Status Report

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18 Nov. 2019

KLab meeting

This week

- Made MC of 2.2 MeV gamma-ray with D.R. for n-tagging study
  - Added new trigger algorithm to WCSimWCTrigger.cc

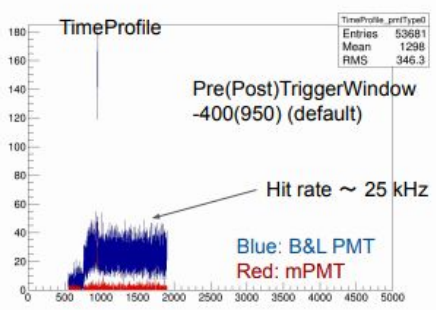
New trigger for WCSim

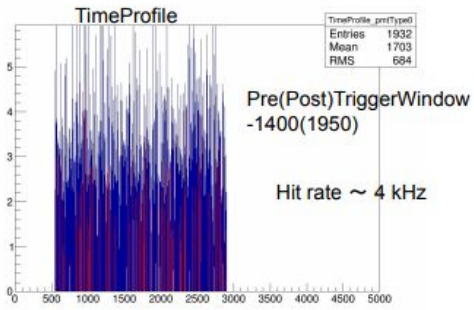
- I showed left plot at last meeting:
  - dark rate (D.R.) was not consistent with 4.2 kHz
  - strange step of D.R.
- → Reason: wrong trigger
  - Default NDigits of WCSim:
    triggers when # of hits in 200ns window > threshold
  - Stat. fluctuation of D.R.
    fired the trigger
- Added new trigger logic for produce MC for n-tagging study
  - Fixed trigger time
  - Only one trigger in the event

Expand timing window

From slide of 8 Nov. 2019 mPMT

- Changed mac file
  - /DAQ/TriggerNDigits/Pre(Post)TriggerWindow: -400(950) → -1400(1950)
  - /DAQ/TriggerSaveFailures/Pre(Post)TriggerWindow: -400(950) → -1400(1950)
  - → PreTriggerWindow does not affected because the D.R. started at 550 ns for both configuration.
  - → And also D.R. became small.
  - Below histograms have 10 events of 2.2 MeV gamma-ray

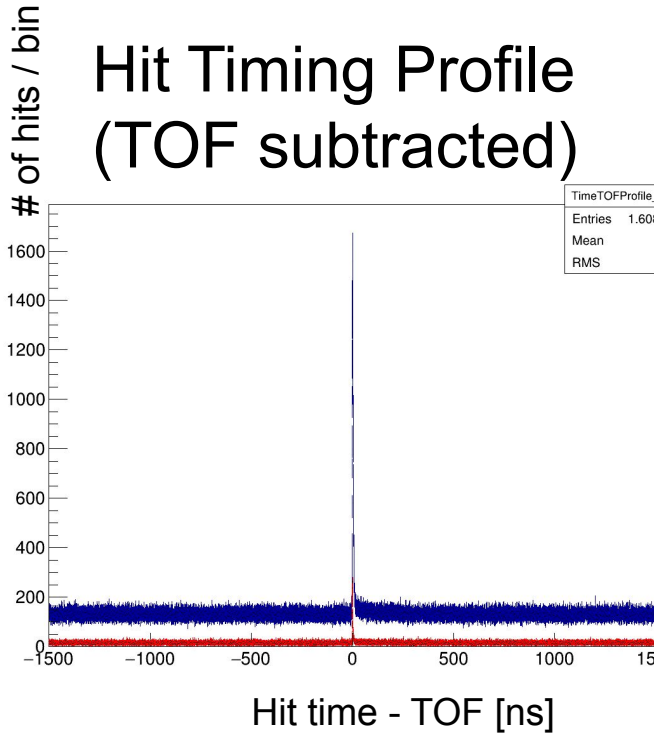


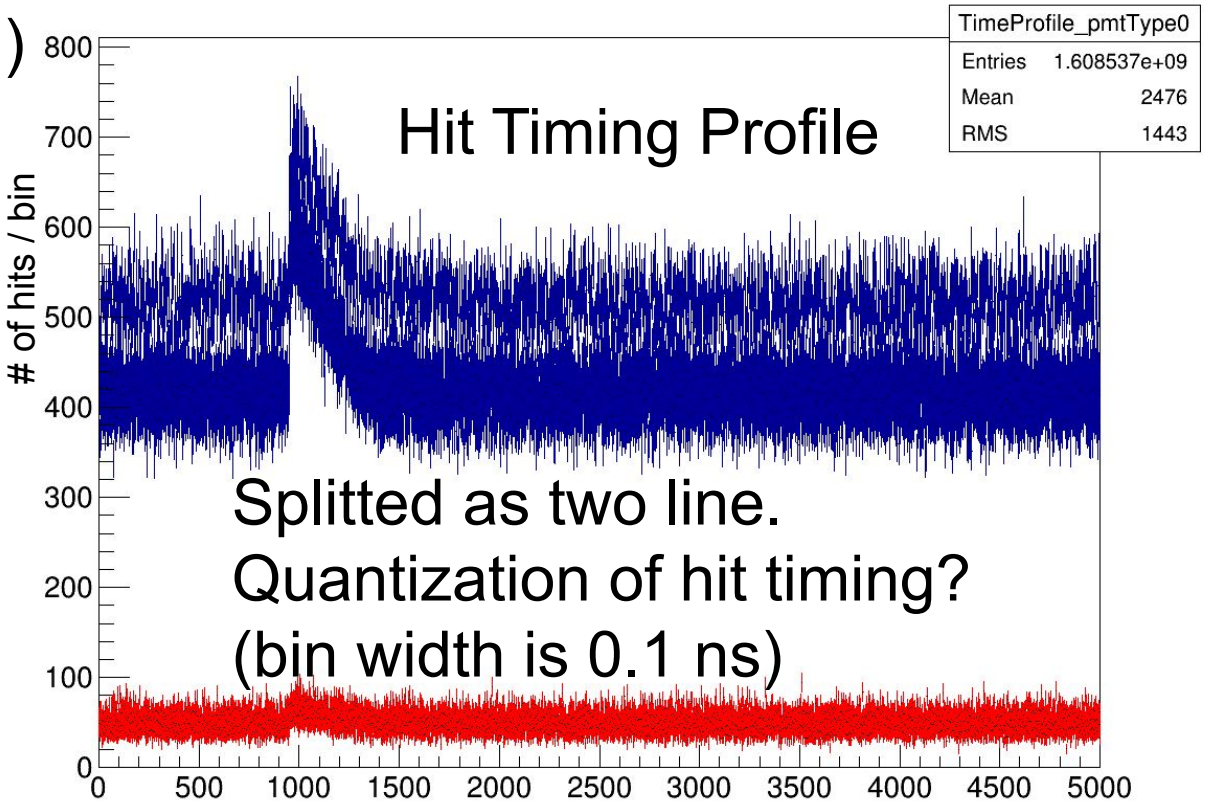


MC production for n-tagging study

- 2.2 MeV gamma-ray: 10,000 events
  - WCSim
  - Uniformly random vertex position and direction
  - D.R. : gamma-rayの±1E6 ns (~5x capture time)
- Peak of right plot came from vertex position (because trigger time is fixed)

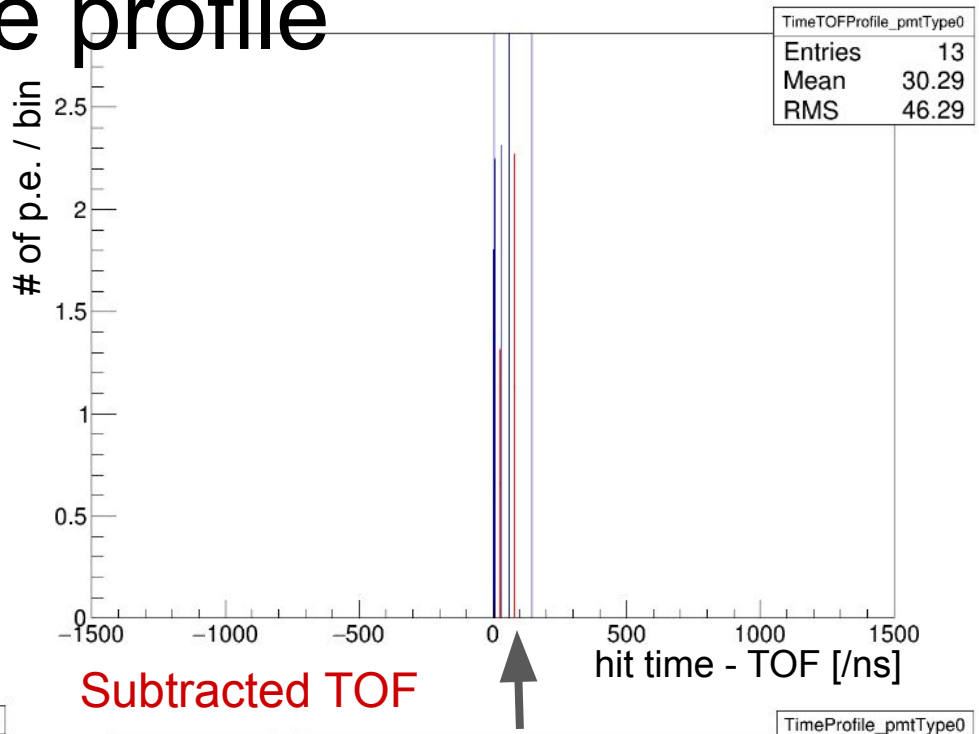
Hit Timing Profile (TOF subtracted)



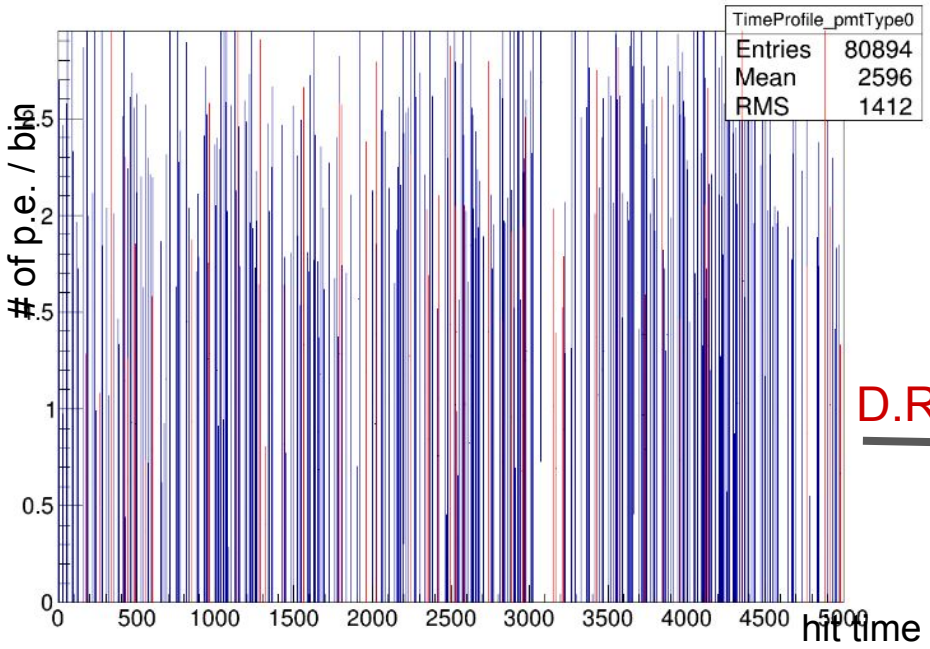


2.2 MeV gamma time profile

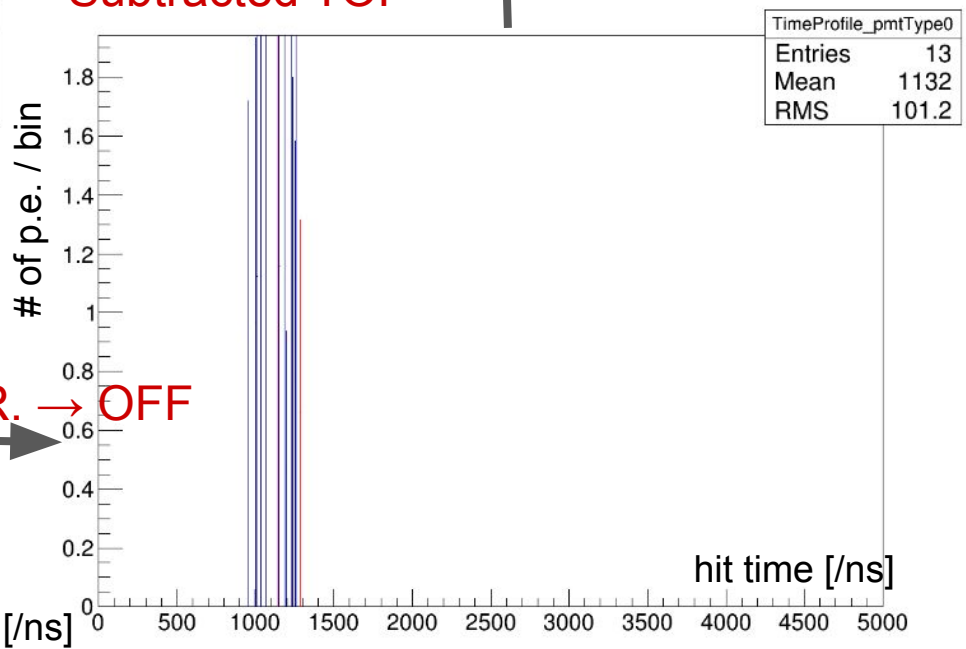
- Only ~ 10 hits
- I cannot find signal hits in left plot



Subtracted TOF



D.R. → OFF



Algorithm of Harada-san

- Try same algorithm in the case of mPMT hybrid

Algorithm

Harada-san's n-tagging study for HK
(Slide of his local meeting)

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- The Algorithm is constructed from 3 parts.

1.Event Pre-selection
→rough selection by using N10 method.

2.Vertex Reconstruction
→reconstruction by using prompt positron position.

3.TMVA Evaluation
→multi variate analysis method is used.

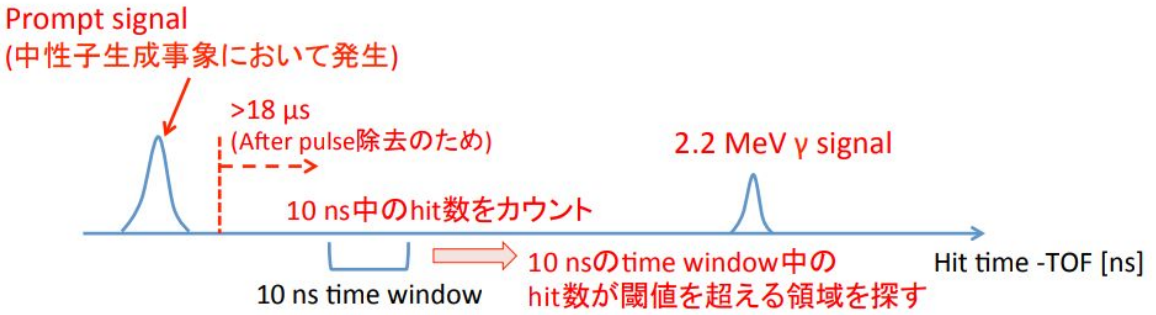
Todo

- Tuning of N10 method:
  - How many hits are expected by the 2.2 MeV signal?
  - How about the time window? 10 ns is valid?
  - How about the threshold of hits for pretrigger ?

