Status of SIDIS look at first production output

Simulation workshop
July 8

Ralf Seidl (RIKEN)

Status

- Test production for SIDIS output is available under:
  - high Q^2, ~3.8 M DIS events, Q^2>100 GeV
    eicS3/eictest/ECCE/MC/ana.14/5f210c7/SIDIS/pythia6/ep_18x100highq2
  - Low Q2, ~5 M DIS events, 1<Q^2<100 GeV
    eicS3/eictest/ECCE/MC/ana.14/5f210c7/SIDIS/pythia6/ep_18x100lowq2
- Use nearly EventEvaluator module (all clusters combined, vertex set to origin for cluster eta calculation)
- PID is still using true PDG values (→ still need to address this)
- For Hadronic final states use: charged particles + Calorimeter clusters (currently chose neutrals either via PDG or reject charged via Barcode → currently adjusting for track projections)
- Currently use tracking information for all charged particles (→ there may be regions where EMCal info is better for electrons)

DIS Kinematic reconstruction using hadronic FS

- JB method: use only hadronic final state

$$y_{JB} = \frac{E_p \sum_h E_h - p_{z,p} \sum_h p_{z,h} - m_p^2}{E_p E_e - p_{z,p} p_{z,e}}$$

$$Q^2_{JB} = \frac{\sum_h p^2_{x,h} + \sum_h p^2_{y,h}}{1 - y}$$

$$x_{JB} = \frac{Q^2}{ys}$$

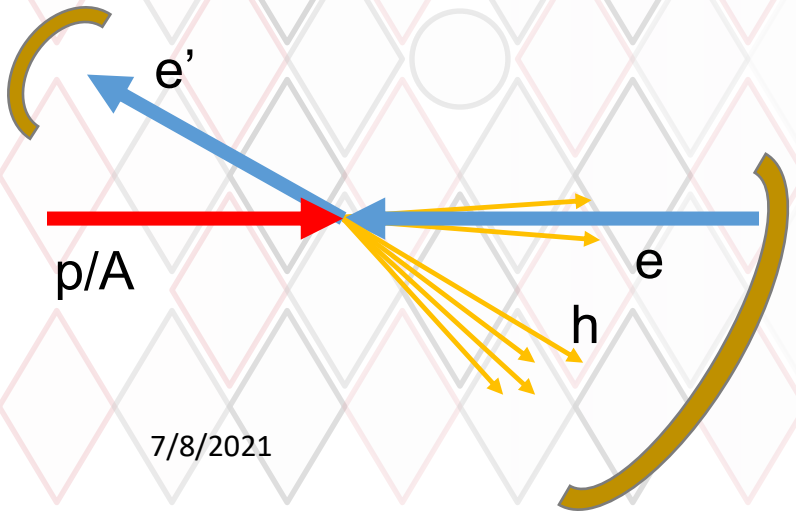
- DA method: use both

$$y_{DA} = \frac{\tan\theta_h/2}{\tan\theta_e/2 + \tan\theta_h/2}$$

$$Q^2_{DA} = \frac{4E_2^2}{\tan\theta_e/2\,(\tan\theta_e/2 + \tan\theta_h/2)}$$

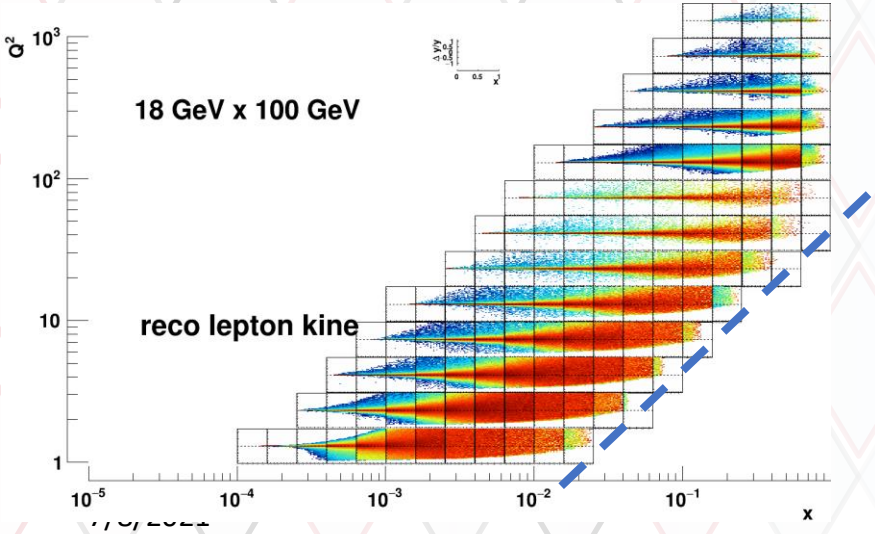
$$x_{DA} = \frac{Q^2}{ys}$$

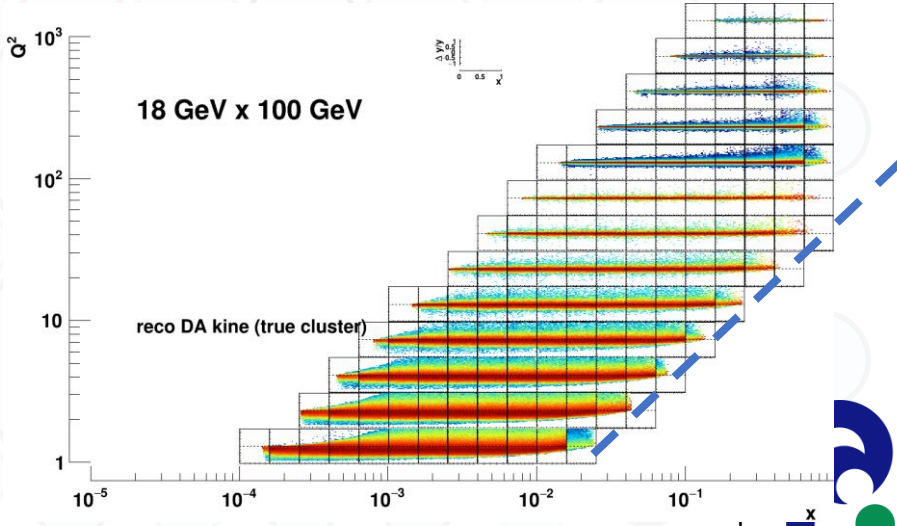
$$\tan\theta_h/2 = \frac{\sum_h E_h - \sum_h p_{z,h}}{\sqrt{\sum_h p^2_{x,h} + \sum_h p^2_{y,h}}}$$



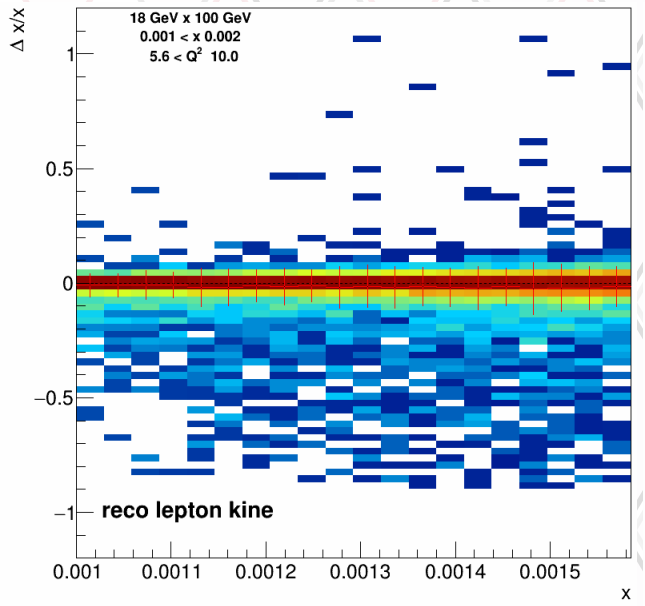
DIS kinematic reconstruction

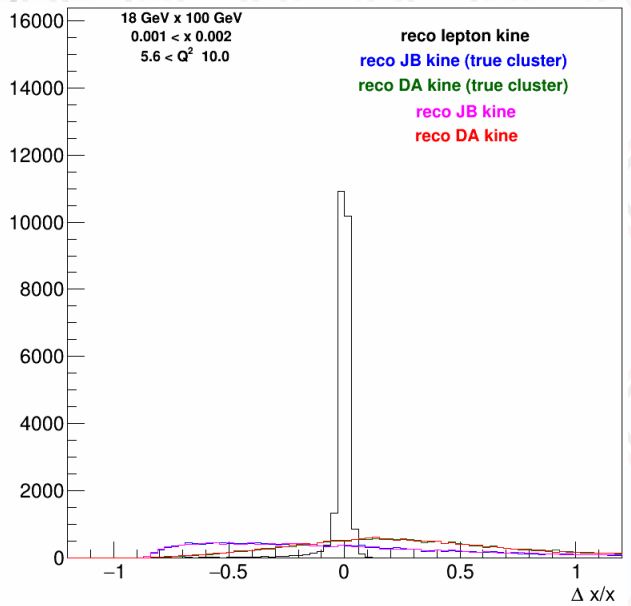
- First try to understand the best reconstruction methods for different kinematic regions
- Especially low y (bottom right corner in x-Q2 plane) is important for overlap of many (SI)DIS measurements to existing fixed-target measurements (HERMES, COMPASS, JLAB)

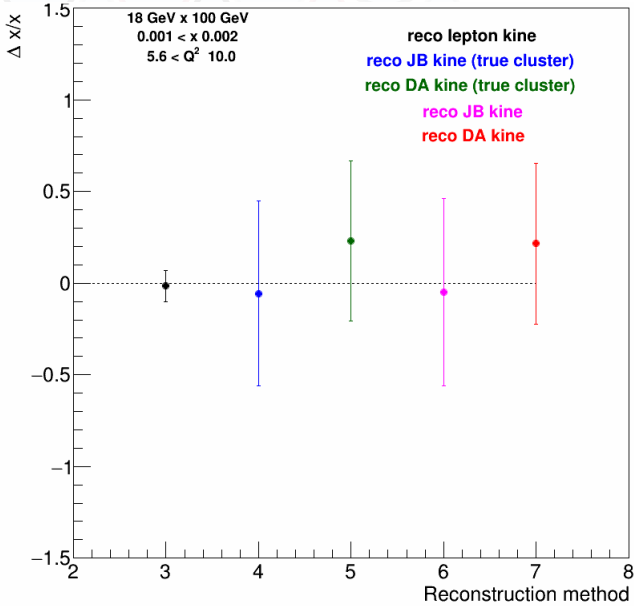




Kinematic reco example plots (x, high y)

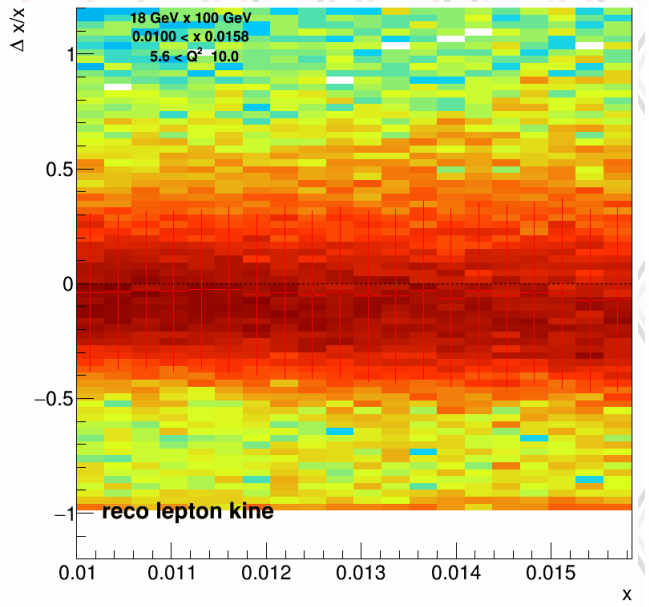


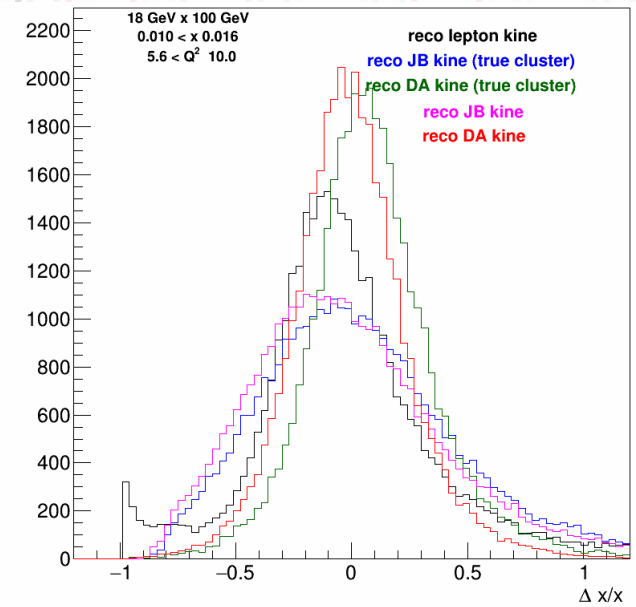


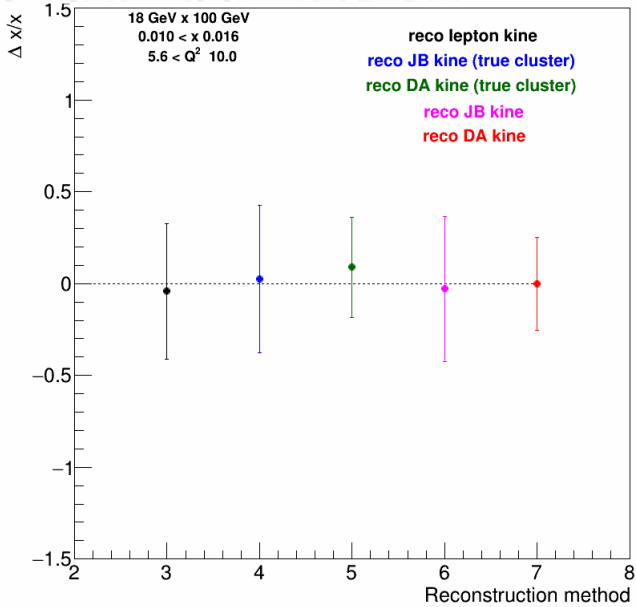


1. ($var_{reco} - var_{true} / var_{true}$) distributions as a function of variable/x/z in one x-Q2 bin
2. ($var_{reco} - var_{true} / var_{true}$) distribution in one x-Q2 bin
3. Mean and width for various reconstruction methods

Kinematic reco example plots (x, med y)

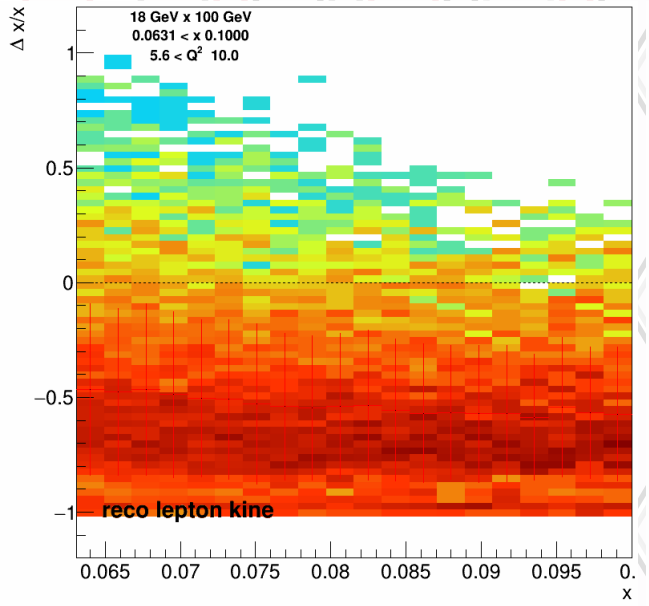


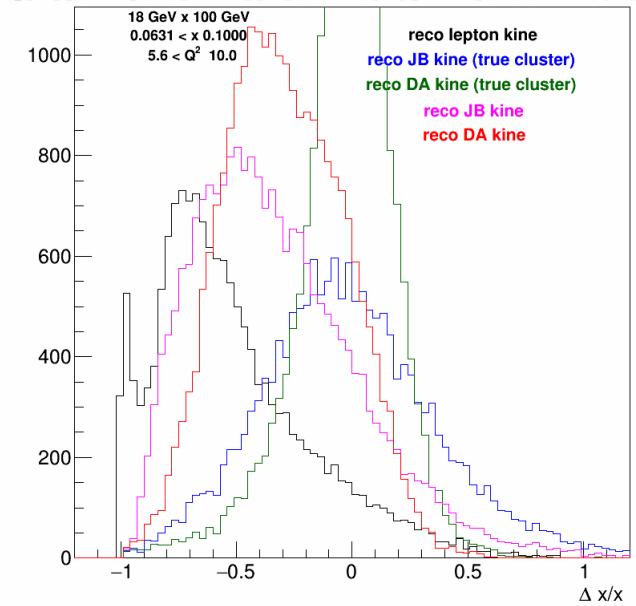


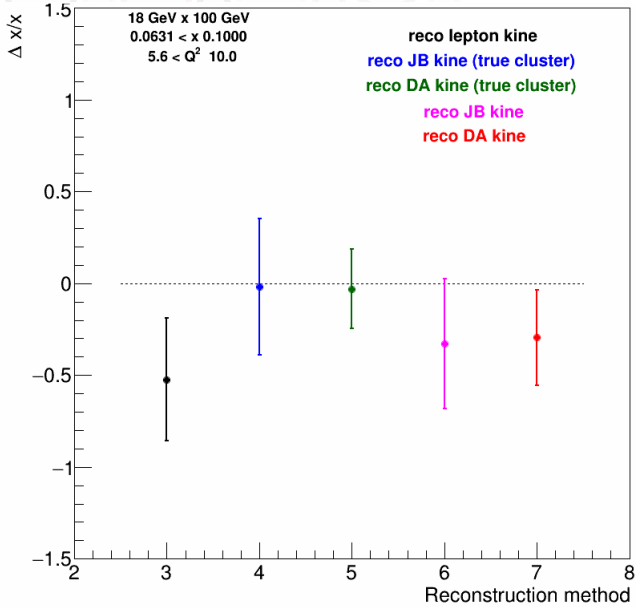


- At medium y all resolutions similar,

Kinematic reco example plots (x, low y)

