SHMS Aerogel Detector update

Hall C Users Meeting

The Catholic University of America

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01/25/2013

Overview

Kaon Aerogel Detector

→ Concepts and Design

→ Construction and Assembly

Detector components characterization:

→ PMTs

- Quantum efficiency
- Uniformity of photocathode

→ Aerogel

- Dimension
- Optical properties
  - Refractive Index
  - Transmittance

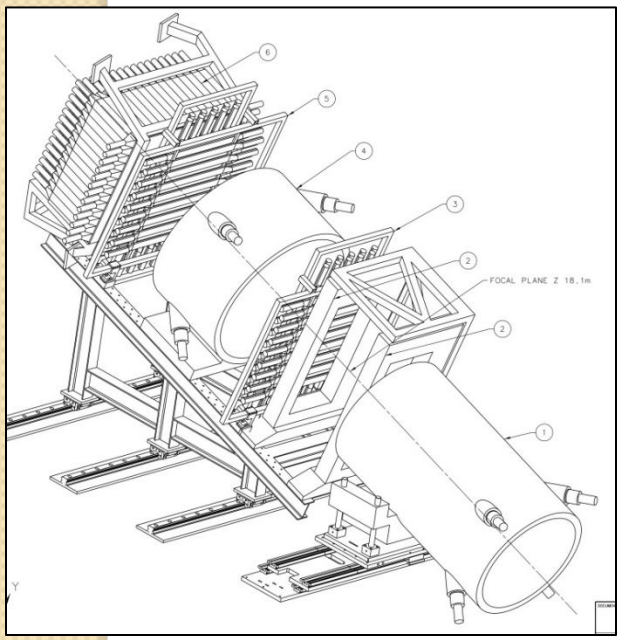
Kaon Aerogel Cerenkov Detector

CONCEPTS AND DESIGN

Why an Aerogel detector?

Access to strangeness physics

PID @ SHMS

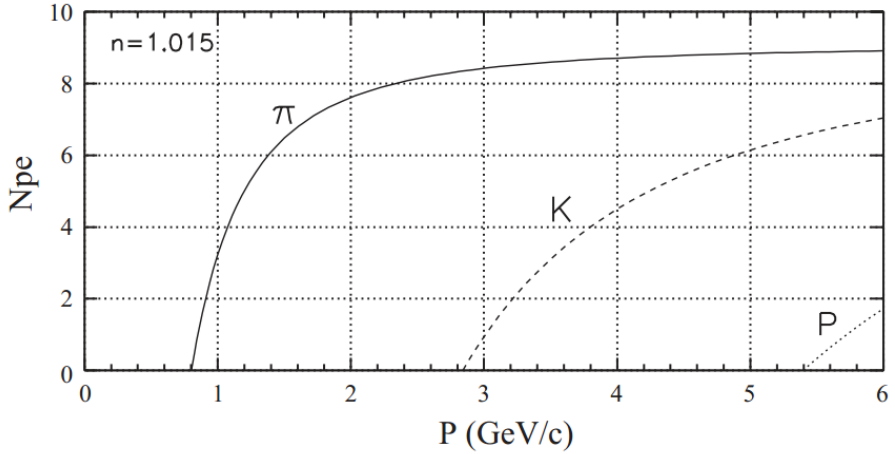


SHMS base detector system provides particle identification for *e*, π, *p* over the full momentum range

- Noble gas Cerenkov: e/π
- Heavy gas Cerenkov: π/K
- Lead glass: e/π

But no K/p!

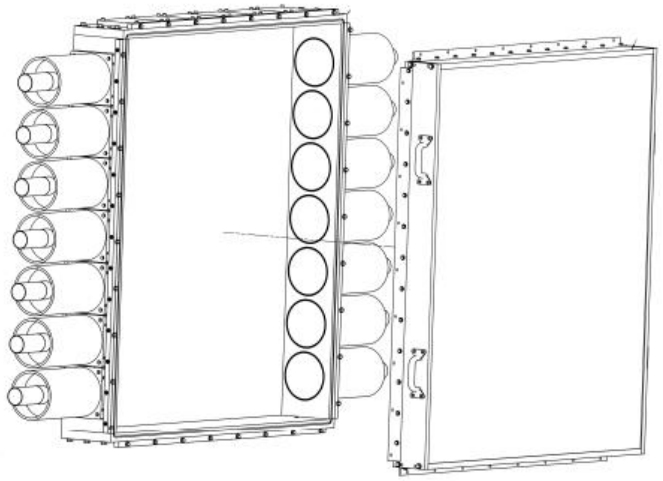
Kaon x Proton → **AEROGEL CERENKOV DETECTOR**



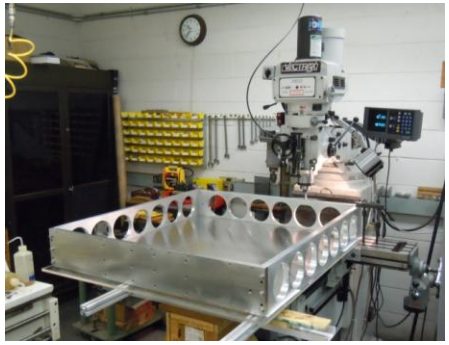
R. Asaturyan *et al*, "The aerogel threshold Cherenkov detector for the High Momentum Spectrometer in Hall C at Jefferson Lab", NIM-A (2005)

Kaon Aerogel Cerenkov Detector

CONSTRUCTION AND ASSEMBLY

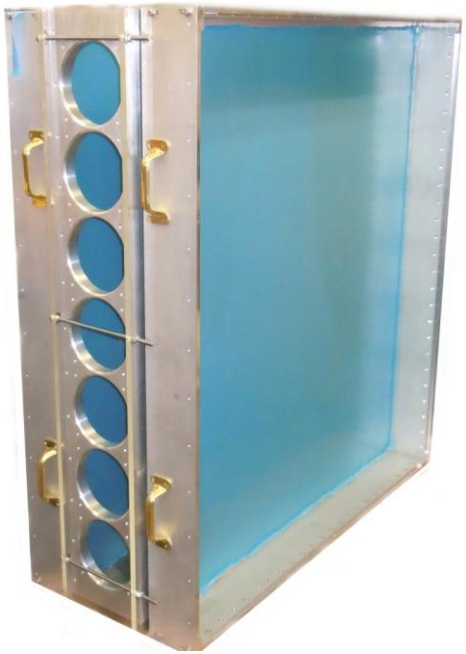


Machining at CUA



Detector machining completed with:

01 detector box,
to hold 14(+6) 5 inches PMTs

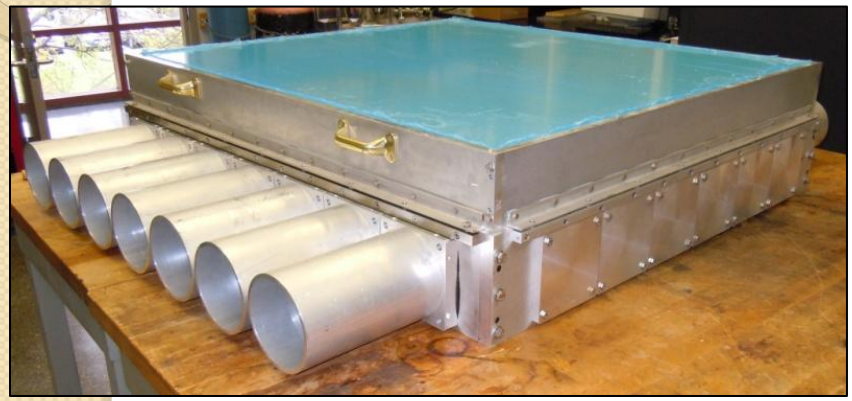


03 aerogel trays,
for different refractive indexes

http://www.vsl.cua.edu/cua_phy/index.php/MainPage:Nuclear:KaonDetector:Pictures

Detector Assembly

Detector assembled without major mechanical problems:



PMTs placed inside shielding:

Part of the detector at JLab:

✓ Two trays already at JLab

✓ Installing of aerogel with n=1.03 and 1.02 on these trays in a semi-clean room

Next steps:

❑ Cover walls with reflective material

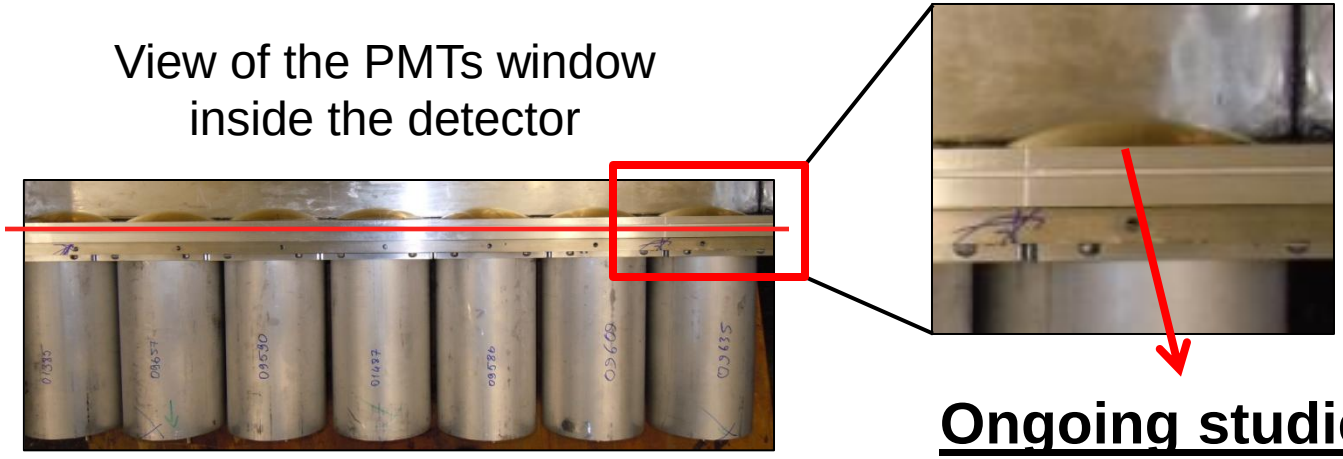
❑ Fill trays with aerogel

❑ Tests of fully assembly detector with cosmic rays

Installation details

View of the PMTs window inside the detector

PMT shielding configuration:
Aluminum tube and mu-metal cylinder



Top view

Ongoing studies:

Effects of the PMTs window installed partially exposed to possible magnetic fields

Kaon Aerogel Cerenkov Detector

COMPONENTS CHARACTERIZATION

PMTs

Aerogel

Choosing PMTs

What are the best PMTs set we can use? Studied characteristics:

→ Gain

→ Quantum efficiency (light collection efficiency)

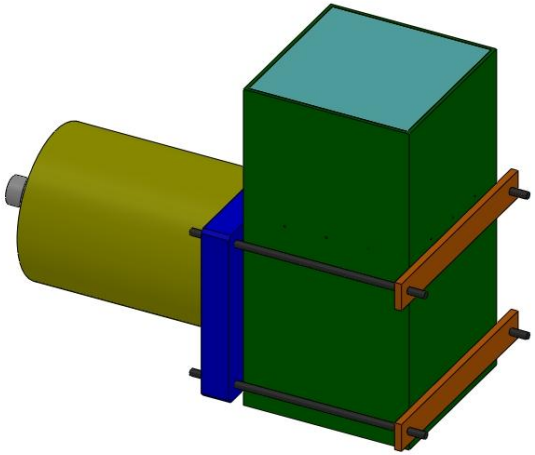
Different models/manufacturers of PMT

→ XP4500/B (already have)

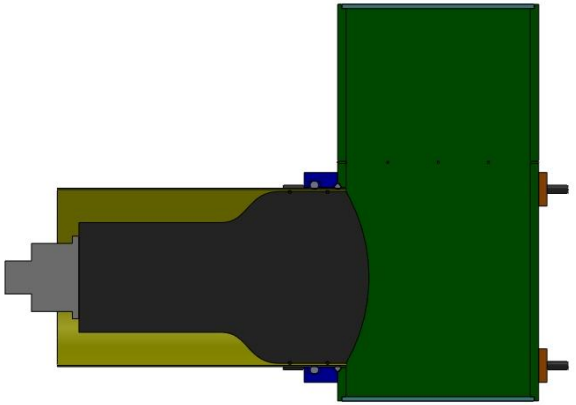
→ HMS XP4572 (not available for purchase)

→ Hamamatsu R1250 (available for purchase)

