Background upper limit extimation through MC simulations

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Motivation of the Analysis

- Activities values used to perform MC simulations so far are taken from Tables #3 and 4 of the XENON collaboration paper (E. Aprile et al., EPJ C, 75:546, 2015). These analysis were performed on material samples that were not coming from a specific PMT.

- In this paper are also shown measures (Table #5) about pieces extracted directly from a PMT. Analysis results highlight higher activities.

PMT version (nr. of units)	Batch nr.	t [d]	Activity [mBq/PMT]						
			^{238}U	^{226}Ra	^{235}U	^{228}Ra	^{228}Th	^{40}K	^{60}Co
v-20 (10)	0	15	< 18	< 0.82	< 0.79	0.9(3)	0.9(2)	12(2)	1.3(2)
v-21 (10)	1	26	< 18	0.4(1)	0.5(1)	< 1.1	0.4(1)	12(2)	0.7(1)
v-21 (16)	2	15	< 16	0.5(1)	0.29(9)	< 0.85	< 0.61	13(2)	0.79(8)
v-21 (15)	3	11	< 20	< 0.82	< 0.52	< 1.1	0.5(2)	13(2)	0.73(9)
v-21 (15)	4	22	< 13	0.5(1)	0.35(9)	0.4(1)	0.4(1)	12(2)	0.73(9)
v-21 (15)	5	16	< 17	0.6(1)	< 0.57	< 0.93	< 0.62	14(2)	0.63(7)
v-21 (11)	6	23	< 15	0.6(1)	< 0.55	< 0.77	0.7(1)	14(2)	0.71(7)
v-21 (4)[1]	6b	39	–	0.5(1)	< 0.30	0.3(1)	0.3(1)	8(1)	0.9(1)
v-21 (11)	7	23	< 19	1.0(1)	0.4(1)	< 0.77	0.7(1)	15(2)	1.0(1)
v-21 (15)	8	14	< 20	0.9(2)	< 0.85	0.7(2)	1.0(2)	20(3)	1.2(1)
v-21 (4)[1]	8b	36	–	0.7(1)	< 0.36	0.3(1)	0.2(1)	10(1)	1.4(2)
v-21 (15)	9	20	< 14	0.57(9)	< 0.44	< 0.79	0.5(1)	13(2)	0.81(8)
v-21 (15)	10	26	< 15	0.45(7)	< 0.44	0.5(1)	0.45(8)	13(2)	0.87(8)
v-21 (15)	11	12	< 10	0.5(2)	< 0.47	< 1.17	0.6(1)	12(2)	0.77(9)
v-21 (15)	12	18	< 10	< 0.71	< 0.45	0.7(2)	0.7(1)	11(2)	0.78(8)
v-21 (15)	13	34	< 10	0.50(6)	0.38(8)	0.6(1)	0.50(7)	12(1)	0.82(7)
v-21 (15)	14	21	< 16	0.53(8)	< 0.41	< 0.82	0.5(1)	14(2)	0.81(8)

Table #5

PMT component	Isotope	Activity[mBq/PMT]
Kovar Body	40K	< 0.99
	60 Co	7.0 e-02
	238 U	< 0.095
	226 Ra	< 0.26
	232 Th	< 0.0032
	228 Th	< 0.34
Quartz Window	40K	< 8.1e-02
	232 Th	< 4.5e-03
	238 U	< 0.33
	226 Ra	0.036
	232 Th	< 1.2e-02
	228 Th	< 1.2e-02
Ceramic Feedthrough	40K	1.1
	60 Co	< 0.02
	238 U	2.4
	226 Ra	0.26
	232 Th	0.23
	228 Th	0.11

Activities used so far in MC Analysis

The present Monte Carlo analysis has the goal to provide an upper limit of PMT backgrounds estimation taking into account the activities of Table #5 of the XENON collaboration article.

