Comparing the Background Model 2 with MCC11

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DUNE BGTF meeting

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Simulation of Radon in LAr

- Start with ^{222}Rn in LAr.
- Simulation of other BG isotopes from in different materials/detector components is coming soon.
- Larsoft and dunetpc version:

  larsoft_v09_10_02_e19_prof

  dunetpc develop branch (v09_10_02)
- Generator: RadioGen vs DECAY0

Proposing Background Model 2

Position	Isotope	Activity/Unit	Reference
LAr	^{39}Ar	0.00141 Bq/cc	MCC11
LAr	^{42}Ar	0.0001283768 Bq/cc	MCC11
LAr	^{85}Kr	0.00016 Bq/cc	MCC11
LAr	^{222}Rn	0.0000014 Bq/cc	New Goal
APA frame steel	^{60}Co	0.000082 Bq/cc	MCC11, MPIK
APA frame steel	^{238}U	0.0216 Bq/cc	Requirement
APA frame steel	^{232}Th	0.00018 Bq/cc	ProtoDUNE I Beam
APA CuBe wires	U early	0.000000258 Bq/cc	Measurement
APA CuBe wires	U late	$\leq$0.00000000034 Bq/cc	Measurement
APA CuBe wires	Th early	0.0000000086 Bq/cc	Measurement
APA CuBe wires	Th late	0.00000001 Bq/cc	Measurement
APA CuBe wires	^{40}K	0.0000039 Bq/cc	Measurement
APA electronic boards	^{40}K	0.0000037 Bq/cc	Majorana
APA electronic boards	^{238}U	0.0000058 Bq/cc	Majorana
APA electronic boards	^{232}Th	0.0000036 Bq/cc	Majorana
CPA	^{40}K	0.0027195 Bq/cc	MCC11
CPA	^{238}U	0.06105 Bq/cc	Requirement
PDs	^{222}Rn	0.000005 Bq/cc	MCC11
PDs	^{210}Po	0.0000001 Bq/cc	Estimation
Field Cage	^{40}K	0.000348 Bq/cc	EDELWEISS
Field Cage	^{226}Ra	0.000216 Bq/cc	EDELWEISS
Field Cage	^{228}Th	0.000427 Bq/cc	EDELWEISS

Table 1: Background Model 2

The proposed new background model was discussed on BGTF Meeting 14/10/2020. See my slides here: https://indico.fnal.gov/event/46943/

Full table available here: https://www.overleaf.com/6175337632brpsxjfxmryc

New Radiological fcl File

- Materials: more materials are now considered, including APA wires. Field Cage, etc.
- Isotopes: more BG isotopes, especially ^{232}Th Chain and Tl.
- Activities: up-to-date activity.

Isotopes

Checked the whole decay chain to make sure we have all “dangerous” alpha and beta emitter considered.

isotope	decay mode	energy (MeV)	in decay0	note
^{238}U	alpha	4.270	yes	
^{234}Th	beta	0.273	yes	
^{234m}Pa	beta	2.195	yes	
^{234}U	alpha	4.859	yes	
^{230}Th	alpha	4.770	yes	
^{226}Ra	alpha	4.871	yes	
^{222}Rn	alpha	5.590	yes	
^{218}Po	alpha	6.114	yes	beta (0.02%) Q=0.265
^{214}Pb	beta	1.024	yes	
^{214}Bi	beta (99.979%)	3.272	yes	to ^{214}Po
	alpha (0.021%)	5.617	yes	to ^{210}Tl
^{214}Po	alpha	7.833	yes	BiPo event
^{210}Tl	beta	5.489	no	
^{210}Pb	beta	0.063	yes	alpha(1.9E-6%)
^{210}Bi	beta	1.162	yes	alpha(1.32E-4%) Q=5.036
^{210}Po	beta	5.407	yes	

Table 1: Alpha and beta emitters in ^{238}U Chain.

isotope	decay mode	energy (MeV)	in decay0	note
^{232}Th	alpha	4.083	no	
^{228}Ra	beta	0.046	yes	
^{228}Ac	beta	2.127	yes	
^{228}Th	alpha	5.520	no	
^{224}Ra	alpha	5.789	no	
^{220}Rn	alpha	6.405	no	
^{216}Po	alpha	6.907	no	
^{212}Pb	beta	0.574	yes	
^{212}Bi	beta (64.06%)	2.254	yes	to ^{212}Po
	alpha (35.94%)	6.207	yes	to ^{208}Tl
^{212}Po	alpha	8.954	yes	BiPo event
^{208}Tl	beta	5.001	yes	

