Analysis Update

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Outline

- Research summary
- Global Tracking Method
- Analysis
  - NC elastic
  - CCQE
  - NC/CCQE ratio in KE
- Conclusions

Research plan

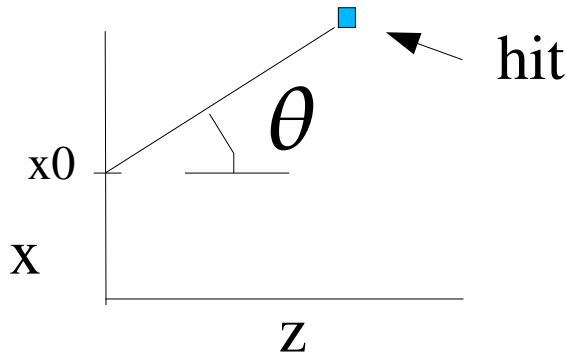
- Goal is to find ratio of NC/CCQE cross sections and use this to extract delta-s
- In order to do this I need to keep as many low energy (proton KE < ~200MeV) events as possible in both the NC elastic and CCQE samples
- I am using an algorithm that allows me to find short (low energy) proton tracks for NC elastic and CCQE MRD stopped events

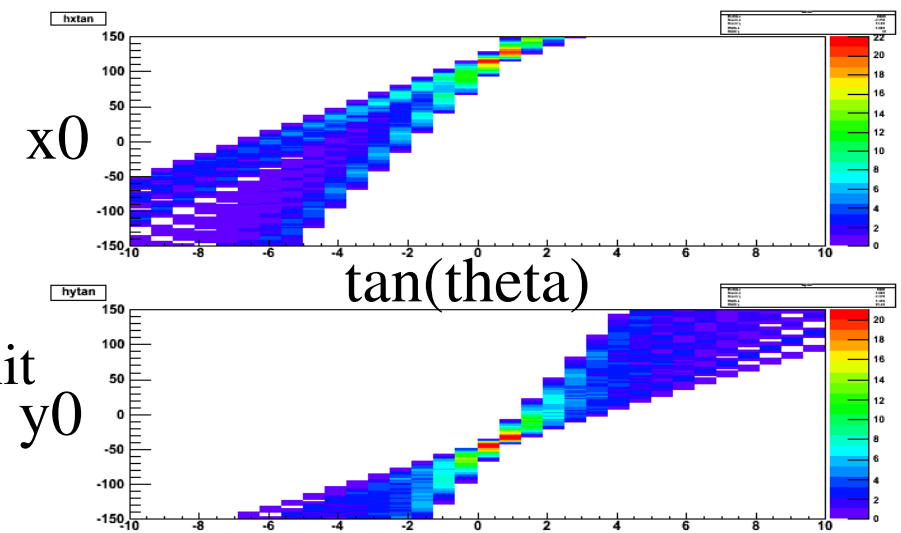
Current status

- Found NC elastic and CCQE samples and found the ratio as a function of KE
- Made fits of dirt and detector MC to data in position (x-z and y-z) to determine scaling factors for both in the NC(p) sample
- Am looking at how varying delta-s in the MC affects the overall NC elastic cross section (CCQE cross section not dependent on delta-s)

Global tracking method

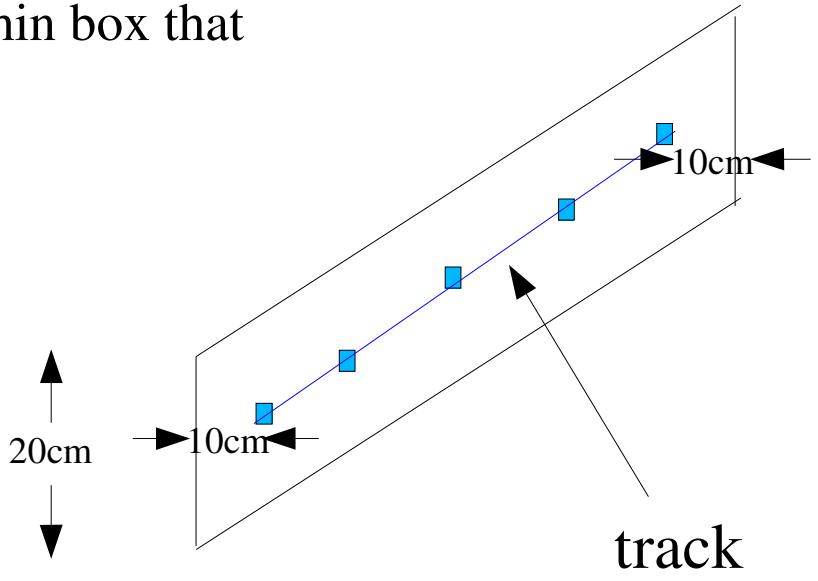
- Wanted to put together a tracking system that can find small clusters of hits (low energy protons)
- Look for clusters of hits by finding the angle that each hit makes with respect to a reference point (x0)
- Put the location of every hit in a particular event into a 2D histogram of x0 vs. tan(theta)
- Find the bin in this 2D histogram with the highest number of entries, this bin will correspond to a track/cluster in the detector
- x0 is set 50cm upstream from highest energy hit (arbitrary reference point)



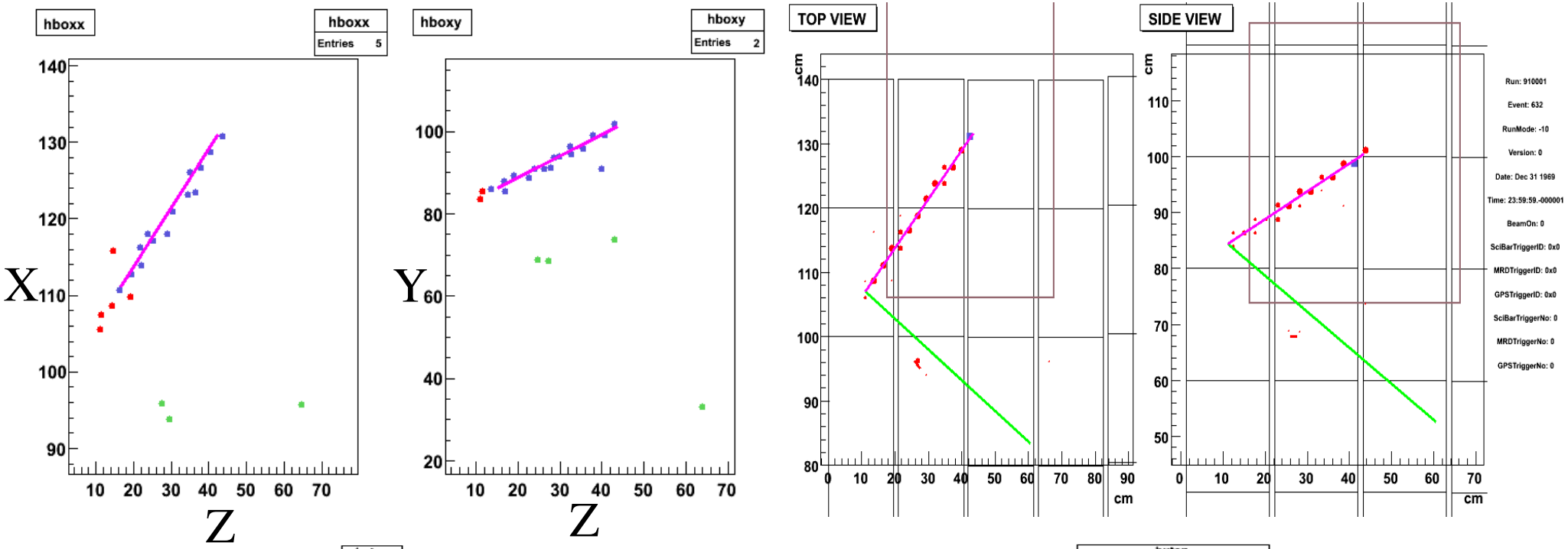


Summary of tracking/cluster algorithm

- Using a tan(theta) bin size of 0.25 (can be adjusted to change resolution)
- Once hits on track are found additional hits are found by drawing a box around it and collecting all hits within box that are not included on the track
- The hits along the track are combined with the hits in the box to form a cluster, and the energy from the cluster is used for energy reconstruction
- I am finding the projection length (x and y views) using coordinates of track hits with highest and lowest z values



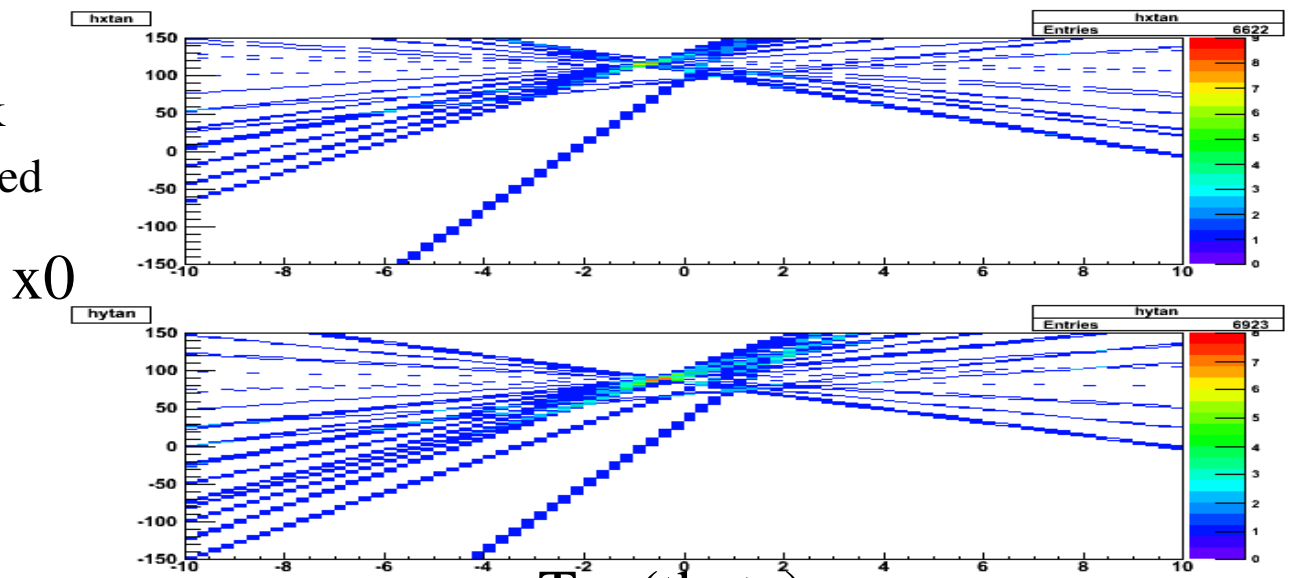
Sample event



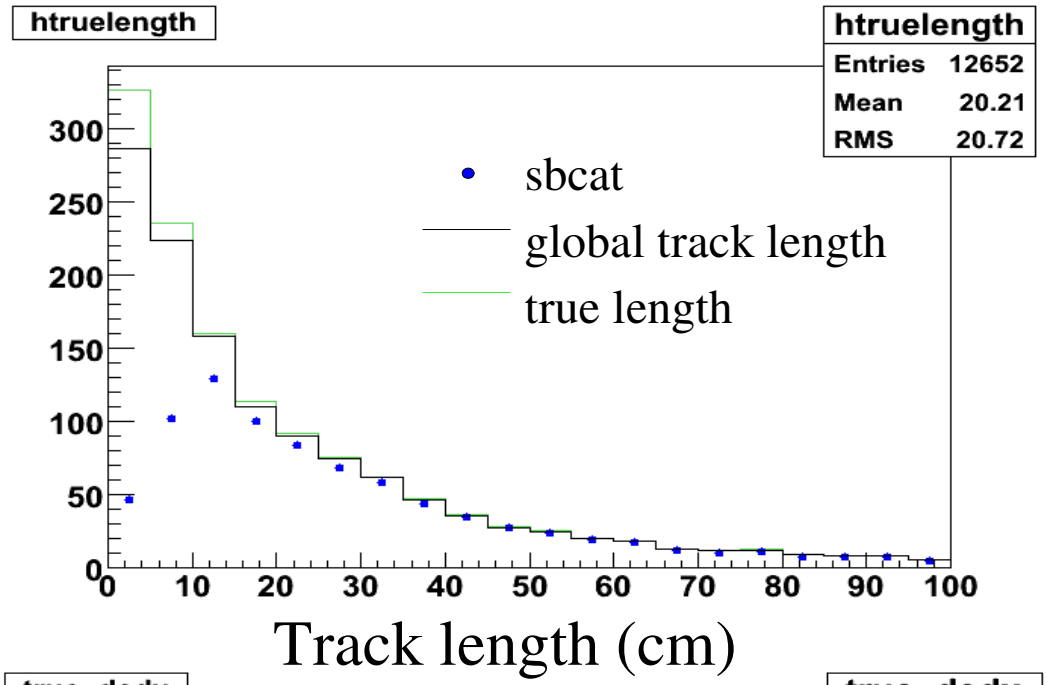
Blue hits = track

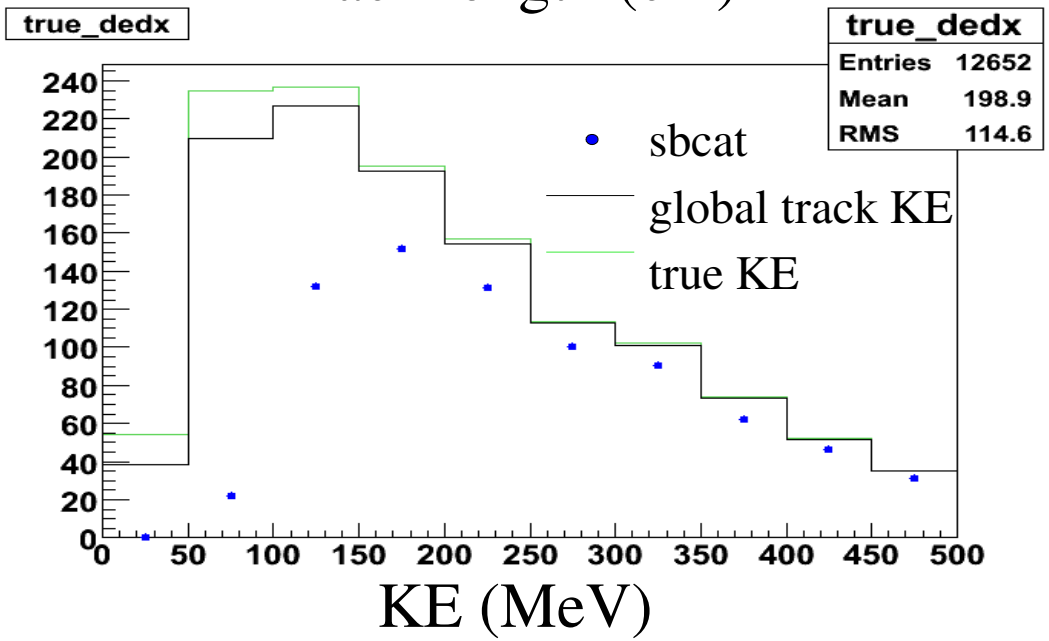
Red hits = off track

Green hits = not used



Benefits of using this method





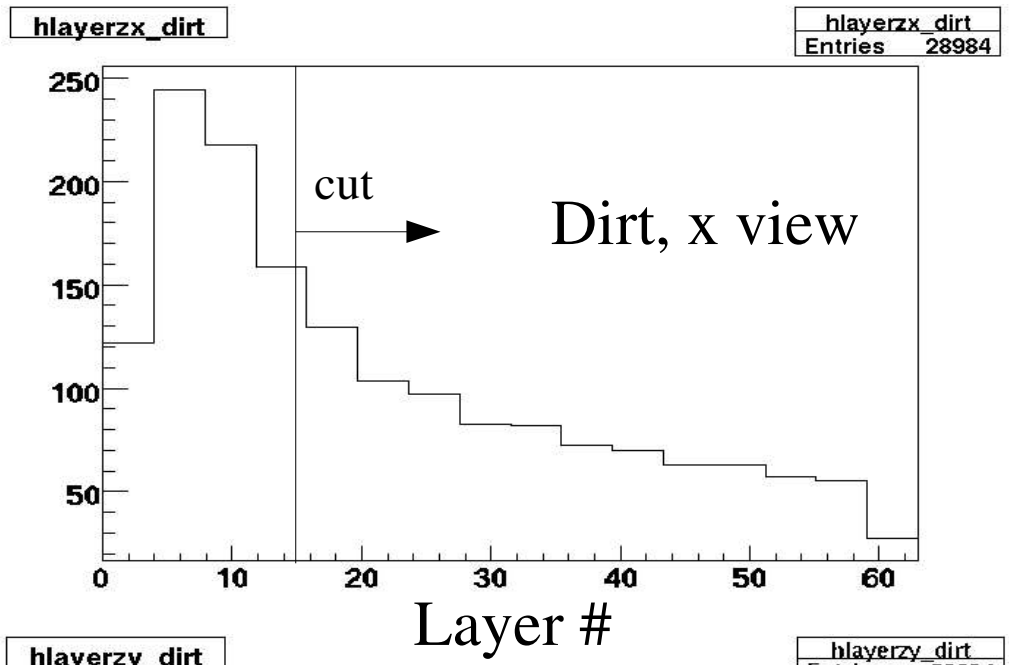
- Looked at MC sample of 17431 NC (p) events and compared global tracking to sbcat
- Global tracking method found proton tracks in 12403 events, sbcat found proton tracks in 8097 events
- The extra protons were mostly in the low energy region (<200MeV)

