FDIRC Simulations and Measurements Update

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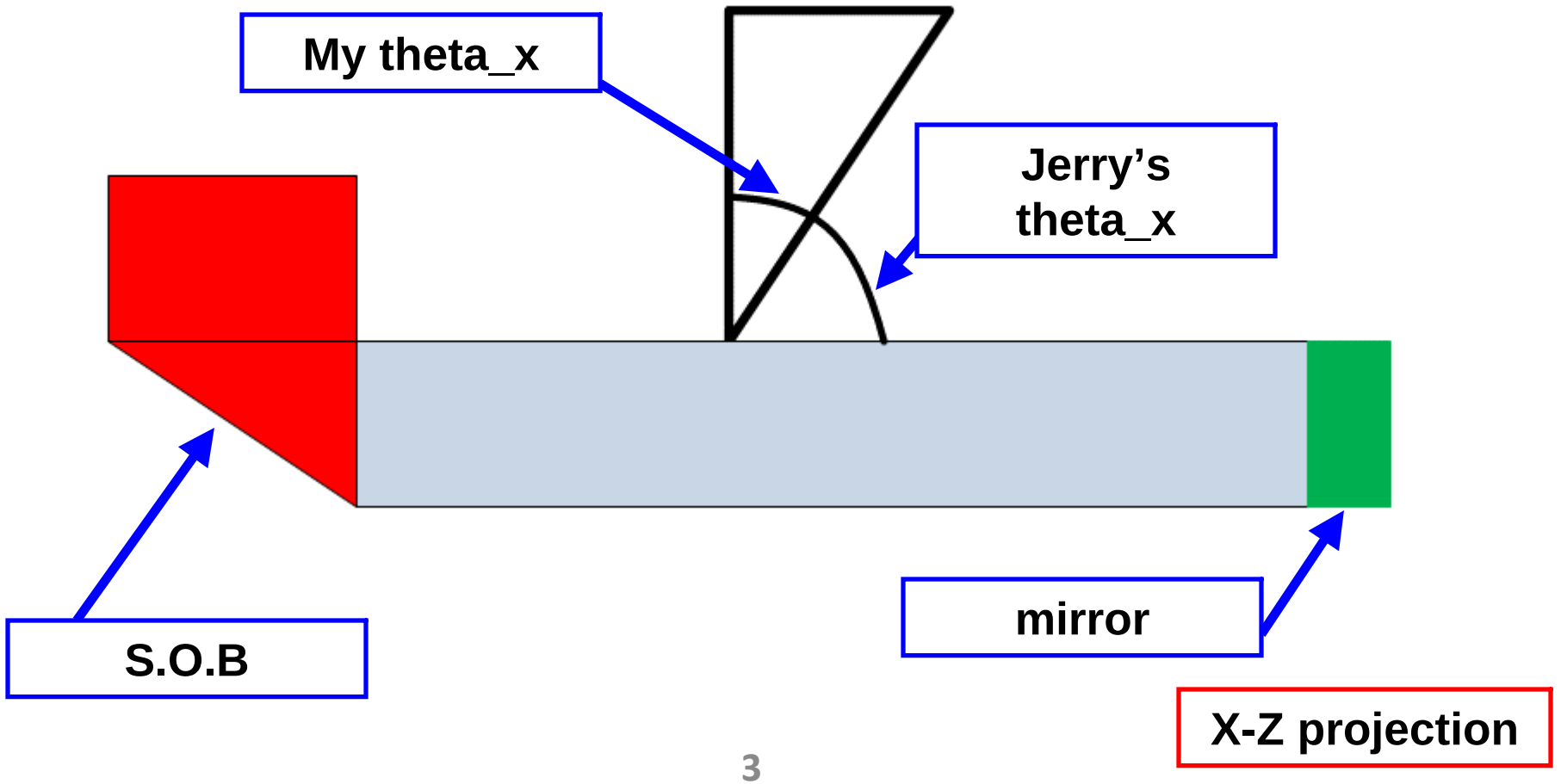
Data Cuts to .dts2 files for Cherenkov Imaging

Table 4.1: List of parameter cuts done to the CRT data set to measure Cherenkov angular resolution.

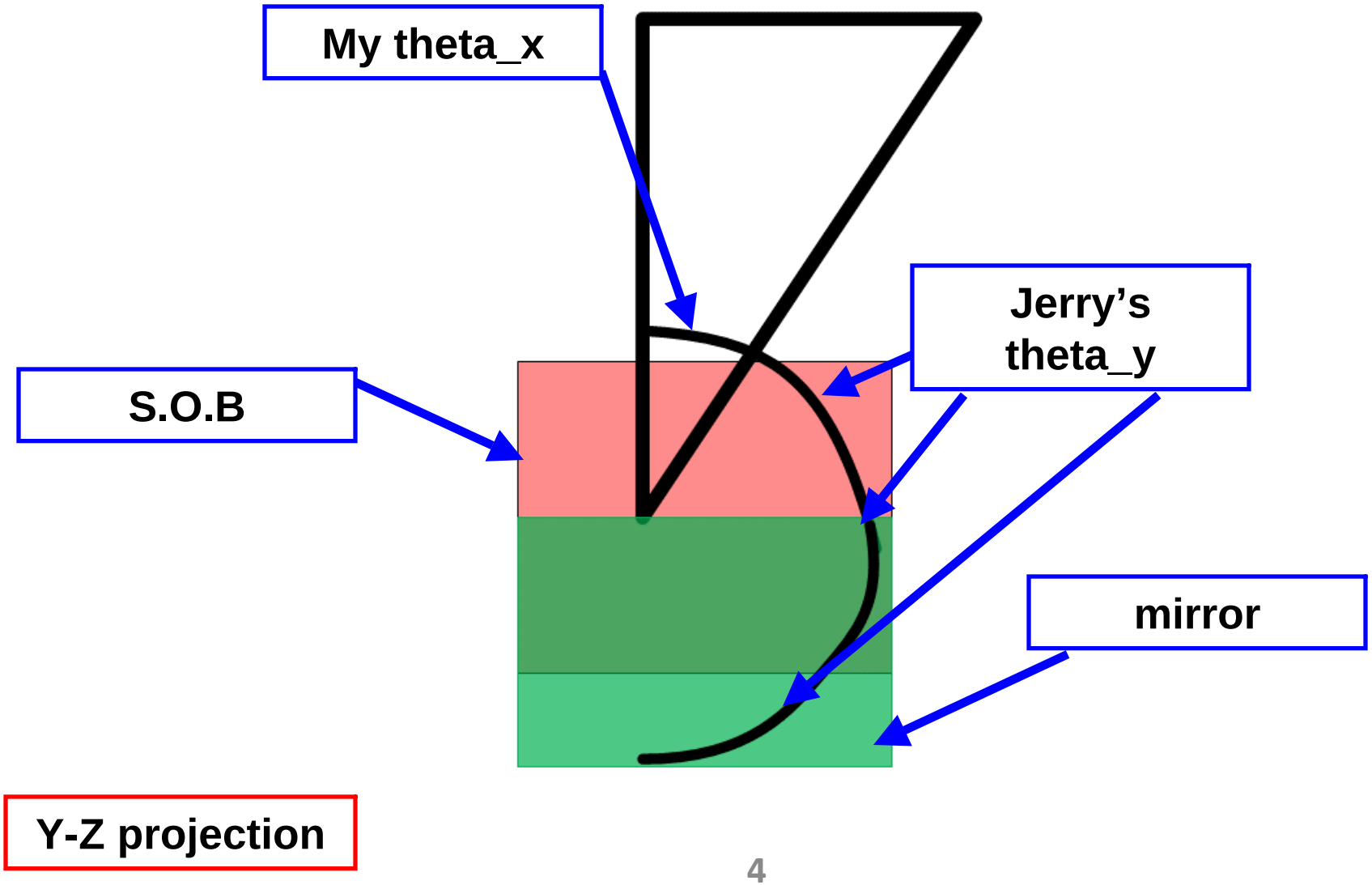
Went through radiator bar	true
good iron stack track	true
energy cutoff	> 1.6 GeV
θ_x	-100 mrad $< \theta_x <$ 100 mrad
θ_y	-5 mrad $< \theta_y <$ 5 mrad
time cut	830 ns $<$ T $<$ 900 ns
charge cut	-0.2 pC $>$ Q $>$ -2.0 pC
Use foward photons	true
Use mirror reflected photons	true

