Tests with Polarized Amplitudes for $\gamma p \to \eta\pi^0 p$

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Amplitude Analysis Working Group Meeting

Strategy and Goals

- Focus on resonance region
- Fit in bins of $m(\pi^0\eta)$ $\rightarrow$ drop energy dependent part of the amplitude
- Simultaneous fit to all different beam polarization data sets

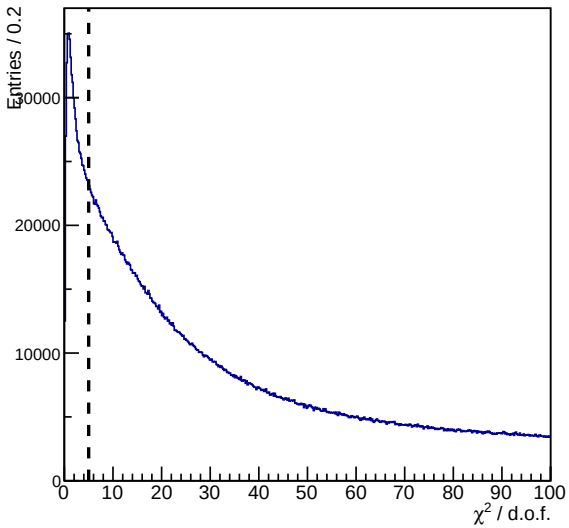
$\rightarrow$ Understand Z_l^m amplitudes (defined as: $Z_l^m(\Omega,\Phi) = Y_l^m(\Omega)e^{-i\Phi}$)

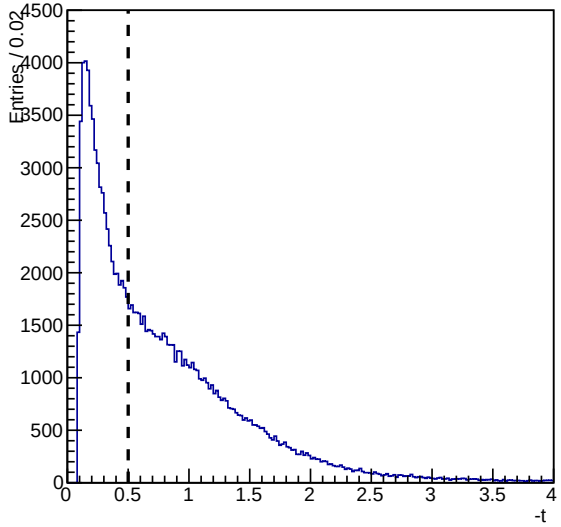
$$I(\Omega,\Phi) = 2\kappa \sum_k \Bigg\{ (1-P_\gamma) \left| \sum_{\ell,m} [\ell]^{(-)}_{m;k} \mathrm{Re}[Z^m_\ell(\Omega,\Phi)] \right|^2 + (1-P_\gamma) \left| \sum_{\ell,m} [\ell]^{(+)}_{m;k} \mathrm{Im}[Z^m_\ell(\Omega,\Phi)] \right|^2 +$$
$$(1+P_\gamma) \left| \sum_{\ell,m} [\ell]^{(+)}_{m;k} \mathrm{Re}[Z^m_\ell(\Omega,\Phi)] \right|^2 + (1+P_\gamma) \left| \sum_{\ell,m} [\ell]^{(-)}_{m;k} \mathrm{Im}[Z^m_\ell(\Omega,\Phi)] \right|^2 \Bigg\}$$

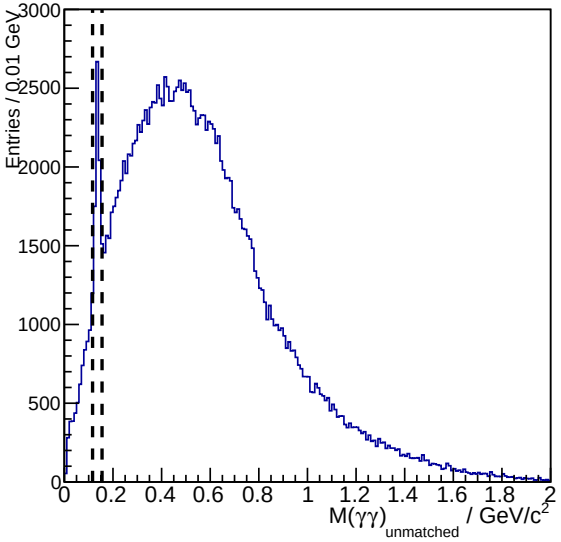
[M.Shepherd, GlueX-doc-4094],[V.Mathieu, PRD100(2019) 5, 054017]

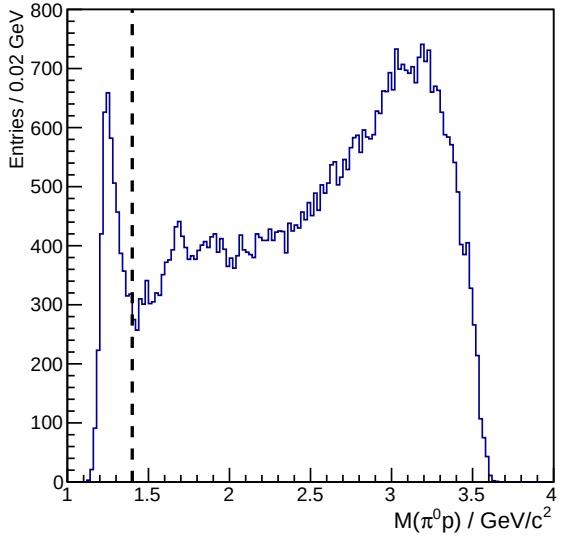
Event Selection $\gamma p \to \pi^0 \eta p$

- Standard skim cuts
- No accidentals subtraction
- $\Delta T_{RF} < 2\,\text{ns}$
- Select combo with best χ^2_{4C}
- $\chi^2_{4C}/\text{d.o.f.} < 5$
- $MM^2 < 0.05\,\text{GeV}$
- $-t < 0.5\,\text{GeV}$
- $8.2\,\text{GeV} < E_{\text{beam}} < 8.8\,\text{GeV}$
- $E_{\text{unused}} < 0.01\ \text{GeV}$
- $M(\pi^0 p) > 1.4\,\text{GeV}/c^2$
- $M(\eta p) > 1.65\,\text{GeV}/c^2$
- Veto $0.12 < M(\gamma\gamma) < 0.15$, unmatched photons









