SHMS AEROGEL OVERVIEW

The Catholic University of America

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University of South Carolina

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Mississippi State University

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Florida International University

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Yerevan Physics Institute

Hamlet Mkrtchyan, Arthur Mkrtchyan, Arshak Asaturyan, Vardan Tadevosyan, S. Zhamkochyan

01/13/2012

Hall C Users Meeting

Why an Aerogel detector? (PID)

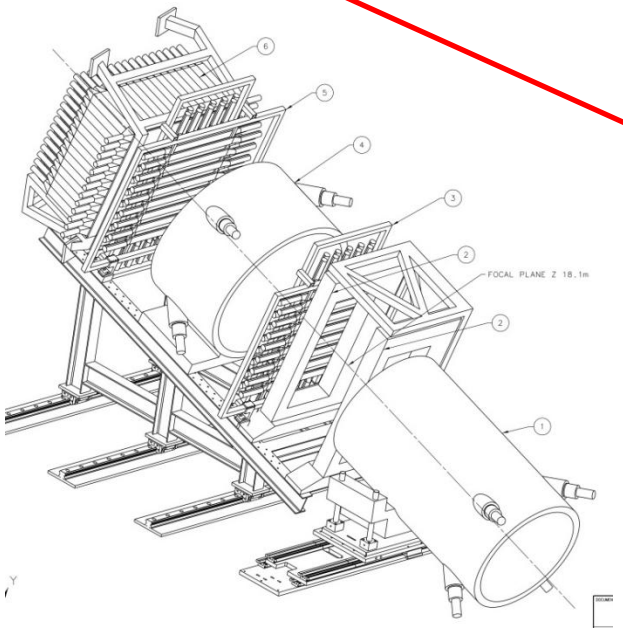
Access to strangeness physics

Particle IDentification

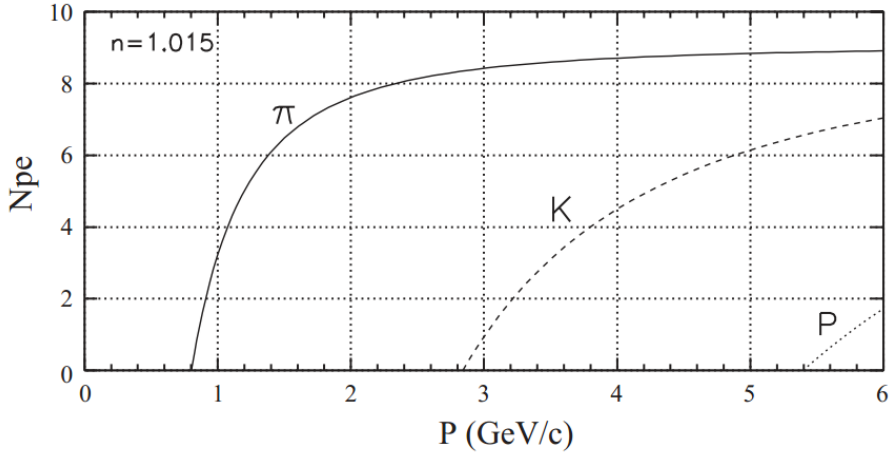
SHMS base detector system provides particle identification for *e*, π, *p* over the full momentum range

- 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)

SHMS (e,e'K+) program in Hall C

To date four experiments have been approved for Hall C at 11 GeV that will use this detector

Experiment	**Physics Motivation**	**SHMS Momenta (GeV/c)**	**Worst Fore/Bkd Rate Ratio**
Color Transparency (E12-06-107)	• vanishing of *h*-*N* interaction at high *Q*. • exclusive π, *K* production from nuclei.	5.1-9.6	1(K):10(p)
SIDIS p_T (E12-09-017)	• extract mean k_T of u,d,s quarks in proton. • SIDIS π , K production.	1.5-5.0	
SIDIS R (E12-06-104)	• Measure the ratio $R=\sigma_L/\sigma_T$ • SIDIS, π , K production.	1.5-5.0	
Kaon Factorization (E12-09-011)	study of soft-hard factorization in exclusive K+ production. L/T separations vs. Q2, t.	2.6-7.1	1(K):3(p)

