Acceptance Study for SciBooNE Charged-Current Coherent Pion Production Technical Note Rough Draft

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Abstract

Should there be an abstract?

1 Introduction

The goal of this document is to provide a reference for the acceptance study performed for the SciBooNE charged current coherent pion re-analysis as well as provide documentation to the code used in this study (in the event anything needs to be revisited in the future).

The code currently lives in this github repository labeled SciBooNE-MC and the corresponding ROOT files used in the simulation can be downloaded from here (insert dropbox/Google Drive Link here)

The paper is structured such that Section 2 outlines samples used in this study, Section 3 describes the SciBooNE detector as it was simulated in this study, Section 5 gives a high level summary of the results including the event-reduction table as well as the CC-Coh-π acceptance results.

Sections **??** - **??** provide supporting plots which are used to generate the acceptance tables found in Section **??**.

The appendix is left to explain how the code is run and the details of the scripts within.

1.1 Goal

The goal of the reanalysis is to examine the acceptance modeling for the SciBooNE results in the presence of modern neutrino generators and updated models in order to understand why SciBooNE did not observe Charged-Current Coherent Pion Production at low neutrino energy. The purpose of this acceptance study is to blah blah blah... (coming back to this later...)

2 Samples

Five different samples were used in this study, three samples for ν-mode and two samples in $\bar{\nu}$-mode. [1] Table 1 summarizes these samples. Details on these samples can be found in Appendix

[1]All of these samples were generated by Callum Wilkinson (many thanks)

Summary of samples

Mode	NEUT version	Pion-Model	Number of simulated events
ν	5.3.6	Rein-Sehgal	1,000,000
ν	5.3.6	Berger-Sehgal	1,000,000
ν	x.x.x	Rein-Sehgal	100,000
$\bar{\nu}$	5.3.6	Rein-Sehgal	1,000,000
$\bar{\nu}$	5.3.6	Berger-Sehgal	1,000,000

Table 1: Summary of the samples used to build the acceptance model for this study.

3 Simulation

This section is intended to detail the nuances of this acceptance model, and to detail what assumptions are made in the acceptance modeling to result in accurate classifications of events as Charged-Current Coherent Pion Production.

3.1 The Detector

For the purposes of this acceptance study, the SciBooNE experiment as being composed of two sub-detectors. The first (and the more upstream) of the sub-detectors, is the Scintillator Bar Tracker (SciBar) which was originally conceived and constructed to function as the near detector for the K2K experiment [reference]. The second (and more downstream) of the sub-detectors, is the Muon Range Detector (MRD), which is the detector designed and constructed specifically for SciBooNE for measuring the momentum of muons produced from charged-current neutrino interactions up to 1.2 GeV/c by using the observed range of the trajectory of the muon. These detectors and the corresponding coordinate system we will use throughout this note are shown in Figure 3.1

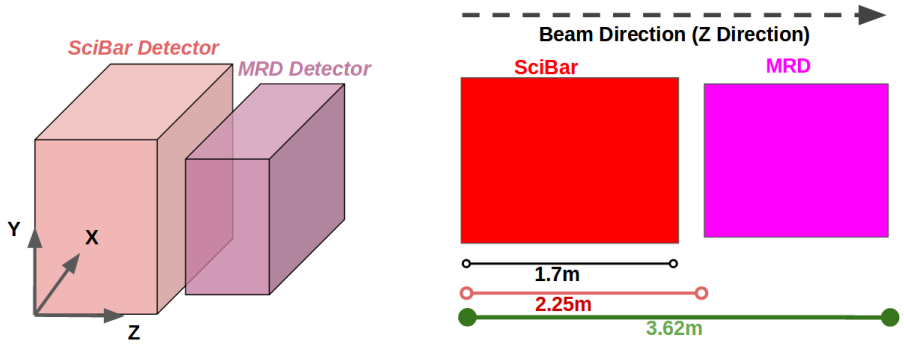

Figure 1: Representation of the SciBooNE detector and the coordinate frame we use in this study

3.1.1 The Scintillator Bar Tracker (SciBar)

The Scintillator Bar Tracker (SciBar) sub-detector is a scintillator detector (go into more detail?). In this acceptance study, the z-direction starts at 0 at the front face of the SciBar sub-detector. The direction of the beam is in the z-direction, which means the xy-plane is perpindicular to the beam. The dimensions of the sub-detector have the x and y dimensions of the same length of 3.0 m. The

z dimension is 1.7 m. This simulation models the scintillator materials as having a constant energy depostion (dE/dx) value of 2.04 MeV/cm.

3.1.2 The Muon Range Detector (MRD)

The Muon Range Detector (MRD), depicted in Figure 3.1.2 is located 0.55 m downstream of SciBar in the z-direction, and is a composition of 2 sets of 13 alternating slabs of steel-scintillator layers, where the scintillator layers alternate between being horizontally oriented or vertically oriented, in the xy-plane. The steel layers have a z-direction thickness of 5.08 cm and the scintillator layers have a z-direction thickness of 0.6 cm. Combining all the layers of the different alternating materials results in 26 scintillator layers that "sandwich" 25 steel layers inbetween and gives a total z-direction dimension of being 1.37m. The xy-plane is modeled as a square again (as was the case with SciBar, too) with dimensions in the x-direction and the y-direction of 2.6 m. The energy deposition (dE/dx) of the muon for the scintillator layers is again a constant of 2.04 MeV/cm and the energy deposition for the steel layers are a constant with value 11.43 MeV/cm.

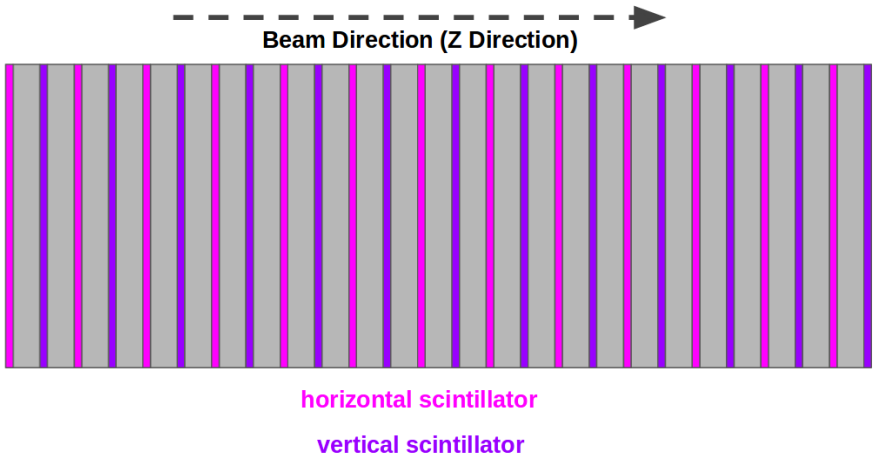

Figure 2: Depiction of the Muon Range Detector (MRB) which consists of alternating layers of horizontal scintillator (shown in pink) steel slabs (showin in grey) and vertical scintillator (shown in purple)

4 Event Selection

4.1 Event Classifications

There were three different classifications for events that qualified as CC-Coh Pion Production events, that the muon made it to the MRD, and the muon penetrated at least three layers of steel. These categories will be referenced multiple times throughout the remainder of this paper, which makes pertinent that the reader has an understanding of what each of the three specifically mean for any event that falls under any of these classifications.

4.1.1 Stopped

An event is classified as "Stopped," if the event qualified as being a CC-Coh Pion Production event, the muon of the event reached the MRD, penetrated three layers of steel, and stopped (or embedded) in the MRD without exiting the sides or the back face. Events that are classified as "Stopped" are included in the combined samples of this acceptance study and are called "Good" events. Maybe put in the dimensions of the xy-plane and z-direction that meet this classification for the MRD? This is shown in the figure below.

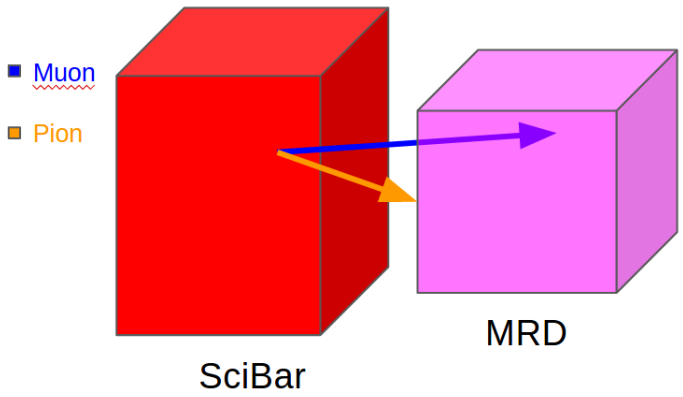

Figure 3: Depiction of an event that was classified as "Stopped."

4.1.2 Not-Stopped

An event is classified as "Not-Stopped," if the event qualified as being a CC-Coh Pion Production event, the muon of the event reached the MRD, and the muon passed out the back face of the MRD without stopping. Events that are classified as "Not-Stopped" are included in the combined samples of this acceptance study and are also called "Good" events. Maybe put in the dimensions of the xy-plane and z-direction that meet this classification for the MRD? This is shown in the figure below.

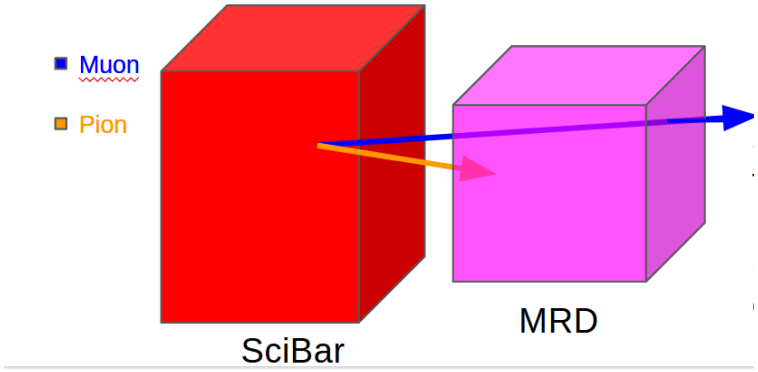

Figure 4: Depiction of an event that was classified as "Not-Stopped."

4.1.3 Out-Side

An event is classified as "Out-Side," if the event qualified as being a CC-Coh Pion Production event, the muon of the event reached the MRD, penetrated three layers of steel, and then passed through one of the sides of the MRD (not including the back face) without stopping. Events that are classified as "Out-Side" are not included in the combined samples because there was not enough material traversal for an accurate reconstruction of the particles momentum and energy to be made. Maybe put in the dimensions of the xy-plane and z-direction that meet this classification for the MRD? This is shown in the figure below.

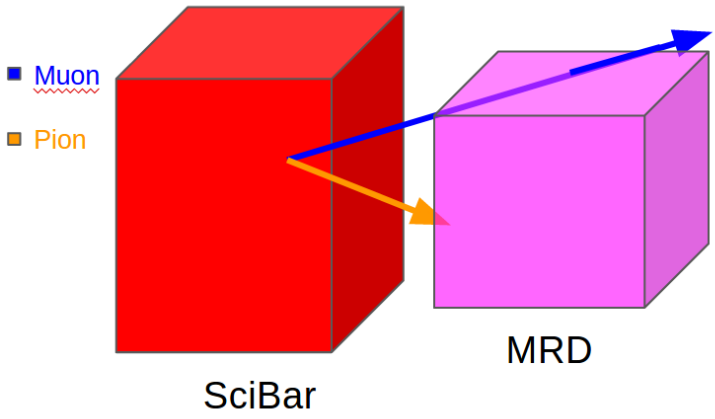

Figure 5: Depiction of an event that was classified as "Out-Side."

4.2 Stepping Through the Detectors Along an Event

I do not know if I am really going to include this here or not...

5 Results

A Appendix: Sample Details

Appendix on samples

A.1 ν-Mode Rein-Sehgal NEUTv5.3.6

A sample of 1,000,000 ν interactions were simulated using the NEUT generator (v5.3.6) and the Rein-Sehgal model for coherent pion production. This sample correspond to the file labeled

`SciBooNE_numu_coh_RooTrack.root`

found at the following link (put link to sample here).

A.2 ν-Mode Berger-Sehgal NEUTv5.3.6

A sample of 1,000,000 ν interactions were simulated using the NEUT generator (v5.3.6) and the Berger-Sehgal model for coherent pion production. This sample correspond to the file labeled

`SciBooNE_numu_coh_RooTrack_NEW.root`

found at the following link (put link to sample here).

A.3 ν-Mode Rein-Sehgal NEUTvx.x.x

A sample of 100,000 ν interactions were simulated using the NEUT generator (vx.x.x, believed to be the version used by the SciBooNE collaboration in the original publication) and the corresponding older Rein-Sehgal model for coherent pion production. This sample correspond to the file labeled

`SciBooNE_numu_coh_OLDNEUT_RooTrack.root`

found at the following link (put link to sample here).

A.4 *bar*ν-Mode Rein-Sehgal NEUTv5.3.6

A sample of 1,000,000 $\bar{\nu}$ interactions were simulated using the NEUT generator (v5.3.6) and the Rein-Sehgal model for coherent pion production. This sample correspond to the file labeled

`SciBooNE_numubar_coh_RooTrack.root`

found at the following link (put link to sample here).

A.5 $\bar{\nu}$-Mode Berger-Sehgal NEUTv5.3.6

A sample of 1,000,000 $\bar{\nu}$ interactions were simulated using the NEUT generator (v5.3.6) and the Berger-Sehgal model for coherent pion production. This sample correspond to the file labeled

`SciBooNE_numubar_coh_RooTrack_NEW.root`

found at the following link (put link to sample here).

A.6 Vertex Distributions

The events were all given a random initial point that was generated with the goal that the vertex distributions of this simulation would closely match the vertex distributions that Hiraide (need to put a reference) showed in his thesis. This was done by... etc.

Put in the code **for** how we made the vertex distributions of the interactions.

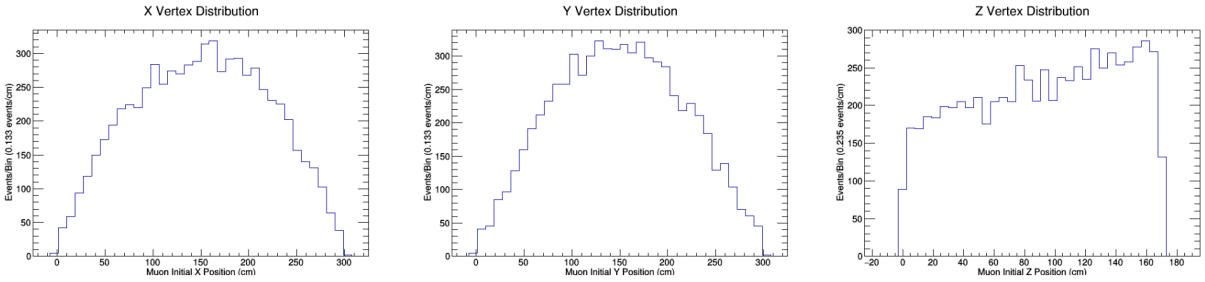

Figure 6: Vertex distributions of the events in the new Rein-Sehgal sample.

A.7 NewNMReinSehgal.C

This file is the macro that corresponds to the "NewNMReinSehgal.h" file, which connects with this file: "SciBooNE_numu_coh_RooTrack.root". This file performs the main analysis for this generated sample, and then organizes the information into many different histograms. The histograms are then written to a file titled "totalmuoninfoRS.root" inside the "ROOTFILES" directory. The "ROOTFILES" directory is included in the SciBooNE-MC repository (it is absolutely pertinent that this directory be located where the macro files are located due to how the calls of the combined data macros reference the now saved histograms). When this macro is run (which can take a while), it also plots a few different histograms. The histograms that are plotted are the ones shown in the figures below with descriptions included with the corresponding figures. The order that the histograms appear in this paper is the same order they will be shown when this macro is run in root.

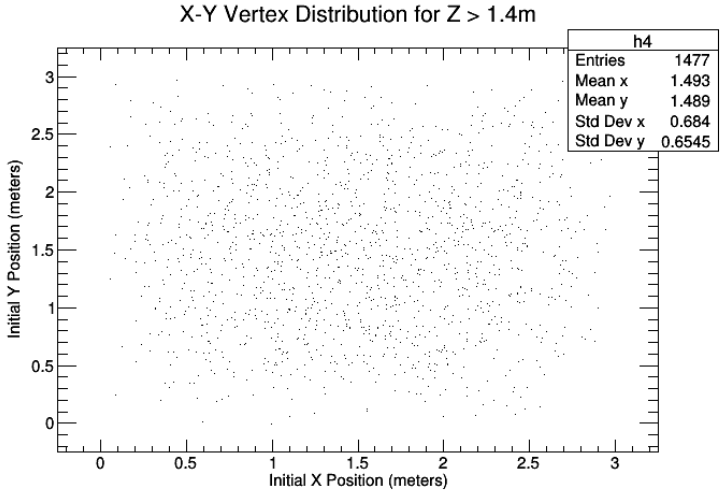

Figure 7: New Rein-Sehgal X-Y vertex distributions for muons that made it to the MRD.

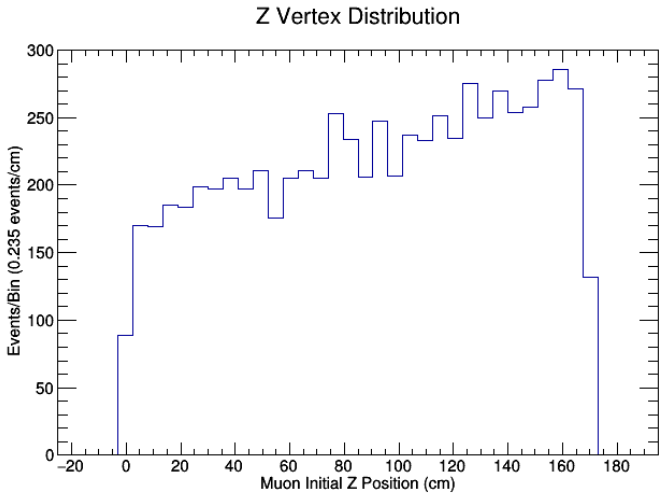

Figure 8: New Rein-Sehgal Z vertex distributions for the interactions.

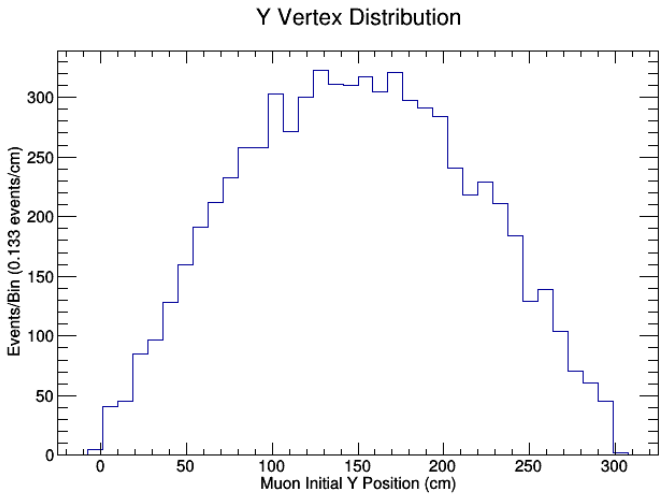

Figure 9: New Rein-Sehgal Y vertex distributions for the interactions.

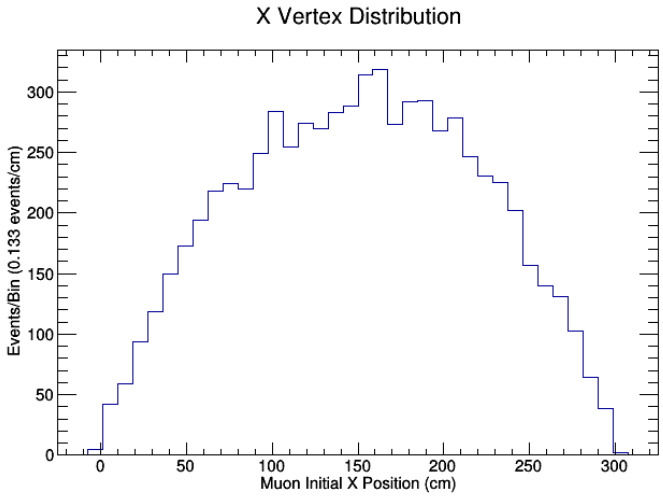

Figure 10: New Rein-Sehgal X vertex distributions for the interactions.

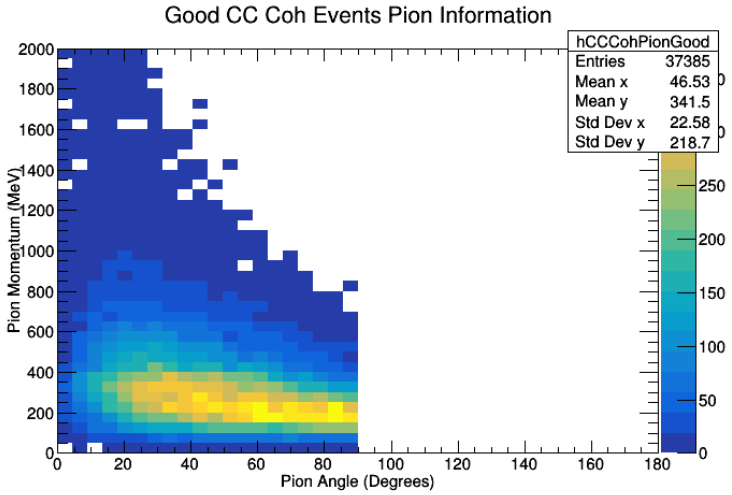

Figure 11: This is a 2D histogram for the momentum and angle of the pion in the CC Coh Pion events that met the qualification of being "good".

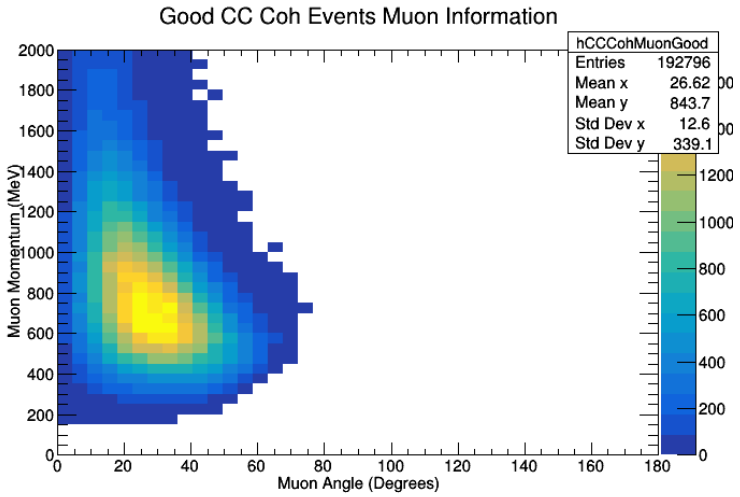

Figure 12: This is a 2D histogram for the momentum and angle of the muon in the CC Coh Pion events that met the qualification of being "good".

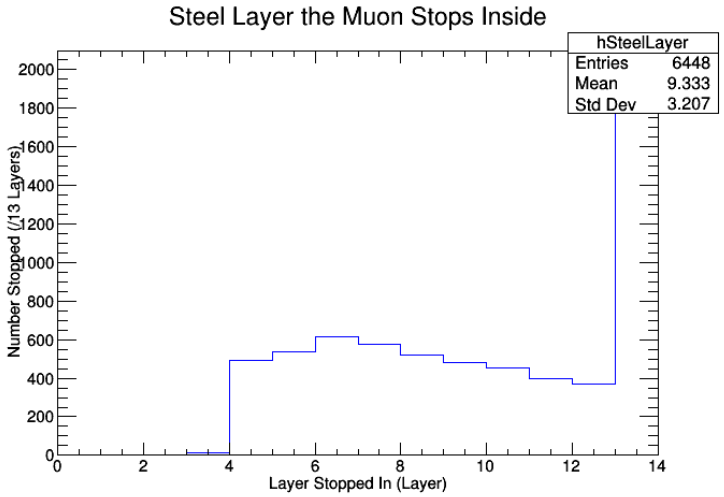

Figure 13: This histogram depicts the amount of muons that embedded in what layer of steel.

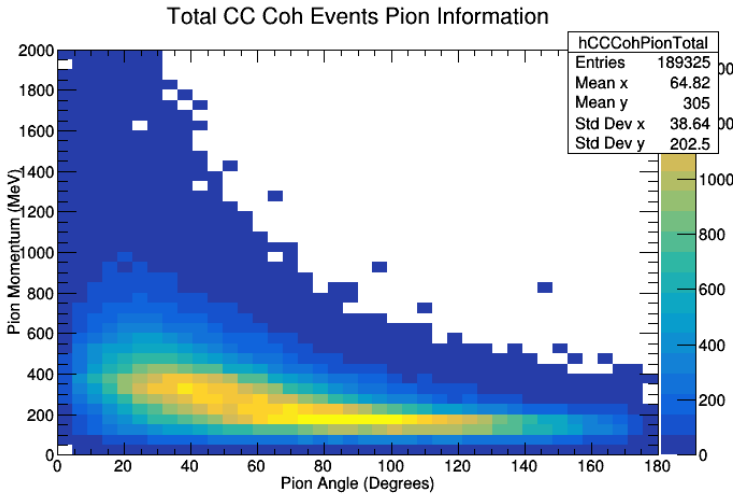

Figure 14: This is a plot right here. Nice of you to notice!

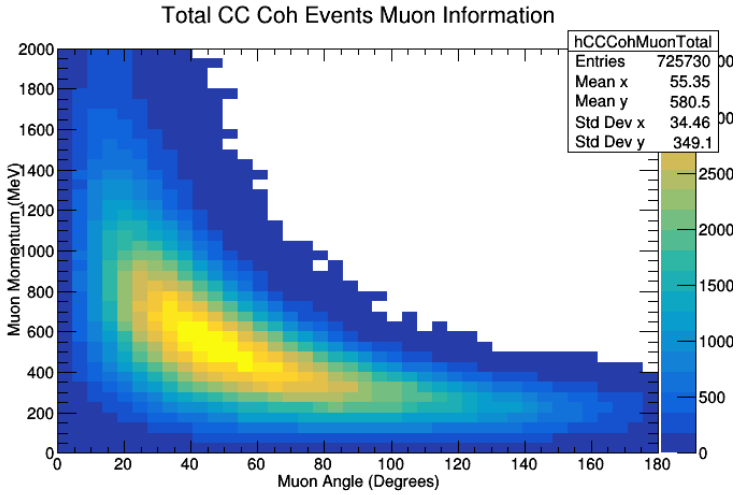

Figure 15: This is a plot right here. Nice of you to notice!

The NewNMReinSehgal.C macro also calculates many different quantities for the generated simulation of the events and saves the information in histograms that are later called upon through the plotting macros (which are after all of the analysis macros). The first quantity that is calculated for the different vertexes is the momentum of both the muon and the pion, which are both calculated using the equations:

$$|\vec{p}_\mu| = \sqrt{P_{\mu_x}^2 + P_{\mu_y}^2 + P_{\mu_z}^2} \tag{1}$$

$$|\vec{p}_\pi| = \sqrt{P_{\pi_x}^2 + P_{\pi_y}^2 + P_{\pi_z}^2} \tag{2}$$

The momentum is reported in units of MeV/c.