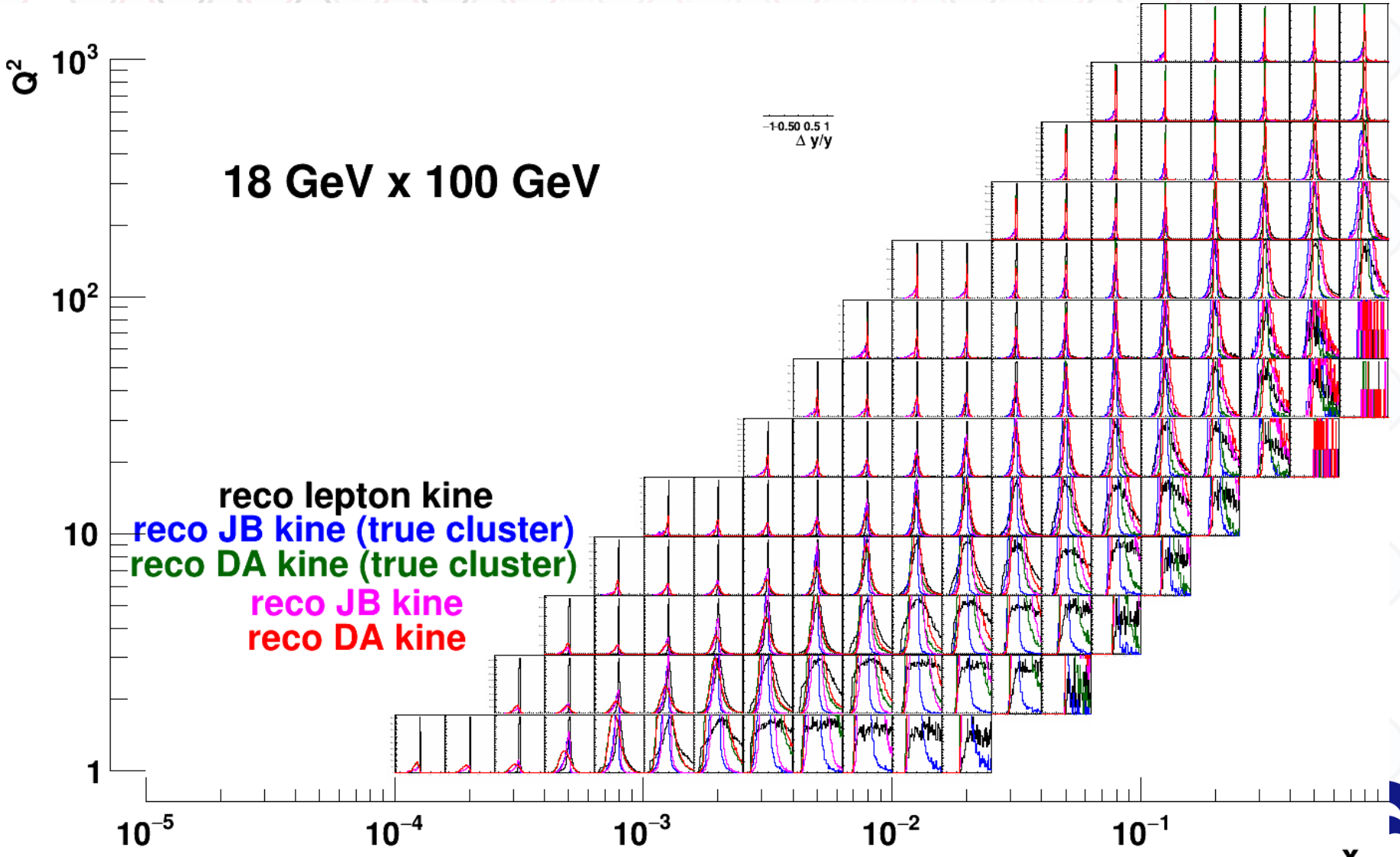




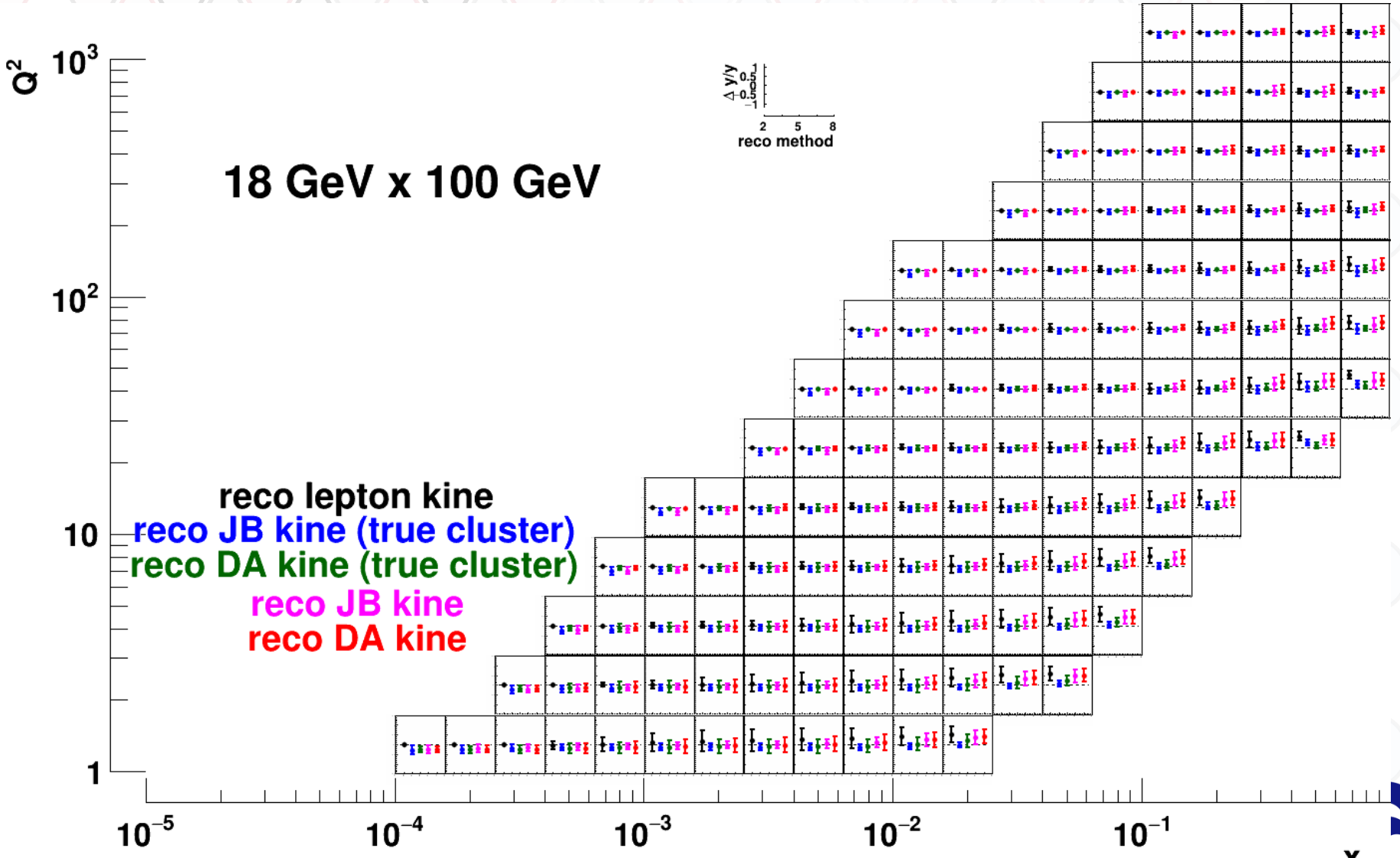


- Low y, lepton very

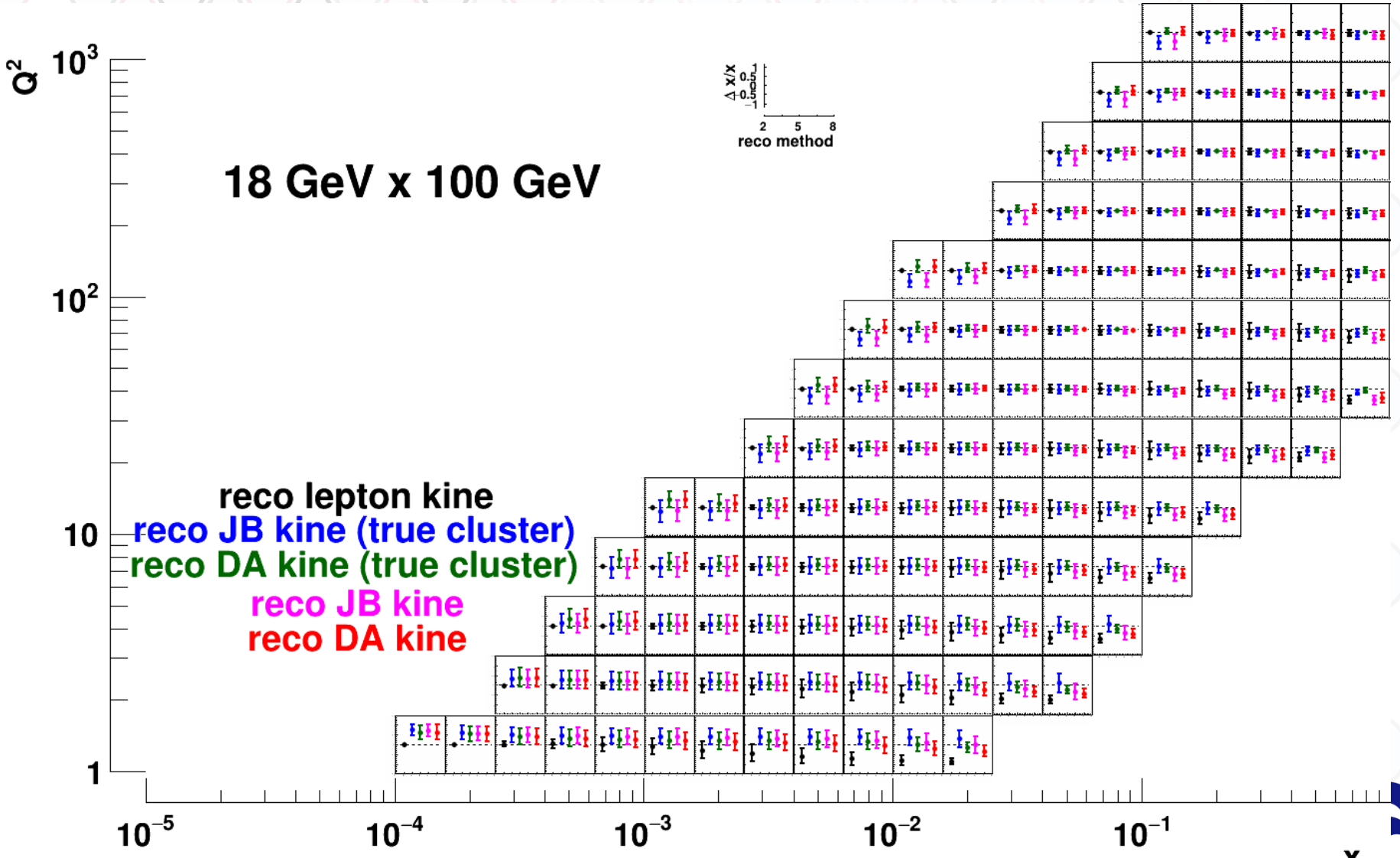
Accumulated resolutions



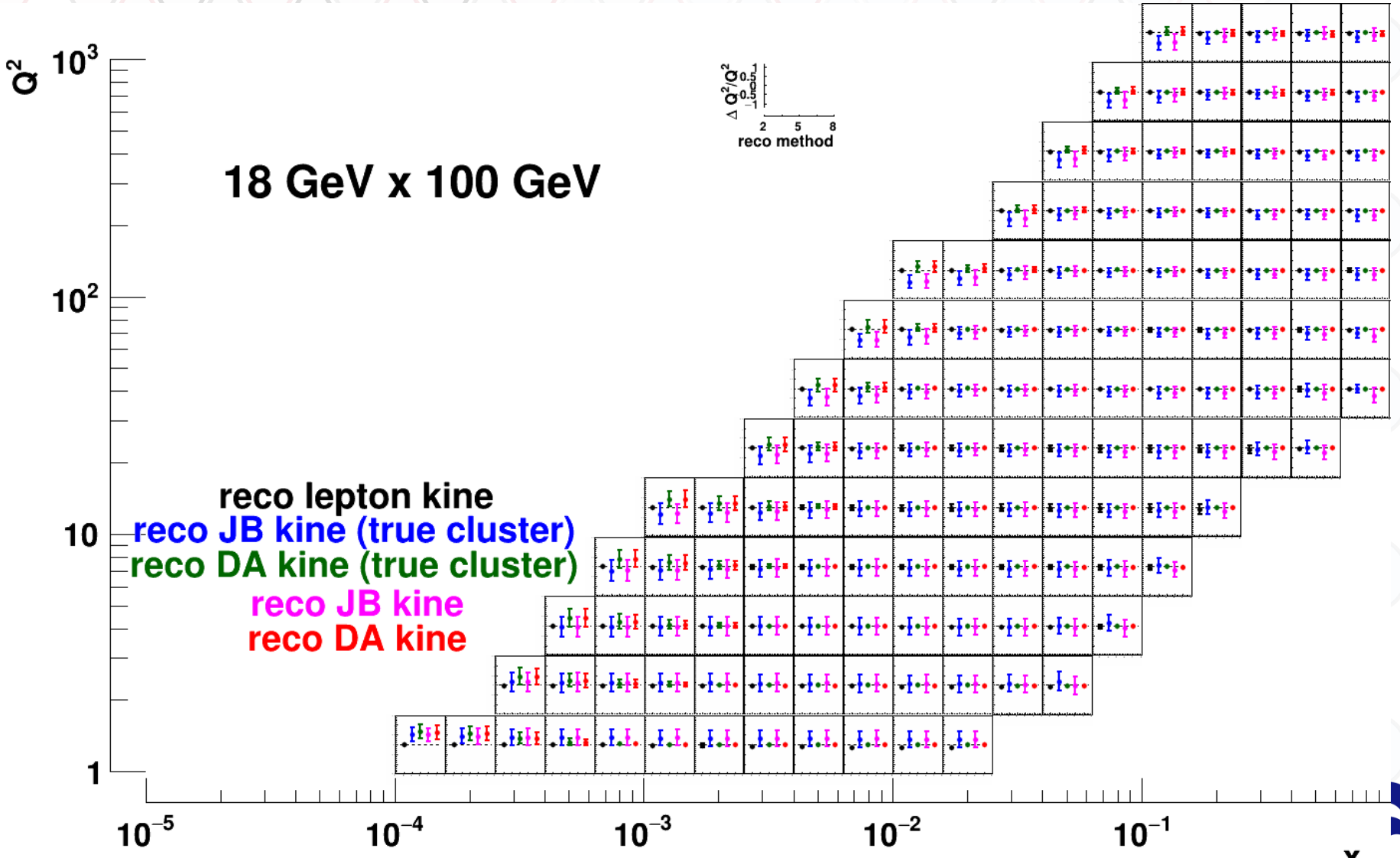
All y resolution widths and means



All x resolution widths and means



All Q^2 resolution widths and means

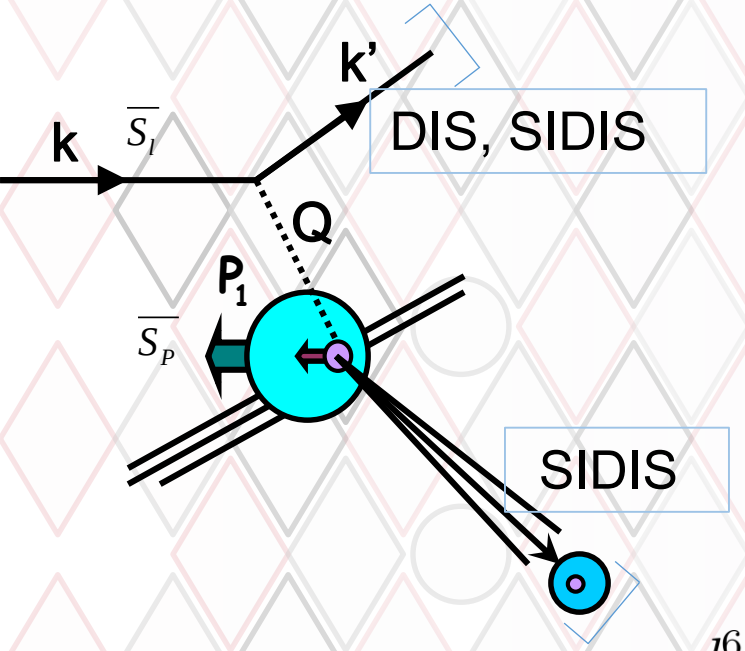


Conclusions DIS kinematics

- Generally lepton method works reliably for high y, substantial degradation at lower y
- DA method combines the best of both worlds for the most part, generally much better than lepton method at low y
- JB method with largest uncertainties, but still somewhat batter at low y than lepton method, only method applicable for CC events (no charged lepton)

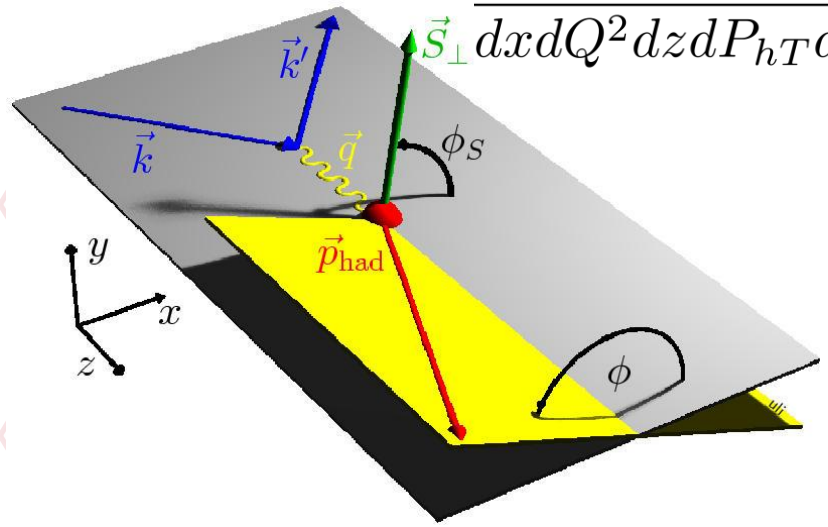
SIDIS Kinematics

Detect also final-state hadron(s) and make use of flavor, etc. sensitivity of Fragmentation functions



z:	Fractional hadron momentum wrt to parton momentum (0<z<1)
P_{hT}:	transverse hadron momentum wrt to virtual photon (convolution over intrinsic transverse momenta of PDFs and FFs)
ϕ_S:	Azimuthal angle of nucleon (transverse) spin wrt to scattering plane, along virtual photon axis
ϕ_h:	Azimuthal angle of hadron wrt to scattering plane, along virtual photon axis

