AI-driven evaluation of $\pi^+ n$ electroproduction cross sections and structure functions from the CLAS data

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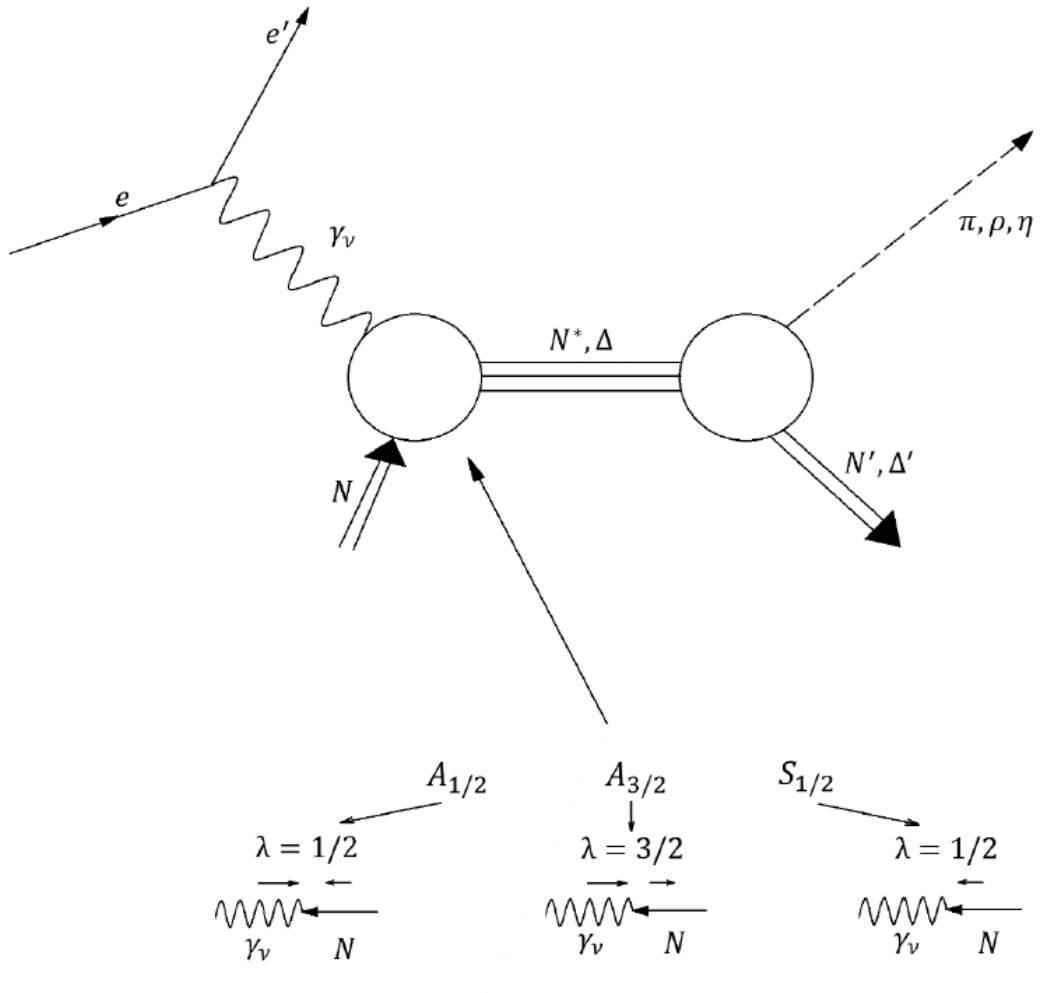
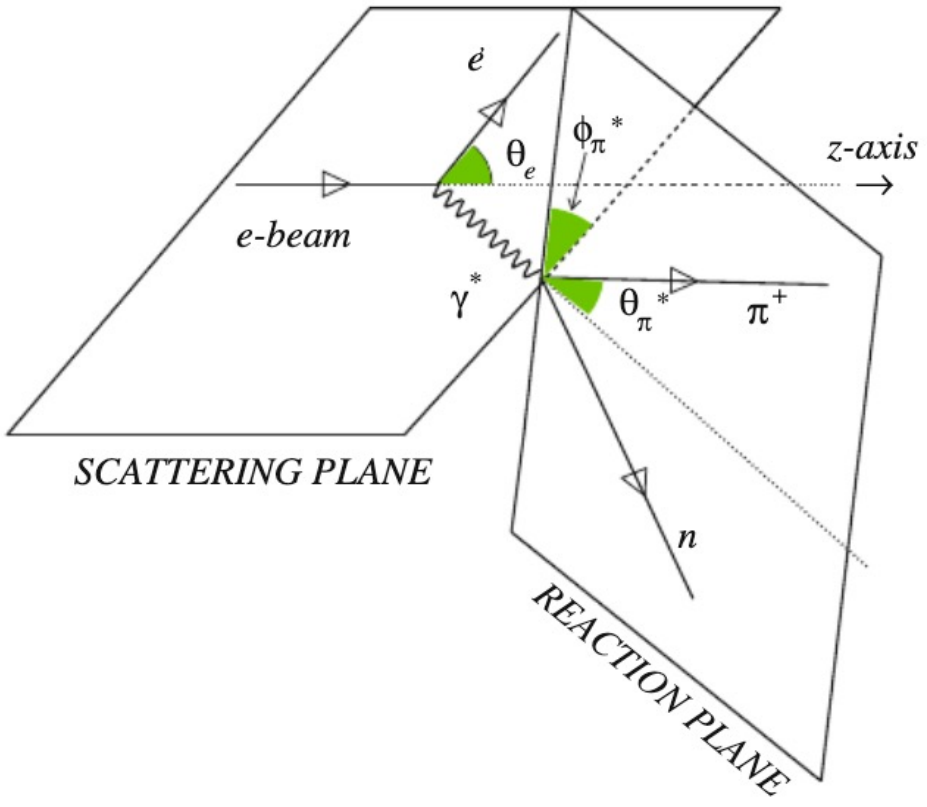
2024

Reaction



$$e^- + p \rightarrow e^- + n + \pi^+$$

Kinematics of a single pion electroproduction reaction



E - initial energy of the electron beam

W - invariant mass of the final hadrons system

Q^2 - photon virtuality

θ – pion emission polar angle

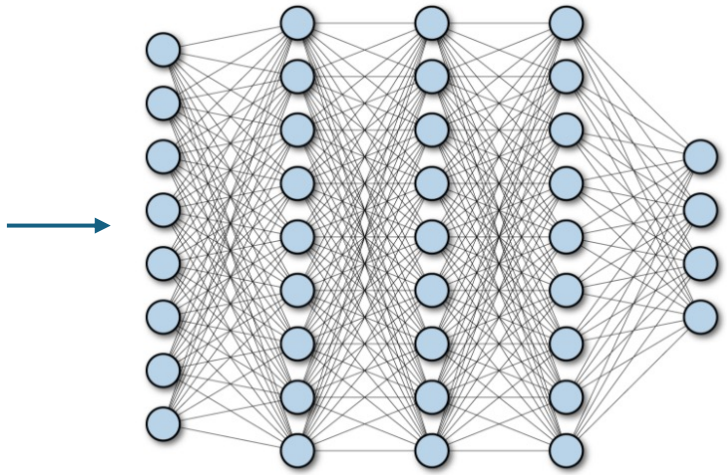
ϕ - angle between the scattering plane and the reaction plane

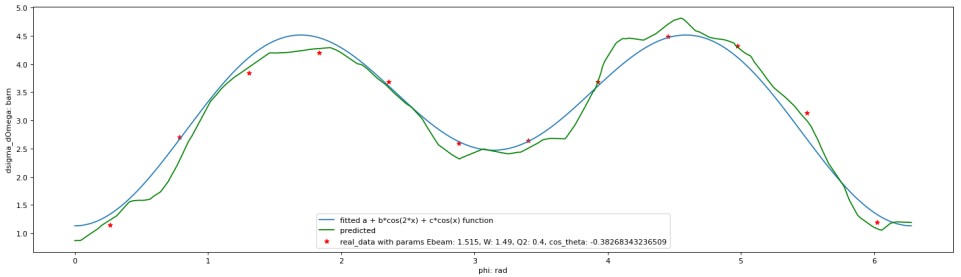
$\frac{d\sigma}{d\Omega}$ - differential cross-section

Objective of the work

	Ebeam	W	Q2	cos_theta	phi	dsigma_dOmega	error	id
0	1.515	1.11	0.3	0.991445	0.261799	15.3700	5.264366	E8M1
1	1.515	1.11	0.3	0.991445	0.785398	4.5110	1.743136	E8M1
2	1.515	1.11	0.3	0.991445	1.308997	4.4780	1.611260	E8M1
3	1.515	1.11	0.3	0.991445	1.832596	5.1360	1.523529	E8M1
4	1.515	1.11	0.3	0.991445	2.356194	5.0780	1.219442	E8M1
...	...	...	...	...	...	...	...	...
98022	5.499	2.01	4.0	0.975000	3.730641	0.1012	0.043165	E141M160
98023	5.499	2.01	4.0	0.975000	3.992441	0.1199	0.076638	E141M160
98024	5.499	2.01	4.0	0.975000	4.646939	0.1578	0.095391	E141M160
98025	5.499	2.01	4.0	0.975000	4.777839	0.2346	0.158557	E141M160
98026	5.499	2.01	4.0	0.975000	6.086836	0.1250	0.077753	E141M160

93435 rows × 8 columns





Input - Dataset

CLAS Physics Database
created in collaboration between Hall B at Jefferson Lab and SINP MSU

