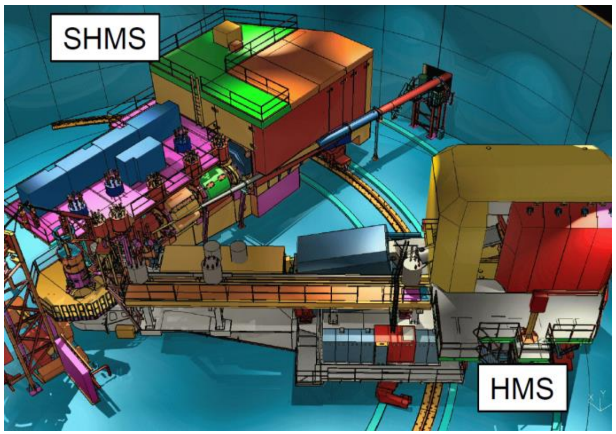
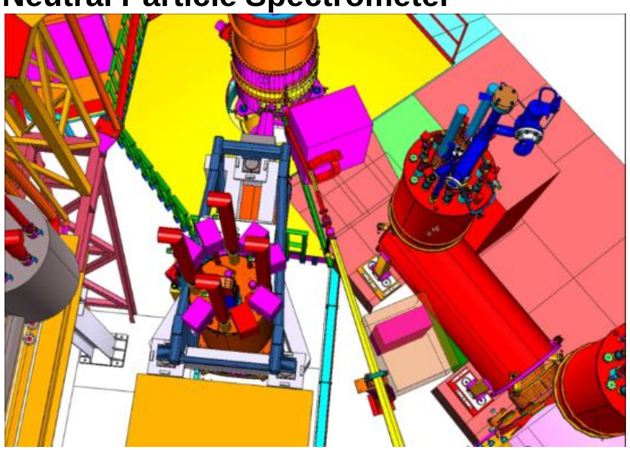
Meson Form Factors and Deep Exclusive Meson Production Experiments



Neutral Particle Spectrometer



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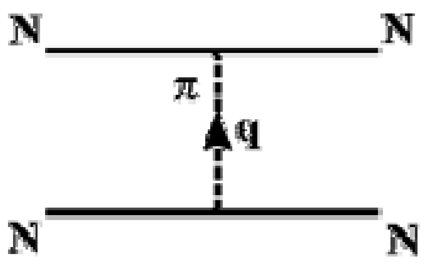
Thomas Jefferson National Accelerator Facility

Mapping Parton Distribution Amplitudes and Functions

ECT*, Trento, Italy, 10-14 September 2018

Pion and Kaon are of particular Importance

- The pion is responsible for the long-range part of the nuclear force, acting as the basis for meson exchange forces and playing a critical role as an elementary field in nuclear structure Hamiltonians



- As the lightest meson, it must be a valence $q\bar{q}$ bound state, but understanding its structure through QCD has been exceptionally challenging

See also talk by C.D. Roberts

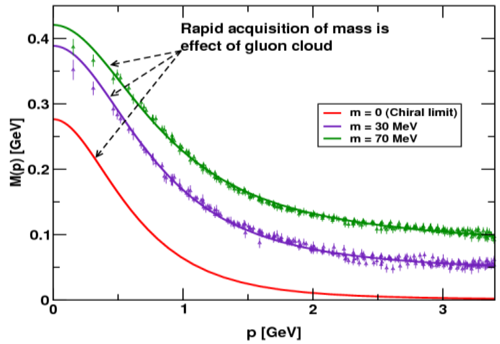
- *E.g.*, with constituent quarks Q: in the nucleon m_Q ~ ⅓m_N ~ 310 MeV, in the pion m_Q ~ ½m_π ~ 70 MeV, in the kaon (with one s quark) m_Q ~ 200 MeV – **This is not real**.
- The mass of bound Goldstone boson states increases as √m with the mass of the constituents

$$f_\pi m_\pi^2 = (m_u^\zeta + m_d^\zeta)\rho_\pi^\zeta$$
$$f_K m_K^2 = (m_u^\zeta + m_s^\zeta)\rho_K^\zeta$$

- In both DSE and LQCD, the mass function of quarks is the same, regardless what hadron the quarks reside in – **This is real**. It is the Dynamical Chiral Symmetry Breaking (DχSB) that makes the pion and kaon masses light.
- We exist because Nature has supplied two light quarks that combine to form the pion, which is unnaturally light and so easily produced

Overview Form Factors

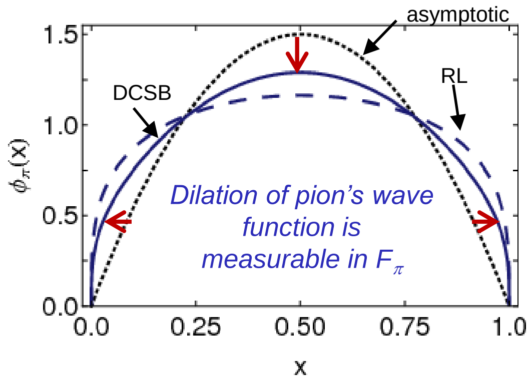
- ❑ ***Pion and kaon form factors*** are of special interest in hadron structure studies
  - ➢ The *pion* is the lightest QCD quark system and also has a central role in our understanding of the dynamic generation of mass - *kaon* is the next simplest system containing strangeness



Clearest test case for studies of the transition from non-perturbative to perturbative regions

- ❑ Recent advances and future prospects in experiments
  - ➢ Dramatically improved precision in F_π measurements

12 GeV JLab data have the potential to quantitatively reveal hard QCD's signatures



- ❑ Form factor data and measurements go hand-in-hand with activities on theory side, e.g.

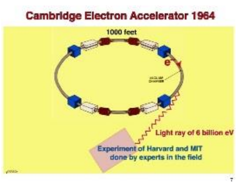
Distribution amplitudes – normalization fixed by pion wave function whose dilation from conformal limit is a signature of DCSB

See also talks by C.D. Roberts, G.Bali, and M. Ding

Meson Form Factor Data Evolution

Experiment

Capability to reliably access large Q^2 regime



DESY

Jefferson Lab

JLab 6 GeV

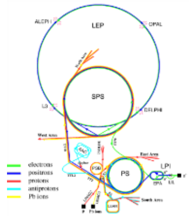
JLab 12 GeV

EIC

1959 1971 1976 1979 1981 1984 1986 1997 2003 2004 2017+ 2025+

Cornell University

Fermilab



Theory

- Accessing the form factor through electroproduction
- Extraction of meson form factor from data
- Electroproduction formalism

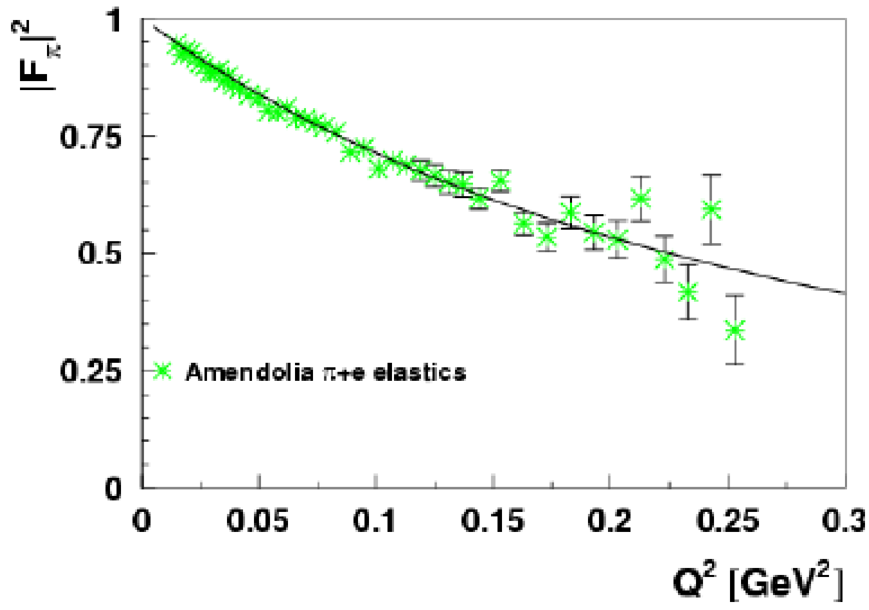
Theory

Major progress on large Q^2 behavior of meson form factor

Experimental Determination of the π^+ Form Factor

Through π-e elastic scattering

- At low Q^2, $F_{\pi+}$ can be measured directly via high energy elastic π^+ scattering from atomic electrons
  - CERN SPS used 300 GeV pions to measure form factor up to $Q^2 = 0.25$ GeV^2
    [Amendolia et al, NPB277,168 (1986)]
  - These data used to constrain the pion charge radius: $r_\pi = 0.657 \pm 0.012$ fm



- The maximum accessible Q^2 is roughly proportional to the pion beam energy
  - $Q^2 = 1$ GeV^2 requires 1000 GeV pion beam

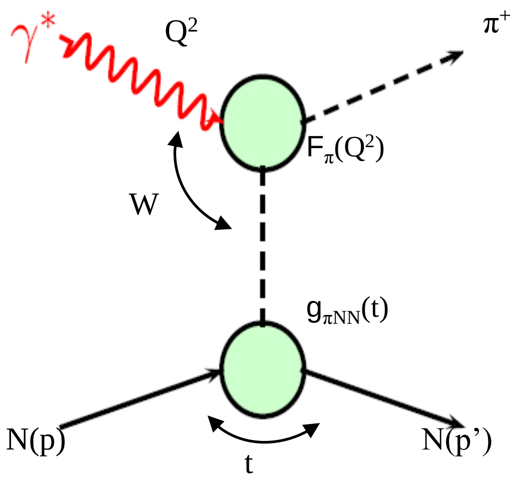
Experimental Determination of the π^+ Form Factor

Through pion electroproduction

- $F_{\pi+}$ measured indirectly using the "pion cloud" of the proton via the *p(e,e'π^+)n process*
  - At small $-t$, the pion pole process dominates the longitudinal cross section, σ_L
  - In the Born term model, F_π^2 appears as

$$\frac{d\sigma_L}{dt} \propto \frac{-t}{(t-m_\pi^2)} g_{\pi NN}^2(t) Q^2 F_\pi^2(Q^2,t)$$

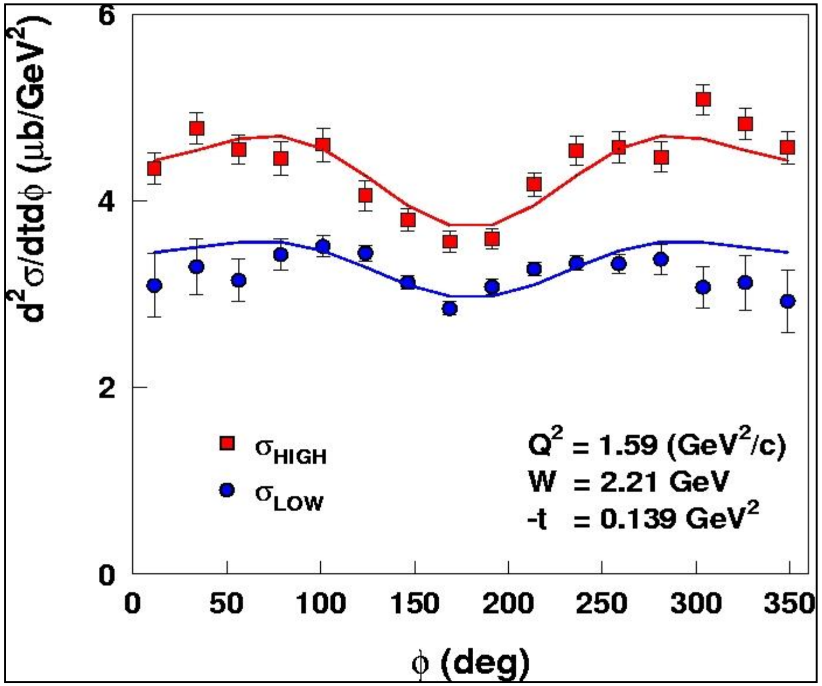
[In practice one uses a more sophisticated model]



