

# $\eta$ and $\eta'$ electroproduction using CLAS12 RGK 6.5 GeV Golden Runs

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## Why study $\eta$ and $\eta'$ 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
- $\eta$  &  $\eta'$  electroproduction:
  - ▶ complementary tool to study nucleon resonances  $N^*$
  - ▶ both  $\eta$  &  $\eta'$  act as "isospin filters"
- RGK 6.5 GeV data:
  - ▶ smaller center of mass W range  $\sim(0.5-3.5)\text{GeV}$  and photon virtuality  $Q^2$  range  $\sim(0-6)\text{GeV}^2$  than RGA data
  - ▶ easier to see resonances for low W

# Data

- $E_{\text{beam}} = 6.535 \text{ GeV}$
- 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)
  - ▶  $Q^2 \sim (0-6) \text{ GeV}^2$  &  $W \sim (0.5-3.5) \text{ GeV}$
- 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: $ep \rightarrow ep\eta$

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

## ■ Reaction: $ep \rightarrow ep\eta'$

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

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

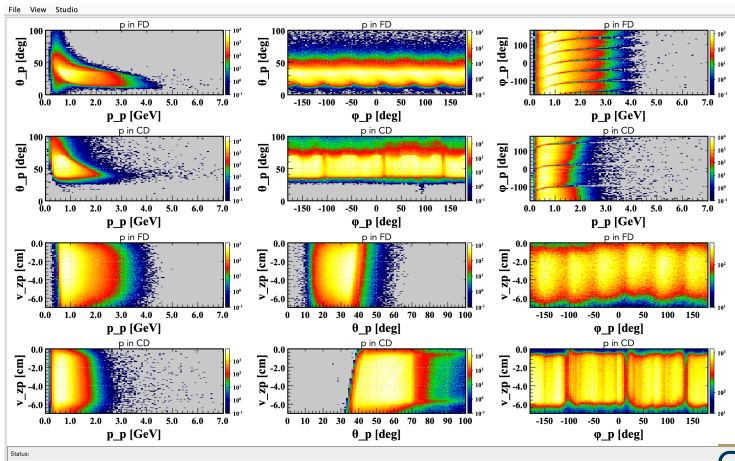
P. Zyla et al. (Particle Data Group), "Review of Particle Physics", **PTEP** **2020**, 083C01 (2020).

## Process for analysis

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

# proton kinematics

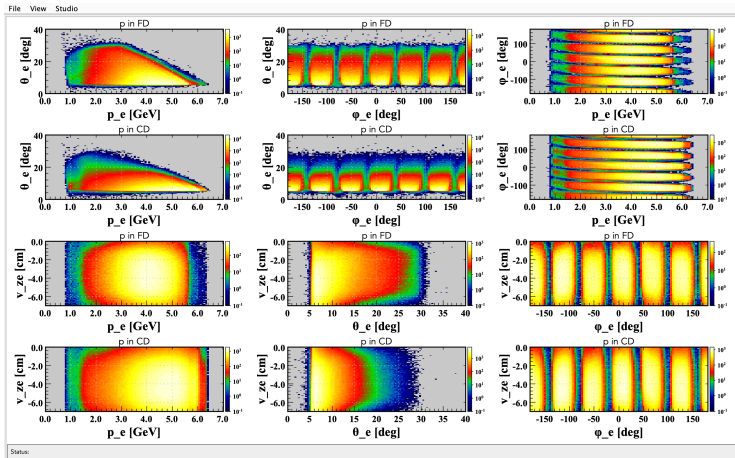
- $\sim 24.6\%$  of protons in FD &  $\sim 75.4\%$  in CD
- in FD if  $\theta < \sim 40^\circ$  & in CD if  $\theta > \sim 40^\circ$
- protons with lower p in CD



Status:

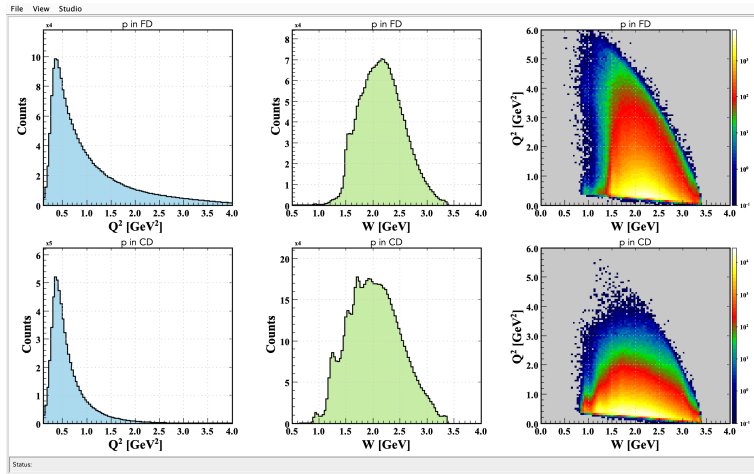
# electron kinematics

- smaller  $\theta$  for electrons when proton in CD
- slightly larger p for electrons when proton in CD



# $Q^2$ and $W$

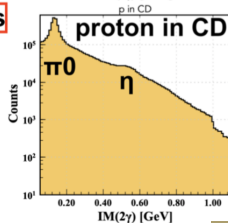
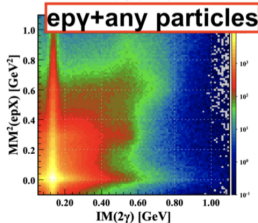
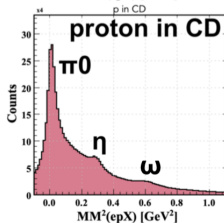
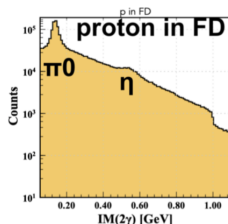
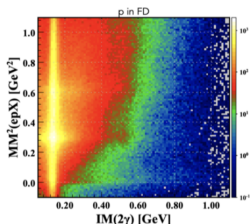
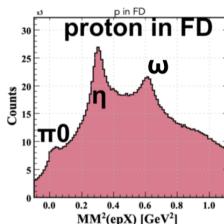
- larger  $Q^2$  range when protons in FD
- more resonances visible in  $W$  for when protons in CD