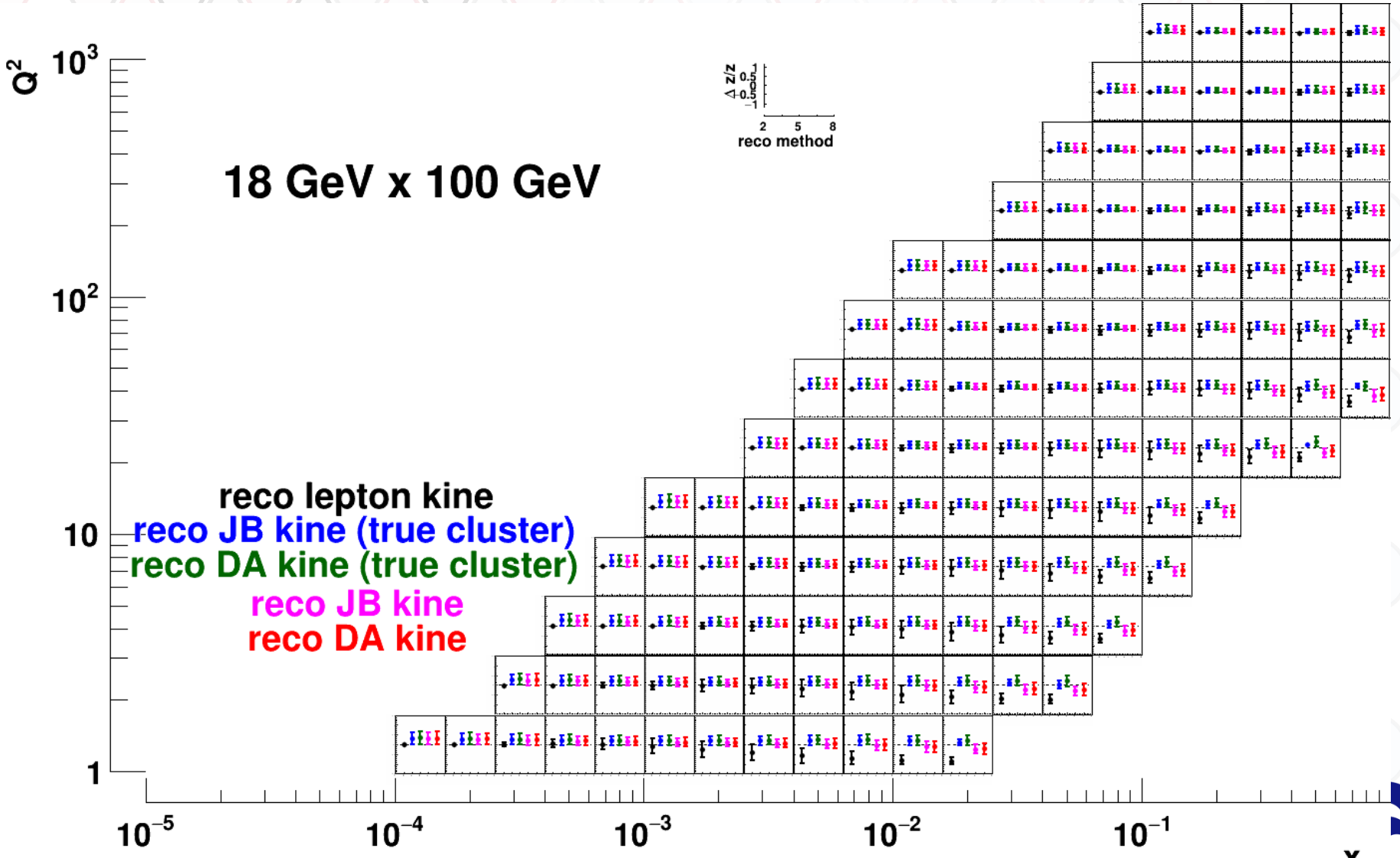
$$\frac{d^6\sigma}{\vec{S}_\perp dx dQ^2 dz dP_{hT} d\phi_S d\phi_h} \overset{LO}{\propto} \sum_{q,\bar{q}} e_q^2 q(x, Q^2, k_t) \otimes D^h_{1,q}(z, Q^2, p_t)$$



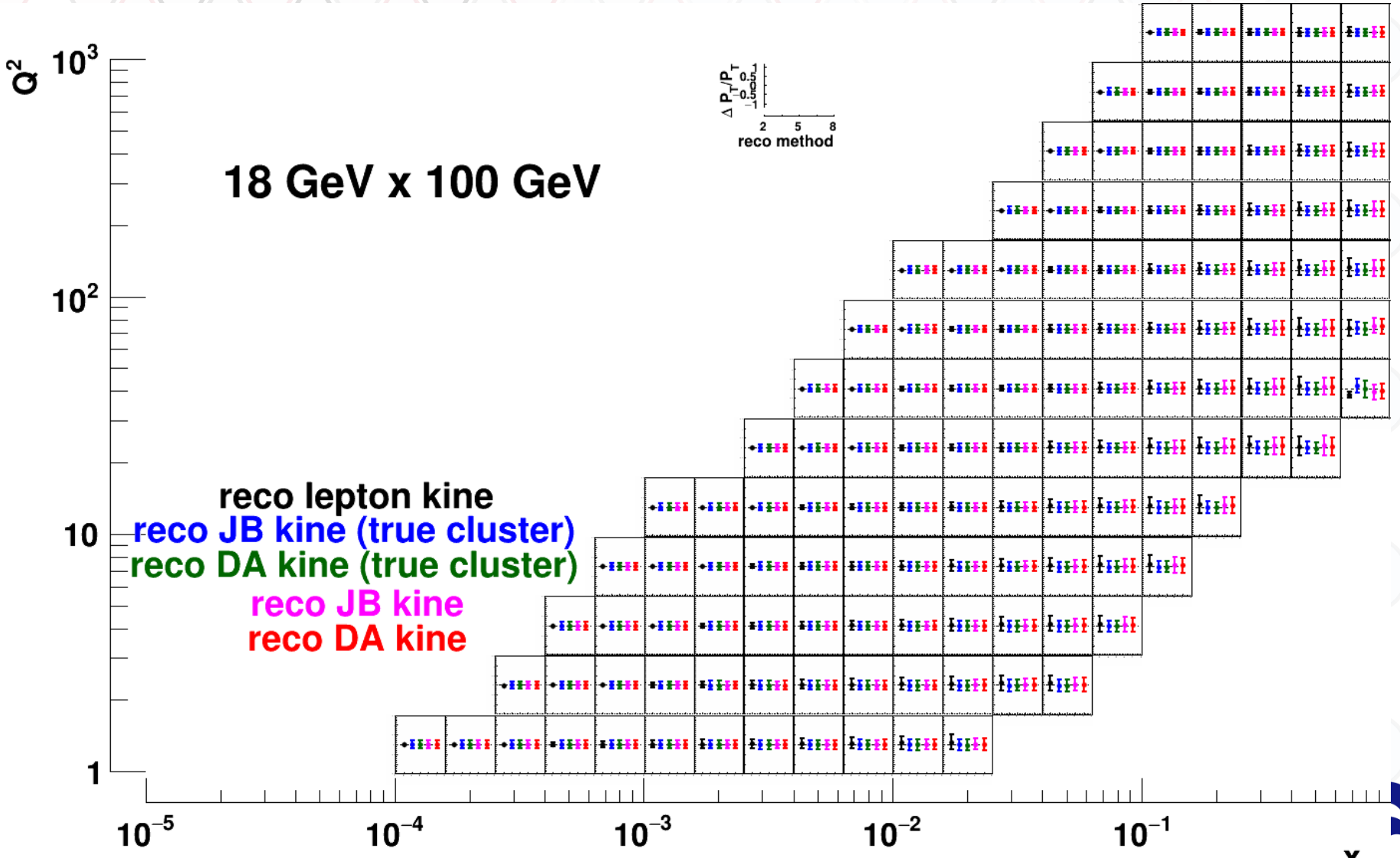
- Transverse momentum and angles rely also on correct boost to hadron rest system
- Current fragmentation: related to struck quark
- Target fragmentation: related to nucleon remnant

RIKEN

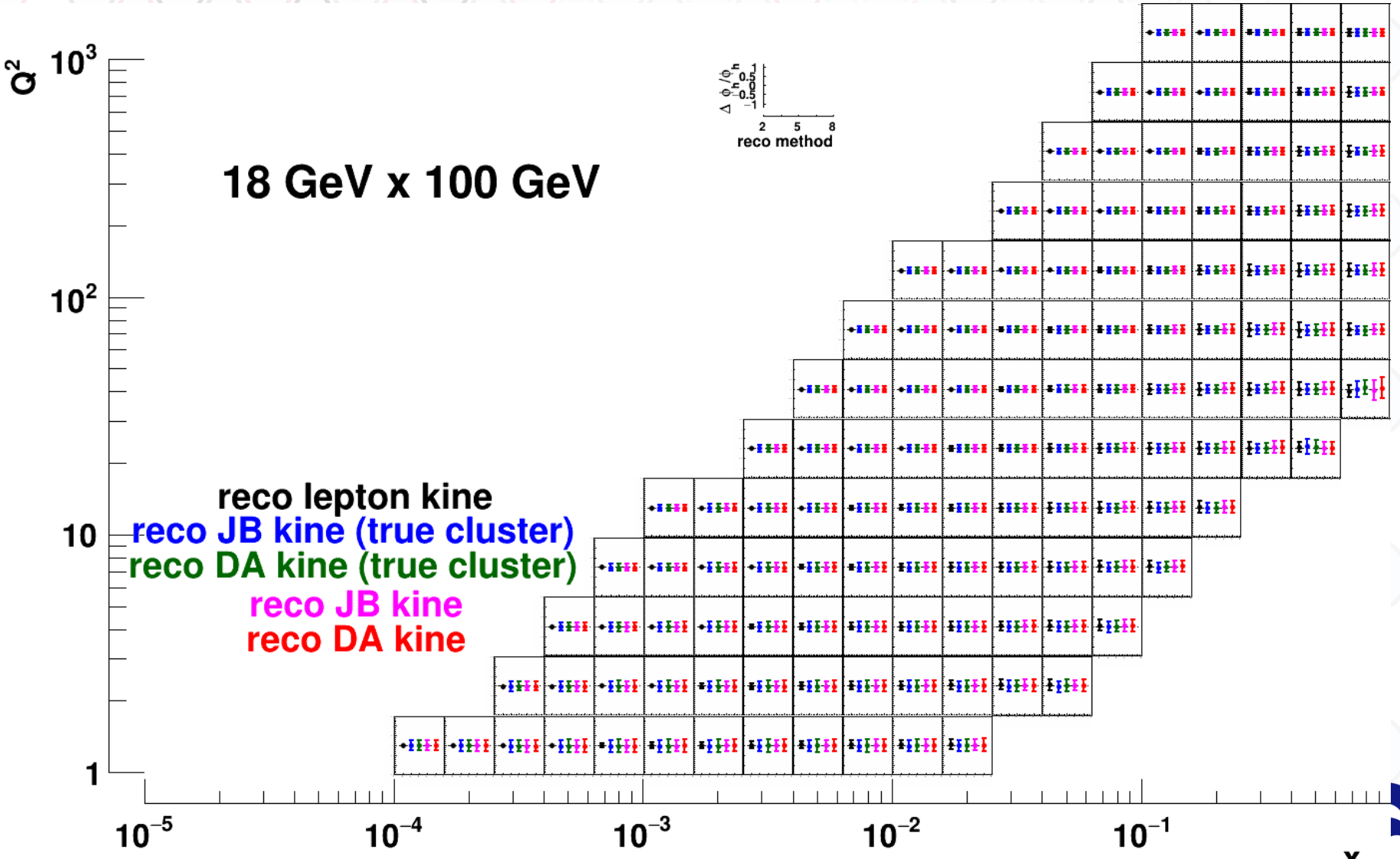
SIDIS resolutions I (z)



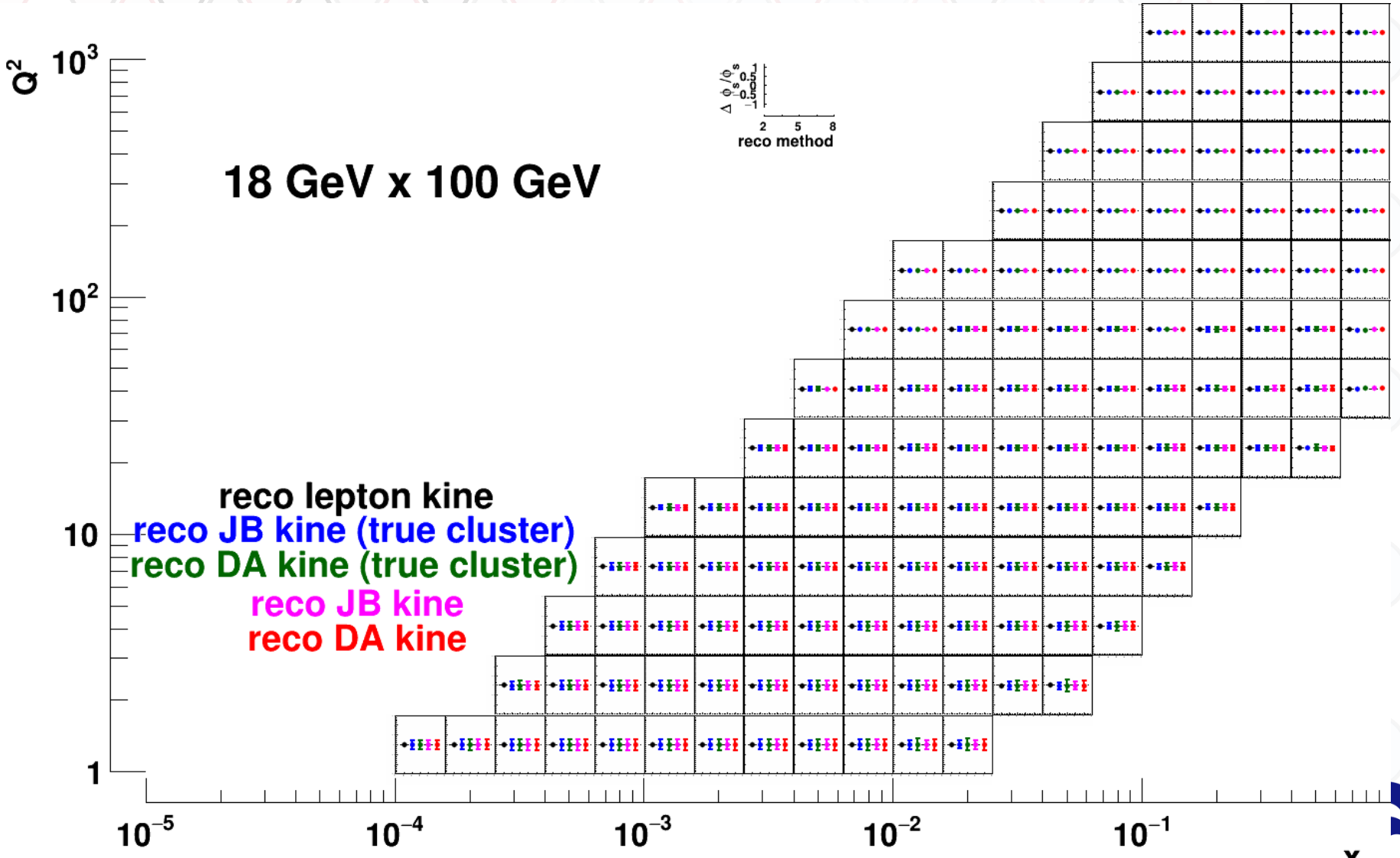
SIDIS resolutions I (P_{hT})



SIDIS resolutions III (ϕ_h)

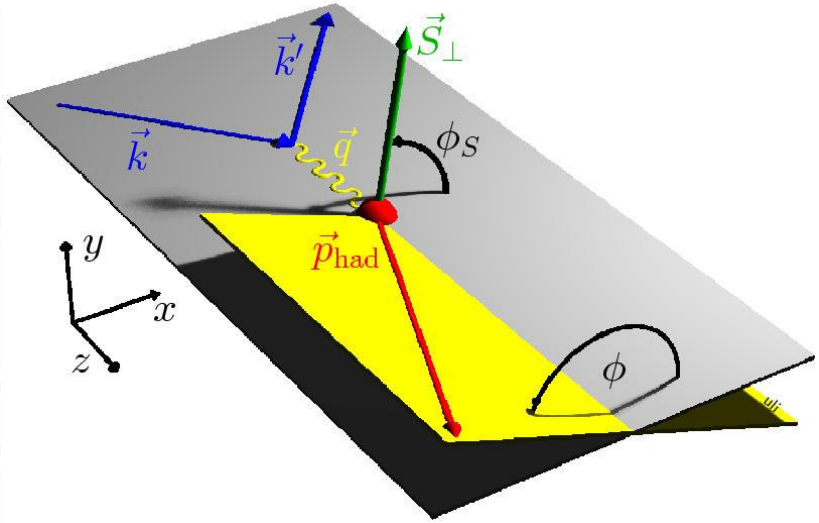


DIS resolutions (ϕ_s)



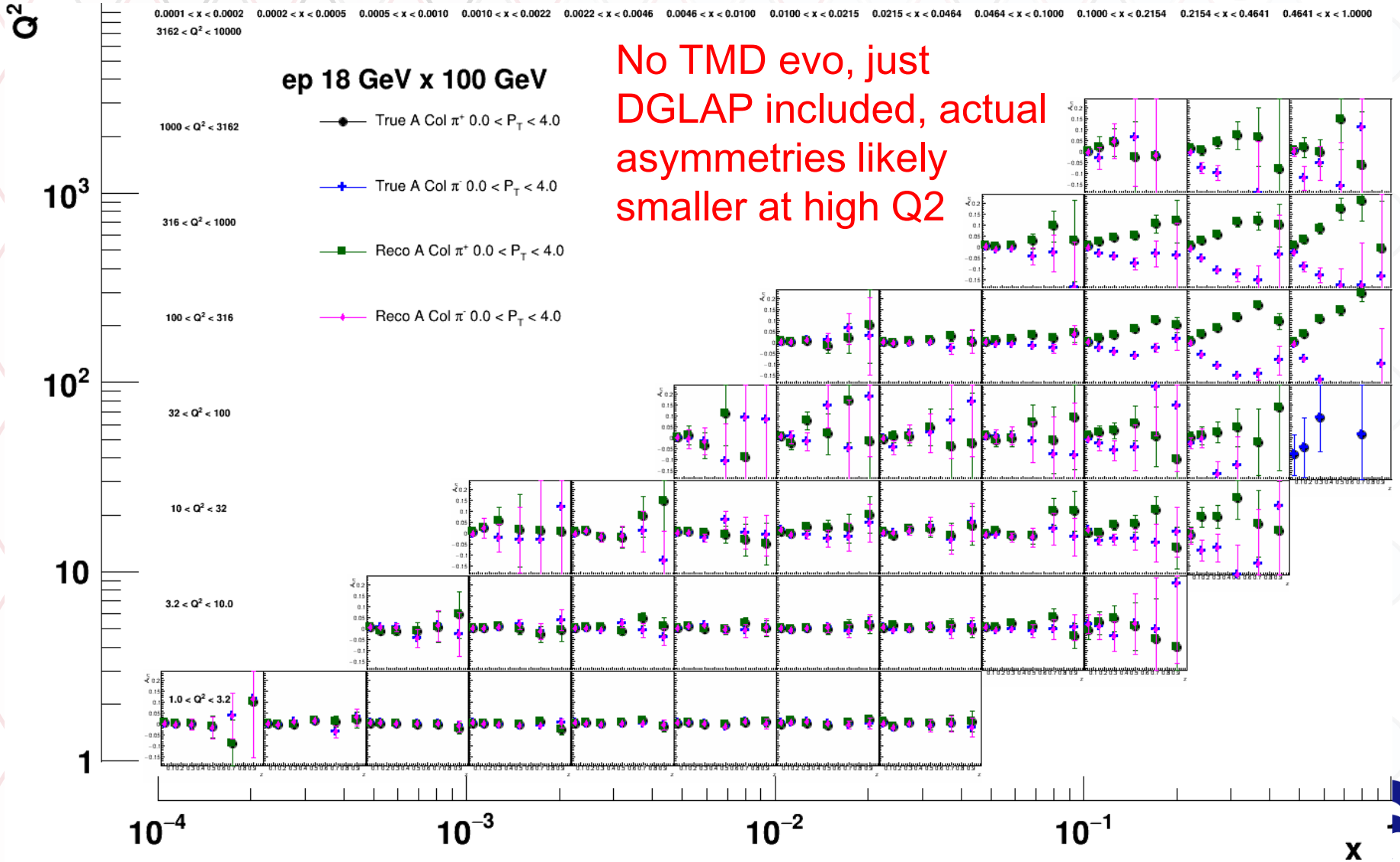
Sivers/Collins measurements in SIDIS

- Use test production output and calculate Sivers and Collins asymmetries
- Reweight events according to true parton flavor q, hadron h, x, z, Q^2, P_{hT}, azimuthal angles and random spin orientiation
- $ep^{\uparrow} \rightarrow e'hX$
- A_{UT} asymmetries (Unpolarized lepton beam, Transversely polarized target)
- Different azimuthal modulations related to Sivers effect ($\sin(\phi-\phi_s)$) and Collins effect ($\sin(\phi+\phi_s)$)
- Fit simultaneously in the reconstructed events and calculate asymmetries