[18 us:1000us) → ～ 90 %
[18 us:500us) → ～ 83 %

Slide of Okajima-san, 2016 JPS spring→

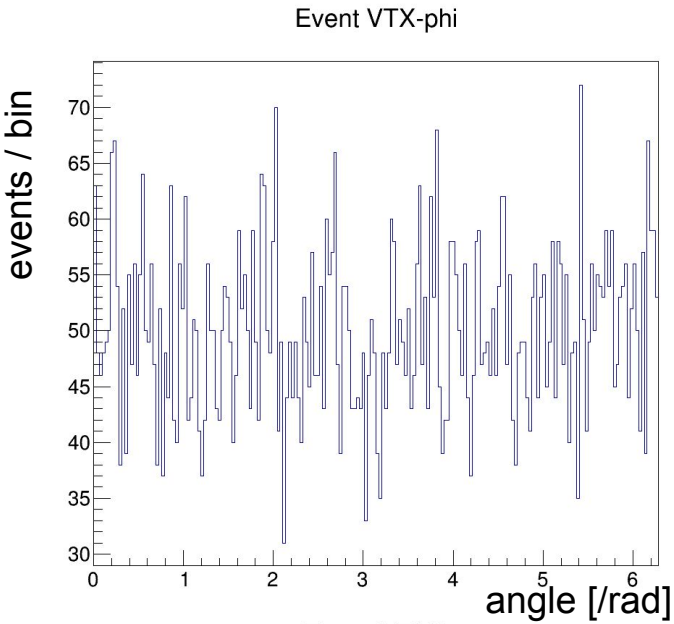
2.2 MeV γの探索

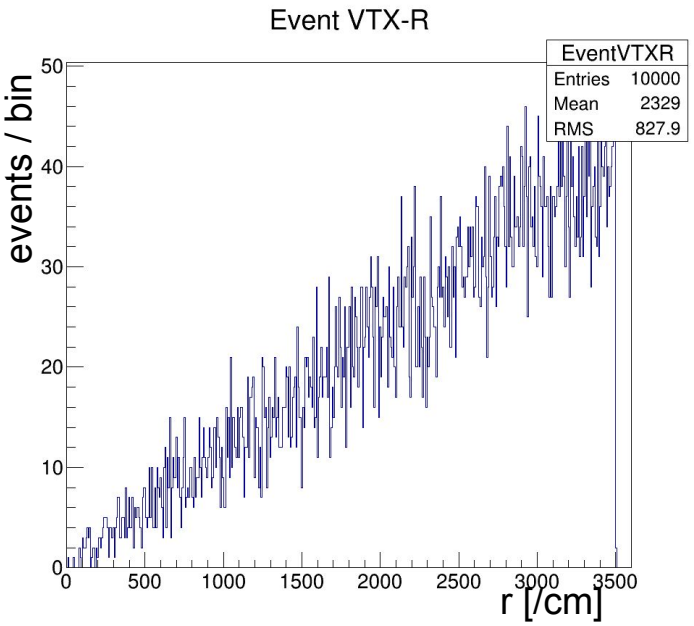


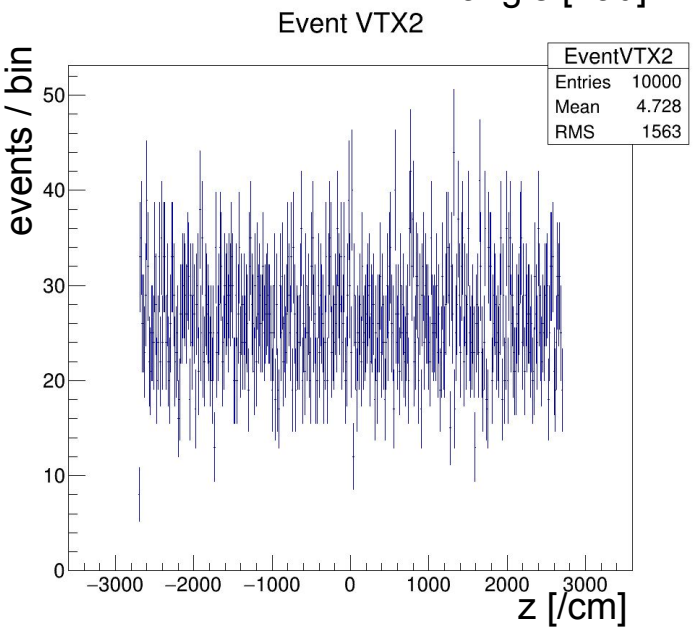
- 各hitについて(信号のhit time) – (time of flight(TOF))を計算し、分布を作成
  - Prompt signal生成から十分に (18 μs) 時間が経過した後のsignalを検出するため、今回の評価ではprompt signalについてはシミュレートしていない
- 10 ns window中のhit数 (N_{10})が閾値を超えた時点を、2.2 MeV γ由来の信号の検出時間候補とする。

2.2 MeV gamma MC w/o D.R.

- HK hybrid option
  - B&L 20 P.C., mPMT 10 P.C.
  - D.R.: B&L 4.2 kHz, mPMT 100 Hz
- 10,000 events
  - Uniform in the tank
  - Isotropy direction

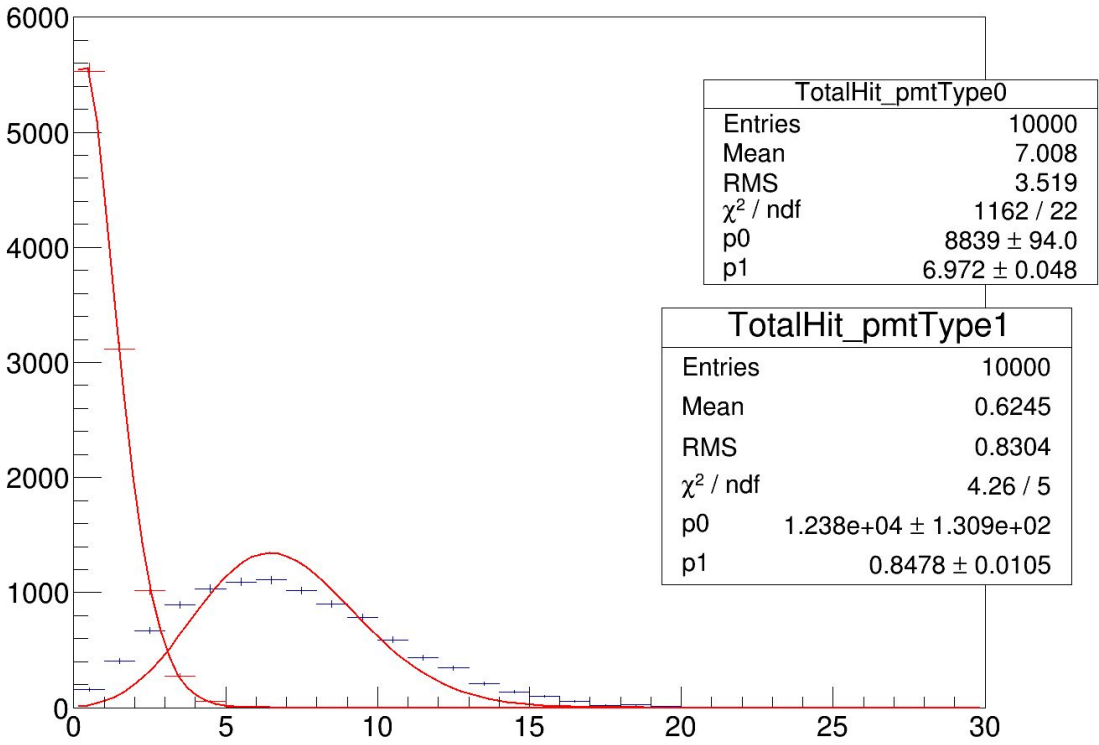






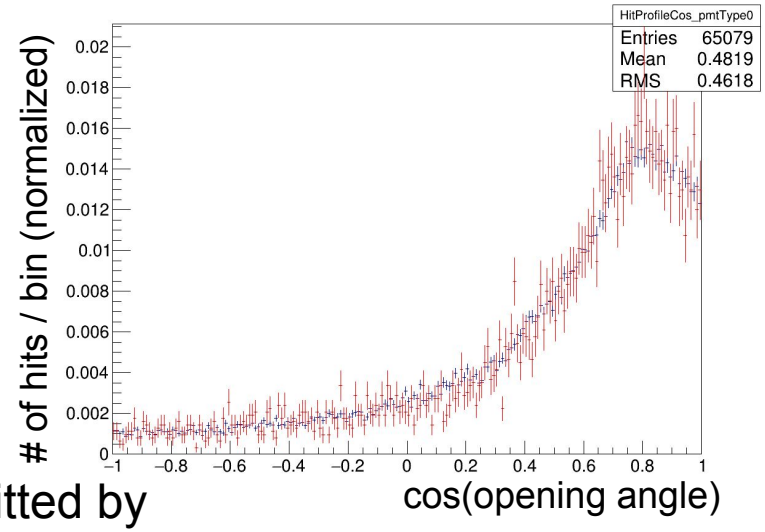
2.2 MeV gamma MC w/o D.R. (cont'd)

- # of hits:
  - B&L: ~ 7
  - mPMT: ~ 1 (6000 events have no hits of mPMT)
  - Linear dependency of P.C. → more mPMT is better
  - If 3k mPMT case, # of hits is expected ~0.3 p.e.
    → I think there will be little effect of mPMT to n-tagging performance

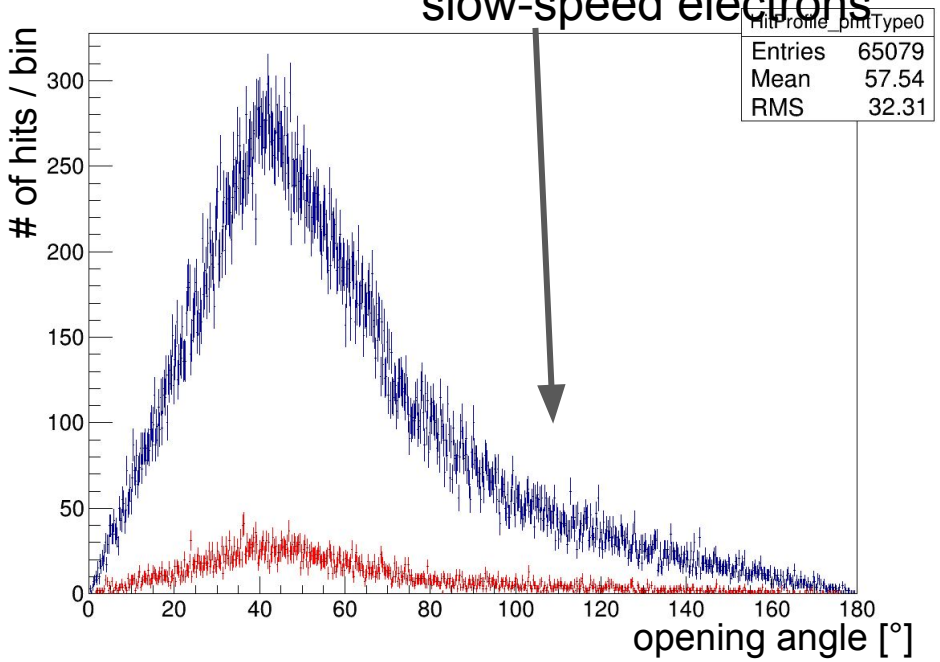


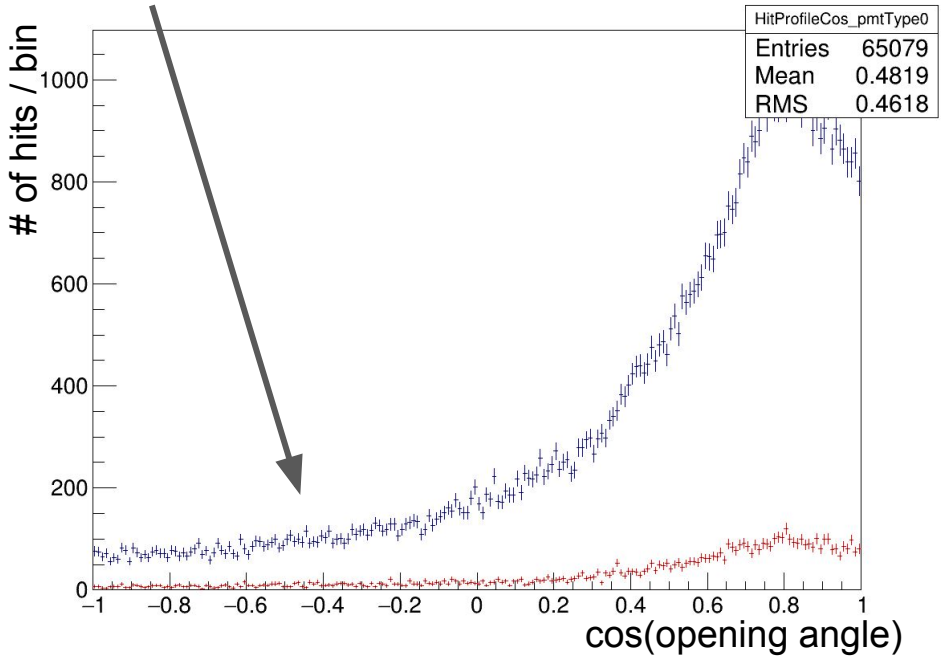
2.2 MeV gamma MC w/o D.R. (cont'd)

- PMT hit distributions
  - mPMT and B&L distributions are same



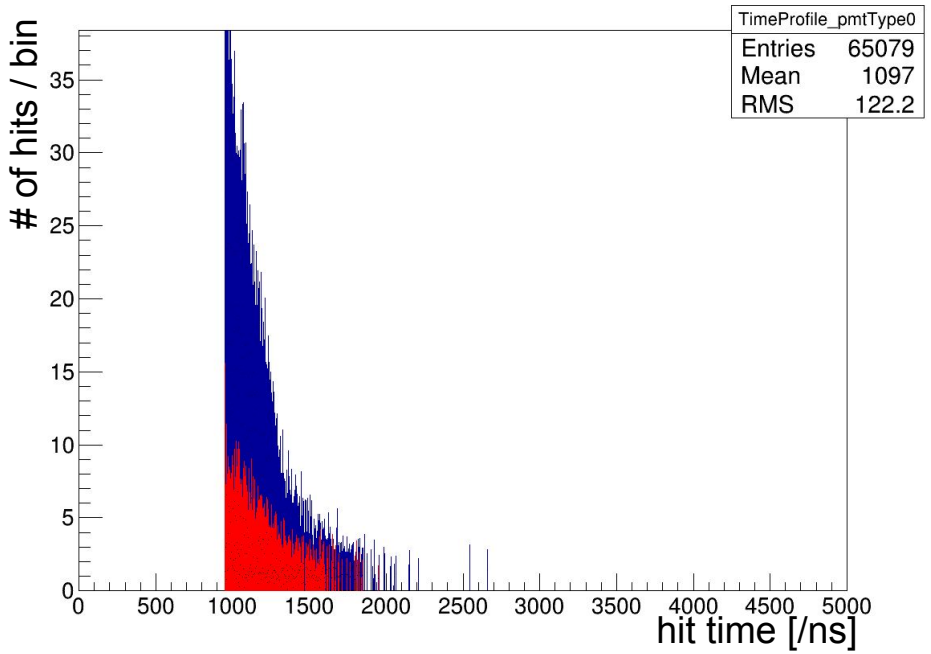
Scattered photons or photons emitted by slow-speed electrons

