

IBD & Radioactivity simulation from Fifteen

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Radioactivity decay rates

	gds	Iso	PMT	sst
U	10^{-3} ppb	10^{-3} ppb	132 ppb	0.0012 Bq/kg
Th	10^{-3} ppb	10^{-3} ppb	256 ppb	0.006 Bq/kg
K40	10^{-3} ppb	10^{-3} ppb	0.0115%	0.013 Bq/kg
Co60				0.002 Bq/kg

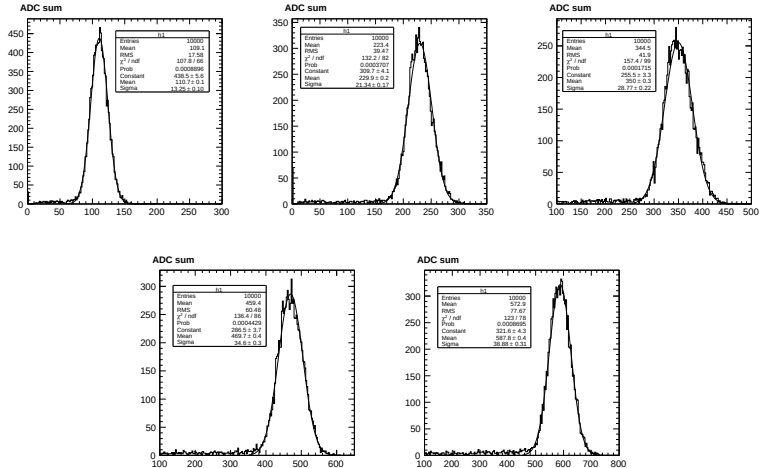
	U(ppb)	Th(ppb)	K40(ppm)	Co60(mBq/kg)	mass(kg)
Bond epoxy	122 ± 2	146 ± 4	211 ± 4	0.0	0.017
Oil-proof epoxy	<1	<3	<2	0.0	0.472
Semi-flexible lead	30 ± 10	<10	<10	0.0	0.009
Magnetic shield foil	<0.4	<0.7	<0.5	0.0	0.020
Stainless steel mount	<0.9	$5^{+8.7}_{-5.0}$	<2	26 ± 8.2	0.213
Low-background glass	153 ± 25	335 ± 90	165.6 ± 45	0.0	0.809
Dynode metal structure	17 ± 3	24 ± 10	<3	32 ± 5	0.065

- Doc 4222
- 20 tons gd-doped liquid scintillator, 21.5 tons un-doped liquid scintillator, 19 tons stainless steel, 192 PMTs.

	gds	iav	lso	oav	oil
Free protons(Doc4217)	1.54e+30	4.16e+28	1.65e+30	9.21e+28	3.32e+30
Rates (s^{-1})	0.013	3.5e-4	0.014	7.6e-4	0.028
Lifetime (s)	78.4	2896.1	73.0	1309.2	36.3

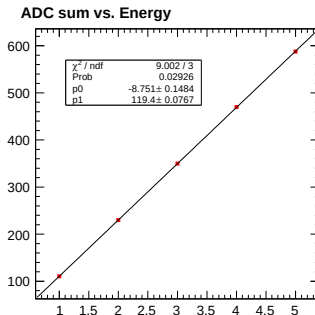
- IBD & Radioactivity events are mixed together using Sim15 package.
- MDC09b data, about 30 million readouts studied.

Energy calibration



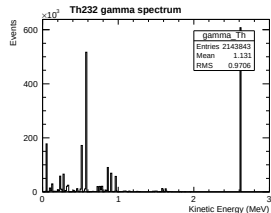
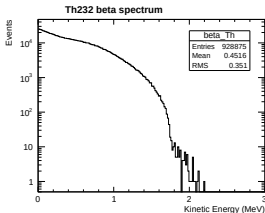
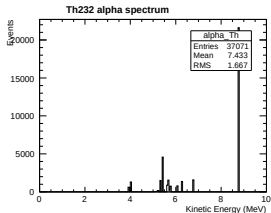
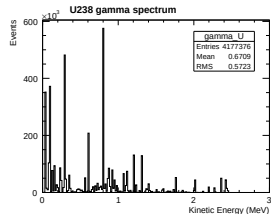
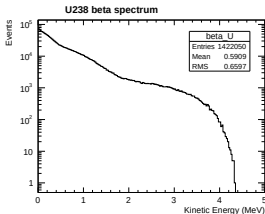
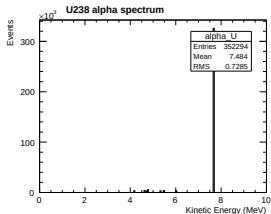
- 1,2,3,4,5 MeV γ in Gd-doped liquid scintillator.

