

Study of Optical Surface Models in Geant4 Simulation for Crystal Bar

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Outline

- Geant4 Optical Simulation of a Single Crystal Bar for Crystal ECAL
 - Bar length impacts
 - Uniformity scan lengthways
 - Comparison of different optical surface model
- Conclusion

Geant4 Optical Simulation of a Single Crystal Bar

Simulation:

- Crystal bar with ESR wrapping
- Process: scintillating & Cherenkov
- PDE & absorption & boundary effect & air gap
- Record number of photons detected by 2 SiPMs
- Record time information of every detected photons





Crystal ECAL:

- Scintillating & Cherenkov light
- Number of photons: proportional to deposited energy
- Time information: potential for timing



Bar length impacts

- 1GeV muon for MIP response
- Change bar length from 5mm to 400mm, transverse size: 1cm²
- BGO & PWO crystal (light yield: 8200/MeV vs 120/MeV)
- Energy deposition ~ 9MeV
- Impact on light output (number of detected photons)







Bar length impacts

- 1GeV muon for MIP response
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- Energy deposition ~ 9MeV
- Impact on timing (ideal condition: first detected photon as time stamp)





ESR wrapping

z+ end

Air gap

6mm SiPM

z- end

1GeV mu-

Crystal bar

Uniformity scan lengthways

- 662keV gamma for ¹³⁷Cs source, change hit positions
- 400mm BGO crystal bar, transverse size: 1cm²
- Fit the 662keV photopeak to get corresponding #photons
- #photons detected is almost independent of hit positions







Comparison of different optical surface model

- The results mentioned above are based on unified model
- Simulation setup: similar to the uniformity scan
- Comparison of unified/LUT/DAVIS model on #photons detected







Comparison of different optical surface model

• Drawback of unified model with ideally polished surface: trapped photons





• Drawback of LUT model: wrong direction of reflected photons



- Some reflected photons transmit towards outside of the crystal bar
- Need more studies



Comparison of different optical surface model

- Experiment: 400 mm BGO crystal bar with ESR & ¹³⁷Cs source
- Picoscope 6000E oscilloscope
- C13365-3050SA $3 \times 3 \text{ mm}^2$ SiPM module
- The same configuration as the simulation



DetectedPhoton_VaryGunPos





- Trends are not pronounced enough
- Refractive index
 - Air: 1.00029
 - Epoxy: 1.52
 - BGO: 2.15
- R-index has significant impact on light output
- Optical coupling grease for SiPMs?
- Need higher energy particle source?





- The #photons detected decreases exponentially with the length of the crystal
- Timing resolution depends heavily on the #photons detected, ~700ps with 400mm BGO crystal for MIP
- Good uniformity along the bar length
- Optical model: both unified & LUT models can be used at present