updated

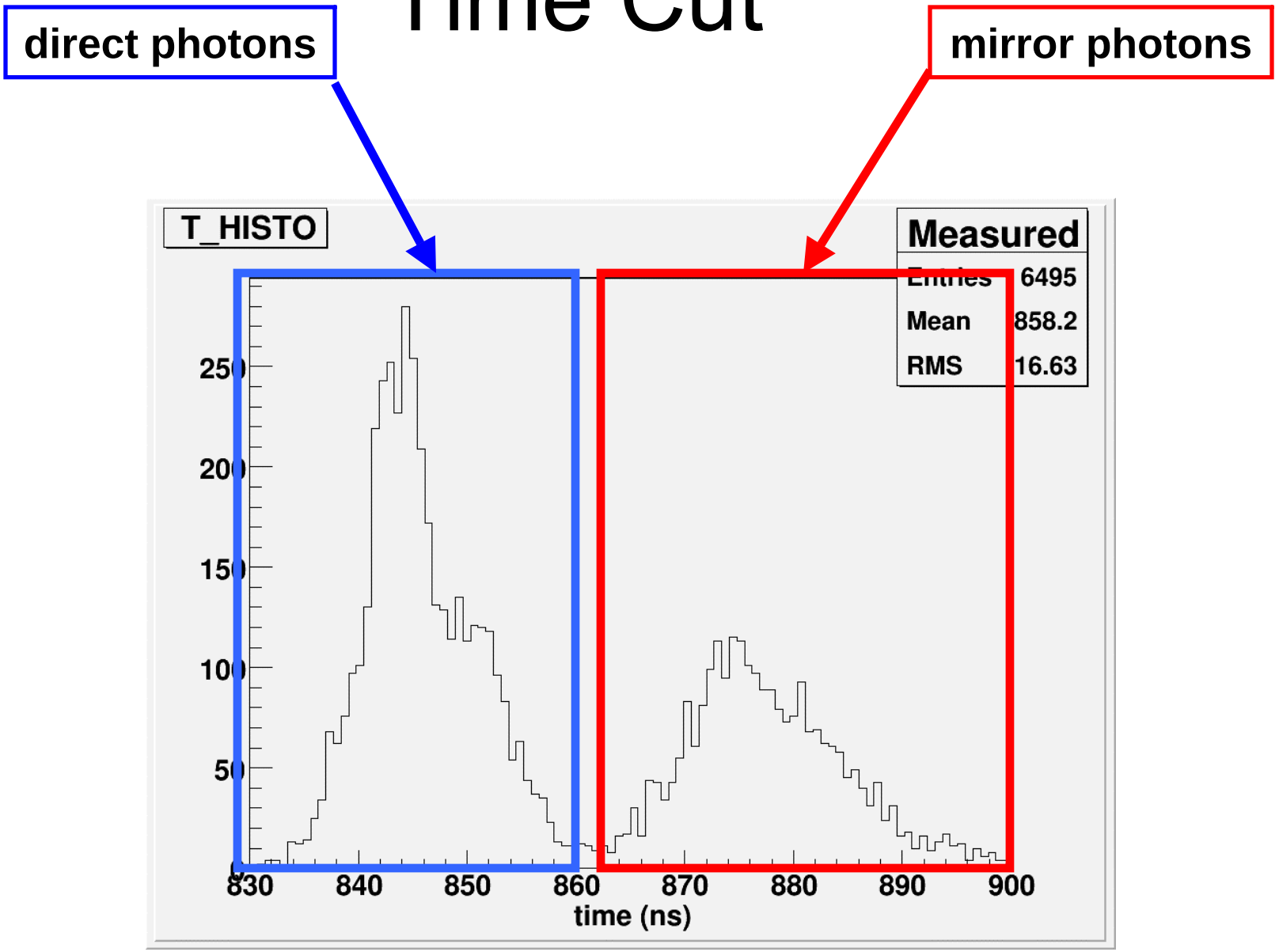
theta_x = theta_x + 90^{o}



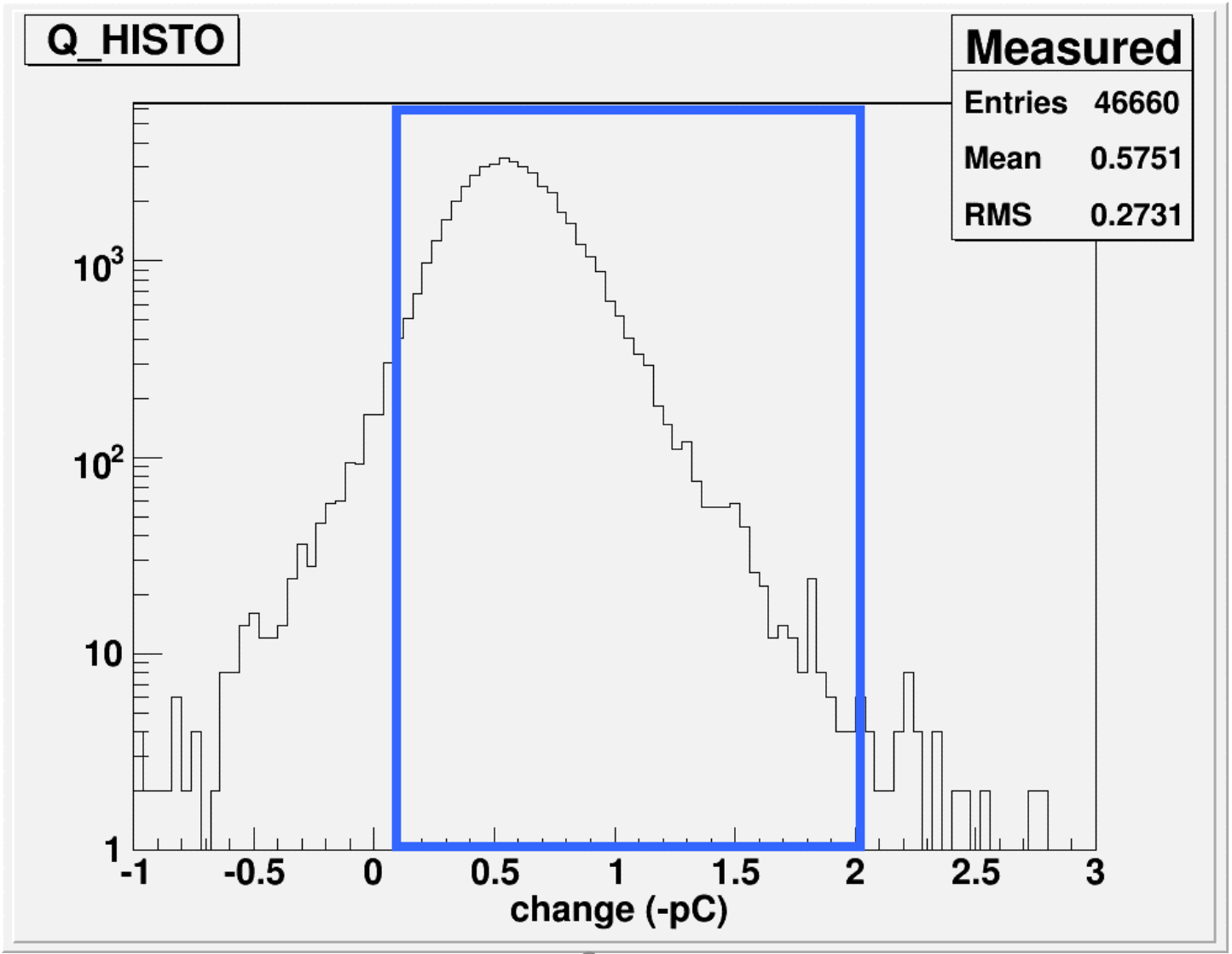
theta_y = theta_y + 270°

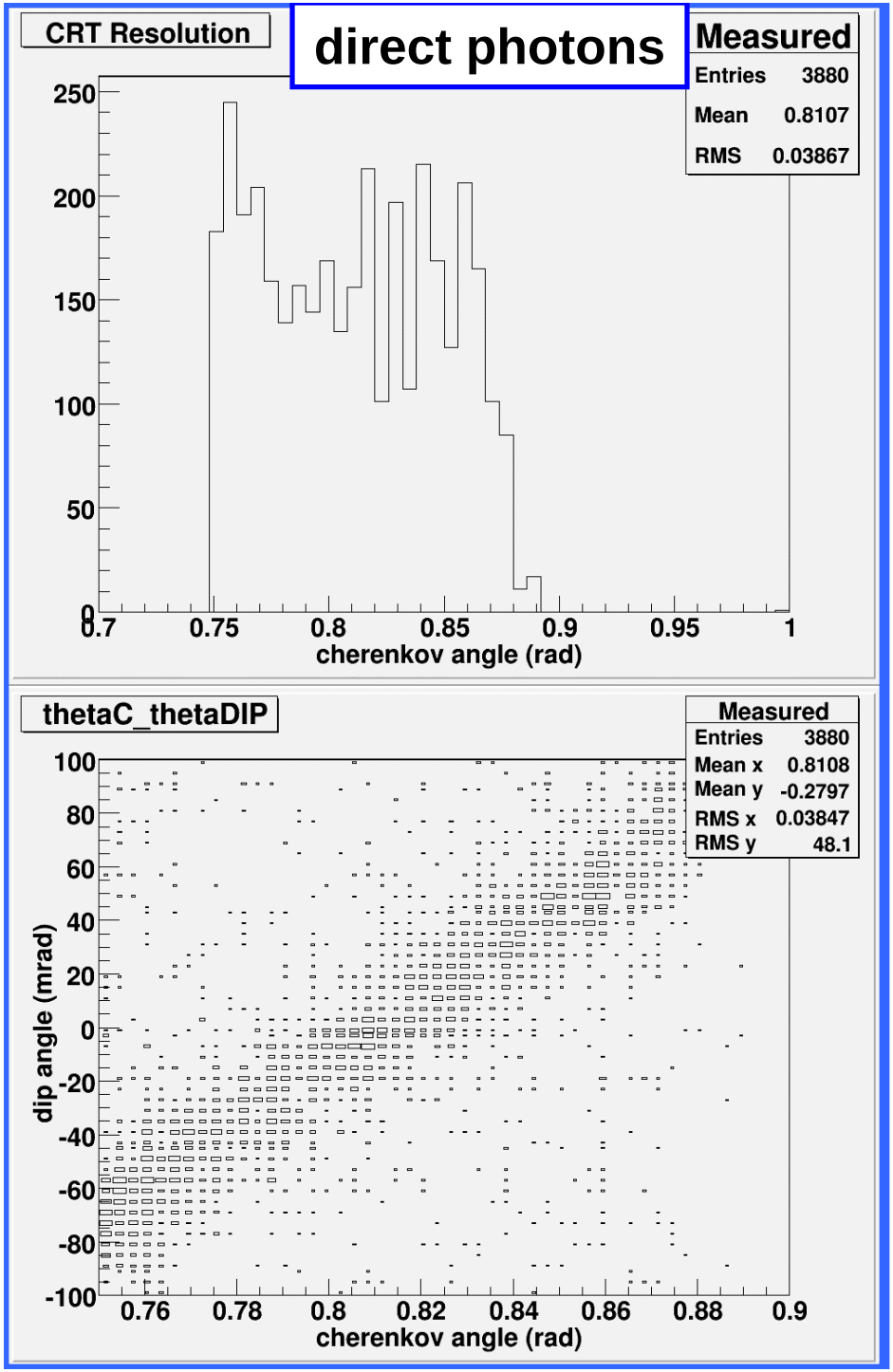


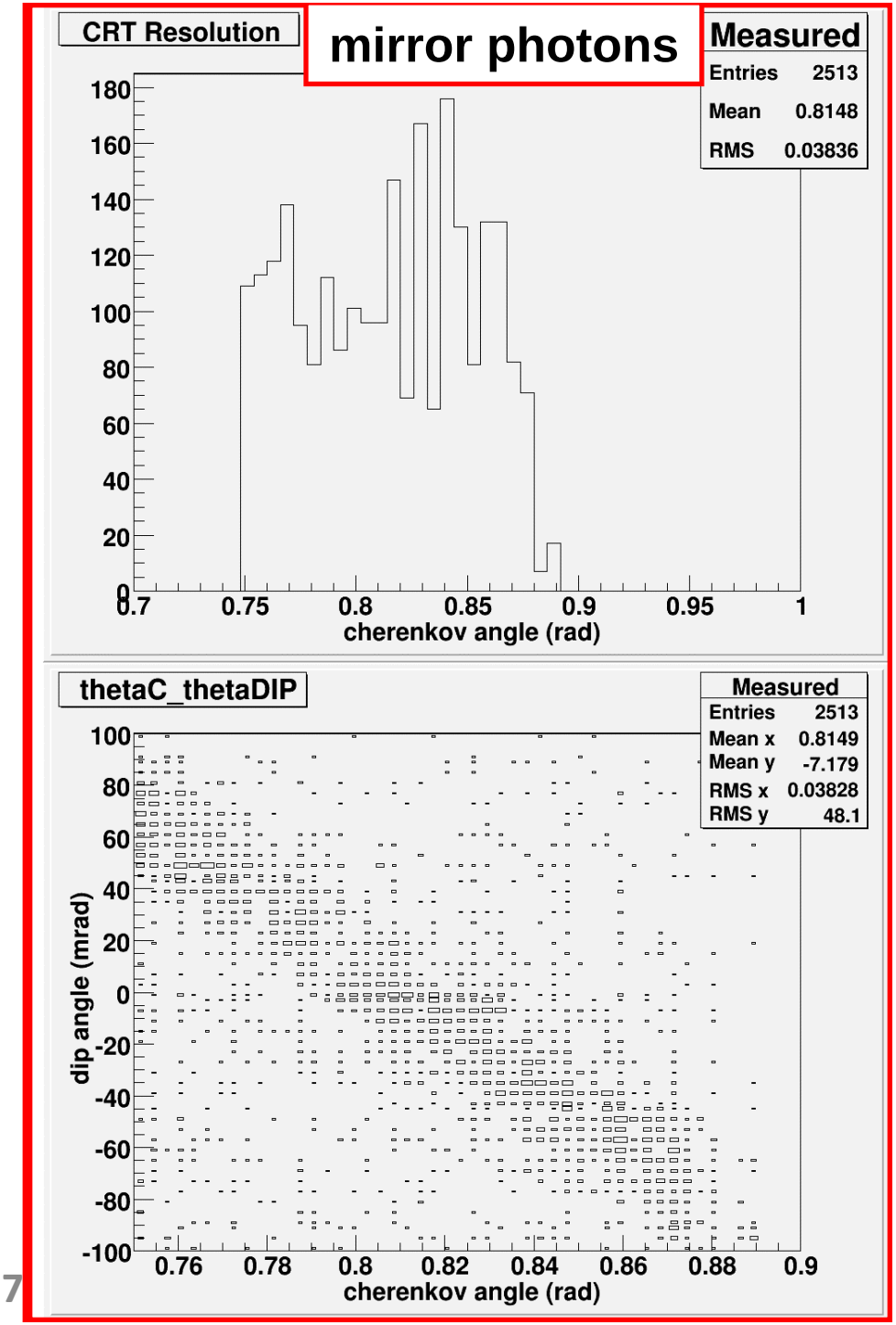
Time Cut

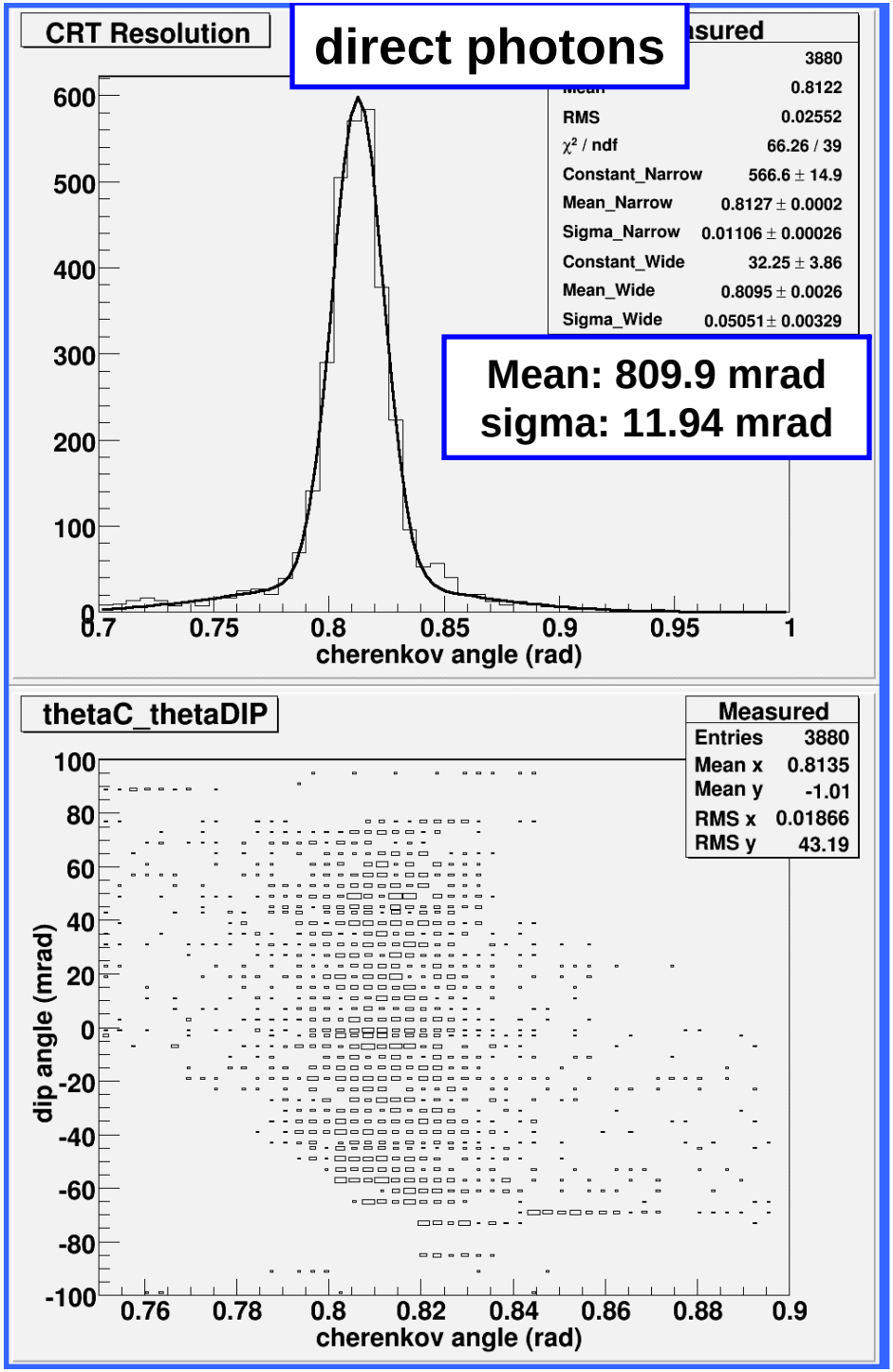

direct photons
mirror photons
T_HISTO
Measured
Entries 6495
Mean 858.2
RMS 16.63
250
200
150
100
50
0
830
840
850
860
870
880
890
900
time (ns)

