THE CHARGED KAON ELECTROMAGNETIC FORM FACTOR AT JEFFERSON LAB

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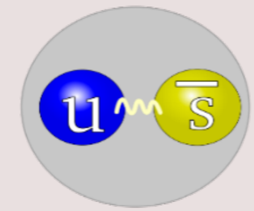
Meson Form Factor

Kaon Form Factor, $F_K(Q^2)$

Kaon is an important candidate for the meson internal structure studies

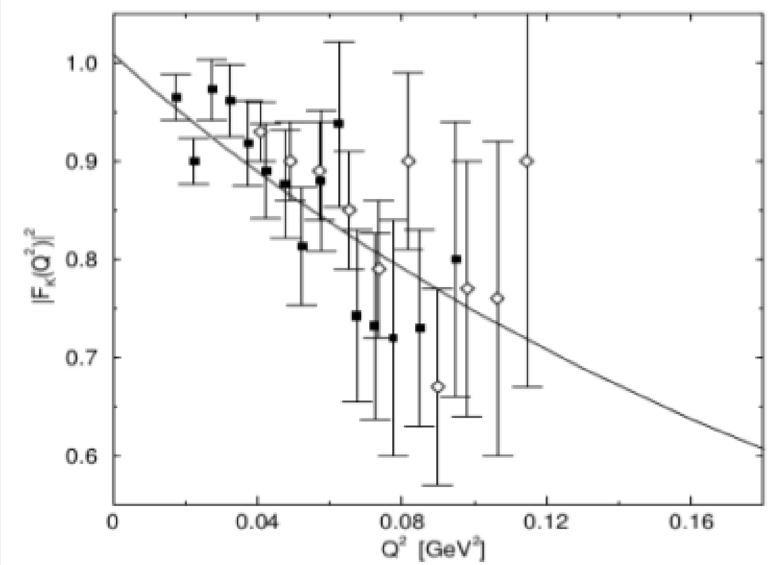
Clearest case for studying the effect in internal structure of hadron when replacing a lighter quark (d) in Pion with the heavier one (s)



K^+

Direct method

At very low Q^2



[Amendolia, et al., PL **B178** (1986) 435]

Q^2 , four-momenta of the exchange virtual photon

$$\sqrt{< r_K^2 >} = 0.53 \pm 0.05 fm$$

$F_K(Q^2)$ at Jefferson Lab Regime

$F_K(Q^2)$ can also be extracted using an indirect technique

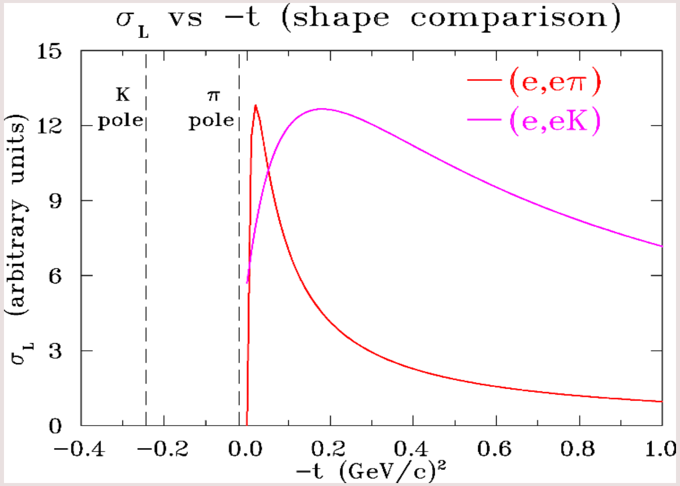
Kaon cloud of the proton can be used to scatter an electron

