Study of the ice thickness for the second period of E97110

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December 28, 2016

1 Introduction

During the running of E97110, ice built up on the surface of the polystyrene foam that thermally isolated the septum bore from the target chamber. The amount of ice is unknown. This document estimates the ice thickness. 2.1 GeV at 6° elastic carbon data are used in this study. The ice thickness is estimated by comparing at the $W - M_T$ spectrum of the carbon elastic peak between data and simulation. The HRS resolution in the simulation is kept the same for all ice thicknesses (1.38E-04). Multiple scattering due to ice is added in the simulation. For the empty target run, an shift of 0.45 MeV was applied to the $W - M_T$ spectrum to account for less thickness and a small energy drift between carbon and empty run. For 1.1 GeV, the empty target run does not adequately subtract the background and thus the ice thickness cannot be estimated accurately.

Table 1: Normalization factors for elastic carbon target and no target run for 2.1 GeV.

Target (run)	PS	LT	Q (μC)	ϵ_{PID}	ϵ_{VDC}	$\epsilon_{trigger}$
Carbon (2393)	14	0.9965	418	0.9842	0.9559	0.9996
^{4}He (2408)	10	0.9911	989	0.9842	0.9870	0.9996

Table 2: Cuts applied to 2.1 GeV. These cuts are applied to select the carbon foil at the center, and to minimize the background.

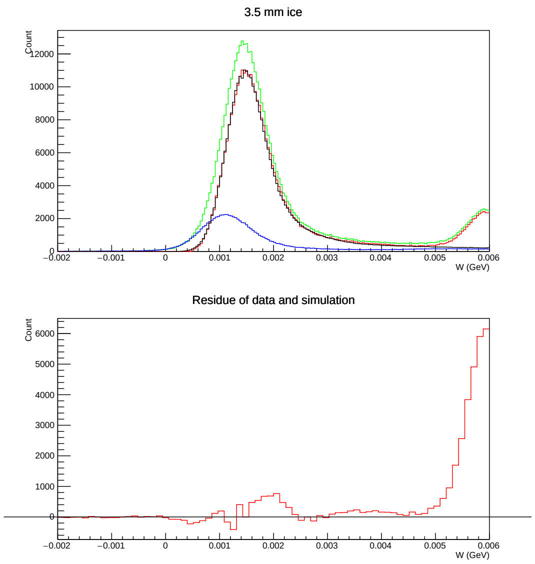
Variable	Min	Max
$y_{target}(mm)$	-8	8
θ_{target} (mrad)	-30	30
ϕ_{target} (mrad)	-8	8

Table 3: Radiation lengths for one carbon foil run with different ice thicknesses. For each thickness, $W - M_T + \epsilon$ needs to be shifted a small amount to match data and simulation spectra. Hence different value of target mass is used. *Inl*, *outl* are the incoming and outgoing radiation lengths. ρ_{in}, ρ_{out} are the average densities of incoming, outgoing material. The nominal value is shown in bold fonts.

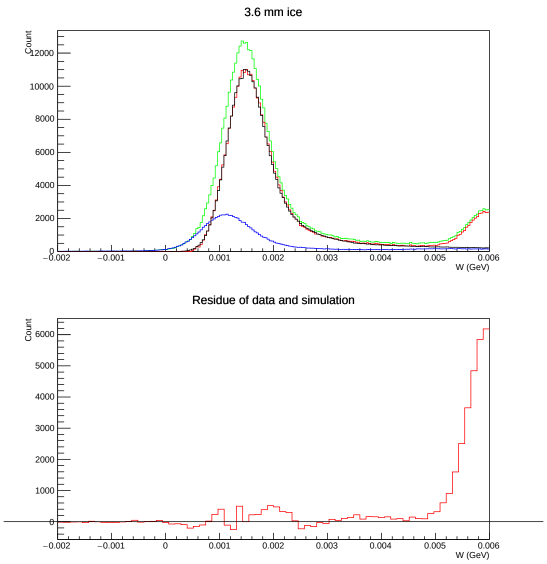
Beam (GeV)	Ice (mm)	inl	outl	$< \rho_i >$	$< \rho_o >$	ϵ GeV
	3.5	0.002466	0.018257	0.10458	0.740185	0.00035
	3.6	0.002466	0.018515	0.10458	0.749525	0.00034
	3.7	0.002466	0.018774	0.10458	0.758865	0.00032
2.1	3.75	0.002466	0.018903	0.10458	0.763535	0.00032
	3.8	**0.002466**	**0.019033**	**0.10458**	**0.768205**	**0.00032**
	4	0.002466	0.019550	0.10458	0.786885	0.00028
	4.14	0.002466	0.019912	0.10458	0.799961	0.00026
	4.3	0.002466	0.020326	0.10458	0.814905	0.00024
	4.5	0.002466	0.020844	0.10458	0.833585	0.00021
	5	0.002466	0.022138	0.10458	0.880285	0.00013

