Updates on Tracking Reconstruction

Weizhi Xiong / Jinlong Zhang

SoLID Collaboration meeting

Oct. 9th 2020

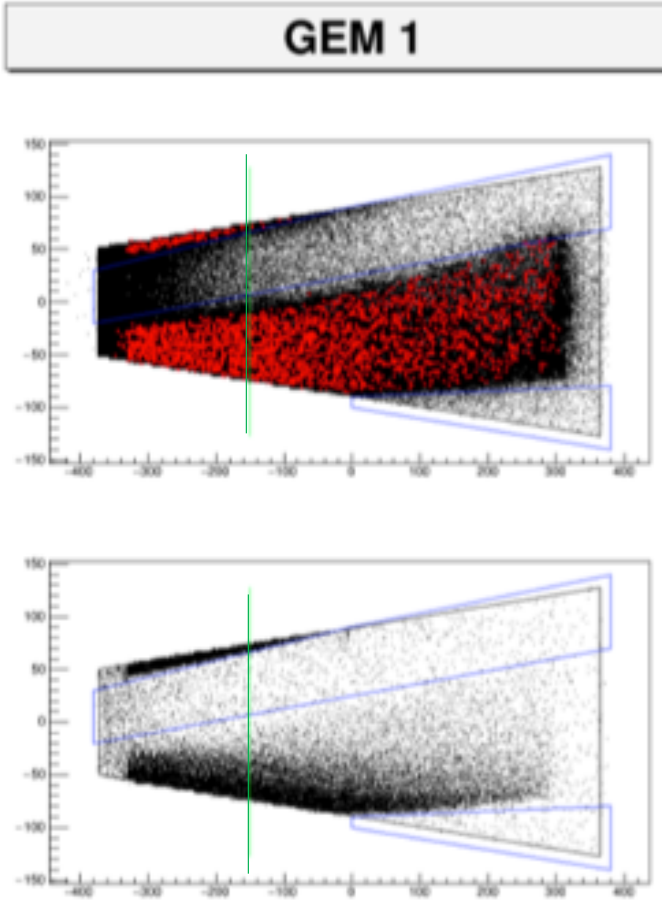
Outline

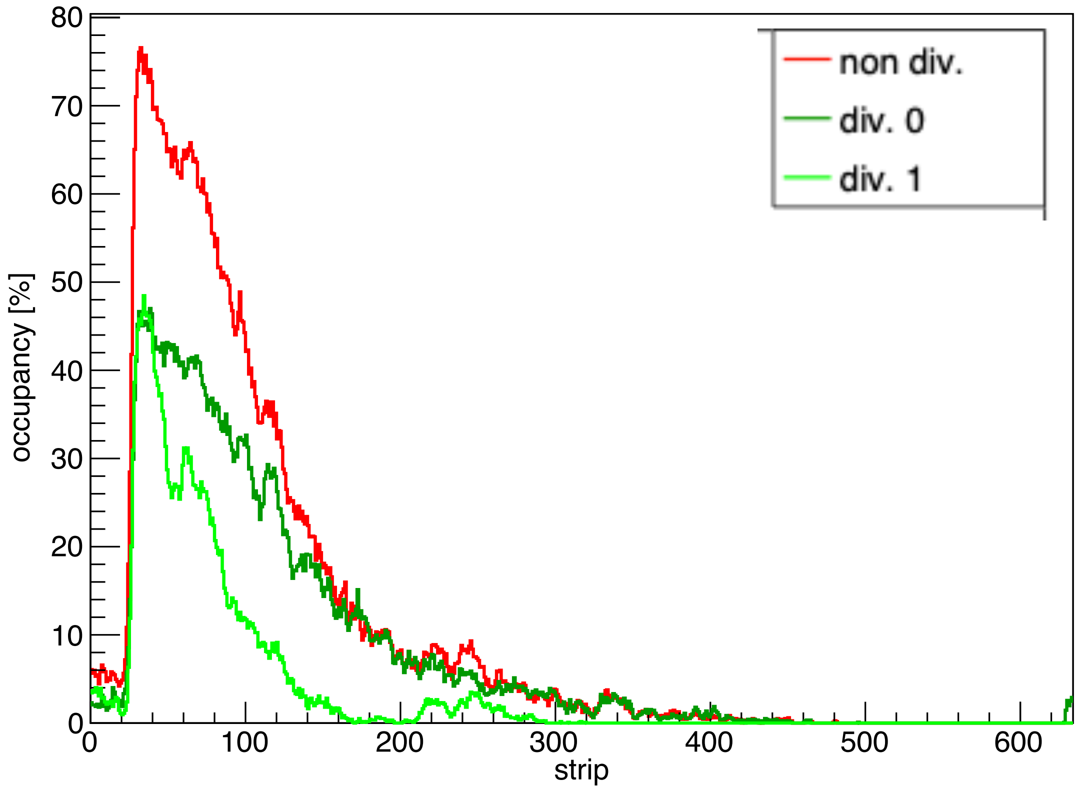
- Tracking reconstruction with segmented strips
- Shielding for PVDIS GEM
- SIDIS pion tracking

- VMM3 digitization and tracking updates from Jinlong

Tracking reconstruction with segmented strips

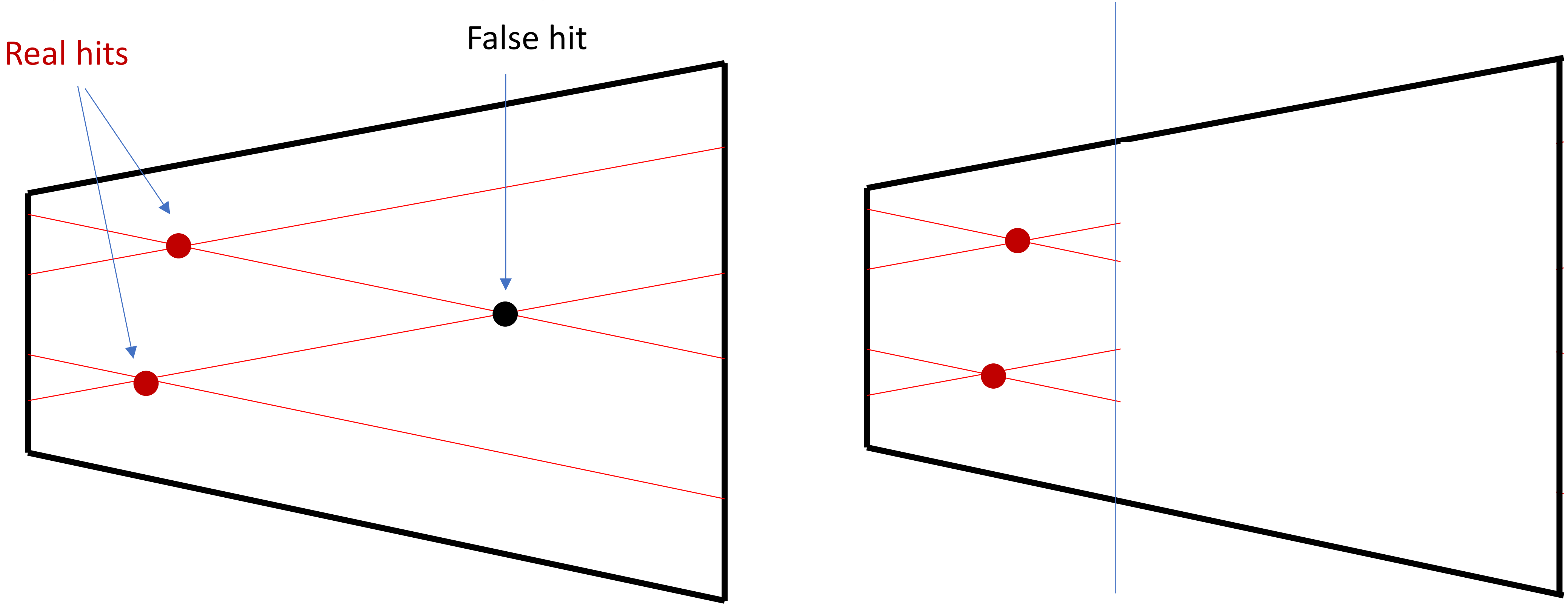
- GEM digitization with segmented strips developed by Rich years ago (https://solid.jlab.org/DocDB/0000/000055/003/gem%20digitization.pdf), but the GEM reconstruction code still only handle whole strips





GEM clustering

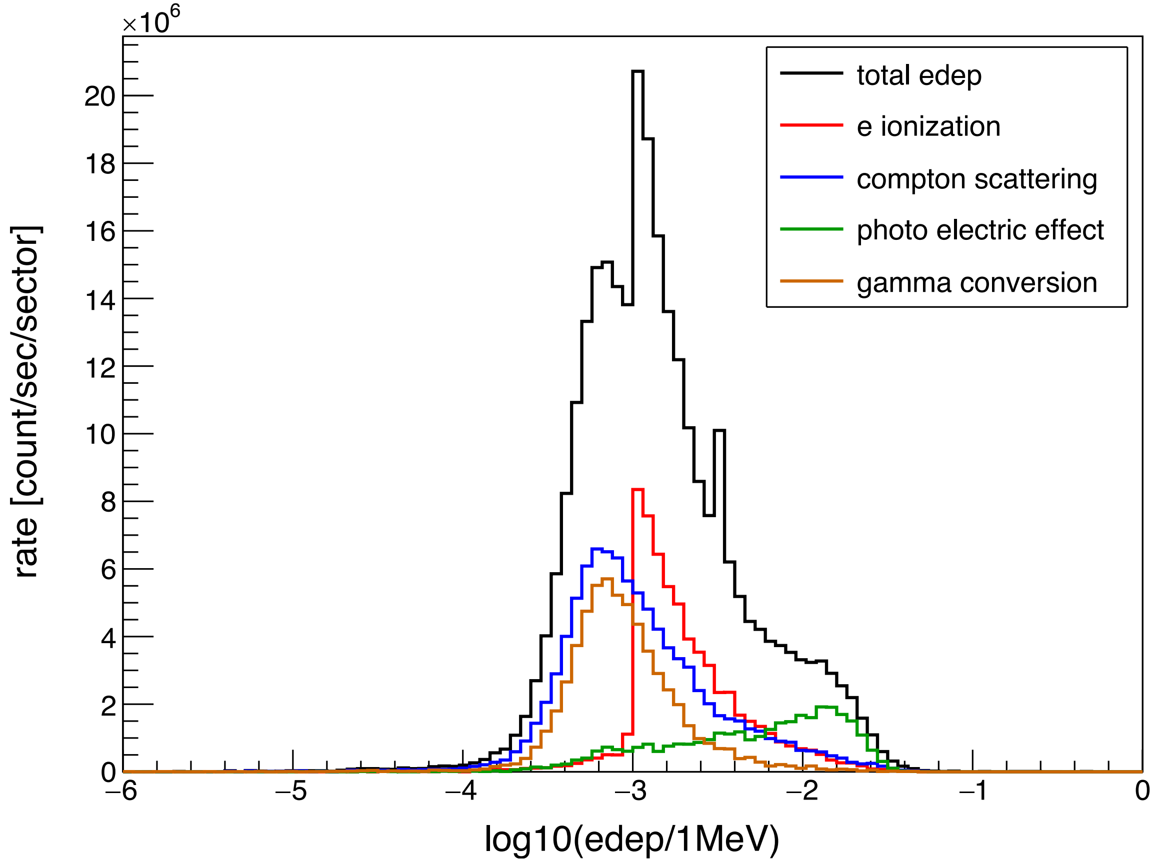
- Other than reduce pile-up and occupancy, segmented strips also helps in eliminating false hits
- The false hit on the right hand plot is eliminated because the strips have no physical intersection within the plane, and thus cannot be fired by the same particle hit

