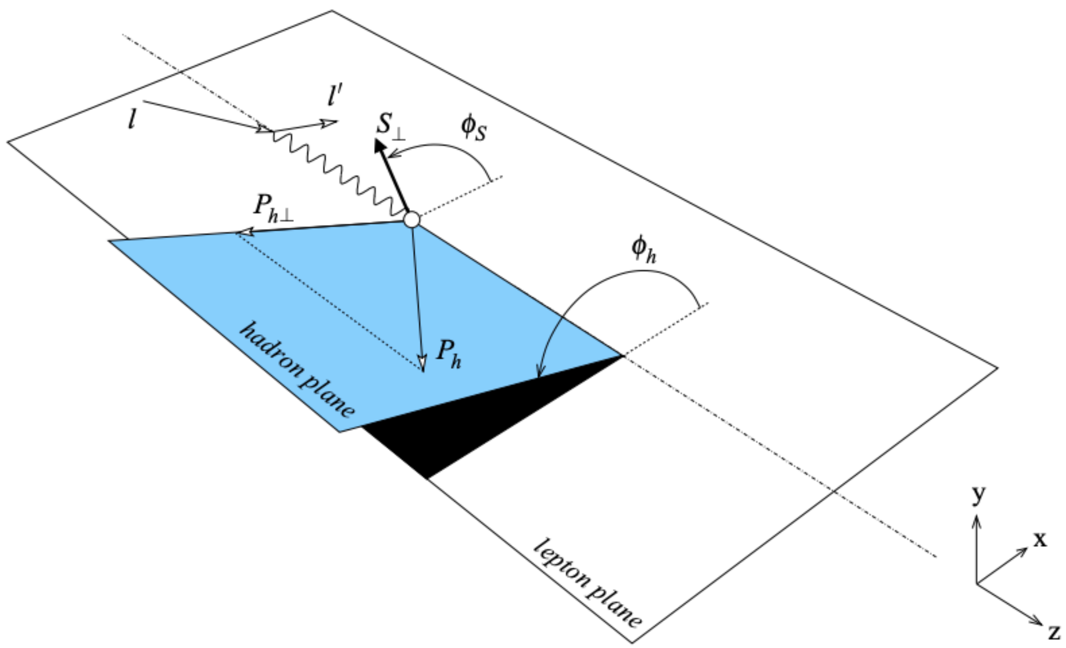
SIDIS kinematic reconstruction studies with ATHENA

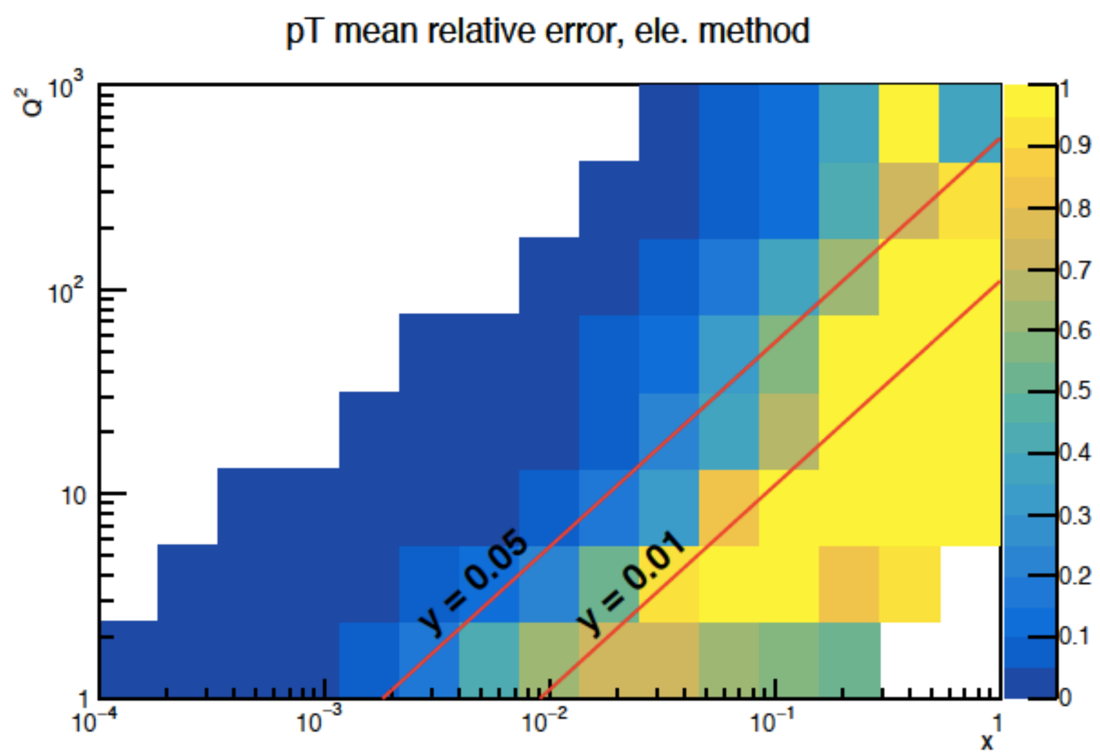
Connor Pecar

Project detector SIDIS WG Meeting, 4-27-22

Duke
UNIVERSITY

SIDIS reconstruction with ATHENA full sim.





