Geant4 simulation on the light yield of BTOF prototypes

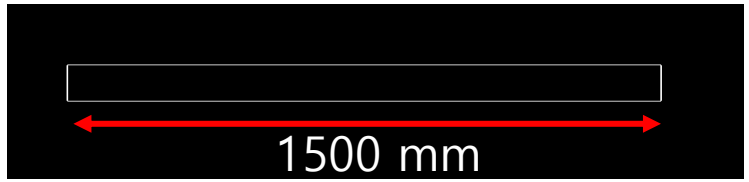
최재민

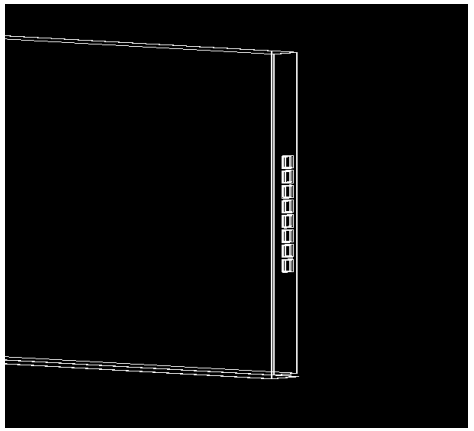
Introduction

- In order to find the condition that maximizes light yield, simulation was performed by changing the light guide, thickness of scintillator, and type of MPPC.