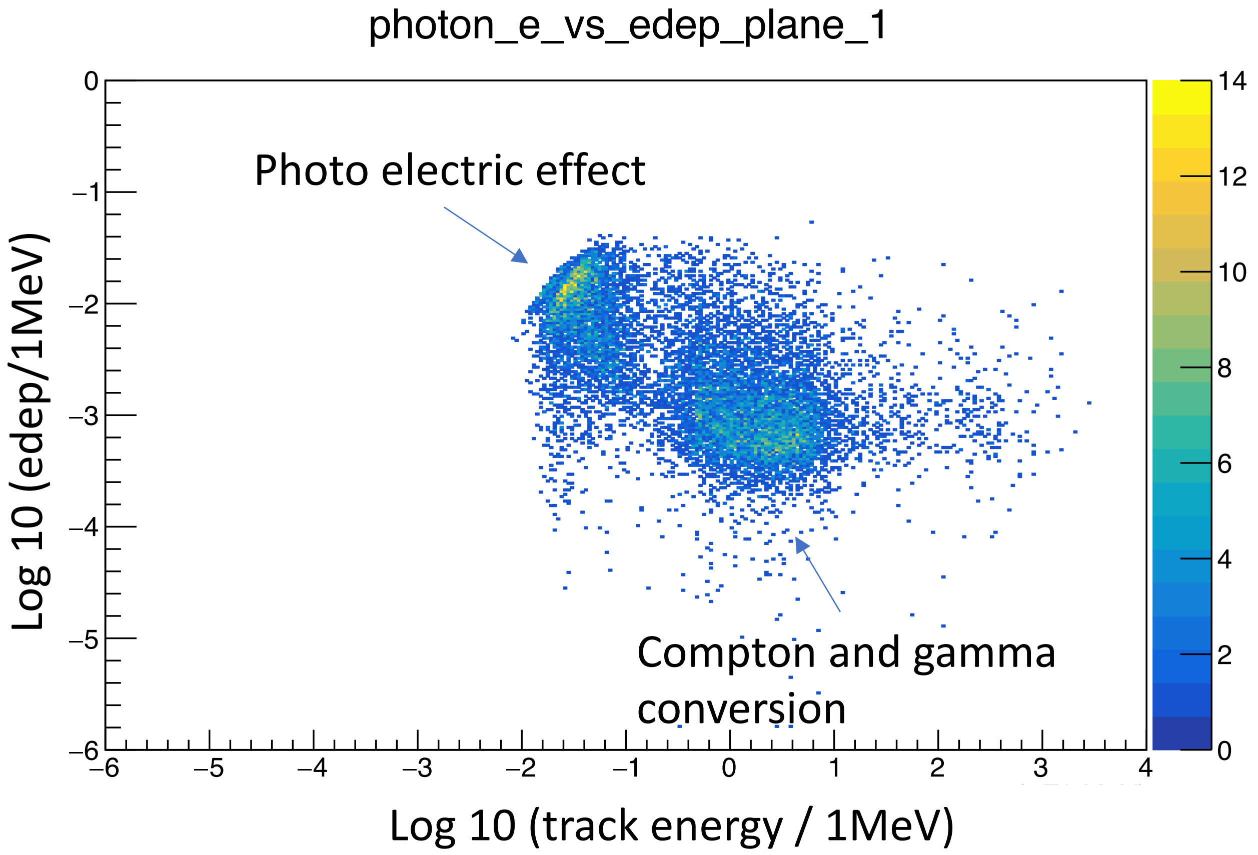


- For each pair of 1D GEM clusters, look at the strips that have the maximum ADC (for now)
- If these two strips have no physical intersection within the plane, then reject this pair

Shielding for PVDIS background

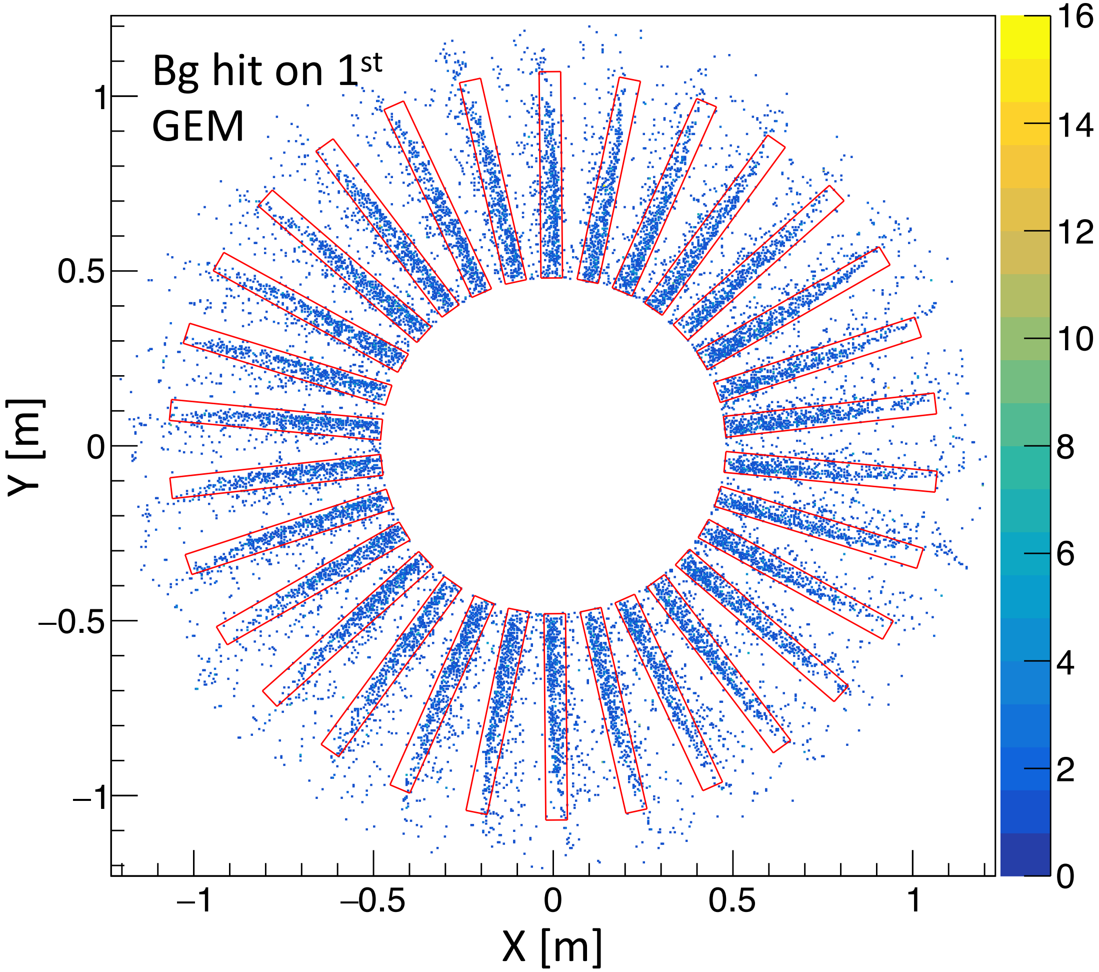
- Backgrounds in GEM mostly come from four processes: charged particle ionization in GEM gas, Compton scattering, photo electric effect and gamma conversion
- Most of the background deposit ~1keV energy, some deposit more than 10keV and they often come from photo electric effect