	Ebeam	W	Q2	cos_theta	phi	dsigma_dOmega	error	id
0	1.515	1.11	0.3	0.991445	0.261799	15.3700	5.264366	E8M1
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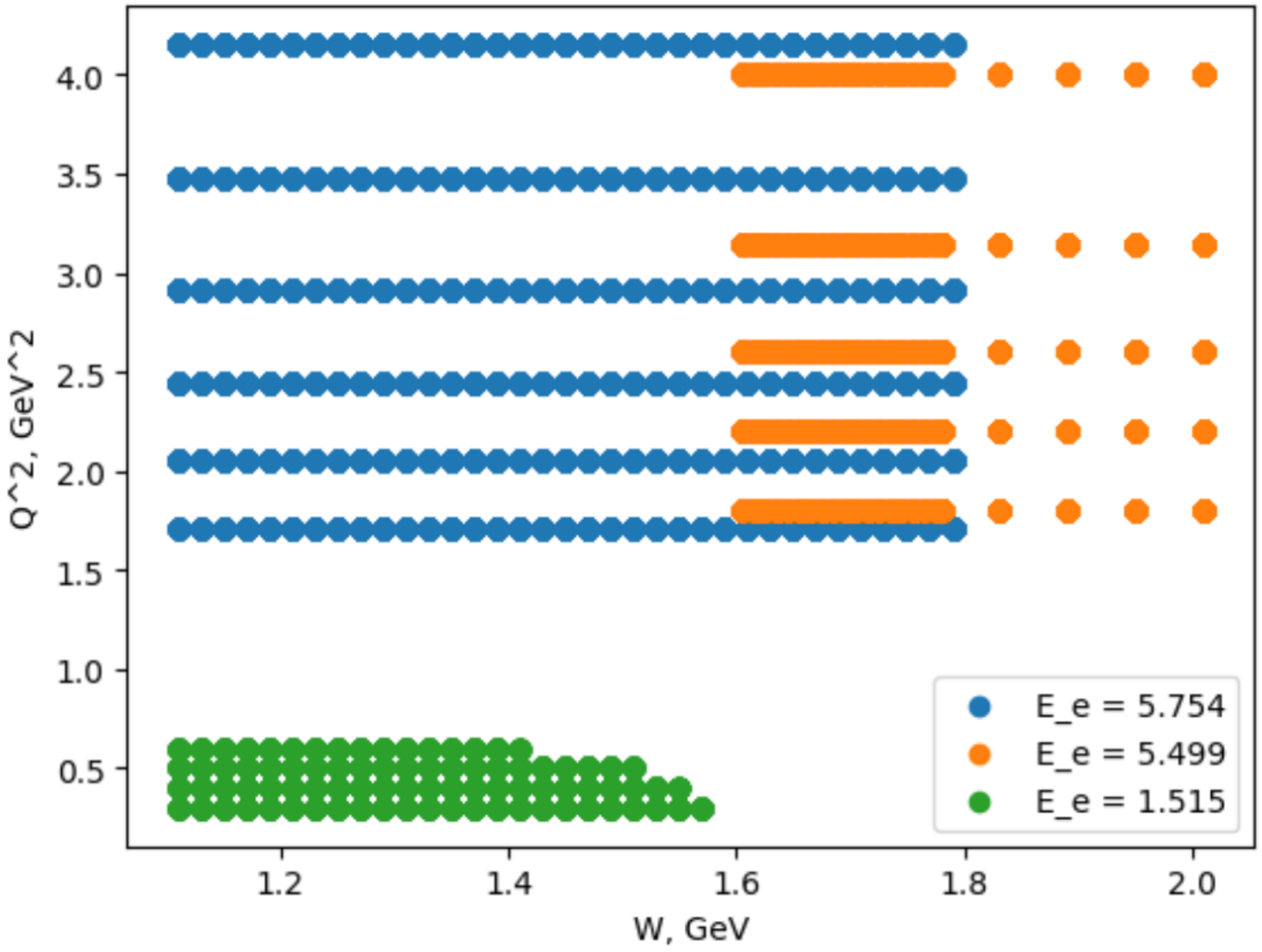
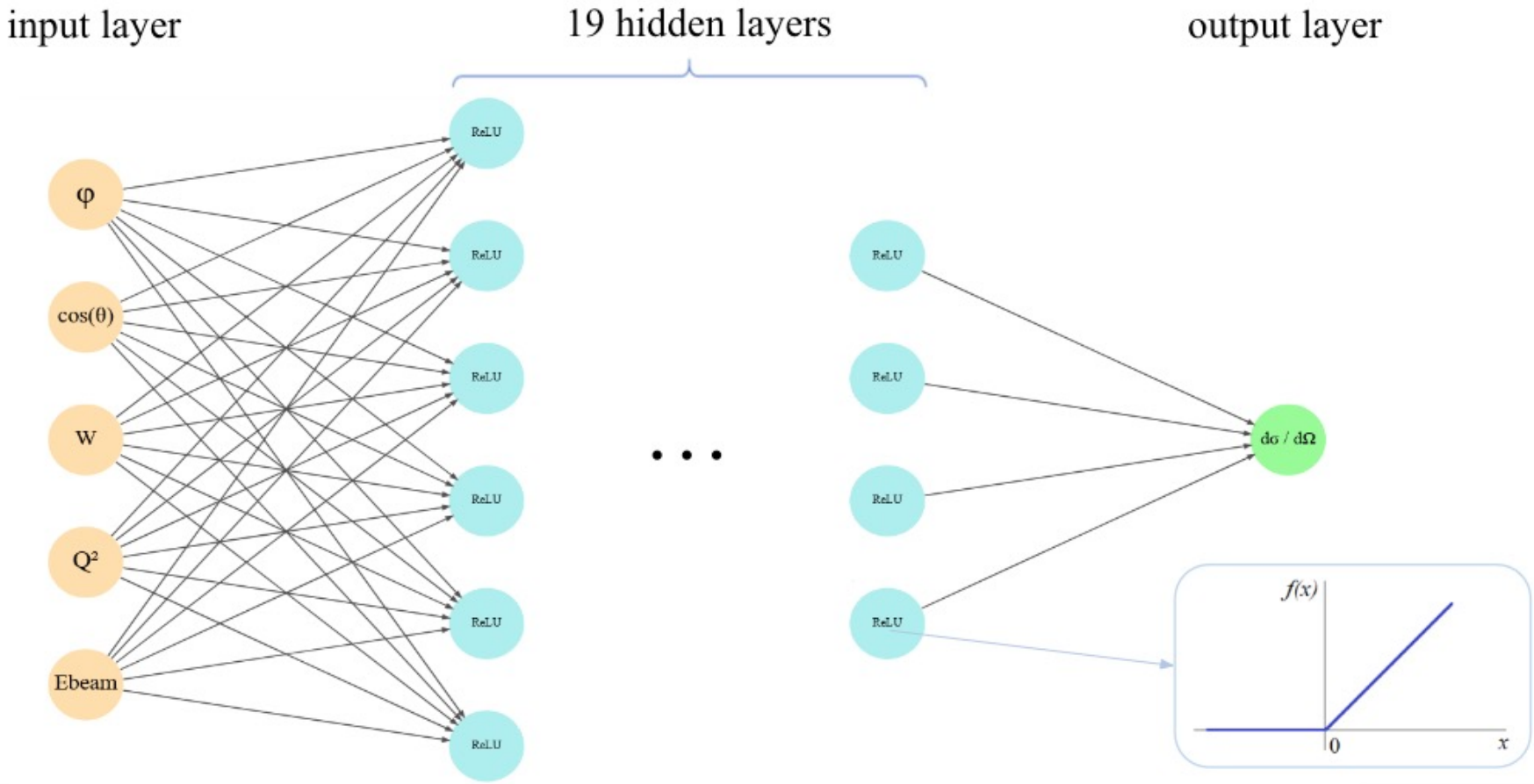
98026	5.499	2.01	4.0	0.975000	6.086836	0.1250	0.077753	E141M160

93435 rows × 8 columns

Input – ‘Population map’



Network architecture



Validation - baseline

$$MAE(\mathrm{d}\sigma/\mathrm{d}\Omega) \cong 0.08\, mcb/sr$$

$$\mathrm{AVG}(\mathrm{d}\sigma/\mathrm{d}\Omega) = 1.158 \pm 0.2\, mcb/sr$$

Validation

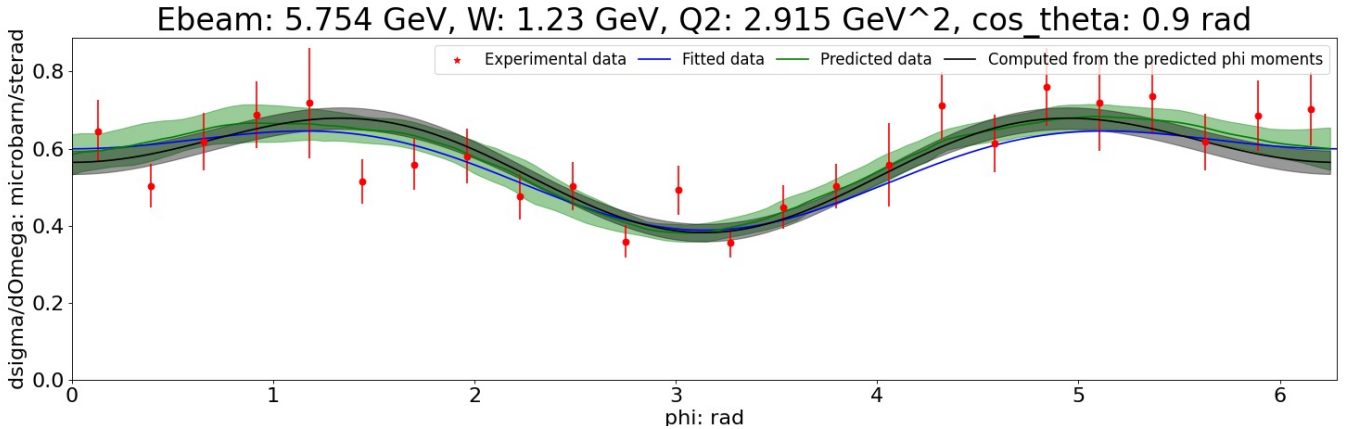
$$\frac{d\sigma_{\gamma_v}}{d\Omega_\pi} = \frac{d\sigma_u}{d\Omega_\pi} + \varepsilon \frac{d\sigma_{tt}}{d\Omega_\pi} \cdot cos2\varphi + \sqrt{2\varepsilon(1+\varepsilon)} \frac{d\sigma_{lt}}{d\Omega_\pi} \cdot cos\varphi \equiv A + Bcos2\varphi + Ccos\varphi$$