Activities Re-Scaling Process

PMT version (nr. of units)	Batch nr.	t [d]	Activity [mBq/PMT]						
			^{238}U	^{226}Ra	^{235}U	^{228}Ra	^{228}Th	^{40}K	^{60}Co
v-20 (10)	0	15	< 18	< 0.82	< 0.79	0.9(3)	0.9(2)	12(2)	1.3(2)
v-21 (10)	1	26	< 18	0.4(1)	0.5(1)	< 1.1	0.4(1)	12(2)	0.7(1)
v-21 (16)	2	15	< 16	0.5(1)	0.29(9)	< 0.85	< 0.61	13(2)	0.79(8)
v-21 (15)	3	11	< 20	< 0.82	< 0.52	< 1.1	0.5(2)	13(2)	0.73(9)
v-21 (15)	4	22	< 13	0.5(1)	0.35(9)	0.4(1)	0.4(1)	12(2)	0.73(9)
v-21 (15)	5	16	< 17	0.6(1)	< 0.57	< 0.93	< 0.62	14(2)	0.63(7)
v-21 (11)	6	23	< 15	0.6(1)	< 0.55	< 0.77	0.7(1)	14(2)	0.71(7)
v-21 (4)[1]	6b	39	–	0.5(1)	< 0.30	0.3(1)	0.3(1)	8(1)	0.9(1)
v-21 (11)	7	23	< 19	1.0(1)	0.4(1)	< 0.77	0.7(1)	15(2)	1.0(1)
v-21 (15)	8	14	< 20	0.9(2)	< 0.85	0.7(2)	1.0(2)	20(3)	1.2(1)
v-21 (4)[1]	8b	36	–	0.7(1)	< 0.36	0.3(1)	0.2(1)	10(1)	1.4(2)
v-21 (15)	9	20	< 14	0.57(9)	< 0.44	< 0.79	0.5(1)	13(2)	0.81(8)
v-21 (15)	10	26	< 15	0.45(7)	< 0.44	0.5(1)	0.45(8)	13(2)	0.87(8)
v-21 (15)	11	12	< 10	0.5(2)	< 0.47	< 1.17	0.6(1)	12(2)	0.77(9)
v-21 (15)	12	18	< 10	< 0.71	< 0.45	0.7(2)	0.7(1)	11(2)	0.78(8)
v-21 (15)	13	34	< 10	0.50(6)	0.38(8)	0.6(1)	0.50(7)	12(1)	0.82(7)
v-21 (15)	14	21	< 16	0.53(8)	< 0.41	< 0.82	0.5(1)	14(2)	0.81(8)
Average = Atot			15.4	0.62	4.70 e-02	0.75	0.56	12.82	0.88

A1' = A1 x Atot / (A1+A2+A3)

PMT component	Isotope	Activity[mBq/PMT]	
Kovar Body	40K	< 0.99	A1
	60 Co	7.0 e-02	
	238 U	< 0.095	
	226 Ra	< 0.26	
	232 Th	< 0.0032	
	228 Th	< 0.34	
Quartz Window	40K	< 8.1e-02	A2
	232 Th	< 4.5e-03	
	238 U	< 0.33	
	226 Ra	0.036	
	232 Th	< 1.2e-02	
	228 Th	< 1.2e-02	
Ceramic Feedthrough	40K	1.1	A3
	60 Co	< 0.02	
	238 U	2.4	
	226 Ra	0.26	
	232 Th	0.23	
	228 Th	0.11	

