Accessing the gluon Sivers function via dihadron pairs

Javier Jiménez-López, 07/21/2026

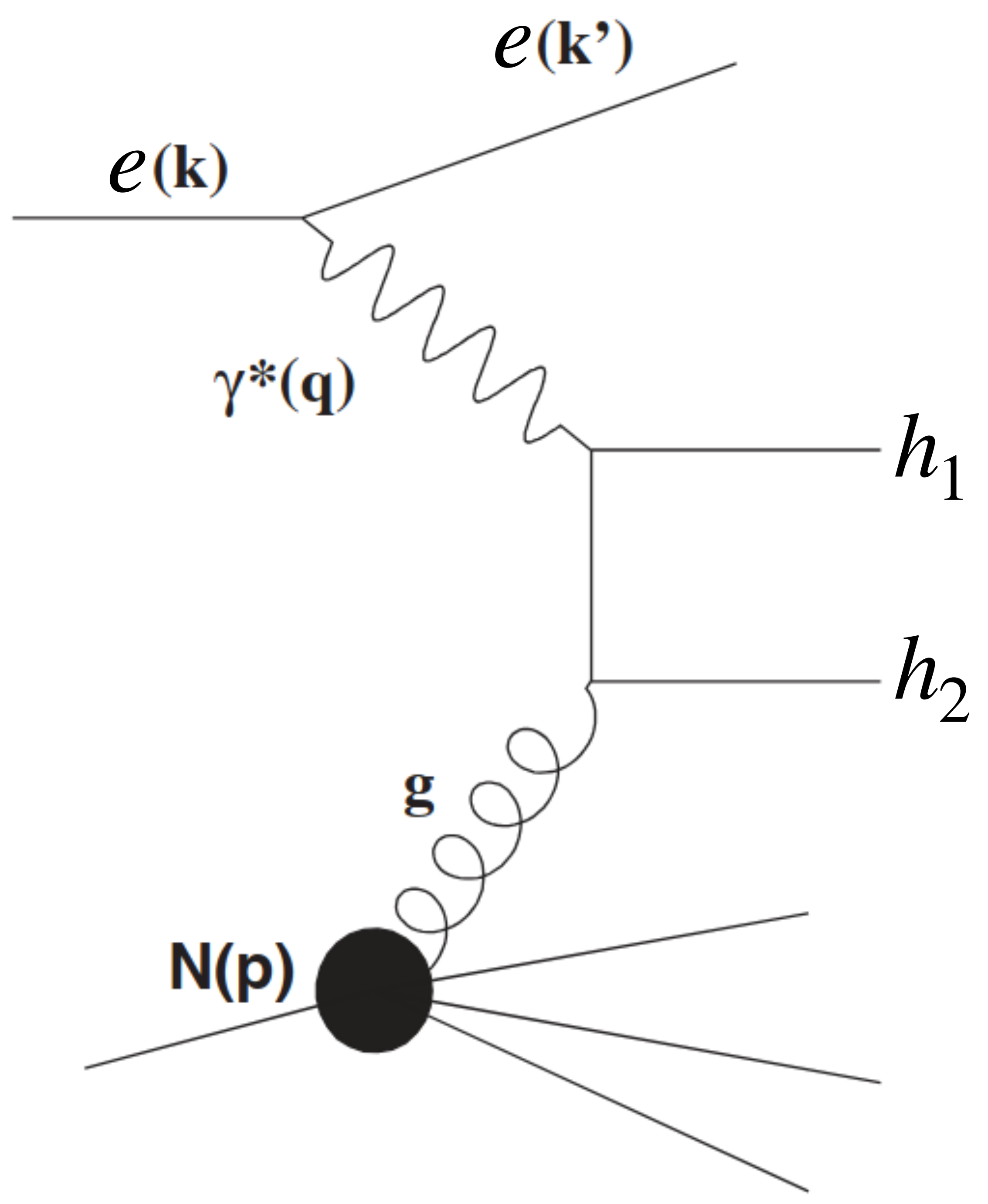
VRIJE
UNIVERSITEIT
BRUSSEL

The Sivers function measures the correlation between a parton's transverse momentum and a transversely polarised proton's spin.

Why should we care about it?

- It tells us about gluon orbital motion.
- At the EIC, thanks to the polarised beams, sensitive channels are available.

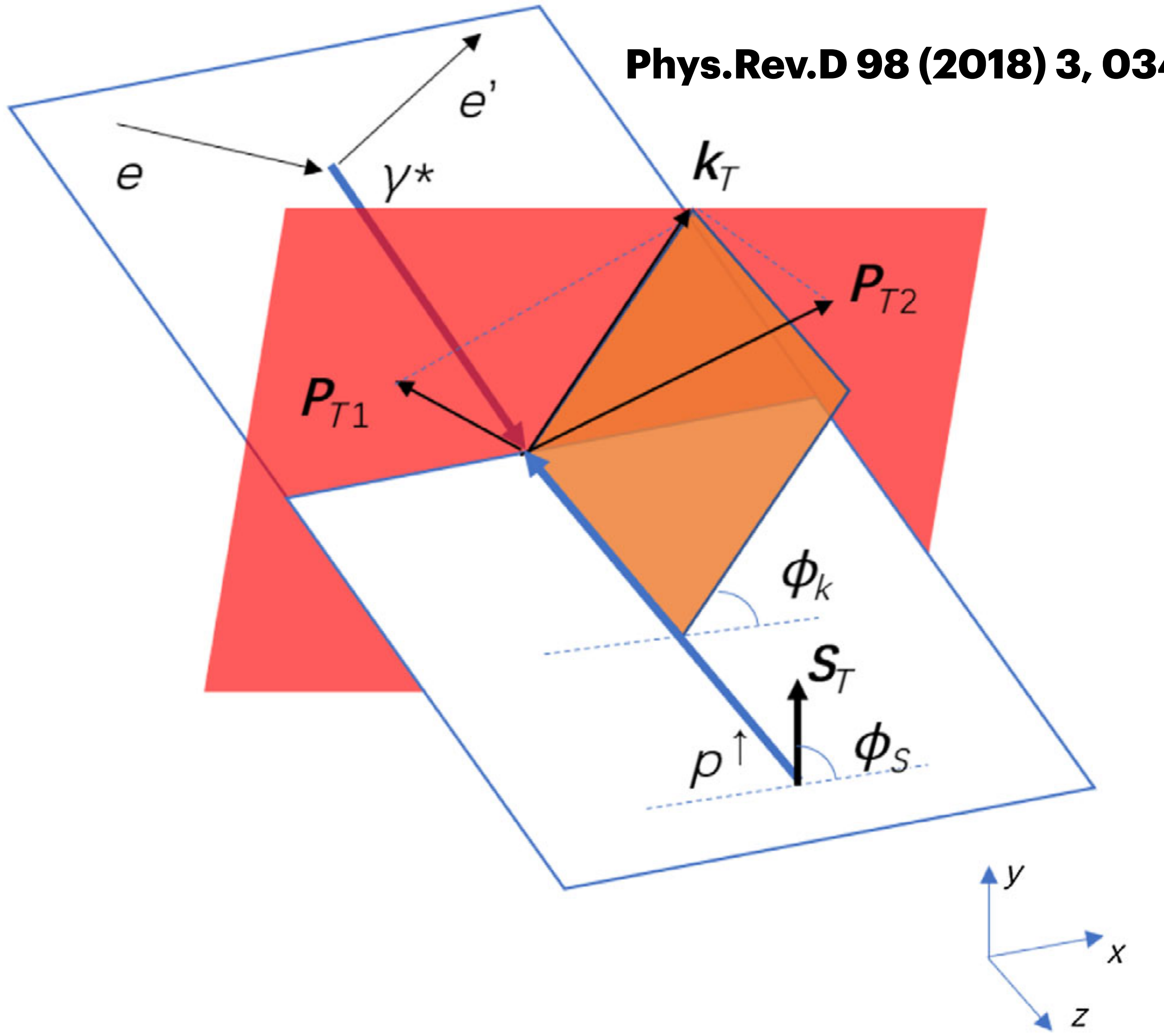
Hadron pairs provide access to the gluon through photon-gluon fusion. $\Longrightarrow$



Based on **Phys.Rev.D 98 (2018) 3, 034011**

SIDIS and Sivers

Phys.Rev.D 98 (2018) 3, 034011



$$\sin(\phi_h - \phi_S)$$

$$\hat{f}_{g/p^\uparrow}(x, k_\perp, Q^2) = f_{g/p}(x, k_\perp, Q^2) + \frac{1}{2}\Delta f_{g/p^\uparrow}(x, k_\perp, Q^2)\, \boldsymbol{S}\cdot\left(\hat{\boldsymbol{P}} \times \hat{\boldsymbol{k}}_\perp\right)$$

$$\Delta f_{g/p^\uparrow}(x, k_\perp, Q^2) = -\frac{2k_\perp}{m_p} f_{1T}^{\perp g}(x, k_\perp, Q^2)$$

$$A_{UT}(\phi_{hS} = \phi_h - \phi_S, k_T) = \frac{d\sigma^\uparrow(\phi_{hS}, k_T) - d\sigma^\downarrow(\phi_{hS}, k_T)}{d\sigma^\uparrow(\phi_{hS}, k_T) + d\sigma^\downarrow(\phi_{hS}, k_T)} \propto \frac{\Delta f_{g/p^\uparrow}(x, k_\perp, Q^2)}{2 f_{g/p}(x, k_\perp, Q^2)}$$

Setting $w_i = \dfrac{\Delta f_{g/p^\uparrow}(x, k_\perp, Q^2)}{2 f_{g/p}(x, k_\perp, Q^2)}$ $\Longrightarrow$ $A_{UT} = \dfrac{1}{PN}\displaystyle\sum_{k=1}^{N} w_i$

$P = 70\,\%$

***JHEP* 08 (2010) 130**

Dataset description and kinematic estimators

- Beam configurations considered:
  - 9×130 GeV^2 with $\mathscr{L}_{int} = 0.5$ fb^{-1}.
  - 9×275 GeV^2 with $\mathscr{L}_{int} = 1.25$ fb^{-1}.
- Simulation campaign: 26.06.0 (5M events per Q^2 range).
- Kinematic cuts:
  - $Q^2 > 1$ GeV^2.
  - $0.1 < y < 0.9$.
  - $z_h > 0.1$.
- Transverse momentum imbalance of the dihadron pair: $P_T = |P_{1T} - P_{2T}|/2$.
- Transverse momentum sum of the dihadron pair: $k_T = |P_{1T} + P_{2T}|$.
- Kinematic conditions:
  - $P_{iT} > 1.4$ GeV. (Removes background)
  - $k_T < 0.7P_T$ (Ensures back-to-back hadrons and TMD validity range).

