

Uniformity Optimization Study of Scintillating Glass Tiles for an Imaging Hadron Calorimeter

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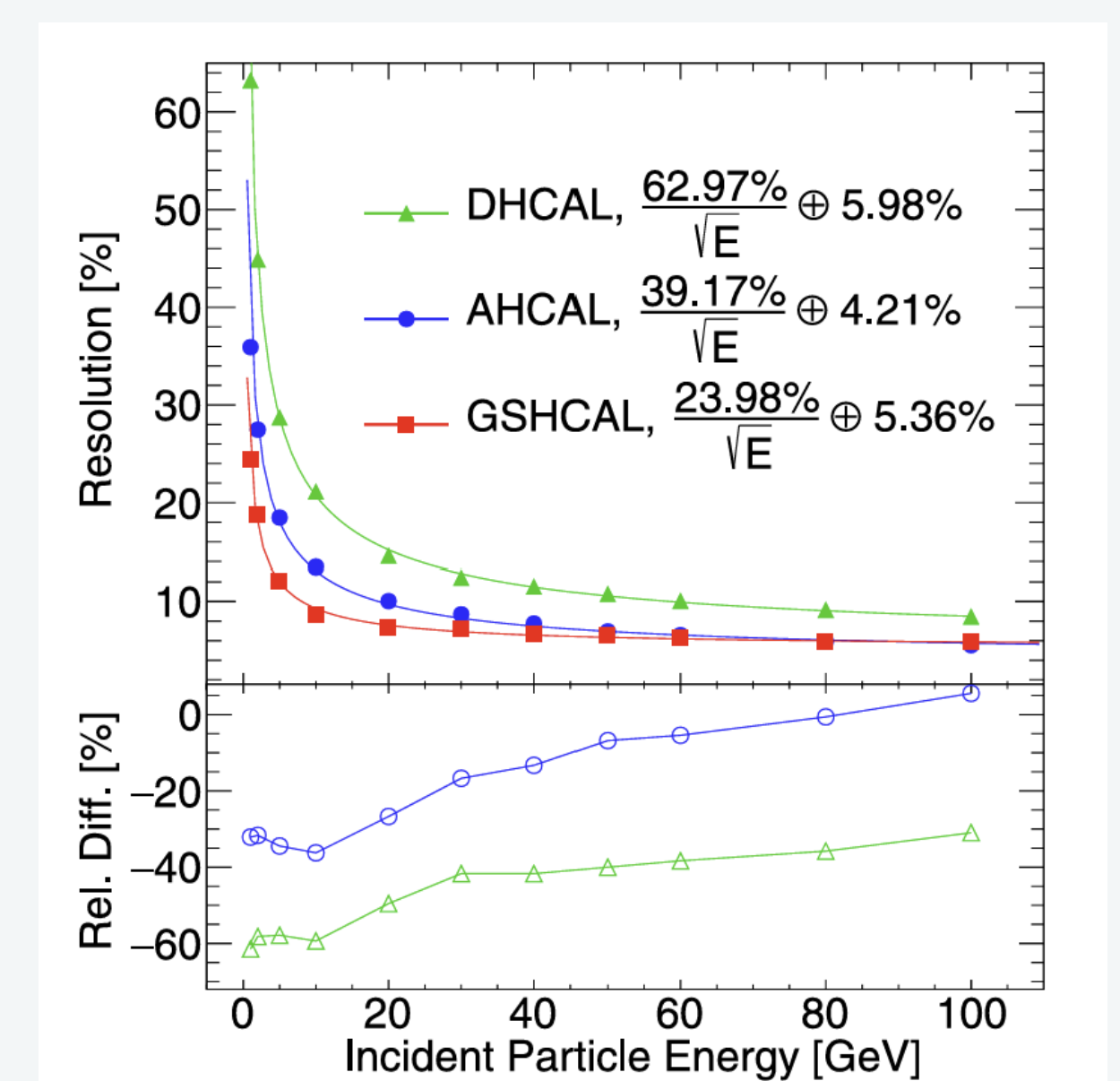
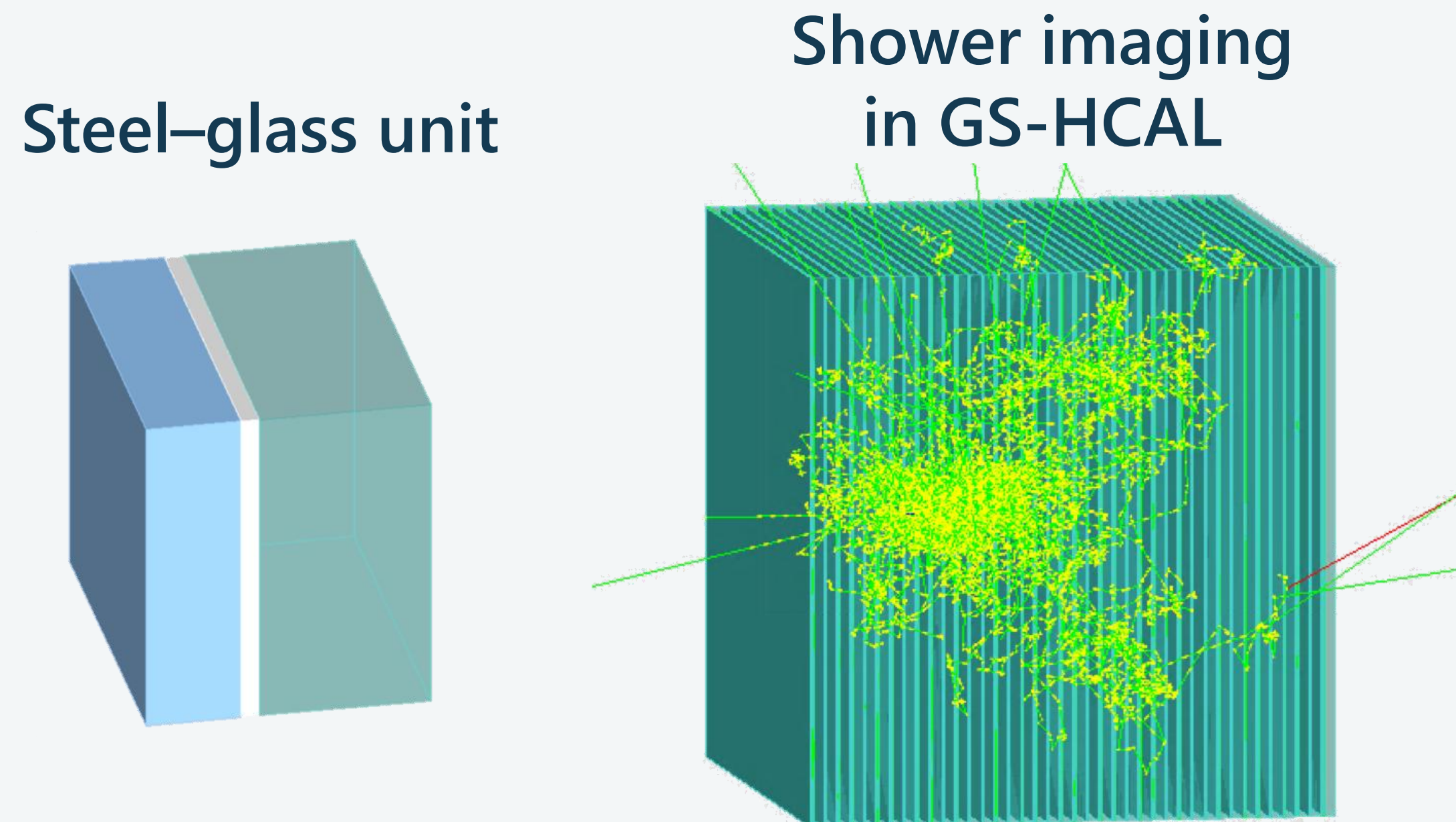
01 Glass Scintillator HCAL

