THE CATHOLIC UNIVERSITY of AMERICA

EXCLUSIVE MESON PRODUCTION IN HALL C AT JLAB 12 GEV

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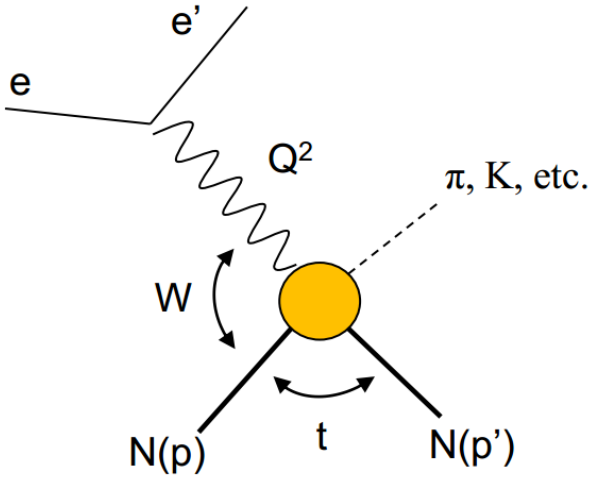
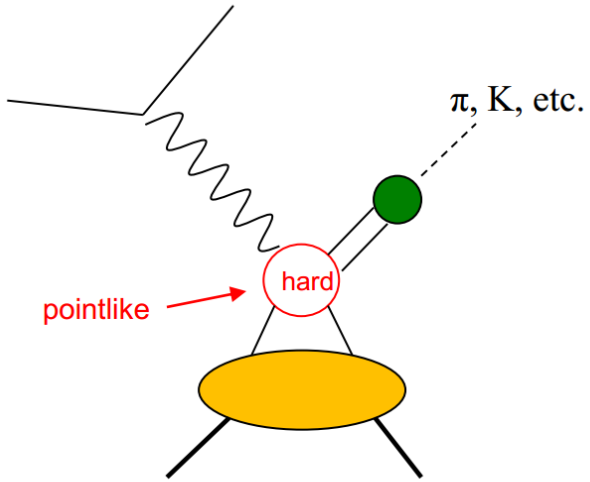
Meson Reaction Dynamics

Two ways to look at meson electroproduction



t-channel process

- Described by t-channel exchange meson pole term in limit of small t
- Spatial distribution described by *form factor*

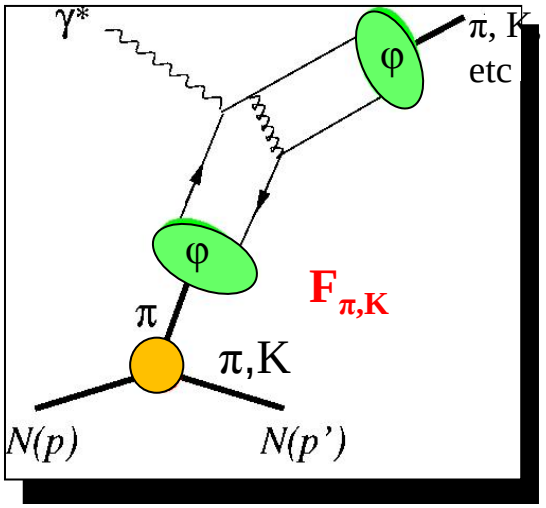


handbag

- At sufficiently high Q2, process can be described in terms of the "handbag diagram"
- Non-perturbative (soft) physics is represented by the GPDs

