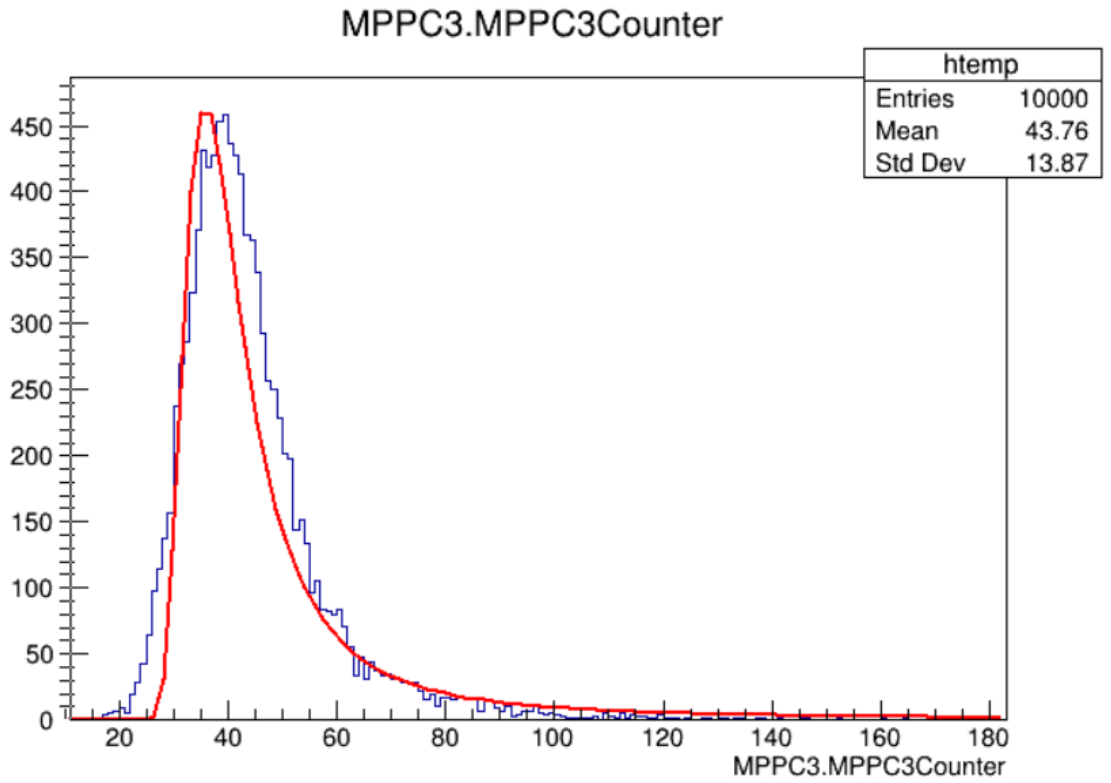
Position dependency

Choi Jae Min

Landau convoluted with Gaussian

- According to Bethe-Bloch formula, energy deposit on thin scintillator follows the Landau distribution.
- The statistical functions such as the capture in WLS process and reflection follow the Gaussian distribution.
- Therefore, Landau convoluted with Gaussians should be used as fitting function.
- Because it is impossible to convolute from –infinite to +infinite, integration range is from +-5sigma.

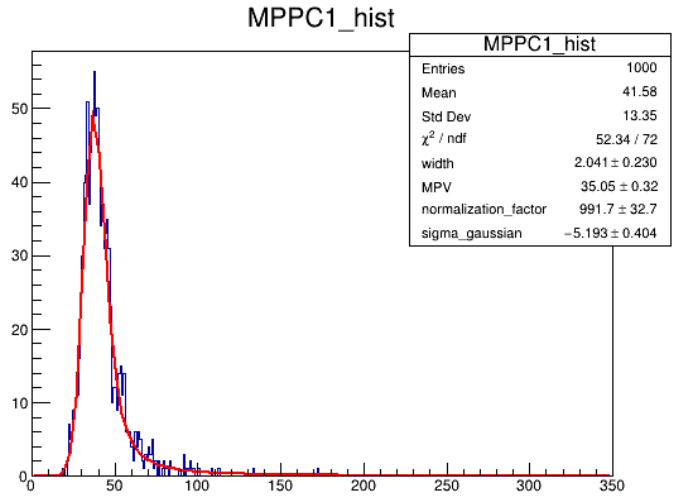
Reference

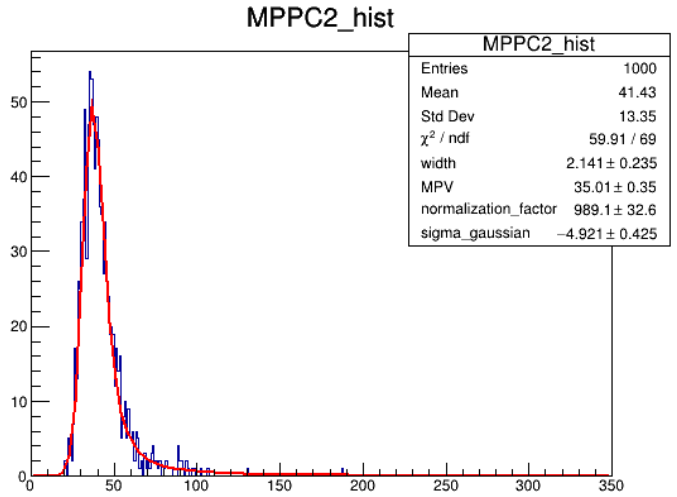


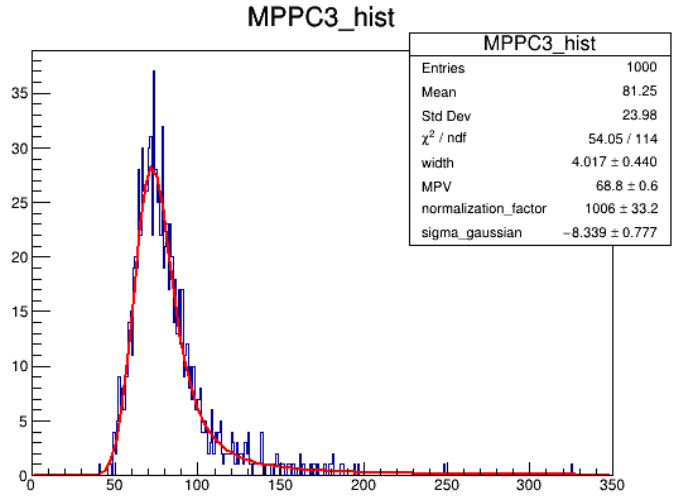
Fitting result with Landau distribution

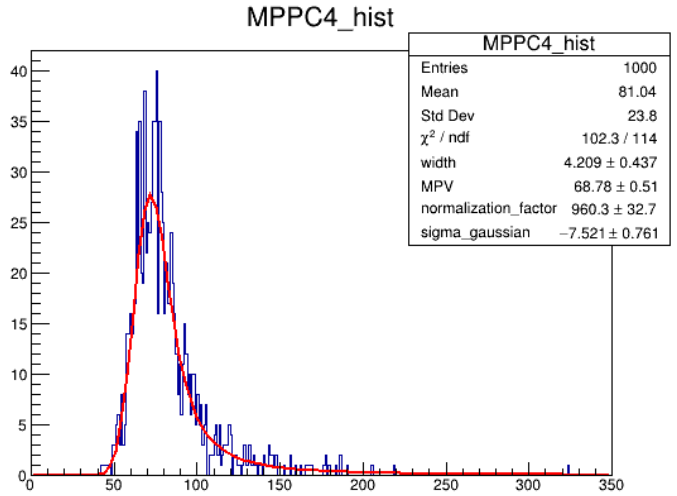
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	Constant	2.57279e+03	4.16289e+01	5.27154e-02	-1.34135e-06
2	MPV	3.66461e+01	1.10169e-01	2.46157e-04	4.90414e-04
3	Sigma	3.47939e+00	4.38730e-02	4.84967e-06	-5.33688e-02