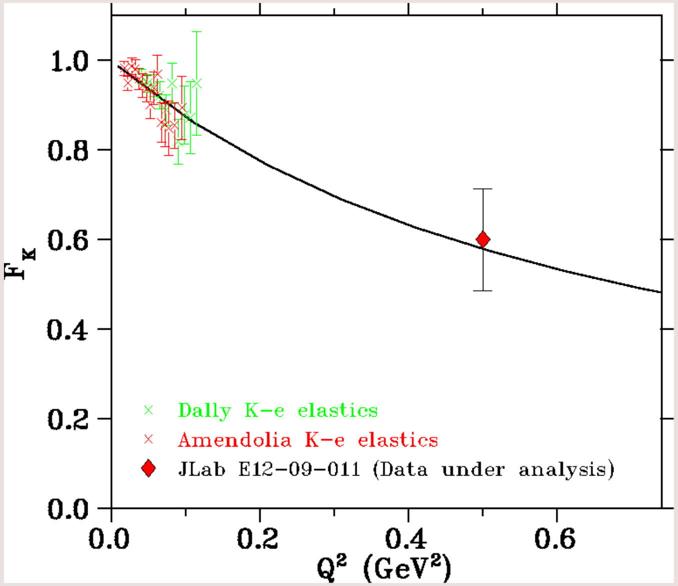
Measurements at low Q^2 are imperative to understand the indirect technique

Models are required to extract the form factor from the separated longitudinal cross section

Born term model

$$\frac{d\sigma_L}{dt} \propto \frac{-tQ^2}{(t-m_K^2)} g^2_{K\Lambda N}(t)\, F_K^2(Q^2,t)$$



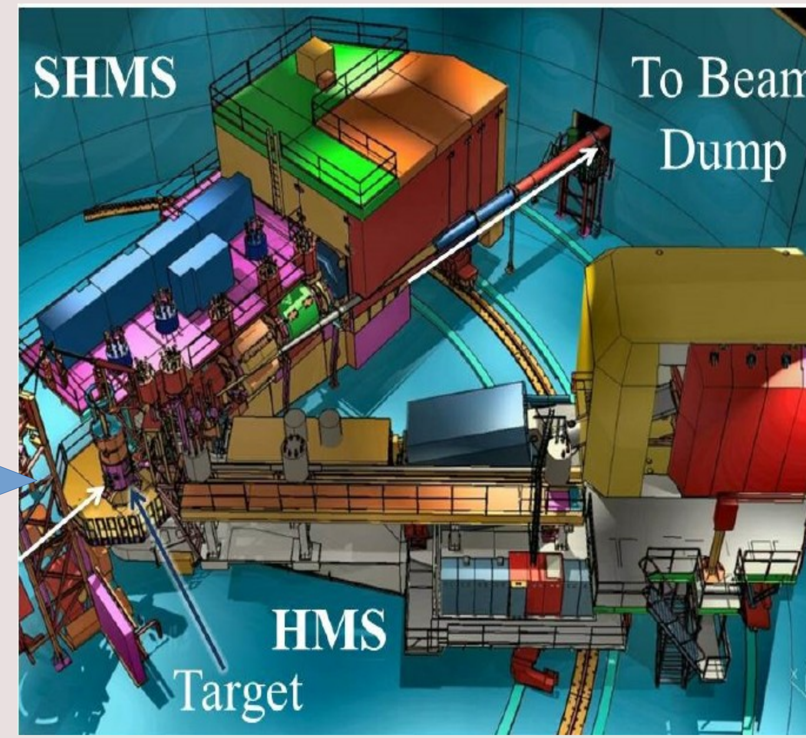


Jefferson Lab and Experiment

Jefferson Lab: Located at Newport News, Virginia USA

Continuous Electron Beam Accelerator Facility (CEBAF)

