Kinematical Overlap of ωp and $\rho\Delta$ Final States
in Photoproduction at 9 GeV

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I consider here the kinematic overlap among these final states in γp interactions, all of which lead to the same final state $\pi^+\pi^-\pi^0 p$:

$$\omega p$$
$$\rho^0\Delta^+$$
$$\rho^-\Delta^{++}$$
$$\rho^+\Delta^0$$

At 9 GeV, the cross-section for $\gamma p \to \pi^+\pi^-\pi^0 p$ is ≈ 18 μb and for $\gamma p \to \omega p$ is ≈ 2 μb[1]. The cross section for $\gamma p \to \rho^0\Delta^+$ is ≈ 0.3 μb with a 30% error[2]. The cross section for $\gamma p \to \rho^-\Delta^{++}$ is 0.7 ± 0.1 μb[3]. And finally the cross section for $\gamma p \to \rho^+\Delta^0$ is 0.7 ± 0.5 μb[4]. These cross sections are corrected for branching ratios. As a reminder, from isospin considerations, $\Delta^+ \to \pi^0 p$ is favored over $\Delta^+ \to \pi^+ n$ by 2:1 while $\Delta^0 \to \pi^0 n$ is favored over $\Delta^0 \to \pi^- p$ by 2:1. The cross sections for the three $\rho\Delta$ processes are in total comparable to ωp.

At 9 GeV the cross section for $\gamma p \to \rho p$ is ≈ 0.3 μb [1]. Indeed the ratio of diffractive ρ to diffractive ω production is 9:1 and roughly constant with incident energy in this regime. When the recoil proton is replaced with a Δ, the cross-sections are expected to fall with energy since the exchange particle has to carry isospin and the drop in cross sections with energy is observed so the ratio for $(\gamma p \to \rho\Delta)/(\gamma p \to \omega p)$ falls with energy.

To understand how the kinematical overlap I generated equal numbers of these events with a t distribution given by $e^{-5|t|}$. I assumed here that the mass resolution of the ω is 30 MeV – the natural width is 8 MeV.

See Figure 1. The upper plot shows the 3π effective mass distribution for the ωp final state (solid histogram) and the $\rho\Delta$ final state (dotted). Note the logarithmic scale. The bottom plot shows the πp effective mass for the two final states: $\rho\Delta$ (solid) and ωp (dotted). Also see Figure 2 which shows the correlation plot of the $\pi_3 p$ effective mass with $\pi_1\pi_2$ effective mass (where 1, 2, 3 labels the pions) for the reaction γp. The ρ and Δ bands are shown where a band is defined by $m_0 \pm \Gamma$ for the resonance. These indicate little kinematic overlap.

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[1] J. Ballam *et al.* Phys. Rev. **D7** 3150 (1973).
[2] Y. Eisenberg *et al.* Phys. Phys. Rev. **D5** 15 (1972)
[3] C. A. Nelson *et al.* Phys. Rev. **D17** 647 (1978
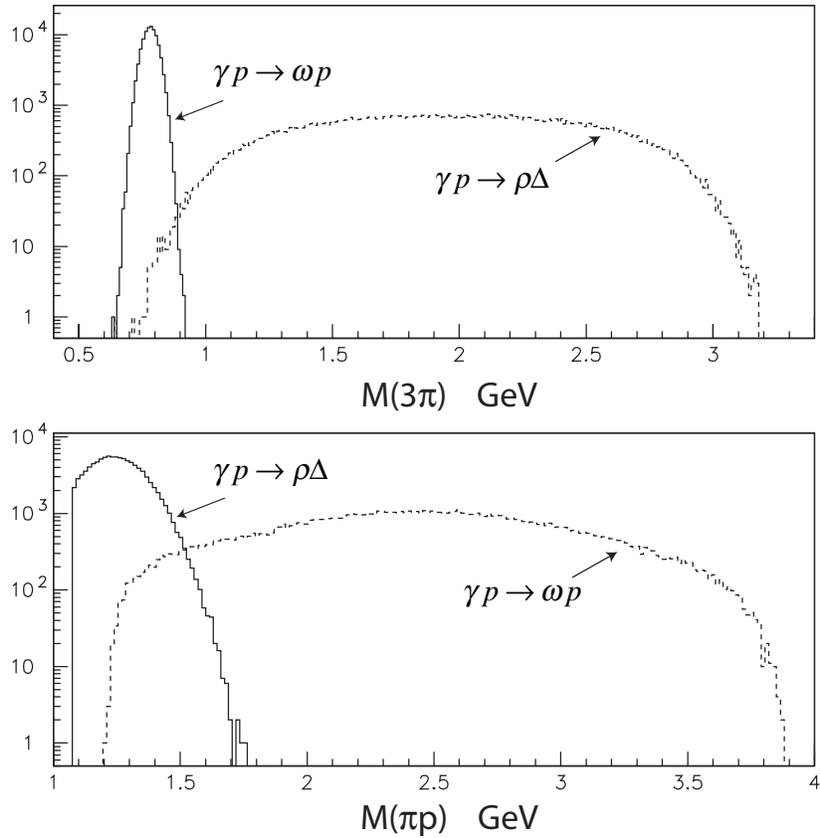[4] J. Ballam *et al.* Phys. Rev. Lett. **26** 995 (1971

