Extraction of Charged Kaon Asymmetries from E1-F Data

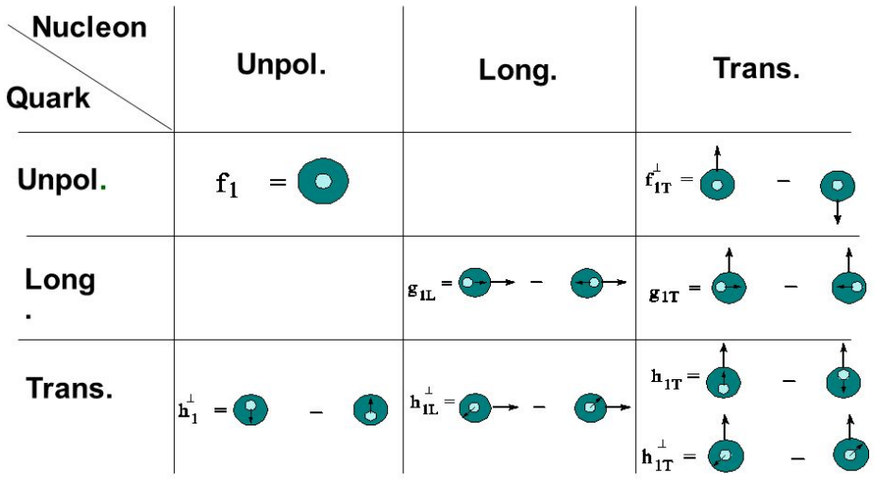
David Riser in collaboration with
Kyungseon Joo, Nick Markov

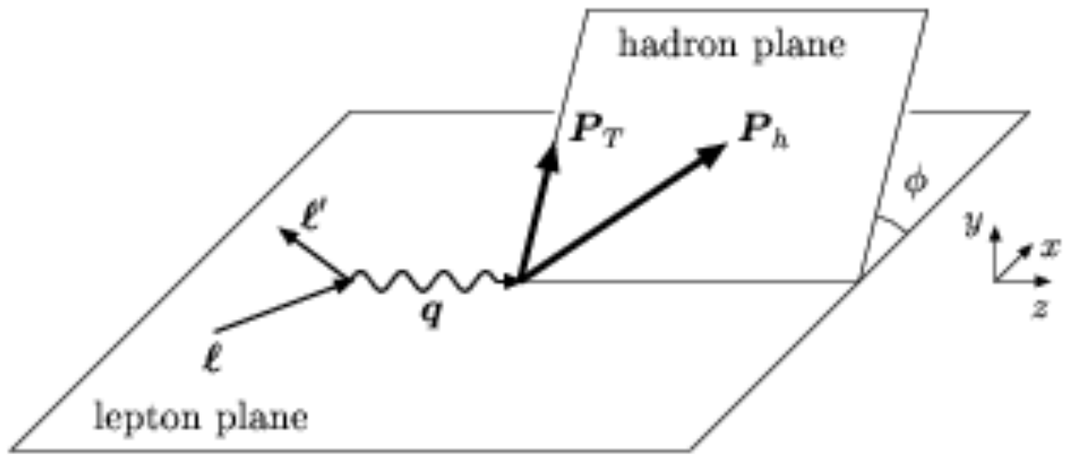
David Riser
University of Connecticut

- Introduction and Motivation
- Data Analysis
- Results
- Conclusion and Future

Currently there is big interest in 3-D nucleon structure in the form of **GPDs** and **TMDs**

"Leading-Twist" *TMD* Quark Distributions





The **SIDIS** cross section can be expressed in terms of model independent structure functions

$$\frac{d\sigma}{dx_B\, dQ^2\, dz\, d\phi_h\, dp_{h\perp}^2} = K(x,y,Q^2)\Big\{F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\,\varepsilon(1+\varepsilon)}\cos\phi_h F_{UU}^{\cos\phi_h} + \varepsilon\cos(2\phi_h)F_{UU}^{\cos 2\phi_h} + \lambda_e\sqrt{2\,\varepsilon(1-\varepsilon)}\sin\phi_h F_{LU}^{\sin\phi_h}\Big\}$$

beam spin asymmetry gives access to $A_{LU}^{\sin\phi} = \dfrac{F_{LU}^{\sin\phi}}{F_{UU,T} + \varepsilon F_{UU,L}}$

David Riser
University of Connecticut

TMD and Fragmentation Functions

$$C[\omega f D] = x \sum_a e_a^2 \int d^2\vec{p}_\perp d^2\vec{k}_\perp \delta^{(2)}\left(\vec{p}_\perp - \vec{k}_\perp - \vec{P}_{h\perp}/z\right) \omega(\vec{p}_\perp, \vec{k}_\perp) f^a(x, p_\perp^2) D^a(z, k_\perp^2)$$

$$F_{LU}^{\sin\phi} = \frac{2M}{Q}\mathcal{C}\left(-\frac{\hat{\mathbf{h}}\cdot\mathbf{k_T}}{M_h}\left(xeH_1^\perp + \frac{M_h}{M} f_1 \frac{\tilde{G}^\perp}{z}\right) + \frac{\hat{\mathbf{h}}\cdot\mathbf{p_T}}{M}\left(xg^\perp D_1 + \frac{M_h}{M} h_1^\perp \frac{\tilde{E}}{z}\right)\right)$$

David Riser
University of Connecticut

TMD and Fragmentation Functions

$$C[\omega f D] = x \sum_a e_a^2 \int d^2\vec{p}_\perp d^2\vec{k}_\perp \delta^{(2)}\left(\vec{p}_\perp - \vec{k}_\perp - \vec{P}_{h\perp}/z\right) \omega(\vec{p}_\perp, \vec{k}_\perp) f^a(x, p_\perp^2) D^a(z, k_\perp^2)$$

$$F_{LU}^{\sin\phi} = \frac{2M}{Q}\mathcal{C}\left(-\frac{\hat{\mathbf{h}}\cdot\mathbf{k_T}}{M_h}\left(xeH_1^\perp + \frac{M_h}{M} f_1 \frac{\tilde{G}^\perp}{z}\right) + \frac{\hat{\mathbf{h}}\cdot\mathbf{p_T}}{M}\left(xg^\perp D_1 + \frac{M_h}{M} h_1^\perp \frac{\tilde{E}}{z}\right)\right)$$

twist-3 pdf

Collins FF

unpolarized dist. function

twist-3 FF

twist-3 t-odd dist. funcion

Boer-Mulders

twist-3 FF

Structure function has a **twist-3** piece in every term

David Riser
University of Connecticut

Observing **kaons** in the final state gives access to the non-perturbative sea of quark anti-quark pairs that arise from gluon interaction in the nucleon.

Several experiments* involving kaons are approved for CLAS12:

- E12-09-007: Studies of partonic distributions using semi-inclusive production of kaons
- E12-09-008: Studies of the Boer-Mulders Asymmetry in Kaon electroproduction with Hydrogen and Deuterium Targets
- E12-09-009: Studies of Spin-Orbit Correlations in Kaon Electroproduction in DIS with polarized hydrogen and deuterium targets

*This list is not exhaustive, others can be found at: https://misportal.jlab.org/mis/physics/experiments/

David Riser
University of Connecticut

Data Analysis

- Event Selection
- Electron, Kaon ID
- Kinematic Cuts
- Binned fits

David Riser
University of Connecticut

Select from data:

$$e\ p\ \rightarrow e'\ K^{\pm} X$$

Subject to the constraints:

$$Q^2 > 1.00\ GeV^2/c^2$$

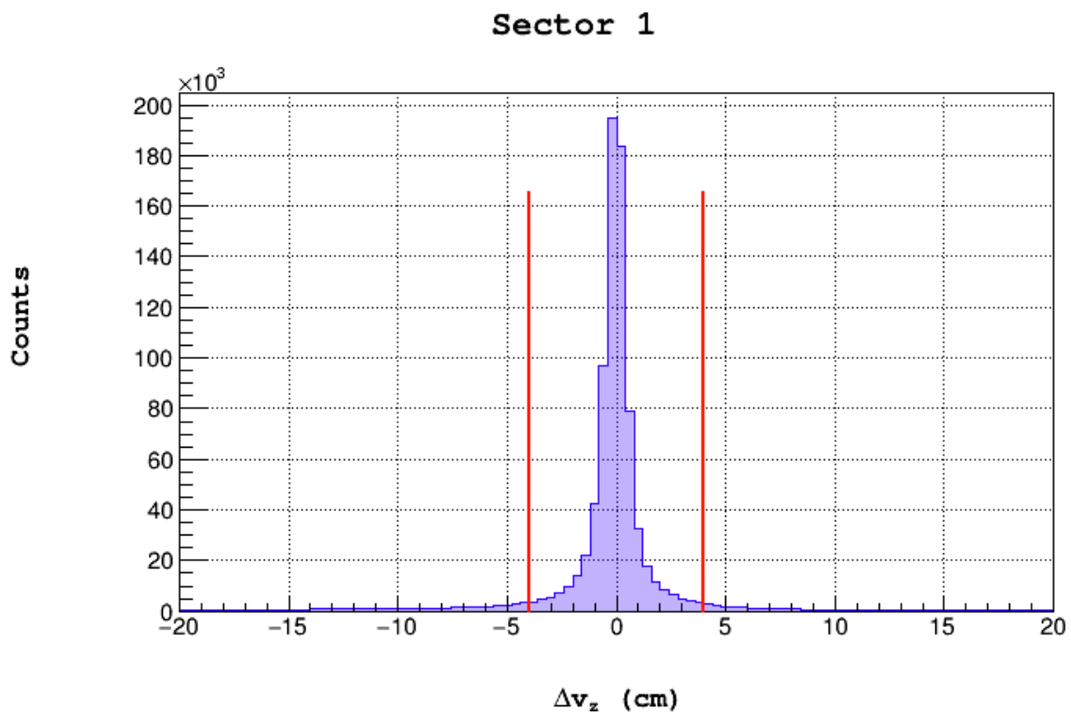
$$W > 2.00\ GeV/c^2$$

$$0.3 < z_h < 0.7$$

$$M_X > 1.27\ GeV/c^2$$

kaon identification done by applying cleaning cuts first

- vertex difference with electron
- drift chamber region 1 fiducial cut for positives
- inner calorimeter deposition