Kinematic variables reconstructed with the electron method

Gluon and quark parametrisation

Model 1

$$\Delta f_{g/p^\uparrow}(x,k_\perp) = 2\mathcal{N}_g(x) f_{g/p}(x,Q^2) h(k_\perp) \frac{\exp(-k_\perp^2/\langle k_\perp^2\rangle)}{\pi\langle k_\perp^2\rangle}$$

$$\mathcal{N}_g(x) = N_g x^{\alpha_g}(1-x)^{\beta_g} \frac{(\alpha_g+\beta_g)^{(\alpha_g+\beta_g)}}{\alpha_g^{\alpha_g}\beta_g^{\beta_g}}$$

$$h(k_\perp) = \sqrt{2e}\,\frac{k_\perp}{M_g}\exp(-k_\perp^2/M_g^2)$$

- Quark parameters: ***JHEP* 04 (2017) 046**
- Gluon parameters: ***JHEP* 09 (2015) 119**

$$N_g = 0.65\,,\ \alpha_g = 2.8\,,\ \beta_g = 2.8\,,$$

$$M_g = \sqrt{0.5487}\ \text{GeV}\,,\ \langle k_\perp^2\rangle = 0.25\,\text{GeV}^2$$

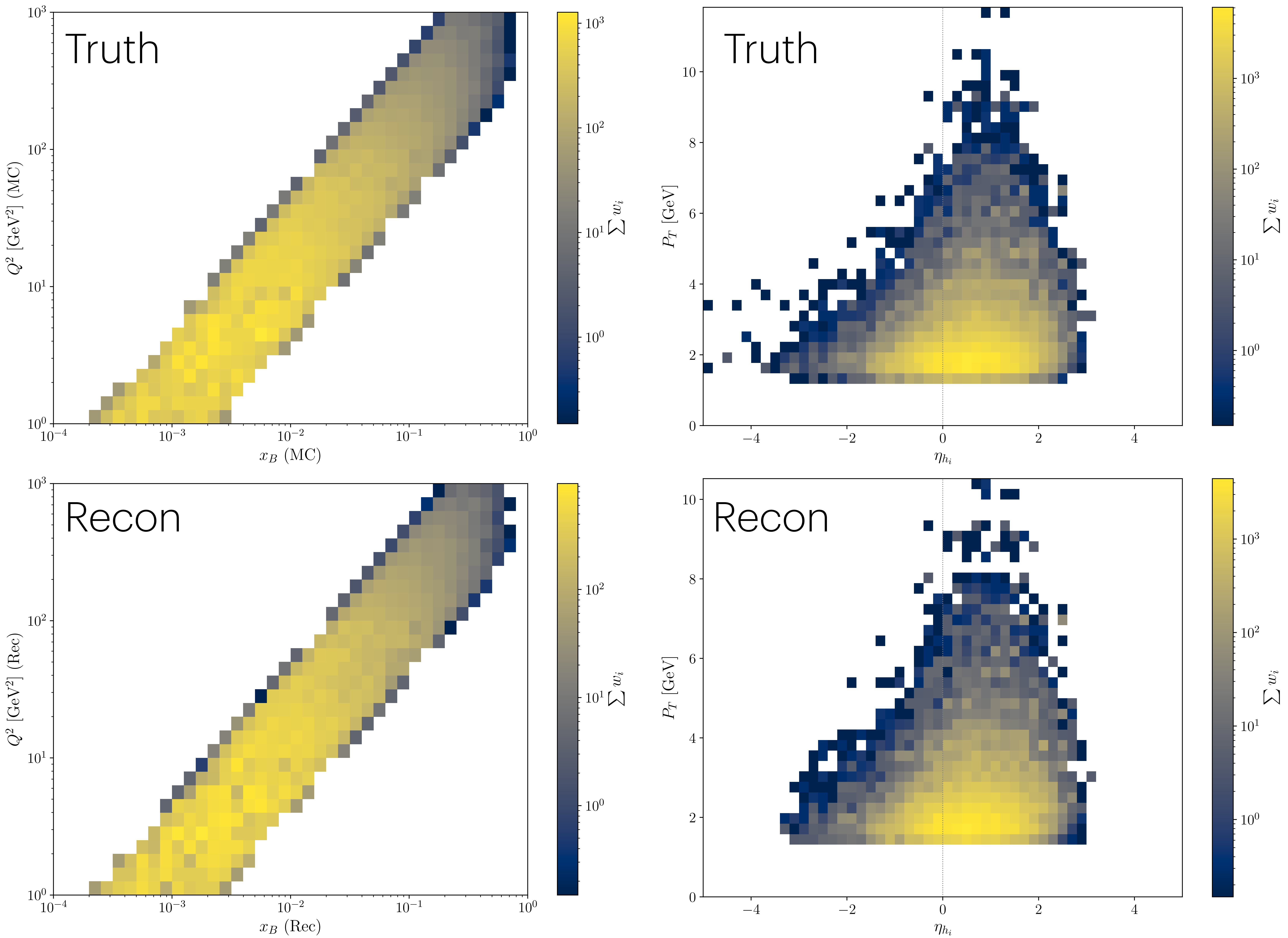
Model 2

$$f_{1T}^{\perp g} = -\frac{2\sigma m_p}{k_\perp^2+\sigma^2} f_g(x,k_\perp,Q^2) \text{ with } \sigma = 0.8 \text{ GeV}$$

