LHRS Analysis for d_2^n

Acceptance: Aperture and Target Cut Studies and Narrow Bin Study

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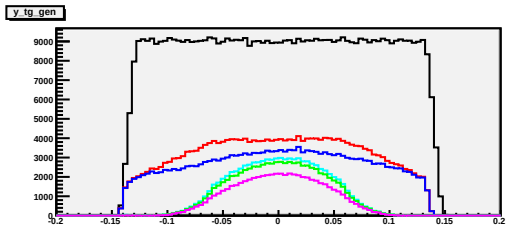
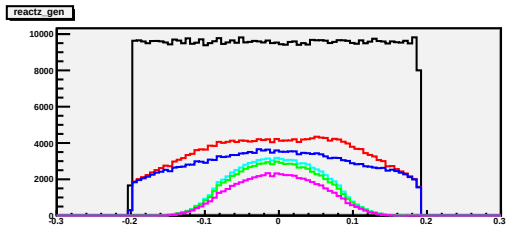
Outline

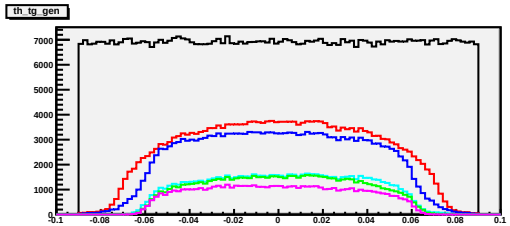
Aperture Cut Study (1)

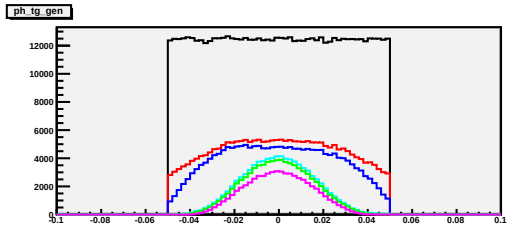
How Do the Distributions 'Evolve' as the Particle Traverses the LHRS?

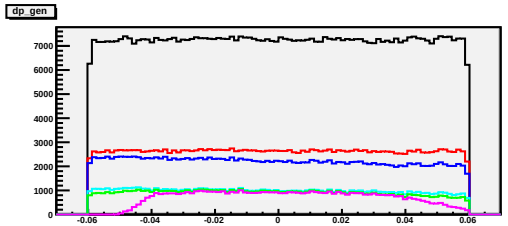
- Left to right, starting from the top: y_{tg}, Z_r, θ_{tg}, ϕ_{tg}, $\delta p/p$







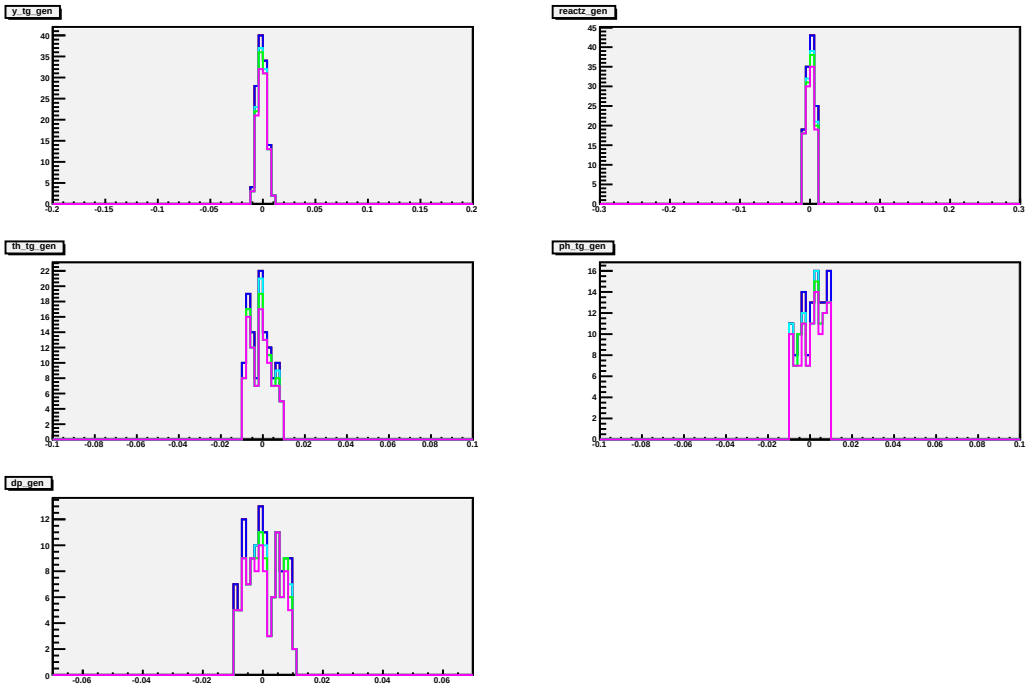




- Black = No cuts
- Red = Passed Q1 exit
- Blue = Passed dipole entrance
- Cyan = Passed dipole exit
- Green = Passed Q3 entrance
- Magenta = Passed Q3 exit
- These cuts are cumulative as we go along!

