

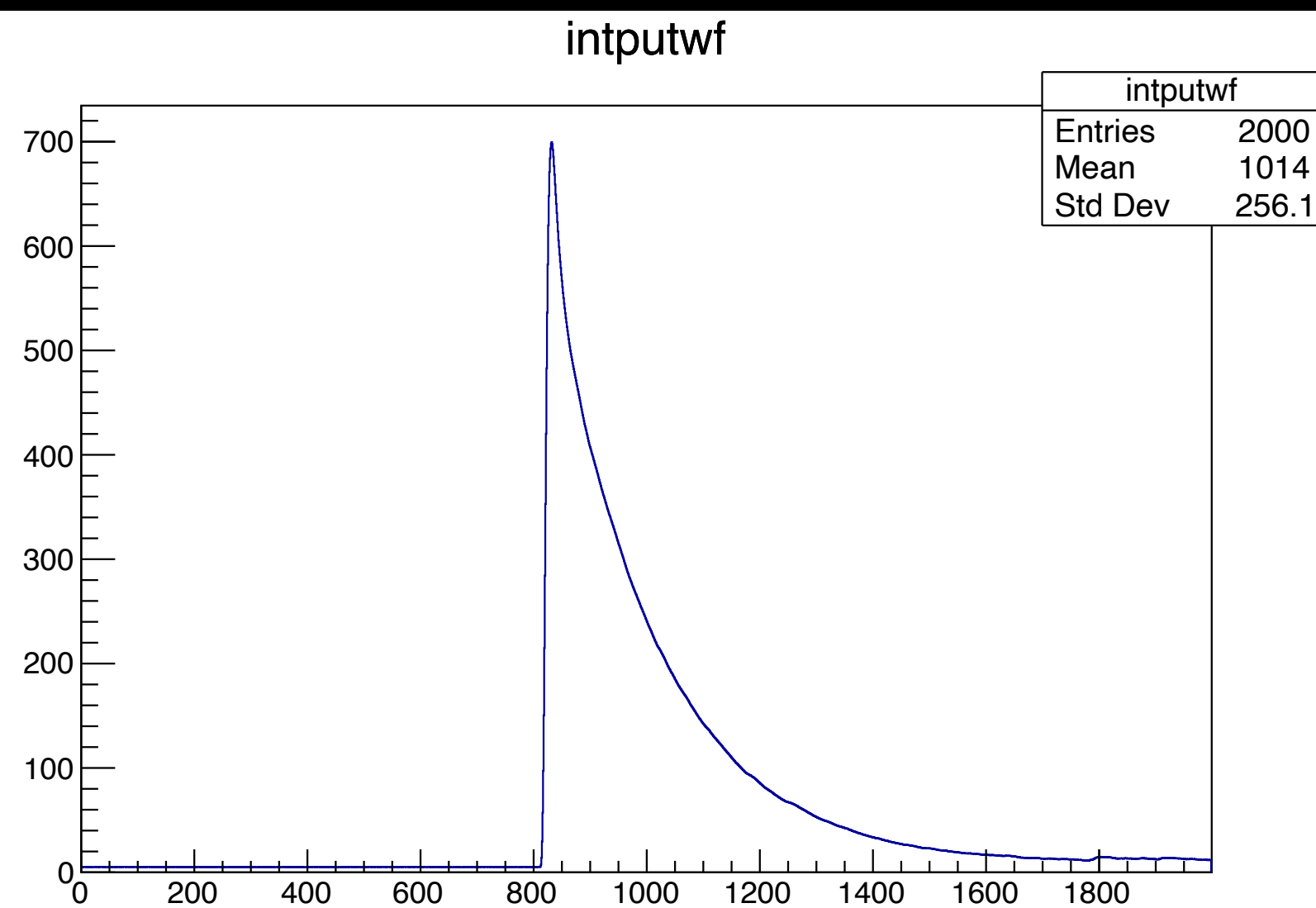
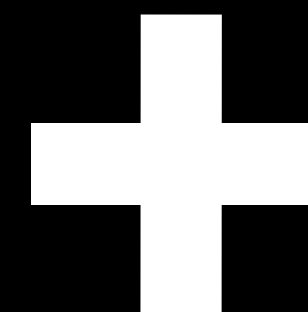
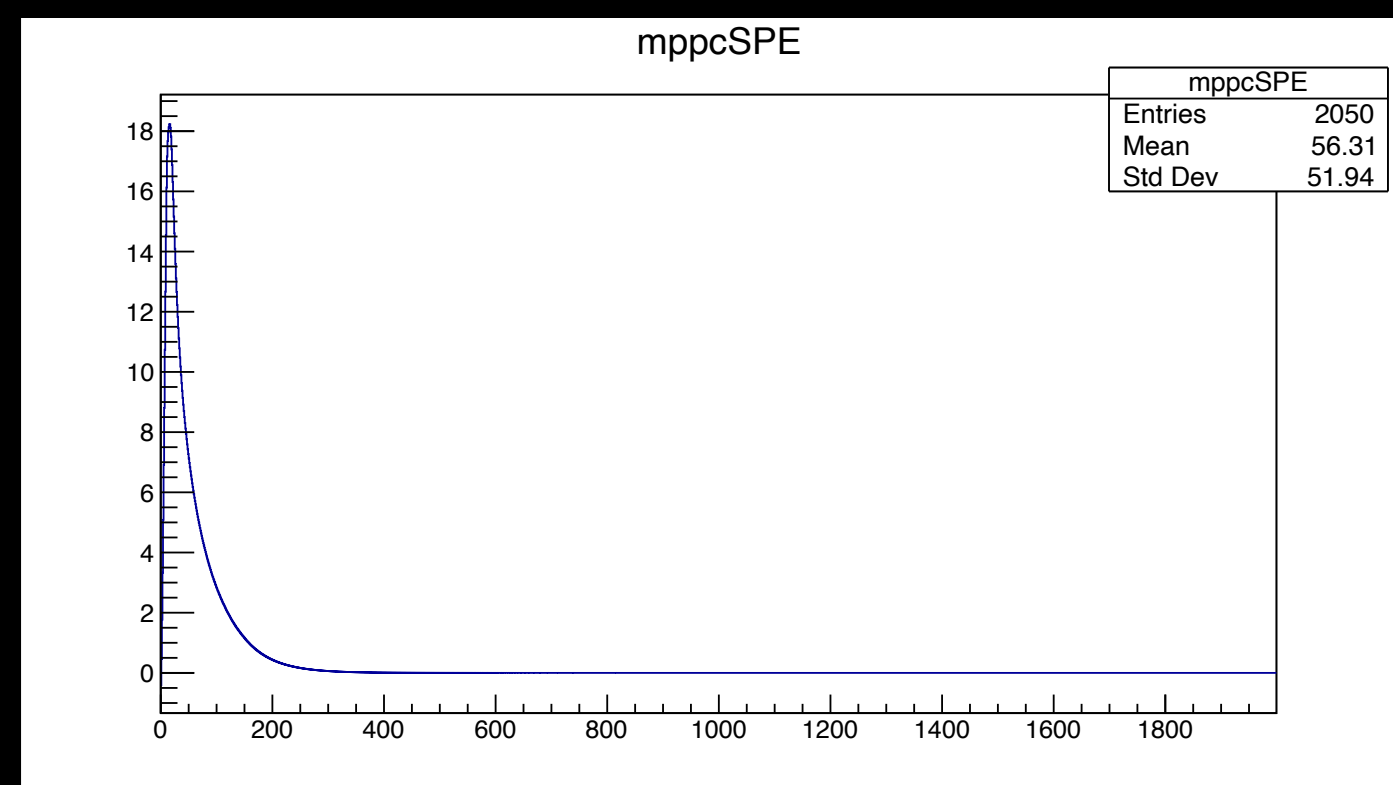
Attenuation Waveform Analysis

Kyle Spurgeon - 07 August, 2020

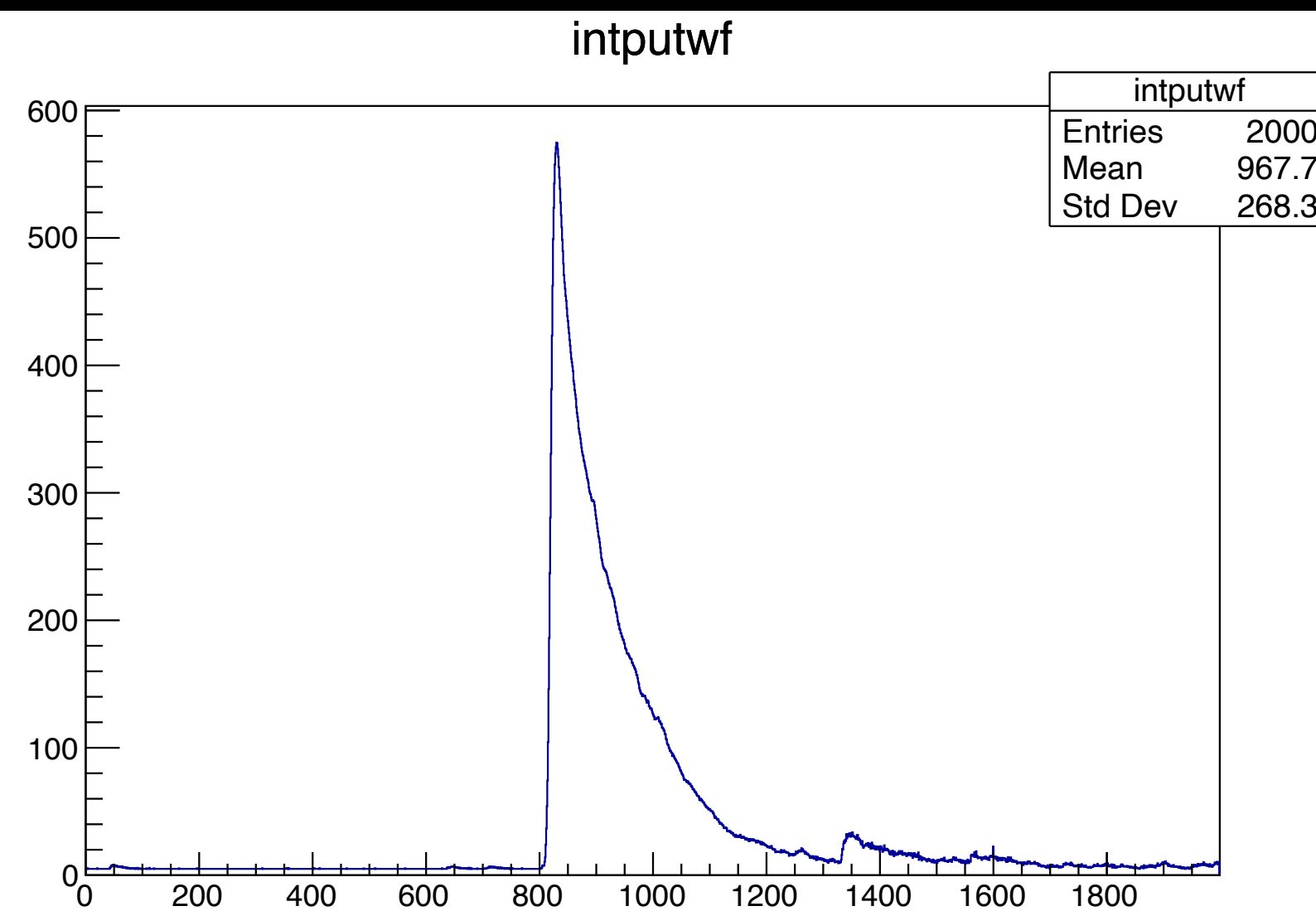
- Look (very) briefly at deconvolution results
- Recap how the attenuation study is performed
- Present updated results
- Look at waveform components of results
- Brief dive into how light attributes change over ProtoDUNE run conditions

Deconvolution

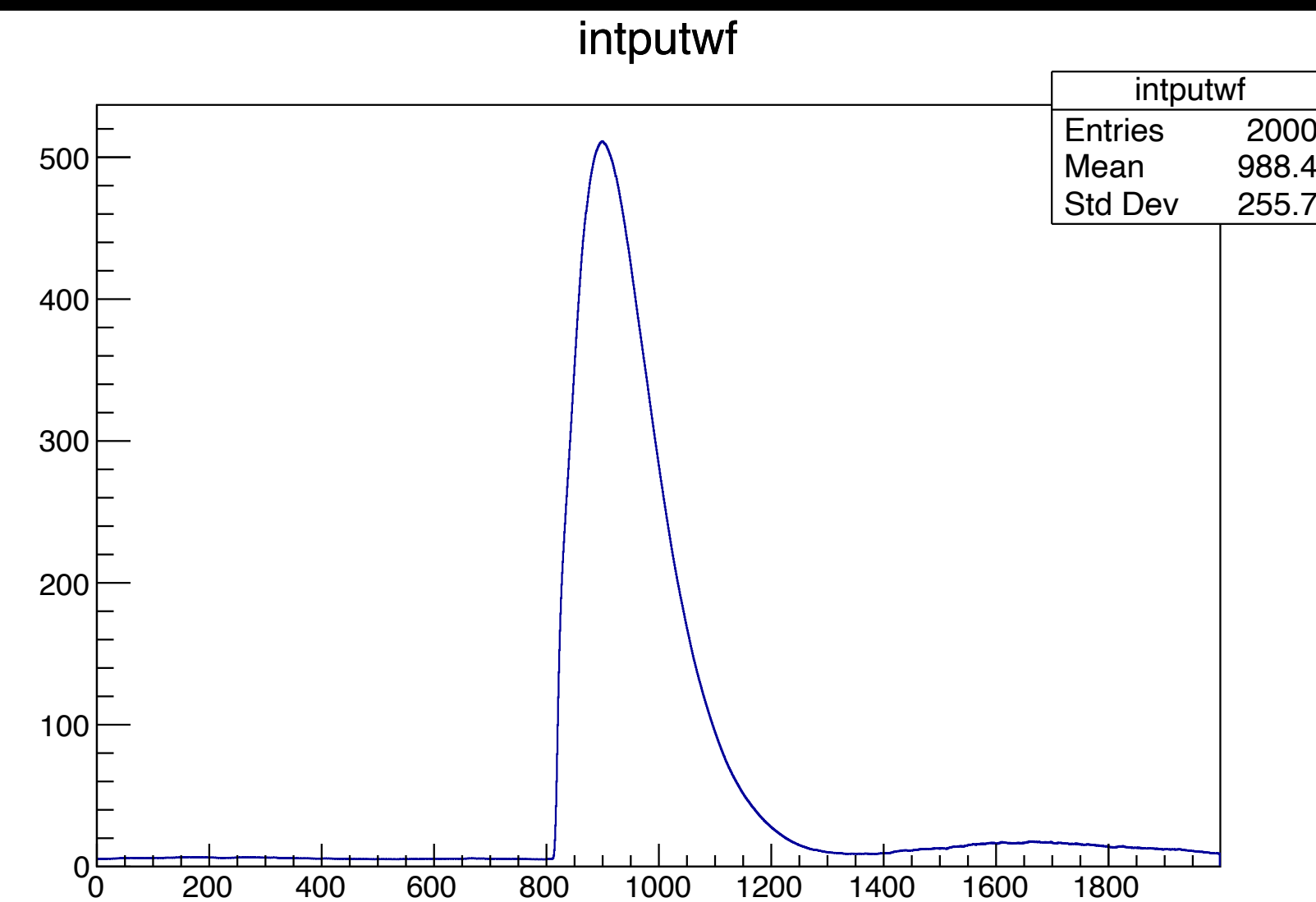
Results from all Indiana University Double Shift Light guides with Hamamatsu Chips for tracks at 125+/-10cm from PDS for one run from all 3 epochs



LAr



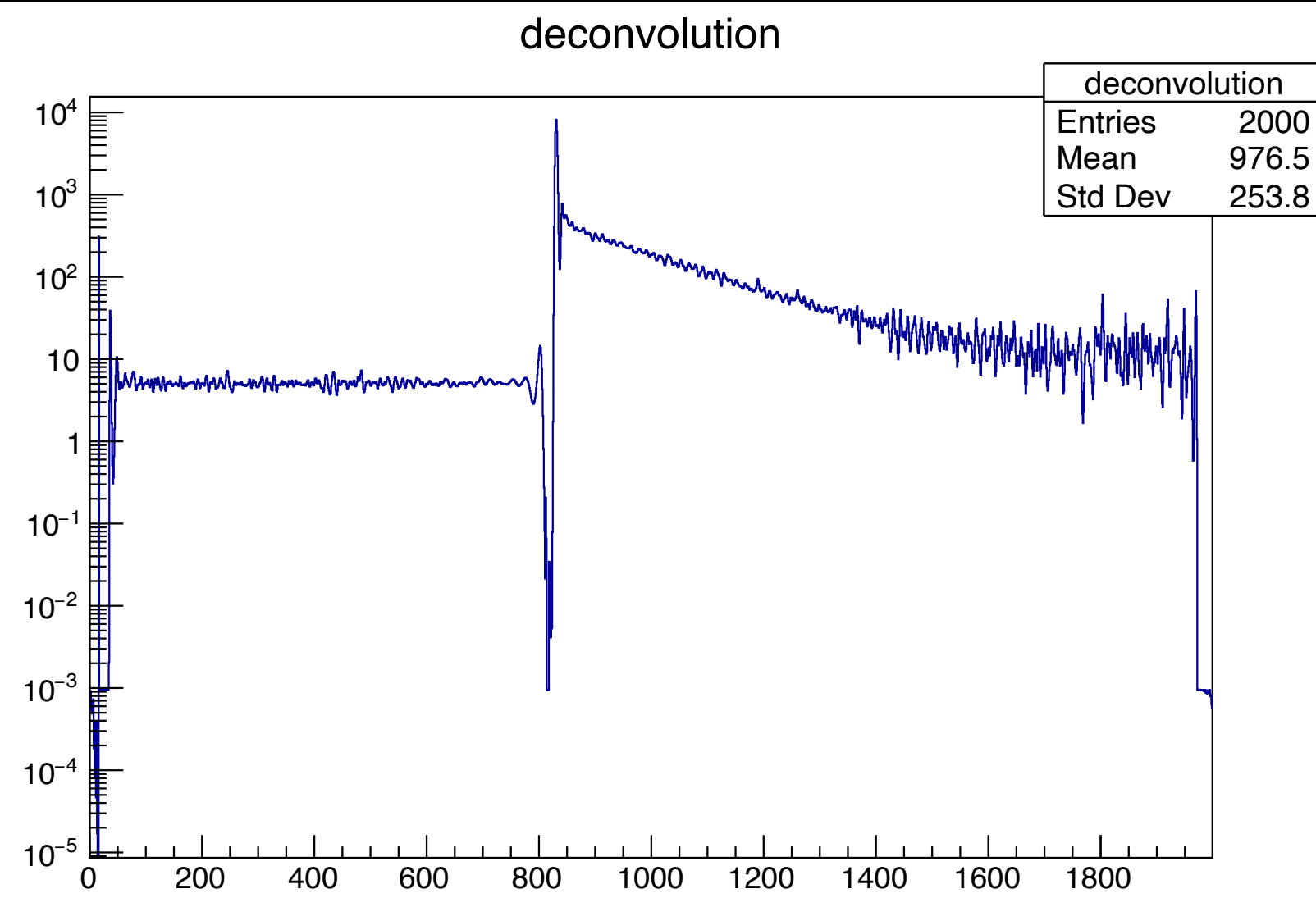
LAr + N



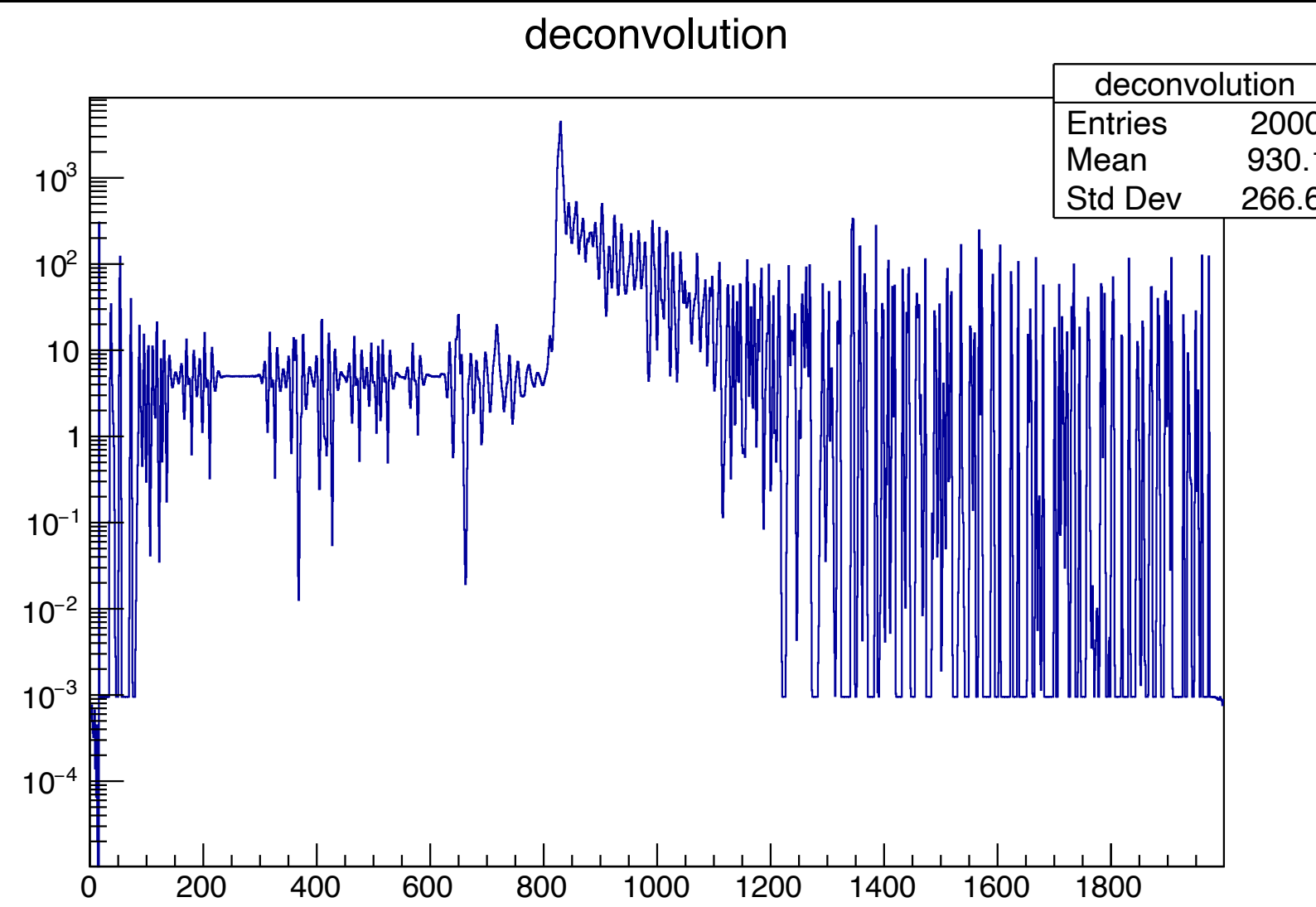
LAr + N + Xe

Deconvolution

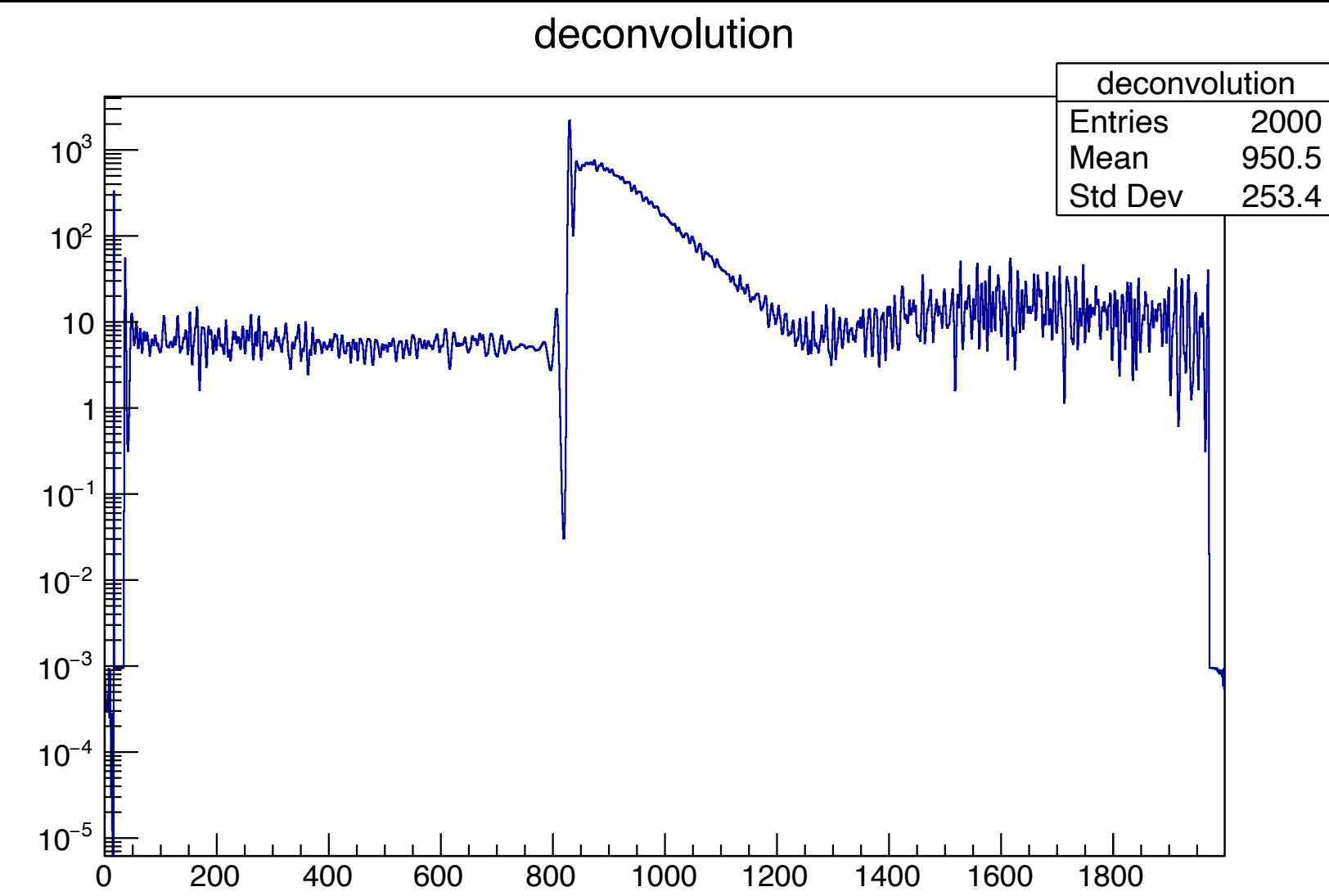
Results from all Indiana University Double Shift Light guides with Hamamatsu Chips for tracks at 125+/-10cm from PDS for one run from all 3 epochs



LAr



LAr + N



LAr + N + Xe

Attenuation Analysis

- Looking at light incident vs distance from PDS
- Provide an avenue to Rayleigh Scattering Lengths
- Will present current results from data for all 3 epochs (Pure LAr, +N, +N+Xe)
 - All beam left IU Double shift light guides with SensL C-series chips
 - All beam left IU Double shift light guides with Hamamatsu chips
 - Beam left ARAPUCA
- Still need to complete MC generation for comparisons

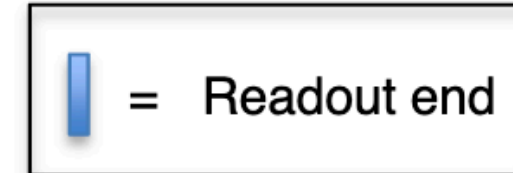
Entire PD Channel Map



APA- Face A



APA- Face B



USDaS						
PD Module	HB	SSP	SSPch	DAQch	OptDet	
002-0047-FL34	Hamamatsu	SSP503	0-3	216	219	41
002-0008-IU54	Hamamatsu	SSP503	4-7	220	223	43
002-0058-FL24	Hamamatsu	SSP503	8-11	224	227	45
002-0063-IU19	Hamamatsu	SSP504	0-3	228	231	47
003-0026-FL07*	SensL-C1	SSP501	0-3	192	195	49
002-0014-IU26	Hamamatsu	SSP504	4-7	232	235	51
003-0024-FL33	SensL-C1	SSP501	4-7	196	199	53
003-0004-IU48	SensL-C1	SSP501	8-11	200	203	55
002-0041-FL36	Hamamatsu	SSP504	8-11	236	239	57
002-0036-IU47	SensL-C1	SSP502	0-3	204	207	59

MSDaS						
PD Module	HB		SSPch	DAQch	OptDet	
002-0002-FL22	Hamamatsu	SSP601	0-3	240	243	21
002-0054-IU22	Hamamatsu	SSP601	4-7	244	247	23
002-0059-FL08	Hamamatsu	SSP601	8-11	248	251	25
002-0020-IU09	Hamamatsu	SSP602	0-3	252	255	27
002-0060-FL39	Hamamatsu	SSP602	4-7	256	259	29
ARAPUCA-2	Hamamatsu	SSP603	0-3	264	267	31
		SSP603	4-7	268	271	
		SSP603	8-11	272	275	
002-0055-FL40	Hamamatsu	SSP602	8-11	260	263	33
002-0013-IU01	Hamamatsu	SSP604	0-3	276	279	35
002-0011-FL15	Hamamatsu	SSP604	4-7	280	283	37
002-0031-IU02	Hamamatsu	SSP604	8-11	284	287	39

DSDaS						
PD Module	HB	SSP	SSPch	DAQch	OptDet	
001-0003-FL01	SensL-C1	SSP401	0-3	144	147	1
002-0044-IU50	SensL-C1	SSP401	4-7	148	151	3
002-0039-FL29	SensL-A1	SSP401	8-11	152	155	5
003-0002-IU27	SensL-C1	SSP402	0-3	156	159	7
002-0025-FL25	SensL-C1	SSP402	4-7	160	163	9
003-0011-IU37	SensL-C1	SSP402	8-11	164	167	11
003-0048-FL42	SensL-C1	SSP403	0-3	168	171	13
002-0023-IU53	SensL-C1	SSP403	4-7	172	175	15
002-0038-IU35	SensL-C1	SSP403	8-11	176	179	17
002-0040-FLP06*	SensL-C1	SSP404	0-3	180	183	19

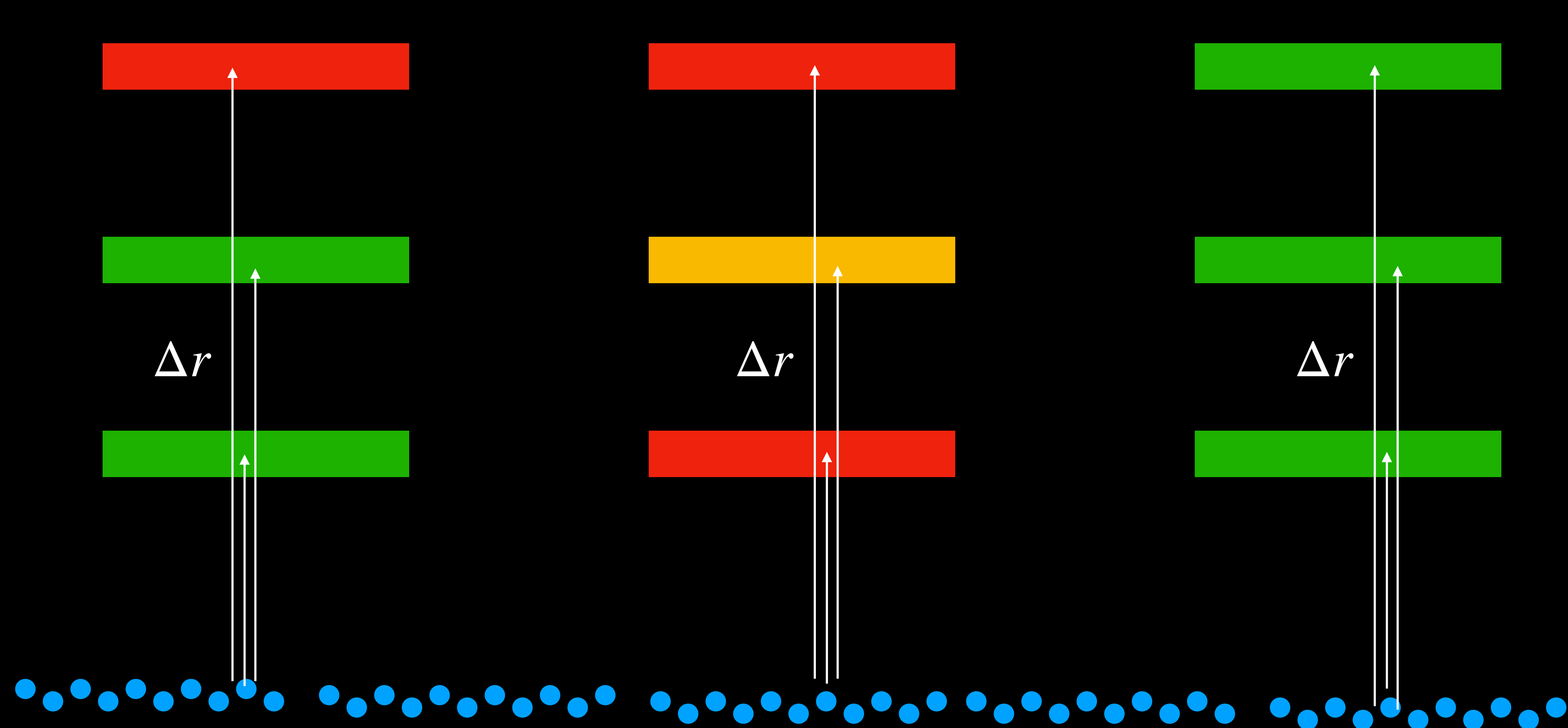
*Modified SSP

SSP_Serial#		
USDaS	MSDaS	DSDaS
127	131	120
125	130	119
132	129	118
121	128	117
USRaS	MSRaS	DSRaS
123	113	109
116	112	108
115	111	107
114	102	106



So one track contributes:
 7 data points to the "SensL" graph
 7 Data point to the "Hamamatsu" graph
 1 data point to the ARAPUCA graph

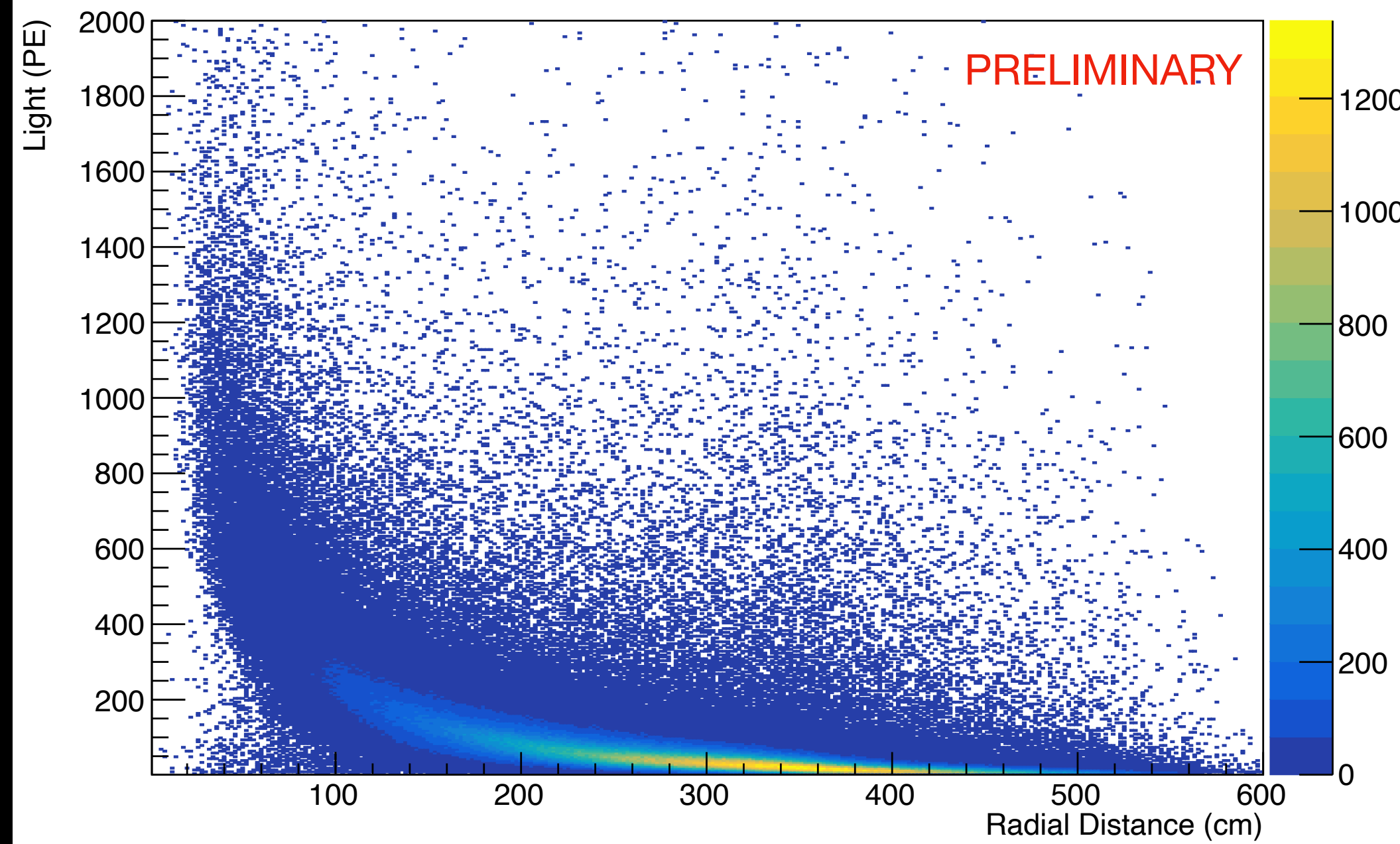
Distance Calculation



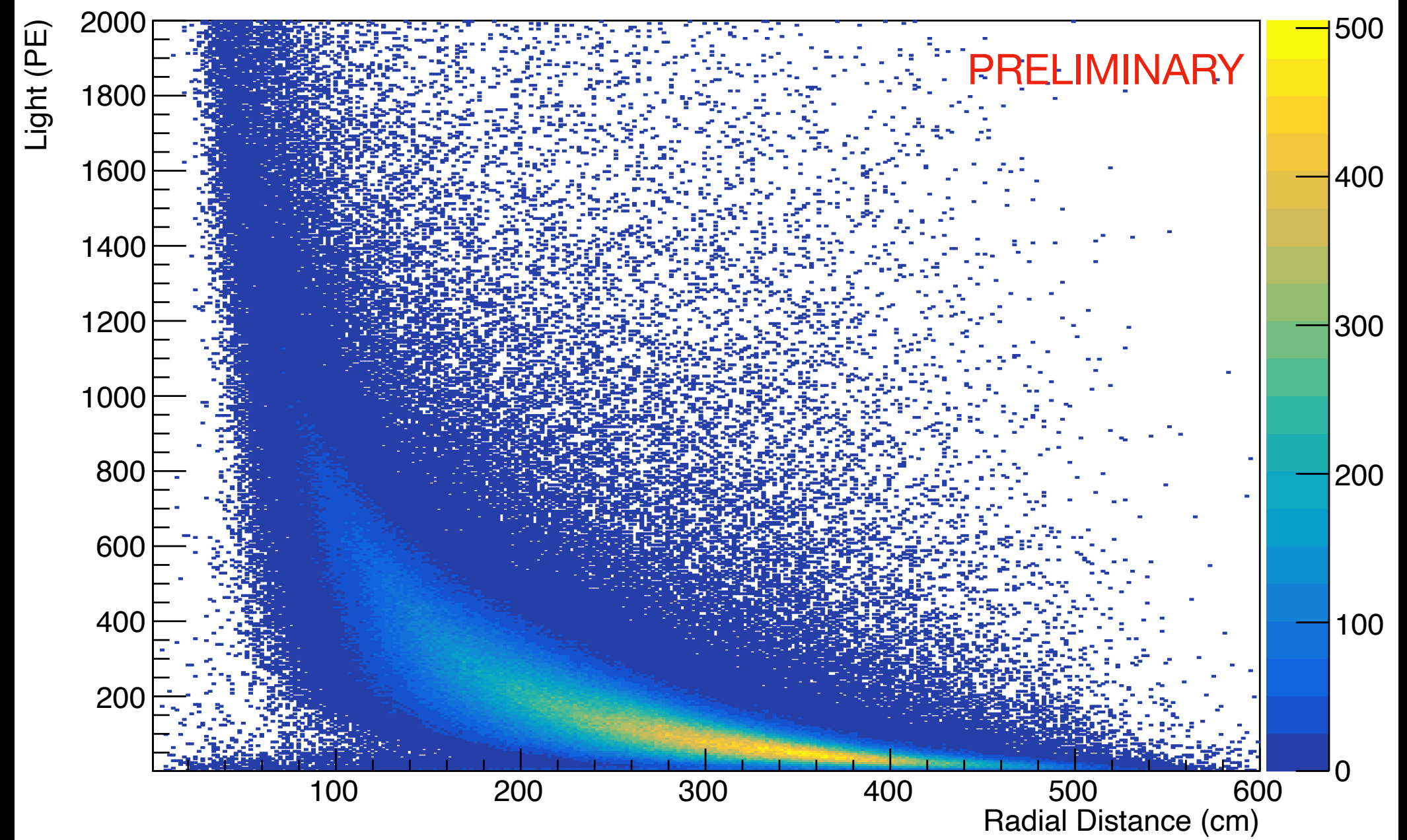
■ IU DSLG with Hamamatsu ■ IU DSLG with SensL C-Series

