Beam Spin Asymmetries of Deeply Virtual Exclusive ρ^0 Production at CLAS12

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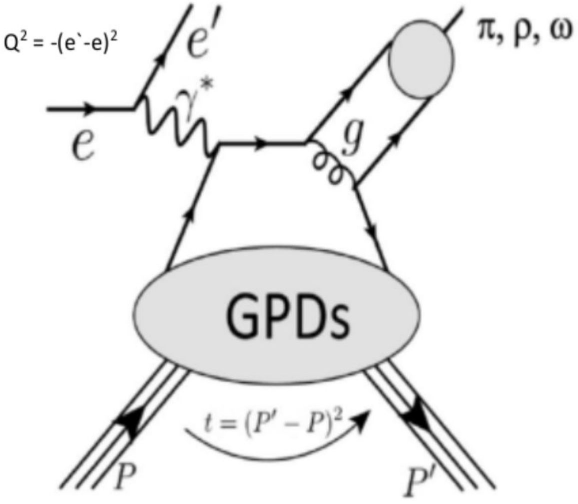
Motivation

- Generalized Parton Distribution (GPDs) give insight into the internal nucleon structure
- Accessing GPDs can be done by using different channels of deeply virtual vector meson production (DVMP)
  - With different channels accessing different GPDs
- Experimental results can help constrain and improve theoretical calculations of GPDs



	Meson	GPD flavor composition
$\tilde{H}, \tilde{E}$	π^+	$\Delta u - \Delta d$
	π^0	$2\Delta u + \Delta d$
$H_T, \bar{E}_T$	η	$2\Delta u - \Delta d$
H, E	ρ^0	$2u + d$
	ρ^+	$u - d$
	ω	$2u - d$

Motivation

- GPDs can be access using structure functions extracted from experimental results like beam spin asymmetries and cross sections

$$\sigma = \sigma_0 + \sqrt{2\epsilon(1+\epsilon)}\sigma_{LT}^{\cos\phi}\cos\phi + \epsilon\sigma_{TT}^{\cos 2\phi}\cos 2\phi + \lambda_e\sqrt{2\epsilon(1-\epsilon)}\sigma_{LT'}^{\sin\phi}\sin\phi$$

$$A_{LU}^{sin(\phi_t)} = \mathrm{Im}[\langle \bar{E}_T\rangle_{LT}^{*}\langle H\rangle_{LL} + \frac{1}{2}\langle H_T\rangle_{LT}^{*}\langle E\rangle_{LL}]$$

Goloskokov-Kroll model:

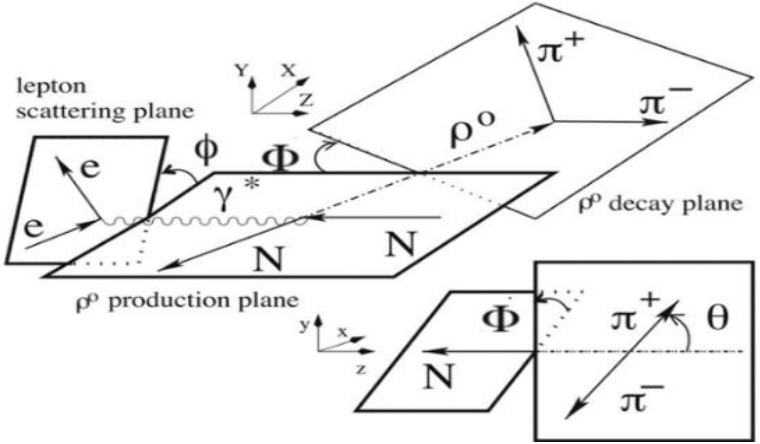
$$\sigma_L \sim \left\{ \left(1-\xi^2\right)\left|\langle\tilde{H}\rangle\right|^2 - 2\xi^2\mathrm{Re}\left[\langle\tilde{H}\rangle^*\langle\tilde{E}\rangle\right] - \frac{t'}{4m^2}\xi^2\left|\langle\tilde{E}\rangle\right|^2\right.$$

$$\sigma_T \sim \left[\left(1-\xi^2\right)|\langle H_T\rangle|^2 - \frac{t'}{8m^2}|\langle\bar{E}_T\rangle|^2\right]$$

$$\sigma_{LT} \sim \xi\sqrt{1-\xi^2}\frac{\sqrt{-t'}}{2m}\ \mathrm{Re}\left[\langle H_T\rangle^*\langle\tilde{E}\rangle\right]$$

$$\sigma_{TT} \sim \frac{t'}{16m^2}|\langle\bar{E}_T\rangle|^2$$

$$\sigma_{LT'} \sim \xi\sqrt{1-\xi^2}\frac{\sqrt{-t'}}{2m}\ \mathrm{Im}\left[\langle H_T\rangle^*\langle\tilde{E}\rangle\right]$$



Event Selection

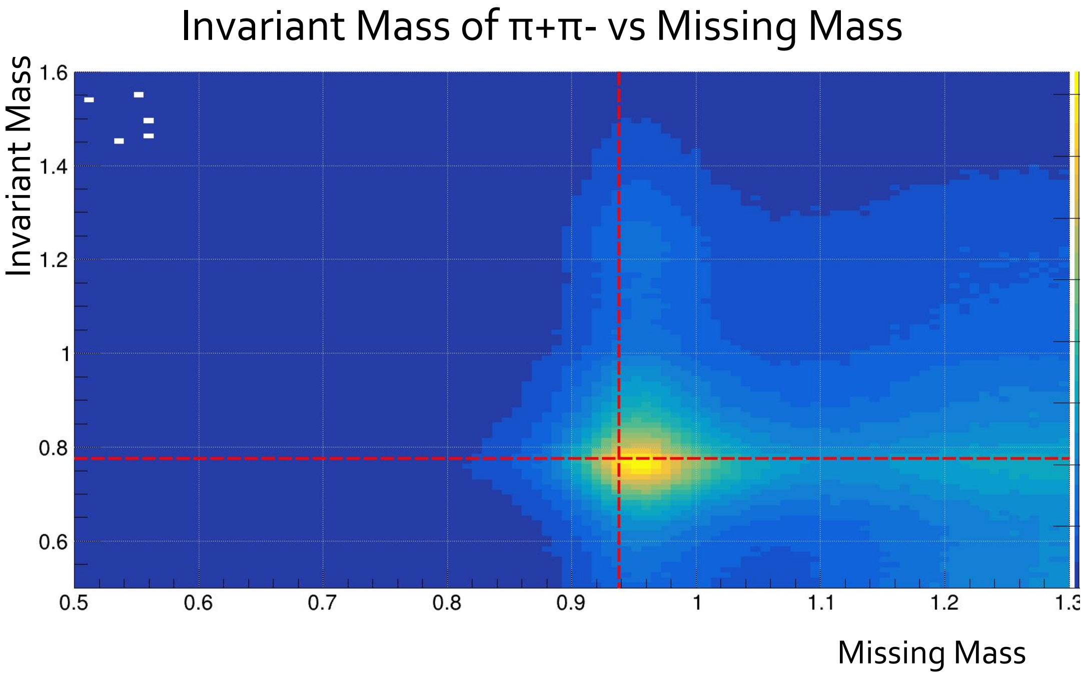
Data Sets:

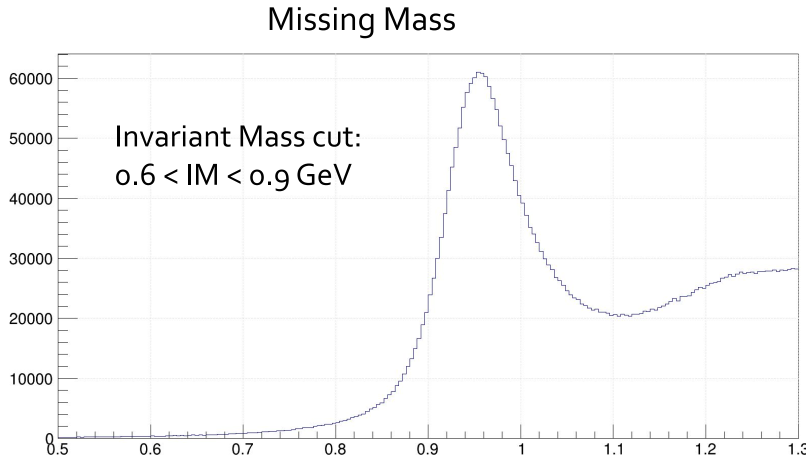
- RGA's Fall 2018 Inbending and Outbending
- Standard RGA's particle ID
- RGA's Momentum Corrections

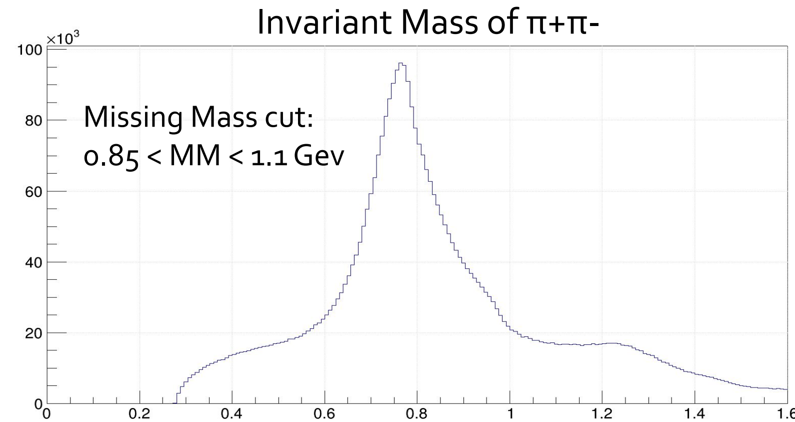
Channel:

- $ep \to e\rho^0 p \to e\pi^+\pi^-(p)$
    - The outgoing proton is identified by missing mass techniques
    - ρ^0 decays into $\pi^+\pi^-$
    - The electron, and pions are found using forward detector
    - SIDIS cuts: $Q^2 > 1$ GeV^2, $W > 2$ GeV

