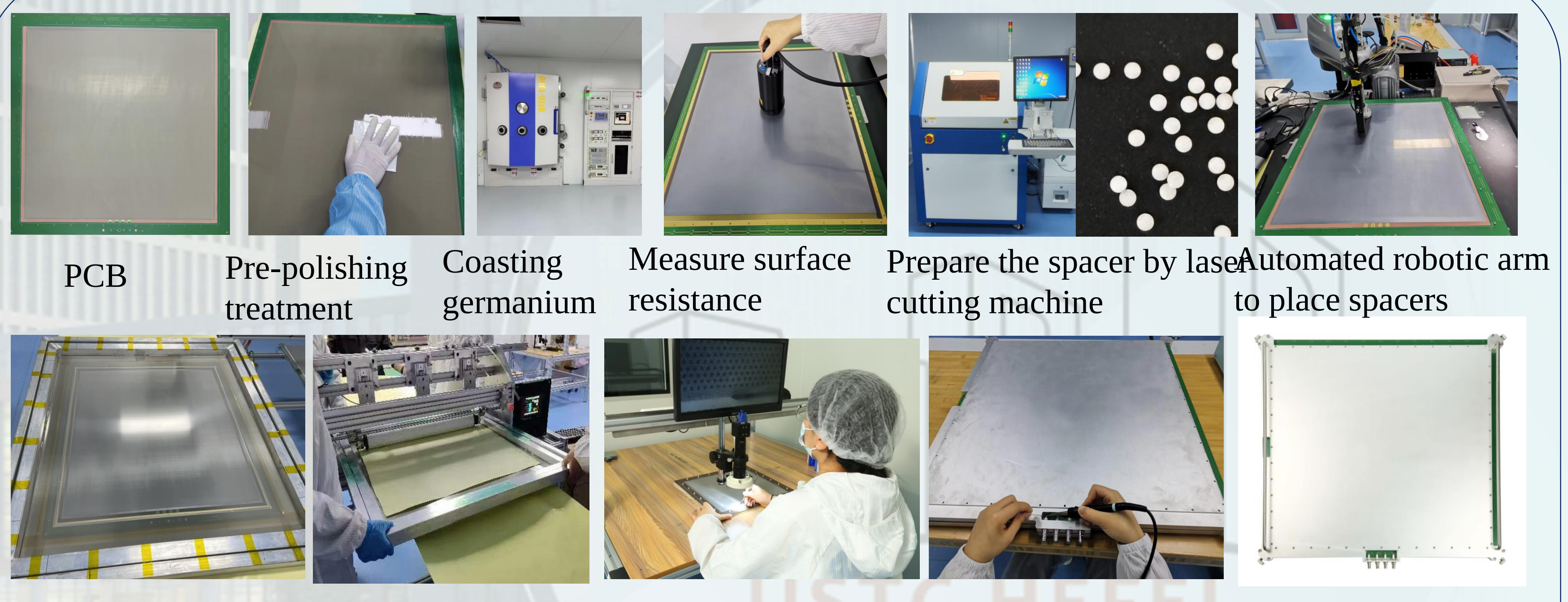

PCB
Pre-polishing treatment
Coasting germanium
Measure surface resistance
Prepare the spacer by laser cutting machine
Automated robotic arm to place spacers
The **back-to-back** mesh frame mounting
Thermal bonding
Edge cutting and check up
Install the drift electrode and gas chamber
A finished Micromegas detectors

Fig. 3 The full-process of fabricatting a Micromegas detector using TBM.

The Multi-layer Tracker System for Muography

Several muography systems of different sizes and layers have been established in the laboratory and used to calibrate the detector`s performance of efficiency and position resolution[3], as shown in Fig. 4. The muon tomography and radiography were established that based on the desktop platform and all-terrain car platform respectively.At the same time, trajectory reconstruction algorithms and multi-layer alignment algorithms are being studied.

Fig. 4 the three different size multi-layer Micormegas detector system for muon tomography or radiography: 150x150 mm^2, 400x400 mm^2, 600x600 mm^2.