■ ARAPUCA

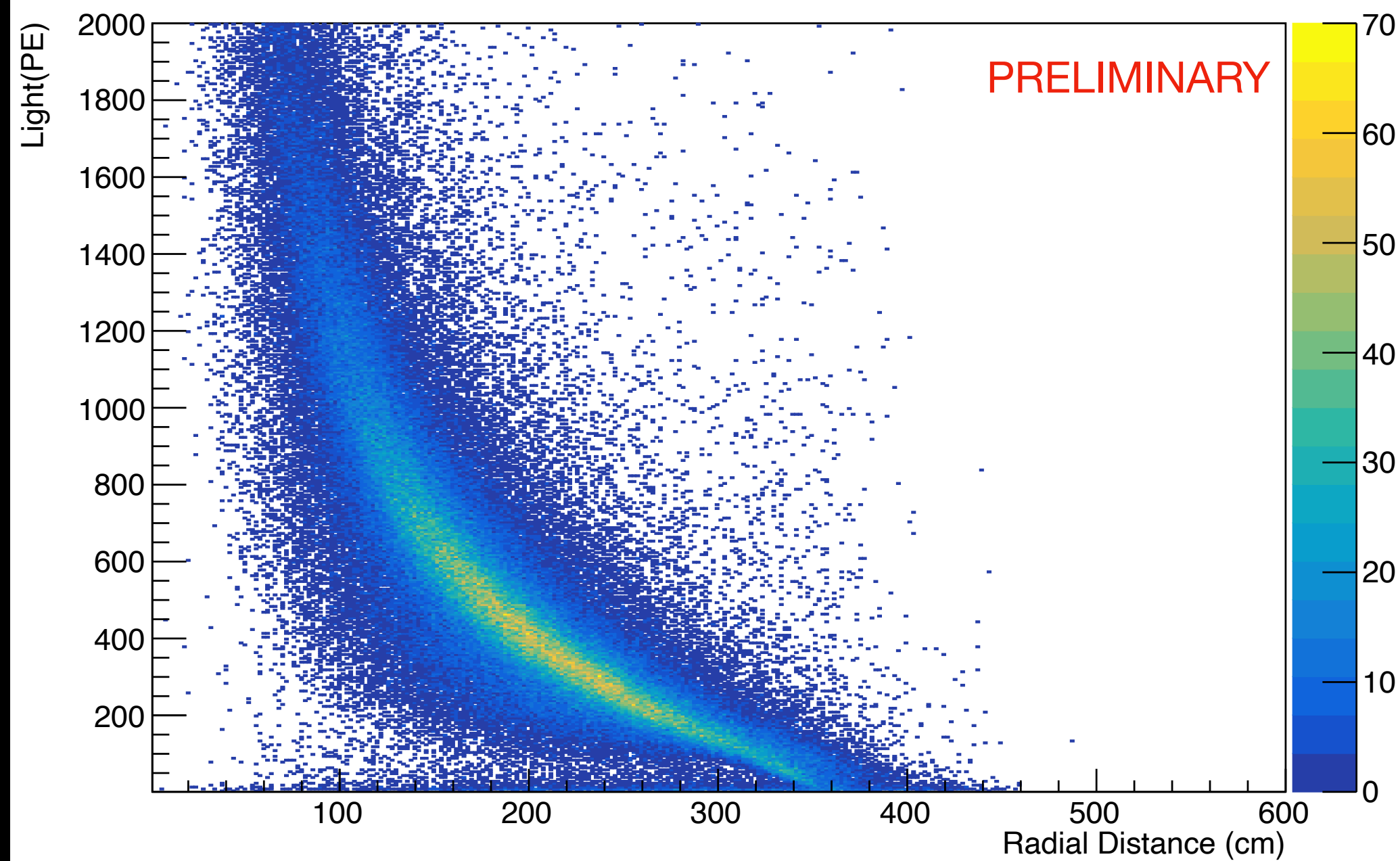
DS_Sensl_C1



DS_hamamatsu

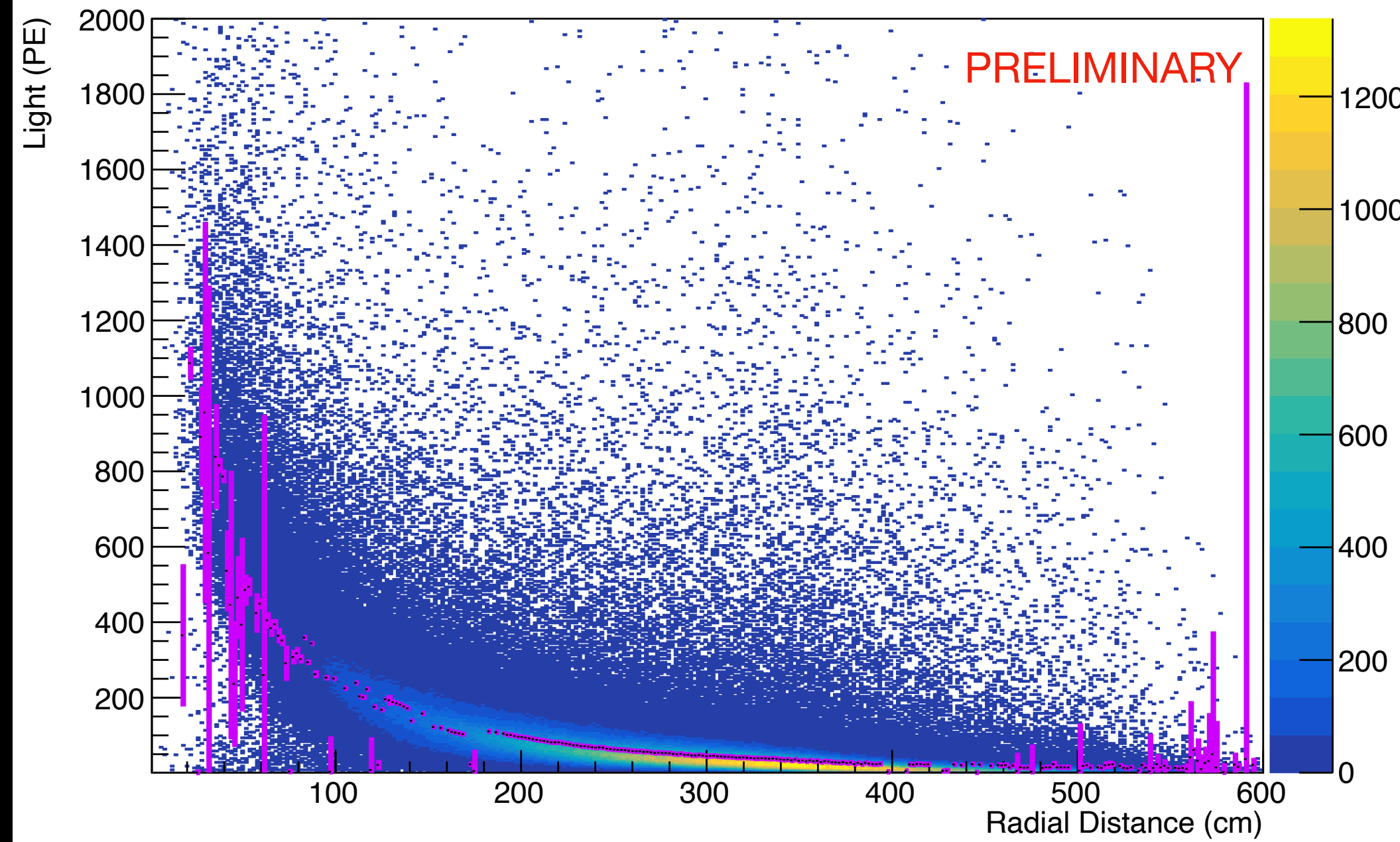


ARAPUCA2_APA6_prof

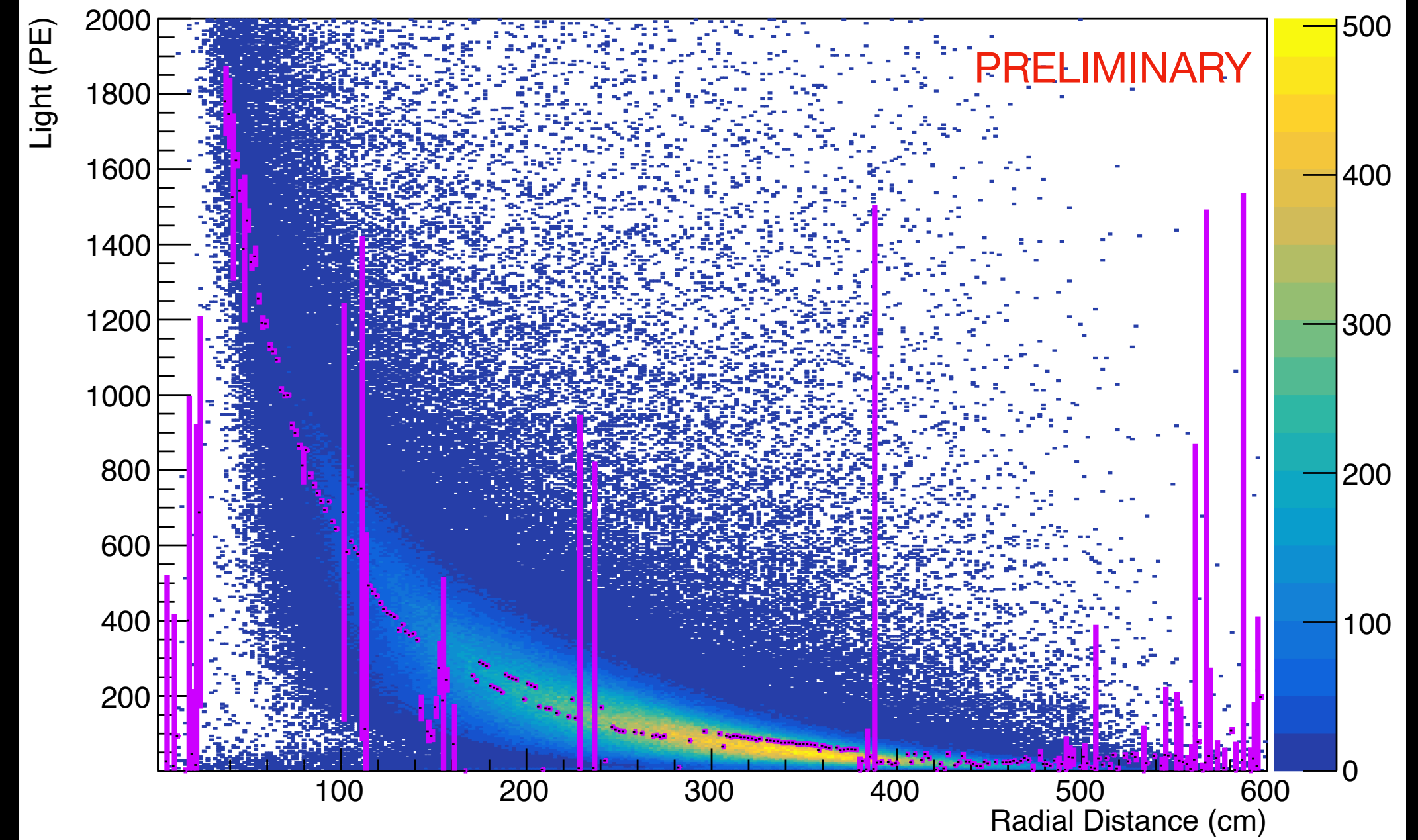


LAr Attenuation Plots

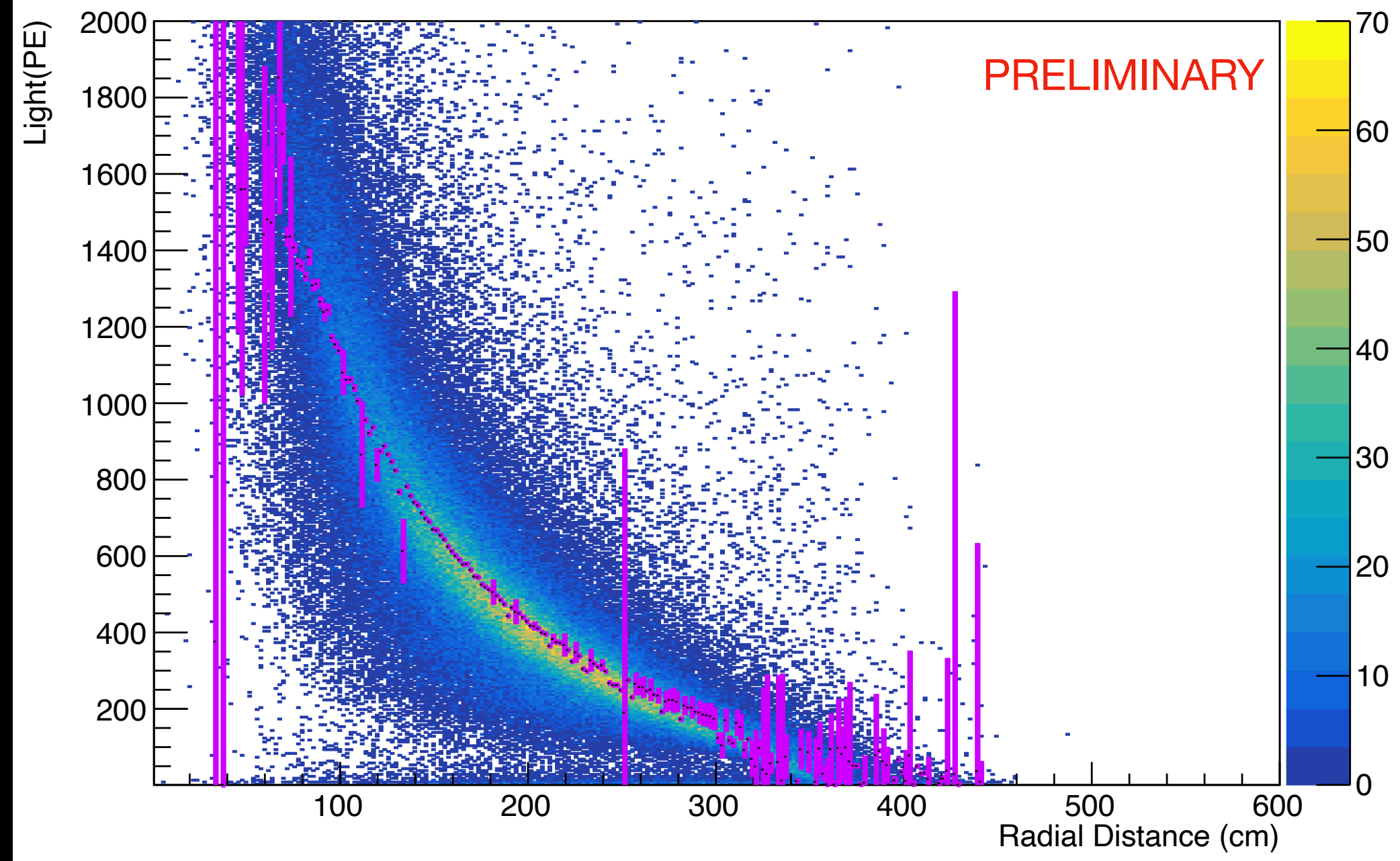
DS_Sensl_C1



DS_hamamatsu

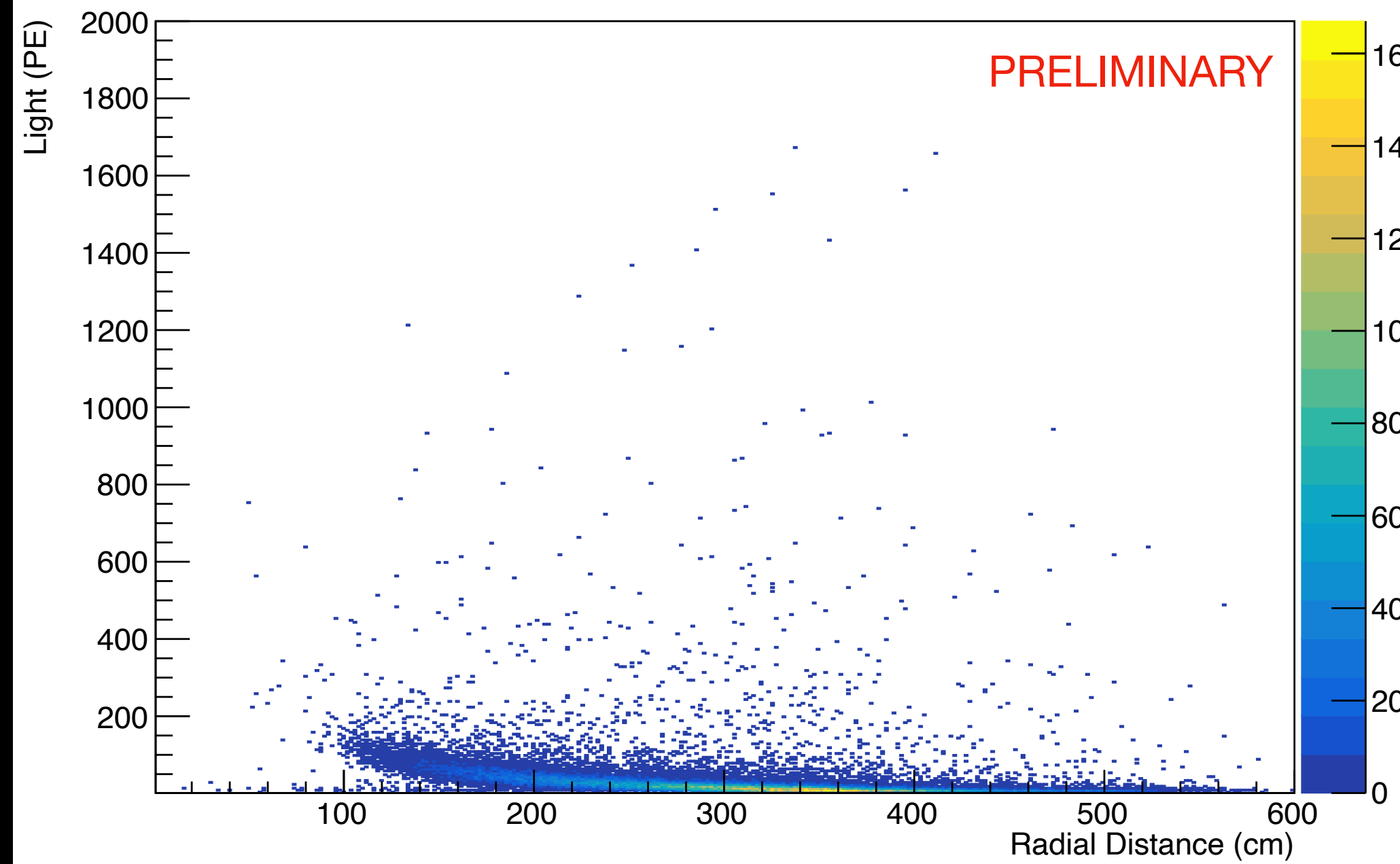


ARAPUCA2_APA6_prof

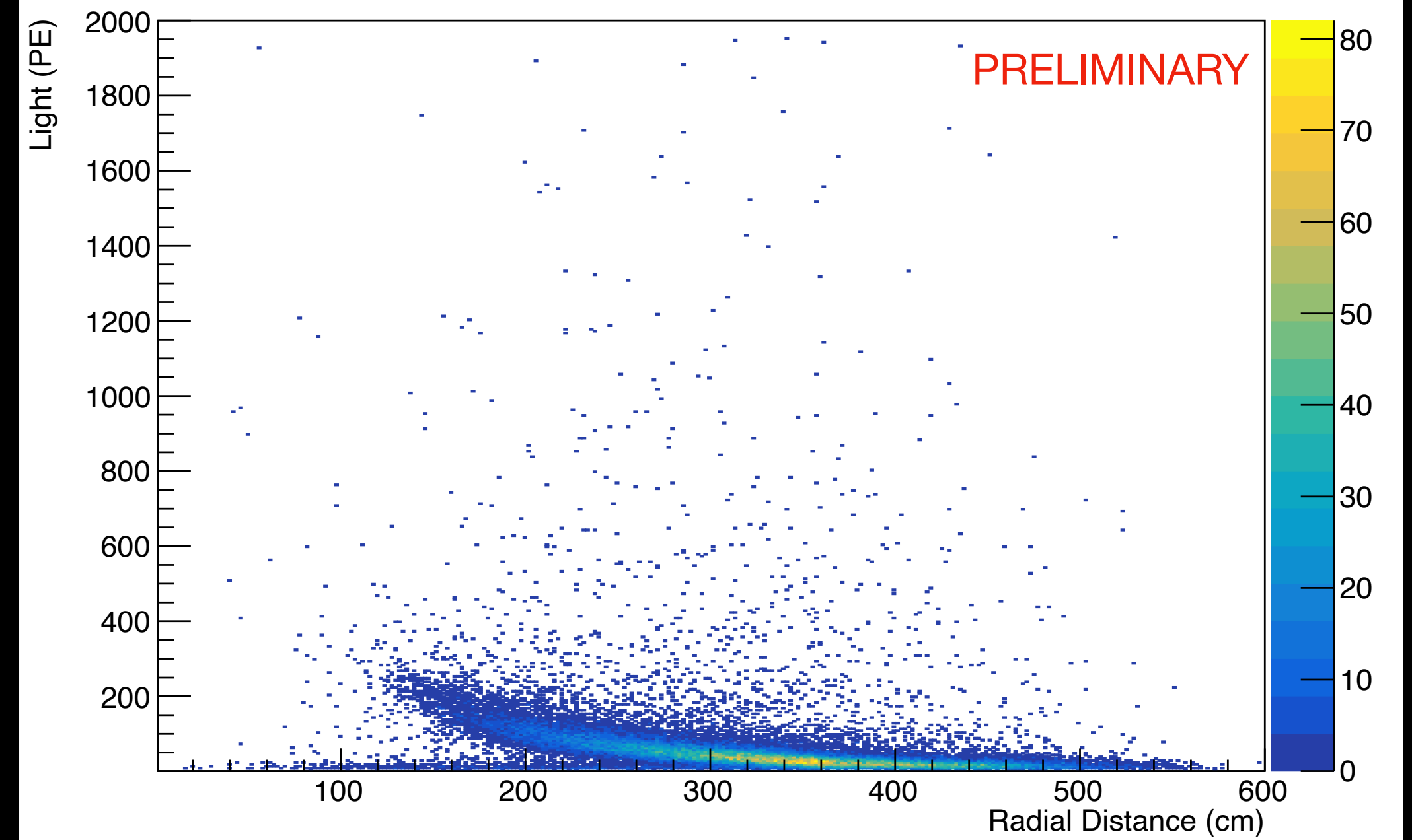


LAr Attenuation Plots

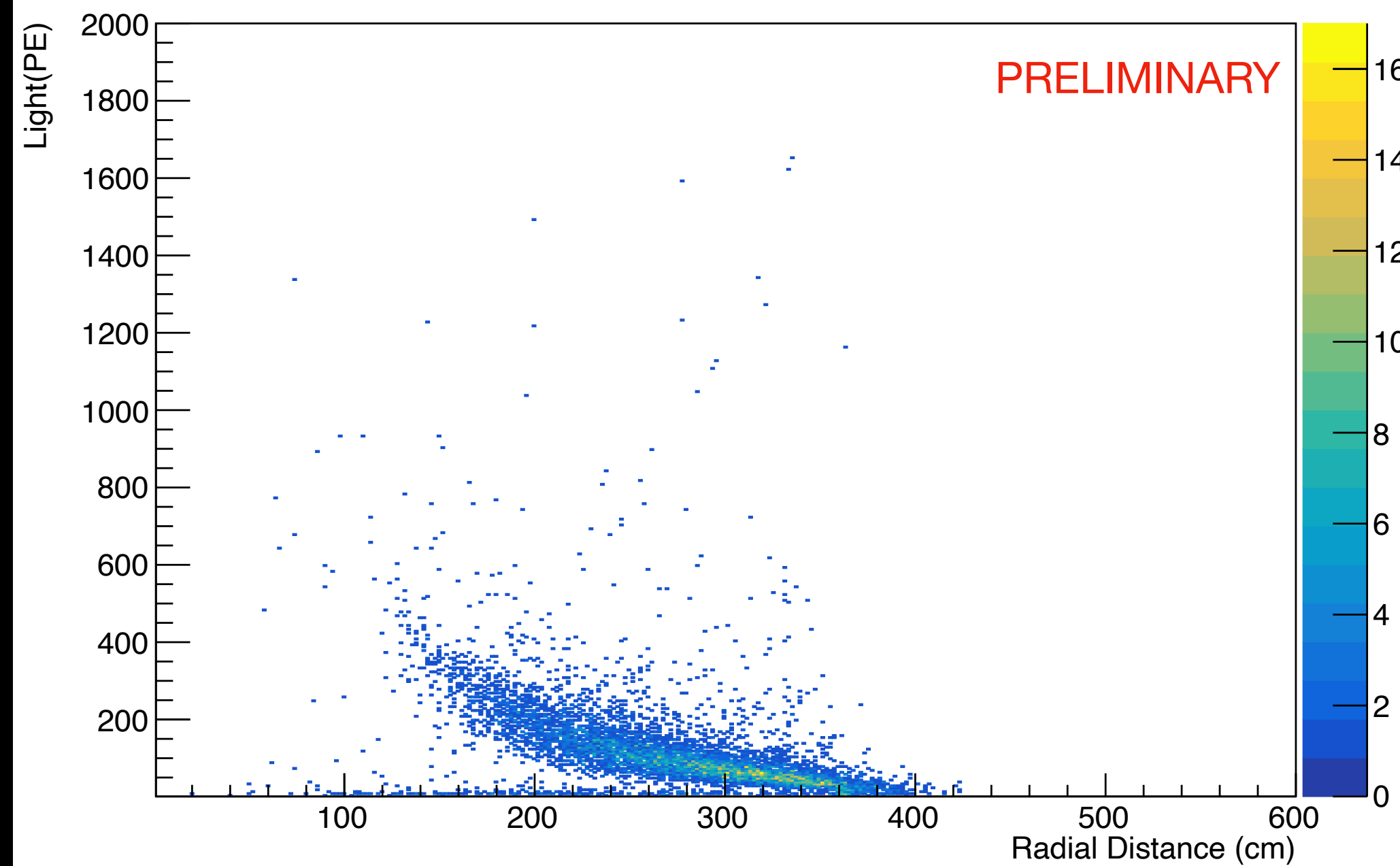
DS_Sensl_C1



DS_hamamatsu

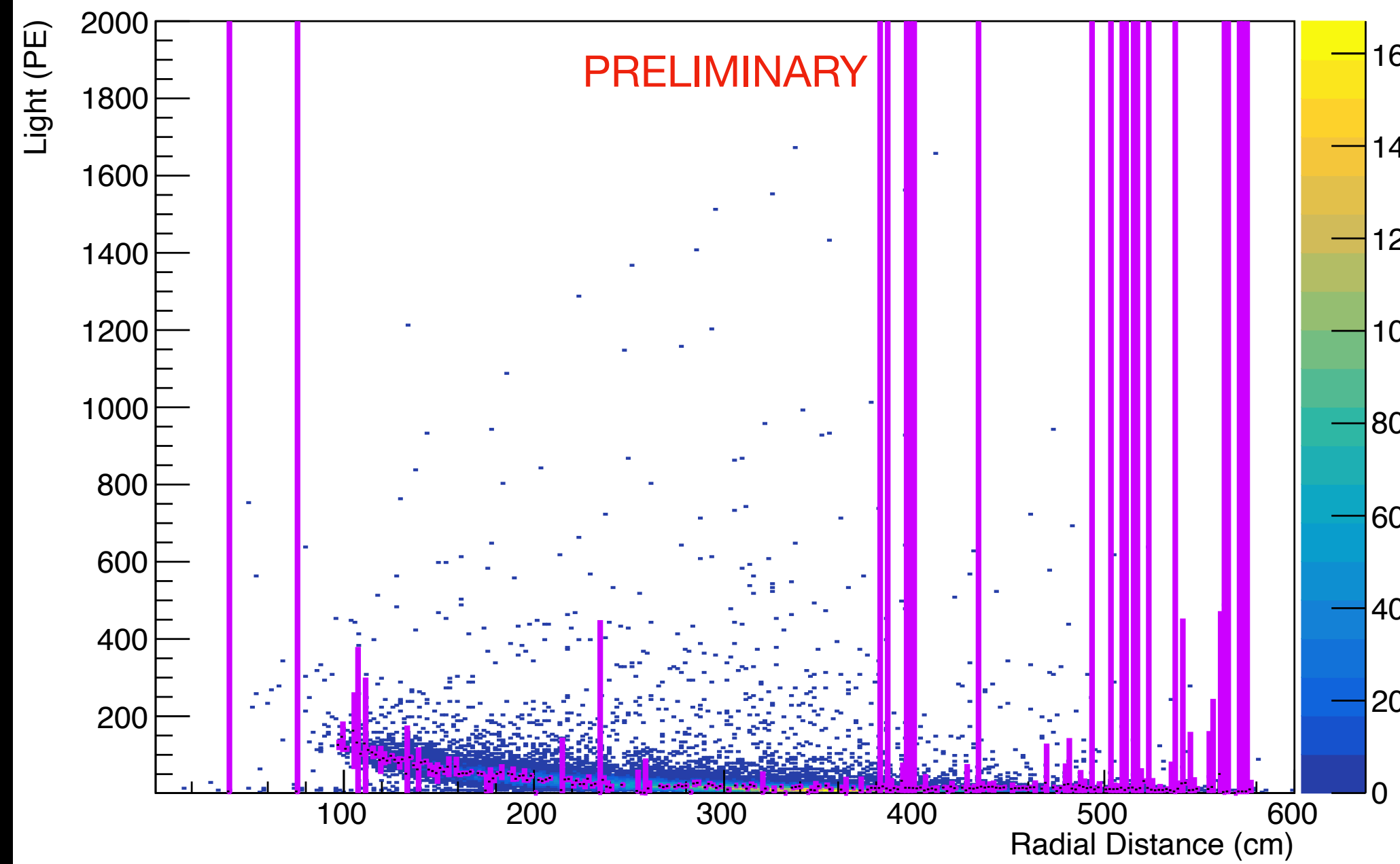


ARAPUCA2_APA6_prof

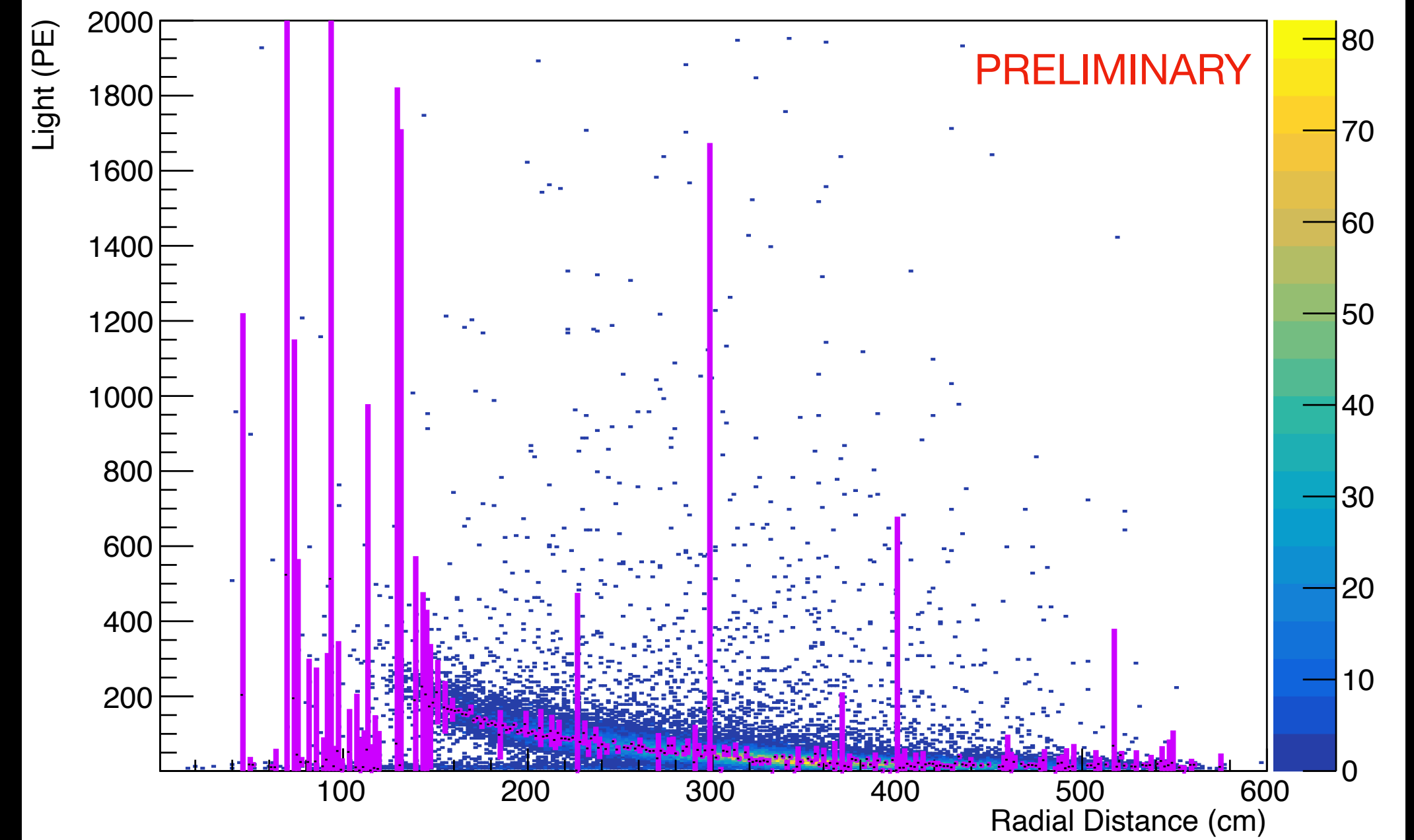


LAr + N Attenuation Plots

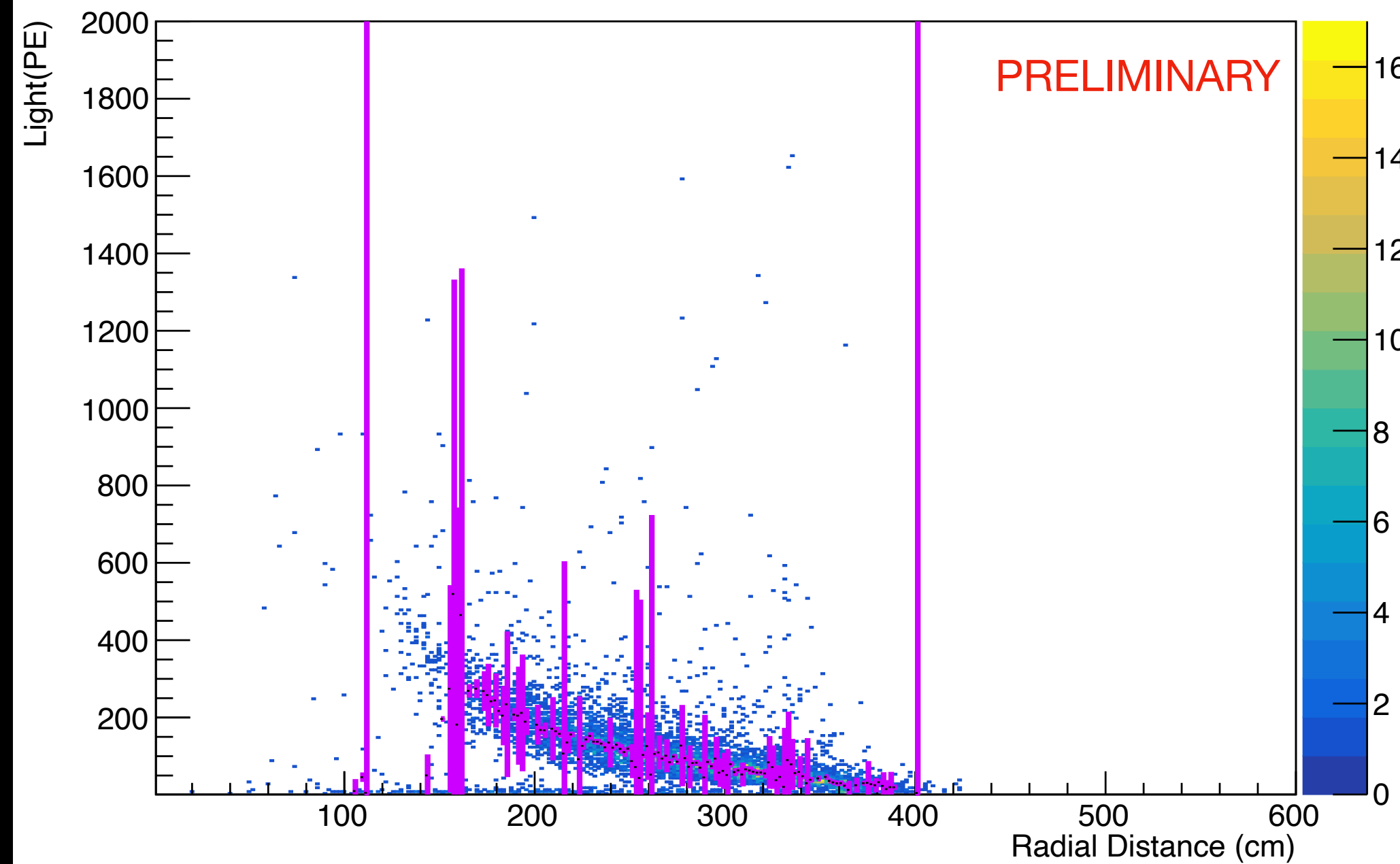
DS_Sensl_C1



DS_hamamatsu

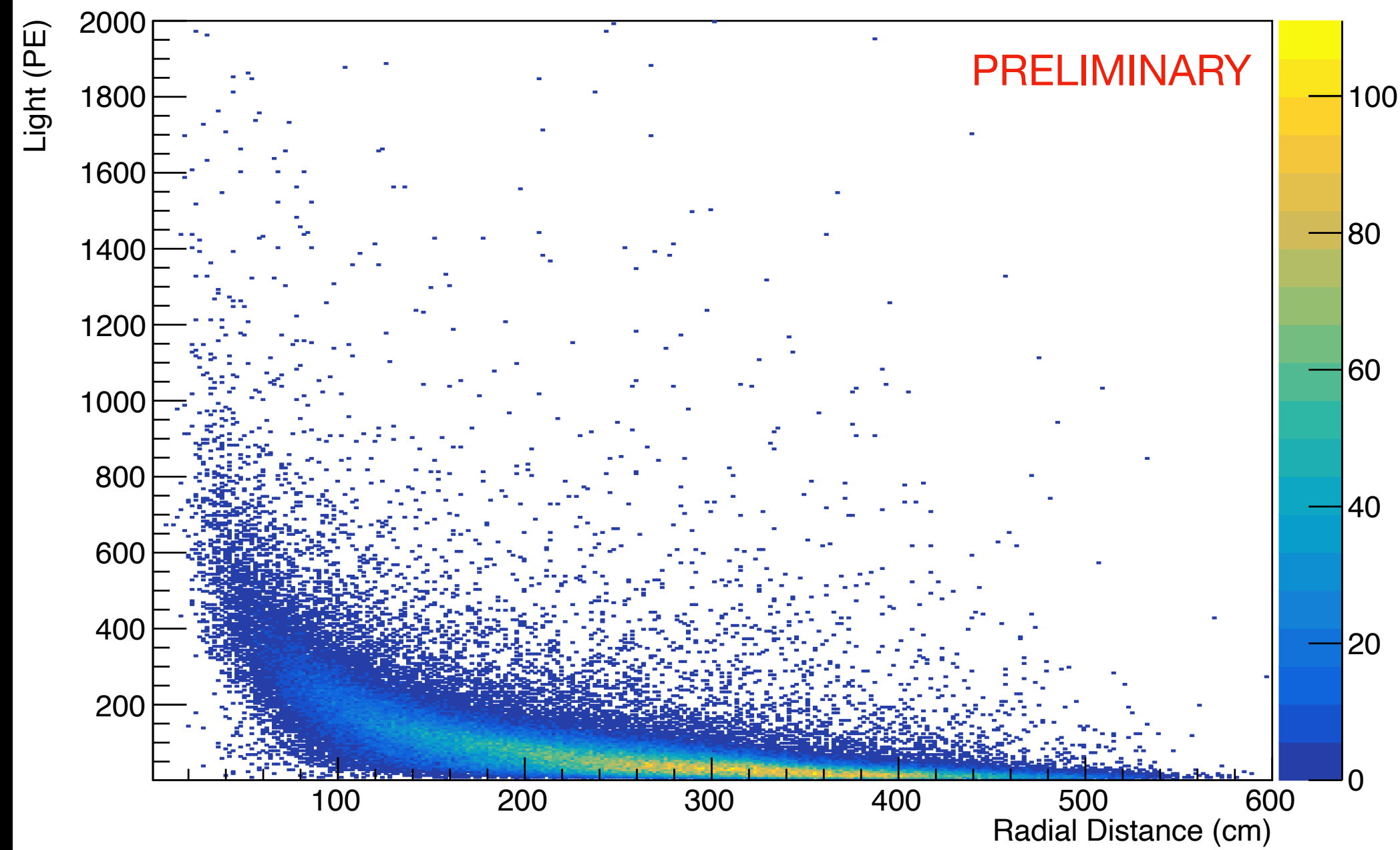


ARAPUCA2_APA6_prof

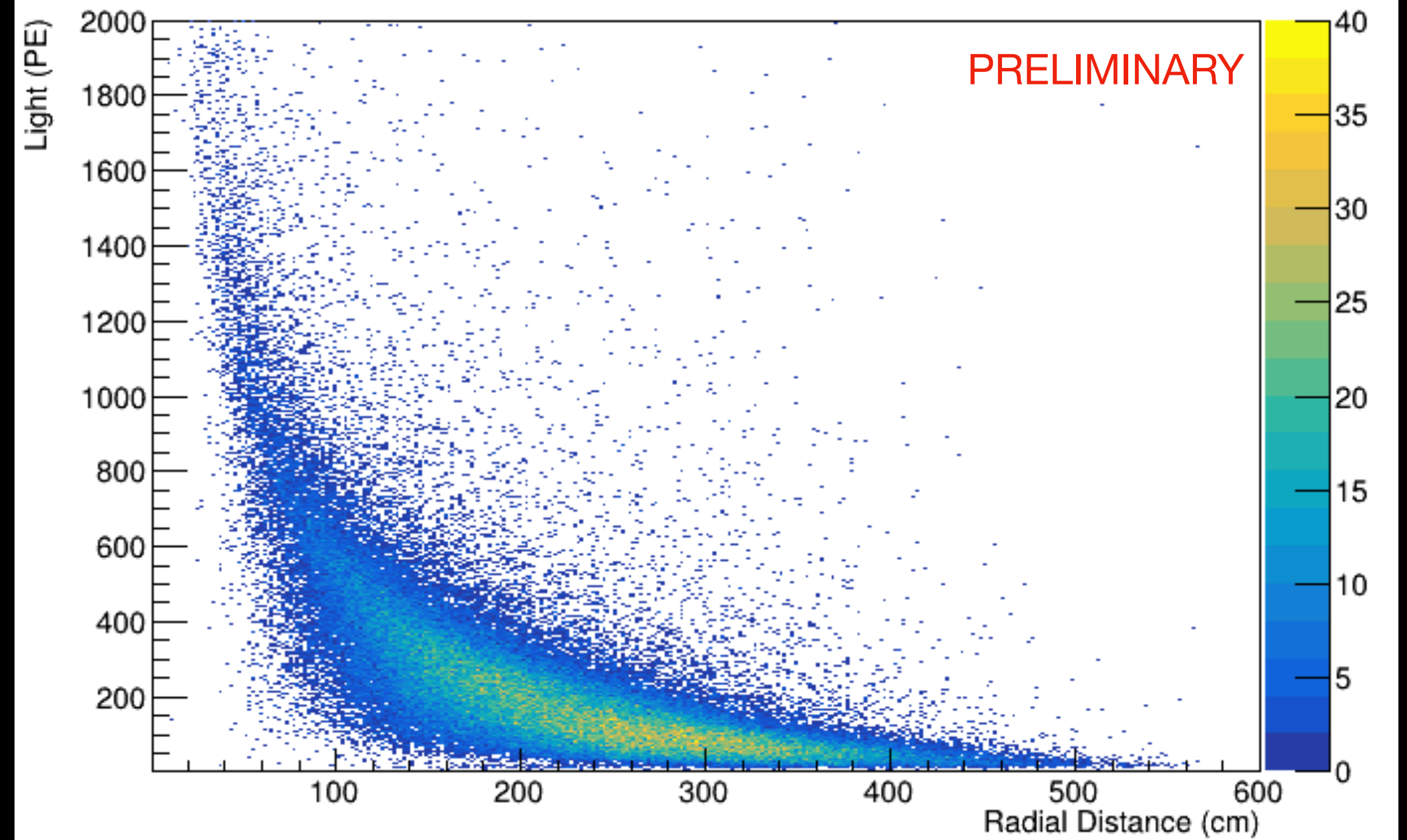


LAr + N Attenuation Plots

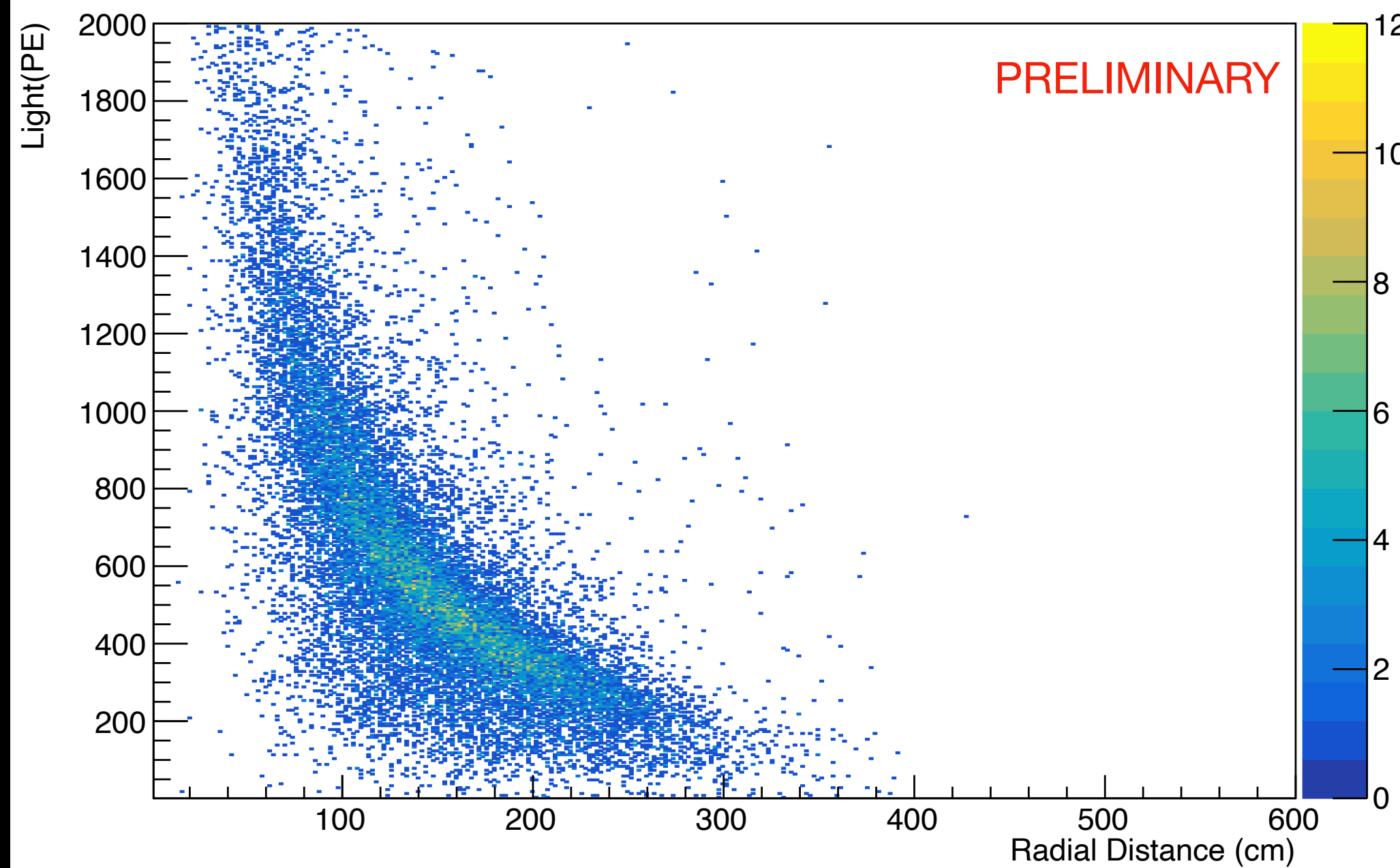
DS_Sensl_C1



DS_hamamatsu

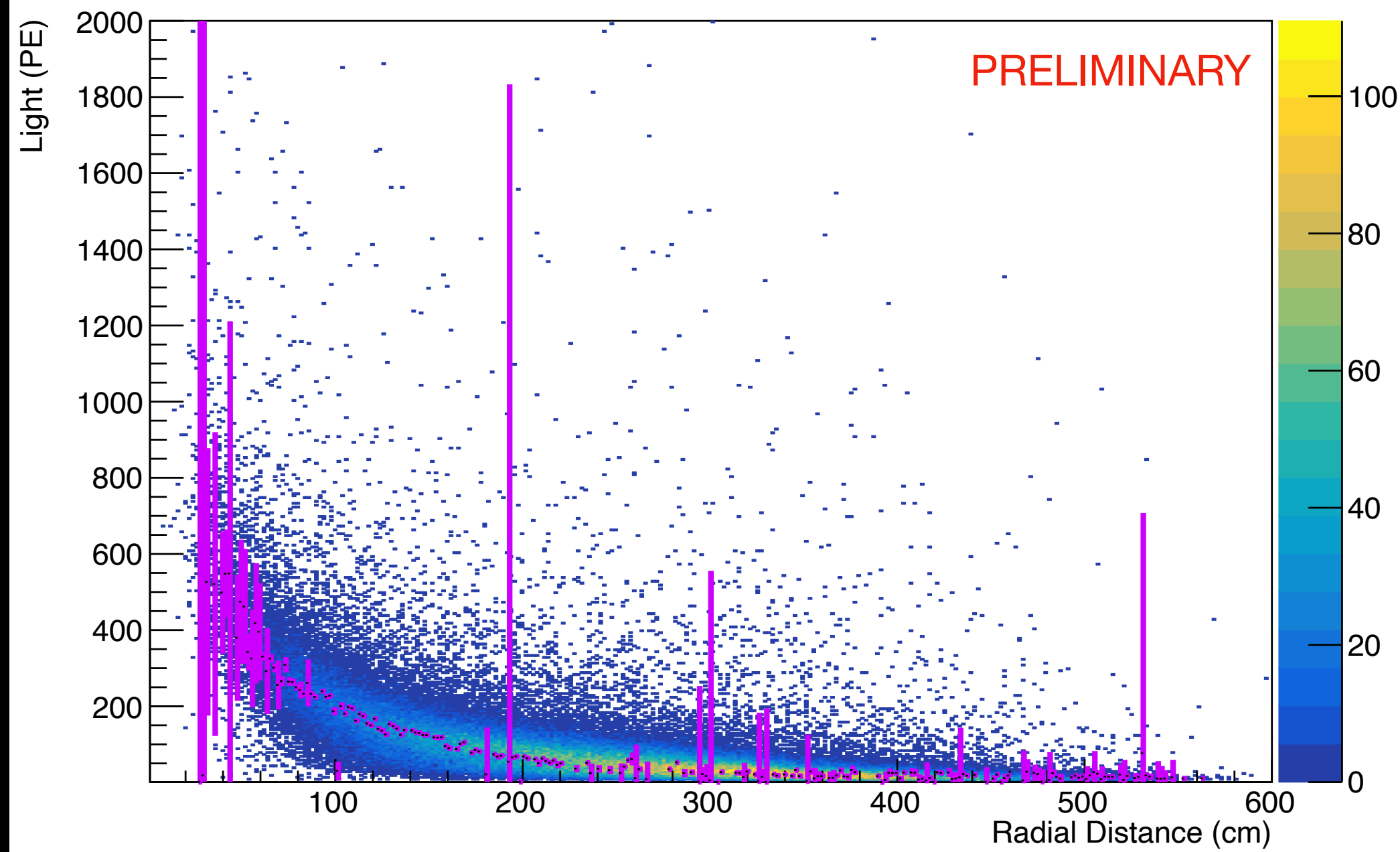


ARAPUCA2_APA6_prof

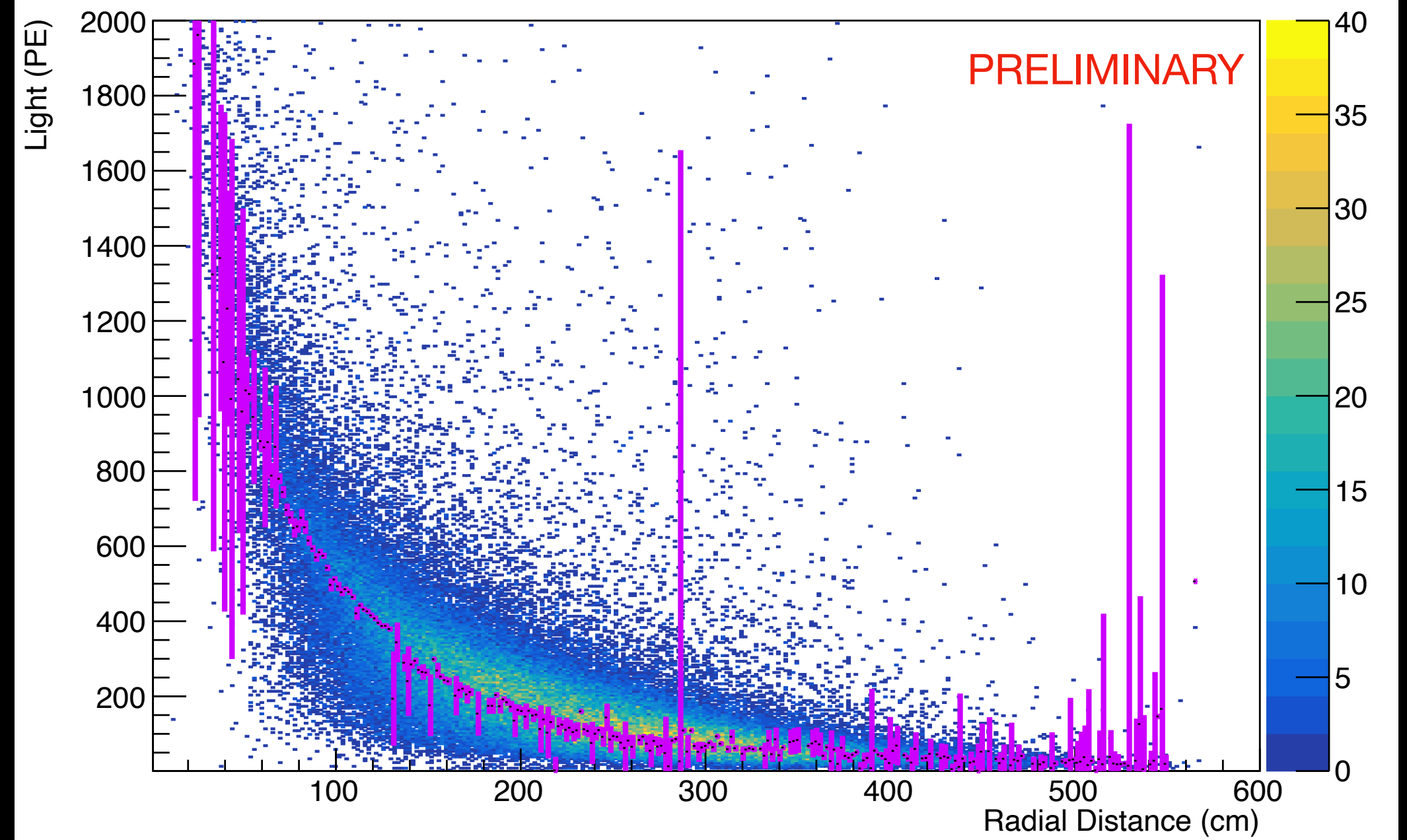


LAr + N + Xe Attenuation Plots

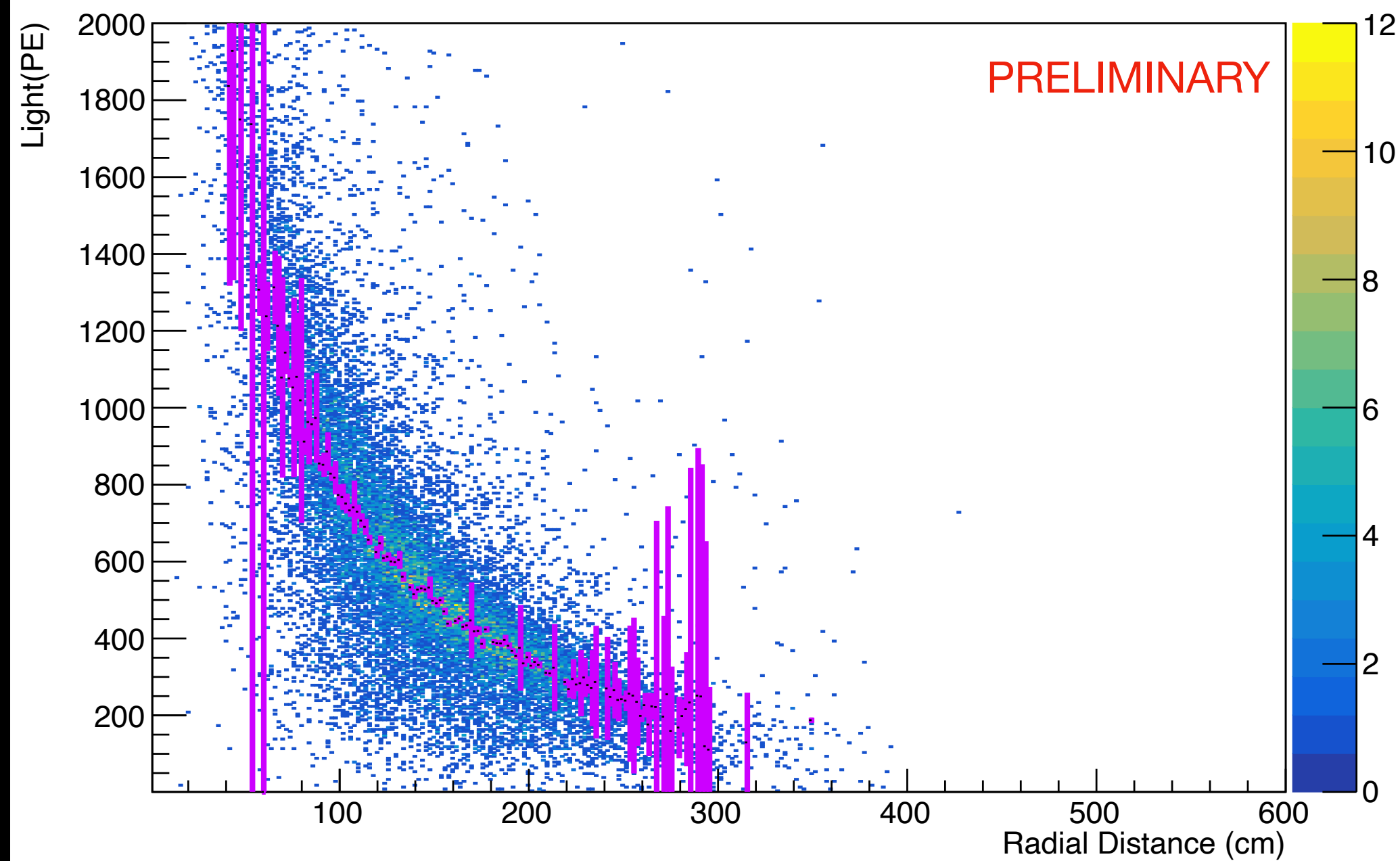
DS_Sensl_C1



DS_hamamatsu



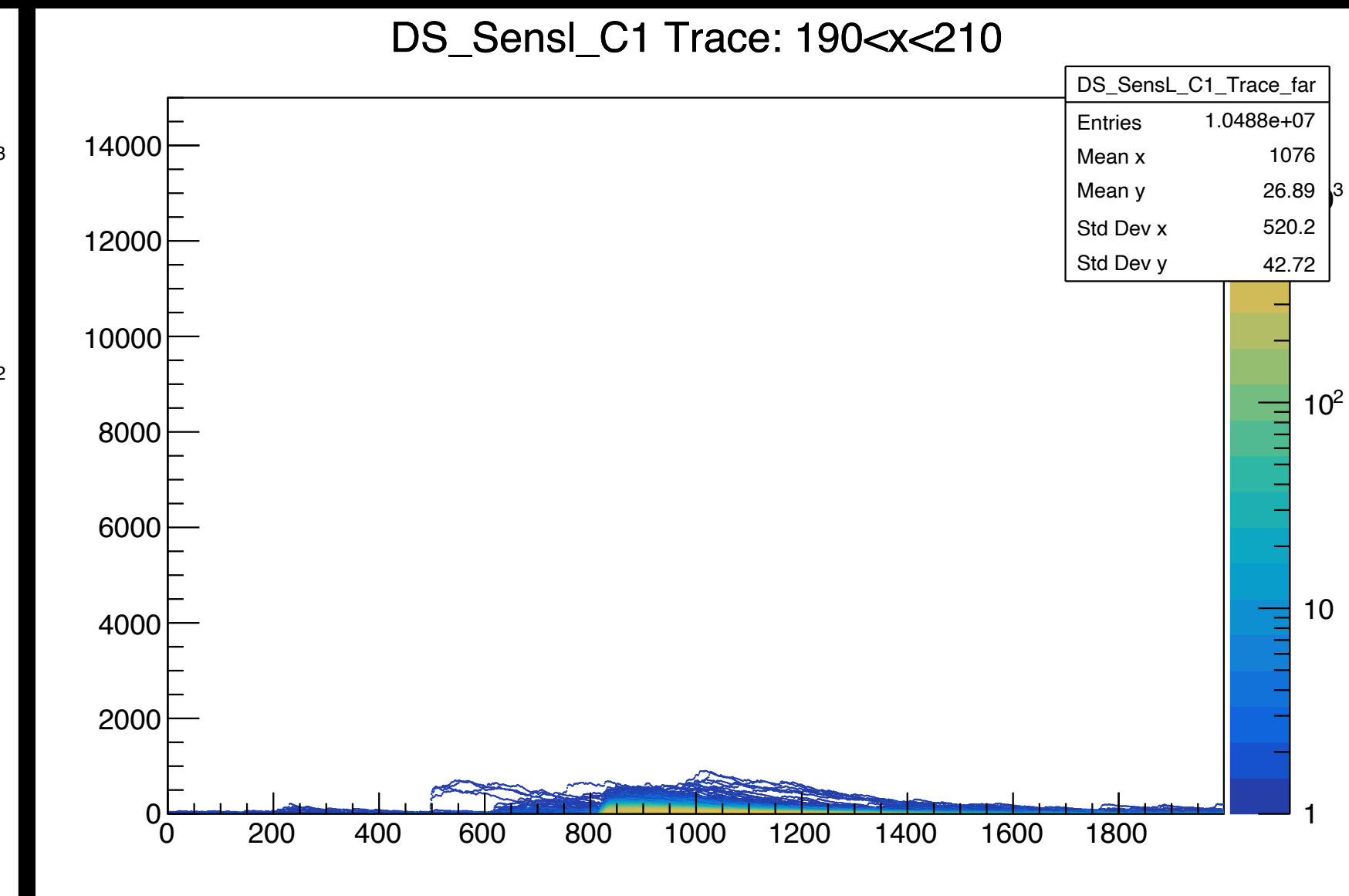
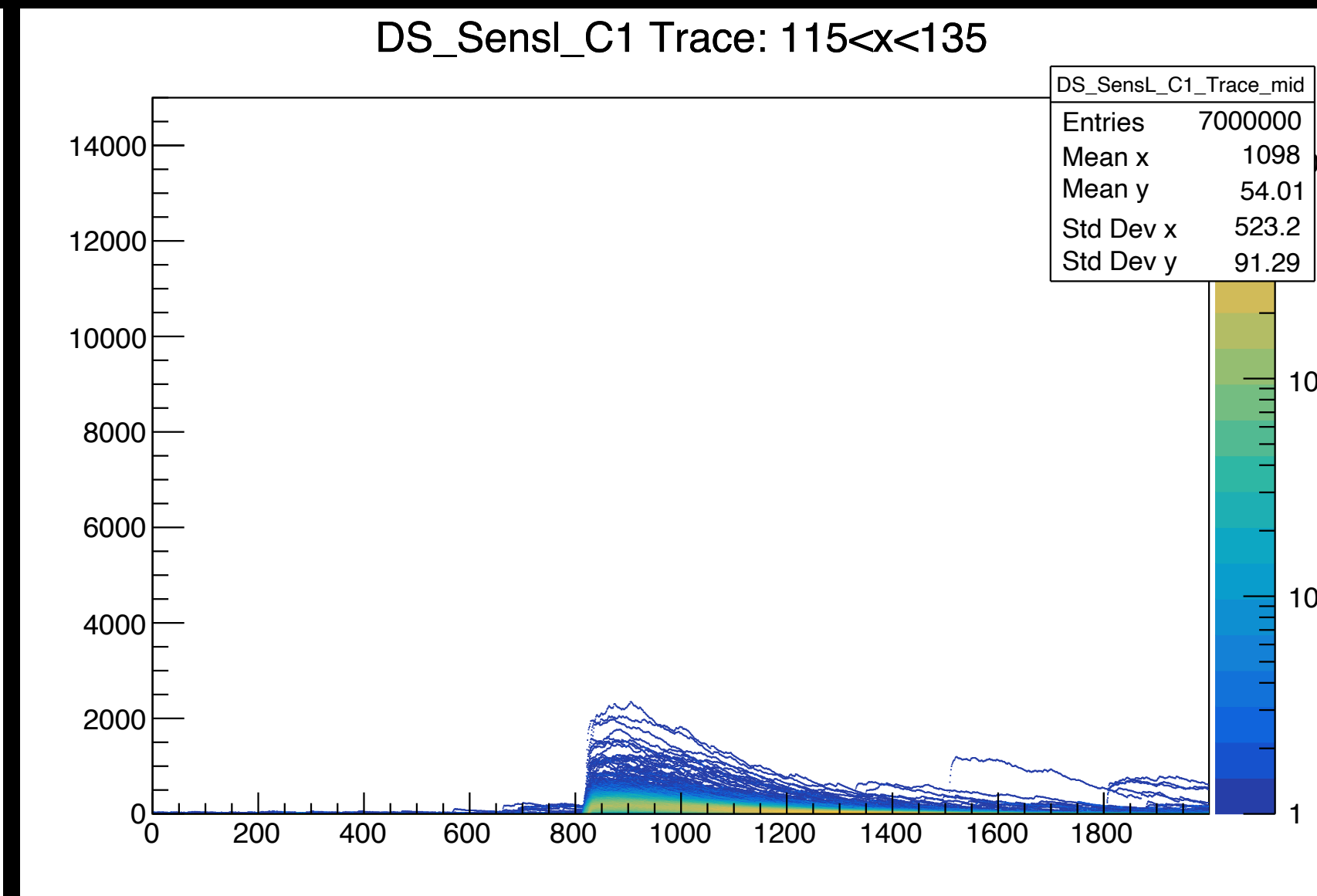
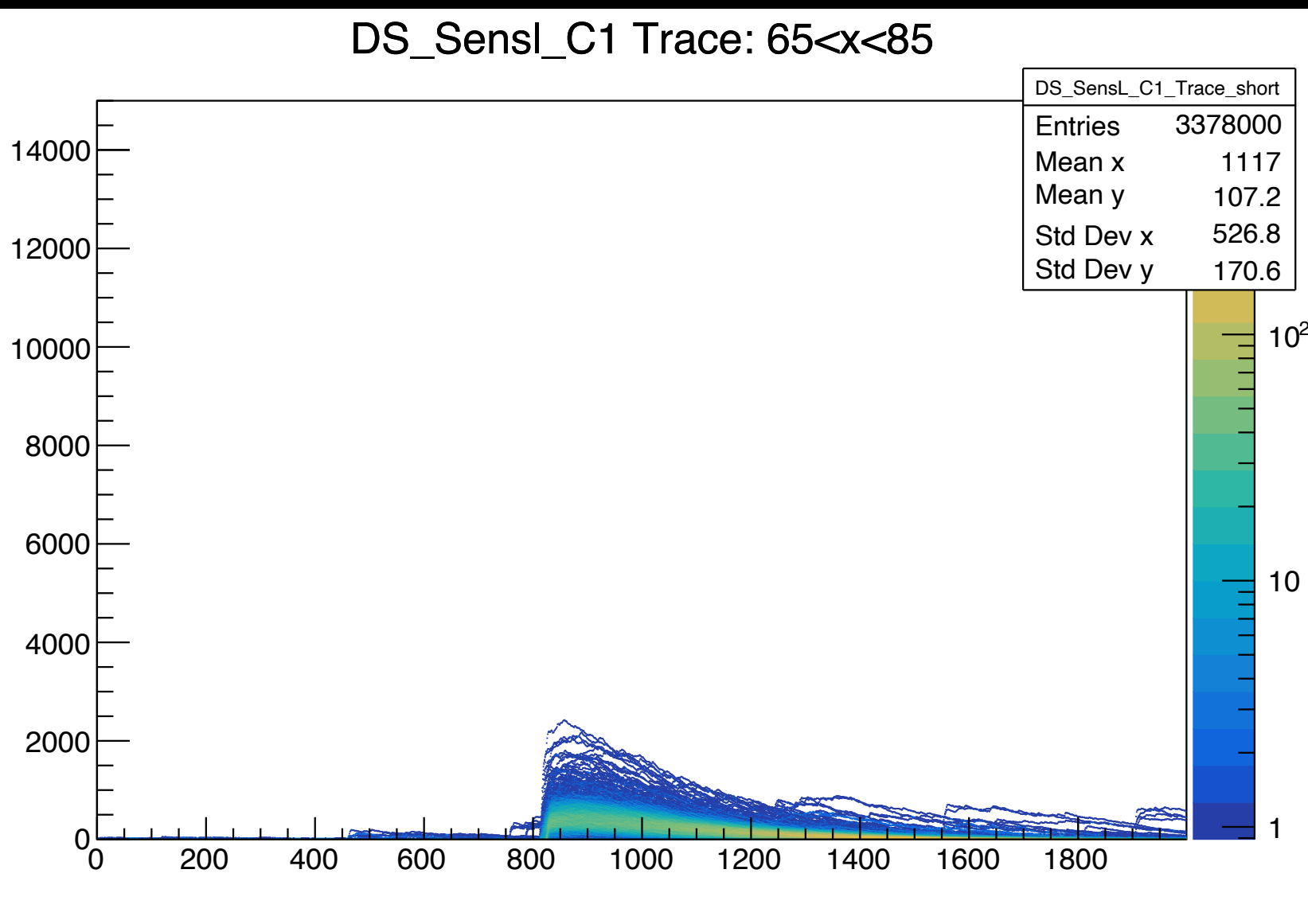
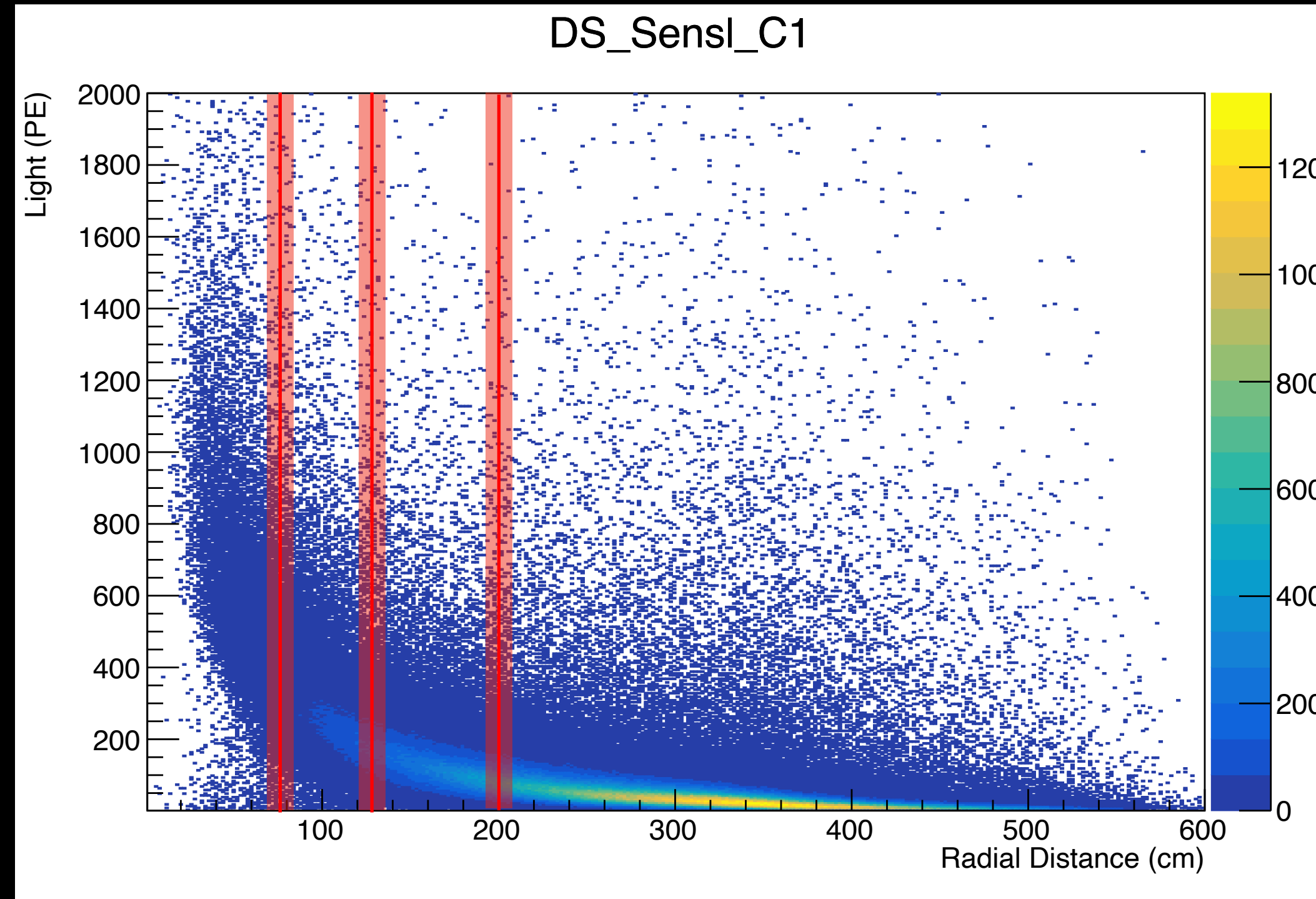
ARAPUCA2_APA6_prof



LAr + N + Xe Attenuation Plots

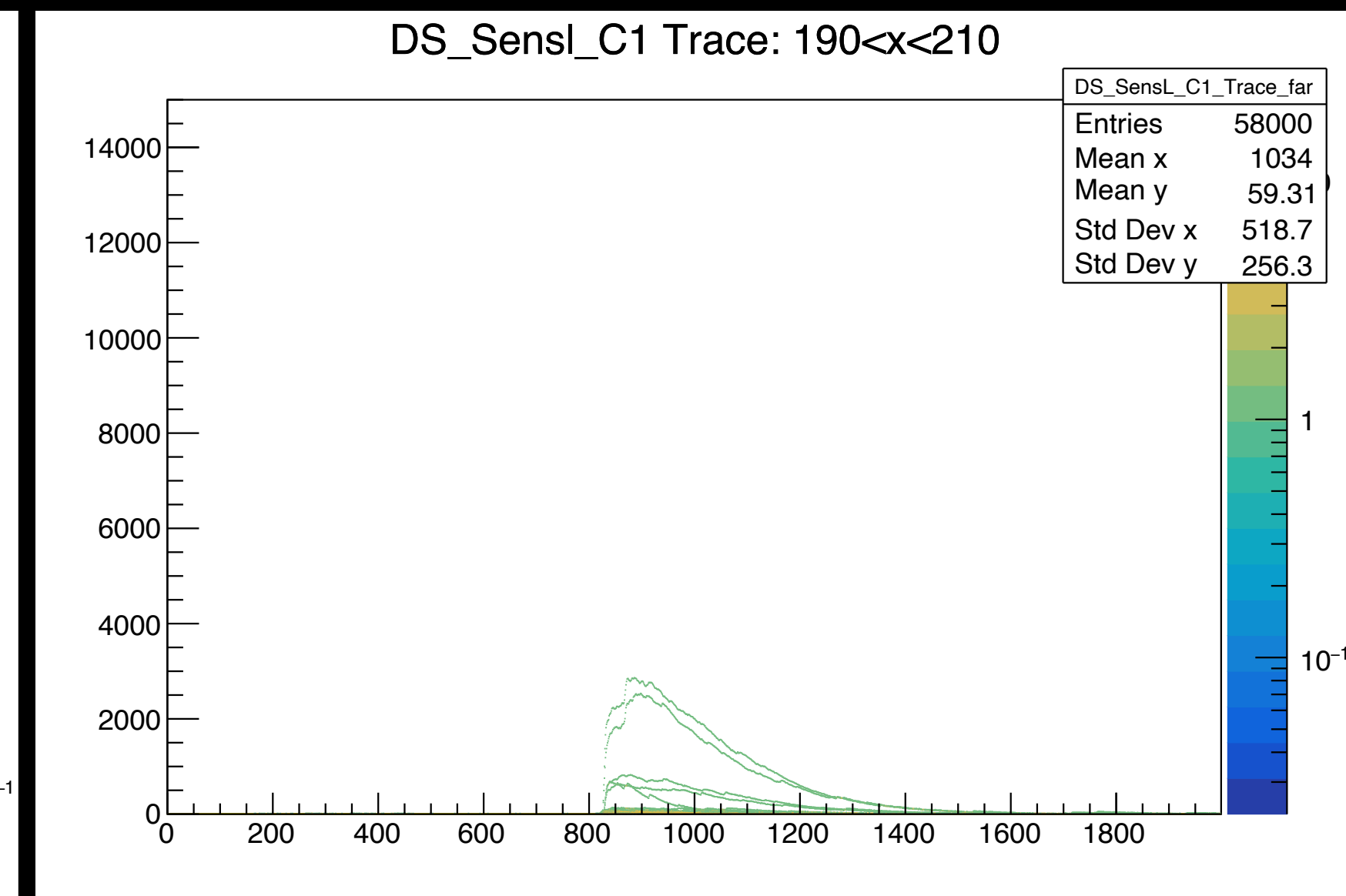
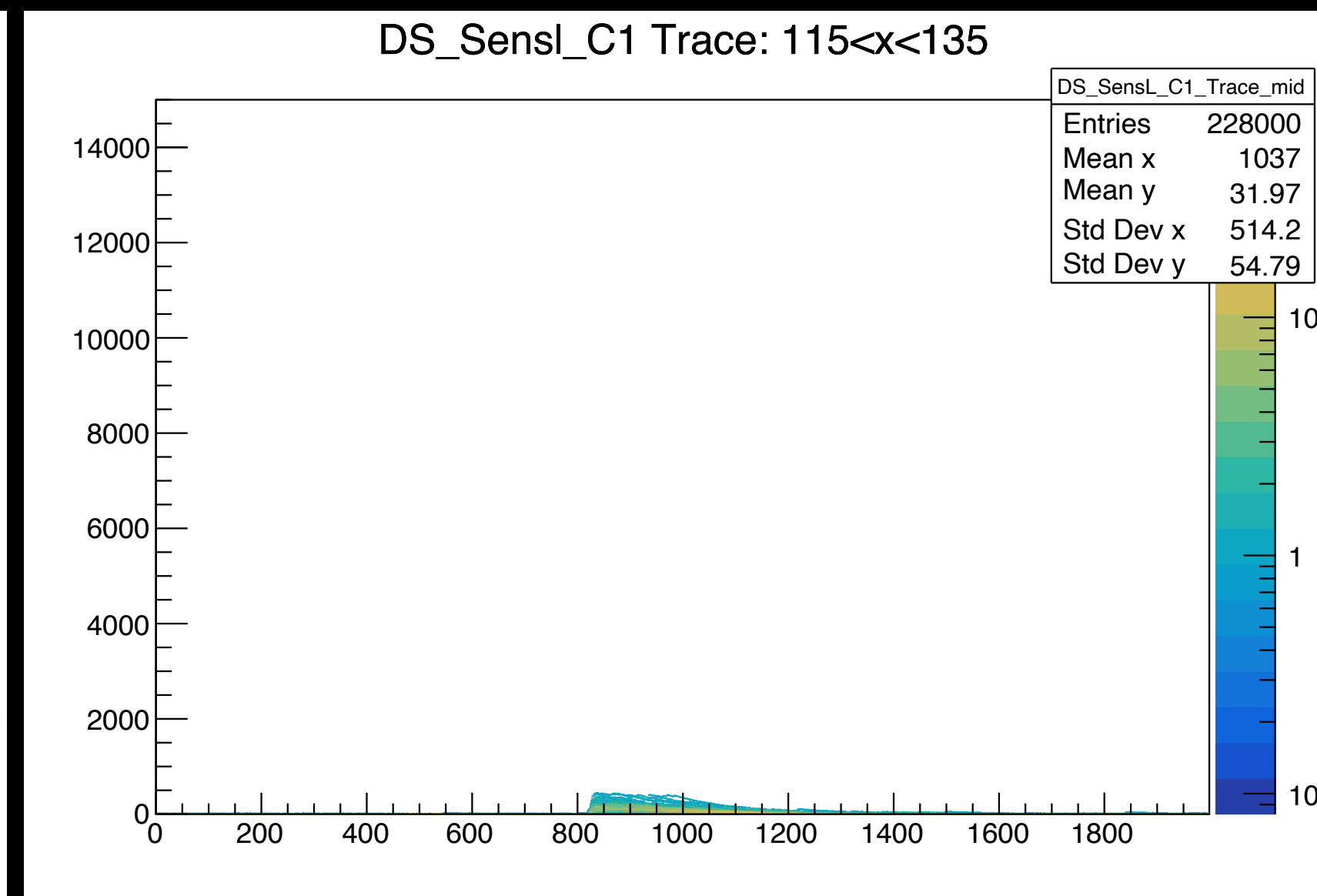
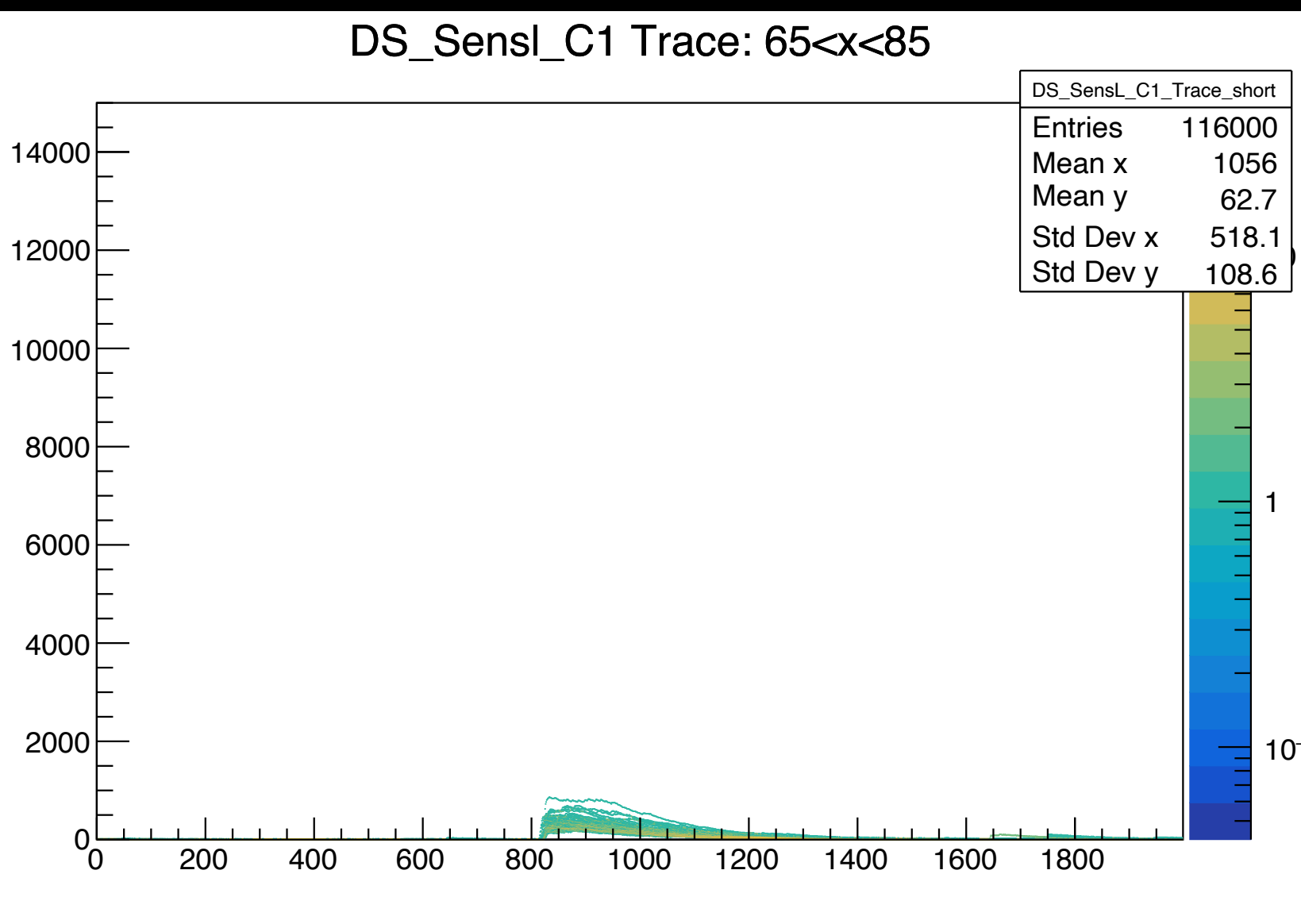
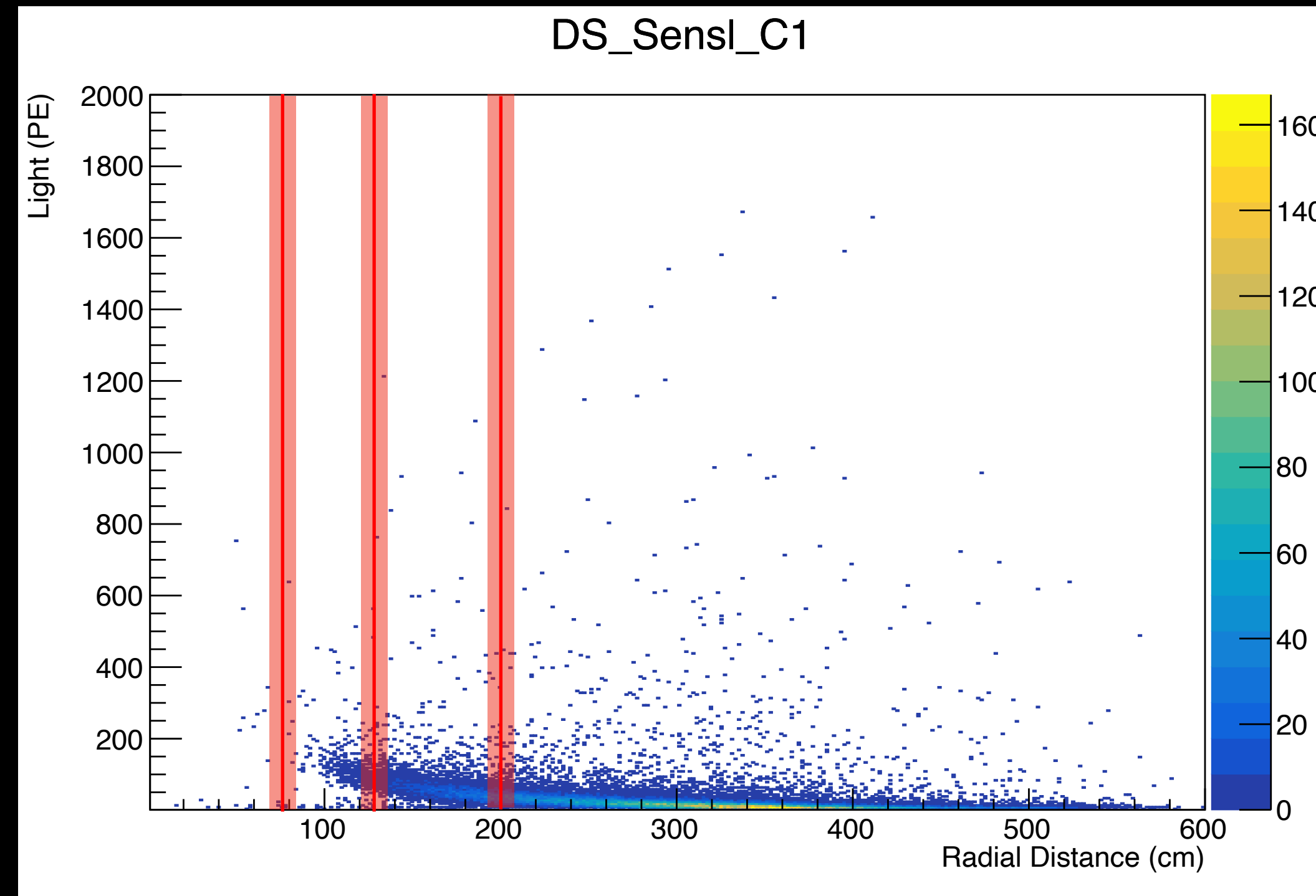
run 5785

