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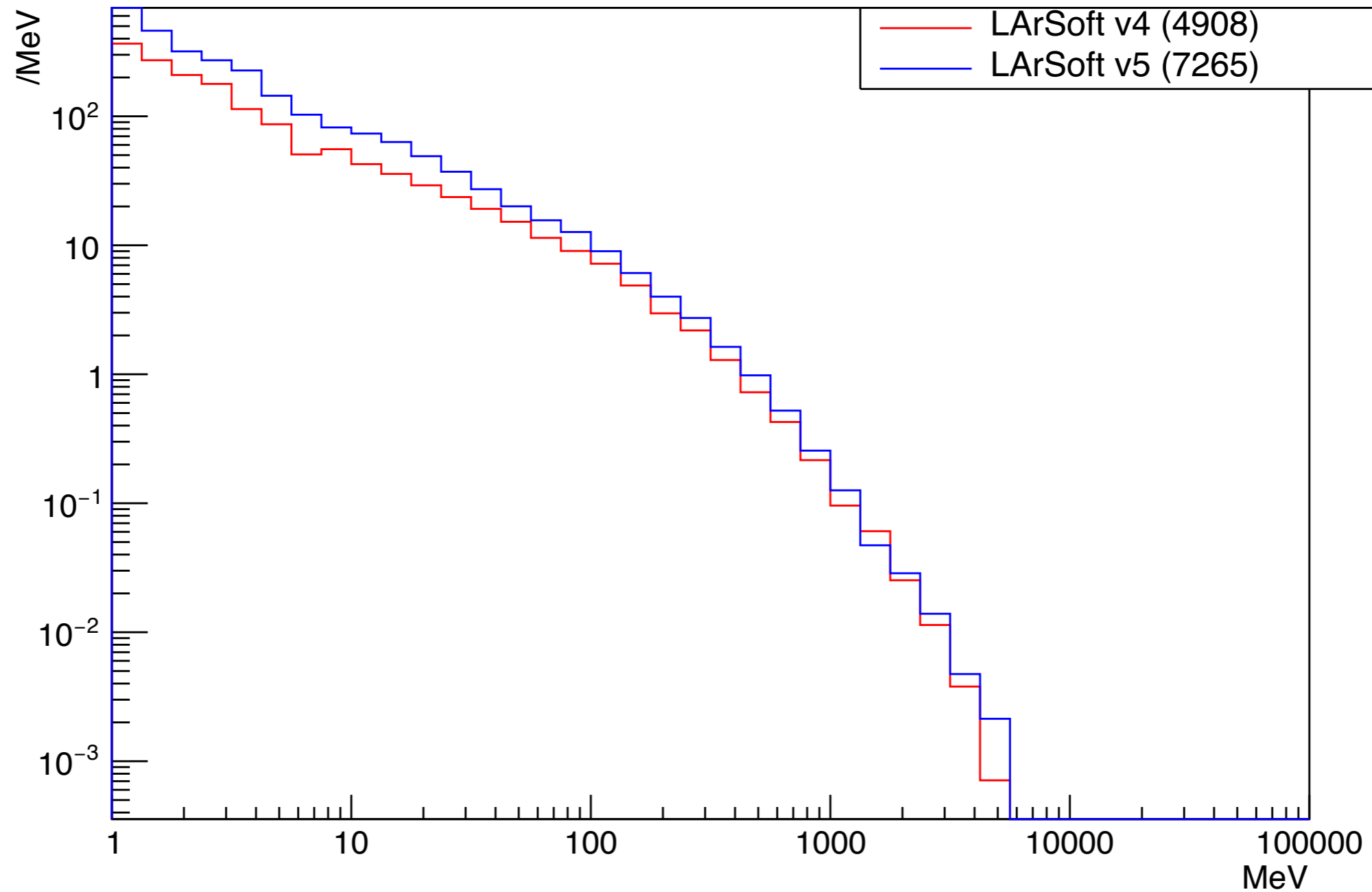
# COSMOGENIC PROTON DECAY BACKGROUND

Matt Robinson  
Vitaly Kudryavtsev  
Karl Warburton

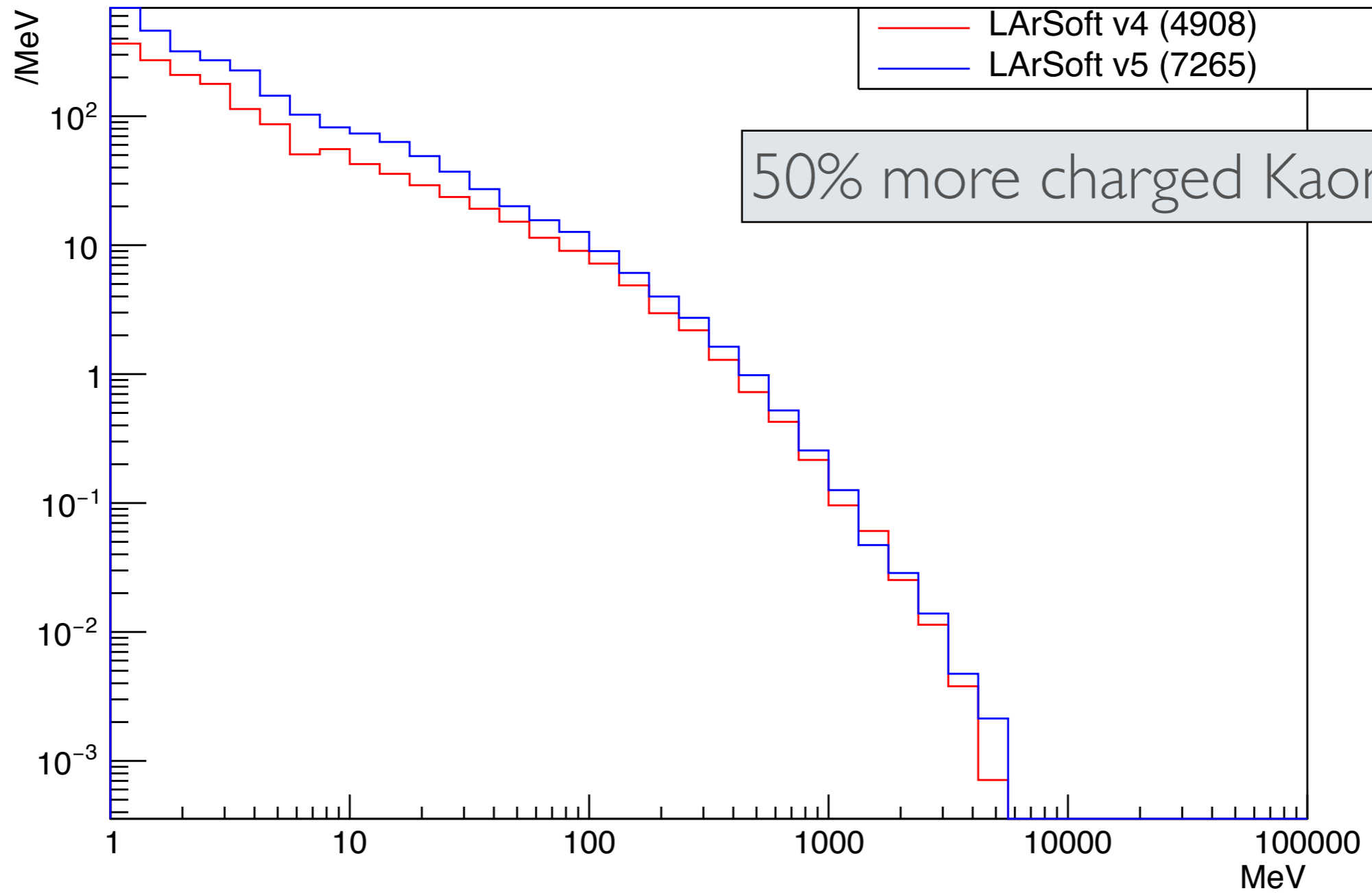
# SWITCH TO GEANT4.10.X

- As discussed at previous meeting geant4.10.1 and later handle Kaons significant differently.
- Comparison of a small sample  $10^6$  muons showed significant higher  $K^\pm$  production.
- This has now been followed up with a simulation of  $10^8$  muons ( $\sim 20$  years running) with larsoft v05\_09\_00 (thereby with geant4.10.1).