Shape of Scintillator

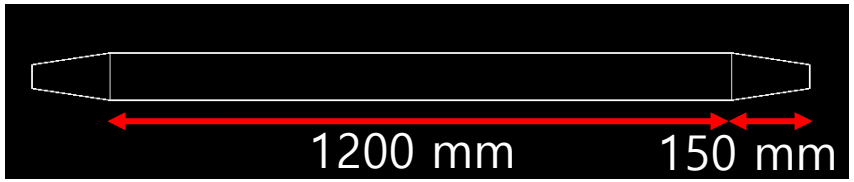
Without light guide

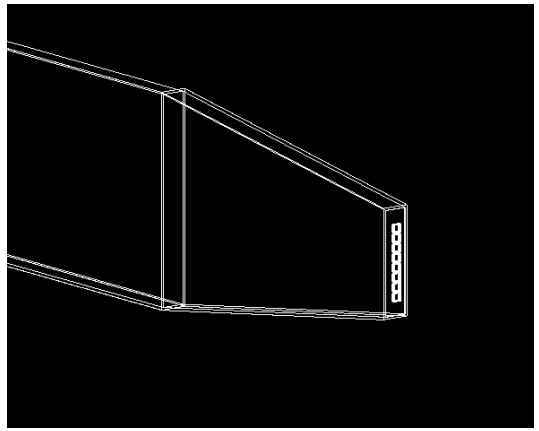


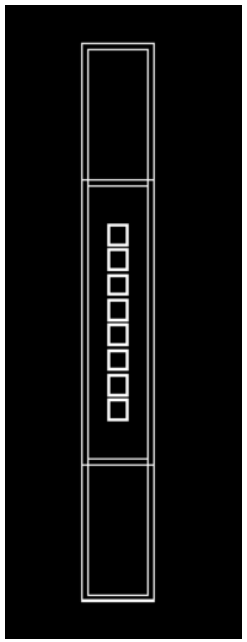


단면적 10 mm X 90 mm

Light guide1

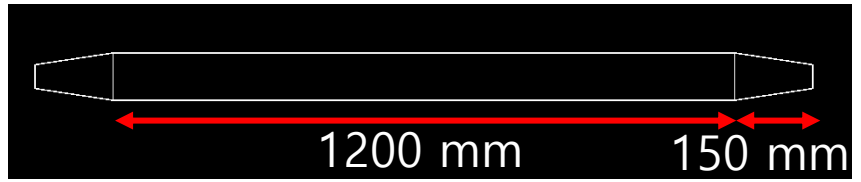


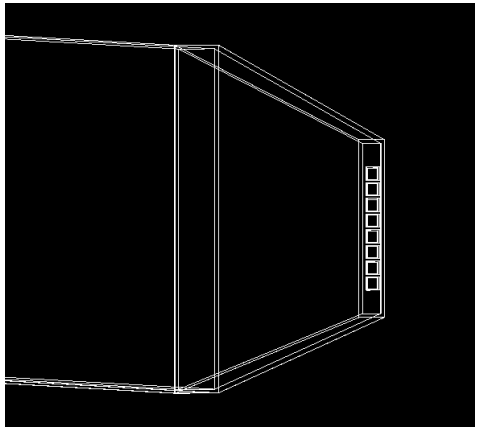


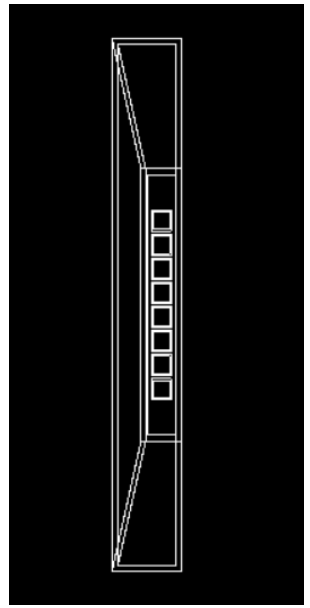


아랫면 10 mm X 90 mm
윗면 10 mm X 45 mm

Light guide2



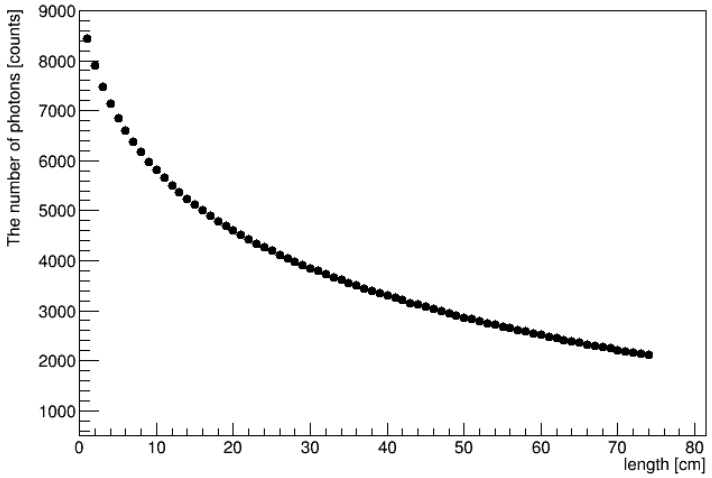




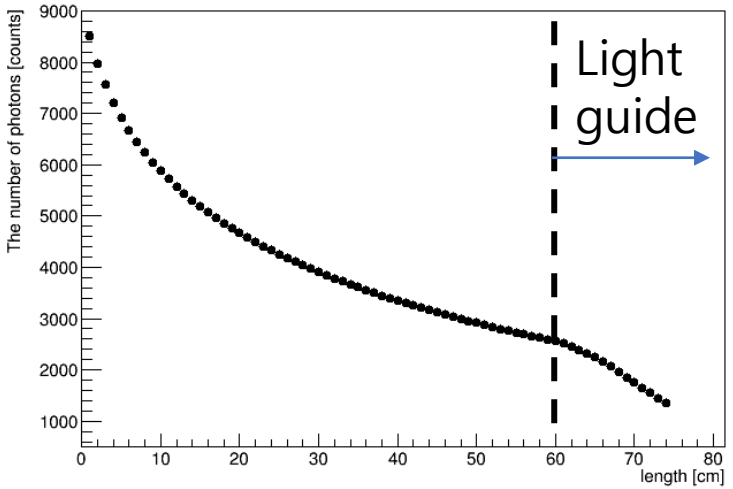
아랫면 10 mm X 90 mm
윗면 5 mm X 45 mm

The number of photons

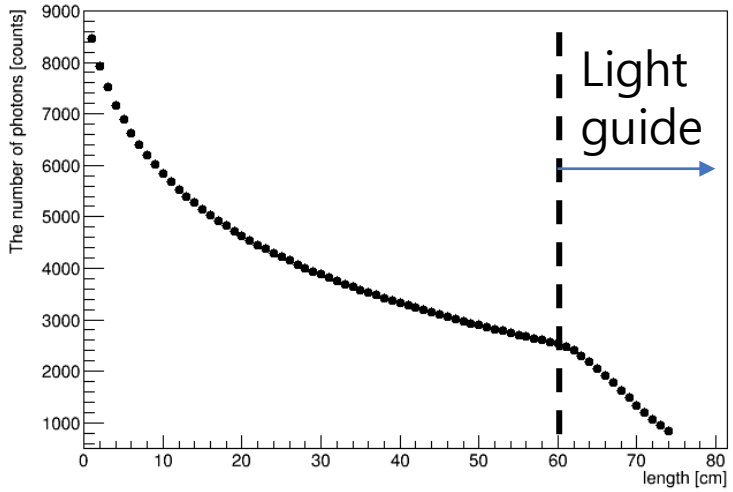
Without light guide



Light guide1

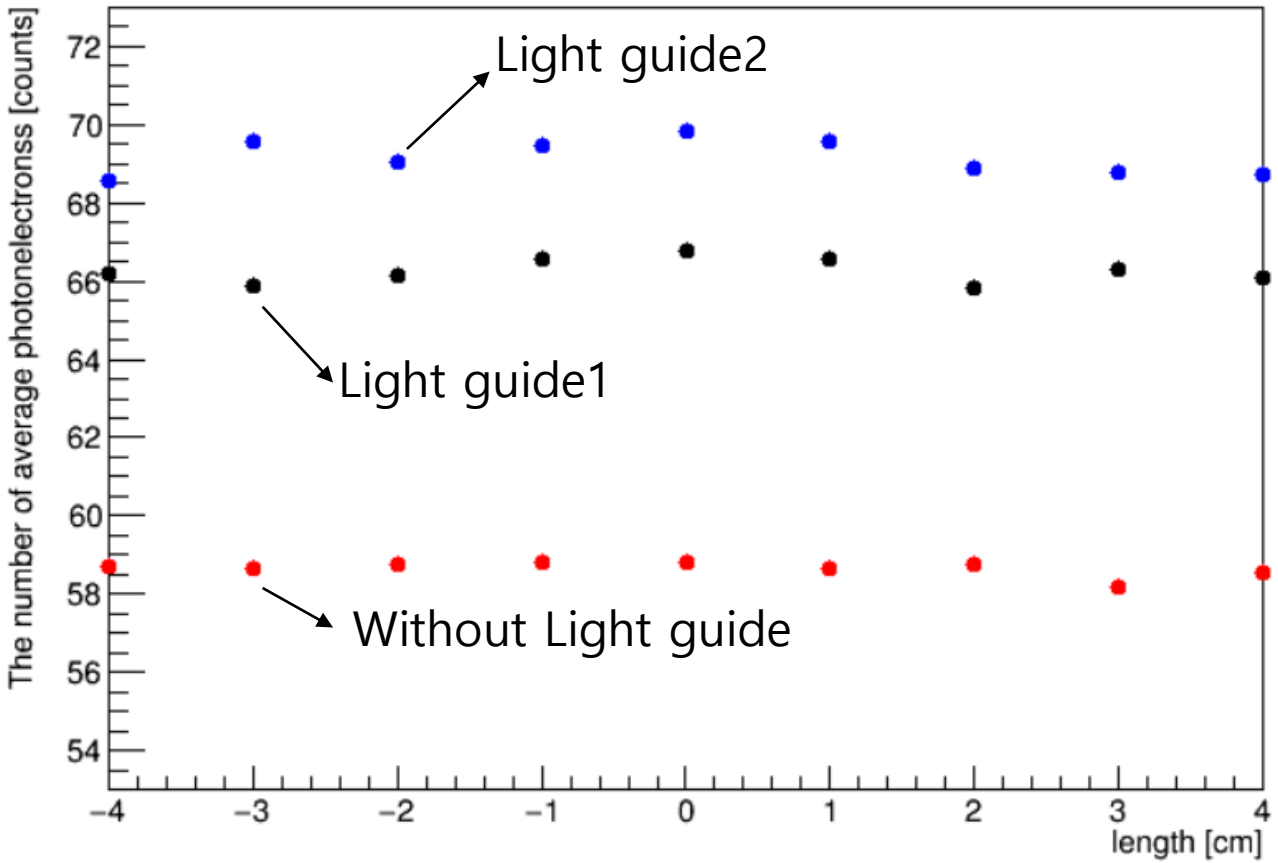


Light guide2



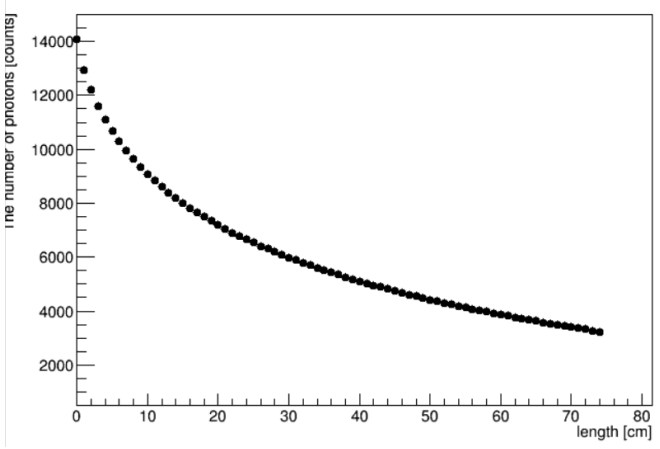
Area	10 mm X 90 mm	10 mm X 45 mm	5 mm X 45 mm
The number of photon at the end of scintillator	2106.08	1349.41	834.54
the number of photons per area($/mm^2$)	2.34	3.00	3.71
The number of photons	165.4	188.2	196.6
The number of photoelectrons	58.83	66.79	69.81

Width dependence

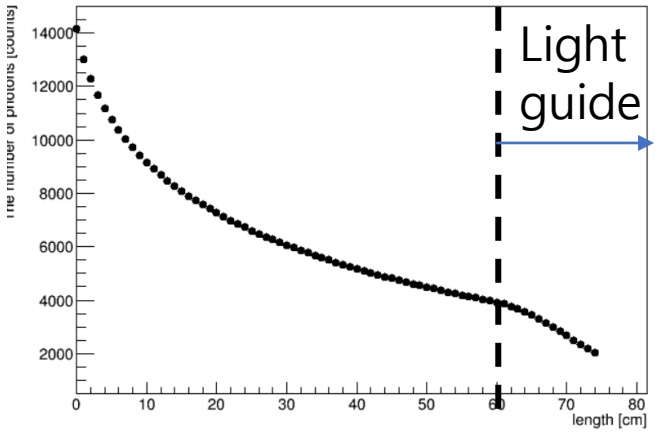


Thickeness of scintillator = 15 mm

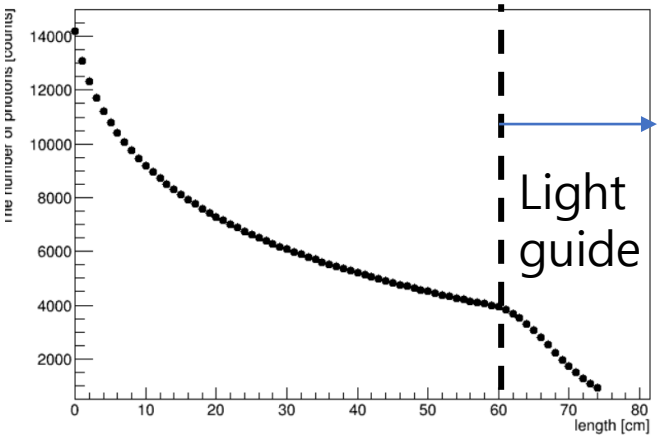
Without light guide



Light guide1



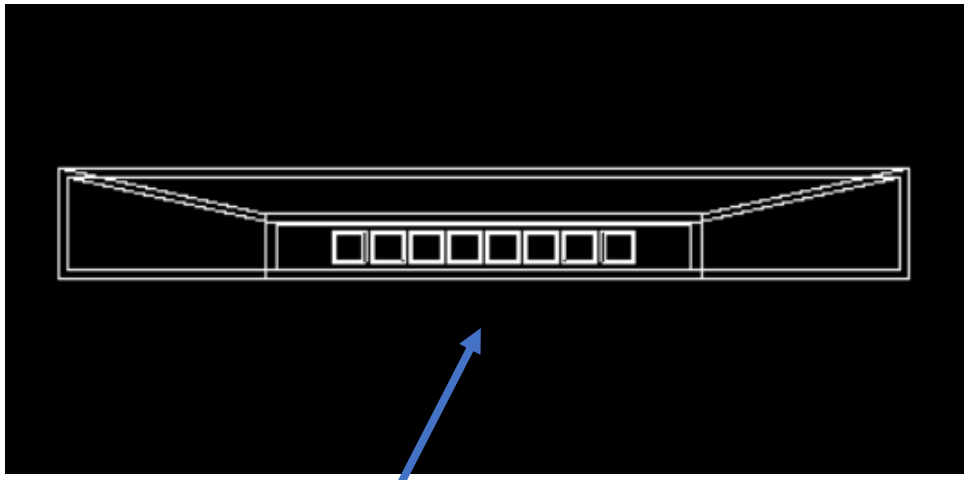
Light guide2



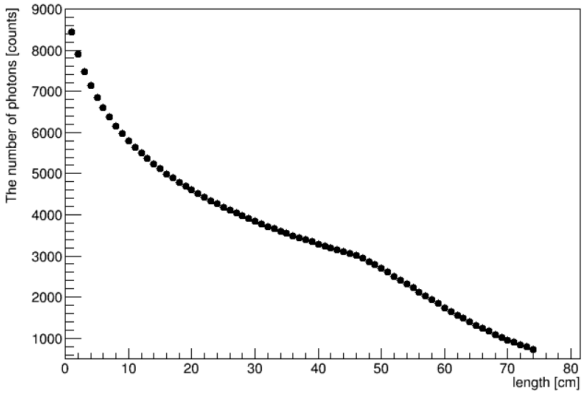
Area67.98	15 mm X 90 mm	15 mm X 45 mm	5 mm X 45 mm
The number of photon at the end of scintillator	3232.65	2046.73	920.629
the number of photons per area($/mm^2$)	2.39	3.03	4.09
The number of photons at MPPC	169.2	191.4	201.8
The number of photoelectrons at MPPC	60.11	67.98	71.67

Photon density is unchanged

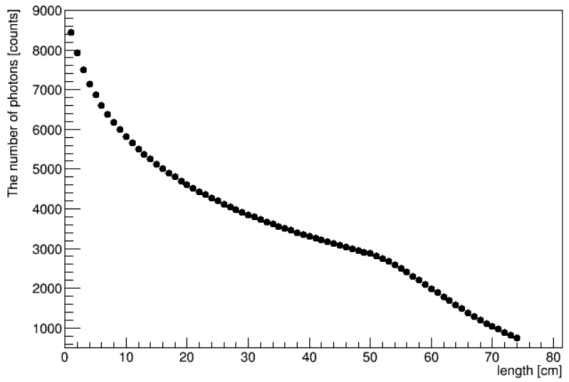
Light guide



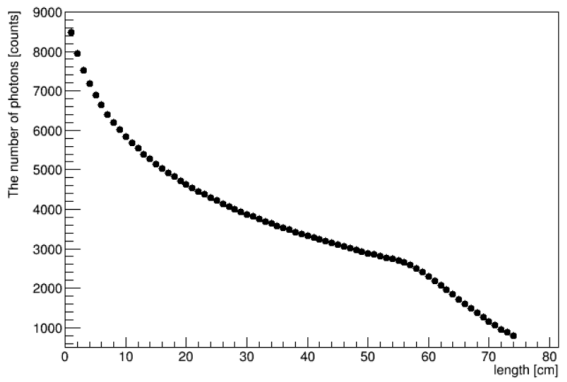
Scintillator length



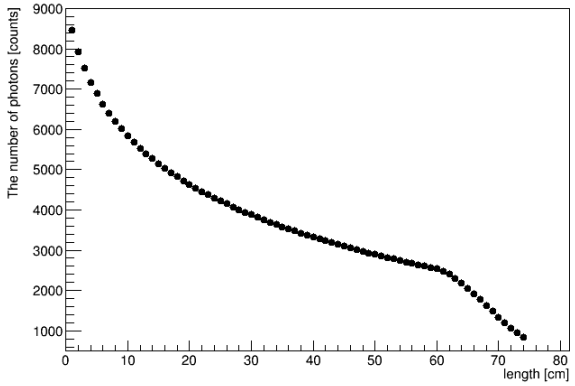
900 mm



1000 mm



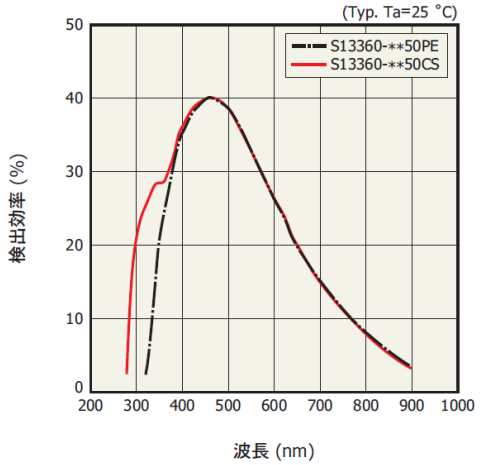
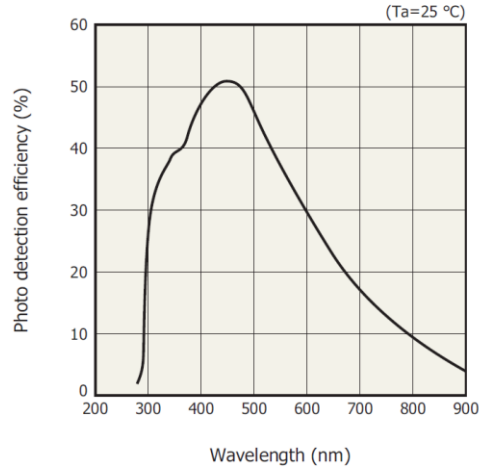
1100 mm



1200 mm

Scintillator length	900 mm	1000 mm	1100 mm	1200 mm
The number of photon at the end of scintillator	733.40	757.27	791.62	834.54
the number of photons per area	3.26	3.37	3.52	3.71
The number of photons	188.5	190.5	191.2	196.6
The number of photoelectrons	66.88	67.72	67.85	69.81

Types of MPPC(with light guide1, 10mm)

MPPC type	3050PE	6050PE	4050HS
MPPC area X Number	3 mm X 3 mm X 8	6 mm X 6 mm X 5	4 mm X 4 mm X 8
Total MPPC area(mm^2)	72	180	128
PDE			
The number of photons	188.2	461.3	330
The number of photoelectrons	66.79	163.7	154.2
Converting ratio	0.355	0.355	0.467

X 2.5 →

X 0.711 →

X 2.45 →

X 0.715 →

X 0.942 →

Conclusion

- We performed Monte Carlo study on shape of BTOF and effect of MPPC with GEANT4

- Photon detection efficiencys and refractive index are given by HAMAMATSU Ltd.

- As cross-section of scintillator gets smaller, as area covered with MPPC increases, the light yield increases.