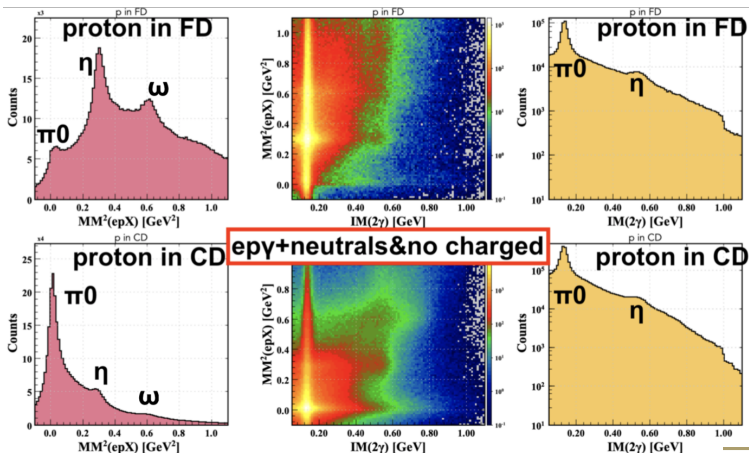
# $ep\gamma X$

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



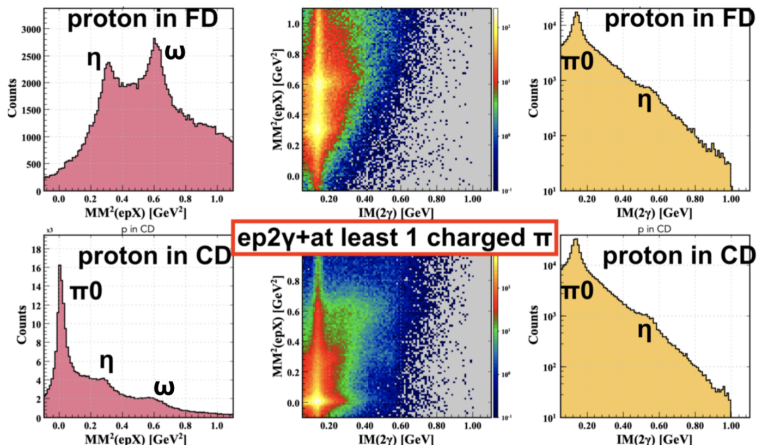
# $ep\gamma X_n$

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



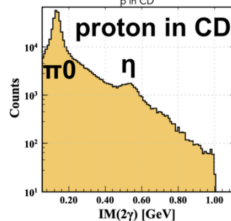
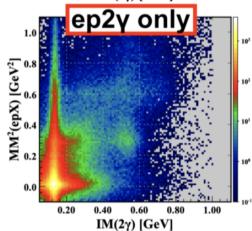
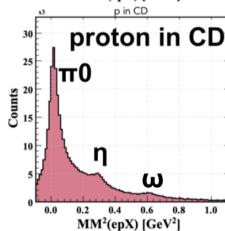
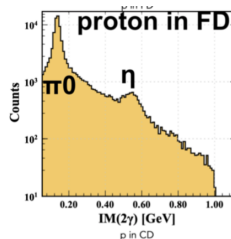
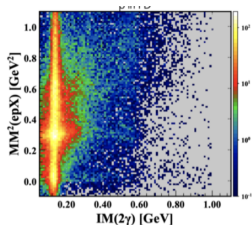
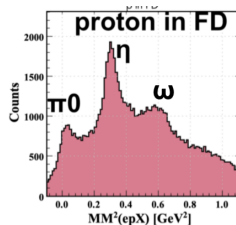
# $ep2\gamma\pi^\pm X_\pm$

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



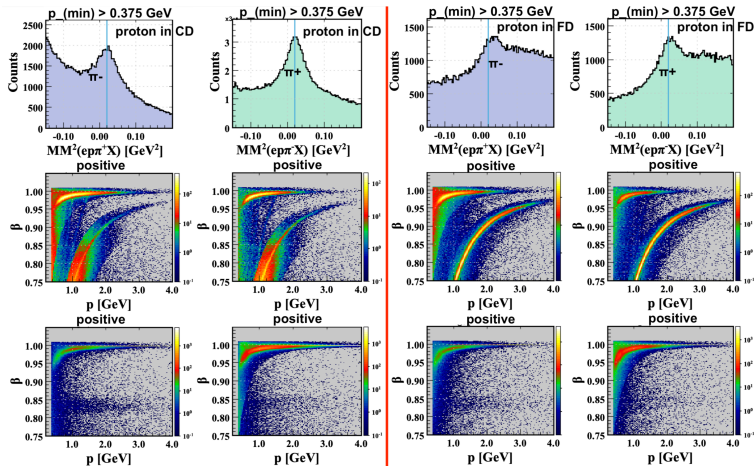
# $ep2\gamma$

- explicitly detect  $ep2\gamma$  and nothing else
- prominent  $\eta$  & reduced  $\omega$  peak in  $MM^2$  when proton in FD



# charged pions

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



# Conclusions

- smaller  $Q^2$  range & more resonances in  $W$  when proton in CD
- comparatively more  $\eta$  than  $\pi^0$  in  $MM^2$  when proton in FD
- $IM(2\gamma)$  dominated by  $\pi^0$
- 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

# Acknowledgements

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