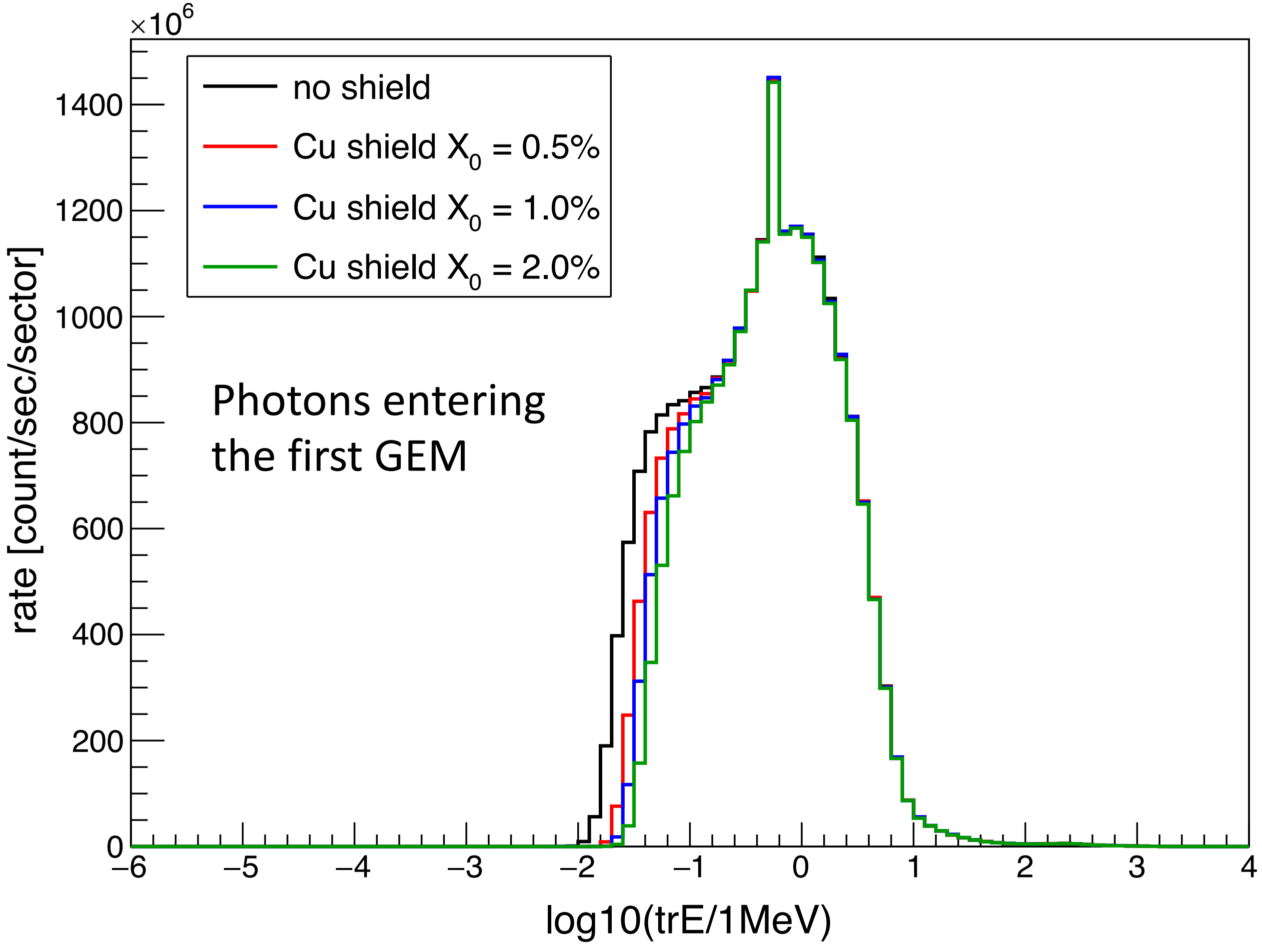




Shielding for PVDIS background

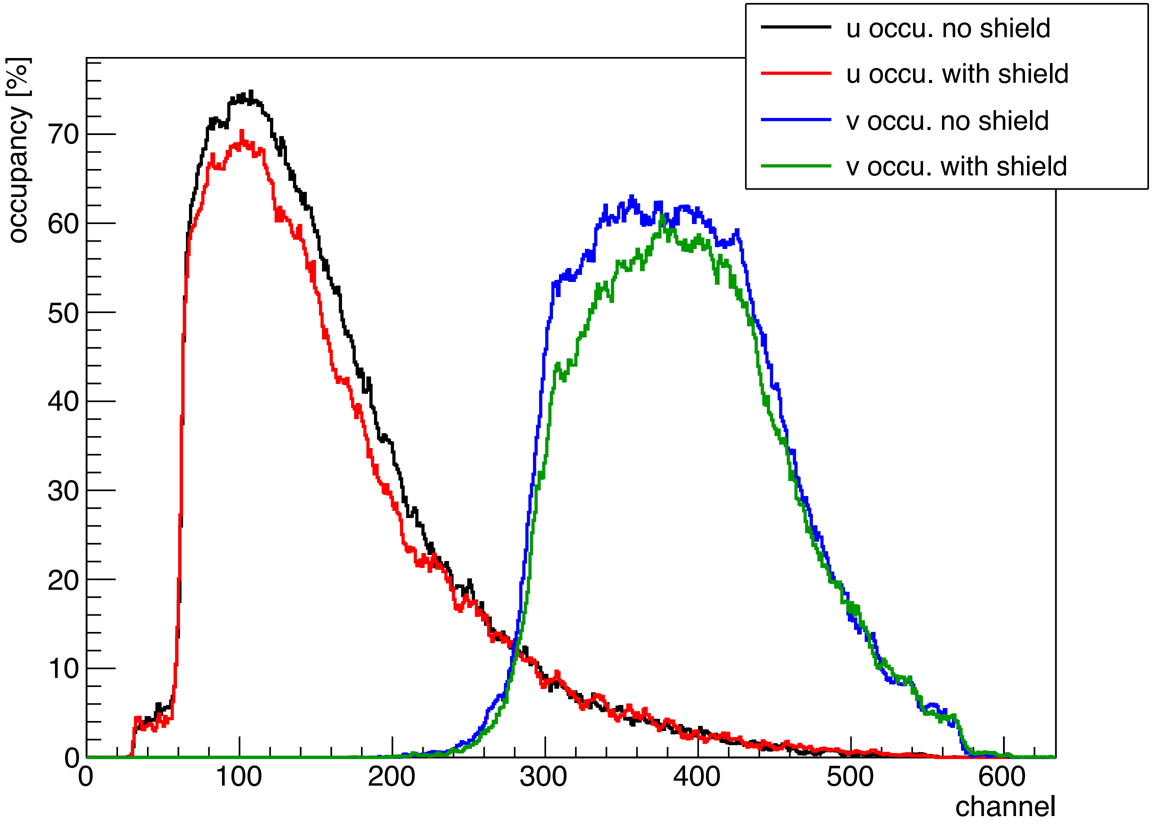
- Putting thin copper shield (~ 1% rad length, shown in red boxes) immediately in front of the hot background region
- Quite effective in blocking 10 to 100 keV photons going into the chamber

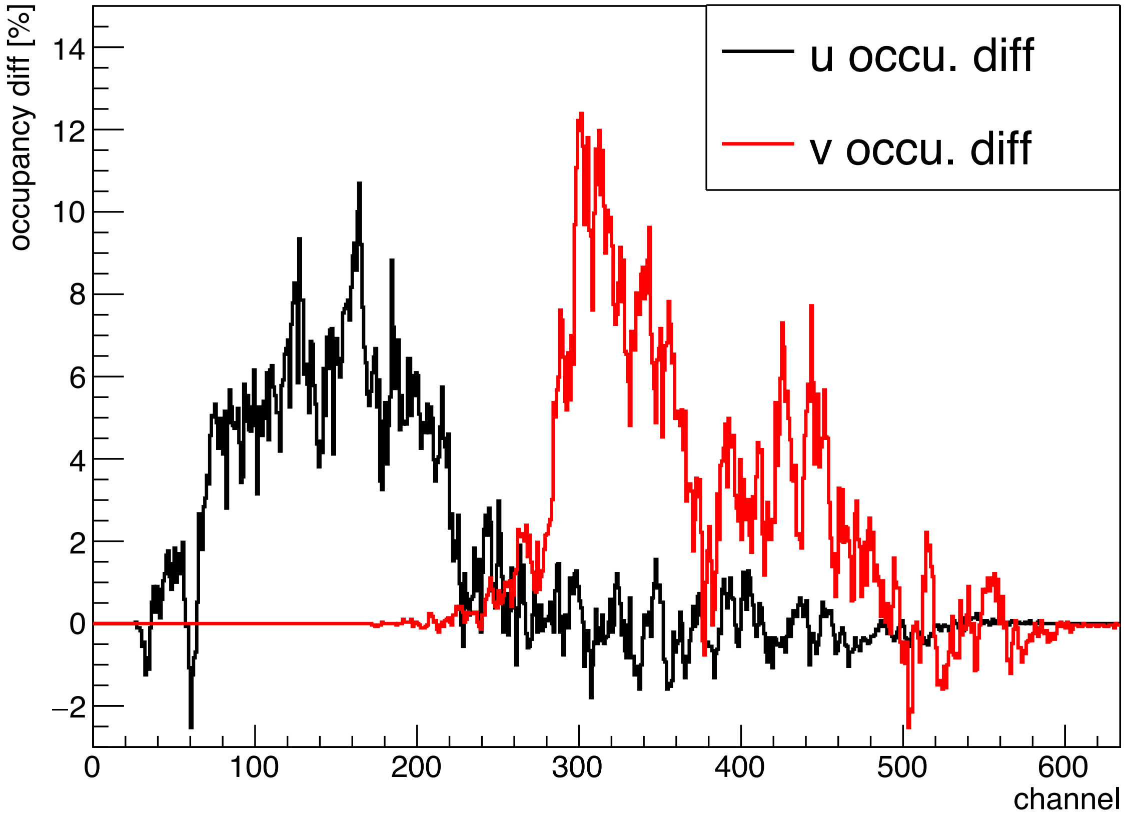




Shielding for PVDIS background

- ~5% reducing on the GEM raw occupancy in the hot background region, for the first PVDIS GEM
- For background due to photo electric effects, the shield actually cut them by a factor of 2



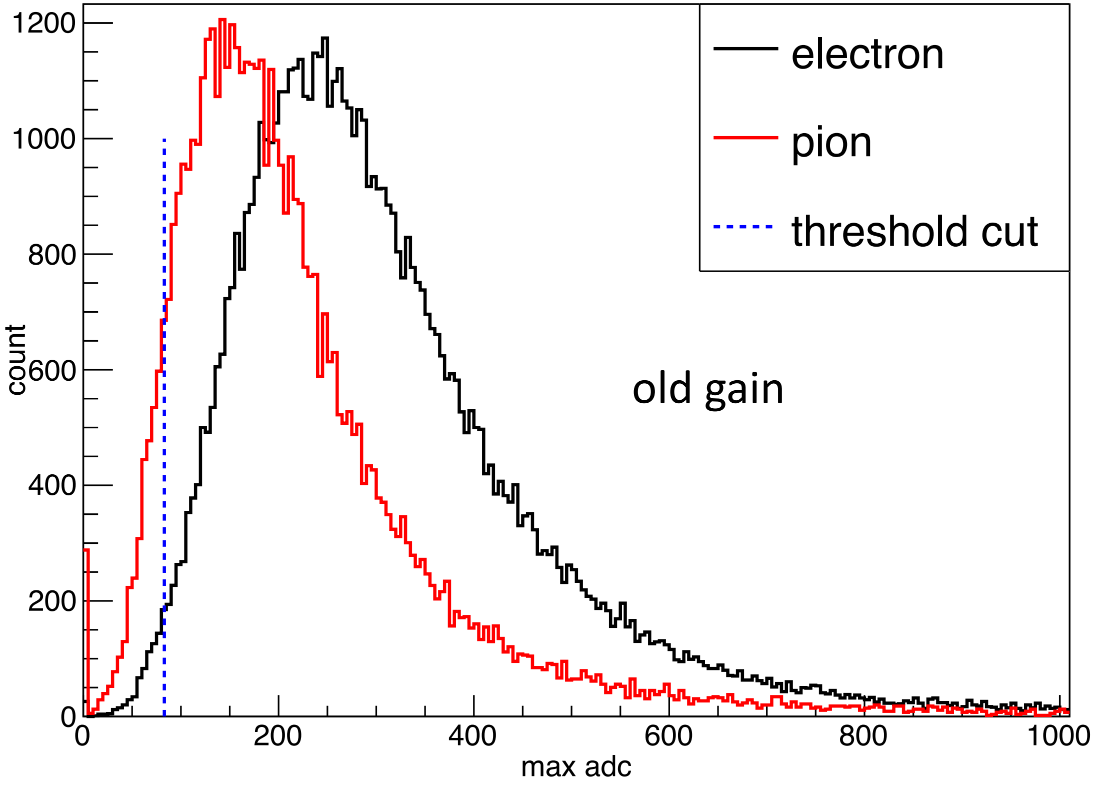


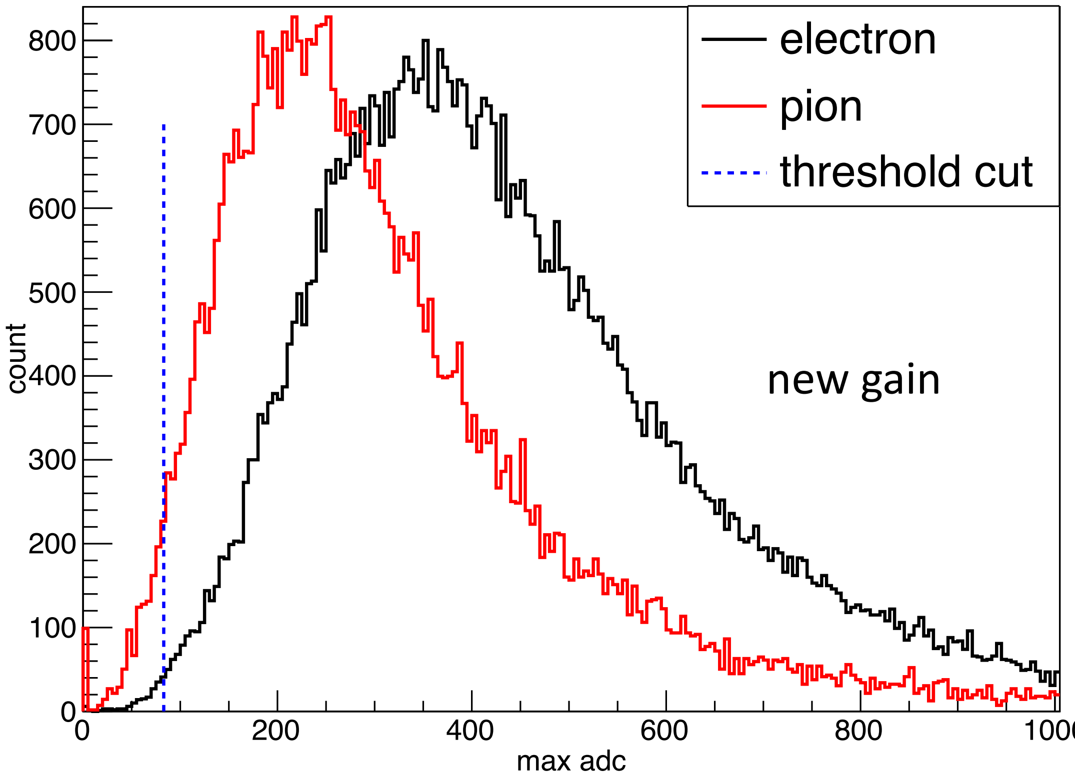
New changes for pion tracking

- Starting from SPD instead of FAEC (assume MRPC not available)
  - 60 phi segments, each phi segment has 4 types of SPD detectors with different sizes (10cm, 20cm, 30cm and 45cm in radial direction)
  - No position reconstruction, so when we project the track on SPD, we have to cut at least the size of the detector (Going to look for EC MIP signal see if better constraint is possible)
  - No energy information
  - Pion track can be very low energy such as 600 MeV
- Pion signal in GEM is about 200eV smaller than electron's, which peak at 600eV. Need to increase the gain of the chamber in order to ensure reasonable pion detection efficiency
- Pion and punch through the shielding, need to apply some cut to remove these events