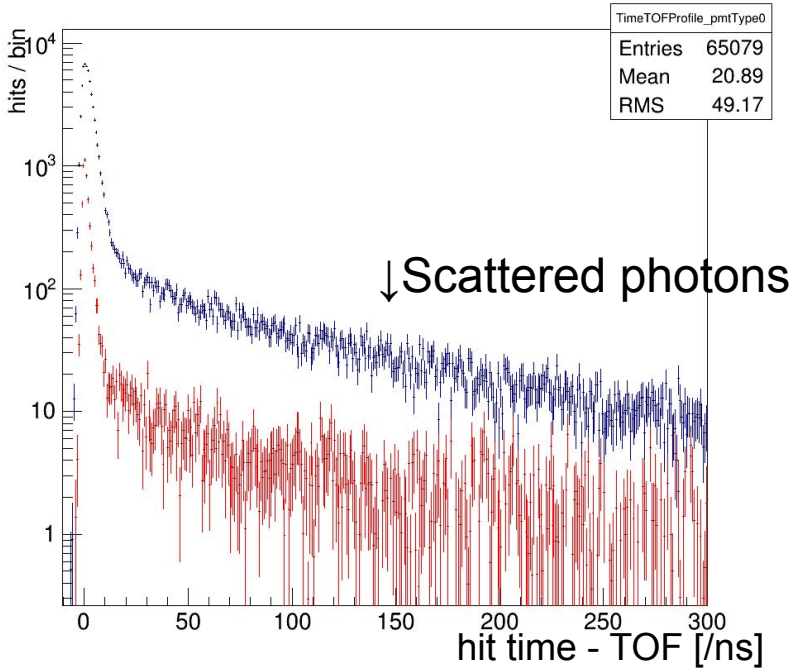




2.2 MeV gamma MC w/o D.R. (cont'd)

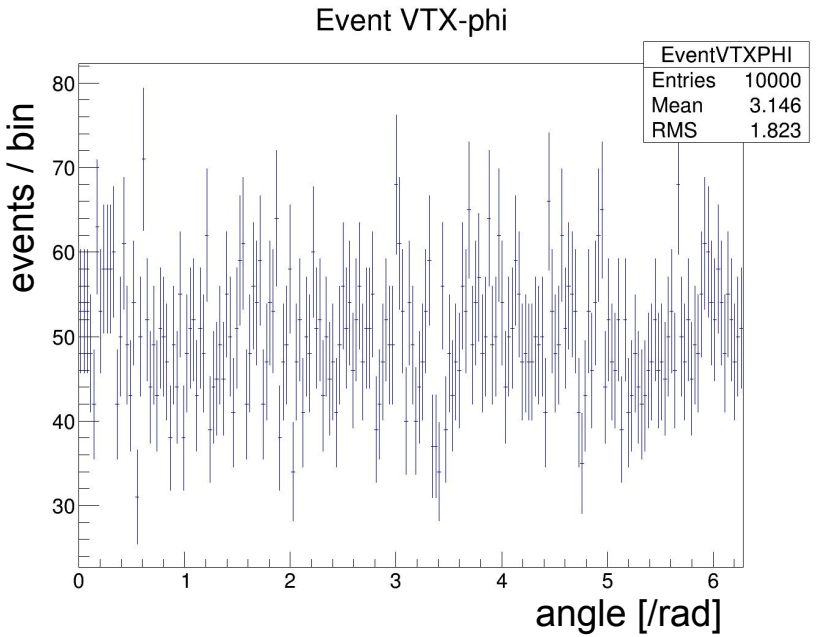
- Timing profiles
  - Left: not TOF subtracted
    - Including information of vertex dist. in shoulder of dist. shaoe
  - Right: TOF subtracted
    - Reflects features of Cherenkov photons
      - Scatter, shower particles (PMT timing res.)

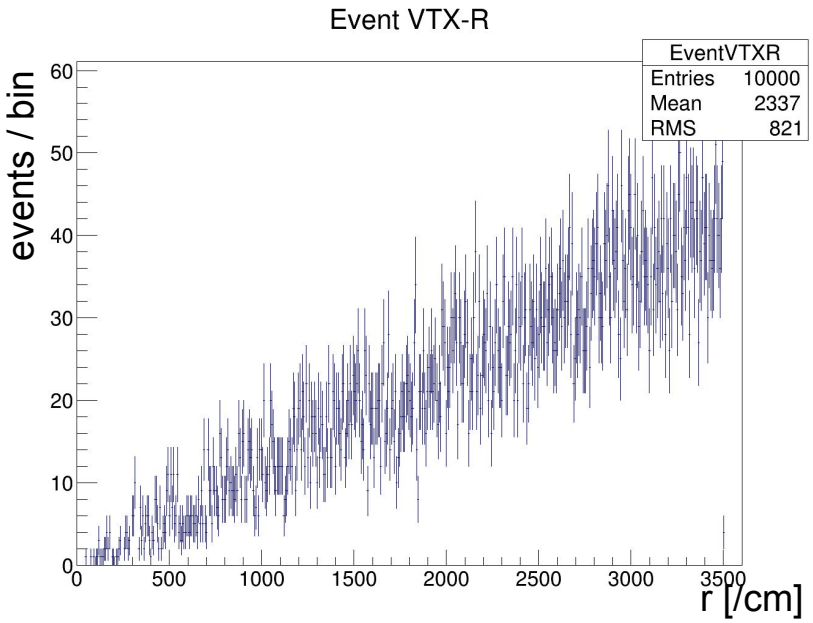


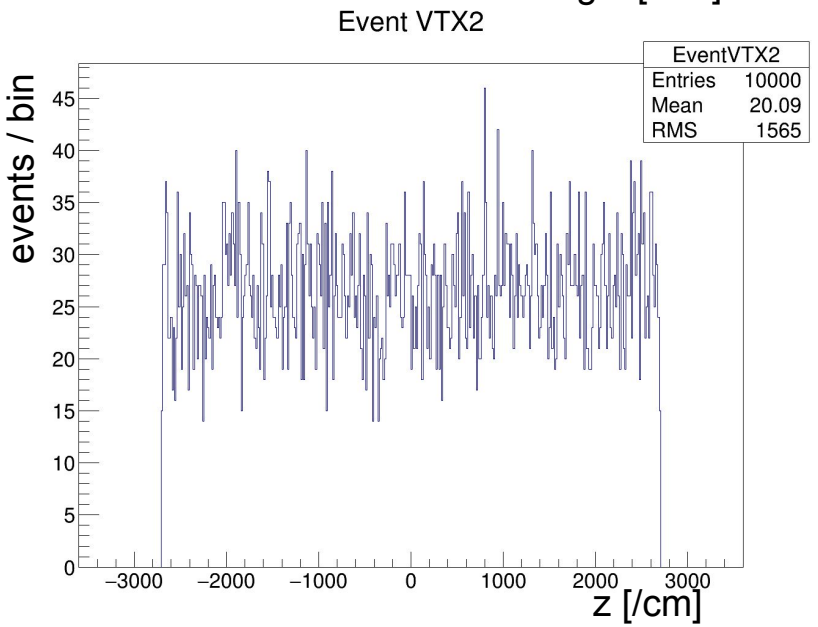


2.2 MeV gamma MC w/ D.R.

- Added D.R. with time window
  ~ 2,000,000 ns
  (10 x capture time)







2.2 MeV gamma MC w/ D.R. (cont'd)

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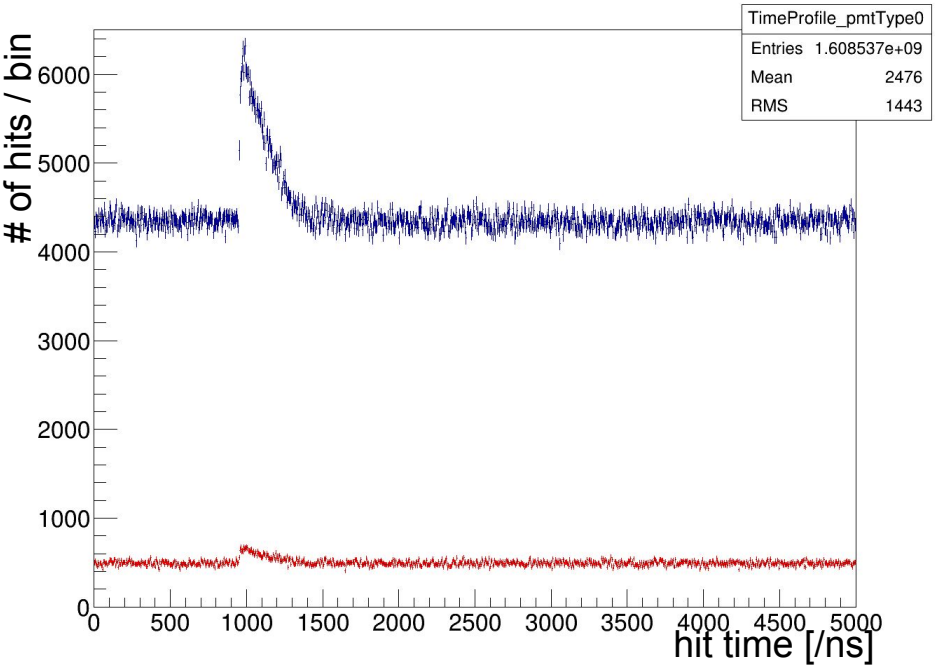
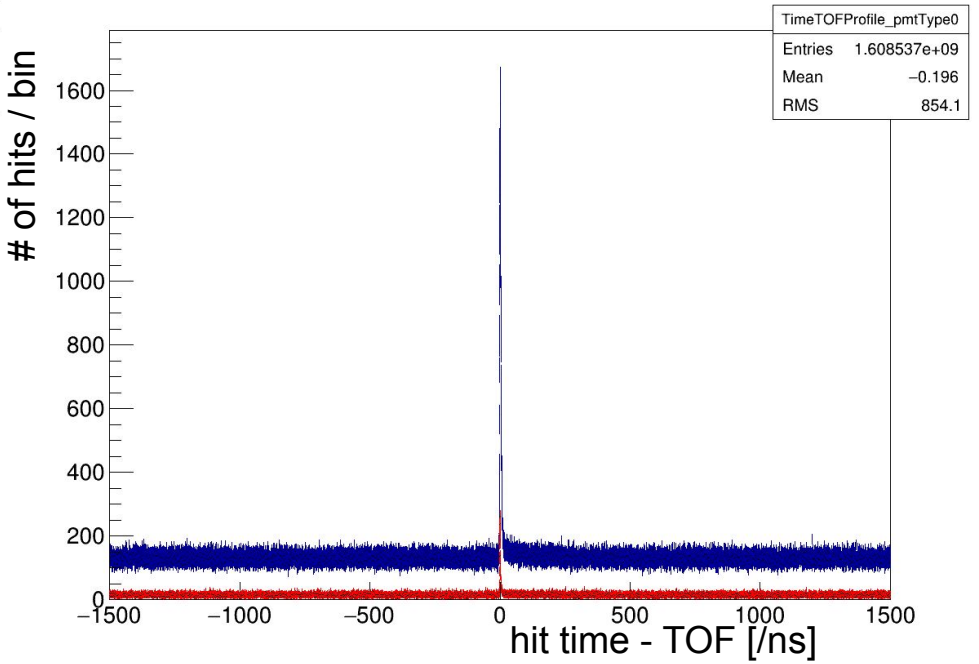
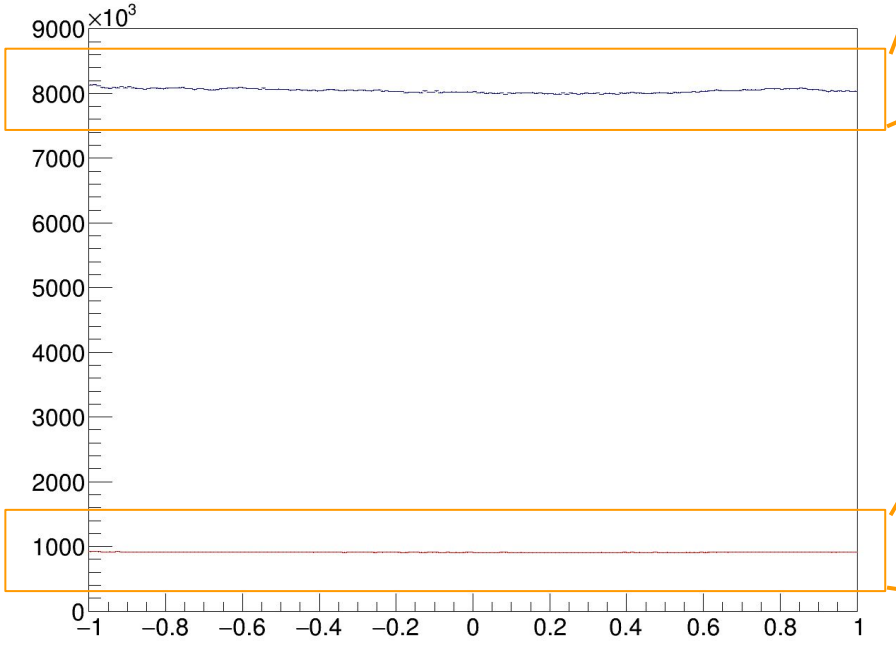
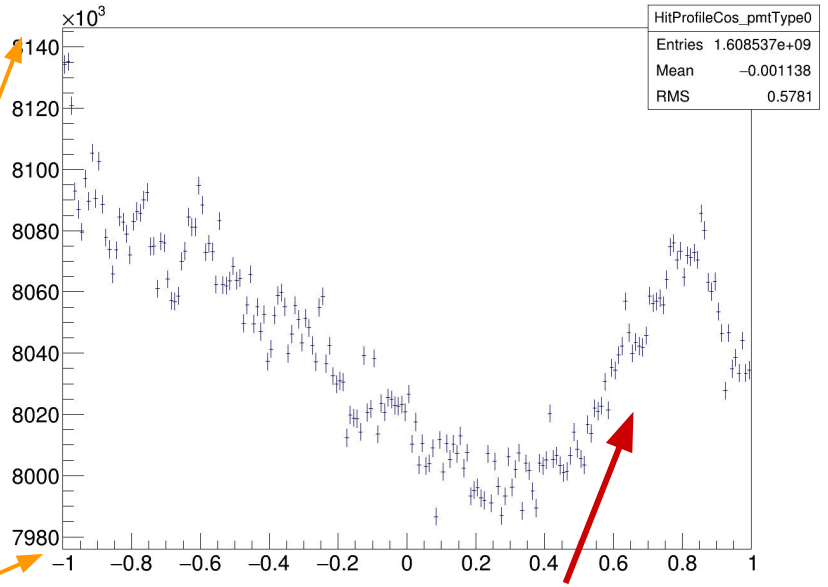




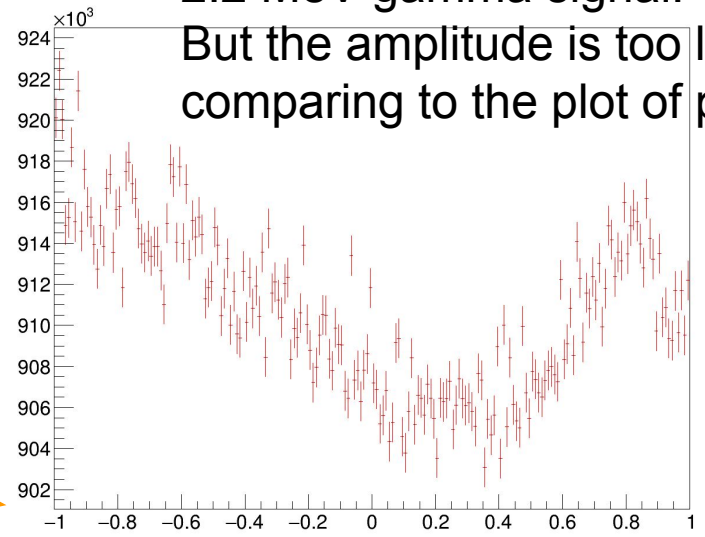
2.2 MeV gamma MC w/ D.R. (cont'd)

- Non isotropic D.R.
- → PMT distribution?





