Status Report

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8 Nov. 2019

mPMT-Japan meeting

New

- Event leakage
  - Checked rawer distributions;
    - vertex resolution (dependencies of dWall)
- n-tagging
  - Timing profiles; something strange
  - Expended time window to evaluate tagging efficiency

Events leakage

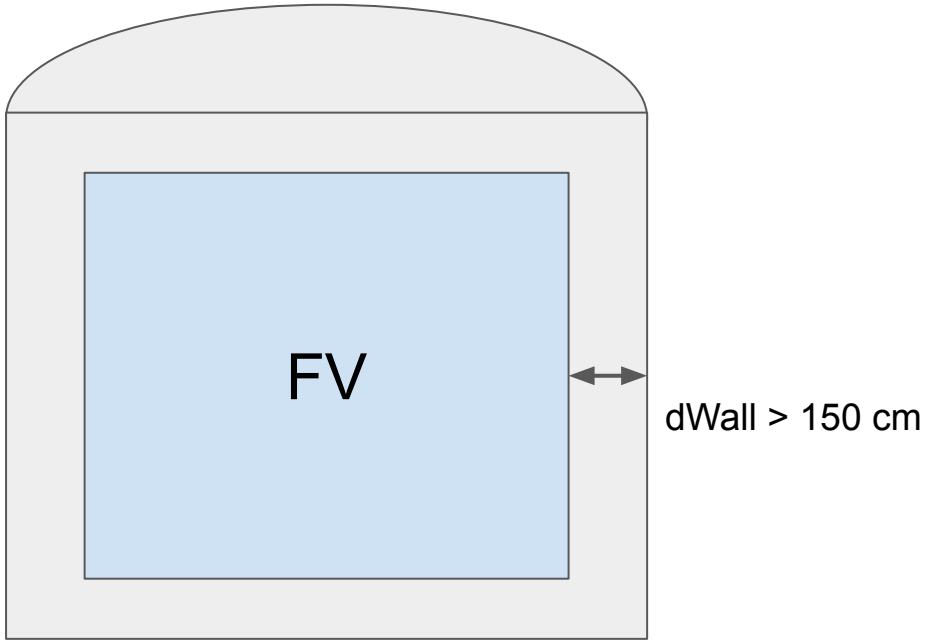
Miss-reconstruction rate

Slide of 1st Nov.
mPMT-Japan meeting

- Calculated the miss-rec. rate: how many events are reconstructed inner volume.

$$(\text{miss-rec. rate}) = \frac{(\#\text{ of events generated out of FV and reconstructed in FV})}{(\#\text{ of events generated out of FV})}$$

- FV := {volume | dWall > 150 cm}
- Calculated it at some energies: 3,4,5,6,8,10,15 MeV



Remind

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- WCSim MC generation
  - Detector: HK mPMT Hybrid
    - B&L: 20 k (20PC)
      - D.R. : 4.2 kHz
    - mPMT: 10 k (10PC)
      - D.R. : 100 Hz
  - Particle: electrons
  - Energy: 3, 4, 5, 6, 8, 10, 15 MeV
  - # of events: 10k for each energy
  - Position: uniform in the water tank
  - Direction: isotoropy

FV Cut : dWall150 cm

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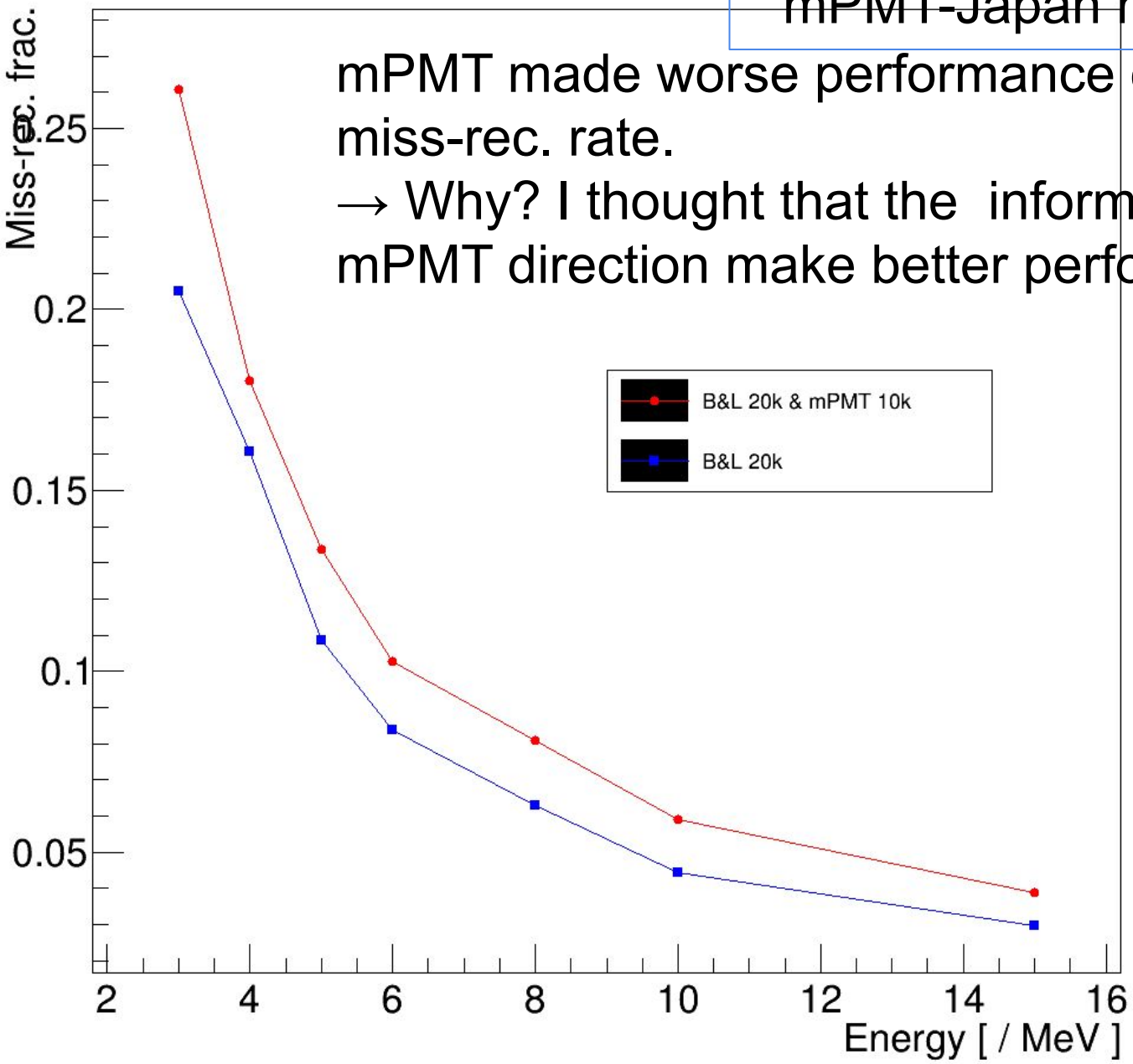
mPMT made worse performance of miss-rec. rate.

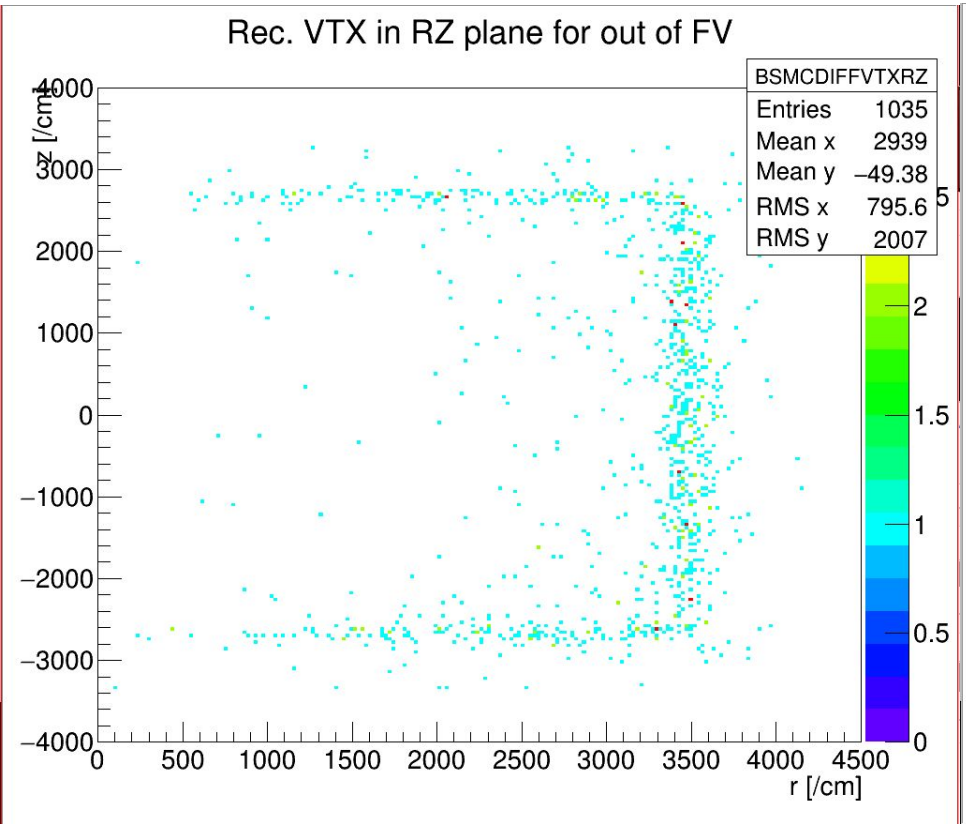
→ Why? I thought that the information of mPMT direction make better performance.

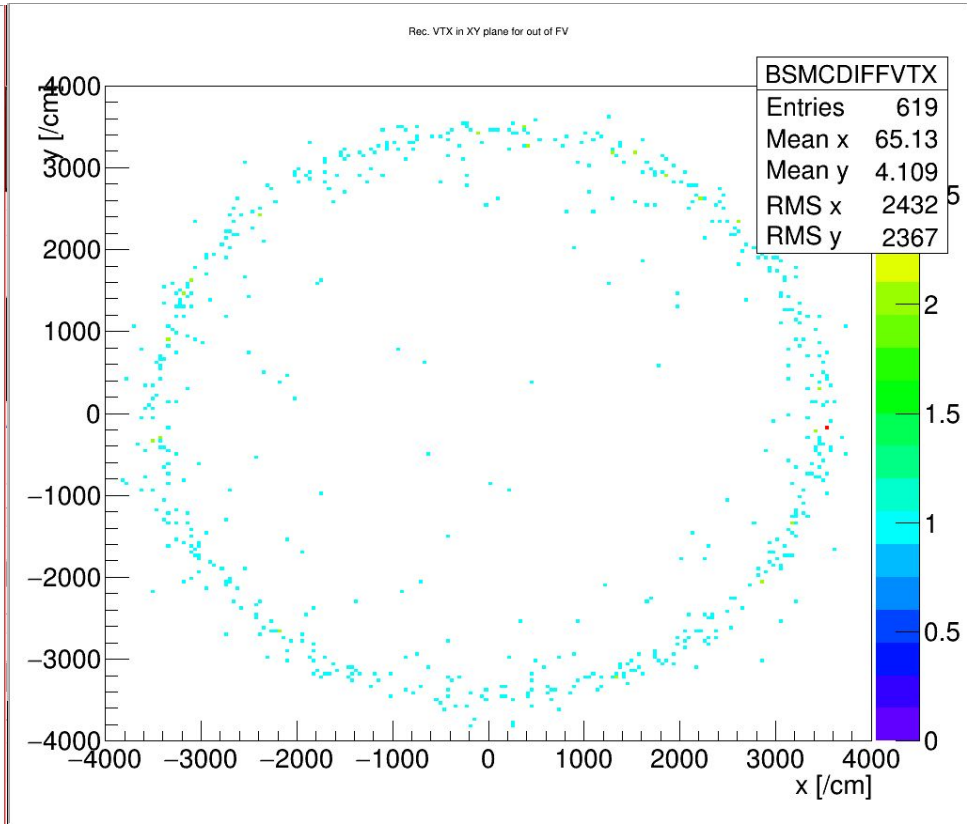


Events out of FV

Slide of 1st Nov.
mPMT-Japan meeting

- I plot the reconstructed events which generated out of FV (3MeV)
- These are **w/ mPMT**
- Right plot shows only barrel events

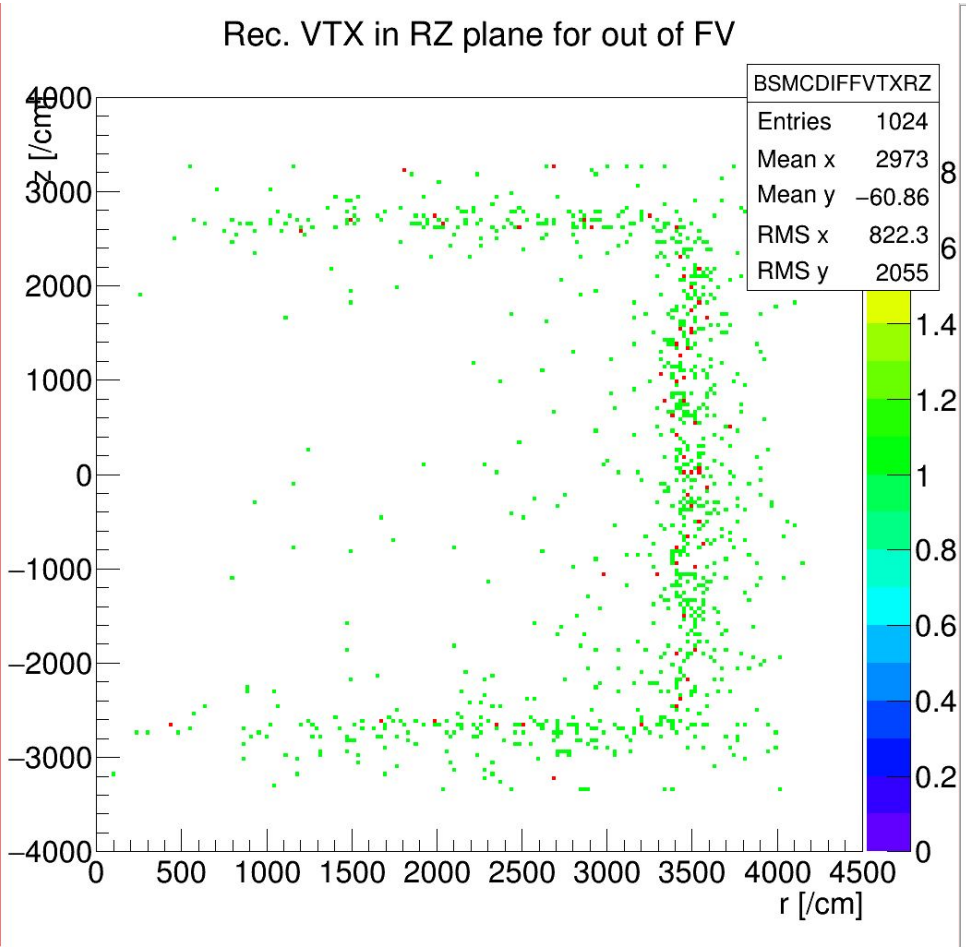


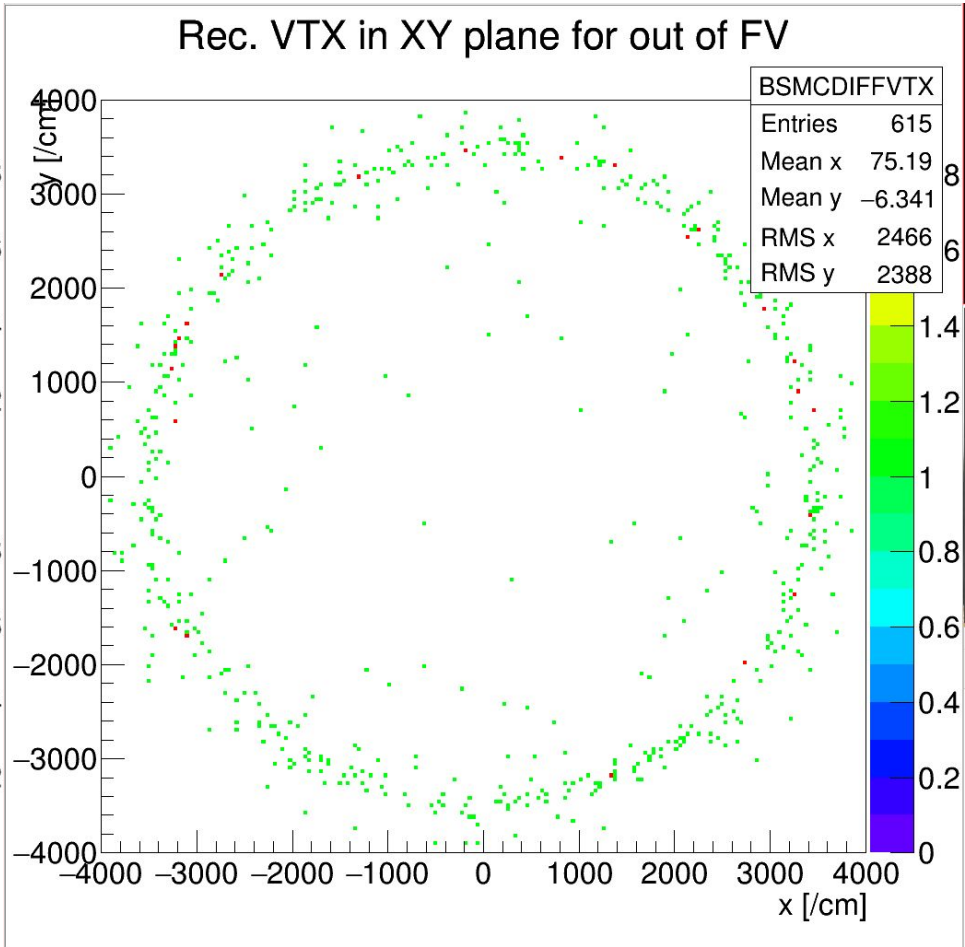


Events out of FV

Slide of 1st Nov.
mPMT-Japan meeting

- I plot the reconstructed events which generated out of FV (3MeV)
- These are **w/o mPMT** (right plot shows only barrel).