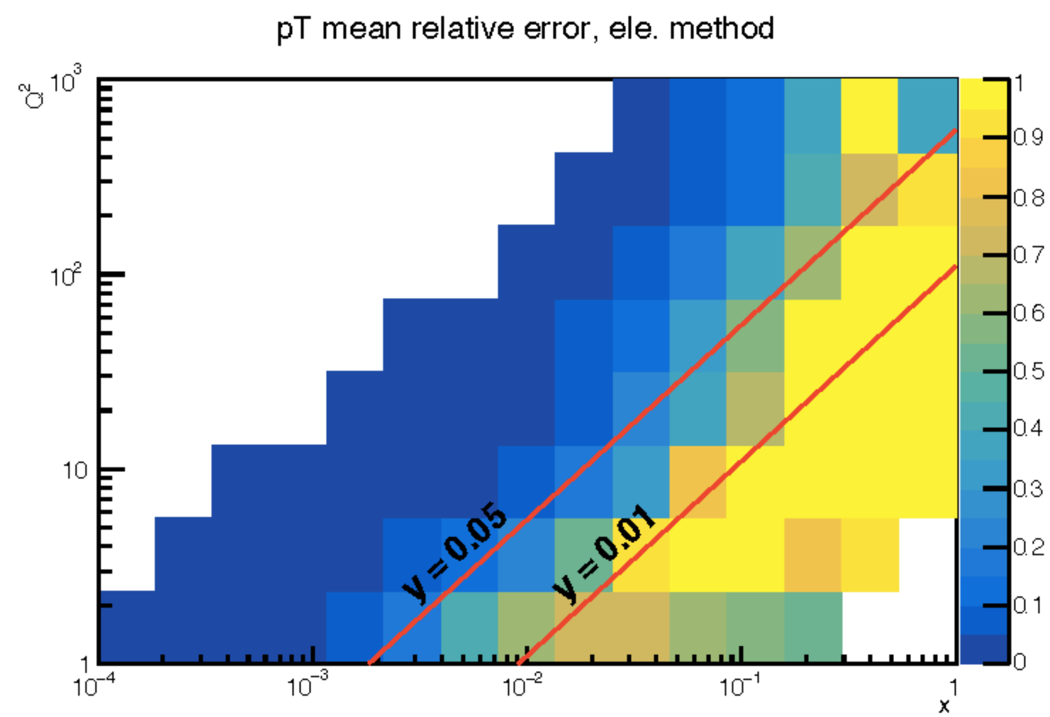
- With ATHENA full simulation, found electron method to break down around y = 0.05
- Radiative effects potentially more problematic when using scattered electron, or if electron not detected

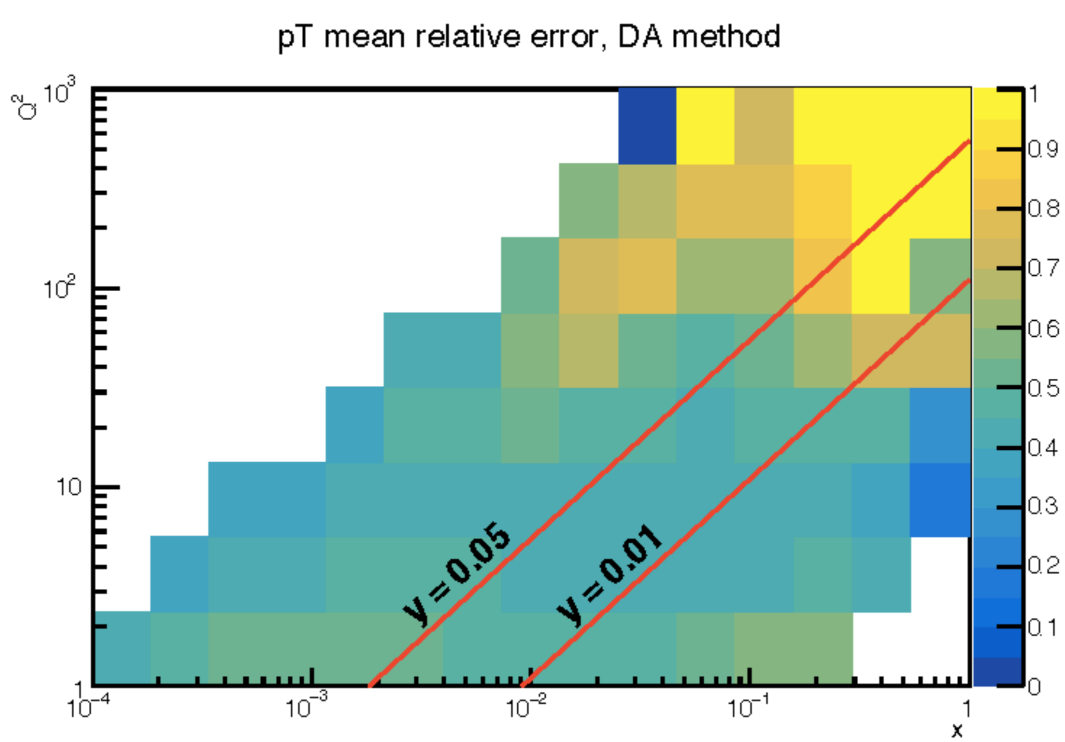
SIDIS reconstruction with ATHENA full sim.