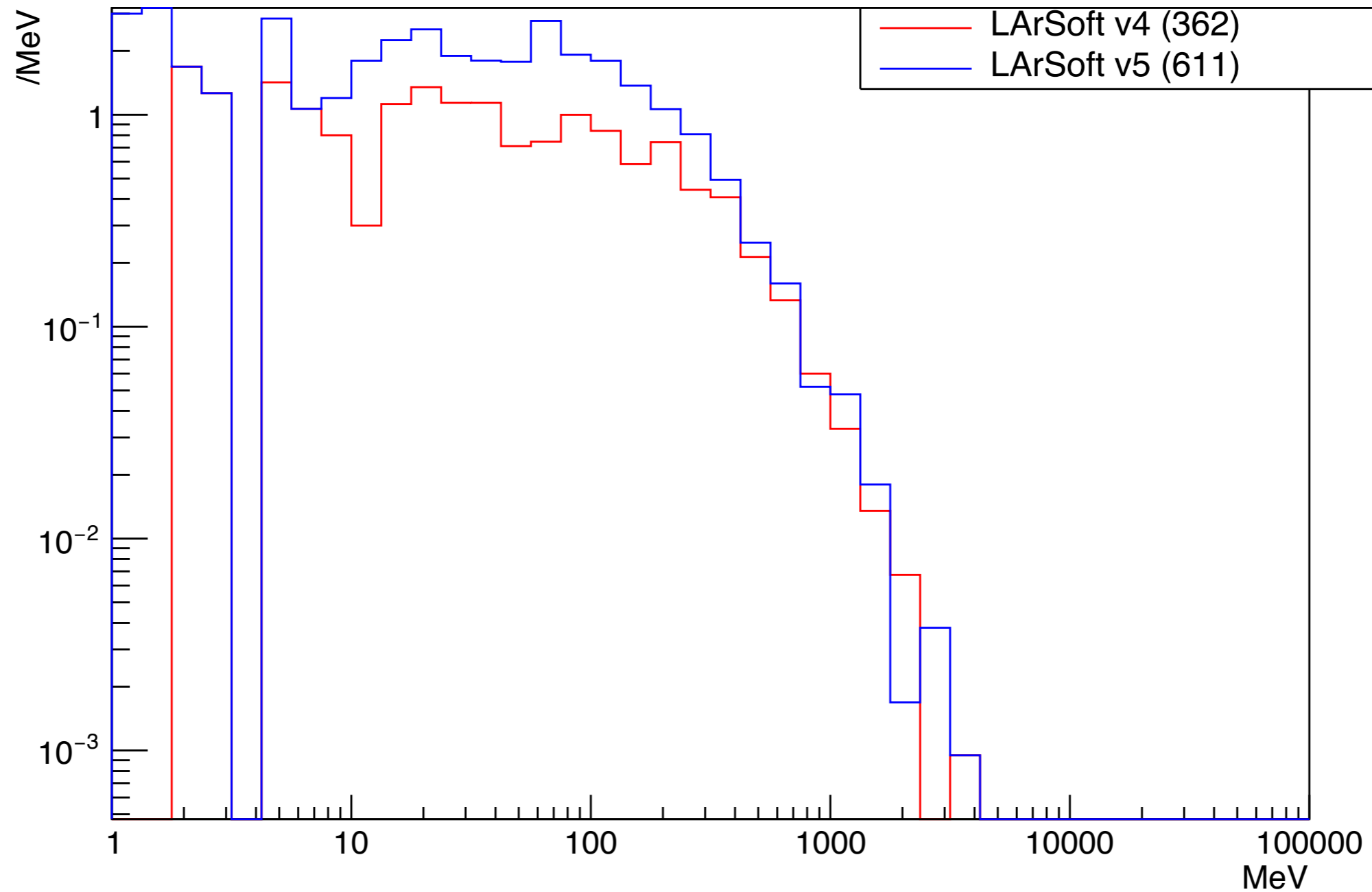
## All Kaons, $10^8$ filtered muons



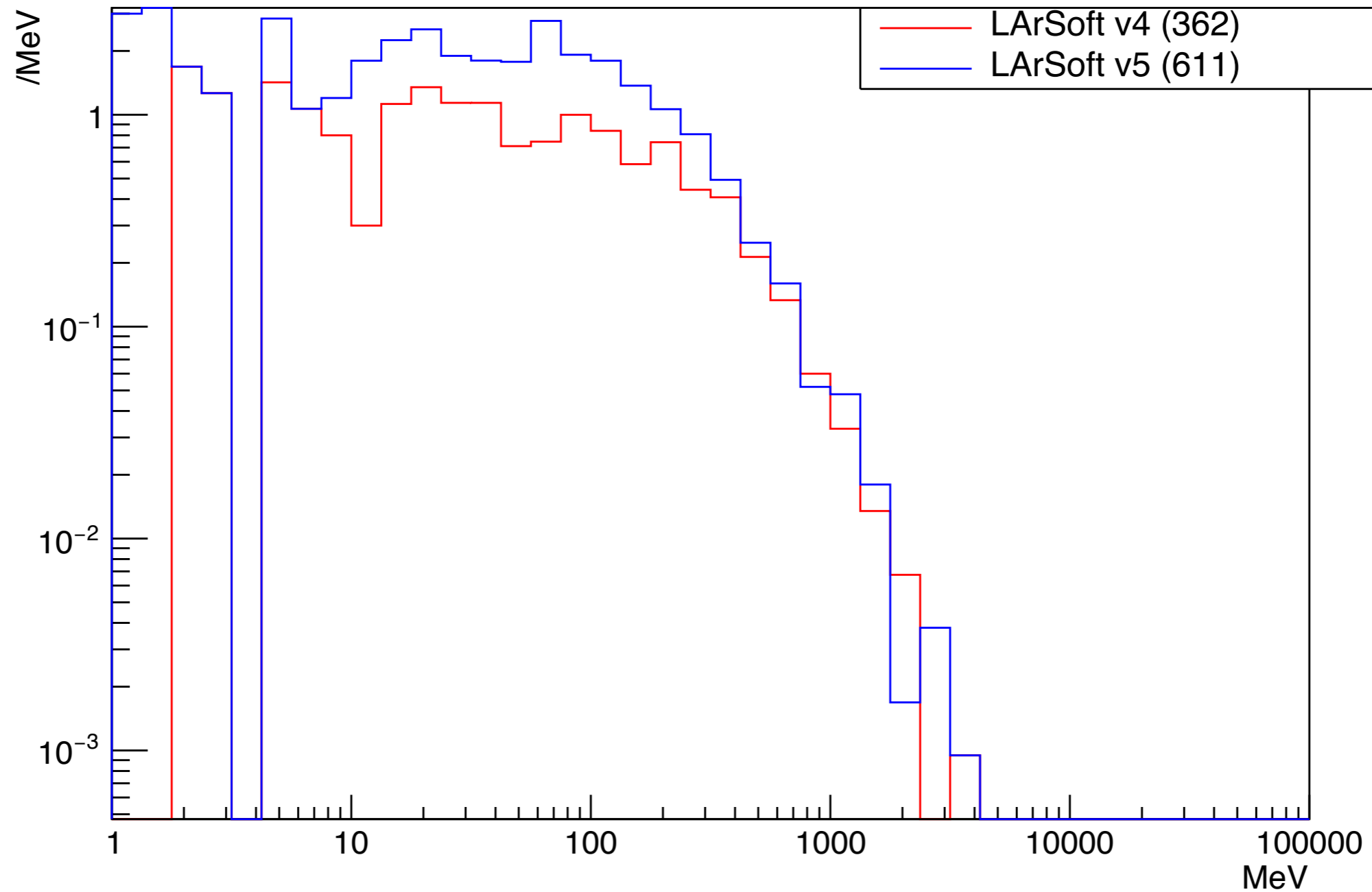
## All Kaons, $10^8$ filtered muons