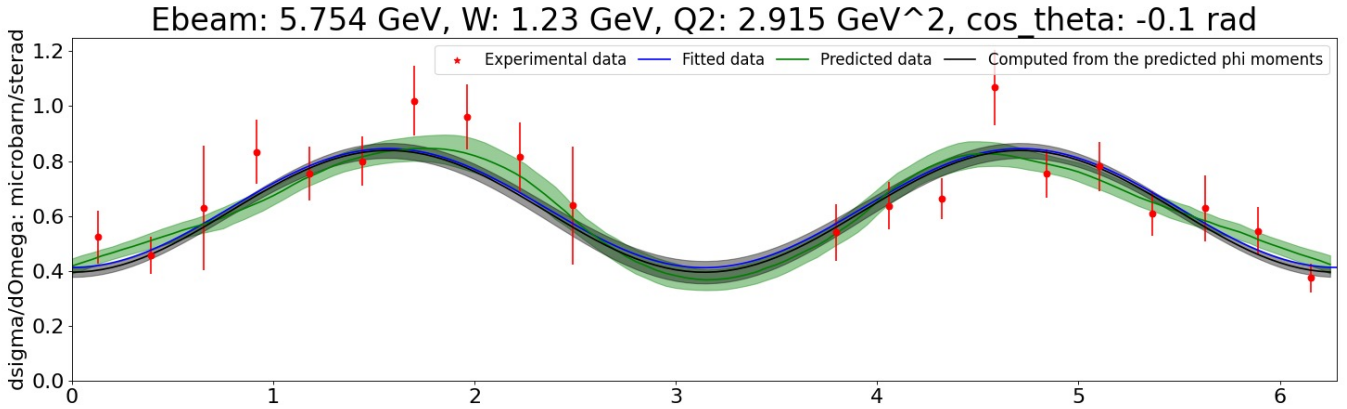
Validation – example №1

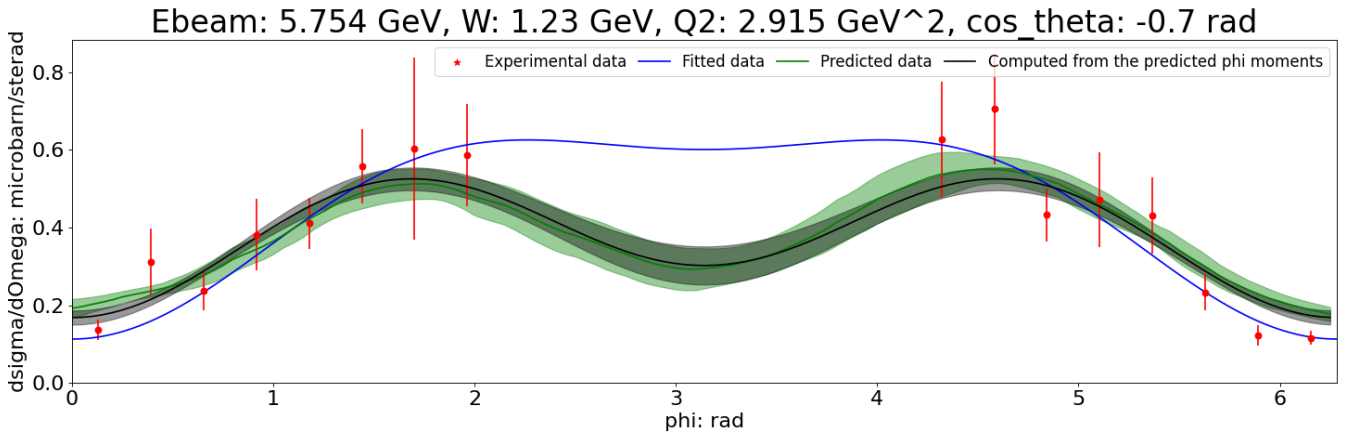
E = 5.754 GeV; Q^2 = 2.915 GeV^2

1st, 2nd, 3rd resonance regions
&
Structure functions

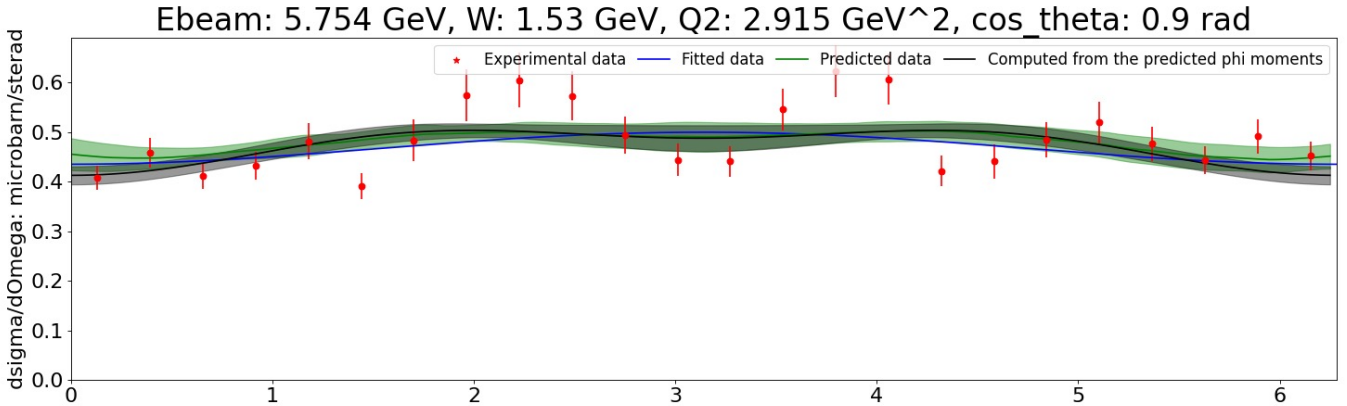
E = 5.754 GeV; Q^2 = 2.915 GeV^2 - 1st resonance maximum

