

# Impact of new minimum energy threshold of FEMC for soft photon detection in charmonium production

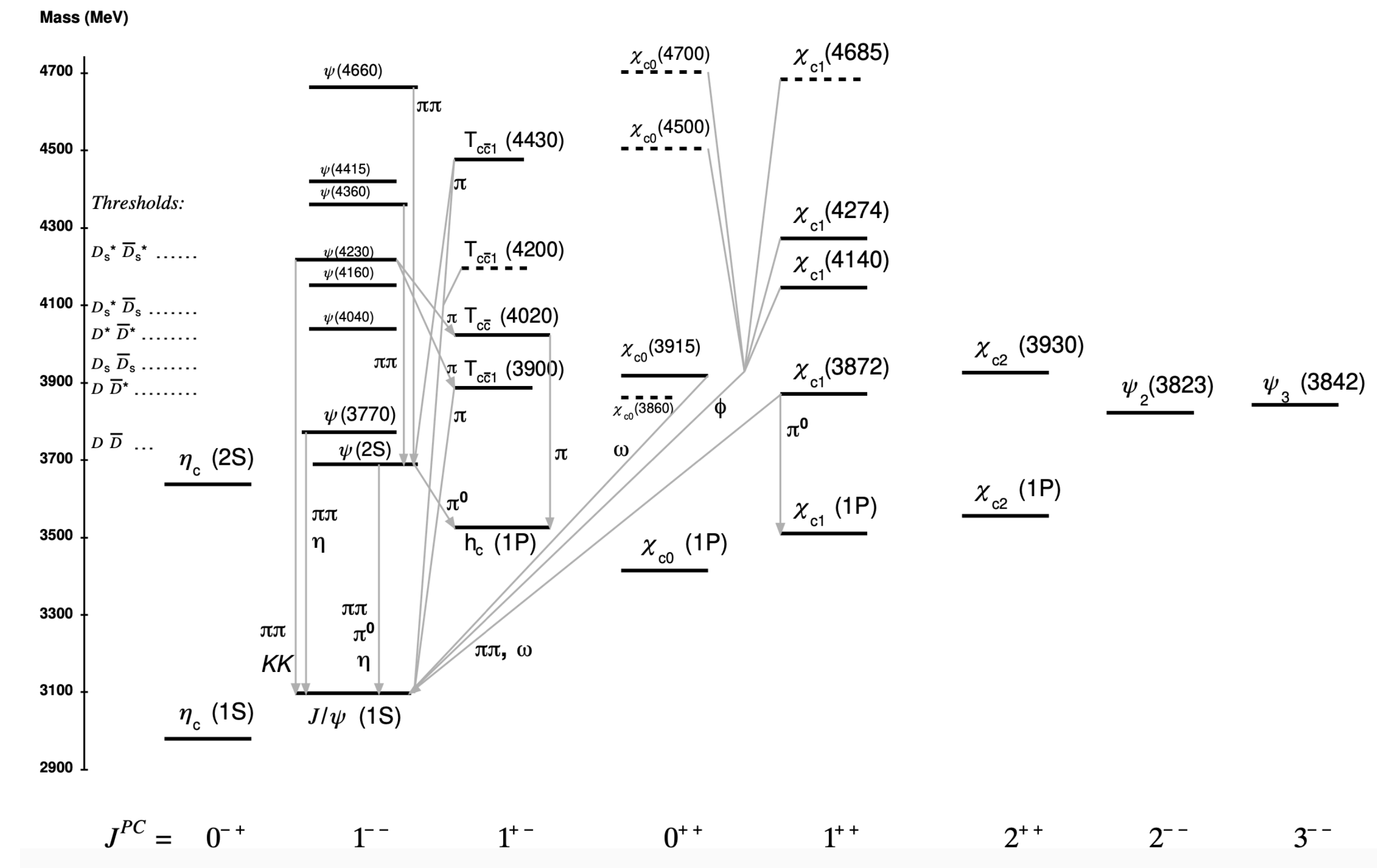
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# Charmonium spectroscopy

