A MC study of JPAC's $\eta\pi$ Moments

- Comparing different methods to calculate moments
- Effects of GlueX acceptance on calculated moments
- Recognize a P-wave on generated/accepted moments

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Generate Waves/Resonances

γp->ηπp->($\gamma\gamma$)($\gamma\gamma$)p

t-distribution: exp. with b=4.0

E_photon=(7.6-8.2) according to data

Polarization=40%

Diamond angle =0

PyPWA-simulation (different set of waves)

mass,width

a0(980):0.980;0.075

a2(1320):1.306;0.114

π1(1600):1.584;0.492

a2(1700):1.722;0.247

Acceptance

mcwrapper/G3

reconstruction/jana

reaction filter/etapi0__B4

DSelector: analysis cuts

Moments

$$I(\phi,\theta) = \sum_{L,M} H(LM) Y_L^M(\phi,\theta)$$

from waves

$$\boxed{H(LM) = \sum_{l,m,l',m'} \left(\frac{2l'+1}{2l+1}\right)^{1/2} {}^{\epsilon}\rho_{l,m,l',m'} (l'm'LM|lm)(l'0L0|l0).}$$

$${}^{\epsilon}\rho_{l,m,l',m'} = \sum_k {}^{\epsilon}T_{lmk}\, {}^{\epsilon}T^{*}_{l'm'k} = {}^{\epsilon}T_{lm}\, {}^{\epsilon}T^{*}_{l'm'}$$

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

$$H^1(00) = 2\left[|S_0^{+}|^2 + |P_0^{(+)}|^2 + |D_0^{(+)}|^2\right]$$

$$H^0(10) = H^1(10) + \frac{4}{\sqrt{5}} Re(P_1^{(+)} D_1^{(+)*})$$

$$H^1(10) = \frac{8}{\sqrt{15}} Re(P_0^{(+)} D_0^{(+)*}) + \frac{4}{\sqrt{3}} Re(S_0^{(+)} P_0^{(+)*})$$

$$H^0(11) = H^1(11) + 2\frac{2}{\sqrt{5}} Re(P_1^{(+)} D_2^{(+)*})$$

$$H^1(11) = \frac{2}{\sqrt{5}} Re(P_0^{(+)} D_1^{(+)*}) - \frac{2}{\sqrt{15}} Re(P_1^{(+)} D_0^{(+)*}) + \frac{2}{\sqrt{3}} Re(S_0^{(+)} P_1^{(+)*})$$

$$H^0(20) = H^1(20) - \frac{2}{5}|P_1^{(+)}|^2 + \frac{2}{7}|D_1^{(+)}|^2 - \frac{4}{7}|D_2^{(+)}|^2$$

$$H^1(20) = \frac{4}{5}|P_0^{(+)}|^2 + \frac{4}{7}|D_0^{(+)}|^2 + \frac{4}{\sqrt{5}} Re(S_0^{(+)} D_0^{(+)*})$$

$$H^0(21) = H^1(21) + \frac{2}{7}\sqrt{6} Re(D_1^{(+)} D_2^{(+)*})$$

$$H^1(21) = \frac{2}{\sqrt{5}} Re(S_0^{(+)} D_1^{(+)*}) + \frac{2\sqrt{3}}{5} Re(P_0^{(+)} P_1^{(+)*}) + \frac{2}{7} Re(D_0^{(+)} D_1^{(+)*})$$

$$H^0(22) = \frac{2}{\sqrt{5}} Re(S_0^{(+)} D_2^{(+)*}) - \frac{4}{7} Re(D_0^{(+)} D_2^{(+)*})$$

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

Unnormalized moments

$$H^0(LM) = \int d\Omega I(\Omega) D^L_{M0}(\phi,\theta,0)$$

$$H^1(LM) = \int d\Omega I(\Omega) D^L_{M0}(\phi,\theta,0) cos(2\Phi)$$

$$H^0(LM) = \sum_i^N Re(D^L_{M0}(\phi_i,\theta_i,0)) = \sum_i^N h^0(LM)$$

$$H^1(LM) = \sum_i^N Re(D^L_{M0}(\phi_i,\theta_i,0)) cos(2\Phi) = \sum_i^N h^1(LM)$$

$$h(000) = 1$$

$$h(010) = cos(\theta)$$

$$h(011) = \frac{-1}{\sqrt{2}} sin(\theta) cos(\phi)$$

$$h(020) = \frac{1}{2} * (3cos^2(\theta) - 1)$$

$$h(021) = \frac{-\sqrt{3}}{2} sin(\theta) cos(\theta) cos(\phi)$$

$$h(022) = \frac{\sqrt{6}}{4}(1 - cos^2(\theta)) cos(2\phi)$$

$$h(030) = \frac{1}{2}(5cos^3(\theta) - 3cos(\theta))$$

$$h(031) = \frac{-\sqrt{3}}{4} sin(\theta)(5cos^2(\theta) - 1) cos(\phi)$$

$$h(032) = \sqrt{\frac{15}{8}}(1 - cos^2(\theta)) cos(\theta) cos(2\phi)$$

$$h(033) = \frac{-\sqrt{5}}{4}(1 - cos^2(\theta))^{\frac{3}{2}} cos(3\phi)$$

$$h(040) = \frac{1}{8}(35cos^4(\theta) - 30cos^2(\theta) + 3)$$

$$h(041) = \frac{-\sqrt{5}}{4} sin(\theta)(7cos^3(\theta) - 3cos(\theta)) cos(\phi)$$

