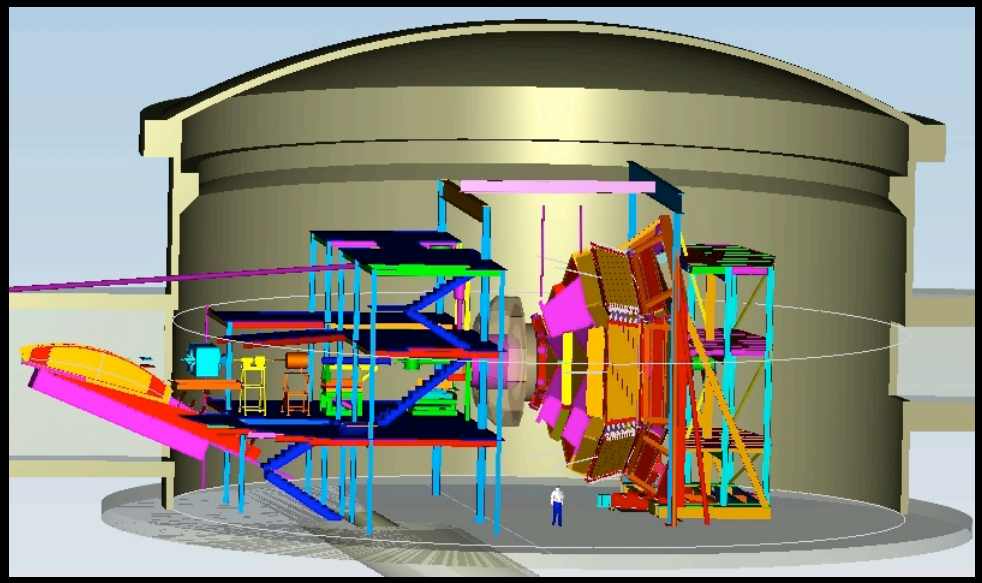
CLAS12 RICH Detector Workshop
Opportunities in Kaon Physics



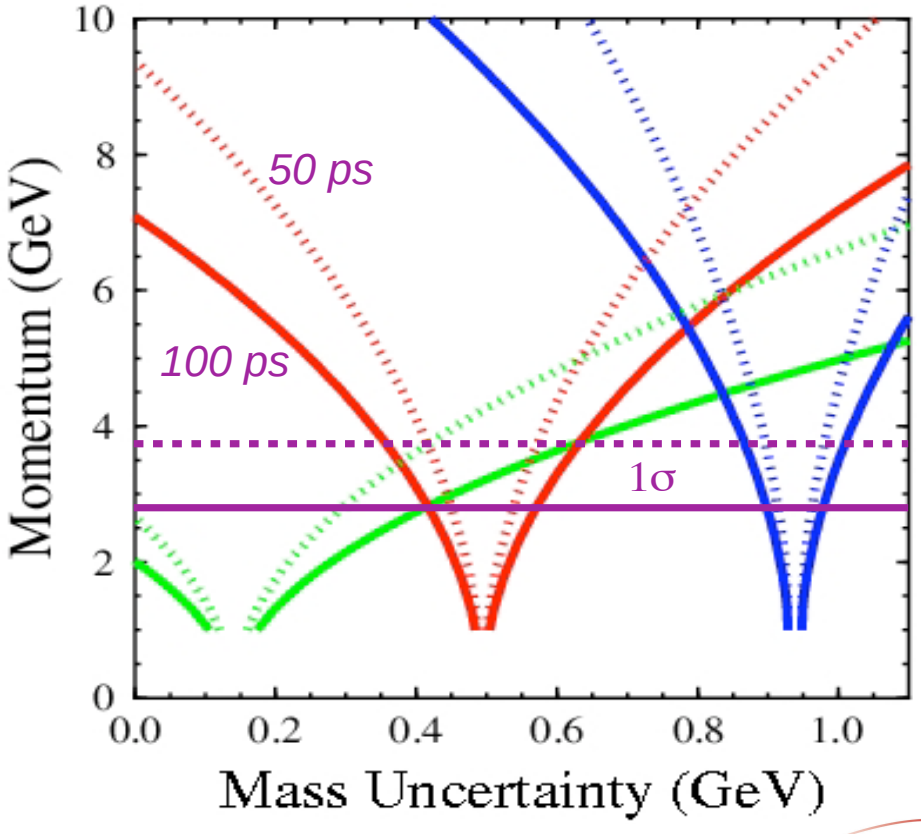
Daniel S. Carman
Jefferson Laboratory

CLAS12 Particle Identification

- CLAS12 hadron identification in the forward direction presently relies heavily on the forward TOF system.

  → *The nominal timing resolution for the panel−1b counters will be ~100 ps.*

$$\left(\frac{\Delta m}{m}\right)^2 = \left(\frac{\Delta p}{p}\right)^2 + \gamma^4\left[\left(\frac{\Delta L}{L}\right)^2 + \left(\frac{\Delta t}{t}\right)^2\right]$$



ΔL=1.0 cm

Δp=1%

- Even with the original FTOF design of ~50 ps, kaon particle identification was deemed marginal.

Supplementing hadron PID is now much more important for the kaon program!

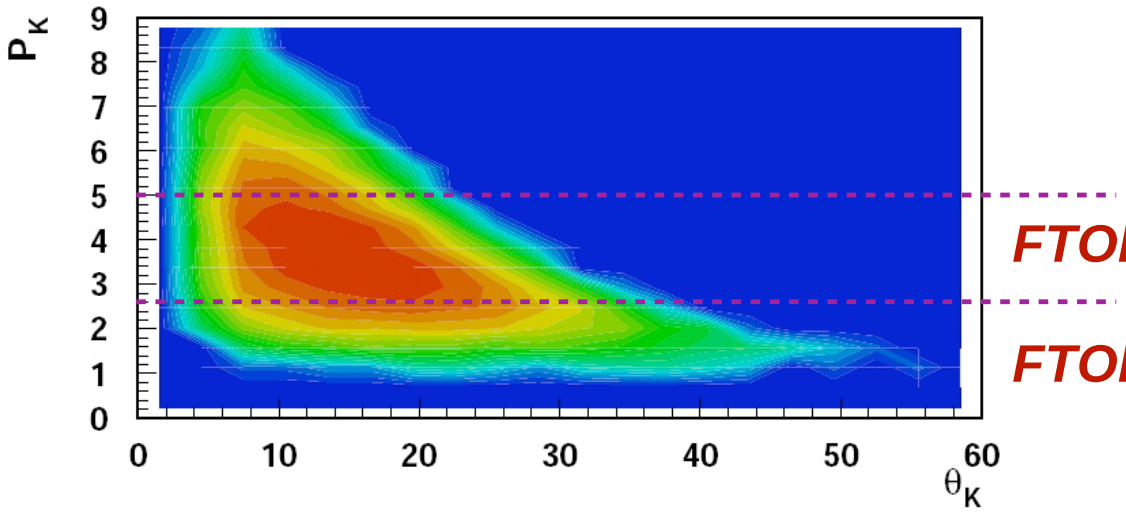
CLAS12 PID Overview

THE GOOD THE BAD THE UGLY

CLAS12 PID Forward Detectors	πK			πp			Kp		
	p<2.6	2.6<p<5	p>5	p<2.6	2.6<p<5	p>5	p<2.6	2.6<p<5	p>5
FTOF	✓	✓		✓	✓		✓	✓	
LTCC		✓	✓		✓	✓			
HTCC			✓			✓			

