Tracking Calibration: Status and Performance

Norman Graf (SLAC)

HPS Collaboration Meeting
May the 4ce, 2017

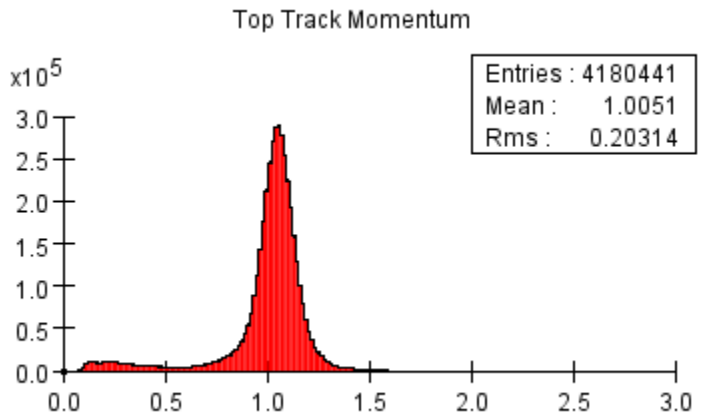
Goals

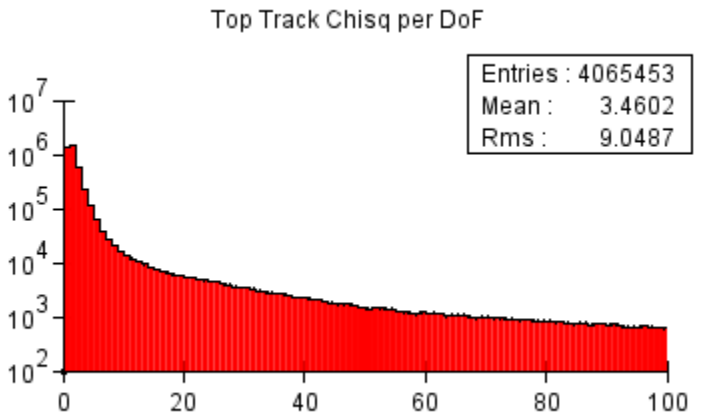
- Understand existing tracking performance and impact on physics analyses.
  - Track-finding efficiency analyses presented by Matt and Holly.
  - Alignment analysis presented by Alessandra.
  - This talk about position, momentum and mass resolutions.
- Develop strategies and algorithms to calibrate the detector.

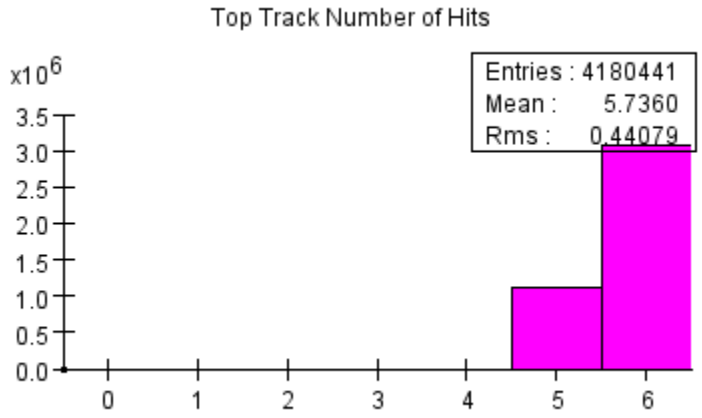
Event Samples

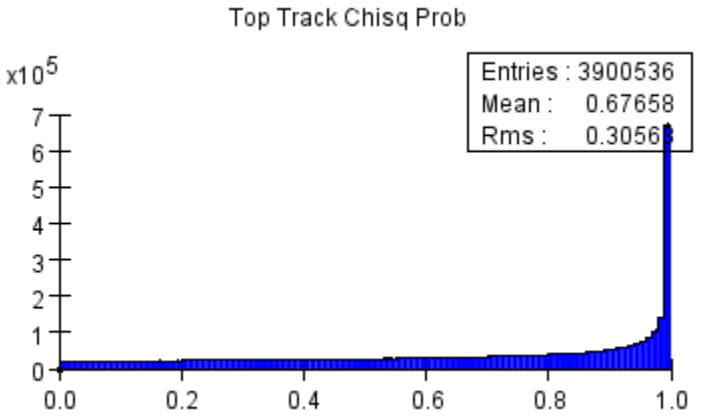
- 2015 Data: tweakpass6
- 2016 Data: pass
- Fee skims
  - 2015: Run 5772, 2016: 10% skims
  - Elastic scatters provide momentum calibration
- Møller skims
  - 2015: 100% skims, 2016: 10%skims
  - Invariant mass provides check on energy scale
  - Vertex position provides information on beam position
  - Vertex momentum provides information on beam direction.
- Loose selection criteria to minimize selection bias

2015 Fee Top

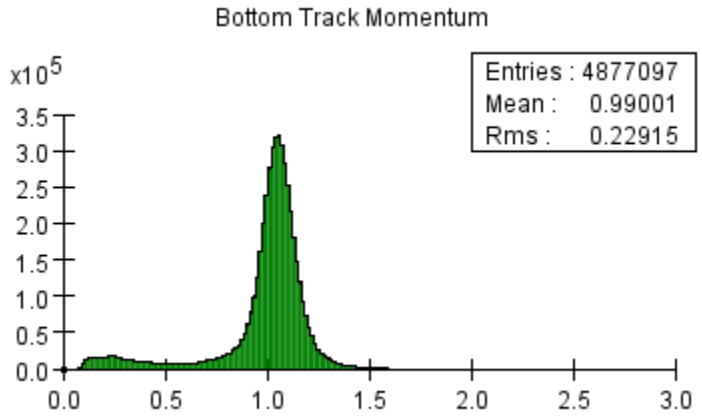

Top Track Momentum
Entries : 4180441
Mean : 1.0051
Rms : 0.20314
x10^5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0

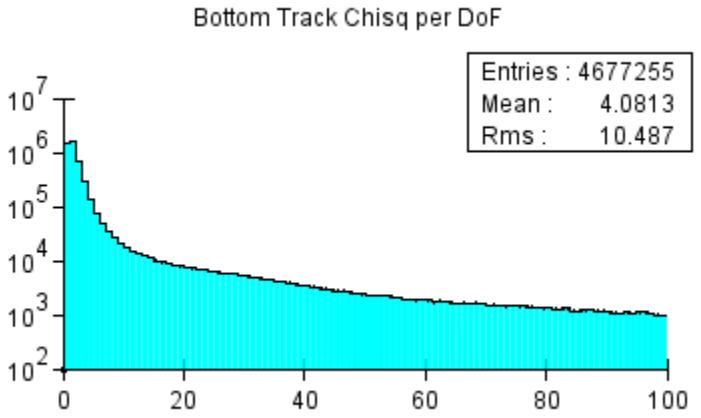

Top Track Chisq per DoF
Entries : 4065453
Mean : 3.4602
Rms : 9.0487
10^7
10^6
10^5
10^4
10^3
10^2
0
20
40
60
80
100

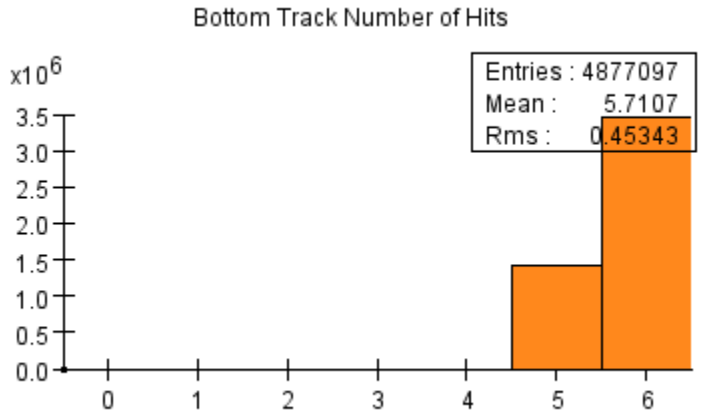

Top Track Number of Hits
Entries : 4180441
Mean : 5.7360
Rms : 0.44079
x10^6
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
6

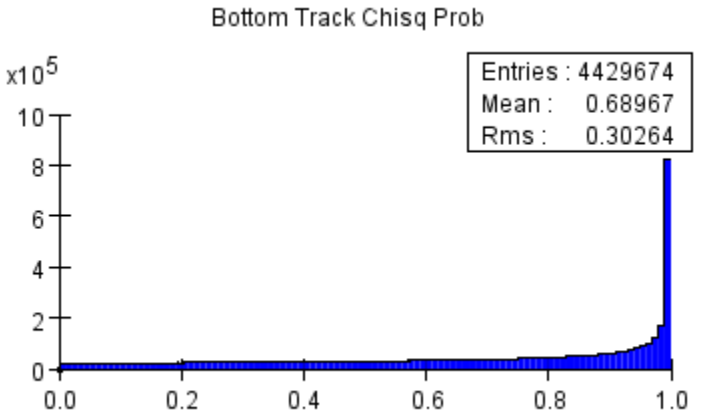

Top Track Chisq Prob
Entries : 3900536
Mean : 0.67658
x10^5
7
6
5
4
3
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0