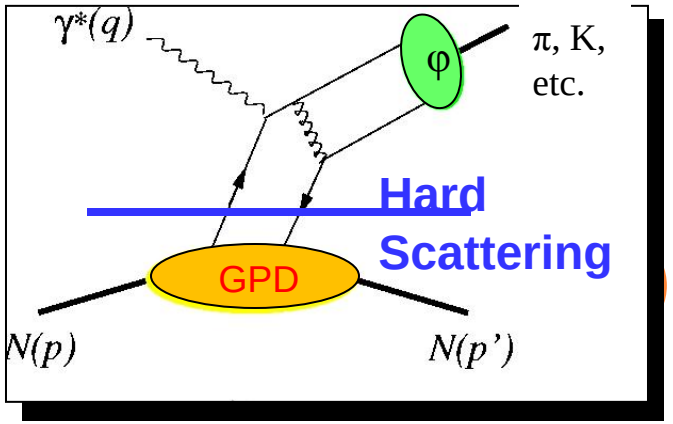
Soft-Hard Transition: Form Factors & GPDs

- Form factors and GPDs are essential to understand the structure of hadrons



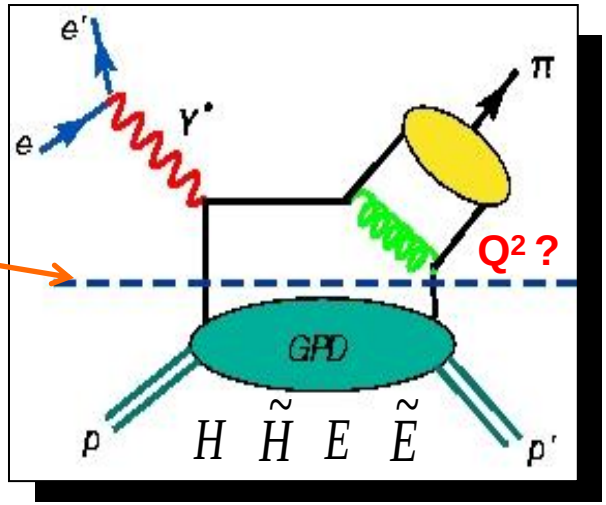
- But measurements of form factors and GPDs have certain prerequisites:
  - For form factors, must make sure that σ_L is dominated by the meson pole term at low -t
  - For GPDs, must demonstrate that factorization applies

- A *comparison of pion and kaon* production data may shed further light on the reaction mechanism
  - quasi-model independent
  - more robust than calculations based on QCD factorization and present GPD models



Factorization Tests

- … are tests of the reaction mechanism



Factorization

- One of the most stringent tests of factorization is the *Q^2 dependence of the electroproduction cross section*
  - σ_L scales to leading order as Q^{-6}
  - σ_T scales as Q^{-8}
  - As Q^2 becomes large: $\sigma_L >> \sigma_T$

- Factorization theorems for meson electroproduction have been proven rigorously only for longitudinal photons *[Collins, Frankfurt, Strikman, 1997]*

