Highly granular hadronic calorimeter with scintillating glass tiles: R&D highlights

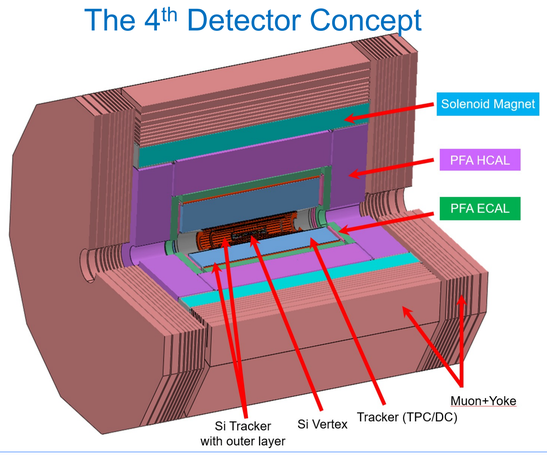
Dejing Du, Peng Hu, Yong Liu, Sen Qian
Institute of High Energy Physics, Chinese Academy of Sciences
On behalf of the CEPC calorimetry team, CALICE and Glass Scintillator Collaborations

42ND INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS
18-24 July 2024
ICHEP 2024 | PRAGUE

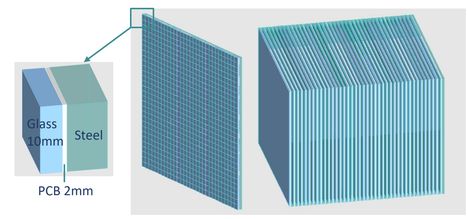
Introduction and Motivations

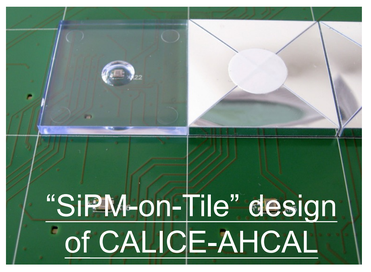
- PFA-oriented detector system: the CEPC 4th conceptual design
  - Hadronic calorimeter (HCAL) with glass scintillator tiles
  - Requires glass scintillator to be dense, bright, cost efficient
  - Expect to significantly improve hadronic energy resolution
- R&D activities for glass scintillator HCAL
  - HCAL design, simulation studies and hardware developments
  - Glass scintillator tiles: testing with cosmics/sources/beams
    - Key requirement: MIP response ~100 p.e. in 10 mm thickness
  - PFA optimization and physics performance studies[1]