2015 Fee Bottom



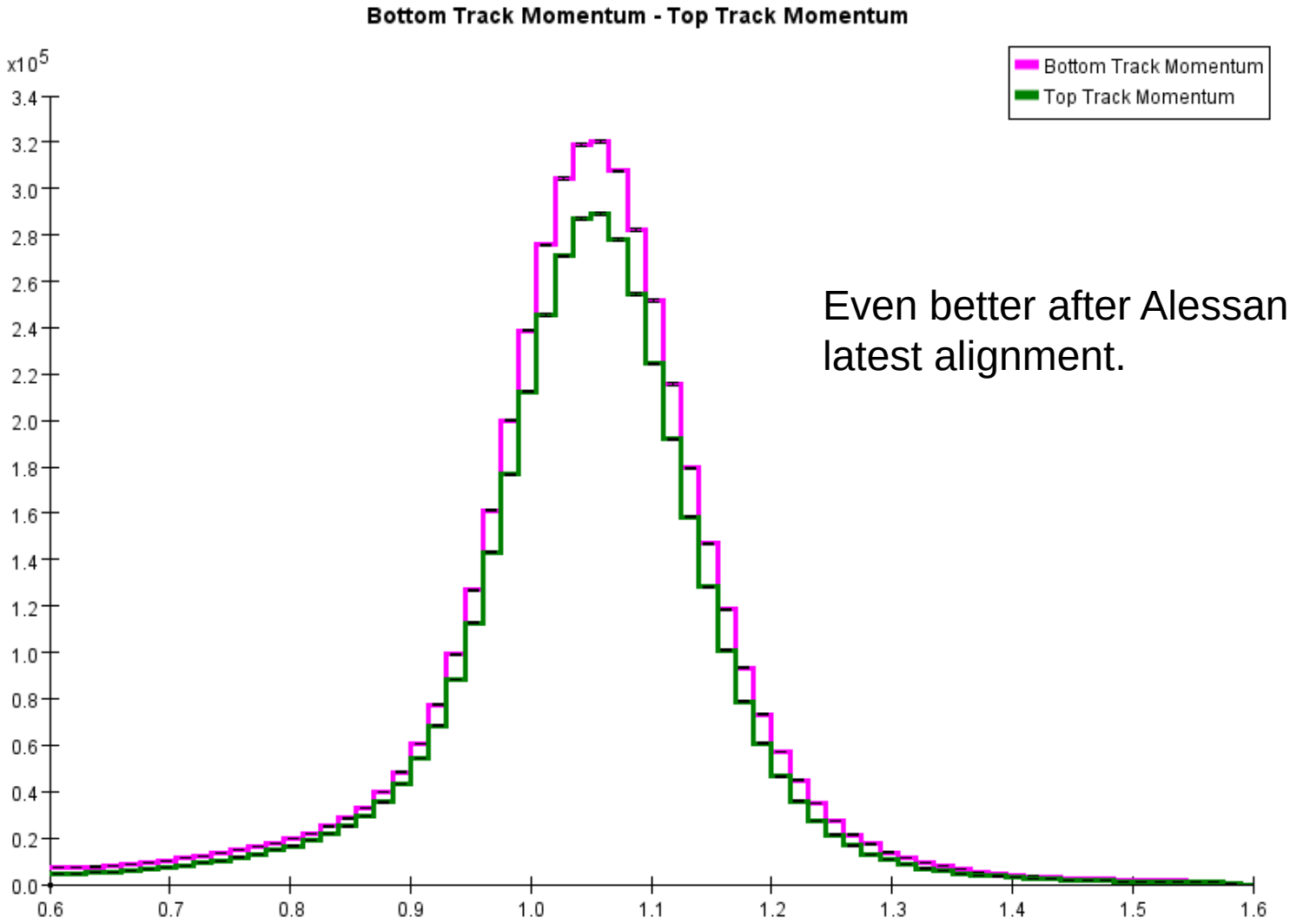






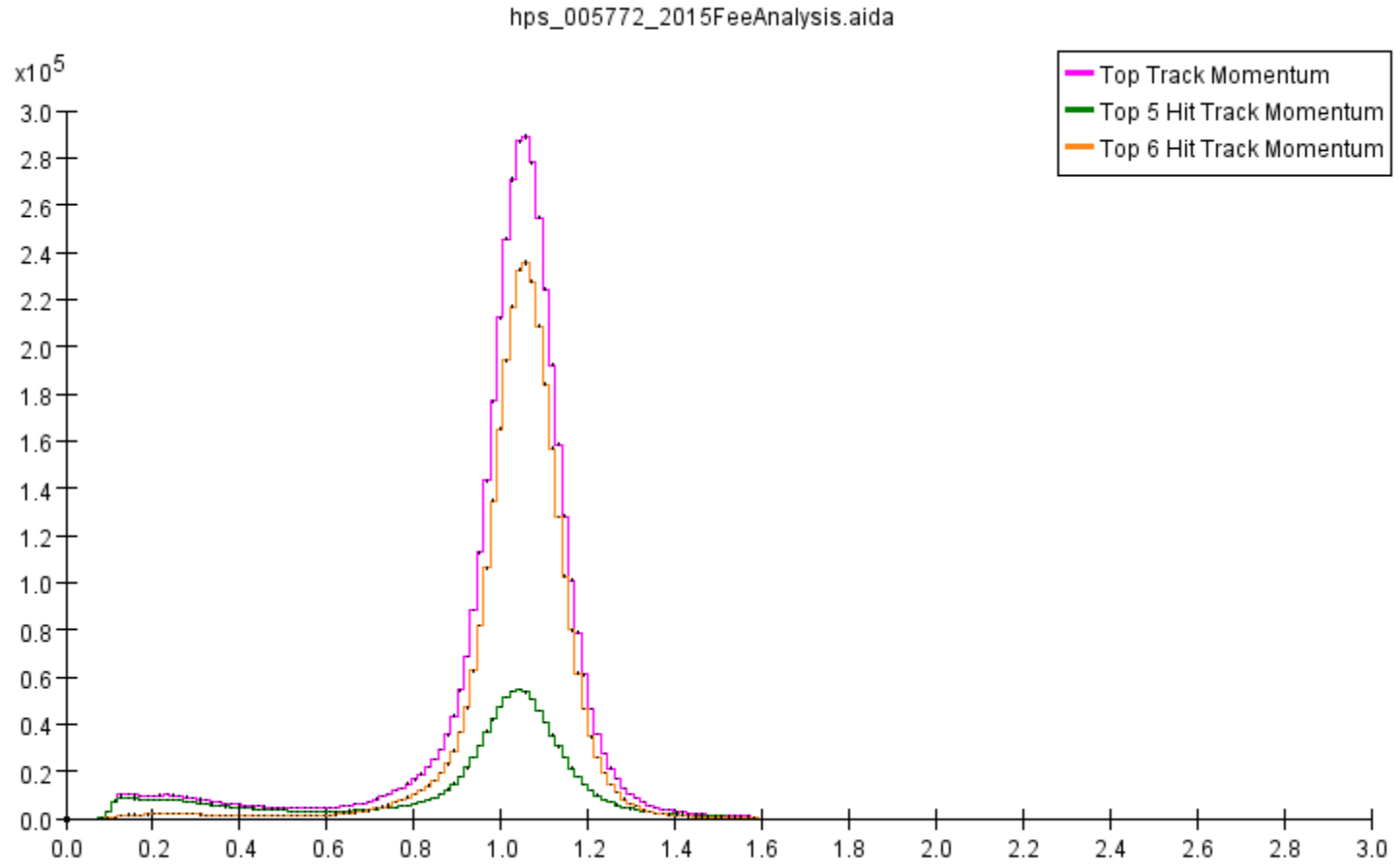
2015 Fee

- Compare top and bottom: Pretty Good

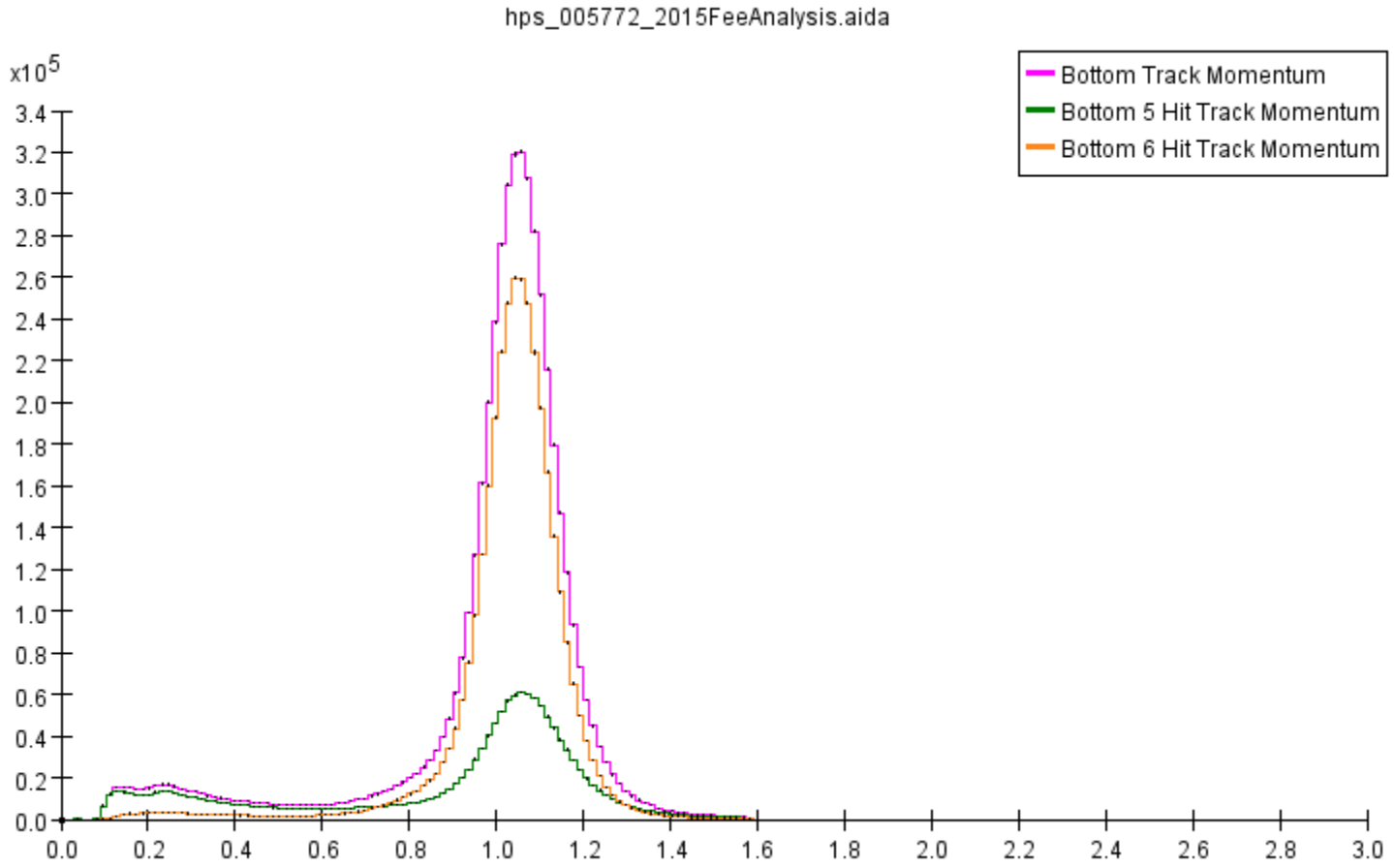


Even better after Alessandra's latest alignment.

2015 Fee Top 5 vs 6 Hit Tracks



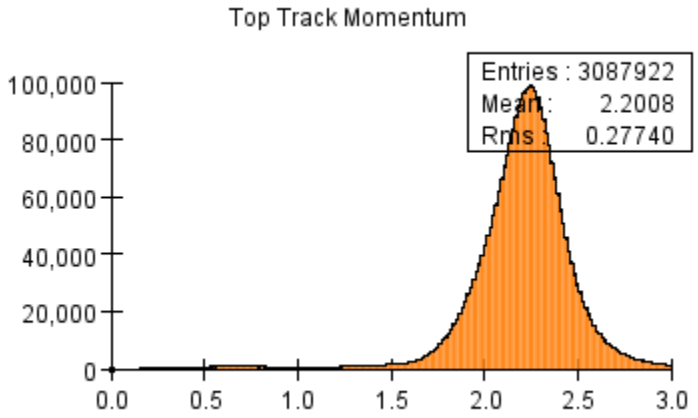
2015 Fee Bottom 5 vs 6 Hit Tracks

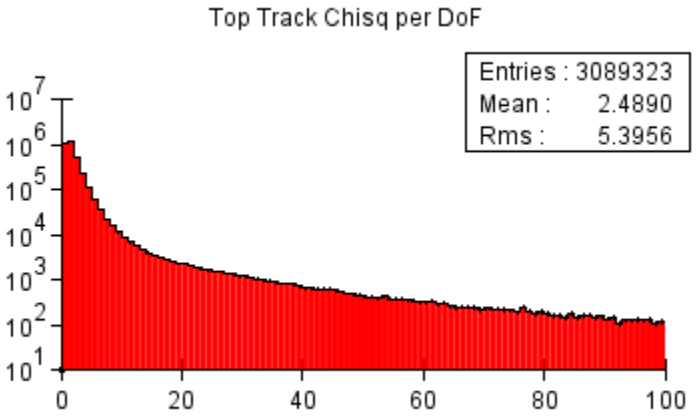


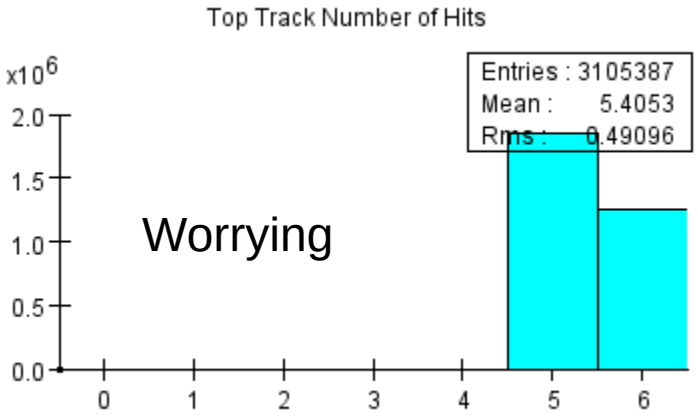
2015 Fee

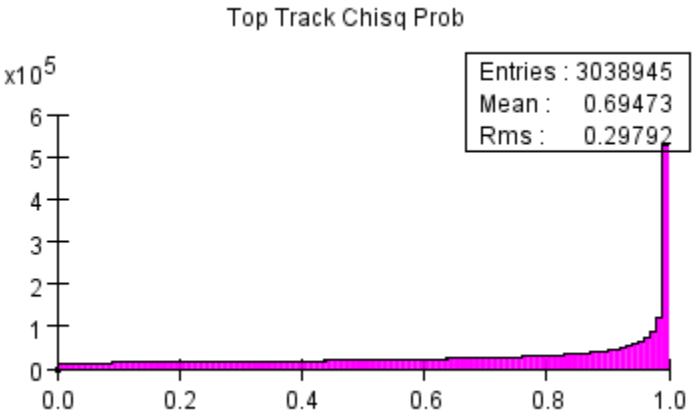
- Qualitatively looks OK
- Top agrees with Bottom
- 5Hit Tracks agree with 6 Hit Tracks
- Will re-run with latest alignment and update with fits and numbers

2016 Fee Top

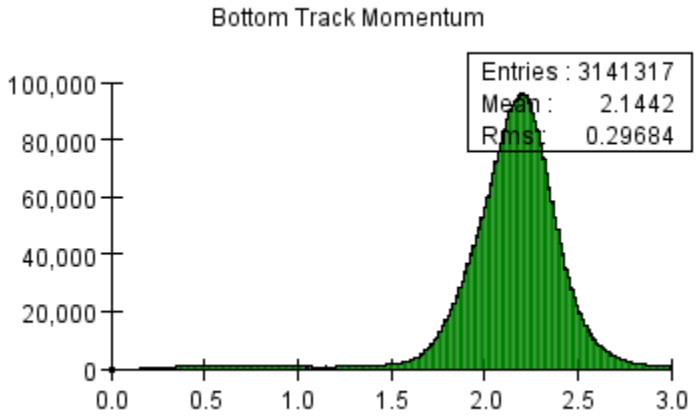

Top Track Momentum
Entries : 3087922
Mean : 2.2008
Rms : 0.27740
100,000
80,000
60,000
40,000
20,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0

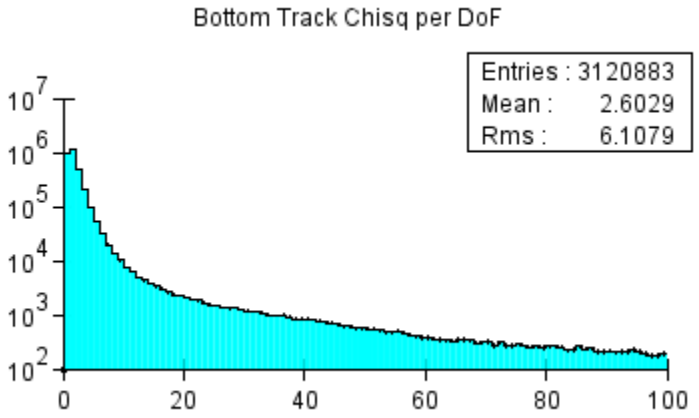

Top Track Chisq per DoF
Entries : 3089323
Mean : 2.4890
Rms : 5.3956
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
20
40
60
80
100

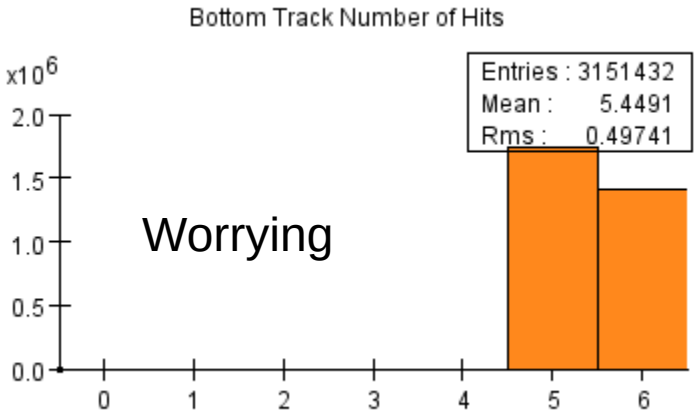

Top Track Number of Hits
Entries : 3105387
Mean : 5.4053
Rms : 0.49096
x10^6
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
6
Worrying

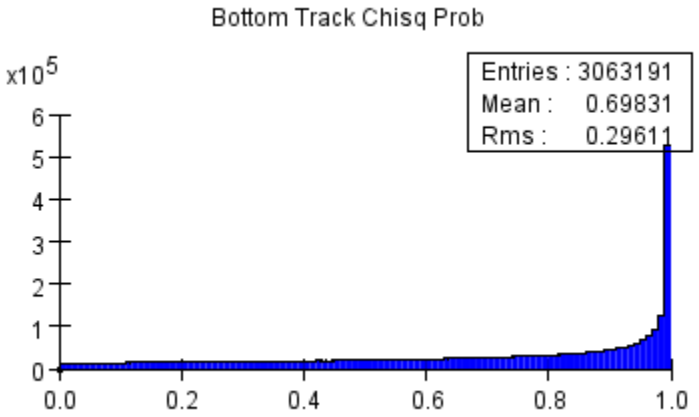

Top Track Chisq Prob
Entries : 3038945
Mean : 0.69473
Rms : 0.29792
x10^5
6
5
4
3
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0