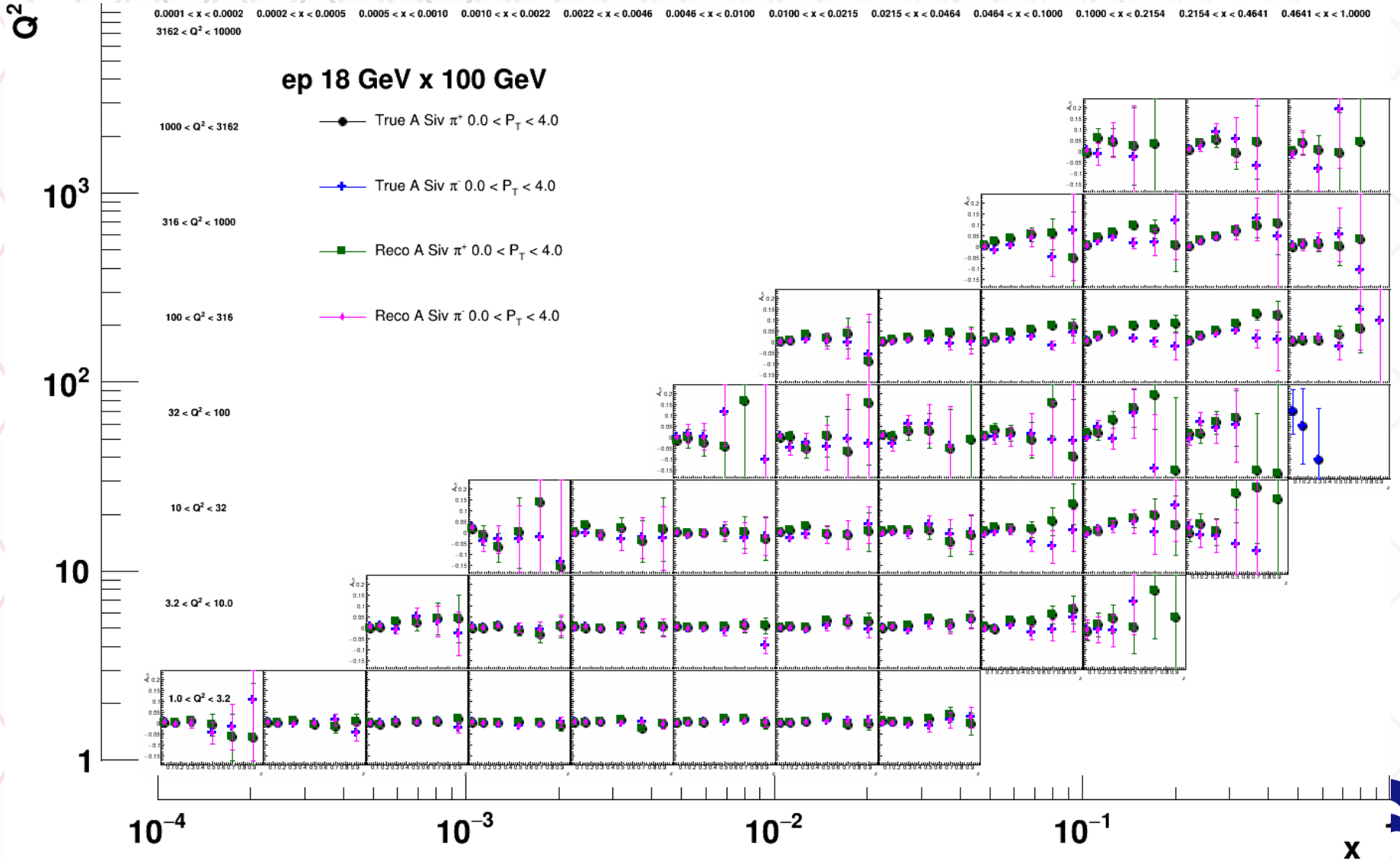
- Currently still true PID used,
- input asymmetries (structure functions) from Torino global fits

A_{UT} calculations (~2 fb^{-1}@high Q^2, ~0.008 fb^{-1}@low Q^2 scattered lepton method), Torino parameterization

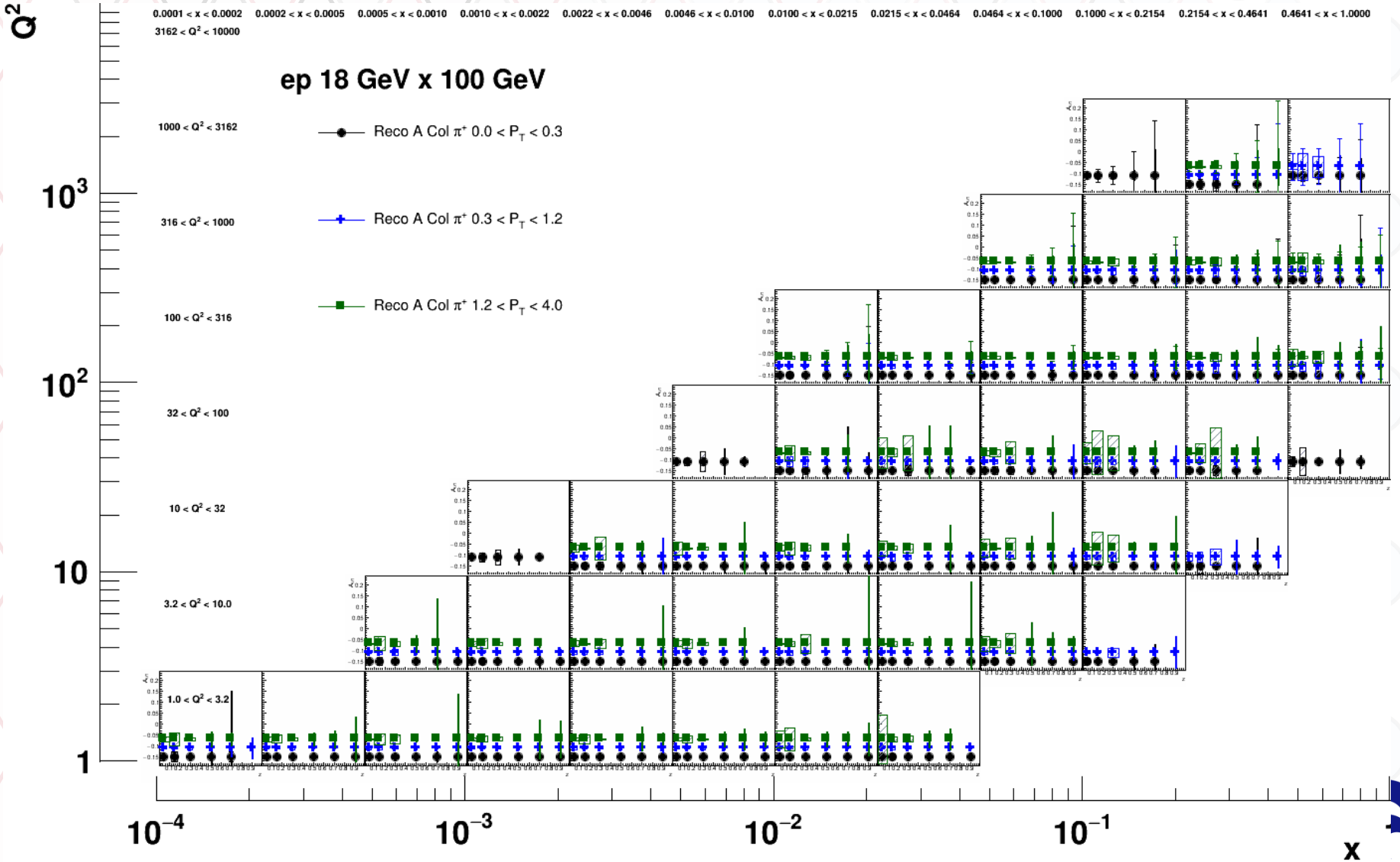


No TMD evo, just DGLAP included, actual asymmetries likely smaller at high Q2

A_{UT} calculations (~2 fb^{-1}@high Q^2, ~0.008 fb^{-1}@low Q^2), Torino parameterization

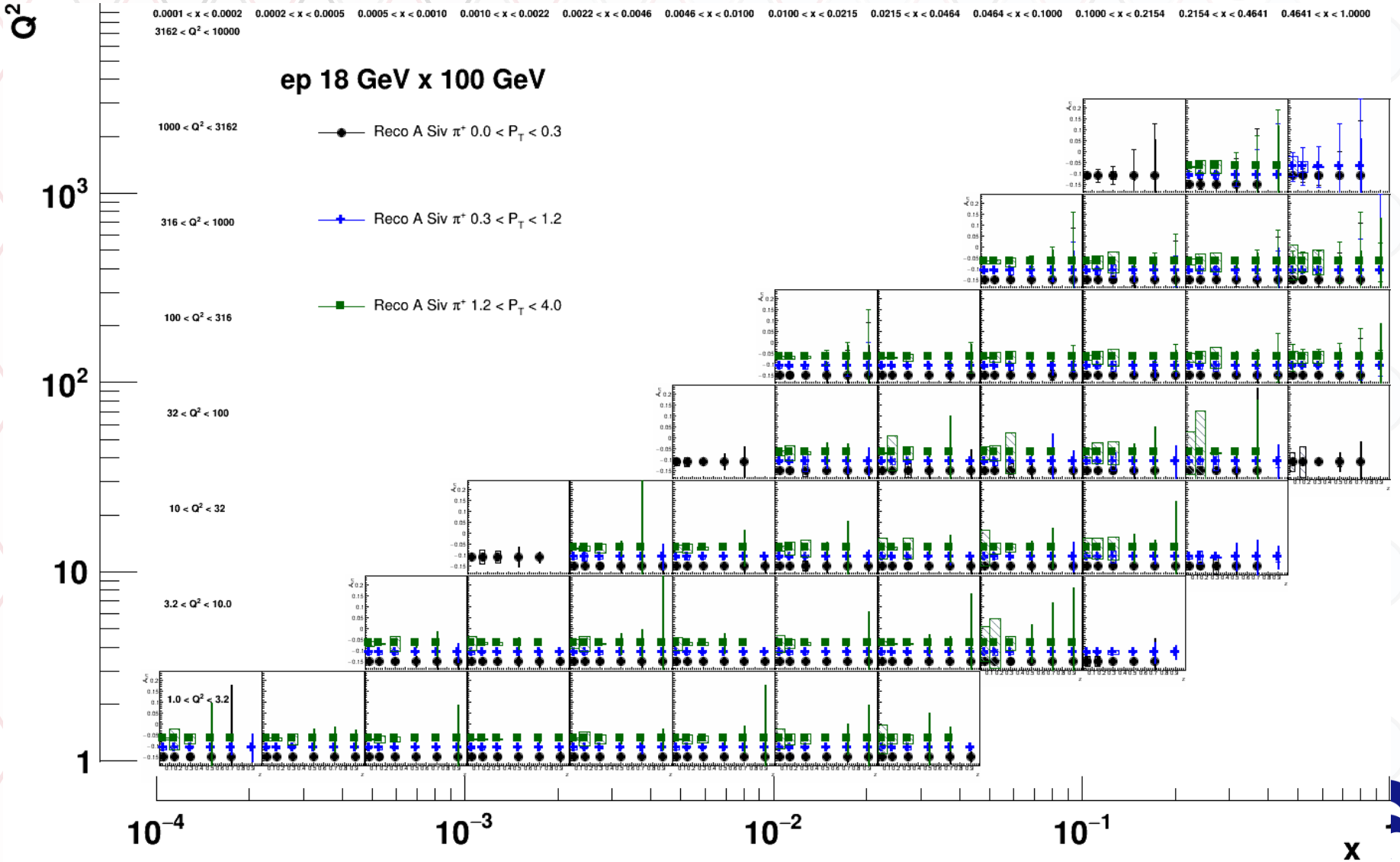


A_{UT} projections for 10fb^{-1} ,Collins π^+

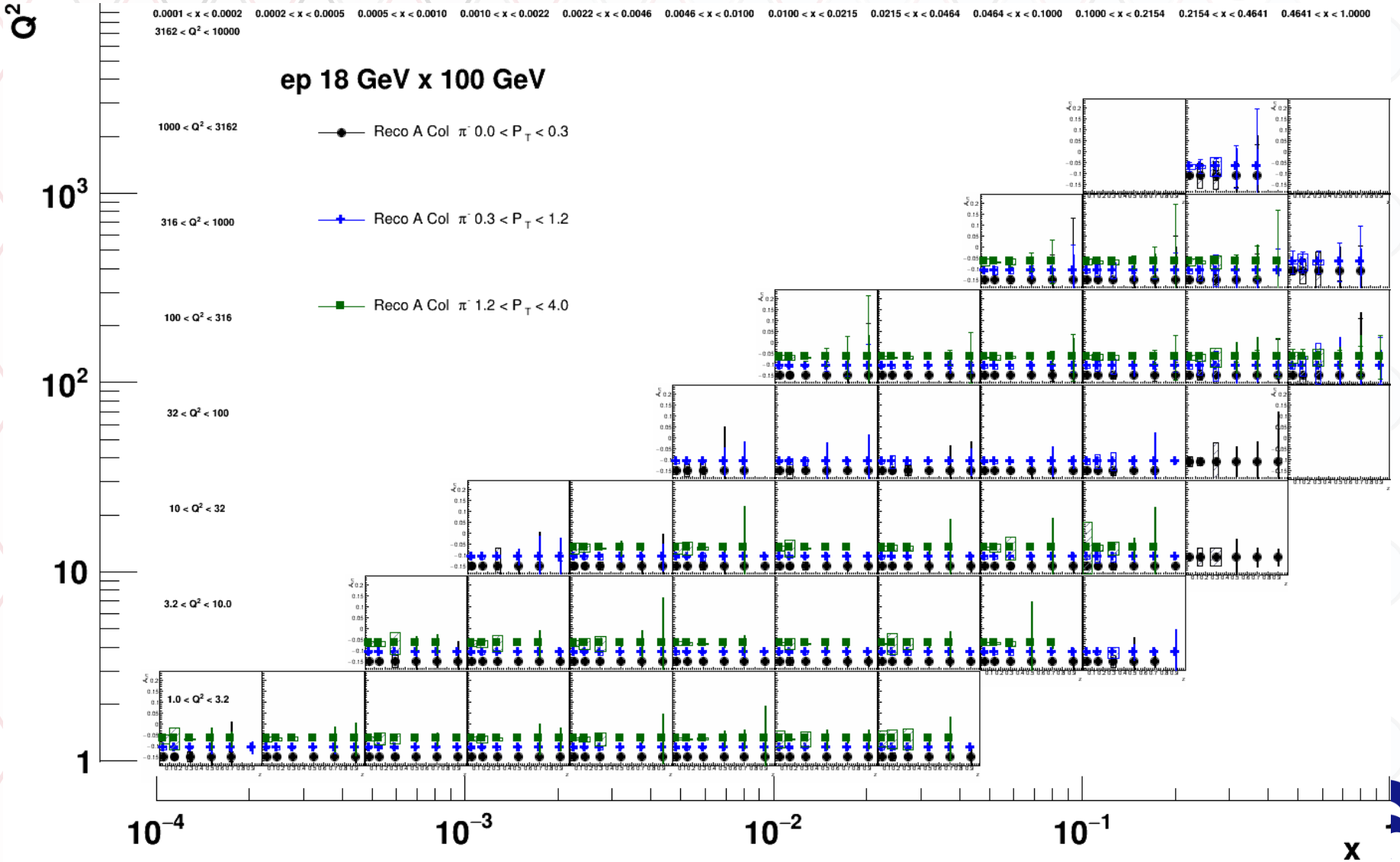


RIKEN

A_{UT} projections for 10fb^{-1} ,Sivers π^+



A_{UT} projections for 10fb^{-1} ,Collins π^-

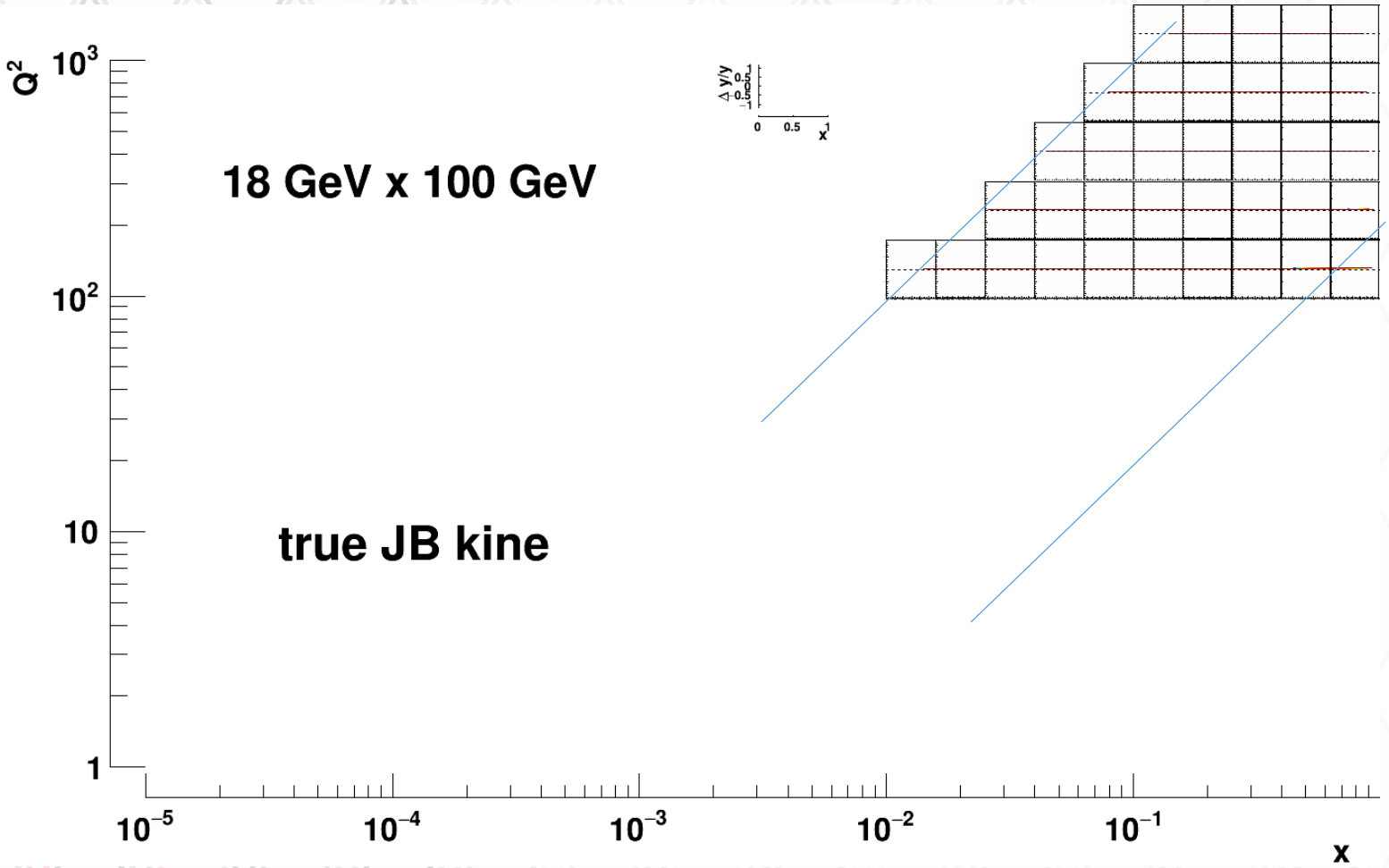


Conclusions

- Test production output from 18 x 100 high Q^2/low Q^2 simulations already available (almost 4M/5M events corresponds to ~2/ 0.008 fb^{-1})
- Kinematic reconstruction methods look reasonable, qualitatively better than previous ePHENIX production test
- SIDIS variables get also reconstructed well
- Calculation of corresponding azimuthal asymmetries also prepared for first production output:
  - Pretty reasonable output, not too large deviations from in put asymmetries seen (ie small systematics)
  - Projections using new simulations almost ready to give theorists
- Still remaining work: PID, cluster projections, more statistics and collision energies