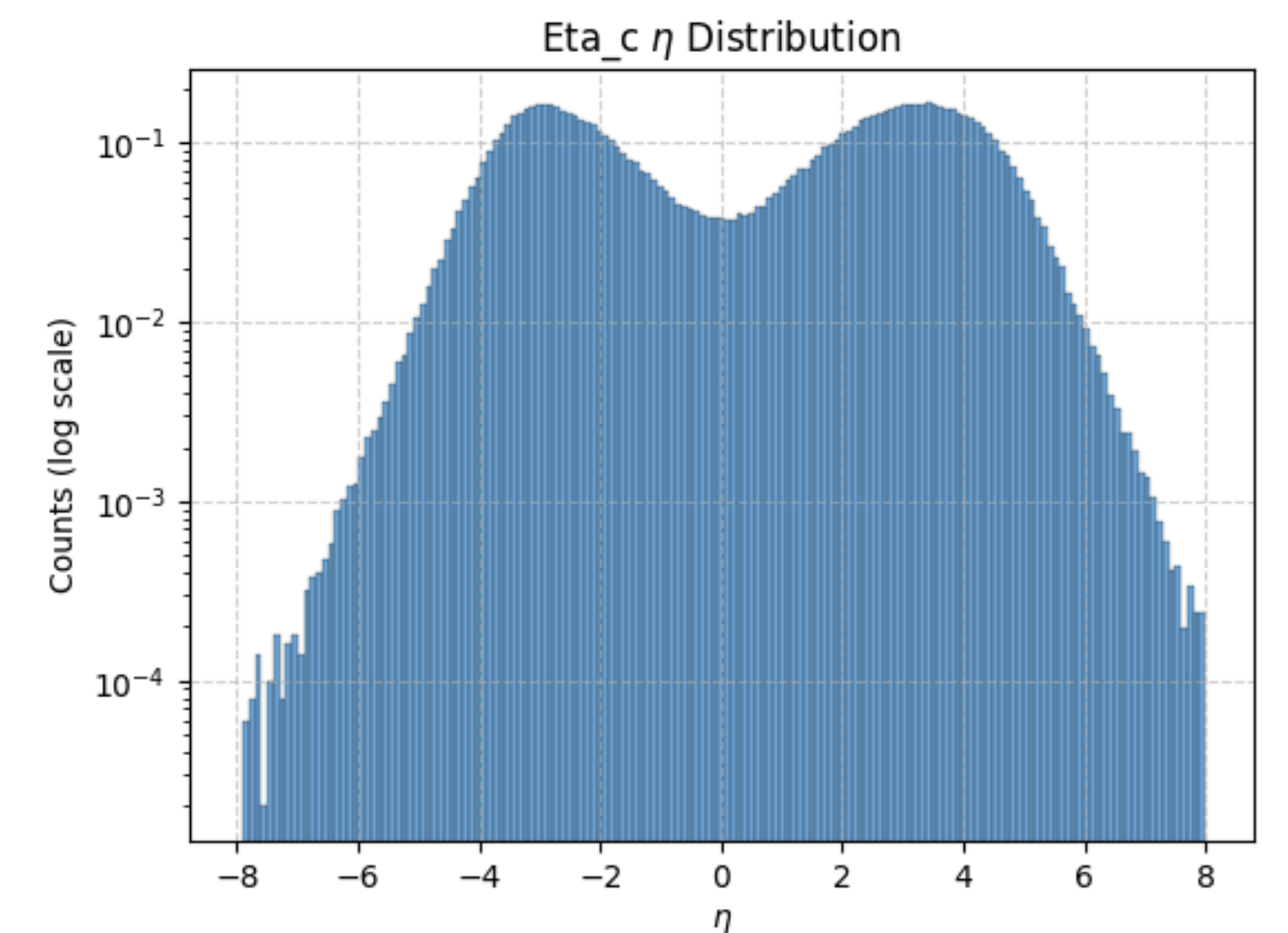
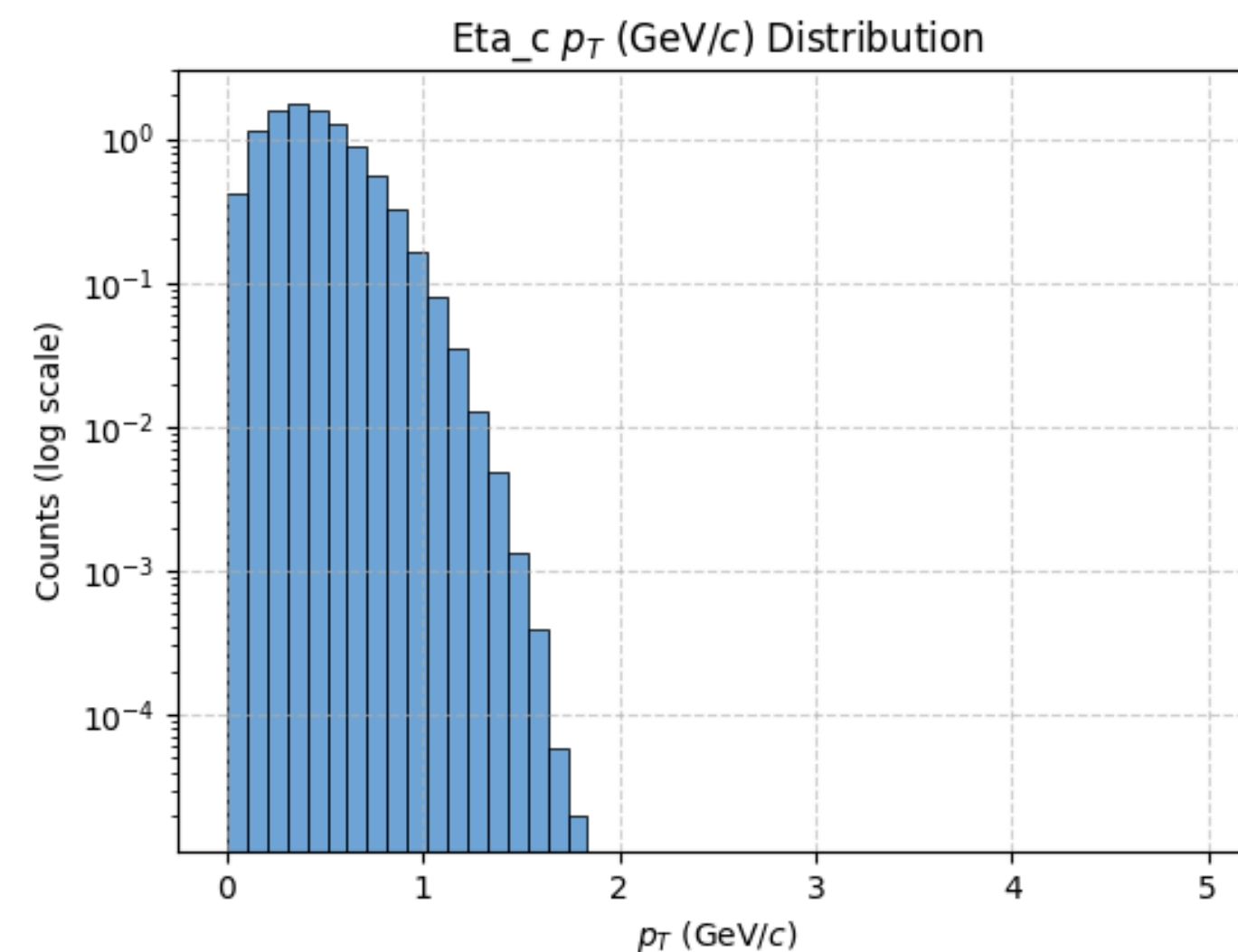
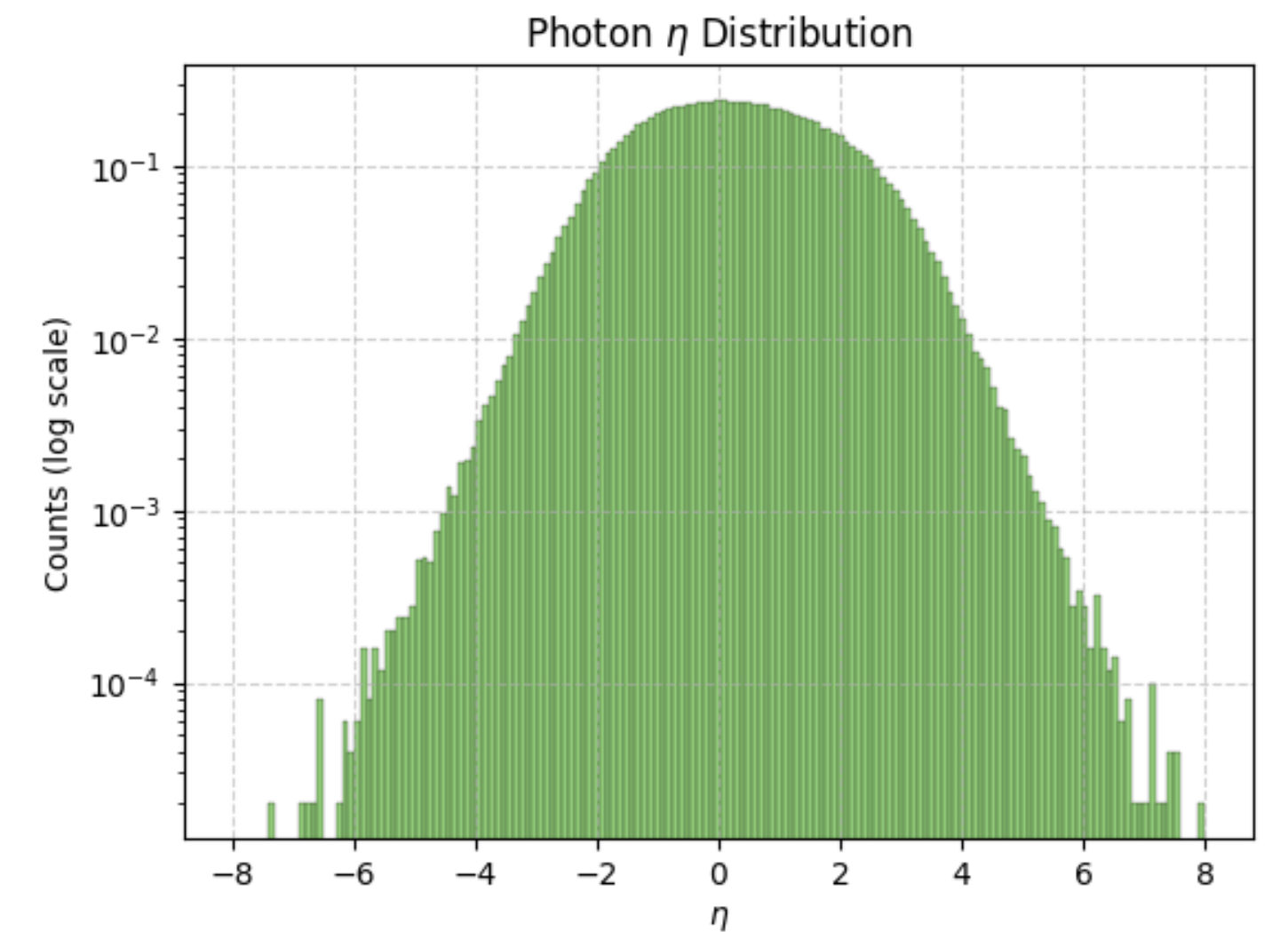
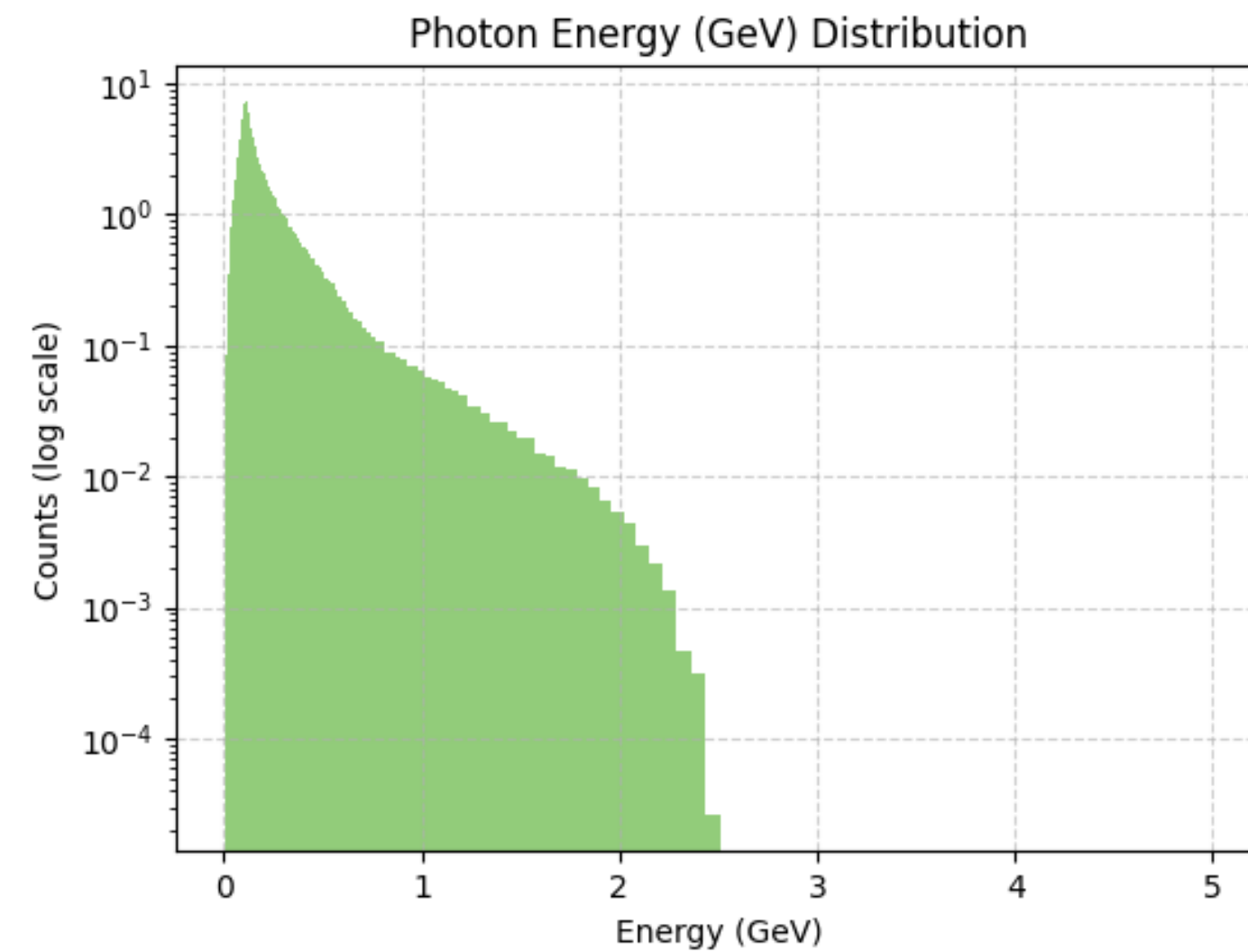
- ◆ Soft photon decay often found in charmonium spectroscopy including exotica
- ◆ Also found in various exclusive processes: photon-phomeron and double-pomeron interactions as well as  $\gamma\gamma$

