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Acceptances and Resolutions in the E852 $\pi^- p \to \pi^+\pi^-\pi^- p$ and $\pi^- p \to \pi^-\pi^0\pi^0 p$ Data Samples.*

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Abstract

This note describes the acceptances and resolutions of the E852 $\pi^- p \to \pi^+\pi^-\pi^- p$ and $\pi^- p \to \pi^-\pi^0\pi^0 p$ data samples in all of the important kinematic variables, including 3π mass, t of the production, and the decay angles of both the resonance and isobar.

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1 Introduction

Each event in the E852 $\pi^- p \to \pi^+\pi^-\pi^- p$ and $\pi^- p \to \pi^-\pi^0\pi^0 p$ data samples can be completely described kinematically[†] by specifying the 3π invariant mass, the t of the production[‡], the angles of the 3π system decaying to $(isobar)\pi$, and the angles of the isobar decaying to $\pi\pi$. Since these variables are central to the data analyses performed on the 3π systems, it is important to understand both the acceptance of the detector as a function of these variables and the resolution to which the detector can measure them.

The angles of the 3π system decaying to $(isobar)\pi$ are given in the Gottfried-Jackson system. These angles will be referred to as the decay angles of the resonance. In the $\pi^- p \to \pi^+\pi^-\pi^- p$ mode (referred to as the "charged" mode), one of the π^- is randomly selected to be the bachelor, leaving a $\pi^+\pi^-$ combination to form the isobar. In the $\pi^- p \to \pi^-\pi^0\pi^0 p$ mode (referred to as the "neutral" mode), the unique π^- is taken as the bachelor, which corresponds to a $\pi^0\pi^0$ isobar. In the Gottfried-Jackson system the z-axis is defined as the beam direction in the 3π rest frame, the y-axis is the cross product between the recoil nucleon direction in the 3π rest frame and the z-axis, and the x-axis is the cross product of the y-axis and z-axis. The $\cos\theta$ and ϕ angles of the resonance decay specify the direction of the isobar in the 3π rest frame with respect to the Gottfried-Jackson axes.

The angles of the isobar decay to $\pi\pi$ are given in the helicity frame. Here, the z-azis is defined as the isobar direction in the 3π rest frame, the y-axis is defined as the cross product between the Gottfried-Jackson z-axis (above) and the helicity z-axis, and the x-axis is the cross product of the y-axis and z-axis. The $\cos\theta$ and ϕ angles of the isobar decay specify the direction of one of the isobar daughters (chosen randomly) in the isobar rest frame with respect to the helicity axes.

2 Acceptances

To determine the acceptances a large number of events were randomly generated in both the charged and neutral modes. The t distributions were generated according to te^{-10t}, 3π masses were flat between 0.5 and 2.5 GeV/c^2, and all decay angles were also flat. Generated events were sent through a detector simulation (turning tracks to hits), and then subjected to the same trigger requirements, reconstruction, kinematic fitting, and analysis cuts as were used on the data. Dividing the reconstructed distributions by the generated distributions is a measure of the detector acceptance.

Figure 1 shows the acceptance of the 3π invariant mass (averaged over all other variables), and the t acceptance (also averaged over all other variables). The blue curves are for the neutral mode; the red curves the charged mode. The shape of the mass acceptance was found to be very similar to that shown in figure 1 in different bins of t, and vice versa: the shape of the t acceptance was relatively insensitive to the mass bin. The dotted lines on the t acceptance curves (at $t = 0.08\,\mathrm{GeV}^{-2}c^2$ and

[†] In E852, the beam energy is fixed at 18.3 GeV/c.

[‡] We define $t \equiv -(P_{BEAM} - P_{3\pi})^2$, where P_{BEAM} and $P_{3\pi}$ are the four-momenta of the beam and 3π system, respectively.

