Good-pion distributions for the ISS Hg target

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We examine the pion production distributions for the ISS neutrino factory baseline design. Interactions of the initial 10 GeV proton beam with a mercury target were taken from MARS-generated distributions. We compare the total distribution of pions produced at the target with the pion distributions that result in muons with phase space within the ISS accelerator acceptance.

1. Introduction

In the ISS neutrino factory design [1] pions are created from proton interactions in a mercury target. From all the pions created at the target only a small fraction ultimately decay to muons that fit into the acceptance of the accelerator system. We refer to these as the "good" pions. We examine in this report some characteristics of the initial phase space of these good pions.

2. Method of analysis

The analysis started with a MARS [2] file of 10 GeV protons interacting with a mercury target[1]. The proton bunch had a 2 ns pulse length. The mercury target length was 25 cm. The beam and target crossed at an angle corresponding to a 60 cm long interaction diamond. The target was immersed in a 20 T solenoid field. The target had a radius of 5 mm. Pions and muons produced in the target were then tracked for 295 m through the ISS front end. In the ISS design the front end is followed by the accelerator sections where the normalized acceptances are A_{TN} = 30 mm and A_{LN} = 150 mm. We tagged all muons that were included in the accelerator acceptance at the exit of the front end system. We then examined the production characteristics of those pions which produced the accepted muons.

[1] This file was prepared by Harold Kirk.

3. Good pion distributions

Table 1 summarizes the ISS pion and muon production for each interacting proton in the mercury target.

Table 1. Pion and muon production (per interacting proton)

	total π	μ after front end	μ_A
positive	2.865	0.155	0.074
negative	2.892	0.193	0.088

The "total" number of pions is only approximate since it represents those pions collected in the 20 T solenoid field that reach the end of the target, are moving downstream, and have a radius less than 15 cm. The third column gives the number of all muons that reach the end of the ISS front end. The last column gives the number of muons in the accelerator acceptance. We see that about 8% of the initial proton interactions produce an accepted muon.

Figure 1 shows contour plots of good π^+ and π^- production as a function of pion total momentum and polar angle.

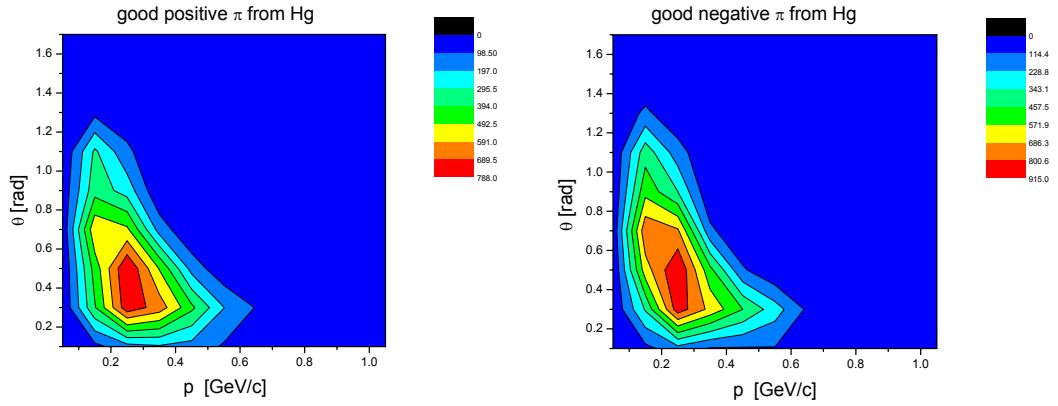

Figure 1. Contour plots of good pions as a function of momentum and angle.

We see that the peak in the production of good pions occurs for momenta around 250 MeV/c and for polar angles around 400 mrad.

A comparison of the momentum distributions for the total and good pions is shown in Fig. 2. These data are summed over all polar angles.

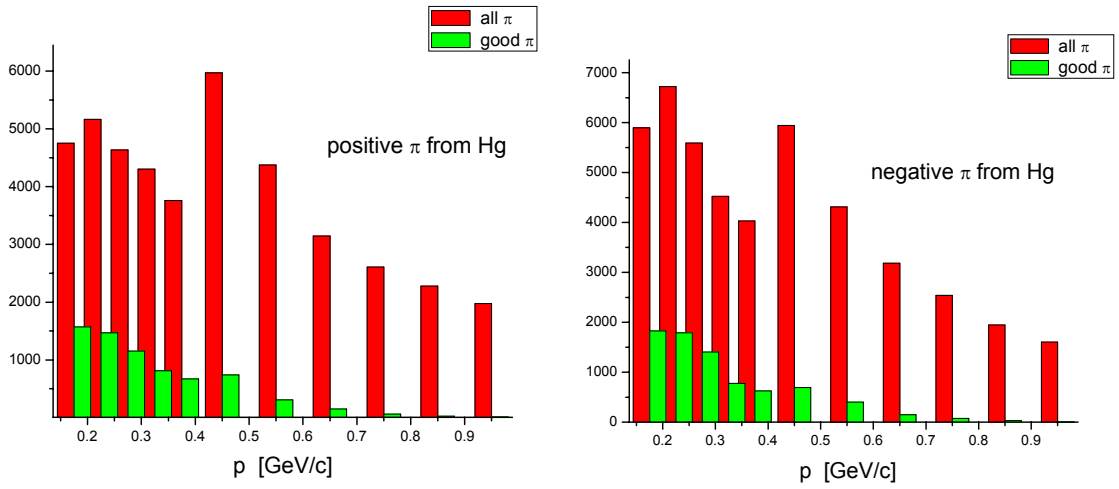

Figure 2. Pion momentum distributions.