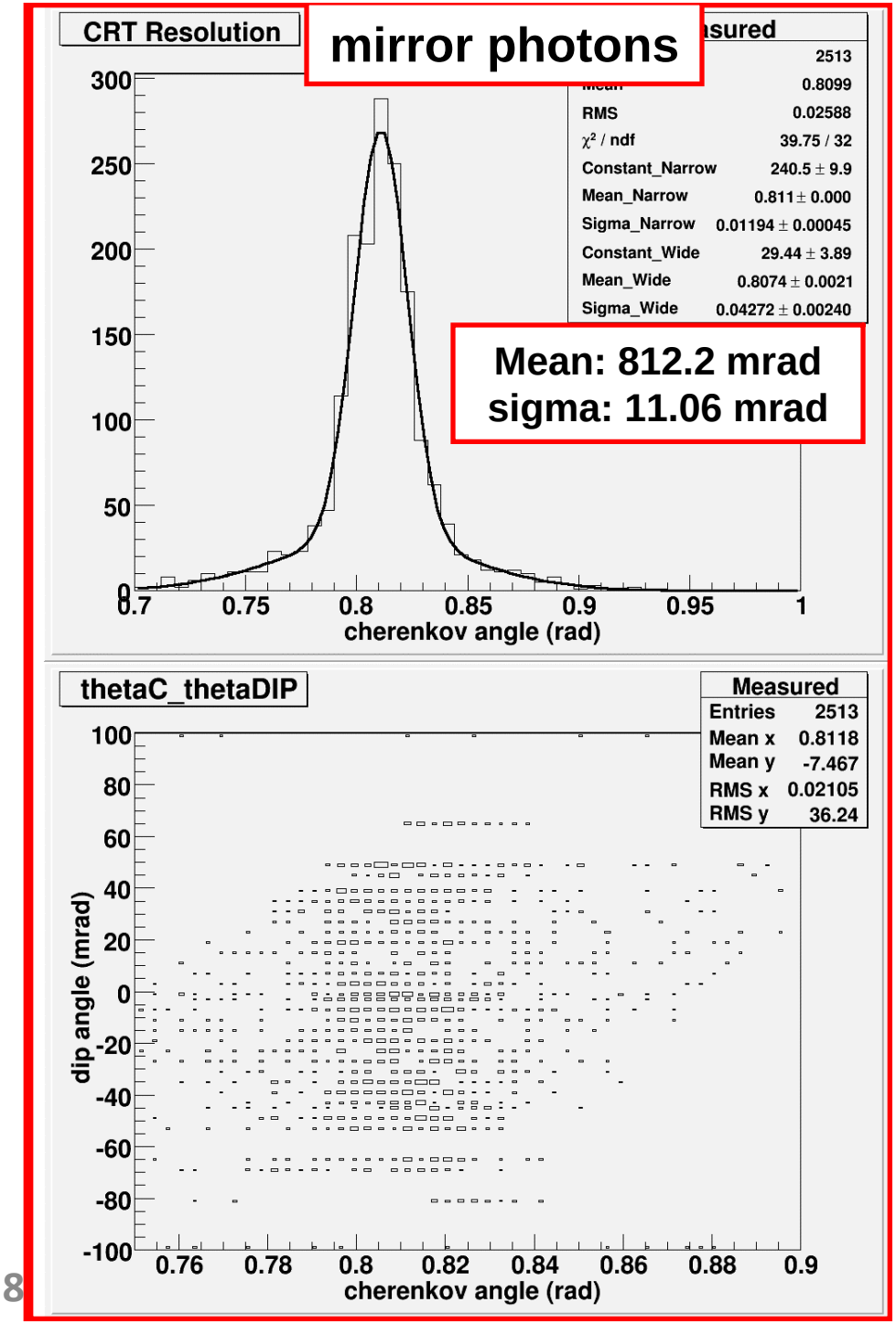
Charge Cut


Q_HISTO
Measured
Entries 46660
Mean 0.5751
RMS 0.2731
10^3
10^2
10
1
-1
-0.5
0
0.5
1
1.5
2
2.5
3
change (-pC)

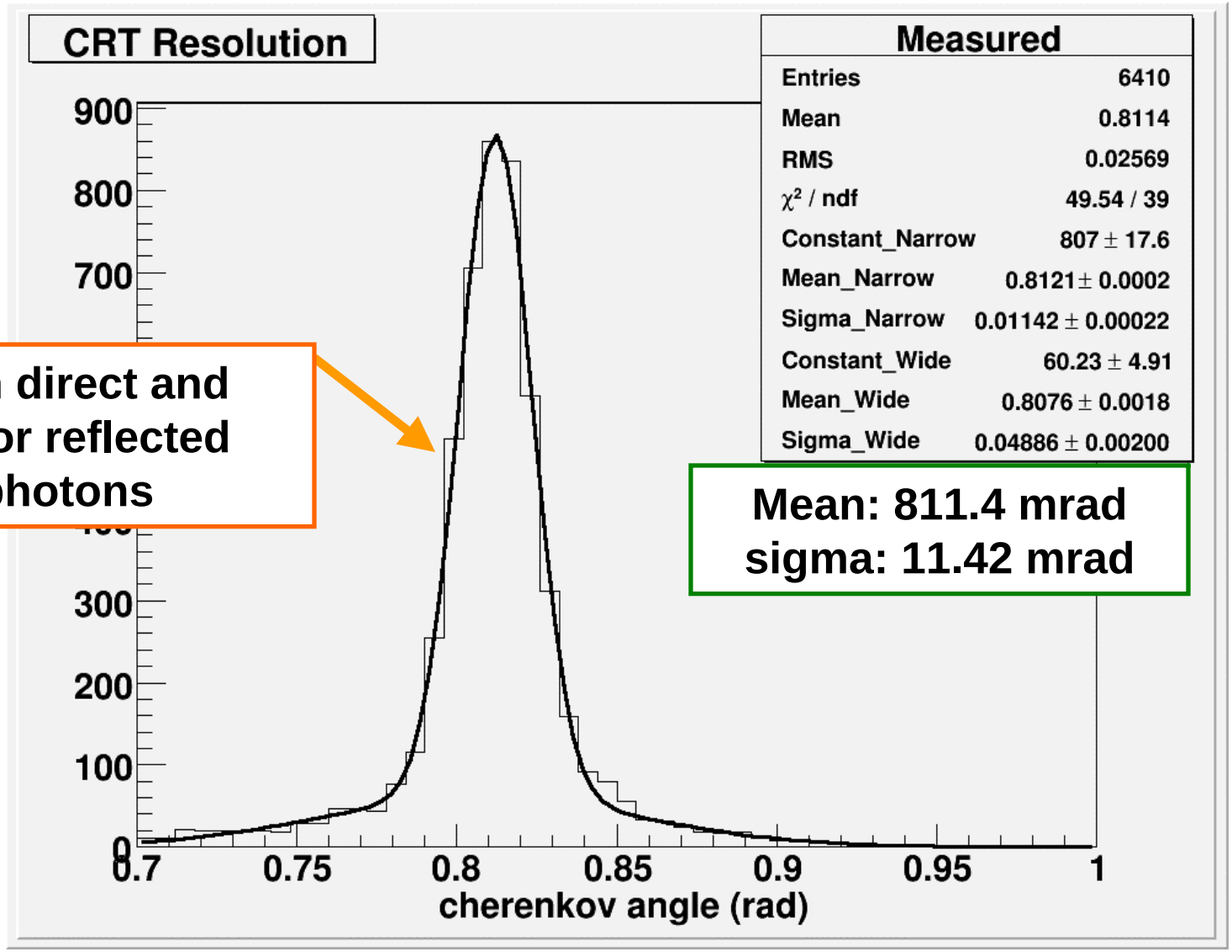

CRT Resolution
direct photons
Measured
Entries 3880
Mean 0.8107
RMS 0.03867
cherenkov angle (rad)
thetaC_thetaDIP
Measured
Entries 3880
Mean x 0.8108
Mean y -0.2797
RMS x 0.03847
RMS y 48.1
dip angle (mrad)
cherenkov angle (rad)