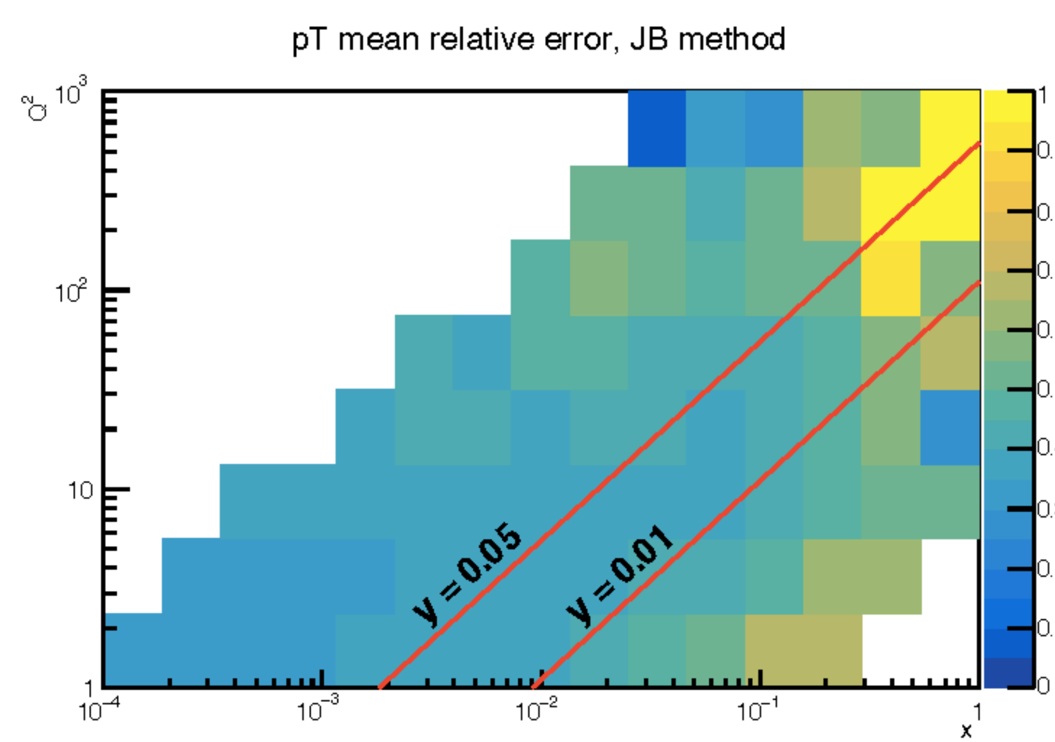
- With ATHENA full simulation, found electron method to break down around y = 0.05
- Methods using HFS improve performance at large-x
  - q_x, q_y from HFS
  - calculating q_z, q_t from y and Q2

$$Q^2 = -q^2 \qquad y = \frac{p_1.q}{p_1.k_1}$$

  - Found HFS methods more reliable if q determined in head-on frame, then transformed back to lab frame, but still some issues



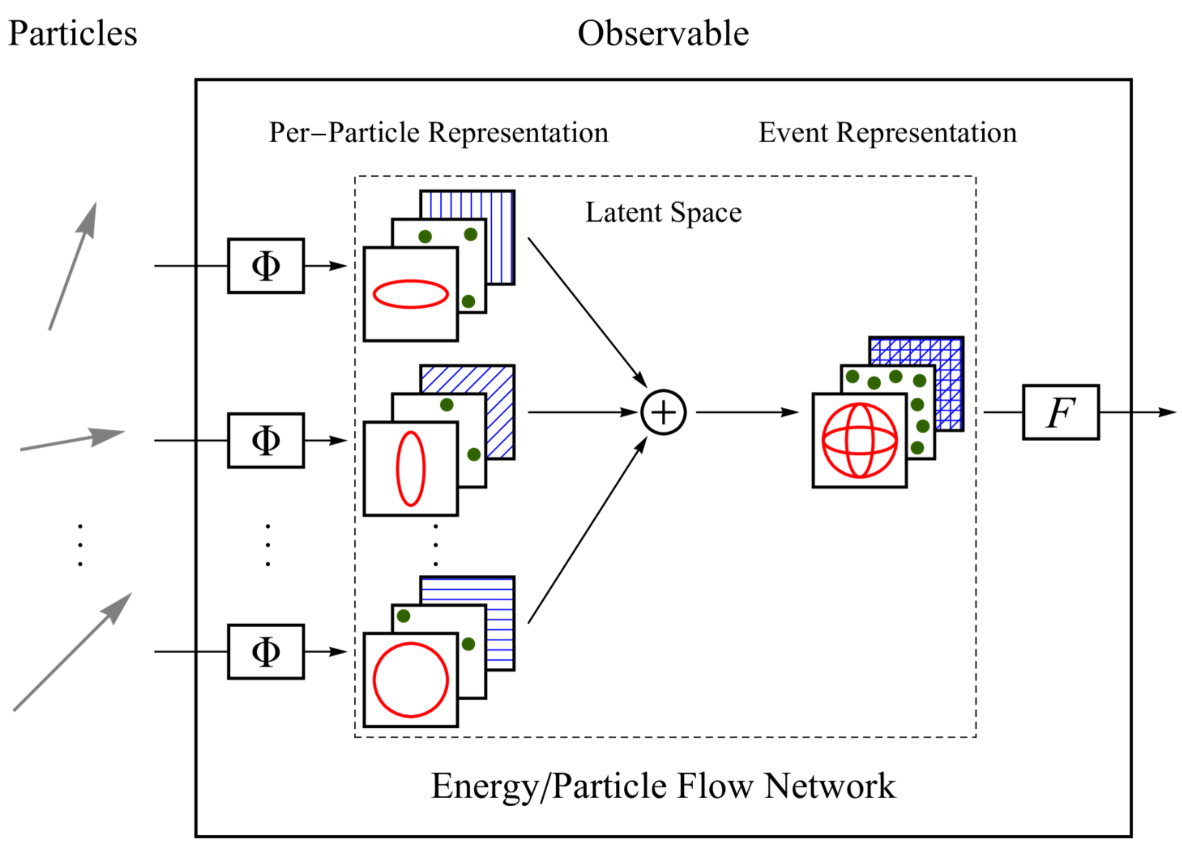




ML SIDIS reconstruction: electron correction

- Developing a machine learning approach on ATHENA/Detector1 full simulation which can better combine HFS and electron for SIDIS reconstruction
- Currently training with reconstructed particle level information
- Want to use some graph-like architecture to represent hadronic final state
- Some physics-motivated architectures to learn from sets of particles have been developed
  - Currently, primarily using particle flow networks (arXiv:1810.05165)