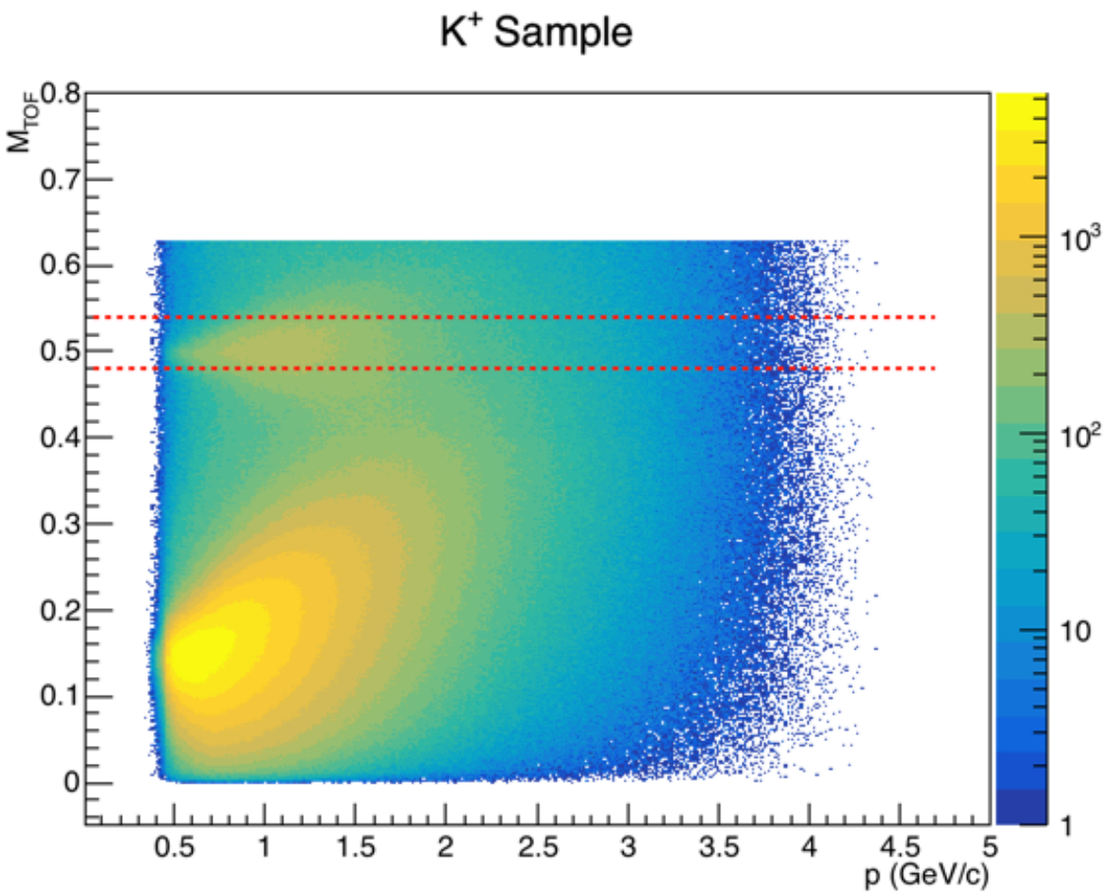


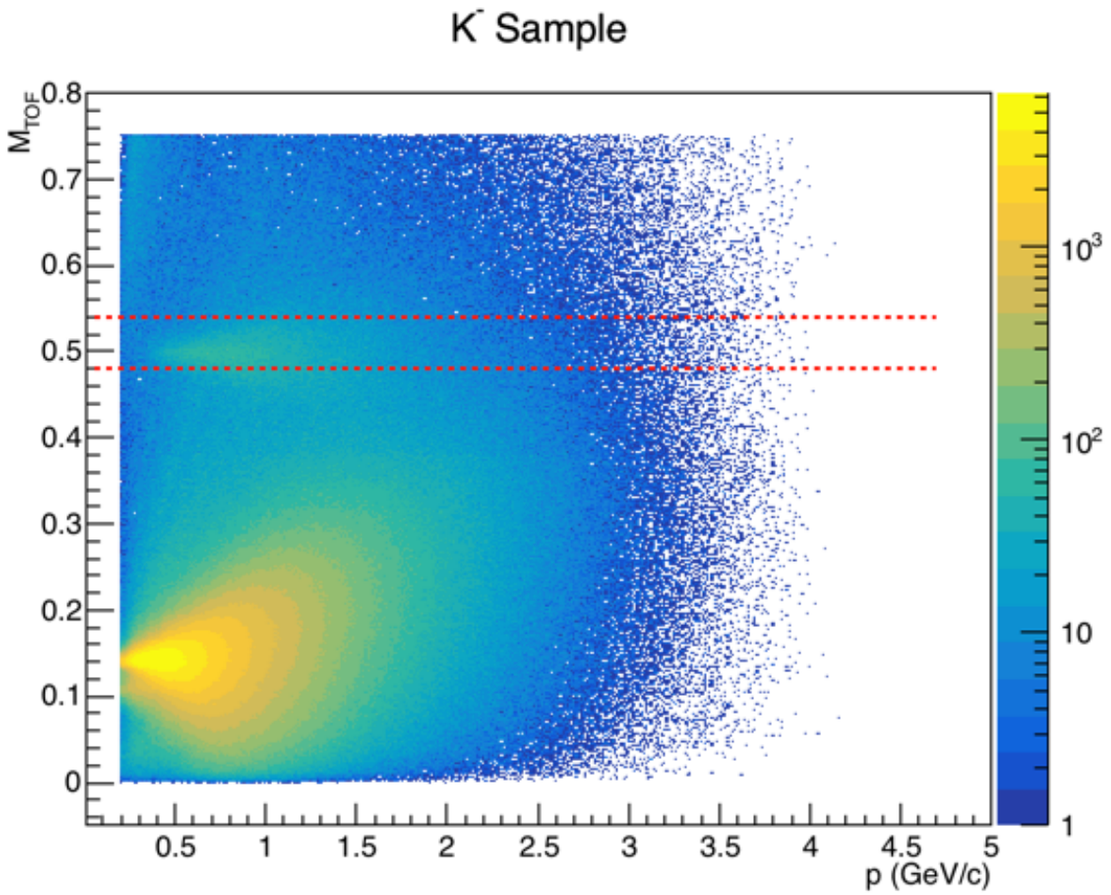
Select from data:

$$e\ p\ \rightarrow e'\ K^{\pm} X$$

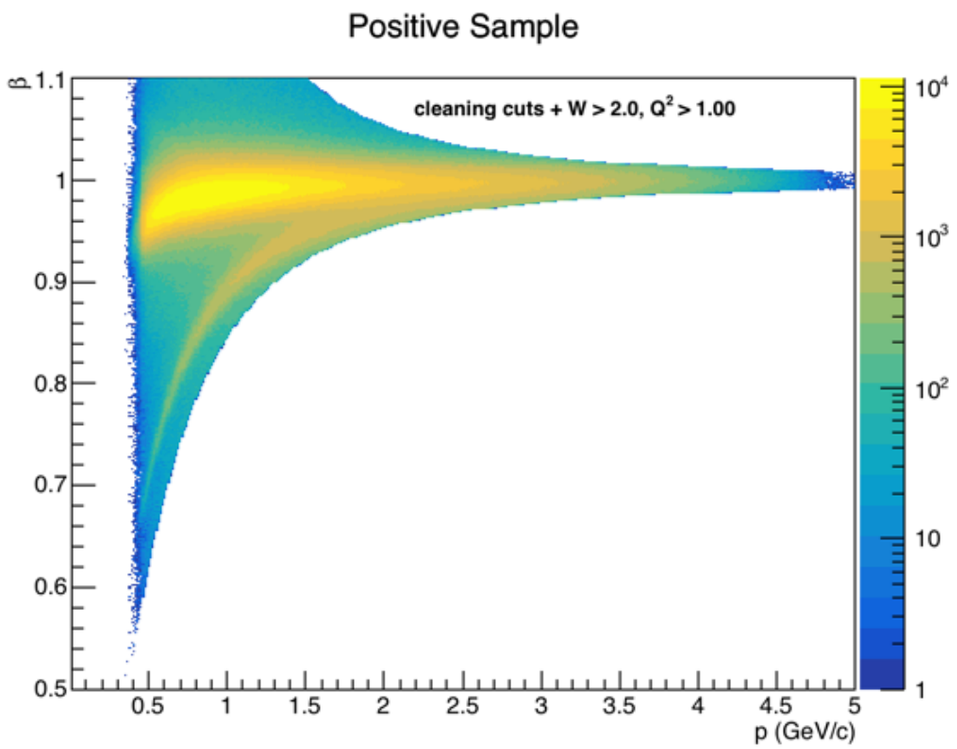
final selection done with timing cut on time of flight mass

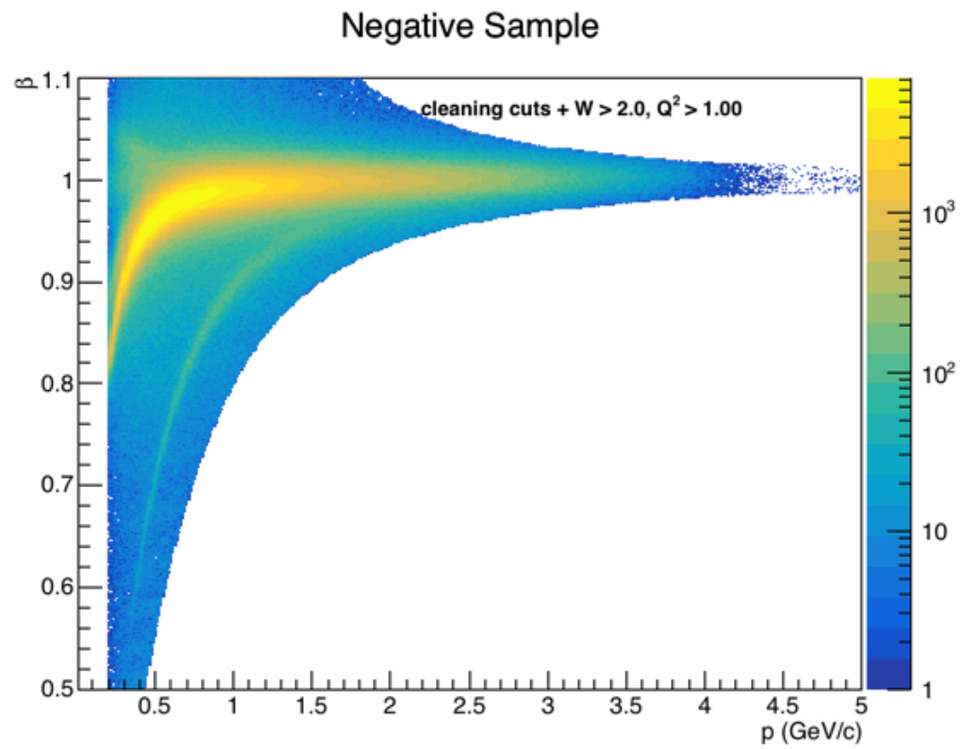
$$M^2_{TOF} = p^2\ \frac{1-\beta^2}{\beta^2}$$