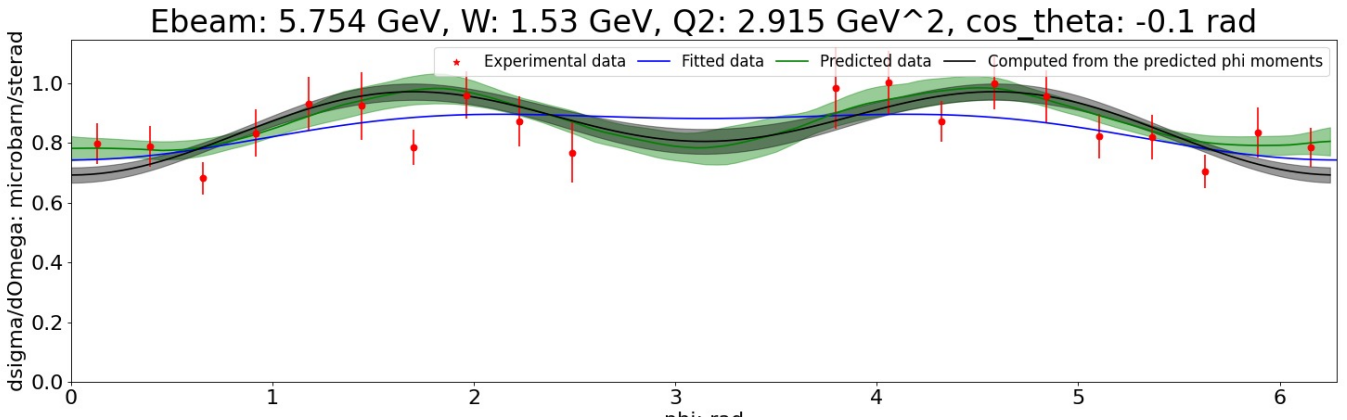


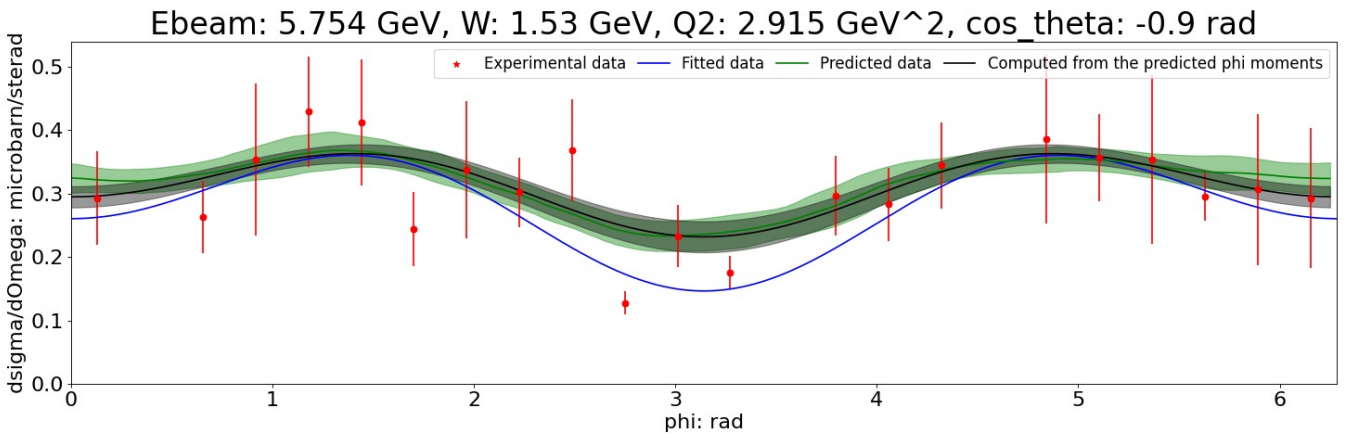




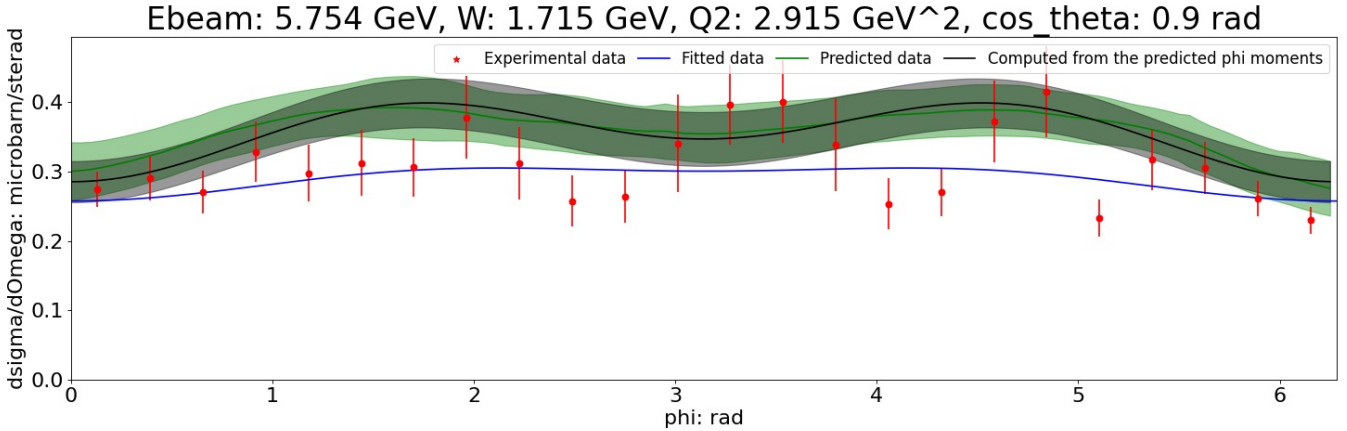
E = 5.754 GeV; Q^2 = 2.915 GeV^2 - 2nd resonance maximum

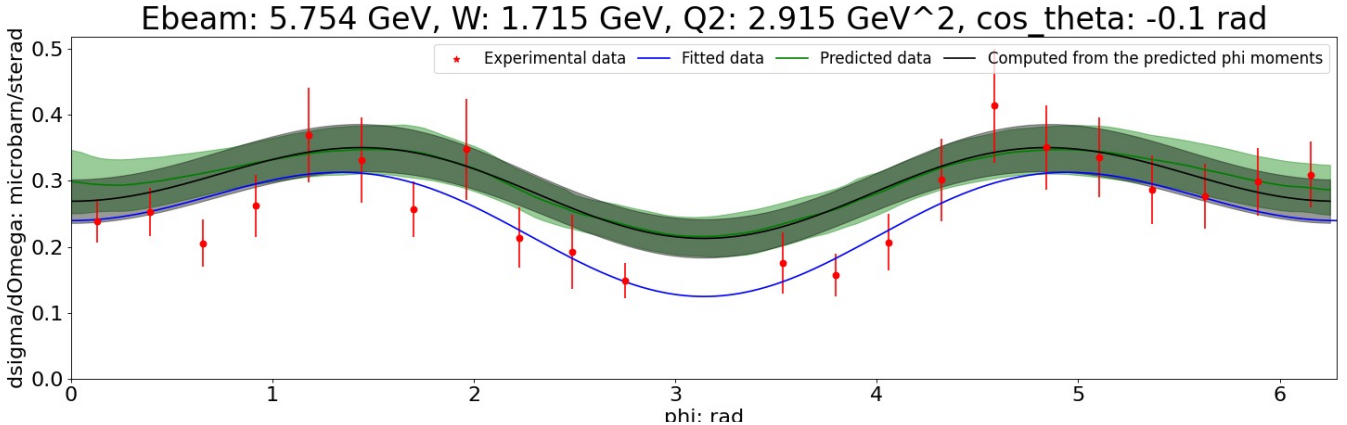


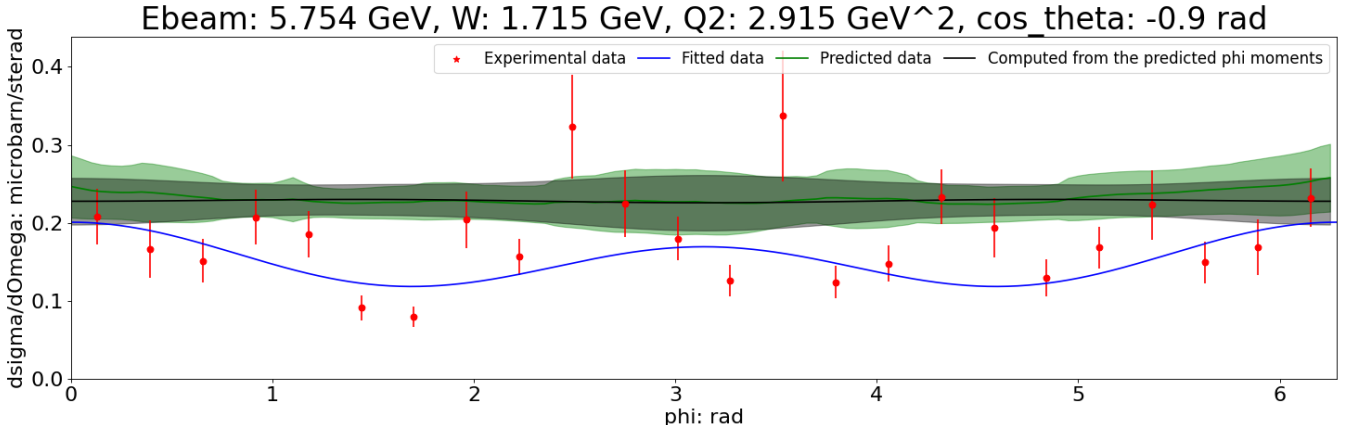




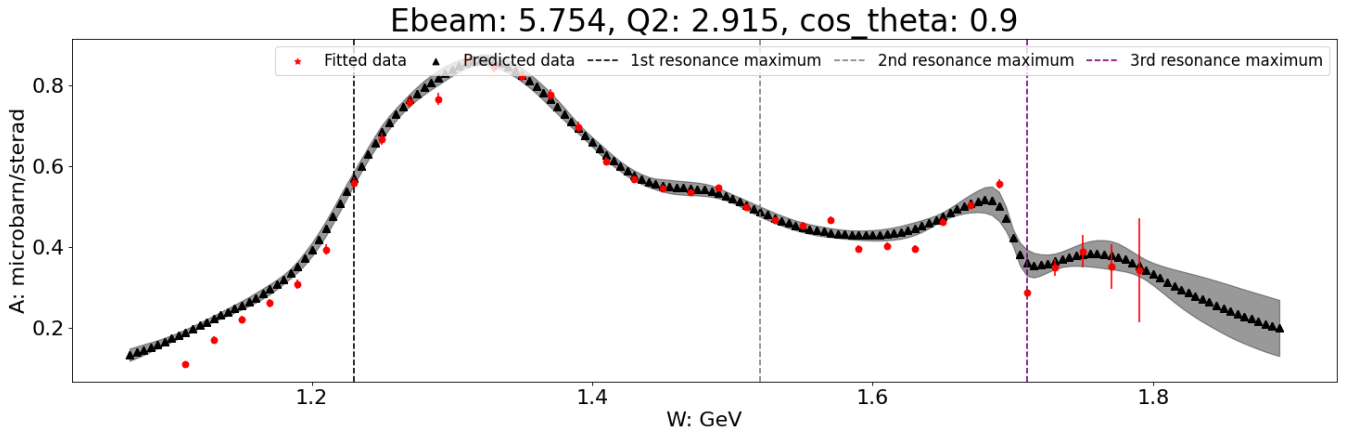
E = 5.754 GeV; Q^2 = 2.915 GeV^2 - 3rd resonance maximum