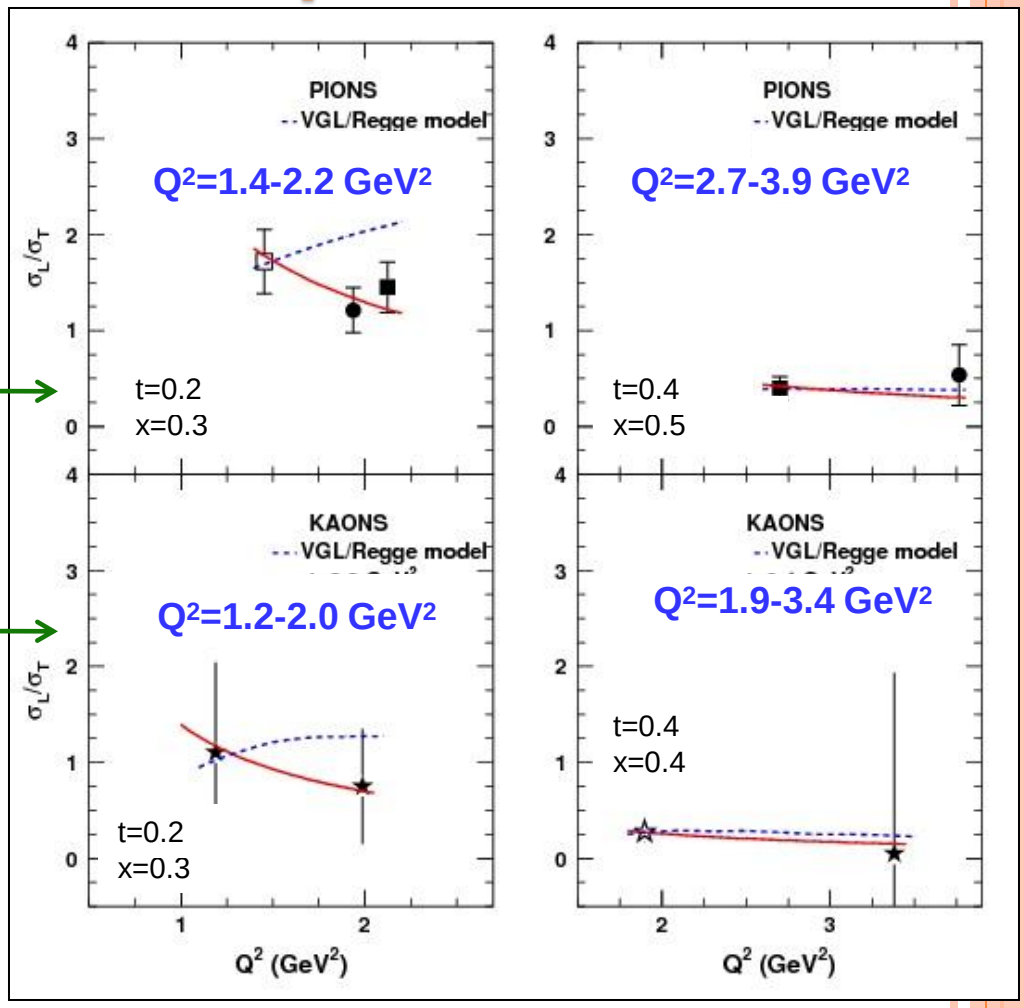
$$2\pi \frac{d\sigma}{dt d\varphi} = \frac{d\sigma_T}{dt} + \varepsilon \frac{d\sigma_L}{dt} + \sqrt{2\varepsilon(1+\varepsilon)} \frac{d\sigma_{LT}}{dt} \cos\varphi + \varepsilon \frac{d\sigma_{TT}}{dt} \cos 2\varphi$$

Q^{-n} scaling of σ_L and σ_T

- To access physics contained in GPDs, one is limited to the kinematic regime where hard-soft factorization applies
- A test is the Q^2 dependence of the cross section:
  - $\sigma_L \sim Q^{-6}$ to leading order
  - $\sigma_T \sim Q^{-8}$
- Difficult to draw a conclusion from current π^+, K^+ σ_L/σ_T ratios
  - Limited W and Q^2 coverage
  - Uncertainties from scaling in x, t

σ_L/σ_T → **π**

σ_L/σ_T → **K**



High quality σ_L and σ_T data for both kaon and pion would provide important information for understanding the meson reaction mechanism