Aperture Cut Study (2)

Narrow Bin Cut: What Percentage (w) Gets Through?



- $\Delta\theta = 20$ mrad
- $\Delta\phi = 20$ mrad
- $\Delta Z_r = 1.0$ cm
- $\Delta y_{tg} = 1.0$ cm
- $\Delta p/p = 1.0\%$
- $w = 0.8361 \pm 0.1122$

Aperture Cut Study (3)

Narrow Bin Cut: A Closer Look by Aperture

Weight Factors by Aperture	
Aperture	w
Q1 (ex)	1.0000 ± 0.1280
D (en)	1.0000 ± 0.1280
D (ex)	0.9016 ± 0.1185
Q3 (en)	0.8770 ± 0.1162
Q3 (ex)	0.8361 ± 0.1122

- Remember we have chosen a central bin for this study – this is why everything passes through Q1
- 10% drop from entering Q1 to exiting D
- Lose another 7% upon exiting Q3 $\Rightarrow$ lose 17% total
  - Why are we losing this much?

Narrow Bin Studies (1)

Investigation of Low Acceptance When the Particle Traverses the LHRS

- To investigate, we do the following:
  1. Generate events in the narrow (full) range:
     - $\Delta p/p = 0.5\%$
     - $\Delta\theta_{tg} = 5$ mrad
     - $\Delta\phi_{tg} = 5$ mrad
  2. Toggle energy loss and multi-scattering calculations with:
     - No materials in the e^- path after scattering from ^{3}He (vacuum)
     - Single materials in the path (e.g., glass, ^{4}He, air, etc.)
     - All materials in the path

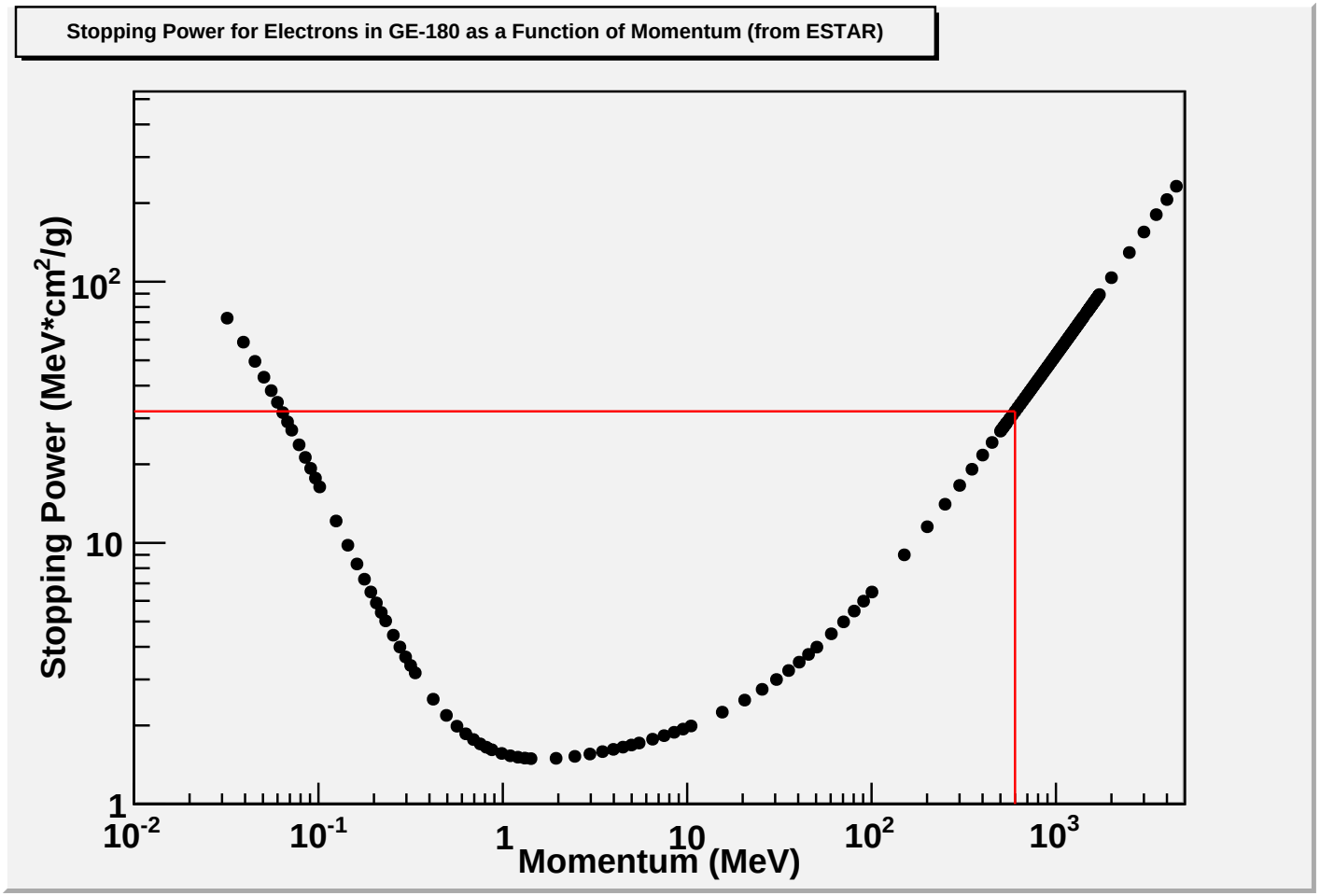
Narrow Bin Studies (2)
The Affect of Energy Loss on Acceptance