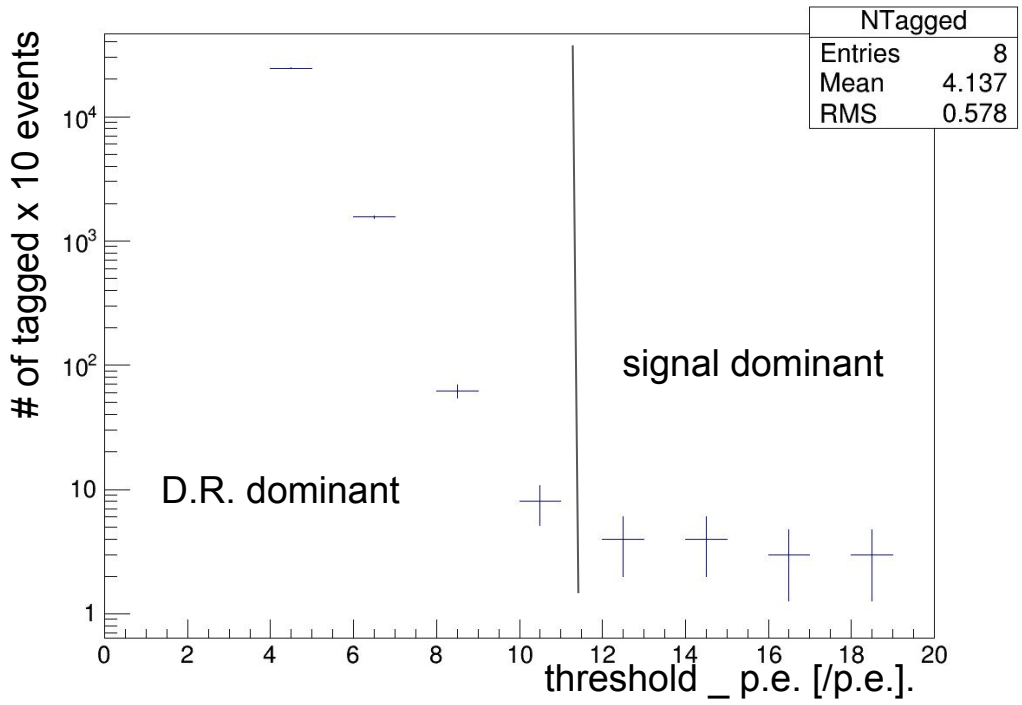
2.2 MeV gamma signal.
But the amplitude is too large comparing to the plot of p.10



Plan

- Check timing scale of 2.2 MeV gamma signal
- → Determine N10 timing window (whether or not 10 ns is good for mPMT hybrid case)

# of tagged candidate with N10 method (preliminary)

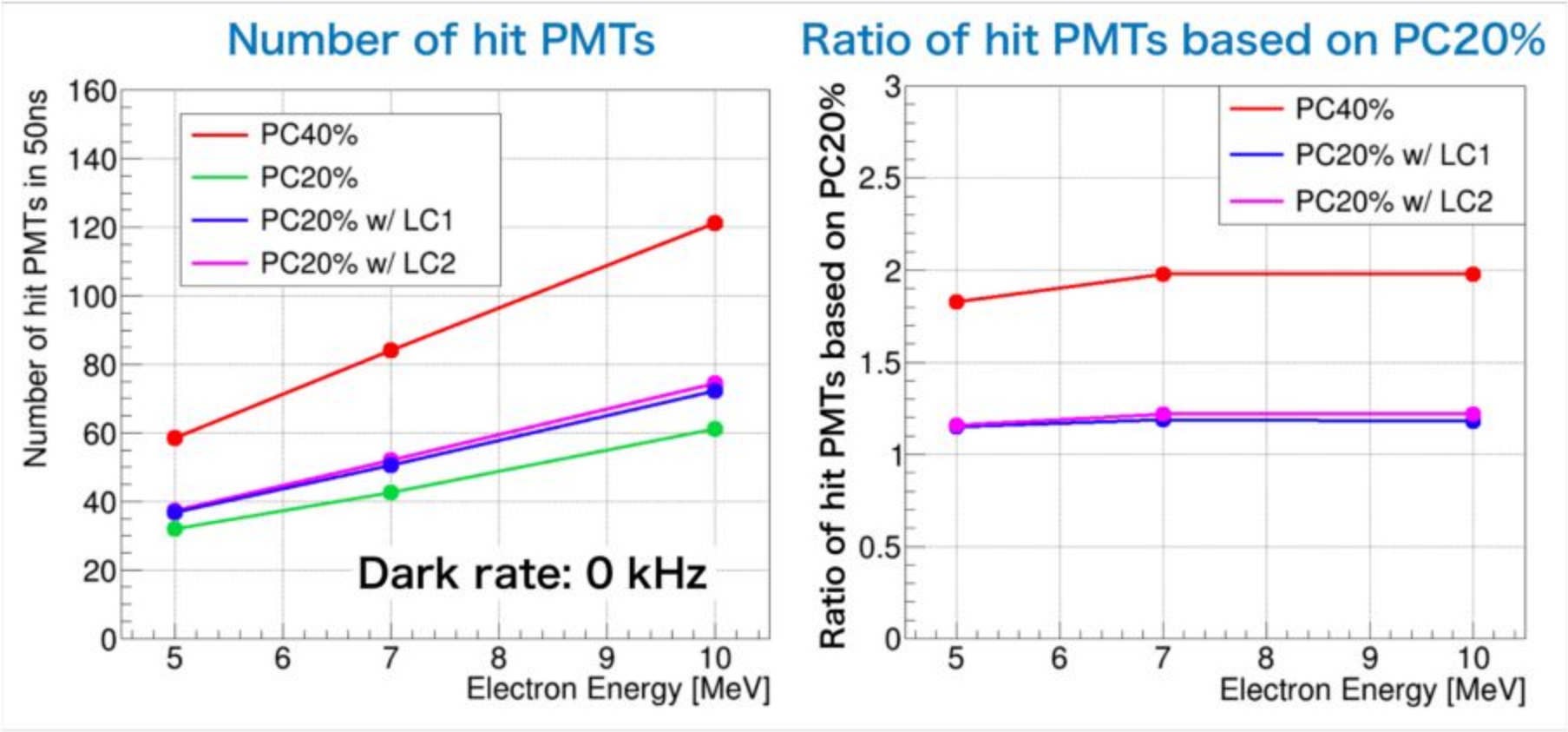


threshold = 10 p.e. case（preliminary)
# of candidate of N10 method is shown↓

```
FirePreTrigger: Result: # of pretrigger = 3
FirePreTrigger: Result: # of pretrigger = 1
FirePreTrigger: Result: # of pretrigger = 3
FirePreTrigger: Result: # of pretrigger = 2
FirePreTrigger: Result: # of pretrigger = 2
FirePreTrigger: Result: # of pretrigger = 6
FirePreTrigger: Result: # of pretrigger = 3
FirePreTrigger: Result: # of pretrigger = 4
FirePreTrigger: Result: # of pretrigger = 1
FirePreTrigger: Result: # of pretrigger = 2
FirePreTrigger: Result: # of pretrigger = 3
FirePreTrigger: Result: # of pretrigger = 3
FirePreTrigger: Result: # of pretrigger = 1
FirePreTrigger: Result: # of pretrigger = 3
FirePreTrigger: Result: # of pretrigger = 1
FirePreTrigger: Result: # of pretrigger = 2
FirePreTrigger: Result: # of pretrigger = 0
FirePreTrigger: Result: # of pretrigger = 1
:
```

Number of hit PMTs

From Shinoki-san



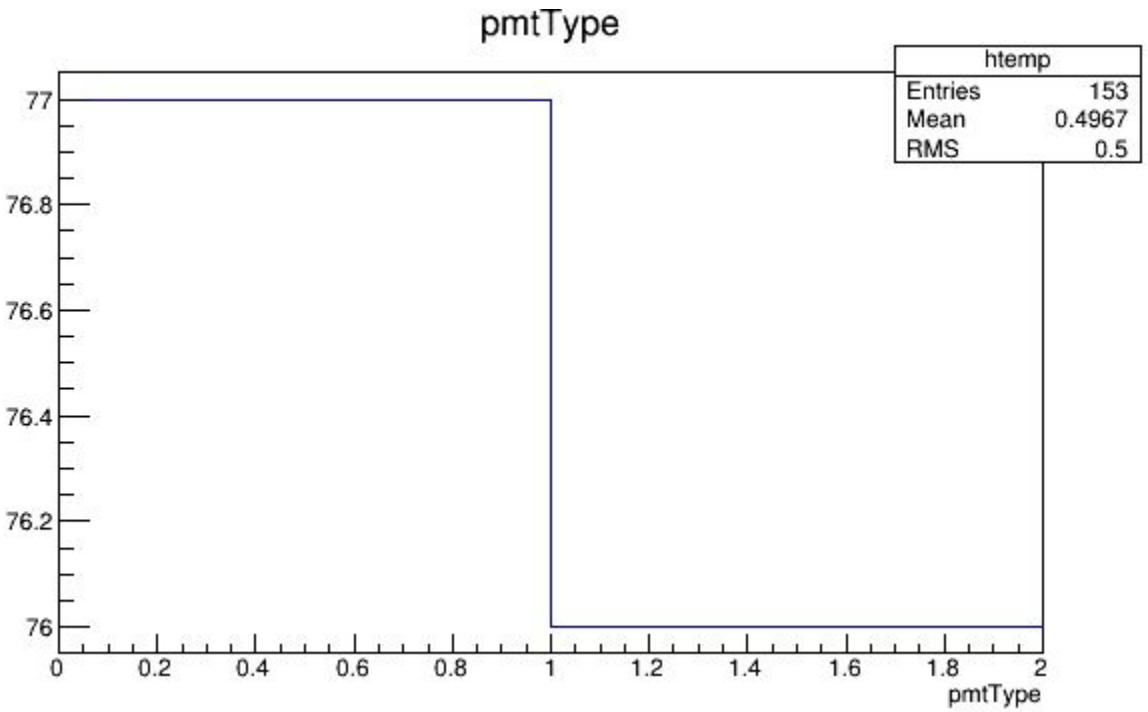
- HK PMT with LC can collect ~20% more photons

Ishitsuka-san's slide for LC
(Slide of HK 8th Proto-collab. meeting)

B&L 20 P.C. + mPMT 10 P.C. case
→ effective P.C. ~ 24 P.C.

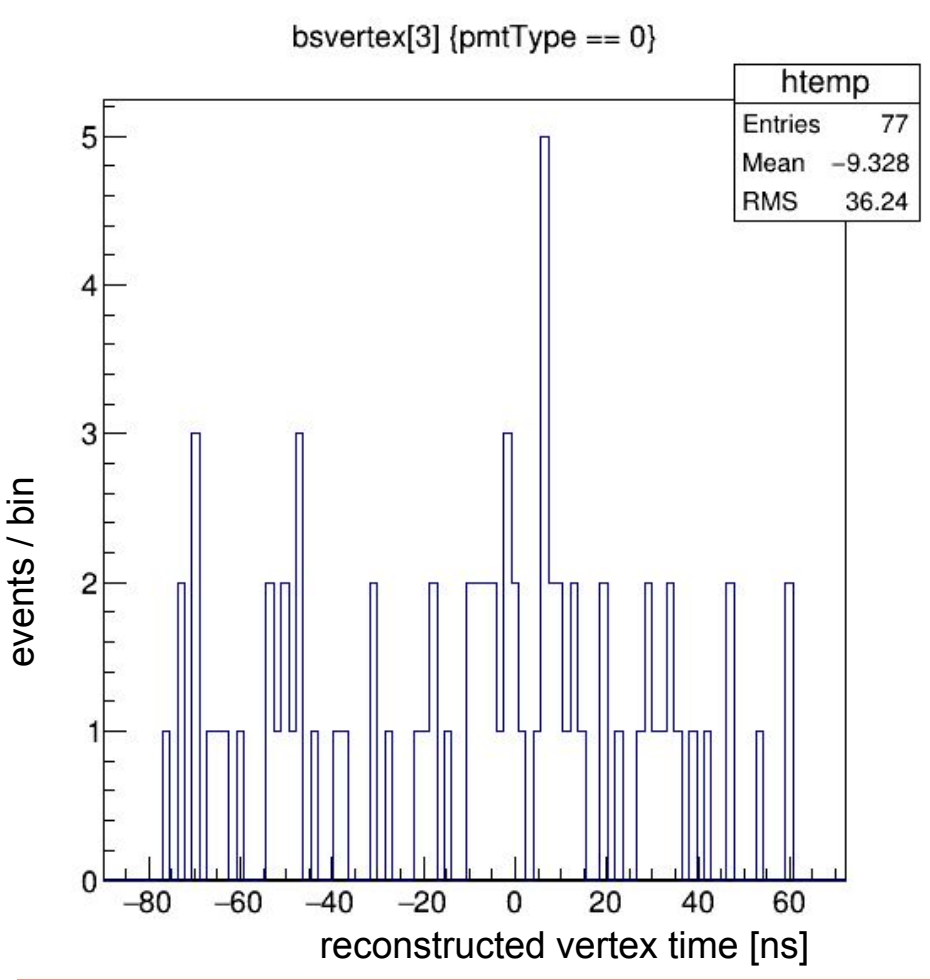
2.2 MeV gamma with FitVertexLE

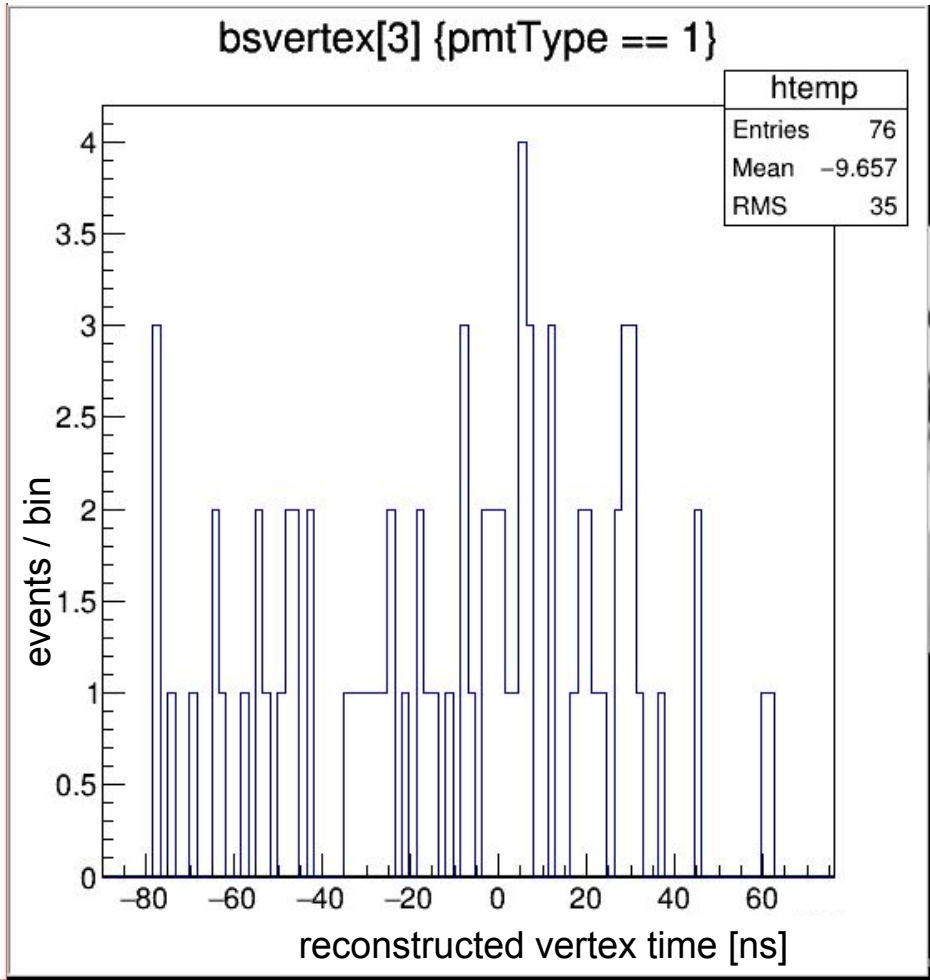
- Tried the reconstruction of 2.2 MeV gamma with FitVertexLE
  - 100 events are put into FitVertexLE (fitting take 11 min / events)
  - D.R. is generated in the time window whose width is 1e6 ns (capture time is not included)
  - → # of reconstructed events: 77 (w/o mPMT), 76 (w/ mPMT)