Kaon Kinematics

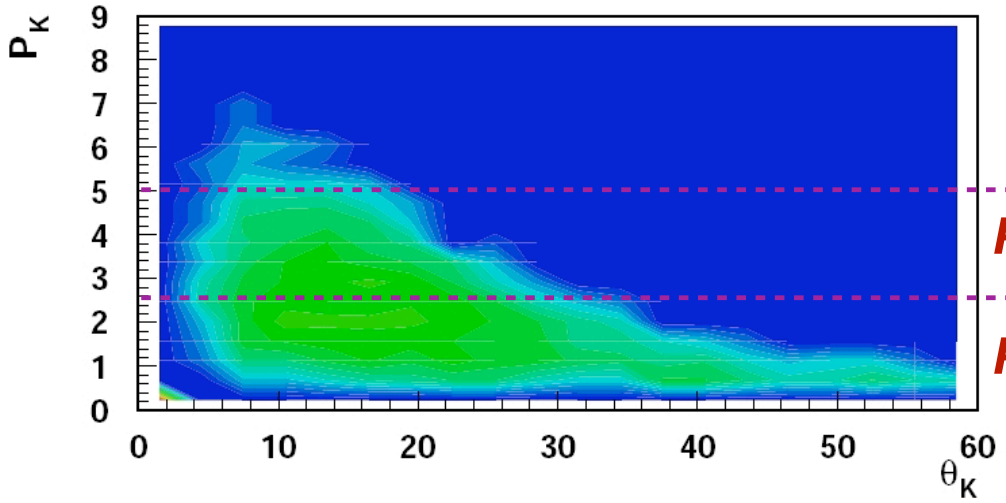
CLAS12 Simulation



$$e + p \rightarrow e' + K^+ + Y$$

FTOF+LTCC

FTOF



$$e + p \rightarrow e' + K^{*+}(892) + Y$$

FTOF+LTCC

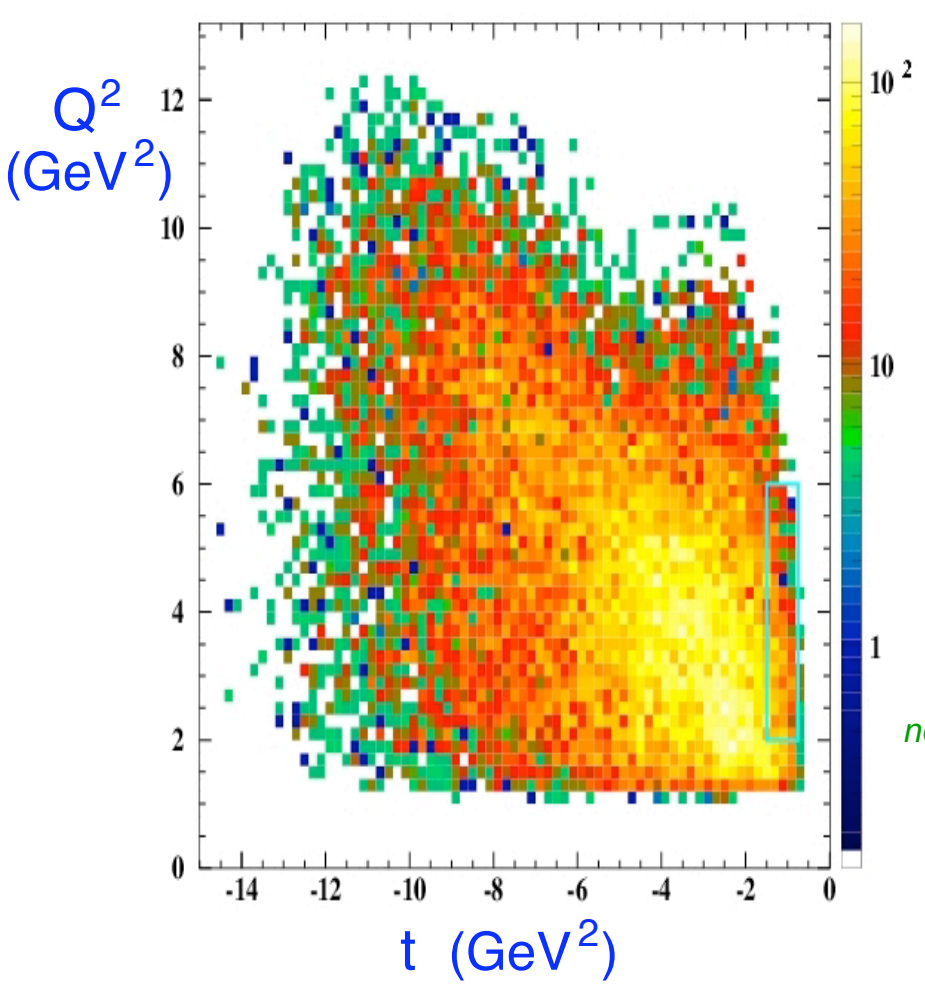
FTOF

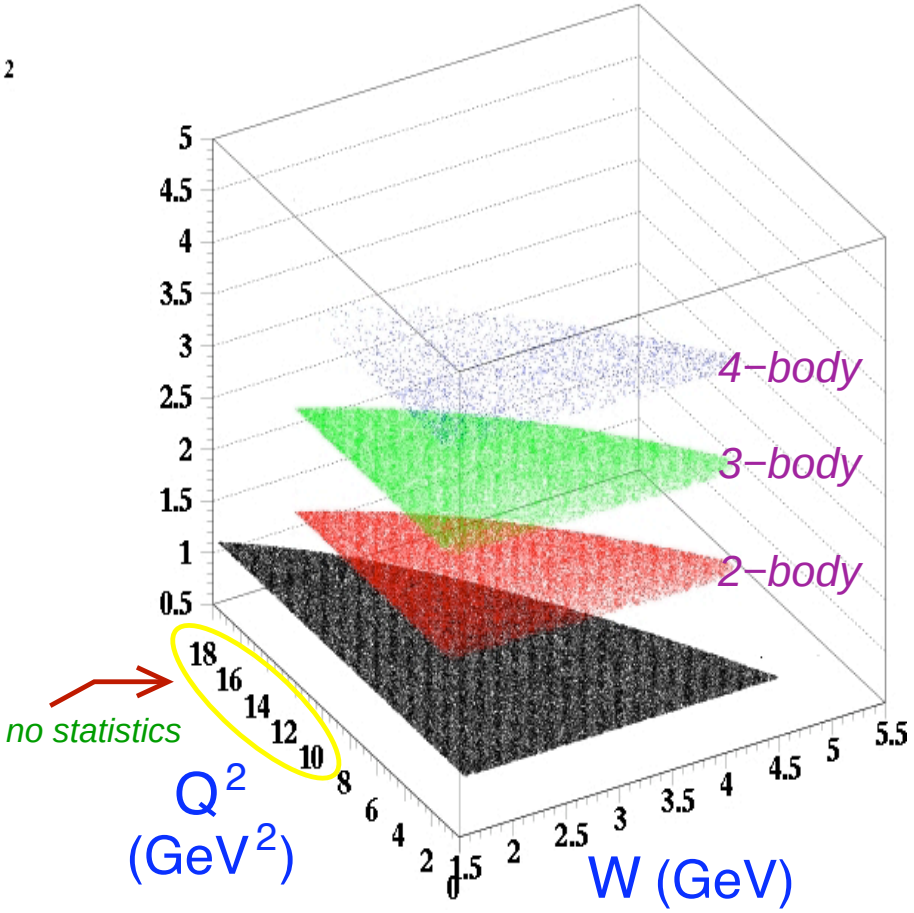
Program Requirements

- In order to carry out a high–quality program of KY physics at 11 GeV, the following requirements are deemed important:
  - Highly polarized CW electron beam;
  - Good electron identification: (e/π) separation over all phase space;