Electron beam (E_b) **3 - 12 GeV**



SHMS → Super High Momentum Spectrometer

HMS → High Momentum Spectrometer

Hall C

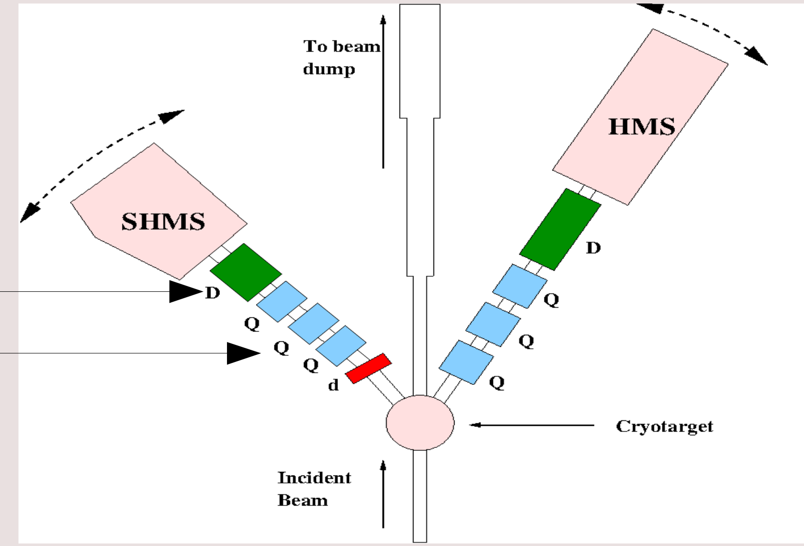
Magnetic dipole is used to select the particles of specific momentum range

SHMS angles 5.5 – 40 deg

SHMS momenta 0.5 – 11.0 GeV/c

Dipole

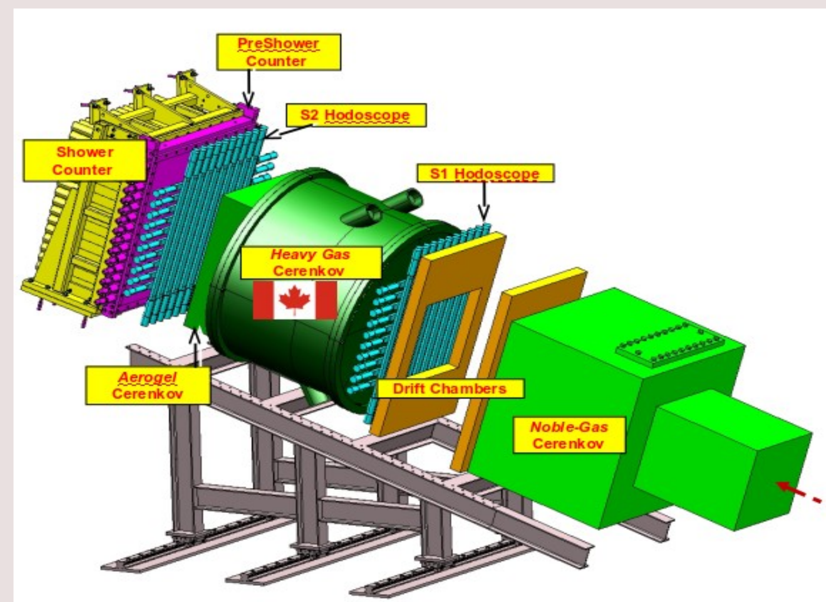
Quadrupole



HMS angles 10.5 – 90 deg

HMS momenta 0.5 – 7.0 GeV/c

SHMS detectors stack



KaonLT Experiment (E12-09-011)

