PWA Challenge with polarized photon beam

Florida International University 2020

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Generated $2*10^6$ $(p\eta\pi^0)$ events with AmpTools

The wave set: $[l]_{m;k}^{(\epsilon)} = \left\{S_0^{(+)}, P_{0,1}^{(+)}, D_{0,1,2}^{(+)}\right\}_{k=0}$ with M>= 0

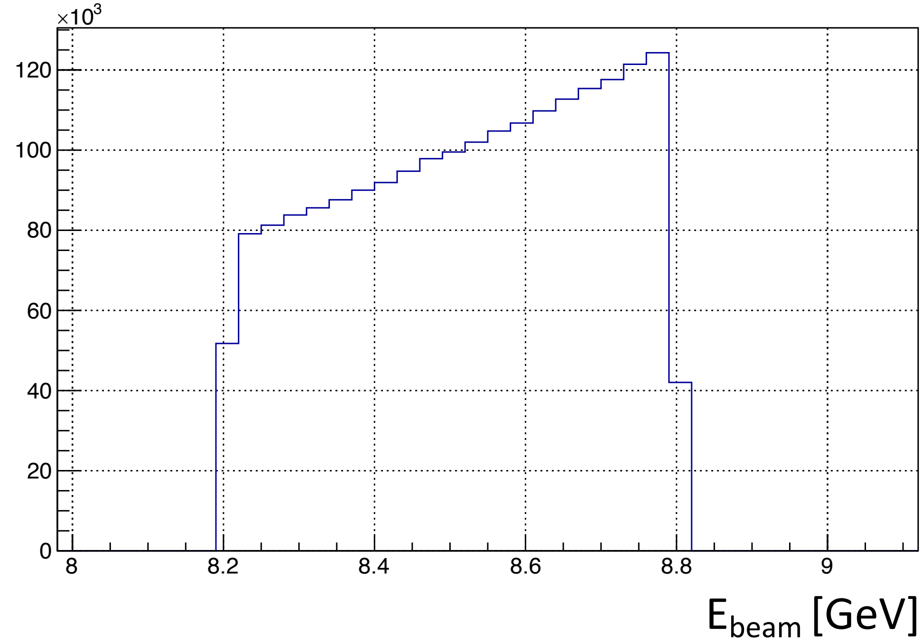
Generated amplitudes are

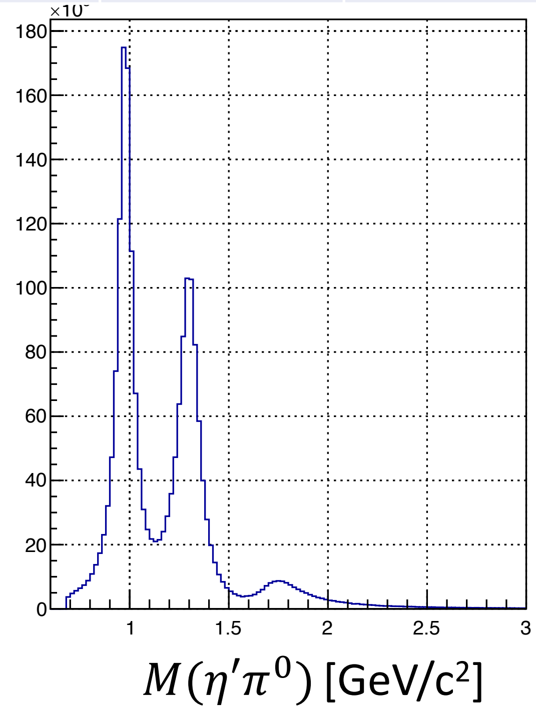
- S0/a_0(980 MeV)
- P1/π_1(1600 MeV) (exotic)
- D1/a2 (1320 MeV)
- D1/a2' (1700 MeV)

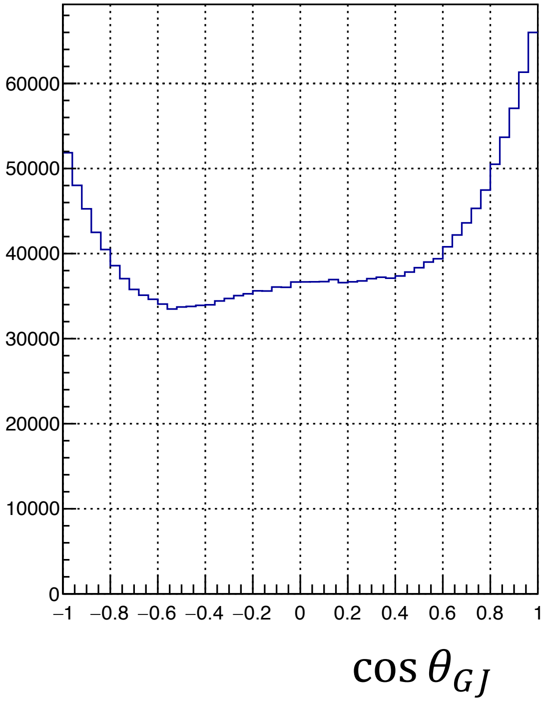
θ_{pol}=1.77 Deg.

P_γ =0.3

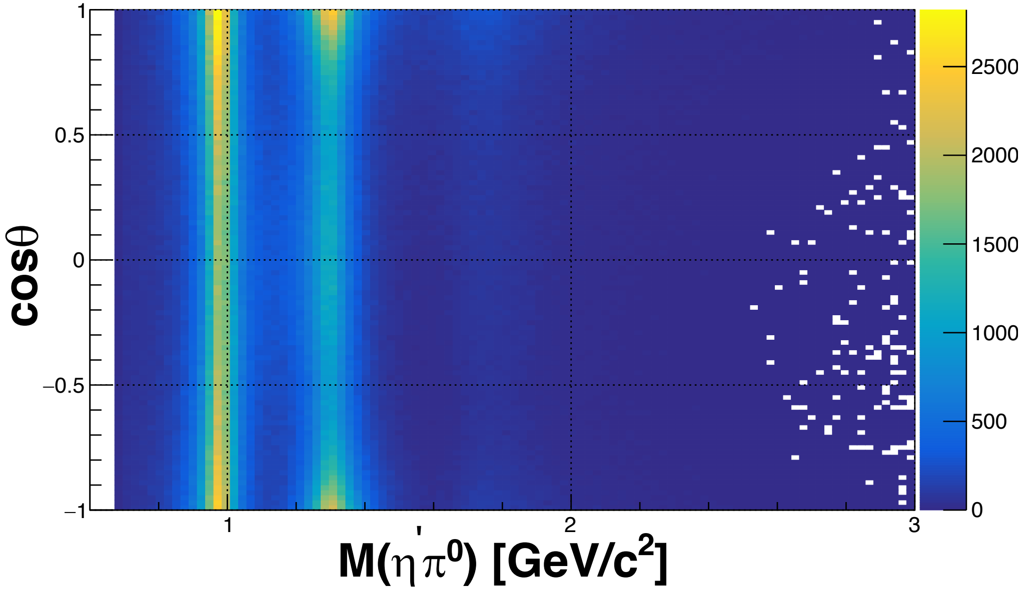
J	M	ε	Real	Imaginary	BW Mass	BW Width
0	0	+1	1000	0	0.980	0.075
1	0, 1	+1	70	70	1.564	0.492
2	0,1,2	+1	150	150	1.306	0.114
2	0,1,2	+1	50	50	1.722	0.247