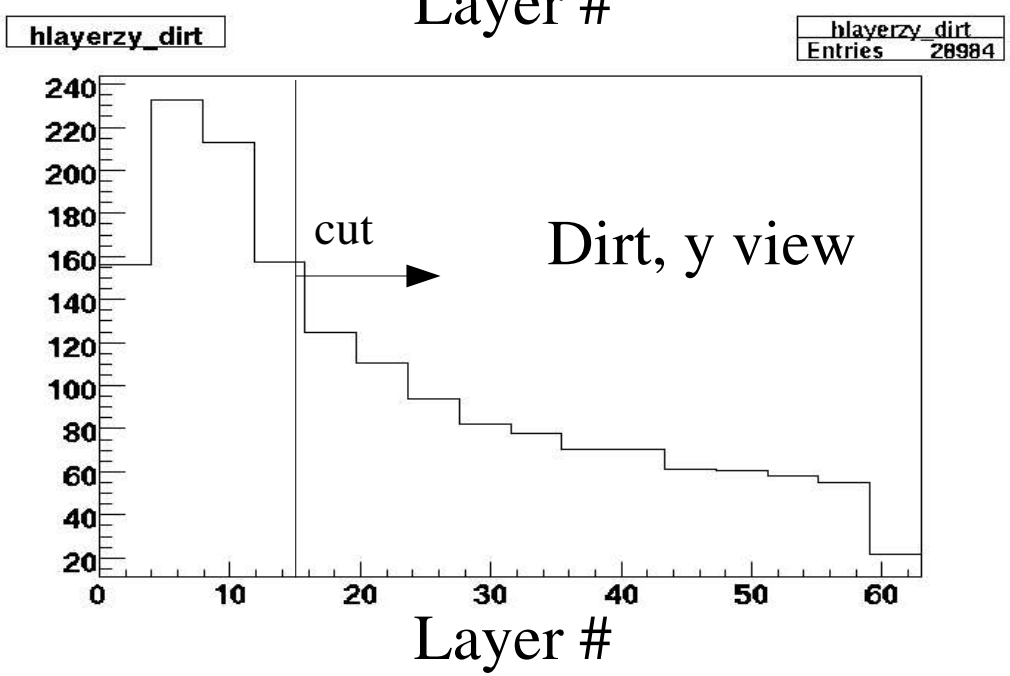
NC elastic analysis

- Using MA = 1.1 NEUT data
- Apply four cuts:
  - At least 2 hits w/ >= 10 pe's/view
  - Veto cut (<= 1 hit within region defined by abs(x or y) >= 130 and z within first two or last two layers)
  - Michel cut
  - dE/dx cut (divided sample into five regions of different track length, applied separate minimum dE/dx value for each region)

	Data	Dirt	MC total	NC(p)	NC(n)	NC pi	CCQE	CC pi	Other
# of events	8937	1617	5285	**3313**	**660**	830	342	62	5
Fraction		23.4%		**48.0%**	**9.6%**	12.0%	5.0%	1.0%	0.0%

Dirt and detector MC fitting



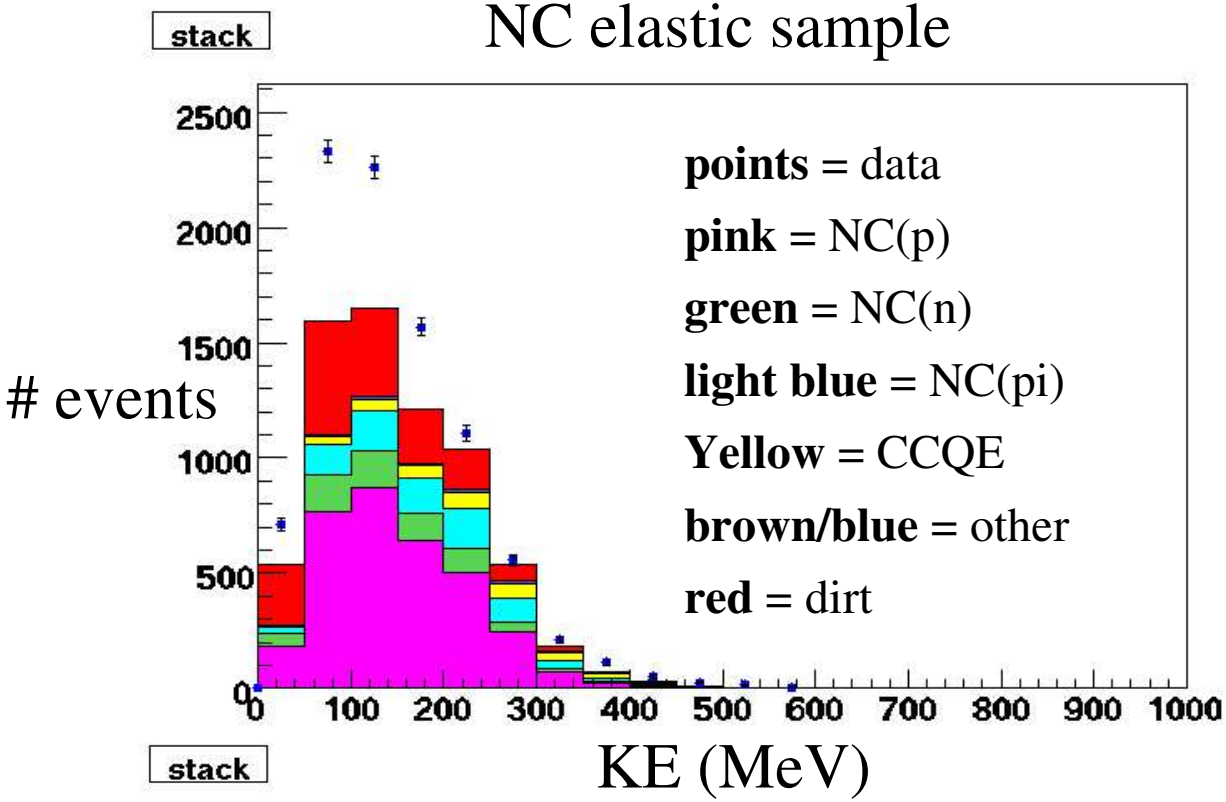


Looked at three different samples: whole NC sample, layer <= 15 (x view), layer <= 15 (y view)

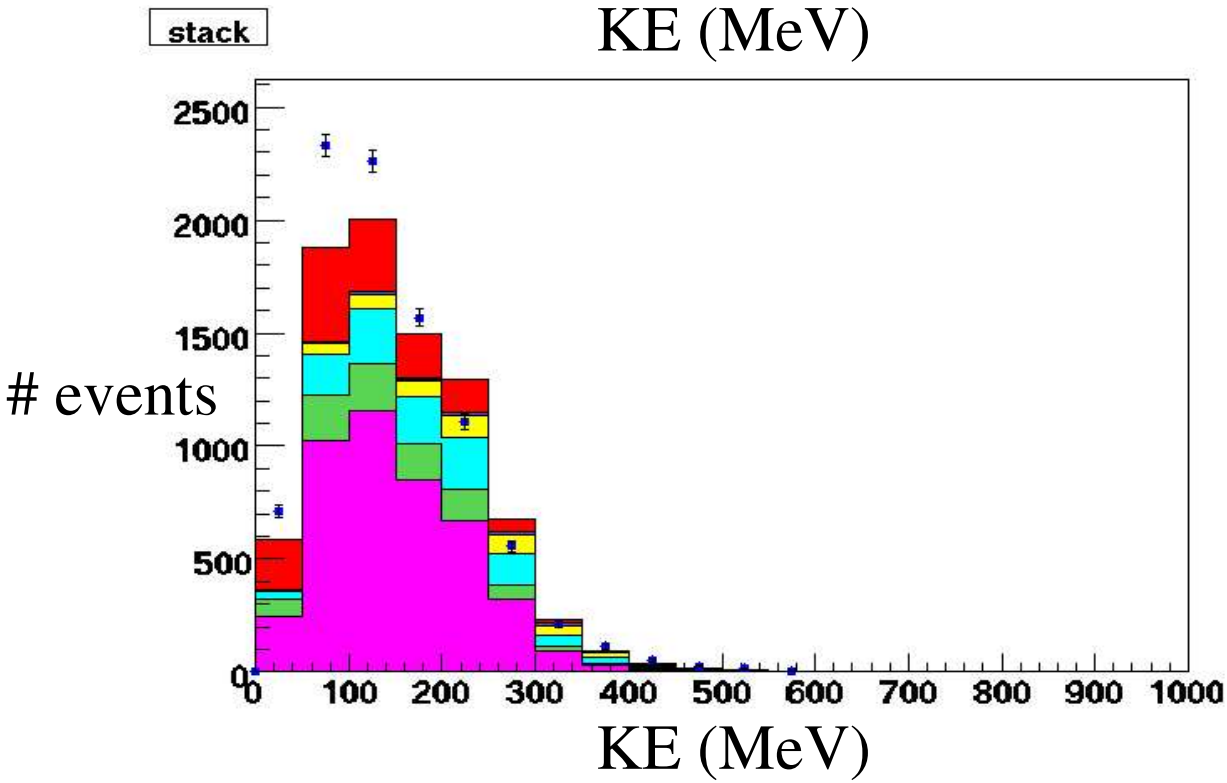
Made 2D fits of detector MC + dirt to data for each of the three samples

Obtained scaling factors for dirt and detector MC:
Dirt scaling factor = 0.84
Detector MC scaling factor = 1.33

NC elastic sample



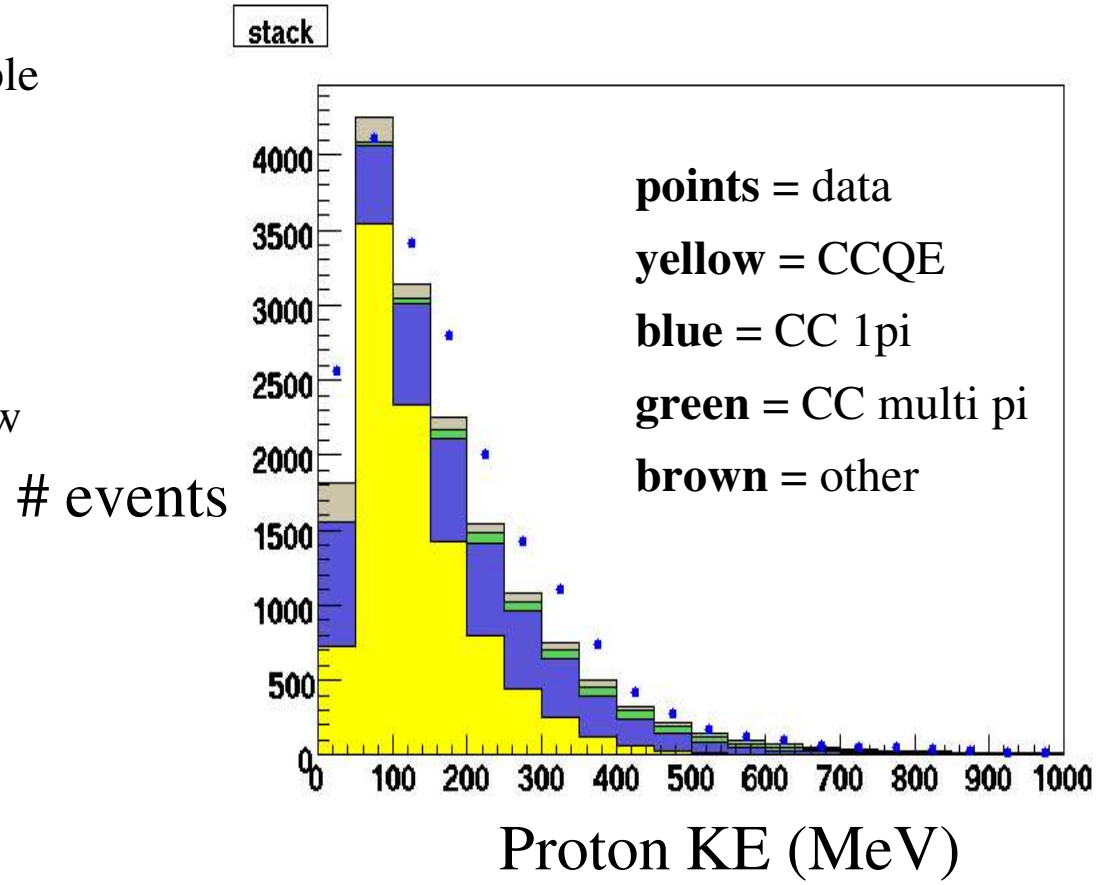
KE distribution with no scaling factors applied



KE distribution with scaling factors of 1.33 and 0.84 applied to detector MC and dirt samples, respectively