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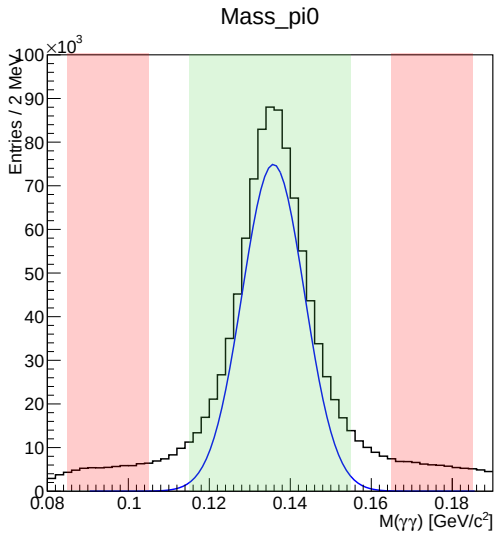

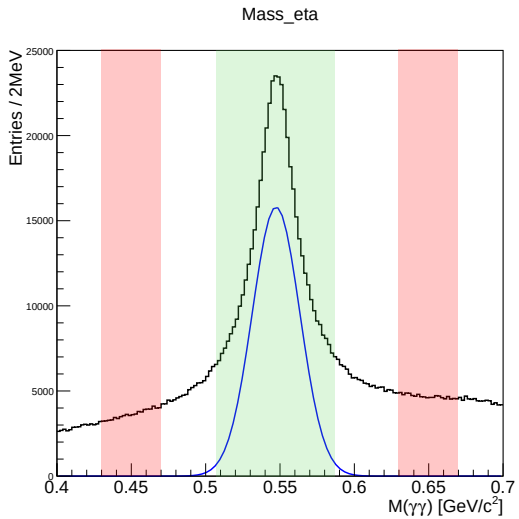

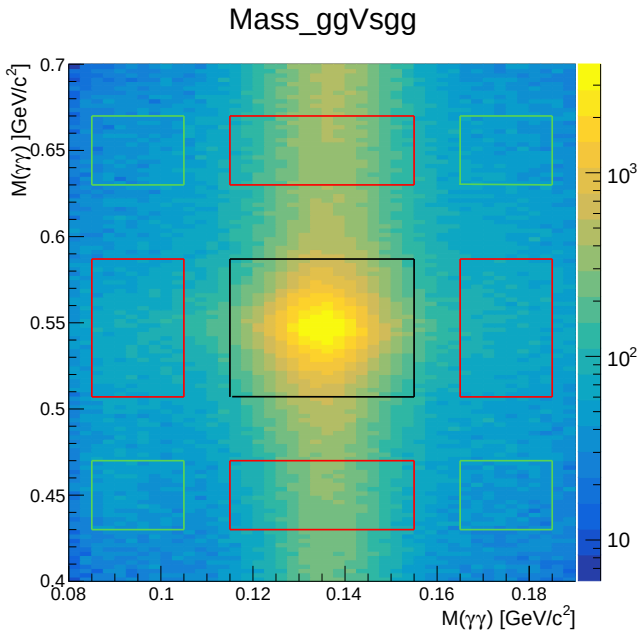

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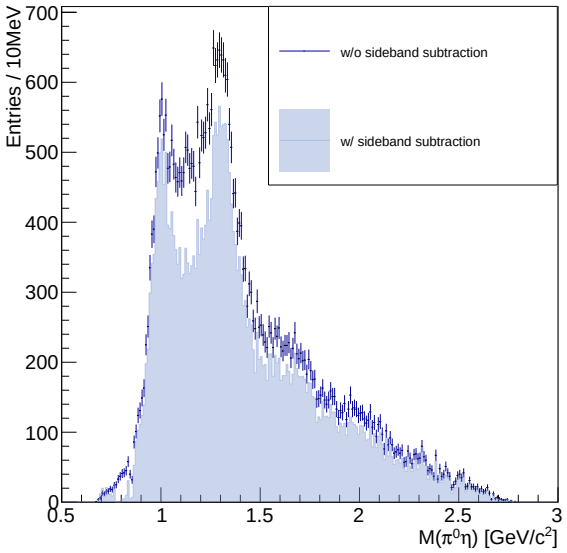
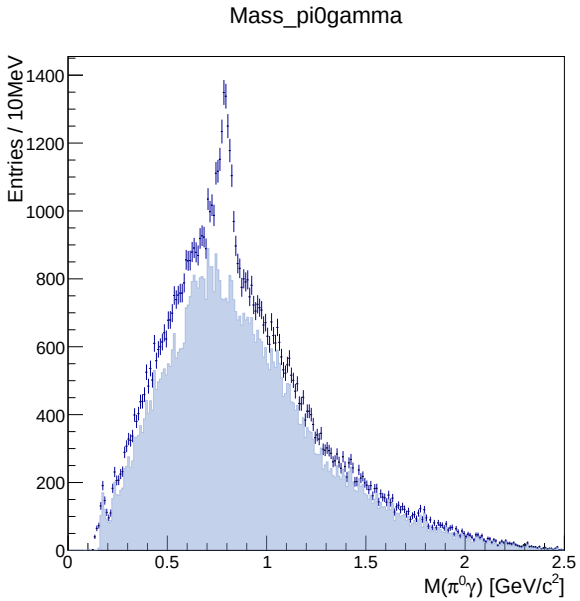
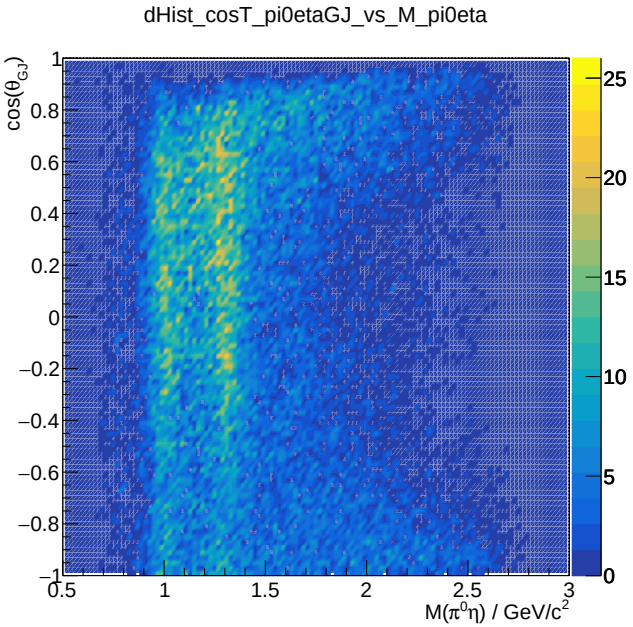
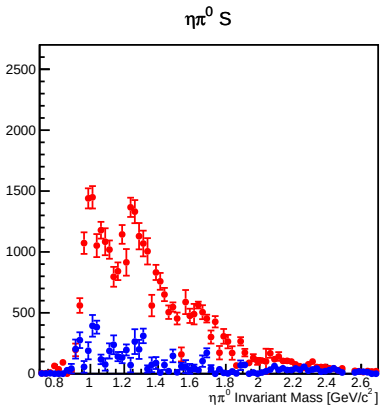
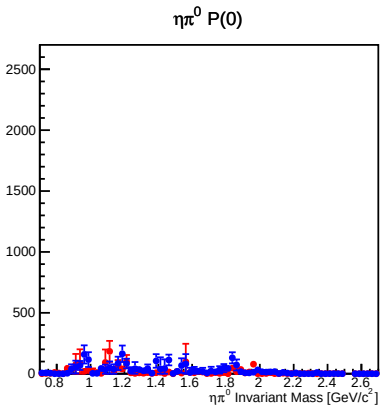