Acceptance Study Under Various Configurations			
Material in Path†	Energy Loss	Multi-scattering	w (%)
Vacuum	off	off	100
Vacuum	off	on	100
Vacuum	on	on	98.64
^{4}He	off	on	100
^{4}He	on	on	98.58
GE-180	off	on	100
GE-180	on	on	84.42
Air	off	on	100
Air	on	on	97.86
All	on	on	83.61

- †: Materials listed are in addition to ^{3}He
  - Example: For the ^{4}He entry, materials in the path are ^{3}He and ^{4}He; all other materials are swapped out for vacuum.

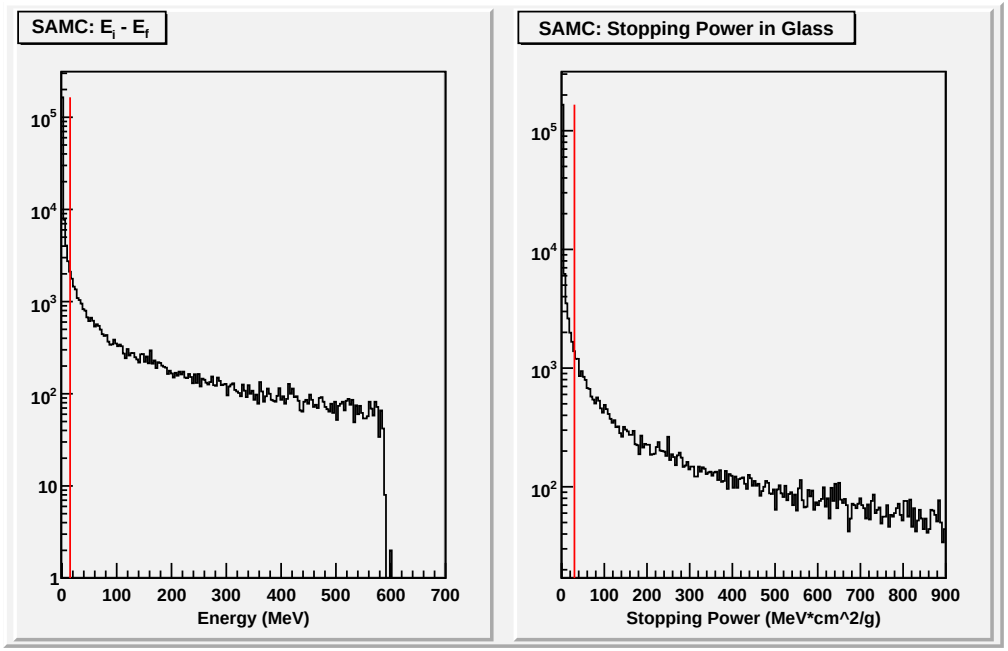
Narrow Bin Studies (3)

A Closer Look at the Glass Cell: Stopping Power for GE-180



Narrow Bin Studies (4)

From SAMC: Energy Before and After Energy Loss



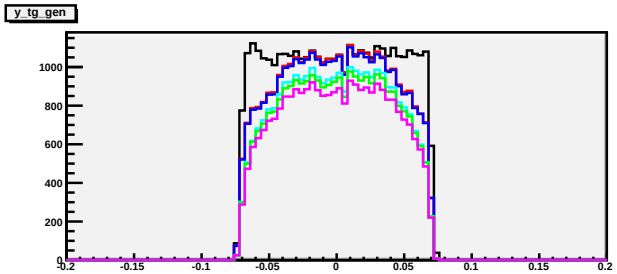
- From the previous page:

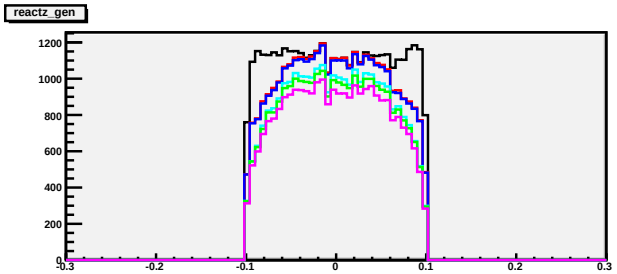
$$p = 600\ \mathrm{MeV}$$
$$\frac{dE}{dx} \sim 32\ \mathrm{MeV}\cdot\mathrm{cm}^2/\mathrm{g}$$