CCQE sample

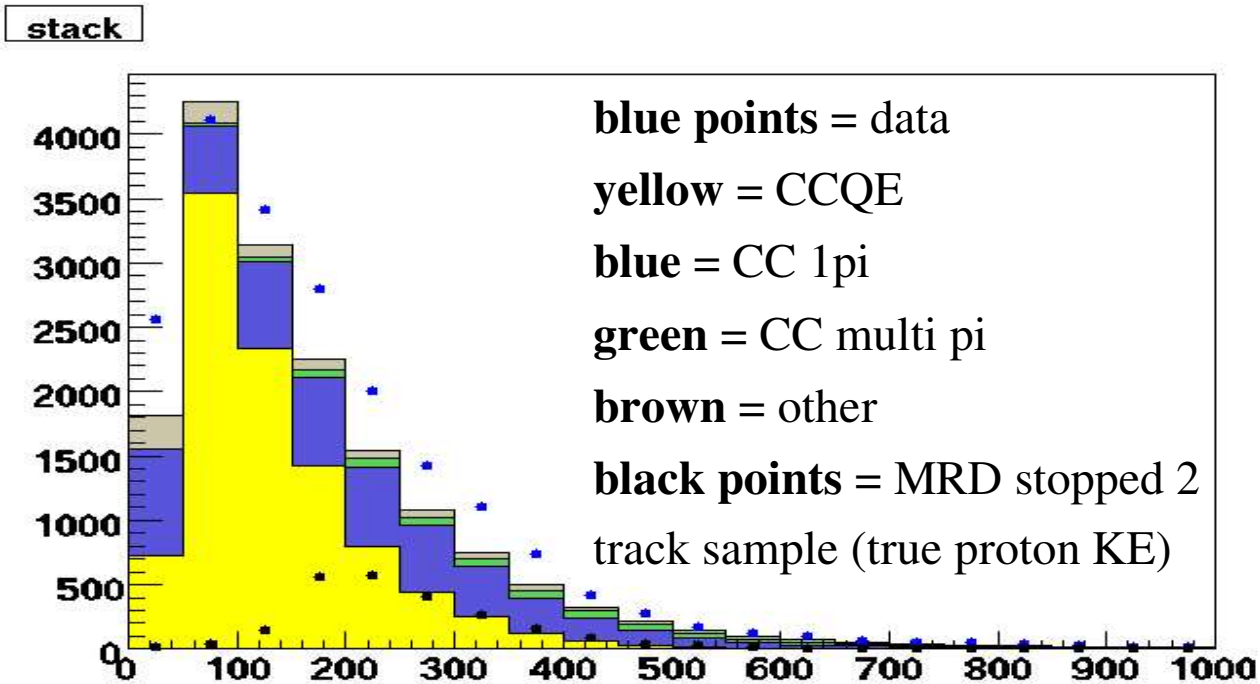
- Using code from Nakaji to generate sample similar to Jose's MRD stopped sample
- Removing muon track hits and using my tracking program to find remaining track
- Applying one cut: >= 3 track hits per view



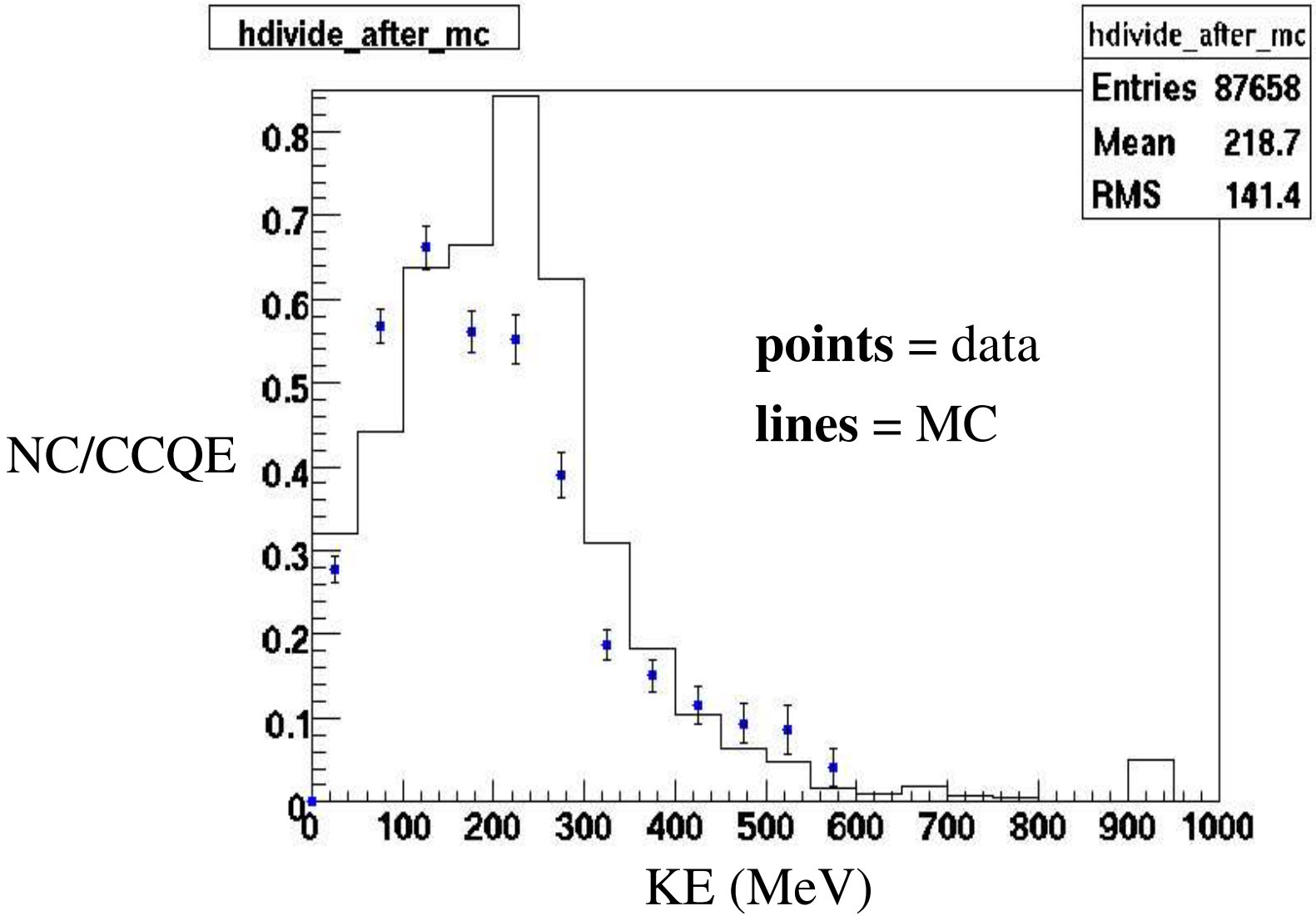
	# of events	fraction
Data	19570	
MC total	16447	
CCQE	**9758**	**59.3%**
CC 1pi	5018	30.5%
CC multi pi	627	3.8%
Other	1042	6.3%

Finding proton track in CCQE events

- In order to find the proton KE in CCQE events I had to first remove the muon track (found with sbcat) and then apply the global tracking to the remaining hits
- I did not remove any hits within 10cm of the vertex, these hits could potentially belong to proton



NC/CCQE ratio in KE

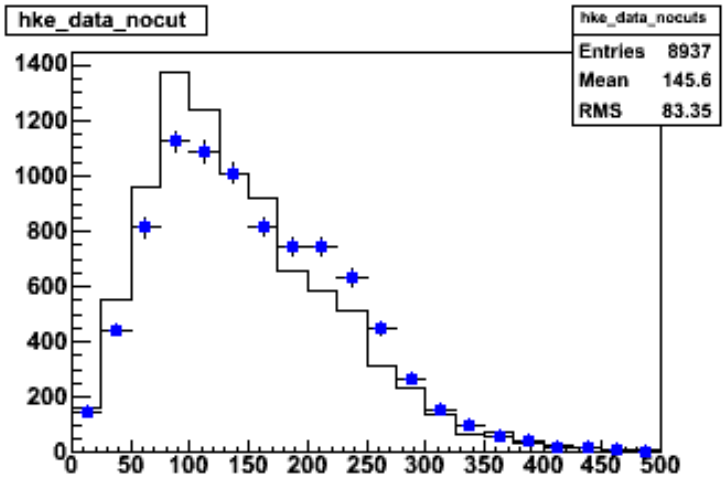


Conclusions

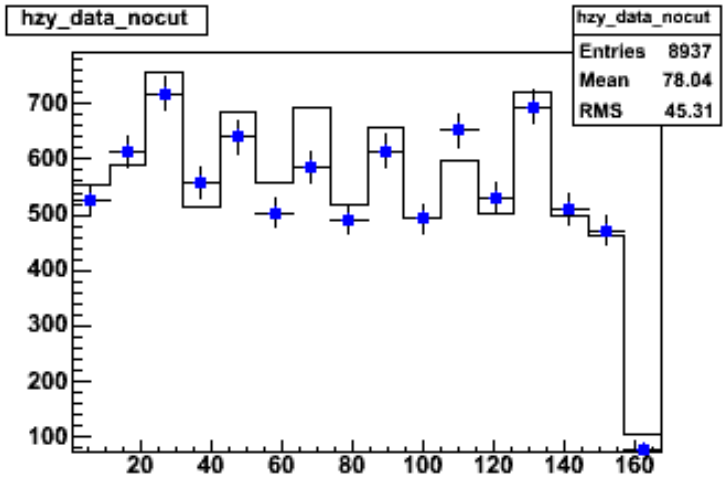
- Have found NC/CCQE in KE
- Will need to find out how different values of delta-s change the NC elastic distribution, in order to do this I will need to figure out how to re-weight the NC elastic MC sample

Backup slides

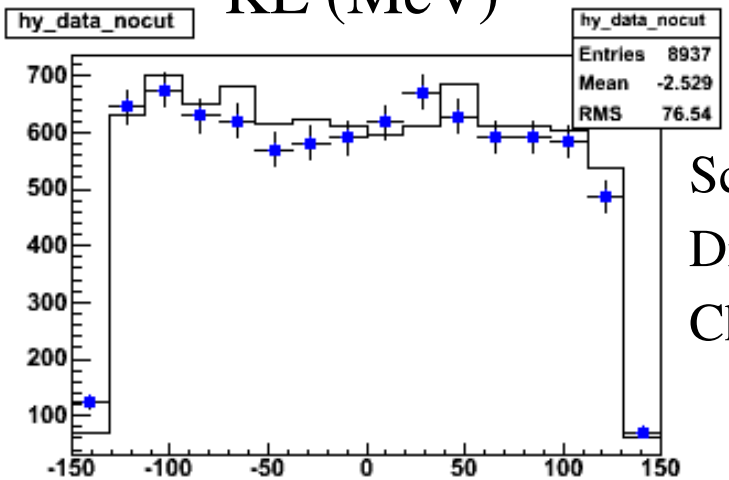
Plots made using scaling factors from z-y 2D distribution



KE (MeV)



Z



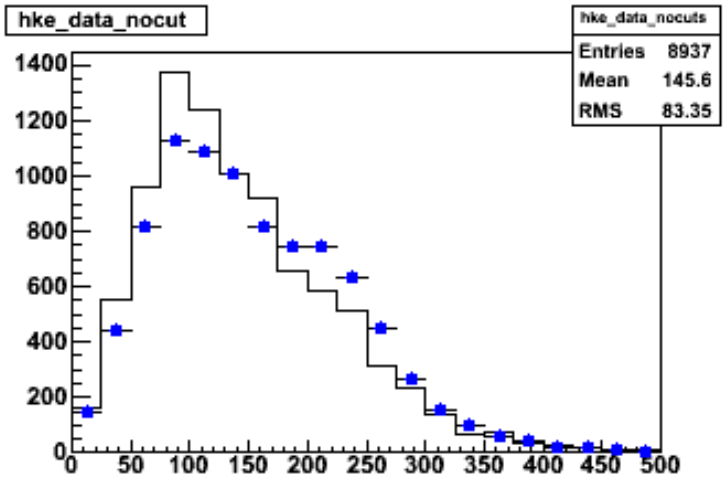
Y

Scaling factors from 2D z-y: Det. MC = 1.44+-0.04,

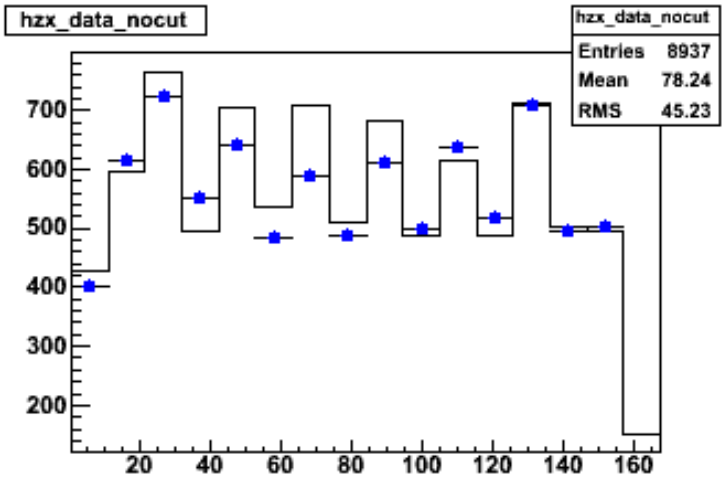
Dirt MC = 0.67+-0.14

Chi^2 = 235, dof = 141

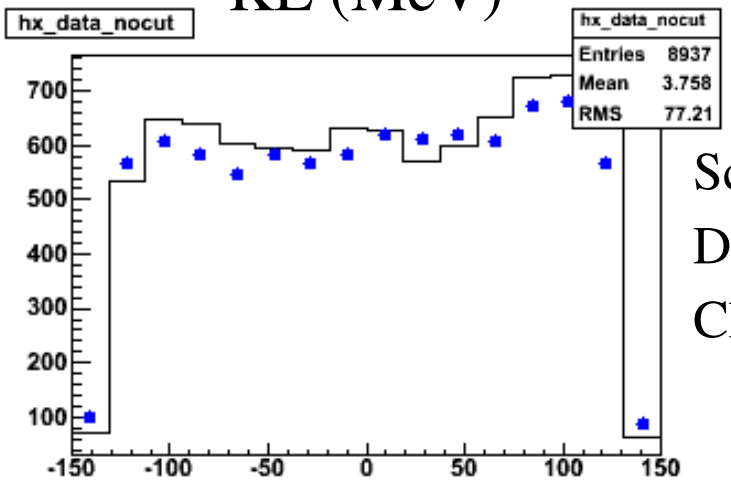
Plots made using scaling factors from z-x 2D distribution



KE (MeV)



Z



X

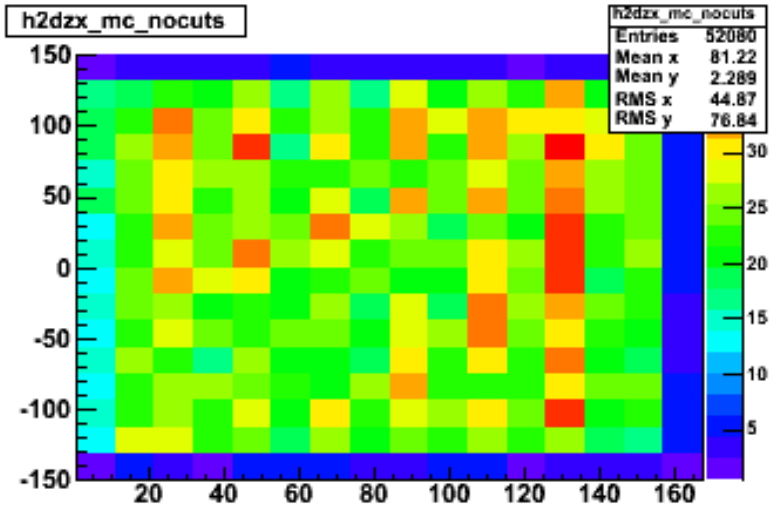
Scaling factors from 2D z-x: Det. MC = 1.43+-0.04,