- Model built to correct electron method:
  - HFS features: four-momentum
  - Electron four-momentum concatenated with latent space variables
  - Learned average of Q2, x using deep learning model (arXiv:2108.11638) also included in latent space variables

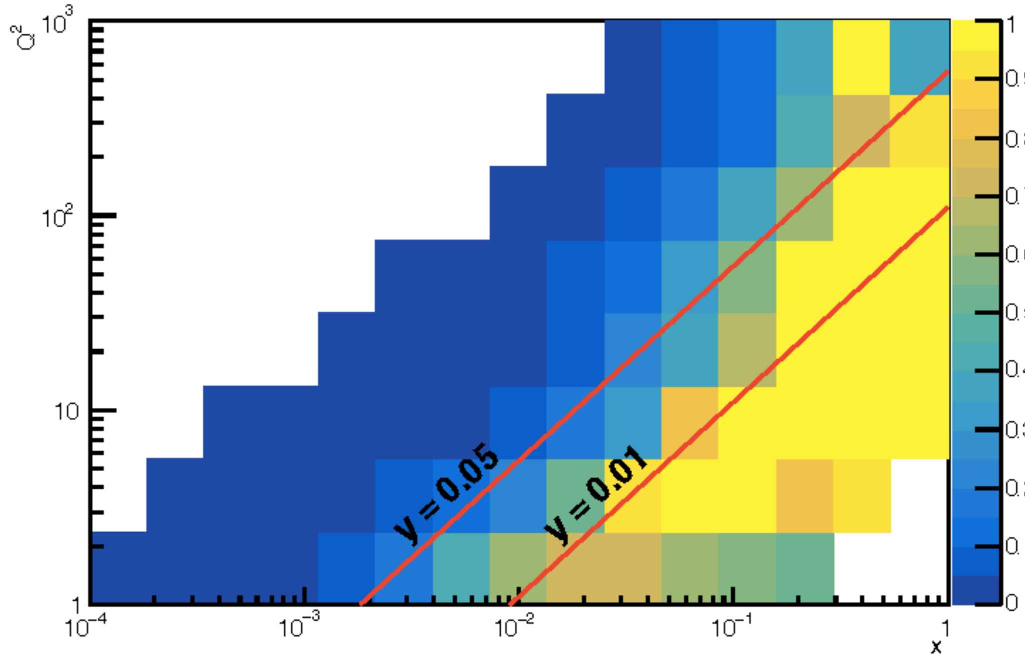


arXiv:1810.05165

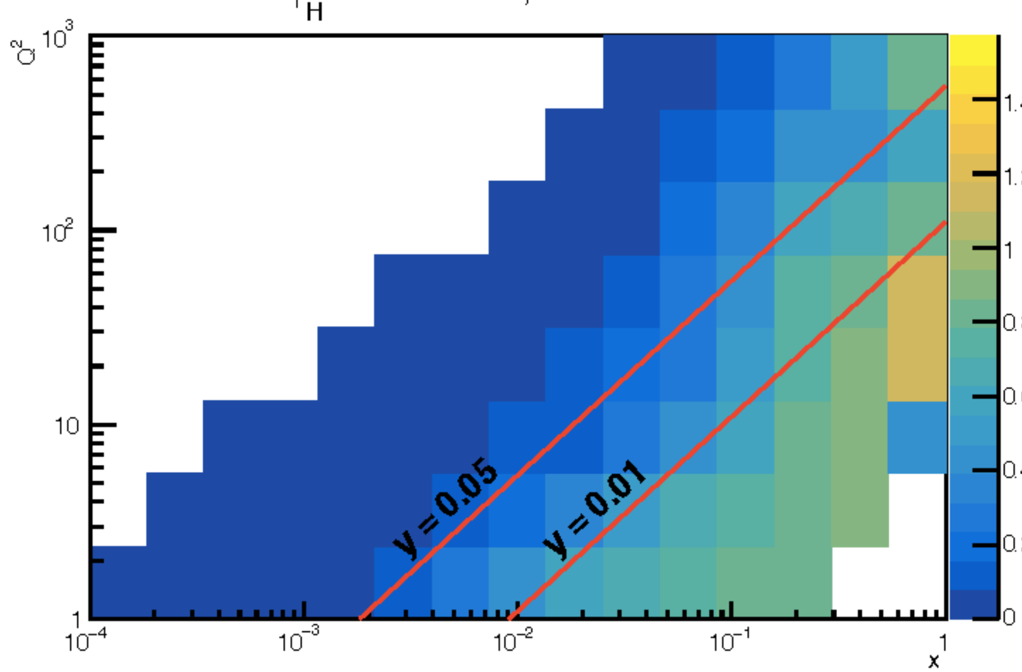
ML SIDIS reconstruction: electron correction