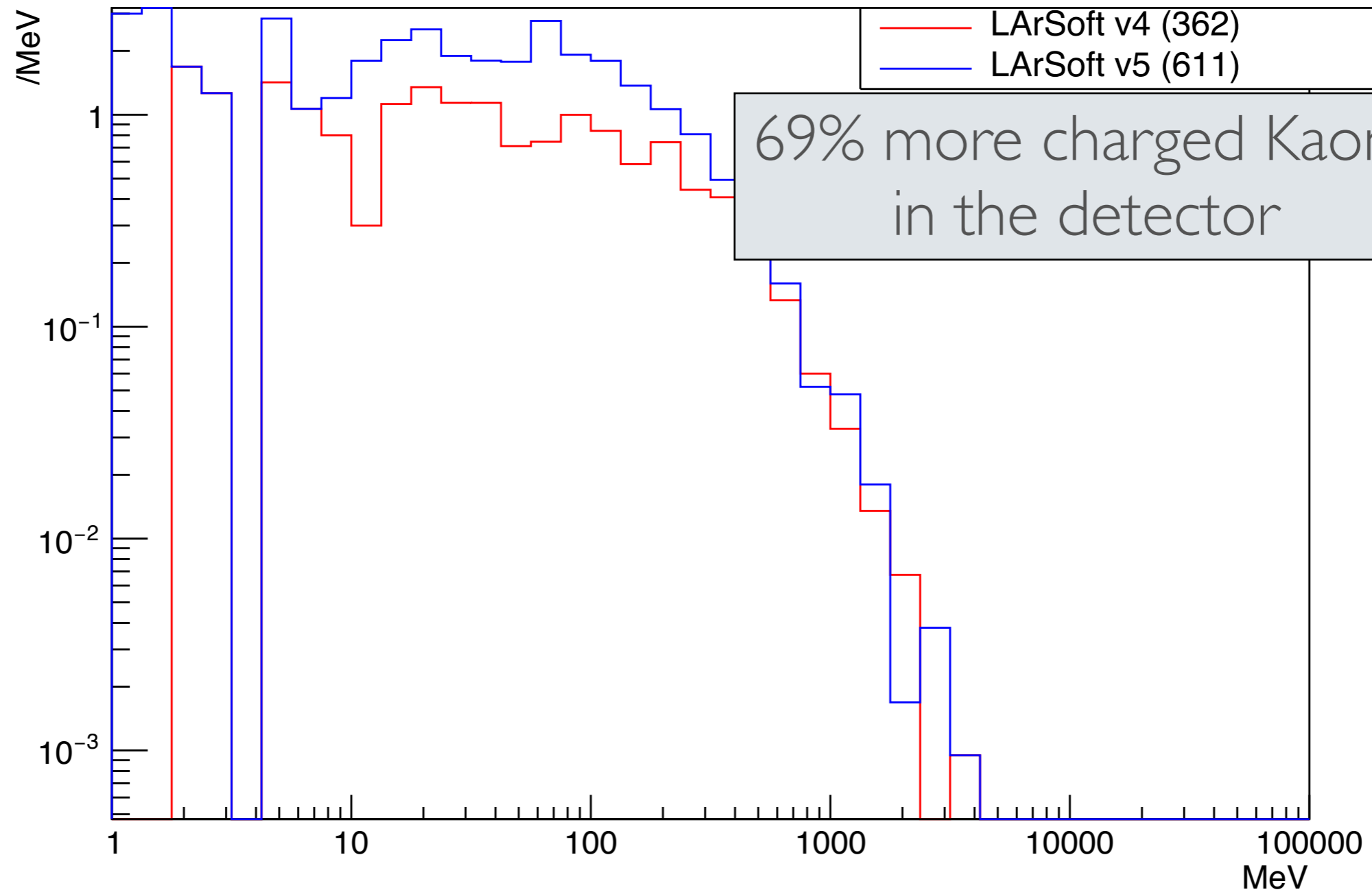
## Kaon Seen in Detector, $10^8$ filtered muons



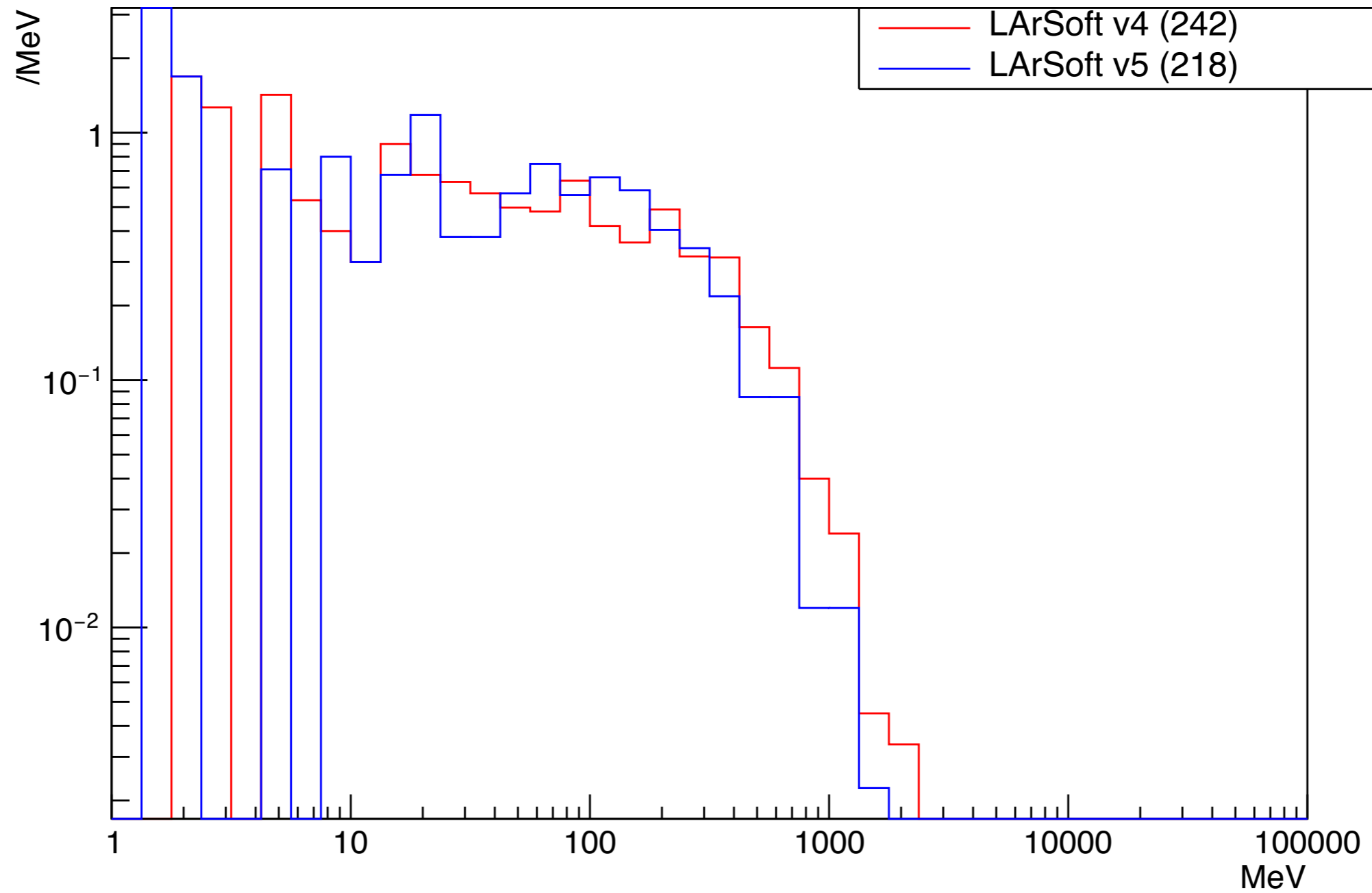
## Kaon Seen in Detector, $10^8$ filtered muons