$$h(042) = \sqrt{\frac{5}{32}}(1 - cos^2(\theta))(7cos^2(\theta) - 1) cos(2\phi).$$

$$h(100) = cos(2\Phi)$$

$$h(110) = cos(\theta) cos(2\Phi)$$

$$h(111) = \frac{-1}{\sqrt{2}} sin(\theta) cos(\phi) cos(2\Phi)$$

$$h(120) = \frac{1}{2} * (3cos^2(\theta) - 1) cos(2\Phi)$$

$$h(121) = \frac{-\sqrt{3}}{2} sin(\theta) cos(\theta) cos(\phi) cos(2\Phi)$$

$$h(122) = \frac{\sqrt{6}}{4}(1 - cos^2(\theta)) cos(2\phi) cos(2\Phi)$$

$$h(130) = \frac{1}{2}(5cos^3(\theta) - 3cos(\theta)) cos(2\Phi)$$

$$h(131) = \frac{-\sqrt{3}}{4} sin(\theta)(5cos^2(\theta) - 1) cos(\phi) cos(2\Phi)$$

$$h(132) = \sqrt{\frac{15}{8}}(1 - cos^2(\theta)) cos(\theta) cos(2\phi) cos(2\Phi)$$

$$h(133) = \frac{-\sqrt{5}}{4}(1 - cos^2(\theta))^{\frac{3}{2}} cos(3\phi) cos(\Phi)$$

$$h(140) = \frac{1}{8}(35cos^4(\theta) - 30cos^2(\theta) + 3) cos(2\Phi)$$

$$h(141) = \frac{-\sqrt{5}}{4} sin(\theta)(7cos^3(\theta) - 3cos(\theta)) cos(\phi) cos(2\Phi)$$

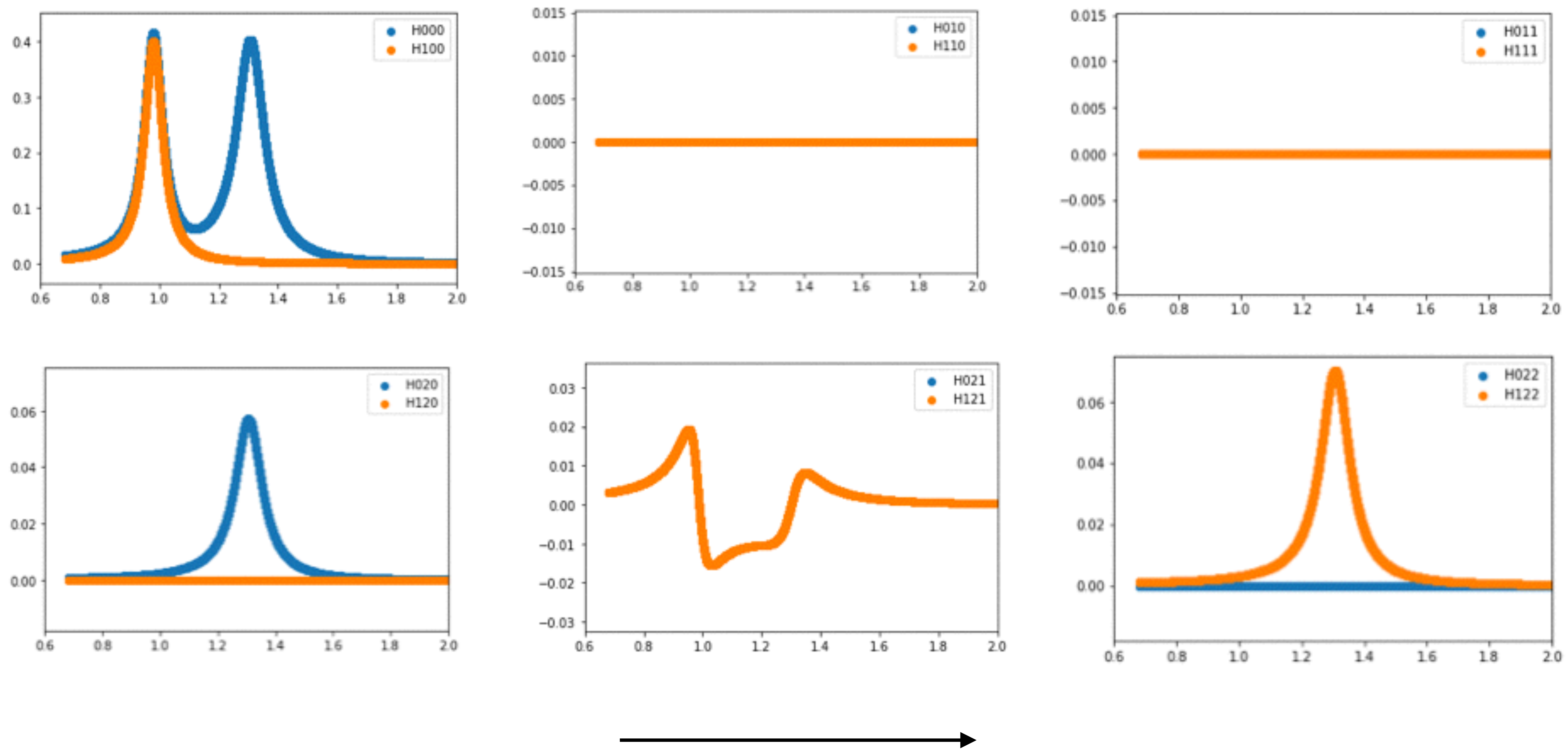
$$h(142) = \sqrt{\frac{5}{32}}(1 - cos^2(\theta))(7cos^2(\theta) - 1) cos(2\phi) cos(2\Phi).$$