The next quantity that is calculated in the macro is the angle from the beam-direction for both the muon and the pion, which are labeled as either θ_μ, or θ_π, respectively. The angle from the beam-direction is the same as the angle from the z-direction, and this angle is known as the azimuthal

angle. The calculation of the azimuthal angle is slightly more involved than the simple calculation used for finding the magnitude of the momentum of the two particles, and is calculated using the equations:

$$\theta_\mu = tan^{-1}(\sqrt{P_{\mu_x}^2 + P_{\mu_y}^2}/P_{\mu_z}) \tag{3}$$

$$\theta_\pi = tan^{-1}(\sqrt{P_{\pi_x}^2 + P_{\pi_y}^2}/P_{\pi_z}) \tag{4}$$

The angles are reported in units of °, and should run from 0° to 180°. In the case of Charged-Current Coherent Pion Production, the angle should never be larger than 90°.

The last two quantities that this analysis macro calculates are the two different types of four-momentum transfers specific to this interaction, which are Q^2 and $|t|$. The Q^2 corresponds to the four-momentum transfer from the neutrino and muon to the nucleus and pion, and is calculated using the equation:

$$Q^2 = |(P_{\nu_\mu} - P_\mu)^2| \tag{5}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute Q^2:

$$Q^2 = |(P_{\nu_{\mu,x}} - P_{\mu_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E})^2| \tag{6}$$

Q^2 is reported in units of $(MeV/c)^2$.

The $|t|$ corresponds to the four-momentum transfer from the neutrino, muon, and pion to the nucleus, and is calculated using the equation:

$$|t| = |(Q - P_\pi)^2| = |(P_{\nu_\mu} - P_\mu - P_\pi)^2| \tag{7}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute $|t|$:

$$|t| = |(P_{\nu_{\mu,x}} - P_{\mu_x} - P_{\pi_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y} - P_{\pi_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z} - P_{\pi_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E} - P_{\pi_E})^2| \tag{8}$$

$|t|$ is reported in units of $(MeV/c)^2$.

A.8 NewNMBergerSehgal.C

This file is the macro that corresponds to the "NewNMBergerSehgal.h" file, which connects with this file: "SciBooNE_numu_coh_RooTrack_NEW.root". This file performs the main analysis for this generated sample, and then organizes the information into many different histograms. The histograms are then written to a file titled "totalmuoninfoBS.root" inside the "ROOTFILES" directory. The "ROOTFILES" directory is included in the SciBooNE-MC repository (it is absolutely pertinent that this directory be located where the macro files are located due to how the calls of the combined data macros reference the now saved histograms).

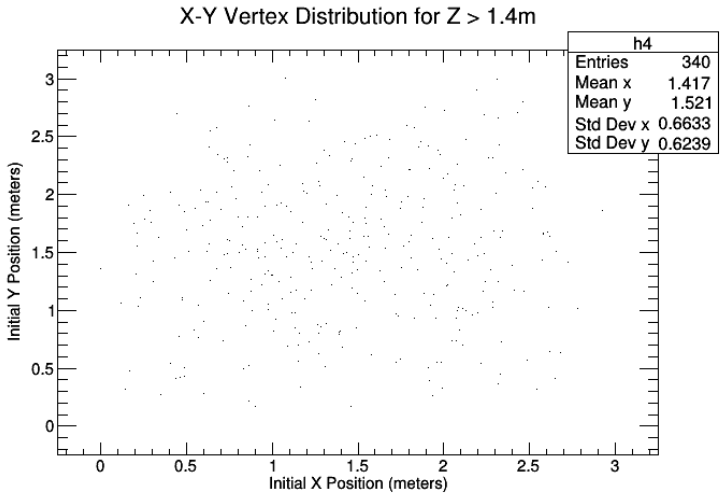

Figure 16: This is a plot right here. Nice of you to notice!

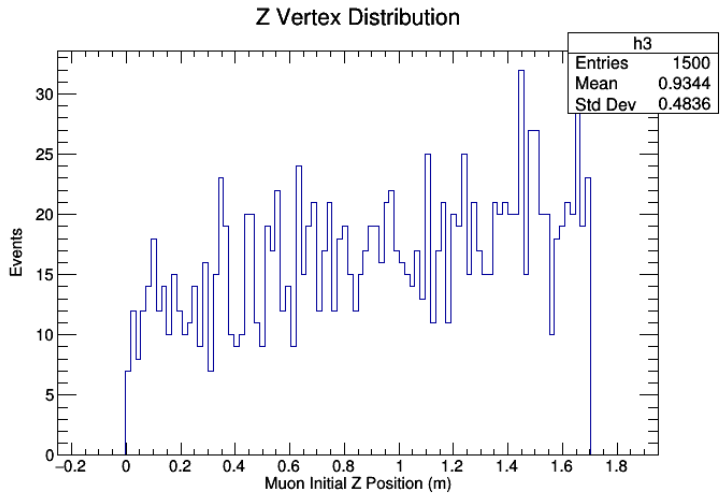

Figure 17: This is a plot right here. Nice of you to notice!

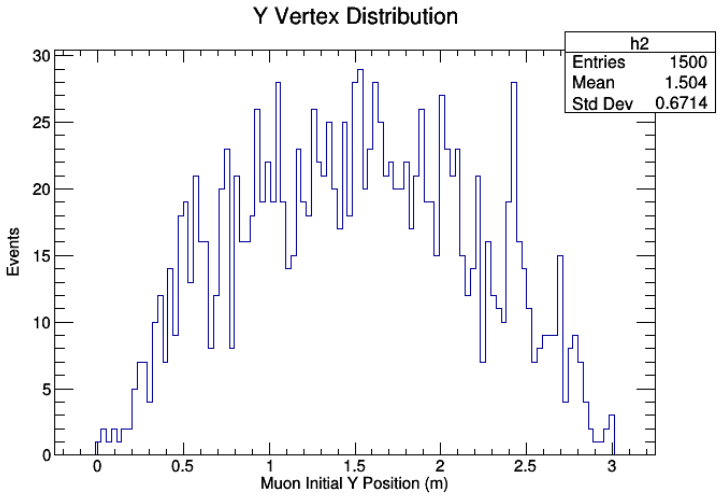

Figure 18: This is a plot right here. Nice of you to notice!

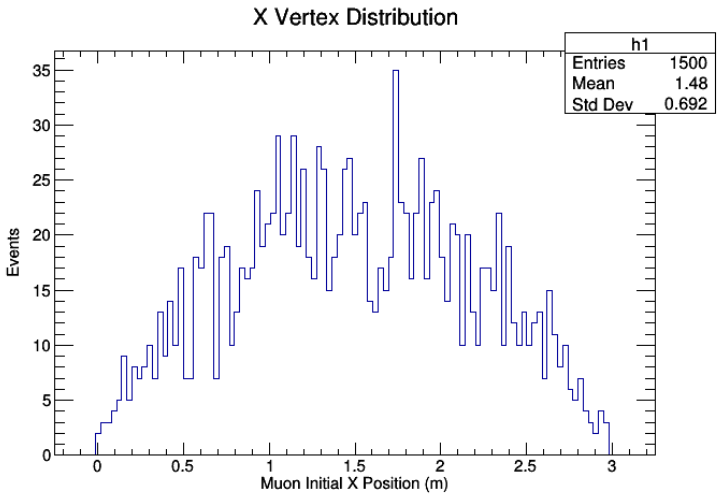

Figure 19: This is a plot right here. Nice of you to notice!

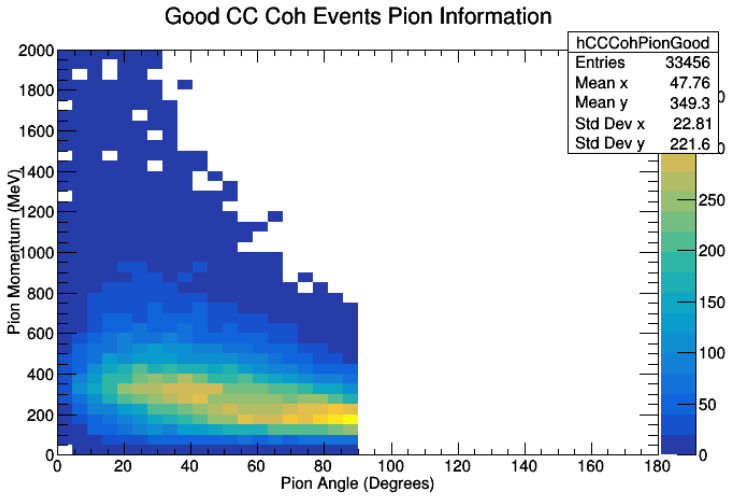

Figure 20: This is a plot right here. Nice of you to notice!

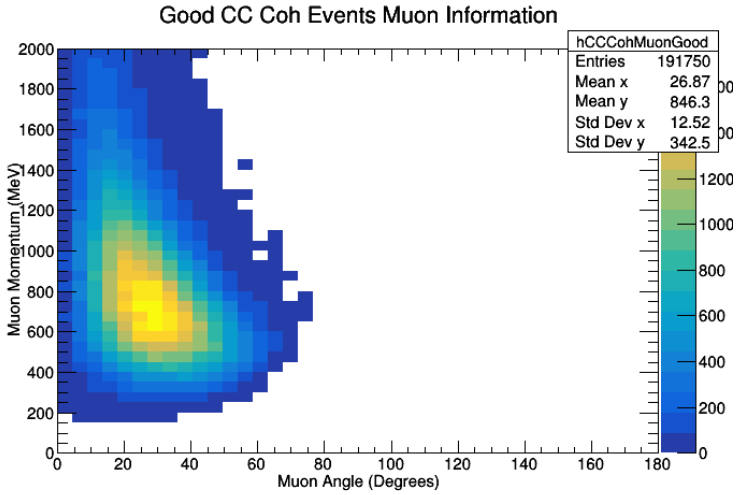

Figure 21: This is a plot right here. Nice of you to notice!

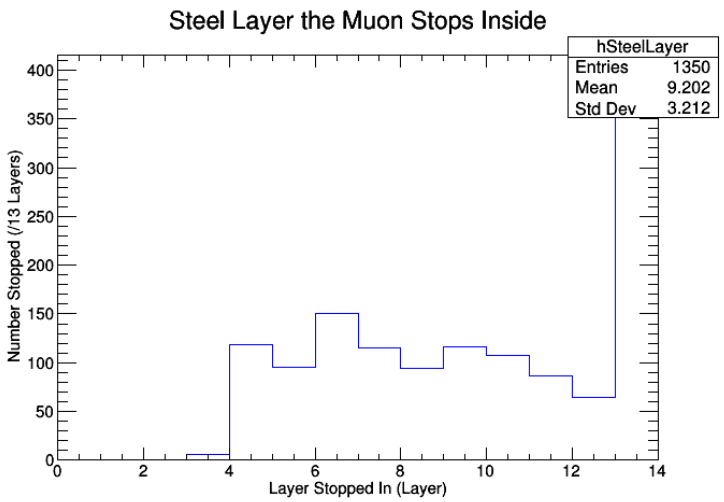

Figure 22: This is a plot right here. Nice of you to notice!

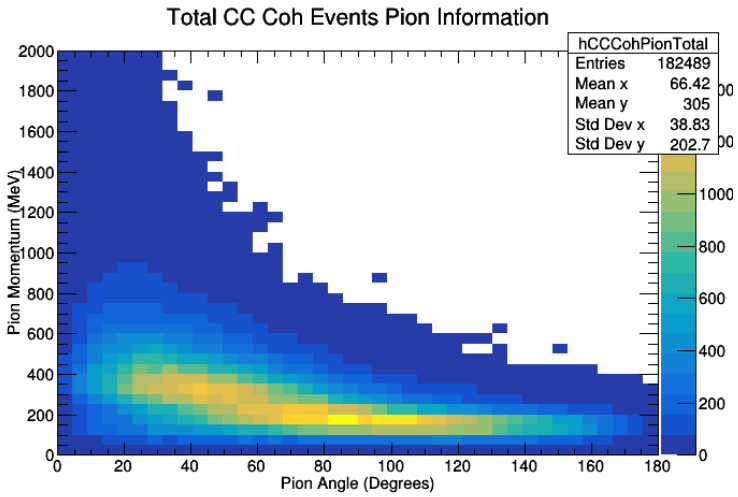

Figure 23: This is a plot right here. Nice of you to notice!

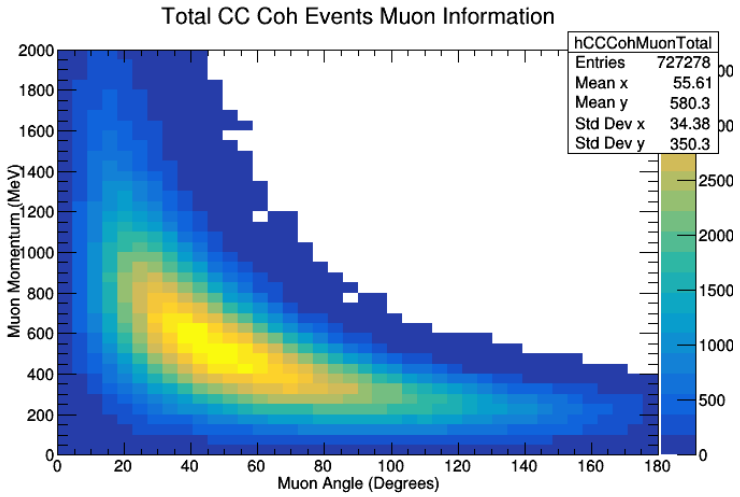

Figure 24: This is a plot right here. Nice of you to notice!

The NewNMBergerSehgal.C macro also calculates many different quantities for the generated simulation of the events and saves the information in histograms that are later called upon through the plotting macros (which are after all of the analysis macros). The first quantity that is calculated for the different vertexes is the momentum of both the muon and the pion, which are both calculated using the equations:

$$|\vec{p}_\mu| = \sqrt{P_{\mu_x}^2 + P_{\mu_y}^2 + P_{\mu_z}^2} \tag{9}$$

$$|\vec{p}_\pi| = \sqrt{P_{\pi_x}^2 + P_{\pi_y}^2 + P_{\pi_z}^2} \tag{10}$$

The momentum is reported in units of MeV/c.

The next quantity that is calculated in the macro is the angle from the beam-direction for both the muon and the pion, which are labeled as either θ_μ, or θ_π, respectively. The angle from the beam-direction is the same as the angle from the z-direction, and this angle is known as the azimuthal angle. The calculation of the azimuthal angle is slightly more involved than the simple calculation used for finding the magnitude of the momentum of the two particles, and is calculated using the equations:

$$\theta_\mu = tan^{-1}(\sqrt{P_{\mu_x}^2 + P_{\mu_y}^2}/P_{\mu_z}) \tag{11}$$

$$\theta_\pi = tan^{-1}(\sqrt{P_{\pi_x}^2 + P_{\pi_y}^2}/P_{\pi_z}) \tag{12}$$

The angles are reported in units of °, and should run from 0° to 180°. In the case of Charged-Current Coherent Pion Production, the angle should never be larger than 90°.

The last two quantities that this analysis macro calculates are the two different types of four-momentum transfers specific to this interaction, which are Q^2 and $|t|$. The Q^2 corresponds to the four-momentum transfer from the neutrino and muon to the nucleus and pion, and is calculated using the equation:

$$Q^2 = |(P_{\nu_\mu} - P_\mu)^2| \tag{13}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute Q^2:

$$Q^2 = |(P_{\nu_{\mu,x}} - P_{\mu_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E})^2| \quad (14)$$

Q^2 is reported in units of $(MeV/c)^2$.

The $|t|$ corresponds to the four-momentum transfer from the neutrino, muon, and pion to the nucleus, and is calculated using the equation:

$$|t| = |(Q - P_\pi)^2| = |(P_{\nu_\mu} - P_\mu - P_\pi)^2| \quad (15)$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute $|t|$:

$$|t| = |(P_{\nu_{\mu,x}} - P_{\mu_x} - P_{\pi_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y} - P_{\pi_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z} - P_{\pi_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E} - P_{\pi_E})^2| \quad (16)$$

$|t|$ is reported in units of $(MeV/c)^2$.

A.9 OldNMReinSehgal.C

This file is the macro that corresponds to the "OldNMReinSehgal.h" file, which connects with this file: "SciBooNE_numu_coh_OLDNEUT_RooTrack.root". This file performs the main analysis for this generated sample, and then organizes the information into many different histograms. The histograms are then written to a file titled "totalmuoninfoOBS.root" inside the "ROOTFILES" directory. The "ROOTFILES" directory is included in the SciBooNE-MC repository (it is absolutely pertinent that this directory be located where the macro files are located due to how the calls of the combined data macros reference the now saved histograms).

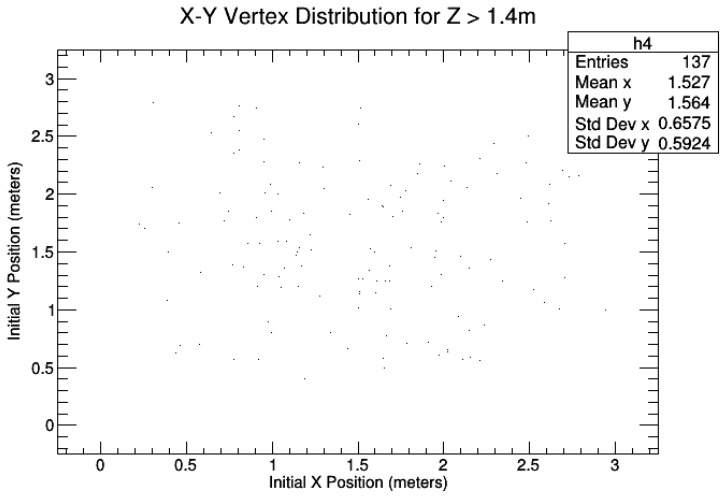

Figure 25: This is a plot right here. Nice of you to notice!

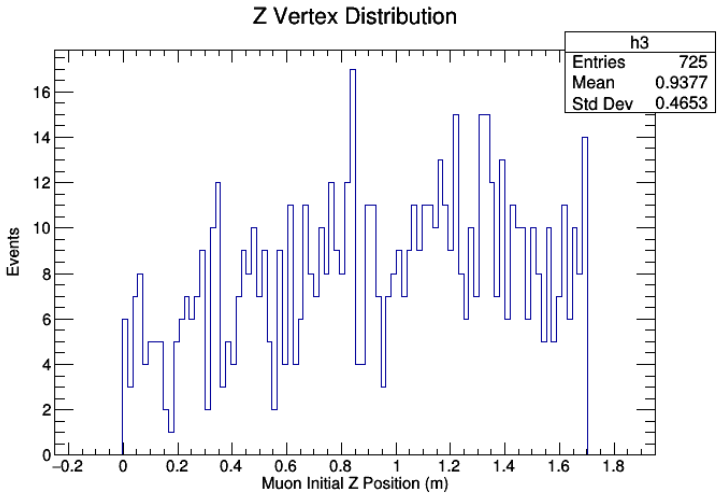

Figure 26: This is a plot right here. Nice of you to notice!

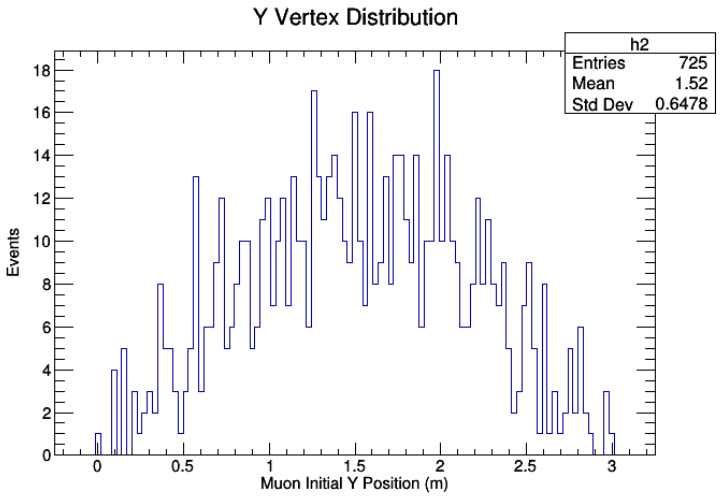

Figure 27: This is a plot right here. Nice of you to notice!

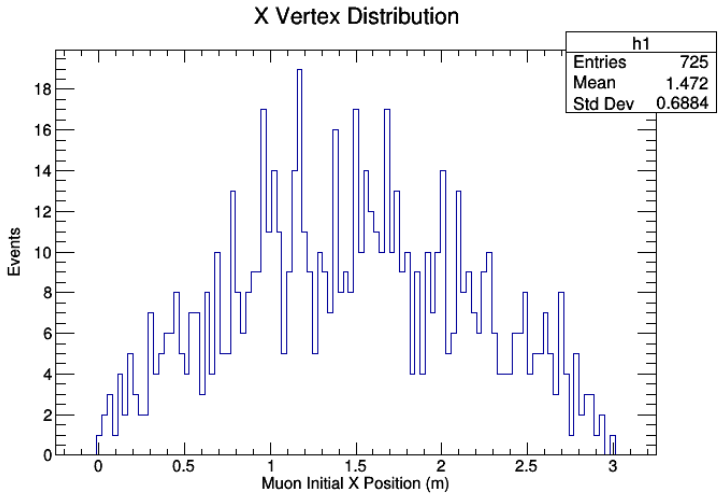

Figure 28: This is a plot right here. Nice of you to notice!

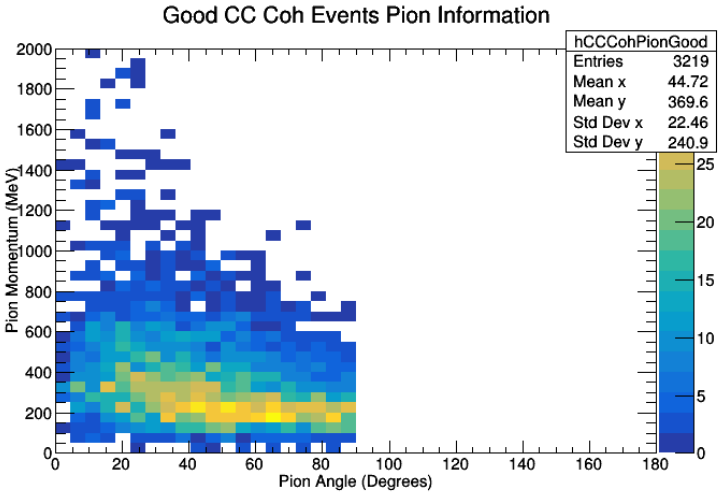

Figure 29: This is a plot right here. Nice of you to notice!

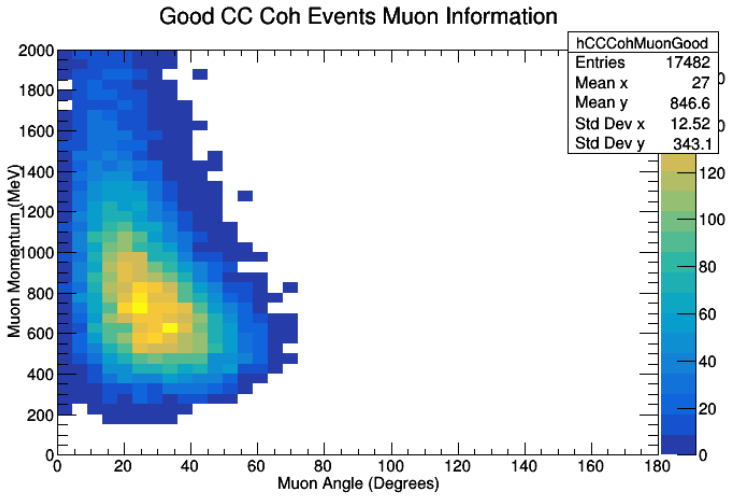

Figure 30: This is a plot right here. Nice of you to notice!

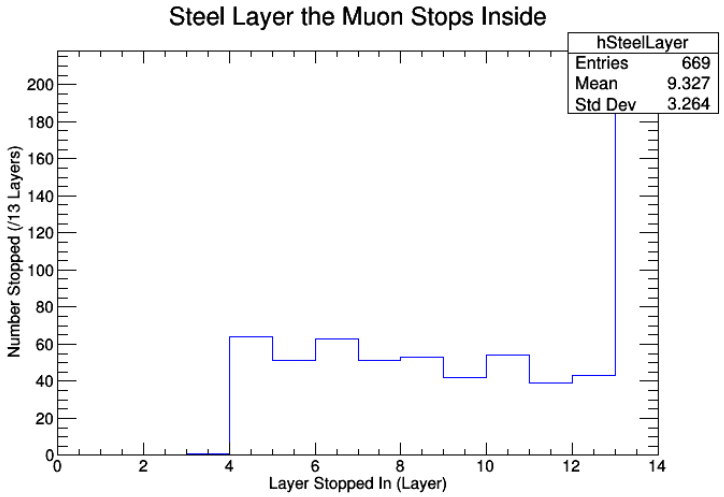

Figure 31: This is a plot right here. Nice of you to notice!

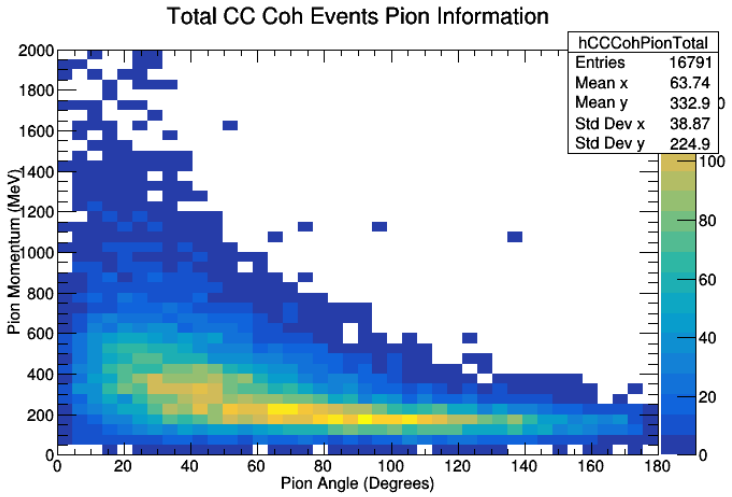

Figure 32: This is a plot right here. Nice of you to notice!

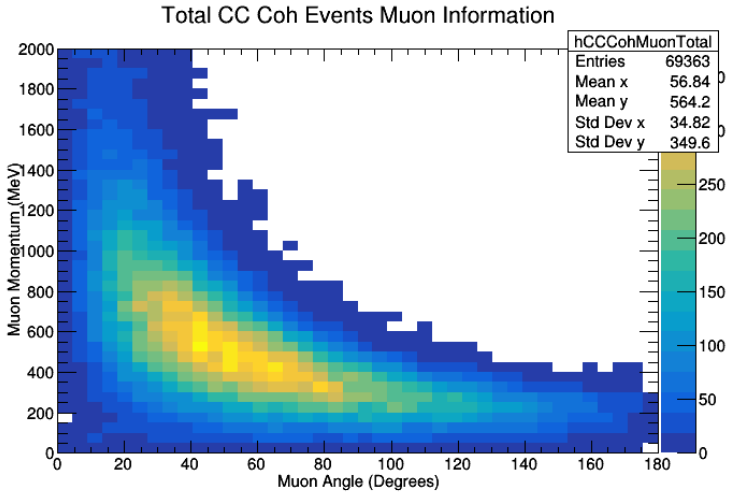

Figure 33: This is a plot right here. Nice of you to notice!

The OldNMReinSehgal.C macro also calculates many different quantities for the generated simulation of the events and saves the information in histograms that are later called upon through the plotting macros (which are after all of the analysis macros). The first quantity that is calculated for the different vertexes is the momentum of both the muon and the pion, which are both calculated using the equations:

$$|\vec{p}_\mu| = \sqrt{P_{\mu_x}^2 + P_{\mu_y}^2 + P_{\mu_z}^2} \tag{17}$$

$$|\vec{p}_\pi| = \sqrt{P_{\pi_x}^2 + P_{\pi_y}^2 + P_{\pi_z}^2} \tag{18}$$

The momentum is reported in units of MeV/c.