Exclusive KaonLT experiment's reaction systems

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

$$M_\Lambda = 1115.68\ MeV^2/c^2$$

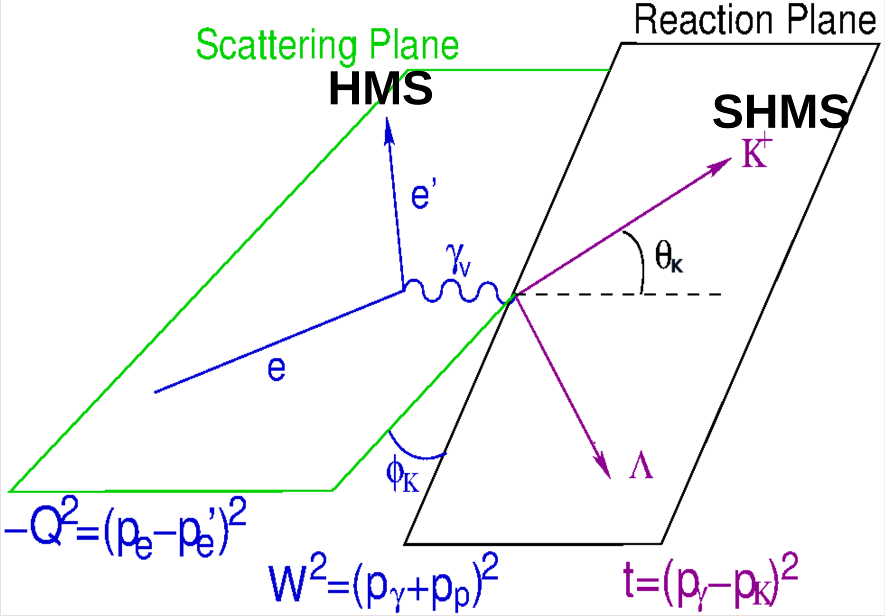
$$e + p \rightarrow e' + K^+ + \Sigma^0$$

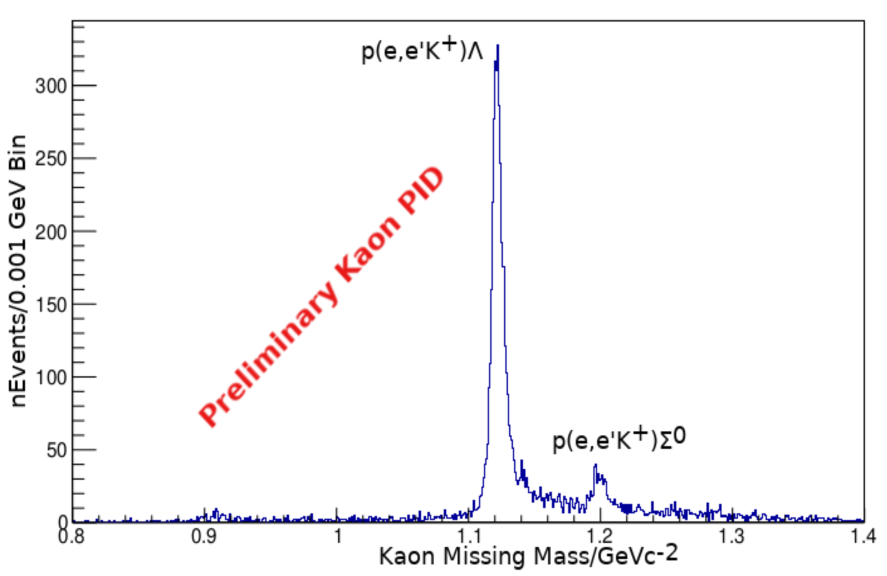
$$M_{\Sigma^0} = 1192.64\ MeV^2/c2$$

Missing mass equation

$$M_{miss} = [(E_b + m_p - E_{e'} - E_{K^+})^2 - (P_e - p_{e'} - p_{K^+})^2]^{\frac{1}{2}}$$

$$E_b = 6.19\ GeV, Q^2 = 3.0\ GeV^2/c^2$$
$$W = 2.32\ GeV, P_{SHMS} = 3.48\ GeV/c$$





