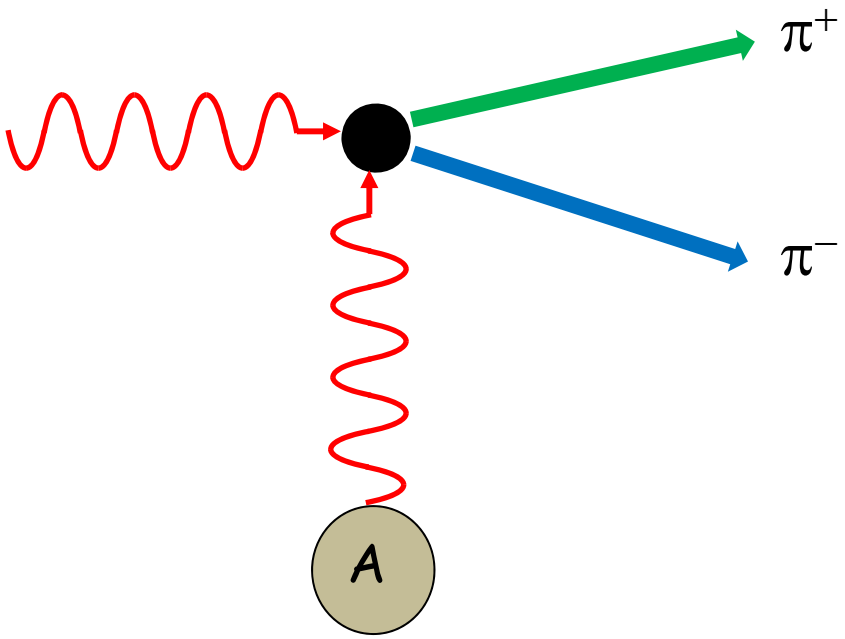
Charged pion polarizability measured in $\gamma\gamma \rightarrow \pi^+\pi^-$

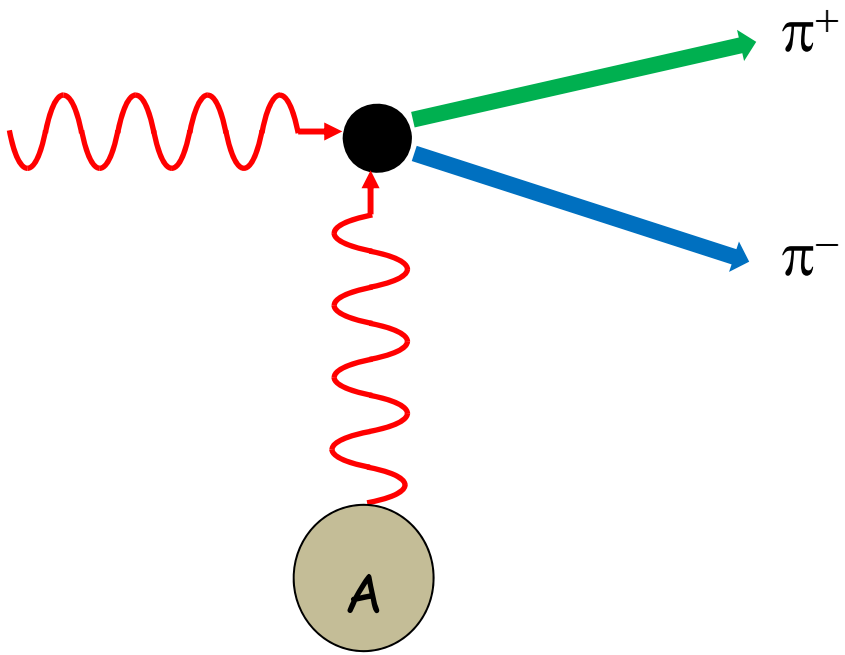


Hadron polarizabilities are fundamental constants that encode information about the structure of hadrons.

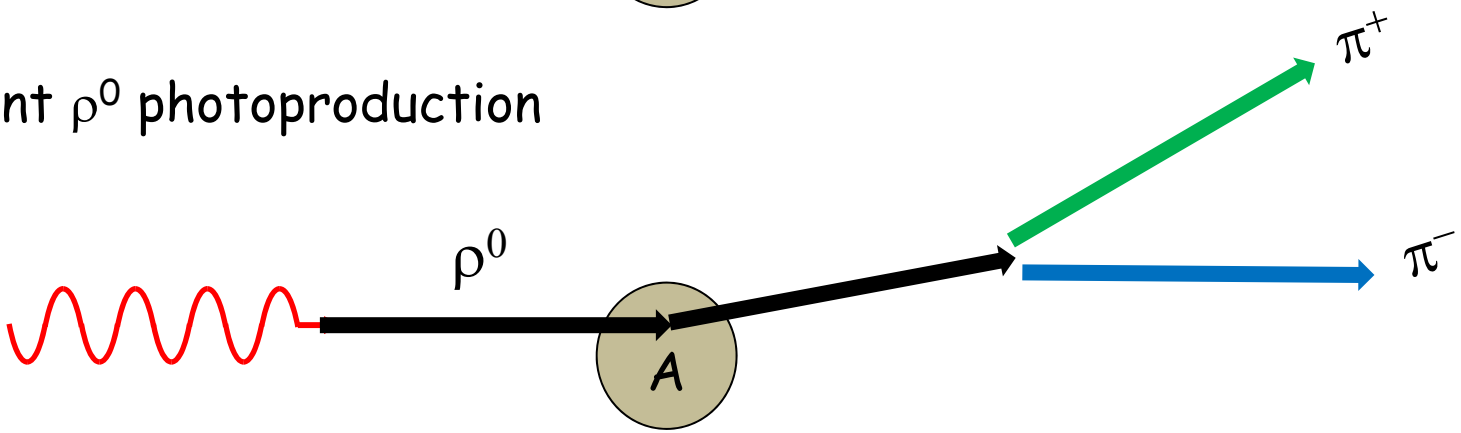
The pion is the lightest strongly interacting particle observed in nature. QCD symmetries are especially relevant in predicting properties of the pion.