Signal amplitude pion vs electron

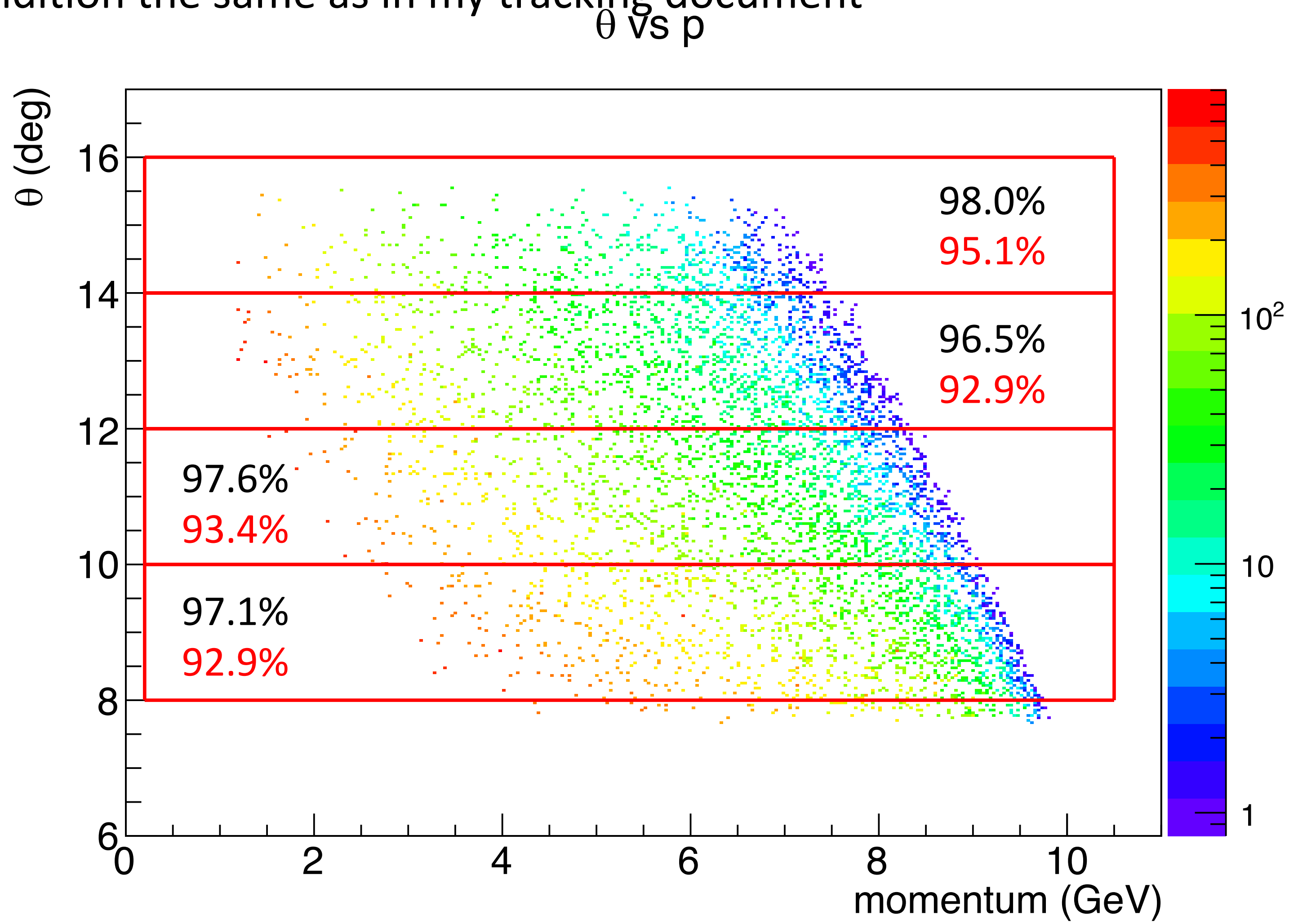
- Distributions for the maximum ADC of a cluster
- Pion signal significantly smaller than electron's, 10 to 20% efficiency loss due to threshold hold cut
- Need to increase the gain by 50% in order to reach reasonable detection efficiency





Effect of increasing gain on electron tracking

- Stat uncertainty of single track efficiency and accuracy about 1.5% level
- Increasing the chamber gain actually increases the overall performance slightly
- 100% bg, all condition the same as in my tracking document

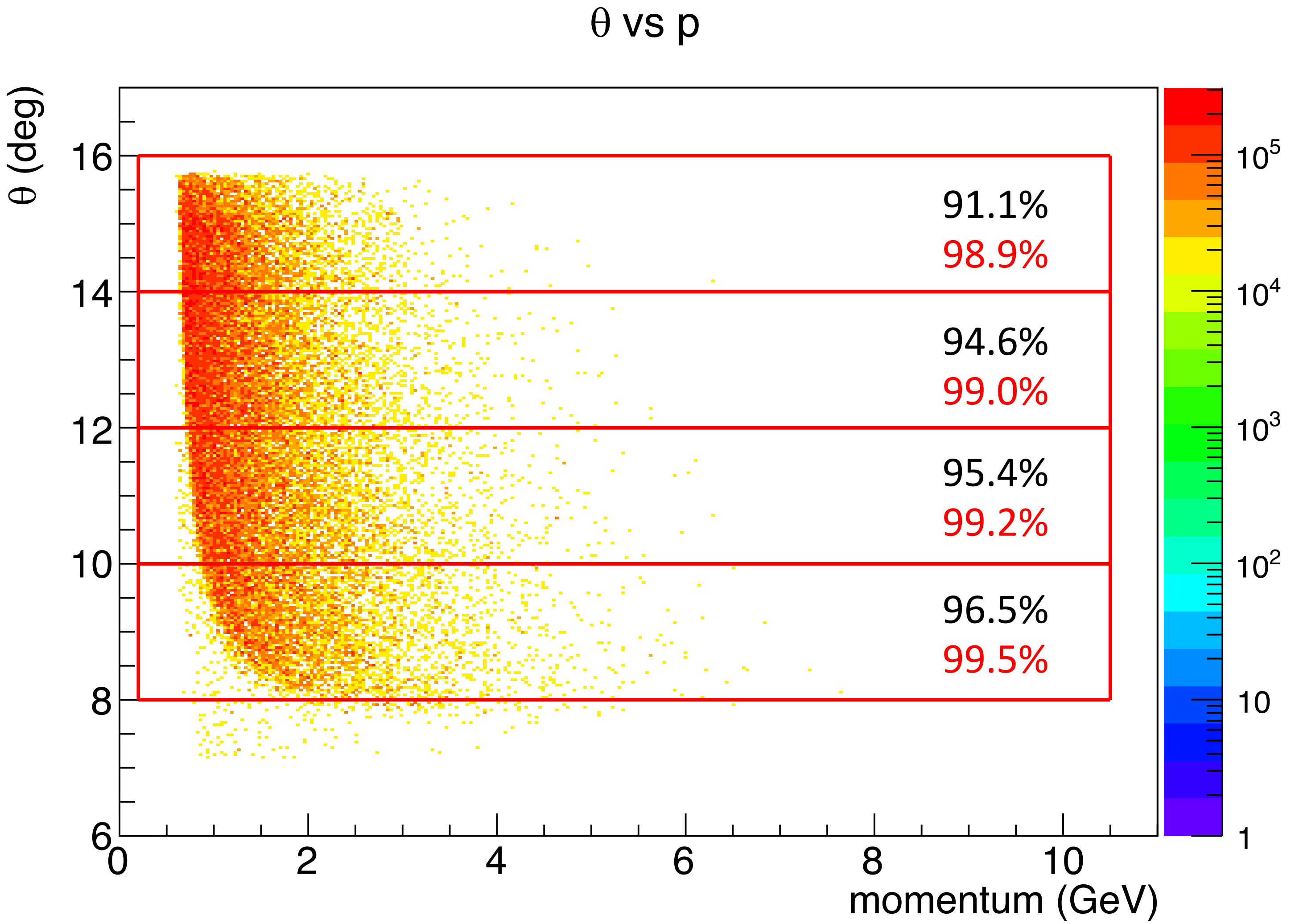


Black number is single track efficiency

Red number is single track accuracy

Pion tracking results (0% bg)

- This is with 0% bg, just to show that the code is working, stat uncertainty is about 0.1% to 0.2%

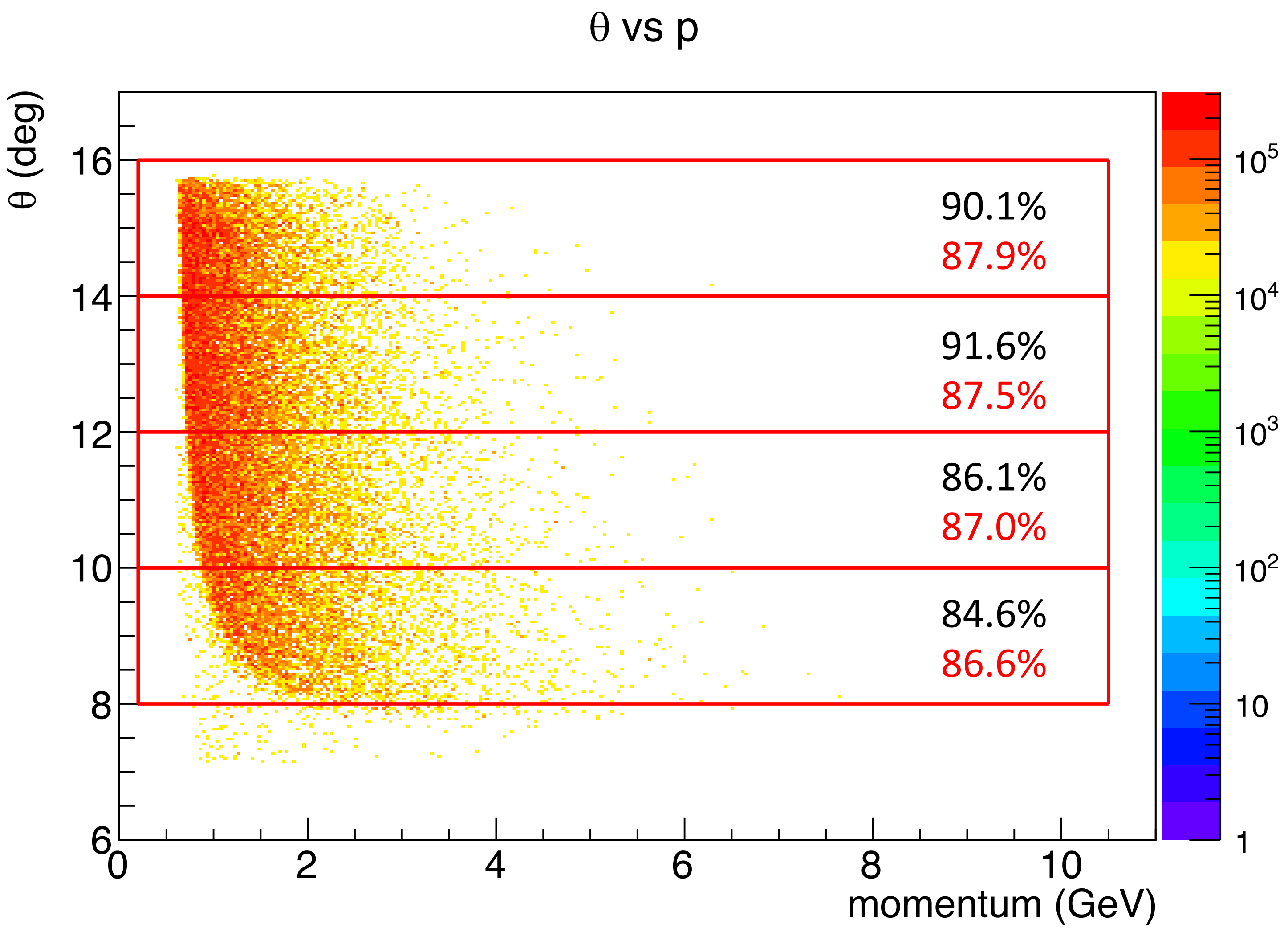


Black number is single track efficiency

Red number is single track accuracy

Pion tracking results (100% bg)