Energy calibration

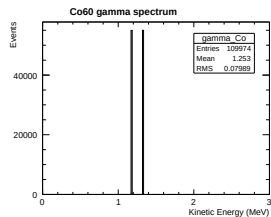
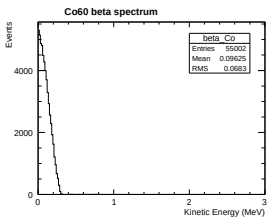
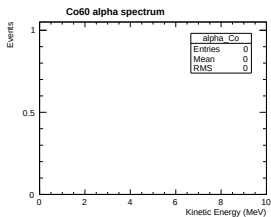
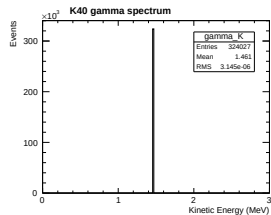
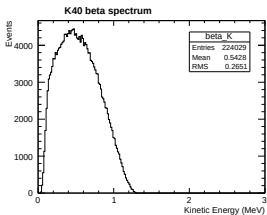
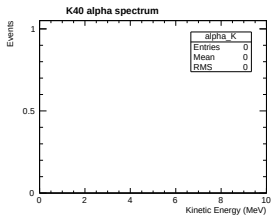


- Fit with a linear function

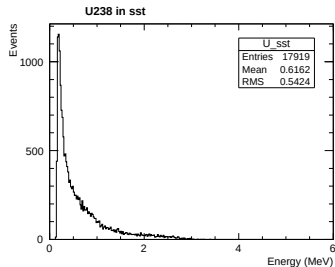
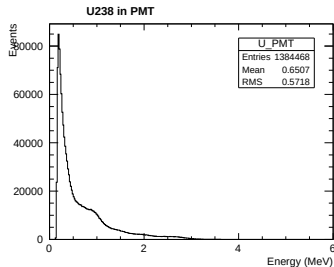
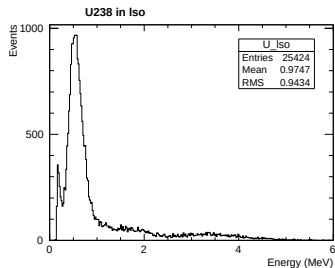
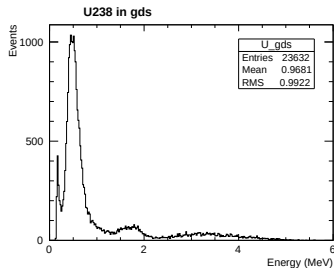
Generated spectrum



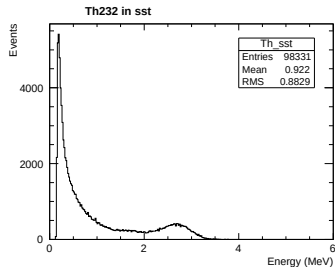
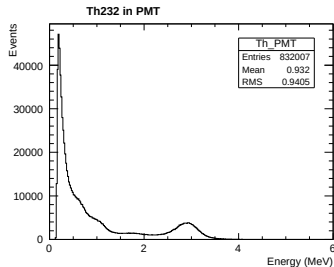
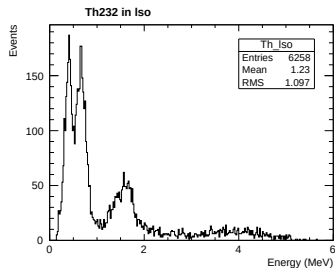
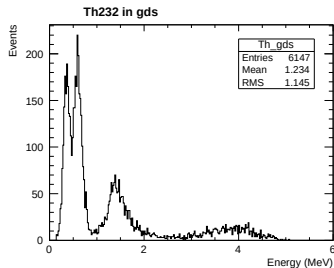
- Generated α , β , γ spectra for events which pass trigger.



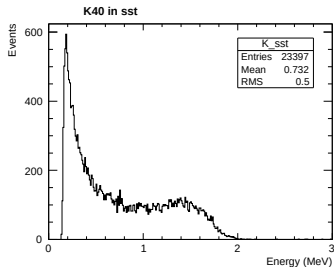
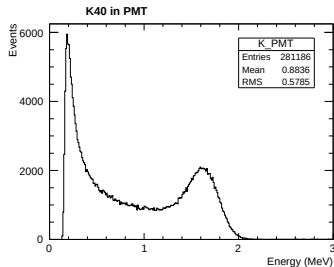
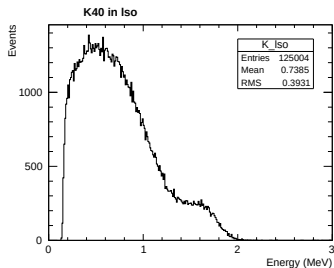
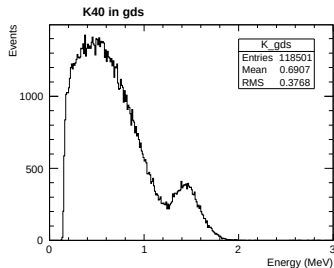
Energy spectra after calibration