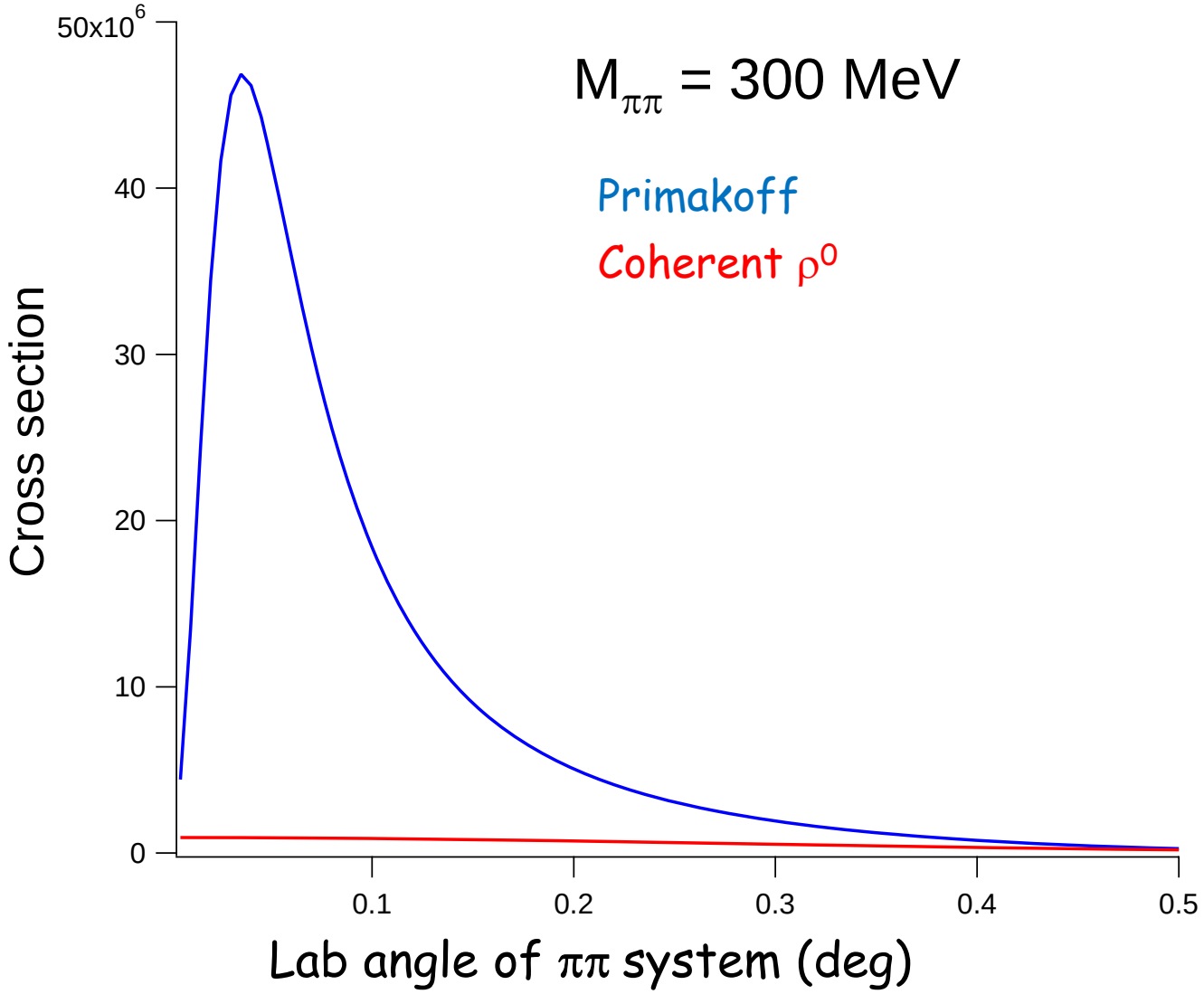
- Theoretical predictions
- Previous experiments
- Primakoff experiment in Hall D to measure $\alpha_{\pi+} - \beta_{\pi+}$