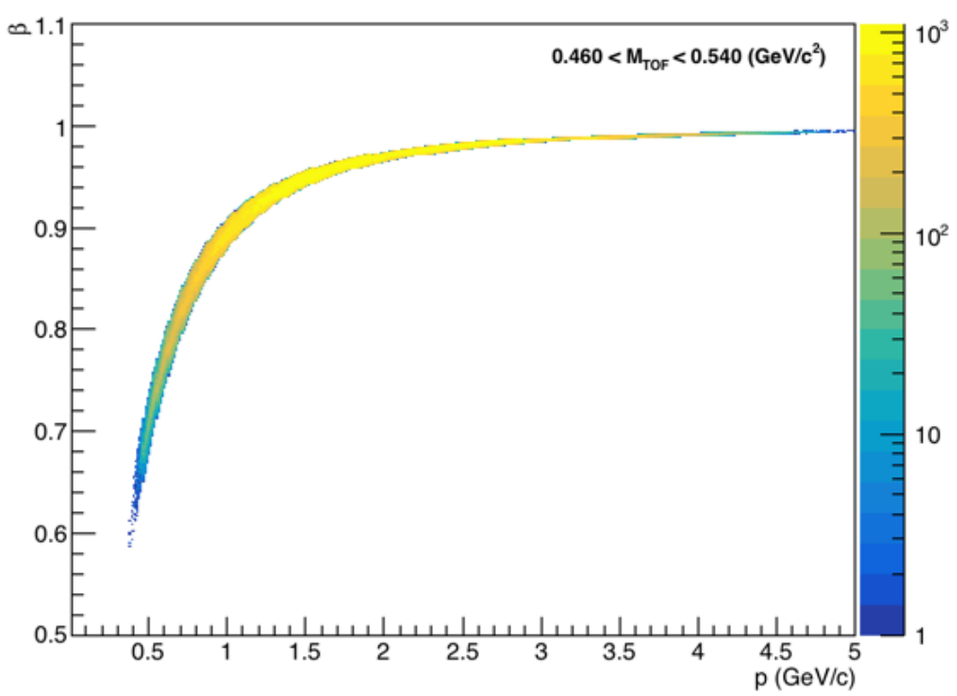


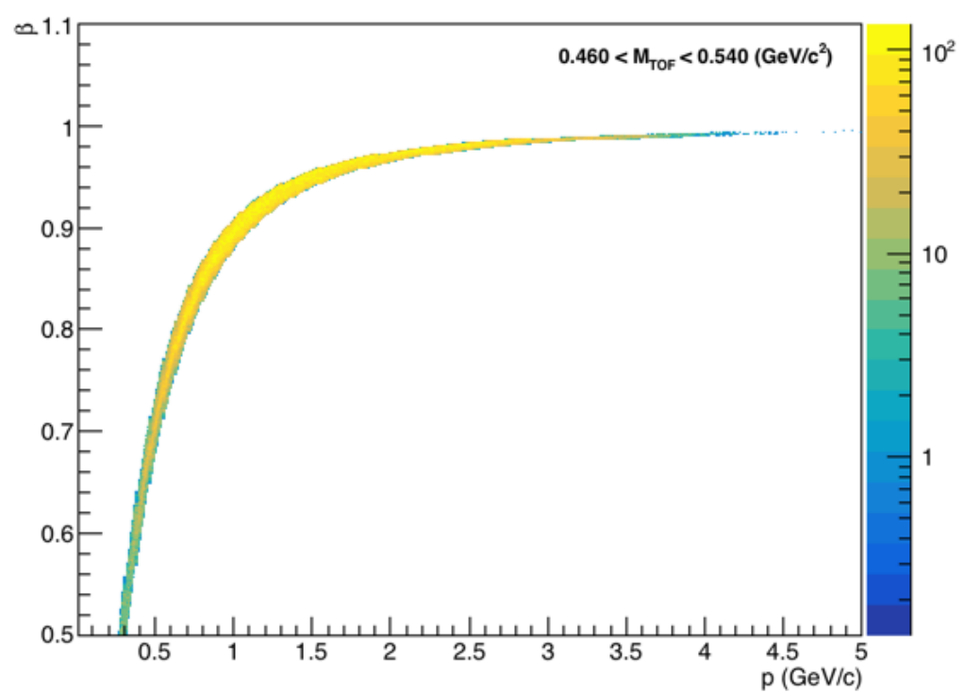


David Riser
University of Connecticut

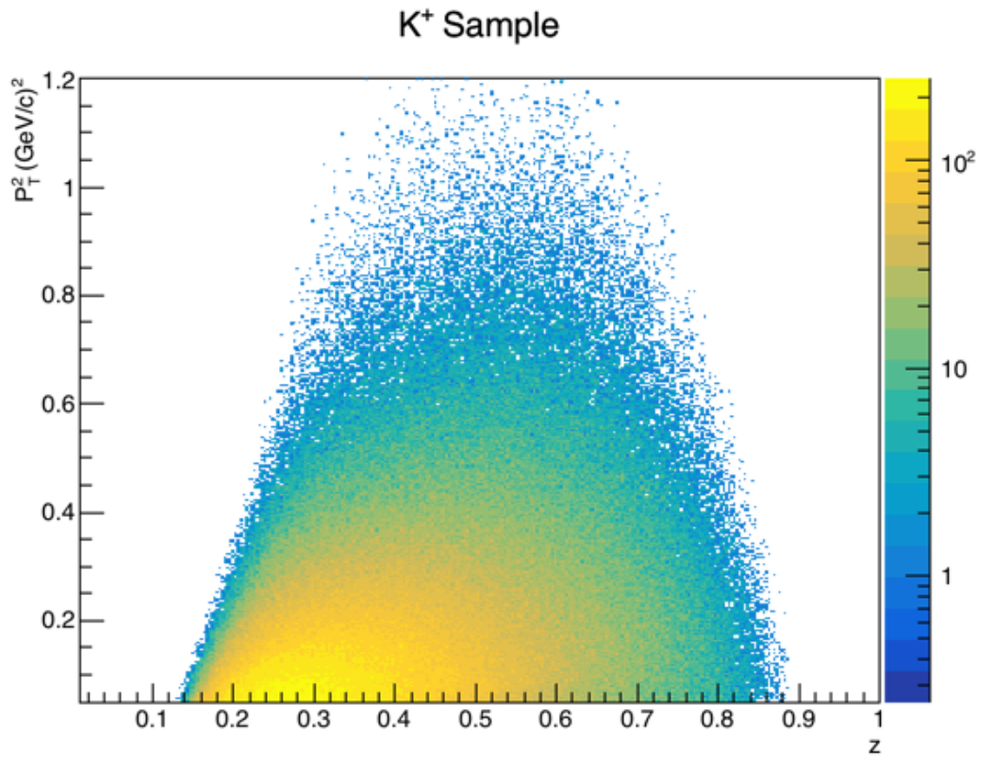


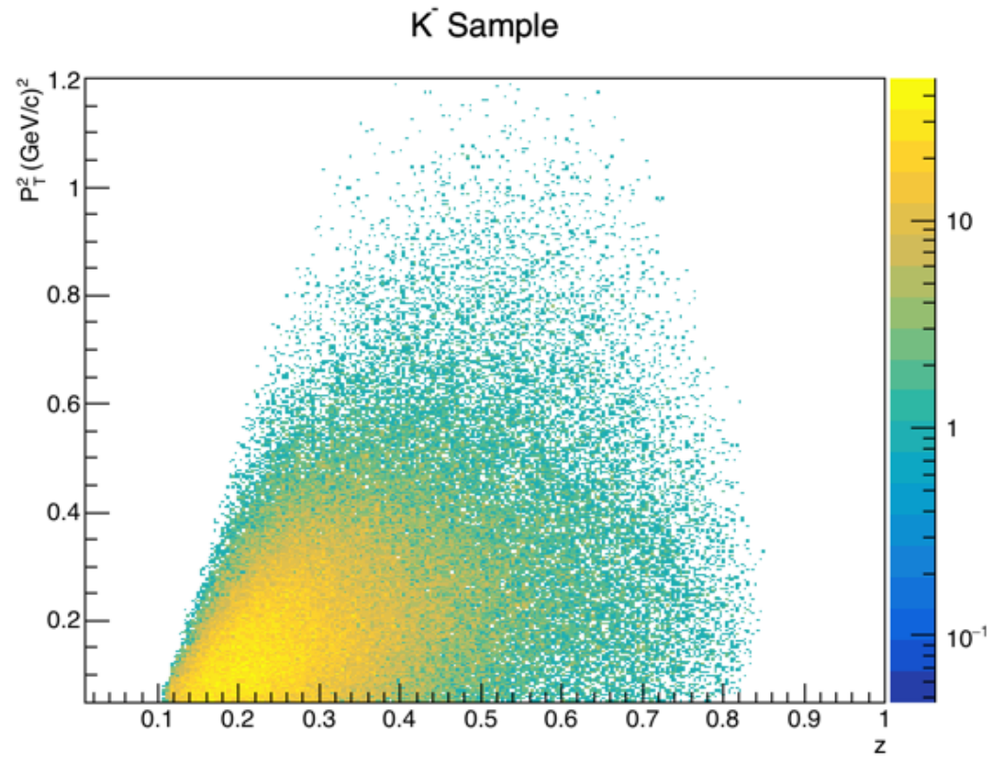


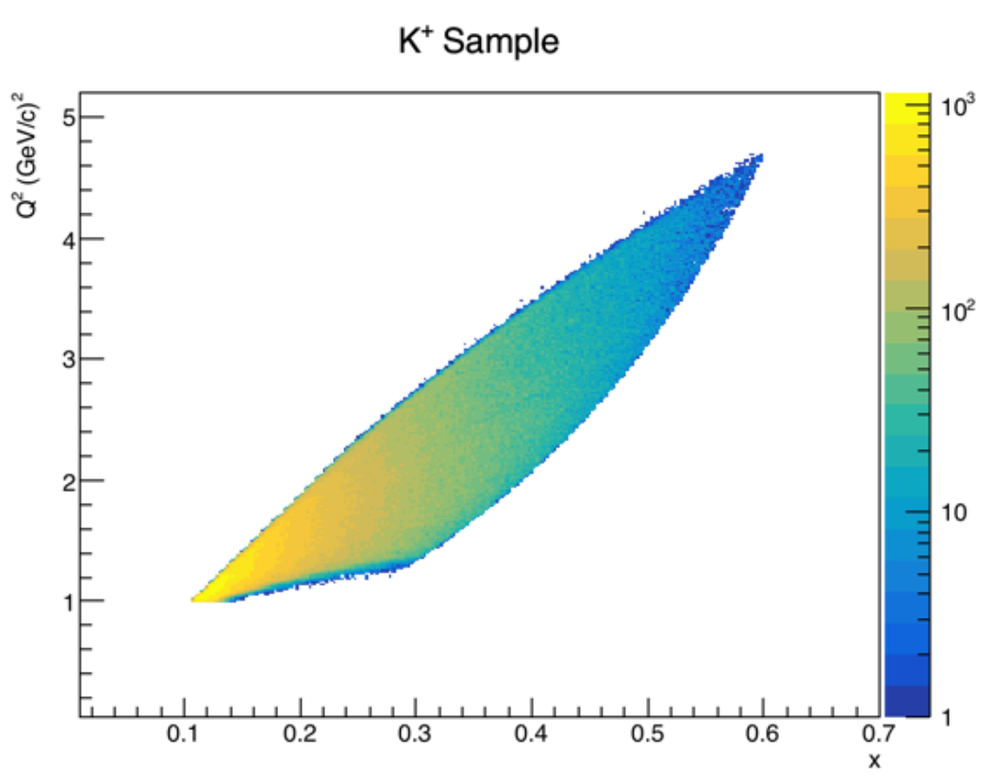


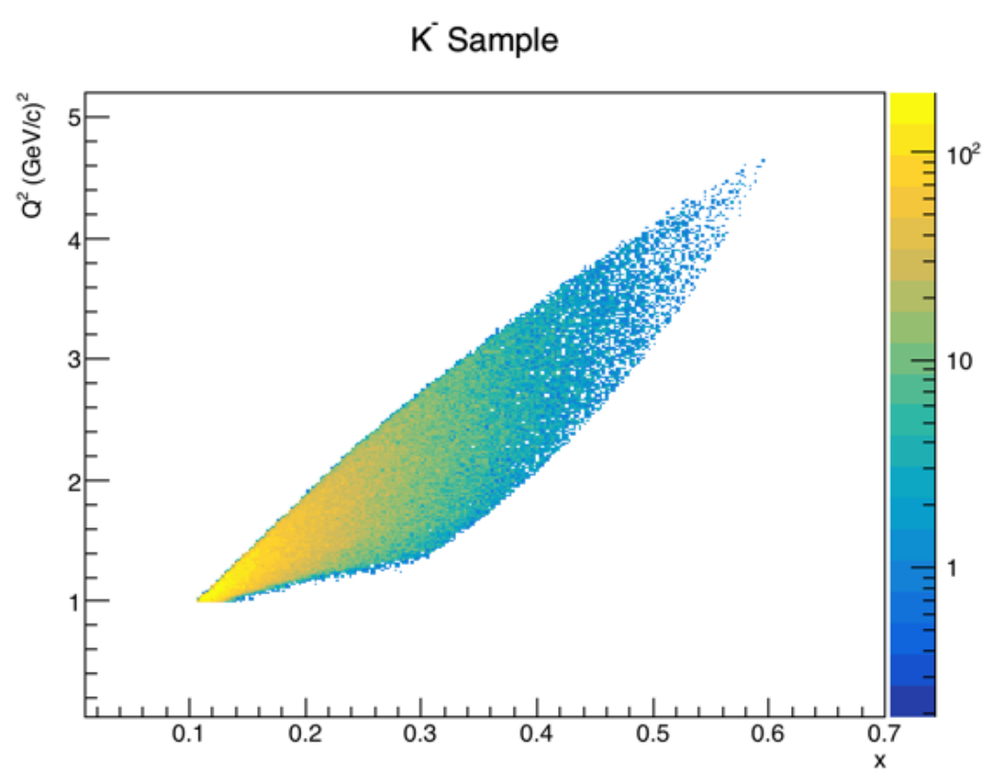


David Riser
University of Connecticut



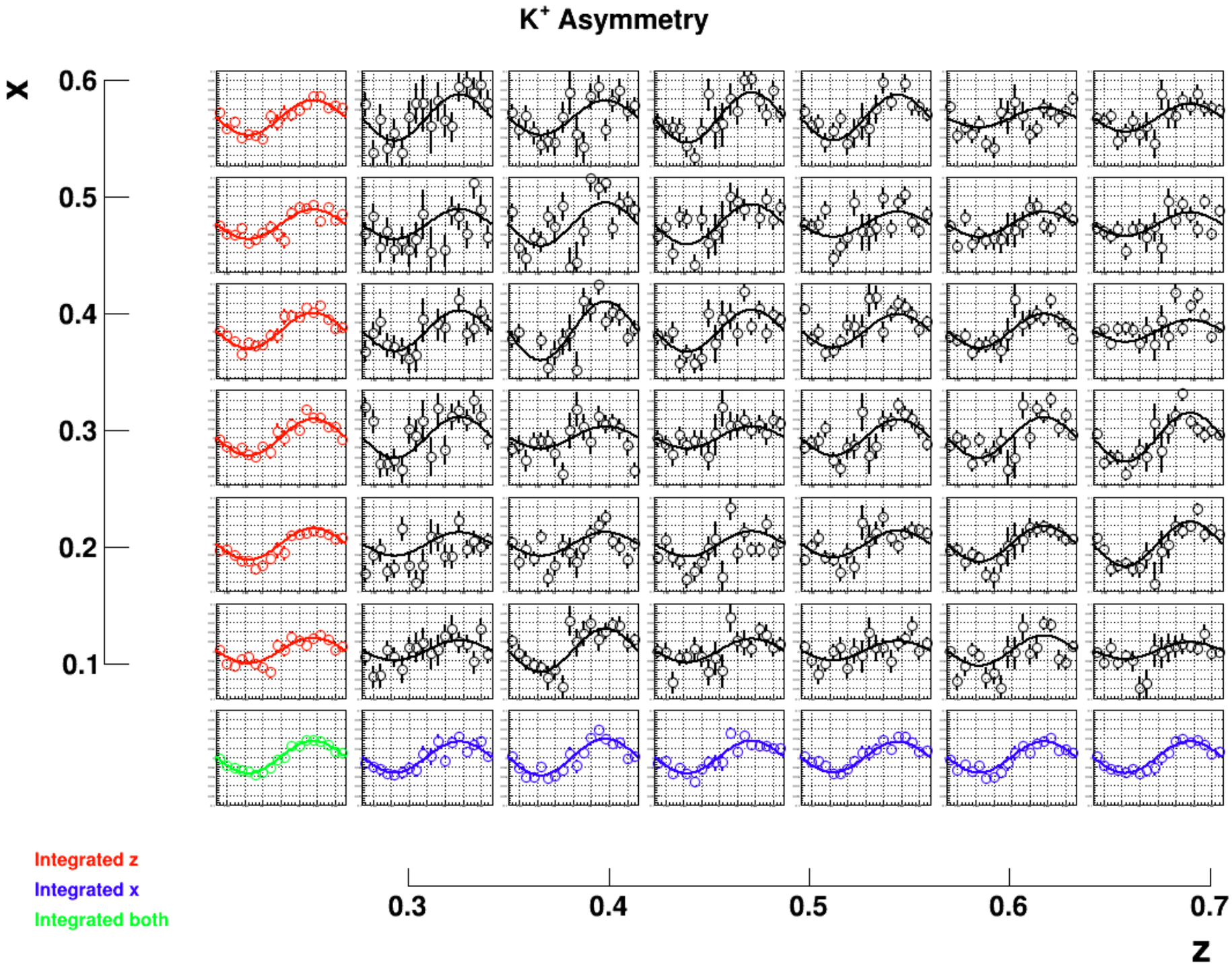