Electron method

pT mean relative error, ele. method

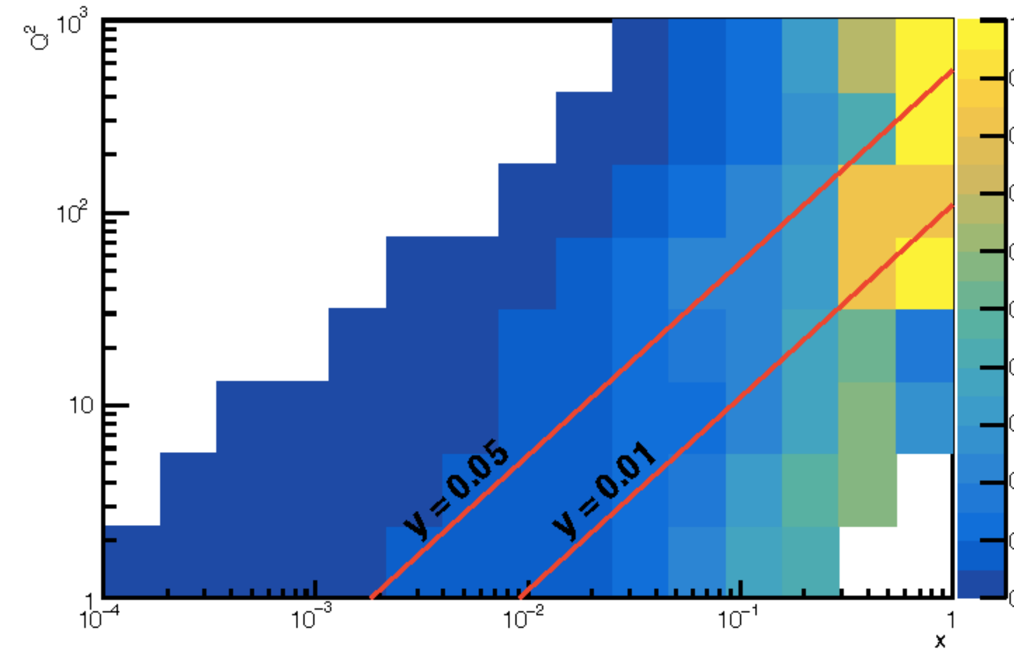


ϕ_H mean error, ele. method

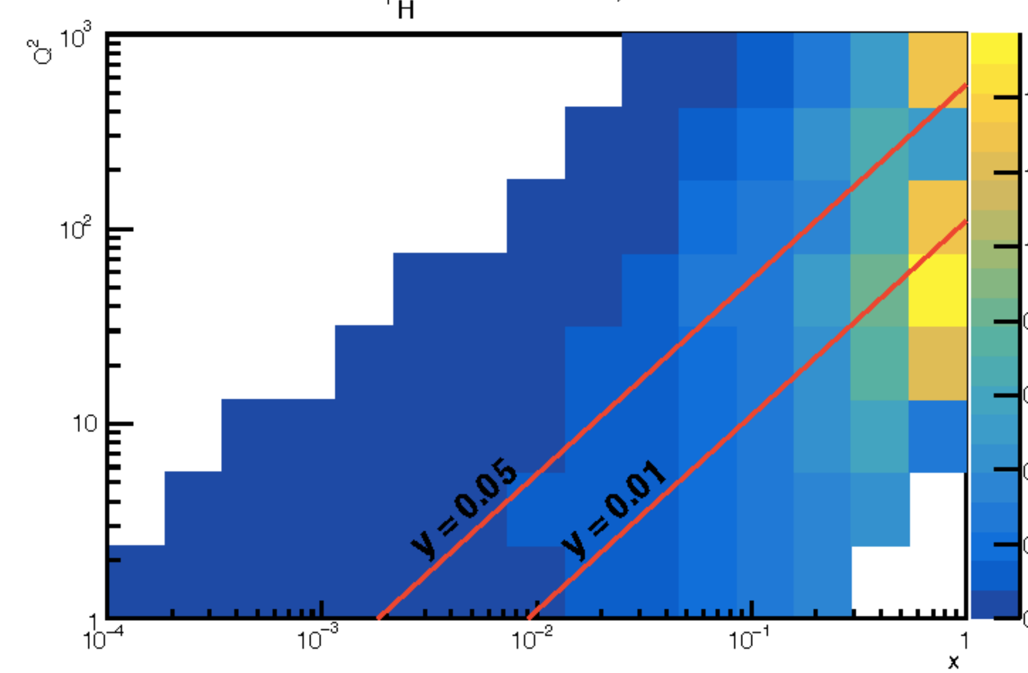