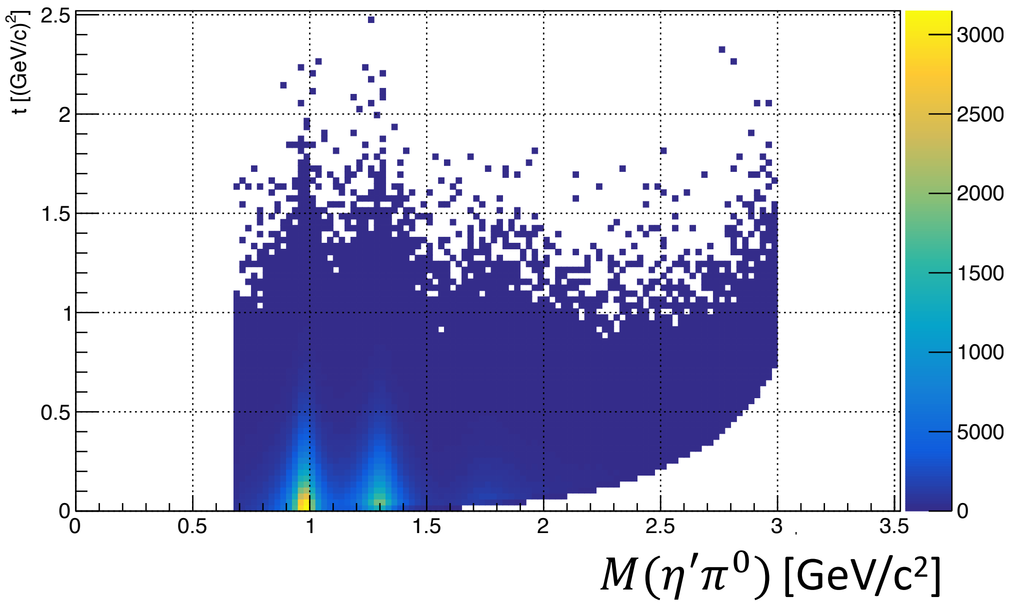


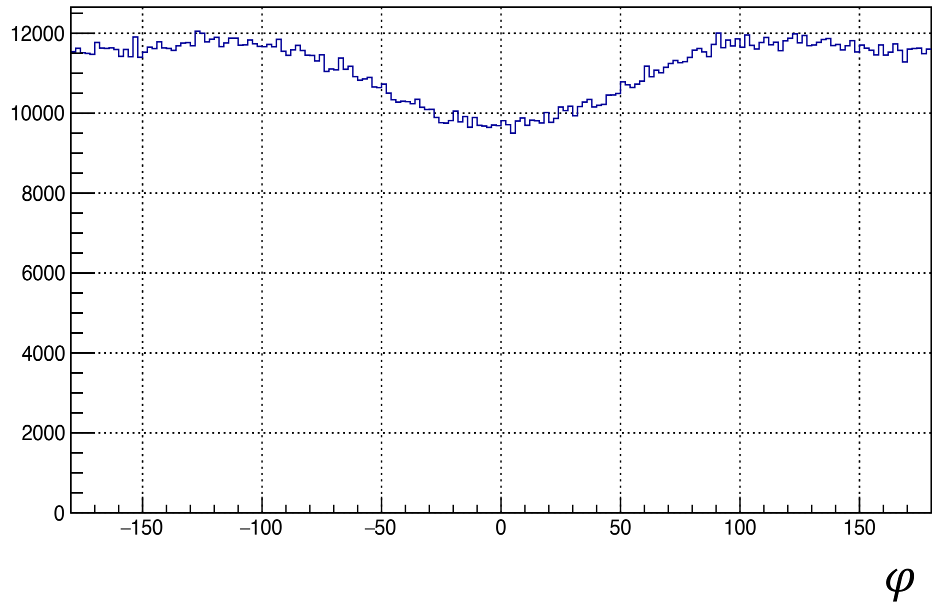


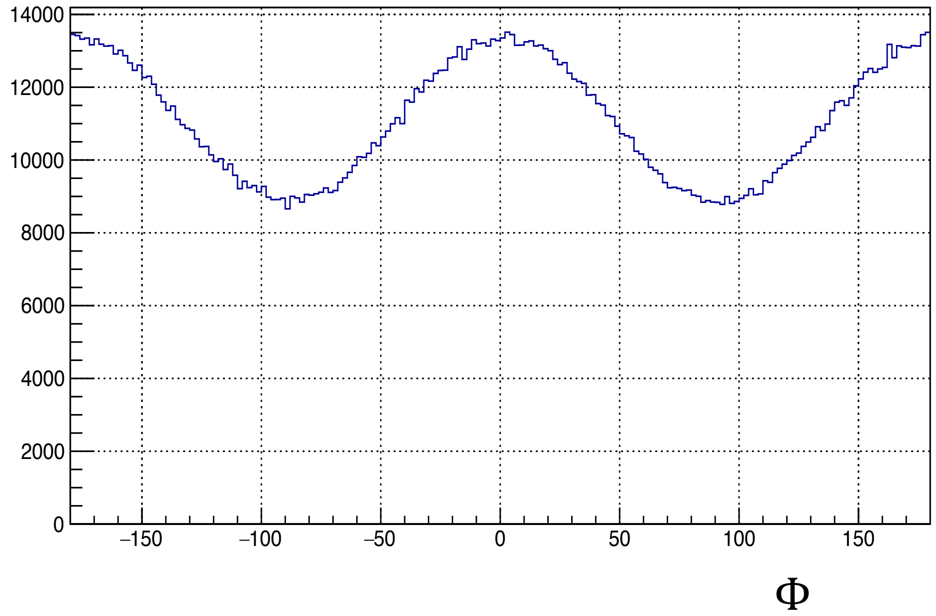


Generated $2*10^6$ $(p\eta'\pi^0)$events with AmpTools









Procedure

For the wave set $[l]^{(\epsilon)}_{m;k} = \left\{S_0^{(+)}, P_{0,1}^{(+)}, D_{0,1,2}^{(+)}\right\}_{k=0}$ with M>= 0

1. Fit intensity to find partial waves using AmpTools.
2. Calculate moments in terms of partial waves

$$H^0(00) = H^1(00) + 2\left[|P_1^{(+)}|^2 + |D_1^{(+)}|^2 + |D_2^{(+)}|^2\right]$$

• • •

$$H^1(22) = H^0(22) + \frac{\sqrt{6}}{7}|D_1^{(+)}|^2 + \frac{\sqrt{6}}{5}|P_1^{(+)}|^2$$

3. Compare results from two different fits
    - Fit 1 : fit with true wave set using good starting values for production coefficients (fit parameters)
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4. Compare these results to moments obtained by weighting each event by corresponding intensity as defined in Mathiew et al.

$$H^0(LM) = \frac{P_\gamma}{2}\int_\circ I(\Omega,\Phi)\, d^L_{M0}(\theta)\cos M\phi,$$

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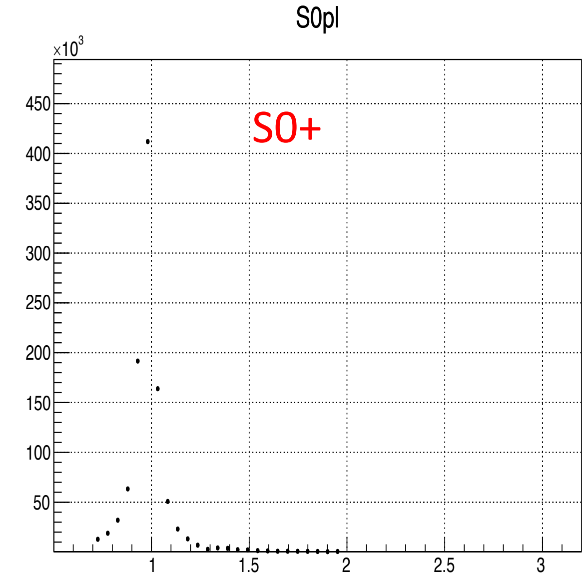
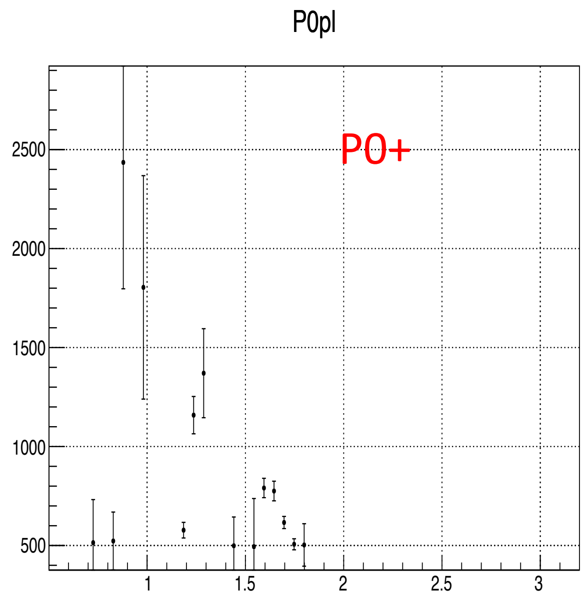
with $\int_\circ = (1/\pi P_\gamma)\int_0^\pi \sin\theta d\theta \int_0^{2\pi} d\phi \int_0^{2\pi} d\Phi$

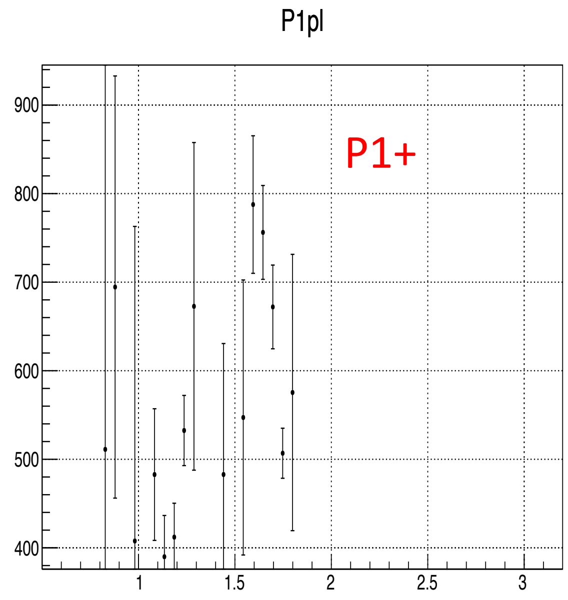
5. Compare to the moments calculated using Vincent's codes.

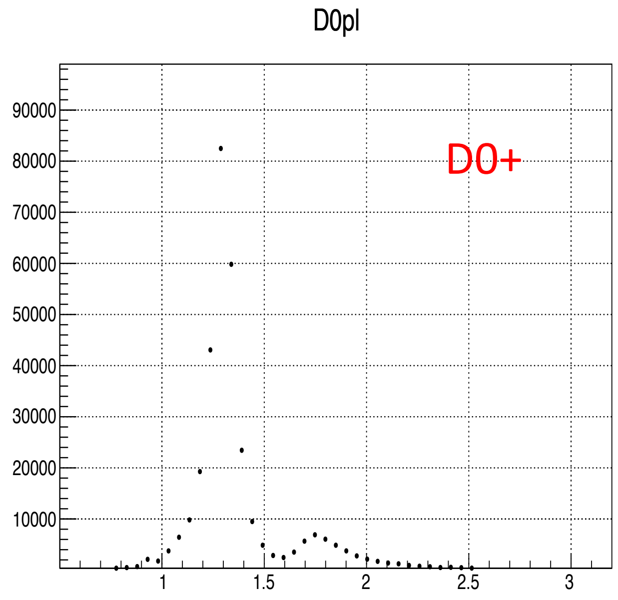
Fit 1 results (fitting in M and t bins)