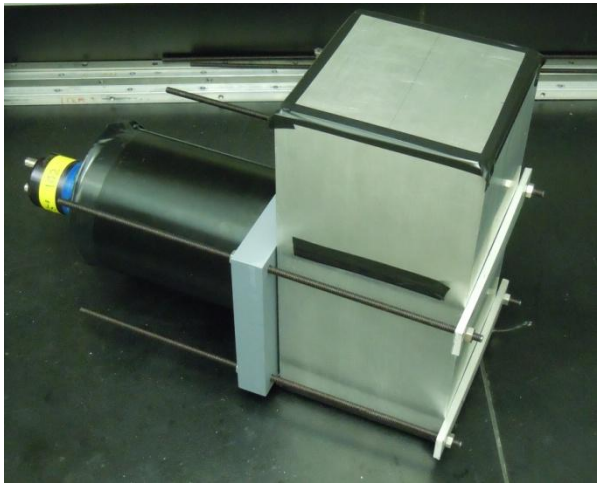
Kaon Detector Prototype



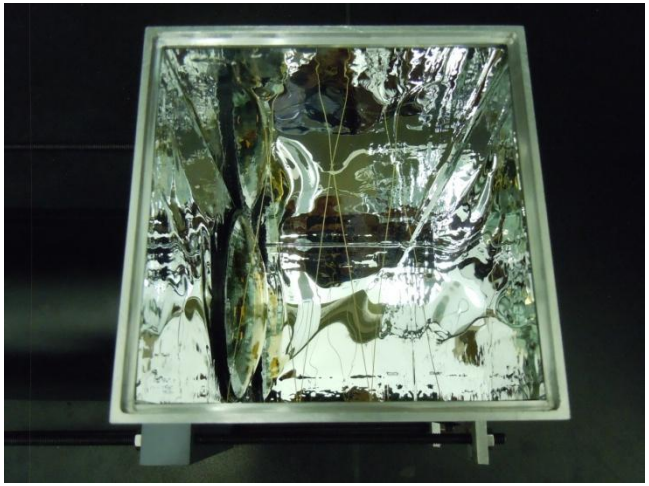
Design for construction



Section of the design

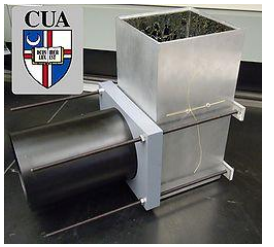


Constructed prototype

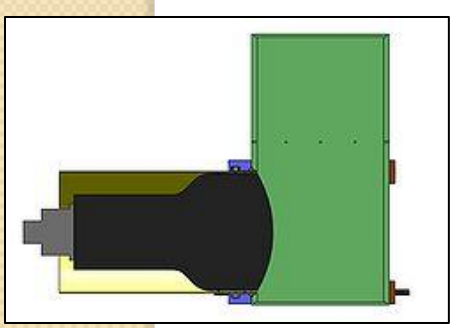


Inner part covered with Mylar

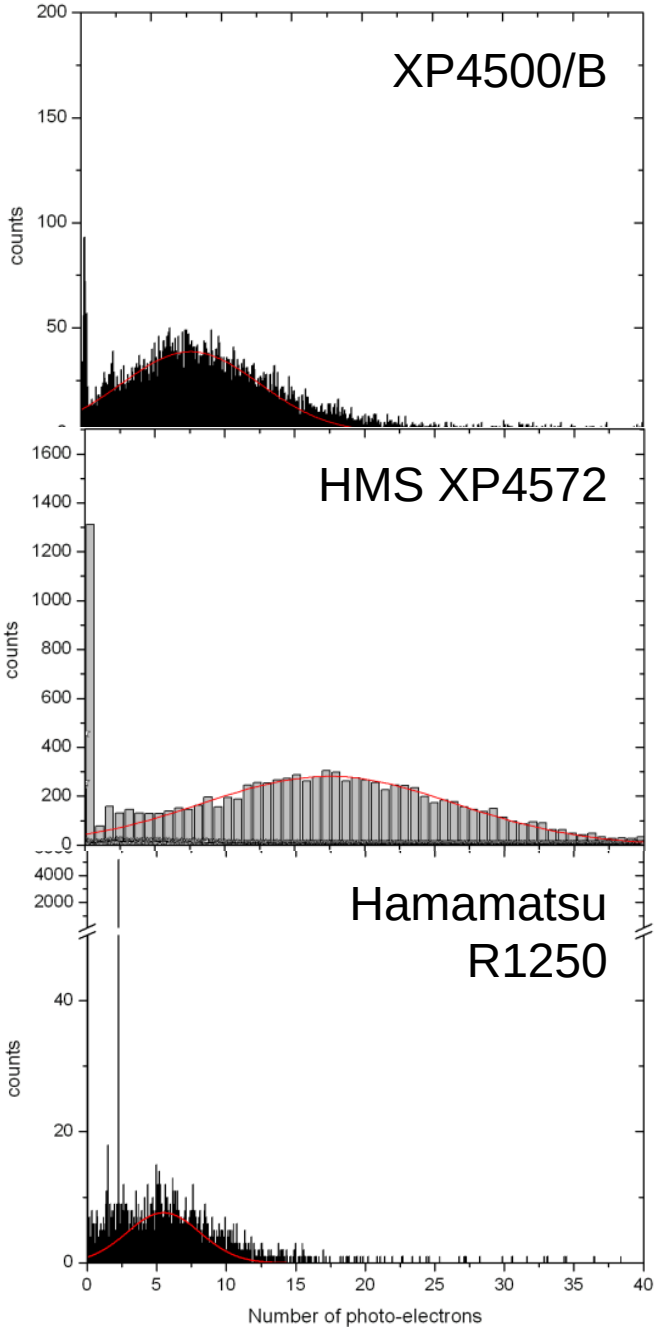
Photon Yield Measurements

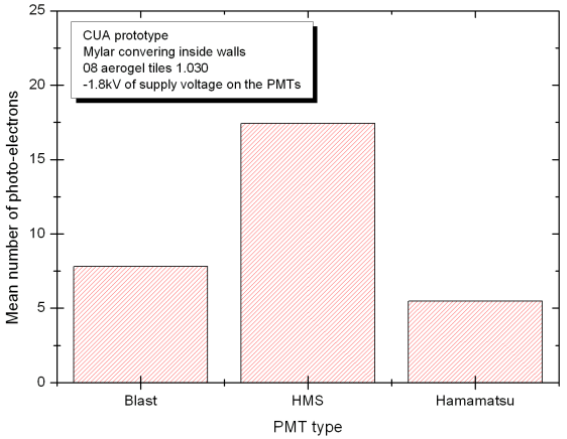


