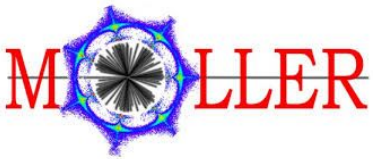
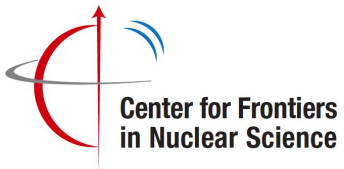
Moller Deconvolution: Missed Hits and other updates

Nathan Shankman (SBU)
Nuclear Meeting
11/13/2026

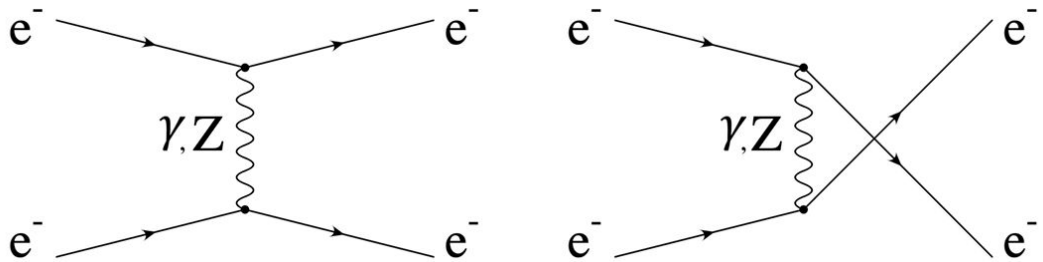






Context

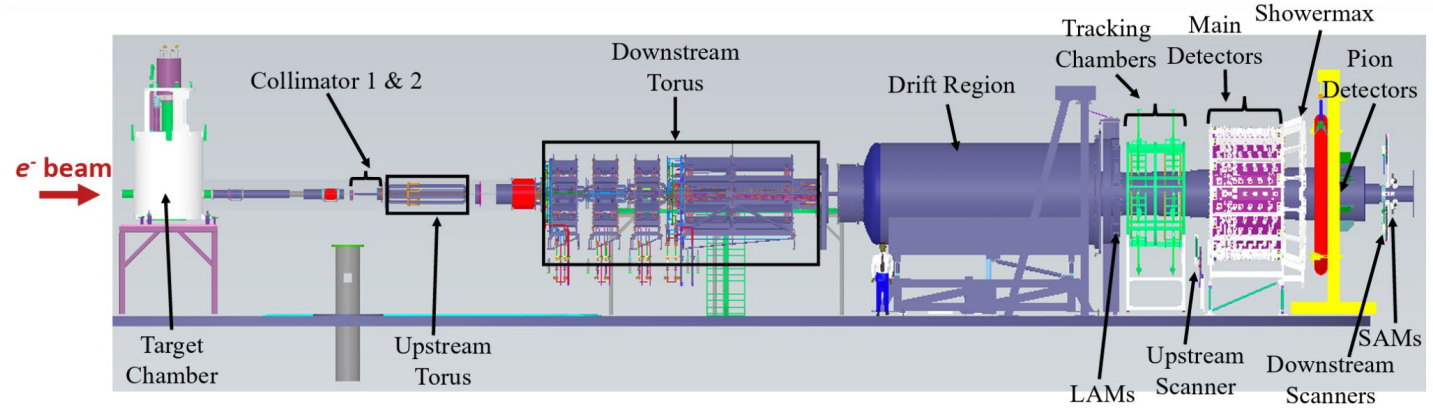
- Standard Model Precision Measurement
- Parity-Violating Electron Scattering (PVES)
- Longitudinally polarized electrons scatter off unpolarized electrons in liquid hydrogen (LH2) target



$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}$$

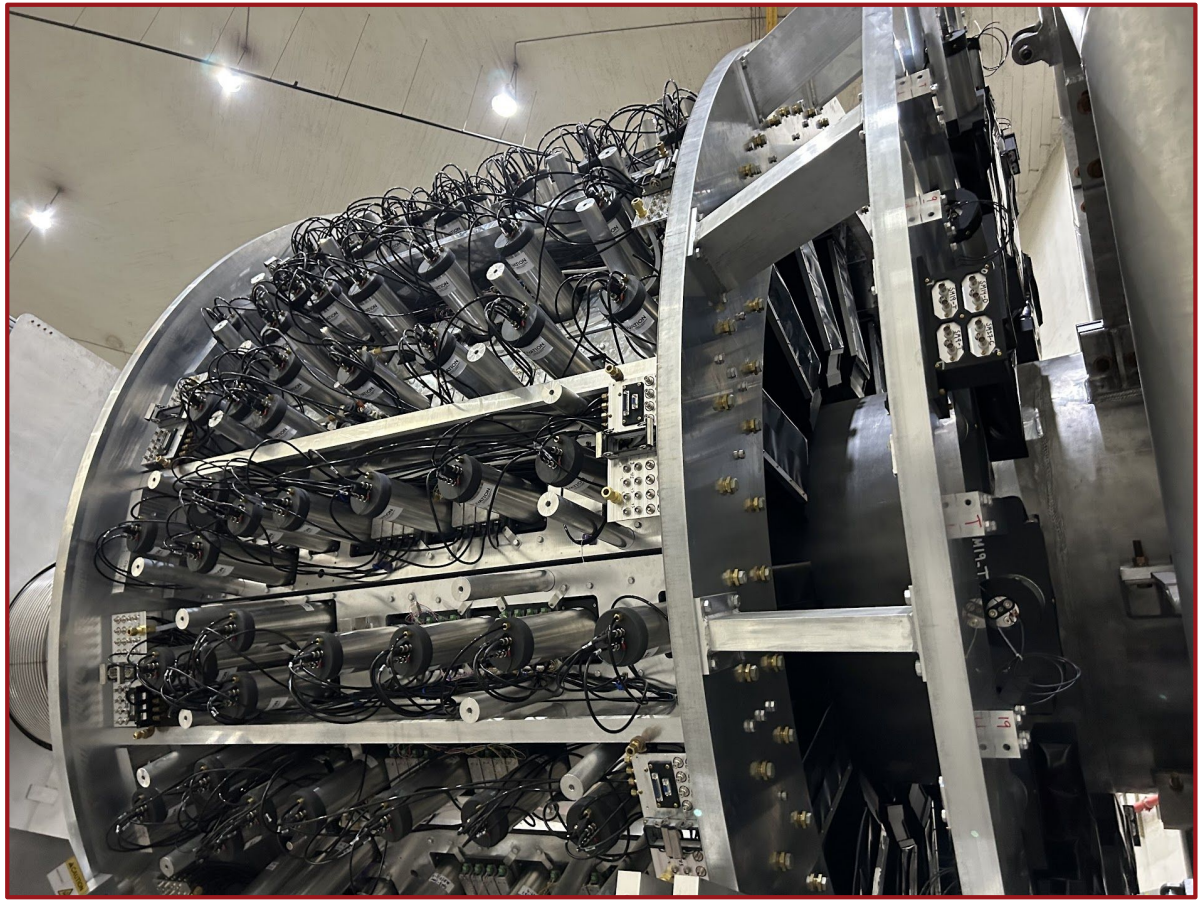
$$A_{PV} = -mE \frac{G_F}{\sqrt{2}\pi\alpha} \frac{4\,sin^2\,\theta}{(3+cos^2\,\theta)^2} Q_W^e, \qquad Q_W^e = 1 - 4\sin^2\theta_W \sim 0.075$$

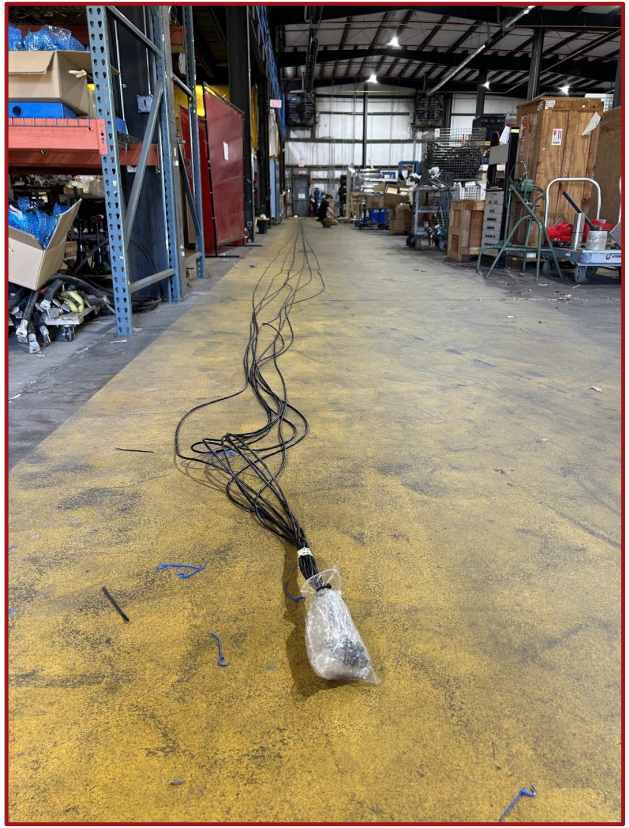
Design


e⁻ beam
Collimator 1 & 2
Downstream Torus
Drift Region
Tracking Chambers
Main Detectors
Showermax
Pion Detectors
Target Chamber
Upstream Torus
LAMs
Upstream Scanner
Downstream Scanners
SAMs



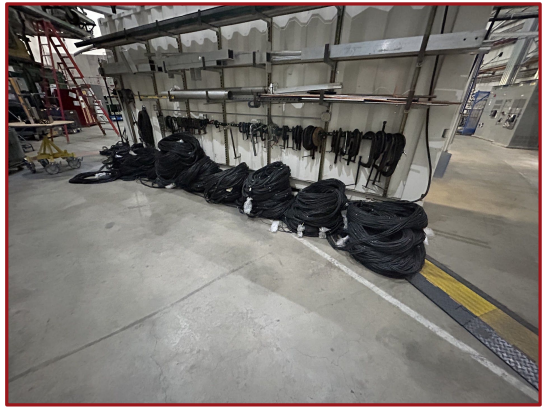






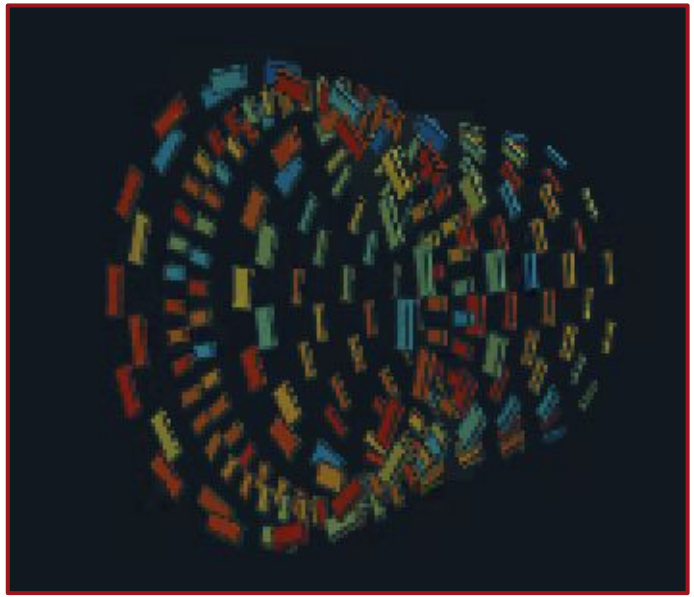


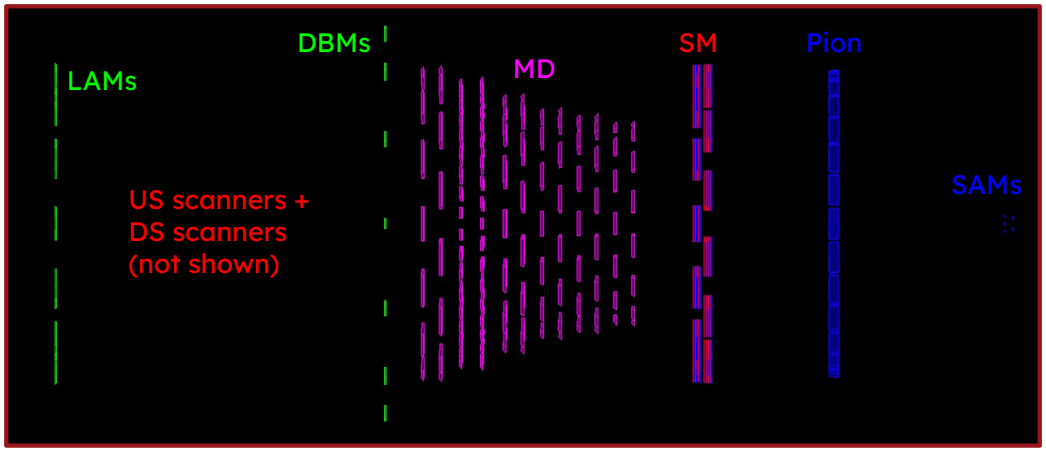


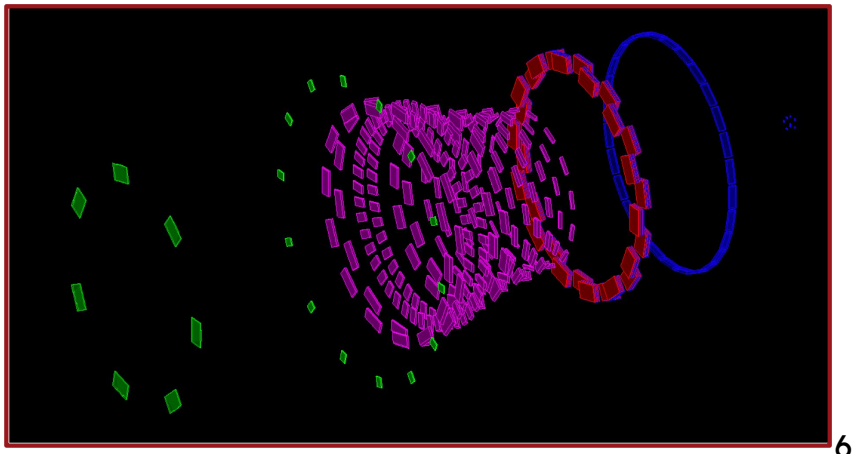


Counting Mode Scalar Display

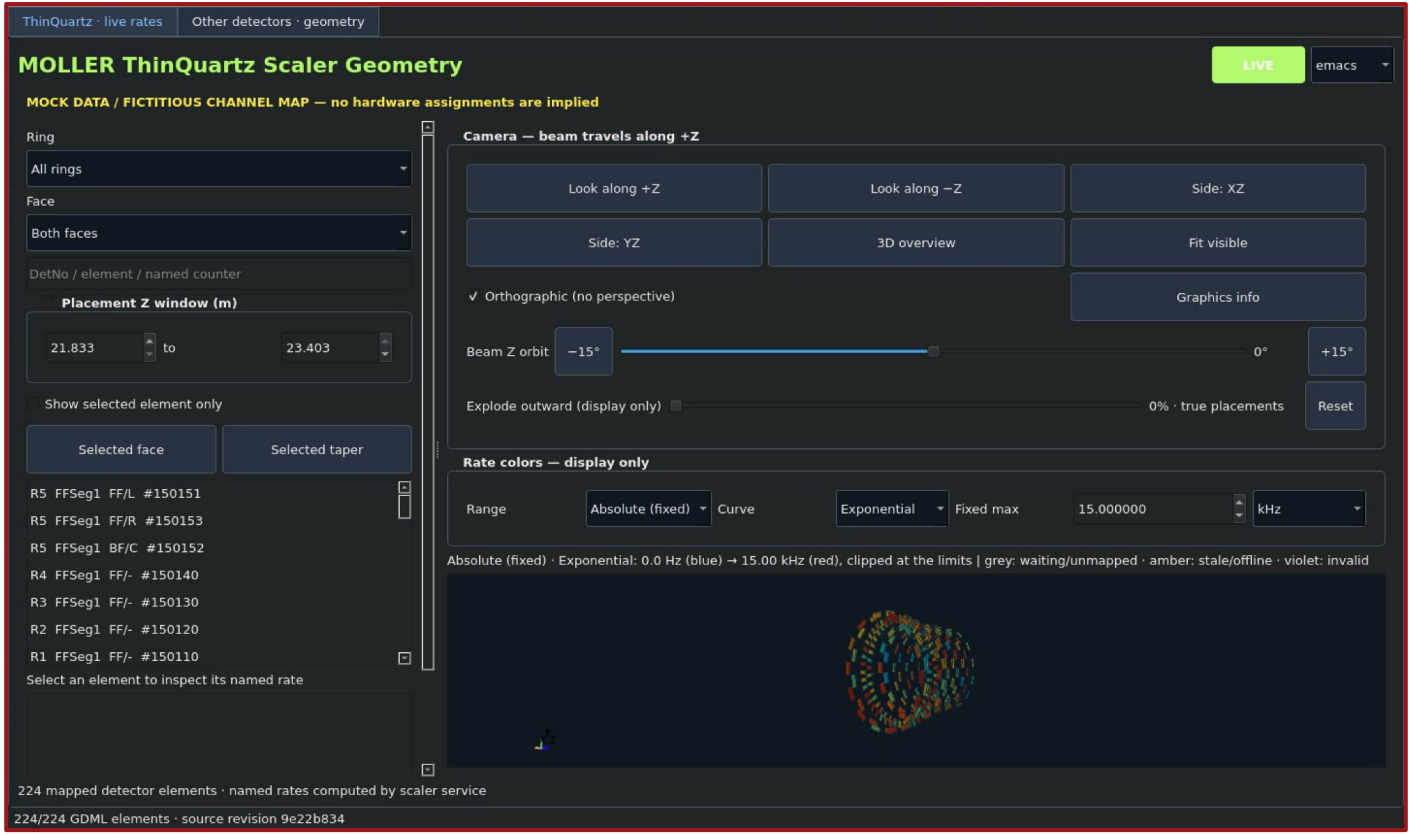
- Integration mode and counting mode
- Integration: Primary data taking
- Counting: Calibration
- People in the control center want a nice visual of live rates (signals over time)
- I need to add detectors







