pXp analysis

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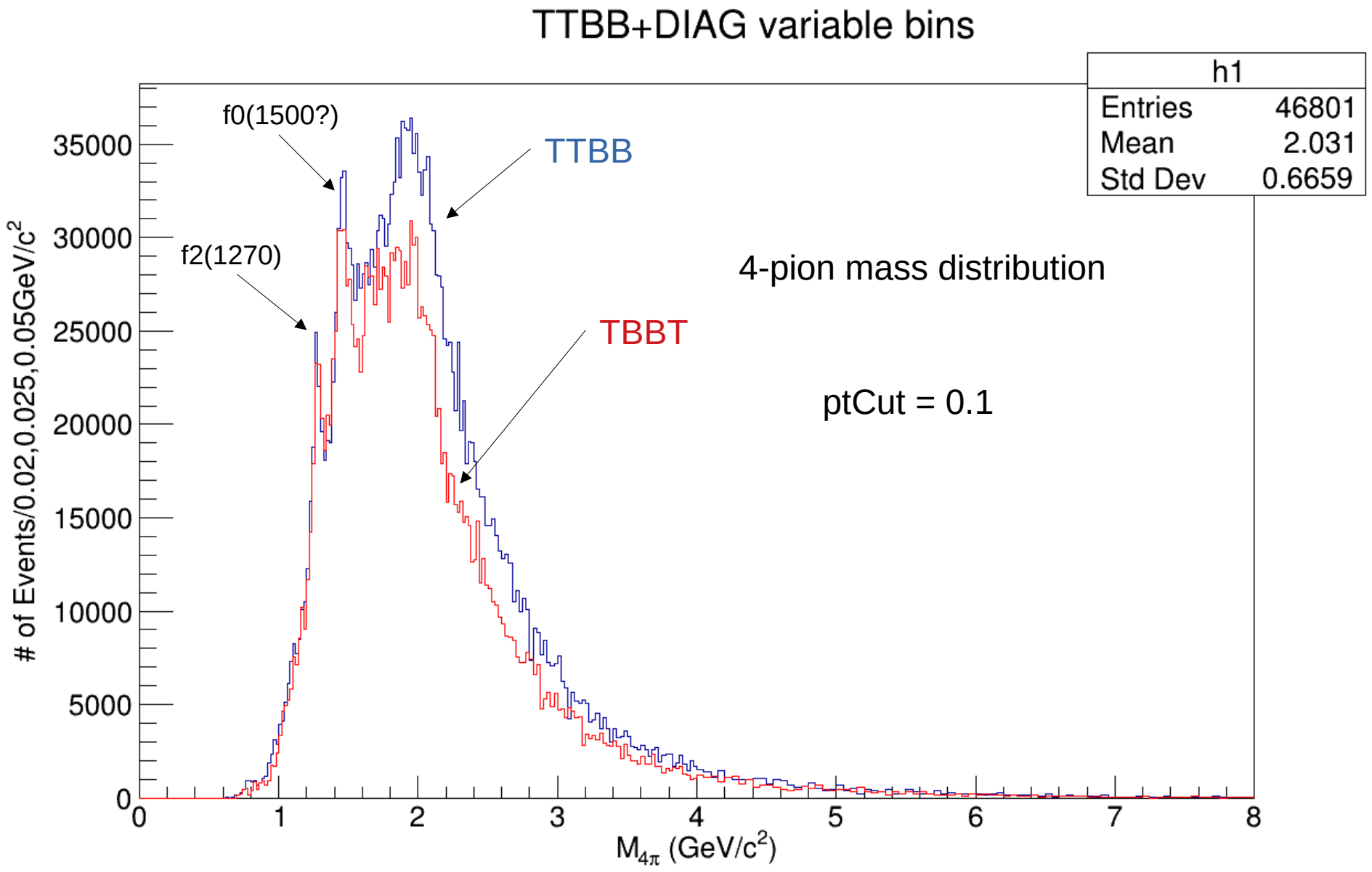
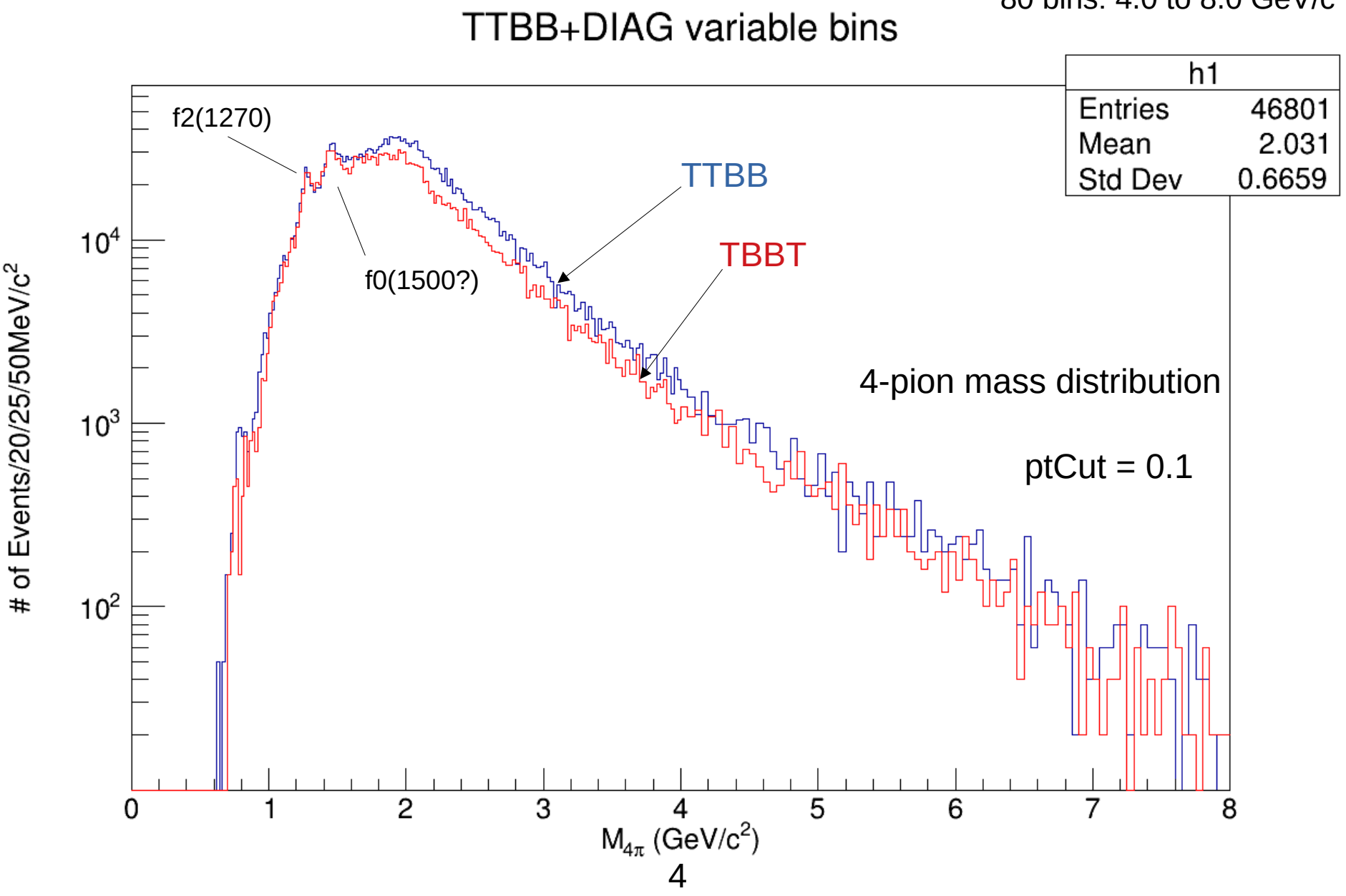
Overview

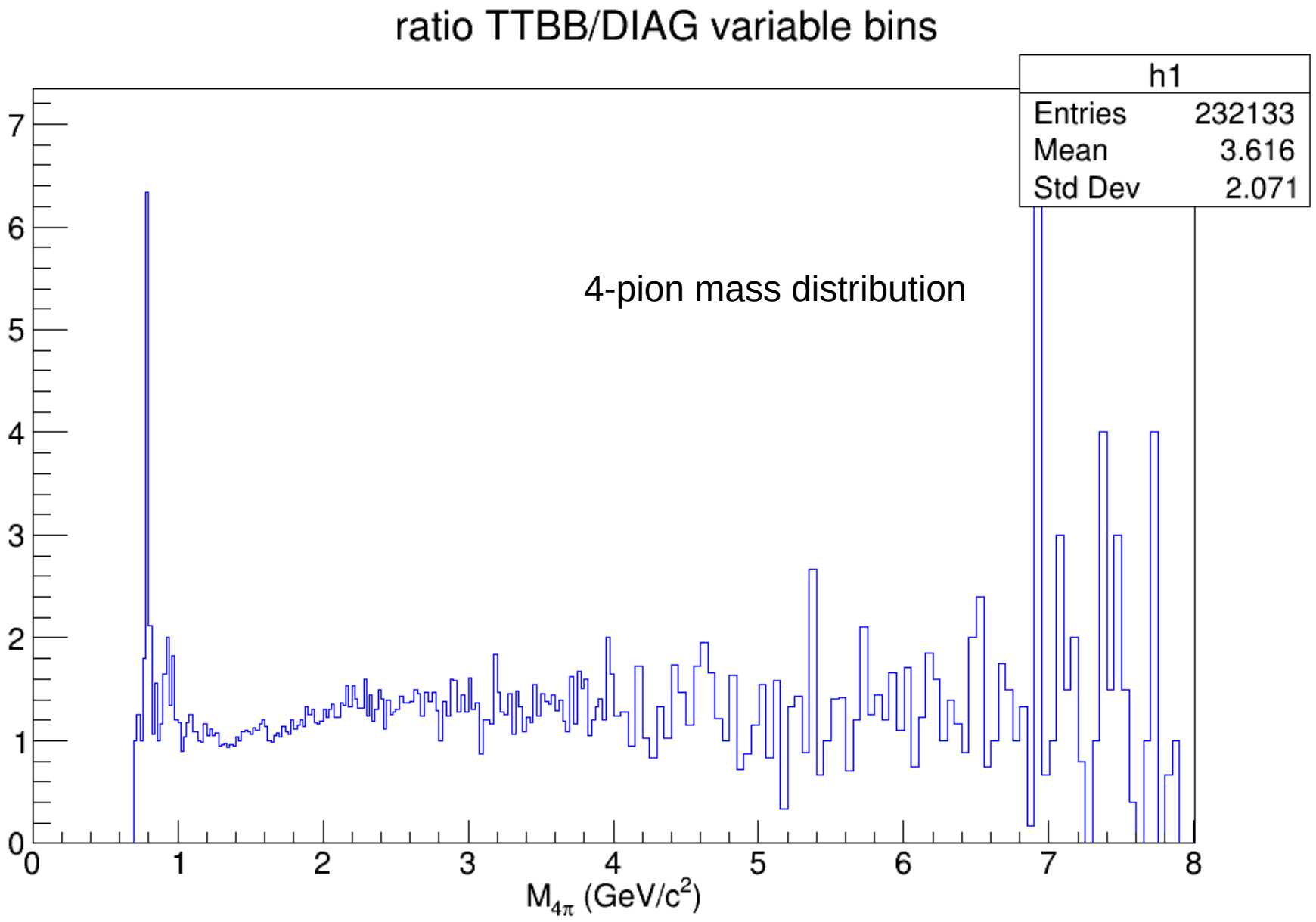
- 4-track 2015 sample
- 4-pion mass distribution using PID
- ratio TTBB/DIAG: spike
- transverse x and y position of the vertex
- understanding the vertex collection
- looking for the secondary vertex for the K-shorts: MyKshorts class
- Kshort collection
- Kshort mass distribution
- Kshort x, y, z, pt, eta, phi
- Kshort lifetime
- Lambda collection

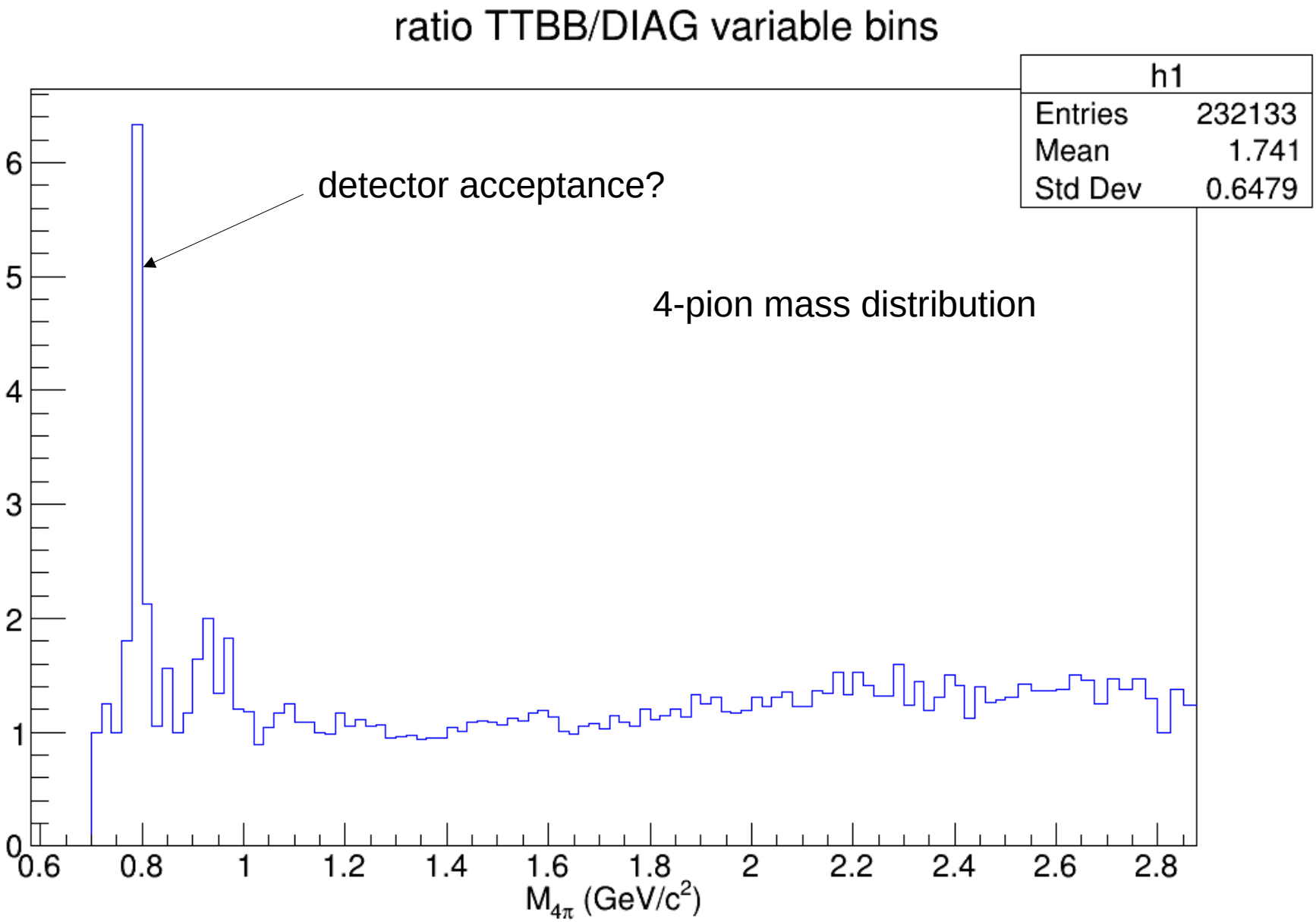

TTBB+DIAG variable bins
h1
Entries 46801
Mean 2.031
Std Dev 0.6659
f0(1500?)
f2(1270)
TTBB
TBBT
4-pion mass distribution
ptCut = 0.1
# of Events/0.02,0.025,0.05GeV/c²
M4π (GeV/c²)
0
5000
10000
15000
20000
25000
30000
35000
0
1
2
3
4
5
6
7
8

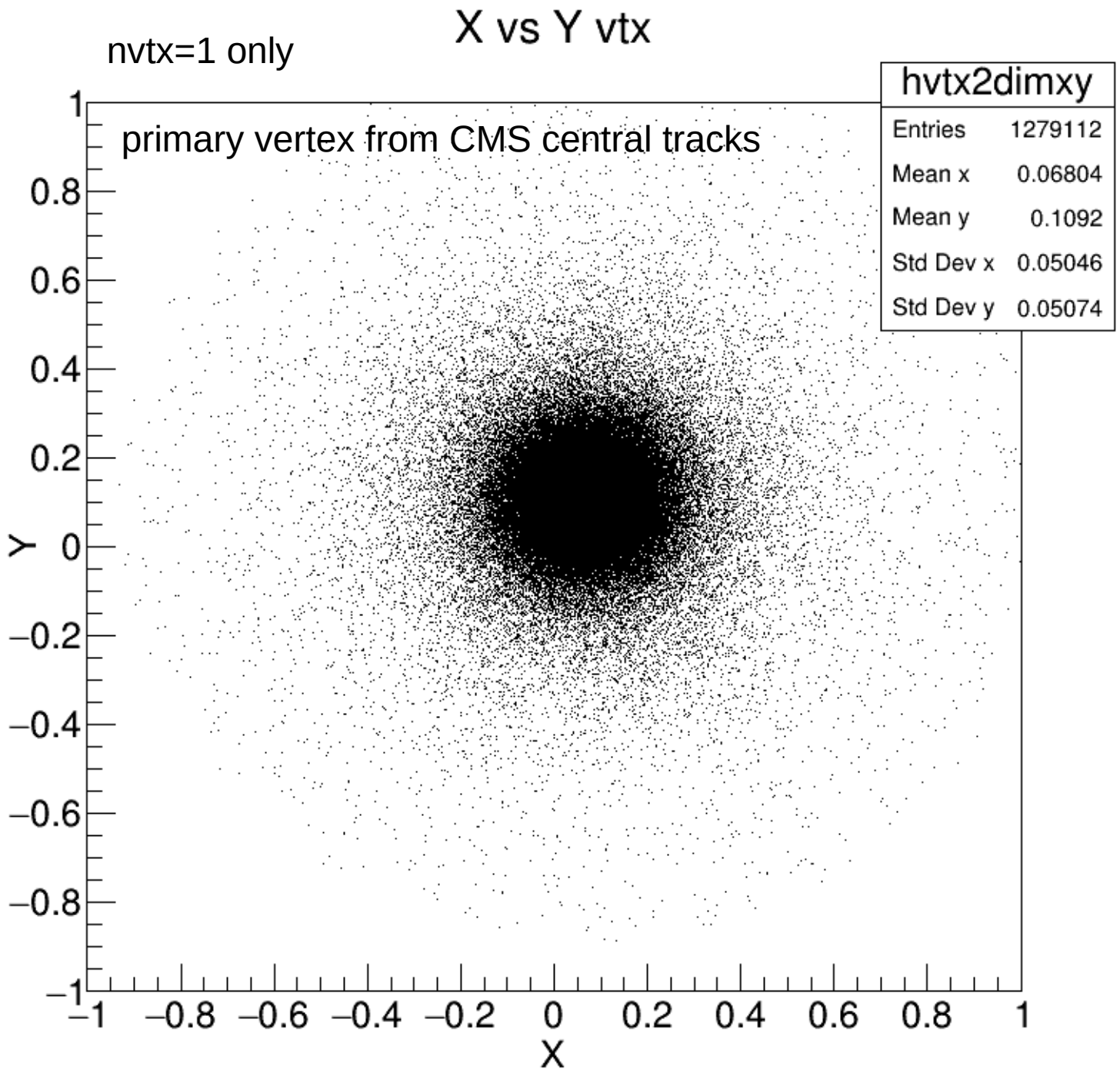
cut 2, Q=0

125 bins: 0.0 to 2.5 GeV/c²
60 bins: 2.5 to 4.0 GeV/c²
80 bins: 4.0 to 8.0 GeV/c²

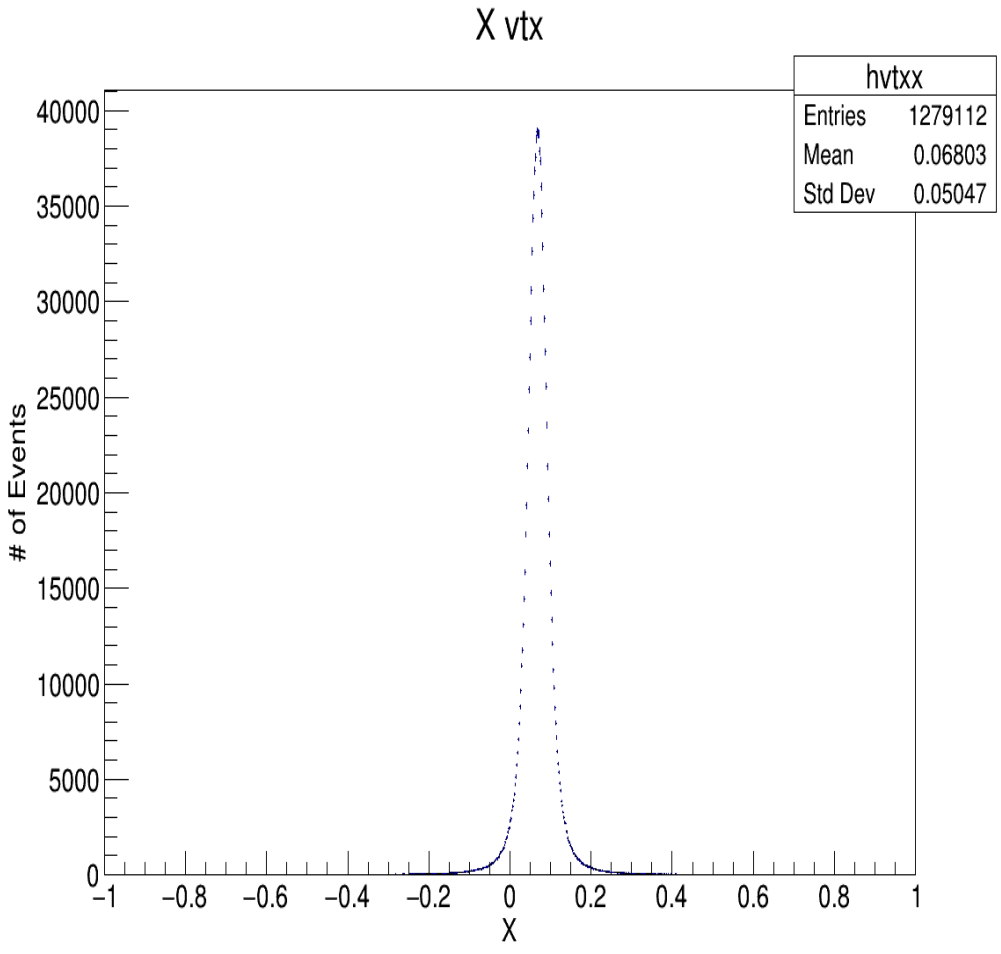


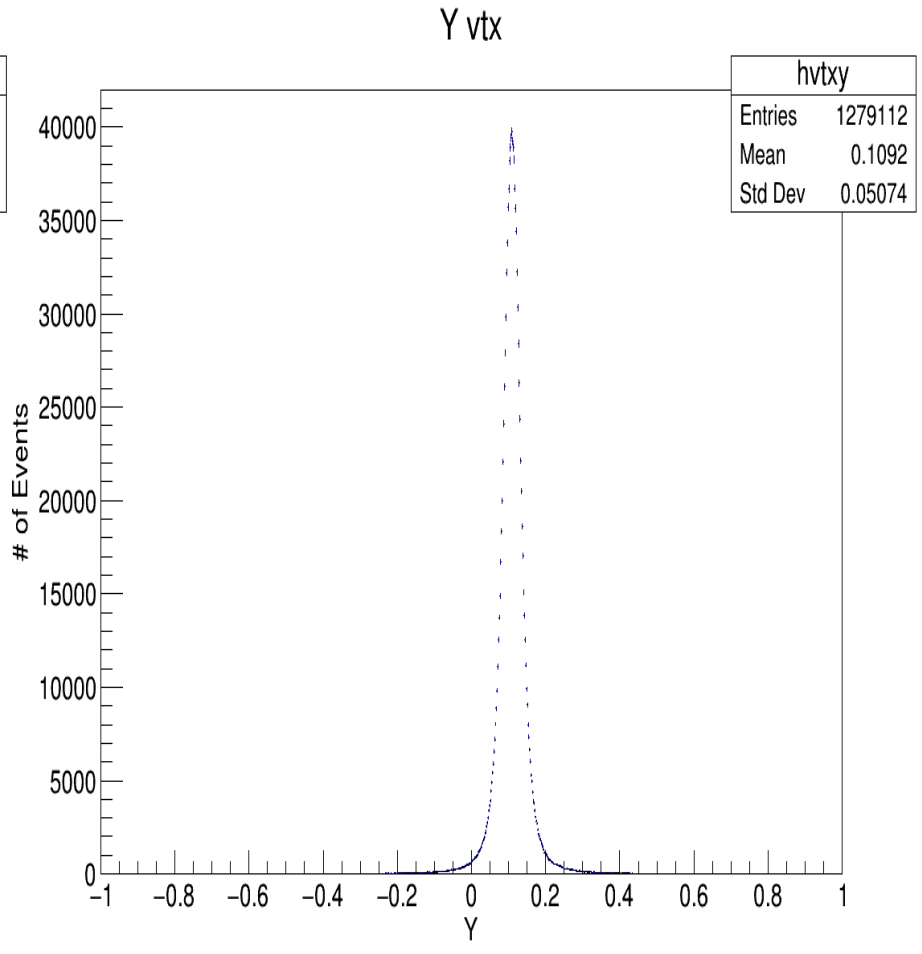

ratio TTBB/DIAG variable bins
h1
Entries 232133
Mean 3.616
Std Dev 2.071
4-pion mass distribution
0
1
2
3
4
5
6
7
8
$M_{4\pi}$ (GeV/c^2)