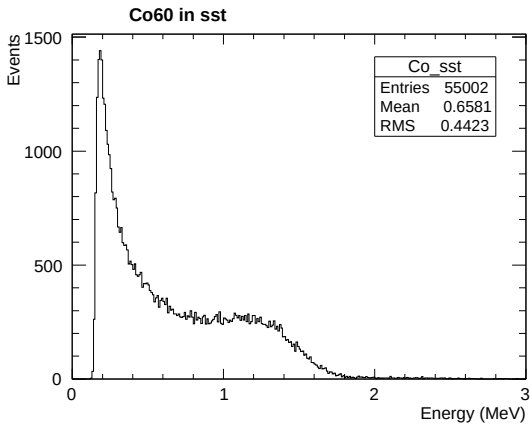
Energy spectra after calibration



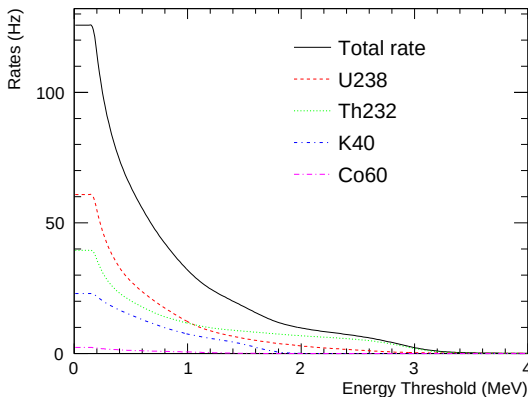
Energy spectra after calibration



Energy spectra after calibration



Radioactivity background rates



- Radioactivity background rates vs. energy threshold

Radioactivity rates (>1 MeV)

> 1 MeV	gds	Iso	PMT	sst	Sum(Hz)
U	0.23	0.25	11.33	0.13	11.95
Th	0.10	0.10	10.06	1.26	11.53
K40	0.94	1.20	4.95	0.31	7.39
Co60				0.58	0.58
Sum	1.28	1.55	26.34	1.70	31.44
U	0.23	0.25	7.77	0.12	8.37
Th	0.01	0.01	4.70	0.51	5.23
K40	0.90	0.97	4.20	0.20	6.27
Co60				0.49	0.49
Sum	1.13	1.23	16.67	0.84	20.36

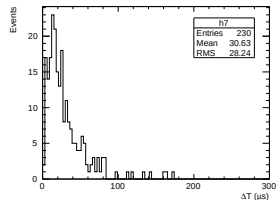
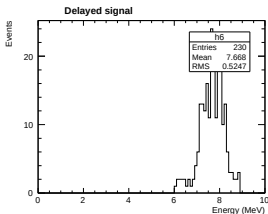
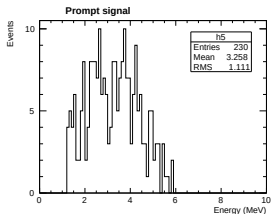
- The lower table is from Doc 3854.
- Detailed PMT radiation measurement is the main reason for higher rates of radioactivity. GenDecay also give higher rates than legacy generators.

Radioactivity rates (>0.5 MeV)

> 0.5 MeV	gds	Iso	PMT	sst	Sum(Hz)
U	0.60	0.75	25.46	0.32	27.13
Th	0.19	0.20	17.46	2.09	19.93
K40	3.15	3.55	7.31	0.54	14.54
Co60				1.19	1.19
Sum	3.94	4.50	50.22	2.94	62.80
U	0.89	1.05	14.52	0.21	16.67
Th	0.02	0.02	9.13	1.02	10.19
K40	2.90	2.98	6.09	0.39	12.36
Co60				1.03	1.03
Sum	3.81	4.05	29.75	1.62	40.26

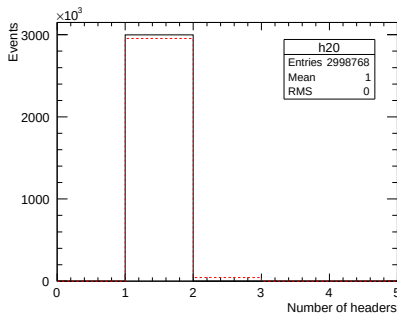
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Looking for IBD events



- Require: $1 < E_{prompt} < 6 \text{ MeV}$, $E_{delay} > 6 \text{ MeV}$, $\Delta T < 200 \mu\text{s}$
- Simulation corresponds to 6.6 hour real time.
- All from true IBD events, no background seen.

Multiple input headers



- 29998768 readouts, 29998768 ElecHdr, 44703(0.15%) have 2 SimHdr (also 2 GenHdr).

- Extensively studied the radioactivity background rates using GenDecay package. The radioactivity rate is higher than previous study.
- Studied the mixing effect using Sim15 package.
- MC data and script:
 - MC data:
`pdsf:/eliza7/dayabay/data/sim/dayabay/1970/calibration/ibd15/0101/`
 - Example script to analyze:
`~NuWa-trunk/dybgaudi/Production/MDC09b/python/MDC09b/chkIBD15`