

Performance Study of BSO Crystal Bars for High-Granularity Electromagnetic Calorimeters

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01 Motivation & Concept

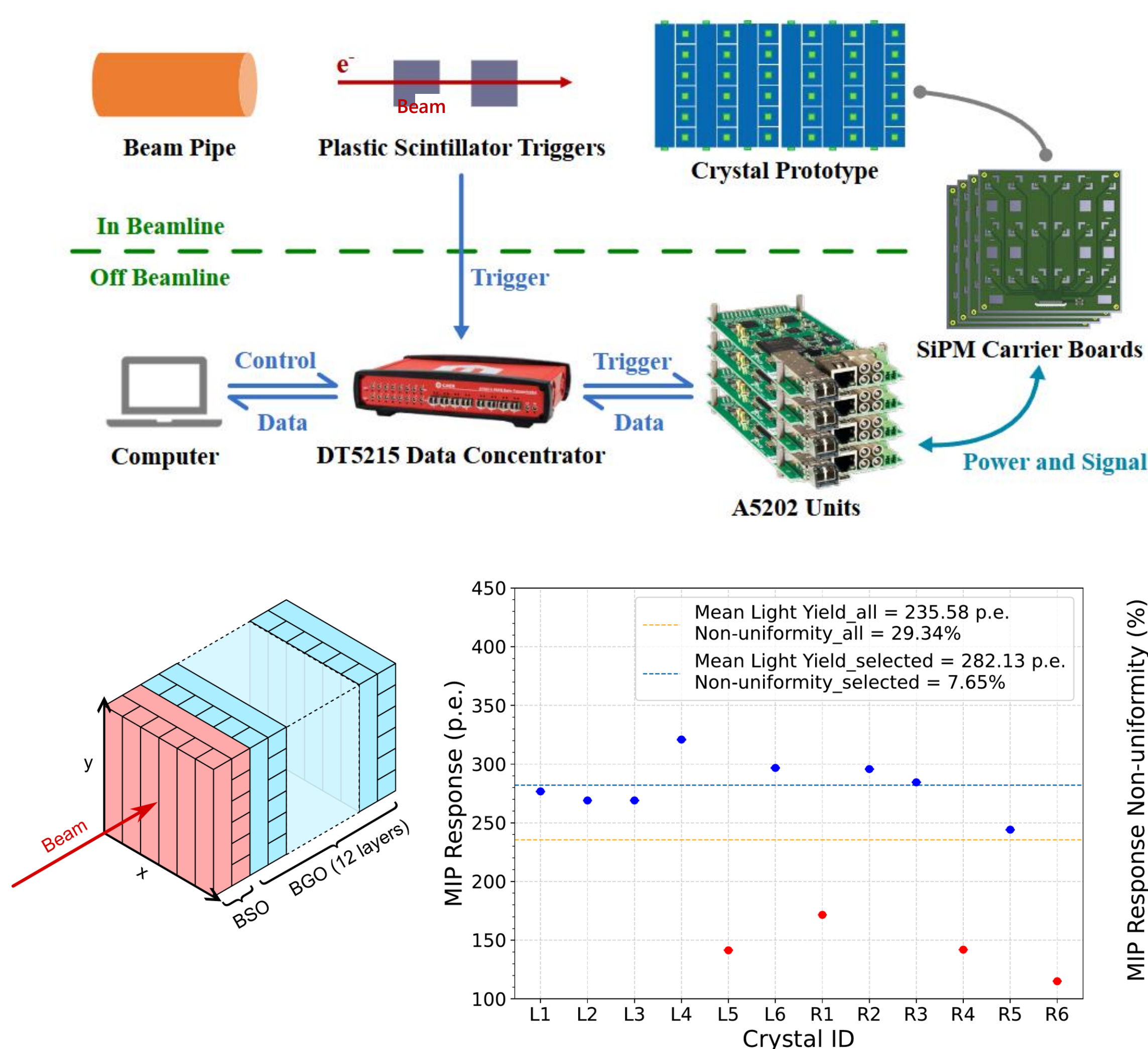
Crystal ECAL for future e^+e^- colliders

➤ BSO as an alternative [1,2]

- Faster scintillation
- Potential cost benefit

➤ Design

- $15 \times 15 \times \sim 400$ mm³ bars
- Orthogonal layers with two-ended SiPMs



Typical crystal properties [3]