Designed for CEPC / FCC-ee

- Density: 6 g/cm³
- Tile dimensions: 4 × 4 × 1 cm³
- Total number of layers: 40
- Total nuclear interaction length: 5 λ

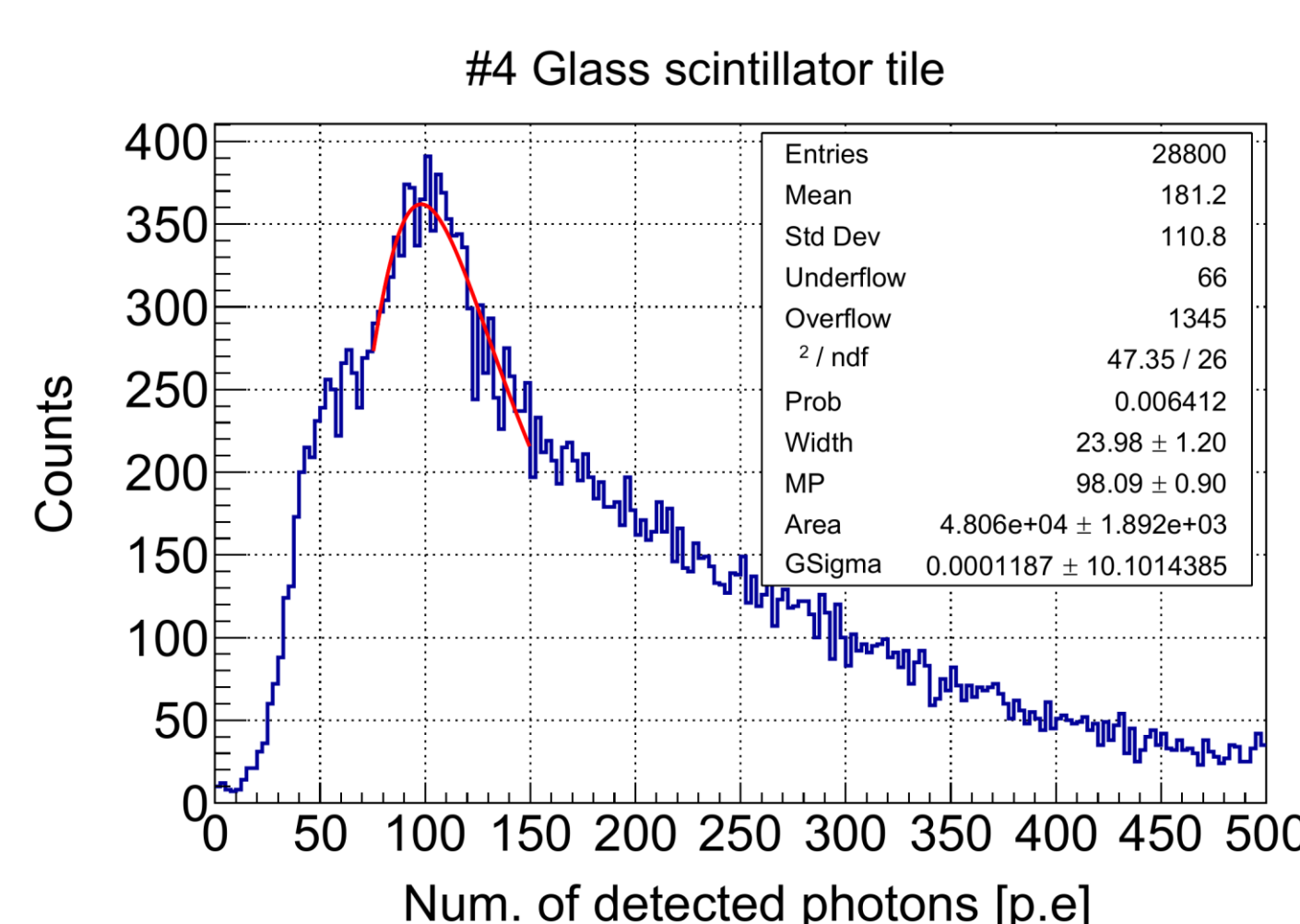
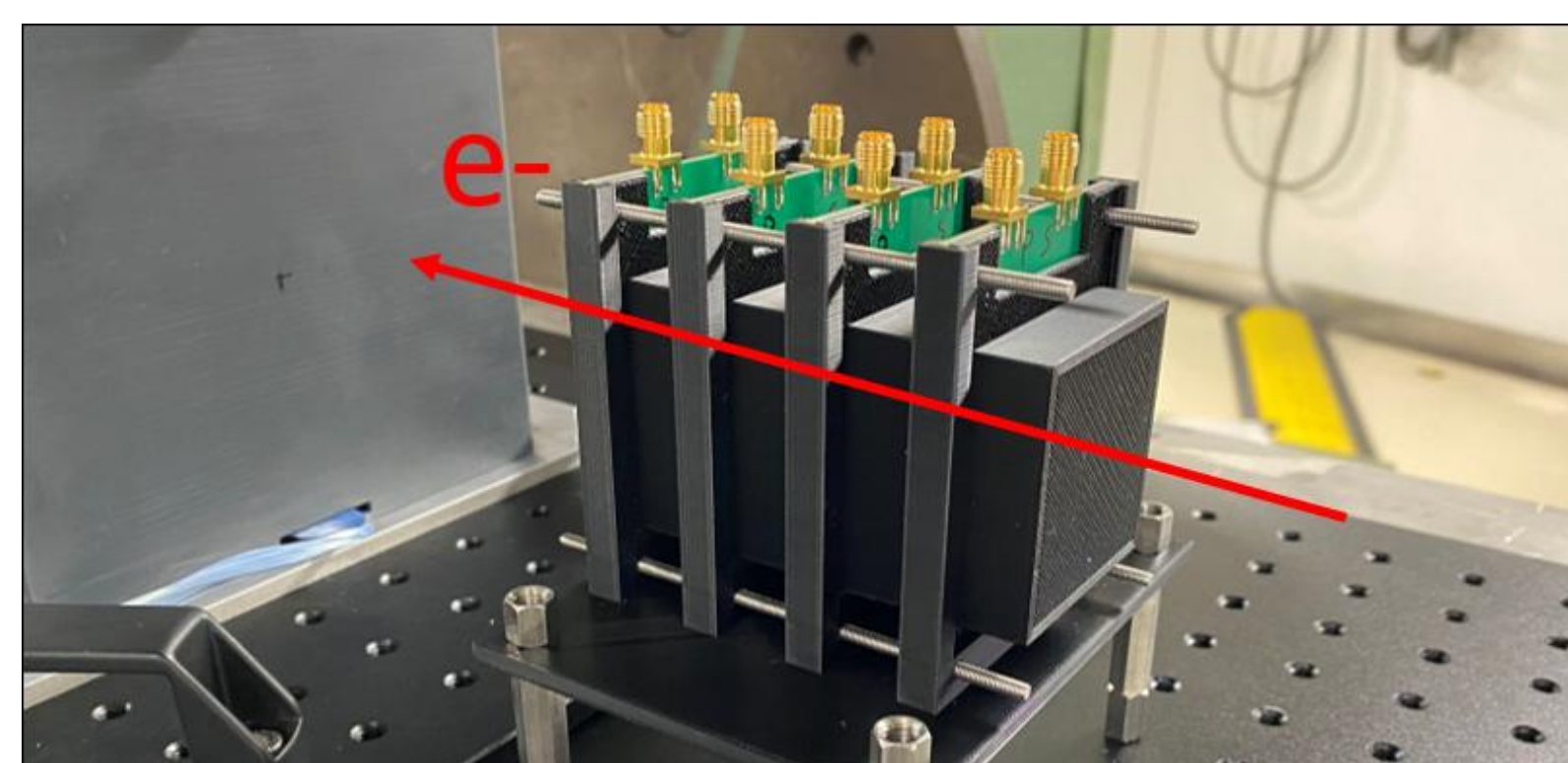
Use high-density glass [2, 3]