2016 Fee Bottom



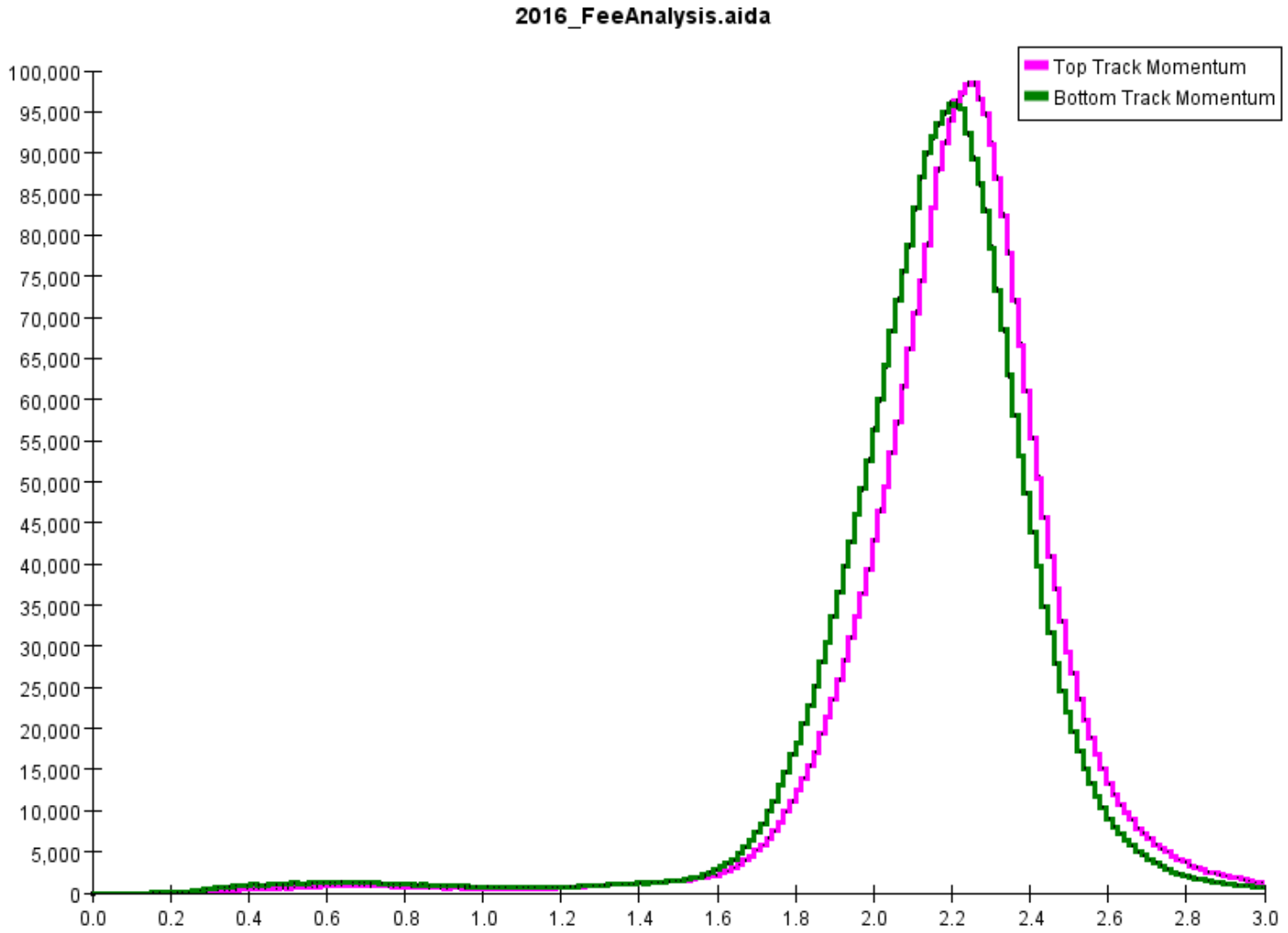






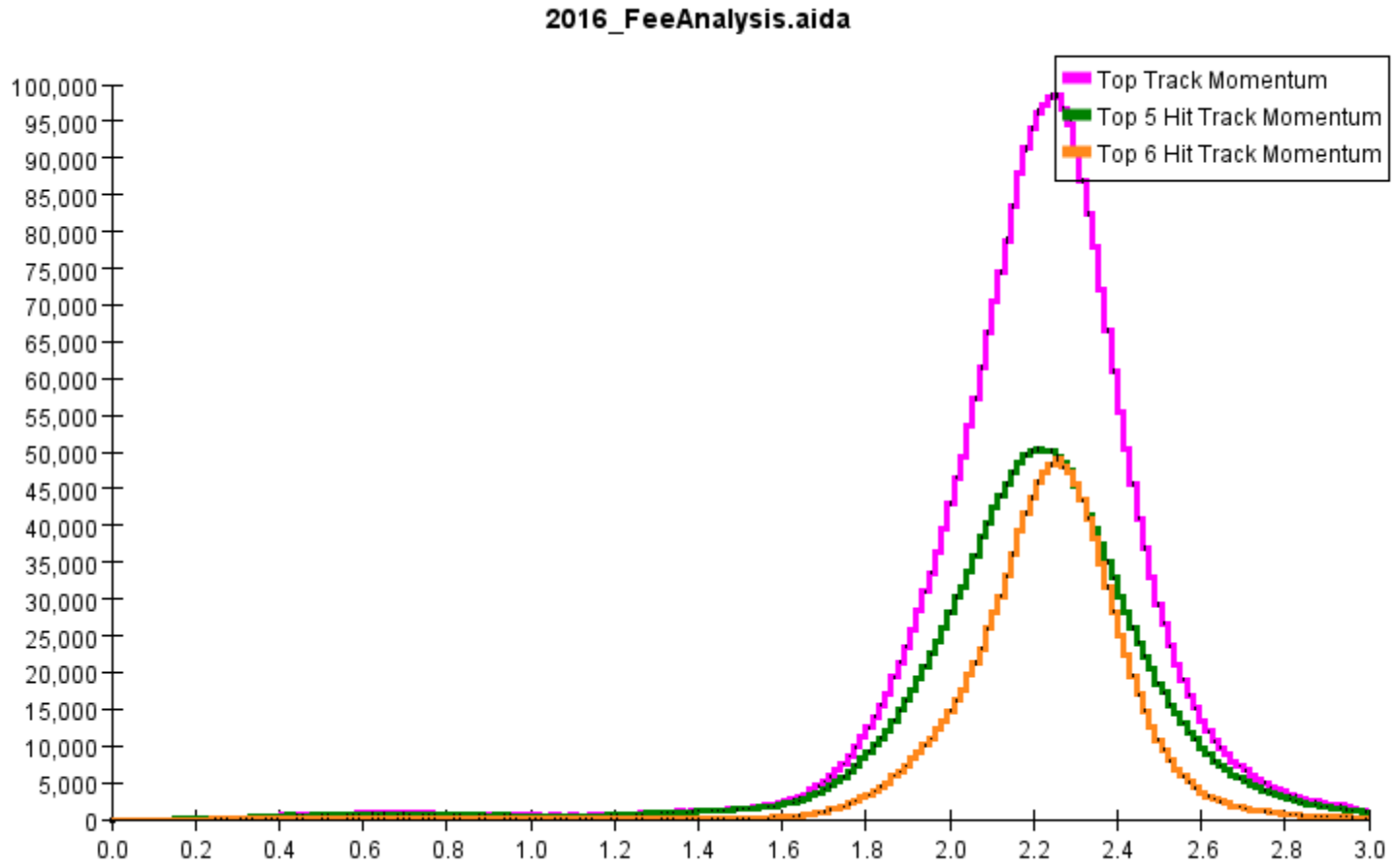
2016 Fee

- Compare top and bottom: Clear Discrepancy



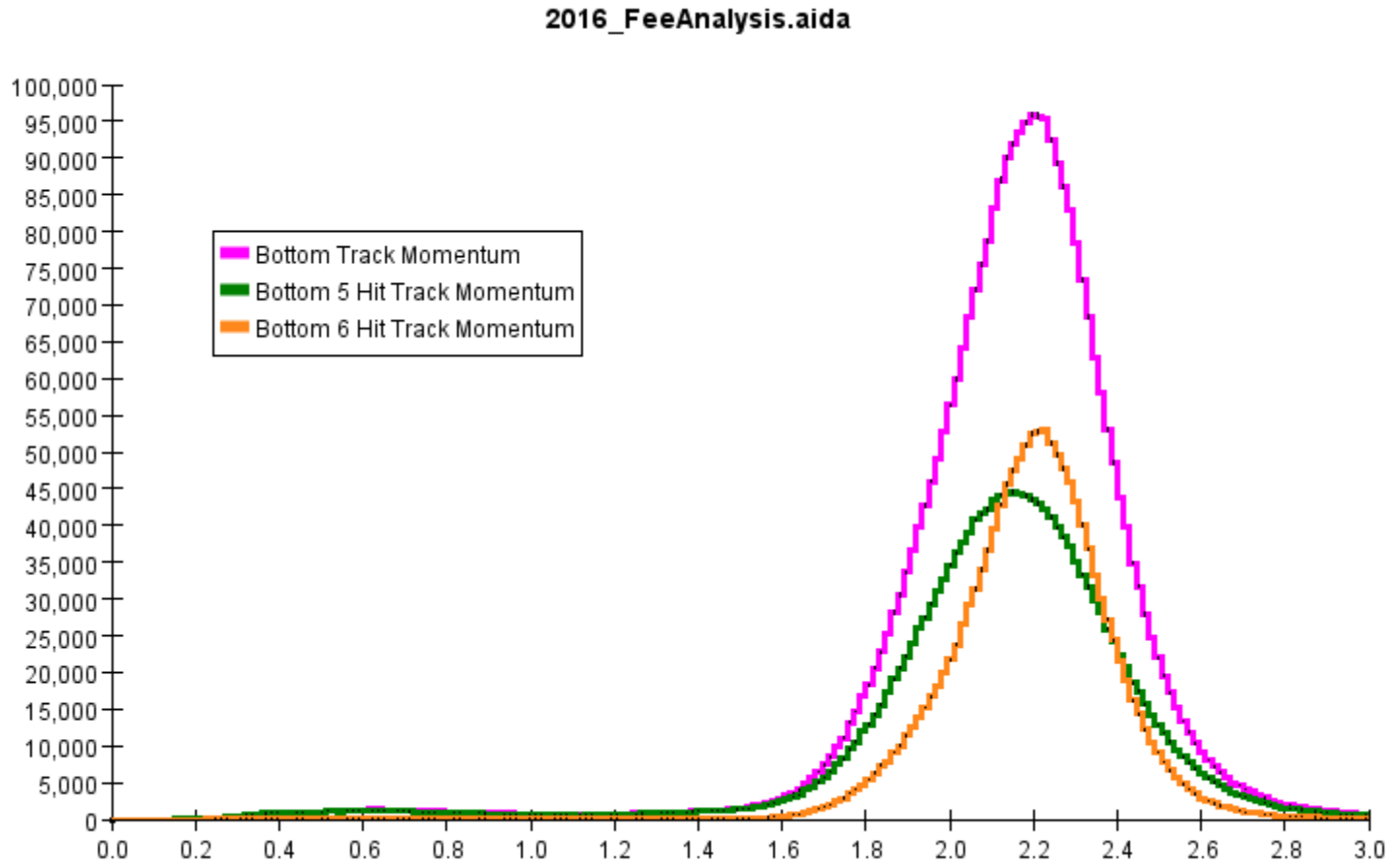
2016 Fee Top 5 vs 6 Hit Tracks

- Difference in Mean and Width



2015 Fee Bottom 5 vs 6 Hit Tracks

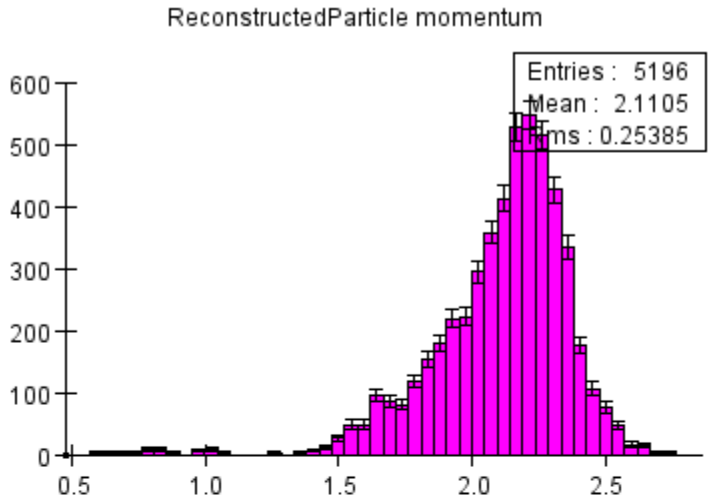
- Difference in Mean and Width

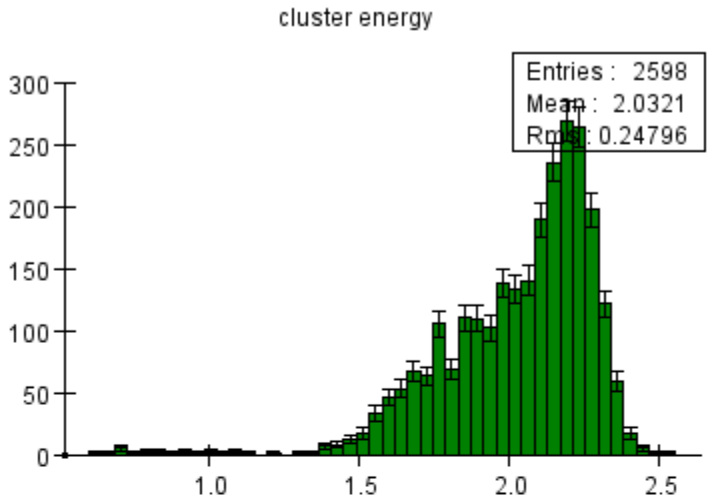


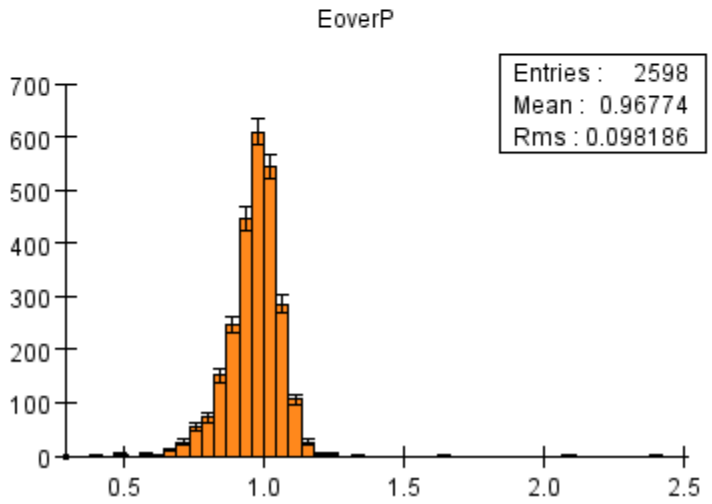
2016 Fee

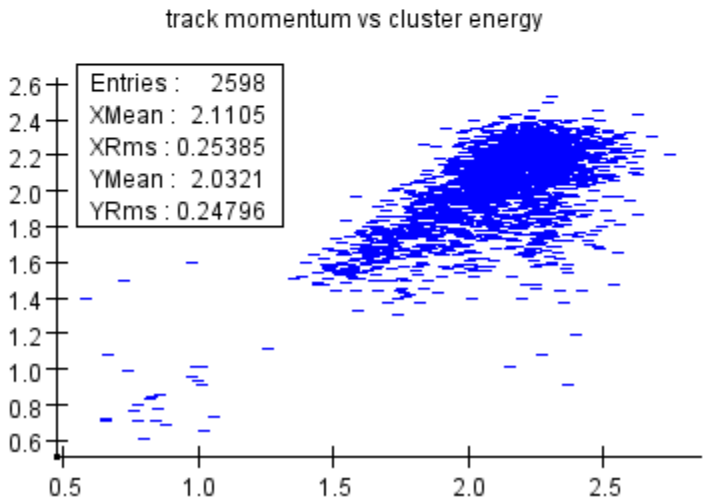
- Lots of discrepancies
- Top disagrees with Bottom
- 5Hit Tracks disagree with 6 Hit Tracks
- Will re-run with latest alignment and update with fits and numbers
- Stay tuned…

Track Quality (not great, but not bad)





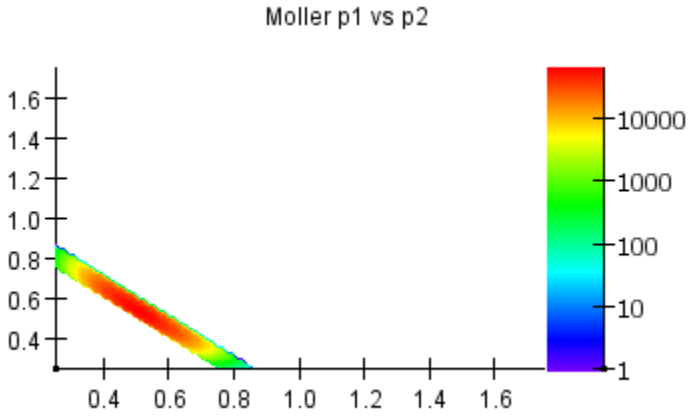


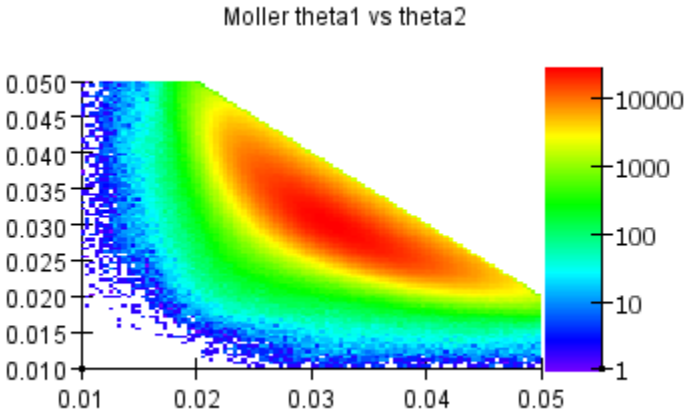


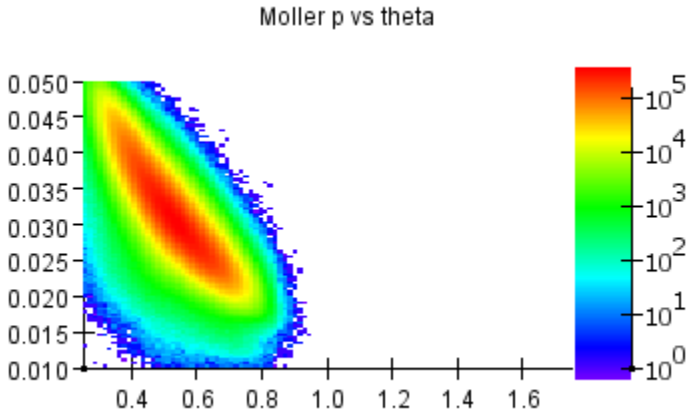
Møller Analysis

- Loose cuts
  - Require track cluster match
  - | Cluster dt | < 2ns
  - Cuts on psum eBeam+/-5%
  - Cuts on thetasum
- Three Vertex collections
  - Unconstrained
  - BeamspotConstrained
  - TargetConstrained