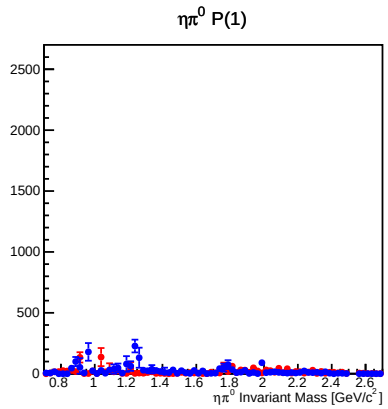


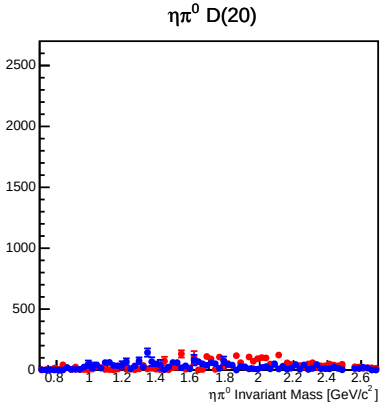


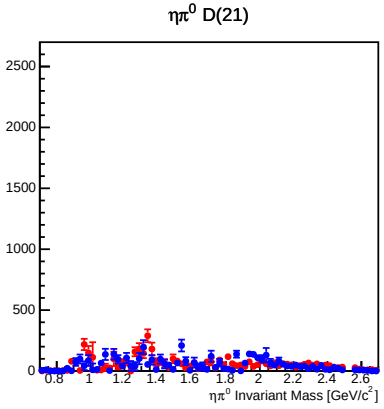
Reminder: Binned Fit with Z_l^m Amplitudes - 0°

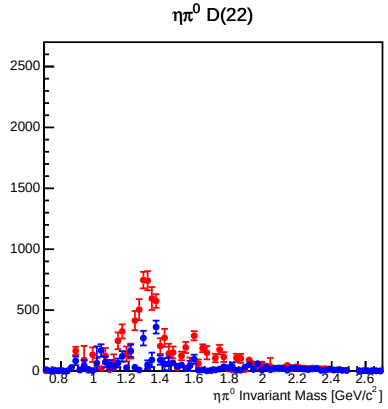


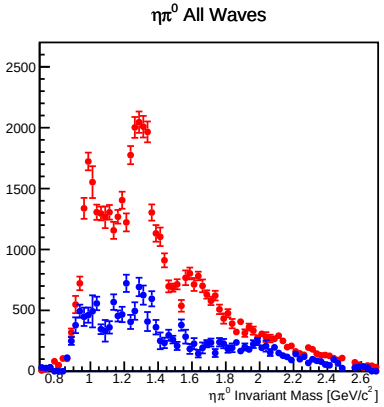












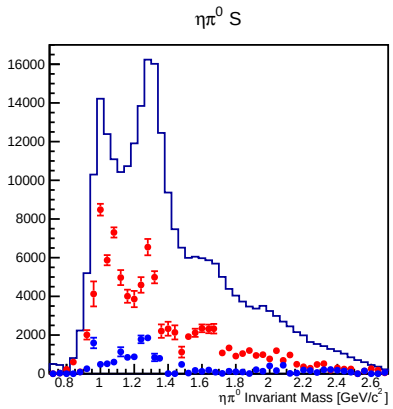
- Data: 2018-01 and 2018-08
- All y-axes: Entries/26MeV
- All four polarizations and unpolarized in **one combined fit**
- Shown here: 0°
- Hypothesis: S-, P- and D-waves, positive and negative reflectivity
- To study:

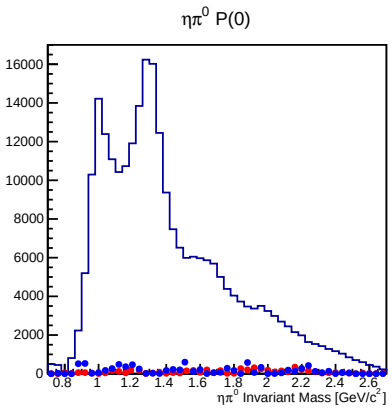
→ Leakage $D \rightarrow S$-wave

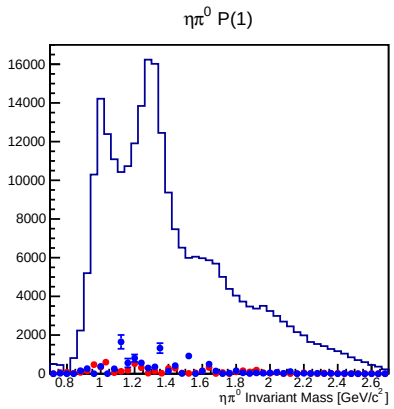
→ Negative reflectivity contribution

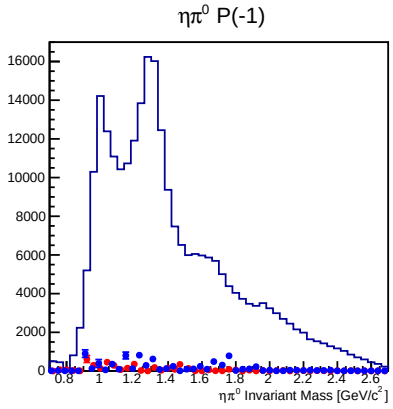
→ Extension of waveset (negative m)

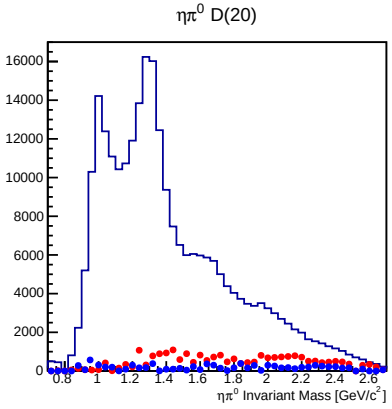
New Binned Fit with Z_l^m Amplitudes: Extended Waveset