Higher sampling fraction leads to better hadronic resolution



02 DESY Beam Test

- 9 glass tiles
- 5 GeV electrons



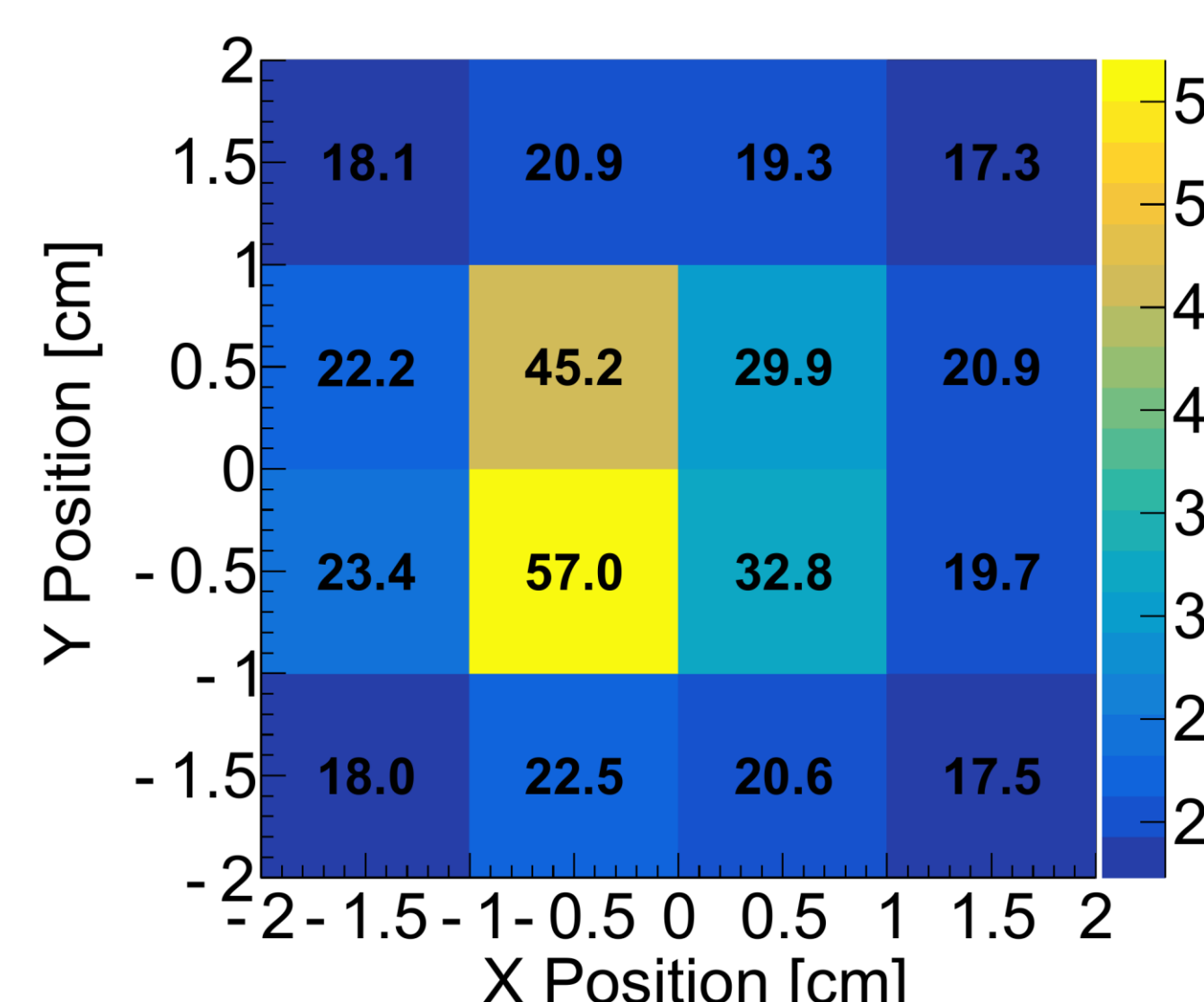
Central response

72–98
p.e. / MIP

Target: 60–100 p.e./MIP [1]