The 4th Detector Concept



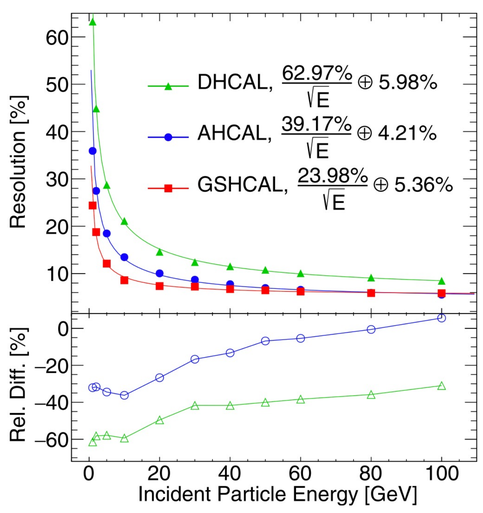
Glass scintillator HCAL

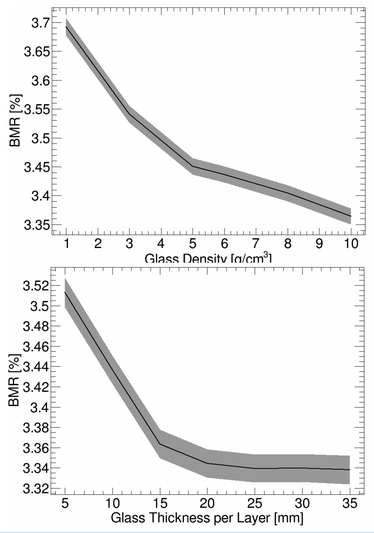


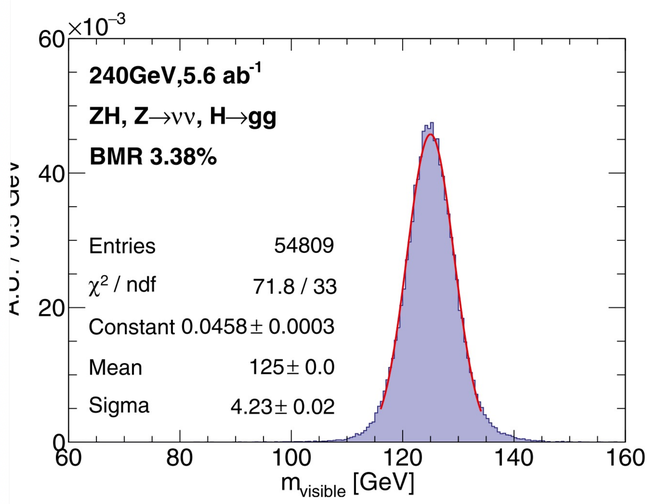


Simulation Studies and Design Optimisations

- **Geant4 simulation studies with Particle-Flow Algorithm (Arbor)**
  - Better energy resolution for single hadrons
  - Significantly improved Boson Mass Resolution
- **Optimisations to guide scintillator glass R&D[1]**
  - Varying density and thickness of glass tiles
  - Balance between performance and glass tile production challenges
  - Optimal: density of 6 g/cc and thickness of 10mm



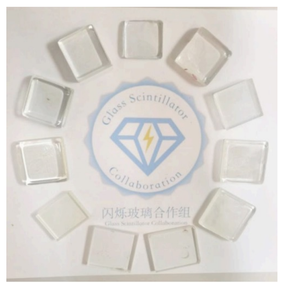




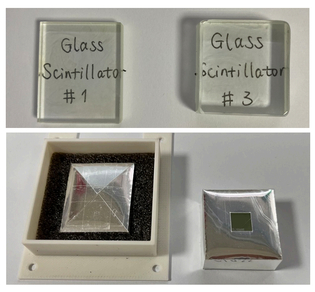
CERN beamtest with muons

- **First batch of large-area glass scintillator tiles**
  - 11 tiles successfully tested at CERN PS-T9 in May 2023
  - Various tile dimensions: 25–40 mm in length, 5–10 mm in thickness

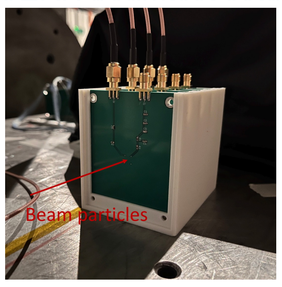
Glass tiles before wrapping



Glass tiles with ESR

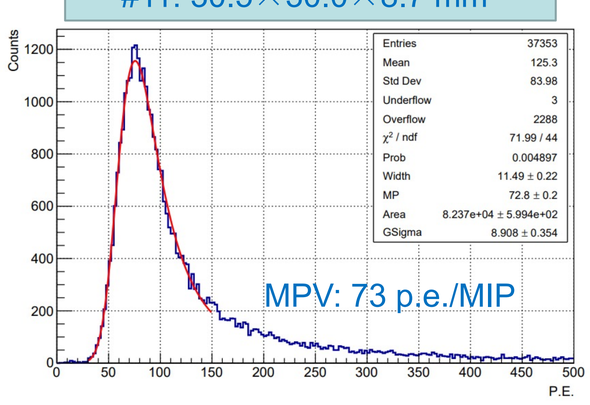


CERN beamtest setup

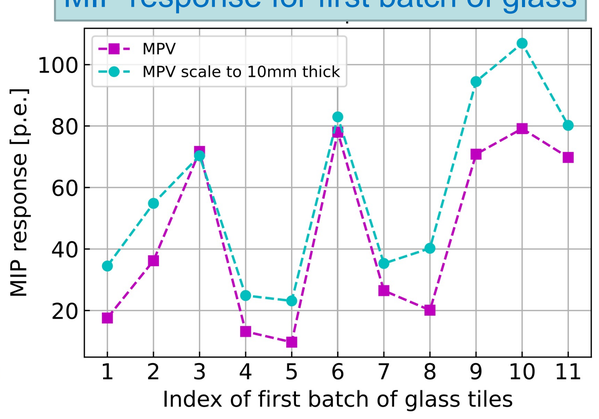


- **CERN beamtest results[2]**
  - Observed clear MIP signals in all 11 glass tiles (with 10 GeV muons)
  - MIP response range for all samples: 10–79 p.e./MIP