2 Conclusion

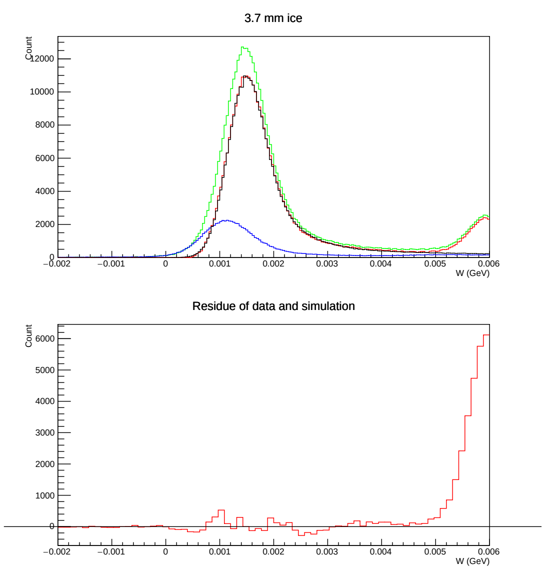
The data from the experiment and simulation are shown on Fig.1, Fig.2 and Fig.3, as well as the residuals between the simulation and experiment. For 2.1 GeV, the ice thickness is 3.8 ± 0.2 mm. From Fig. 4 the nominal thickness and its uncertainty can be determined by inspecting the residual plots. In addition, 1.1 GeV at 9° data is studies as well, however, due to not perfect subtract background so $W - M_T$ spectrum is not so clean as shown in Fig. 5. For this run it was taken one month after the 2.1 GeV at 6° and ice thickness for 1.1GeV is 6 mm of ice. In conclusion, ice thickness for second period is 5.0 ± 1.5 mm.