CRT Resolution
mirror photons
Measured
Entries 2513
Mean 0.8148
RMS 0.03836
cherenkov angle (rad)
thetaC_thetaDIP
Measured
Entries 2513
Mean x 0.8149
Mean y -7.179
RMS x 0.03828
RMS y 48.1
dip angle (mrad)
cherenkov angle (rad)

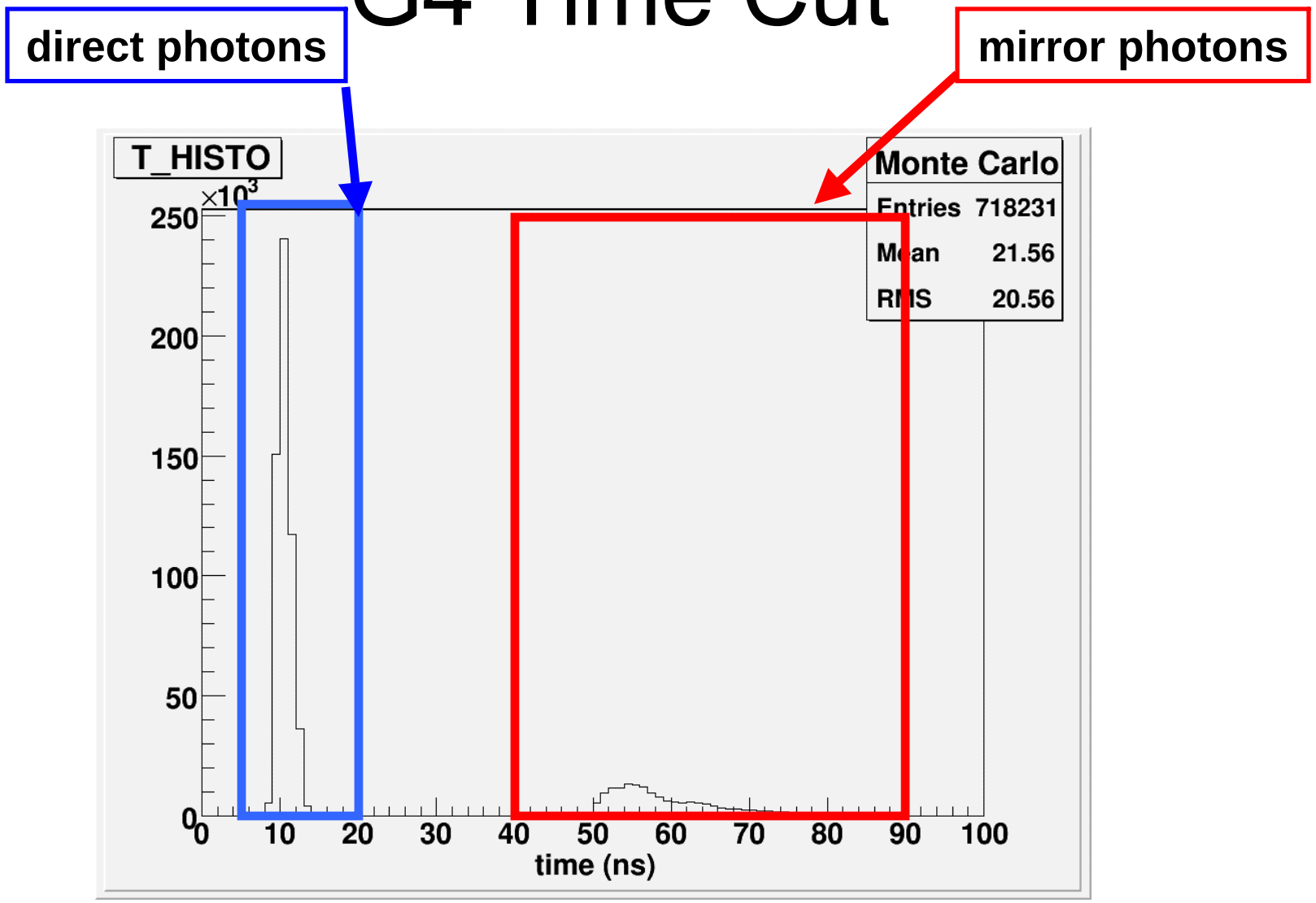

CRT Resolution
direct photons
Measured
3880
0.8122
RMS 0.02552
χ² / ndf 66.26 / 39
Constant_Narrow 566.6 ± 14.9
Mean_Narrow 0.8127 ± 0.0002
Sigma_Narrow 0.01106 ± 0.00026
Constant_Wide 32.25 ± 3.86
Mean_Wide 0.8095 ± 0.0026
Sigma_Wide 0.05051 ± 0.00329
Mean: 809.9 mrad
sigma: 11.94 mrad
cherenkov angle (rad)
thetaC_thetaDIP
Measured
Entries 3880
Mean x 0.8135
Mean y -1.01
RMS x 0.01866
RMS y 43.19
dip angle (mrad)
cherenkov angle (rad)


CRT Resolution
mirror photons
Measured
2513
0.8099
RMS 0.02588
χ² / ndf 39.75 / 32
Constant_Narrow 240.5 ± 9.9
Mean_Narrow 0.811 ± 0.000
Sigma_Narrow 0.01194 ± 0.00045
Constant_Wide 29.44 ± 3.89
Mean_Wide 0.8074 ± 0.0021
Sigma_Wide 0.04272 ± 0.00240
Mean: 812.2 mrad
sigma: 11.06 mrad
cherenkov angle (rad)
thetaC_thetaDIP
Measured
Entries 2513
Mean x 0.8118
Mean y -7.467
RMS x 0.02105
RMS y 36.24
dip angle (mrad)
cherenkov angle (rad)

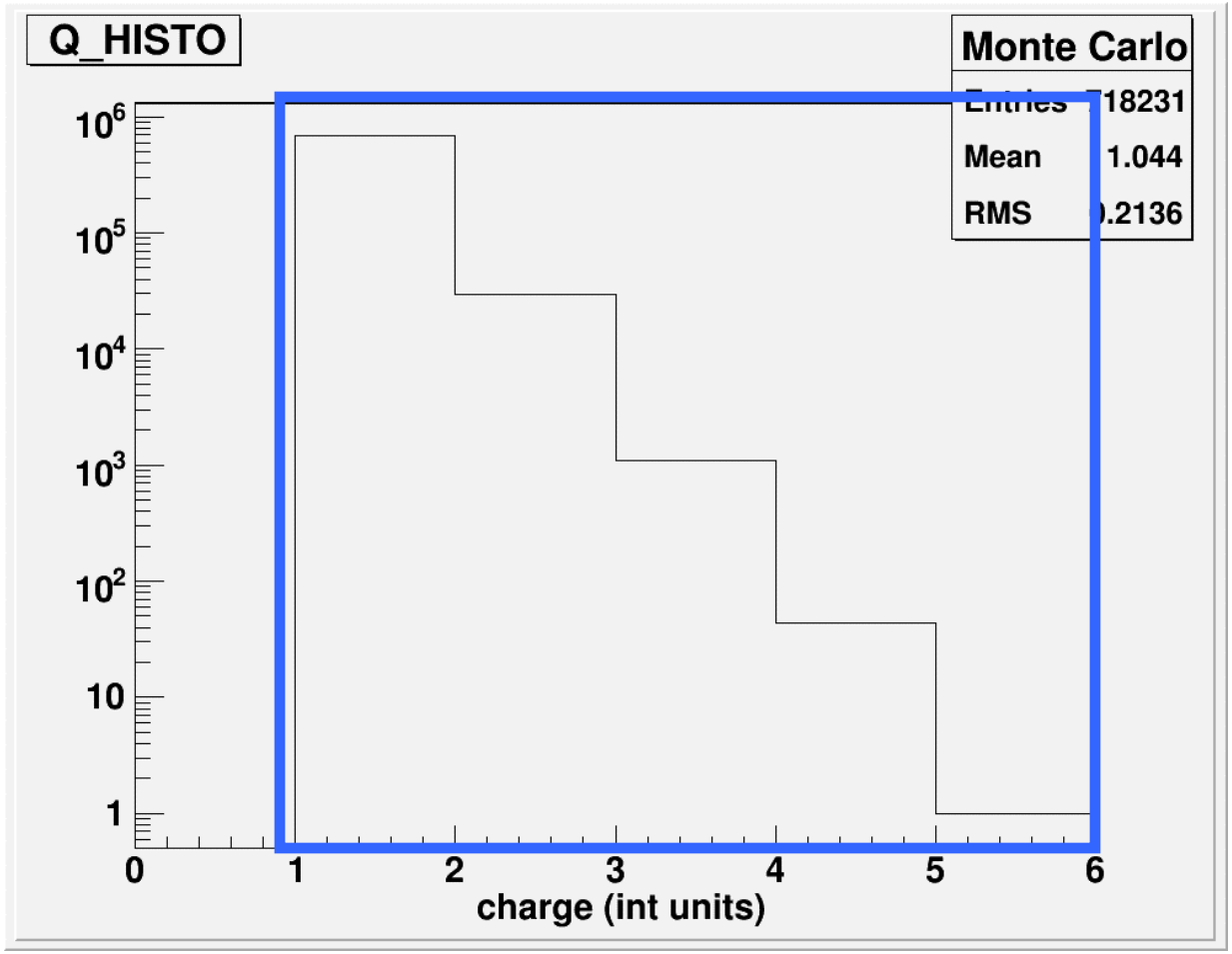
CRT Measured Resolution After Dip Corrects

