Nuclear Transparency of Kaons

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Outline

- **Nuclear Transparency**
- **Nuclear Transparency with Kaons**
- **Preliminary Results**
- **Analysis plan**

Nuclear Transparency

Ratio of cross-sections for exclusive processes from nuclei to those from nucleons is termed as Nuclear Transparency

σ_0 = **free (nucleon) cross-section**

σ_N **parameterized as =** $\sigma_0 A^{\alpha}$

$$T = \frac{\sigma_N}{A\sigma_0}$$

Experimentally α = 0.72 – 0.78, for p,k,π

Transparency Experiment with Pions/Kaons

Experiment ran in July `04 and December `04 at Jefferson Lab

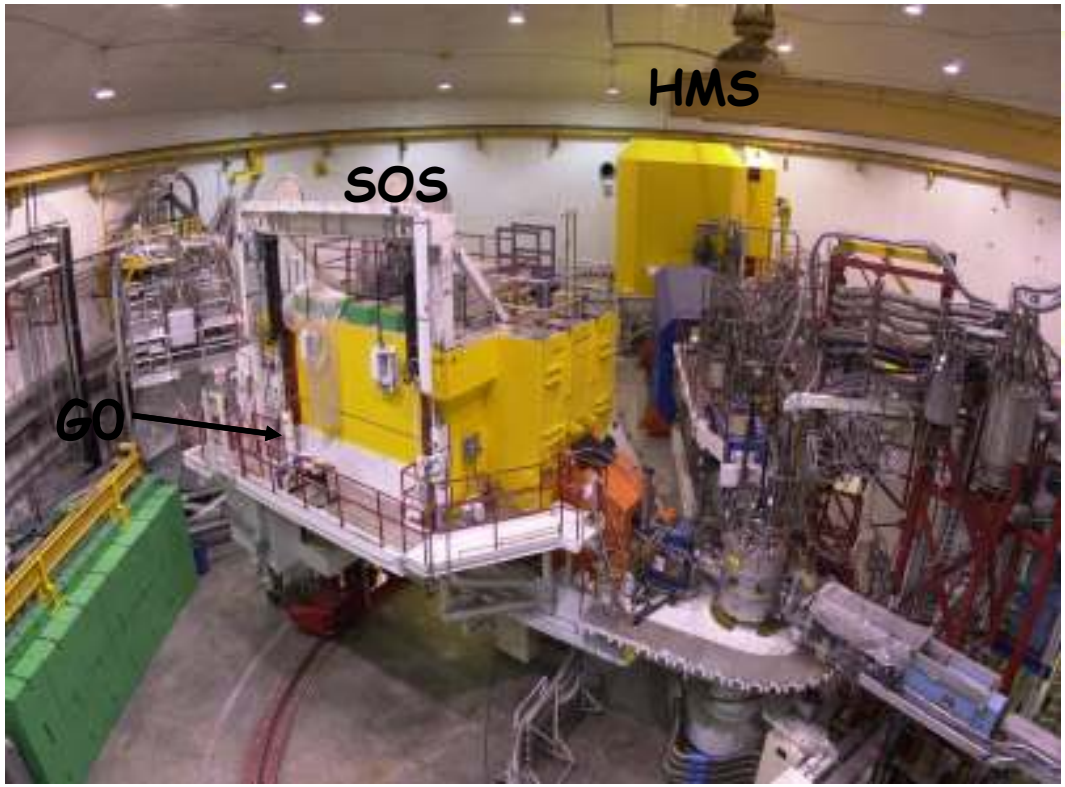
JLab Experiment E01-107: A(e,e' π^+)