- ◆ Acceptance sensitive to minimum energy threshold of FEMC
- ◆ Example with  $J/\psi \rightarrow \eta_c + \gamma$ 
  - ◆  $J/\psi$  meson: 3096 MeV,  $0^{-}(1^{--})$
  - ◆  $\eta_c$  meson: 2984 MeV,  $0^{+}(-^{+})$
  - ◆ BR~1.4% of soft photon (~ 100 MeV) with non-isotropic angular distribution
  - ◆ Goal : Estimate acceptance loss in coherent photoproduction of  $J/\psi \rightarrow \eta_c + \gamma$

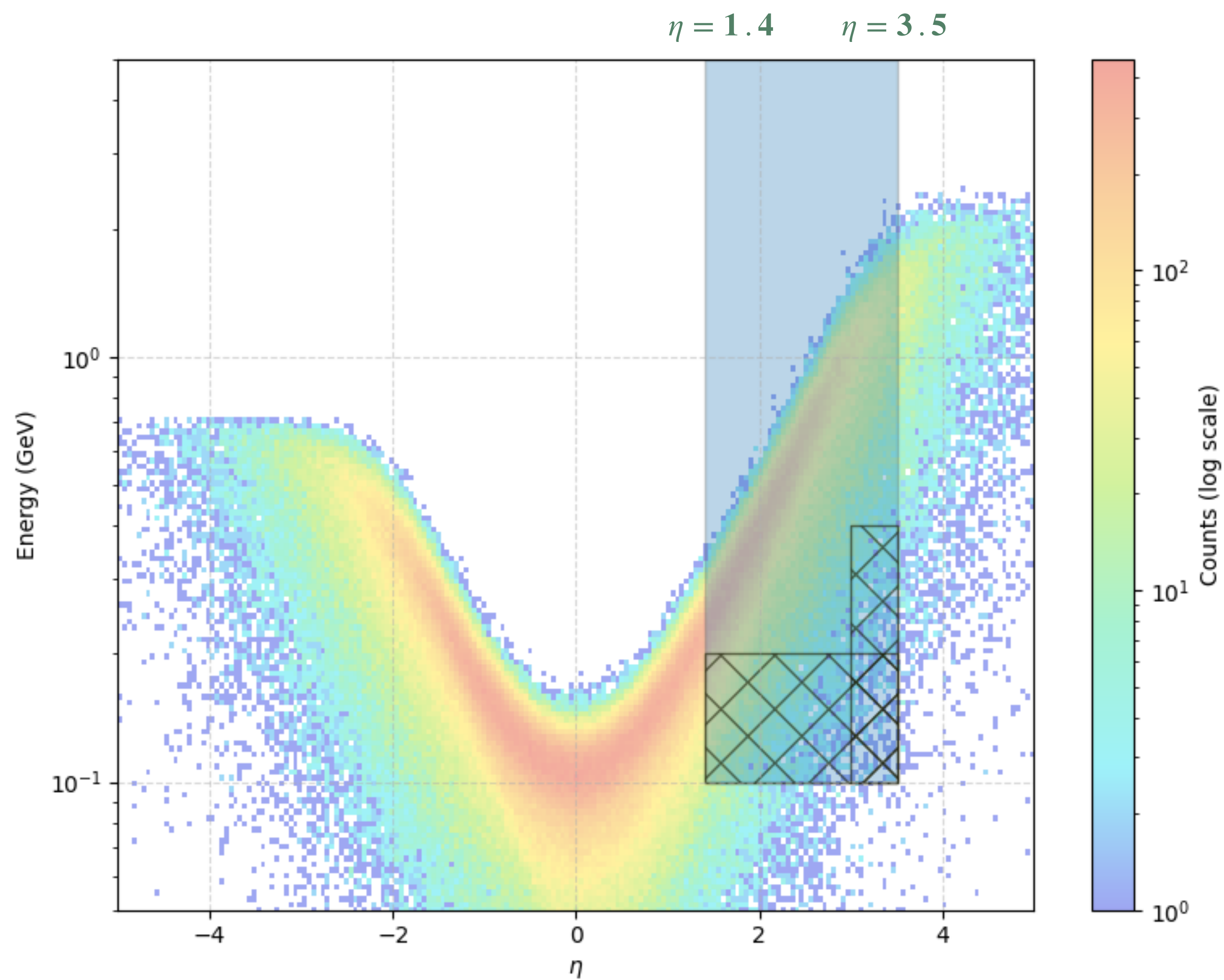


# $J/\psi \rightarrow \eta_c + \gamma$ in ep collisions at $10 \times 130$ GeV

- ◆ Coherent  $J/\psi$  photoproduction generated with eSTARLight
- ◆ ep collisions at  $10 \times 130$  GeV
- ◆ Coherent  $J/\psi$  photoproduction in  $0 < Q^2 < 0.01$  GeV<sup>2</sup>,  
decaying into  $J/\psi \rightarrow \eta_c + \gamma$
- ◆ Isotropic angular distribution assuming unpolarized  $J/\psi$



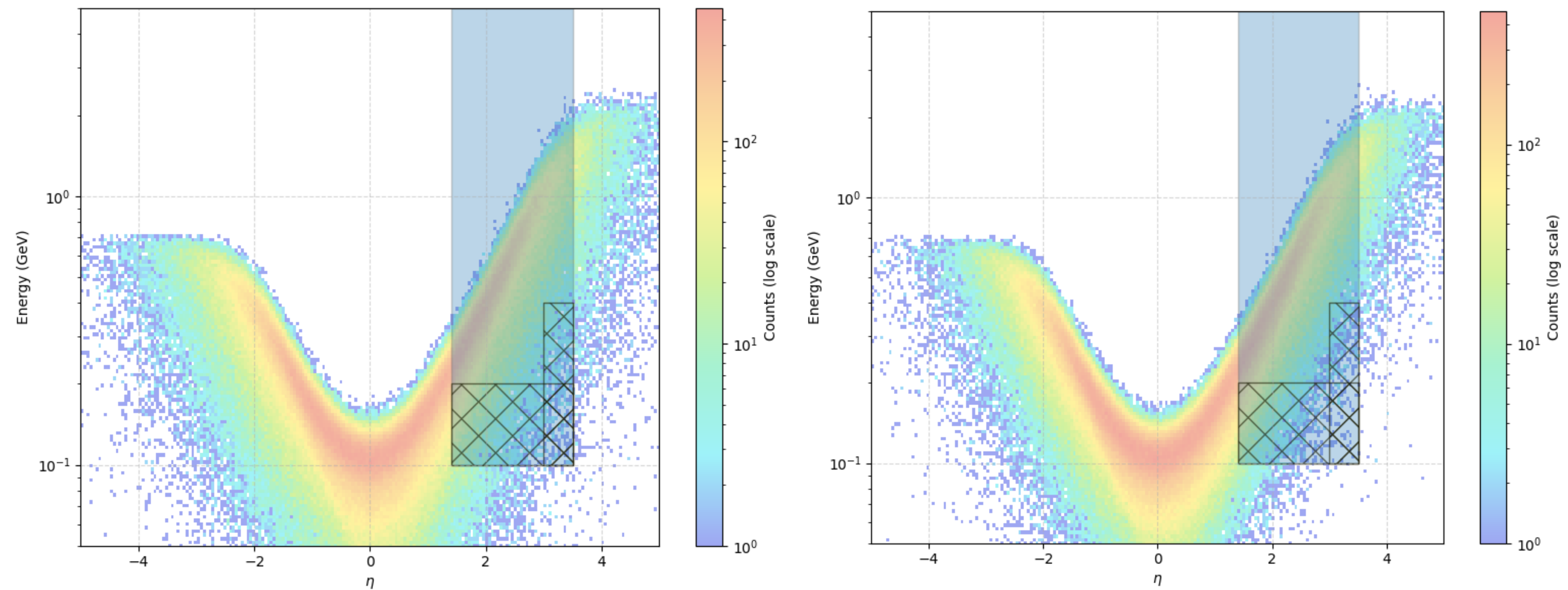
# Acceptance of soft photon from $J/\psi \rightarrow \eta_c + \gamma$ in ep collisions at $10 \times 130$ GeV



Photon in EMC acceptance $ \eta  < 3.5$ & $E > 100$ MeV	78.56%
Photon in FEMC acceptance $1.4 < \eta < 3.5$ & $E > 100$ MeV	22.75%
Fraction of photon rejected due to new threshold (hashed area)	2.62%