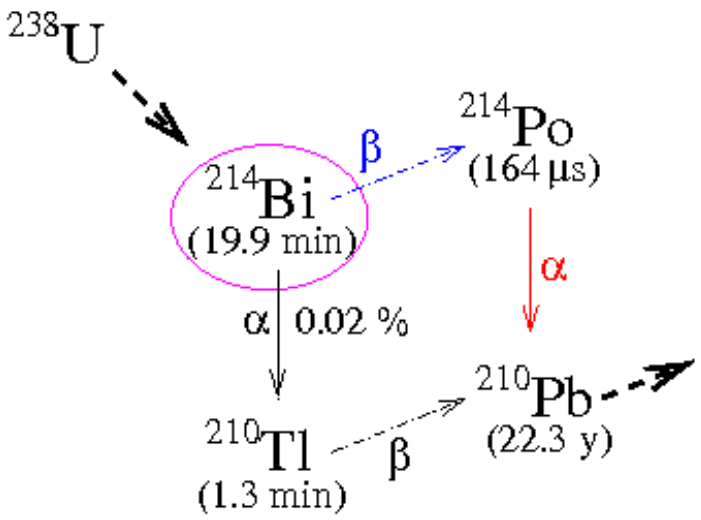
Table 2: Alpha and beta emitters in ^{232}Th Chain.

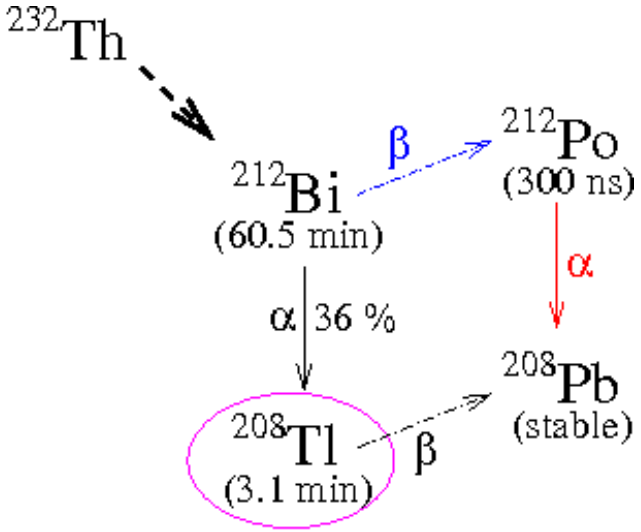
Full table available here: https://www.overleaf.com/6175337632brpsxjfxmryc

Adding Tl208 & Tl210

Added some decays that were not considered in MCC11, such as: Tl208, Tl210. BiPo event was generated automatically, but the Tl was ignored in the past. And unfortunately can not be simply added to the chain.

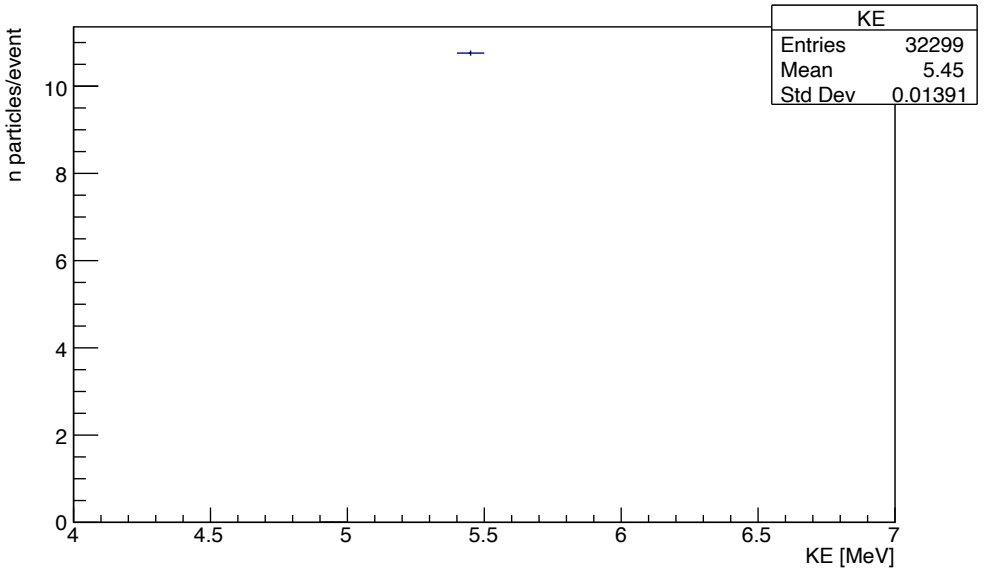
My solution: treat them as separate isotopes, and use the modified activity = branching ratio * activity of the Th232/U238 chain respectively.