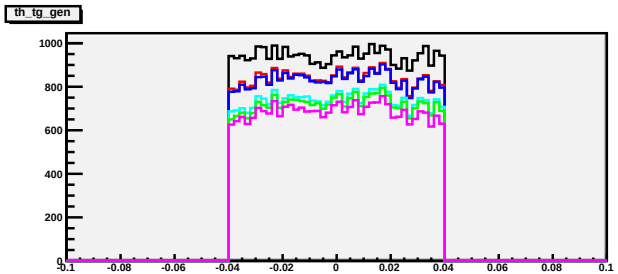
- For those particles that lost $> 15\ \mathrm{MeV}$, they account for 20% of all events

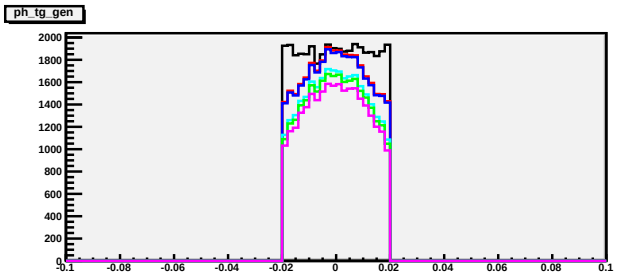
Target Cut Study (1)

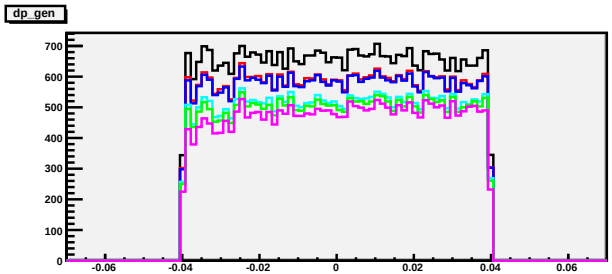
Cut Set 1 (All Aperture Cuts are Shown in the Various Colors)





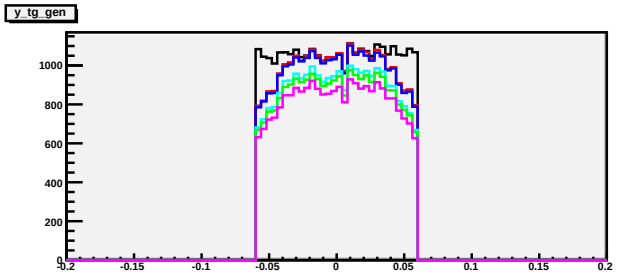


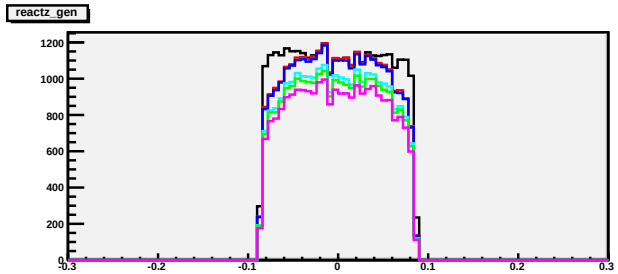


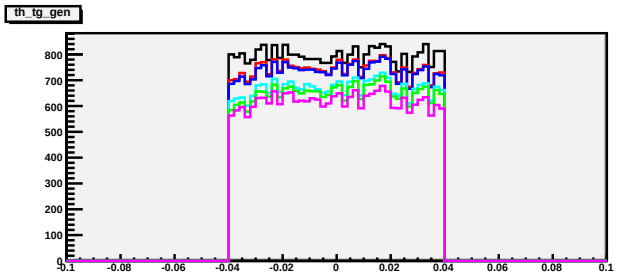


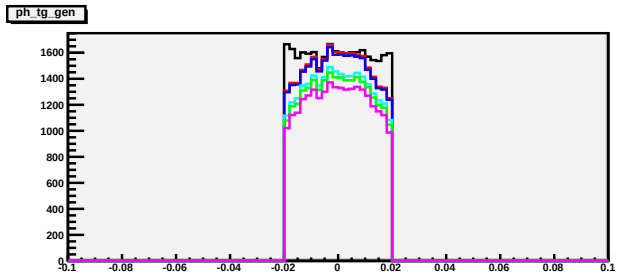
Target Cut Study (2)

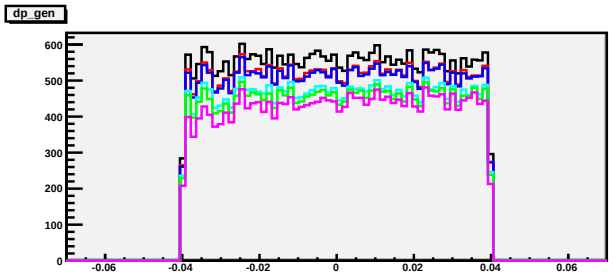
Cut Set 2 (All Aperture Cuts are Shown in the Various Colors)