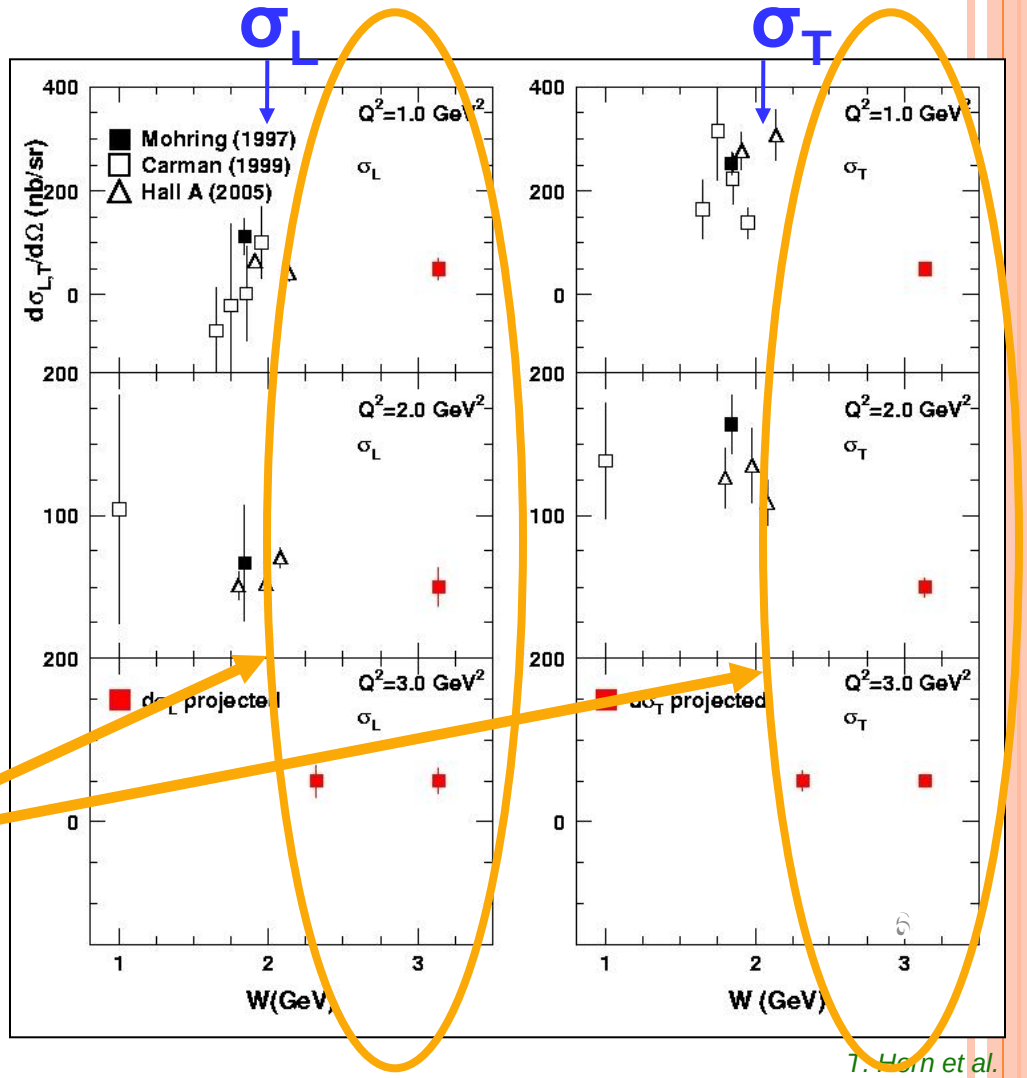
JLab 12 GeV: L/T separated kaon cross sections

- Approved experiment E12-09-011 will provide first L/T separated **kaon** data *above* the resonance region (W>2.5 GeV)

- Onset of kaon factorization

- Understanding of hard exclusive reactions
  - –QCD model building
  - –Coupling constants

E12-09-011: Precision data for W > 2.5 GeV



T. Horn et al.

Transverse Contributions

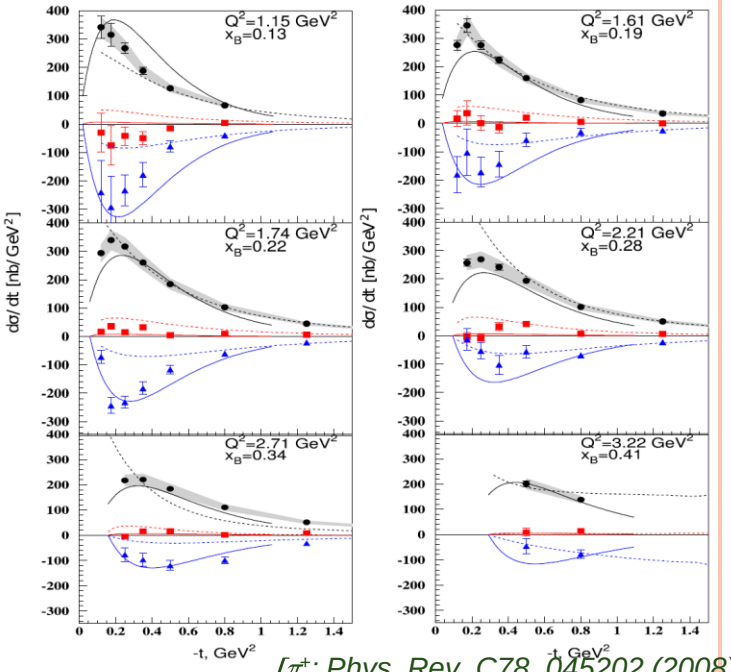
- Recent data suggest strong contributions from transversally polarized photons