  - Good kaon pid: (K/π) and (K/p) separation over all phase space;
  - Good hermeticity: Final state id requires detection of 3 or 4 particles;
  - Resolution: Reliance on missing–mass technique implies very good momentum and timing resolution;
  - Neutral particle identification: Some reactions can benefit from detection of final state neutrons and photons.

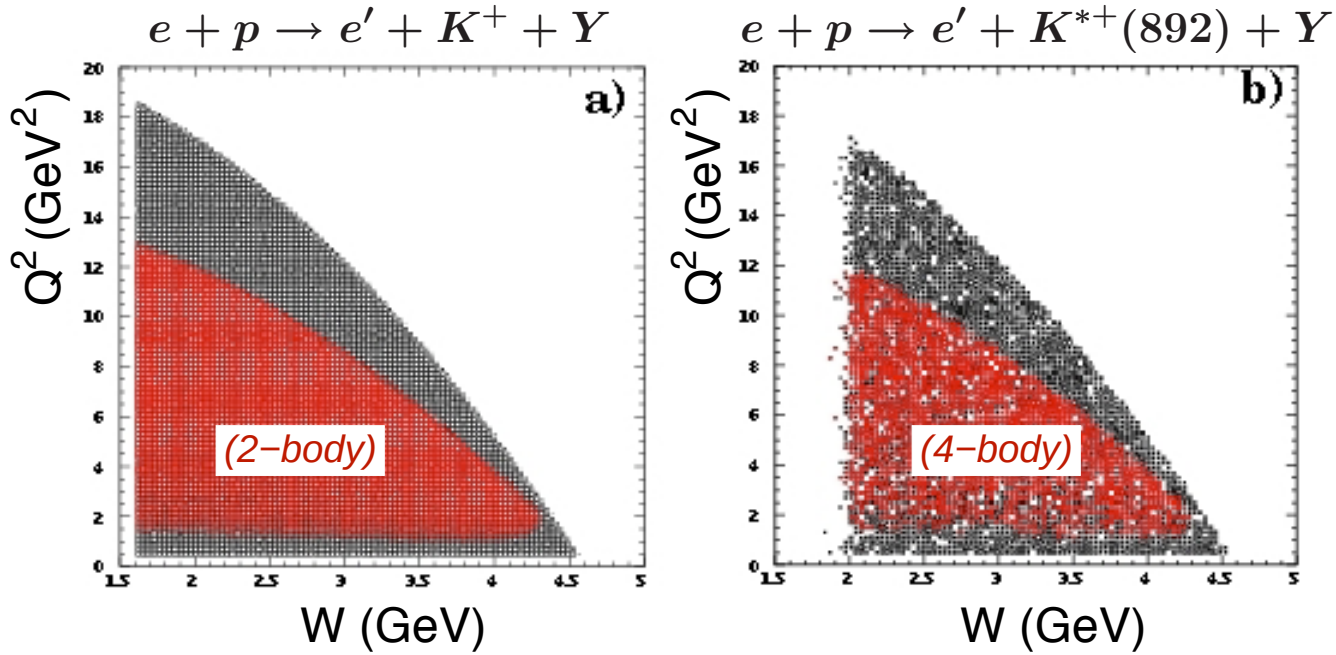
Kinematic Coverage I

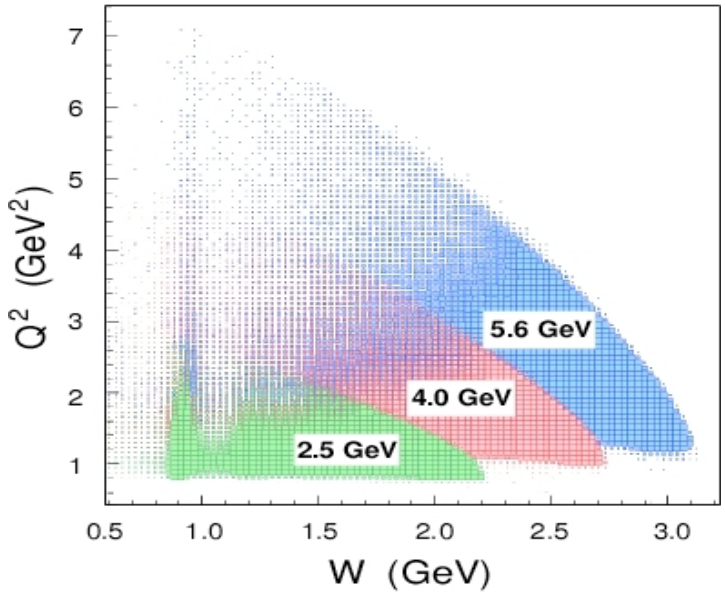
- Study kinematic distributions for the $e + p \rightarrow e' + K^+ + Y$ reaction at 11 GeV.