- 4050SH MPPC has higher efficiency an 3050PE or 6050PE

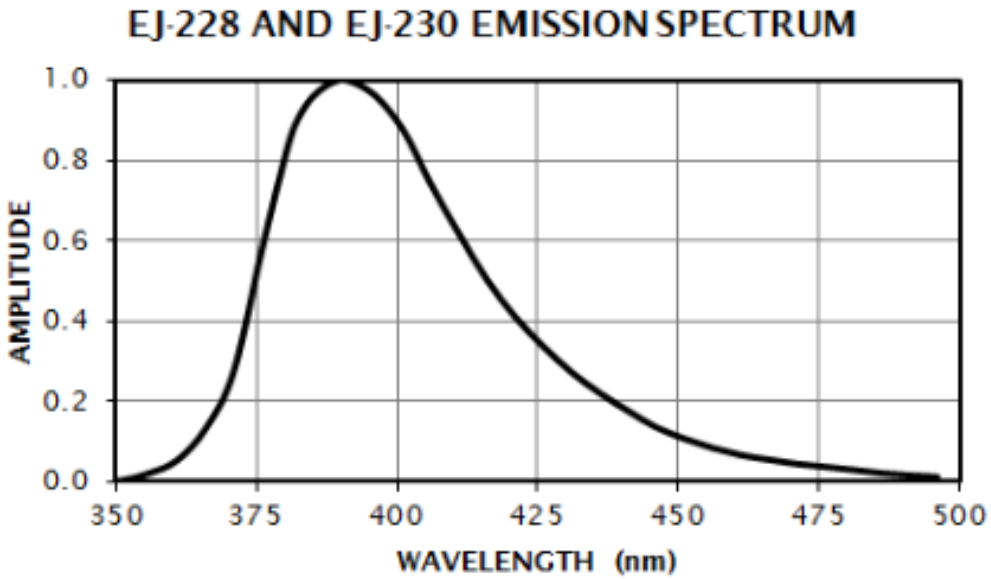
backup

Scintillator definition

PROPERTIES	EJ-228	EJ-230
Light Output (% Anthracene)	67	64
Scintillation Efficiency (photons/1 MeV e^-)	10,200	9,700
Wavelength of Maximum Emission (nm)	391	391
Light Attenuation Length (cm)	–	120
Rise Time (ns)	0.5	0.5
Decay Time (ns)	1.4	1.5
Pulse Width, FWHM (ns)	1.2	1.3
No. of H Atoms per cm^3 ($x10^{22}$)	5.15	5.15
No. of C Atoms per cm^3 ($x10^{22}$)	4.69	4.69
No. of Electrons per cm^3 ($x10^{23}$)	3.33	3.33
Density (g/cm^3)	1.023	1.023

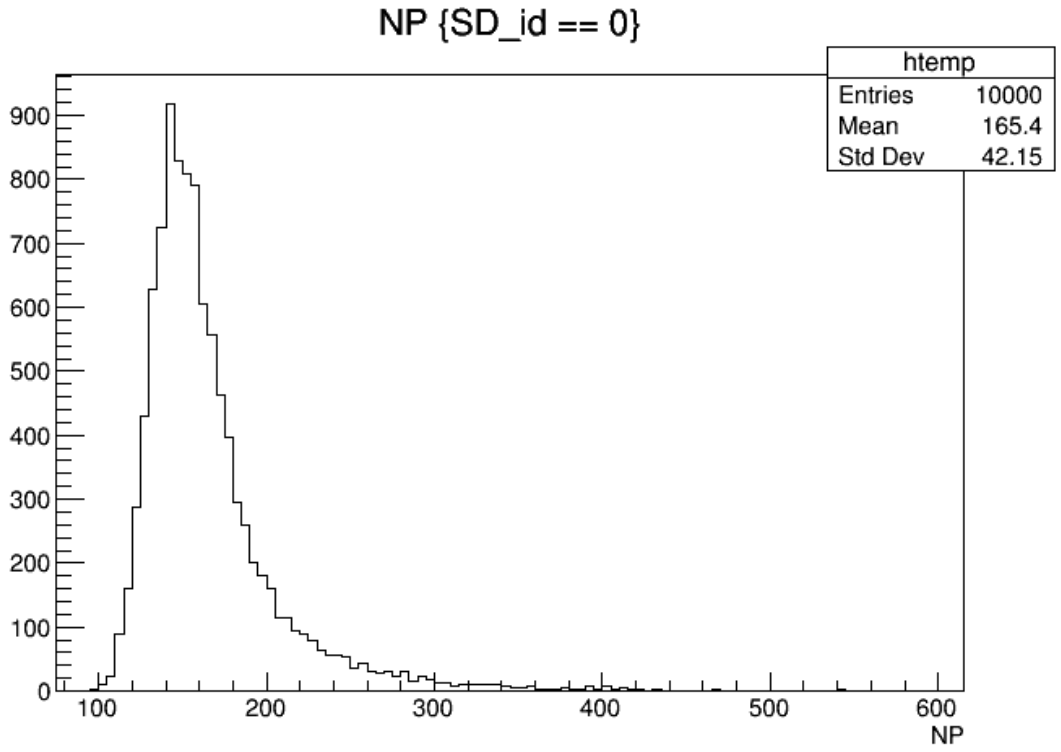
Polymer Base	Polyvinyltoluene
Refractive Index	1.58
Softening Point	75°C
Vapor Pressure	Vacuum-compatible
Coefficient of Linear Expansion	7.8×10^{-5} below 67°C
Light Output vs. Temperature	At 60°C, L.O. = 95% of that at 20°C No change from -60°C to 20°C
Temperature Range	-20°C to 60°C

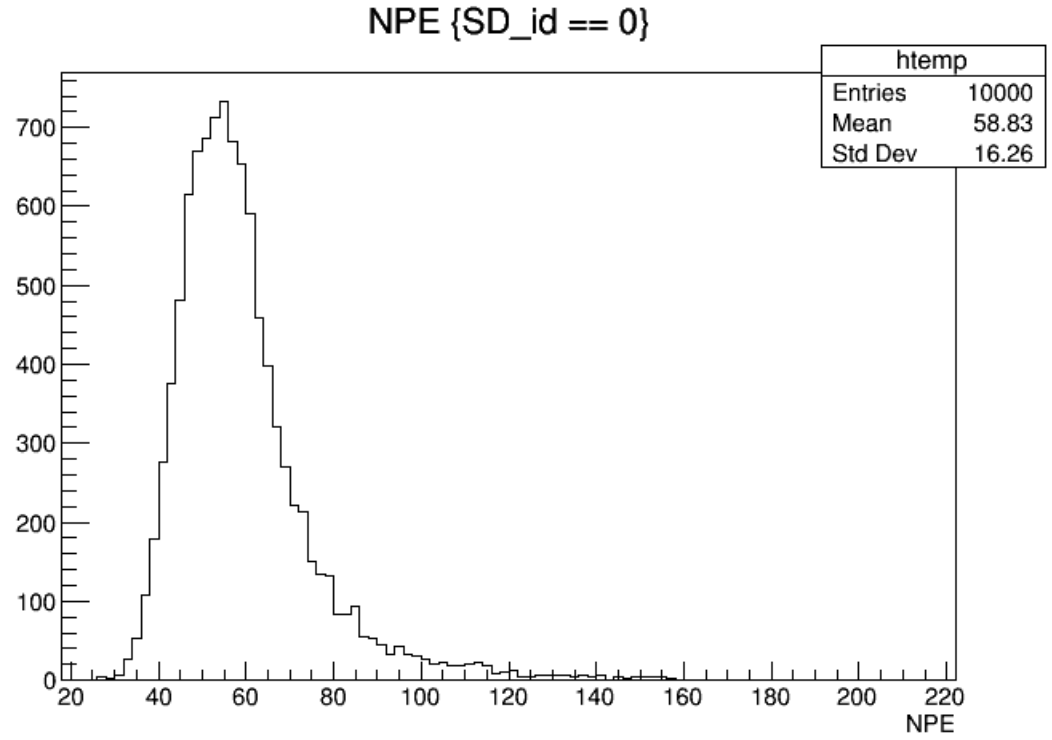
- Density : 1.023 g/cm^3
- Refractive index = 1.58
- Attenuation length = 120 cm
- Scintillation efficiency = 9700 / 1 MeVee