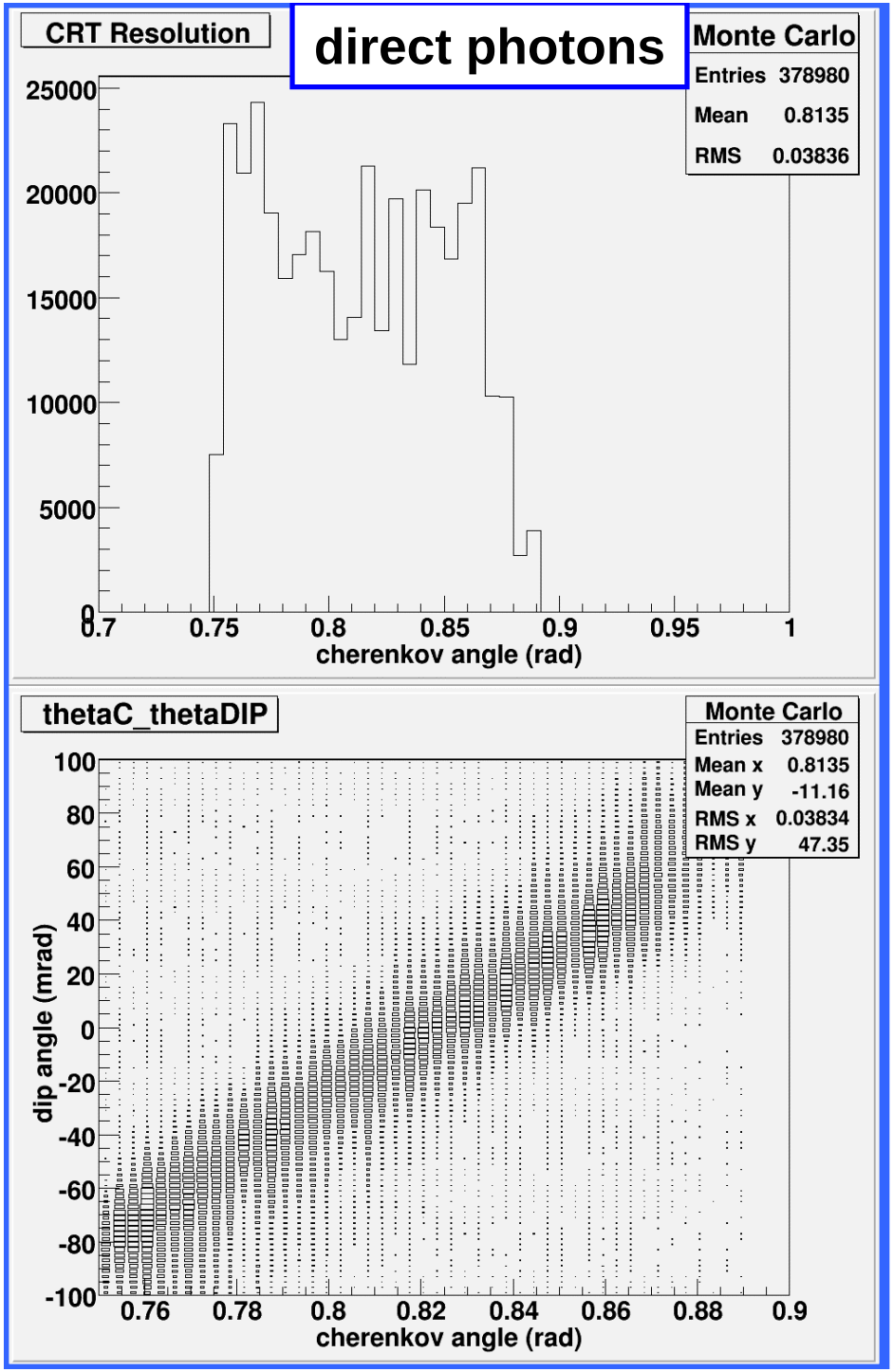


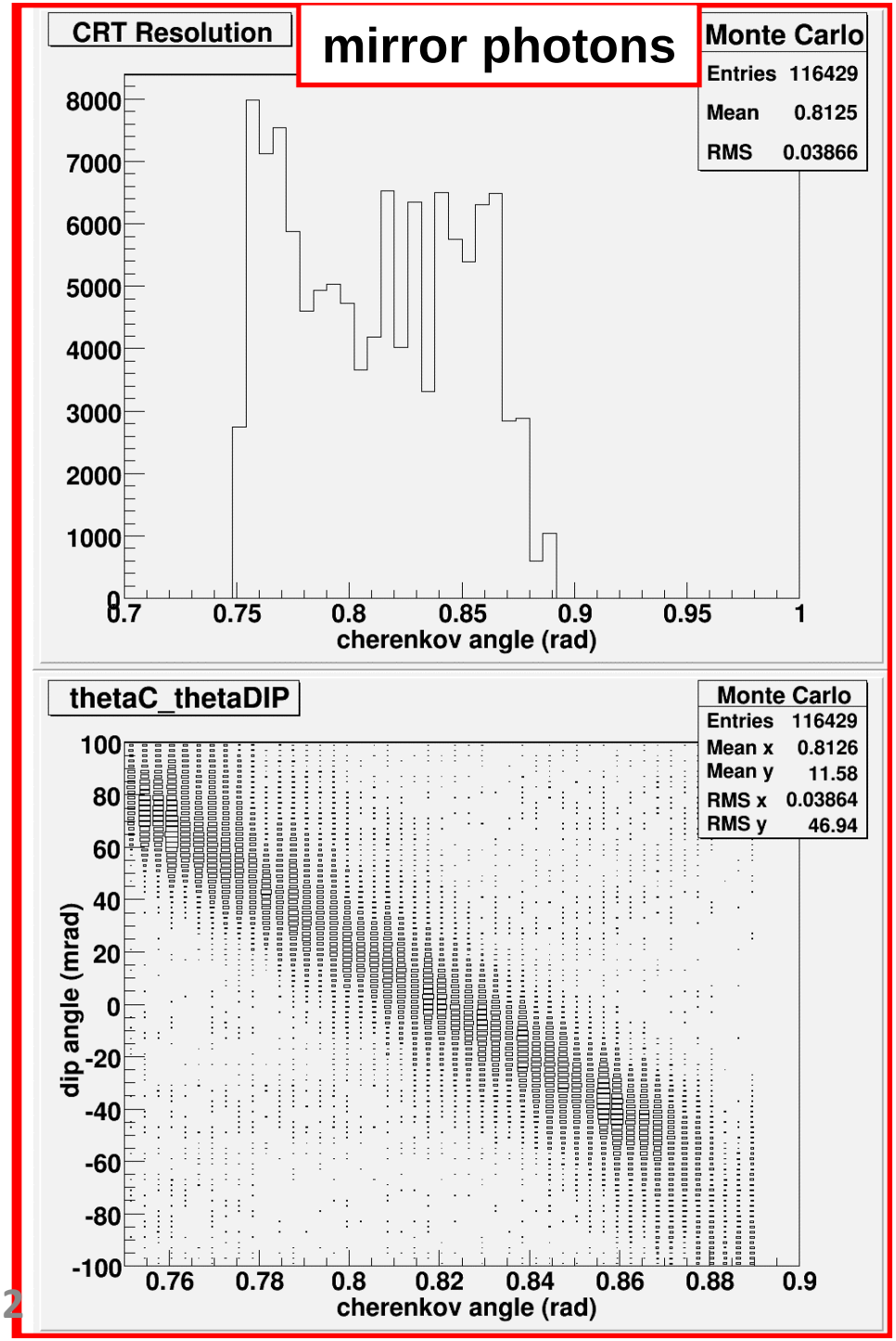
G4 Time Cut

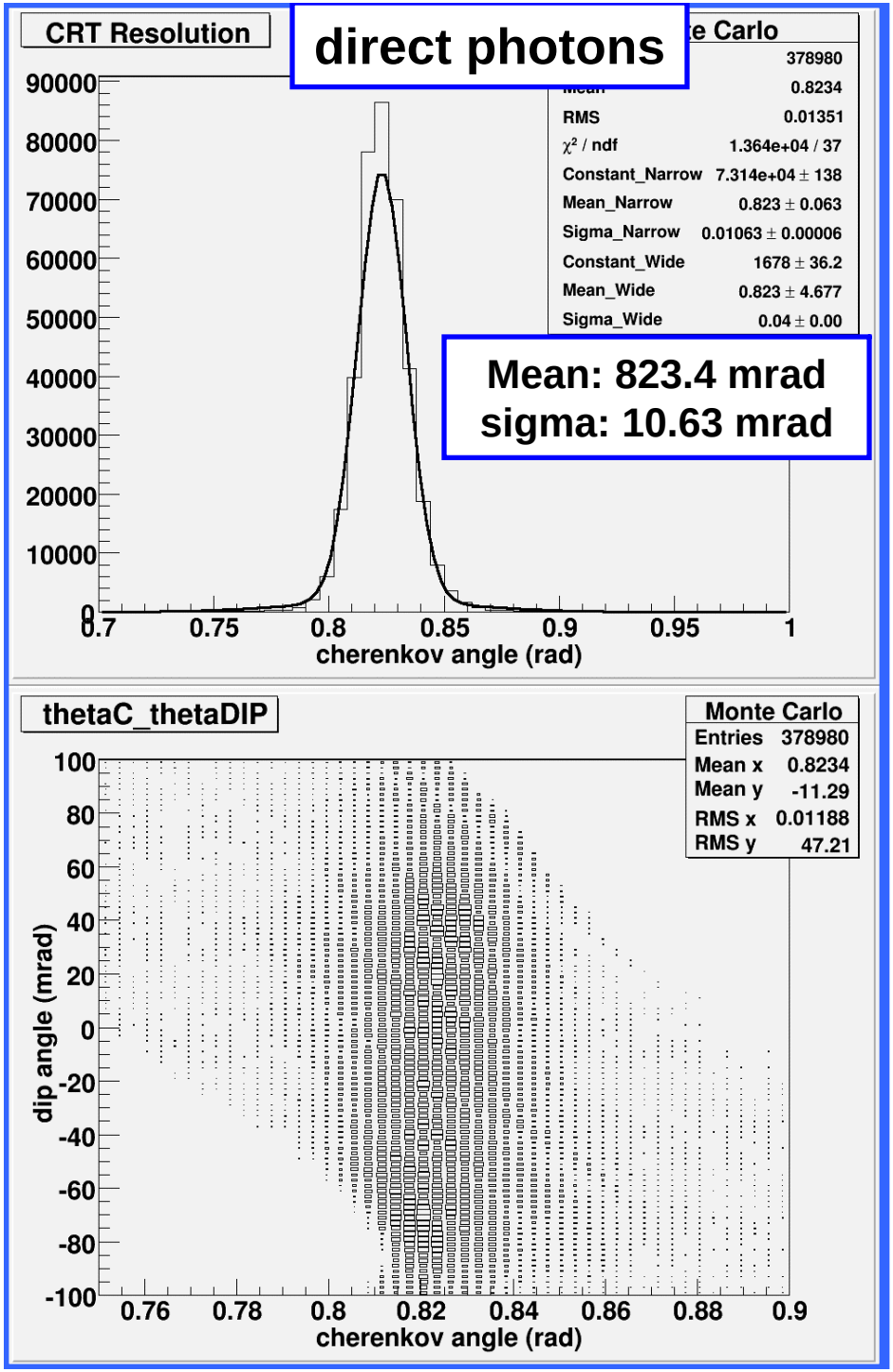

direct photons
mirror photons
T_HISTO
Monte Carlo
Entries 718231
Mean 21.56
RMS 20.56
×10³
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
time (ns)