α Energy of ^{222}Rn

α energy generated by decay0 generator is 5.45 MeV, and it was 5 MeV from in RadioGen module used for MCC11.



Decay0

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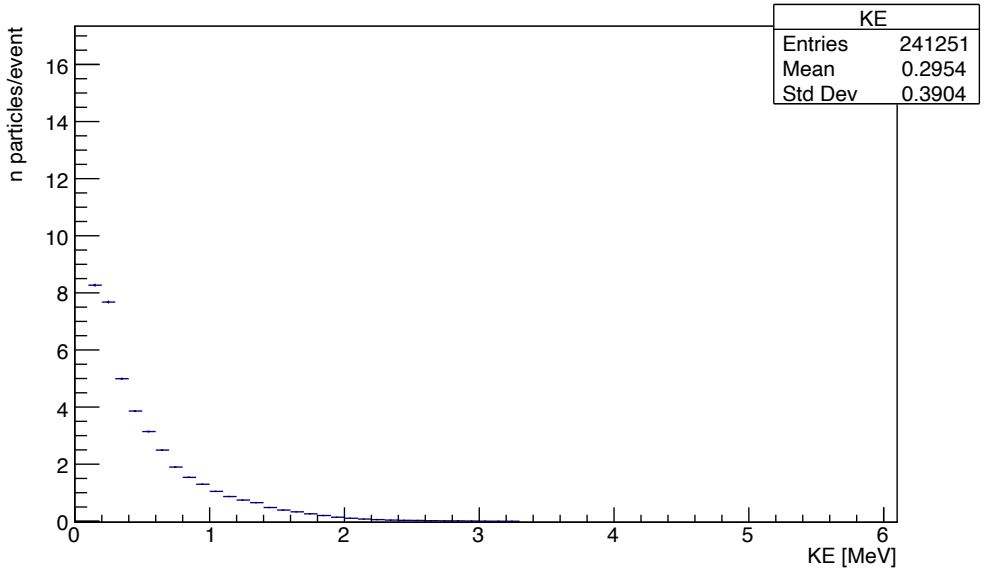
Table 1: Alpha and beta emitters in ^{238}U Chain.

Nuclear data

β Energy Spectrum of ^{238}U Chain



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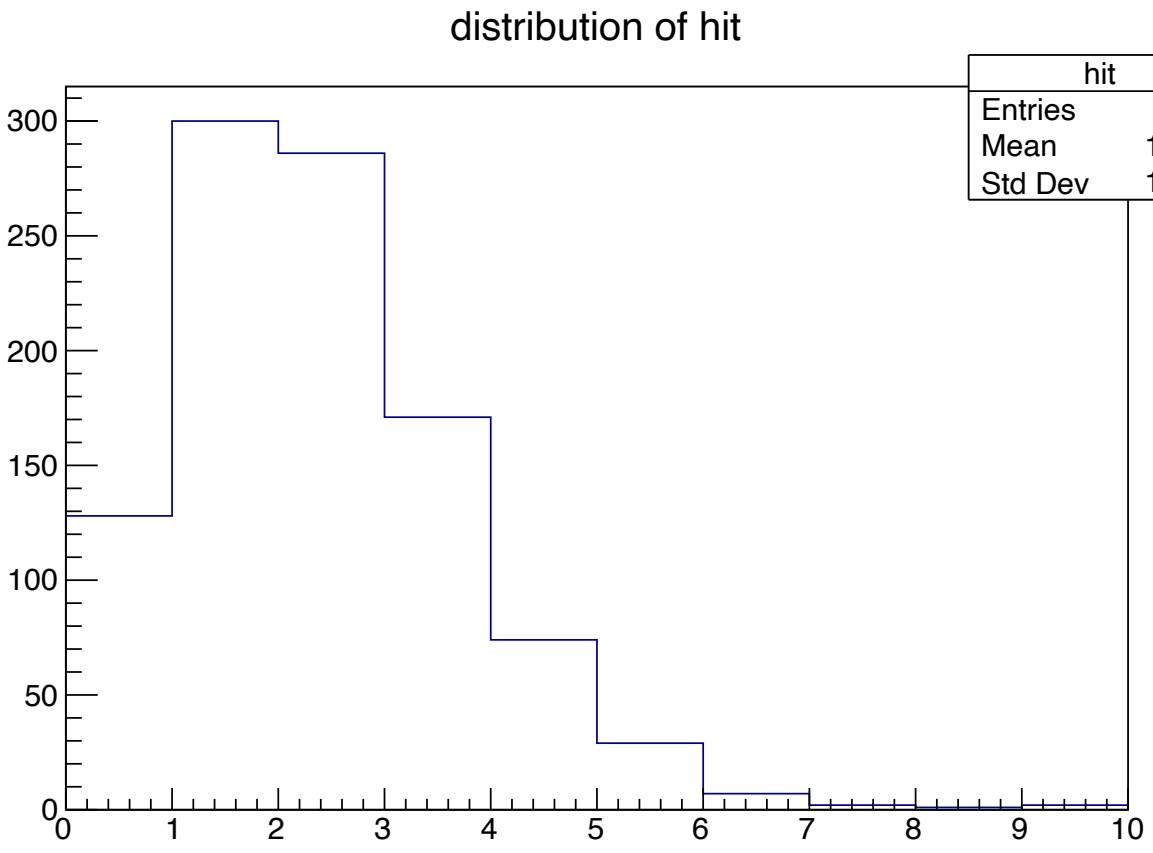
Distribution of Hits – MCC11