Dirt MC = 0.66+-0.14

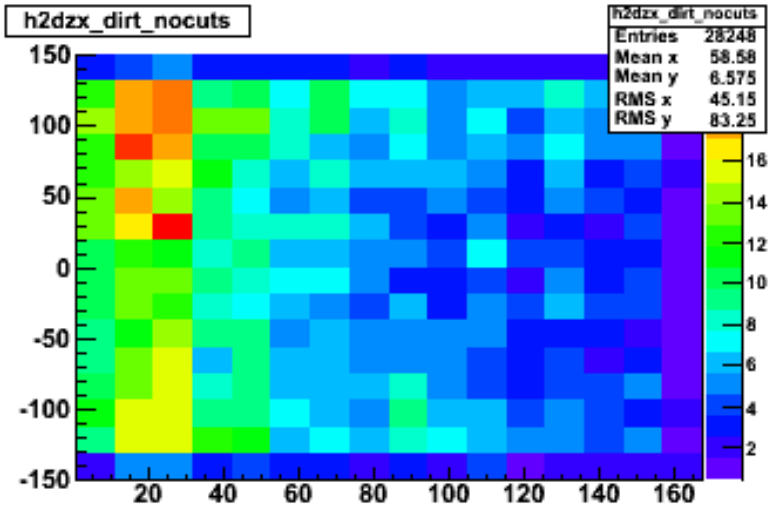
Chi^2 = 265, dof = 141

Whole NC sample (Z-X)

chi^2 = 264, MC det.: 1.43+-0.04, MC dirt: 0.66+-0.14

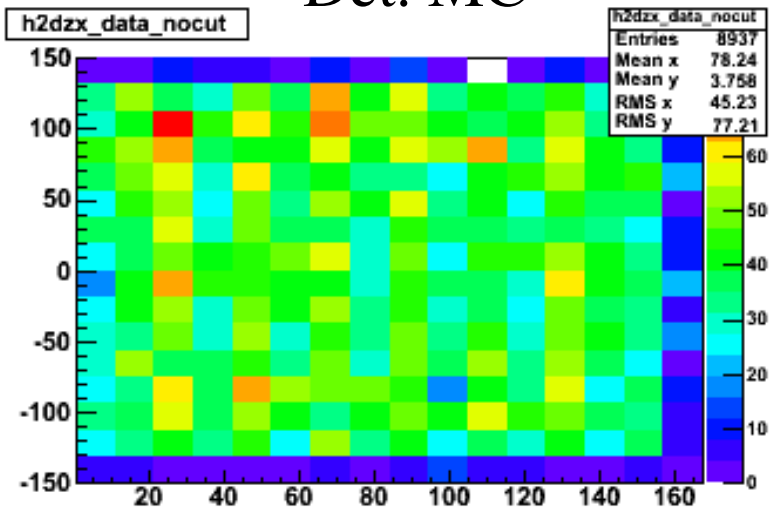


Det. MC

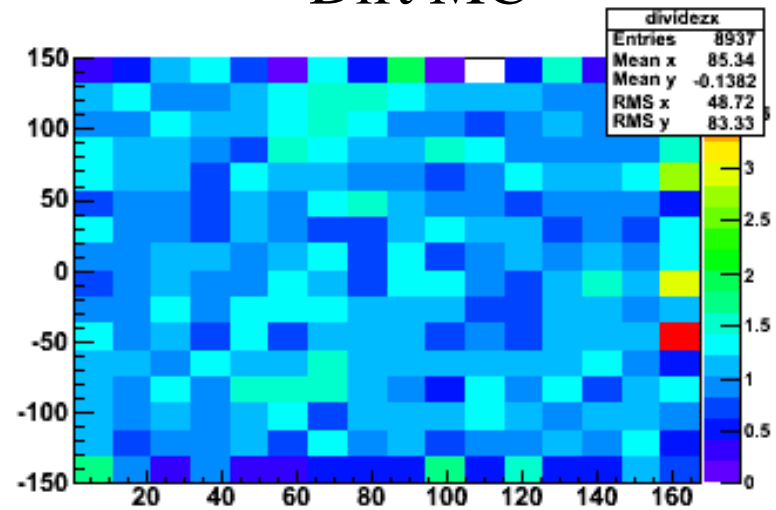


Dirt MC

X



Data

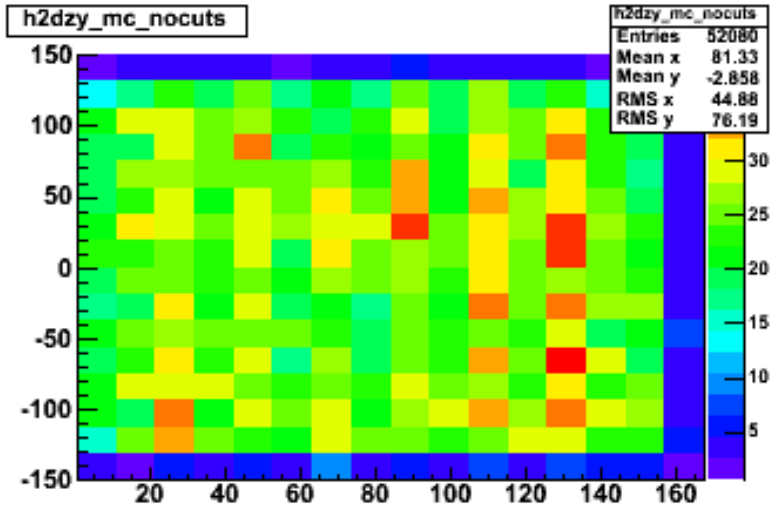


Data/(dirt + det. MC)

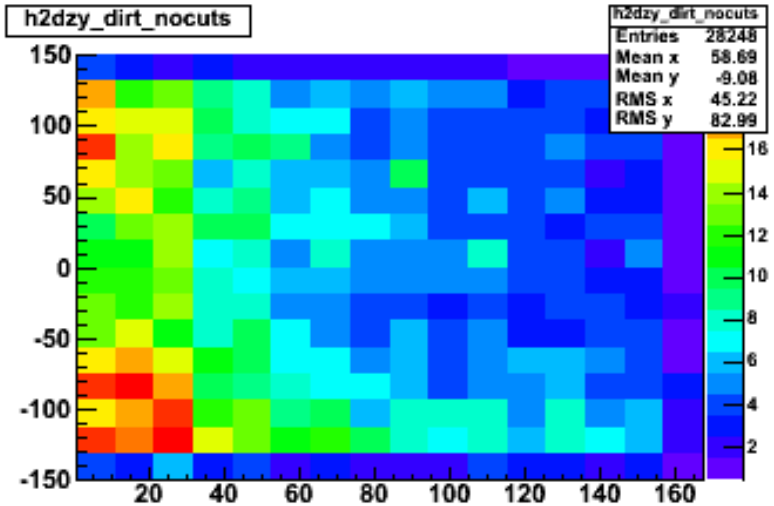
Z

Whole NC sample (Z-Y)

chi^2 = 235, MC det.: 1.44+-0.04, MC dirt: 0.67+-0.14

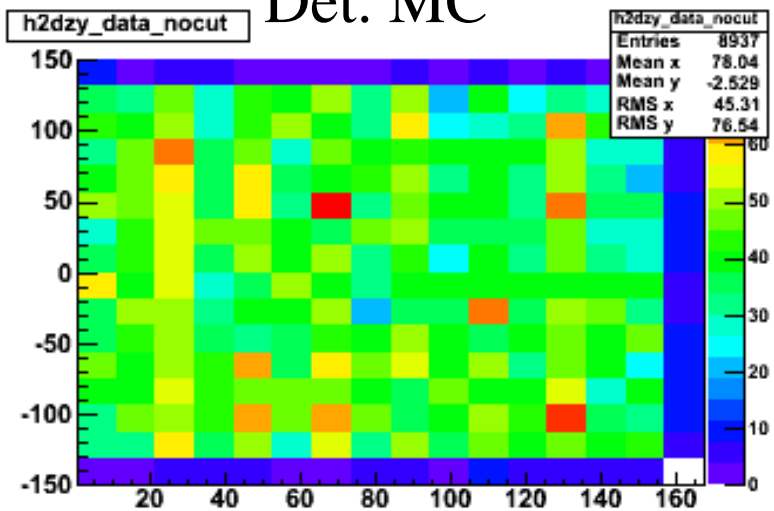


Det. MC

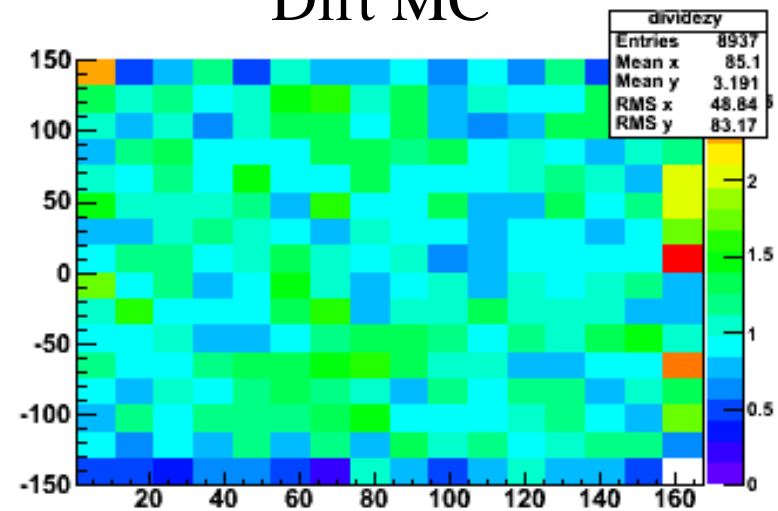


Dirt MC

Y



Data

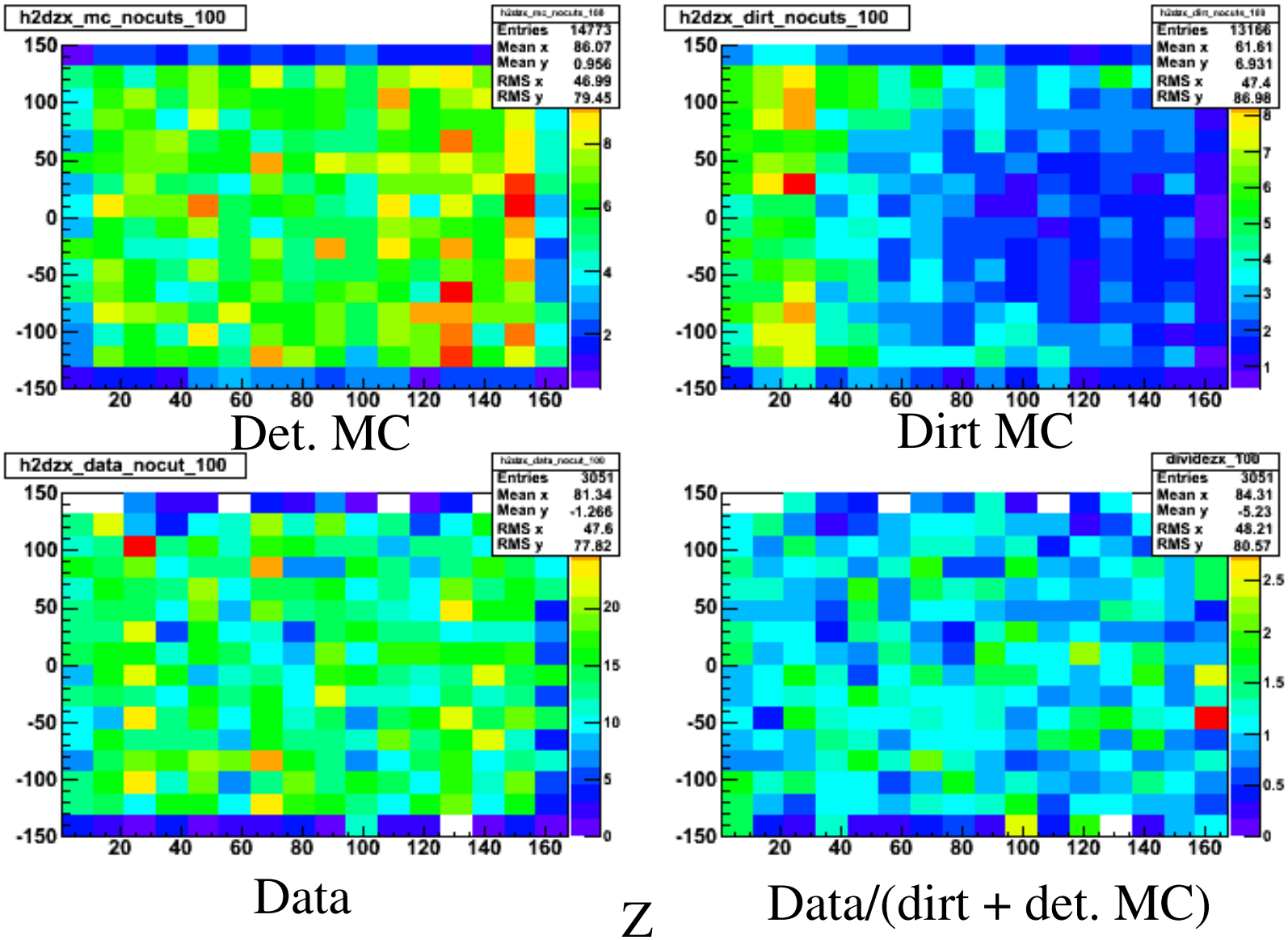


Data/(dirt + det. MC)

