

Modelling the Response of CLLBC(Ce) and TLYC(Ce) SiPM-Based Radiation Detectors in Mixed Radiation Fields with Geant4

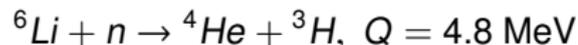
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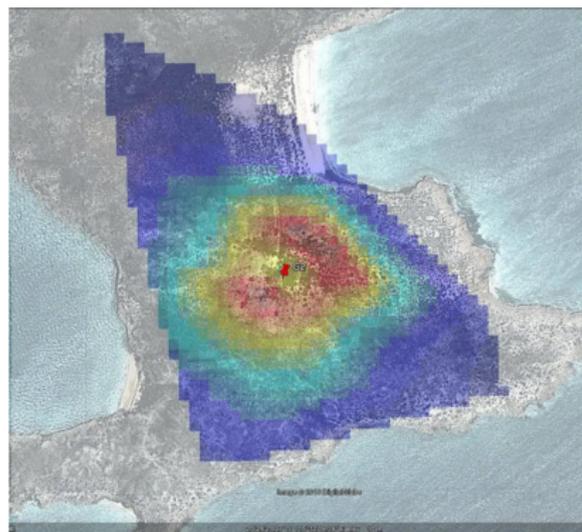
J. M. C. Brown et al. arXiv:2303.09709 (2023)

CLLBC(Ce) and TLYC(Ce) Scintillators:

- + Capable of measuring mix gamma ray neutron fields:



- + High level of interest in nuclear security and space science
- + Simulation parameters for these in Geant4 materials not well known



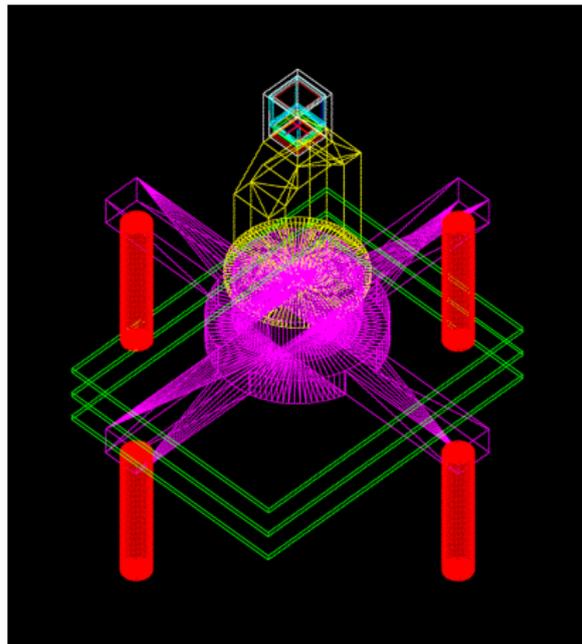
Montebello Island, Western Australia
Ex-British nuclear weapons testing site
Courtesy: A. Flynn (ANSTO)

Experimental Platform and Geant4 Benchmarking

1/2-inch RMD Inc. Crystals



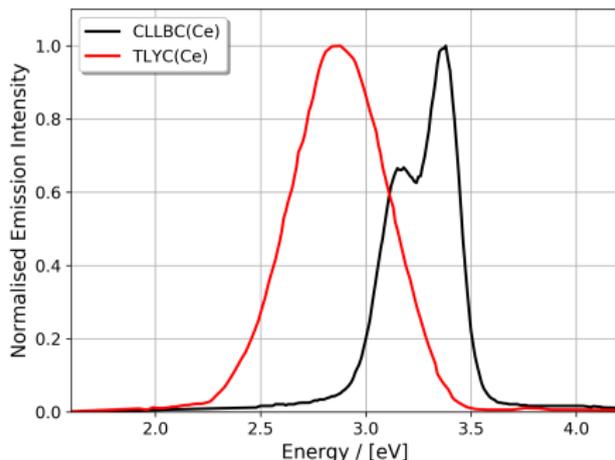
Implemented Geant4 Geometry



Radioactive Sources: Am-241, Cs-137, Co-60, Eu-152, and Cf-252

Physics Settings

- + Geant4 version 10.7
- + QGSP_BIC_HP_EMZ physics
- + Optical physics enabled
- + Gamma Sources: 48×10^6 Decays
- + Cf-252: 48×10^7 Decays
- + Production Cut: 100 μm
- + Low-energy Cut: 250 eV
- + De-excitation: All