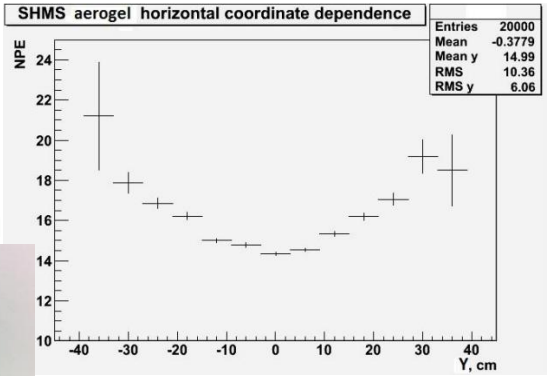
Kaon aerogel project

Current Status:

NSF-MRI Consortium (NSF-PHY-1039446)

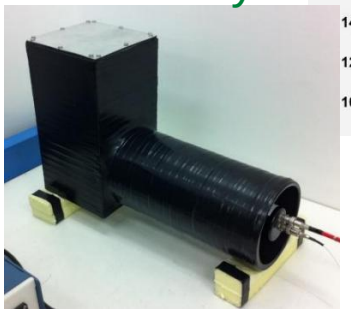
CUA

- Detector box construction
- GEANT4 simulations
- Aerogel material and PMT studies



Yerevan Physics Institute → talk by Arthur Mkrtchyan

- GEANT4 simulations
- Prototype for aerogel material tests
- Aerogel material and PMT quality studies