Event Selection: Missing Mass (ep->$e\pi^+\pi^-X$) cut







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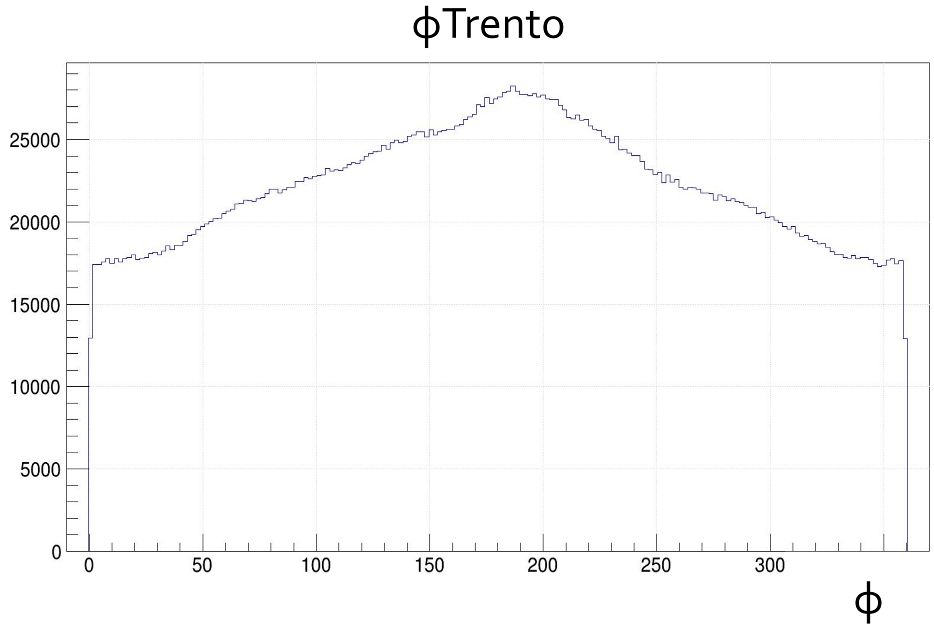
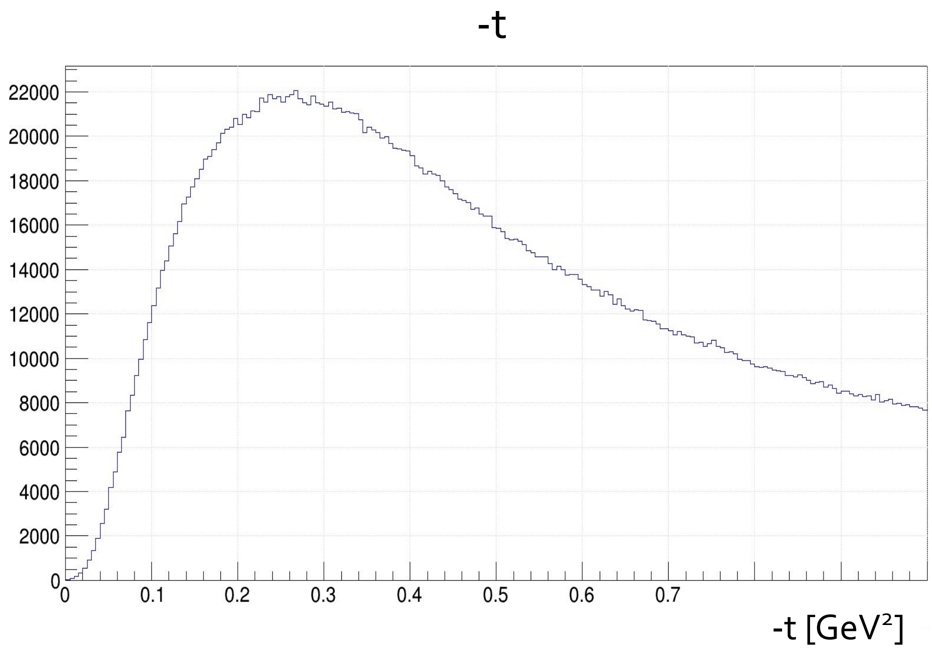
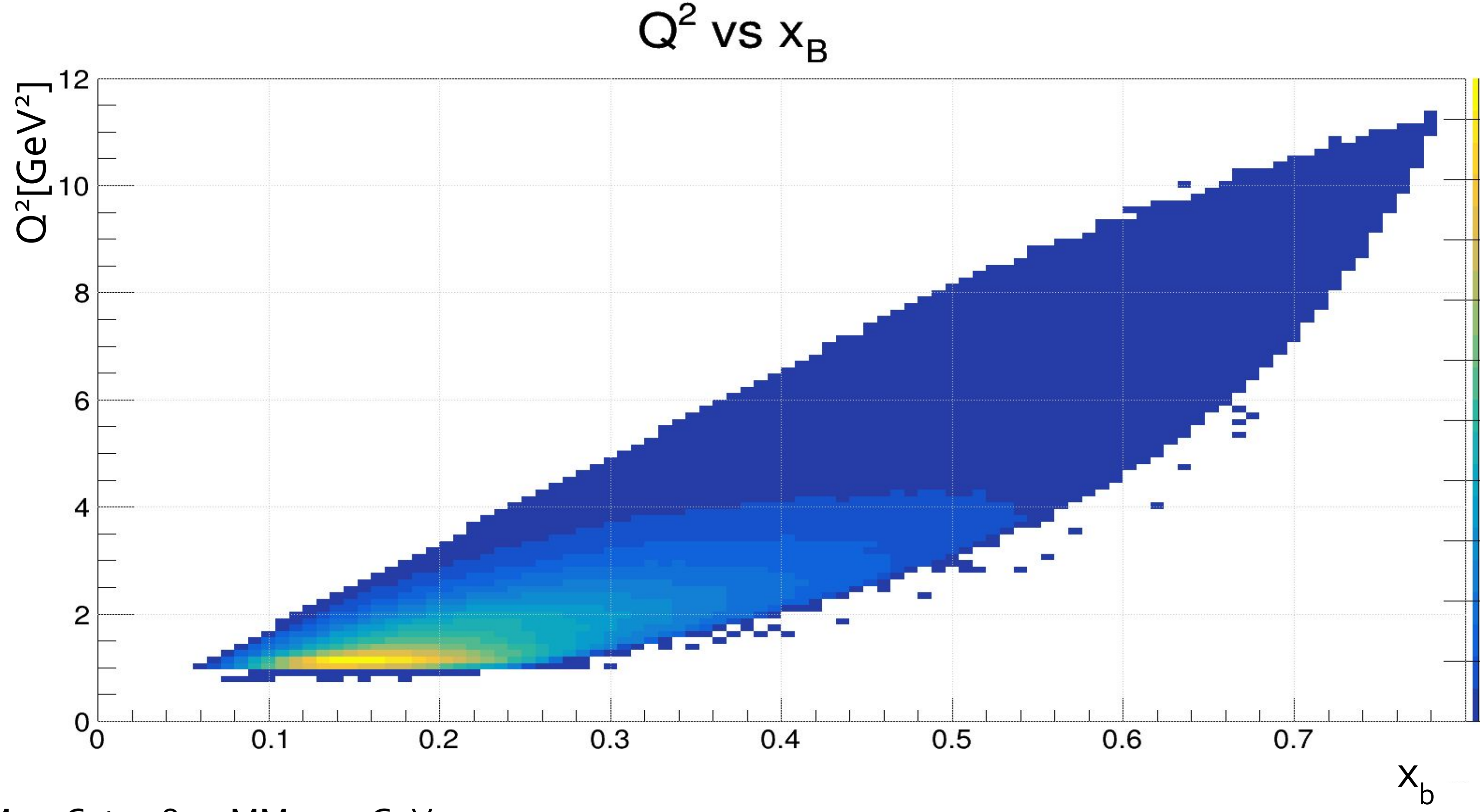
Exclusive Kinematics





Missing Mass Cut: 0.85 < MM < 1.1 GeV

Exclusive Kinematics

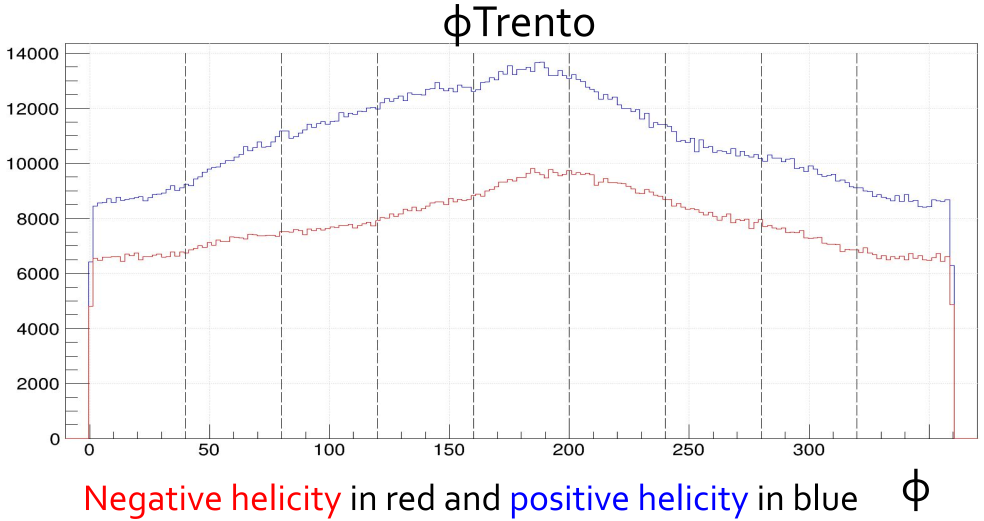


Missing Mass Cut: 0.85 < MM < 1.1 GeV

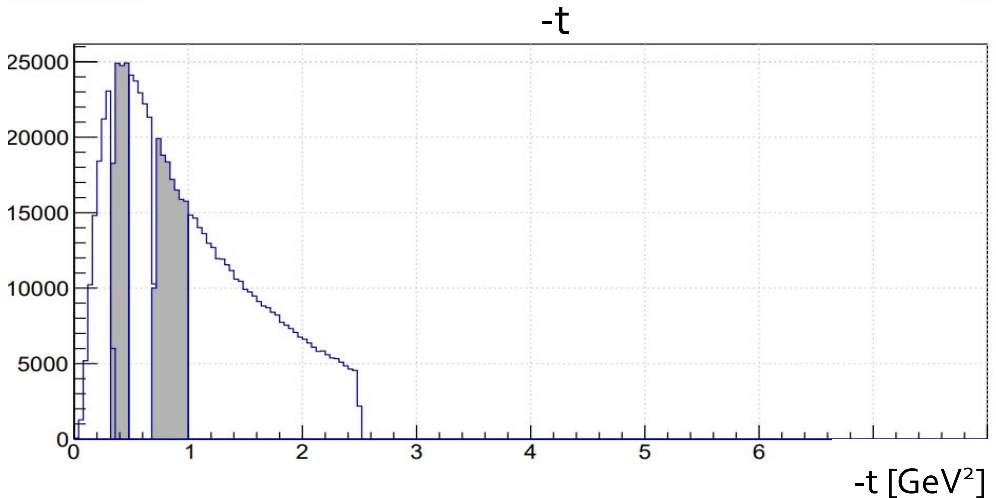
1D Bins in -t

- 5 bins in -t
- 9 equidistance bins in ϕ
- Events were divided into either positive or negative helicity
- 90 invariant mass were fitted
- N+ and N- are the amplitude of ρ^0 fits in positive and negative helicity bins
- -t<1 is the region with dominant GPDs contributions (-t/Q2<<1)

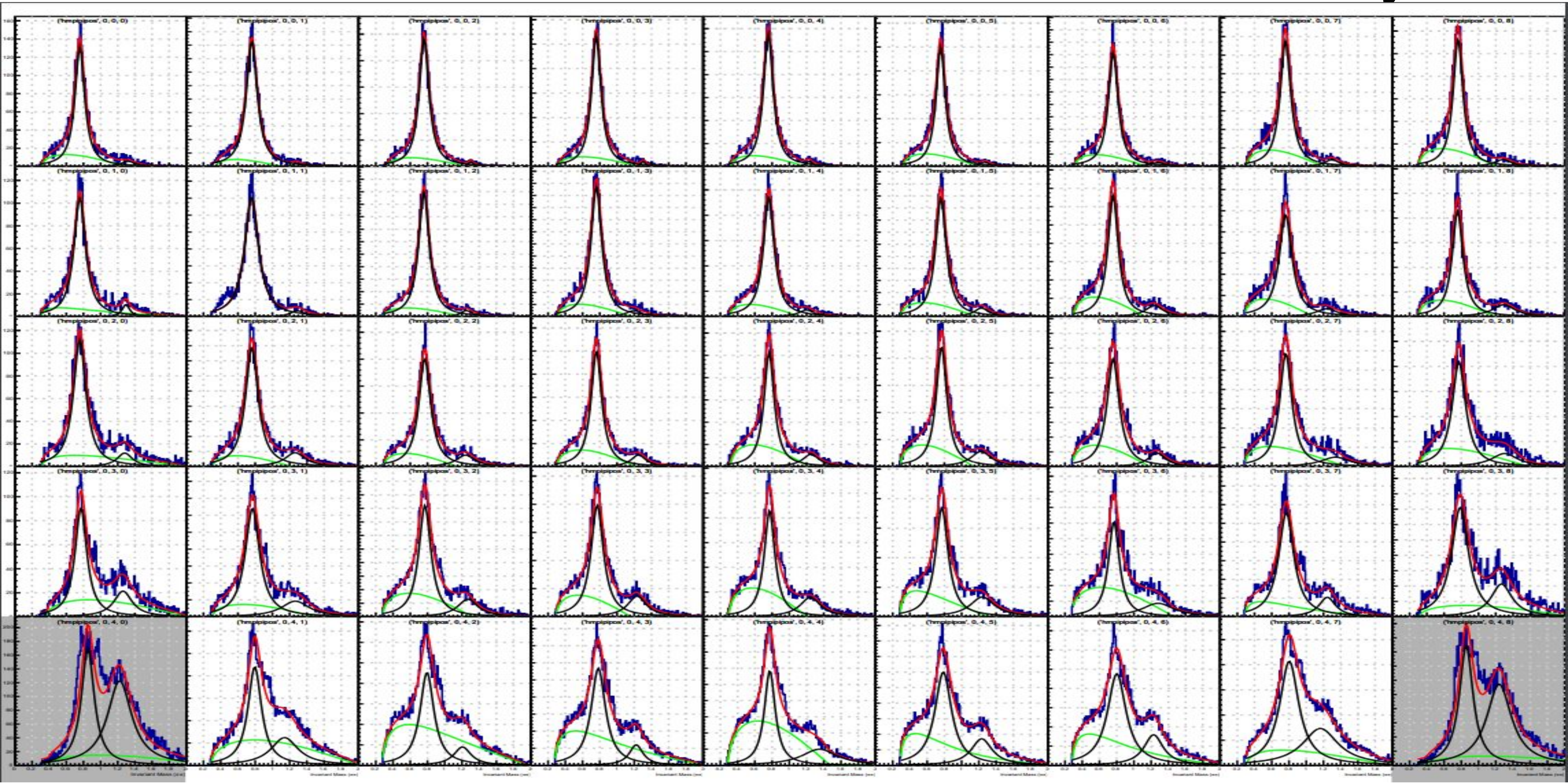
$$BSA = \frac{1}{P_b}\frac{N_i^+ - N_i^-}{N_i^+ + N_i^-}$$