- Recent theoretical work found that σ_T can be interpreted in terms of transversity GPDs [*S.V. Goloskokov, P. Kroll, Eur. Phys. J. C **65**, 137 (2010), S.V. Goloskokov, P. Kroll, Eur. Phys. J. A **47**, 112 (2011)*]

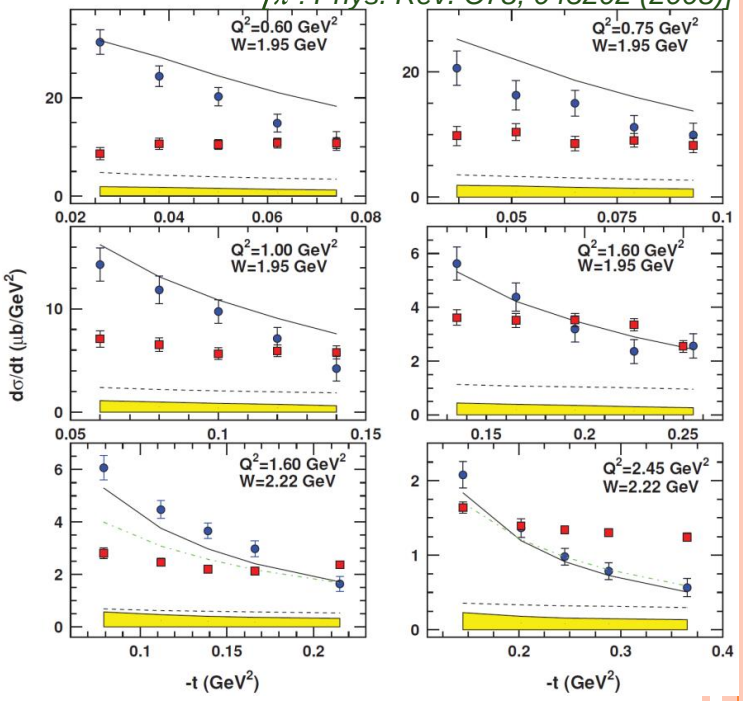
Relative contribution of σ_L and σ_T in π° production is a good probe of transversity effects

- ➢ Could confirm the large contribution of of transversely polarized photons to this process
- ➢ May subsequently allow for detailed investigation of transversity GPDs

