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Line Shape and Beam Energy in the GlueX Experiment
PRELIMINARY

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Abstract

This note examines the effect on hybrid meson searches above 2.5 GeV/c^2 of lowering the electron beam energy from 12 to 11 GeV. The effect on line shape and meson resonance – baryon resonance overlap is studied. In this preliminary note we study the effect on line shape. The resonance overlap will be discussed in the next version of this note. But the preliminary study reported on here indicates that lowering the electron beam energy will severely jeopardize the discovery potential of GlueX. A study of the Dalitz plot boundaries for the reaction $\gamma p \to \pi^+ \rho^0 n$ has also been added. This is still a work in progress.

Introduction

This note discusses some of the effects of lowering the beam electron beam energy in the GlueX experiment from 12 to 11 GeV. To maintain the same degree of linear polarization we would have to operate the photon beam in the range from 7 to 8 GeV as opposed to the planned 8 to 9 GeV. We are interested in two aspects of meson searches — the effect on the line shape of produced resonances and on the overlap of meson resonances with baryon resonances. Both effects are expected to degrade the spectroscopy of produced mesons with mass m_X and the degradation becomes more severe as m_X increases and the photon beam energy decreases.

Line shape

In this preliminary version of this note we start with the line shape distortion. We expect mesons to be produced peripherally, with a distribution in momentum transfer squared from beam to particle X that is exponential. In particular, $t = |(p_\gamma - p_X)^2|$ and for this particular study we assume that the yield of a resonance is given by:

$$\int_{t_{min}}^{t_{max}} e^{-\alpha t} dt \qquad (1)$$

Note that in our definition of t the quantity is intrinsically positive. Also note that t_{min} and t_{max} depend on m_X and photon beam energy E_γ. We assume $\alpha = 10$ (GeV/c)$^{-2}$.

We assume a Breit-Wigner line shape for the resonances. In this study we considered four m_x masses: 2.5, 2.6, 2.7 and 2.8 GeV/c^2. We used a width $\Gamma = 0.15$ GeV/c^2. For a given m_x the upper end of the mass range considered was fixed by kinematics and the lower range as set at $m_x - 5 \cdot \Gamma$.

The photon beam energy was chosen uniform in the range from 7 to 8 GeV or 8 to 9 GeV.

Figure 1 shows the effect on line shape as a function of m_X for the two ranges of photon beam energies. Note the severe impact on line shape and yield as the photon range is lowered. The figures also show a dashed vertical line to indicate the central masses. Note that even for the higher E_γ range there is a slight mass shift. The effect of changing α is shown in Figure 2.

This is work in progress but this preliminary study clearly shows that decreasing the photon beam energy from 12 to 11 GeV will severely jeopardize the discovery potential of GlueX.

Meson and baryon resonance overlap

In Figure 3 we show the Dalitz plot boundaries for a typical hybrid search reaction:

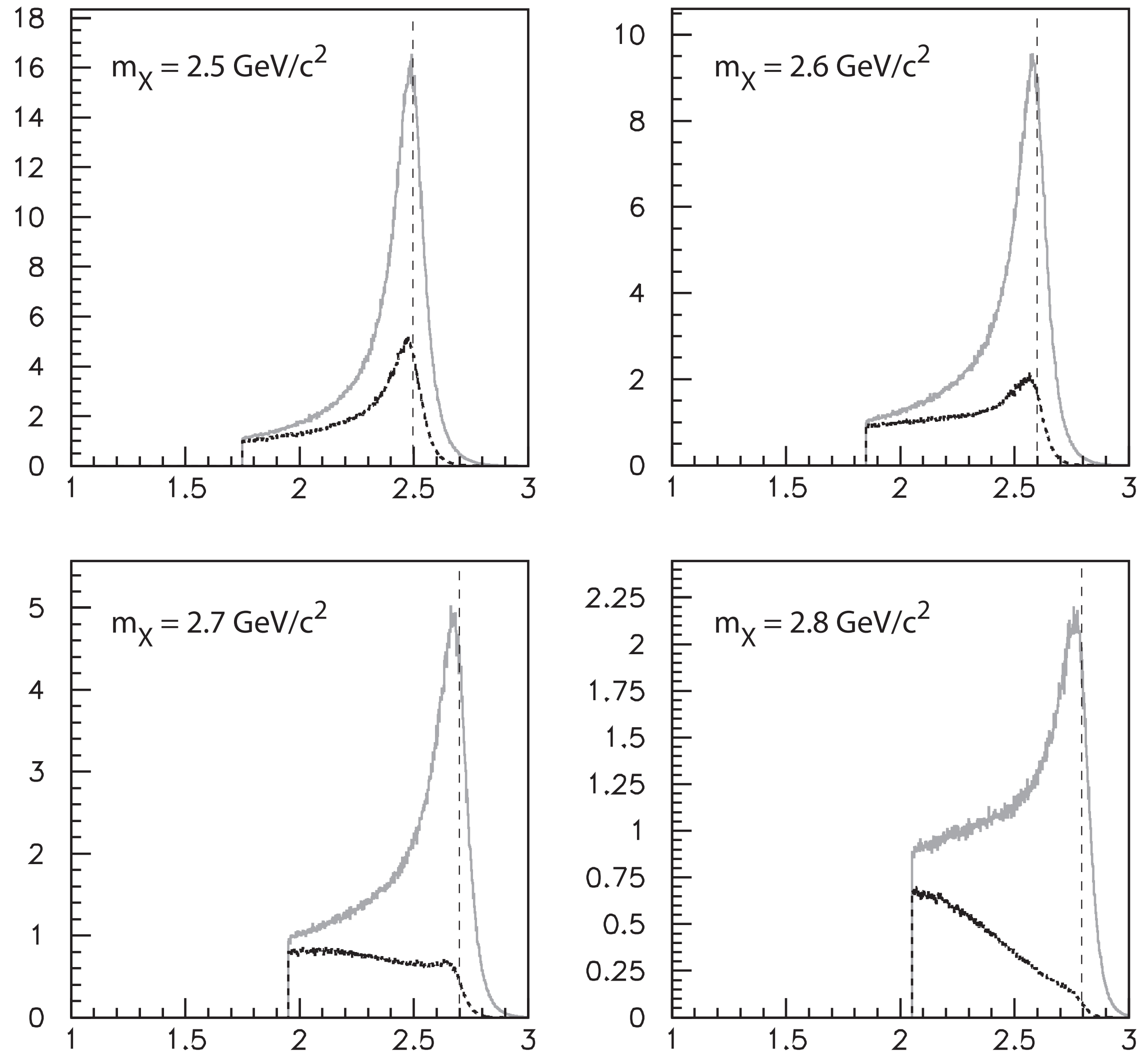

Figure 1: Line shape for resonances produced with photons in the range 8 to 9 GeV [gray] and 7 to 8 GeV [black] for resonances of mass 2.5, 2.6, 2.7 and 2.8 GeV/c^2. The dashed vertical line indicates the central masses of the resonances.

$$\gamma p \rightarrow \pi^+ \rho^0 n \tag{2}$$

We assume a fixed mass (0.76 GeV/c^2) for ρ and consider three values for the photon beam energy: E_γ = 7, 8 and 9 GeV. We also indicate the regions $M_{\pi n} < 1.5$ GeV/c^2 where baryon resonances are expected to dominate and $M_{\pi\rho} > 2.5$ GeV/c^2 and $M_{\pi\rho} > 2.8$ GeV/c^2 – where sensitivity to hybrid meson searches should be maintained.

The next step will be to generate events according to reaction 2, folding in a realistic t distribution where the final state can be reached either by $\gamma p \rightarrow \rho^0 \Delta^+$ or $\gamma p \rightarrow X^+ n$ where $X^+ \rightarrow \pi^+ \rho^0$ and then study the region where the two are kinematically inseparable.