{S,D}-waves moments

(only 2 waves)

0.5. |1,0,0>:a_0
0.5 .|1,2,1>:a_2

Moments from Waves



mass

$$H^0(00) = H^1(00) + 2[|D_1^{(+)}|^2]$$
$$H^1(00) = 2[|S_0^{+}|^2]$$
$$H^0(10) = 0$$
$$H^1(10) = 0$$
$$H^0(11) = 0$$
$$H^1(11) = 0$$

no-P wave

$$H^0(20) = \frac{2}{7}|D_1^{(+)}|^2$$
$$H^1(20) = 0$$
$$H^0(21) = H^1(21)$$
$$H^1(21) = \frac{2}{\sqrt{5}} Re(S_0^{(+)} D_1^{(+)*})$$
$$H^0(22) = 0$$
$$H^1(22) = \frac{\sqrt{6}}{7}|D_1^{(+)}|^2$$

generated MC **accepted MC**

{S,D}-waves moments

Unnormalized Moments

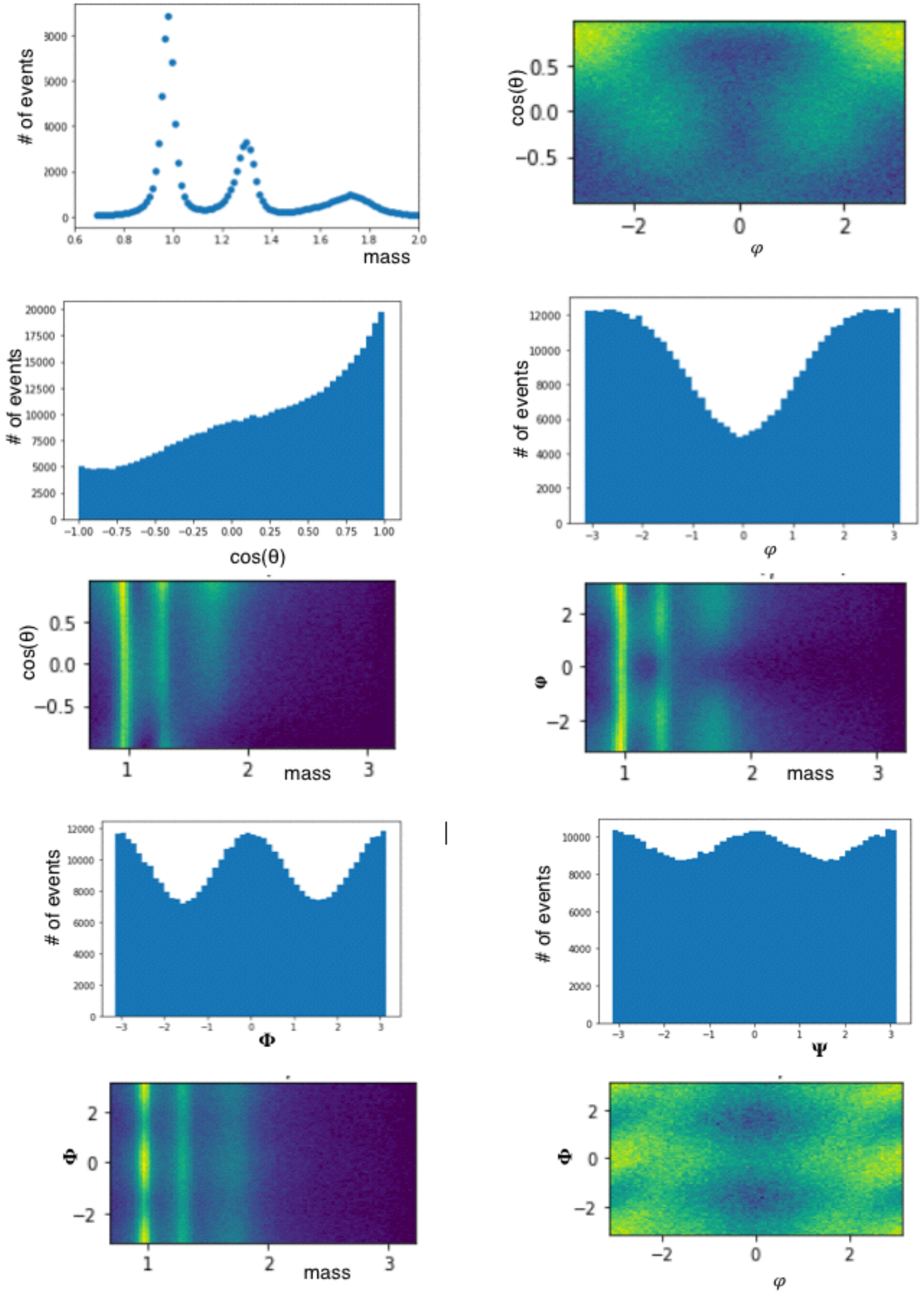
mass

- Both methods produced similar results.
- GlueX acceptance can mimic P waves.