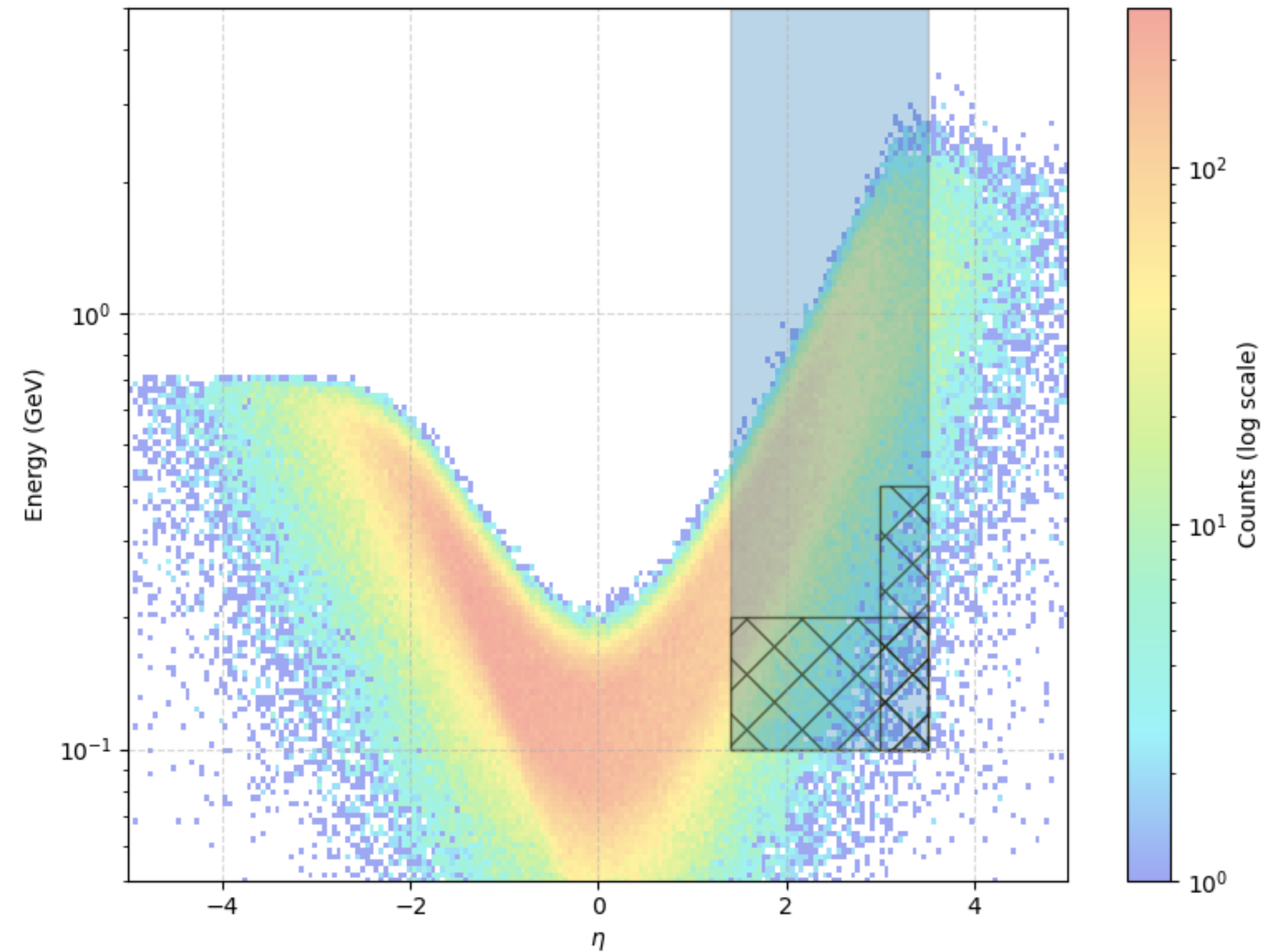
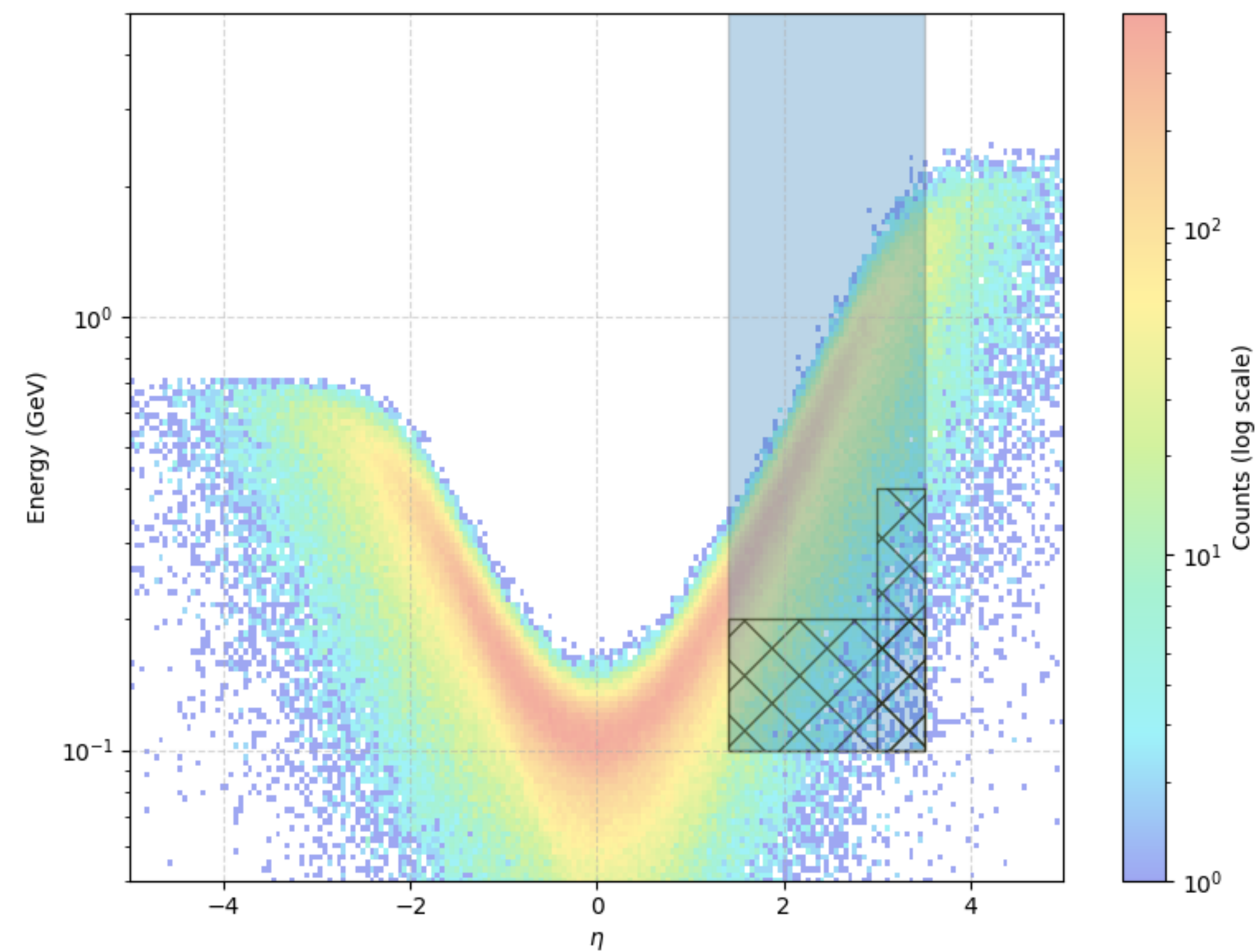


# Impact of $J/\psi$ polarization



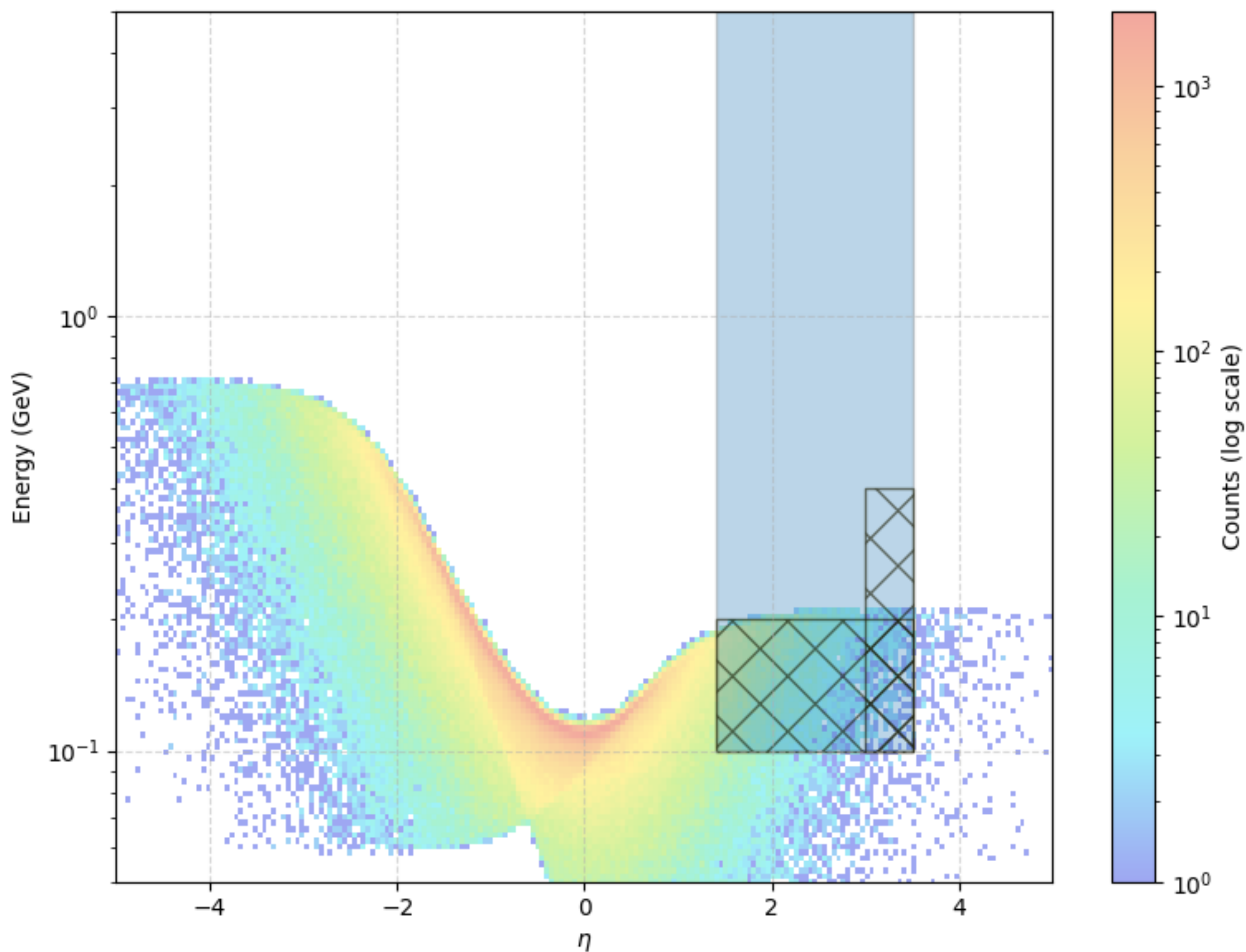
	unpolarized ( $P(\theta) = \text{constant}$ )	Fully polarized ( $P(\theta) = 1 + \cos^2(\theta)$ )
Photon in EMC acceptance	78.56%	80.83%
Photon in FEMC acceptance	22.75%	22.95%
Fraction of photon rejected due to new threshold (hashed area)	2.62%	2.18%

