1 Hard and Intermediate Interactions Version 3

One of the positron interaction systematic errors has to do with how well we can validate the simulation of hard and intermediate interactions. Hard interaction events are arbitrarily defined here to be events in which the decay positron loses more than $1MeV/c$ of momentum from were it is generated to where it goes through the last DC. Intermediate interactions are those events whose decay positrons have lost less than $1MeV/c$.

In our simulation we can look at the reconstructed decay positron distribution over the thrown distribution to see how large a correction is needed to account for hard and intermediate interactions. A Michel fit of the reconstructed to thrown distributions for all events, and for events that lose less than $< 1MeV/c$ can be made to estimate the size of correction. Plots of the change in the muon decay parameters is shown in Figure 1 for ρ, Figure 2 for δ, and Figure 3 for ξ. Note that the sign needs to be flipped for the systematic because of the order the fit was done.

Fits of the hard interactions to the thrown distributions failed, so to estimate the hard contributions the difference between fits to all events and fits to intermediate events is considered. The size of the corrections from the fit results are in Table 2 for δ, and Table 1 for $P_\mu\xi$. The size of the correction Δ $P_\mu\xi$ and $\Delta\delta$ depends on the location of the muon stopping Bragg peak in the stopping target. For ρ the result was relatively insensitive to the stopping position. The result for rho was $\Delta\rho_{intermediate} = 0.006$, and $\Delta\rho_{hard} = 0.006$. Given that we trust our simulation of hard interactions to 14% and intermediate interactions to 5%, the resulting systematic error for ρ is estimated as $0.006 * 0.05 + 0.006 * 0.14 =$ *0.0011*.

Note: The numbers presented in the note will be smaller now since we can reduce the 14% and 5% numbers based on Rob's analysis of upstream stops.

μ Location in Target	Δ P$_\mu\xi$ Inter.	Δ P$_\mu\xi$ Hard	Systematic Error
PC 5 stops (upstream)	-0.0125	0.0015	-0.0004
centered ($\frac{1}{2}$)	-0.0068	-0.0037	-0.0009
$\frac{3}{4}$	-0.0015	-0.0105	-0.0015

Table 1: Δ P$_\mu\xi$ corrections due to intermediate and hard interactions for each of the three different muon stopping locations of data. The systematic error is based on 14% validation of hard interactions and 5% validation of intermediate interactions.

μ Location in Target	$\Delta\delta$ Inter.	$\Delta\delta$ Hard	Systematic Error
PC 5 stops (upstream)	0.0045	0.0015	+0.0004
centered ($\frac{1}{2}$)	0.0015	0.0065	+0.0010
$\frac{3}{4}$	0.0005	0.0095	+0.0014

Table 2: $\Delta\delta$ corrections due to intermediate and hard interactions for each of the three different muon stopping locations of data. The systematic error is based on 14% validation of hard interactions and 5% validation of intermediate interactions.