The next quantity that is calculated in the macro is the angle from the beam-direction for both the muon and the pion, which are labeled as either θ_μ, or θ_π, respectively. The angle from the beam-direction is the same as the angle from the z-direction, and this angle is known as the azimuthal

angle. The calculation of the azimuthal angle is slightly more involved than the simple calculation used for finding the magnitude of the momentum of the two particles, and is calculated using the equations:

$$\theta_\mu = tan^{-1}(\sqrt{P_{\mu_x}^2 + P_{\mu_y}^2}/P_{\mu_z}) \tag{19}$$

$$\theta_\pi = tan^{-1}(\sqrt{P_{\pi_x}^2 + P_{\pi_y}^2}/P_{\pi_z}) \tag{20}$$

The angles are reported in units of °, and should run from 0° to 180°. In the case of Charged-Current Coherent Pion Production, the angle should never be larger than 90°.

The last two quantities that this analysis macro calculates are the two different types of four-momentum transfers specific to this interaction, which are Q^2 and $|t|$. The Q^2 corresponds to the four-momentum transfer from the neutrino and muon to the nucleus and pion, and is calculated using the equation:

$$Q^2 = |(P_{\nu_\mu} - P_\mu)^2| \tag{21}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute Q^2:

$$Q^2 = |(P_{\nu_{\mu,x}} - P_{\mu_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E})^2| \tag{22}$$

Q^2 is reported in units of $(MeV/c)^2$.

The $|t|$ corresponds to the four-momentum transfer from the neutrino, muon, and pion to the nucleus, and is calculated using the equation:

$$|t| = |(Q - P_\pi)^2| = |(P_{\nu_\mu} - P_\mu - P_\pi)^2| \tag{23}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute $|t|$:

$$|t| = |(P_{\nu_{\mu,x}} - P_{\mu_x} - P_{\pi_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y} - P_{\pi_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z} - P_{\pi_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E} - P_{\pi_E})^2| \tag{24}$$

$|t|$ is reported in units of $(MeV/c)^2$.

A.10 NewANMReinSehgal.C

This file is the macro that corresponds to the "NewANMReinSehgal.h" file, which connects with this file: "SciBooNE_numubar_coh_RooTrack.root". This file performs the main analysis for this generated sample, and then organizes the information into many different histograms. The histograms are then written to a file titled "totalmuoninfoRSBar.root" inside the "ROOTFILES" directory. The "ROOTFILES" directory is included in the SciBooNE-MC repository (it is absolutely pertinent that this directory be located where the macro files are located due to how the calls of the combined data macros reference the now saved histograms).

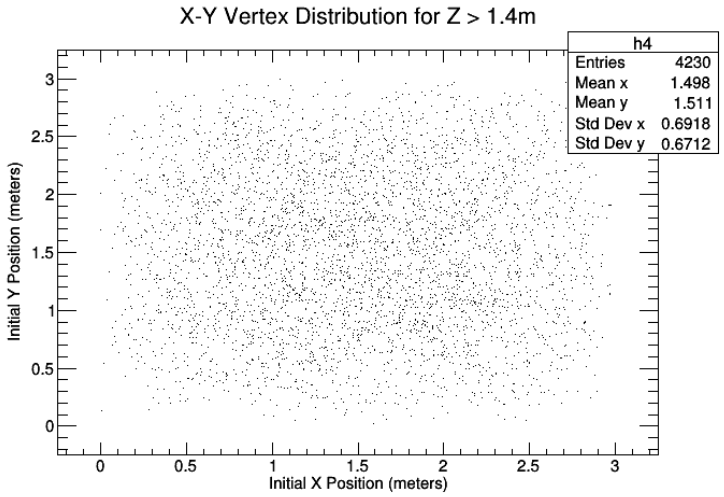

Figure 34: This is a plot right here. Nice of you to notice!

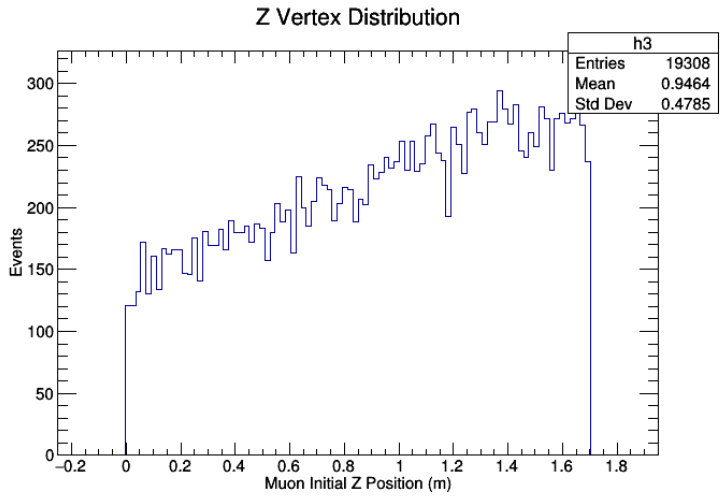

Figure 35: This is a plot right here. Nice of you to notice!

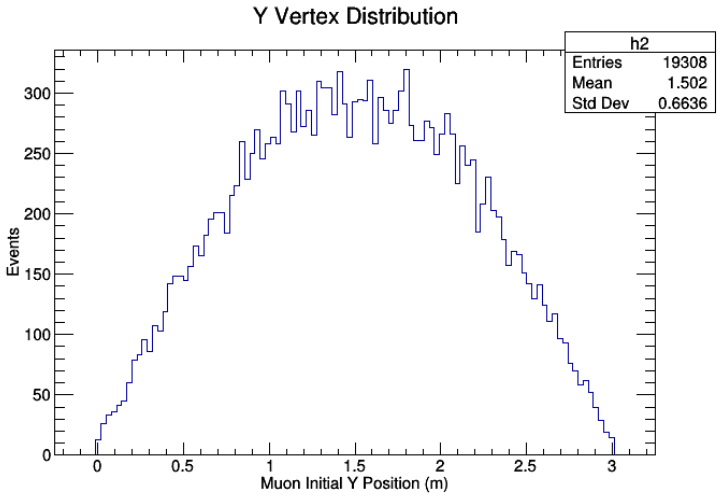

Figure 36: This is a plot right here. Nice of you to notice!

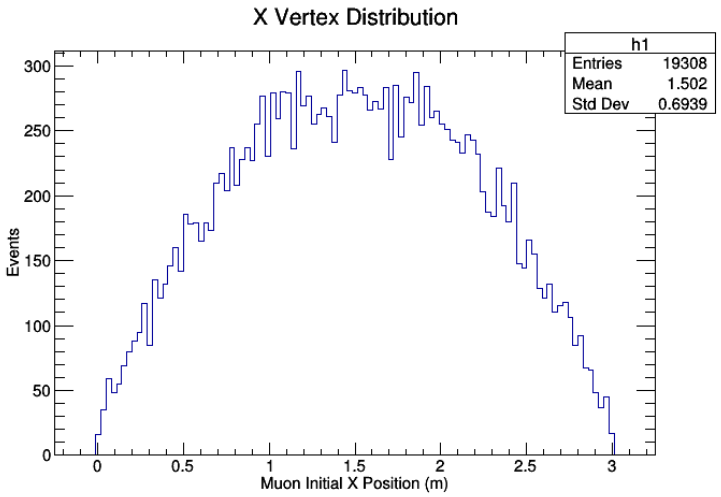

Figure 37: This is a plot right here. Nice of you to notice!

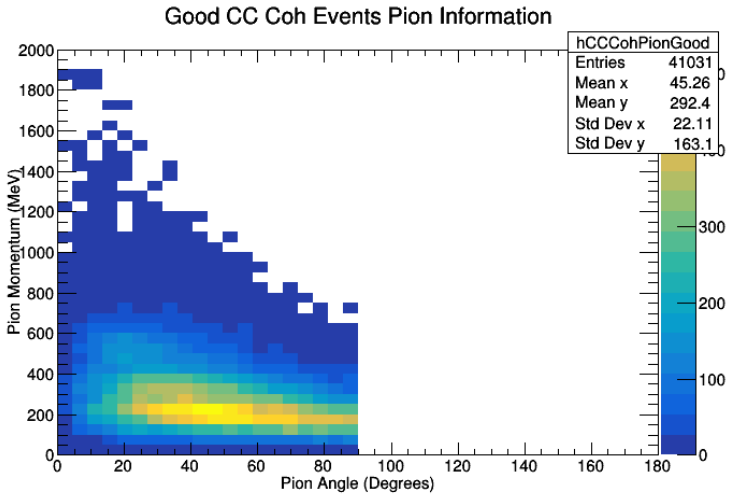

Figure 38: This is a plot right here. Nice of you to notice!

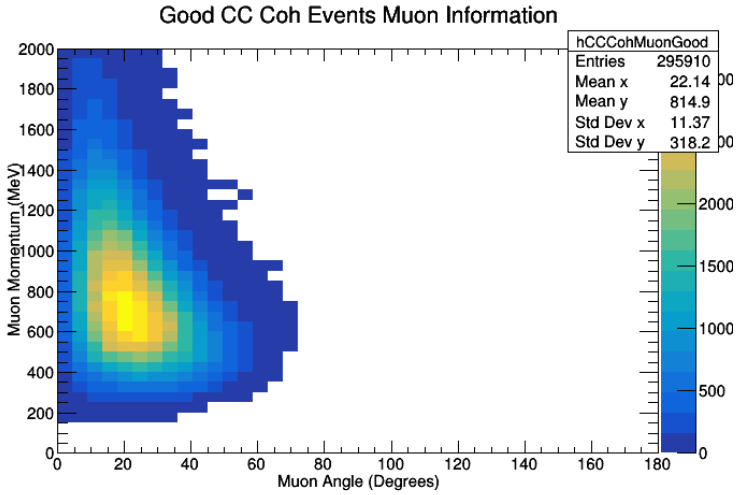

Figure 39: This is a plot right here. Nice of you to notice!

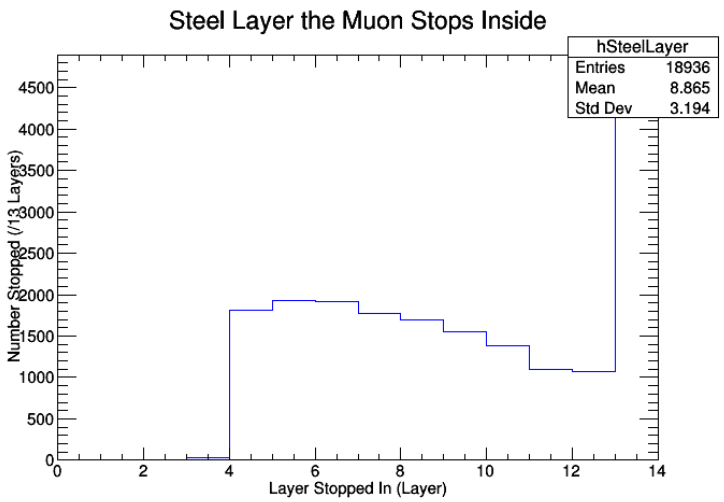

Figure 40: This is a plot right here. Nice of you to notice!

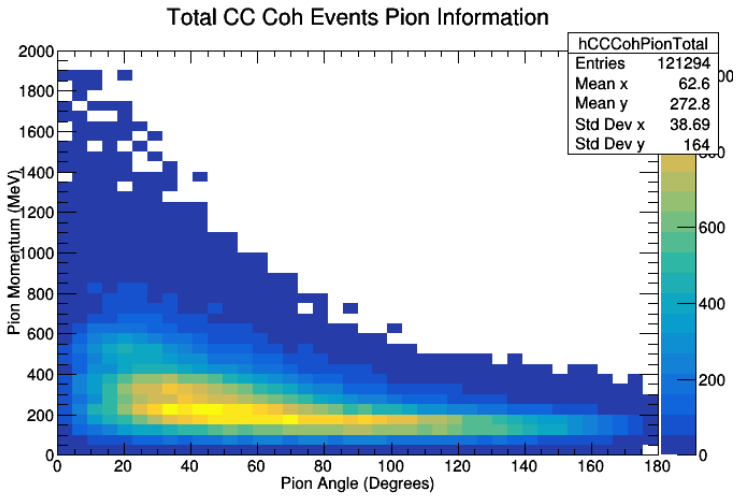

Figure 41: This is a plot right here. Nice of you to notice!

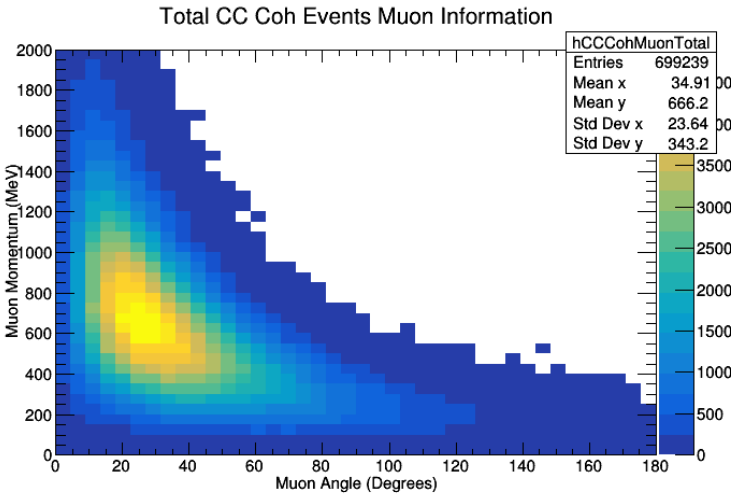

Figure 42: This is a plot right here. Nice of you to notice!

The NewANMReinSehgal.C macro also calculates many different quantities for the generated simulation of the events and saves the information in histograms that are later called upon through the plotting macros (which are after all of the analysis macros). The first quantity that is calculated for the different vertexes is the momentum of both the muon and the pion, which are both calculated using the equations:

$$|\vec{p}_\mu| = \sqrt{P_{\mu_x}^2 + P_{\mu_y}^2 + P_{\mu_z}^2} \tag{25}$$

$$|\vec{p}_\pi| = \sqrt{P_{\pi_x}^2 + P_{\pi_y}^2 + P_{\pi_z}^2} \tag{26}$$

The momentum is reported in units of MeV/c.

The next quantity that is calculated in the macro is the angle from the beam-direction for both the muon and the pion, which are labeled as either θ_μ, or θ_π, respectively. The angle from the beam-direction is the same as the angle from the z-direction, and this angle is known as the azimuthal angle. The calculation of the azimuthal angle is slightly more involved than the simple calculation used for finding the magnitude of the momentum of the two particles, and is calculated using the equations:

$$\theta_\mu = tan^{-1}(\sqrt{P_{\mu_x}^2 + P_{\mu_y}^2}/P_{\mu_z}) \tag{27}$$

$$\theta_\pi = tan^{-1}(\sqrt{P_{\pi_x}^2 + P_{\pi_y}^2}/P_{\pi_z}) \tag{28}$$

The angles are reported in units of °, and should run from 0° to 180°. In the case of Charged-Current Coherent Pion Production, the angle should never be larger than 90°.

The last two quantities that this analysis macro calculates are the two different types of four-momentum transfers specific to this interaction, which are Q^2 and $|t|$. The Q^2 corresponds to the four-momentum transfer from the neutrino and muon to the nucleus and pion, and is calculated using the equation:

$$Q^2 = |(P_{\nu_\mu} - P_\mu)^2| \tag{29}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute Q^2:

$$Q^2 = |(P_{\nu_{\mu,x}} - P_{\mu_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E})^2| \tag{30}$$

Q^2 is reported in units of $(MeV/c)^2$.

The $|t|$ corresponds to the four-momentum transfer from the neutrino, muon, and pion to the nucleus, and is calculated using the equation:

$$|t| = |(Q - P_\pi)^2| = |(P_{\nu_\mu} - P_\mu - P_\pi)^2| \tag{31}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute $|t|$:

$$|t| = |(P_{\nu_{\mu,x}} - P_{\mu_x} - P_{\pi_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y} - P_{\pi_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z} - P_{\pi_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E} - P_{\pi_E})^2| \tag{32}$$

$|t|$ is reported in units of $(MeV/c)^2$.

A.11 NewANMBergerSehgal.C

This file is the macro that corresponds to the "NewANMBergerSehgal.h" file, which connects with this file: "SciBooNE_numubar_coh_RooTrack_NEW.root". This file performs the main analysis for this generated sample, and then organizes the information into many different histograms. The histograms are then written to a file titled "totalmuoninfoBSBar.root" inside the "ROOTFILES" directory. The "ROOTFILES" directory is included in the SciBooNE-MC repository (it is absolutely pertinent that this directory be located where the macro files are located due to how the calls of the combined data macros reference the now saved histograms).

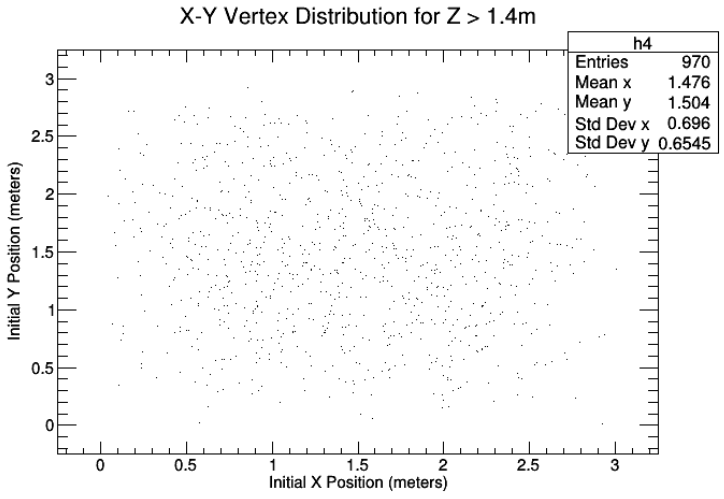

Figure 43: This is a plot right here. Nice of you to notice!

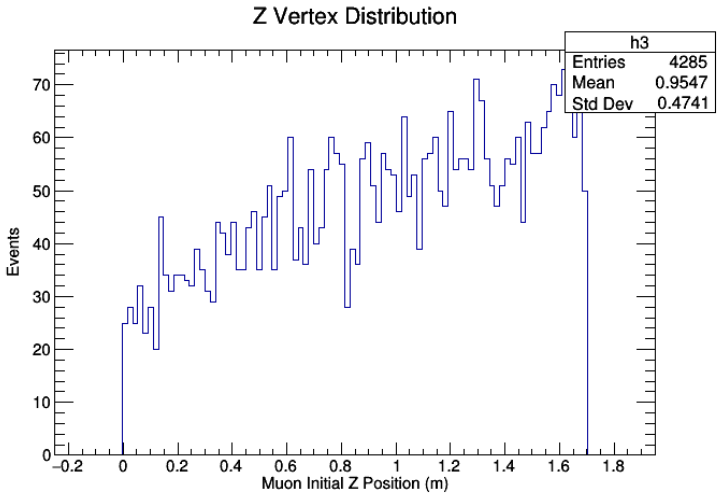

Figure 44: This is a plot right here. Nice of you to notice!

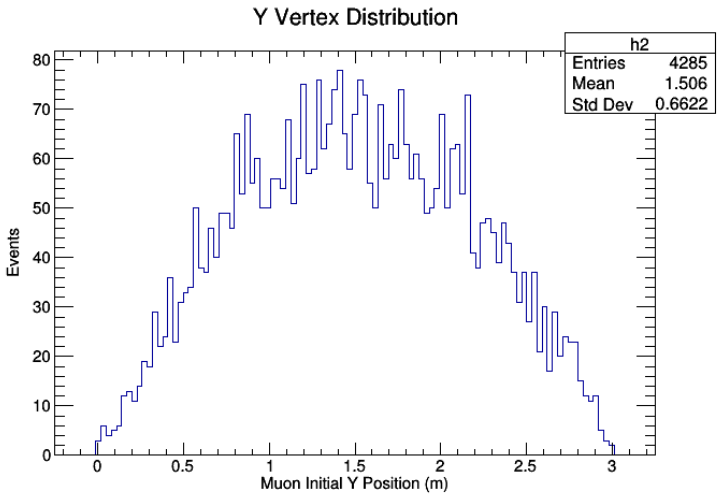

Figure 45: This is a plot right here. Nice of you to notice!

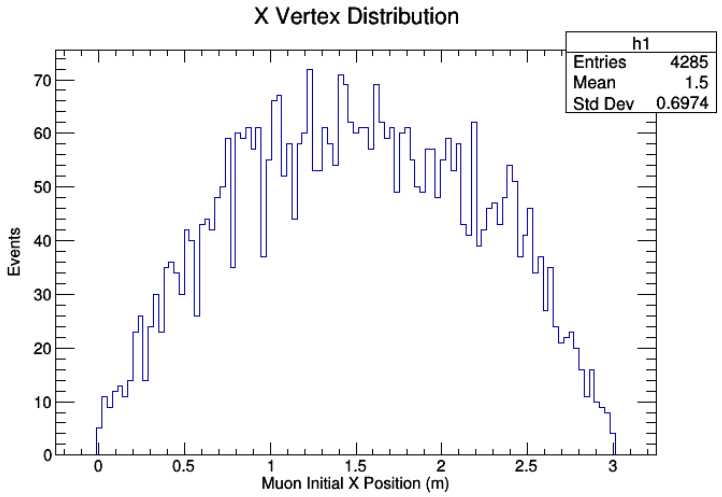

Figure 46: This is a plot right here. Nice of you to notice!

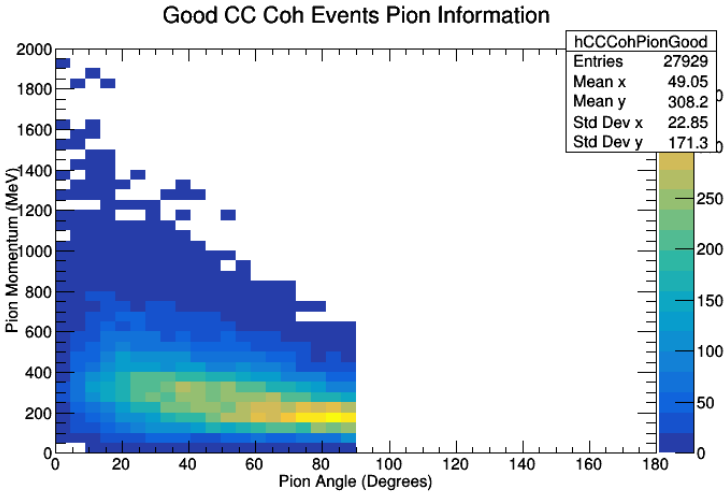

Figure 47: This is a plot right here. Nice of you to notice!

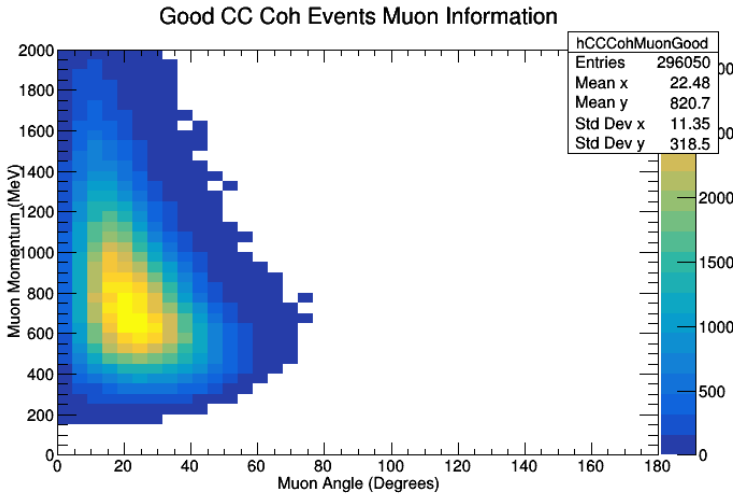

Figure 48: This is a plot right here. Nice of you to notice!

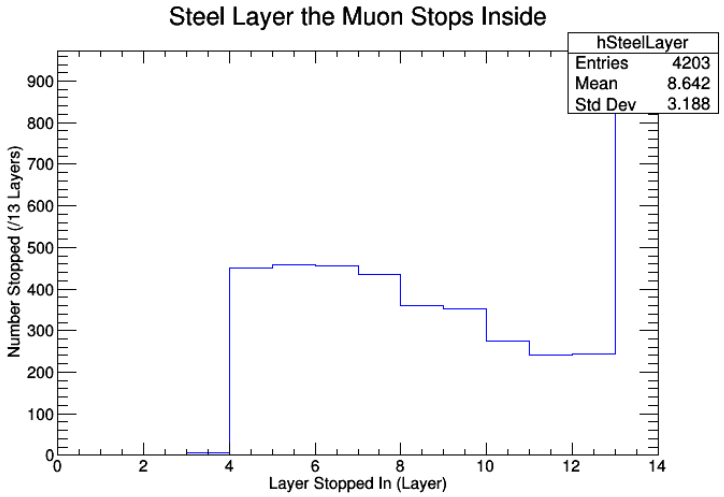

Figure 49: This is a plot right here. Nice of you to notice!

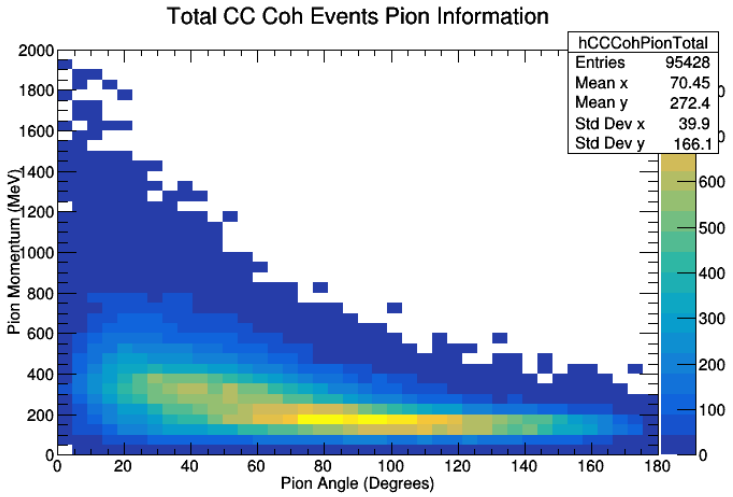

Figure 50: This is a plot right here. Nice of you to notice!

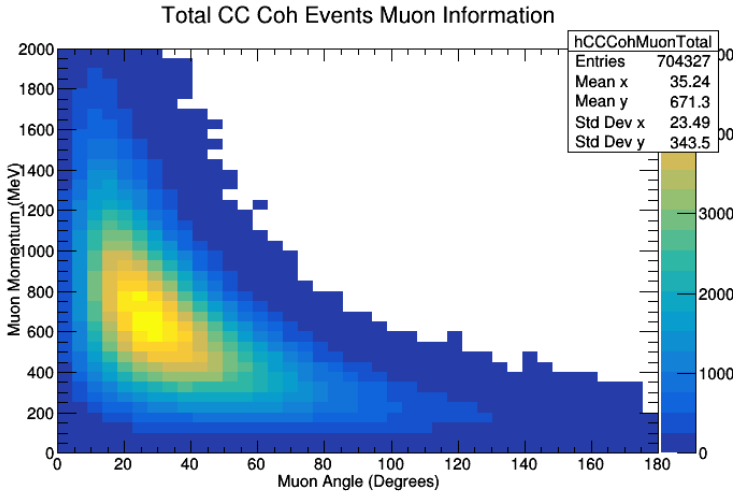

Figure 51: This is a plot right here. Nice of you to notice!