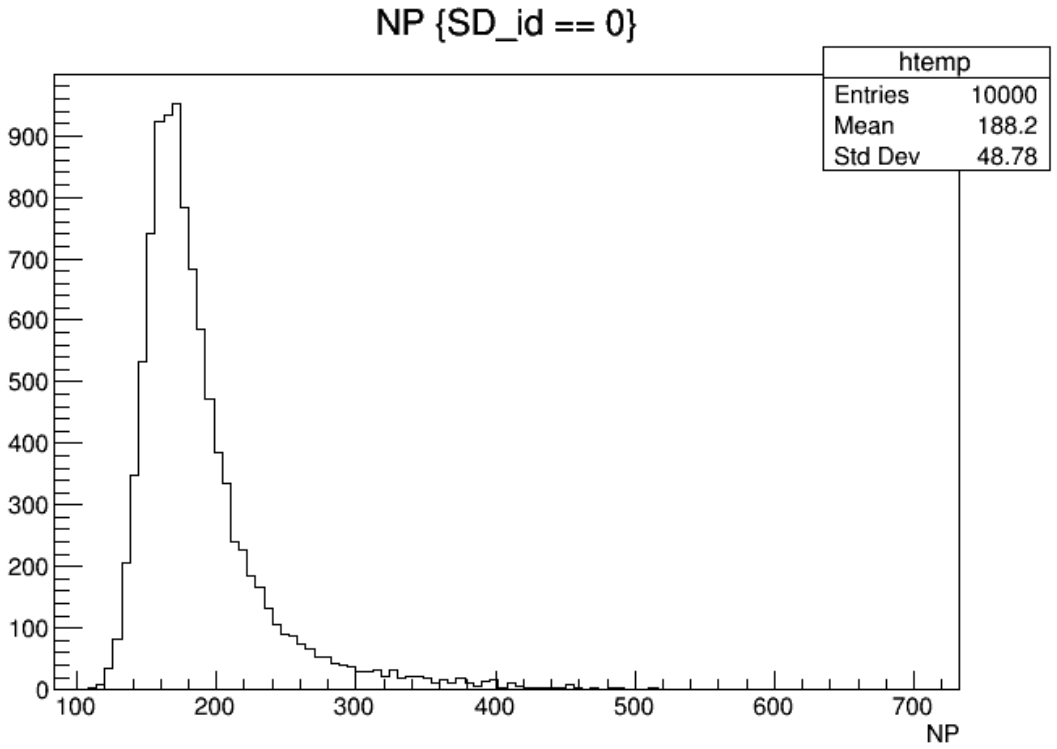
Shape

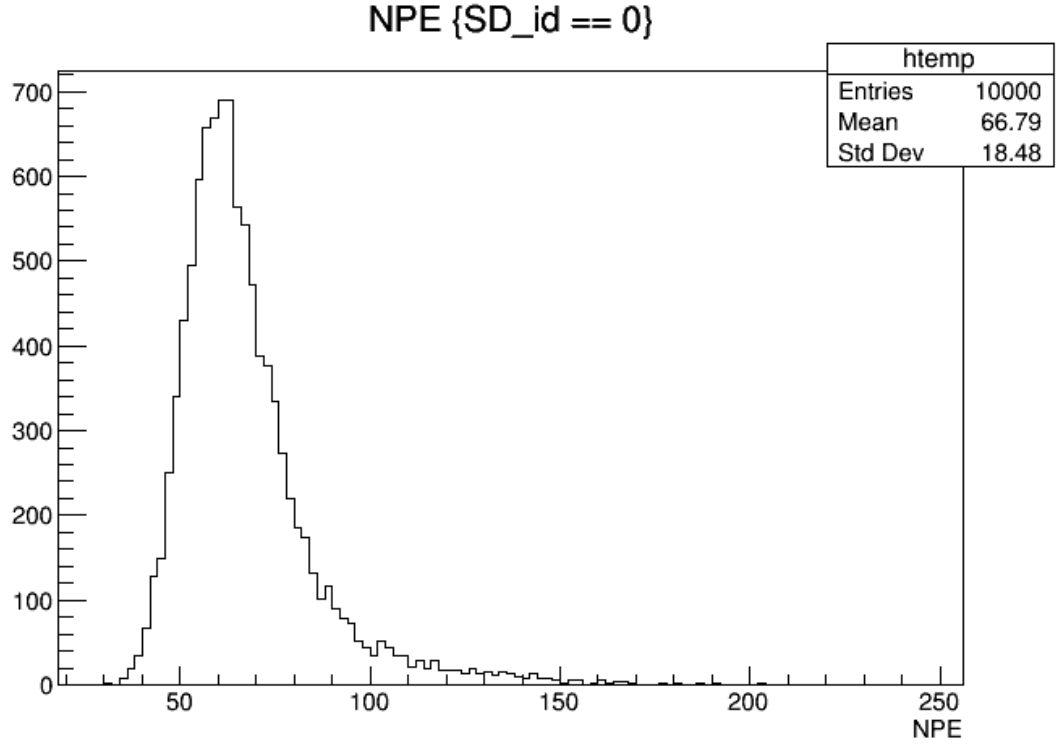
3050PE – without light guide



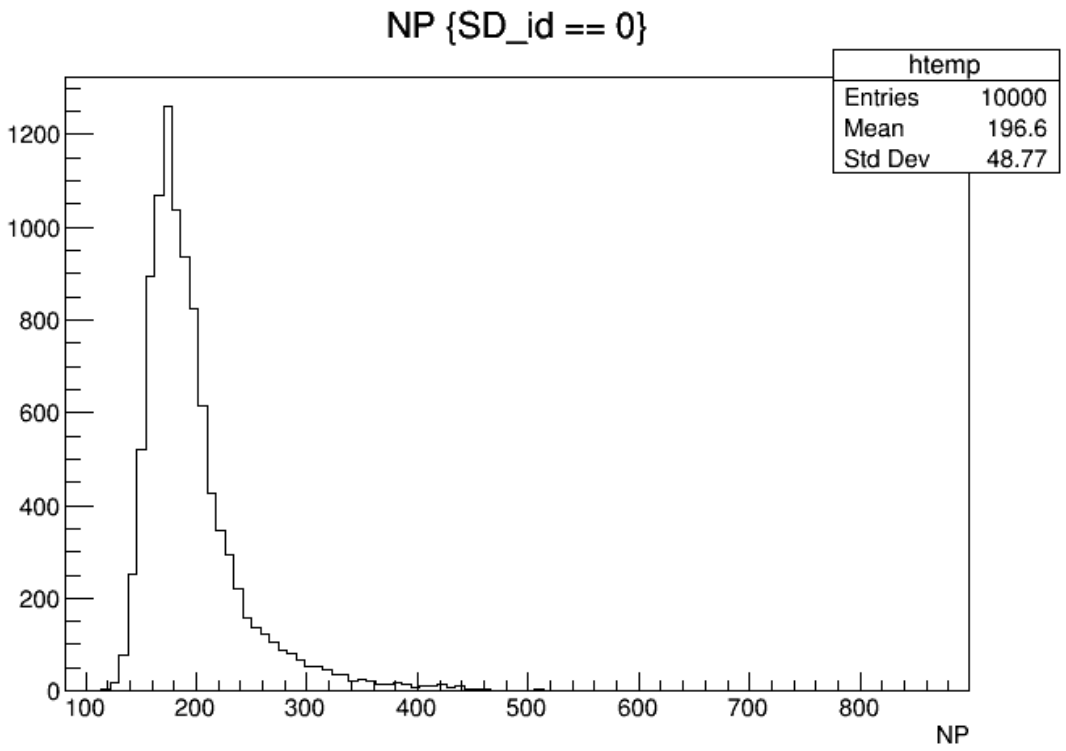


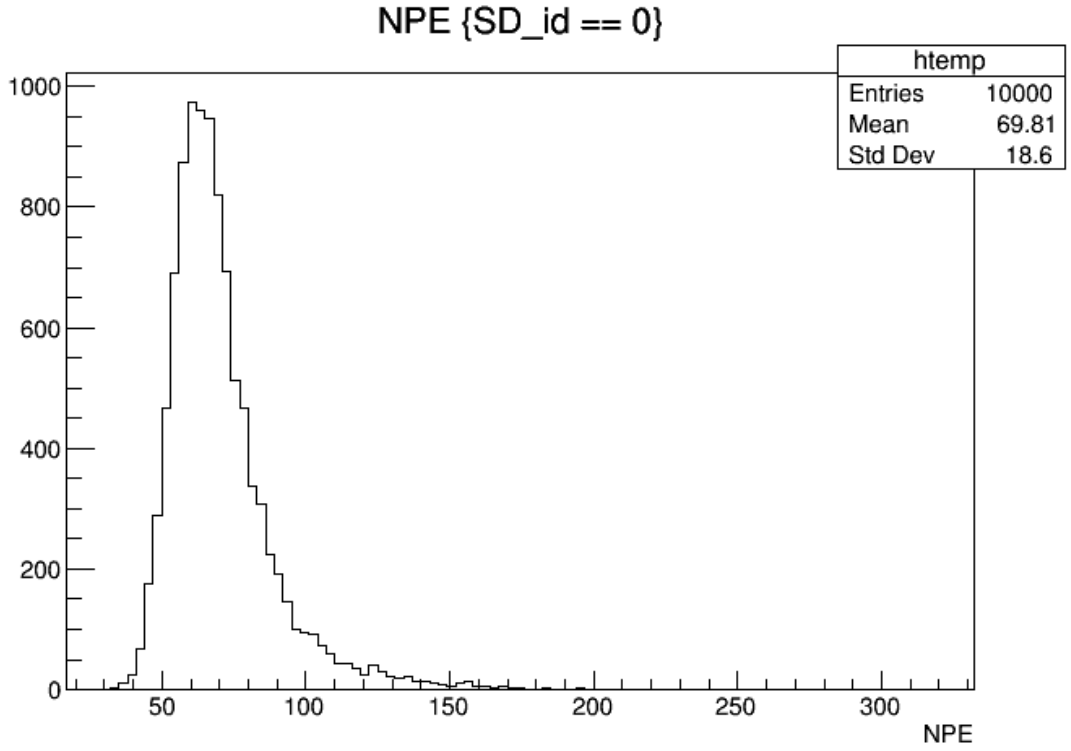
3050PE – light guide1





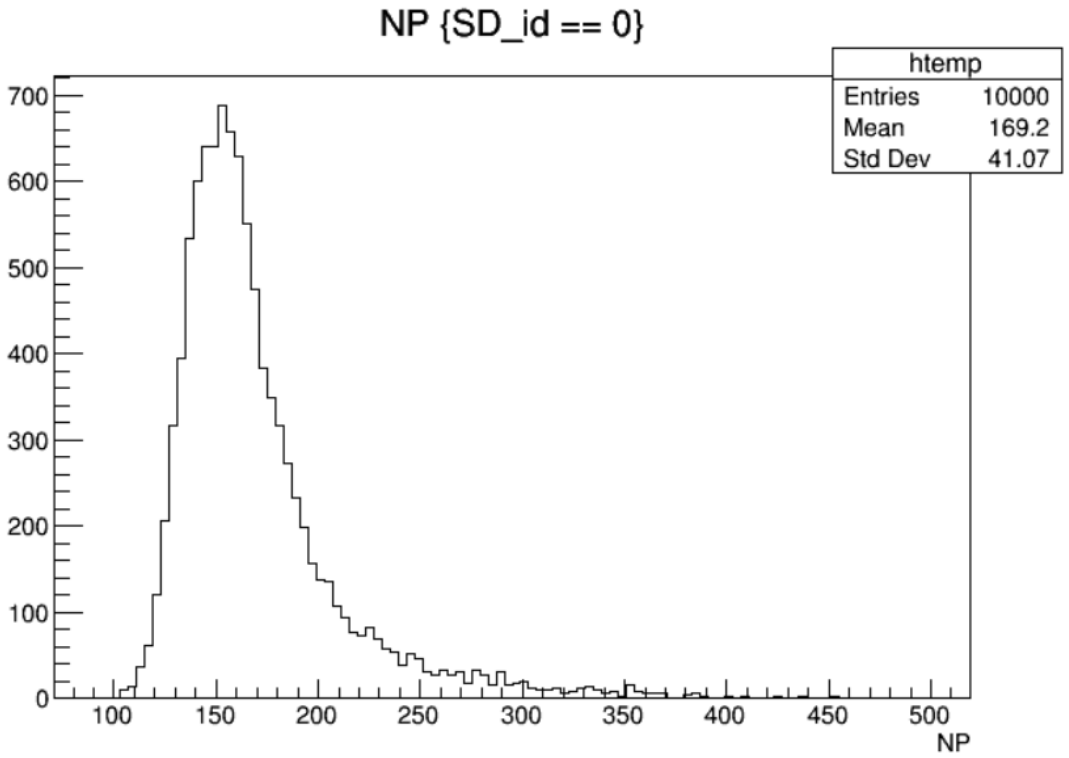
3050PE – light guide2

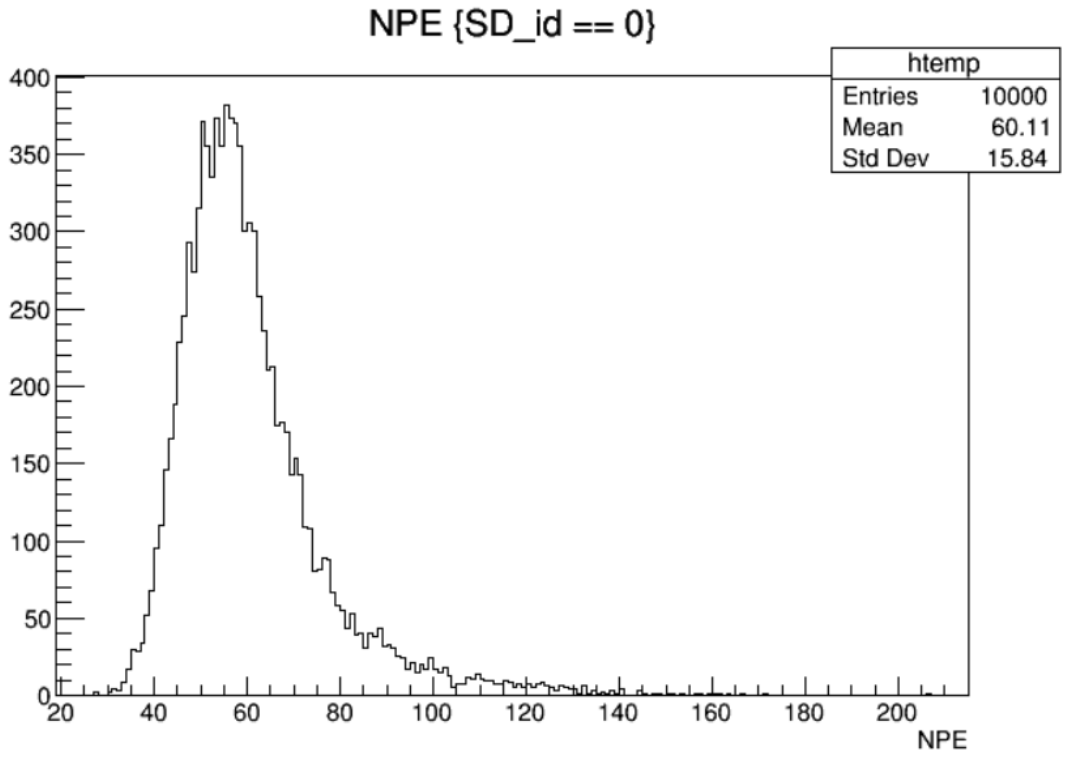




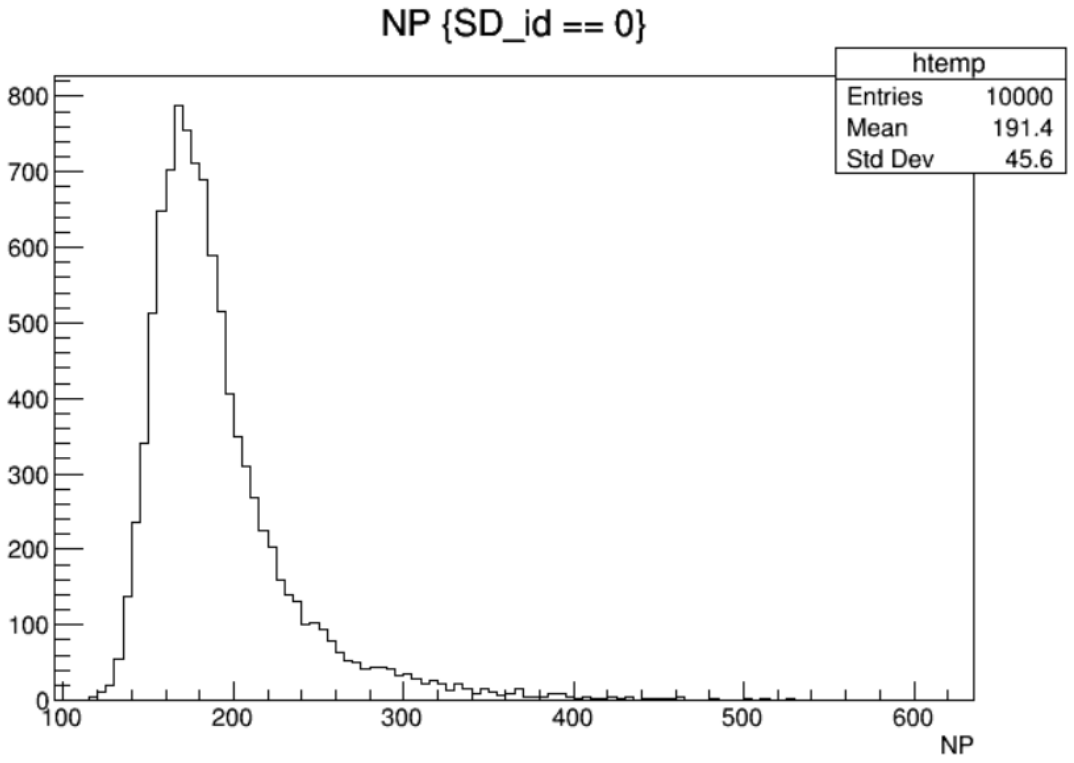