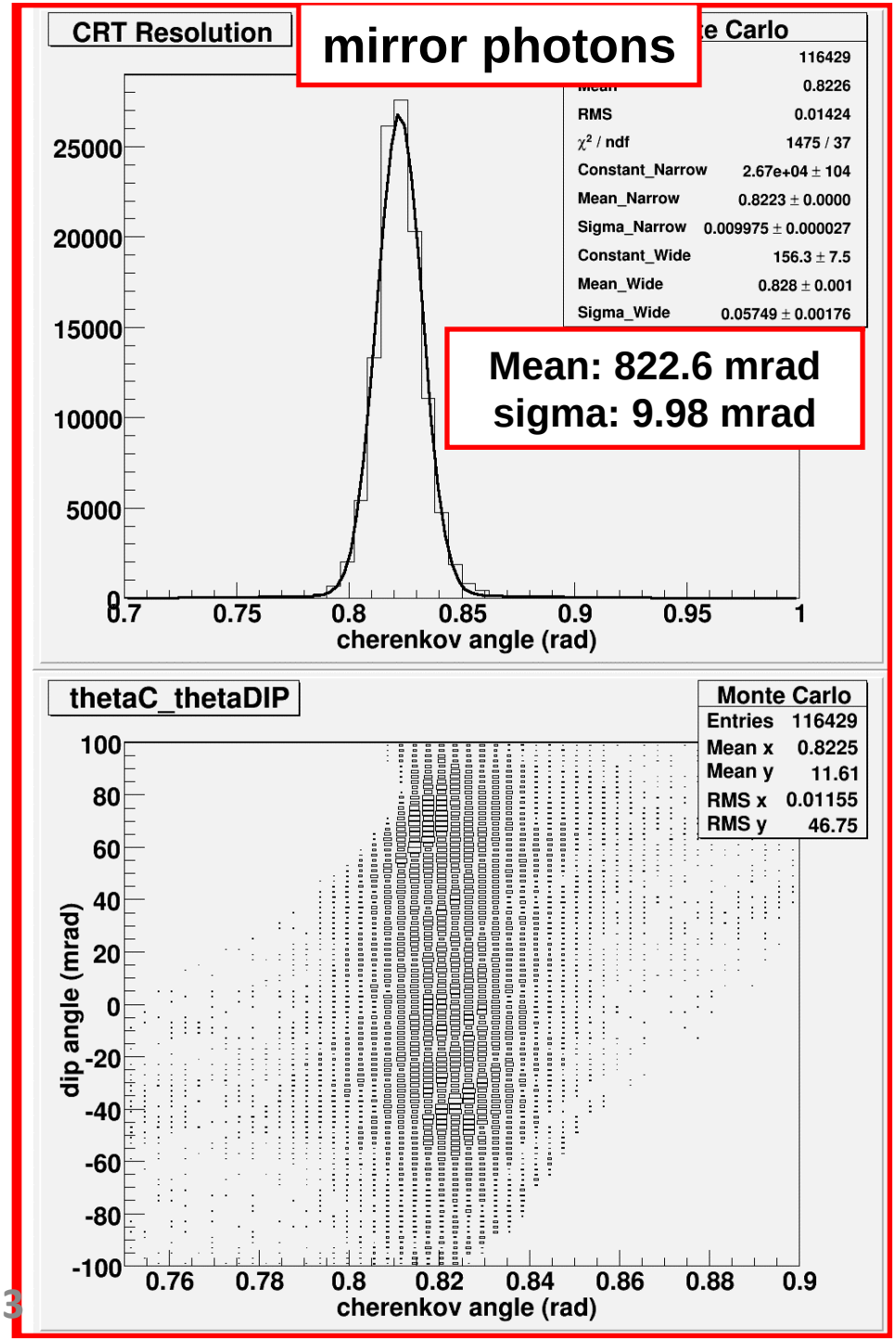
G4 Charge Cut



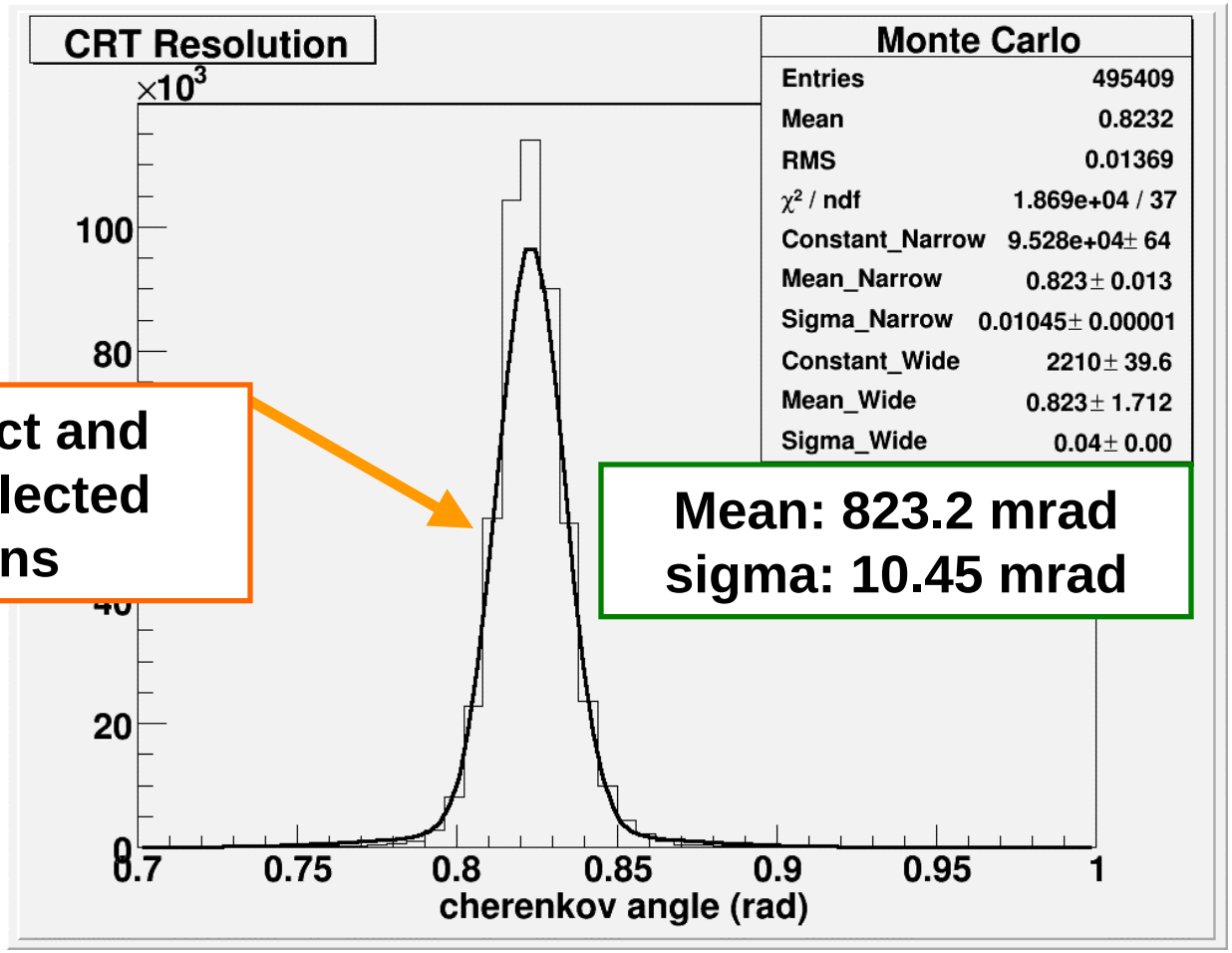

direct photons
CRT Resolution
Monte Carlo
Entries 378980
Mean 0.8135
RMS 0.03836
cherenkov angle (rad)
thetaC_thetaDIP
Monte Carlo
Entries 378980
Mean x 0.8135
Mean y -11.16
RMS x 0.03834
RMS y 47.35
dip angle (mrad)
cherenkov angle (rad)


mirror photons
CRT Resolution
Monte Carlo
Entries 116429
Mean 0.8125
RMS 0.03866
cherenkov angle (rad)
thetaC_thetaDIP
Monte Carlo
Entries 116429
Mean x 0.8126
Mean y 11.58
RMS x 0.03864
RMS y 46.94
dip angle (mrad)
cherenkov angle (rad)


CRT Resolution
direct photons
Monte Carlo
Entries 378980
Mean 0.8234
RMS 0.01351
χ² / ndf 1.364e+04 / 37
Constant_Narrow 7.314e+04 ± 138
Mean_Narrow 0.823 ± 0.063
Sigma_Narrow 0.01063 ± 0.00006
Constant_Wide 1678 ± 36.2
Mean_Wide 0.823 ± 4.677
Sigma_Wide 0.04 ± 0.00
Mean: 823.4 mrad
sigma: 10.63 mrad
cherenkov angle (rad)
thetaC_thetaDIP
Monte Carlo
Entries 378980
Mean x 0.8234
Mean y -11.29
RMS x 0.01188
RMS y 47.21
dip angle (mrad)
cherenkov angle (rad)


CRT Resolution
mirror photons
Monte Carlo
Entries 116429
Mean 0.8226
RMS 0.01424
χ² / ndf 1475 / 37
Constant_Narrow 2.67e+04 ± 104
Mean_Narrow 0.8223 ± 0.0000
Sigma_Narrow 0.009975 ± 0.000027
Constant_Wide 156.3 ± 7.5
Mean_Wide 0.828 ± 0.001
Sigma_Wide 0.05749 ± 0.00176
Mean: 822.6 mrad
sigma: 9.98 mrad
cherenkov angle (rad)
thetaC_thetaDIP
Monte Carlo
Entries 116429
Mean x 0.8225
Mean y 11.61
RMS x 0.01155
RMS y 46.75
dip angle (mrad)
cherenkov angle (rad)

Monte Carlo Resolution After Dip Corrects



Both direct and mirror reflected photons

Mean: 823.2 mrad
sigma: 10.45 mrad

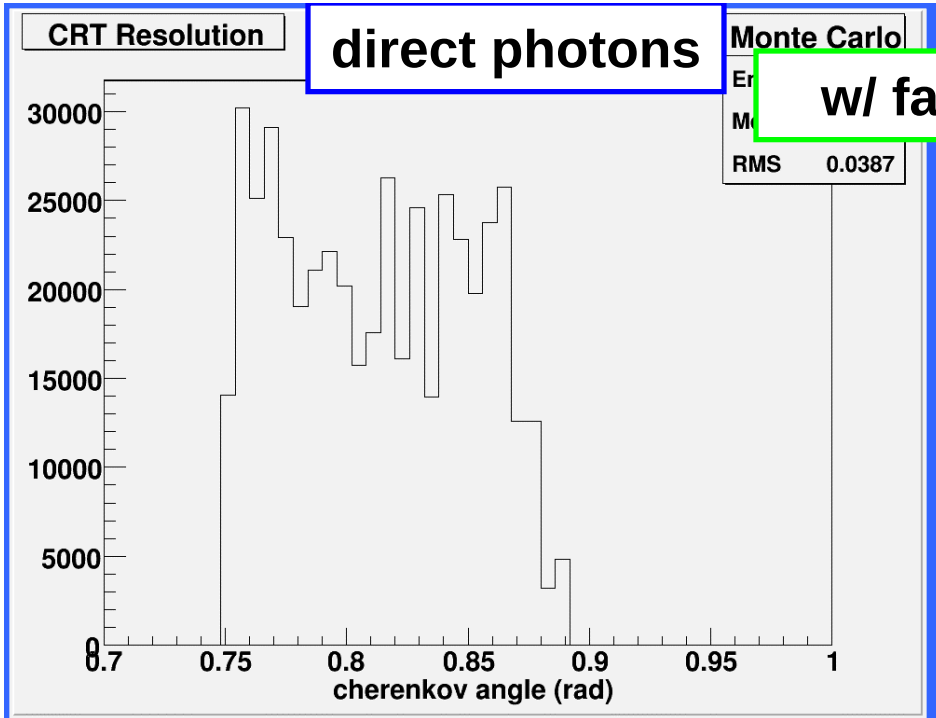
Why the Wide Secondary Superimposed Gaussian in CRT measurement?