- Requirements:
  - Full L/T separation of the cross section – isolation of σ_L
  - Selection of the pion pole process
  - Extraction of the form factor using a model
  - Validation of the technique - model dependent checks

L/T Separation Example

- σ_L is isolated using the Rosenbluth separation technique
  - Measure the cross section at two beam energies and fixed W, Q^2, -t
  - Simultaneous fit using the measured azimuthal angle (ϕ_π) allows for extracting L, T, LT, and TT
- Careful evaluation of the systematic uncertainties is important due to the $1/\varepsilon$ amplification in the σ_L extraction
  - Spectrometer acceptance, kinematics, and efficiencies
- Magnetic spectrometers a must for such precision cross section measurements
  - This is only possible in Hall C at JLab



$$2\pi\frac{d^2\sigma}{dt\,d\phi} = \varepsilon\frac{d\sigma_L}{dt} + \frac{d\sigma_T}{dt} + \sqrt{2\varepsilon(\varepsilon+1)}\,\frac{d\sigma_{LT}}{dt}\cos\phi + \varepsilon\frac{d\sigma_{TT}}{dt}\cos 2\phi$$

σ_L will give us F_π

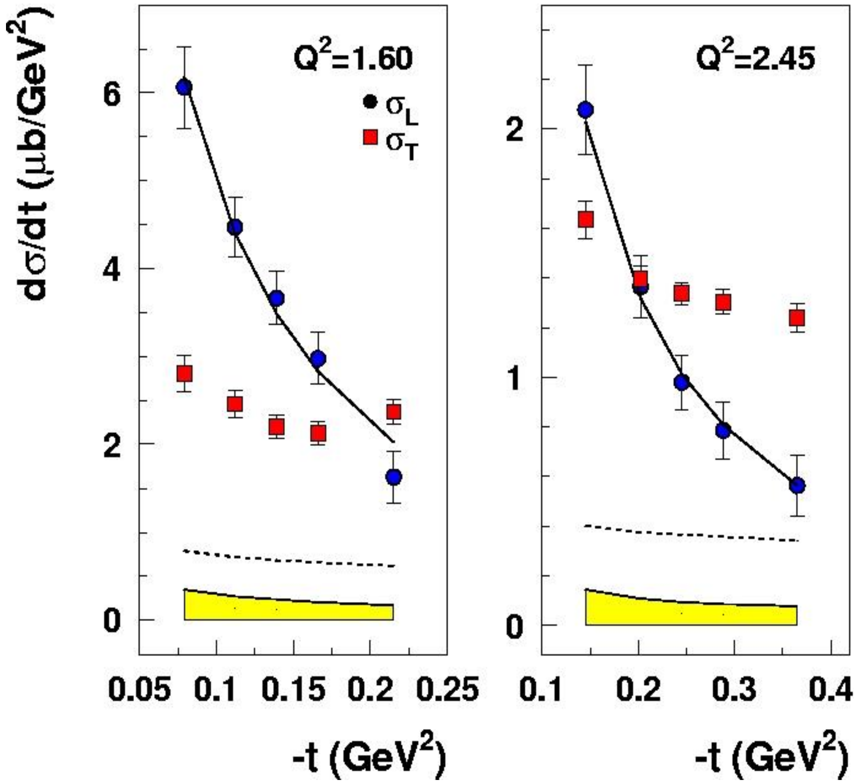
Extraction of F_π from σ_L Jlab data

[Horn et al., PRL **97**, (2006) 192001]

- JLab 6 GeV F_π experiments used the VGL/Regge model as it has proven to give a reliable description of σ_L across a wide kinematic domain

  [Vanderhaeghen, Guidal, Laget, PRC **57**, (1998) 1454]

  - Feynman propagator replaced by π and ρ trajectories
  - Model parameters fixed by pion photoproduction data
  - Free parameters: $\Lambda_\pi^2, \Lambda_\rho^2$



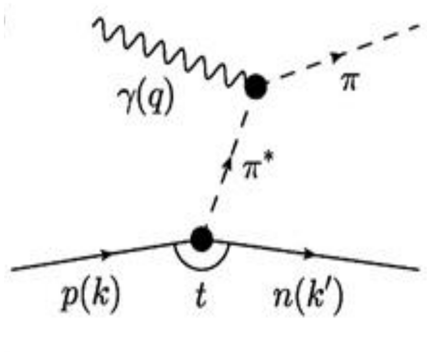
$$F_\pi(Q^2) = \frac{1}{1+Q^2/\Lambda_\pi^2}$$

$$\Lambda_\pi^2 = 0.513,\ 0.491\ GeV^2$$

$$\Lambda_\rho^2 = 1.7\ GeV^2$$

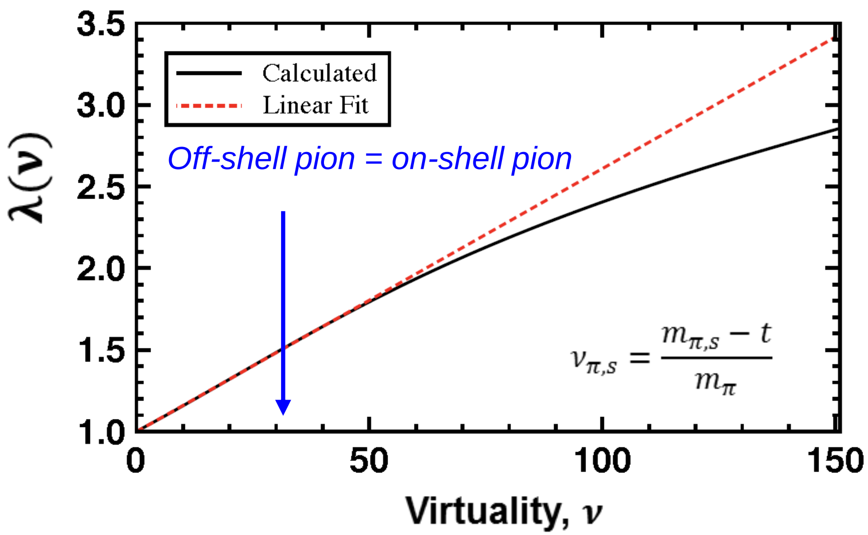
Fit of σ_L to model gives F_π at each Q^2

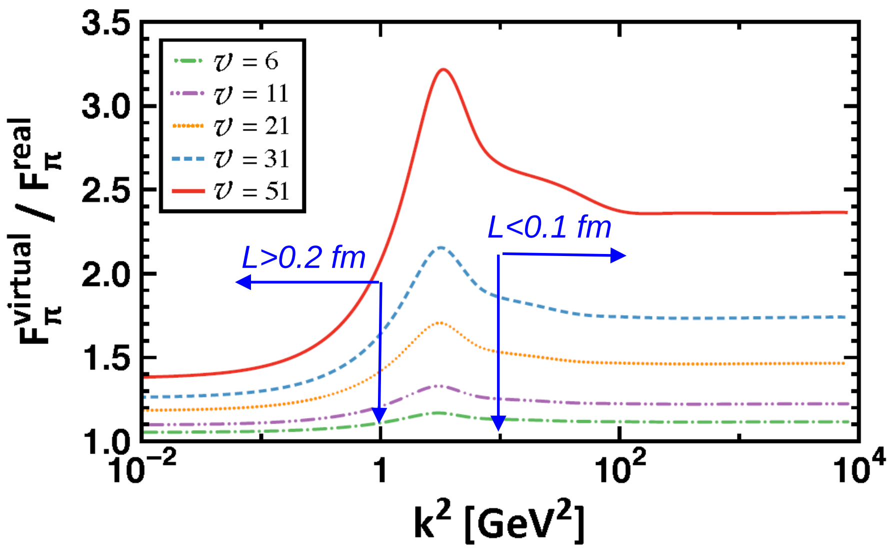
Off-shellness considerations



In the Sullivan process, the mesons in the nucleon cloud are virtual (off-shell) particles

S-X Qin, C.Chen, C. Mezrag, C.D. Roberts, Phys. Rev. C97 (2018), no. 1, 015203





- ❑ Recent calculations estimate the effect in the BSE/DSE framework – as long as $\lambda(\nu)$ is linear in ν the meson pole dominates
  - ○ Within the linearity domain, alterations of the meson internal structure can be analyzed through the amplitude ratio
- ❑ *Off-shell meson* = *On-shell meson* for t<0.6 GeV^2 (ν =30) for pions and t<0.9 GeV^2(ν_s~3) for kaons

This means that pion and kaon form factor can be accessed through the Sullivan process

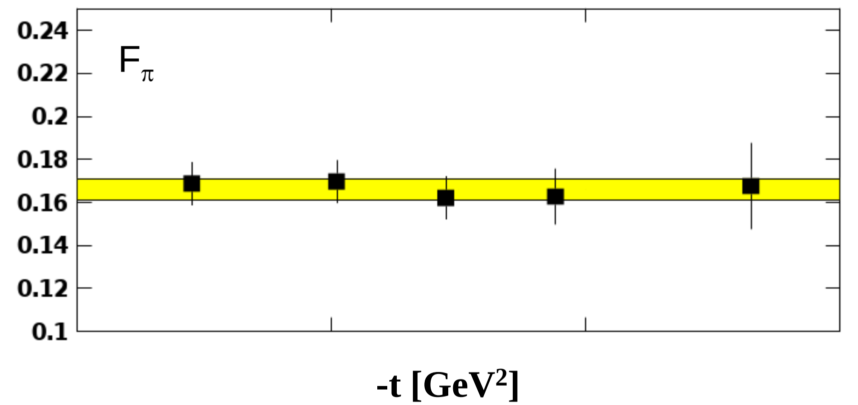
Experimental Validation

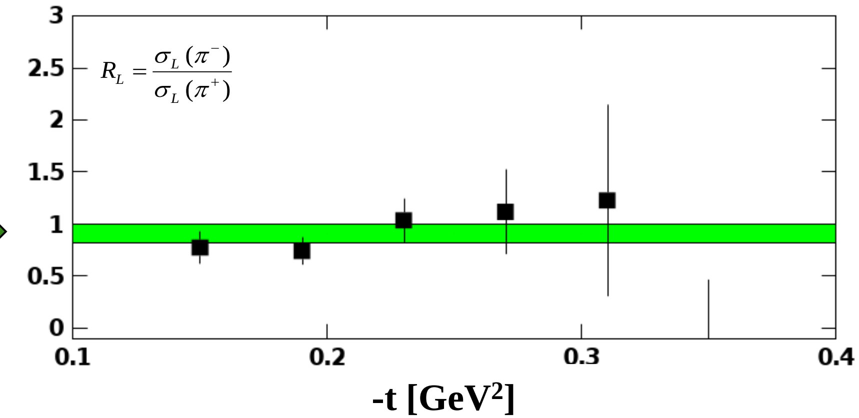
Experimental studies over the last decade have given *confidence* in the electroproduction method yielding the physical pion form factor

- Experimental studies include:
  - Take data covering a range in –t and compare with theoretical expectation
    - F_π values do not depend on -t – confidence in applicability of model to the kinematic regime of the data
  - Verify that the pion pole diagram is the dominant contribution in the reaction mechanism
    - R_L approaches the pion charge ratio, consistent with pion pole dominance

      *[Huber et al, PRL**112** (**2014**)182501]*
  - Extract F_π at several values of t_{min} for fixed Q^2