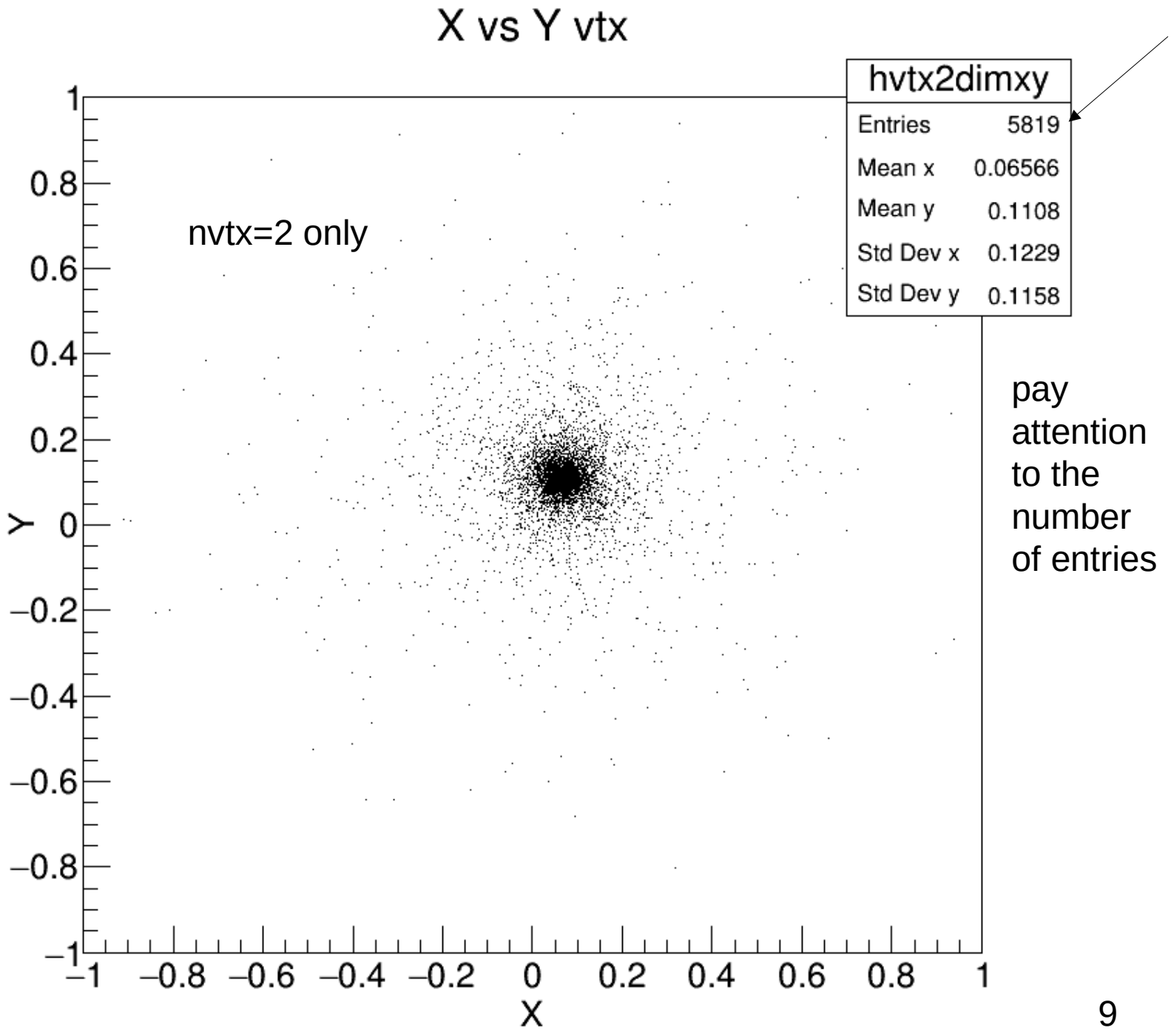

ratio TTBB/DIAG variable bins
h1
Entries 232133
Mean 1.741
Std Dev 0.6479
detector acceptance?
4-pion mass distribution
0
1
2
3
4
5
6
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
$M_{4\pi}$ (GeV/c^2)


X vs Y vtx
nvtx=1 only
primary vertex from CMS central tracks
hvtx2dimxy
Entries 1279112
Mean x 0.06804
Mean y 0.1092
Std Dev x 0.05046
Std Dev y 0.05074
Y
X
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1

nvtx=1 only

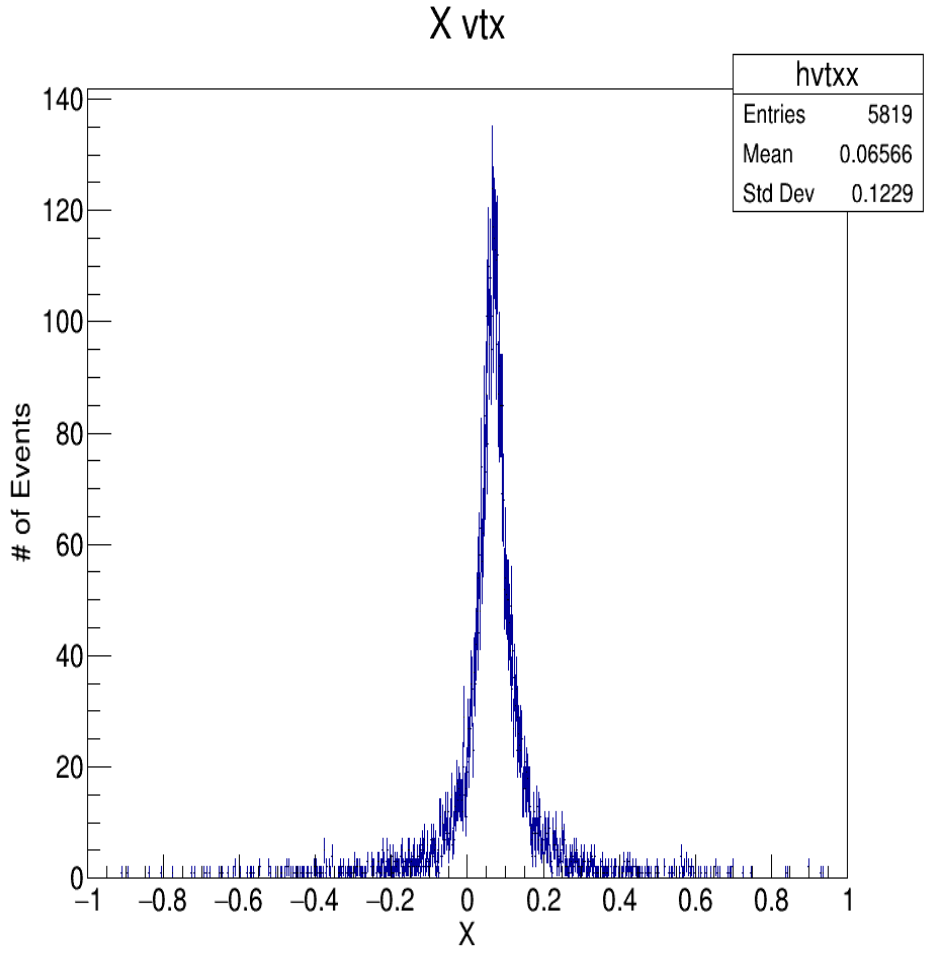

X vtx
hvtxx
Entries 1279112
Mean 0.06803
Std Dev 0.05047
# of Events
X
40000
35000
30000
25000
20000
15000
10000
5000
0
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1

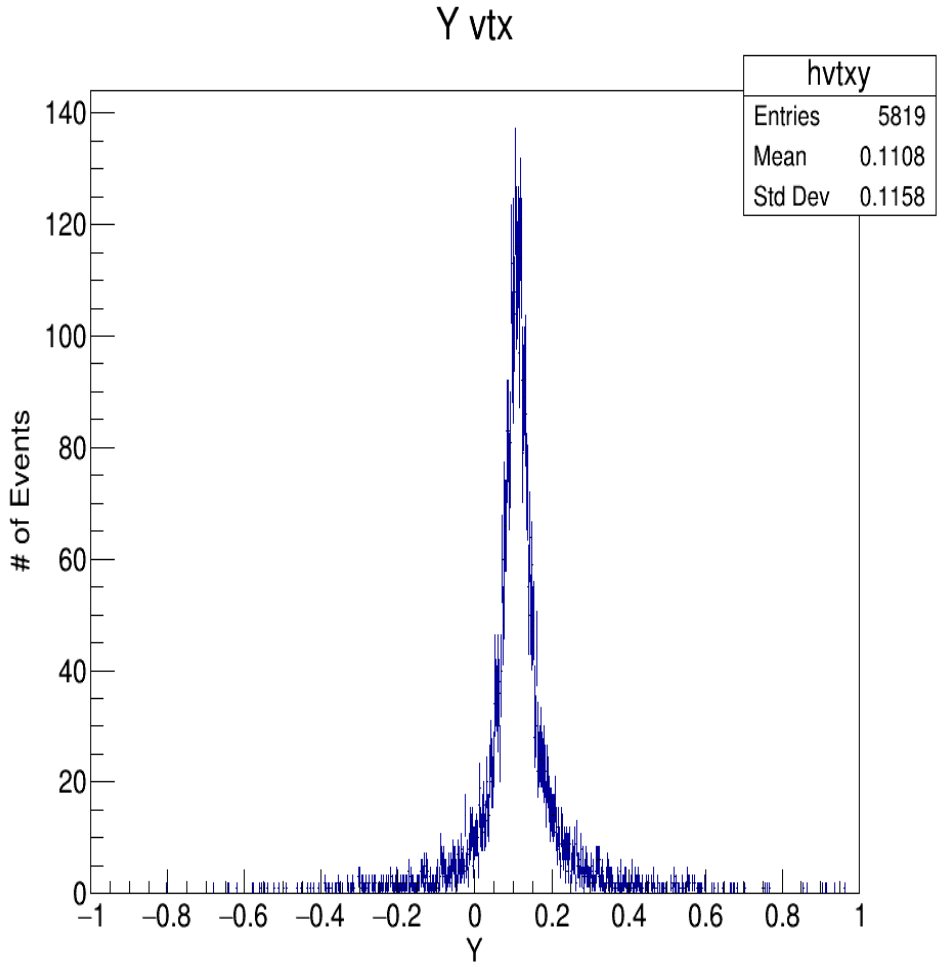

Y vtx
hvtxy
Entries 1279112
Mean 0.1092
Std Dev 0.05074
# of Events
Y
40000
35000
30000
25000
20000
15000
10000
5000
0
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1

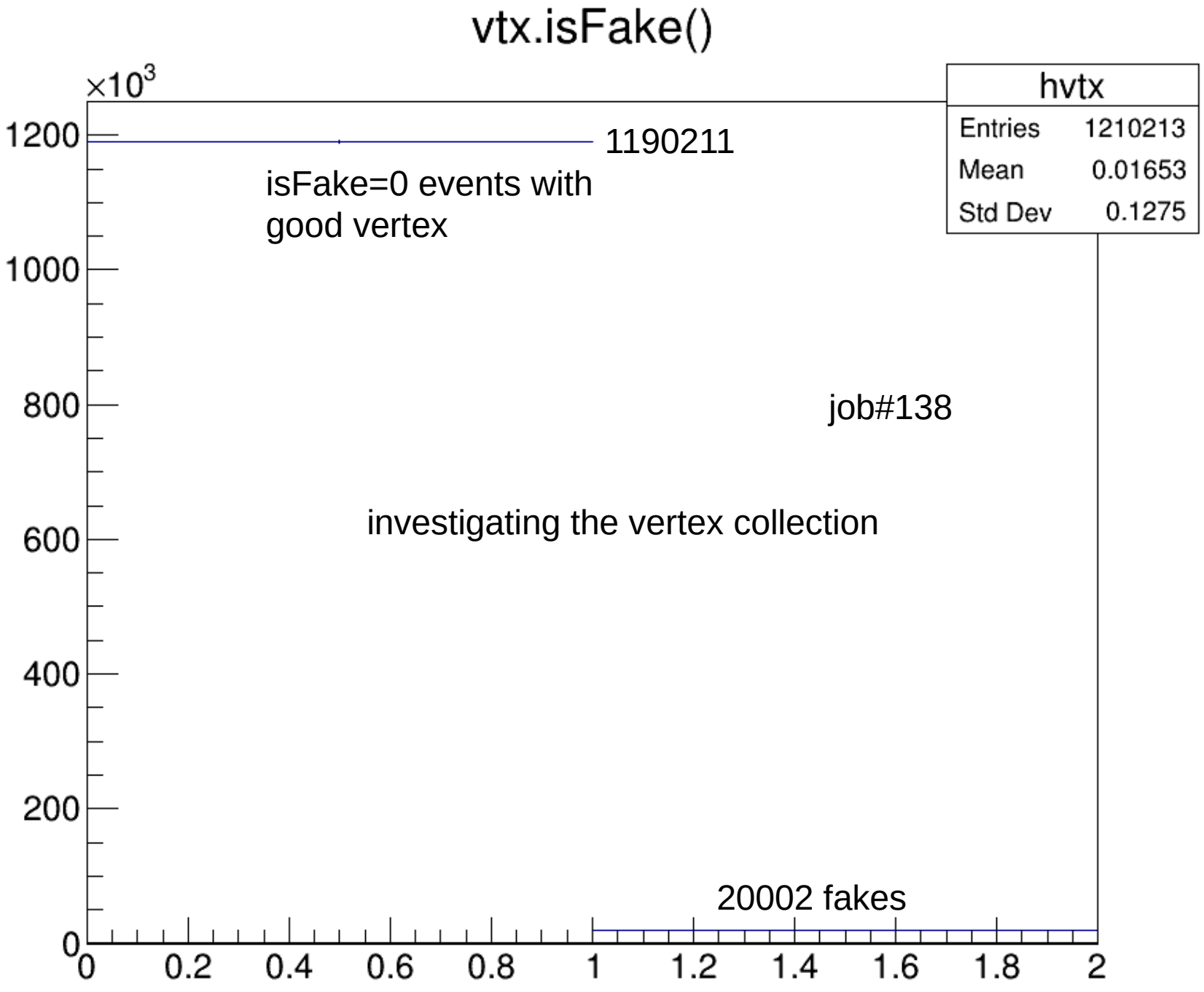

X vs Y vtx
hvtx2dimxy
Entries 5819
Mean x 0.06566
Mean y 0.1108
Std Dev x 0.1229
Std Dev y 0.1158
nvtx=2 only
pay attention to the number of entries
X
Y
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1