SensL



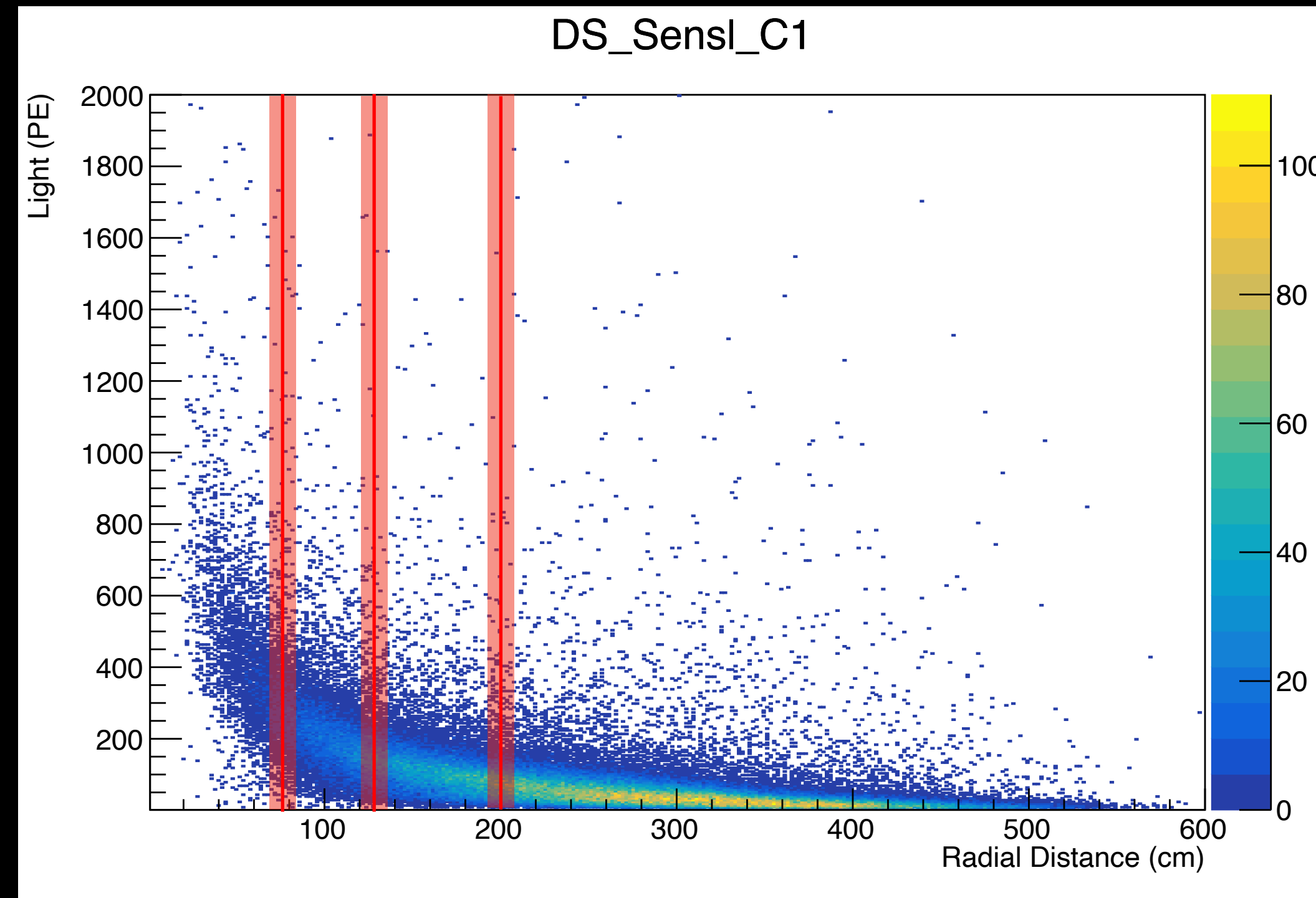
run 10440

SensL



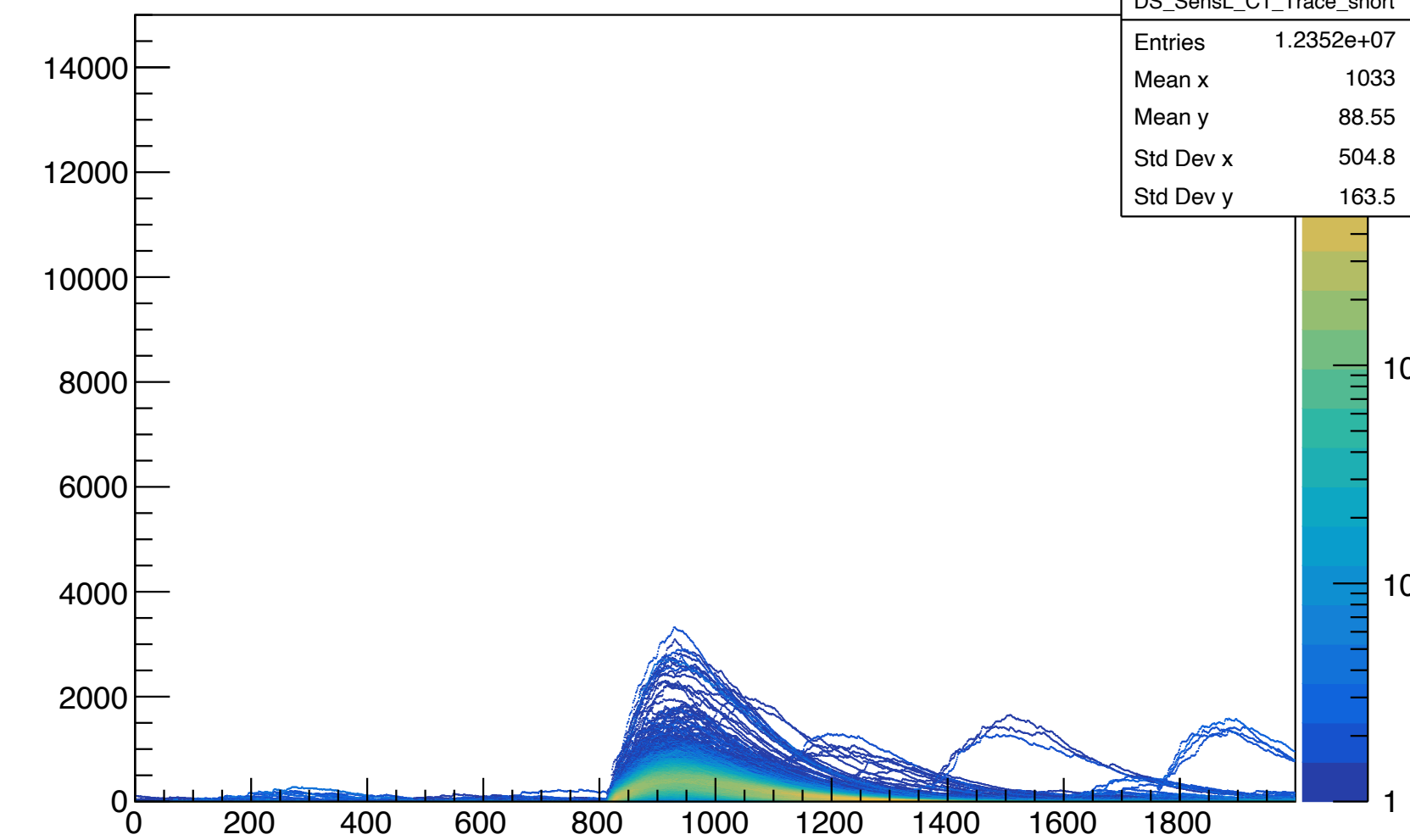
run 11460

SensL



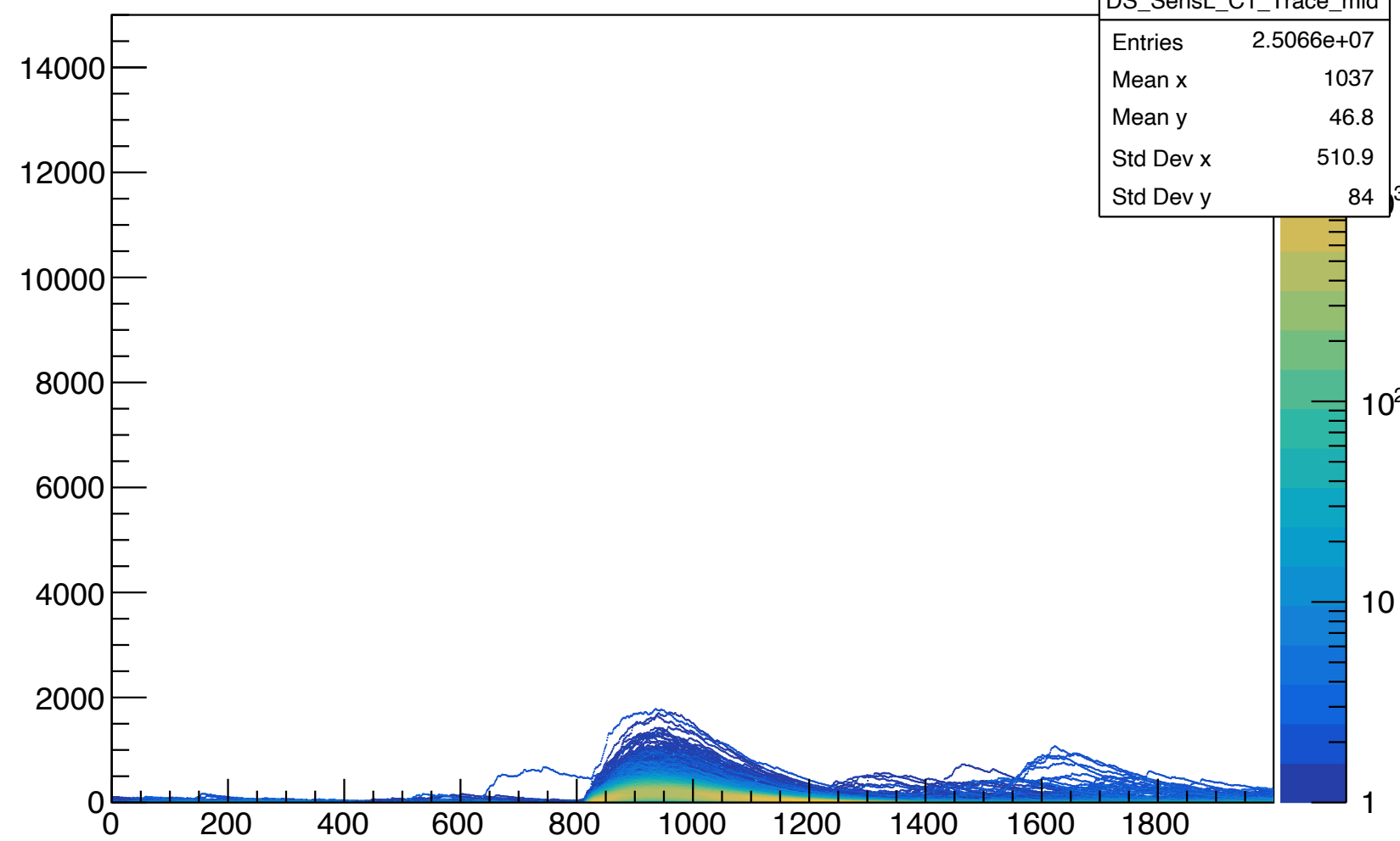
DS_SensL_C1 Trace: 65<x<85

DS_SensL_C1_Trace_short	
Entries	1.2352e+07
Mean x	1033
Mean y	88.55
Std Dev x	504.8
Std Dev y	163.5



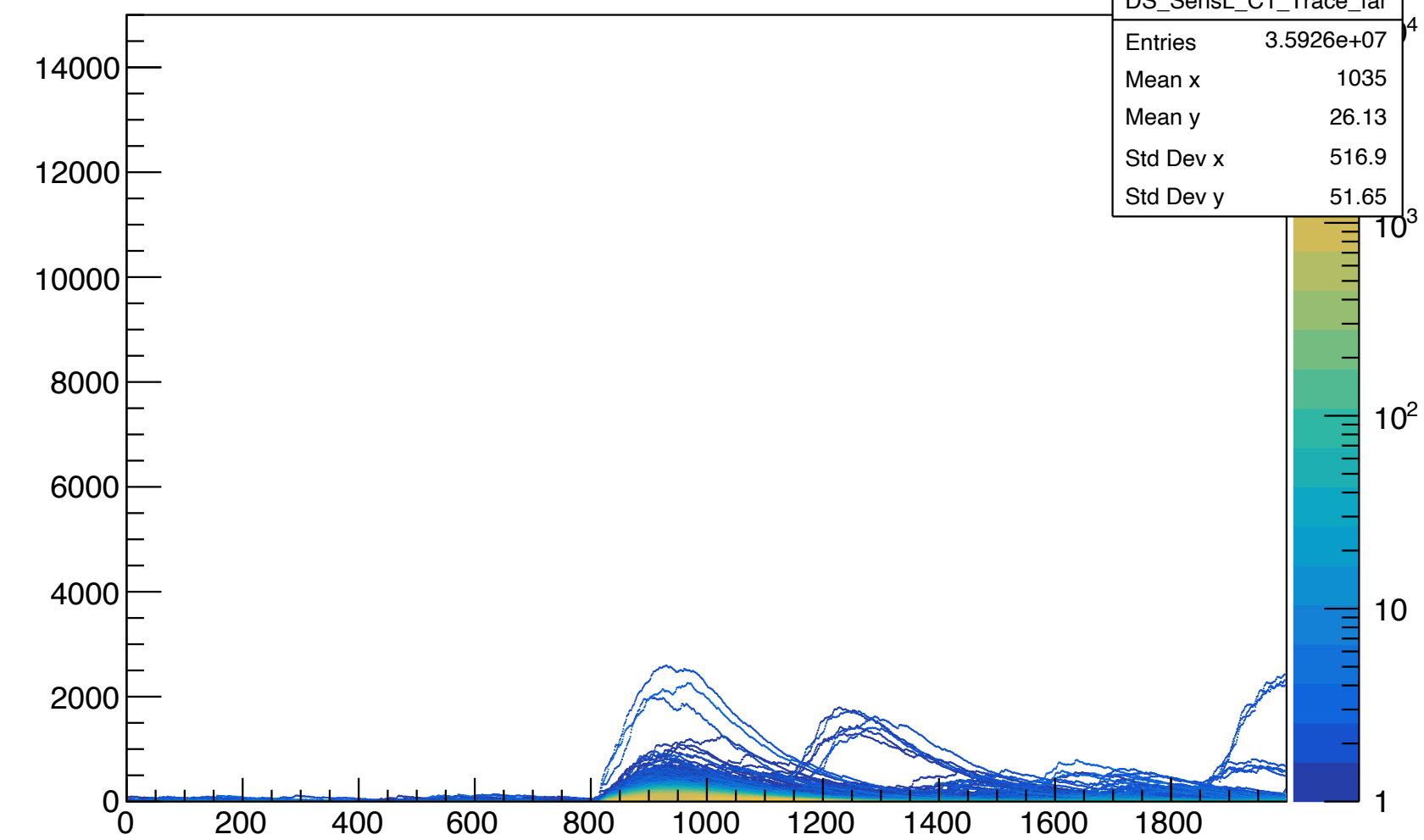
DS_SensL_C1 Trace: 115<x<135

DS_SensL_C1_Trace_mid	
Entries	2.5066e+07
Mean x	1037
Mean y	46.8
Std Dev x	510.9
Std Dev y	84



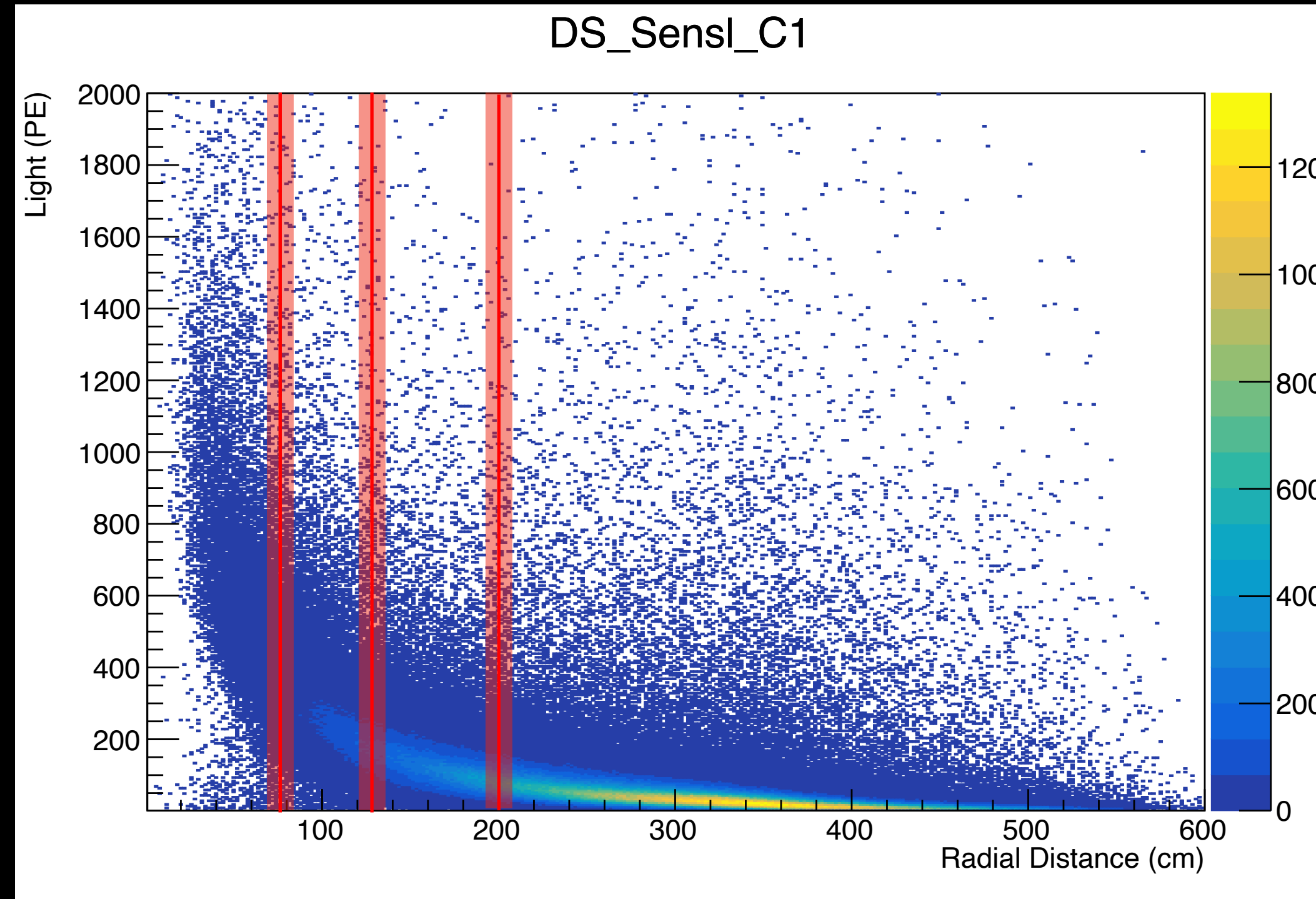
DS_SensL_C1 Trace: 190<x<210

DS_SensL_C1_Trace_far	
Entries	3.5926e+07
Mean x	1035
Mean y	26.13
Std Dev x	516.9
Std Dev y	51.65

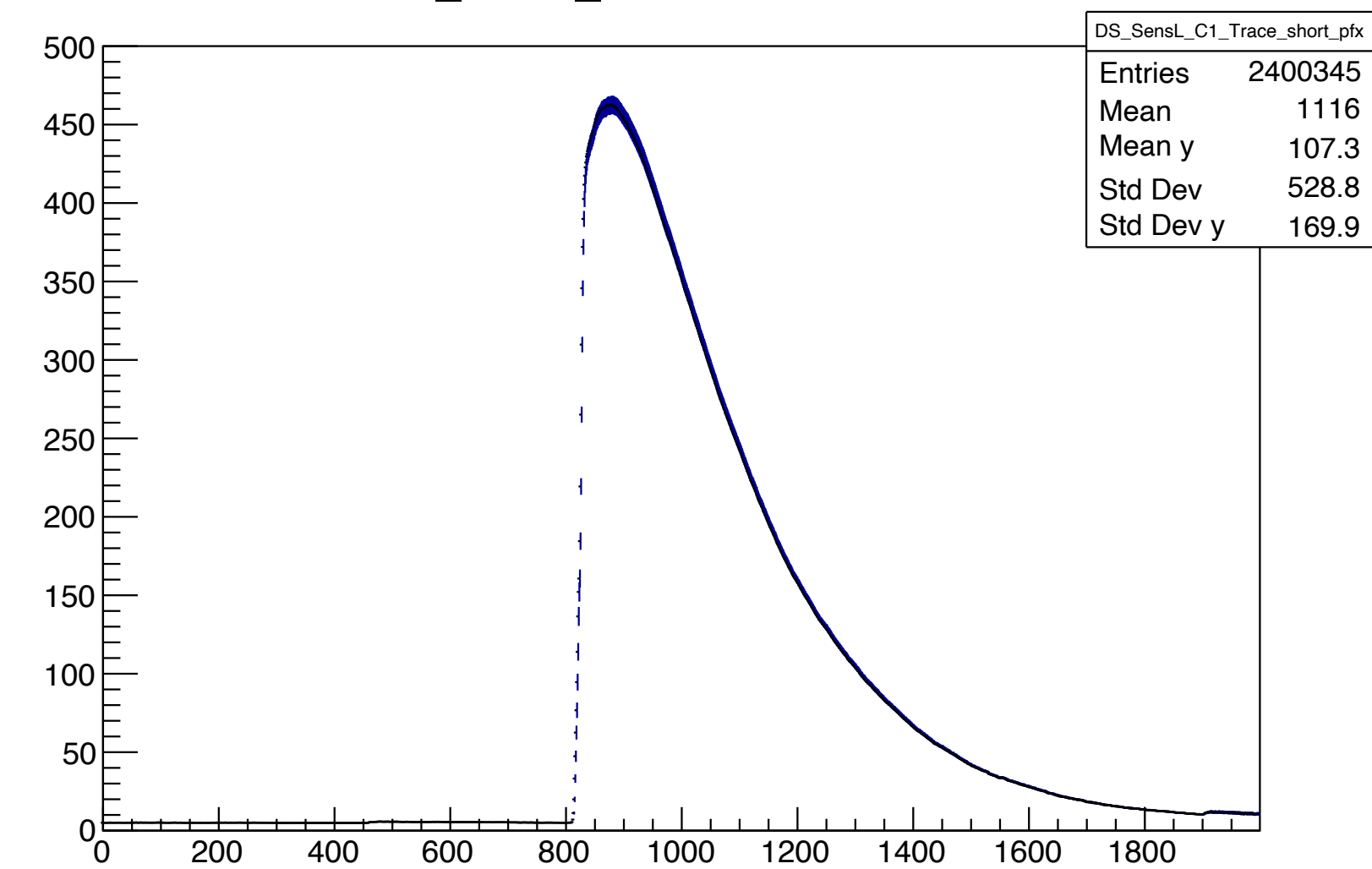


run 5785

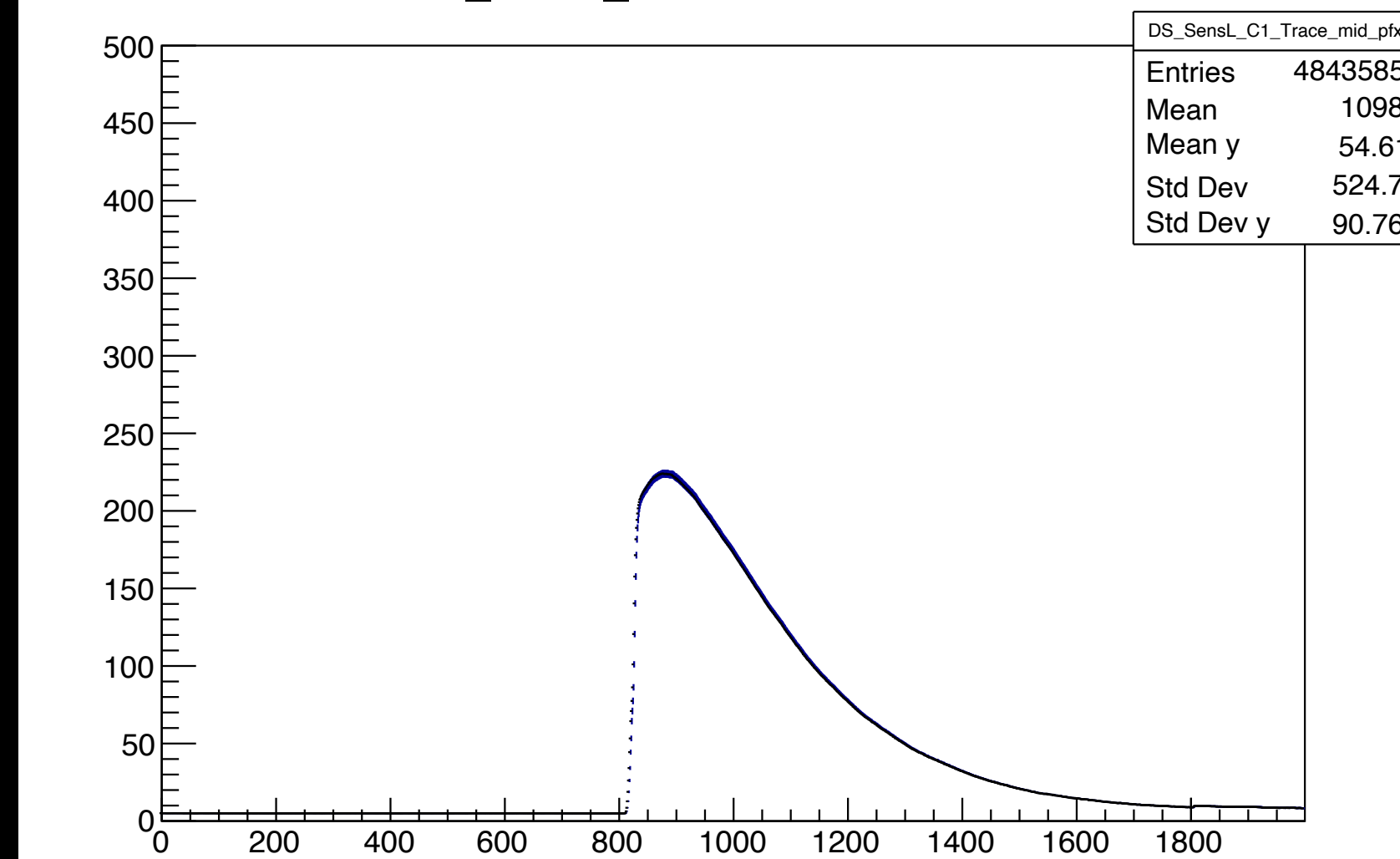
SensL



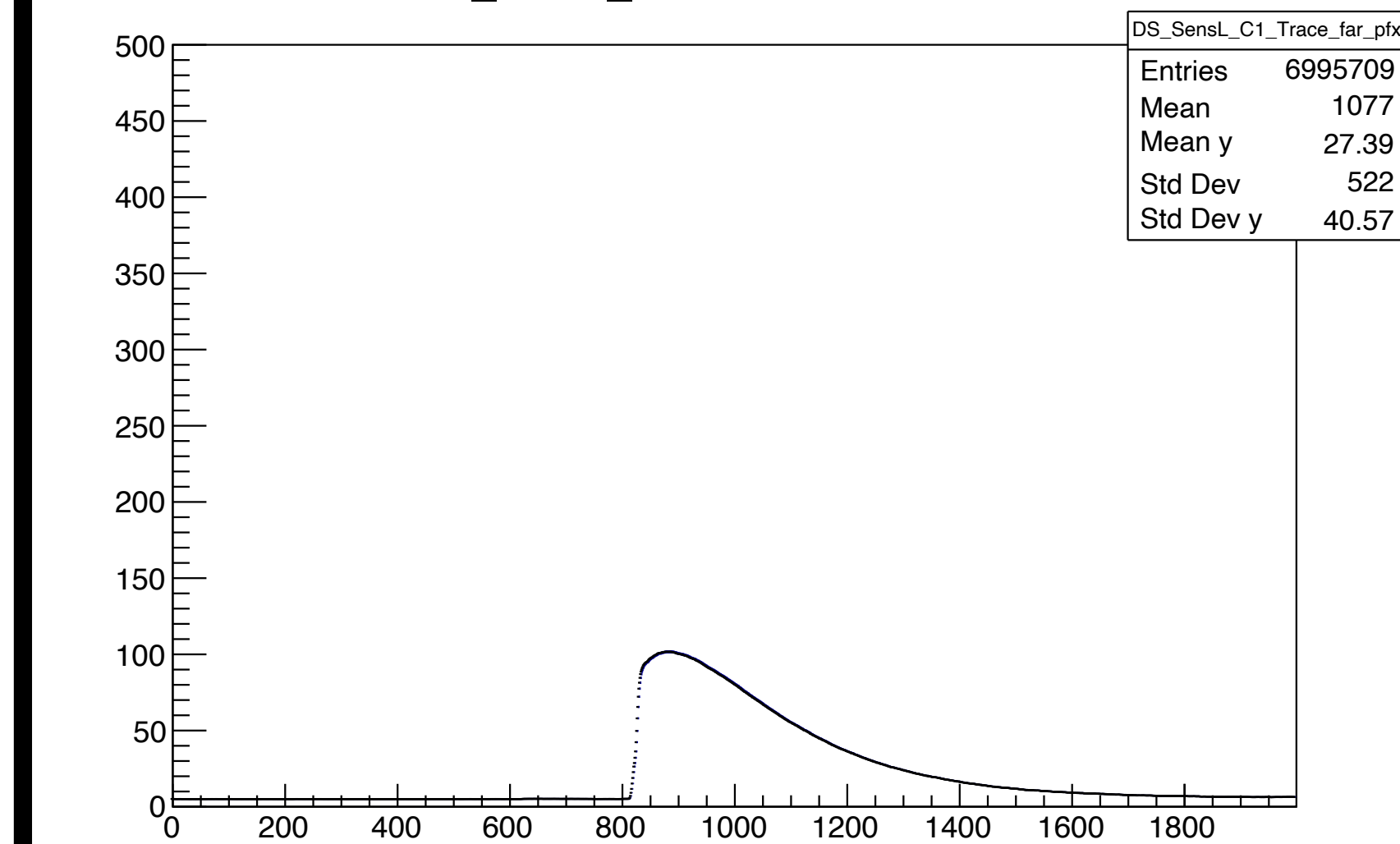
DS_SensL_C1 Trace: 65<x<85



DS_SensL_C1 Trace: 115<x<135

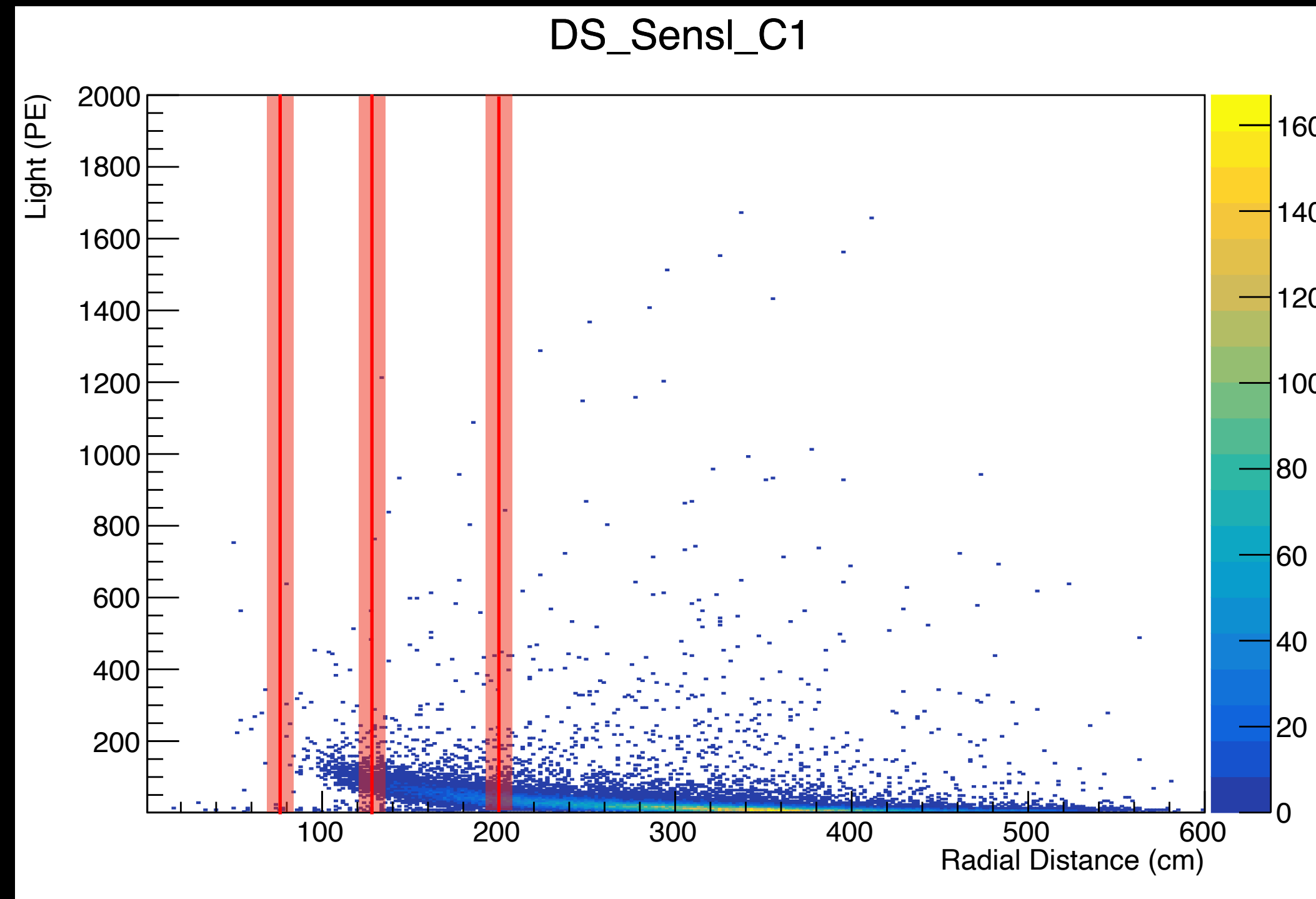


DS_SensL_C1 Trace: 190<x<210

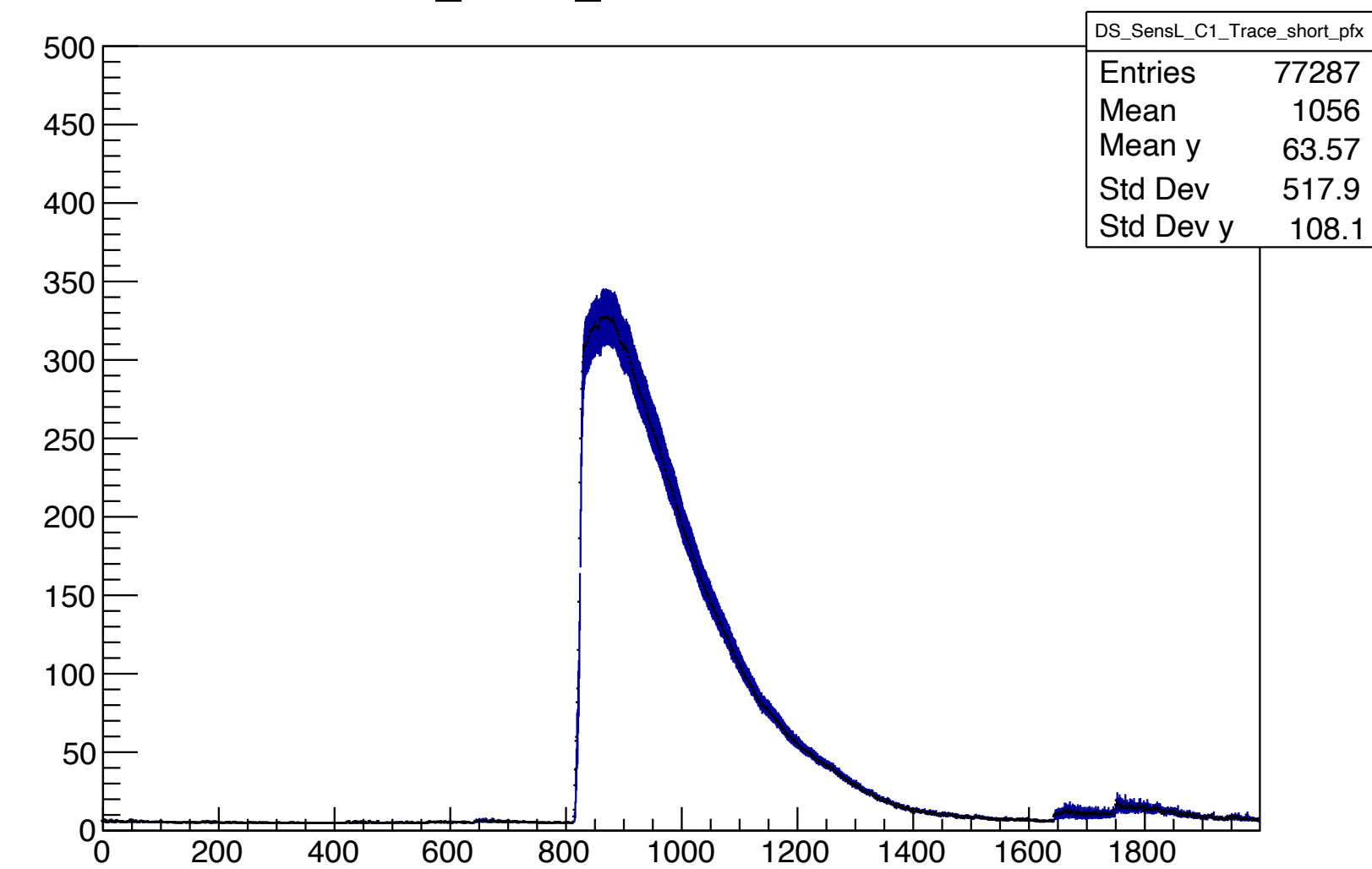


run 10440

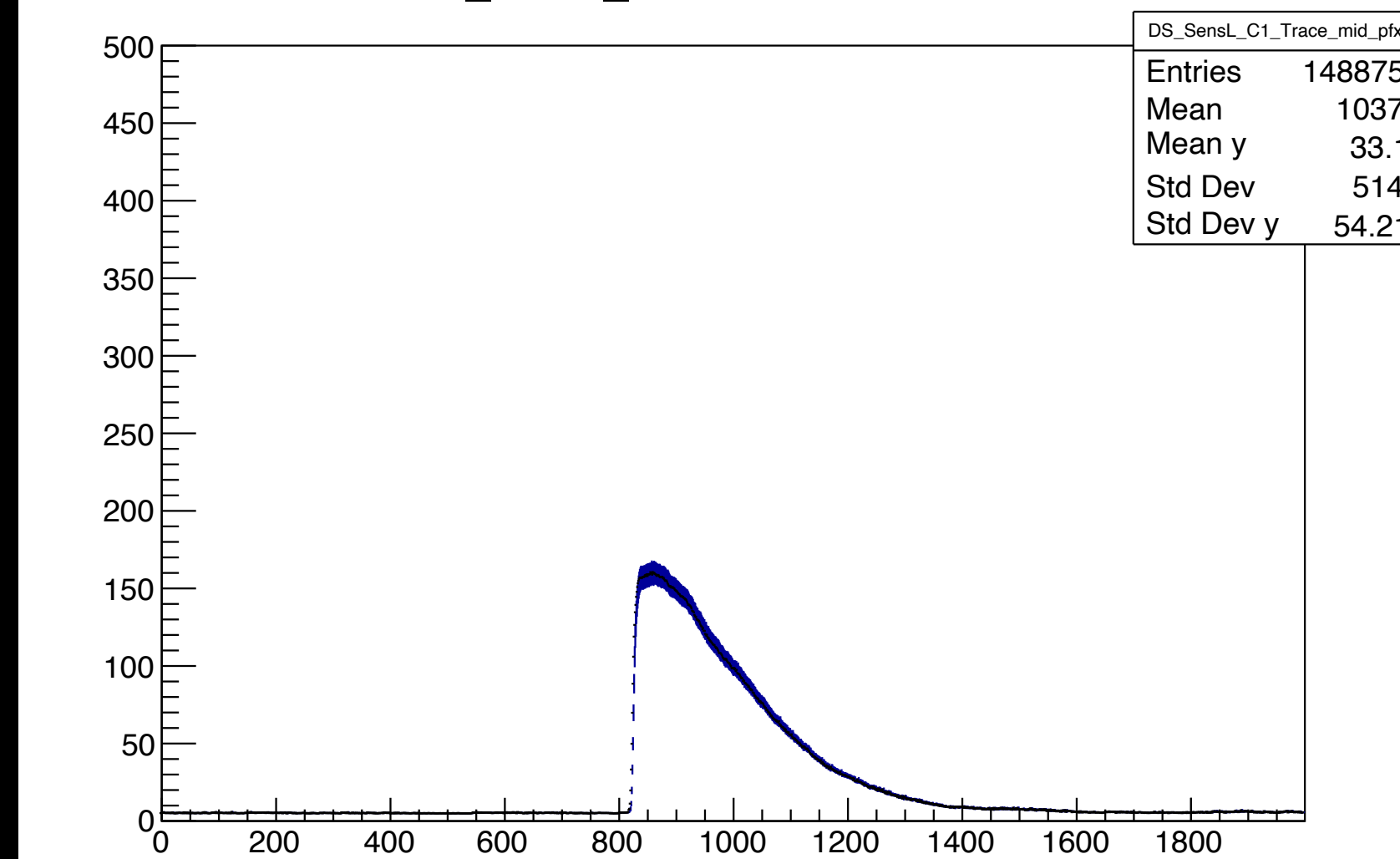
SensL



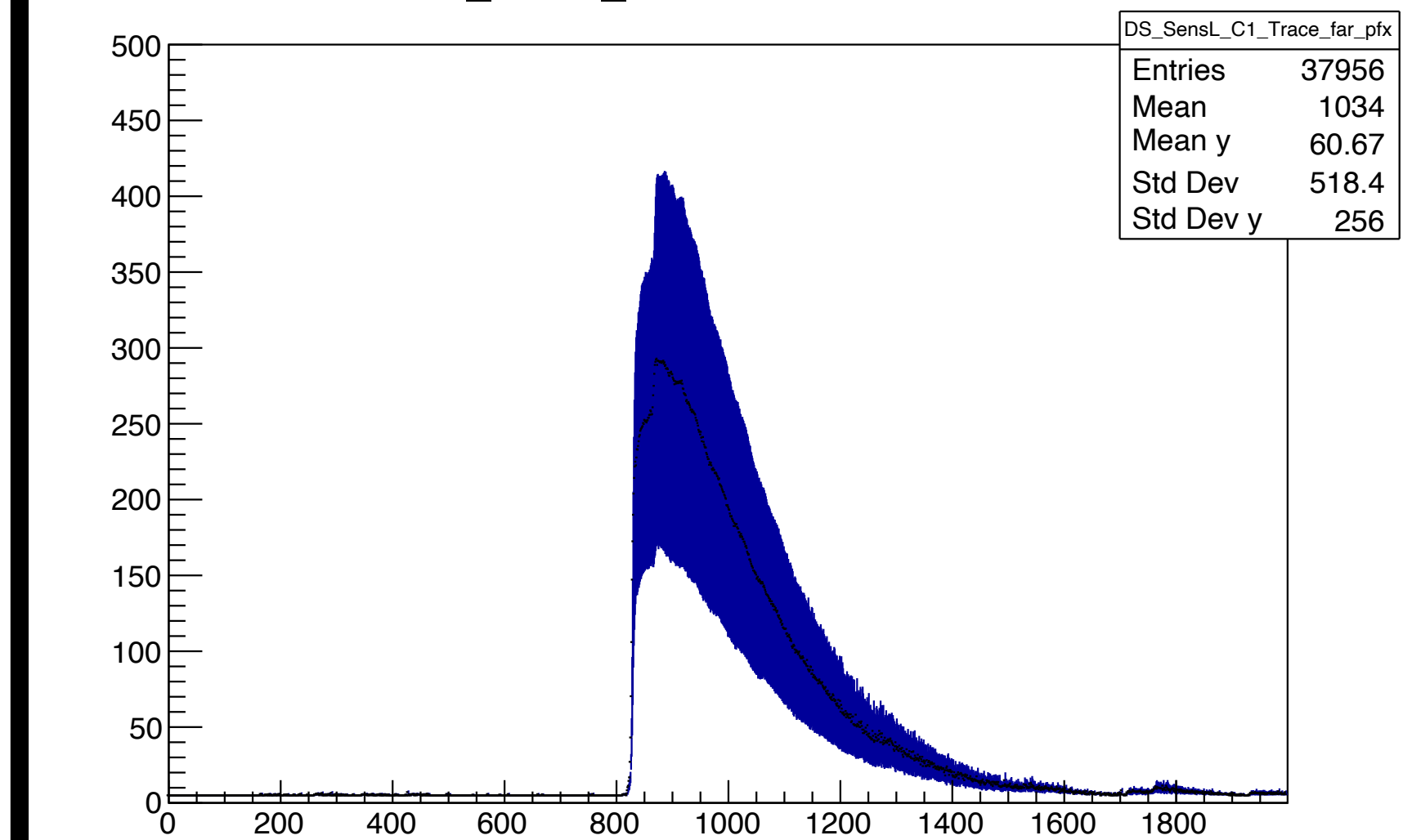
DS_SensL_C1 Trace: 65<x<85



DS_SensL_C1 Trace: 115<x<135

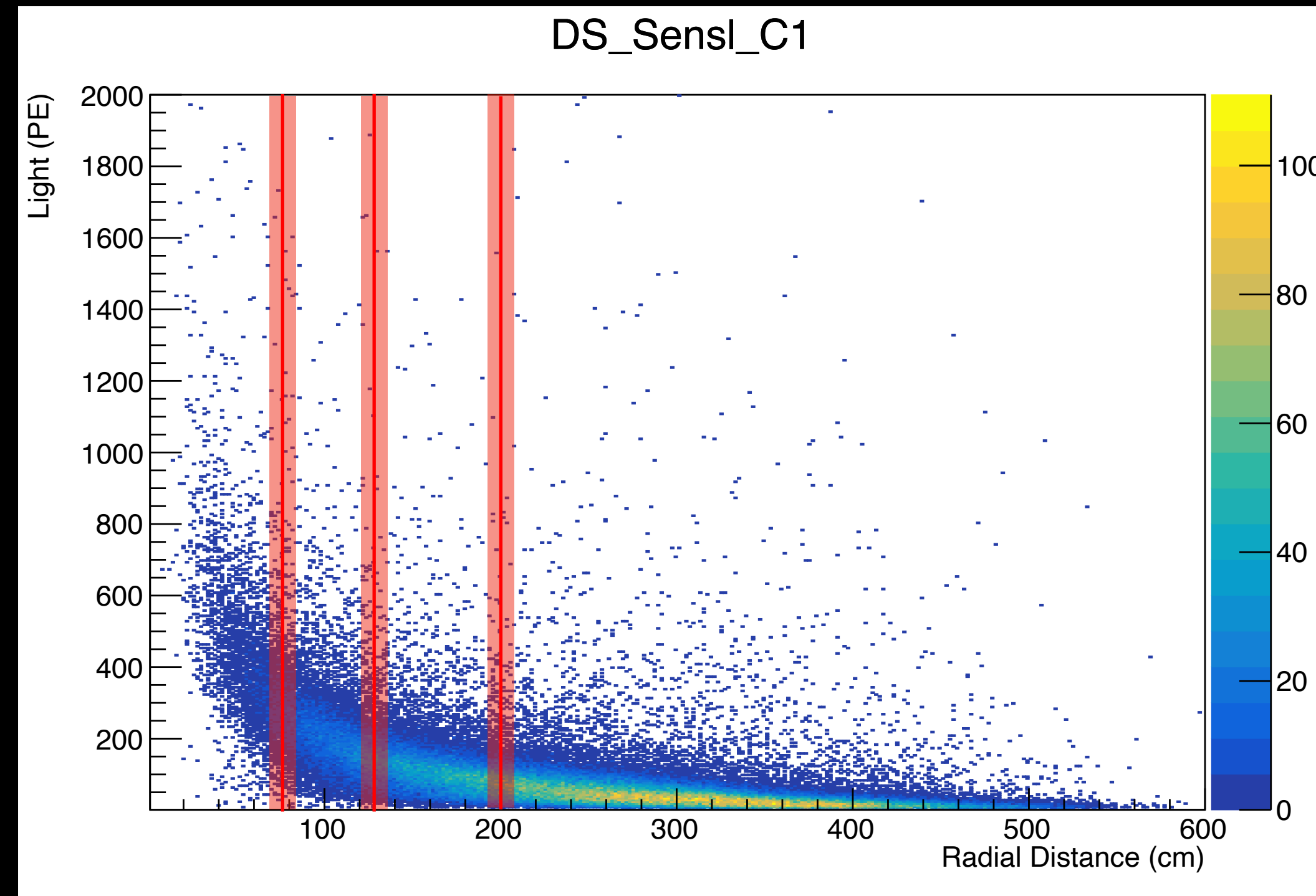


DS_SensL_C1 Trace: 190<x<210

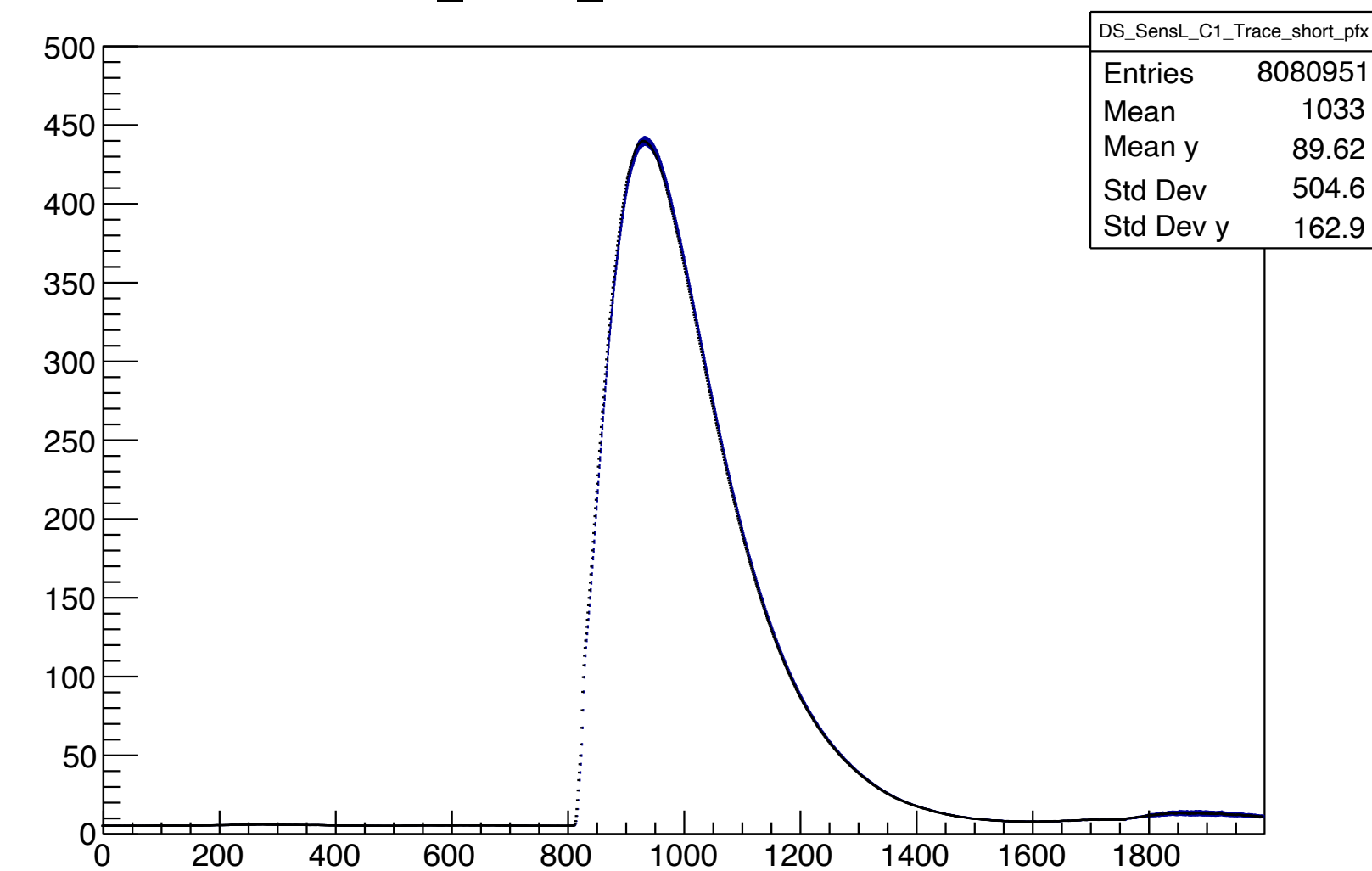


run 11460

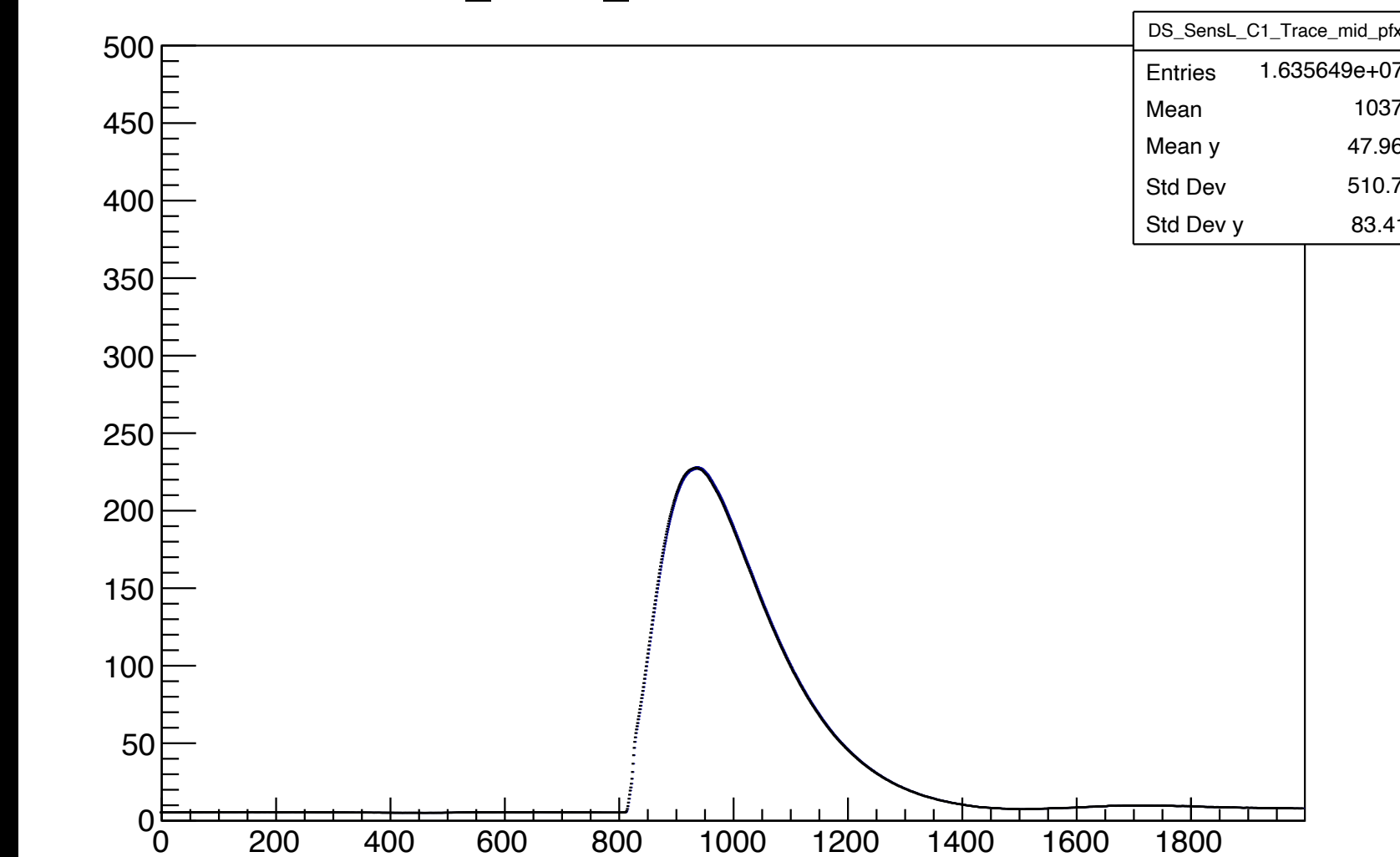
SensL



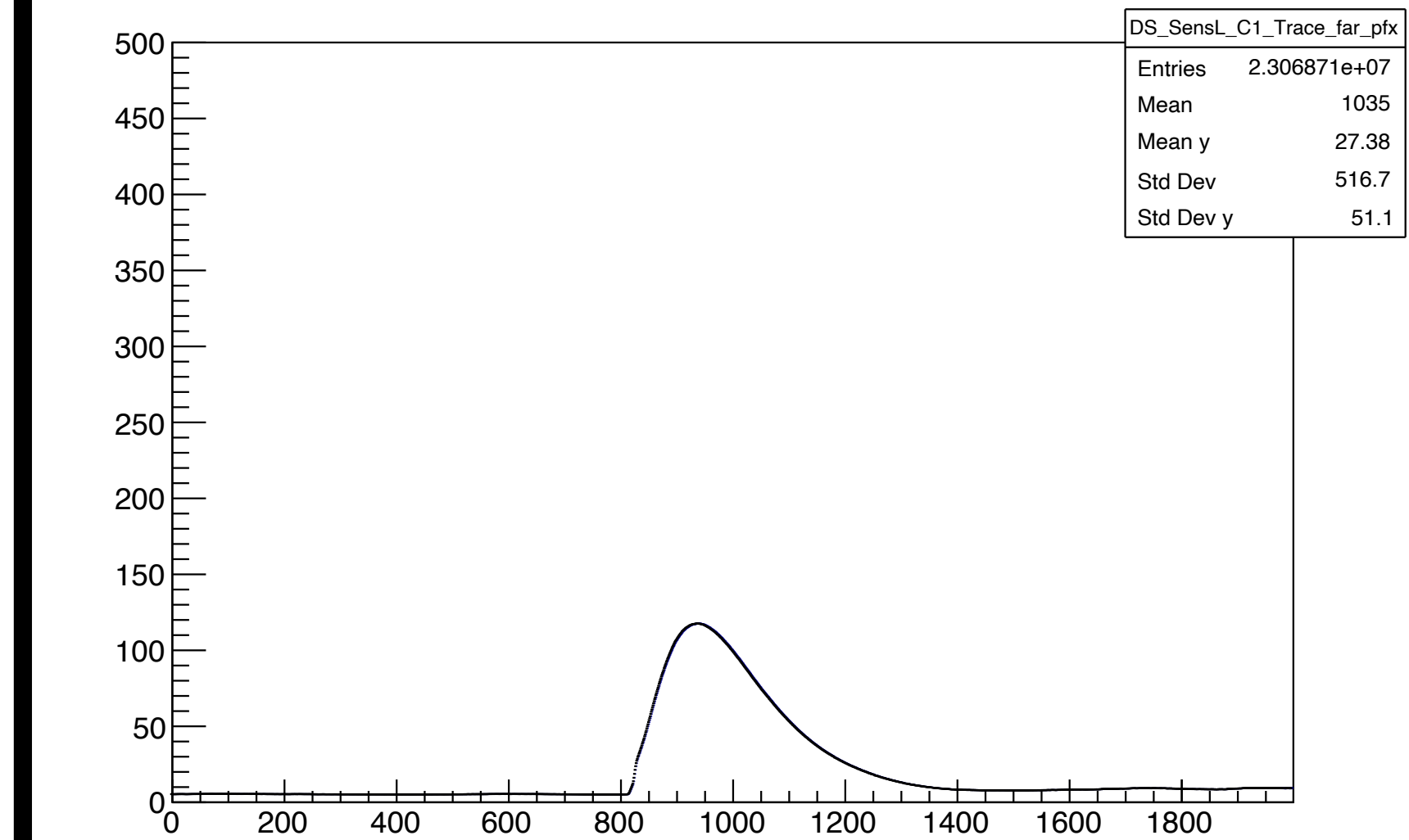
DS_SensL_C1 Trace: 65<x<85



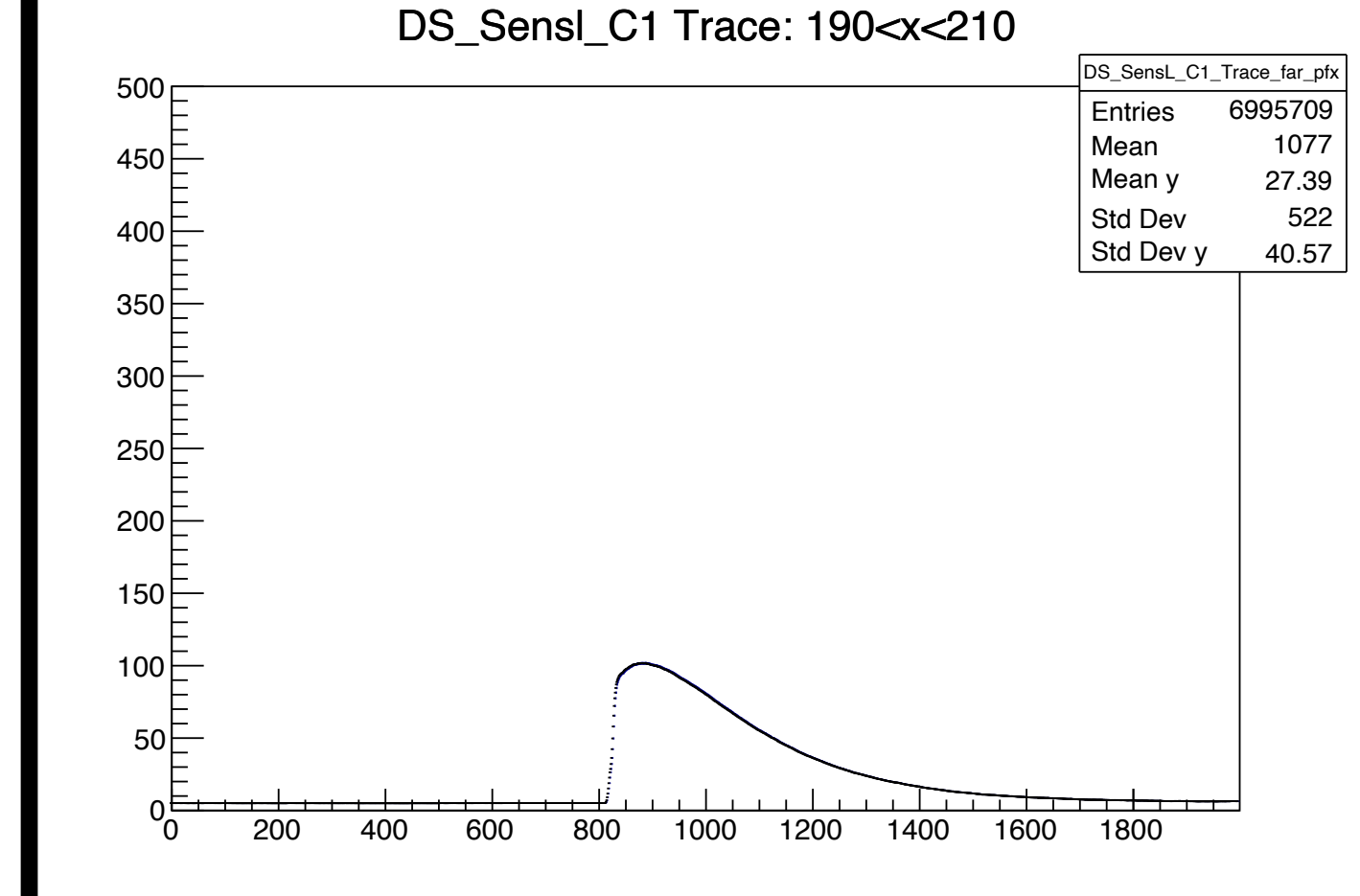
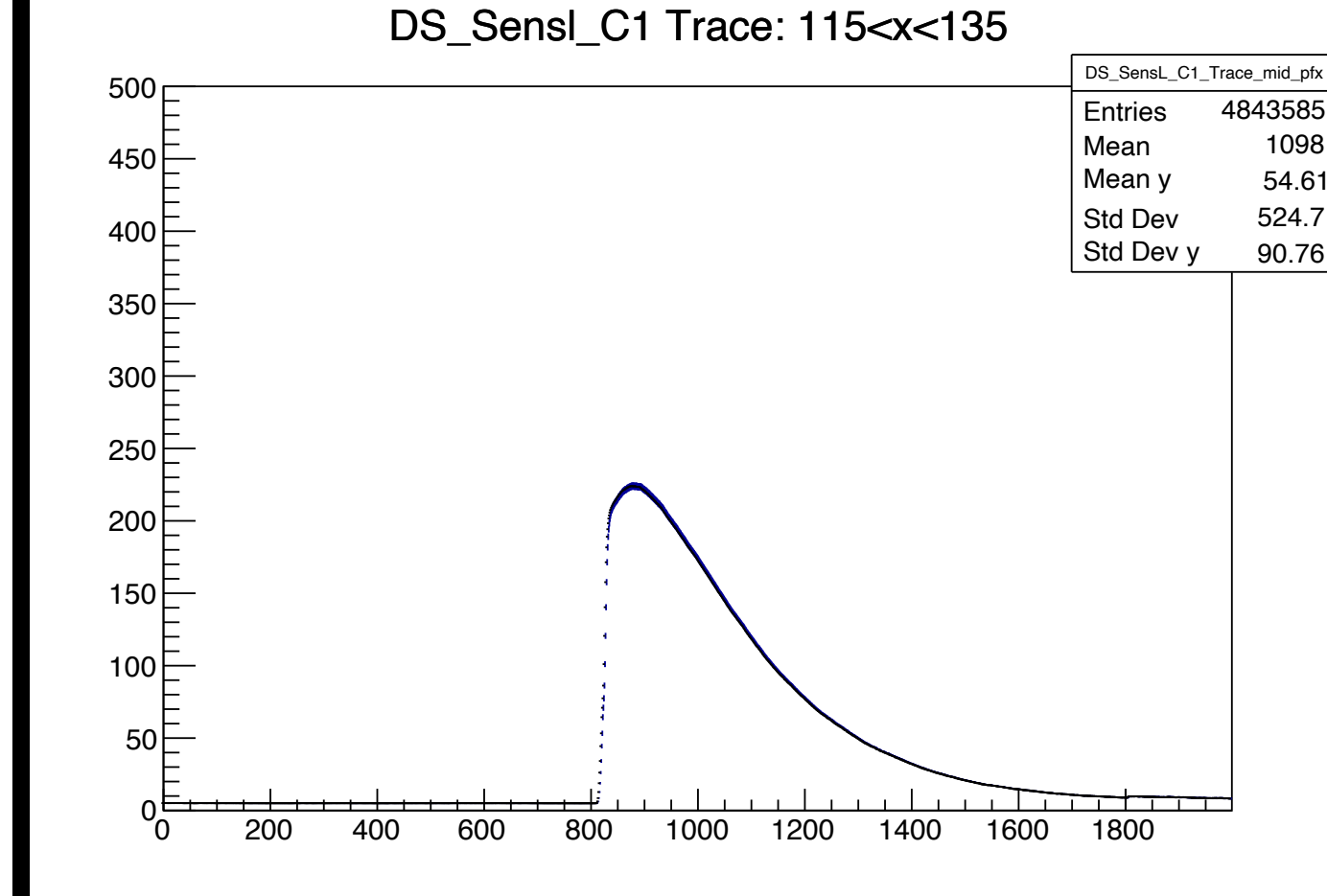
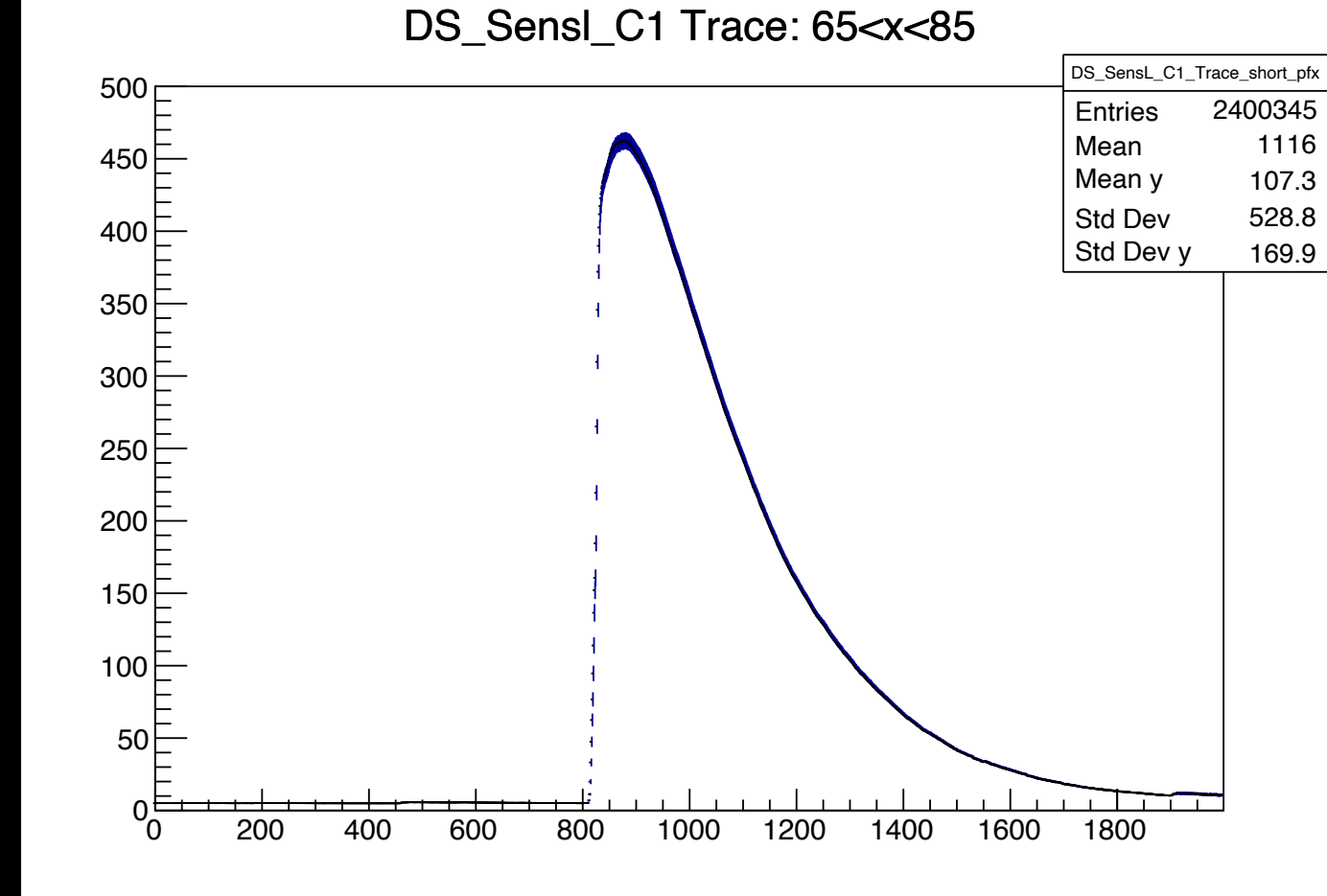
DS_SensL_C1 Trace: 115<x<135