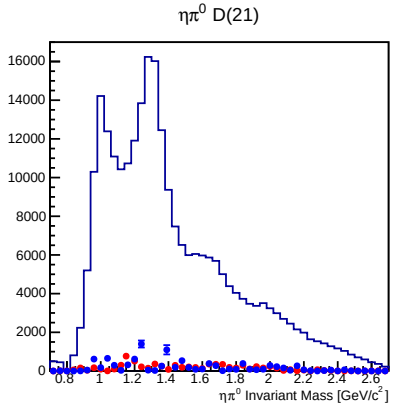


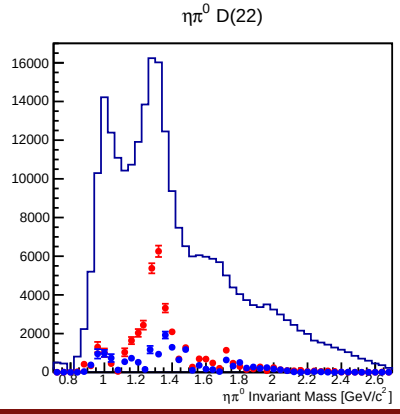


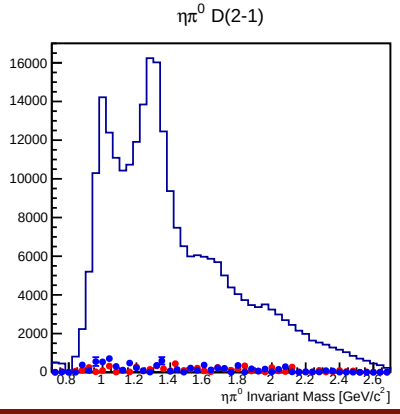


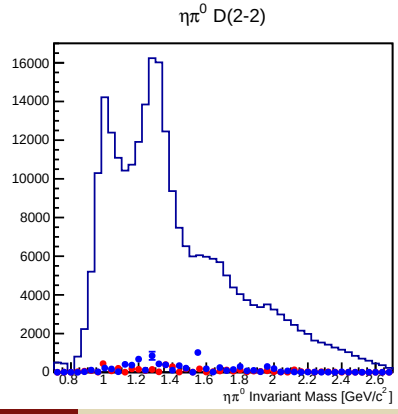






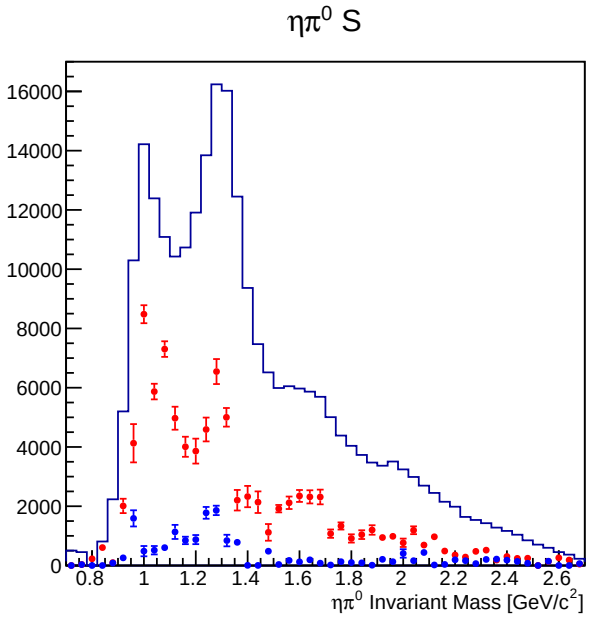


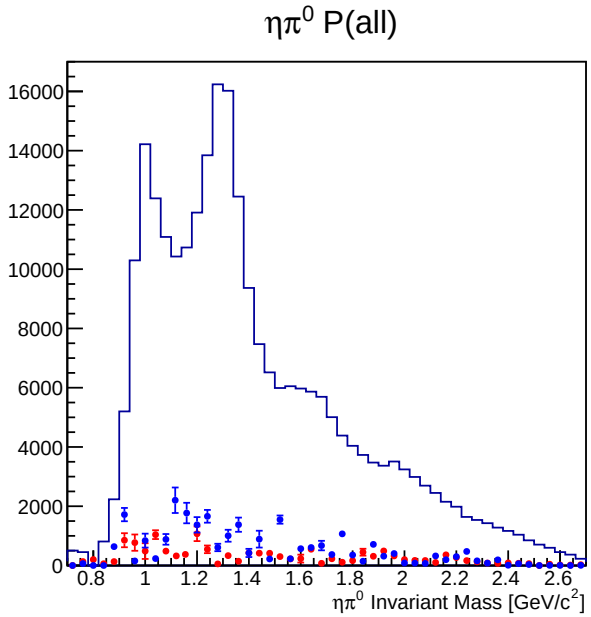


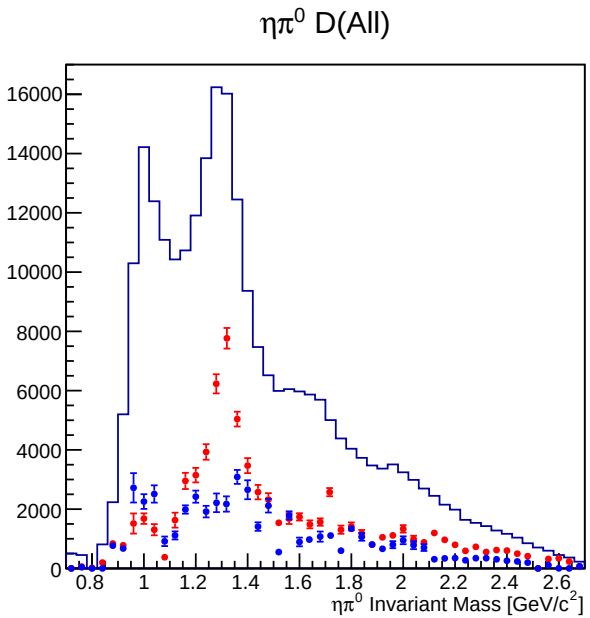


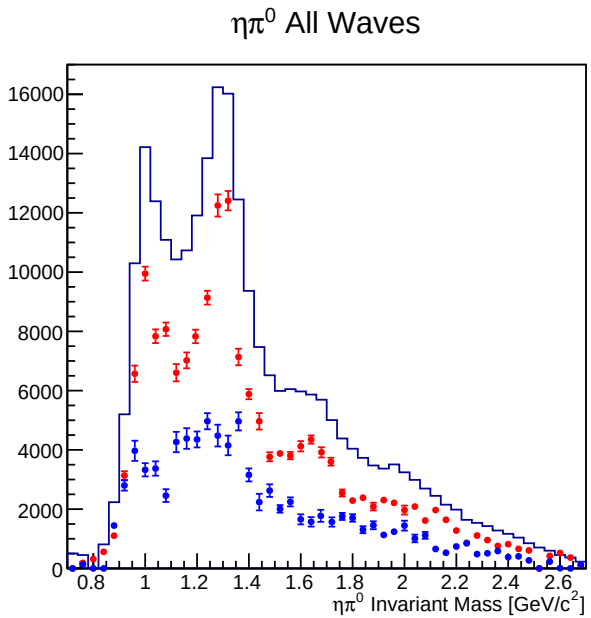
- Data: 2018-01 and 2018-08
- All y-axes: Entries/40MeV
- All four polarizations and unpolarized in **one combined fit**
- Hypothesis: S-, P- and D-waves, positive and negative reflectivity

New Binned Fit with Z_l^m Amplitudes: Extended Waveset





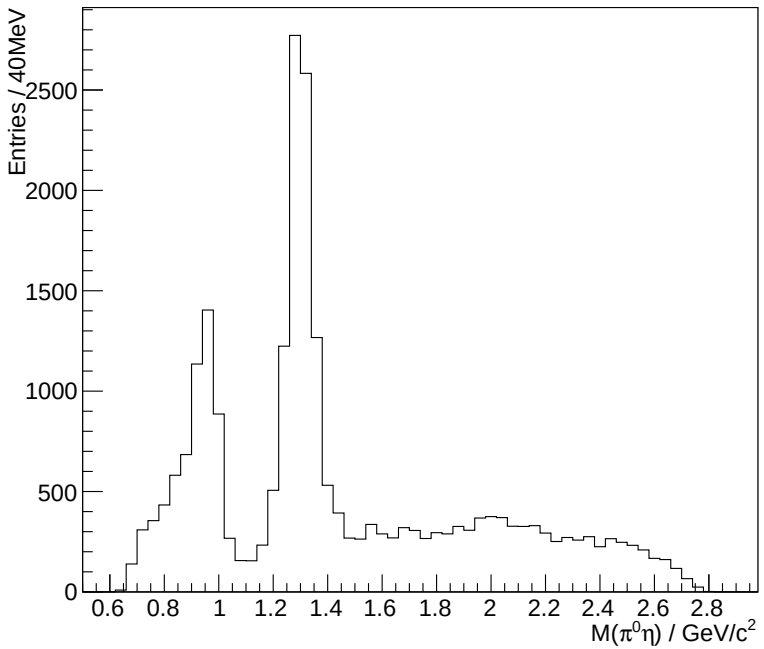




- Data: 2018-01 and 2018-08
- All y-axes: Entries/40MeV
- All four polarizations and unpolarized in **one combined fit**
- Hypothesis: S-, P- and D-waves, positive reflectivity only

