η and η' electroproduction using CLAS12 RGK 6.5 GeV Golden Runs

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Why study η and η' electroproduction?

- CLAS12 physics program
  - new data with a variety of beam energies
  - studies of nucleon resonance spectrum & structure in electroproduction of variety of final states
- η & η' electroproduction:
  - complementary tool to study nucleon resonances N^*
  - both η & η' act as "isospin filters"
- RGK 6.5 GeV data:
  - smaller center of mass W range ~(1-3)GeV and photon virtuality Q^2 range ~(0.5-6)GeV^2 than RGA data
  - easier to see resonances for low W

Data

- $E_{beam} = 6.535$ GeV
- Data: RGK
  - Golden runs
    - 5893, 5901, 5906, 5907, 5913, 5916, 5920, 5928, 5929, 5936, 5940, 5941, 5949, 5950, 5951, 5962, 5968, 5969, 5971
  - 60 nA beam current
  - trigger version 6 (FT - out)
  - Q^2 ∼(0.5-6)GeV^2 & W∼(1-3)GeV
- wagon: $ep\gamma X$

run	type	file size	events
5893	DST	202 GB	∼100 mil
5893	$ep\gamma$	742 MB	∼530k
Golden Runs	$ep\gamma$	18 GB	∼13 mil

Data

- Reaction: $ep \to ep\eta$

$\eta(548)$	Mode	Channel	BR
	Neutral		72%
		$\to 2\gamma$	39%
		$\to 3\pi^0 \to 6\gamma$	33%
	Charged		28%
		$\to \pi^+\pi^-\pi^0 \to \pi^+\pi^-2\gamma$	23%

- Reaction: $ep \to ep\eta'$

$\eta'(958)$	Channel	BR
	$\to \pi^+\pi^-\eta$	43%
	$\rho^0\gamma \to \pi^+\pi^-\gamma$	29%
	$\to \pi^0\pi^0\eta \to 6\gamma$	23%

- caveat: difficulty getting all $6\gamma \implies$ ID 4γ & find final 2γ

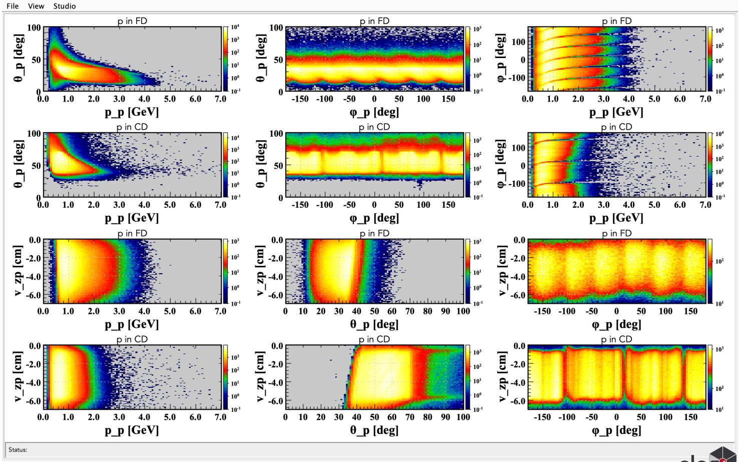
P. Zyla et al. (Particle Data Group), "Review of Particle Physics", **PTEP 2020**, 083C01 (2020).

Process for analysis

- asses data: which channels of η and η' suitable for N^* analysis
- run $ep\gamma$ wagon to skim data for:
  - electrons in FD
  - protons in FD or CD
  - γ in FD
  - all channels have ep and at least 1γ
- separate channels by if proton is in FD or CD

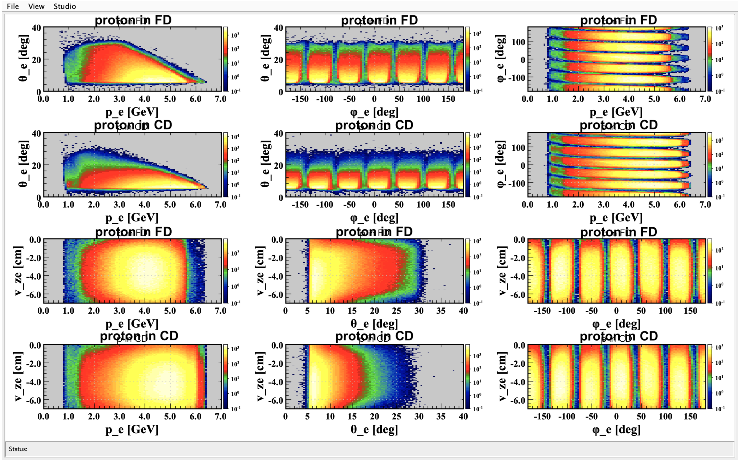
proton kinematics

- ~24.6% of protons in FD & ~75.4% in CD
- in FD if $\theta <\sim 40°$ & in CD if $\theta >\sim 40°$
- protons with lower p in CD