*[T. Horn, C.D. Roberts, J. Phys. G**43** (**2016**) no.7, 073001]*

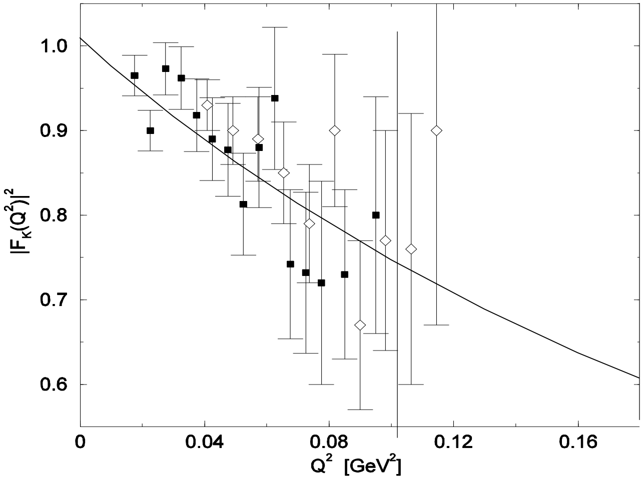


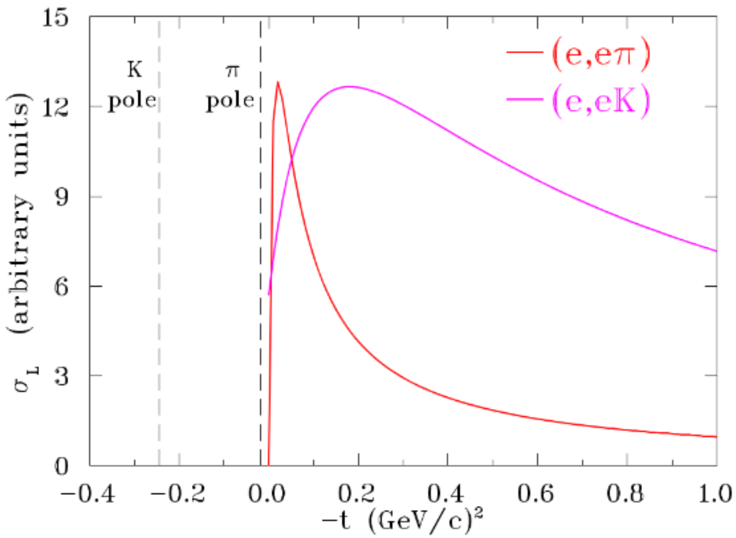


$$R_L = \frac{\sigma(n(e,e'\pi^-)p)}{\sigma(p(e,e'\pi^+)n))} = \frac{|A_v - A_s|^2}{|A_v + A_s|^2}$$

Extension to systems containing strangeness: the K^+ Form Factor

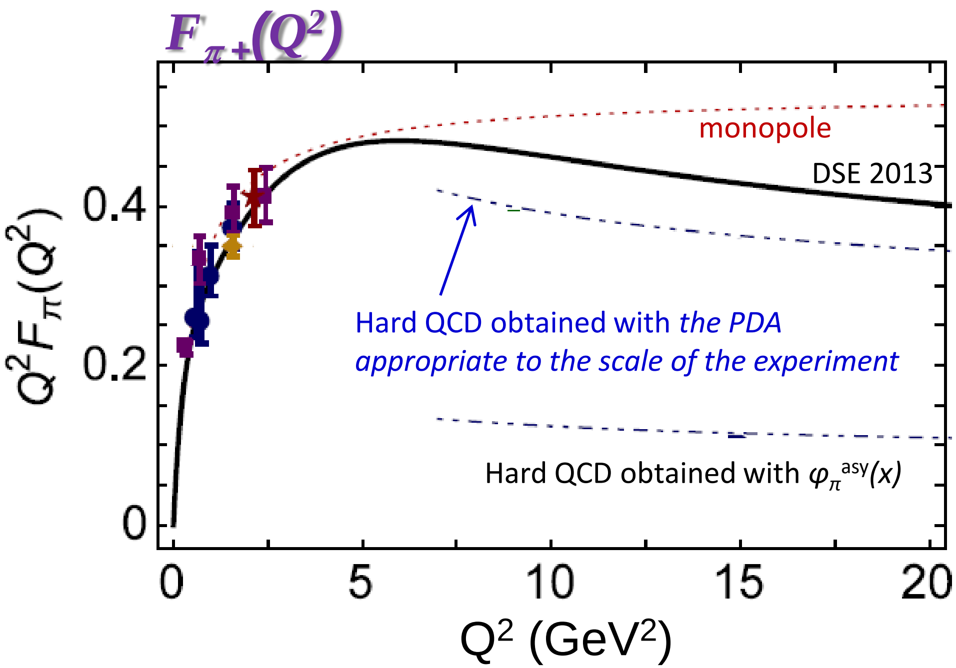
- Like for pions, elastic K^+ scattering from electrons used to measure charged kaon for factor at low Q^2
  - CERN SPS used 250 GeV kaons to measure form factor up to $Q^2 = 0.13$ GeV^2 *[Amendolia et al, PLB 178, 435 (1986)]*
  - These data used to constrain the kaon RMS radius: $r_K = 0.58 \pm 0.04$ fm

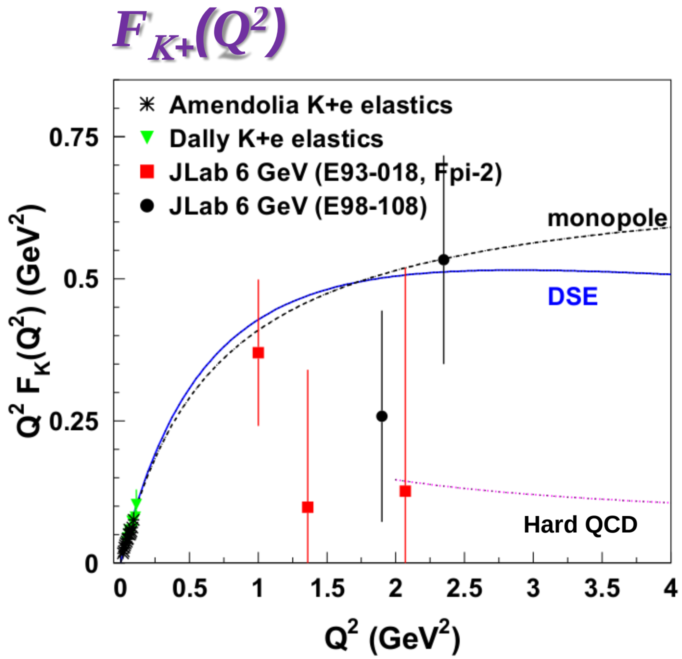




- Can "kaon cloud" of the proton be used in the same way as the pion to extract kaon form factor via ***p(e,e'K$^+$)Λ*** ?
  - ➢ *Need to quantify the role of the kaon pole*

$F_{\pi^+}(Q^2)$ and $F_{K^+}(Q^2)$ in 2018





[M. Carmignotto et al., Phys. Rev. C ***97*** *(****2018****) no.2, 025204]*

*[F. Gao et al., Phys. Rev. D 96 (****2017****) no. 3, 034024]*

- F*actor ~3* from hard QCD calculation evaluated with asymptotic valence-quark Distribution Amplitude (DA) *[L. Chang, et al., PRL* ***111*** *(2013) 141802; PRL* ***110*** *(****2013****) 1322001]*
  - Trend consistent with time like meson form factor data up to Q^2=18 GeV^2 *[Seth et al, PRL* ***110*** *(2013) 022002]*

- <u>Recent developments</u>: when comparing the hard QCD prediction with a pion valence-quark DA of a form appropriate to the scale accessible in experiments, magnitude is in better agreement with the data

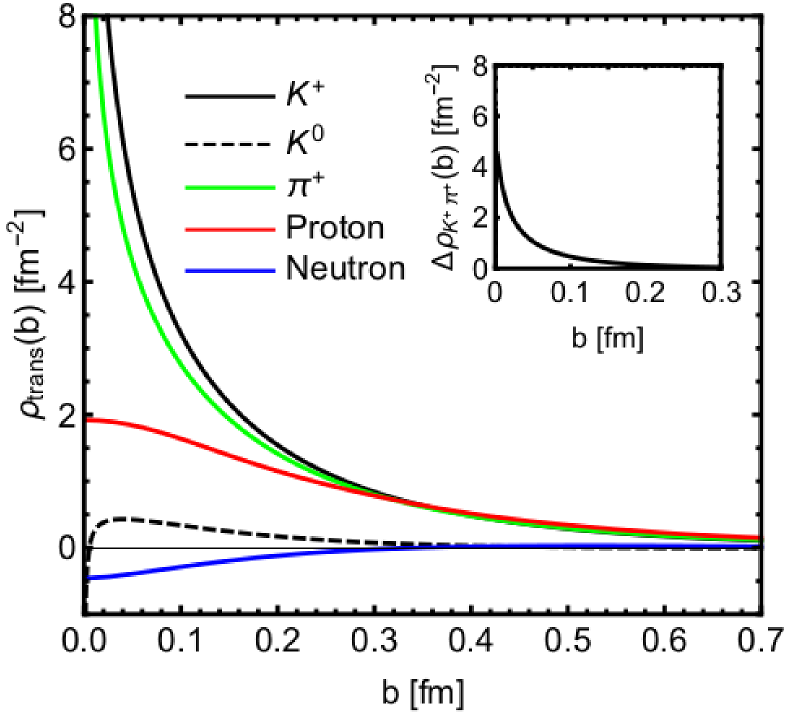
[I. Cloet, et al., PRL ***111*** *(2013) 092001]*

Pion and Kaon transverse Charge Density

- Transverse charge densities allow interpretation of FFs in terms of physical charge density and are also related to the Generalized Parton Distributions

*[M. Carmignotto et al., Phys. Rev. C**90** 025211 **(2014)**]*

*[N.A. Mecholsky et al., Phys. Rev. C**96** 065207 **(2017)**]*



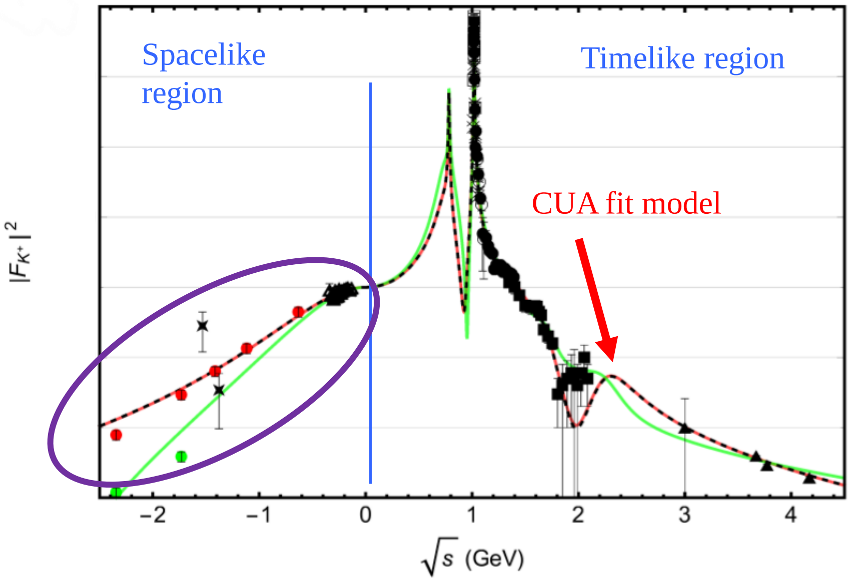
$$\rho_\pi(b) = \frac{1}{\pi R^2}\sum_{n=1}^{\infty} F_\pi(Q_n^2)\frac{J_0(X_n \frac{b}{R})}{[J_1(X_n)]^2} \qquad Q_n \equiv \frac{X_n}{R}$$

- Uncertainty in the analysis dominated by incompleteness error
  - Estimated using the monopole as upper bound and a light front model as lower bound