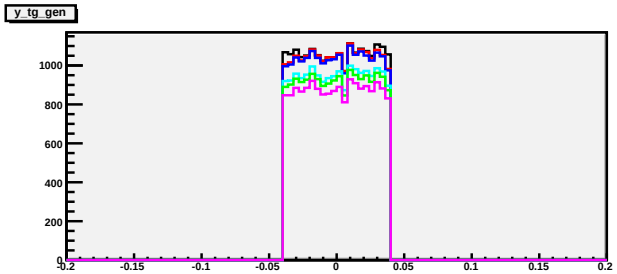


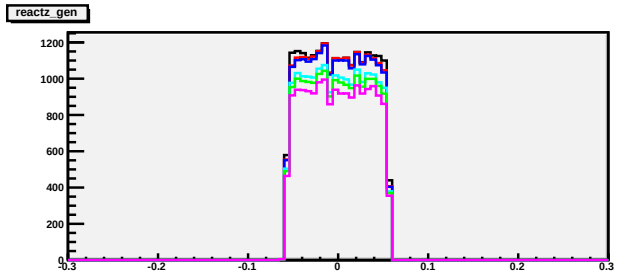


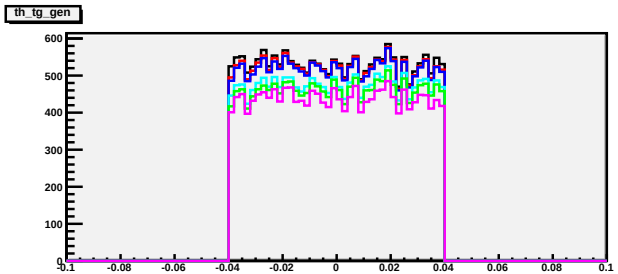


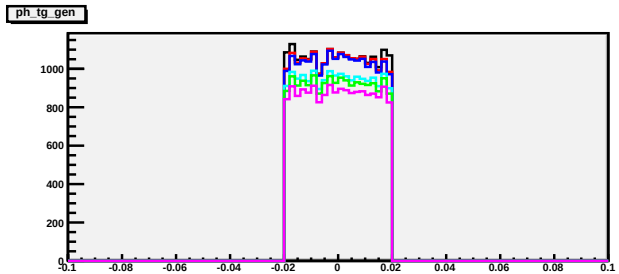
Target Cut Study (3)

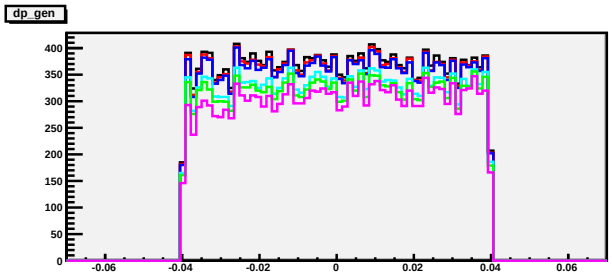
Cut Set 3 (All Aperture Cuts are Shown in the Various Colors)











Target Cut Study (4)
Summary: A Few Different Cut Sets

Cut Sets for Acceptance Study [Full Widths]						
Set #	$\delta p/p$ (%)	θ_{tg} (mrad)	ϕ_{tg} (mrad)	y_{tg} (cm)	Z_r (cm)	w
1	7	80	40	16	20	0.7268 ± 0.0058
2	7	80	40	12	20	0.7764 ± 0.0066
3	7	80	40	9	20	0.8249 ± 0.0084