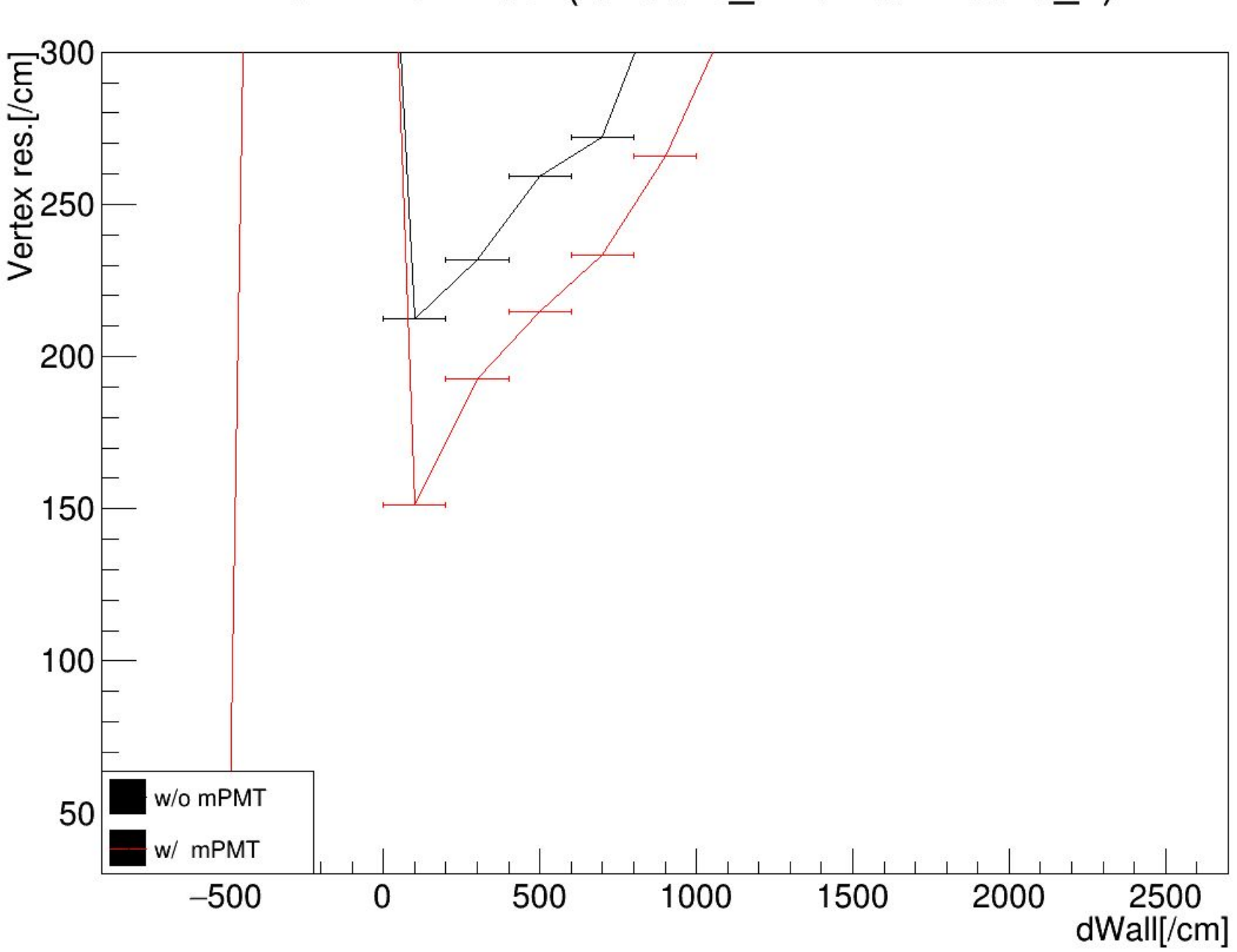




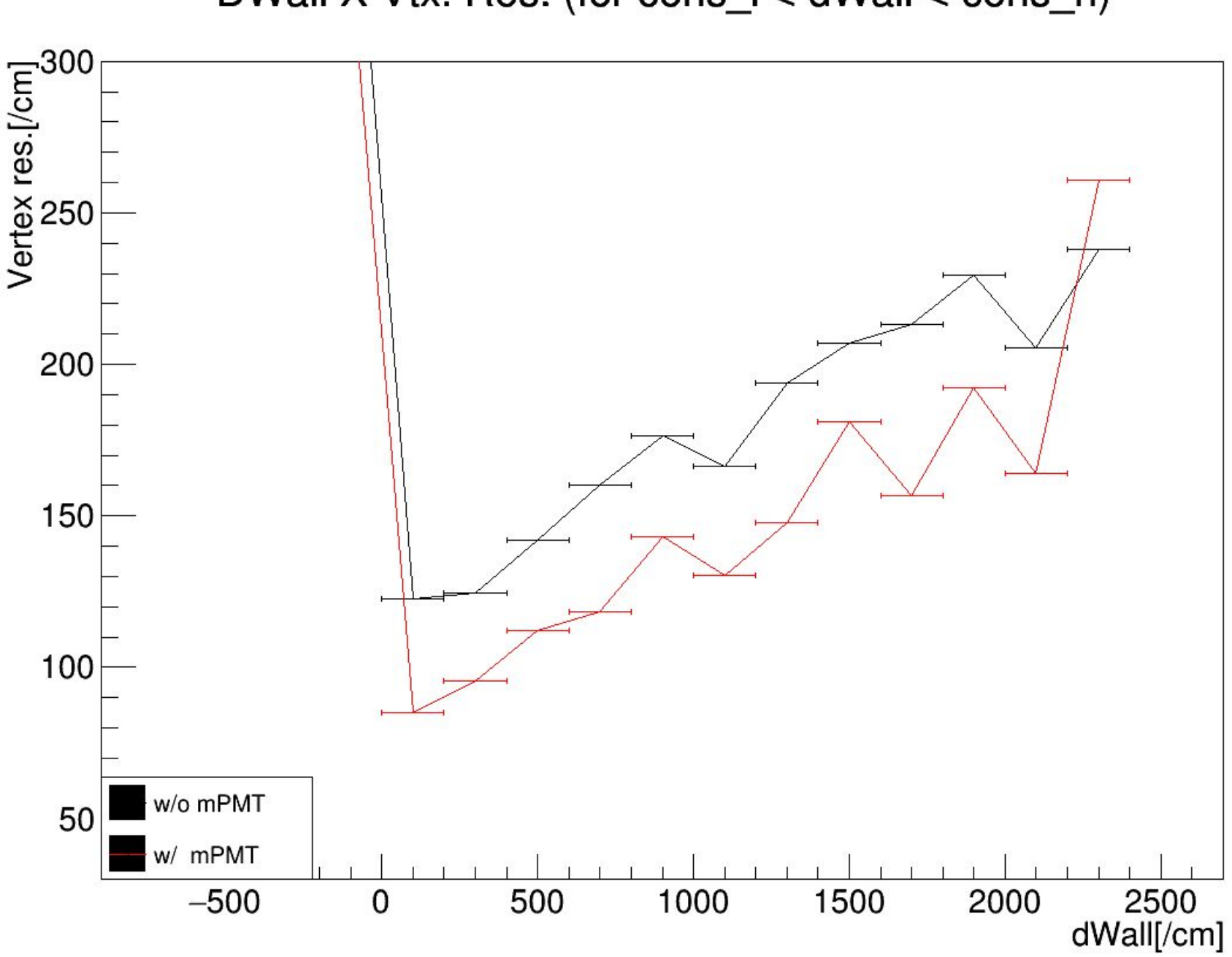
Other distribution

- I drawn some plots
  - dWall vs vertex resolution
  - Distance from rec. vertex to mc. vertex
  - dWall vs distance from rec. to mc.
- I compared these plots w/ mPMT and w/o mPMT.

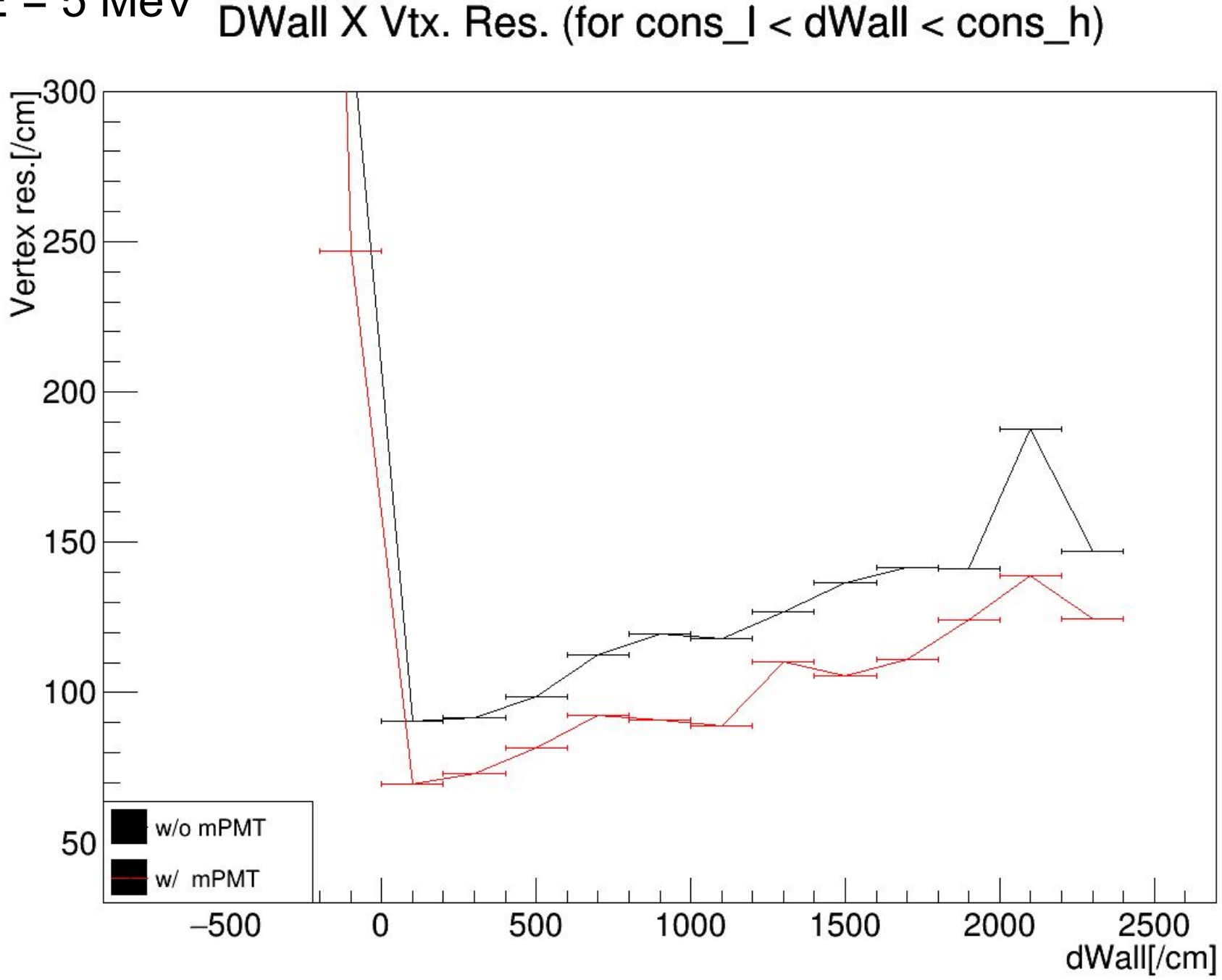
E = 3 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

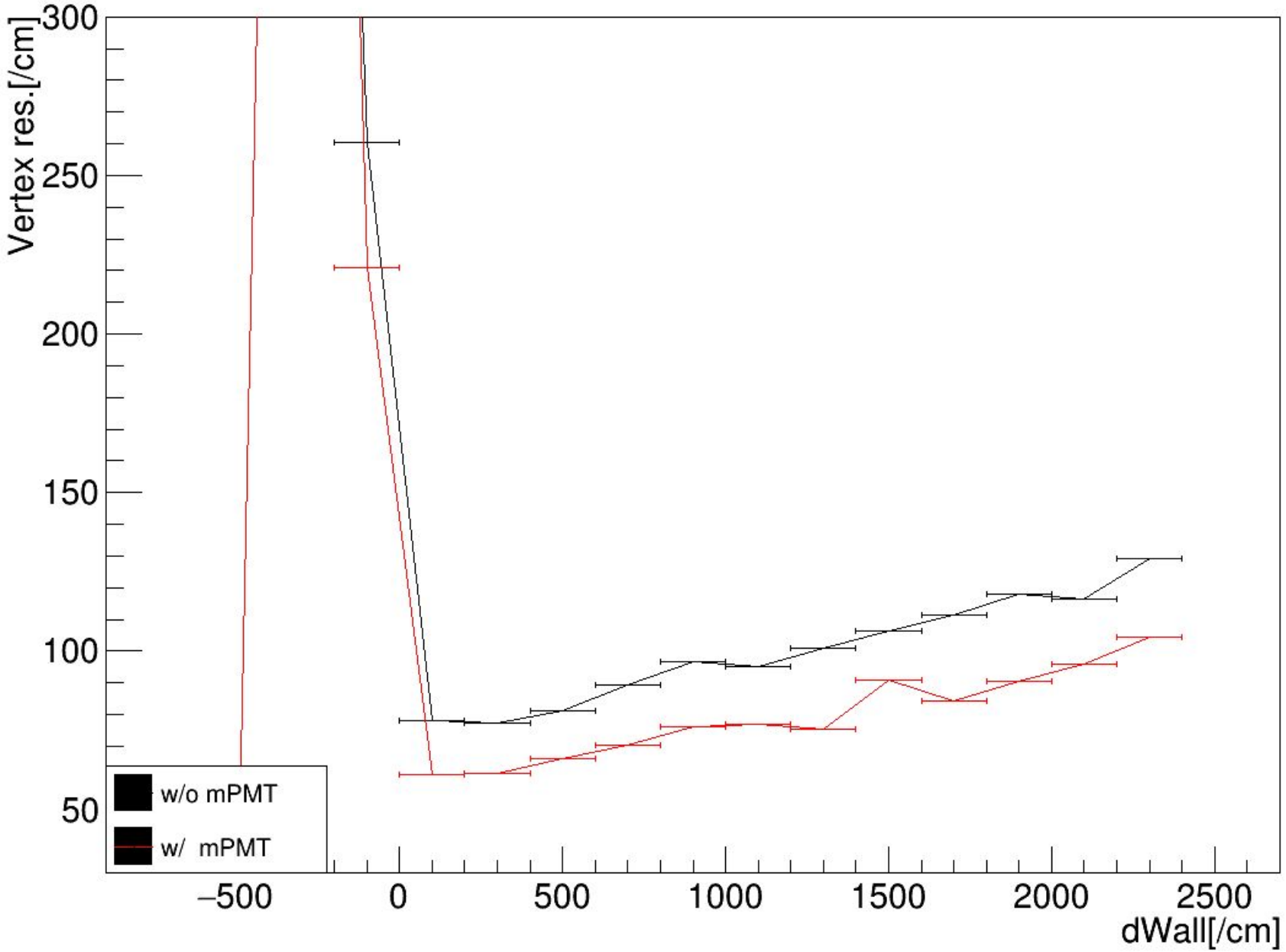
E = 4 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

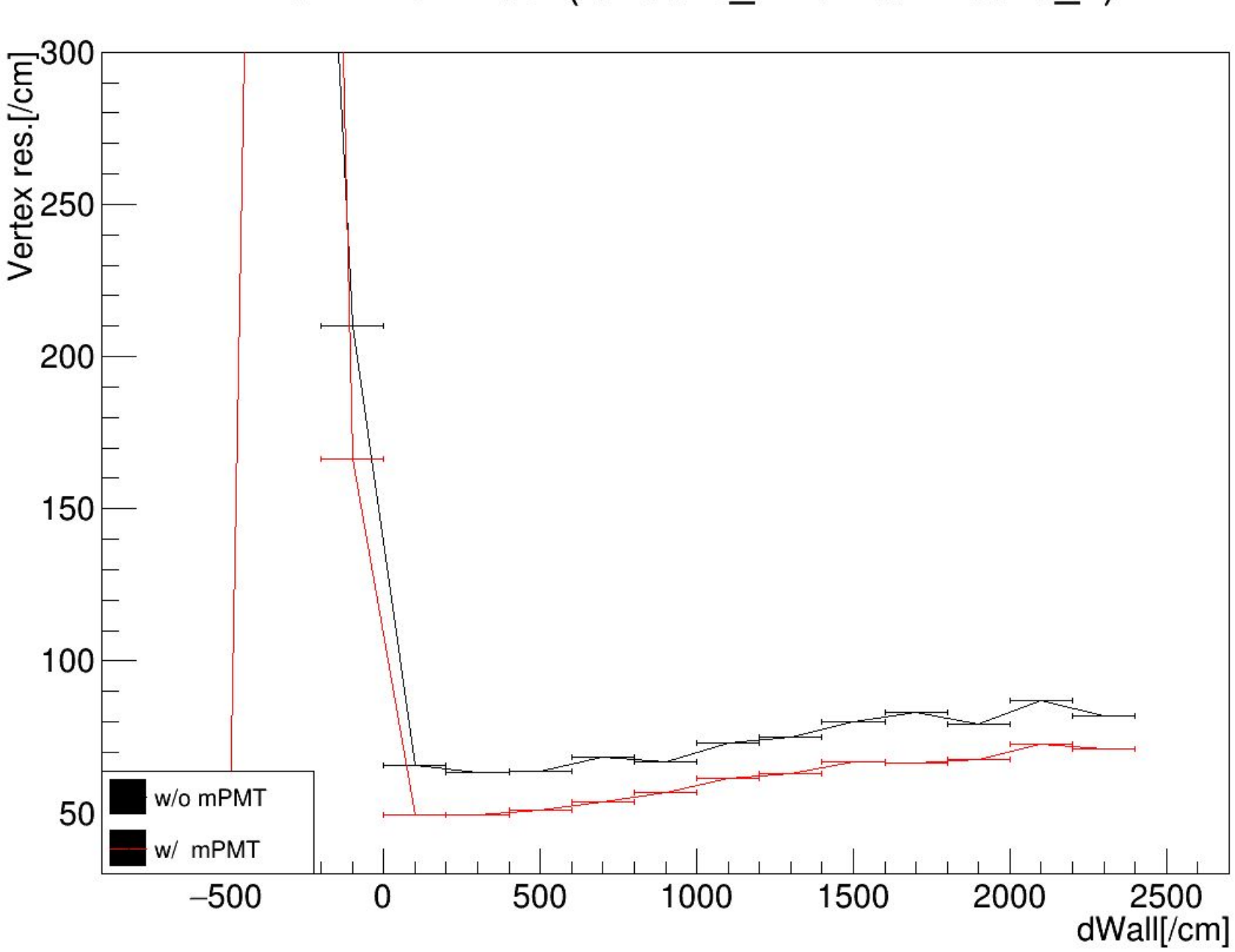
E = 5 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