# Q<sup>2</sup> Dependence



	$0 < Q^2 < 0.01 \text{ GeV}^2$	$1 \text{ GeV}^2 < Q^2 < 2 \text{ GeV}^2$
Photon in EMC acceptance	78.56%	77.98%
Photon in FEMC acceptance	22.75%	18.37%
Fraction of photon rejected due to new threshold (hashed area)	2.62%	2.61%

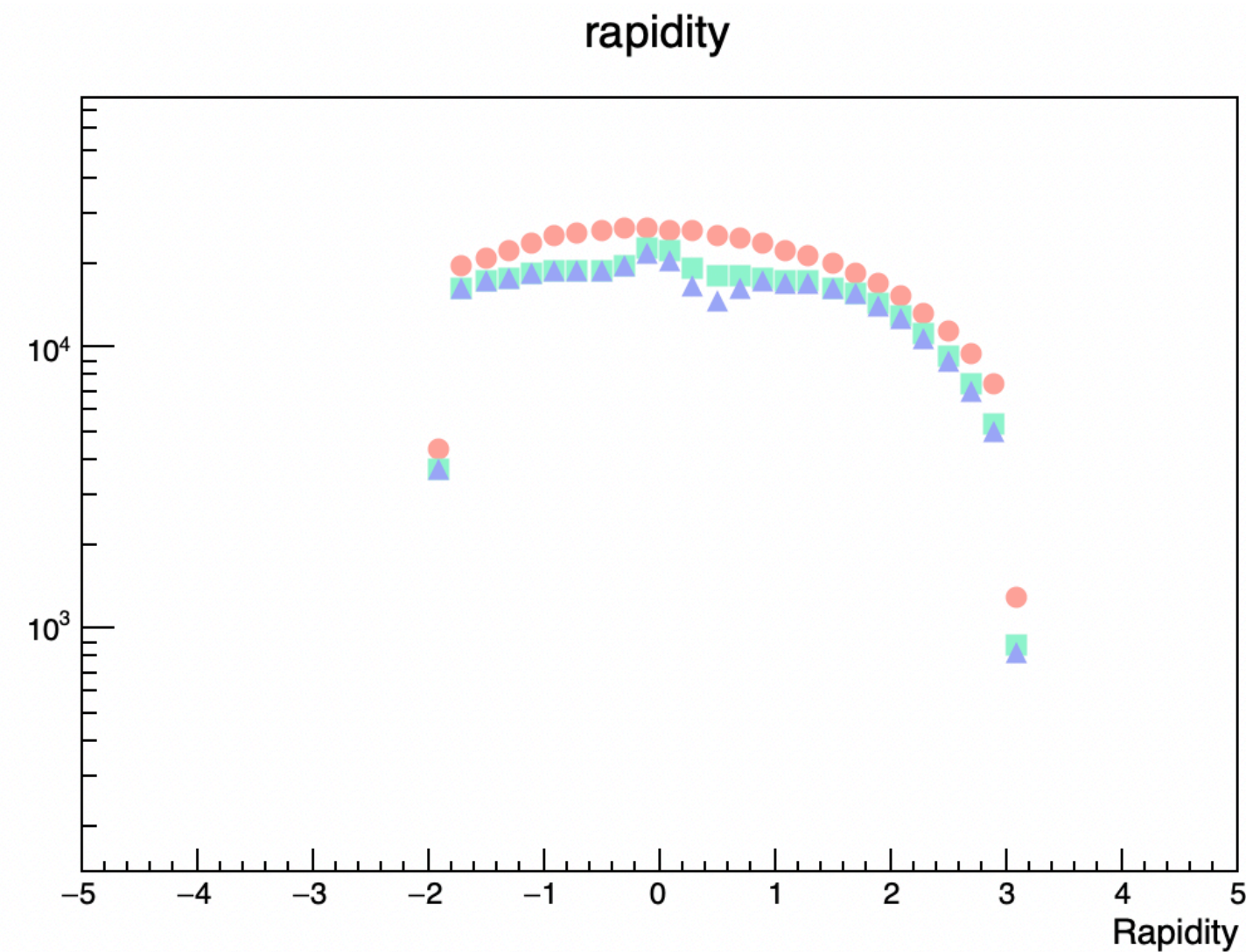
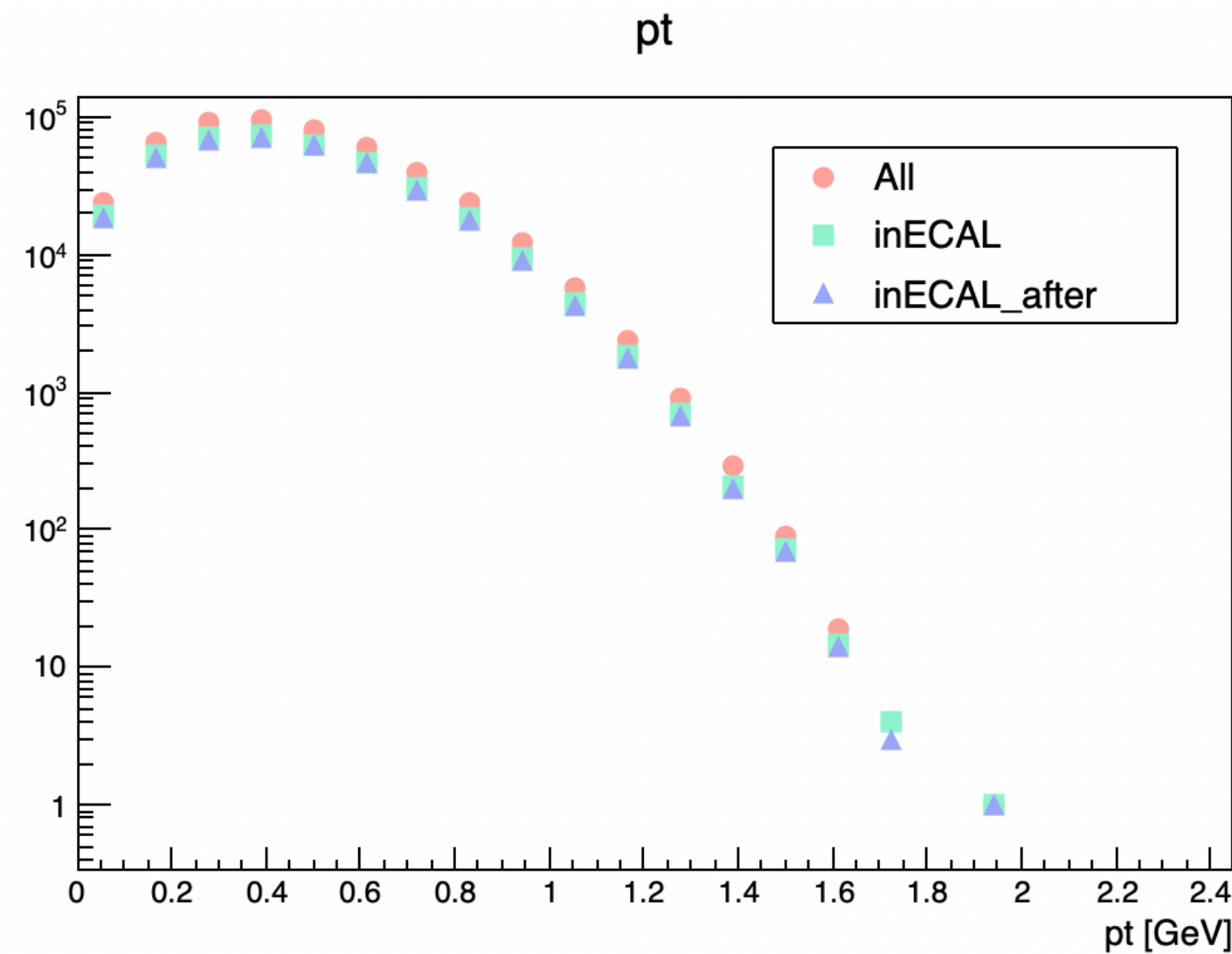
# $J/\psi \rightarrow \eta_c + \gamma$ in e-Au collisions at $10 \times 100$ GeV



Photon in EMC acceptance $ \eta  < 3.5$ & $E > 100$ MeV	79.43%
Photon in FEMC acceptance $1.4 < \eta < 3.5$ & $E > 100$ MeV	2.97%
Fraction of photon rejected due to new threshold (hashed area)	2.89%