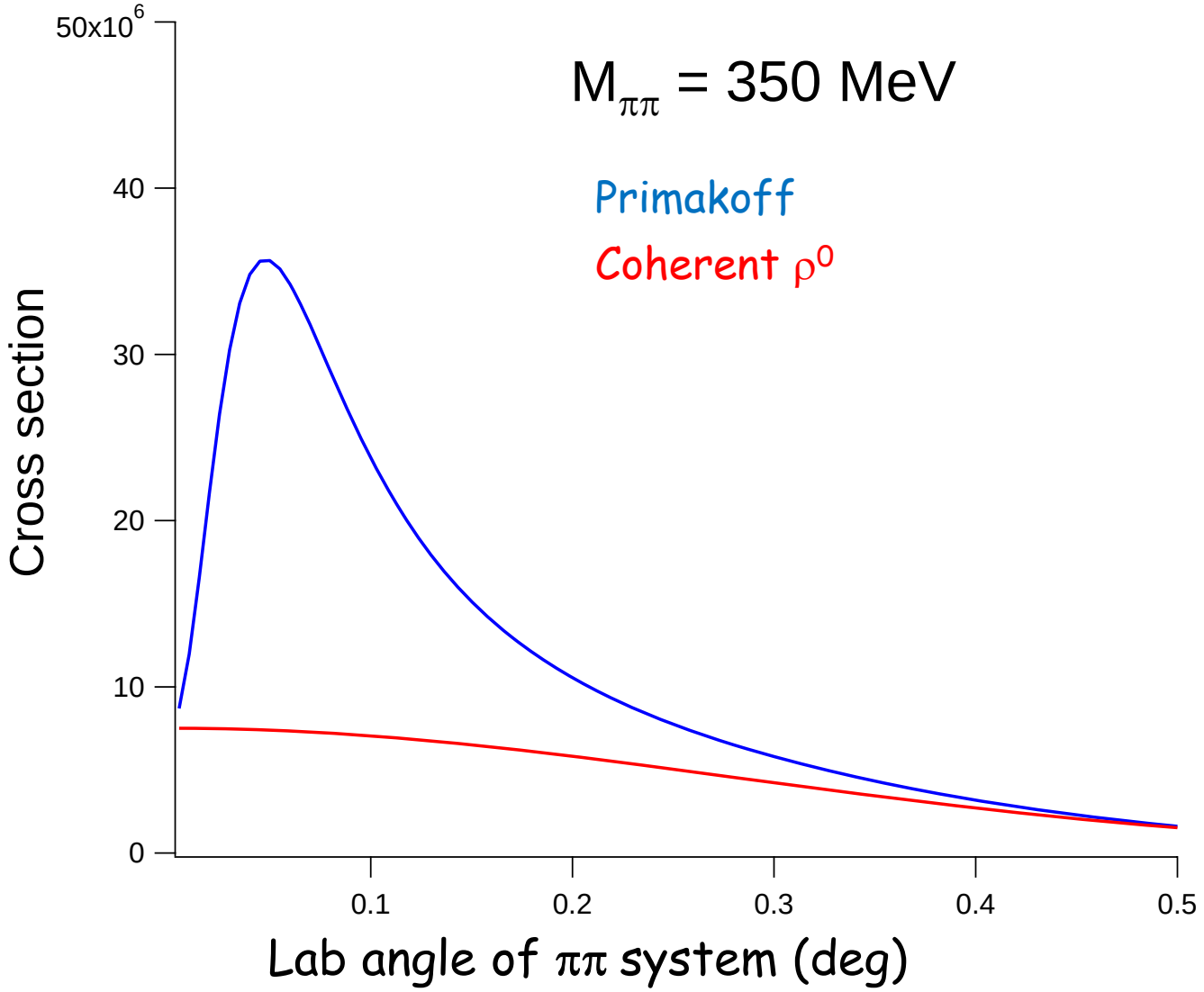
Primakoff photoproduction

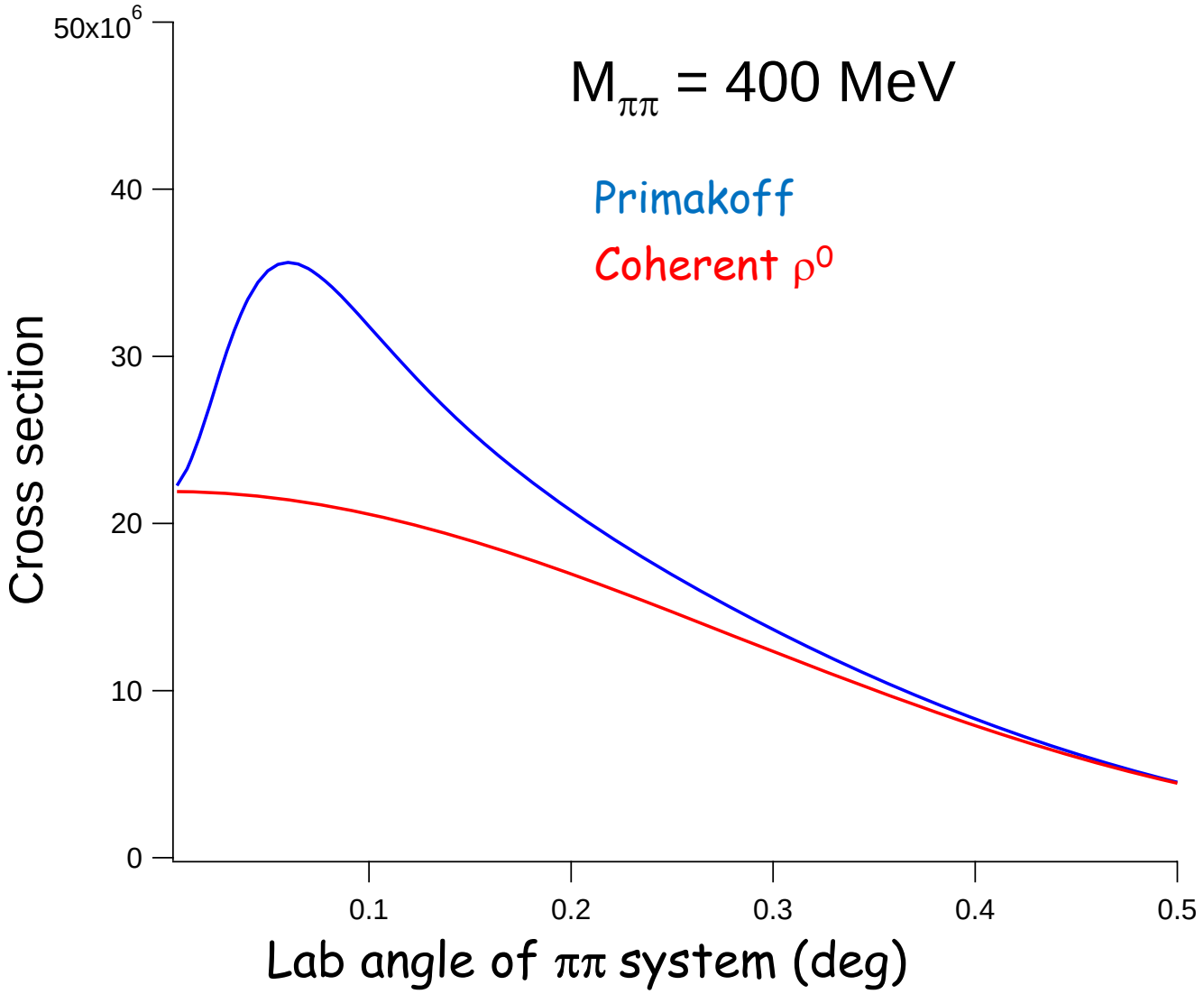


Coherent ρ^0 photoproduction




50x10^6
40
30
20
10
0
Cross section
0.1
0.2
0.3
0.4
0.5
Lab angle of ππ system (deg)
M_ππ = 300 MeV
Primakoff
Coherent ρ^0


$M_{\pi\pi}$ = 350 MeV
Primakoff
Coherent ρ^0
Cross section
50x10^6
40
30
20
10
0
0.1
0.2
0.3
0.4
0.5
Lab angle of ππ system (deg)


$M_{\pi\pi}$ = 400 MeV
Primakoff
Coherent ρ^0
Cross section
50x10^6
40
30
20
10
0
0.1
0.2
0.3
0.4
0.5
Lab angle of ππ system (deg)