Activities Re-Scaling Outcomes

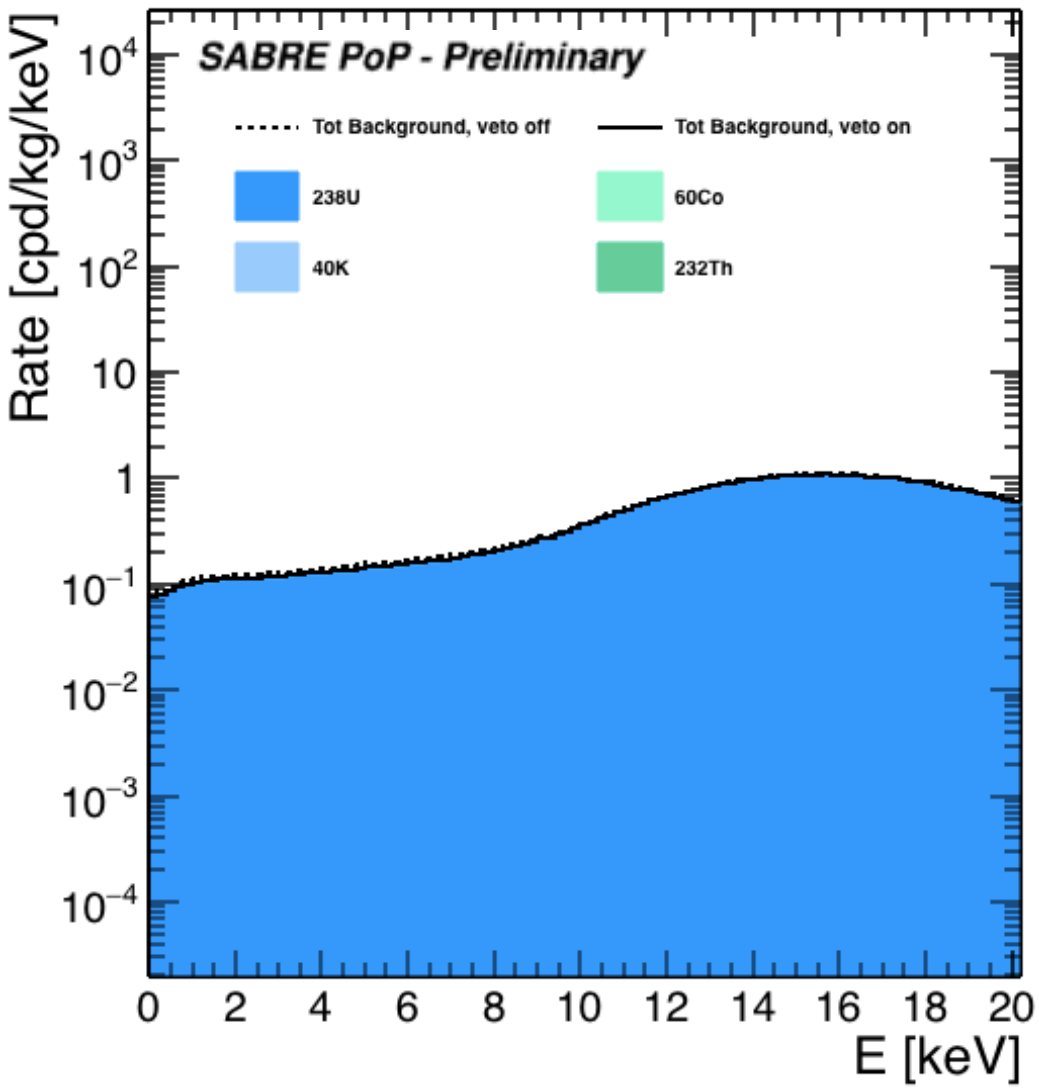
PMT component	Isotope	Activity[mBq/PMT]	Rescaled Activity[mBq/PMT]	Ratio Rescaled Activity/Previous Activity
Kovar Body	40K	< 0.99	< 5.848	5.9
	60 Co	7.0 e-02	0.651	9.3
	238 U	< 0.095	< 2.735	28.8
	226 Ra	< 0.26	< 6.013 e-02	0.2
	232 Th	< 0.0032	< 8.687 e-03	2.7
	228 Th	< 0.34	< 5.382 e-01	1.6
Quartz Window	40K	< 8.1e-02	< 4.784 e-01	5.9
	232 Th	< 4.5e-03	< 4.188 e-02	9.3
	238 U	< 0.33	< 9.499	28.8
	226 Ra	0.036	8.326 e-03	0.2
	232 Th	< 1.2e-02	< 3.258 e-02	2.7
	228 Th	< 1.2e-02	< 1.900 e-02	1.6
Ceramic Feedthrough	40K	1.1	6.497	5.9
	60 Co	< 0.02	< 1.861 e-01	9.3
	238 U	2.4	6.908 e+01	28.8
	226 Ra	0.26	6.013 e-02	0.2
	232 Th	0.23	6.244 e-01	2.7
	228 Th	0.11	0.174	1.6