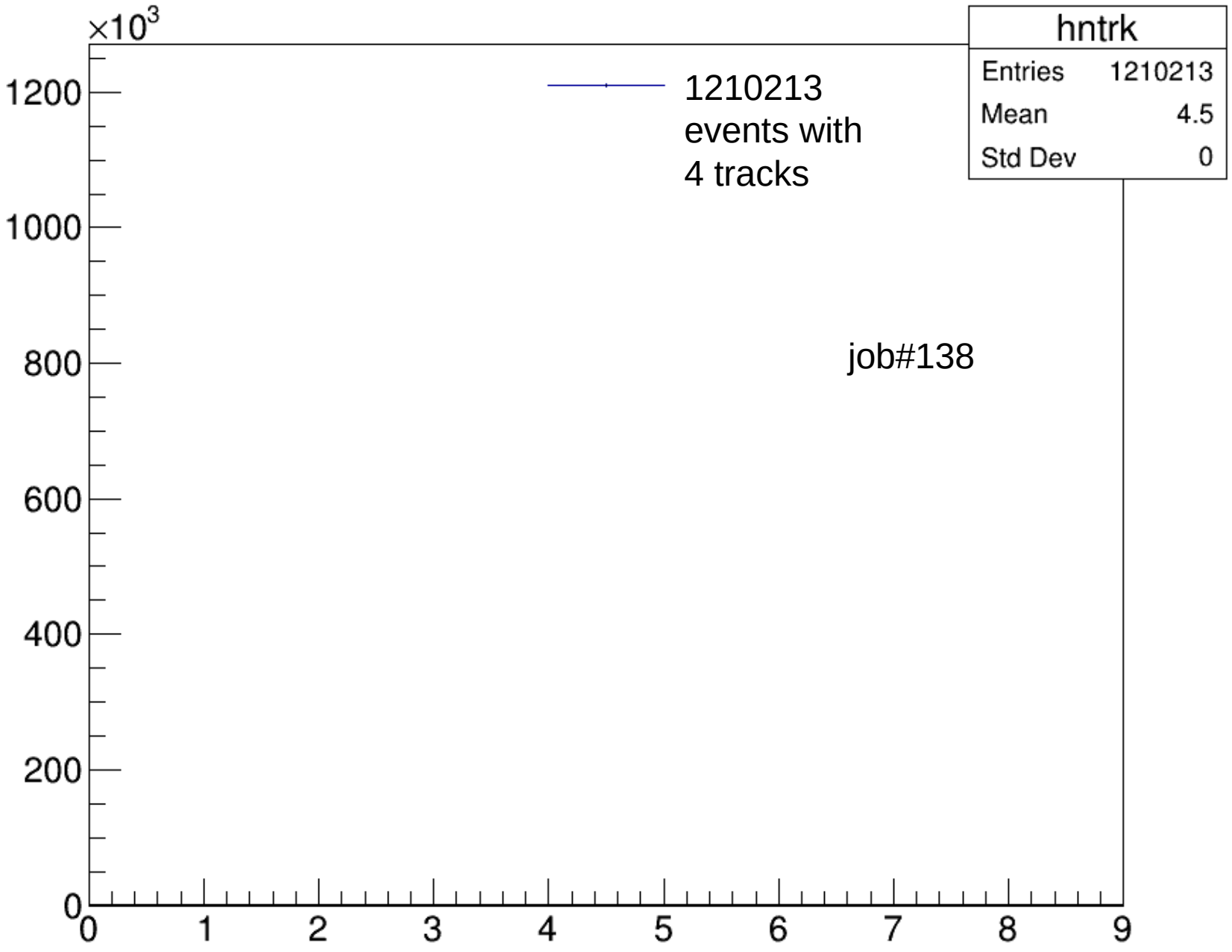
nvtx=2 only

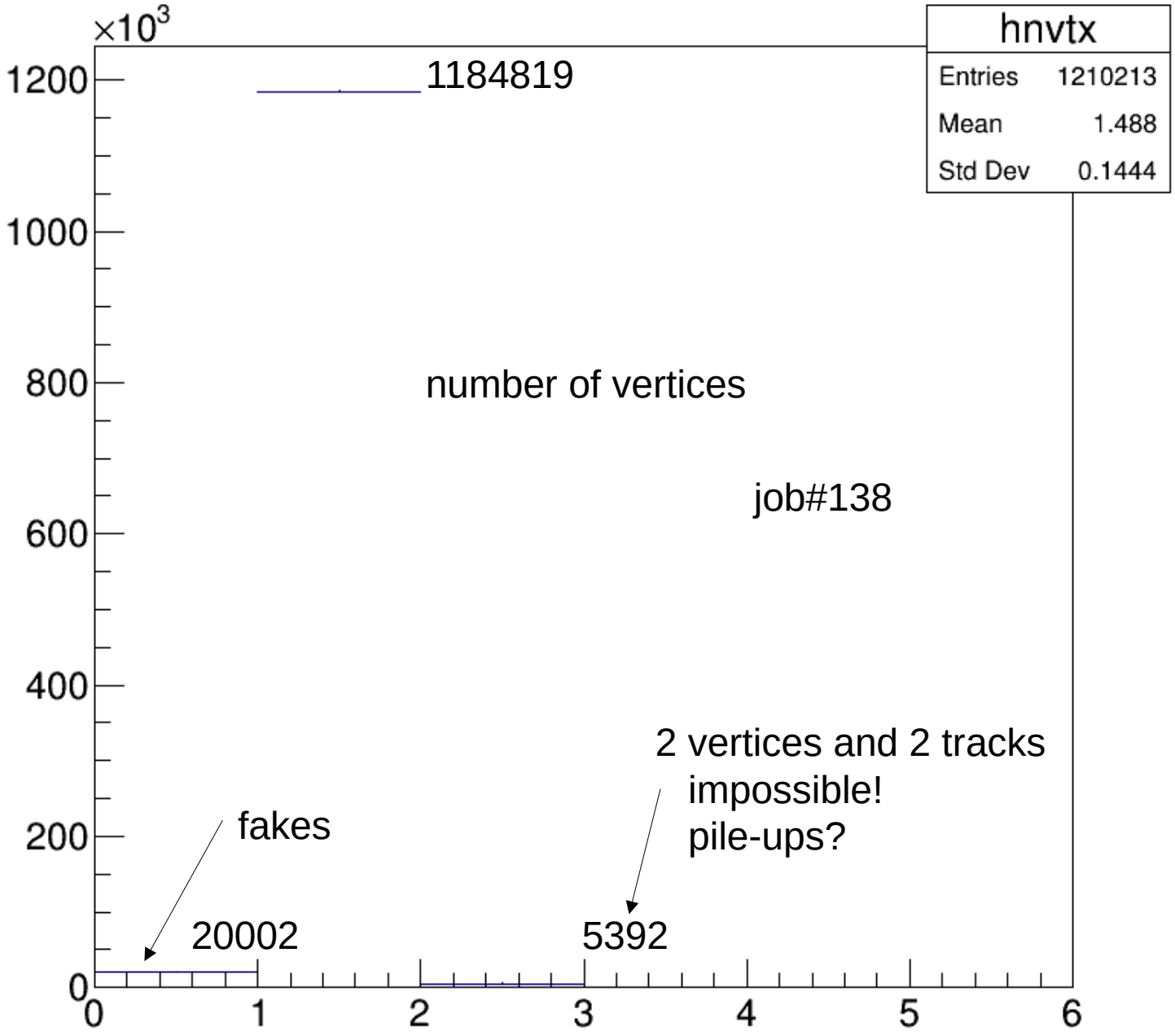
they look like pretty much primary

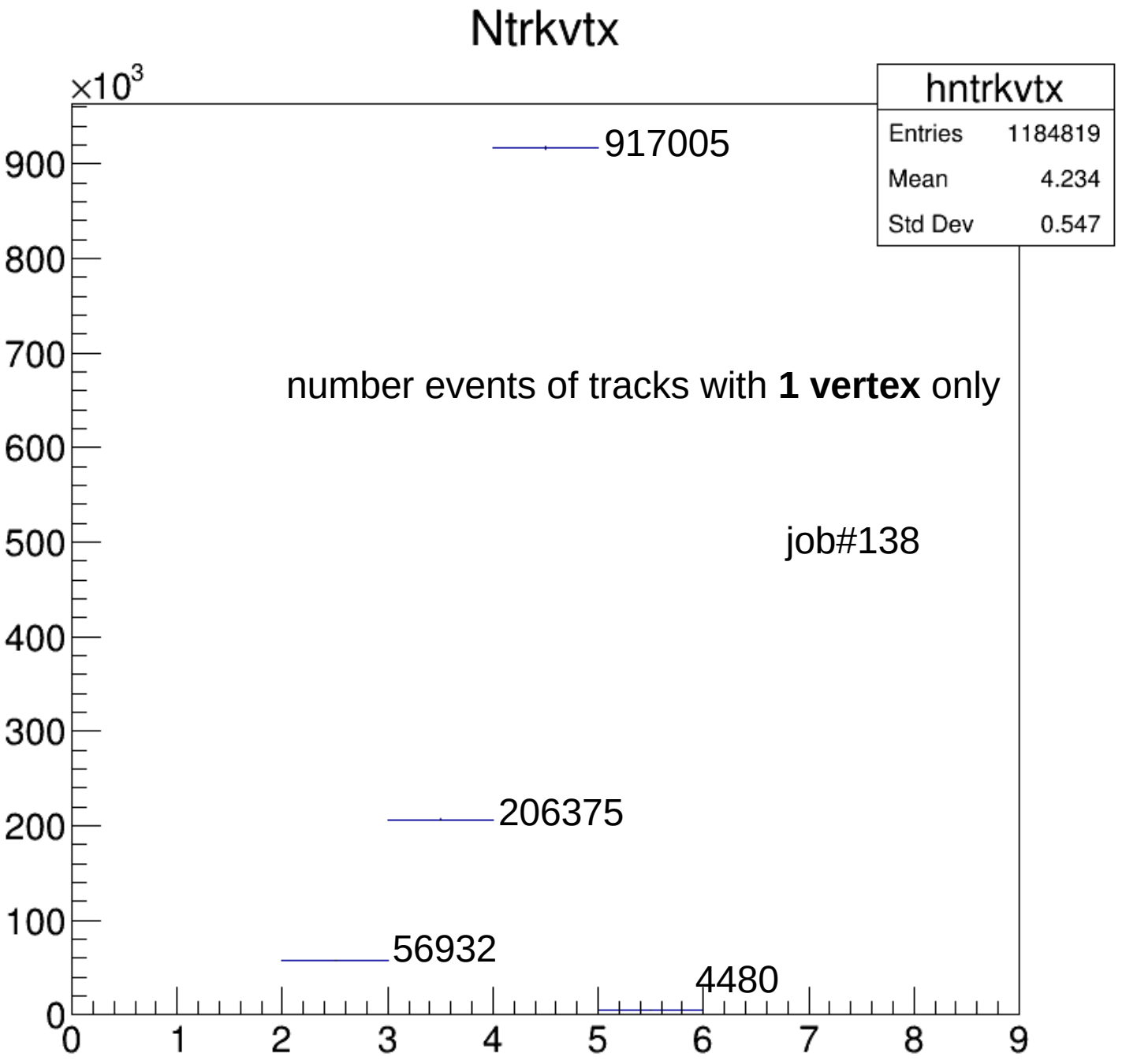


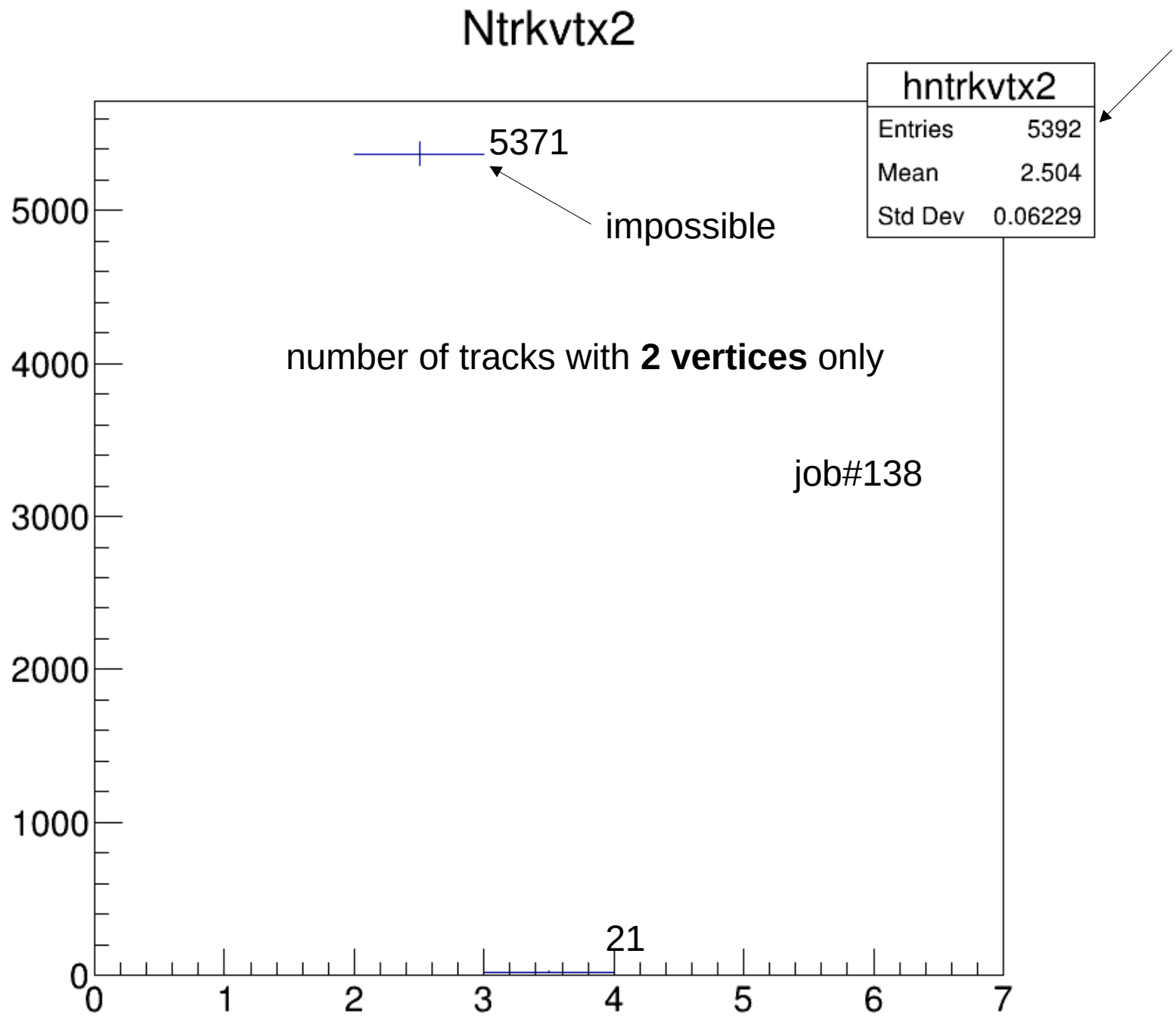



vtx.isFake()
×10^3
1200
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
hvtx
Entries 1210213
Mean 0.01653
Std Dev 0.1275
1190211
isFake=0 events with
good vertex
job#138
investigating the vertex collection
20002 fakes


Ntrk for nPixelHits>0
×10^3
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
9
hntrk
Entries 1210213
Mean 4.5
Std Dev 0
1210213
events with
4 tracks
job#138


Nvtx
×10^3
hnvtx
Entries 1210213
Mean 1.488
Std Dev 0.1444
1184819
number of vertices
job#138
2 vertices and 2 tracks
impossible!
pile-ups?
fakes
20002
5392
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6

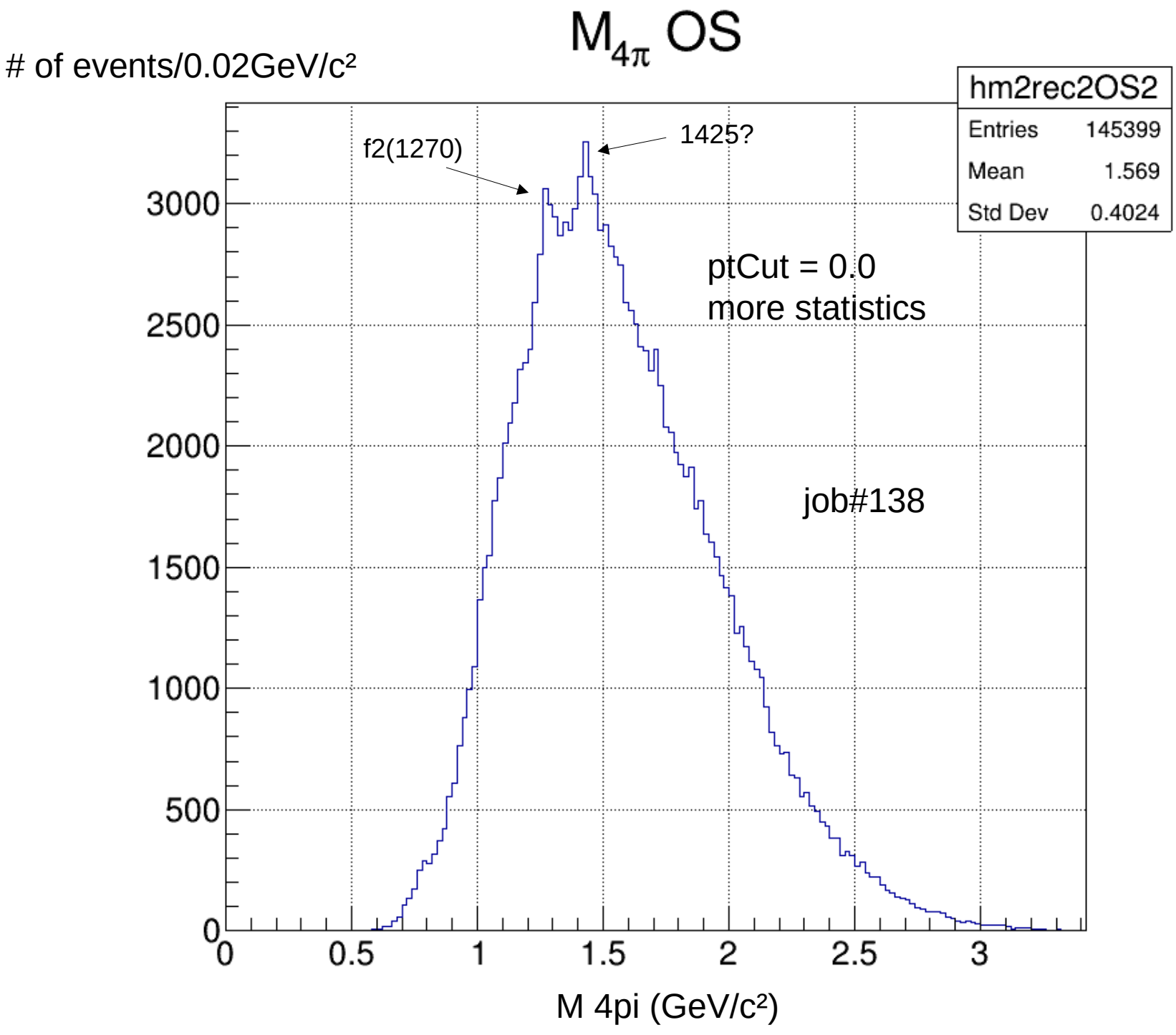

Ntrkvtx
hntrkvtx
Entries 1184819
Mean 4.234
Std Dev 0.547
×10^3
917005
206375
56932
4480
number events of tracks with **1 vertex** only
job#138
0
100
200
300
400
500
600
700
800
900
0
1
2
3
4
5
6
7
8
9

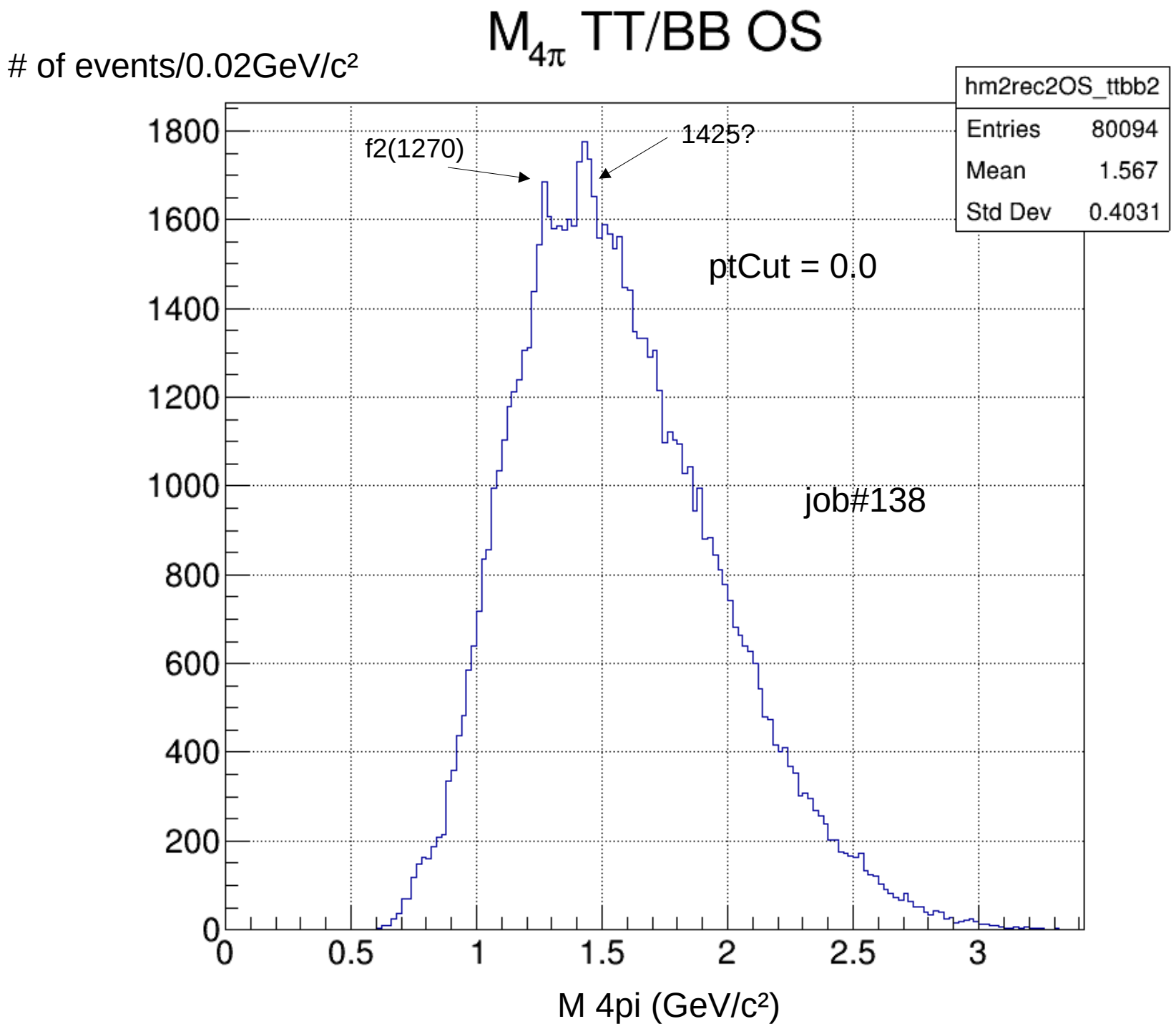

Ntrkvtx2
hntrkvtx2
Entries 5392
Mean 2.504
Std Dev 0.06229
5371
impossible
number of tracks with **2 vertices** only
job#138
21
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
7

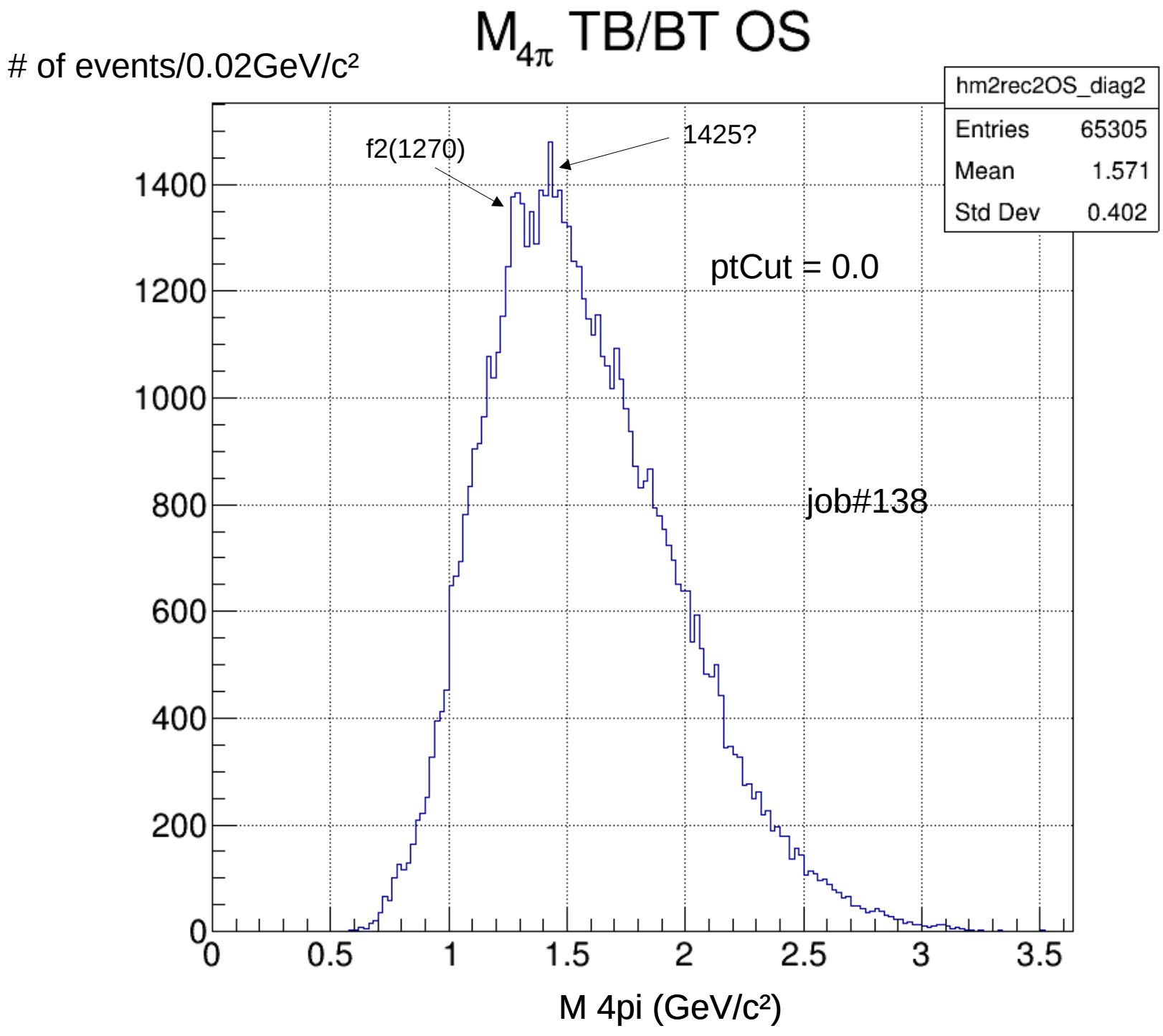
4-pion and pion-pair mass distributions

new conditions:

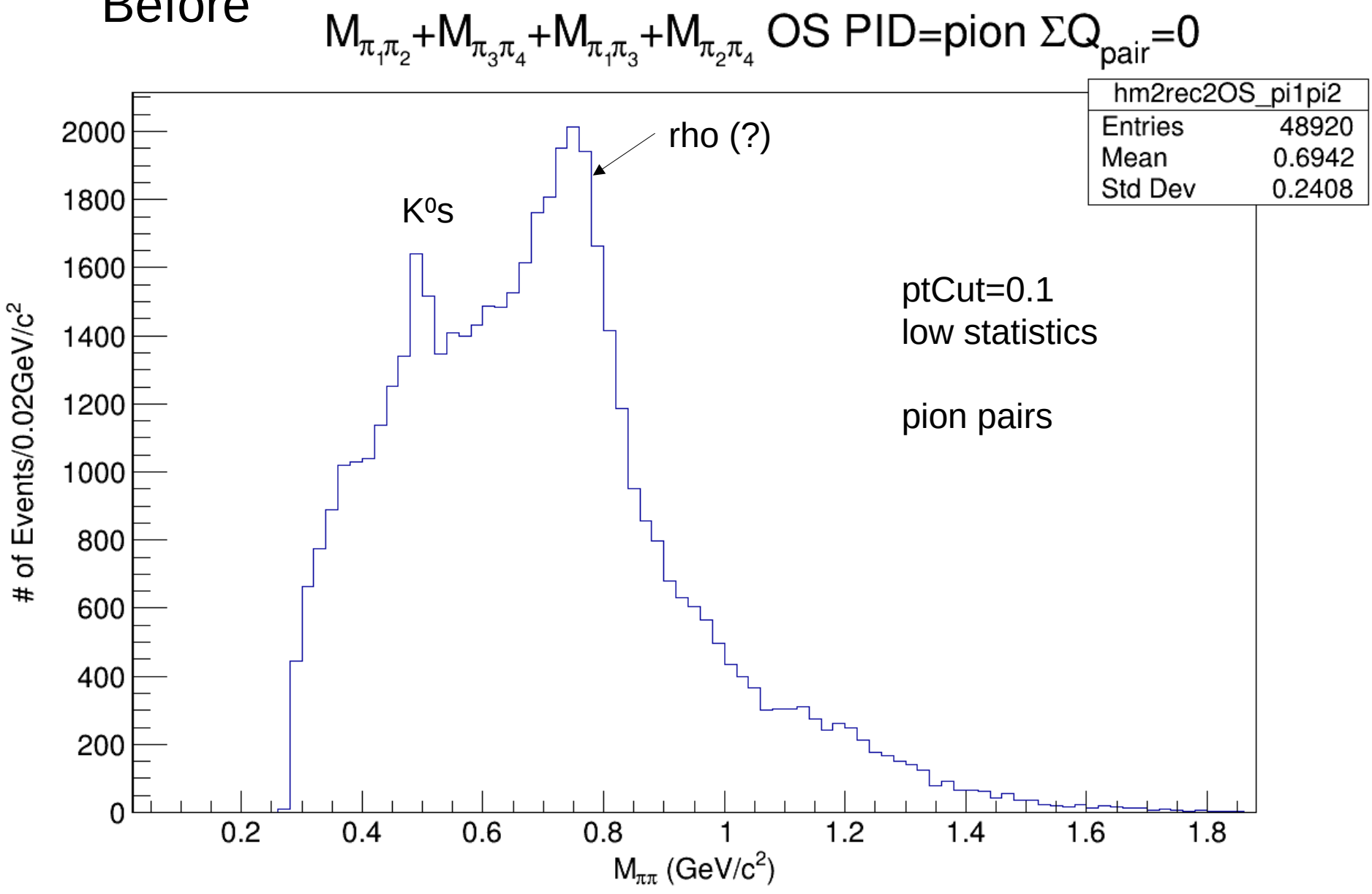
1. pTcut=0.0
2. no CTpycut
3. no CTpxcut
4. PID yes
5. total charge = 0
6. charge of the pion-pairs = 0
7. fiducial yes

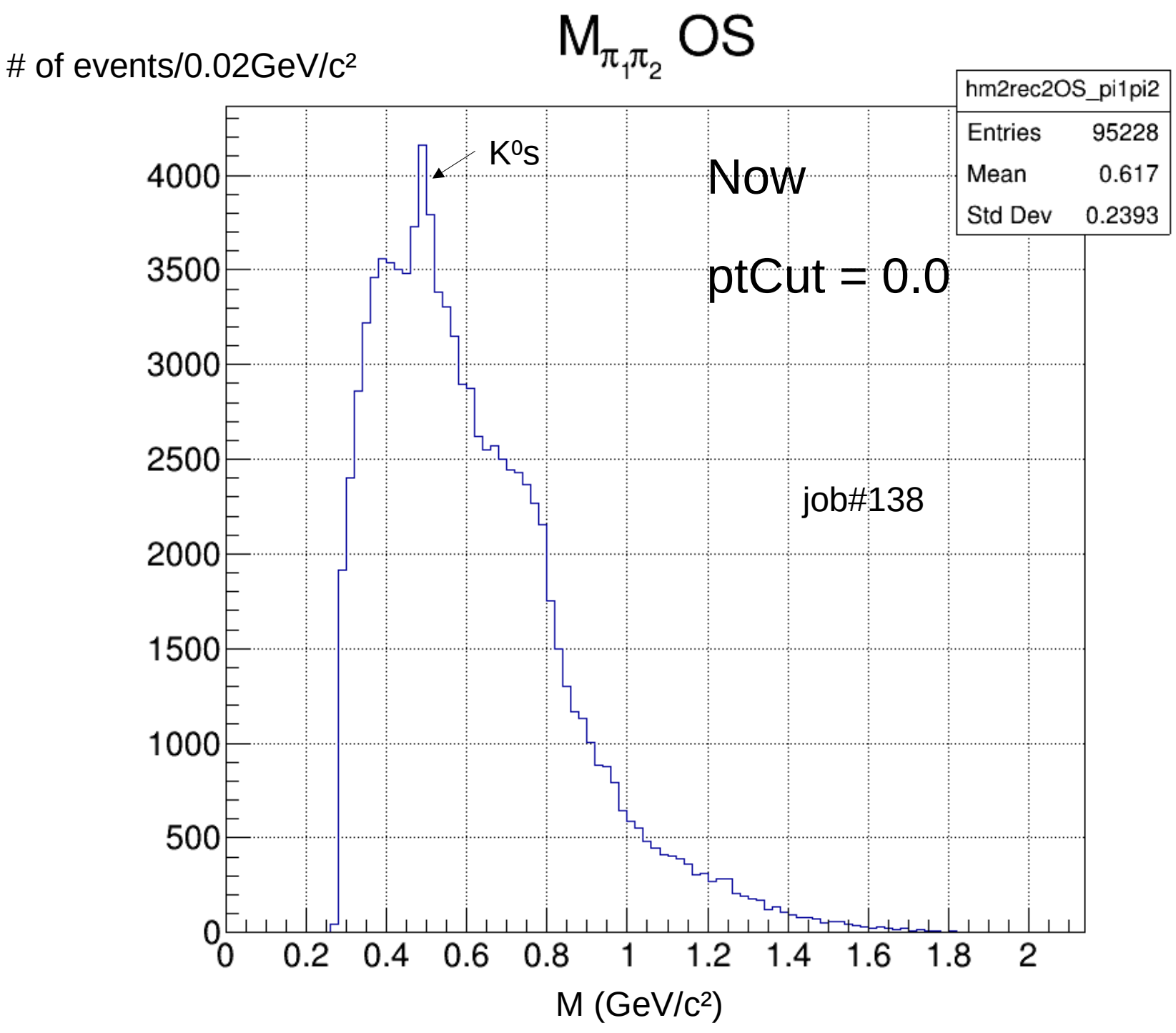

$M_{4\pi}$ OS
# of events/0.02GeV/c²
hm2rec2OS2
Entries 145399
Mean 1.569
Std Dev 0.4024
f2(1270)
1425?
ptCut = 0.0
more statistics
job#138
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
M 4pi (GeV/c²)

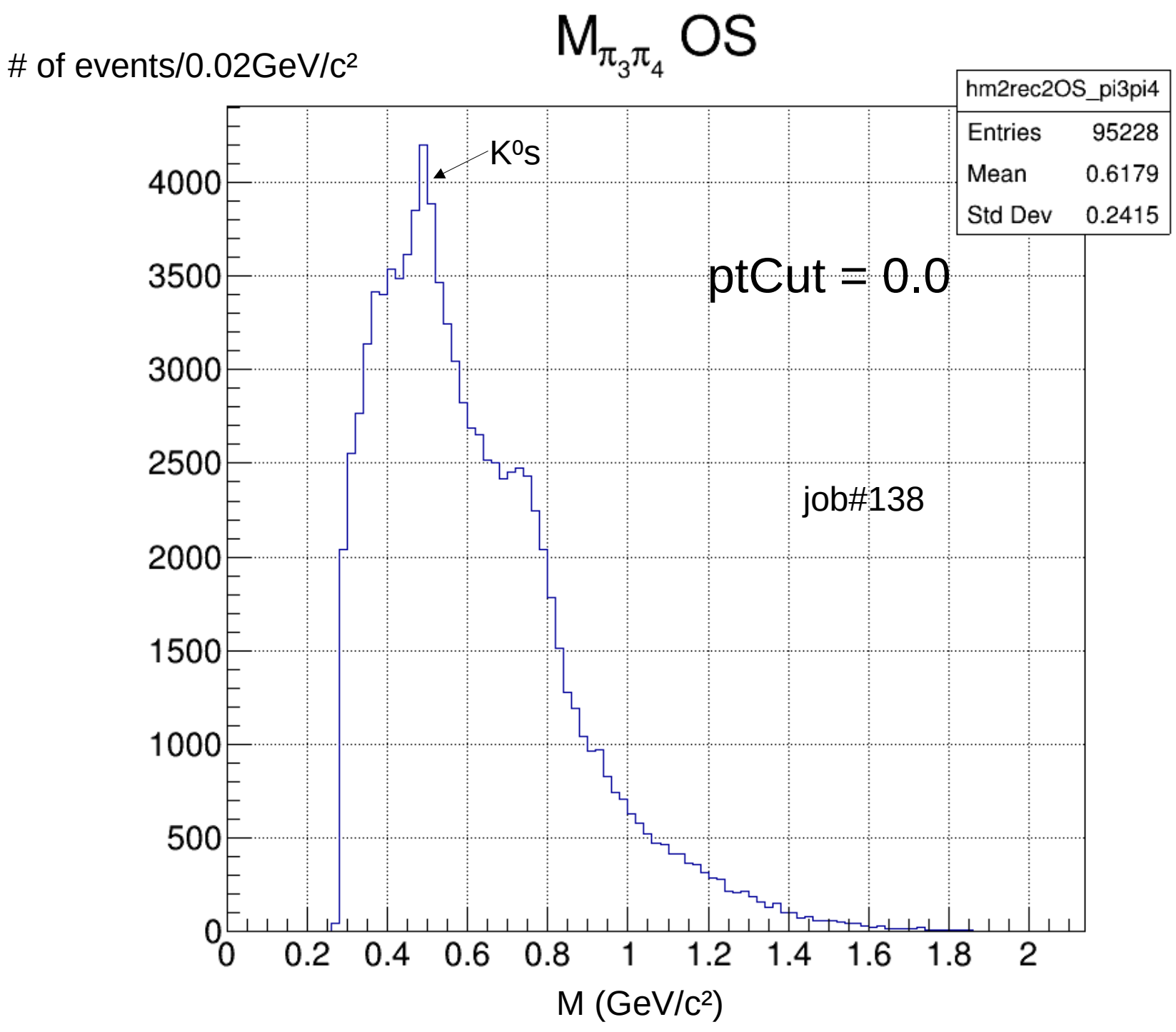

$M_{4\pi}$ TT/BB OS
# of events/0.02GeV/c²
hm2rec2OS_ttbb2
Entries 80094
Mean 1.567
Std Dev 0.4031
f2(1270)
1425?
ptCut = 0.0
job#138
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
M 4pi (GeV/c²)

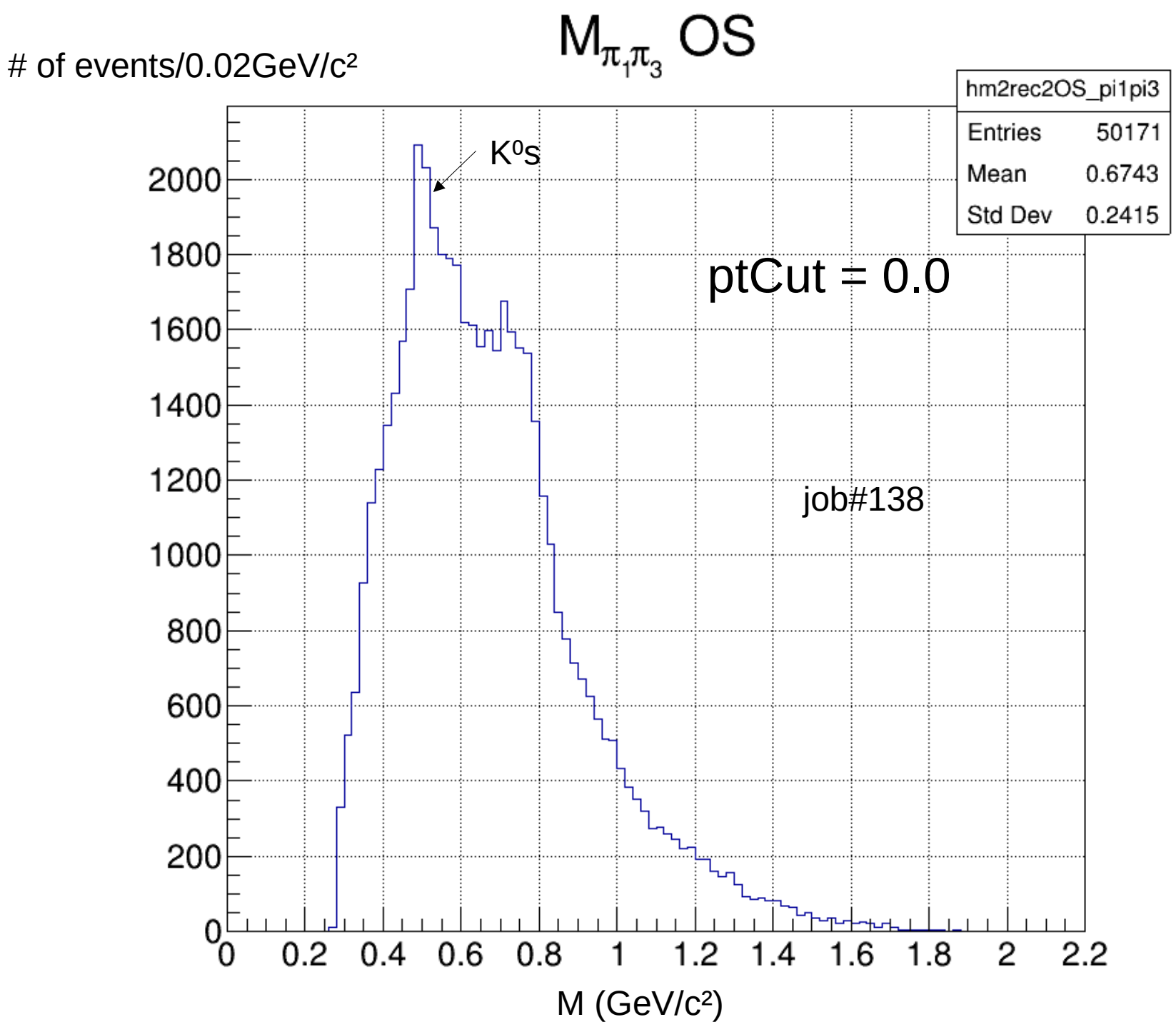

$M_{4\pi}$ TB/BT OS
# of events/0.02GeV/c²
hm2rec2OS_diag2
Entries 65305
Mean 1.571
Std Dev 0.402
f2(1270)
1425?
ptCut = 0.0
job#138
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5
M 4pi (GeV/c²)

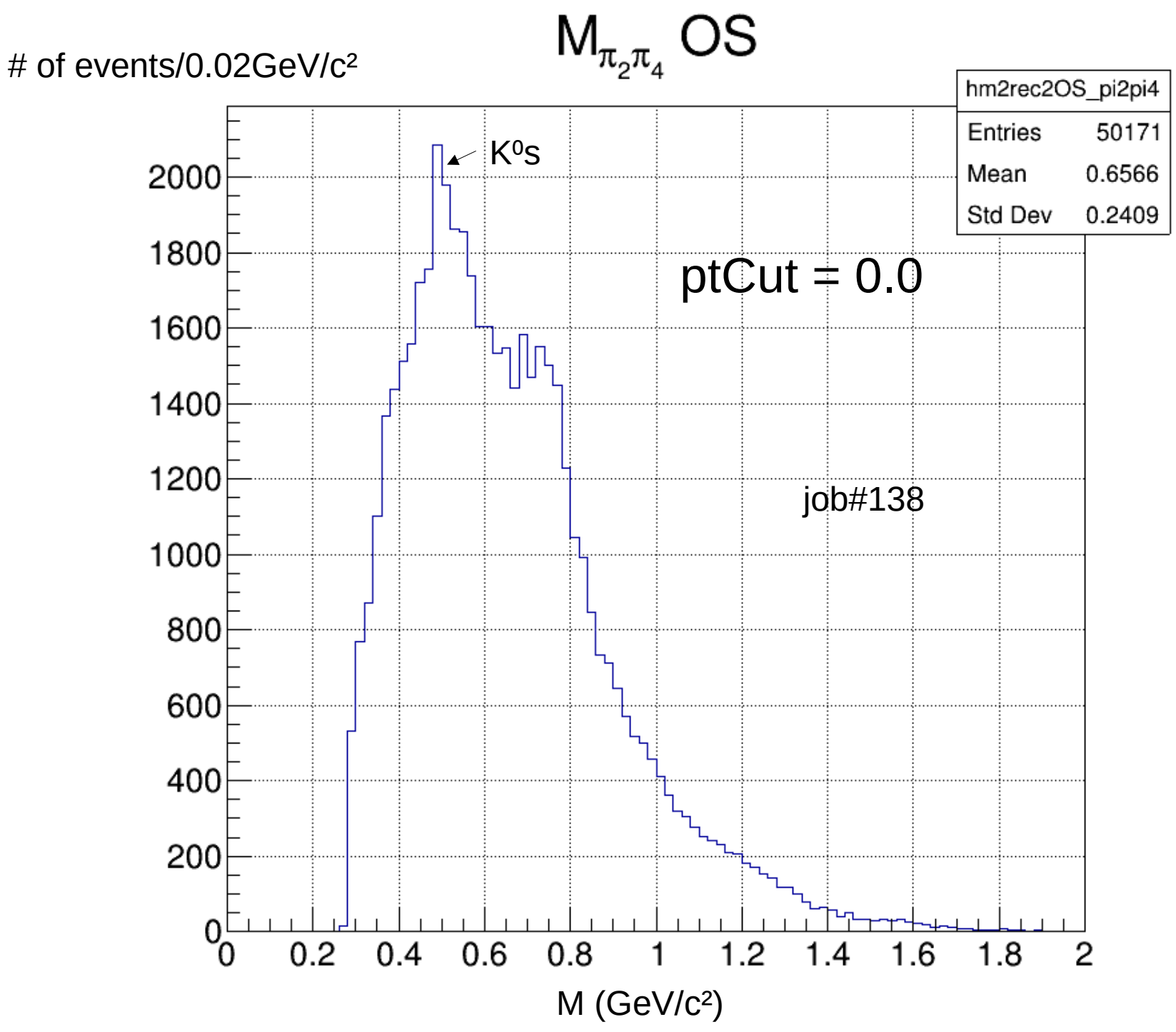
Before

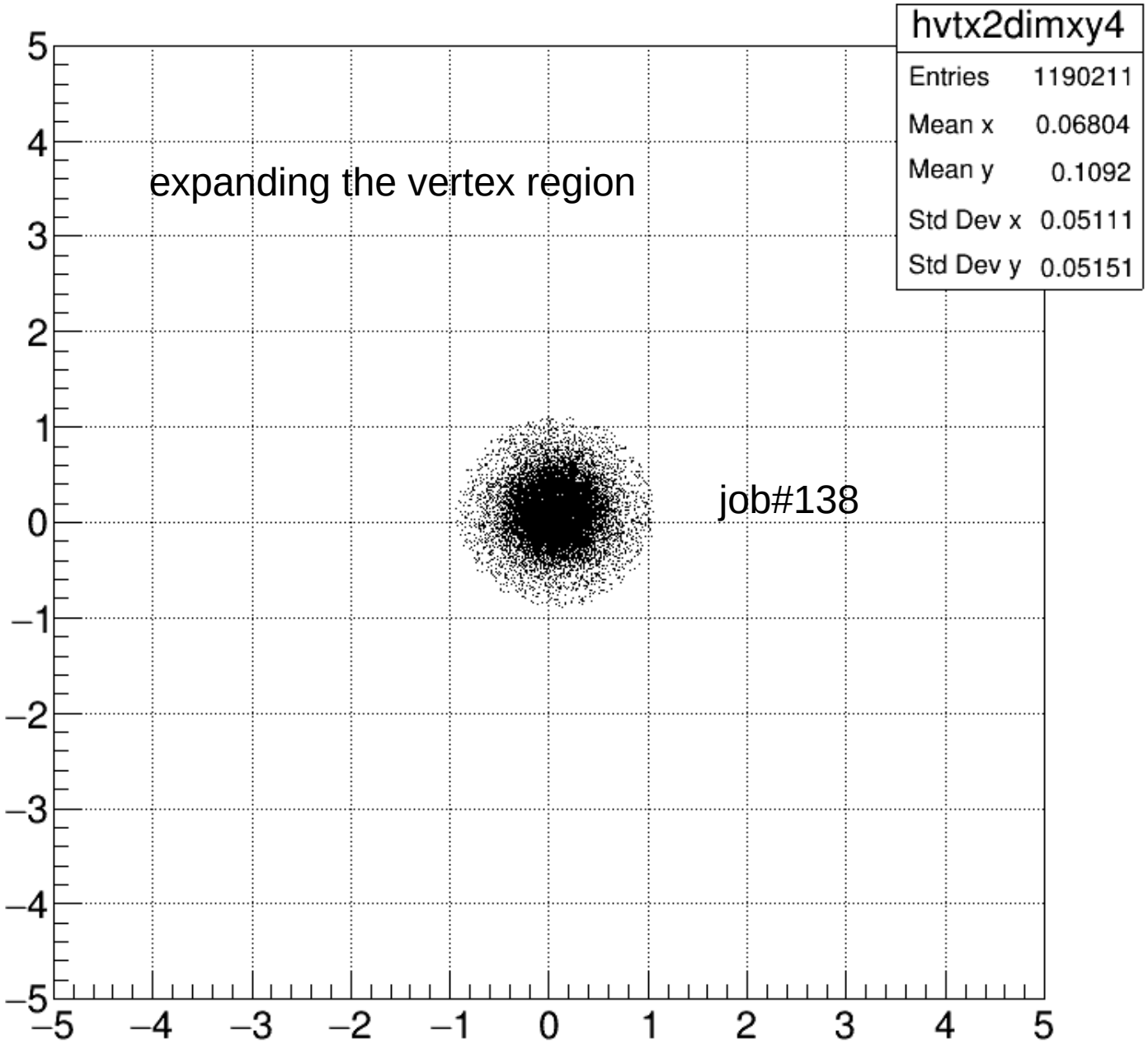

$M_{\pi_1\pi_2}+M_{\pi_3\pi_4}+M_{\pi_1\pi_3}+M_{\pi_2\pi_4}$ OS PID=pion $\Sigma Q_{pair}=0$
hm2rec2OS_pi1pi2
Entries 48920
Mean 0.6942
Std Dev 0.2408
rho (?)
K⁰s
ptCut=0.1
low statistics
pion pairs
# of Events/0.02GeV/c²
$M_{\pi\pi}$ (GeV/c²)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8