Thickness

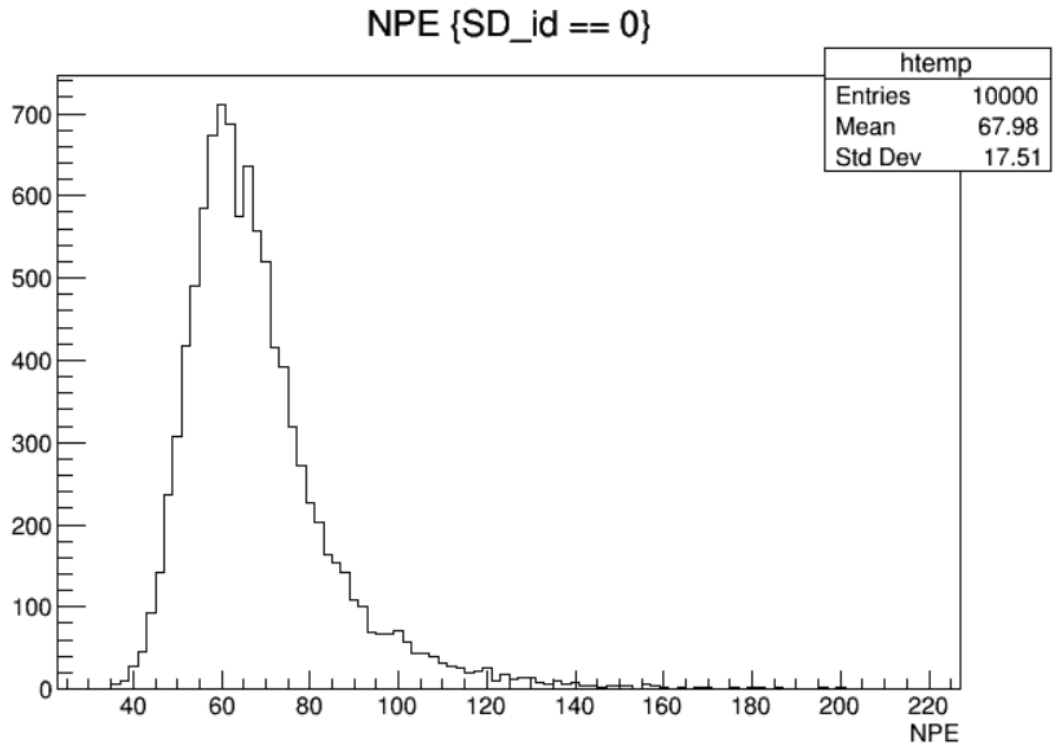
3050PE – without light guide 15mm



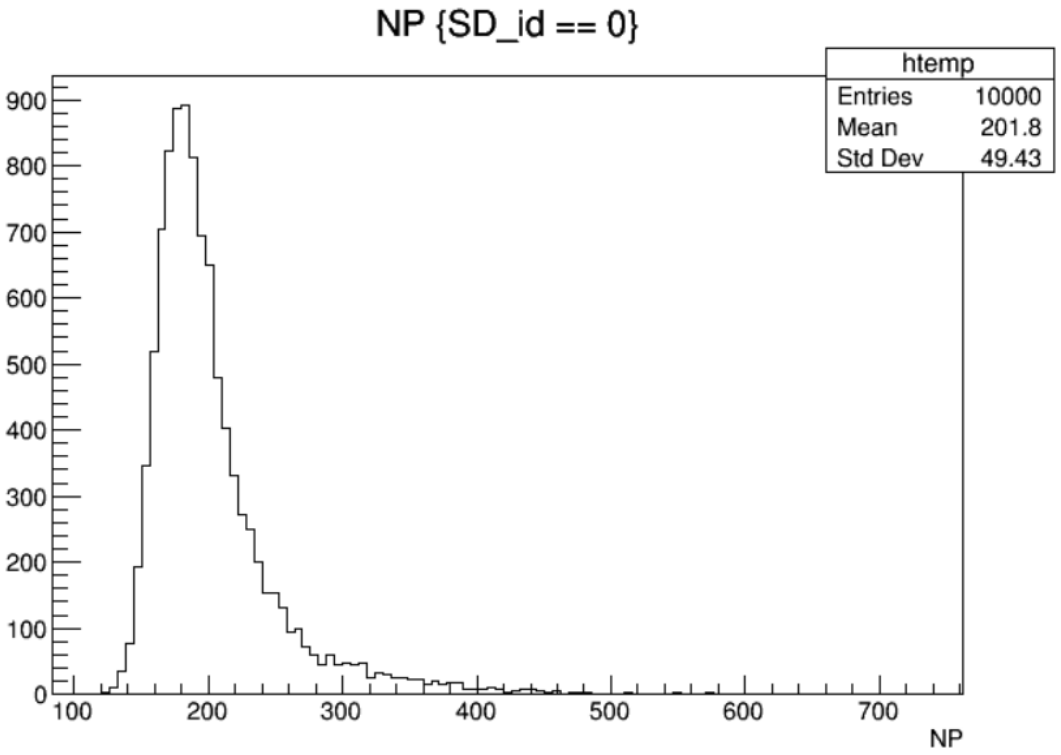


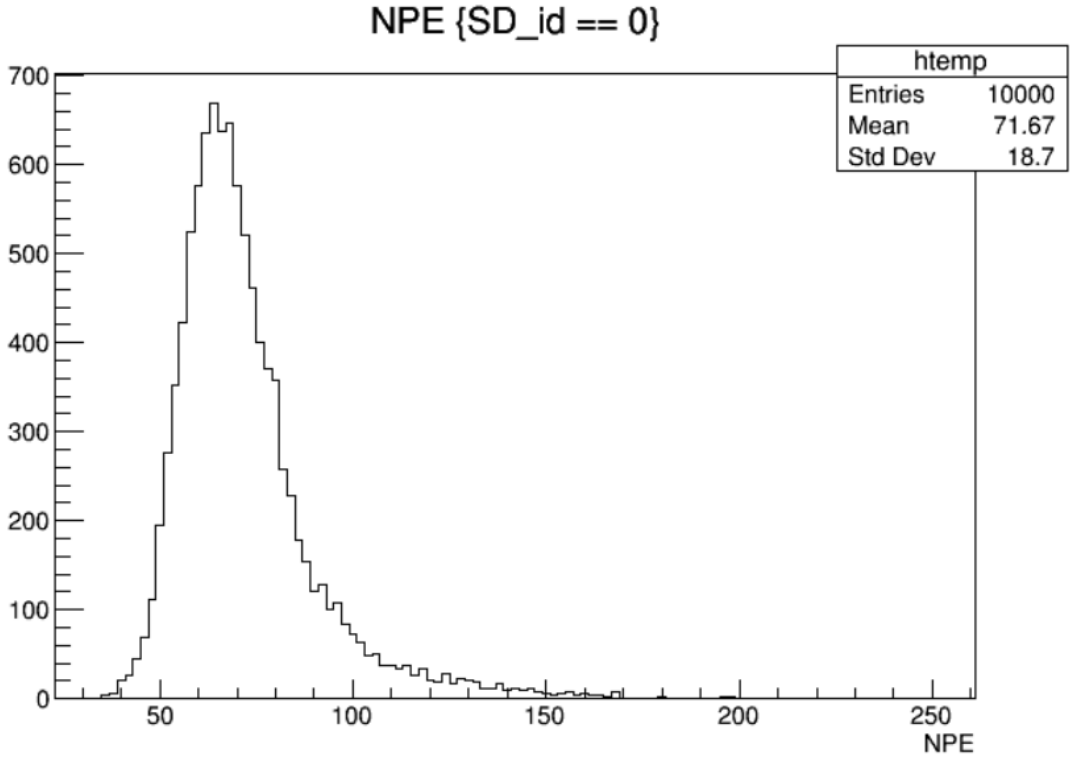
3050PE – light guide1 15mm





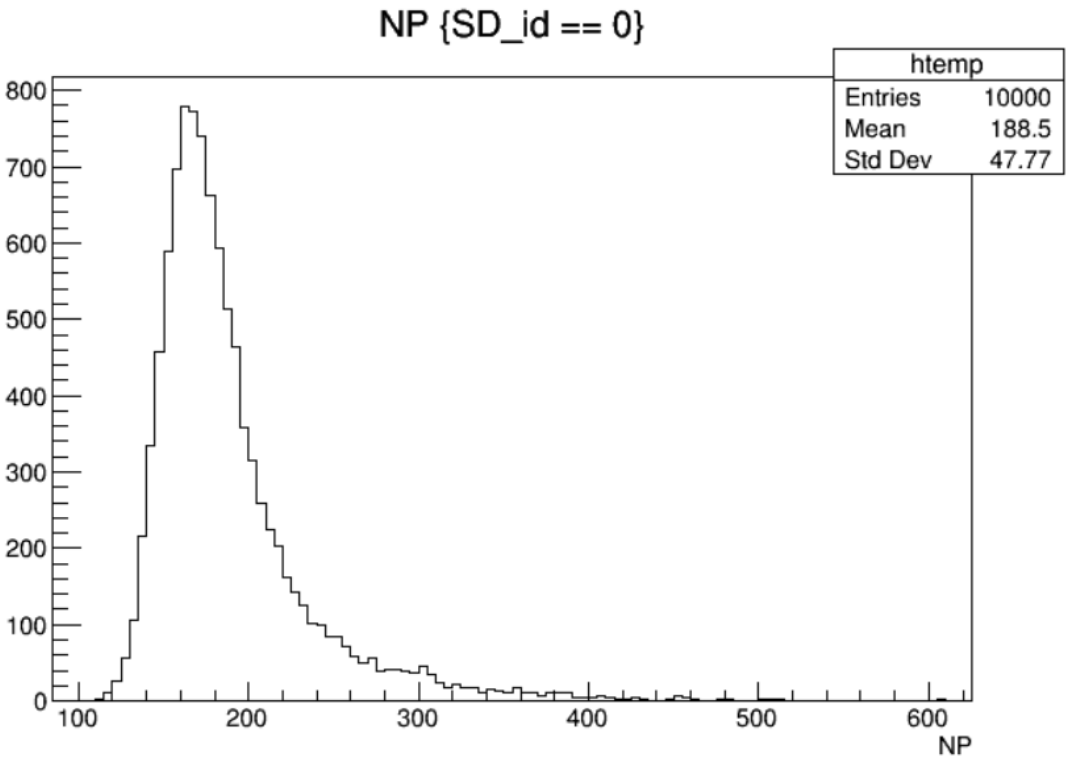
3050PE – light guide2 15mm





Angle

900 mm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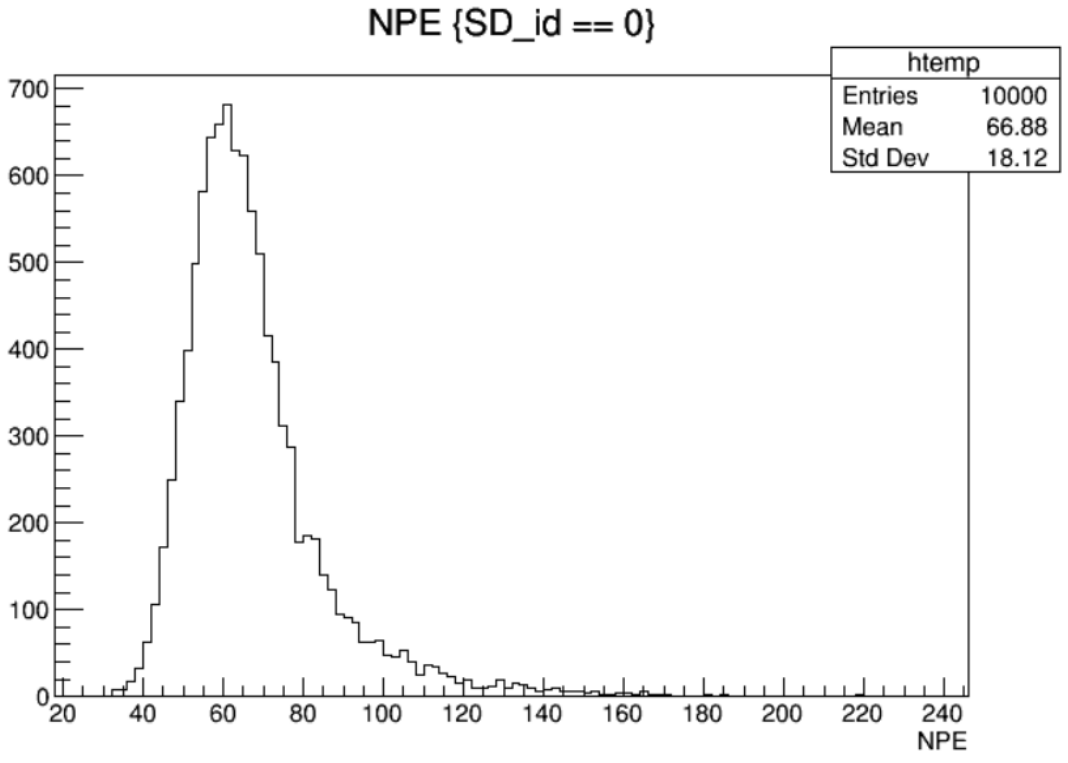