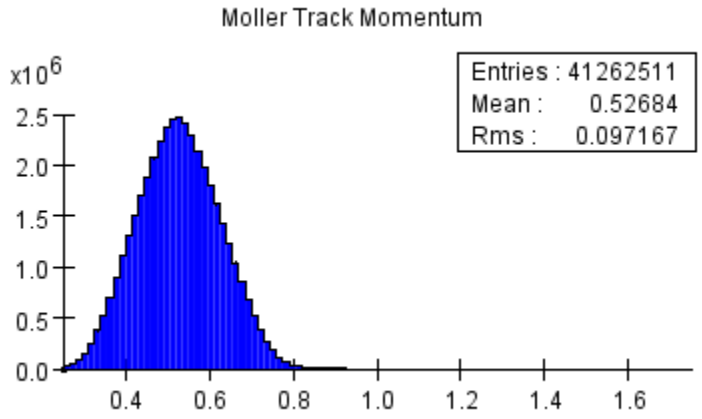
2015 Møller Electron Kinematics

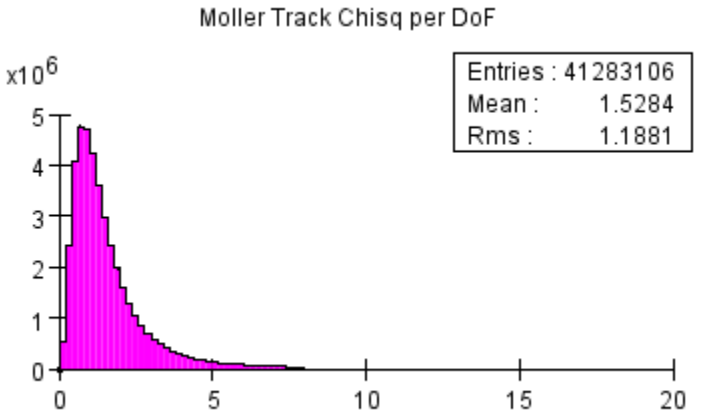


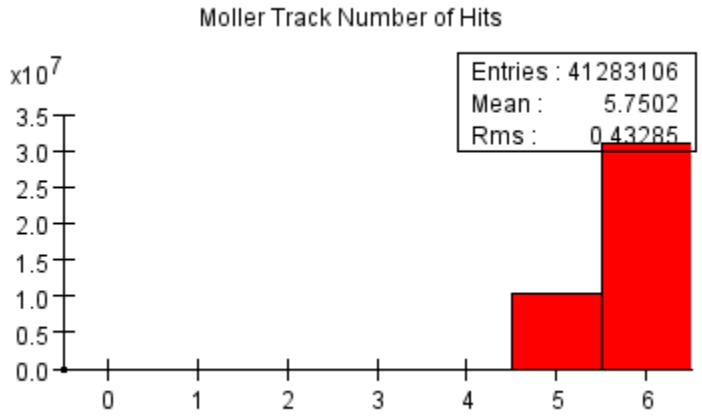


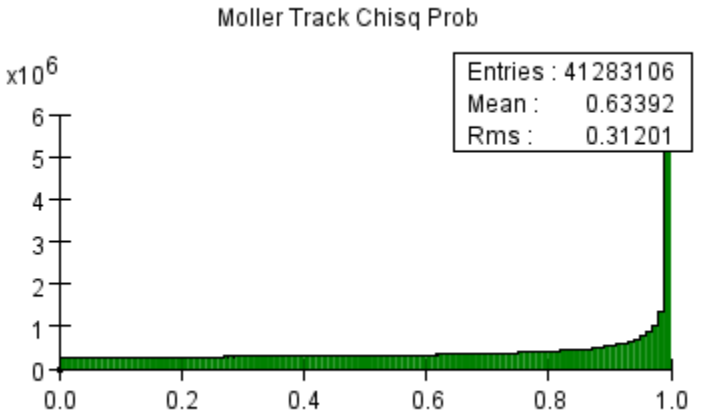


2015 Møller Track Quality



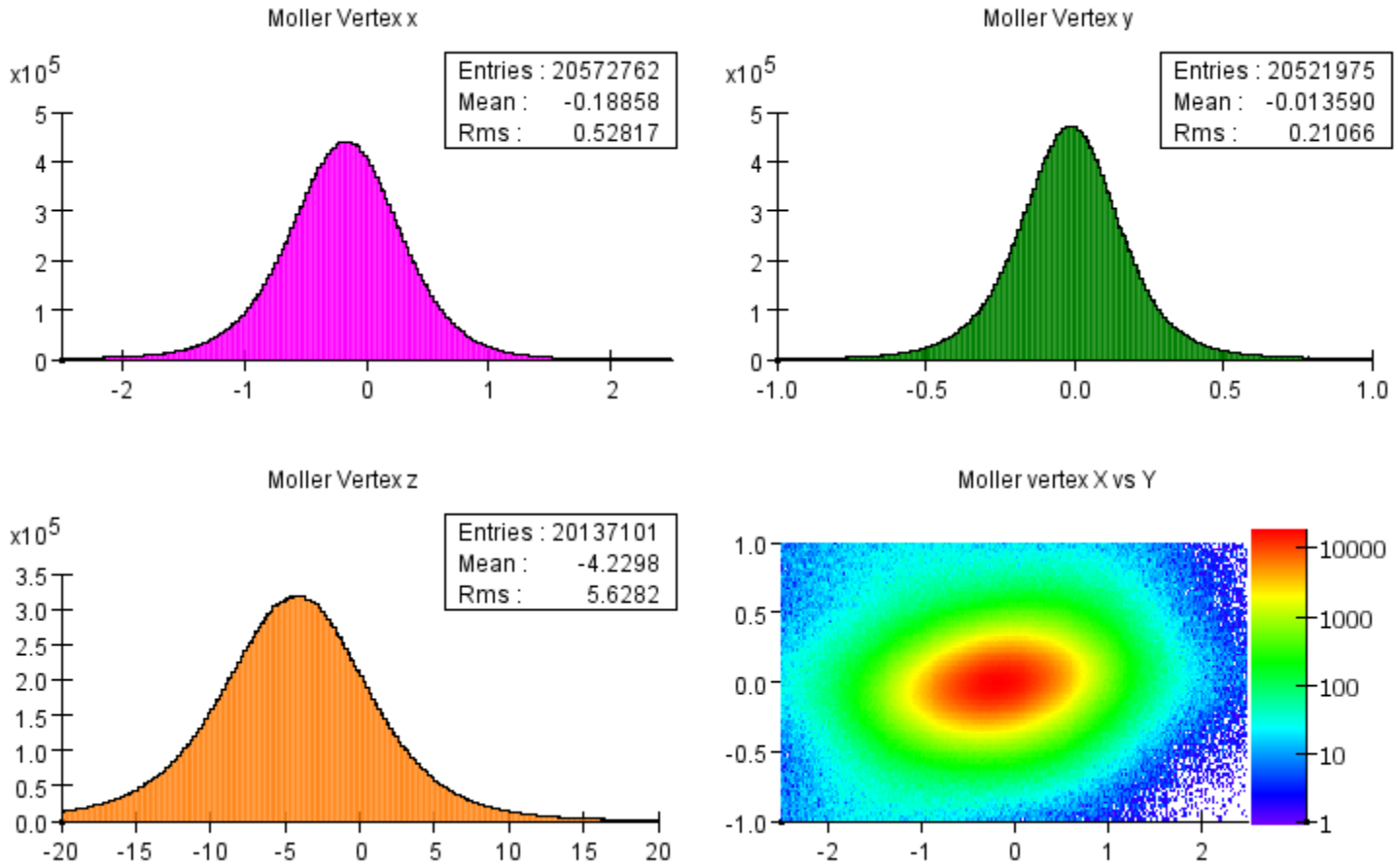






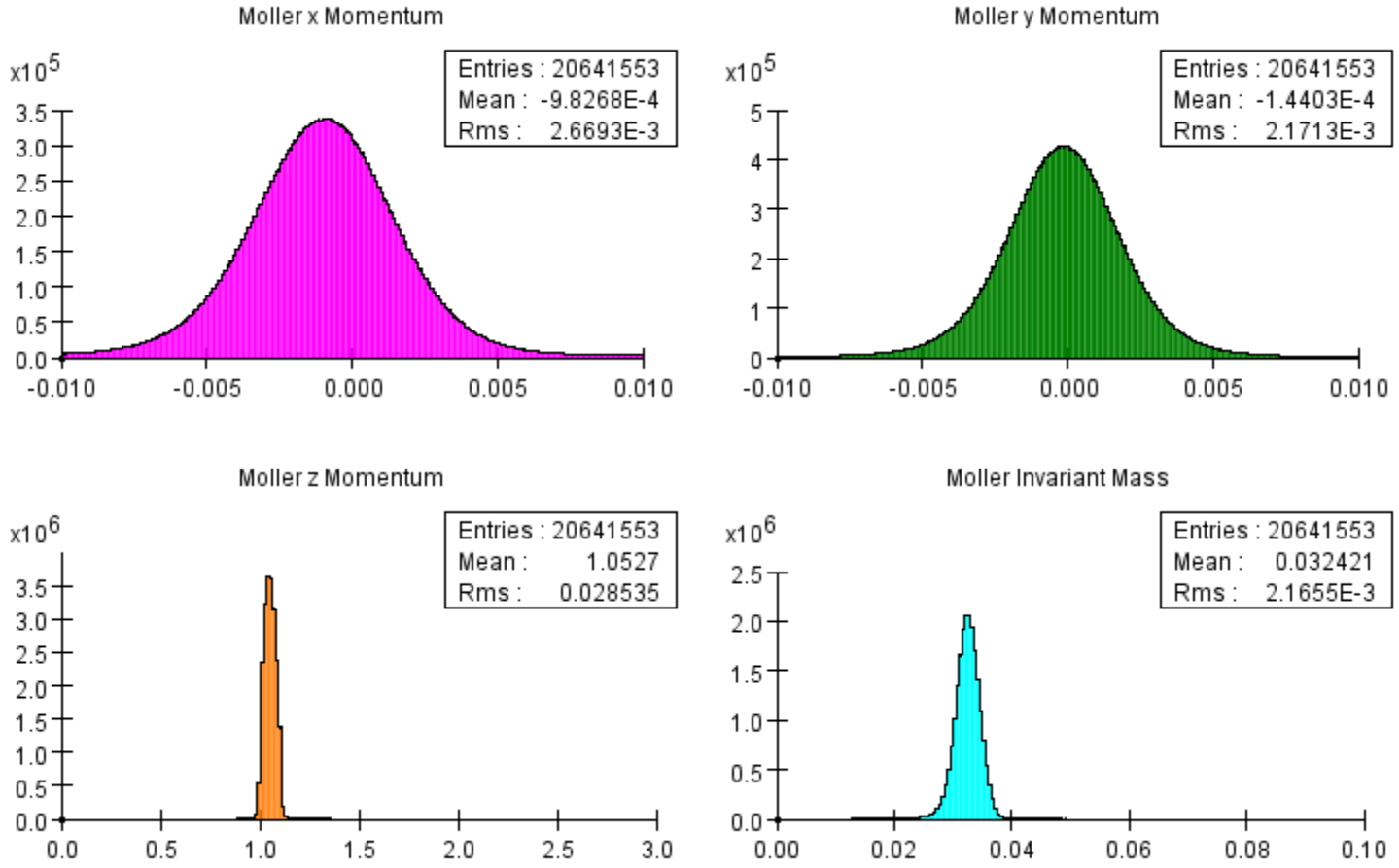
2015 Møller Position

- Where is the Beam & Target?