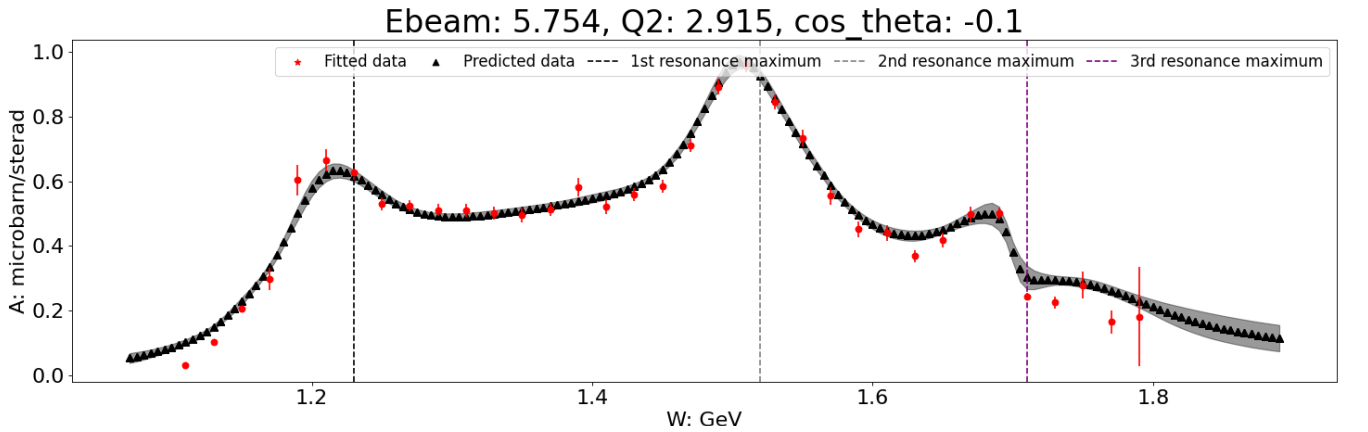


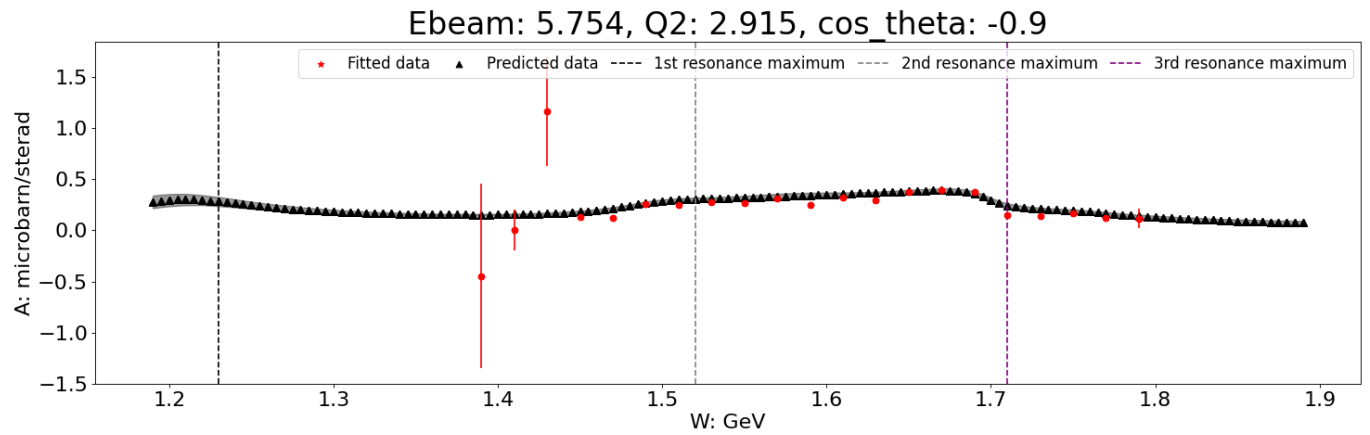




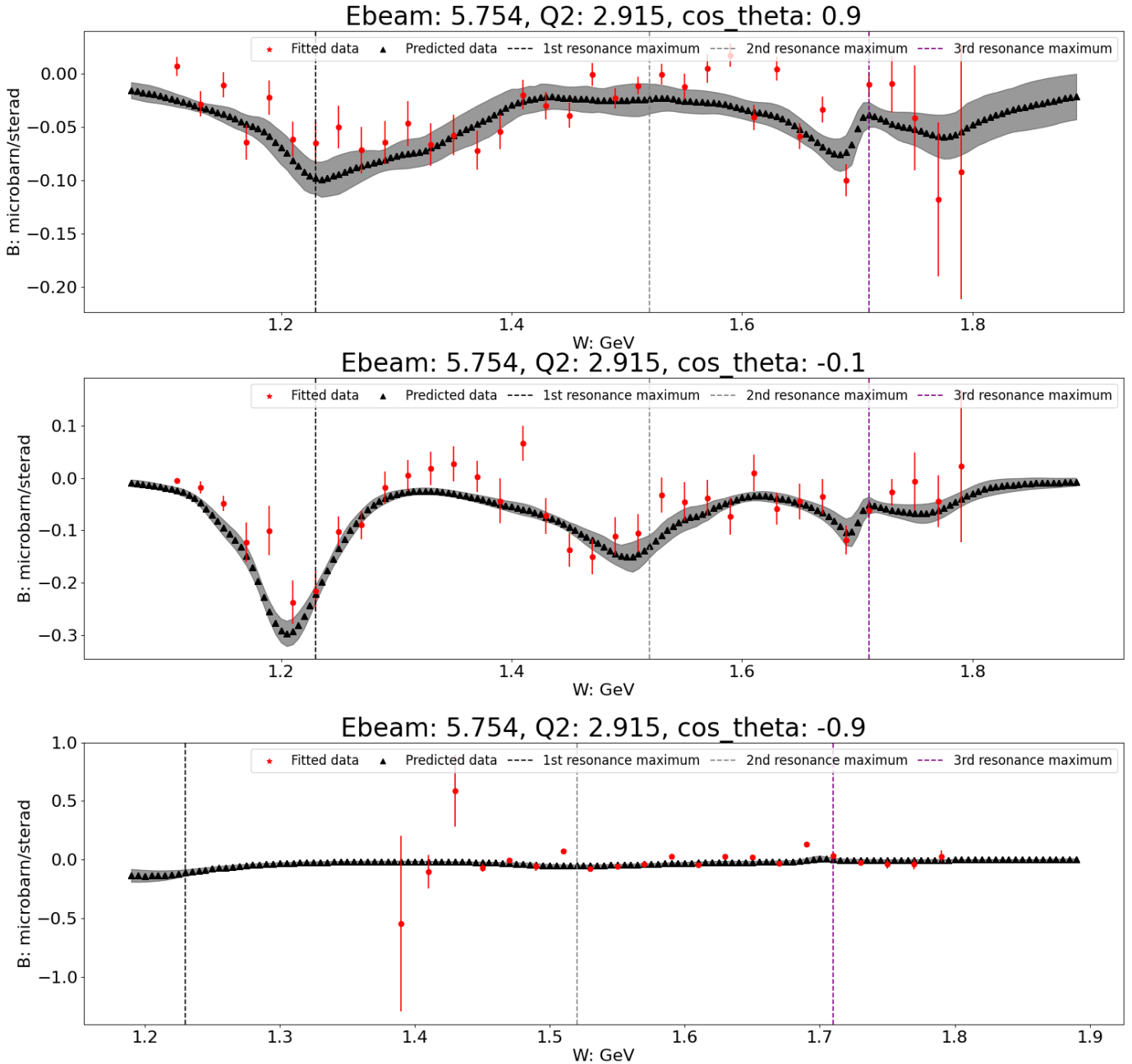
E = 5.754 GeV; Q^2 = 2.915 GeV^2 - A function