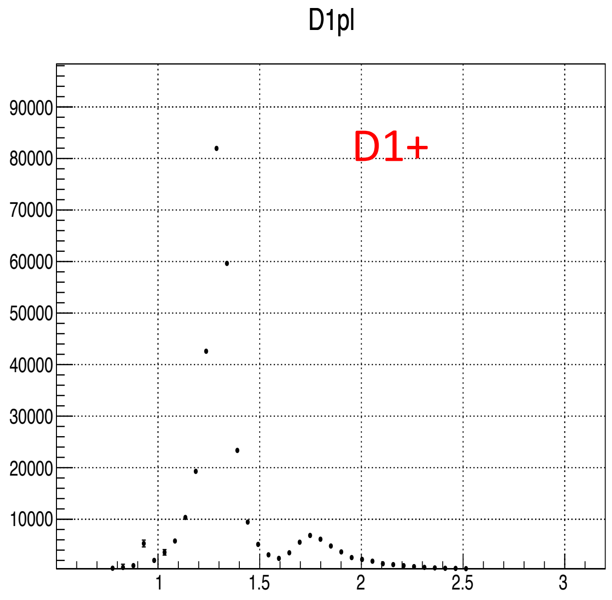
Amplitudes used in fitting are S0-, P0+, P1+, D0+, D1+, D2+. Good starting values for fit parameters

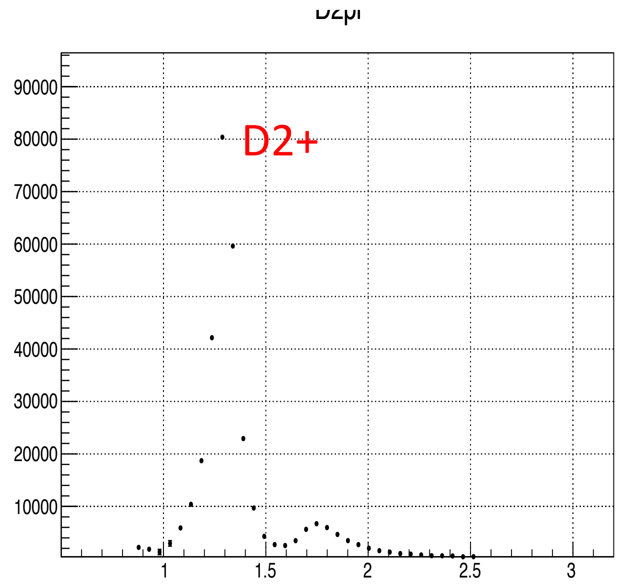


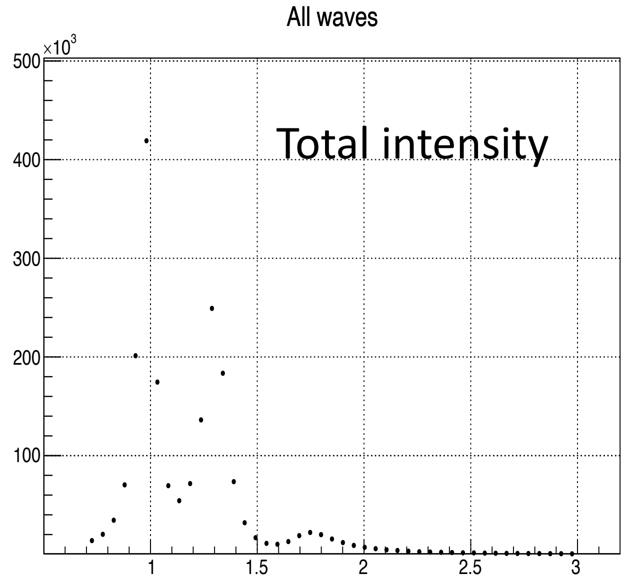






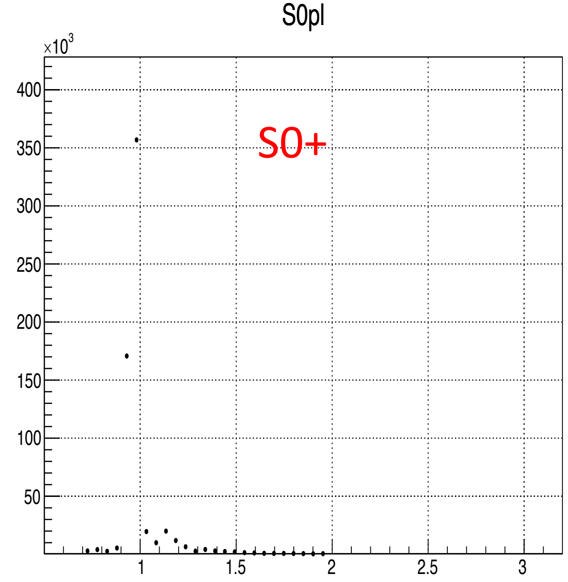


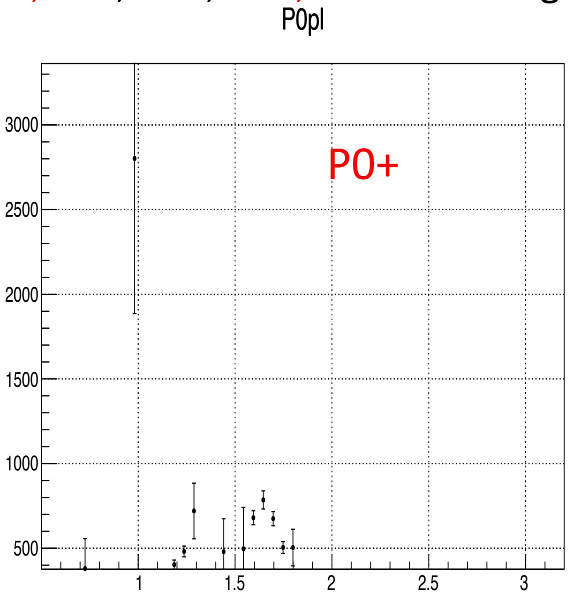


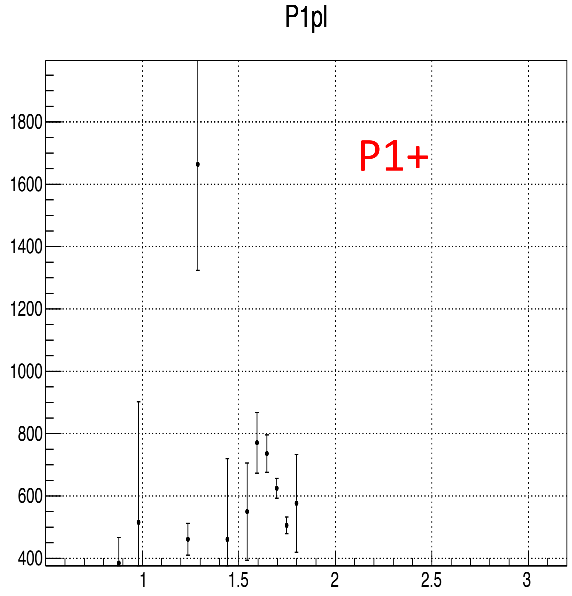


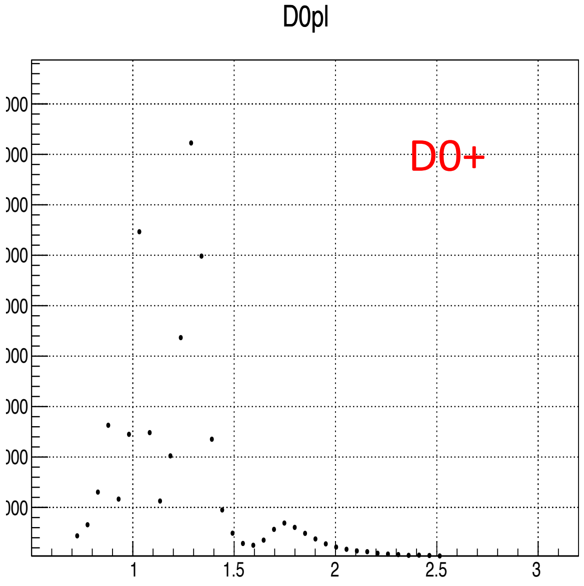
Fit 2 results (fitting in M and t bins)

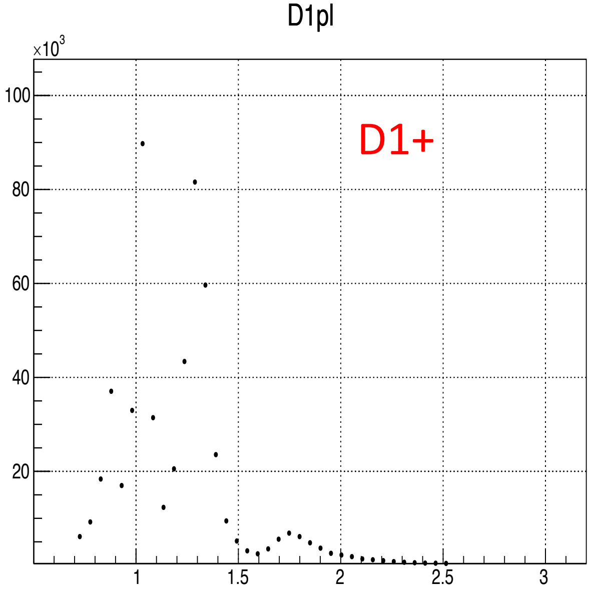
Amplitudes used in fitting are S0-, P0+, P1+, D0+, D1+, D2+. Using 1 for real and imaginary components of the fit parameters