(errors:stat/root)

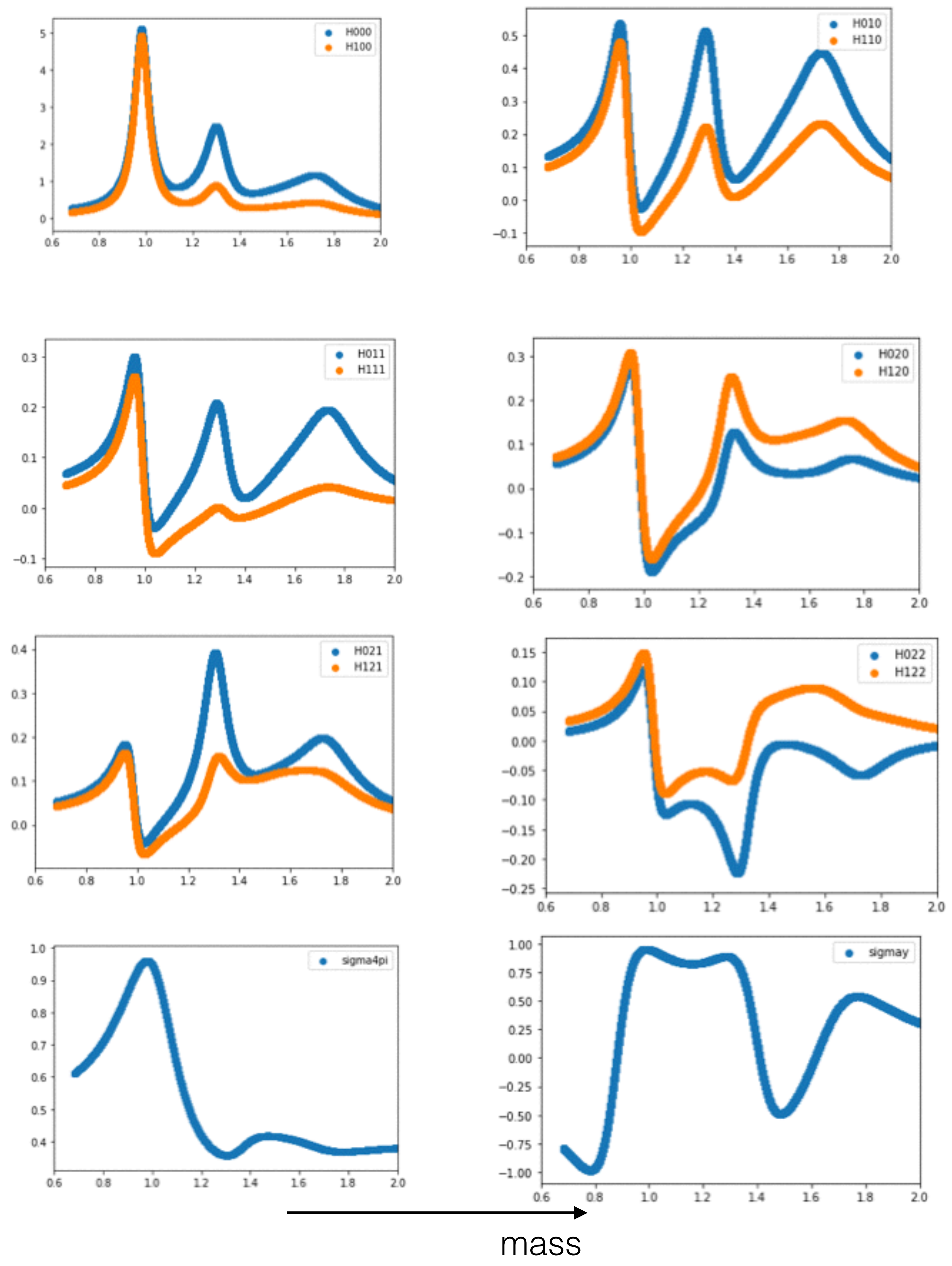
{S,P,D}-waves moments

(with P waves)