Counting Mode Scalar Display



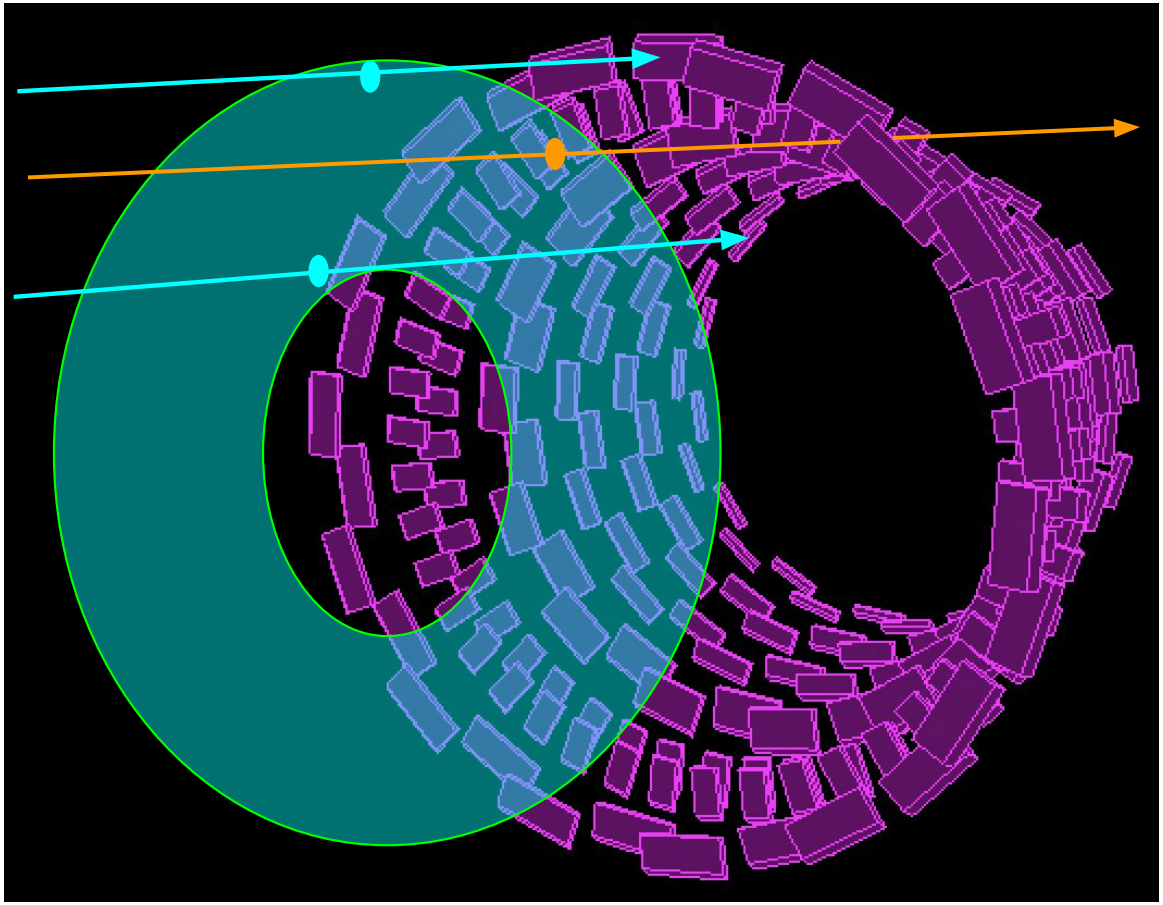
Casey Morean made this

Deconvolution Studies

- We care about electrons scattering off electrons (moller)
- Many other processes occur:
  - Electrons gently scatter of LH2 nuclei (elastic)
  - Electrons scatter off and break apart LH2 nuclei into new particles (inelastic)
  - Electrons gently scatter off Al nuclei (Al elastic)
  - Electrons scatter off Al nuclei and knock out or excite a nucleon (Al quasielastic)
  - Electrons scatter off and break apart Al nuclei into new particles (Al inelastic)
  - Pions are created in inelastic scattering
- These processes will create signals in our detector
- Our signals will be convoluted
- We need to deconvolute
  - Deconvolution task force
  - Missed Hits

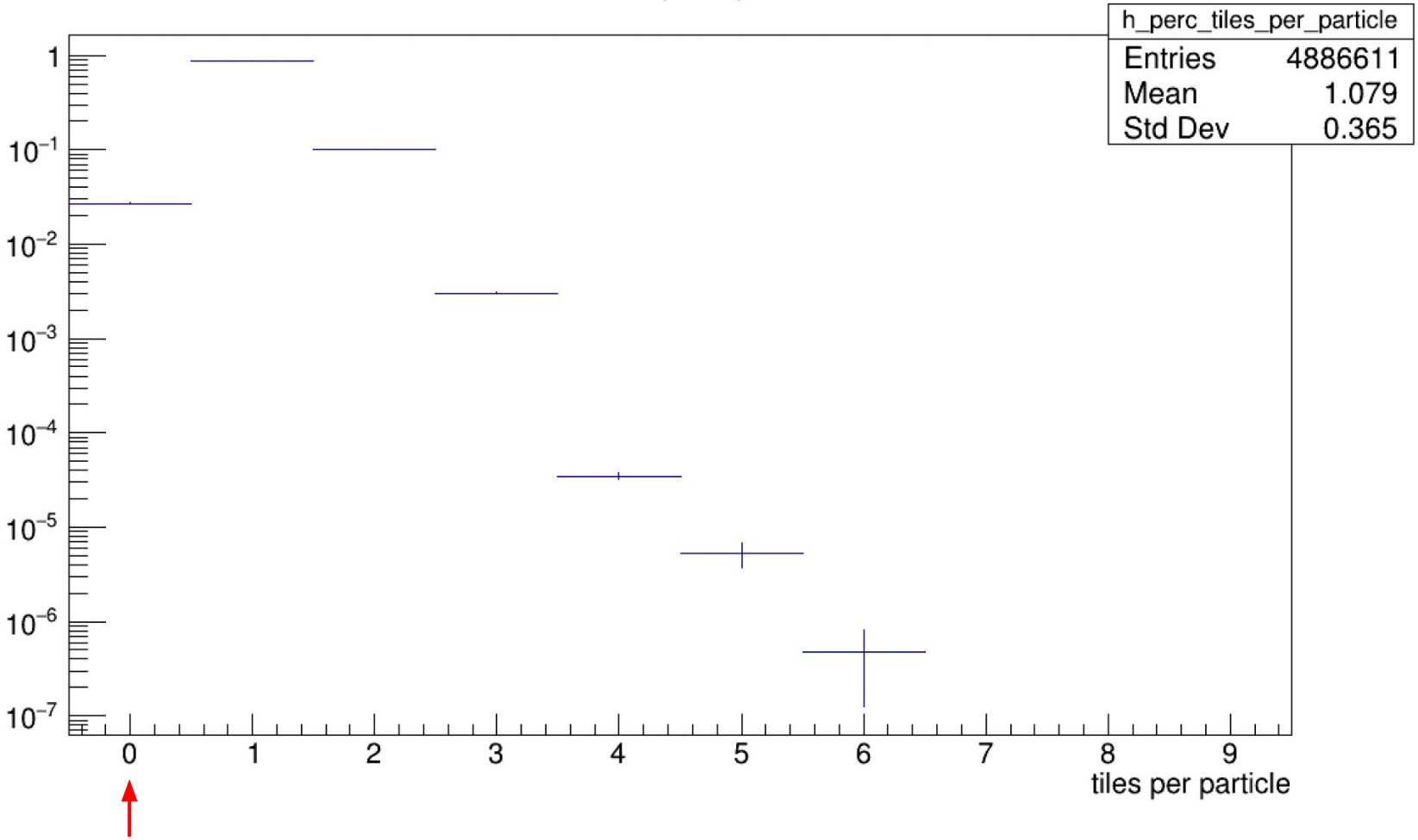
Missed Hits

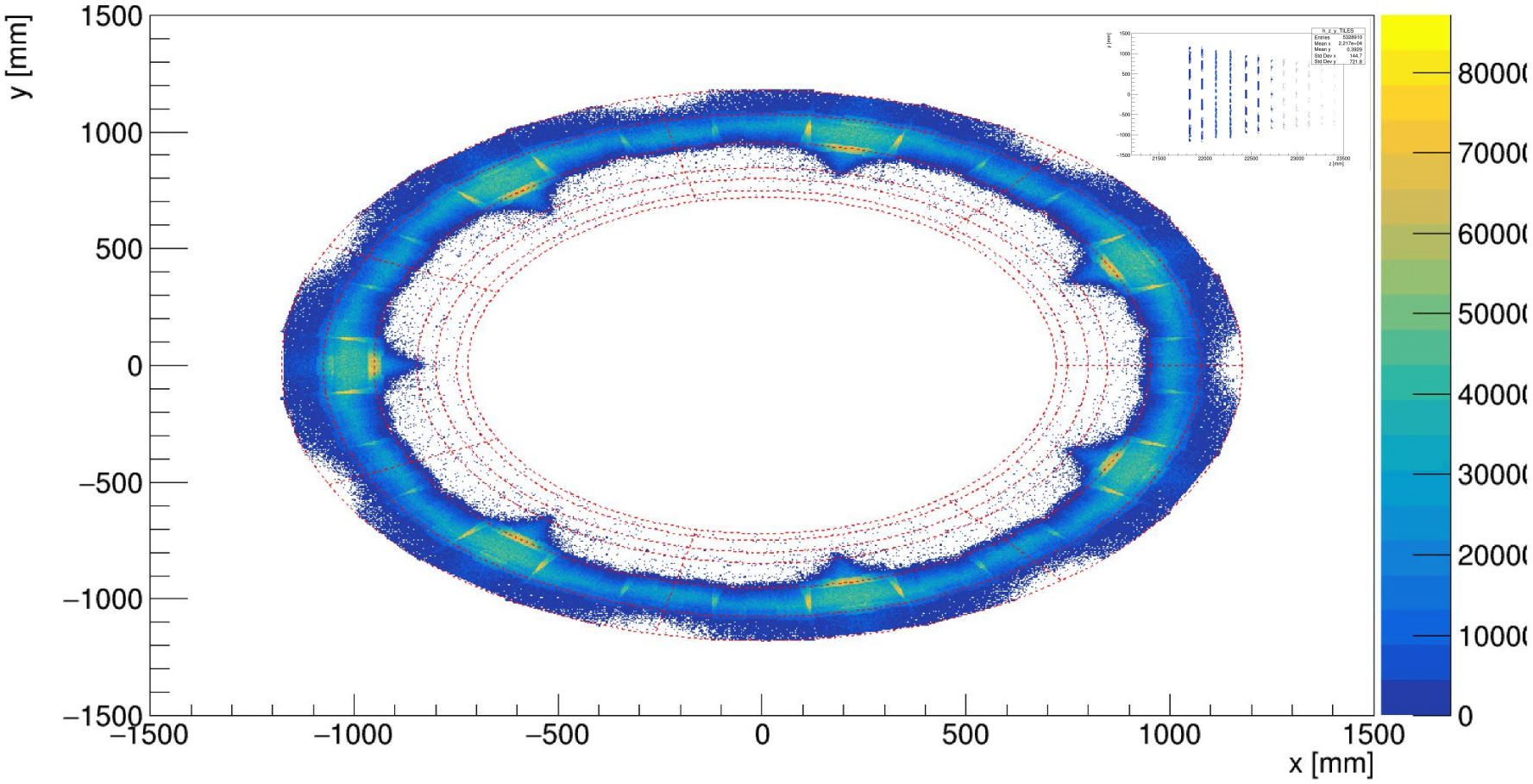
- Electrons that should hit a main tile but don’t
- Why does this happen?
- Geant4 & remoll
- Hit on virtual plane but not tile? **MISS**



Consider moller scattering
~ 10,000,000 events

RW tiles per particle




y [mm]
1500
1000
500
0
−500
−1000
−1500
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−1000
−500
0
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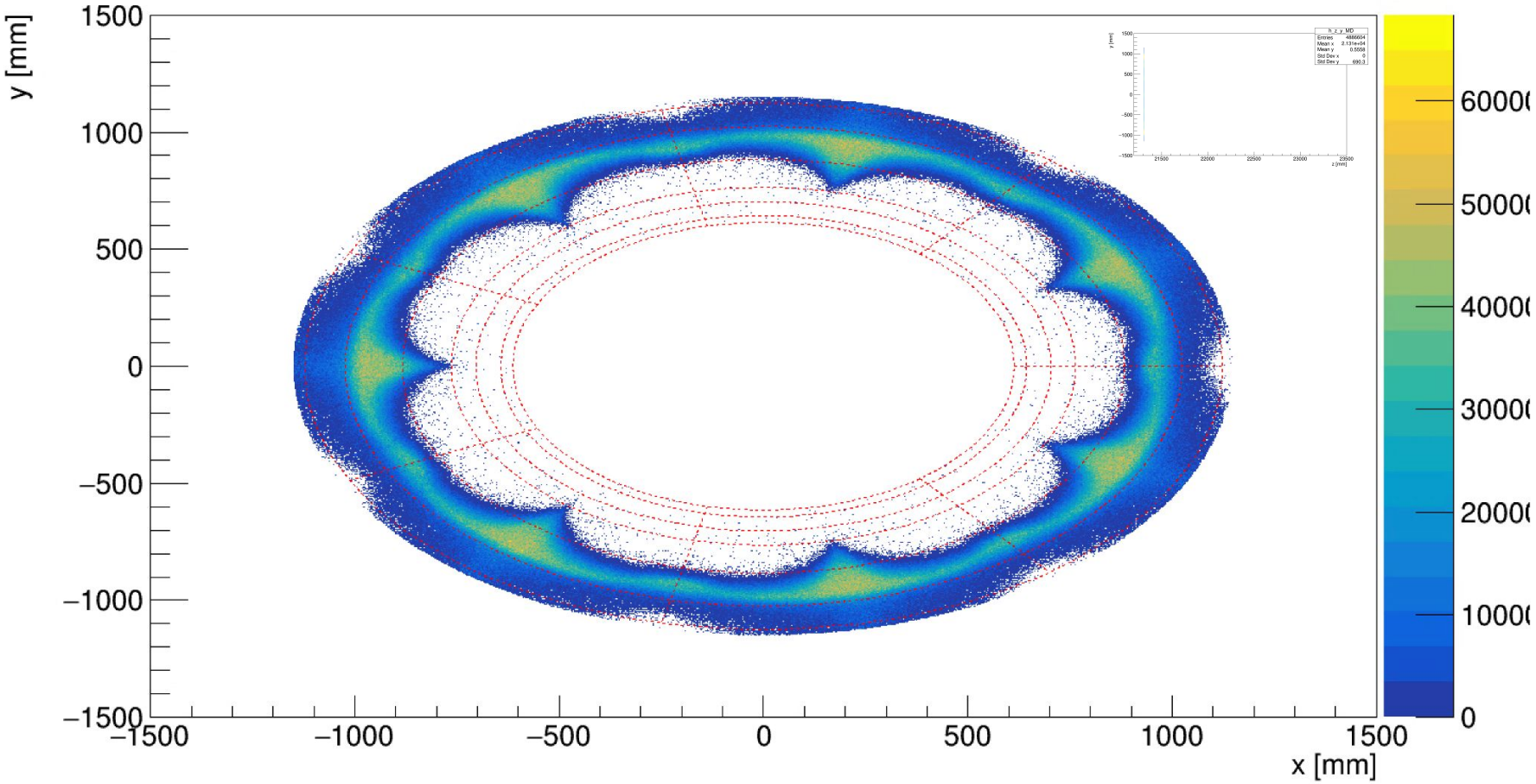
1500
x [mm]
8000
7000
6000
5000
4000
3000
2000
1000
0