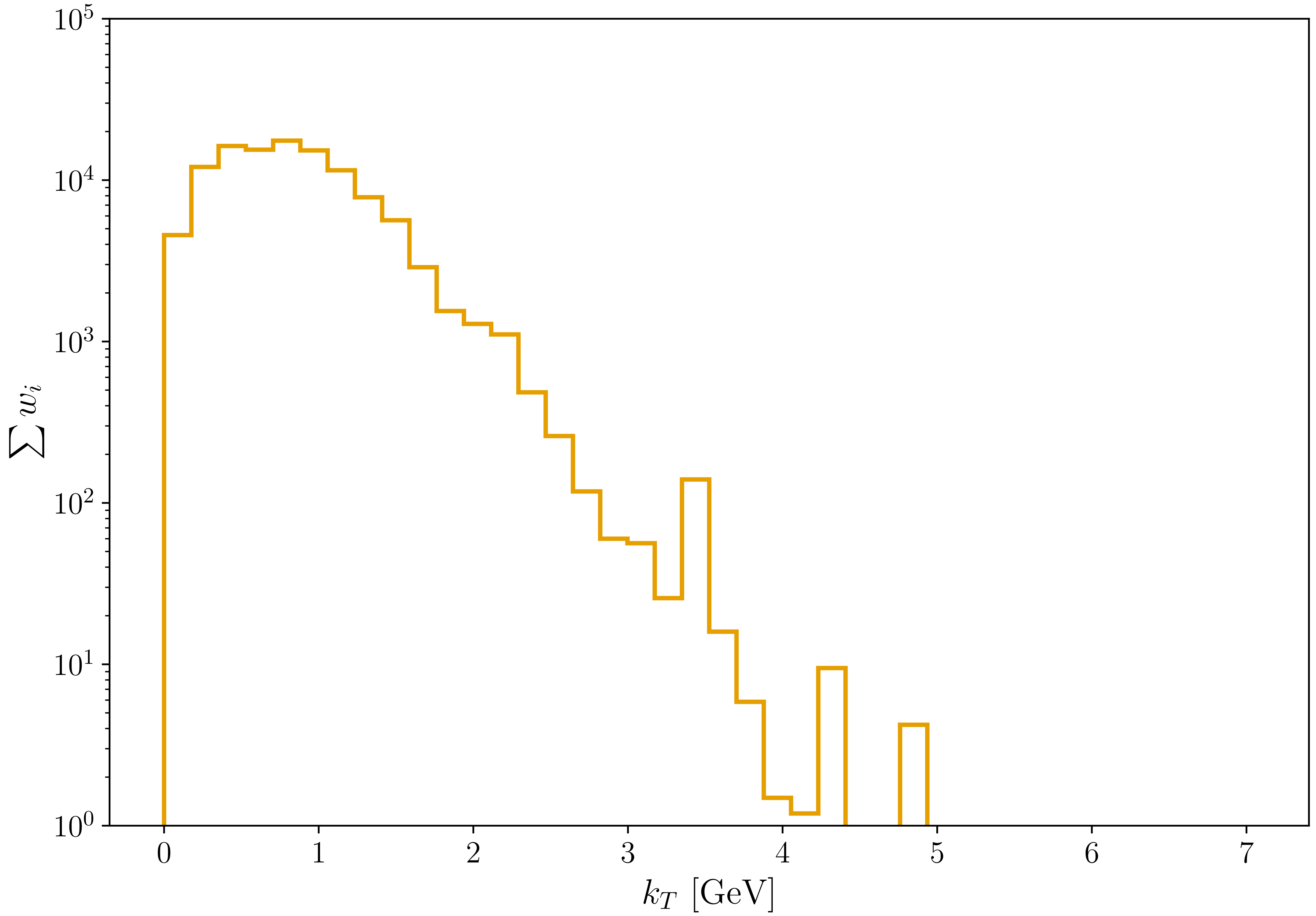
Phys. Rev. D 70, 074025

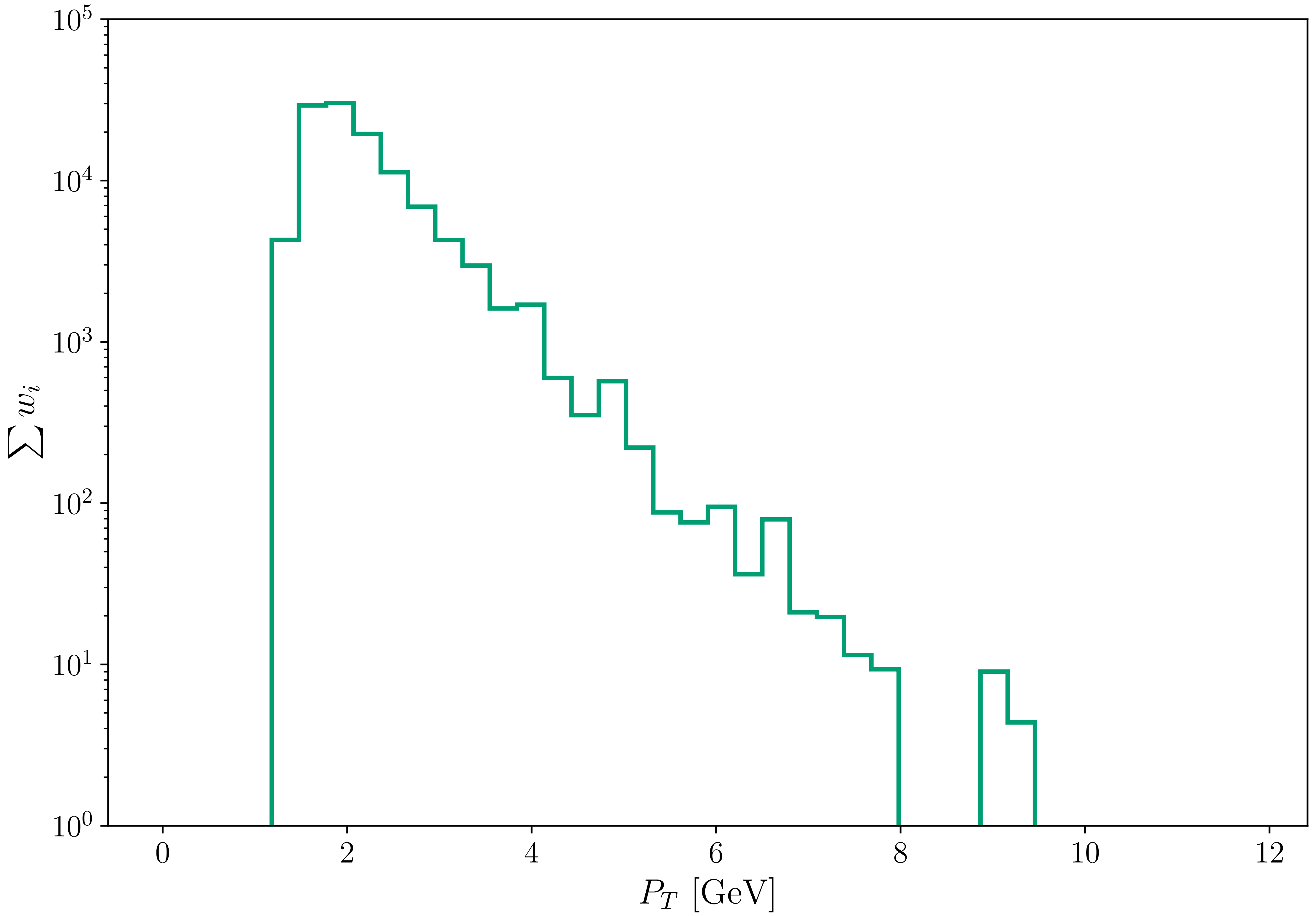
For quarks only Model 1 has been used

Kinematic variables $9 \times 130\ \mathrm{GeV}^2$

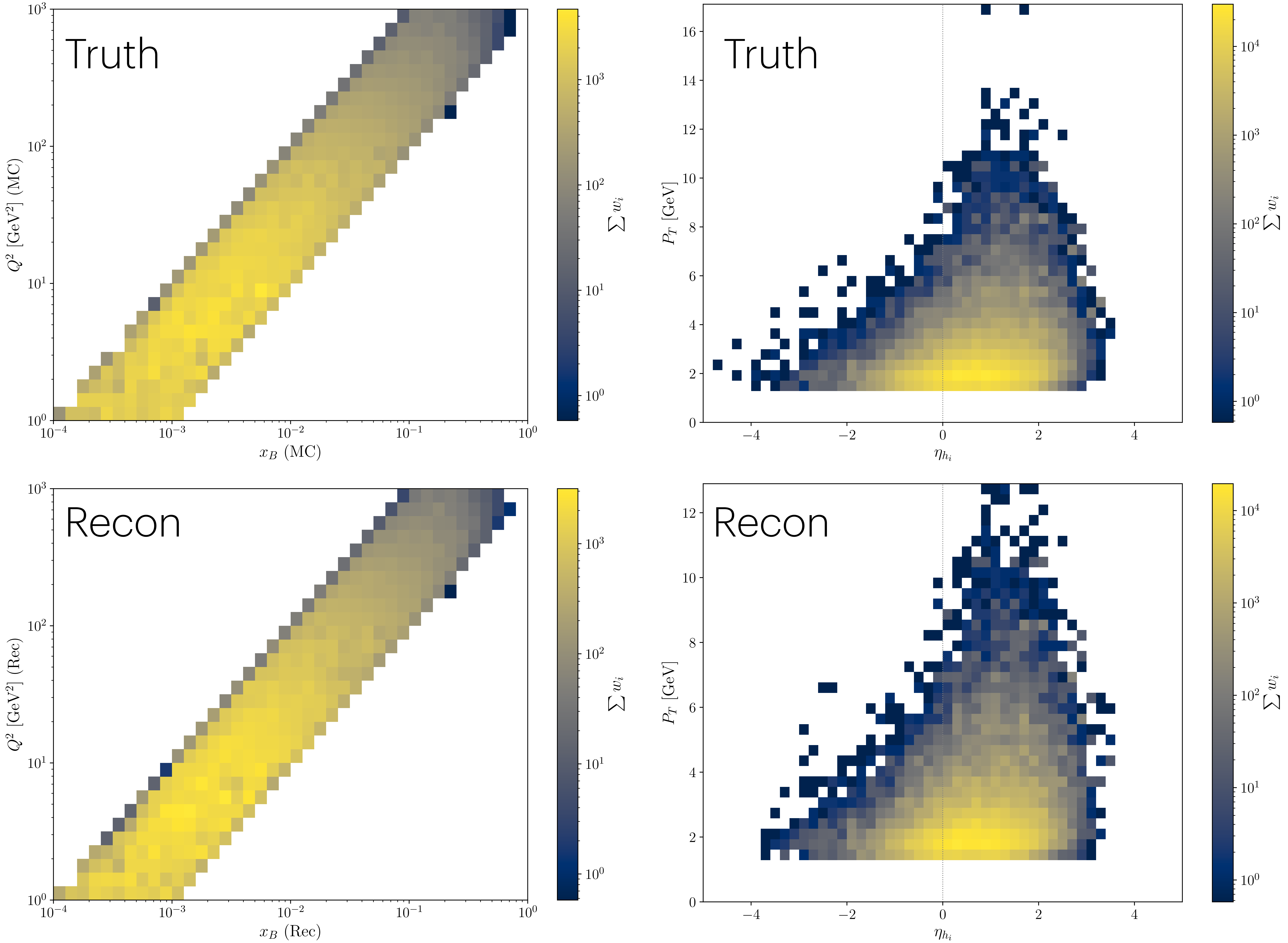


Kinematic variables $9 \times 130\,\mathrm{GeV}^2$