Fitting Results – 26.5 mm

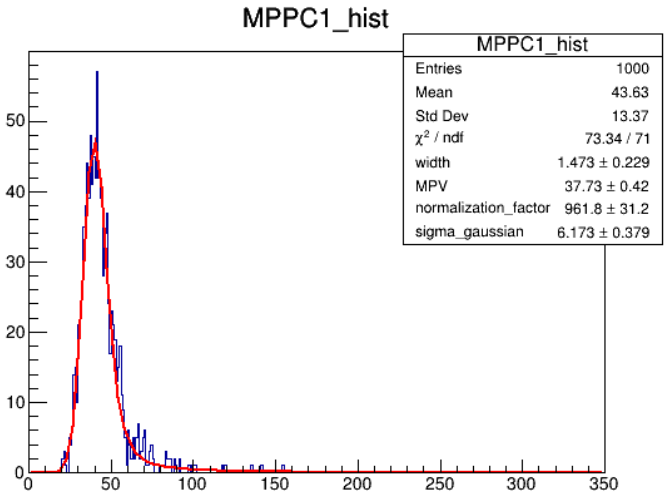


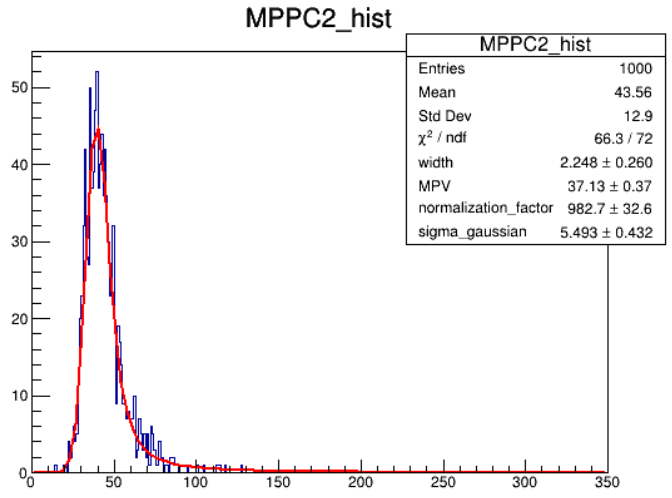


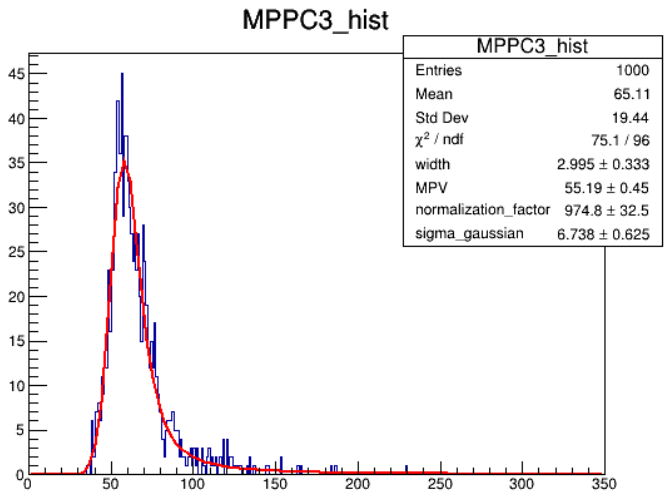


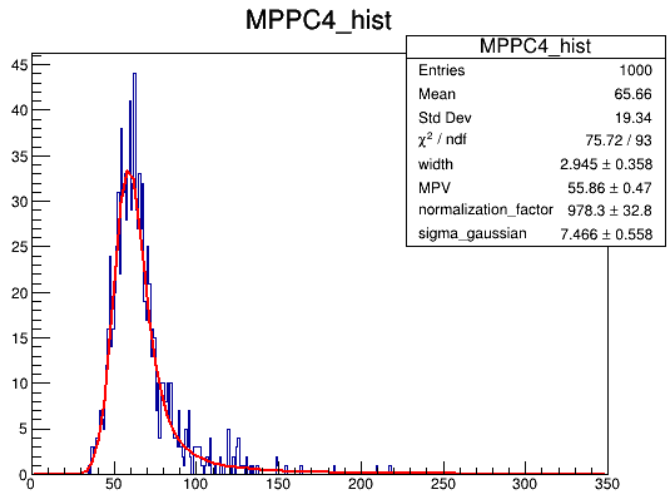


Fitting Results – 227 mm

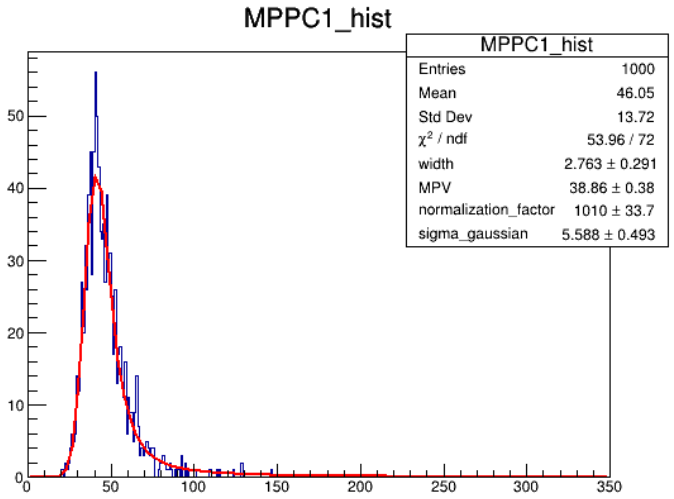


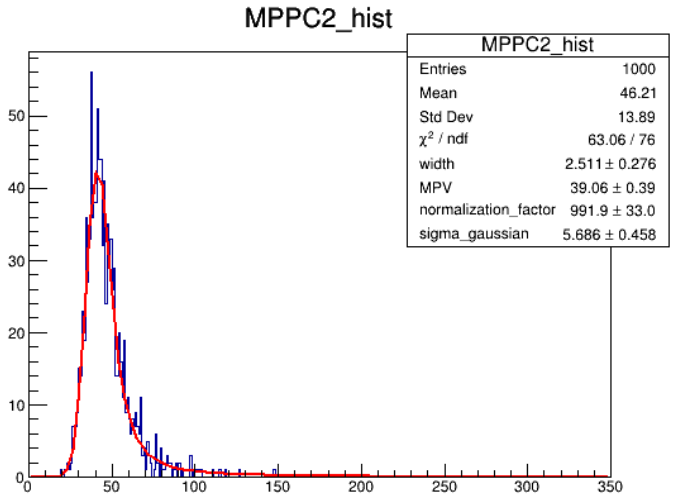


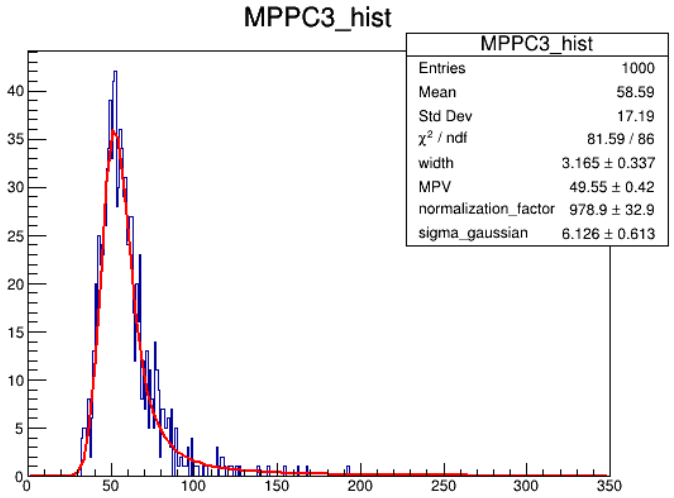


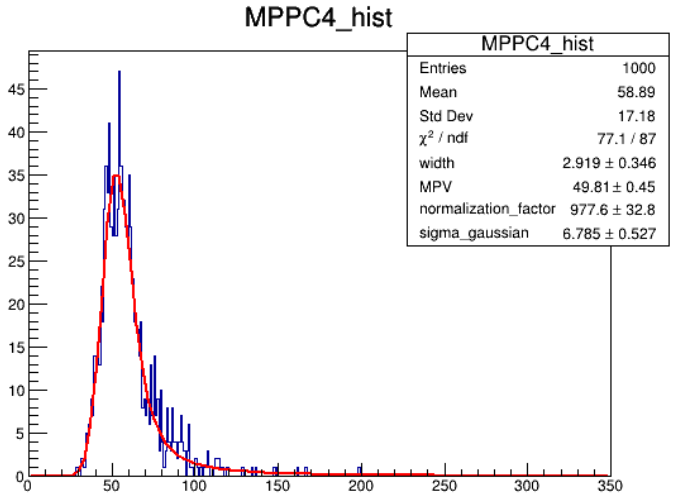


Fitting Results – 428 mm

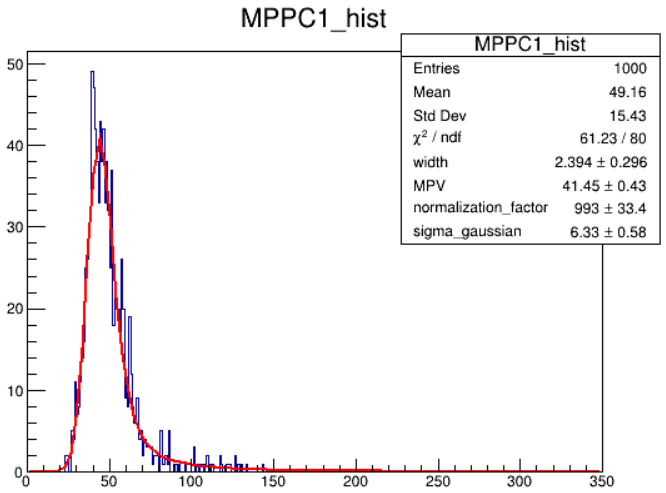


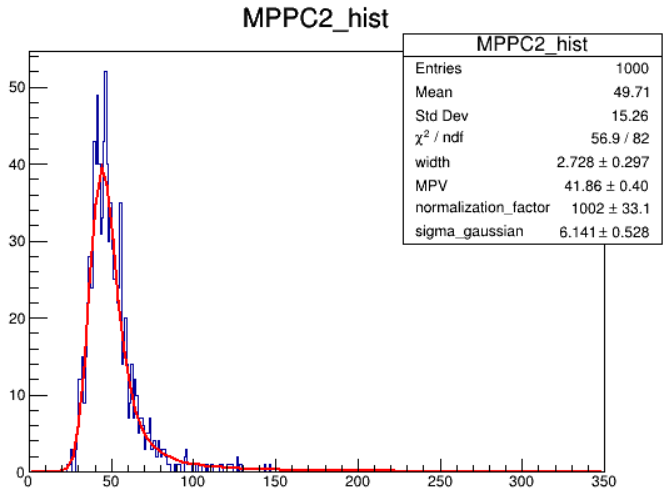


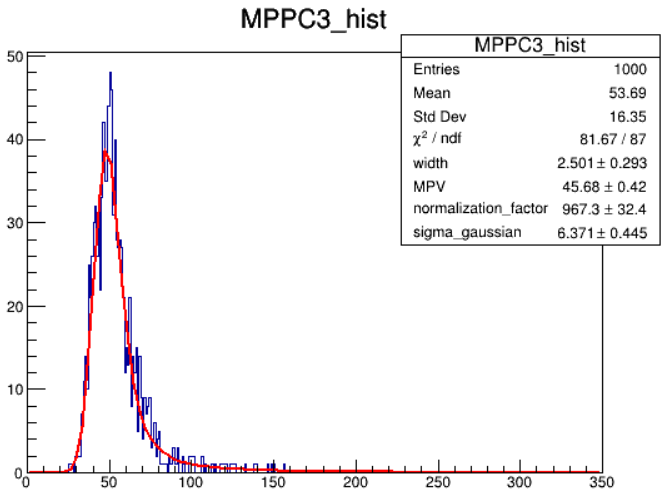


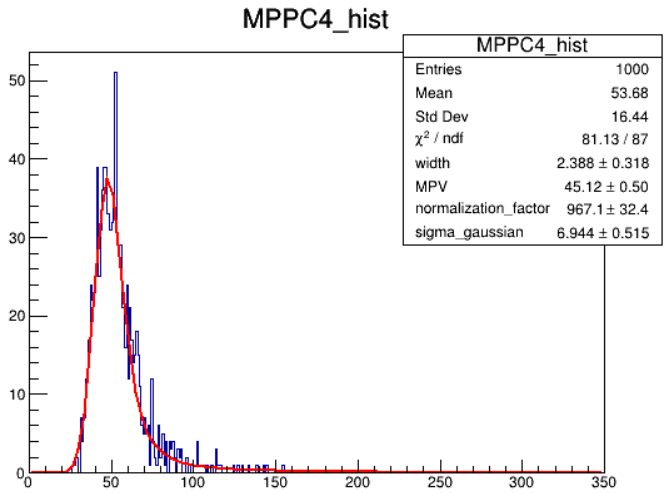


Fitting Results – 628 mm

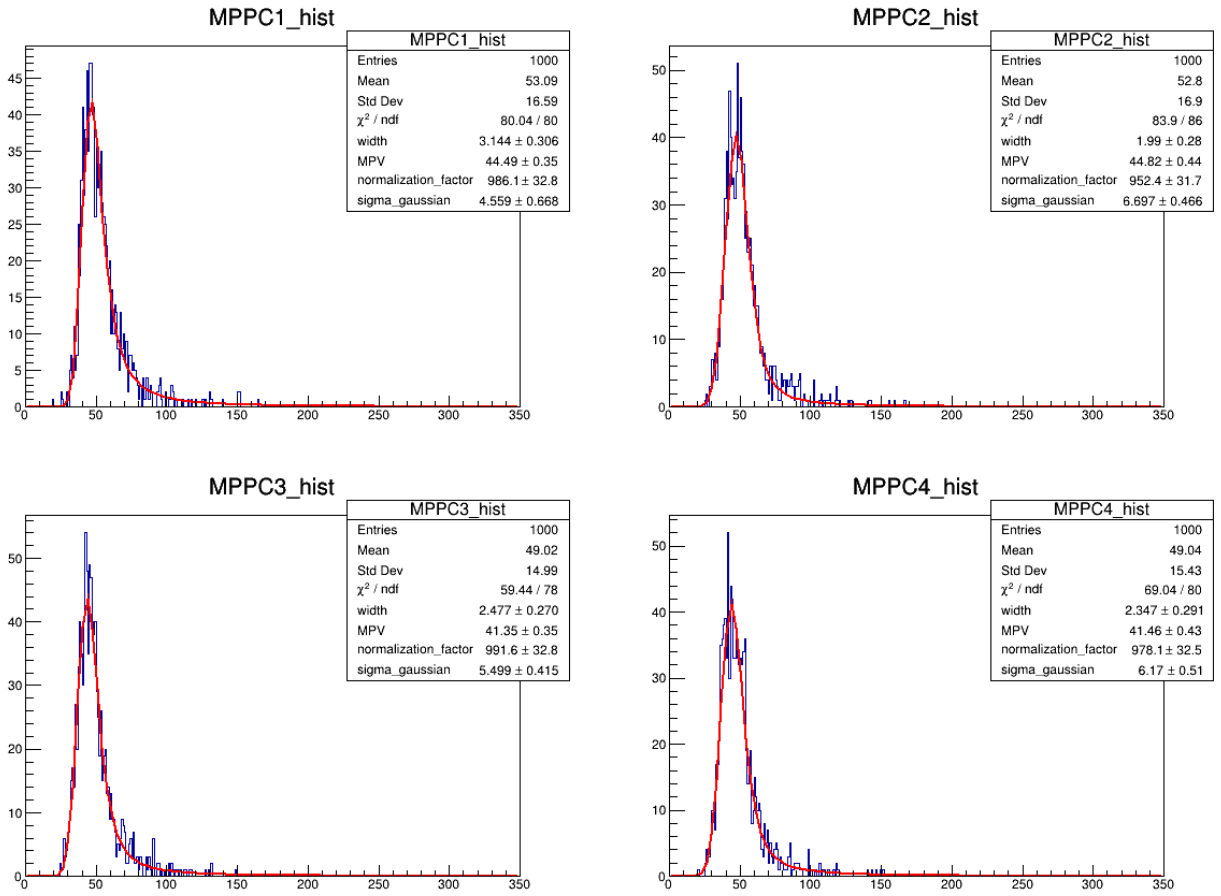




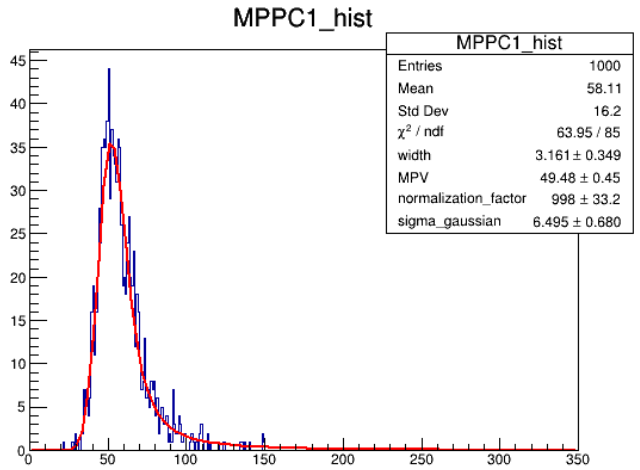


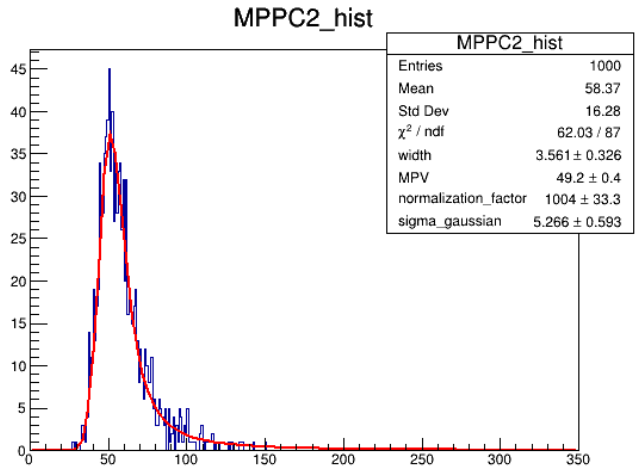


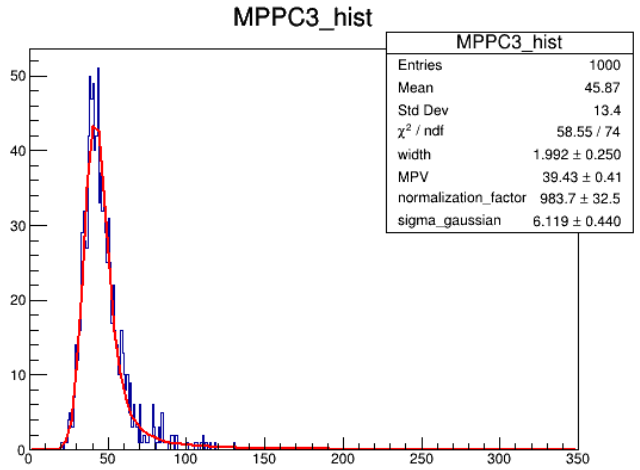