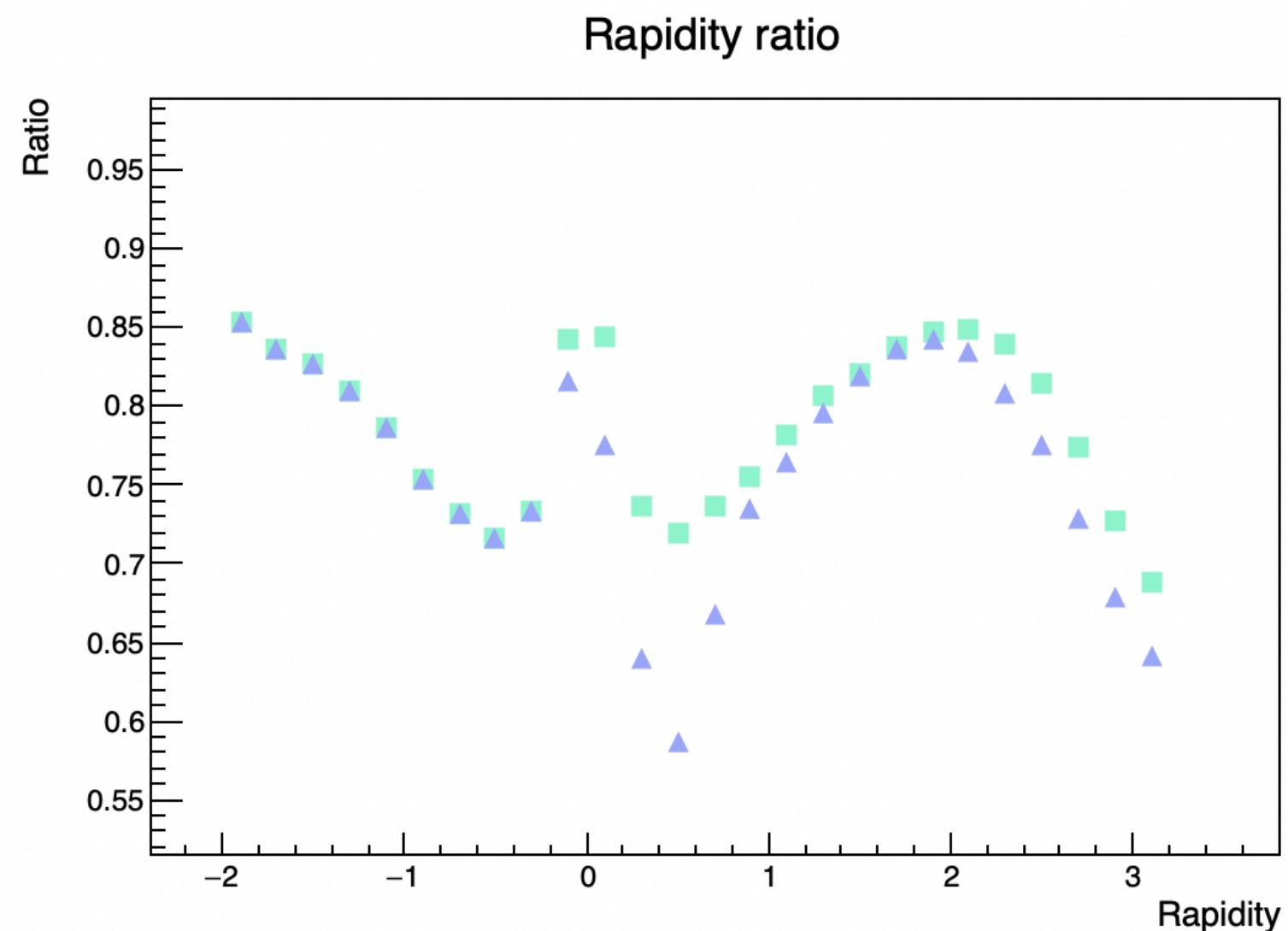
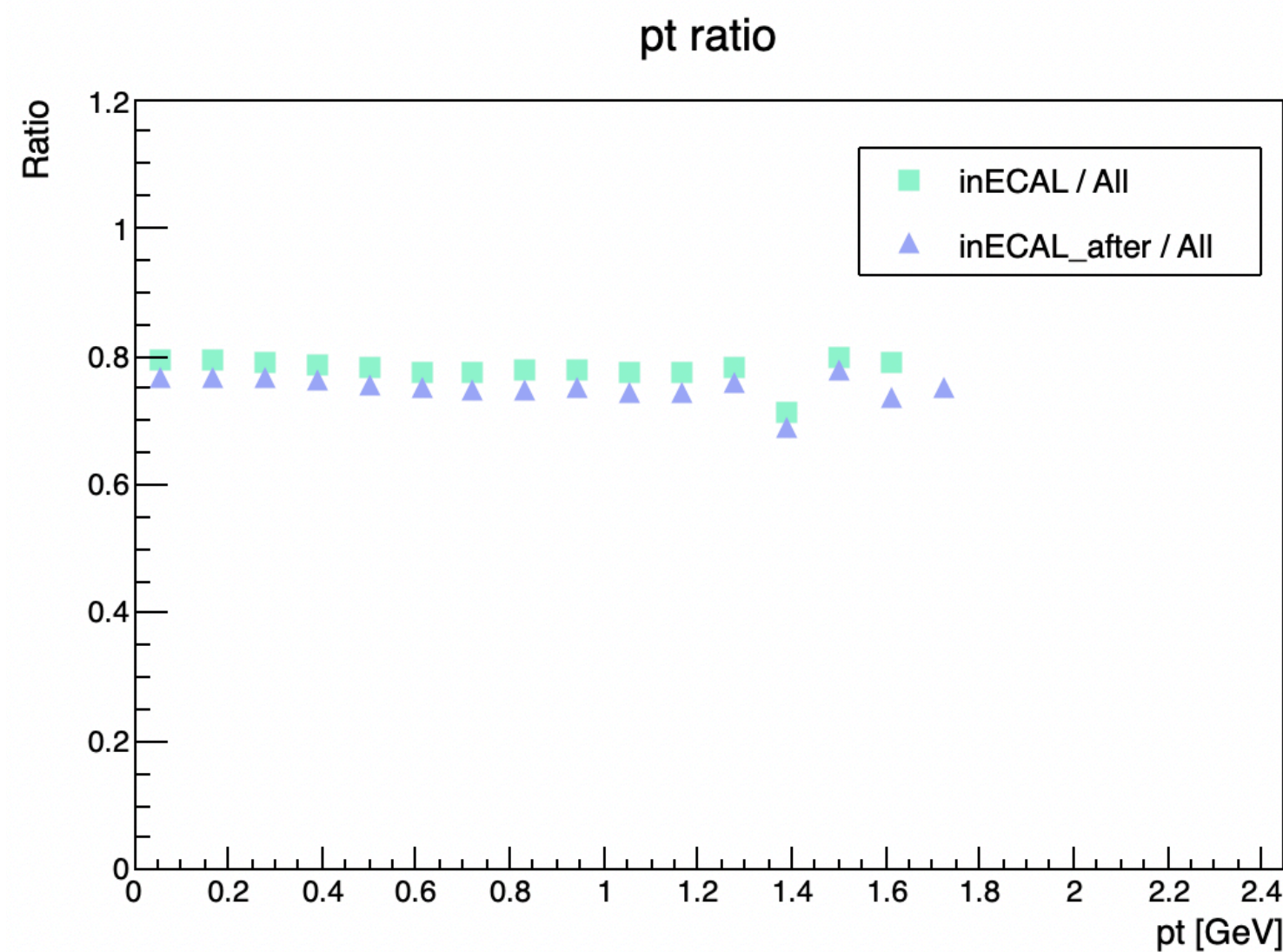