## Kaon Seen in Detector, $10^8$ filtered muons

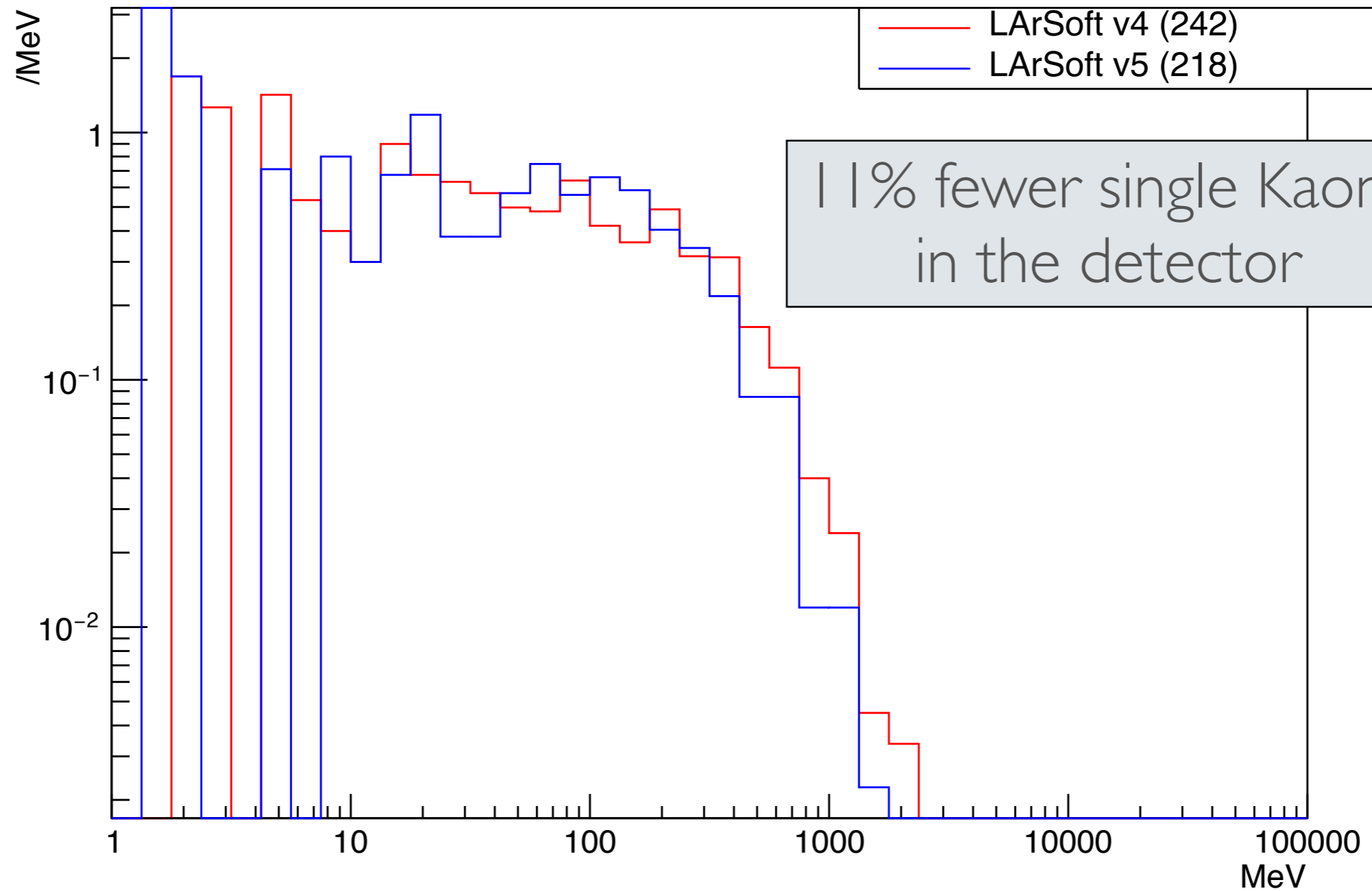


### Only one Kaon in Detector, $10^8$ filtered muons

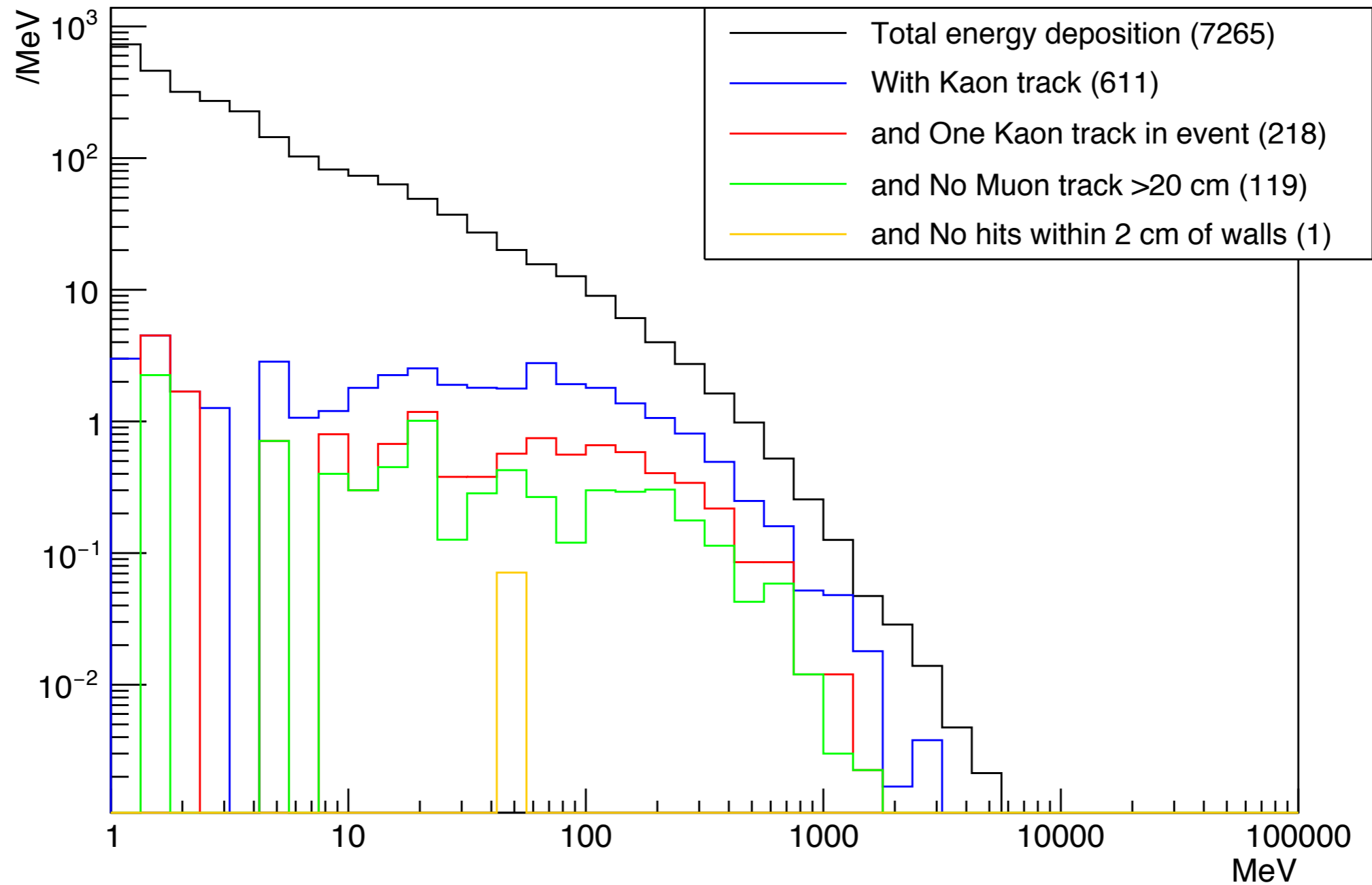




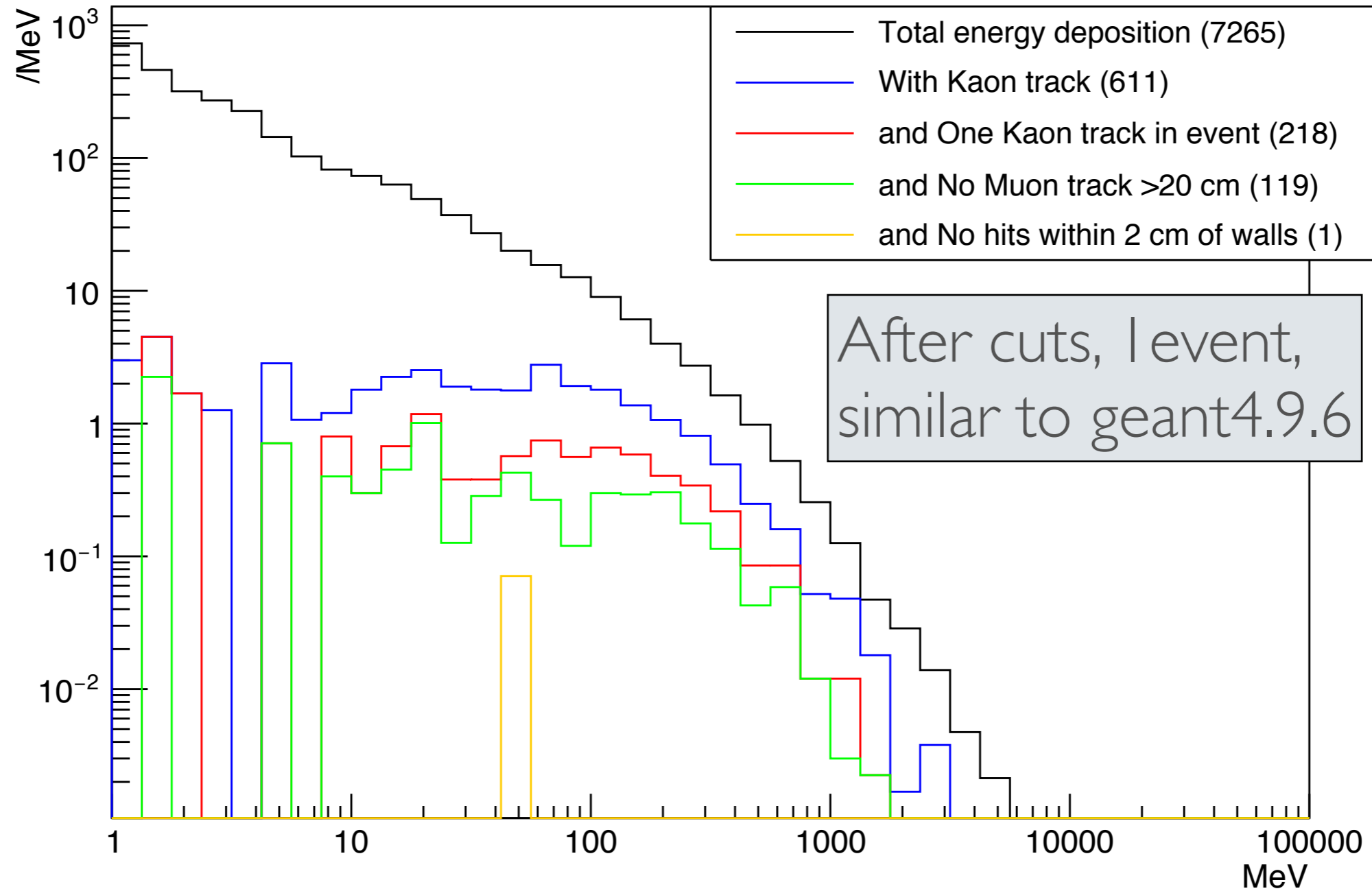
### Only one Kaon in Detector, $10^8$ filtered muons