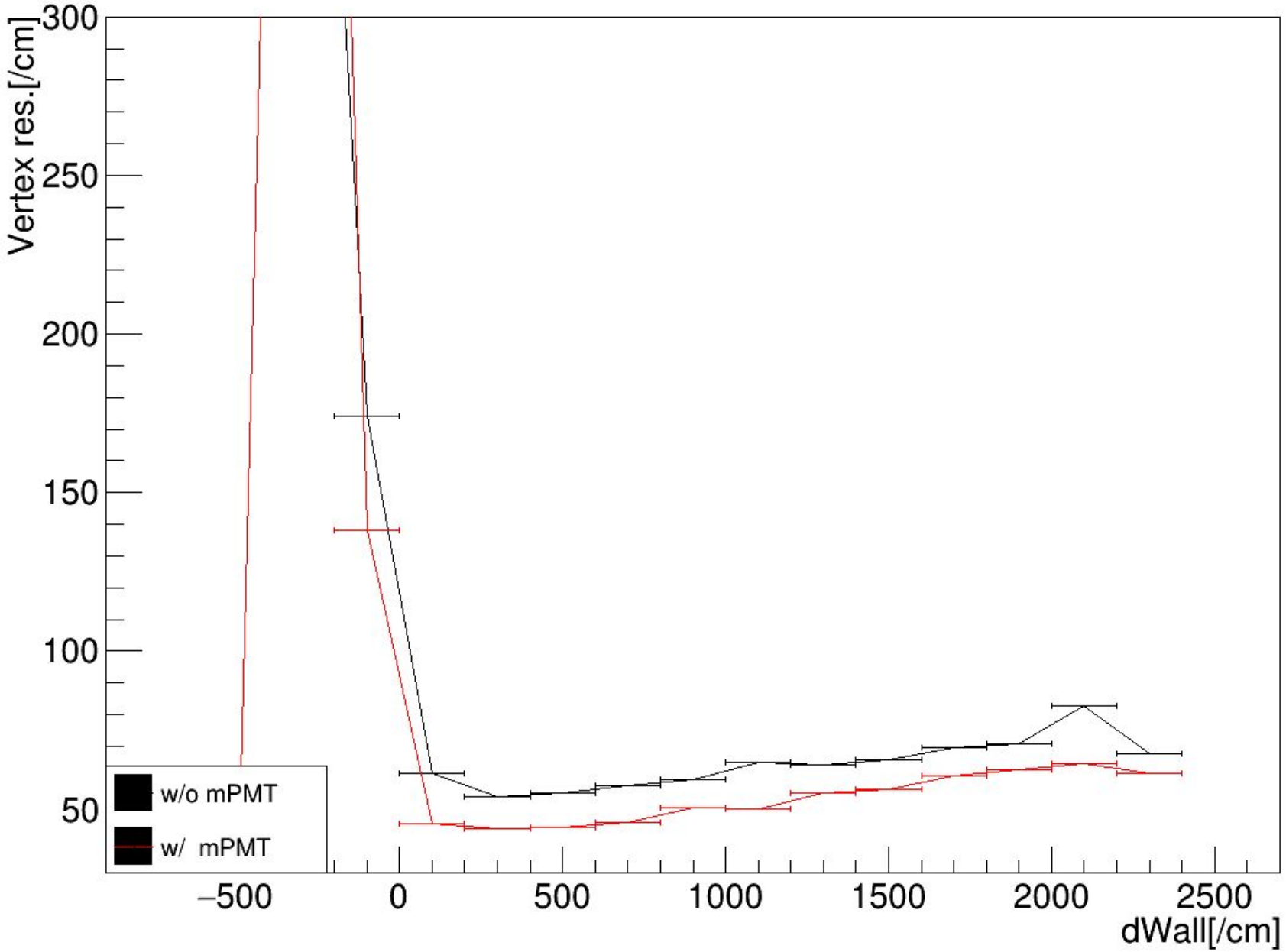
E = 6 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

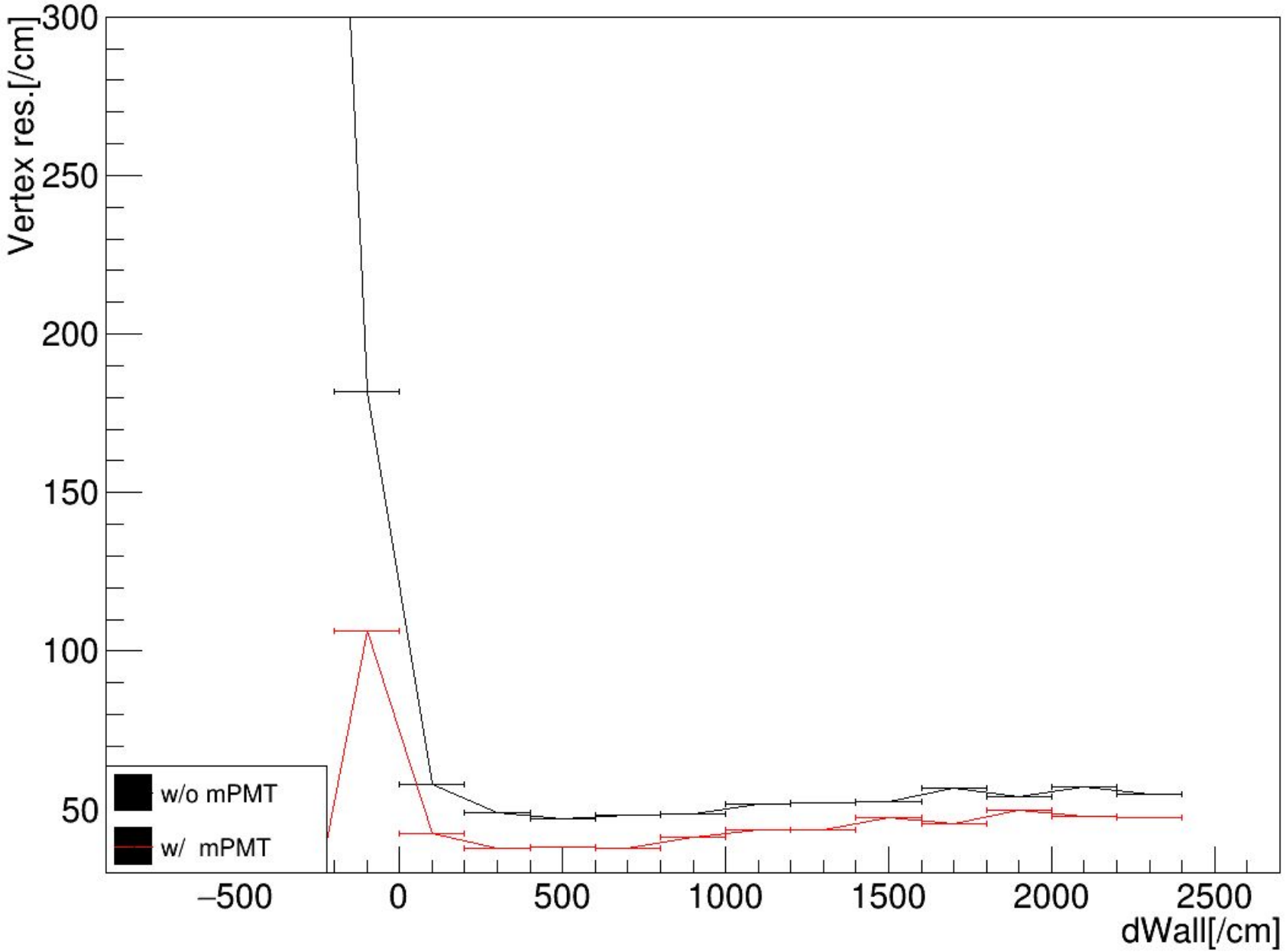
E = 8 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

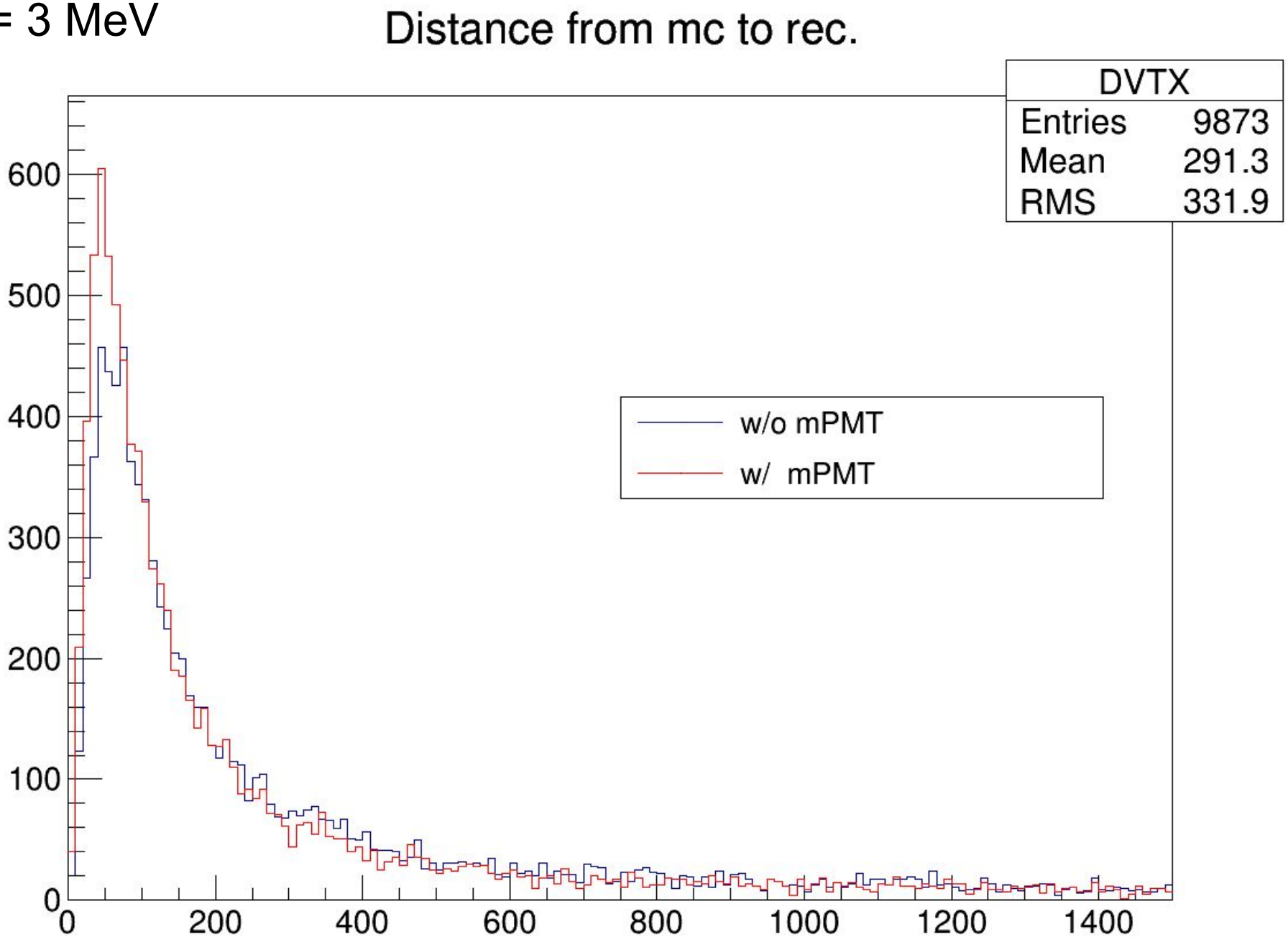
E = 10 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

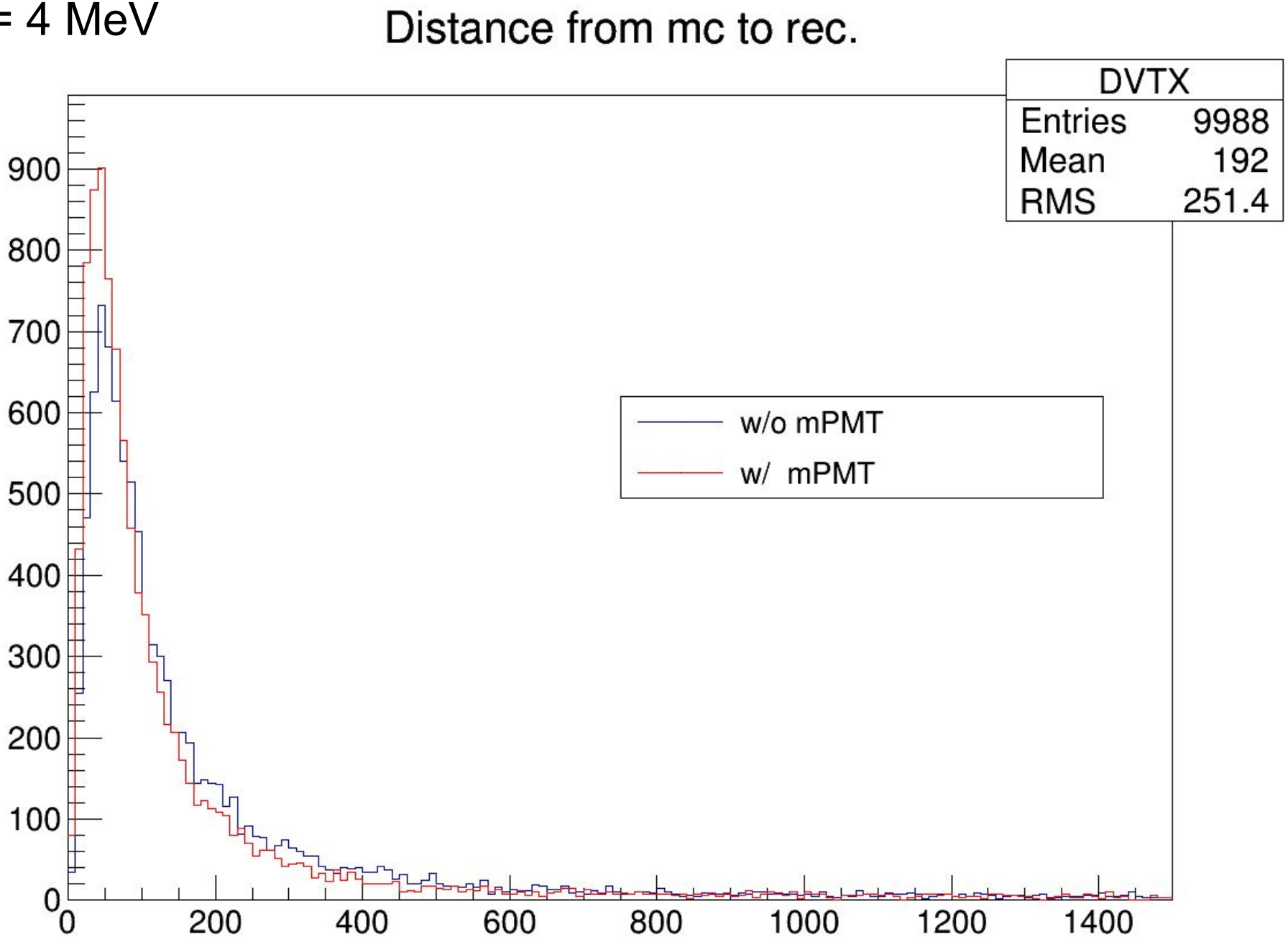
E = 15 MeV


DWall X Vtx. Res. (for cons_l < dWall < cons_h)
Vertex res.[/cm]
300
250
200
150
100
50
w/o mPMT
w/ mPMT
−500
0
500
1000
1500
2000
2500
dWall[/cm]