Use linearly polarized photons to separate the Primakoff signal from the coherent ρ^0 photoproduction

$$\gamma\, p \rightarrow \rho^0\, p$$

- S-channel helicity conservation for ρ^0 photoproduction

$$N(\theta,\Psi)=\frac{3}{8\pi}\sin^2\theta\left(1+P_\gamma\cos 2\Psi\right)$$

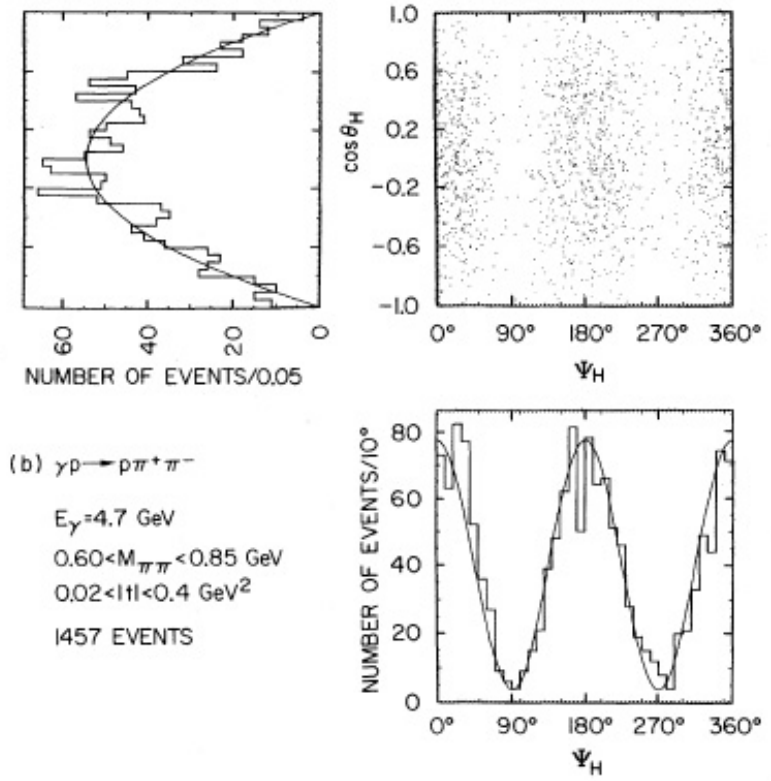


FIG. 13. Reaction $\gamma p \rightarrow p\rho^0$ at (a) 2.8 GeV and (b) 4.7 GeV, respectively. ρ-decay angular distributions in the helicity system without background subtraction. The curves are proportional to $\sin^2\theta_H$ and $(1+P_\gamma \cos 2\Psi_H)$.