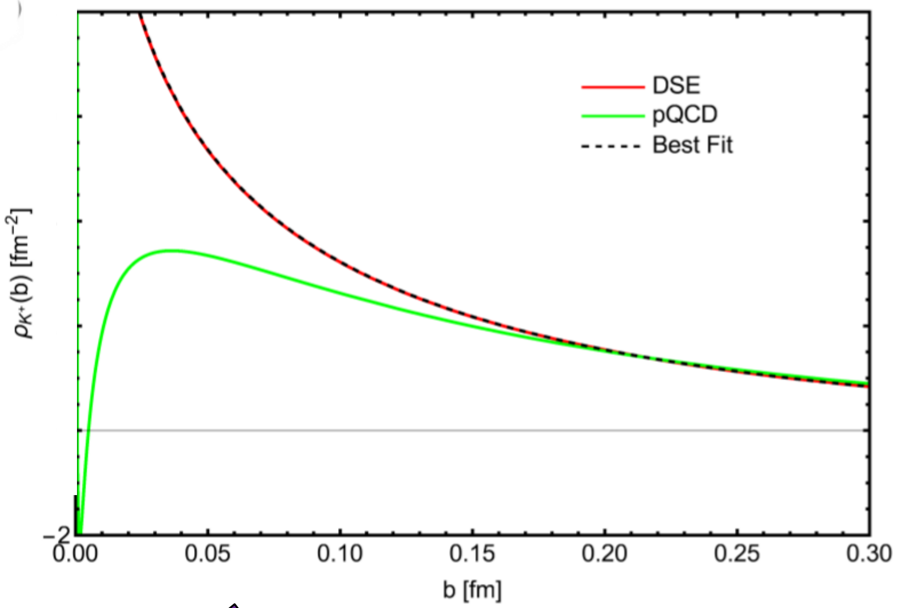
- ρ_π and ρ_p coalesce for *0.3 fm < b < 0.6 fm; and so does* ρ_{K^+}
- It would be interesting to extract the transverse charge density for different flavors

Impact of future data

$$F_K(t) = \frac{1}{\pi}\int_{4m_K^2}^{\infty} dt' \frac{\operatorname{Im} F_K(t')}{t' - t + i\varepsilon}$$



Transverse density assuming very different behavior of the form factor



Perhaps also interesting to see if any impact of mass-dependence of the meson form factor

*[N.A. Mecholsky et al., Phys. Rev. C**96** 065207 **(2017)**]*

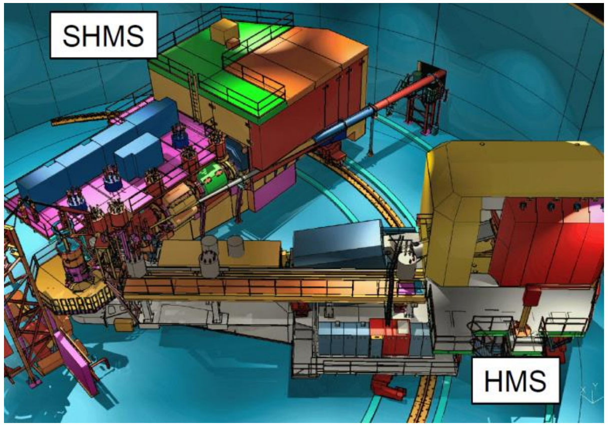
*[M. Chen, M Ding, L. Chang, C.D. Roberts, arXiv:1808.09461 **(2018)**]*

JLab12: F_π measurements

- CEBAF 10.9 GeV electron beam and SHMS small angle capability and controlled systematics are essential for extending precision measurements to higher Q^2

- The JLab 12 GeV π^+ experiments:
  - ***E12-06-101***: determine F_π up to Q^2=6 GeV^2 in a dedicated experiment
    - Require t_{min}<0.2 GeV^2 and $\Delta\varepsilon$>0.25 for L/T separation
    - Approved for 52 PAC days with "A" rating, high impact

    *E12-**06**-101 spokespersons: G. Huber, D. Gaskell*

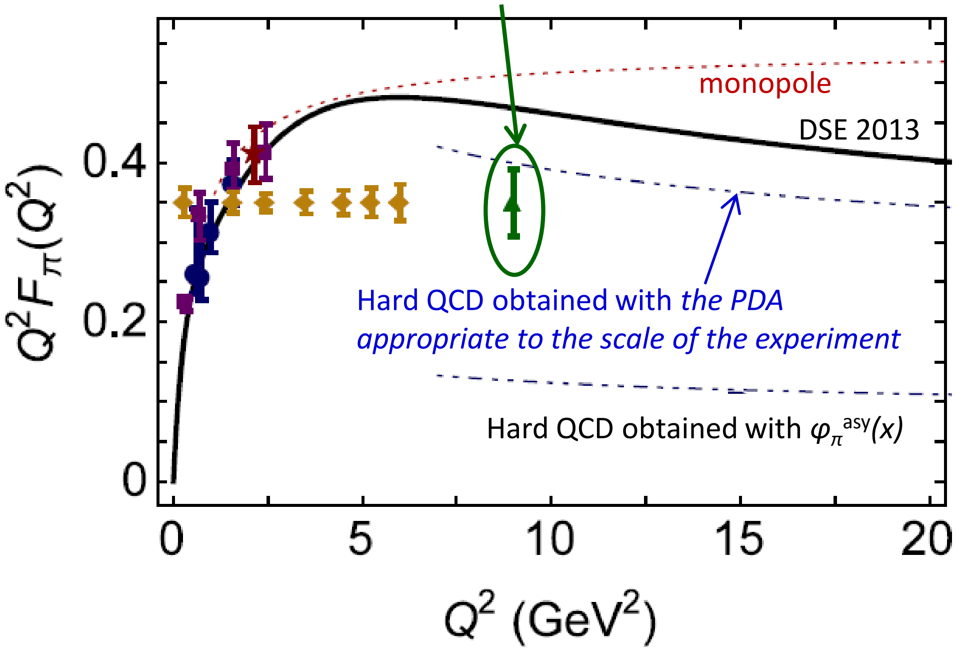


  - ***E12-07-105***: probe conditions for factorization of deep exclusive measurements in π^+ data to highest possible Q^2~9 GeV^2 with SHMS/HMS
    - Potential to extract F_π to the highest Q^2~9GeV^2 achievable at Jlab 12 GeV
    - Approved for 40 PAC days with "A-" rating

    *E12-**07**-105 spokespersons: T. Horn, G. Huber*

JLab12: F_π kinematic reach

Measurement at Q^2=8.5 GeV^2 and t_{min}~0.5 GeV^2



- JLab 12 GeV and HMS+SHMS in Hall C allow for:
  - Measurements of σ_L up to Q^2=8-9 GeV^2
  - Reliable F_π extractions from existing data to the highest possible Q^2
  - Validation of F_π extraction at highest Q^2

Projected precision using R from VR model and assumes pole dominance

JLab 12 GeV experiments have the potential to access the perturbative scaling regime quantitatively – may also provide info on log corrections.

These results would also have implications for nucleon structure interpretation.

JLab12: Opportunities for $F_{K+}(Q^2)$ Measurements

❑ E12-09-011: Possible K^+ form factor extraction to highest possible Q^2

*E12-**09**-011spokespersons: T. Horn, G. Huber, P. Markowitz*

- Extraction like in the pion case by studying the model dependence at small t
- Comparative extractions of F_π at small and larger t show only modest model dependence
  - larger t data lie at a similar distance from pole as kaon data

❑ Recent theoretical efforts to understand role of the strange quark

*[F. Gao et al., Phys. Rev. D 96 (**2017**) no. 3, 034024]*

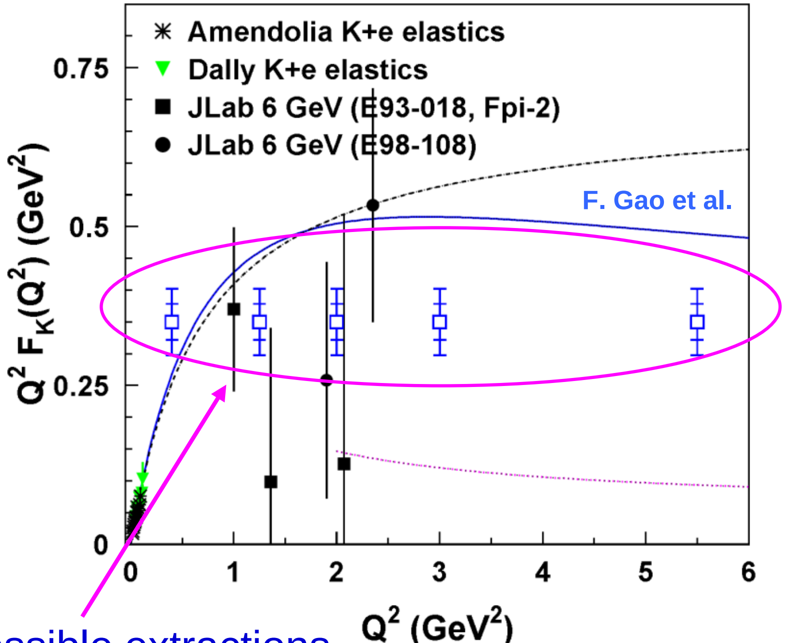
*[P.T.P. Hutauruk et al., Phys. Rev. C **94 (2016)** 035201]*

*[C. Chen et al., Phys. Rev. D **93 (2016)** no. 7, 074021]*

*[S-S Xu et al., arXiv:1802.09552 (**2018**)]*

*[T. Horn, C.D. Roberts, J. Phys. G**43** (**2016**) no.7, 073001]*

*[M. Carmignotto et al., Phys. Rev. C**97** (**2018**) no.2, 025204]*



Possible extractions from 2018/19 run

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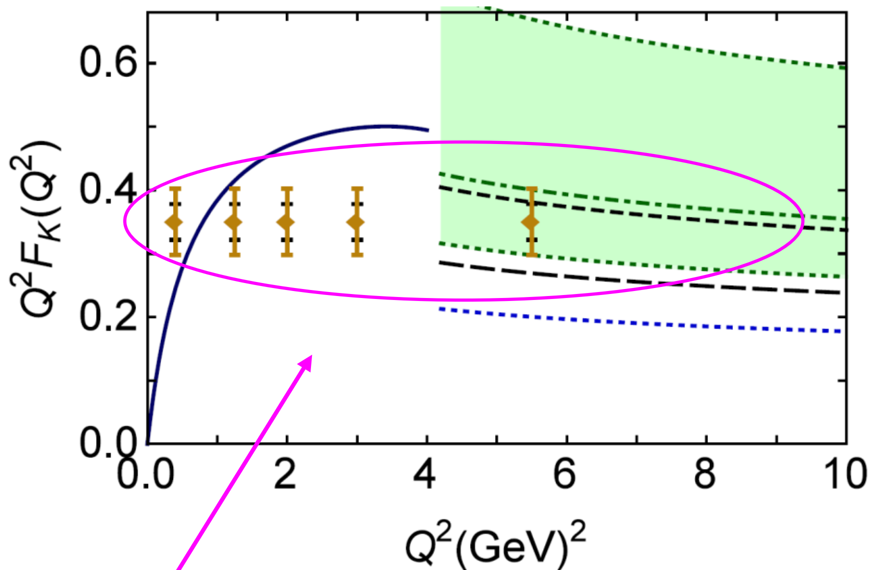