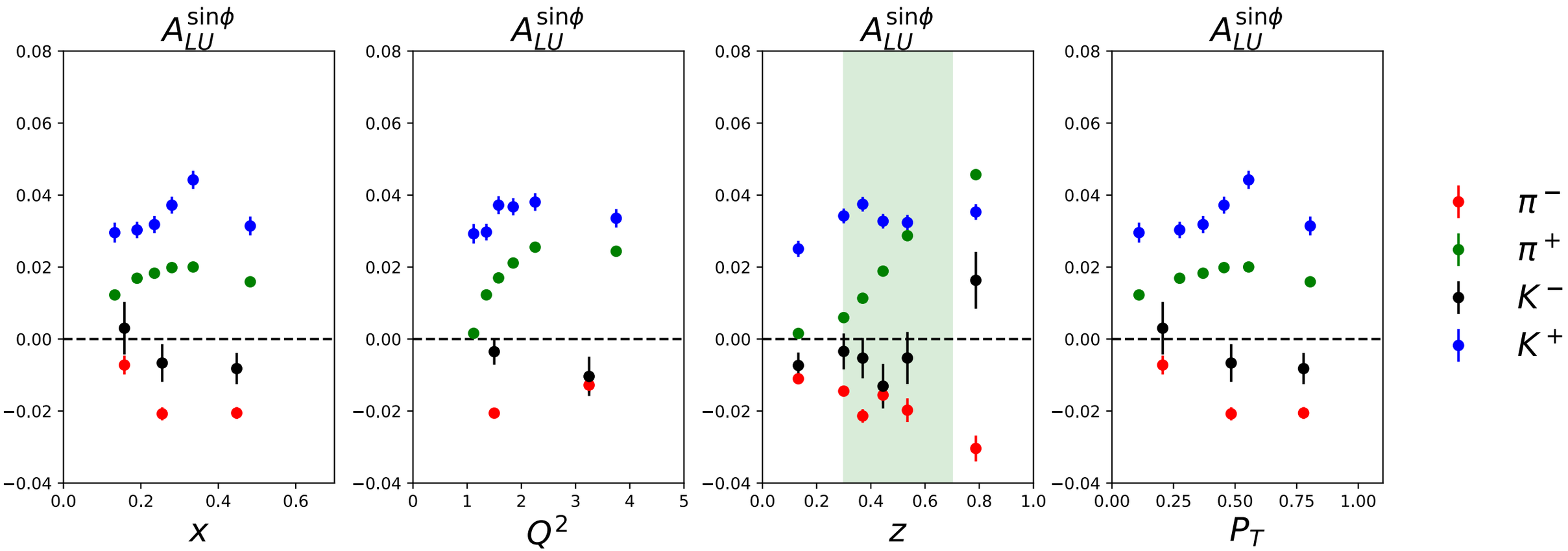




David Riser
University of Connecticut

observed asymmetry for positive **kaon** with same sign as positive pion





David Riser
University of Connecticut

Summary

- We identified charged kaons in a reasonable range of momentum
- Beam spin asymmetries were extracted for integrated distributions of x, q2, z, pt