600
NP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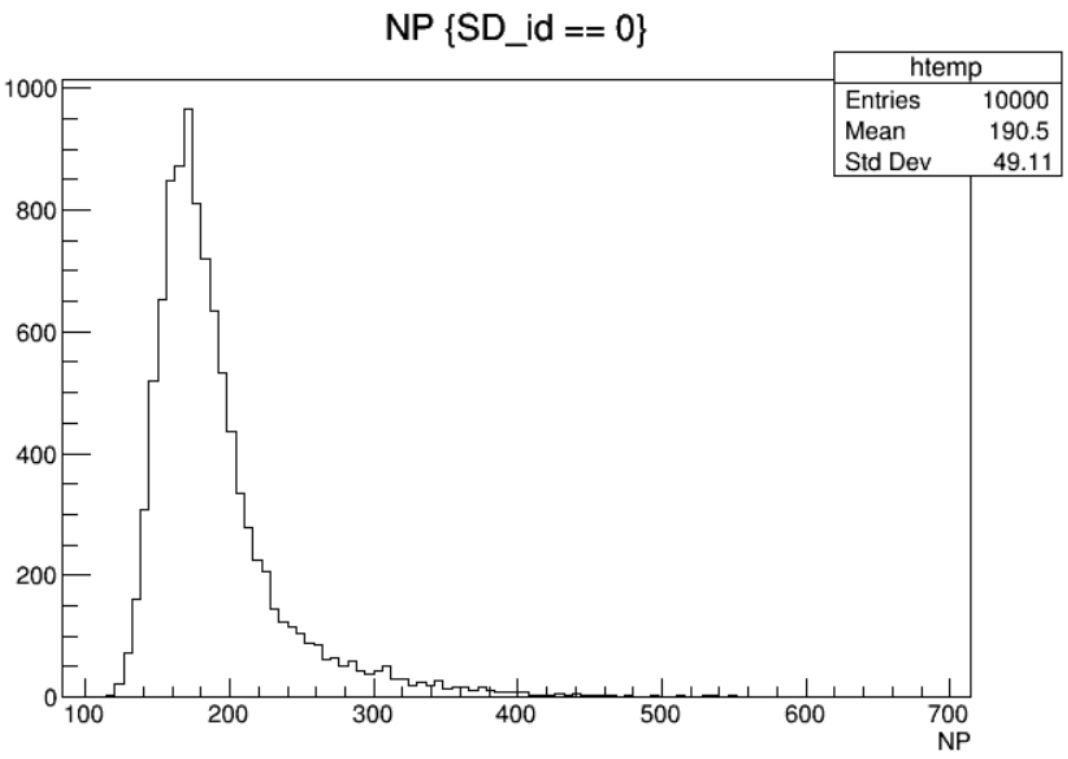
140
160
180
200
220
240
NPE

1000 mm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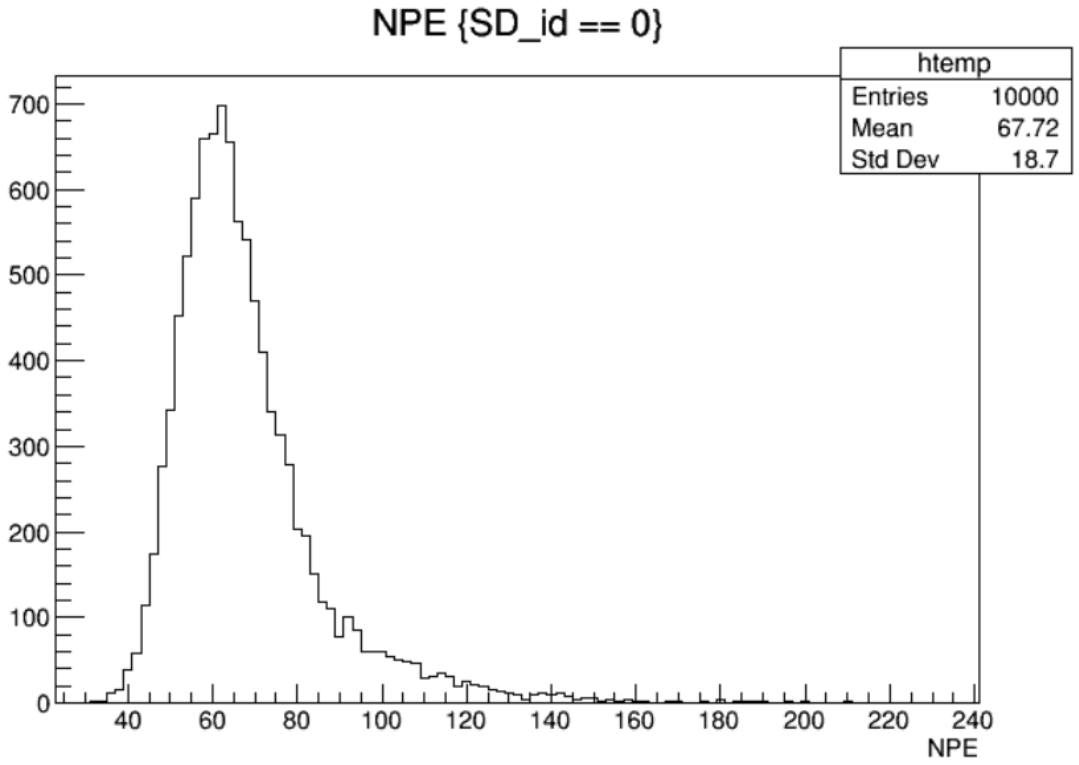
700
NP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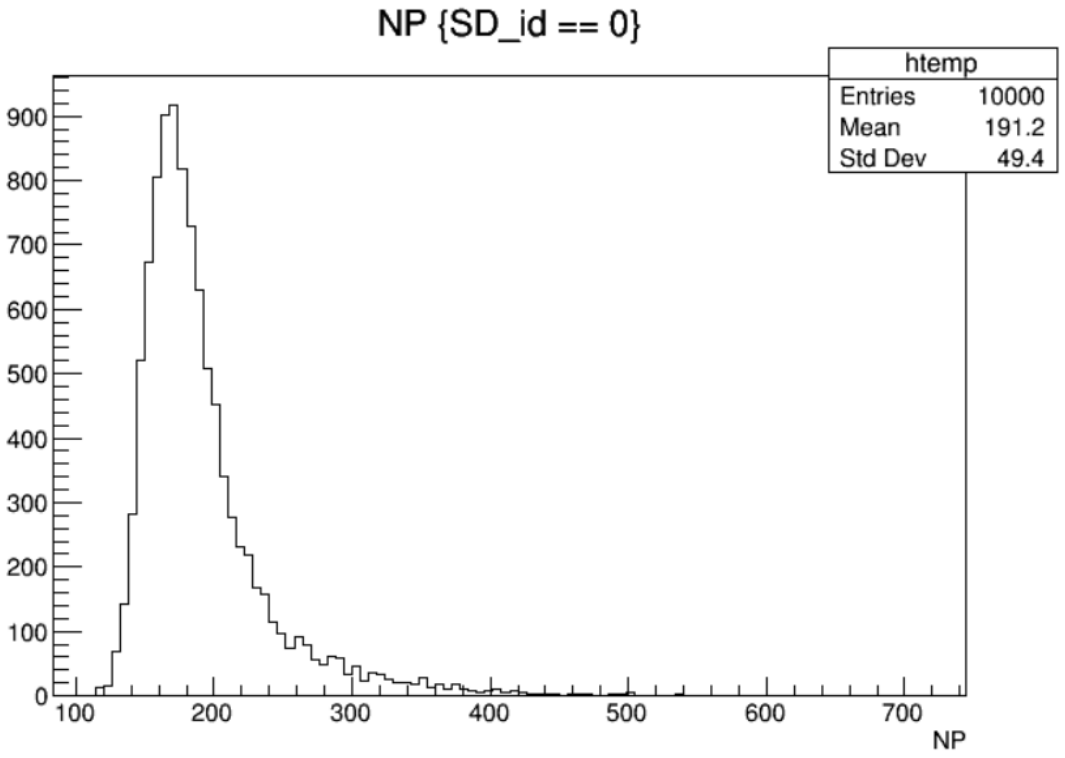
NPE