Low refractive index aerogel has very low light yield…



Photon yield of the prototype, just exchanging PMTs

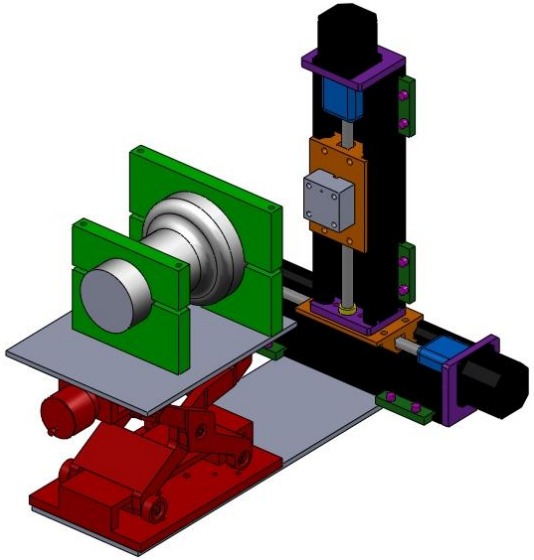


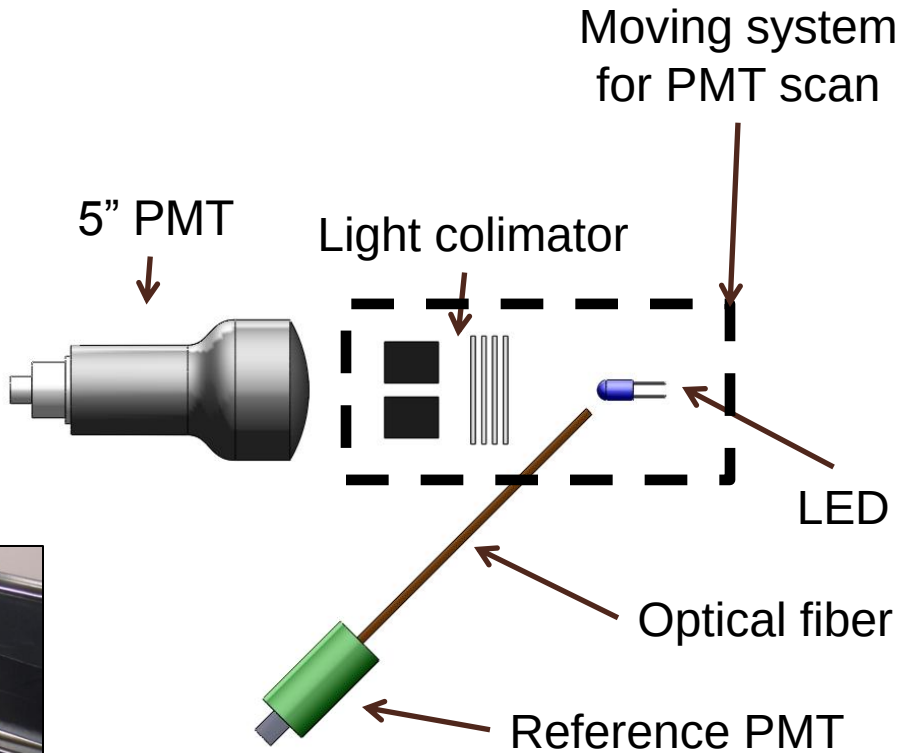


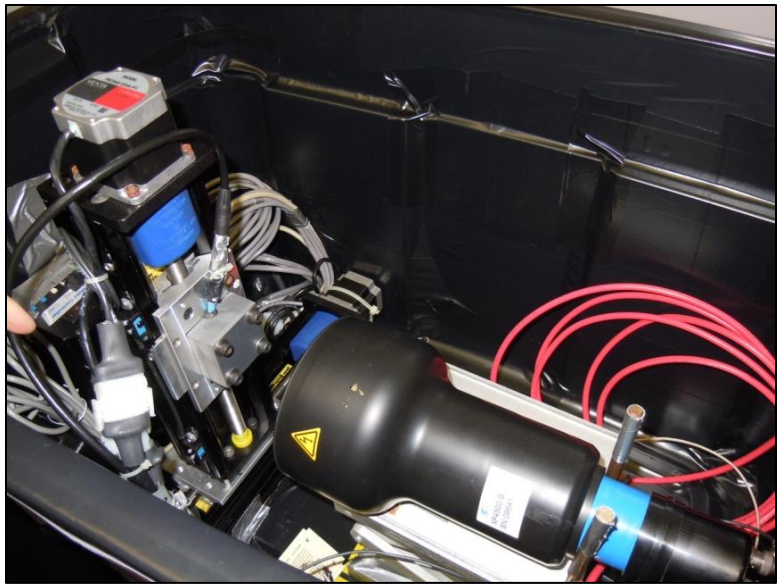
HMS XP4572 PMTs have the best QE
(but not available for purchase)

XP4500/B PMTs are better in QE. Are there alternative/better options?