y [mm]
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−500
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−1000
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0
500
1000
1500
x [mm]
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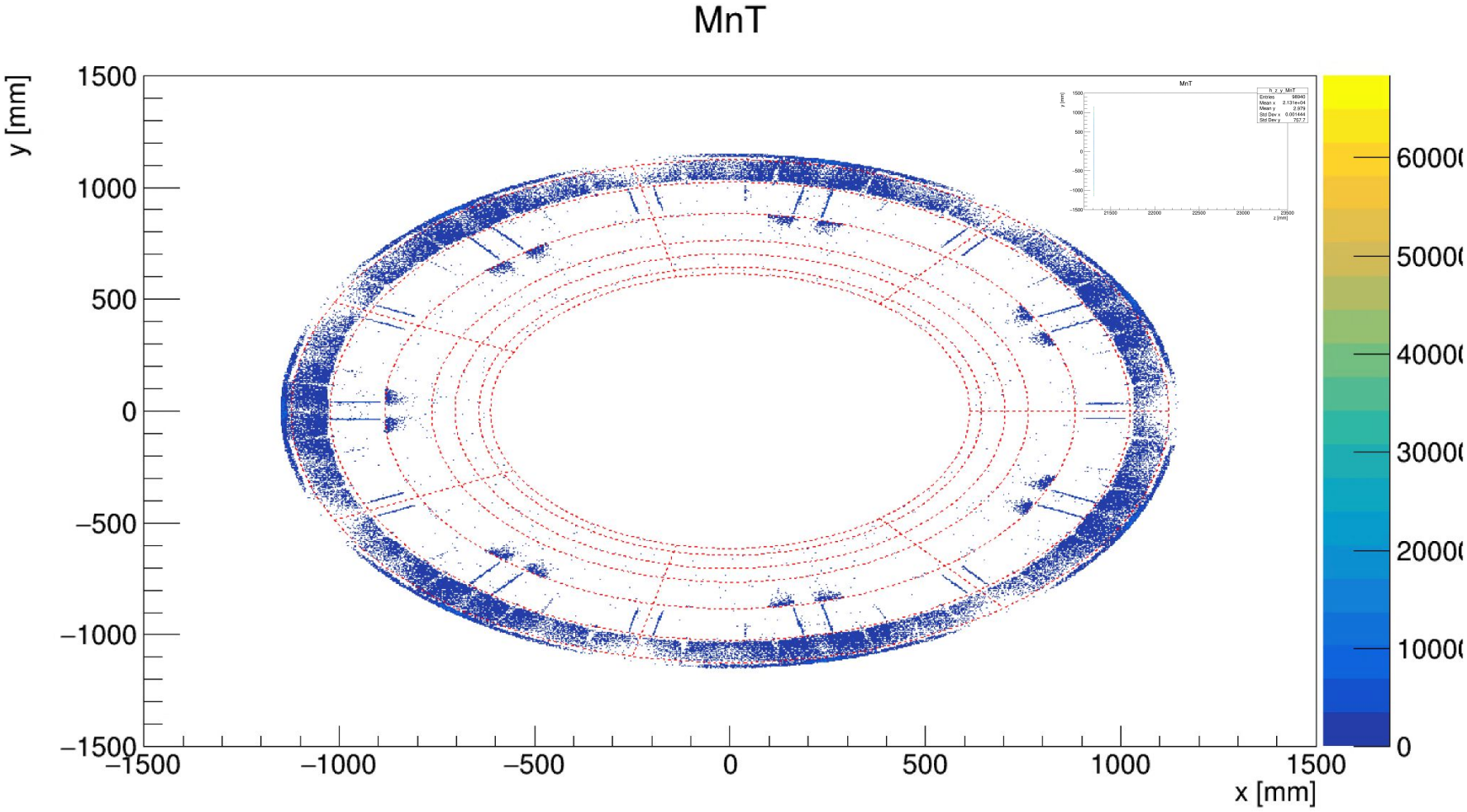
40000
30000
20000
10000
0


MnT
y [mm]
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x [mm]
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50000
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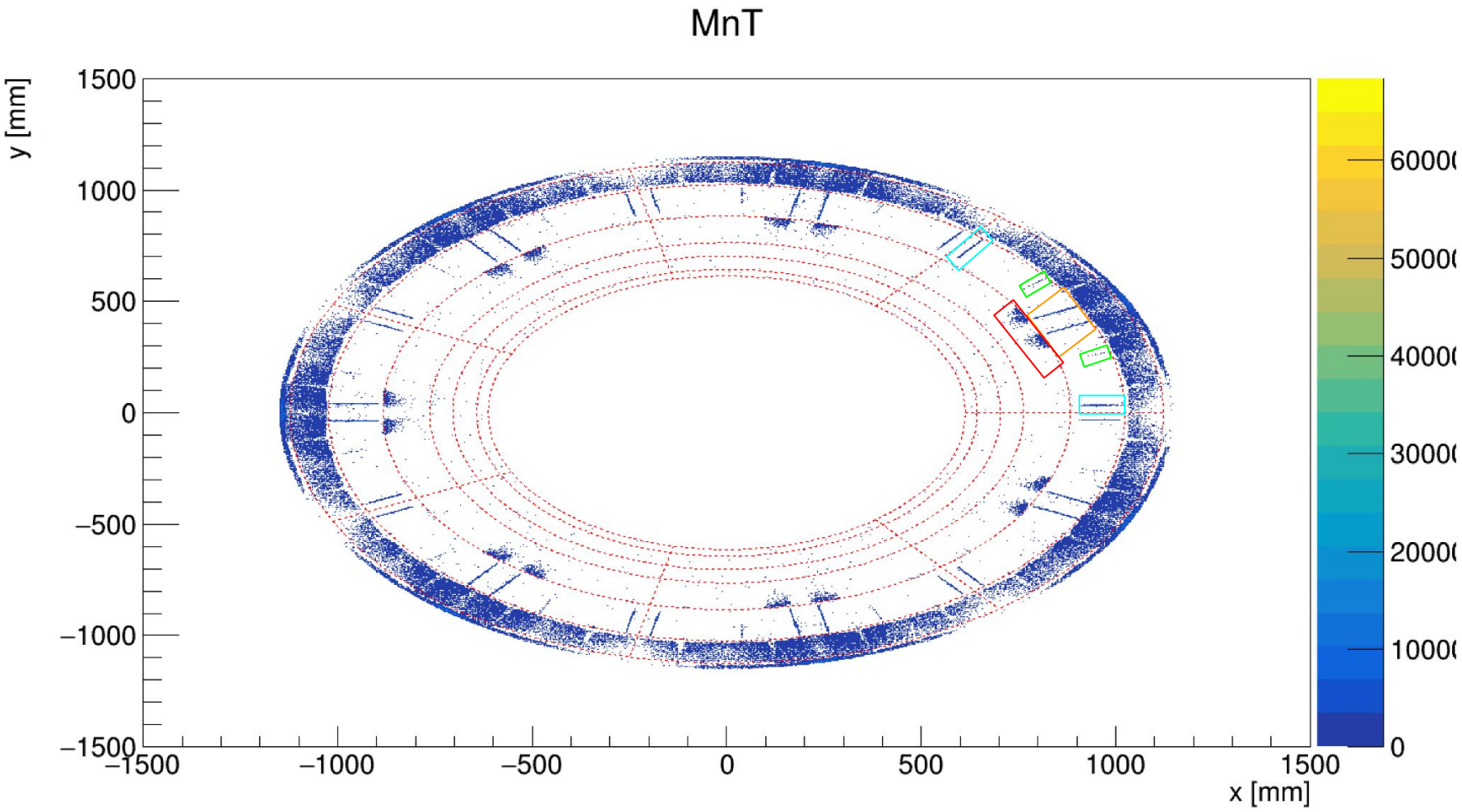
MnT


MnT
y [mm]
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500
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500
1000
1500
x [mm]
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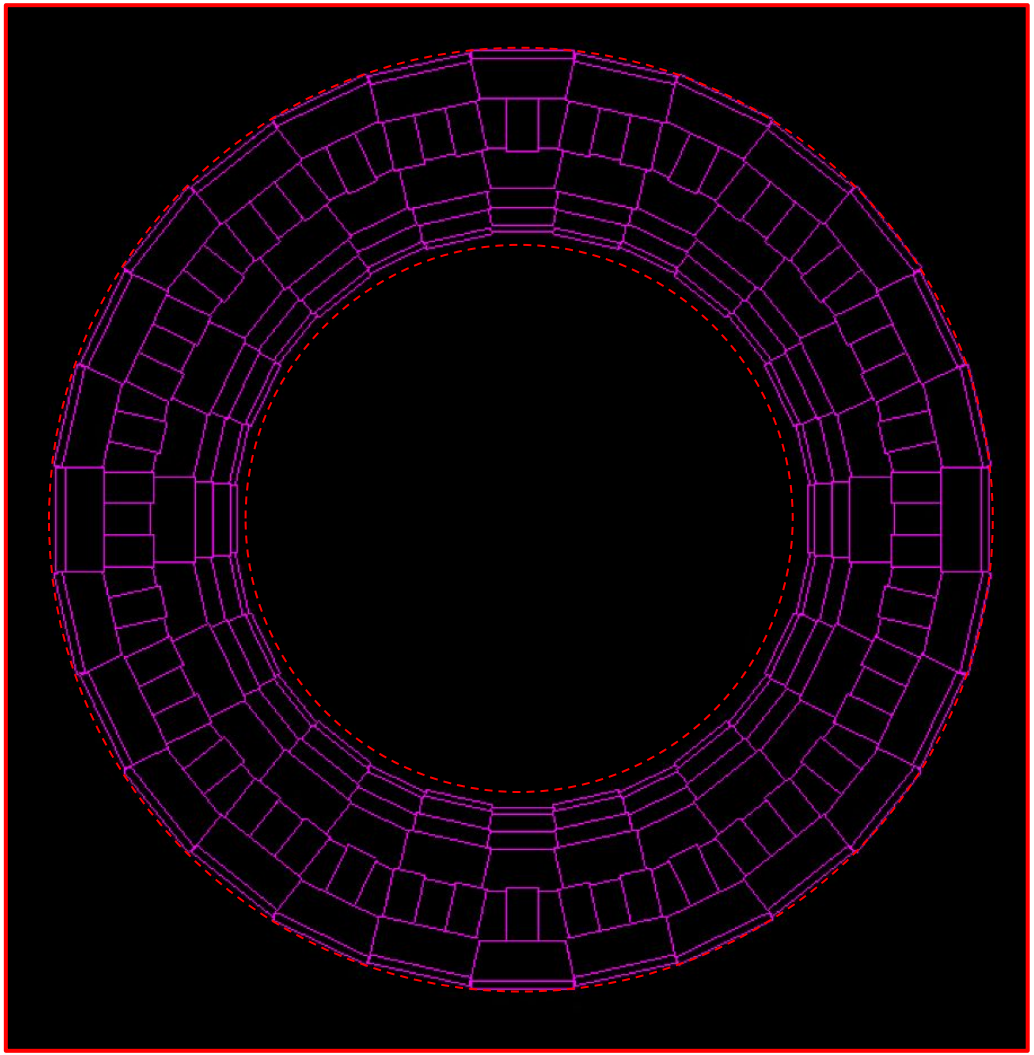
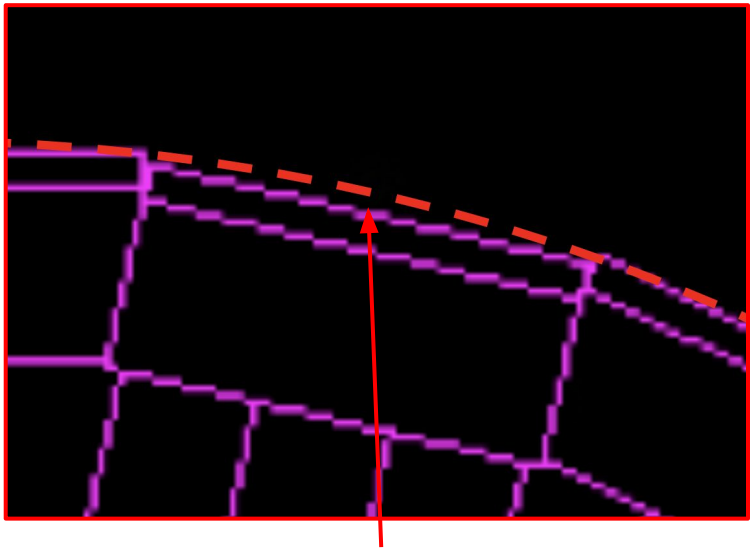
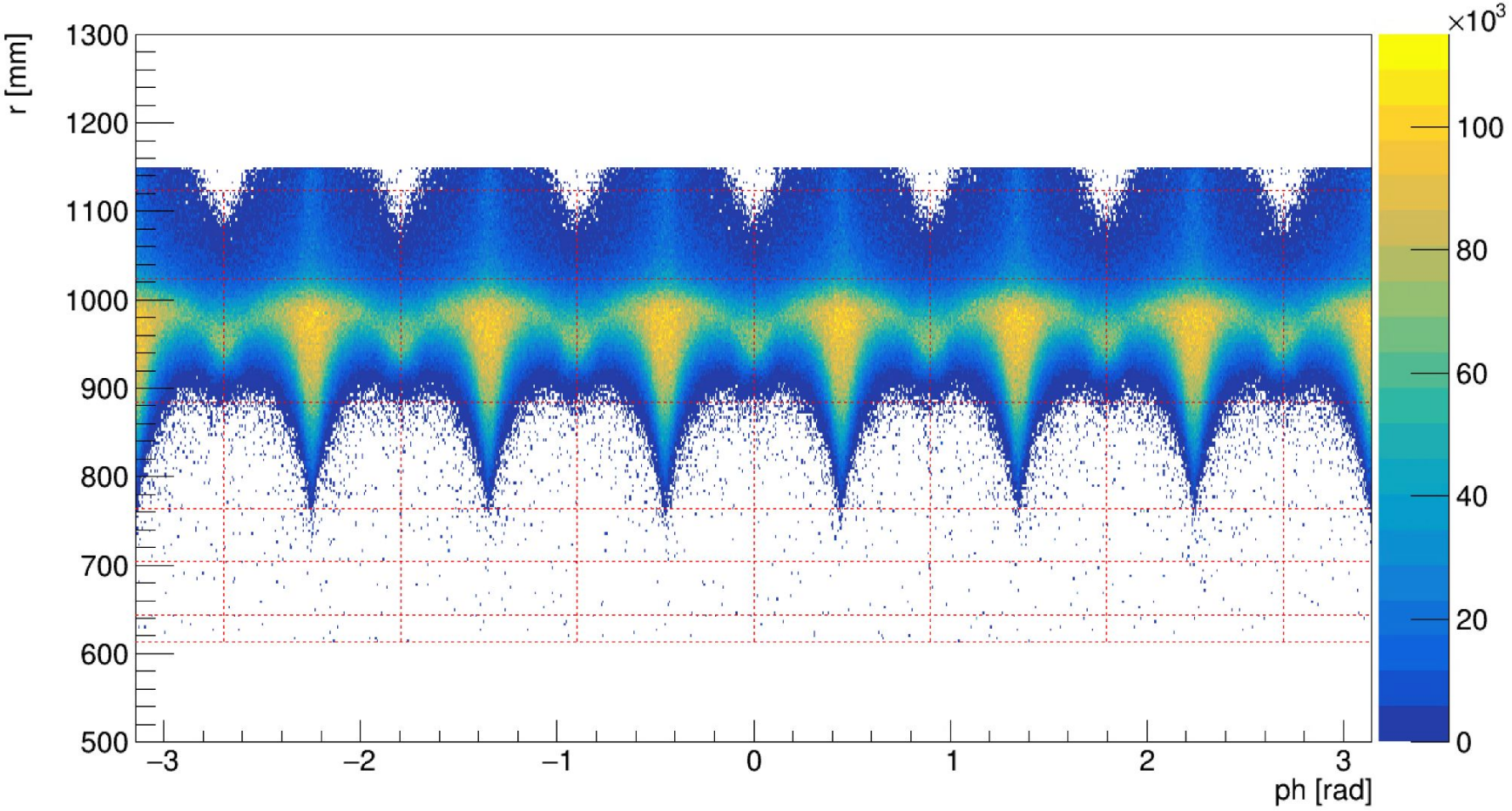
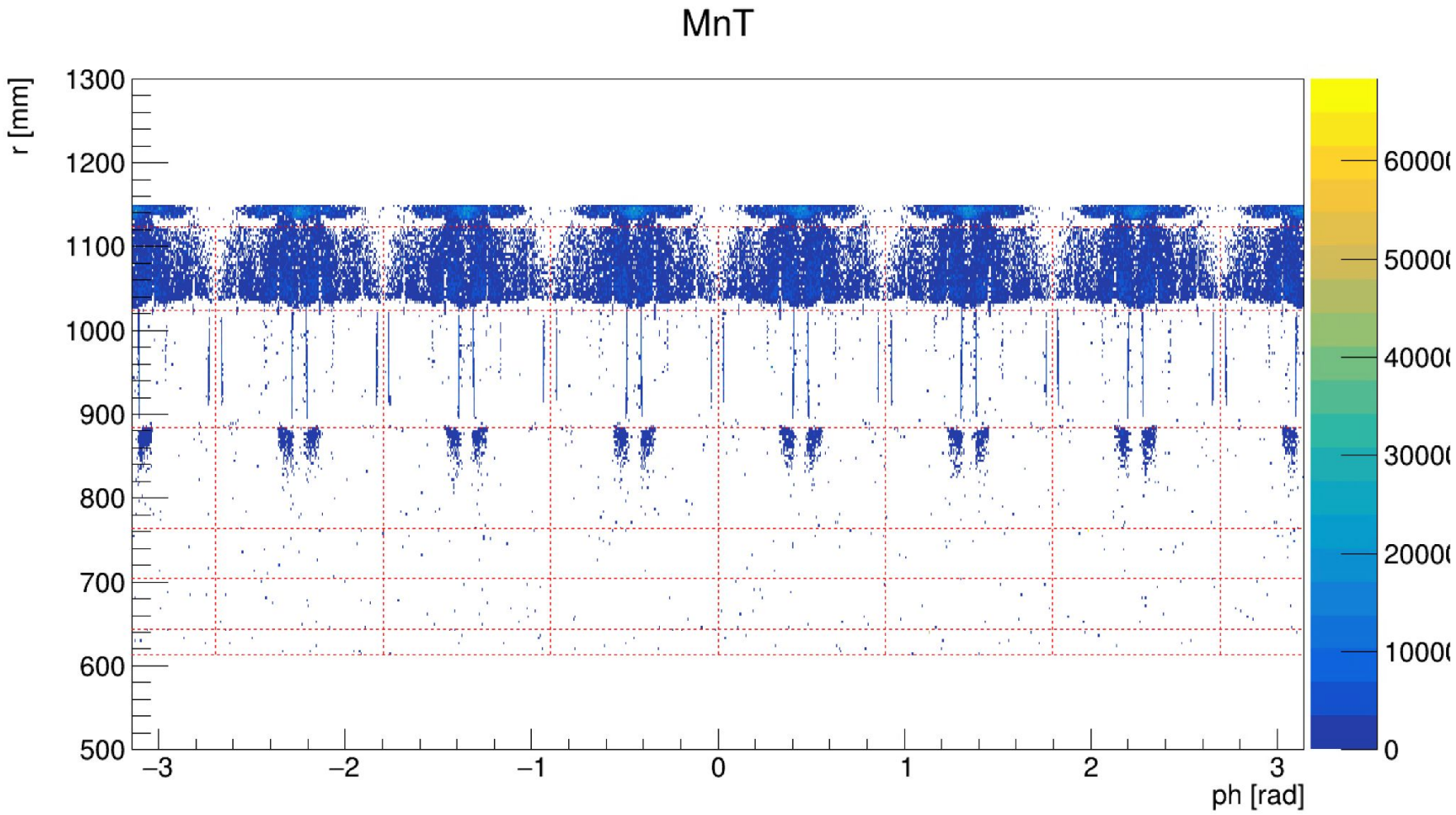
5000
4000
3000
2000
1000
0