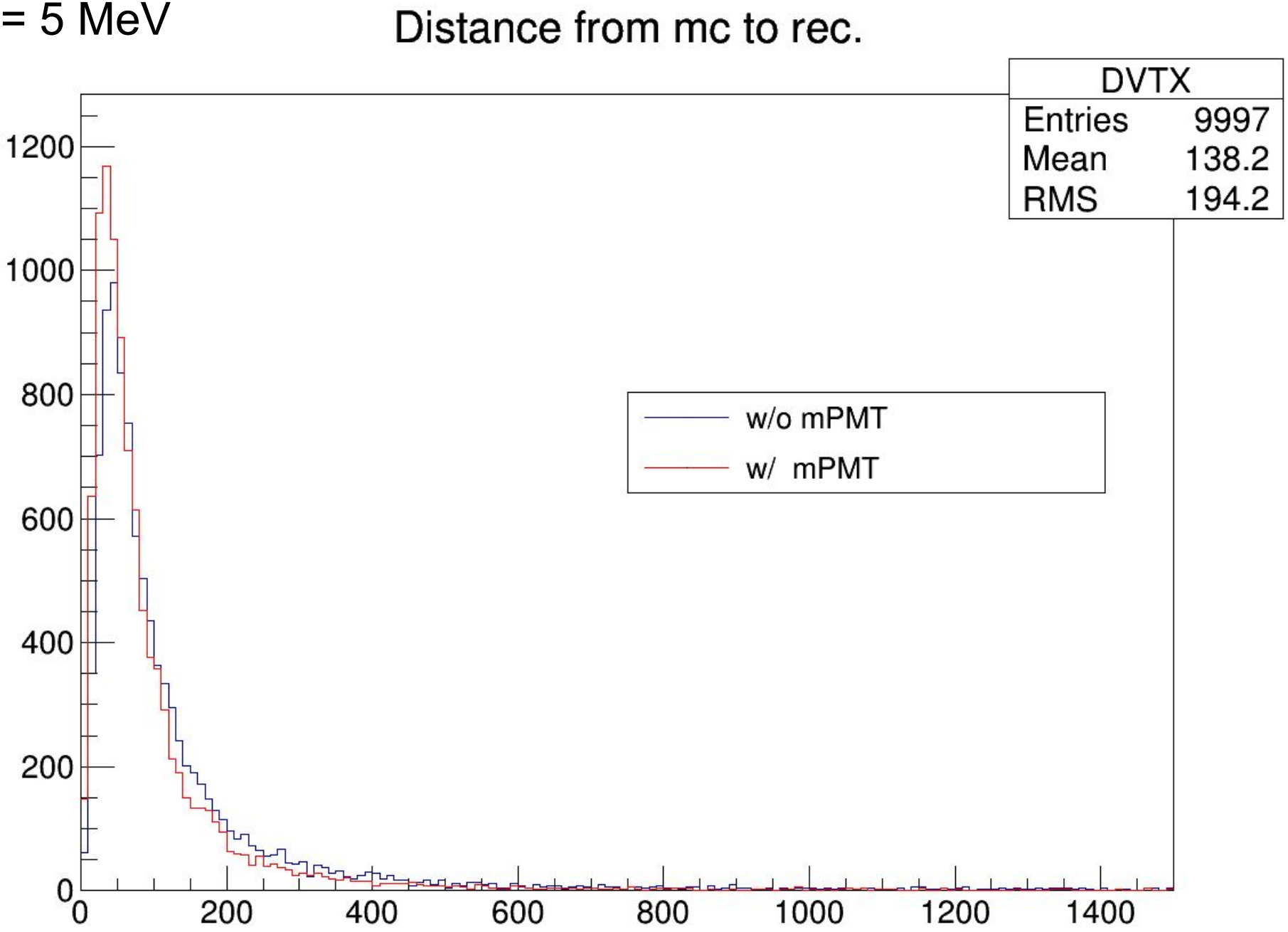
E = 3 MeV


Distance from mc to rec.
DVTX
Entries 9873
Mean 291.3
RMS 331.9
w/o mPMT
w/ mPMT
0
100
200
300
400
500
600
0
200
400
600
800
1000
1200
1400

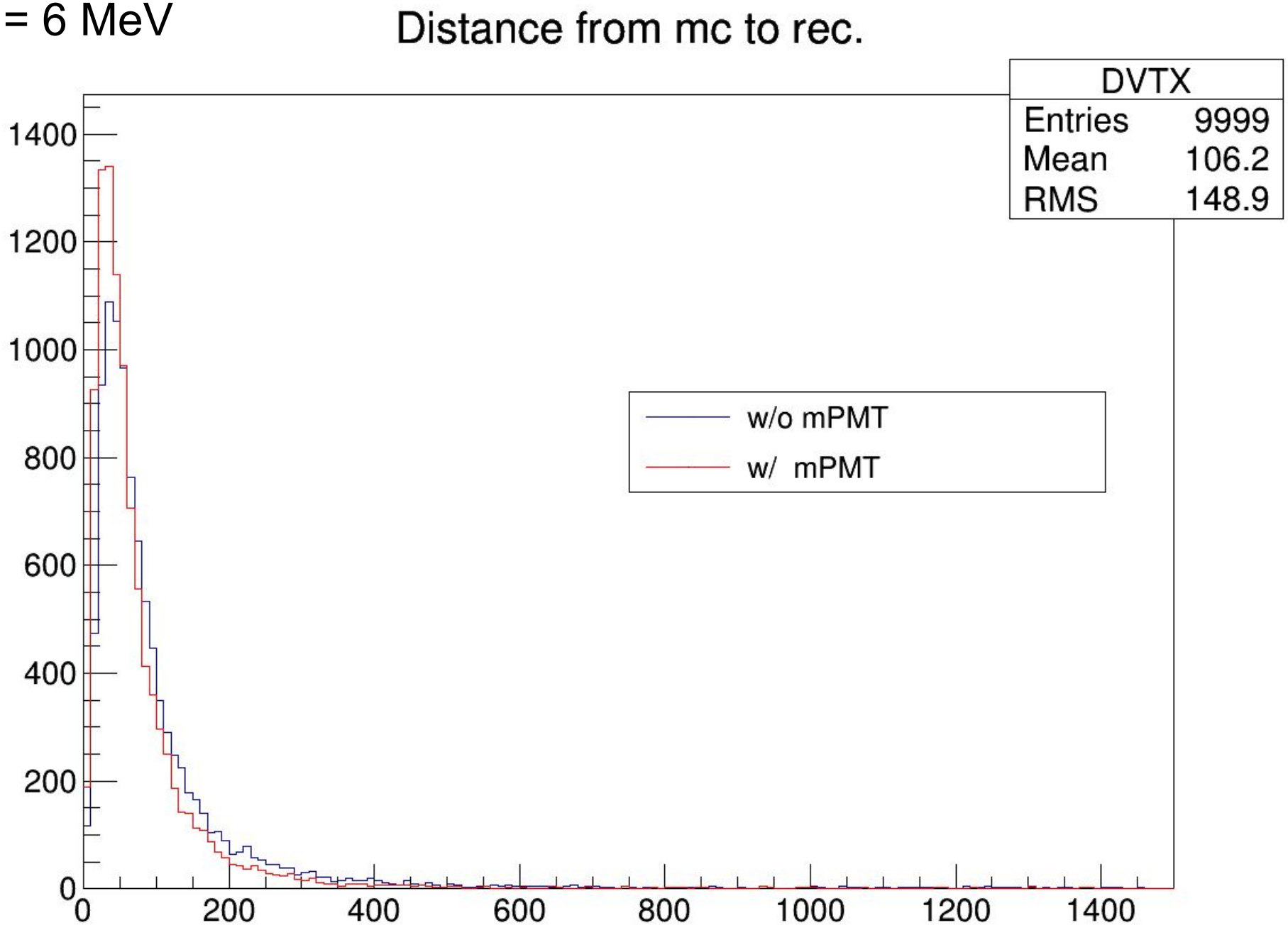
E = 4 MeV


Distance from mc to rec.
DVTX
Entries 9988
Mean 192
RMS 251.4
w/o mPMT
w/ mPMT
0
100
200
300
400
500
600
700
800
900
0
200
400
600
800
1000
1200
1400

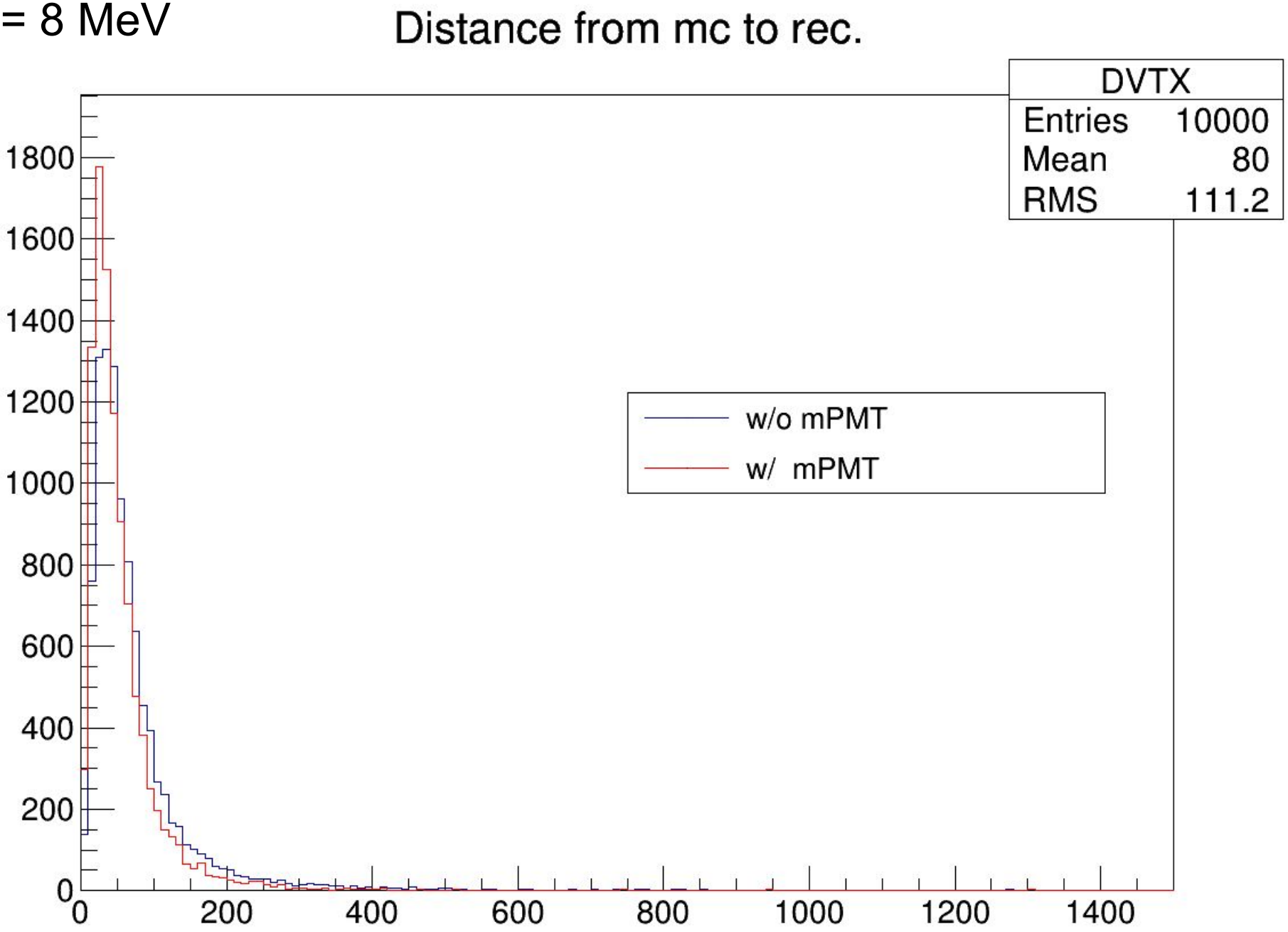
E = 5 MeV


Distance from mc to rec.
DVTX
Entries 9997
Mean 138.2
RMS 194.2
w/o mPMT
w/ mPMT
0
200
400
600
800
1000
1200
1400

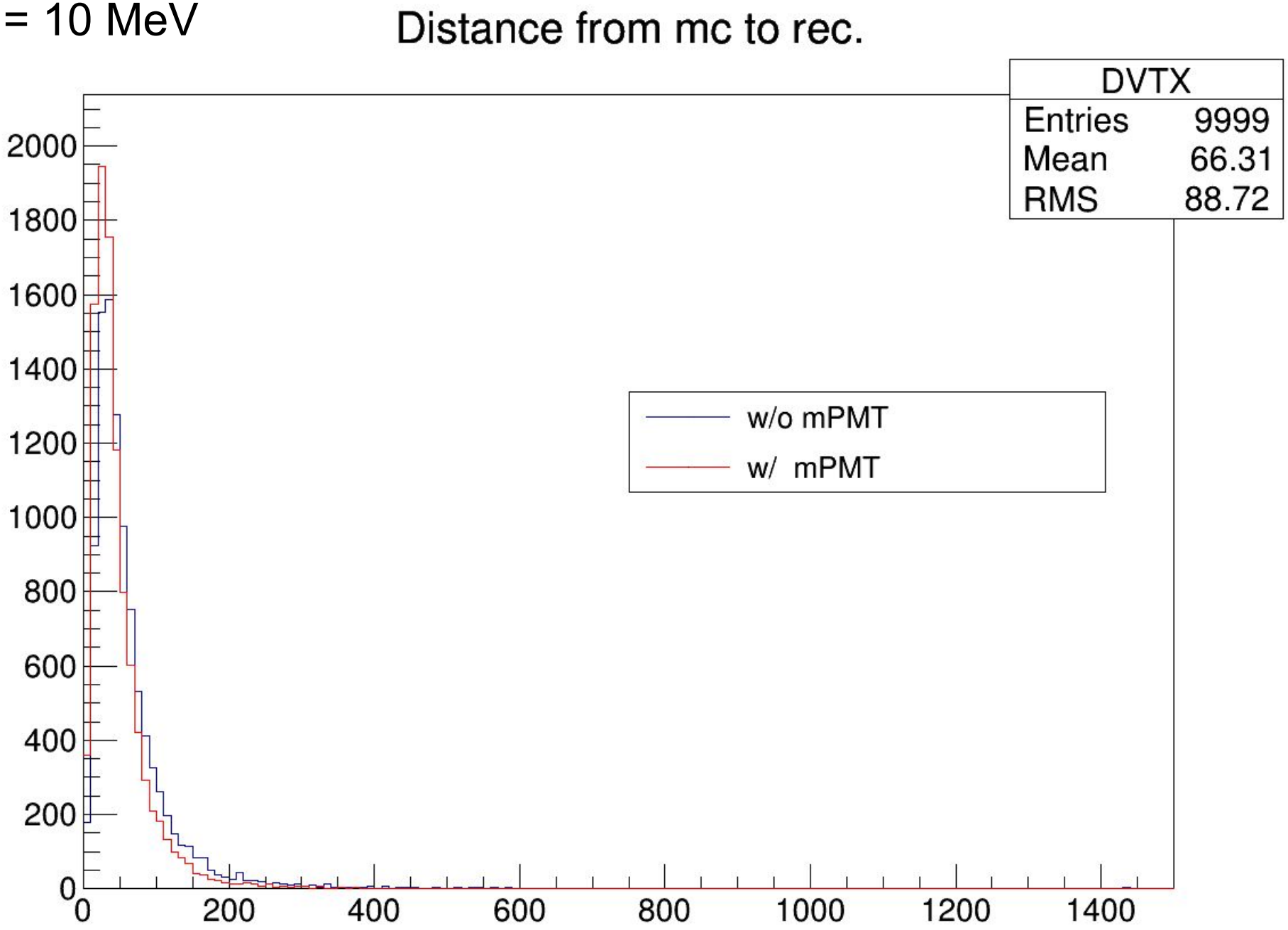
E = 6 MeV


Distance from mc to rec.
DVTX
Entries 9999
Mean 106.2
RMS 148.9
w/o mPMT
w/ mPMT
0
200
400
600
800
1000
1200
1400

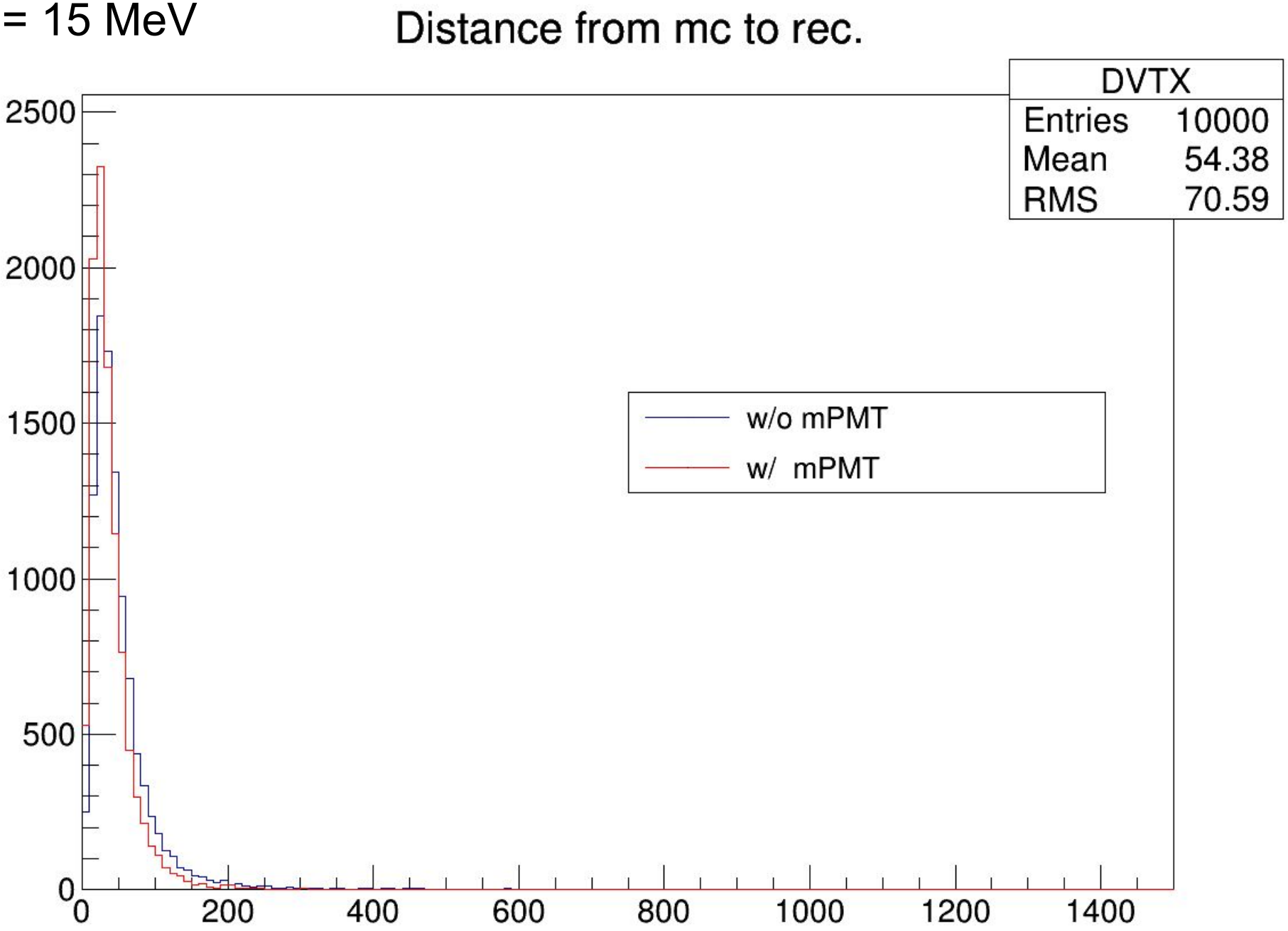
E = 8 MeV


Distance from mc to rec.
DVTX
Entries 10000
Mean 80
RMS 111.2
w/o mPMT
w/ mPMT
0
200
400
600
800
1000
1200
1400
1600
1800
0
200
400
600
800
1000
1200
1400