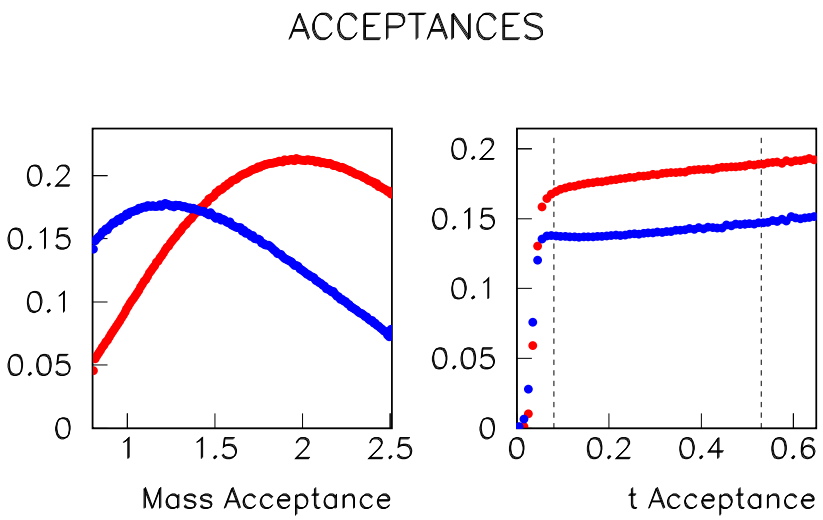

Figure 1: The 3π invariant mass acceptance (averaged over all other variables), and the t acceptance (also averaged over all other variables). The blue curves are for the neutral mode; the red curves the charged mode.

$0.53\,\mathrm{GeV}^{-2}c^2$) indicate the regions of t used in the 3π analyses.

Angular acceptances (with the conventions defined above) are shown in figure 2, where each curve is an average over all 3π masses and all t. The variation of the angular acceptances in different 3π mass bins is shown in figures 3 to 6.

3 Resolutions

To calculate the resolutions of the kinematic variables, charged and neutral 3π events were generated in the same way as they were for the acceptance calculations. After sending the events through a detector simulation, through trigger requirements, reconstruction, kinematic fitting, and analysis cuts, the kinematic variables of the accepted events were compared to the variables of the generated events. For some kinematic variable V (mass, t, or angles) a distribution of

$$\Delta V \equiv V_{ACCEPTED} - V_{GENERATED}$$

was formed and the RMS of this distribution was taken as the resolution.

Results for the 3π mass and the t resolutions are shown in figure 7. Figure 8 shows the resolutions of the angles (whose conventions are described above).