This little triangle space will count as missed hits but are not actually missed hit.


r [mm]
1300
1200
1100
1000
900
800
700
600
500
−3
−2
−1
0
1
2
3
ph [rad]
×10^3
100
80
60
40
20
0


MnT
r [mm]
1300
1200
1100
1000
900
800
700
600
500
−3
−2
−1
0
1
2
3
ph [rad]
60000
50000
40000
30000
20000
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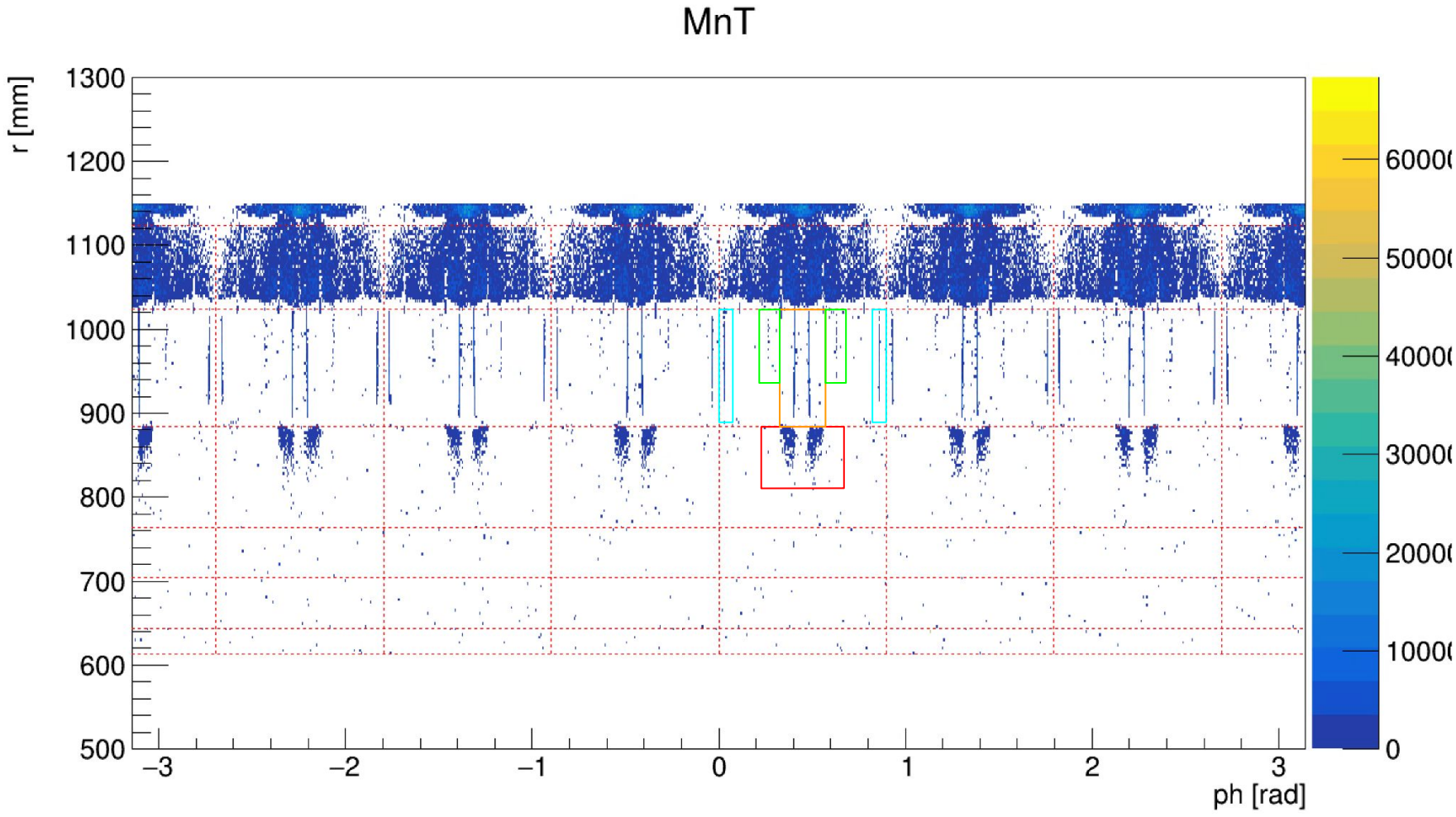
0


MnT
r [mm]
1300
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1100
1000
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0
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3
ph [rad]
60000
50000
40000
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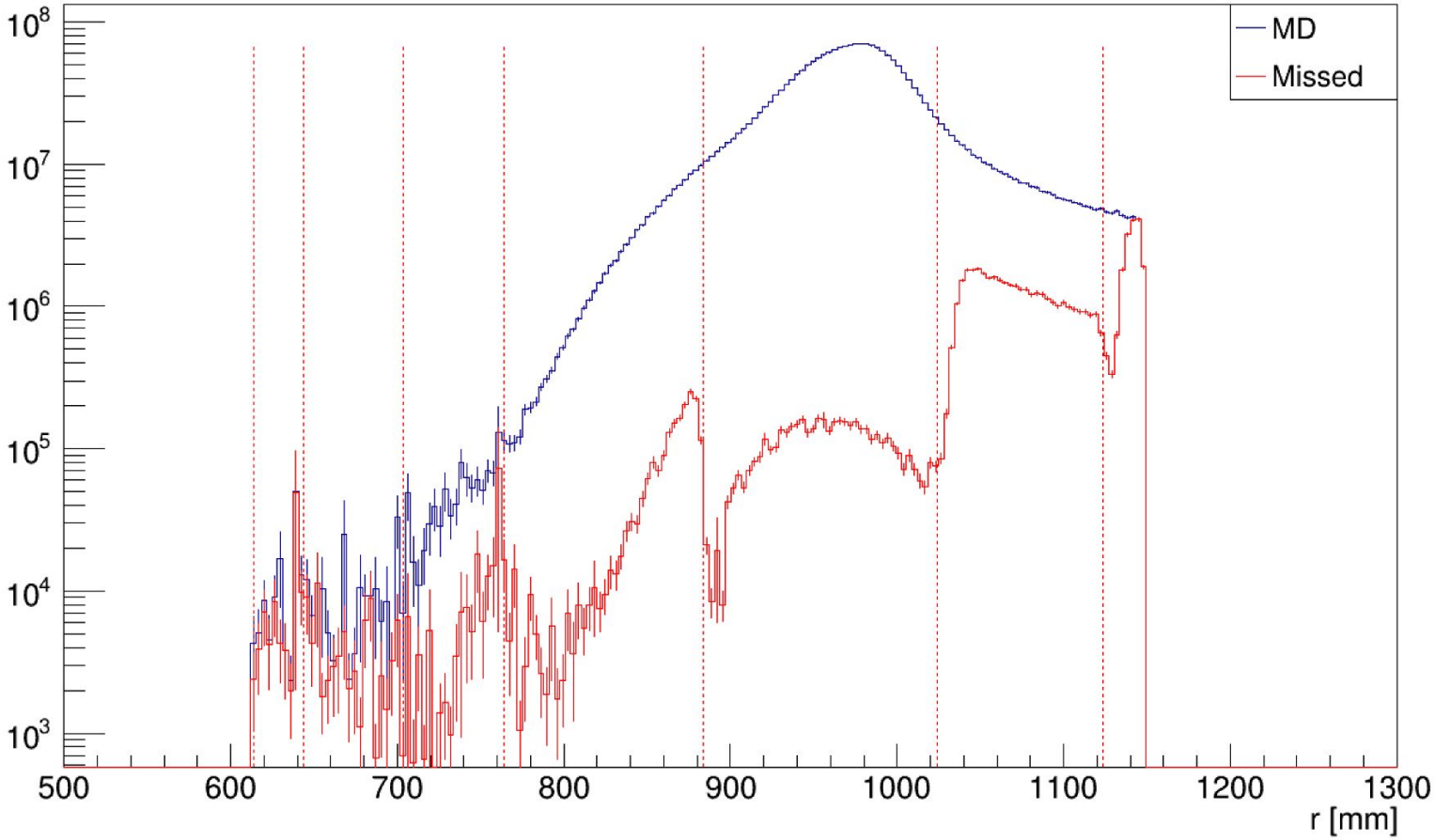
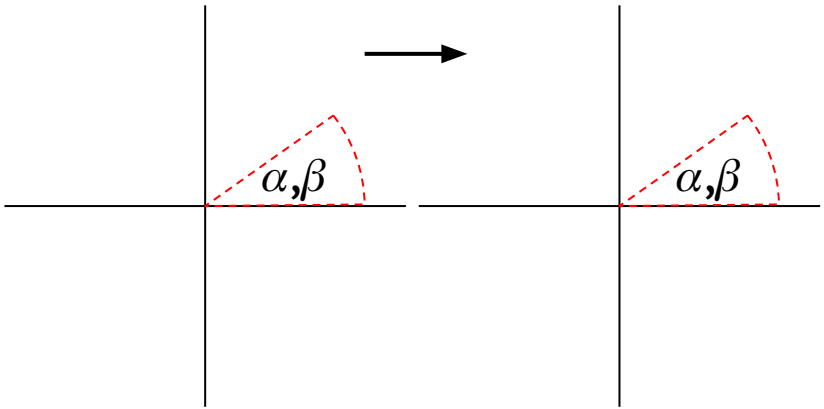
10000
0

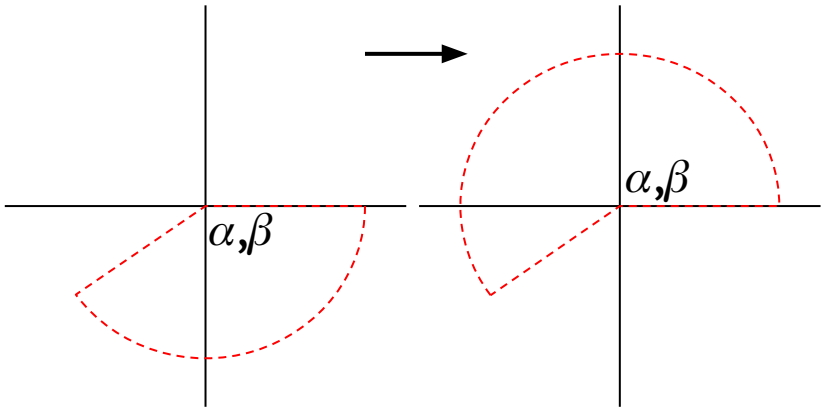

MD
Missed
10^8
10^7
10^6
10^5
10^4
10^3
500
600
700
800
900
1000
1100
1200
1300
r [mm]

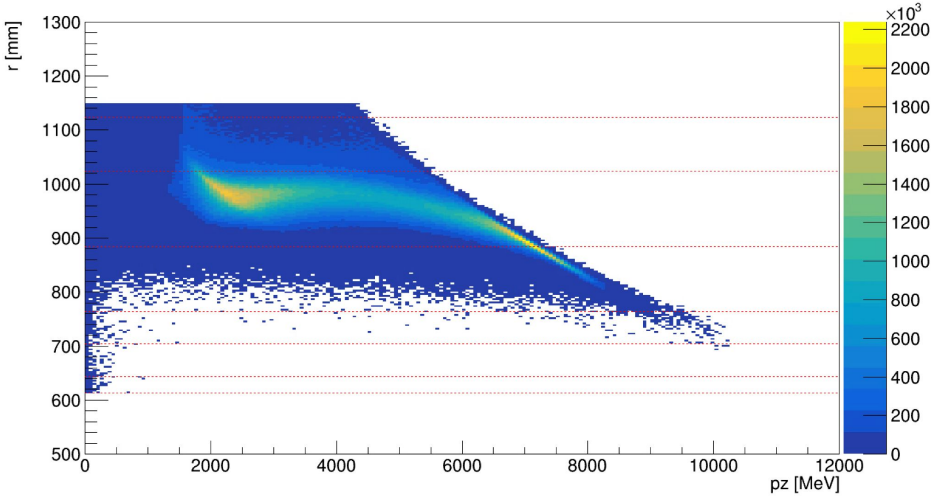
New variable: pr & pth

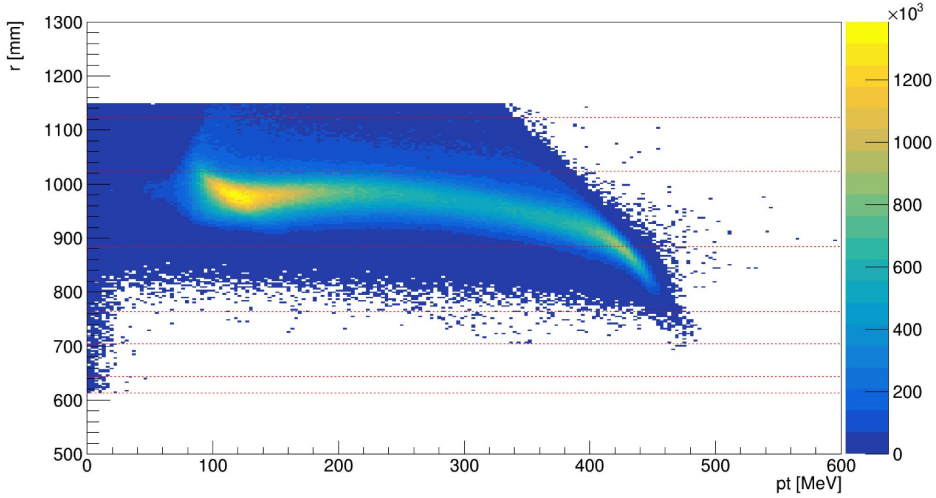
```
double PTH(double x, double y, double r, double px, double py){
        double pt = std::sqrt(px*px+py*py);
        double pr = (x*px+y*py)/r;
        double pth = std::sqrt(pt*pt-pr*pr);
        double alpha = atan2(y,x); if(alpha<0) alpha+=2.*PI;
        double beta = atan2(py,px); if(beta<0) beta+=2.*PI;
        if (alpha<beta) pth = +pth;
        if (alpha>beta) pth = -pth;
        if (alpha==beta) pth = 0.;
        return pth;
}
```