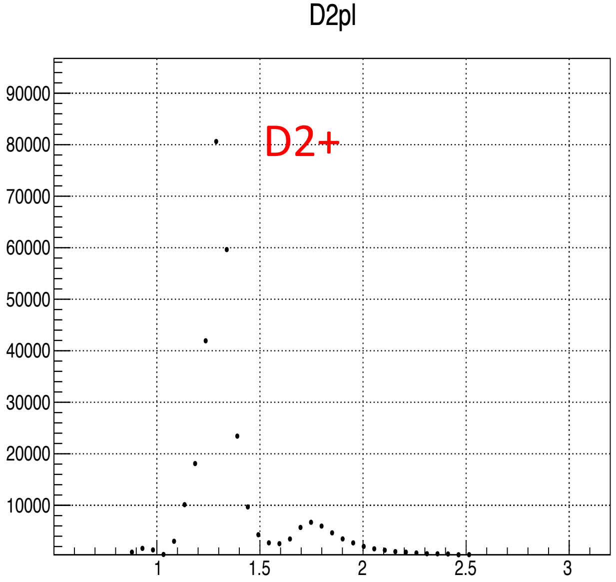


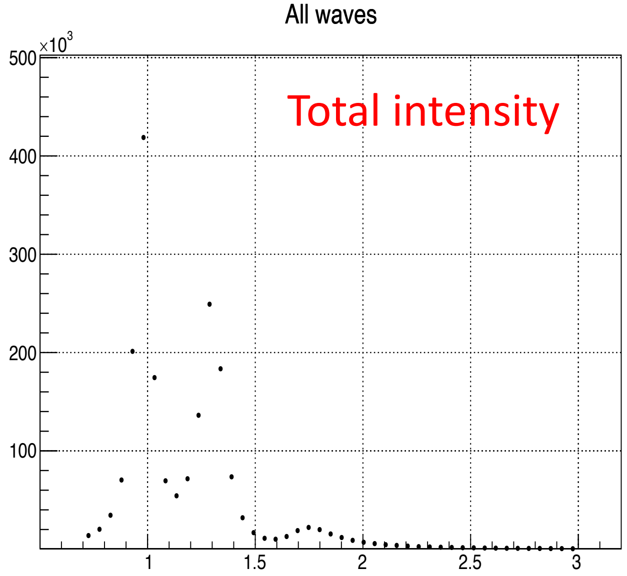












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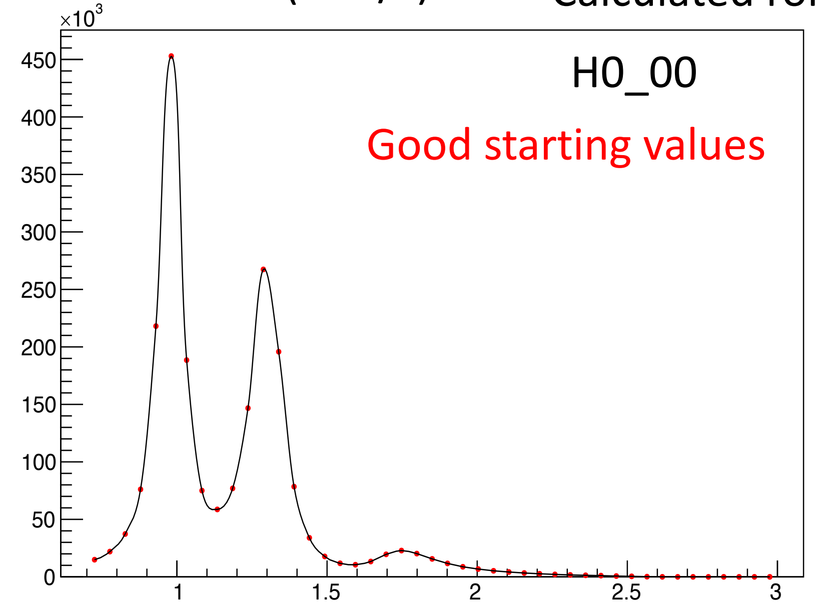
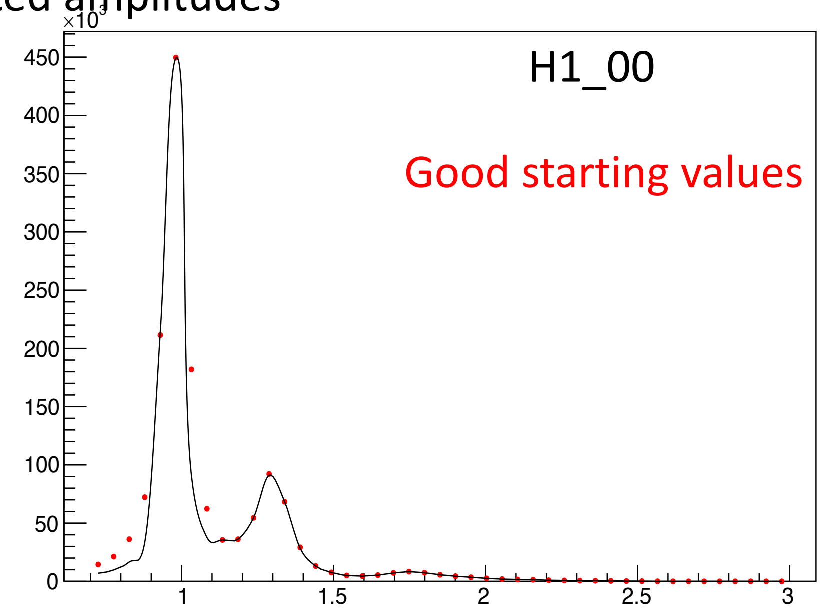
Polarized moments calculated with partial waves

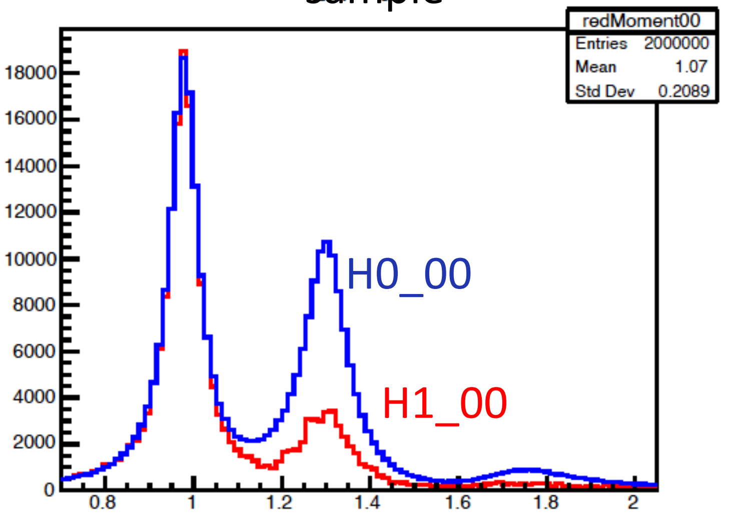
$0<t<0.3\ (GeV/c)^2$

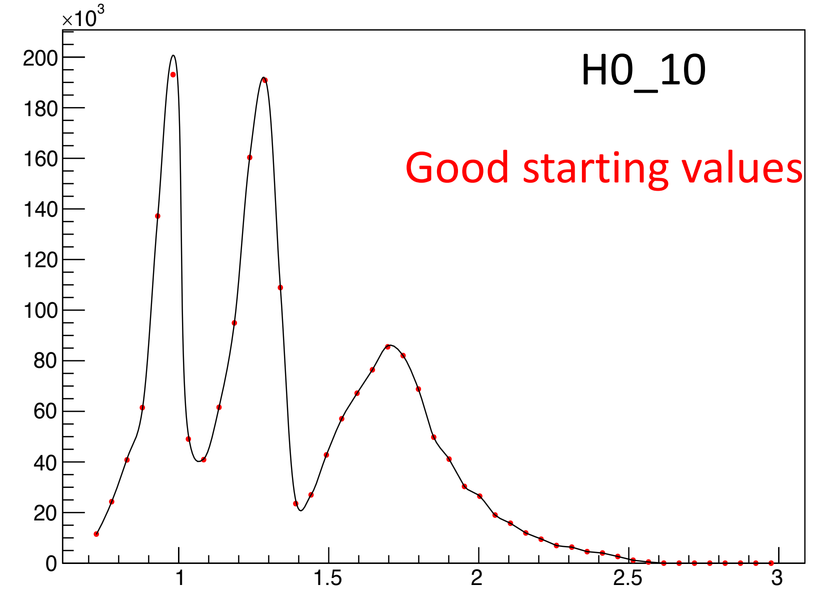
Calculated rom fitted amplitudes

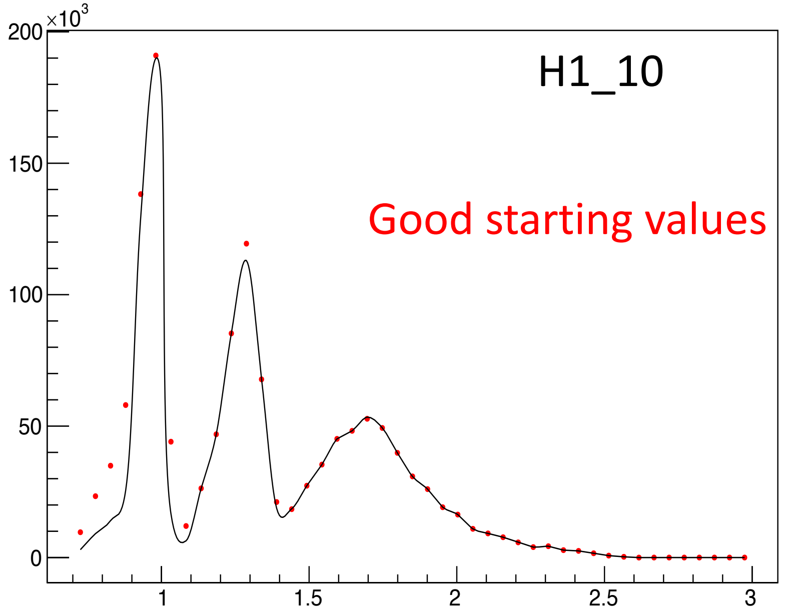
Obtained by weighting events of data sample