Negative helicity in red and positive helicity in blue



1D Bins in -t: Invariant Mass Fits Positive Helicity



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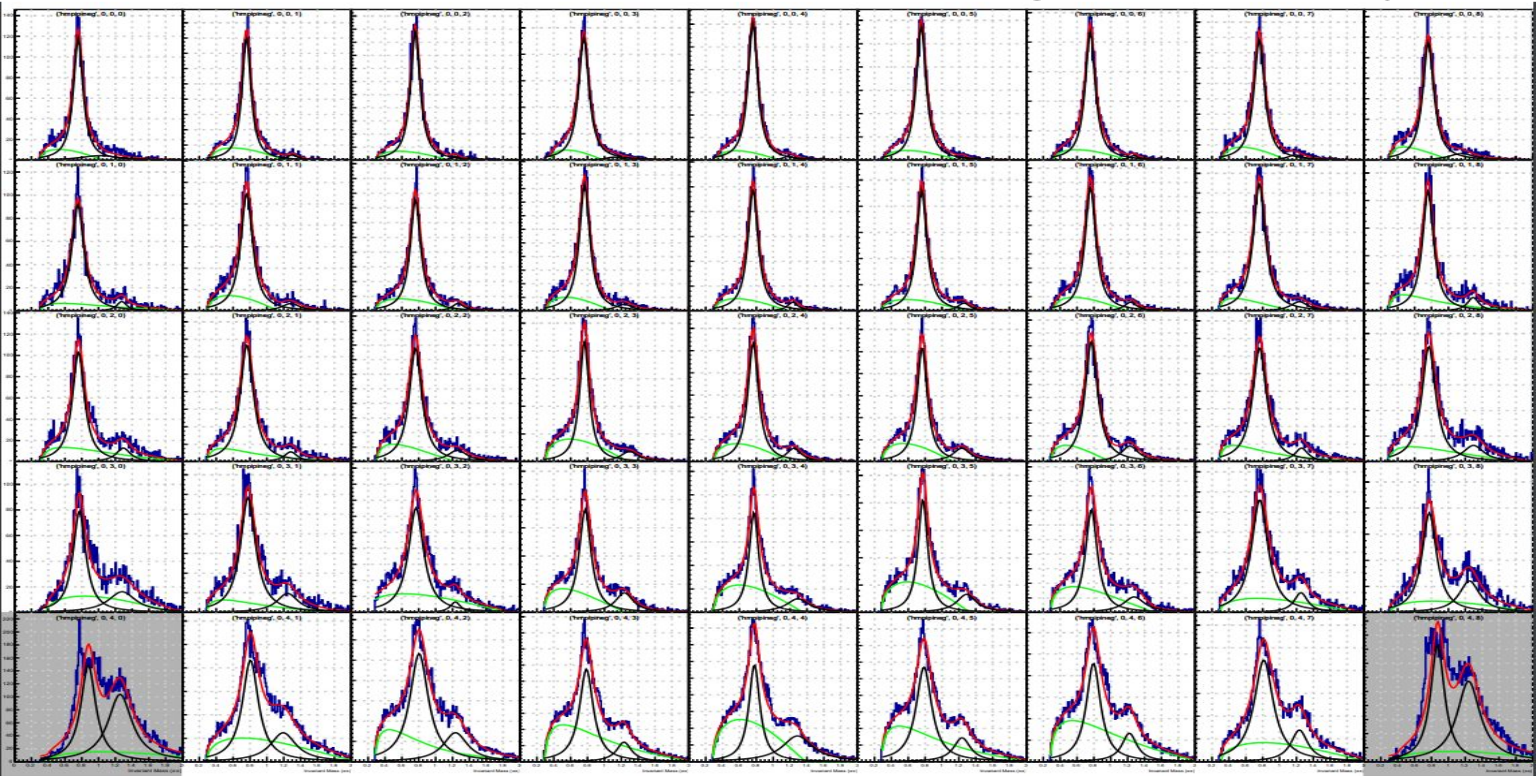
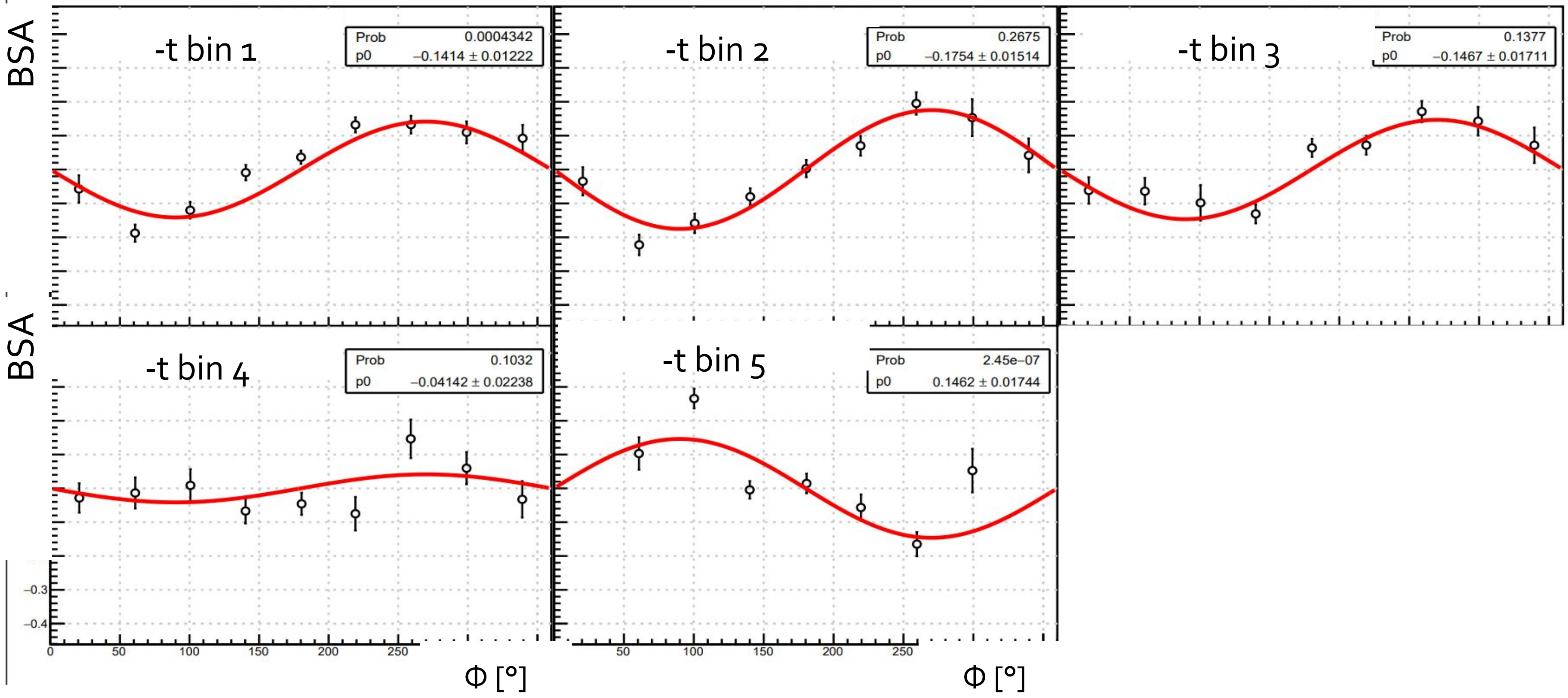
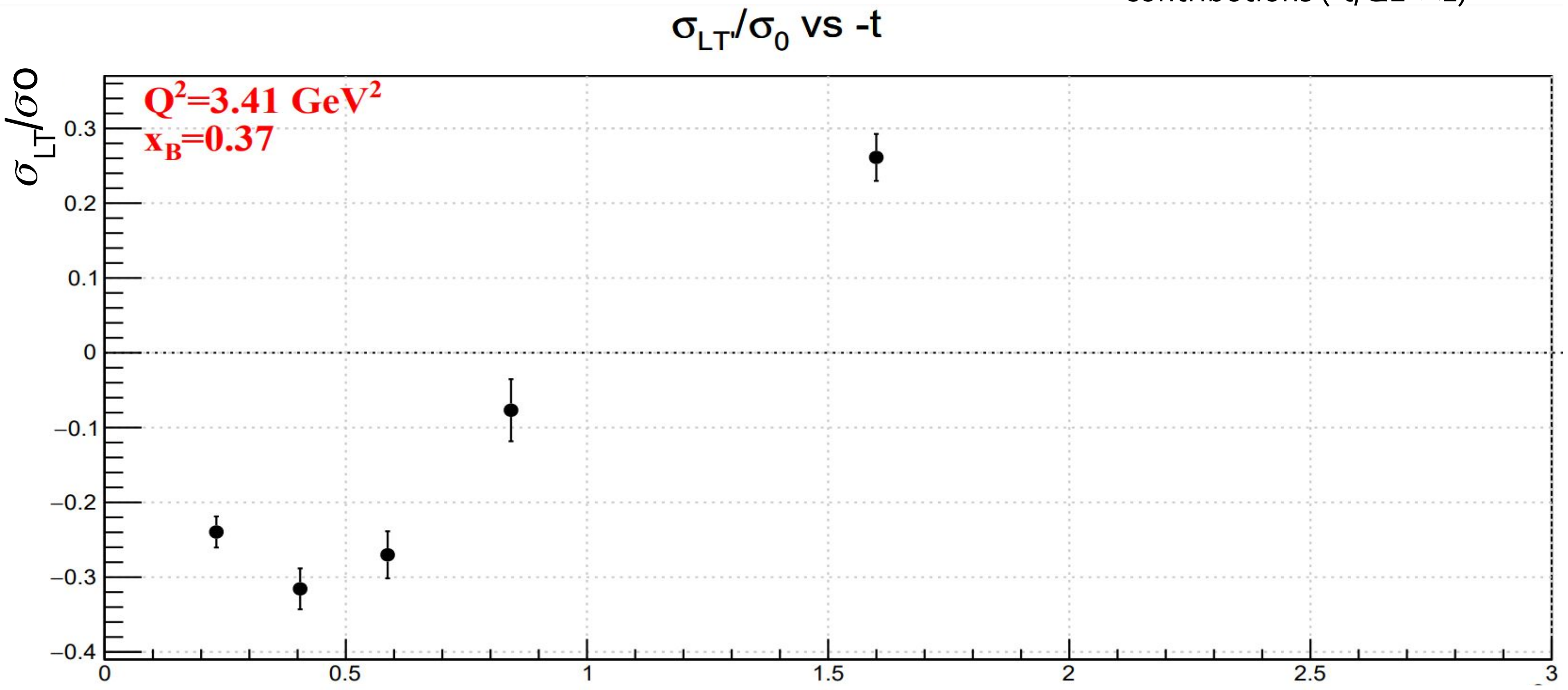