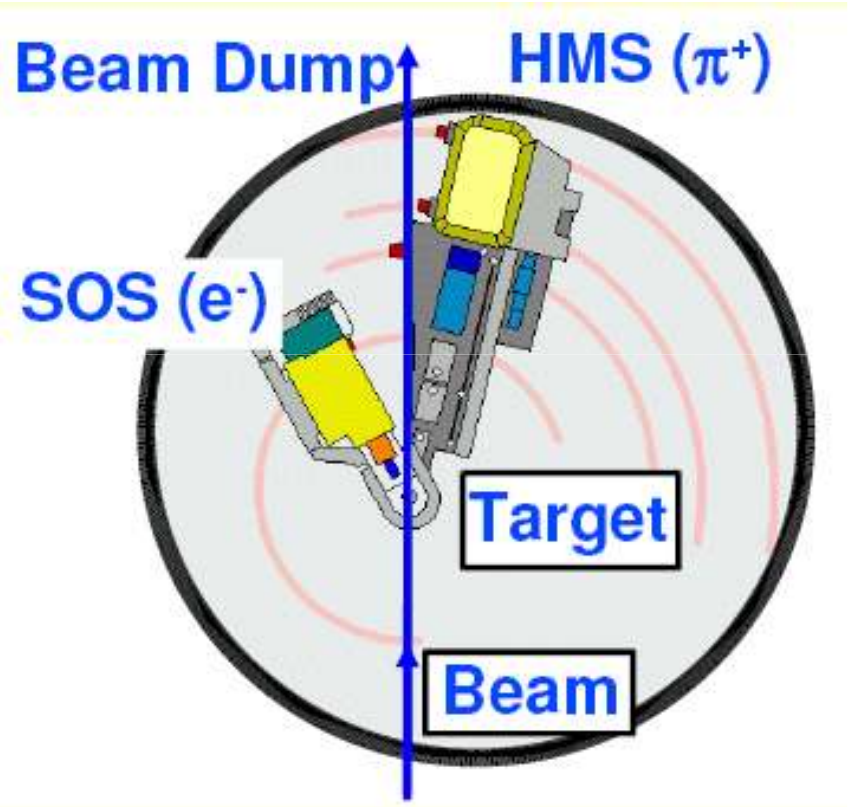
Spokespersons : D. Dutta & Rolf Ent

Data collected on LH_2, LD_2, ^{12}C, ^{63}Cu, and ^{197}Au at
P_π of 2.8, 3.2, 3.4, 4.0 and 4.4 (GeV/c)
Q^2 of 1.1, 2.15, 3.0, 4.0 and 4.7 $(GeV/c)^2$

The experiment was measuring pion transparency, however one gets kaons along with pions during data collection because kaons fall within the coincidence window.