Kinematic Coverage II





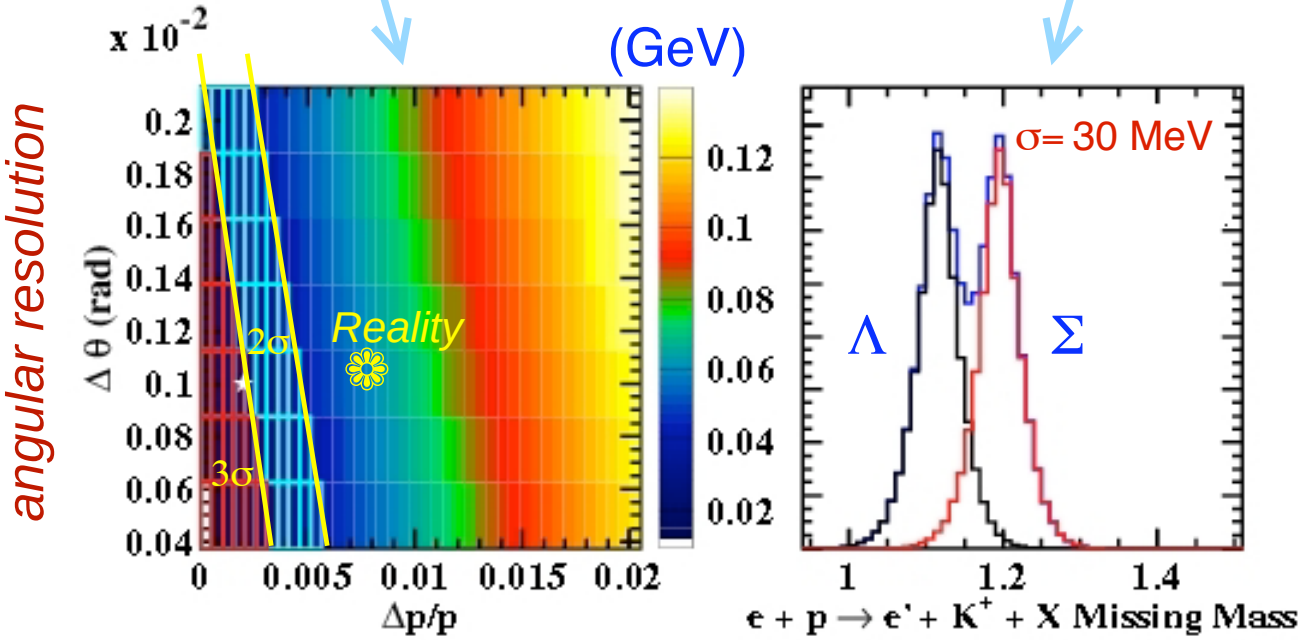
- The KY physics program at 11 GeV doubles our reach in Q^2 and W, and takes us well past the resonance region to where K–Y dynamics are more easily interpreted in terms of quark–gluon degrees of freedom.

Resolution Issues I

- Final state identification relies on the missing–mass technique to isolate the KY events.

MASS RESOLUTION

ONE EXAMPLE:

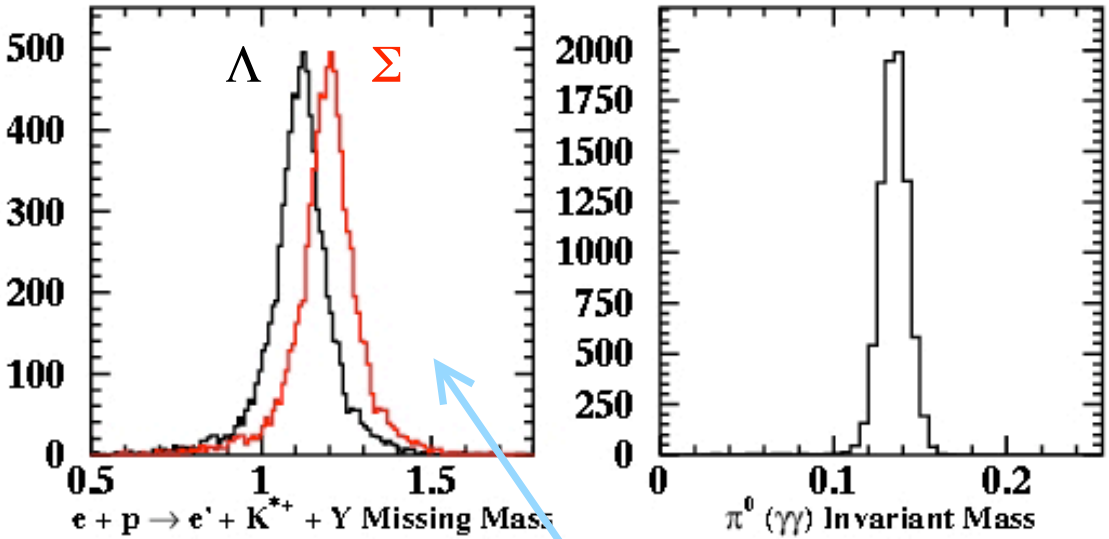


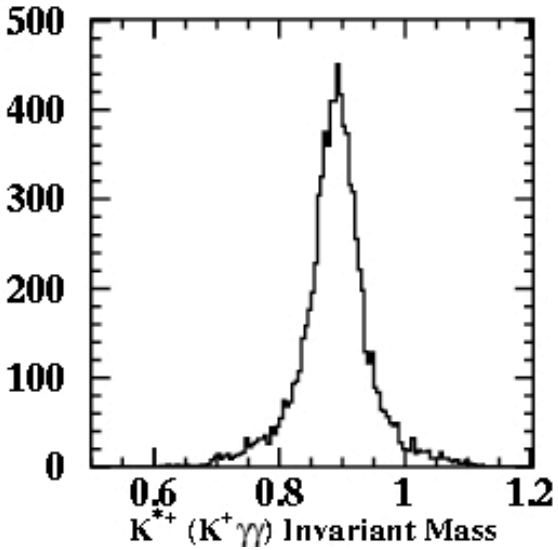
Impossible for exclusive studies??

Ground state hyperon separation very marginal, even without pid backgrounds!