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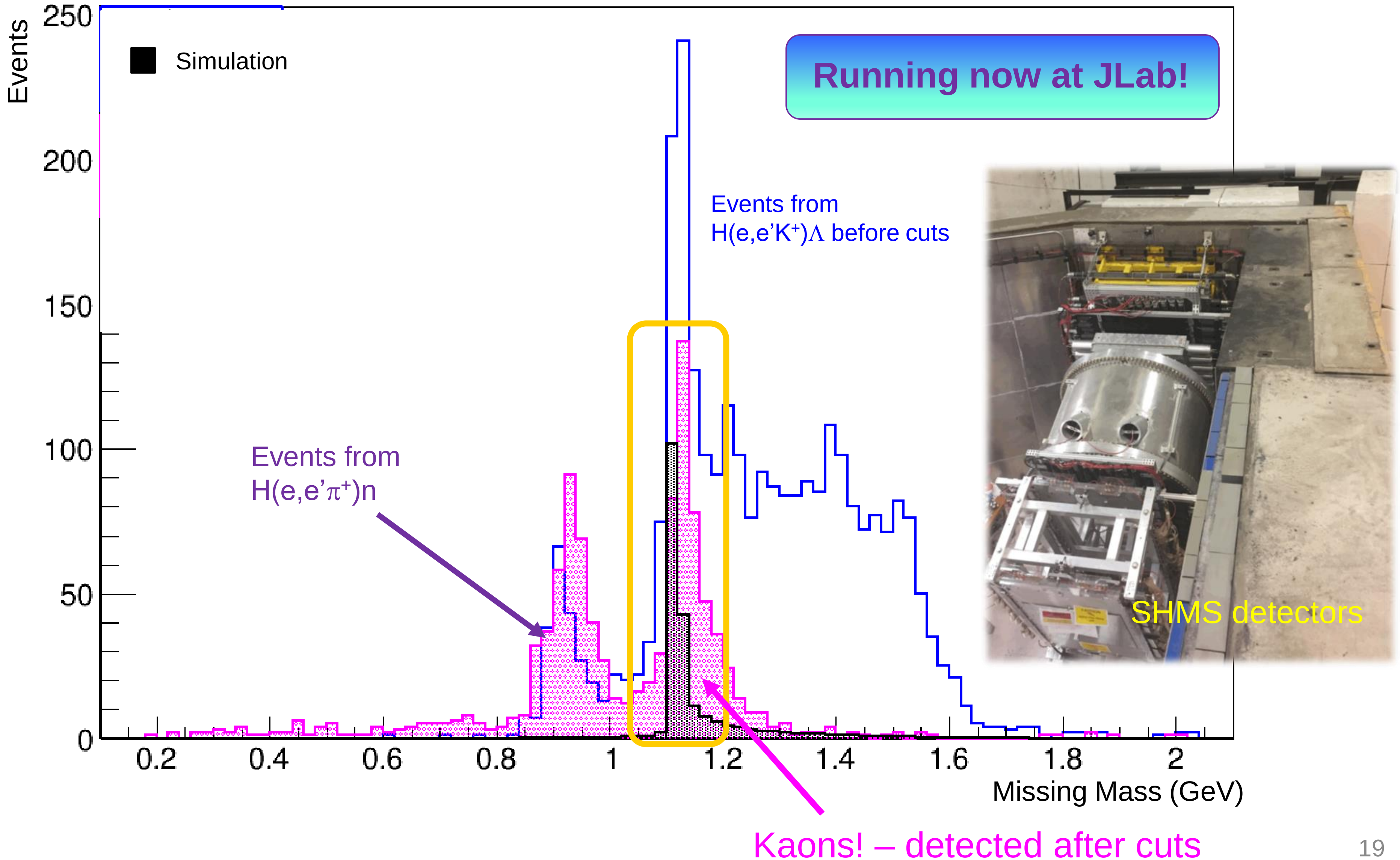
*[S-S Xu et al., arXiv:1802.09552 (**2018**)]*

First Exclusive Kaons from 2018 Data!



Exploring the 3D Nucleon Structure

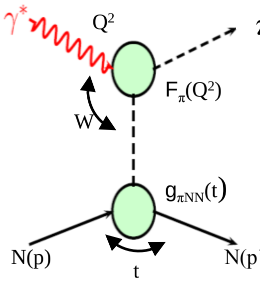
- After decades of study of the partonic structure of the nucleon we finally have the experimental and theoretical tools to systematically move beyond a 1D momentum fraction (x_{Bj}) picture of the nucleon.
  - High luminosity, large acceptance experiments with polarized beams and targets.
  - Theoretical description of the nucleon in terms of a 5D Wigner distribution that can be used to encode both 3D momentum and transverse spatial distributions.

- Deep Exclusive Scattering (DES) cross sections give sensitivity to electron-quark scattering off quarks with longitudinal momentum fraction (Bjorken) x at a transverse location b.

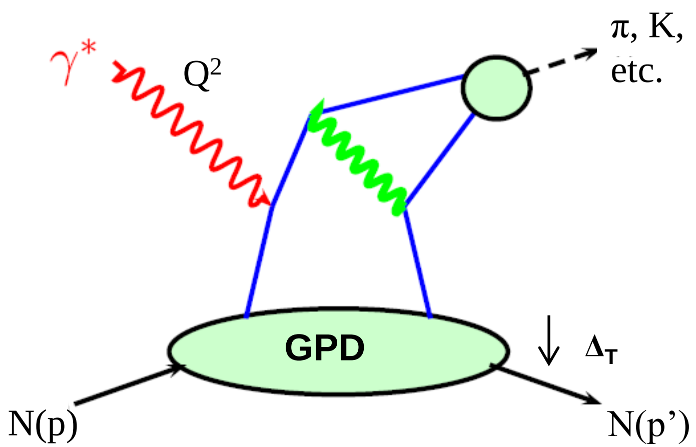
See also talk by H. Moutarde

- Semi-Inclusive Deep Inelastic Scattering (SIDIS) cross sections depend on transverse momentum of hadron, $P_{h\perp}$, but this arises from both intrinsic transverse momentum (k_T) of a parton and transverse momentum (p_T) created during the [parton → hadron] fragmentation process.

Towards GPD flavor decomposition: DVMP



- Relative contribution of σ_L and σ_T to cross section are of great interest for nucleon structure studies



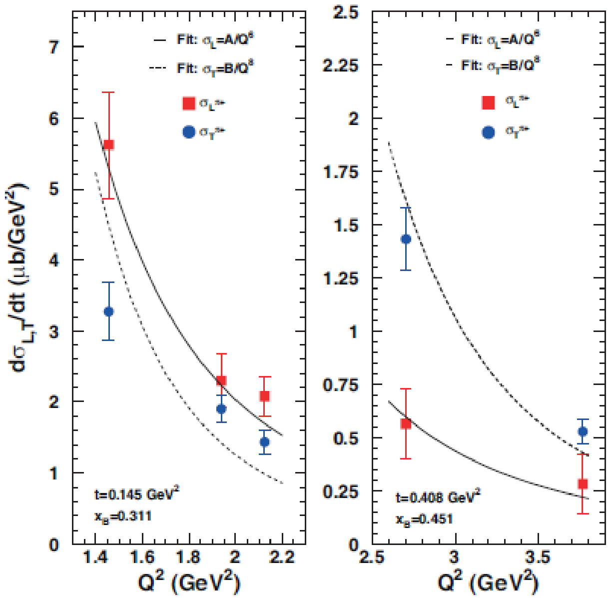
- described by 4 (helicity non-flip) GPDs:
  - *H, E* (unpolarized), $\tilde{H}$, $\tilde{E}$ (polarized)
- Quantum numbers in DVMP probe individual GPD components selectively
  - Vector : ρ°/ρ+/*K** select *H, E*
  - **Pseudoscalar: π,η,*K* select the polarized GPDs, $\tilde{H}$ and $\tilde{E}$**
- Reaction mechanism can be verified experimentally - **L/T separated cross sections to test QCD Factorization**

- Recent calculations suggest that leading-twist behavior for light mesons may be reached at Q^2=5-10 GeV^2
- JLab 12 GeV can provide experimental confirmation in the few GeV regime

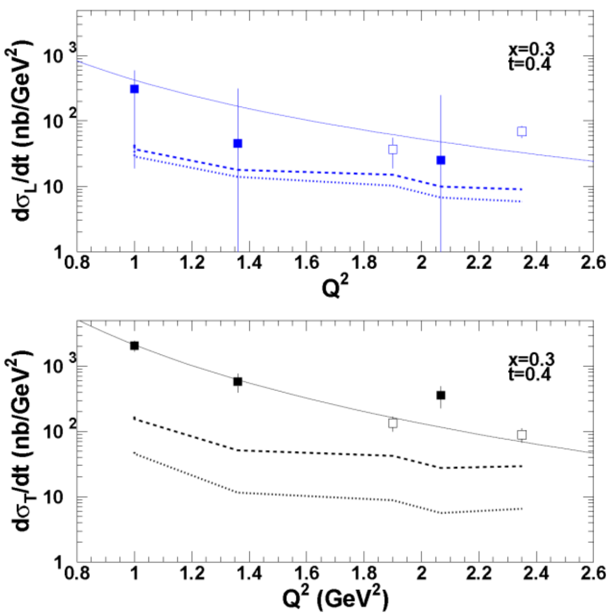
Results from 6 GeV JLab

- Data demonstrate the technique of measuring the Q^2 dependence of L/T separated cross sections at fixed x/t to test QCD Factorization
  - Consistent with expected factorization, but small lever arm and relatively large uncertainties
  - GPD models cannot reproduce ρ^0 data at small W

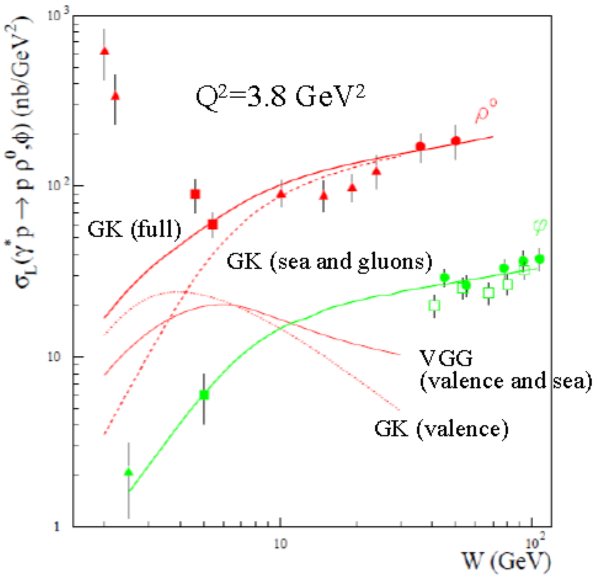
π^+ *[T. Horn et al., Phys. Rev. C* ***78****, 058201* ***(2008)****]*



K^+ *[M. Carmignotto et al., Phys. Rev. C97 (2018) no.2, 025204]*



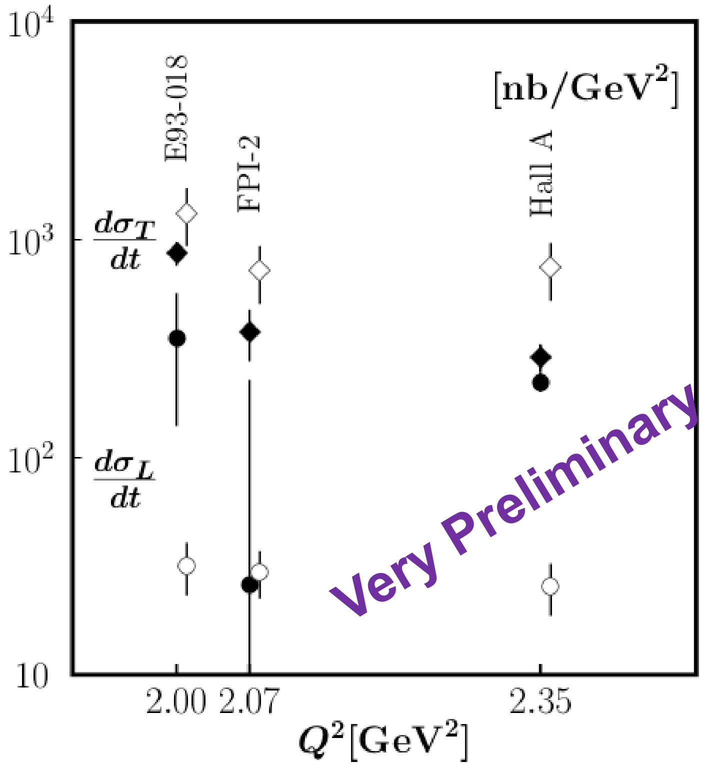
ρ^0



[L. Favart, M. Guidal, T. Horn, P. Kroll, Eur. Phys. J A 52 (2016) no.6, 158]