Property	BSO(Bi ₄ Si ₃ O ₁₂)	BGO(Bi ₄ Ge ₃ O ₁₂)
Density (g/cm ³)	6.80	7.13
Radiation length (cm)	1.15	1.12
Decay time (ns)	100	300
Emission peak (nm)	470	480
Light yield (ph/MeV)	1/5-1/4 of BGO's	8000-10000

02 CERN PS-T9 Beam Test

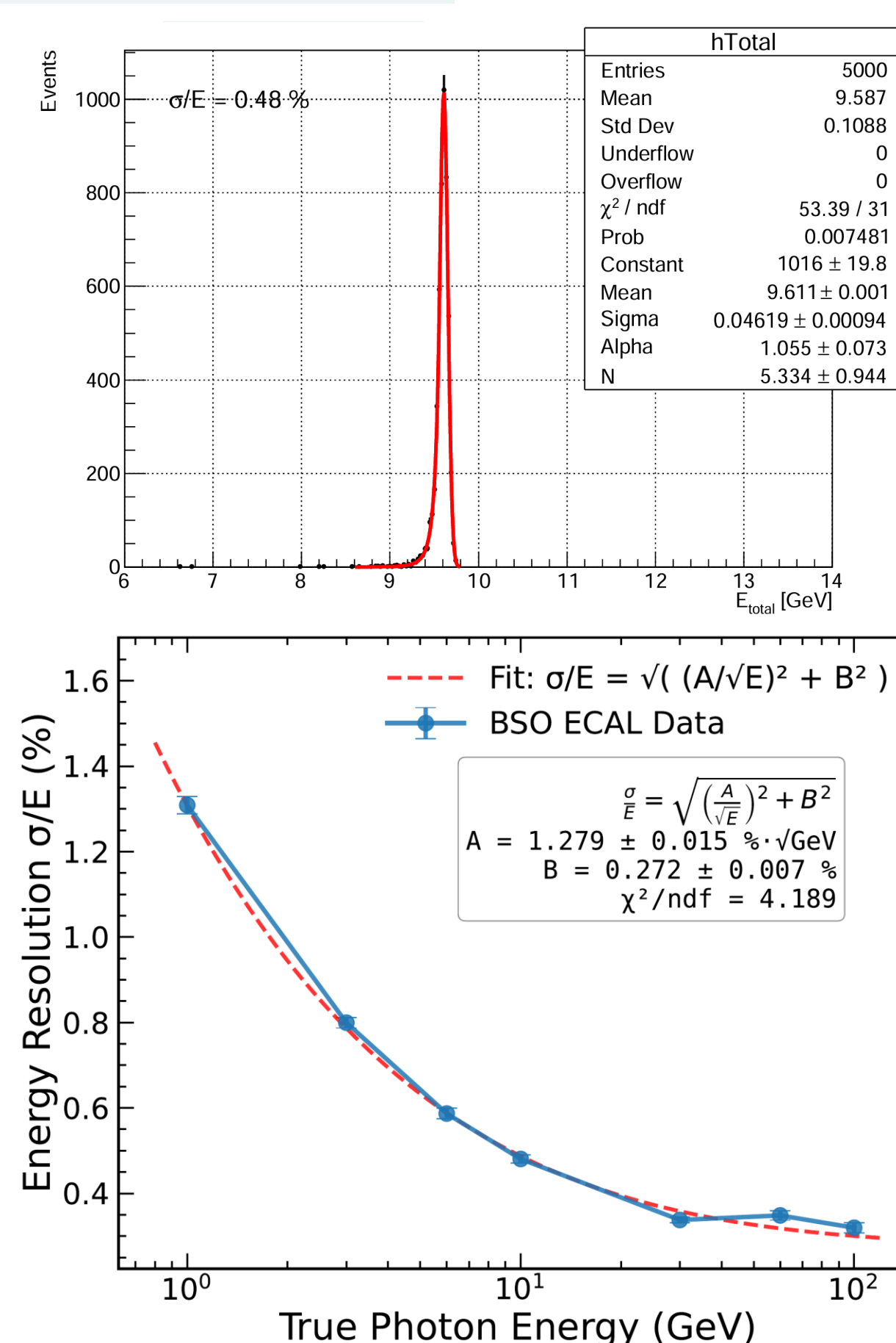
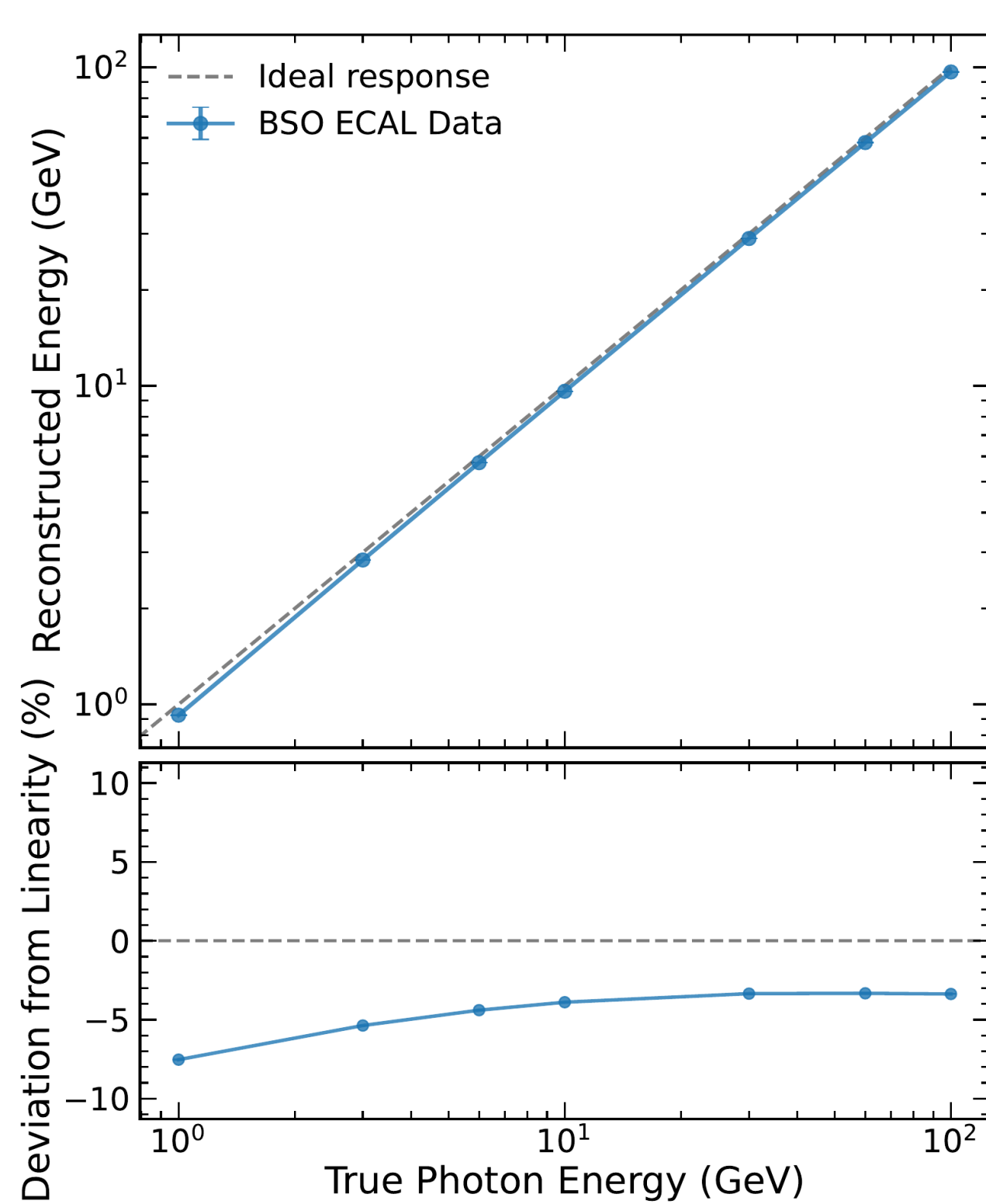
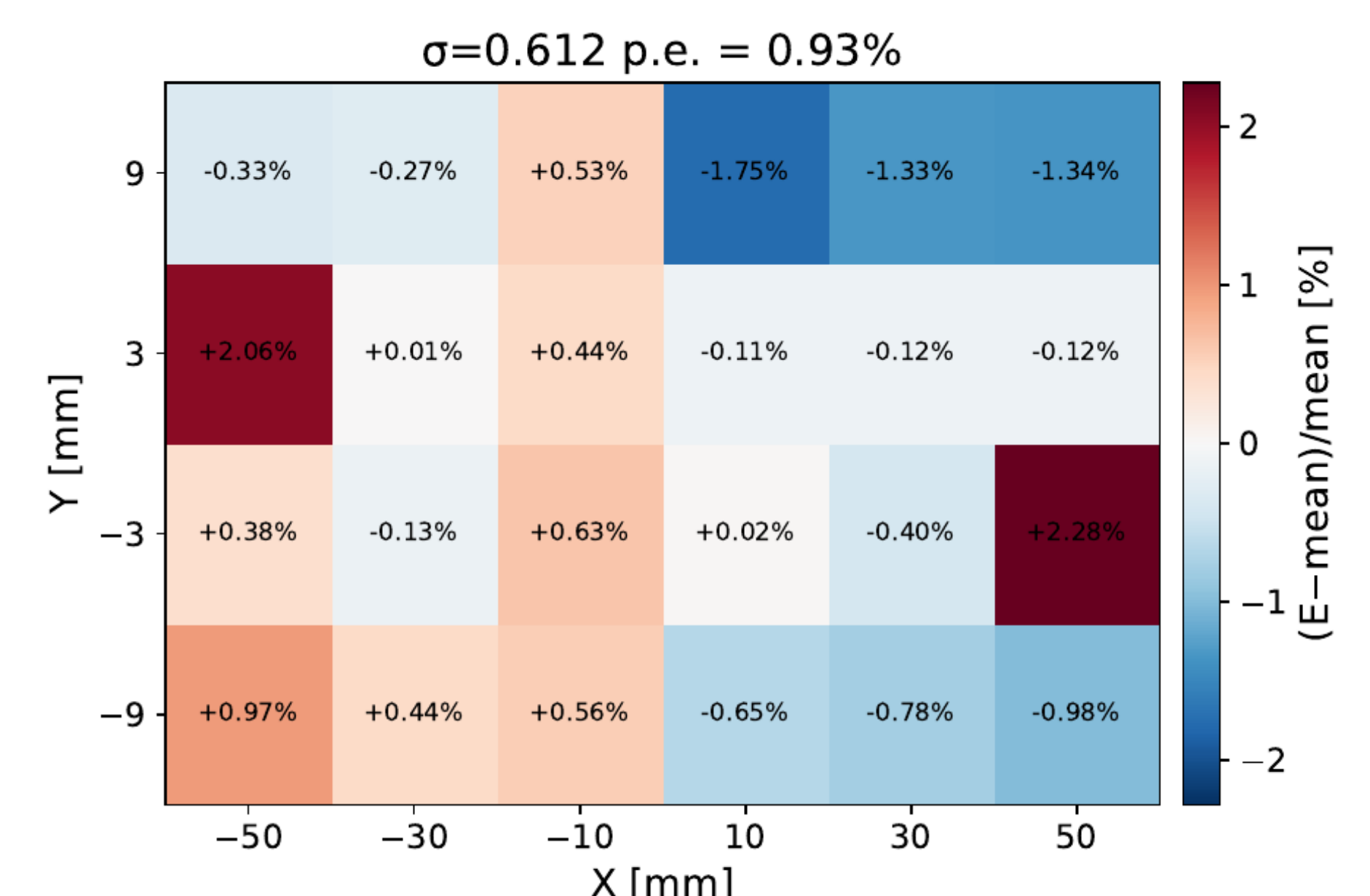
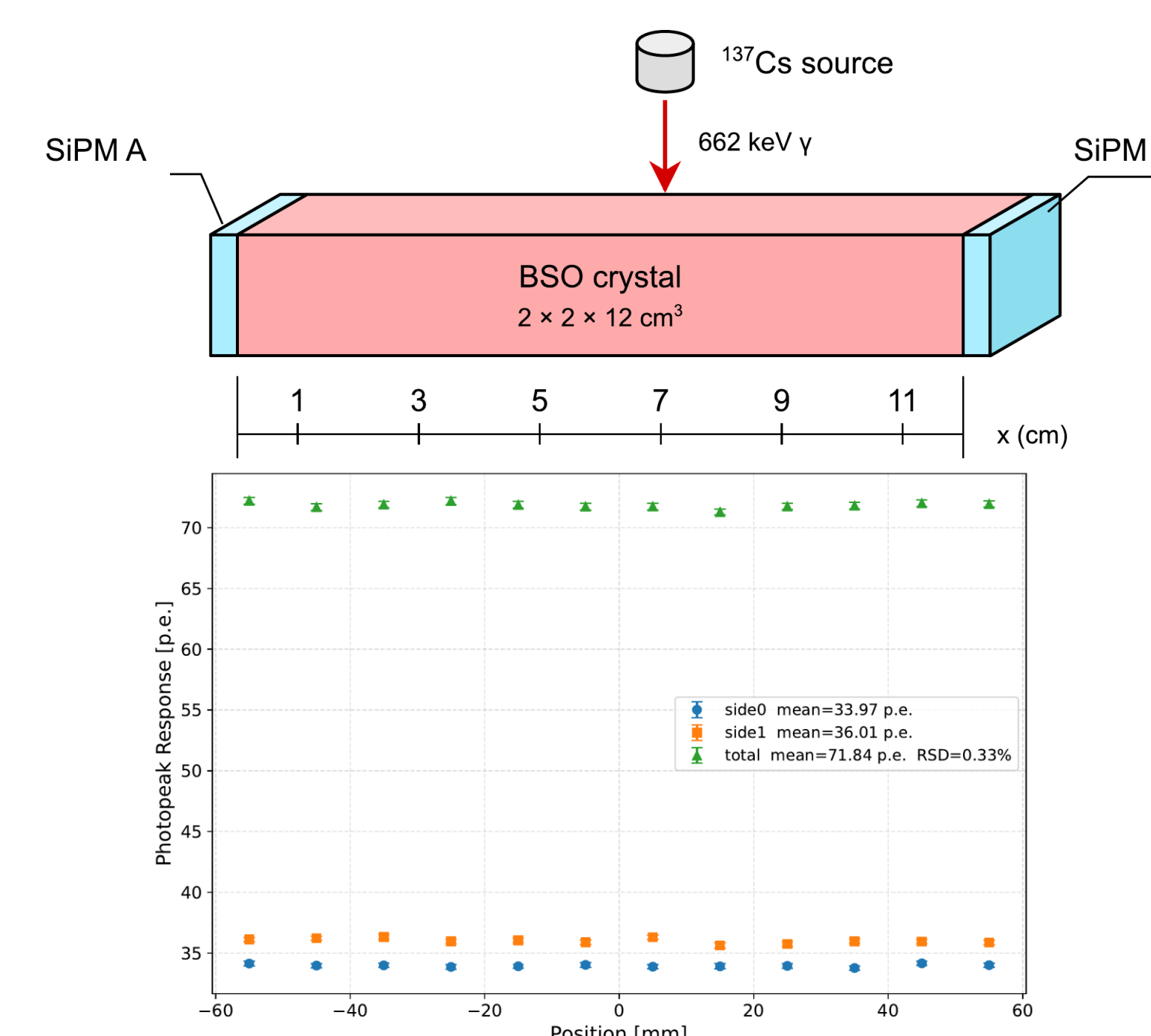
- ✓ 12 BSO bars, $20 \times 20 \times 120$ mm³
- ✓ 10 GeV pion beam
- ✓ 6×6 scan with 2 cm step
 - MIP selection: one hit bar per layer
 - Fit: Landau function convolved with Gaussian
 - MPV as MIP response
- Light yield: 282 p.e./MIP
- Non-uniformity:
 - <1% intra-bar
 - 7.65% inter-bar