Future Work

- Work carefully with negative kaons
- Study pion contamination and systematics

Thanks to: Kyungseon Joo, Harut Avakian, Nick Markov,
Nobuo Sato, Brandon Clary, Kemal Tezgin

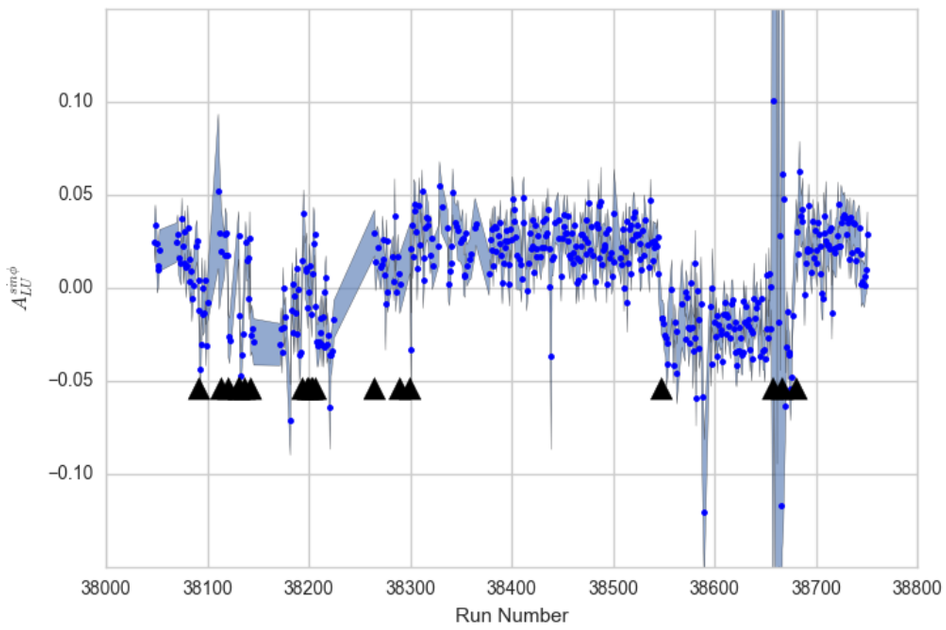
David Riser
University of Connecticut

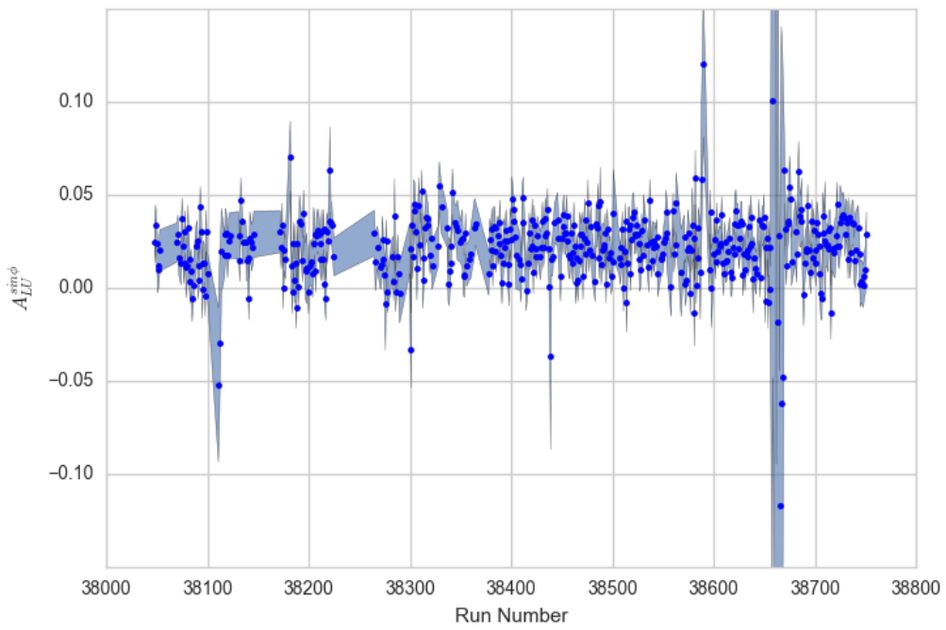
Extra Slides

Measurement of the beam spin asymmetry is done experimentally by recording events with different electron helicity states and counting the ratio below. Helicity flipping occurs at high enough frequency that acceptance effects are expected to cancel.

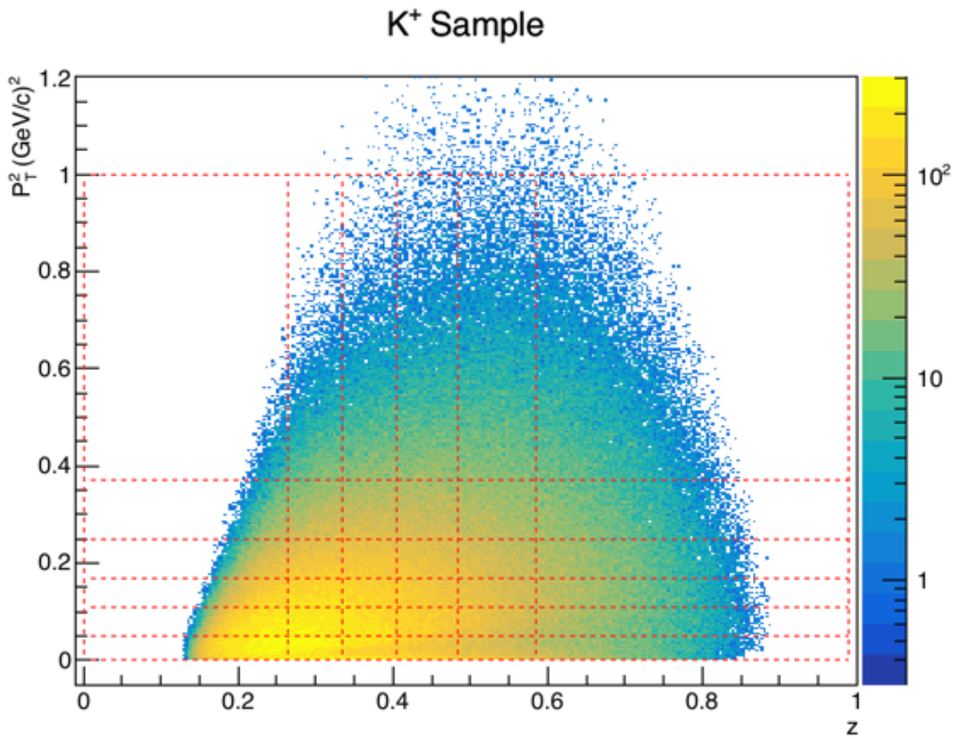
$$A_{LU}^{\sin\phi} = \frac{1}{P_e}\frac{N^+ - N^-}{N^+ + N^-}$$

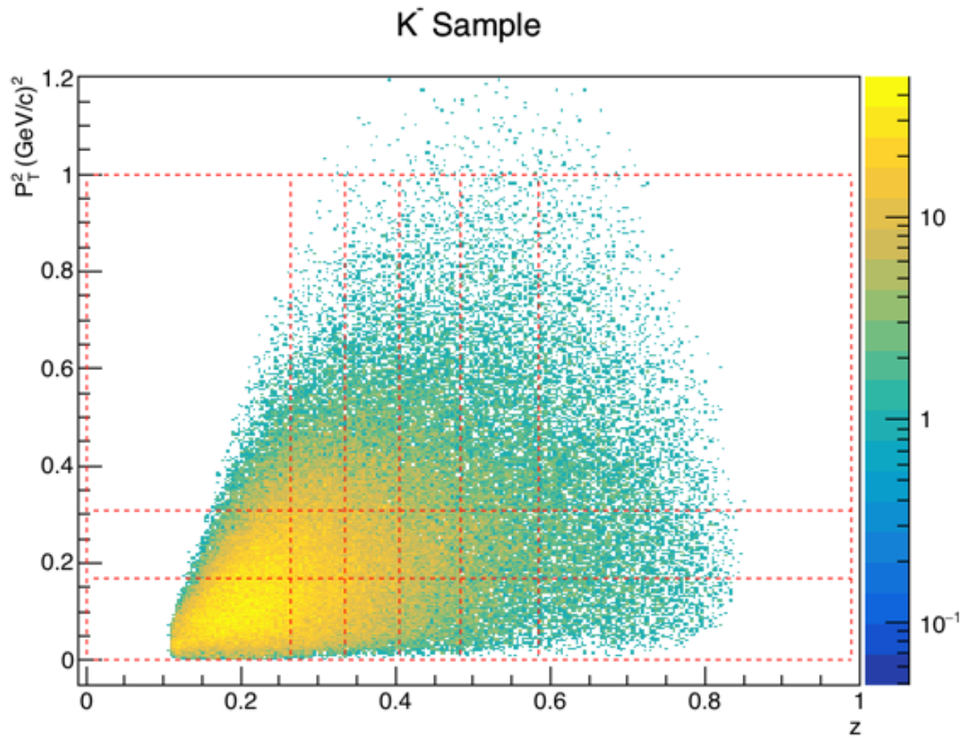
The **average beam polarization** was determined to be (75 +/- 3) %, and the wave-plate position was determined as a function of run number by analyzing the sine phi moment for positive pions.