# Impact on $J/\psi$ acceptance in ep collisions



◆ Acceptance as a function of  $J/\psi$  transverse momentum and rapidity

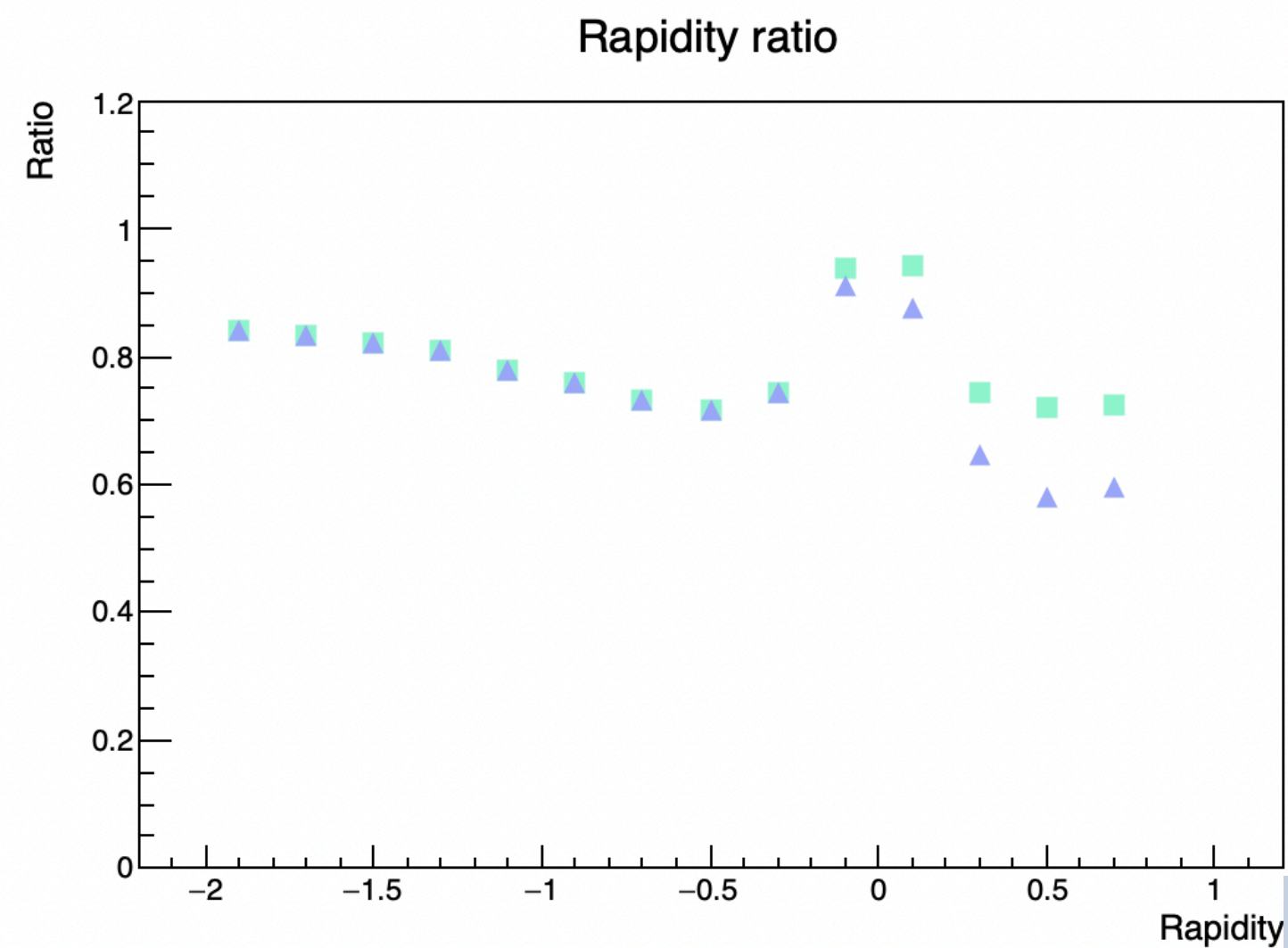
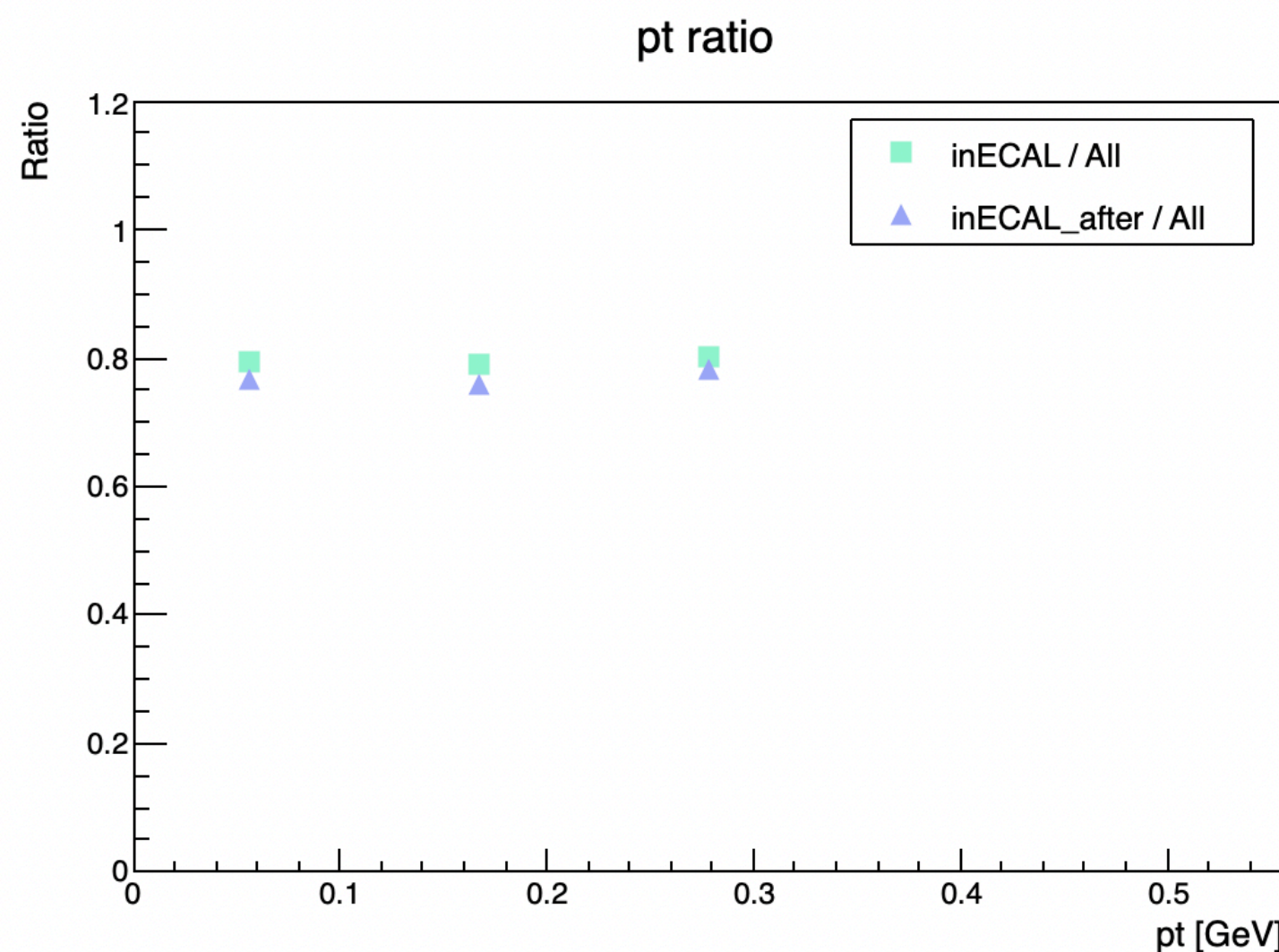
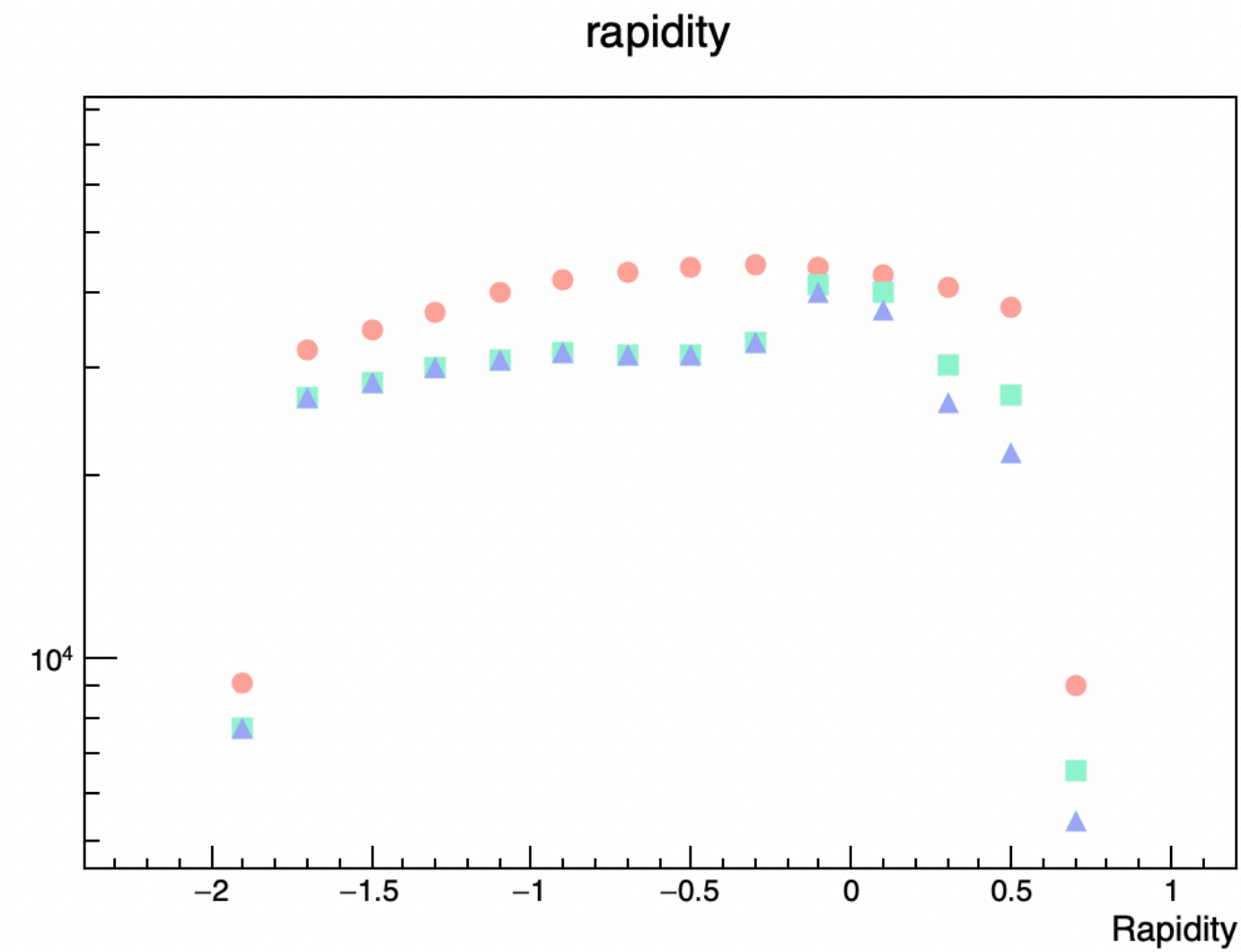
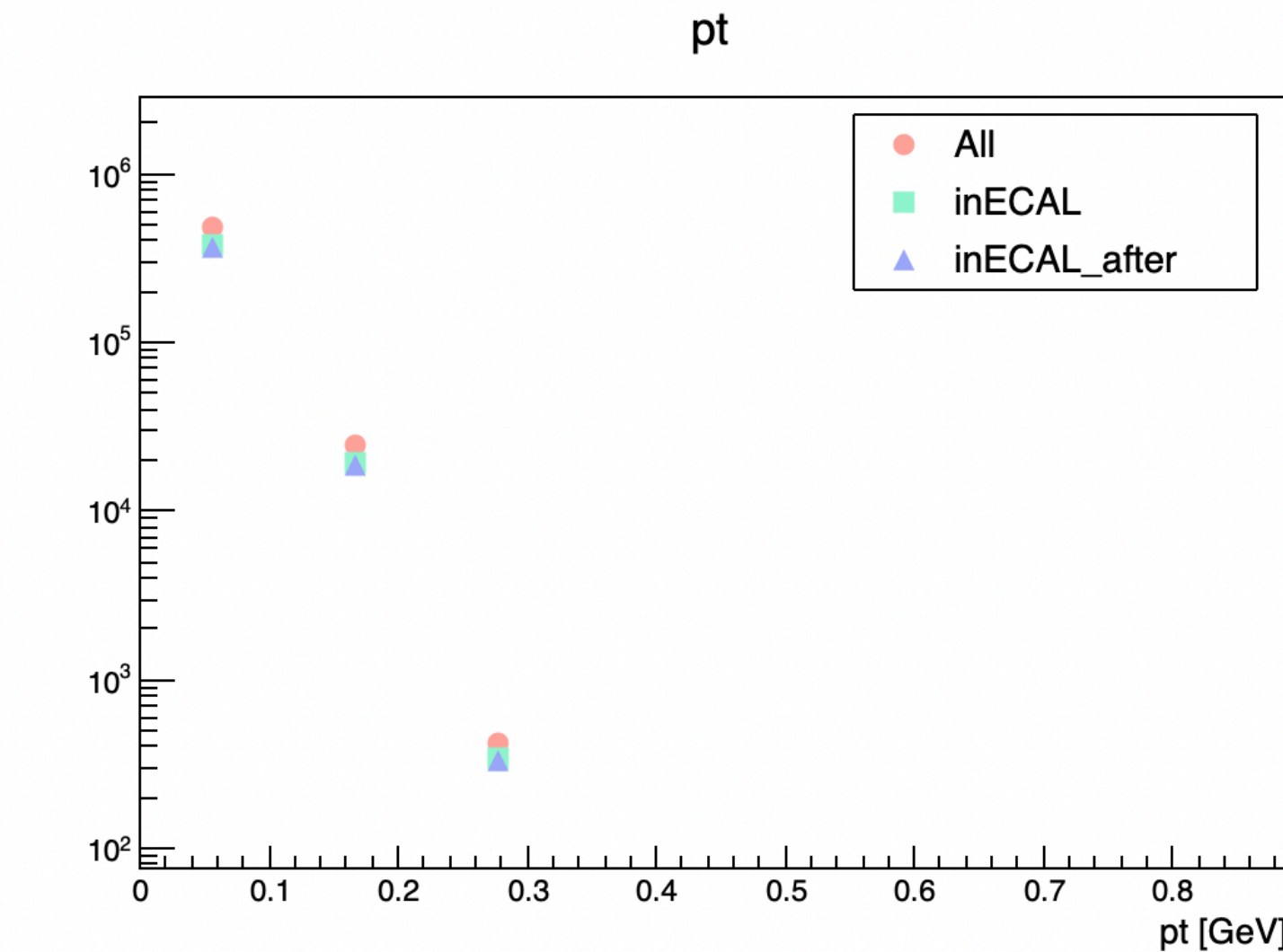
◆ Assuming eta\_c is fully reconstructed (acc. X eff. = 1), acceptance is calculated by