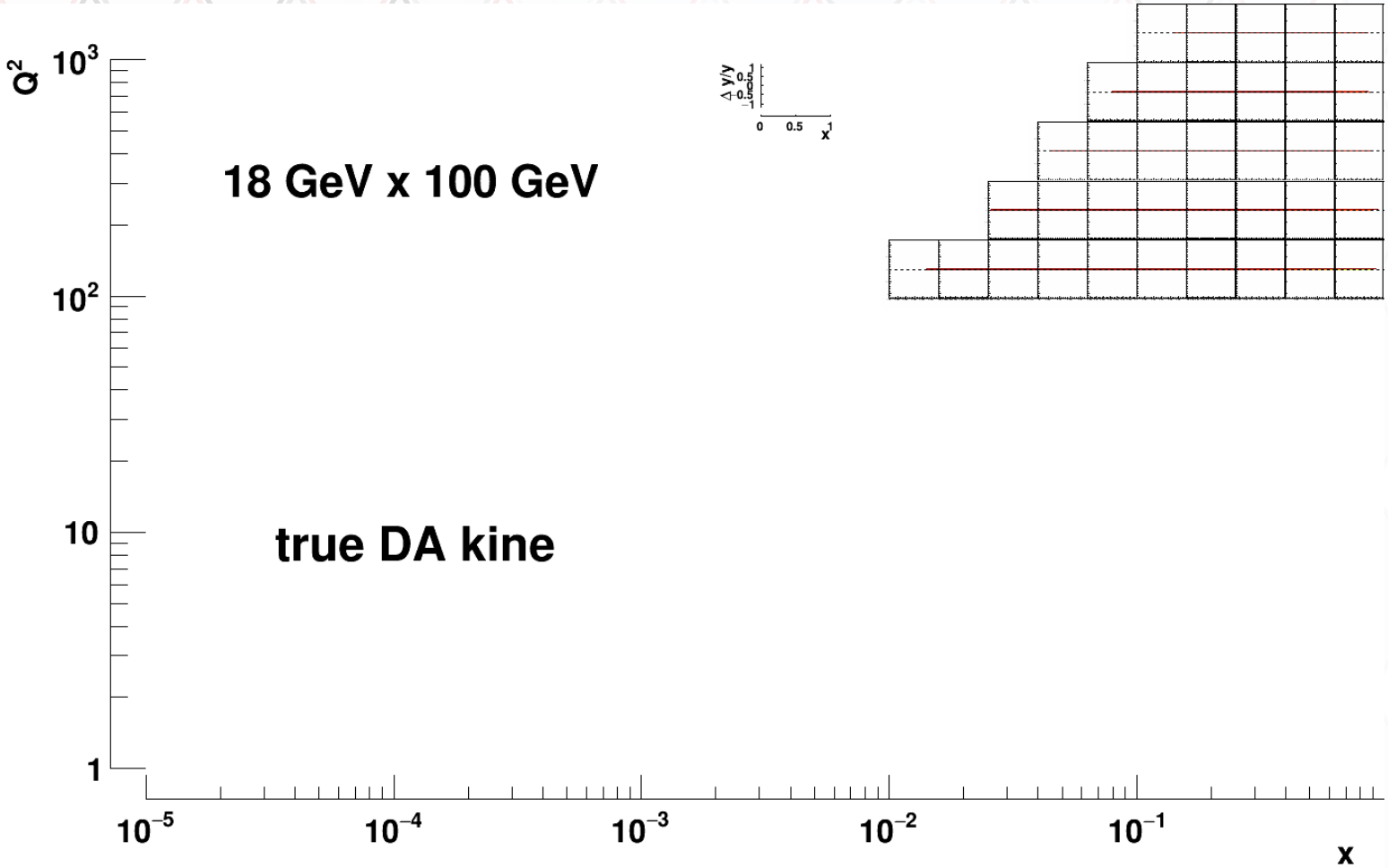
RIKEN

y resolution JB method (true particles)



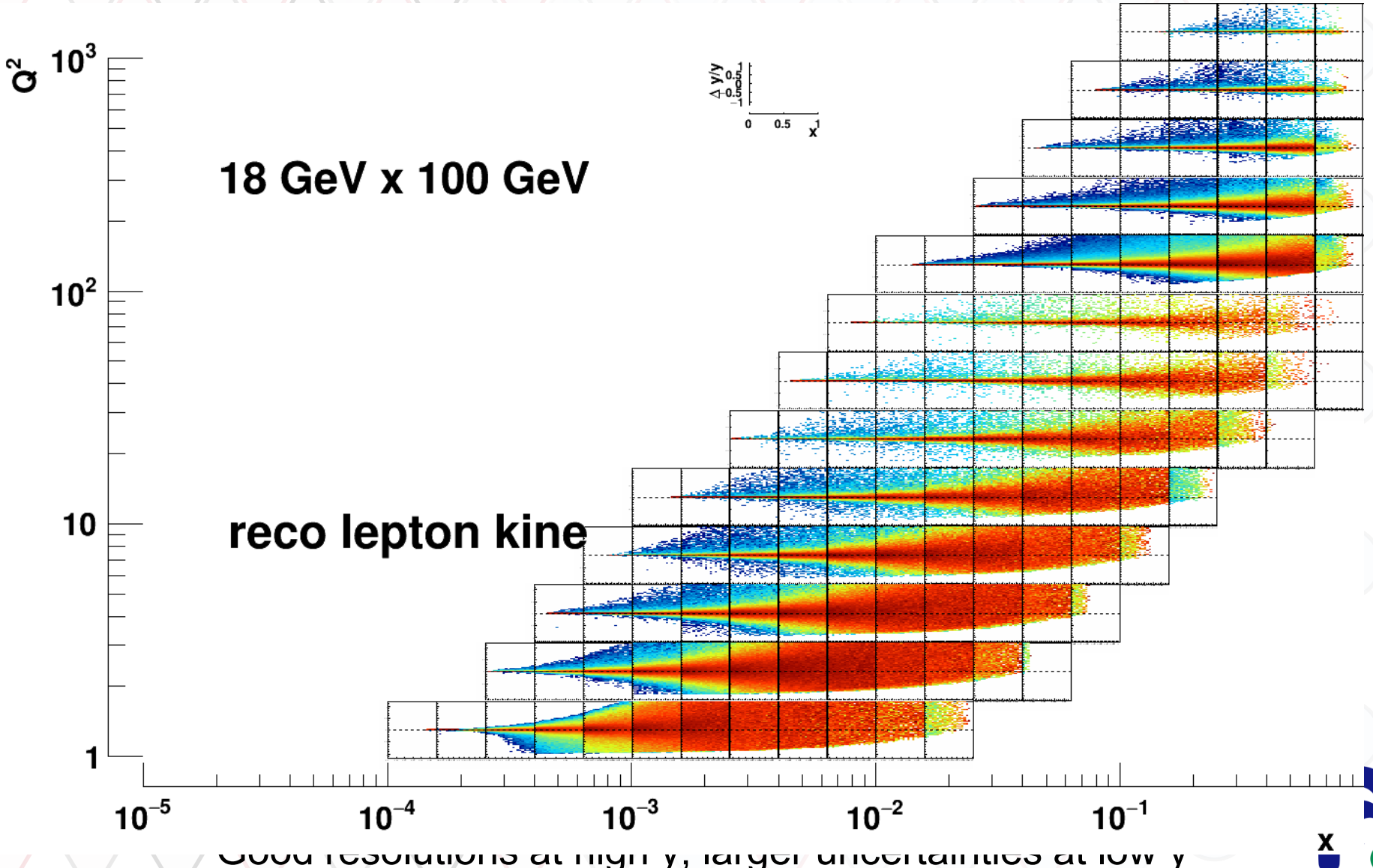
Consistency check that JB method equivalent

y res DA method (true particles)



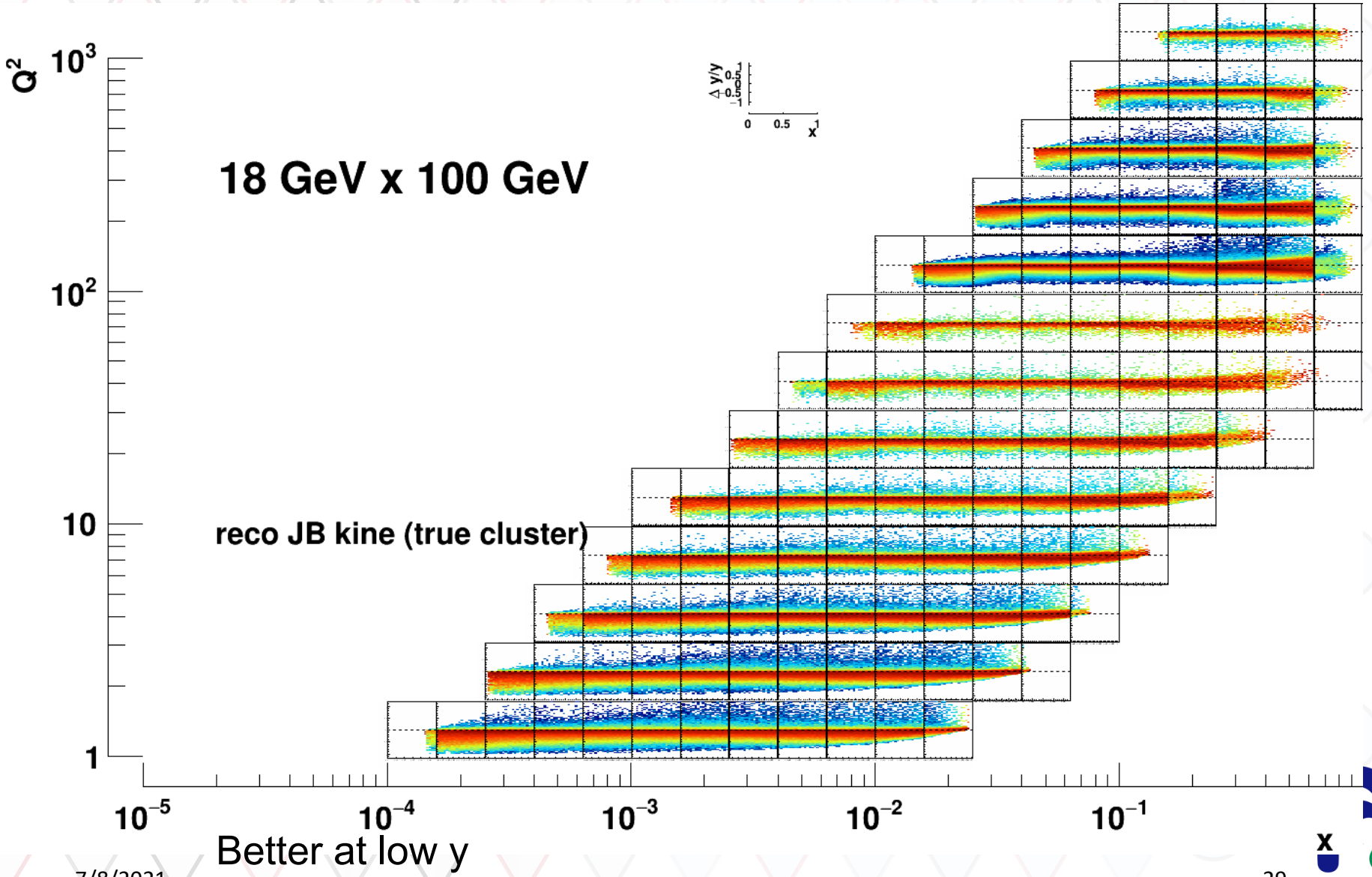
Consistency check that DA method equivalent

y resolution using scattered lepton

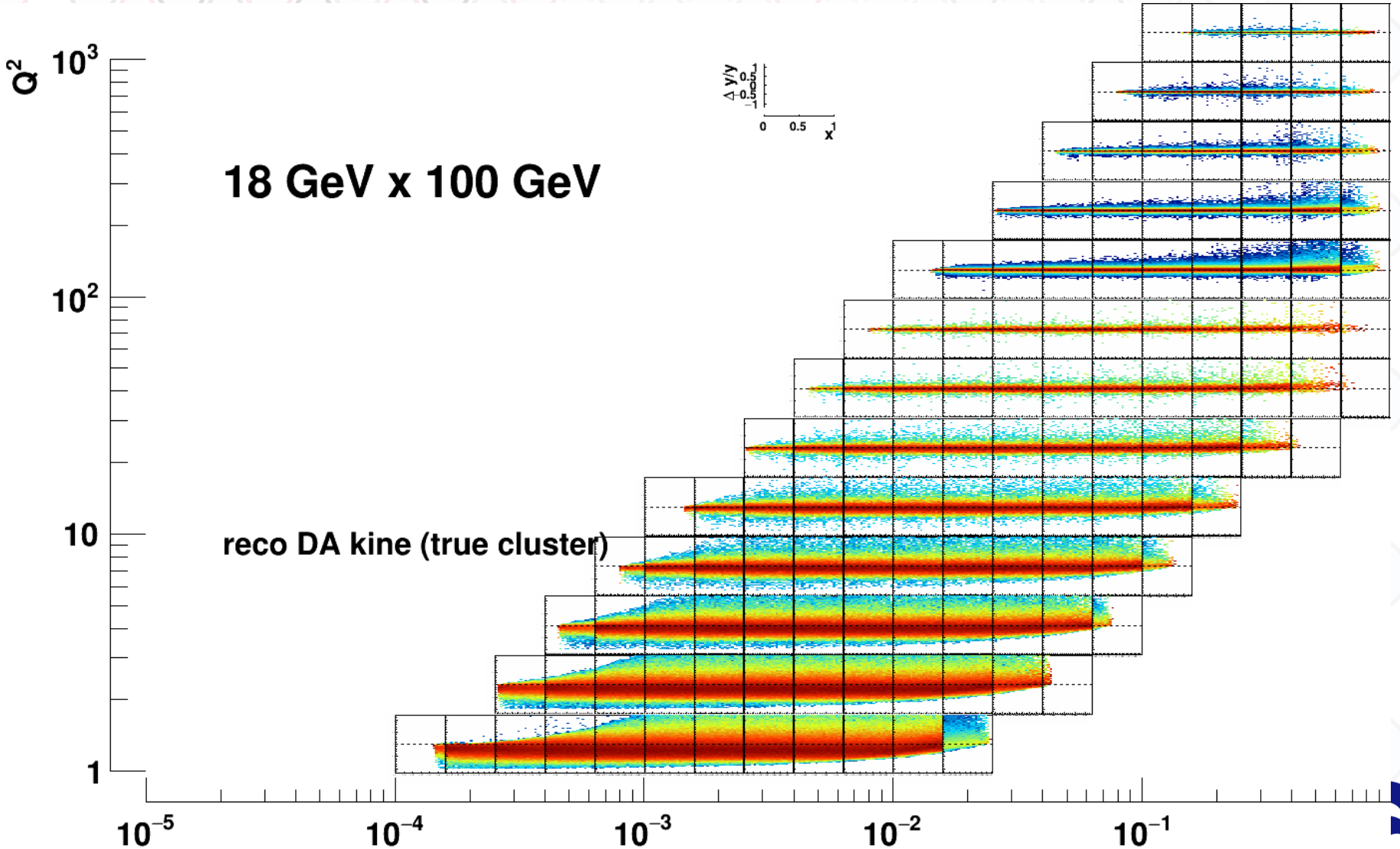


Good resolutions at high y, larger uncertainties at low y

y resolution JB true neutral clusters (use PDG)

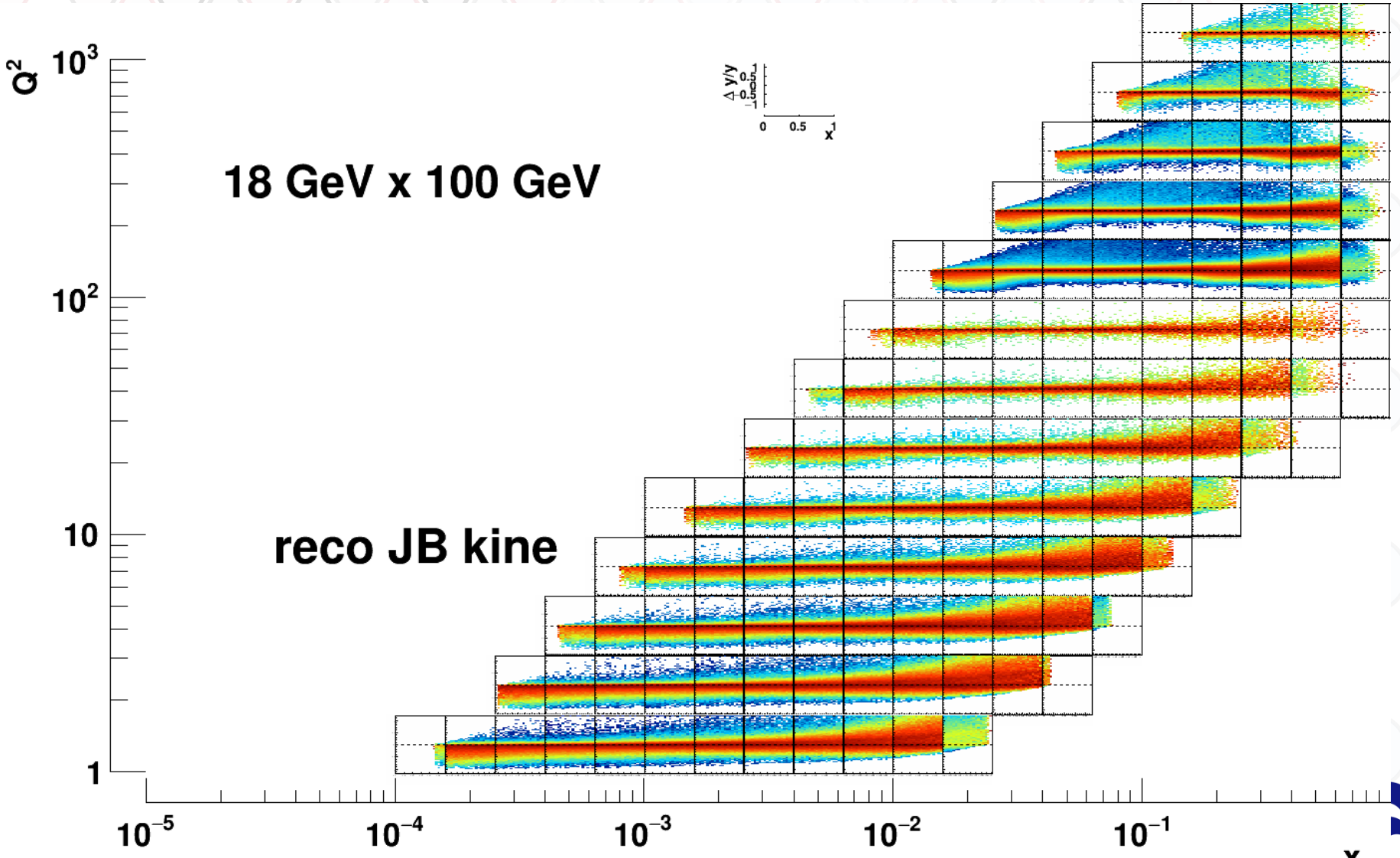


Y resolution DA true neutral clusters (use PDG)