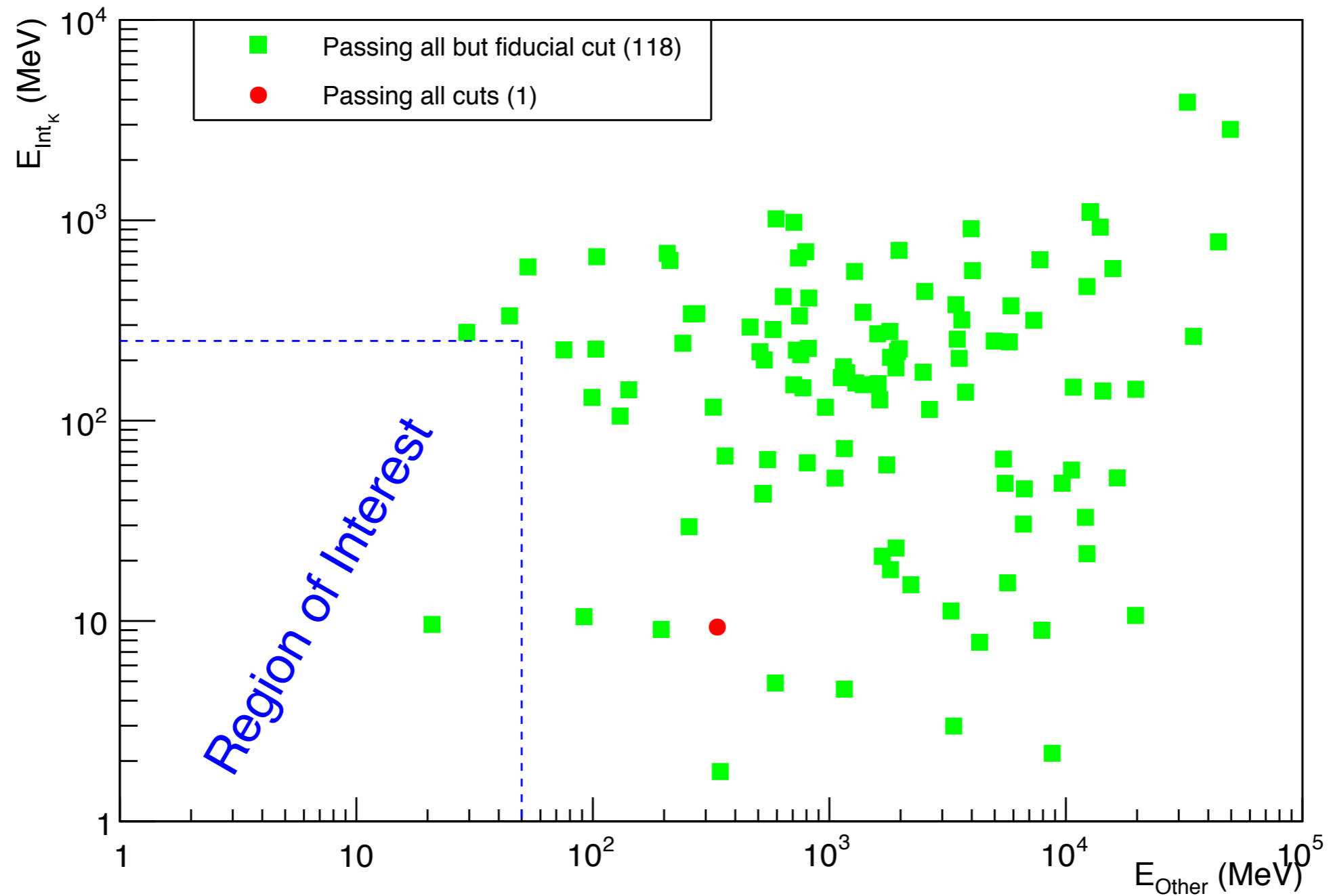
## Charged Kaon Spectrum, $10^8$ filtered muons



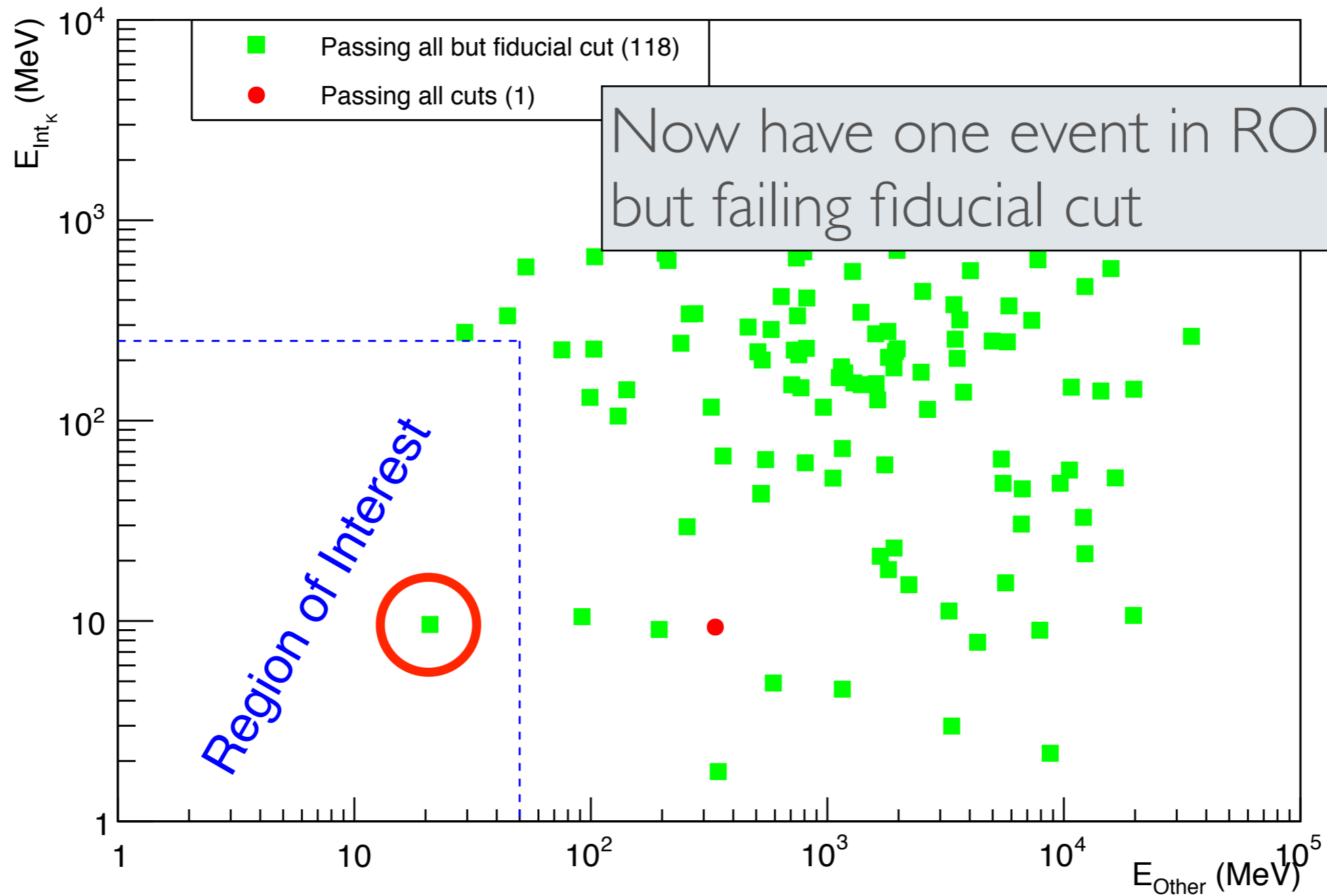
## Charged Kaon Spectrum, $10^8$ filtered muons