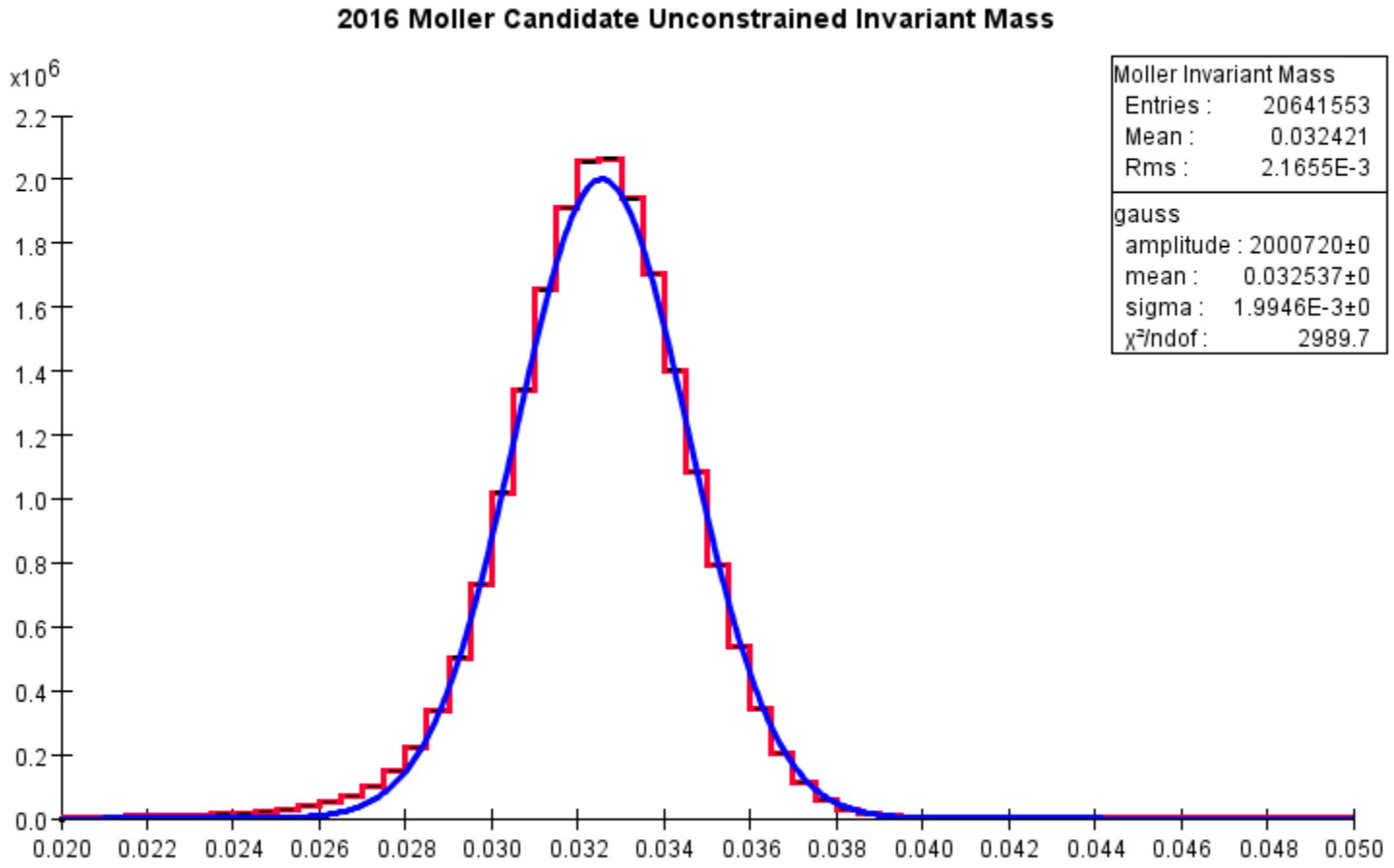
2015 Møller Direction

- Rotate Vertex into Beam(Physics) Coordinates



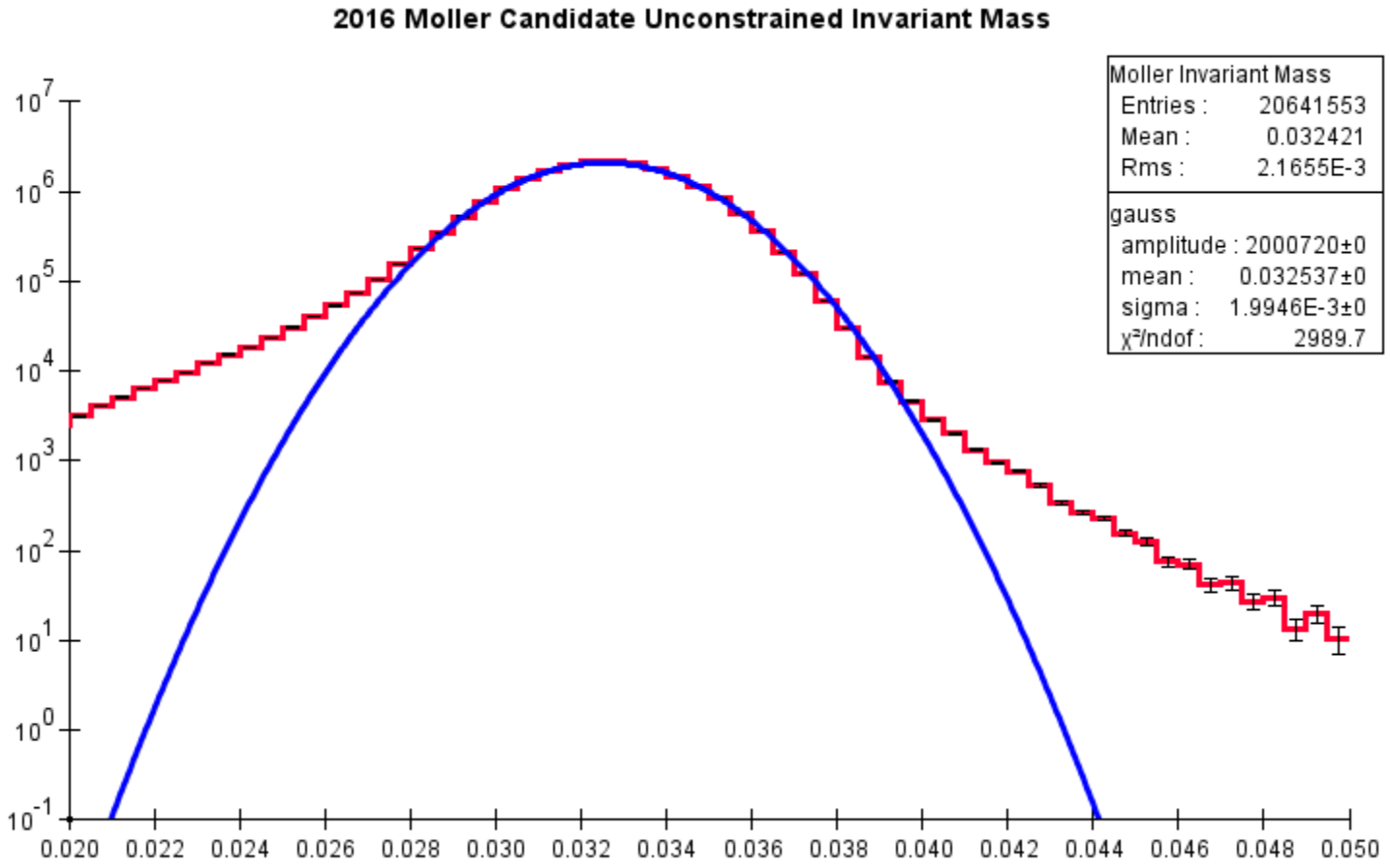
2015 Møller Invariant Mass

- Unconstrained Vertex



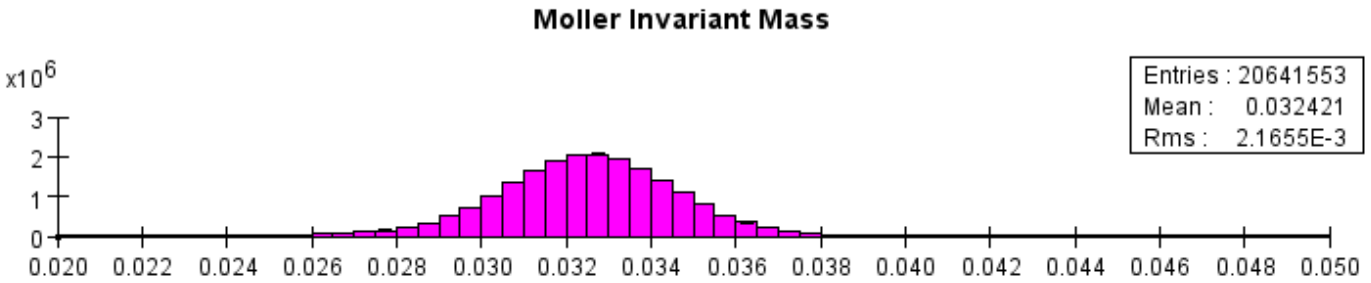
2015 Møller Invariant Mass

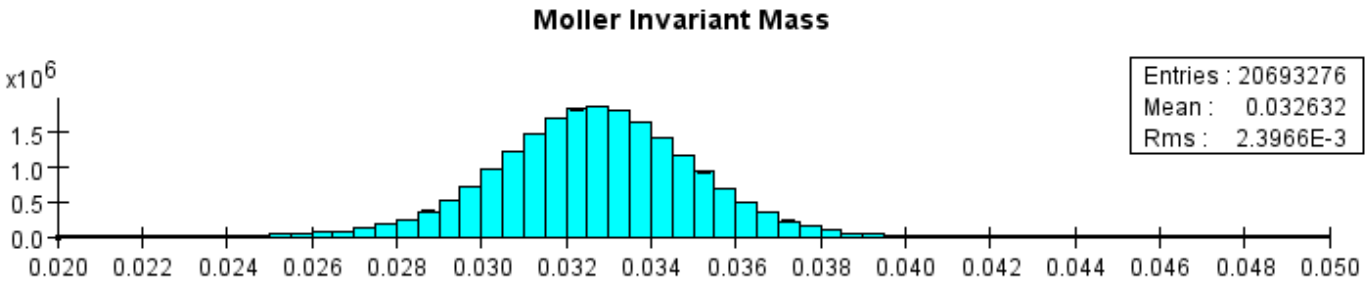
- Unconstrained Vertex

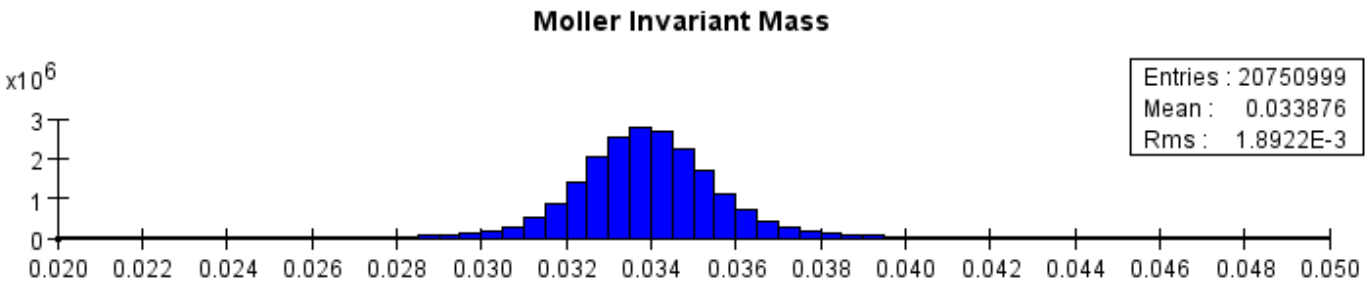


2015 Møller Invariant Mass

- Unconstrained, BeamspotConstrained, Target Constrained

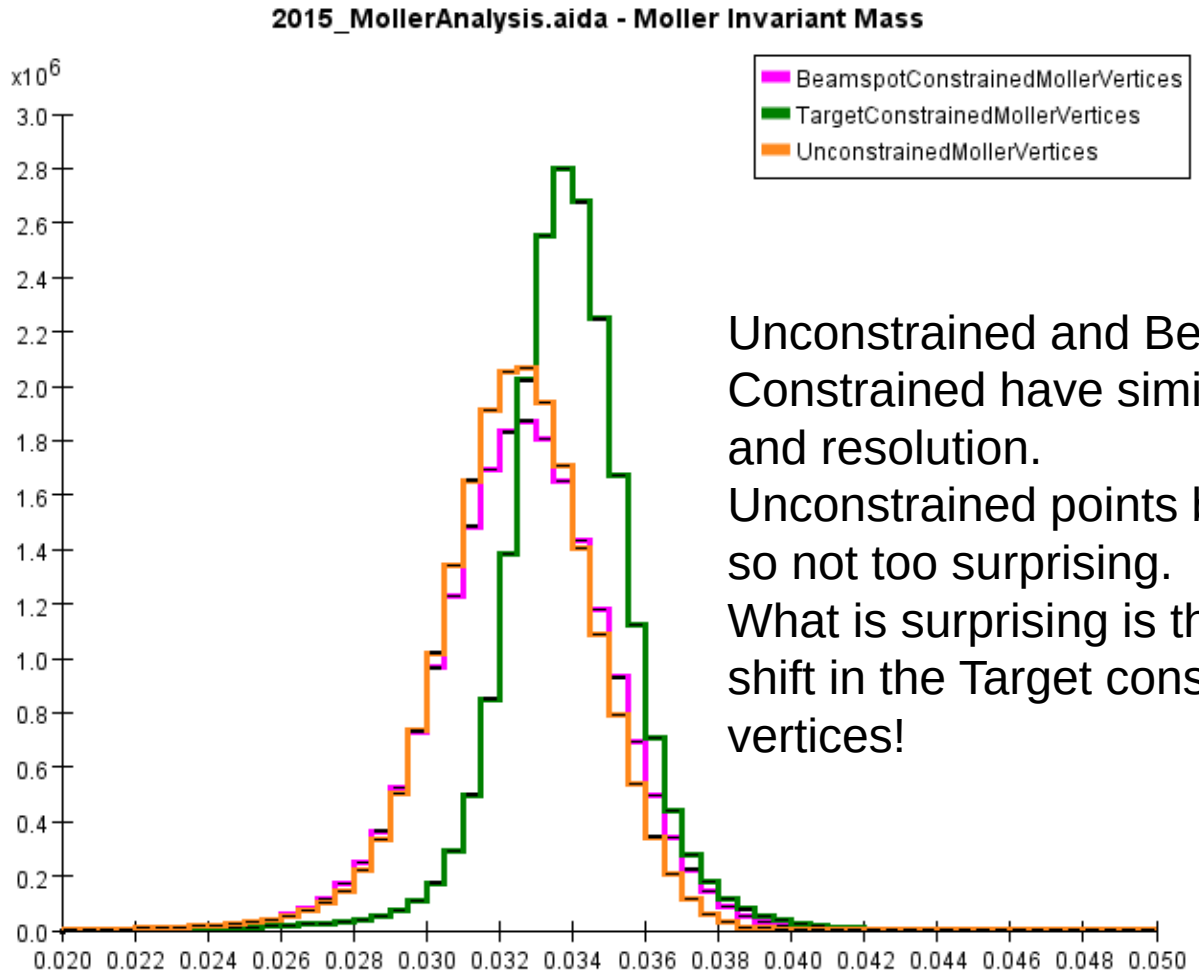






2015 Møller Invariant Mass

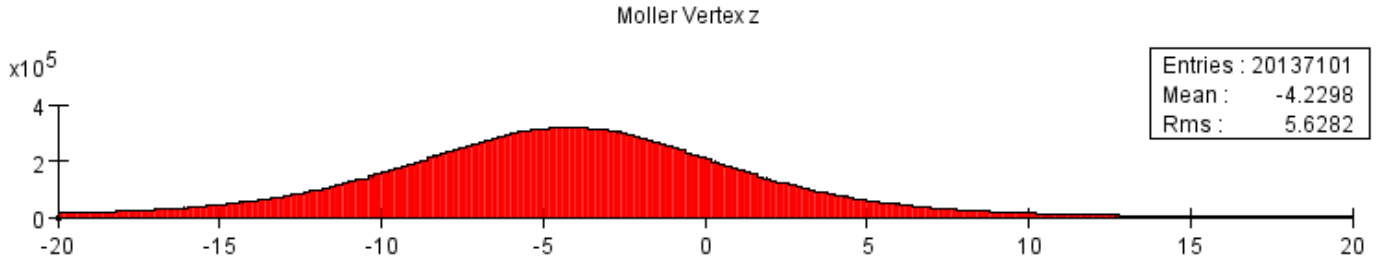
- Unconstrained, BeamspotConstrained, Target Constrained

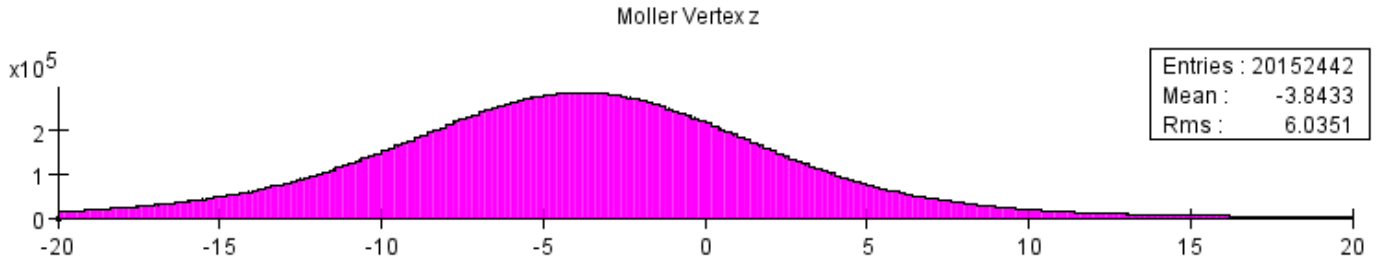


Unconstrained and Beamspot Constrained have similar mass and resolution.
Unconstrained points back to IP so not too surprising.
What is surprising is the mass shift in the Target constrained vertices!

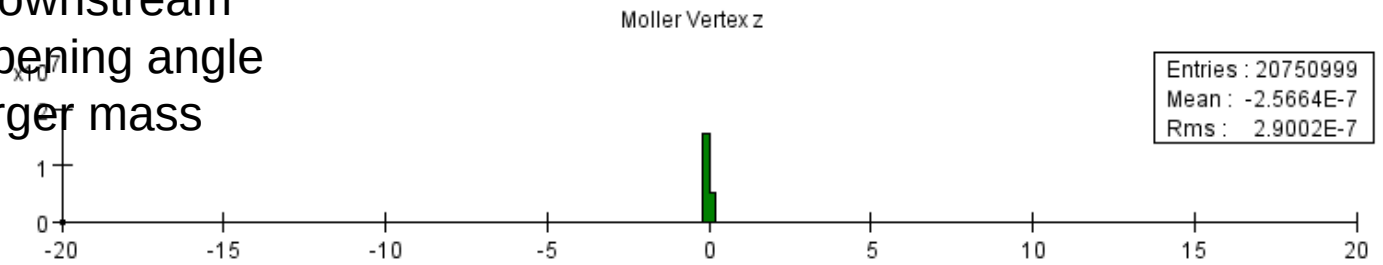
2015 Møller Vertex Position

- Unconstrained, BeamspotConstrained, Target Constrained

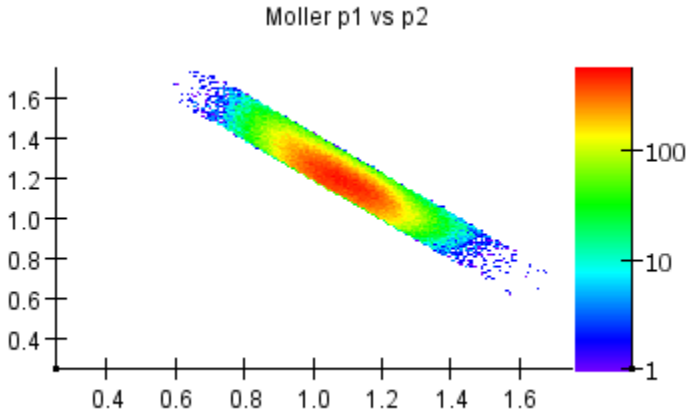


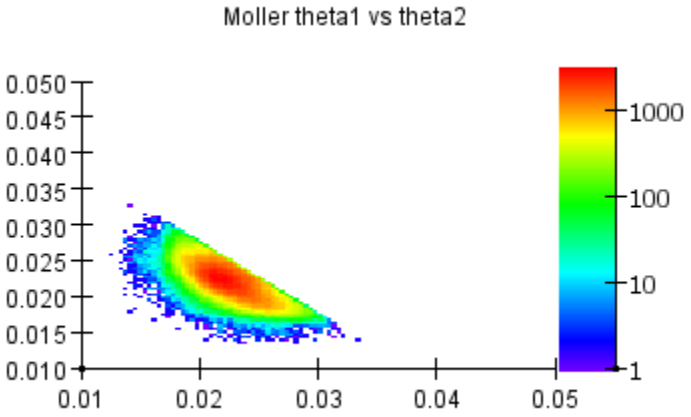


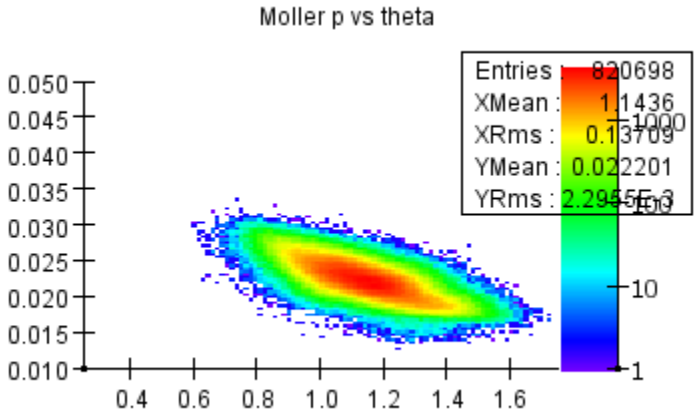
Bingo!
We're fitting to a target at z=0!
Forcing vertex downstream forces greater opening angle and therefore larger mass
FIX THIS!