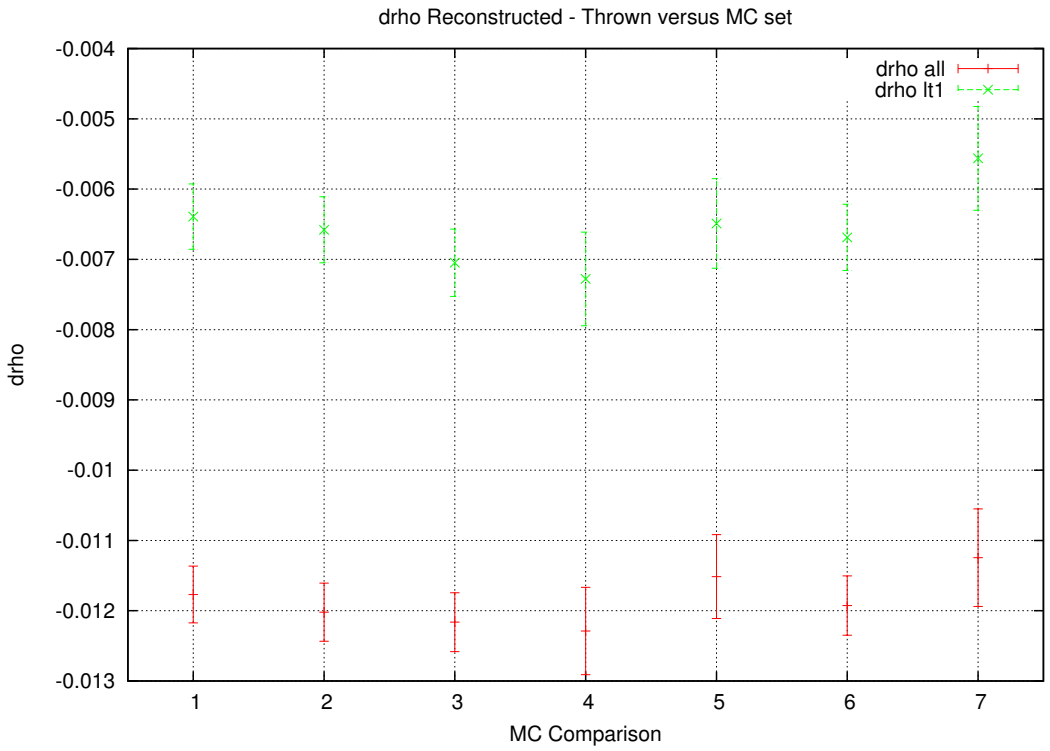

Figure 1: $\Delta\rho$ from spectrum fits to distributions of $\cos\theta$ versus total momentum of reconstructed to thrown decay positron distributions. Michel fits of all events to are shown as '+' and the fits to events with decay positrons that lose less than $1MeV/c$ are shown as 'x'. Points 1 and 2 are for muons stopping centered, points 3 to 6 are stopping at three-quarters, and point 7 is for muons stopping further upstream.