Particle flow network + electron

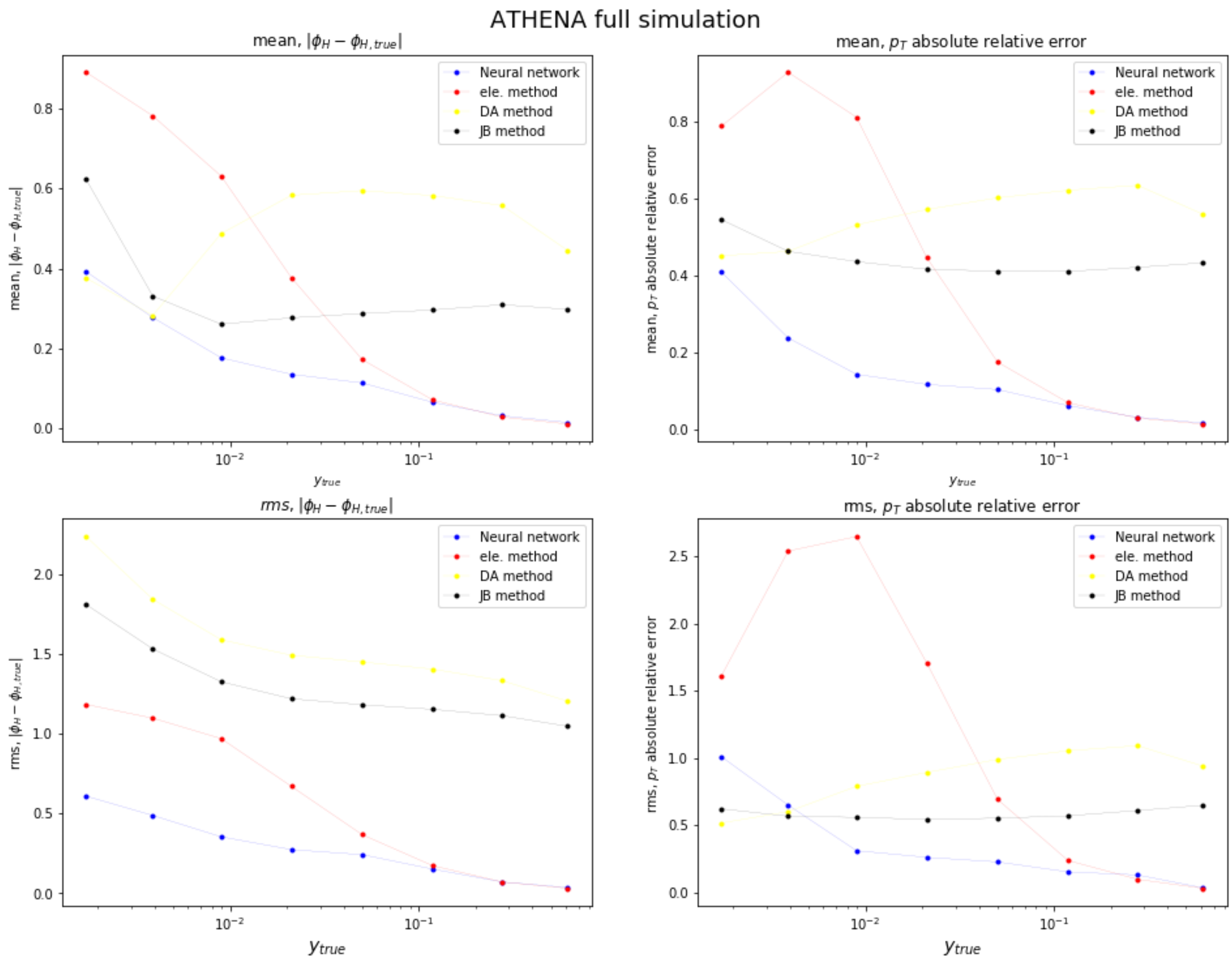
pT mean relative error, NN



ϕ_H mean error, NN

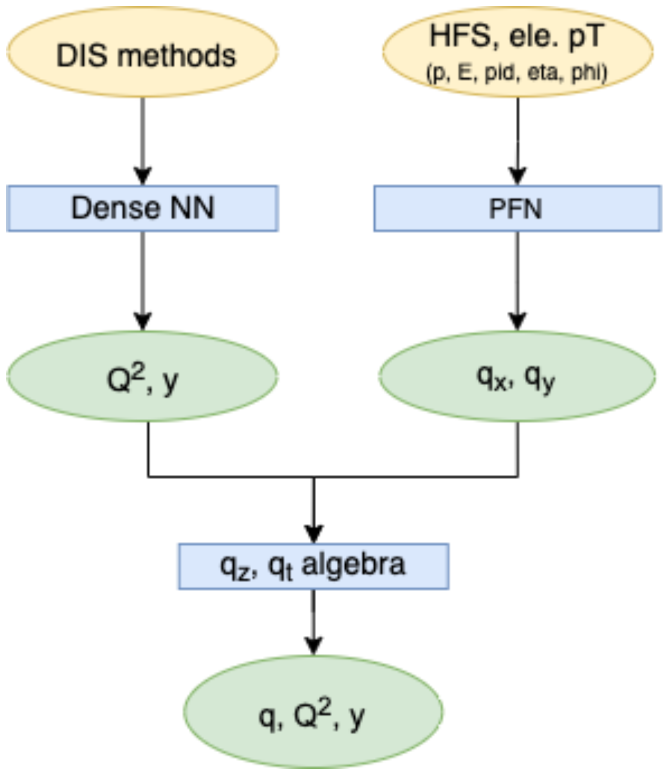