Kaon L/T: First Comparison with Models

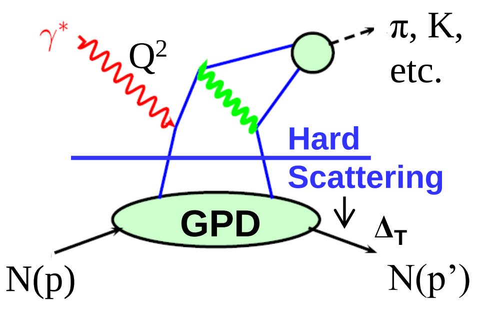
Here, compare with P. Kroll's GPD model (circles=σ_L, diamonds=σ_T)

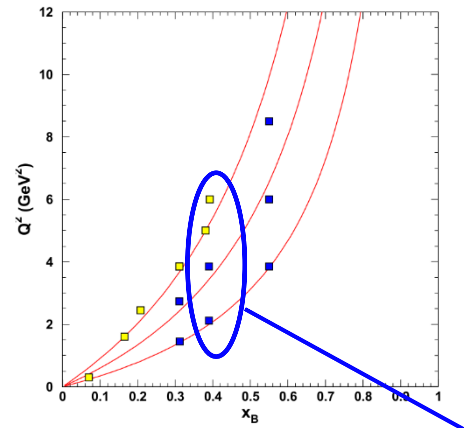


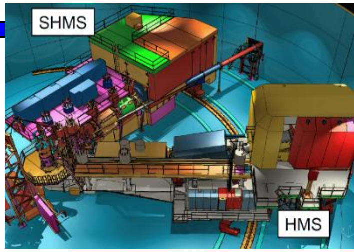
- Solid symbols are data
  - σ_L is comparable to σ_T at Q^2=2.4 GeV^2
- Open symbols model calculations
  - Model overpredicts σ_T
  - Model underpredicts σ_L

- Separated cross section data over a large range in Q^2 are essential for:
  - Testing factorization and understanding dynamical effects in both Q^2 and –t kinematics
  - Interpretation of non-perturbative contributions in experimentally accessible kinematics

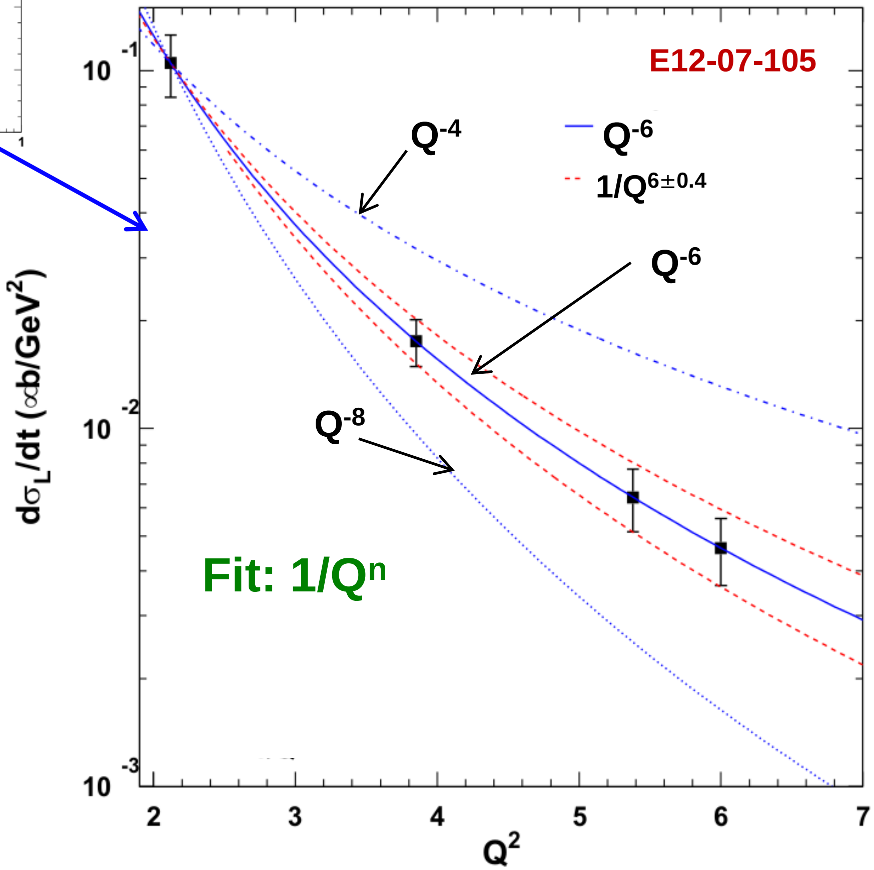
JLab12: confirming potential for nucleon structure studies with pion production







*E12-**07**-105 spokespersons: T. Horn, G. Huber*

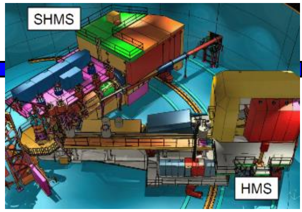


- **E12-07-105 (P12):** Measure the Q^2 dependence of the π electro production cross section at fixed x and -t
  - Factorisation theorem predicts σ_L scales to leading order as Q^{-6}

x	Q^2 (GeV^2)	W (GeV)	-t $(GeV/c)^2$
0.3	1.5-2.7	2.0-2.6	0.1
0.4	2.1-6.0	2.0-3.2	0.2
0.5	3.9-8.5	2.0-2.8	0.5

Considered for running **in 2020+**

JLab12: confirming potential for nucleon structure studies with kaon production



- **E12-09-011 (KAONLT)**: Separated L/T/LT/TT cross section over a wide range of Q^2 and t

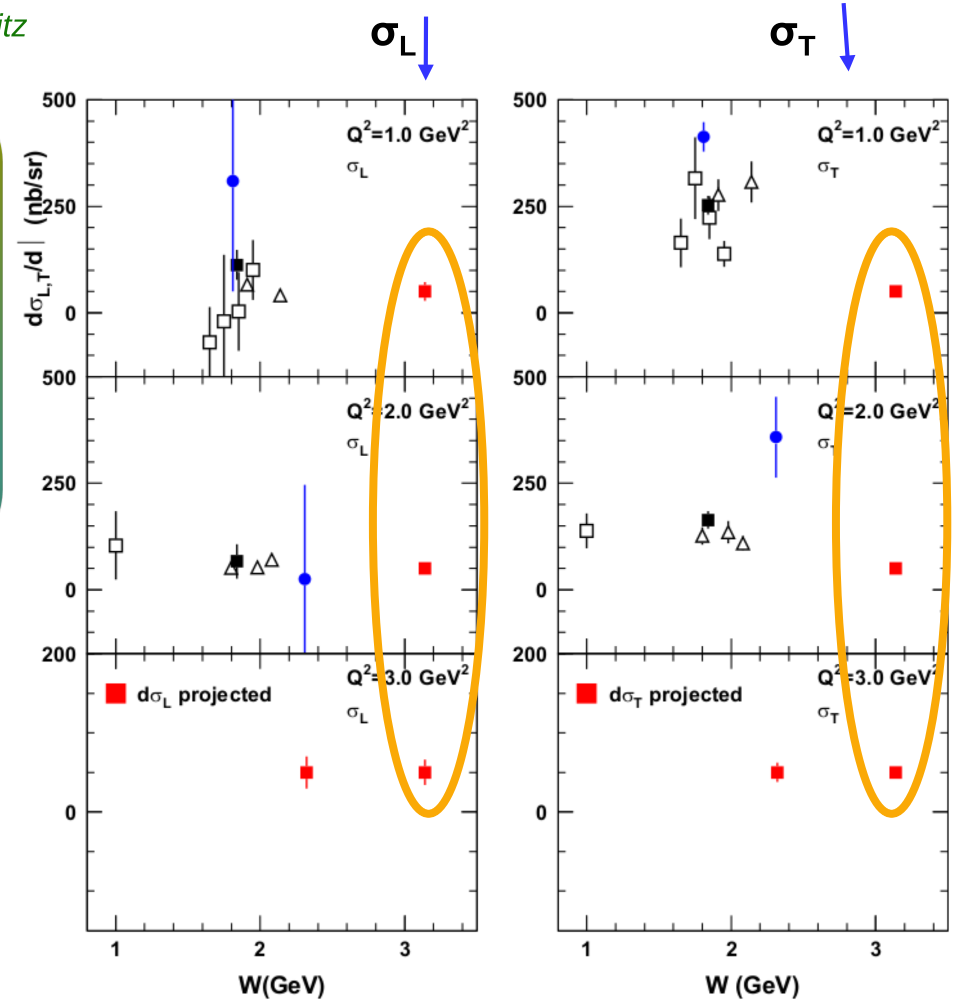
*E12-**09**-011 spokespersons: T. Horn, G. Huber, P. Markowitz*

JLab 12 GeV Kaon Program features:

- First cross section data for Q^2 scaling tests with kaons
- Highest Q^2 for L/T separated kaon electroproduction cross section
- First separated kaon cross section measurement above W=2.2 GeV

Now running in Hall C at Jlab (2018/19)

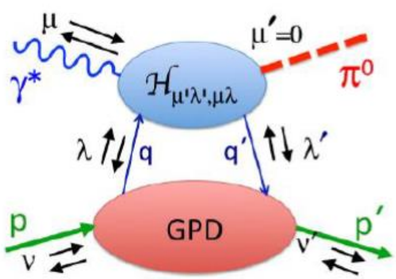
x	Q^2 (GeV^2)	W (GeV)	-t $(GeV/c)^2$
0.1-0.2	0.4-3.0	2.5-3.1	0.06-0.2
0.25	1.7-3.5	2.5-3.4	0.2
0.40	3.0-5.5	2.3-3.0	0.5



[blue points from M. Carmignotto, PhD thesis **(2017)**]

Transverse Contributions may allow for probing a new set of GPDs

See also talk by H. Moutarde



$$\widetilde{H}^{\pi} = \frac{1}{3\sqrt{2}}\left[2\widetilde{H}^{u} + \widetilde{H}^{d}\right]$$

- ❑ 4 Chiral-odd GPDs (parton helicity flip)

- ❑ A large transverse cross section in meson production may allow for accessing helicity flip GPDs

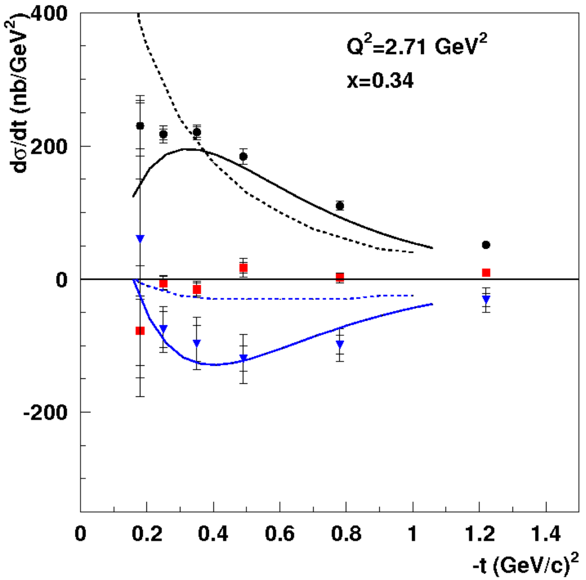
$$\sigma_T = \frac{4\pi\alpha_e}{2\kappa}\frac{\mu_\pi^{\ 2}}{Q^4}\left[(1-\xi^2)|\langle H_T \rangle|^2 - \frac{t'}{8m^2}|\langle \bar{E}_T \rangle|^2\right]$$