Resolution Issues II

$$e + p \rightarrow e' + K^{*+}(892) + Y$$
$$K^{*+}(892) \rightarrow K^{+}\pi^{0}$$





Photon Resolution:

5% momentum

3 mrad angle

Poor hyperon separation with missing–mass technique.

– kinematic fit –– resolution improvement??

Program Overview

JUST A SAMPLE OF THE PROGRAMS ...

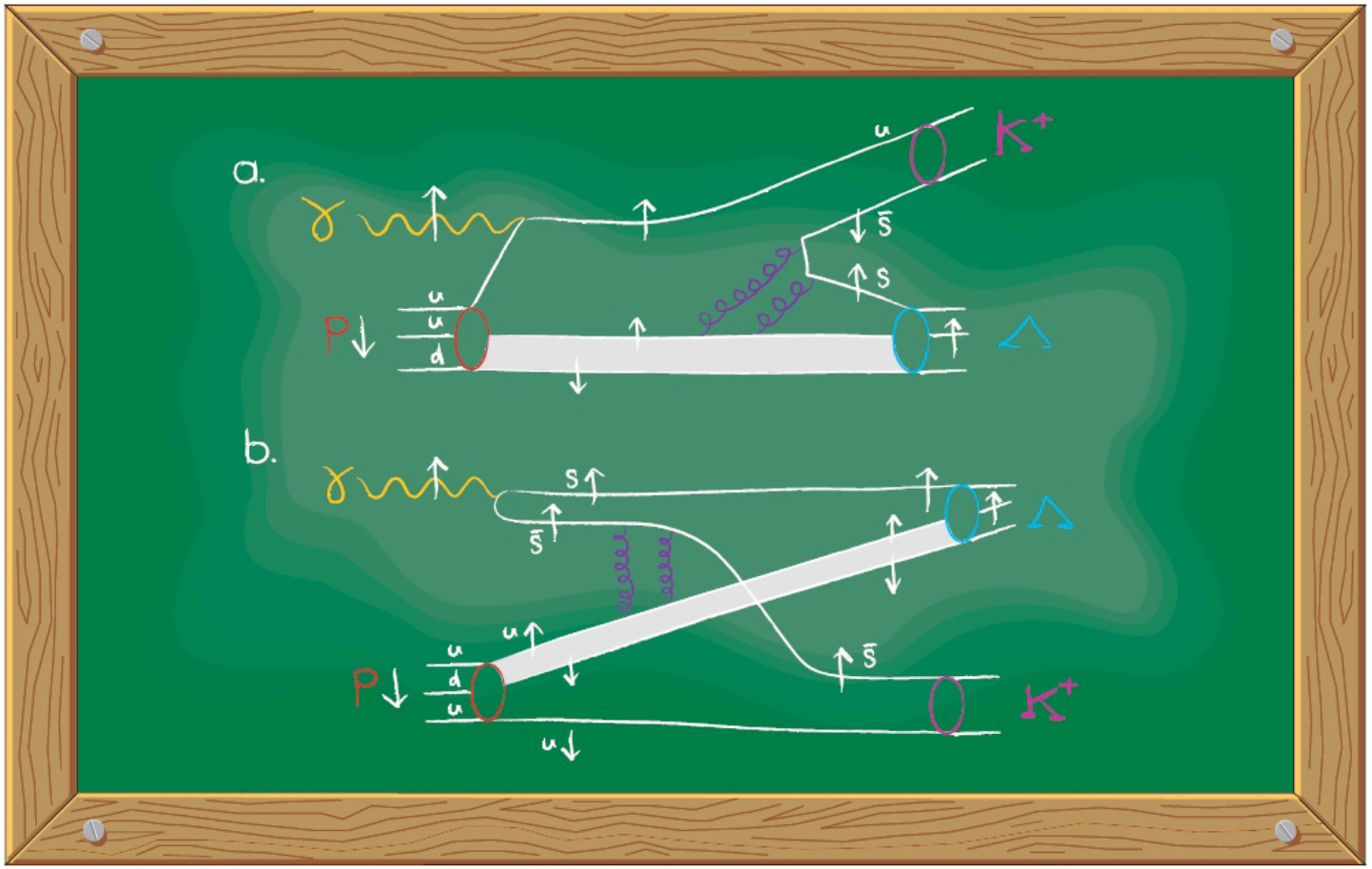
- (Semi)–Exclusive Kaon Production:
  - *N* physics at higher momentum transfers.*
  - *Comparisons between K and K* production dynamics.*
  - *Quark dynamics of $s\bar{s}$ pair production.*
- Hard Exclusive Kaon Electroproduction
  - *Study of flavor−changing GPDs.*
  - *Hadronization models.*
  - *Quark distribution functions.*

Exclusive Kaon Production

- N* physics program
  - *The broad range of momentum transfers accessible by CLAS12 will allow a detailed mapping of the N* form factors to regions beyond where models based on meson−baryon degrees of freedom are applicable.*
  - *The ability to measure hyperon polarization observables will provide access to a broader range of the photon−nucleon response.*
- KY and K*Y production dynamics
  - *Comparisons of KY and K*Y dynamics over a broad kinematic range are important to access additional final states applicable for coupled channels models.*
  - *Comparisons of hyperon polarization observables for both cases will allow for insight into the dynamics of quark−pair creation operators.*

Quark–Pair Creation Dynamics

- CLAS has published papers that use the measured Lambda polarization to provide information on the quantum numbers of the s–sbar quark pair creation operator.

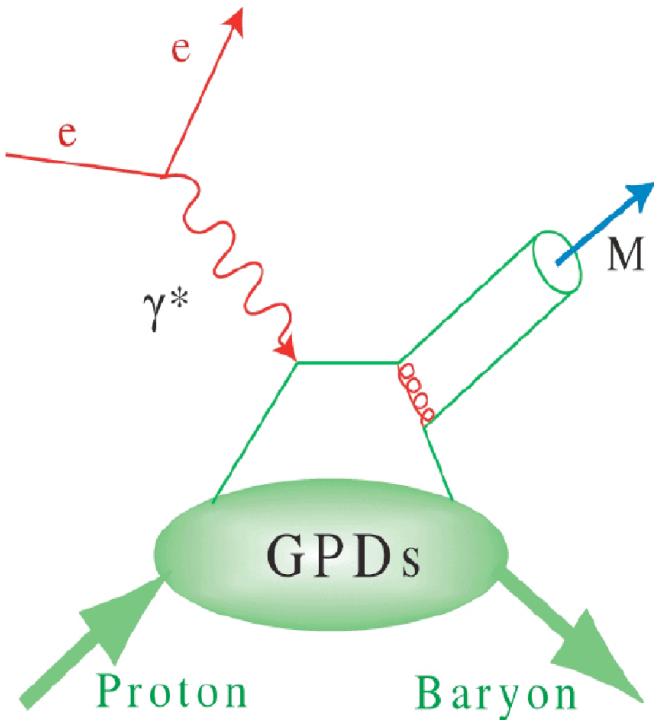


INTERPRETATION CLEARER AT HIGHER VIRTUALITY!