- Results with 100% bg, stat uncertainty around 1% per bin

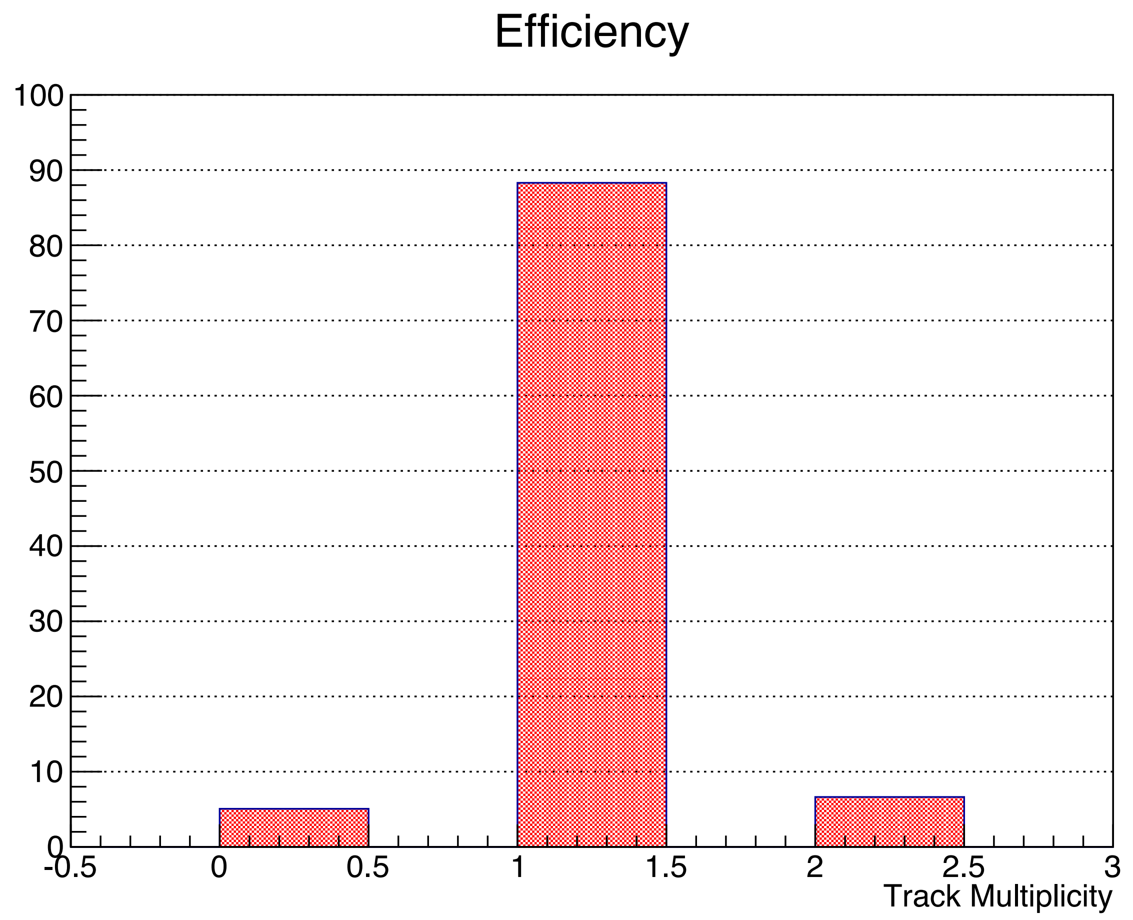


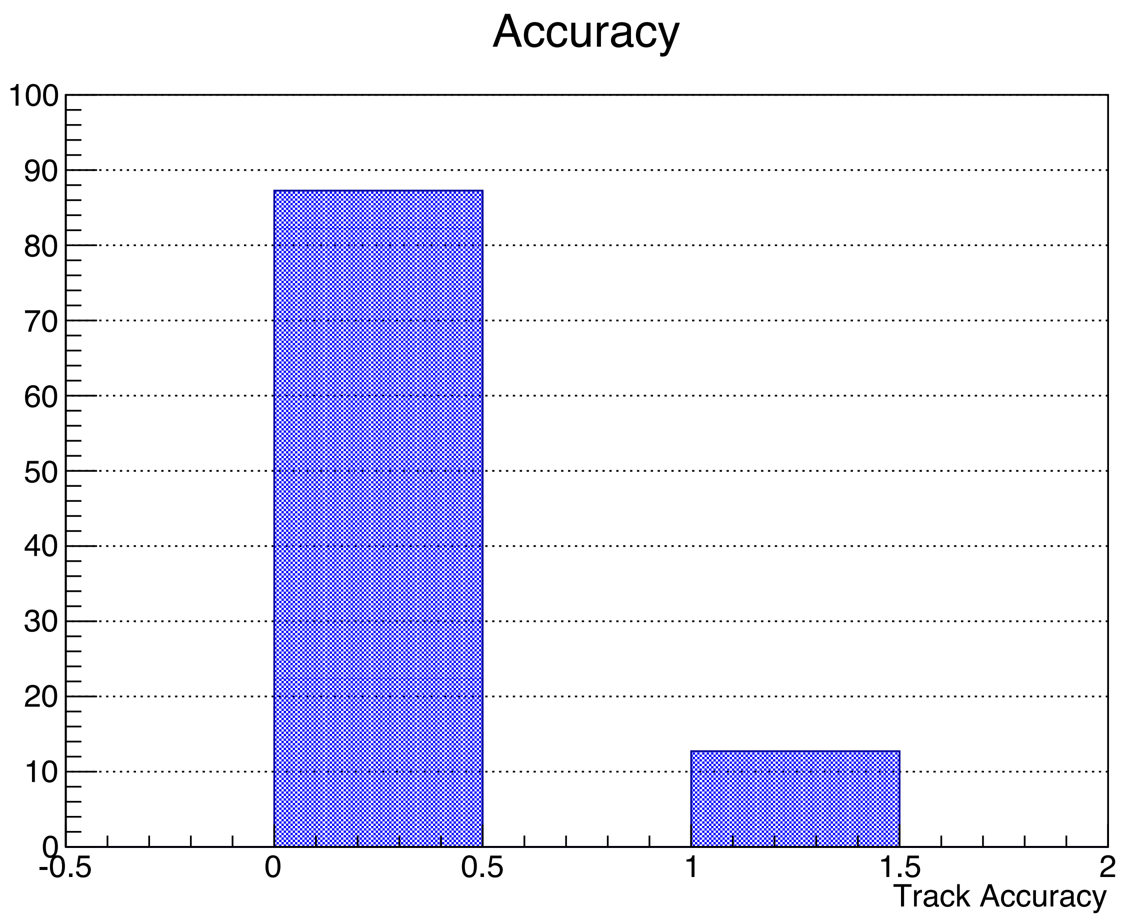
Black number is single track efficiency

Red number is single track accuracy

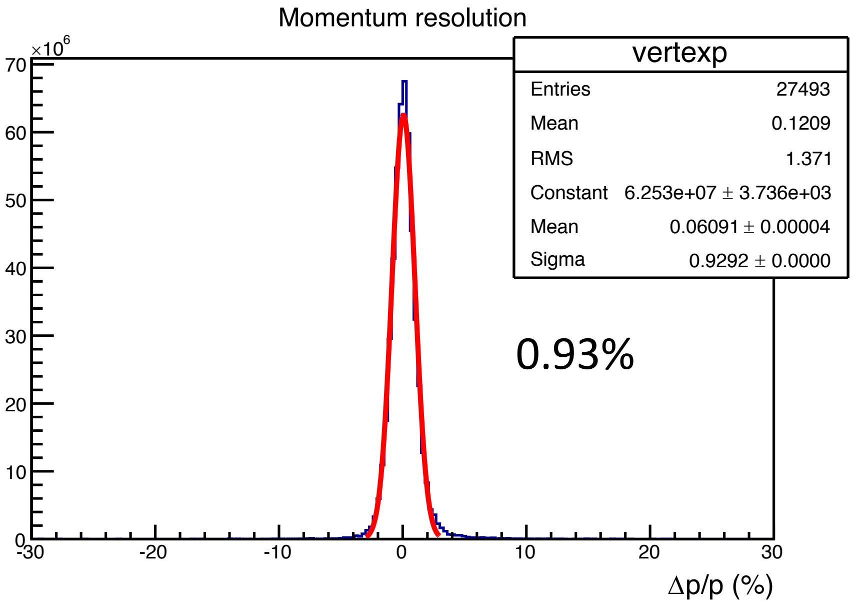
Pion tracking efficiency

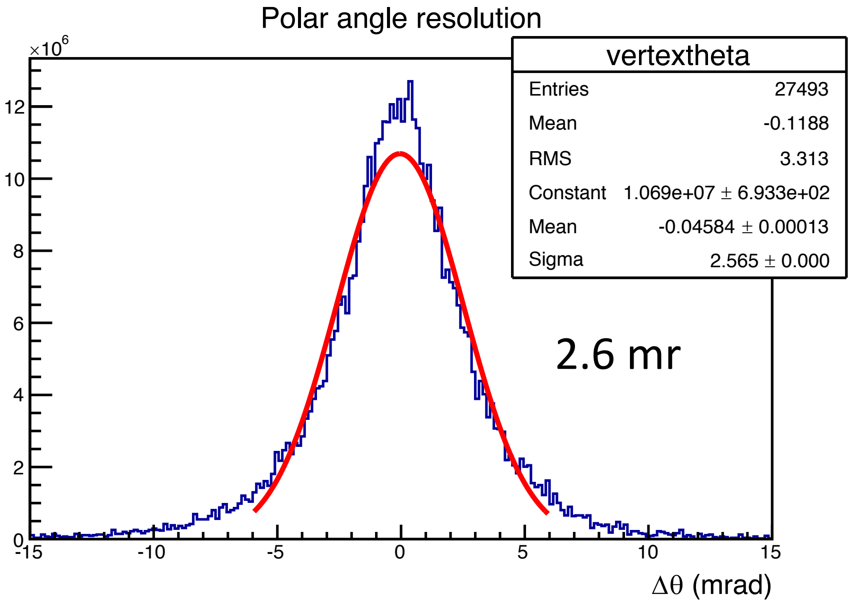
- Average efficiency and accuracy for pion tracks in the FA region
- About 88.3% single track efficiency, 87.3% single track accuracy