The NewANMBergerSehgal.C macro also calculates many different quantities for the generated simulation of the events and saves the information in histograms that are later called upon through the plotting macros (which are after all of the analysis macros). The first quantity that is calculated for the different vertexes is the momentum of both the muon and the pion, which are both calculated using the equations:

$$|\vec{p}_\mu| = \sqrt{P_{\mu_x}^2 + P_{\mu_y}^2 + P_{\mu_z}^2} \tag{33}$$

$$|\vec{p}_\pi| = \sqrt{P_{\pi_x}^2 + P_{\pi_y}^2 + P_{\pi_z}^2} \tag{34}$$

The momentum is reported in units of MeV/c.

The next quantity that is calculated in the macro is the angle from the beam-direction for both the muon and the pion, which are labeled as either θ_μ, or θ_π, respectively. The angle from the beam-direction is the same as the angle from the z-direction, and this angle is known as the azimuthal

angle. The calculation of the azimuthal angle is slightly more involved than the simple calculation used for finding the magnitude of the momentum of the two particles, and is calculated using the equations:

$$\theta_\mu = tan^{-1}(\sqrt{P_{\mu_x}^2 + P_{\mu_y}^2}/P_{\mu_z}) \tag{35}$$

$$\theta_\pi = tan^{-1}(\sqrt{P_{\pi_x}^2 + P_{\pi_y}^2}/P_{\pi_z}) \tag{36}$$

The angles are reported in units of °, and should run from 0° to 180°. In the case of Charged-Current Coherent Pion Production, the angle should never be larger than 90°.

The last two quantities that this analysis macro calculates are the two different types of four-momentum transfers specific to this interaction, which are Q^2 and $|t|$. The Q^2 corresponds to the four-momentum transfer from the neutrino and muon to the nucleus and pion, and is calculated using the equation:

$$Q^2 = |(P_{\nu_\mu} - P_\mu)^2| \tag{37}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute Q^2:

$$Q^2 = |(P_{\nu_{\mu,x}} - P_{\mu_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E})^2| \tag{38}$$

Q^2 is reported in units of $(MeV/c)^2$.

The $|t|$ corresponds to the four-momentum transfer from the neutrino, muon, and pion to the nucleus, and is calculated using the equation:

$$|t| = |(Q - P_\pi)^2| = |(P_{\nu_\mu} - P_\mu - P_\pi)^2| \tag{39}$$

This equation is the four-momentum notational form. The code follows the equation below in order to compute $|t|$:

$$|t| = |(P_{\nu_{\mu,x}} - P_{\mu_x} - P_{\pi_x})^2 + (P_{\nu_{\mu,y}} - P_{\mu_y} - P_{\pi_y})^2 + (P_{\nu_{\mu,z}} - P_{\mu_z} - P_{\pi_z})^2 + (P_{\nu_{\mu,E}} - P_{\mu_E} - P_{\pi_E})^2| \tag{40}$$

$|t|$ is reported in units of $(MeV/c)^2$.

A.12 NMCombinedPlots.C

I need to come back and insert all of my images here.

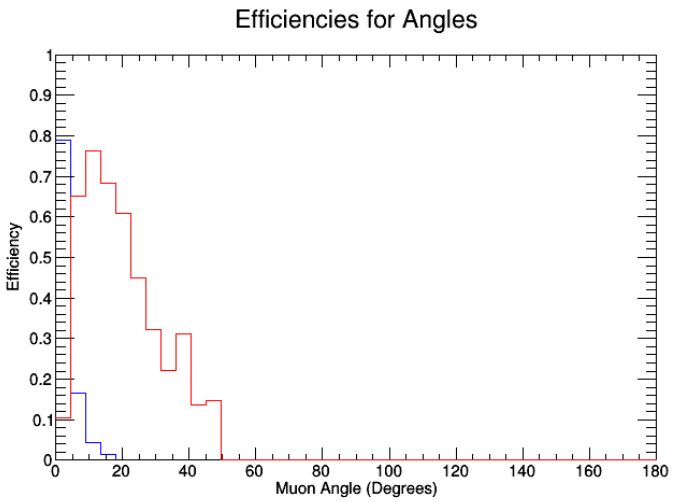

Figure 52: This is a plot right here. Nice of you to notice!

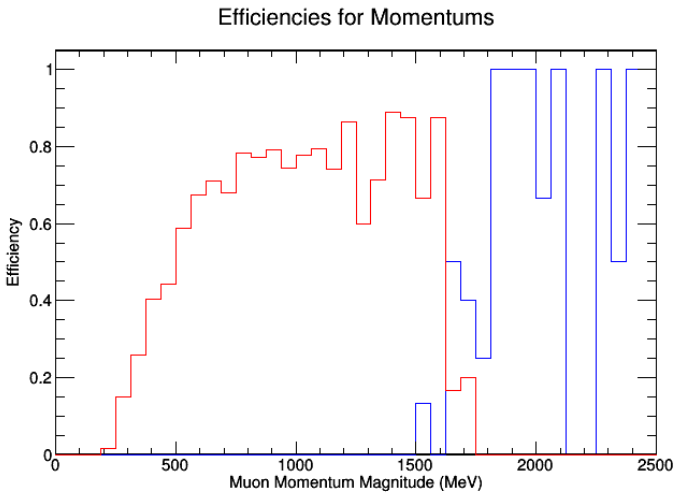

Figure 53: This is a plot right here. Nice of you to notice!

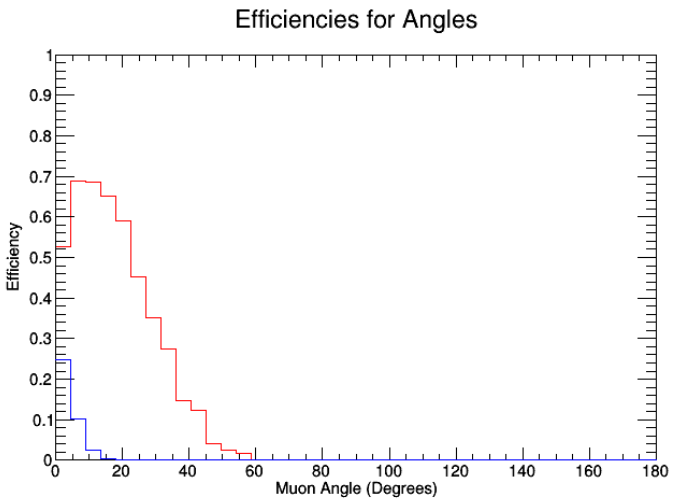

Figure 54: This is a plot right here. Nice of you to notice!

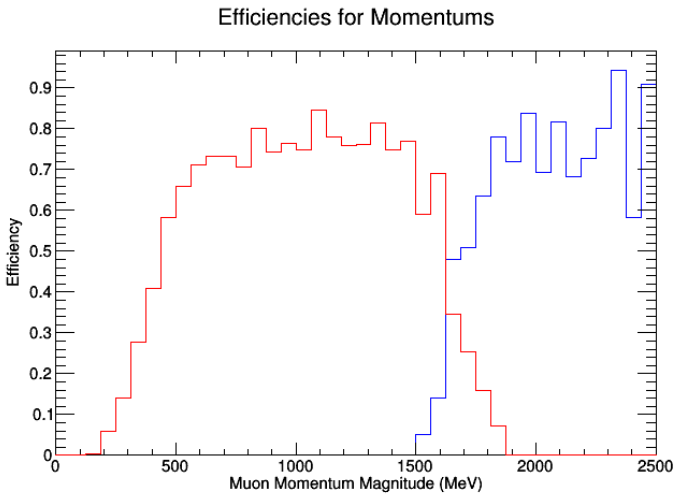

Figure 55: This is a plot right here. Nice of you to notice!

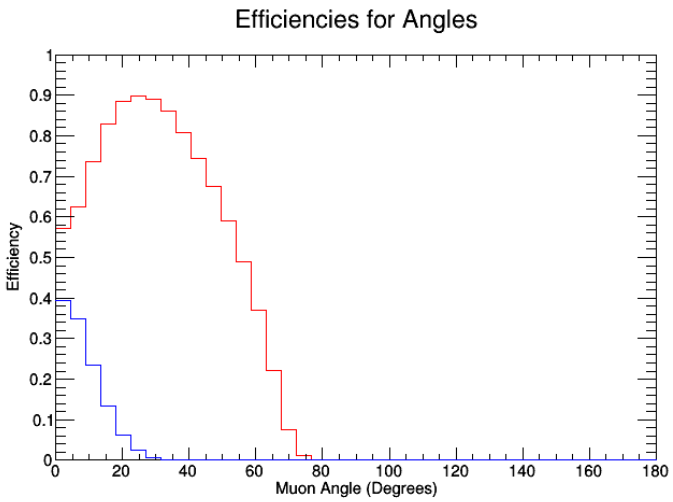

Figure 56: This is a plot right here. Nice of you to notice!

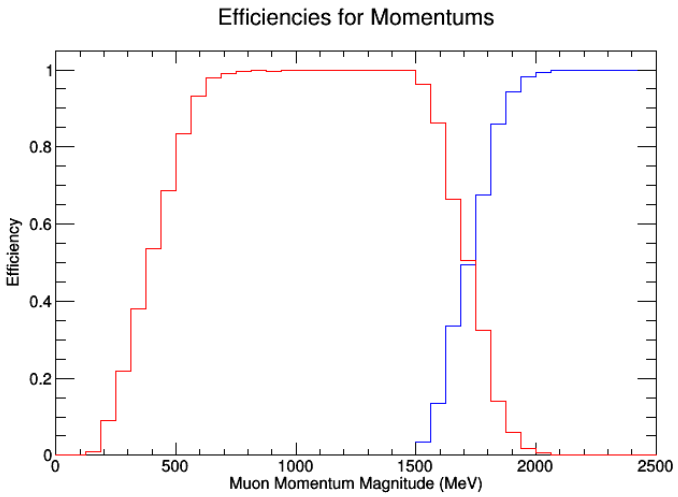

Figure 57: This is a plot right here. Nice of you to notice!

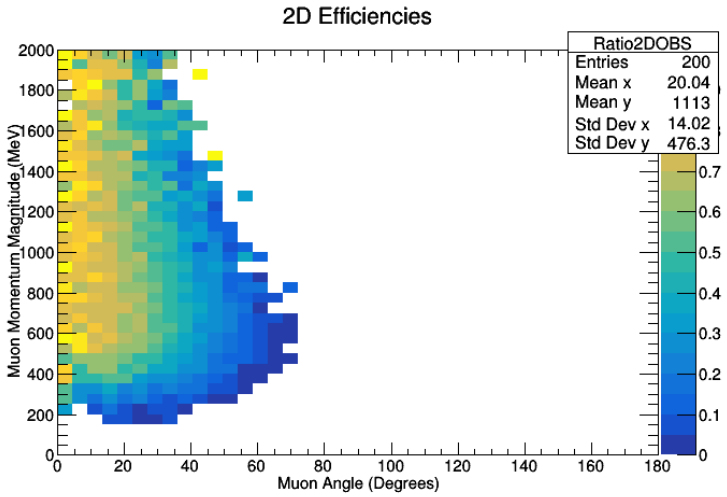

Figure 58: This is a plot right here. Nice of you to notice!

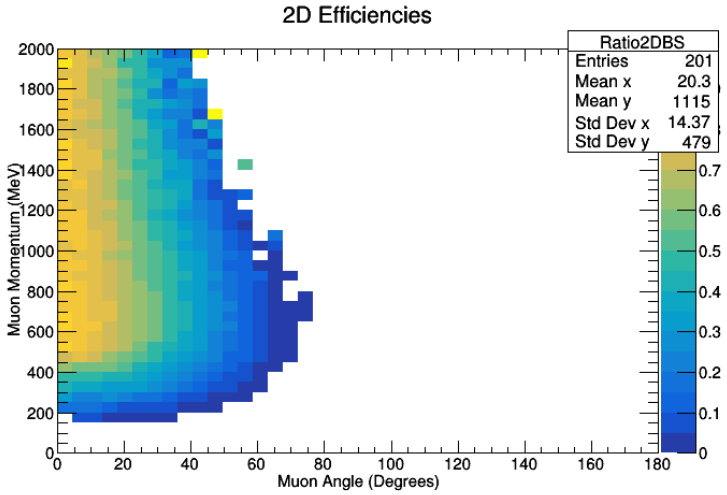

Figure 59: This is a plot right here. Nice of you to notice!

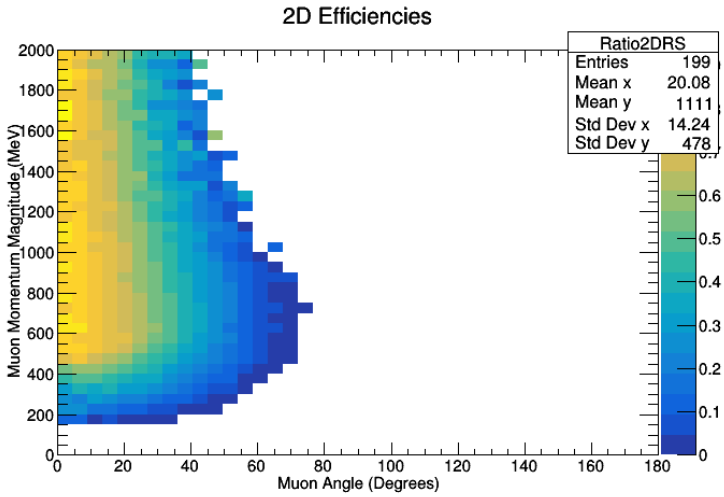

Figure 60: This is a plot right here. Nice of you to notice!

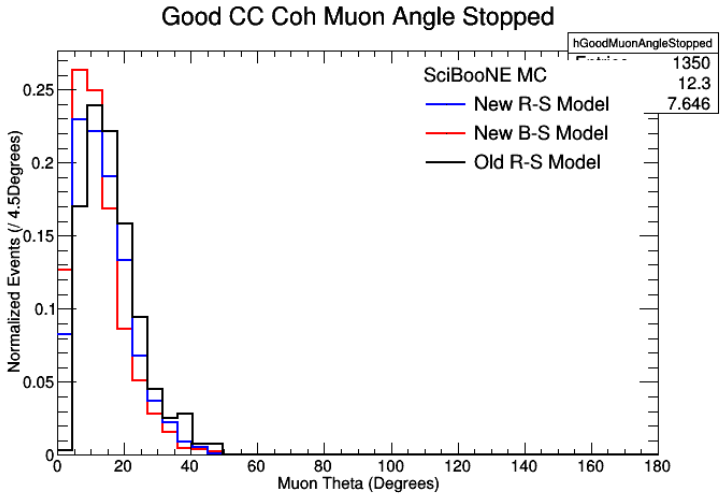

Figure 61: This is a plot right here. Nice of you to notice!

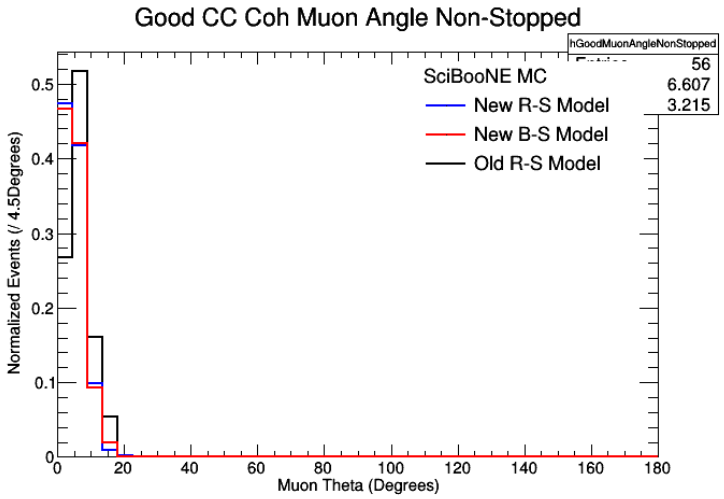

Figure 62: This is a plot right here. Nice of you to notice!

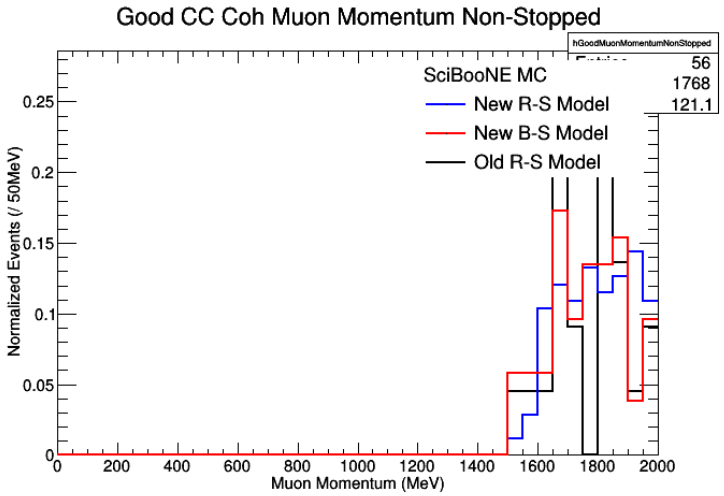

Figure 63: This is a plot right here. Nice of you to notice!

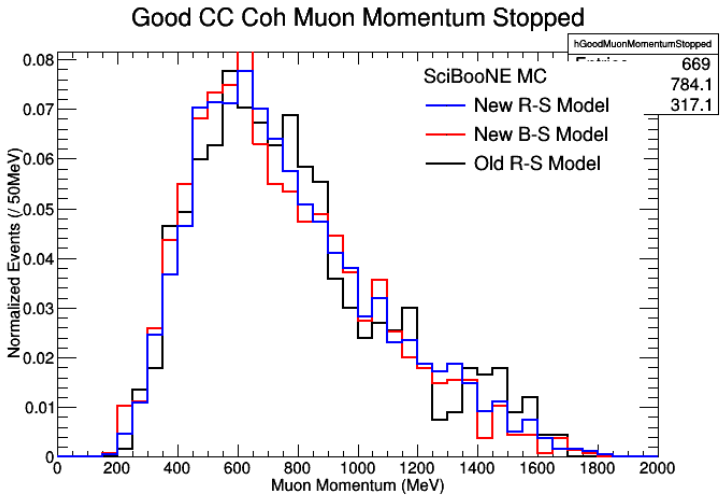

Figure 64: This is a plot right here. Nice of you to notice!

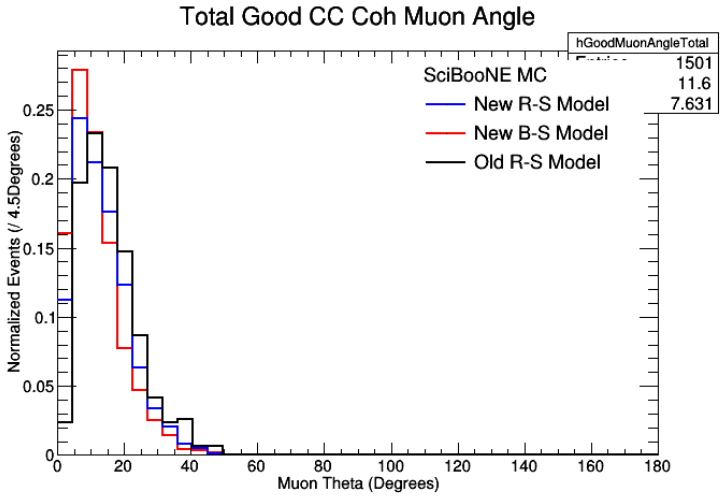

Figure 65: This is a plot right here. Nice of you to notice!

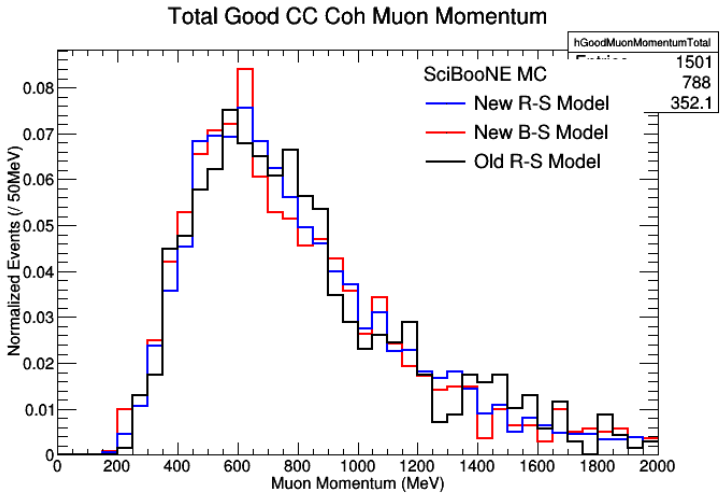

Figure 66: This is a plot right here. Nice of you to notice!

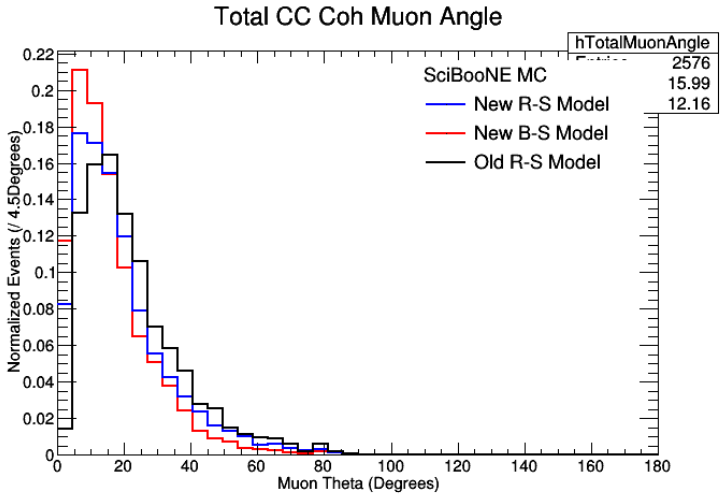

Figure 67: This is a plot right here. Nice of you to notice!

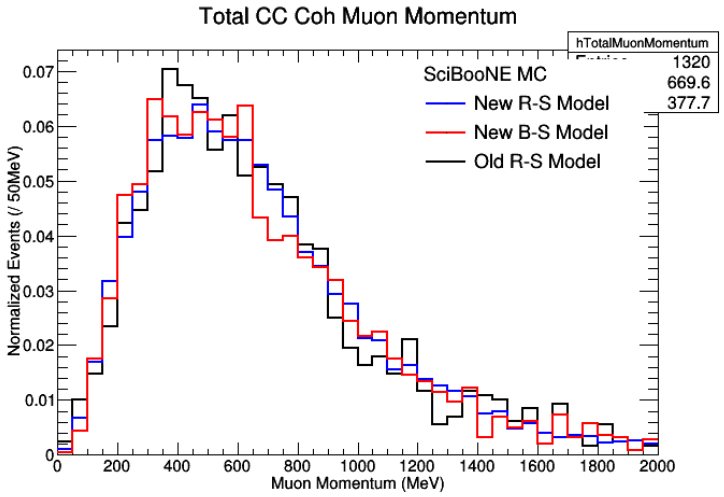

Figure 68: This is a plot right here. Nice of you to notice!

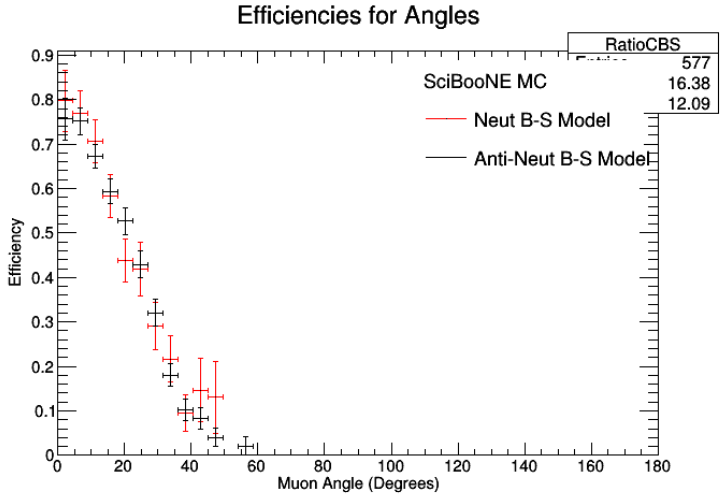

Figure 69: This is a plot right here. Nice of you to notice!

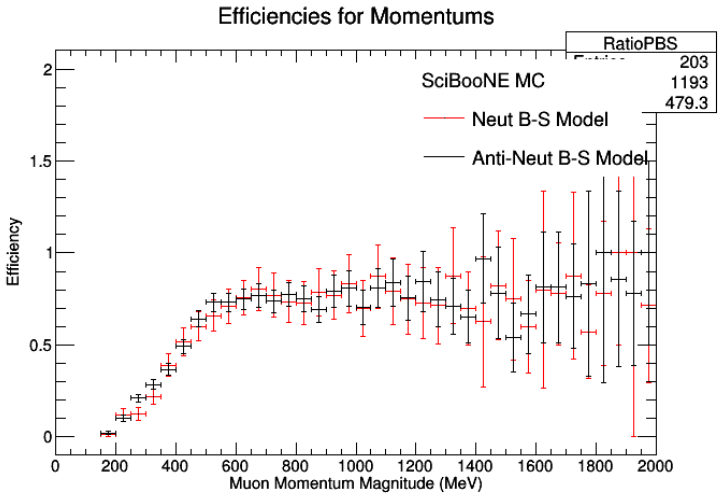

Figure 70: This is a plot right here. Nice of you to notice!

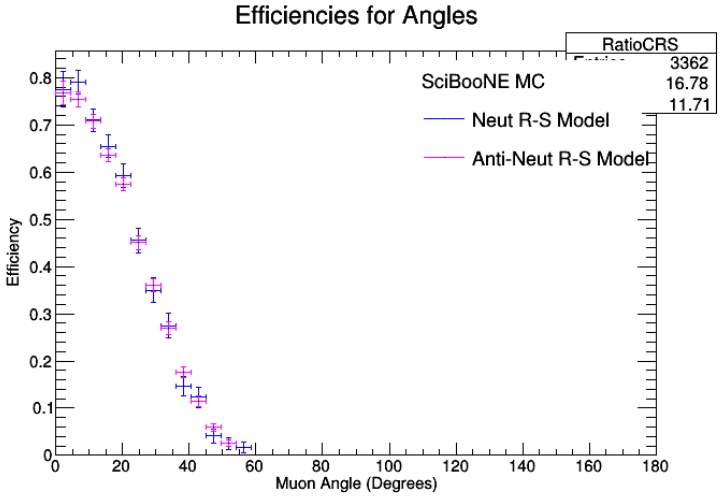

Figure 71: This is a plot right here. Nice of you to notice!

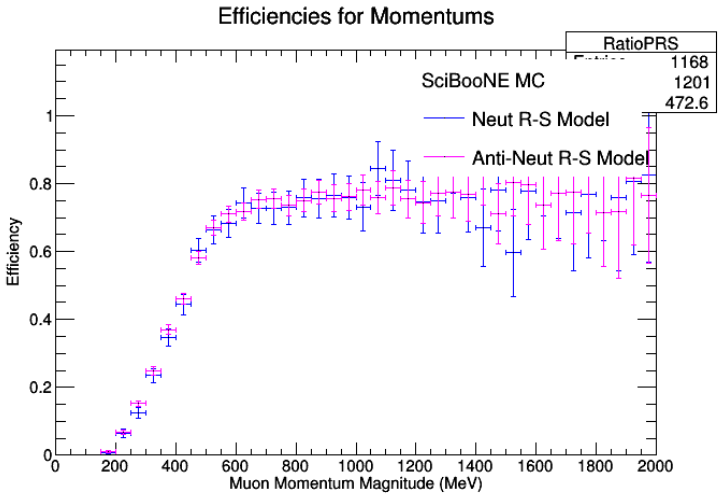

Figure 72: This is a plot right here. Nice of you to notice!