PMT uniformity scans

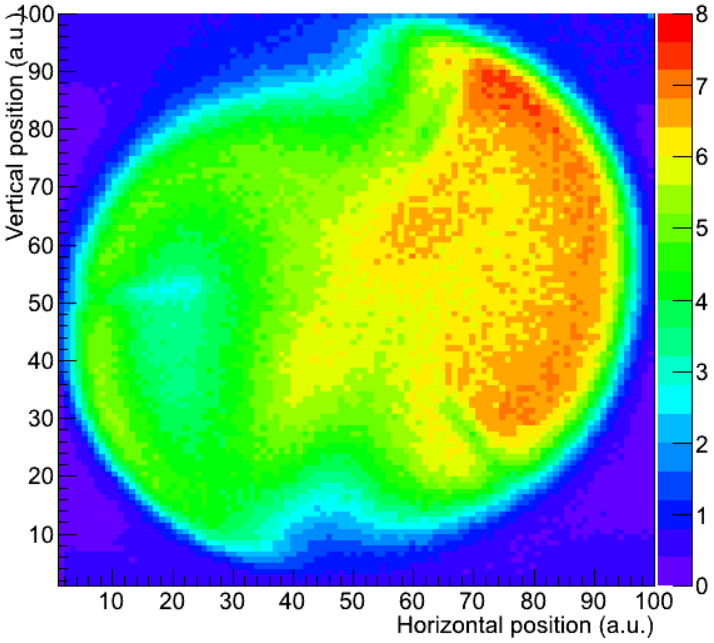




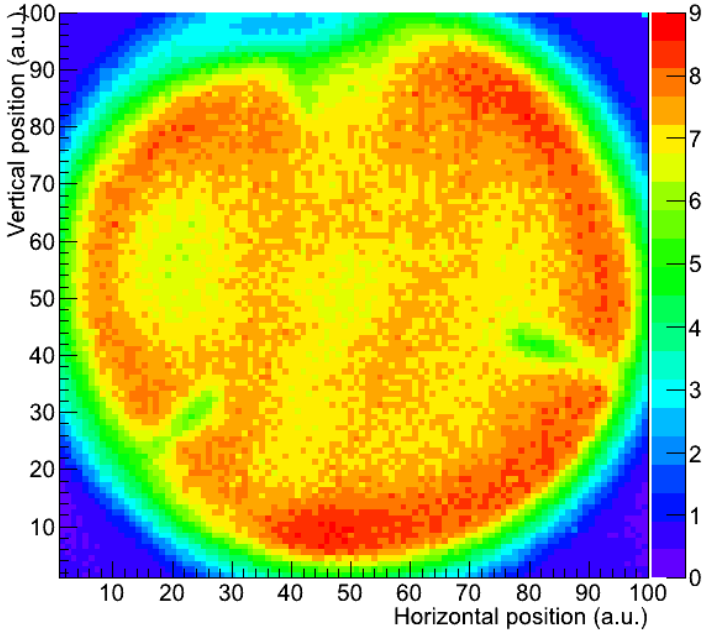


Results of PMTs scans

XP4500/B



HMS XP4572 PMTs



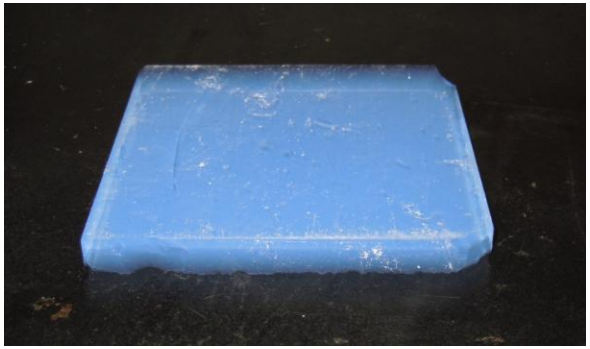
Kaon Aerogel Cerenkov Detector

COMPONENTS CHARACTERIZATION

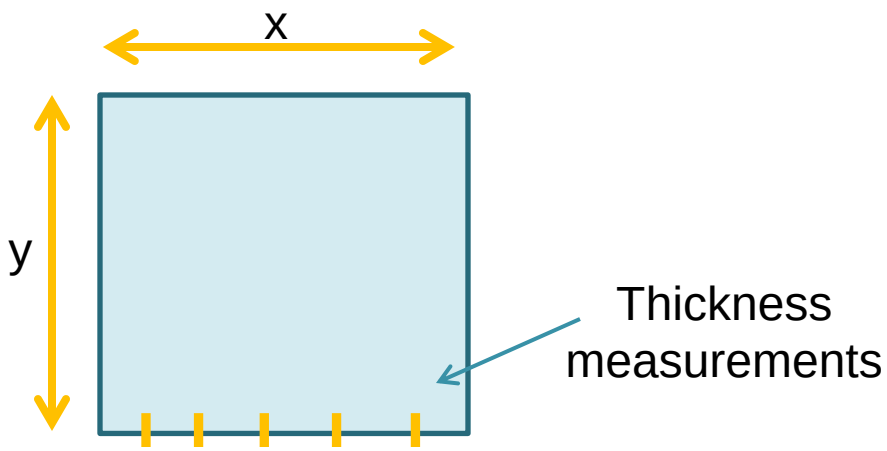
PMTs

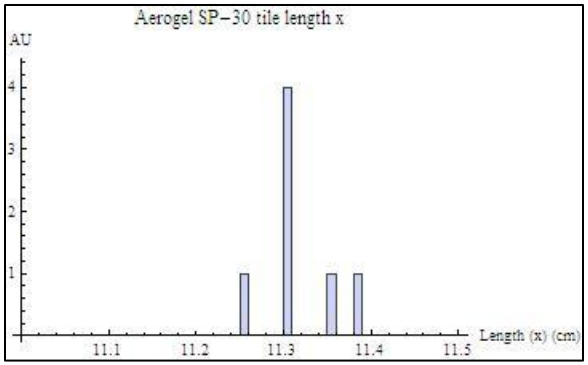
Aerogel

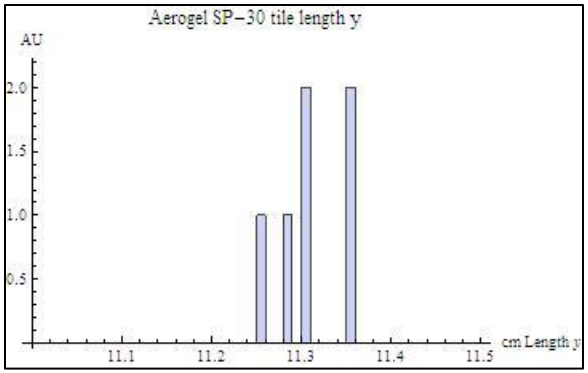
- Dimensions
- Refractive index
- Transparency

