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Background assessment and performance of the COSINE-100 detector

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The COSINE-100 dark matter search experiment is an array of NaI(Tl) crystal detectors located in the Yangyang Underground Laboratory (Y2L). To understand measured backgrounds in the NaI(Tl) crystals we have performed Monte Carlo simulations using the Geant4 toolkit and developed background models for each crystal that consider contributions from both internal and external sources, including cosmogenic nuclides. The background models are based on comparisons of measured data with Monte Carlo simulations that are guided by a campaign of material assays and are used to evaluate backgrounds and identify their sources. The average background level for the six crystals (70 kg total mass) that are studied is 3.5 counts/day/keV/kg in the (2−6) keV energy interval. The dominant contributors in this energy region are found to be ^{210}Pb and ^{3}H.

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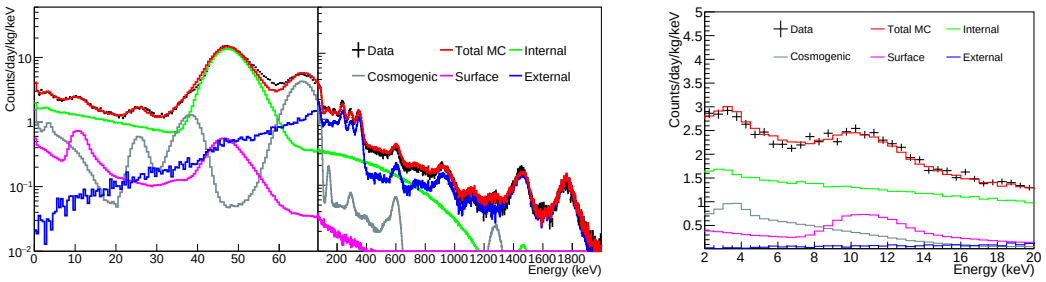
1. Background modeling

COSINE-100 is a dark matter search experiment consisting of a 106 kg array of eight ultra-pure NaI(Tl) crystals[1]. To model the COSINE-100 detector backgrounds, We have simulated background spectra from radioactive sources: full decay chains of ^{238}U, ^{232}Th, and ^{40}K from the crystals, 16 PMTs, and the other external sources; bulk and surface ^{210}Pb from the crystals; surface 210Pb from PTFE reflector; ^{125}I, ^{121}Te, ^{121m}Te, ^{123m}Te, ^{125m}Te, ^{127m}Te, ^{113}Sn, ^{109}Cd, ^{22}Na, and ^{3}H for cosmogenic isotopes, and have fitted them to the data to estimate their unknown contamination levels [2]. The overall simulated background spectra well describe the measured data from the crystals as shown inFig 1 (a). The low energy background spectra are shown in Fig 1 (b) [2].



(a) (b)

Figure 1: Comparison of data and Monte Carlo simulation of the single hit background spectra of Crystal-7 in the energy interval 0 keV - 2 MeV (a) and 2 keV - 20 keV (zoom in plot) (b).

2. Summary

The simulated background spectra of the NaI(Tl) detectors well describe the measured data. The background levels in unit of dru (counts/day/keV/kg) in the 2−6 keV energy interval is listed in table 1 which shows the dominant background contributions are from ^{210}Pb and ^{3}H [2].

Table 1: Background events in unit of dru (counts/day/keV/kg) in the 2−6 keV interval.

Source position		Crystal-1	Crystal-2	Crystal-3	Crystal-4	Crystal-6	Crystal-7
Internal	^{40}K	0.10 ± 0.02	0.20 ± 0.02	0.10 ± 0.01	0.10 ± 0.01	0.05 ± 0.01	0.05 ± 0.01
	^{210}Pb	2.50± 0.10	1.69± 0.09	0.57± 0.05	0.71± 0.05	1.46± 0.07	1.50± 0.07
	Other($\times 10^{-4}$)	7.0±0.1	15±1	7.3±0.1	7.7±0.1	14±1	14±1
Cosmogenic	^{3}H	2.35± 0.90	0.81± 0.40	1.54± 0.77	1.97± 0.66	0.69± 0.67	0.58± 0.54
	^{109}Cd	0.05±0.04	0.009±0.009	0.13± 0.06	0.29± 0.15	0.08± 0.08	0.09± 0.09
	Other	-	-	0.02± 0.01	0.09± 0.04	0.06± 0.03	0.05± 0.03
Surface		0.64± 0.64	0.51± 0.51	1.16± 0.51	0.22± 0.16	0.34± 0.20	0.38± 0.21
External		0.03± 0.02	0.05± 0.04	0.03± 0.02	0.03± 0.02	0.04± 0.03	0.03± 0.02
Total simulation		5.68± 1.04	3.28± 0.67	3.57± 0.76	3.41± 0.75	2.74± 0.61	2.70± 0.51
Data		5.64± 0.10	3.27± 0.07	3.35± 0.07	3.19± 0.05	2.62± 0.05	2.64± 0.05

References

[1] G. Adhikari *et al.* (COSINE-100 Collaboration), *Eur. Phys. J. C 78 (2018) 107.*

[2] P. Adhikari *et al.* (COSINE-100 Collaboration), *Eur. Phys. J. C 78 (2018) 490.*