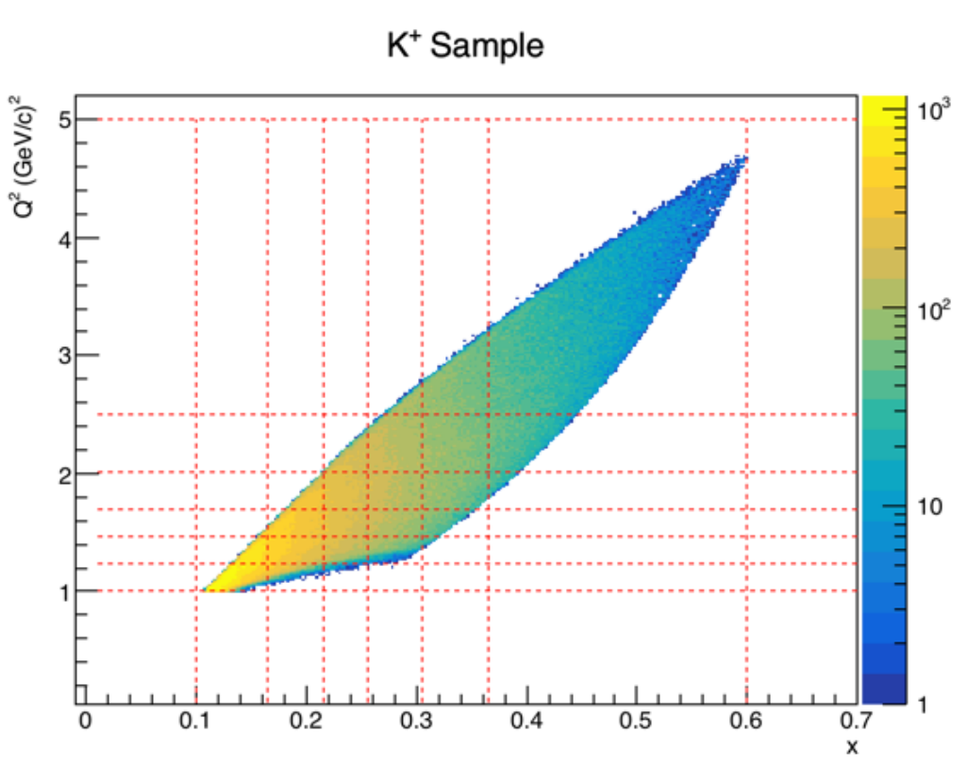


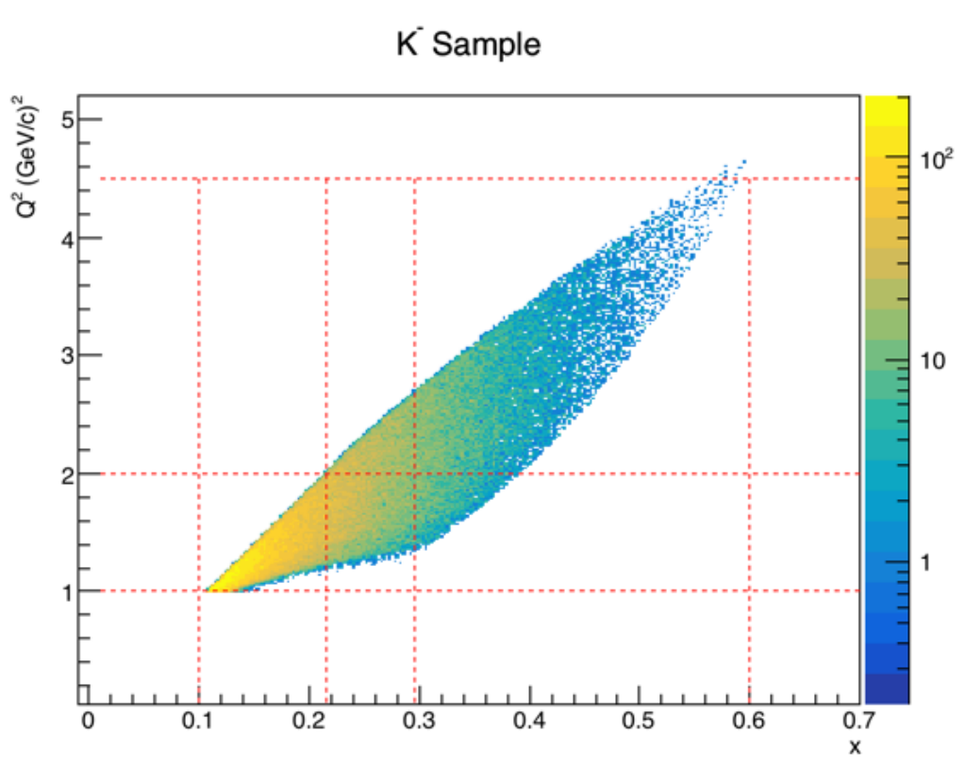


David Riser
University of Connecticut



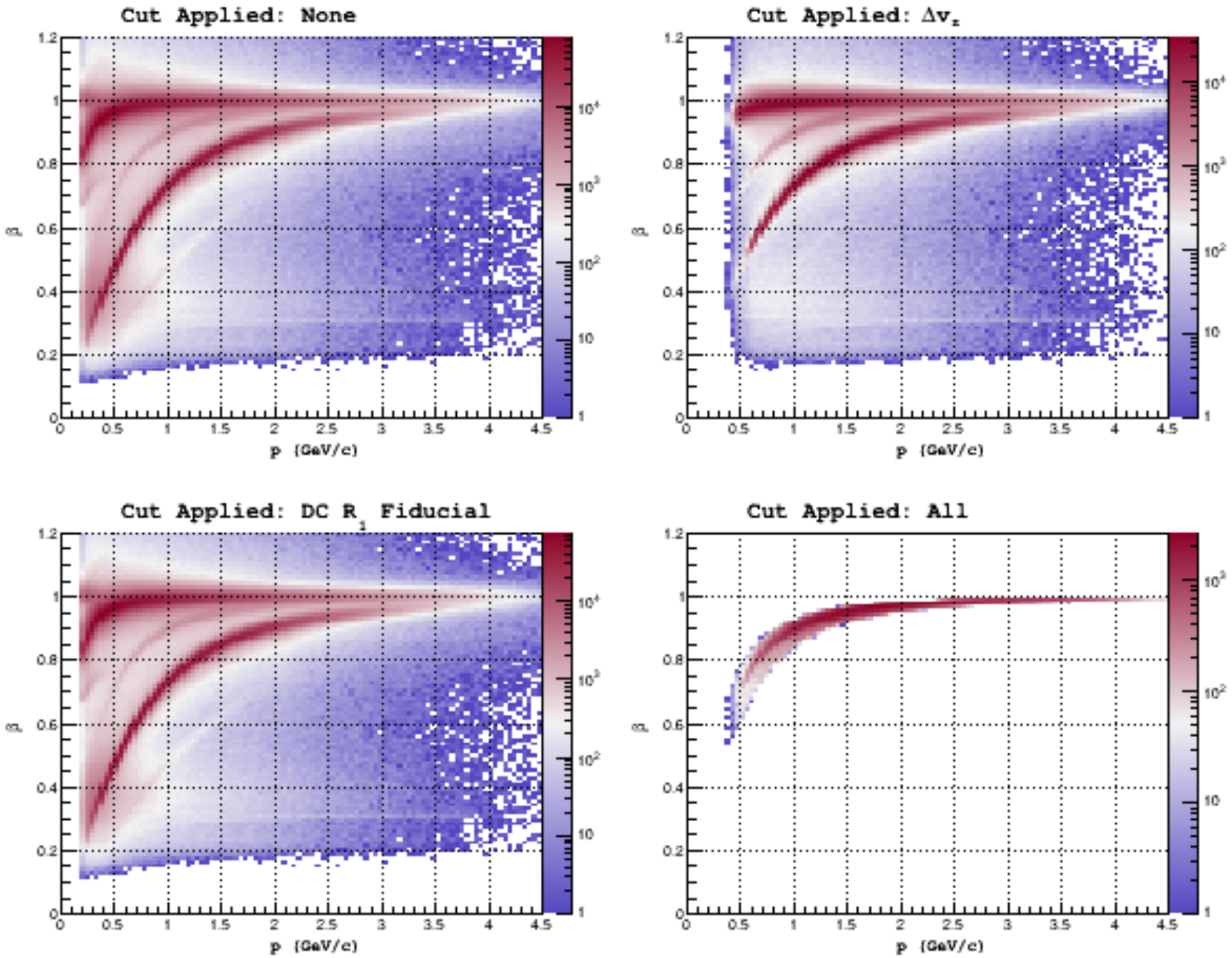






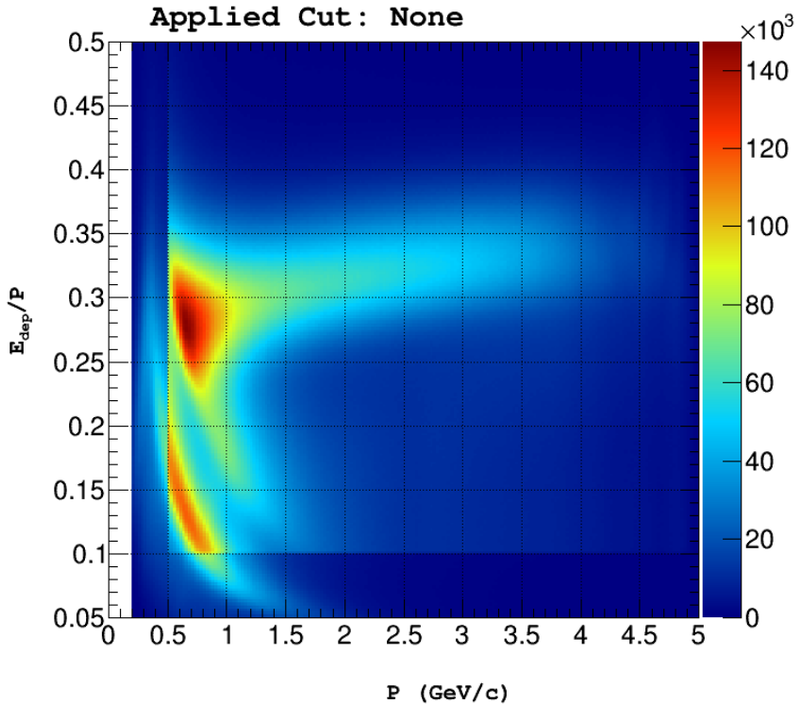
David Riser
University of Connecticut

Effect of cuts on standard distribution for positive kaons

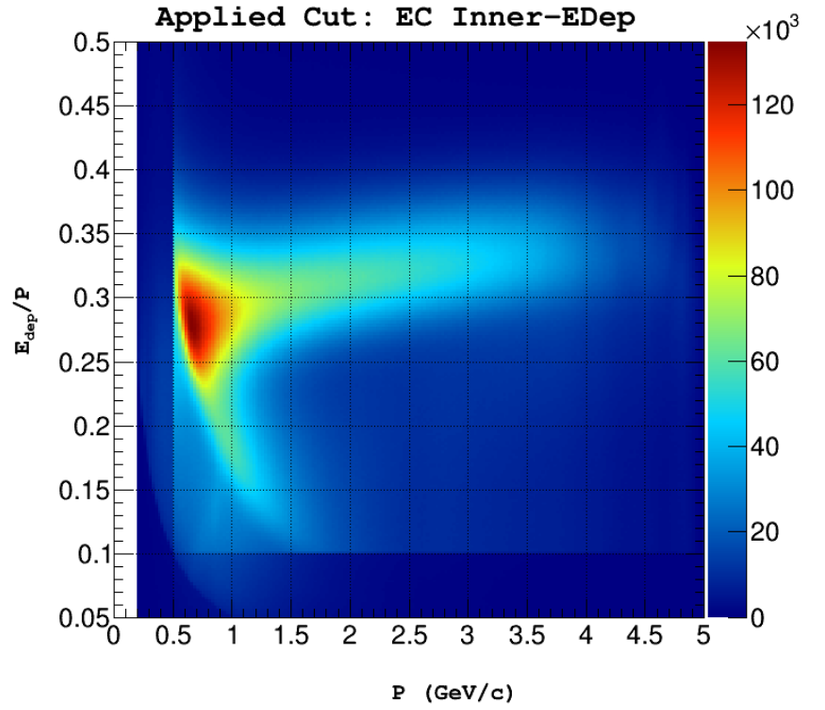


David Riser
University of Connecticut