Florida International University

- Response of large diameter PMTs in a magnetic field

University of South Carolina

- Initial PMT gain testing during summer 2011

Mississippi State University

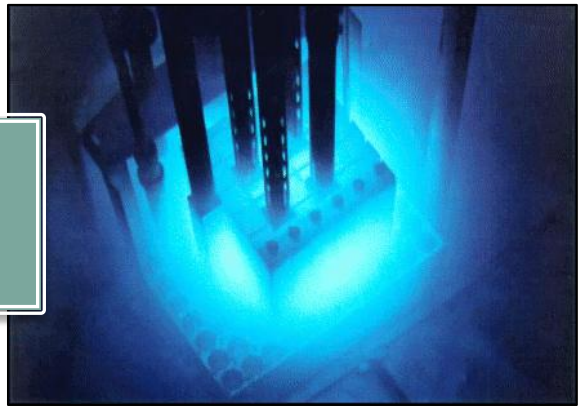
- Third aerogel index

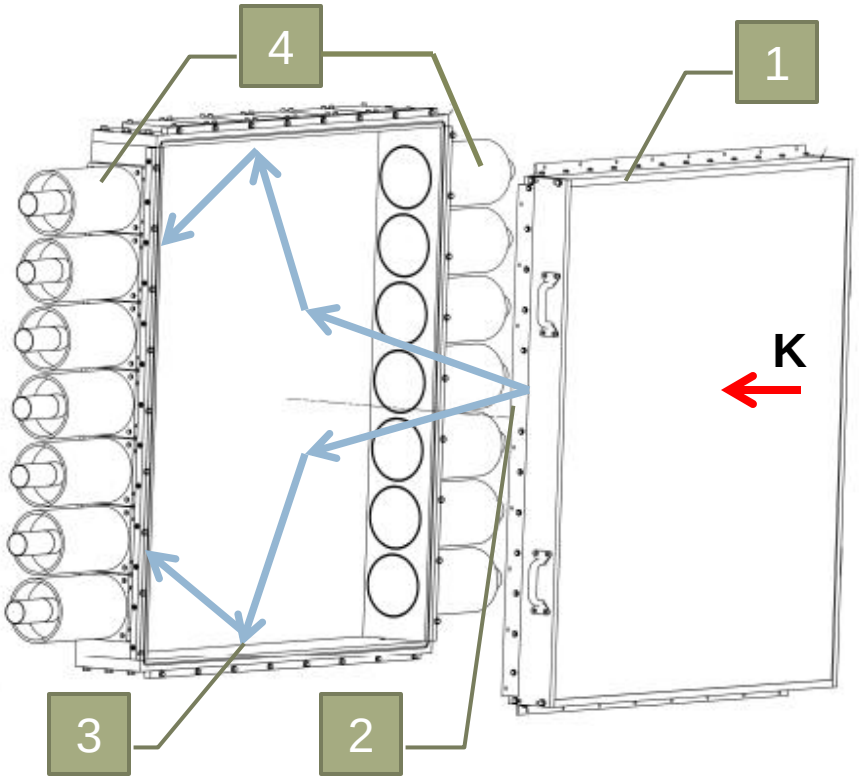
Concepts and design

Aerogel detector concepts

Aerogel is the lightest solid, almost as light as gas

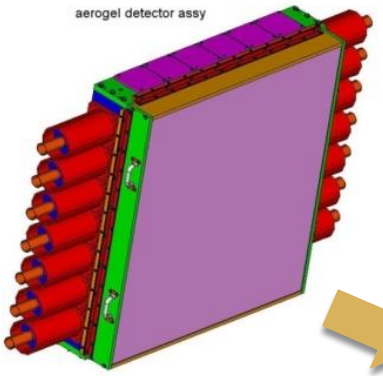
Cerenkov radiation in a nuclear reactor



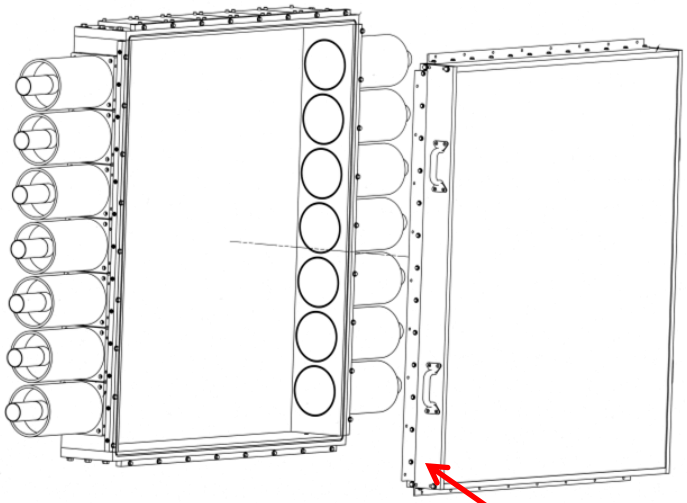


1. Particle passes through aerogel box
2. If $v > \frac{c}{\sqrt{n}}$, Cerenkov radiation (photons) is emitted
3. Reflections of photons on the wall, covered with Millipore
4. Some photons hit the PMTs giving a trigger signal

SHMS aerogel detector design



Design drawing
[B. Metzger]



Based on the HMS aerogel detector design, but modified for SHMS and experimental requirements

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

Diffusion box, covered with reflective material

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

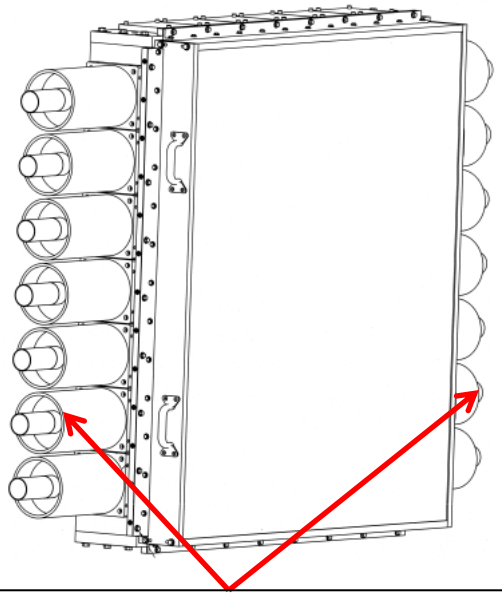
MF-Millipore Membrane Filters

Refractive index options:
n = 1.03
n = 1.02
n = 1.010 or 1.015

Acquired n=1.03, 1.02 aerogel from MIT/Bates experiment with help from the Yerevan group in Spring 2011

SHMS aerogel detector design

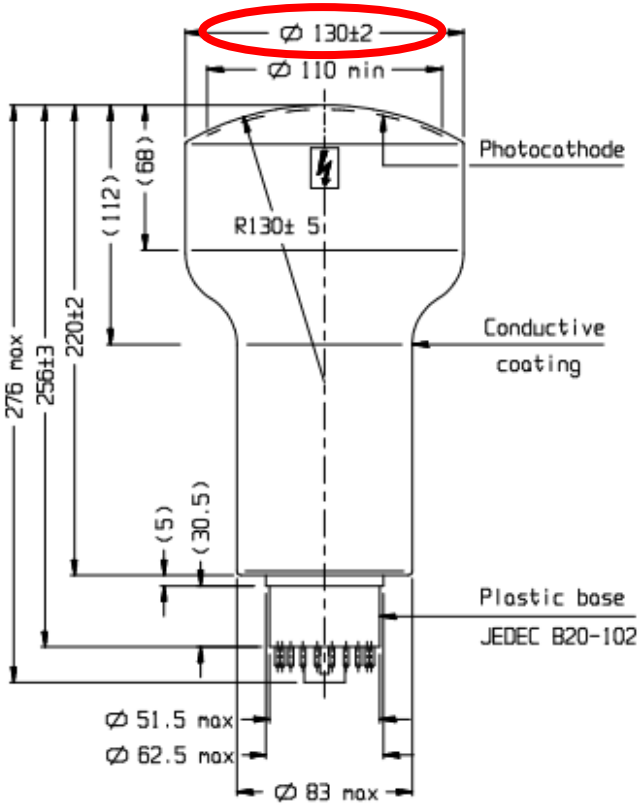
Photosensors



14 PMTs, to collect the light

- Acquired ~65 5-inch PMTs from MIT/Bates experiment with help from the Yerevan group in Spring 2011