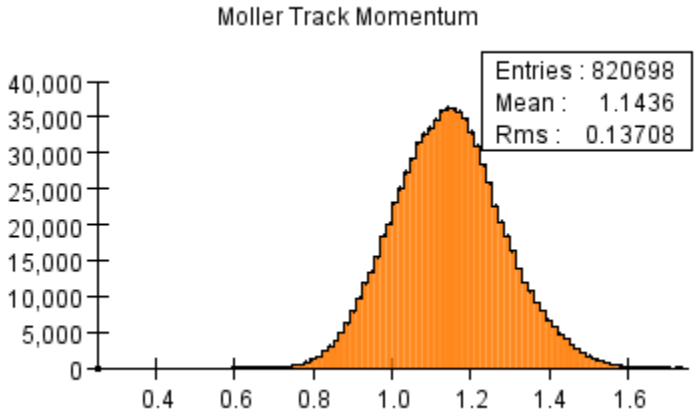
2016 Møller Electron Kinematics

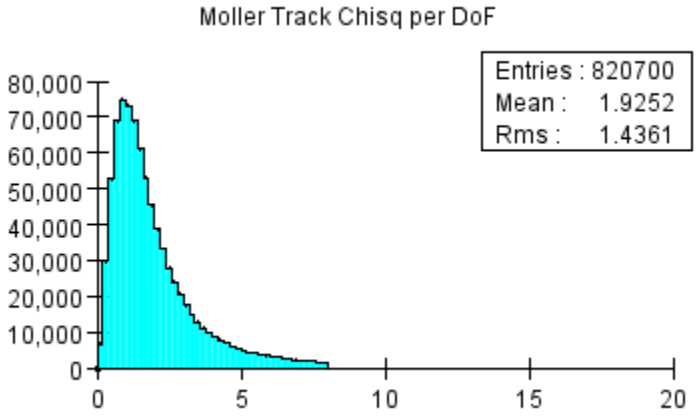


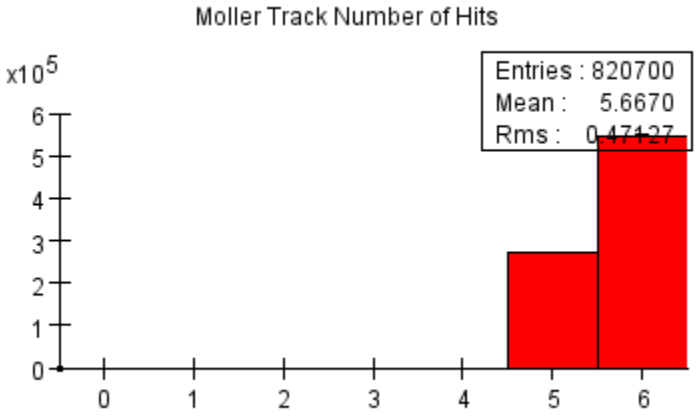


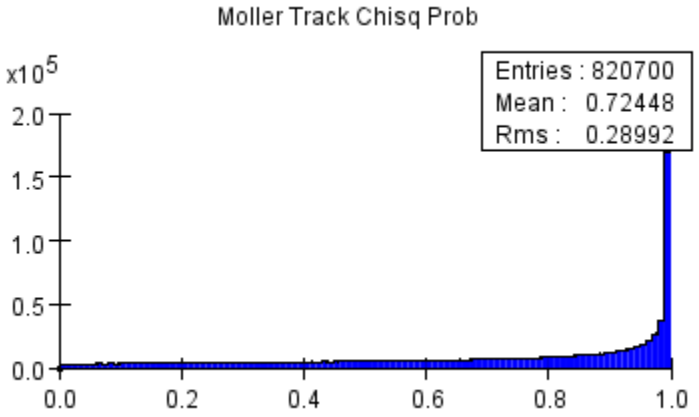


2016 Møller Track Quality



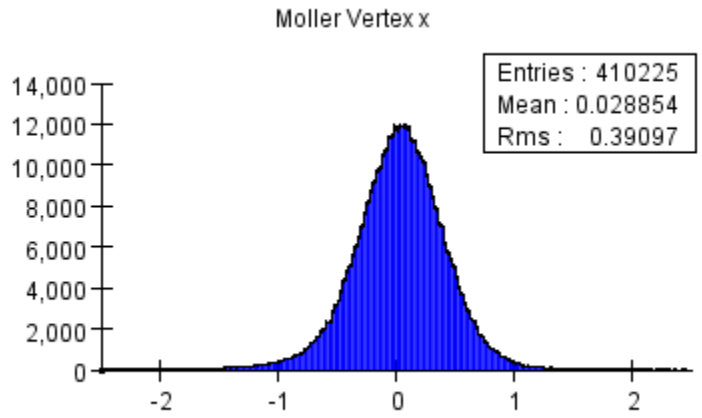


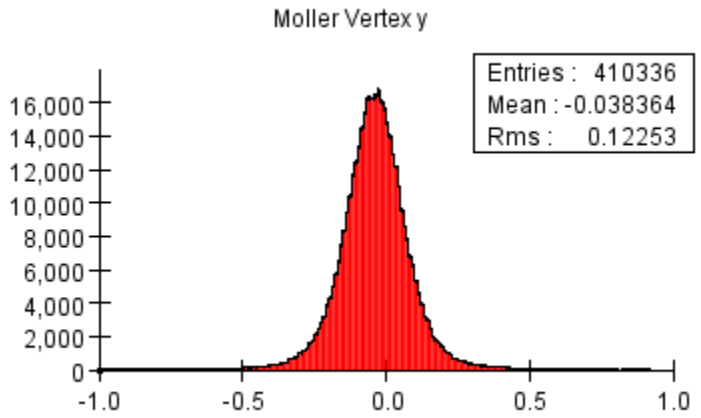


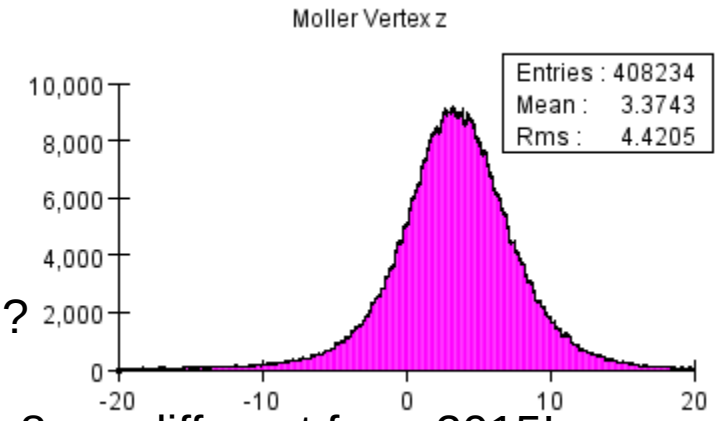


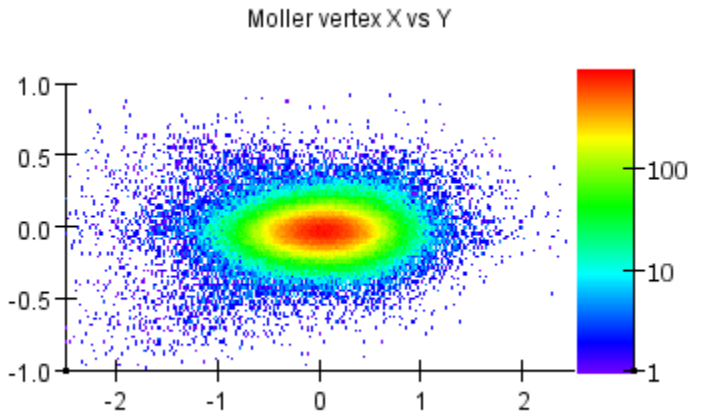
2016 Møller Position

- Where is the Beam & Target?





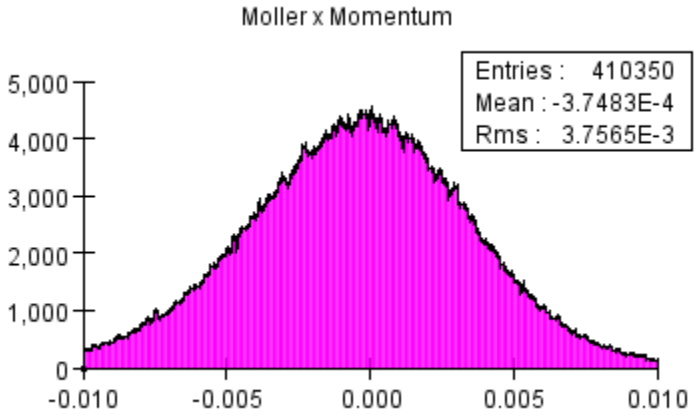


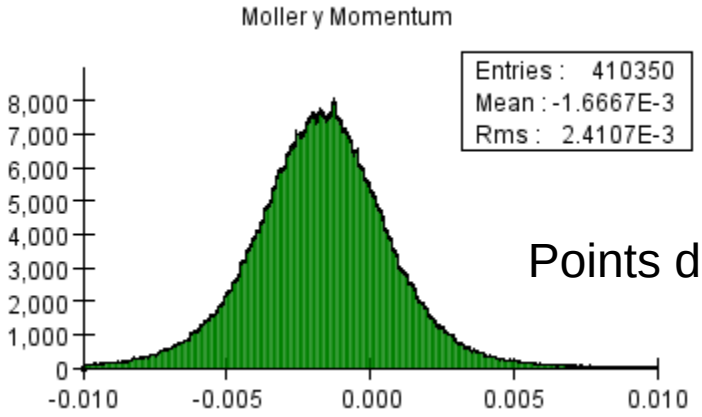


What!?
+3!!!!
That's 8mm different from 2015!

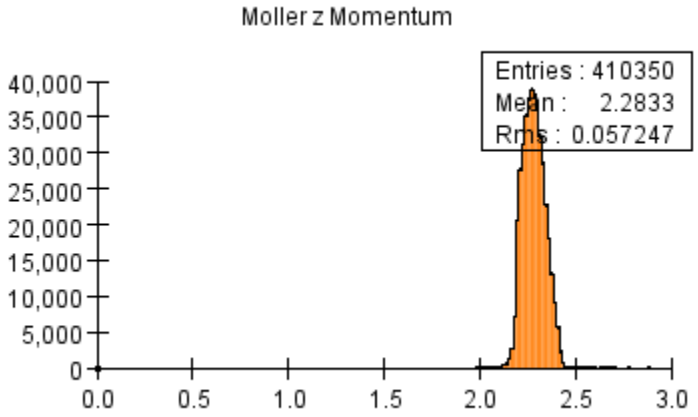
2016 Møller Direction

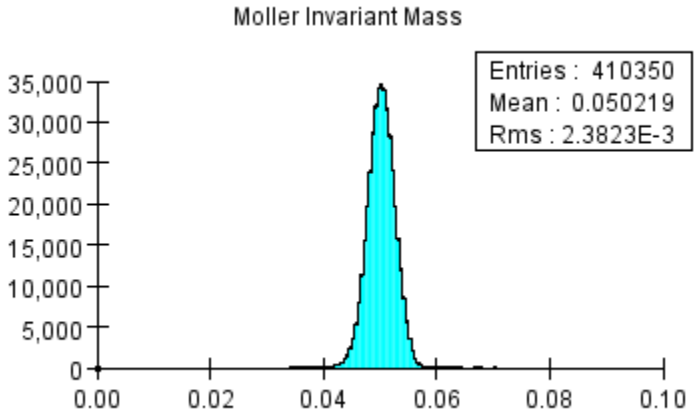
- Rotate Vertex into Beam(Physics) Coordinates





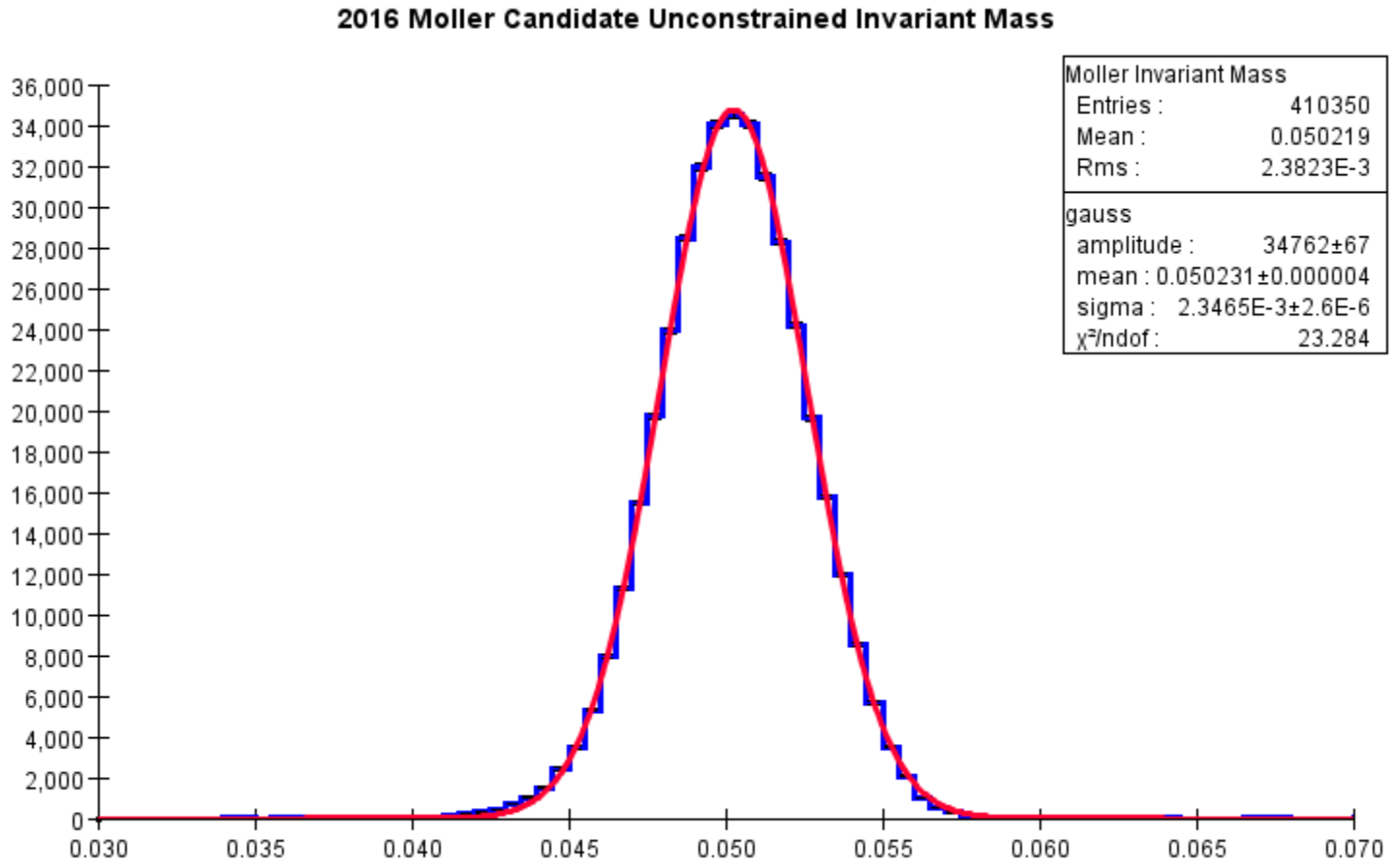
Points down?