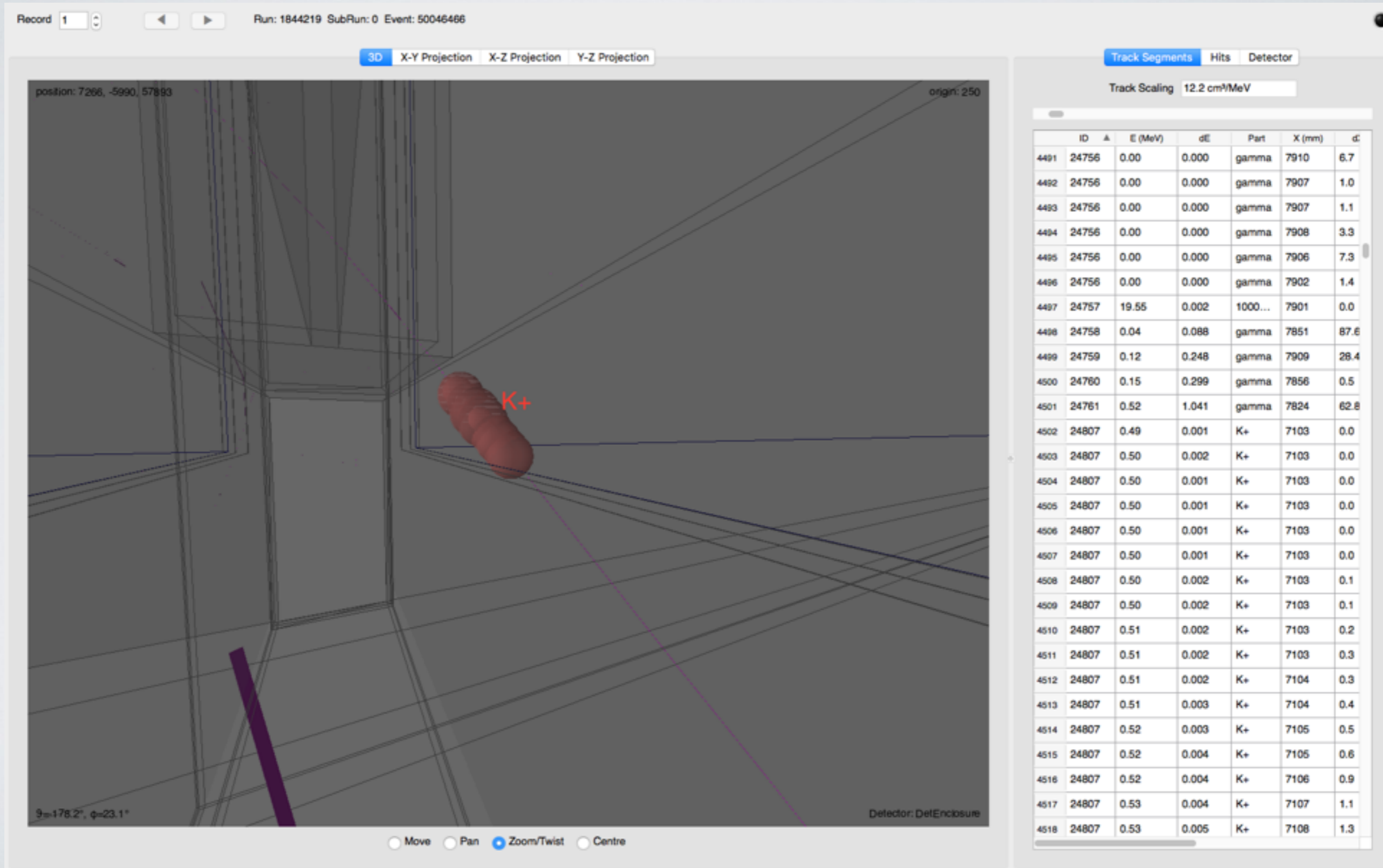


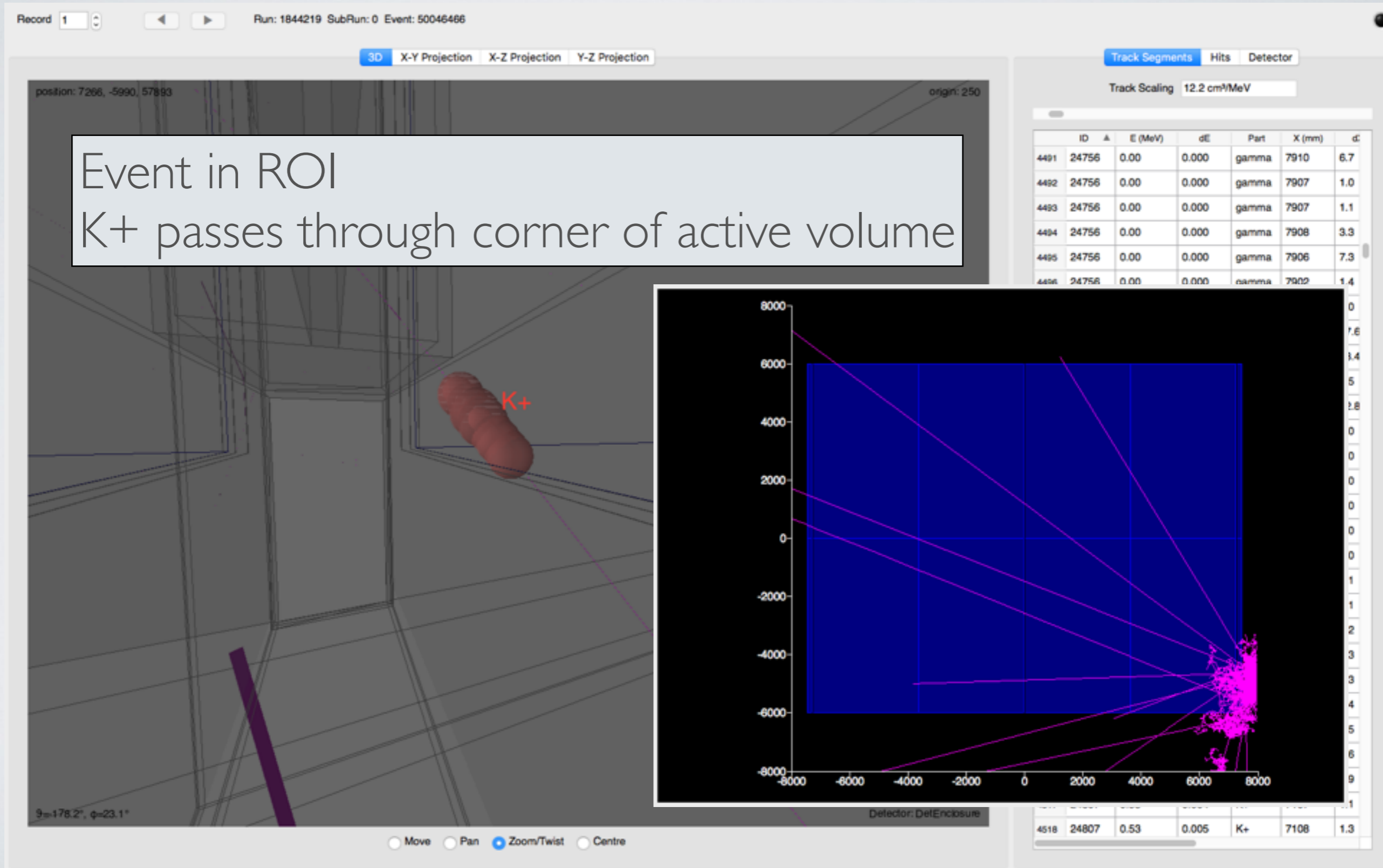
## Background Candidates



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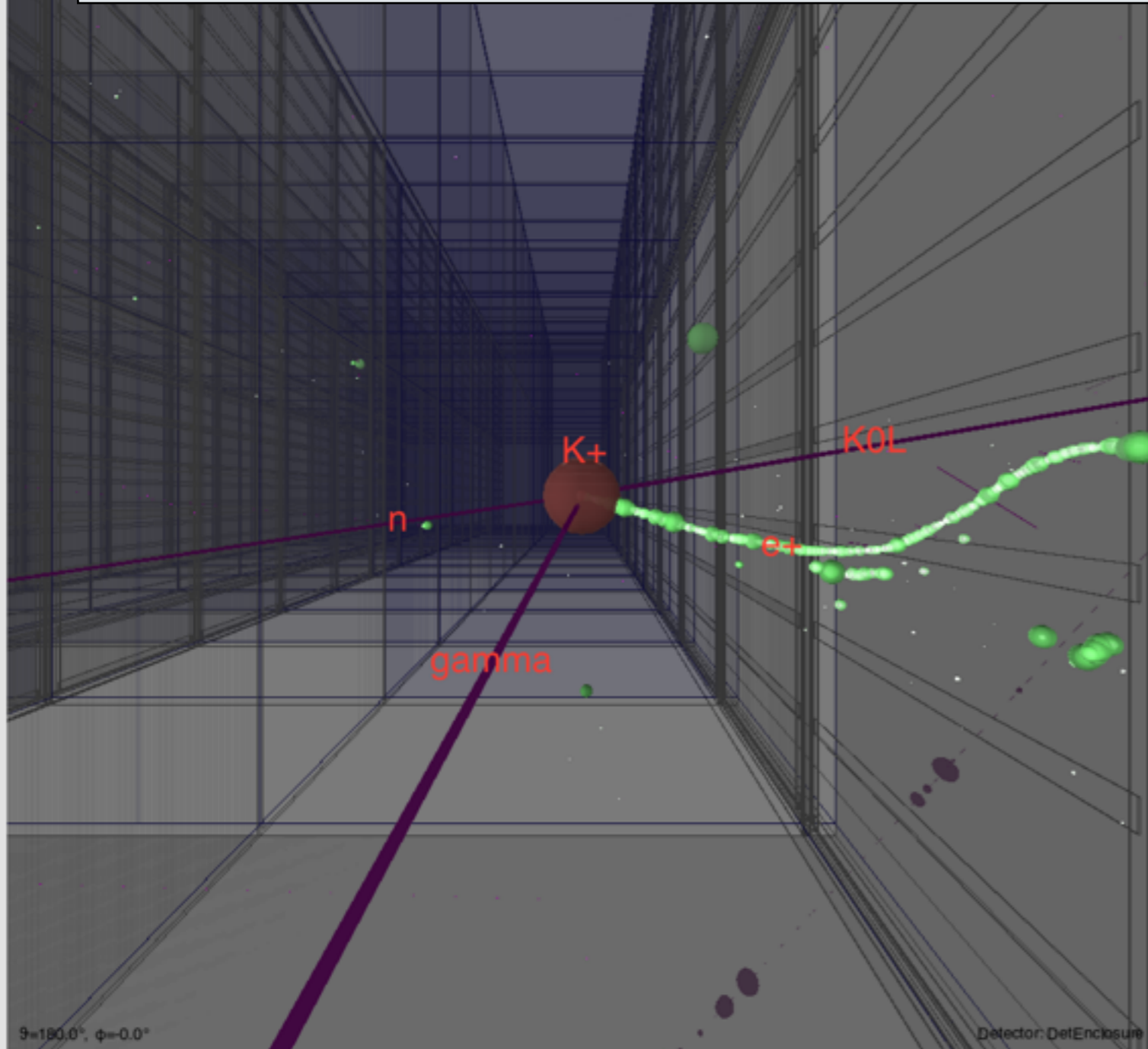






Record 2 Run: 1844219 SubRun: 0 Event: 31341098

Event passing all cuts, but outside ROI



Track Segments Hits Detector

Track Scaling 347 cm<sup>2</sup>/MeV

	ID	E (MeV)	dE	Part	A	X (mm)	dX	Y (mm)	dY	Z (mm)	
6499	1245	9.14	0.014	K-		-8551	0.4	-2494	16.0	18597	14.0
6500	1245	9.15	0.005	K-		-8551	0.0	-2488	1.6	18589	1.4
6501	1245	9.16	0.014	K-		-8550	0.4	-2477	16.4	18581	14.0
6502	1245	9.17	0.010	K-		-8550	0.1	-2467	3.0	18572	2.7
6503	142844	0.49	0.000	K+		-5772	0.0	-3816	0.0	17425	0.0
6504	142844	0.49	0.000	K+		-5772	0.0	-3816	0.0	17425	0.0
6505	142844	0.49	0.000	K+		-5772	0.0	-3816	0.0	17425	0.0
6506	142844	0.49	0.000	K+		-5772	0.0	-3816	0.0	17425	0.0
6507	142844	0.49	0.001	K+		-5772	0.0	-3816	0.0	17425	0.1
6508	142844	0.50	0.002	K+		-5772	0.2	-3816	0.0	17425	0.3