Z

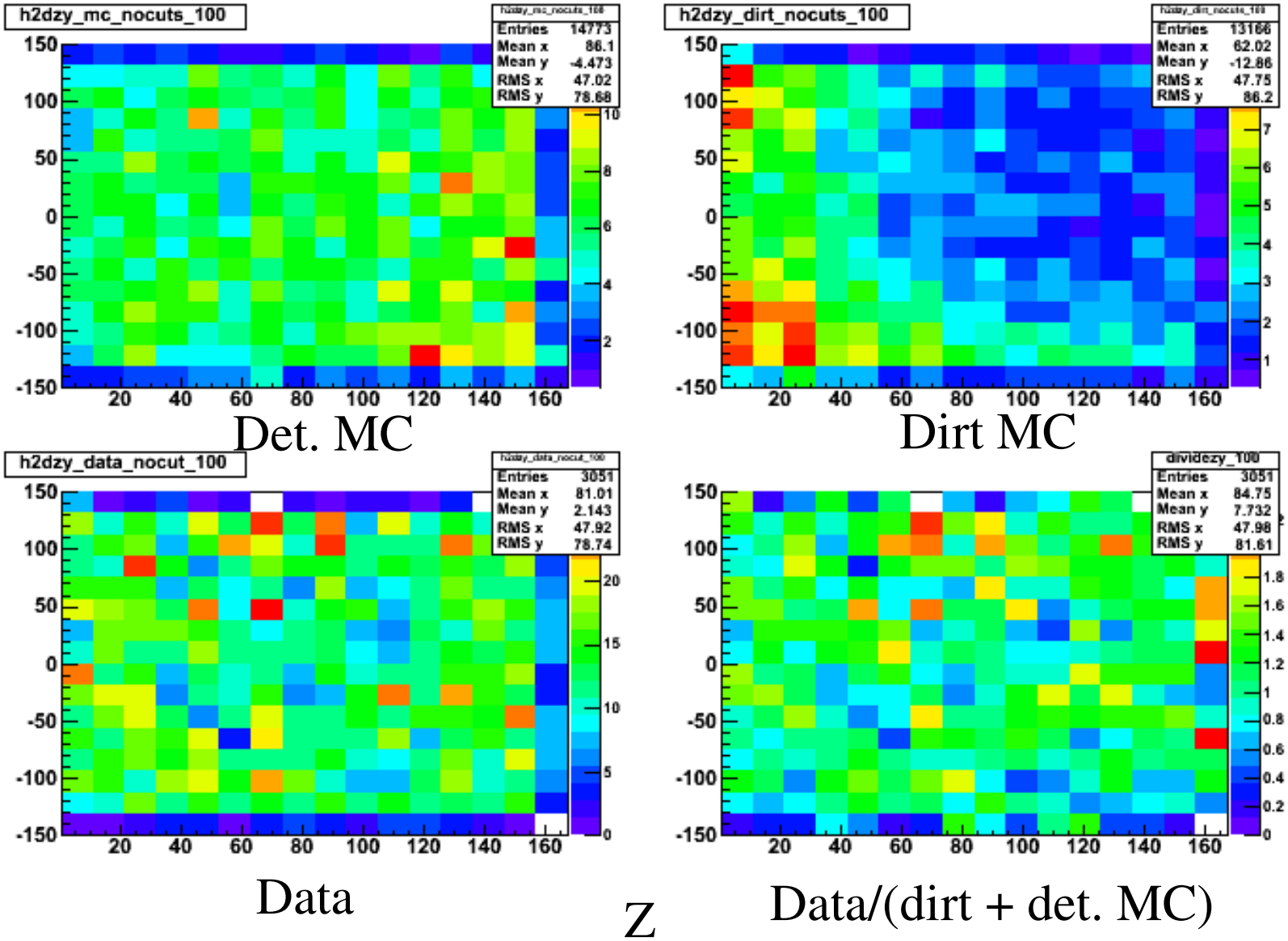
NC sample (Z-X) < 100MeV

chi^2 = 194, MC det.: 1.75+-0.10, MC dirt: 0.67+-0.18



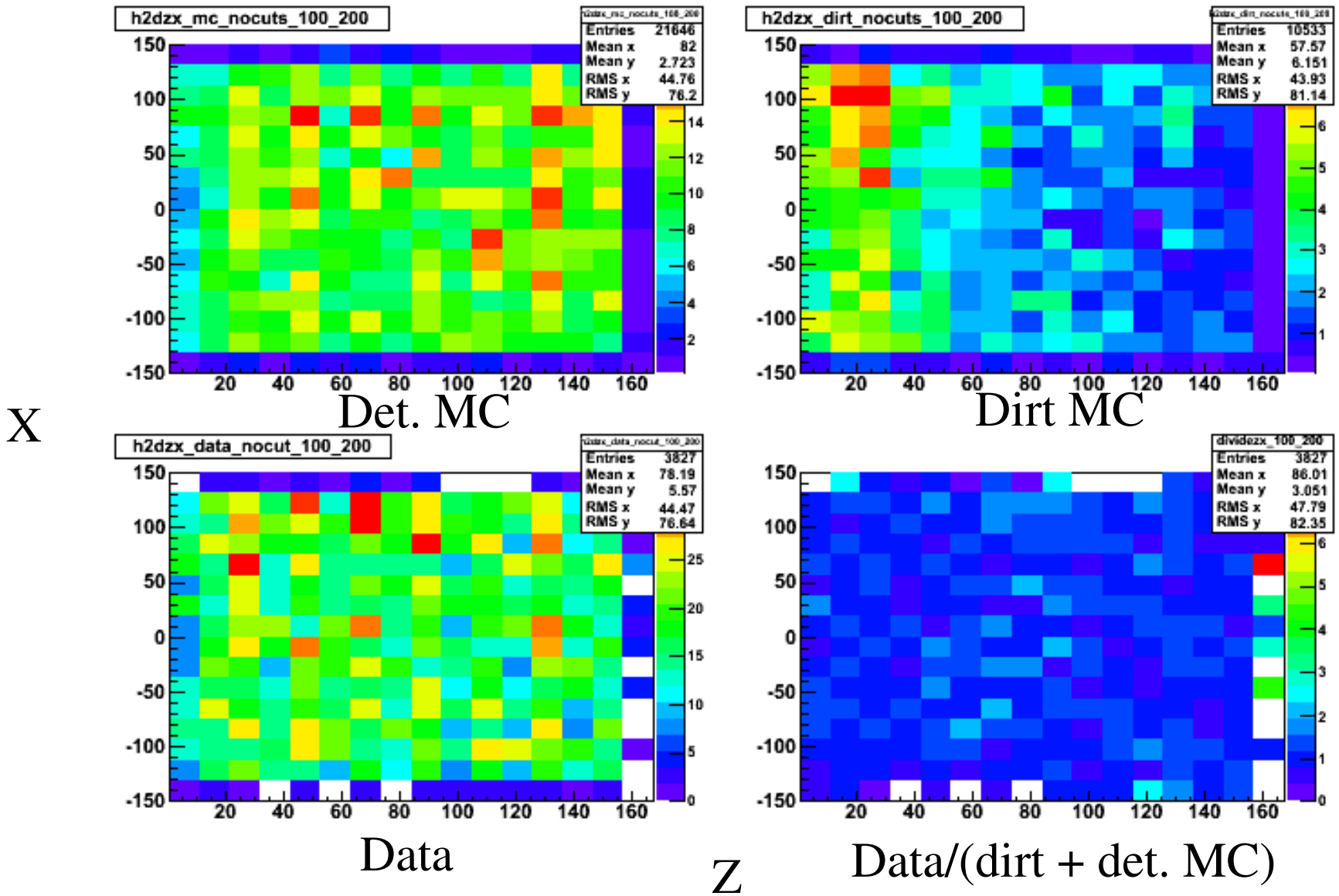
NC sample (Z-Y) < 100MeV

chi^2 = 229, MC det.: 1.62+-0.12, MC dirt: 0.76+-0.22



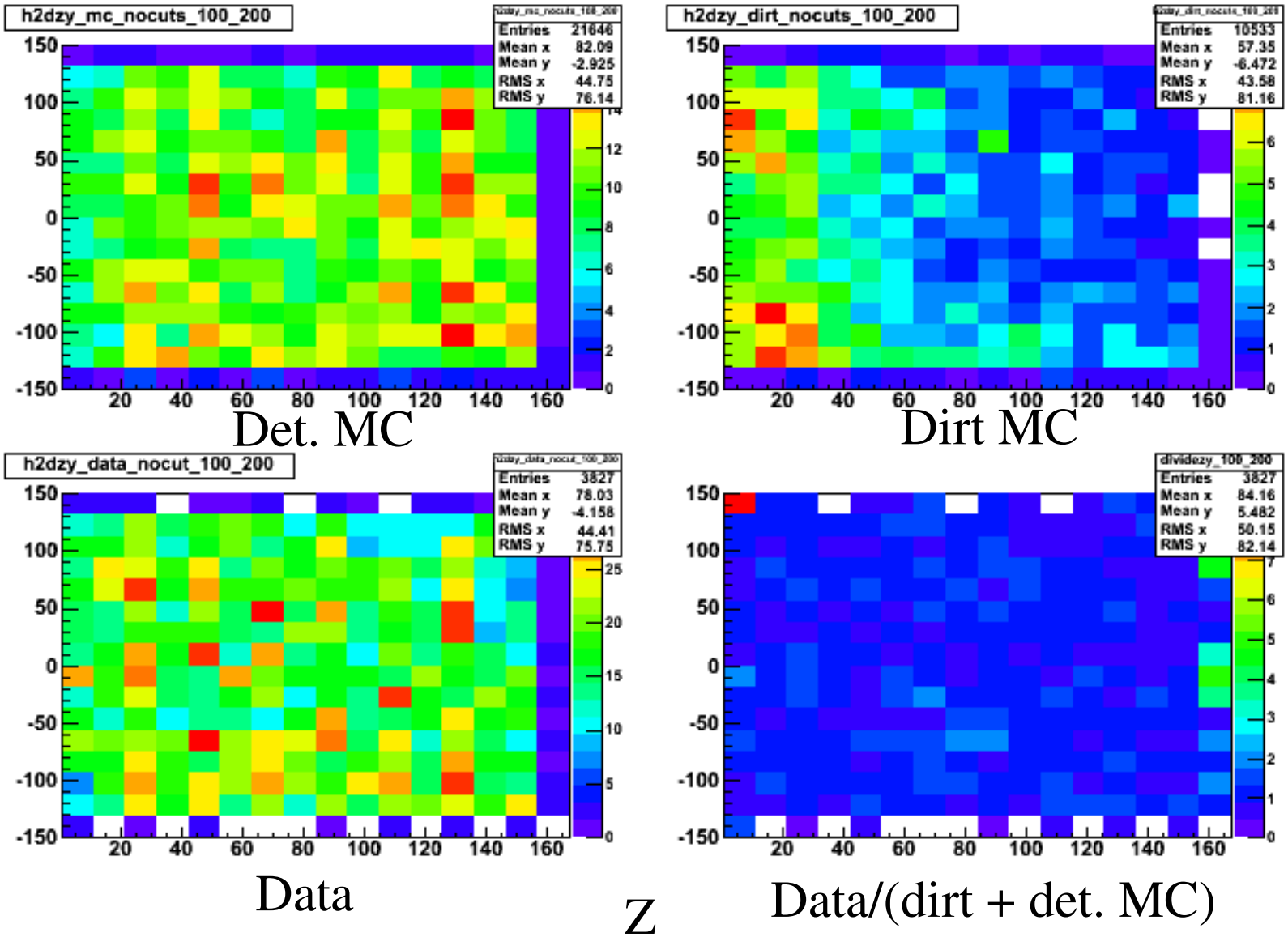
NC sample (Z-X) between 100 and 200MeV

chi^2 = 228, MC det.: 1.33+-0.07, MC dirt: 0.95+-0.23



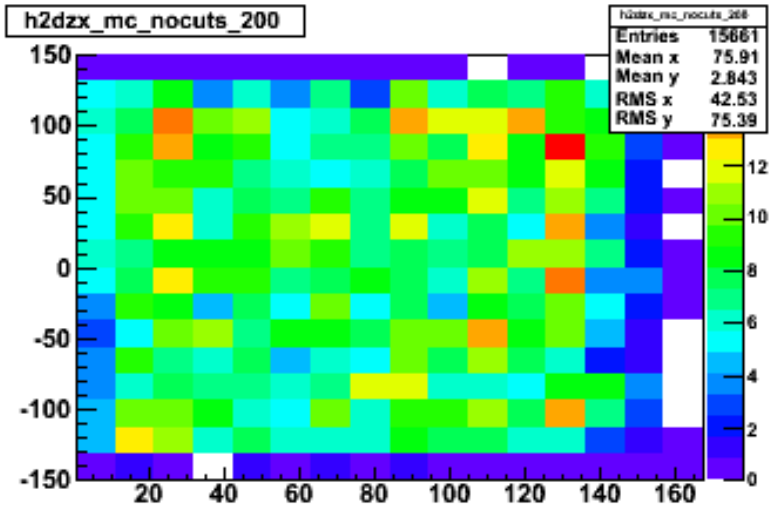
NC sample (Z-Y) between 100 and 200MeV

chi^2 = 196, MC det.: 1.41+-0.06, MC dirt: 0.87+-0.22

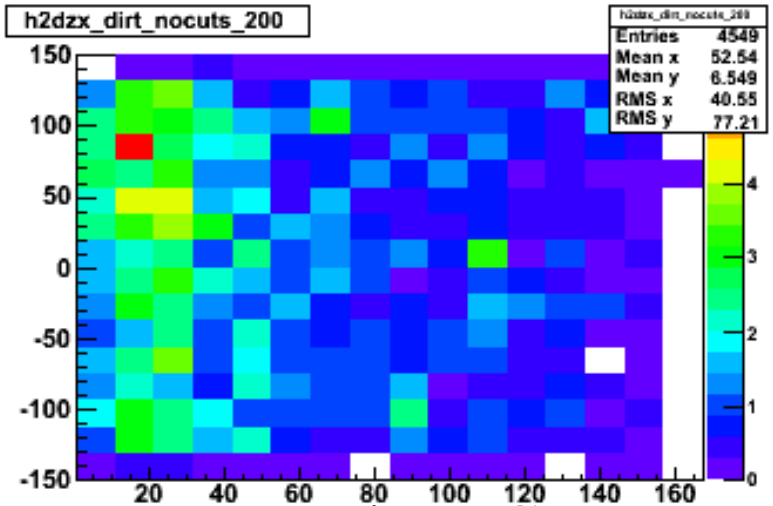


NC sample (Z-X) > 200MeV

chi^2 = 248, MC det.: 0.94+-0.05, MC dirt: 0.94+-0.35

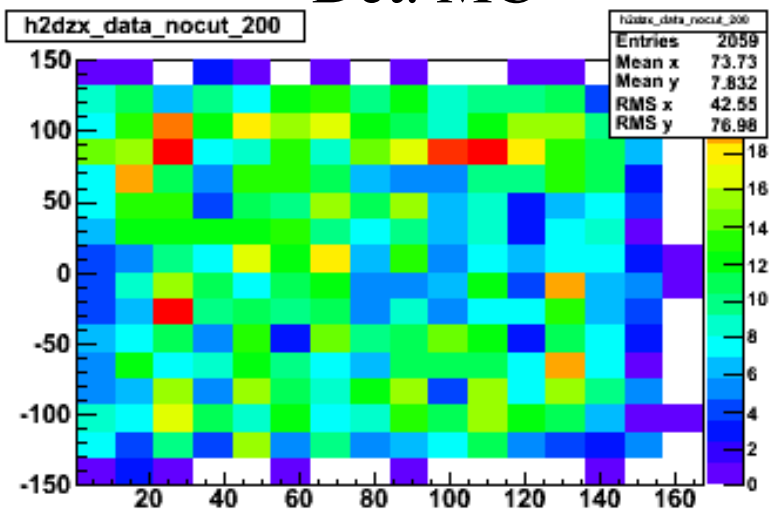


Det. MC

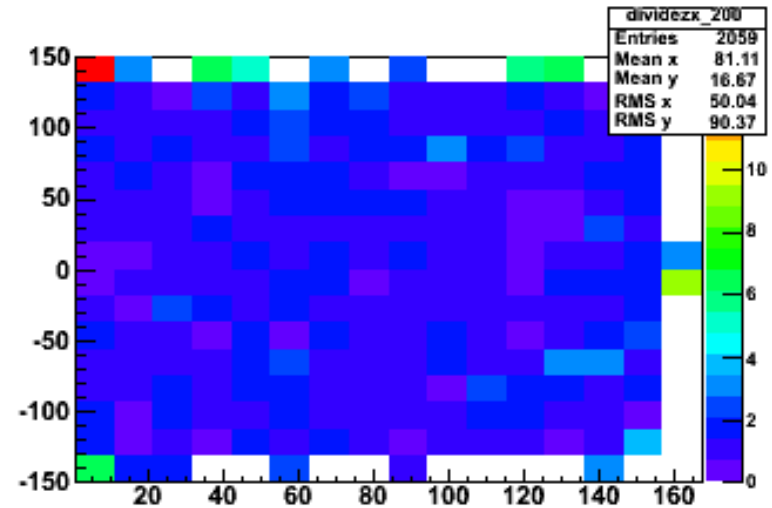


Dirt MC

X



Data

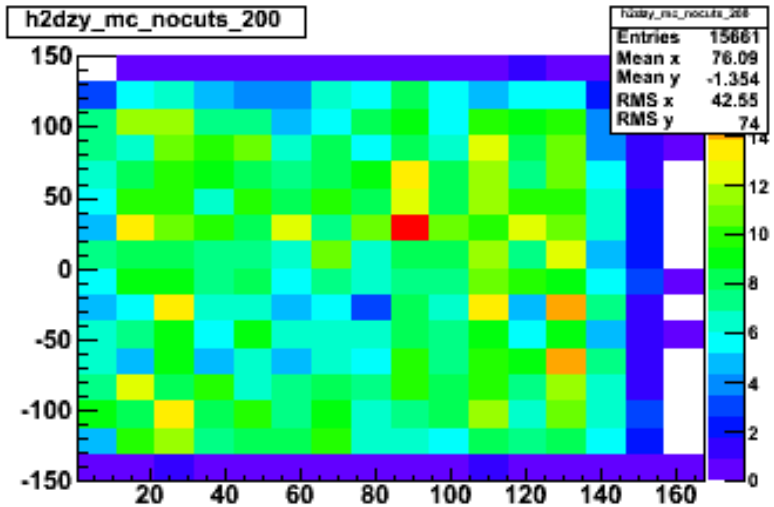


Z

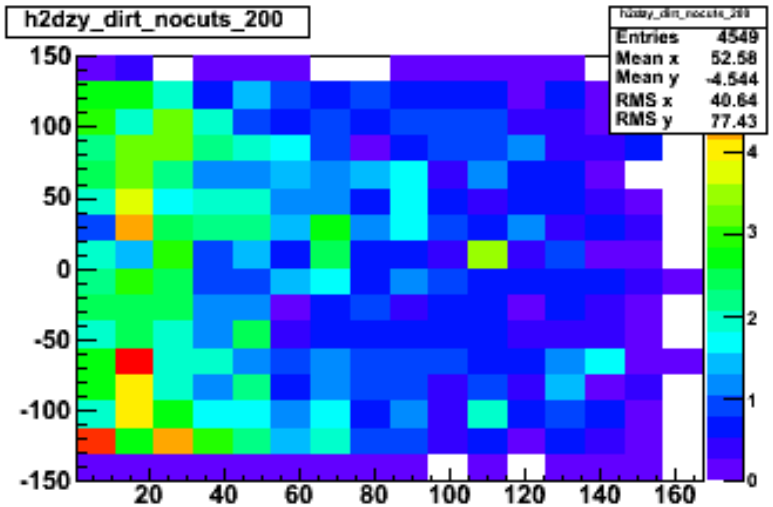
Data/(dirt + det. MC)