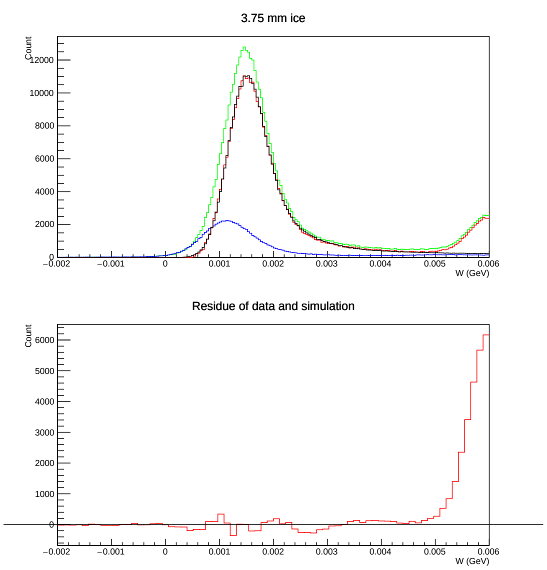
(a) 3.5 mm ice



(b) 3.6 mm ice

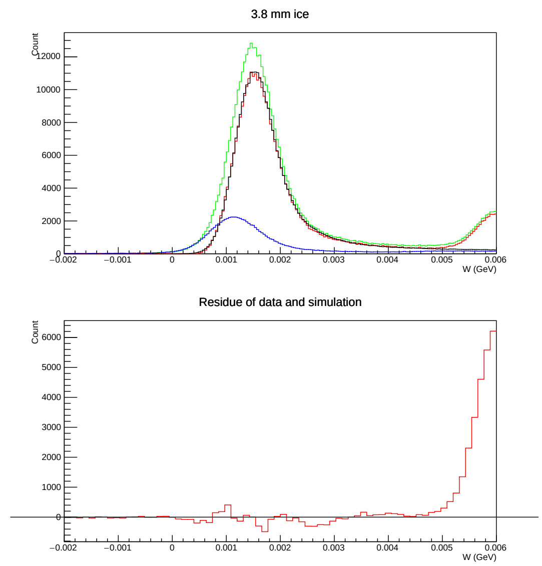


(c) 3.7 mm ice

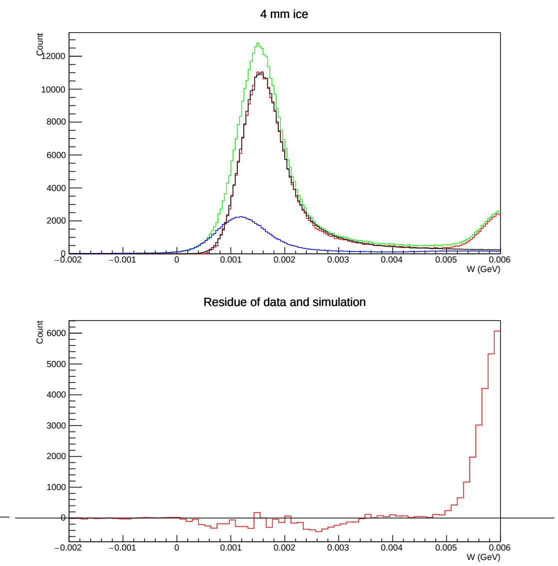


(d) 3.75 mm ice

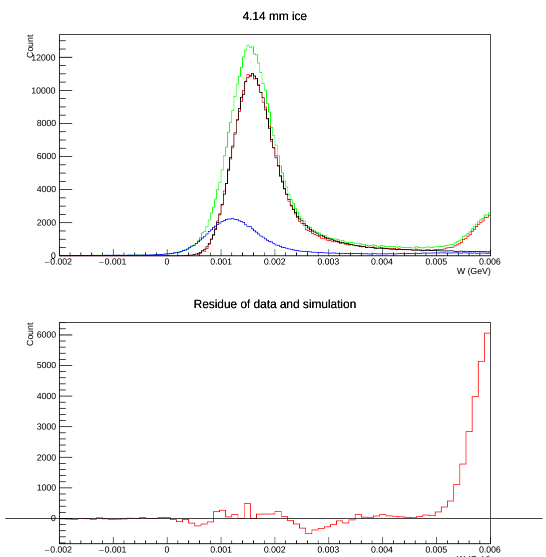
Figure 1: $W - M_T$ spectra for 2.1 GeV. Top plots: Green: carbon run (experimental data), Blue: no target run (experimental data), Red: clean carbon (Green - Blue), Black: simulation. The bottom plots are the residual between data and simulation. A 0.45 MeV shift is applied to ^{4}He spectrum to account for its lower radiation length (no carbon contribution) and possible energy shift. This is done by requesting a residual near zero in the high energy tail in $W - M_T$ spectrum.