Hall C

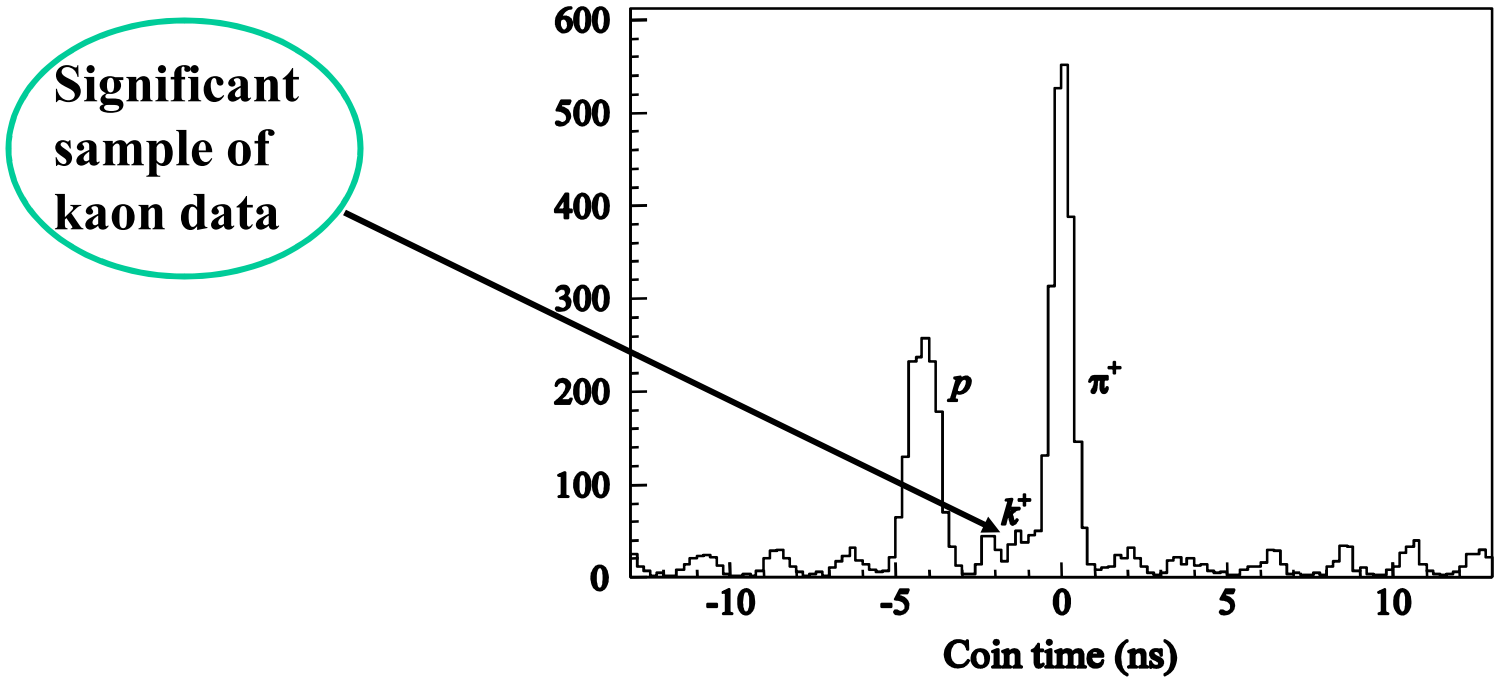




HMS- High Momentum Spectrometer
SOS- Short Orbit Spectrometer

JLab Experiment E01-107

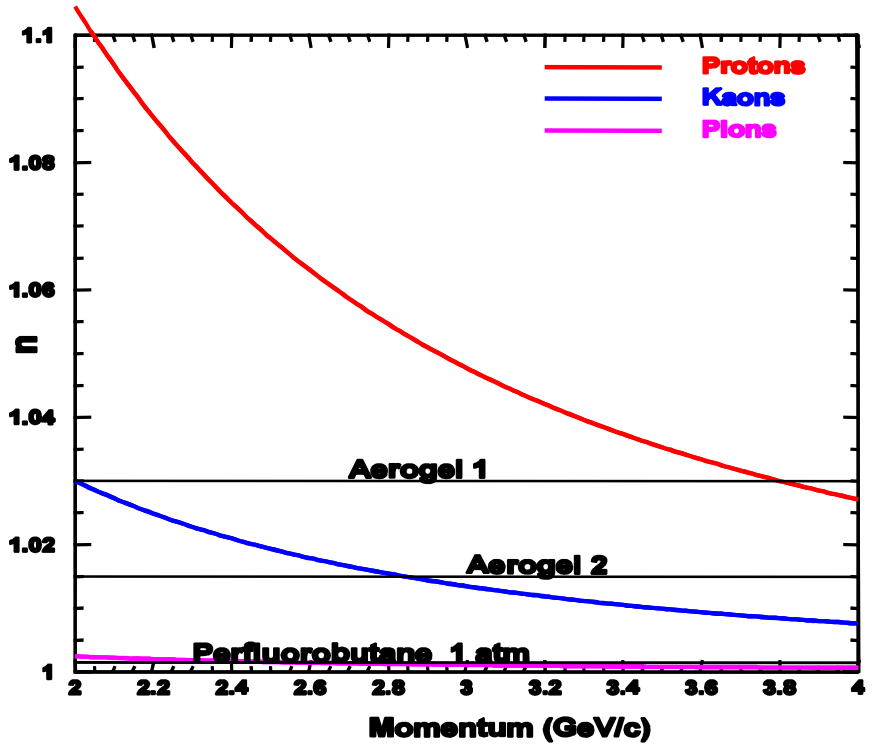
Typical coincidence time spectrum showing the different particles detected

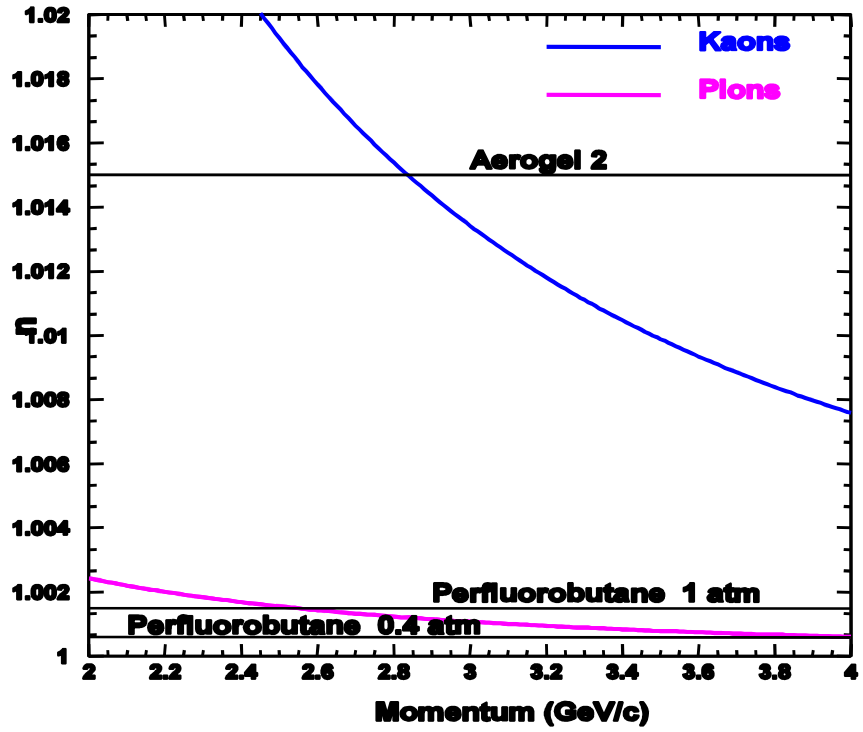


Coincidence time = Time taken by electron to reach SOS - Time taken by hadrons to reach HMS (within a 30ns window)

Kaon transparency from electro-production has never been measured before!!!

Particle Identification in the HMS





Aerogel Cherenkov (Aerogel2 of n = 1.015) (for k/p separation)

Gas Cerenkov (Perflurobutane at 1 atm.) (for pi/k separation)