03 Response Map

Position scan of glass #4

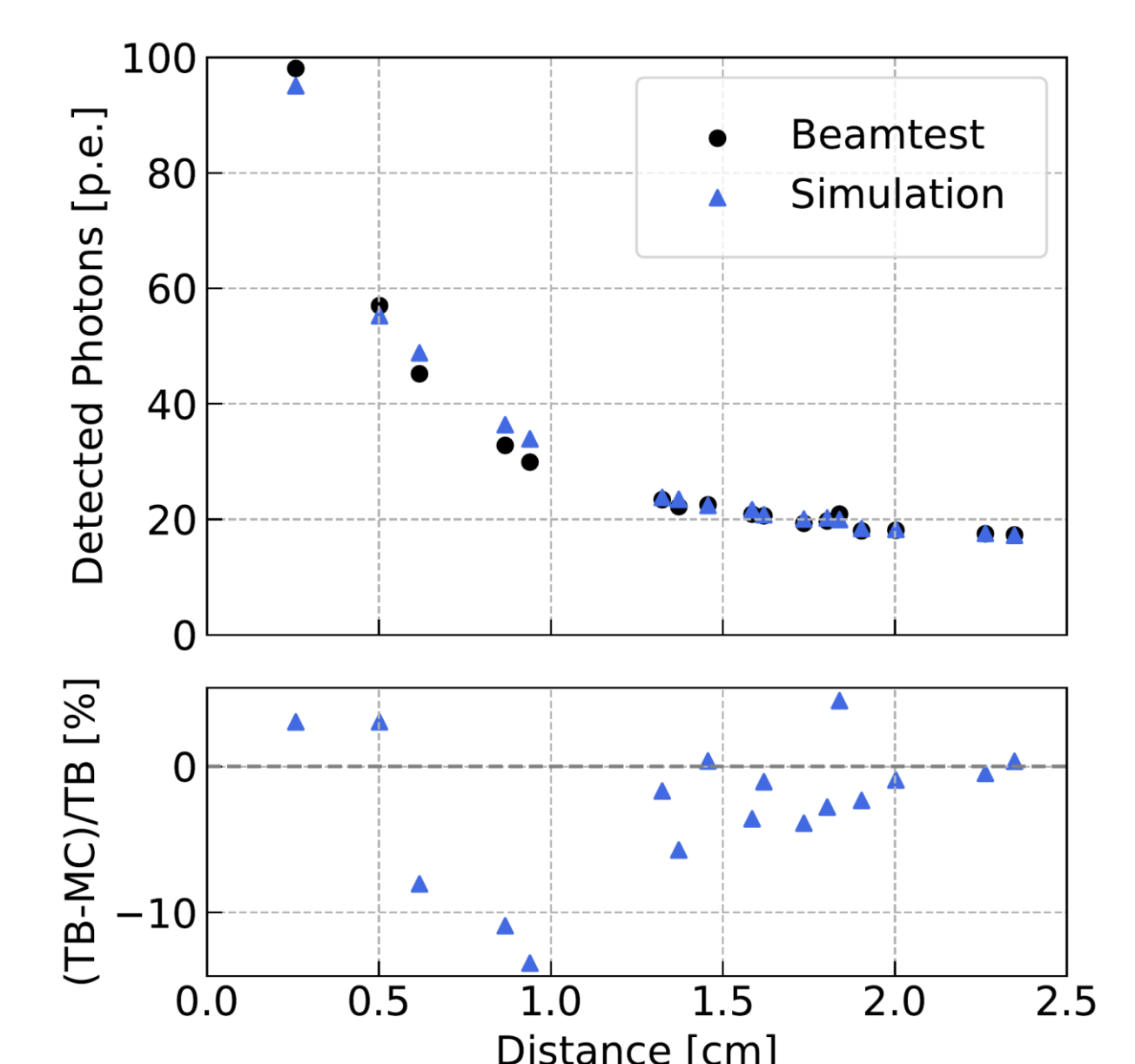


Very bad uniformity

- U = 43.9% on 16-point grid
- U = 69.8% including centre

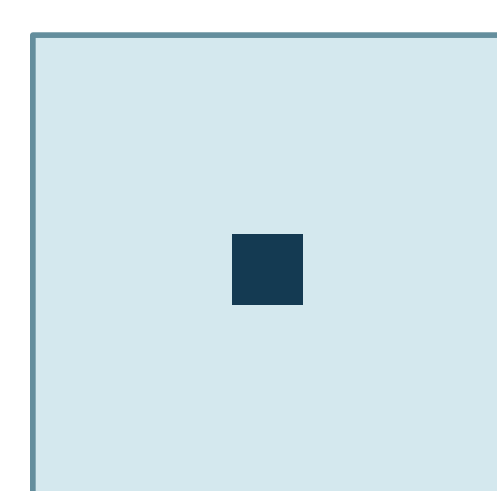