#11: 30.5×30.0×8.7 mm³



MIP response for first batch of glass

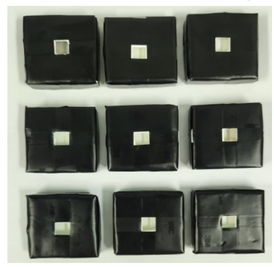


DESY beamtest with electrons

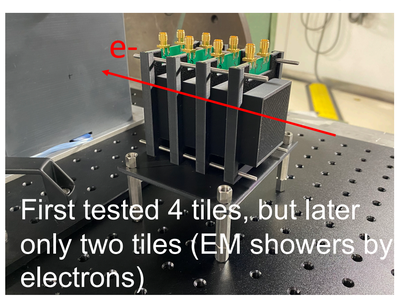
- **Second batch of large-area glass scintillator tiles**
  - 9 new glass tiles with standard dimensions ($4\times4\times1\mathrm{cm}^3$) successfully tested at DESY in Oct. 2023 with 5 GeV e- beam

Glass tiles (standard size)

Glass tiles wrapped with Teflon and black tapes

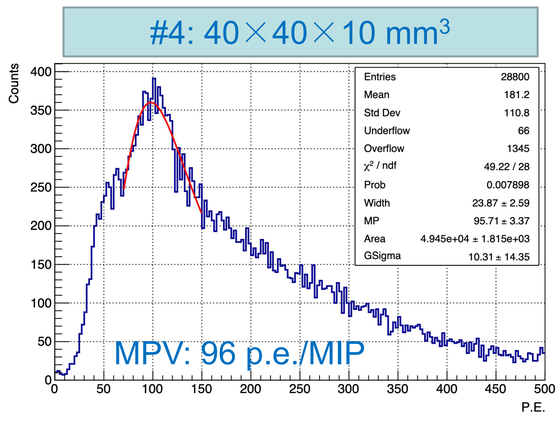


DESY beamtest setup

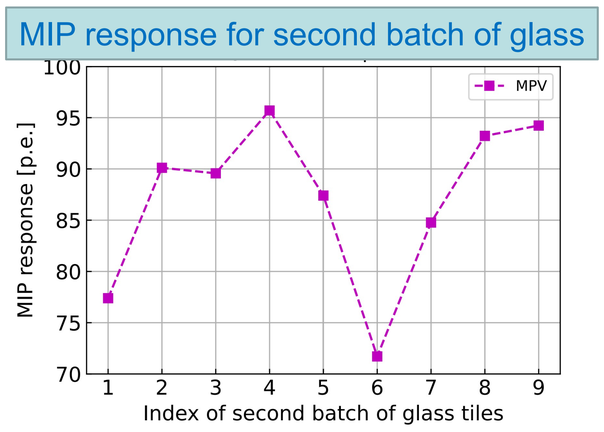


- **Beamtest results**
  - Observed clear (quasi-) MIP signals in all 13 glass samples
  - Typical MIP response: 71–96 p.e./MIP, showed generally relatively good uniformity within the same batch

#4: 40×40×10 mm³



MIP response for second batch of glass



Conclusions

- Successful beamtests with the first batch of 11 glass scintillator tiles and second batch of 9 glass tiles in standard dimensions
- Promising results in the first batch of glass tiles, some samples expected to achieve the requirement of 100 p.e./MIP with thickness scaling
- For the second batch of tiles in standard dimensions, the Quasi-MIP response range of 71–96 p.e./MIP → promising to achieve the goal

Acknowledgements

This work was received funding from the EURO-LABS. The authors would like to thank the technical support from beamtest facilities of CERN and DESY and the CALICE collaboration.

Reference

[1] Peng Hu et al., GSHCAL at future $e+e-$ Higgs factories
[2] Dejing Du et al., Muon beamtest results of high-density glass scintillator tiles