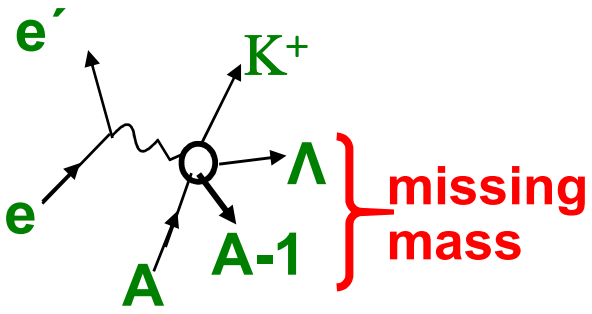
Particle Identification in the HMS

Reactions

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

$e + A \rightarrow e' + K^+ + \Lambda + X$

Energy & Momentum Conservation

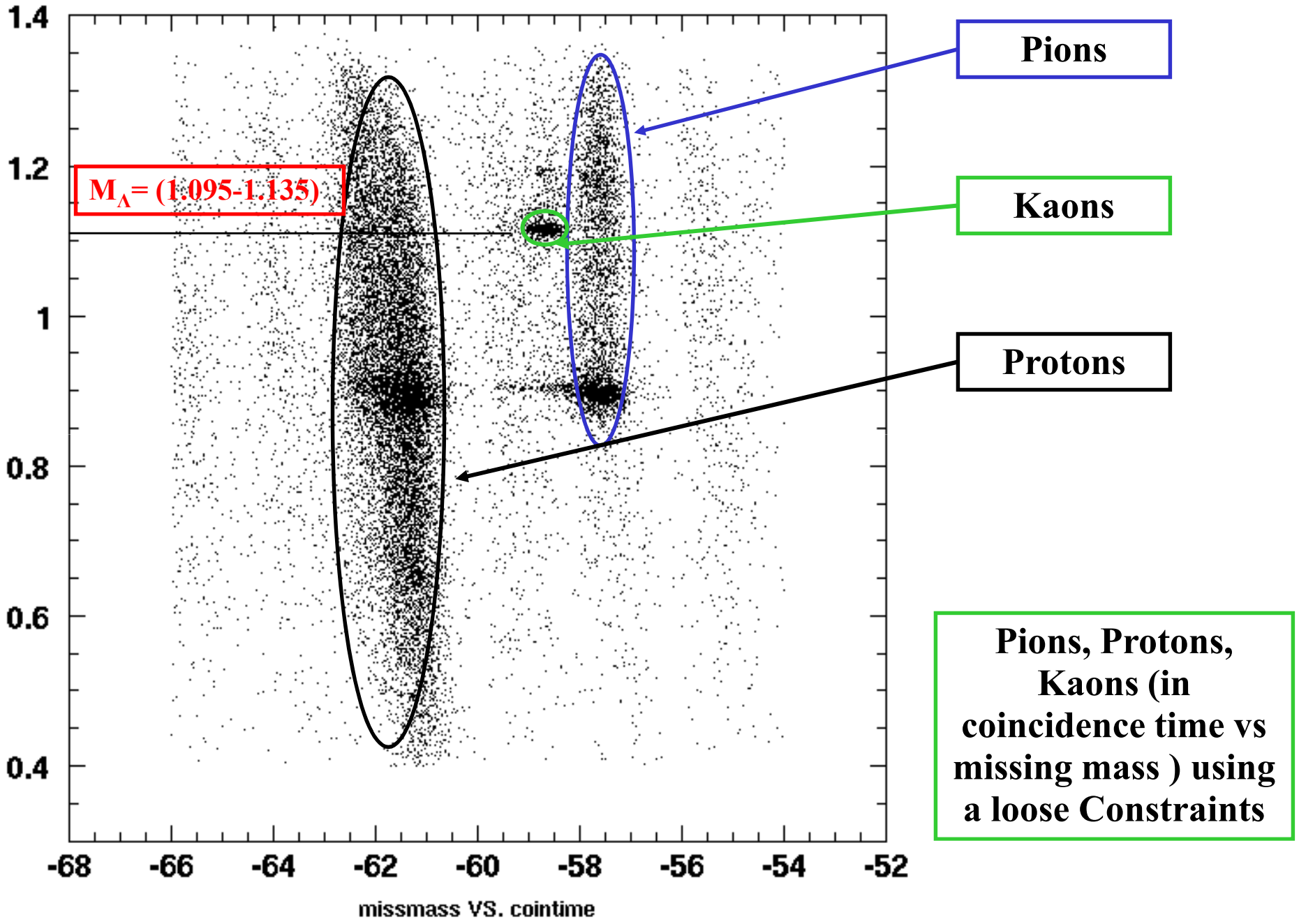


$E_e + M_p = E_{e'} + E_{K^+} + E_\Lambda$

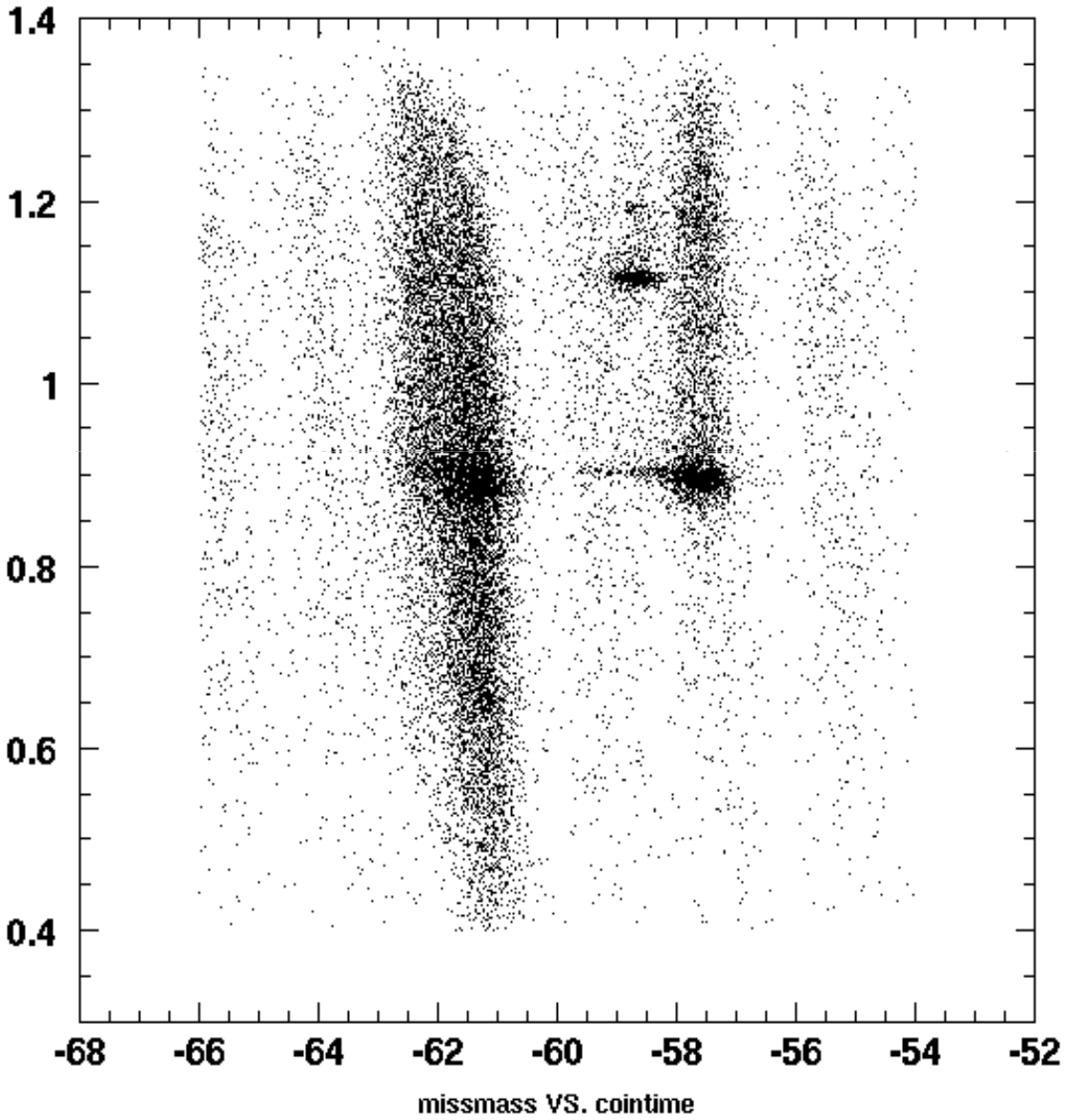
$P_e + 0 = P_{e'} + P_{K^+} + P_\Lambda$

Mass of Λ is $M_\Lambda = [E_\Lambda^2 - P_\Lambda^2]^{1/2}$

$M_\Lambda = 1.115\ GeV/c^2$


1.4
1.2
1
0.8
0.6
0.4
-68
-66
-64
-62
-60
-58
-56
-54
-52
missmass VS. cointime
M_Λ= (1.095-1.135)
Pions
Kaons
Protons
Pions, Protons, Kaons (in coincidence time vs missing mass) using a loose Constraints

Before & After Application of Constraints on Kaon(Liquid Hydrogen) Data



Pions, Protons & Kaons before application of all constraints for H target

- **Missing Mass**
- **Coincidence Time**
- **Gas Cherenkov**
- **Aerogel Cherenkov**
- **Other acceptances**

Experimental Simulation "SIMC"

Ingredients of SIMC:

1. Realistic Models of the magnetic spectrometers including multiple scattering and energy loss in all intervening material encountered by the particles.