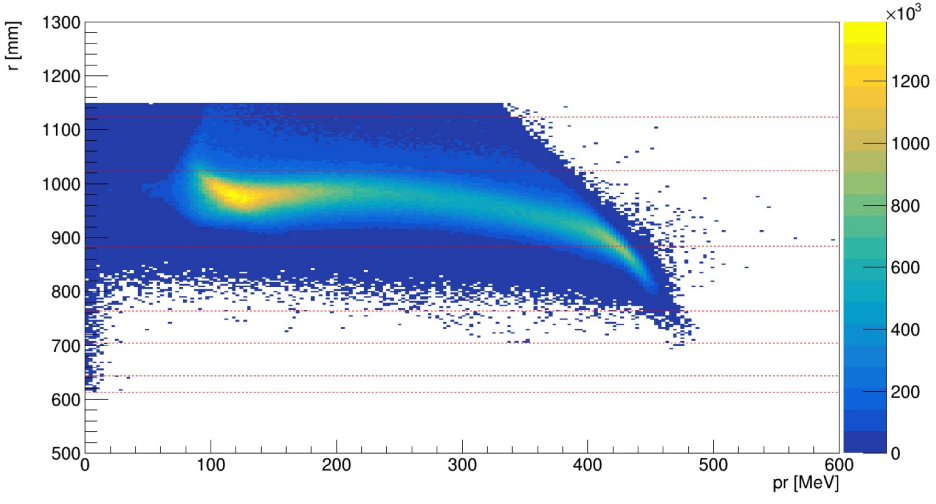
$[\ -\pi\ ,\ \pi\ ] \rightarrow [\ 0\ ,\ 2\pi\ ]$






r [mm]
pz [MeV]
×10^3


r [mm]
pt [MeV]
×10^3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pr [MeV]
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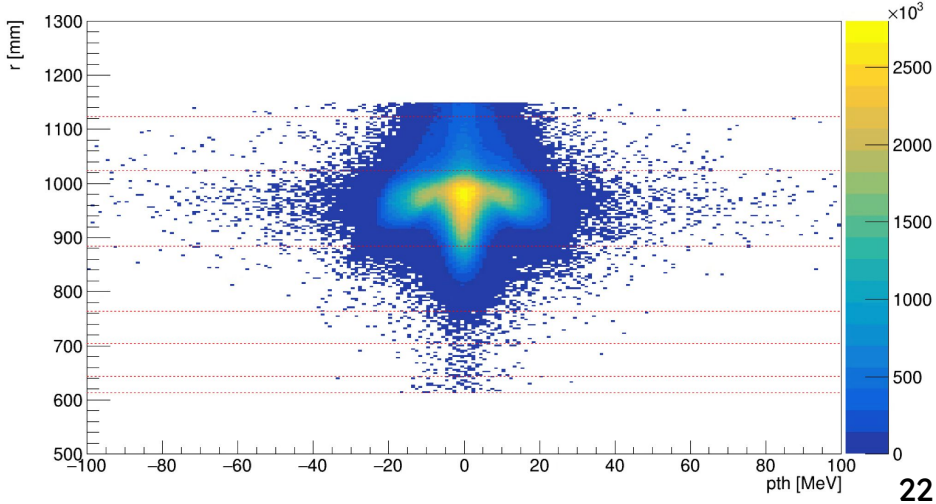
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pth [MeV]
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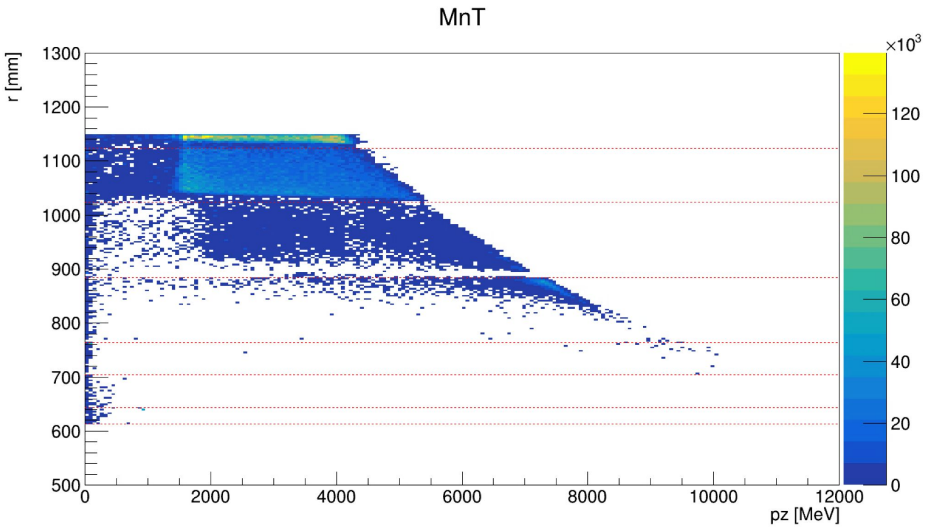
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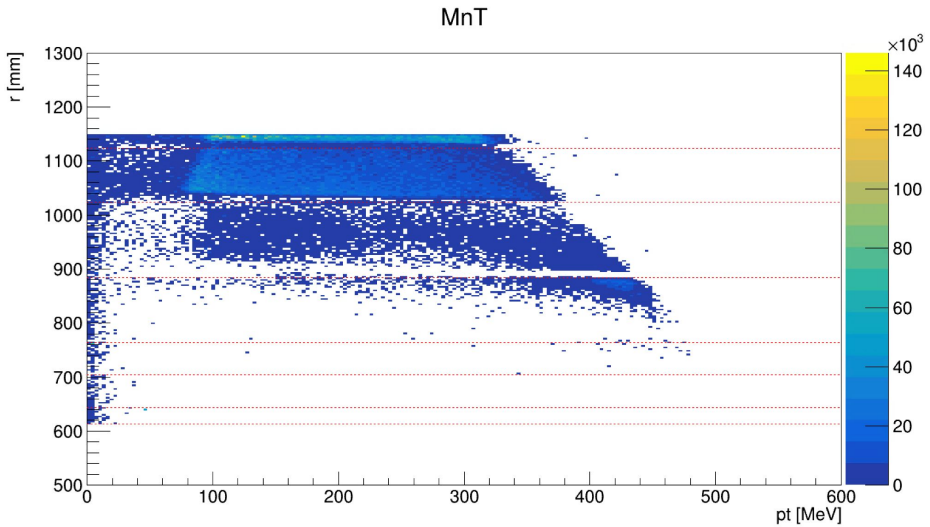
r [mm]
pz [MeV]
×10³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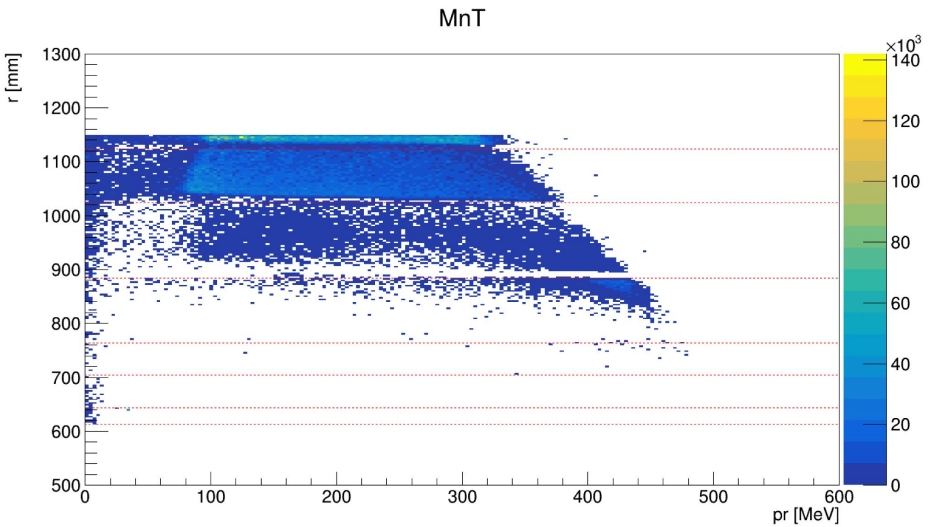
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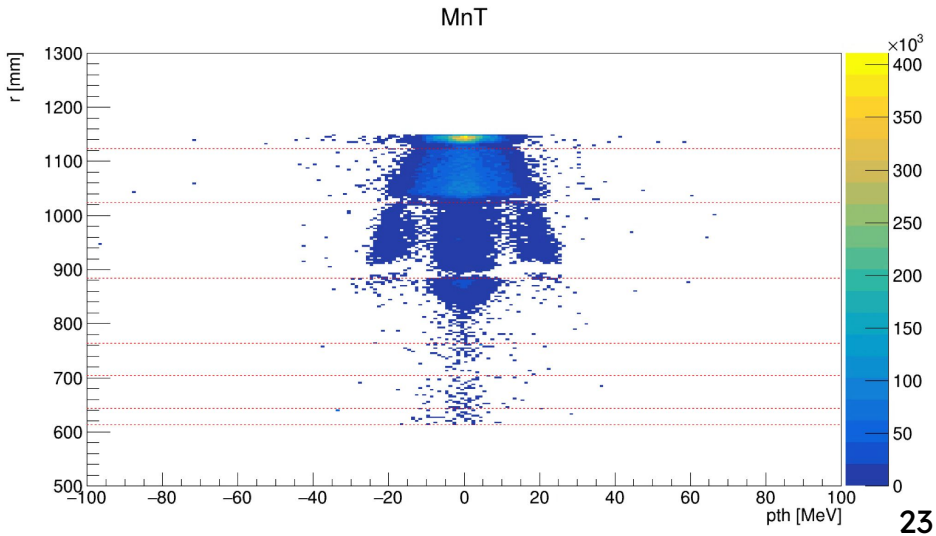
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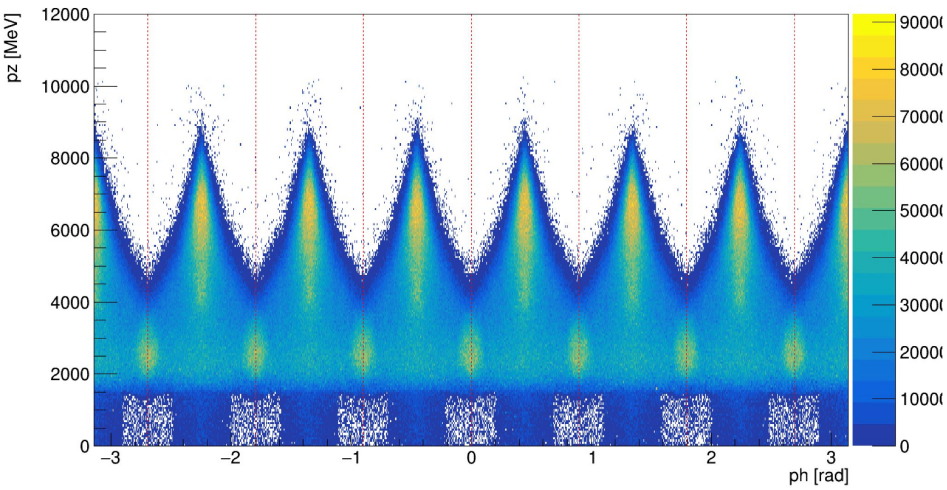
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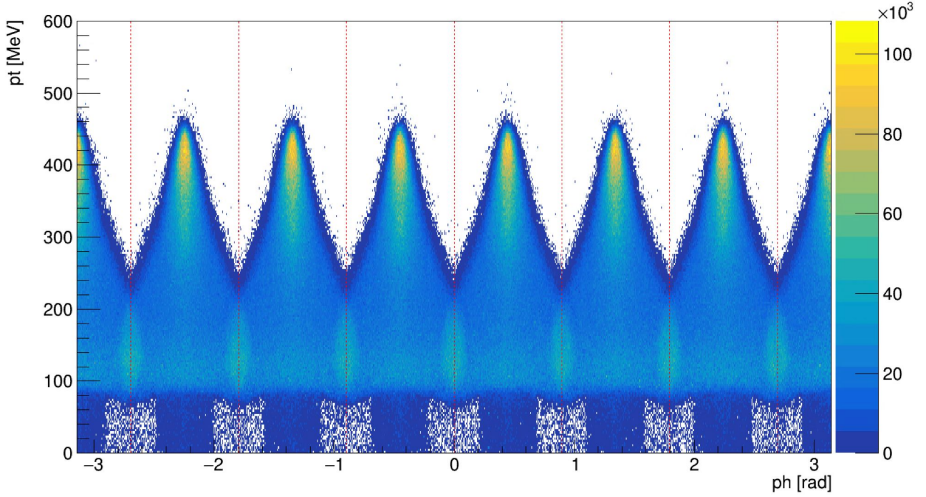
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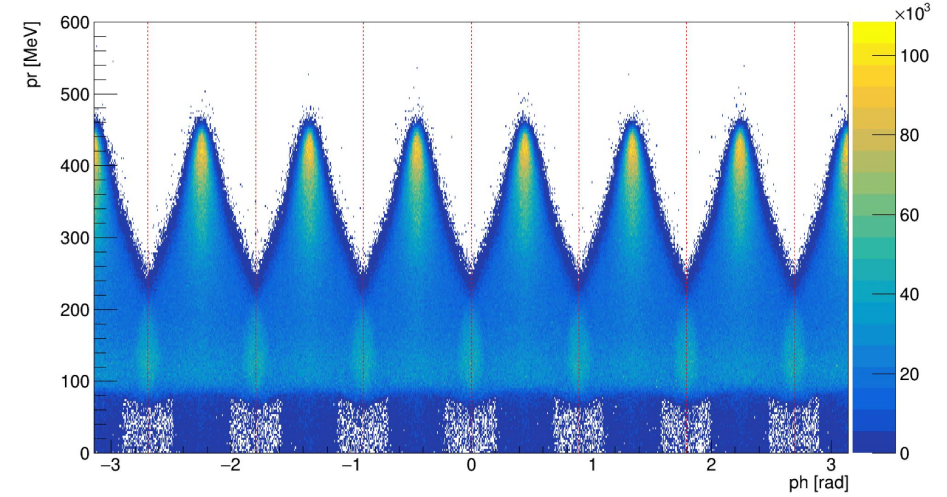
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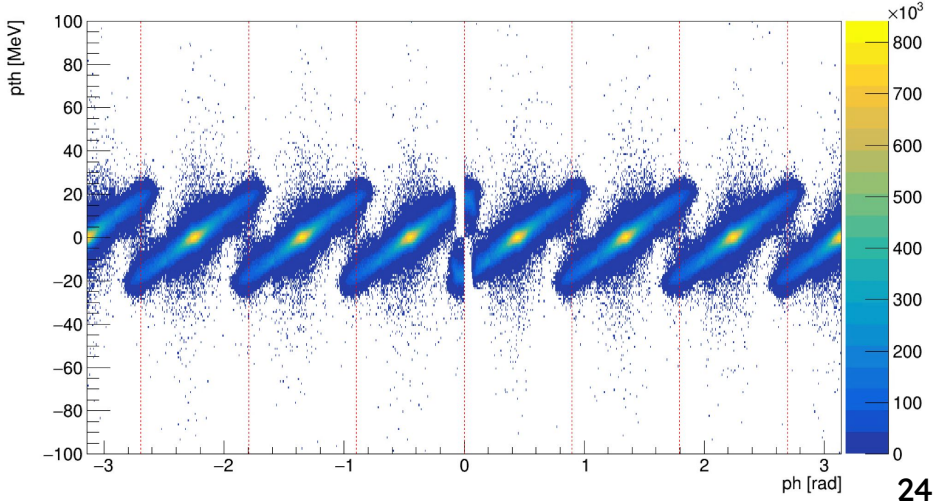
×10^3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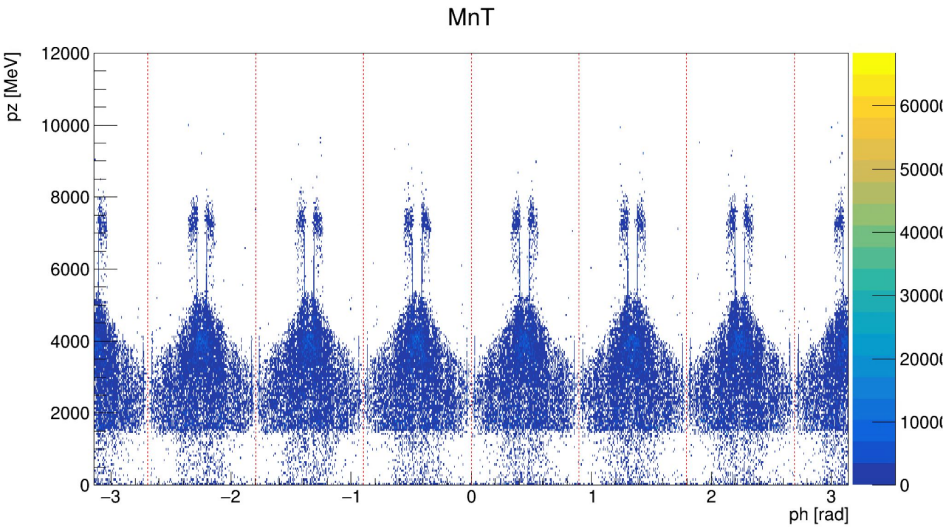
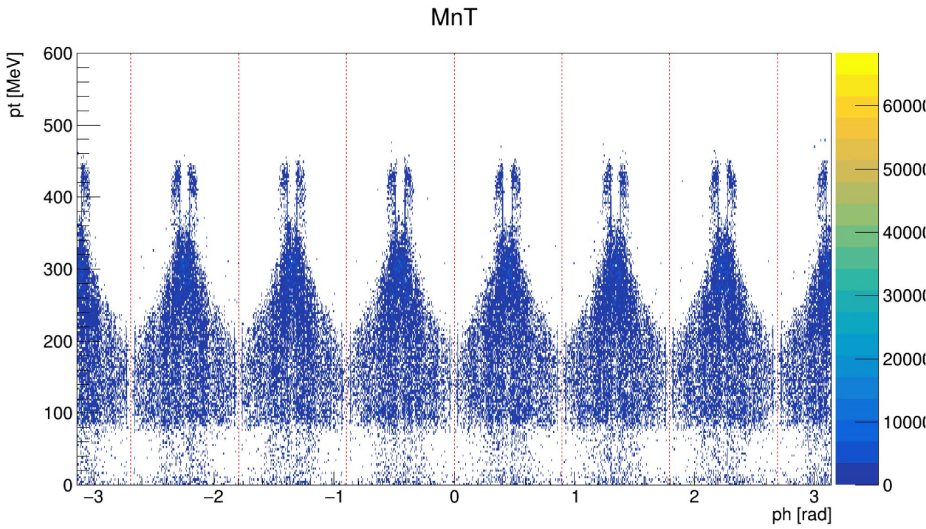