Fitting Results – 829 mm

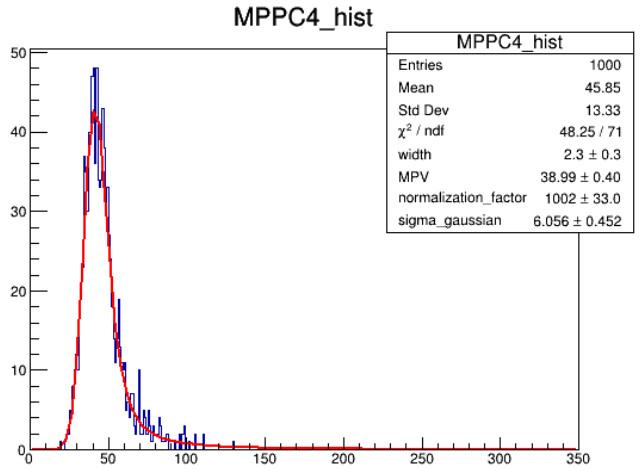


Fitting Results – 1030 mm

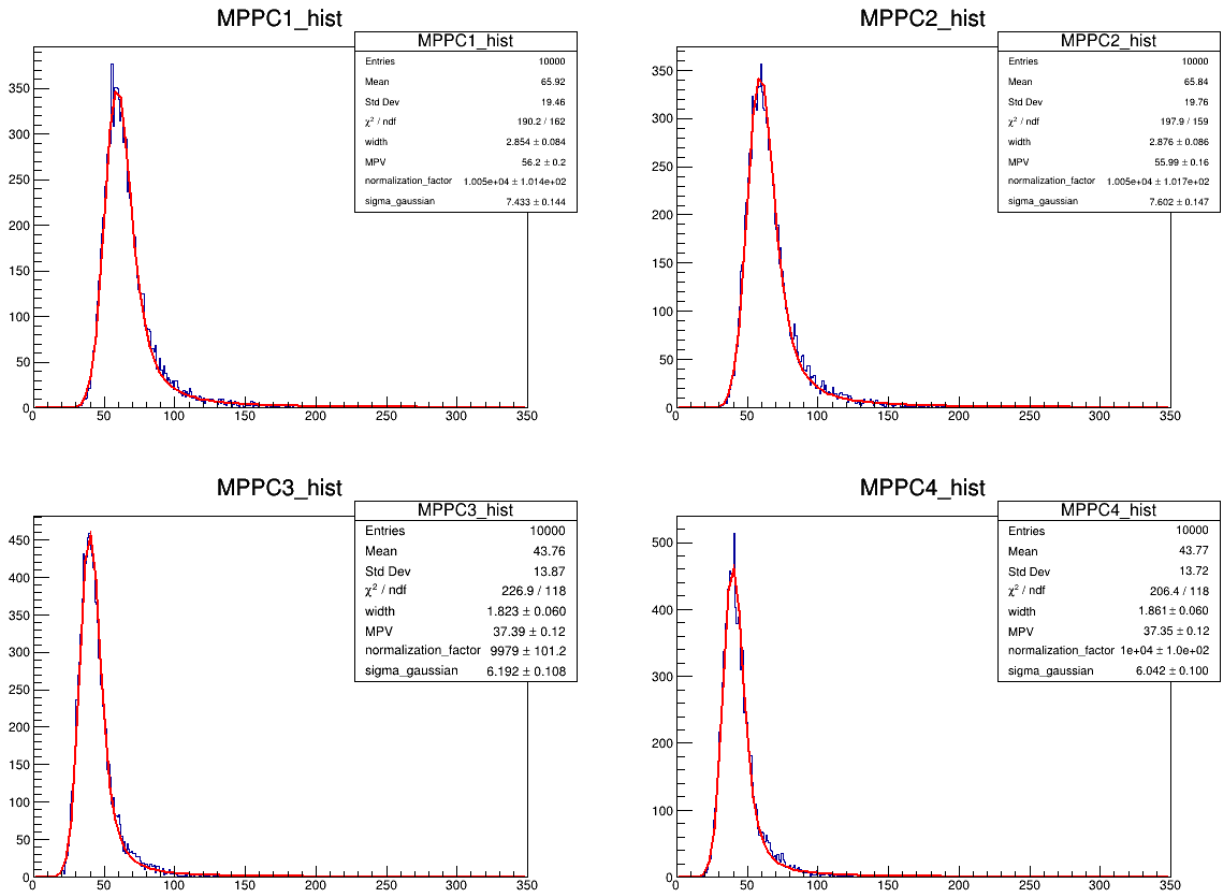




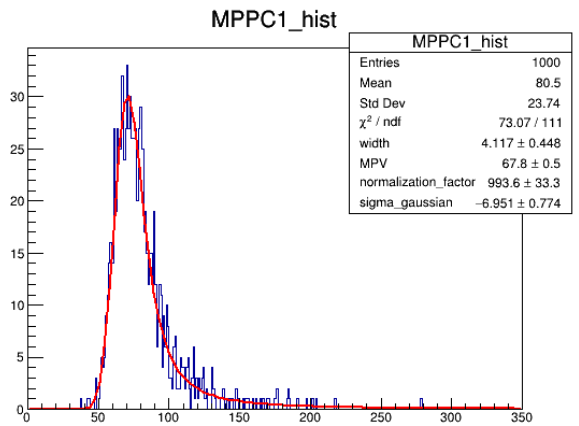


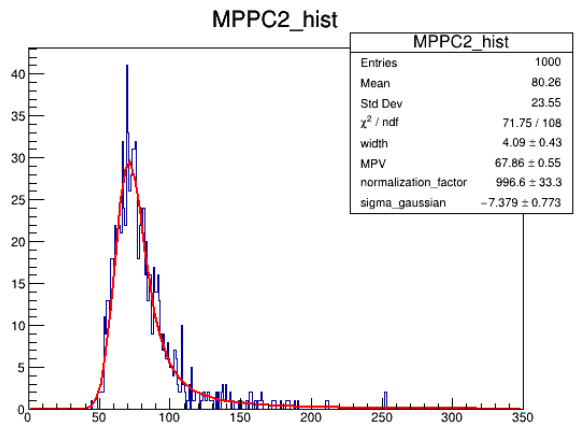


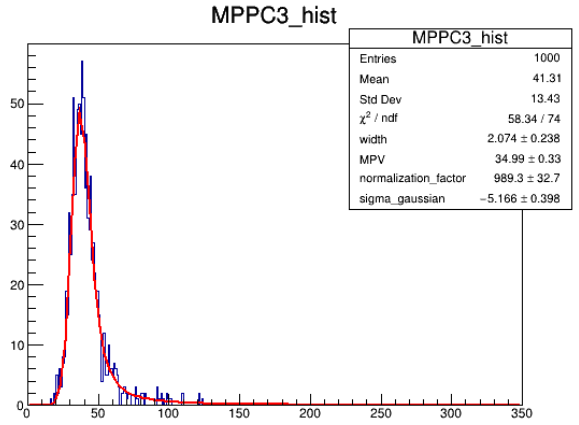
Fitting Results – 1231 mm

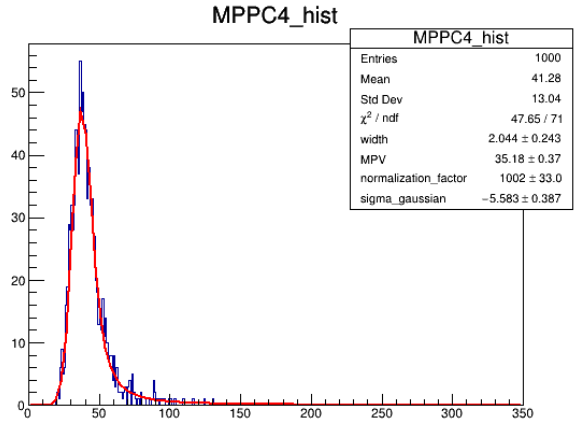


Fitting Results – 1432 mm

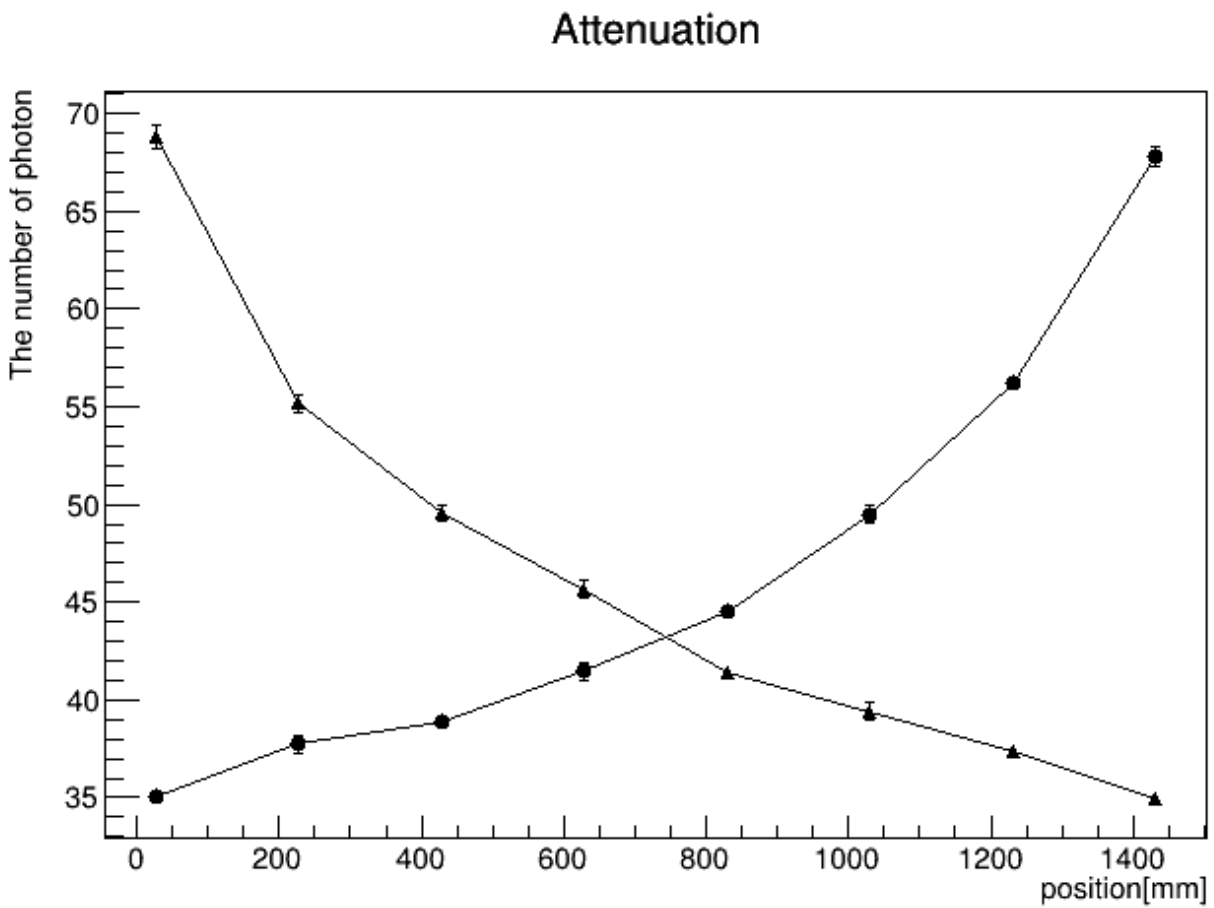




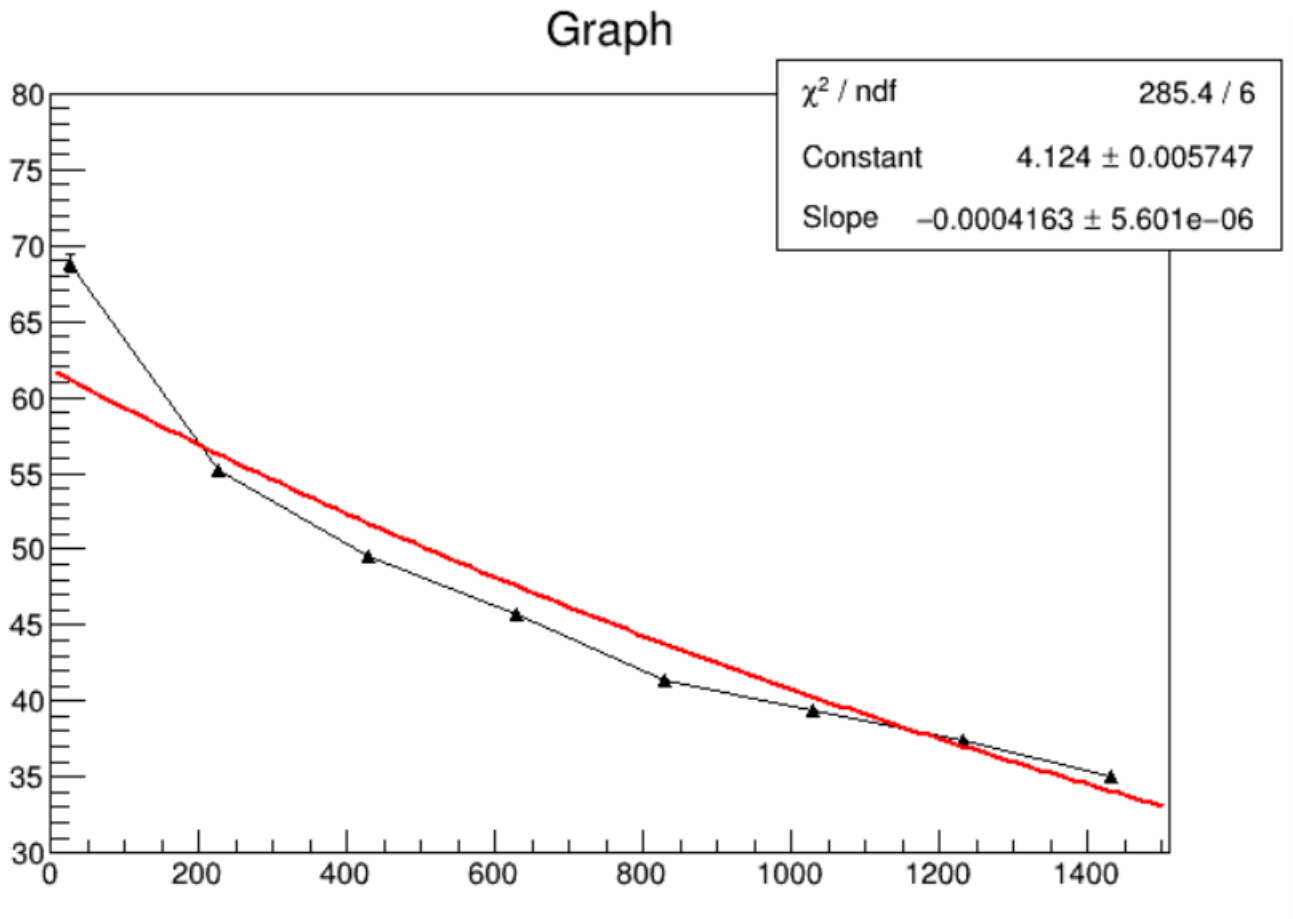




Attenuation Graph



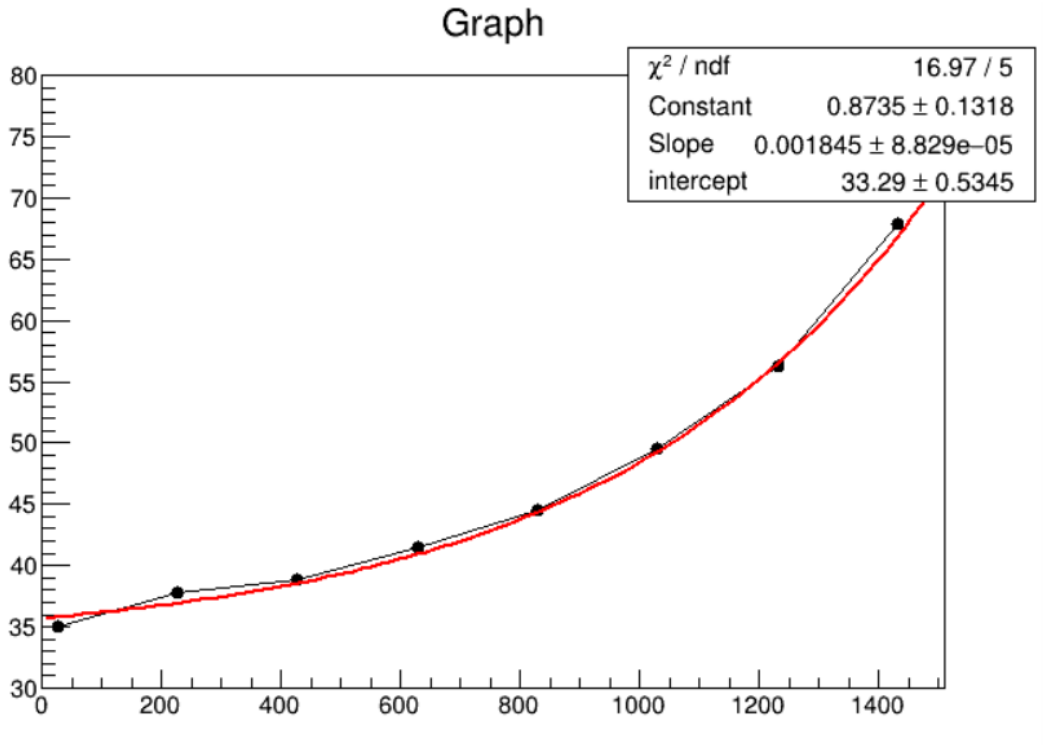
Fitting result with exp([0]+[1]*x)

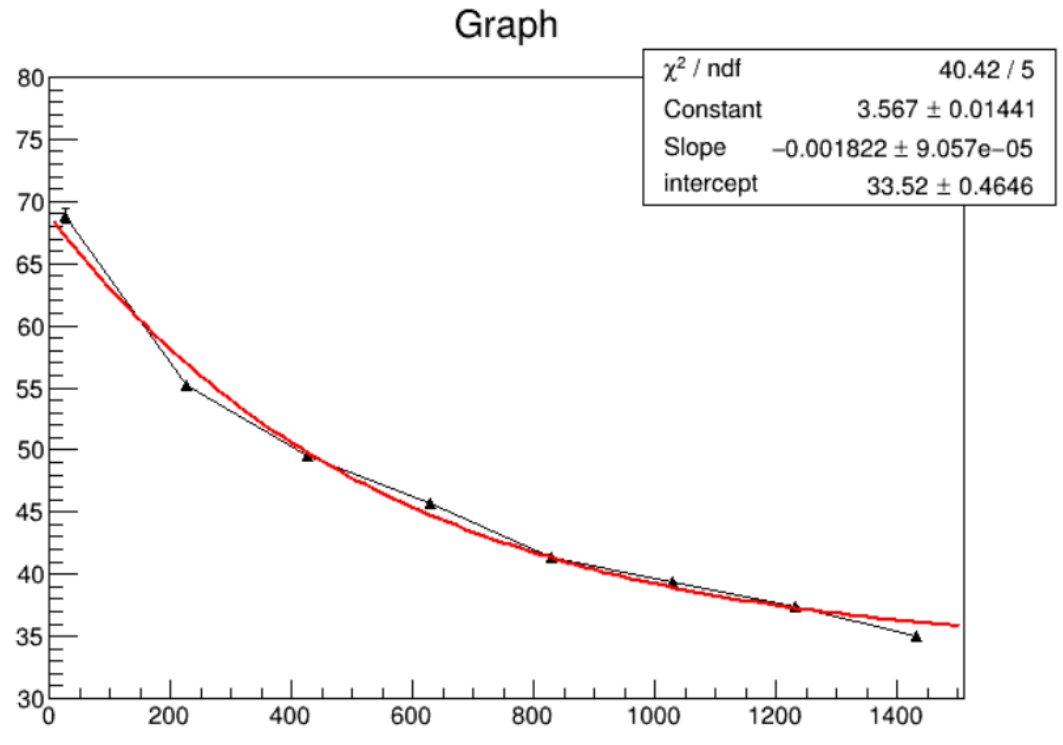


Fitting attenuation graph

- Well fitted function : [0]*Tmath::Exp(x/[1])+[2]
- >> 기본적으로 위치와 관계없이 scintillator 내부에서 반사되어 균일하게 있는 빛이 있고, 추가적으로 위치에 관계된 exponential 함수가 존재한다?