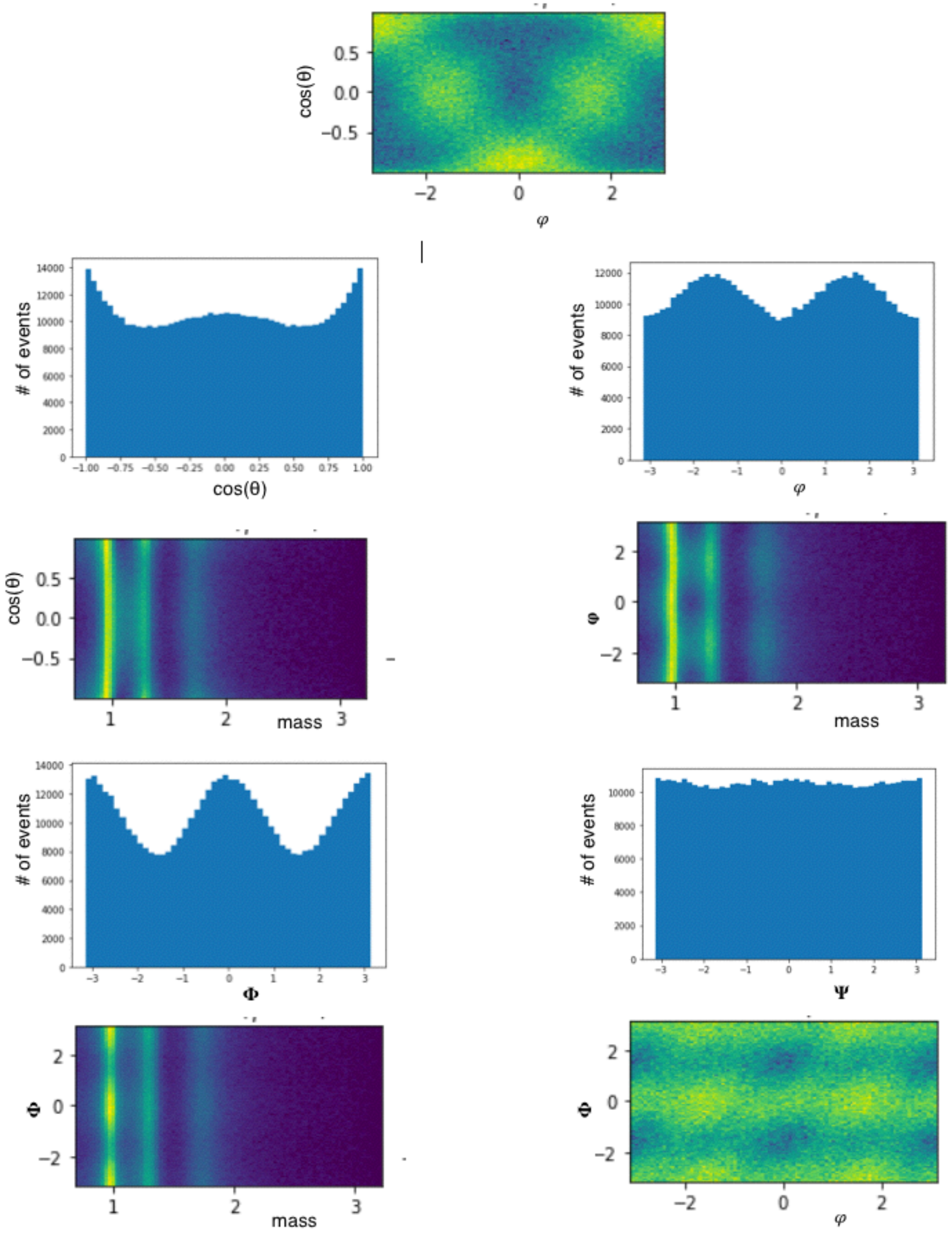
0.7 . |1,0,0>:a_0
0.15 .|1,2.0,>+|1,2,1>+|1,2,2>:a_2
0.05 .|1,1.0,>+|1,1,1>:$\boldsymbol{\pi}_1$
0.1 .|1,2.0,>+|1,2,1>+|1,2,2>:a_2