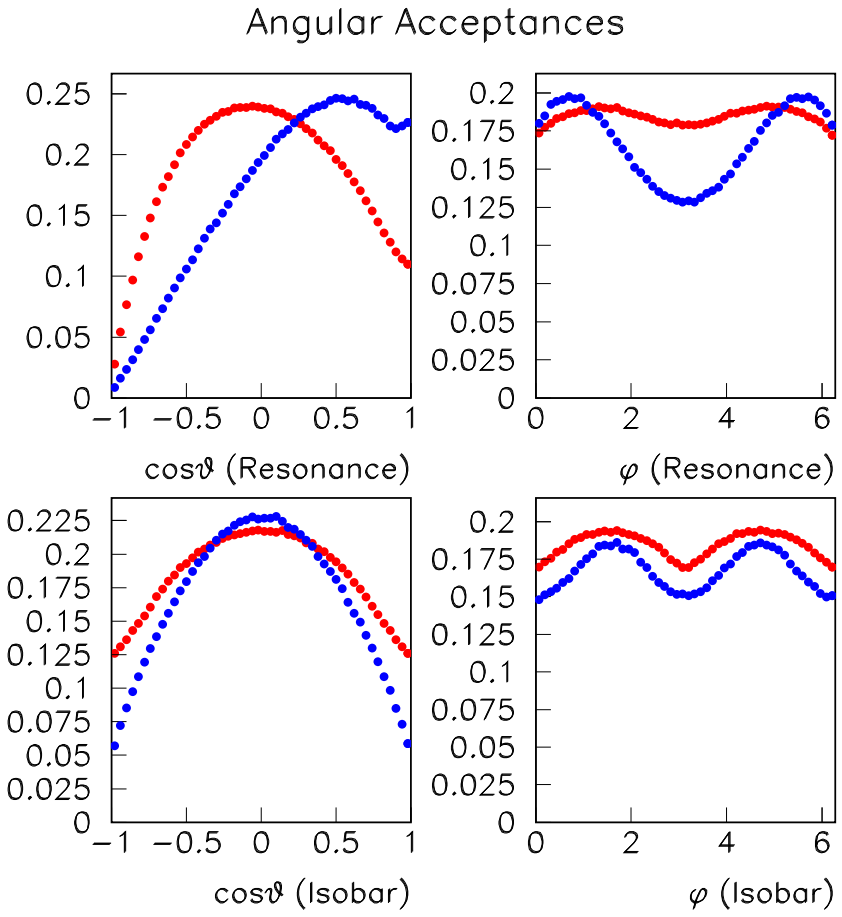

Figure 2: Angular acceptances. The top two plots show the acceptance of the angles ($\cos\theta$ and ϕ) of the resonance decay. The bottom two plots are the angles for the isobar decay. The blue curves are for the neutral mode; the red curves the charged mode. The definitions of the angles are described in the text.

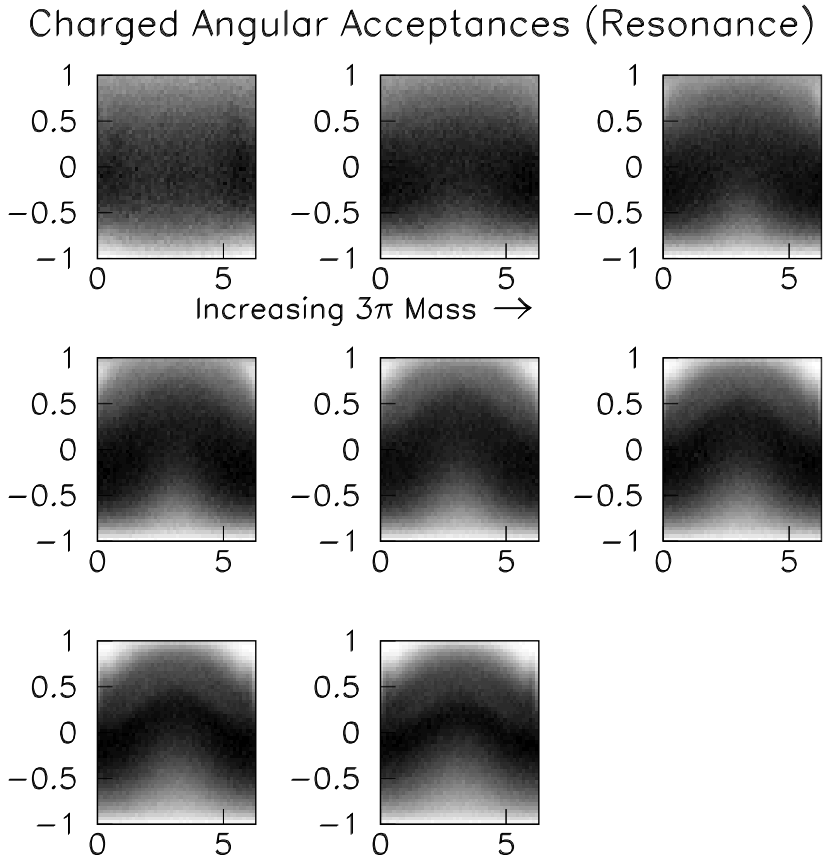

Figure 3: The evolution of angular acceptances as a function of 3π mass. Angles are for the resonance decay in the charged 3π mode. Shown is the acceptance plotted as $\cos\theta vs.\phi$. Darker regions have higher acceptance. The mass bins shown are in increments of $0.2\,\mathrm{GeV}/c^2$ starting with $0.8\,\mathrm{GeV}/c^2$ and ending with $2.4\,\mathrm{GeV}/c^2$. Mass increases as the plots go from left to right and top to bottom.