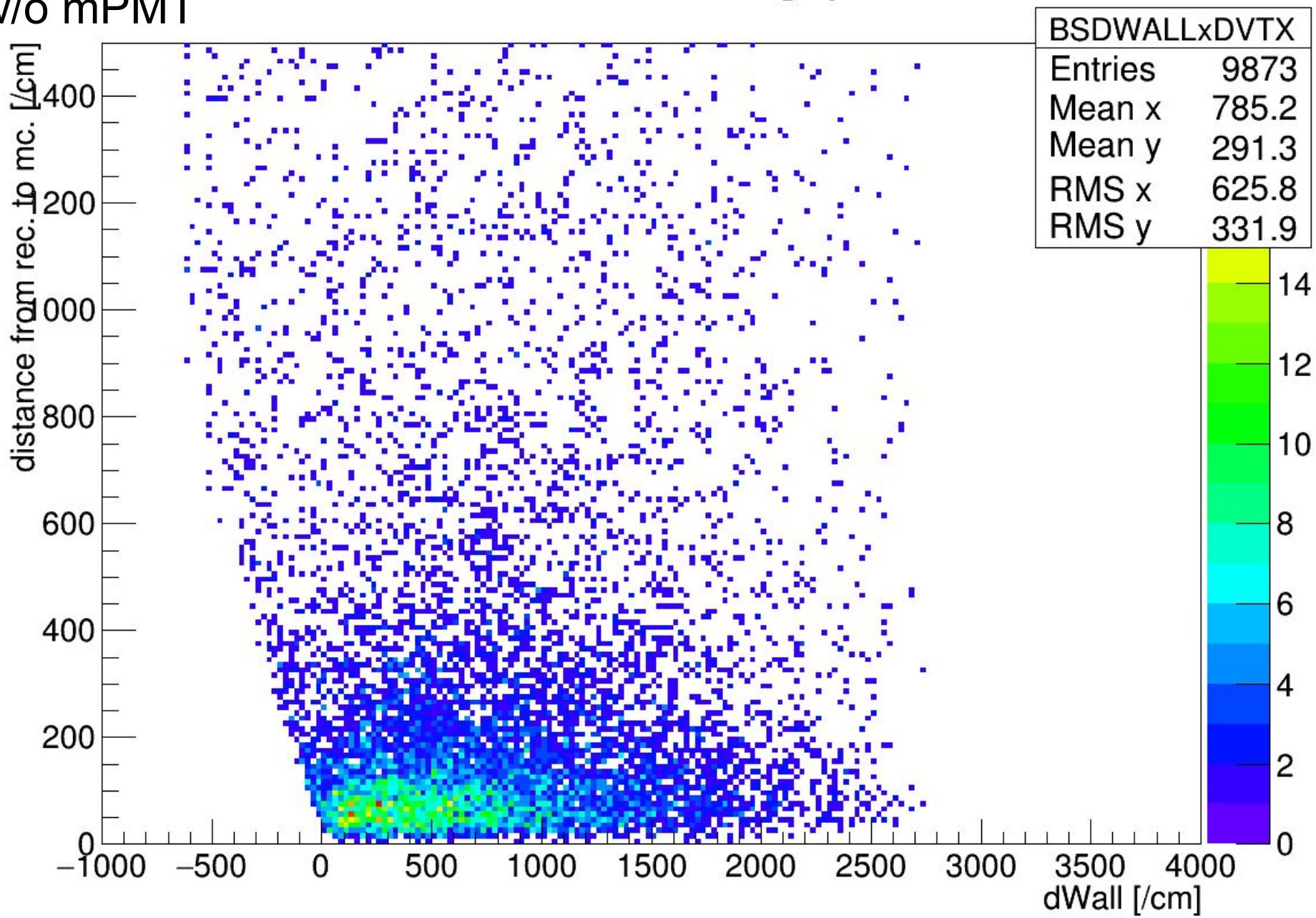
E = 10 MeV


Distance from mc to rec.
DVTX
Entries 9999
Mean 66.31
RMS 88.72
w/o mPMT
w/ mPMT
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400

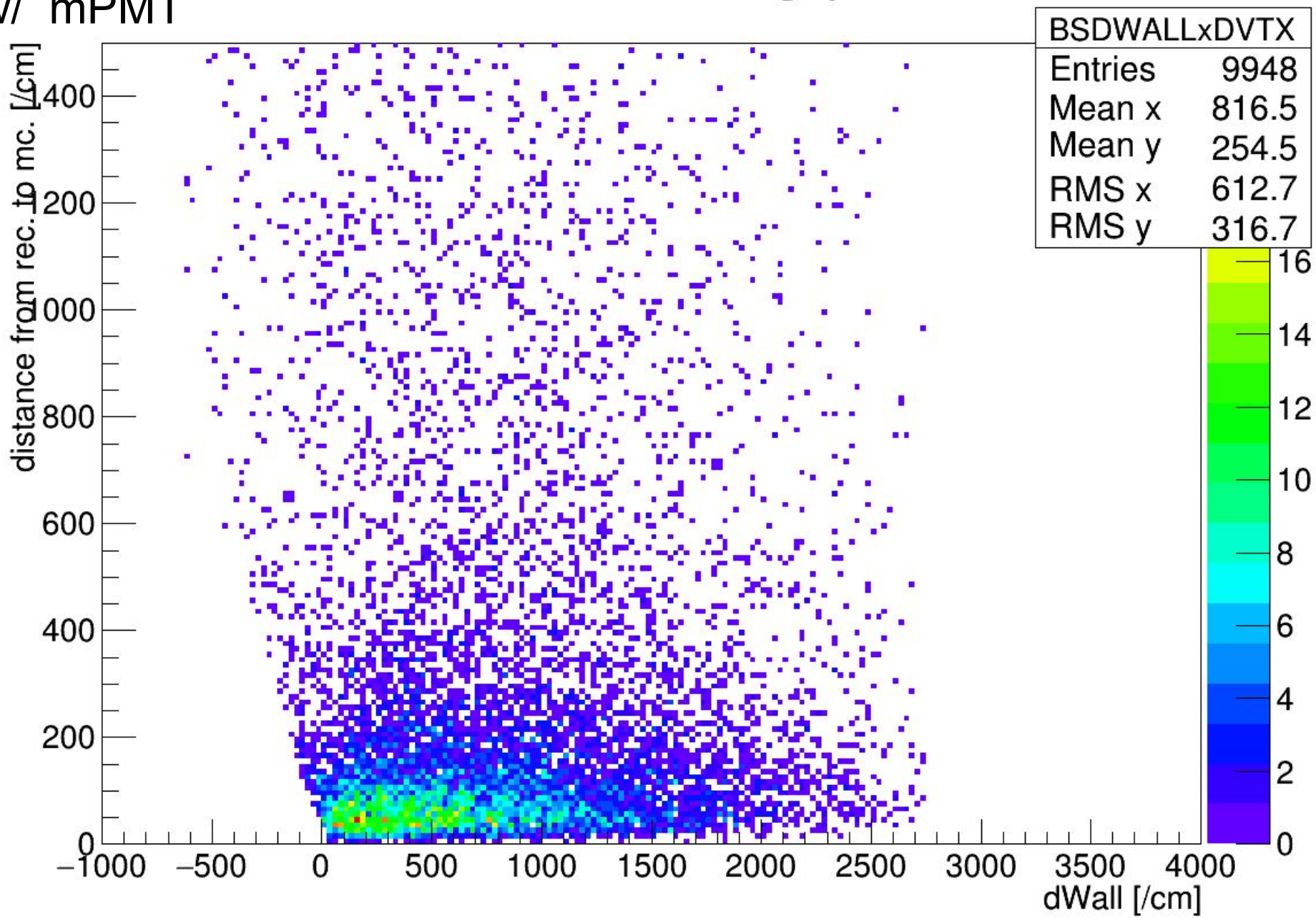
E = 15 MeV


Distance from mc to rec.
DVTX
Entries 10000
Mean 54.38
RMS 70.59
w/o mPMT
w/ mPMT
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
1400

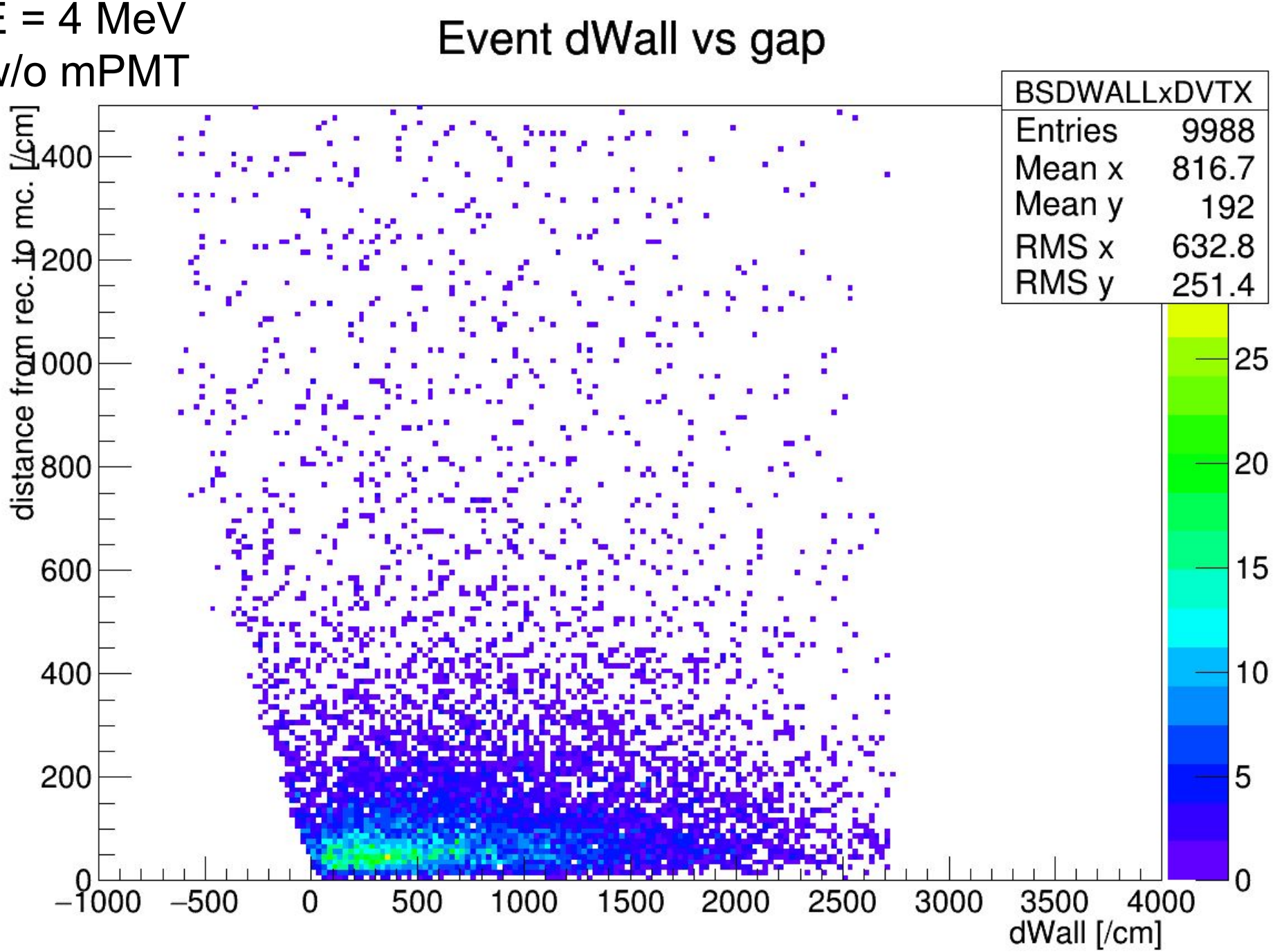
E = 3 MeV
w/o mPMT



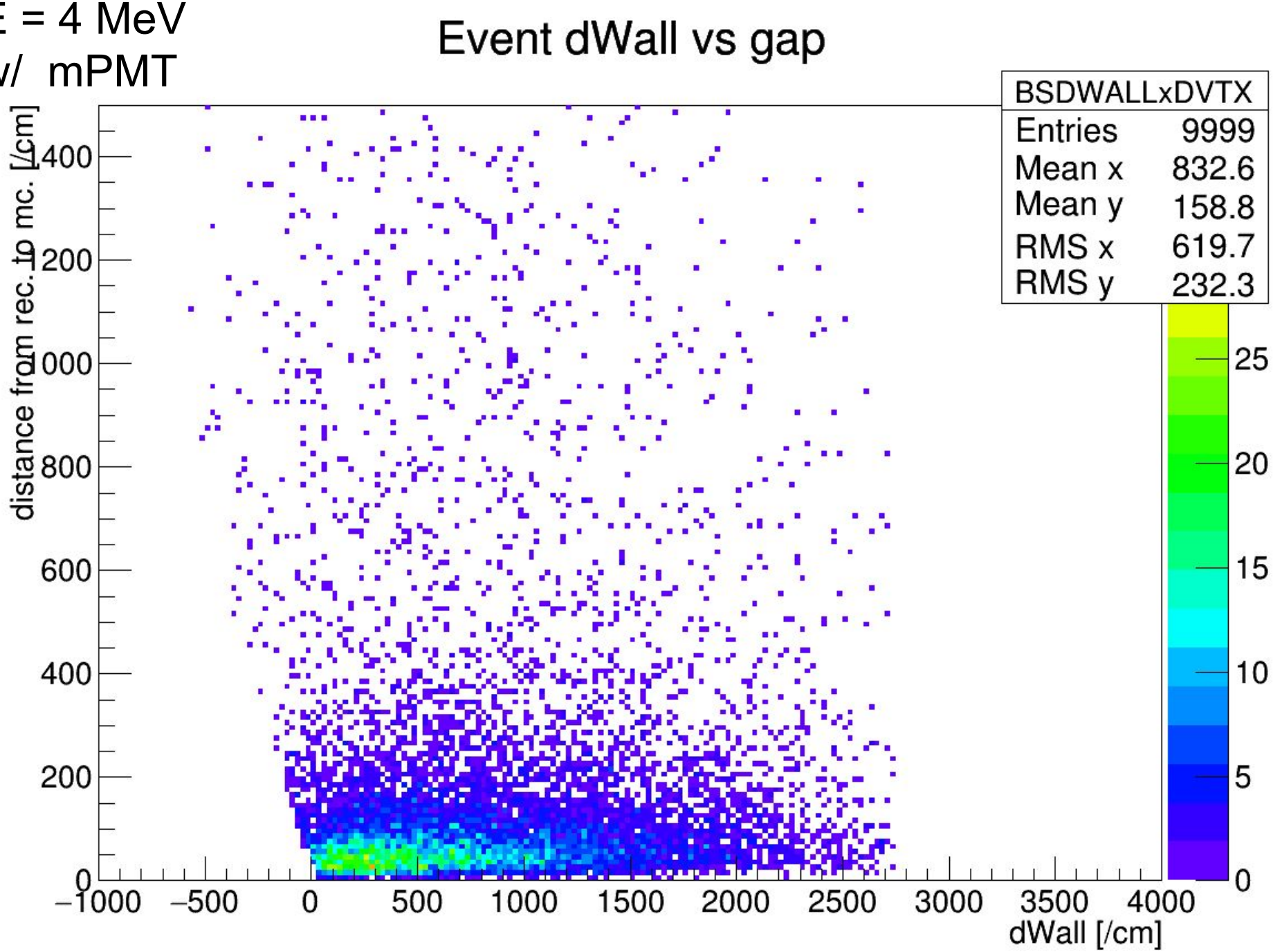
E = 3 MeV
w/ mPMT


Event dWall vs gap
BSDWALLxDVTX
Entries 9948
Mean x 816.5
Mean y 254.5
RMS x 612.7
RMS y 316.7
distance from rec. to mc. [/cm]
dWall [/cm]
0
200
400
600
800
1000
1200
1400
−1000
−500
0
500
1000
1500
2000
2500
3000
3500
4000
0
2
4
6
8
10
12
14
16