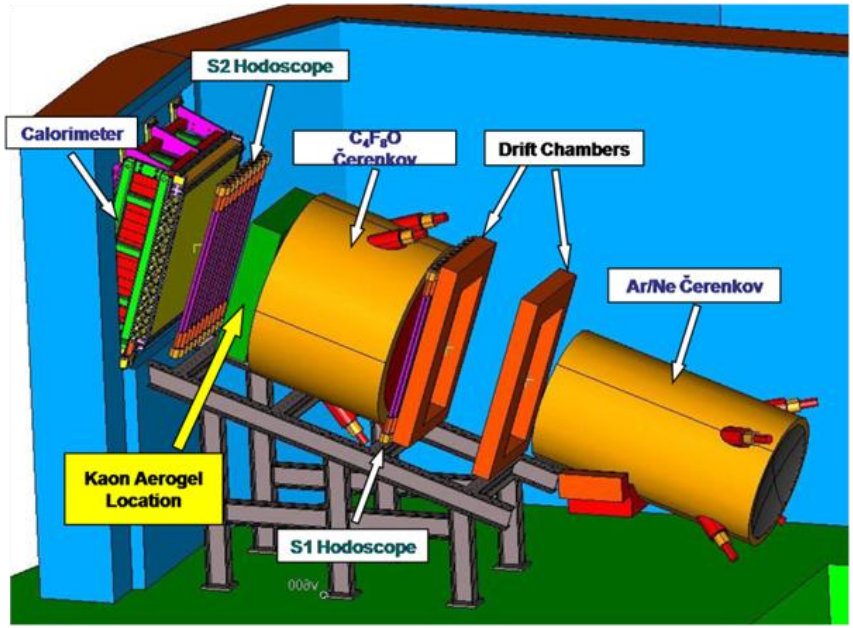
[I. Bedlinskiy et al., PRL 109, 112001 (2012)]



[π^+: Phys. Rev. C78, 045202 (2008)]



JLAB / SHMS Detector System: How to measure kaons

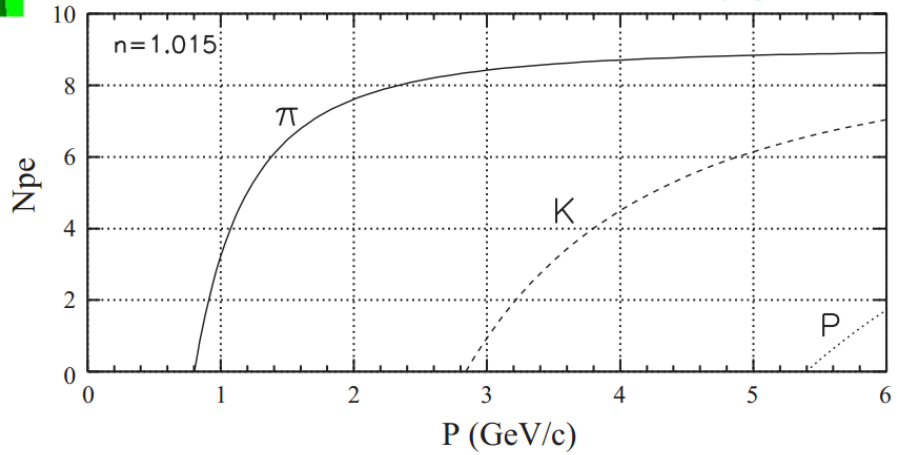


Kaon Aerogel Cerenkov Detector inside the SHMS, in Hall C.

SHMS particle identification system (for the full momentum range):

- **Kaon Aerogel Detector: K/p**
- Noble gas Cerenkov: e/π
- Heavy gas Cerenkov: π/K
- Lead glass: e/π

Cherenkov Radiation created by particles



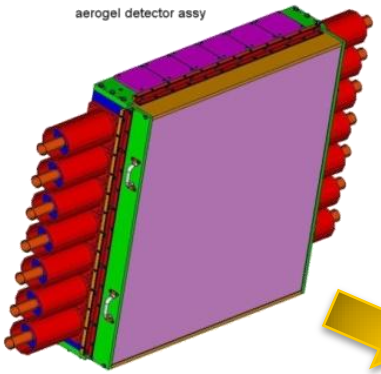
Cherenkov radiation:

- Threshold in particle's velocity for the radiation of light.
- Refractive index of material determine this threshold.