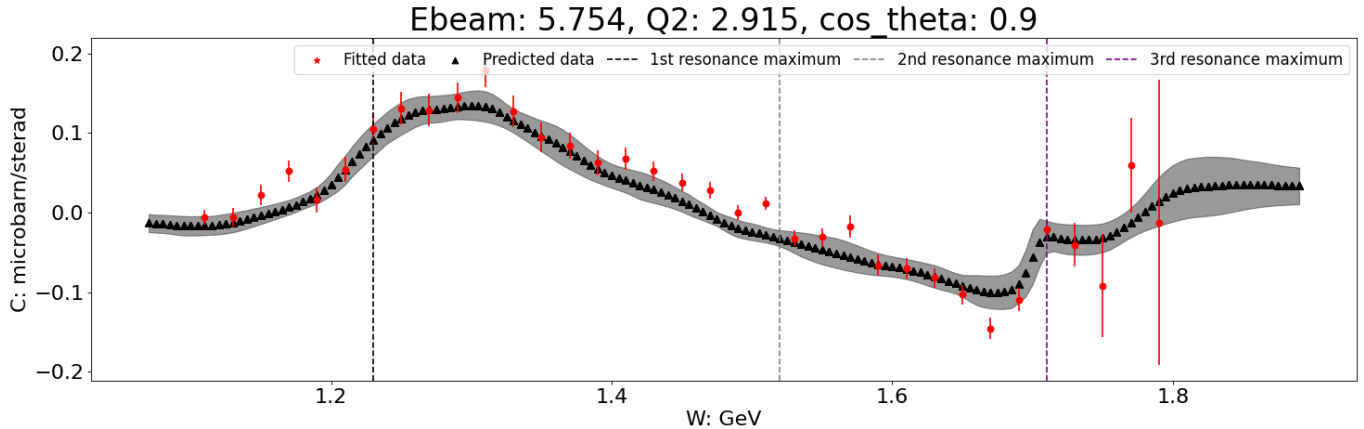


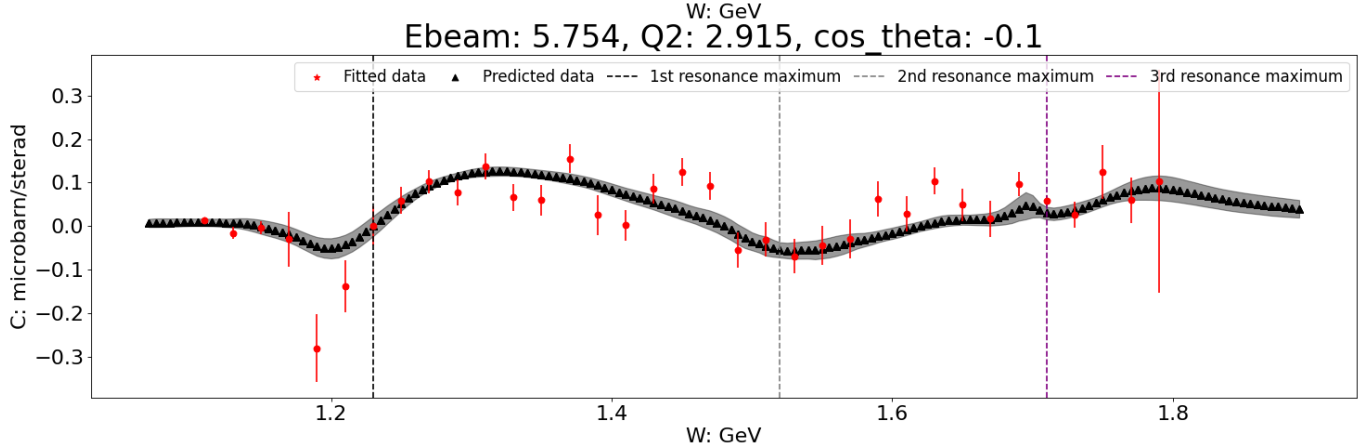


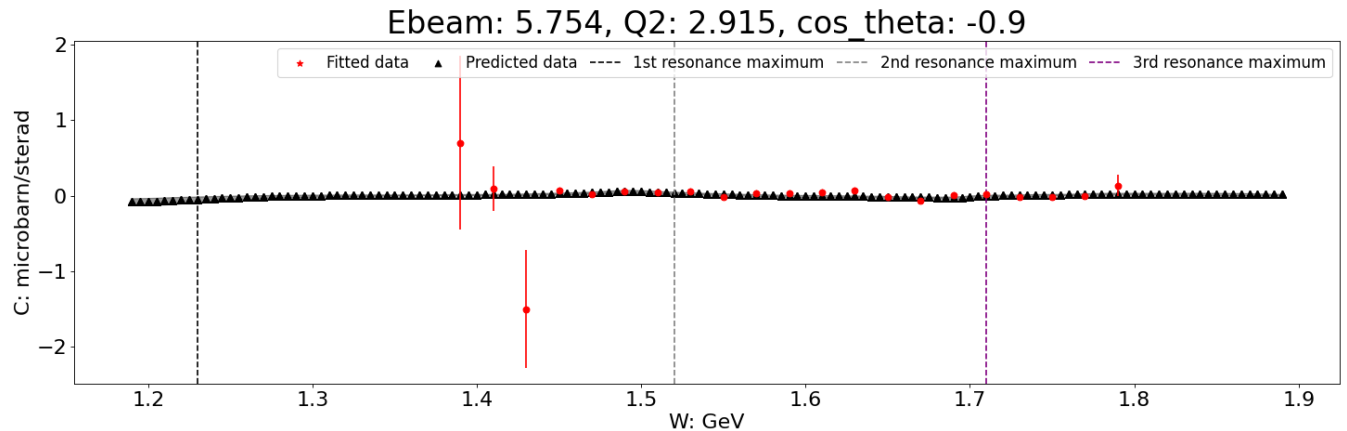
E = 5.754 GeV; Q^2 = 2.915 GeV^2 - B function