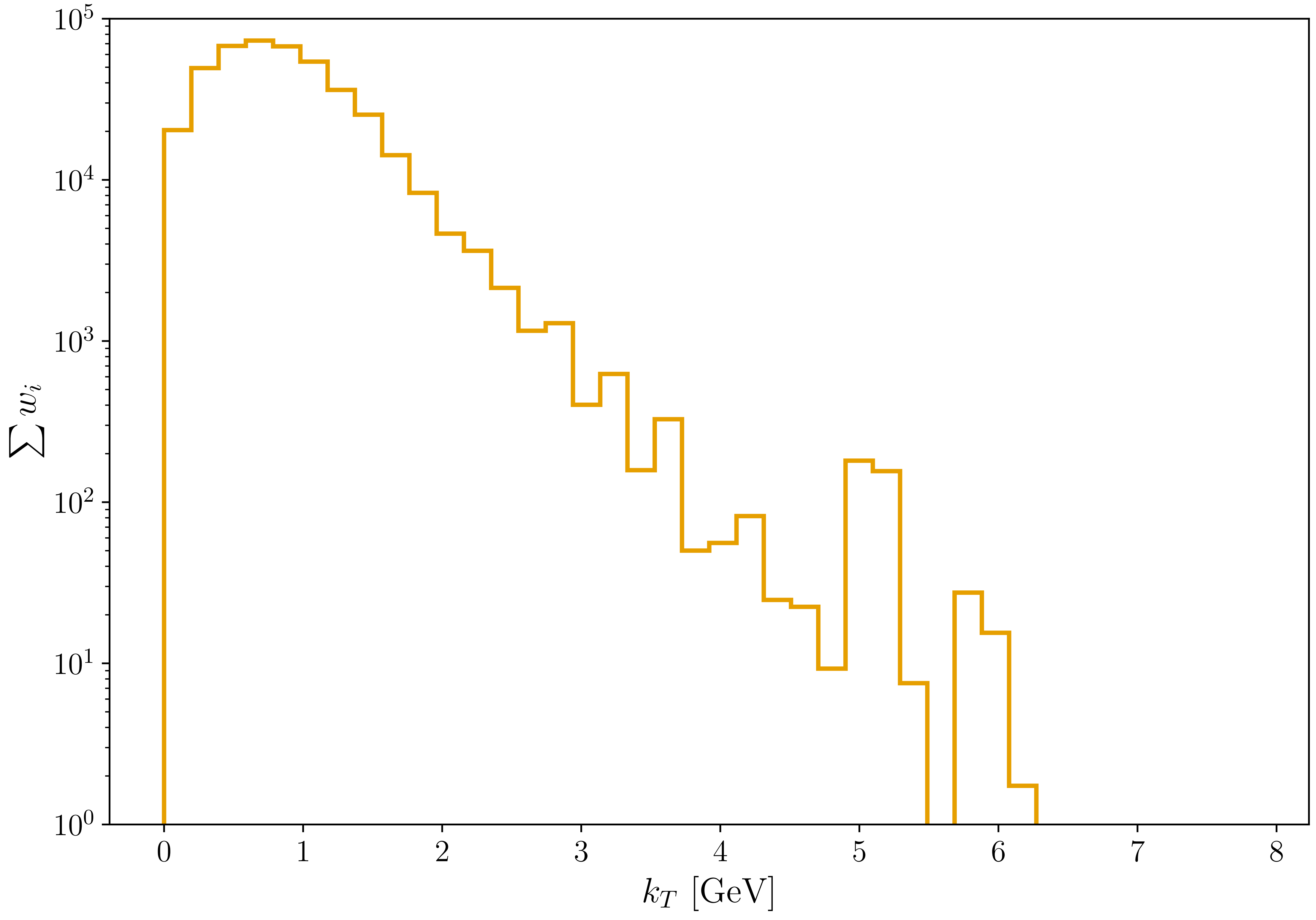


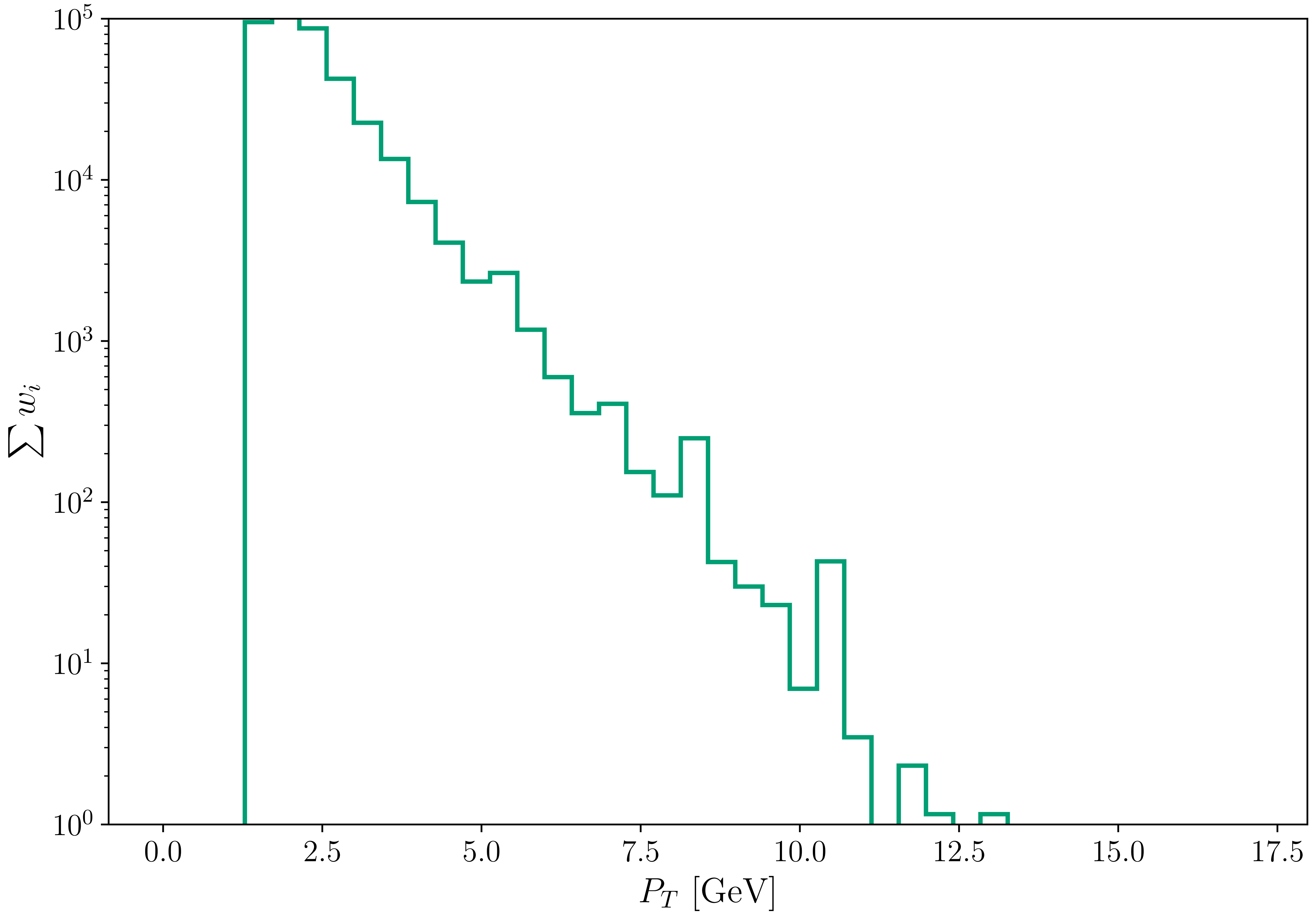


Kinematic variables $9 \times 275\ \mathrm{GeV}^2$

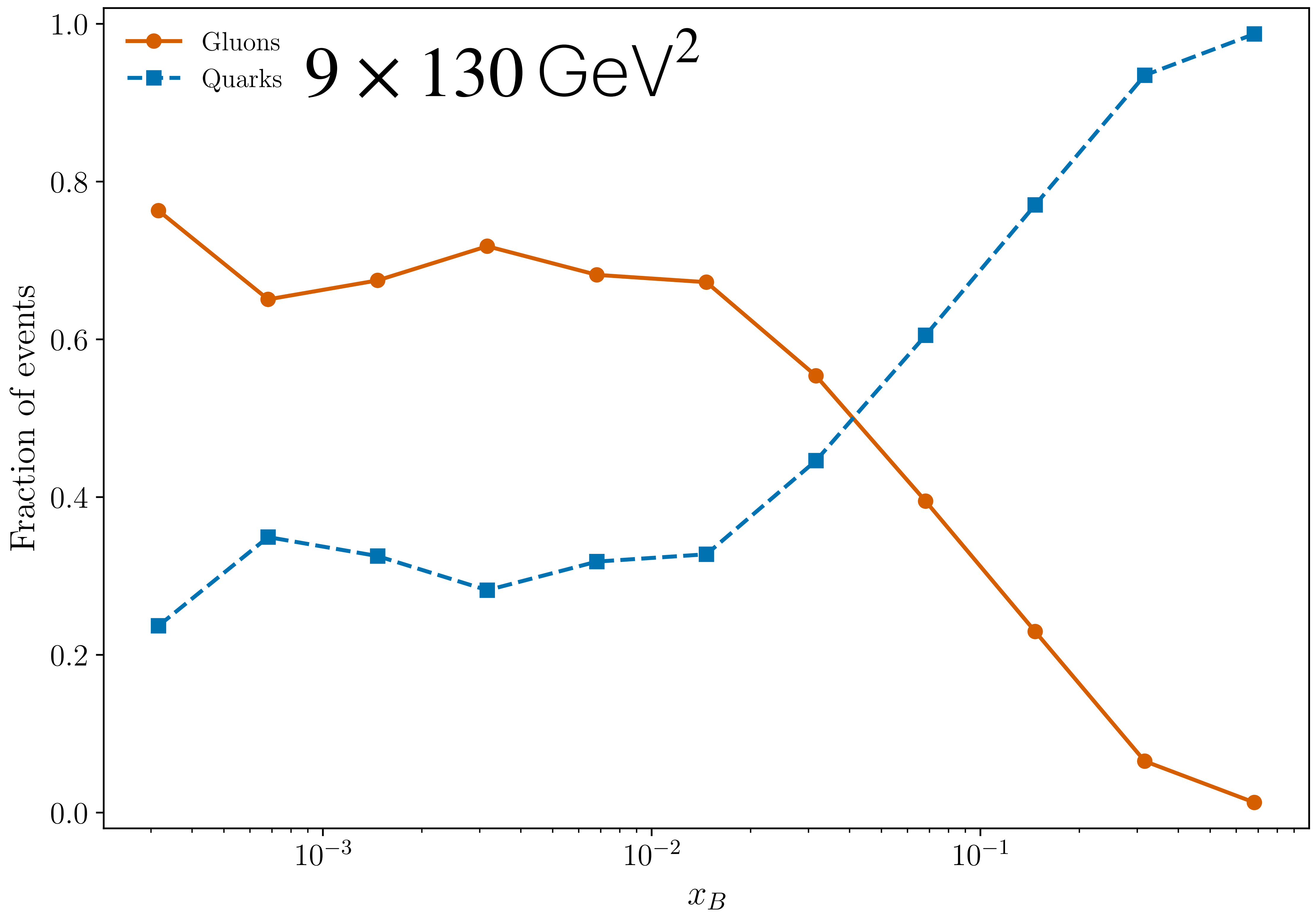


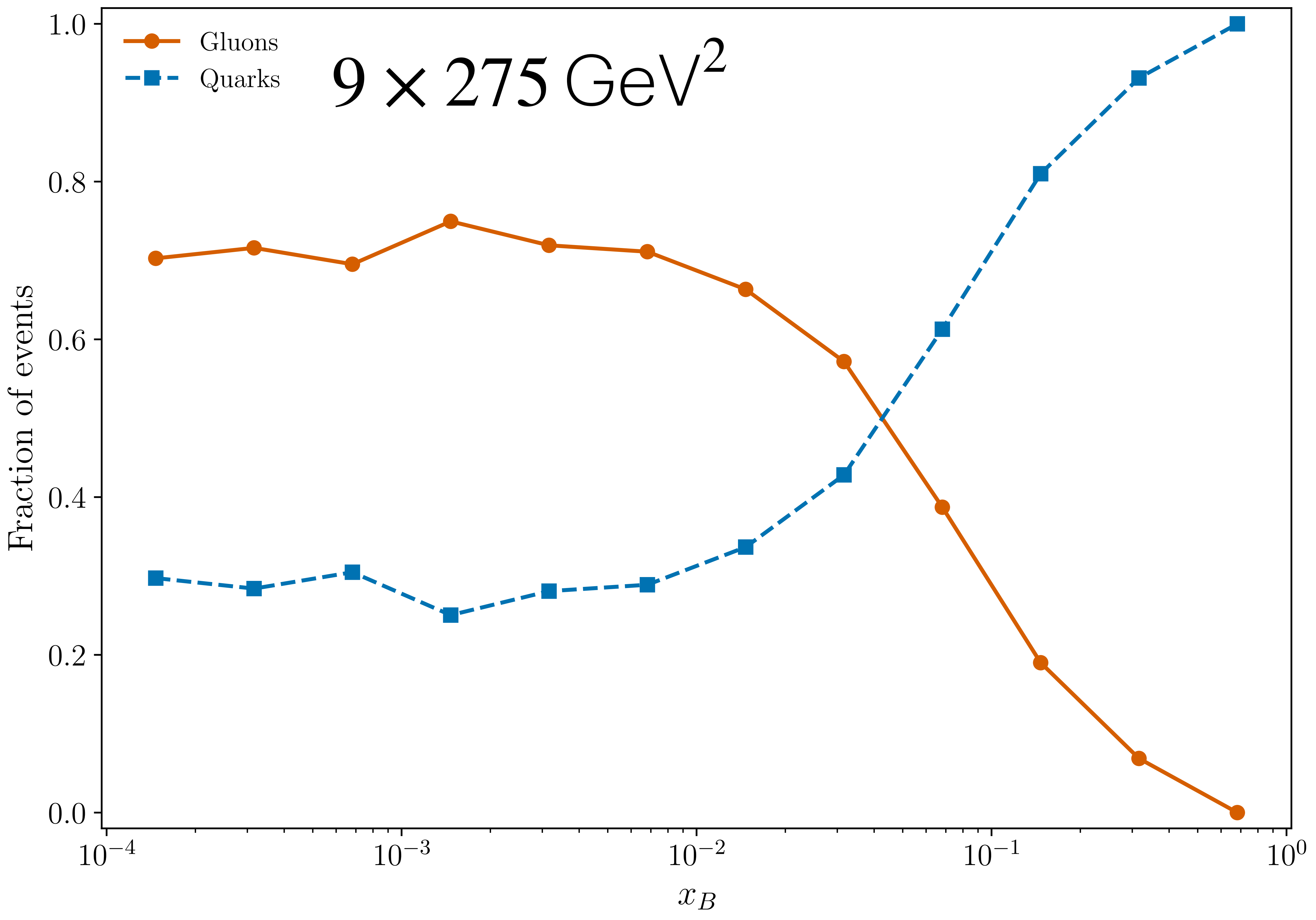
Kinematic variables 9×275