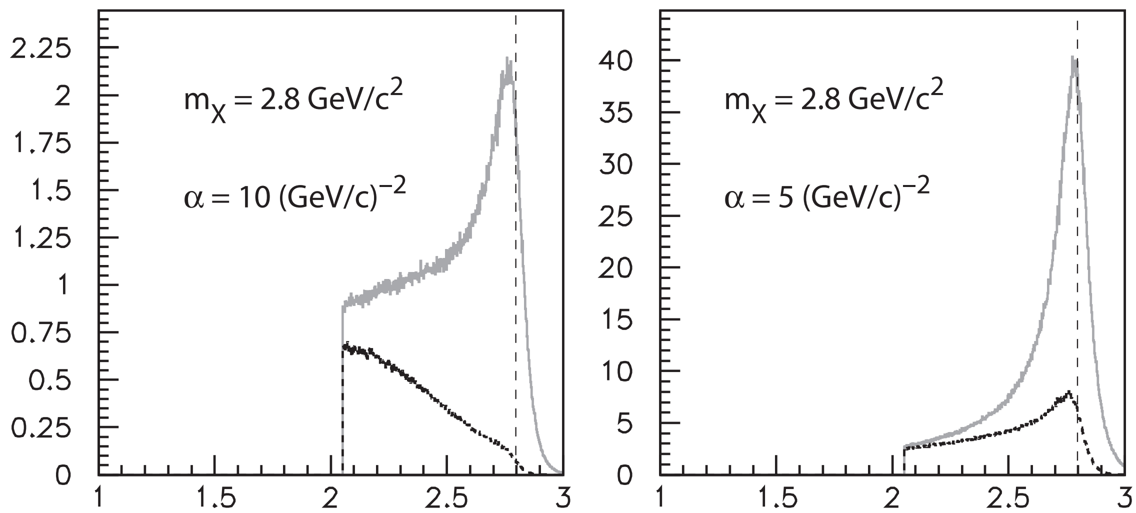

Figure 2: Line shape for resonances produced with photons in the range 8 to 9 GeV [gray] and 7 to 8 GeV [black] for a resonance mass of 2.8 GeV/c^2 and two difference values of α.The dashed vertical line indicates the central masses of the resonances.

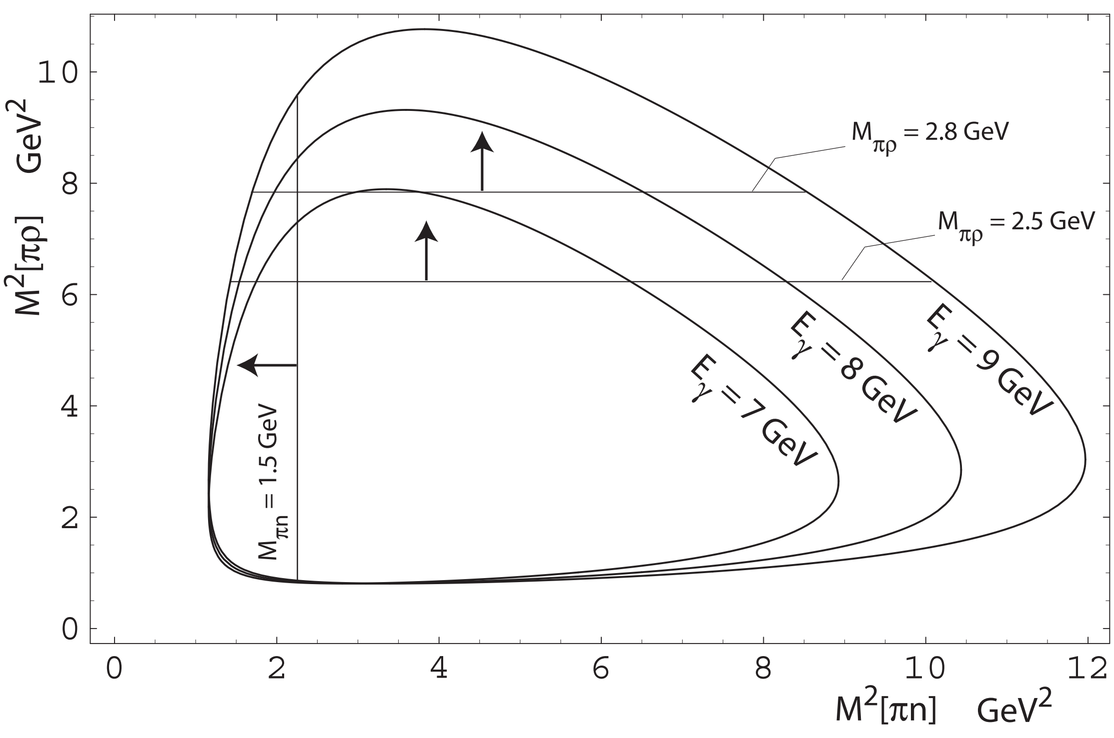

Figure 3: Dalitz plot boundaries for the reaction $\gamma p \to \pi \rho n$ for three different photon beam energies: $E_\gamma = 7$, 8 and 9 GeV. Regions of $M_{\pi n} < 1.5$ GeV/c^2 and $M_{\pi\rho} > 2.5$ GeV/c^2 and $M_{\pi\rho} > 2.8$ GeV/c^2 are show.