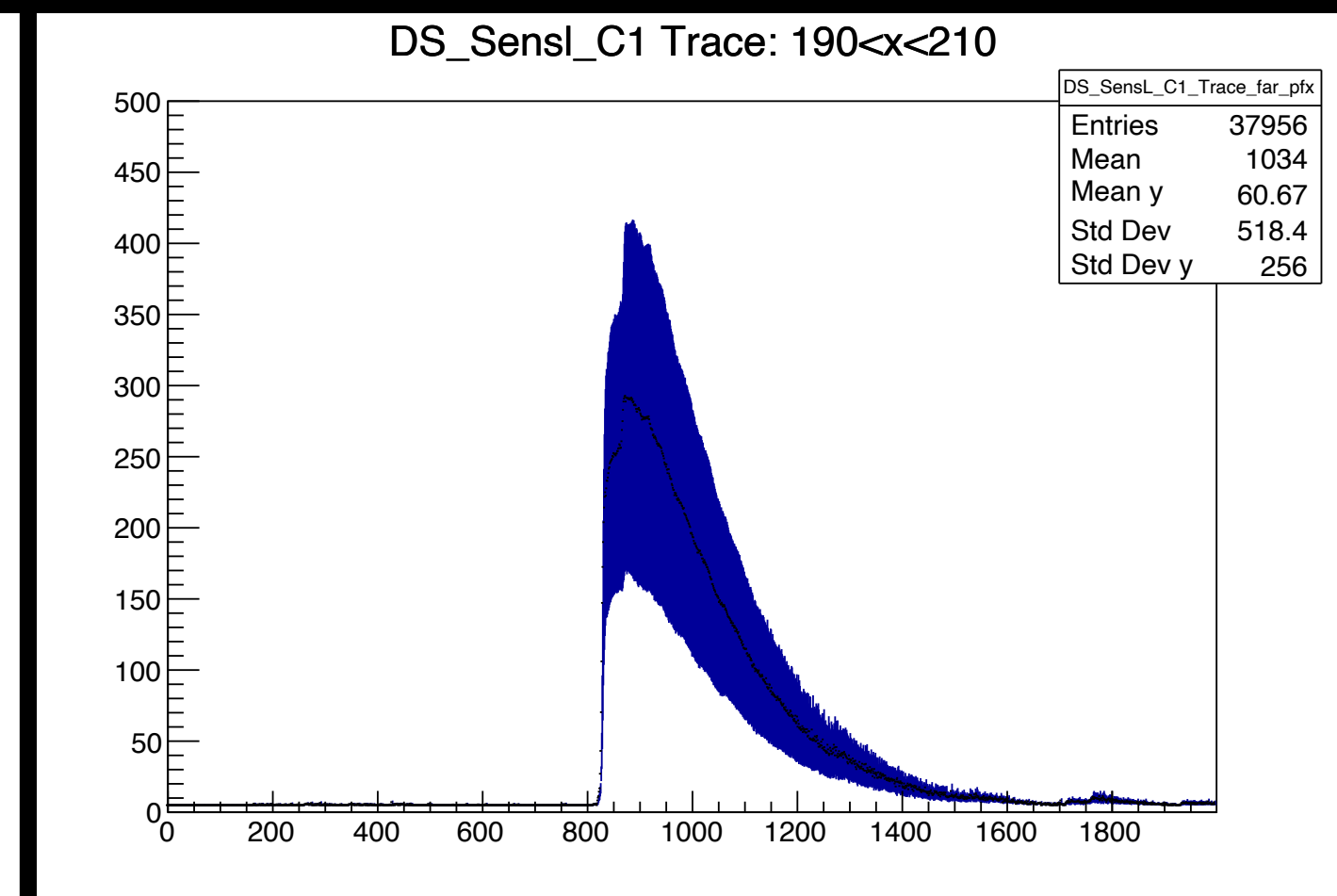
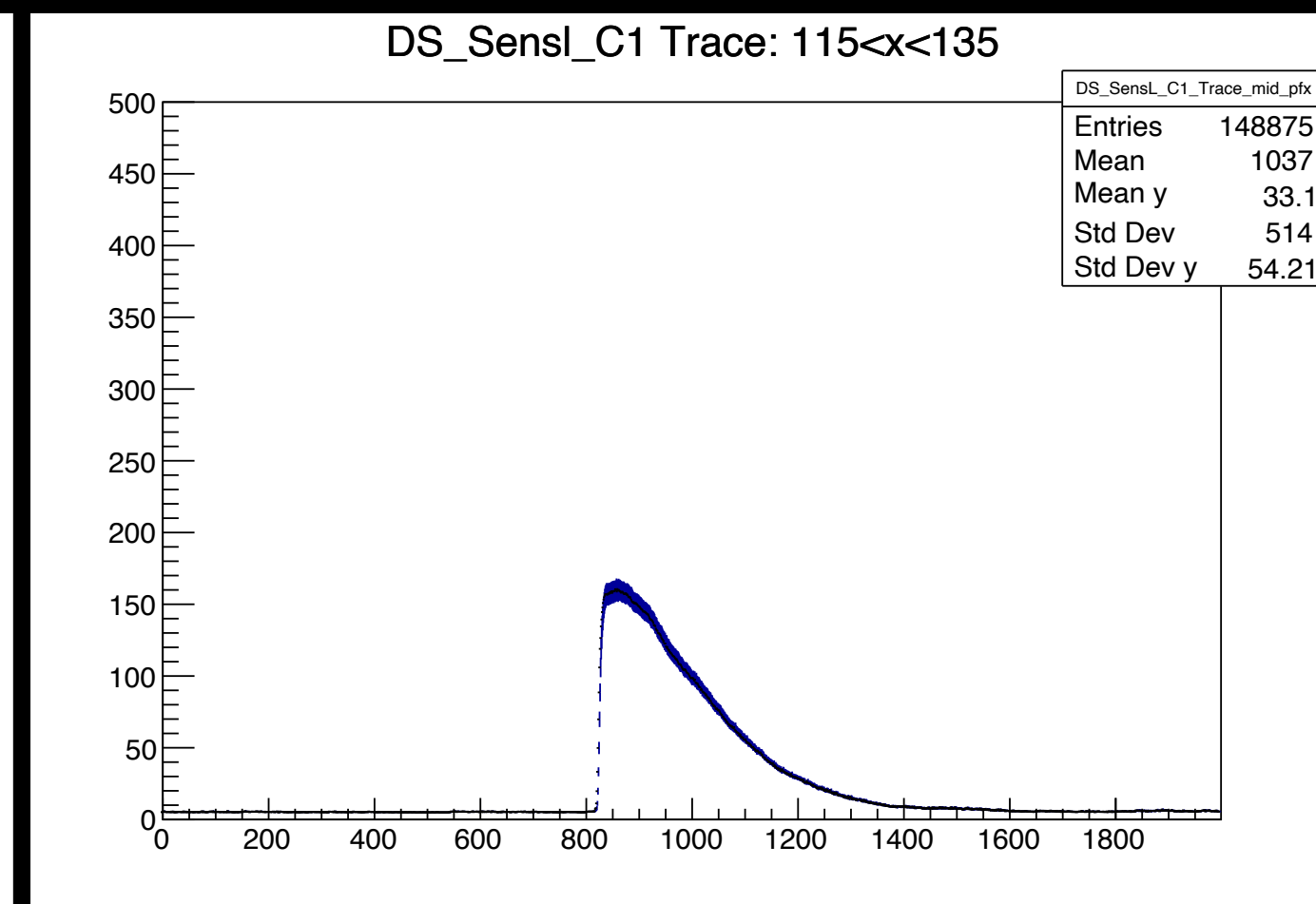
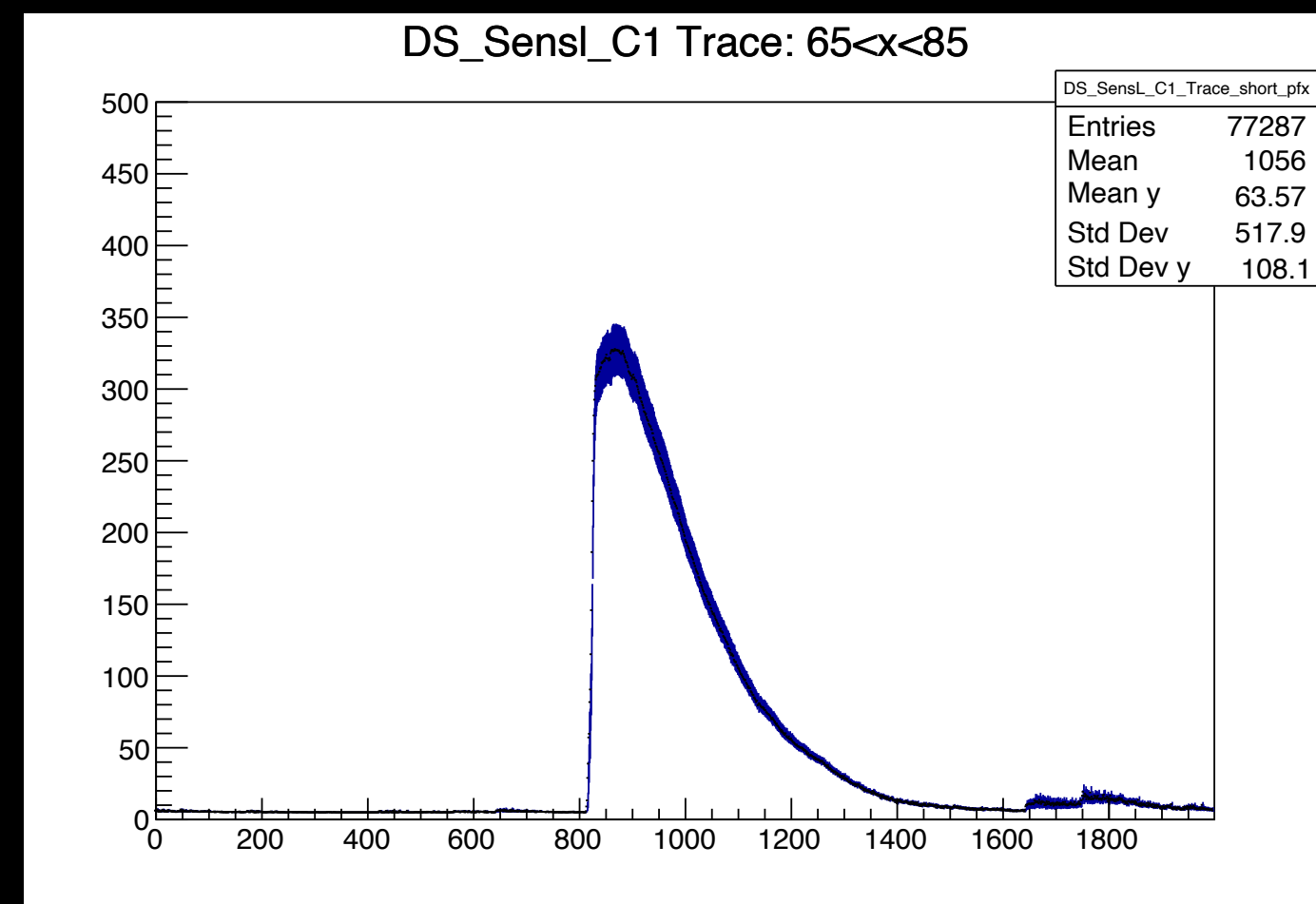
DS_SensL_C1 Trace: 190<x<210



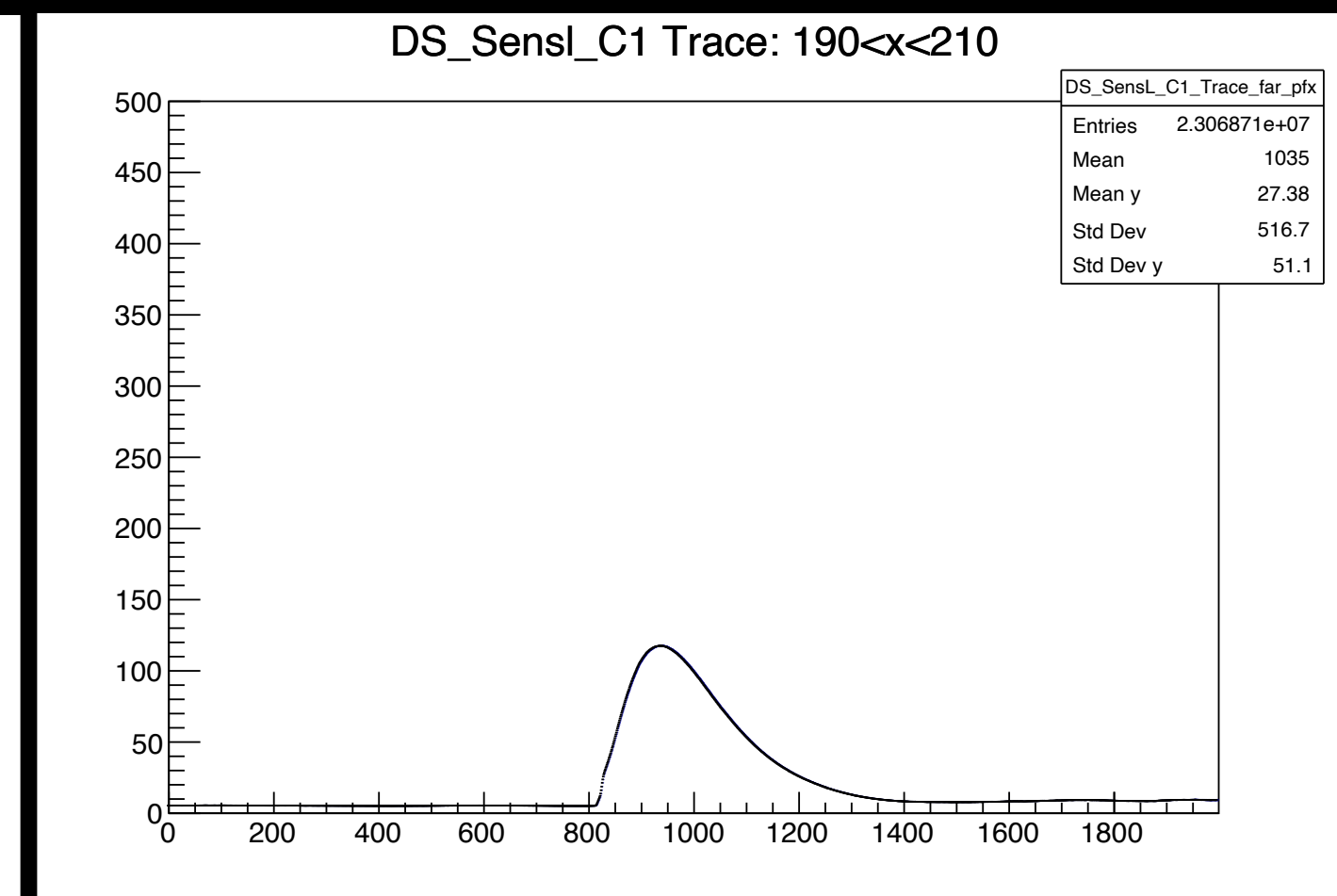
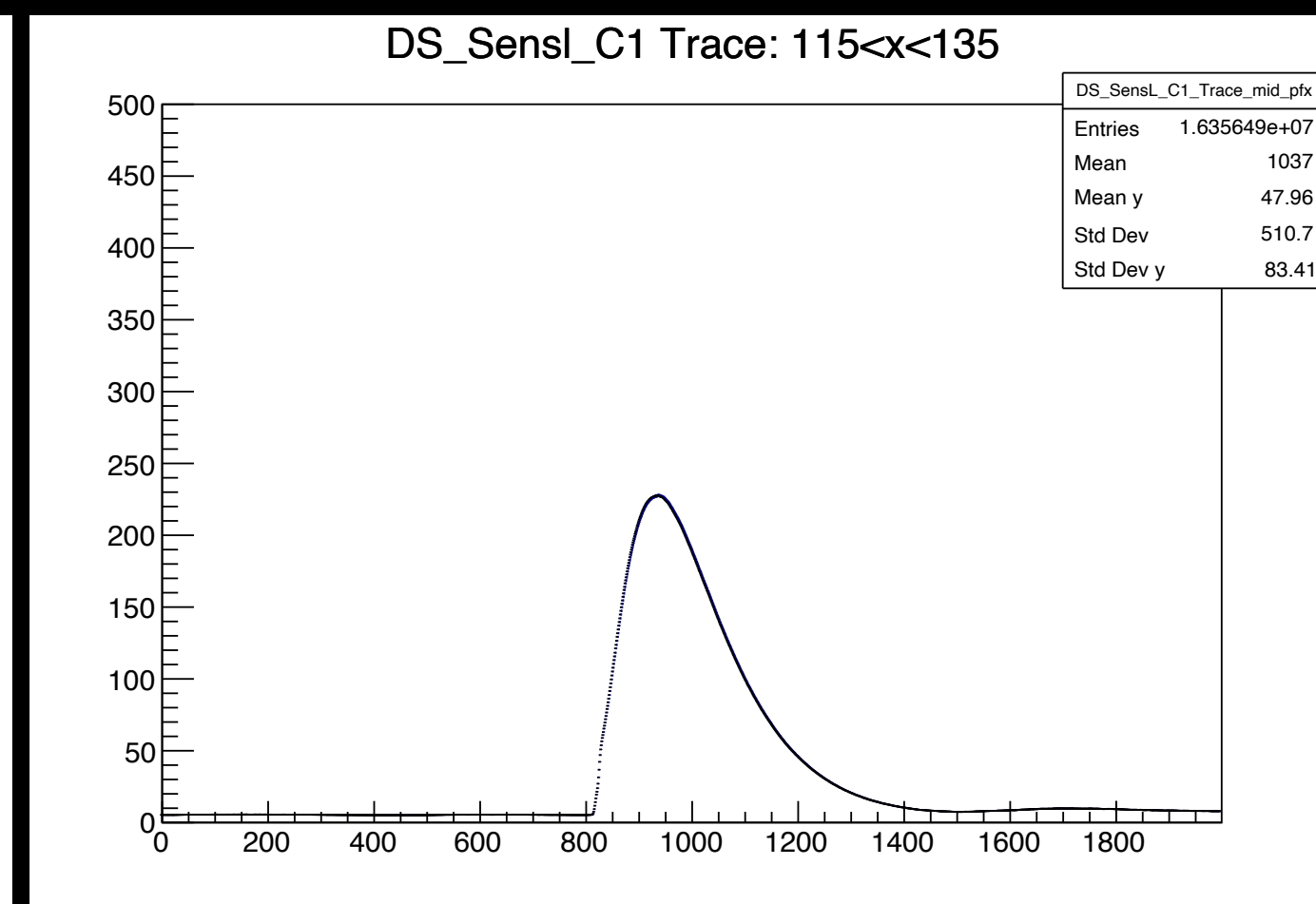
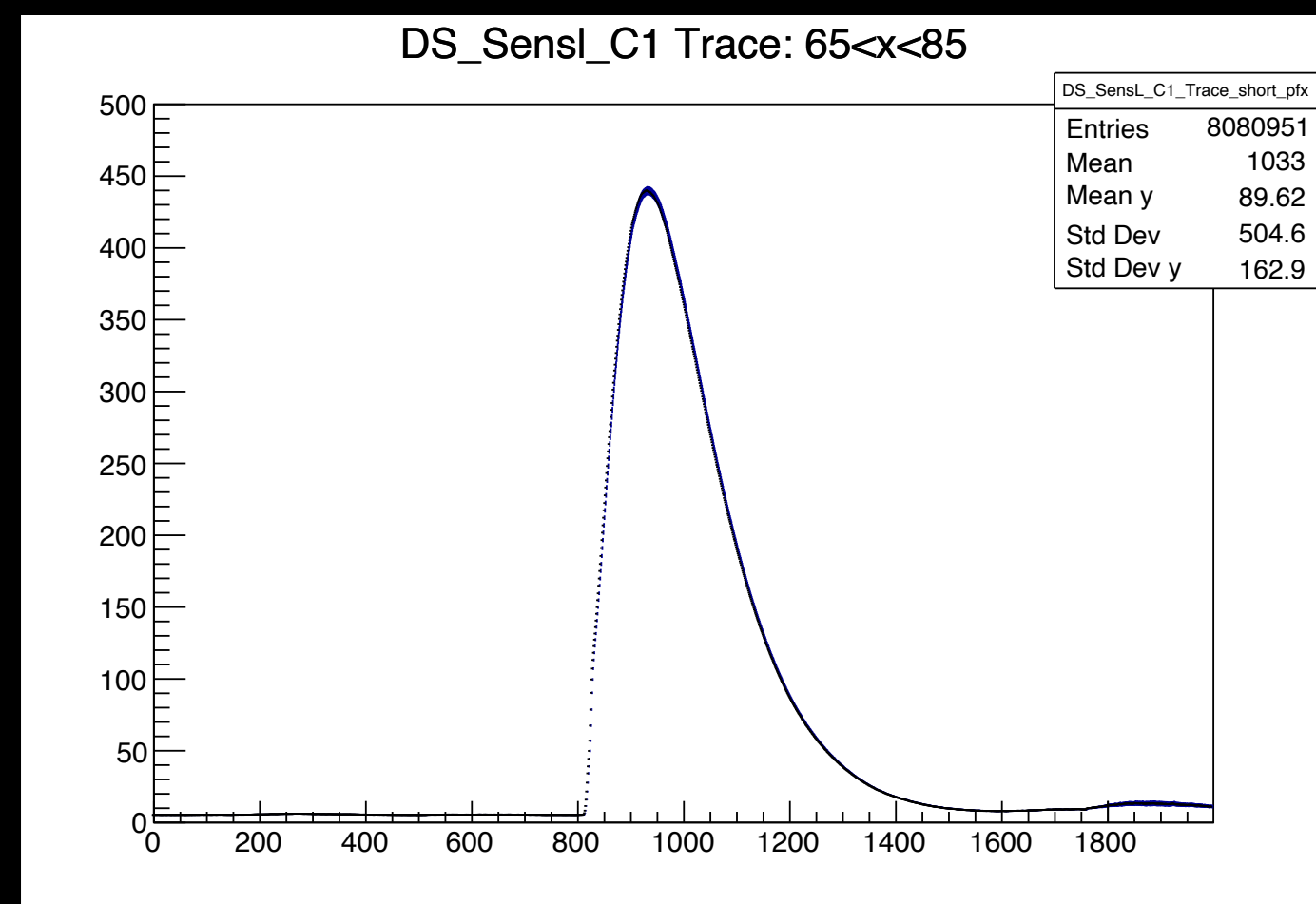
Run 5785
LAr



Run 10440
LAr + N



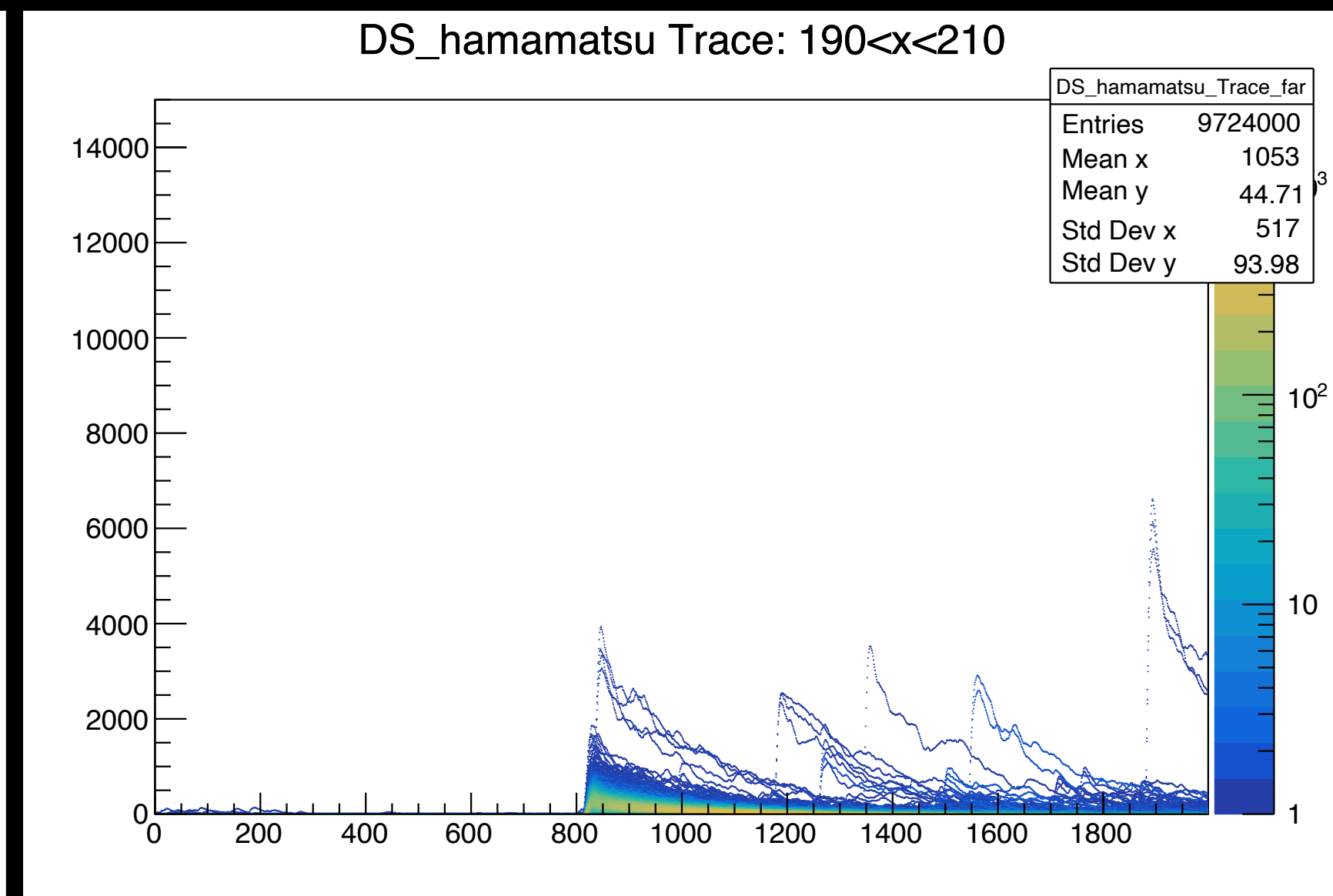
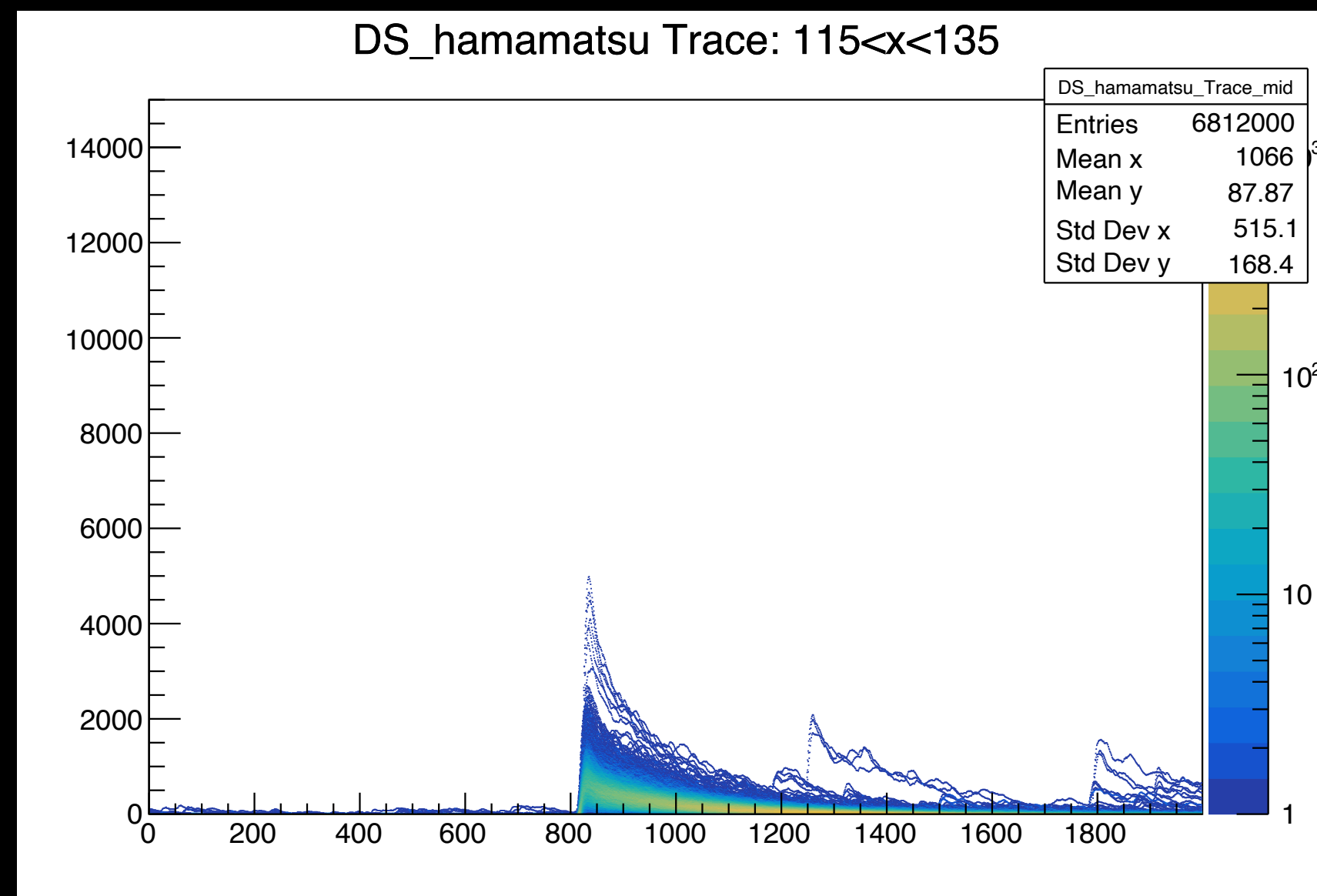
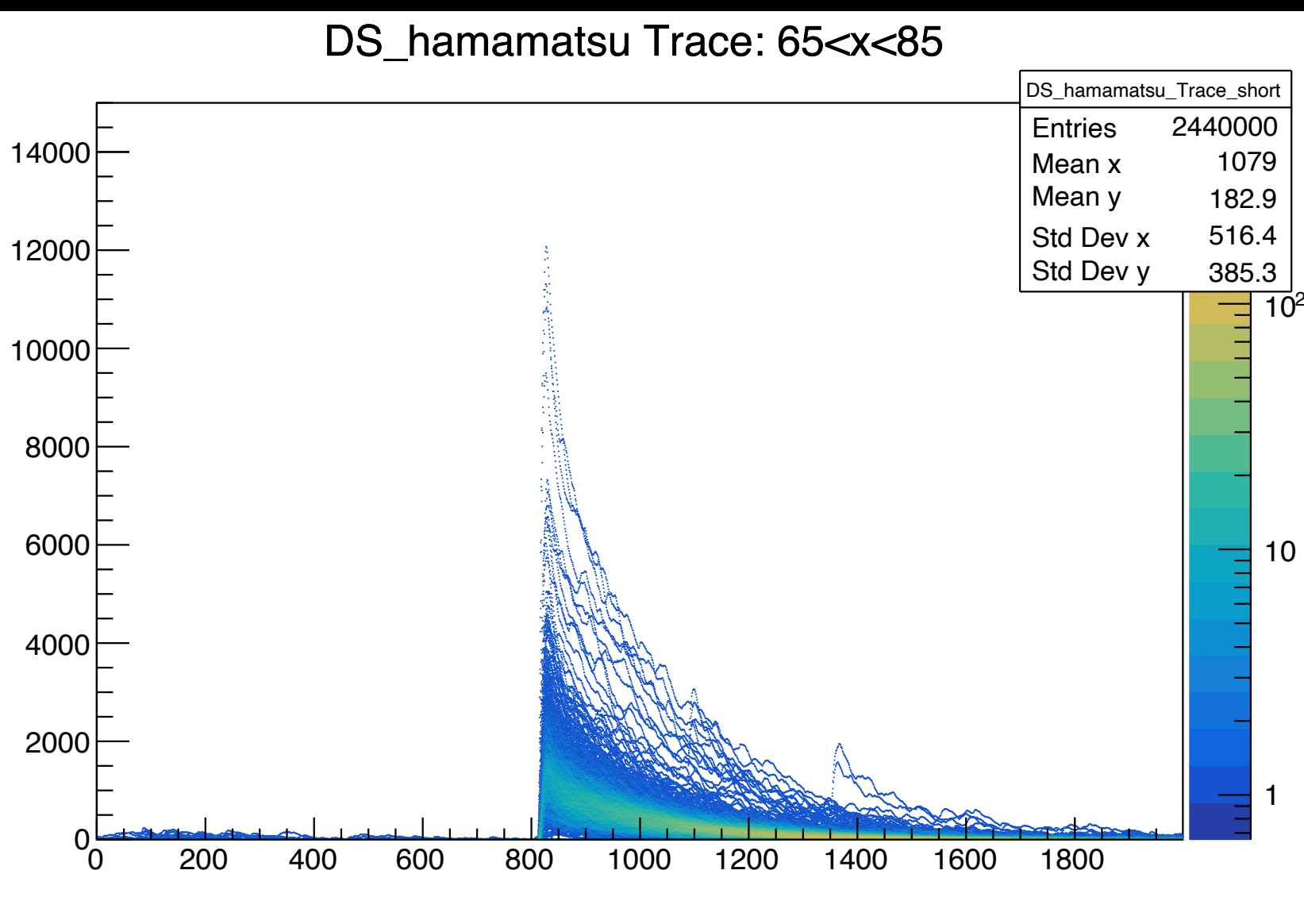
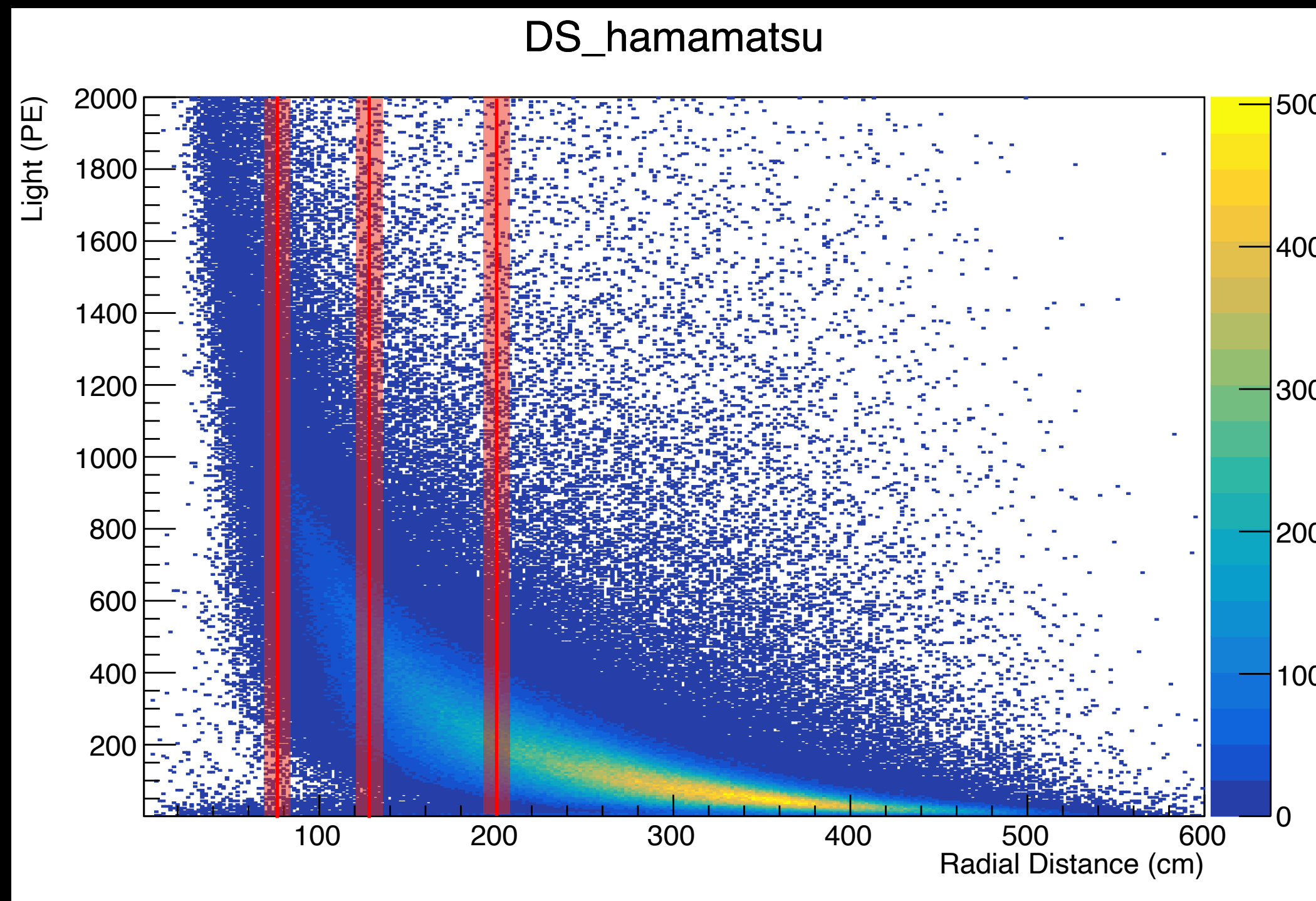
Run 11460
LAr + N + Xenon



SensL

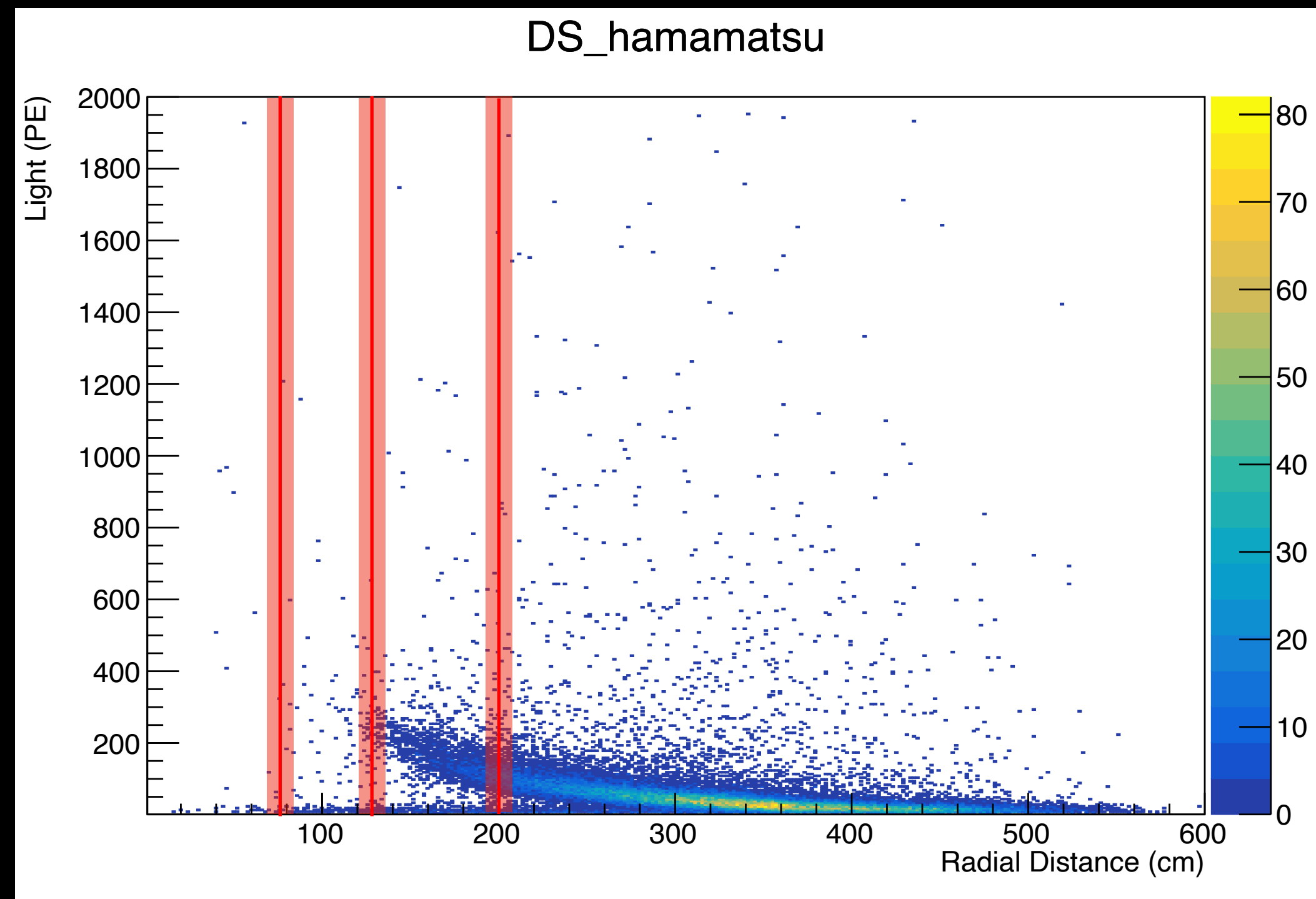
Run	Distance	Amplitude	Integral	Amp % of LAr	Integral % of LAr	fast area / slow area
5785	75	462.7	165259.13	100	100	0.6186
11040	75	327.93	89493.66	71.9	54.2	1.1256
11460	75	440.05	122798.03	95.1	74.3	0.1942
5785	125	224.01	83496.74	100	100.0	0.5965
11040	125	160.61	47157.02	71.7	56.5	1.0142
11460	125	227.67	67471.04	101.6	80.8	0.17
5785	200	101.76	42392.1	100	100.0	0.526
11040	200	292.93	84509.65	287.9	199.4	0.6567
11460	200	117.7	40202.76	115.7	94.8	0.145

run 5785 Hamamatsu

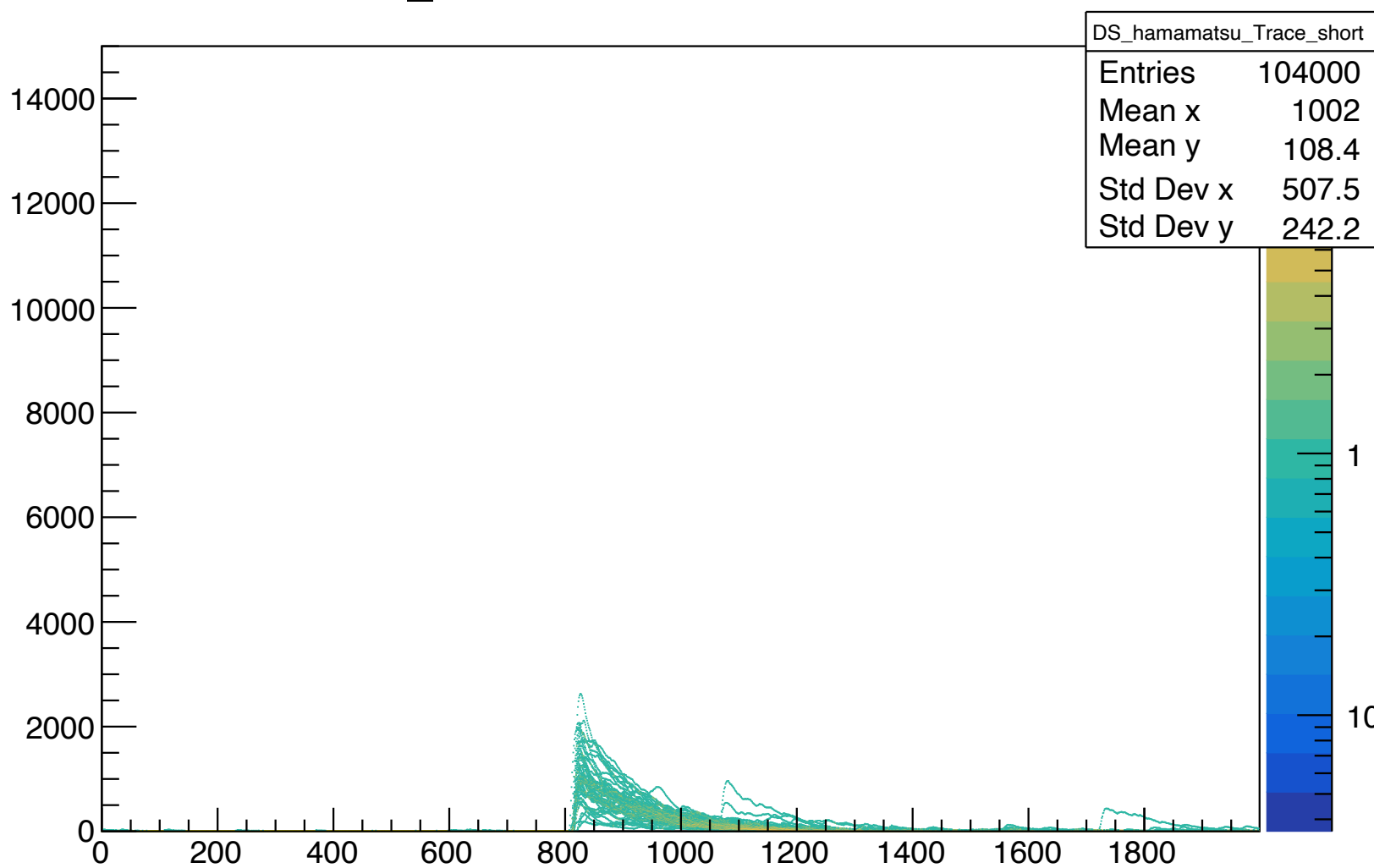


run 10440

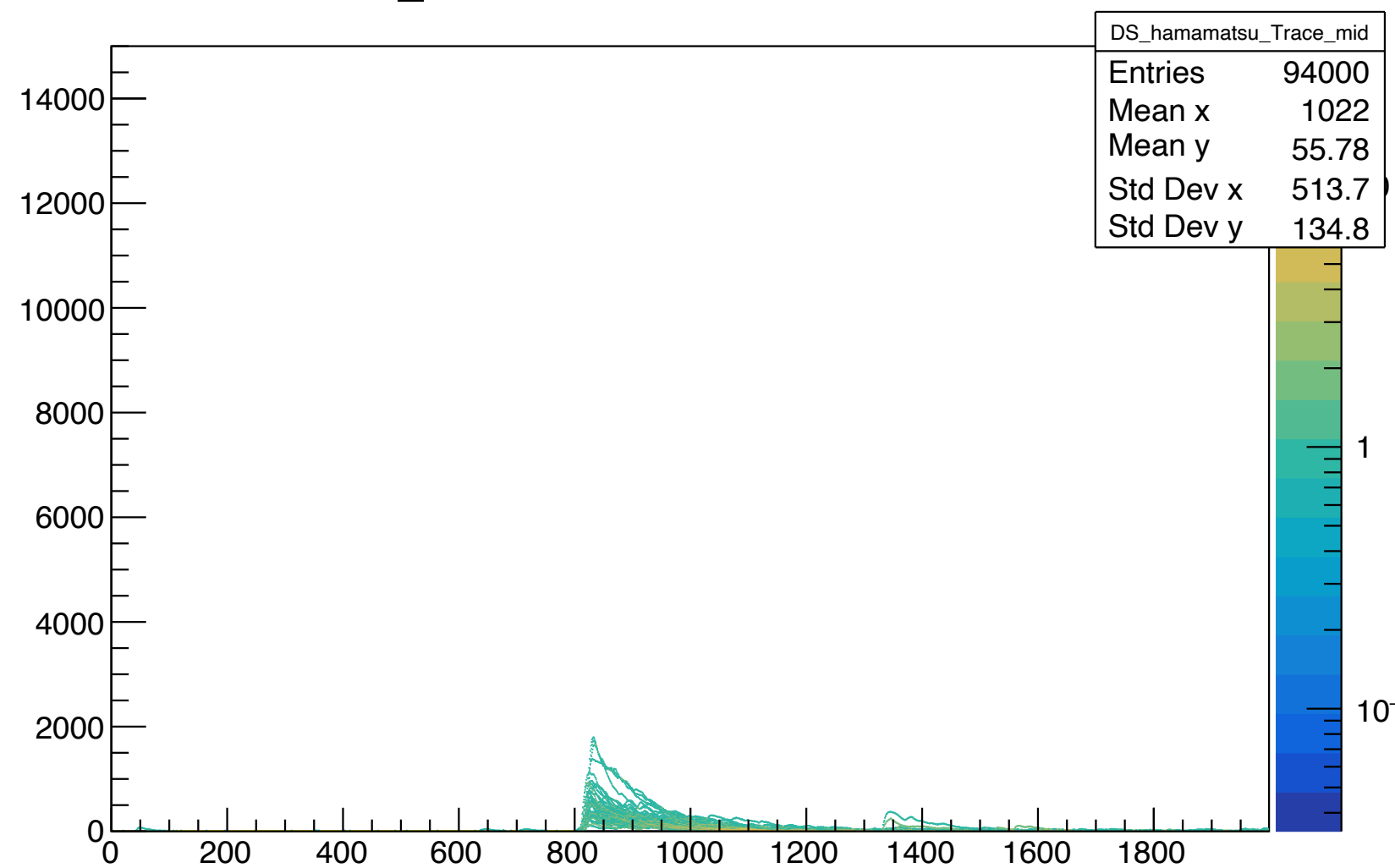
Hamamatsu



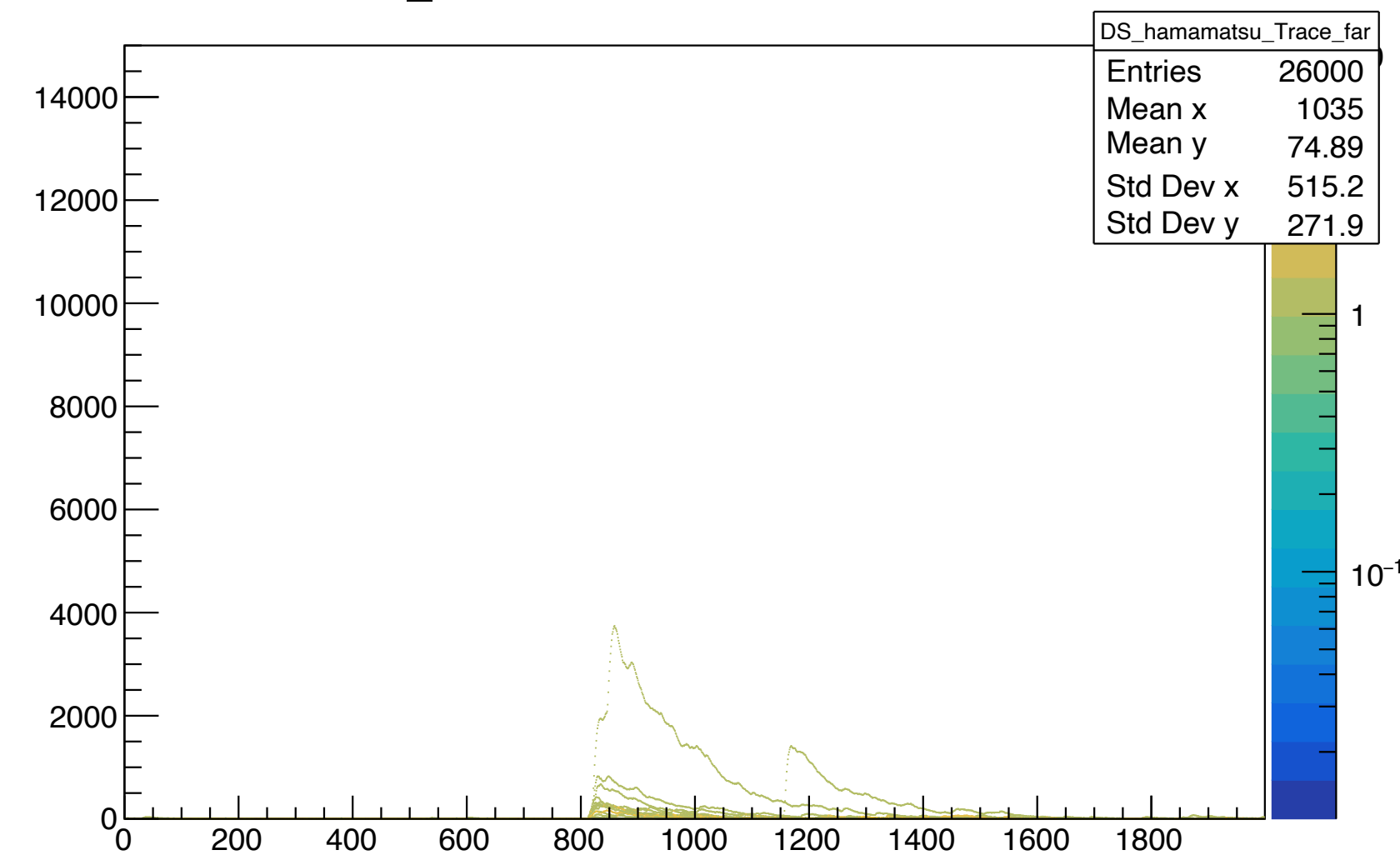
DS_hamamatsu Trace: $65 < x < 85$



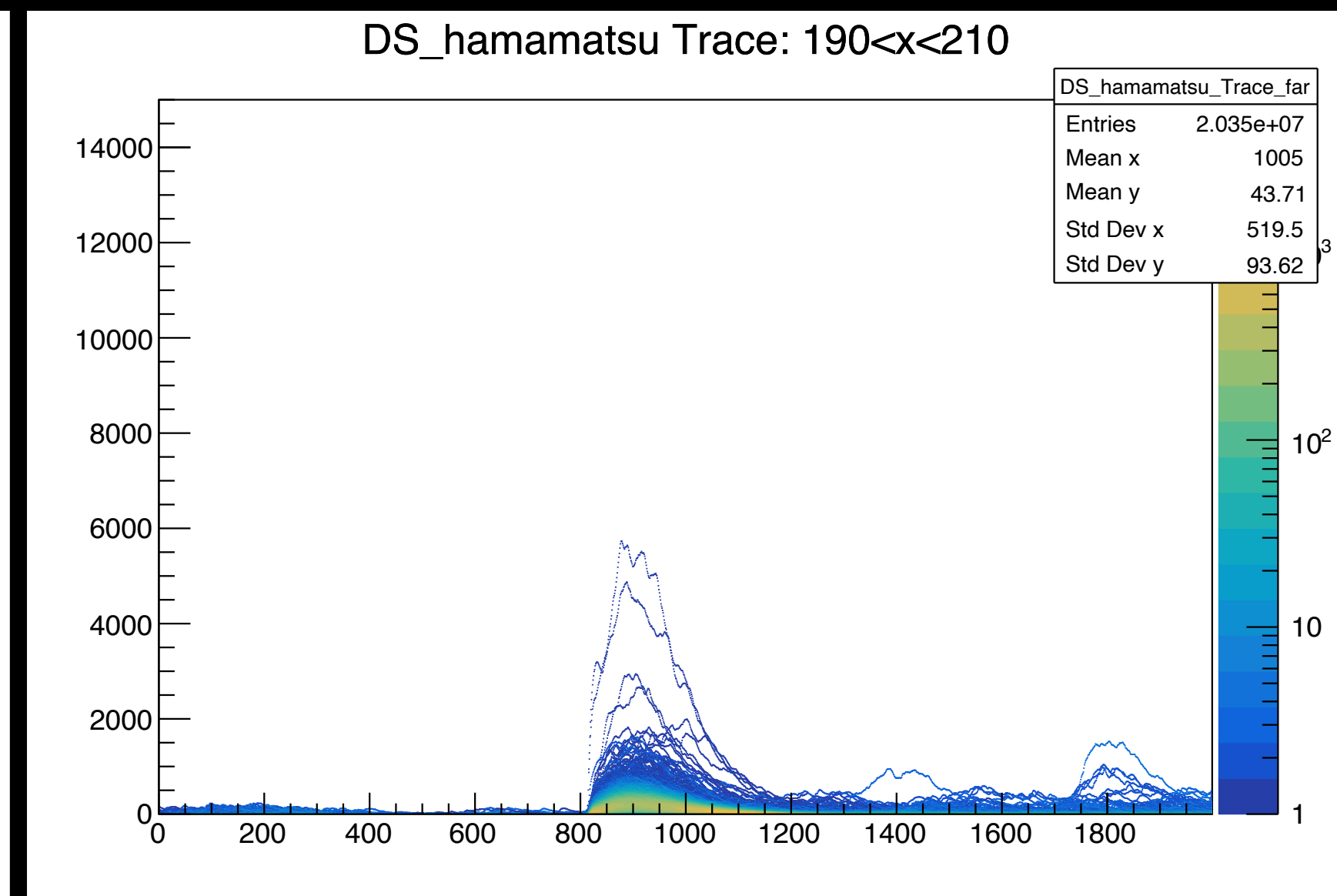
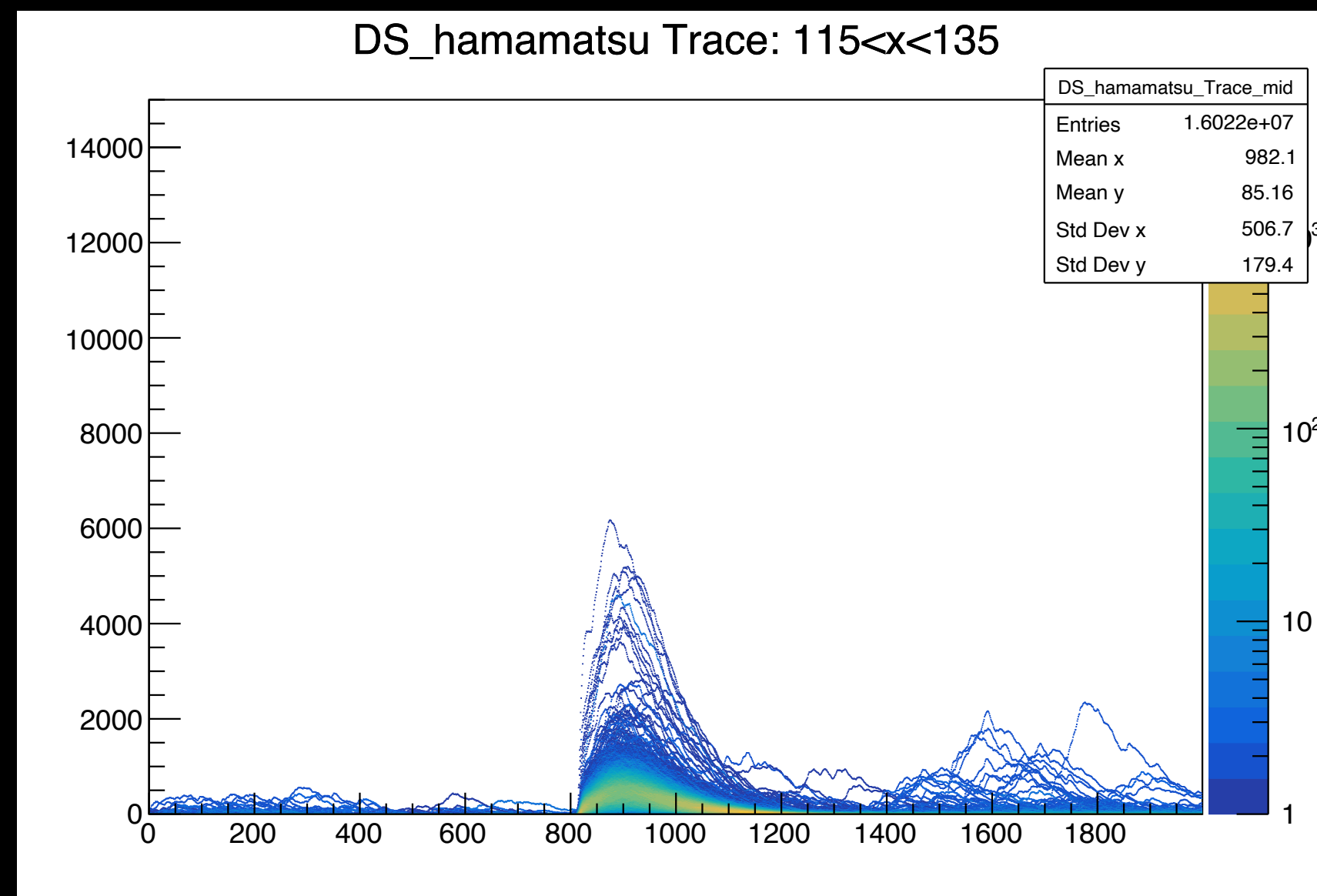
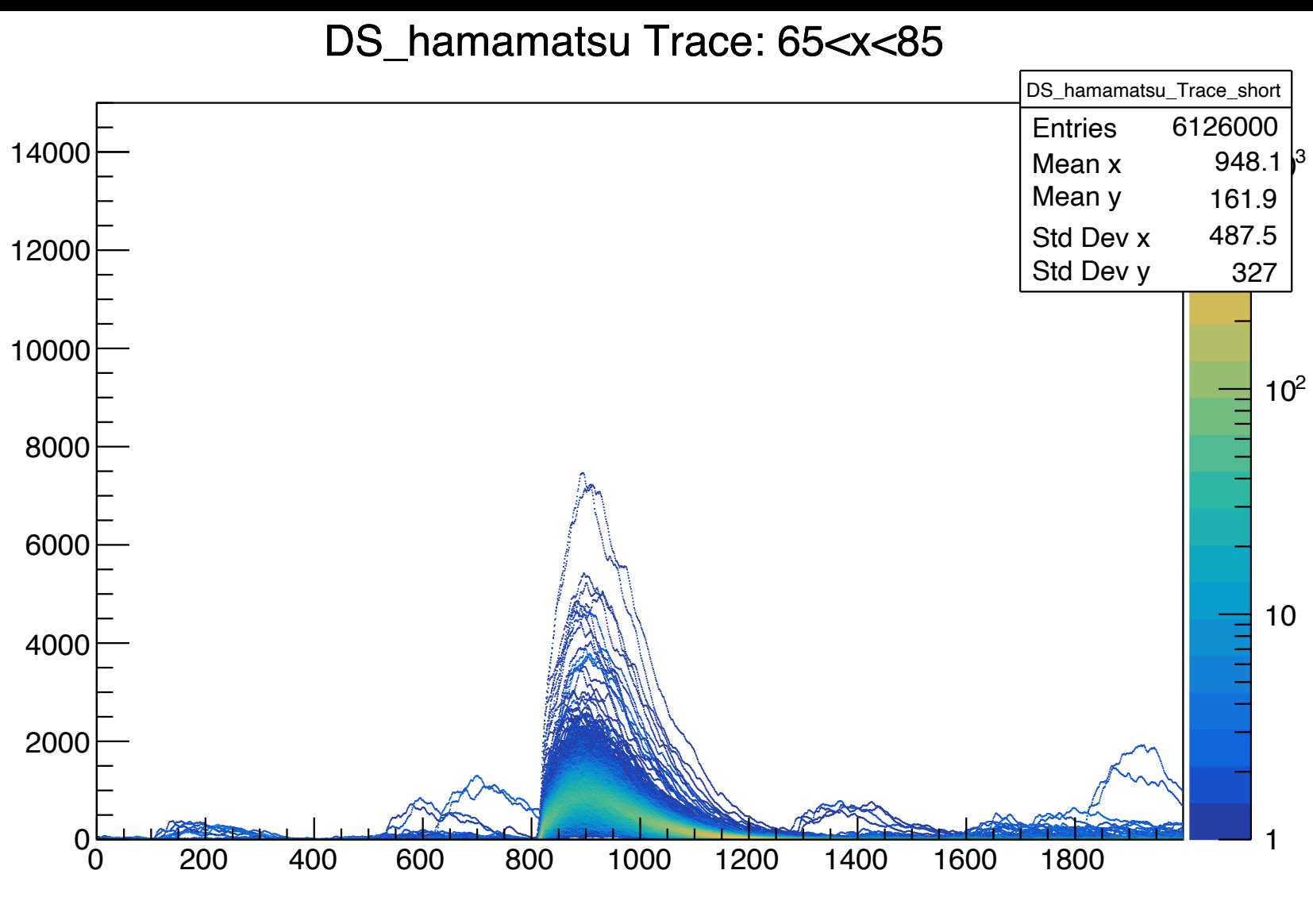
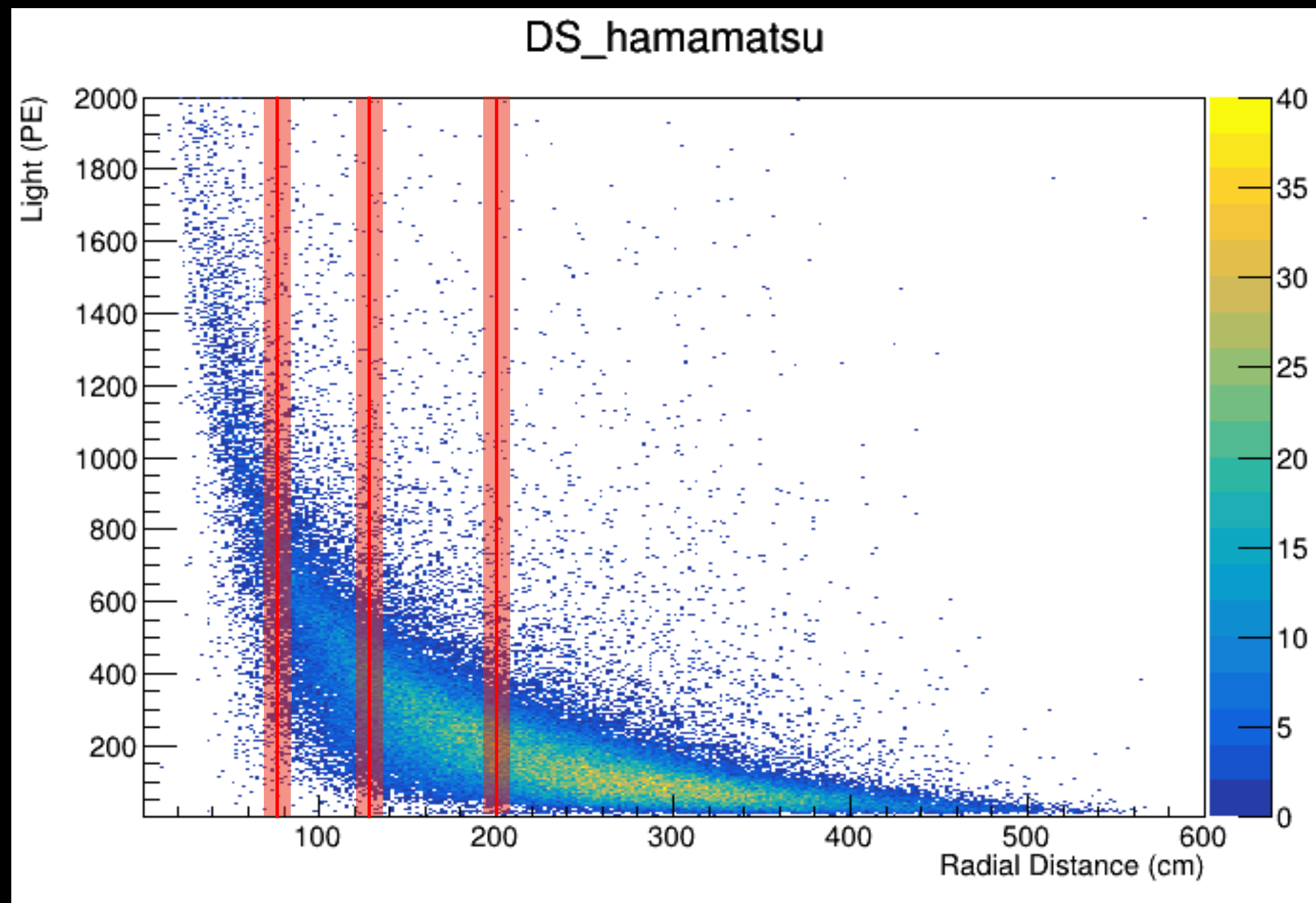
DS_hamamatsu Trace: $115 < x < 135$