1D Bins in -t: BSA



1D Bins in -t: σ_{LT}/σ_0 Moment

-t<1 is the
region with dominant GPDs
contributions (-t/Q2<<1)

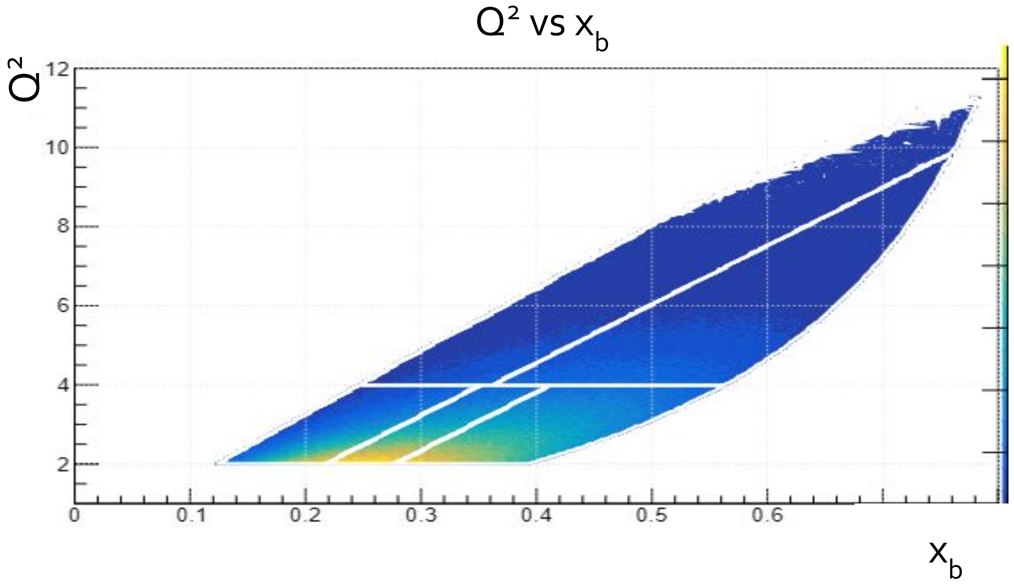


-t [GeV²]

3D Bins in x_b,Q^2, and -t

- 5 bins in Q^2 and x_b
- Further divided into -t bins
- 9 equidistance bins in ϕ
- Events were divided into either positive or negative helicity
- 135 invariant mass were fitted
- N+ and N- are the amplitude of ρ^0 fits in positive and negative helicity bins

$$BSA = \frac{1}{P_b}\frac{N_i^+ - N_i^-}{N_i^+ + N_i^-}$$



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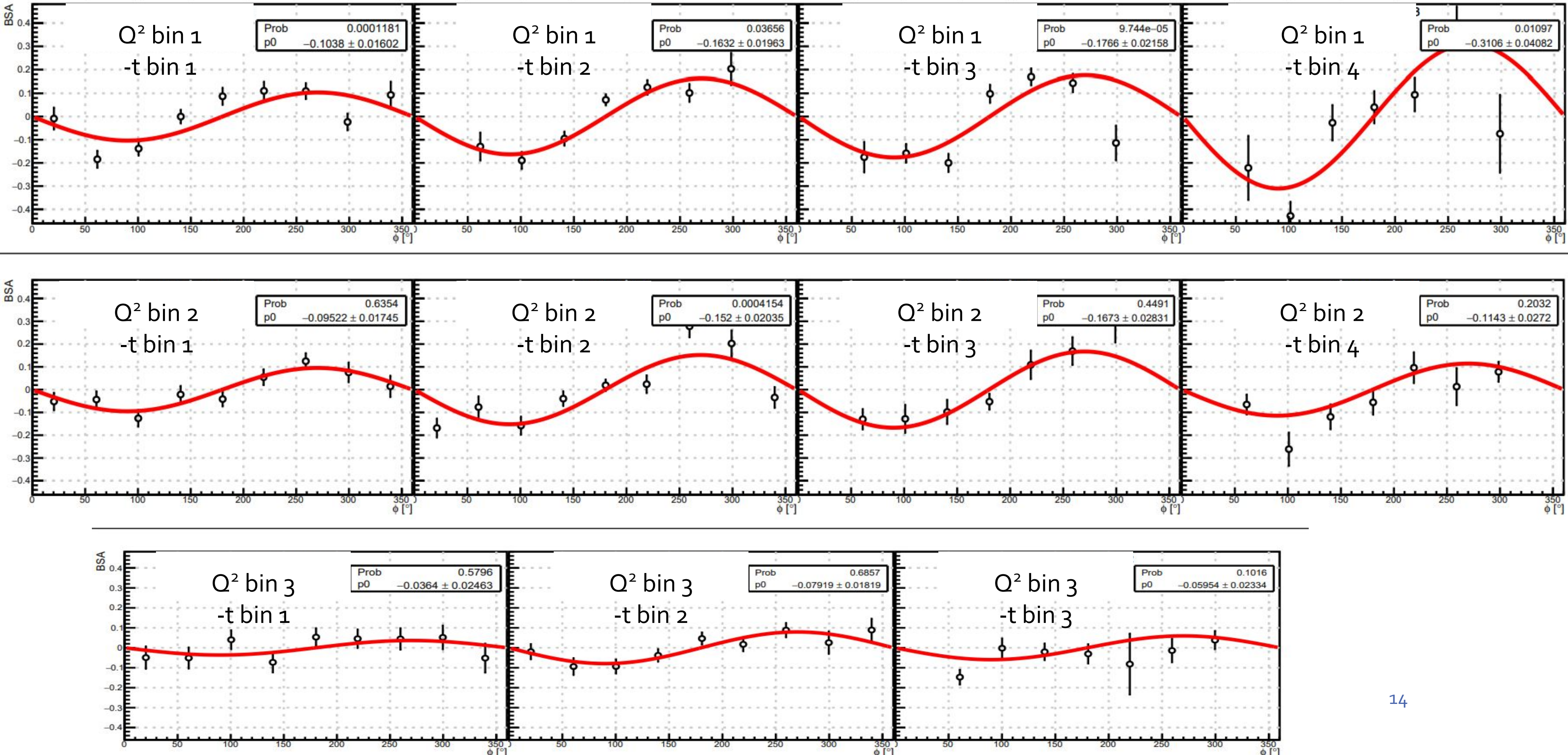
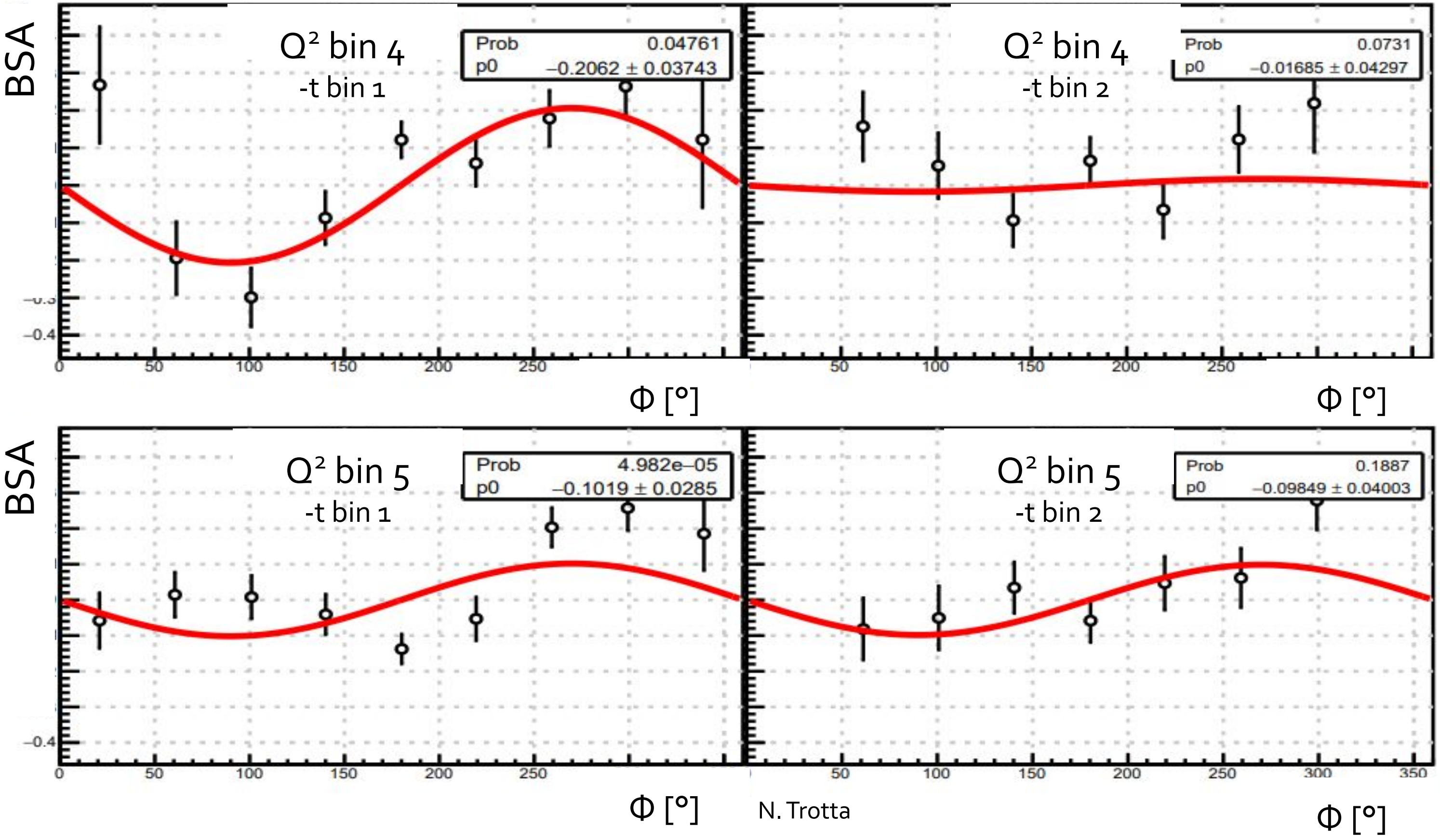
3D Bins in x_b,Q^2, and -t: BSA Inbending