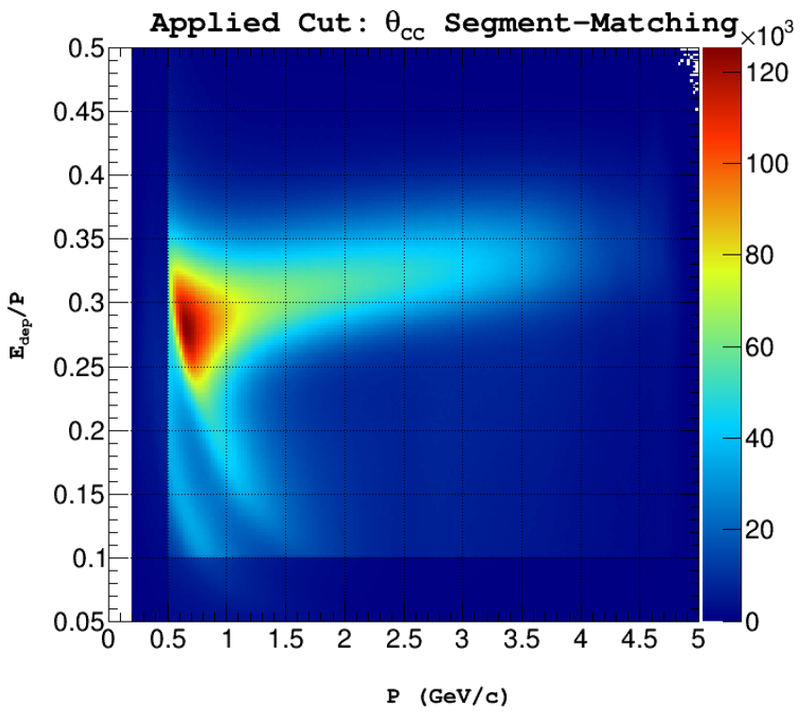
Pass: 1.000



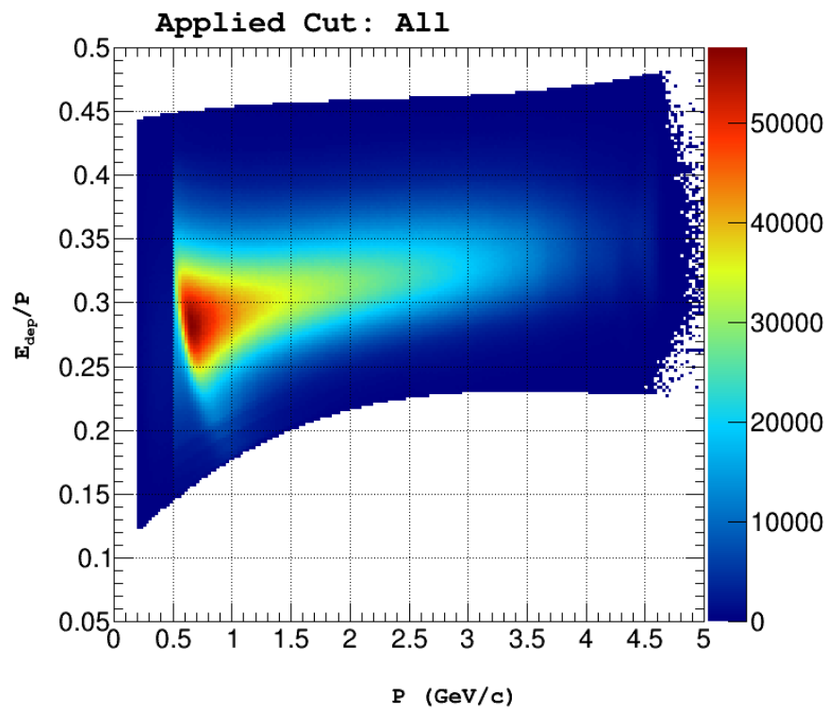
Pass: 0.730



Pass: 0.607



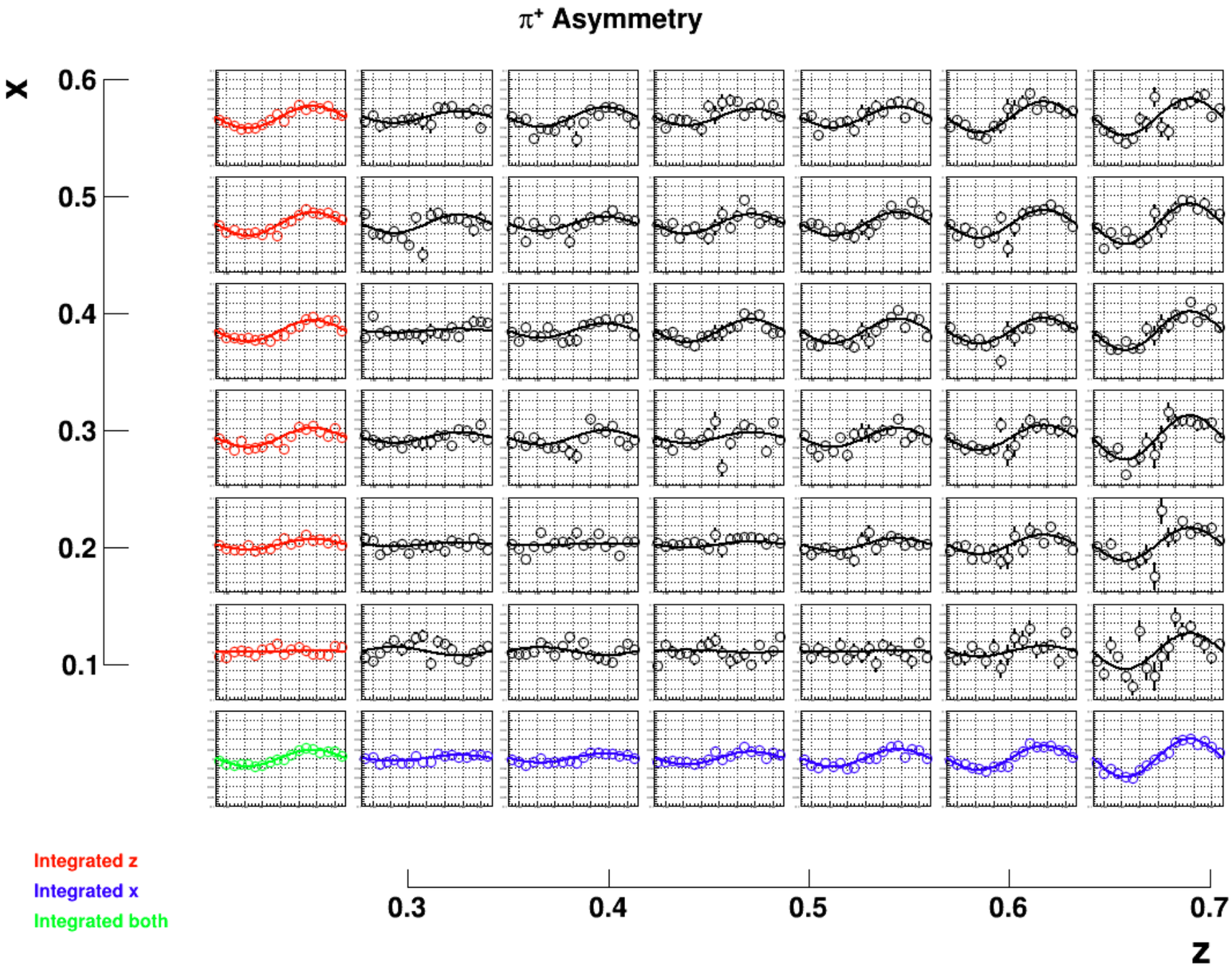
Pass: 0.187

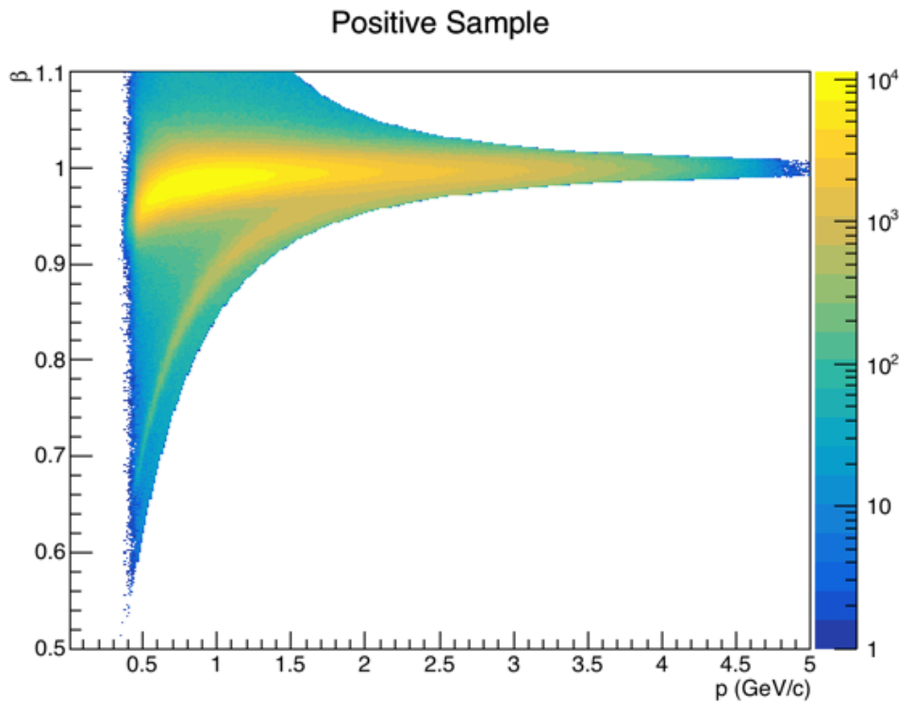


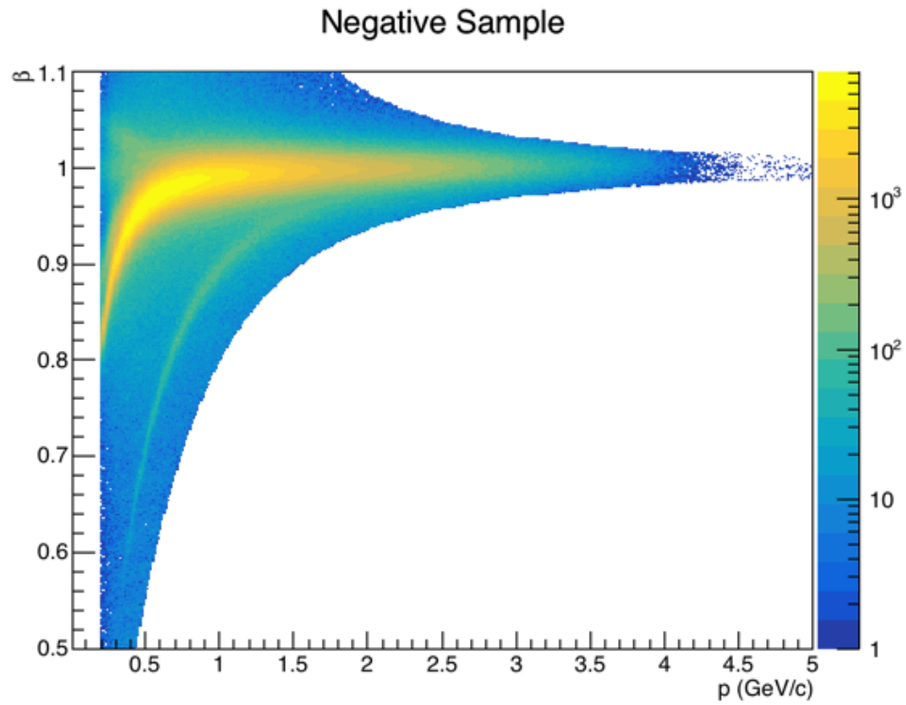
David Riser
University of Connecticut

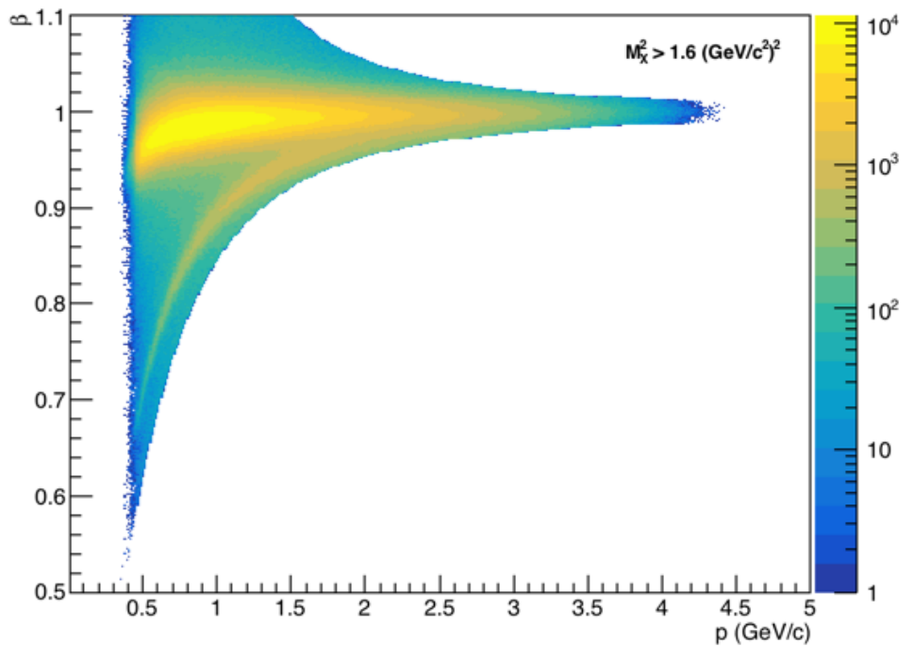