1100 mm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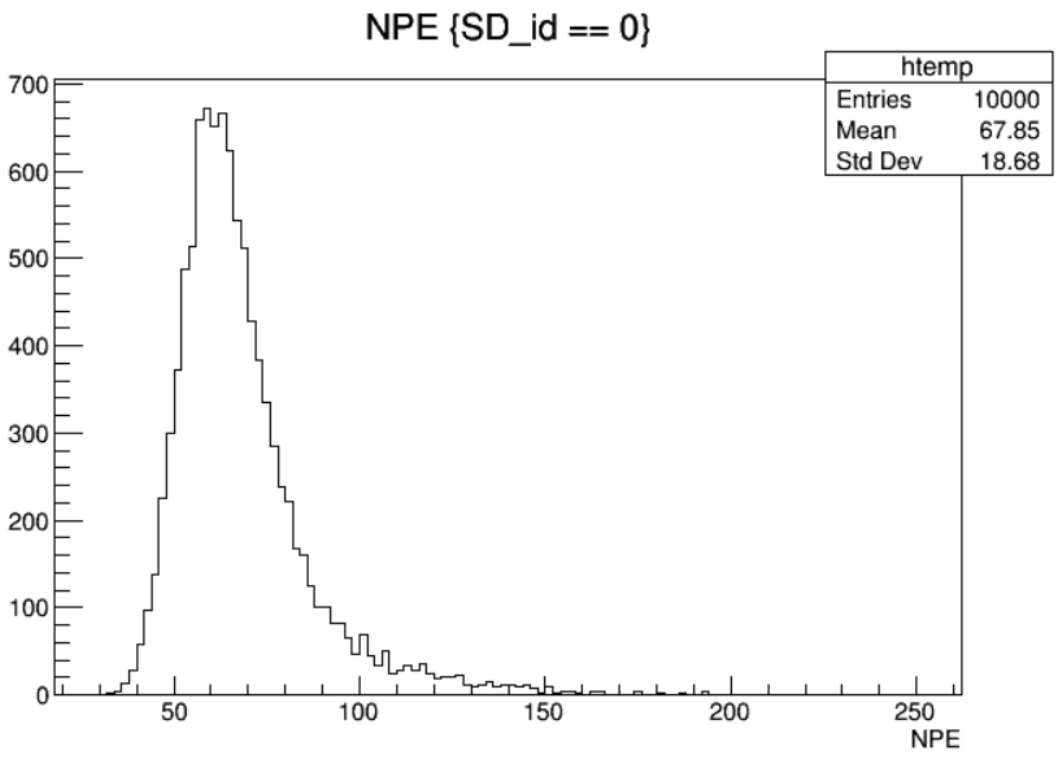
NP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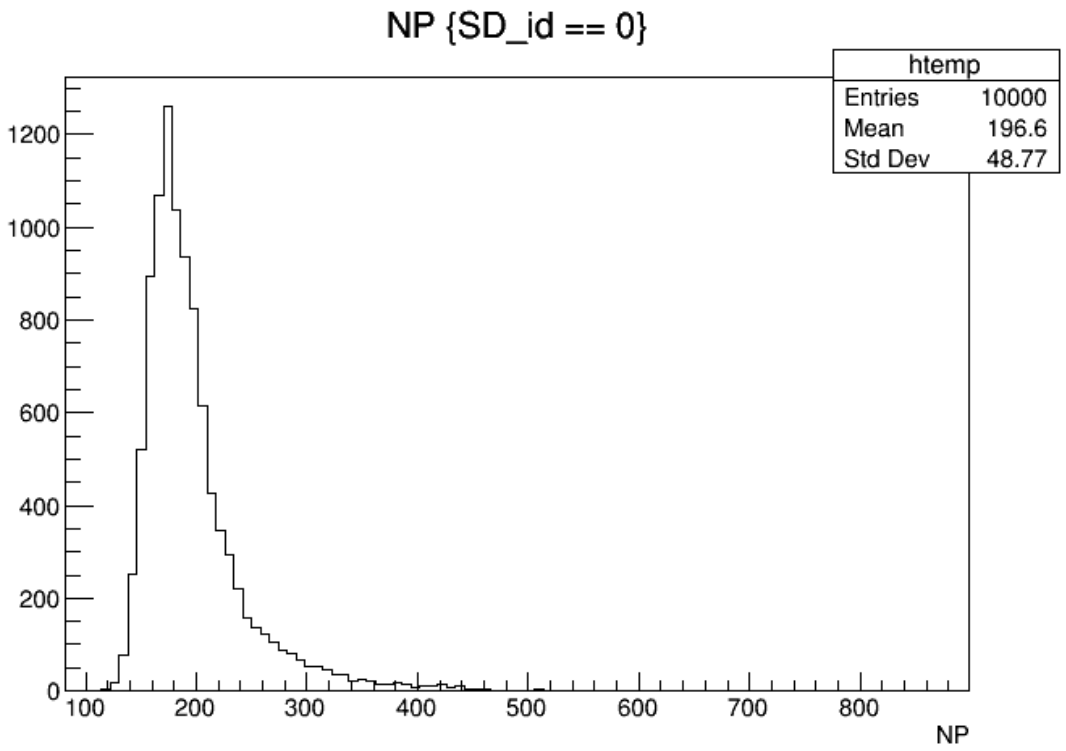
NPE

1200 mm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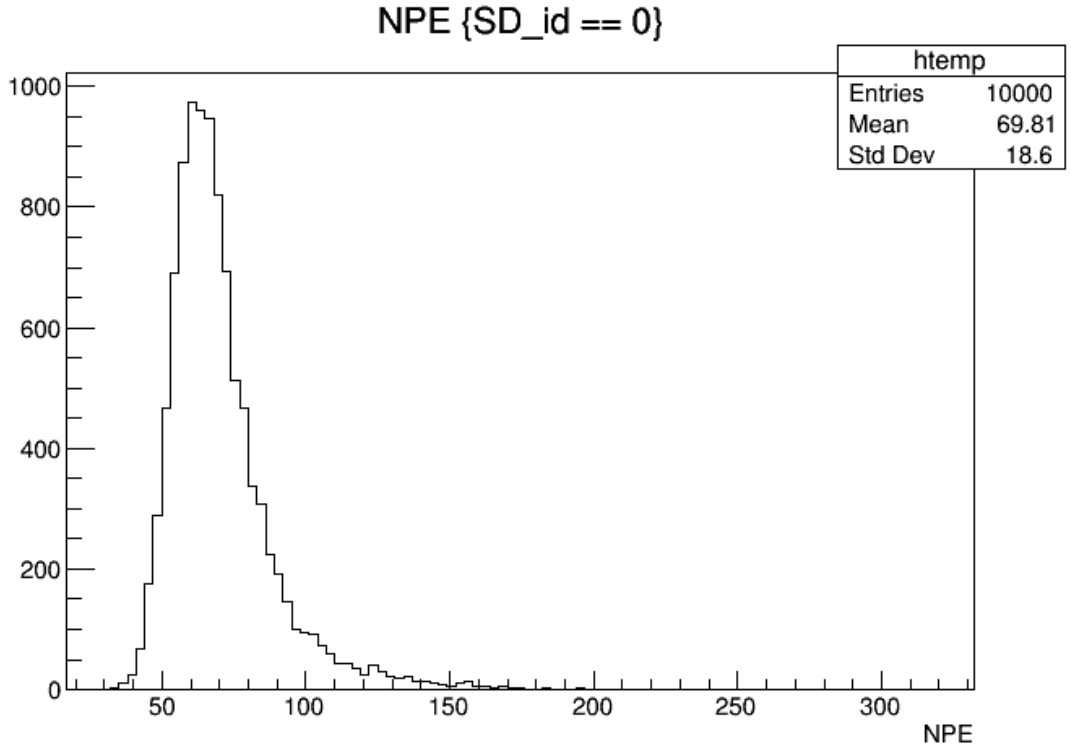
NP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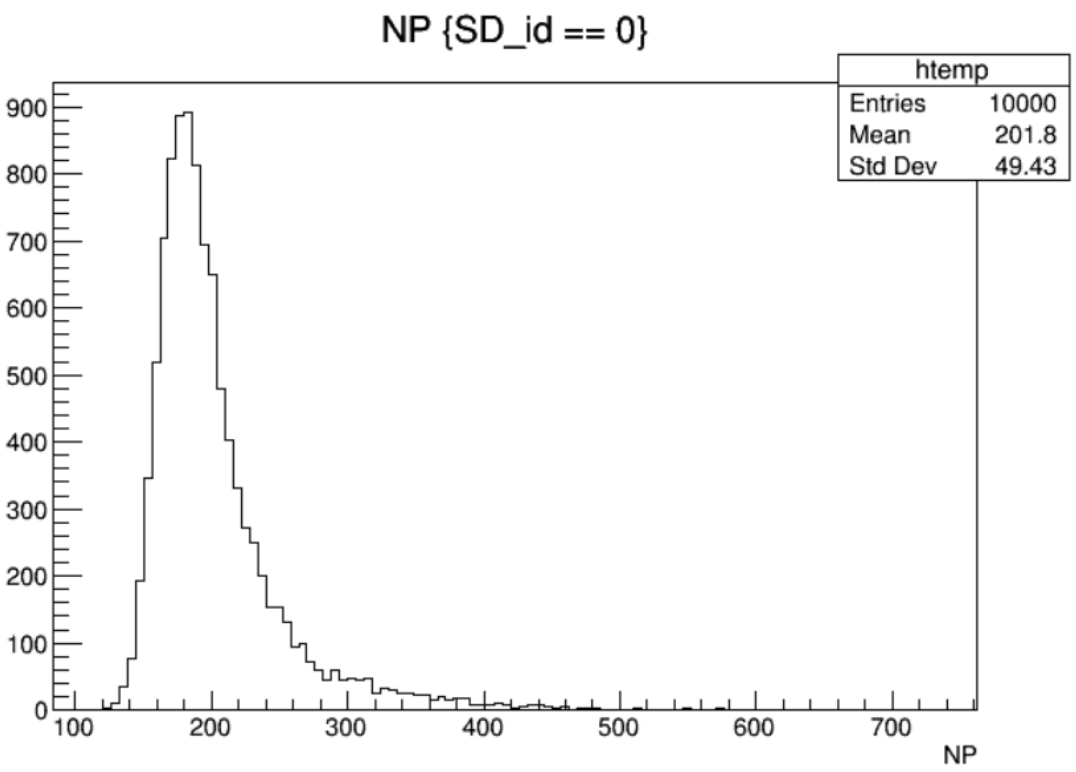
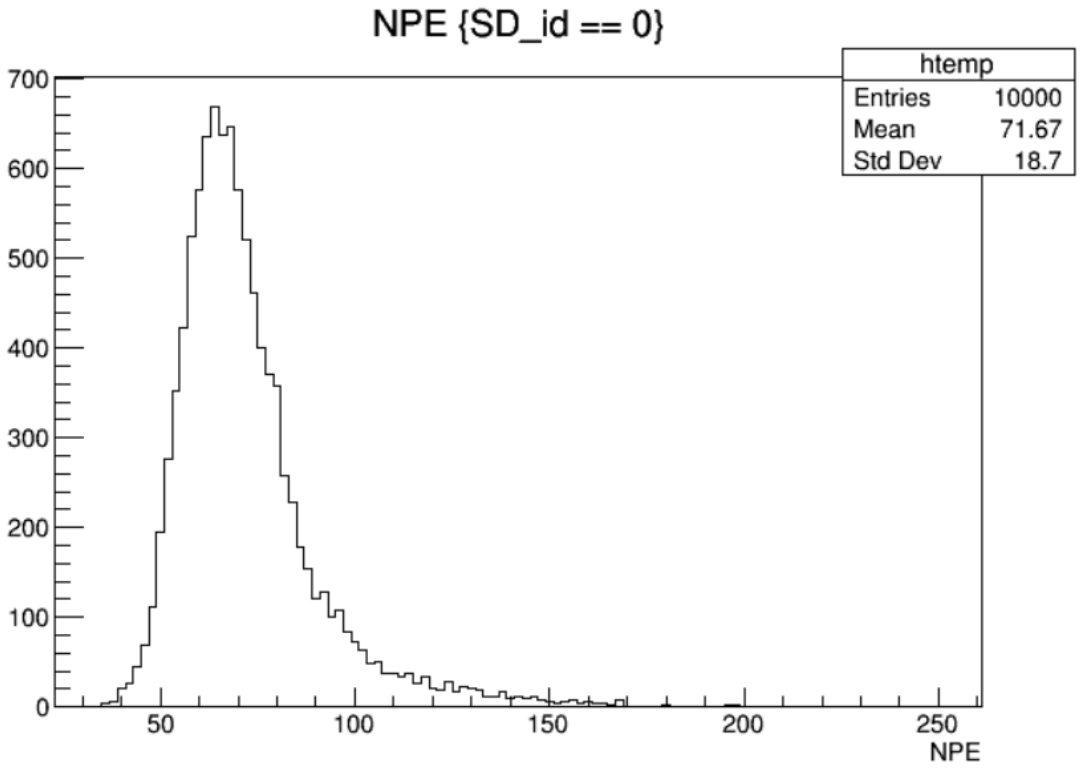
300
NPE