Figure 1: The upper plot shows the 3π effective mass distribution for the ωp final state (solid histogram) and the $\rho\Delta$ final state (dotted). Note the logarithmic scale. The bottom plot shows the πp effective mass for the two final states: $\rho\Delta$ (solid) and ωp (dotted).
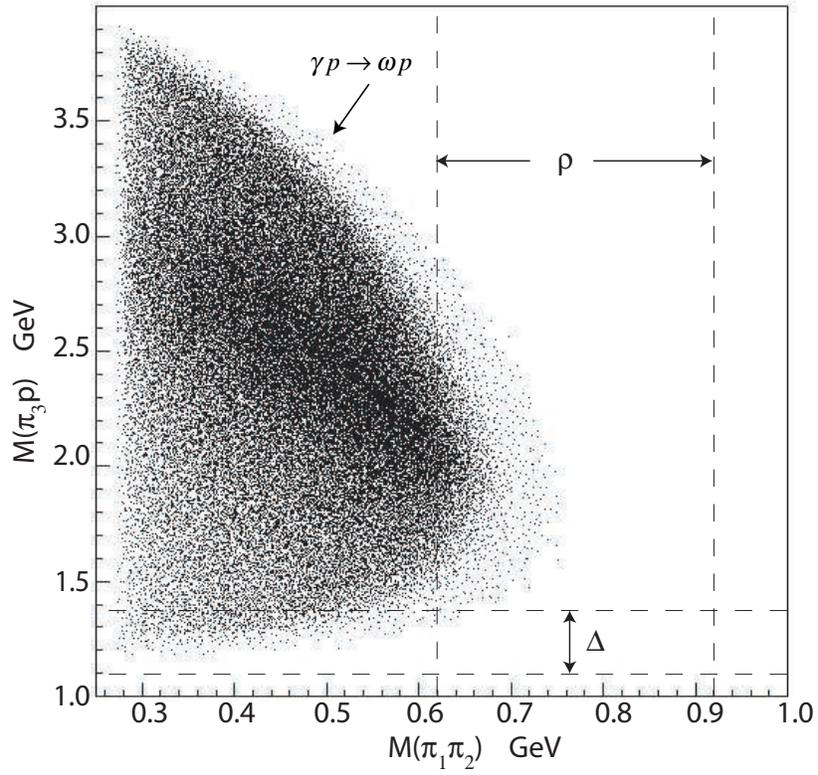
Figure 2: Correlation plot of the $\pi_3 p$ effective mass with $\pi_1 \pi_2$ effective mass (where 1, 2, 3 labels the pions) for the reaction γp. The ρ and Δ bands are shown where a band is defined by $m_0 \pm \Gamma$ for the resonance.