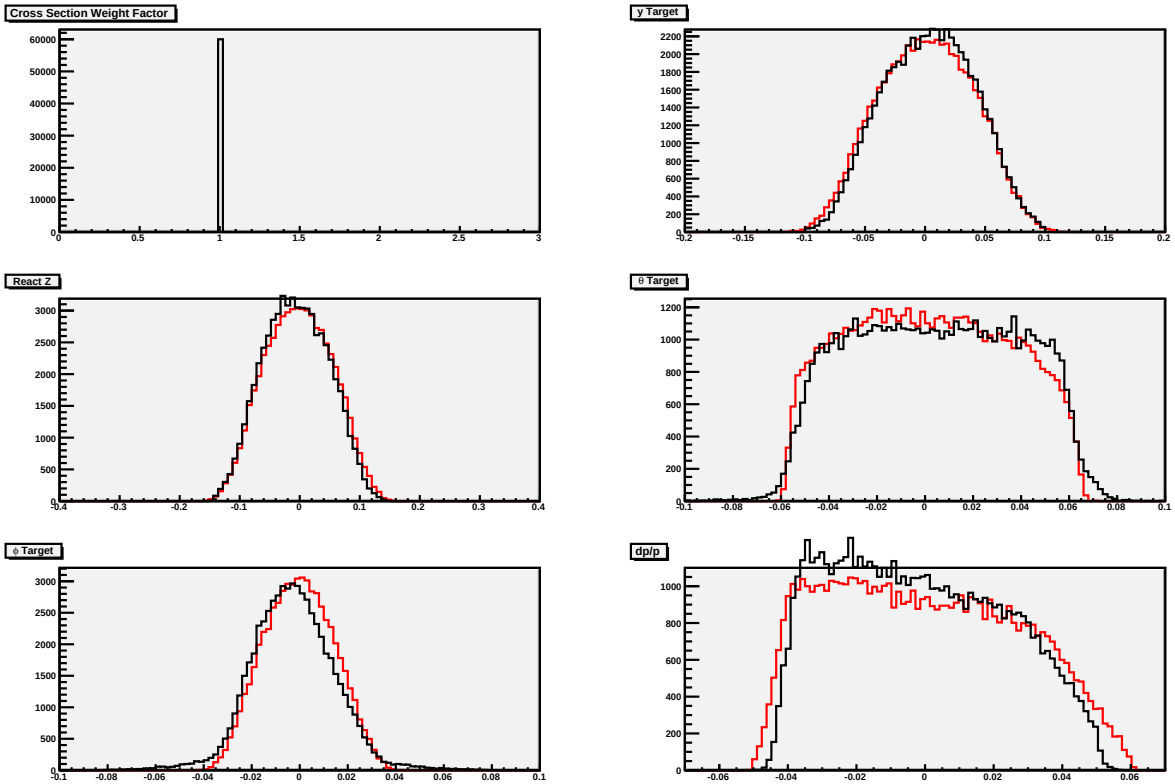
- Largest variation seen in y_{tg}
  - Cut choices for all other variables are chosen so as to avoid edge effects (especially in $\delta p/p$, θ_{tg})
  - Decided upon a cut of $\Delta\phi_{tg} = 40$ mrad: A wider cut includes the fall-off in ϕ_{tg}, $\Rightarrow y_{tg}$ shows variation (see the appendix)
- Note how ϕ_{tg} changes with the change in y_{tg}
  - Considering that the other target variable distributions do not change much in terms of shape, it seems that the best cut on y_{tg} is the one corresponding to cut set 3 because ϕ_{tg} tends to behave consistently across the chosen range of $\Delta\phi_{tg} = 40$ mrad (the widest acceptable range in ϕ_{tg})

Cross Section-Weighted Distributions (1)
Method and Motivation

- While SAMC does include multiple scattering and energy loss effects, there is no direct application of the cross section to the reconstructed variables.
- We can add this effect in by weighting the reconstructed variables by the cross section:
  - For the i^{th} event, apply the weight factor $f_i = \sigma_i / \sigma_{\text{avg}}$
  - σ_i is the cross section for the i^{th} event
  - σ_{avg} is the average cross section from the SAMC run
- σ is calculated with contributions from:
  - Elastic tail
  - Quasi-elastic tail (utilizes the peaking approximation and accounts for Fermi Motion in the nucleus)
  - 'Dip' region (corresponding to $W_R = 1500, 1700\ \text{MeV}$)
  - DIS region
  - The tails are also corrected for soft photon radiation

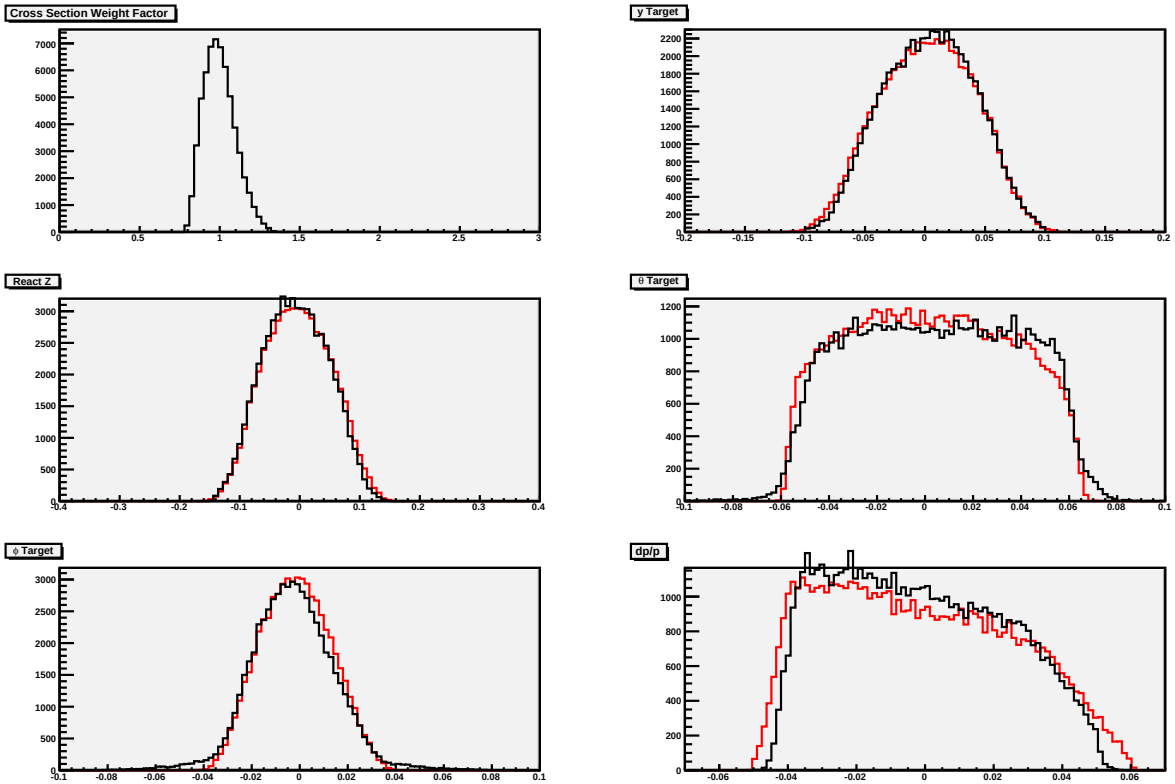
Cross Section-Weighted Distributions (2)