2. Decay of kaons in flight, and radiative corrections for all particles.

3. Model of the electro production of kaons from protons

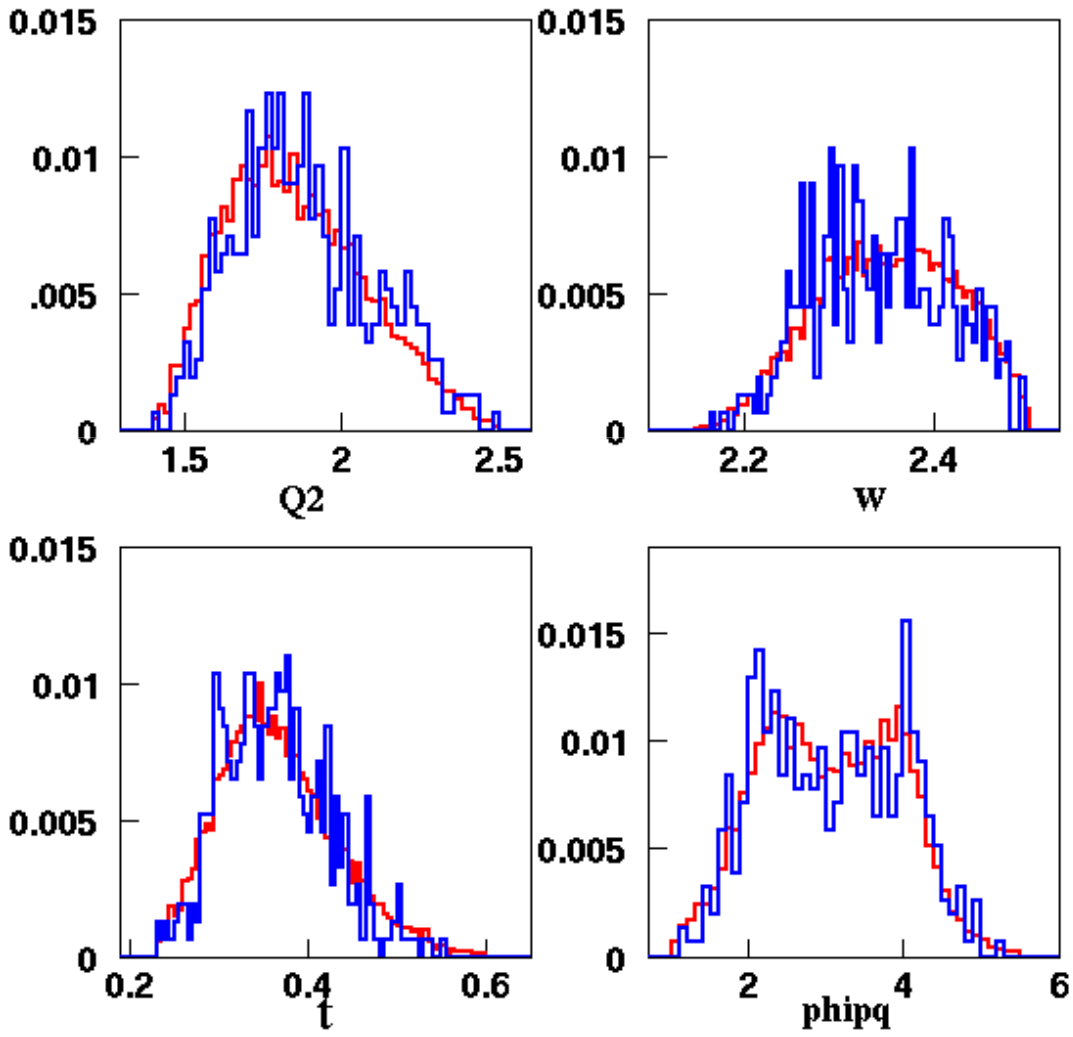
4. For heavier targets proton model is convoluted with a realistic spectral function for each target.

Spectral function = probability of finding a proton inside the nucleus with a certain energy and momentum.

Transparency to be extracted as $$T = \frac{\sigma_{A^{Expt}} / \sigma_{A^{Model}}}{\sigma_{p^{Expt}} / \sigma_{p^{Model}}}$$