NC sample (Z-Y) > 200MeV

chi^2 = 228, MC det.: 1.02+-0.05, MC dirt: 0.58+-0.30

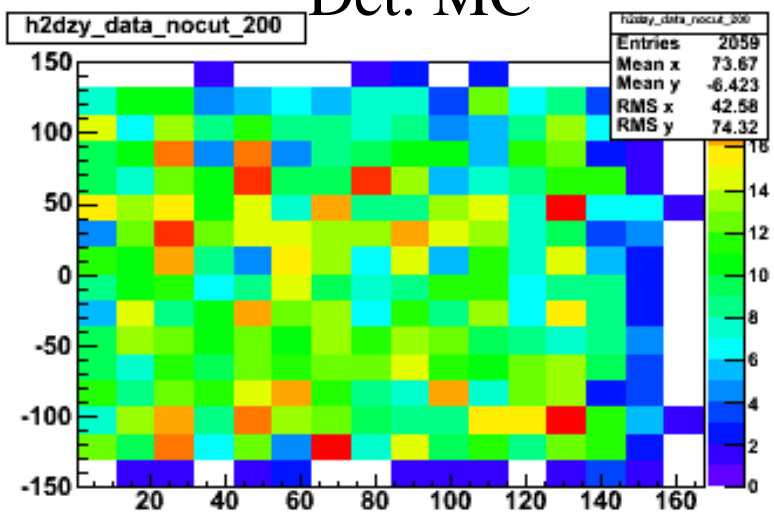


Det. MC

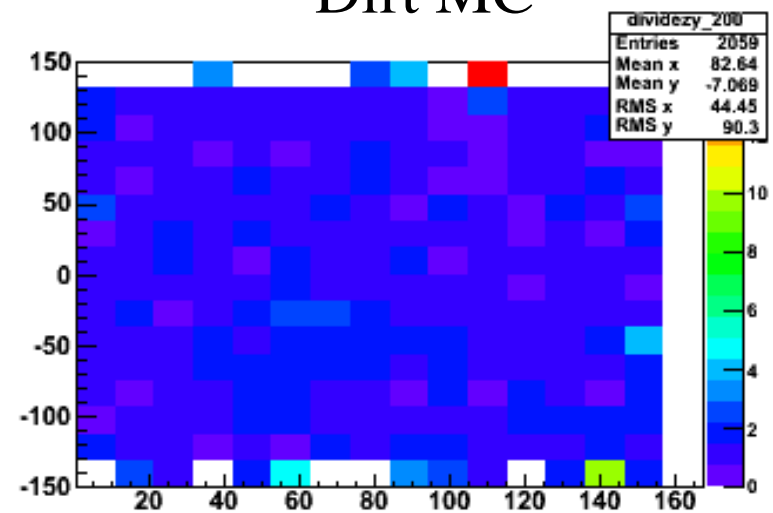


Dirt MC

Y



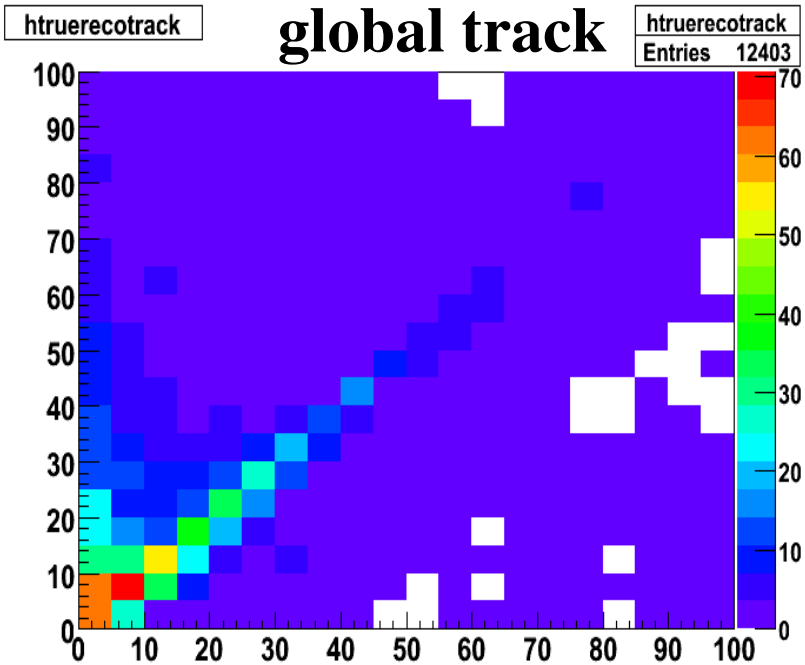
Data

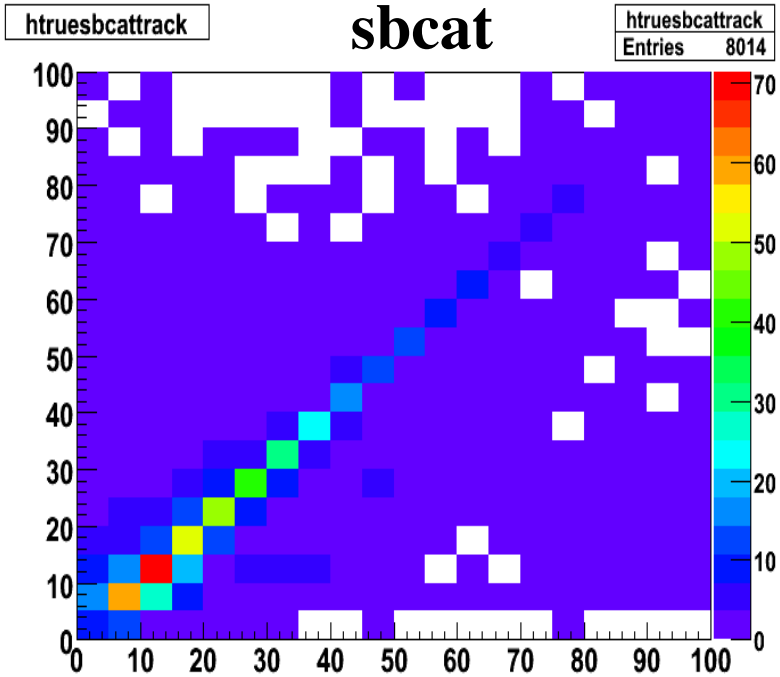


Z

Data/(dirt + det. MC)

Reco. track length (cm)

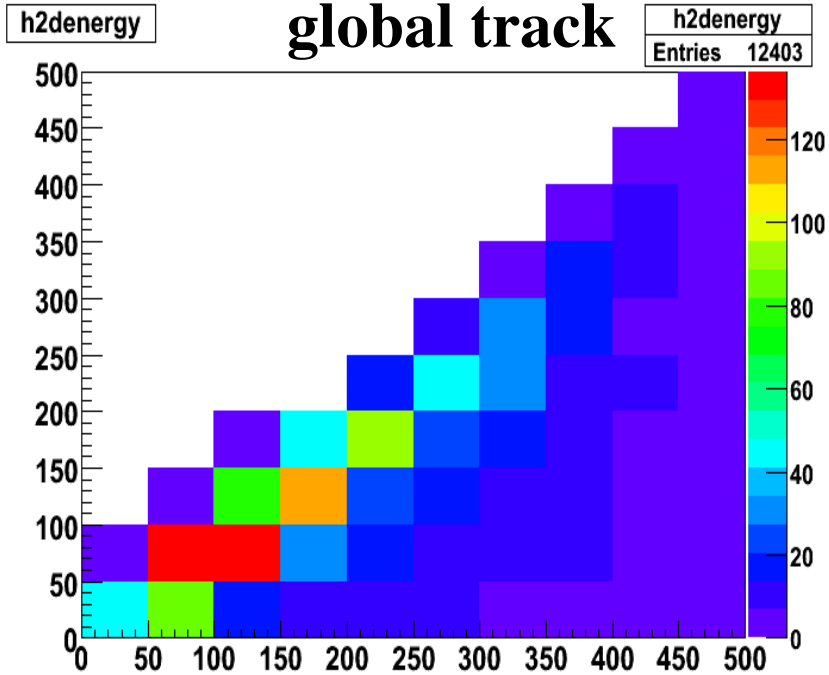


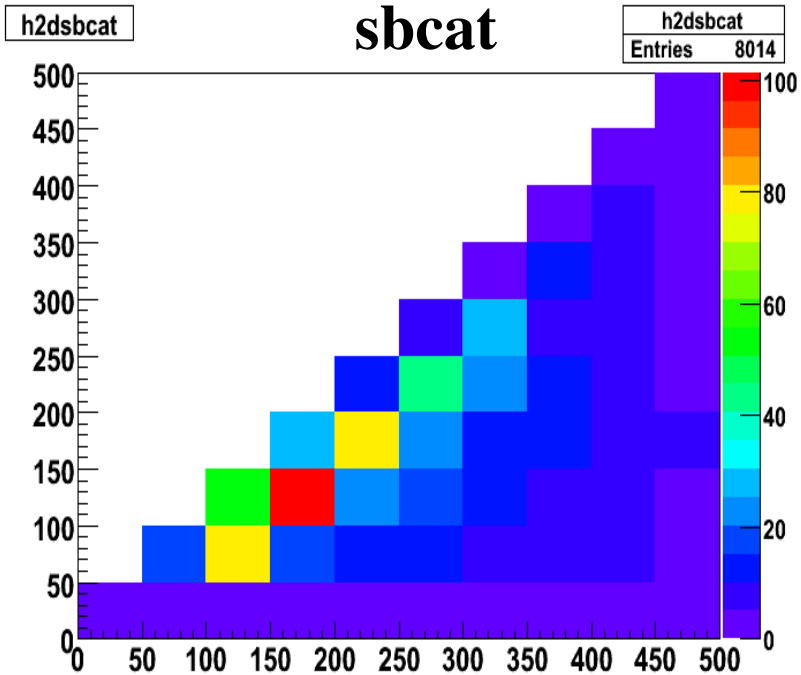


Track length (cm)

Track length (cm)

Reco. KE (MeV)

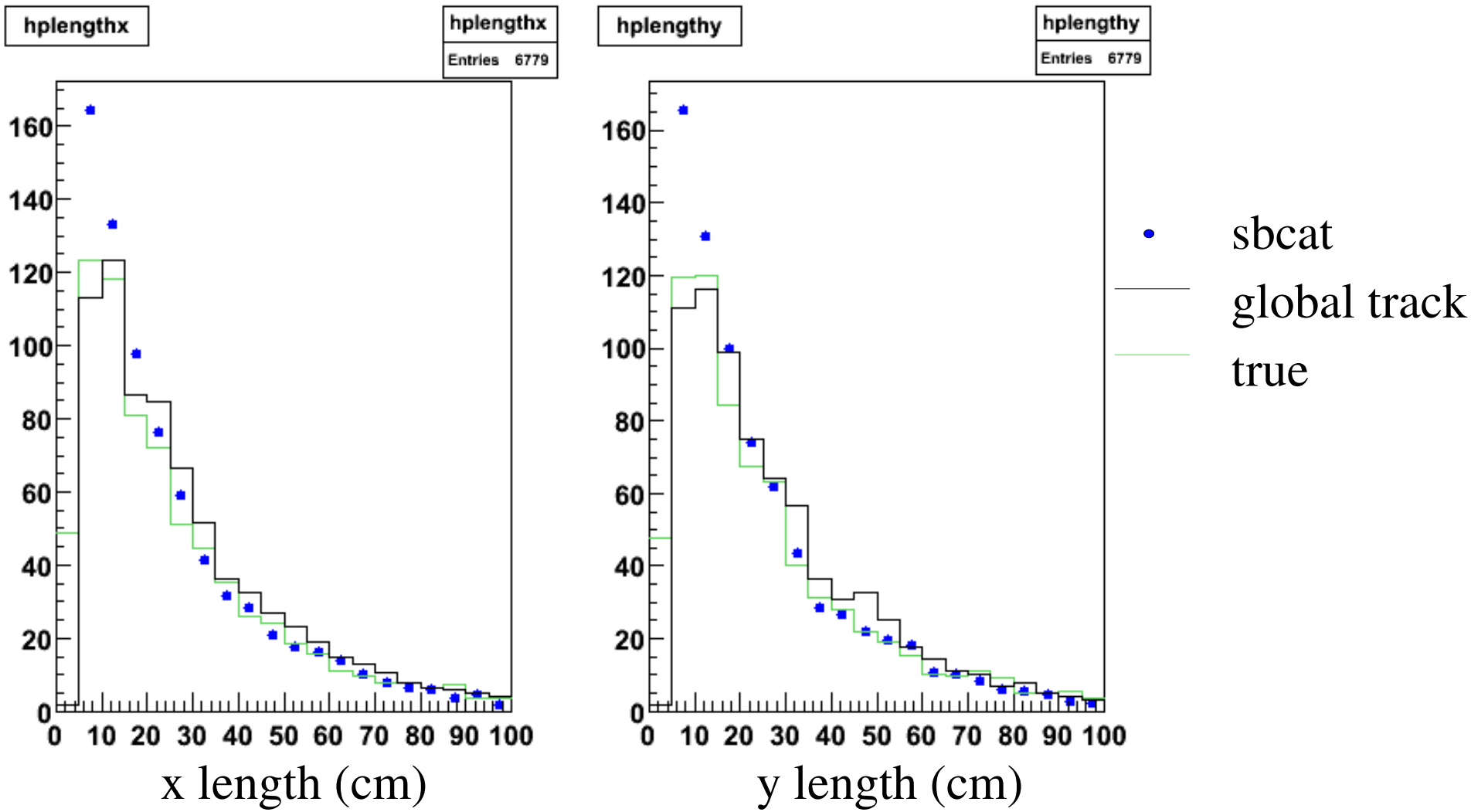




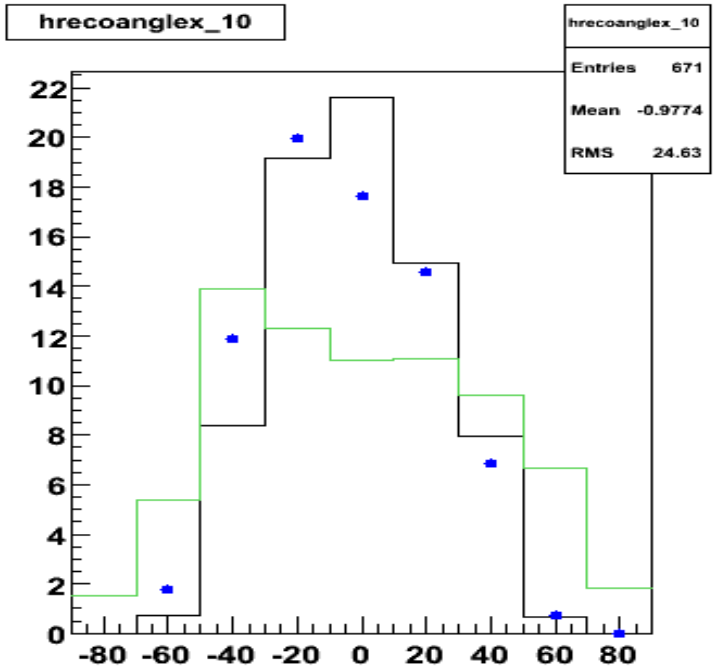
True KE (MeV)