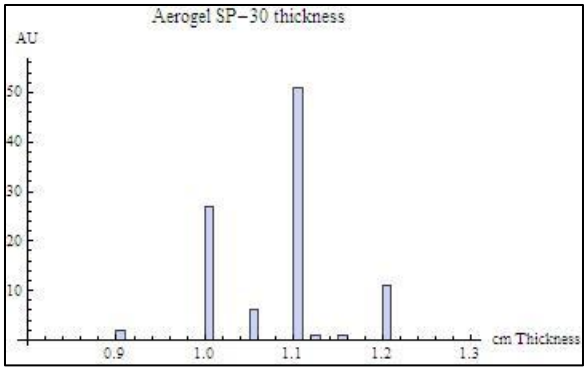


Dimensions of Aerogel Tiles









Mean x = 11.31 +- 0.04 cm

Mean y = 11.31 +- 0.04 cm

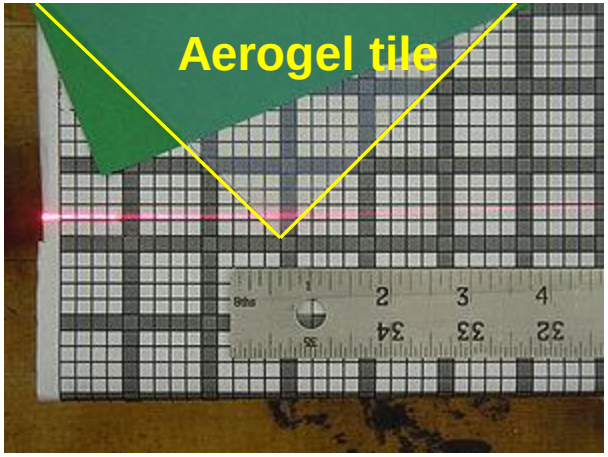
Thickness = 1.07 +- 0.08 cm

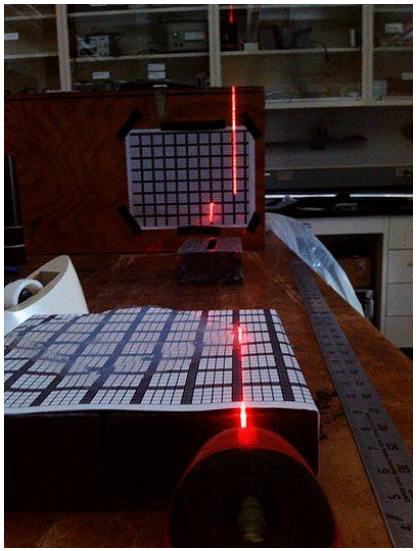
Position-dependent variation: 2-13%

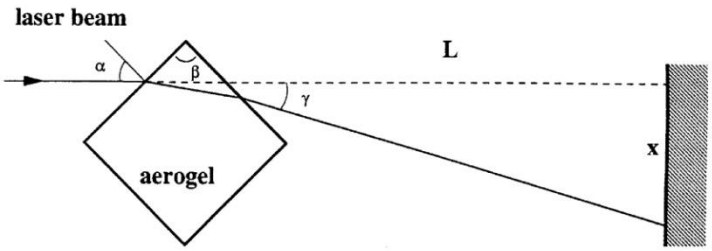
Tile-to-tile variation: <16%

Refractive index

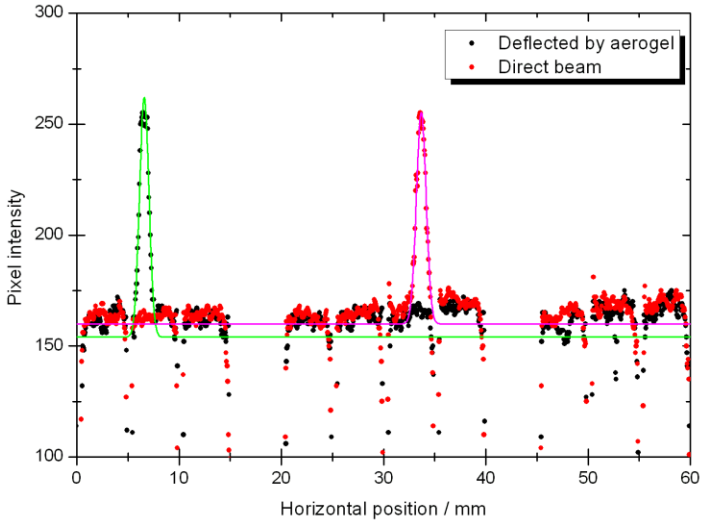
Setup for measuring the refractive index





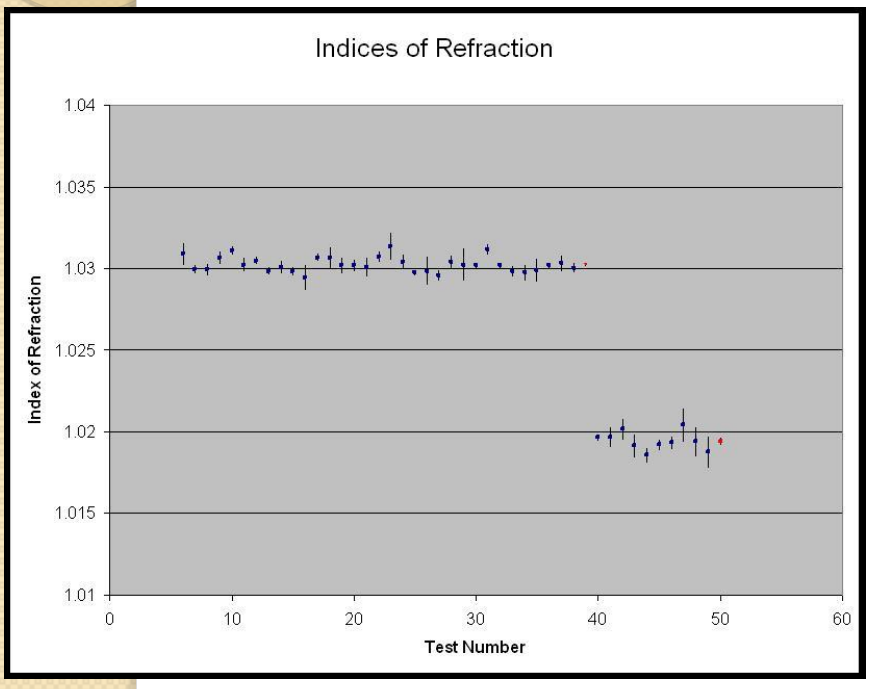


$$\gamma = \alpha - \beta + \arcsin\left[n \cdot \sin\left(\beta - \arcsin\left(\frac{\sin(\alpha)}{n} \right) \right) \right]$$