Comparison of Liquid Hydrogen Data vs Simulation(SIMC)applying all constraints

All particle identification and acceptance constraints applied

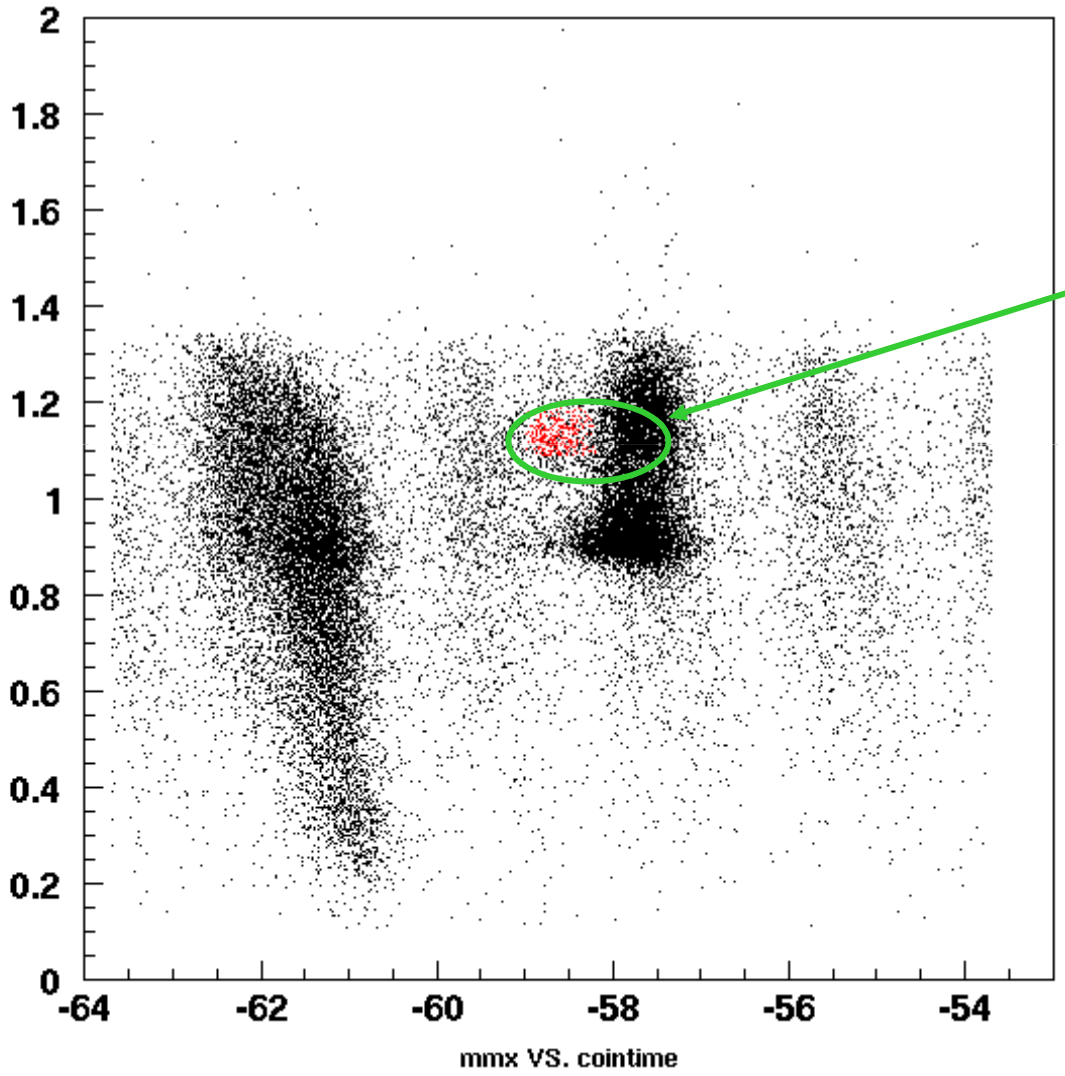


$\sigma = \sigma (Q^2, W, t, phipq)$

Q^2 = Four Momentum Transferred Squared
W = Center of Mass Energy
t = Momentum transferred squared
phipq = Angle Between Reaction Plane & Scattering Plane

Red – SIMC
Blue – Data

Before & After Application of Constraints on Kaon(Liquid Deuterium) Data

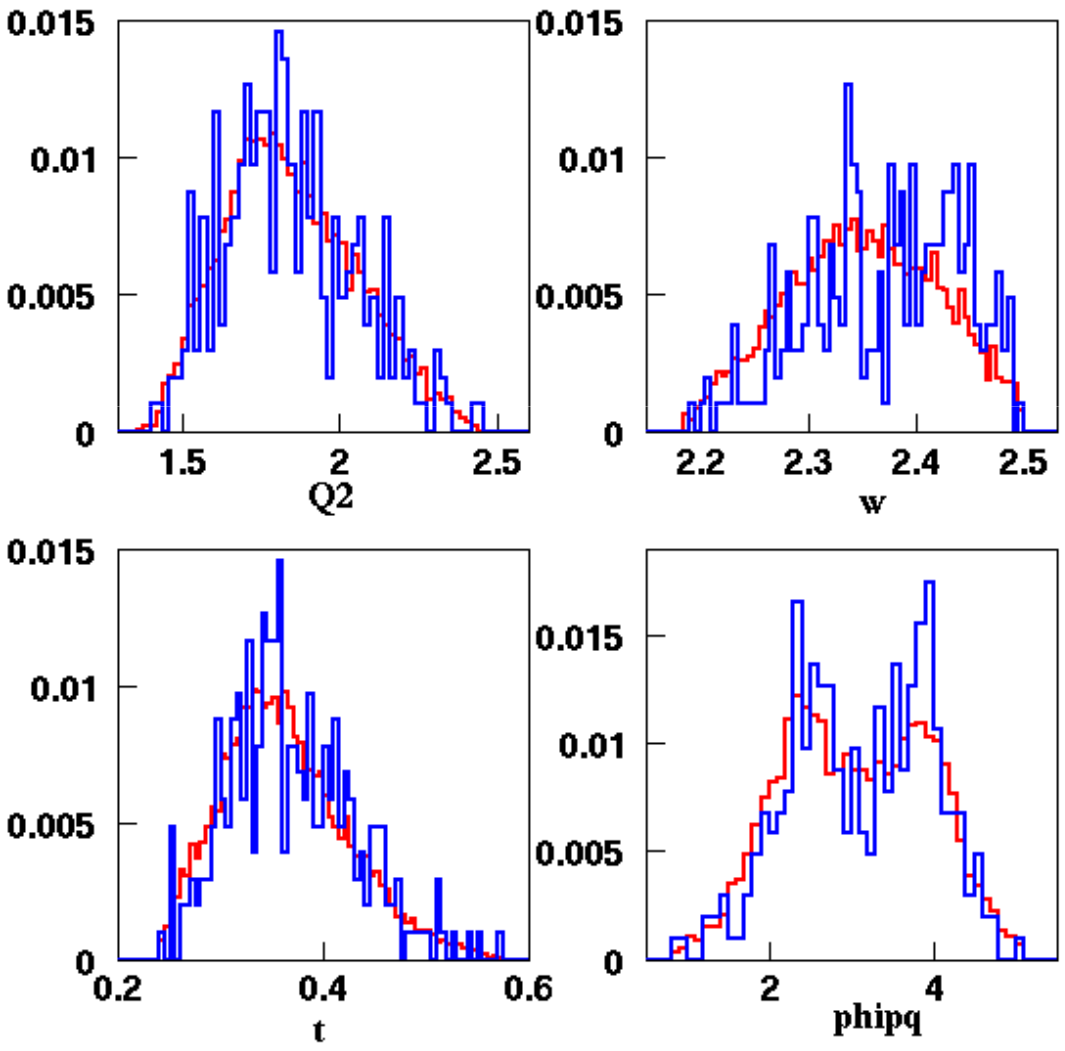


Kaons separated after application of all constraints on LD target

- **Missing Mass**
- **Coincidence Time**
- **Gas Cherenkov**
- **Aerogel Cherenkov**
- **Other acceptances**