Moments from Waves



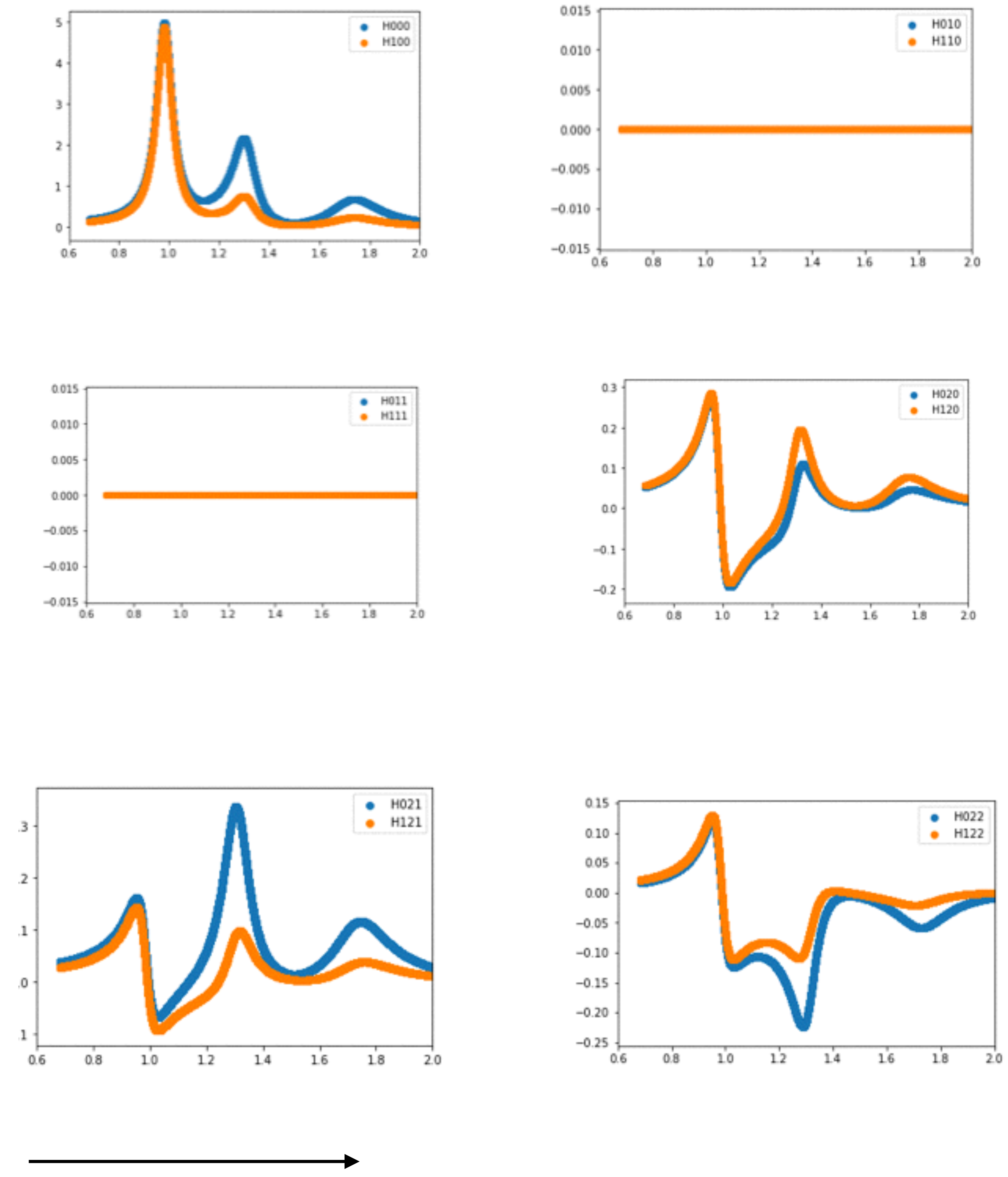
{S.D}-waves moments

(without P waves)



0.7 . |1,0,0>:a_0
0.2 .|1,2.0,>+|1,2,1>+|1,2,2>:a_2
0.1 .|1,2.0,>+|1,2,1>+|1,2,2>:a_2

Moments from Waves



mass

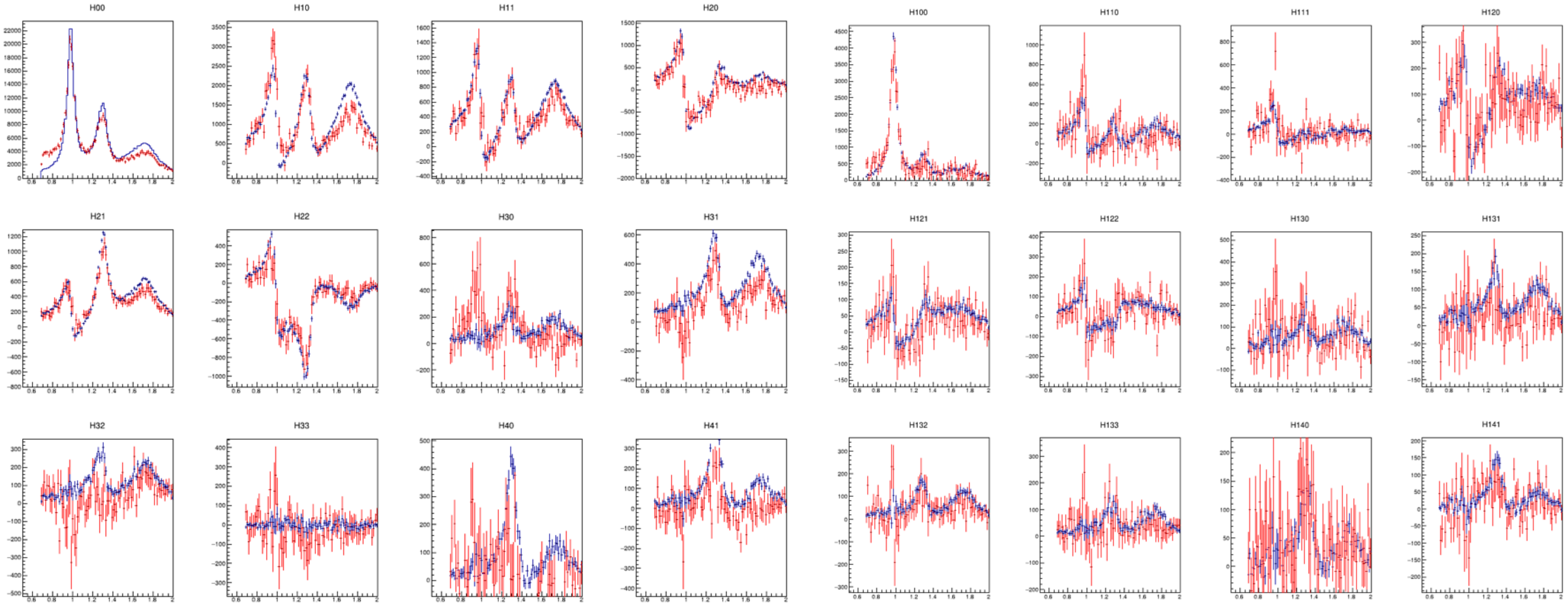
25 words

{S,P,D}-waves moments

generated MC **accepted MC**

(with P waves)