2.2 MeV gamma with FitVertexLE (cont'd)

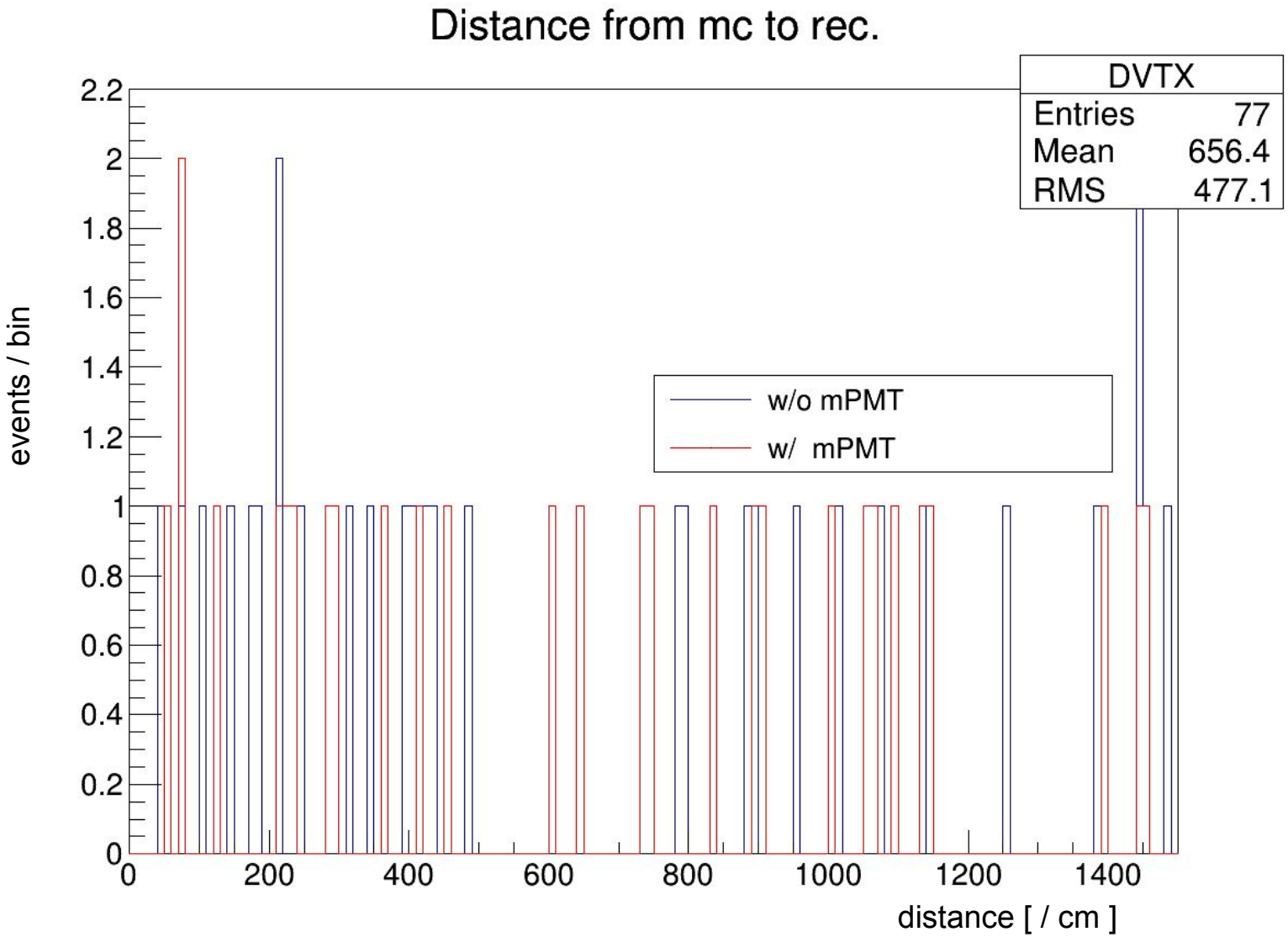
- Reconstructed timing distribution of 2.2 MeV gamma
-





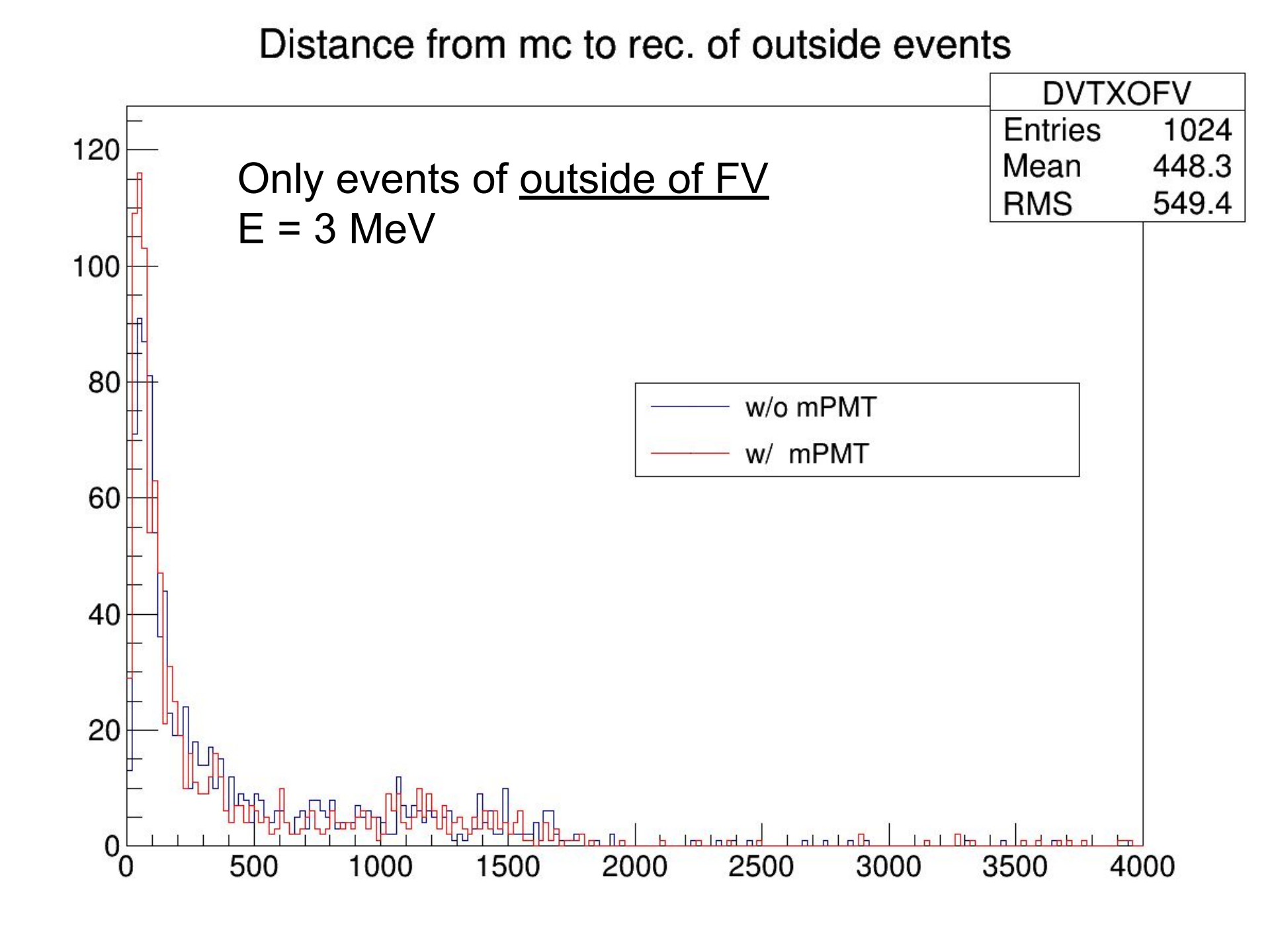
2.2 MeV gamma with FitVertexLE (cont'd)

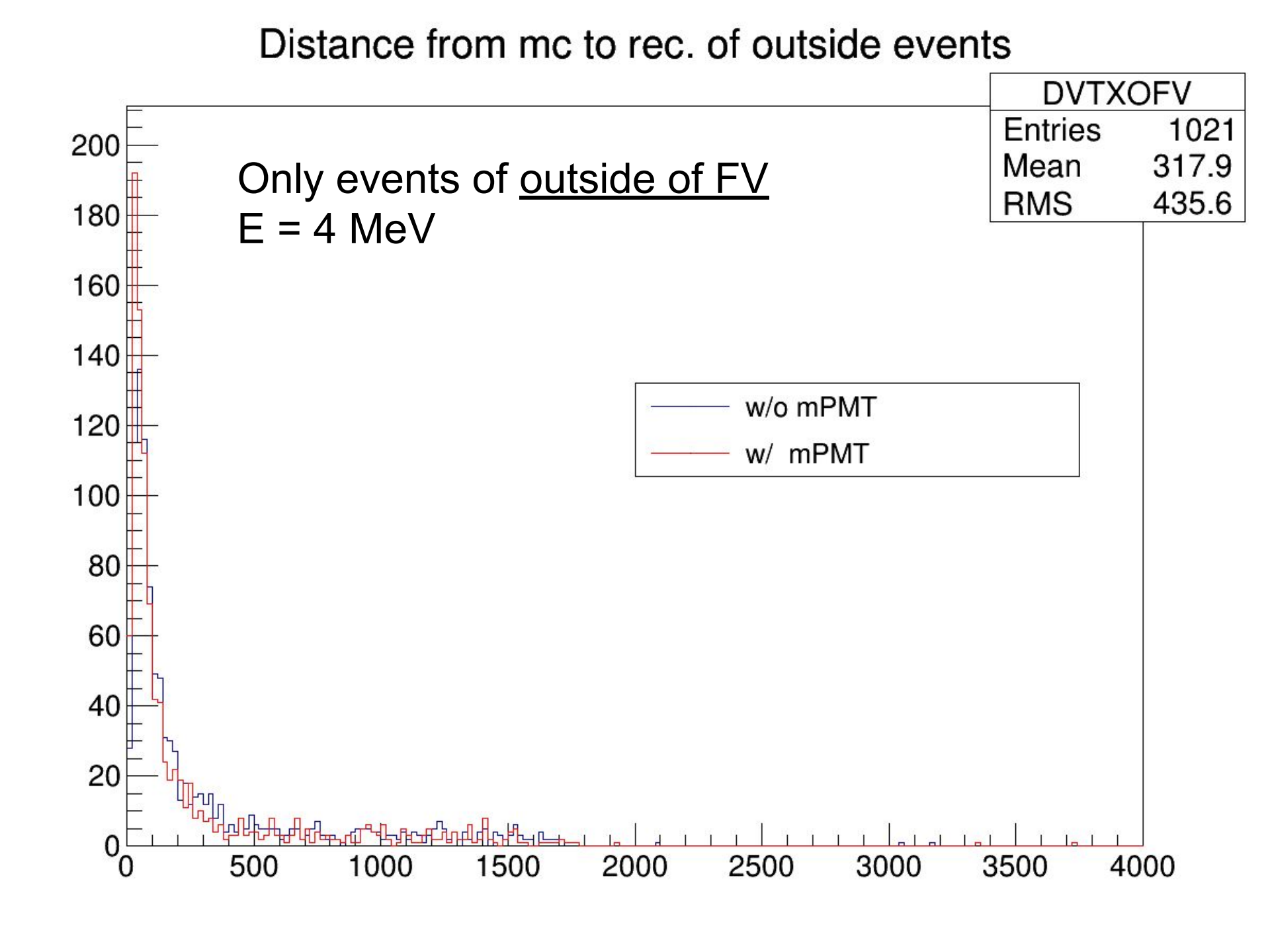
- Failed to find vertex position ? (need more stat.)