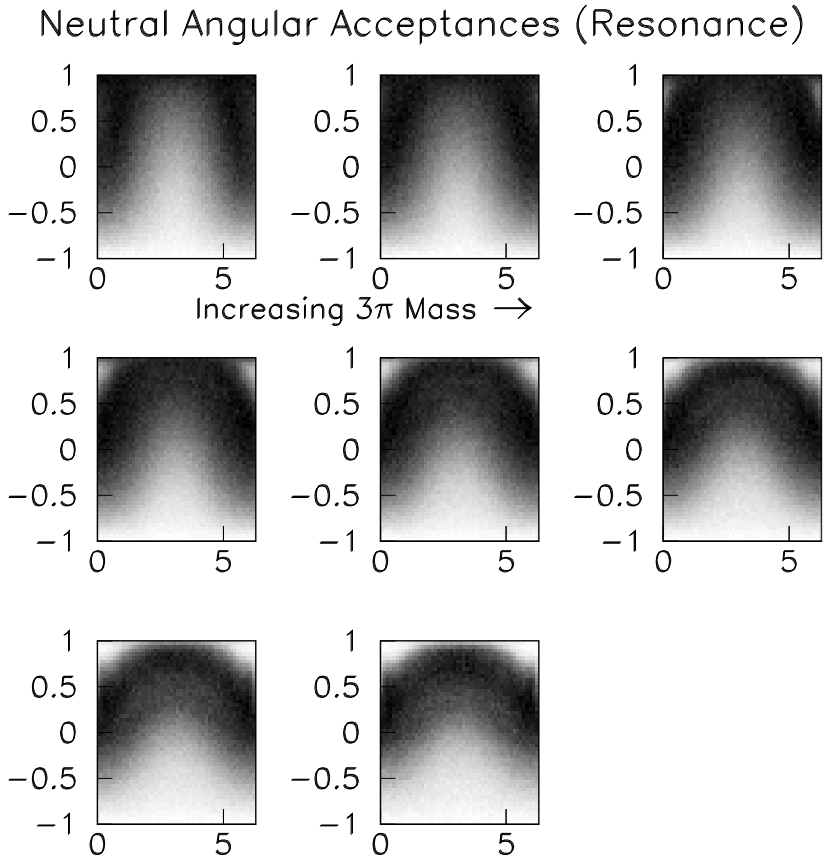

Figure 4: The evolution of angular acceptances as a function of 3π mass. Angles are for the resonance decay in the neutral 3π mode. Shown is the acceptance plotted as $\cos\theta vs.\phi$. Darker regions have higher acceptance. The mass bins shown are in increments of $0.2\,\mathrm{GeV}/c^2$ starting with $0.8\,\mathrm{GeV}/c^2$ and ending with $2.4\,\mathrm{GeV}/c^2$. Mass increases as the plots go from left to right and top to bottom.