Rosenbluth Separation Technique

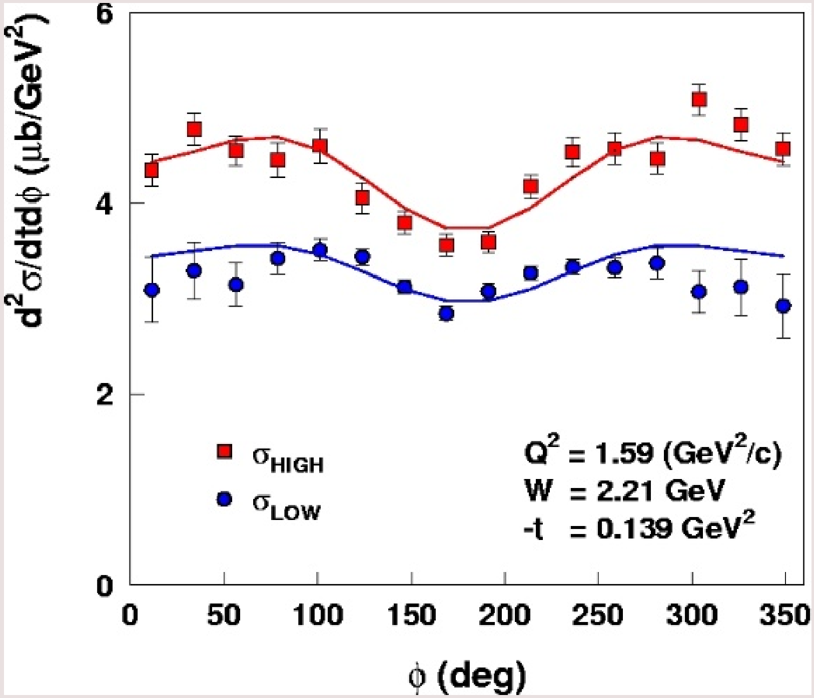
Rosenbluth Separation Technique is required to separate the cross-section terms

Fix Q^2, W and -t, measure cross-section at two beam energies

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

Virtual-photon polarization:

$$\varepsilon = \left(1 + 2\frac{(E_e - E_{e'})^2 + Q^2}{Q^2}\tan^2\frac{\theta_{e'}}{2}\right)^{-1}$$



Simultaneous fit at 2 ε values to determine cross-section terms

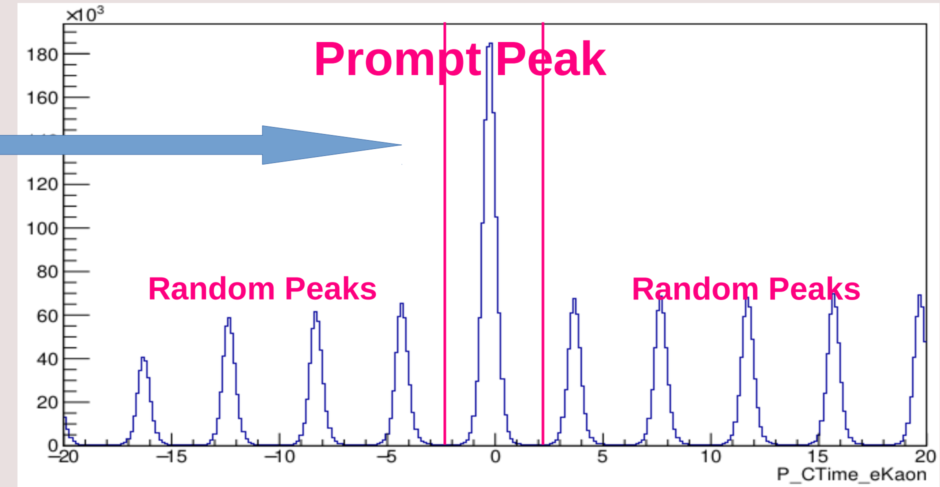
Systematic uncertainties crucial due to $1/\Delta\varepsilon$ error amplification in longitudinal cross-section

