Pion Backgrounds in the CPP Experiment

Coherent sources of $\pi^+\pi^-$

1. Primakoff $\gamma A \to \gamma\gamma A \to \pi^+\pi^- A$

2. σ photo-production $\gamma A \to \sigma A \to \pi^+\pi^- A$

3. ρ^0 photo-production $\gamma A \to \rho^0 A \to \pi^+\pi^- A$

These process will interfere since they have identical final states

Incoherent sources of $\pi^+\pi^-$

1. $\gamma N \to \rho^0 N \to \pi^+\pi^- N$

2. $\gamma N \to \pi\Delta \to \pi^+\pi^- N$ called the “Drell” process in the literature

In a nucleus Pauli blocking suppresses these processes at low t

Pion Backgrounds in the CPP Experiment (cont.)

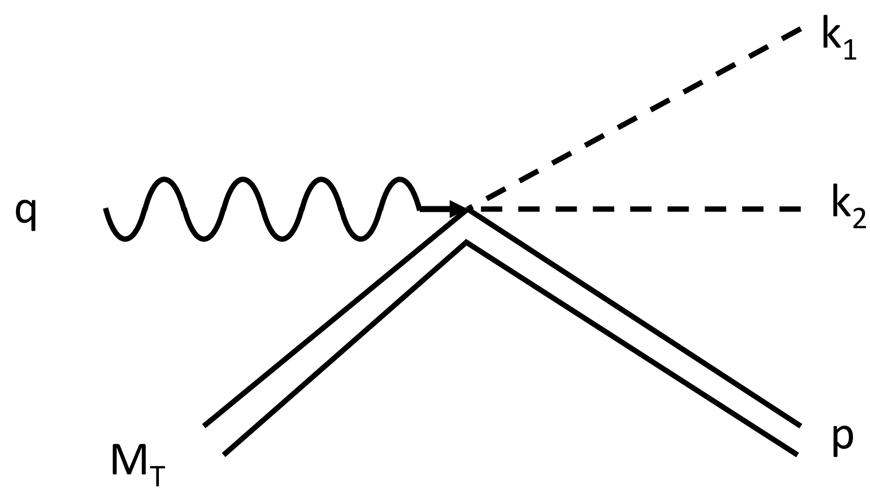
Inelastic sources of $\pi^+\pi^-$

1. $\gamma A \to \omega A \to \pi^+\pi^0\pi^- A$
2. $\gamma N \to \rho^0\Delta \to \pi^+\pi^-\pi N$
3. $\gamma N \to \pi N^* \to \pi\pi\Delta \to \pi^+\pi^-\pi N$

Expect the first to be largest, since it's a coherent process

Pion Backgrounds in the CPP Experiment (cont.)

Final state interactions can occur in the $\pi^+\pi^-$, π^+A, and π^-A scattering states. Changes the distribution of events in 3-body phase space.



$$m_{\pi\pi}^2 = s = (k_1 + k_2)^2$$

$$u = (k_1 + p)^2$$

$$v = (k_2 + p)^2$$

$$t = (q - k_1 - k_2)^2$$

$$\frac{dN}{dm_{\pi\pi}} \cong F\left(m_{\pi\pi}, t, \sqrt{u} - M_T, \sqrt{v} - M_T\right)$$

≈ pion energy in πA CM frame

Pion Backgrounds in the CPP Experiment (cont.)

Experimentalists have used many different distributions to parameterize the $m_{\pi\pi}$ dependence of cross sections in the ρ^0 region

$$\frac{dN}{dm_{\pi\pi}} = F_{BW}\left(m_{\pi\pi}, m_{\rho}, \Gamma(m_{\pi\pi})\right) + F_{BKG}\left(m_{\pi\pi}\right)$$

F_{BW} is often taken as a relativistic Breit-Wigner, skewed, with an energy dependent width.

F_{BKG} is a non-resonant background: could have contributions from any of the coherent, incoherent or inelastic reactions, and from final state interactions.

Pion Backgrounds in the CPP Experiment (cont.)

- Bulos, McClellan and Zeus(Breitweg et al.) use this parameterization for the resonant part. Described as "relativistic p-wave Breit-Wigner", I believe originally derived by J.D. Jackson. Used in the CPP proposal development.

$$\Gamma = \Gamma_0 \frac{m_\rho}{m_{\pi\pi}} \left[\frac{m_{\pi\pi}^2 - 4m_\pi^2}{m_\rho^2 - 4m_\pi^2} \right]^{3/2} = \Gamma_0 \frac{m_\rho}{m_{\pi\pi}} \left(\frac{p_{cm}}{p_{cm@\rho^0 peak}} \right)^3$$

$$F_{BW}(m_{\pi\pi}) = \frac{m_{\pi\pi}\Gamma}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2\Gamma^2}$$

- Bulos et al. takes this for the backgound term: described as a FSI where the pion scatters diffractively (elastically) from the nucleus