GPDs for N→Y Transitions I

- The study of hard exclusive processes with strangenss production focusses on flavor–changing GPDs.
  - *Flavor non−diagonal GPDs provide a new tool for studying the non−perturbative structure of N to Y transitions.*
  - *Statistics may be comparable to DVCS statistics, but the theoretical interpretations may not be as clear.*

HANDBAG DIAGRAM



(factorization shown only for longitudinal photons)

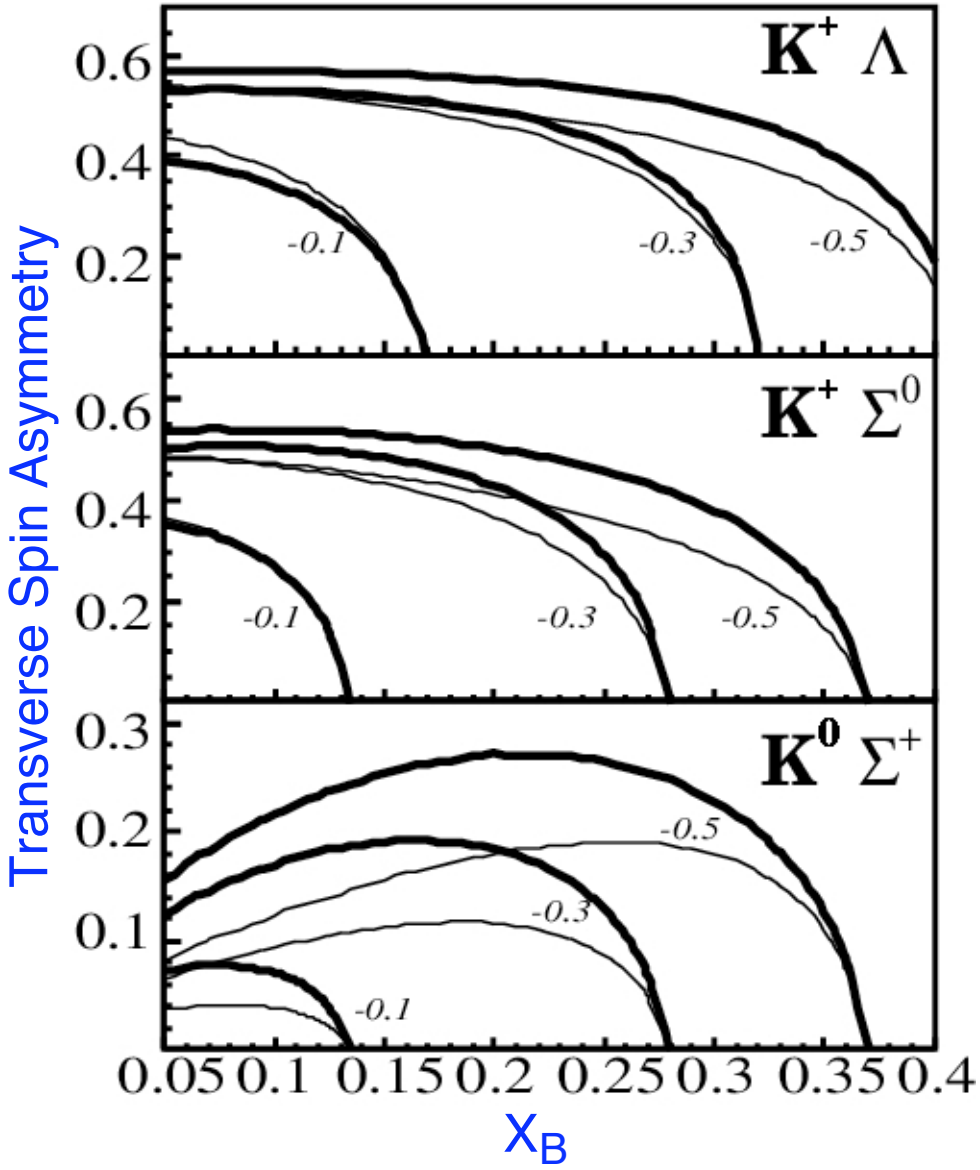
$$\int_{-1}^{1} dx\, H^{N\to Y}(x,\xi,t) = f_1^{N\to Y}(t) - \xi\frac{m_Y + m_N}{2m_N} f_3^{N\to Y}(t)$$

$$\int_{-1}^{1} dx\, E^{N\to Y}(x,\xi,t) = f_2^{N\to Y}(t) + \xi f_3^{N\to Y}(t)$$

$$\int_{-1}^{1} dx\, \tilde{H}^{N\to Y}(x,\xi,t) = g_1^{N\to Y}(t) + \frac{m_Y - m_N}{2m_N} g_2^{N\to Y}(t)$$

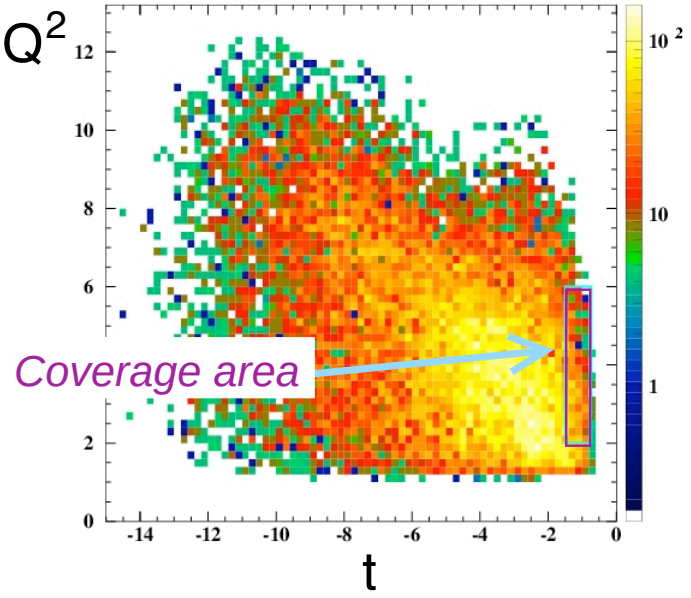
$$\int_{-1}^{1} dx\, \tilde{E}^{N\to Y}(x,\xi,t) = g_3^{N\to Y}(t) + \frac{1}{\xi} g_2^{N\to Y}(t)$$

GPDs for N→Y Transitions II



- Hyperon polarization distributions for unpolarized target.
- Asymmetries are large!