E = 5.754 GeV; Q^2 = 2.915 GeV^2 - C function





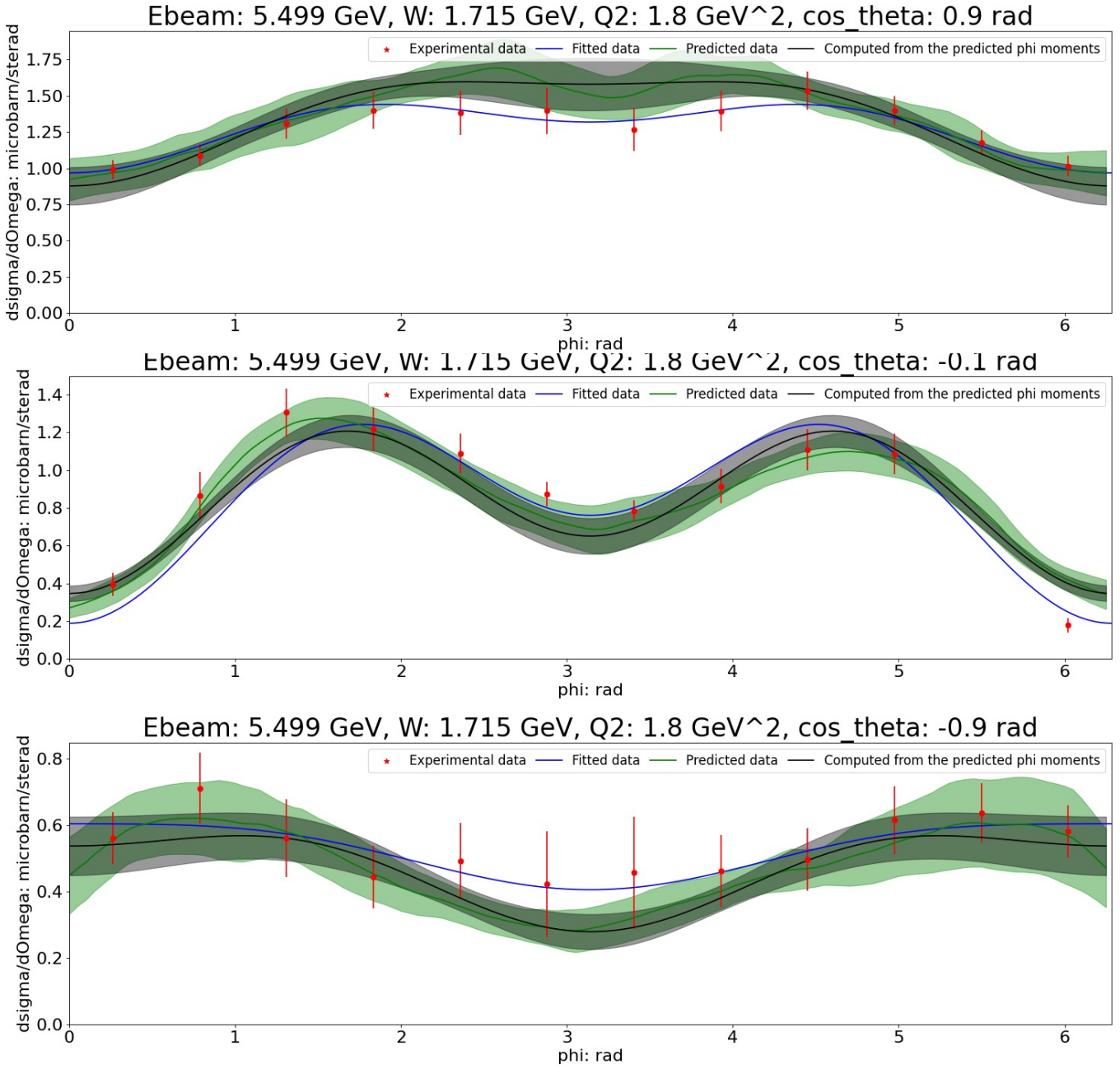


Validation – example №2

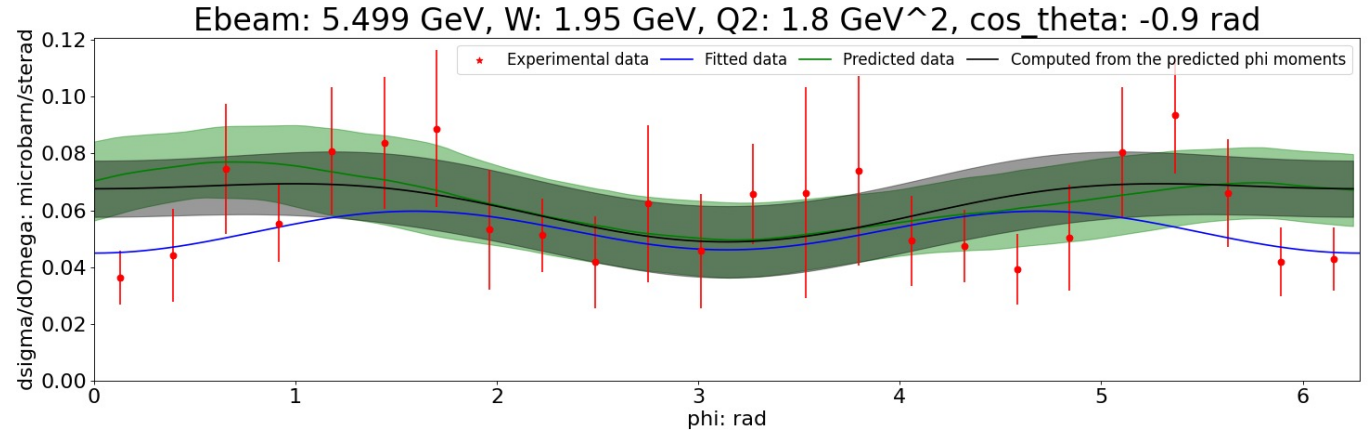
E = 5.499 GeV; Q^2 = 1.8GeV^2

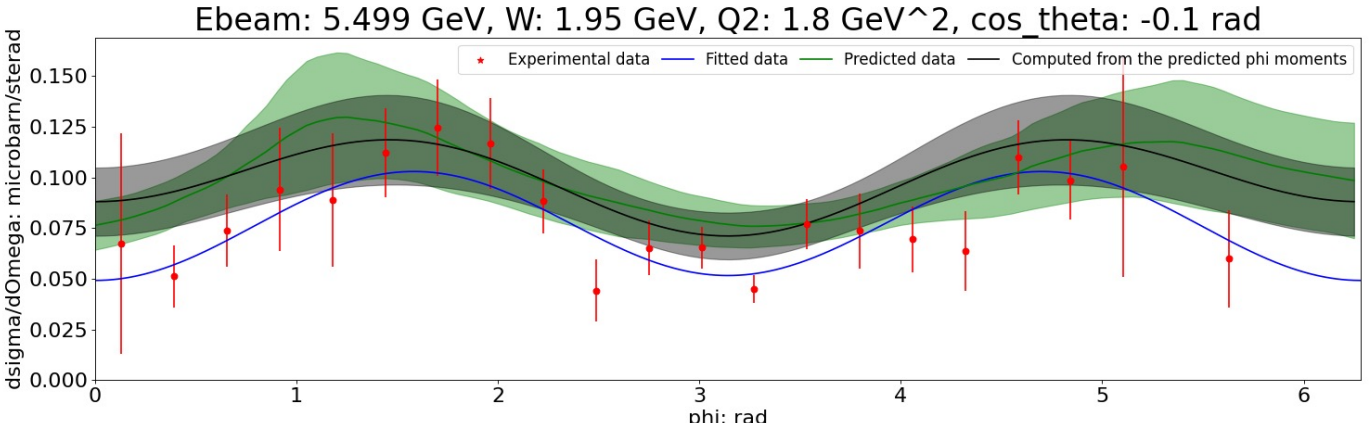
3rd, 4th resonance regions
&
Structure functions

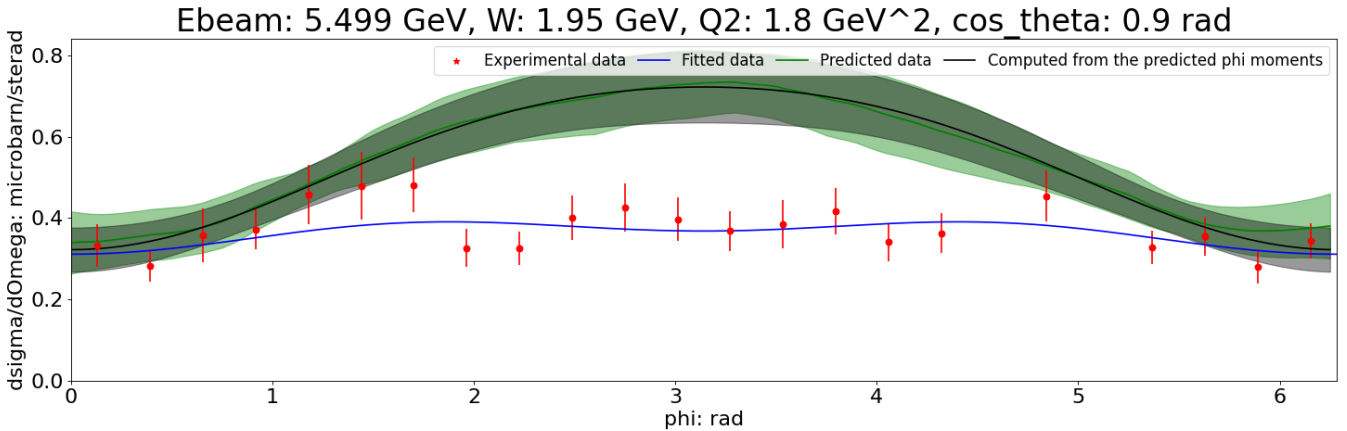
E = 5.499 GeV; Q^2 = 1.8 GeV^2 - 3rd resonance maximum



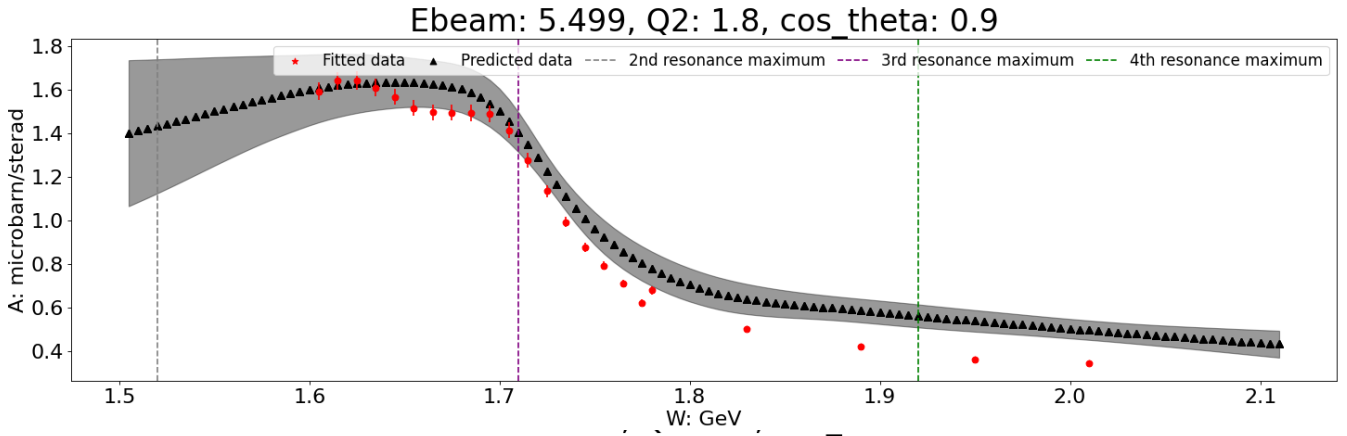
E = 5.499 GeV; Q^2 = 1.8 GeV^2 - 4th resonance maximum