- ➢ Model predictions based on handbag in good agreement with 6 GeV data

  *[Goloskokov, Kroll, EPJ C65, 137 (2010); EPJ A**45**, 112 (**2011**)]*

  *[Goldstein, Gonzalez Hernandez, Liuti, J. Phys. G **39 (2012)** 115001]*

  *[Ahmad, Goldstein, Liuti, PRD **79 (2009)**]*



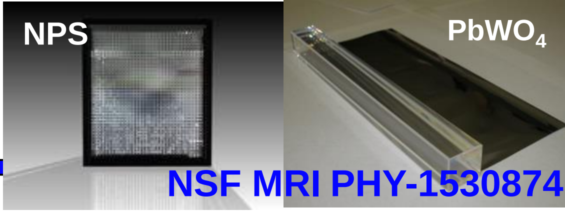
*[Favart, Guidal, Horn, Kroll , EPJA (**2016**)]*

*[Bedlinskiy et al. PRL 109 (**2012**) 112001]*

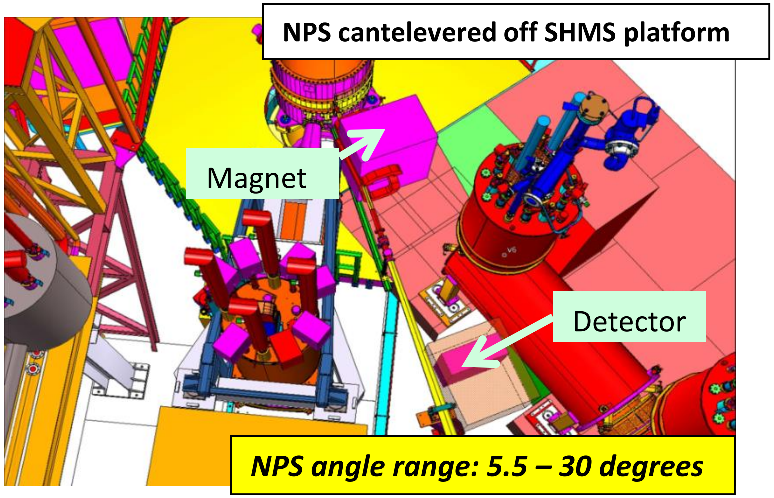
- ❑ JLab 12 GeV will provide relative σ_L and σ_T contributions to the π^0 cross section up Q^2~6 GeV^2 to verify reaction mechanism

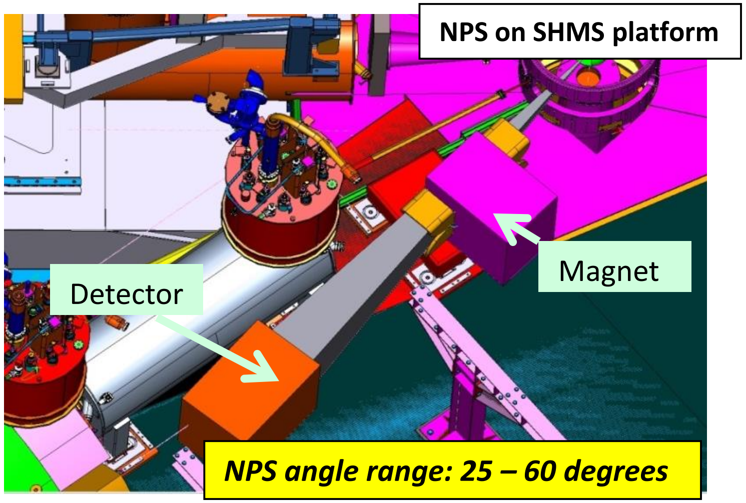
- ➢ Exclusive π^0 data may also be helpful for constraining non-pole contributions in F_π extraction

New Opportunities with the Neutral Particle Spectrometer (NPS)



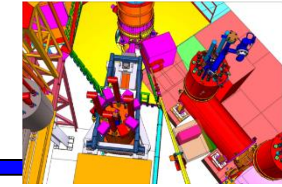
- The NPS is envisioned as a facility in Hall C, utilizing the well-understood HMS and the SHMS infrastructure, to allow for precision (coincidence) cross section measurements of neutral particles (γ and π^0).



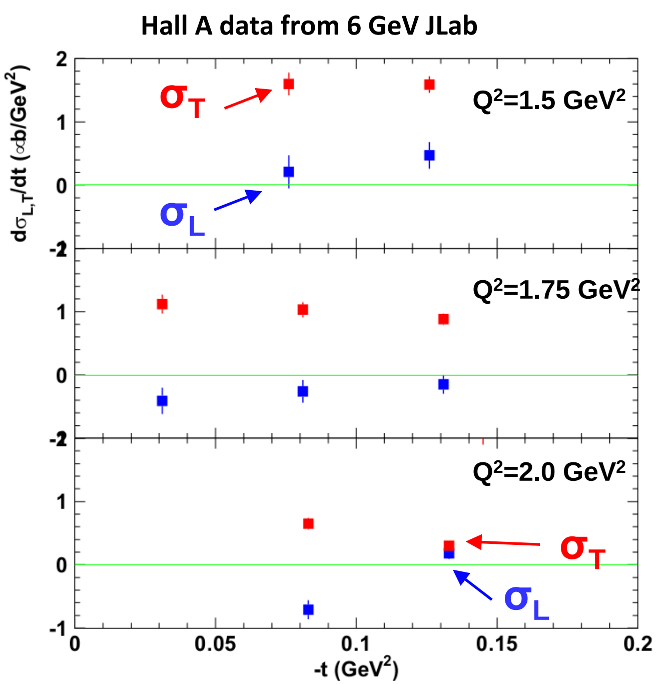


- Approved experiments to date
  - E12-13-010 – Exclusive Deeply Virtual Compton and π^0 Cross Section Measurements in Hall C
  - E12-13-007: Measurement of Semi-inclusive π^0 production as Validation of Factorization
  - E12-14-003 – Wide-angle Compton Scattering at 8 and 10 GeV Photon Energies
  - E12-14-005 – Wide Angle Exclusive Photoproduction of π^0 Mesons
  - E12-17-008 – Polarization Observables in Wide-Angle Compton Scattering
- Conditionally approved experiments: TCS with transverse target

E12-13-010: Exclusive π^0 cross section

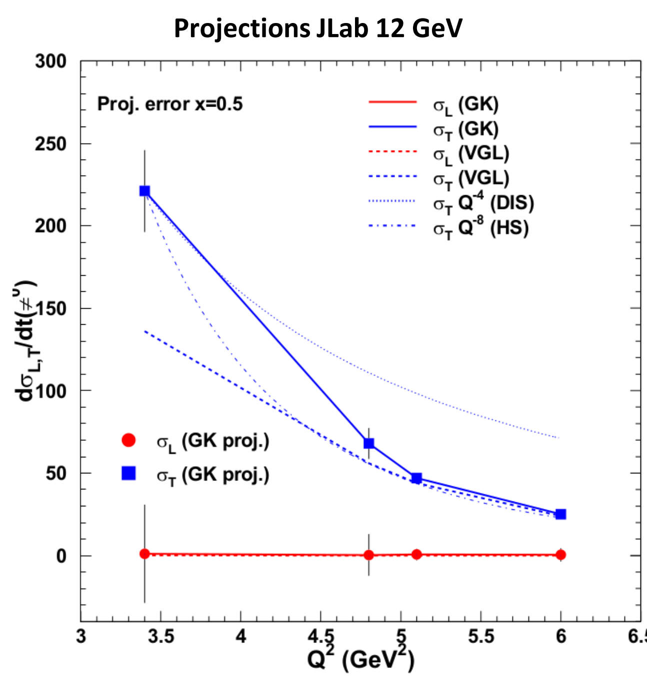


- Relative L/T contribution to π^0 cross section important in probing transversity
  - If σ_T large: access to transversity GPDs
- Results from Hall A suggest that σ_L in π^0 production is non-zero up to Q^2=2 GeV^2
- Need to understand Q^2/t dependence for final conclusion on dominance of σ_T



*M. Defurne et al, PRL **117** (**2016**) no.26, 262001*

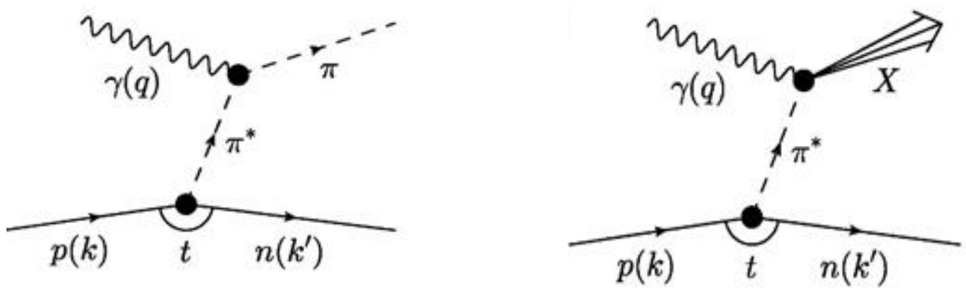
E12-13-010 projections



E12-13-010 will provide essential data on σ_T and σ_L at higher Q^2 for reliable interpretation of 12 GeV GPD data

Towards the Pion/Kaon Structure Function

- Is there anything besides the meson elastic form factors that can be learned by isolating the One Pion Exchange Contribution?



- Sullivan was the first to consider the "Drell" process, with π+X final states where m_X^2 grows linearly with Q^2

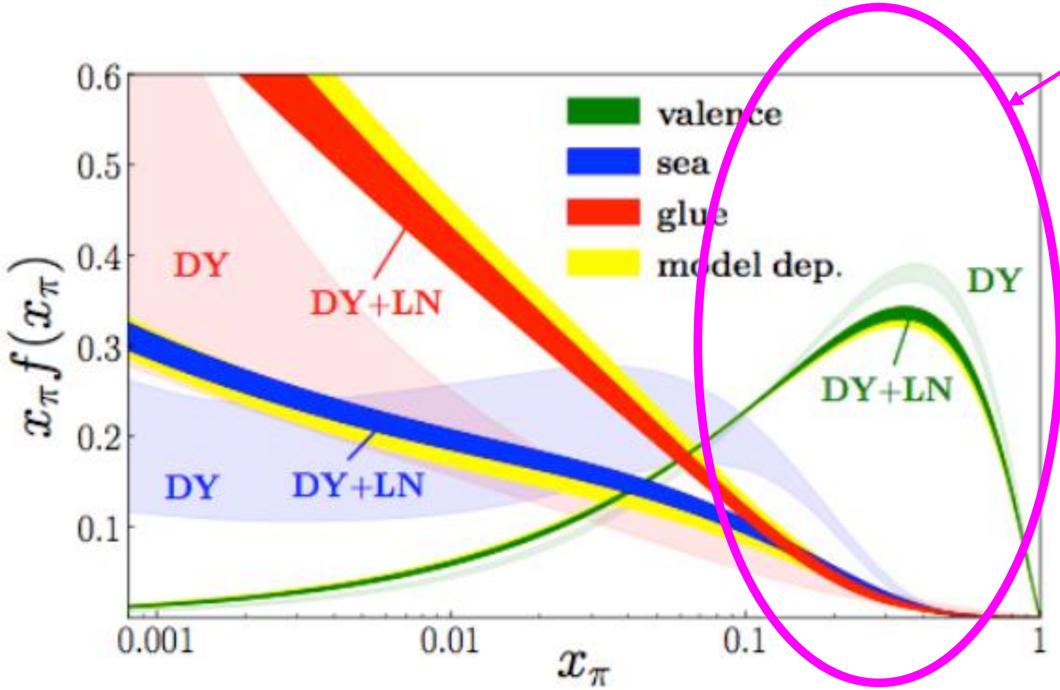
- A simple calculation gives the minimum momentum transfer squared $t_{min} = (q-k)^2_{min} \to \infty$ as $Q^2 \to \infty$
  - The requirement of being near the pion pole at $t = m_\pi^2$ can never be satisfied and processes of this type play no role in the scaling region

- Similar consideration for offshellness as for meson FF – a well-constrained experimental analysis should be reliable in regions of -t

Pion and Kaon Structure Functions

See also talks by S. Platchkov and T. Keppel

- ❑ First MC global QCD analysis of pion PDFs
  - ➢ Using Fermilab DY and HERA Leading Neutron data