6509	142844	0.50	0.006	K+		-5772	1.0	-3816	0.1	17426	1.4
6510	139802	1.08	1.181	K+		-8542	0.1	-3264	3.0	19037	1.1
6511	139802	1.68	0.016	K+		-8542	0.8	-3250	26.0	19031	9.6
6512	139802	1.70	0.012	K+		-8543	0.4	-3229	15.2	19024	5.5
6513	139802	1.71	0.011	K+		-8543	0.5	-3213	16.6	19018	6.1
6514	139802	1.73	0.030	K+		-8544	0.9	-3189	32.9	19009	12.0
6515	139802	1.75	0.008	K+		-8544	0.4	-3166	12.3	19000	4.5
6516	139802	1.76	0.007	K+		-8545	0.4	-3154	10.6	18996	3.5
6517	139802	1.76	0.008	K+		-8545	0.4	-3143	11.7	18992	4.4
6518	139802	1.78	0.025	K+		-8546	1.7	-3118	38.5	18982	14.0
6519	139802	1.80	0.017	K+		-8548	1.1	-3086	25.6	18970	9.6
6520	139802	1.81	0.007	K+		-8548	0.3	-3068	9.9	18964	3.7
6521	139802	1.82	0.004	K+		-8549	0.1	-3061	4.4	18961	1.6
6522	139802	1.82	0.001	K+		-8549	0.0	-3059	1.2	18960	0.4
6523	139802	1.82	0.002	K+		-8549	0.0	-3057	1.0	18960	0.4
6524	139802	1.83	0.014	K+		-8549	0.6	-3046	22.3	18955	8.3
6525	139802	1.84	0.008	K+		-8550	0.3	-3029	11.8	18949	4.4
6526	139802	1.85	0.011	K+		-8550	0.4	-3014	17.2	18943	6.5