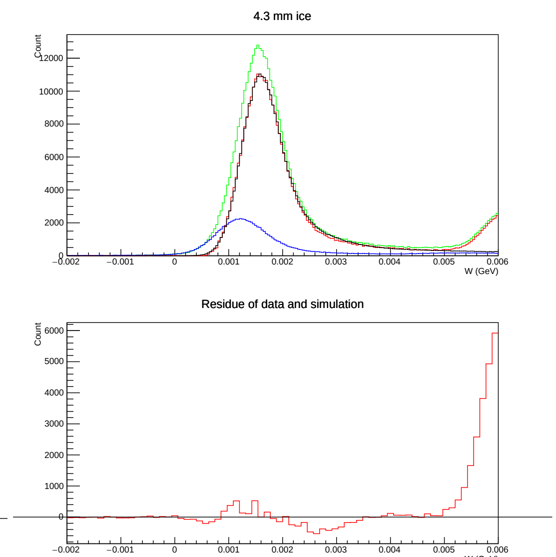
(a) 3.8 mm ice



(b) 4 mm ice

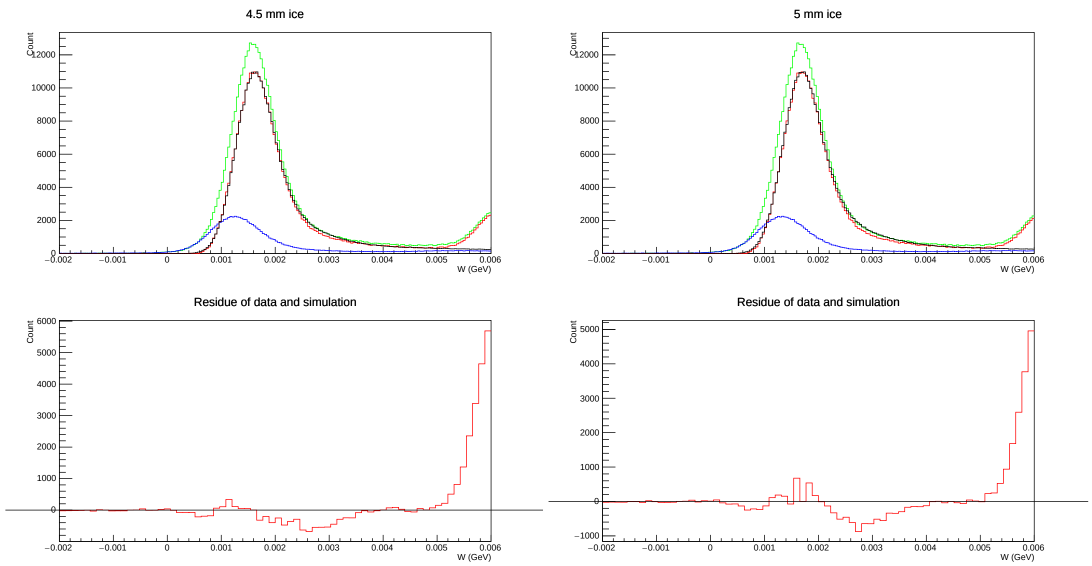


(c) 4.14 mm ice



(d) 4.3 mm ice

Figure 2: Same as Fig 1 but for different ice thickness values.



(a) 4.5 mm ice

(b) 5 mm ice

Figure 3: Same as Fig 1 but for different ice thickness values.

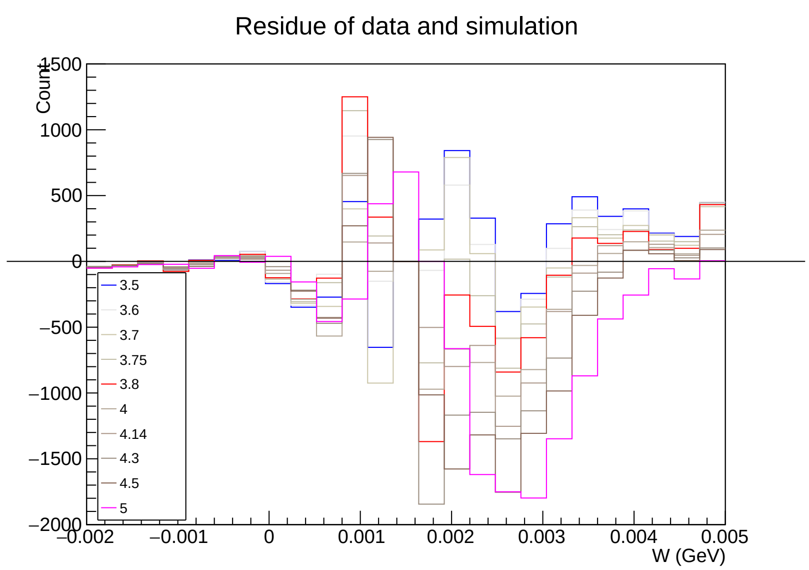


Figure 4: Residue plot for all ice thickness values for 2.1 GeV at 6°.

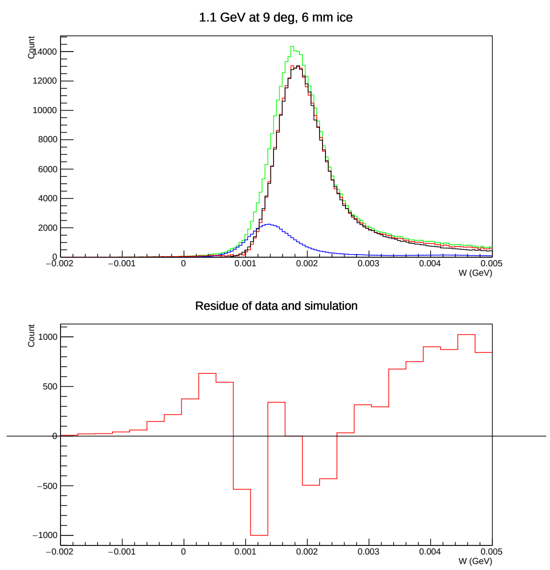


Figure 5: Same as Fig 1 but this is for 1.1 GeV at 9°.