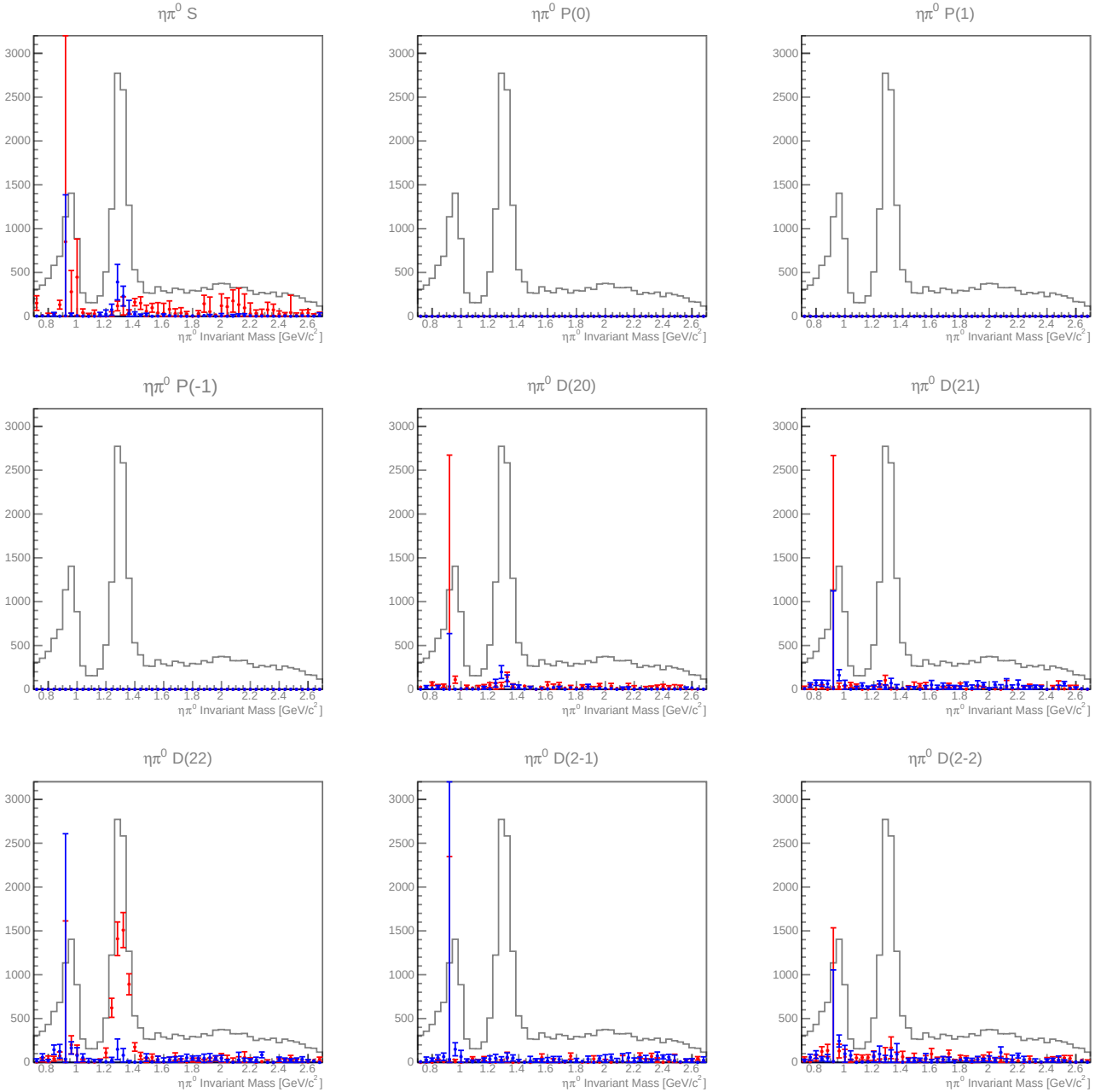
Update: Fit to Reconstructed Toy MC

- Generated using AmpTools w/ Z_l^m amplitudes (Polarization: 0°)
- Hypothesis: $a_0(980)$, $a_2(1320)$ and non-resonant S-wave component (overlapping!)
- Dynamics: Breit-Wigner description
- Reconstruction: same settings as for 2018-08 data
- 100M events flat MC generated and reconstructed



	Parameter	Value (Re,Im)
$a_0(980)$	S_0^-	(0, 0)
	S_0^+	(600, 0)
non-res	S_0^-	(0, 0)
	S_0^+	(600, 250)
$a_2(1320)$	D_0^-	(0, 0)
	D_0^+	(34, 17)
	D_1^-	(20, 10)
	D_1^+	(32, 23)
	D_2^-	(20, 50)
	D_2^+	(20, 106)
	D_{-1}^-	(0, 0)
	D_{-1}^+	(2, 23)
	D_{-2}^-	(0, 0)
	D_{-2}^+	(20, 16)

Binned Fit with Z_l^m Amplitudes to Reconstructed Toy Data

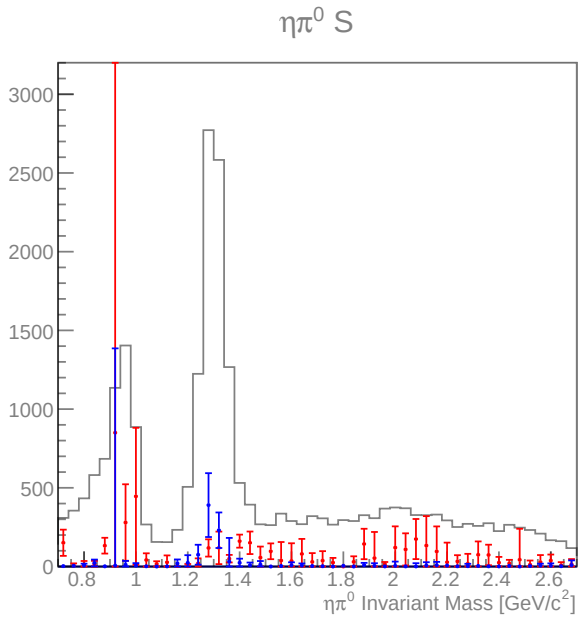


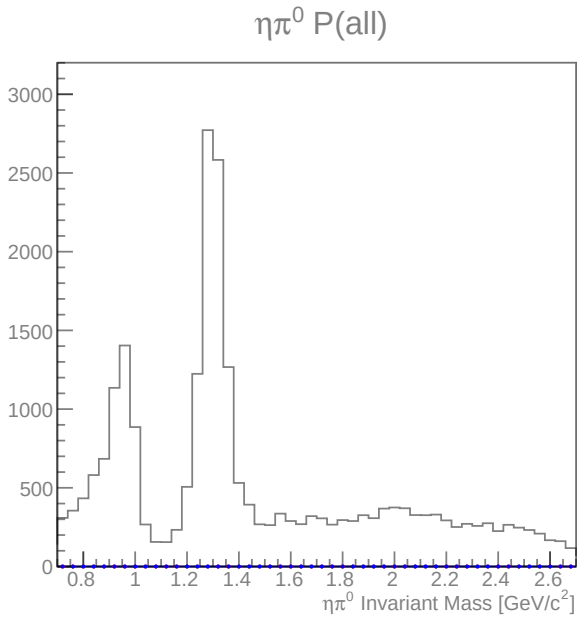
- All y-axes: Entries/40MeV
- Fit Hypothesis: $S_0^{\pm}, D_0^{\pm}, D_1^{\pm}, D_2^{\pm}, D_{-1}^{\pm}, D_{-2}^{\pm}$ waves