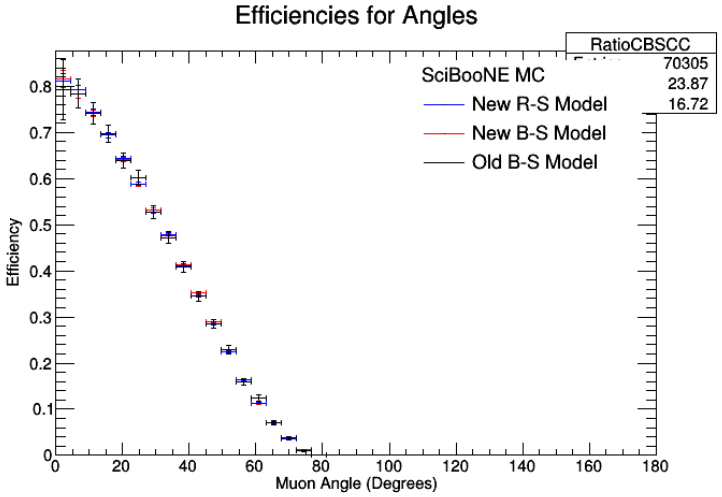

Figure 73: This is a plot right here. Nice of you to notice!

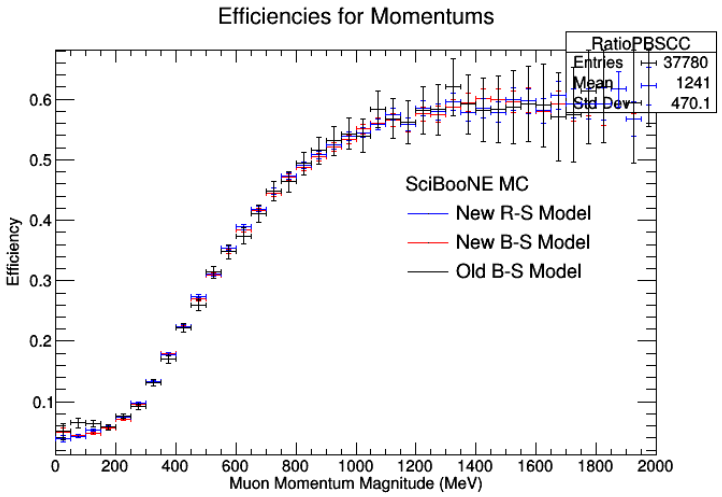

Figure 74: This is a plot right here. Nice of you to notice!

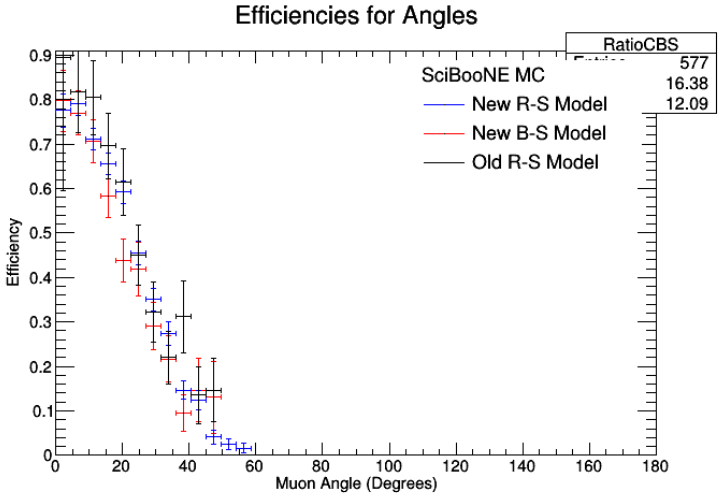

Figure 75: This is a plot right here. Nice of you to notice!

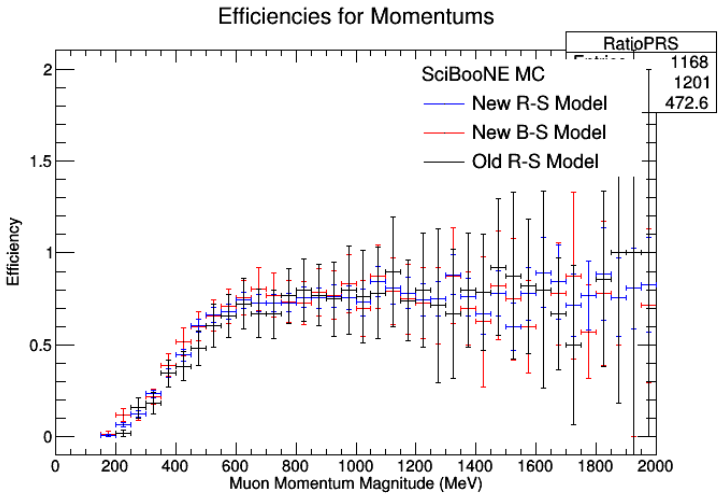

Figure 76: This is a plot right here. Nice of you to notice!

A.13 NMPionPlotting.C

I need to come back and insert all of my images here.

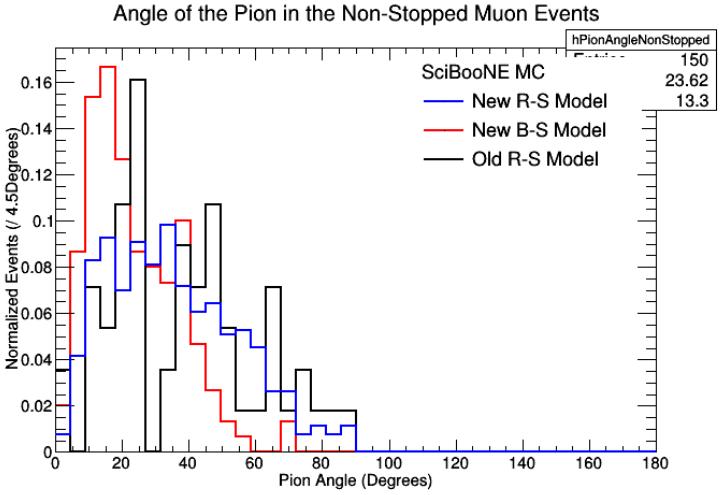

Figure 77: This is a plot right here. Nice of you to notice!

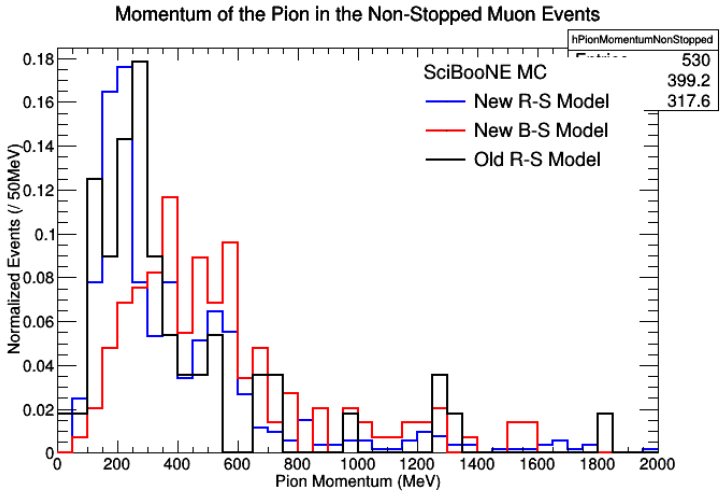

Figure 78: This is a plot right here. Nice of you to notice!

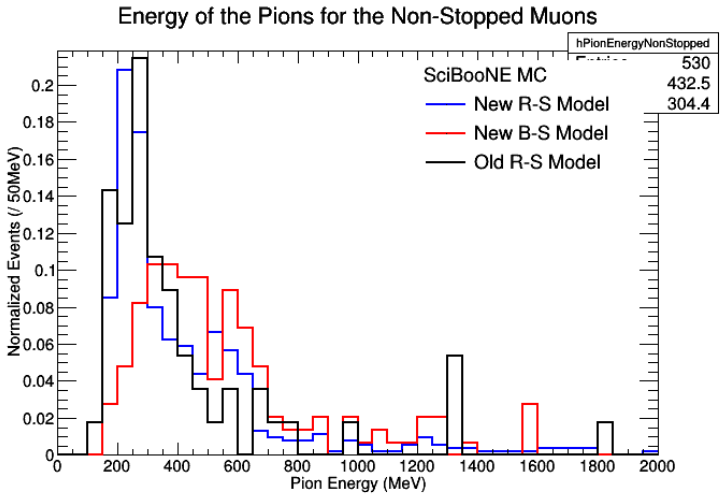

Figure 79: This is a plot right here. Nice of you to notice!

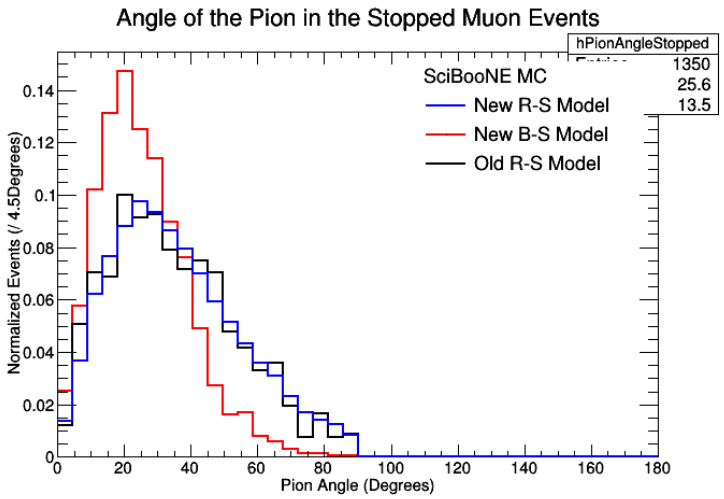

Figure 80: This is a plot right here. Nice of you to notice!

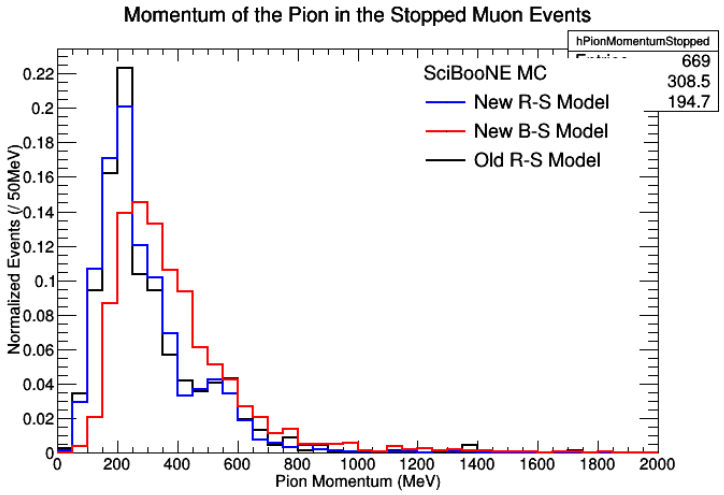

Figure 81: This is a plot right here. Nice of you to notice!

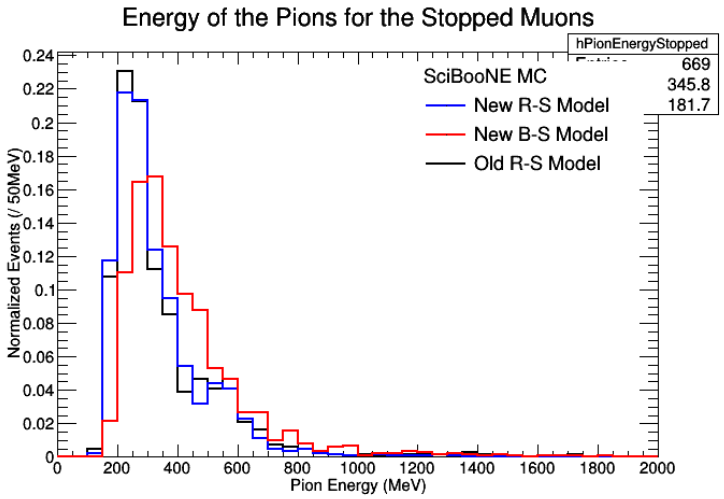

Figure 82: This is a plot right here. Nice of you to notice!

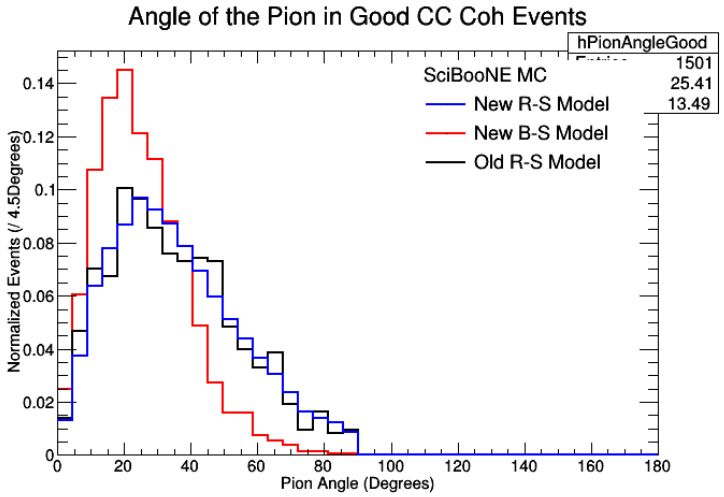

Figure 83: This is a plot right here. Nice of you to notice!

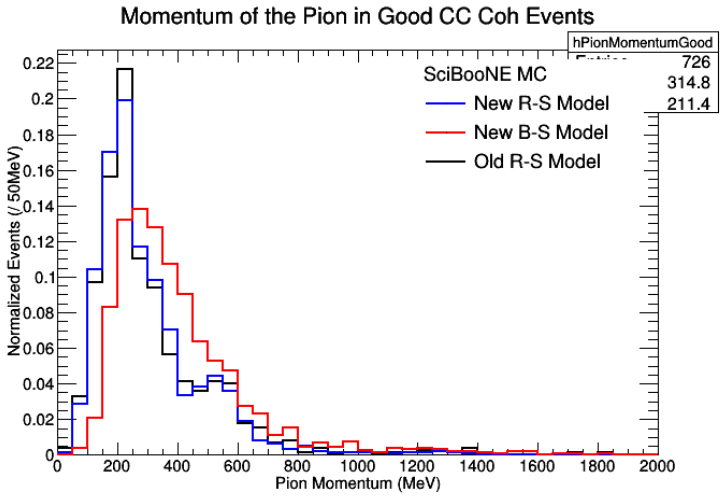

Figure 84: This is a plot right here. Nice of you to notice!

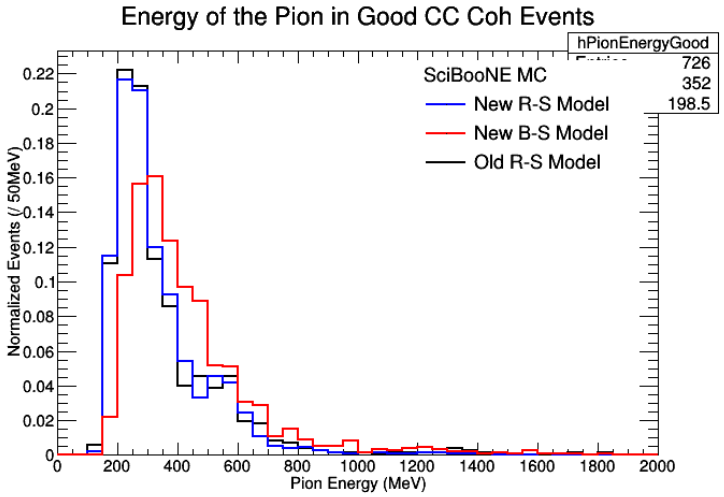

Figure 85: This is a plot right here. Nice of you to notice!

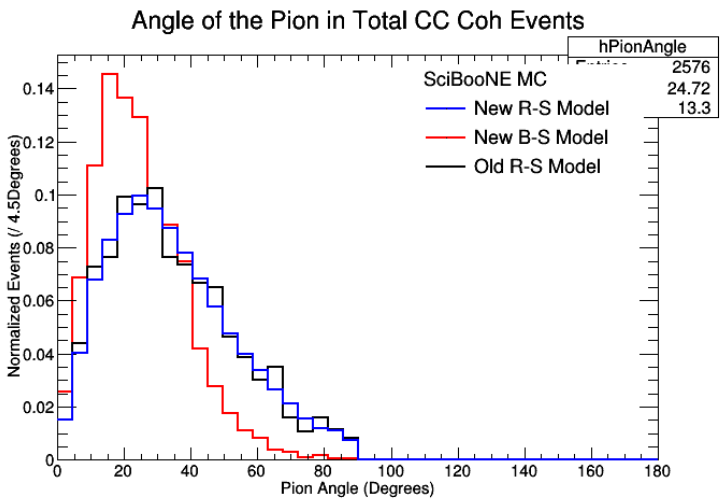

Figure 86: This is a plot right here. Nice of you to notice!

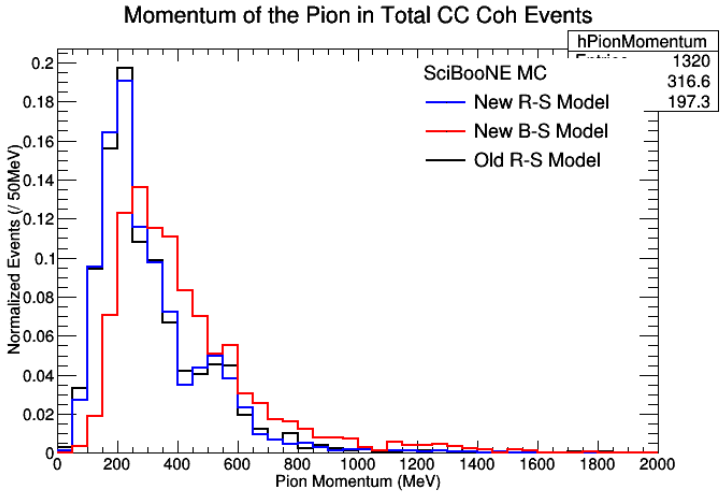

Figure 87: This is a plot right here. Nice of you to notice!

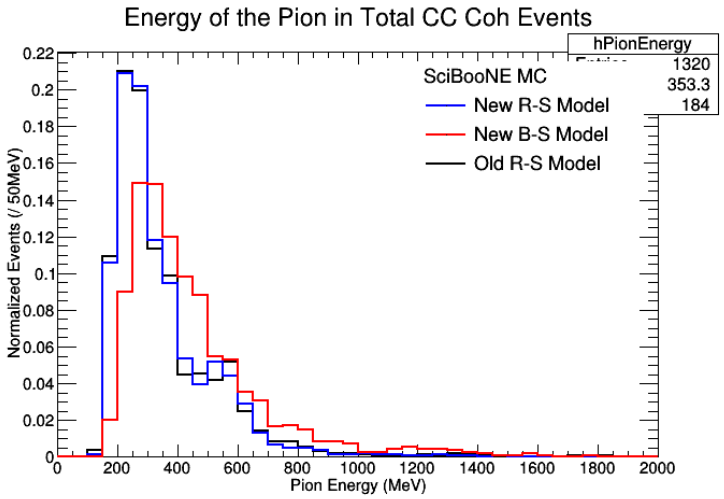

Figure 88: This is a plot right here. Nice of you to notice!

A.14 NMFourSquaredPlotting.C

I need to come back and insert all of my images here.

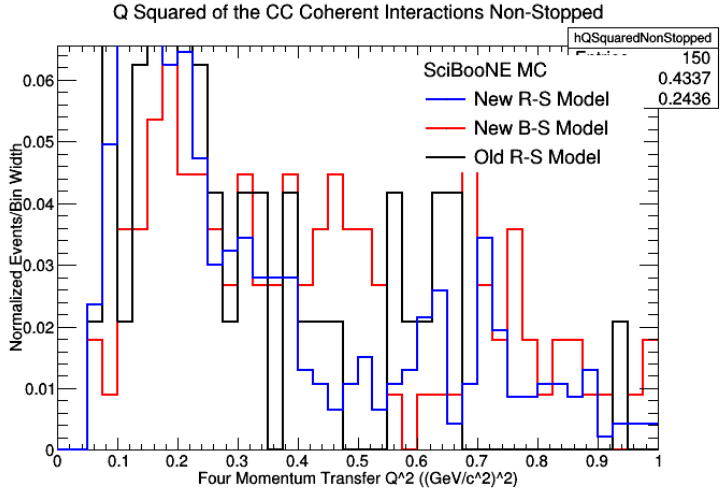

Figure 89: This is a plot right here. Nice of you to notice!

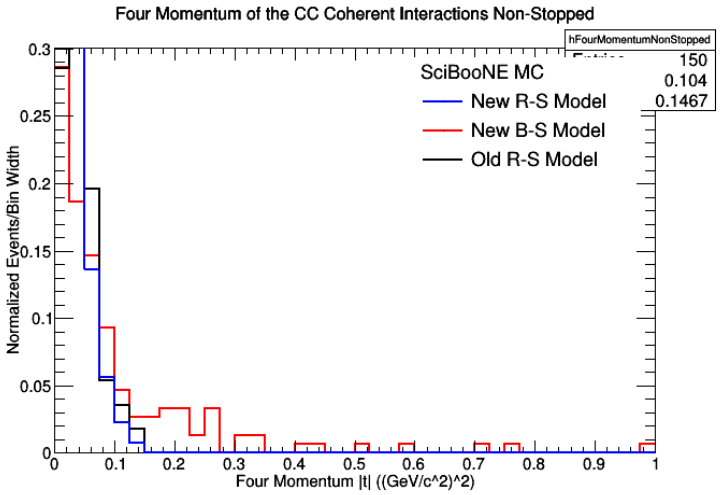

Figure 90: This is a plot right here. Nice of you to notice!

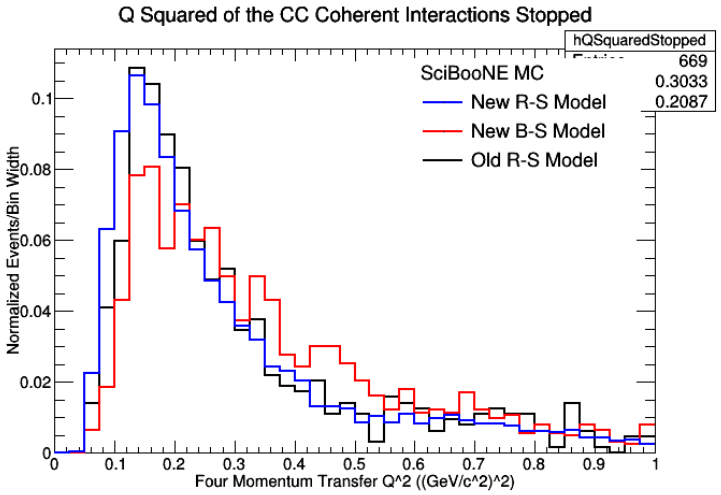

Figure 91: This is a plot right here. Nice of you to notice!

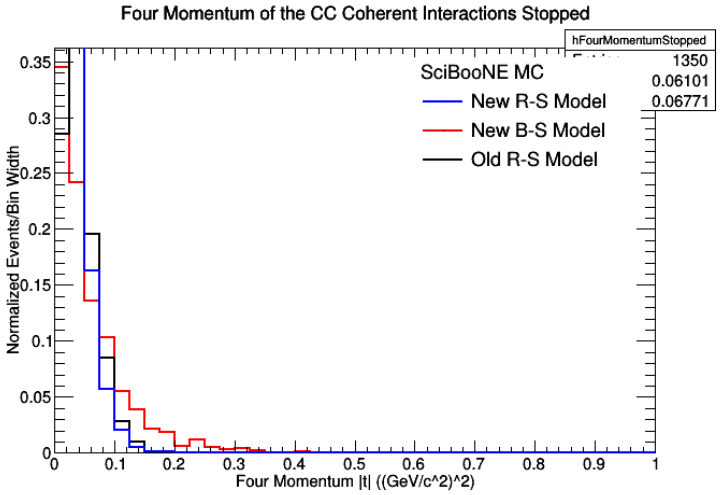

Figure 92: This is a plot right here. Nice of you to notice!

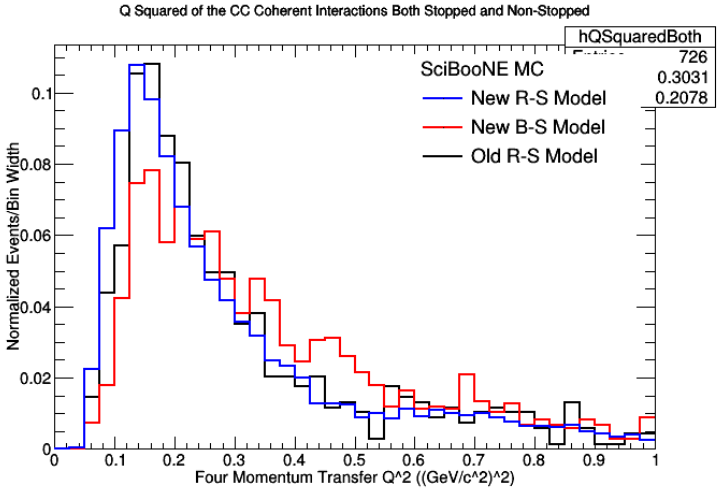

Figure 93: This is a plot right here. Nice of you to notice!

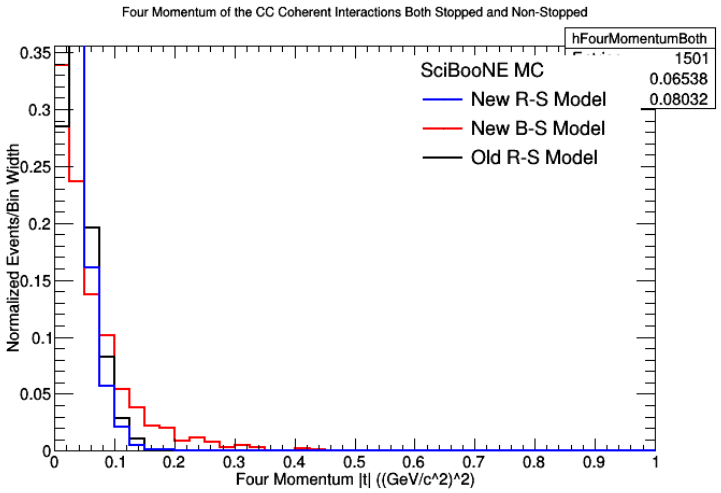

Figure 94: This is a plot right here. Nice of you to notice!

A.15 ANMCombinedPlots.C

I need to come back and insert all of my images here.