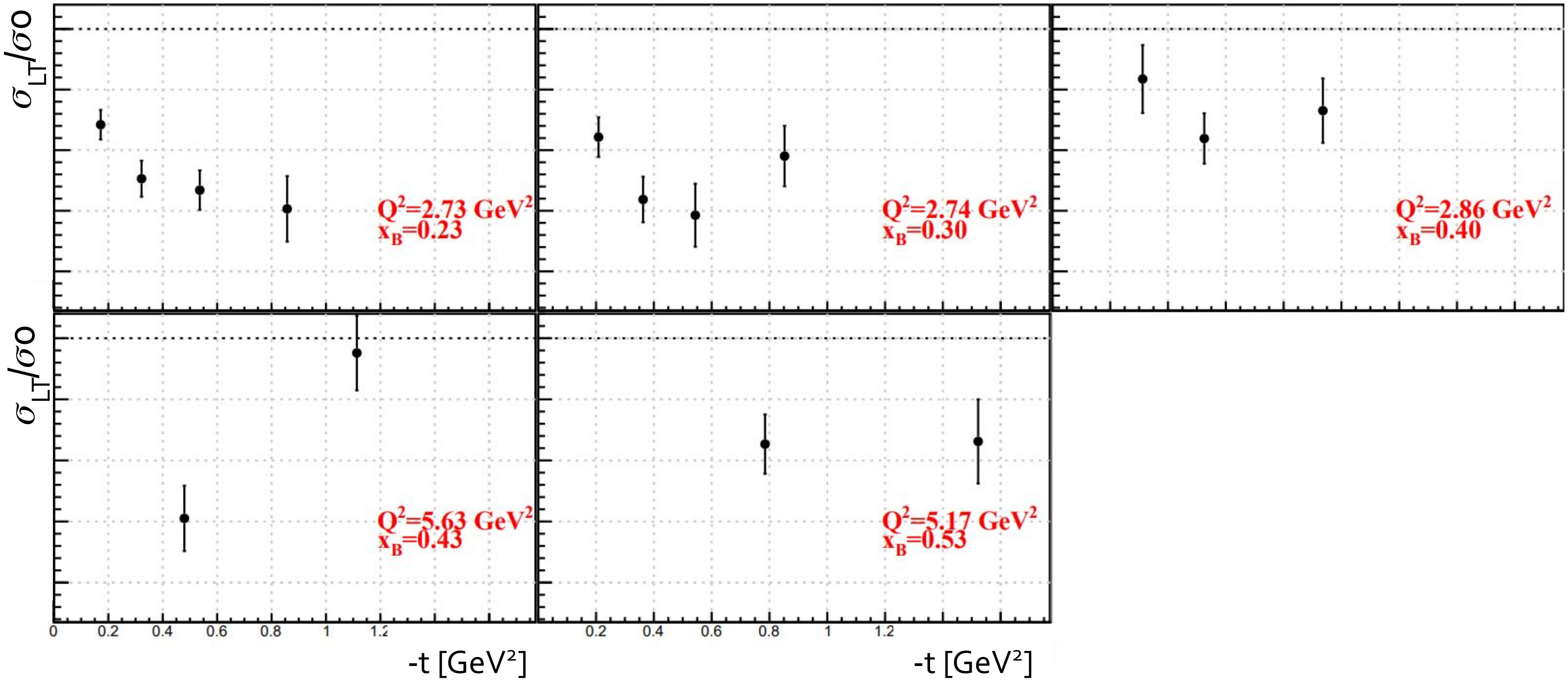


3D Bins in x_b,Q^2, and -t: BSA Inbending



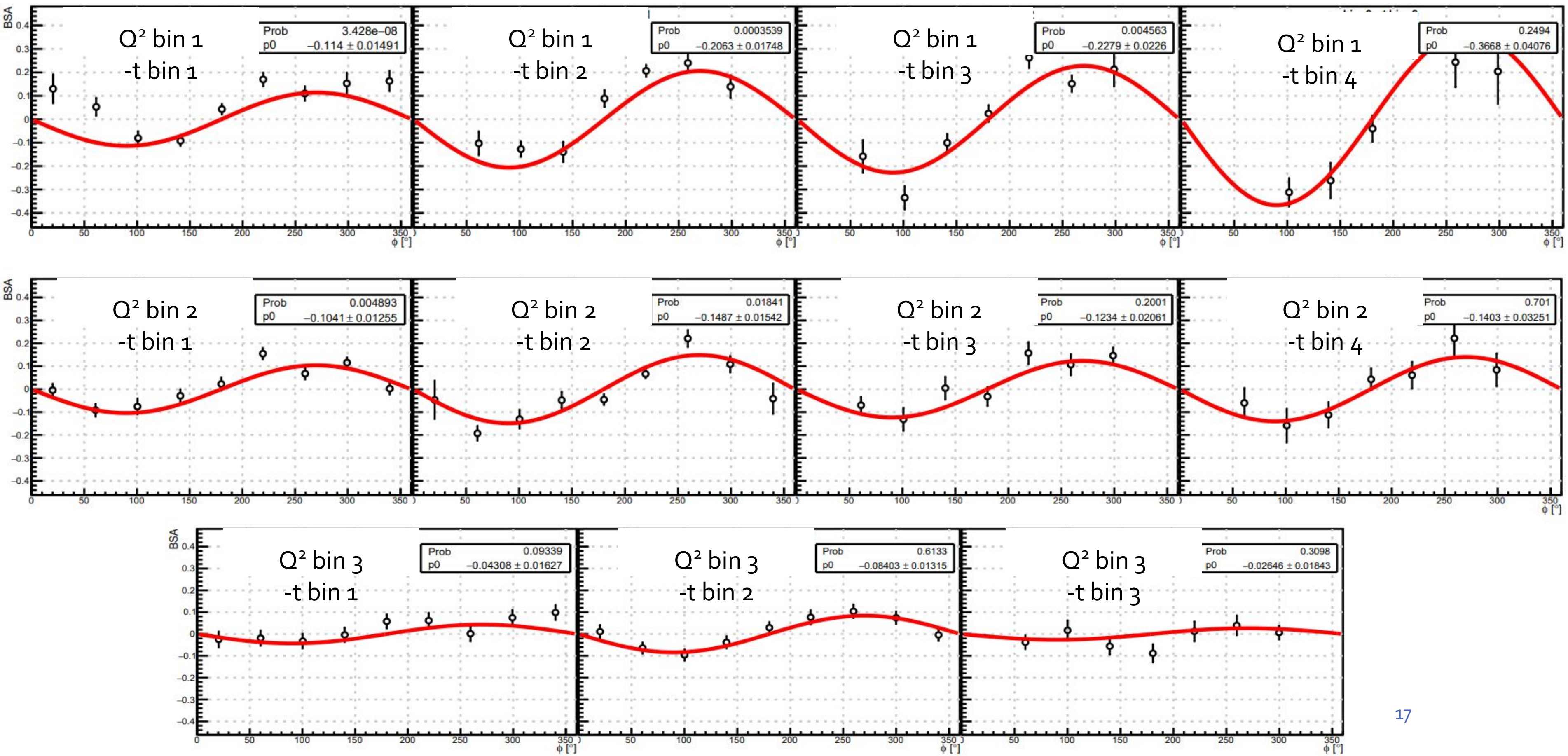
3D Bins in x_b,Q^2, and -t: σ_{LT}/σ_0

Dashed line zero

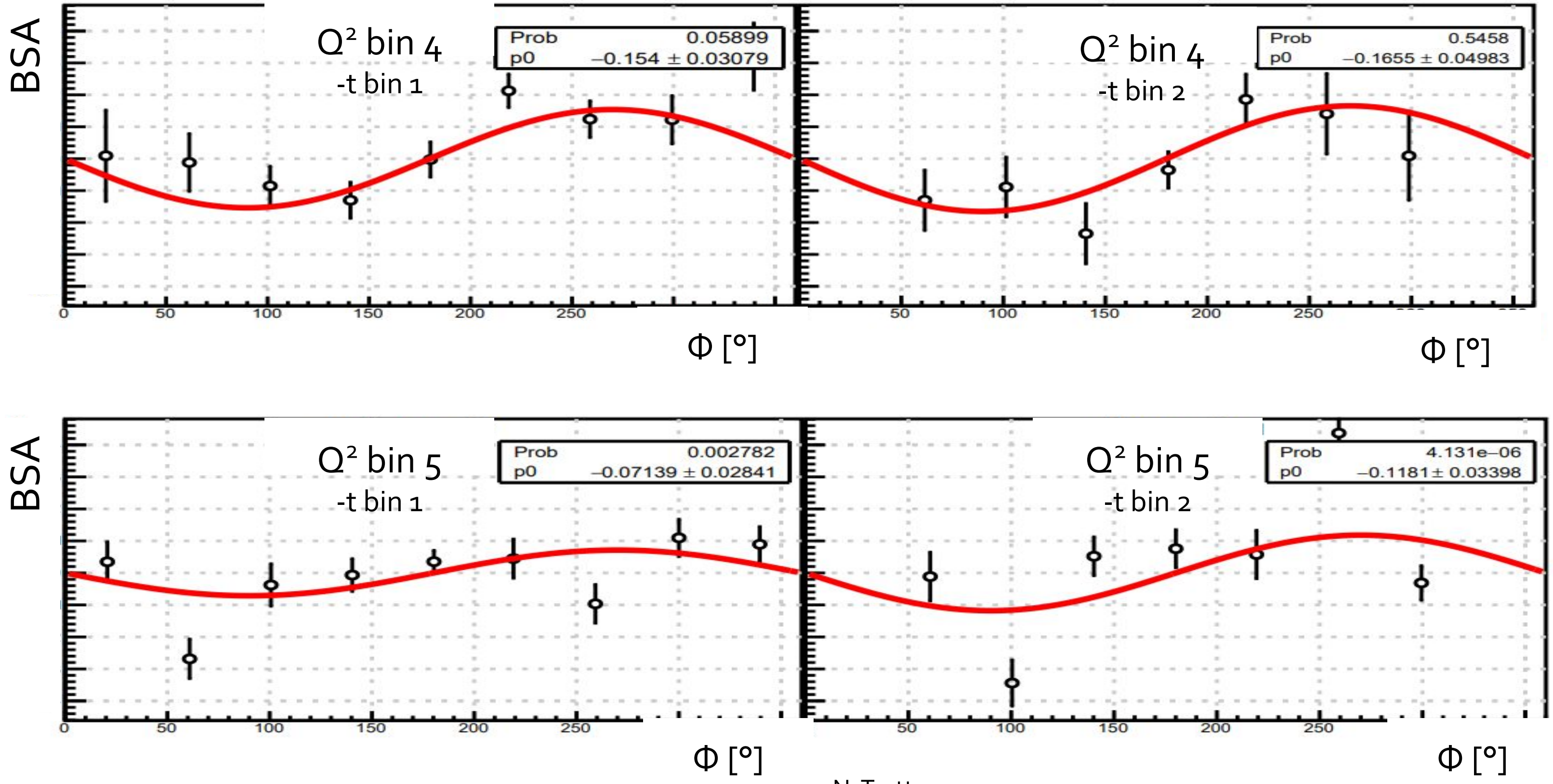


Inbending

3D Bins in x_b,Q^2, and -t: BSA Outbending

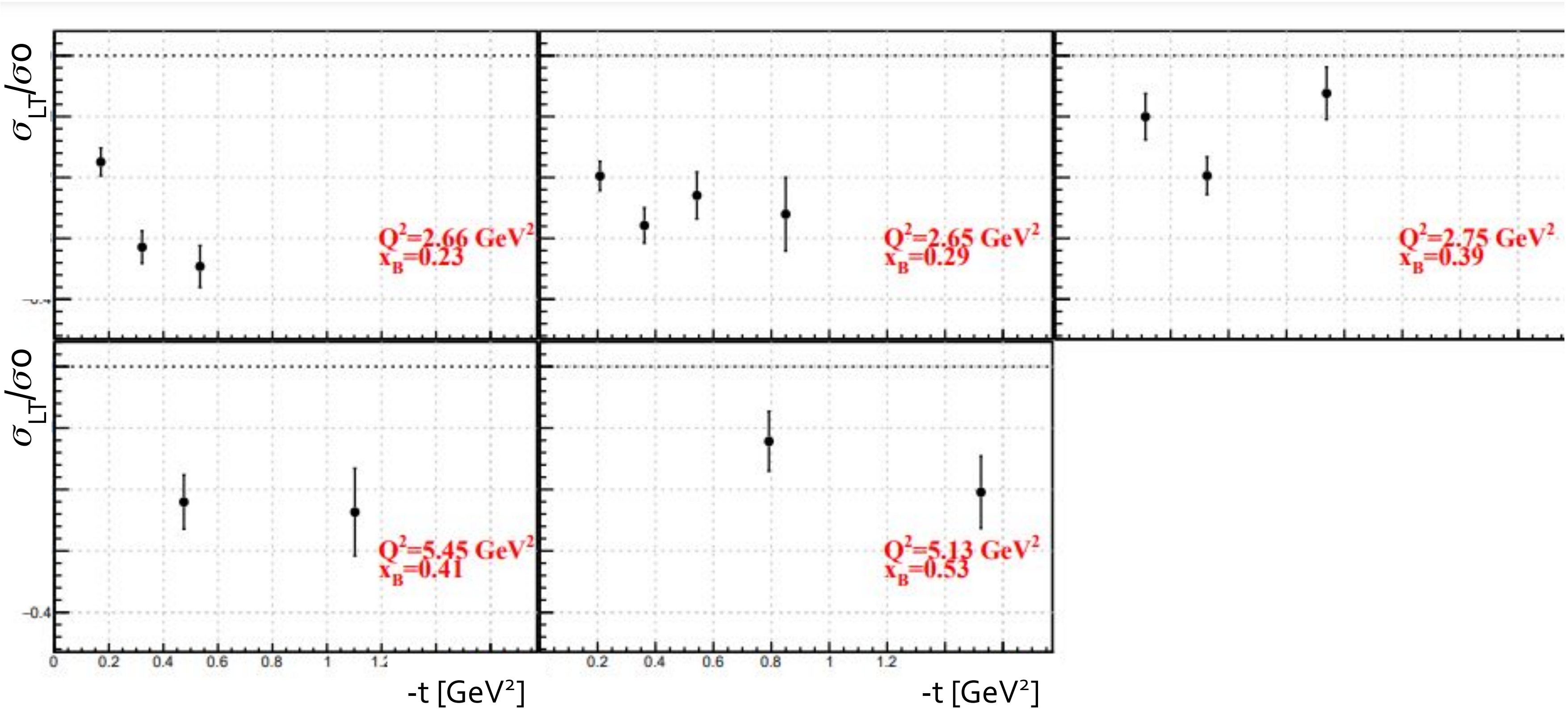


3D Bins in x_b,Q^2, and -t: BSA Outbending



3D Bins in x_b,Q^2, and -t: σ_{LT}/σ_0

Dashed lines are zero



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Outbending

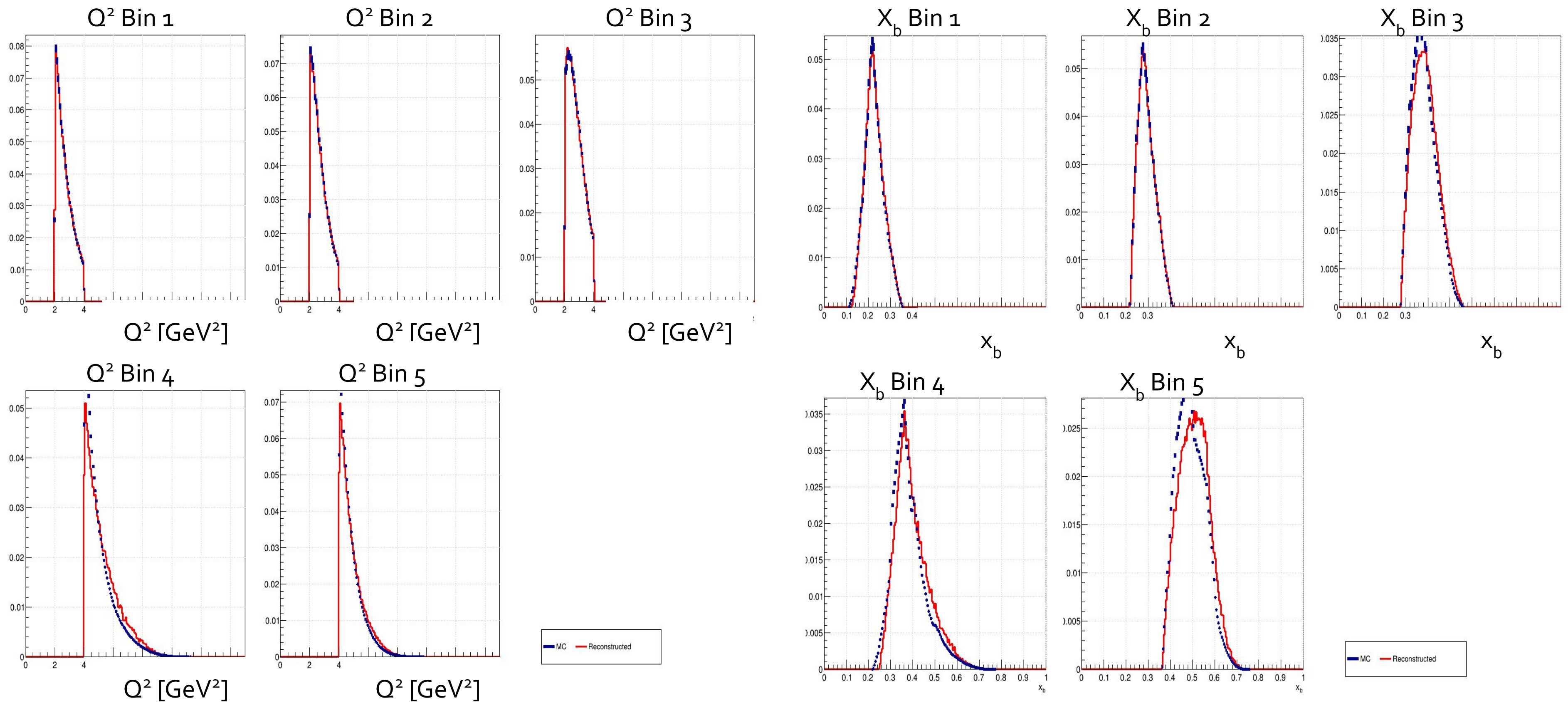
Maximum Likelihood Estimation Method (MLM)

- Can be used to to extract the modulations as an alternative method to the background subtraction
  - Allows for extraction of the modulations without binning in the azimuthal angle, ϕ
  - No assumptions are made about the distributions of the parameters