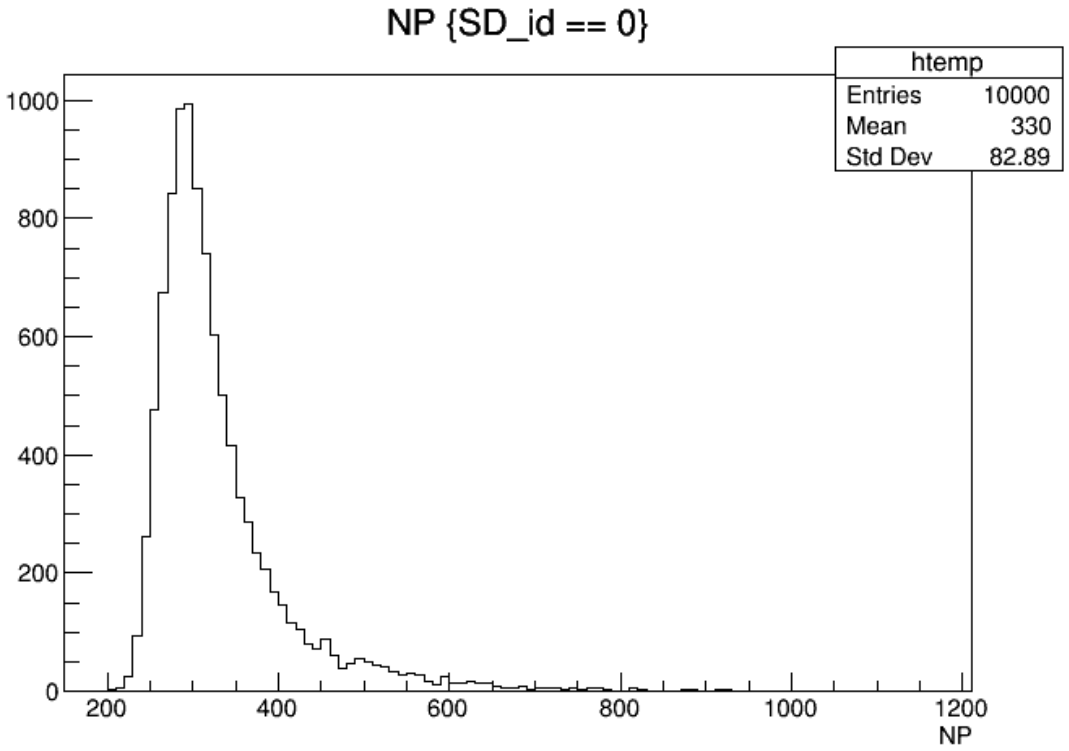
MPPC

3050PE – light guide2 15mm





4050PE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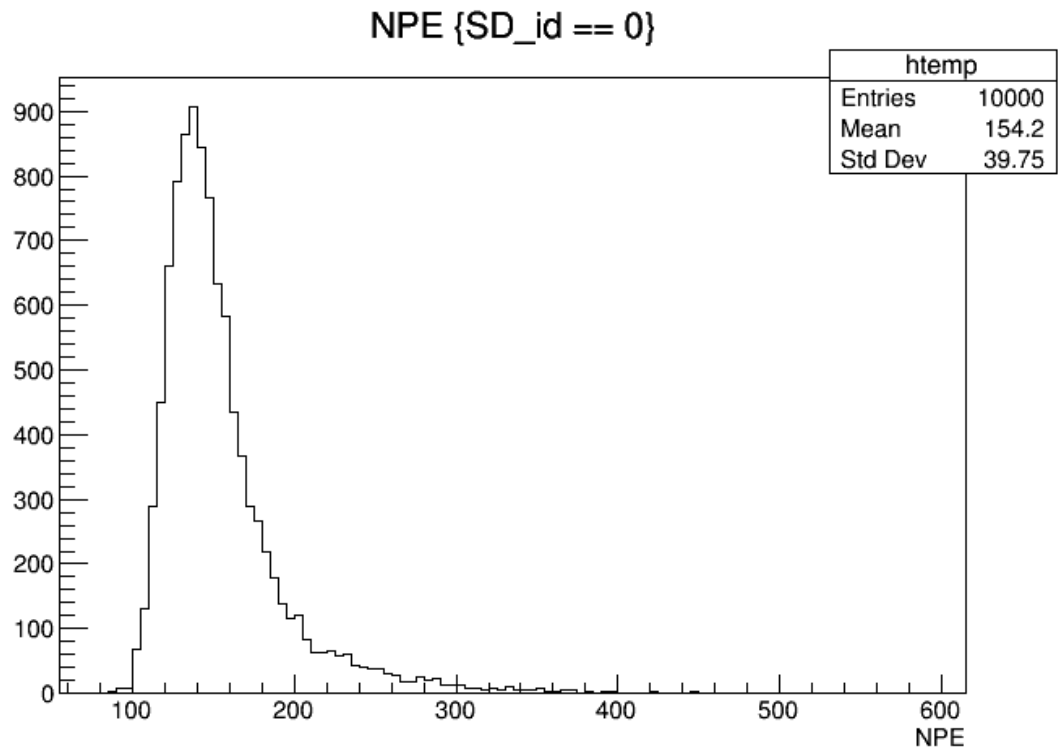
800
1000
1200
NP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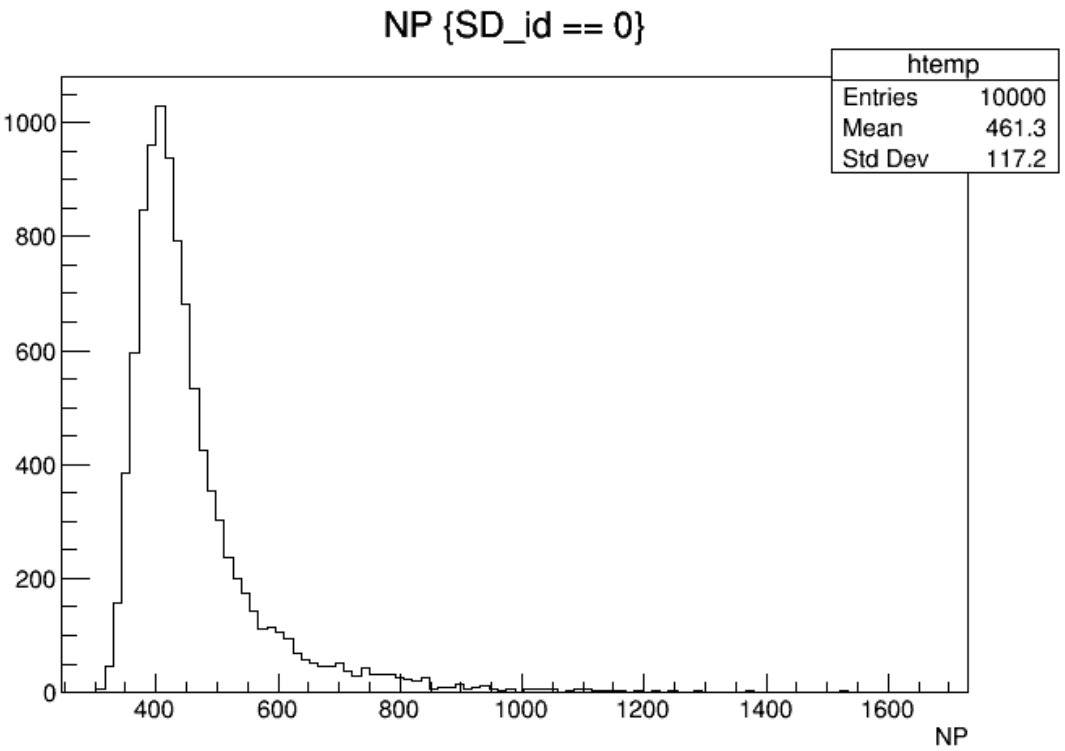
0
100
200
300
400
500
600
NPE

6050PE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htemp
Entries 10000
Mean 461.3
Std Dev 117.2
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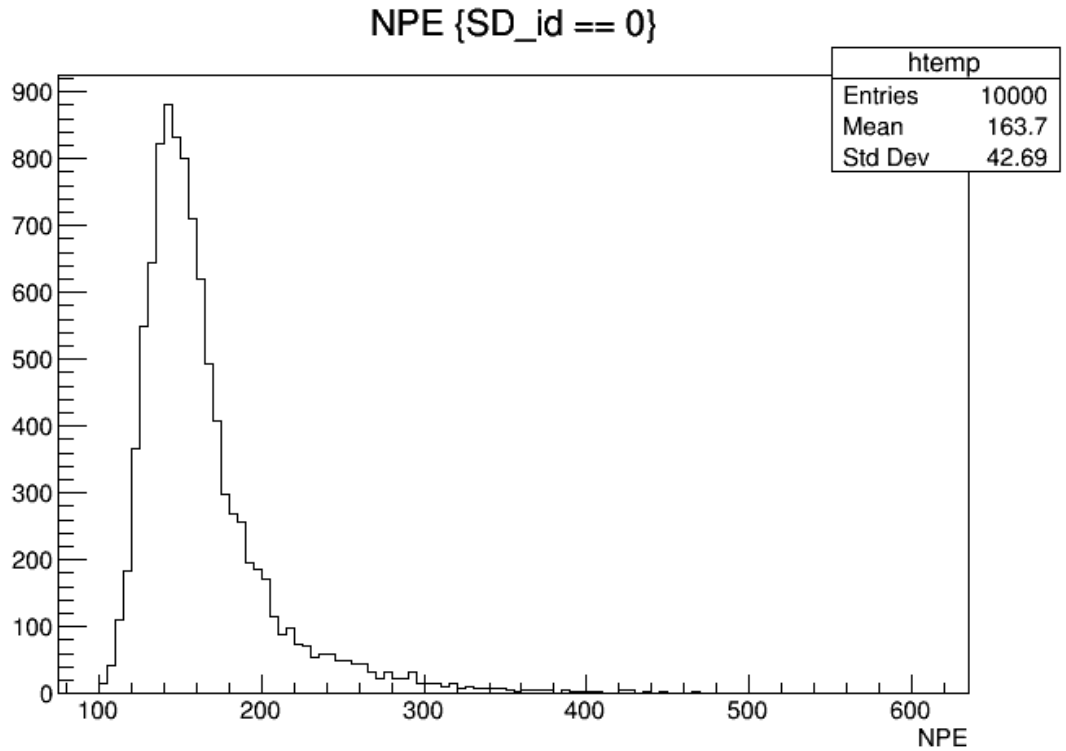
800
600
400
200
0
400
600
800
1000
1200
1400
1600
NP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Entries 10000
Mean 163.7
Std Dev 42.69
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800
700
600
500
400
300
200
100
0
100
200
300
400
500
600
NPE