Move Pan Zoom/Twist Centre



Record 2 Run: 1844219 SubRun: 0 Event: 31341098

Event passing all cuts, but outside ROI

$K_{0L}$  sneaks in from side



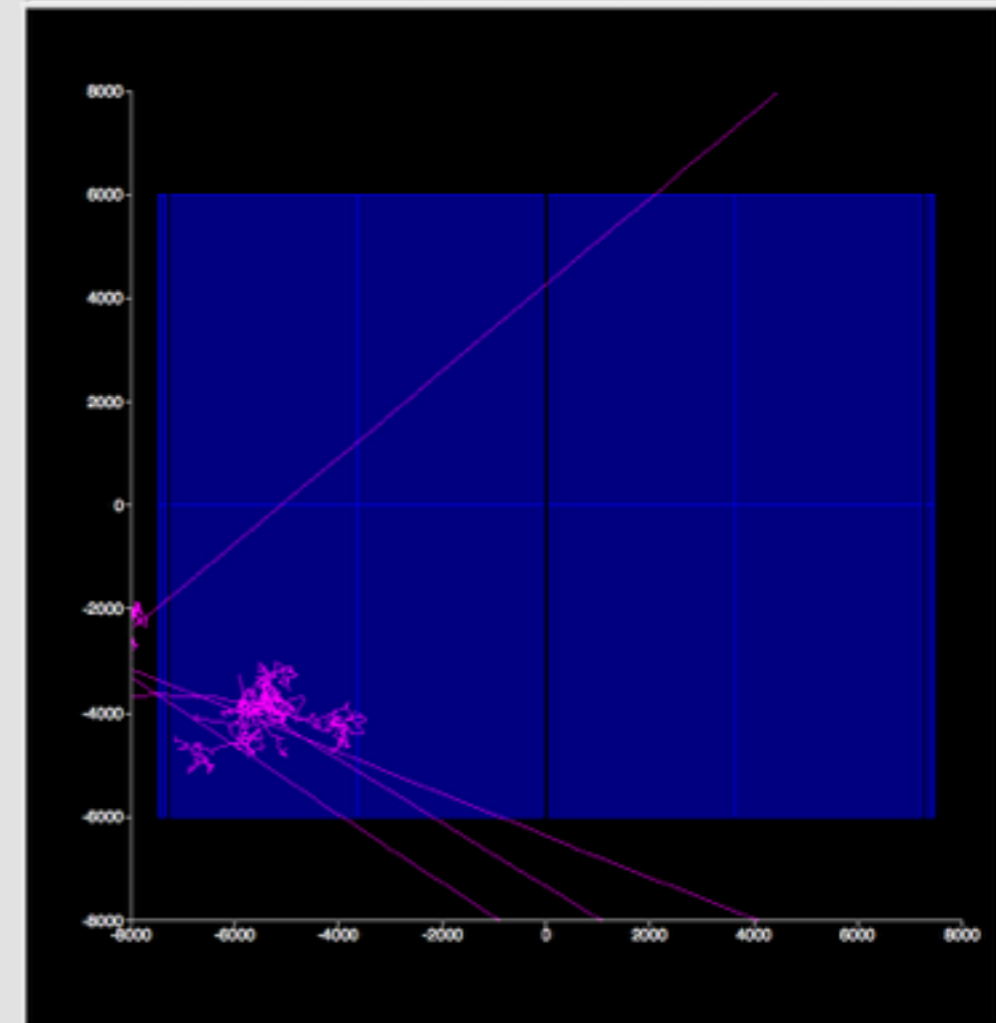
$\theta=180.0^\circ, \phi=-0.0^\circ$

Detector: DetEnclosure

○ Move ○ Pan ● Zoom/Twist ○ Centre

Track Segments Hits Detector

Track Scaling 347 cm<sup>2</sup>/MeV



6520	139802	1.81	0.007	K+	-8548	0.3	-3068	9.9	18964	3.7
6521	139802	1.82	0.004	K+	-8549	0.1	-3061	4.4	18961	1.6
6522	139802	1.82	0.001	K+	-8549	0.0	-3059	1.2	18960	0.4
6523	139802	1.82	0.002	K+	-8549	0.0	-3057	1.0	18960	0.4
6524	139802	1.83	0.014	K+	-8549	0.6	-3046	22.3	18955	8.3
6525	139802	1.84	0.008	K+	-8550	0.3	-3029	11.8	18949	4.4
6526	139802	1.85	0.011	K+	-8550	0.4	-3014	17.2	18943	6.5

Another passing all but fiducial, outside ROI

Record 1    Run: 1844219 SubRun: 0 Event: 14233447

3D   X-Y Projection   X-Z Projection   Y-Z Projection

position: 136, -5986, 57804    origin: 389.882

$\theta=170.9^\circ, \phi=-39.1^\circ$     Detector: TPCActiveInner

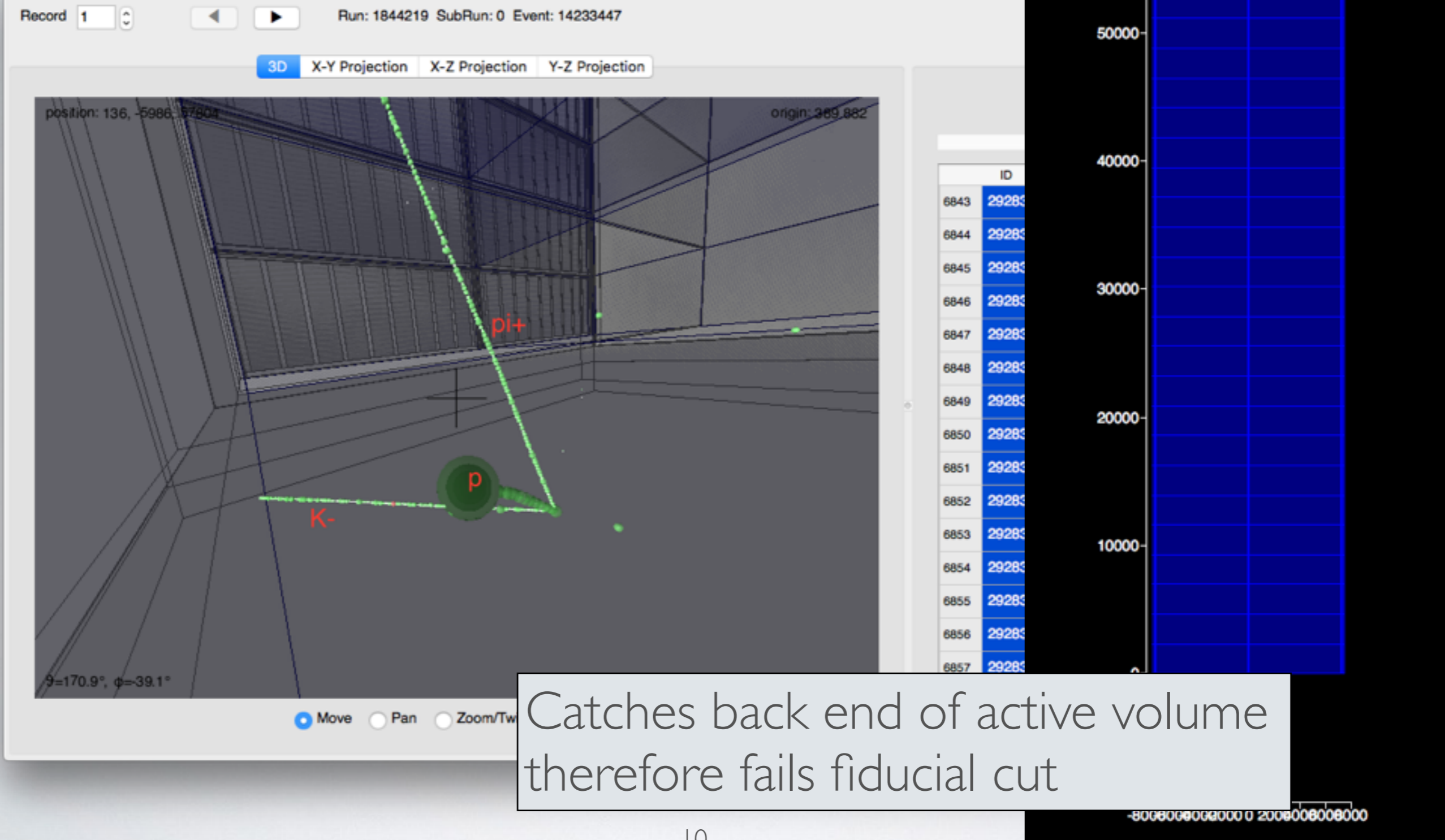
Track Segments   Hits   Detector

Track Scaling 28697 cm<sup>3</sup>/MeV

ID	E (MeV)	dE	Part	X (mm)	d
6843	29283	1.43	K-	555	8.3
6844	29283	1.44	K-	549	4.7
6845	29283	1.44	K-	535	22.6
6846	29283	1.45	K-	520	8.8
6847	29283	1.45	K-	515	1.1
6848	29283	1.46	K-	507	14.5
6849	29283	1.47	K-	474	51.3
6850	29283	1.49	K-	445	5.9
6851	29283	1.49	K-	436	13.3
6852	29283	1.50	K-	421	16.4
6853	29283	1.51	K-	412	1.1
6854	29283	1.51	K-	408	6.5
6855	29283	1.51	K-	403	3.2
6856	29283	1.52	K-	399	6.3
6857	29283	1.52	K-	384	23.7
6858	29284	0.35	pi+	638	21.3

● Move   ○ Pan   ○ Zoom/Twist   ○ Centre

Another passing all but fiducial, outside ROI



Catches back end of active volume therefore fails fiducial cut