$$A_{LU}^{\sin\phi} = \frac{1}{P_e}\frac{N^+ - N^-}{N^+ + N^-}$$

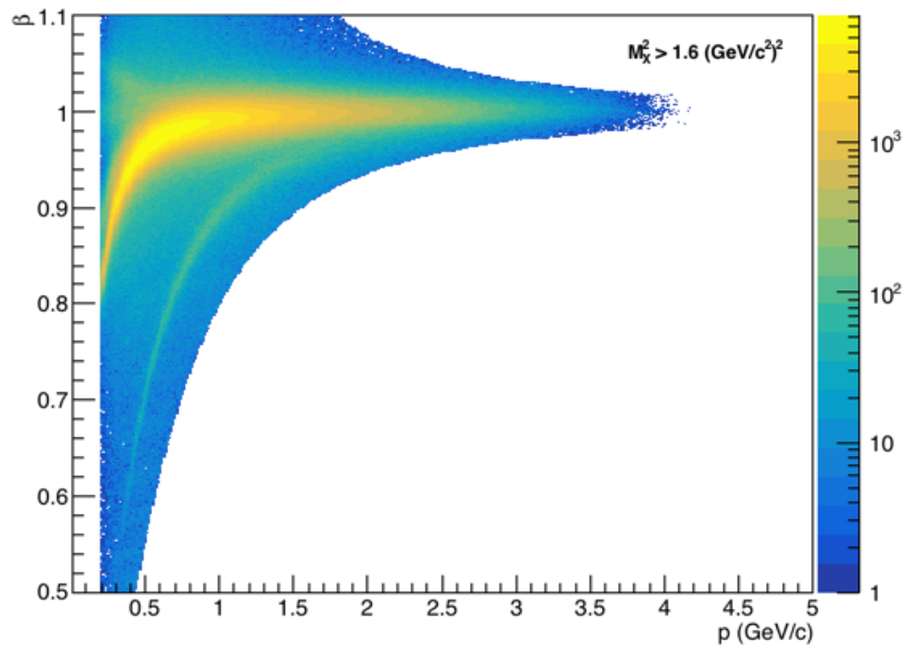
binning dictated by statistics in kaon channels

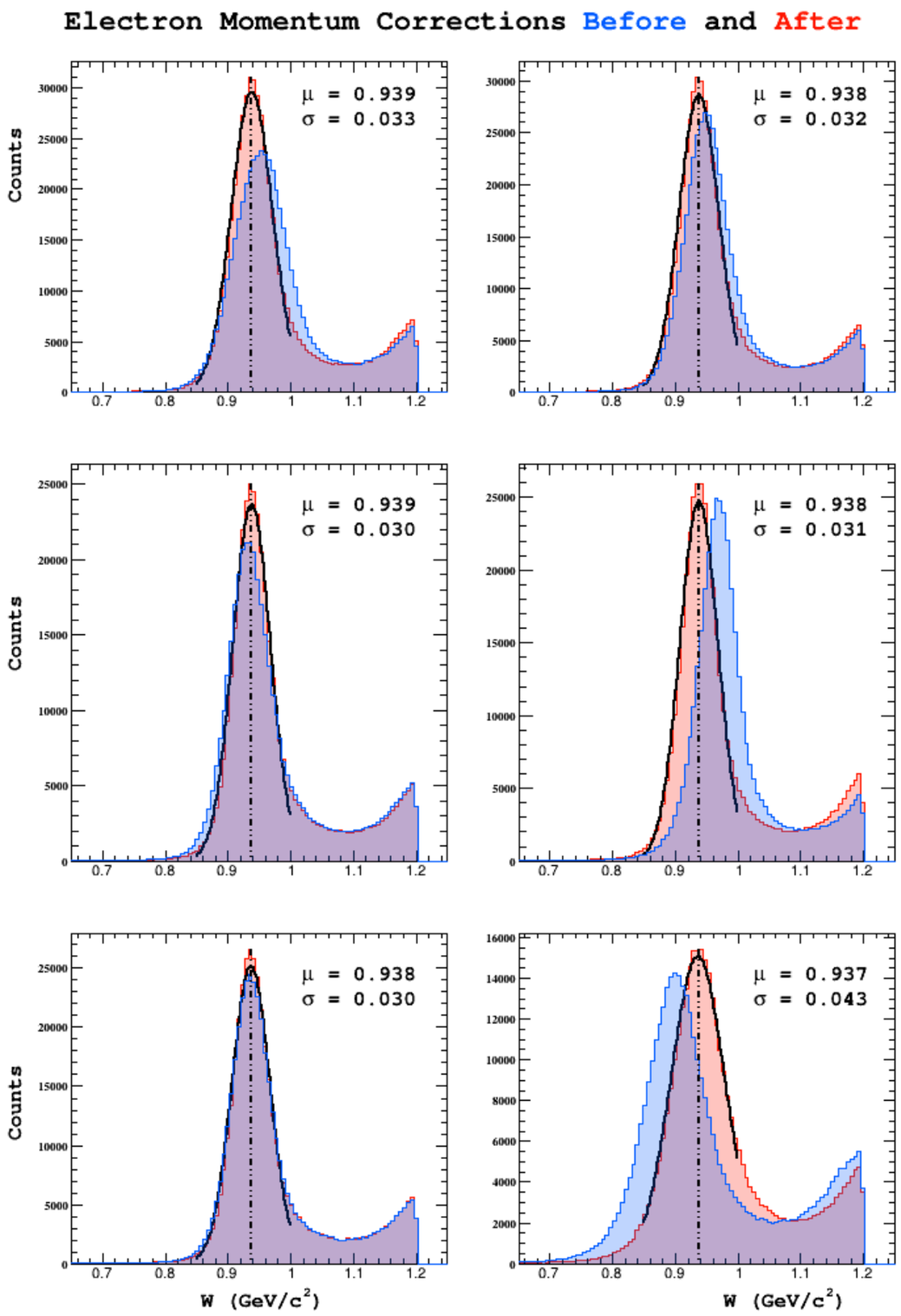



Positive Sample
β
p (GeV/c)


Negative Sample
β
p (GeV/c)


Positive Sample
$M_X^2 > 1.6$ (GeV/c^2)^2
β
p (GeV/c)


Negative Sample
$M_X^2 > 1.6$ (GeV/c^2)^2
β
p (GeV/c)



David Riser
University of Connecticut