Non-uniformity U = σ / mean

04 Optical Model

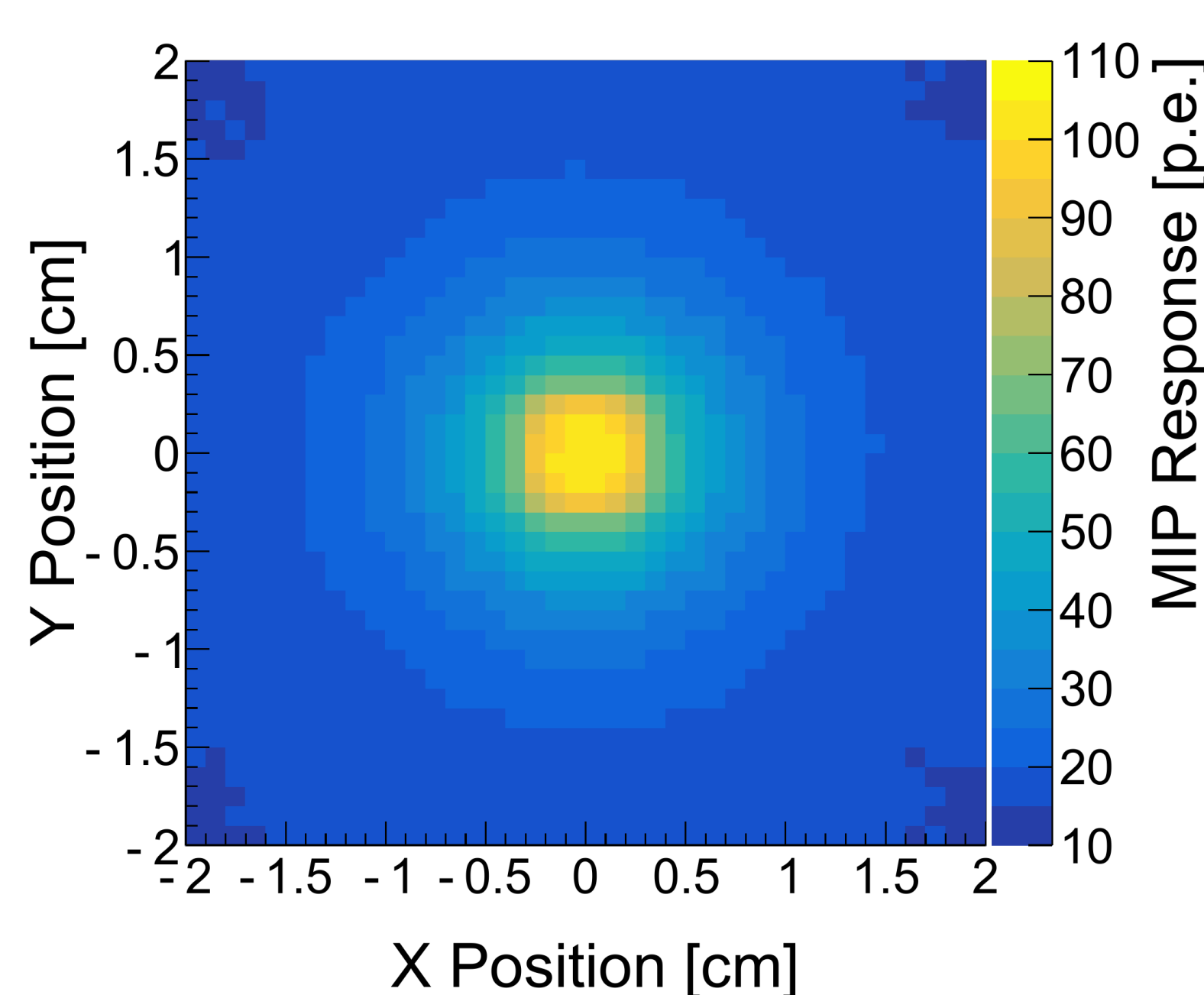


- Consider attenuation of absorption and scattering
- The simulation agrees with the beam-test response within ±14%