Comparison of Data to SAMC Before Cross Section Weighting: Target Variables



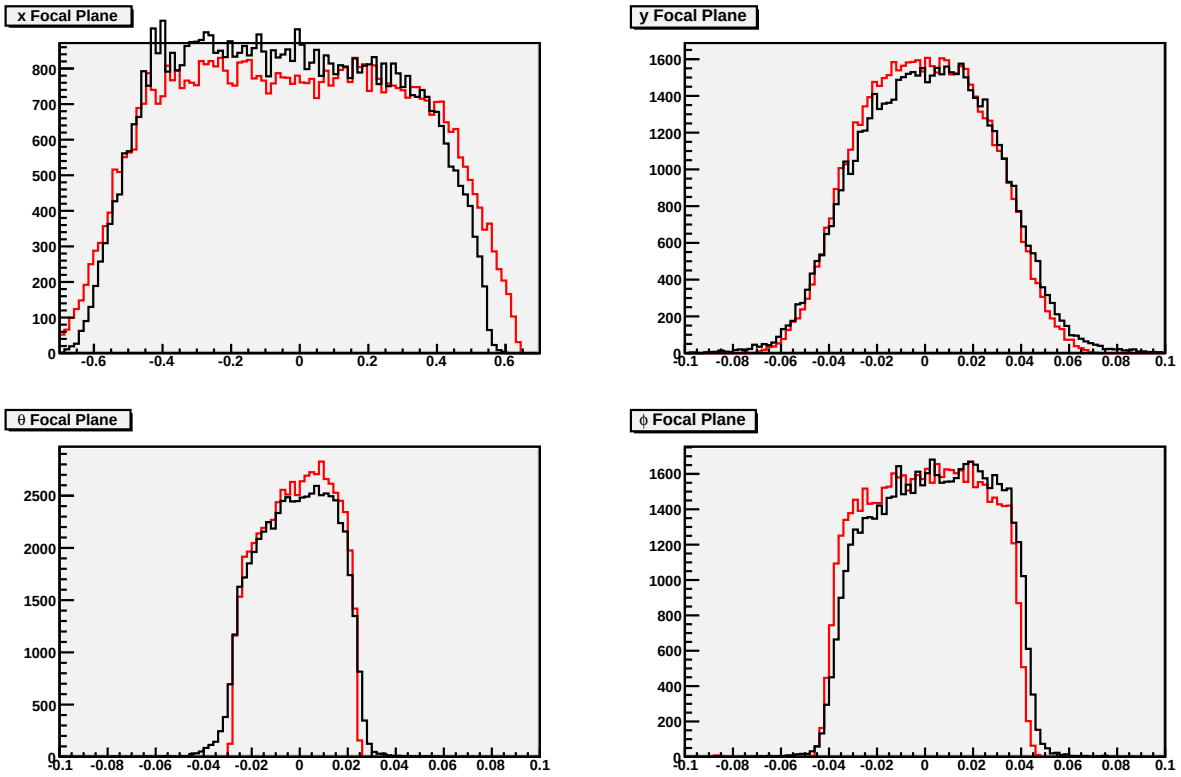
Cross Section-Weighted Distributions (3)