- Requires minimizing the negative log of the likelihood function

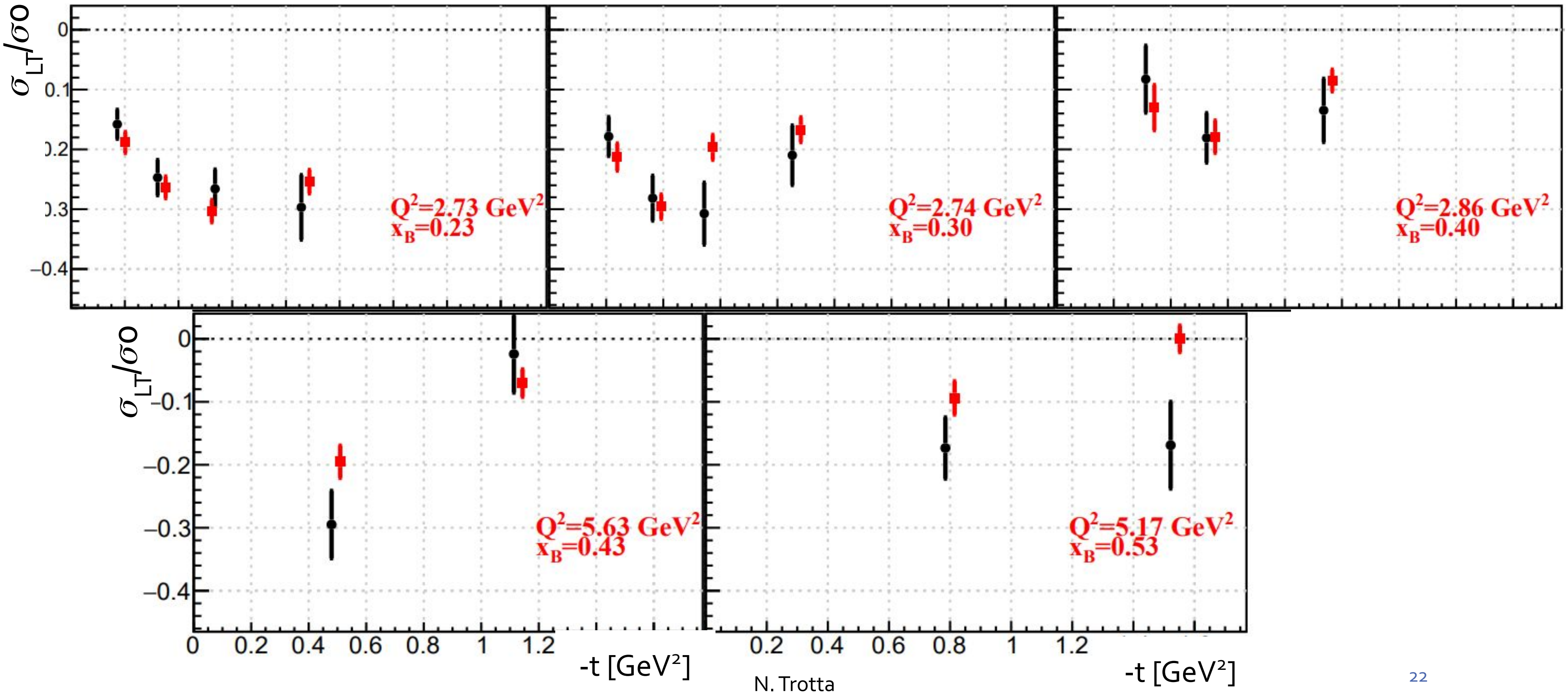
$$-log(L(\vec{\theta})) = N_{data} log(\sum_{i}^{N_{MC}} 1 + A_{UU}^{cos\phi} cos(\phi) + A_{UU}^{cos2\phi} cos(2\phi)) - \sum_{i}^{N_{data}} log(1 + A_{UU}^{cos\phi} cos(\phi) + A_{UU}^{cos2\phi} cos(2\phi) + A_{LU}^{sin\phi} sin(\phi))$$

Simulation: MC vc Reconstructed



3D Bins in x_b,Q^2, and -t: MLM vs χ^2

Red is MLM
Black is χ^2



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Inbending

Outlook and Conclusion

- Our results found that Chiral Odd GPDs play a significant role in vector meson production
- These results come from accessing GPDs through beam spin asymmetries
- Future plans:
    - Cross section measurement
    - Spin density matrix elements (SDMEs)

Thank You!