- ❑ JLab 12 GeV: Tagged Pion and Kaon TDIS
- ❑ Also prospects for kaon DY at COMPASS and pion and kaon LN at EIC

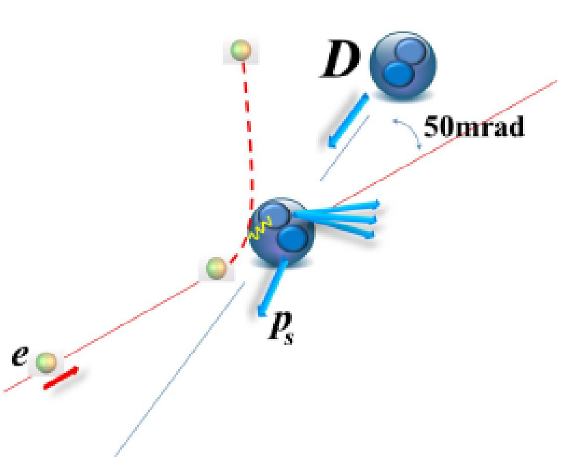
DY = πN Drell-Yan

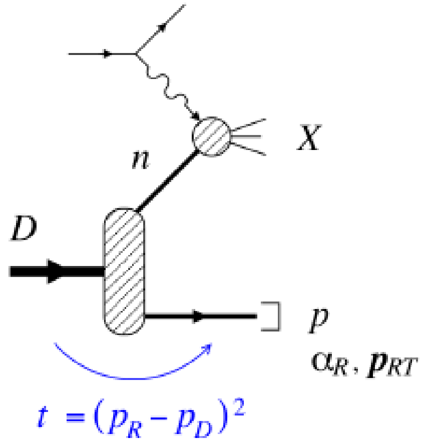
LN = Leading Neutron

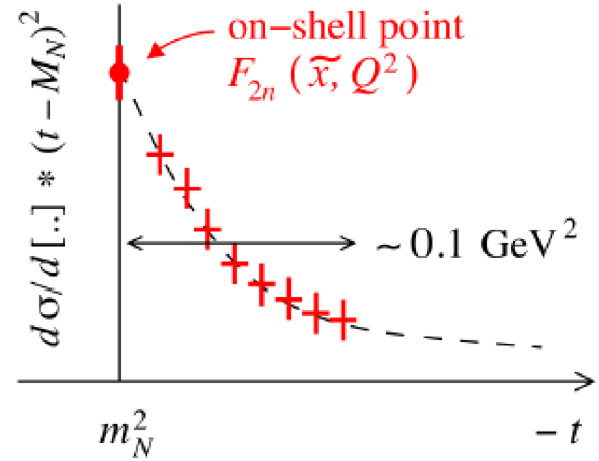
]Barry, Sato, Melnitchouk, Ji (2018, arXiv:1804.01965)]

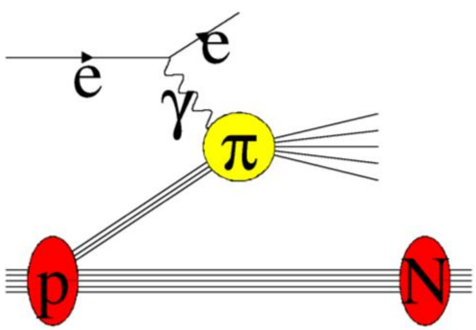
- ➢ Significant reduction of uncertainties on sea quark and gluon distributions in the pion with inclusion of HERA leading neutron data
- ➢ Implications for “TDIS” (Tagged DIS) experiments at JLab

Pion and Kaon Structure Functions at EIC – Versatility is Key









- ❑ Obtain F_2^n by tagging spectator proton from e-d, and extrapolate to on-shell neutron to correct for binding and motion effects.
- ❑ Obtain F_2^π and F_2^K by Sullivan process and extrapolate the measured t-dependence as compared to DSE-based models.

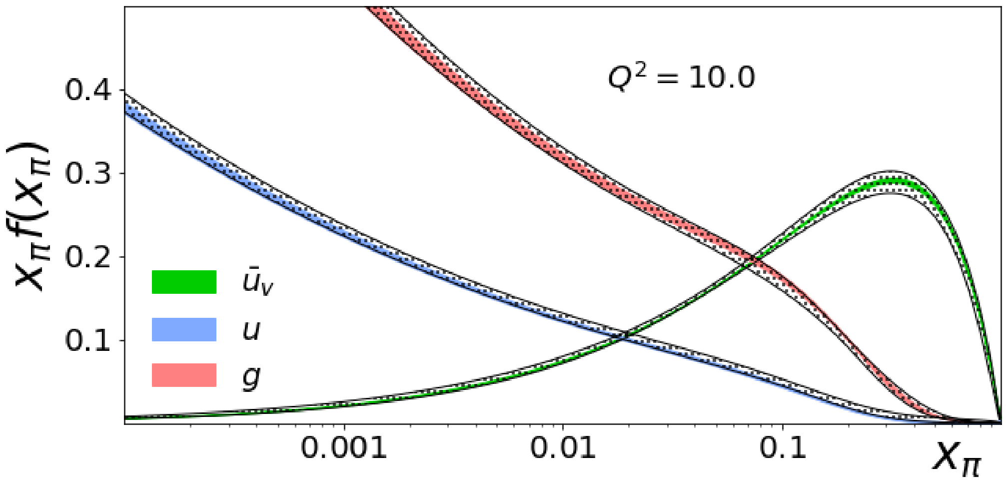
Need excellent detection capabilities, and good resolution in –t

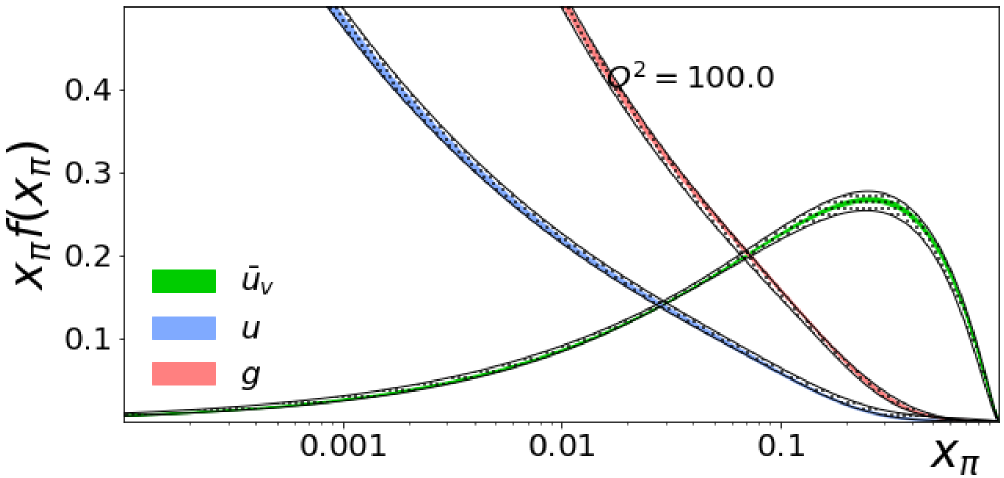
→ See talk by T. Keppel

Global Fits with Existing Data and EIC Projections

- 5 GeV(e^-) x 100 GeV(p)
- 0.1 < y < 0.8
- EIC pseudodata fitted with existing data
- Work ongoing:
  - Why did the curves shift?
  - The pion D-Y data, even if not many, already do constrain the curves surprisingly well – due to the various sum rules?
  - Curves to improve with the EIC projections, especially for kaon as will have similar-quality data.

Precision gluon constraints of pion and kaon pdfs are possible.

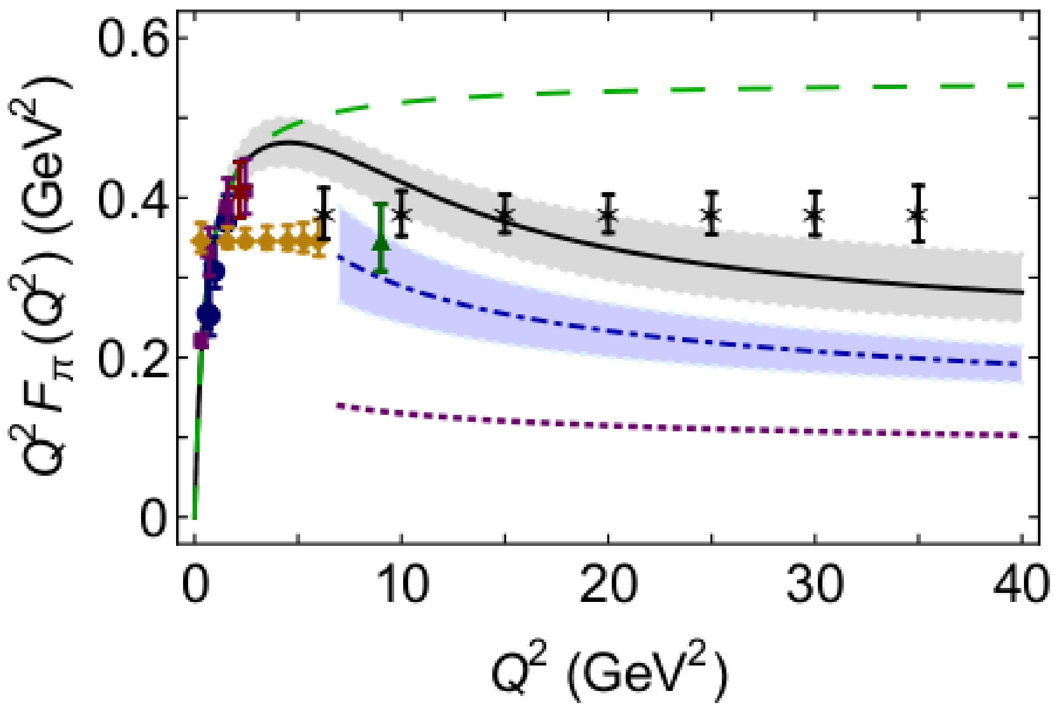




R. Trotta, V. Berdnikov, N. Mecholsky, T. Horn, I. Pegg, N. Sato et al., 2018+

EIC: F_π Measurements

1. VR model shows strong dominance of σ_L at small –t at large Q^2.
2. Assume σ_L dominance
3. Measure the π^-/π^+ ratio to verify – it will be diluted (smaller than unity) if σ_T is not small, or if non-pole backgrounds are large



- ❑ 5 GeV(e^-) x 100 GeV(p)
- ❑ Integrated luminosity: L=20 fb^{-1}/yr
- ❑ Identification of exclusive p(e,e'π^+)n events
- ❑ 10% exp. syst. unc.
- ❑ $R=\sigma_L/\sigma_T$ from VR model, and π pole dominance at small t confirmed in ^2H π^-/π^+ ratios
- ❑ 100% syst. unc. in model subtraction to isolate σ_L

Can we measure kaon form factor at EIC?

Adapted from Garth Huber slides (PIEIC2018)

Summary

- Meson form factor measurements play an important role in our understanding of the structure and interactions of hadrons based on the principles of QCD

- Meson form factor measurements in the space-like region at Q^2>~0.3 GeV^2
  - In general, require a model to extract the form factor at physical meson mass – experimental validation of the extraction is essential
  - K^+ requires experimental verification of pole dominance in σ_L
  - π^+ form factor: reliable measurements up to Q^2=2.45 GeV^2 from JLab 6 GeV

- JLab 12 GeV will dramatically improve the $\pi^+/K^+/\pi^0$ electroproduction data set
  - Pion and kaon form factor extractions up to high Q^2 possible (~9 and ~6 GeV^2)
  - Kaon experiment scheduled to run in 2017/18
  - L/T separated cross sections important for transverse nucleon structure studies – may allow for accessing new type of GPDs

- Beyond 12 GeV, EIC provides interesting opportunities to map pion and kaon structure functions over a large (x, Q^2) landscape – White Paper in progress…