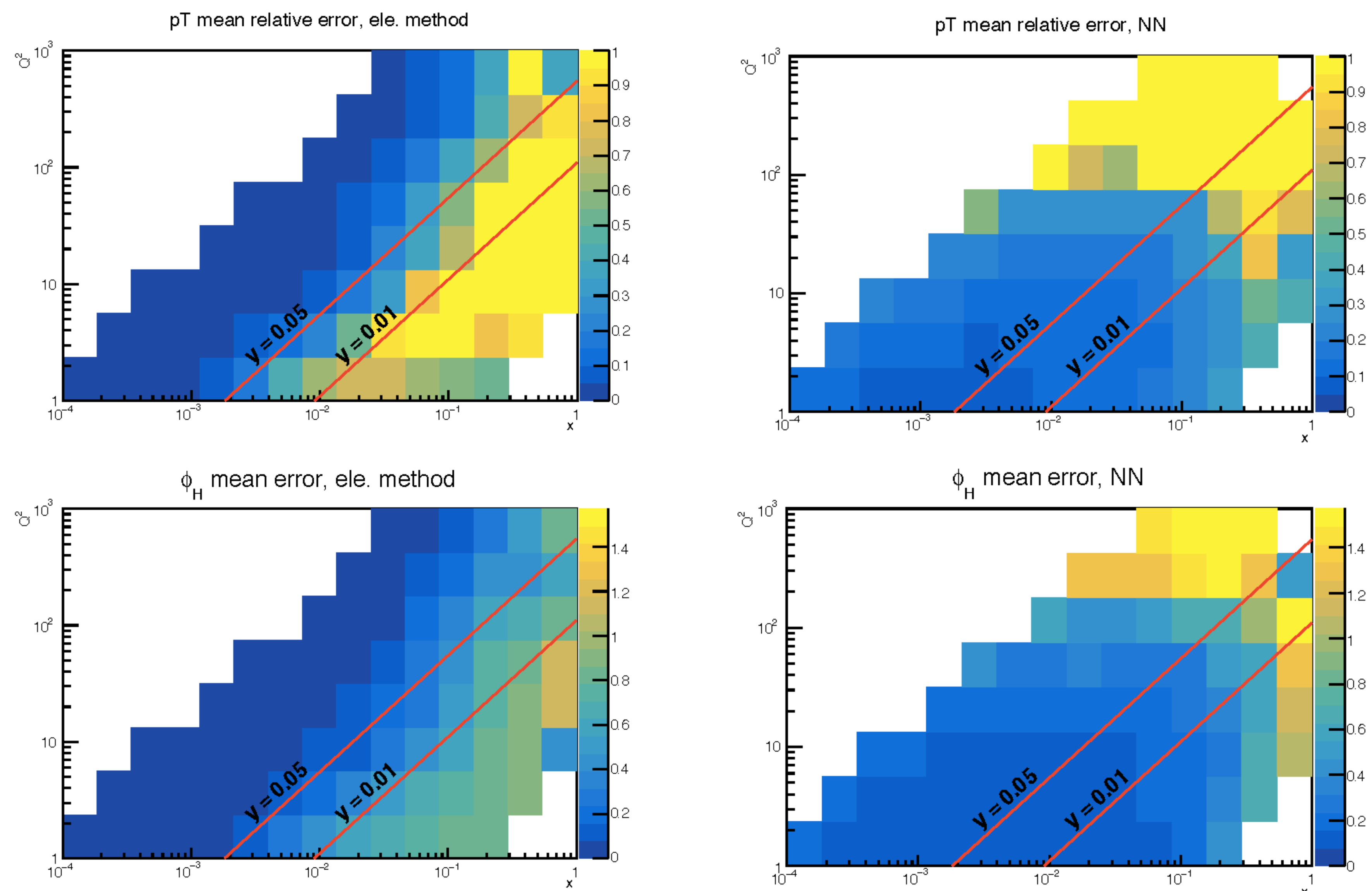
ML SIDIS reconstruction: electron correction



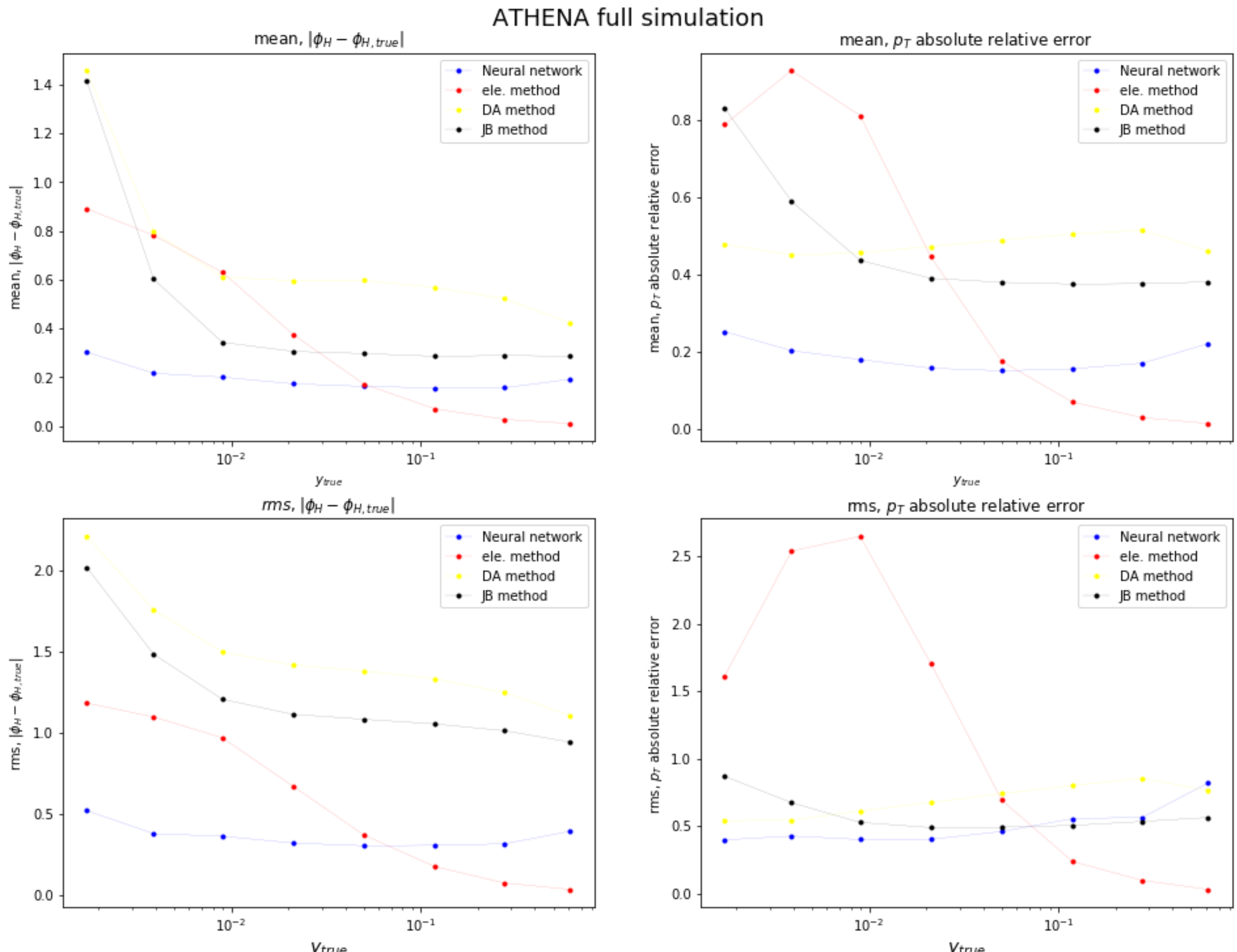
ML SIDIS reconstruction: constraints on q