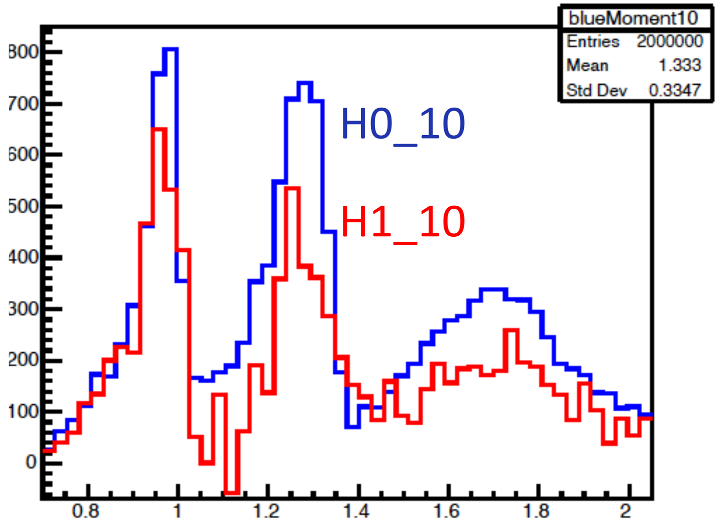








LM = 10



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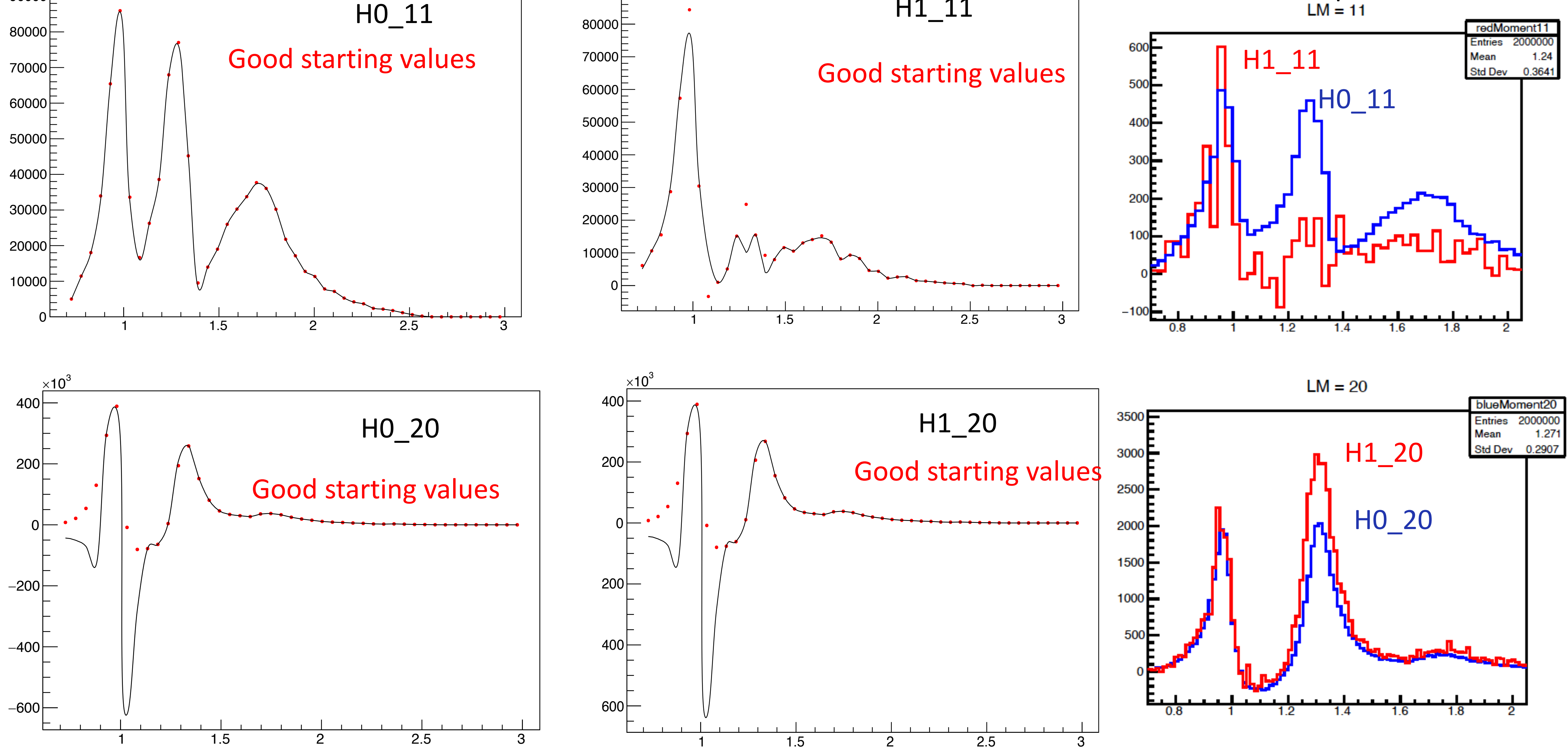

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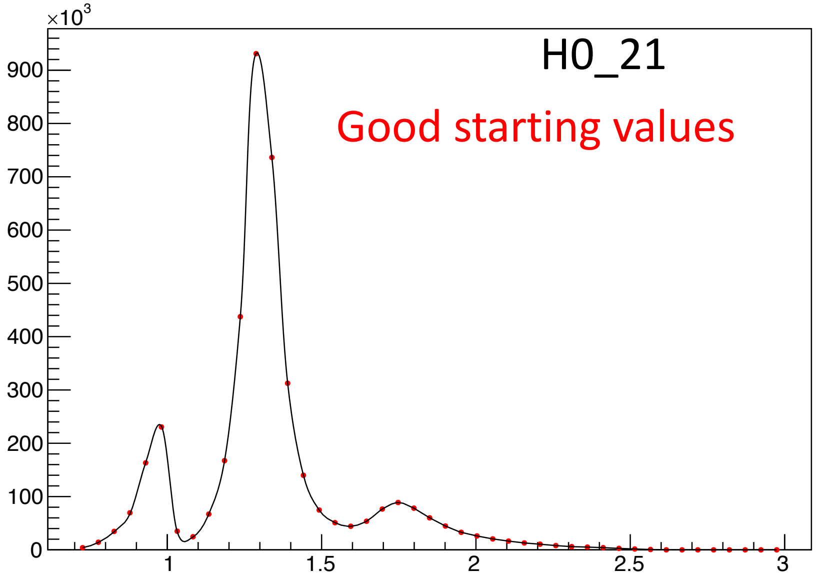
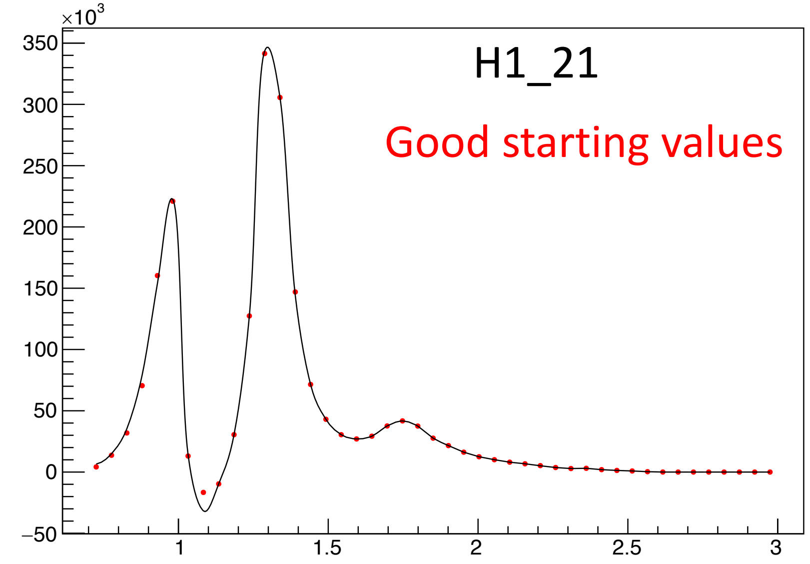
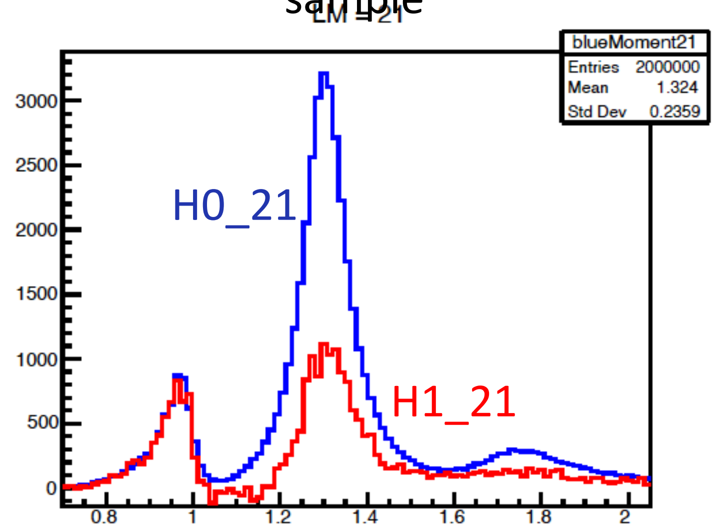
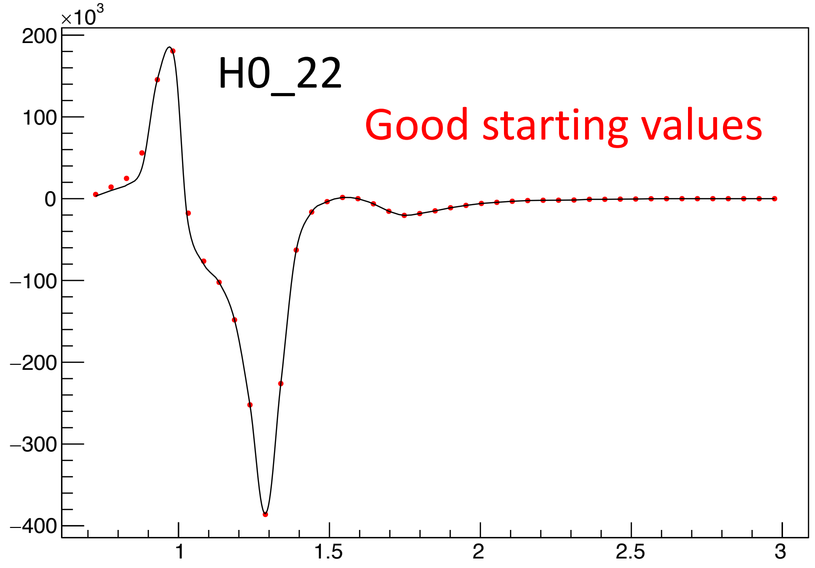
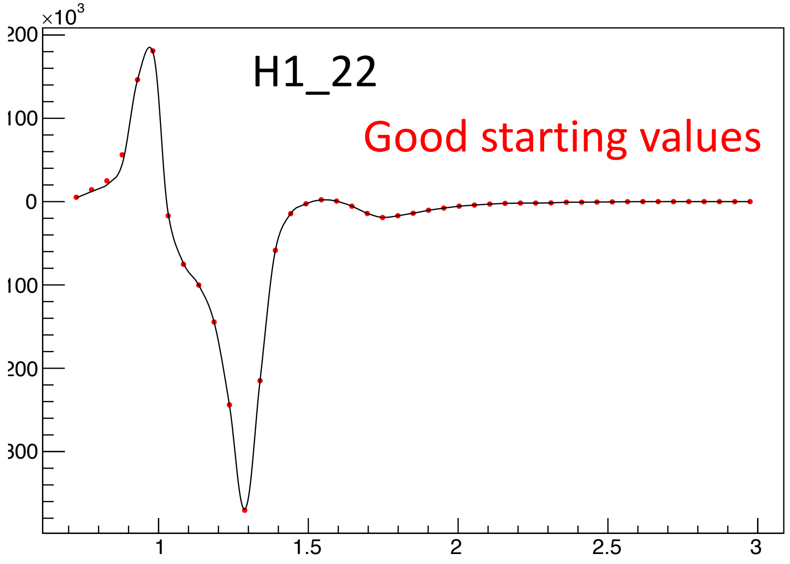
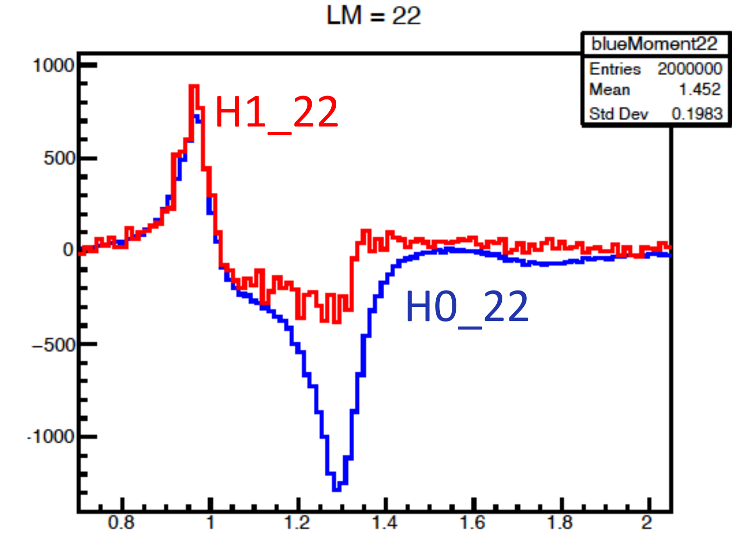