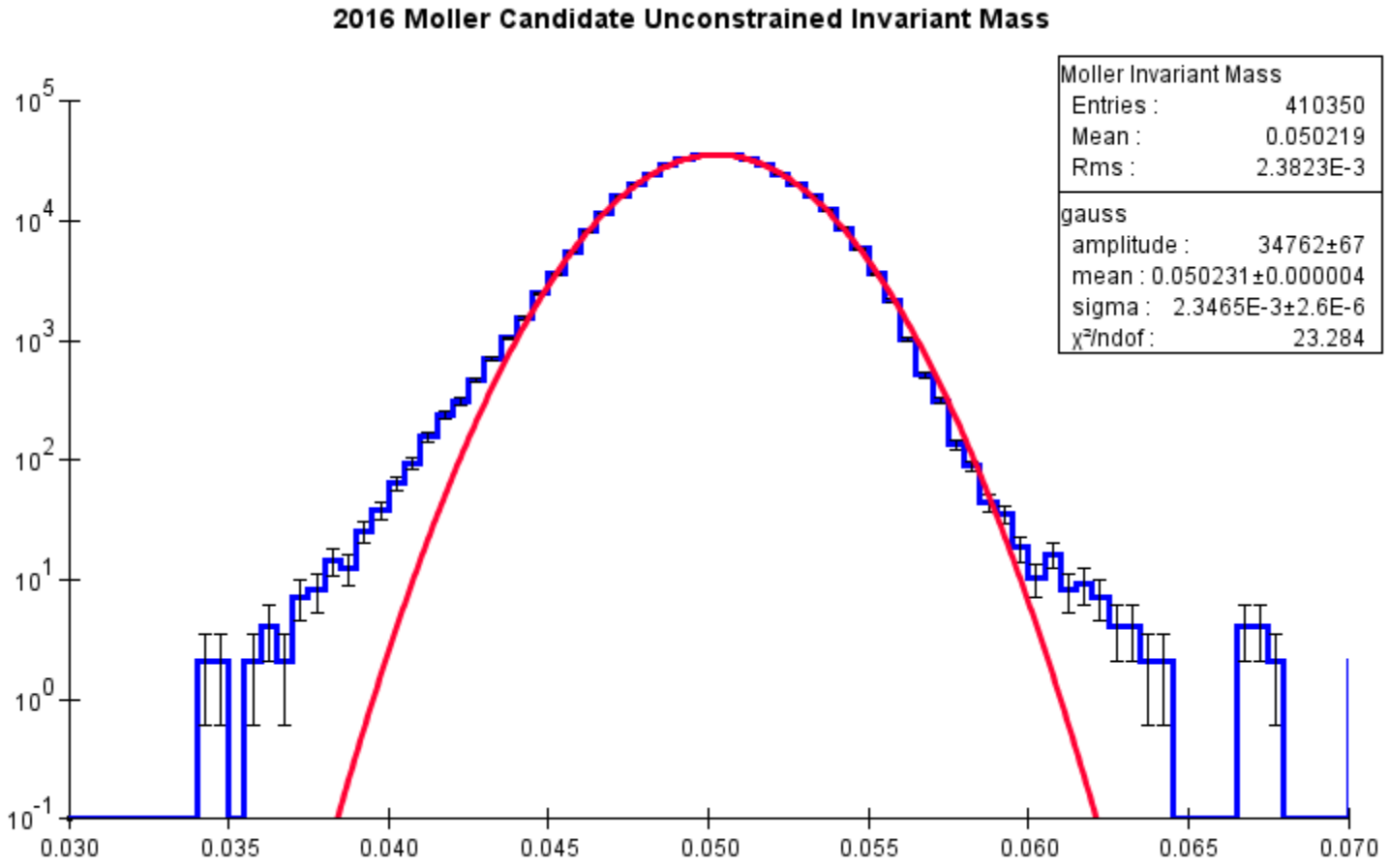
2016 Møller Invariant Mass

- Unconstrained Vertex



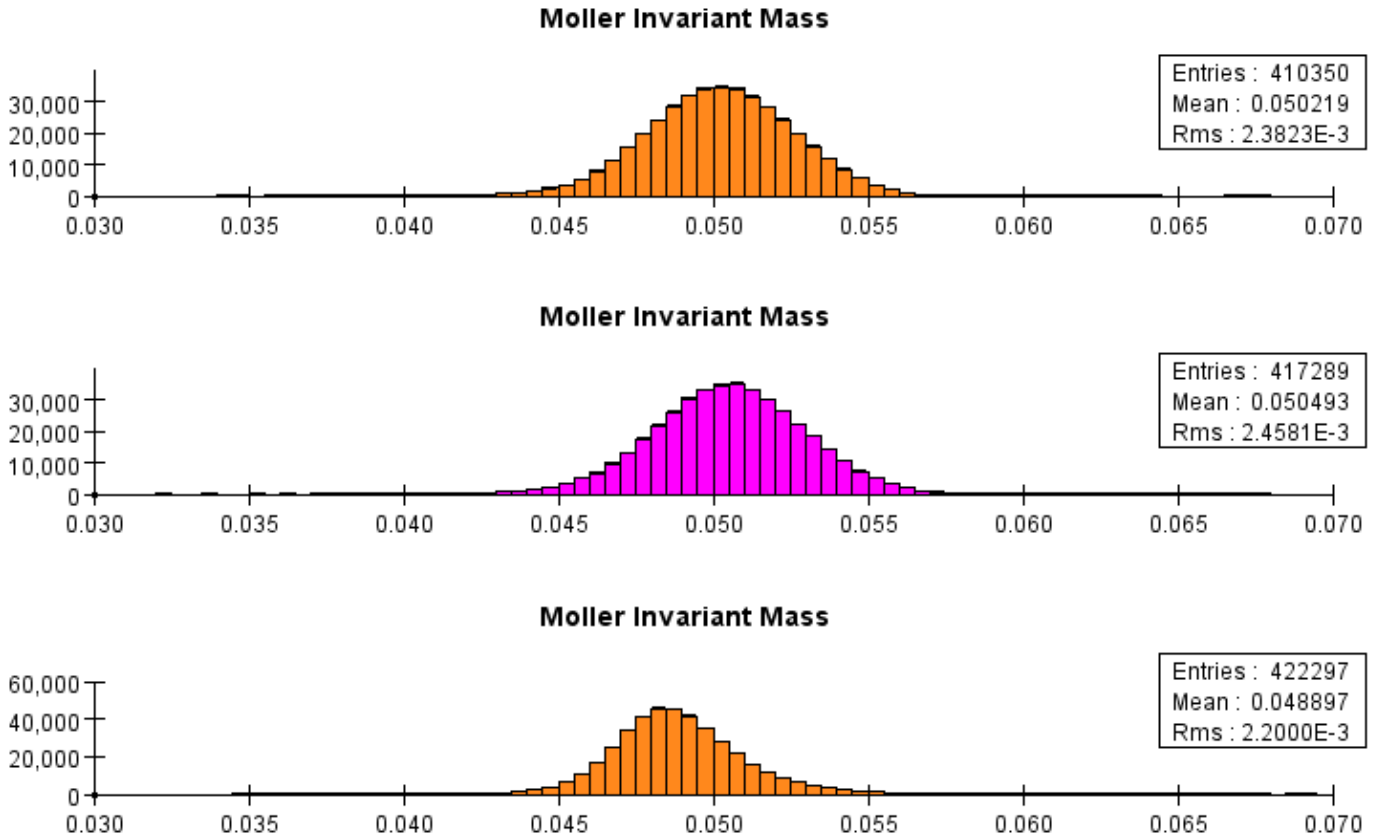
2016 Møller Invariant Mass

- Unconstrained Vertex



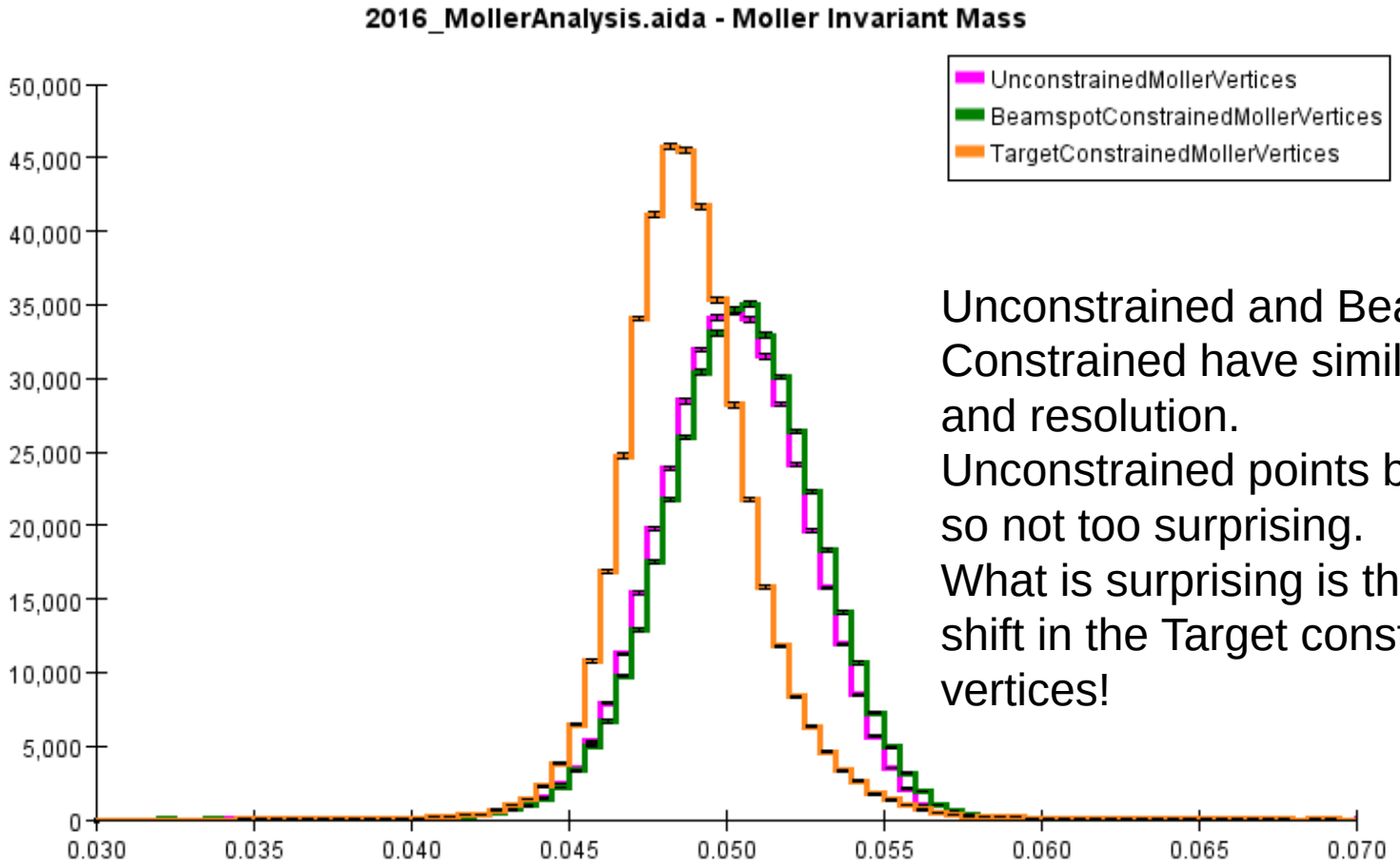
2016 Møller Invariant Mass

- Unconstrained, BeamspotConstrained, Target Constrained



2016 Møller Invariant Mass

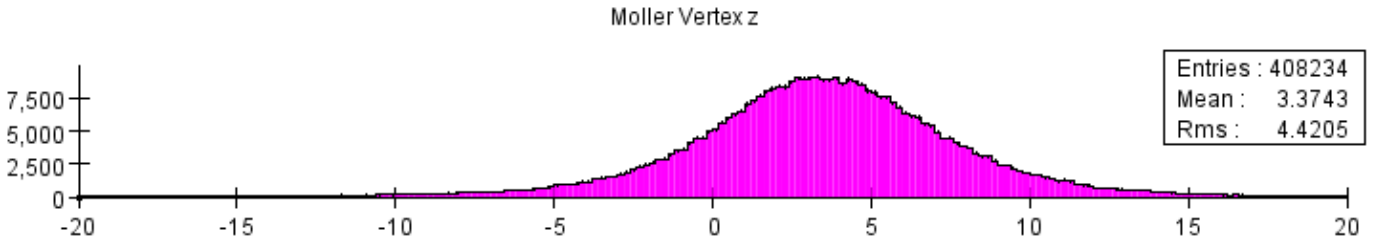
- Unconstrained, BeamspotConstrained, Target Constrained

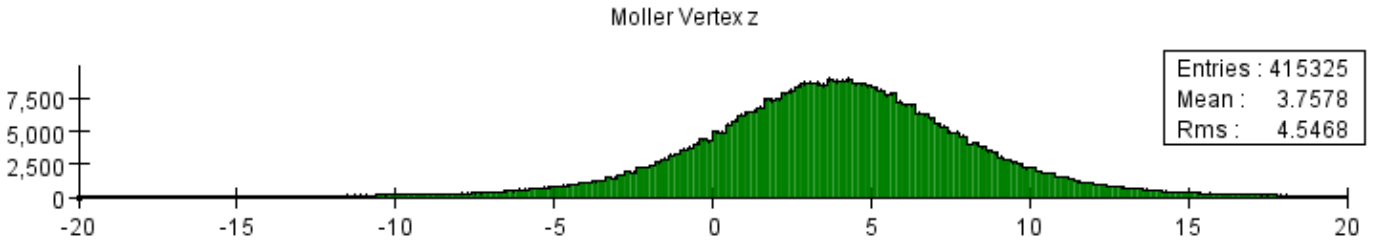


Unconstrained and Beamspot Constrained have similar mass and resolution.
Unconstrained points back to IP so not too surprising.
What is surprising is the mass shift in the Target constrained vertices!