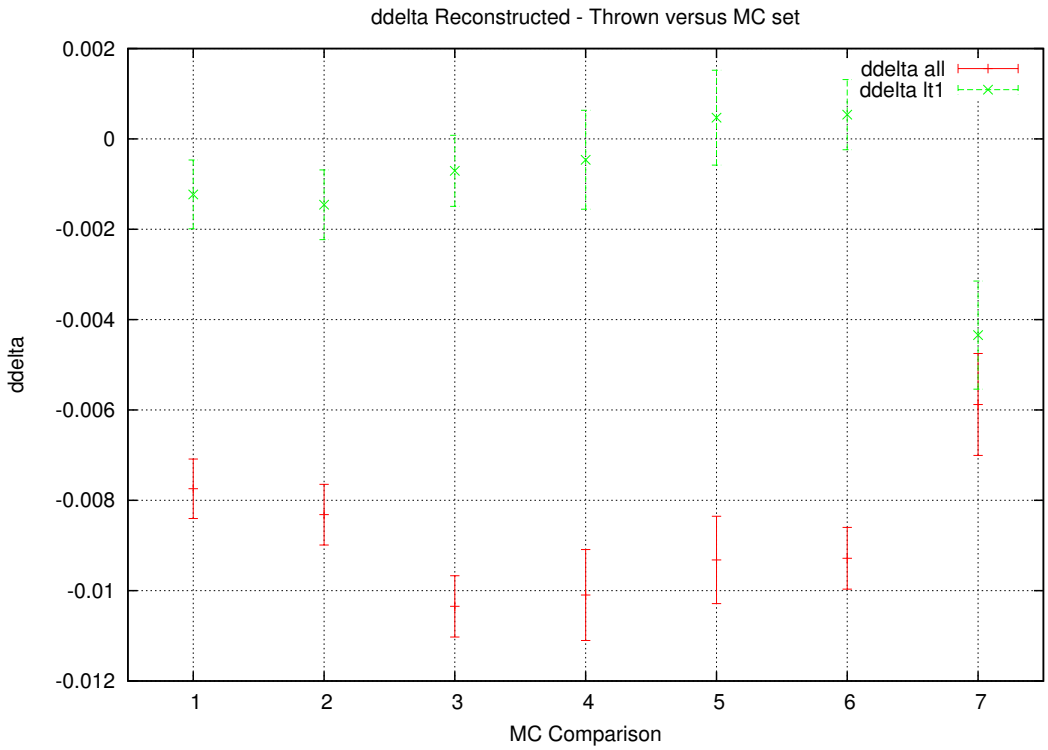

Figure 2: $\Delta\delta$ from spectrum fits to distributions of $\cos\theta$ versus total momentum of reconstructed to thrown decay positron distributions. Michel fits of all events to are shown as '+' and the fits to events with decay positrons that lose less than $1 MeV/c$ are shown as 'x'. Points 1 and 2 are for muons stopping centered, points 3 to 6 are stopping at three-quarters, and point 7 is for muons stopping further upstream.

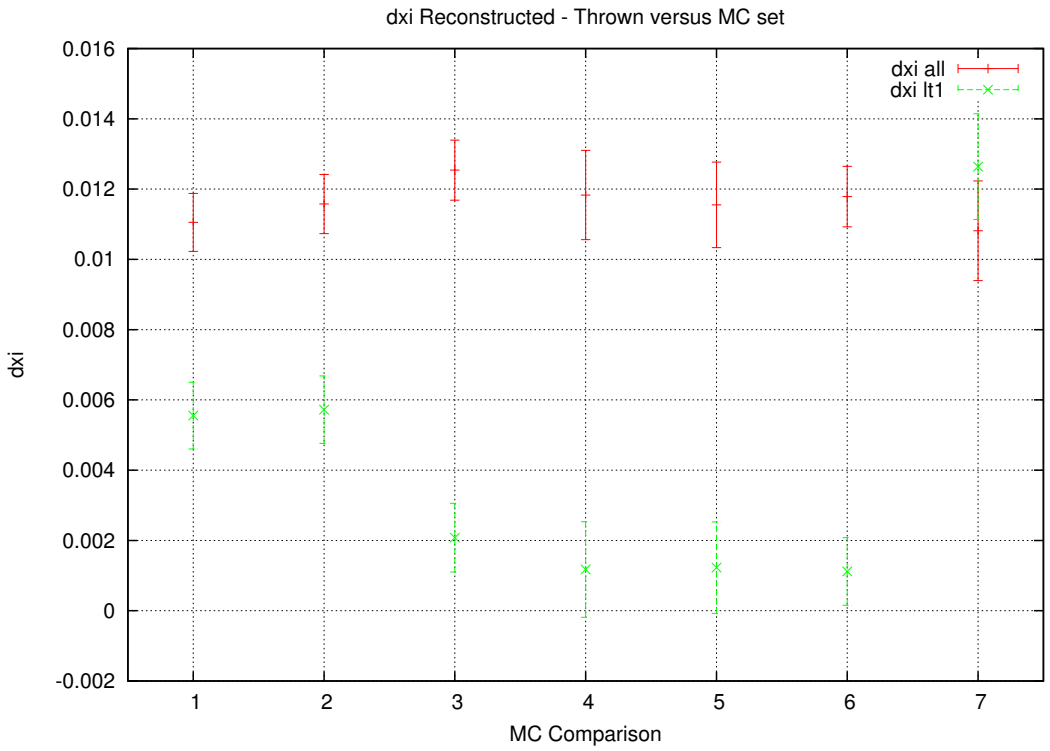

Figure 3: $\Delta\xi$ from spectrum fits to distributions of $\cos\theta$ versus total momentum of reconstructed to thrown decay positron distributions. Michel fits of all events to are shown as '+' and the fits to events with decay positrons that lose less than $1MeV/c$ are shown as 'x'. Points 1 and 2 are for muons stopping centered, points 3 to 6 are stopping at three-quarters, and point 7 is for muons stopping further upstream.