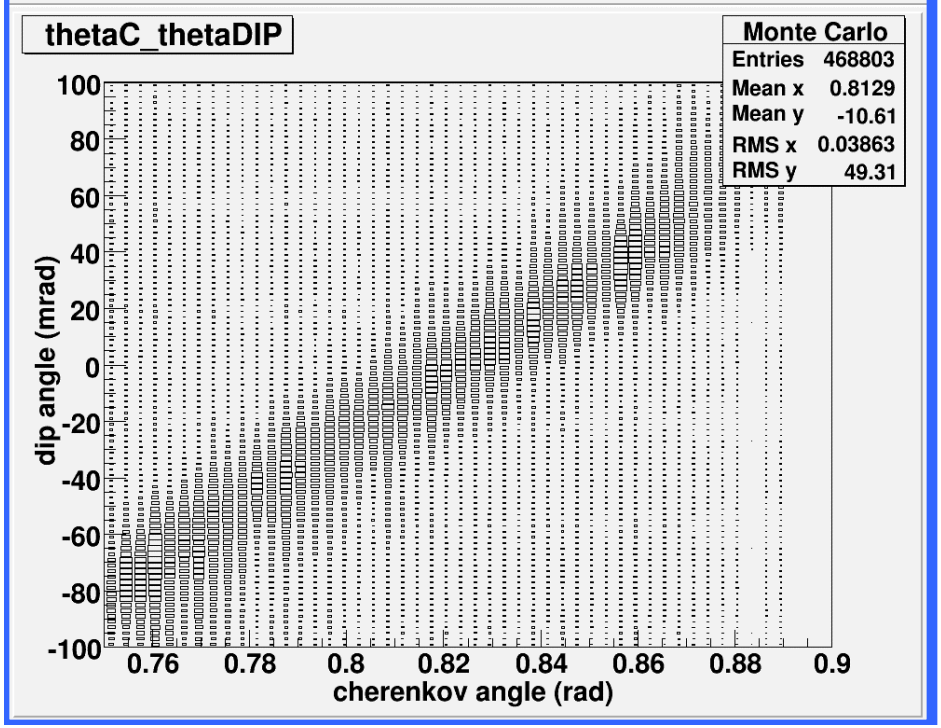
- Possible reason:
  - Electrical cross-talk
  - “fake” hit
    - Due to capacitive loading transitions + AMP oscillations
- I believe it’s some kind of random background hits in timing window
  - Electrical
  - Maybe light leak (optical)
- Thus, I redid G4 Monte Carlo with 0.35% chance of a fake hit for every pad per event