Unnormalized Moments



mass (GeV)

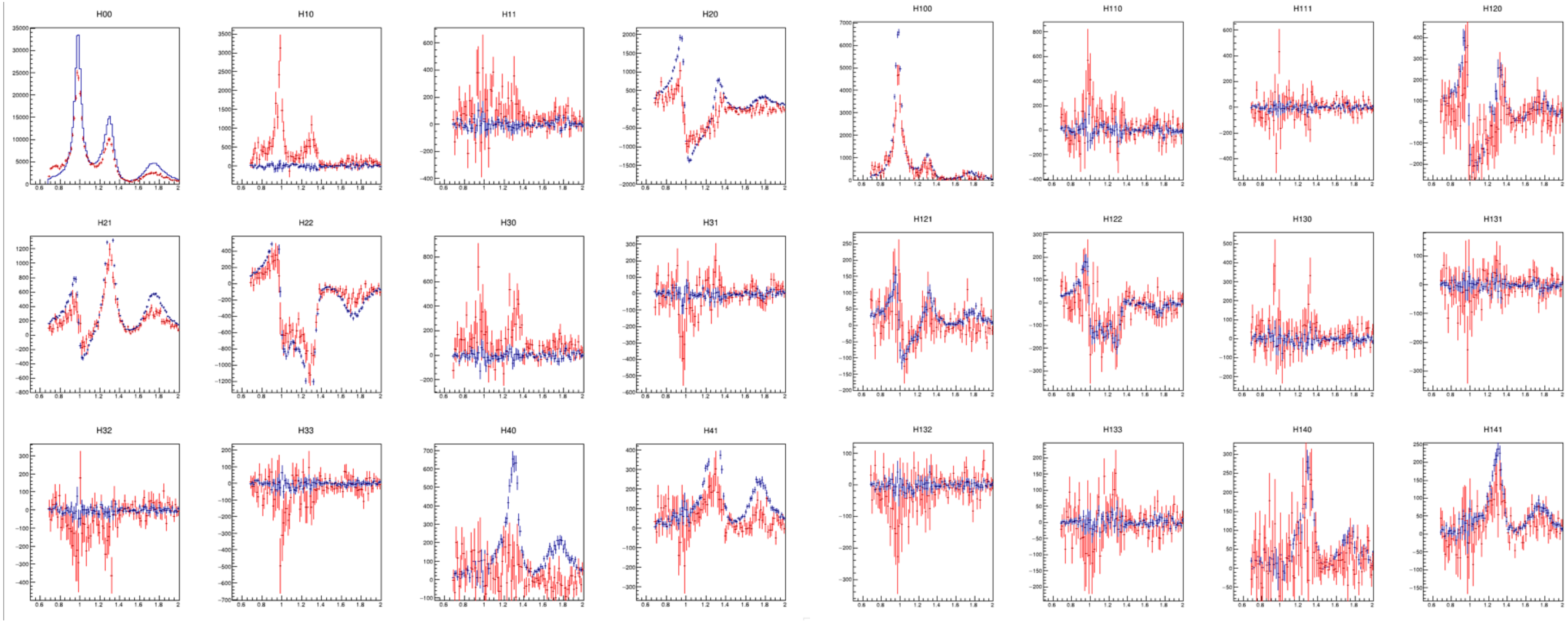
(errors:stat/root)

{S,D}-waves moments

generated MC **accepted MC**

(without P waves)

Unnormalized Moments



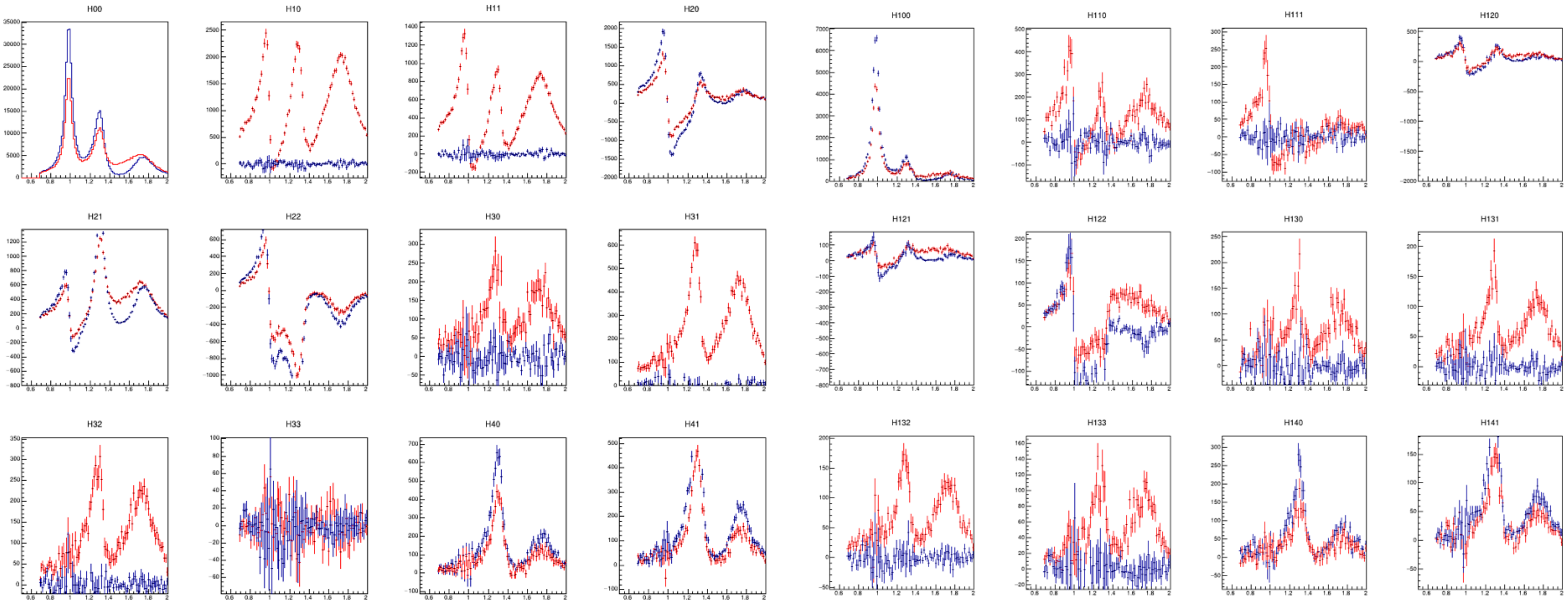
mass (GeV)