$$\frac{\# \text{ of } J/\psi \text{ having soft photons in EMC}}{\# \text{ of } J/\psi \text{ generated}}$$


◆ New minimum energy threshold of FEMC results O(~2%) reduction of acceptance overall, but shows significant rapidity dependence



# Impact on $J/\psi$ acceptance in eAu collisions



◆ Acceptance as a function of  $J/\psi$  transverse momentum and rapidity

◆ Assuming eta\_c is fully reconstructed (acc. X eff. = 1), acceptance is calculated by 
$$\frac{\# \text{ of } J/\psi \text{ having soft photons in EMC}}{\# \text{ of } J/\psi \text{ generated}}$$

◆ New minimum energy threshold of FEMC results O(~2%) reduction of acceptance overall, but shows rapidity dependence

18 GeV e on 100 GeV/n gold will have a rapidity distribution more like the ep runs.



# Summary and conclusion

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- ✦ Using the  $J/\psi \rightarrow \eta c + \gamma$  channel as a benchmark, acceptance loss for soft photons introduced by the new minimum energy threshold of the Forward Electromagnetic Calorimeter (FEMC) was studied.
- ✦ A reduction in photon acceptance of  $\sim 2\text{-}3\%$  is observed. This effect shows a significant dependence on the kinematics of the mother  $J/\psi$  particle, particularly its rapidity.
- ✦ Acceptance loss does not reduce the overall rapidity coverage for the reconstructed  $J/\psi$ , which is important as full coverage is essential for nuclear structure studies over a wide Bjorken- $x$  range. (Caveat: acceptance and efficiency of  $\eta c$  was not considered)
- ✦ Impact observed is not unique to this channel. It represents a general challenge for studies of charmonium radiative decays, as many of these processes emit photons in a similar energy range.

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# Backup

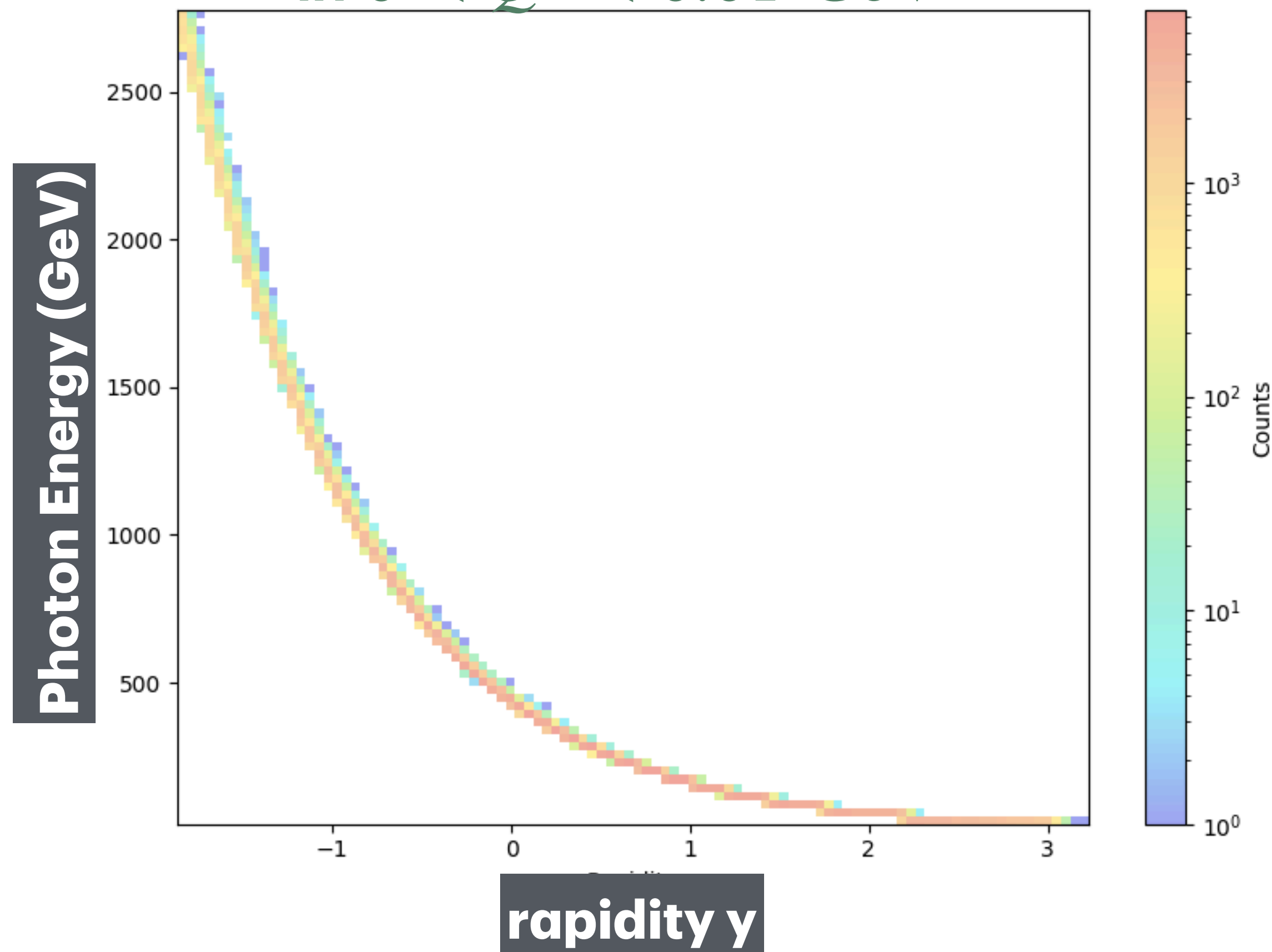


# $J/\psi$ rapidity vs. photon energy

ep collisions at  $10 \times 130$  GeV

Coherent  $J/\psi$  photoproduction

in  $0 < Q^2 < 0.01$  GeV<sup>2</sup>



eAu collisions at  $10 \times 100$  GeV

Coherent  $J/\psi$  photoproduction

in  $0 < Q^2 < 0.01$  GeV<sup>2</sup>