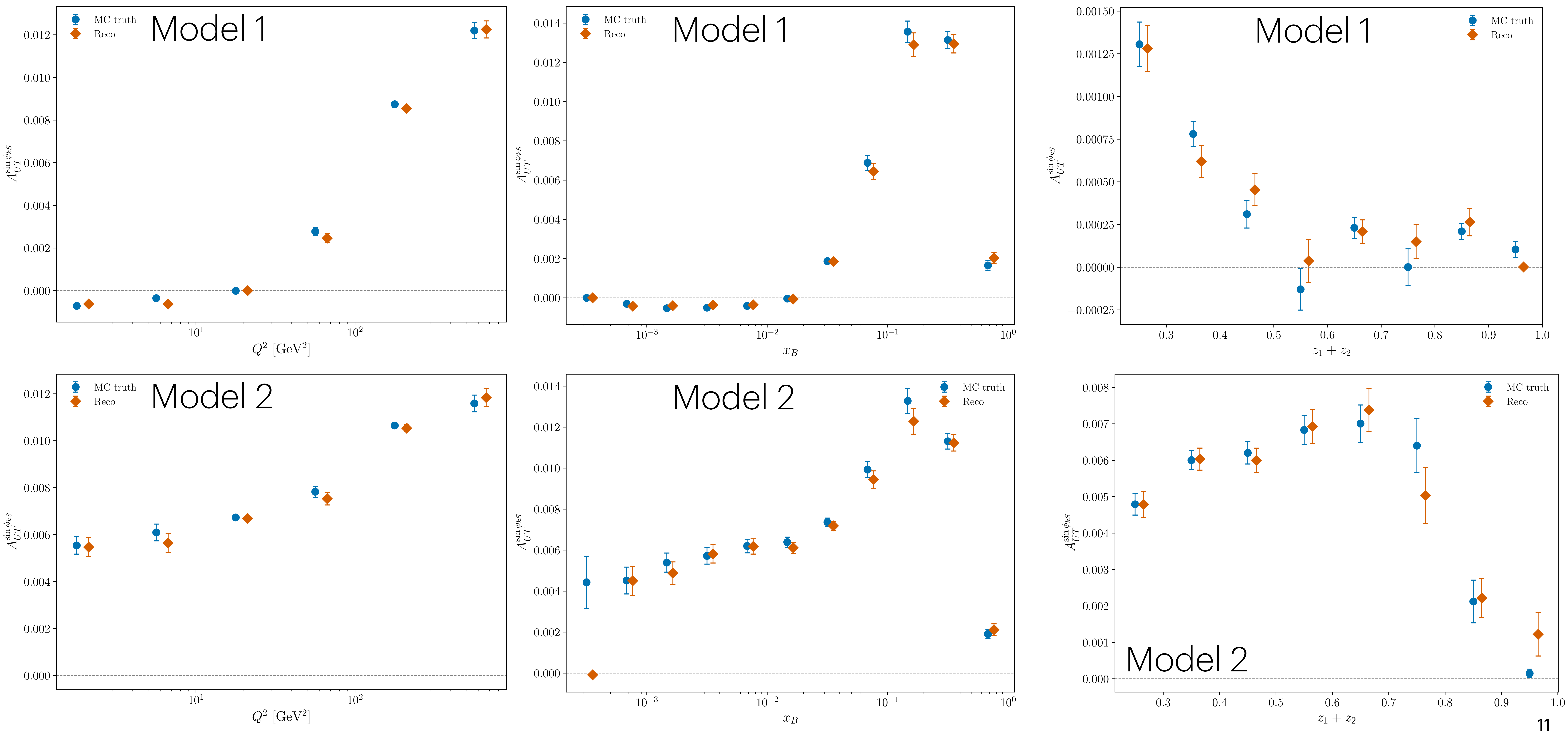


Initial parton fraction

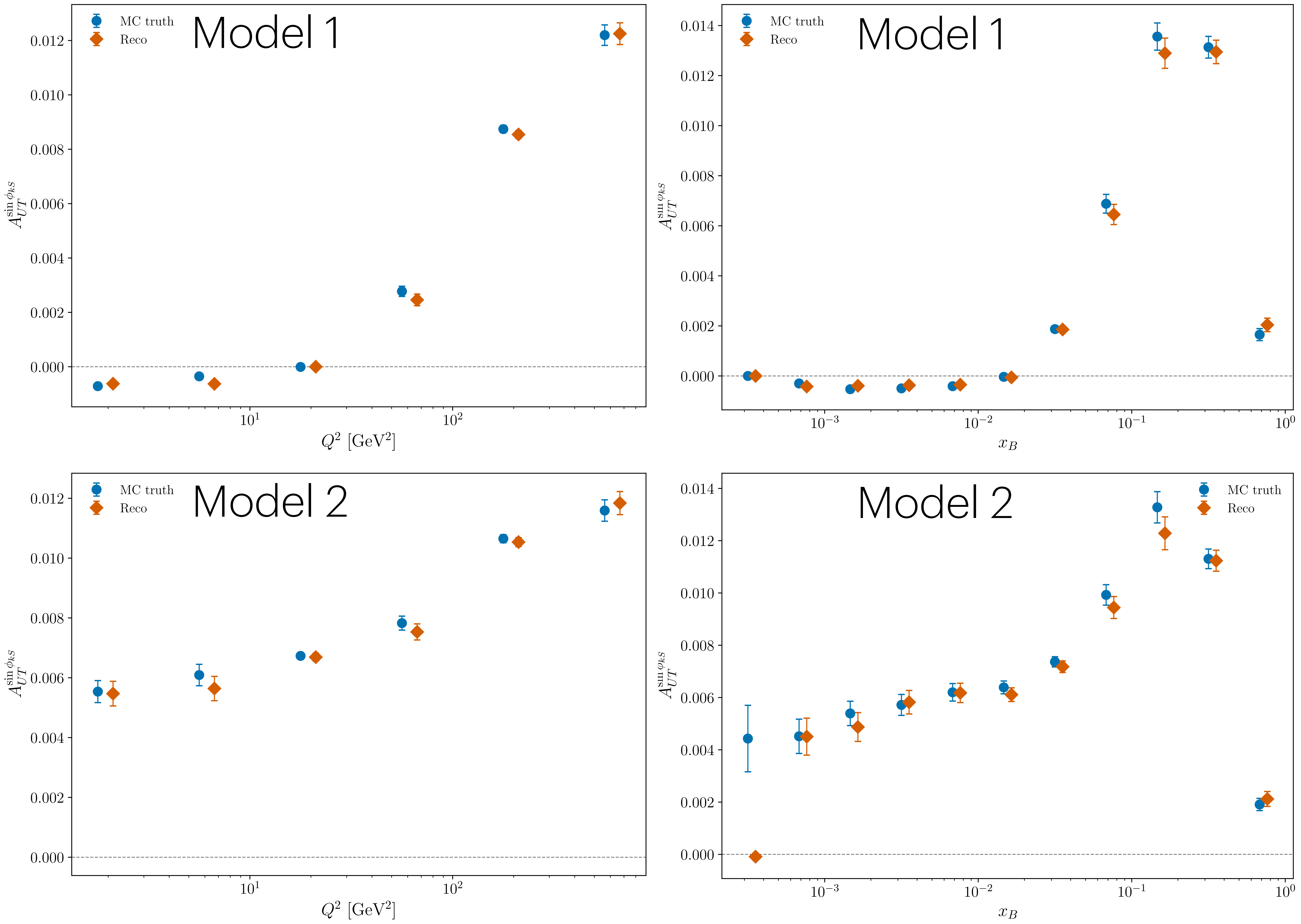


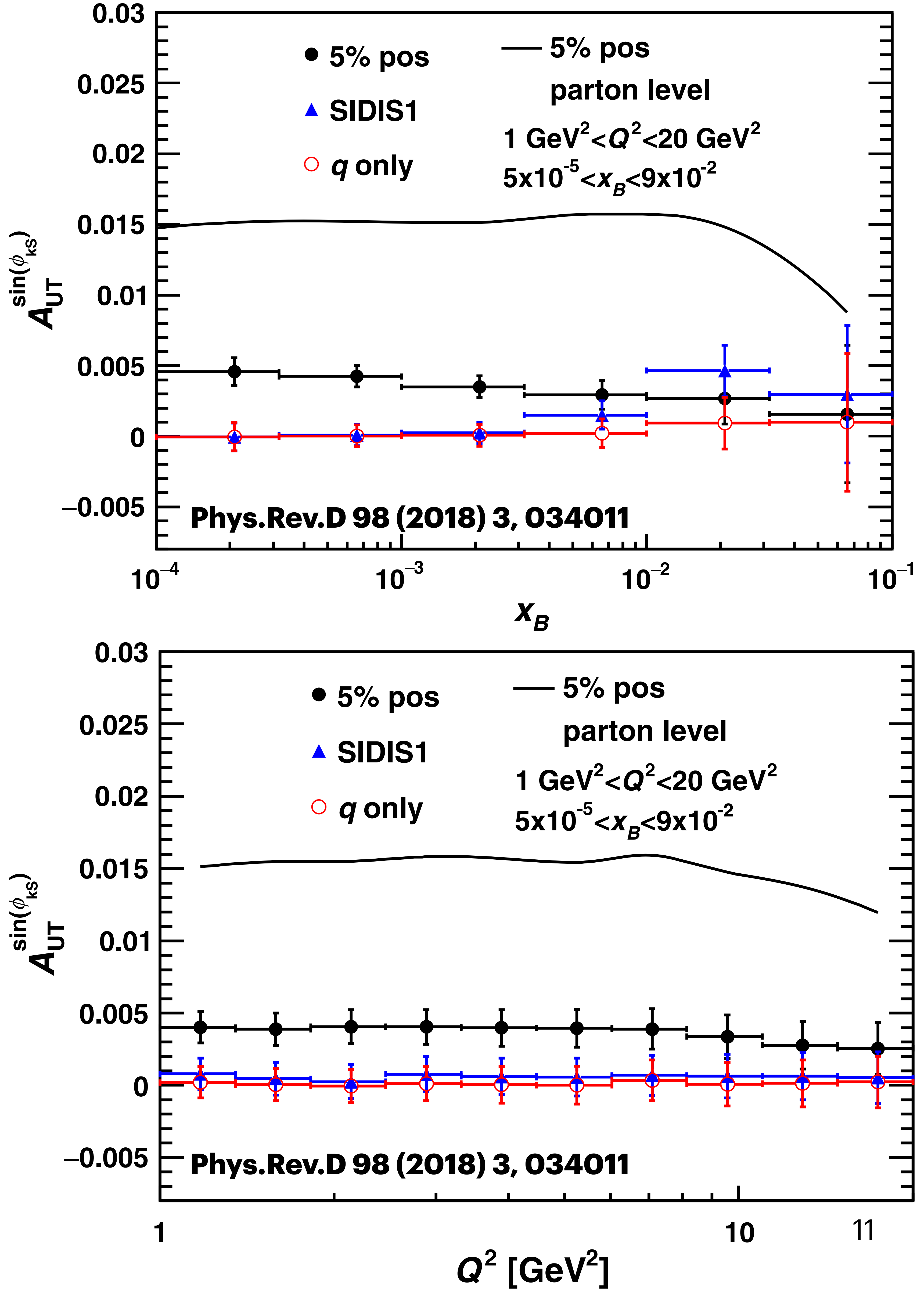


Results for 9×130

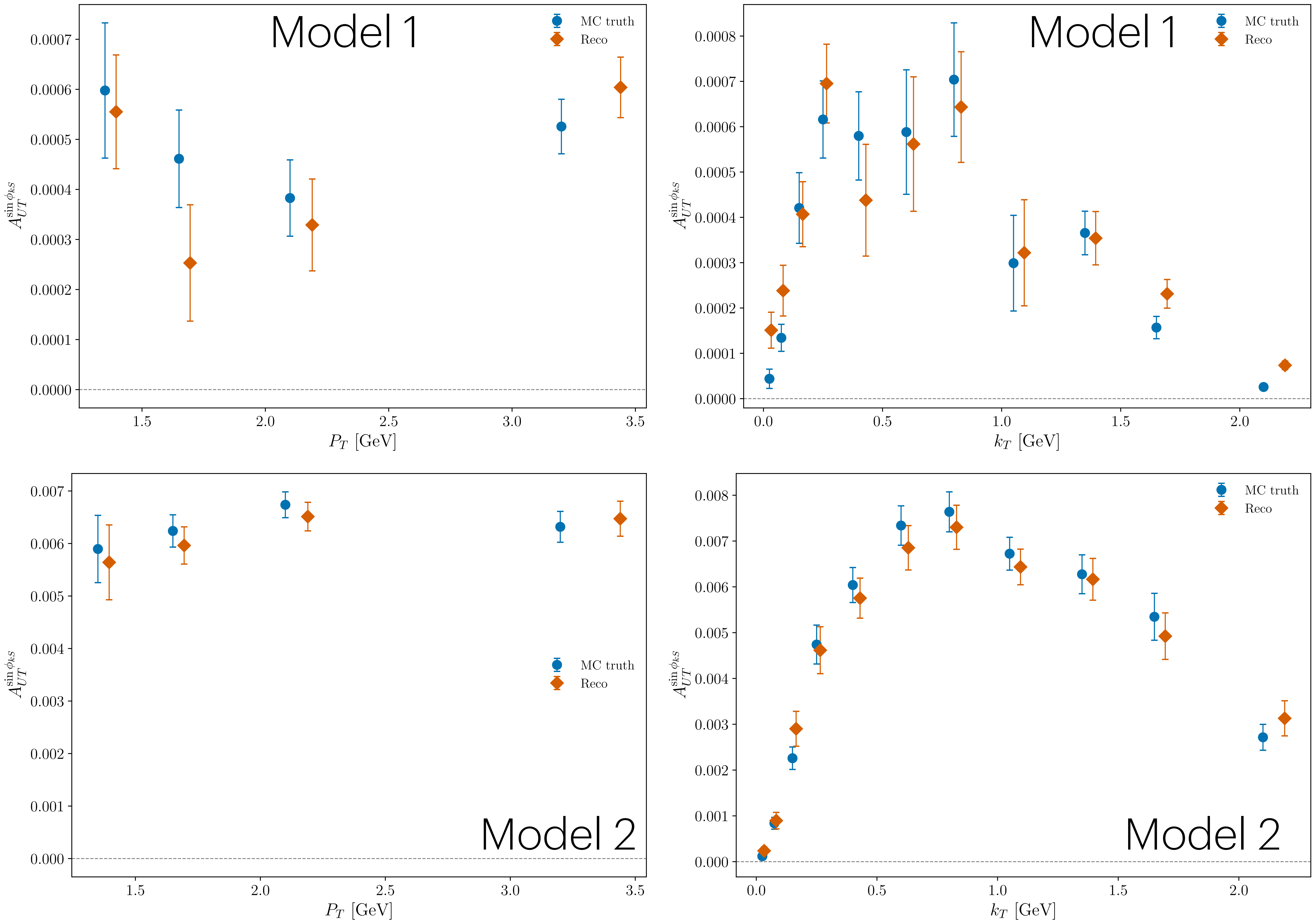


Results for 9×130

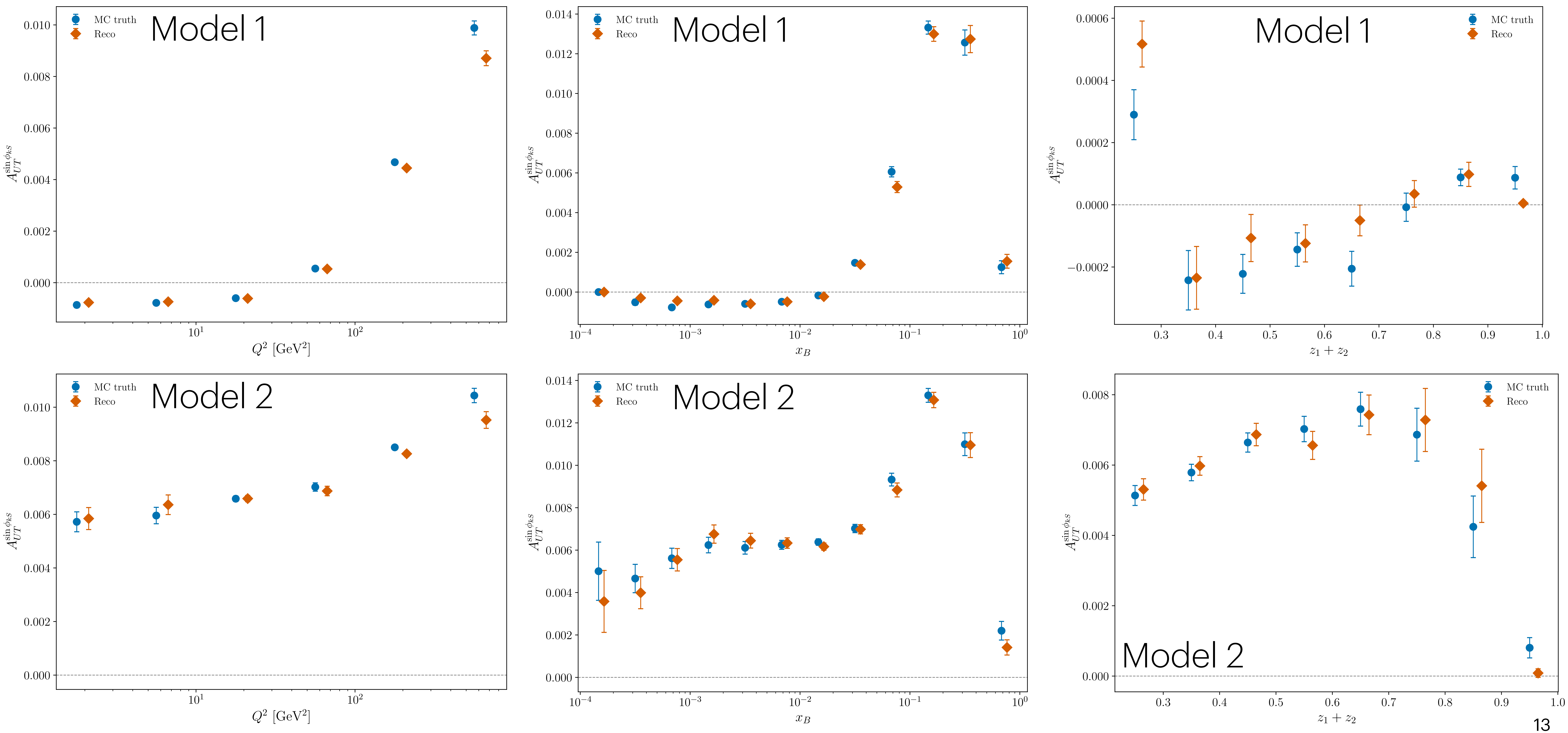