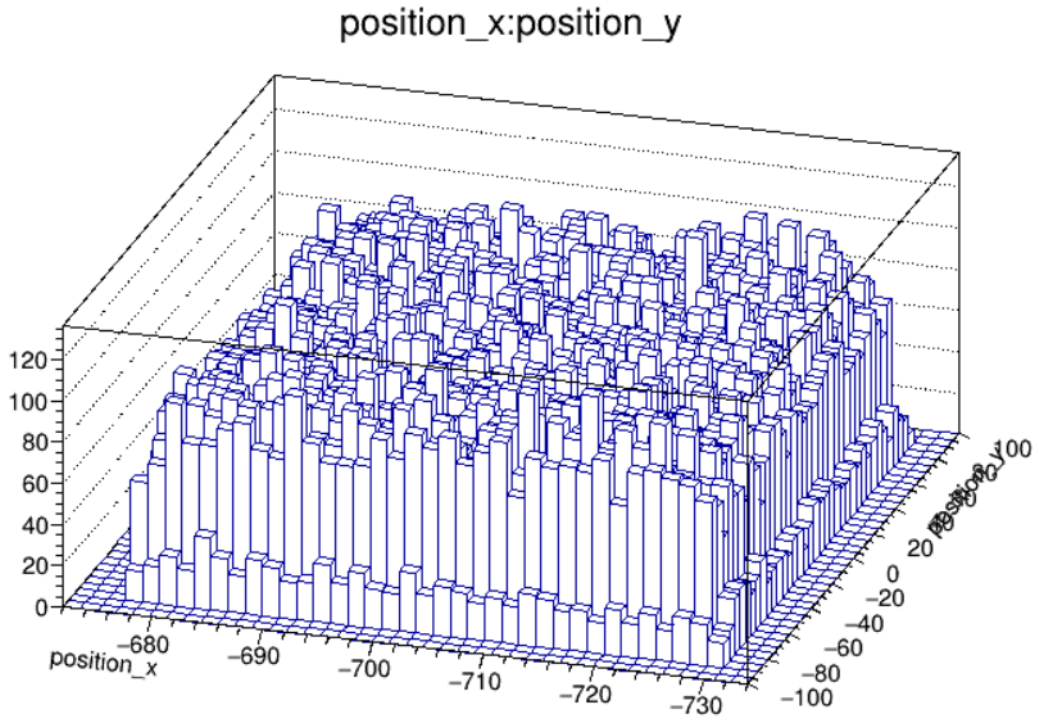
Fitting results

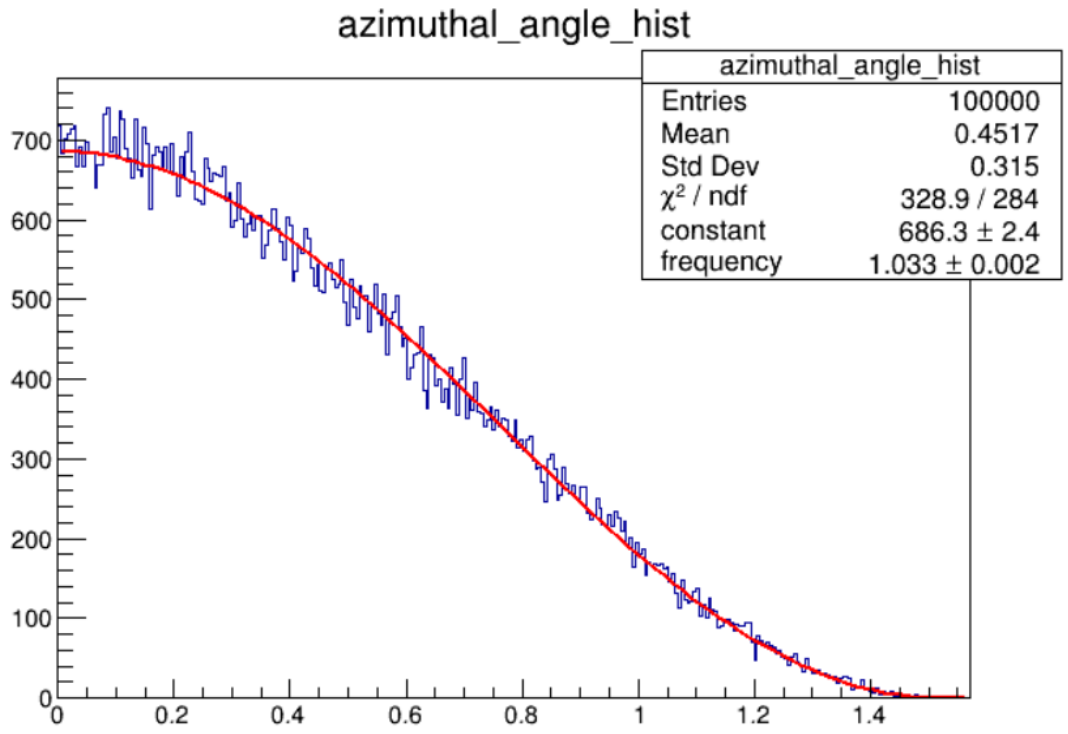




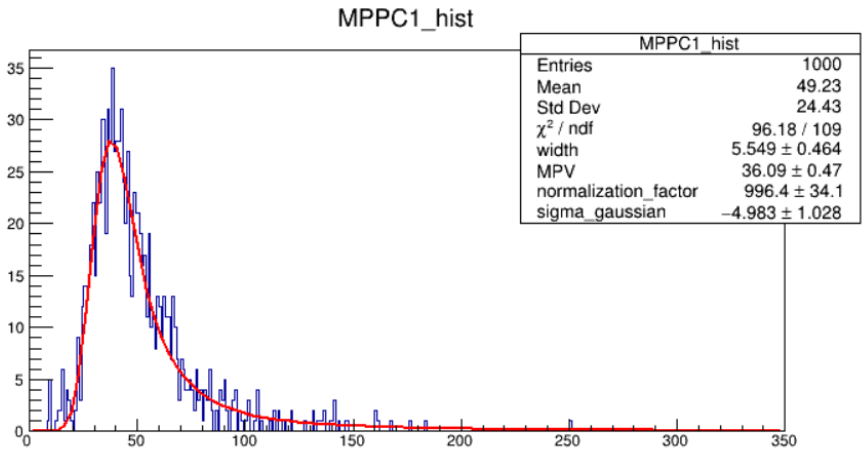
Cosmic ray test

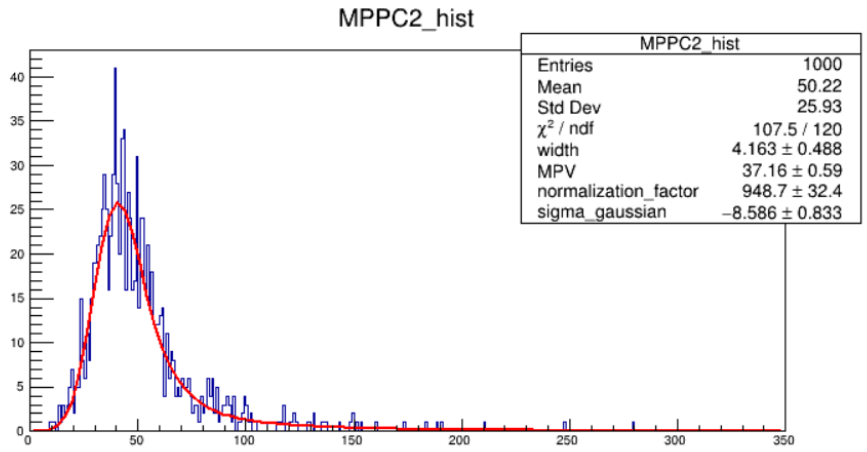
Cosmic ray test

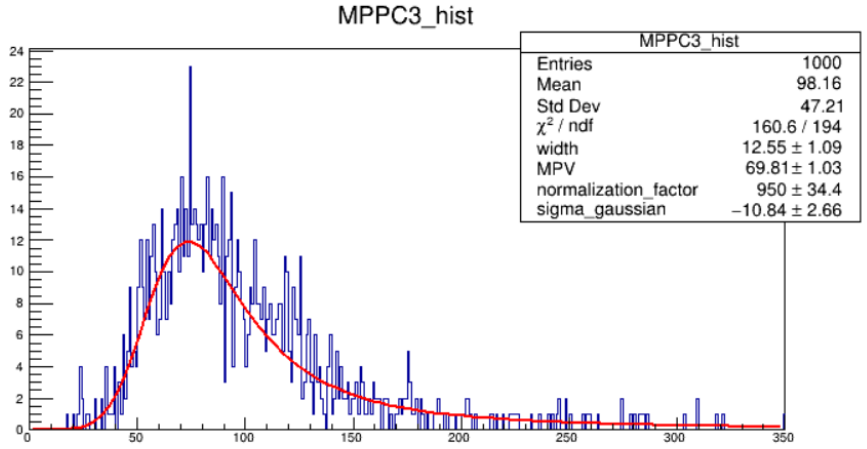


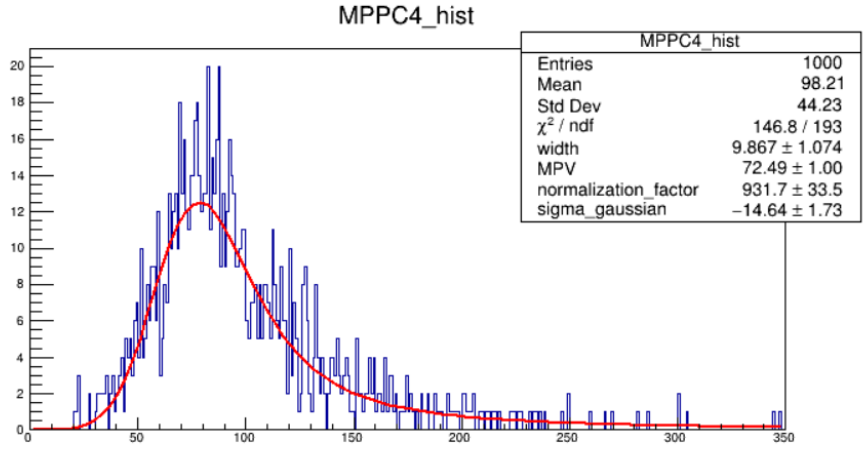


Fitting Results – 26.5 mm

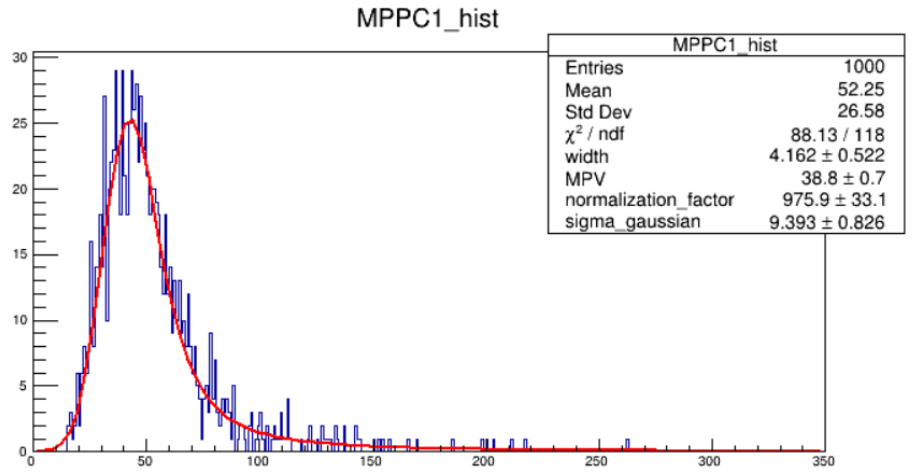


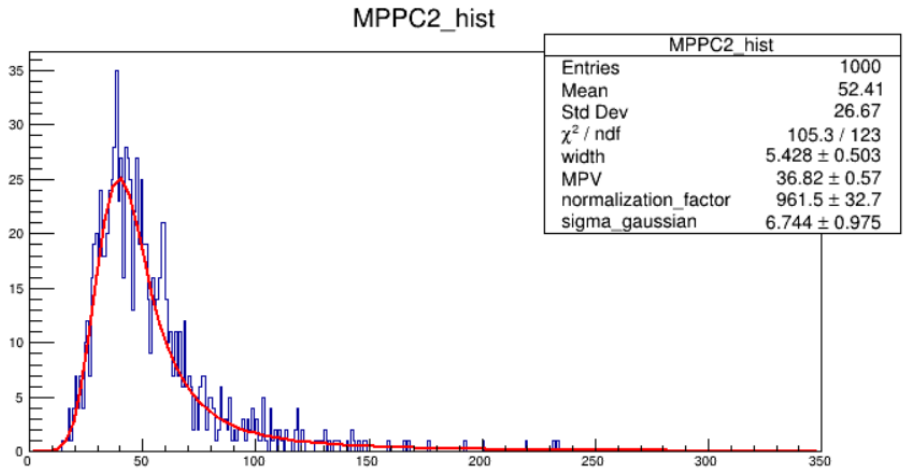


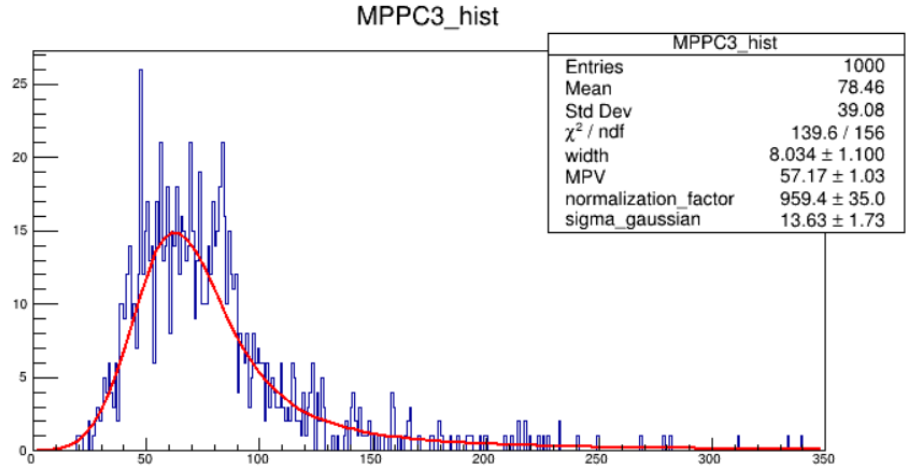


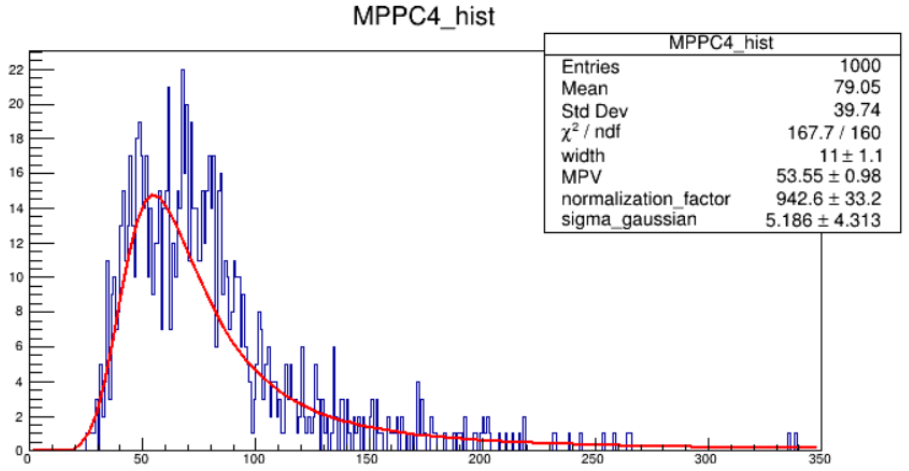


Fitting Results – 227 mm

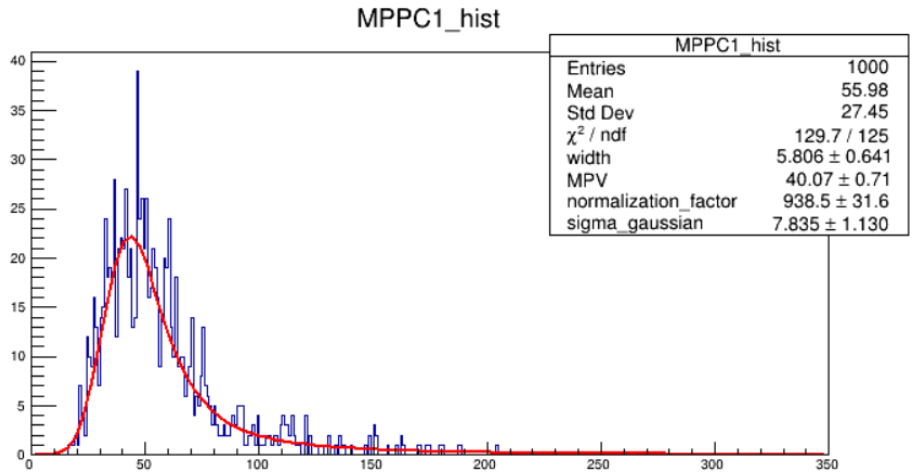


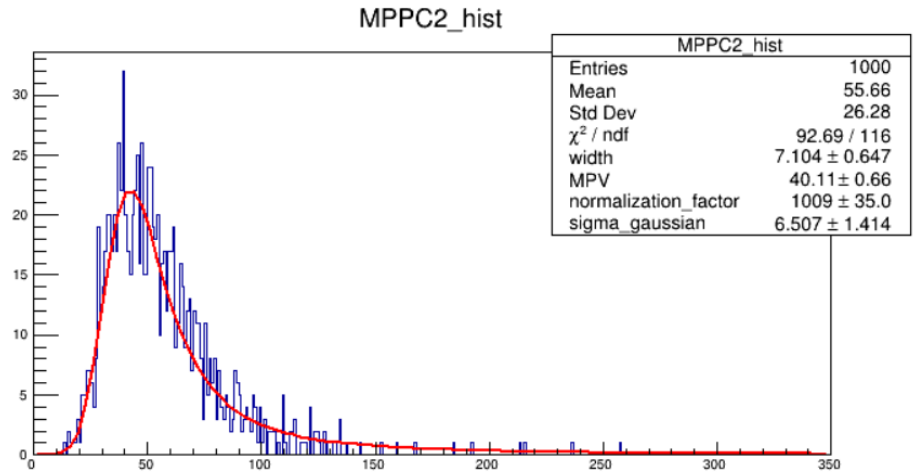