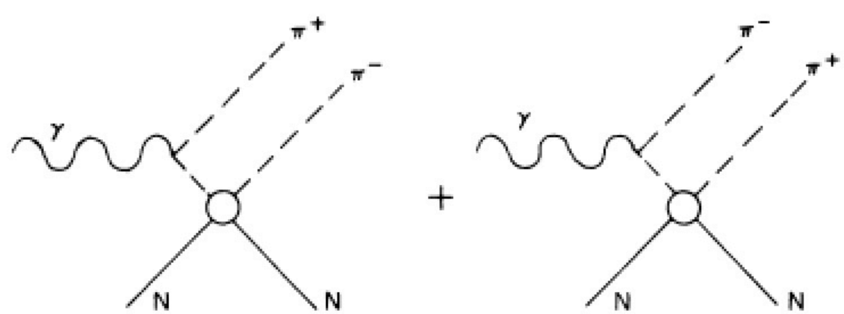
$$F_{BKG}(m_{\pi\pi}) = c_1 \frac{m_\rho^2 - m_{\pi\pi}^2}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2\Gamma^2} + c_2$$

Pion Backgrounds in the CPP Experiment (cont.)

- Zeus(Breitweg et al.) assumes a constant background that's coherent with ρ^0 electro-production, and an incoherent background

$$\frac{dN}{dm_{\pi\pi}} = \left| \frac{\sqrt{m_{\pi\pi} m_\rho \Gamma}}{m_\rho^2 - m_{\pi\pi}^2 + i m_\rho \Gamma} + C_1 \right|^2 + C_2 \left(1 + 1.5 m_{\pi\pi}\right)$$

- McClellan et al. includes a background term called the "Drell" term, and interference with Breit-Wigner. Since this looks like an incoherent process, so I'm not sure why there's an interference term



(b)

Pion Backgrounds in the CPP Experiment (cont.)

- Alvensleben et al. used five different parameterizations for $dN/dm_{\pi\pi}$

$$\Gamma = \Gamma_0 \frac{m_\rho}{m_{\pi\pi}} \left[\frac{m_{\pi\pi}^2 - 4m_\pi^2}{m_\rho^2 - 4m_\pi^2} \right]^{3/2}$$

Isn't the usual definition for this term

$$\frac{dN_1}{dm_{\pi\pi}} = \frac{m_\rho \Gamma}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma^2} \left(\frac{m_\rho}{m_{\pi\pi}} \right)^4 + poly\left(m_{\pi\pi}\right) poly\left(k_\rho\right) poly\left(q_\perp\right)$$

$$\frac{dN_2}{dm_{\pi\pi}} = \frac{m_\rho \Gamma}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma^2} + c_1 \frac{1}{m_{\pi\pi}} \frac{m_{\pi\pi}^2 - m_\rho^2}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma^2} + poly\left(m_{\pi\pi}\right) poly\left(k_\rho\right) poly\left(q_\perp\right)$$

$$\frac{dN_3}{dm_{\pi\pi}} = \frac{m_\rho \Gamma}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma^2} \left(\frac{m_\rho}{m_{\pi\pi}} \right)^4 + c_1 \frac{1}{m_{\pi\pi}} \frac{m_{\pi\pi}^2 - m_\rho^2}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma^2} + poly\left(m_{\pi\pi}\right) poly\left(k_\rho\right) poly\left(q_\perp\right)$$

$$\frac{dN_4}{dm_{\pi\pi}} = \frac{m_\rho \Gamma_0}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma_0^2} + poly\left(m_{\pi\pi}\right) poly\left(k_\rho\right) poly\left(q_\perp\right)$$

$$\frac{dN_5}{dm_{\pi\pi}} = \frac{m_\rho \Gamma}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2 \Gamma^2} + poly\left(m_{\pi\pi}\right) poly\left(k_\rho\right) poly\left(q_\perp\right)$$

Pion Backgrounds in the CPP Experiment (cont.)

- Zeus(Adloff et al.) assumes a $m_{\pi\pi}$ dependent background that's incoherent with ρ^0 electro-production:

$$\Gamma = \Gamma_0 \frac{m_\rho}{m_{\pi\pi}} \left(\frac{p_{\pi-cm}}{p_{\pi-cm@\rho^0 peak}} \right)^3 \frac{2}{1 + \left(\frac{p_{\pi-cm}}{p_{\pi-cm@\rho^0 peak}} \right)^2}$$

$$\frac{dN}{dm_{\pi\pi}} = \frac{m_{\pi\pi}\Gamma}{\left(m_\rho^2 - m_{\pi\pi}^2\right)^2 + m_\rho^2\Gamma^2} \left(\frac{m_\rho}{m_{\pi\pi}} \right)^{1.4} + \alpha_1 \left(m_{\pi\pi} - 2m_\pi\right)^{\alpha_2} e^{-\alpha_3 m_{\pi\pi}}$$

Pion Backgrounds in the CPP Experiment (cont.)

What can we expect to see in the low s region?

- Non-resonant backgrounds are a fact-of-life in hadronic physics, this is well known from photo-pion studies in the $\Delta(1232)$ region.
- Can reasonably expect that $dN/dm_{\pi\pi}$ should smoothly approach zero as $m_{\pi\pi} \rightarrow 2m_{\pi}$ over an interval of 100's of MeV, without a peaking at low $m_{\pi\pi}$. Not sure if all the models presented here obey this.
- Incoherent processes can be modeled with a Fermi-gas model type simulations. This would give predictions for the s,u,v, and t dependence of the reactions, but not absolute cross sections.
- The inelastic contribution from ω decay could be simulated.