Coherent photoproduction of proton antiproton pair on deuterium

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This analysis

- Purpose: study claims of several groups on existence of states at masses M ~ 2.02 GeV and ~ 2.2 GeV decaying to pp
- > Data from CLAS/eg3 run high luminosity, high energy, E_{γ} <5.7 GeV, photoproduction on deuterium (40 cm long LD₂ target)
- > 3-charged particle trigger for most of the run with $E_{\gamma}>4.5$ GeV
- Revers torus field (positives inward)

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- Analysis include photoproduction reactions in fully exclusive final states: $\gamma d \rightarrow p \overline{p} d'$ $\gamma d \rightarrow K^+ K^- d'$ $\gamma d \rightarrow \pi^+ \pi^- d'$ $\gamma d \rightarrow p p \pi^-$ (physics background)
- > The $p\overline{p}$ production has been studied from CLAS/g6c and CLAS/g12 data stets, with much higher (x50) statistics. No evidence of resonances has been found. But, there are ambiguities in production mechanism in photoproduction on the proton target



Coherent production on deuterium

- No ambiguities, production of *hh* can happen only in *t*-channel, no *s*- or *u*-channel contributions
- Detection of the recoil deuteron filters out most of the physics backgrounds
 - $P(K^{*},\pi^{*})$ $P(K^{*},\pi^{*})$ $\overline{p}(K,\pi^{*})$ d t d'

 There is a recoil and produced (decay) proton ambiguity in case of hydrogen target

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Analysis steps

Event selection

- a) Event topology, 3 charged tracks (++-) only, no neutrals
- b) 3-momentum conservation cuts
- c) Tagged photon identification, re-determination of the event start time
- d) Loose PID cuts using TOF mass
- e) Deuteron ID, dE/dx and vertex time, and momentum corrections
- f) Selection based on energy conservation between initial and final states
- Yield/cross section extraction
 - a) Acceptance simulations, *t*-channel production model/GSIM/GPP/ RECSIS (eg3 setup)
 - b) Coherent $\rho^0\text{-photoproduction, }\text{cos}\theta^*$ and t-dependences
 - c) Invariant mass, $\cos\theta^*$ and *t*-dependences of cross sections in -

$$\begin{array}{l} \gamma d \rightarrow p \overline{p} d' \\ \gamma d \rightarrow K^+ K^- d' \\ \gamma d \rightarrow \pi^+ \pi^- d' \end{array}$$





3-momentum conservation: p_x and p_y



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3-momentum conservation: p_z and E_γ



For fully exclusive final state:

$$\Delta p_z = \sum_{i=1}^{3} p_z^i - E_{\gamma} \approx 0$$

 $\pm 4\sigma$ cut is applied to select tagged photon candidate





Matched tagger hits

- The number of 2-matched photons is 10% of 1-matched photon events
- The number of events with 3- or 4-matched photons is <0.5% of 1and 2-matched photon cases, and will be ignored
- Only tiny fraction of 2-matched photons are in the triggered region, Eγ>4.5 GeV (Case#3) and will be ignored as well
- Most of 1-matched photons are the ones selected during the initial data processing (Case #1), for new tagged photon cases (#2), the event start time has been recalculated

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Loose cuts on TOF-mass



Deuteron identification after loose cut on m²









Deuteron ID and the reaction $\gamma d \rightarrow pp\pi^-$



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Simulations

Data

22.5

20

17.5

15

12.5

- Physics model: *t*-channel production of hadron pairs. $Y \propto e^{3t}$
- Pair production according to phase space, isotropic in CM





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Acceptance calculations

- Much smaller acceptances compared to CLAS proton data are due 3-particle final state and reverse torus field.
- Track reconstruction efficiency of 95% was applied in addition ٠



$$\gamma d \rightarrow p\overline{p}d'$$

Cross section of coherent ρ production

Normalization: gflux, number target nuclei, trigger correction (large for eg3)



Invariant mass and *t*-dependence







h^+ angular distribution in the helicity frame





Summary

- Coherent photoproduction of hadron pairs, $\pi^+\pi^-$, K^+K^- , and $p\overline{p}$, has been studied using CLAS /eg3 data. The cross sections as a function of pair invariant mass, transferred momentum squared, and pair CM angle have been extracted
- No resonance structures have been found in the invariant mass of $n\bar{r}$
- In the region of the pair invariant masses >2 GeV, extracted yields for and $p\overline{p}$ came out to be comparable – need an explanation or a model $\pi^+\pi^-$ (di-quarks?)
- Next steps:
 - redo simulations after refining the model using input from extracted yields (corrected enery, $M(h^+h^-)$, t, and $\cos(\theta^*)$ dependences)
 - study run dependence (before and after 2004 Christmas breaks)
 - study track reconstruction efficiency, ρ cross section came out lower than previous SLAC results
 - refine statistical uncertainties (dominated by acceptance and trigger efficiency estimate)







Proton-Antiproton Pair Production in Two-Photon Collisions at LEP





L3 collaboration, arXiv:hep-ex/030601