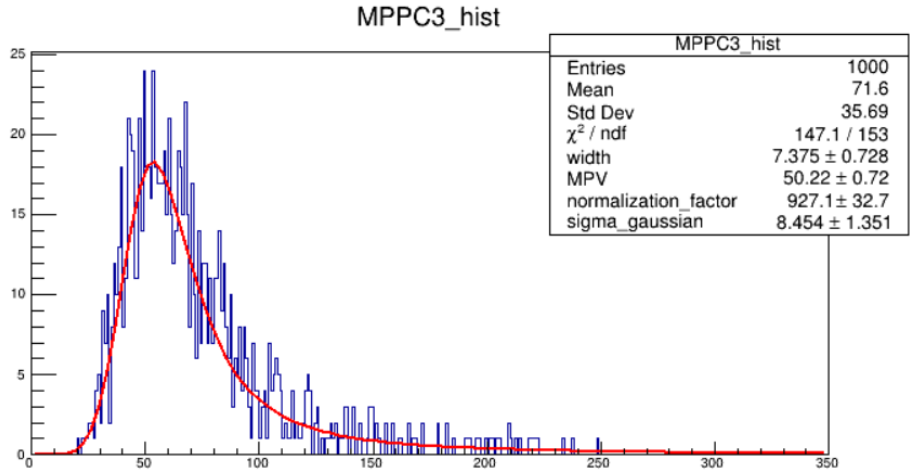


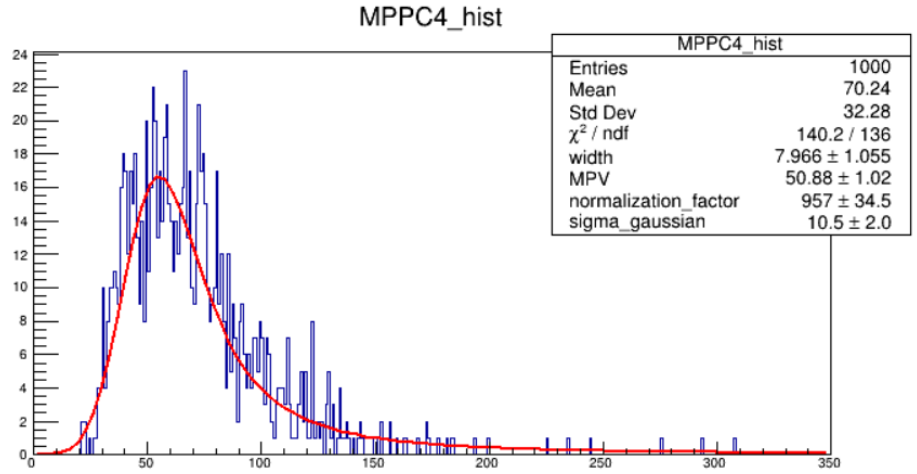


Fitting Results – 428 mm

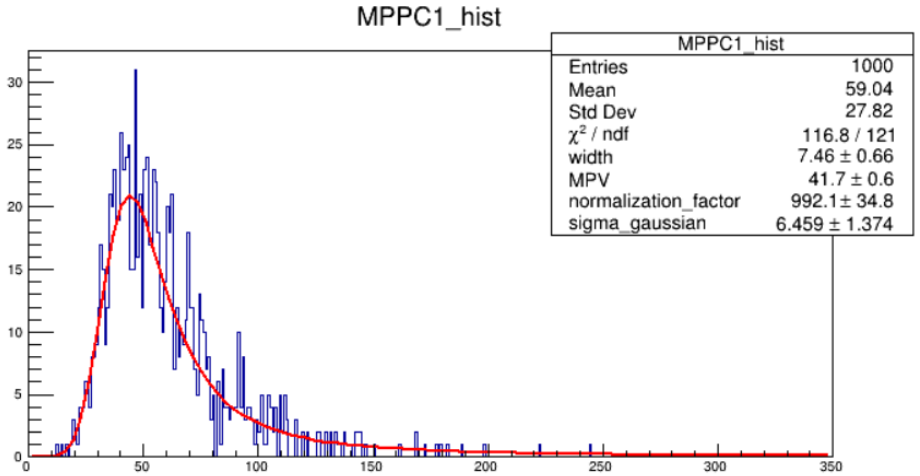


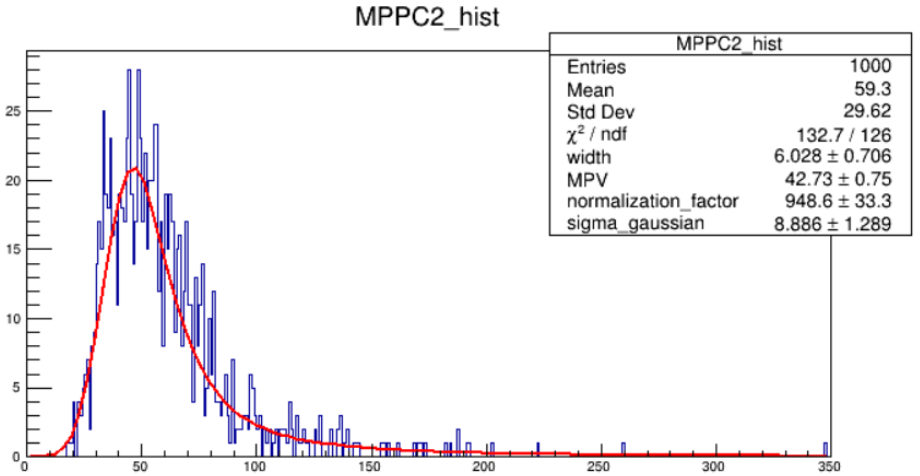


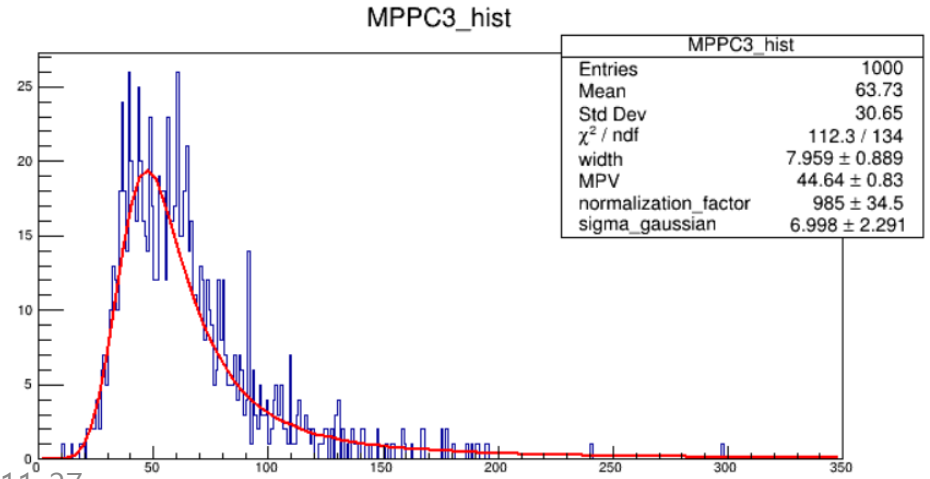


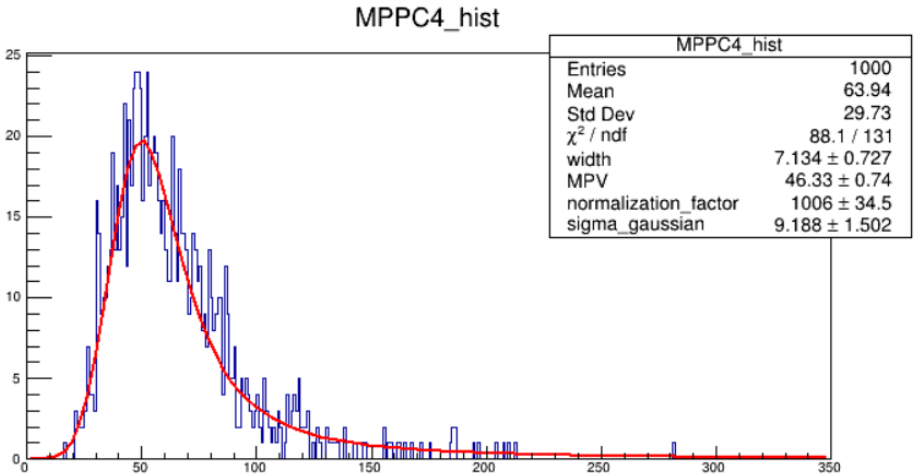


Fitting Results – 628 mm

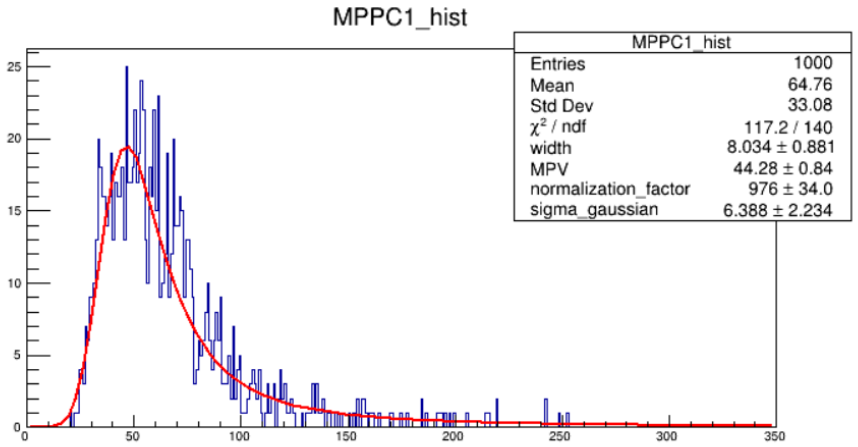


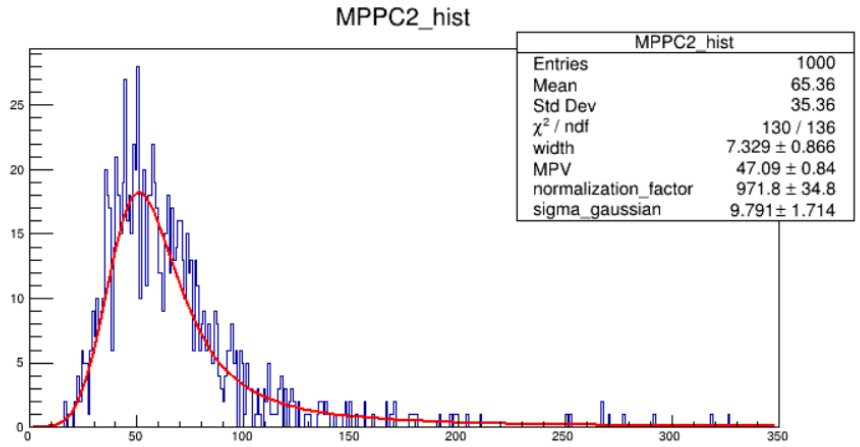


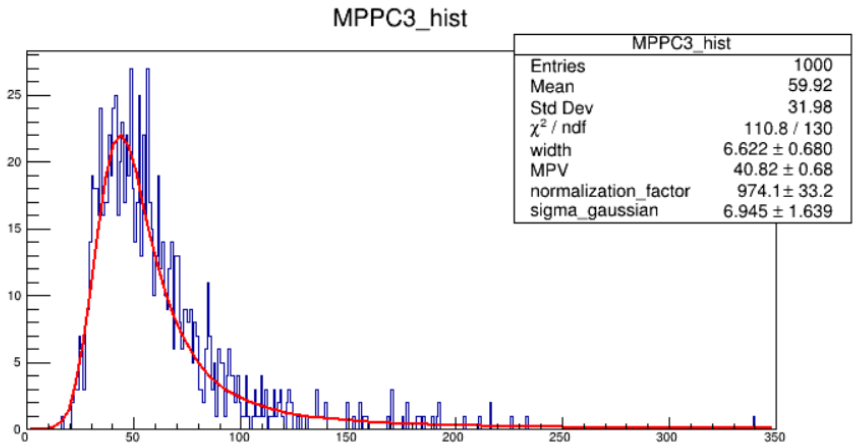


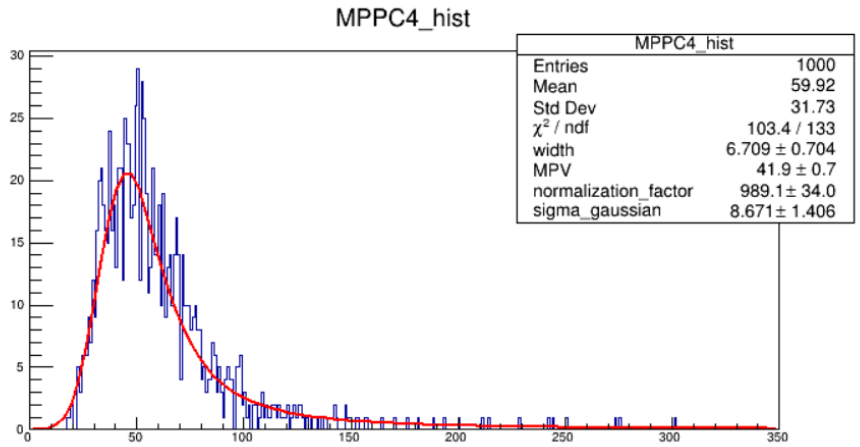


Fitting Results – 829 mm

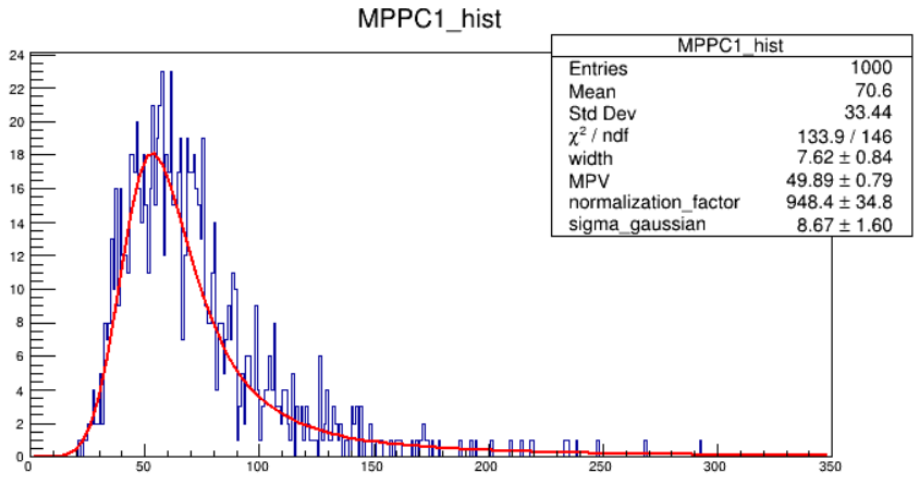


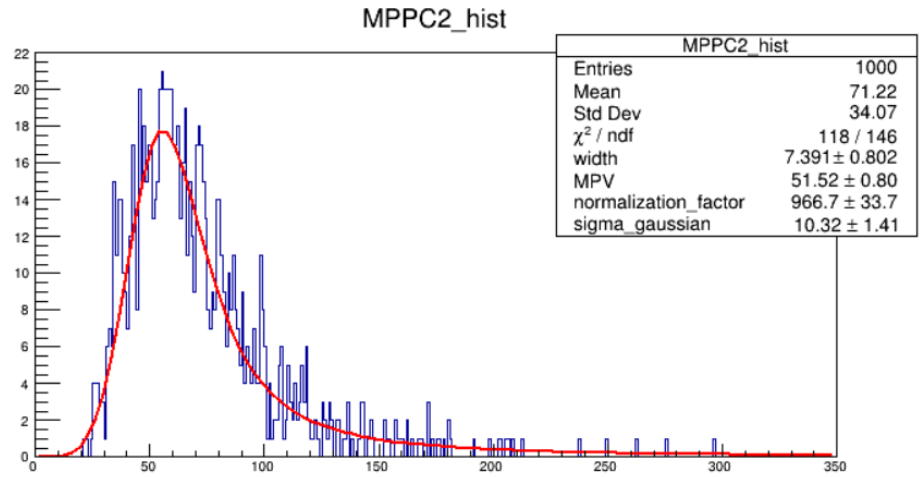


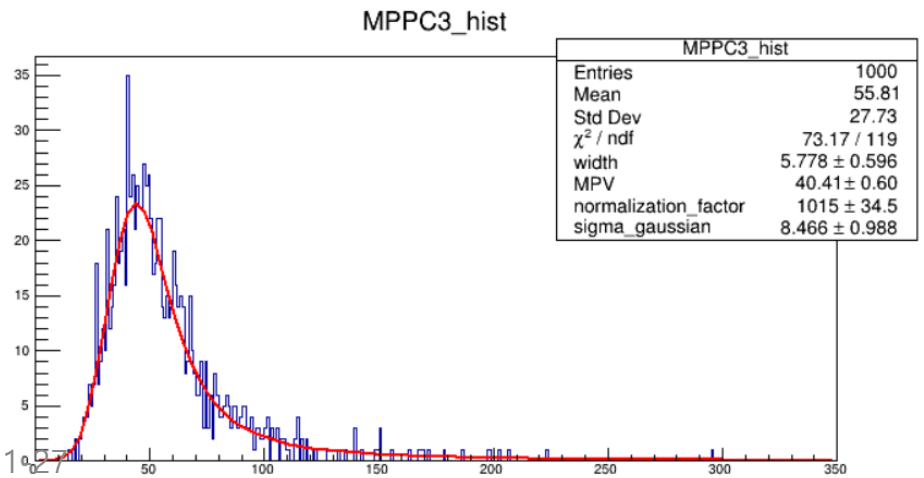