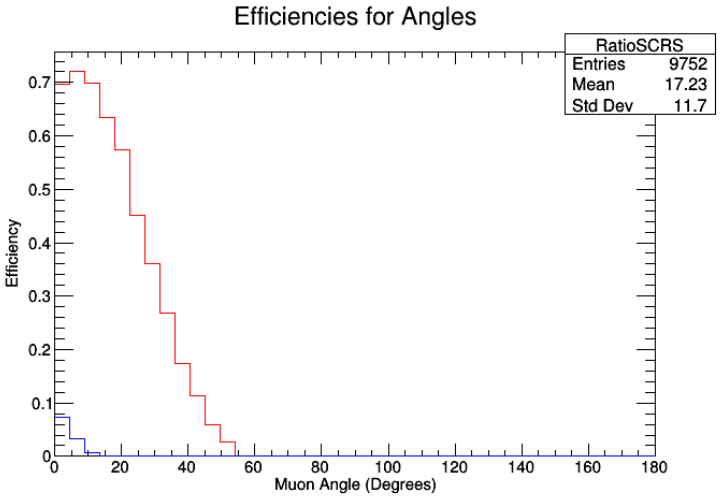

Figure 95: This is a plot right here. Nice of you to notice!

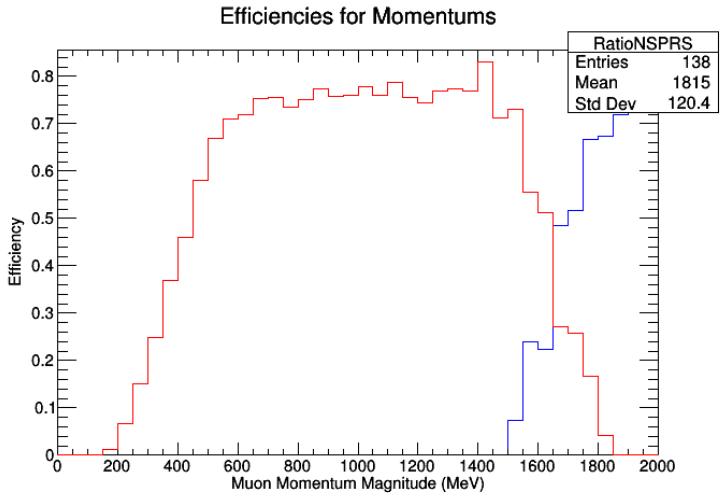

Figure 96: This is a plot right here. Nice of you to notice!

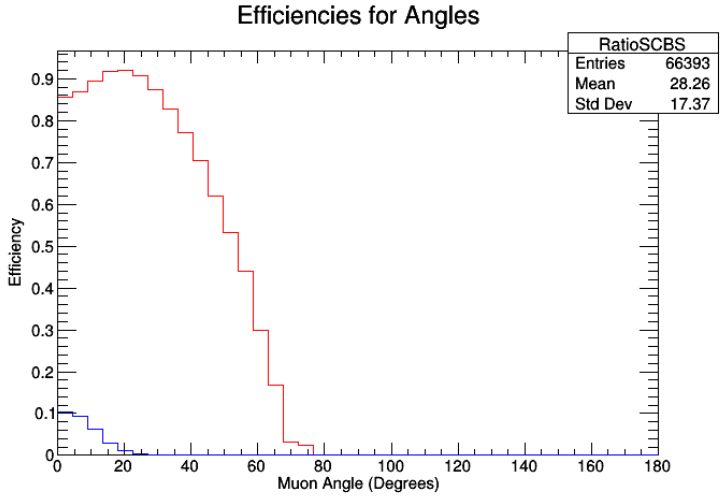

Figure 97: This is a plot right here. Nice of you to notice!

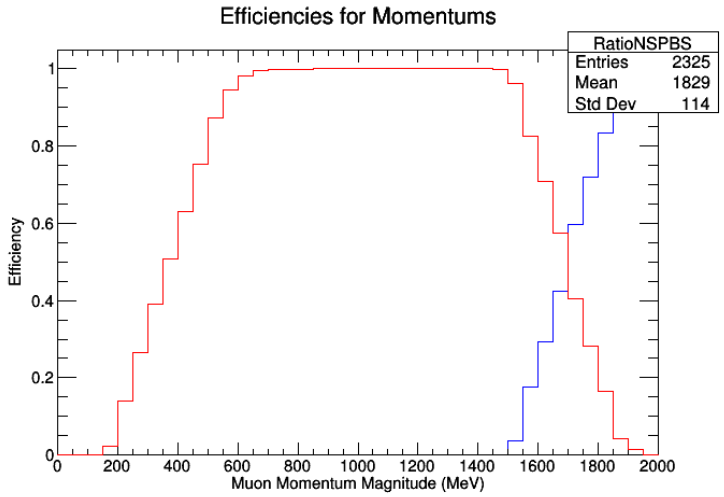

Figure 98: This is a plot right here. Nice of you to notice!

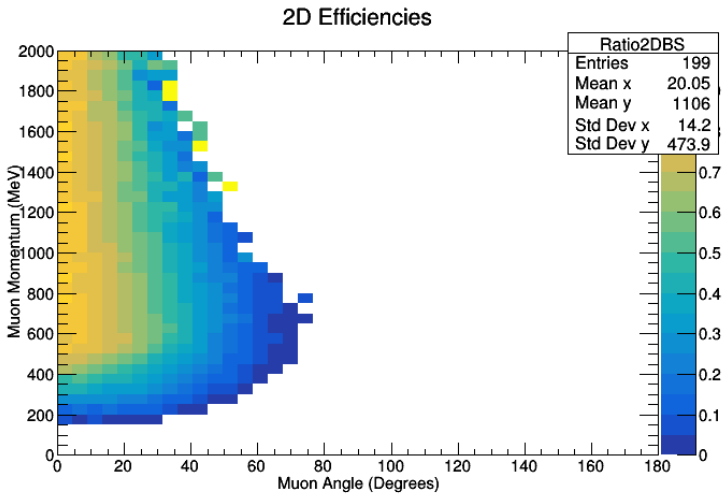

Figure 99: This is a plot right here. Nice of you to notice!

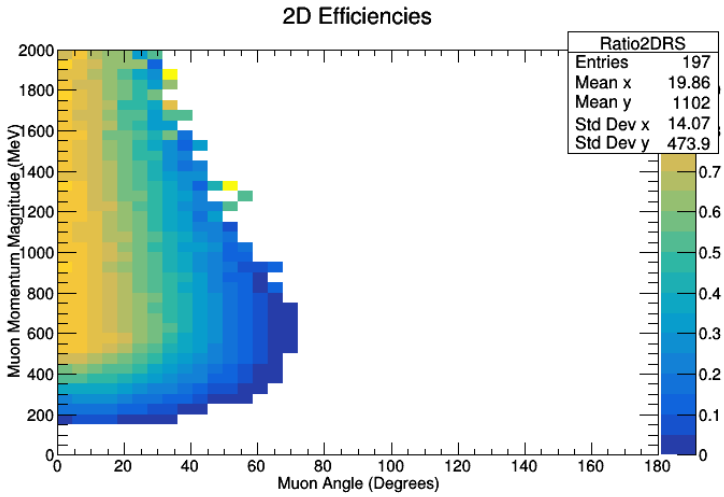

Figure 100: This is a plot right here. Nice of you to notice!

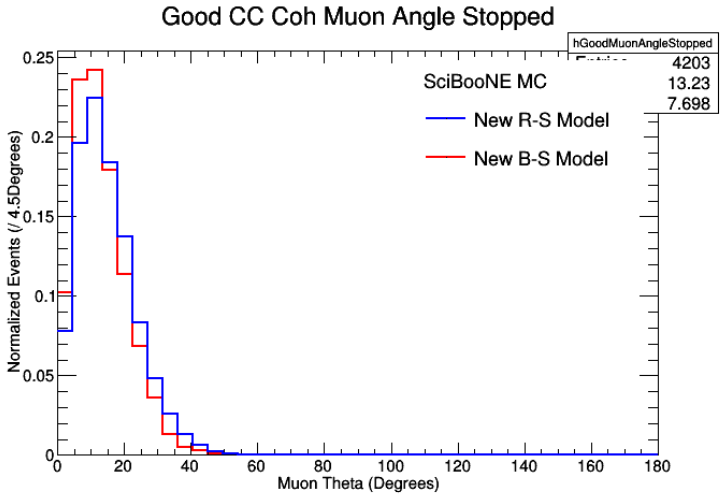

Figure 101: This is a plot right here. Nice of you to notice!

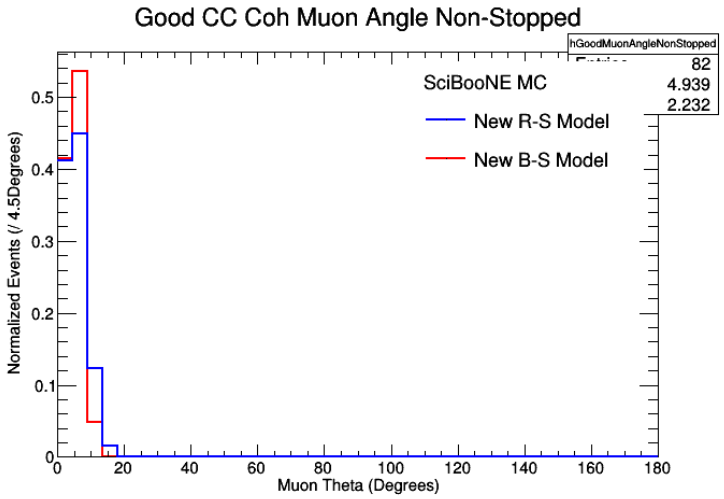

Figure 102: This is a plot right here. Nice of you to notice!

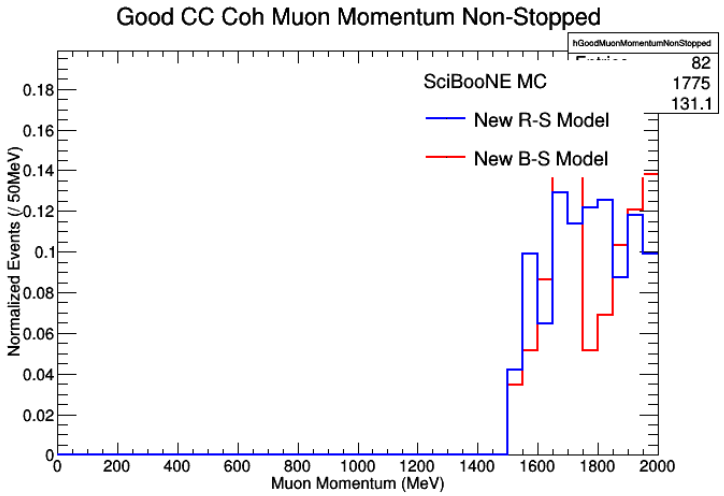

Figure 103: This is a plot right here. Nice of you to notice!

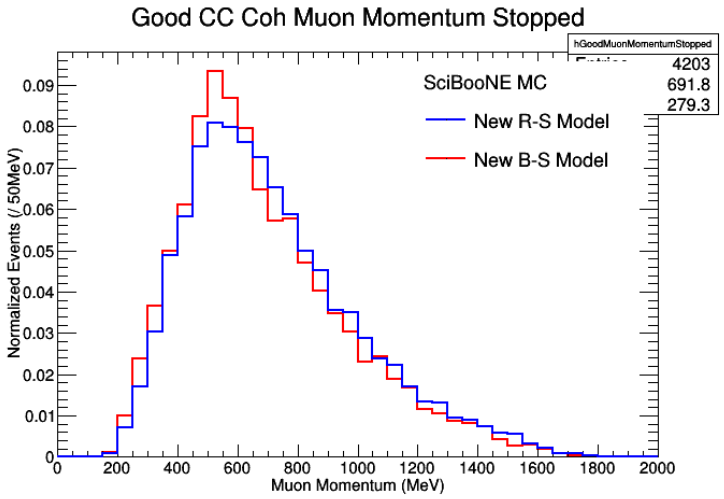

Figure 104: This is a plot right here. Nice of you to notice!

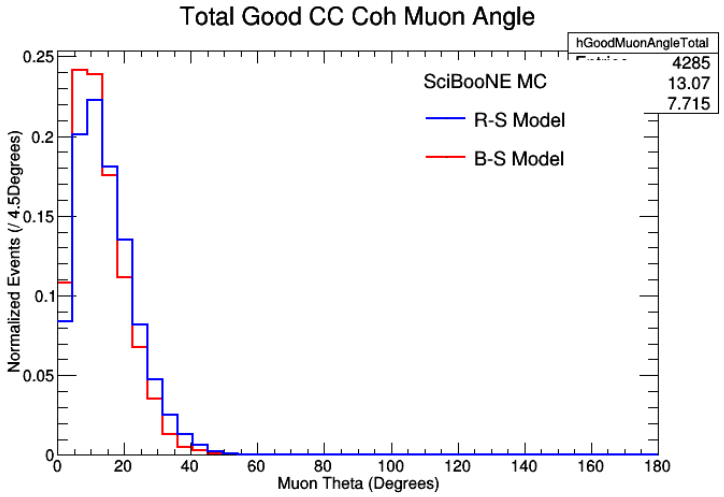

Figure 105: This is a plot right here. Nice of you to notice!

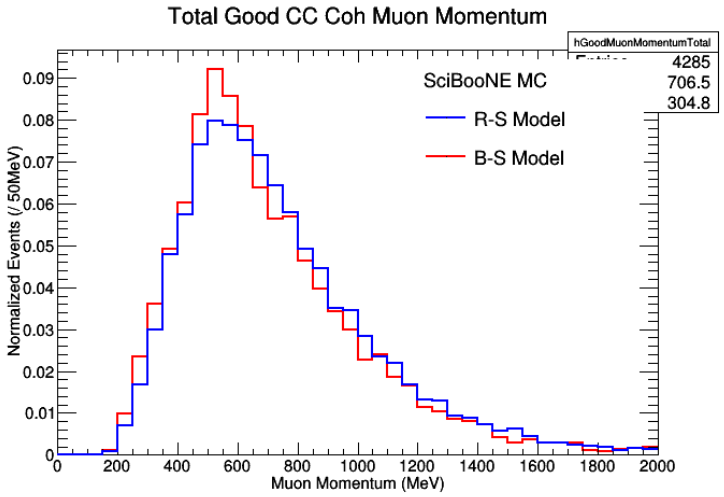

Figure 106: This is a plot right here. Nice of you to notice!

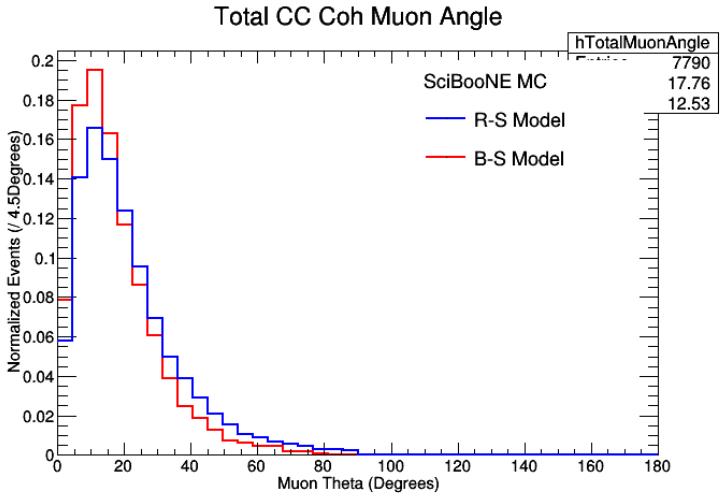

Figure 107: This is a plot right here. Nice of you to notice!

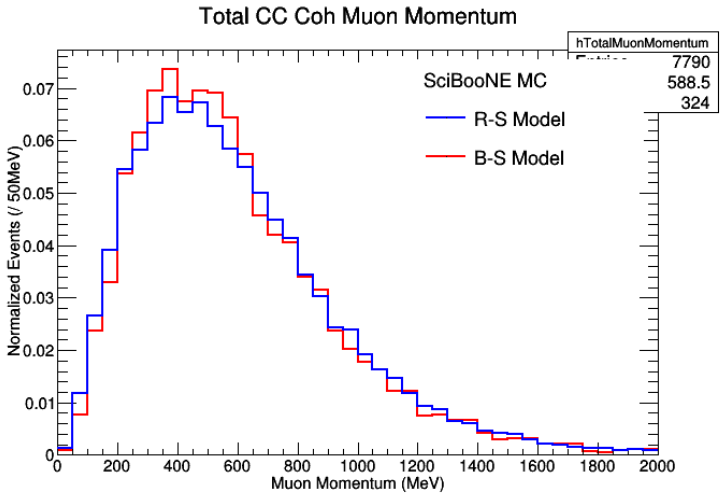

Figure 108: This is a plot right here. Nice of you to notice!

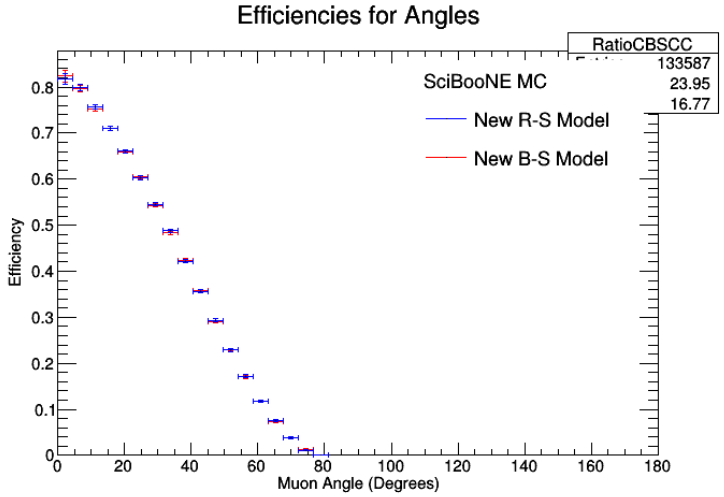

Figure 109: This is a plot right here. Nice of you to notice!

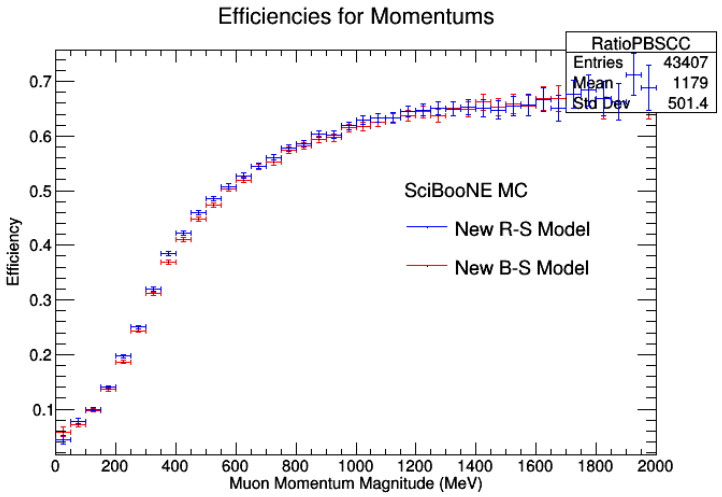

Figure 110: This is a plot right here. Nice of you to notice!

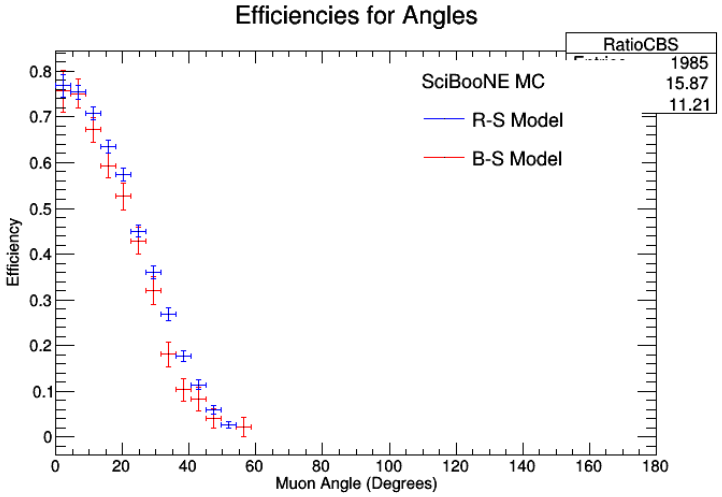

Figure 111: This is a plot right here. Nice of you to notice!

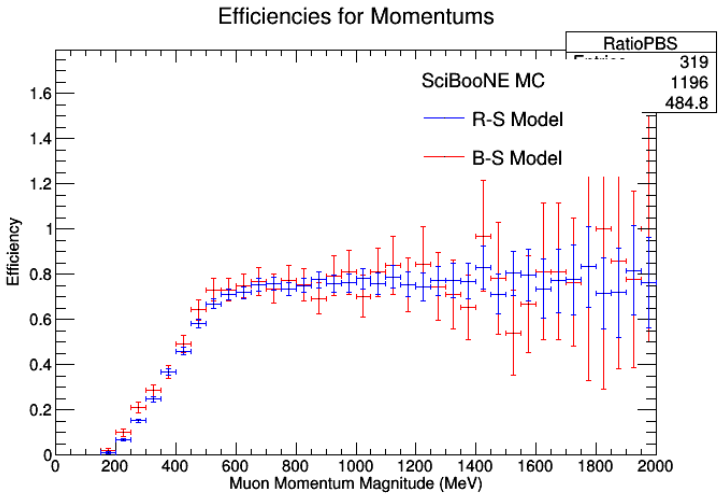

Figure 112: This is a plot right here. Nice of you to notice!

A.16 ANMPionPlotting.C

I need to come back and insert all of my images here.

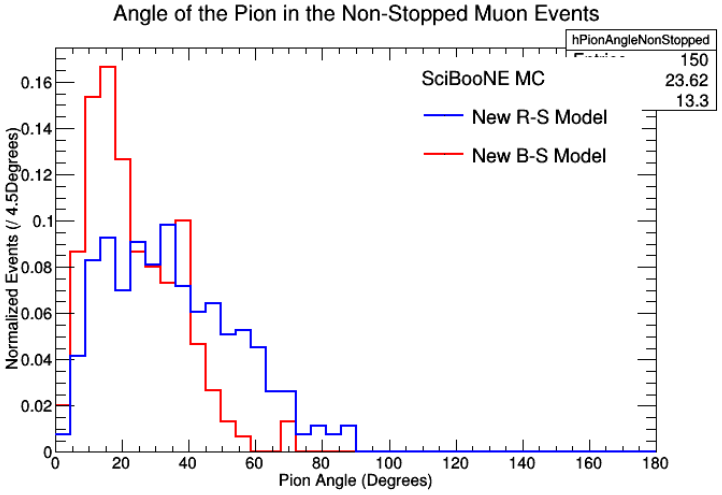

Figure 113: This is a plot right here. Nice of you to notice!

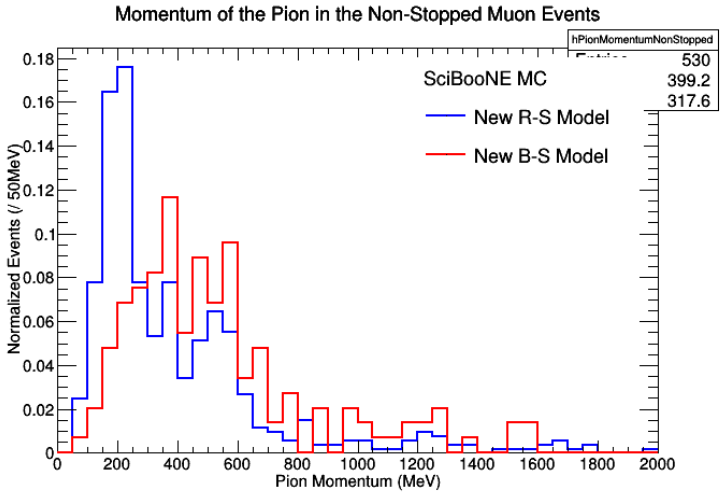

Figure 114: This is a plot right here. Nice of you to notice!

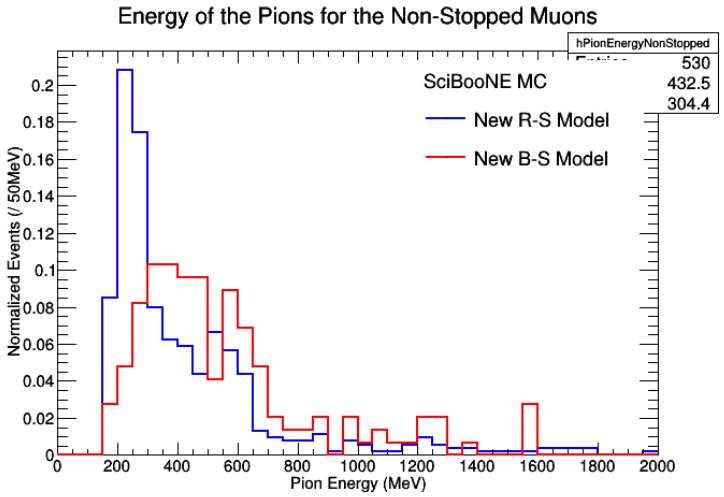

Figure 115: This is a plot right here. Nice of you to notice!

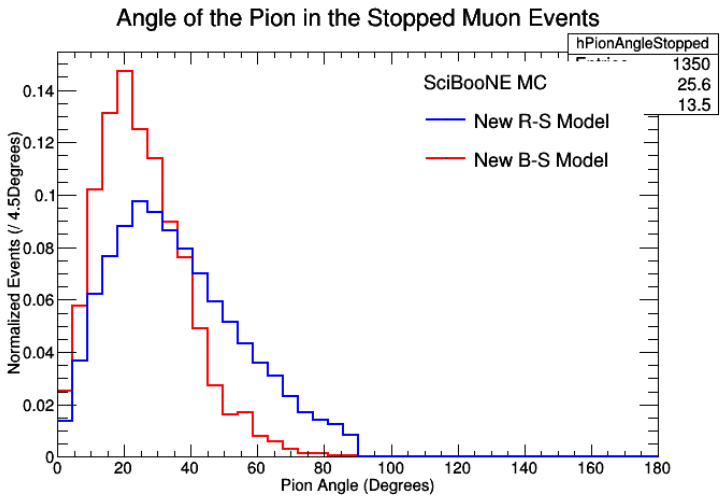

Figure 116: This is a plot right here. Nice of you to notice!

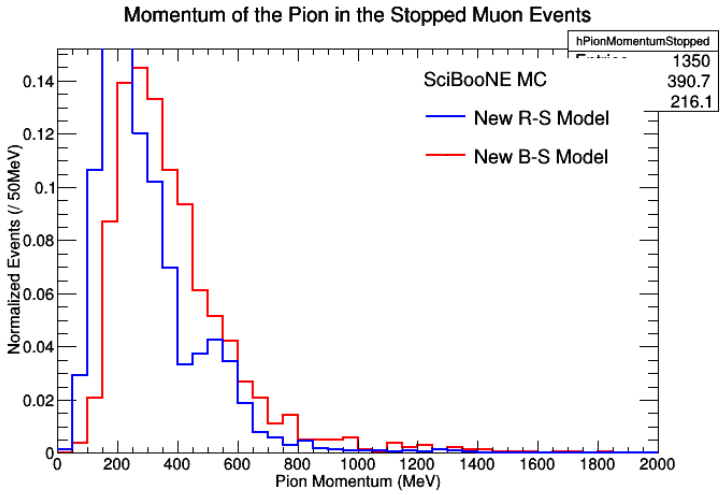

Figure 117: This is a plot right here. Nice of you to notice!