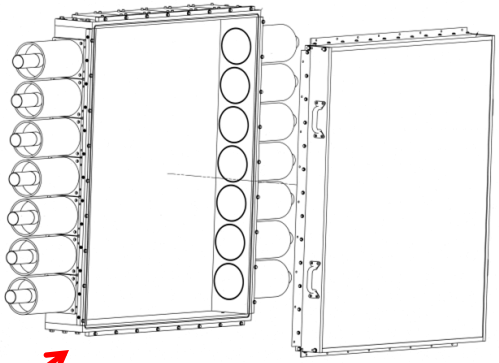
R. Asaturyan *et al*, "The aerogel threshold Cherenkov detector for the High Momentum Spectrometer in Hall C at Jefferson Lab", NIM-A (2005)

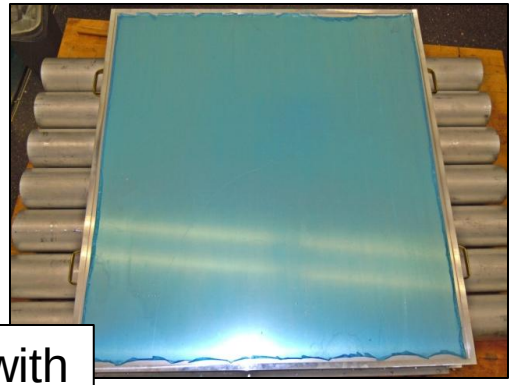
Kaon Aerogel Detector Design Overview

External dimensions of the detector box:
1.10 x 1.00 x 0.45 m^3



Design drawing
[B. Metzger]





Diffusion box, covered with reflective material

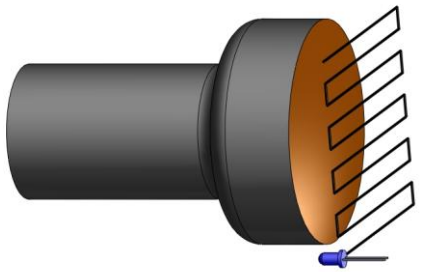
Replaceable aerogel tray, with a ~10cm layer of aerogel