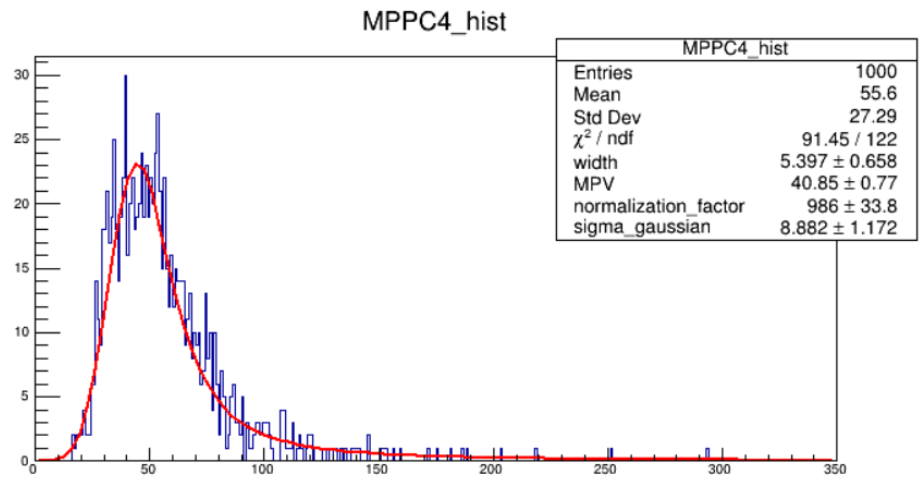


Fitting Results – 1030 mm

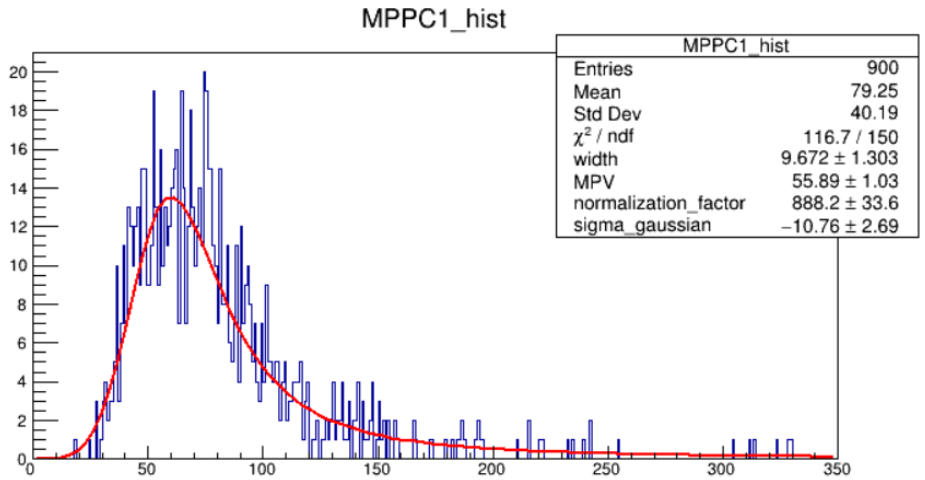


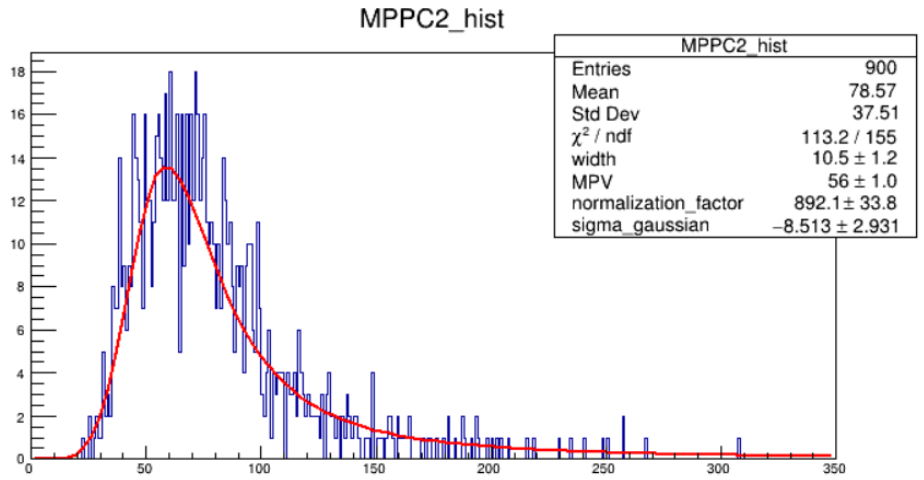


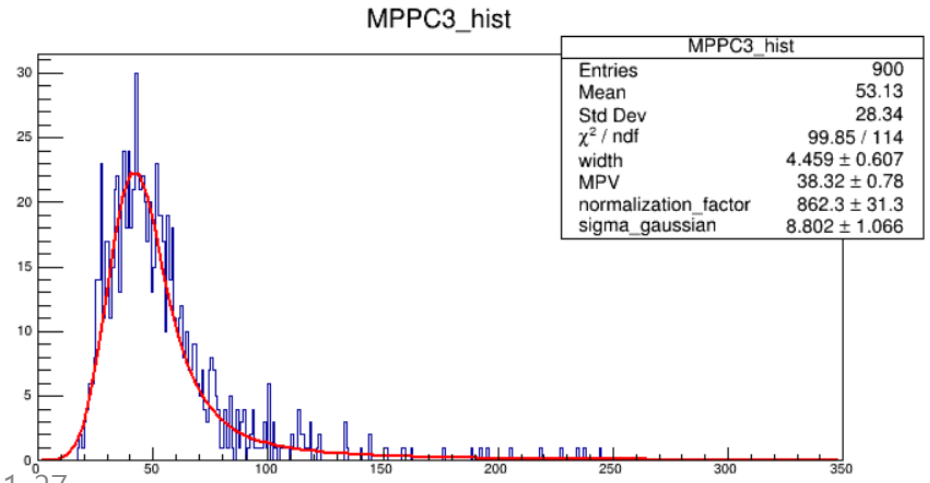


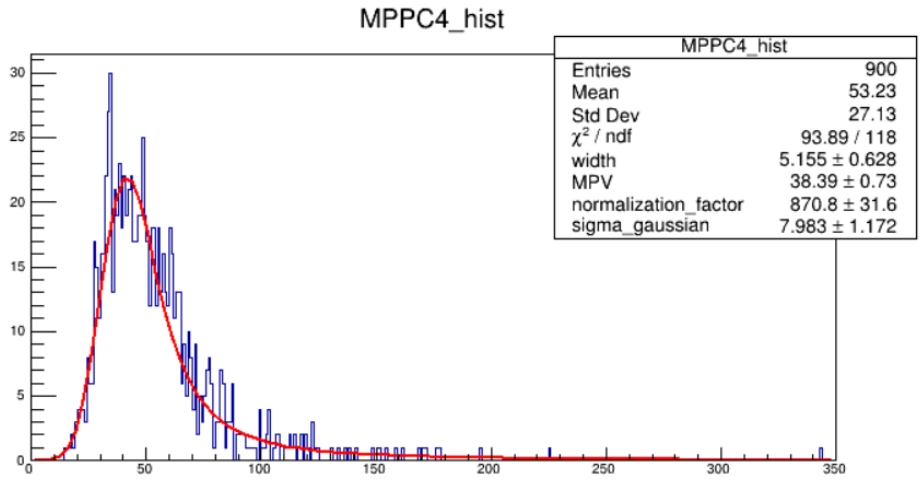


Fitting Results – 1231 mm

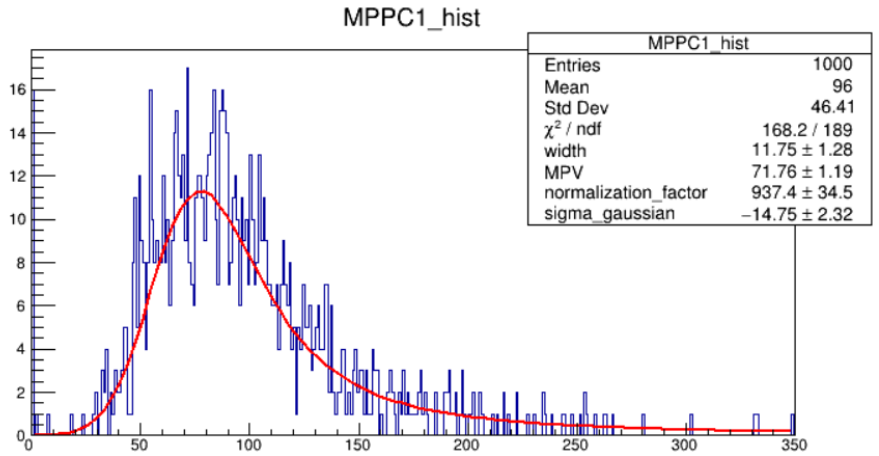


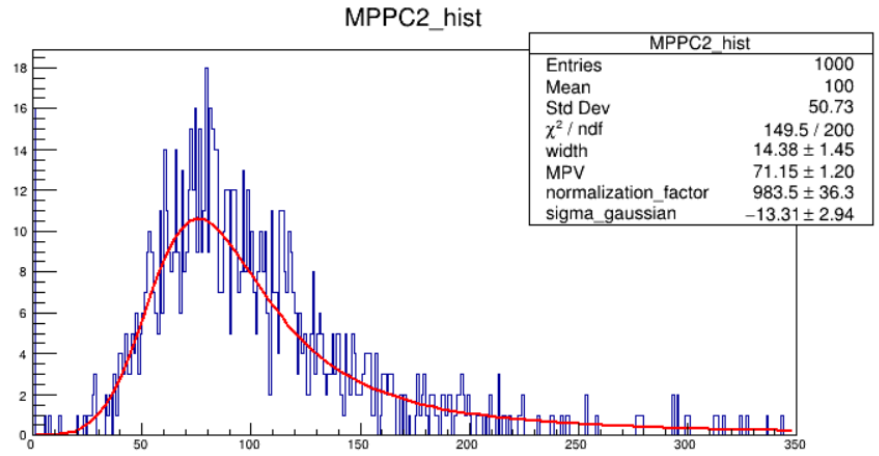


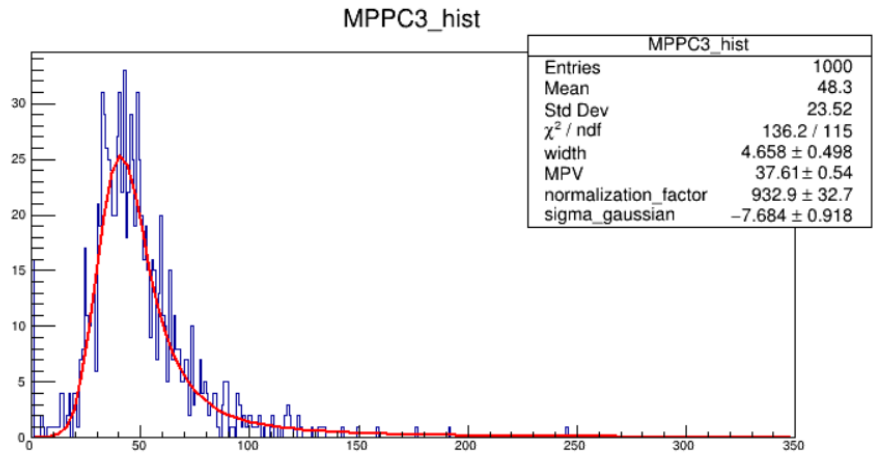


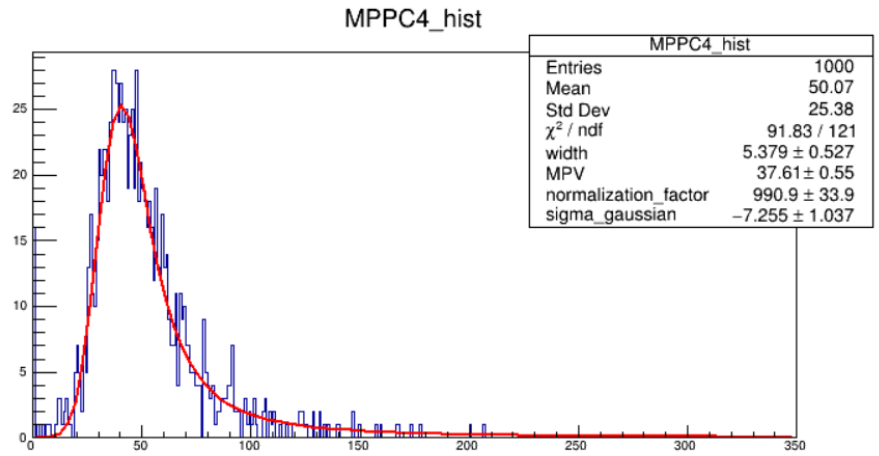


Fitting Results – 1432 mm





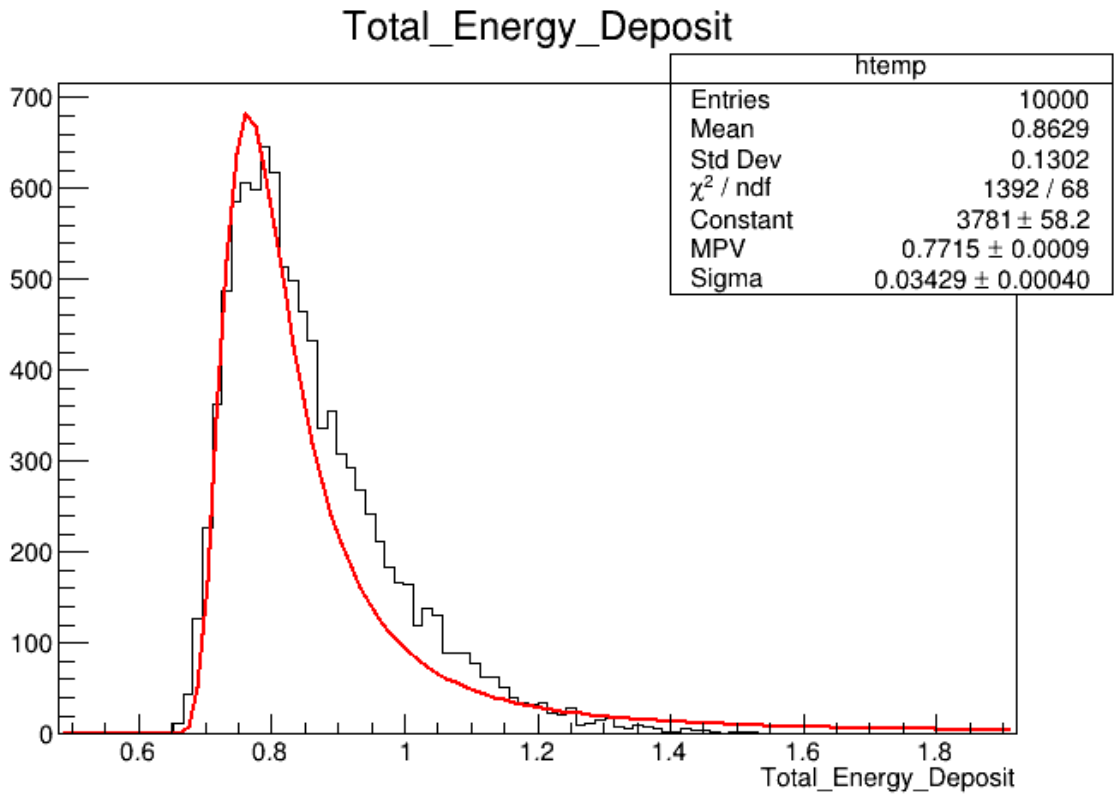




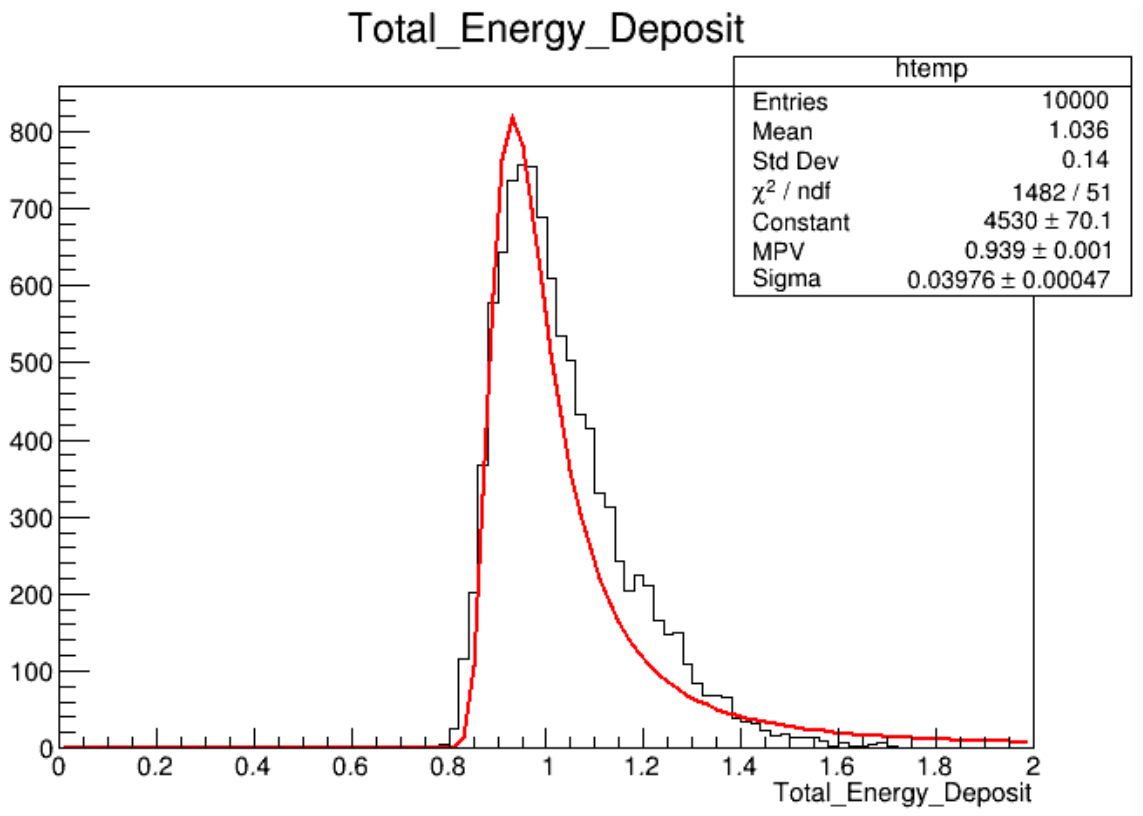
Fitting function

- Landau convoluted with Gaussian + cosine^2 ?