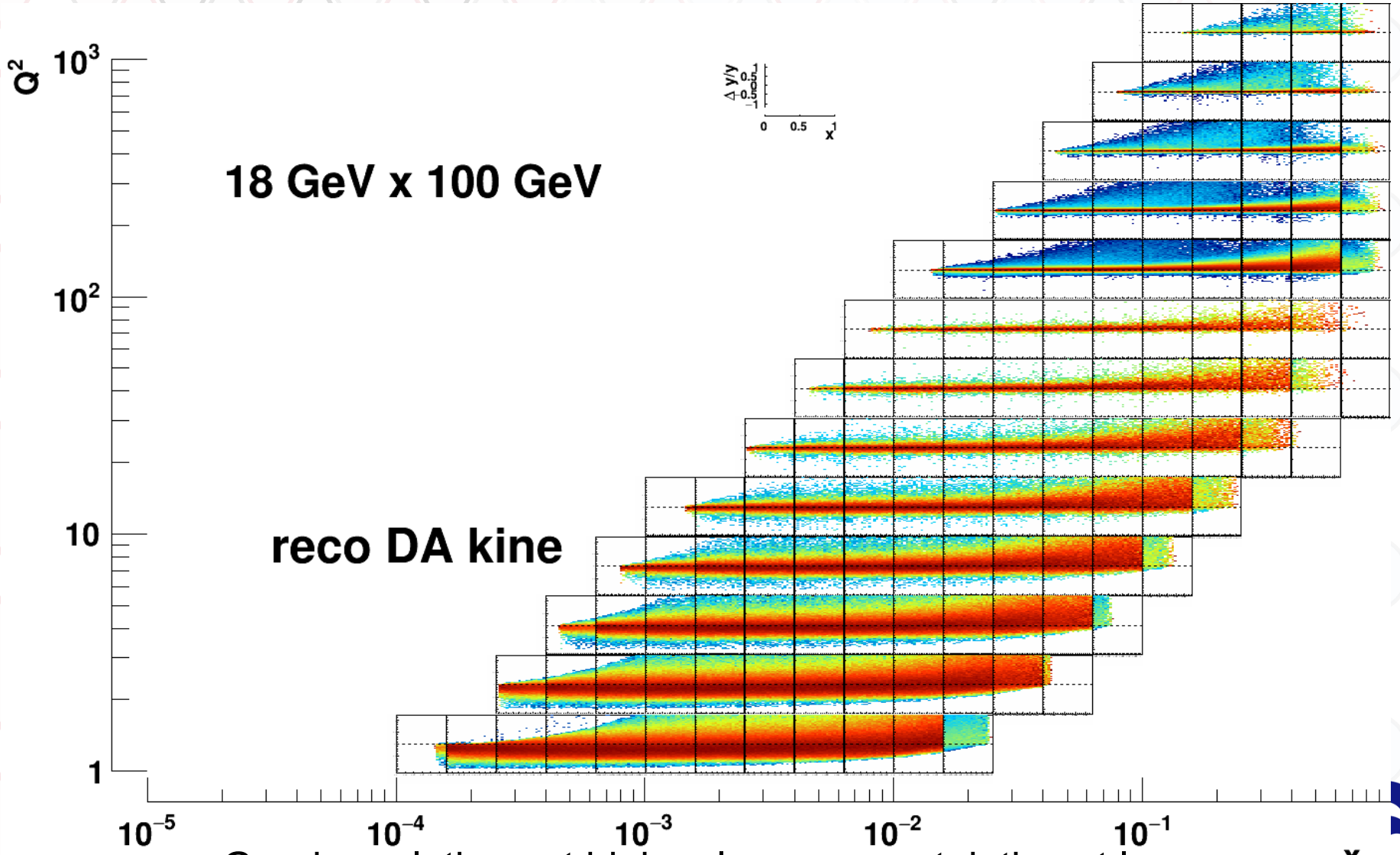


Double angle with best overall resolution

y resolutions JB using Barcode for neutrals

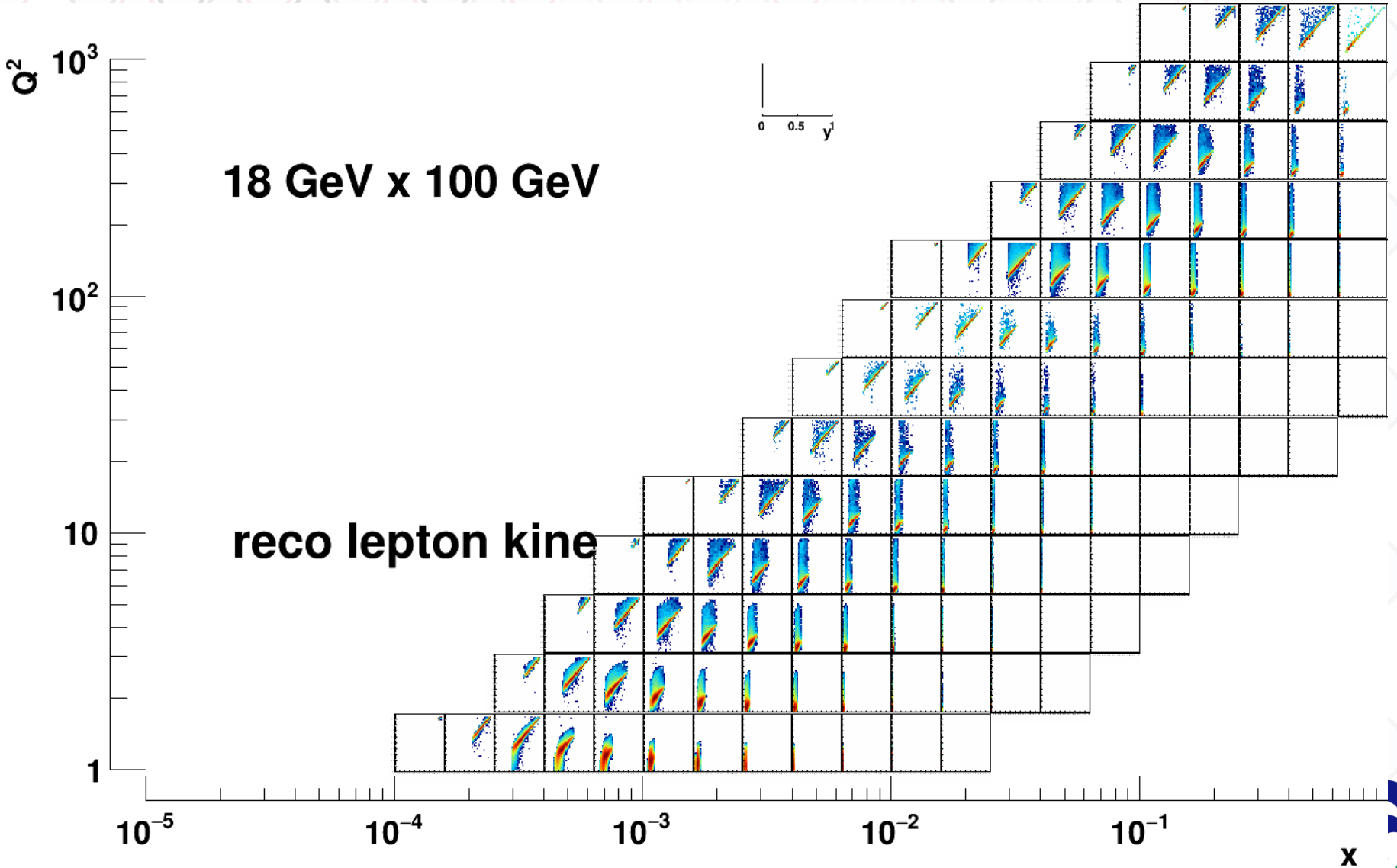


Y resolutions DA using Barcode for neutrals

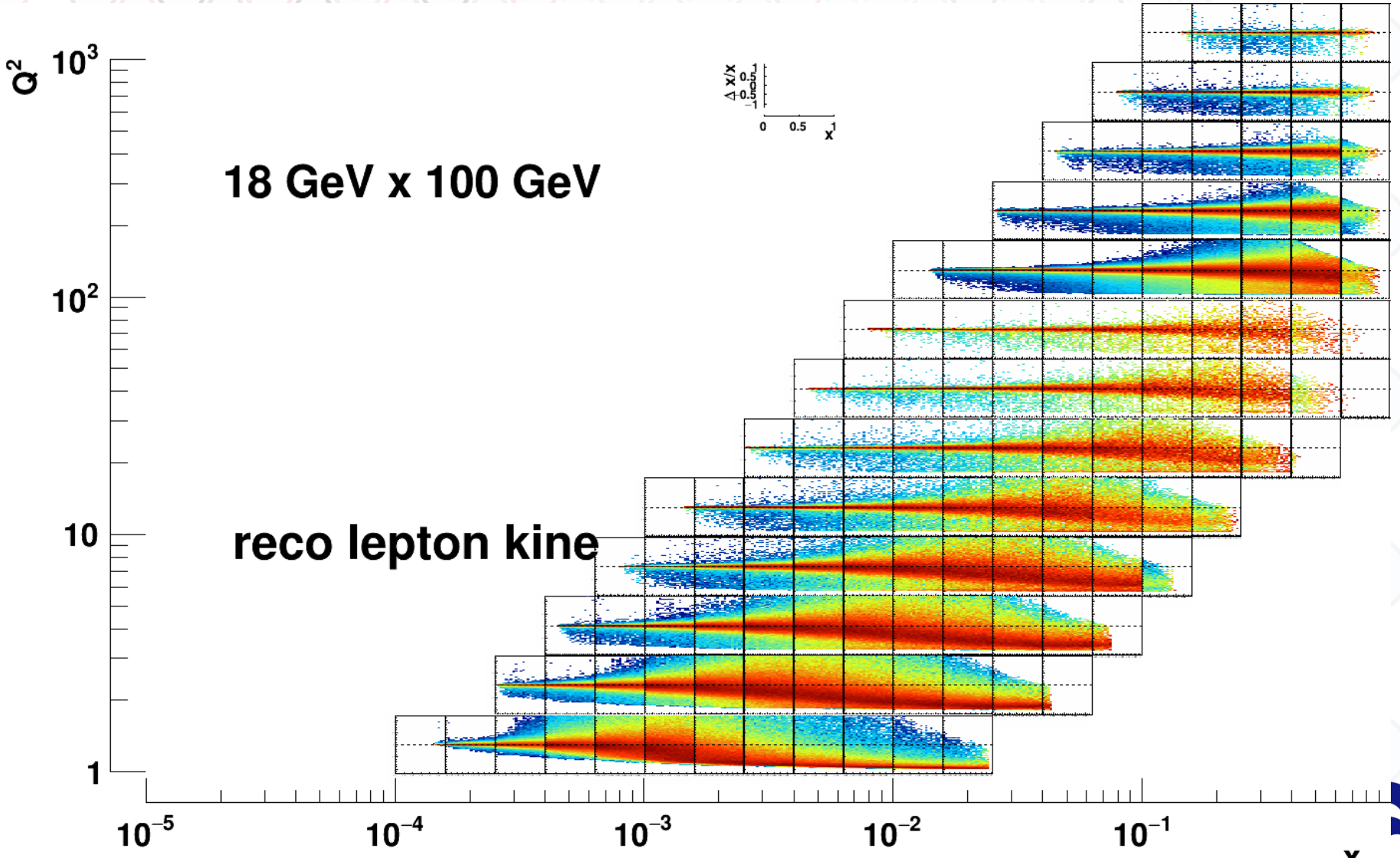


Good resolutions at high y, larger uncertainties at low y

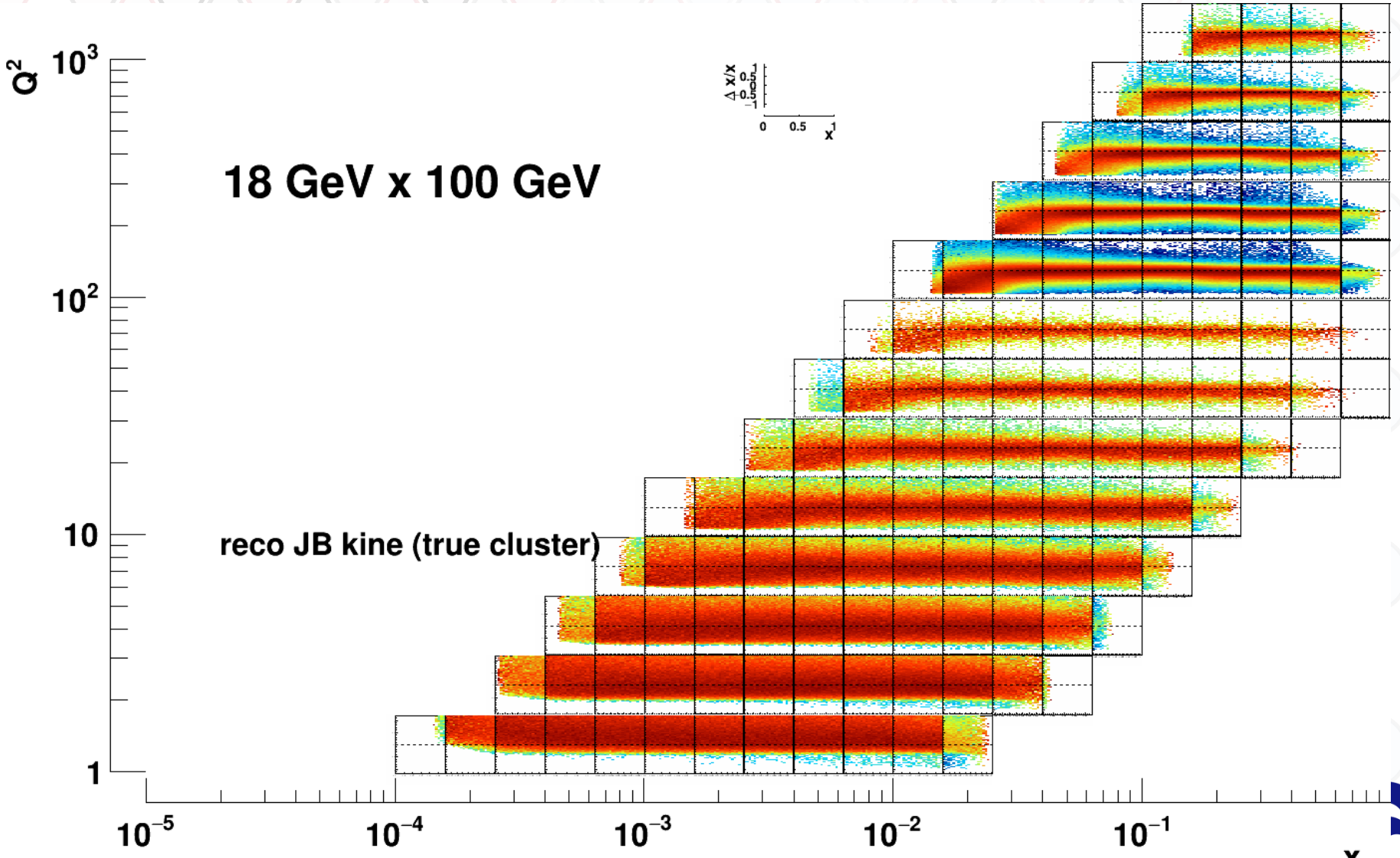
y distributions true vs reco for lepton method