MnT
pz [MeV]
ph [rad]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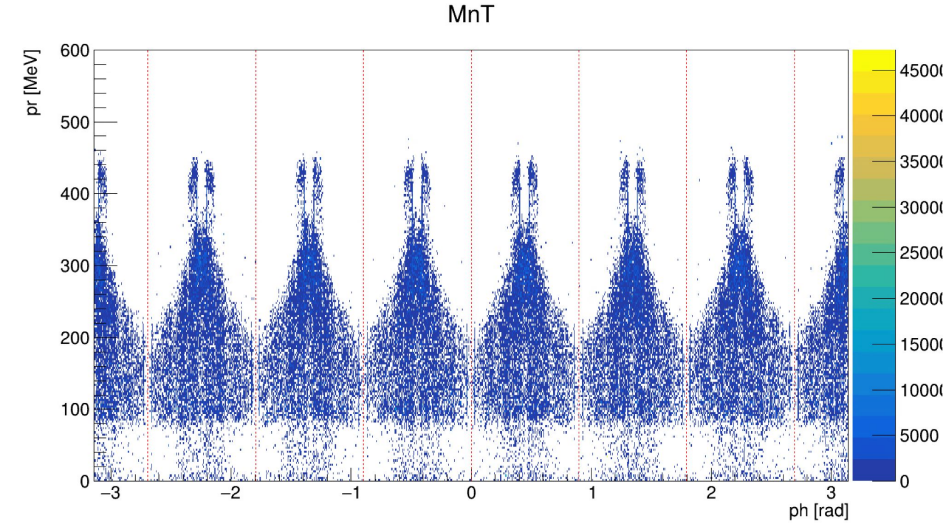
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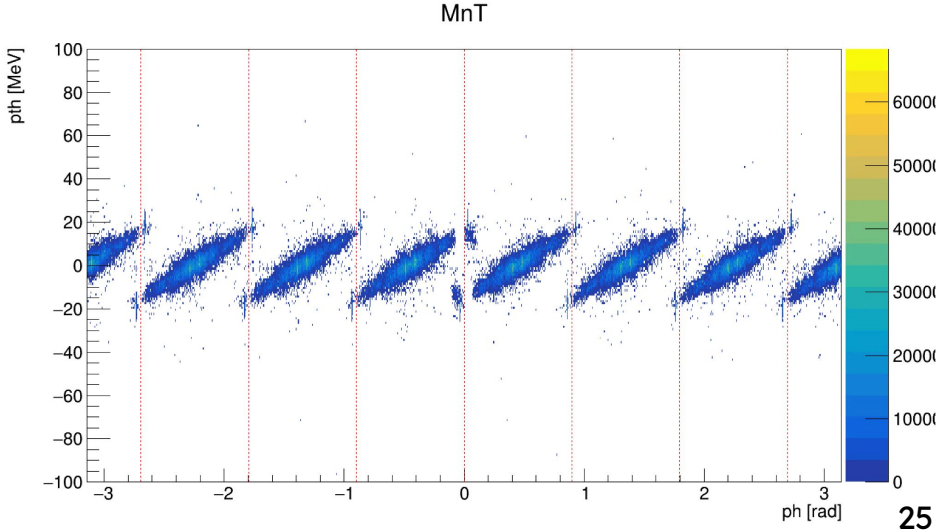
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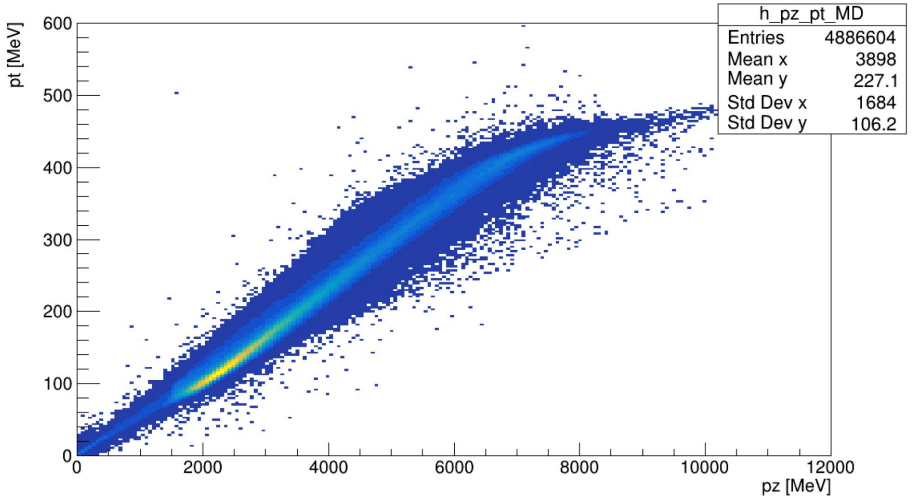
pth [MeV]
ph [rad]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Mean y 227.1
Std Dev x 1684
Std Dev y 106.2
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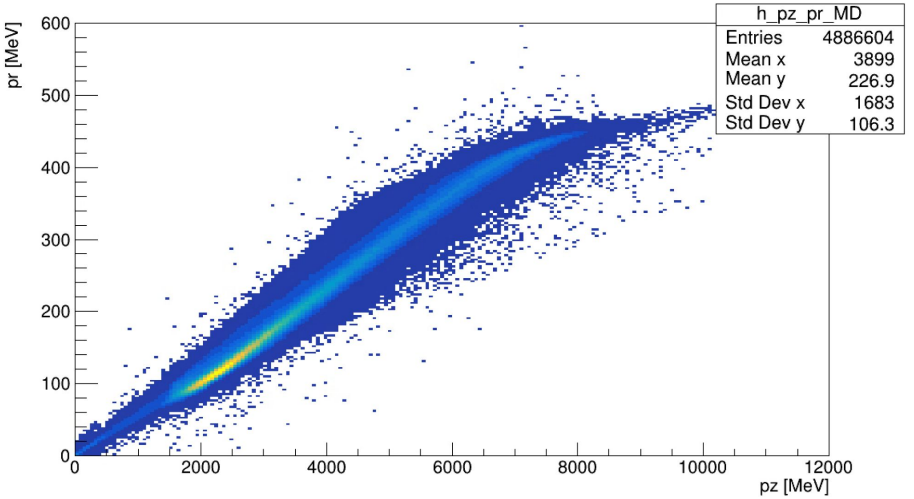
pz [MeV]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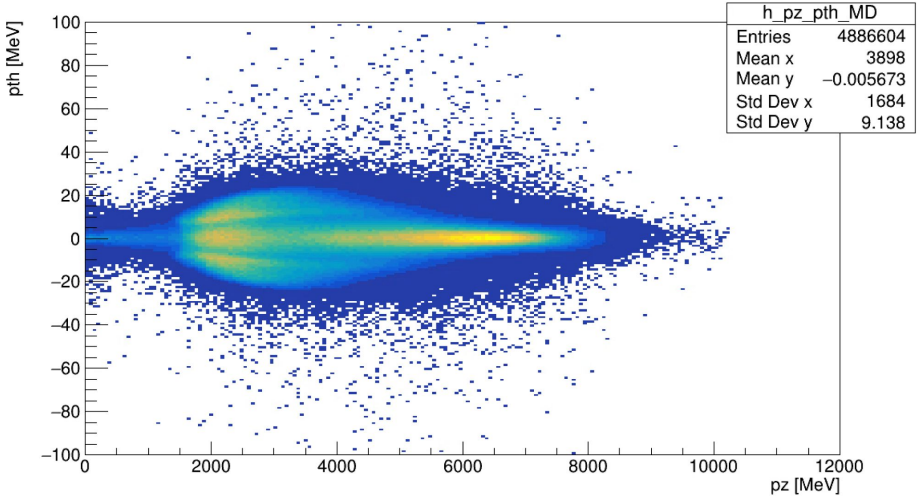
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Std Dev x 1684
Std Dev y 9.138
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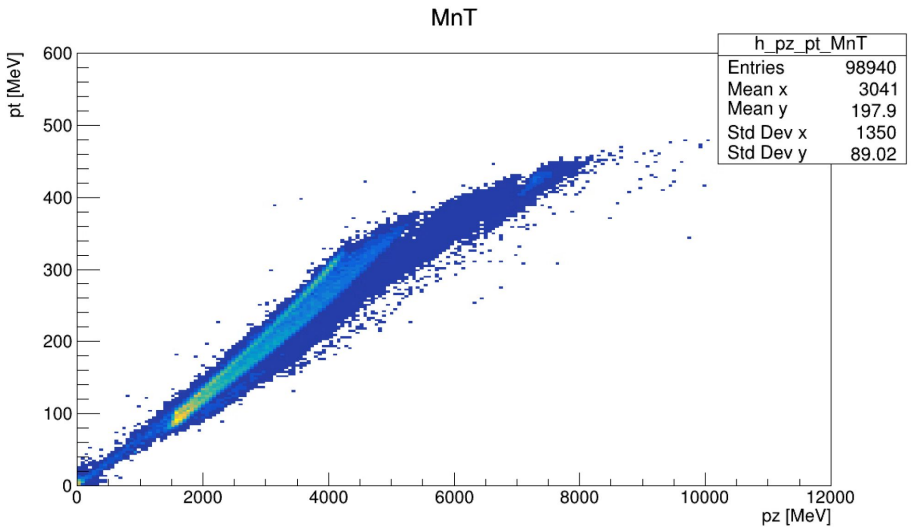
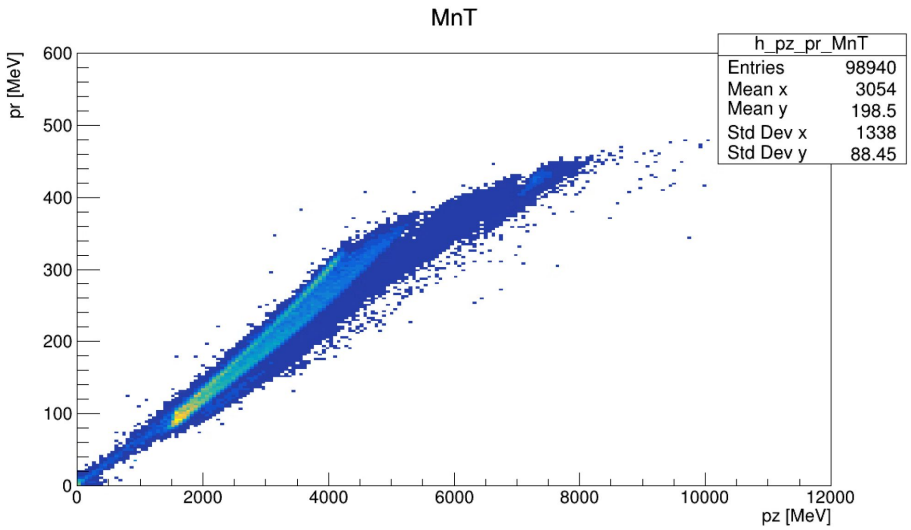
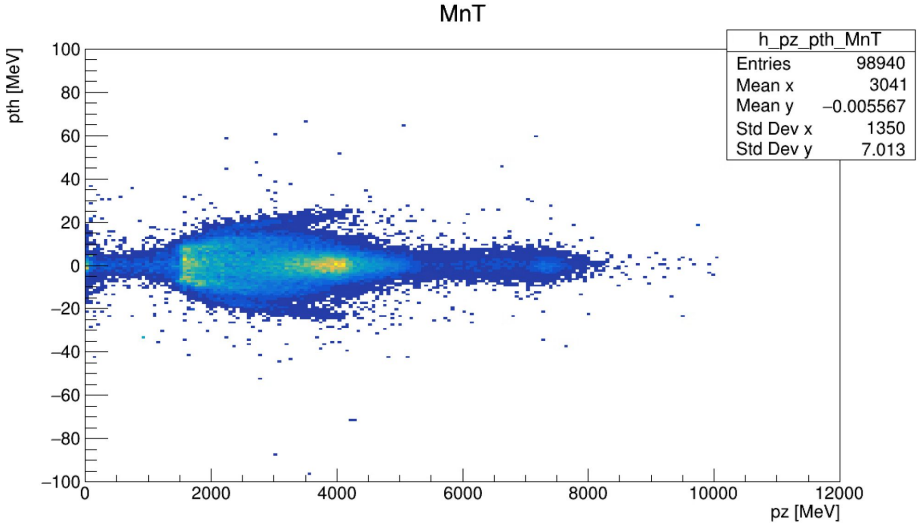
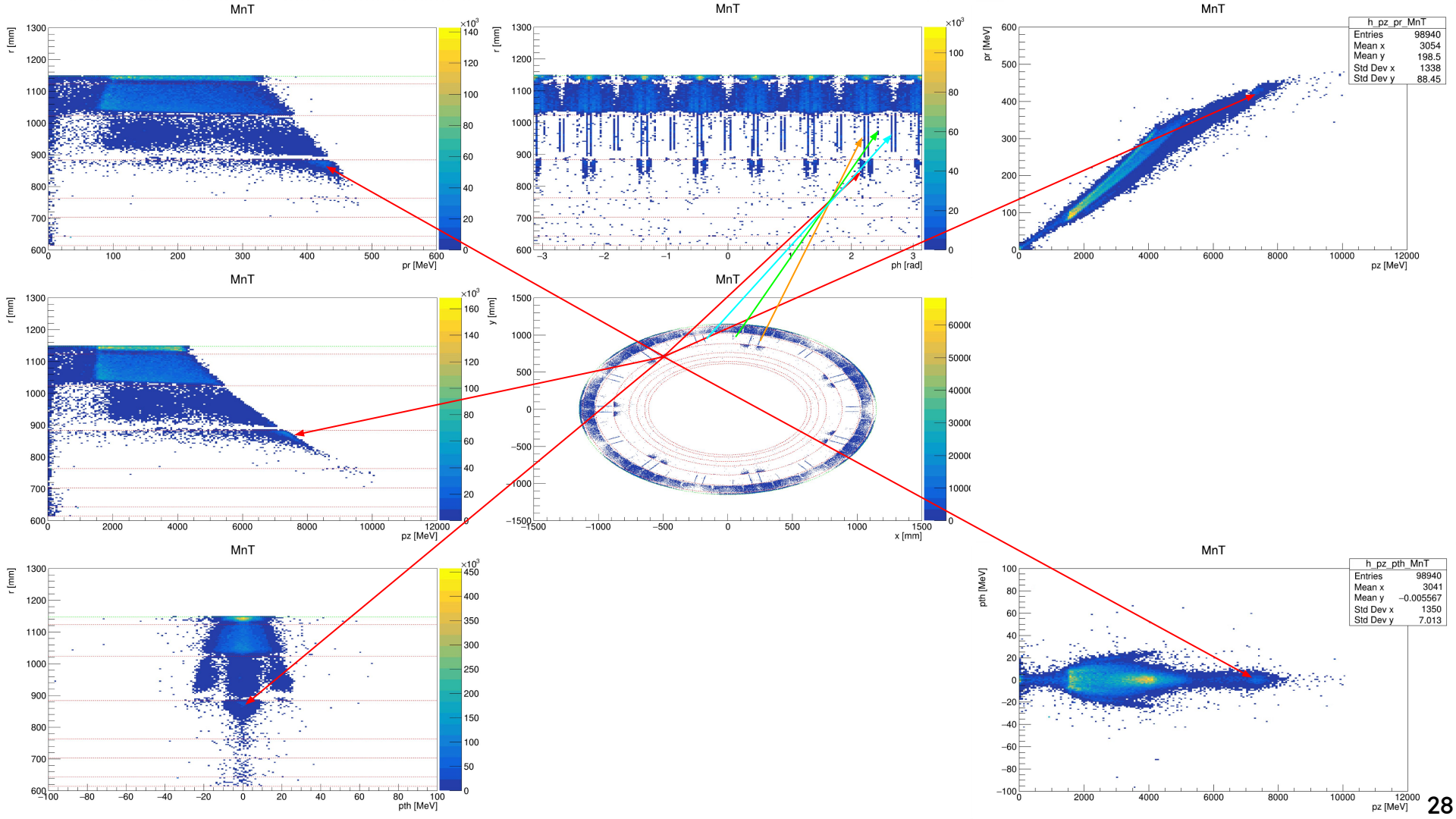
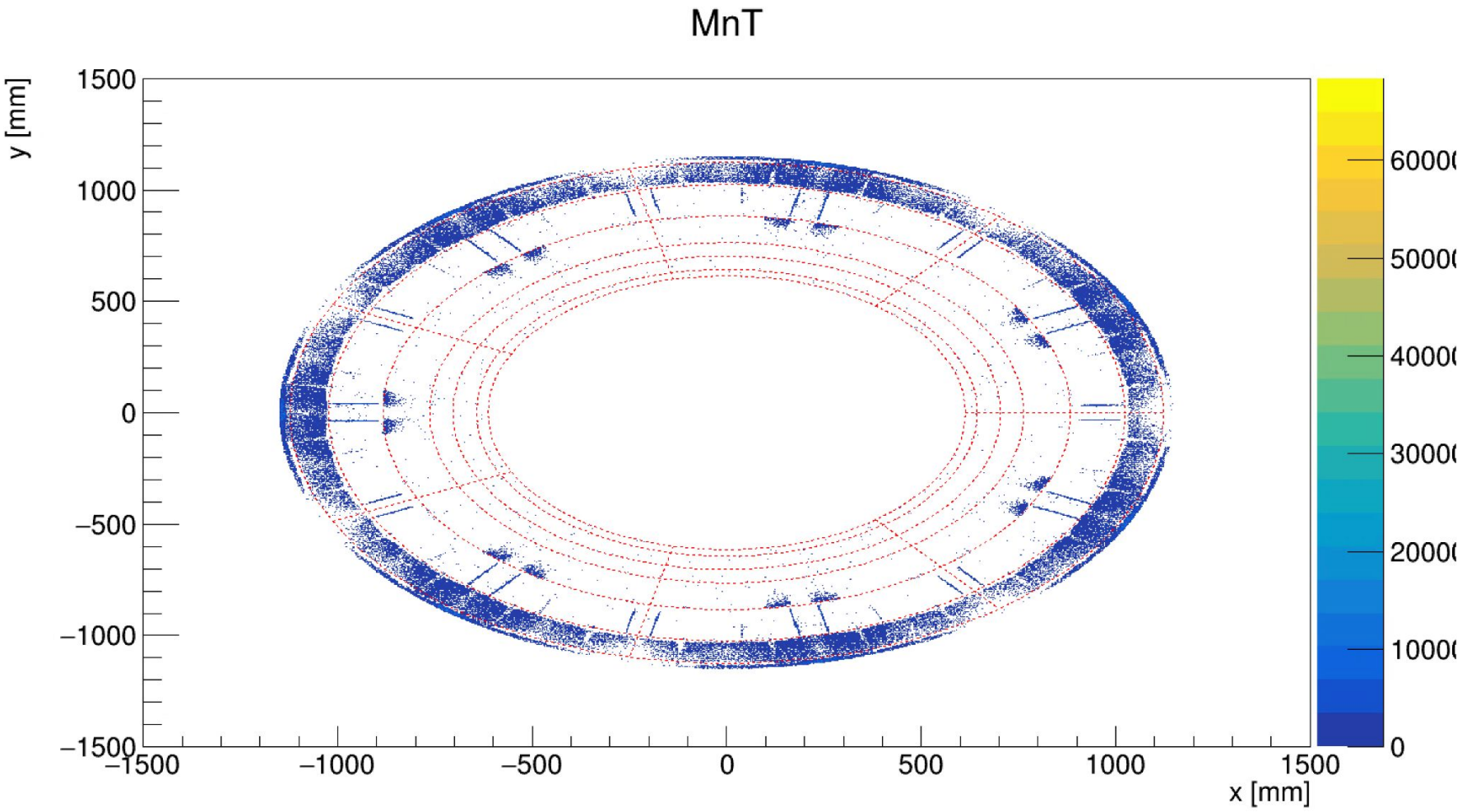
pz [MeV]