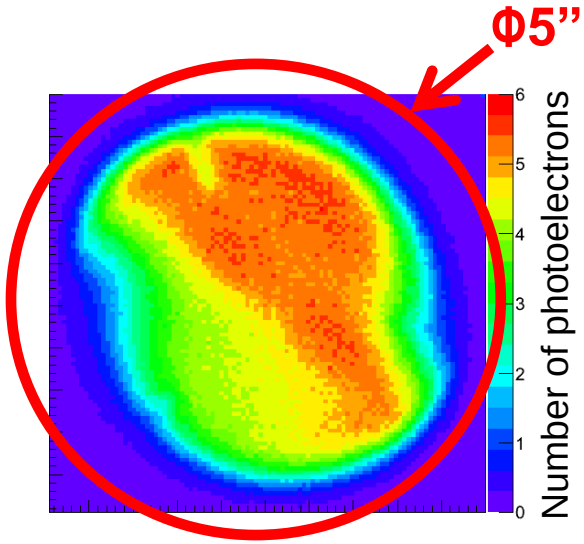
MF-Millipore Membrane Filters

Refractive index options:
n = 1.030
n = 1.020
n = 1.015

Components characterization

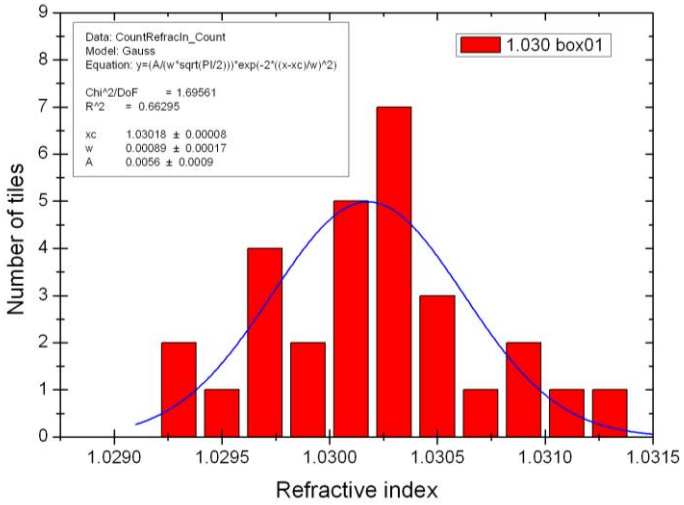
PMTs sensitivity



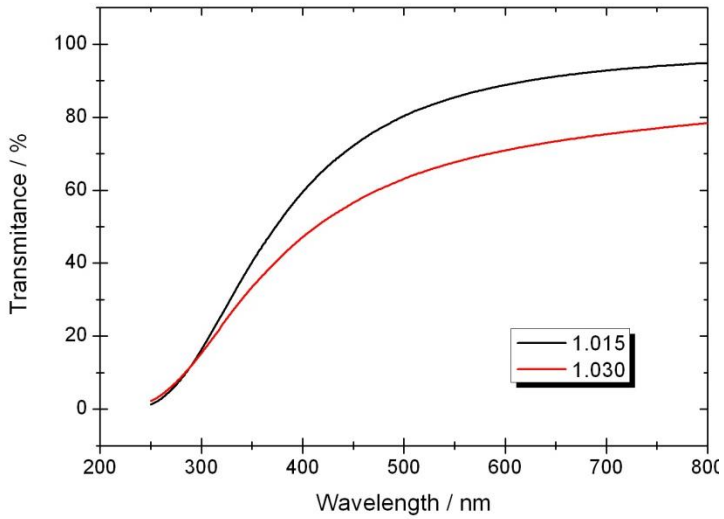


Step motors to position a blue LED in front of the PMT

Aerogel Refractive index uniformity

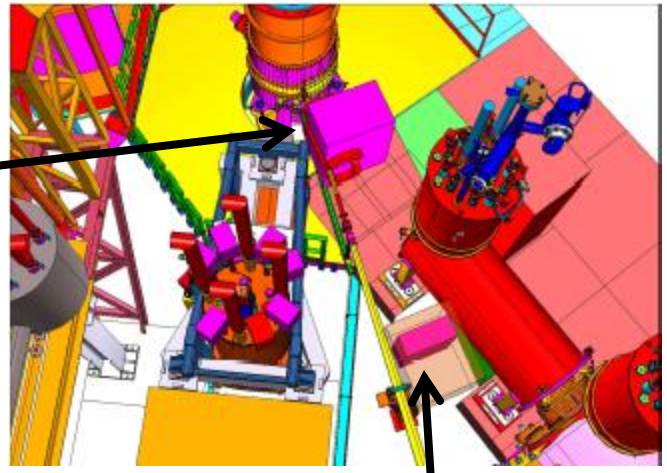


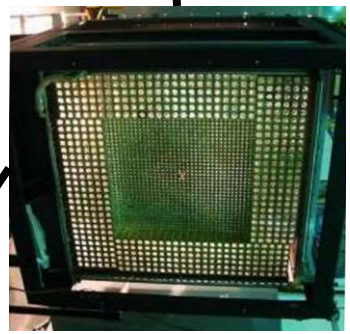
Aerogel Transmittance of light



Neutral Particle Detection Facility

- The detector system will consist of
  - PbWO4 blocks of the PRIMEX setup in a new temperature controlled frame
  - A sweeping magnet
  - Essentially deadtime-less digitizing electronics
  - HV bases with built-in amplifiers





- **Measurement of the photons from DVCS/π^0 decay**

Detector features:

31 x 36 matrix of $PbWO_4$ crystals

2.05 x 2.05 x 18 cm^3 each crystal

Summary

- Meson production plays an important role in our understanding of hadron structure
- JLab 12 GeV will allow rigorous tests of factorization in meson production, for instance, kaon factorization
  - Extended kinematic reach and studies of additional systems
  - Essential prerequisite for studies of valence quark spin/flavor/spatial distributions
- The kaon aerogel Cherenkov detector adds capability to detect kaons to SHMS to carry out our kaon experiments at 12 GeV
- A new neutral particle detection facility will augment Hall C scientific capabilities to include measurements with neutral final states, e.g., DVCS, WACS, π^0 production

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