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Backup Slides

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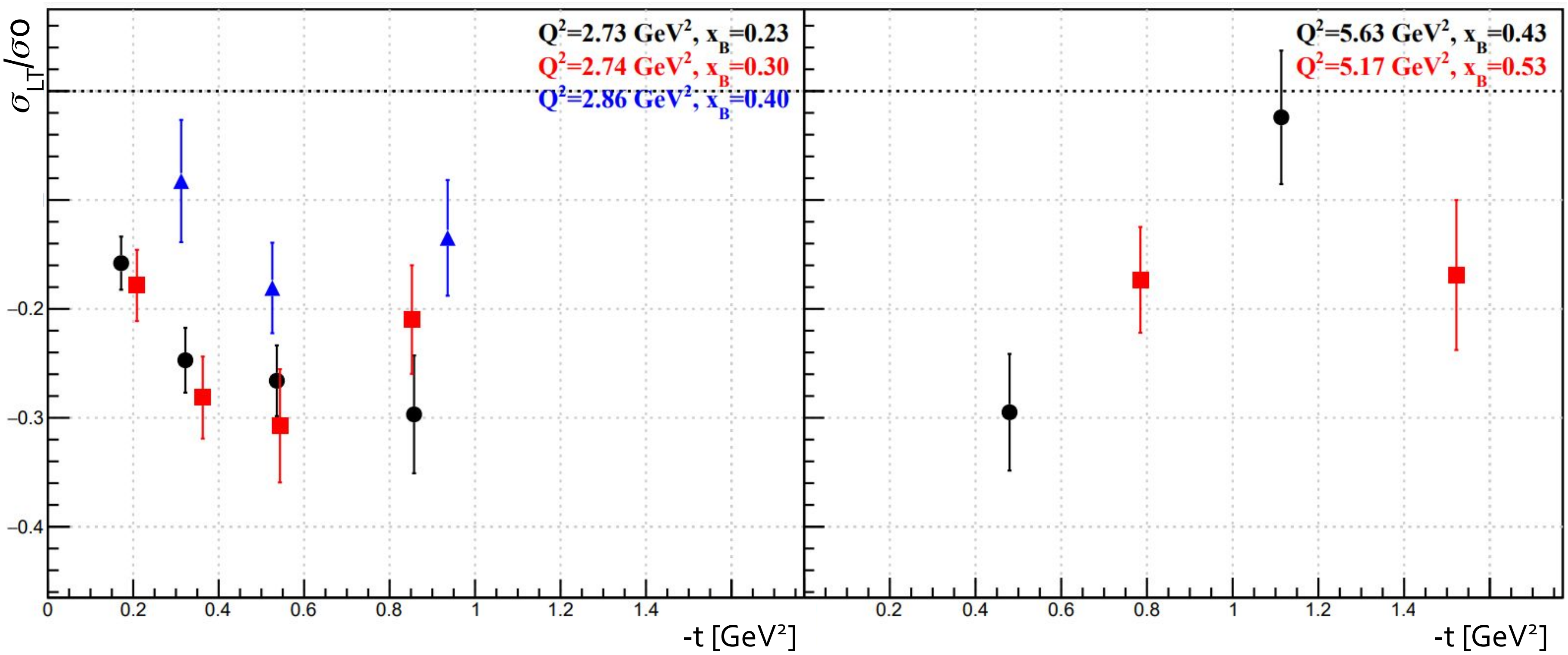
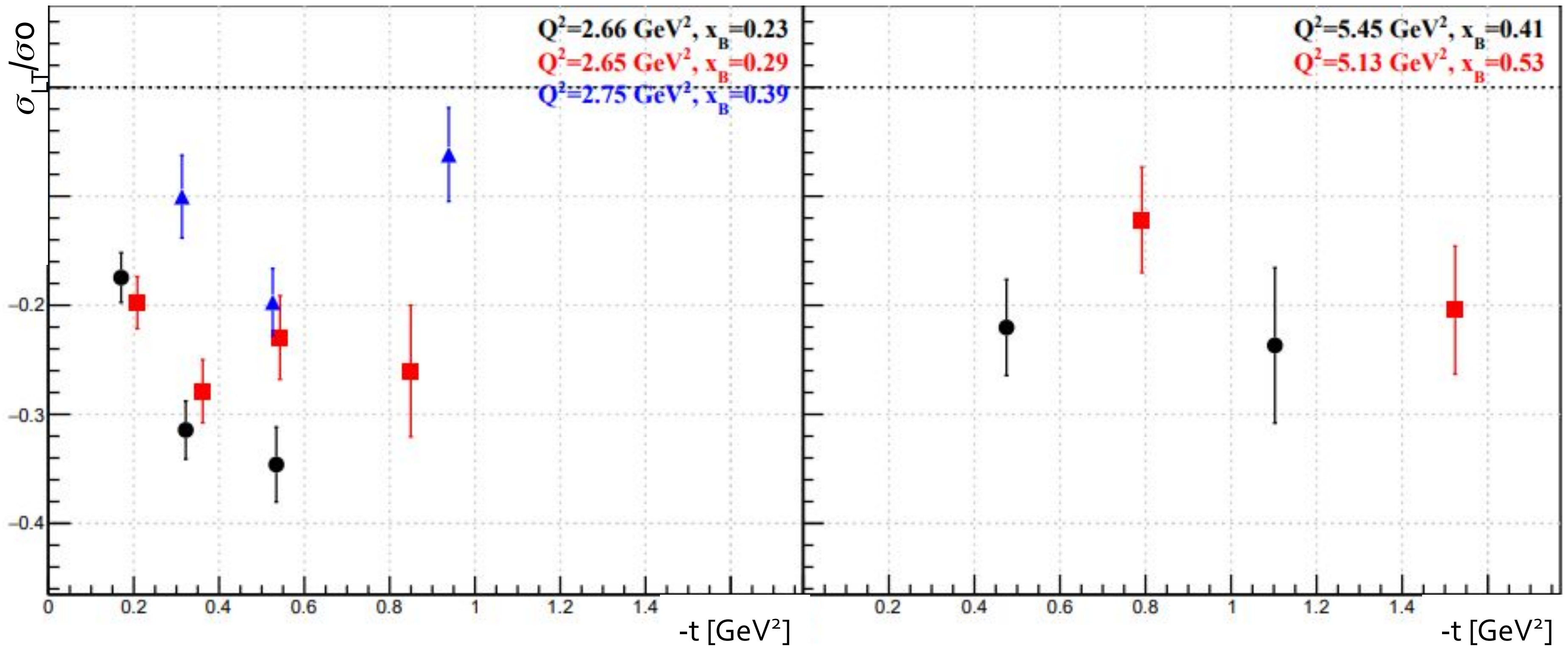
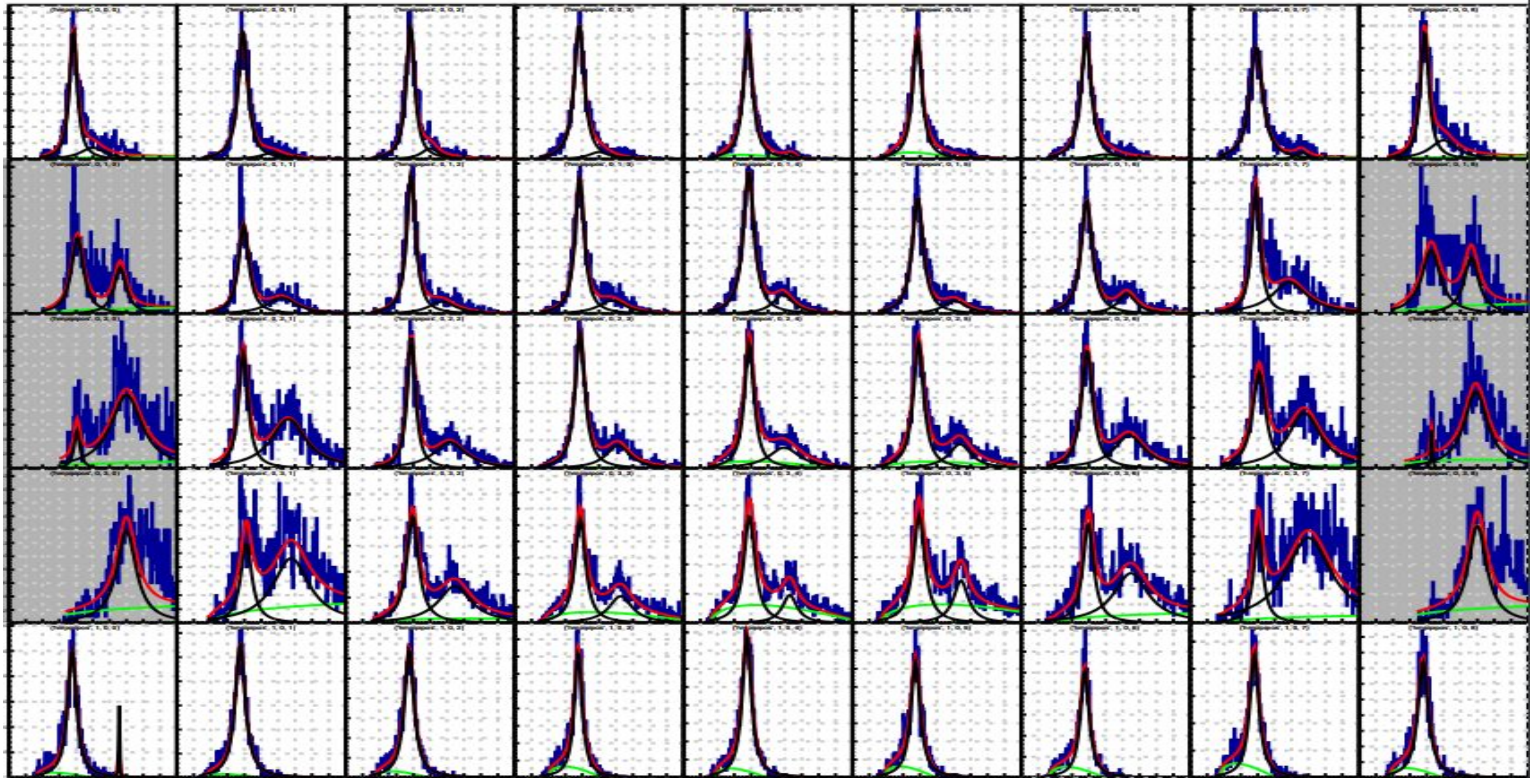
3D Bins in x_b,Q^2, and -t: σ_{LT}/σ_0 Inbending



3D Bins in x_b,Q^2, and -t: σ_{LT}/σ_0 Outbending



3D Bins Invariant Mass Fits Positive Helicity



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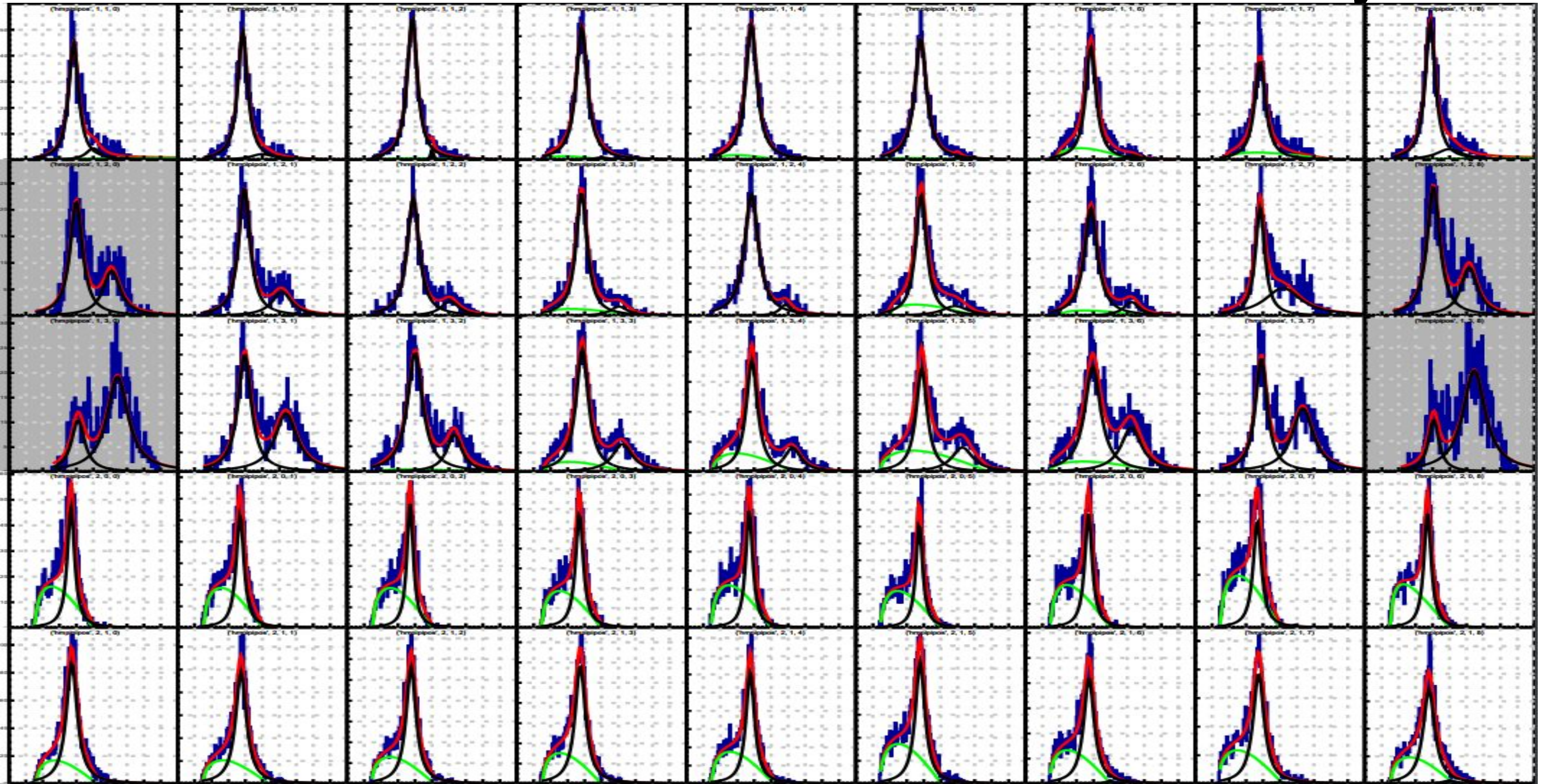