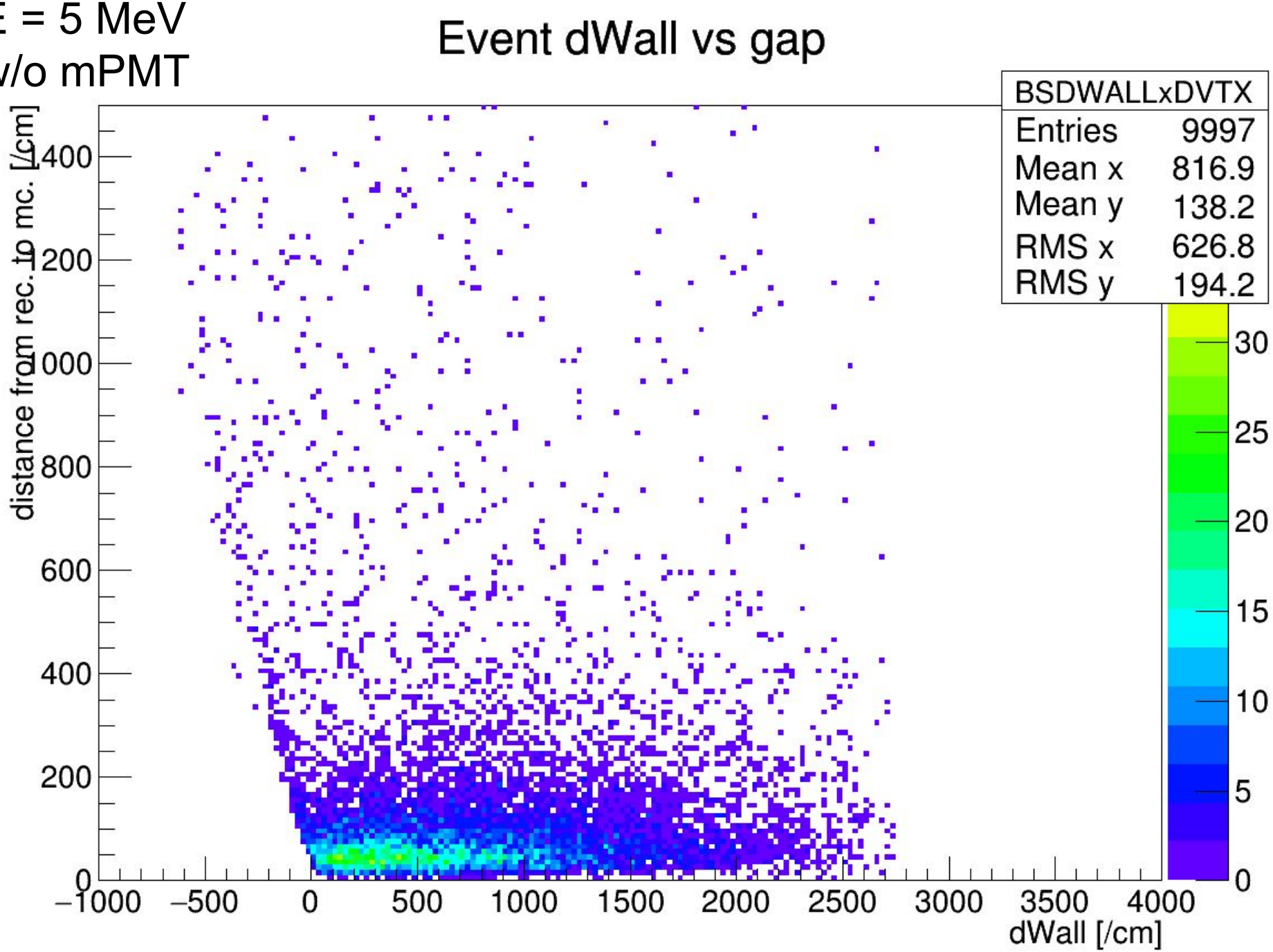
E = 4 MeV
w/o mPMT



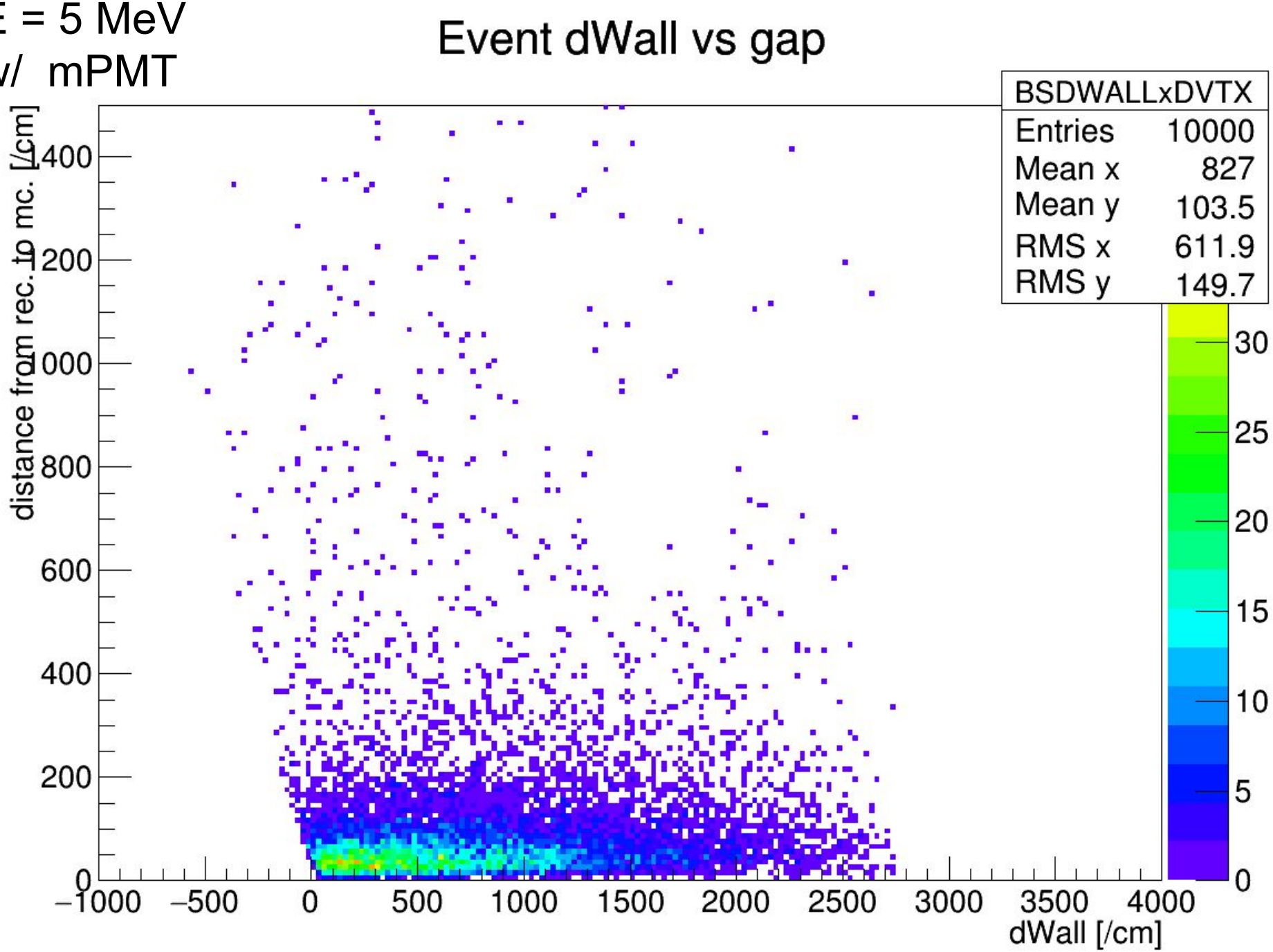
E = 4 MeV
w/ mPMT


Event dWall vs gap
BSDWALLxDVTX
Entries 9999
Mean x 832.6
Mean y 158.8
RMS x 619.7
RMS y 232.3
distance from rec. to mc. [/cm]
dWall [/cm]
0
200
400
600
800
1000
1200
1400
−1000
−500
0
500
1000
1500
2000
2500
3000
3500
4000
0
5
10
15
20
25

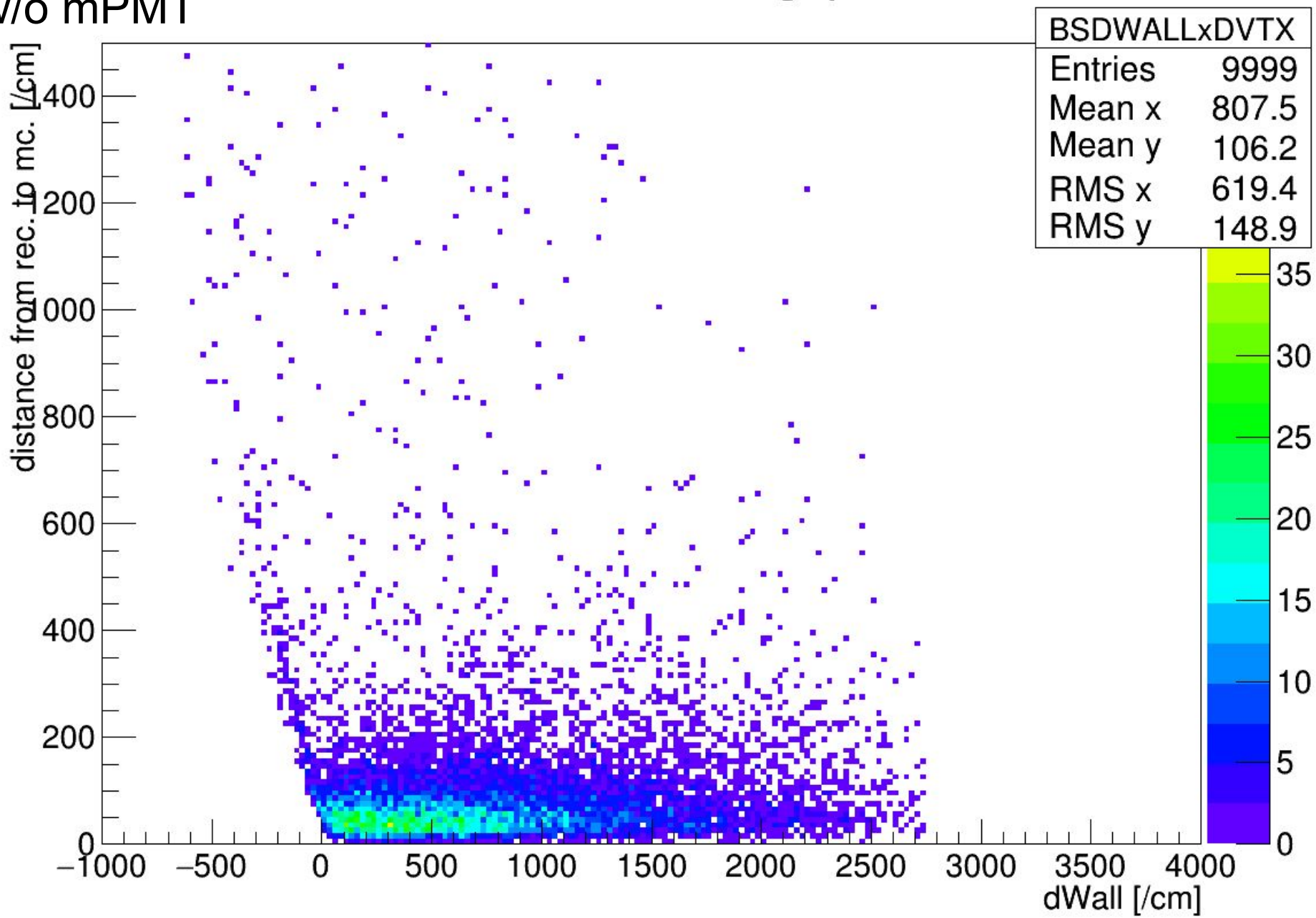
E = 5 MeV
w/o mPMT



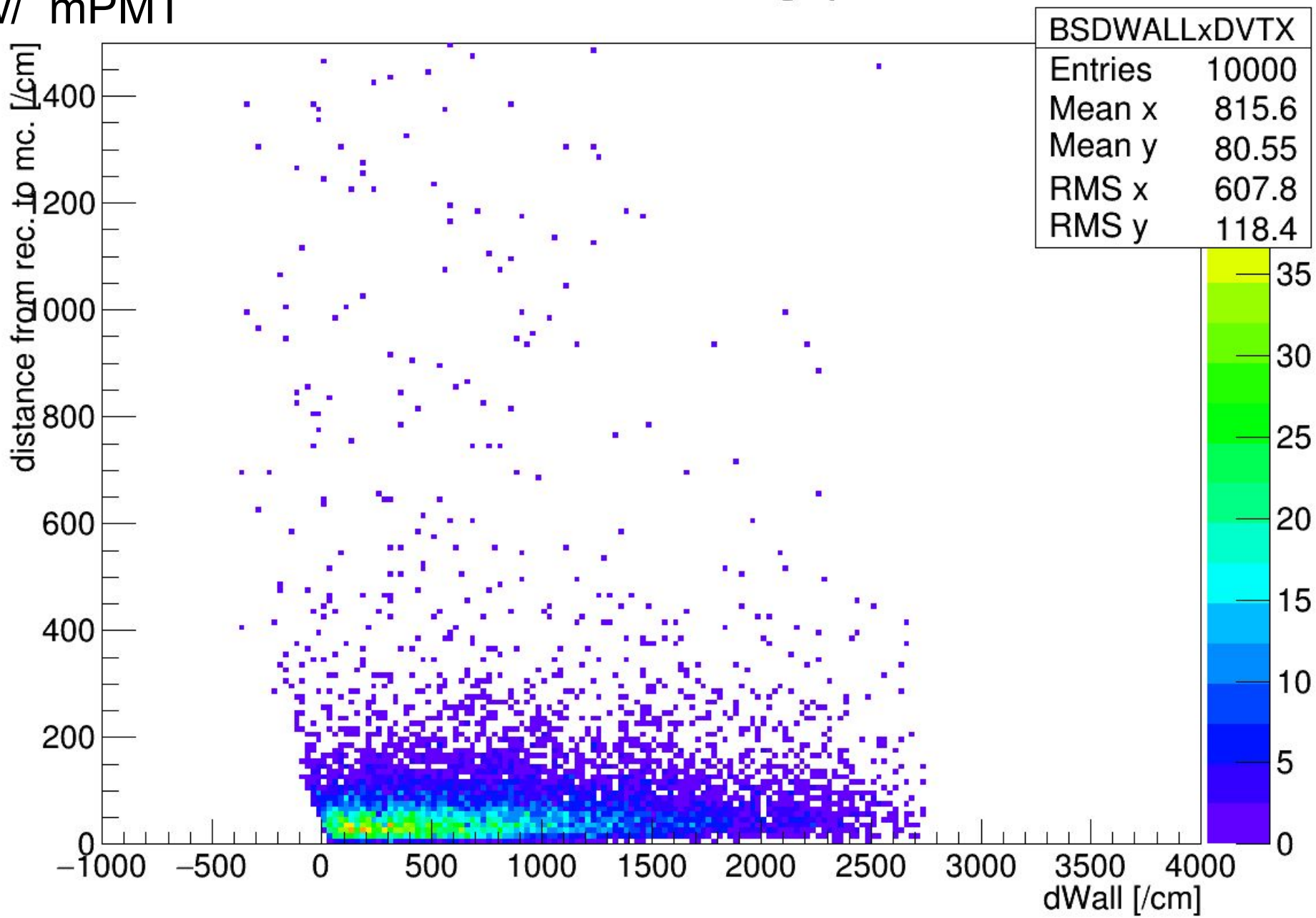
E = 5 MeV
w/ mPMT


Event dWall vs gap
BSDWALLxDVTX
Entries 10000
Mean x 827
Mean y 103.5
RMS x 611.9
RMS y 149.7
distance from rec. to mc. [/cm]
dWall [/cm]
0
200
400
600
800
1000
1200
1400
−1000
−500
0
500
1000
1500
2000
2500
3000
3500
4000
0
5
10
15
20
25
30