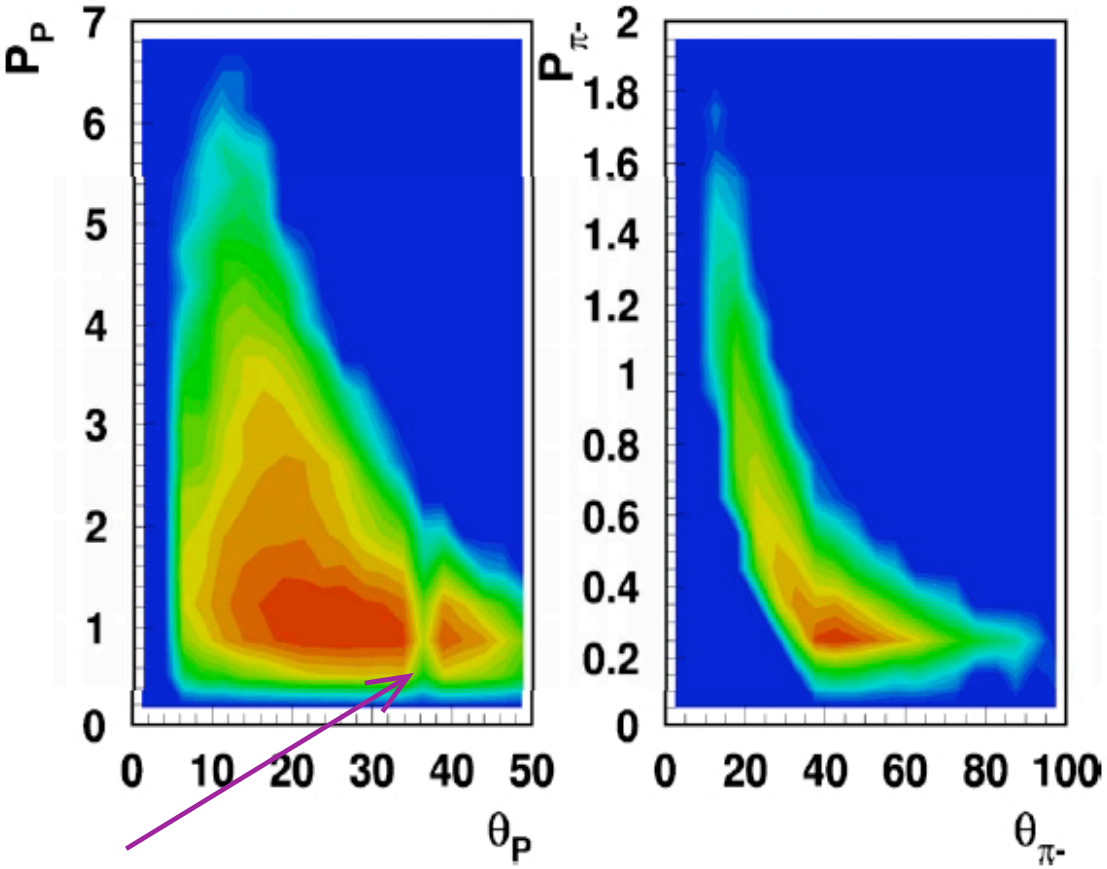
Thin lines: kaon distribution amplitudes.
Thick lines: Chernyak–Zhitnisky amplitudes.

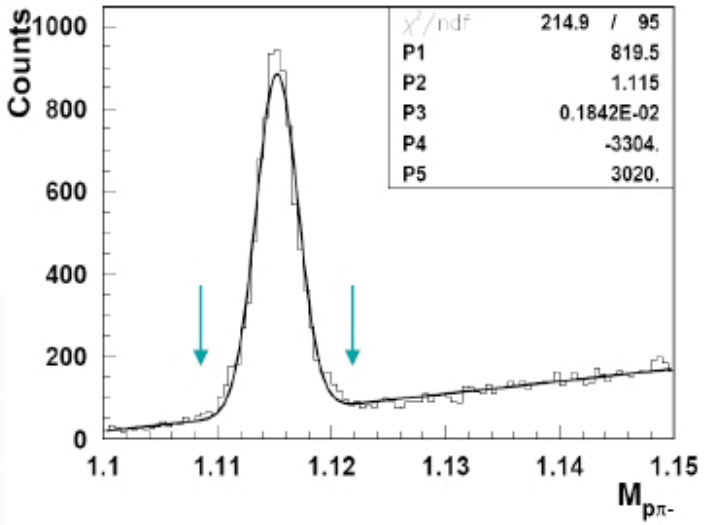


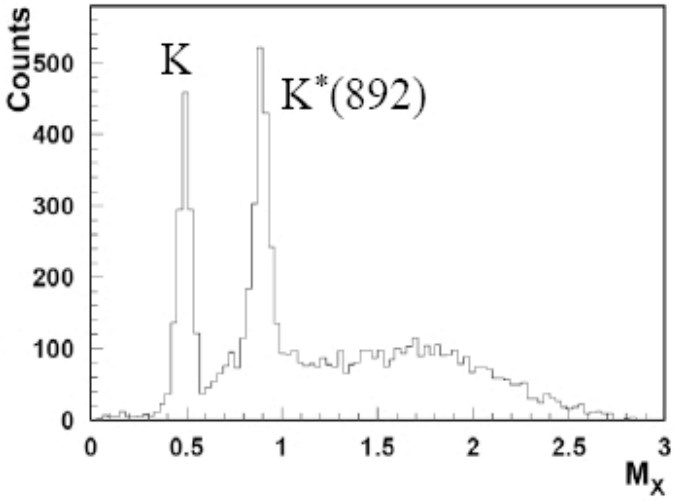
Direct Lambda Detection

ANOTHER AVENUE TO BE EXPLORED:

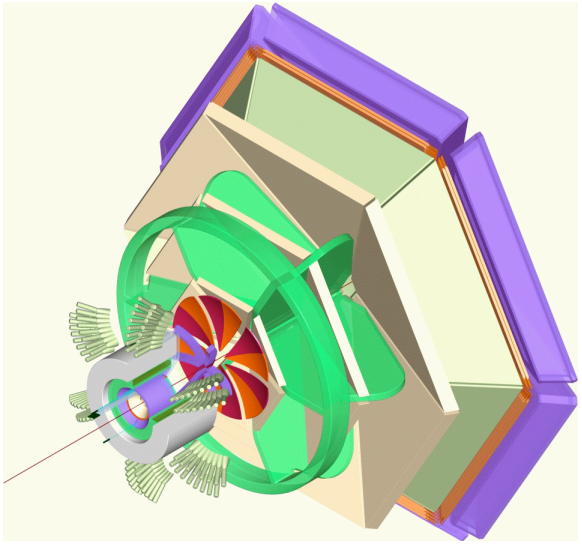
$$ep \rightarrow e\Lambda(p\pi^-)X$$





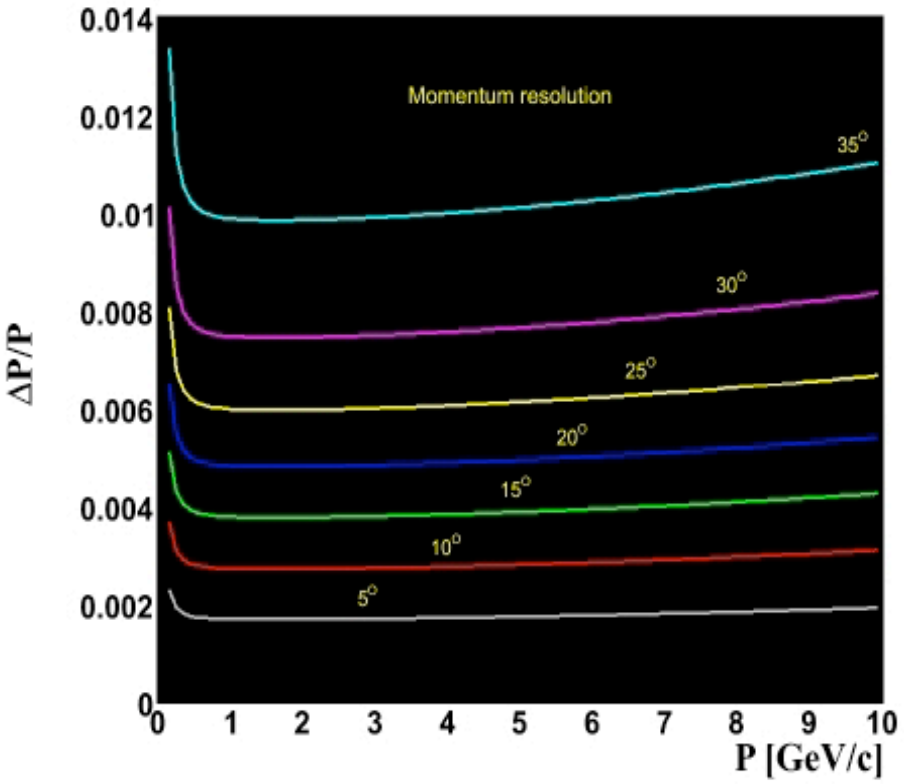


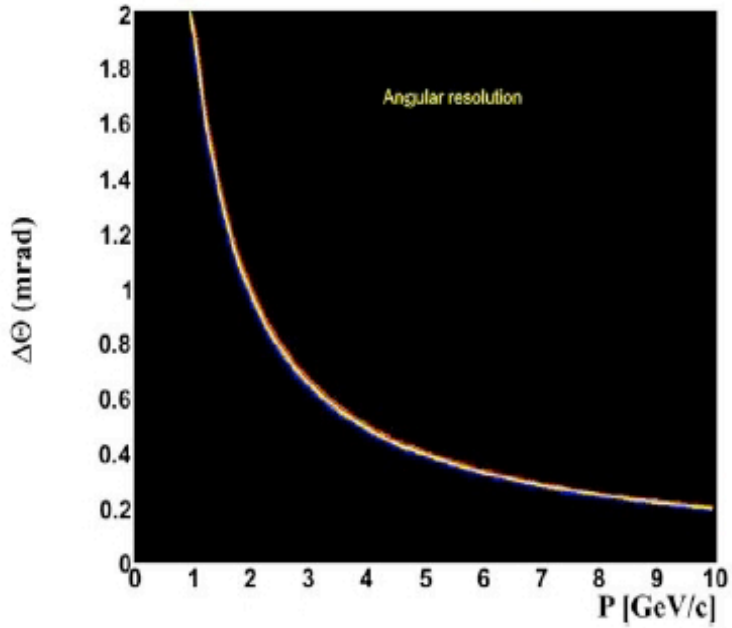
Summary

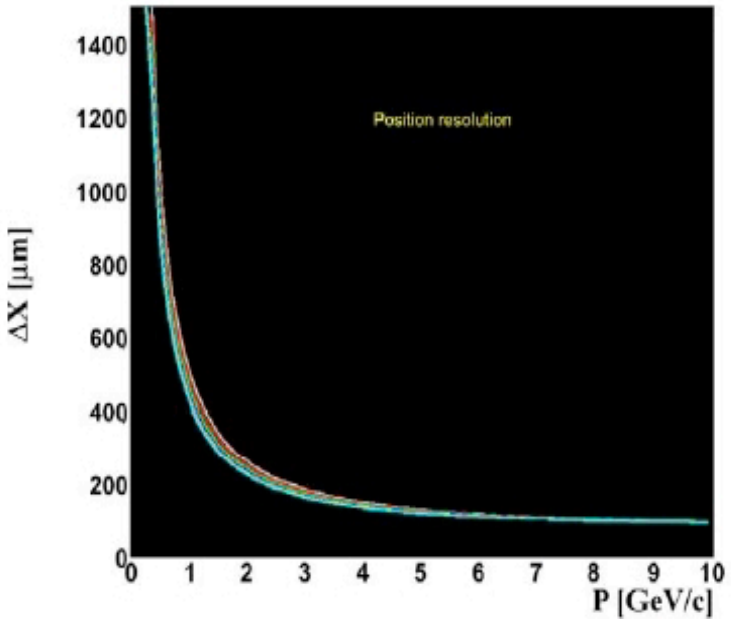


- There is a rich program of kaon physics that can be uniquely addressed with CLAS12.
  - *electron beam, large acceptance, possibility of exclusive reactions, ...*
- Strangeness physics programs focussing on detection of final–state kaons will require better kaon/pion separation than is achievable with the baseline CLAS12 design.
  - *Ground state hyperon separation seems very difficult –– more study needed.*
- Programs will require long running periods in order to achieve meaningful statistics.
- Development of proposals is required to give these areas some voice and some prominence.

CLAS12 Drift Chambers Resolution: Summary







- P resolution < 1%
- θ resolution < 1mrad
- X resolution < 200 μm