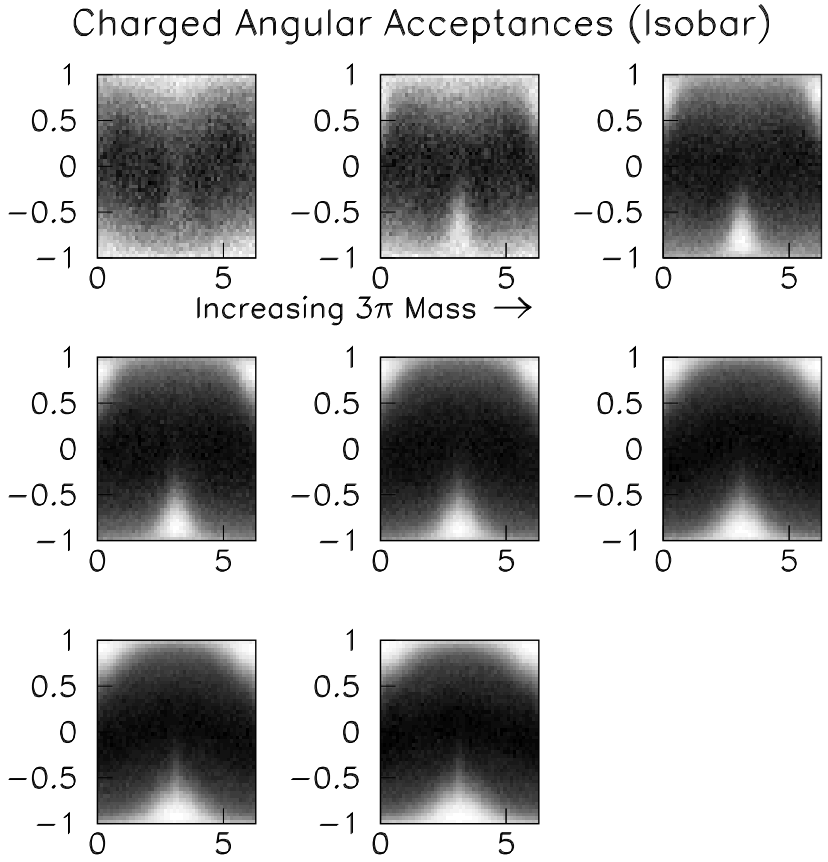

Figure 5: The evolution of angular acceptances as a function of 3π mass. Angles are for the isobar decay in the charged 3π mode. Shown is the acceptance plotted as $\cos\theta vs.\phi$. Darker regions have higher acceptance. The mass bins shown are in increments of $0.2\,\mathrm{GeV}/c^2$ starting with $0.8\,\mathrm{GeV}/c^2$ and ending with $2.4\,\mathrm{GeV}/c^2$. Mass increases as the plots go from left to right and top to bottom.

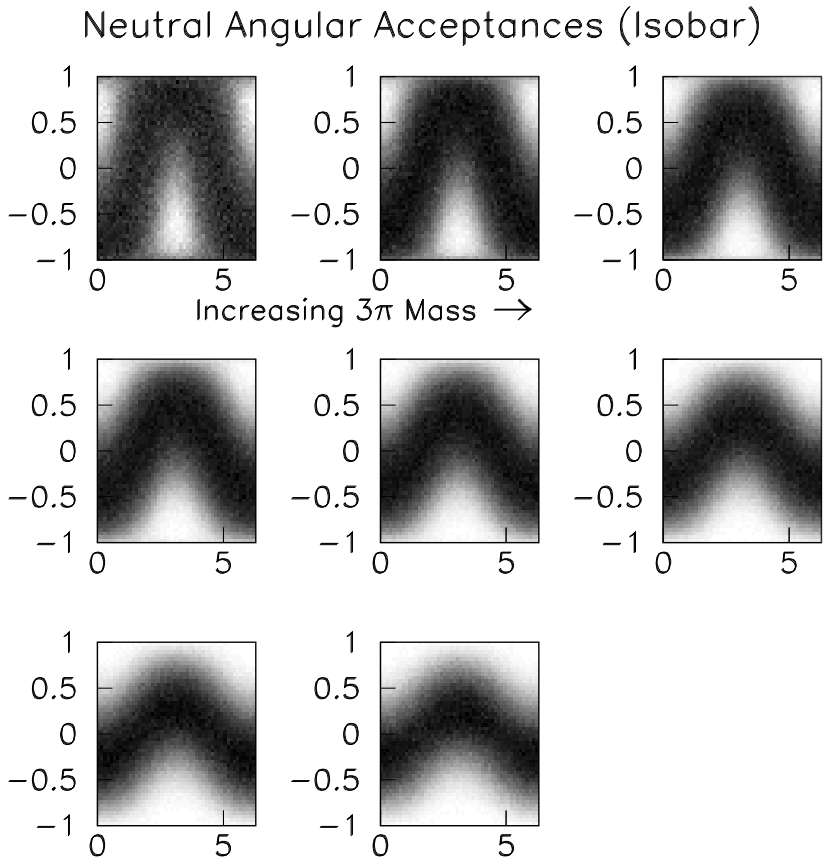

Figure 6: The evolution of angular acceptances as a function of 3π mass. Angles are for the isobar decay in the neutral 3π mode. Shown is the acceptance plotted as $\cos\theta vs.\phi$. Darker regions have higher acceptance. The mass bins shown are in increments of $0.2\,\mathrm{GeV}/c^2$ starting with $0.8\,\mathrm{GeV}/c^2$ and ending with $2.4\,\mathrm{GeV}/c^2$. Mass increases as the plots go from left to right and top to bottom.