Landau distribtuion

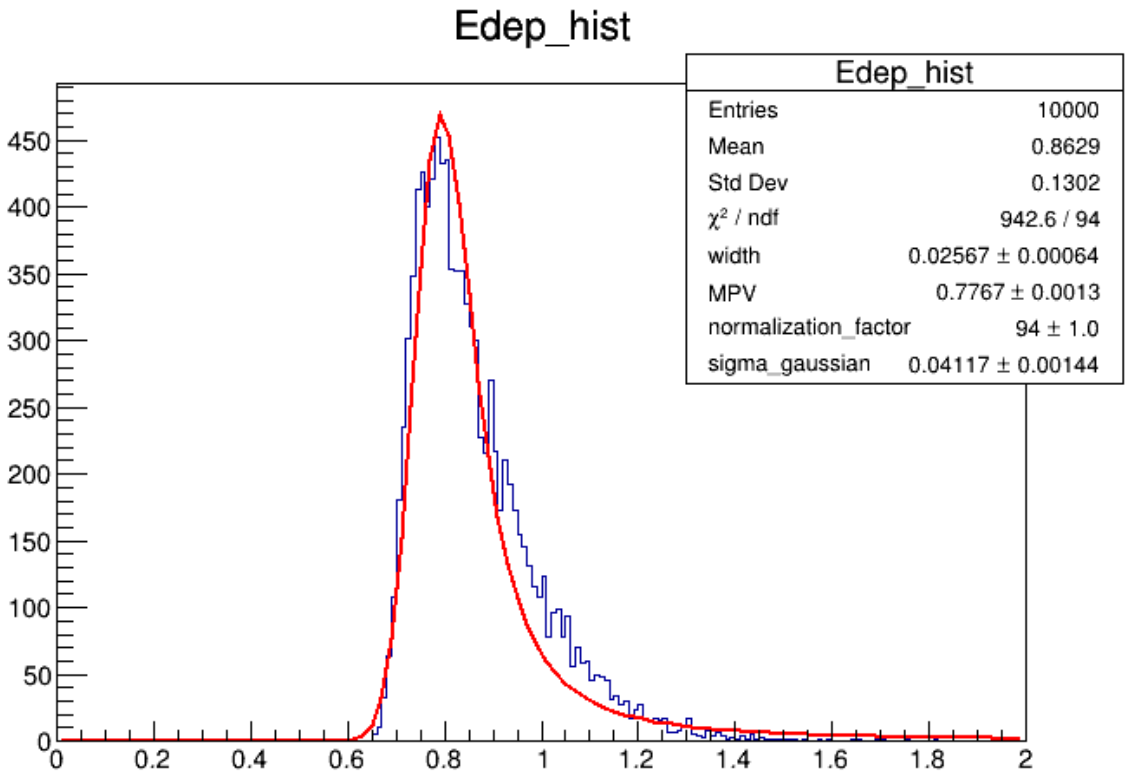


5mm scintillator

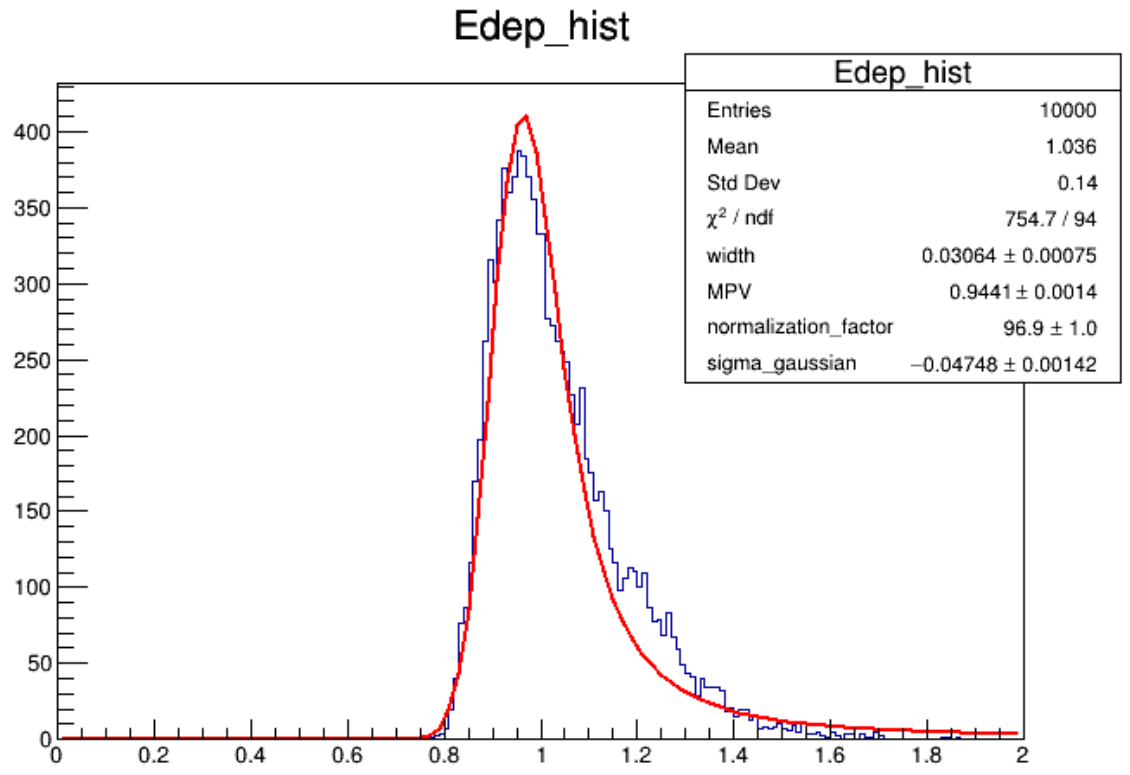


6mm scintillator

Landau Convoluted with Gaussian

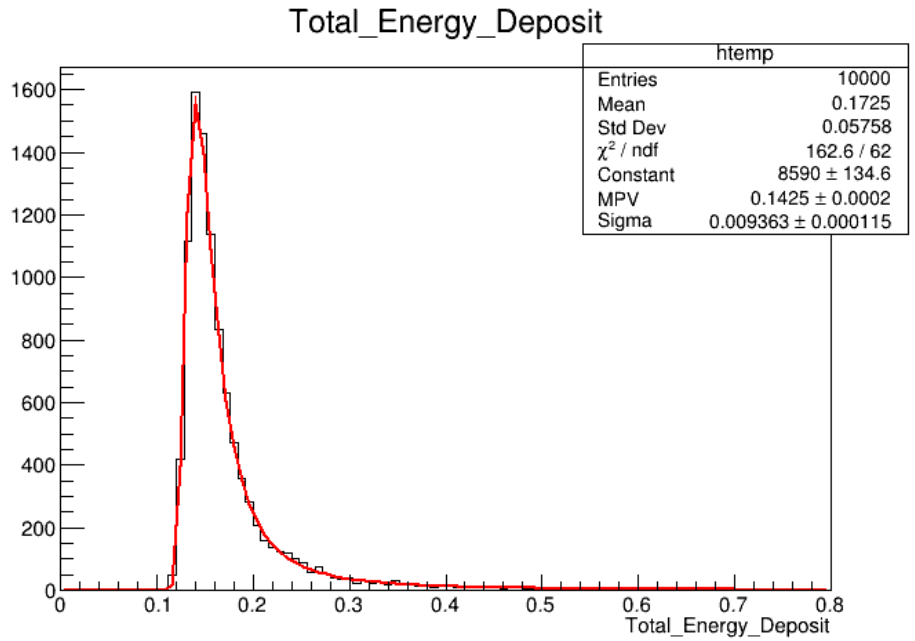


5mm scintillator

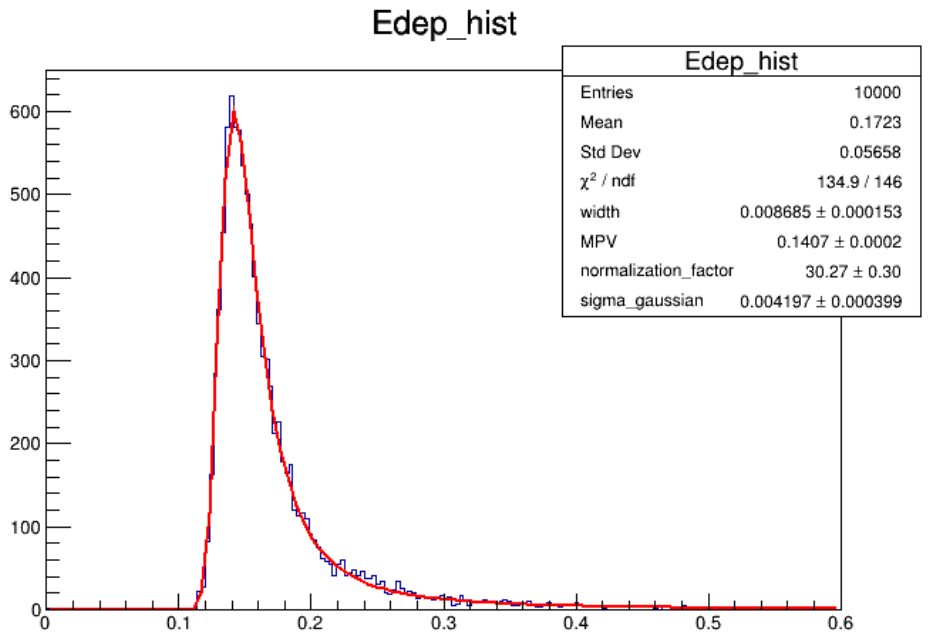


6mm scintillator

Thinner Scintillator

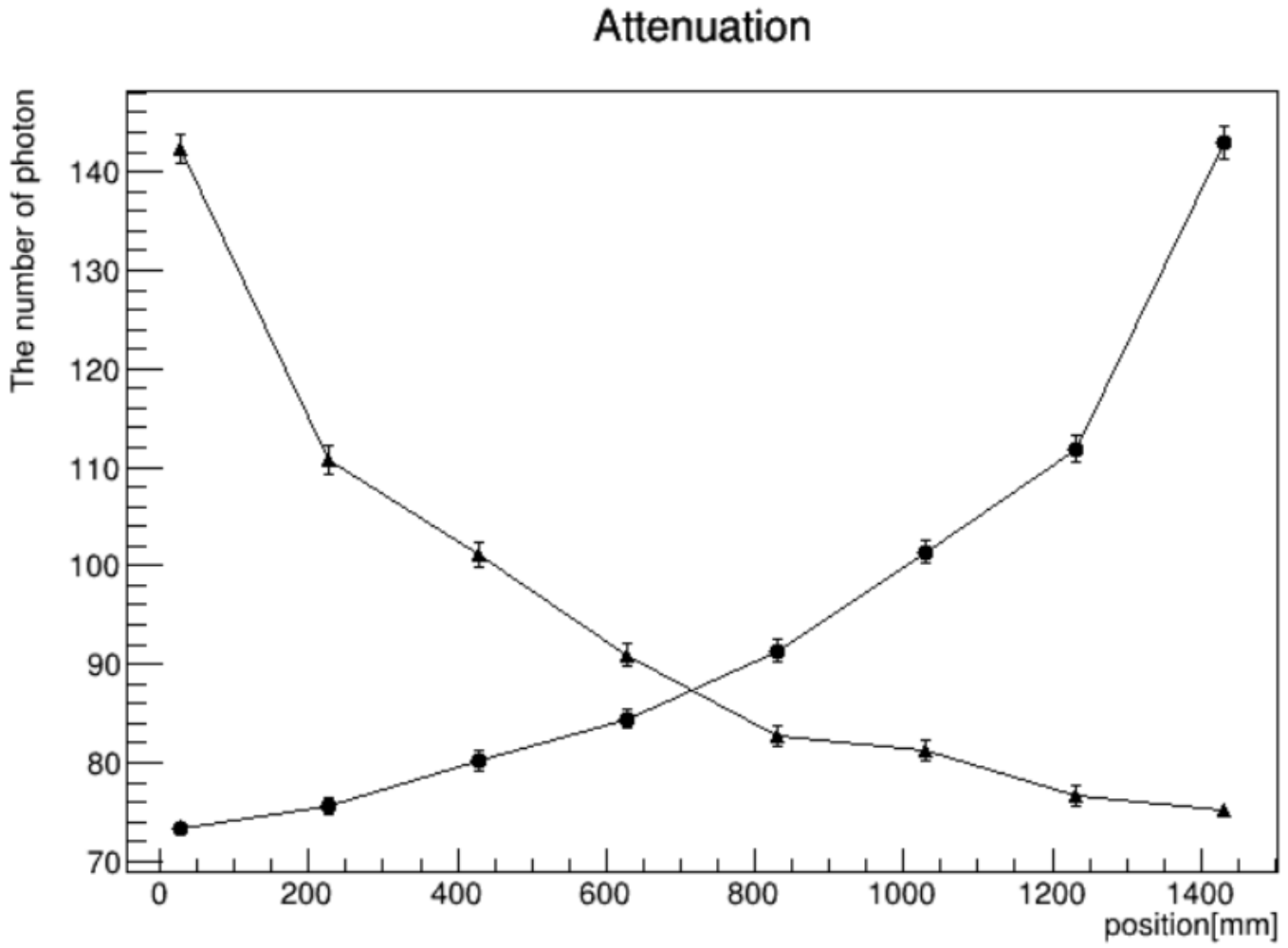


1mm scintillator
with Landau distribution



1mm scintillator
with Lan-Gau distribution

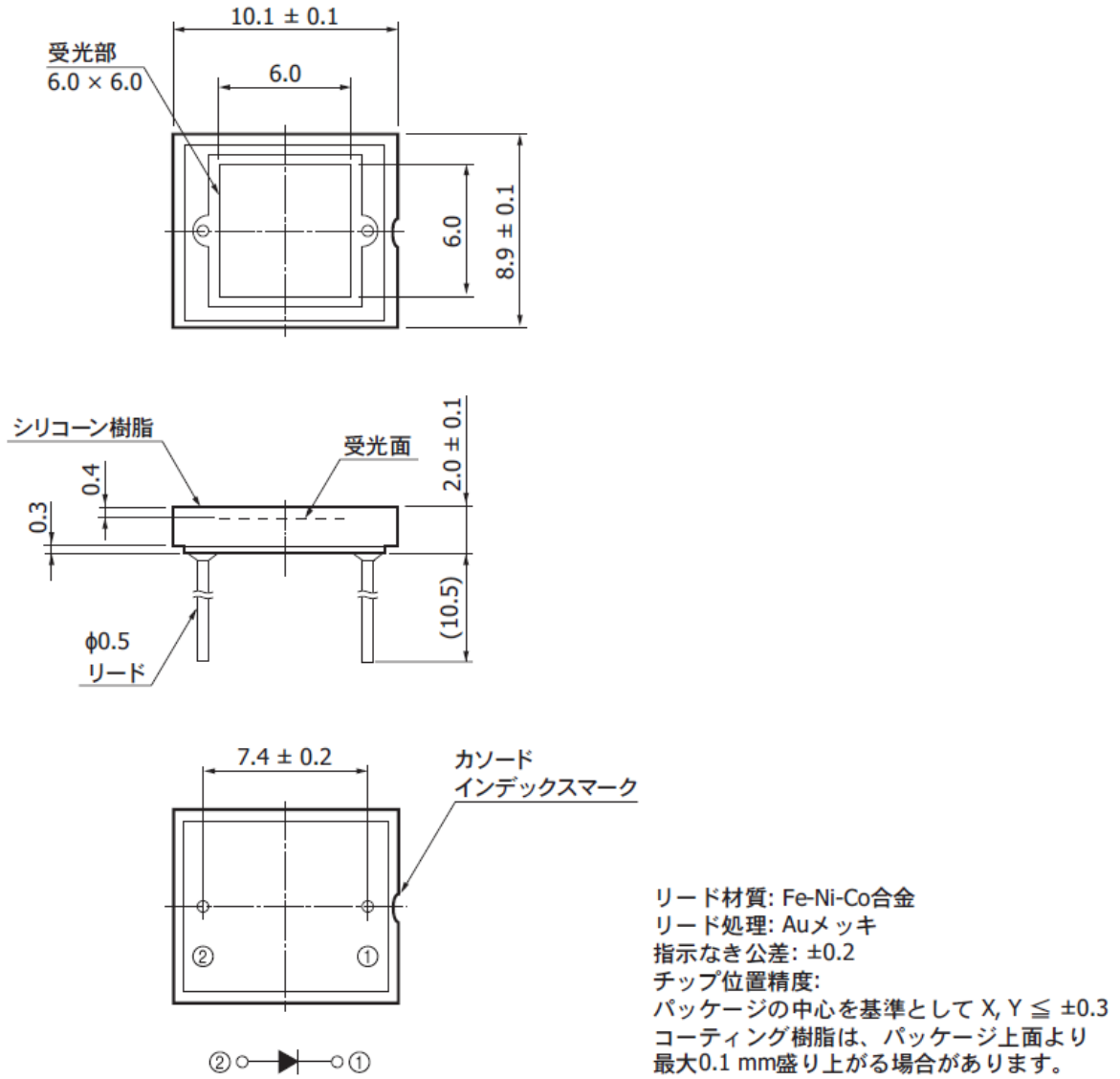
Attenuation Graph



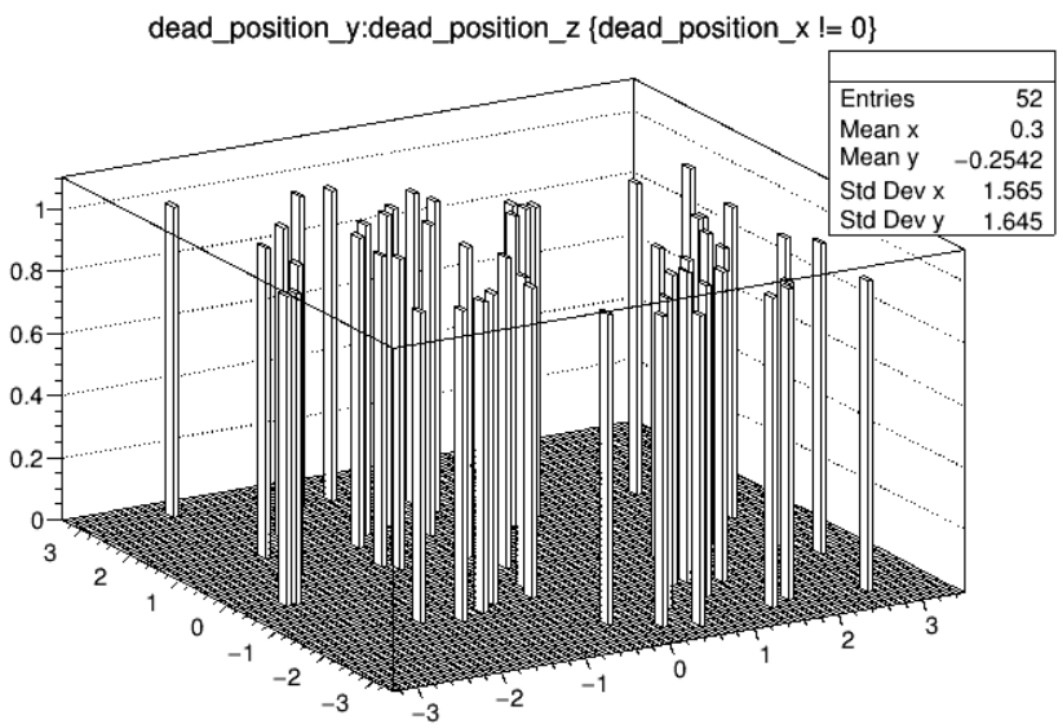
MPPC arriving point

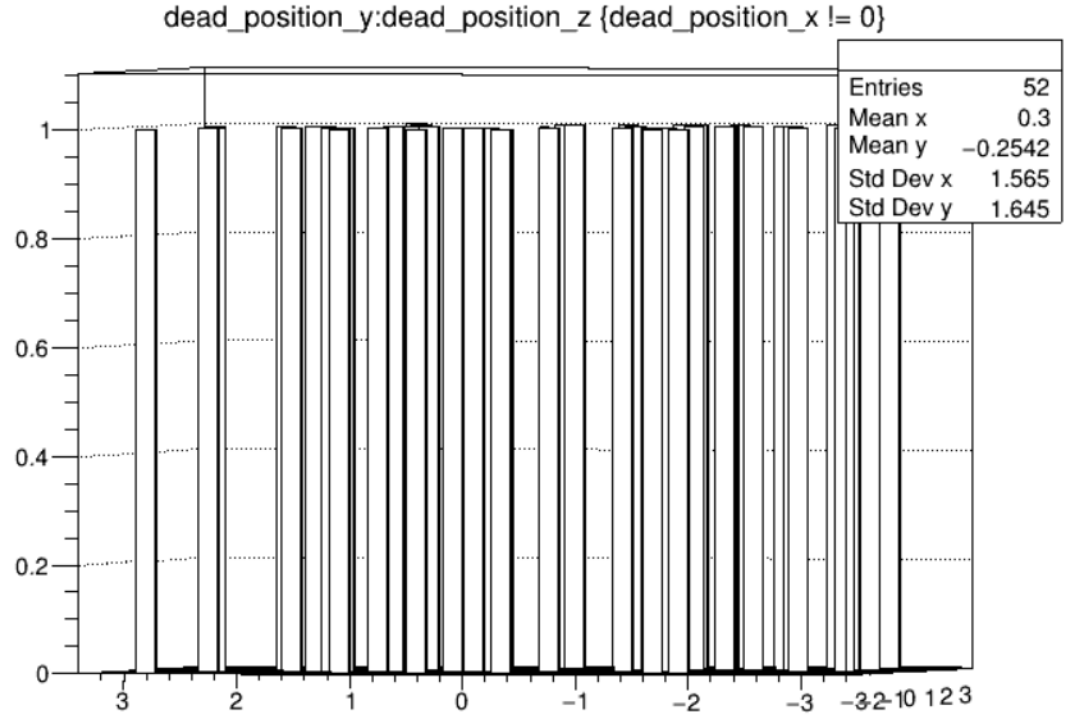
Number of pixels

- In S13360-6050PE, photosensitive area is 6.0 mm X 6.0 mm
- The number of pixels is 14,400.
- Therefore, the size of one pixel is 0.05 mm X 0.05 mm