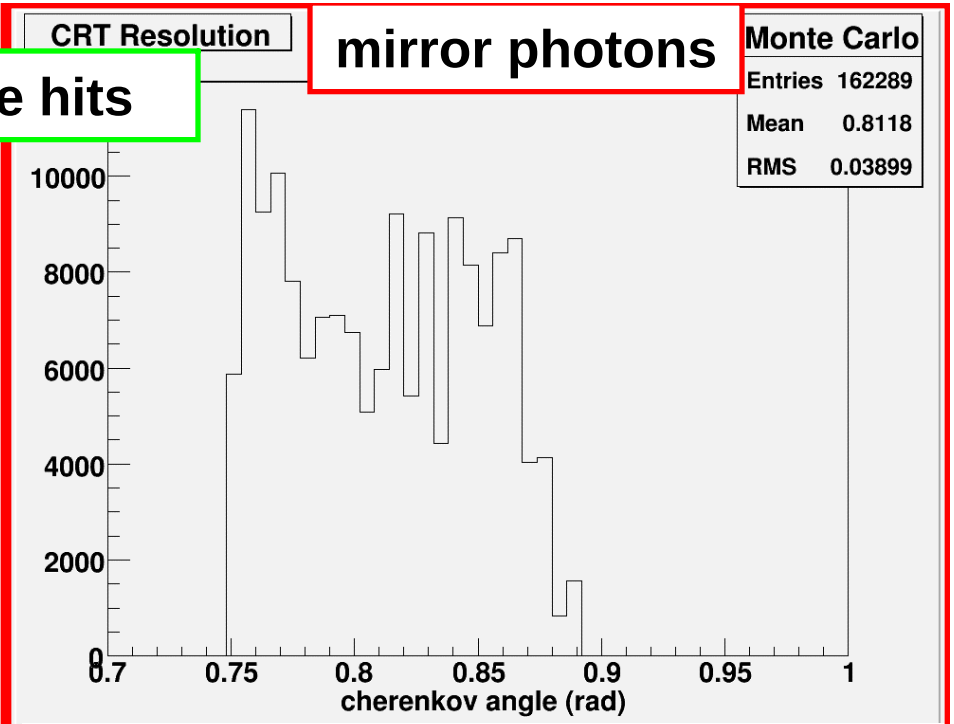
direct photons

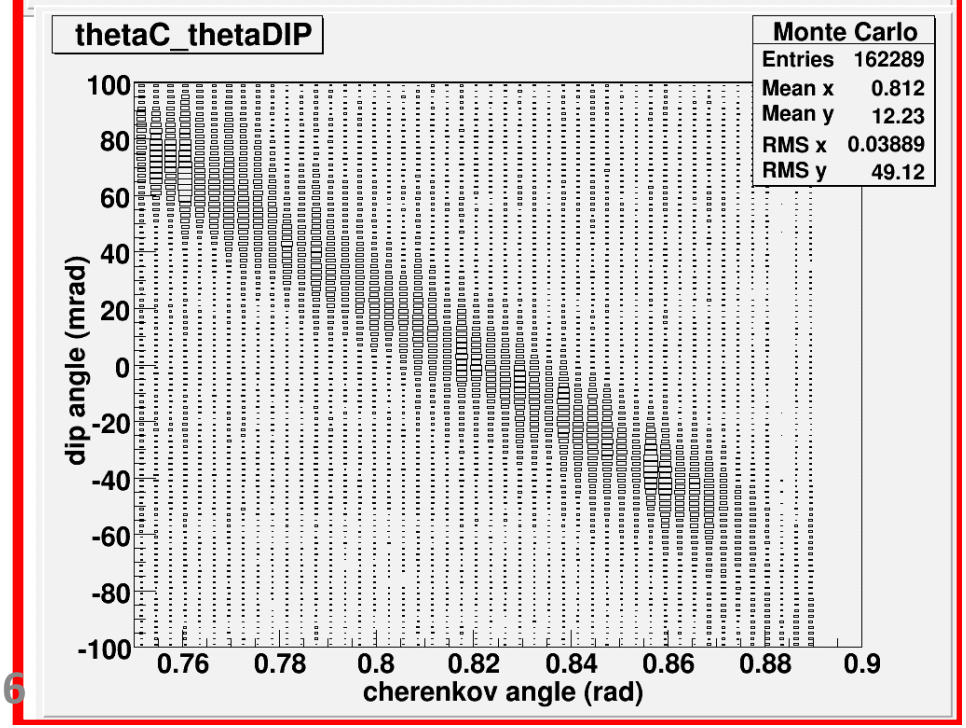
w/ fake hits

mirror photons





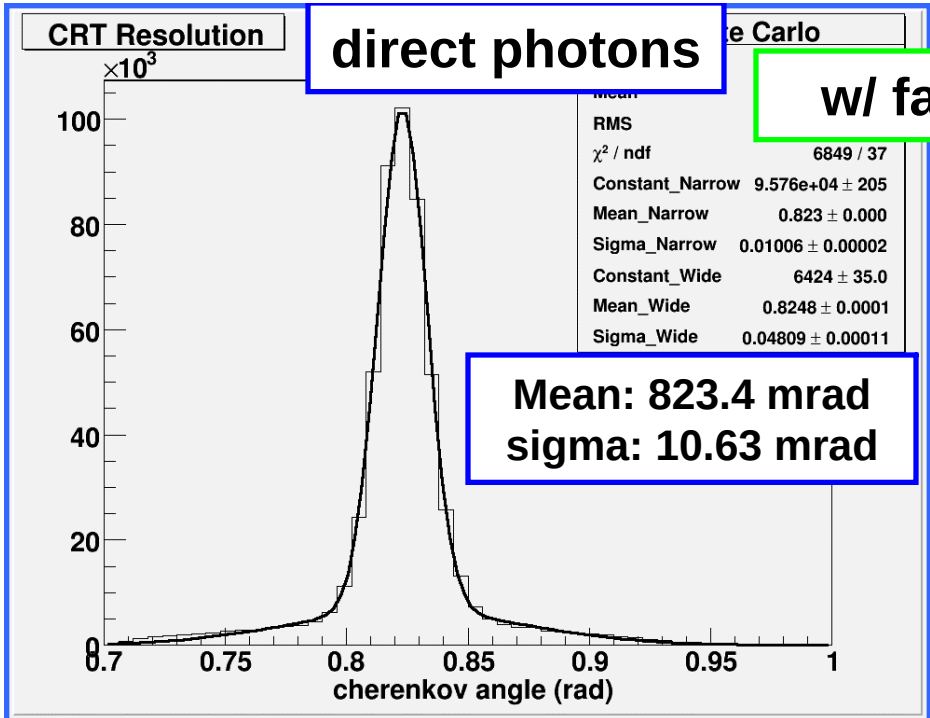




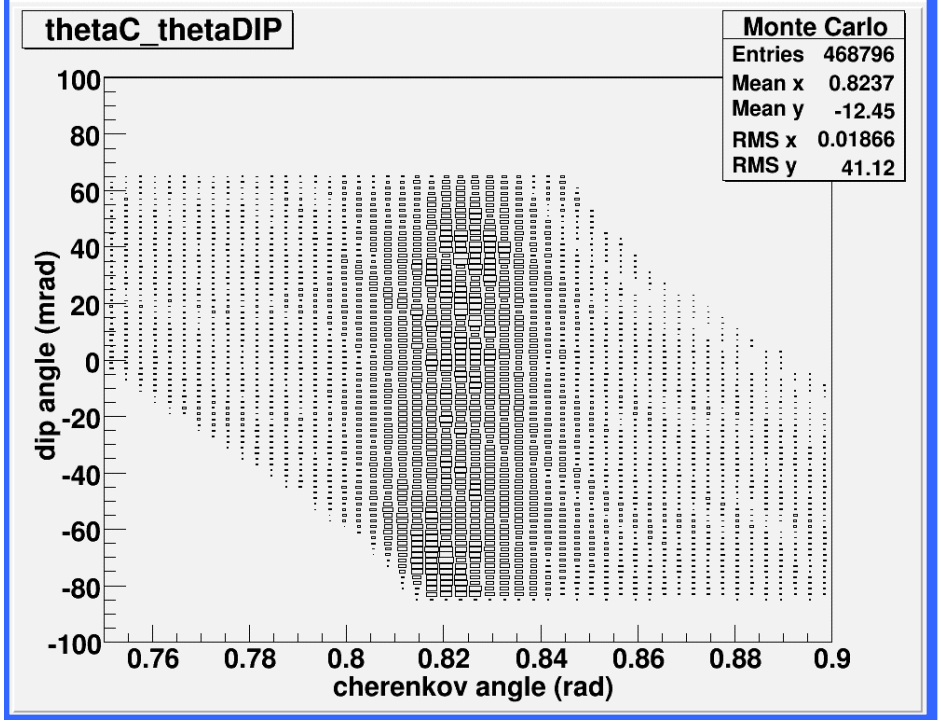
direct photons

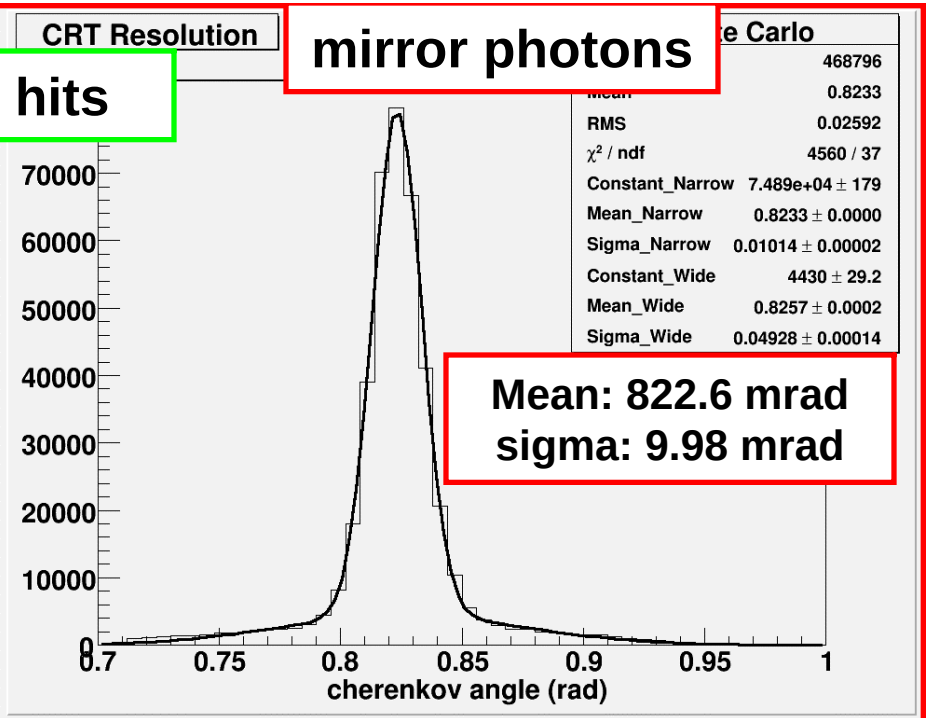
w/ fake hits

mirror photons

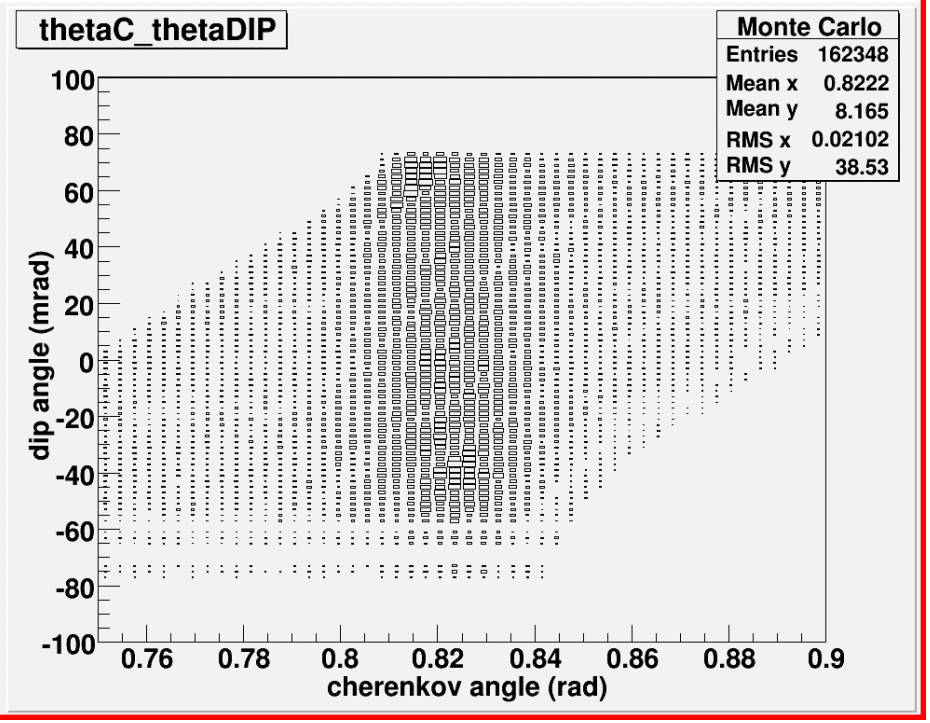


Mean: 823.4 mrad
sigma: 10.63 mrad



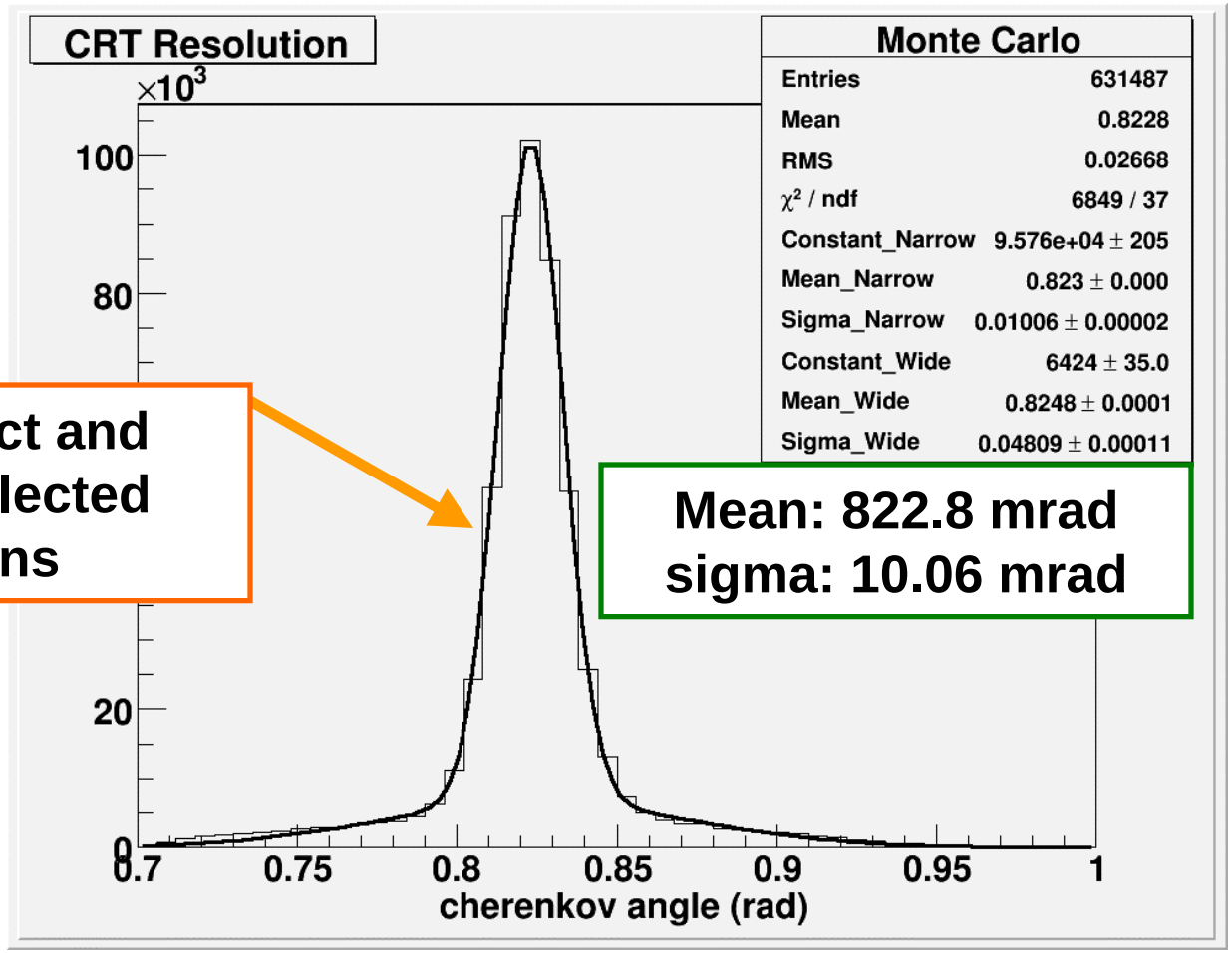


Mean: 822.6 mrad
sigma: 9.98 mrad



Monte Carlo Resolution After Dip Corrects

w/ fake hits

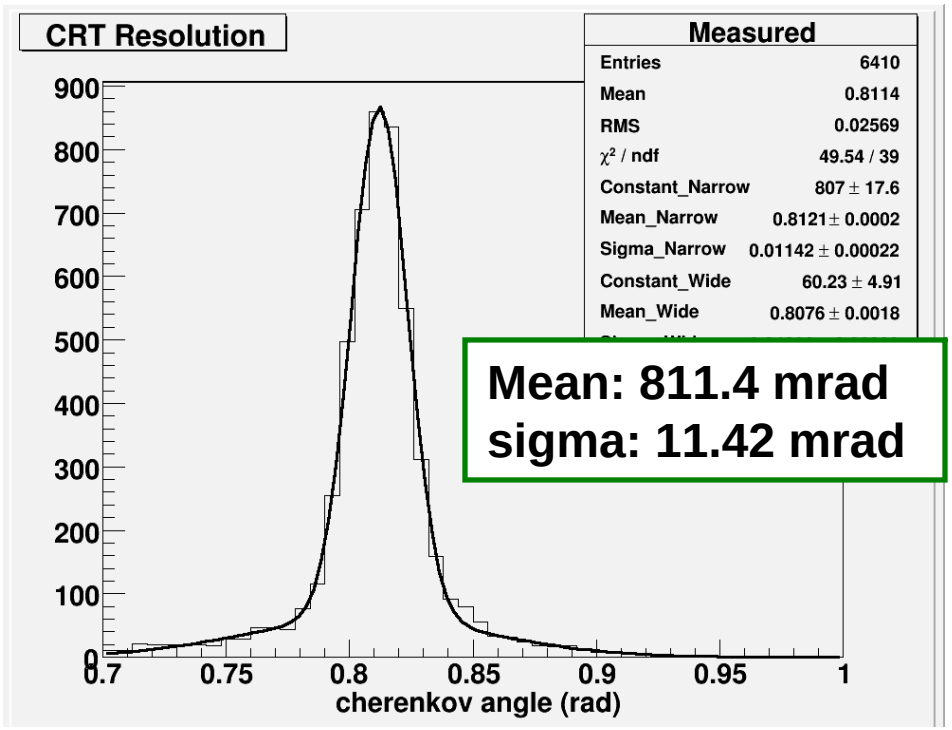


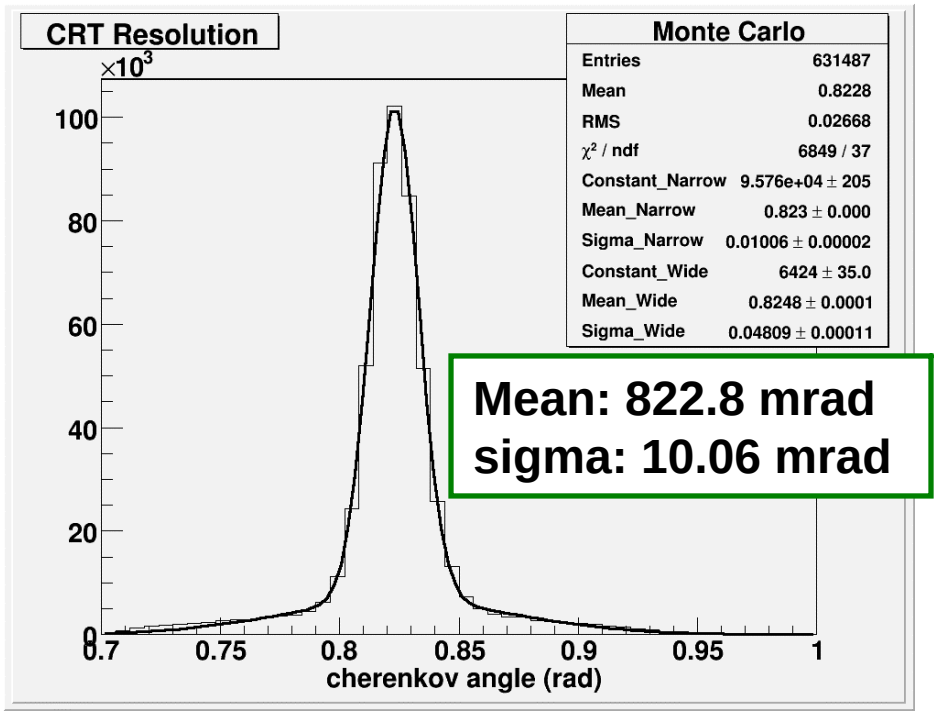
Both direct and mirror reflected photons

Mean: 822.8 mrad
sigma: 10.06 mrad

Cherenkov Angular Resolution Comparison

- $\Theta_C = \cos^{-1}(ky)$
- Slightly greater sigma for CRT measurement due to mis-tagging photons + muon tracking error for dip angle
  - Tracking error ~1.1 mrad (quantization error)
- Difference in mean likely due to measurement error in MaPMT slot position





End of Slides