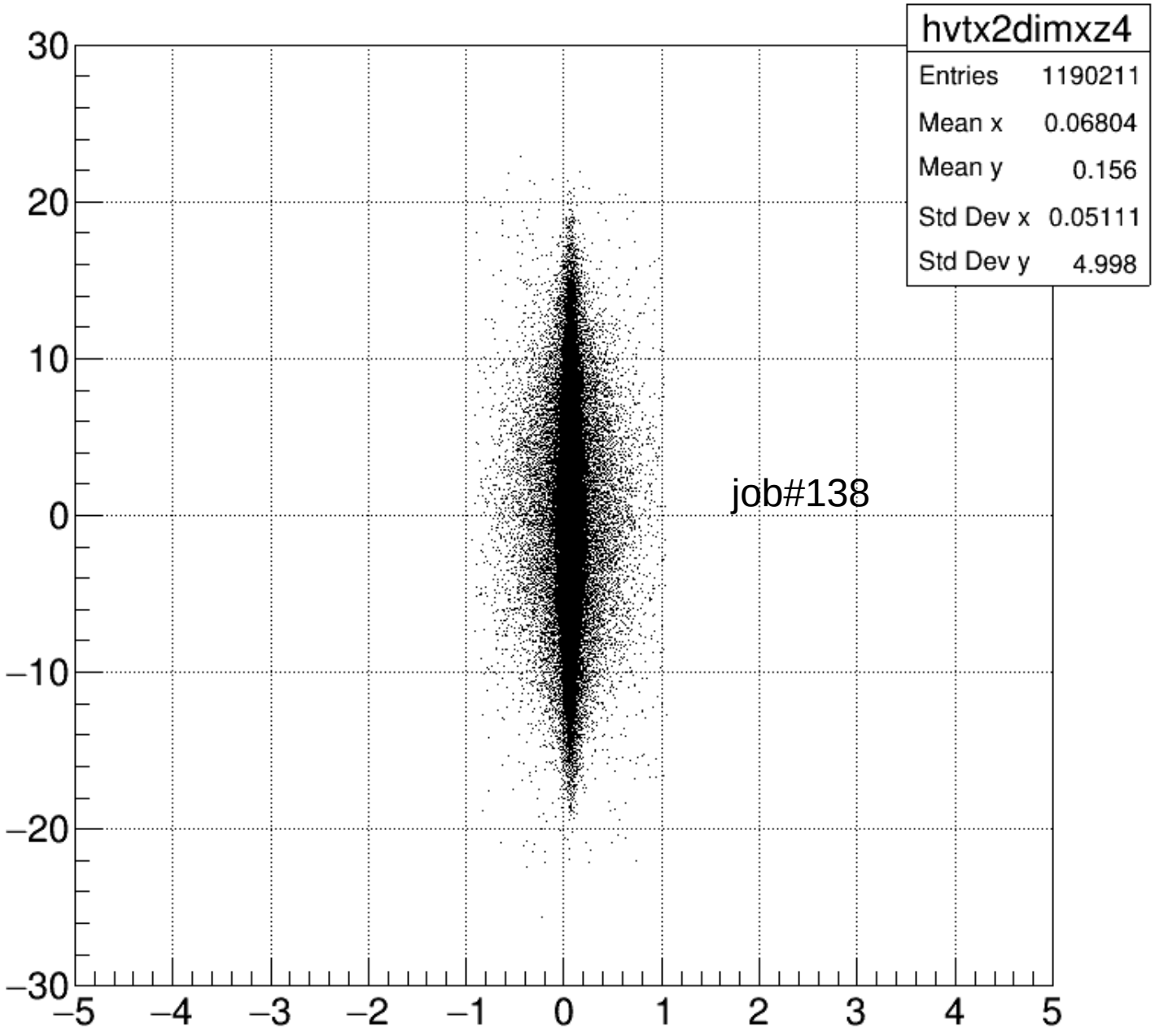

$M_{\pi_1\pi_2}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi1pi2
Entries 95228
Mean 0.617
Std Dev 0.2393
K⁰s
Now
ptCut = 0.0
job#138
4000
3500
3000
2500
2000
1500
1000
500
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
M (GeV/c²)

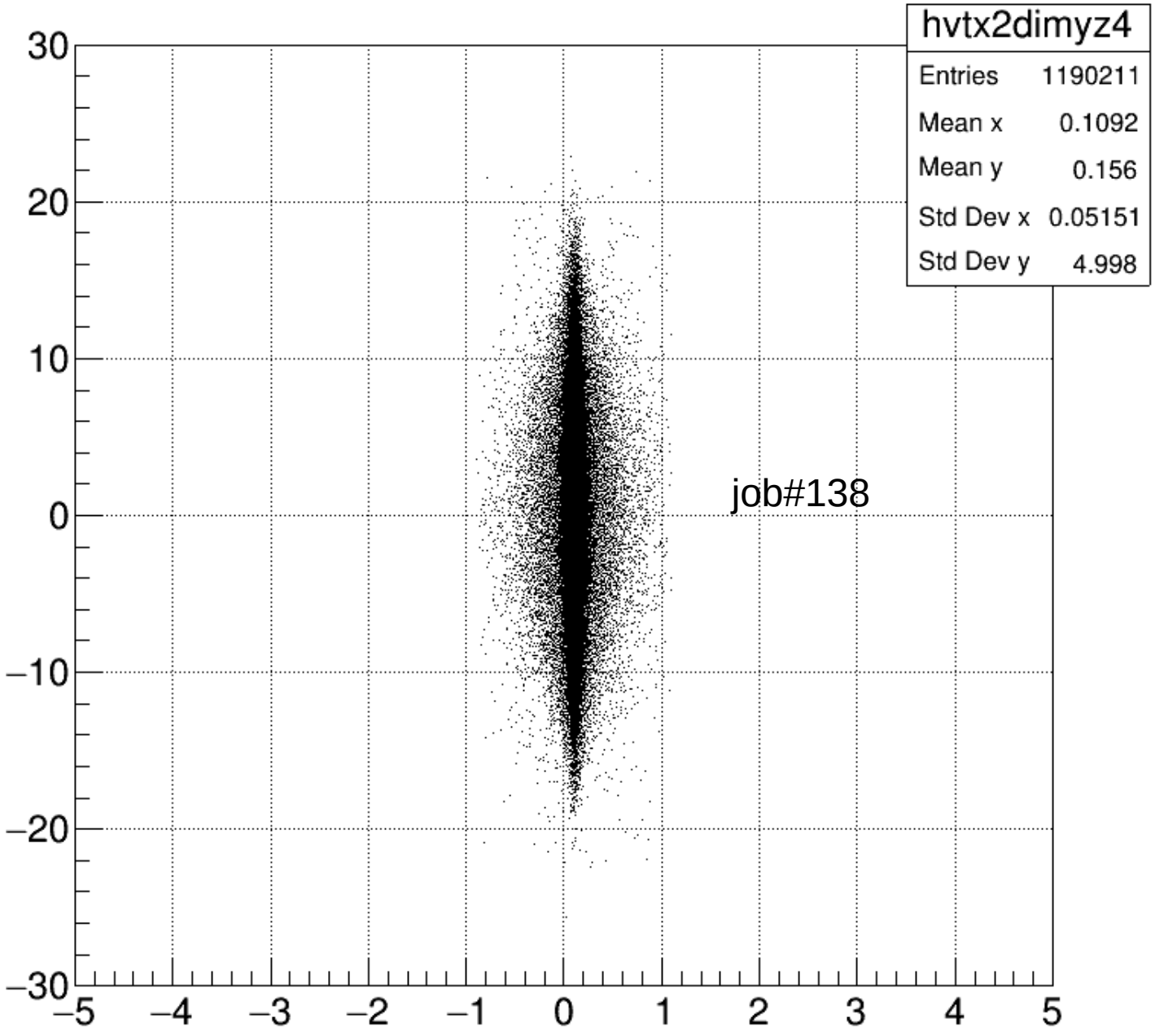

$M_{\pi_3\pi_4}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi3pi4
Entries 95228
Mean 0.6179
Std Dev 0.2415
K⁰s
ptCut = 0.0
job#138
4000
3500
3000
2500
2000
1500
1000
500
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
M (GeV/c²)


$M_{\pi_1\pi_3}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi1pi3
Entries 50171
Mean 0.6743
Std Dev 0.2415
K⁰s
ptCut = 0.0
job#138
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2
M (GeV/c²)


$M_{\pi_2\pi_4}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi2pi4
Entries 50171
Mean 0.6566
Std Dev 0.2409
K⁰s
ptCut = 0.0
job#138
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
M (GeV/c²)


X vs Y vtx
hvtx2dimxy4
Entries 1190211
Mean x 0.06804
Mean y 0.1092
Std Dev x 0.05111
Std Dev y 0.05151
expanding the vertex region
job#138
5
4
3
2
1
0
−1
−2
−3
−4
−5
−5 −4 −3 −2 −1 0 1 2 3 4 5


X vs Z vtx
hvtx2dimxz4
Entries 1190211
Mean x 0.06804
Mean y 0.156
Std Dev x 0.05111
Std Dev y 4.998
job#138
30
20
10
0
−10
−20
−30
−5
−4
−3
−2
−1
0
1
2
3
4
5


Y vs Z vtx
hvtx2dimyz4
Entries 1190211
Mean x 0.1092
Mean y 0.156
Std Dev x 0.05151
Std Dev y 4.998
job#138
30
20
10
0
−10
−20
−30
−5
−4
−3
−2
−1
0
1
2
3
4
5

Vertex Collection: using **itVtx→Print()** per event:

vertex information:
id : 0
x : 0.0868251
y : 0.13628
z : -0.700064
error x : 0.149151
error y : 0.0408441
error z : 0.264829
validity : 1
fake : 0
chi2 : 0.0083628
ndof : 0.942757
chi2n : 0.00887058
ntracks : 2
SumPtTracks: 0.737237

vertex information:
id : 0
x : 0.0445989
y : 0.135187
z : 6.41865
error x : 0.0312259
error y : 0.0336866
error z : 0.0297338
validity : 1
fake : 0
chi2 : 0.991081
ndof : 4.86067
chi2n : 0.203898
ntracks : 4
SumPtTracks: 1.03838

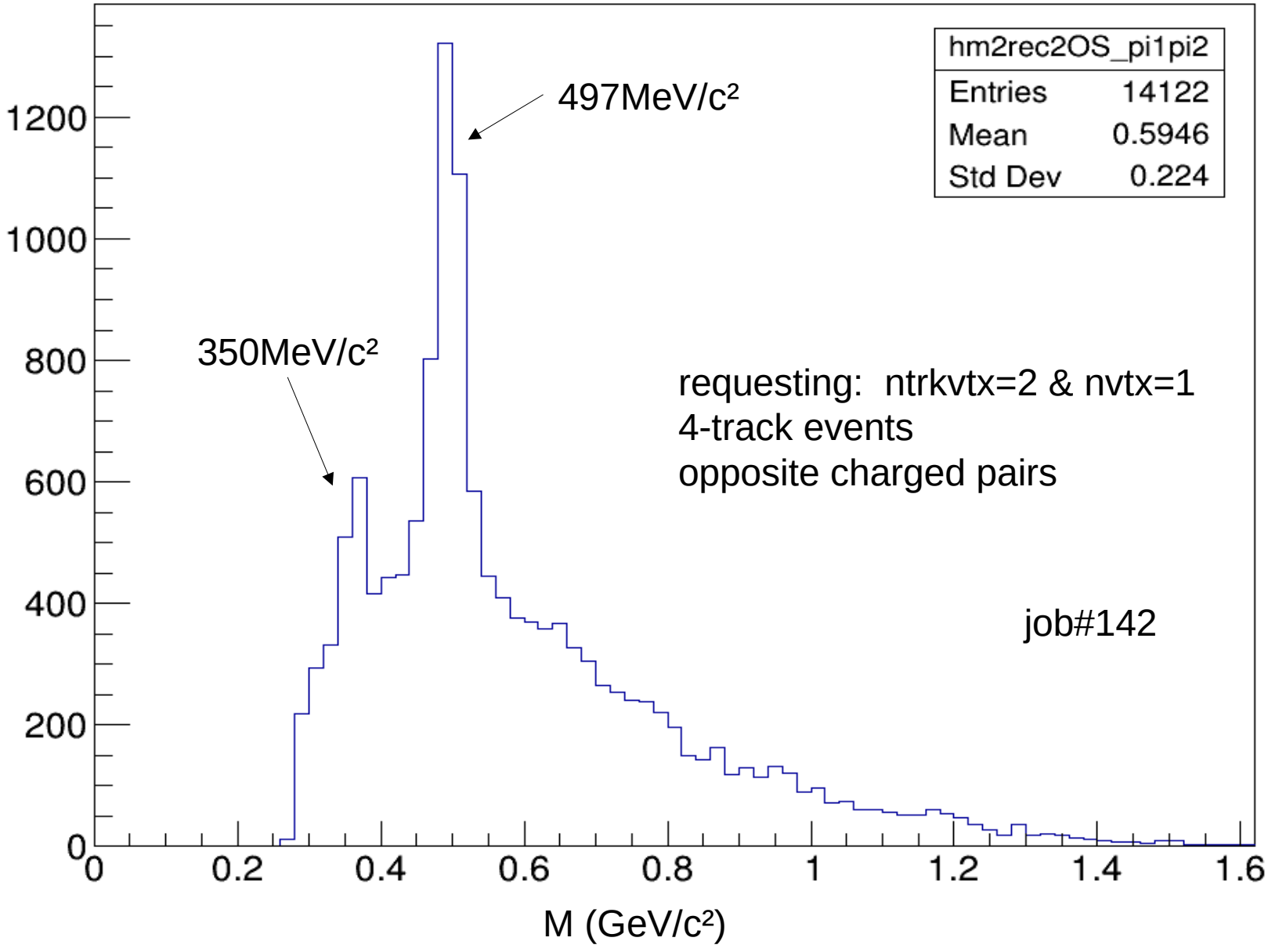
vertex information:
id : 0
x : 0.0719692
y : 0.0268902
z : -5.04181
error x : 0.0355899
error y : 0.0282491
error z : 0.150801
validity : 1
fake : 0
chi2 : 2.91895
ndof : 2.80123
chi2n : 1.04202
ntracks : 3
SumPtTracks: 1.58471

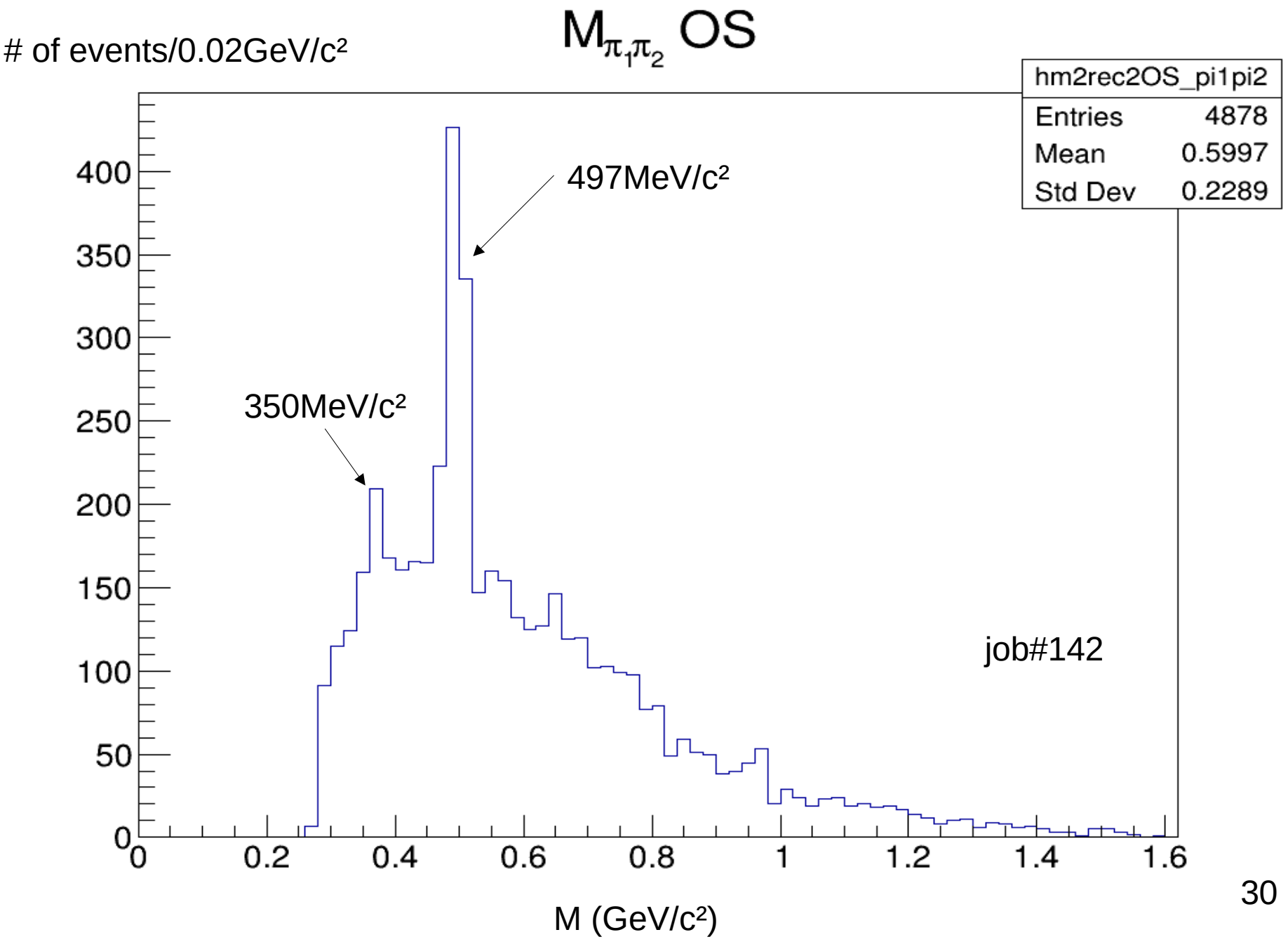
So far we do not have secondary vertex information in the code, only primary.
However, we do have secondary vertex in the data: K-shorts do appear!