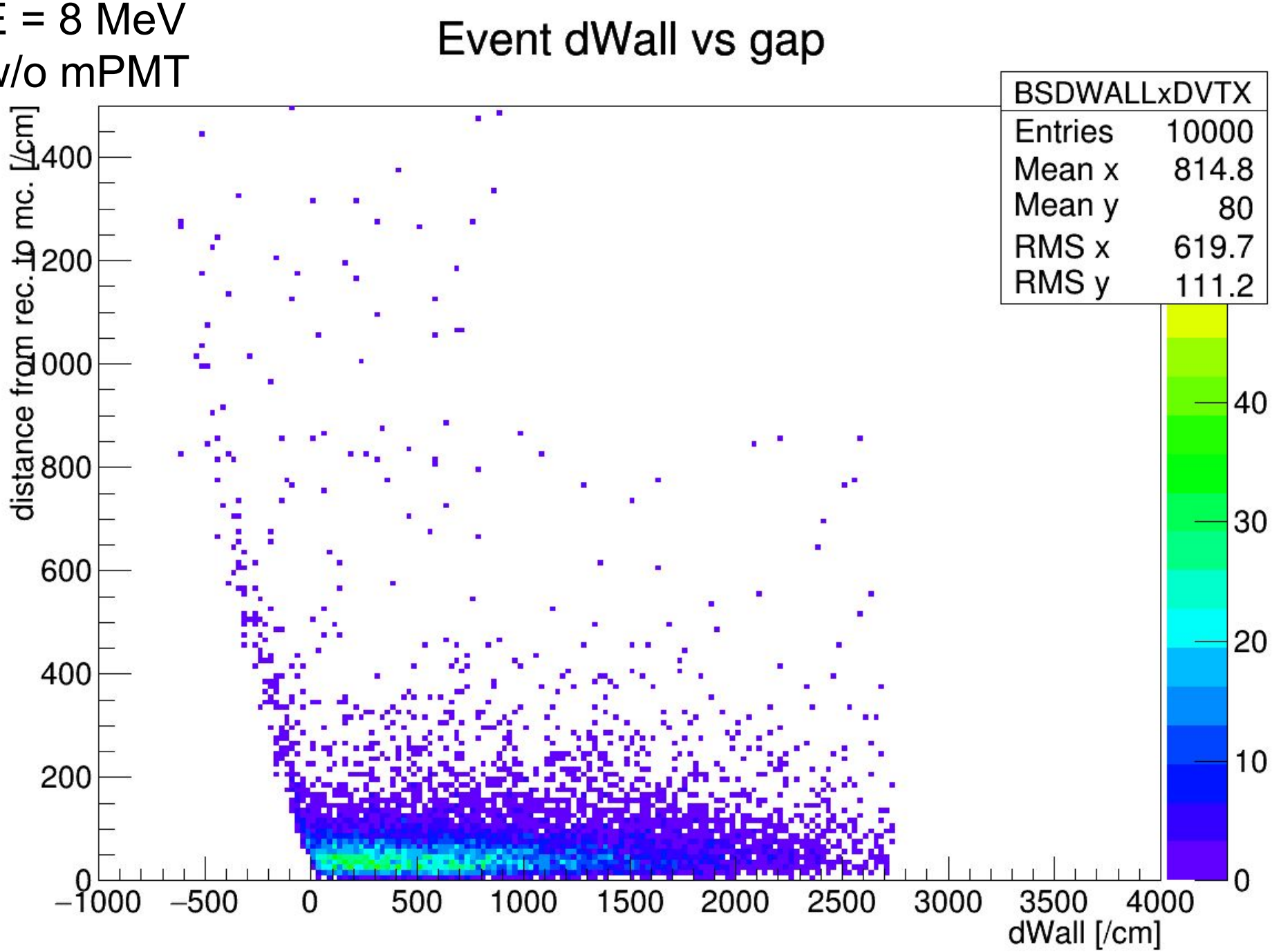
E = 6 MeV
w/o mPMT



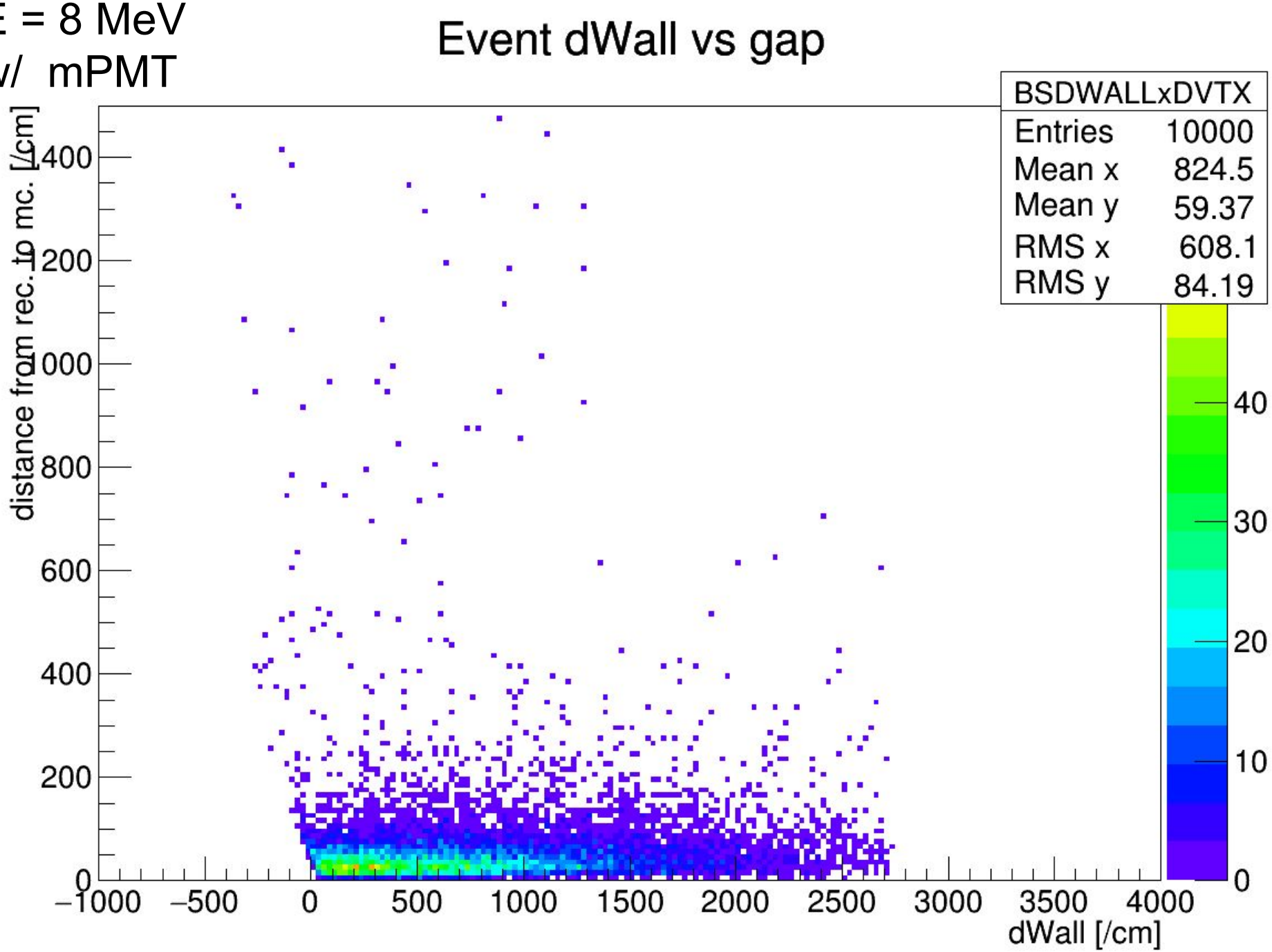
E = 6 MeV
w/ mPMT


Event dWall vs gap
BSDWALLxDVTX
Entries 10000
Mean x 815.6
Mean y 80.55
RMS x 607.8
RMS y 118.4
distance from rec. to mc. [/cm]
dWall [/cm]
0
200
400
600
800
1000
1200
1400
−1000
−500
0
500
1000
1500
2000
2500
3000
3500
4000
0
5
10
15
20
25
30
35

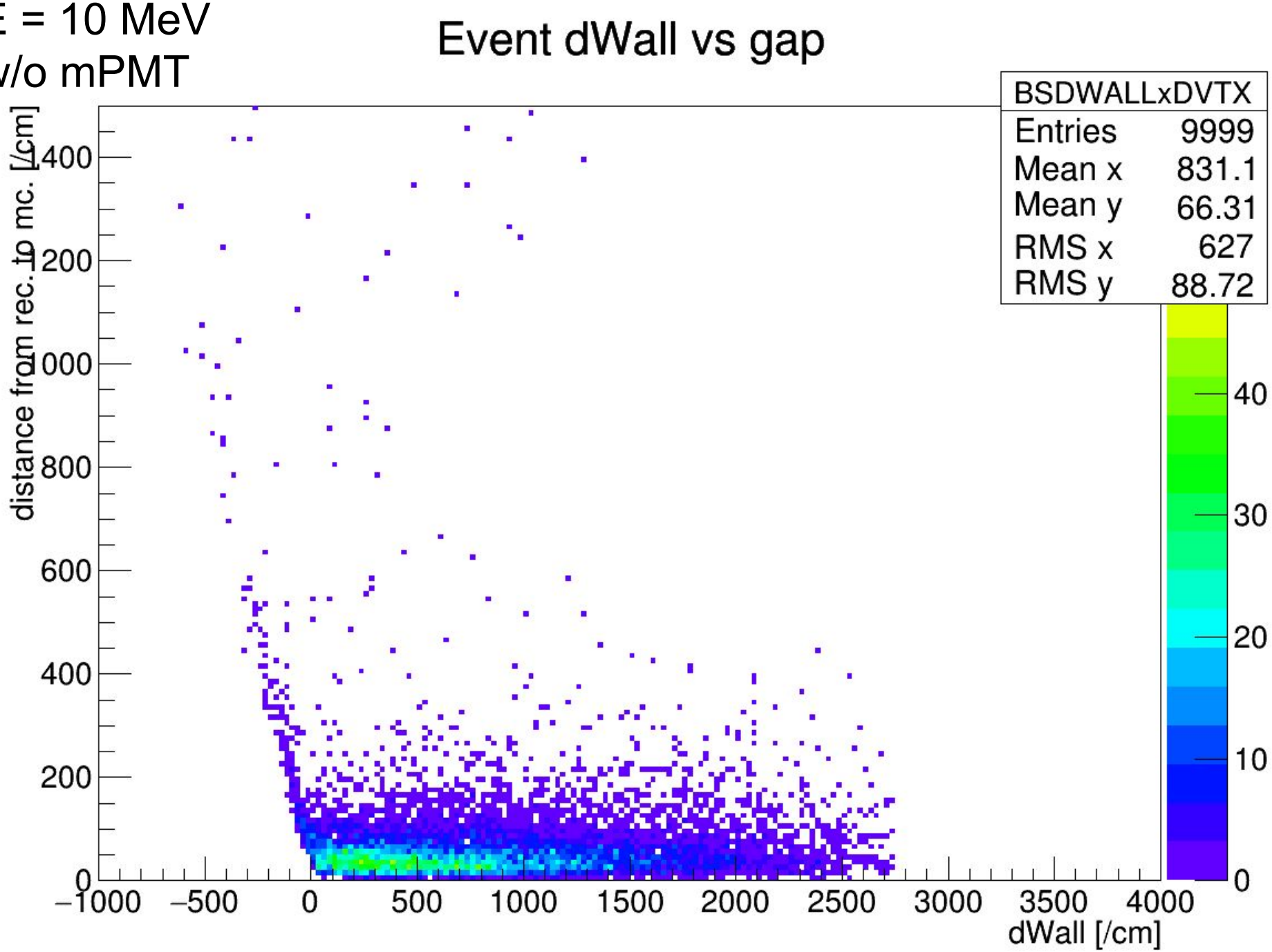
E = 8 MeV
w/o mPMT



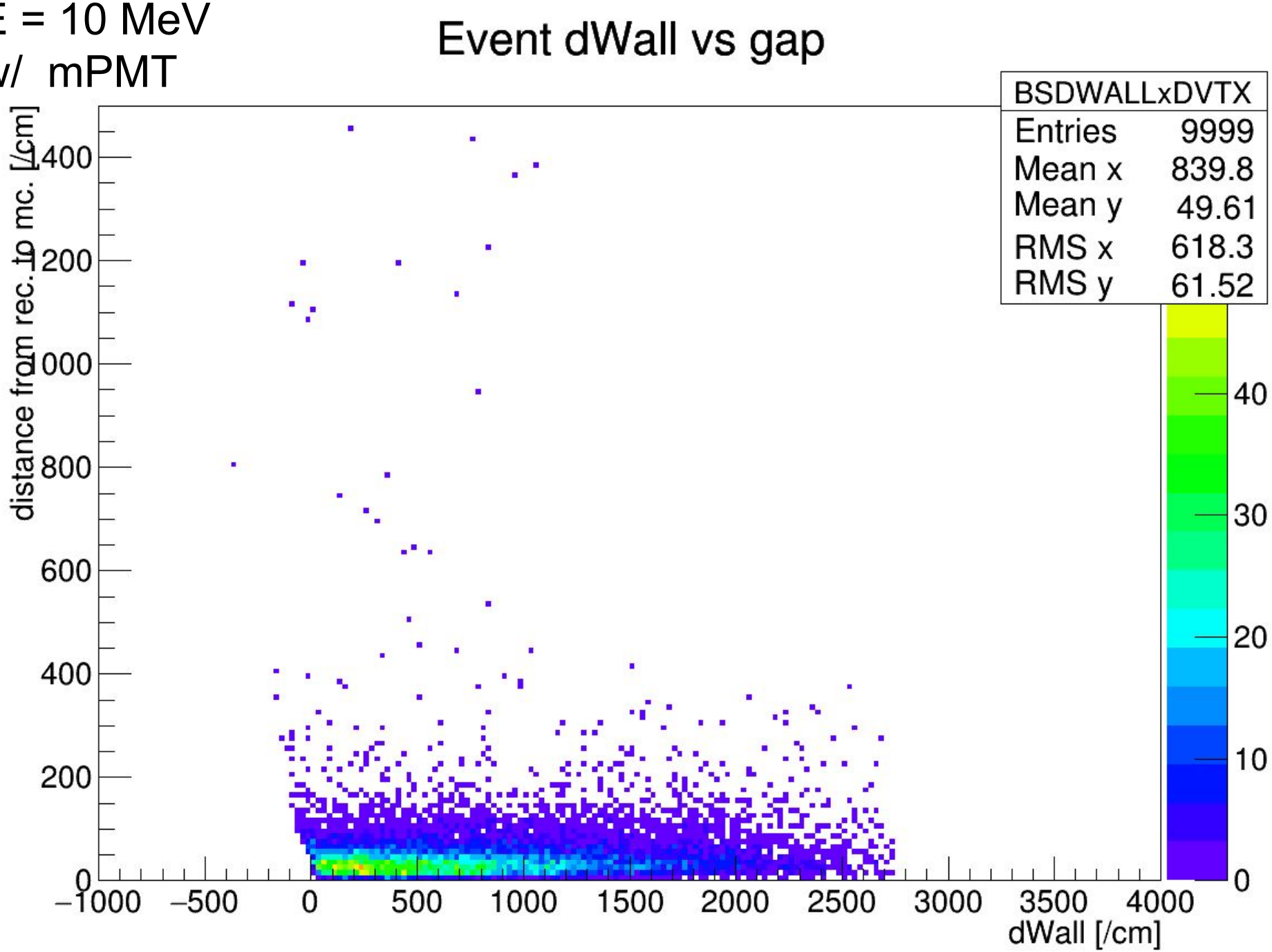
E = 8 MeV
w/ mPMT


Event dWall vs gap
BSDWALLxDVTX
Entries 10000
Mean x 824.5
Mean y 59.37
RMS x 608.1
RMS y 84.19
distance from rec. to mc. [/cm]
dWall [/cm]
0
200
400
600
800
1000
1200
1400
−1000
−500
0
500
1000
1500
2000
2500
3000
3500
4000
10
20
30
40