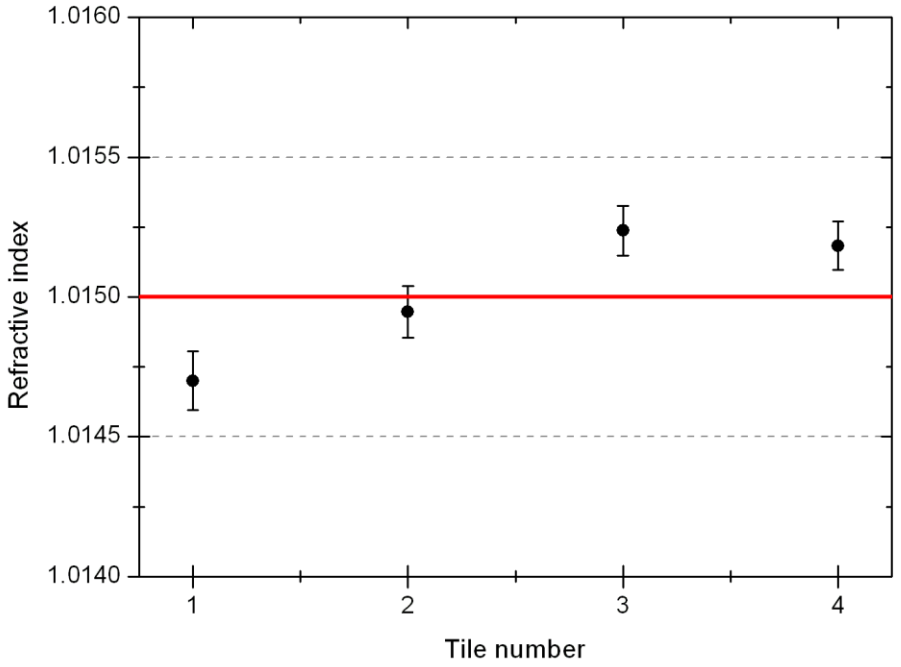


Refractive index

n = 1.030 and 1.020

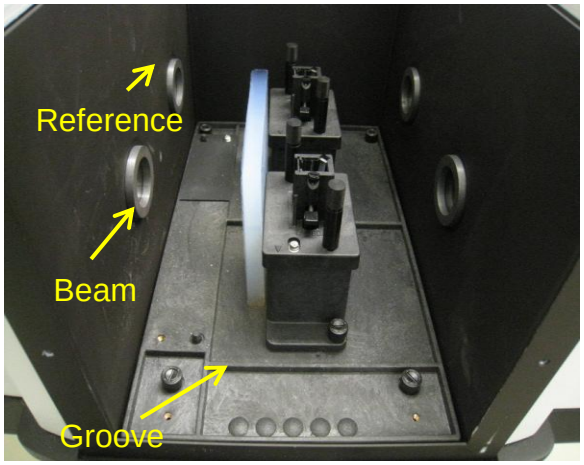


n = 1.015

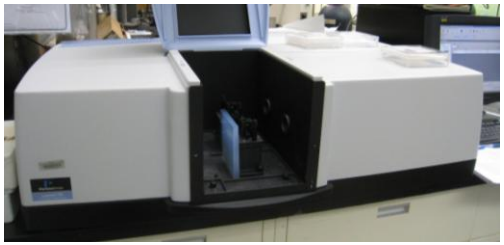


We will characterize a larger sample of tiles

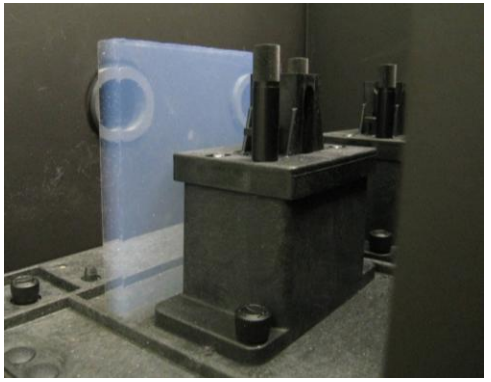
Transmittance



Horizontal alignment



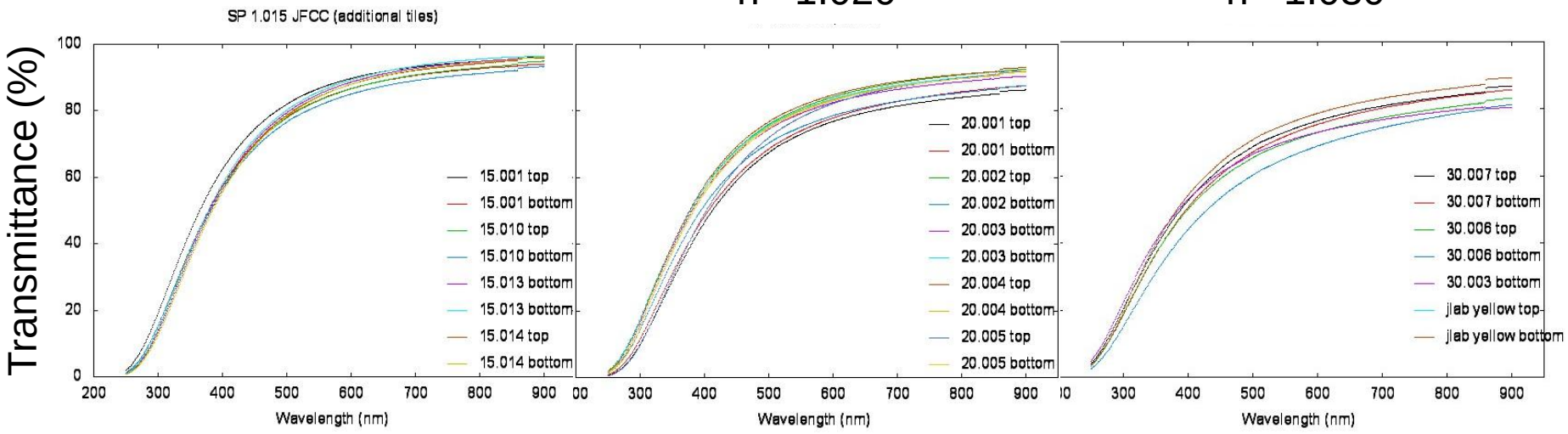
Perkin/Elmer Lambda 750 Spectrometer



Tile aligned for measurement

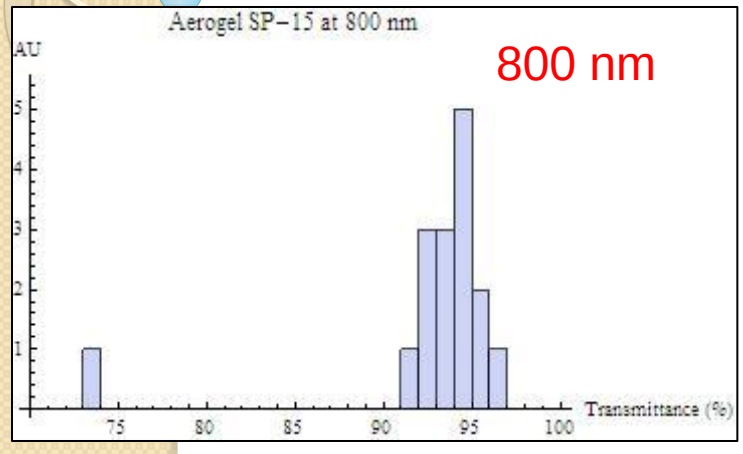
n =1.020

n =1.030



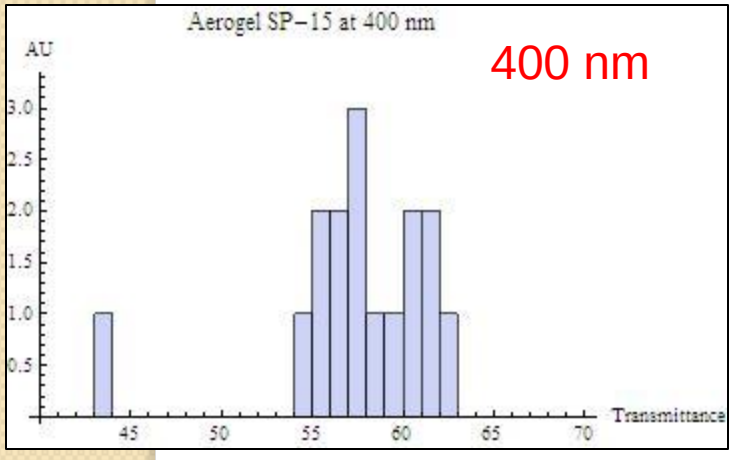
Transmittance Distributions

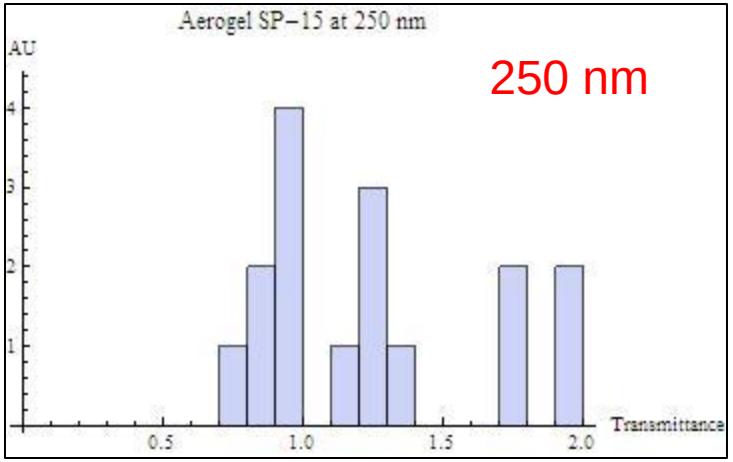
JFCC SP-15



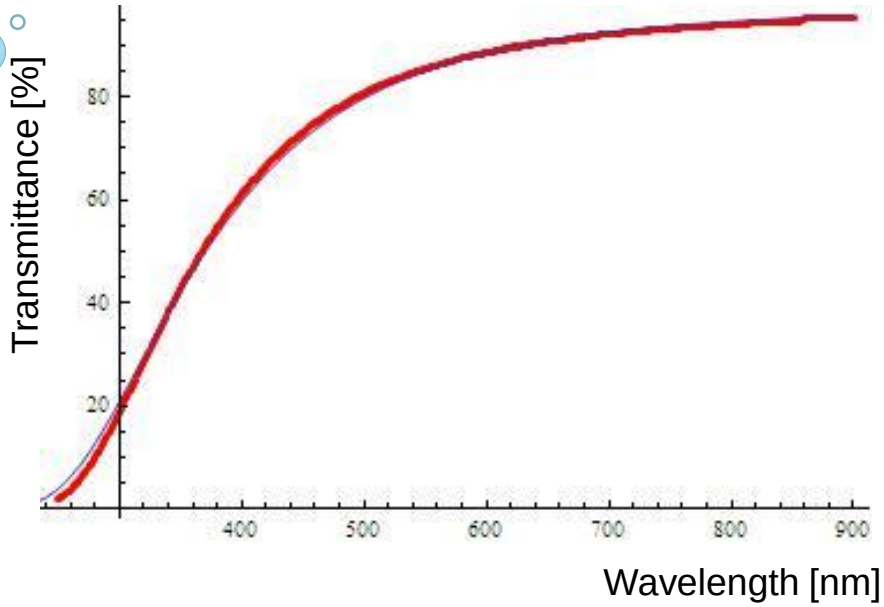
Wavelength (nm)	Standard Deviation (%)*
250	0.4
400	4.5
800	5.4

* Includes: statistical, position, and tile-to-tile dependence





Hunt Parameters



Hunt formula

$$T = A\,e^{-Ct/\lambda^4}$$

T=transmittance

C=clarity coefficient [cm/μm^4]

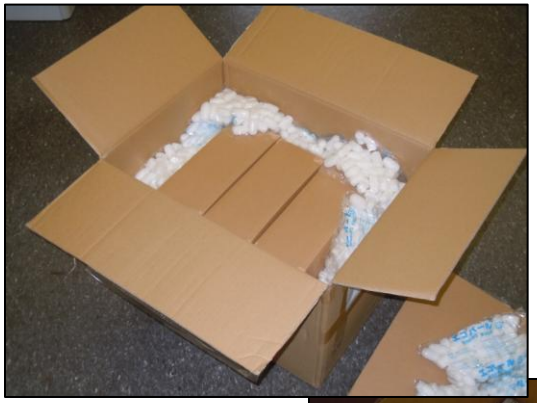
t=thickness [cm]