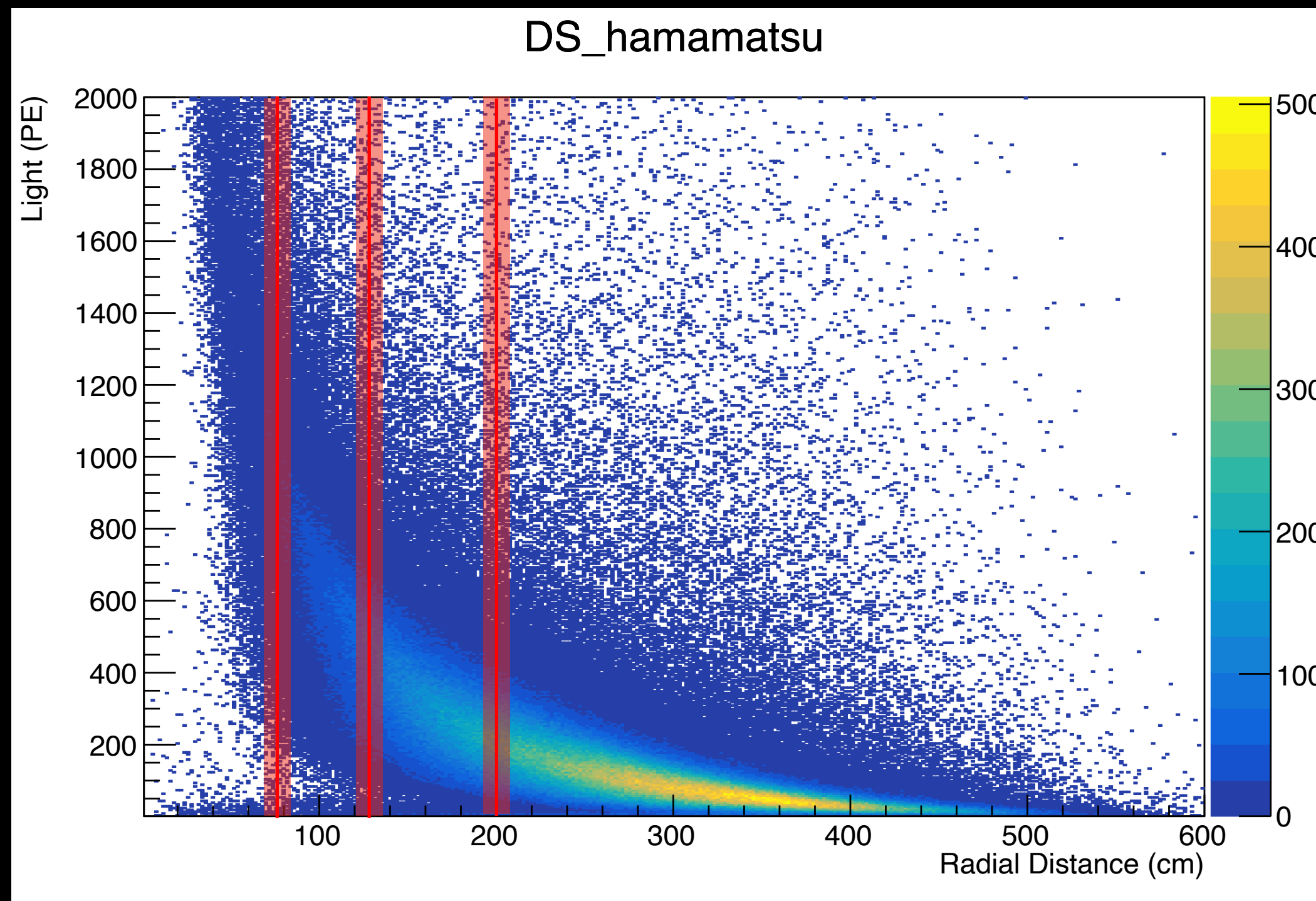
DS_hamamatsu Trace: $190 < x < 210$



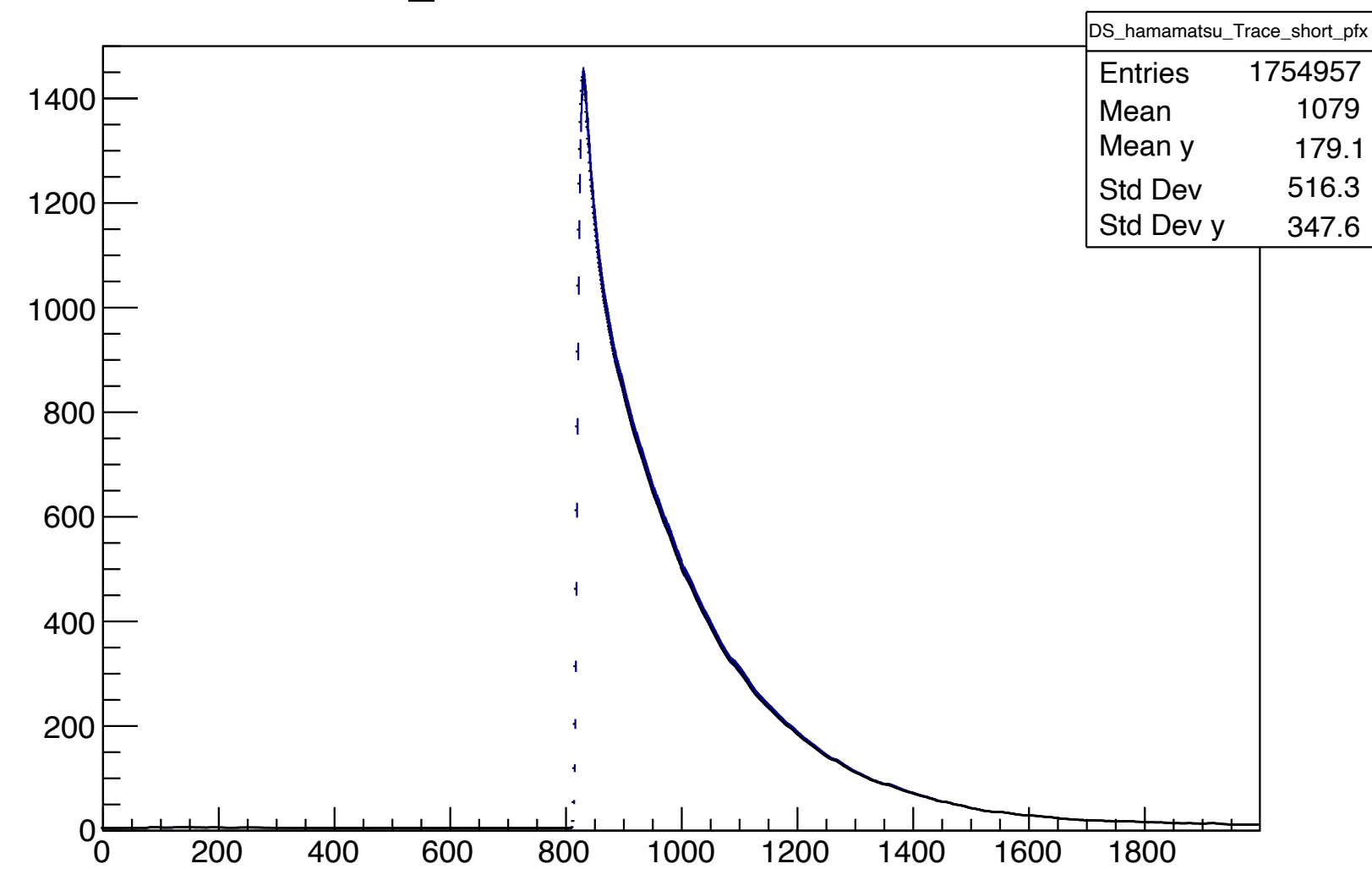
run 11460 Hamamatsu



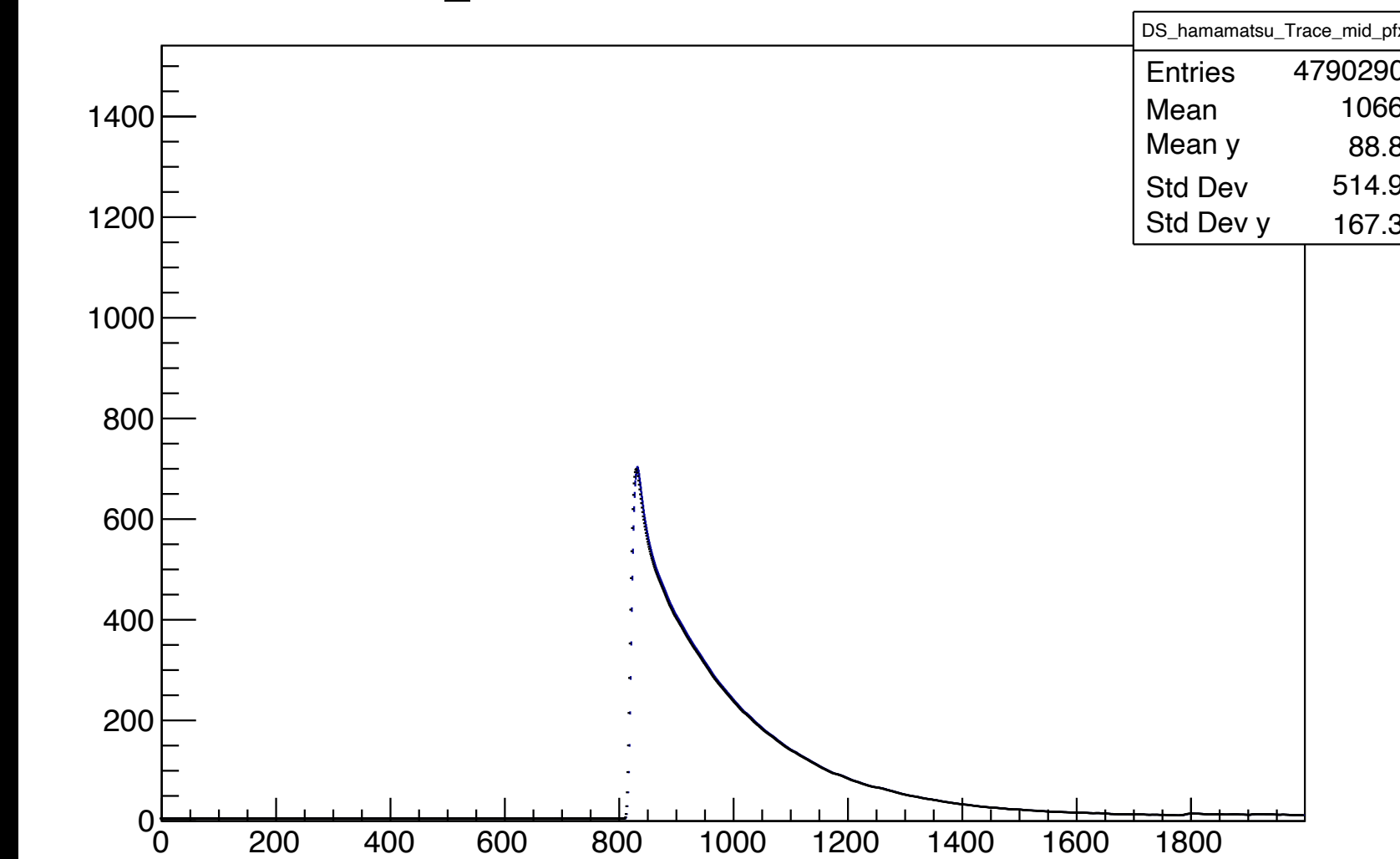
run 5785 Hamamatsu



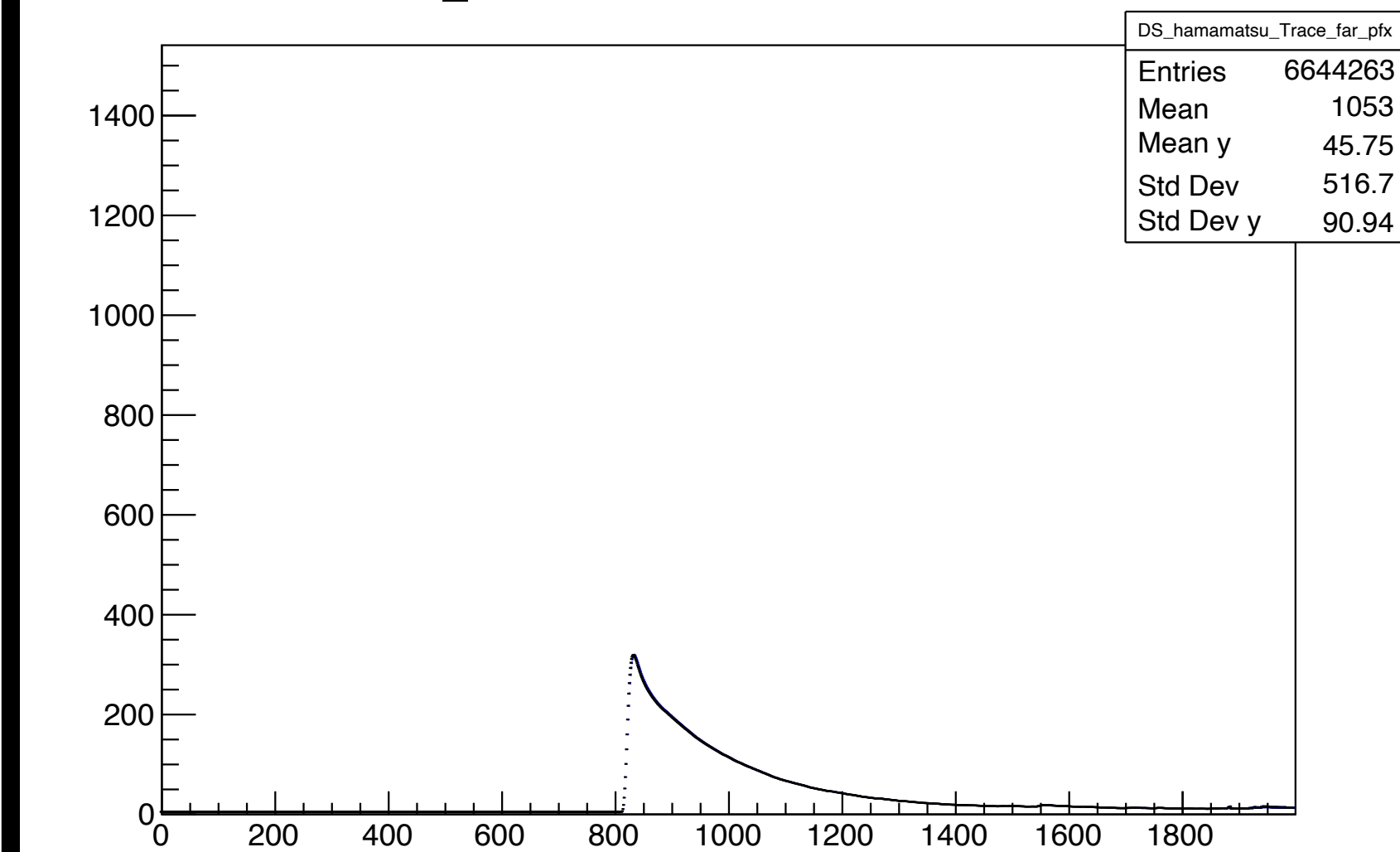
DS_hamamatsu Trace: 65<x<85



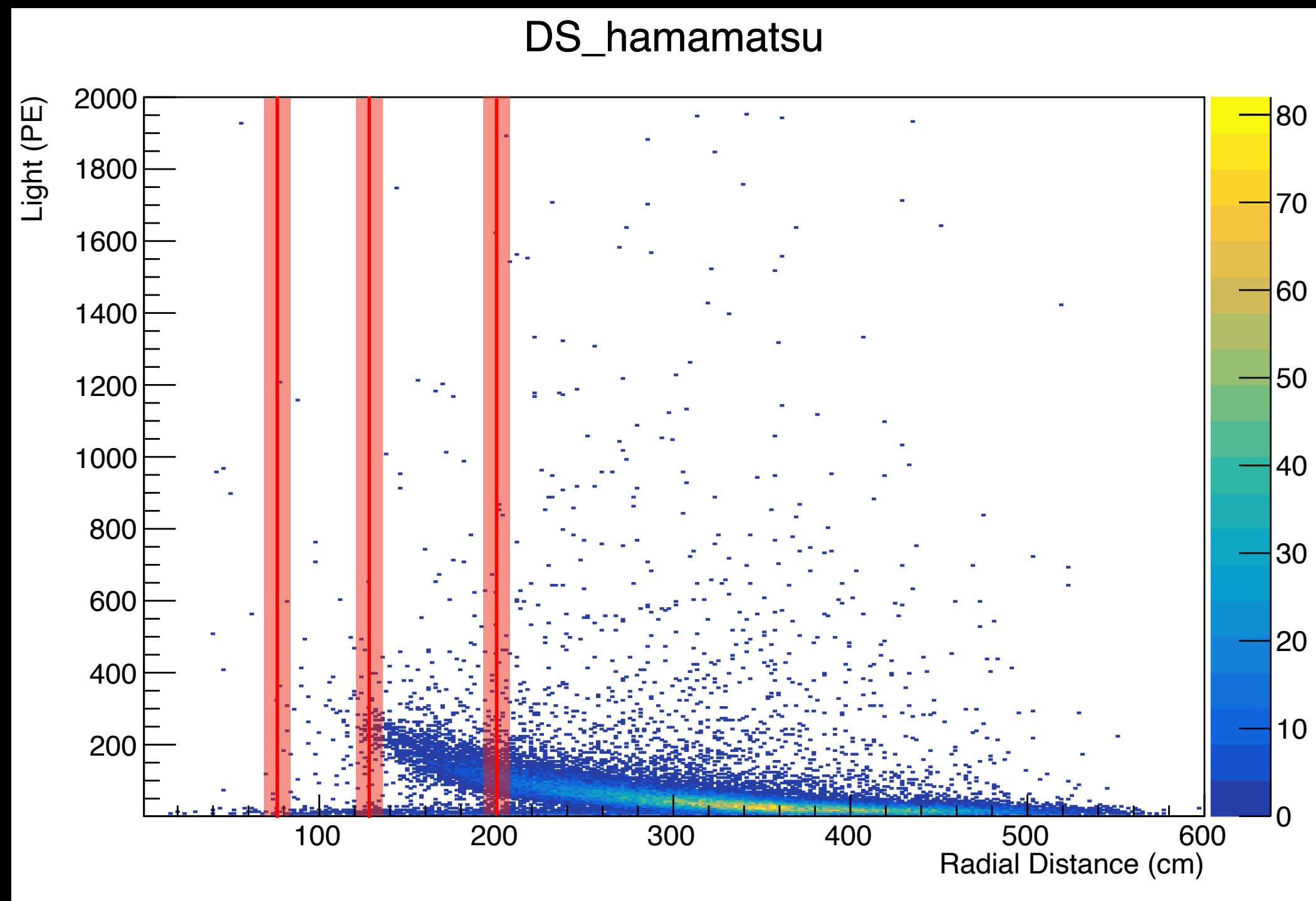
DS_hamamatsu Trace: 115<x<135



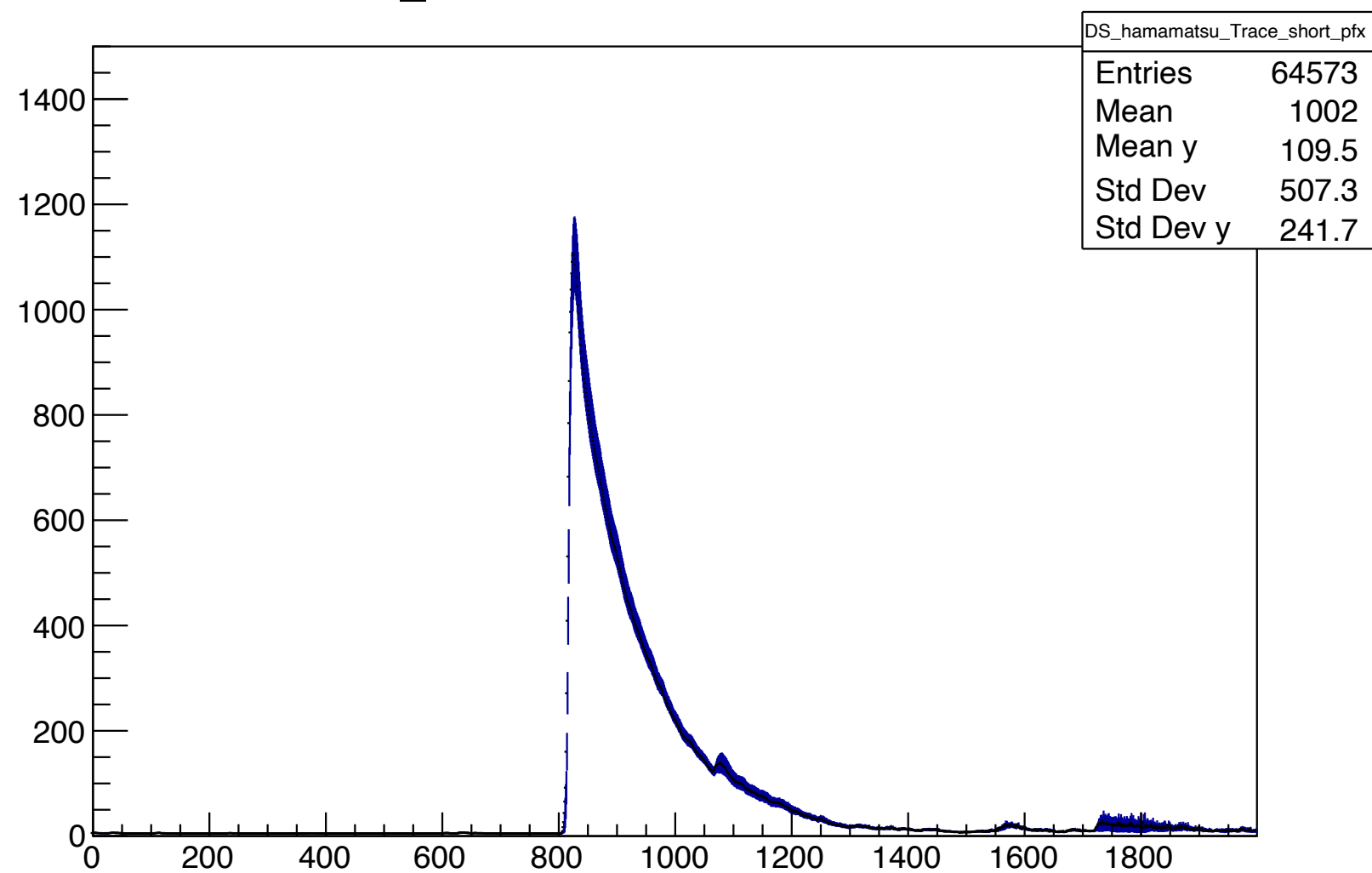
DS_hamamatsu Trace: 190<x<210



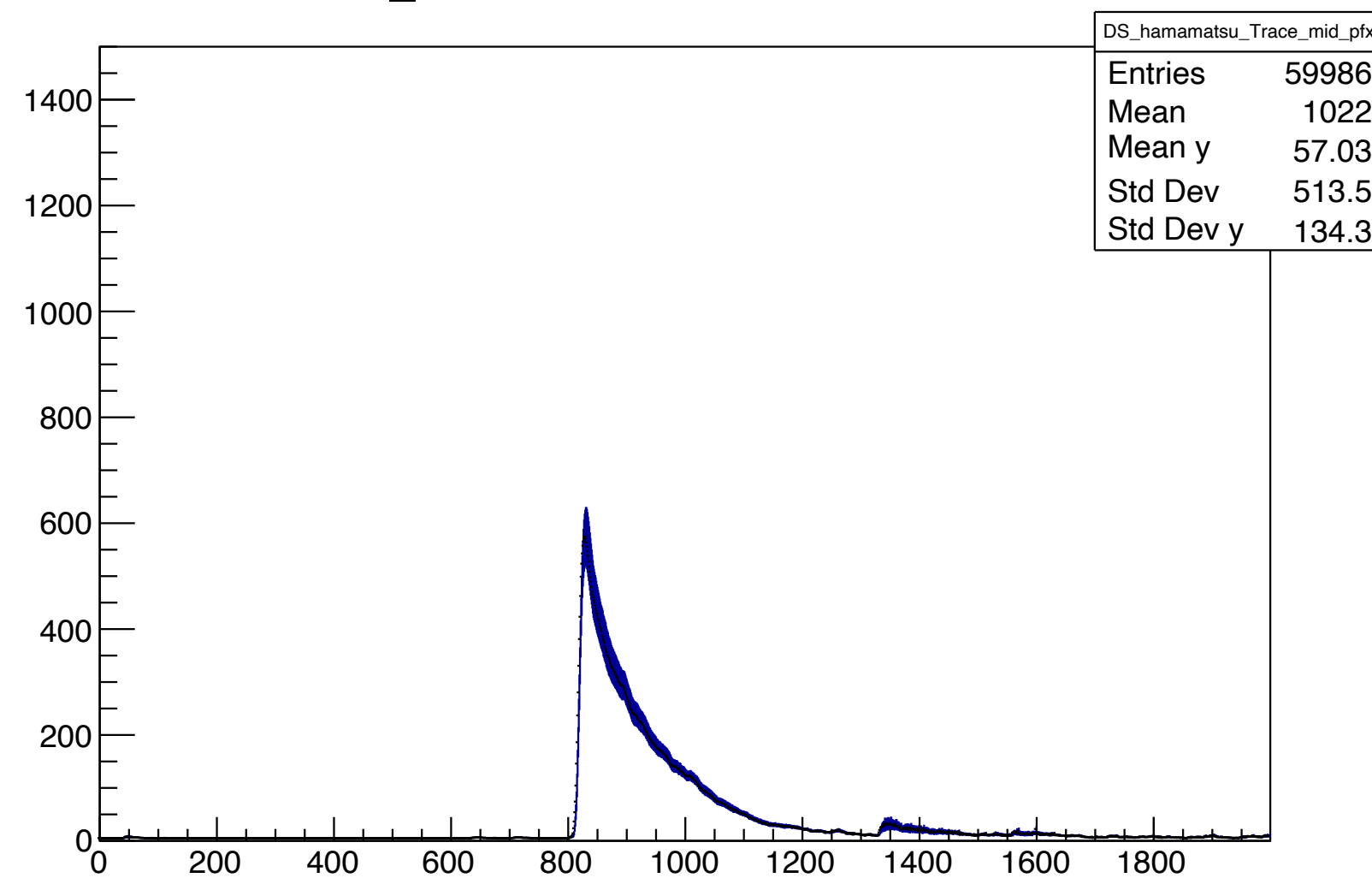
run 10440 Hamamatsu



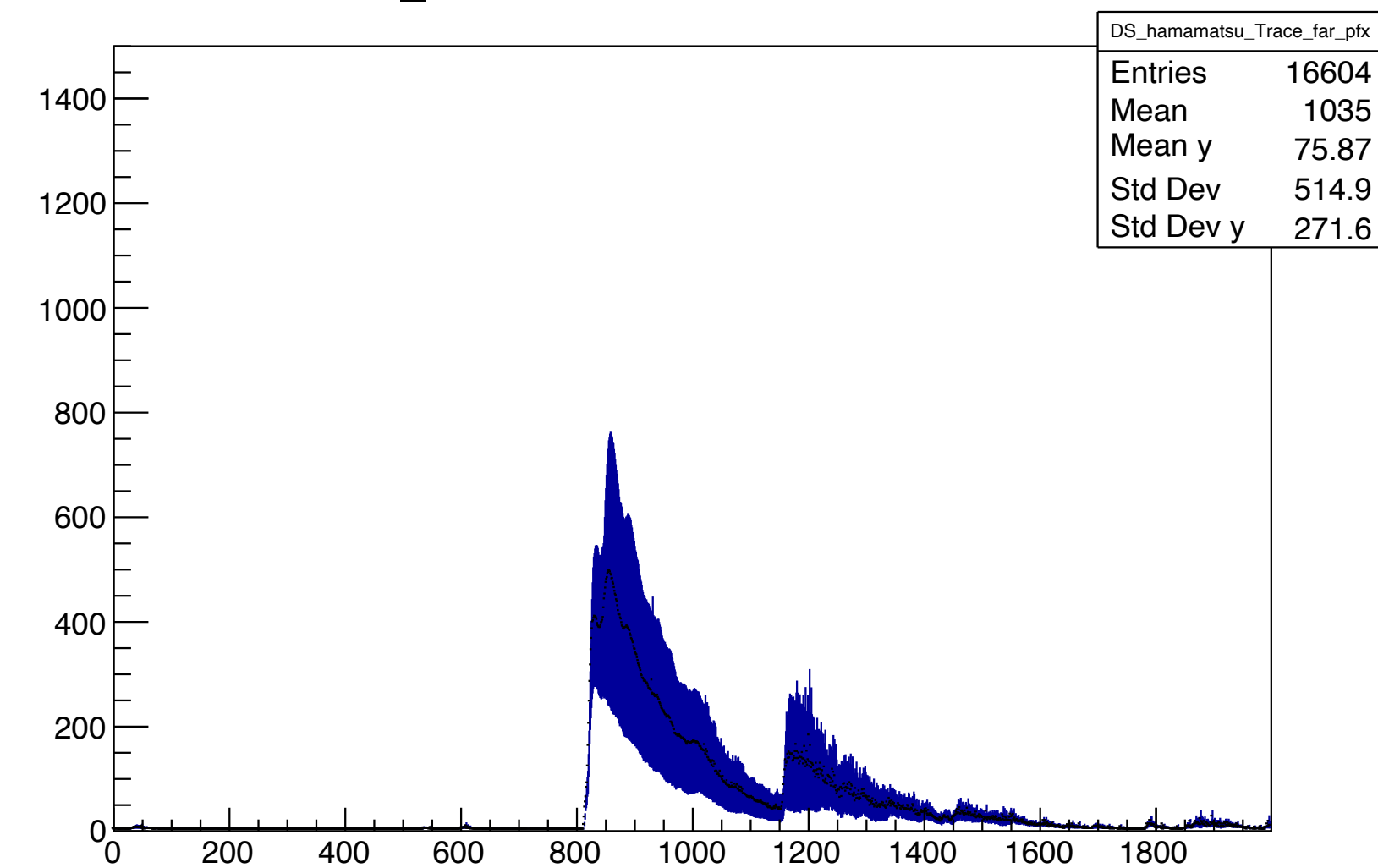
DS_hamamatsu Trace: $65 < x < 85$



DS_hamamatsu Trace: $115 < x < 135$

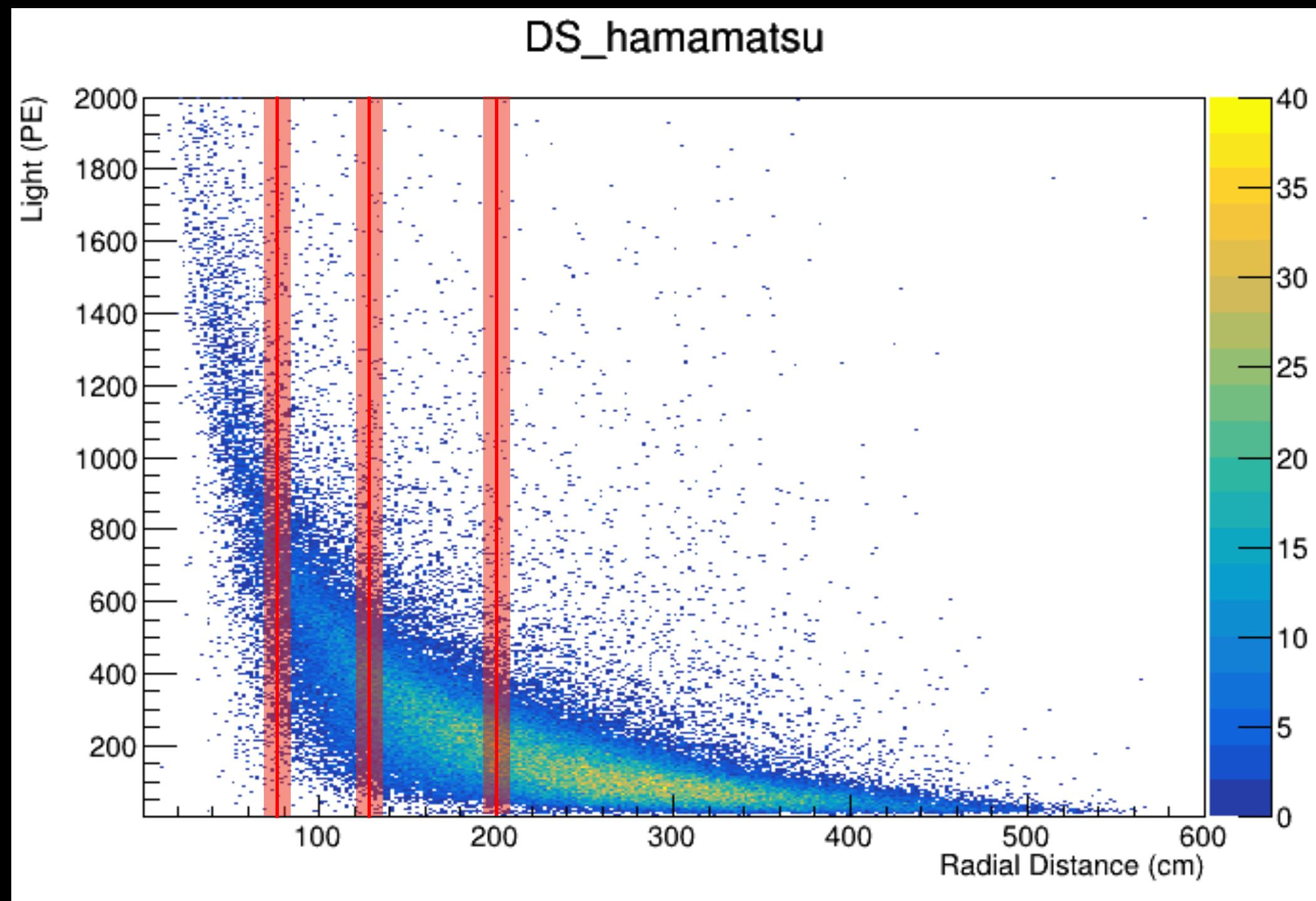


DS_hamamatsu Trace: $190 < x < 210$

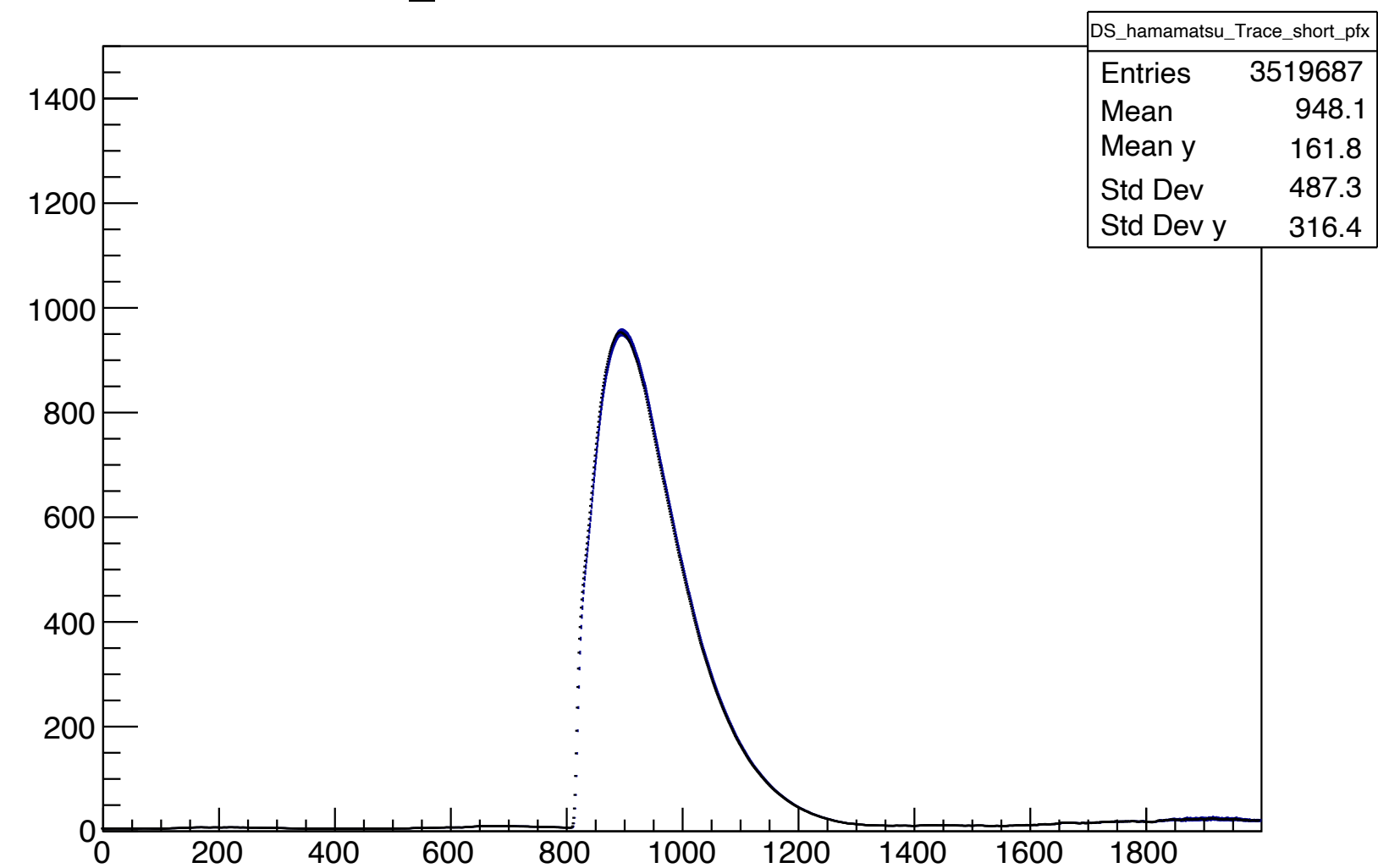


run 11460

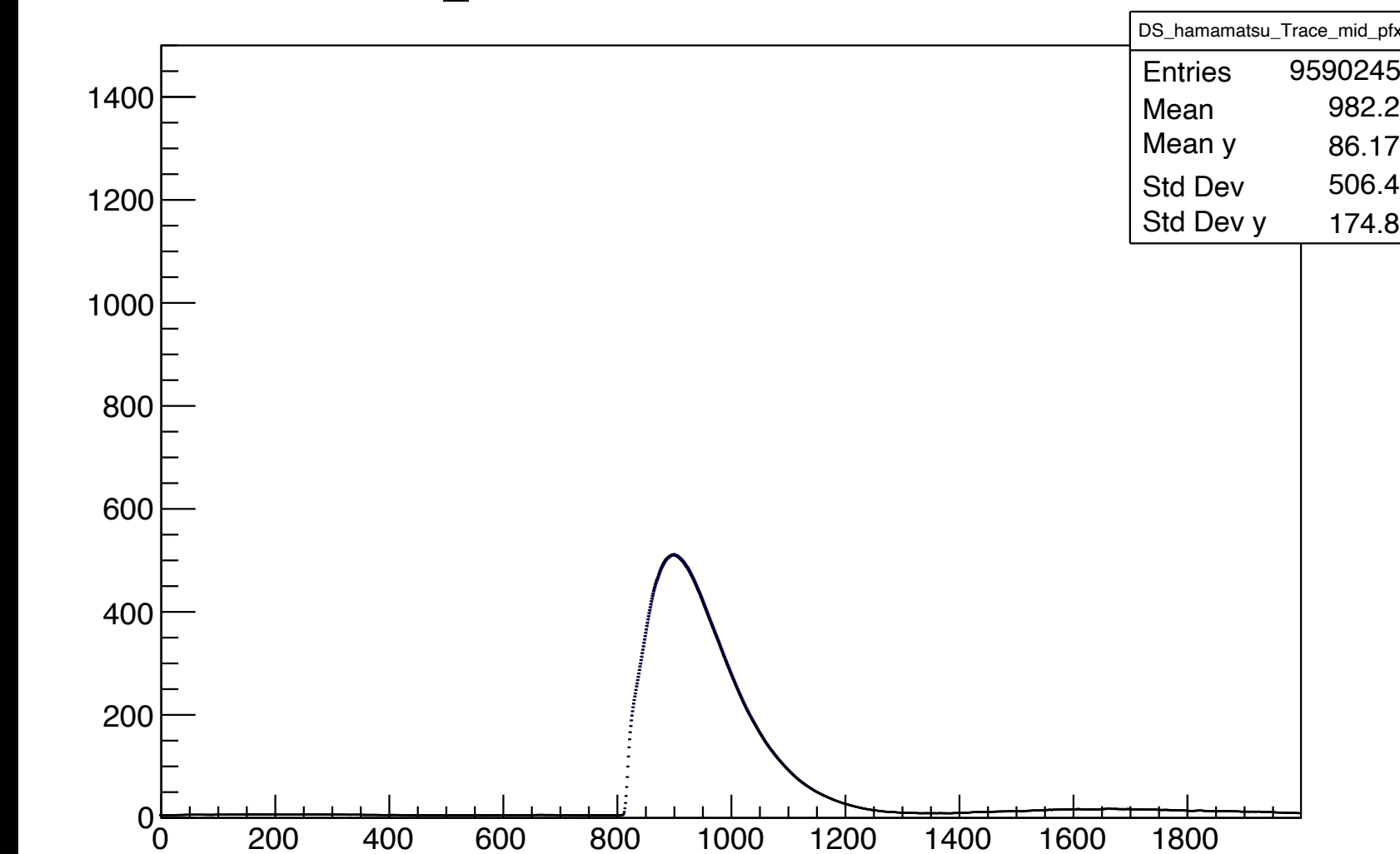
Hamamatsu



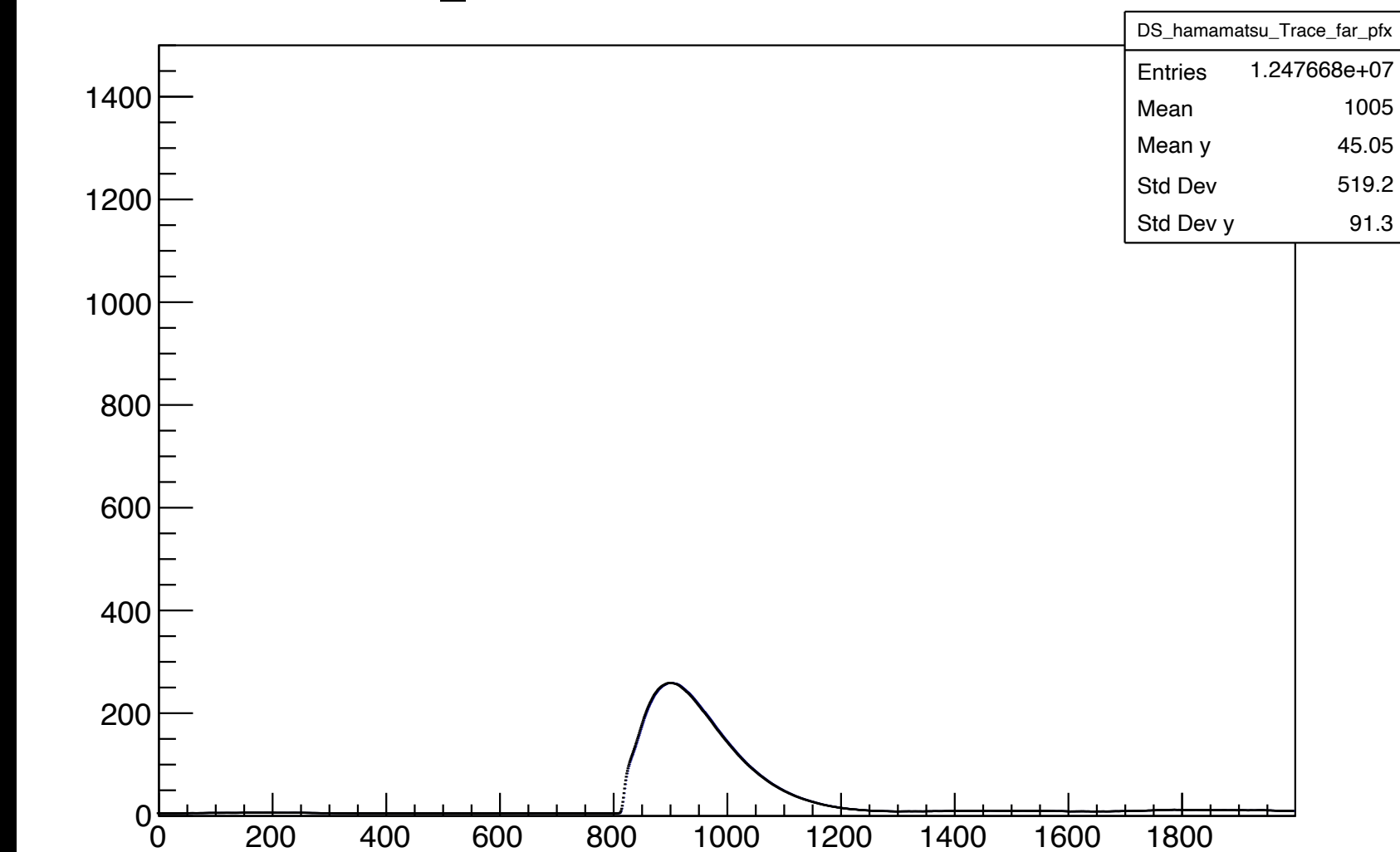
DS_hamamatsu Trace: 65<x<85



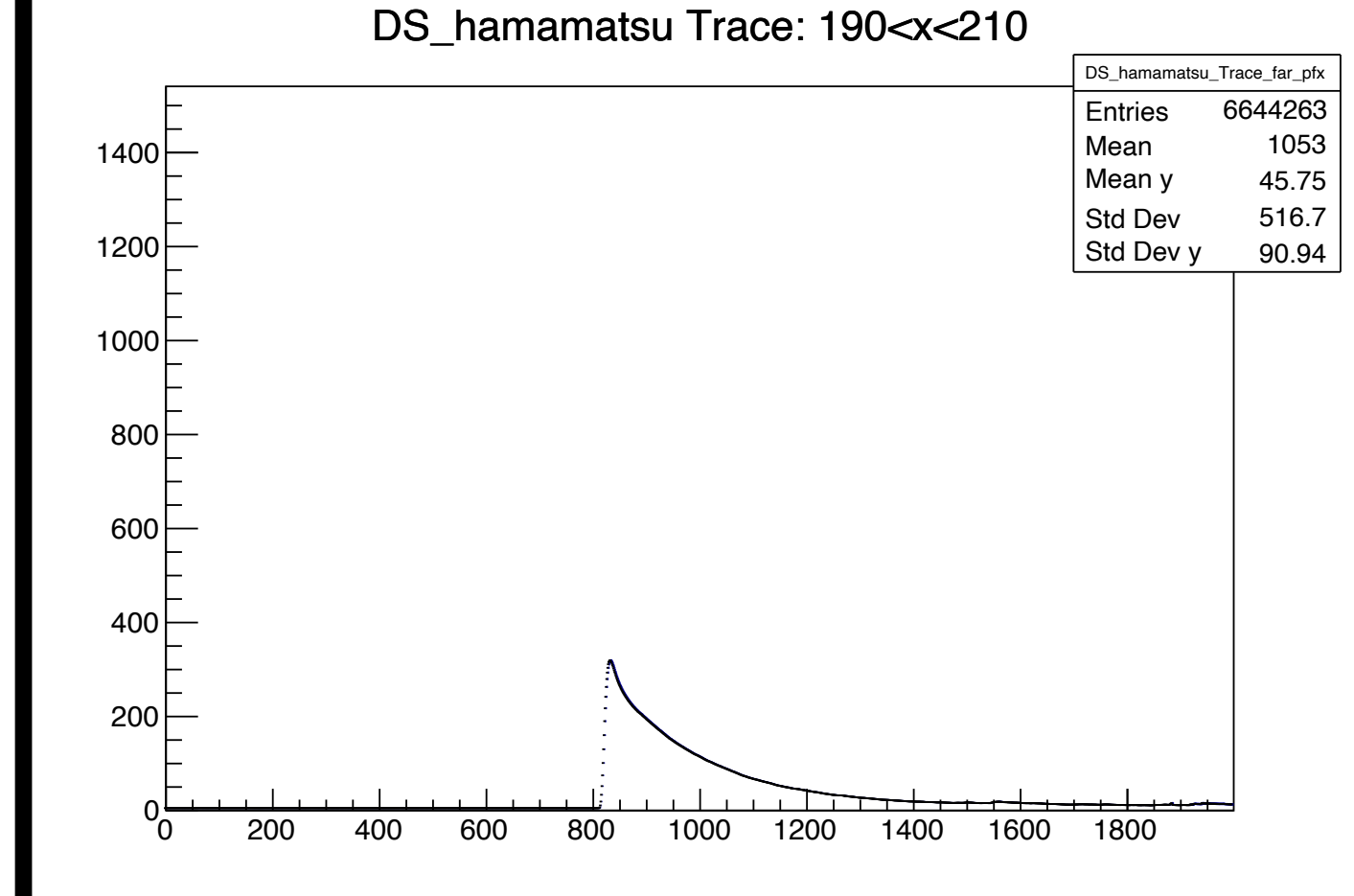
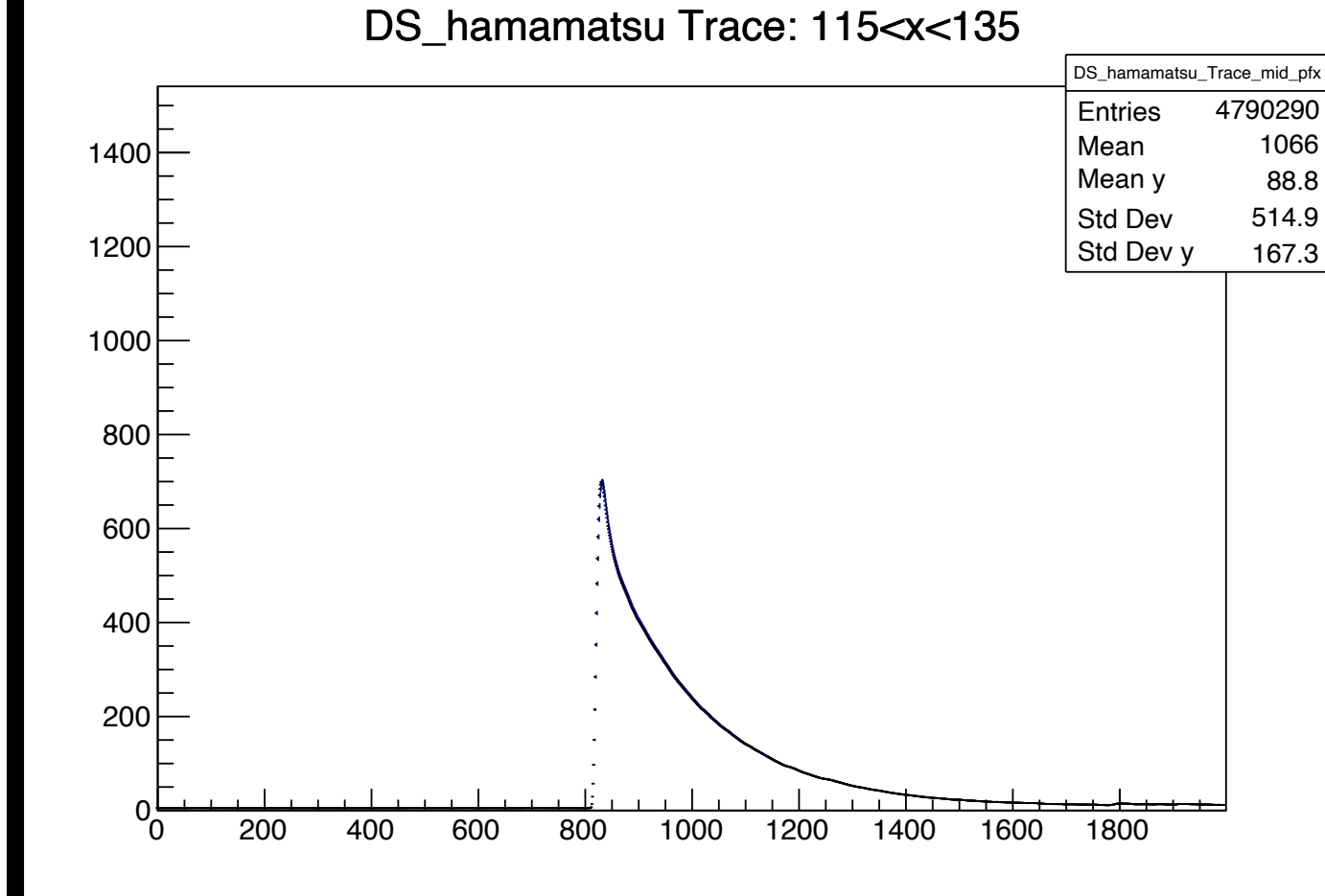
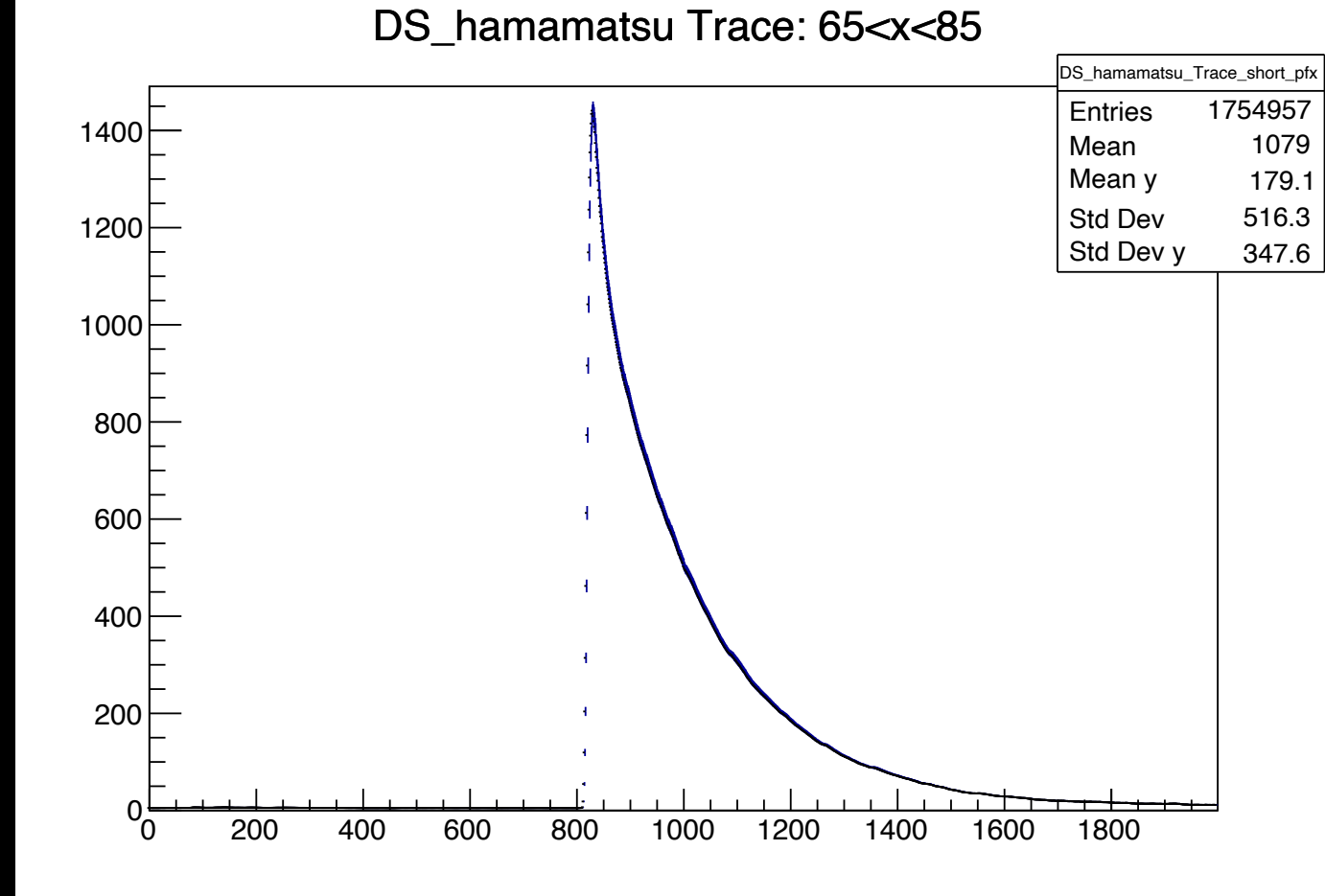
DS_hamamatsu Trace: 115<x<135



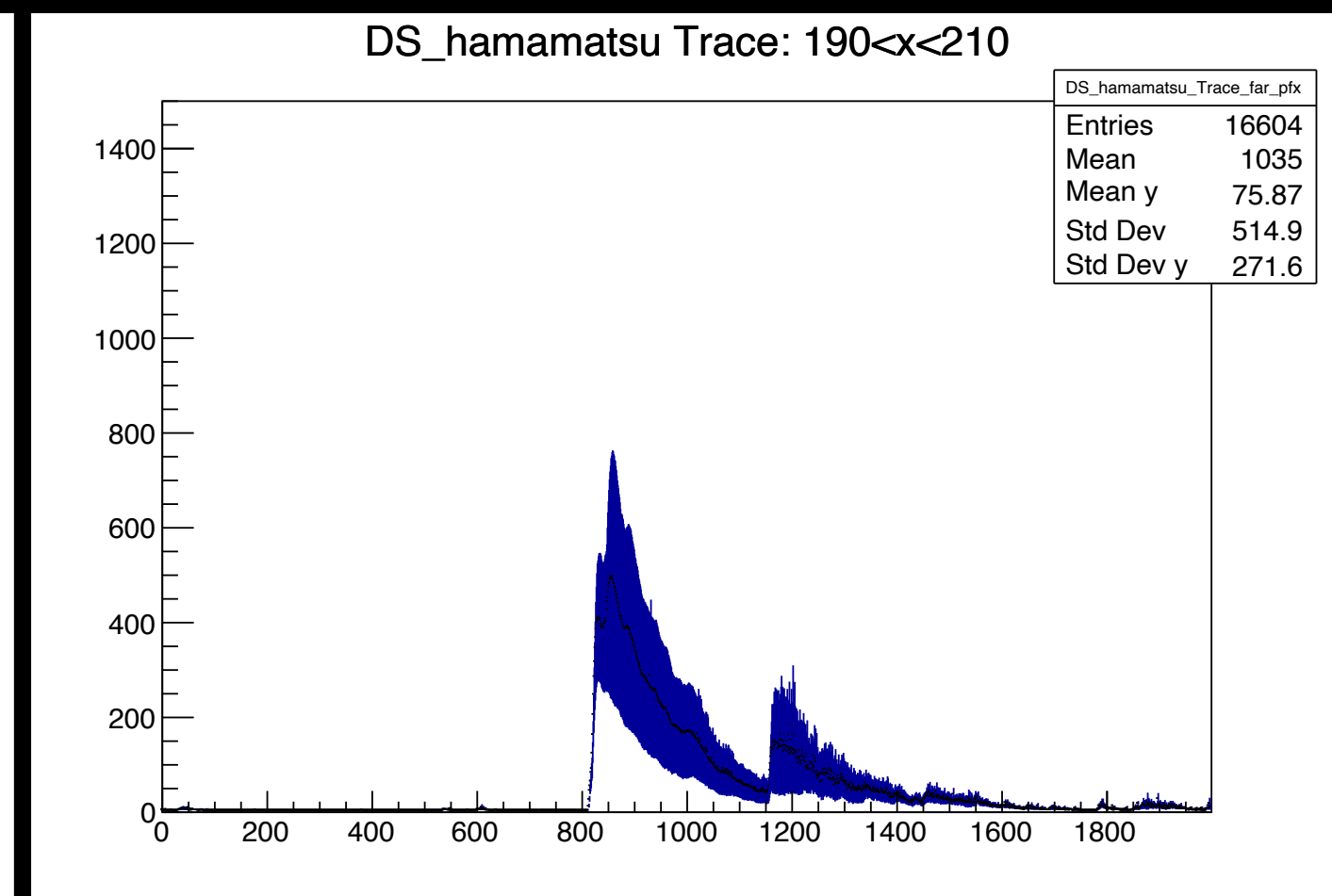
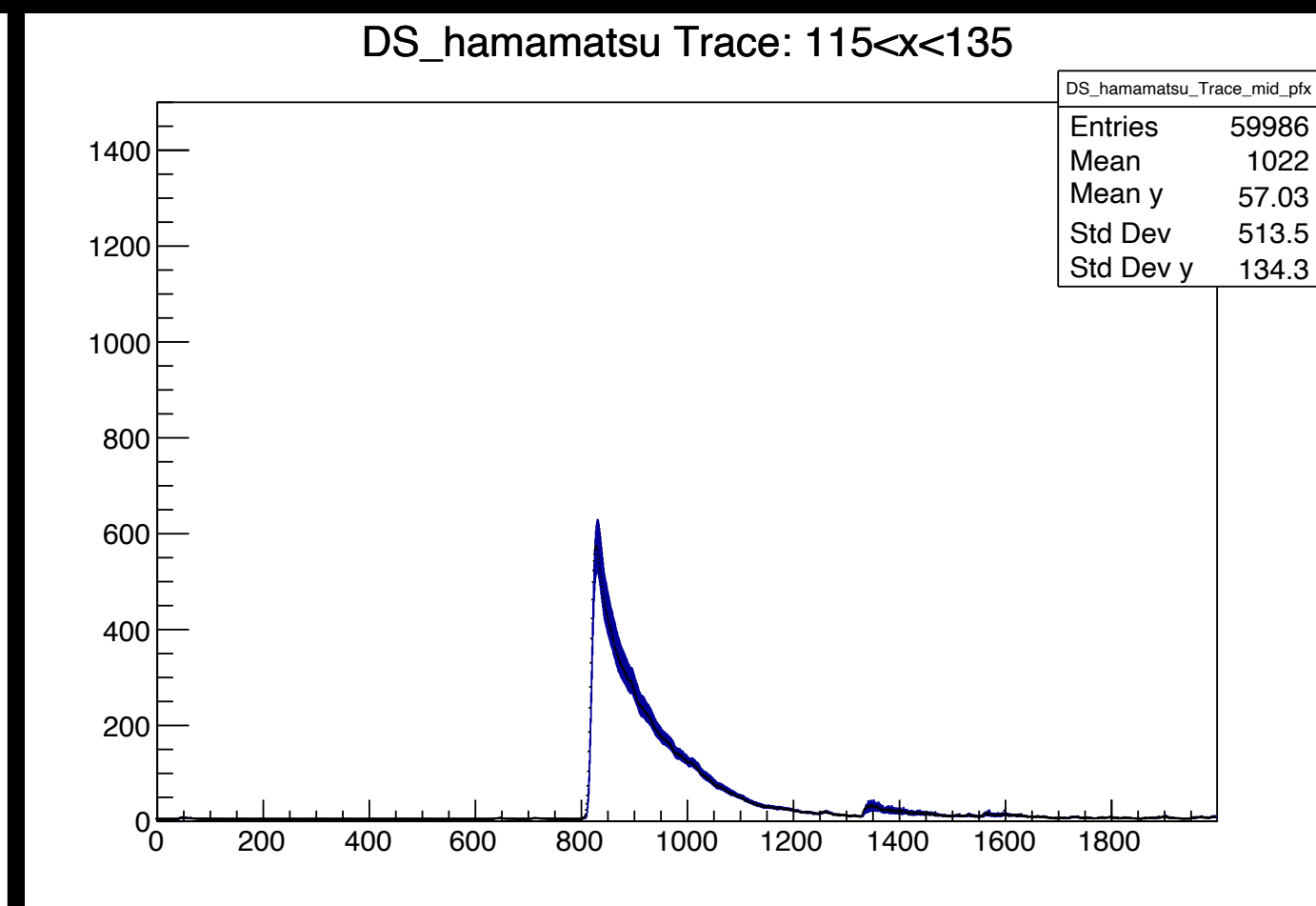
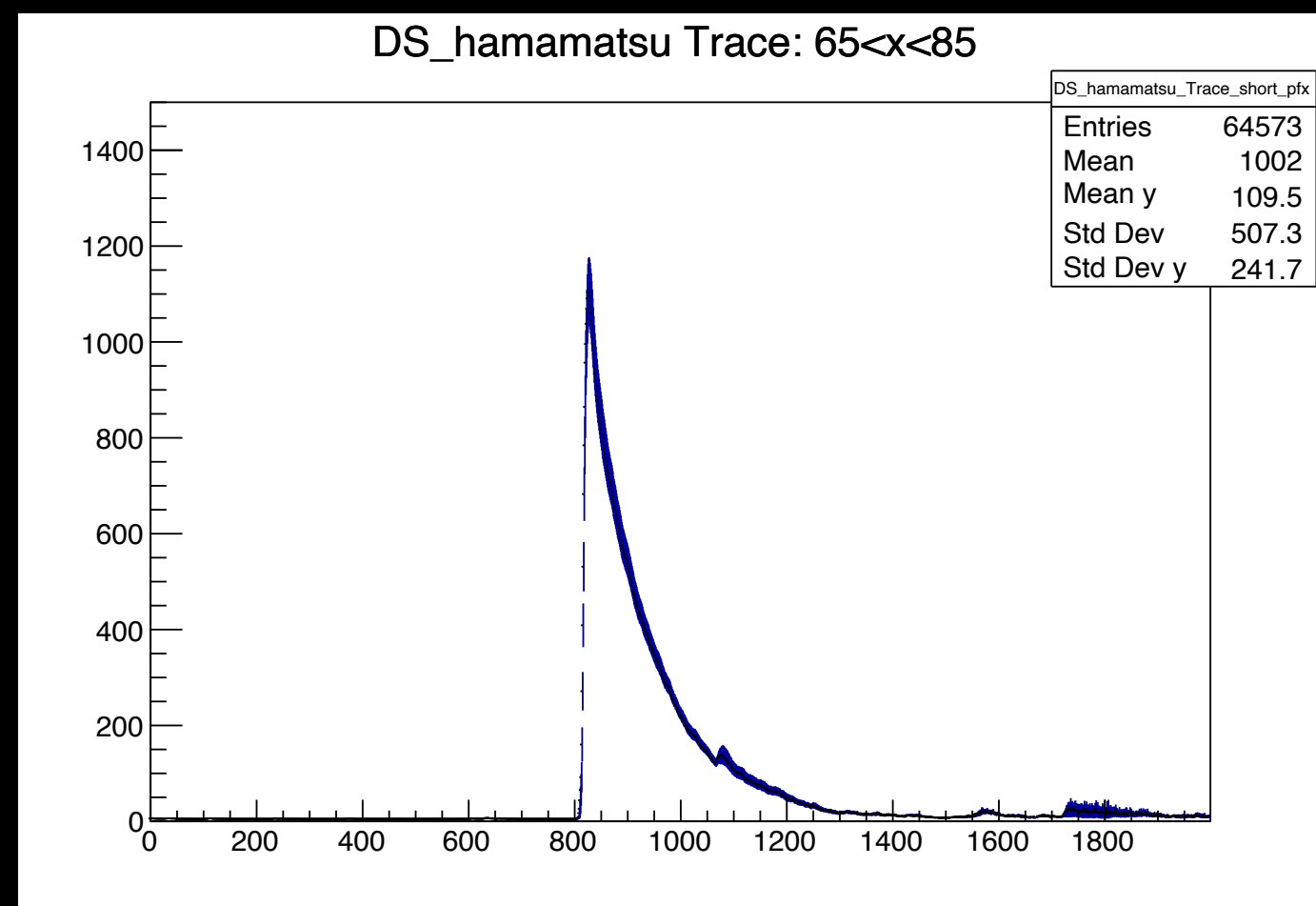
DS_hamamatsu Trace: 190<x<210



