

Position-scan Optical Response of PWO

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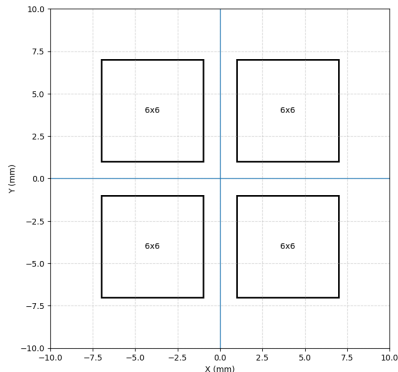


`https:
//github.com/JeffersonLab/glass-prototype`

Branch: main

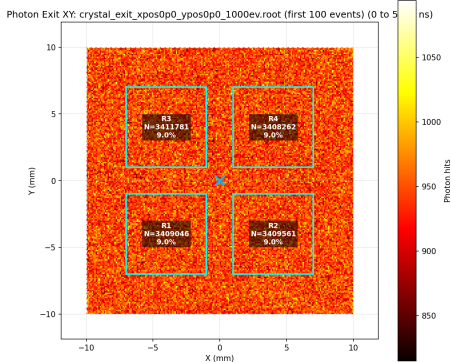
The Setup

- Monoenergetic 1 GeV electrons shot at the front face of a PWO crystal
- Reflector: VM2000
- SiPM configuration: 6×6 mm, 4 cells, 2 mm spacing between them

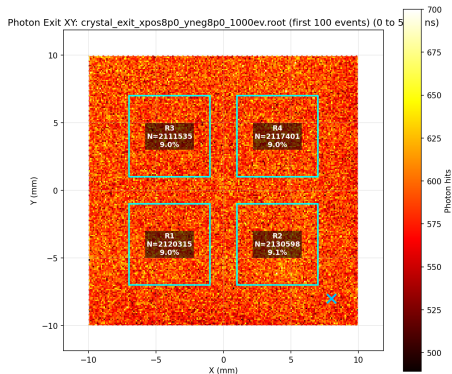


1 GeV Electrons (100 Events): Center vs Edge

Crystal Center



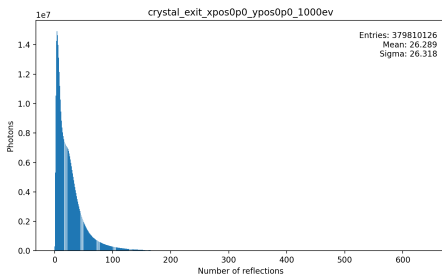
Near the Edge



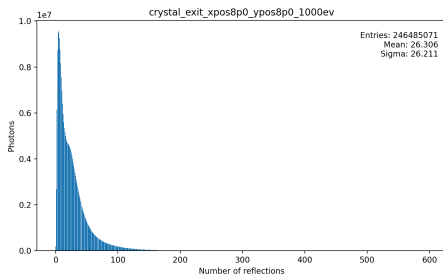
Photon (x, y) at the crystal exit face. Distribution is broad and almost identical for the two beam positions — VM2000 wrap homogenizes the light.

Number of Reflections (20 cm Crystal): Center vs Edge

Crystal Center



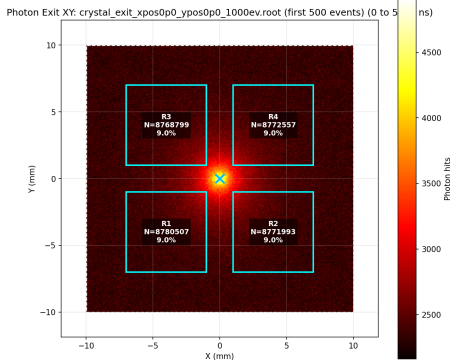
Near the Edge



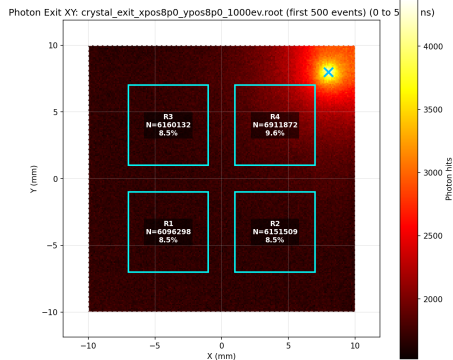
Number of reflections per detected photon. Broad distribution with mean $\langle N \rangle \approx 26$ — most photons bounce off the side walls many times before exiting.