A=absorption process

Index	Hunt parameter A	Hunt Parameter Ct (μm^4)	Standard Deviation
SP-15	0.965	0.0141	6.7%
SP-20	0.918	0.0131	2.7%
SP-30	0.853	0.0119	7.4%

This technique does not measure scattered light.

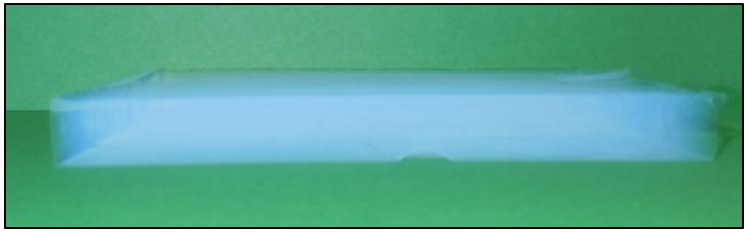
Update on Lowest Index Aerogel



- ✓ 100 JFCC tiles of index 1.015 have arrived and initial testes have been positive!

- ✓ Ordered a new lot of 180 tiles n=1.015

- ✓ We will get a sample of n=1.010 tiles for prototype tests



One 1.015 aerogel tile on a green paper

Kaon Aerogel Cerenkov Detector

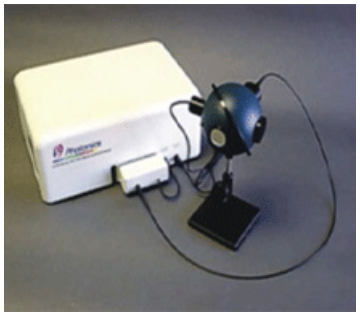
NEXT STEPS OF THE PROJECT

Near future...

→ Assembly the 1.030 and 1.020 aerogel trays at JLab

→ Measurement of the transflectance of the aerogel

Integrating sphere method



→ Receive the second lot of ordered 1.015 tiles

→ Receive a sample of 1.010 tiles for studies

→ Cosmic ray tests with the fully assembled detector

More details at:

www.vsl.cua.edu/cua_phy