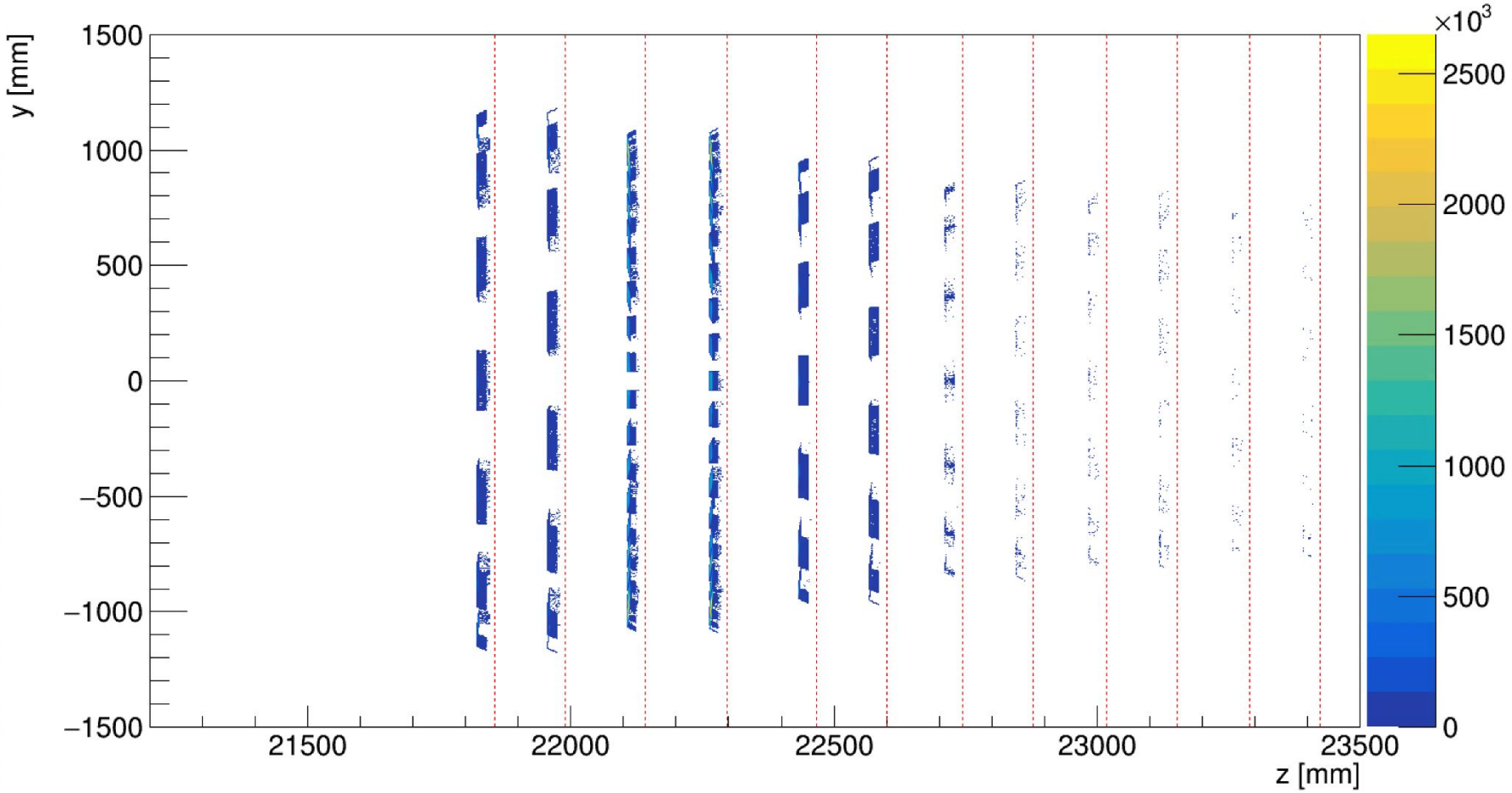

MnT
h_pz_pt_MnT
Entries 98940
Mean x 3041
Mean y 197.9
Std Dev x 1350
Std Dev y 89.02
pt [MeV]
pz [MeV]

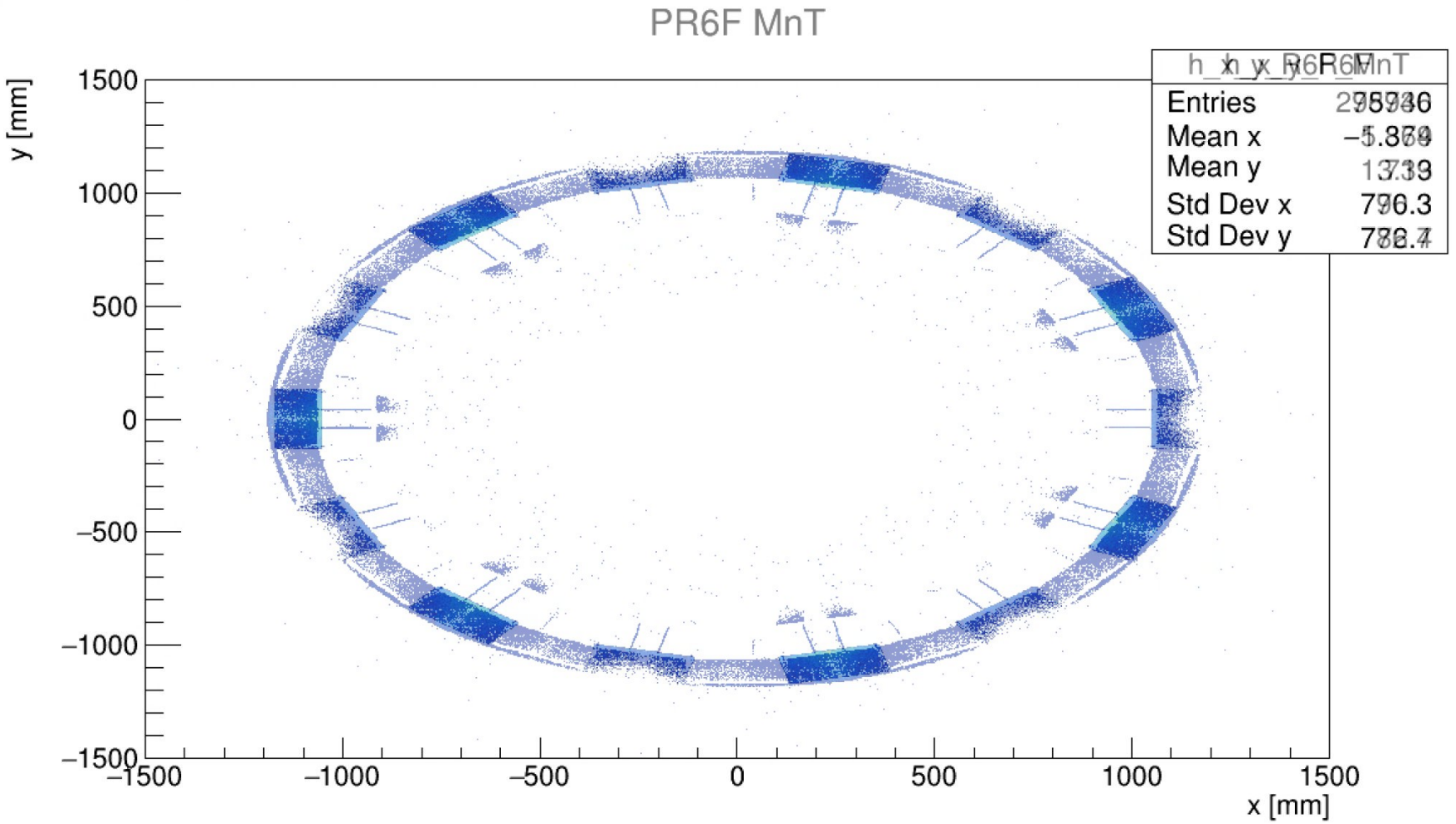

MnT
h_pz_pr_MnT
Entries 98940
Mean x 3054
Mean y 198.5
Std Dev x 1338
Std Dev y 88.45
pr [MeV]
pz [MeV]

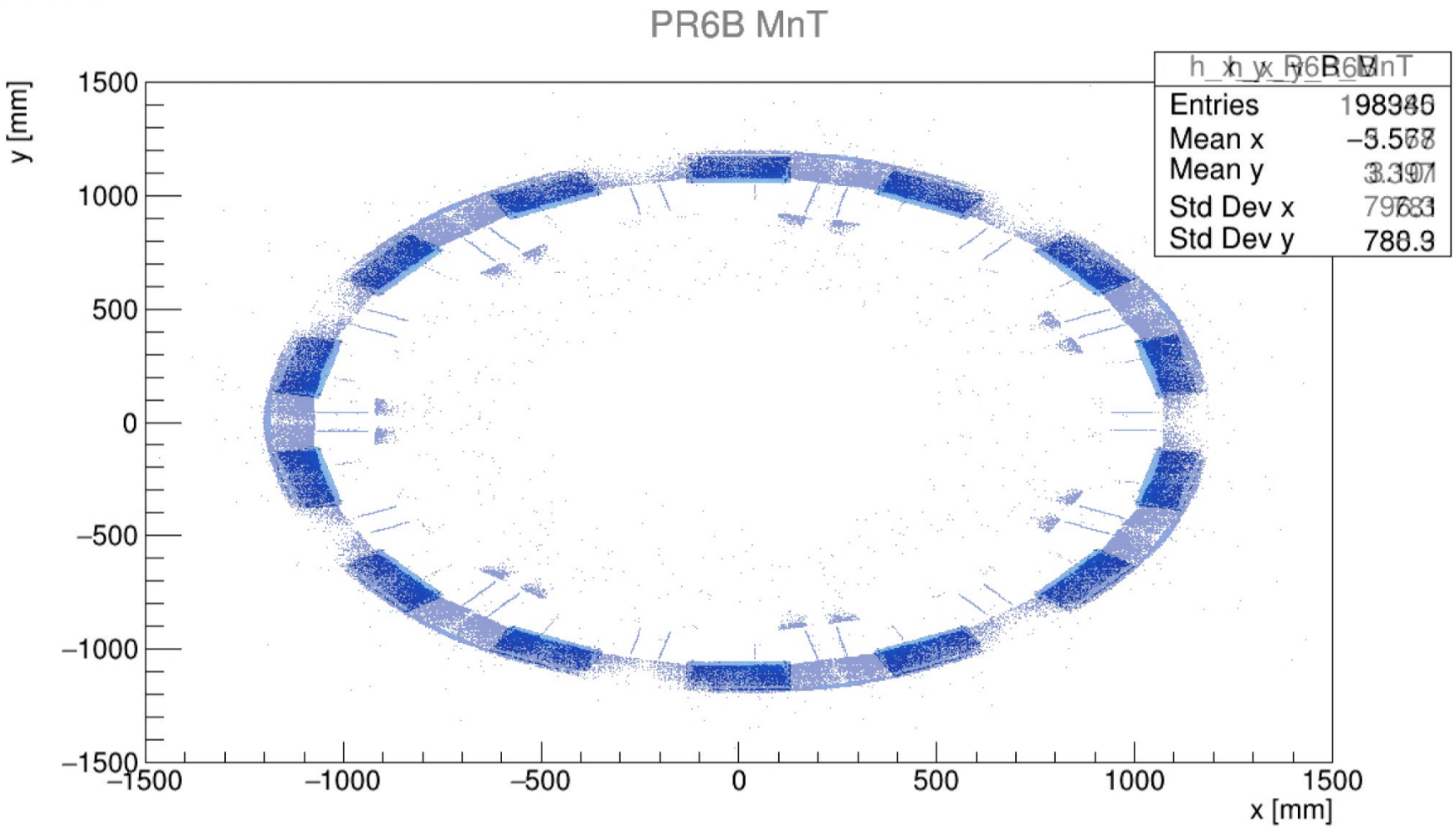

MnT
h_pz_pth_MnT
Entries 98940
Mean x 3041
Mean y −0.005567
Std Dev x 1350
Std Dev y 7.013
pth [MeV]
pz [MeV]