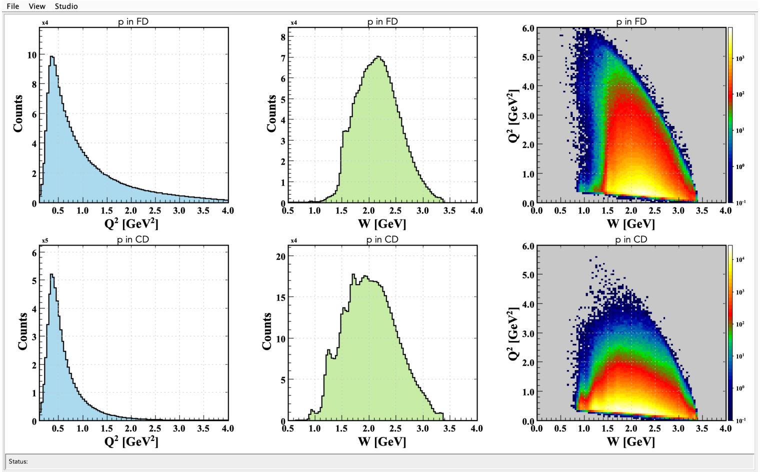
electron kinematics

- smaller θ for electrons when proton in CD
- slightly larger p for electrons when proton in CD



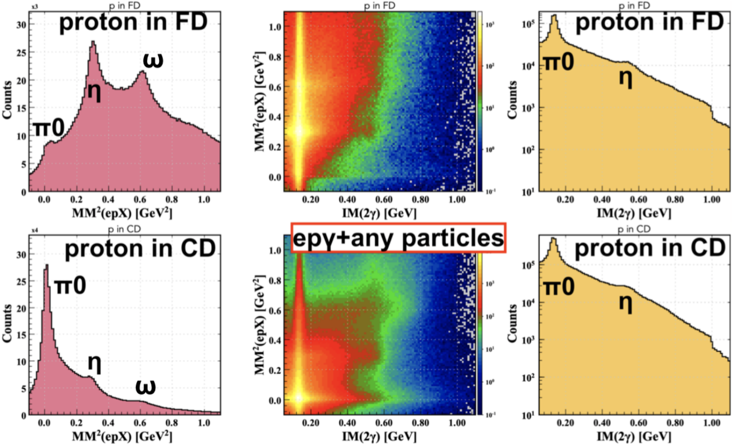
Q^2 & W

- larger Q^2 range when protons in FD
- more resonances visible in W for when protons in CD



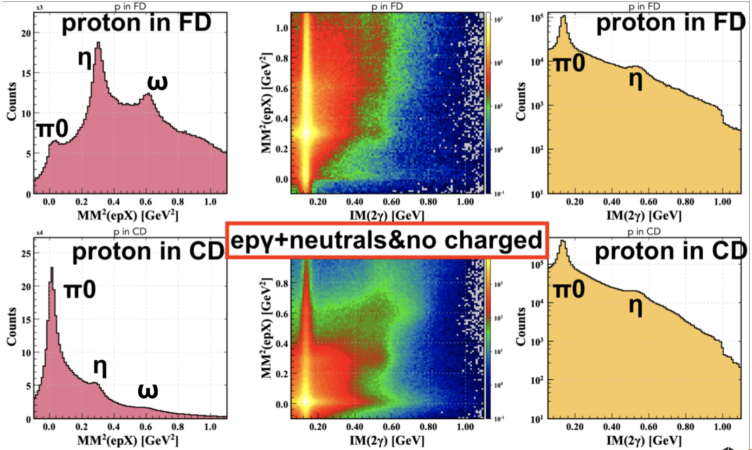
$ep\gamma X$

- explicitly detect $ep\gamma$ & allow any number of neutral/charged particles
- η peak dominates MM^2 when proton in FD