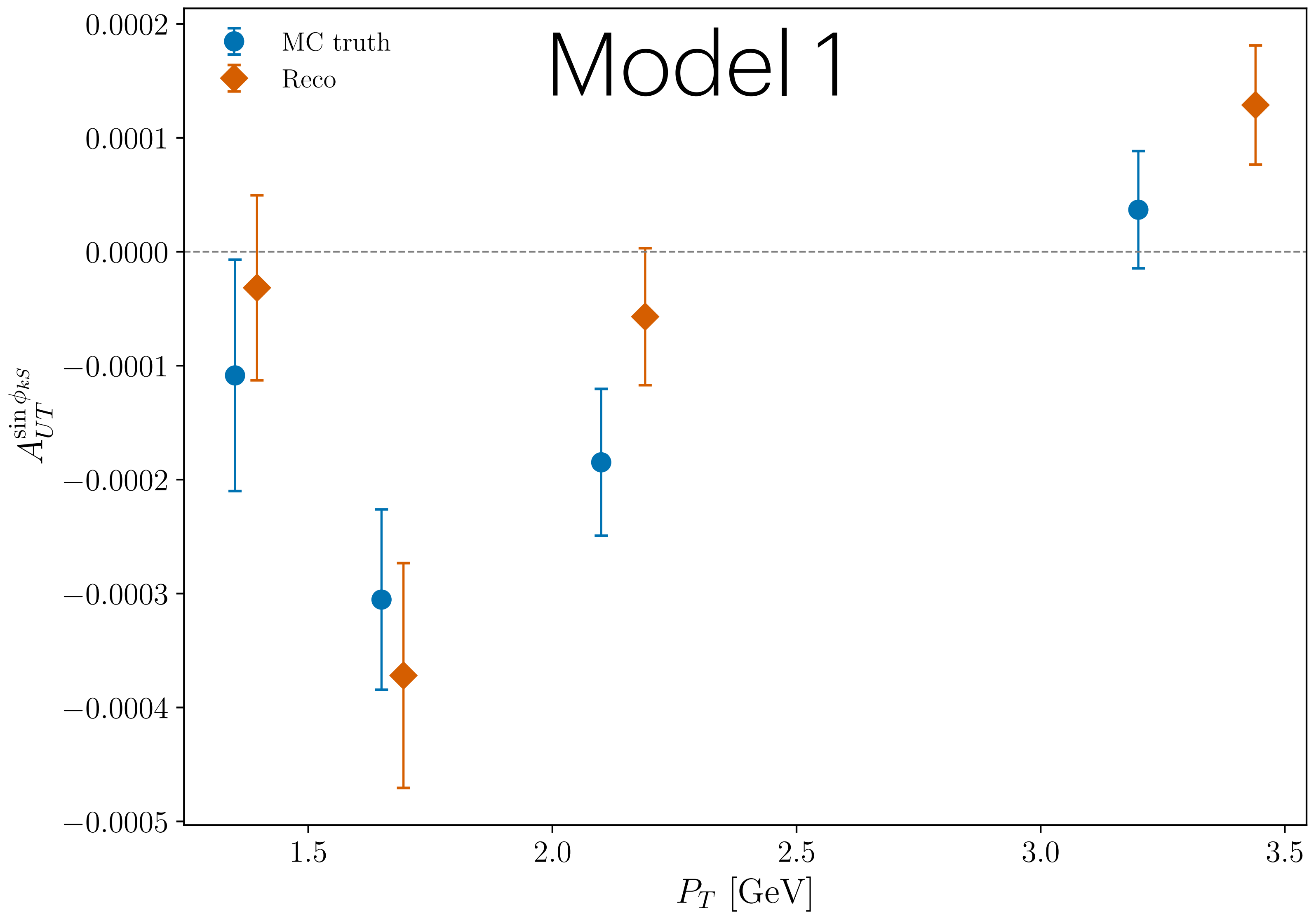
Results for $\mathbf{9 \times 130}$

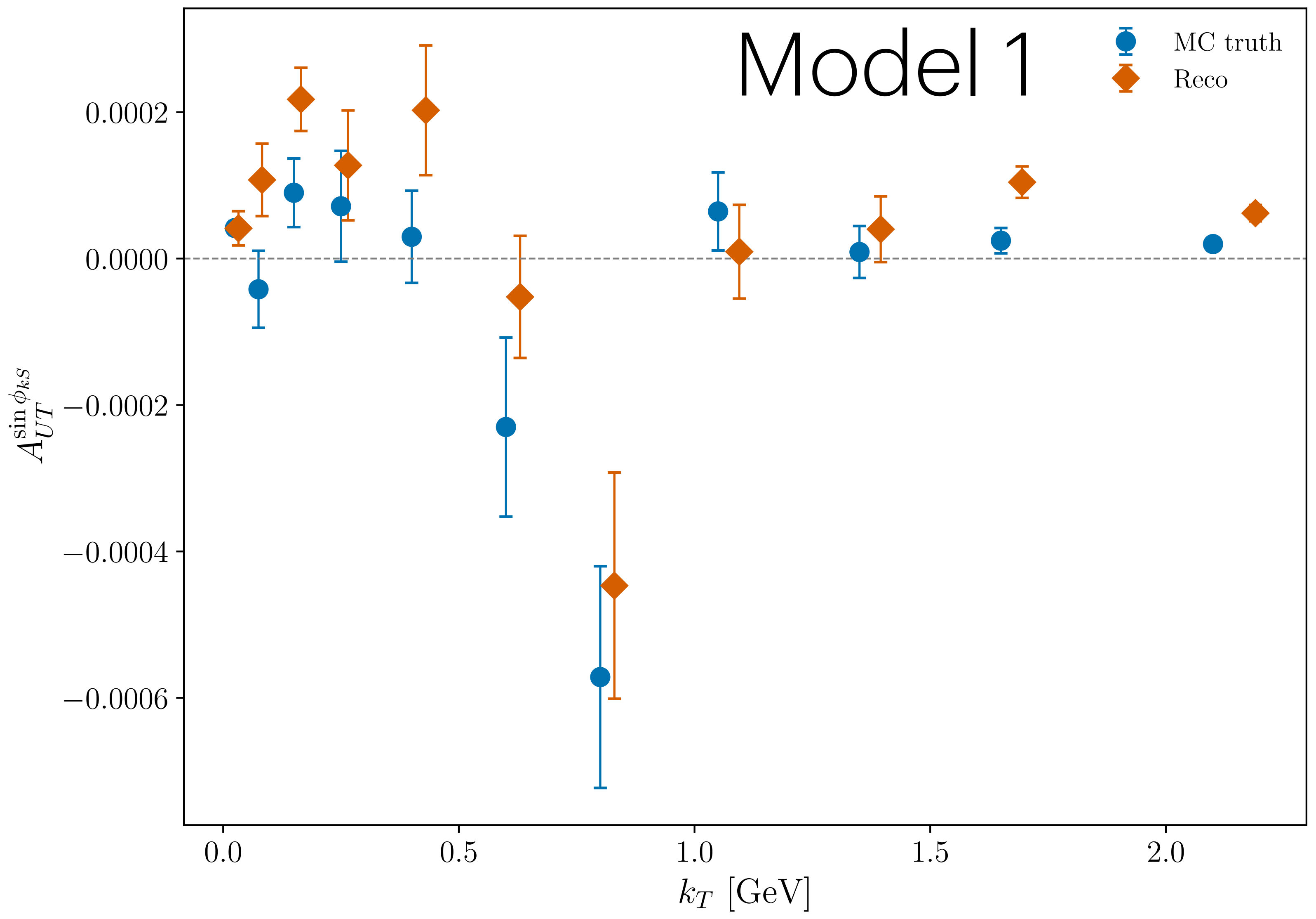


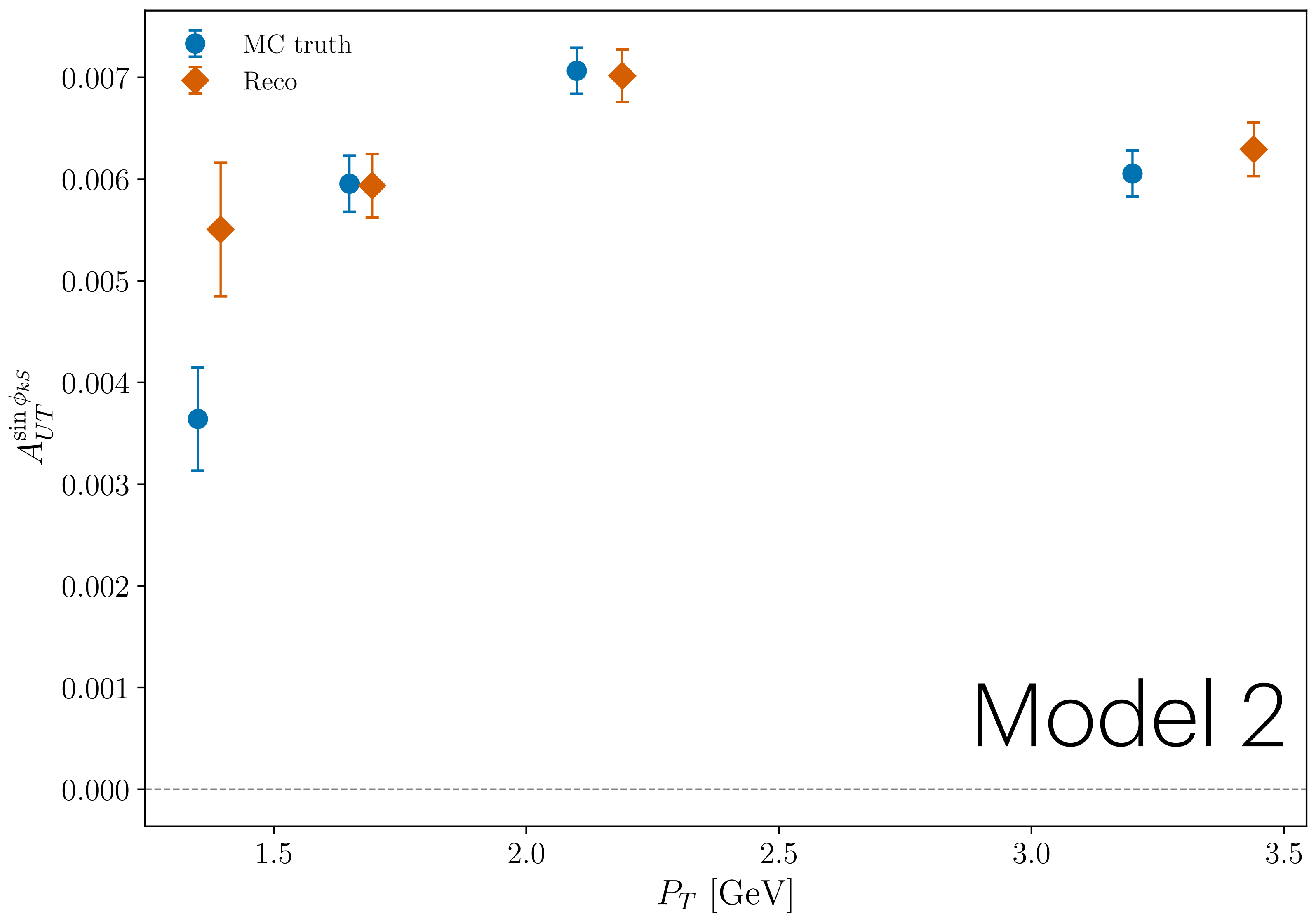
Results for $\mathbf{9 \times 275}$

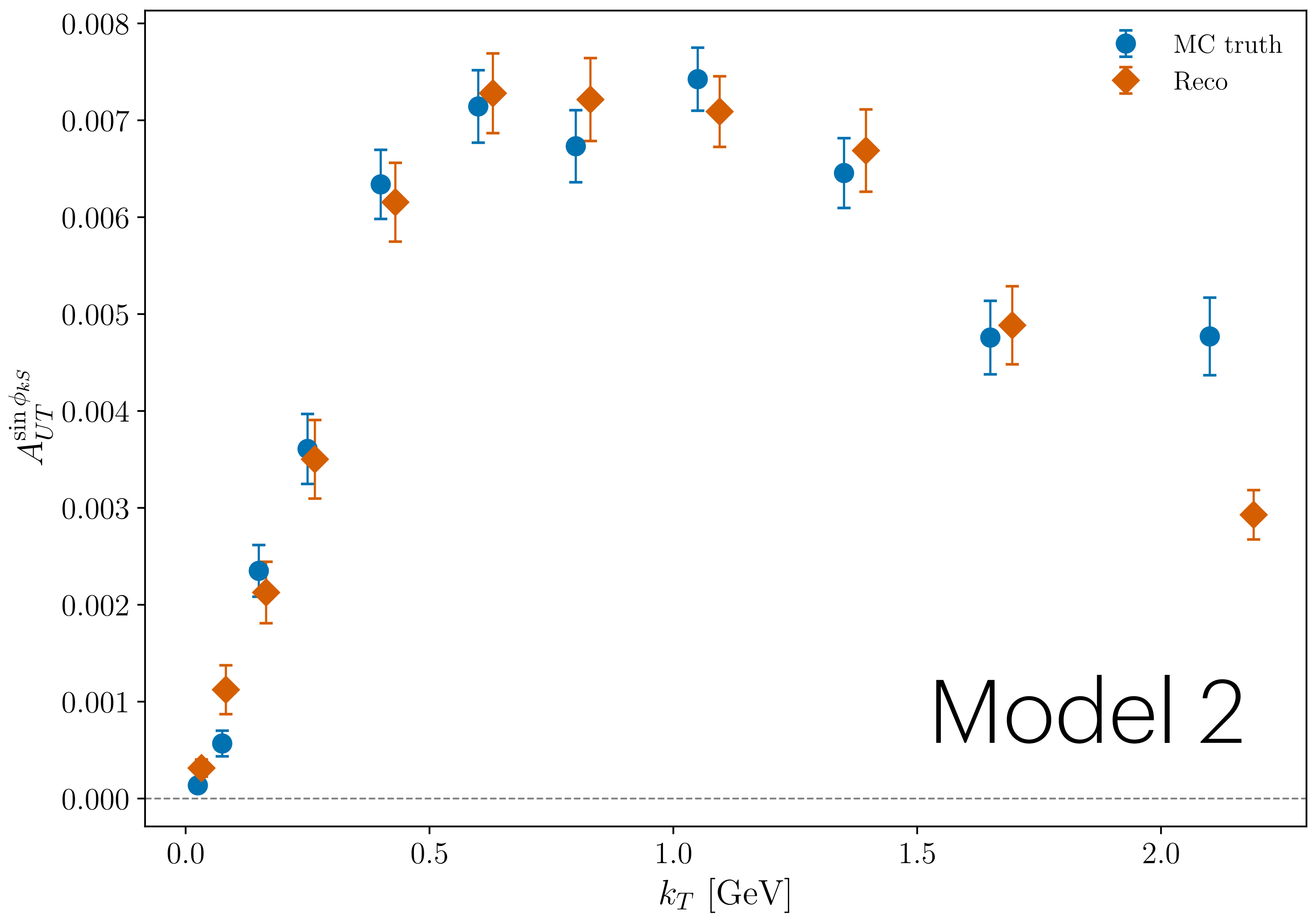


Results for $\mathbf{9 \times 275}$