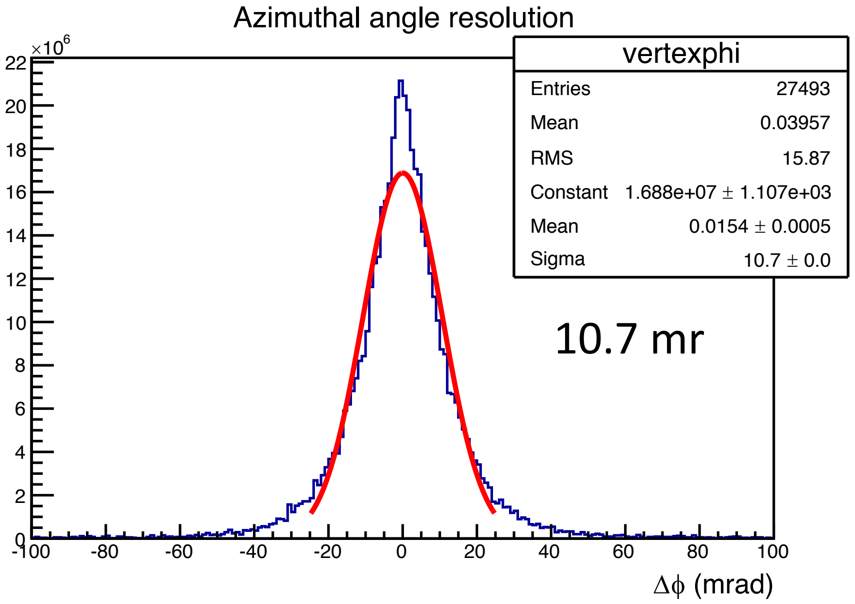


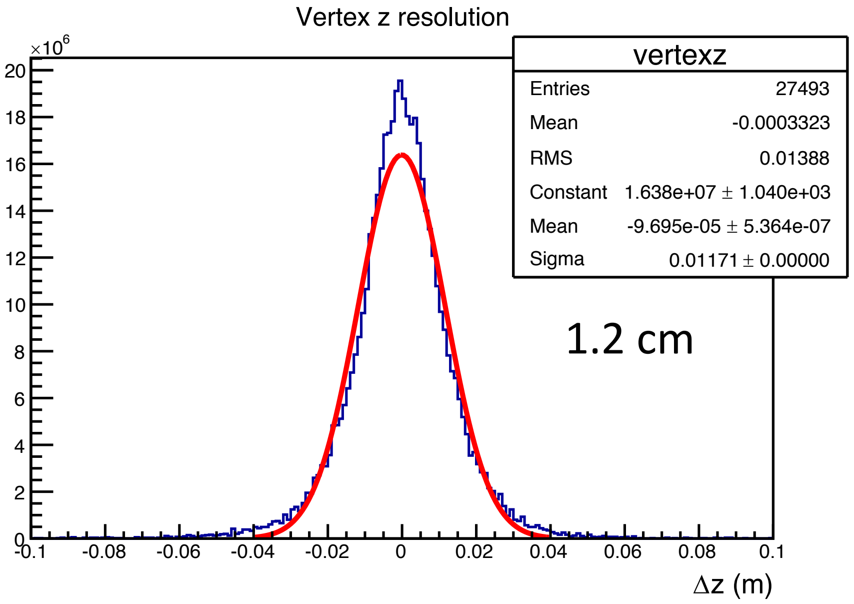


Pion track resolution (0% bg)

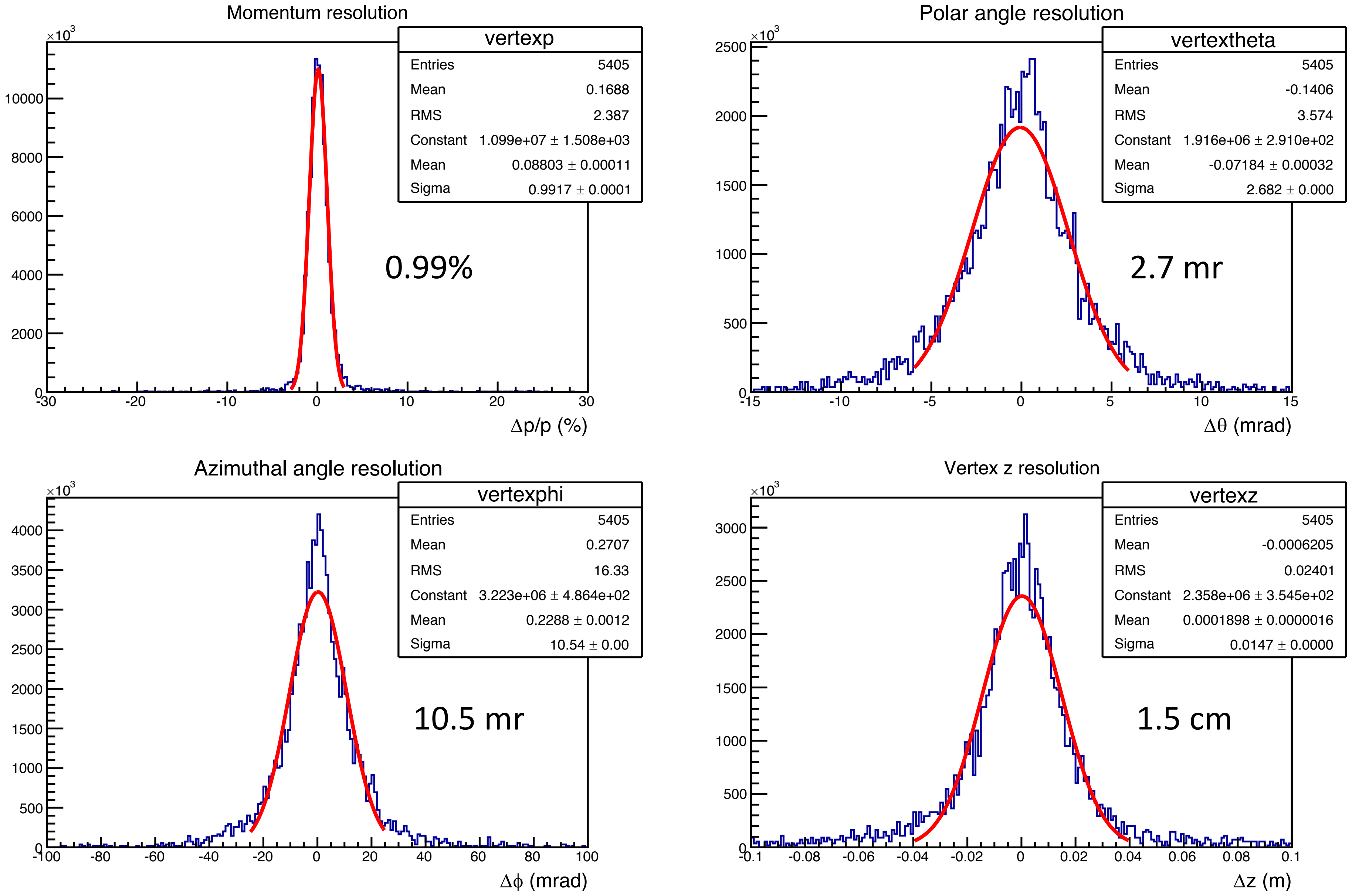








Pion track resolution (100% bg)

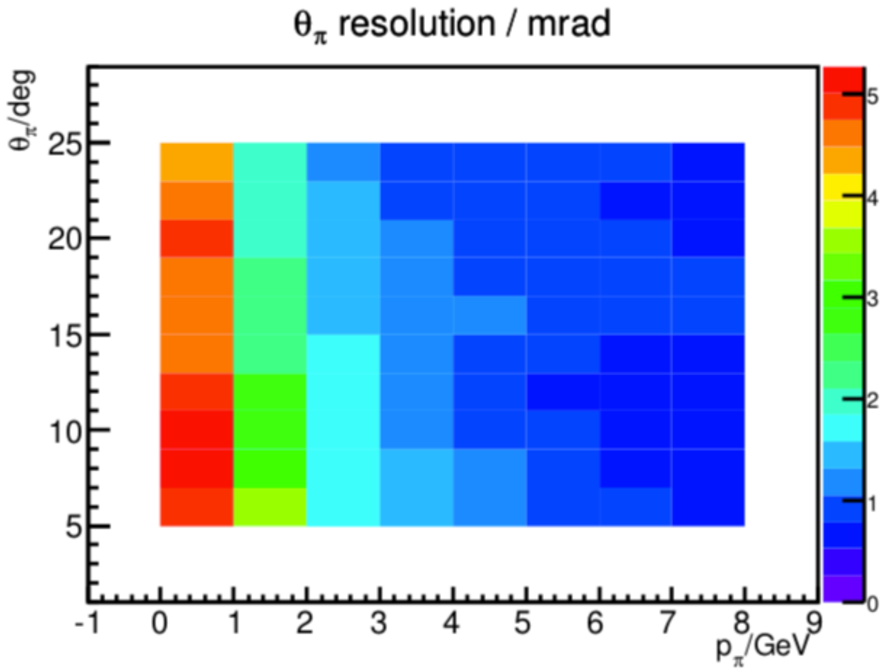


Pion resolution

- Averaged only the entire FA region, scattering angles from 8 to 16 deg

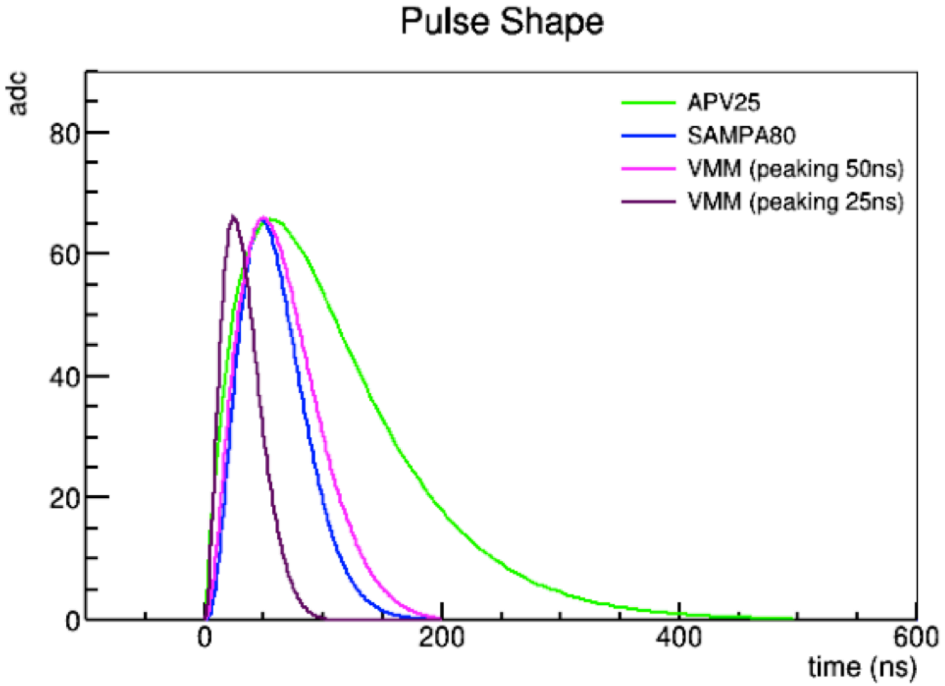
	< 1 GeV	1 ~ 2 GeV	> 2 GeV
Momentum reso [%]	0.85	0.93	1.03
Theta angle reso [mr]	4.0	2.6	1.5
Azimuthal angle reso [mr]	14.2	11	7.0
Vertex z reso [cm]	1.5	1.2	0.8

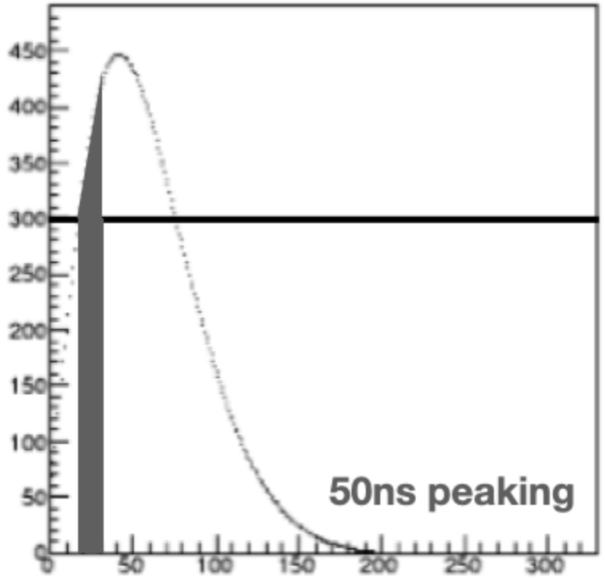
- Agree reasonably well with the pion resolution results shown in the pCDR