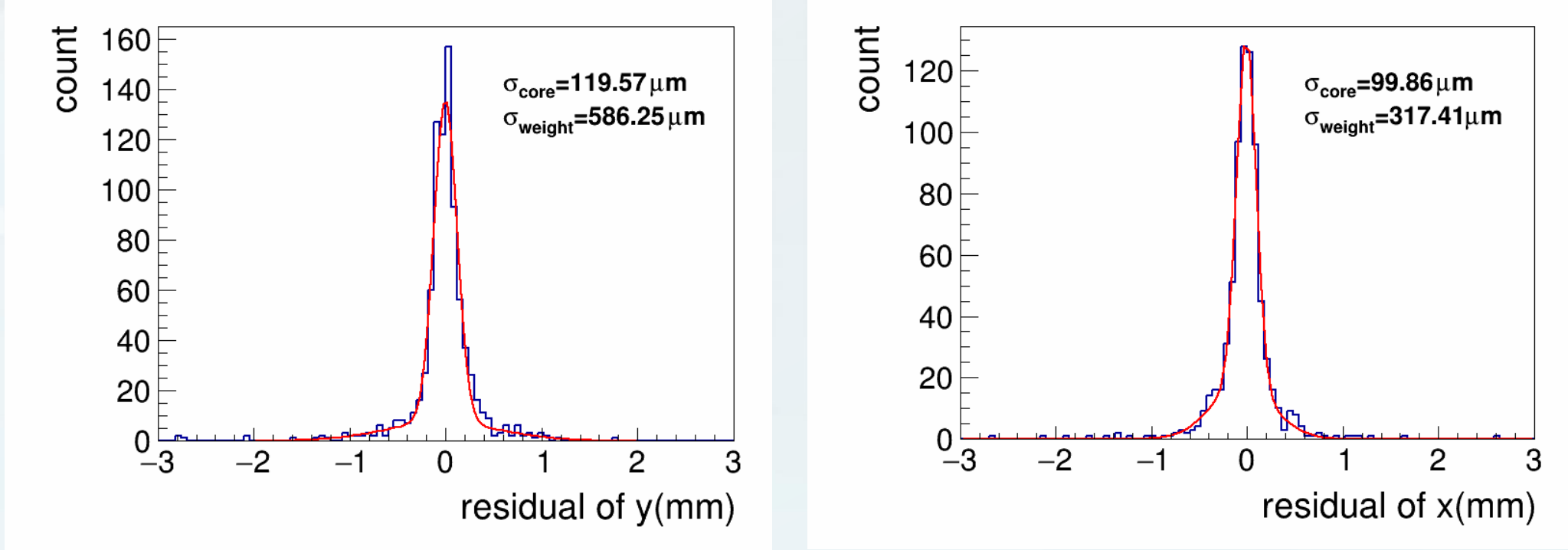
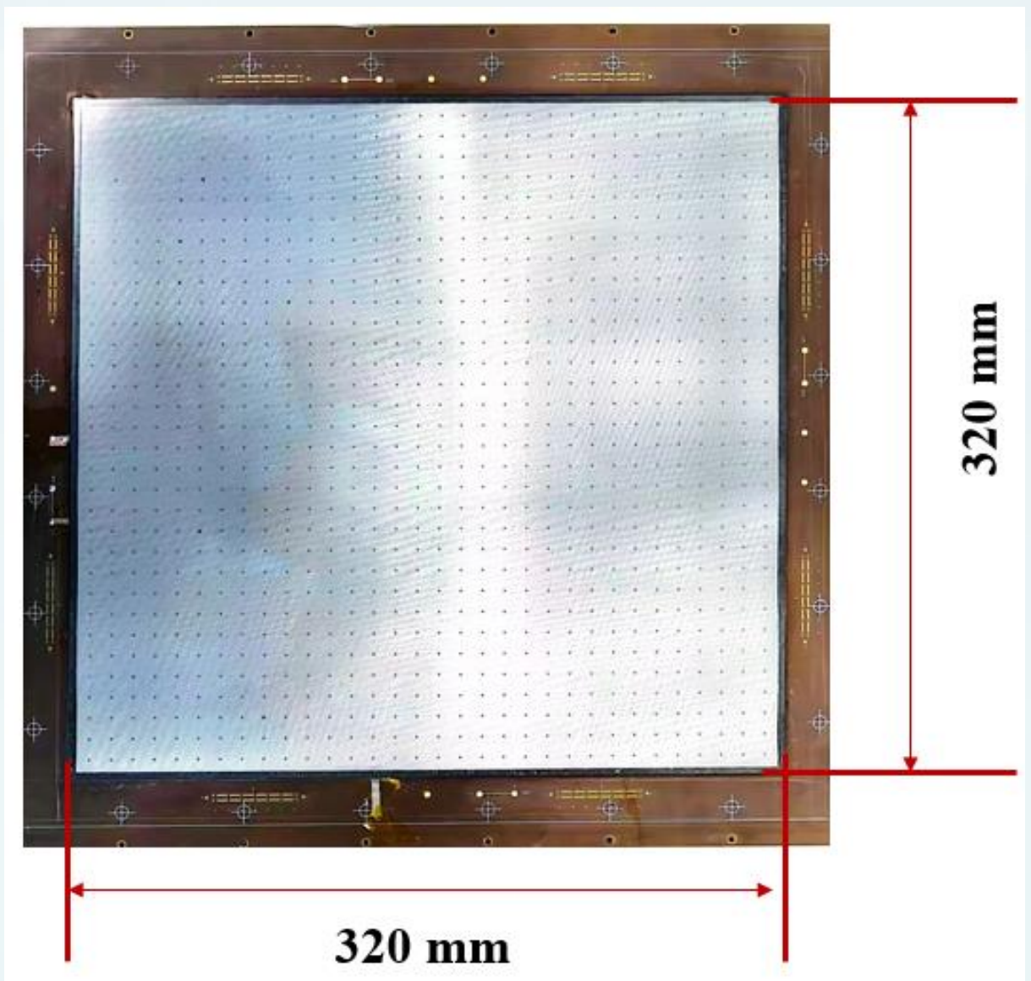


Fig. 5 Spatial resolution of x/y dimensions of 400x400 mm^2 muon radiography system calibrated by cosmic ray muons.

DMM detector and performance



A 320×320 mm^2 double micro-mesh Micromegas detector was fabricated for RICH detector of the STCF project. This new detector aims to provide better time resolution, lower ion backflow, and higher gain.

- Time resolution <300ps for single photon[4]
- The gas gain > 10^5
- IBF ratio > 0.03%[5]

Fig. 6 A 320x320 mm^2 double-mesh Micromegas detector.

Reference

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