Particle Identification (PID) in SHMS

K⁺ ──► **SHMS**

e⁻ ──► **HMS**

Real coincidence

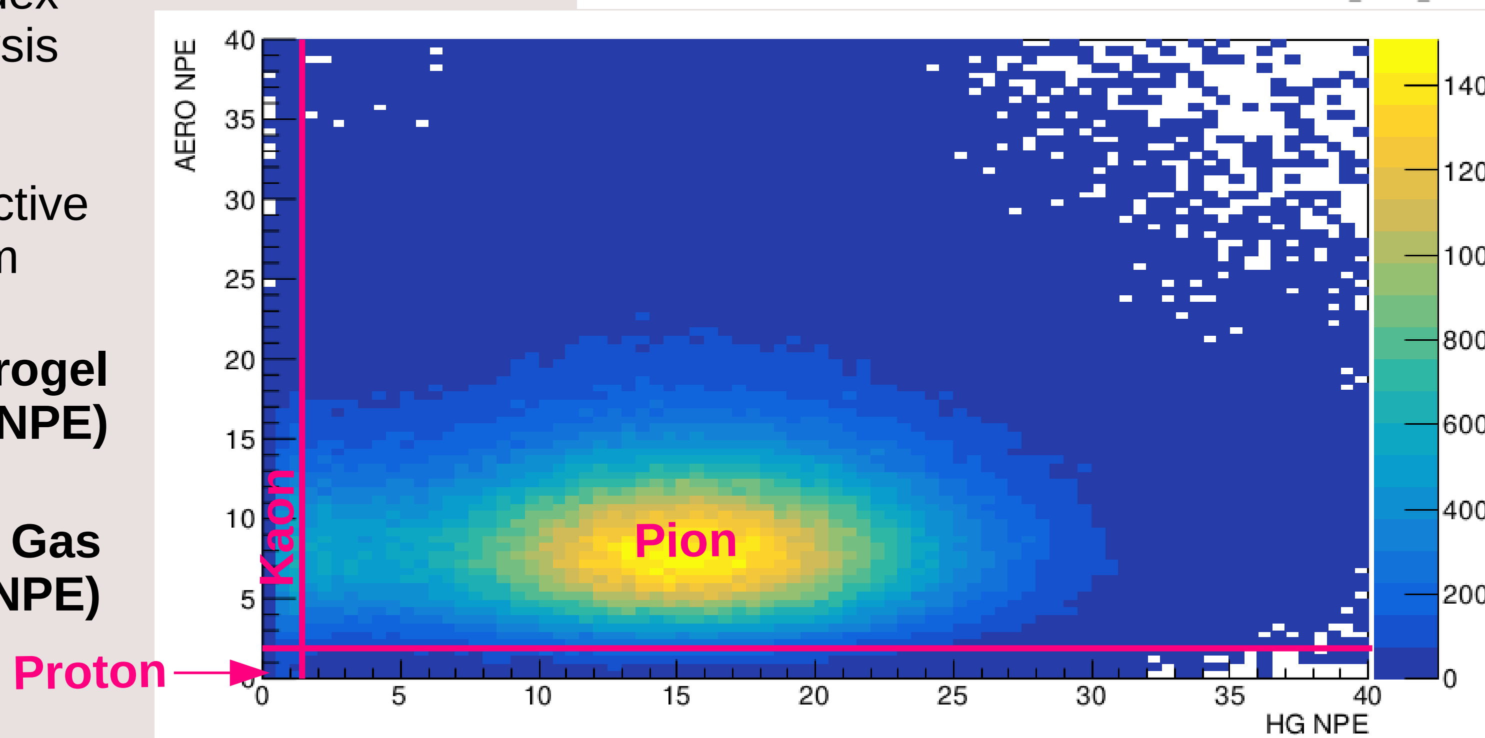


Aerogel refractive index **1.011** of current analysis setting

Heavy Gas refractive index **1.00139** at 1 atm

Y axis Aerogel Cherenkov light (NPE)

X axis Heavy Gas Cherenkov light (NPE)



Future Perspective

We are preparing/starting the data analysis for the producing of known elastics cross-section to understand the used detectors.

When we have a proper understanding of the detectors, then the Rosenbluth Technique will start to be used for the separation of the cross-section terms. Finally, we will start to extract the Kaon form factor at **$Q^2 = 0.5$** from the separated longitudinal cross-section.

Advertisement:

Another talk from our group on the **Pion form factor** will be presented By
Ali Usman
R4-3 Nuclei & Mesons (DNP) / Noyaux et mésons (DPN) on 10^{th} June at 17:10 (ET)

Thank You

NSERC CRSNG

SAPIN-2021-00026

Jefferson Lab
Thomas Jefferson National Accelerator Facility