



Cherenkov and Scintillation Photon Counting Detectors

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BGO for High Sensitivity Lower Cost TOF-PET Systems



Bismuth Germanate (BGO)

- ~10k ph/MeV
- Decay Time: ~300 ns
- Cherenkov yield:
 ~17 at 511 keV



High UV Detection Efficiency in Modern SiPMs

Broadcom NUV-MT SiPM Arrays ~50% PDE 300-400 nm

Cherenkov / Scintillation Profile



Gundacker et al 2020 Phys. Med. Biol. 65 025001

Semi-monolithic BGO photon counting detector

Semi-monolithic crystal

- Spatiotemporal sparsity in optical photon arrivals at each channel
- 3D event positioning capability



Optical bandpass filter

• External optical crosstalk suppression

Analog SiPMs + Readout electronics

- Low-noise high-frequency shaping
- Photon pulse trains per channel

Cates *et al* (2024) *Phys Med Biol* **69** 045025 Lee *et al* (2024) *Nucl Instrum Method A* **1061** 169101 Lee *et al* (2023) *IEEE NSS MIC RTSD Conf Rec* 10338409 Cates *et al* (2022) *Phys Med Biol* **67** 195009

Related works

BERKELEY LAB

Detector module and readout





Low Noise High Frequency Front-End for Excellent SPTR



Low Noise High Frequency Front-End to minimize influence of electronic noise on SPTR



SPTR Measured with ps-Pulsed Laser



Lee et al. Transactions on Rad. Plas. Med. Sci. vol 9, no 4, 2025

Example 511 keV Interactions in the Detector





Detector 3D Positioning Calibration





3.17 x 2 x 5 mm³ Average 3D Positioning Resolution

 \rightarrow Segment the crystal into 43 (X) × 4 (DOI) voxels by interaction position

As applied in Hybrid Optical Detectors



- 1. Position Event with Light Map
- 2. Collect " N_{th} "PDDs using opposing PMTs as time reference

Interaction position (Crystal voxel)



SiPM channel

EOS https://nino.lbl.gov/eos/home.htm

Translated

Technique

As applied in Hybrid Optical Detectors



- 1. Position Event with Light Map
- 2. Collect "N_{th}"PDDs using opposing PMTs as time reference



- Potential method for PMTs without dichroicons.
- Might add another dimension of information in analyses for labeling photons as Cherenkov/Scintillation with dichroicons.



Fast readout electronics applied to LAPPD/HRPPD



Example Detector module from our work

LAPPD with Segmented Readout





Chip in Development



NIH 1R21EB034885



Maybe use this in relation to LAPPD/HRPPD



LAPPD with Segmented Readout