- Combining ML methods to reconstruct DIS variables with PFN
  - Obtaining Q2, y from learned weighted average
  - Getting q_x, q_y from a particle flow network combined with scattered electron pT
    - Scattered electron variables concatenated with latent space variables from HFS
  - Final layer: computes z, t components from constraints on q from Q2, y





ML SIDIS reconstruction: constraints on q



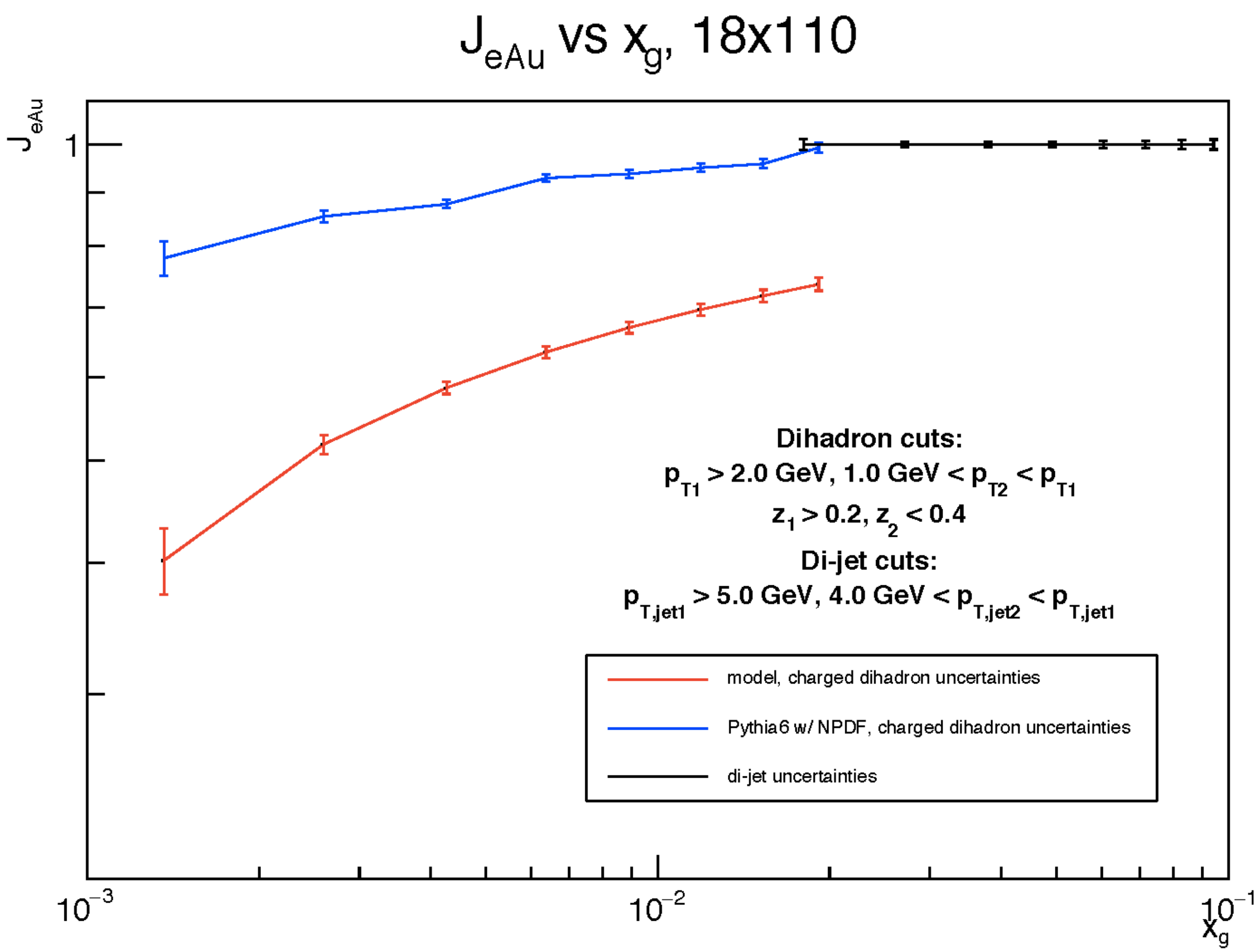
Back-to-back dihadrons for gluon saturation studies

- Dihadron correlations used to probe gluon saturation
- high-pT gluon dijet production expected to dominate at low-x
  - high gluon density smears away-side jet
  - greater suppression of away side jet for heavier ions, scaling with A

$$J_{eA} = \frac{1}{A^{1/3}} \frac{\sigma_{eA}^{pair}/\sigma_{eA}}{\sigma_{ep}^{pair}/\sigma_{ep}}$$

- Studied with ATHENA fast simulation by selecting high-pT trigger and associate hadrons (as well as dijets)
  - Ratio of number of back-to-back pairs to number of trigger hadrons, for p and Au beams

ATHENA saturation projections



Fast simulation, scaled to 10 fb^-1

- Red - ATHENA projected dihadron uncertainties on model from Phys.Rev.D. 89, 074037
- Blue - JeAu using NPDF for Au and p, dihadron uncertainties
- Black - dijet uncertainties, no model calculation available