J. Ballam, et al., Phys. Rev. D, 545 (2008).

Cross sections

$\rho^0 \to \pi^+ \pi^-$ S-channel helicity conservaton: $N(\theta,\Psi) = \frac{3}{8\pi}\sin^2\theta_\pi\left(1 + P_\gamma \cos 2\Psi\right)$

$\gamma\gamma \to \pi^+ \pi^-$ s-wave: $N(\theta,\Psi) = \frac{1}{4\pi}$

$$\left|A_{\mathrm{Primakoff}} + A_\rho\right|^2 =$$

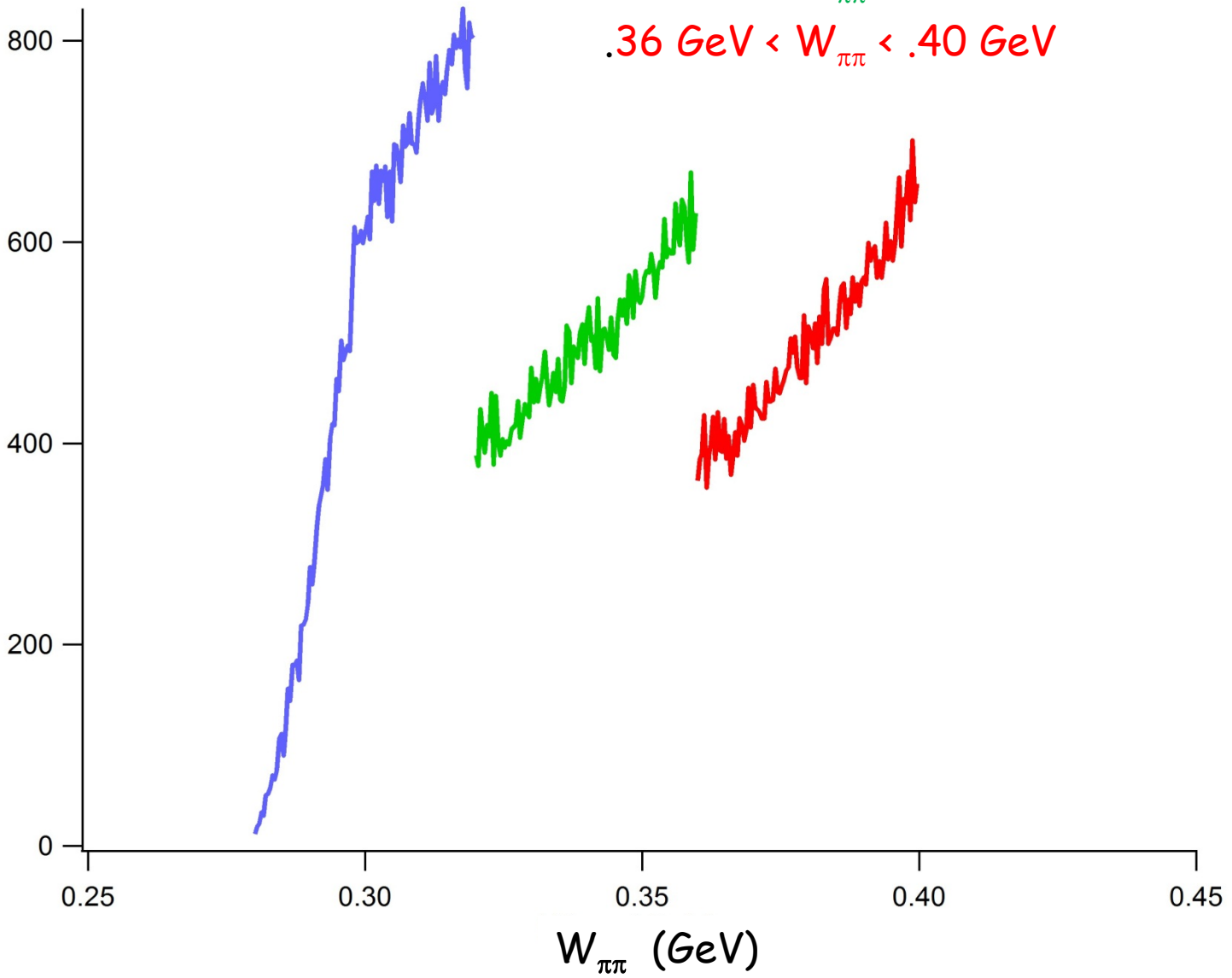
$$\frac{d\sigma_{\mathrm{Primakoff}}}{d\Omega_{\pi\pi}} \frac{d^2\Gamma(\gamma\gamma \to \pi\pi)}{d\Omega_\pi dW_{\pi\pi}}\left(1 + P_\gamma \cos 2\varphi_{\pi\pi}\right) + \frac{3}{8\pi}\sin^2\theta_\pi\left(1 + P_\gamma \cos 2\Psi\right)\frac{d^2\sigma_\rho}{d\Omega_\rho dW_{\pi\pi}}$$

Distributions for thrown events:

.28 GeV < $W_{\pi\pi}$ < .32 GeV

.32 GeV < $W_{\pi\pi}$ < .36 GeV

.36 GeV < $W_{\pi\pi}$ < .40 GeV



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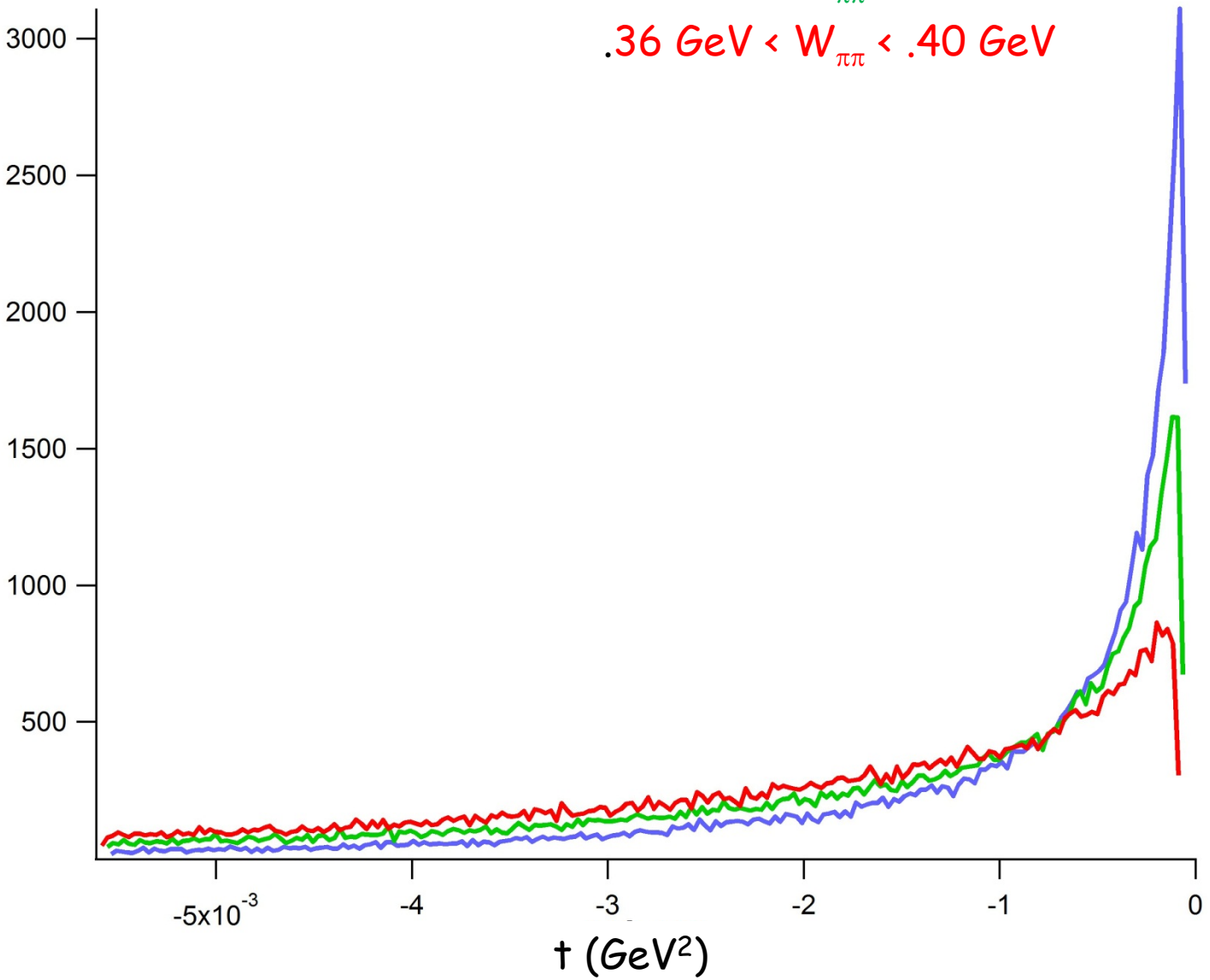
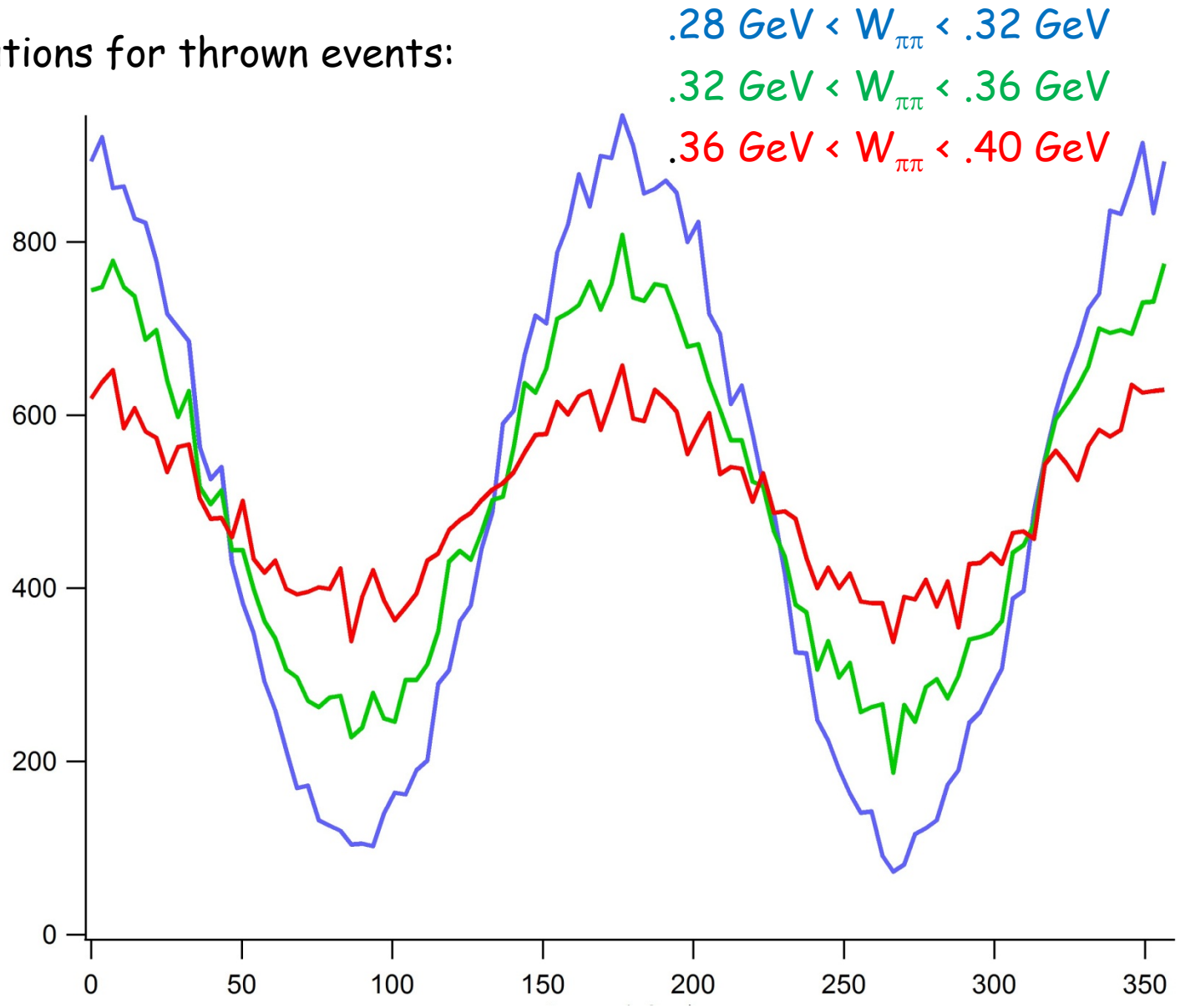
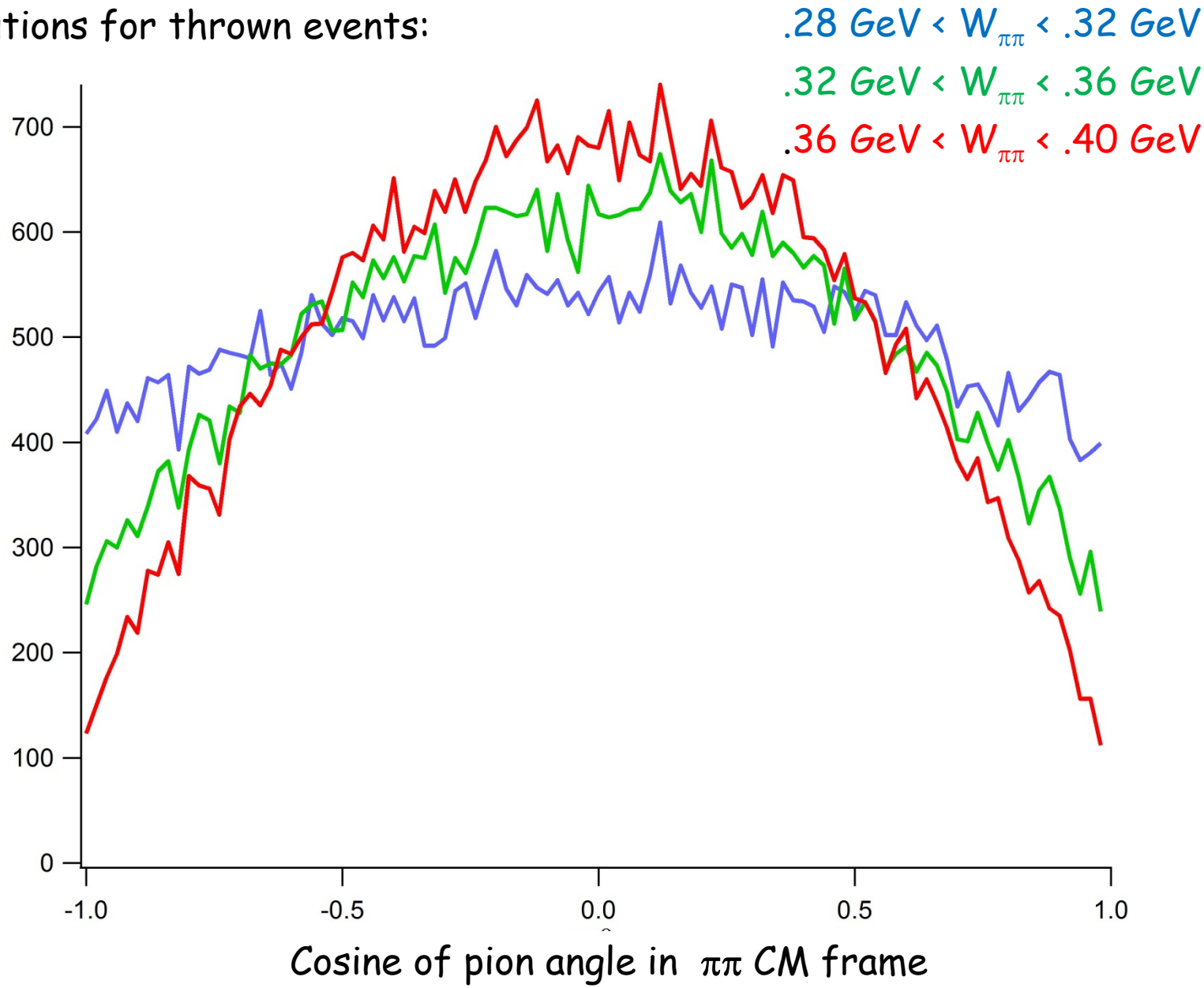