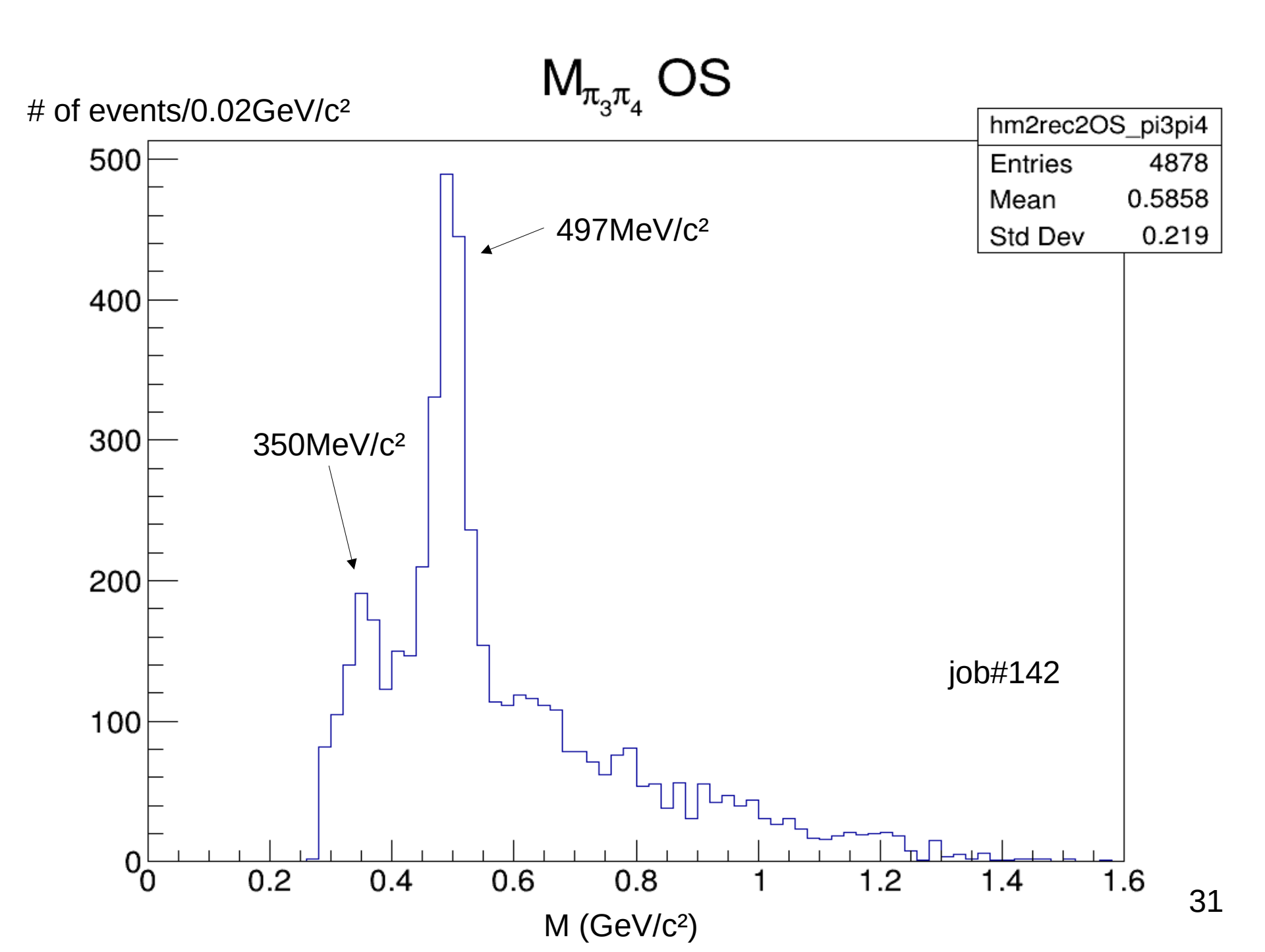
see next plots

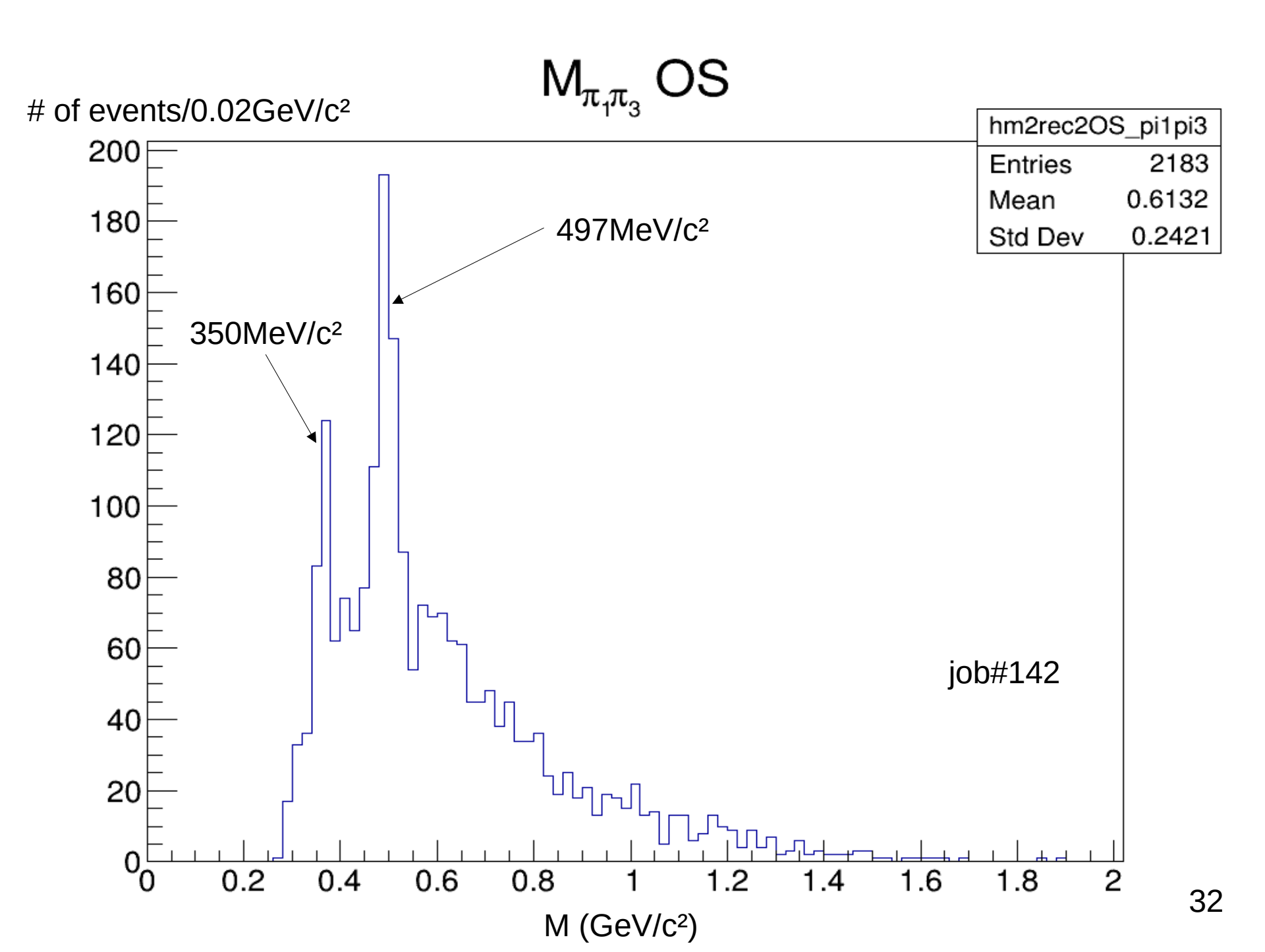
# of events/0.02GeV/c²

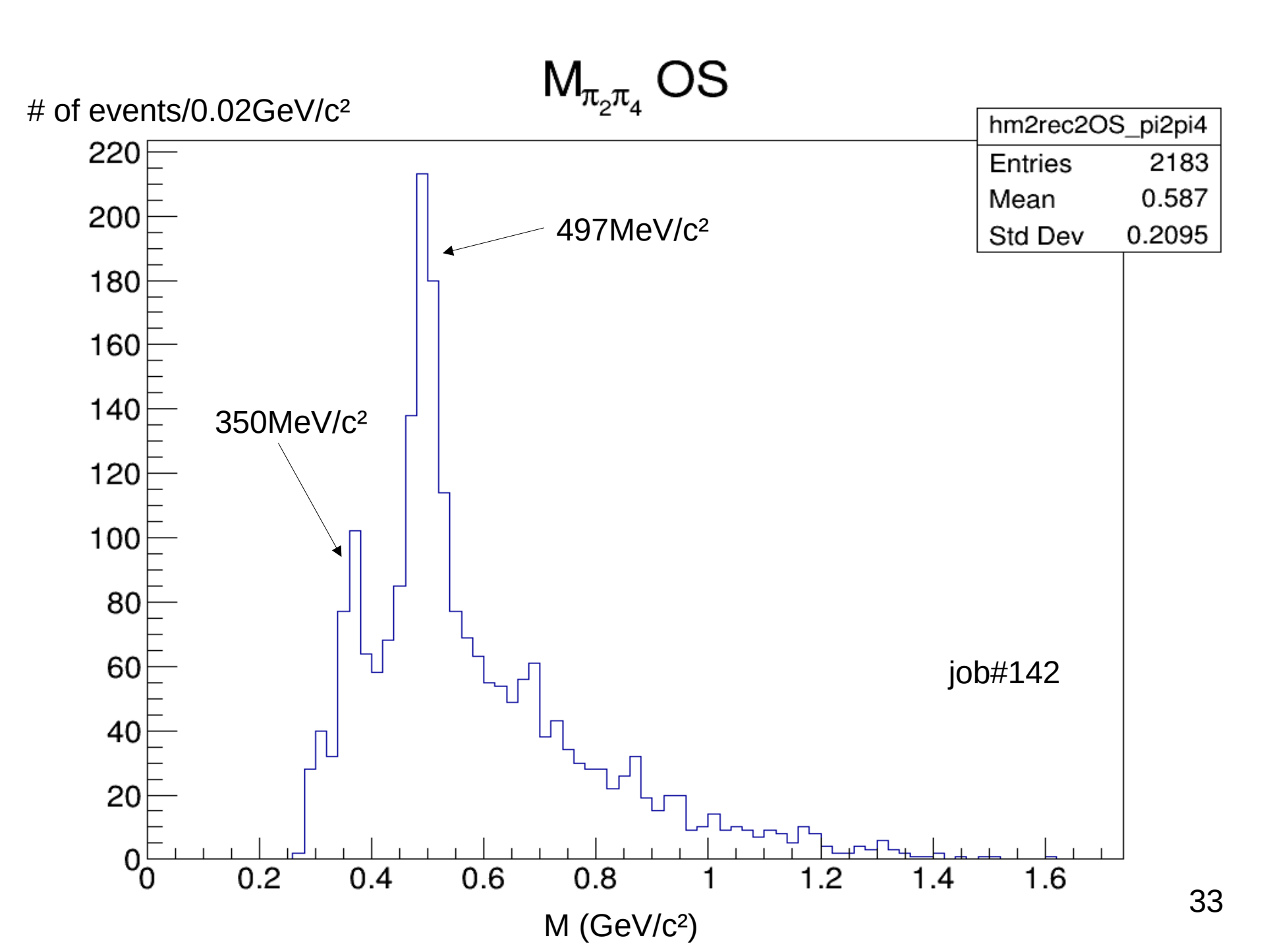
$M_{\pi_1\pi_2}+M_{\pi_3\pi_4}+M_{\pi_1\pi_3}+M_{\pi_2\pi_4}$ OS




$M_{\pi_1\pi_2}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi1pi2
Entries 4878
Mean 0.5997
Std Dev 0.2289
497MeV/c²
350MeV/c²
job#142
0
50
100
150
200
250
300
350
400
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
M (GeV/c²)


$M_{\pi_3\pi_4}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi3pi4
Entries 4878
Mean 0.5858
Std Dev 0.219
497MeV/c²
350MeV/c²
job#142
500
400
300
200
100
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
M (GeV/c²)


$M_{\pi_1\pi_3}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi1pi3
Entries 2183
Mean 0.6132
Std Dev 0.2421
497MeV/c²
350MeV/c²
job#142
M (GeV/c²)
0
20
40
60
80
100
120
140
160
180
200
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


$M_{\pi_2\pi_4}$ OS
# of events/0.02GeV/c²
hm2rec2OS_pi2pi4
Entries 2183
Mean 0.587
Std Dev 0.2095
497MeV/c²
350MeV/c²
job#142
M (GeV/c²)
0
20
40
60
80
100
120
140
160
180
200
220
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

- why do we have a K-short peak in the pion-pair mass distributions requesting ntrkvtx=2 and nvtx=1 for the 4-track events but the transverse x & y positions are primary?

it seems contradictory !

- do we have access to the secondary vertex collection? (for instance, we do not have a Phi collection or MyPhis class)

- is it possible to have access the secondary vertex code?

Kshort mass distribution using the kshort collection via MyKshorts class

Accessing the Kshort collection - secondary vertex :

```
#include "UATree/UADataFormat/interface/MyKshorts.h"
```

defining the Kshort vector:

```
vector<MyKshorts>* kshort_coll = NULL;
```

accessing de Kshort branch:

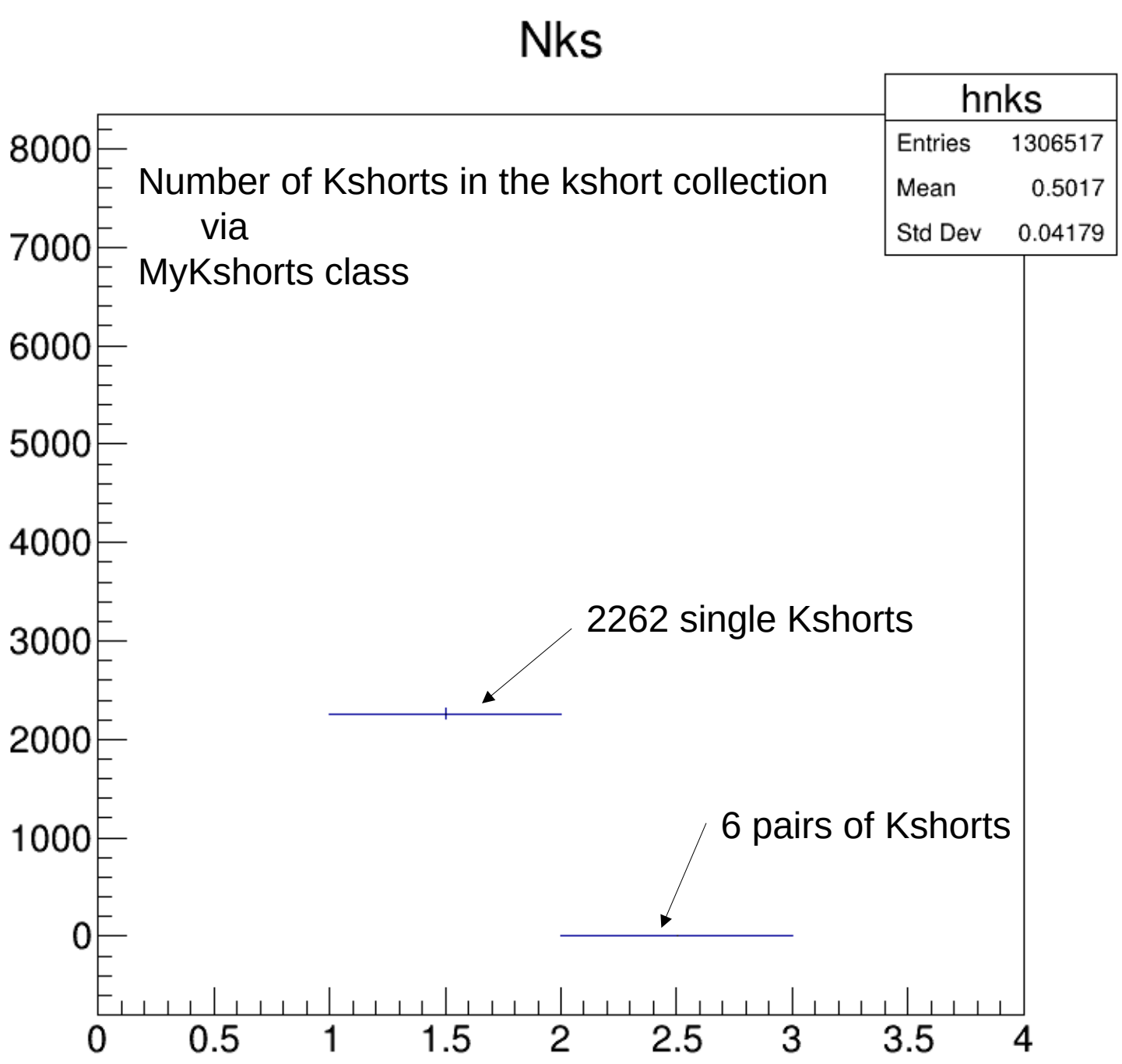
```
tree→SetBranchAddress("Kshort",&kshort_coll);
```

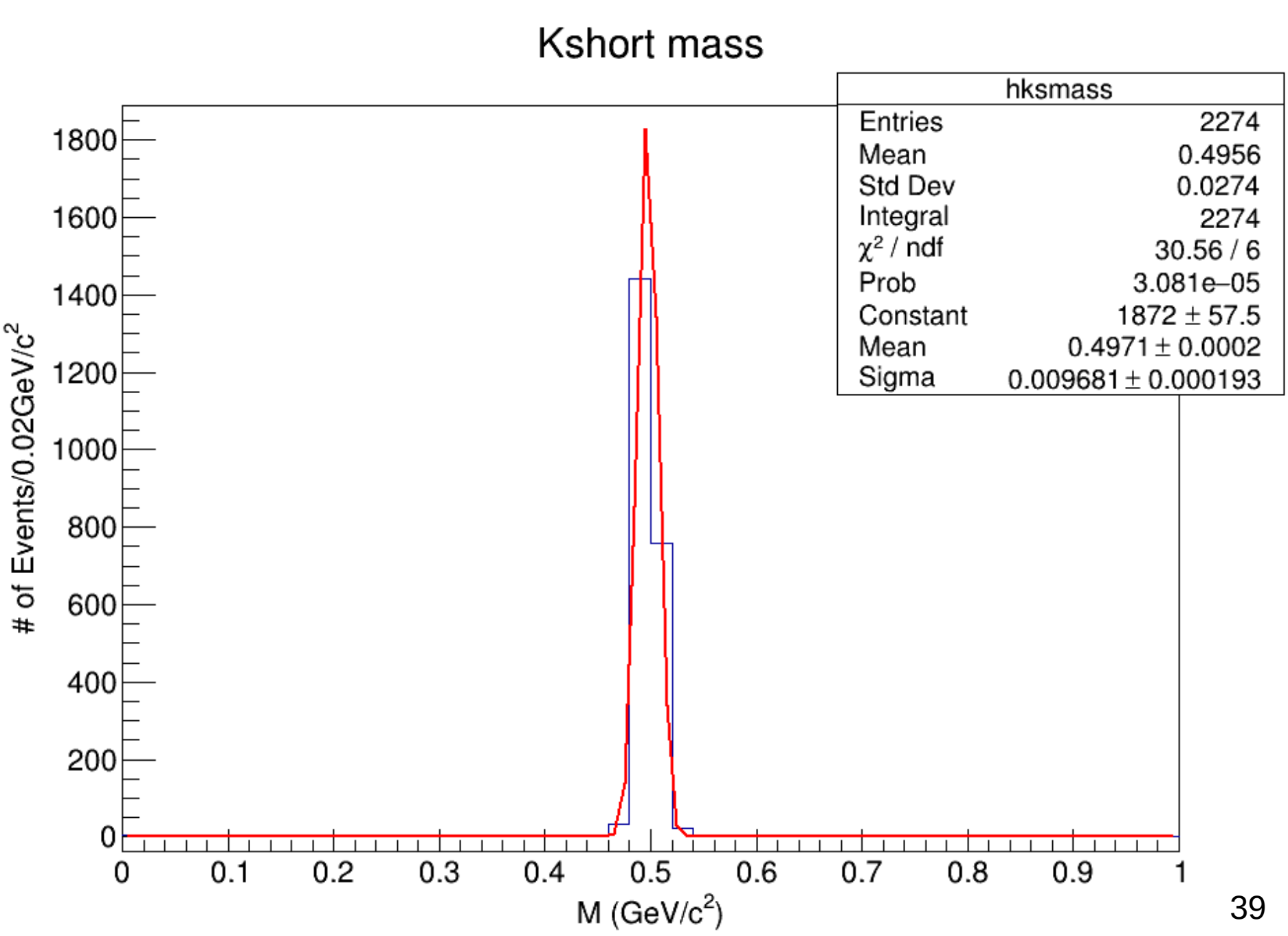
loop over events nested with
loop over Kshorts in the collection:

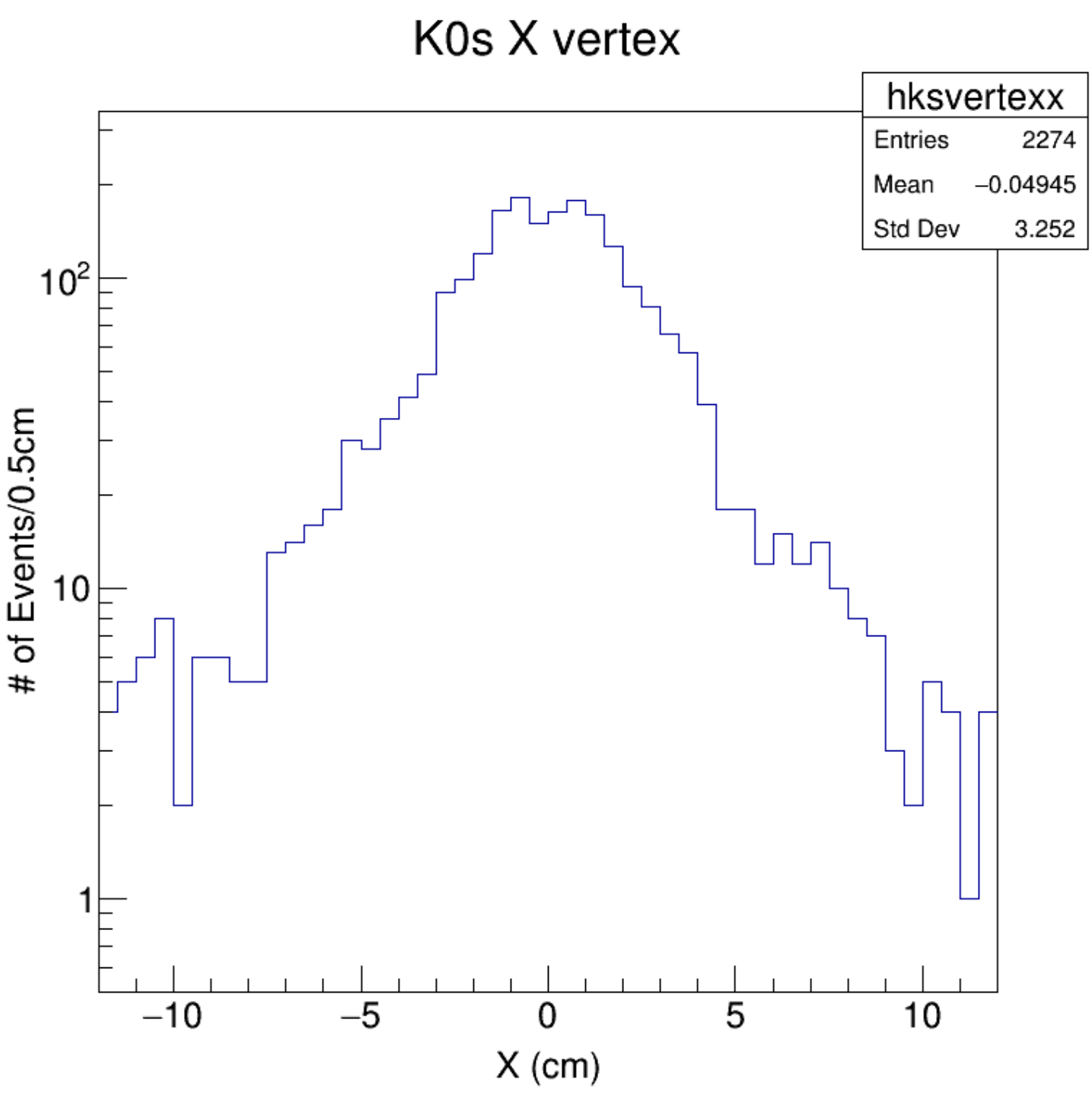
```
int nks=0;
for(vector<MyKshorts>::iterator it_ks = kshort_coll->begin() ; it_ks != kshort_coll->end() ; ++it_ks){
 nks++;
 bool isKshort = nks;
 double ksvertexx = it_ks->vertexx;
 double ksvertexy = it_ks->vertexy;
 double ksvertexz = it_ks->vertexz;
```