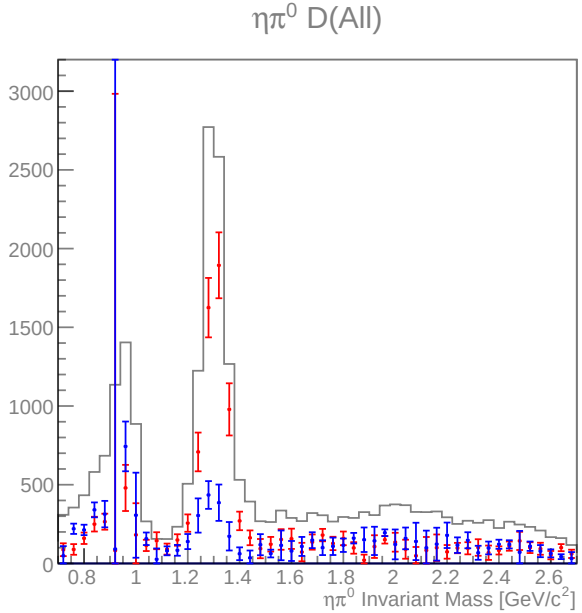
→ Visible $S \rightarrow D$-wave leakage

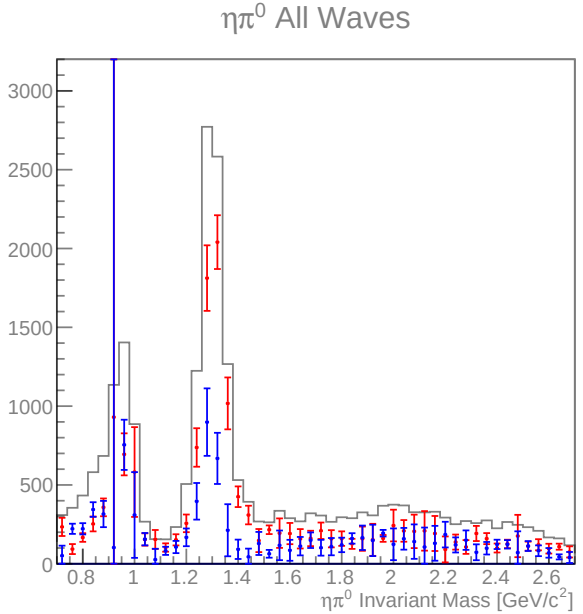
→ Some $D \rightarrow S$-wave leakage

Binned Fit with Z_l^m Amplitudes to Reconstructed Toy Data









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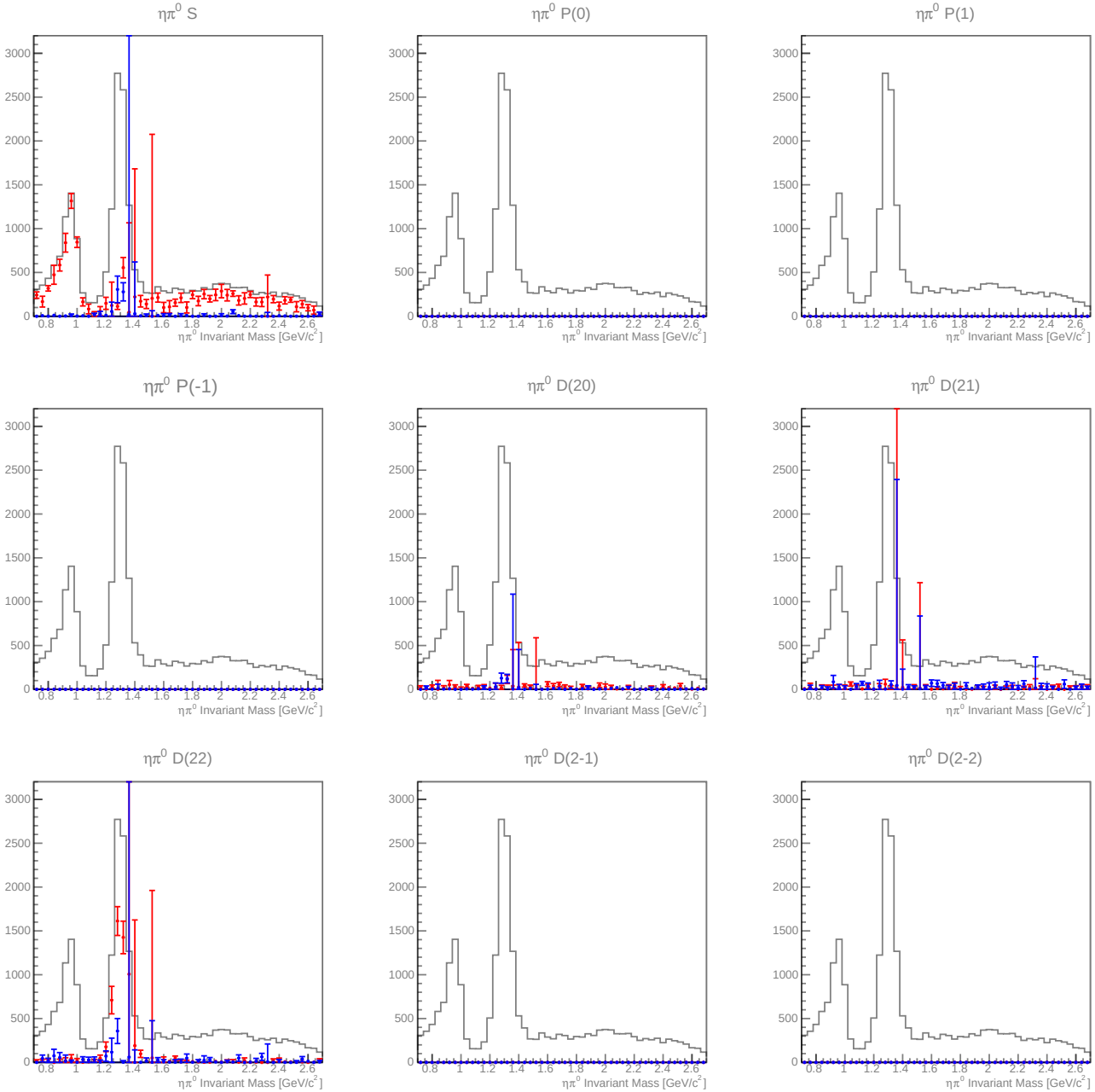
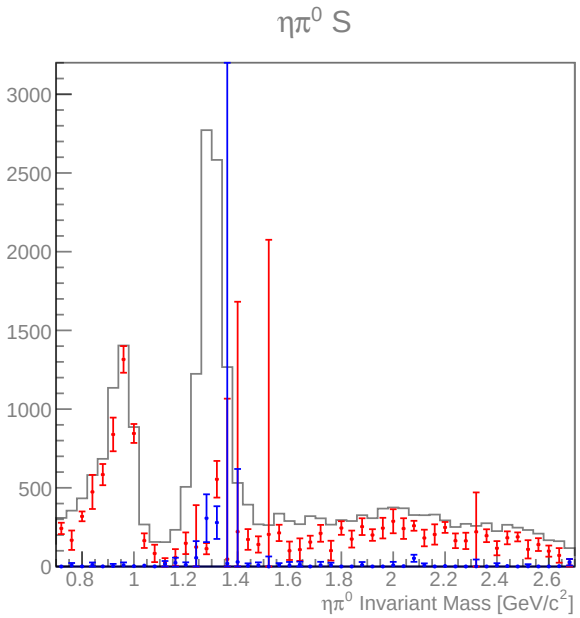