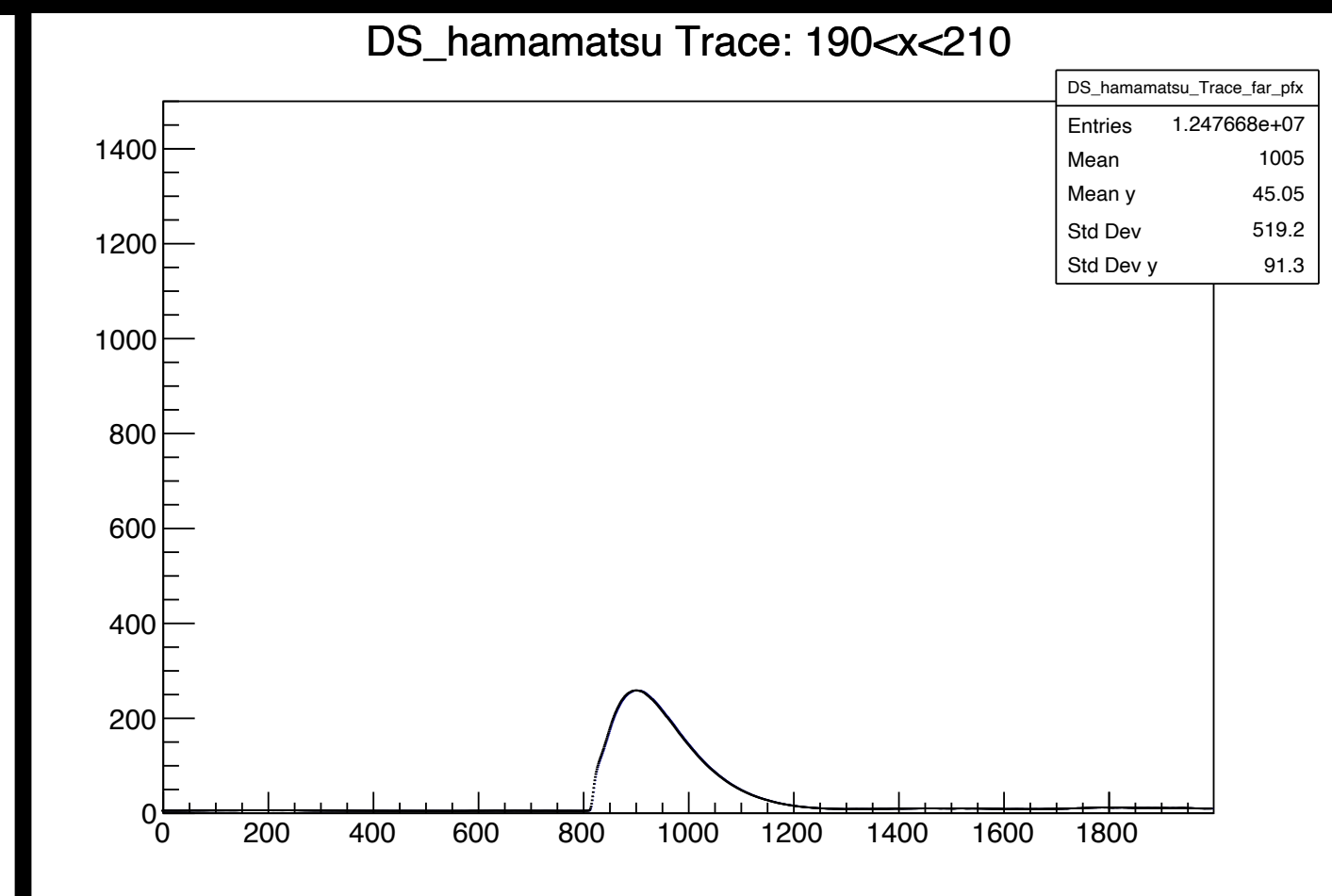
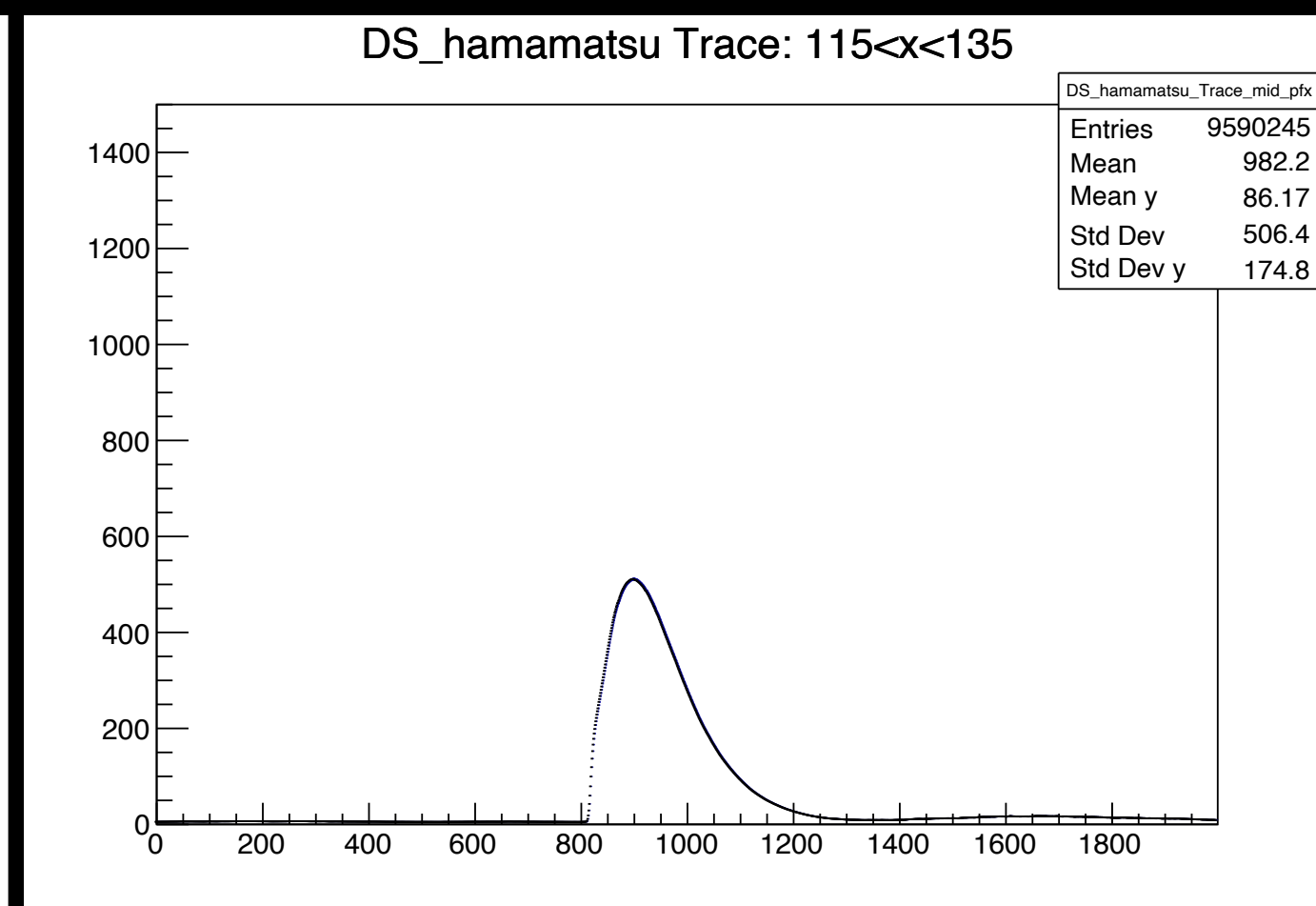
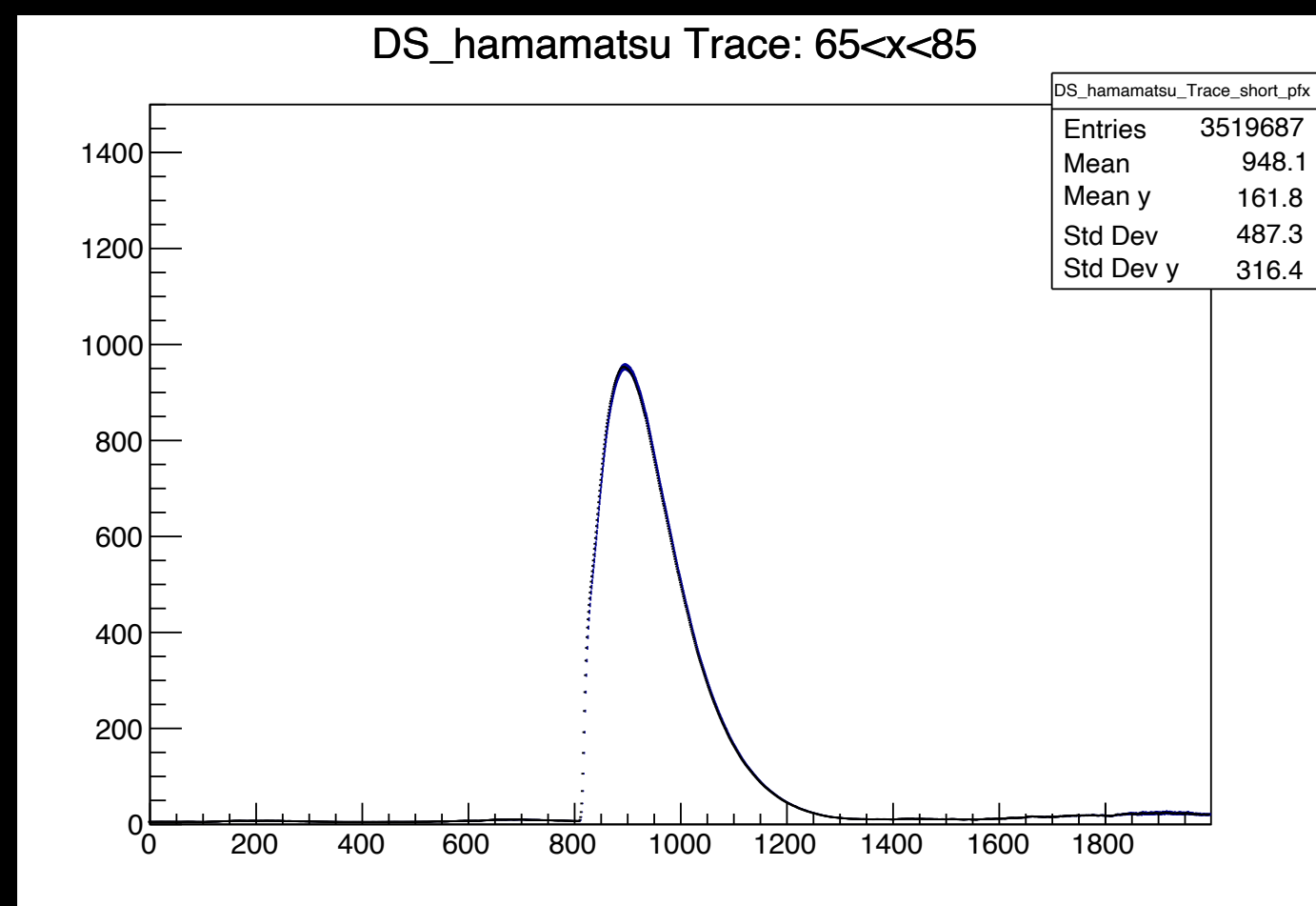
Run 5785
LAr



Run 10440
LAr + N



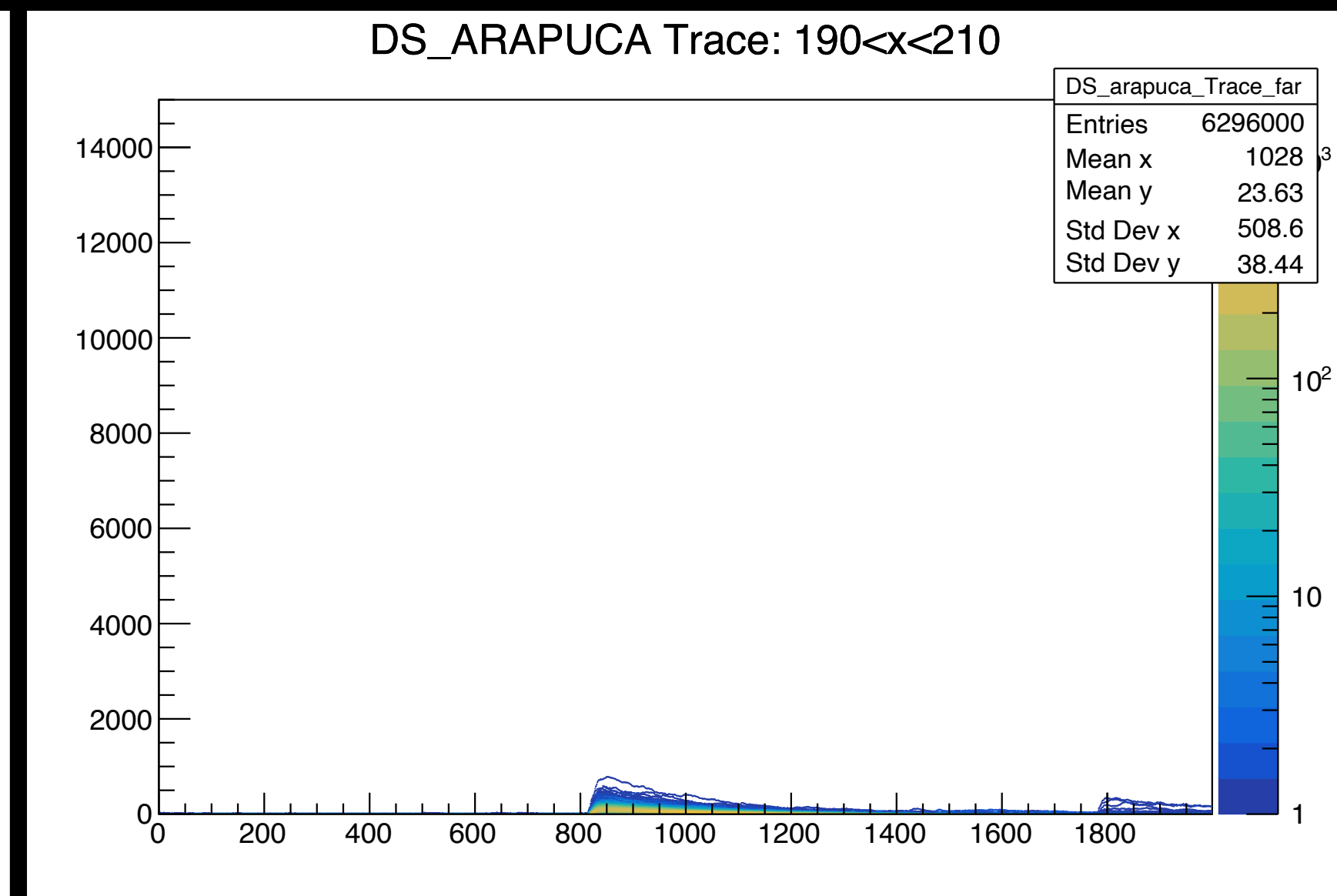
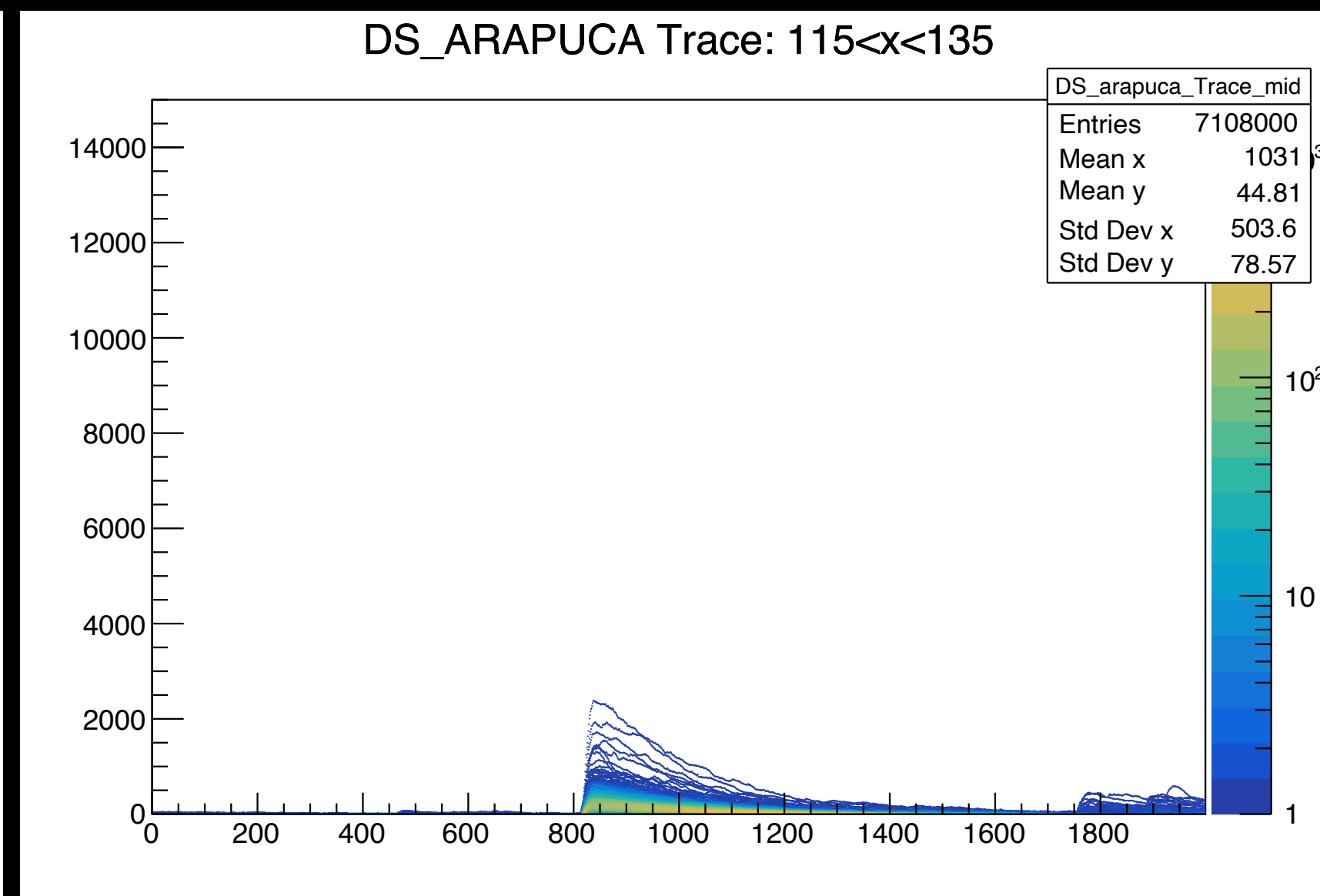
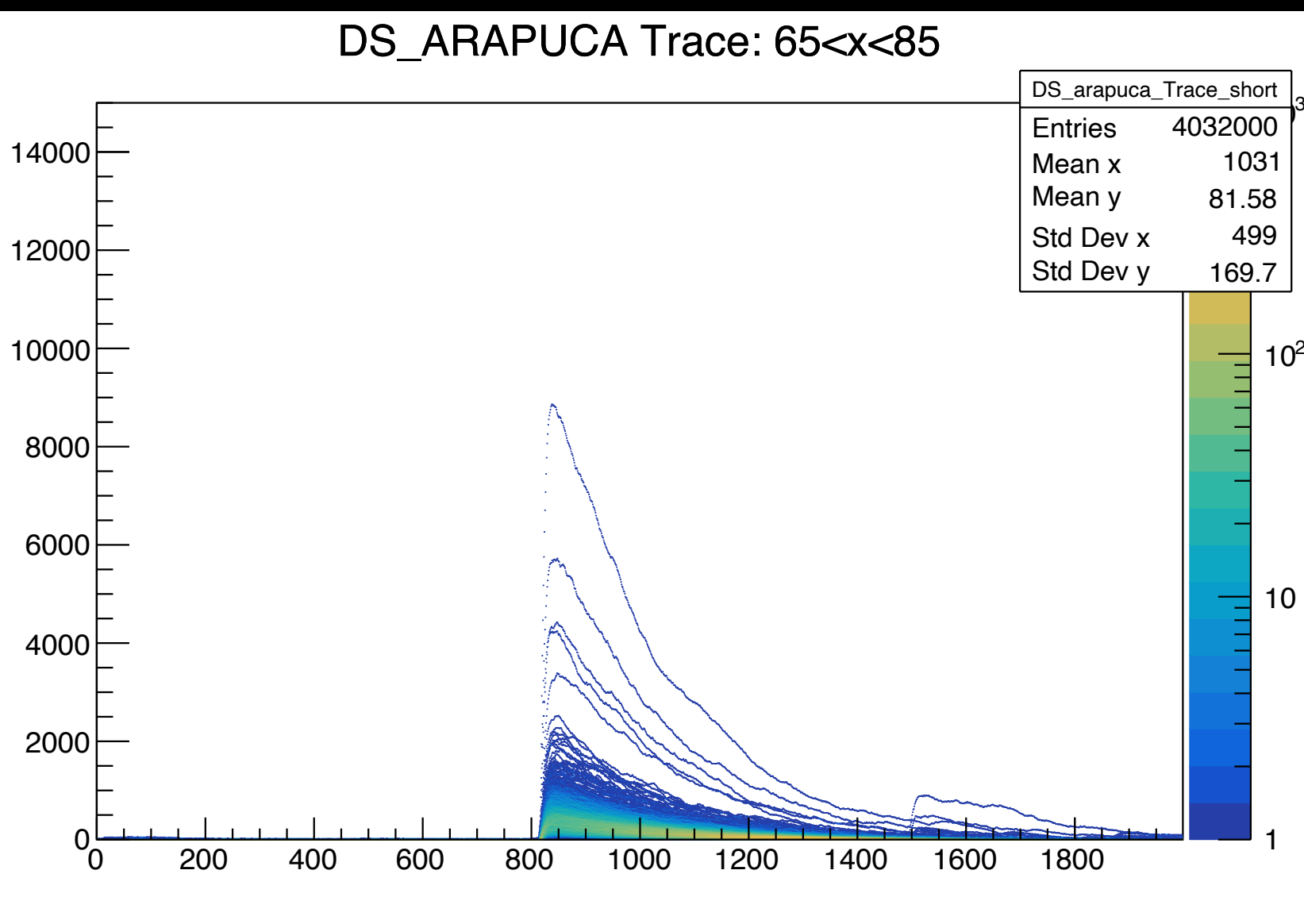
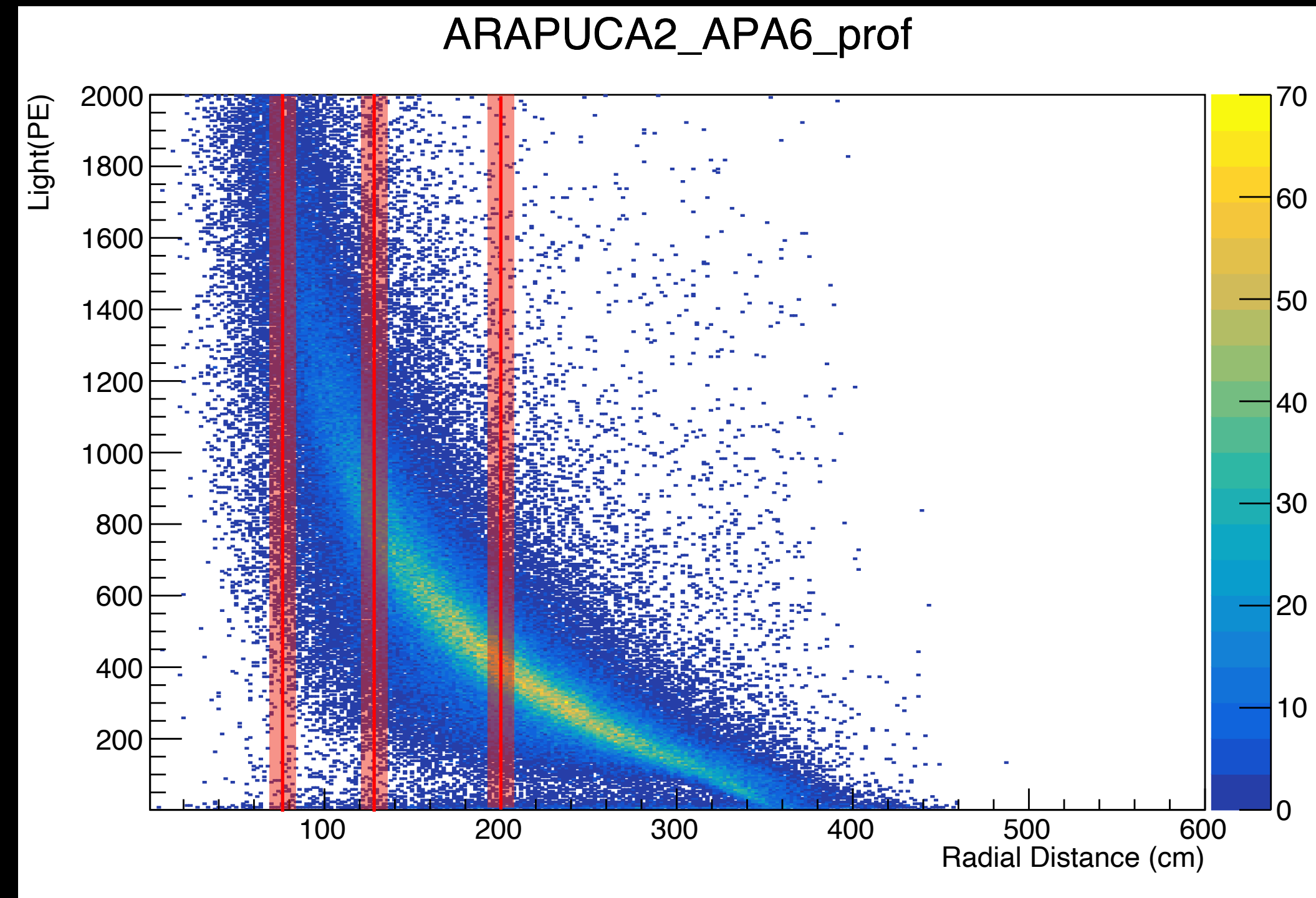
Run 11460
LAr + N + Xenon



Hamamatsu

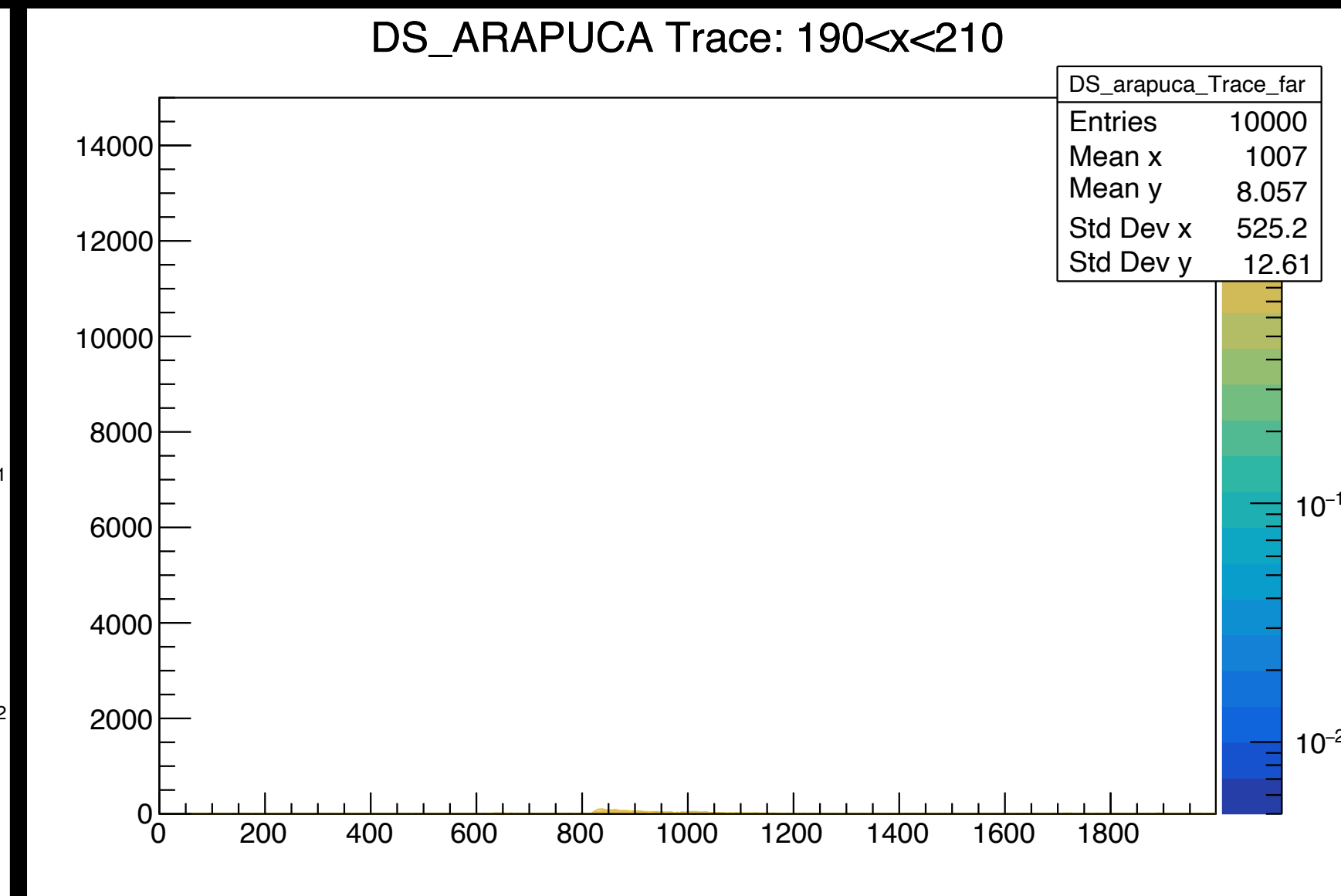
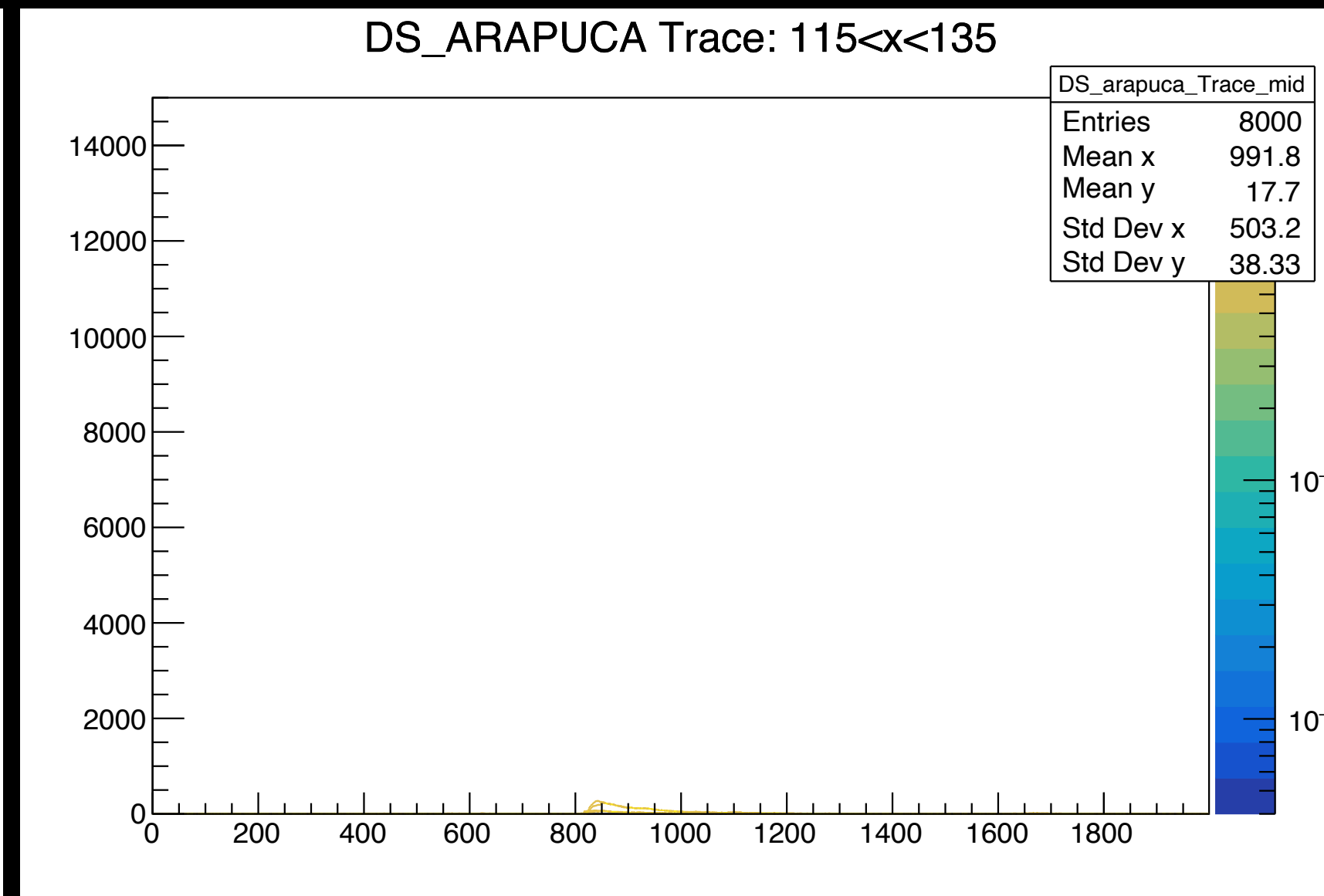
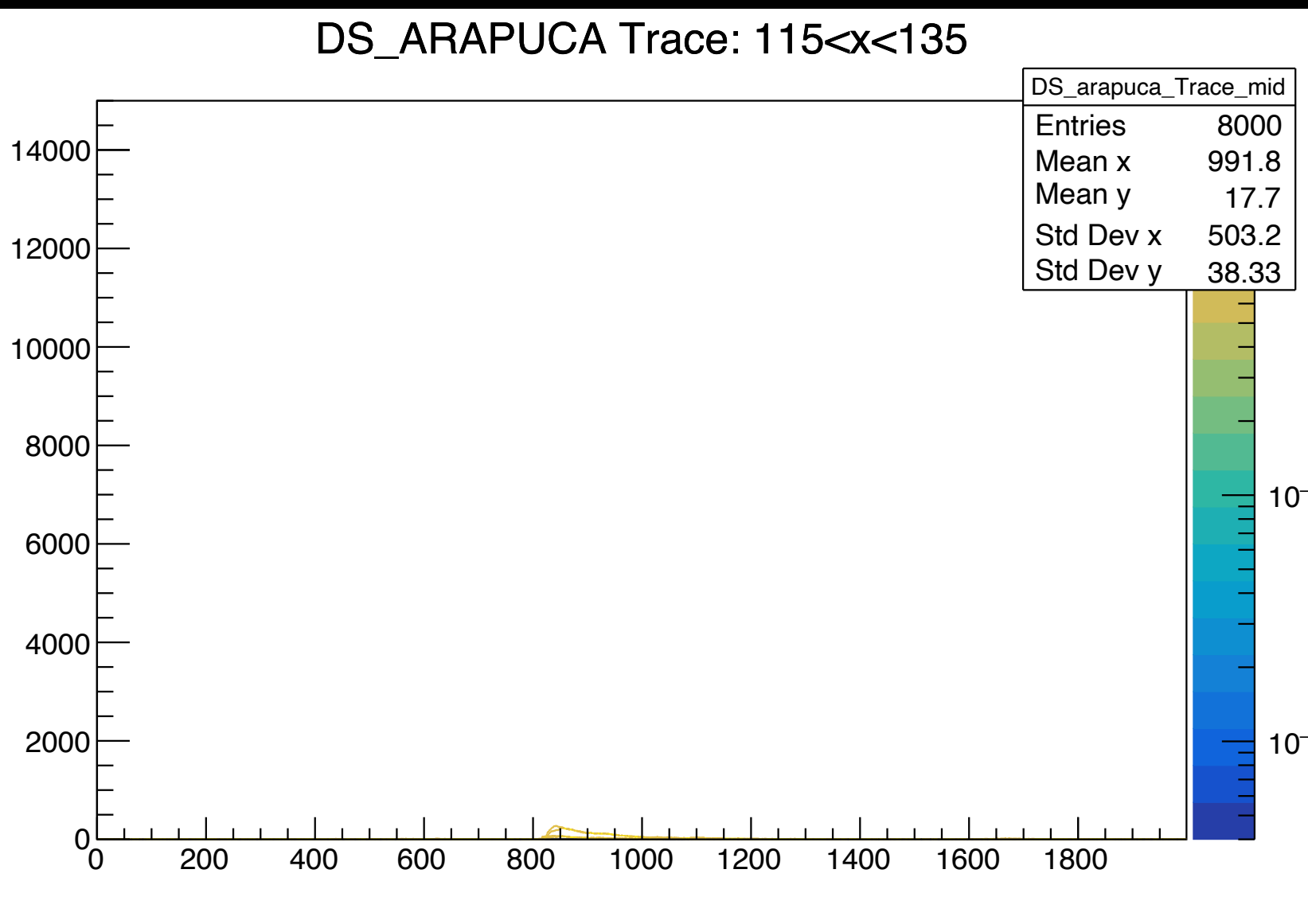
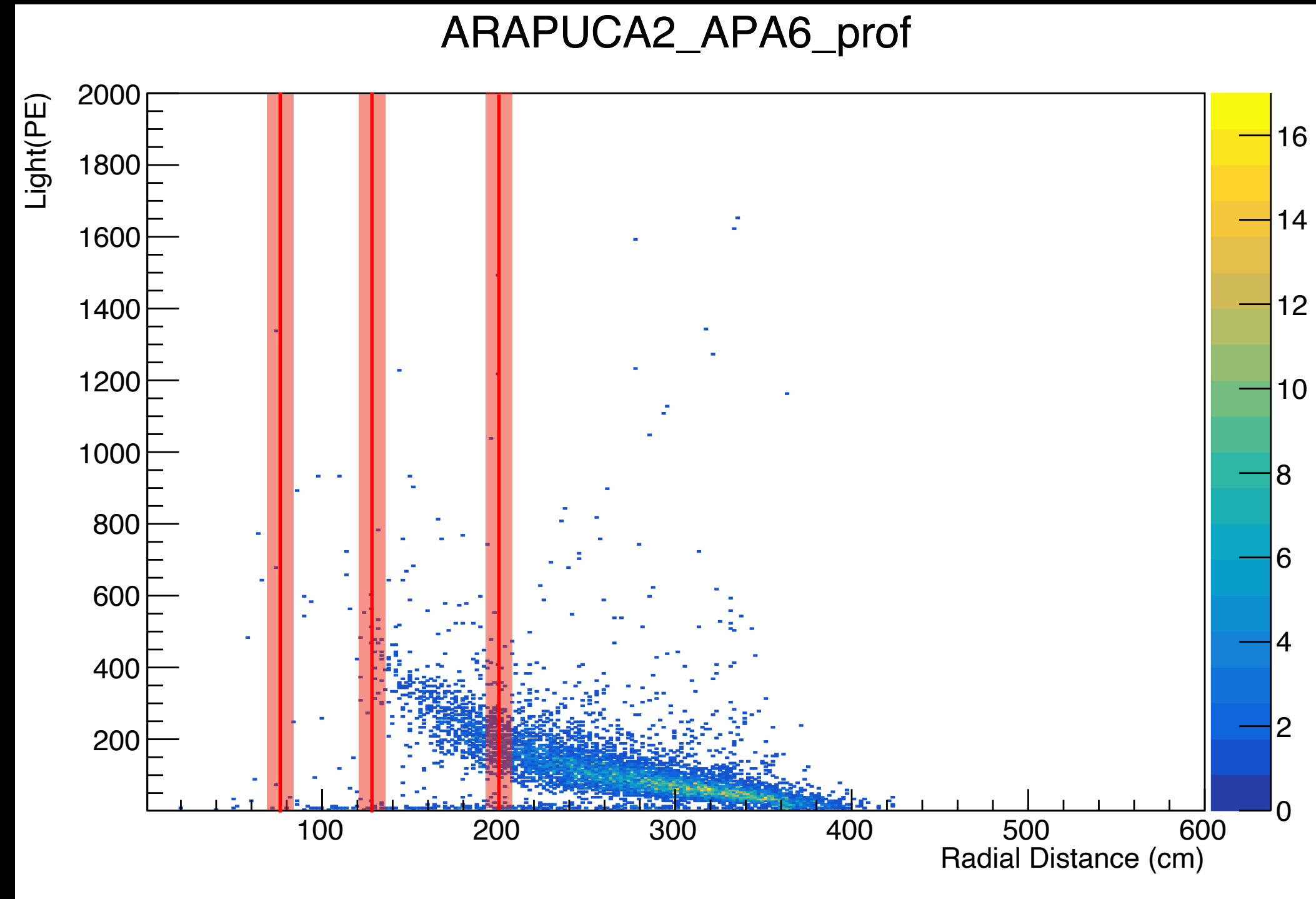
Run	Distance	Amplitude	Integral	Amp % of LAr	Integral % of LAr	fast area / slow area
5785	75	1440.88	264039.46	100.0	100.0	0.4693
11040	75	1106.15	143047.27	76.8	54.2	0.9264
11460	75	953.31	196176.10	66.2	74.3	0.1963
5785	125	699.56	129765.77	100.0	100.0	0.4719
11040	125	574.79	78313.17	82.2	60.3	0.1636
11460	125	511.34	110943.94	73.1	85.5	0.8439
5785	200	319.28	67824.06	100.0	100.0	0.0264
11040	200	499.62	105012.63	156.5	154.8	0.2935
11460	200	258.85	61271.35	81.1	90.3	0.1435

run 5785 ARAPUCA



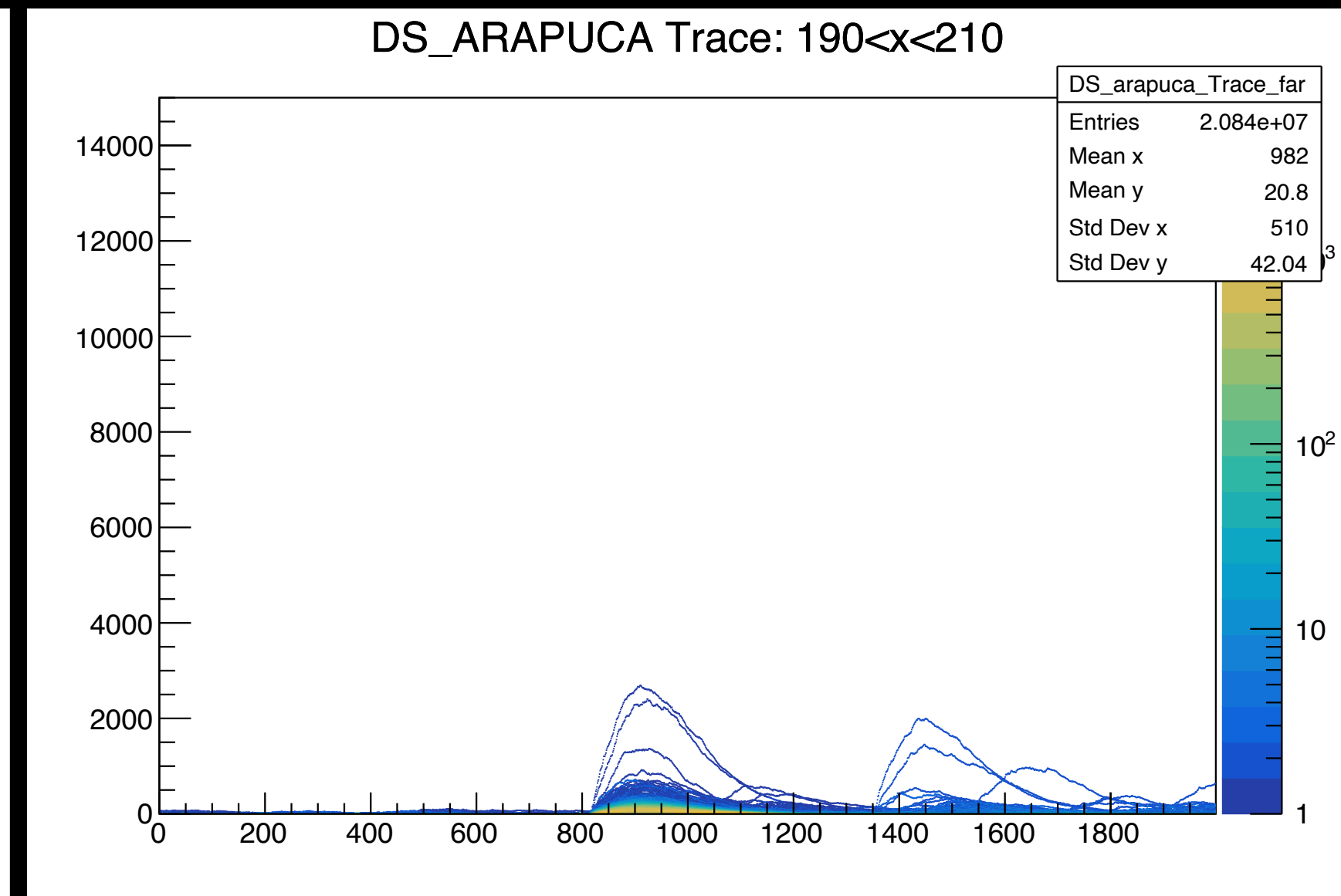
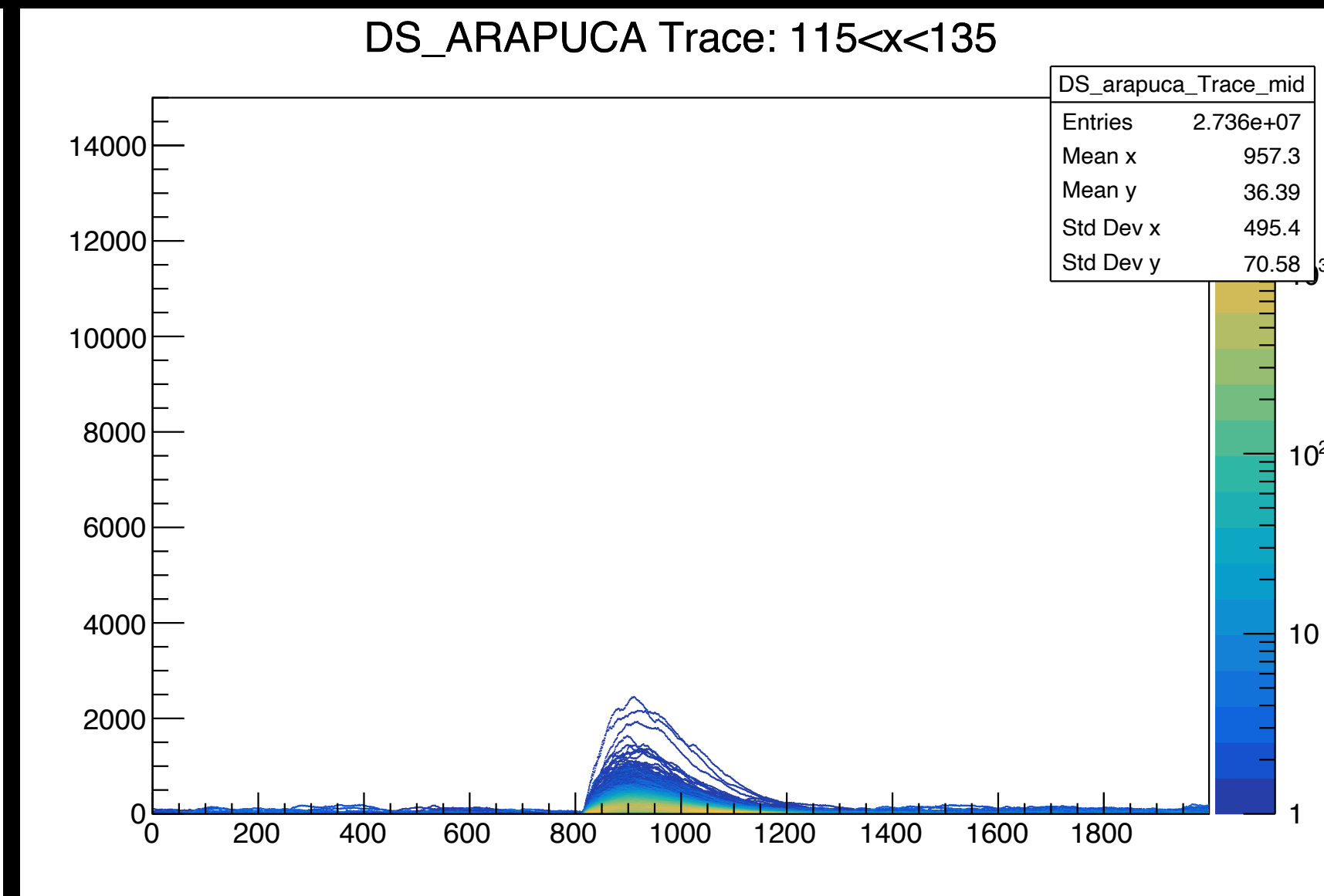
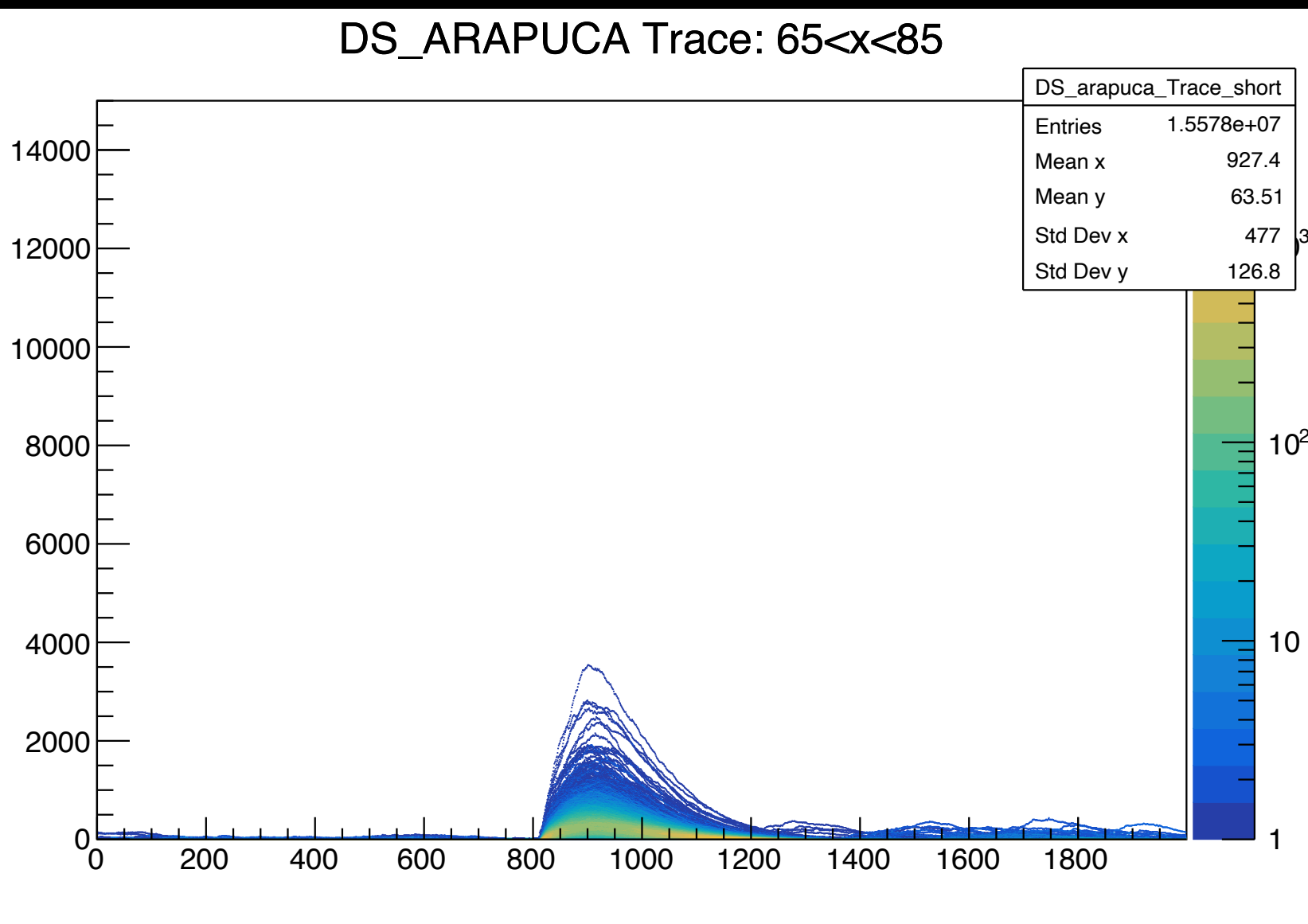
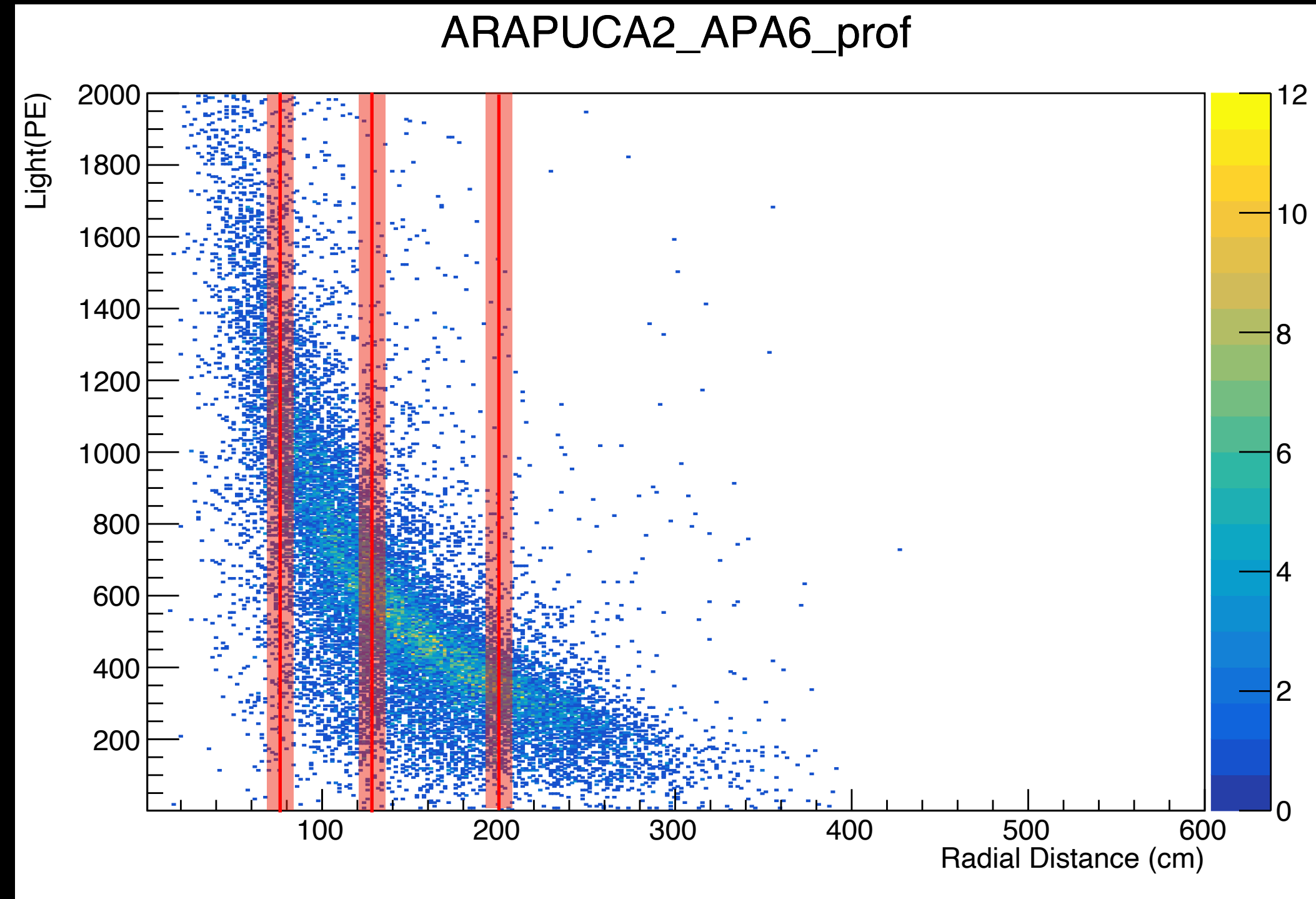
run 10440