True KE (MeV)

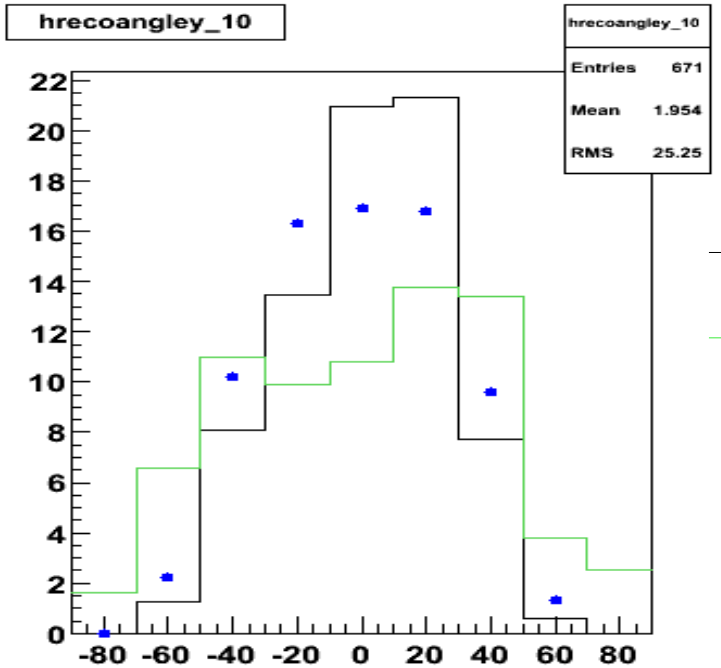
X and Y projection lengths



Track length < 10cm



x proj. angle (deg.)



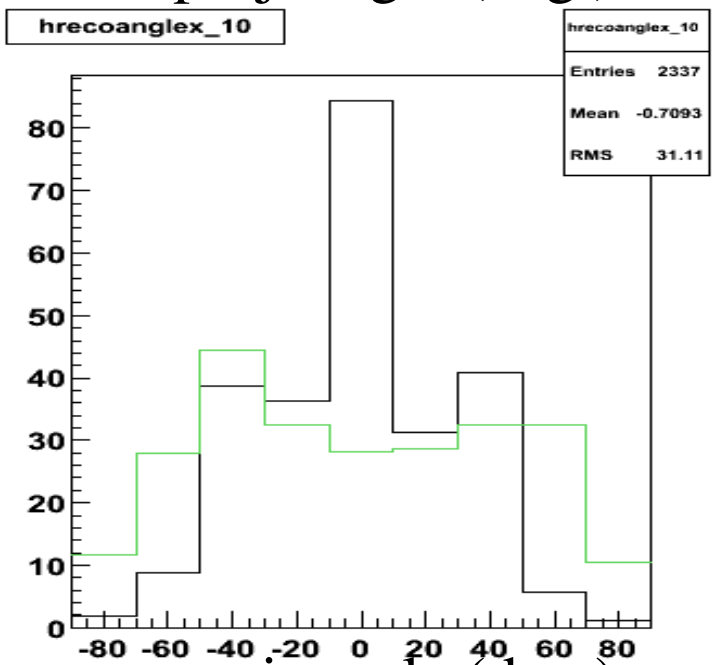
y proj. angle (deg.)

sbcat

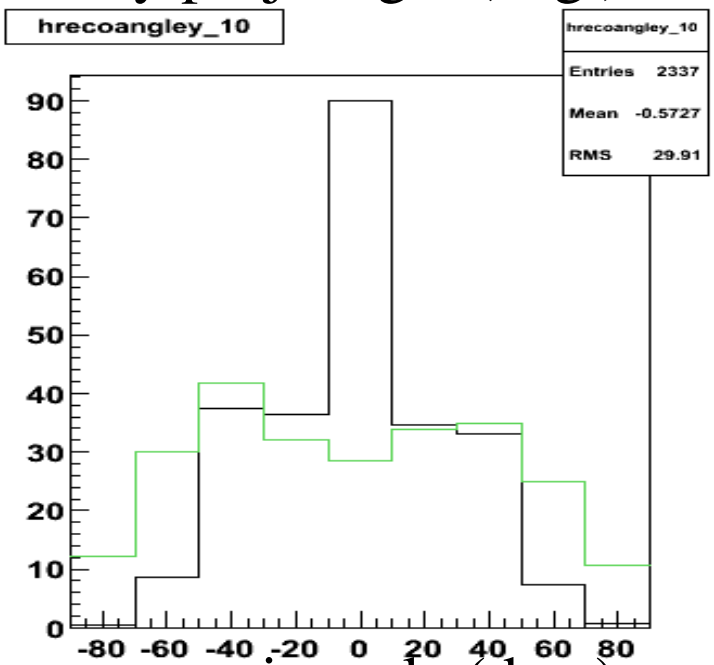
global track angle

true angle

sbcat sample



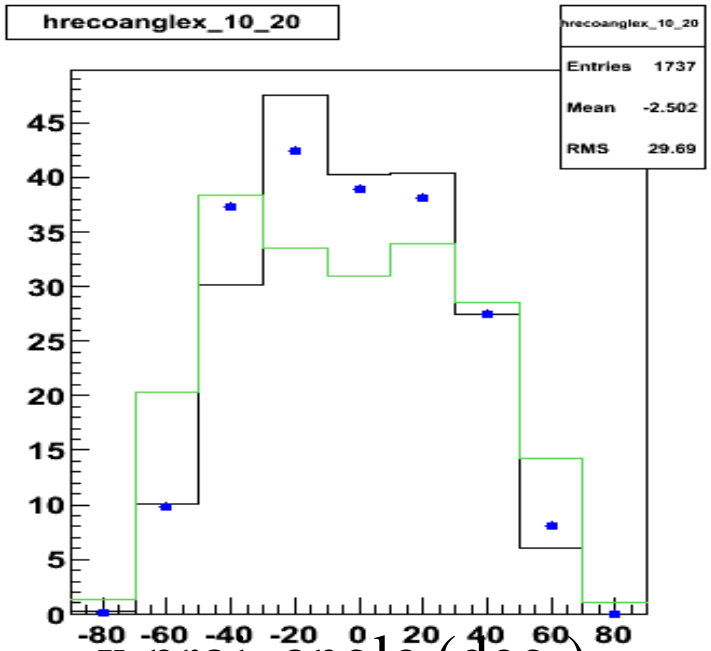
x proj. angle (deg.)



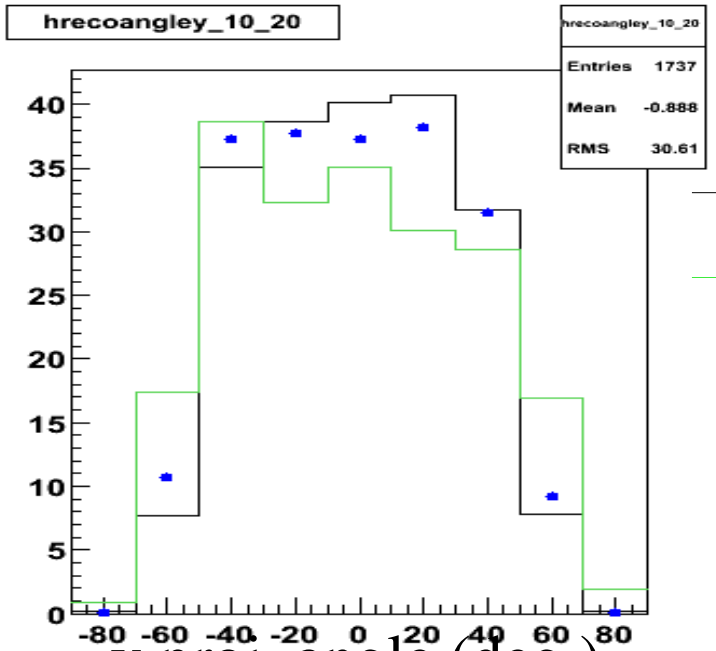
y proj. angle (deg.)

global sample

Track length between 10 and 20cm



x proj. angle (deg.)



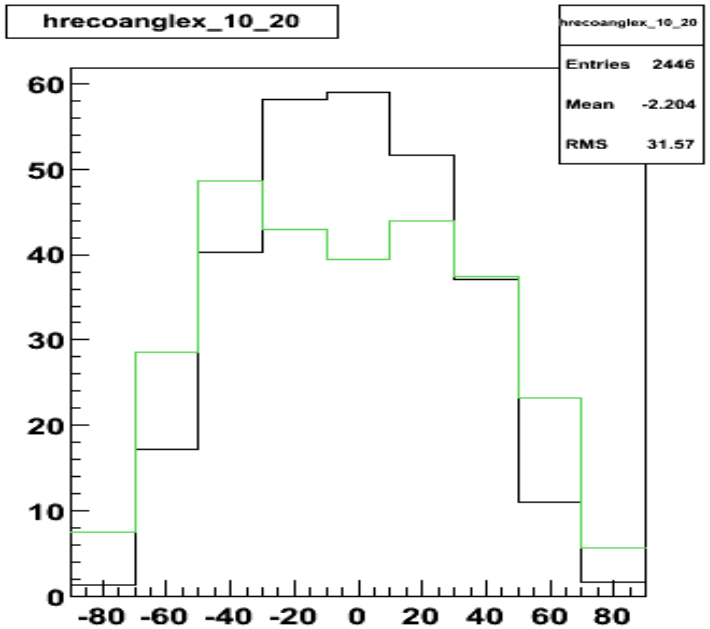
y proj. angle (deg.)

sbcat

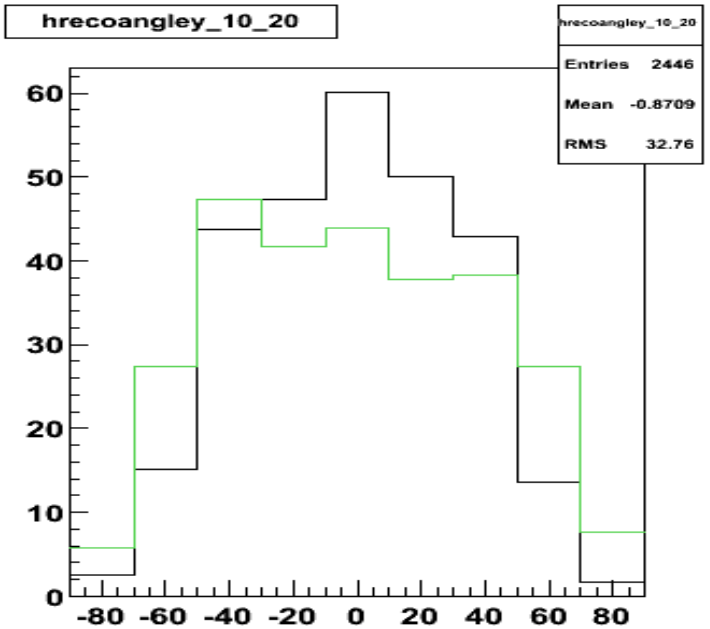
global track angle

true angle

sbcat sample



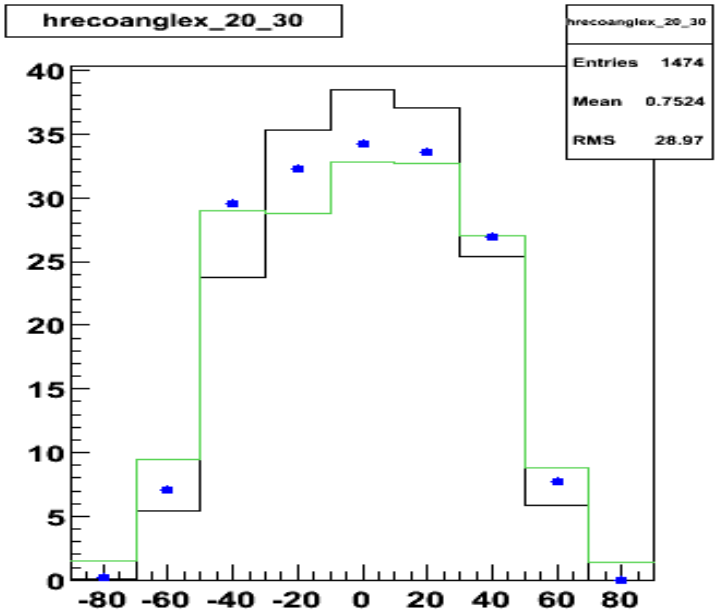
x proj. angle (deg.)



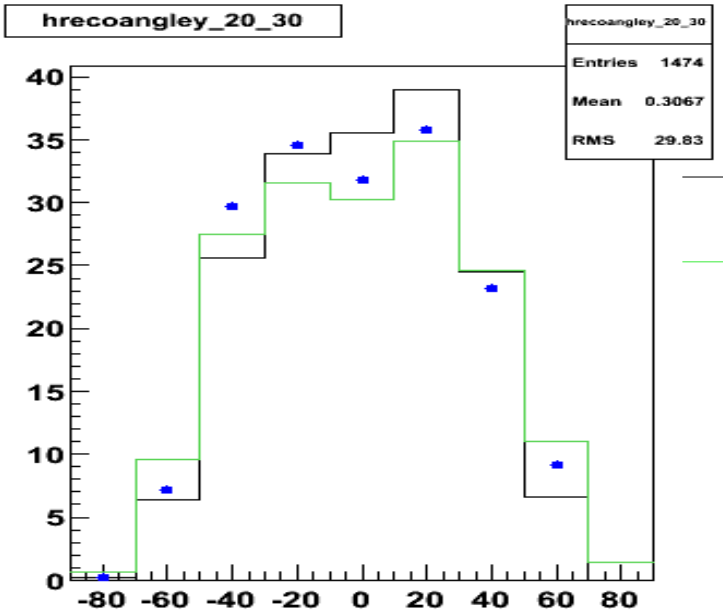
y proj. angle (deg.)

global sample

Track length between 20 and 30cm



x proj. angle (deg.)