Analysis Results

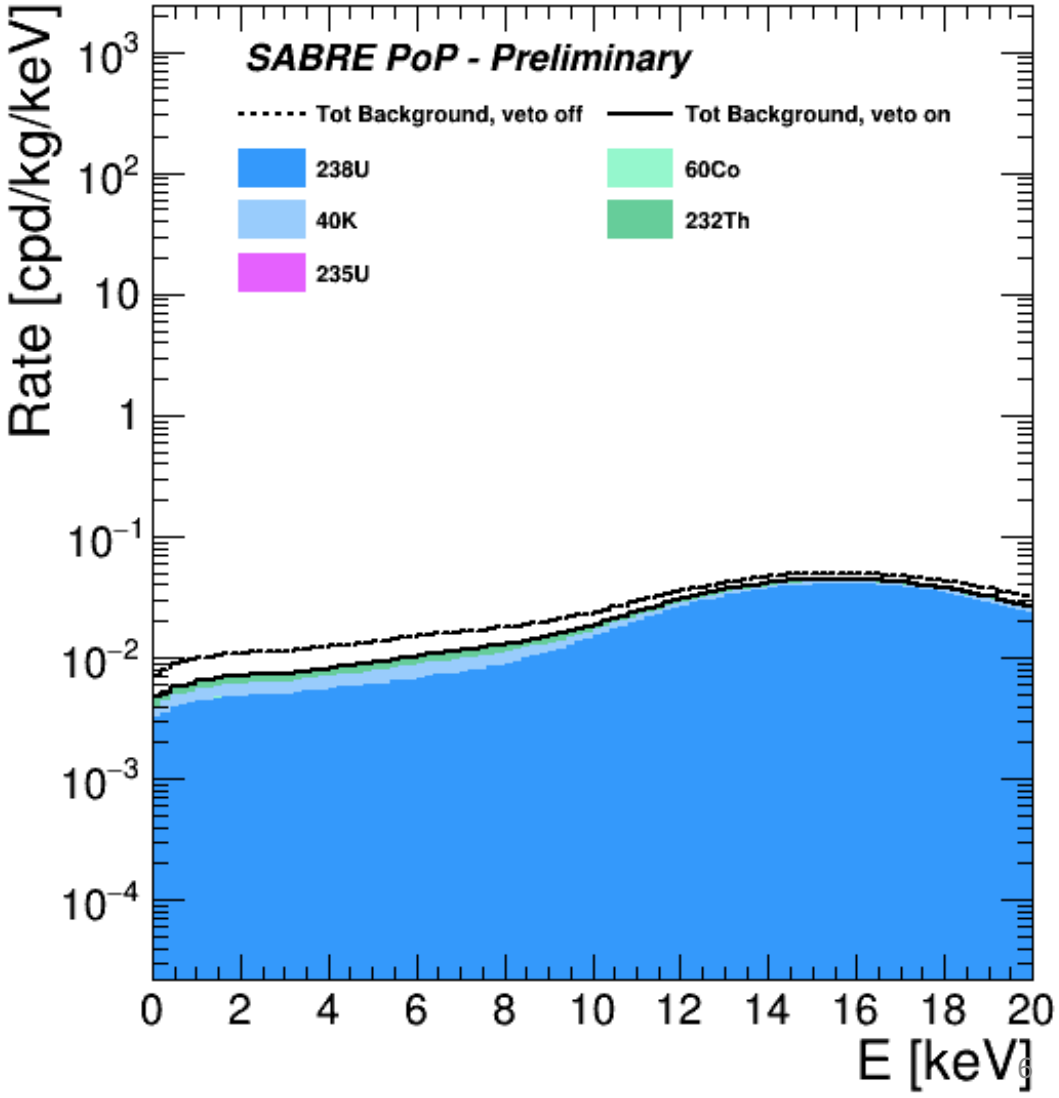
Isotope	Newest Activities	July Activities	Ratio
	Bkg cpd/kg/keV	Bkg cpd/kg/keV	
40K	1.02e-02 +/- 6e-05	1.73e-03 +/- 1e-05	5.90
238U	1.26e-01 +/- 4e-04	7.50e-03 +/- 1e-05	16.80
60Co	2.01e-03 +/- 9e-06	1.99e-04 +/- 1e-06	10.10
232Th	2.76e-03 +/- 8e-06	3.08e-03 +/- 8e-06	0.90
Total	1.41e-01 +/- 4e-04	1.25e-02 +/- 2e-05	11.28