Rn: 0.000005584 Bq/cc

Simulated 1000 events

0 hit 12.8%

1 hit 30%

2 hits 28.6%

3 hits 17.1%

4 hits 7.4%

5 hits 2.9%

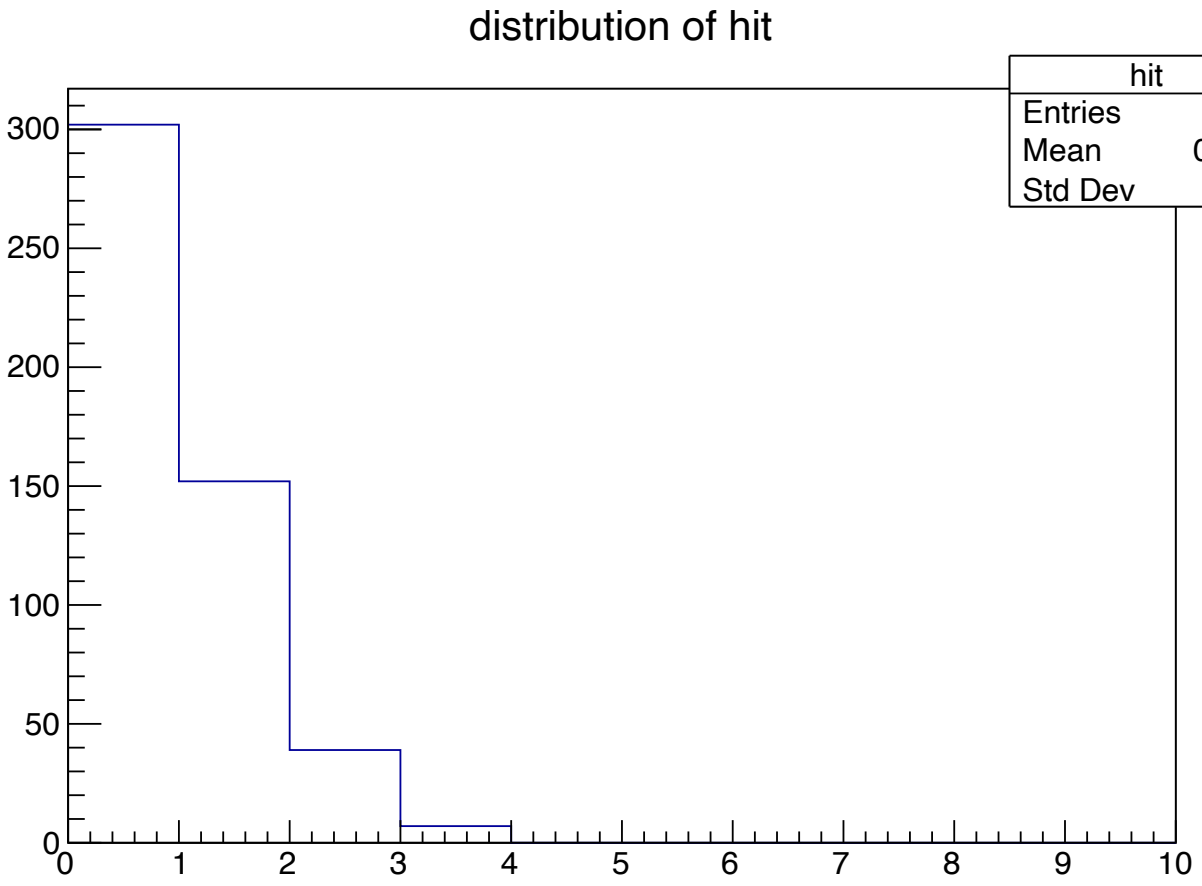
6 hits 0.7%

7 hits 0.2%

8 hits 0.1%

9 hits 0.2%