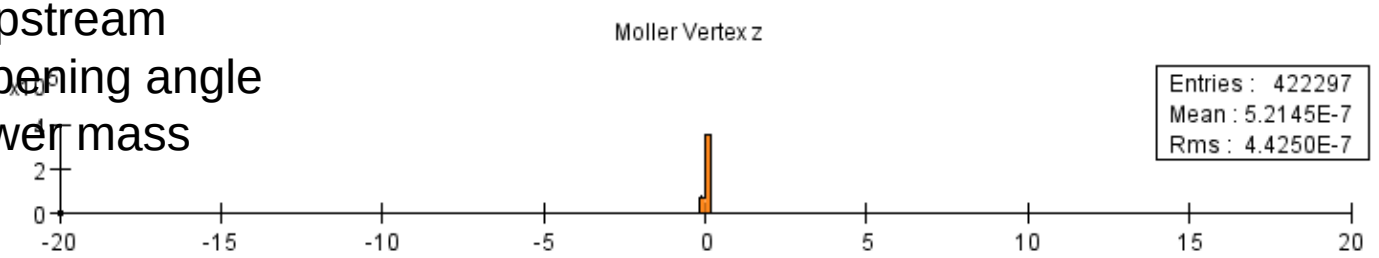
2016 Møller Vertex Position

- Unconstrained, BeamspotConstrained, Target Constrained

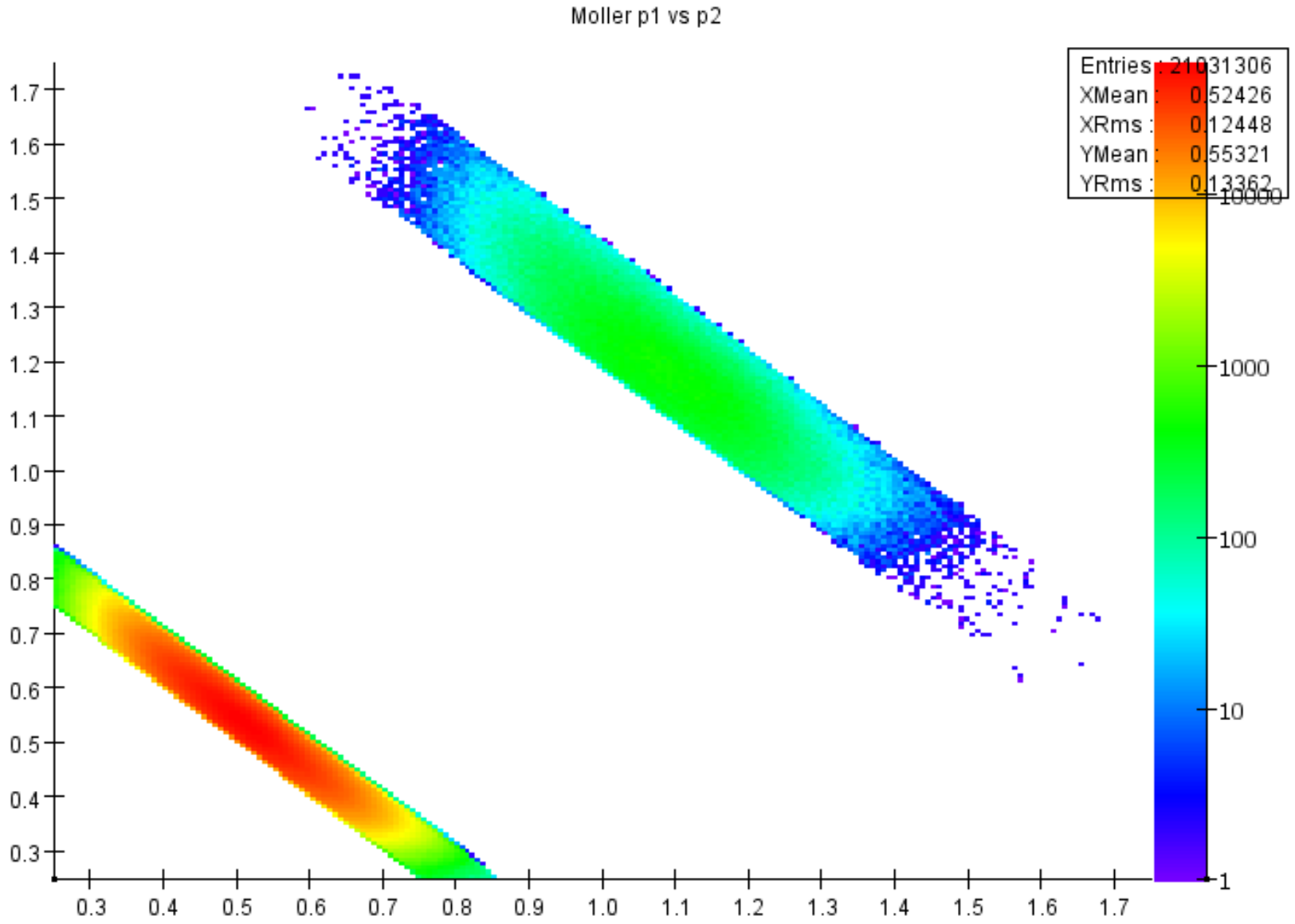




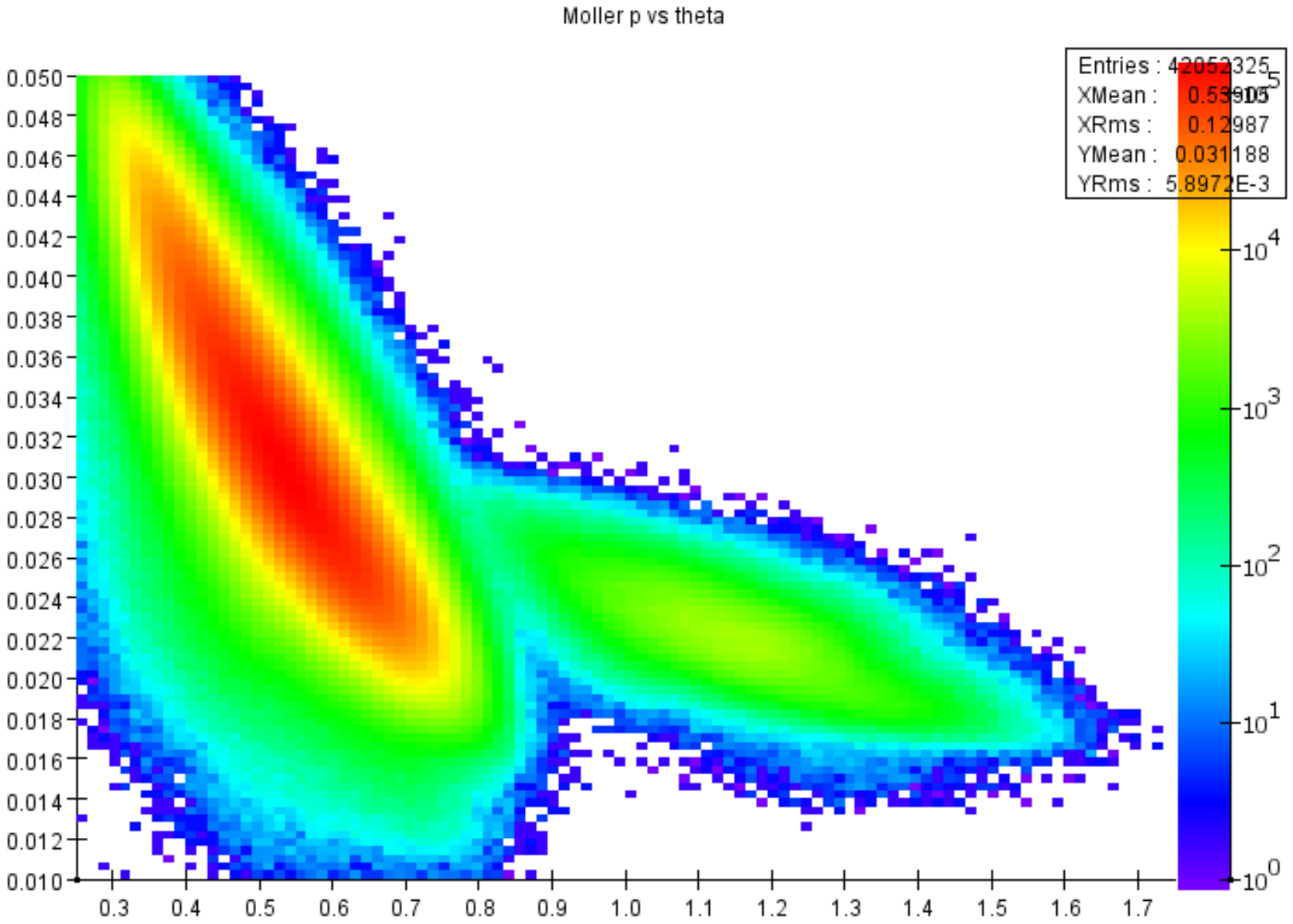
Bingo!
We're fitting to a target at z=0!
Forcing vertex upstream forces smaller opening angle and therefore lower mass
FIX THIS!



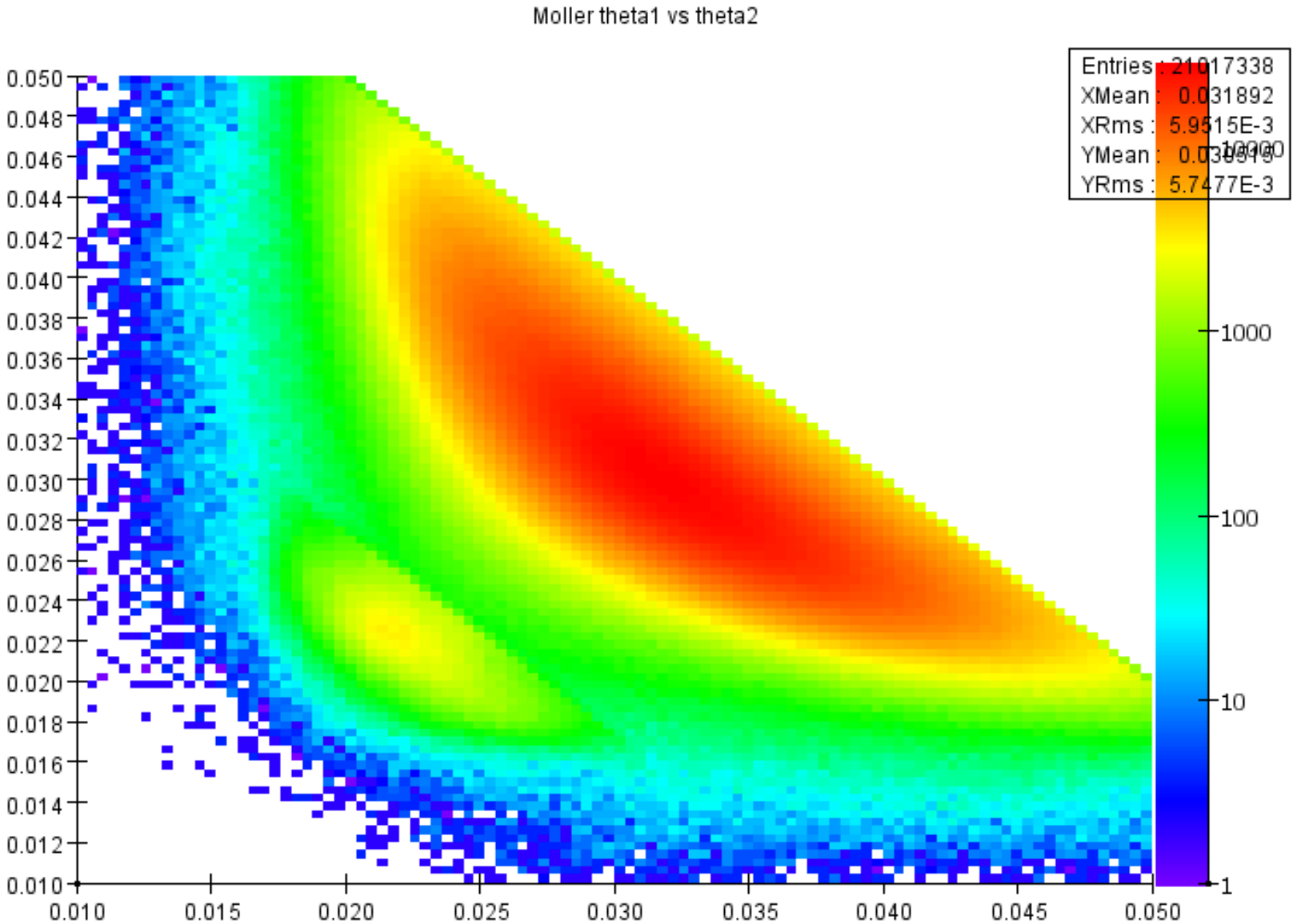
2015 & 2016 Møller electron momenta



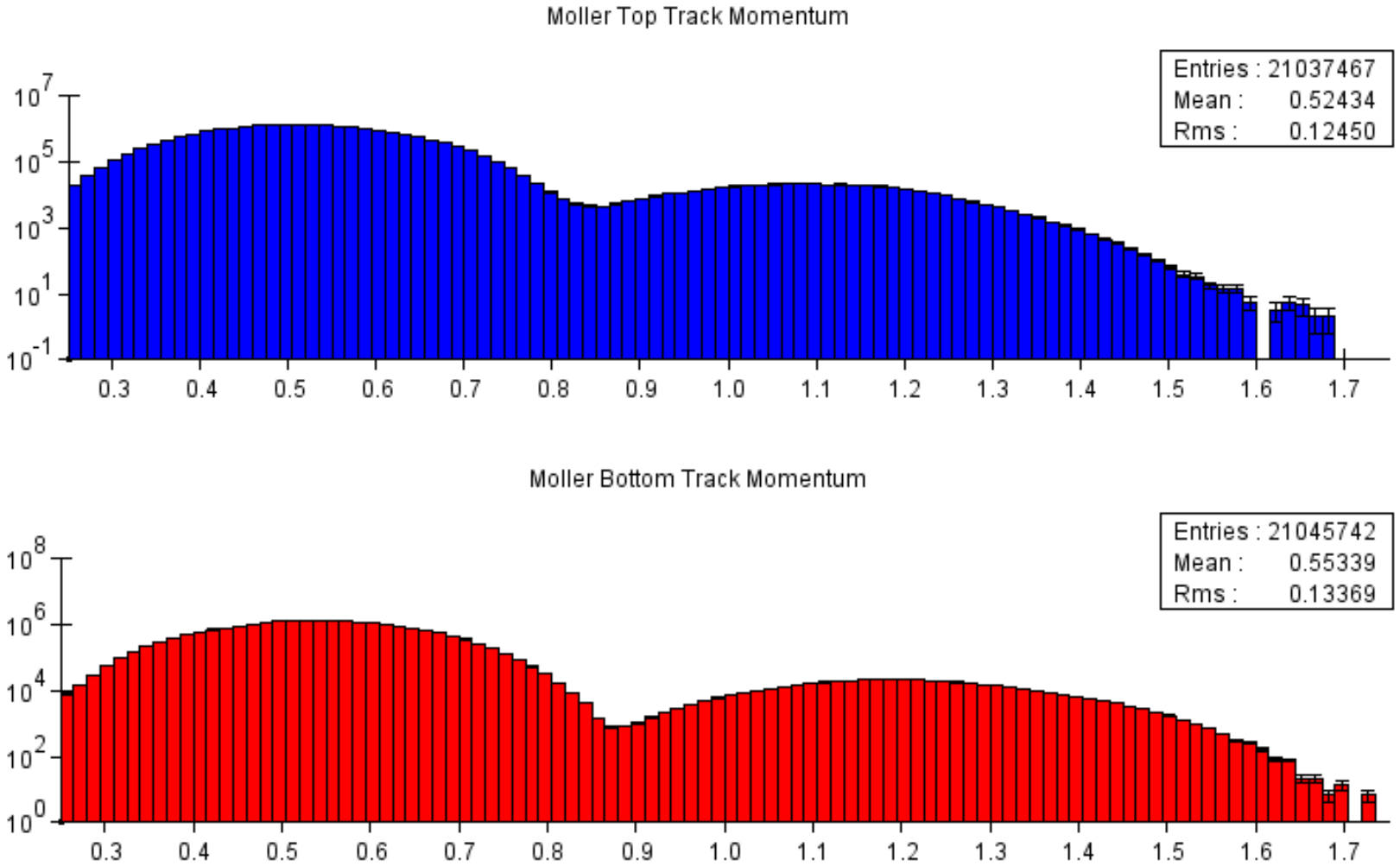
2015 & 2016 Møller electron p vs Θ



2015 & 2016 Møller electron Θ_1 vs Θ_2



2015 & 2016 Møller top/bottom track p



Summary

- Can isolate sufficient statistics of sufficiently pure elasctically scattered beam electrons and Møller pairs to establish momentum and position calibrations for the 1.056GeV and 2.3GeV Data
- 2015 Data has been pushed and prodded into submission (tweakpass6) whereas 2016 Data is pretty raw (pass0)
- Have only provide qualitative comparisons. Will re-reconstruct these events using the latest aligned geometries presented this morning.
- Should always be clear which vertex collections are being used.
  - Unconstrained is useful for vertex analysis, but has worse resolution
  - BeamspotConstrained is similar
  - Target constrained has narrower resolution, but WRONG MASS!
- There are some bugs that need to be fixed.