05 Uniformity Optimization Based on Geant4 Simulation

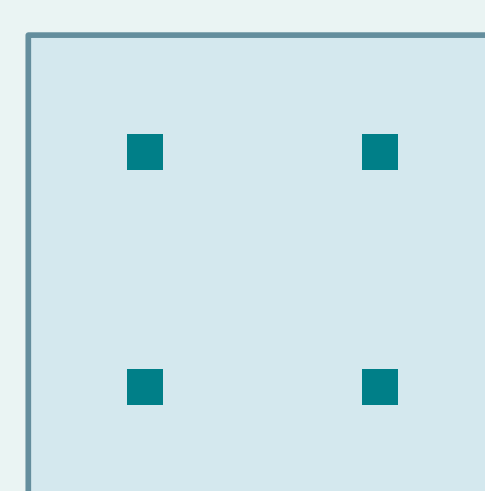


Single SiPM

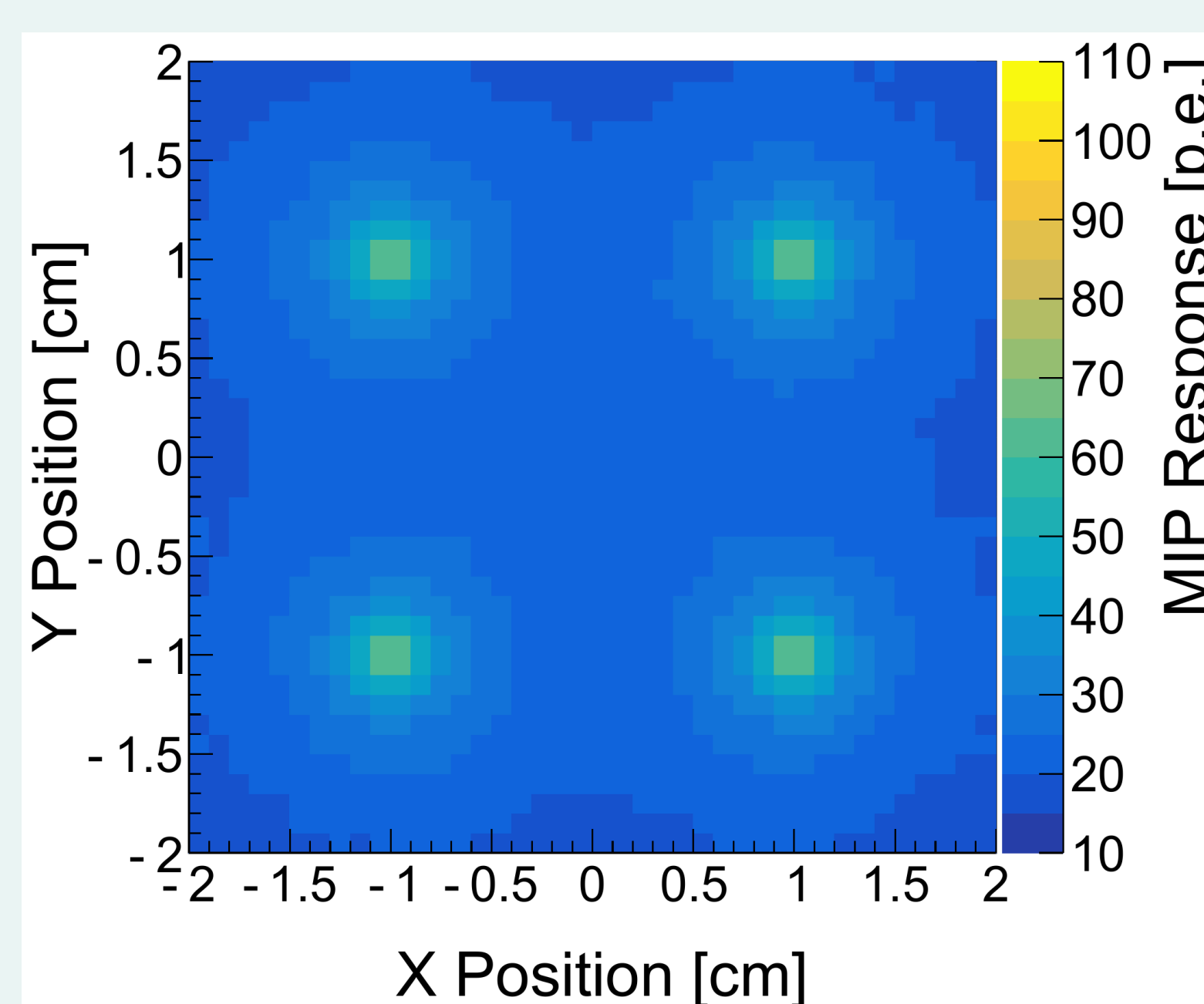
1 × (6 × 6 mm²)

U = 60.0%

Baseline

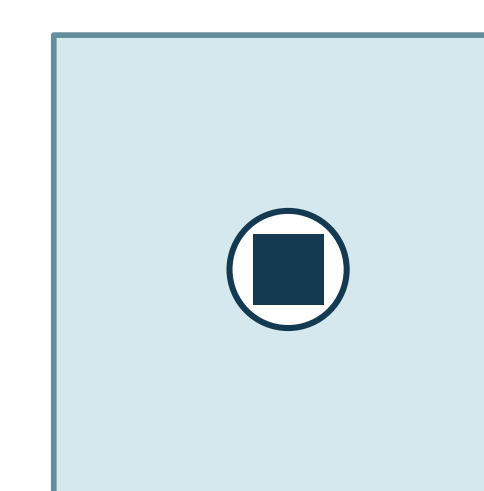


Four SiPMs

4 × (3 × 3 mm²)