03 Laboratory Experiment

- ✓ Collimated ¹³⁷Cs · 662 keV γ
- ✓ Longitudinal scan: 12 positions
- ✓ Two-dimension scan: 6×4 positions

➤ Non-uniformity <1%

Consistent with beam-test, excellent uniformity!



04 Detector Simulation

- ✓ Geant4 of BSO crystal ECAL with 405mm bars
- Incident particle: 1–100 GeV photons

✓ Digitization

- Light yield 282 p.e./MIP
- Poisson statistics
- 1% non-uniformity

➤ Crystal Ball Fit → Energy Resolution

$$\sigma/E = 1.28\%/\sqrt{(E/\text{GeV})} \oplus 0.27\%$$

Excellent energy resolution for EMC!

Conclusions

- Sub-percent intra-bar non-uniformity of BSO
- Simulation supports BSO as an ECAL candidate

Outlook

- Crystal quality control & bar-by-bar calibration
- BSO ECAL prototype validation

[1] F. Yang et al., J. Phys.: Conf. Ser. 587 (2015) 012064. [2] M. Deng et al., IEEE Trans. Nucl. Sci. 73 (2026) 1535-1542.

[3] R.-Y. Zhu, Recent Progress on Inorganic Scintillators for Future High Energy Physics Experiments, SPIE (2021), slide 15.