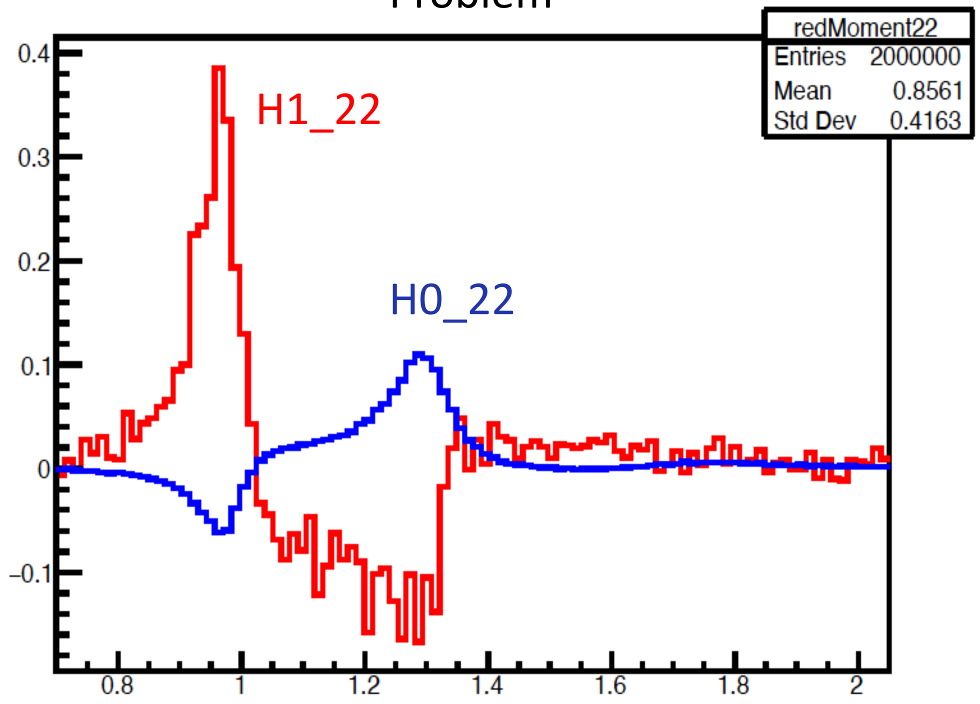
Polarized moments calculated with partial waves

Obtained by weighting events of data sample

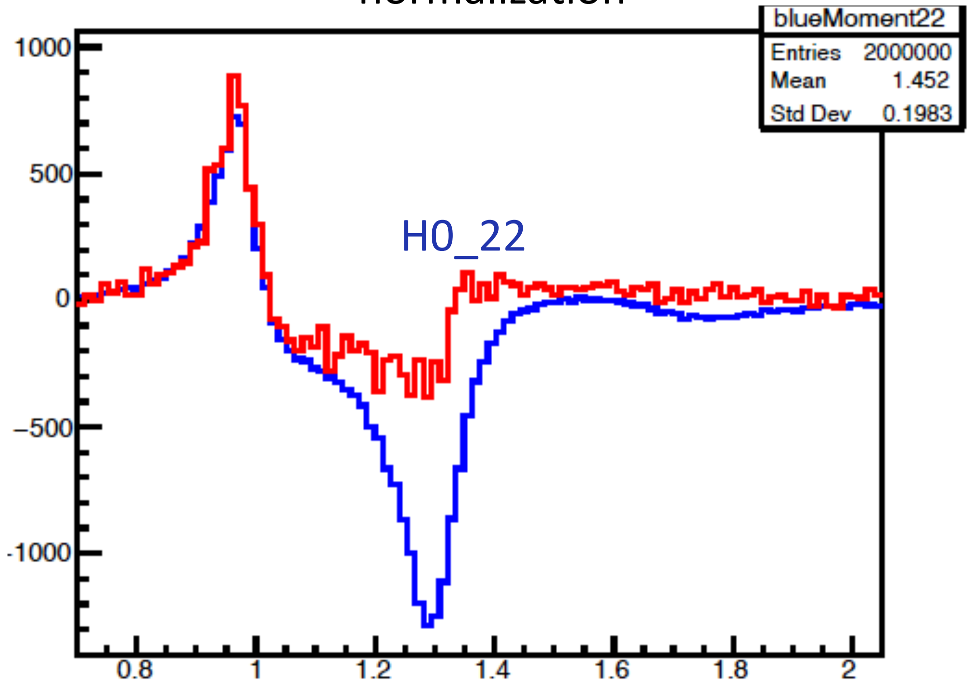
Problem: H0_22 distribution is flipped

Solution: The normalization of the integral to be 1 flips the distribution as integral is negative

Problem



Problem solved by getting rid of normalization



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5. Compare to the moments calculated using Vincent’s codes.