ARAPUCA

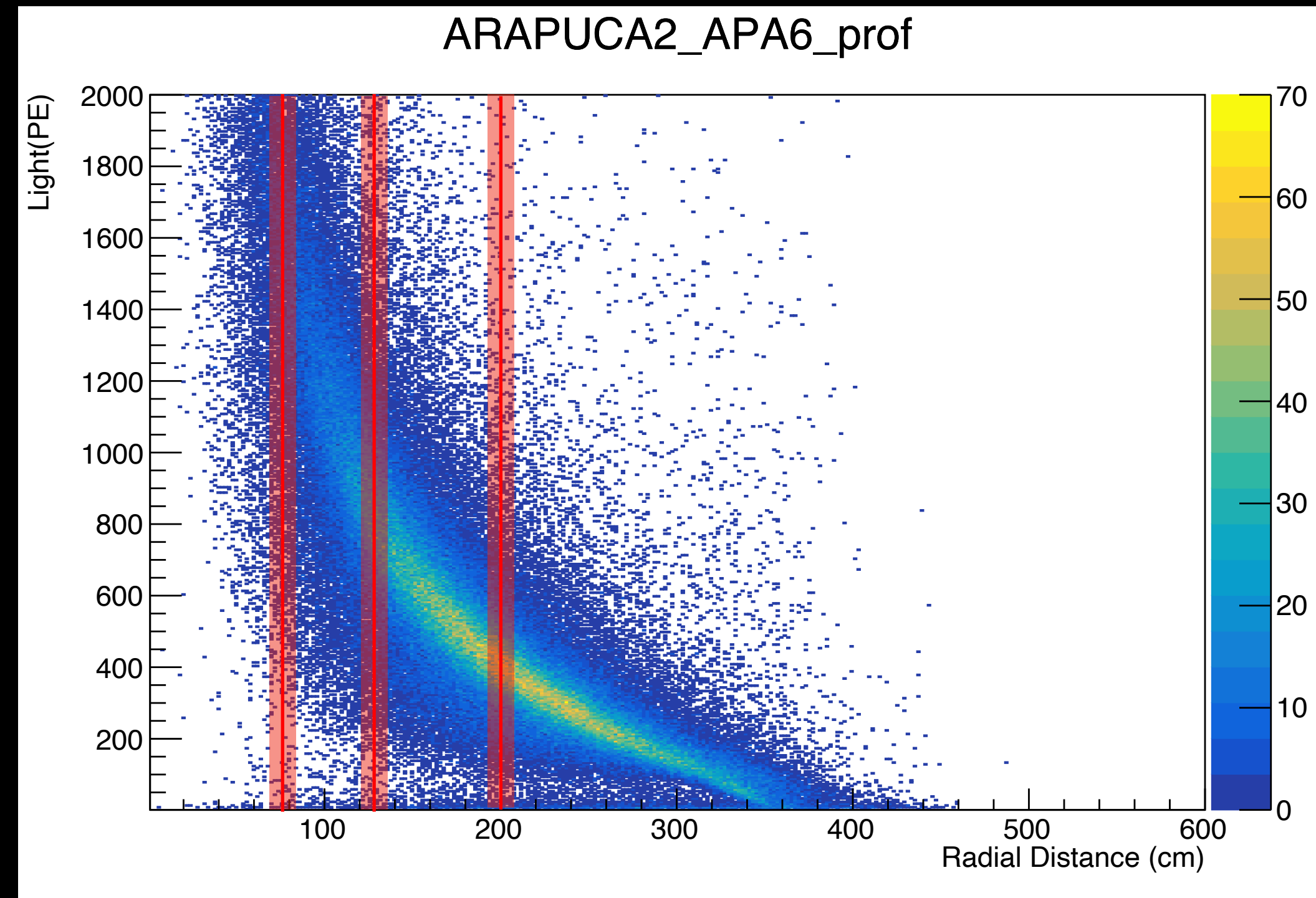


run 11460

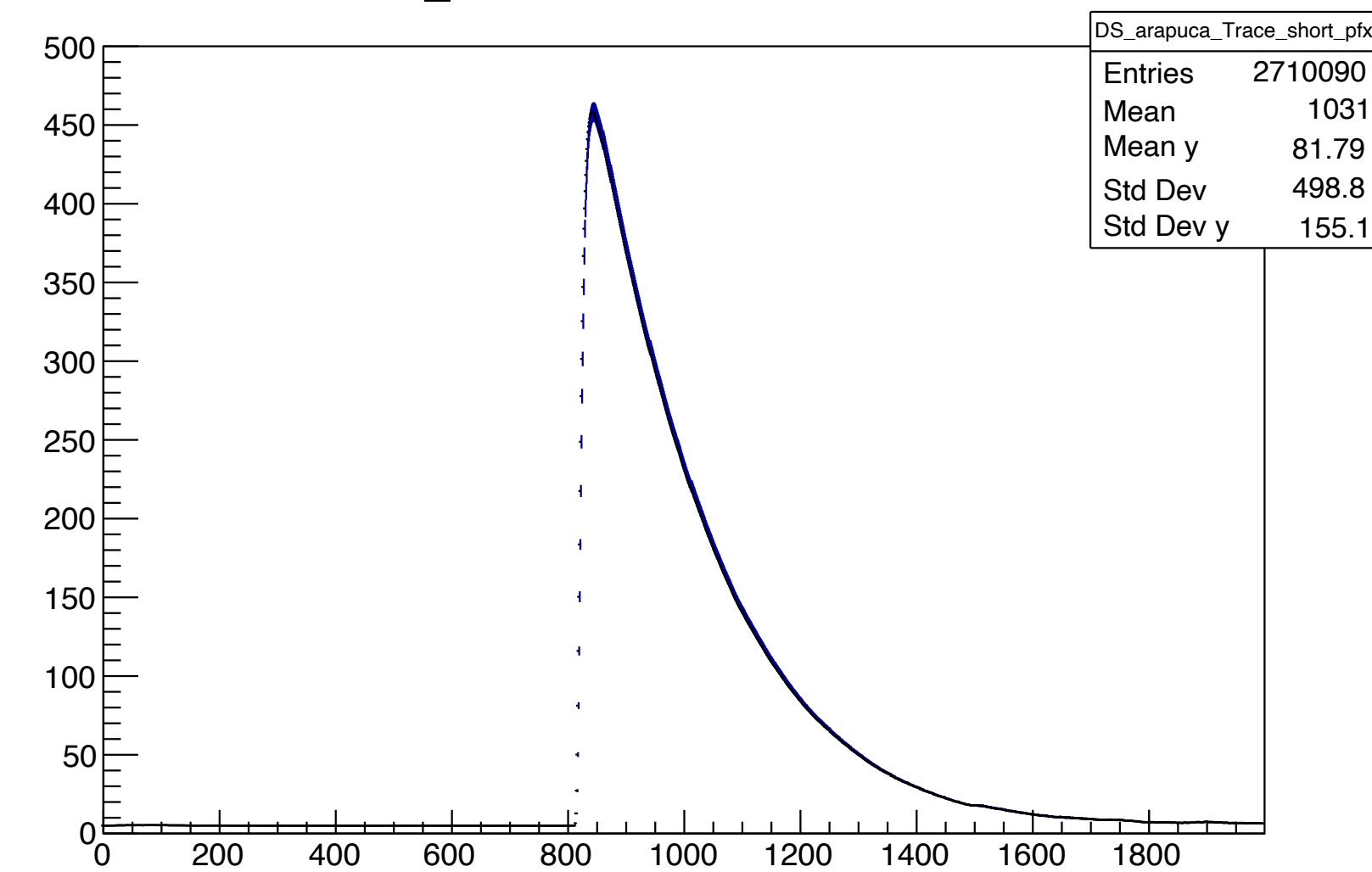
ARAPUCA



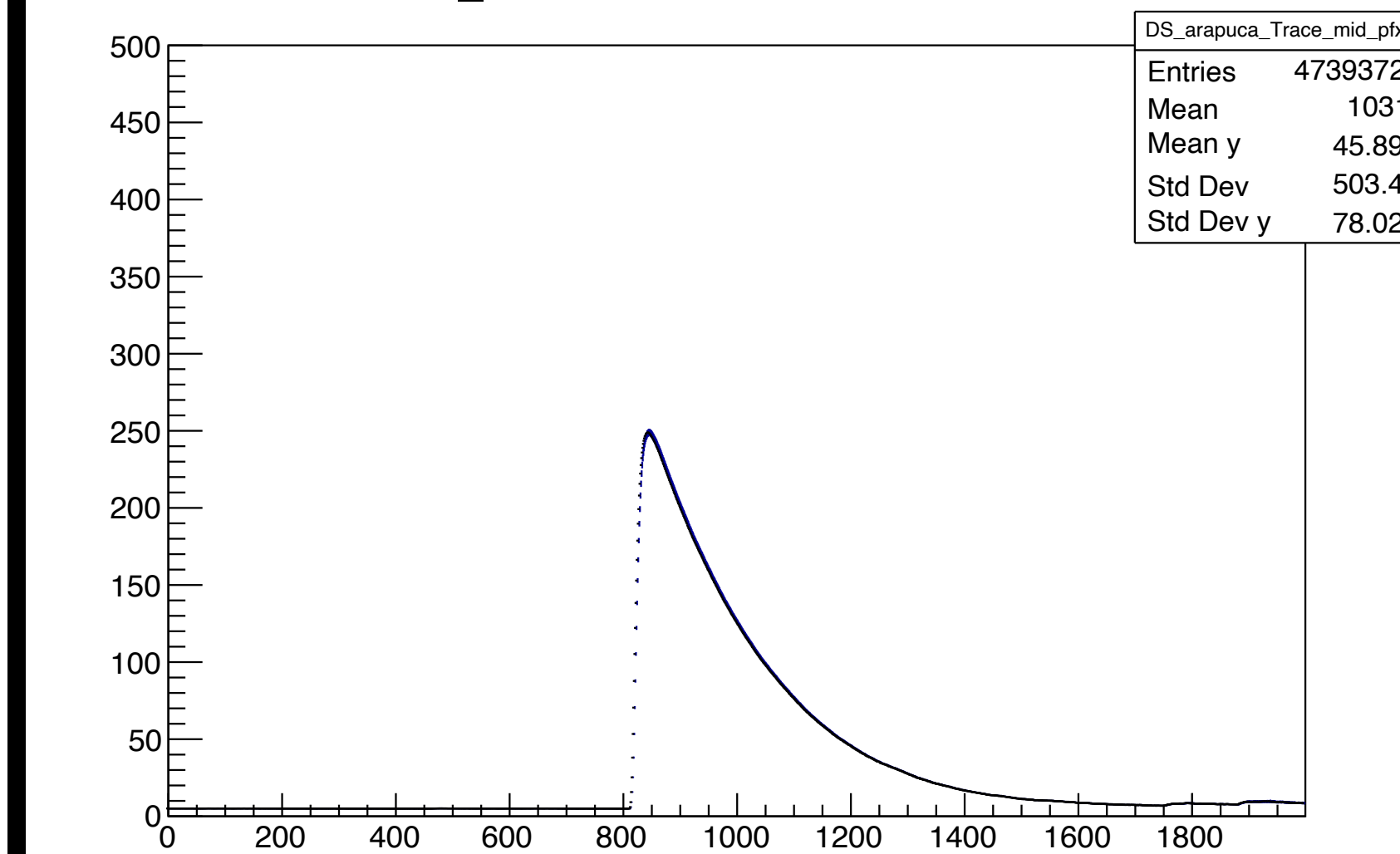
run 5785 ARAPUCA



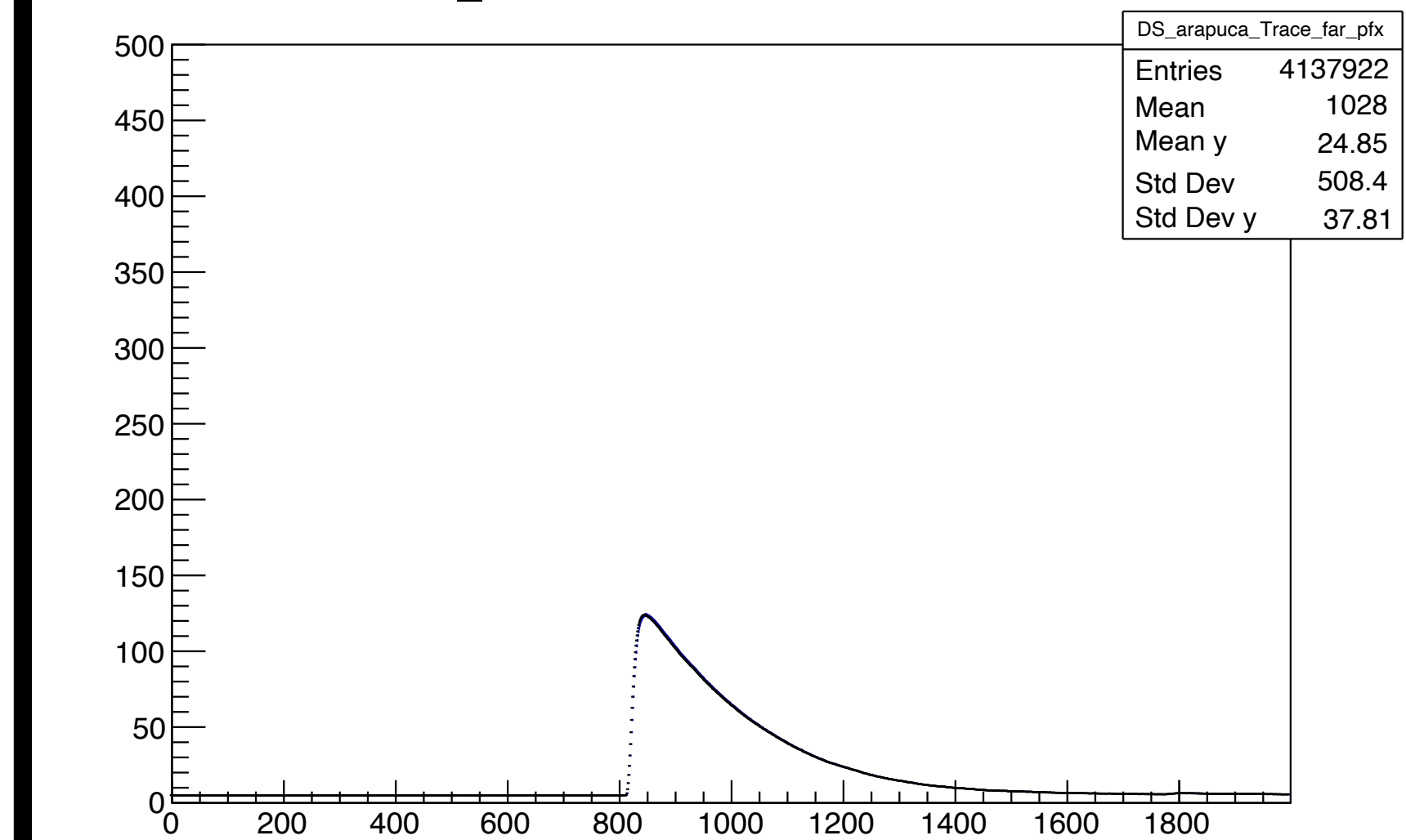
DS_ARAPUCA Trace: 65<x<85



DS_ARAPUCA Trace: 115<x<135

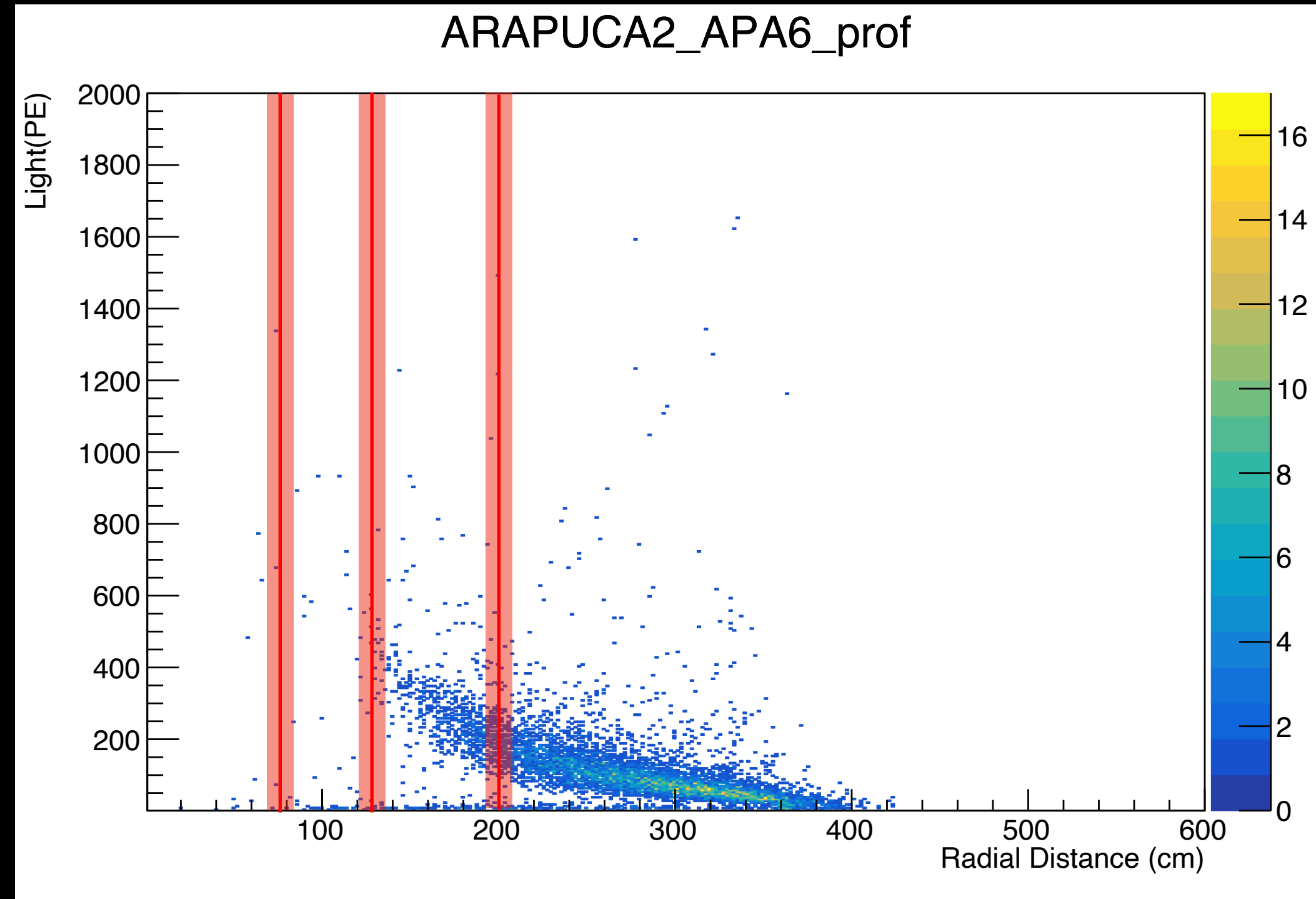


DS_ARAPUCA Trace: 190<x<210

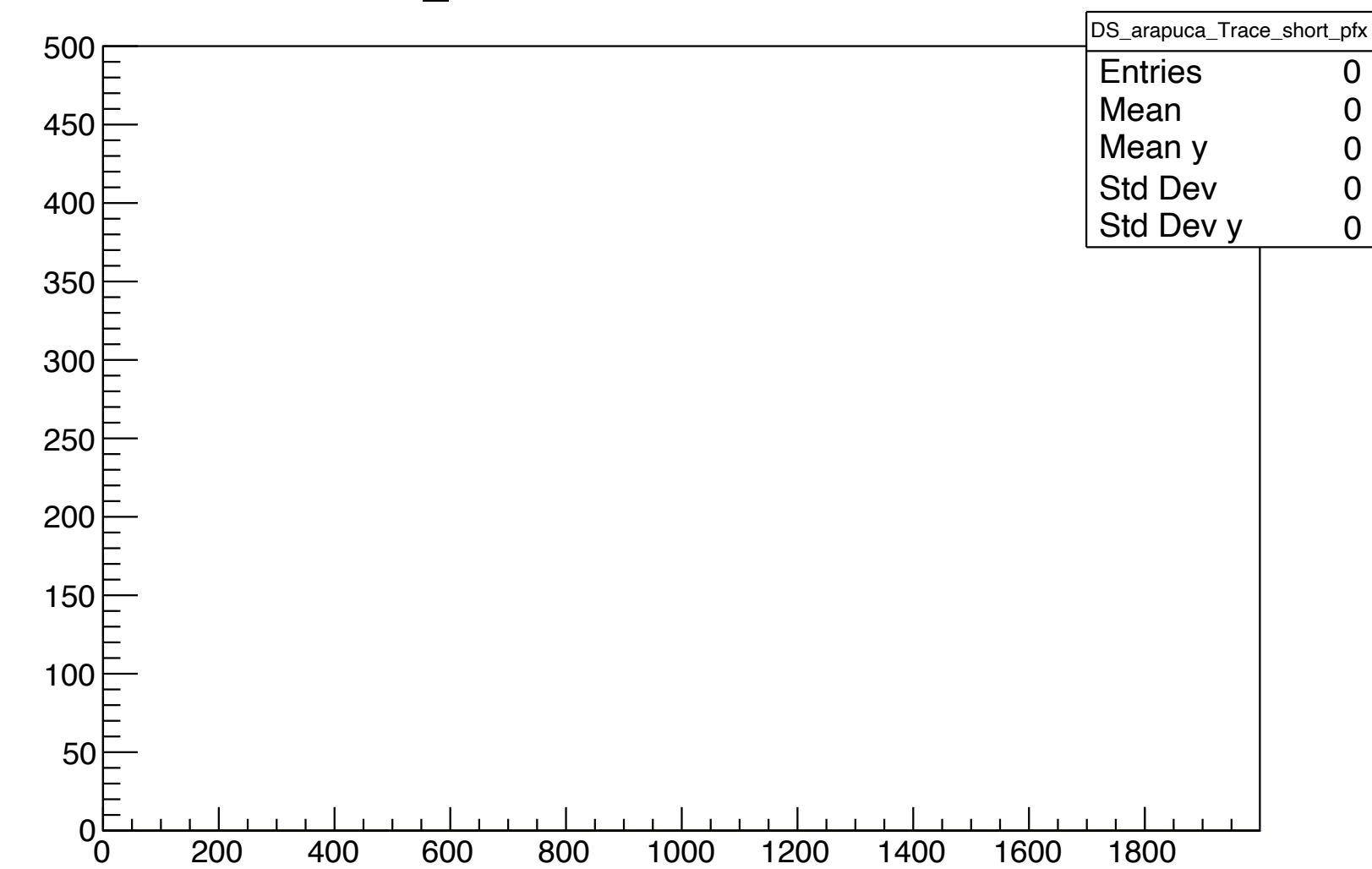


run 10440

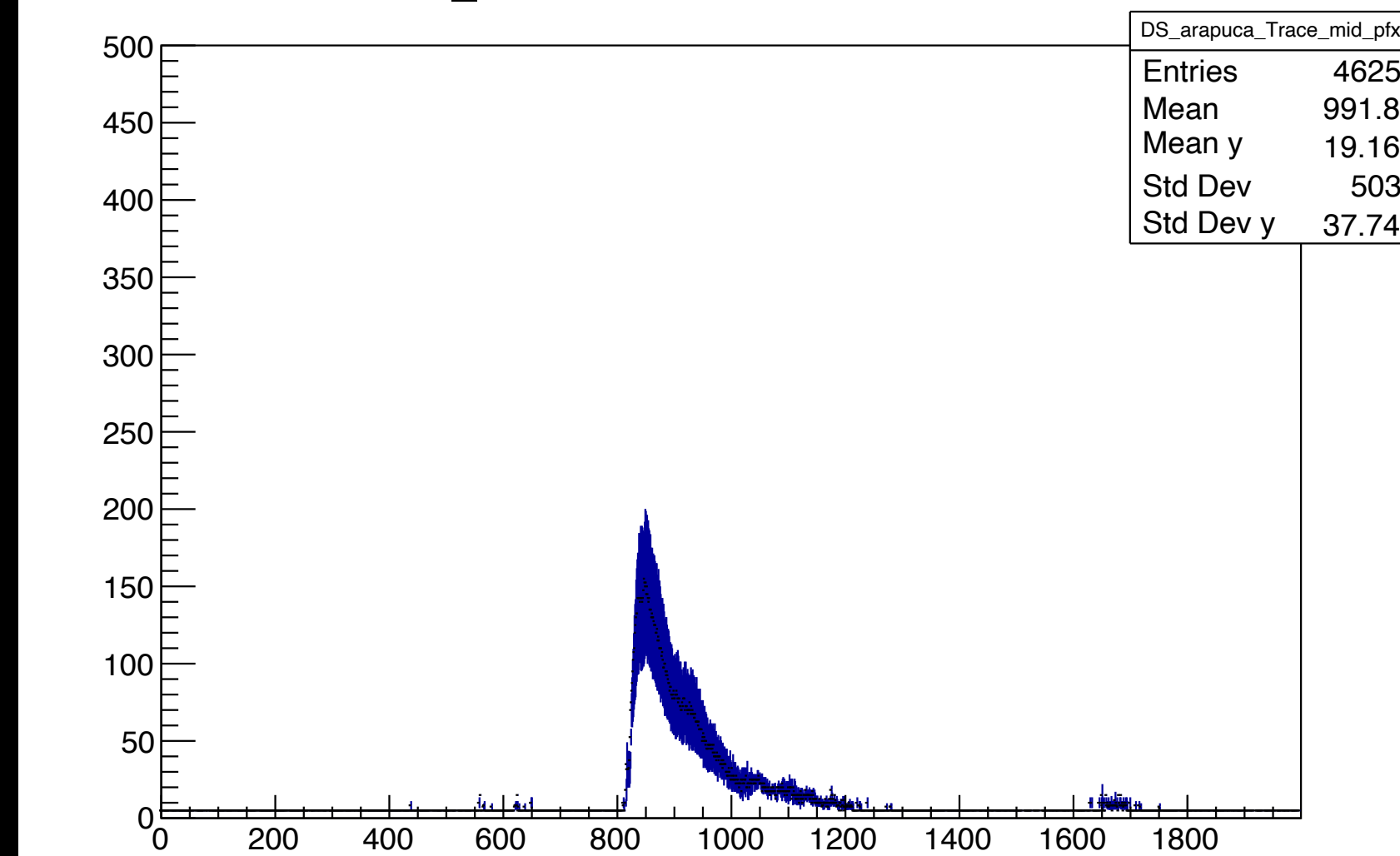
ARAPUCA



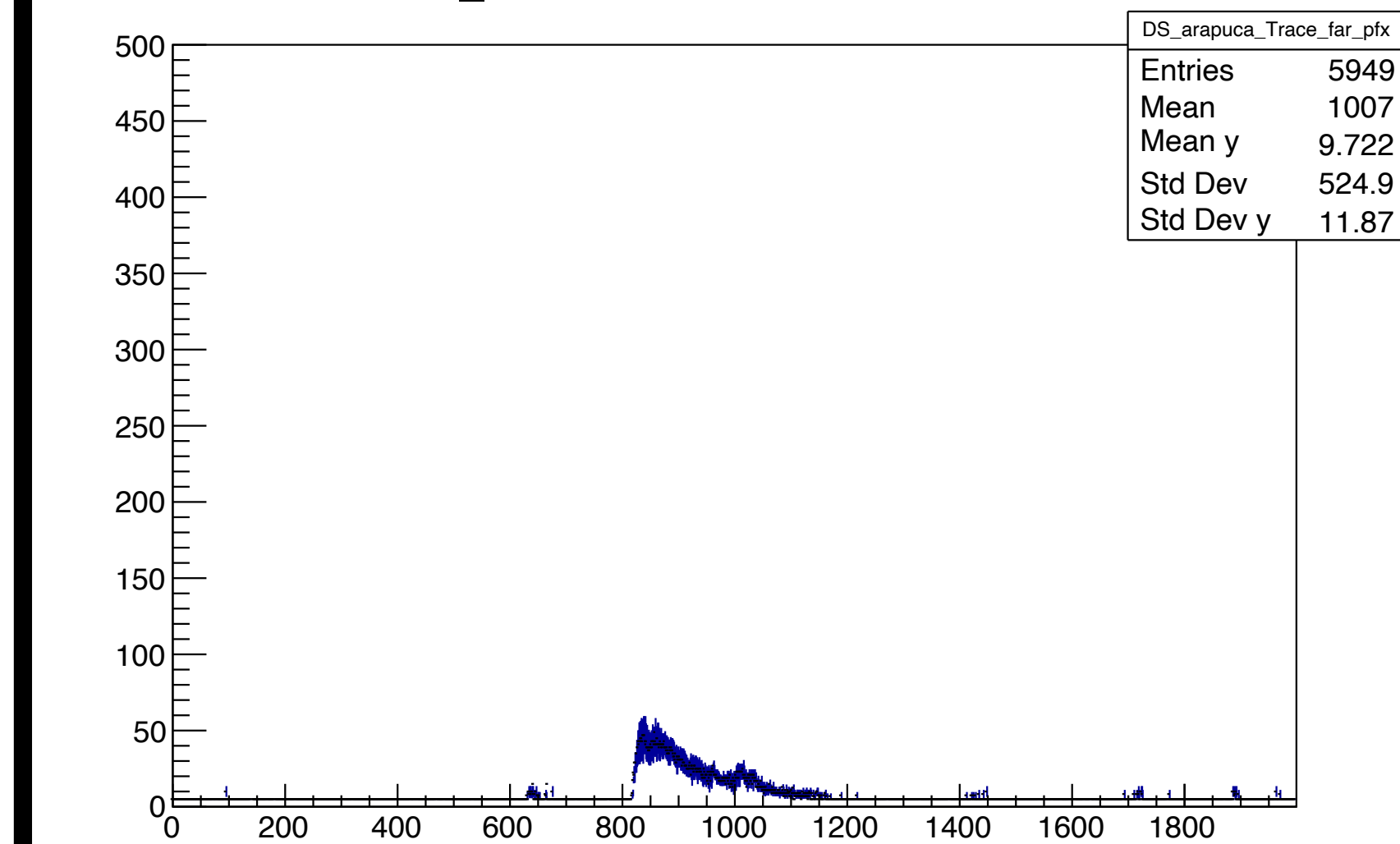
DS_ARAPUCA Trace: 65<x<85



DS_ARAPUCA Trace: 115<x<135

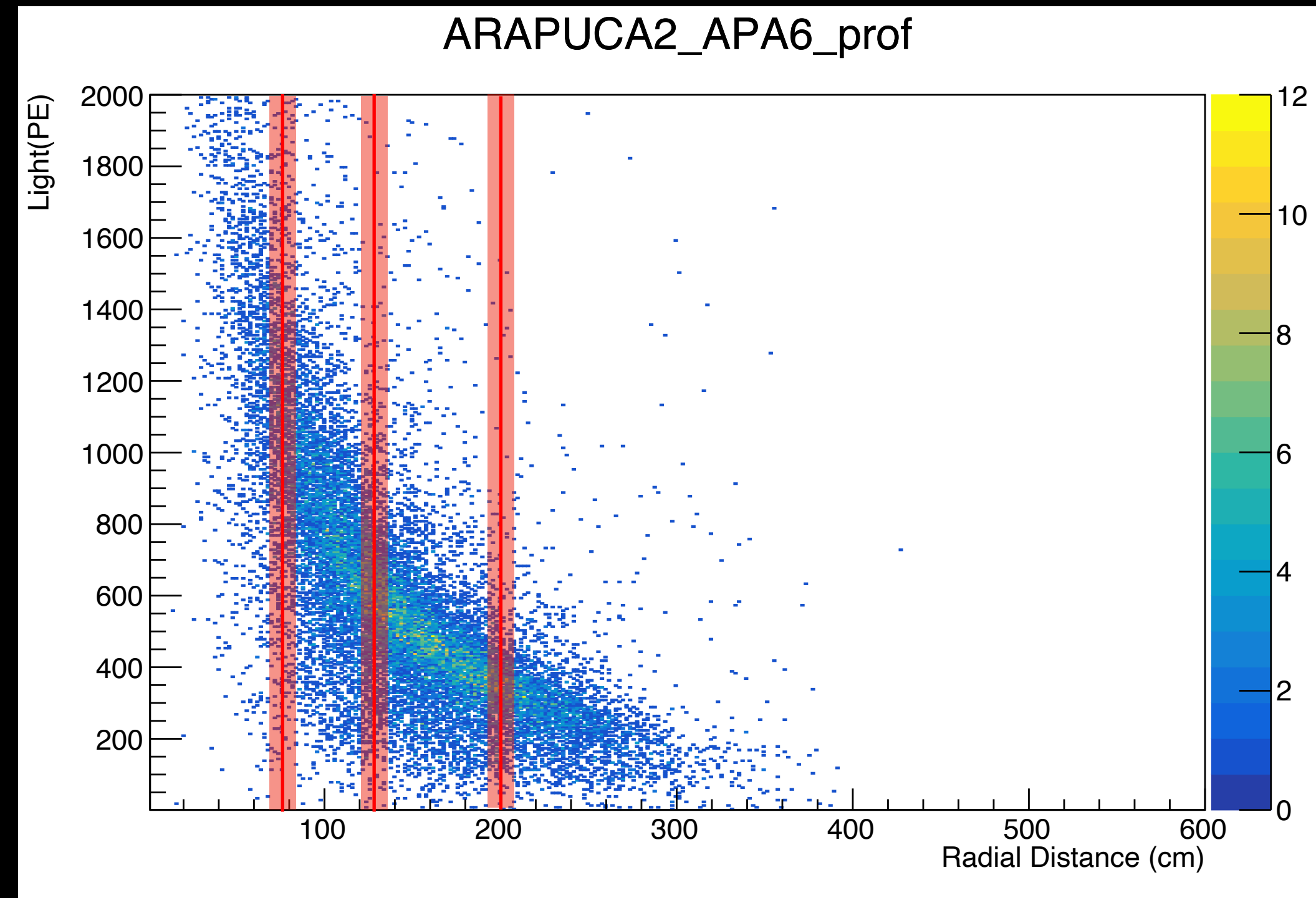


DS_ARAPUCA Trace: 190<x<210

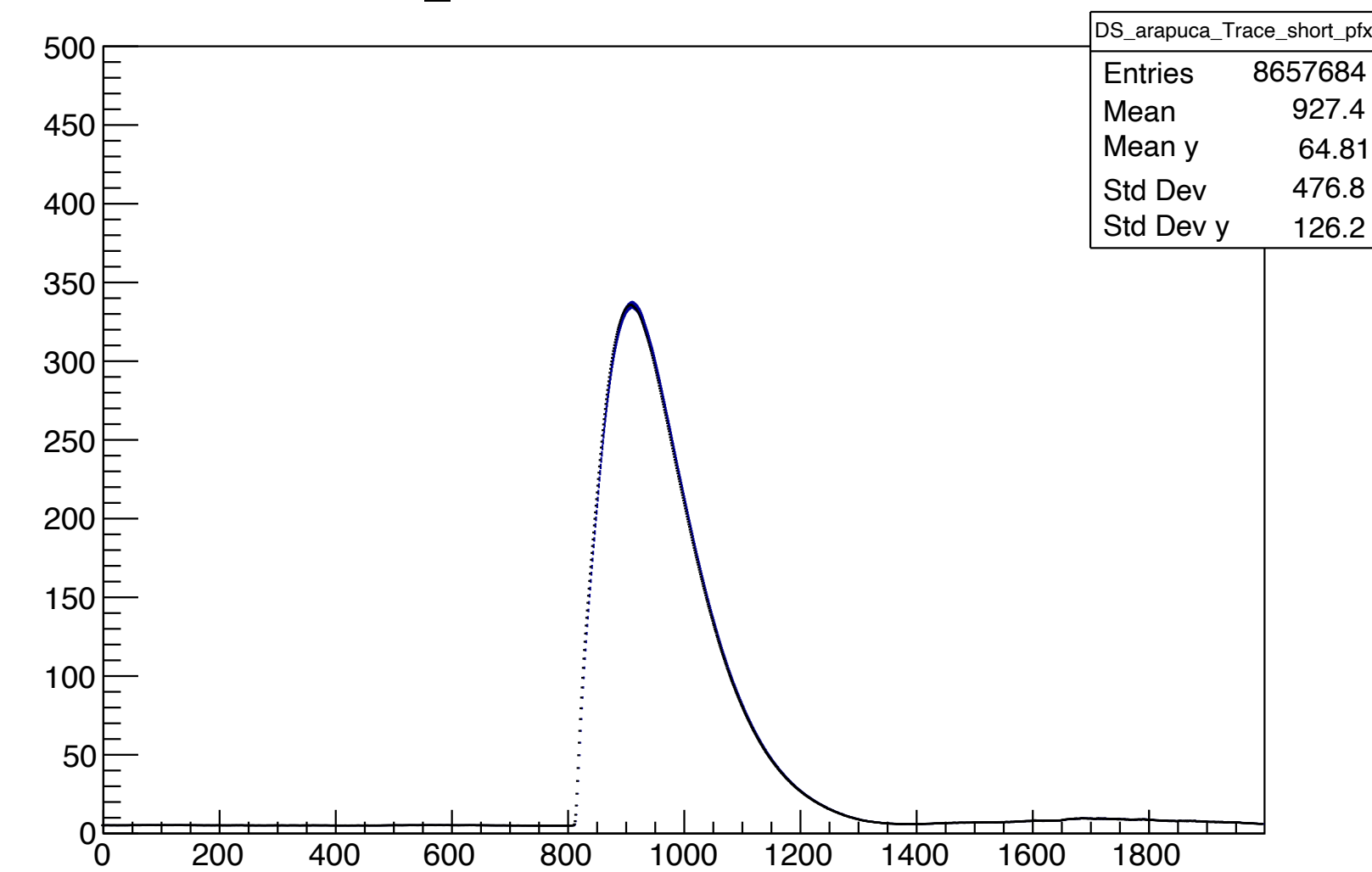


run 11460

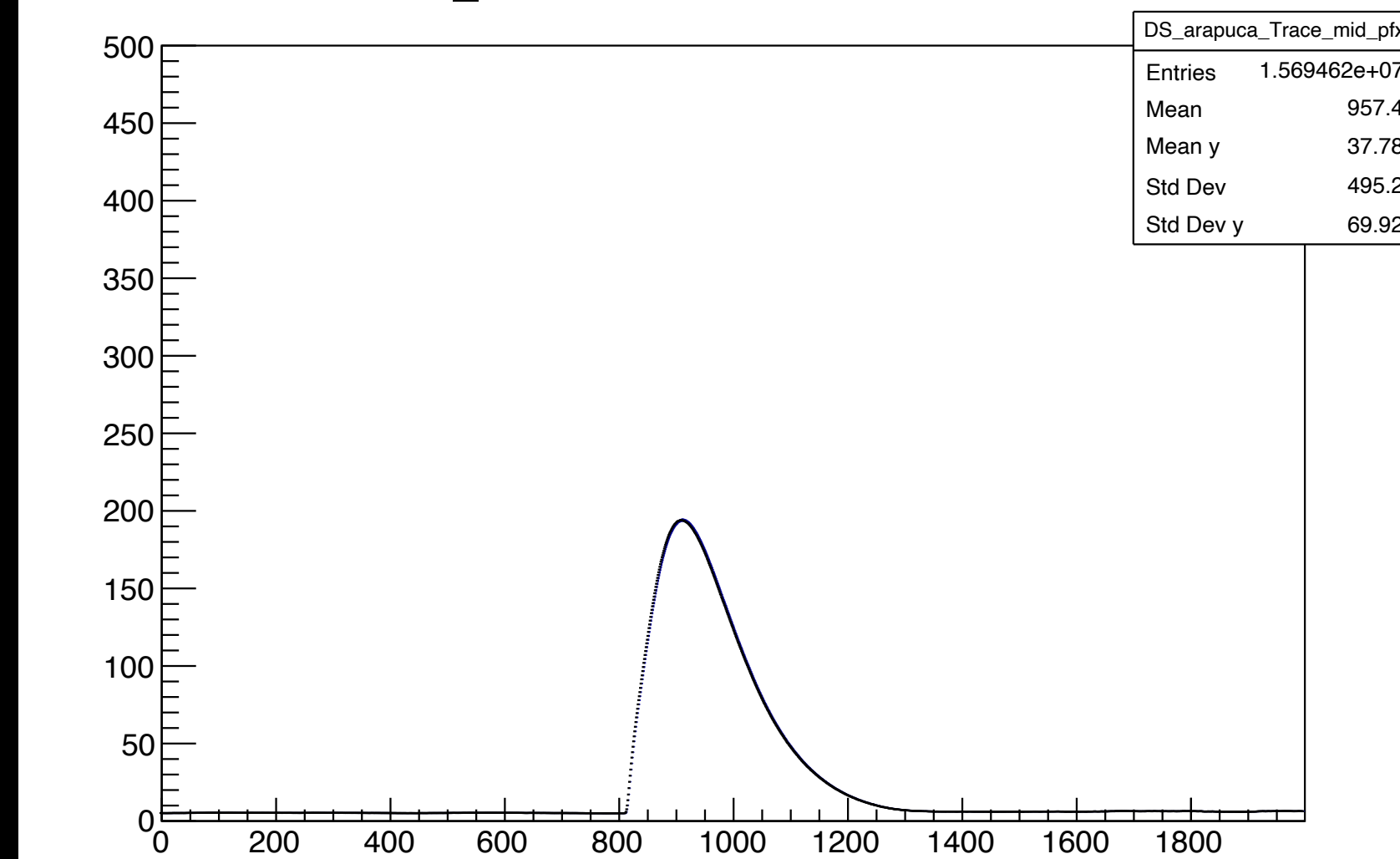
ARAPUCA



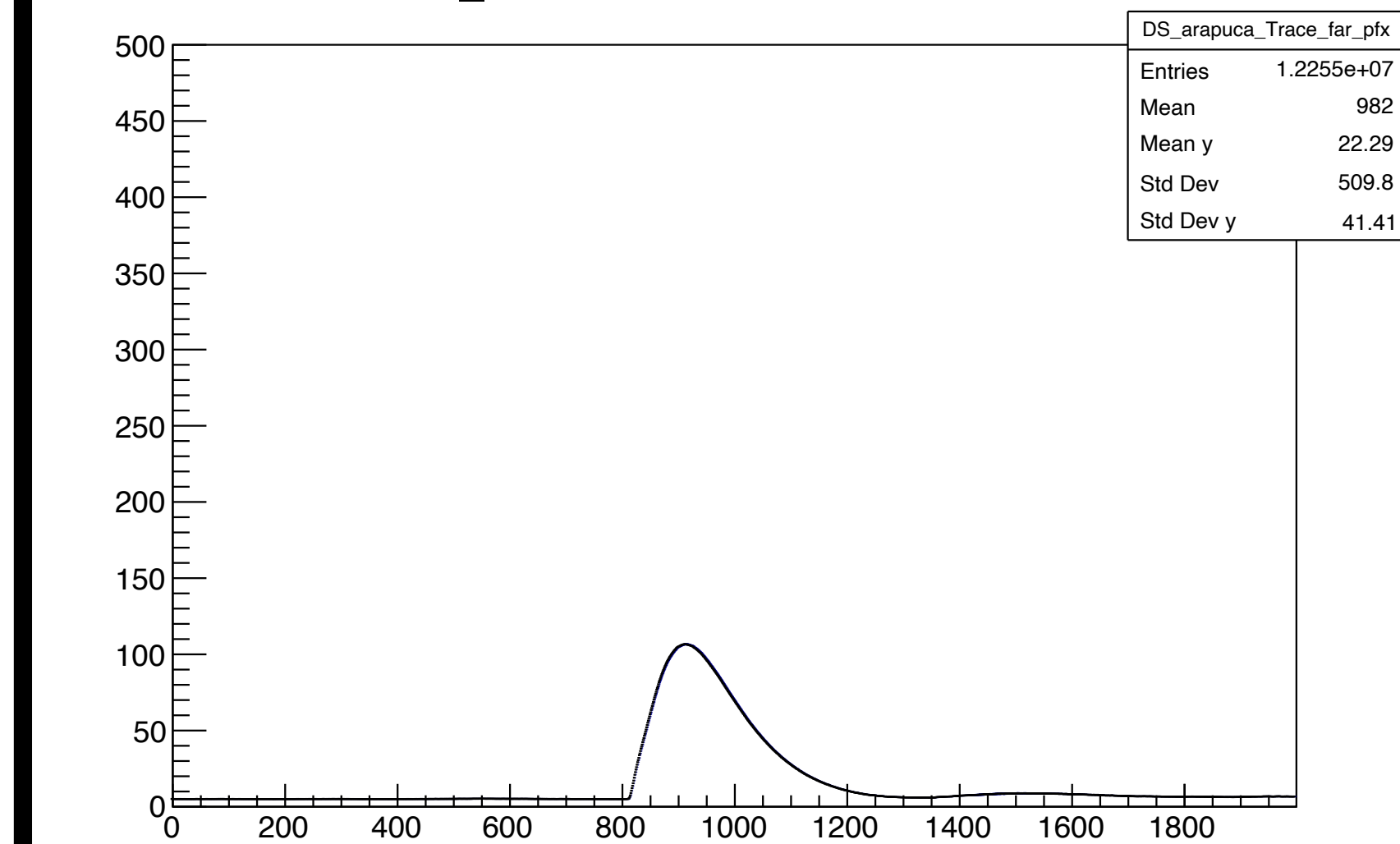
DS_ARAPUCA Trace: 65<x<85



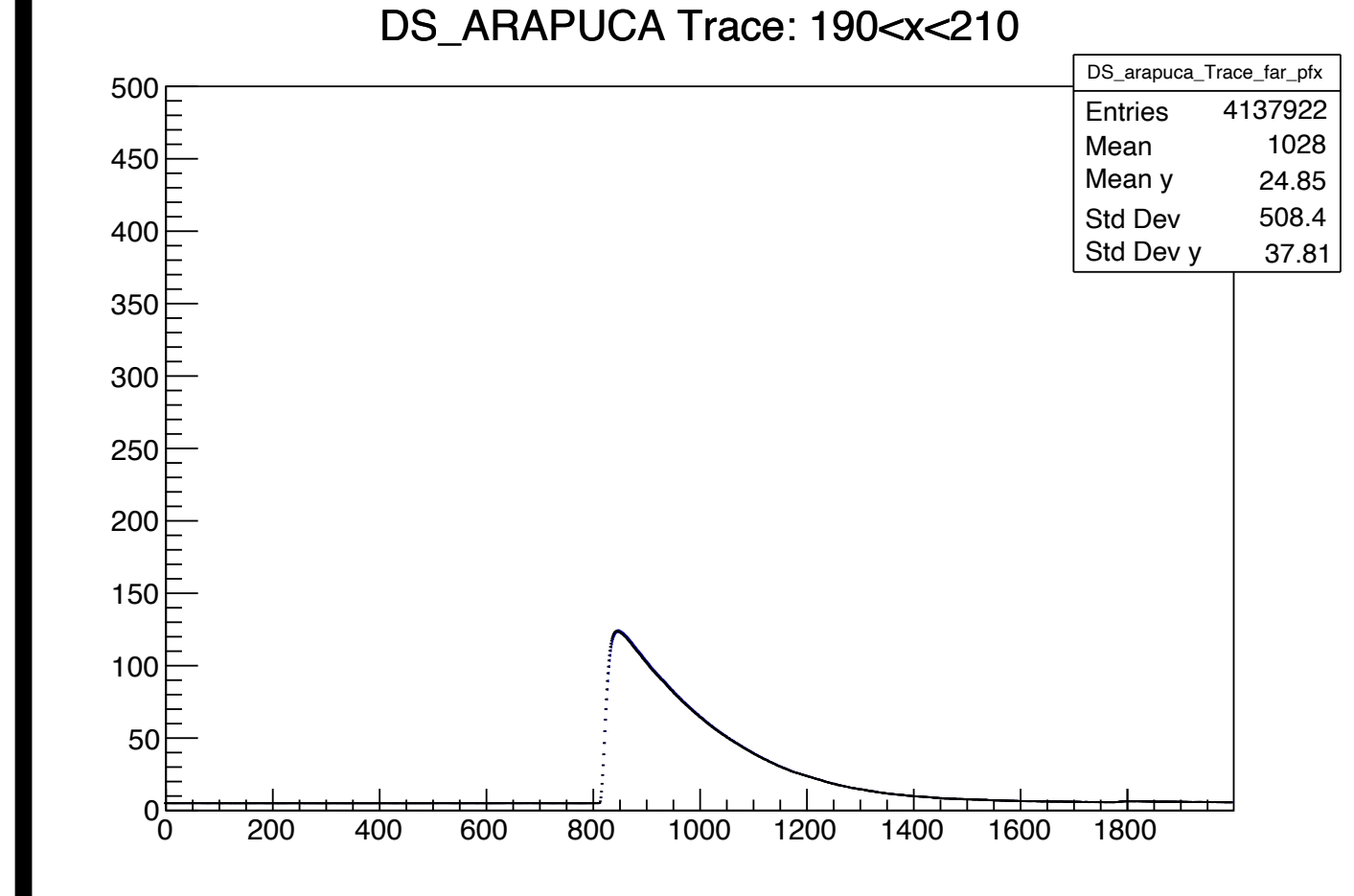
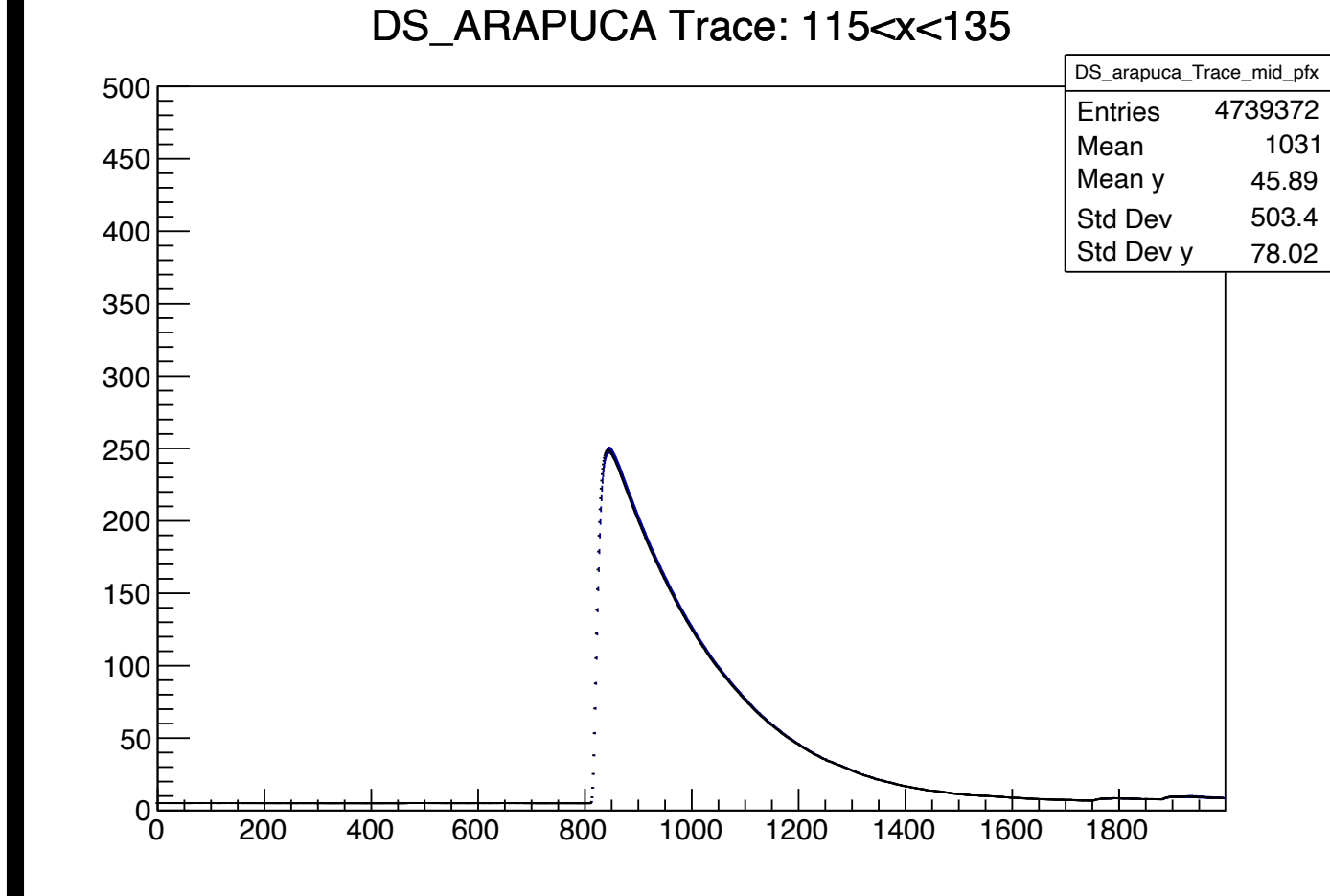
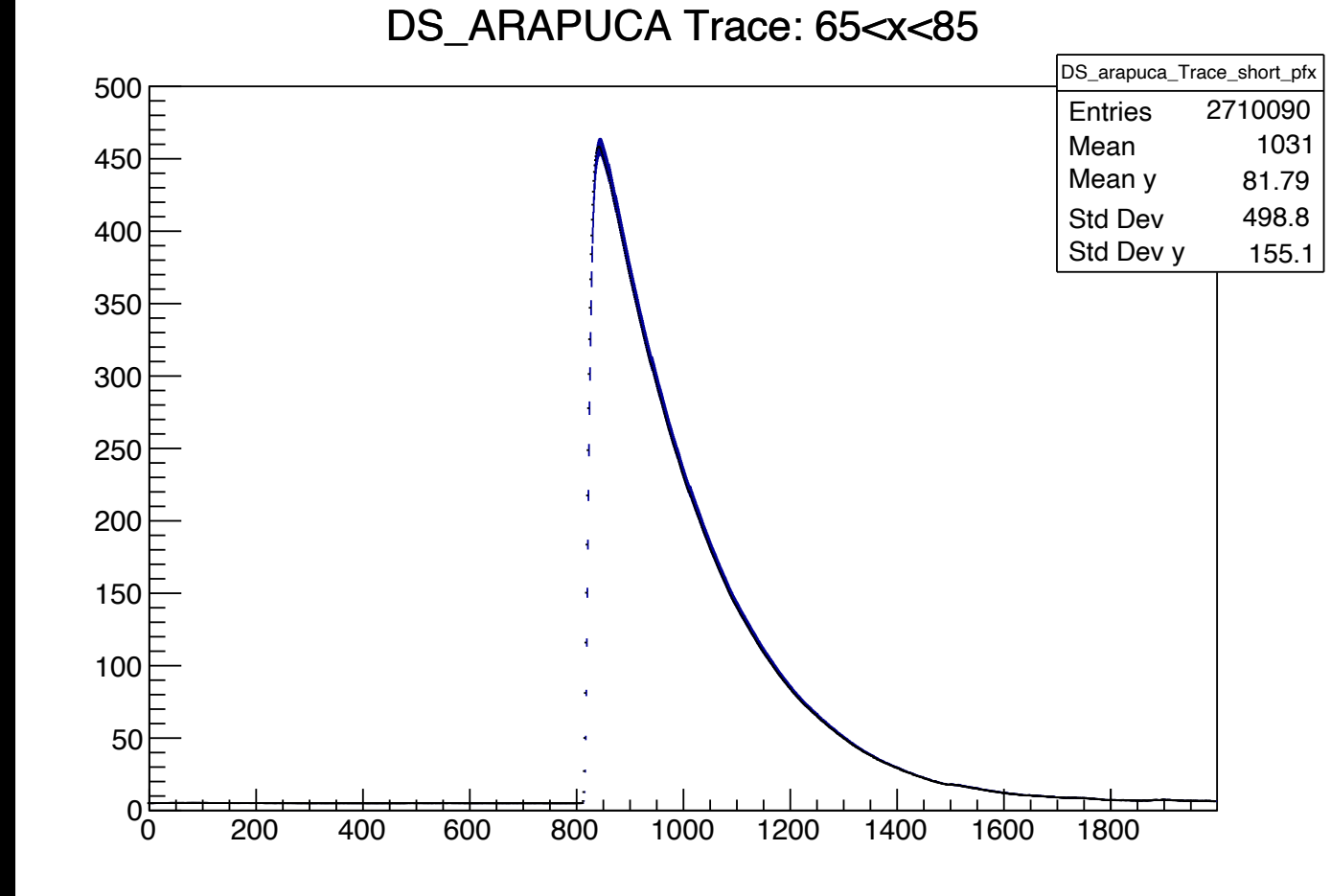
DS_ARAPUCA Trace: 115<x<135



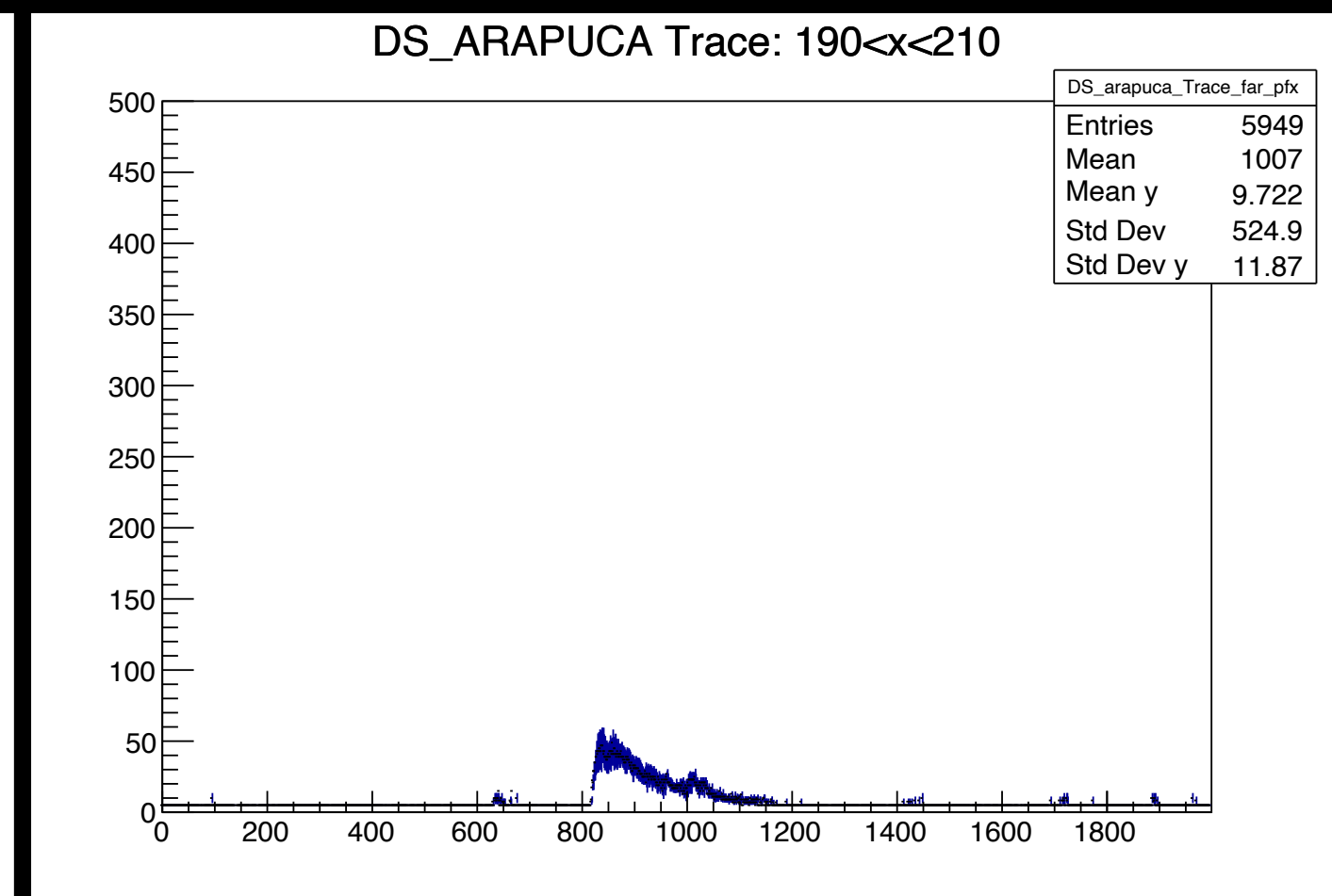
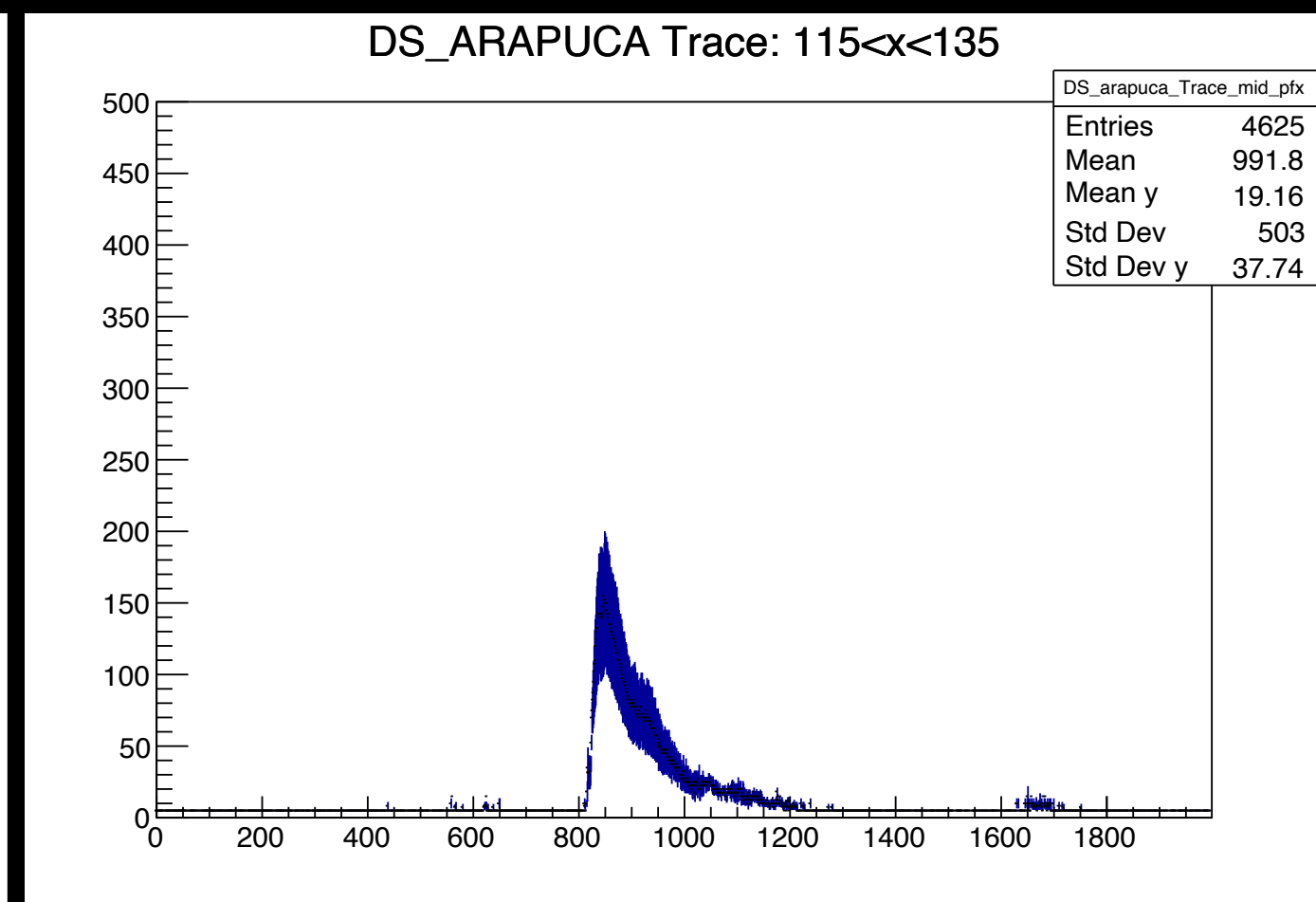
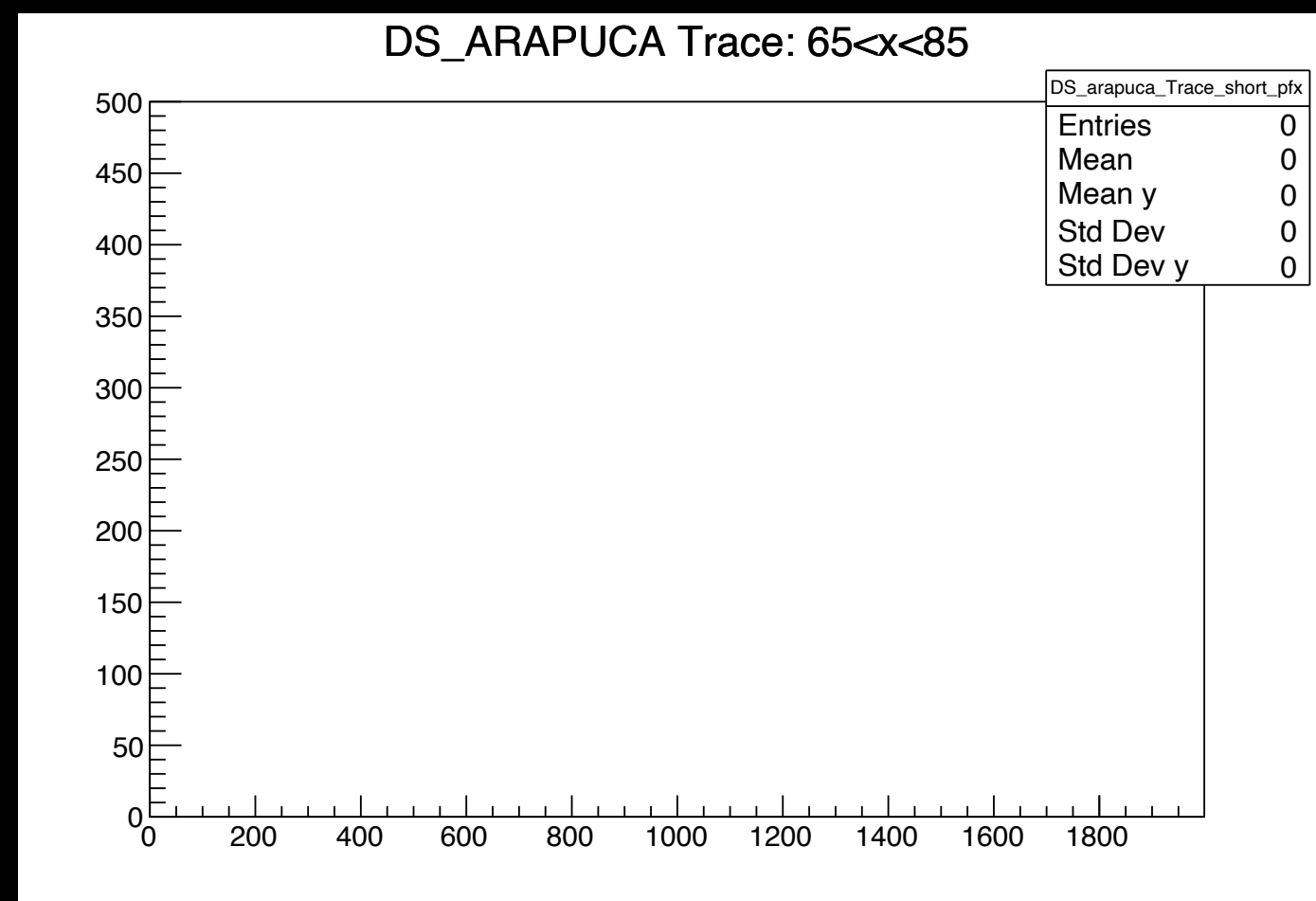
DS_ARAPUCA Trace: 190<x<210



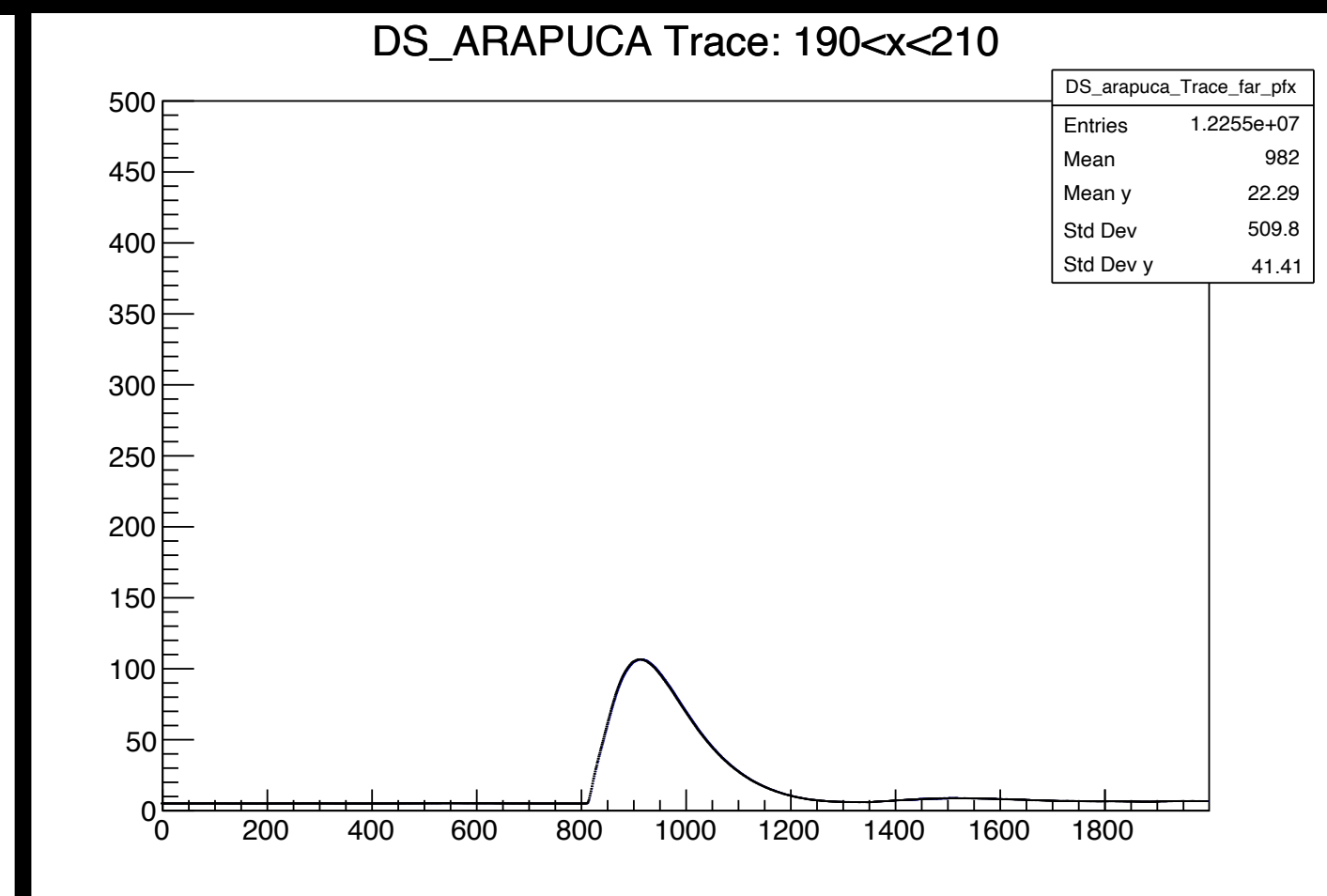
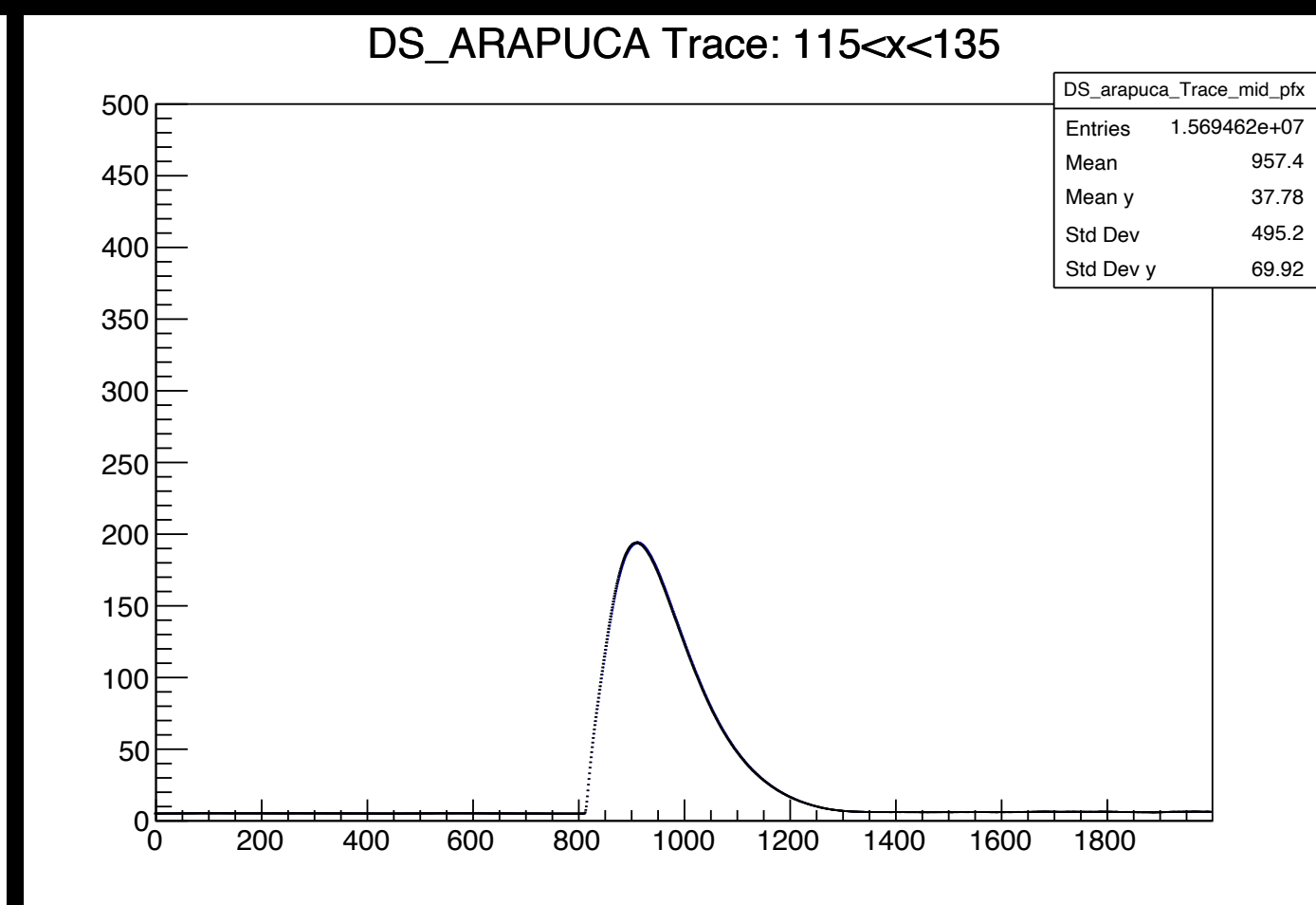
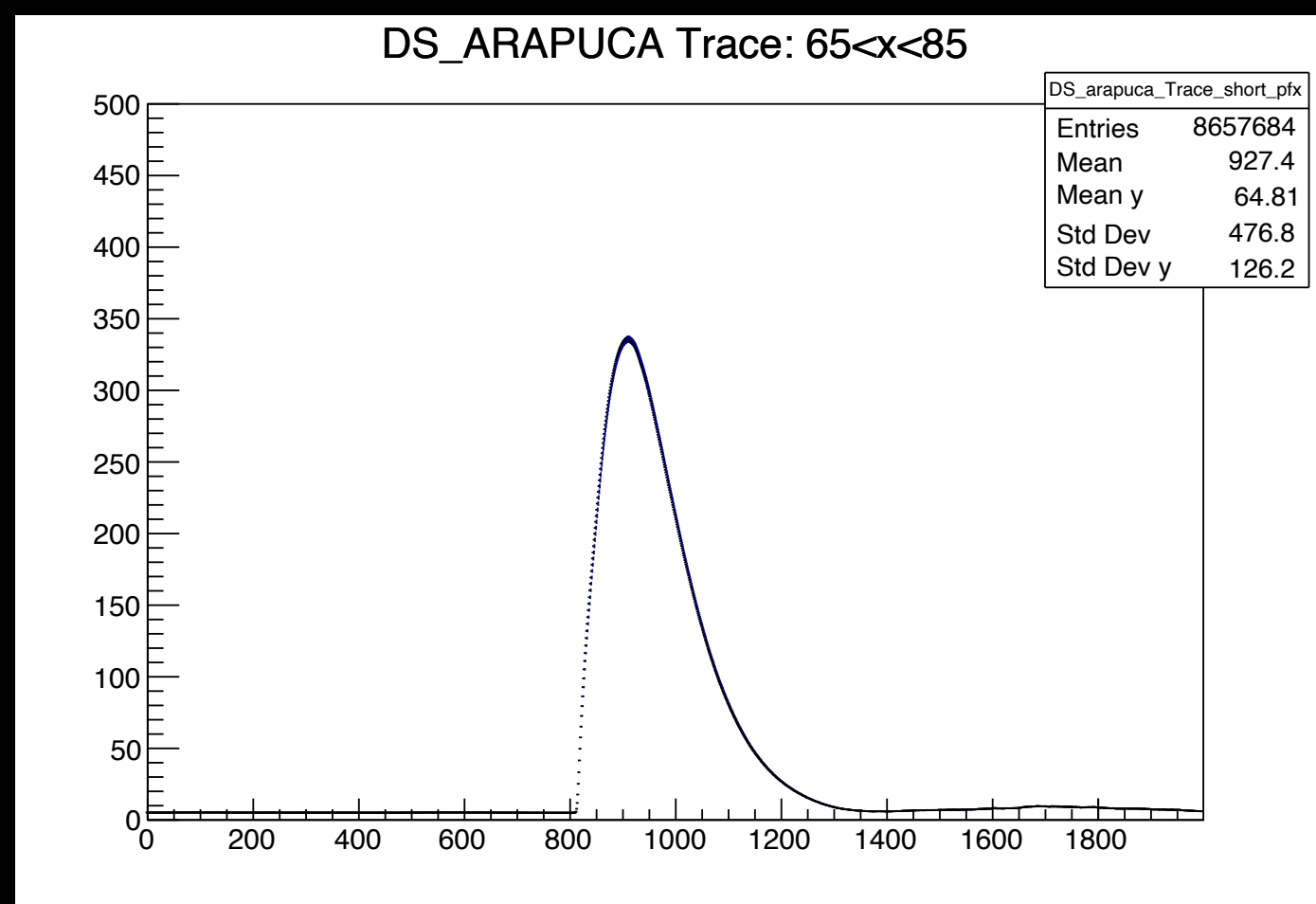
Run 5785
run 11