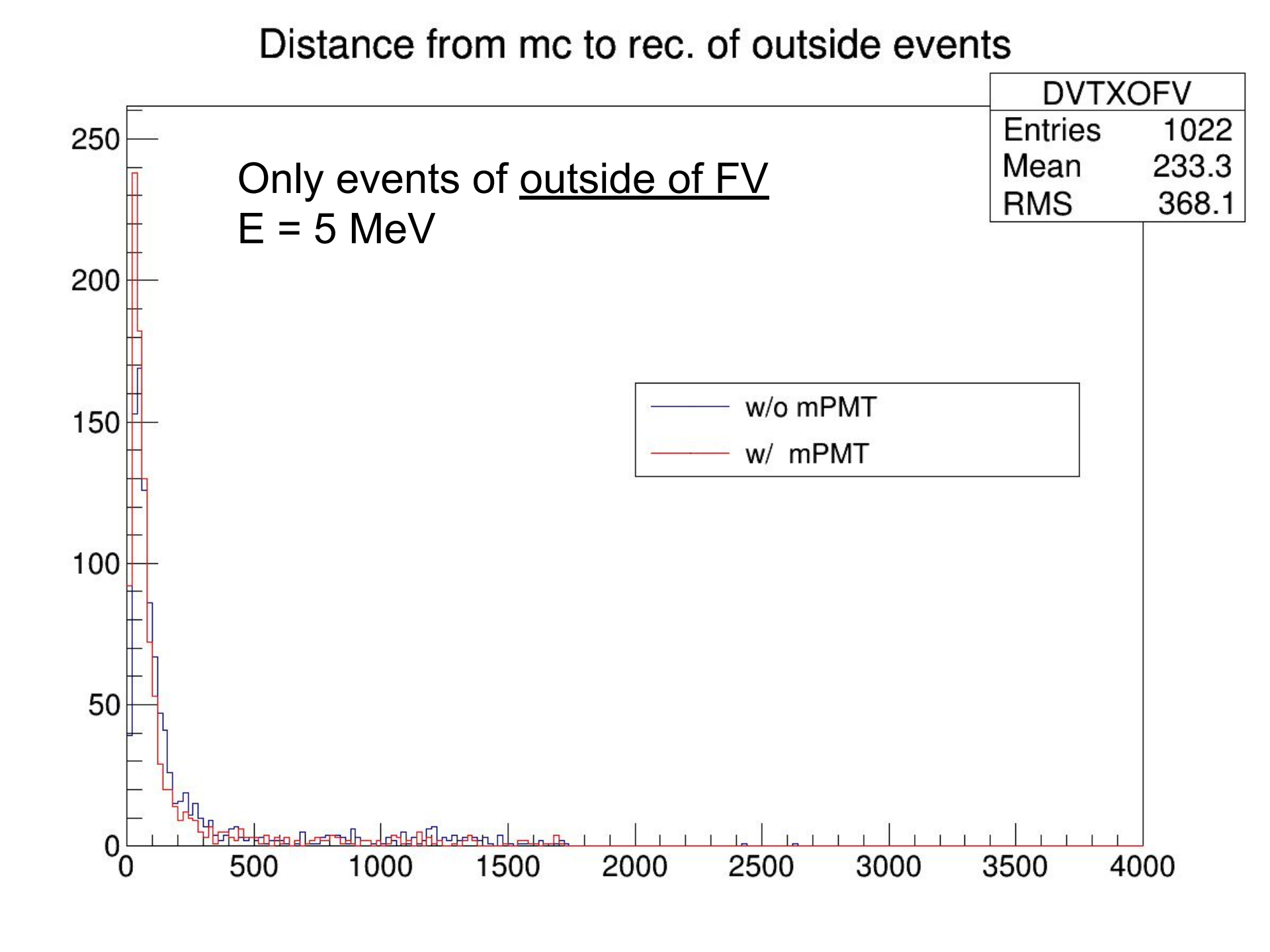


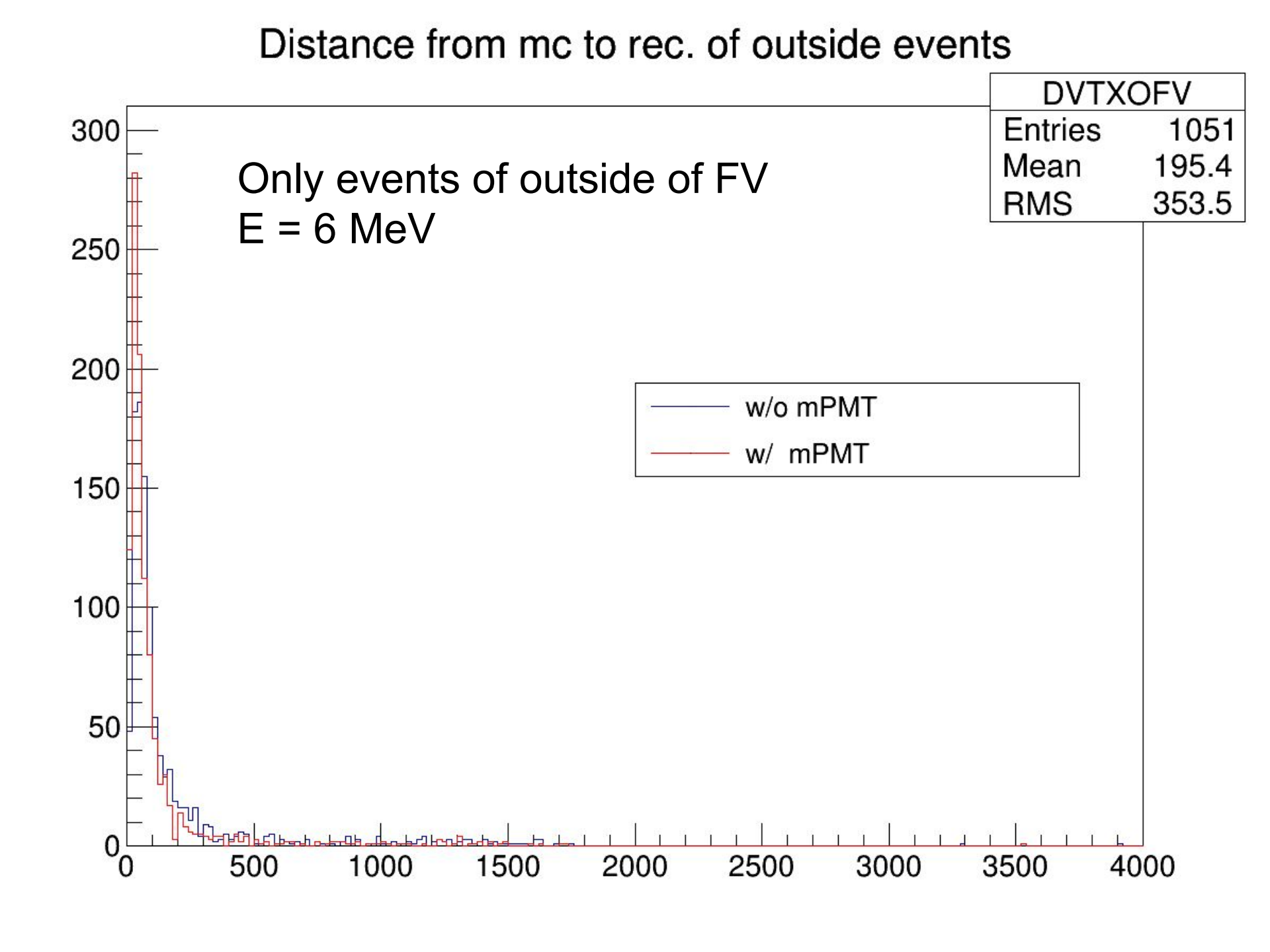
Event leakage

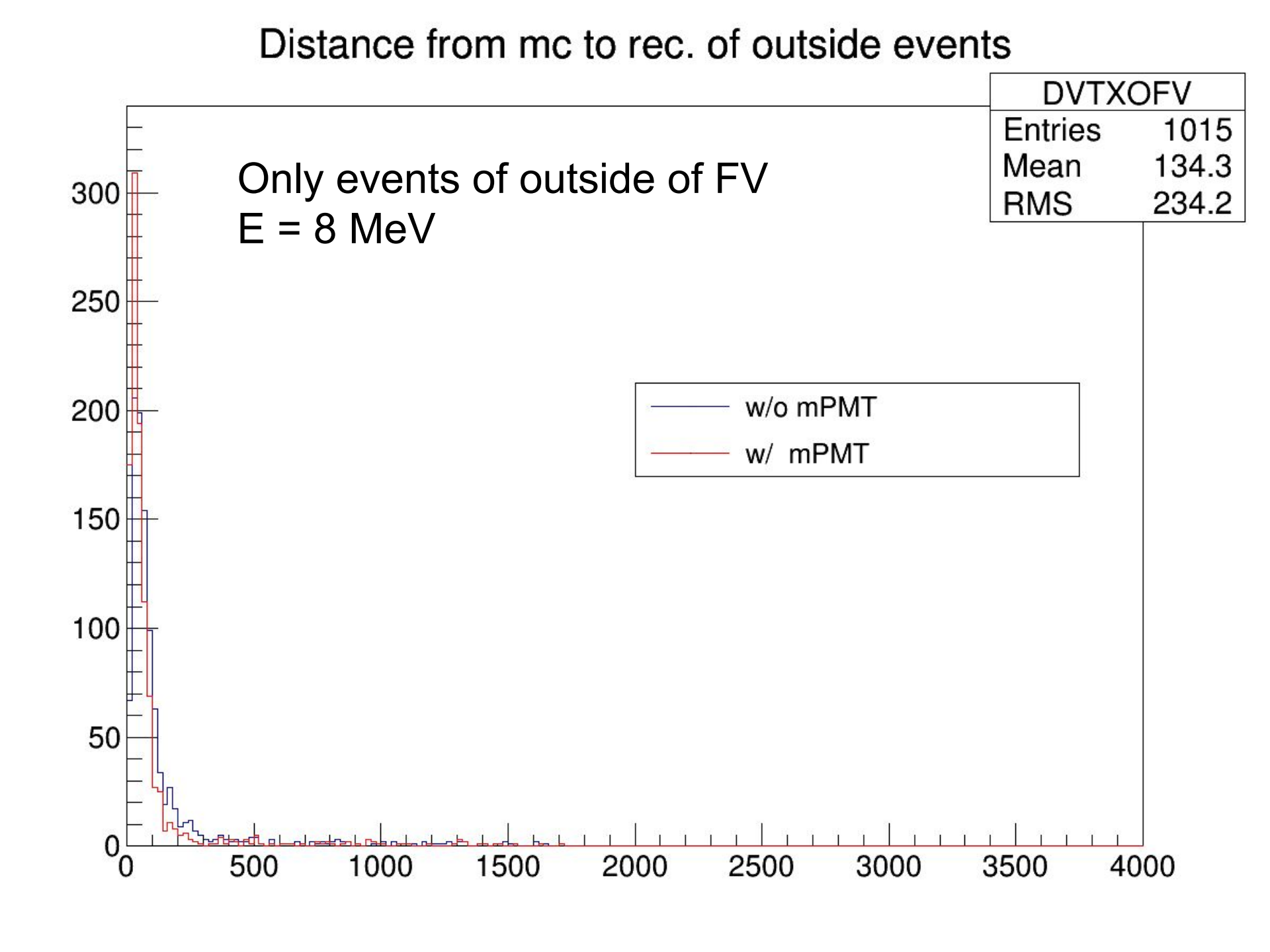
Made new type of plots

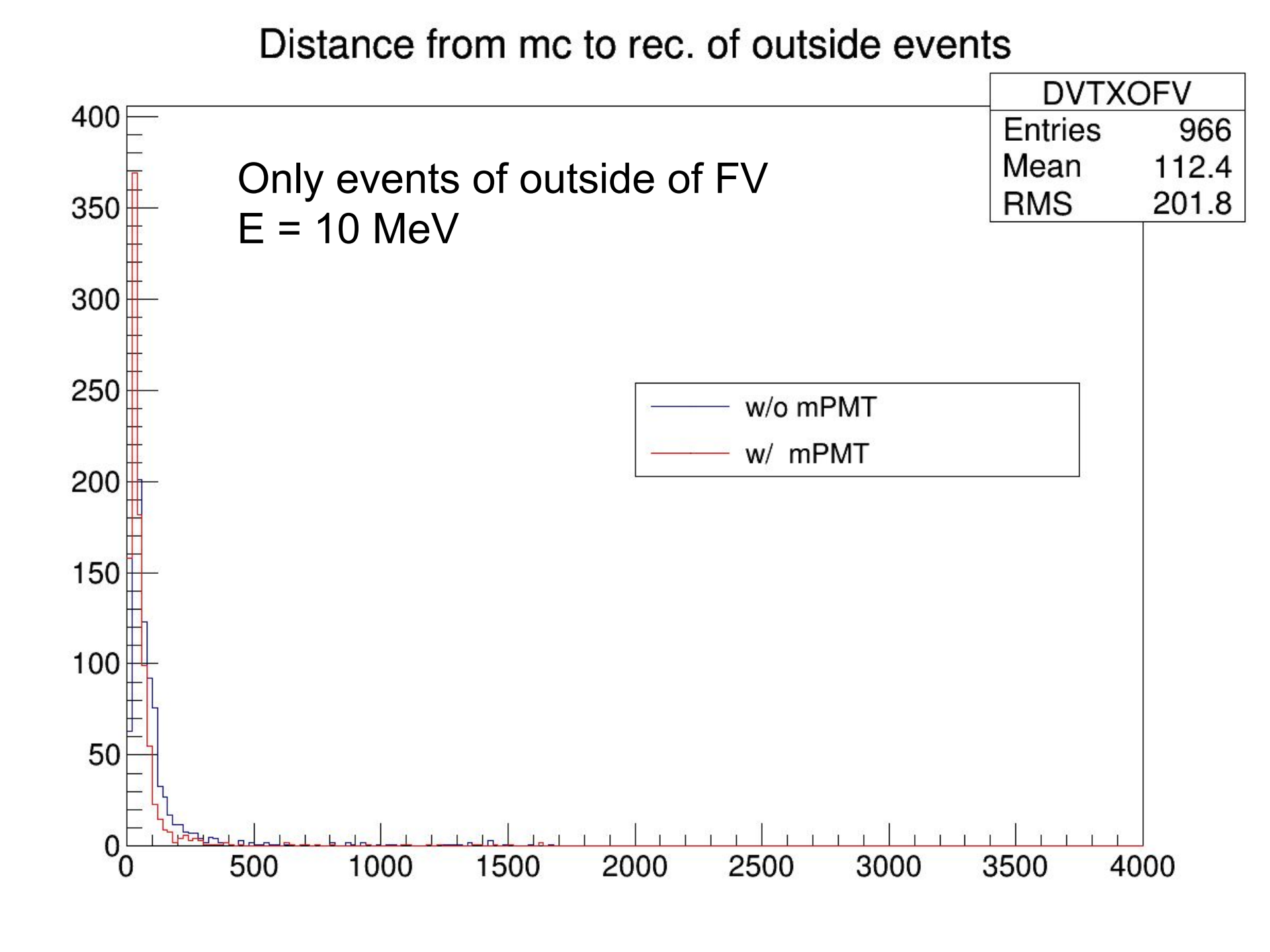

Distance from mc to rec. of outside events
DVTXOFV
Entries 1024
Mean 448.3
RMS 549.4
Only events of outside of FV
E = 3 MeV
w/o mPMT
w/ mPMT
0
20
40
60
80
100
120
0
500
1000
1500
2000
2500
3000
3500
4000

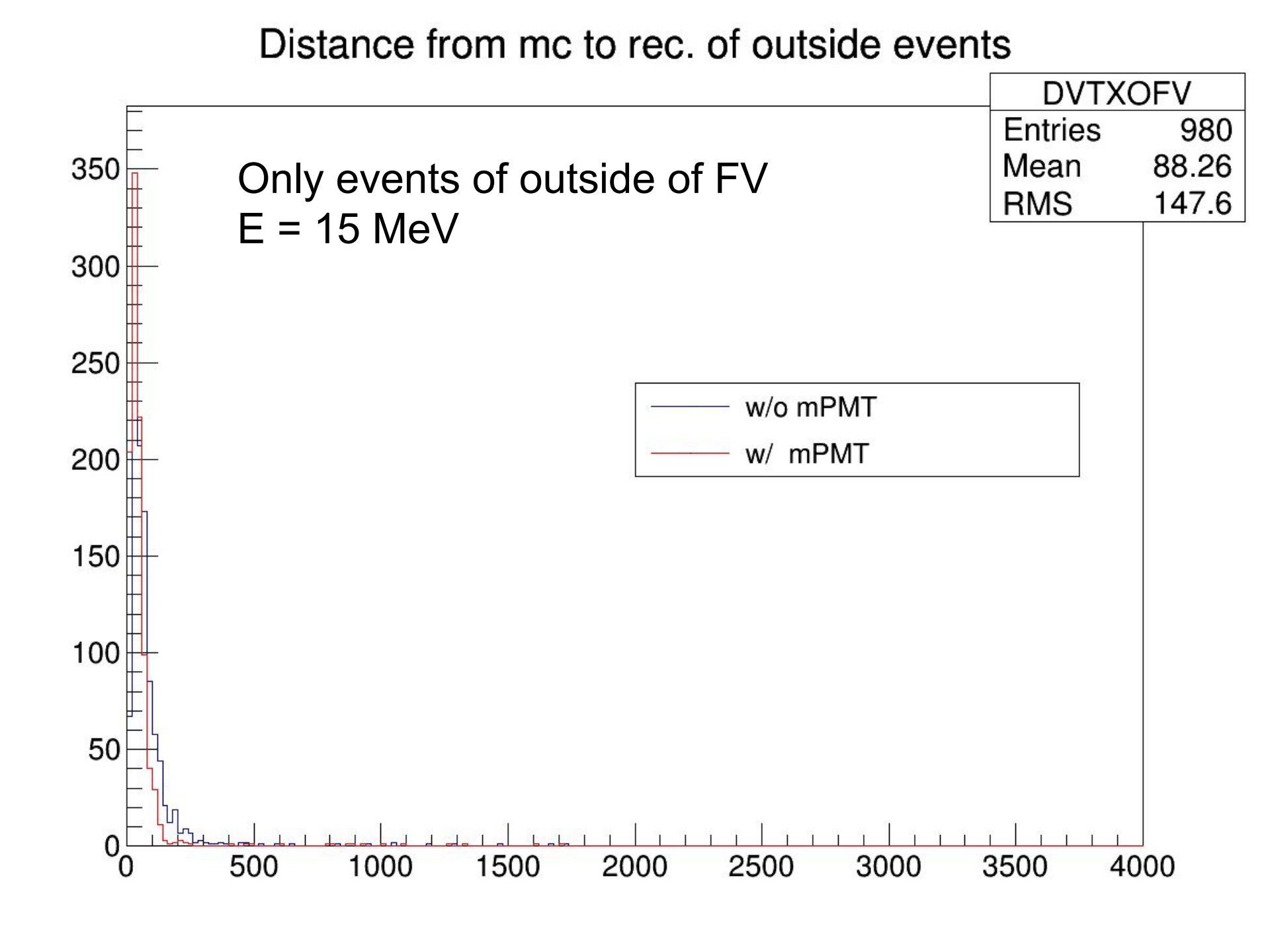

Distance from mc to rec. of outside events
DVTXOFV
Entries 1021
Mean 317.9
RMS 435.6
Only events of outside of FV
E = 4 MeV
w/o mPMT
w/ mPMT
0
20
40
60
80
100
120
140
160
180
200
0
500
1000
1500
2000
2500
3000
3500
4000