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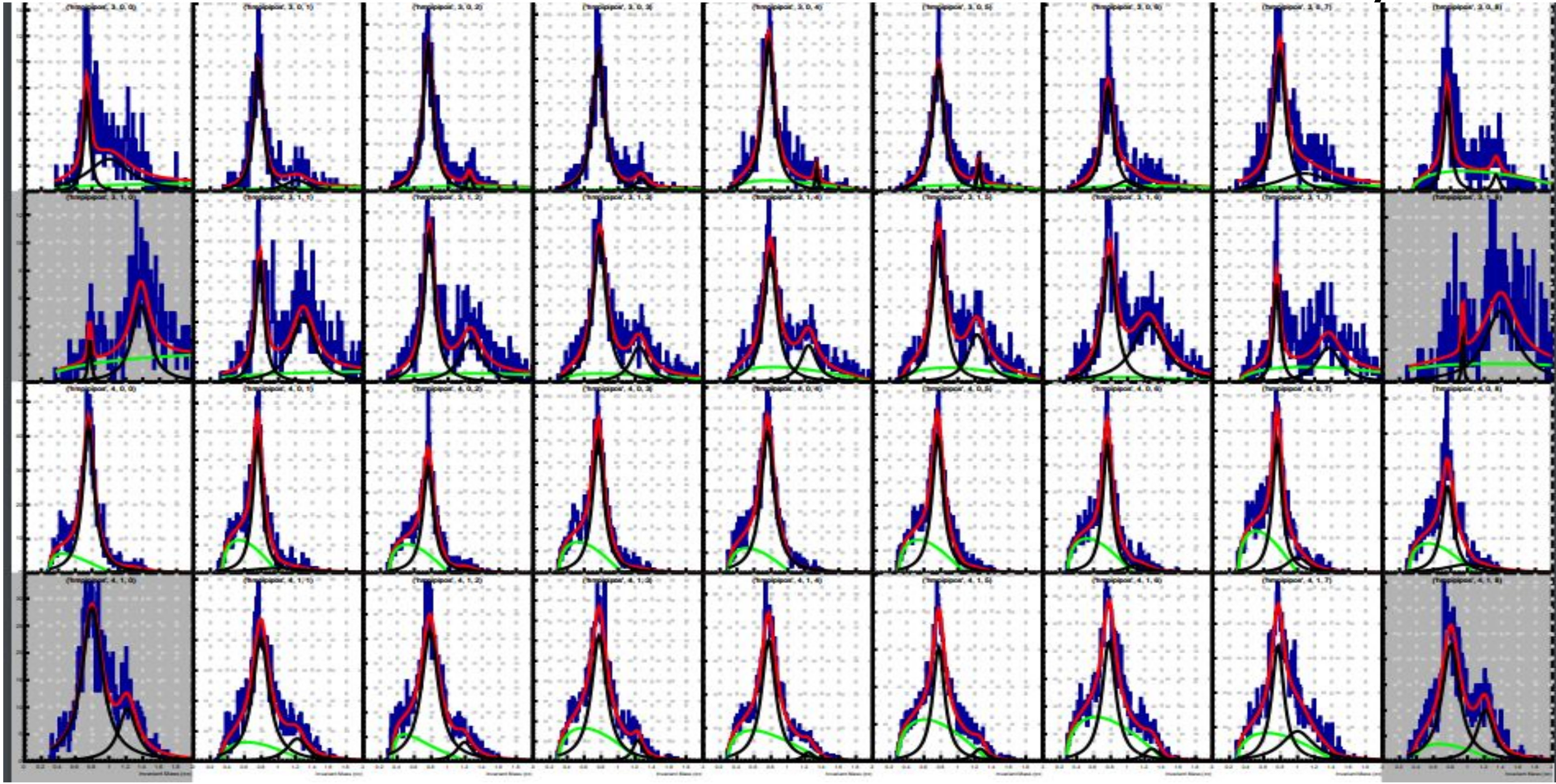

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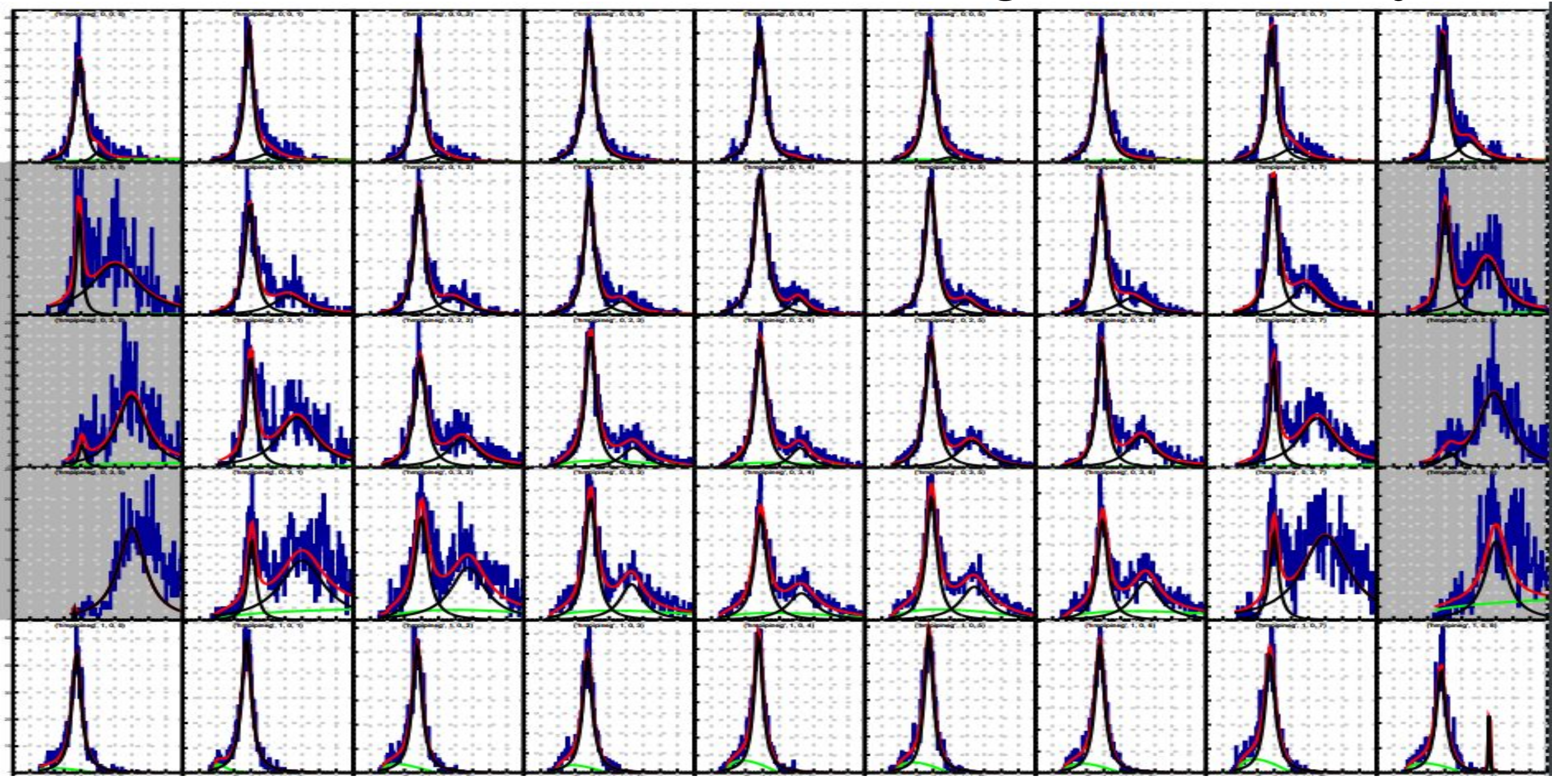

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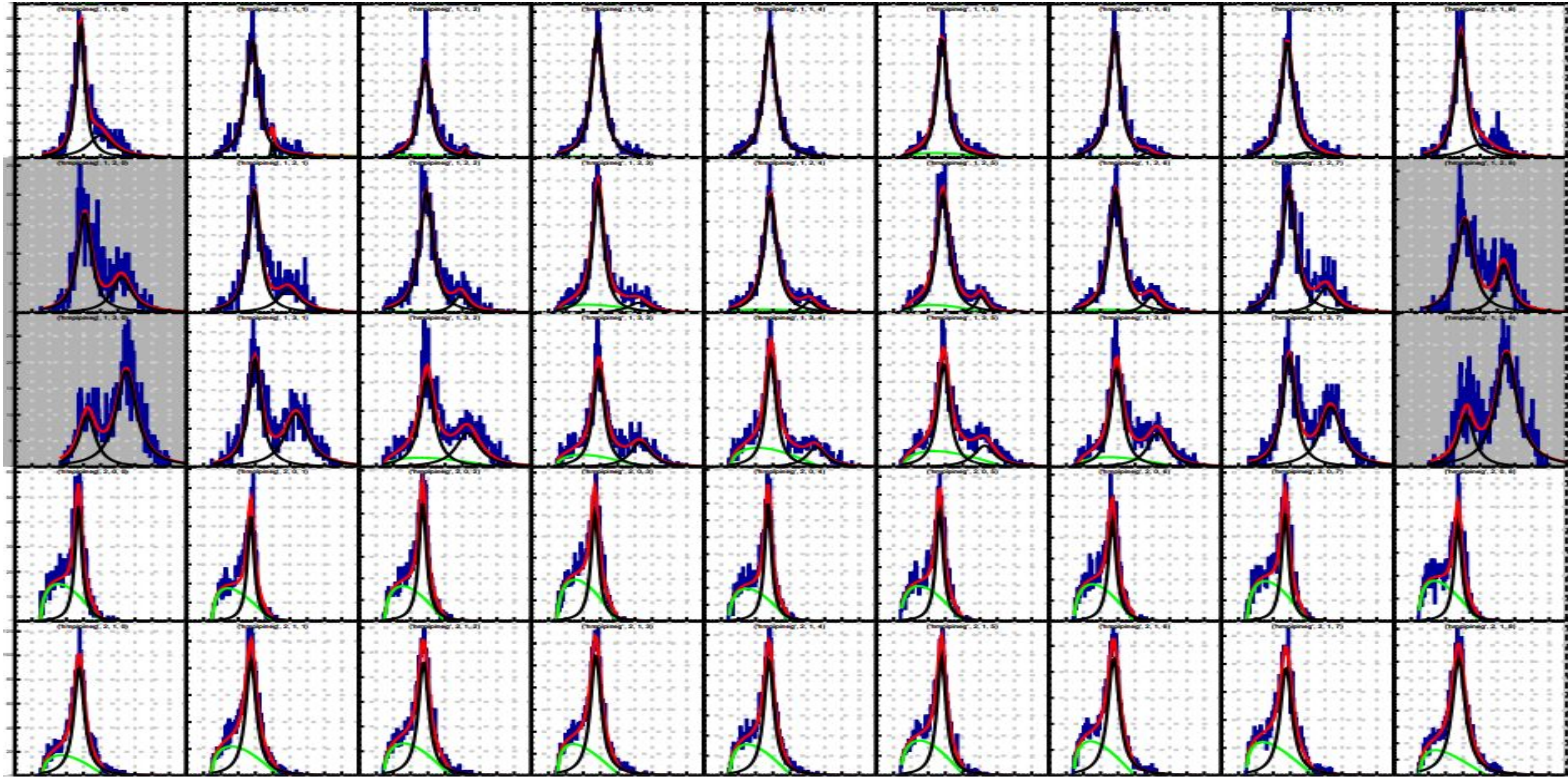

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