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1st method

$$H^0(LM) = \sum_{\ell\ell'} \left(\frac{2\ell'+1}{2\ell+1}\right)^{1/2} C^{\ell 0}_{\ell' 0 L 0} C^{\ell m}_{\ell' m' L M}\ \rho^{\alpha,\ell\ell'}_{mm'}$$

$$H(LM) = -\sum_{\substack{\ell\ell'\\ mm'}} \left(\frac{2\ell'+1}{2\ell+1}\right)^{1/2} C^{\ell 0}_{\ell' 0 L 0} C^{\ell m}_{\ell' m' L M}\ \rho^{\ell\ell'}_{mm'}$$

$$\rho^{0,\ell\ell'}_{mm'} = \frac{\kappa}{2} \sum_{\lambda,\lambda_1,\lambda_2} T^{\ell}_{\lambda m;\lambda_1\lambda_2} T^{\ell'*}_{\lambda m';\lambda_1\lambda_2},$$

$$\rho^{1,\ell\ell'}_{mm'} = \frac{\kappa}{2} \sum_{\lambda,\lambda_1,\lambda_2} T^{\ell}_{-\lambda m;\lambda_1\lambda_2} T^{\ell'*}_{\lambda m';\lambda_1\lambda_2}$$

$$\rho^{2,\ell\ell'}_{mm'} = i\frac{\kappa}{2} \sum_{\lambda,\lambda_1,\lambda_2} \lambda T^{\ell}_{-\lambda m;\lambda_1\lambda_2} T^{\ell'*}_{\lambda m';\lambda_1\lambda_2},$$

$$\rho^{3,\ell\ell'}_{mm'} = \frac{\kappa}{2} \sum_{\lambda,\lambda_1,\lambda_2} \lambda T^{\ell}_{\lambda m;\lambda_1\lambda_2} T^{\ell'*}_{\lambda m';\lambda_1\lambda_2}$$

2nd method

$$H^0(00) = H^1(00) + 2\left[|P_1^{(+)}|^2 + |D_1^{(+)}|^2 + |D_2^{(+)}|^2\right]$$

• • •

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Neglect t dependence due to barrier factor $(\sqrt{-t})^{|m-1|}$

$$[\ell]^{(+)}_{m;0} = N_0 N_R \left(\delta_R \frac{\sqrt{-t}}{m_R}\right)^{|m-1|} \Delta_R(m_{\eta\pi}) P_V(s,t)$$

$$\Delta_R(m_{\eta\pi}) = \frac{m_R\Gamma_R}{m_R^2 - m_{\eta\pi}^2 - i m_R \Gamma_R}$$

$$P_V(s,t) = \Gamma[1-\alpha(t)]\left(1 - e^{-i\pi\alpha(t)}\right) s^{\alpha(t)}$$

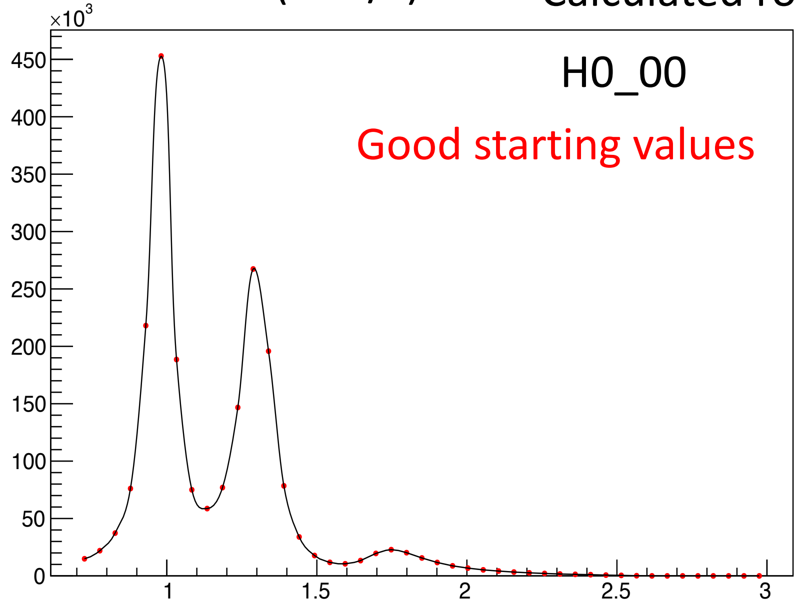
N_0-overall normalization, N_R-relative normalization, δ_R- helicity-flip coupling

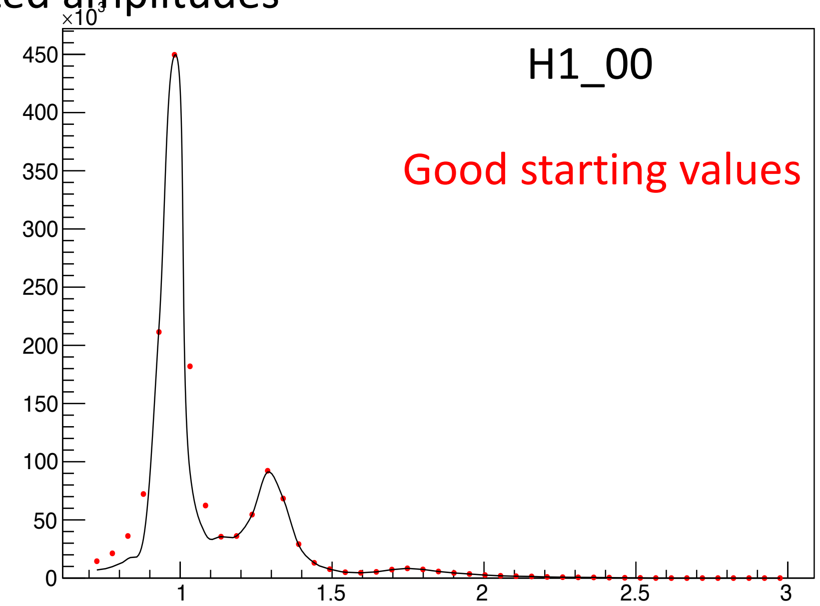
Polarized moments calculated with partial waves

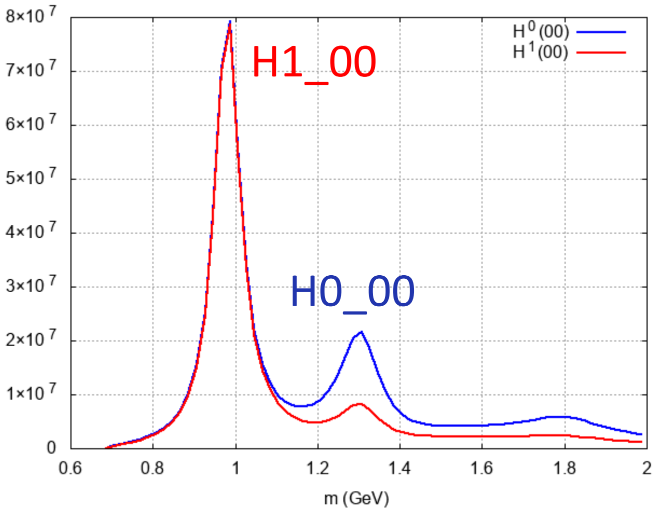
0<t<0.3 $(GeV/c)^2$

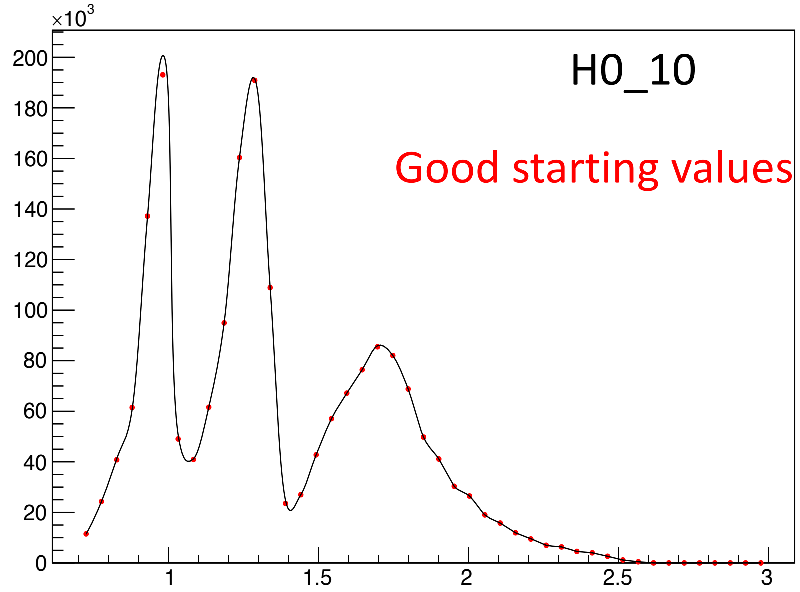
Calculated rom fitted amplitudes

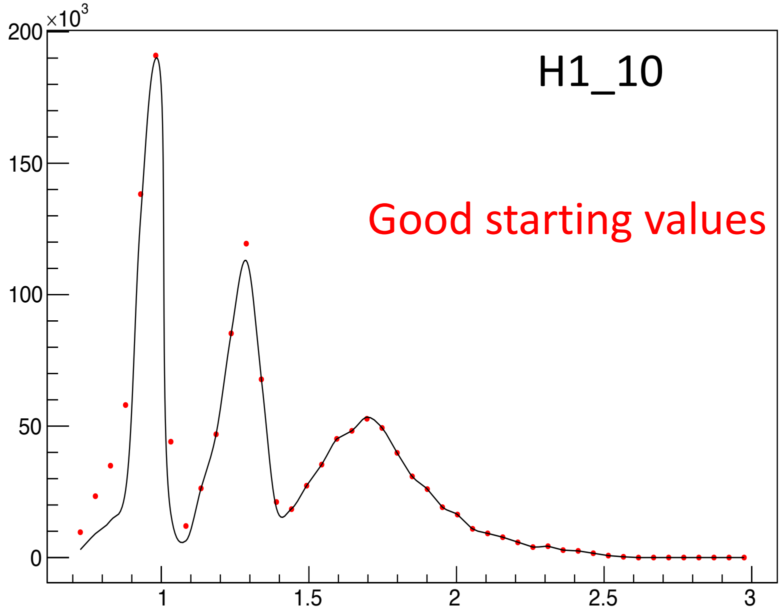
Obtained by weighting events of data sample