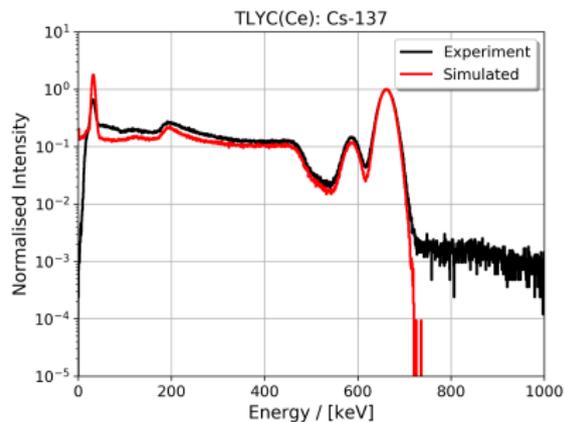
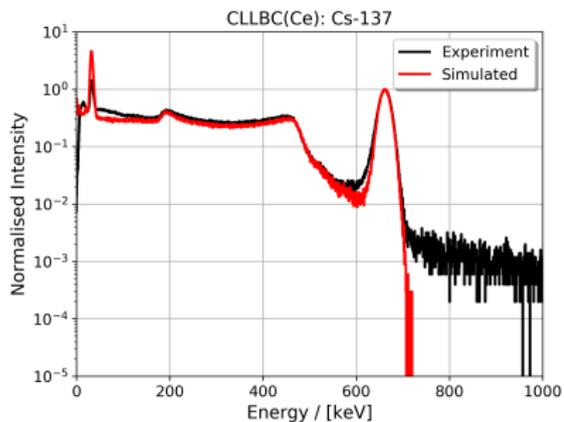
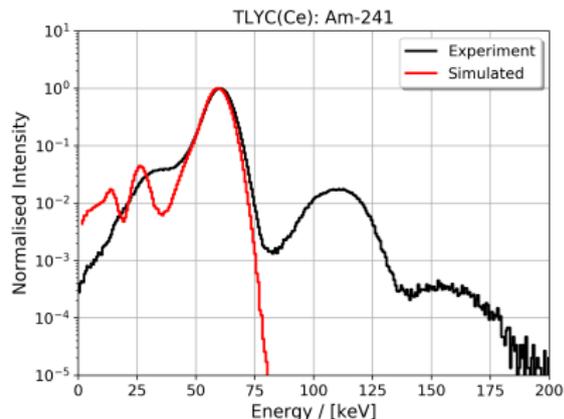
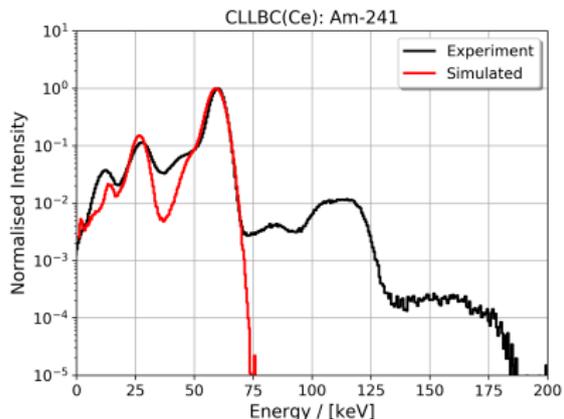


Optical Emission Spectra

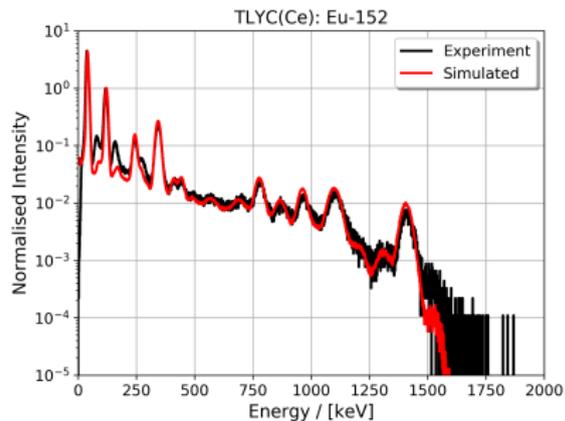
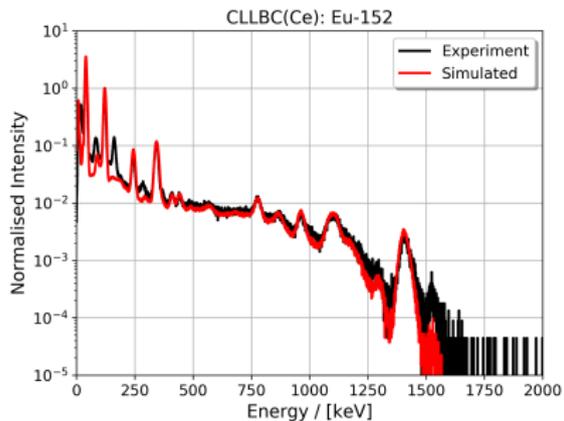
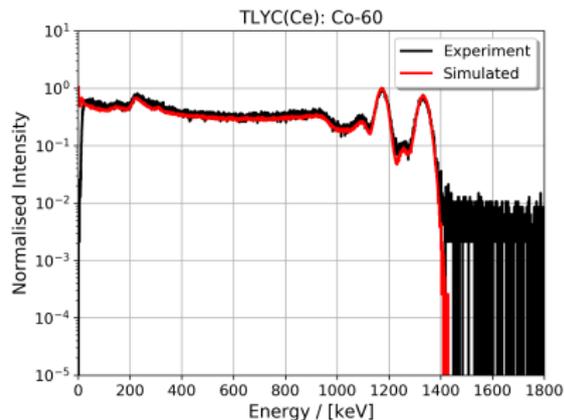
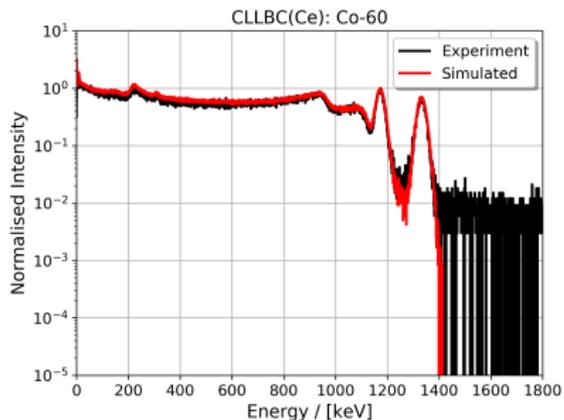
Material Parameters