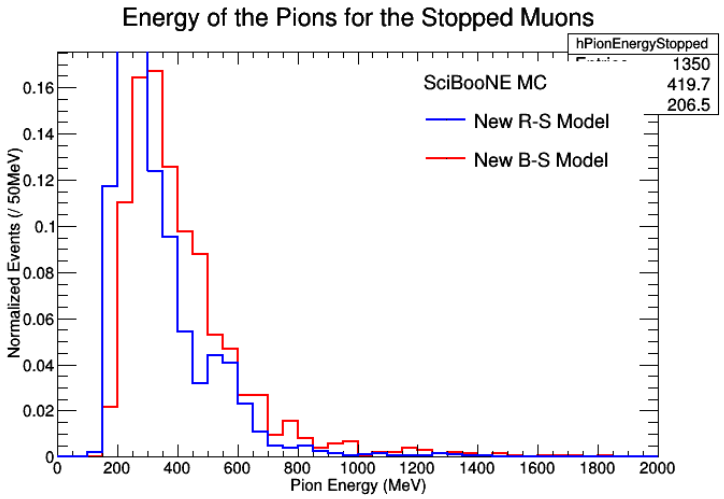

Figure 118: This is a plot right here. Nice of you to notice!

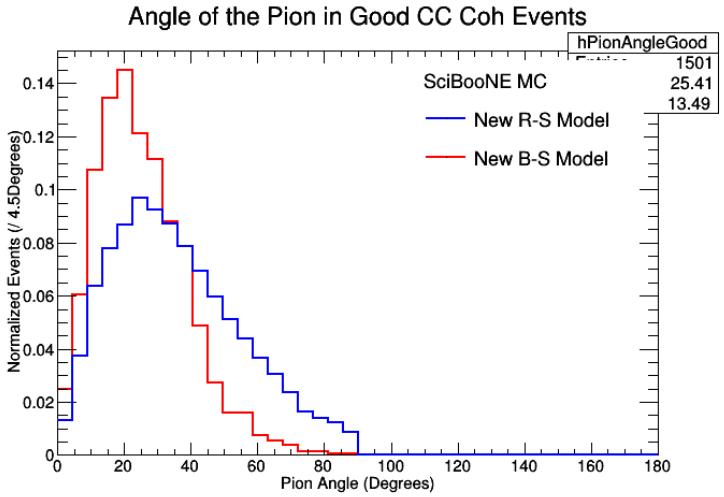

Figure 119: This is a plot right here. Nice of you to notice!

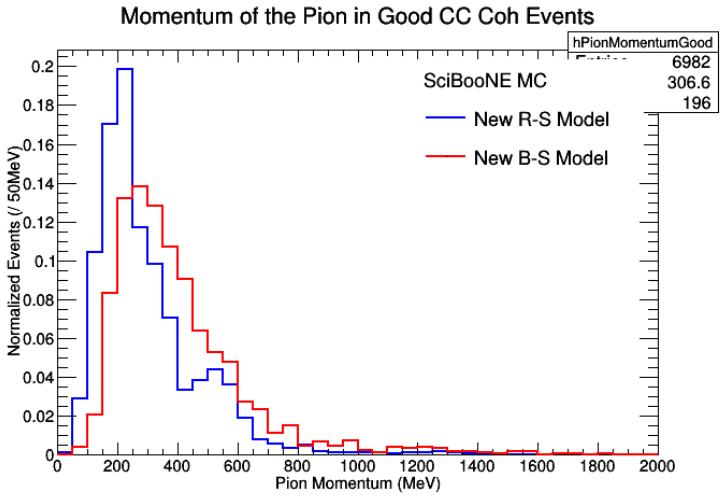

Figure 120: This is a plot right here. Nice of you to notice!

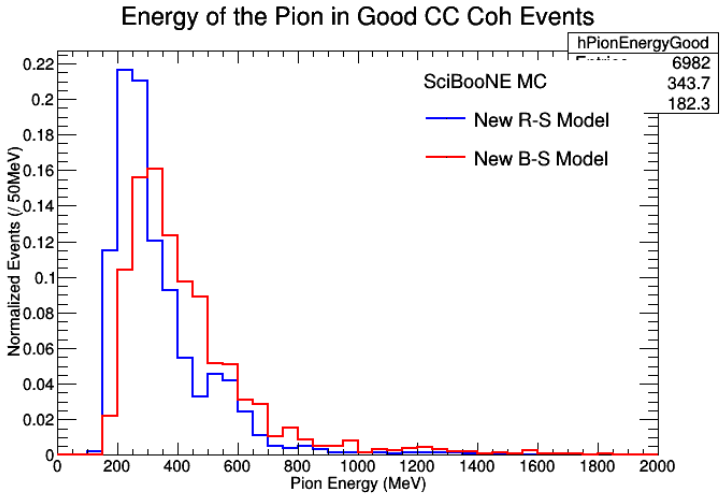

Figure 121: This is a plot right here. Nice of you to notice!

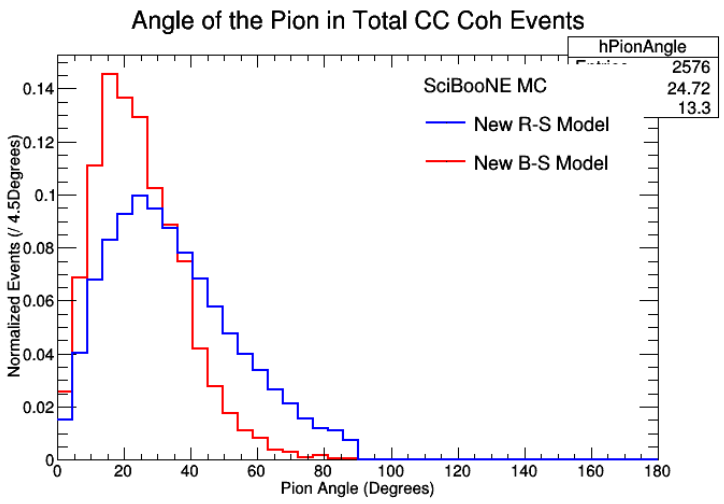

Figure 122: This is a plot right here. Nice of you to notice!

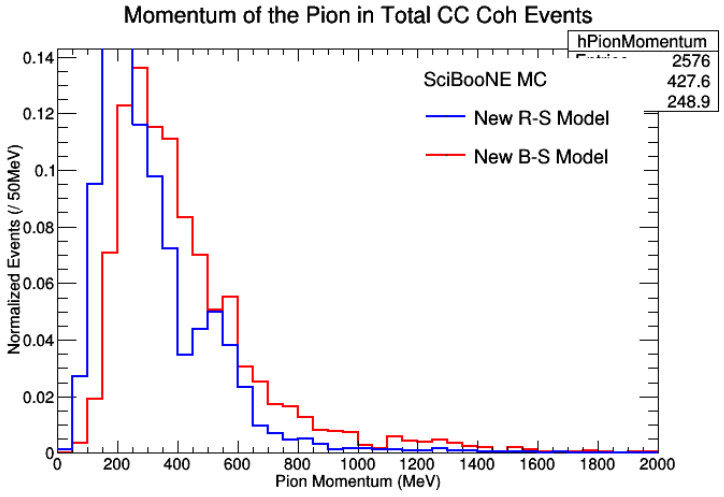

Figure 123: This is a plot right here. Nice of you to notice!

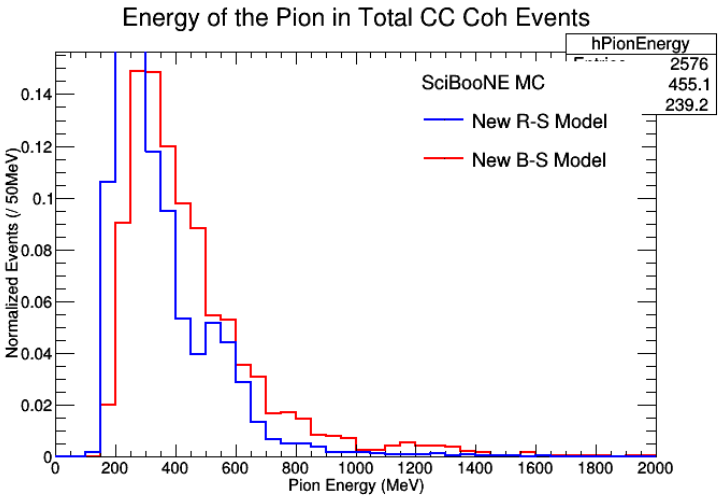

Figure 124: This is a plot right here. Nice of you to notice!

A.17 ANMFourSquaredPlotting.C

I need to come back and insert all of my images here.

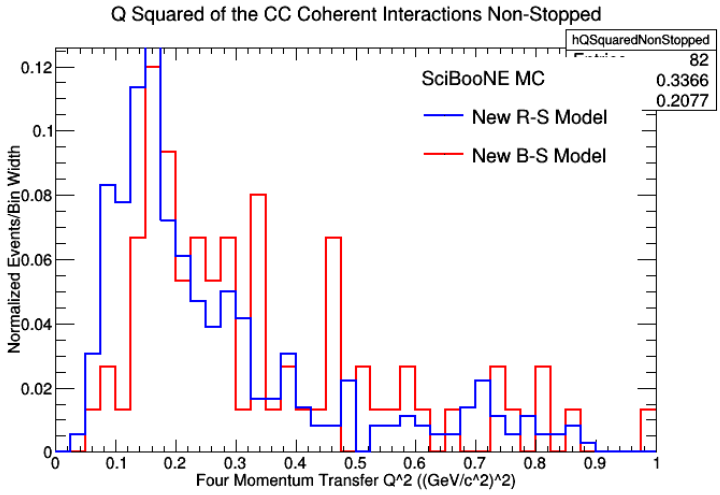

Figure 125: This is a plot right here. Nice of you to notice!

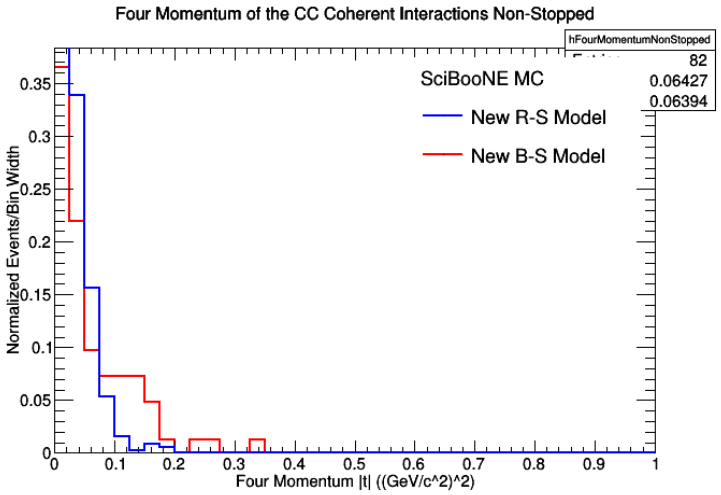

Figure 126: This is a plot right here. Nice of you to notice!

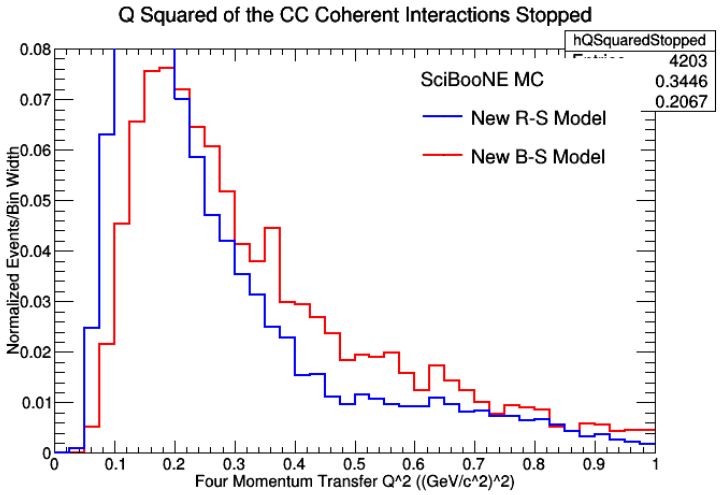

Figure 127: This is a plot right here. Nice of you to notice!

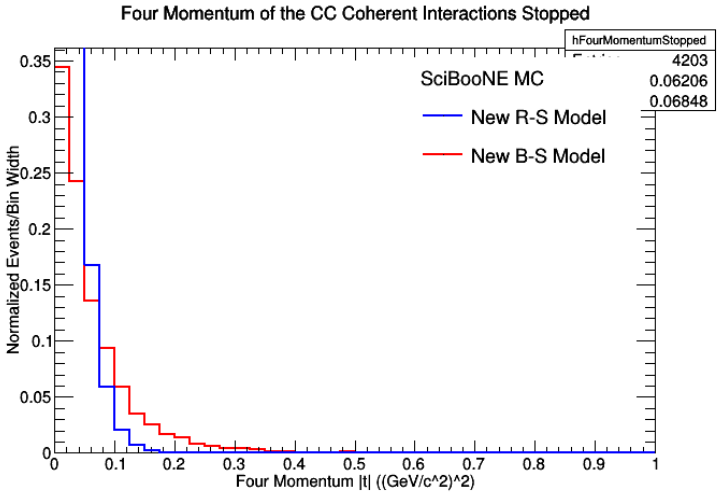

Figure 128: This is a plot right here. Nice of you to notice!

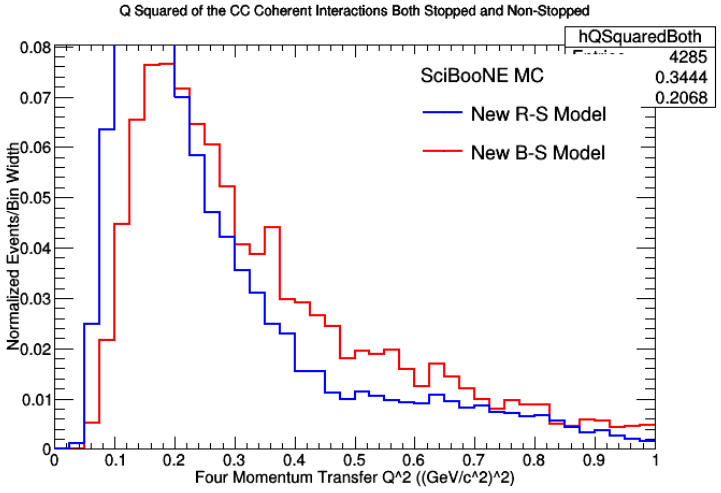

Figure 129: This is a plot right here. Nice of you to notice!

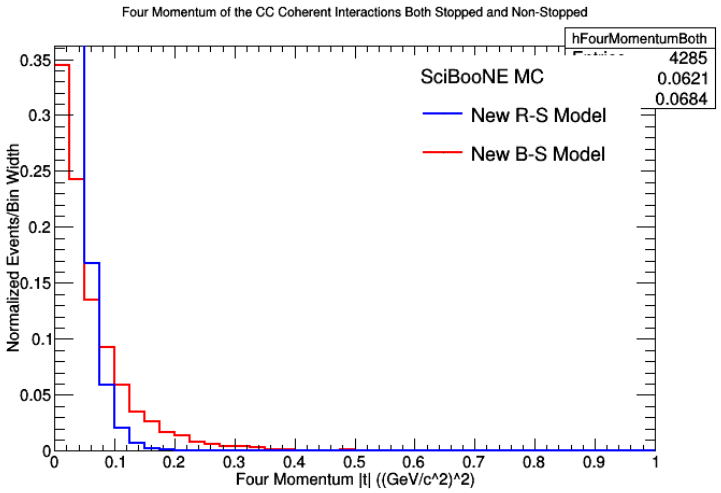

Figure 130: This is a plot right here. Nice of you to notice!

B Steps for Running the Code

The instructions on how to run the code and the order the files need to run in so that there are no resulting error messages, or other issues while running the code, are detailed in this section.

Step 1: This is the first step. (Run the NewNM macros and the NewANM macros and the OldNM macro.)

Step 2: This is the second step. (Run the combined plotting macros.)

Step 3: This is the third step. (Run the Pion Plotting macros.)

Step 4: Etc. (Run the FourSquaredMomentum macros.)

C Closing Remarks and Cautions

These are just a few cautionary suggestions for potential issues that might be encountered while trying to use this code. This will also be where and further closing remarks can be made.

D Acknowledgements

Thank everyone who helped, and thank everyone who gave their inputs into your acceptance study. YOU NEED TO GIVE A HUGE AND SPECIAL THANKS TO DR. ASAADI RIGHT HERE! (He has been suuuuuuuper patient...)

E Appendix

E.1 List of Figures

There will eventually be a huge list of figures here.

E.2 List of Tables

There will eventually be the event reduction tables and 2D histogram tables here.

Table 2: Table for 2D Histogram for New NM-Rein-Sehgal

New NM R-S	0-50 MeV/c	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500
0-4.5 Deg	0	0	0	0.09375	0.259259	0.26087	0.317073	0.45	0.553846	0.716049
4.5-9 Deg	0	0	0	0.123457	0.244681	0.218182	0.40411	0.490291	0.568376	0.766102
9-13.5 Deg	0	0	0	0.0280374	0.150943	0.31	0.334426	0.479167	0.582	0.693122
13.5-18 Deg	0	0	0	0.0696203	0.164502	0.242902	0.389937	0.460102	0.524072	0.648363
18-22.5 Deg	0	0	0	0.0396825	0.134503	0.220374	0.320233	0.4	0.498252	0.56578
22.5-27 Deg	0	0	0	0.0341615	0.120614	0.20088	0.284783	0.356223	0.442424	0.513469
27-31.5 Deg	0	0	0	0.0128535	0.0852575	0.146399	0.240517	0.328982	0.381593	0.467435
31.5-36 Deg	0	0	0	0.00618557	0.047749	0.138308	0.215553	0.260465	0.322889	0.379459
36-40.5 Deg	0	0	0	0	0.0376749	0.104341	0.167825	0.228974	0.272658	0.326716
40.5-45 Deg	0	0	0	0	0.0185547	0.0617036	0.129648	0.175194	0.22549	0.249335
45-49.5 Deg	0	0	0	0	0.00241935	0.0461908	0.0861688	0.129907	0.177771	0.209127
49.5-54 Deg	0	0	0	0	0	0.0115123	0.0555327	0.102639	0.123702	0.161442
54-58.5 Deg	0	0	0	0	0	0	0.0248494	0.0445331	0.0810889	0.106105
58.5-63 Deg	0	0	0	0	0	0	0	0.0165922	0.0418139	0.0557781
63-67.5 Deg	0	0	0	0	0	0	0	0	0.00645756	0.018006
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0.00228571
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New NM R-S	500-550	550-600	600-650	650-700	700-750	750-800	800-850	850-900	900-950	950-1000
0-4.5 Deg	0.816092	0.828829	0.842975	0.845455	0.773438	0.875	0.796748	0.798611	0.870504	0.819549
4.5-9 Deg	0.824047	0.789617	0.844186	0.80404	0.828302	0.807771	0.816514	0.820841	0.809981	0.79823
9-13.5 Deg	0.795417	0.787402	0.784336	0.786013	0.779396	0.757746	0.77907	0.784038	0.763083	0.776828
13.5-18 Deg	0.73062	0.742788	0.7373	0.725131	0.707711	0.713192	0.708657	0.71437	0.713376	0.722747
18-22.5 Deg	0.666667	0.703245	0.681216	0.694102	0.67205	0.674541	0.661496	0.647185	0.673965	0.656648
22.5-27 Deg	0.590521	0.619898	0.653967	0.628604	0.61255	0.617109	0.601285	0.58894	0.579674	0.578595
27-31.5 Deg	0.496599	0.55869	0.57336	0.536199	0.537204	0.545332	0.542526	0.532462	0.524605	0.503756
31.5-36 Deg	0.44563	0.489885	0.50075	0.5	0.512734	0.486242	0.465472	0.455387	0.439182	0.459893
36-40.5 Deg	0.35271	0.399772	0.4	0.410602	0.420808	0.416728	0.404237	0.378892	0.371585	0.362308
40.5-45 Deg	0.297987	0.31442	0.331903	0.342802	0.33975	0.324022	0.312566	0.299735	0.293671	0.284258
45-49.5 Deg	0.220634	0.249649	0.260561	0.269592	0.273593	0.258347	0.252889	0.239492	0.238606	0.221135
49.5-54 Deg	0.165696	0.190045	0.182172	0.214009	0.188606	0.193939	0.207	0.177469	0.140187	0.124514
54-58.5 Deg	0.109863	0.131459	0.132259	0.121872	0.135764	0.133188	0.12807	0.106557	0.122172	0.0814815
58.5-63 Deg	0.0744786	0.0831667	0.0781828	0.0883686	0.0845225	0.0654045	0.074184	0.0883721	0.0841121	0.0405405
63-67.5 Deg	0.0306081	0.0433498	0.053756	0.044898	0.0724638	0.044586	0.0347222	0.0641026	0.0243902	0
67.5-72 Deg	0.0041686	0.0121873	0.017341	0.020155	0.0234114	0.0121212	0.0131579	0.075	0	0
72-76.5 Deg	0	0	0	0	0.00540541	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New NM R-S	1000-1050	1050-1100	1100-1150	1150-1200	1200-1250	1250-1300	1300-1350	1350-1400	1400-1450	1450-1500
0-4.5 Deg	0.834532	0.852174	0.88785	0.762712	0.807692	0.802198	0.811321	0.835443	0.753086	0.779412
4.5-9 Deg	0.803922	0.828974	0.800875	0.820276	0.789474	0.798982	0.801136	0.774026	0.79868	0.744186
9-13.5 Deg	0.74026	0.760633	0.746401	0.713326	0.746803	0.720867	0.735724	0.721683	0.72093	0.716946
13.5-18 Deg	0.704342	0.713103	0.697987	0.688694	0.708895	0.681319	0.674493	0.661465	0.680731	0.635036
18-22.5 Deg	0.660068	0.632723	0.652881	0.627978	0.634488	0.606524	0.599138	0.600991	0.58926	0.585284
22.5-27 Deg	0.57636	0.56538	0.564828	0.553719	0.550962	0.498274	0.550685	0.566828	0.500901	0.497826
27-31.5 Deg	0.498278	0.493626	0.481938	0.446392	0.463785	0.474016	0.465487	0.389868	0.438953	0.384615
31.5-36 Deg	0.432253	0.403556	0.432373	0.361111	0.379648	0.411483	0.370968	0.307116	0.361702	0.355191
36-40.5 Deg	0.373851	0.336748	0.352837	0.316279	0.293333	0.333333	0.282609	0.182432	0.261194	0.25
40.5-45 Deg	0.264297	0.2897	0.274247	0.191235	0.220238	0.204918	0.309524	0.147059	0.169014	0.30303
45-49.5 Deg	0.144772	0.168675	0.216867	0.15534	0.182927	0.113636	0.0645161	0.148148	0.117647	0.0769231
49.5-54 Deg	0.10119	0.178295	0.145161	0.0740741	0.08	0.142857	0.2	0	0	0.1
54-58.5 Deg	0.0571429	0.1	0.0322581	0	0.1	0.333333	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0.136364	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New NM R-S	1500-1550	1550-1600	1600-1650	1650-1700	1700-1750	1750-1800	1800-1850	1850-1900	1900-1950	1950-2000
0-4.5 Deg	0.783333	0.936508	0.8	0.921569	0.921569	0.77193	0.848485	0.861111	0.826087	0.823529
4.5-9 Deg	0.742424	0.784091	0.770642	0.790476	0.754717	0.774194	0.79375	0.813793	0.748387	0.785714
9-13.5 Deg	0.727468	0.697572	0.704835	0.730978	0.747774	0.70068	0.684982	0.73029	0.623853	0.713615
13.5-18 Deg	0.657848	0.664093	0.618938	0.648718	0.634561	0.598291	0.63871	0.638686	0.630252	0.614407
18-22.5 Deg	0.56654	0.562092	0.581633	0.546547	0.532051	0.582707	0.517647	0.569507	0.530055	0.5625
22.5-27 Deg	0.511166	0.513605	0.453674	0.539095	0.447761	0.428571	0.476821	0.462963	0.379032	0.435185
27-31.5 Deg	0.484375	0.360577	0.414634	0.34058	0.242991	0.416667	0.405941	0.333333	0.25974	0.403846
31.5-36 Deg	0.294118	0.293578	0.337349	0.328571	0.272727	0.34375	0.227273	0.290323	0.25	0.380952
36-40.5 Deg	0.430556	0.191489	0.127273	0.238095	0.2	0.25	0.0714286	0.25	0.1	0.333333
40.5-45 Deg	0.16	0.0909091	0.1875	0.1875	0.166667	0	0.2	0	0.5	0
45-49.5 Deg	0	0.6	0	0	0	0.25	0	0	0	0
49.5-54 Deg	0	0	0	0	0	0	0	0	0	0
54-58.5 Deg	0	0	0	0	0	0	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Table 3: Table for 2D Histogram for New NM-Berger-Sehgal