Model XP4500B



Dimensions in millimeters

Detector design considerations

Requirement

- Radiate enough photons to be detected by the PMTs
- Be as transparent as possible to do not absorb the radiated photons

Aerogel layer of 10 cm

- Cover the full Kaon momentum range

Construction of three Aerogel trays:

n = 1.03

n = 1.02

n = 1.010 or 1.015 (?)

To be decided to buy from, e.g., Panasonic (1.015) or Novosibirsk (1.010)

++ Tests ongoing at JLab ++

Implementation

Detector construction

- 01 diffusion box
- 03 aerogel trays

Detector box construction

All materials for the detector box have been purchased in fall 2011

Construction ongoing in CUA machine shop

CUA Machine Shop

Michael

Paul

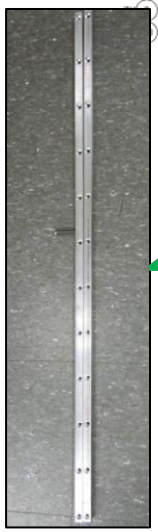
Box construction

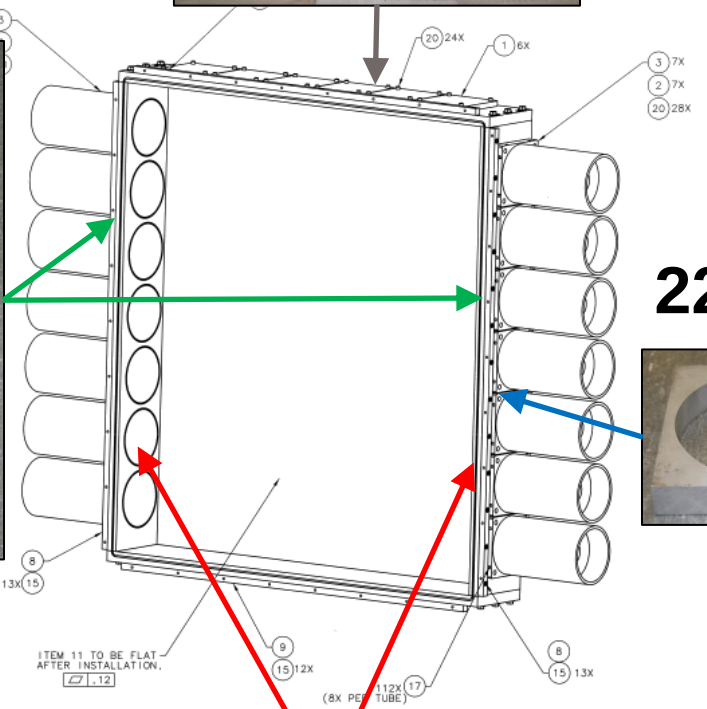
Progress on various parts of the box

Diffusion box

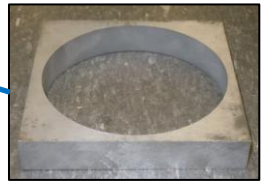
Qty.	Status	Part	Drawing
1	☐	Cover plate	67165-00012 sh. 1
1	☑	Attachment plate	67165-00016 sh. 1
1	☑	Interface plate	67165-00018 sh. 1
6	☑	Tube port cover	67165-00019 sh. 4
22	☐	PMT outer shield	67165-00019 sh. 4
22	💧	PMT outer shield end plate	67165-00019 sh. 4
22	☐	PMT inner shield	67165-00019 sh. 5
2	💧	Diffusion box vertical	67165-00019 sh. 5
1	💧	Diffusion box top	67165-00019 sh. 6
1	☑	Diffusion box lower	67165-00019 sh. 7
2	☑	Diffusion box vertical bar	67165-00019 sh. 8
2	☑	Diffusion box horizontal bar	67165-00019 sh. 8
22	☐	PMT spacer	67165-00019 sh. 8
1	☐	Diffusion box upper plate	67165-00019 sh. 8