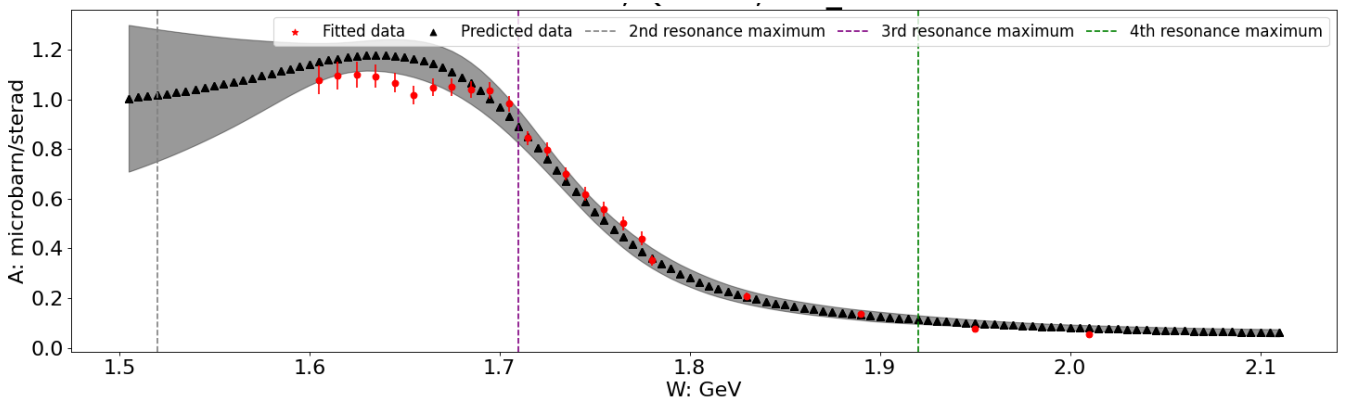


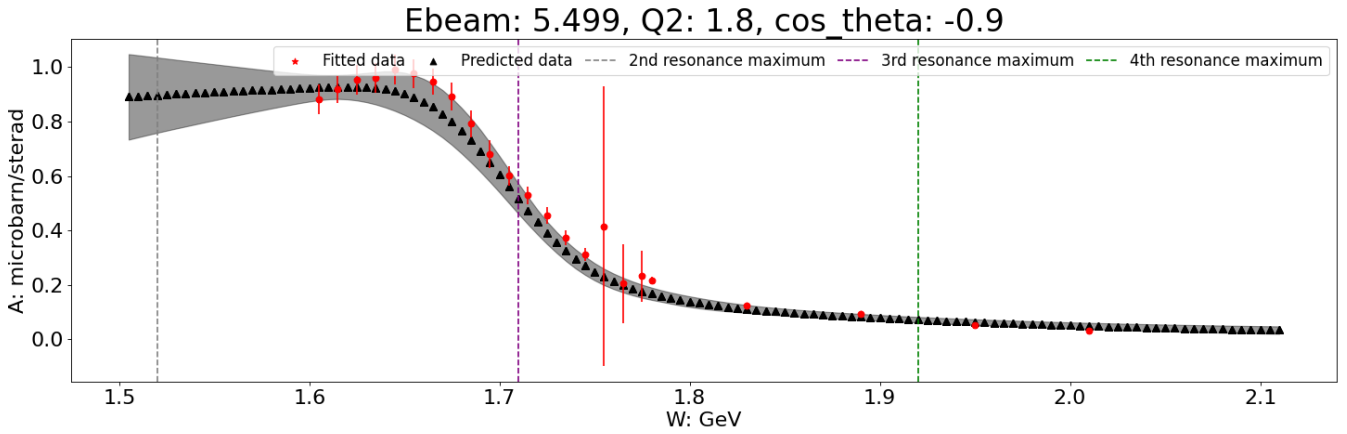




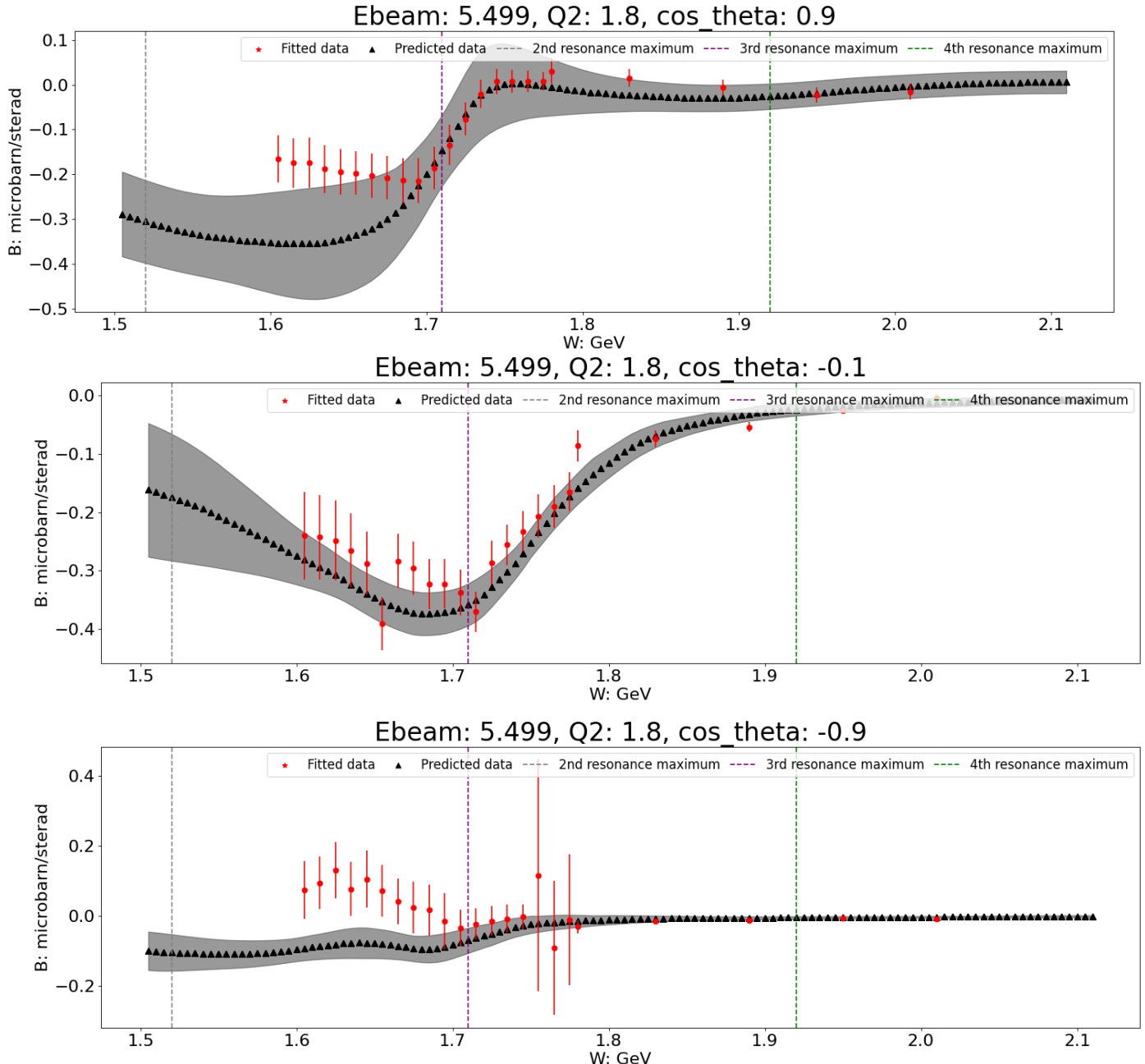
E = 5.499 GeV; Q^2 = 1.8 GeV^2 - A function







E = 5.499 GeV; Q^2 = 1.8 GeV^2 - B function



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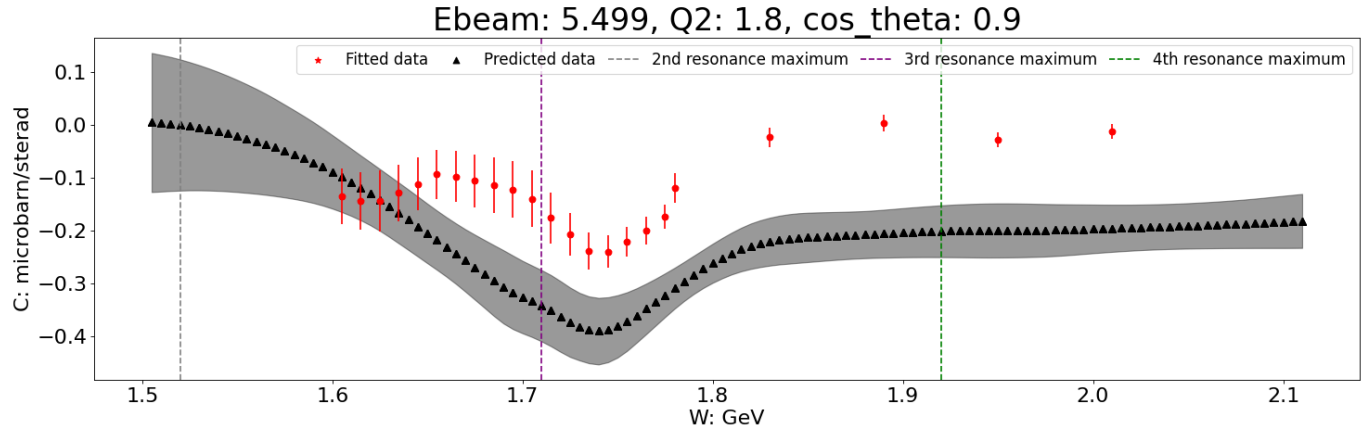

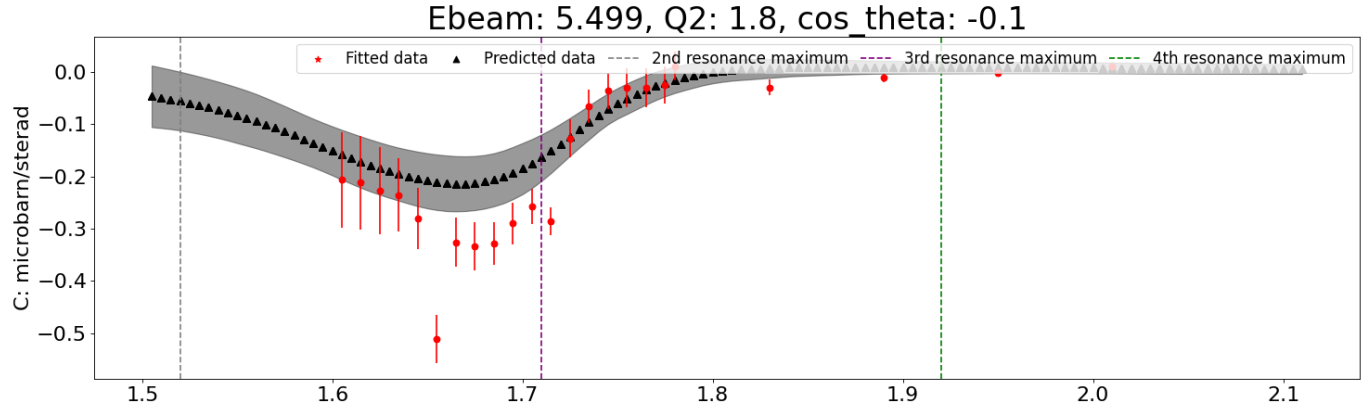

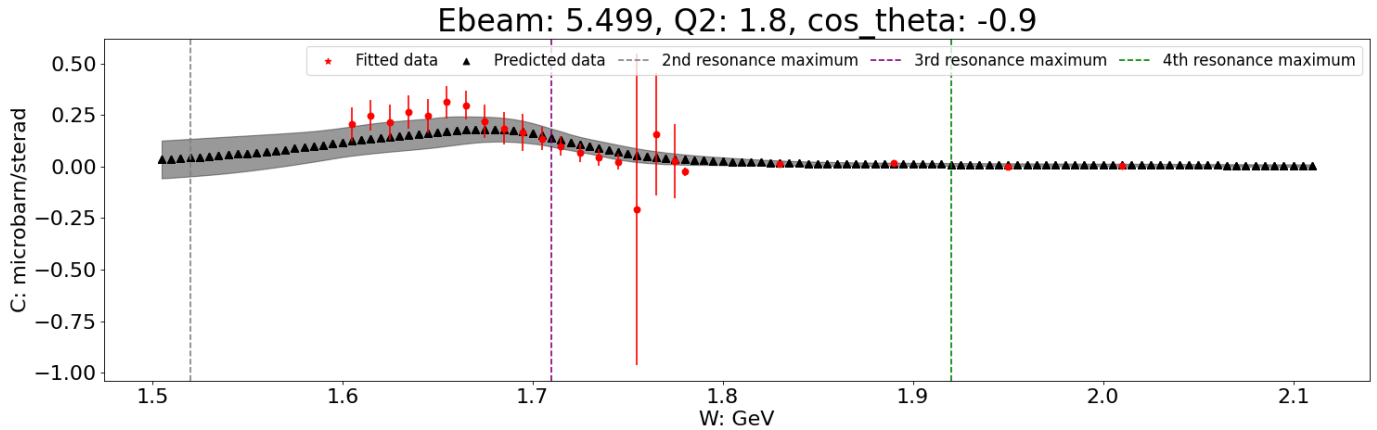

Thank you
for your attention!