Distance from mc to rec. of outside events
DVTXOFV
Entries 1022
Mean 233.3
RMS 368.1
Only events of outside of FV
E = 5 MeV
w/o mPMT
w/ mPMT
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000


Distance from mc to rec. of outside events
DVTXOFV
Entries 1051
Mean 195.4
RMS 353.5
Only events of outside of FV
E = 6 MeV
w/o mPMT
w/ mPMT
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000


Distance from mc to rec. of outside events
DVTXOFV
Entries 1015
Mean 134.3
RMS 234.2
Only events of outside of FV
E = 8 MeV
w/o mPMT
w/ mPMT
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000


Distance from mc to rec. of outside events
DVTXOFV
Entries 966
Mean 112.4
RMS 201.8
Only events of outside of FV
E = 10 MeV
w/o mPMT
w/ mPMT
400
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000

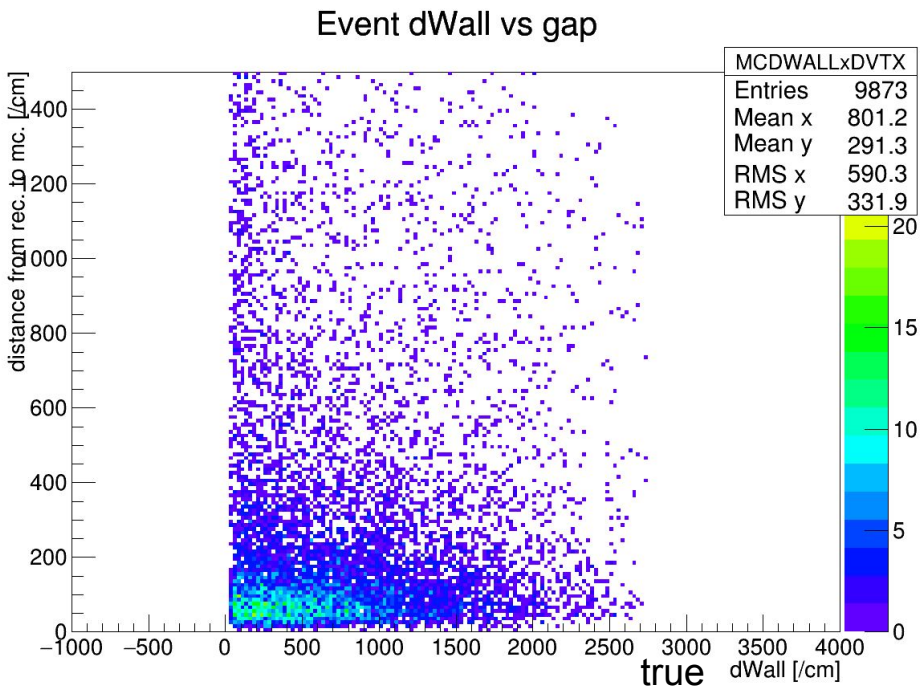

Distance from mc to rec. of outside events
DVTXOFV
Entries 980
Mean 88.26
RMS 147.6
Only events of outside of FV
E = 15 MeV
w/o mPMT
w/ mPMT
0
50
100
150
200
250
300
350
0
500
1000
1500
2000
2500
3000
3500
4000

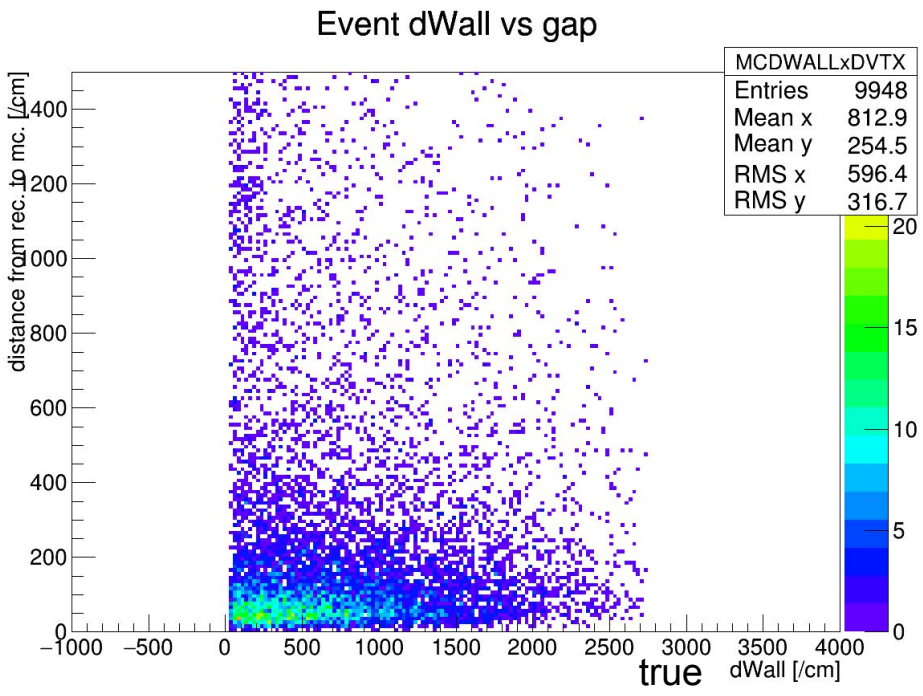
dWall vs distant between MC and rec.

3 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT



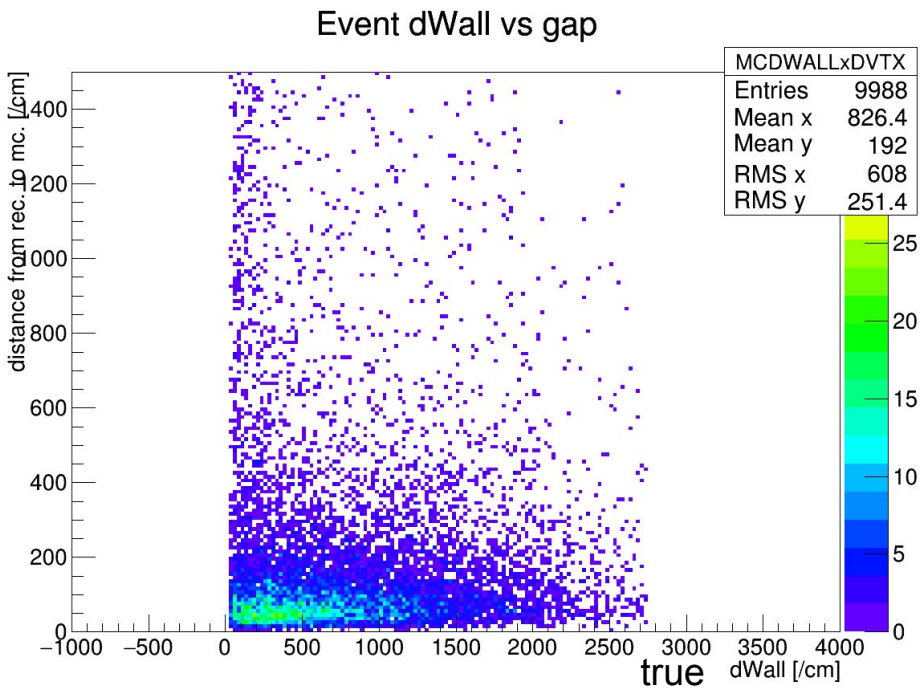


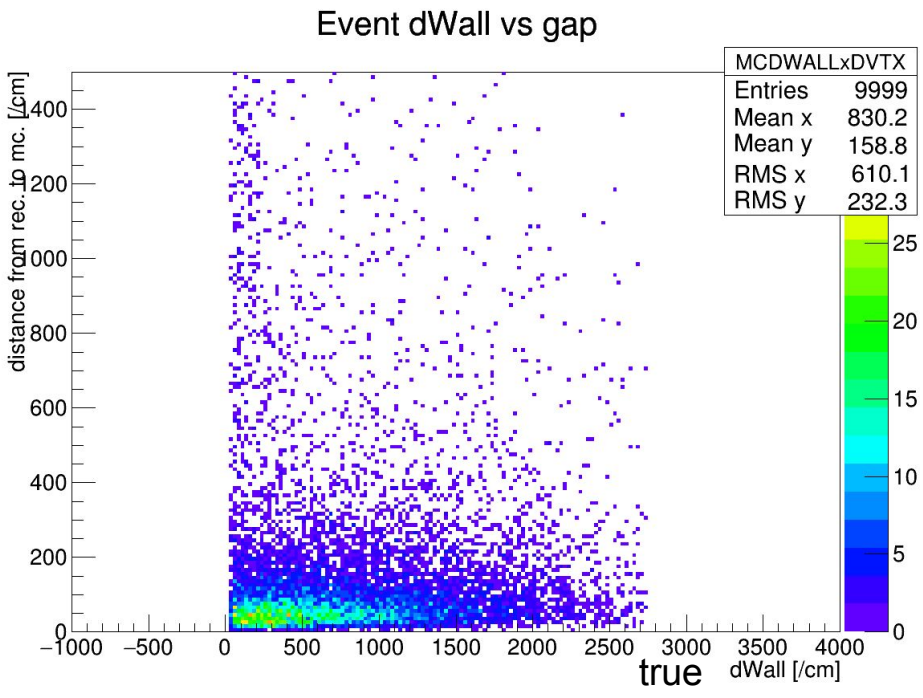
dWall vs distant between MC and rec.

4 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT



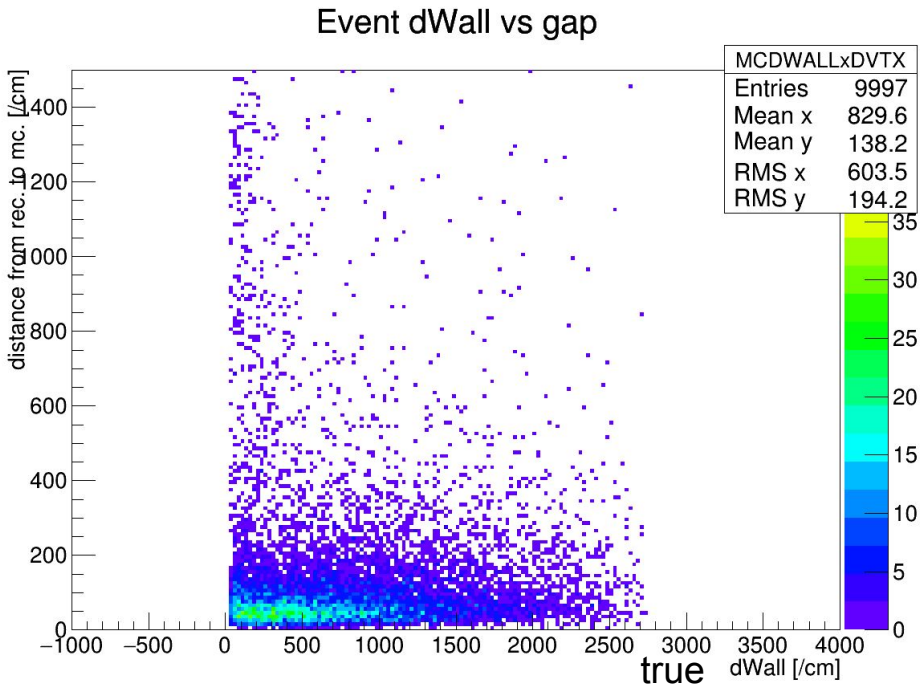


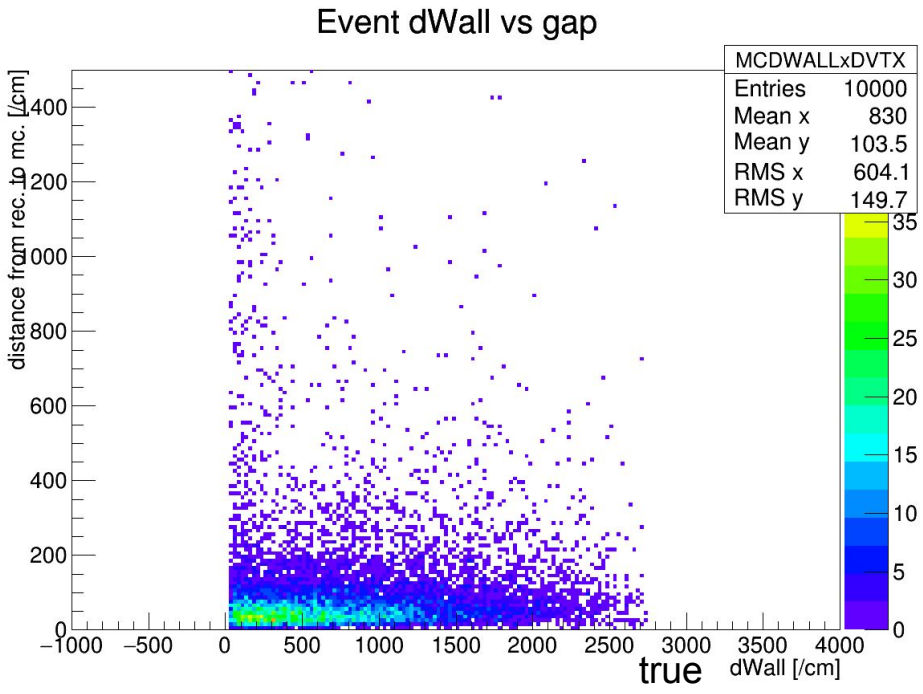
dWall vs distant between MC and rec.