Distributions for thrown events:

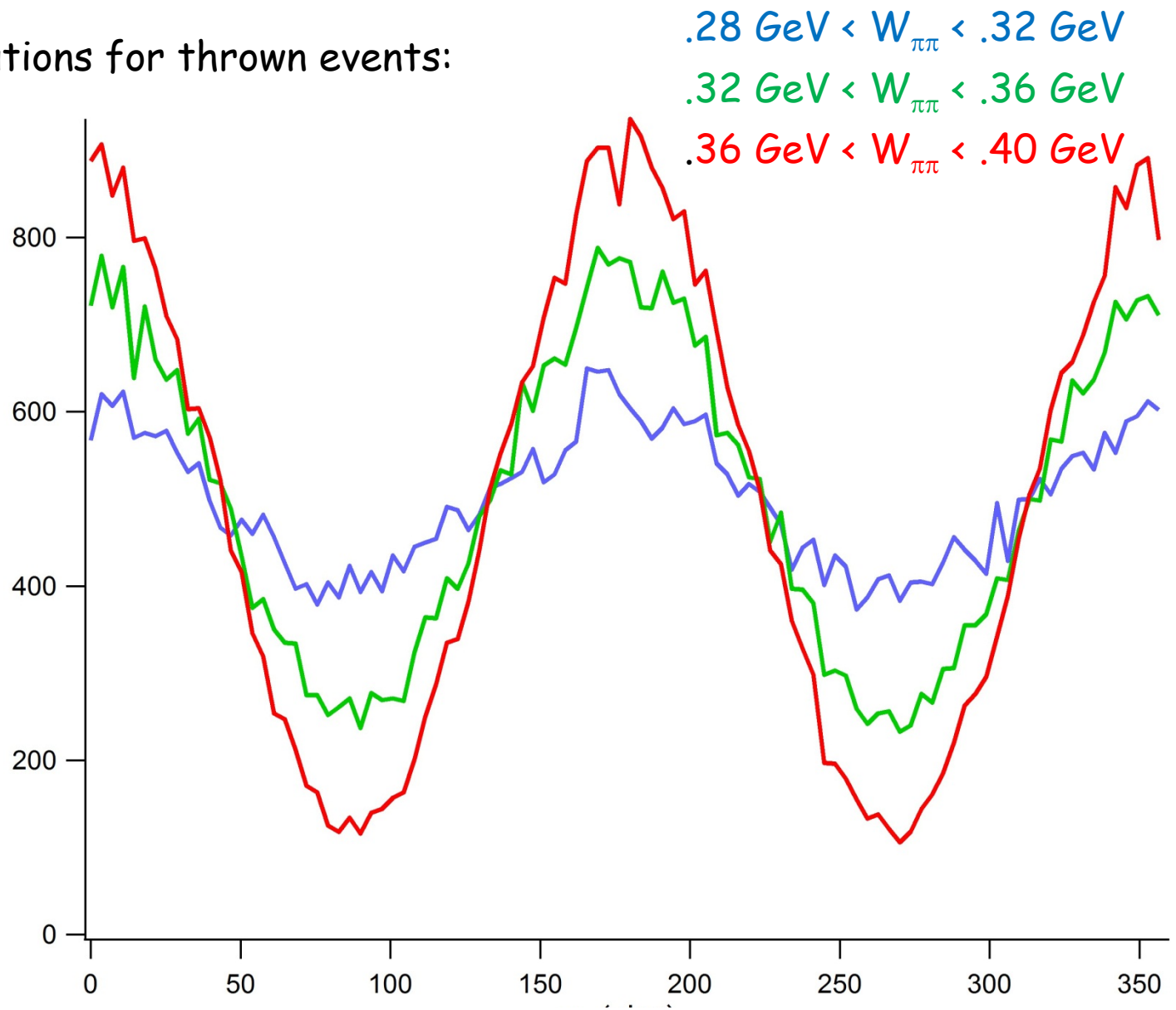


Lab azimuthal distribution of $\pi\pi$ system relative to photon polarization (deg)

Distributions for thrown events:



Distributions for thrown events:



Azimuthal distribution of pion in ππ CM frame relative to photon polarization