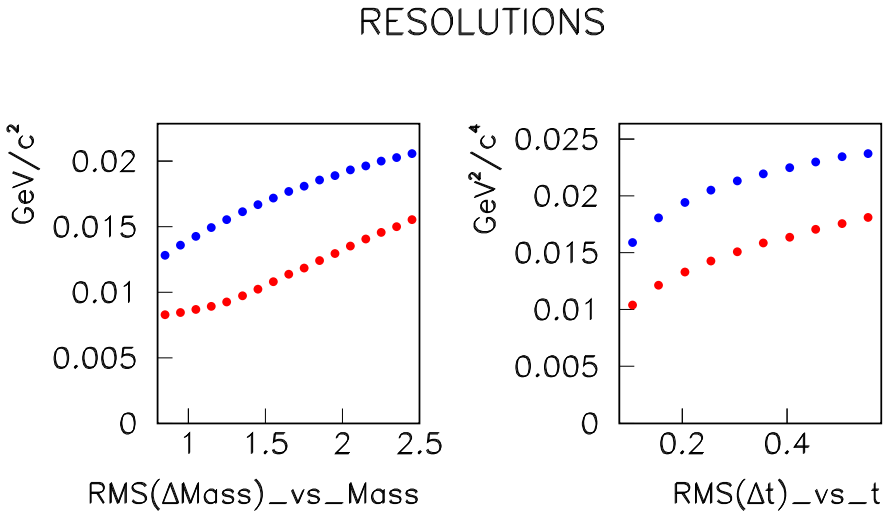

Figure 7: The resolution of the 3π invariant mass, and the resolution of t. The blue curves are for the neutral mode; the red curves the charged mode.

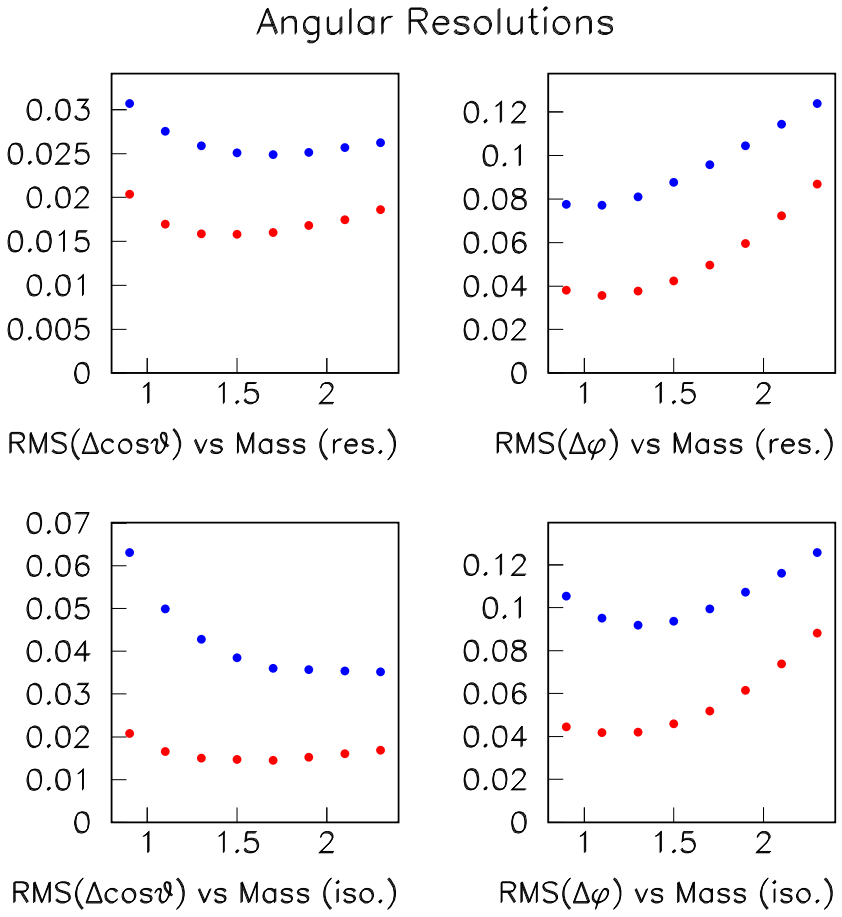

Figure 8: Angular resolutions. The top two plots show the resolutions of the angles ($\cos\theta$ and ϕ) of the resonance decay. The bottom two plots are the angles for the isobar decay. The blue curves are for the neutral mode; the red curves the charged mode. The definitions of the angles are described in the text.