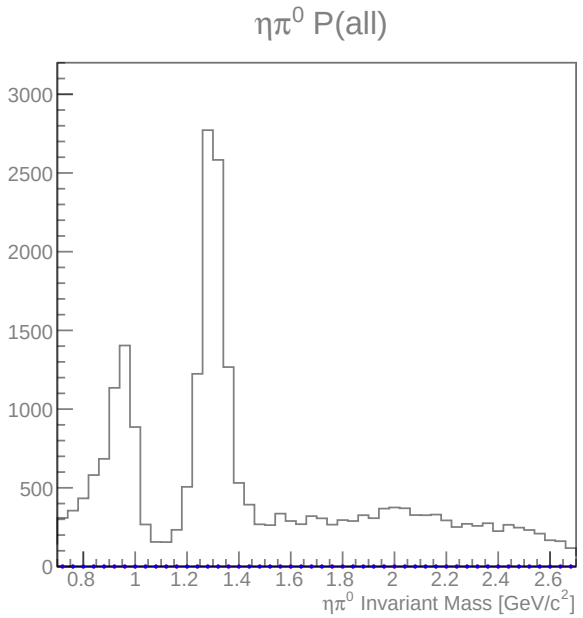
- All y-axes: Entries/40MeV
- Fit Hypothesis: ONLY $S_0^\pm, D_0^\pm, D_1^\pm, D_2^\pm$ waves

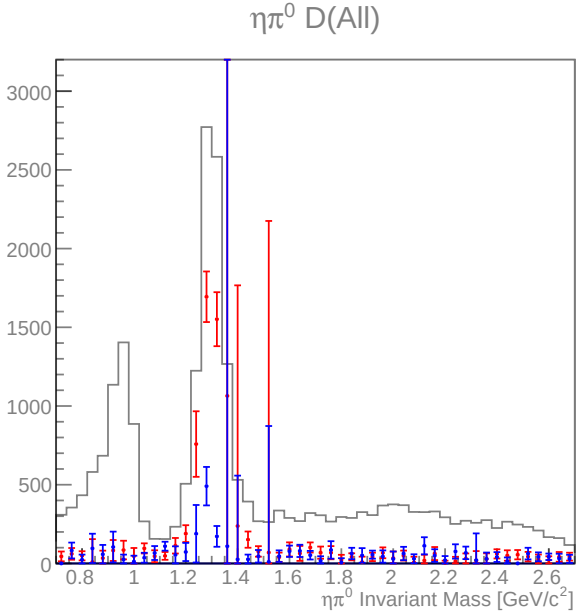
→ NO $S \to D$-wave leakage any more

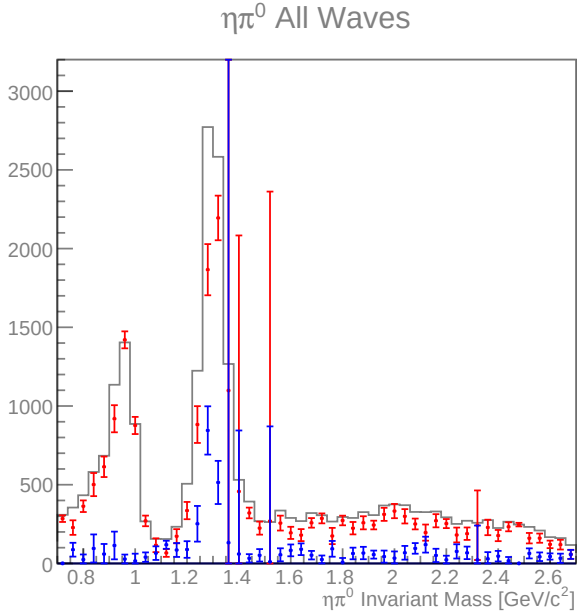
→ Some $D \to S$-wave leakage

Binned Fit with Z_l^m Amplitudes to Reconstructed Toy Data









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→ Further investigation in progress