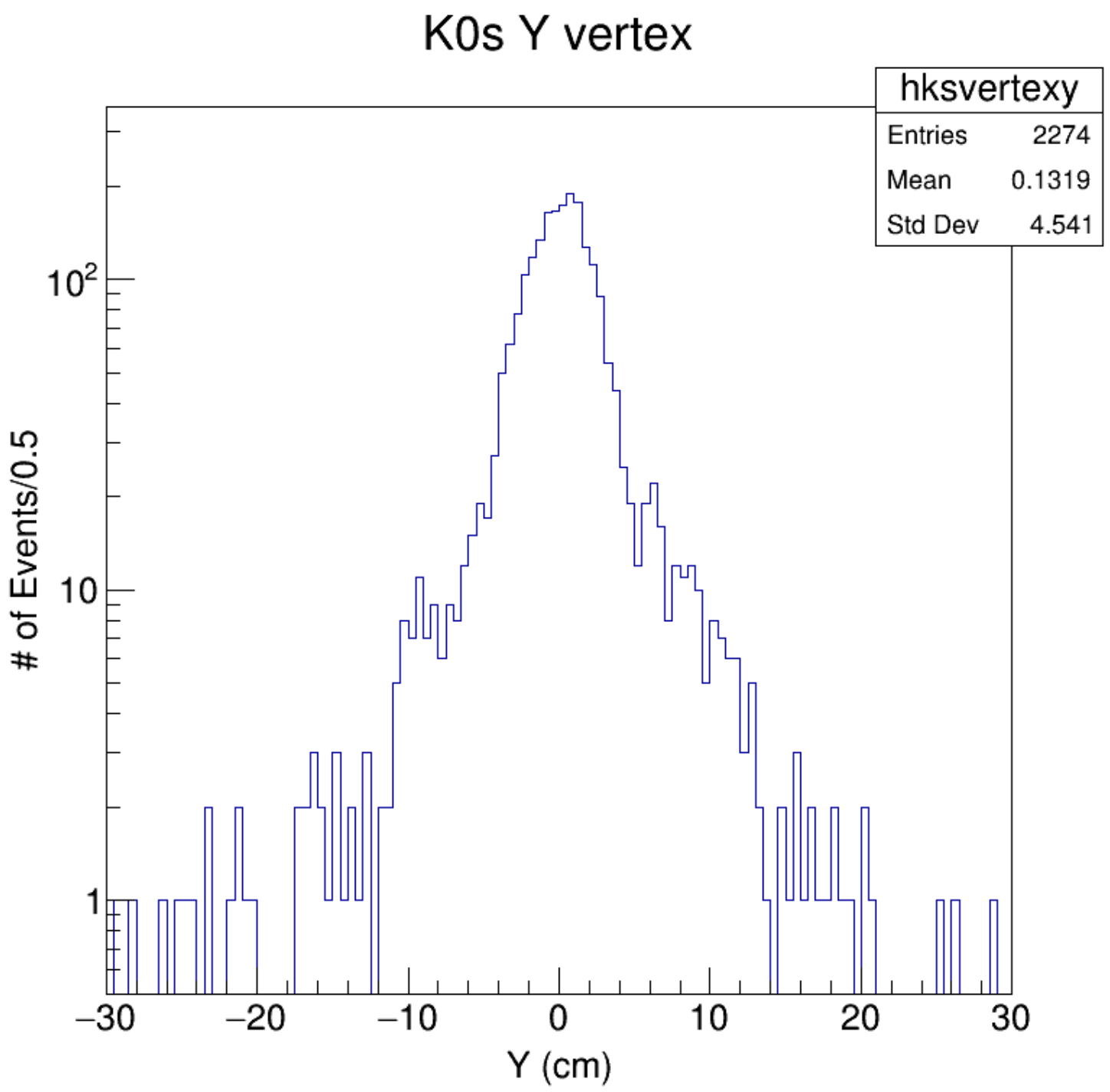
...continue

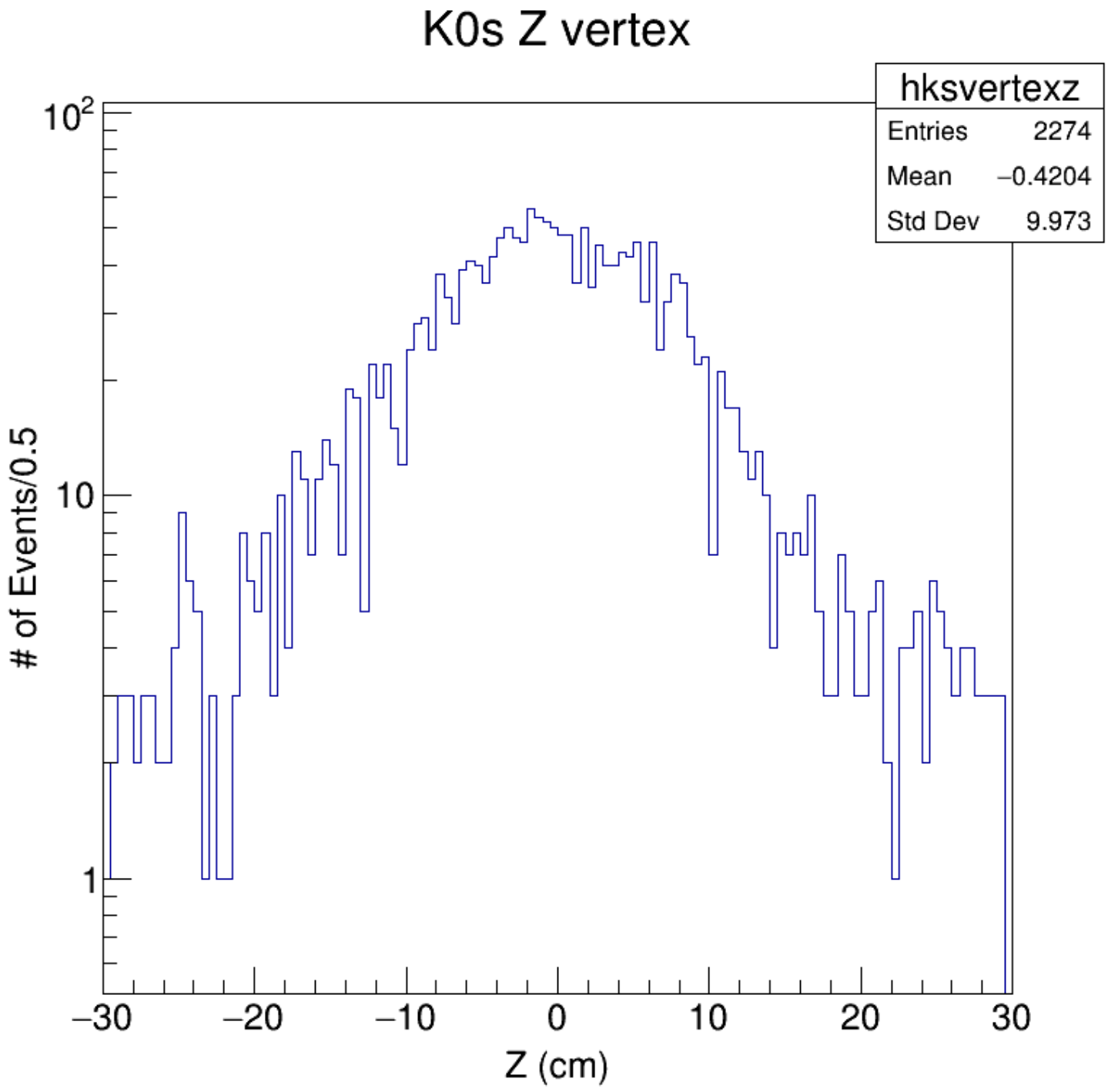
```
        double kspt = it_ks->pt;
        double kseta = it_ks->eta;
        double ksphi = it_ks->phi;
        double ksmass = it_ks->mass;
        double ksradius = TMath::Sqrt((ksvertexx-xvtx)*(ksvertexx-xvtx)+
(ksvertexy-yvtx)*(ksvertexy-yvtx));
        double energy = TMath::Sqrt(kspt*kspt+0.4976*0.4976);
        double gamalorentz = energy/0.4976;
        double kslifetime = ksradius/gamalorentz;
        histosTH1F["hkspt"]->Fill(kspt,wei);
        histosTH1F["hkseta"]->Fill(kseta,wei);
        histosTH1F["hksphi"]->Fill(ksphi,wei);
        histosTH1F["hksmass"]->Fill(ksmass,wei);
        histosTH1F["hksvertexx"]->Fill(ksvertexx,wei);
        histosTH1F["hksvertexy"]->Fill(ksvertexy,wei);
        histosTH1F["hksvertexz"]->Fill(ksvertexz,wei);
        histosTH1F["hksradius"]->Fill(ksradius,wei);
        histosTH1F["hkslifetime"]->Fill(kslifetime,wei);
        histosTH2F["h2dimksxy"]->Fill(ksvertexx,ksvertexy);
        histosTH2F["h2dimksxz"]->Fill(ksvertexx,ksvertexz);
        histosTH2F["h2dimksyz"]->Fill(ksvertexy,ksvertexz);
        it_ks->Print();
      }
      histosTH1F["hnks"]→Fill(nks);
```

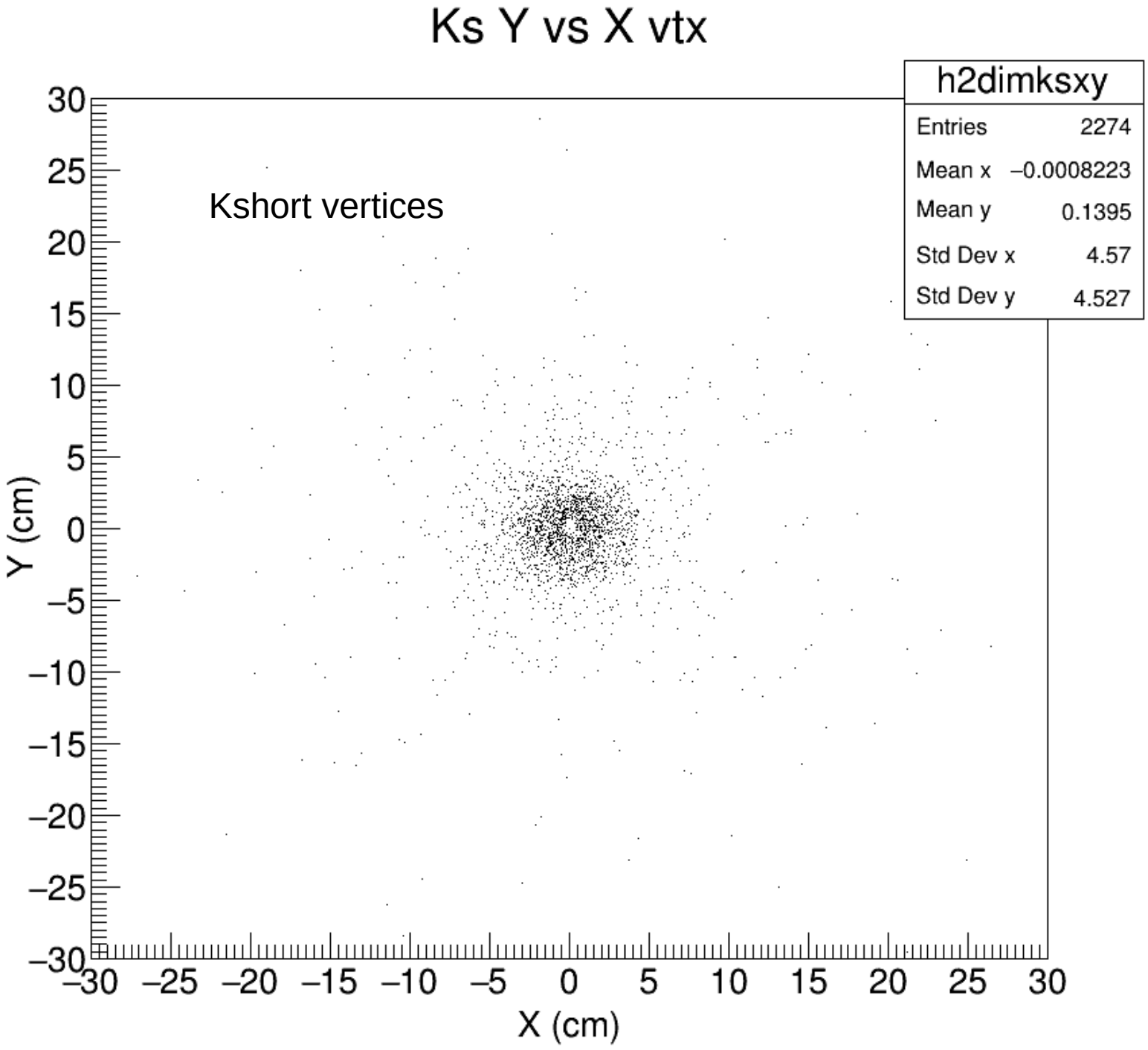

Nks
hnks
Entries 1306517
Mean 0.5017
Std Dev 0.04179
Number of Kshorts in the kshort collection
via
MyKshorts class
2262 single Kshorts
6 pairs of Kshorts
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.5
1
1.5
2
2.5
3
3.5
4

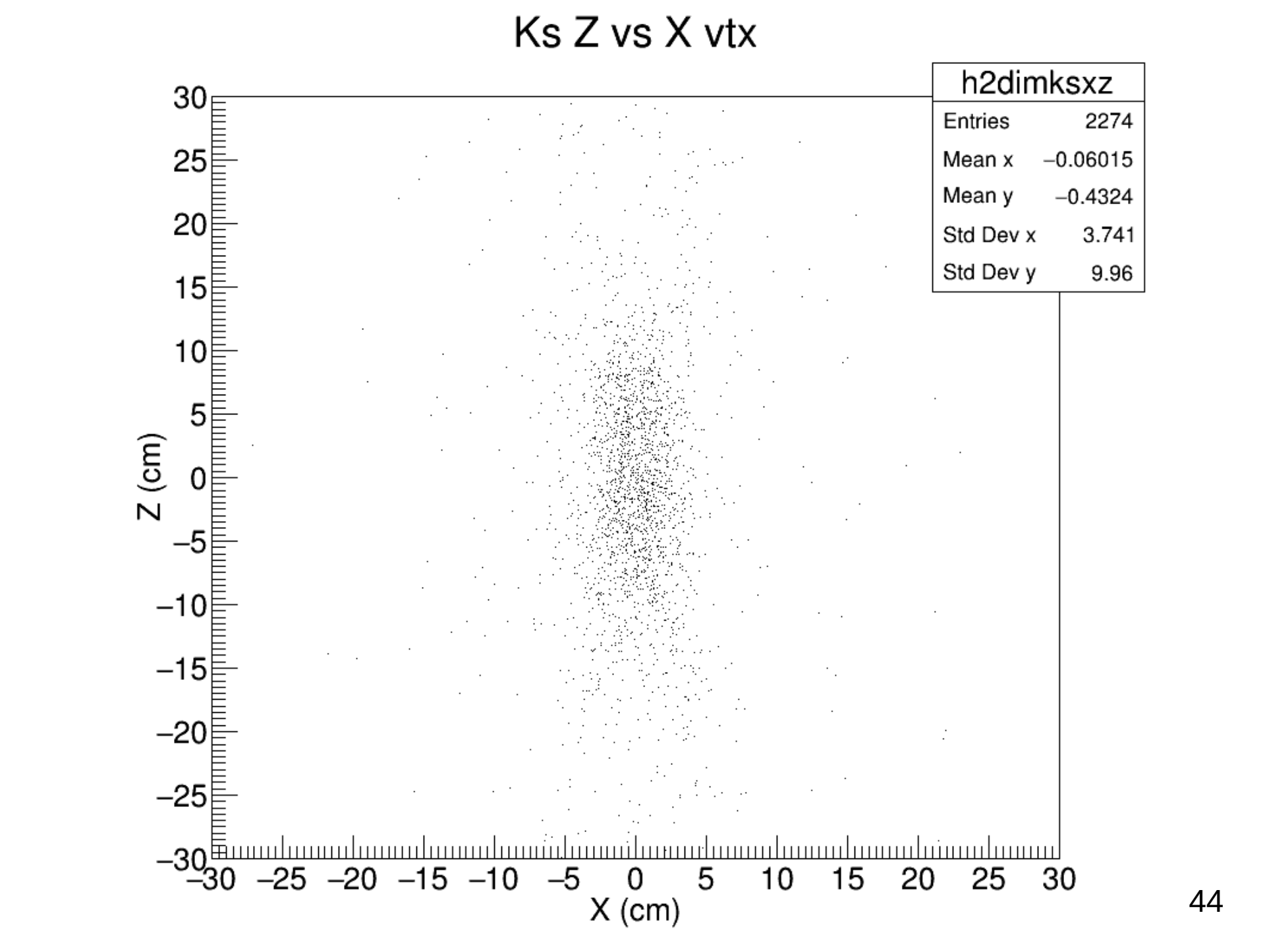

Kshort mass
hksmass
Entries 2274
Mean 0.4956
Std Dev 0.0274
Integral 2274
χ² / ndf 30.56 / 6
Prob 3.081e−05
Constant 1872 ± 57.5
Mean 0.4971 ± 0.0002
Sigma 0.009681 ± 0.000193
# of Events/0.02GeV/c²
M (GeV/c²)
0
200
400
600
800
1000
1200
1400
1600
1800
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

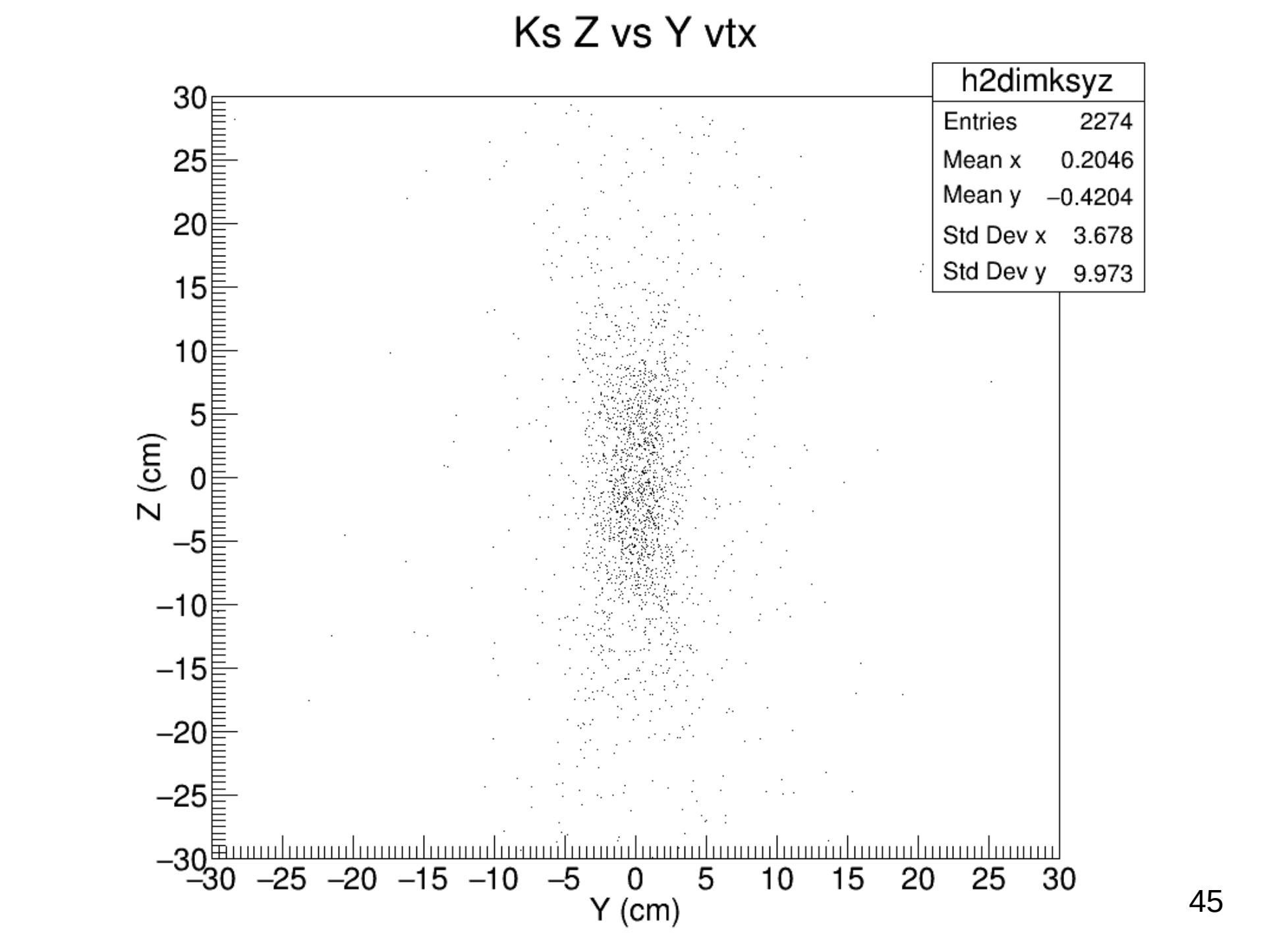

K0s X vertex
hksvertexx
Entries 2274
Mean −0.04945
Std Dev 3.252
# of Events/0.5cm
10²
10
1
−10
−5
0
5
10
X (cm)

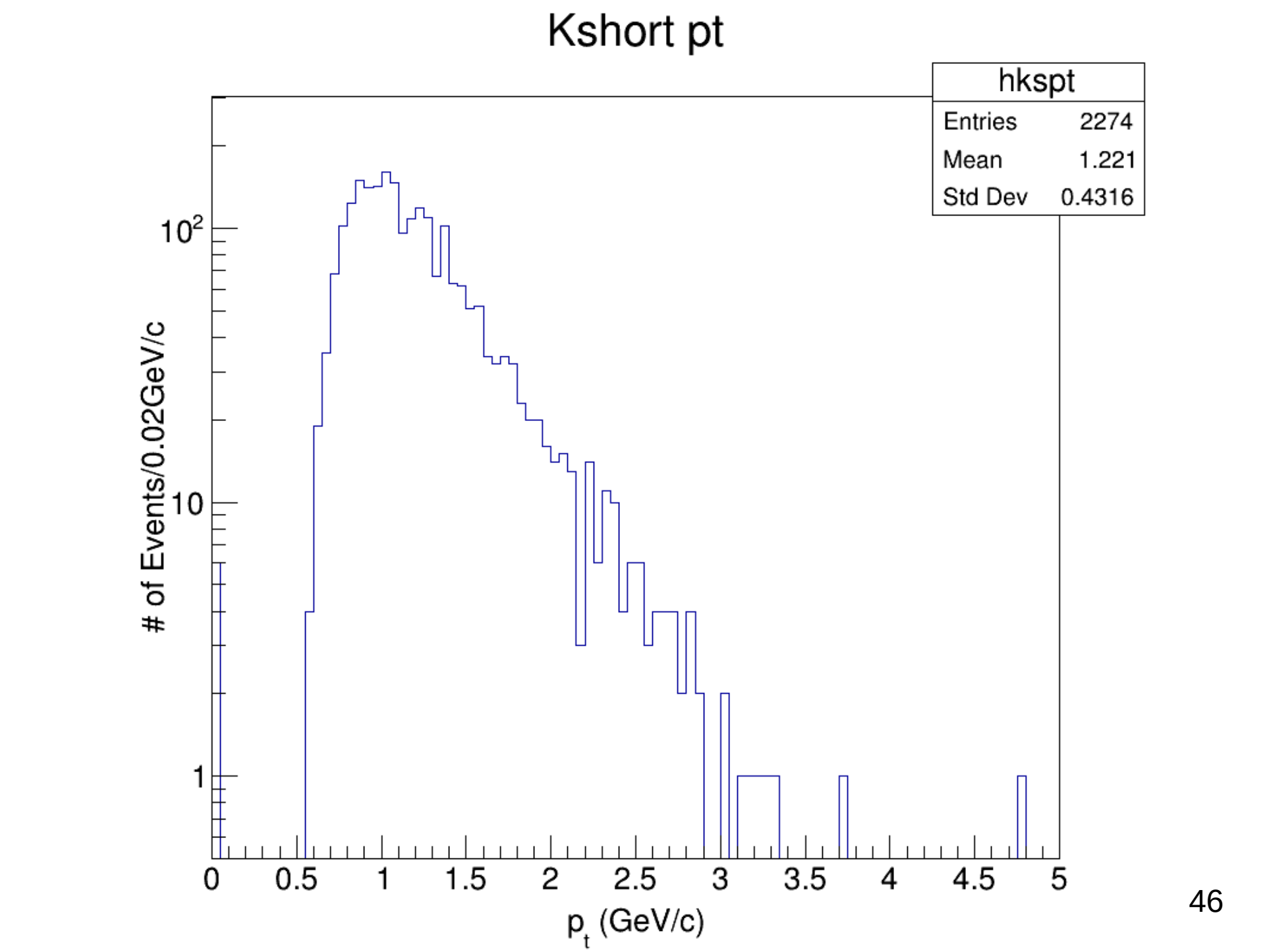

K0s Y vertex
hksvertexy
Entries 2274
Mean 0.1319
Std Dev 4.541
# of Events/0.5
10²
10
1
−30
−20
−10
0
10
20
30
Y (cm)