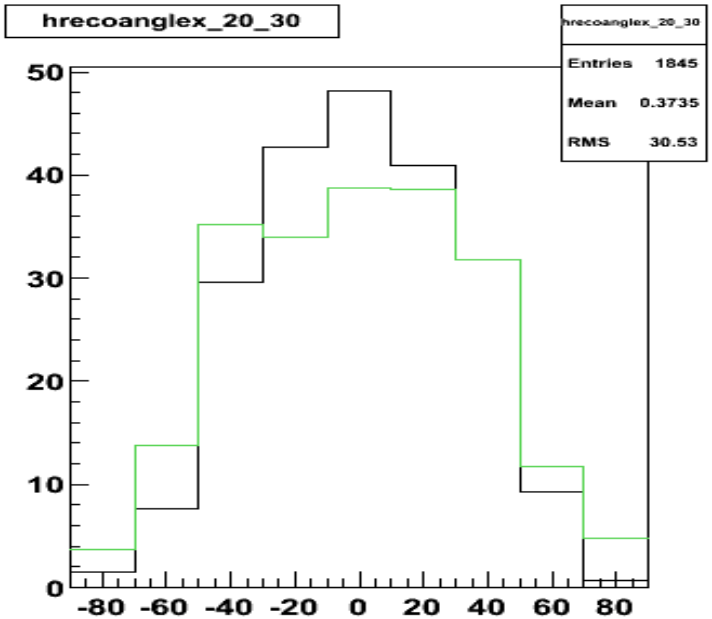
y proj. angle (deg.)

sbcat

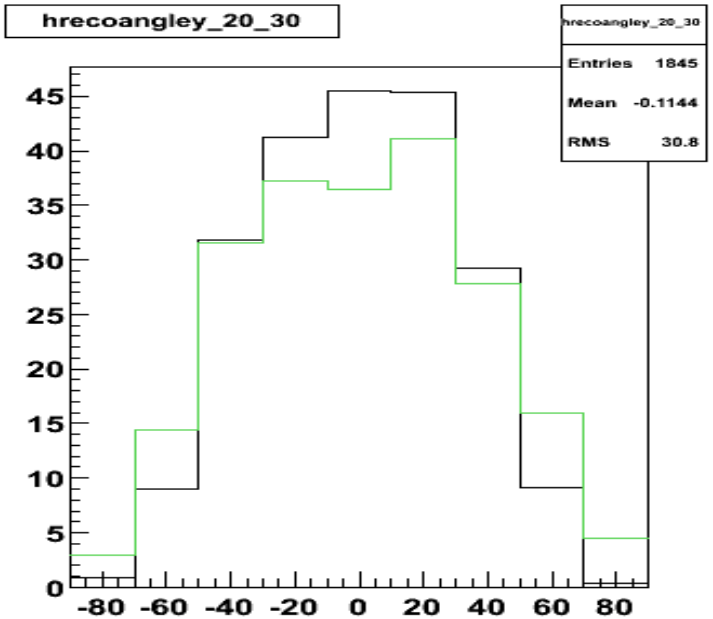
global track angle

true angle

sbcat sample



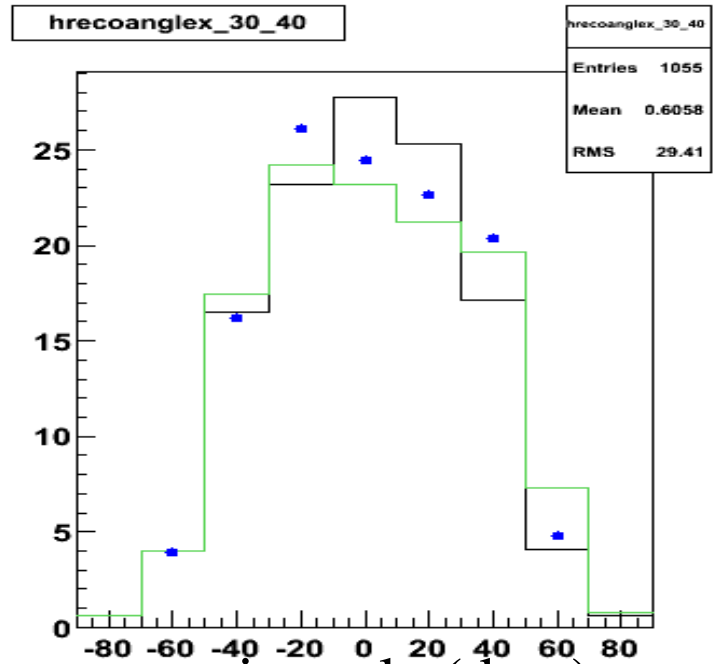
x proj. angle (deg.)



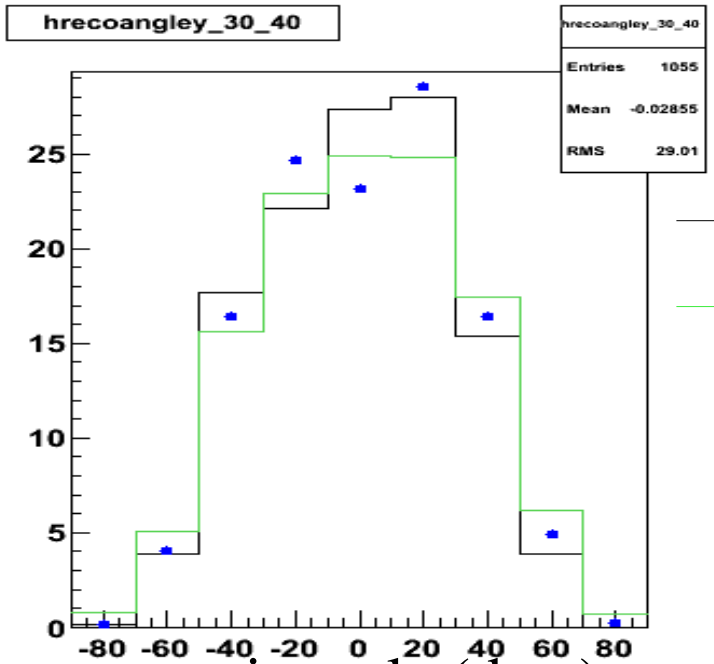
y proj. angle (deg.)

global sample

Track length between 30 and 40cm



x proj. angle (deg.)



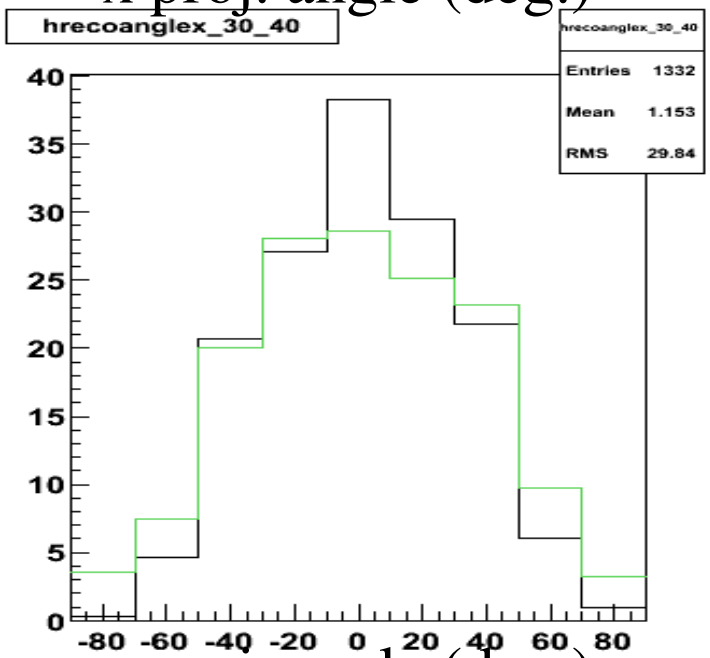
y proj. angle (deg.)

sbcat

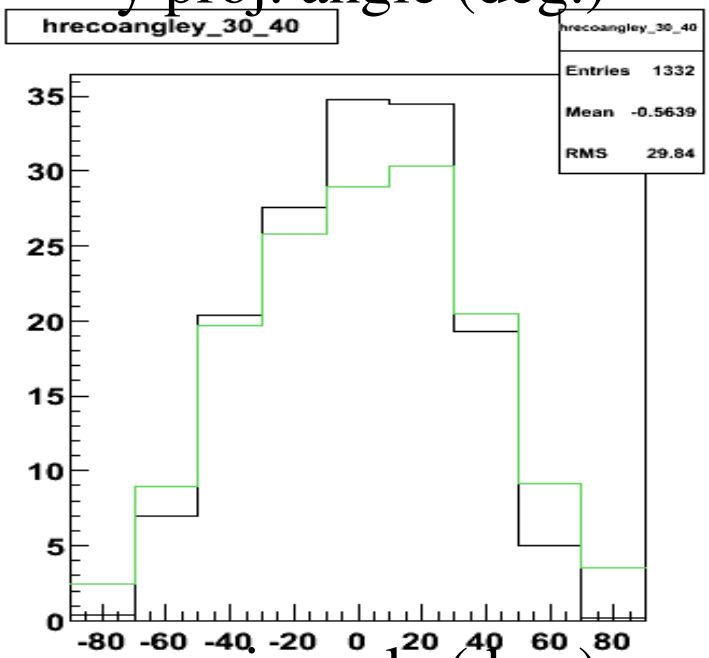
global track angle

true angle

sbcat sample



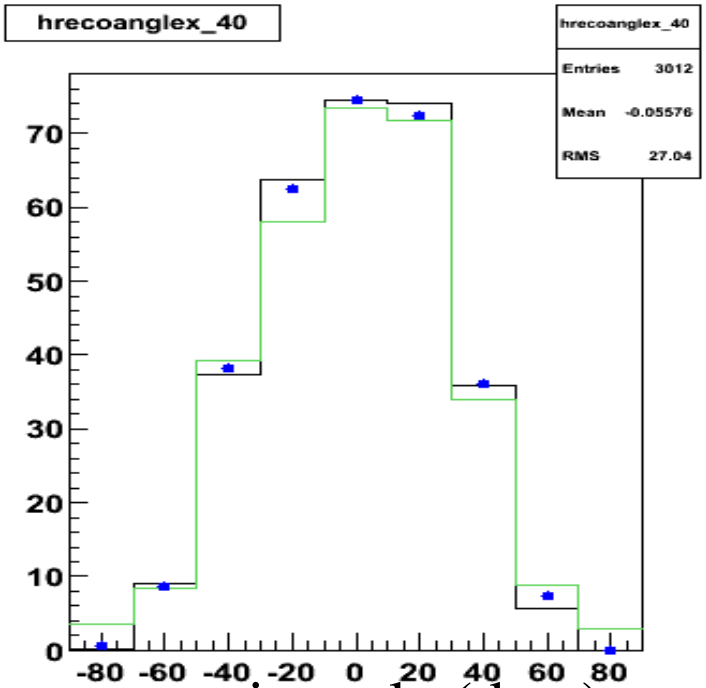
x proj. angle (deg.)

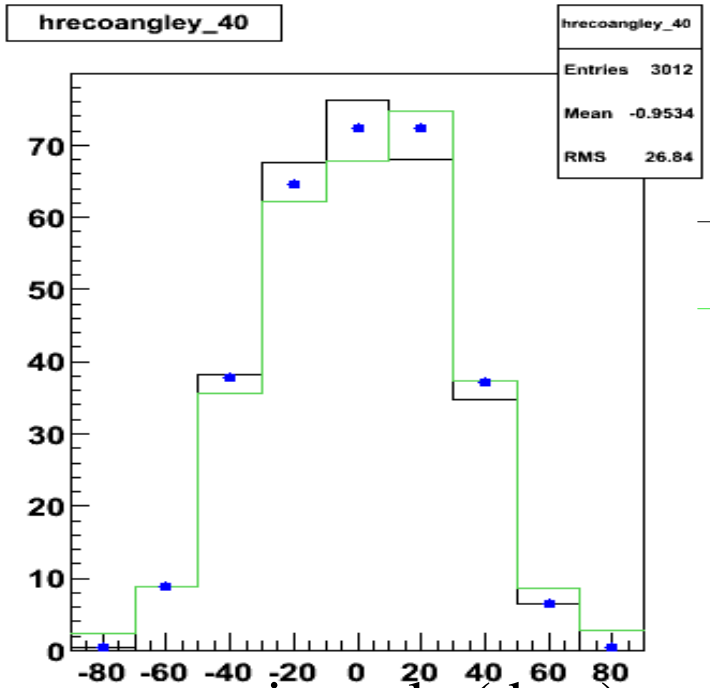


y proj. angle (deg.)

global sample

Track length > 40cm



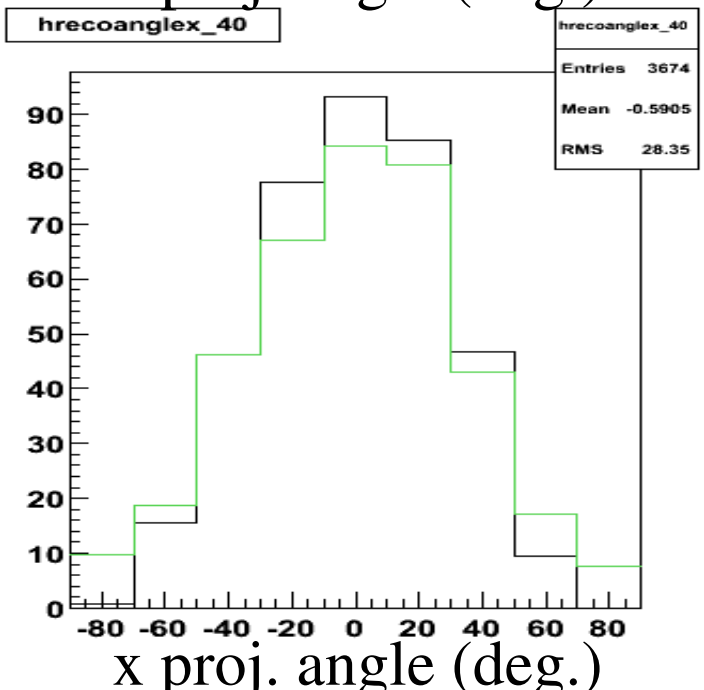


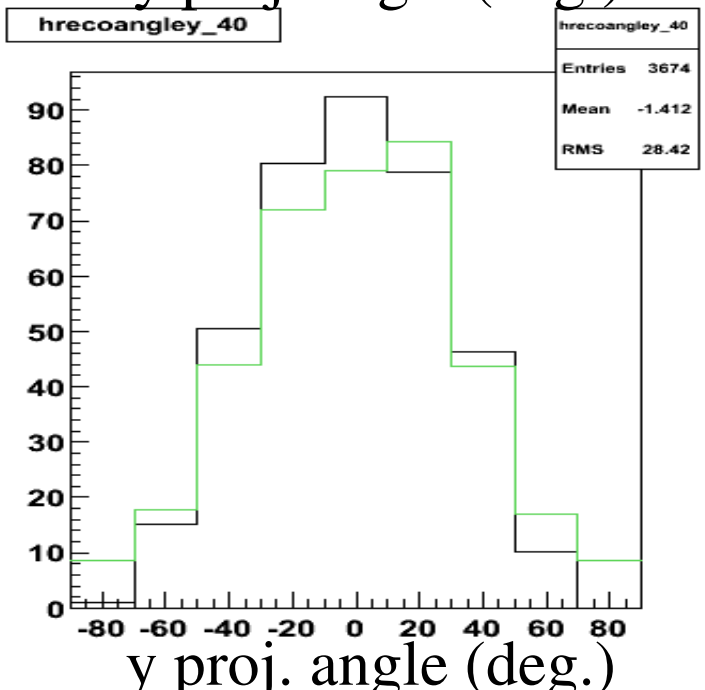
sbcat

global track angle

true angle

sbcat sample





global sample