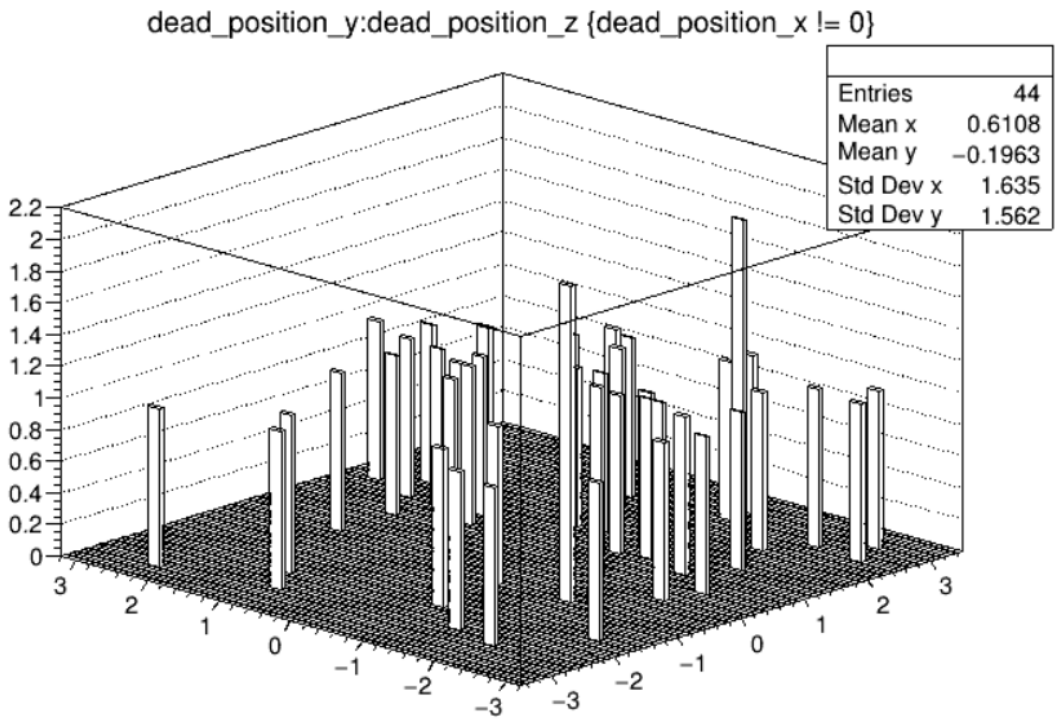
Example for arriving point

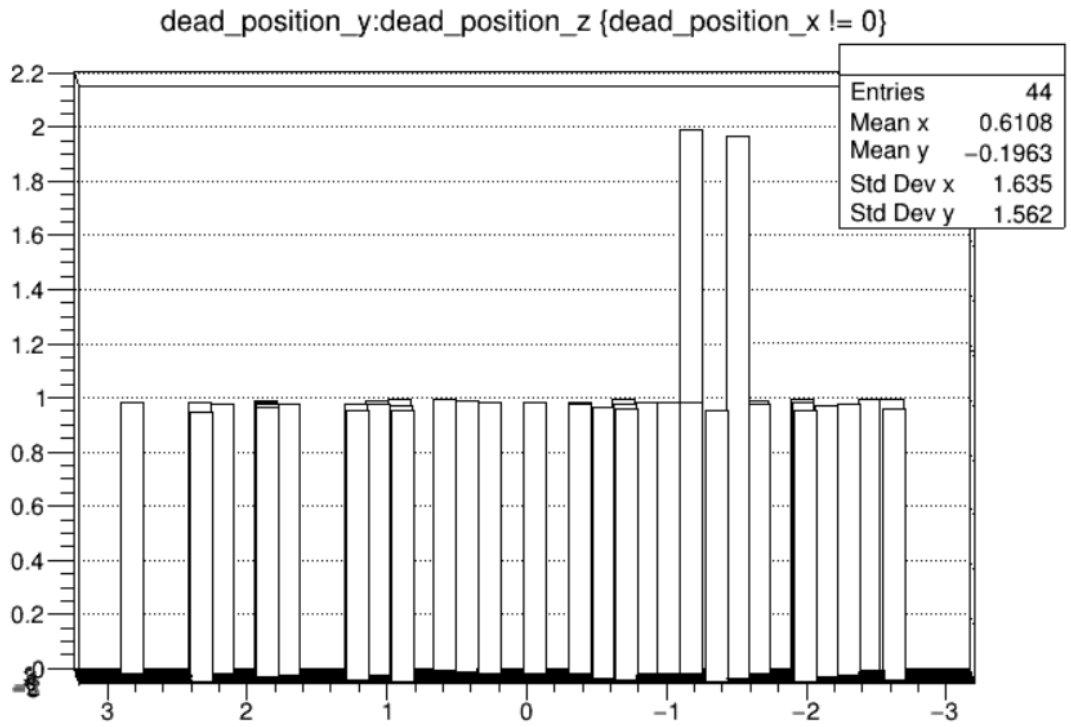




Particle : mu+, Energy : 1.0 GeV, Position 800 mm ~ 858 mm, azimuthal angle : random

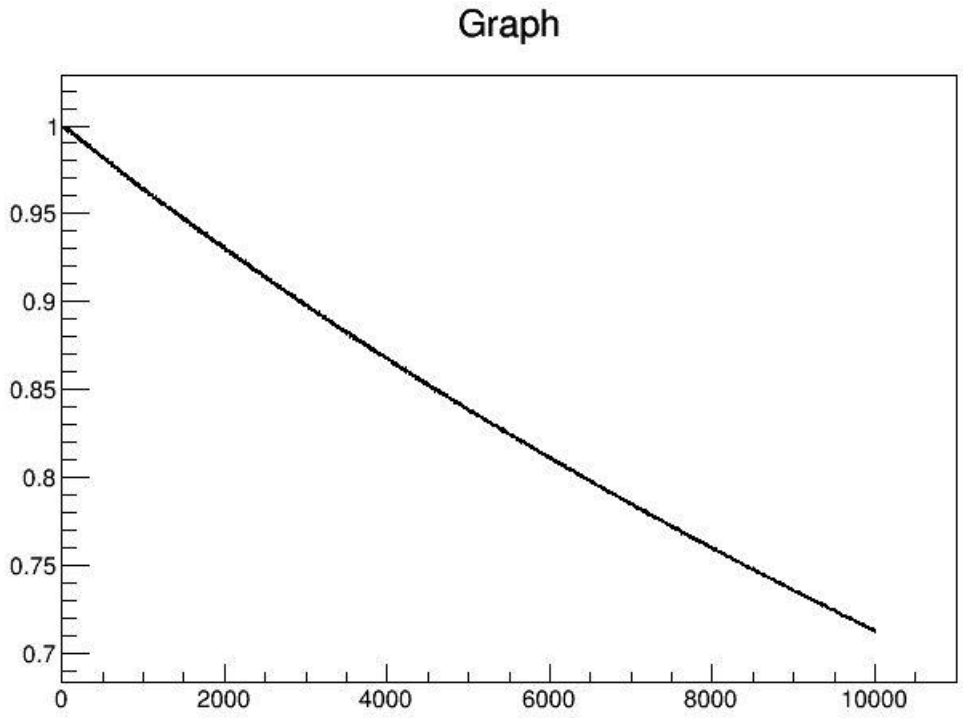
Example for arriving point





Particle : mu+, Energy : 1.0 GeV, Position 829 mm, azimuthal angle : random

MPPC efficiency(before)



- According to data simulated before, MPPC efficiency is more than 99% when the number of photon arrived MPPC is about 50.
- However, in previous slide, efficiency of MPPC is 95%.
- Therefore, we can confirm that it is better to get position where photon is dead.

Data Scan

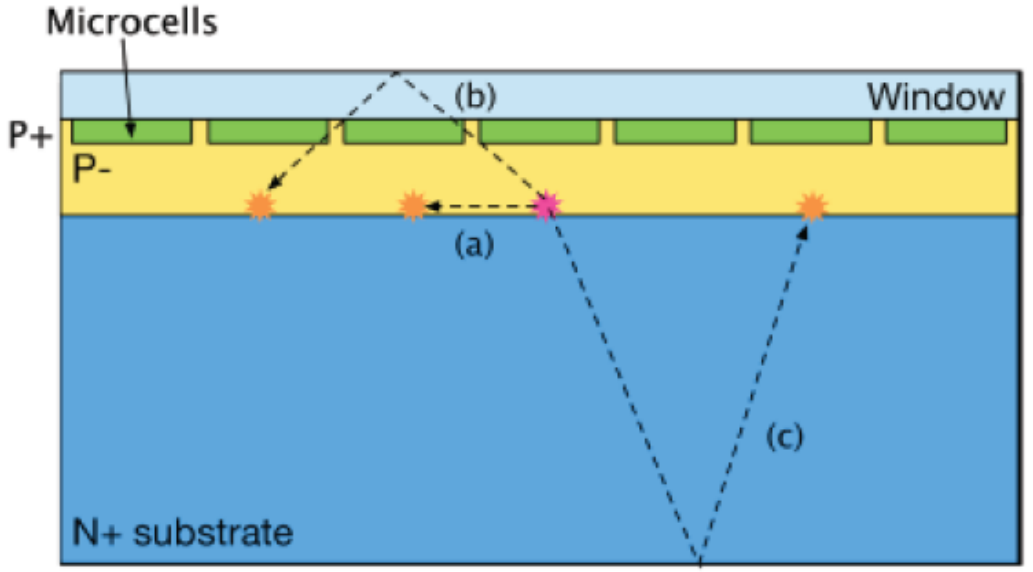
Depth photon is dead

Row	Wavelengt	Arrivetim	dead_posi	dead_posi	dead_posi
2	495.66482	27.049994	-0.075	0.0122921	2.7621747
3	531.22641	18.306062	-0.075200	-1.388803	-1.855543
5	472.47511	12.595095	0.0983981	-2.359289	0.5927234
9	509.12506	99.941598	0.2301079	-0.258006	-2.658202
10	495.27173	21.649616	-0.075	-1.657591	-1.481539
12	495.26786	71.416503	-0.075	-2.907309	0.5969254
19	551.01655	10.969933	-0.075	-1.397039	2.8960944
22	527.81229	8.3054370	0.0891191	1.3068163	-2.127291
23	553.46687	23.514839	-0.209955	-2.835119	2.6596897
29	472.60051	42.094204	0.0012118	-1.578086	1.1850482
30	519.46118	14.115362	-0.075	-1.272596	1.4315671
31	502.58047	21.832017	-0.075	1.2669938	2.2949582
33	504.60251	20.508904	-0.232719	1.8468322	0.2017119
34	485.16280	18.657337	-0.075	-2.521131	1.9159489
41	521.12003	34.111081	-0.075	2.1748794	0.1536476
43	512.25806	6.6447434	-0.075	-1.420504	-1.132903
46	540.35791	28.825205	-0.244389	1.3976723	-0.809266
48	496.66462	16.786160	-0.075	0.3406711	-1.240764
50	546.25941	30.050188	-0.044862	1.6694592	-0.468463
65	490.43407	10.241898	-0.075	2.9068549	-2.260504
72	498.79542	16.935684	-0.075	-1.830788	1.5346593
78	511.92738	15.117979	-0.075	1.1895995	-1.113880
80	493.91074	24.131770	-0.075	-1.541462	1.0157293
82	518.47158	38.027399	-0.075	-1.164062	2.6960930

- Geant4 is not support photoelectric effect for optical photon.
- Therefore, we should kill optical photon is StackingAction.
- When simulating in the above way, there is depth where photon is dead.
- Therefore, assuming photons die at the surface of MPPC, we should recalculate position photons die by making use of momentum of photons.

Cross talk

- Since there is depth where photon is dead, I wondered if we could calculate the cross talk through it.
- However, the cross talk occurs in the near infrared region(780 nm ~ 3000 nm), and considering the emission spectrum of WLS fiber, there is no near infrared photon.



Data Analysis

- The number of photon arrived MPPC will be determined in ROOT not Geant4.

Row	Wavelengt	Arrivetim	dead_posi	dead_posi	dead_posi	momentum_	momentum_	momentum_
0	560.48351	71.965582	-0.075	-0.649449	2.9231450	-2.07e-06	7.534e-07	1.603e-07
1	518.24077	13.875503	-0.075	0.9502090	0.0116243	-1.85e-06	1.257e-06	-8.46e-07
2	492.55629	25.910957	-0.075	2.8250027	1.0306999	-9.12e-07	3.995e-07	-2.31e-06
4	528.11195	19.198898	-0.075	2.2439909	1.3184417	-1.90e-06	1.359e-06	-1.69e-07
7	504.56695	21.874213	-0.153379	1.2662653	-2.214478	4.234e-07	-1.61e-07	2.415e-06
8	508.88691	26.200614	-0.075	1.8785349	1.6880751	-2.03e-06	1.312e-06	-2.41e-07
10	493.45756	54.815216	-0.075	1.0088101	0.4735277	-2.27e-06	-7.78e-07	7.361e-07
12	495.09974	17.427271	-0.075	0.5853046	2.4509685	-2.03e-06	2.306e-07	-1.43e-06
13	498.93336	19.035595	-0.075	1.0443120	2.1531335	-1.92e-06	1.056e-06	1.166e-06
15	488.3682	11.909960	-0.133339	2.1695136	0.7952705	2.078e-06	1.370e-06	-4.96e-07
23	517.50741	11.452656	-0.075	-0.024315	1.3109646	-1.93e-06	-1.28e-06	-5.68e-07
25	504.40479	22.671361	-0.075	-0.658538	0.8280741	-3.18e-07	-2.03e-06	-1.34e-06
28	465.48225	20.288492	-0.075	-1.528035	-0.847632	-2.05e-06	8.315e-07	1.480e-06
30	503.92544	6.2938861	-0.075	-2.655682	-1.644626	-1.94e-06	-1.34e-06	-6.84e-07
31	608.60047	8.8473556	-0.075	1.6236828	0.7445573	-1.71e-06	-5.35e-07	9.589e-07
32	530.72385	8.4291598	-0.075	-2.021257	-2.582119	-2.03e-06	5.567e-07	1.002e-06
33	484.24632	77.985204	-0.075	-2.203228	-0.071967	-2.03e-06	5.689e-07	1.445e-06
36	527.68452	26.261815	-0.075	-1.744257	2.0020439	-2.13e-06	9.430e-07	2.371e-07
38	509.90611	9.1050996	0.0099399	-0.620876	-0.911878	2.012e-06	8.530e-07	1.064e-06
40	485.32905	65.176445	-0.075	-0.382308	0.9137909	-2.20e-06	-1.20e-06	-4.77e-07
41	508.66371	55.736296	-0.075	-2.042421	1.3315787	-2.01e-06	6.079e-08	1.372e-06
58	472.97339	12.920871	-0.234805	-2.438266	2.9664514	7.168e-07	7.793e-07	2.398e-06
60	499.52220	30.305132	-0.075	1.2676407	0.8601464	-2.05e-06	1.377e-06	1.623e-07
61	502.75405	18.871037	0.2166104	-1.221738	0.9411304	1.956e-06	-6.64e-07	-1.34e-06
62	498.95530	15.827229	-0.075	-1.649911	0.7836663	-2.23e-06	1.073e-06	1.785e-07

Effect of Aluminum box

Sensitive Detector for Aluminum box

```
*************************************
*    Row   * Al_box1_c * Al_box1_d *
*************************************
*        0 *      4434 *         0 *
*************************************
```

```
root [3] t5 -> GetEntries()
(long long) 153
root [4] t7 -> GetEntries()
(long long) 225
root [5] t9 -> GetEntries()
(long long) 124
root [6] t11 -> GetEntries()
(long long) 228
```

- There are too many photons which hit aluminum box.
- Considering the number of photon which arrived MPPC, 3500 of photons are from scintillator.
- Therefore, select the photon which is not from scintillator.