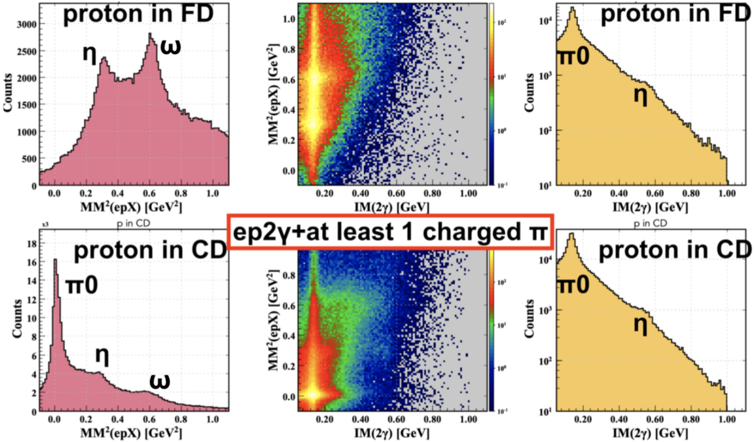
$ep\gamma X_n$

- explicitly detect $ep\gamma$ & allow any number of neutral but no charged particles
- η peak dominates MM^2 when proton in FD



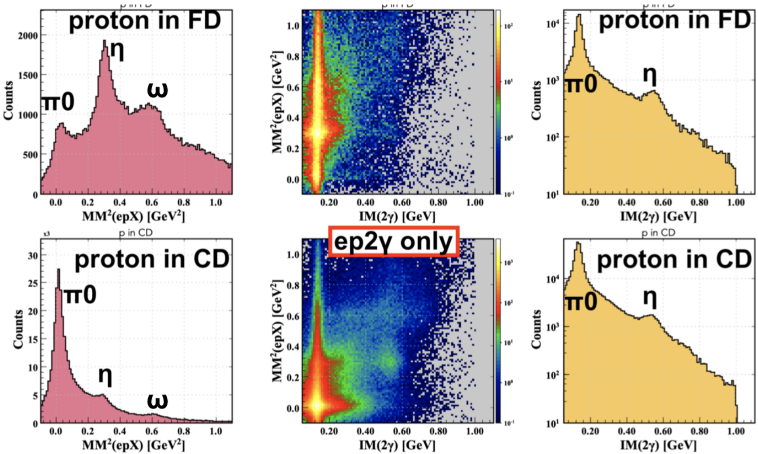
$ep2\gamma\pi^{\pm}X_{\pm}$

- explicitly detect $ep2\gamma$ and at least one charged pion
- no π^0 & ω peak dominates MM^2 when proton in FD



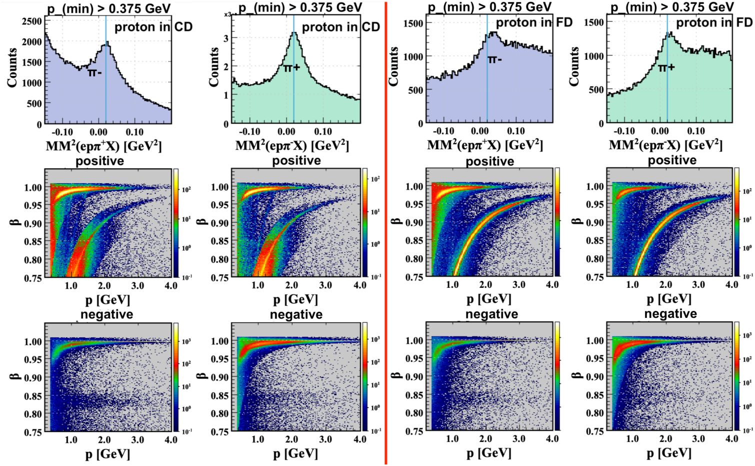
$ep2\gamma$

- explicitly detect $ep2\gamma$ and nothing else
- prominant η & reduced ω peak in MM^2 when proton in FD



charged πs

- $\eta' \to \rho^0\gamma \to \pi^+\pi^-\gamma \implies$ need to find charged pions



Conclusions

- smaller Q^2 range & more resonances in W when proton in CD
- comparatively more η than π^0 in MM^2 when proton in FD
- IM(2γ) dominated by π^0
- have to deal with background when looking at MM^2 of charged pions
- Future Steps:
  - run MC simulations (PYTHIA, phase space generators)
  - create *ep* wagon to compare to $ep\gamma$ skim results

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