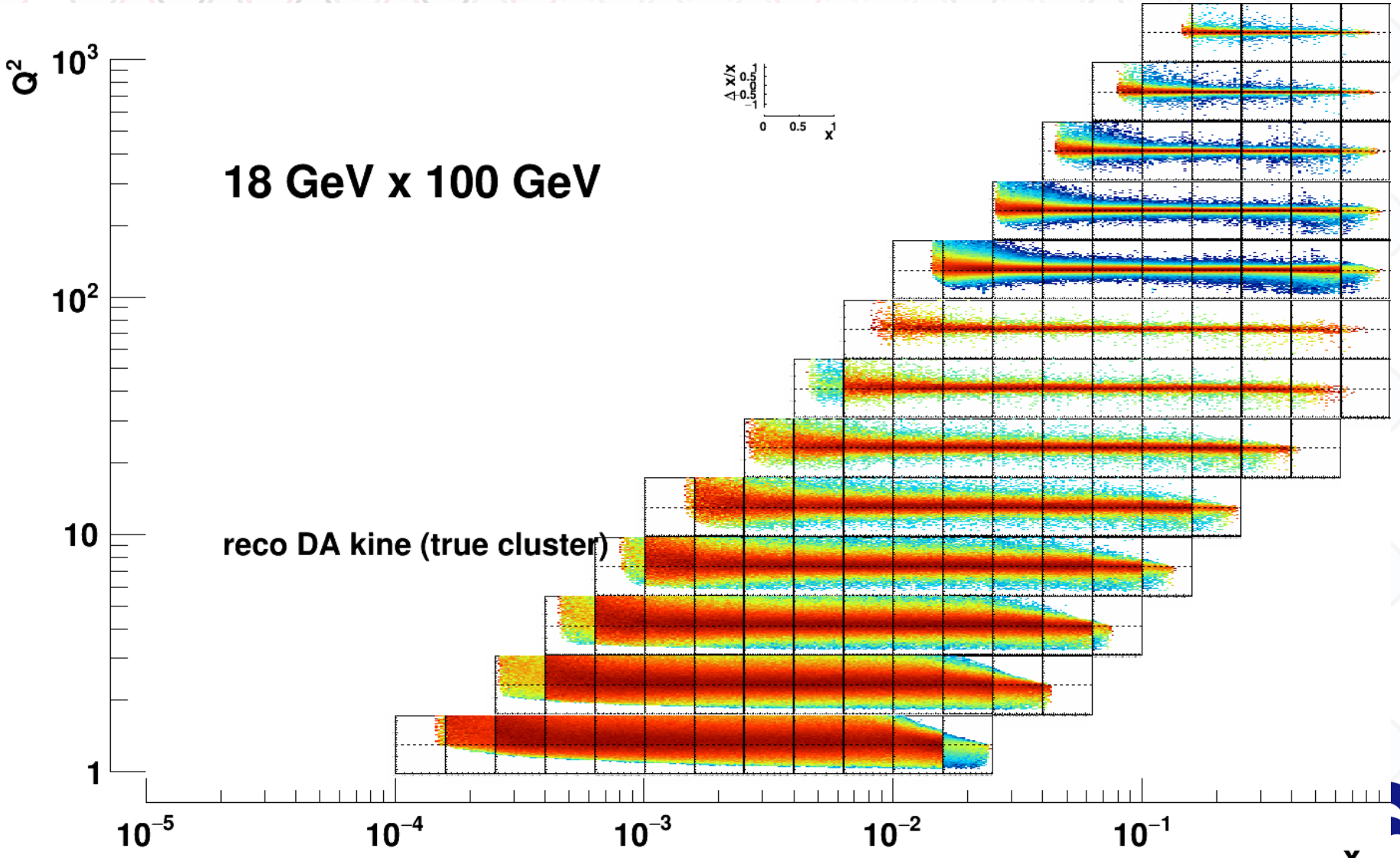
x resolution, lepton method



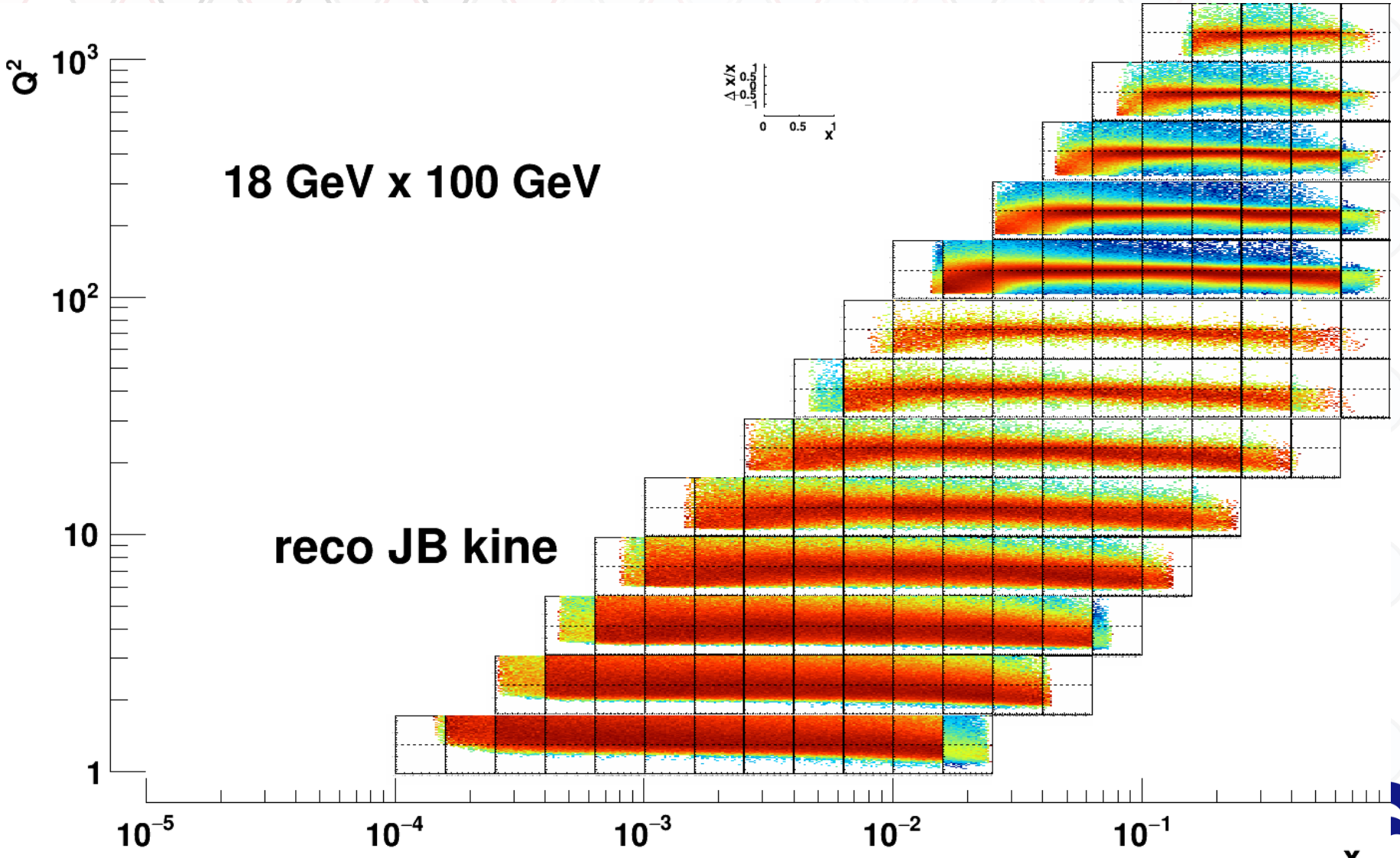
x resolution JB, reco tracks, true clusters



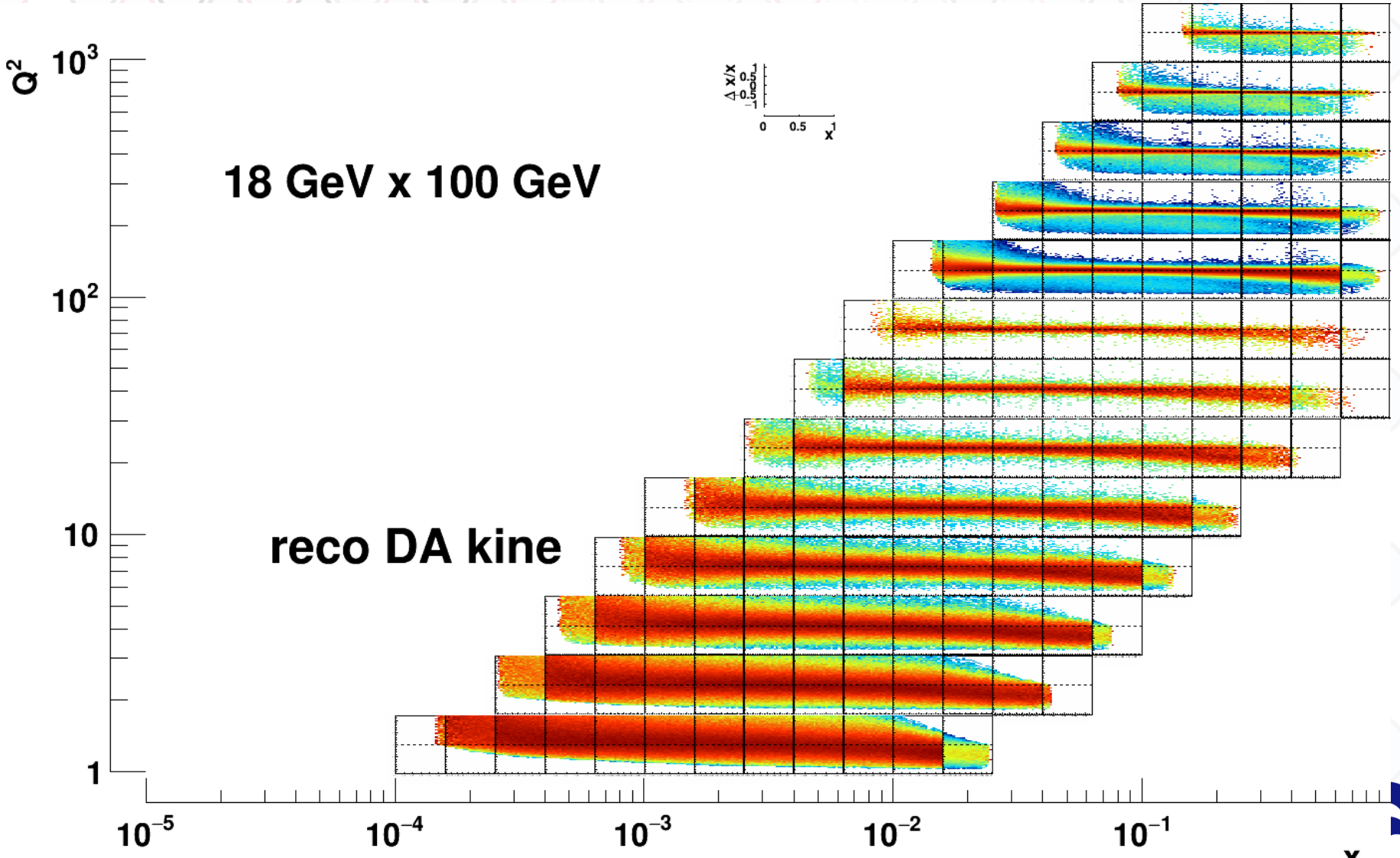
x resolution DA, true clusters



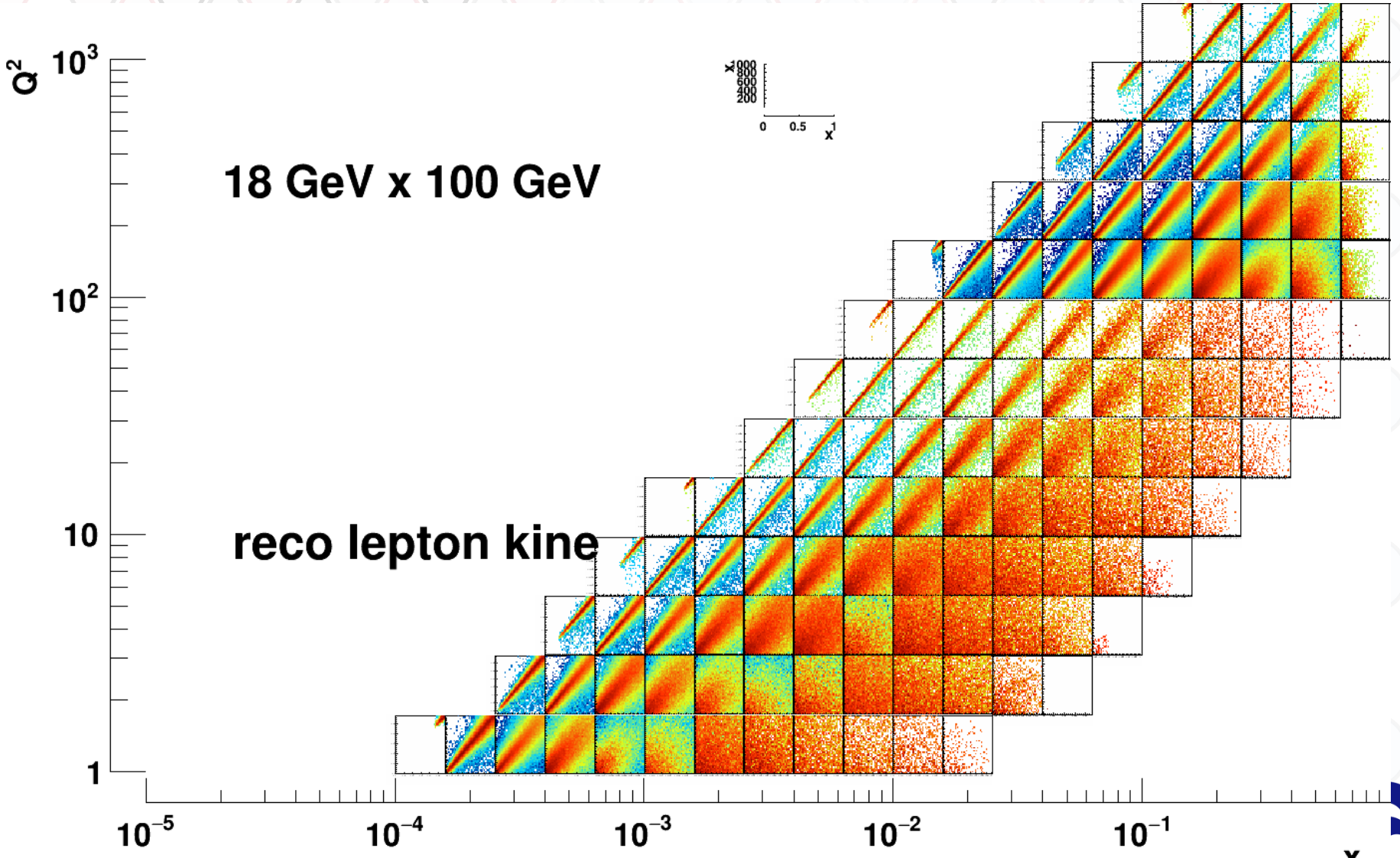
Reco JB, clusters via Barcode



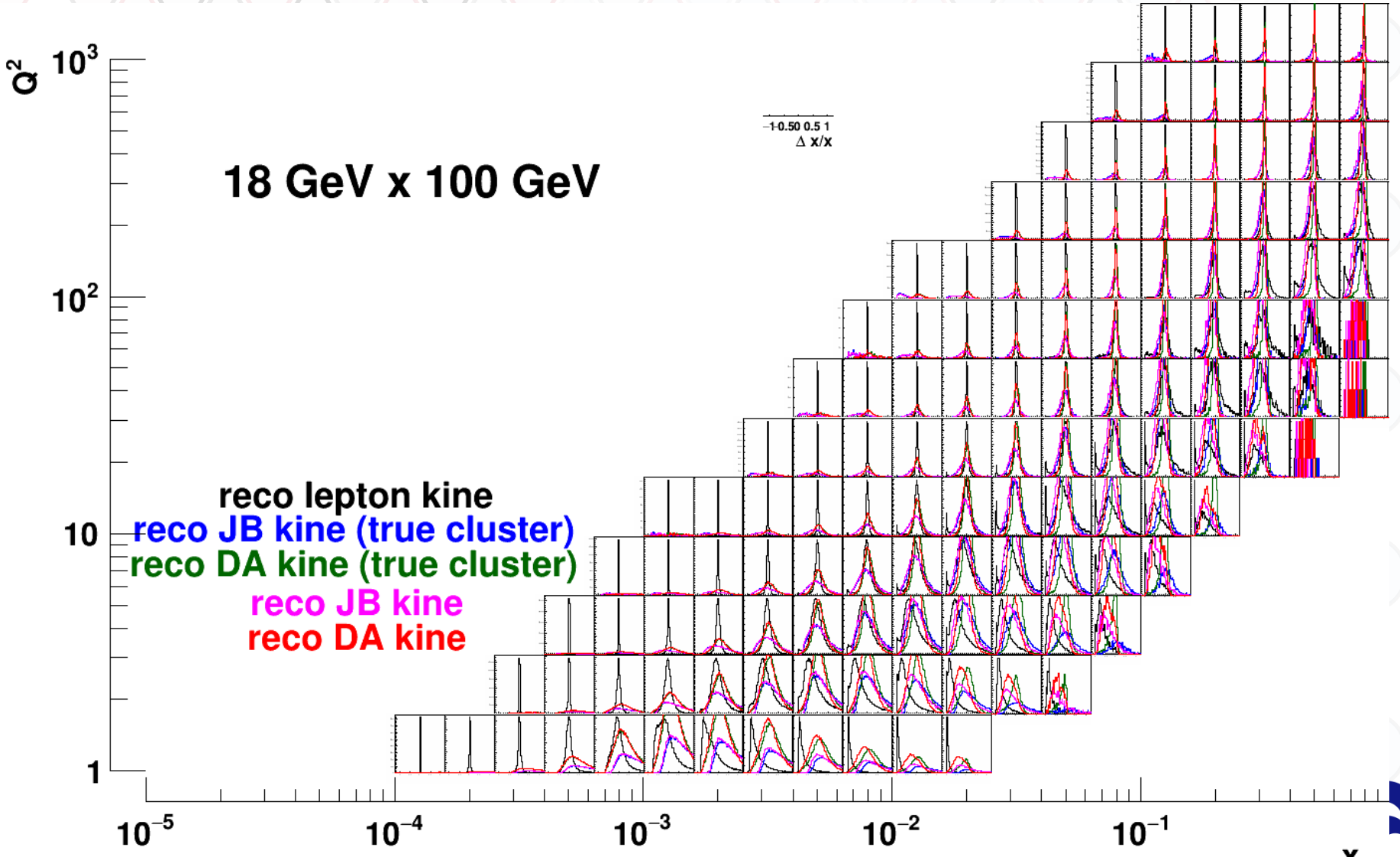
Reco DA, clusters via Barcode



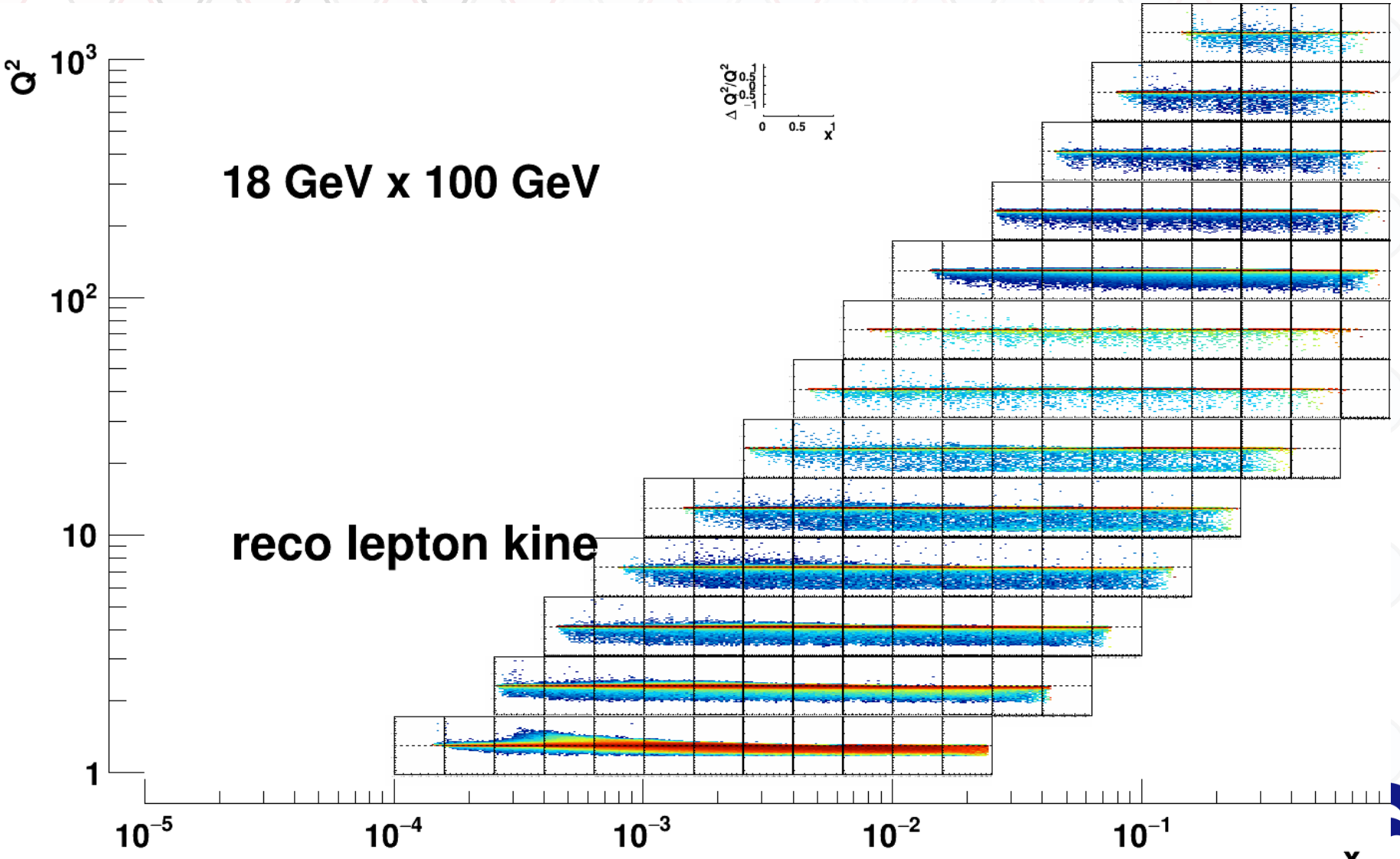
Distributions x true vs reco lepton reco