We see that the momentum distribution of good pions is peaked at low momentum. Most of the good pions are in the range 150-600 MeV/c. The fraction of good pions is shown as a function of momentum in Fig. 3.

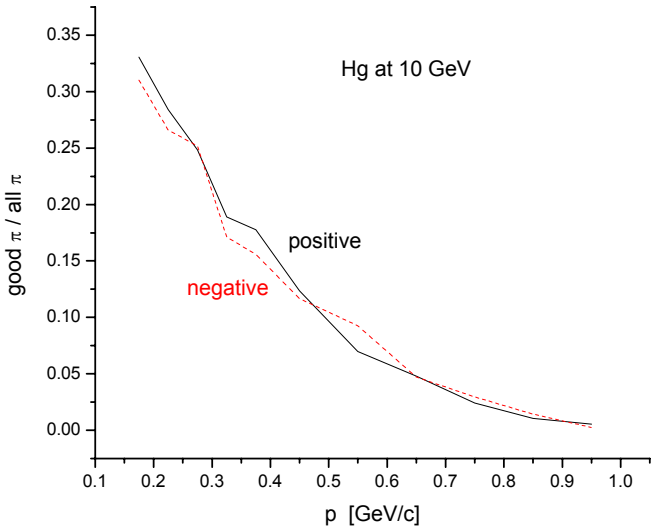

Figure 3. Fraction of good pions as a function of momentum.

A comparison of the polar angle distributions for the total and good pions is shown in Fig. 4. These data are summed over all momenta.

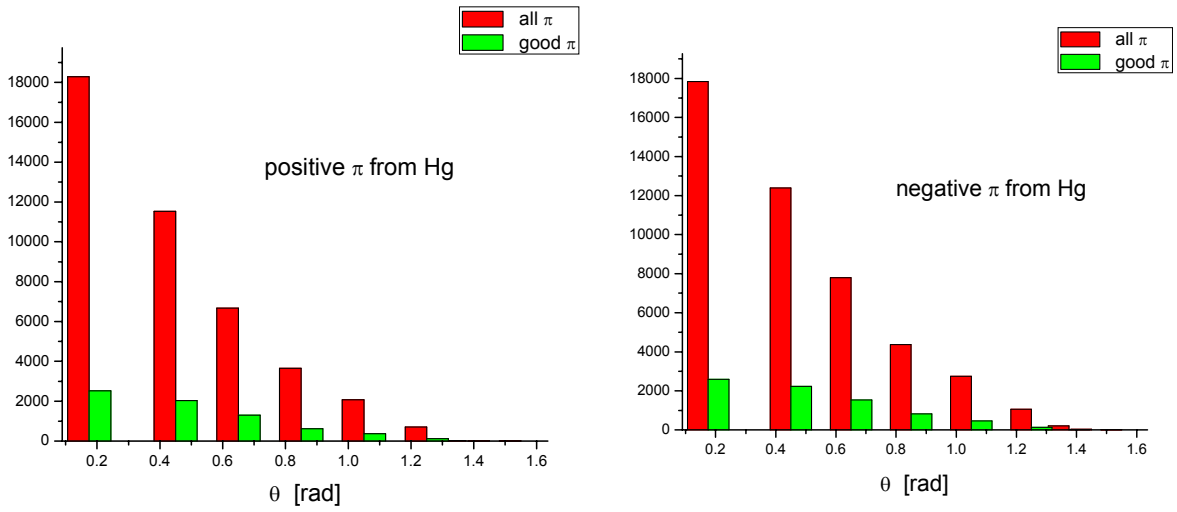

Figure 4. Pion polar angle distributions.

The fraction of good pions is shown as a function of polar angle in Fig. 5.

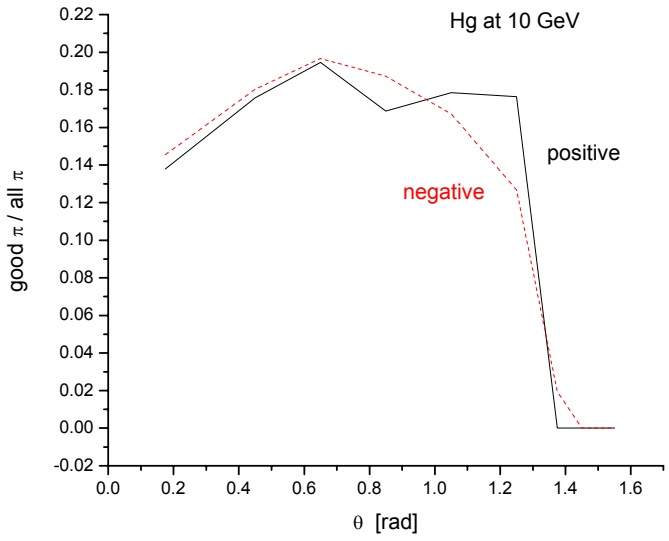

Figure 5. Fraction of good pions as a function of polar angle.

Acknowledgements

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References

[1] M. Zisman, Summary Report of the Accelerator Working Group, International Scoping Study of a Future Neutrino Factory and Superbeam Facility, draft report, 26 March 2007.

[2] N. Mokhov, http://www-ap.fnal.gov/MARS/.