Run 10440
LAr + N



Run 11460
LAr + N + Xenon



ARAPUCA

Run	Distance	Amplitude	Integral	Amp % of LAr	Integral % of LAr	fast area / slow area
5785	75	458.33	114258.84	100.0	100.0	0.6772
11040	75	0	0	0.0	0.0	-
11460	75	335.87	77949.1	73.3	68.2	0.1945
5785	125	248.96	65576.727	100.0	100.0	0.6338
11040	125	155	25804.17	62.3	39.3	0.1776
11460	125	194.07	48334.303	78.0	73.7	0.1659
5785	200	123.97	36586.82	100.0	100.0	0.5305
11040	200	49	14593.50	39.5	39.9	0.9658
11460	200	106.66	31393.41	86.0	85.8	0.1303

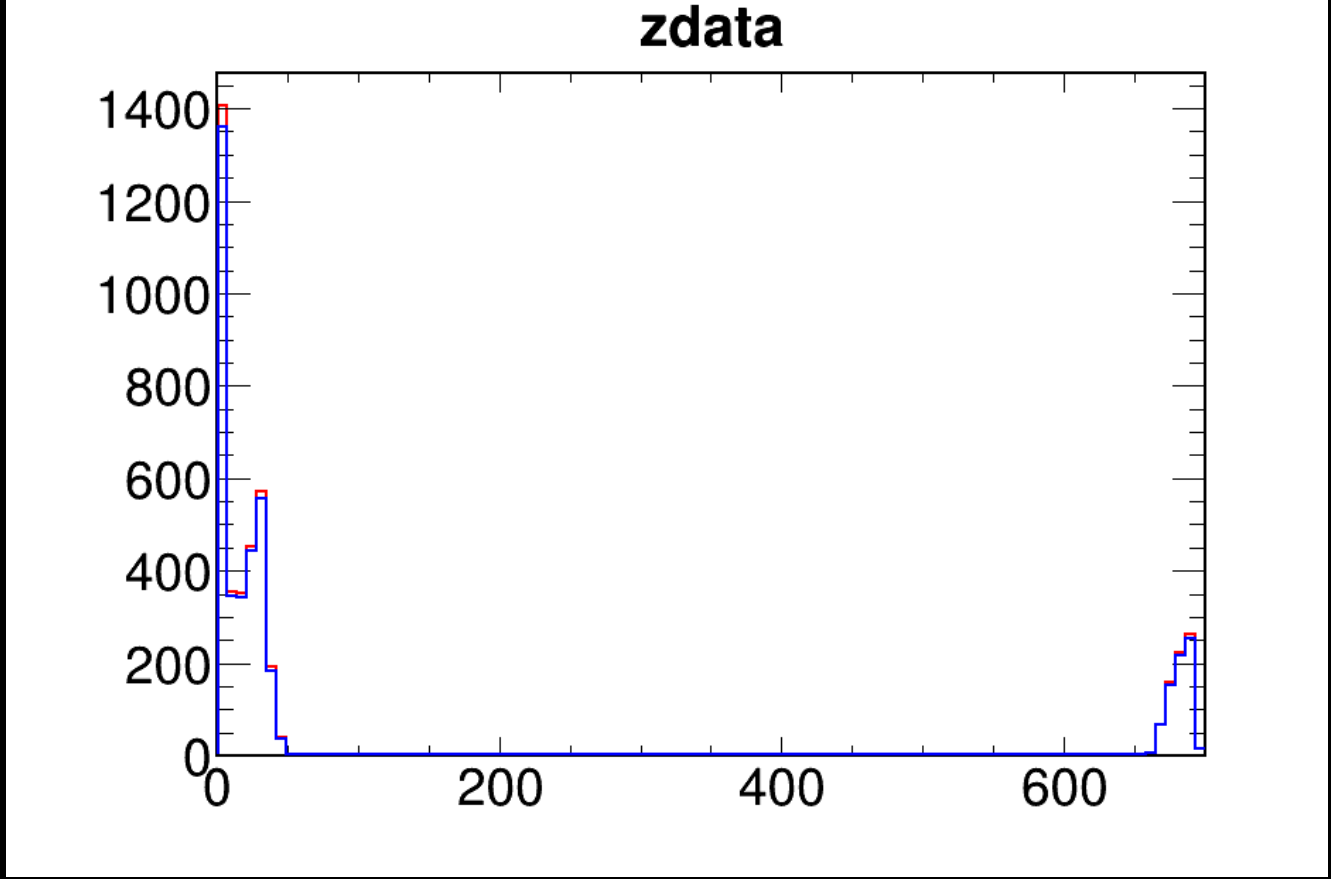
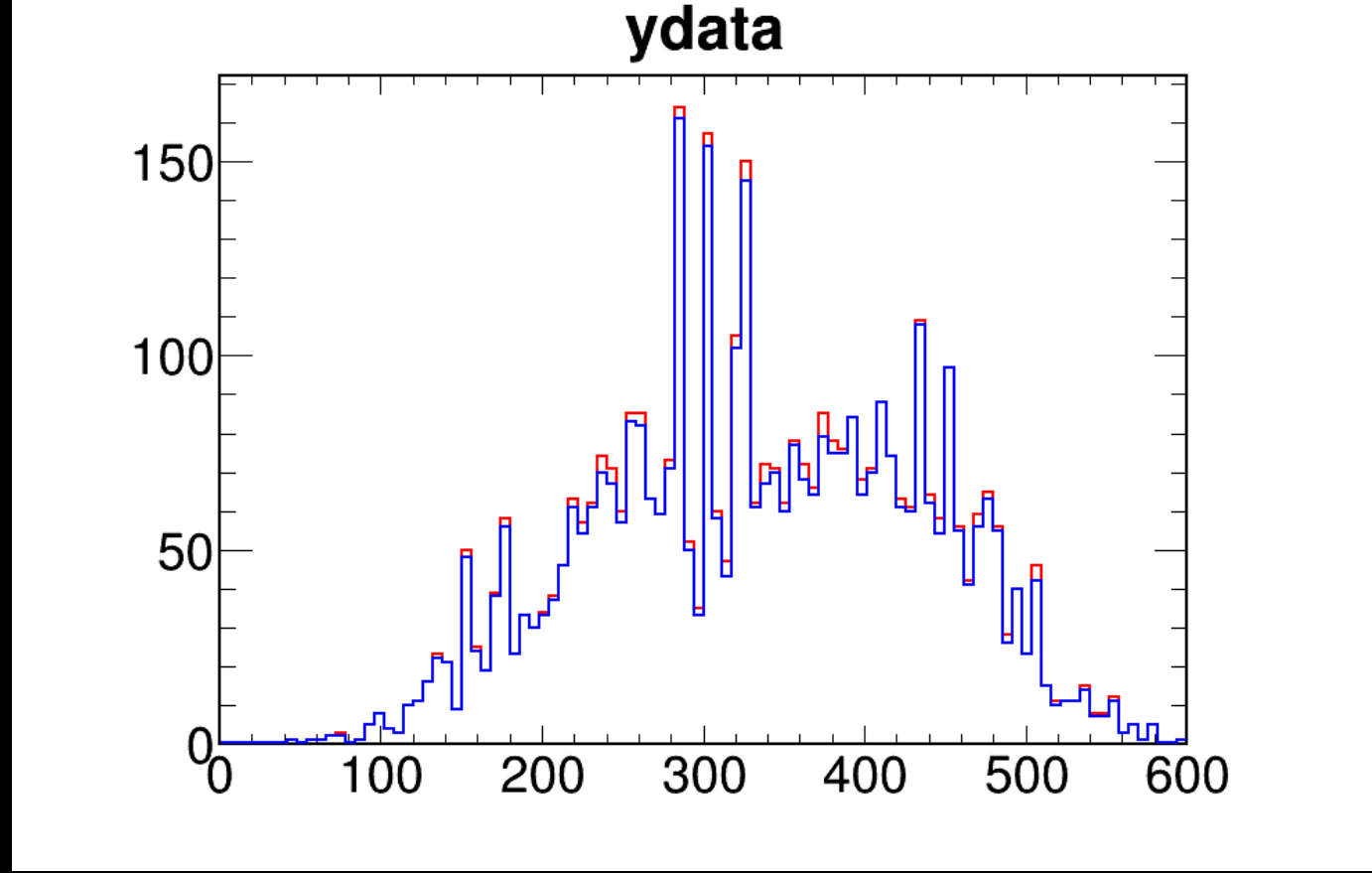
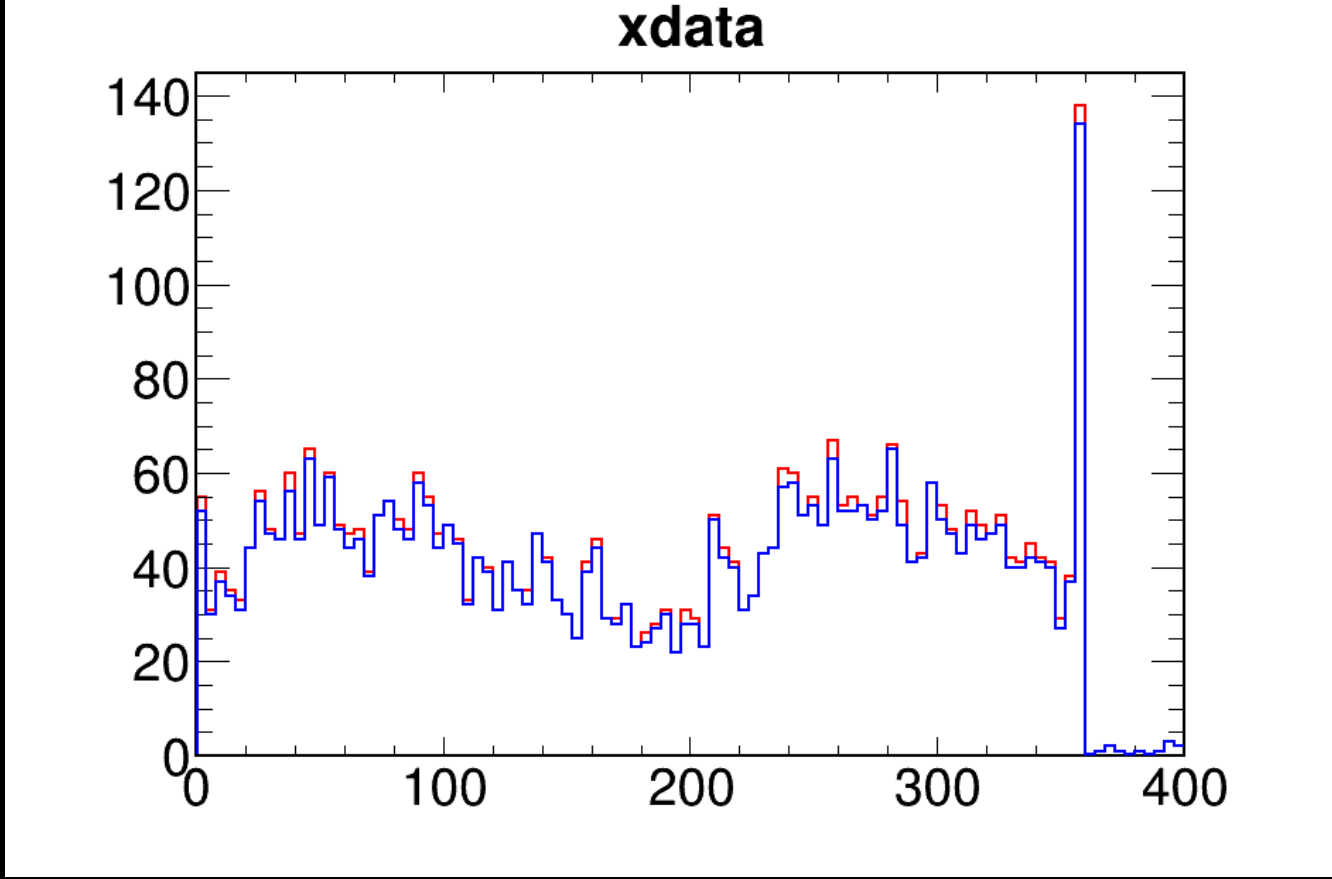
MC Generation - (very) First look

Particle Generation

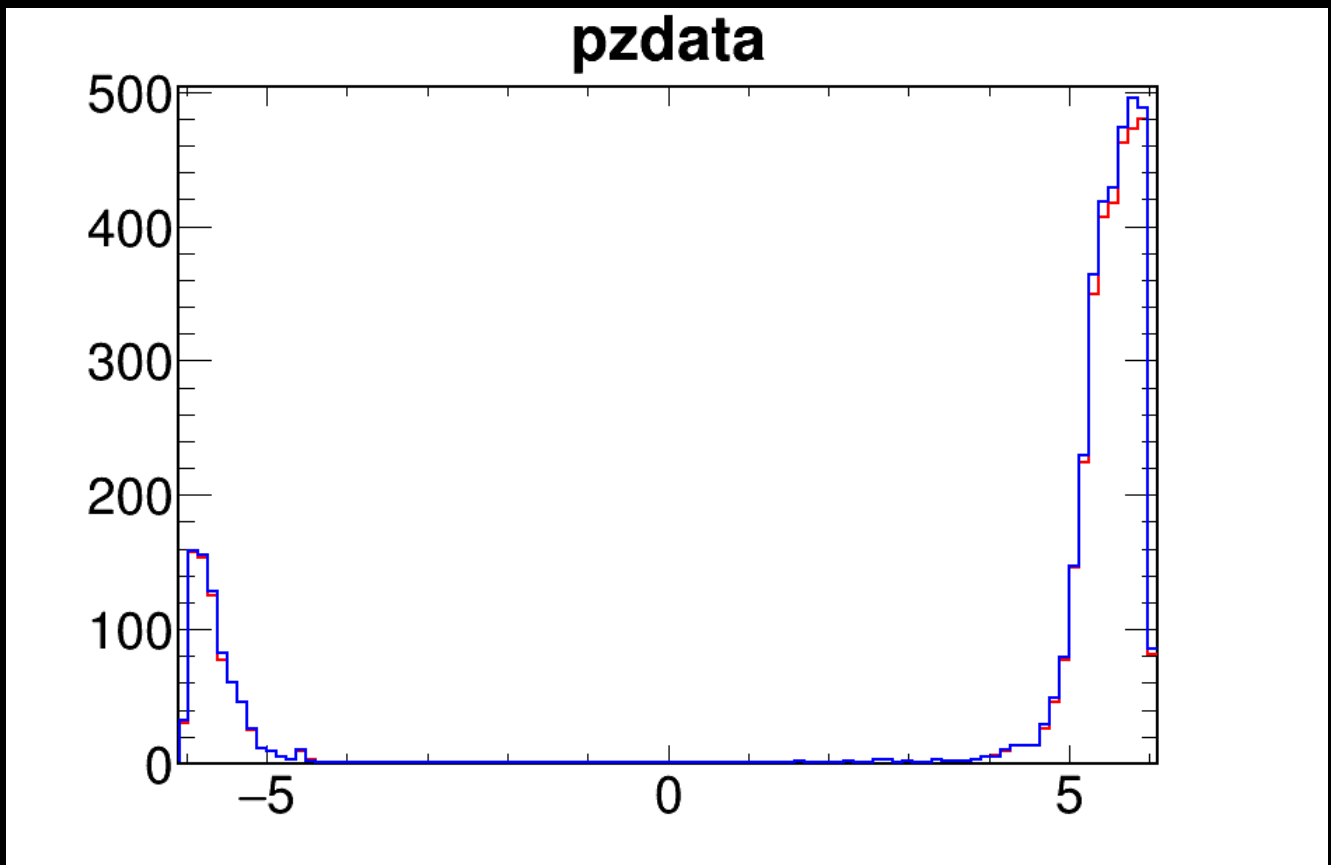
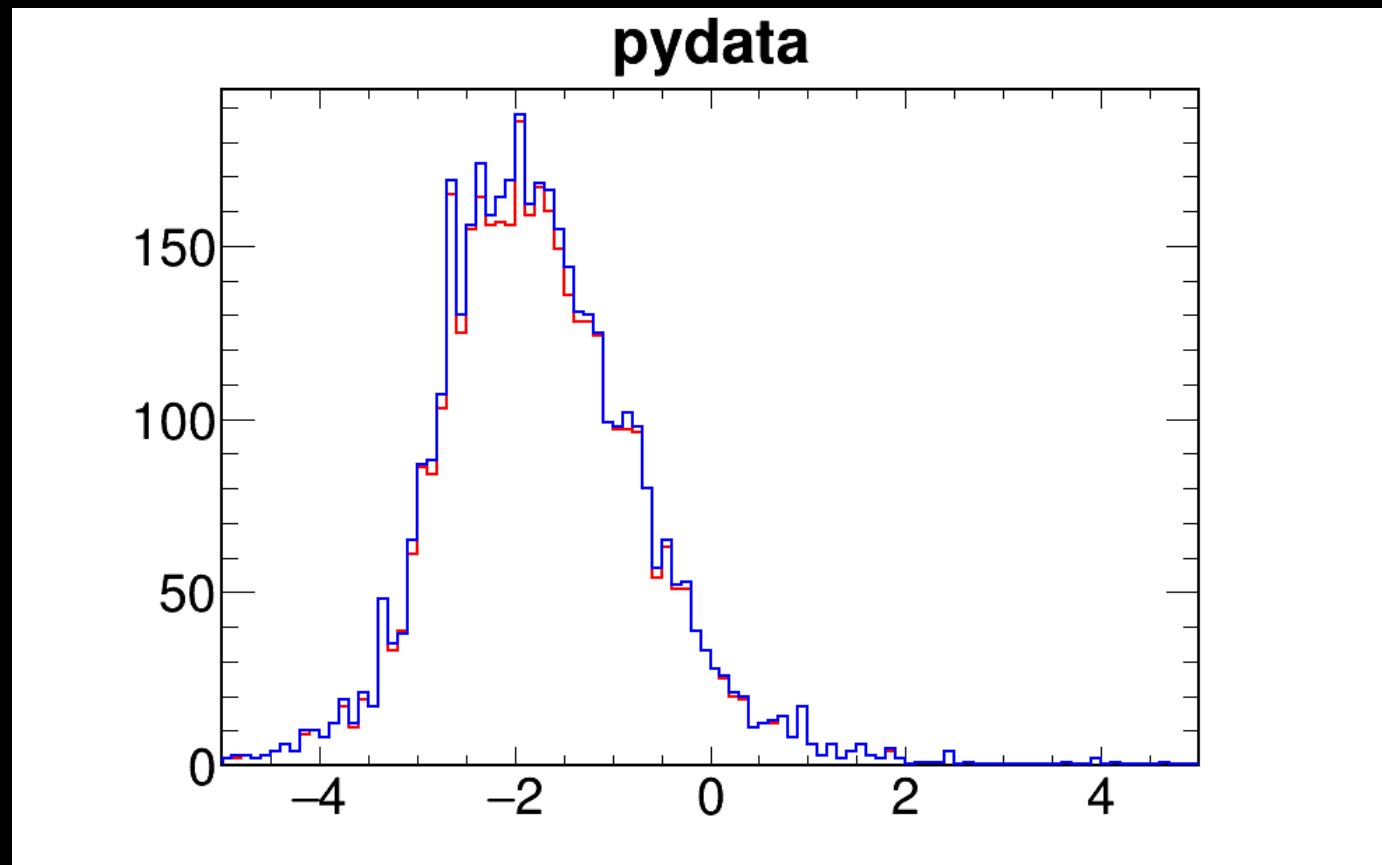
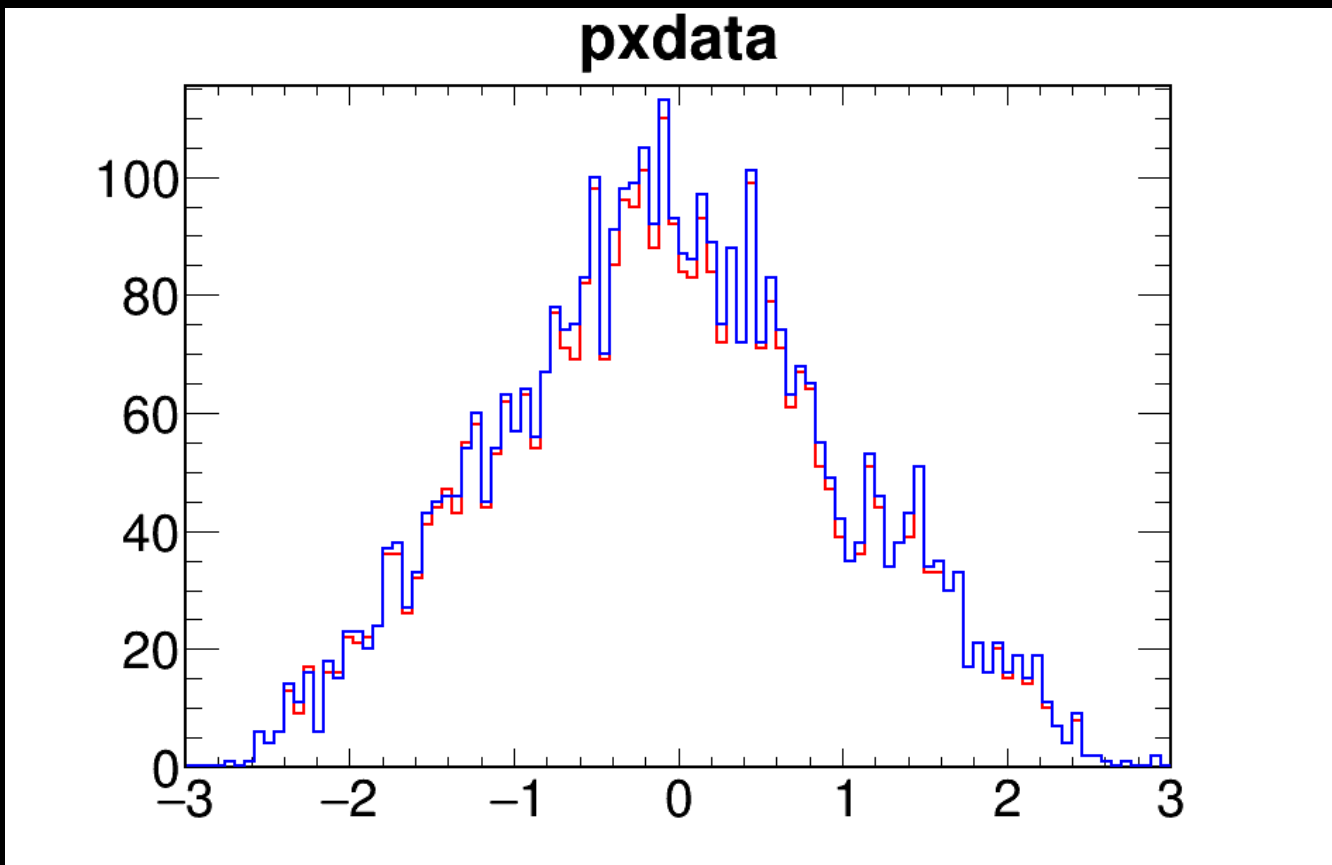
- Next step is to produce MC
- Generation code resurrected by Bryan

— MC
— Data

Position

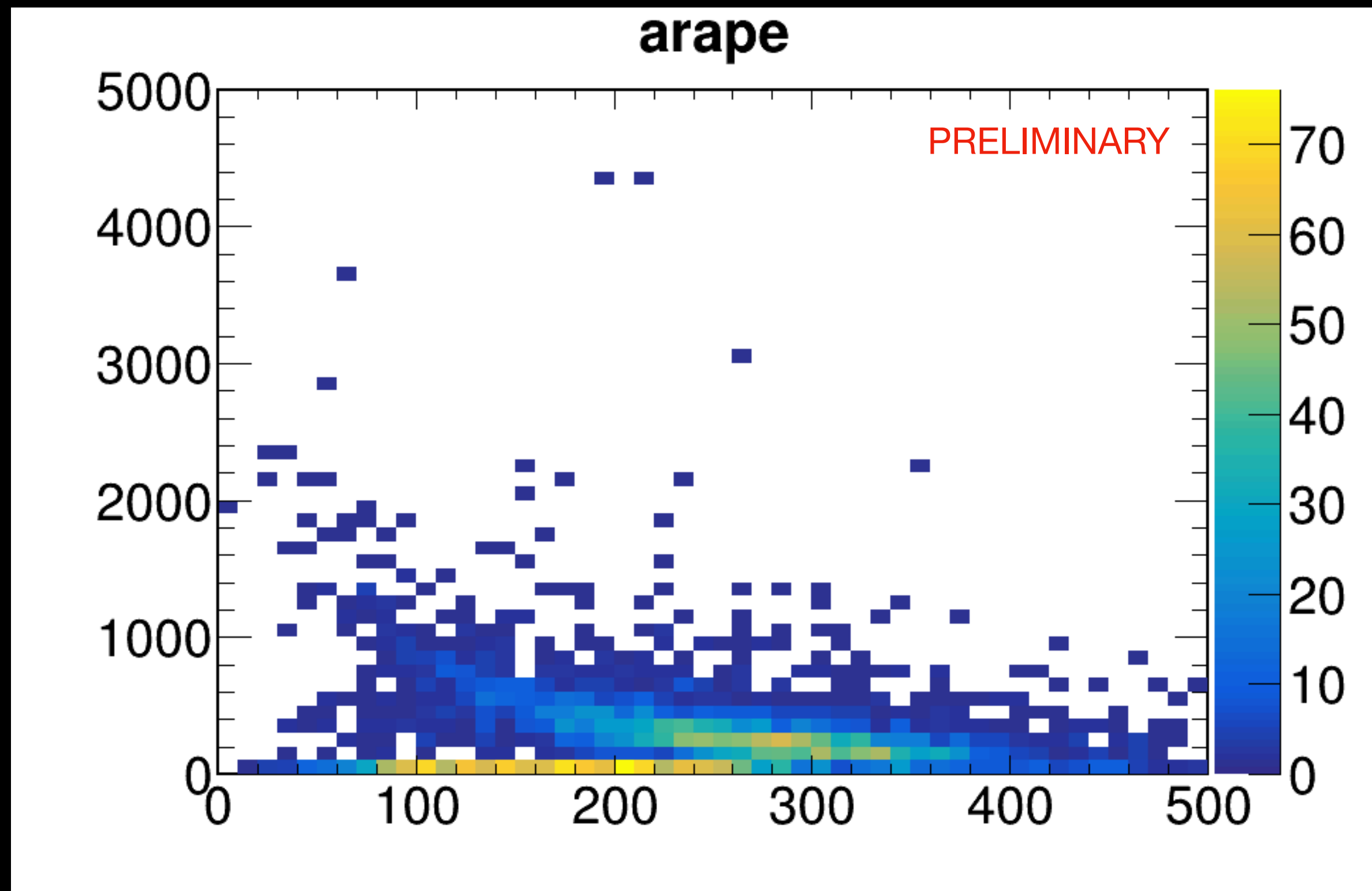


Momentum

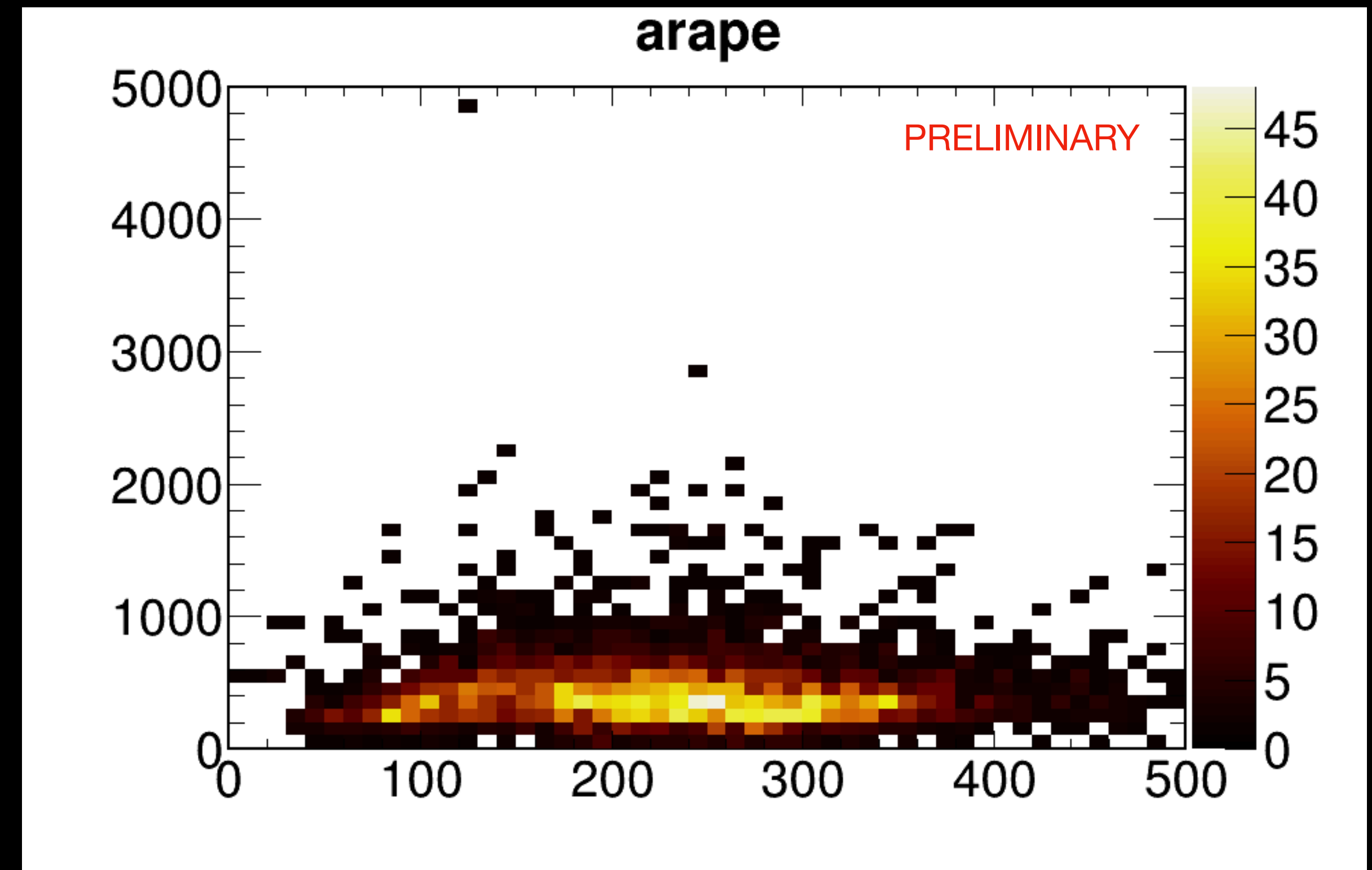


MC Generation - (very) First look

Attenuation Curves



Data - No track "quality" cuts



Monte Carlo

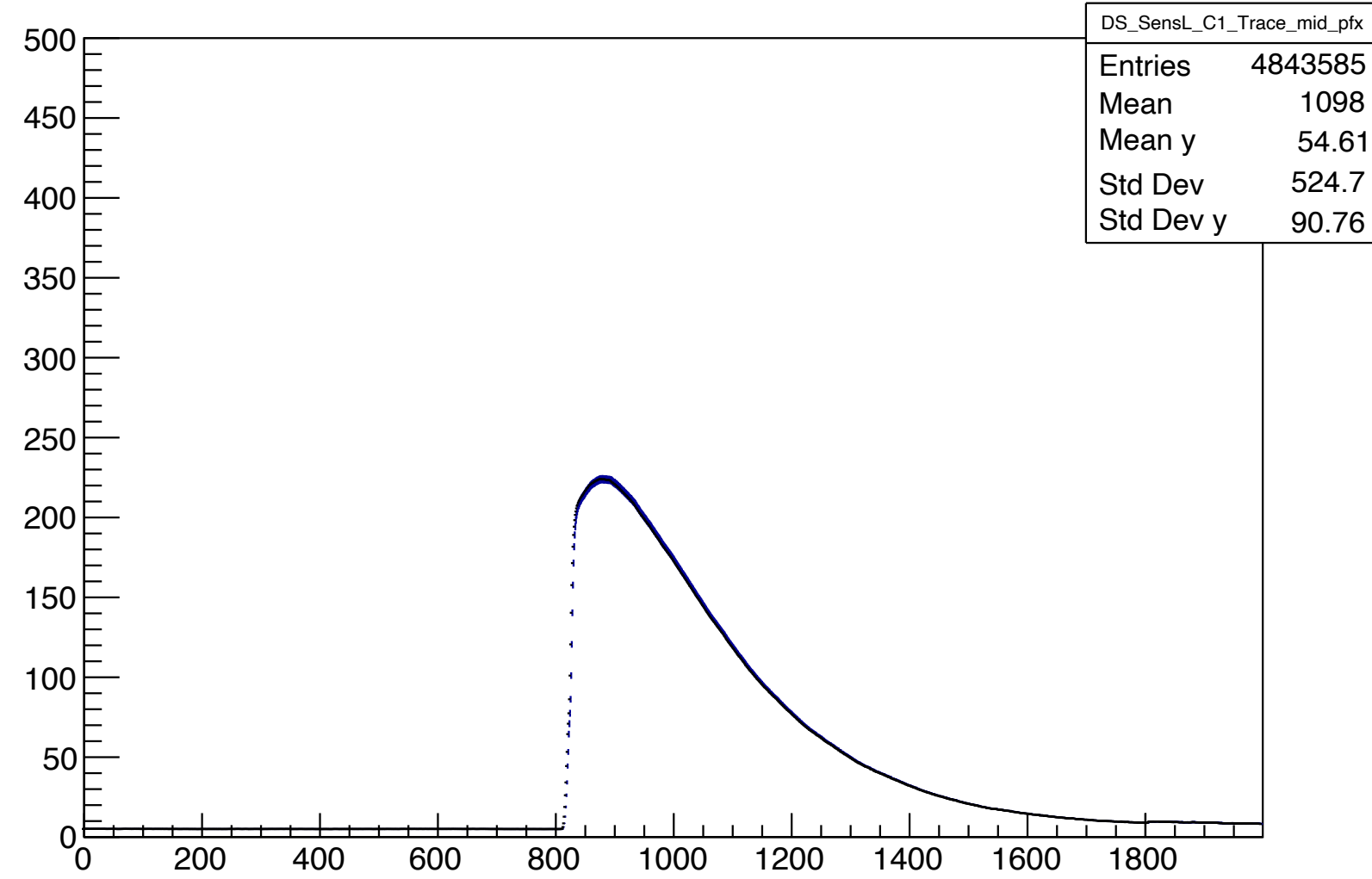
Conclusions and next steps

- We see a large decrease in light from Nitrogen contamination
- We then see a large recovery of light with addition of Xenon
- Working to get absorption and Rayleigh Scattering properties
 - Preparing MC set now for comparisons
- Expand analysis procedure to more runs / higher statistics samples
 - One goal is to look at these metrics for the doping runs
 - In progress - seeing some discrepancy with first results posted for ARAPUCA

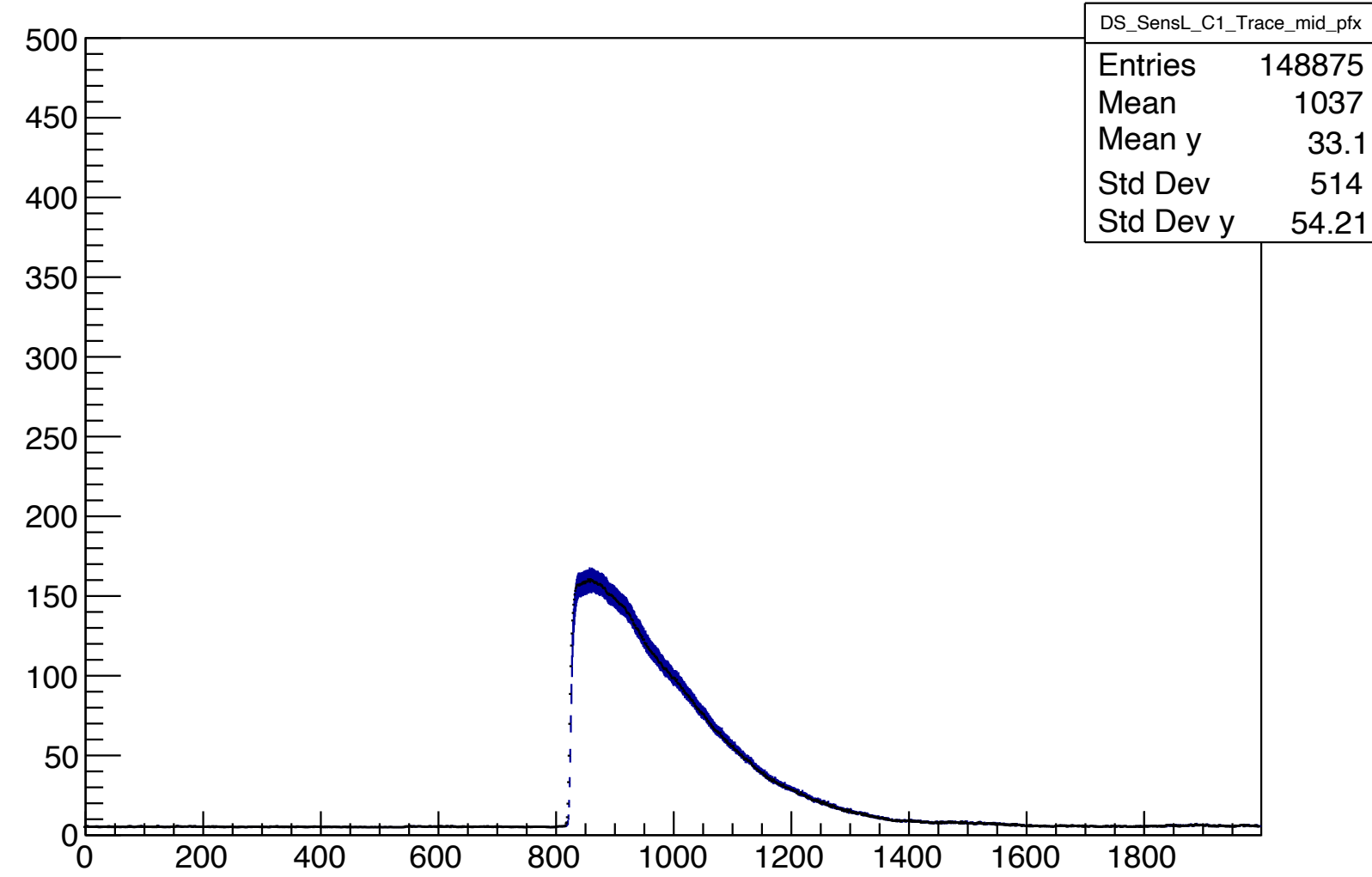
Back-up

SensL 125 cm - 3 runs

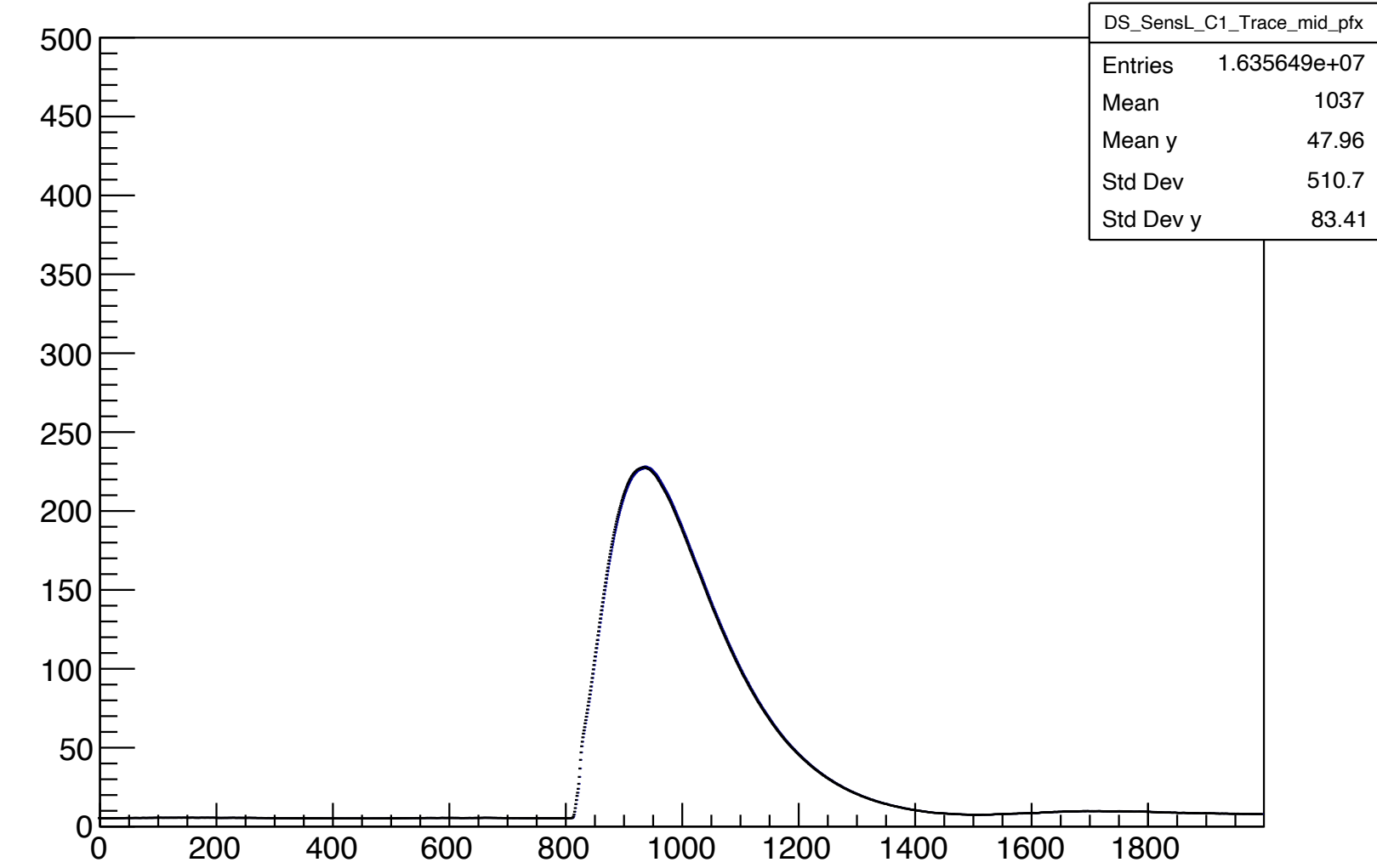
DS_SensL_C1 Trace: 115<x<135



DS_SensL_C1 Trace: 115<x<135



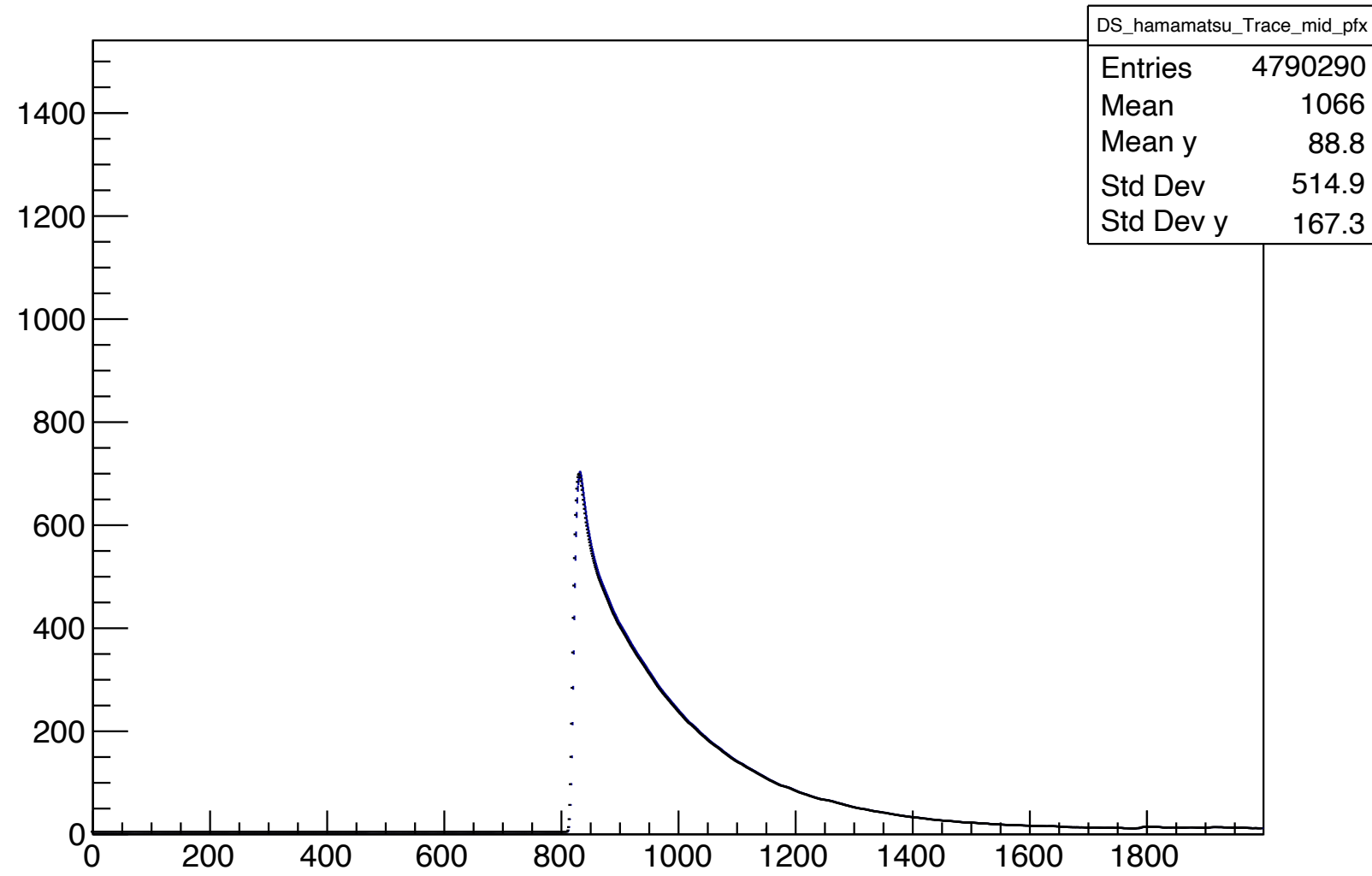
DS_SensL_C1 Trace: 115<x<135



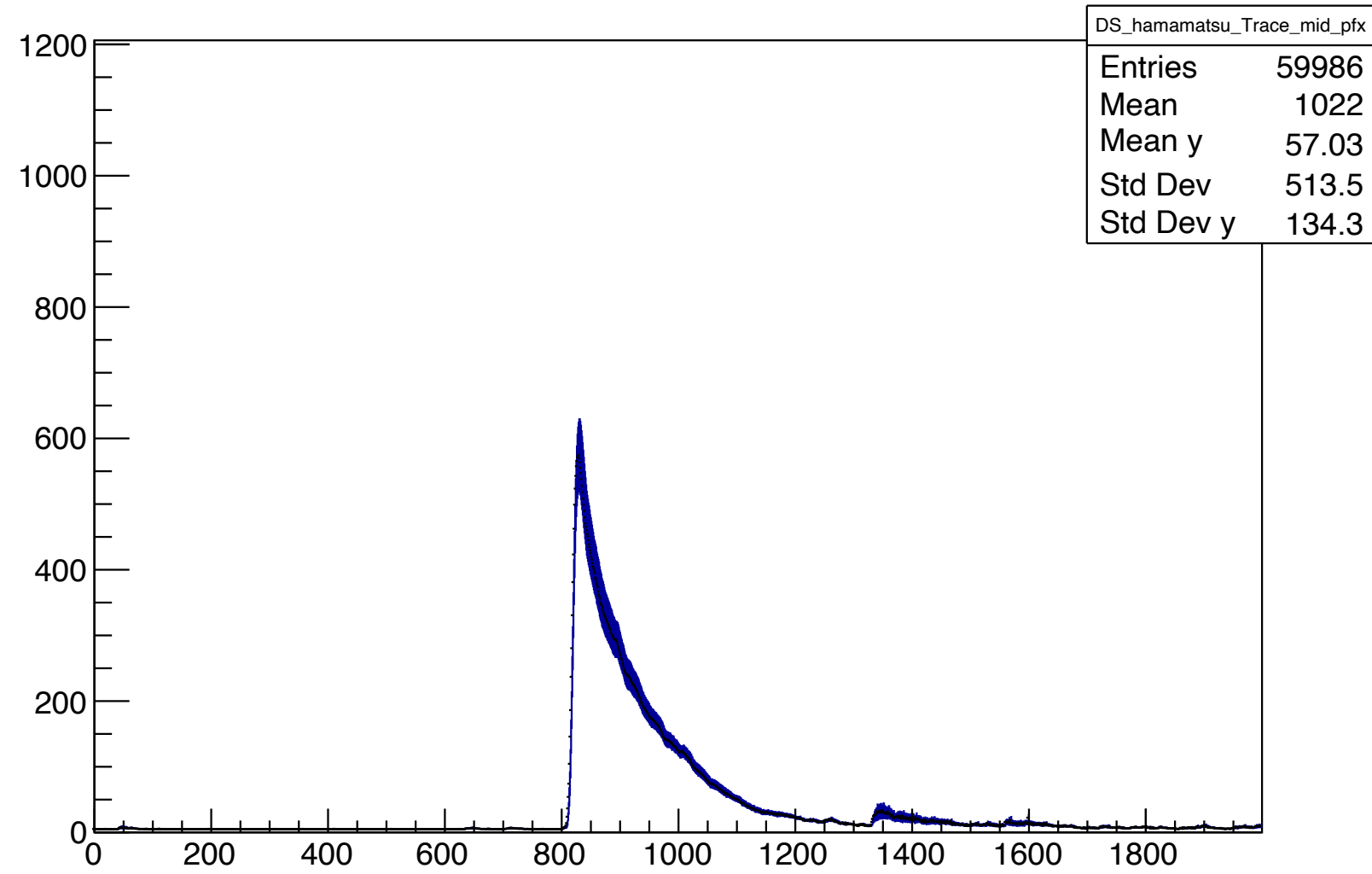
Back-up

Hamamatsu 125 cm - 3 runs

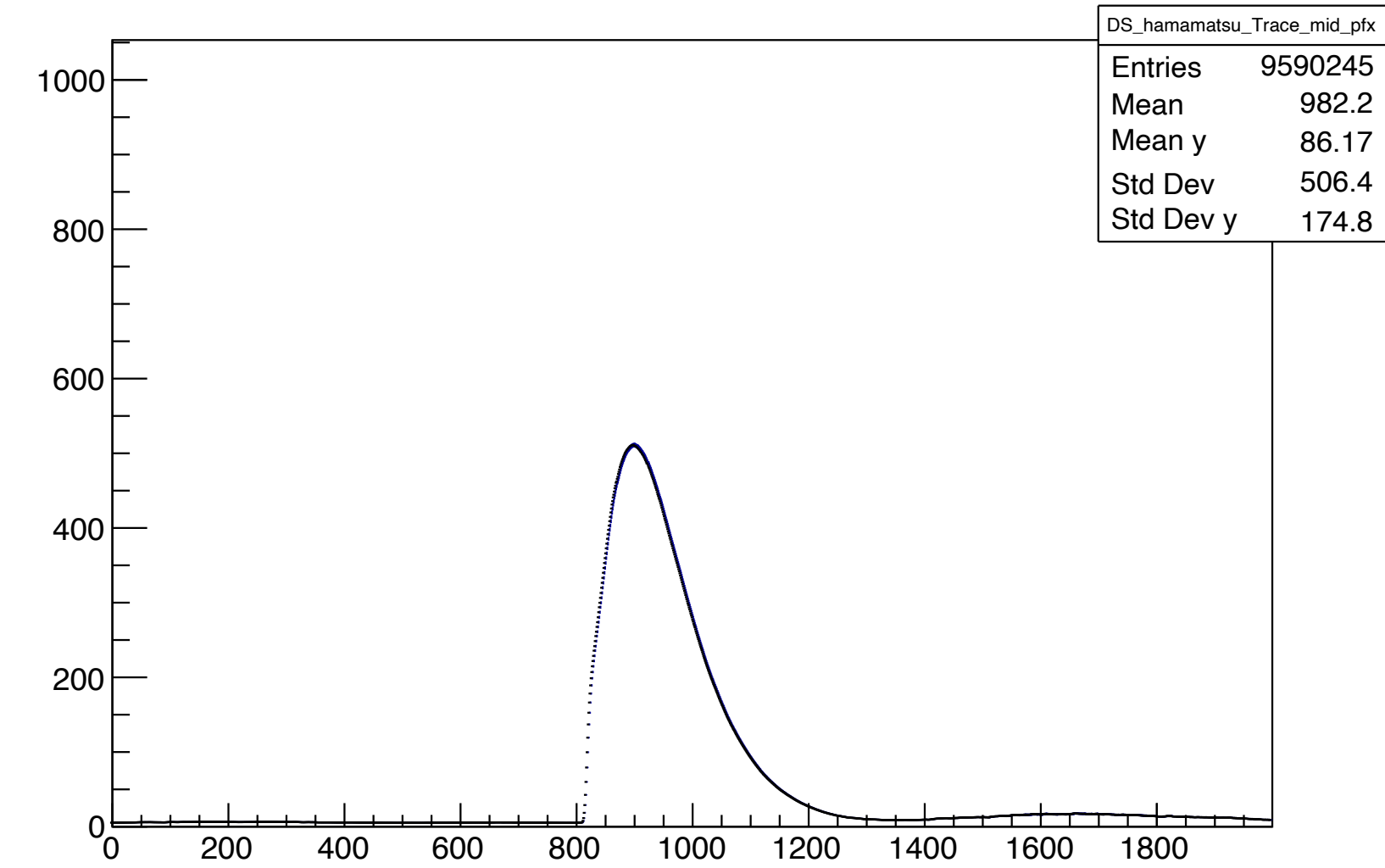
DS_hamamatsu Trace: 115<x<135



DS_hamamatsu Trace: 115<x<135



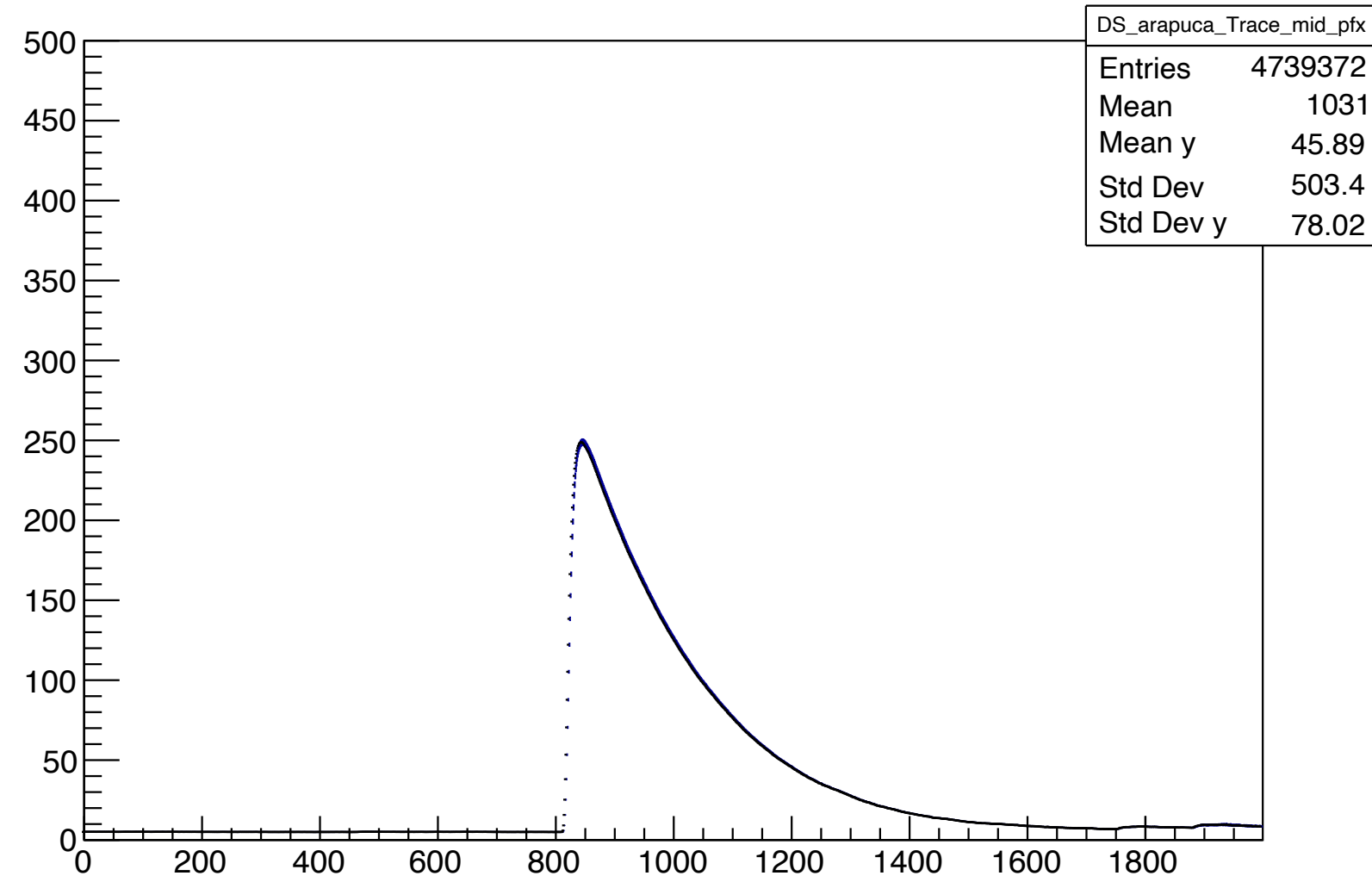
DS_hamamatsu Trace: 115<x<135



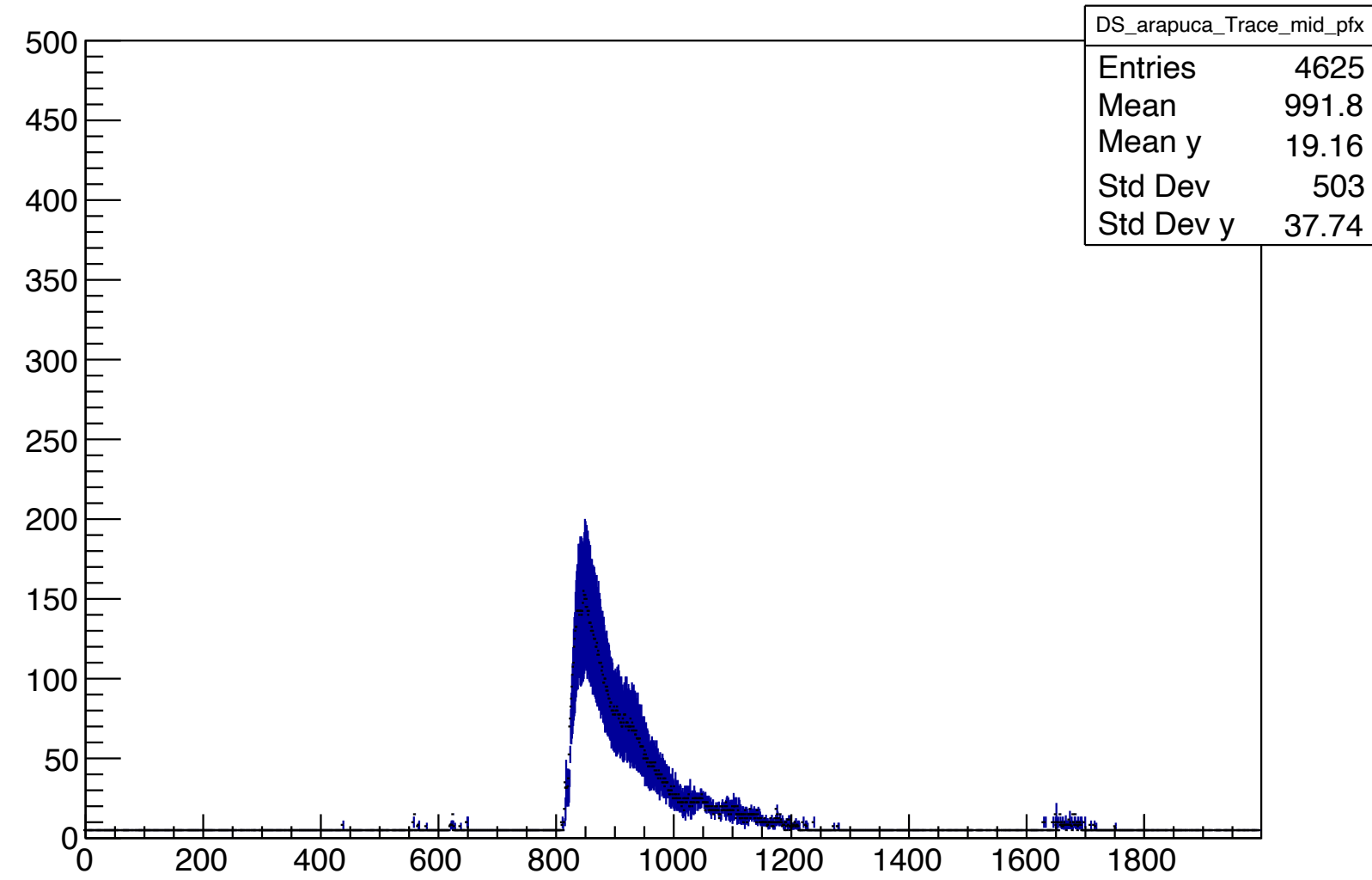
Back-up

ARAPUCA 125 cm - 3 runs

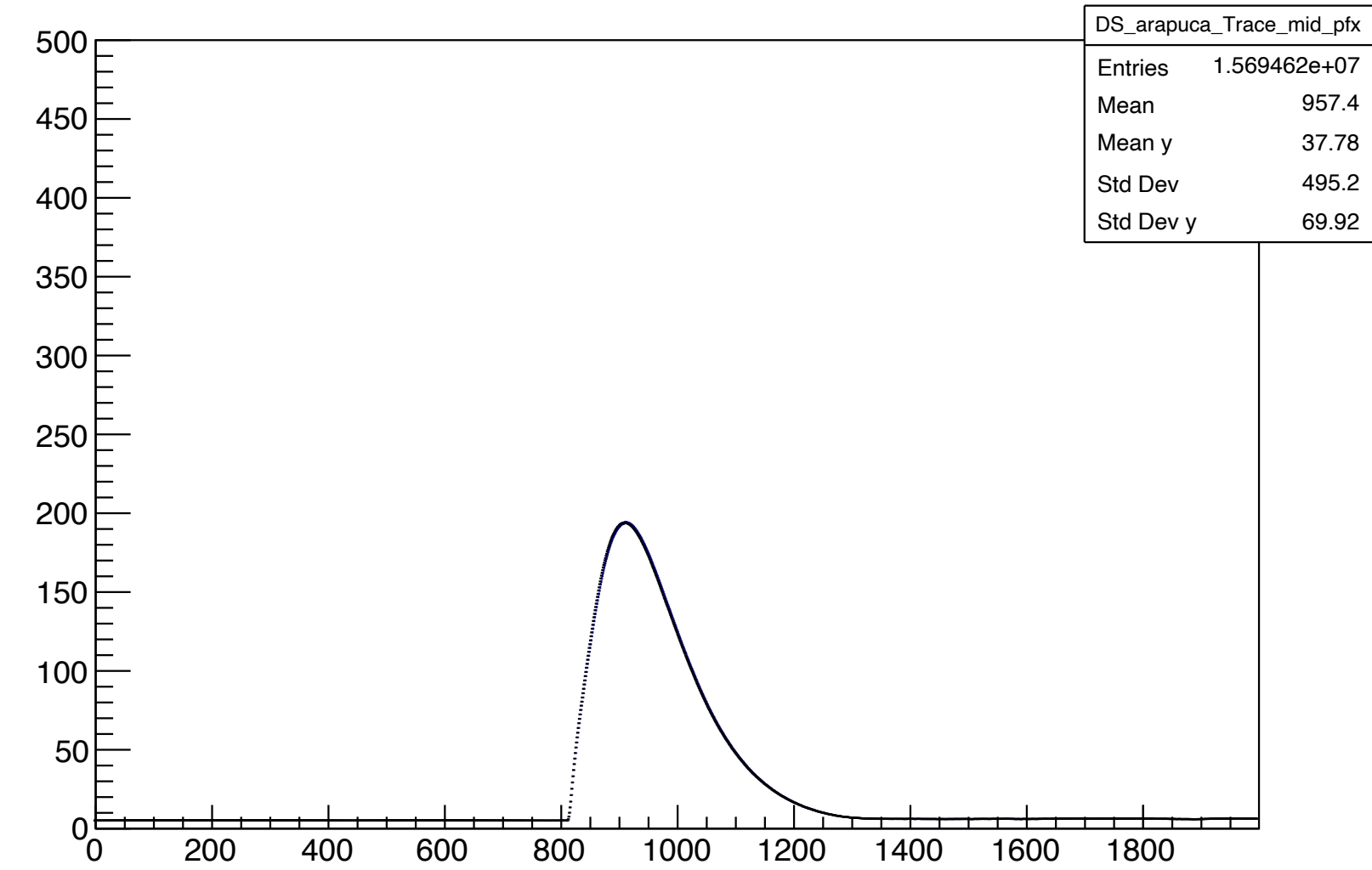
DS_ARAPUCA Trace: 115<x<135



DS_ARAPUCA Trace: 115<x<135



DS_ARAPUCA Trace: 115<x<135



Back-up

Deconvolutions - SPEs