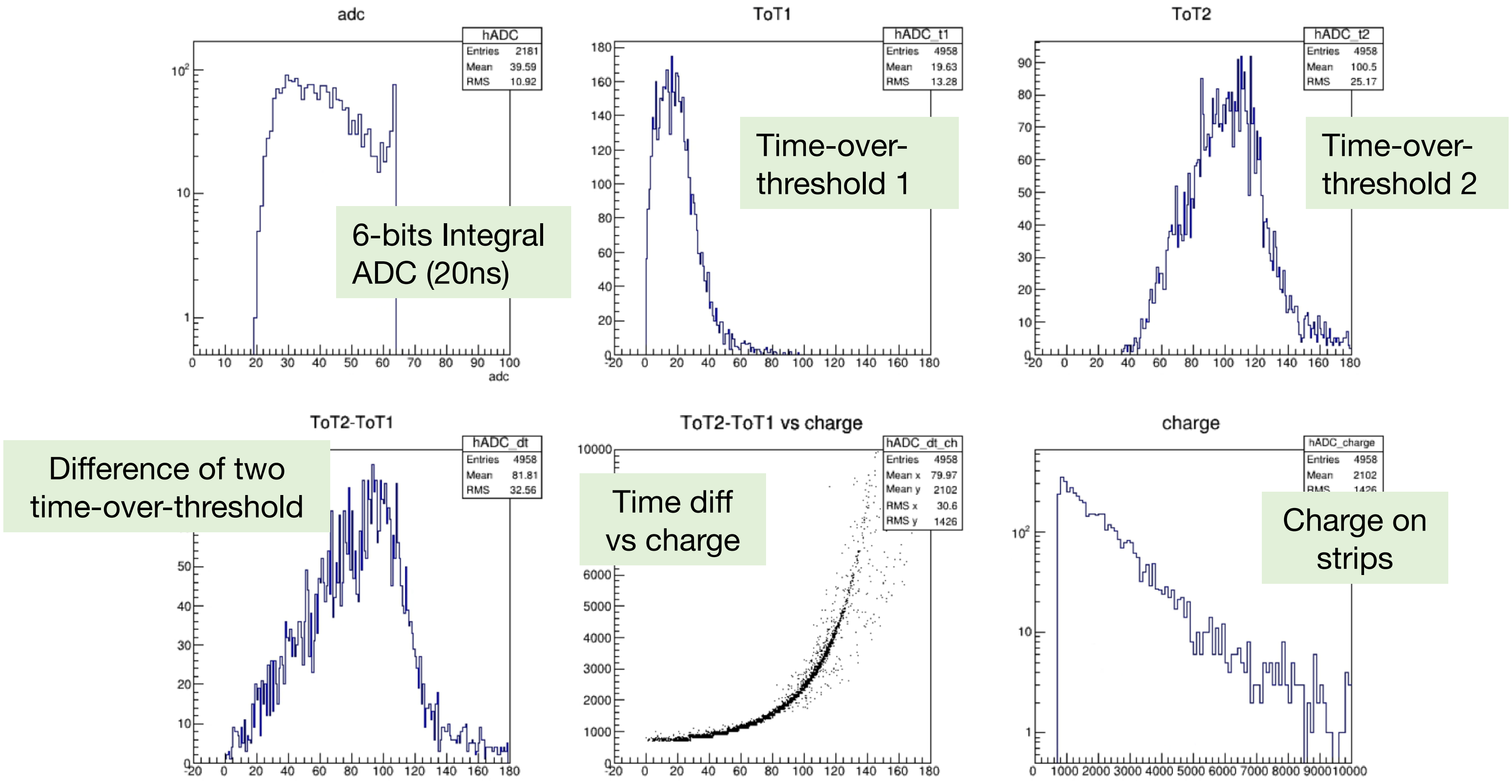
VMM3

- Multi-channel digital output;
- “analyzes” pulse on the fly: 1) seeking peak; 2) recording time over threshold; or 3) integrating in a time window (20ns).
- Low resolution (peak or integration) ADC: 6-bits
- Peaking time **25ns, 50ns**, 100ns, 200ns





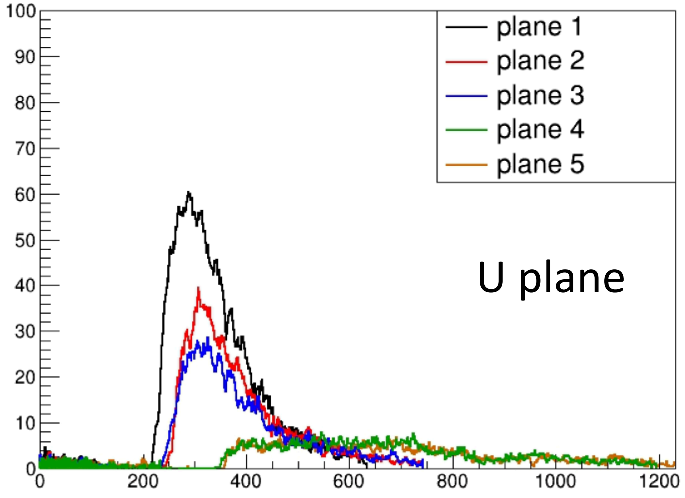
VMM3 Output

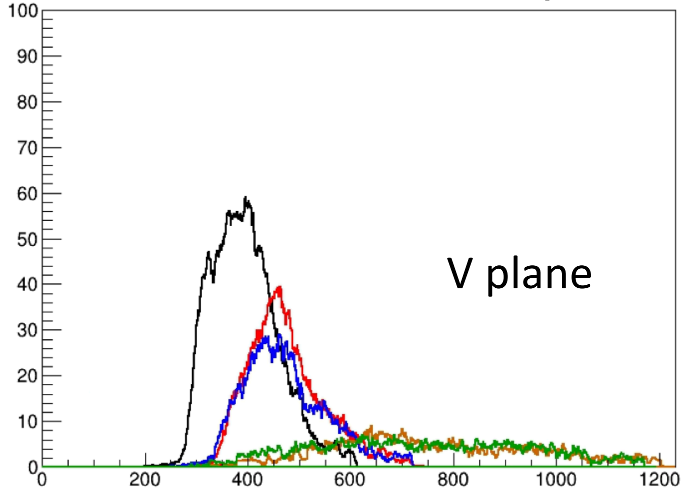


PVDIS with 50 ns peaking time; similar for SIDIS and J/Psi

Occupancy

PVDIS with 25ns peaking time





25ns peaking time

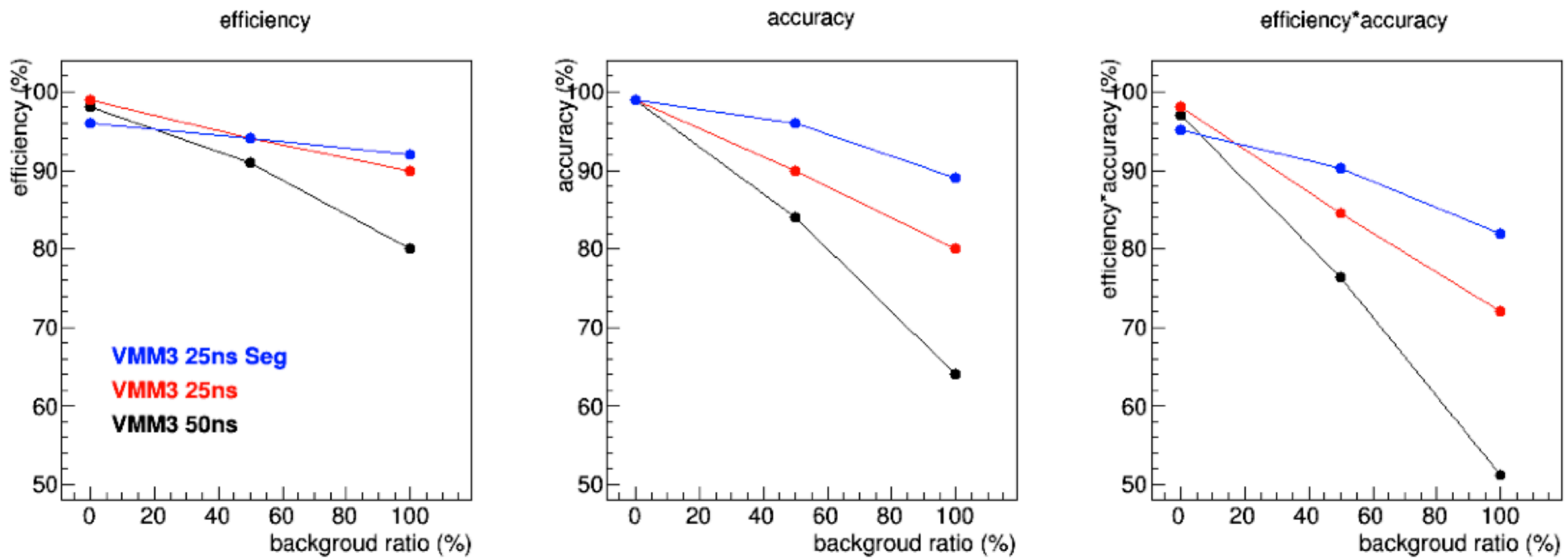
plane index	1	2	3	4	5	6	
PVDIS	11.31	6.06	5.24	2.11	1.92	-	
SIDIS	2.64	7.51	3.60	2.22	2.34	1.80	
J/Psi	6.03	9.84	6.57	5.22	5.61	4.67	%

Tracking performance: Efficiency(accuracy)

Peaking time	50 ns		25 ns		APV25
Background ratio	0%	100%	0%	100%	100%
PVDIS	98.6 (98.9)	77.9 (64.0)	97.9 (99.3)	91.6 (77.8)	85 (82)
SIDIS Large Angle	97.0 (99.3)	87.5 (92.1)	99.6 (99.4)	93.7 (94.8)	92 (96)
SIDIS Forward Angle	99.4 (98.9)	92.0 (88.7)	99.4 (99.3)	97.1 (96.4)	96 (93)
J/Psi Large Angle	--		96.5 (98.7)	88.9 (86.9)	86 (85)
J/Psi Forward Angle			98.4 (98.9)	90.7 (86.0)	89 (81)

%

Strip segmentation



~10% improvement of efficiency x accuracy with strip segmentation.