Isotope	Newest Activities	July Activities	Ratio	Newest Activities	July Activities	Ratio
	Bkg DMM(cpd/kg/keV)	Bkg DMM(cpd/kg/keV)		Bkg KMM(cpd/kg/keV)	Bkg KMM(cpd/kg/keV)	
40K	9.04e-03 -/+ 5e-05	1.54e-03 -/+ 9e-06	5.87	3.50e-04 +/- 2e-05	6.08e-05 +/- 3e-06	5.76
238U	1.21e-01 -/+ 4e-04	5.59e-03 -/+ 1e-05	21.65	9.89e-05 +/- 9e-06	2.12e-04 +/- 3e-06	0.47
60Co	4.96e-05 -/+ 1e-06	4.36e-06 -/+ 2e-07	11.38	4.12e-04 +/- 6e-06	4.17e-05 +/- 6e-07	9.88
232Th	9.33e-04 -/+ 4e-06	1.17e-03 -/+ 5e-06	0.80	9.66e-05 +/- 2e-06	1.11e-04 +/- 2e-06	0.87
Total	1.31e-01 -/+ 4e-04	8.32e-03 -/+ 2e-05	15.75	9.58e-04 +/- 2e-05	4.26e-04 +/- 4e-06	2.25

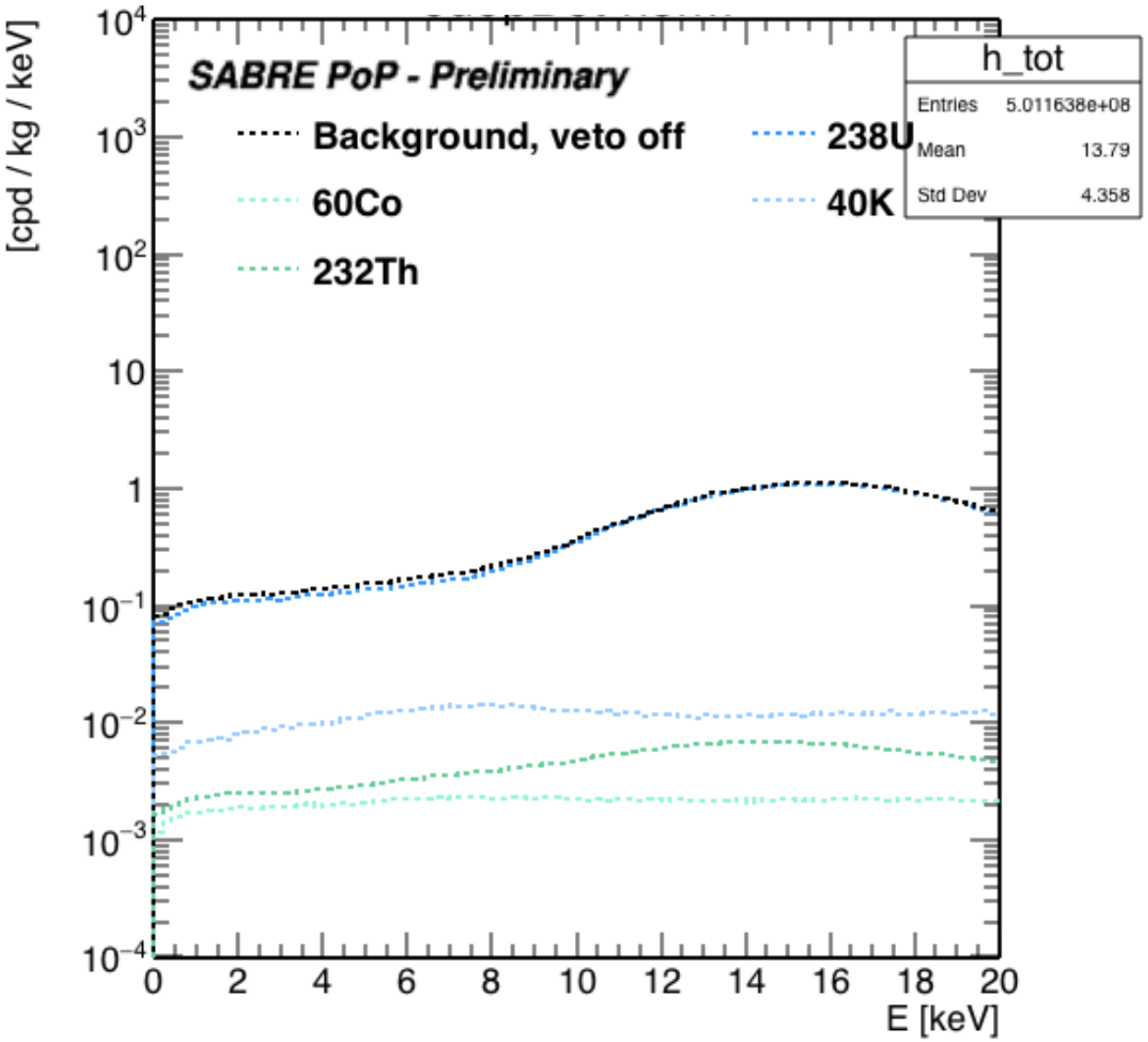
Newest Activities



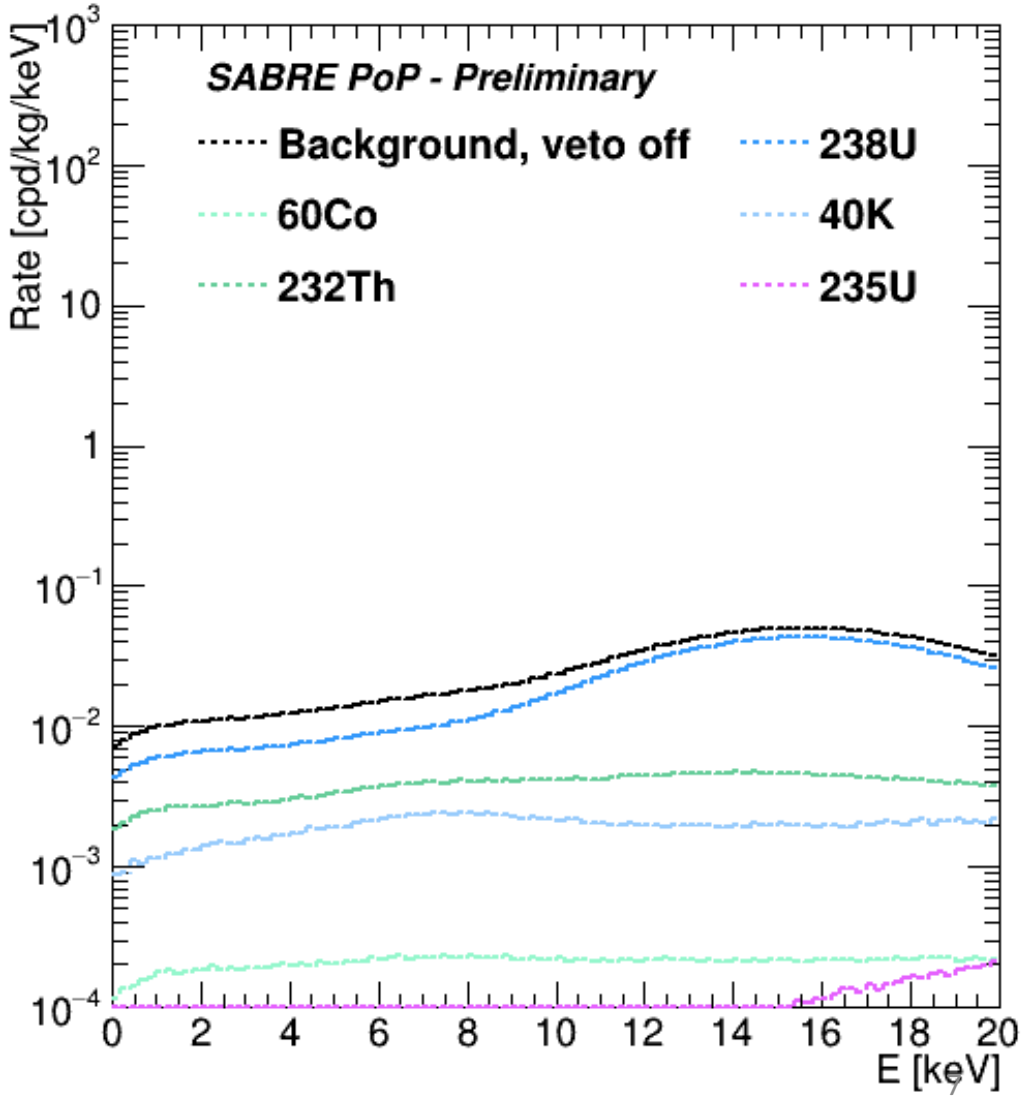
July Activities



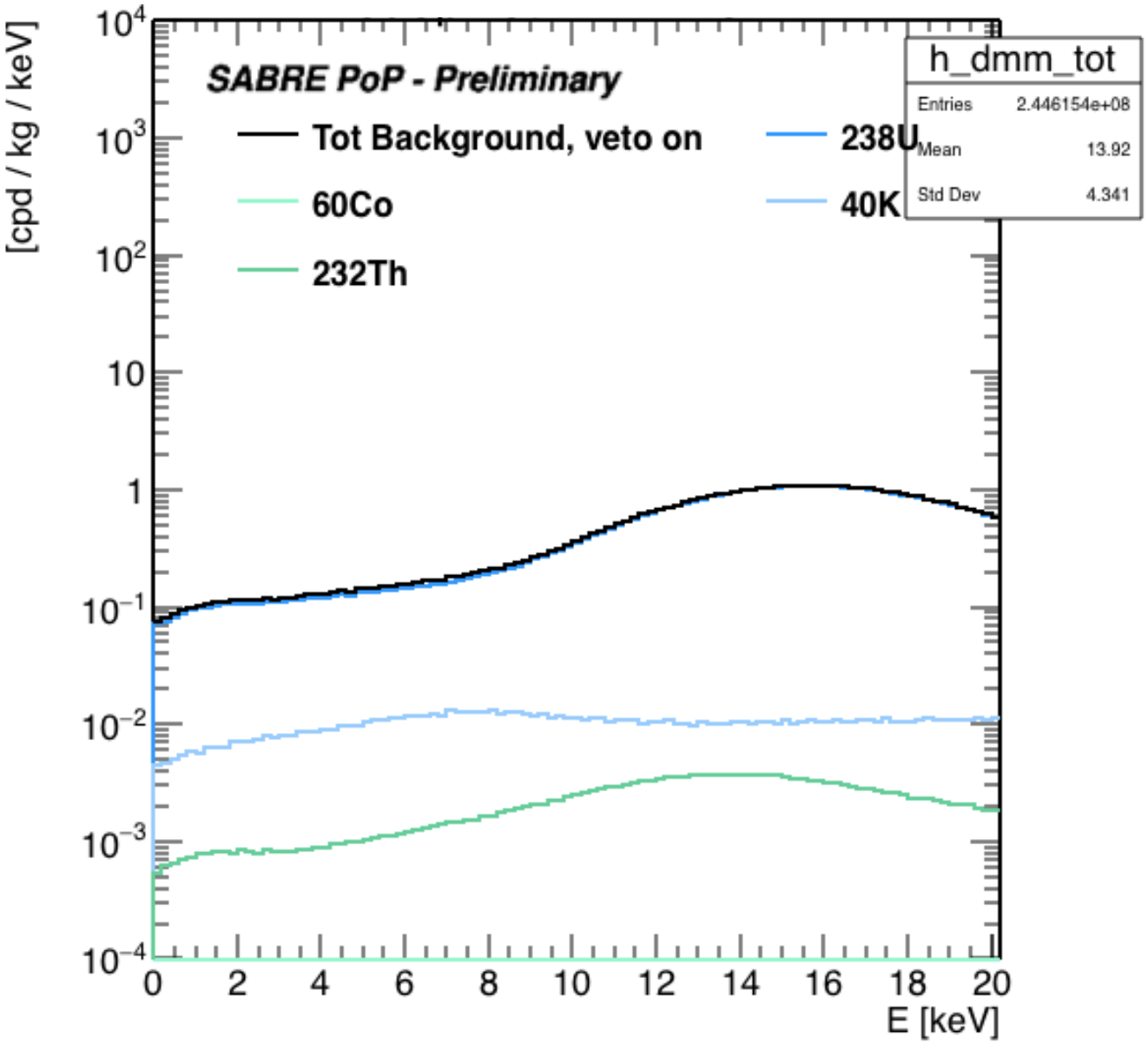
Newest Activities



July Activities



Newest Activities



July Activities