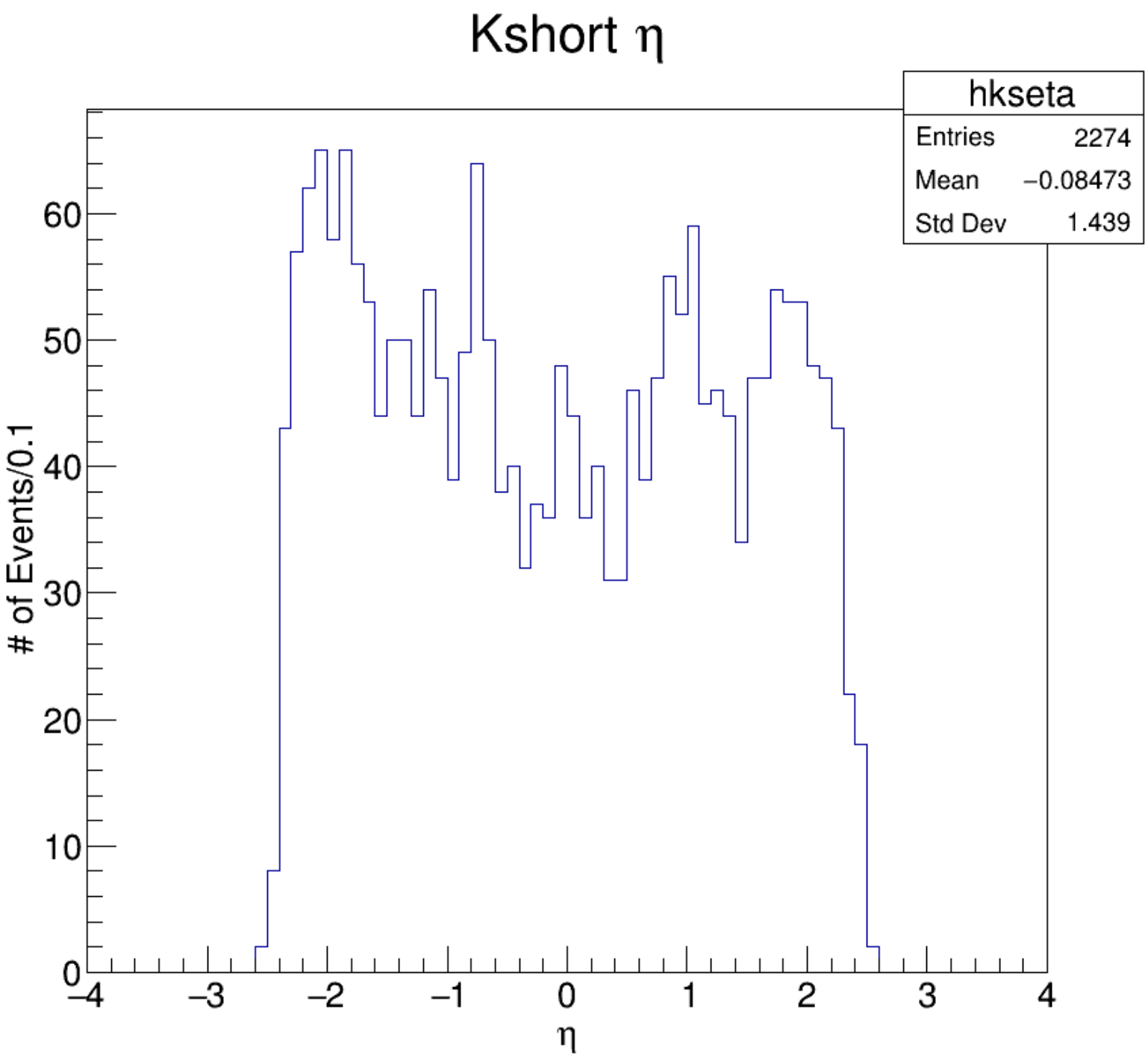

K0s Z vertex
hksvertexz
Entries 2274
Mean −0.4204
Std Dev 9.973
10^2
10
1
# of Events/0.5
−30
−20
−10
0
10
20
30
Z (cm)

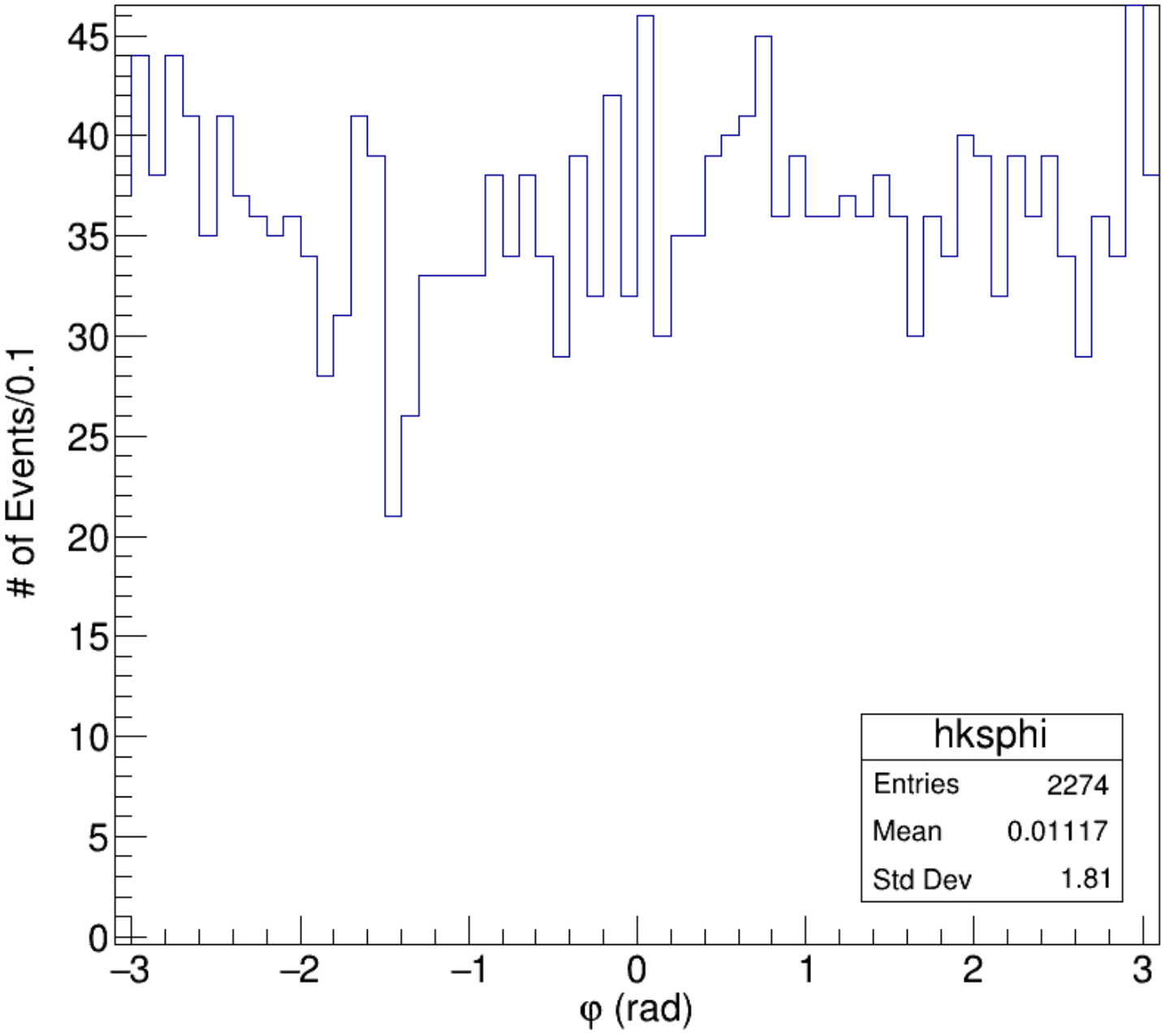

Ks Y vs X vtx
h2dimksxy
Entries 2274
Mean x −0.0008223
Mean y 0.1395
Std Dev x 4.57
Std Dev y 4.527
Kshort vertices
Y (cm)
X (cm)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30

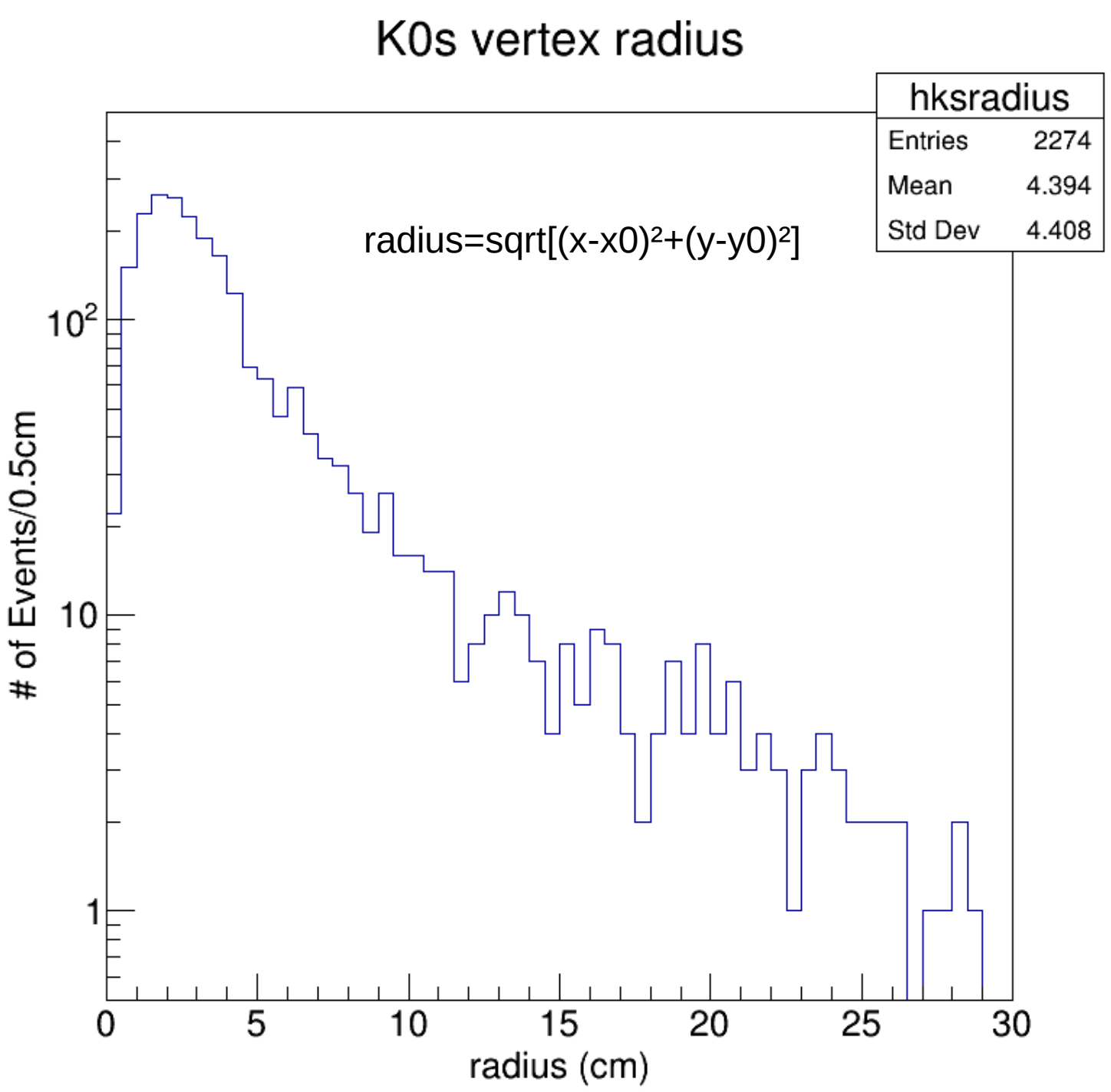

Ks Z vs X vtx
h2dimksxz
Entries 2274
Mean x −0.06015
Mean y −0.4324
Std Dev x 3.741
Std Dev y 9.96
Z (cm)
X (cm)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30

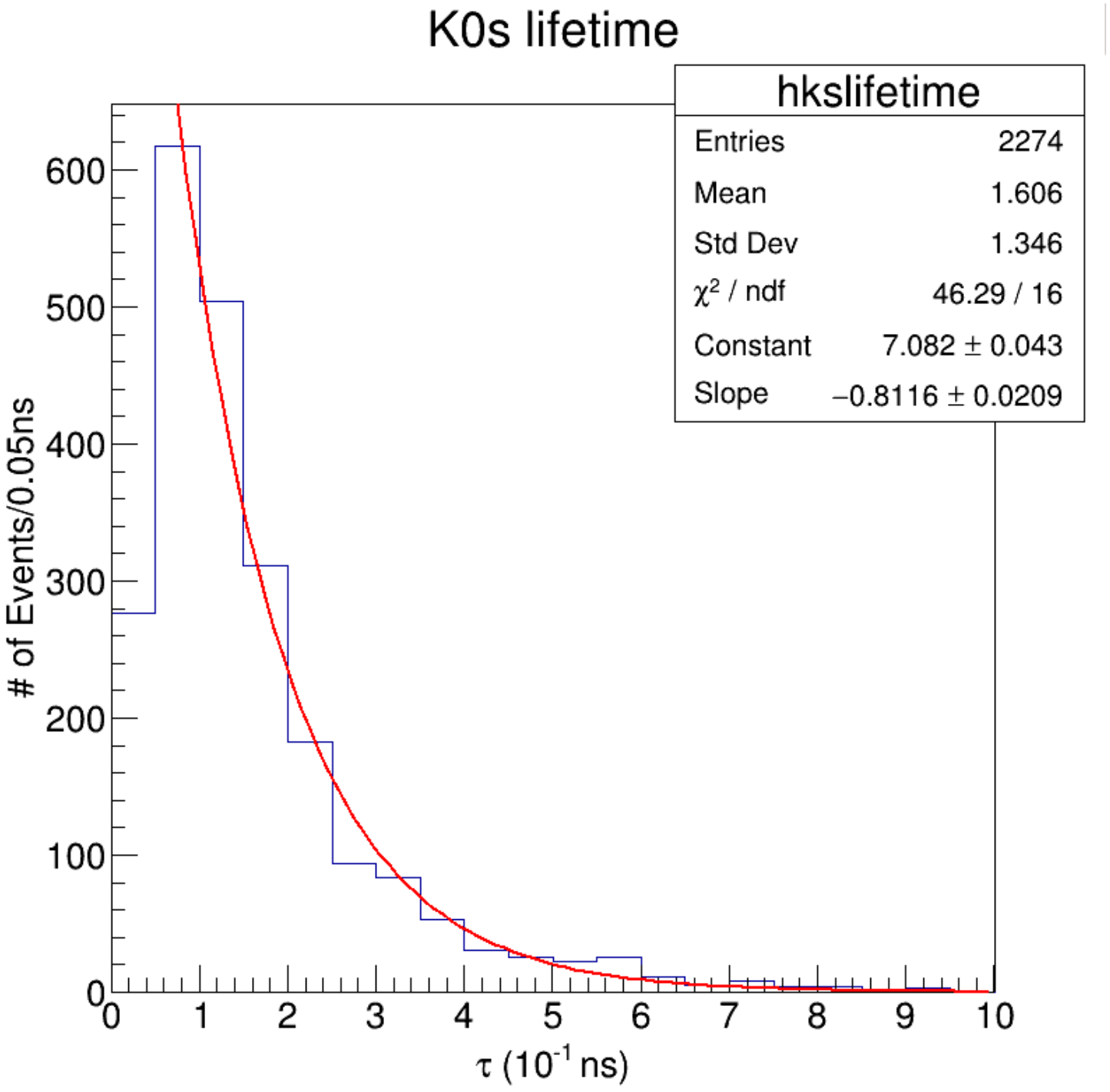

Ks Z vs Y vtx
h2dimksyz
Entries 2274
Mean x 0.2046
Mean y −0.4204
Std Dev x 3.678
Std Dev y 9.973
Z (cm)
Y (cm)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30

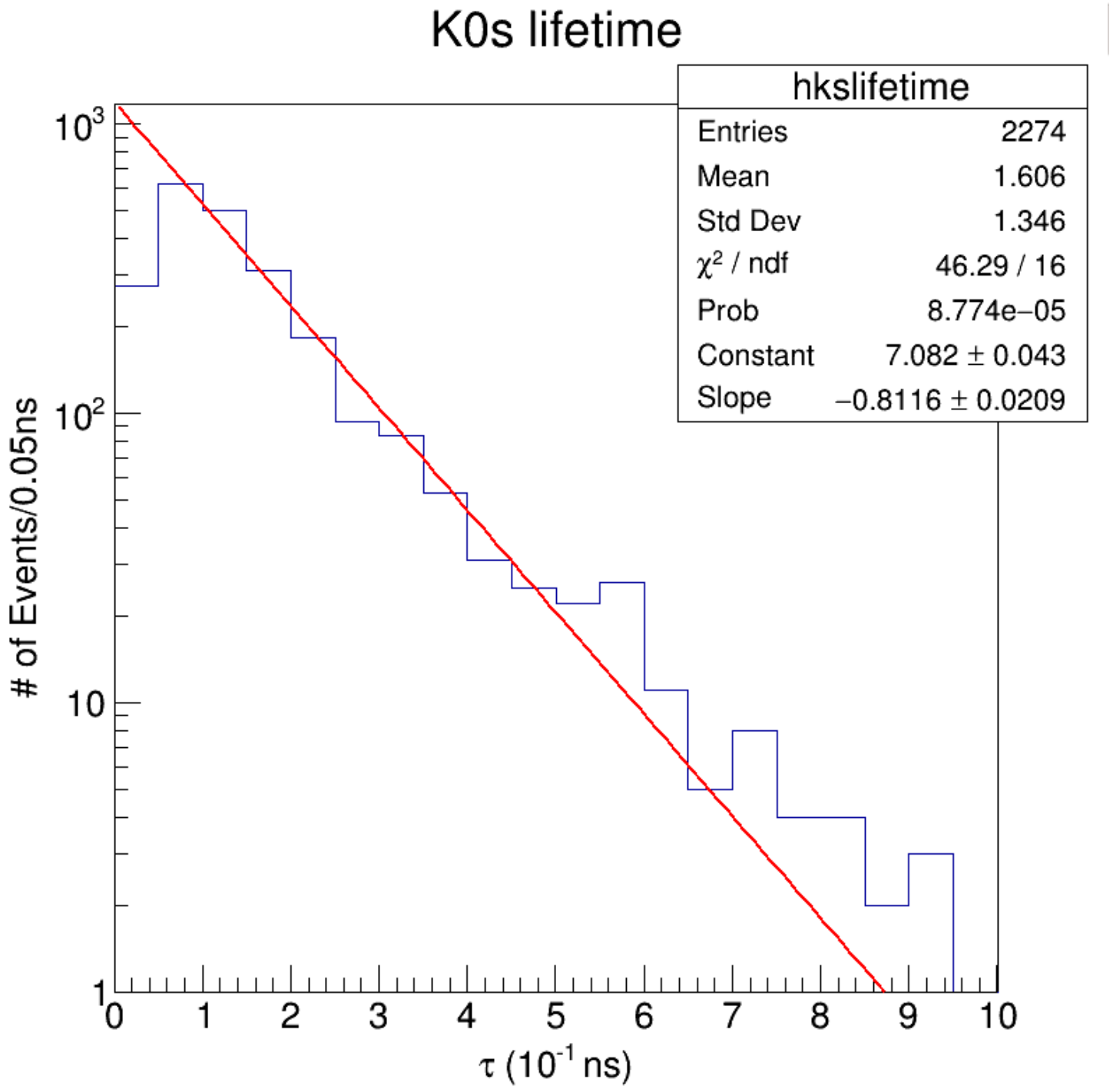

Kshort pt
hkspt
Entries 2274
Mean 1.221
Std Dev 0.4316
# of Events/0.02GeV/c
10^2
10
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
p_t (GeV/c)

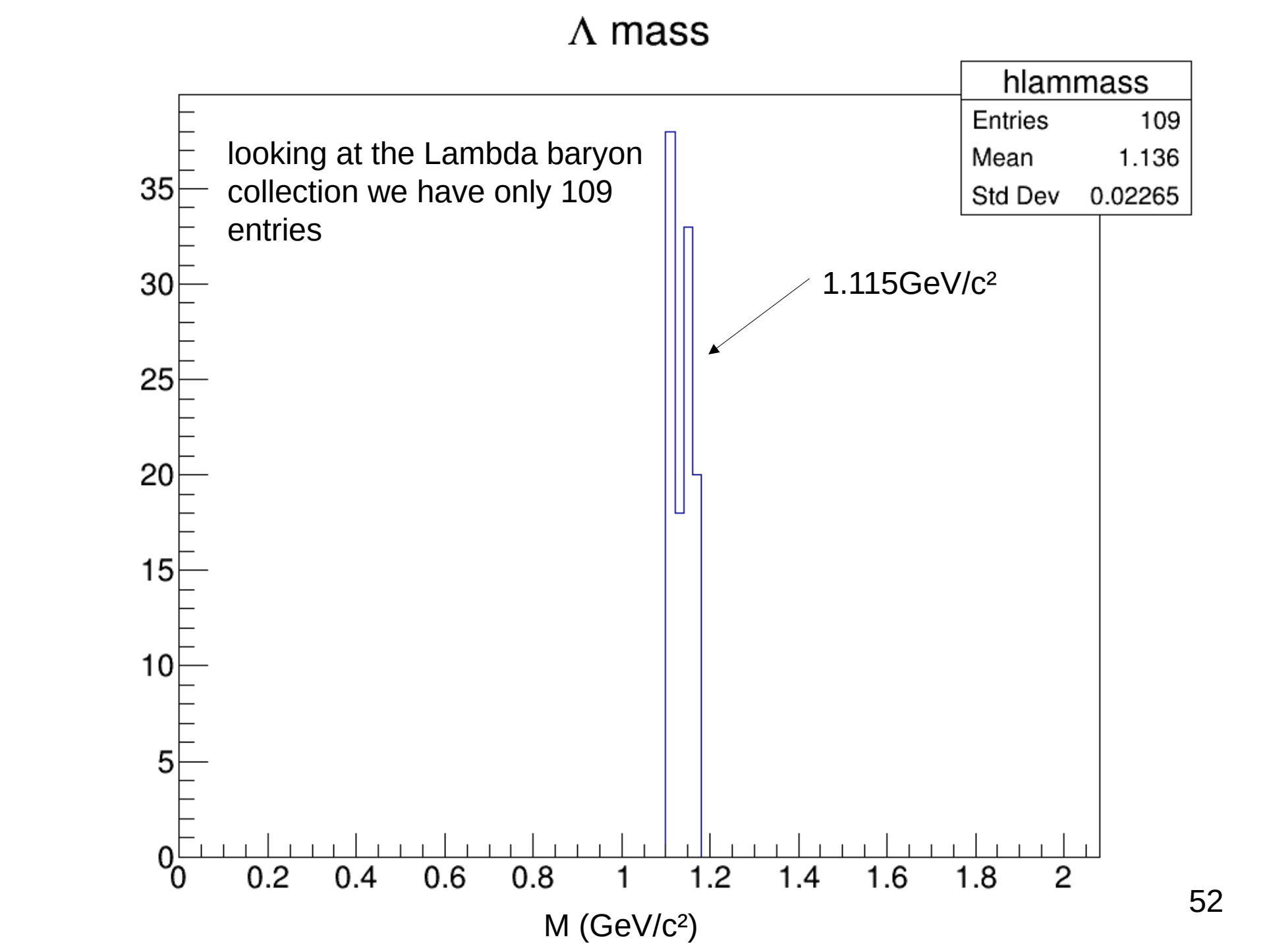

Kshort η
hkseta
Entries 2274
Mean −0.08473
Std Dev 1.439
# of Events/0.1
0
10
20
30
40
50
60
−4
−3
−2
−1
0
1
2
3
4
η


Kshort φ
# of Events/0.1
φ (rad)
hksphi
Entries 2274
Mean 0.01117
Std Dev 1.81


K0s vertex radius
hksradius
Entries 2274
Mean 4.394
Std Dev 4.408
radius=sqrt[(x-x0)²+(y-y0)²]
# of Events/0.5cm
10²
10
1
0
5
10
15
20
25
30
radius (cm)


K0s lifetime
hkslifetime
Entries 2274
Mean 1.606
Std Dev 1.346
χ² / ndf 46.29 / 16
Constant 7.082 ± 0.043
Slope −0.8116 ± 0.0209
# of Events/0.05ns
τ (10⁻¹ ns)
0
100
200
300
400
500
600
0 1 2 3 4 5 6 7 8 9 10


K0s lifetime
hkslifetime
Entries 2274
Mean 1.606
Std Dev 1.346
χ² / ndf 46.29 / 16
Prob 8.774e−05
Constant 7.082 ± 0.043
Slope −0.8116 ± 0.0209
# of Events/0.05ns
τ (10⁻¹ ns)


Λ mass
hlammass
Entries 109
Mean 1.136
Std Dev 0.02265
looking at the Lambda baryon collection we have only 109 entries
1.115GeV/c²
35
30
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
M (GeV/c²)

Thanks for the attention.