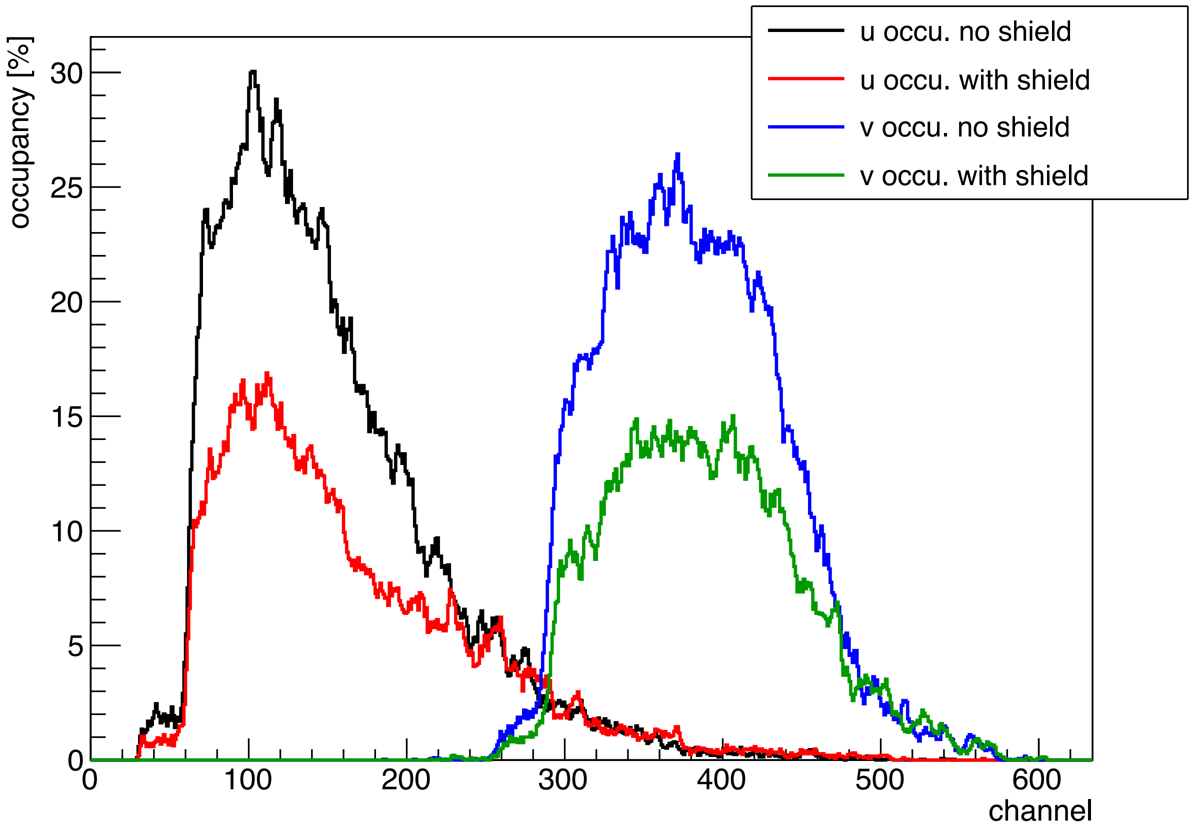
Summary

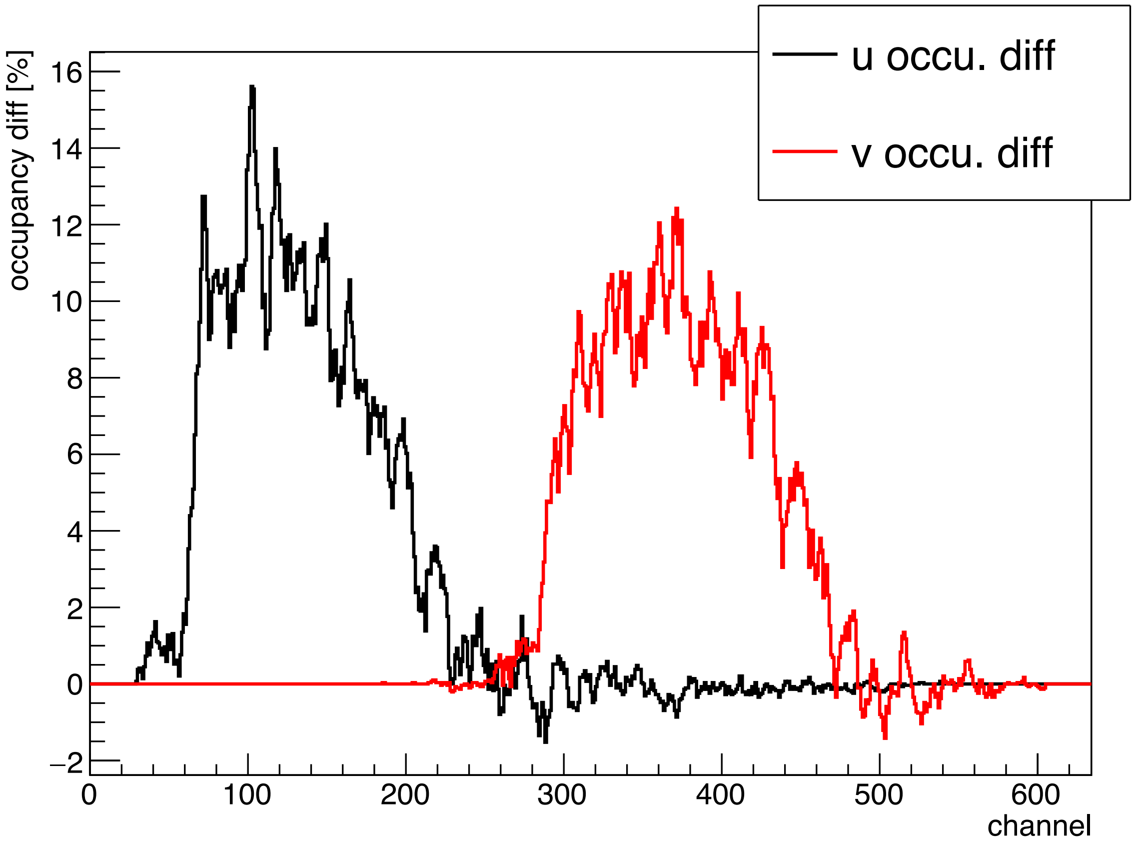
- Tracking reconstruction available for segmented strips
- Small improvement on occupancy by shielding the hot background region with ~1% rad length copper
- Preliminary results for pion tracking obtained
  - Will look at MIP signal on EC for possible better special constraint
  - Will need to combine with electron tracking to do multi-track finding

- VMM3 digitization developed and tested, performance for tracking reconstruction slightly better than APV 25

Backup slides

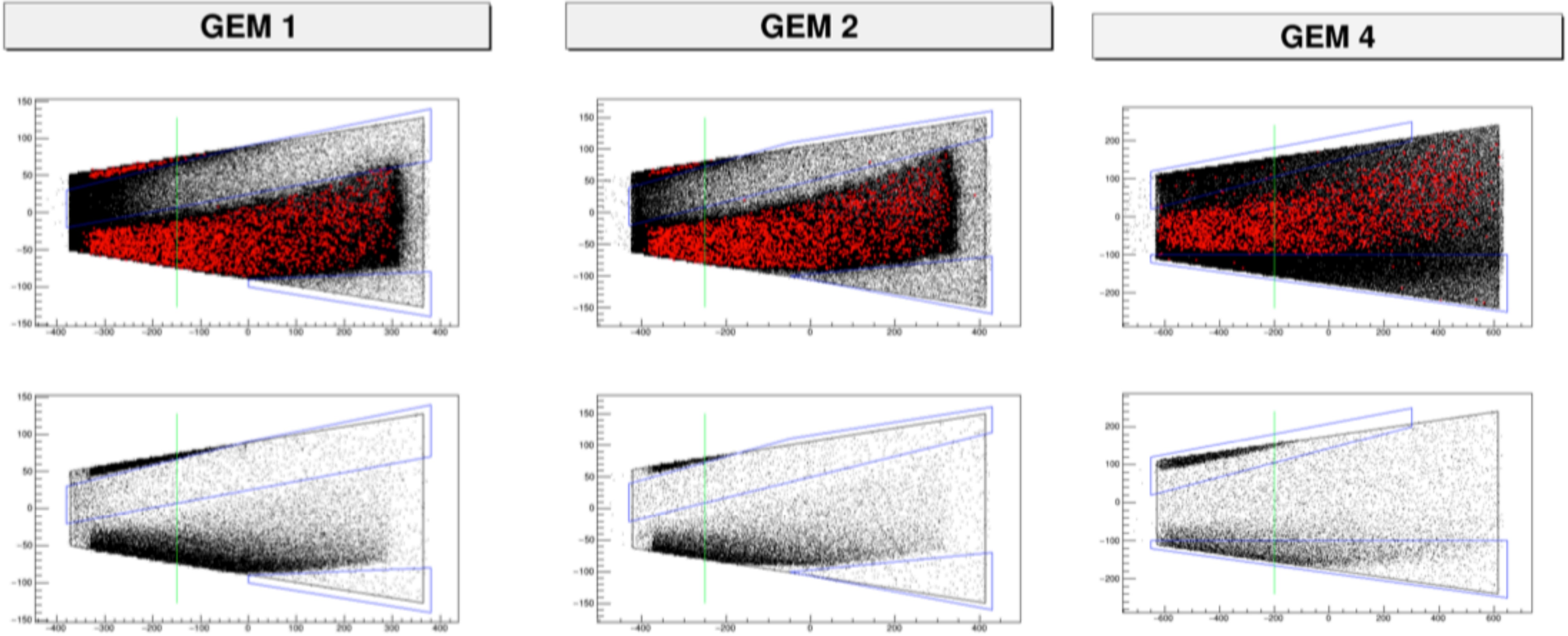
Shielding for PVDIS background



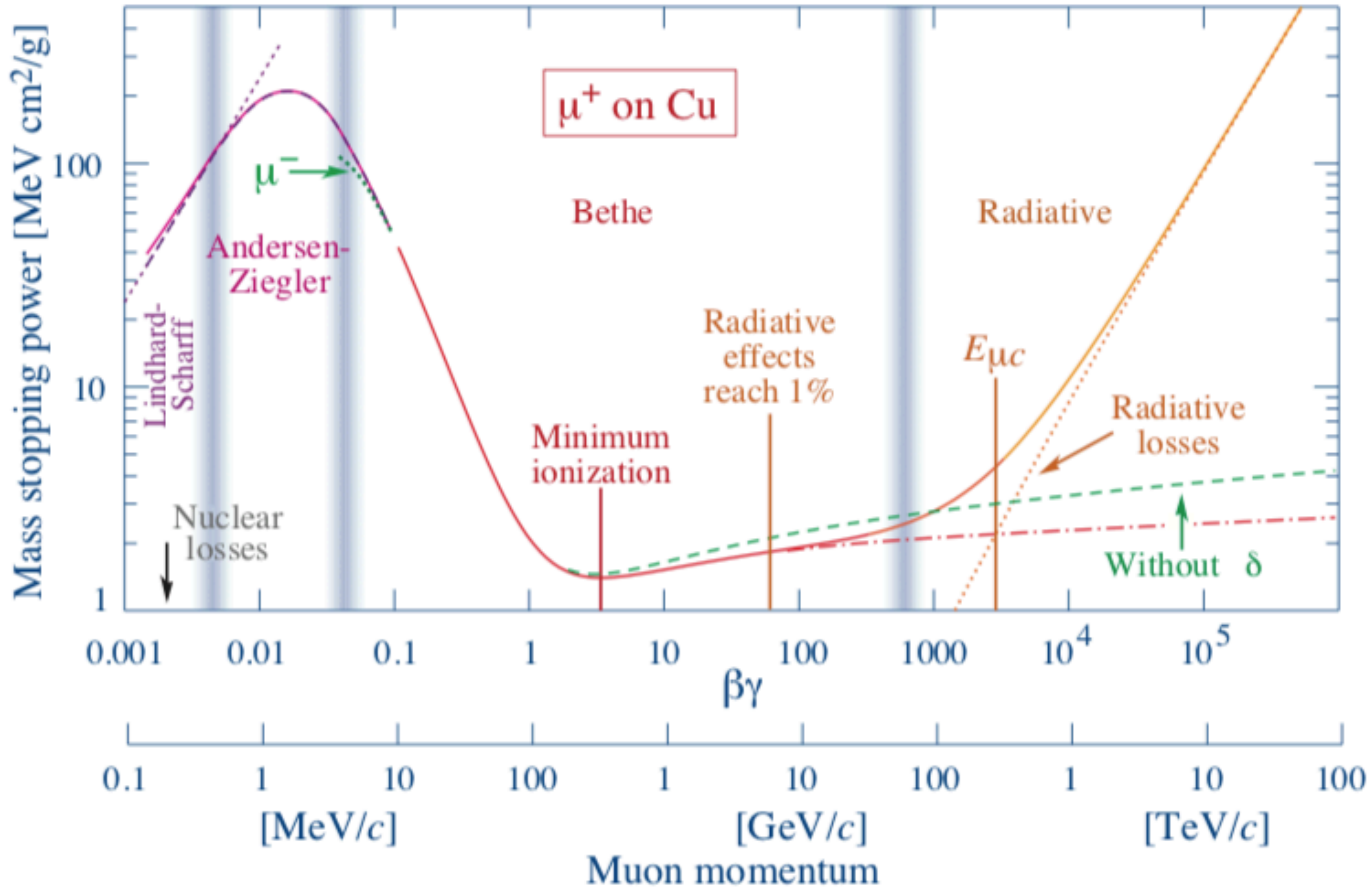


Azimuthal angle offset of PVDIS GEMs

- (https://solid.jlab.org/DocDB/0000/000055/003/gem%20digitization.pdf)



With Rich's offset



μ⁺ on Cu
Mass stopping power [MeV cm²/g]
100
10
1
μ⁻
Bethe
Radiative
Andersen-
Ziegler
Lindhard-
Scharff
Radiative
effects
reach 1%
Eμc
Radiative
losses
Minimum
ionization
Nuclear
losses
Without δ
0.001
0.01
0.1
1
10
100
1000
10^4
10^5
βγ
0.1
1
10
100
1
10
100
1
10
100
[MeV/c]
[GeV/c]
[TeV/c]
Muon momentum