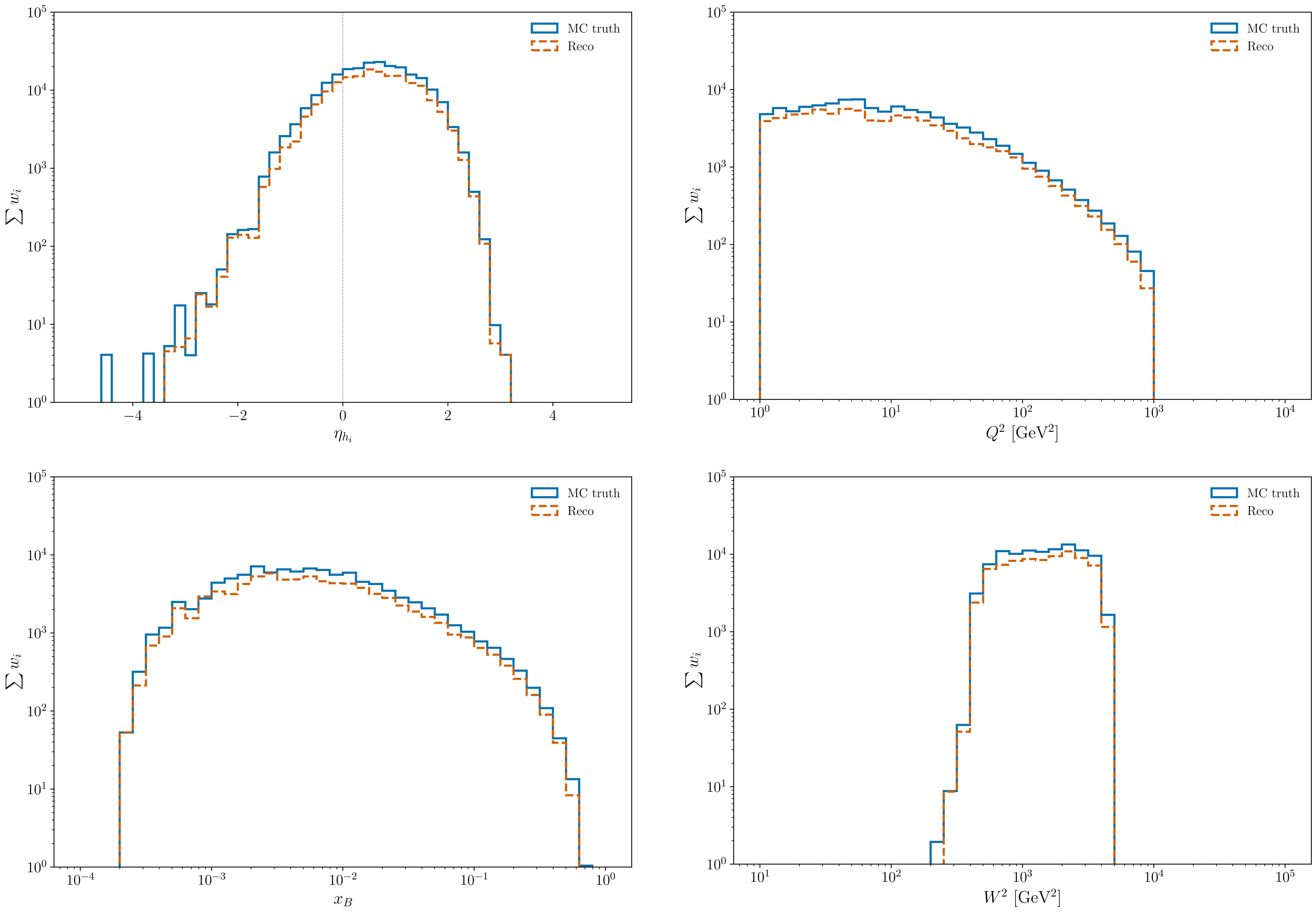


Conclusions

- Accessing the gluon Sivers function at EIC is possible, even during the early science stage.
- Current results have a very strong dependency on the model used to calculate the weights.
- Possible improvements:
  - Work with theorists to improve the parametrisation.
  - Explore the kinematic conditions.
- Results with 18×275 GeV^2 will be ready soon.

Backup

Kinematic variables $9 \times 130\ \mathrm{GeV}^2$



Kinematic variables $9 \times 275\ \mathrm{GeV}^2$