U = 27.2%

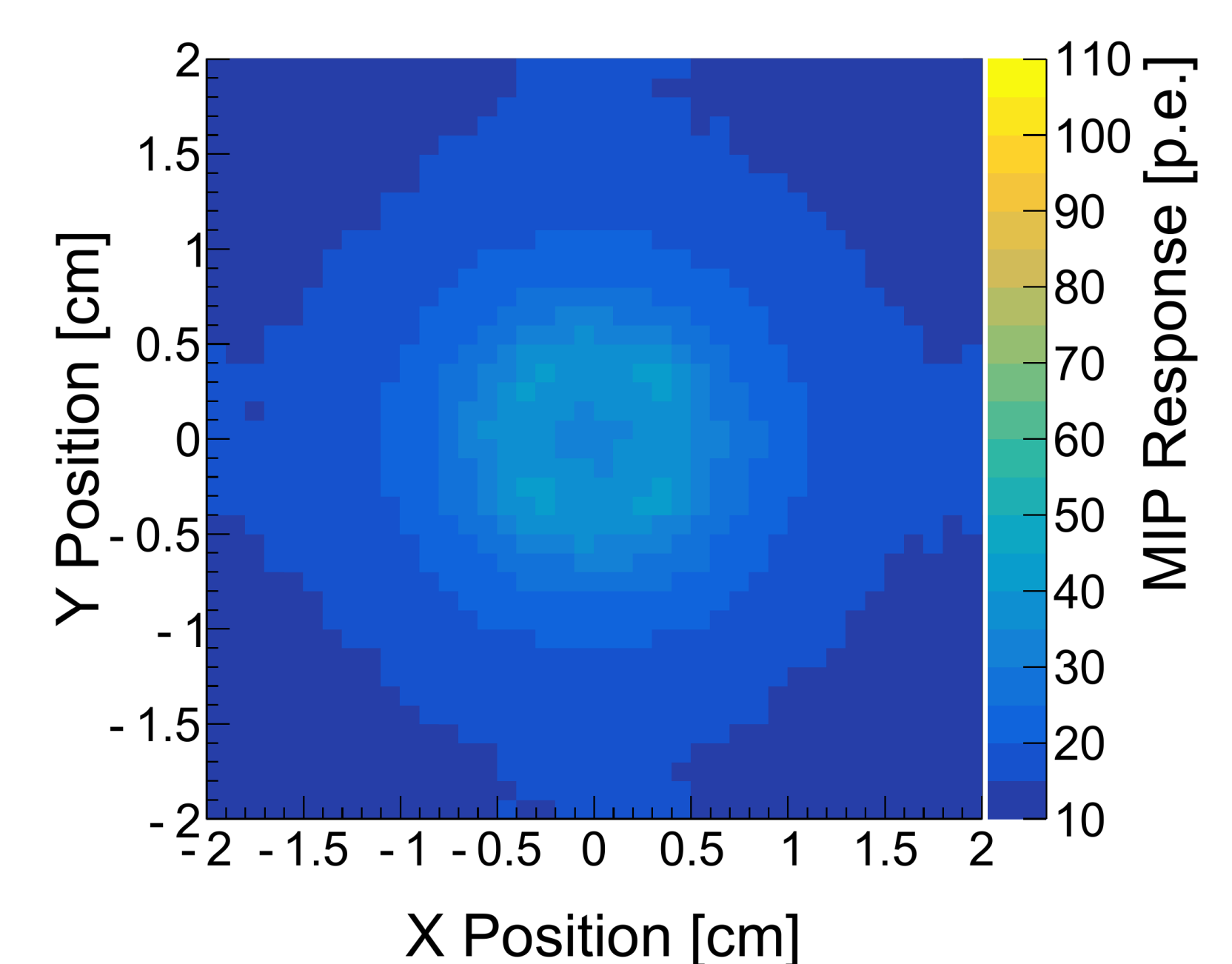
Spatial mean: 24 p.e.



Spherical cavity

Radius 5 mm

Depth 3 mm



U = 35.9%

Spatial mean: 18 p.e.

Conclusions

- All 9 tiles meet the central response target
- Four SiPMs: best uniformity, same SiPM area

Outlook

- Longer attenuation length and better quality in glass production
- Beam validation of optimized geometries

[1] CEPC Reference Detector TDR, arXiv:2510.05260 (2025).

[2] D. Du & Y. Liu, Instruments 6 (2022) 32. [3] P. Hu et al., NIM A 1059 (2024) 168944.