New NM B-S	0-50 MeV/c	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500
0-4.5 Deg	0	0	0	0	0.157895	0.325	0.422222	0.490566	0.615385	0.728571
4.5-9 Deg	0	0	0	0.0625	0.176471	0.235849	0.396694	0.478261	0.581731	0.773279
9-13.5 Deg	0	0	0	0.09375	0.156716	0.223529	0.362963	0.463343	0.5725	0.701245
13.5-18 Deg	0	0	0	0.0382166	0.131222	0.260736	0.330233	0.448833	0.566116	0.634994
18-22.5 Deg	0	0	0	0.039604	0.0973451	0.228145	0.318462	0.419903	0.517013	0.582547
22.5-27 Deg	0	0	0	0.0264026	0.0930736	0.197461	0.321879	0.381265	0.447548	0.521715
27-31.5 Deg	0	0	0	0.00486618	0.0857143	0.152859	0.25358	0.312166	0.395361	0.466491
31.5-36 Deg	0	0	0	0.00754717	0.0815217	0.142292	0.218271	0.283494	0.333753	0.381784
36-40.5 Deg	0	0	0	0	0.032538	0.0817963	0.170164	0.233583	0.275212	0.327416
40.5-45 Deg	0	0	0	0	0.0139147	0.0678972	0.129657	0.192308	0.224483	0.252462
45-49.5 Deg	0	0	0	0	0.00251467	0.0392938	0.0940285	0.141328	0.181437	0.212241
49.5-54 Deg	0	0	0	0	0	0.0110121	0.0531873	0.0958814	0.126534	0.148936
54-58.5 Deg	0	0	0	0	0	0.000456204	0.0199623	0.0552683	0.0810965	0.102659
58.5-63 Deg	0	0	0	0	0	0	0.000714286	0.0128637	0.0467906	0.0568421
63-67.5 Deg	0	0	0	0	0	0	0	0	0.00745573	0.0242928
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0.000740466
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New NM B-S	500-550	550-600	600-650	650-700	700-750	750-800	800-850	850-900	900-950	950-1000
0-4.5 Deg	0.895522	0.807692	0.880435	0.864865	0.843373	0.833333	0.858333	0.833333	0.826087	0.814815
4.5-9 Deg	0.811448	0.817109	0.806366	0.801402	0.814286	0.809211	0.804211	0.755448	0.822709	0.792657
9-13.5 Deg	0.78089	0.798354	0.801724	0.794569	0.782796	0.780287	0.765235	0.773496	0.756598	0.759384
13.5-18 Deg	0.727545	0.736387	0.720152	0.749489	0.762791	0.732403	0.711937	0.704908	0.702804	0.683544
18-22.5 Deg	0.656707	0.692351	0.687027	0.677215	0.689404	0.661647	0.651855	0.661634	0.65554	0.634515
22.5-27 Deg	0.578365	0.637657	0.629688	0.615445	0.637963	0.622396	0.604258	0.581746	0.570899	0.569778
27-31.5 Deg	0.496522	0.564516	0.564264	0.554788	0.551891	0.55257	0.548276	0.521099	0.517559	0.518553
31.5-36 Deg	0.436444	0.472969	0.488325	0.492462	0.479326	0.494505	0.47549	0.45864	0.461108	0.451835
36-40.5 Deg	0.366159	0.387514	0.419254	0.425045	0.403834	0.392764	0.396559	0.400812	0.369942	0.368859
40.5-45 Deg	0.30273	0.319185	0.342679	0.345987	0.330502	0.331052	0.323815	0.305906	0.312284	0.313023
45-49.5 Deg	0.24064	0.244851	0.261486	0.269272	0.268868	0.255423	0.239971	0.254059	0.219613	0.205285
49.5-54 Deg	0.169353	0.187424	0.203203	0.19403	0.204905	0.197958	0.161453	0.159744	0.142512	0.151292
54-58.5 Deg	0.119633	0.118058	0.129529	0.135933	0.125182	0.118211	0.109568	0.118863	0.117073	0.108844
58.5-63 Deg	0.0634228	0.0796216	0.0780856	0.0909091	0.0960929	0.0849558	0.0780781	0.103825	0.0458716	0
63-67.5 Deg	0.0364188	0.0436258	0.0367232	0.039666	0.0363636	0.0426136	0.0162162	0.0357143	0.0227273	0.0416667
67.5-72 Deg	0.00470367	0.0114213	0.0195072	0.0166667	0.0120482	0	0	0.03125	0	0
72-76.5 Deg	0	0	0	0.00280899	0.00649351	0.0123457	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New NM B-S	1000-1050	1050-1100	1100-1150	1150-1200	1200-1250	1250-1300	1300-1350	1350-1400	1400-1450	1450-1500
0-4.5 Deg	0.778846	0.8	0.813725	0.829268	0.84375	0.78022	0.783133	0.898734	0.85	0.825397
4.5-9 Deg	0.804255	0.824945	0.804494	0.814536	0.784504	0.774295	0.813665	0.792994	0.764706	0.790036
9-13.5 Deg	0.766798	0.776286	0.733735	0.717208	0.731677	0.730769	0.708861	0.728296	0.755835	0.75089
13.5-18 Deg	0.703634	0.7086	0.706101	0.683544	0.700457	0.681775	0.68321	0.68171	0.669251	0.644678
18-22.5 Deg	0.653195	0.635392	0.641326	0.620074	0.60516	0.579566	0.597895	0.612863	0.599419	0.5856
22.5-27 Deg	0.571276	0.570789	0.557559	0.528678	0.526667	0.524138	0.529101	0.509404	0.499093	0.539326
27-31.5 Deg	0.515256	0.490654	0.476651	0.444332	0.474736	0.456456	0.431408	0.465169	0.451791	0.405145
31.5-36 Deg	0.42583	0.411765	0.437118	0.397764	0.406551	0.405963	0.389205	0.33564	0.381395	0.393333
36-40.5 Deg	0.345339	0.357923	0.325411	0.296117	0.300654	0.38785	0.366279	0.328	0.348624	0.204819
40.5-45 Deg	0.294294	0.264706	0.272981	0.214286	0.233918	0.189474	0.197368	0.231884	0.222222	0.157895
45-49.5 Deg	0.236769	0.215859	0.180723	0.158879	0.169014	0.0588235	0.0833333	0.166667	0.136364	0.25
49.5-54 Deg	0.132184	0.133858	0.0869565	0.097561	0.0769231	0.0909091	0	0	0	0
54-58.5 Deg	0.0617284	0.0851064	0.0344828	0.0909091	0	0.111111	0	0	0.5	0
58.5-63 Deg	0.0333333	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0.0714286	0.166667	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New NM B-S	1500-1550	1550-1600	1600-1650	1650-1700	1700-1750	1750-1800	1800-1850	1850-1900	1900-1950	1950-2000
0-4.5 Deg	0.873016	0.767442	0.779661	0.847826	0.836735	0.809524	0.861111	0.794872	0.944444	0.833333
4.5-9 Deg	0.793651	0.741784	0.728643	0.759657	0.734884	0.770053	0.780749	0.761905	0.791908	0.794521
9-13.5 Deg	0.708249	0.717833	0.664251	0.747423	0.700581	0.688679	0.681967	0.69338	0.745763	0.685039
13.5-18 Deg	0.668863	0.66548	0.643629	0.637168	0.643038	0.62973	0.607973	0.666667	0.621212	0.622711
18-22.5 Deg	0.590654	0.587156	0.558376	0.564607	0.52568	0.568093	0.52549	0.575342	0.497696	0.557471
22.5-27 Deg	0.484043	0.5	0.535354	0.441767	0.436681	0.482587	0.40113	0.496599	0.461538	0.454545
27-31.5 Deg	0.433735	0.416667	0.362245	0.333333	0.411765	0.283951	0.402439	0.363636	0.285714	0.396825
31.5-36 Deg	0.277372	0.293103	0.308642	0.246753	0.34375	0.181818	0.108108	0.25	0.258065	0.137931
36-40.5 Deg	0.232143	0.186047	0.181818	0.214286	0.285714	0.214286	0.333333	0.166667	0.285714	0.181818
40.5-45 Deg	0.2	0.0526316	0.428571	0.0588235	0.166667	0.166667	0.25	0	0	1
45-49.5 Deg	0.0714286	0.333333	0.2	1	0	0	0	0	0	0
49.5-54 Deg	0	0	0	0	0	0	0	0	0	0
54-58.5 Deg	0	0	0	0	0	0	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Table 4: Table for 2D Histogram for Old NM-Rein-Sehgal

Old NM R-S	0-50 MeV/c	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500
0-4.5 Deg	0	0	0	0	0.333333	0.5	0.5	0.8	0.857143	0.5
4.5-9 Deg	0	0	0	0	0	0.25	0.285714	0.470588	0.466667	0.608696
9-13.5 Deg	0	0	0	0	0.0769231	0.181818	0.285714	0.451613	0.625	0.642857
13.5-18 Deg	0	0	0	0.0714286	0.15	0.290323	0.365854	0.509091	0.621622	0.630952
18-22.5 Deg	0	0	0	0.0571429	0.0689655	0.184211	0.242424	0.505155	0.474227	0.56
22.5-27 Deg	0	0	0	0.0416667	0.04	0.247059	0.280488	0.346154	0.518797	0.465969
27-31.5 Deg	0	0	0	0.0217391	0.0615385	0.1375	0.16	0.296296	0.390863	0.466981
31.5-36 Deg	0	0	0	0.0816327	0.097561	0.07	0.244444	0.290503	0.384259	0.364407
36-40.5 Deg	0	0	0	0	0.04	0.133333	0.155172	0.235577	0.282609	0.296296
40.5-45 Deg	0	0	0	0	0	0.0869565	0.15122	0.161017	0.256228	0.271875
45-49.5 Deg	0	0	0	0	0	0.0434783	0.0843882	0.141176	0.163462	0.159322
49.5-54 Deg	0	0	0	0	0	0.0108696	0.0636364	0.0816327	0.160819	0.133144
54-58.5 Deg	0	0	0	0	0	0	0.023622	0.0238095	0.0320513	0.107463
58.5-63 Deg	0	0	0	0	0	0	0	0.0129032	0.0397554	0.0555556
63-67.5 Deg	0	0	0	0	0	0	0	0	0.0056338	0.0241379
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0.00338983
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Old NM R-S	500-550	550-600	600-650	650-700	700-750	750-800	800-850	850-900	900-950	950-1000
0-4.5 Deg	0.666667	1	0.857143	0.7	0.777778	0.875	0.909091	0.777778	1	0.769231
4.5-9 Deg	0.904762	0.9	0.65	0.8	0.74359	0.877551	0.65	0.782609	0.792453	0.810811
9-13.5 Deg	0.765957	0.721519	0.813953	0.734177	0.732558	0.77907	0.744681	0.865979	0.746988	0.76087
13.5-18 Deg	0.682692	0.773109	0.722222	0.739726	0.70229	0.719178	0.711656	0.753425	0.726115	0.735099
18-22.5 Deg	0.647482	0.656442	0.609929	0.648936	0.705069	0.695187	0.643216	0.673267	0.651961	0.616505
22.5-27 Deg	0.602679	0.631818	0.658291	0.668224	0.632959	0.659574	0.617647	0.593458	0.614213	0.654054
27-31.5 Deg	0.520492	0.59761	0.522727	0.544061	0.550781	0.516981	0.592437	0.524887	0.513228	0.49359
31.5-36 Deg	0.435252	0.453925	0.540881	0.461017	0.456311	0.462838	0.493878	0.474654	0.45	0.416667
36-40.5 Deg	0.37785	0.377049	0.41195	0.424749	0.422222	0.376518	0.409692	0.394737	0.407407	0.360825
40.5-45 Deg	0.289894	0.306818	0.291545	0.340557	0.366534	0.316742	0.337423	0.28777	0.29661	0.257576
45-49.5 Deg	0.242331	0.231003	0.263699	0.285156	0.27907	0.270115	0.273973	0.259259	0.347222	0.285714
49.5-54 Deg	0.170588	0.169381	0.212996	0.220588	0.220238	0.15942	0.142857	0.122807	0.236364	0.129032
54-58.5 Deg	0.107595	0.110701	0.105991	0.138728	0.186992	0.13253	0.176471	0.131579	0	0.357143
58.5-63 Deg	0.0724638	0.0979592	0.0942408	0.0787402	0.0487805	0.0754717	0.15625	0.0416667	0	0.125
63-67.5 Deg	0.0125523	0.0380952	0.04	0.0869565	0	0.0689655	0	0	0	0
67.5-72 Deg	0	0.0212766	0.010989	0.0222222	0	0	0.111111	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Old NM R-S	1000-1050	1050-1100	1100-1150	1150-1200	1200-1250	1250-1300	1300-1350	1350-1400	1400-1450	1450-1500
0-4.5 Deg	0.8	0.777778	1	0.75	0.75	1	0.6	0.833333	1	0.833333
4.5-9 Deg	0.866667	0.807692	0.815789	0.8	0.74359	0.861111	0.923077	0.825	0.875	0.833333
9-13.5 Deg	0.747253	0.851064	0.776316	0.683544	0.791045	0.686567	0.862069	0.706897	0.660377	0.755556
13.5-18 Deg	0.70068	0.688889	0.705357	0.688679	0.711538	0.705882	0.670588	0.694444	0.68	0.677966
18-22.5 Deg	0.639535	0.641176	0.666667	0.635593	0.59375	0.59375	0.6	0.652174	0.625	0.708333
22.5-27 Deg	0.529801	0.594937	0.503817	0.591398	0.653465	0.52	0.578947	0.413793	0.568966	0.377778
27-31.5 Deg	0.531034	0.475	0.521008	0.465116	0.406593	0.517857	0.490566	0.487179	0.444444	0.347826
31.5-36 Deg	0.470588	0.465909	0.454545	0.376812	0.436364	0.348837	0.541667	0.238095	0.4	0.266667
36-40.5 Deg	0.317308	0.397436	0.267857	0.272727	0.285714	0.380952	0.176471	0.2	0.117647	0.166667
40.5-45 Deg	0.140351	0.318182	0.307692	0.208333	0.357143	0.25	0.375	0.25	0.2	0
45-49.5 Deg	0.28	0.217391	0.111111	0.1	0.0833333	0.166667	0.25	0	0.333333	1
49.5-54 Deg	0.0714286	0.1	0.142857	0	0	0	0	0	0	0
54-58.5 Deg	0.1	0	0	0	0	0.333333	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Old NM R-S	1500-1550	1550-1600	1600-1650	1650-1700	1700-1750	1750-1800	1800-1850	1850-1900	1900-1950	1950-2000
0-4.5 Deg	0.909091	0.75	0.666667	1	0	0.666667	0	0.8	1	1
4.5-9 Deg	0.761905	0.85	0.8	0.823529	0.652174	0.923077	0.857143	0.882353	0.533333	0.85
9-13.5 Deg	0.688889	0.604651	0.933333	0.638298	0.714286	0.826087	0.958333	0.842105	0.777778	0.708333
13.5-18 Deg	0.586957	0.653846	0.612245	0.65625	0.68	0.7	0.625	0.76	0.75	0.565217
18-22.5 Deg	0.568182	0.634146	0.461538	0.423077	0.625	0.47619	0.47619	0.76	0.611111	0.722222
22.5-27 Deg	0.666667	0.5	0.444444	0.473684	0.458333	0.647059	0.615385	0.45	0.4	0.333333
27-31.5 Deg	0.380952	0.4	0.384615	0.454545	0.1	0.333333	0.375	0.625	0.2	0.25
31.5-36 Deg	0.3125	0.533333	0.352941	0.4	0.571429	0.222222	0.166667	0	0.666667	0.5
36-40.5 Deg	0.333333	0.333333	0.5	0.285714	0.5	0	0	0	0	0
40.5-45 Deg	0	0	0.5	0	0	0	0	1	0	0
45-49.5 Deg	0	0	0	0	0	0	0	0	0	0
49.5-54 Deg	0	0	0	0	0	0	0	0	0	0
54-58.5 Deg	0	0	0	0	0	0	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Table 5: Table for 2D Histogram for New ANM-Rein-Sehgal

New ANM R-S	0-50 MeV/c	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500
0-4.5 Deg	0	0	0	0.037037	0.173913	0.225352	0.398693	0.510204	0.585034	0.741325
4.5-9 Deg	0	0	0	0.0538922	0.179487	0.264881	0.351406	0.522654	0.611905	0.722011
9-13.5 Deg	0	0	0	0.0881226	0.175824	0.272864	0.369565	0.47927	0.562628	0.680187
13.5-18 Deg	0	0	0	0.0502959	0.162912	0.264642	0.372408	0.45271	0.529918	0.642998
18-22.5 Deg	0	0	0	0.0477273	0.135068	0.240964	0.32415	0.42098	0.500719	0.578125
22.5-27 Deg	0	0	0	0.0256881	0.127932	0.186722	0.284972	0.381885	0.46546	0.511835
27-31.5 Deg	0	0	0	0.0135747	0.0779102	0.157462	0.237522	0.318072	0.385341	0.455377
31.5-36 Deg	0	0	0	0.00265957	0.0702447	0.140581	0.21821	0.292653	0.342622	0.394628
36-40.5 Deg	0	0	0	0	0.0358187	0.107342	0.168067	0.222502	0.294331	0.333169
40.5-45 Deg	0	0	0	0	0.0164051	0.0757272	0.131076	0.200825	0.226708	0.268313
45-49.5 Deg	0	0	0	0	0	0.0478888	0.099454	0.13113	0.177444	0.212046
49.5-54 Deg	0	0	0	0	0	0.0114405	0.0658882	0.103003	0.127891	0.149639
54-58.5 Deg	0	0	0	0	0	0.000554017	0.0170428	0.0537772	0.0883421	0.116889
58.5-63 Deg	0	0	0	0	0	0	0.0010015	0.020202	0.0406544	0.0526316
63-67.5 Deg	0	0	0	0	0	0	0	0.00108167	0.00447928	0.0226148
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New ANM R-S	500-550	550-600	600-650	650-700	700-750	750-800	800-850	850-900	900-950	950-1000
0-4.5 Deg	0.812332	0.808989	0.820399	0.80597	0.846154	0.826087	0.834821	0.846791	0.849776	0.814732
4.5-9 Deg	0.822749	0.806912	0.812763	0.807565	0.807477	0.80314	0.805654	0.802672	0.816404	0.79961
9-13.5 Deg	0.778963	0.784609	0.775579	0.77094	0.780604	0.772247	0.778919	0.774887	0.769928	0.777286
13.5-18 Deg	0.714241	0.754711	0.746173	0.739165	0.72958	0.736591	0.712291	0.723065	0.699029	0.705178
18-22.5 Deg	0.669713	0.700024	0.693197	0.686785	0.675302	0.676973	0.671911	0.662691	0.649262	0.656827
22.5-27 Deg	0.587483	0.641457	0.609761	0.630852	0.616002	0.610015	0.585767	0.589724	0.588134	0.57303
27-31.5 Deg	0.527993	0.566528	0.573181	0.550737	0.538564	0.550457	0.533736	0.525933	0.509007	0.512922
31.5-36 Deg	0.429609	0.48047	0.502938	0.499068	0.49538	0.462372	0.47797	0.465828	0.428421	0.439291
36-40.5 Deg	0.361301	0.382382	0.418154	0.431897	0.40234	0.403238	0.388569	0.407134	0.374224	0.366126
40.5-45 Deg	0.30581	0.320273	0.346117	0.33394	0.333774	0.343066	0.307036	0.329013	0.279793	0.27593
45-49.5 Deg	0.222903	0.250172	0.254128	0.270336	0.280552	0.252766	0.235294	0.240708	0.214834	0.218107
49.5-54 Deg	0.172282	0.178556	0.193367	0.190678	0.185291	0.18963	0.175556	0.136364	0.150327	0.116279
54-58.5 Deg	0.122696	0.124613	0.143336	0.139043	0.133106	0.130564	0.121076	0.105263	0.0547945	0.114286
58.5-63 Deg	0.0724161	0.0817391	0.077907	0.0850662	0.0868263	0.0772947	0.0462963	0.0454545	0.0555556	0
63-67.5 Deg	0.0374384	0.0423729	0.0439122	0.0482759	0.0424242	0.025	0.125	0	0.125	0
67.5-72 Deg	0.00515464	0.0103093	0.0144928	0.00714286	0.0289855	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New ANM R-S	1000-1050	1050-1100	1100-1150	1150-1200	1200-1250	1250-1300	1300-1350	1350-1400	1400-1450	1450-1500
0-4.5 Deg	0.811494	0.835	0.820728	0.821212	0.820946	0.829352	0.86385	0.785124	0.834906	0.820896
4.5-9 Deg	0.808895	0.780172	0.79495	0.806396	0.799636	0.809524	0.799766	0.790123	0.793201	0.770154
9-13.5 Deg	0.764215	0.756151	0.769636	0.756423	0.745802	0.736299	0.725795	0.729068	0.731919	0.712513
13.5-18 Deg	0.708415	0.69735	0.68934	0.693381	0.700468	0.682373	0.673329	0.680972	0.660094	0.631818
18-22.5 Deg	0.646345	0.649693	0.62265	0.628975	0.613897	0.596406	0.591174	0.582904	0.568153	0.597598
22.5-27 Deg	0.583082	0.5553	0.564074	0.557719	0.53367	0.554507	0.527886	0.535211	0.501099	0.488432
27-31.5 Deg	0.498878	0.50292	0.473382	0.487885	0.490838	0.454704	0.467192	0.428571	0.405405	0.464286
31.5-36 Deg	0.425238	0.420697	0.393846	0.374753	0.375394	0.398374	0.379121	0.342857	0.27907	0.290323
36-40.5 Deg	0.347445	0.358079	0.315942	0.337449	0.296512	0.306931	0.295082	0.265625	0.192308	0.2
40.5-45 Deg	0.311653	0.287736	0.211538	0.186275	0.203125	0.222222	0.111111	0.272727	0.2	0
45-49.5 Deg	0.251908	0.234043	0.2	0.307692	0.235294	0	0.4	0	0	0
49.5-54 Deg	0.125	0.181818	0.0833333	0	0.5	0	1	0	0	0
54-58.5 Deg	0.157895	0	0	0	0	0.5	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

New ANM R-S	1500-1550	1550-1600	1600-1650	1650-1700	1700-1750	1750-1800	1800-1850	1850-1900	1900-1950	1950-2000
0-4.5 Deg	0.815642	0.802721	0.80315	0.8	0.836538	0.855556	0.808989	0.783784	0.884058	0.705882
4.5-9 Deg	0.790738	0.80036	0.792494	0.733146	0.794798	0.766323	0.734982	0.759091	0.770335	0.812155
9-13.5 Deg	0.703791	0.716617	0.724876	0.71537	0.701461	0.718579	0.711409	0.698052	0.719368	0.688776
13.5-18 Deg	0.63144	0.590237	0.677481	0.628692	0.681818	0.648734	0.609848	0.615385	0.643275	0.635714
18-22.5 Deg	0.59465	0.57381	0.533875	0.509091	0.476852	0.57377	0.569231	0.522523	0.635294	0.603175
22.5-27 Deg	0.481343	0.509091	0.469388	0.515385	0.494382	0.472222	0.490909	0.390244	0.647059	0.321429
27-31.5 Deg	0.381679	0.402062	0.346154	0.348837	0.358974	0.55	0.307692	0.25	0.125	0.5
31.5-36 Deg	0.282051	0.592593	0.333333	0.533333	0.75	0	0.6	1	0	0
36-40.5 Deg	0.142857	0.166667	0	0.5	0	0	0	0	0	0
40.5-45 Deg	0.333333	0	0	0	0	0	0	0	0	0
45-49.5 Deg	0	0	0	0	0	0	0	0	0	0
49.5-54 Deg	0	0	0	0	0	0	0	0	0	0
54-58.5 Deg	0	0	0	0	0	0	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0

Table 6: Table for 2D Histogram for New ANM-Berger-Sehgal

New ANM B-S	0-50 MeV/c	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500	500-550	550-600	600-650	650-700	700-750	750-800	800-850	850-900	900-950	950-1000	1000-1050	1050-1100	1100-1150	1150-1200	1200-1250	1250-1300	1300-1350	1350-1400	1400-1450	1450-1500	1500-1550	1550-1600	1600-1650	1650-1700	1700-1750	1750-1800	1800-1850	1850-1900	1900-1950	1950-2000
0-4.5 Deg	0	0	0	0.0930233	0.144737	0.283186	0.421384	0.494898	0.668161	0.710247	0.805861	0.796703	0.834184	0.844907	0.827907	0.866324	0.843458	0.855072	0.83208	0.813433	0.818653	0.841432	0.806366	0.833866	0.867133	0.840741	0.819005	0.813084	0.83	0.886667	0.823129	0.825397	0.871795	0.825243	0.824074	0.797297	0.815789	0.774194	0.823529	0.809524
4.5-9 Deg	0	0	0	0.0166667	0.165094	0.269231	0.4	0.541667	0.613402	0.732694	0.797824	0.812245	0.82494	0.814583	0.823051	0.812541	0.792568	0.781479	0.804378	0.794982	0.805085	0.823664	0.813322	0.809233	0.801491	0.754923	0.791063	0.783712	0.79661	0.793729	0.777403	0.774319	0.787879	0.784741	0.817629	0.771523	0.778723	0.776824	0.762376	0.821229
9-13.5 Deg	0	0	0	0.0700935	0.130919	0.271667	0.353012	0.480322	0.569575	0.68139	0.781754	0.795837	0.774114	0.785362	0.773578	0.781475	0.76586	0.762567	0.752009	0.761471	0.748873	0.73664	0.739656	0.735498	0.72956	0.755391	0.720774	0.711163	0.74169	0.714434	0.730546	0.70028	0.702786	0.692029	0.698795	0.727488	0.698895	0.694079	0.706827	0.663507
13.5-18 Deg	0	0	0	0.0401338	0.149742	0.265497	0.336059	0.414129	0.536284	0.638281	0.728386	0.717996	0.747335	0.748866	0.736466	0.7337	0.731489	0.723615	0.700111	0.714206	0.71014	0.691088	0.695486	0.679018	0.673116	0.66913	0.689633	0.664591	0.685662	0.667735	0.664188	0.656201	0.664884	0.654737	0.652068	0.615894	0.627737	0.628571	0.650888	0.613924
18-22.5 Deg	0	0	0	0.0277778	0.137174	0.23849	0.319925	0.423721	0.499227	0.57533	0.655519	0.701815	0.686171	0.689579	0.686069	0.673434	0.65566	0.6686	0.647105	0.657014	0.636641	0.624197	0.638889	0.646891	0.628604	0.584667	0.586435	0.624873	0.603365	0.570149	0.581722	0.600887	0.607558	0.583333	0.531915	0.573034	0.525641	0.527559	0.552632	0.487179
22.5-27 Deg	0	0	0	0.0196464	0.109134	0.204236	0.312057	0.385731	0.447873	0.516755	0.600138	0.645331	0.628718	0.629526	0.604035	0.609545	0.603815	0.602548	0.578702	0.597386	0.569439	0.583187	0.543649	0.537295	0.536066	0.55848	0.548585	0.504687	0.518738	0.493639	0.501502	0.469828	0.469945	0.477273	0.443299	0.445783	0.442623	0.297297	0.405405	0.482759
27-31.5 Deg	0	0	0	0.00315956	0.104046	0.165109	0.256264	0.322028	0.397871	0.445264	0.512134	0.574856	0.561587	0.558263	0.539545	0.545725	0.538095	0.525974	0.509479	0.506996	0.501982	0.5	0.4943	0.457645	0.467143	0.448387	0.4447	0.485531	0.401487	0.407609	0.365517	0.330189	0.263889	0.446809	0.4	0.380952	0.136364	0.333333	0.555556	0.333333
31.5-36 Deg	0	0	0	0	0.0525862	0.124857	0.206051	0.275698	0.333971	0.392423	0.431607	0.47668	0.500539	0.496867	0.476983	0.479711	0.460797	0.455385	0.446729	0.424768	0.438768	0.394628	0.38565	0.408915	0.451791	0.342561	0.429348	0.30303	0.322917	0.333333	0.285714	0.3	0.333333	0.352941	0.166667	1	1	0.333333	0.5	0
36-40.5 Deg	0	0	0	0	0.0444774	0.105837	0.16809	0.234525	0.286885	0.327259	0.353491	0.400137	0.418747	0.422945	0.407023	0.396731	0.398879	0.392036	0.372638	0.364706	0.376984	0.347664	0.323529	0.355856	0.312849	0.325	0.338983	0.410256	0.242424	0.157895	0.25	0.166667	0	0.5	0	0	0	0	0	0
40.5-45 Deg	0	0	0	0	0.0210938	0.0689829	0.137208	0.172468	0.226261	0.272047	0.300615	0.316995	0.337145	0.348088	0.337621	0.320774	0.311813	0.293856	0.315938	0.294333	0.257062	0.283262	0.26	0.298851	0.258065	0.228571	0.210526	0.111111	0.285714	0	1	0.5	0.5	0	0	0	0	0	0	0
45-49.5 Deg	0	0	0	0	0	0.035913	0.0925481	0.127177	0.17693	0.21244	0.229012	0.236659	0.252955	0.271491	0.267346	0.259352	0.254042	0.228395	0.213368	0.222222	0.229299	0.195652	0.196429	0.142857	0.285714	0.333333	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
49.5-54 Deg	0	0	0	0	0	0.0115668	0.0516817	0.101349	0.118959	0.148848	0.169149	0.194822	0.189664	0.203367	0.176355	0.210306	0.188017	0.202572	0.150943	0.148936	0.145455	0.130435	0.142857	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
54-58.5 Deg	0	0	0	0	0	0	0.0210526	0.052506	0.080695	0.104636	0.120419	0.128324	0.143609	0.149563	0.12426	0.149296	0.141667	0.115044	0.149254	0.285714	0	0.0769231	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58.5-63 Deg	0	0	0	0	0	0	0	0.0150616	0.0392791	0.0594262	0.0719951	0.0804312	0.088785	0.0819367	0.0946372	0.0851064	0.0535714	0.0888889	0.125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63-67.5 Deg	0	0	0	0	0	0	0	0	0.00795003	0.0215545	0.0325901	0.0497512	0.0446927	0.0397554	0.0674847	0.0933333	0.0952381	0.047619	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67.5-72 Deg	0	0	0	0	0	0	0	0	0	0.00182983	0.00373599	0.00414938	0.0170648	0.00552486	0.0136986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72-76.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0266667	0	0.0833333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76.5-81 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81-85.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85.5-90 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90-94.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94.5-99 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99-103.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103.5-108 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108-112.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
112.5-117 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117-121.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121.5-126 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126-130.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130.5-135 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135-139.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
139.5-144 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144-148.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148.5-153 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153-157.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157.5-162 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162-166.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166.5-171 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171-175.5 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175.5-180 Deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0