5 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT



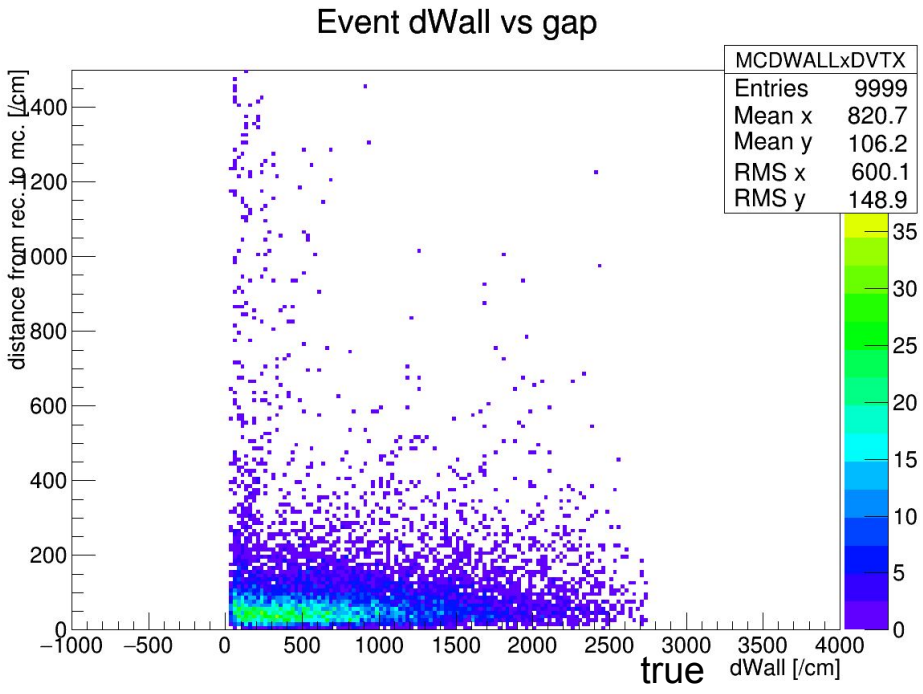


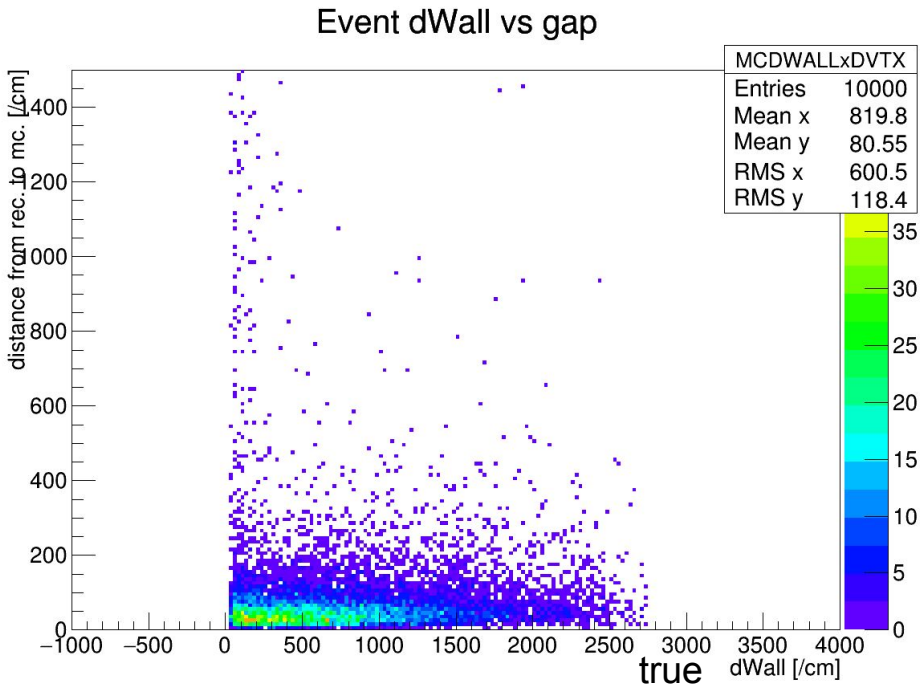
dWall vs distant between MC and rec.

6 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT



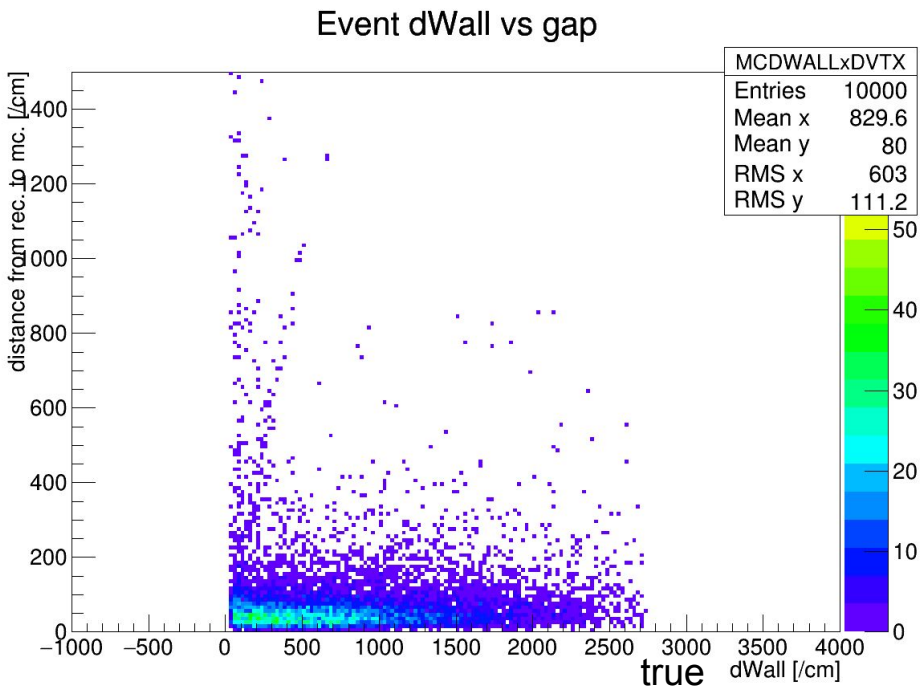


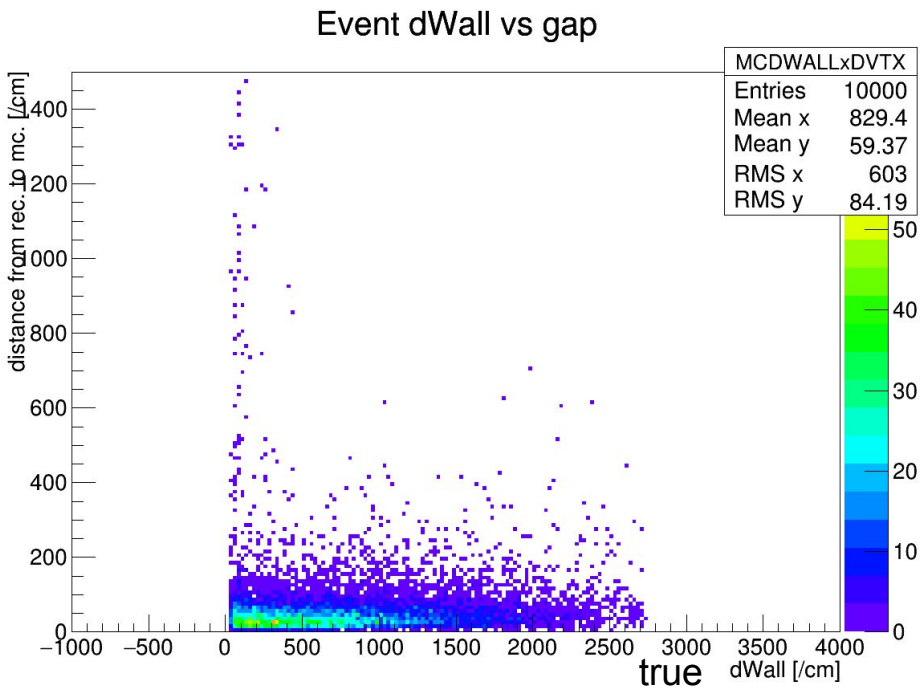
dWall vs distant between MC and rec.

8 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT



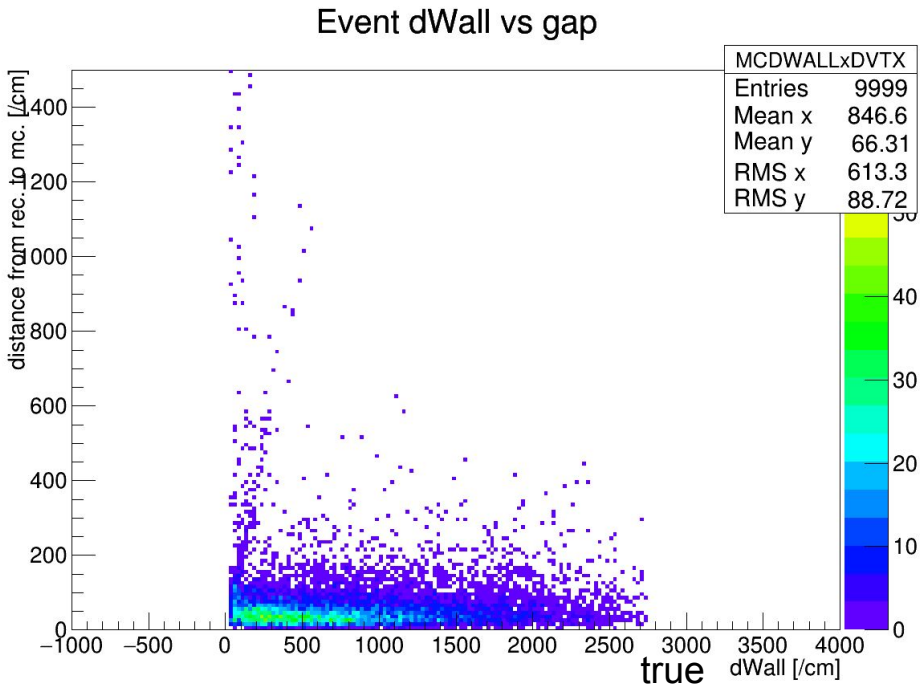


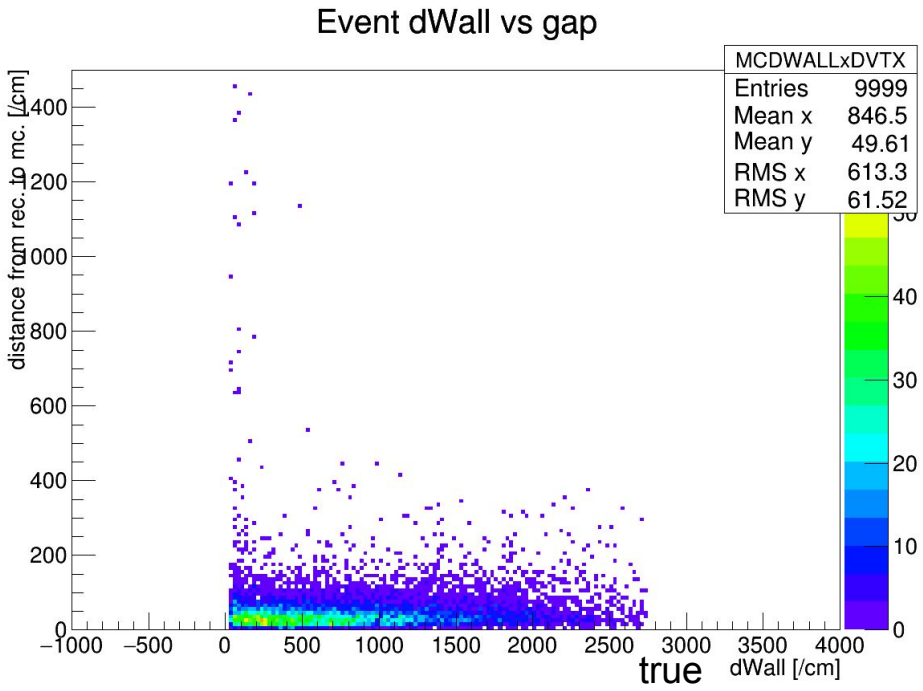
dWall vs distant between MC and rec.

10 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT



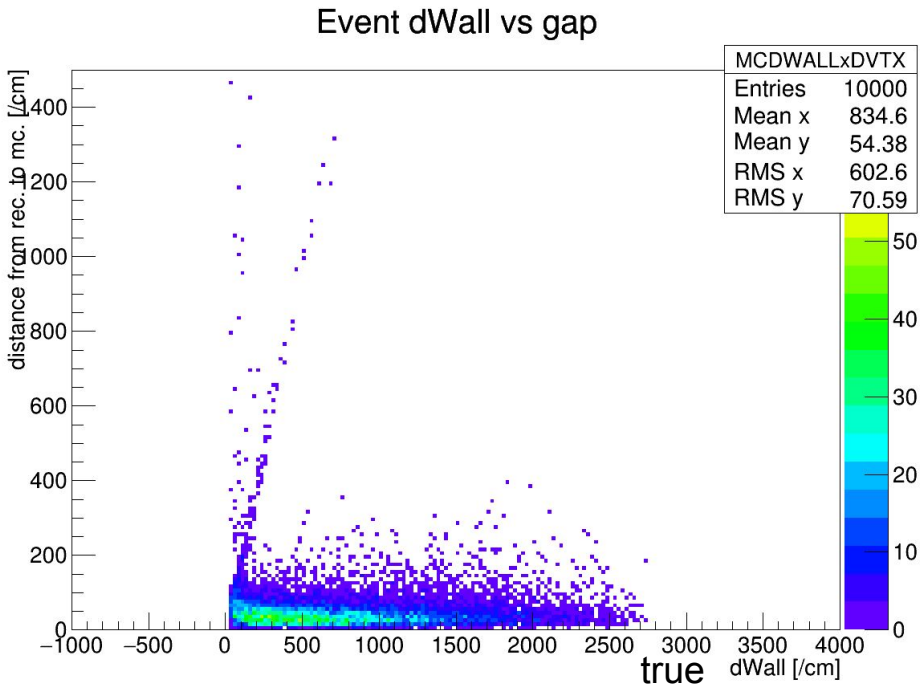


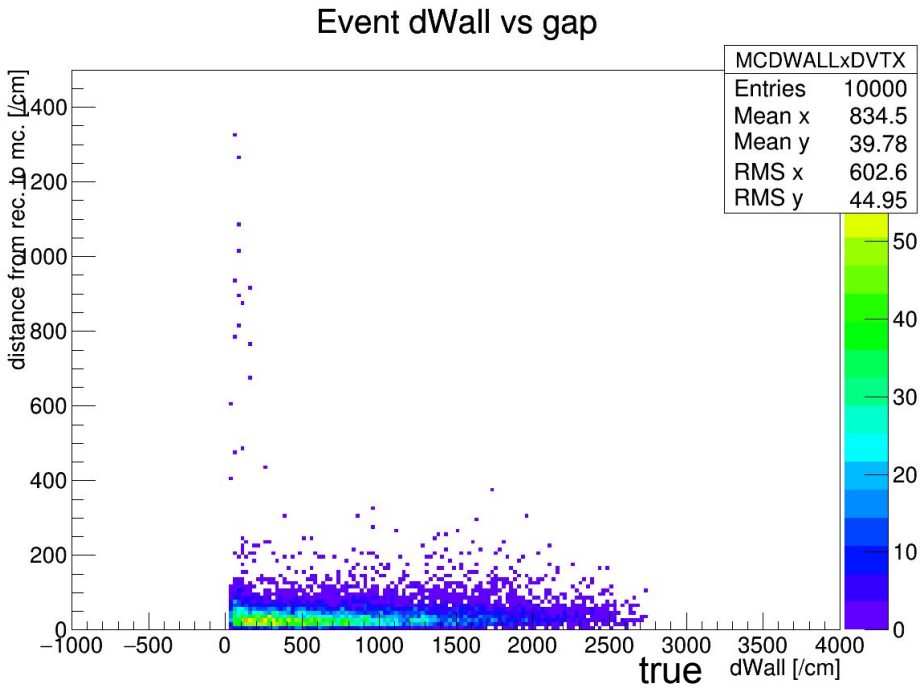
dWall vs distant between MC and rec.

15 MeV

Left: B&L w/o mPMT

Right: B&L w/ mPMT





To do

- Try to generate the directionality PDF

Note

- I will talk about mPMT simulation in a midterm report of Master thesis of Tokyo Tech. Physics Dept.