Comparison of Data to SAMC After Cross Section Weighting: Target Variables



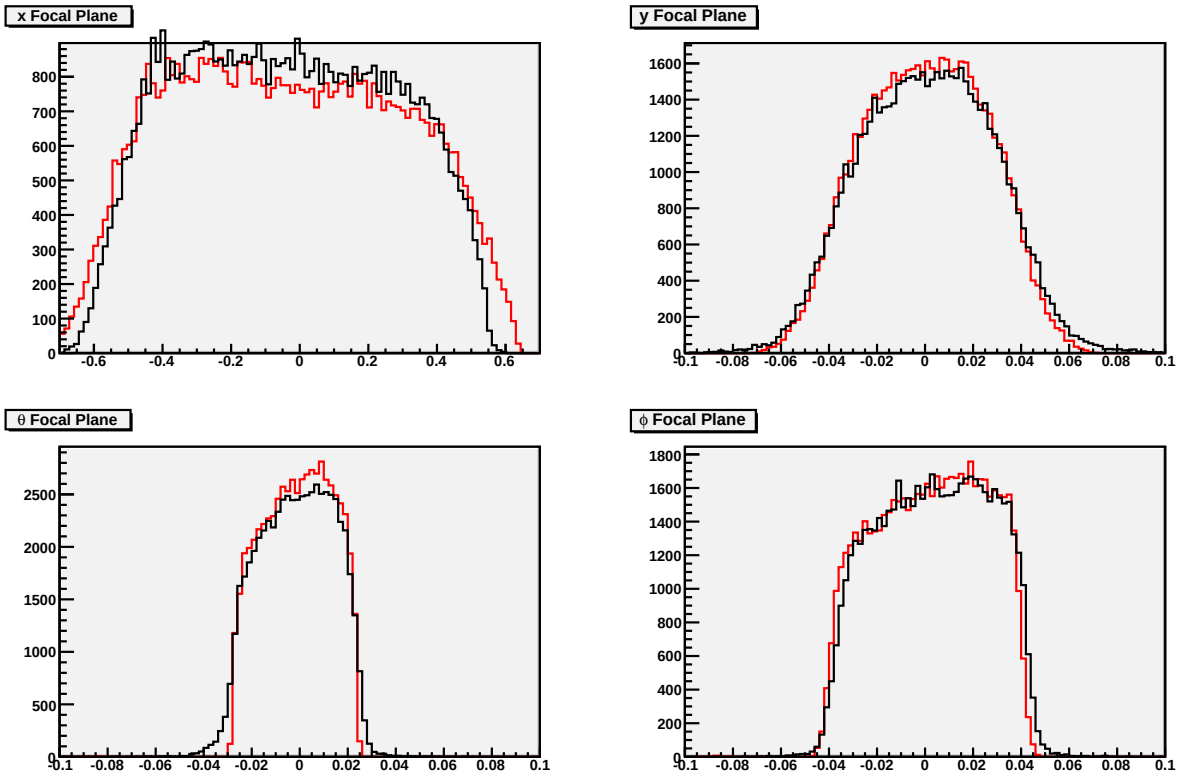
Cross Section-Weighted Distributions (4)

Comparison of Data to SAMC Before Cross Section Weighting: Focal Plane Variables



Cross Section-Weighted Distributions (5)

Comparison of Data to SAMC After Cross Section Weighting: Focal Plane Variables



Summary

- Aperture cuts:
  - It's clear from the plots that the dipole exit is the aperture that's doing the most in terms of defining the 'final' shape of our distributions in each variable (except for $\delta p/p$)
- Target cuts:
  - Changing the width in y_{tg} causes a variation in w up to 10% in this study
  - Cut set 3 shows that a cut on $\Delta y_{tg} = 9\ \mathrm{cm}$ has little effect on the shape of all the other target variable distributions while maintaining a good weight factor (~ 0.82)
- Cross Section-Weighting:
  - SAMC should give another simulation (in addition to QFS) to check our cross sections against
  - Weighting the target variable (and focal plane) distributions by the cross section has little effect on most variables; however, one does see a change in ϕ_{tg}, ϕ_{fp}

What's Next?

- Acceptance:
  - Debug SAMC concerning Simpson integration method
  - Run SAMC for each kinematic bin
- Cross Section:
  - Finish readying the Carbon runs and calculate their cross section
  - Gather appropriate world ^{3}He data to compare to our results
  - Start tweaking QFS and thinking about radiative corrections
- Systematic Errors:
  - Charge
  - Deadtime (livetime)
  - Trigger
  - VDC
  - SAMC

Appendix (1)
Cut Set 4: Wide ϕ_{tg} Cut Study

- $\Delta\phi_{tg} = 50$ mrad
- All cuts on all variables are the same as cut set 3 (see next slide for plots)
- It was found that a variation of $\Delta\phi_{tg}$ from 20–40 mrad showed little to no change in the shape of the other target variable distributions. The weight factor $w \sim 0.82 \pm 0.01$ for such a study (the error bar is to show the range of w, and is not the statistical error bar as is assumed otherwise)
- Cut set 4 yields a weight factor of $w \sim 0.71$, a $\sim 10\%$ drop from the tighter ϕ_{tg} cuts

Appendix (2)
Cut Set 4: Wide ϕ_{tg} Cut Study