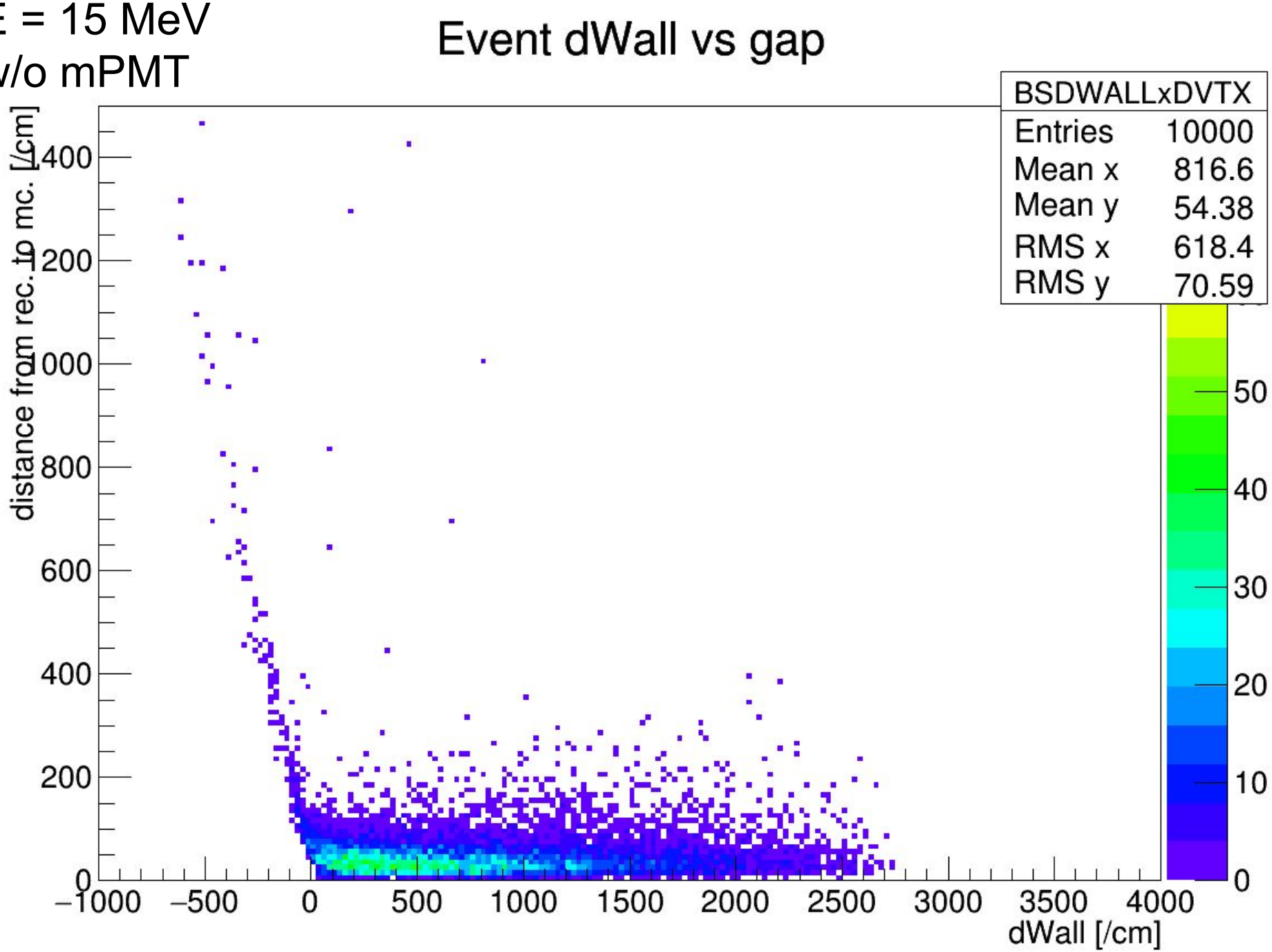
E = 10 MeV
w/o mPMT



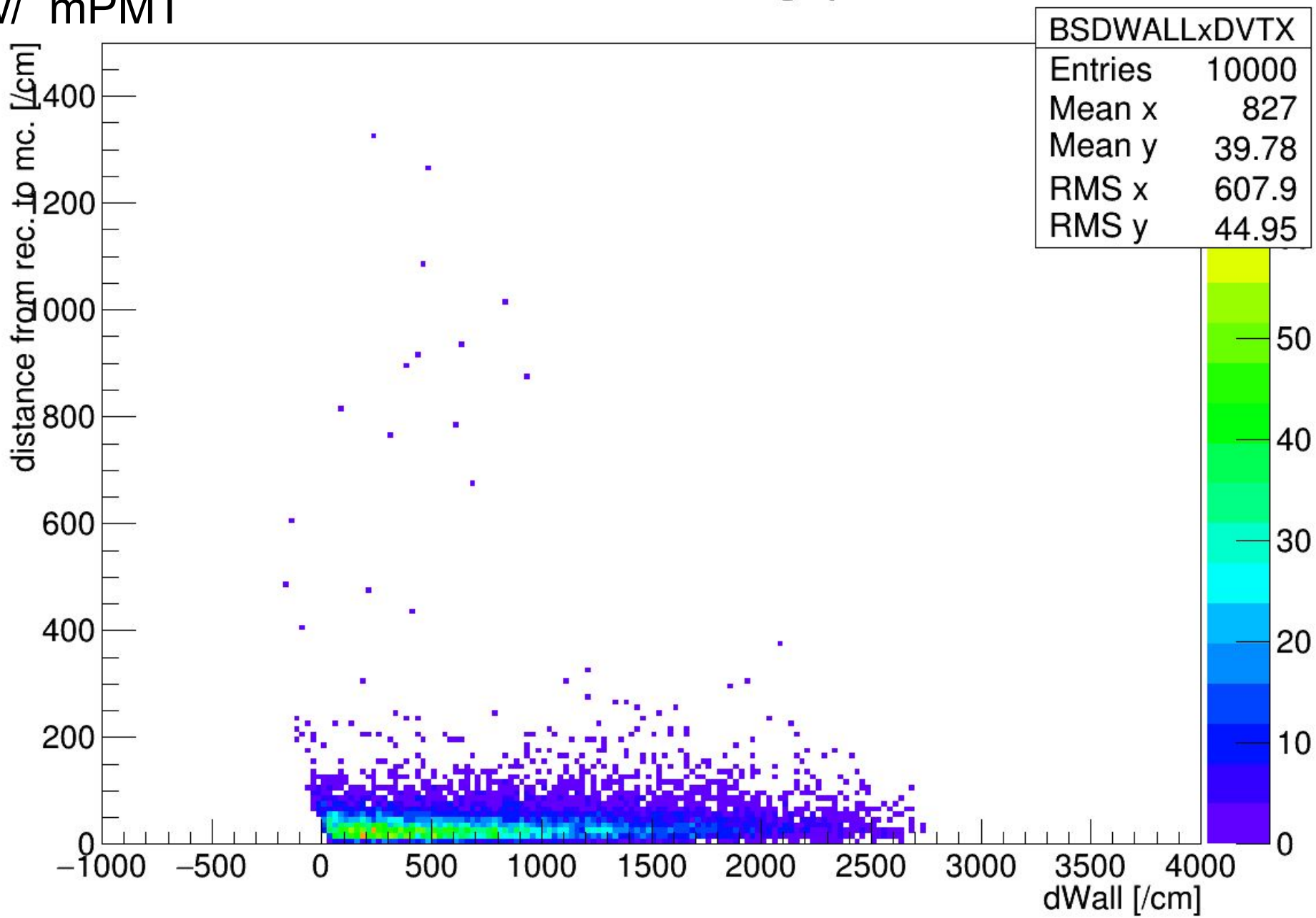
E = 10 MeV
w/ mPMT



E = 15 MeV
w/o mPMT

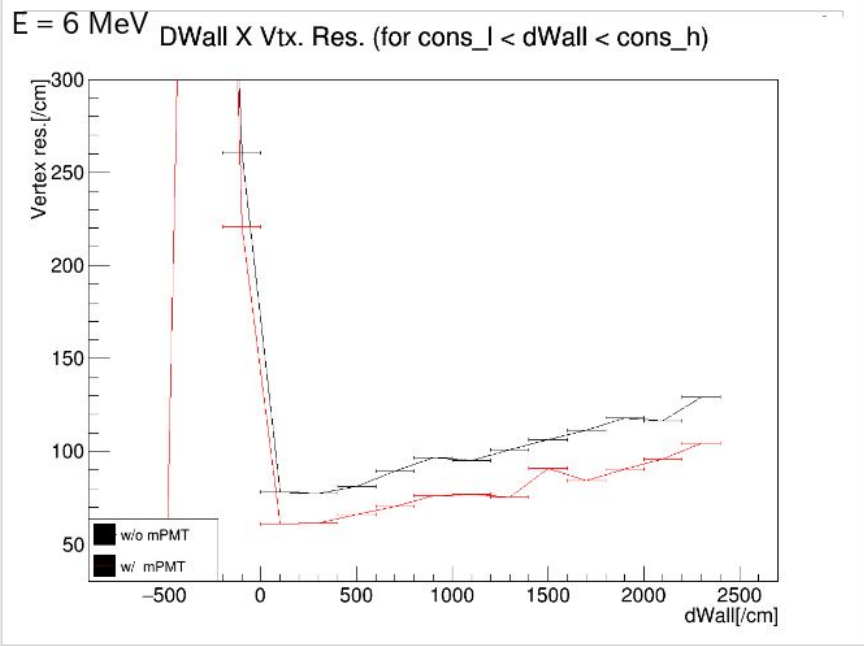


E = 15 MeV
w/ mPMT



Comments

- It looks strange because w/ mPMT configuration has better vertex resolution than one of w/o mPMT config in all dWall regions.
  - Need to check calculation codes for miss-reconstructed events fraction (however the code looks good in prompt check).
- Anyway, directional PDF is not good (reported last week, see backup) and needs modification.



Todo

- Modify the directionality PDF
- Re-fitting and check improvements of miss-reconstructed events fraction.

n-tagging

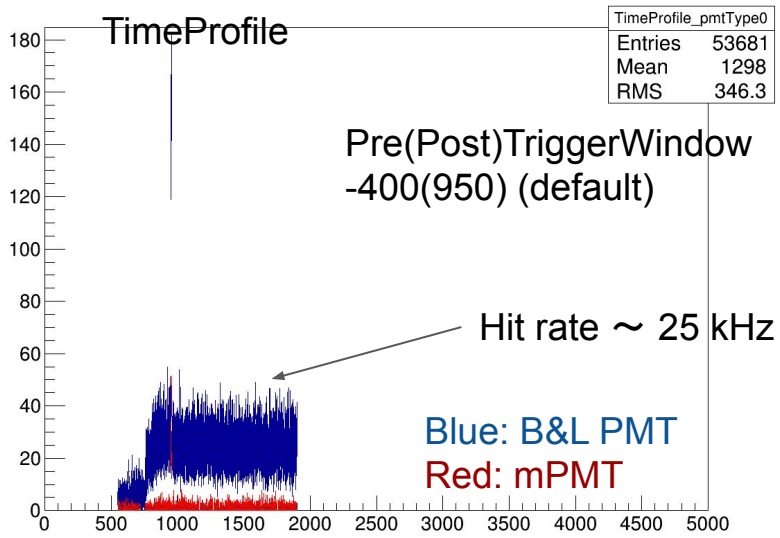
Todo

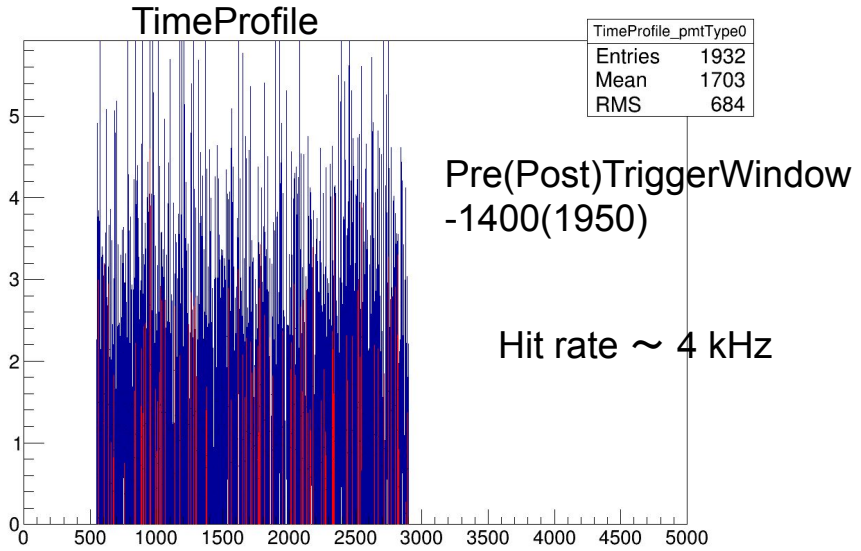
- Generate MC:
  - It is needed to expand timing window of generated events because neutron capture time is about 200 us. → I expanded the timing window of dark hits and digitizer.
- Search vertex of 2.2 MeV gamma

→ I modified configuration and WCSim to expand the timing window and then confirmed that.

Expand timing window

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

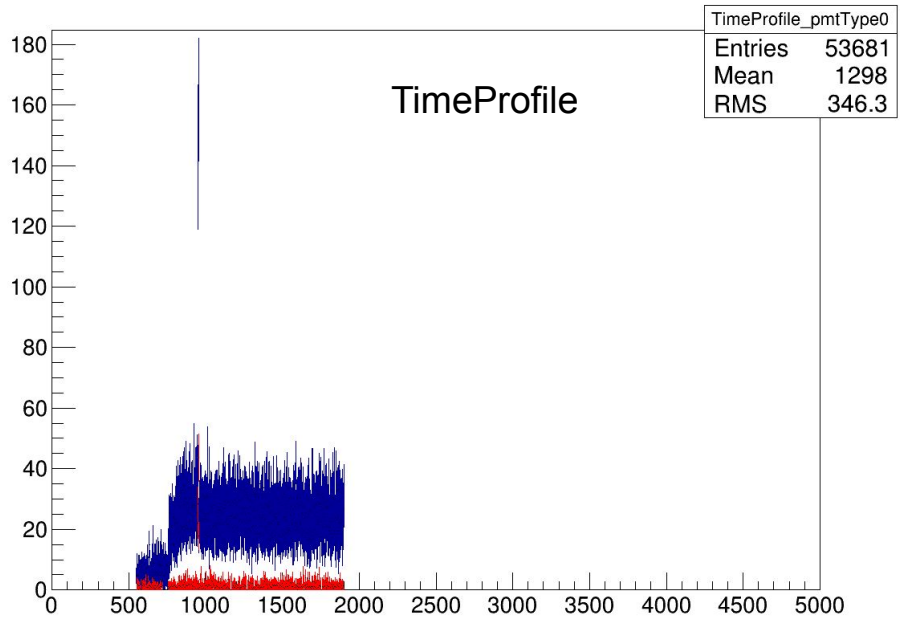


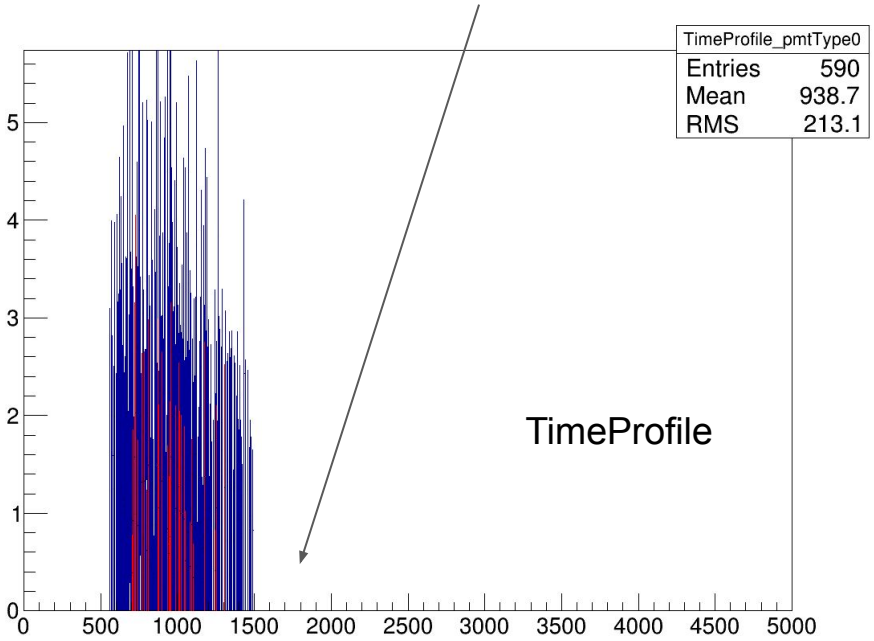


Expand timing window (cont.)

- Changed mac files
  - /DarkRate/SetDarkWindow 500000 → 500
  - → # of hit PMT is decreased
  - Below histograms have 10 events of 2.2 MeV gamma-ray
  - Dark rate window can be changed through mac-file.

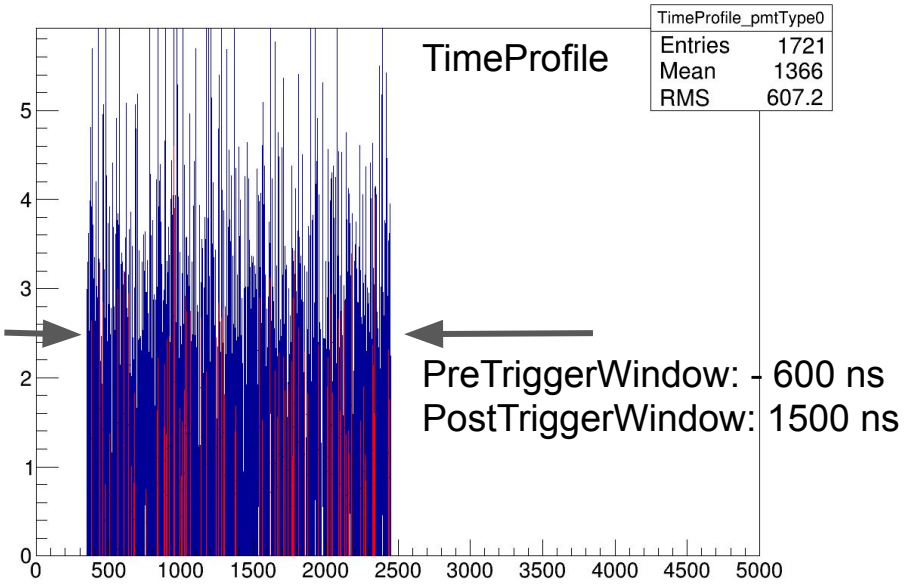
There are no hits around 1700 ns.





Expand timing window (cont.)

- Changed WCSim source codes
  - WCSimWCTrigger.cc: GetPre(Post)TriggerWindow(...);
  - I succeeded to expand trigger time window (below plot)
  - However I could not see any significant peak associated with 2.2 MeV gamma-ray. Is it reasonable?



Todo

- Generate MC:
  - It is needed to expand timing window of generated events because neutron capture time is about 200 us. → I expanded the timing window of dark hits and digitizer. → **OK**
  - Production of MC (plan 1):
    - Expand trigger time window and dark rate window → [0, 1000us] (5 x capture time)
    - Generate 2.2 MeV gamma through position listed files not “gps” (particle generator) because gps cannot emit some particles at random timing. Can I generate the particle randomly in timing?
  - Production of MC (plan2):
    - I heard that Okajima-san and Harada-san studied n-tagging and they prepared signal (2.2MeV gamma) and dark hits separately. I will ask Harada-san in detail.
- Search vertex of 2.2 MeV gamma
  - Try reconstruction of 2.2 MeV gamma with “FitVertexLE” developed by Benjamin-san and evaluate reconstruction efficiency.

```
128  ## select the input nuance-formatted vector file
129  ## you can of course use your own
130  #/mygen/generator muline
131  #/mygen/vecfile inputvectorfile
132  #/mygen/vecfile h2o.2km.001-009x3_G4.kin
133  #/mygen/vecfile mu+.out
```

from “WCSim.mac”

Backup

I checked …

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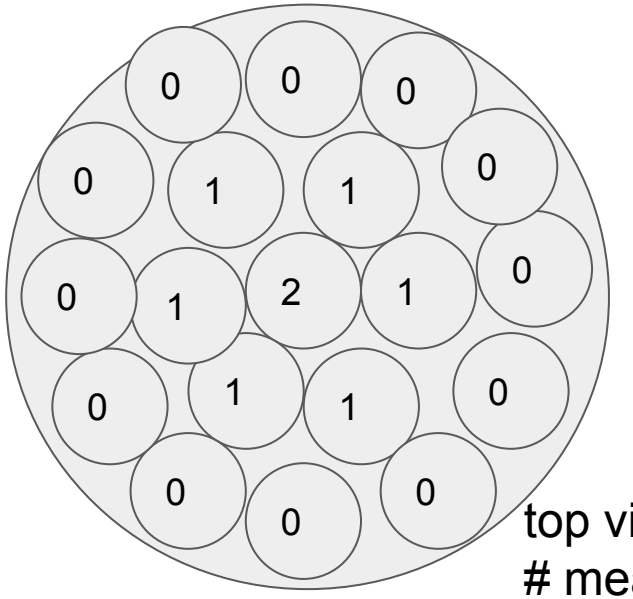
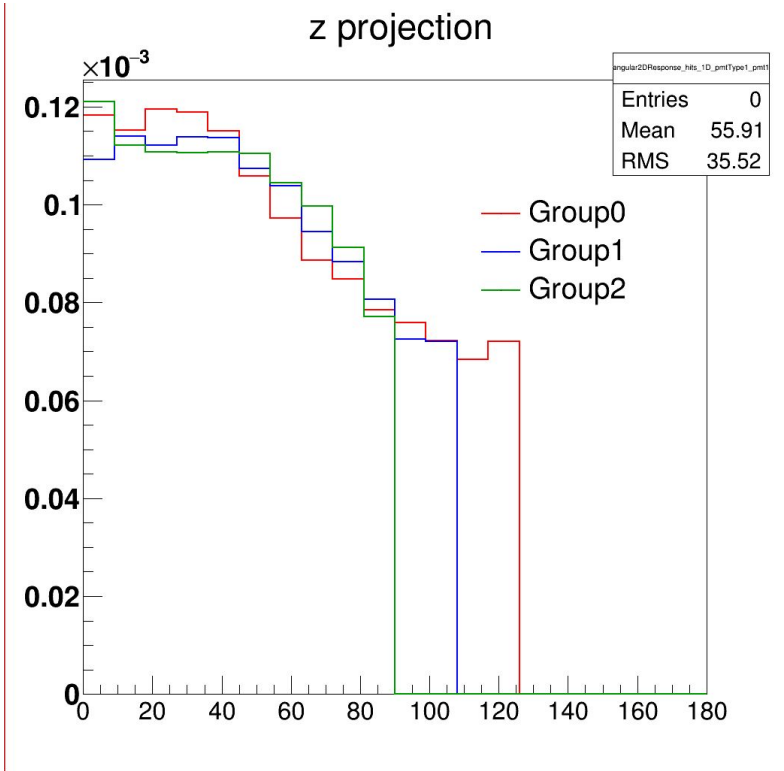
- “findNLLDirectionality(...)”: function giving negative log likelihood of PMT direction information
  - There are non-initialized “pmt_number_in_mpmt” for the direction information. → I added this parameter to the hits information.
  - However this change did not change the result.
- “hPMTDirectionality_1D”: PDF giving NLL for each PMT group in mPMT (right fig.)
  - Does this make sense?
- 

top view of mPMT
means groups



I checked … (cont.)

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- Disabled “useDirectionality”: flag to use “findNLLDirectionality(...)”
  - w/ mPMT: 43/966=0.0445 (0.059 enabled)
  - w/o mPMT: 43/966=0.0445
  - ↑ 10 MeV
  - → The result w/o directionality got better.
  - Direction information is not used correctly?