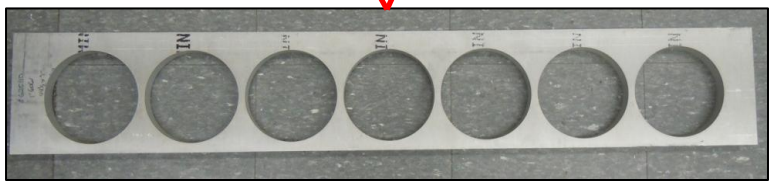
(Legend: ☑ is ready, 🔁 is being milled at the moment, 💧 was cutted (water cutting) for future milling and ☐ is not milled)





22 x





2 x

For construction updates see our Wiki:
http://www.vsl.cua.edu/cua_phy/index.php/MainPage:Nuclear:KaonDetector

03 Aerogel trays construction

Aerogel tray construction will start this spring

Aerogel trays

Qty.	Status	Part	Drawing
3x2	☐	Aerogel box vertical	67165-00020 sh. 3
3x2	☐	Aerogel box horizontal	67165-00020 sh. 4
3x2	☐	Aerogel box vertical angle	67165-00020 sh. 5
3x2	☐	Aerogel box horizontal angle	67165-00020 sh. 5
3x1	☐	Aerogel box bottom plate	67165-00020 sh. 5

(Legend: ☑ is ready, ➔ is being milled at the moment and ☐ is not milled)

For construction updates see our Wiki:
http://www.vsl.cua.edu/cua_phy/index.php/MainPage:Nuclear:KaonDetector

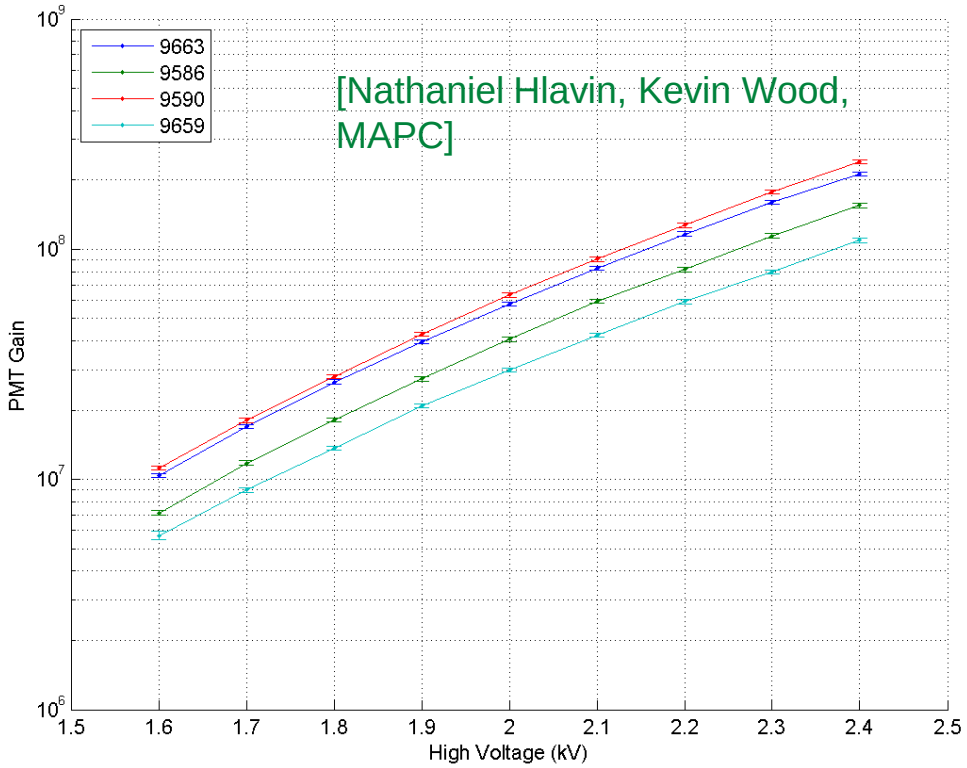
Aerogel material and PMT studies

- PMT characterization
- Aerogel tile characterization

PMT characterization

Initial gain test at JLab:

Done in the summer of 2011
CUA, Yerevan Physics Institute, USC, MSU



Example of gain test for four PMTs

33 of the 65 acquired PMTs were analyzed

PMT s/n	Base s/n	LED intensity (V)			
09592	76	2.5			
Run (#)	hV (V)	Pedestal (channel)	Pedestal Error	Gain	Gain Error
1881	1600	73.05	0.01	2.29E07	4.83E05
1882	1700	73.05	0.01	3.71E07	7.82E05
1887	1800	72.96	0.01	5.98E07	1.28E06
1888	1900	73.02	0.01	9.45E07	1.95E06
1889	2000	72.79	0.01	1.42E08	2.94E06
1890	2100	72.9	0.0	2.08E08	4.33E06
1891	2200	72.8	0.0	2.97E08	6.13E06
1892	2300	72.28	0.01	4.26E08	8.96E06
1893	2400	71.72	0.01	5.98E08	1.26E07

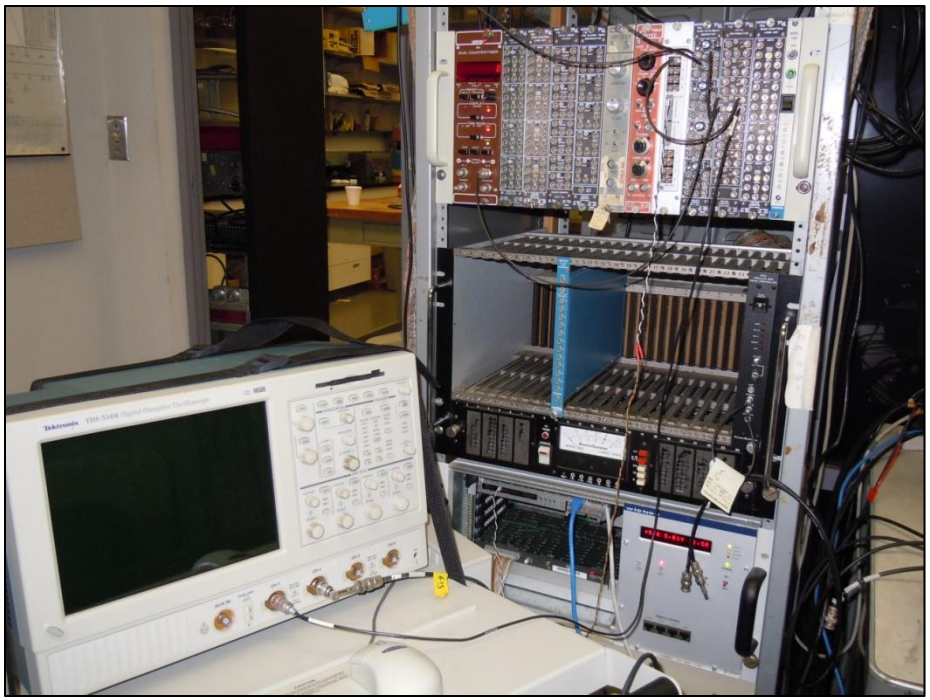
For full table see our Wiki:
http://www.vsl.cua.edu/cua_phy/index.php/MainPage:Nuclear:KaonDetector

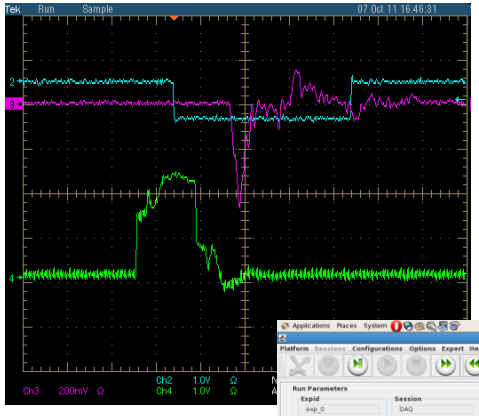
PMT characterization at CUA

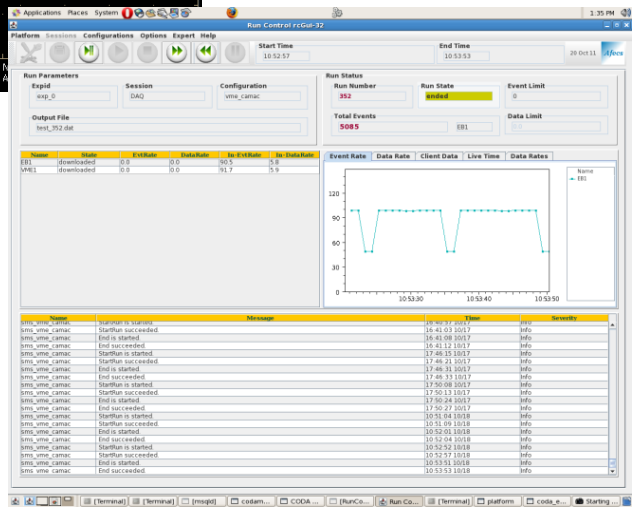
We built a simple data acquisition system at CUA to carry out further PMT tests in summer/fall 2011