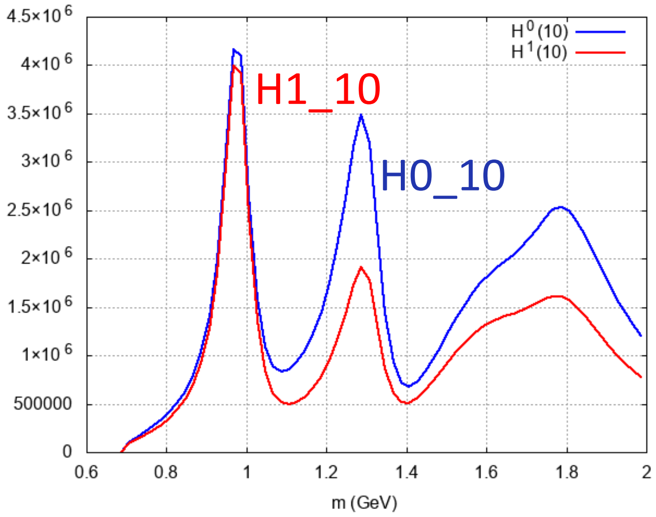












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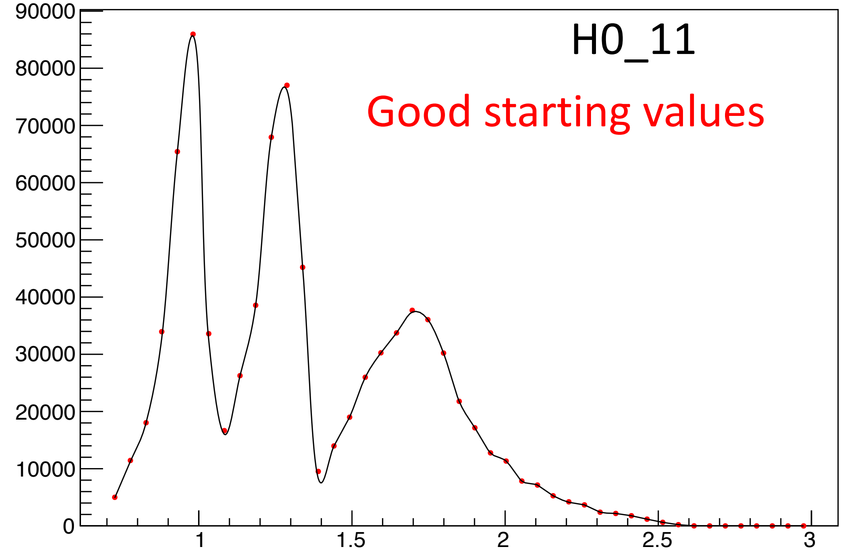

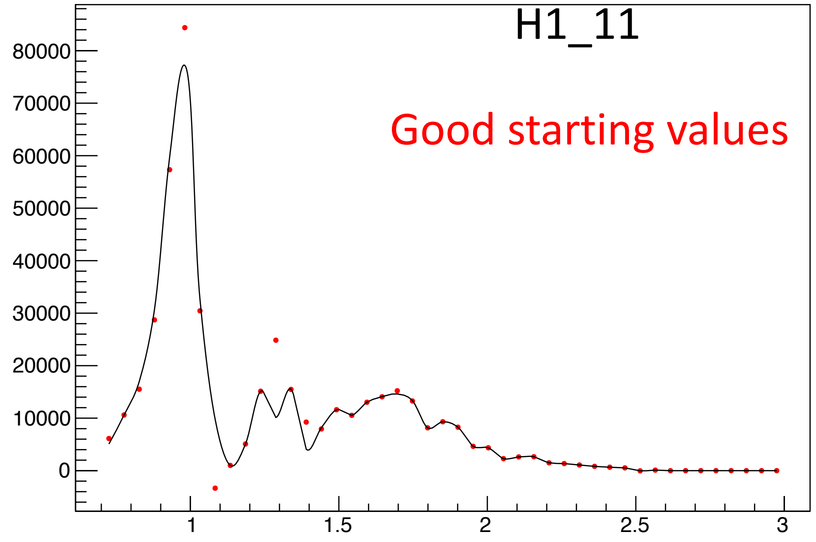

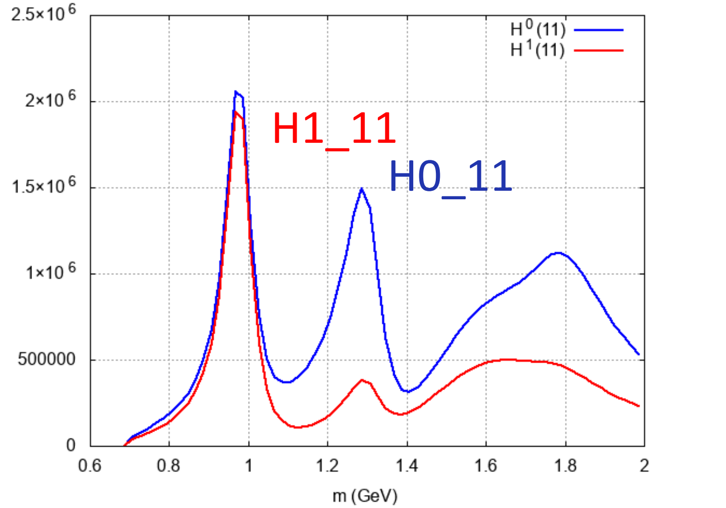

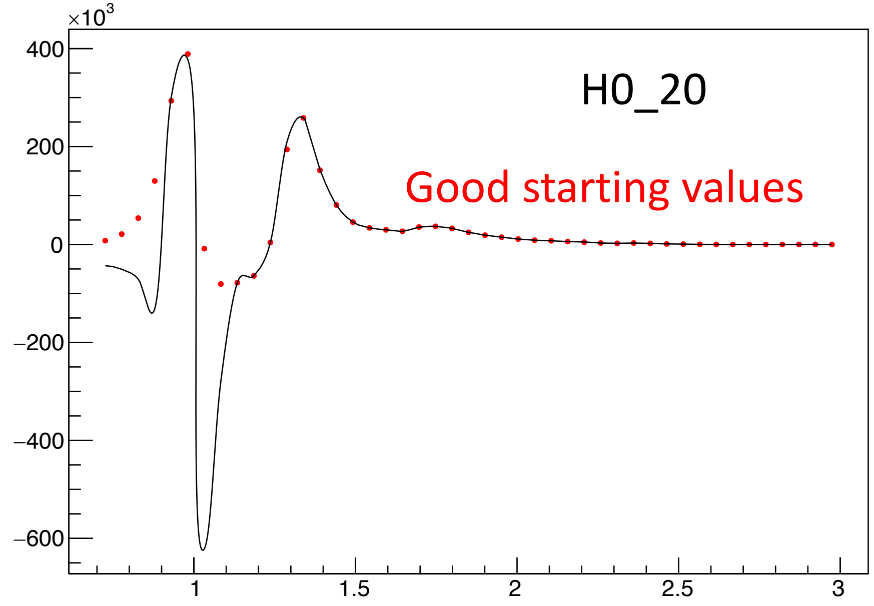

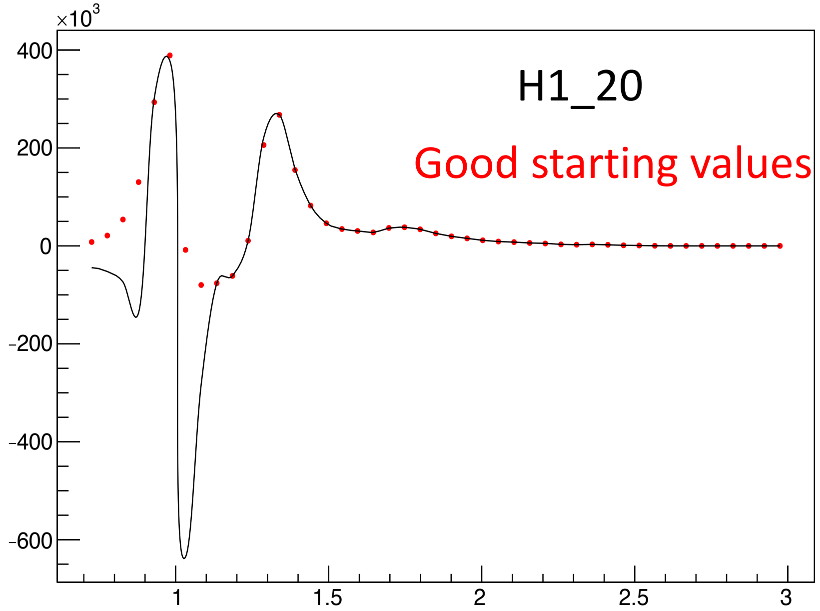

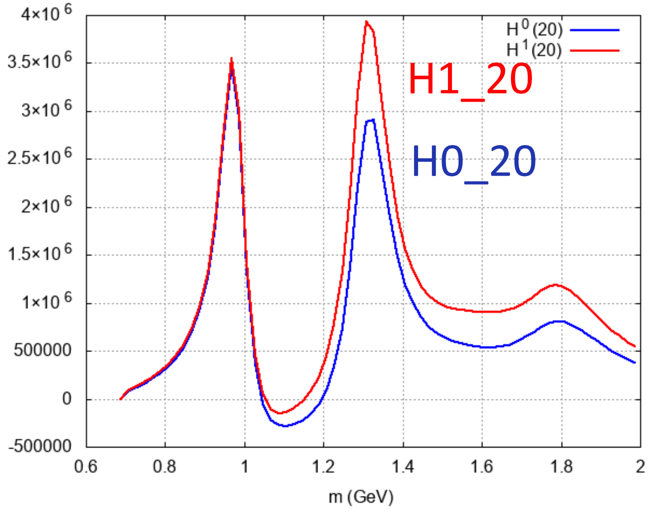

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