Material	Ref. Index	Optical Yield	Decay Times (ns)	Res Scale (@ 662 keV) Birks Con. (mm/keV)
CLLBC(Ce)	1.9	50k per MeV	130 (0.825) 784 (0.175)	2.167 3.85
TLYC(Ce)	2.4	29k per MeV	71 (0.323) 537 (0.677)	2.345 14.2

Results: Am-241 and Cs-137 Energy Spectra



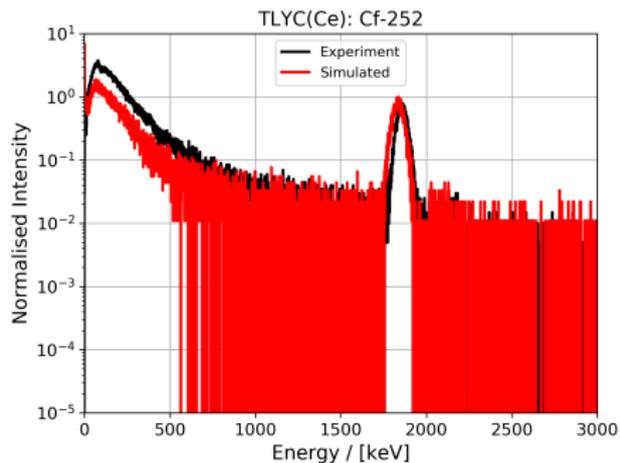
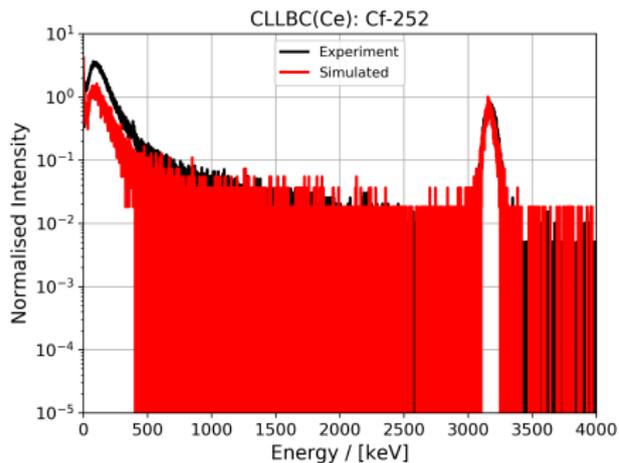
Results: Co-60 and Eu-152 Energy Spectra



Results: Gamma Ray Photopeak FWHM

Radioactive Source / Gamma Ray [keV]	CLLBC(Ce) FWHM[%]		TLYC(Ce) FWHM[%]	
	Experimental	Simulated	Experimental	Simulated
Am-241: 59.54	10.28	12.43	17.29	17.02
Eu-152: 121.78	7.17	8.60	11.72	11.56
Eu-152: 244.70	5.15	6.18	7.47	7.90
Eu-152: 344.28	4.41	5.25	6.87	7.00
Cs-137: 661.66	3.76	3.90	5.08	5.01
Eu-152: 778.91	3.32	3.53	4.53	4.67
Eu-152: 964.06	2.40	3.16	3.71	4.08
Co-60: 1173.23	2.42	2.82	3.60	3.70
Co-60: 1332.49	2.35	2.78	3.44	3.57

Results: Cf-252 Energy Spectra



Results: Li-6 Neutron Capture Peak

Material	Experimental		Simulated	
	Centroid [keV]	FWHM[%]	Centroid [keV]	FWHM[%]
CLLBC(Ce)	3172.73	2.49	3164.93	2.33
TLYC(Ce)	1857.41	3.38	1835.25	4.11

- + CLLBC(Ce) and TLYC(Ce) scintillator material parameters
- + Validation w.r.t. 5 different radioactive sources:
 - Difference in spectra observed due to electronics and scatter
 - High level of correlation in gamma ray photopeak FWHM
 - High level of correlation in neutron centroid and FWHM
- + **J. M. C. Brown et al. arXiv:2303.09709 (2023)**
- + On-going detector physics project:
 - Joint Swinburne-Uni. Melbourne PhD Lysander Miller
 - Optical physics example Bridgeport SiPM-3000
 - NaI(Tl), CsI(Tl), BGO, GAGG(Ce), and EJ-276D plastic

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