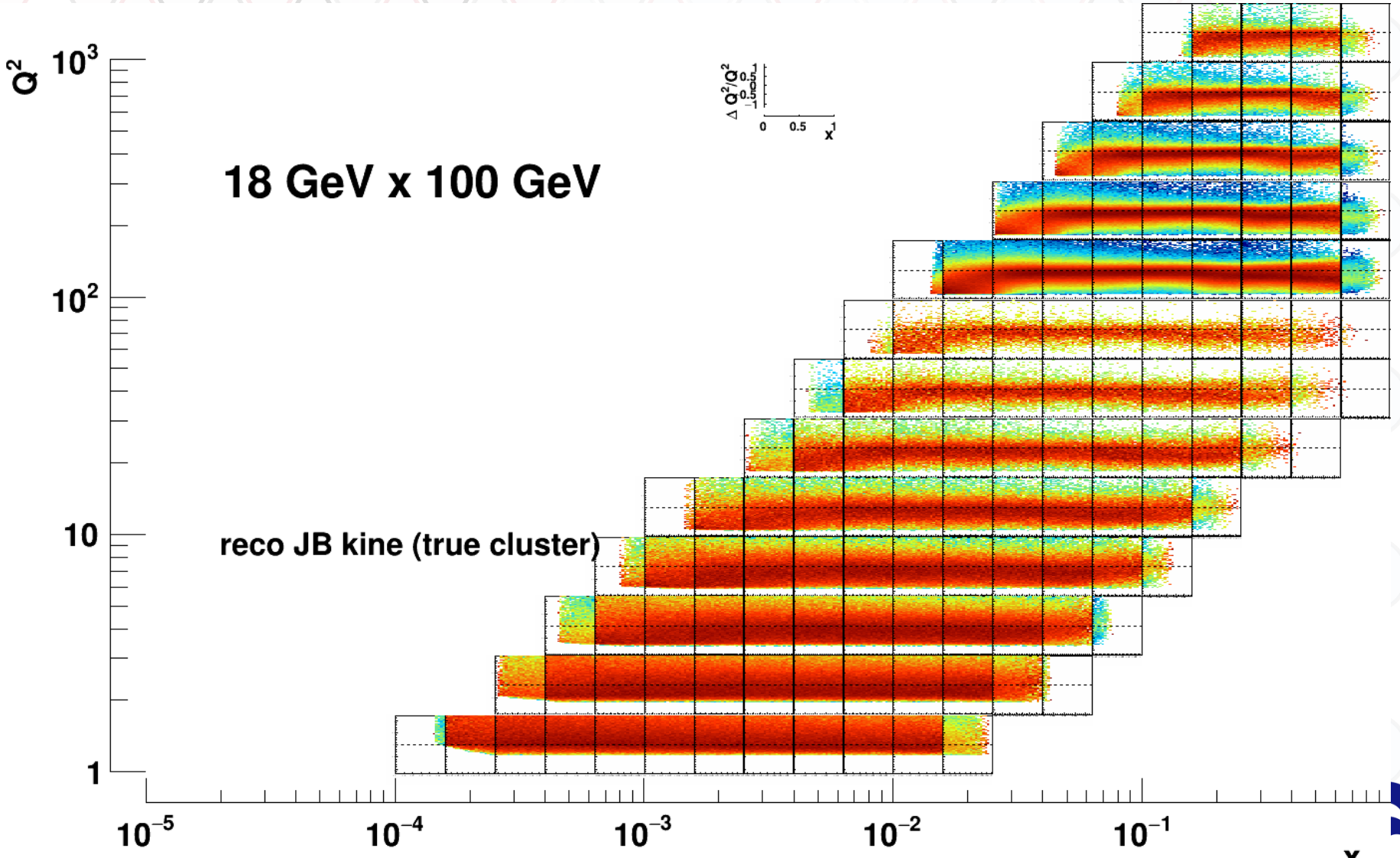
All reco x distributions



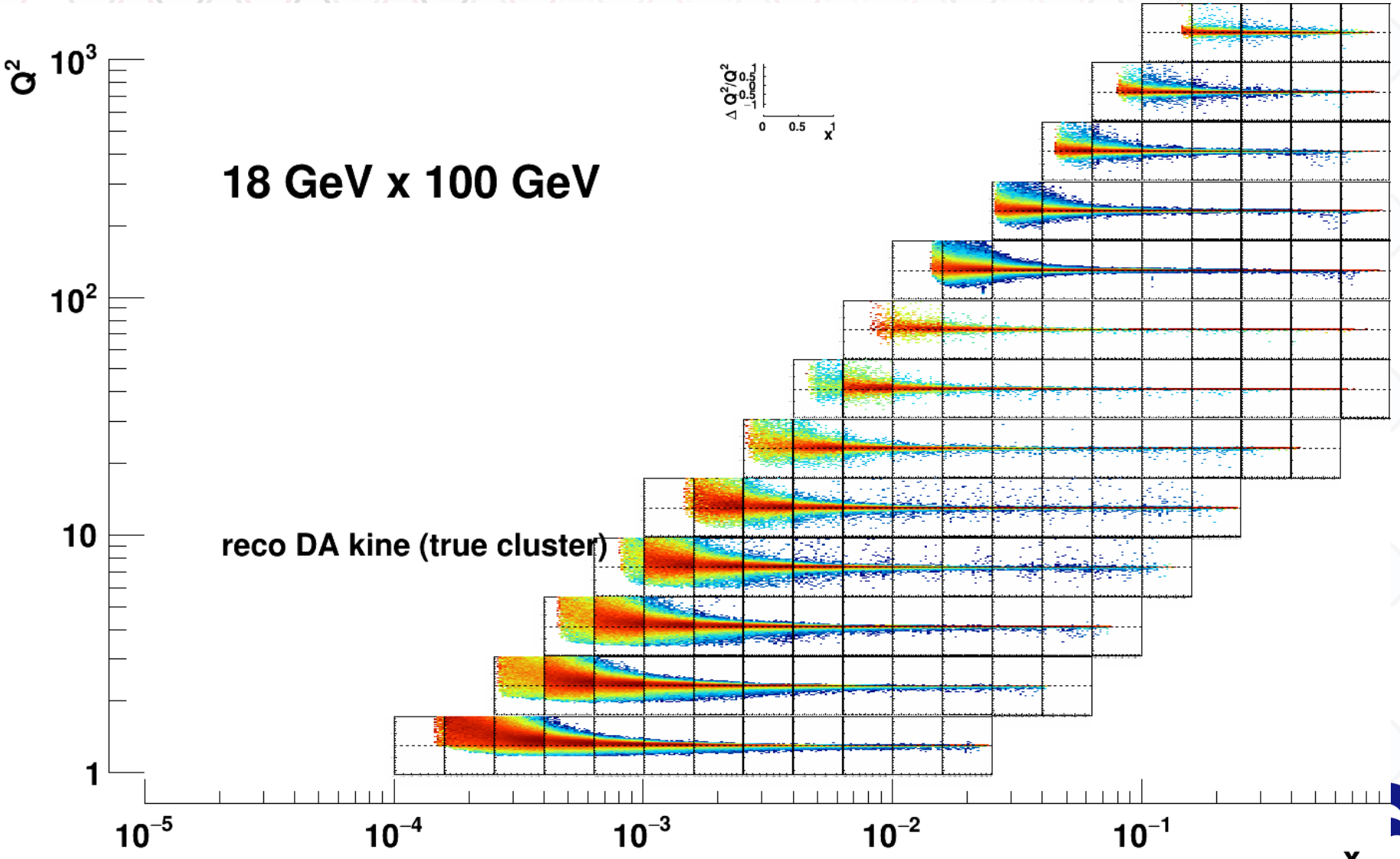
Q2 res lepton method



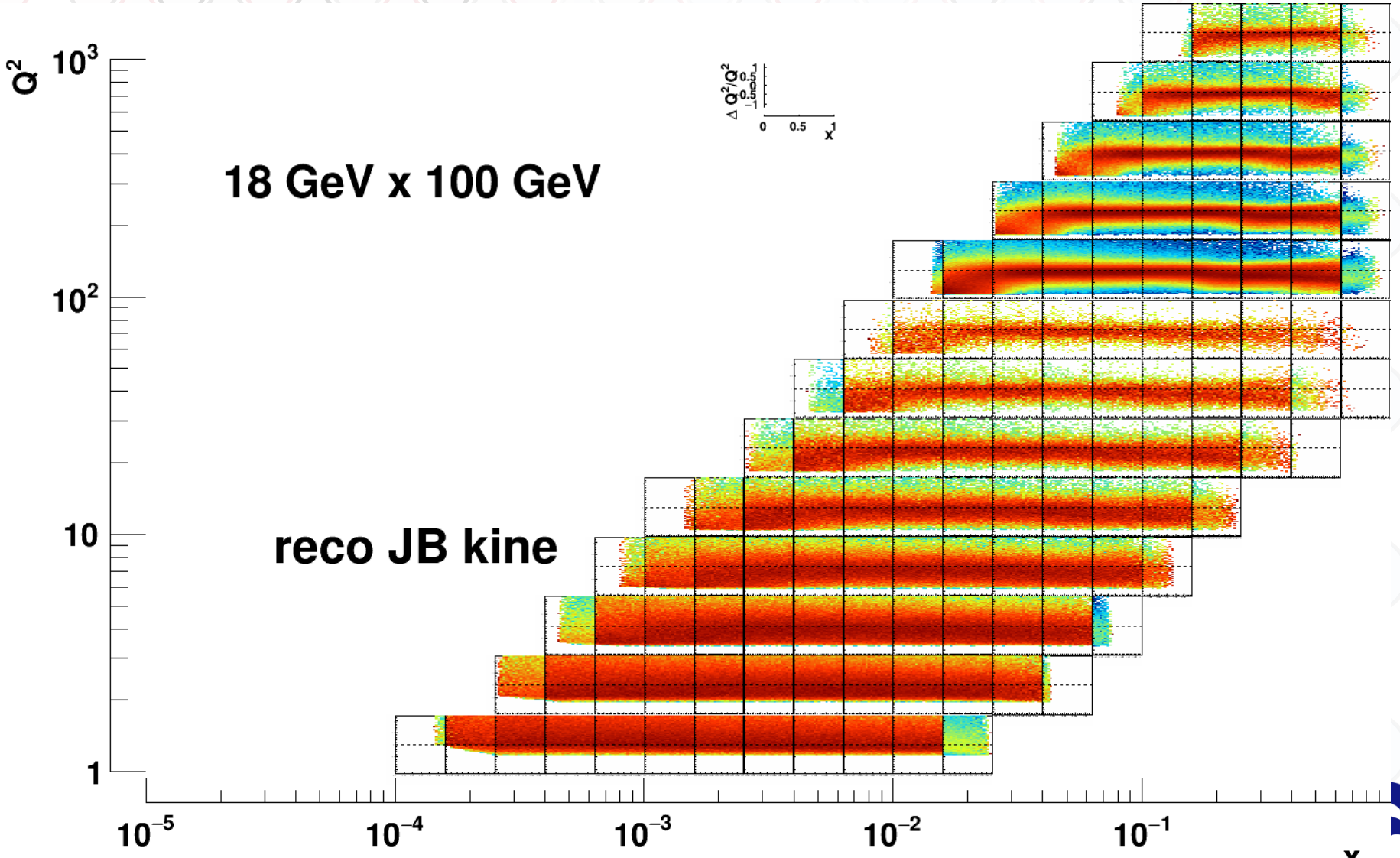
Q2 resolutions JB true cluster (use PDG)



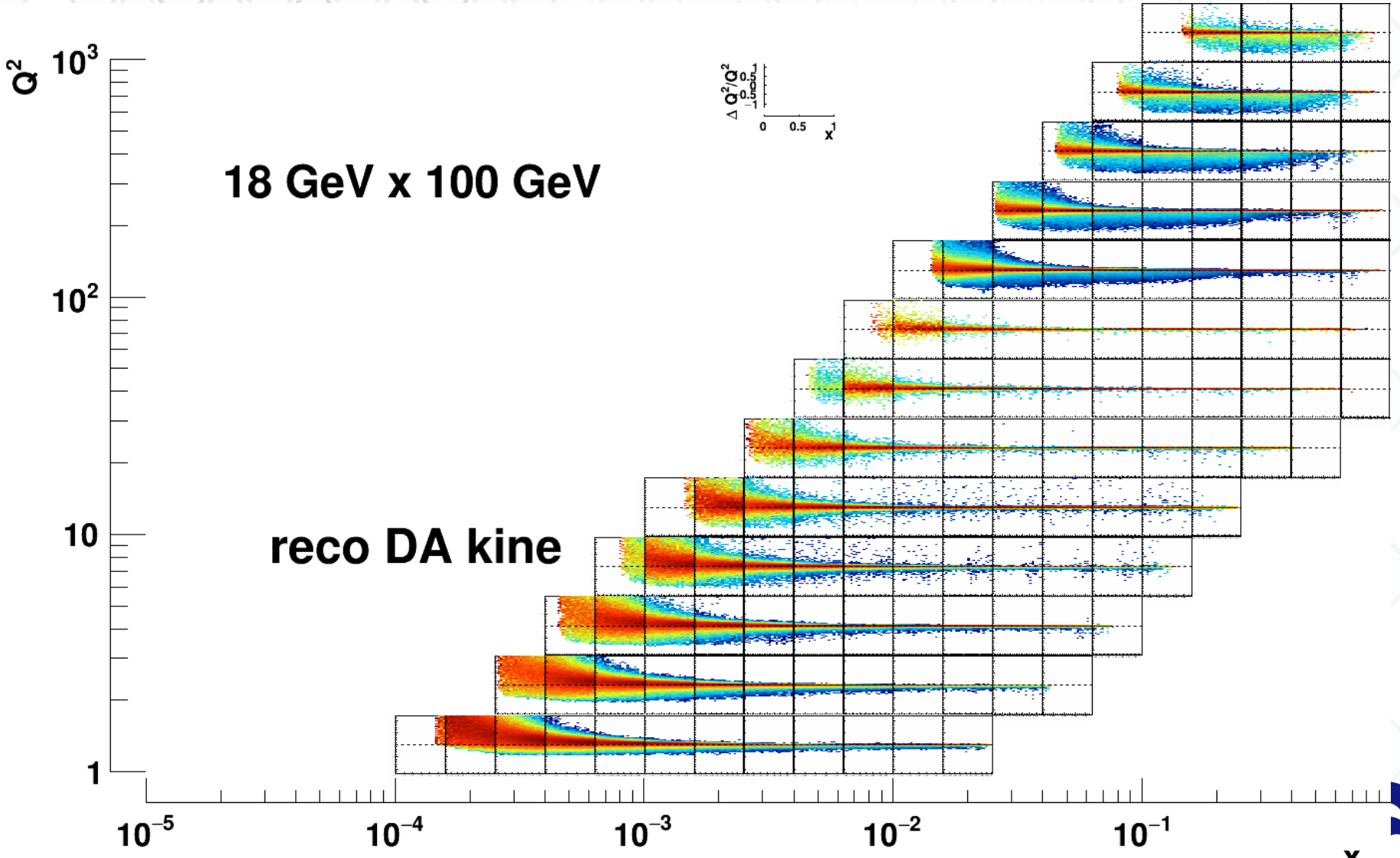
Q2 resolutions DA true cluster (use PDG)



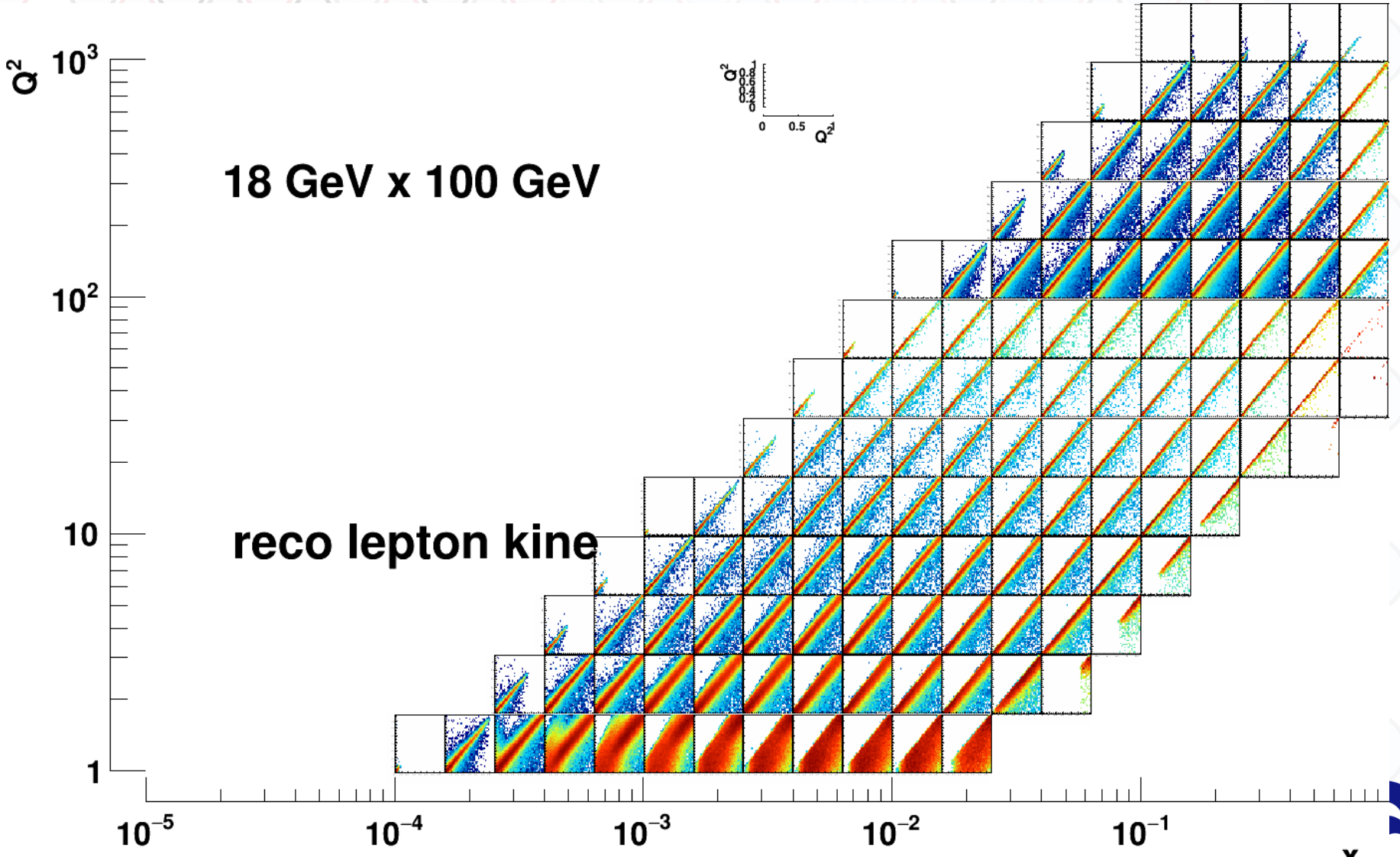
Q2 resolutions JB



Q2 resolutions DA



Q2 true vs reco distributions



All Q2 resolution widths and means