Distribution of Hits – BG Model 2



Rn: 0.0000014 Bq/cc

Simulated 500 events

0 hit 60.4%

1 hit 30.4%

2 hits 7.8%

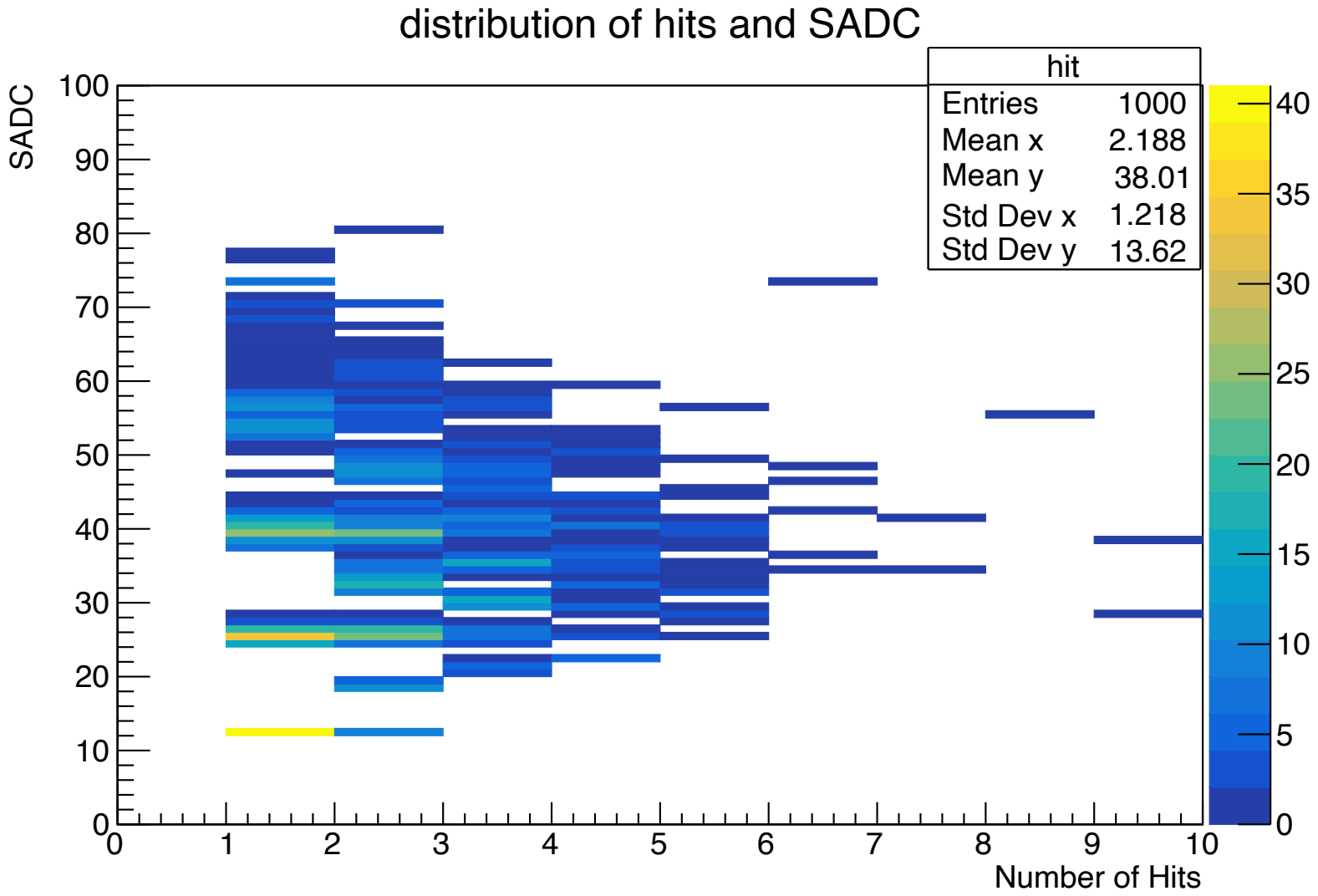
3 hits 1.4%

4 hits 0%

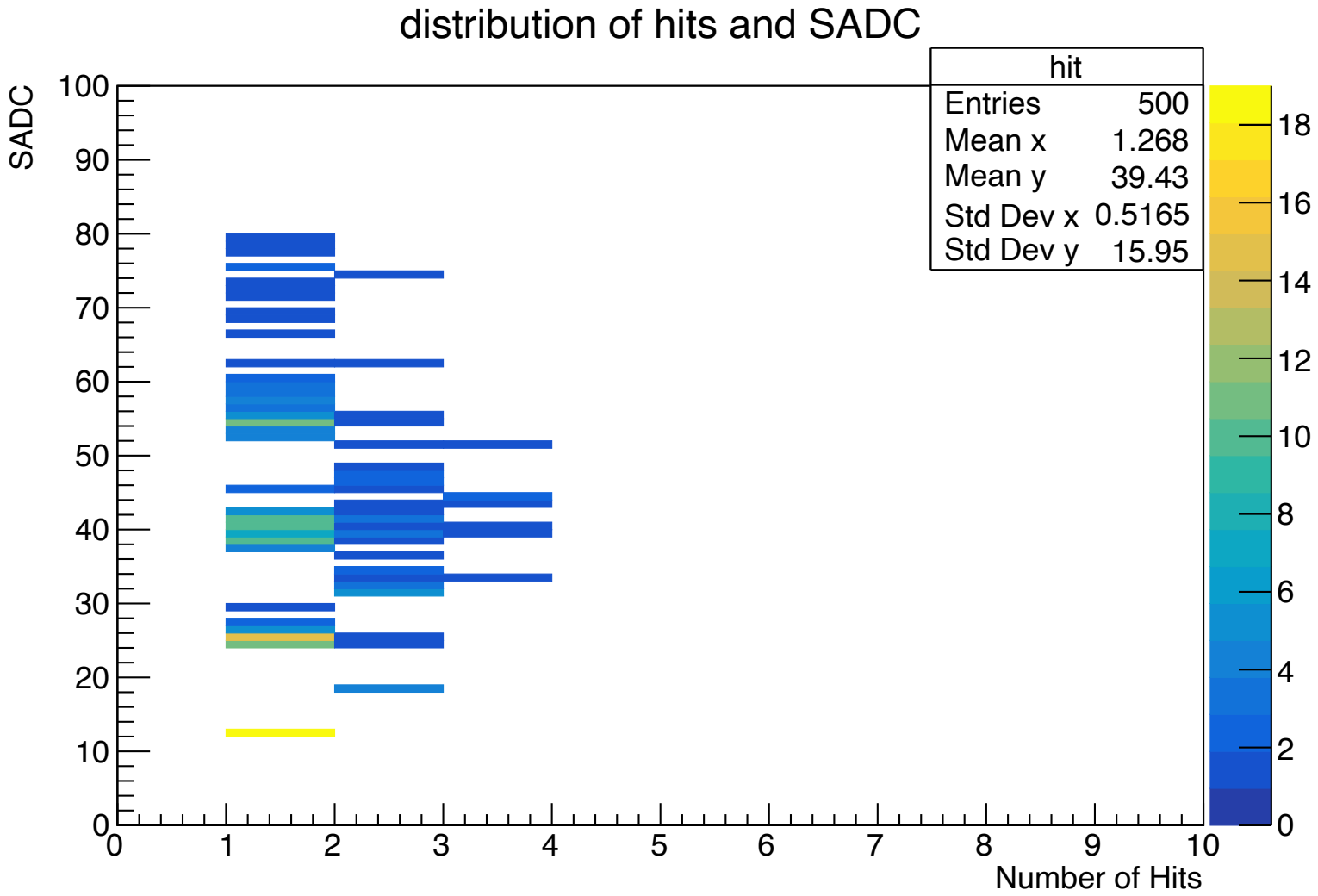
5 hits 0%

Larger simulation still running …

Hits & Summed ADC – MCC11



Hits & Summed ADC – BG Model 2



Next

- Radon only -> full BG simulation
- Determine an approximate upper limit that the SN trigger can tolerate for each of the BGs.