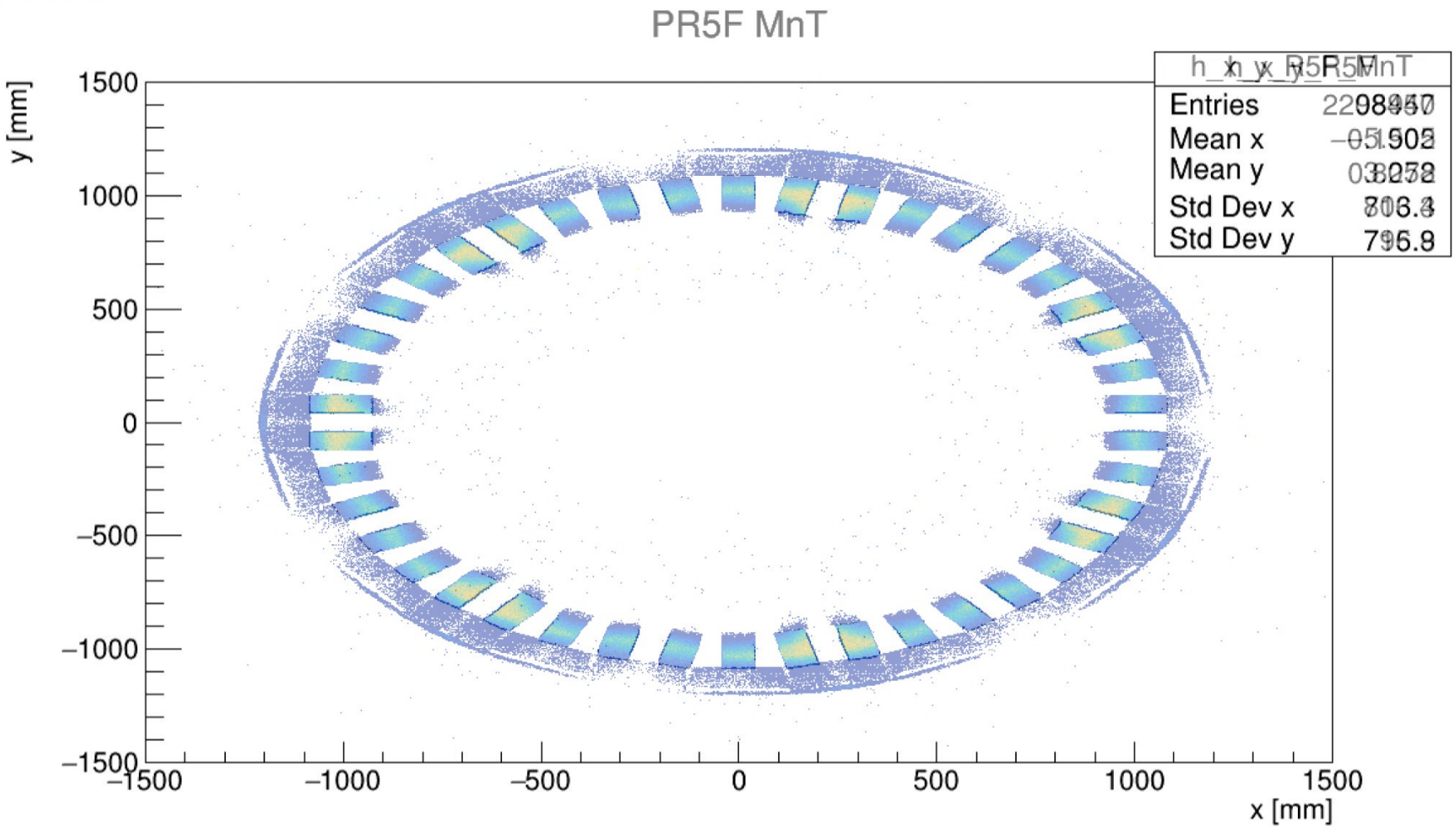

MnT
r [mm]
pr [MeV]
MnT
r [mm]
ph [rad]
MnT
pr [MeV]
pz [MeV]
h_pz_pr_MnT
Entries 98940
Mean x 3054
Mean y 198.5
Std Dev x 1338
Std Dev y 88.45
MnT
r [mm]
pz [MeV]
MnT
y [mm]
x [mm]
MnT
r [mm]
pth [MeV]
MnT
pth [MeV]
pz [MeV]
h_pz_pth_MnT
Entries 98940
Mean x 3041
Mean y −0.005567
Std Dev x 1350
Std Dev y 7.013

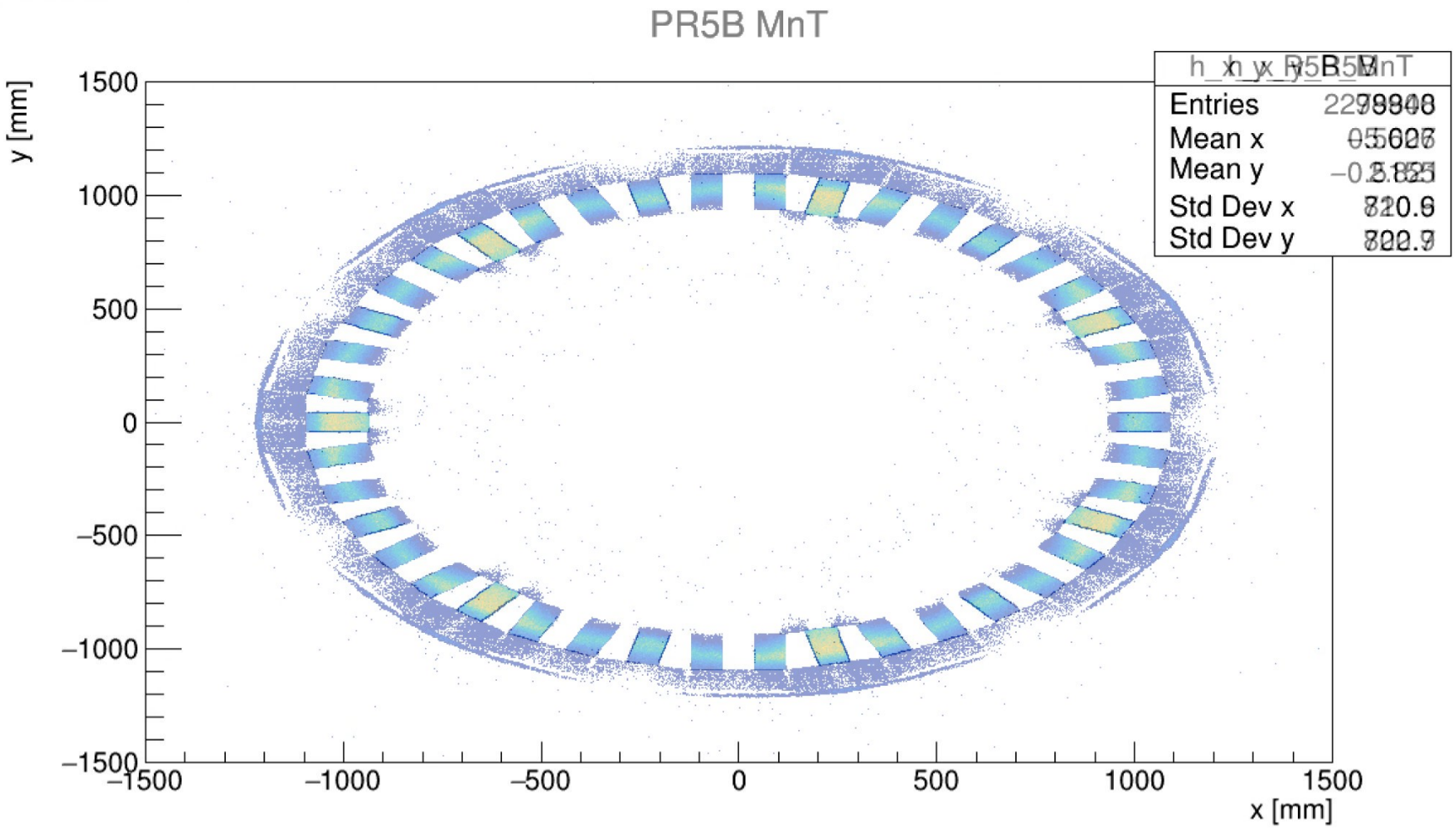

MnT
y [mm]
1500
1000
500
0
−500
−1000
−1500
−1500
−1000
−500
0
500
1000
1500
x [mm]
60000
50000
40000
30000
20000
10000
0

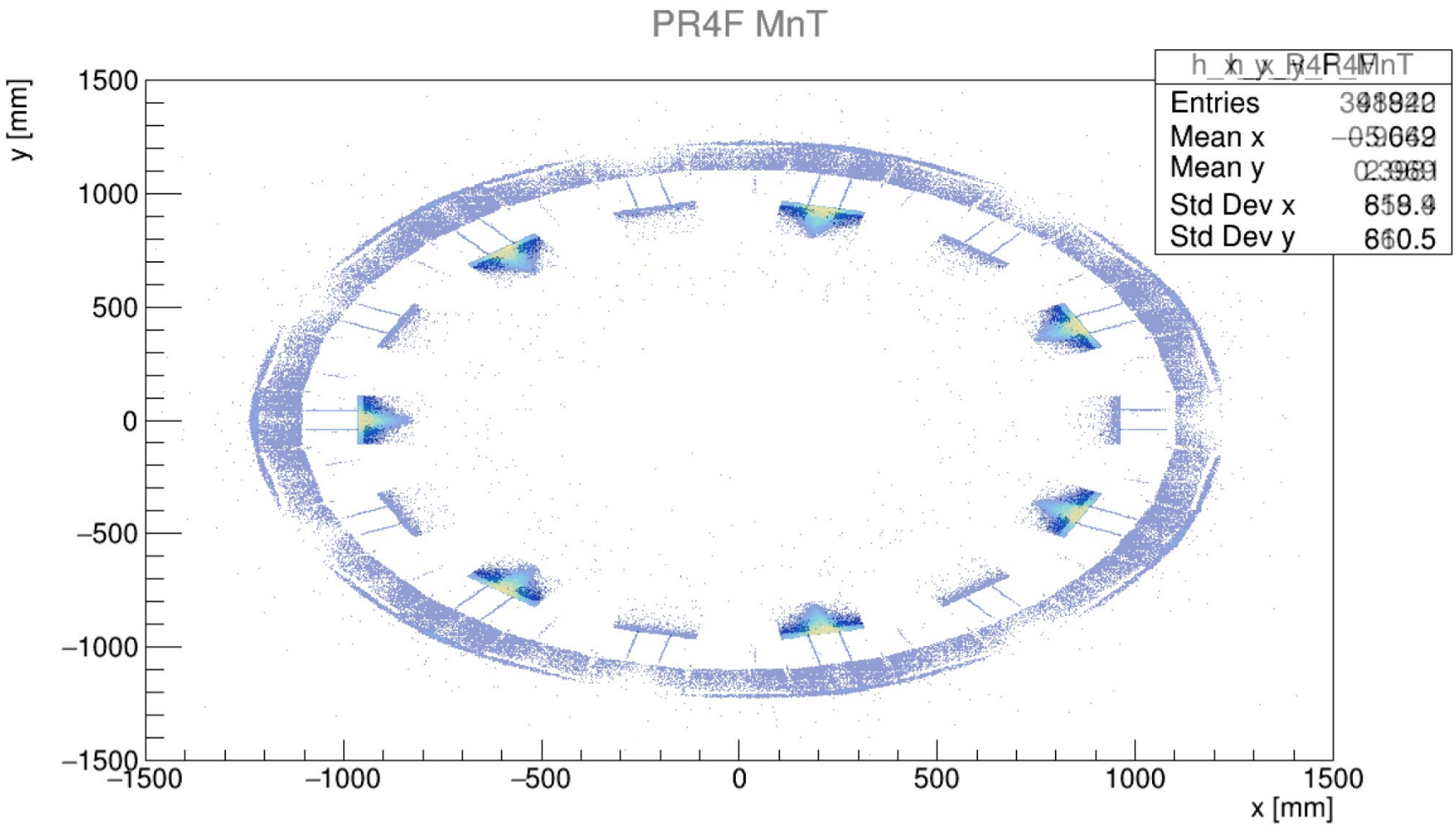

y [mm]
1500
1000
500
0
−500
−1000
−1500
21500
22000
22500
23000
23500
z [mm]
×10^3
2500
2000
1500
1000
500
0

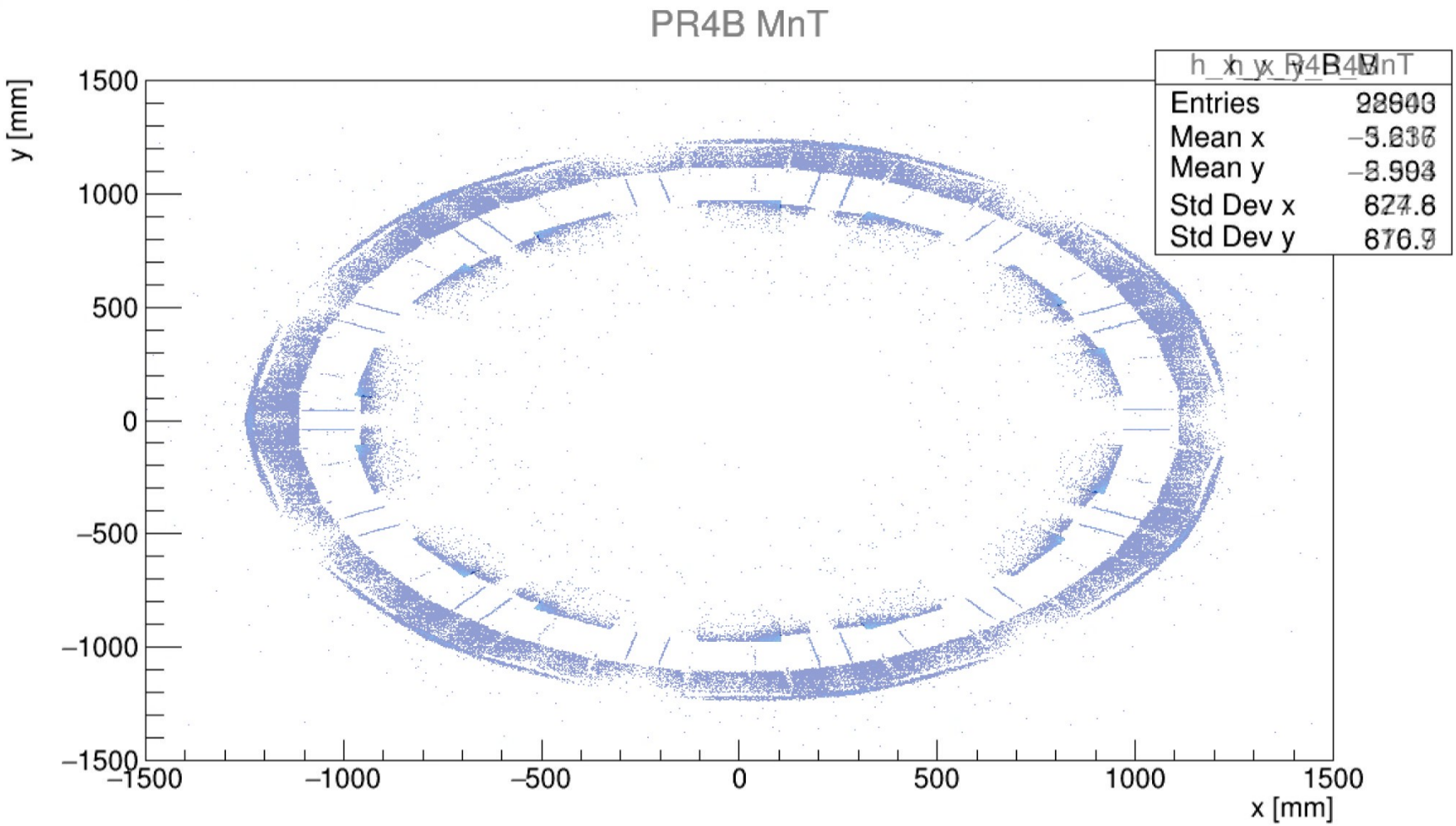

PR6F MnT
h_x_y_PR6F_MnT
Entries
Mean x
Mean y
Std Dev x
Std Dev y
y [mm]
x [mm]
1500
1000
500
0
−500
−1000
−1500


PR6B MnT
h_x_y_PR6B_MnT
Entries
Mean x
Mean y
Std Dev x
Std Dev y
y [mm]
x [mm]
1500
1000
500
0
−500
−1000
−1500


PR5F MnT
h_x_y_PR5F_MnT
Entries
Mean x
Mean y
Std Dev x
Std Dev y
y [mm]
x [mm]
1500
1000
500
0
−500
−1000
−1500


PR5B MnT
h_xy_PR5B_MnT
Entries
Mean x
Mean y
Std Dev x
Std Dev y
y [mm]
x [mm]
1500
1000
500
0
−500
−1000
−1500
−1500
−1000
−500
0
500
1000
1500


PR4F MnT
h_xy_R4F_MnT
Entries
Mean x
Mean y
Std Dev x
Std Dev y
y [mm]
x [mm]
1500
1000
500
0
−500
−1000
−1500


PR4B MnT
h_x_y_PR4B_MnT
Entries
Mean x
Mean y
Std Dev x
Std Dev y
y [mm]
x [mm]
1500
1000
500
0
−500
−1000
−1500

Conclusion

- We may have a very small amount of particles missing tiles through little cracks in the azimuthal acceptance in ring 5
- We may have particle passing through tiles but not being registered as hits by remoll in ring 4 and 6
    - There may be objects in remoll directly in front of or overlapping with ring 6
- Lower maximum r value
- Correlate x,y/r,phi with momentum values
- UVA GEM HV ramp ups



Jefferson Lab