4.5 cm Crystal ($5 X_0$): Center vs Edge

Crystal Center



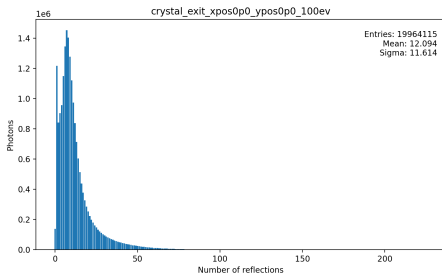
Near the Edge



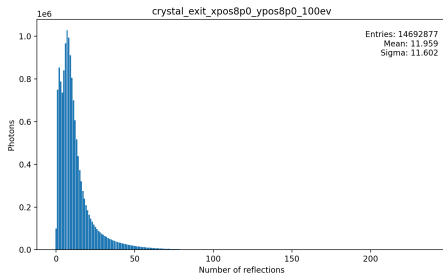
Short crystal — light is no longer fully homogenized: a clear hotspot appears at the electron impact point in both positions.

Number of Reflections (4.5 cm Crystal, $5 X_0$): Center vs Edge

Crystal Center

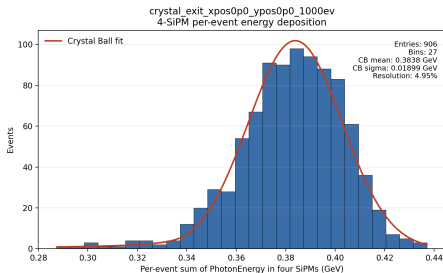


Near the Edge

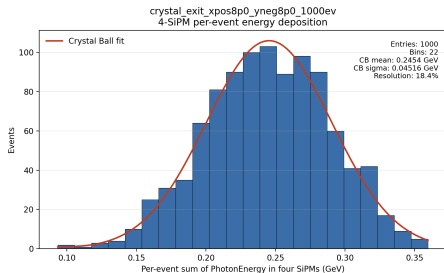


Total Energy Spectrum (Sum of 4 SiPMs, 20 cm): Center vs Edge

Crystal Center



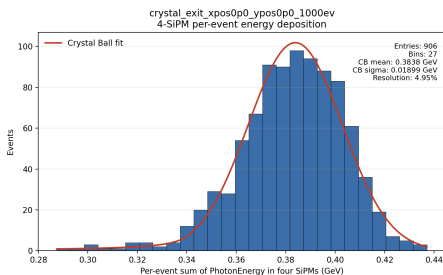
Near the Edge



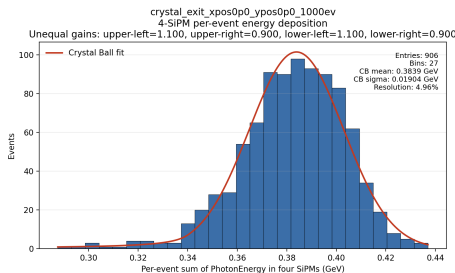
Per-event sum of photon energy over the 4 tiles, fitted with a Crystal Ball. Width is dominated by transverse shower leakage.

Equal vs Unequal Gain (Same Events, 20 cm)

Equal



10% different



Same 1000 events, only the per-tile gain factors change. The widths are essentially identical — the response is insensitive to gain mismatch.

Gain Mismatch \rightarrow Resolution (center beam, 1 GeV, 1000 events)

Gain spread σ_{gain}	CB mean (GeV)	CB σ (GeV)	σ/E
0 (equal)	0.3838	0.01899	4.95%
10%	0.3839	0.01904	4.96%
20%	0.3839	0.01907	4.97%

- Same events in all three rows — only the per-tile gain factors change
- Resolution is statistically indistinguishable across all three cases

Conclusions

- **20 cm crystal:** VM2000 wrap homogenizes the exit light — the four SiPM tiles each receive $\approx 25\%$ of the signal
- Mean number of reflections per detected photon is large ($\langle N_{\text{refl}} \rangle \sim 26$), confirming strong light mixing inside the long crystal
- 4.5 cm crystal ($5 X_0$): fewer reflections and a more position-dependent exit distribution
- The optical response is **insensitive to SiPM gain mismatch** — tested at 0, 10% and 20% per-tile gain spread, σ/E stays at $\approx 4.95\%$ (variation $< 0.02\%$, within statistical noise)