(errors:stat/root)

Comparing models with and w/o P waves

generated MC **{S,P,D}-waves moments** **{S,D}-waves moments**

Unnormalized Moments

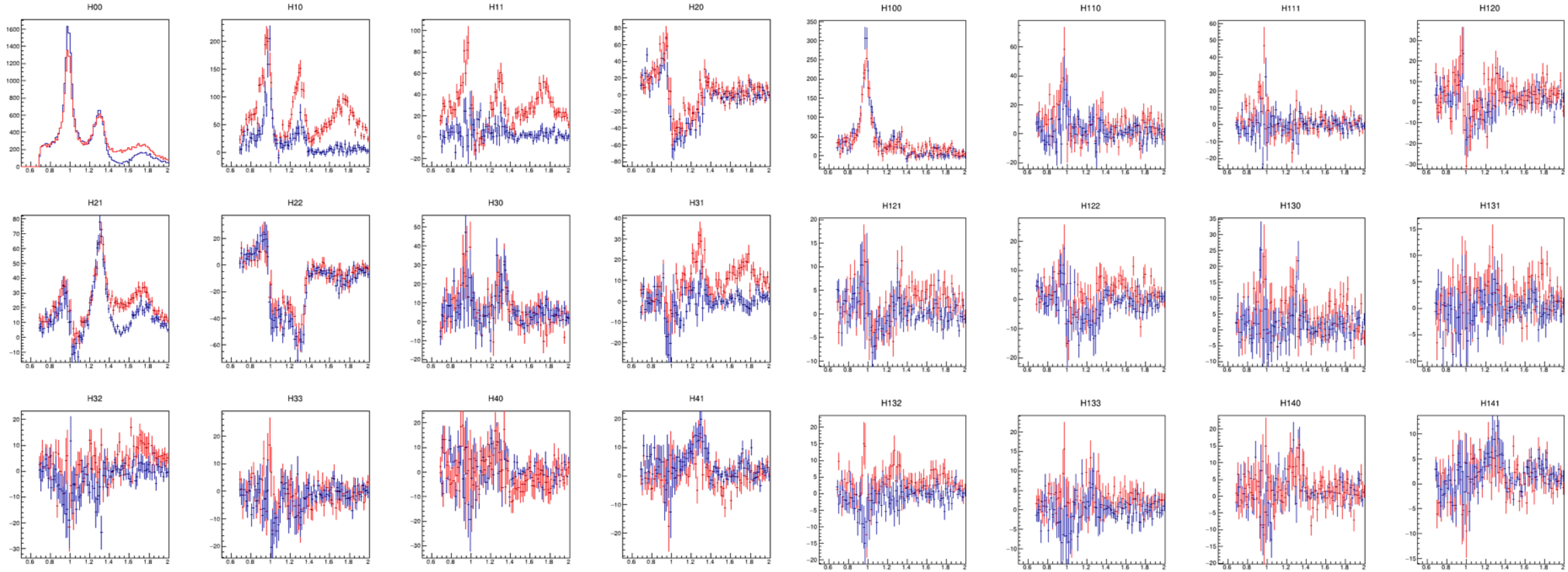


mass (GeV)

(errors:stat/root)

accepted MC **{S,P,D}-waves moments** **{S,D}-waves moments**

Unnormalized Moments



mass (GeV)

(errors:stat/root)

Summary

- Comparing different methods to calculate moments -> Both methods produced similar results.
- Effects of GlueX acceptance on calculated moments -> GlueX acceptance can mimic P waves.
- Recognize P-waves on generated/accepted moments -> Followed theoretical trend but they are smeared by acceptance.

Next

- Comparing different methods to extract acceptance-corrected moments from “data”.
- Will acceptance-correction methods help to recognize P-waves from background/acceptance interferences?