Comparison of Liquid Deuterium Data vs Simulation(SIMC)applying all constraints

All particle identification and acceptance constraints applied



$\sigma = \sigma (Q^2, W, t, phipq)$

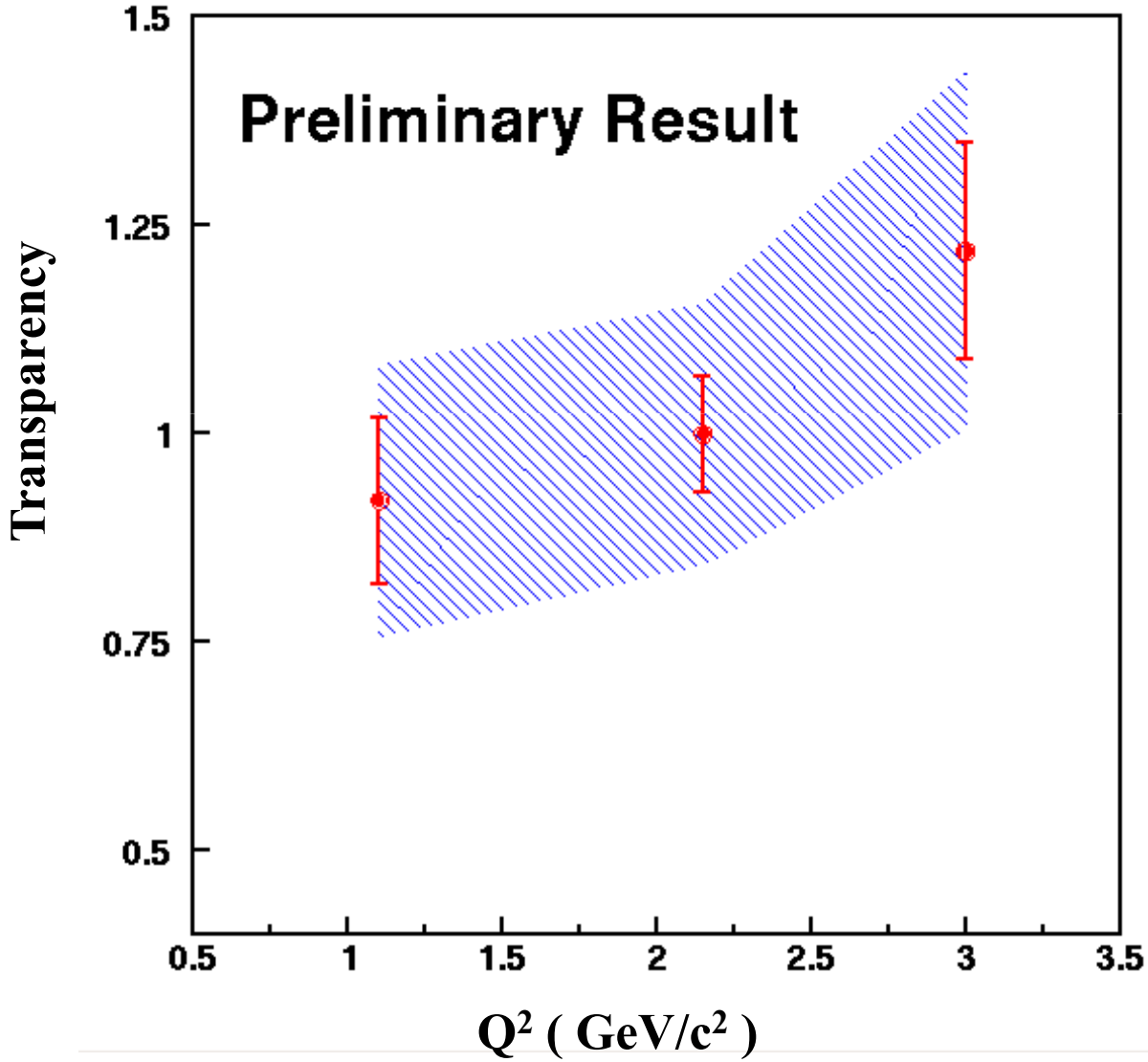
Q^2 = Four Momentum Transferred Squared
W = Center of Mass Energy
t = Momentum transferred squared
phipq = Angle Between Reaction Plane & Scattering Plane

T = 1.00 ±0.1

Stastistical Uncert.

Red – SIMC
Blue – Data

Nuclear Transparency vs Q^2



Analysis Plan

- **Improve the model for p(e, e' K^+) using the hydrogen data**
- **Obtained by iterating a Monte Carlo simulation of the experiment until it agrees with data**
- **Calculate Nuclear Transparencies of Kaon for targets Liquid Deuterium, Carbon, Copper, Gold**

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Thank You