System is ready for PMT tests and initial tests have been performed

CAMAC crate with ADC, using CODA software to extract data



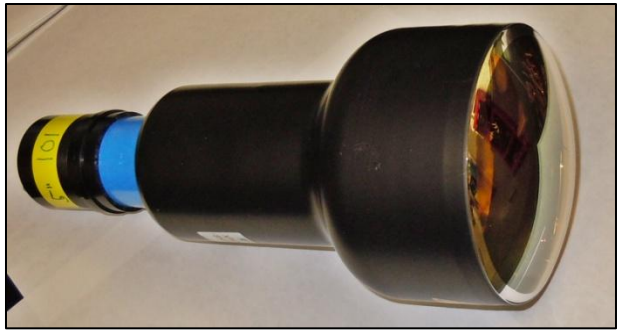




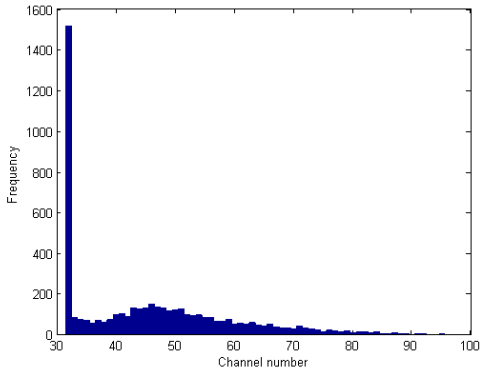
[NH, MM, MAPC]

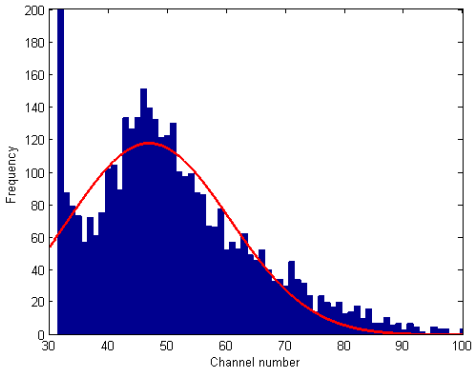
PMT characterization at CUA

PMT gain test:



- Reproduce the gain curve of PMTs tested at JLab
- Analyze other PMTs



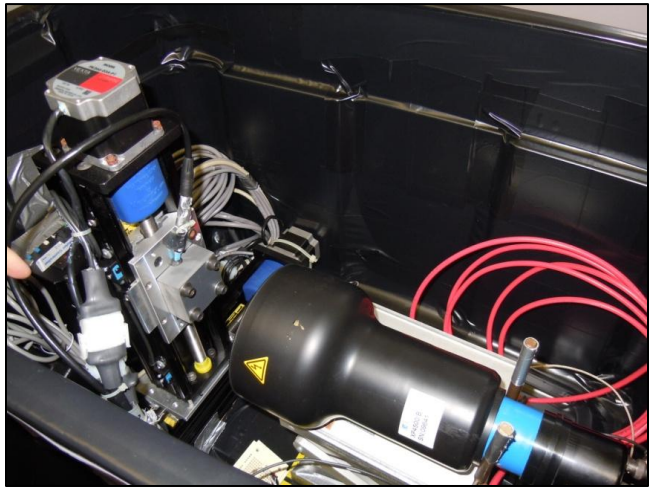


[Nathaniel Hlavin, MAPC]

PMT characterization at CUA

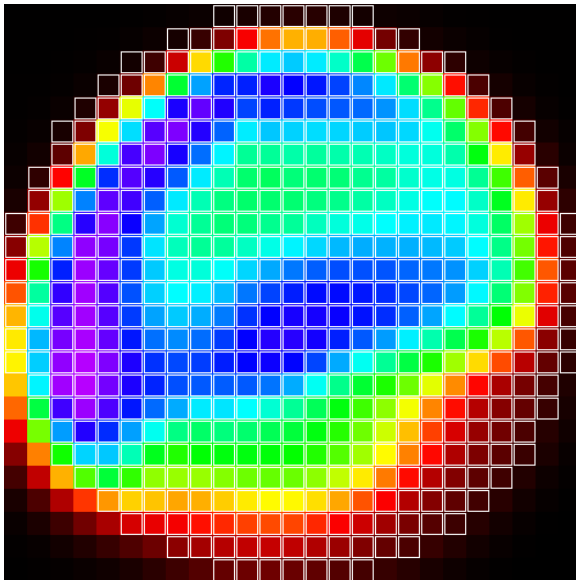
Large PMT incident light position dependence:

[Mike Metz, MAPC]

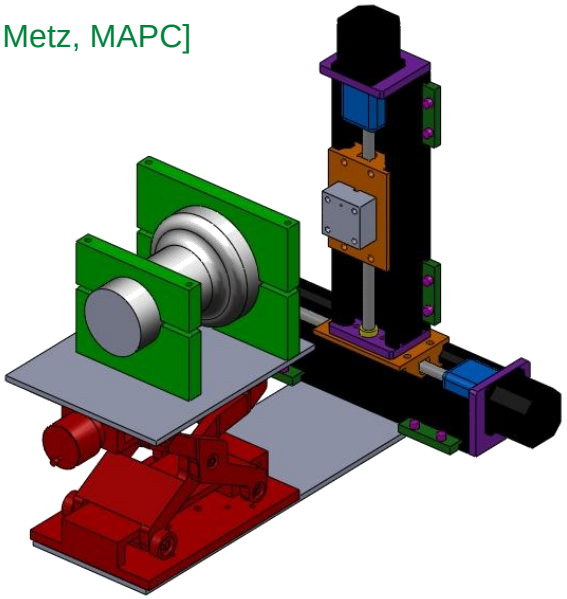


25 x 25 matrix scanning

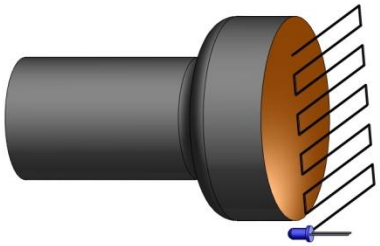
25 x 25 matrix scanning



Due to some misalignment?

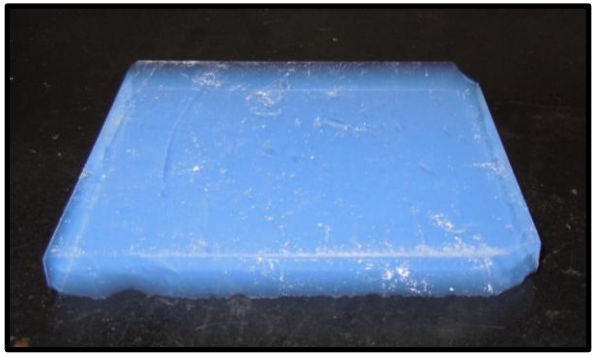


Next experimental setup, reducing alignment tolerance



CAMAC crate with ADC, using CODA software to extract data

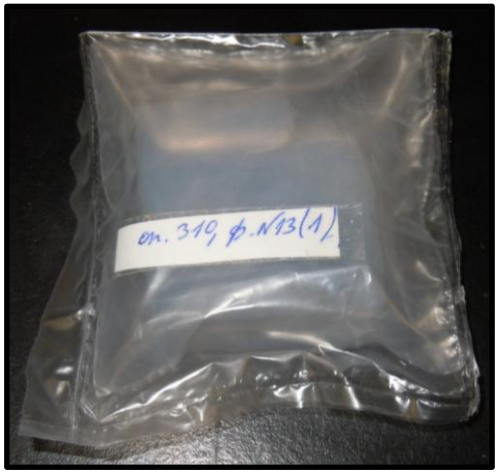
Aerogel material characterization



n = 1.03 aerogel block

Index options:
n = 1.03
n = 1.02
n = 1.010 or 1.015

Cover the full Kaon momentum range



n = 1.010 aerogel (from Novosibirsk)

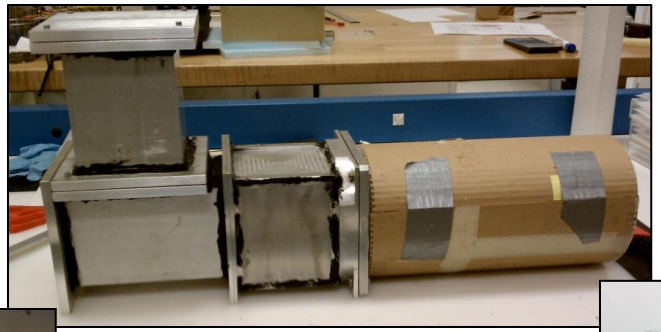
Aerogel material tests (ongoing and to be done):

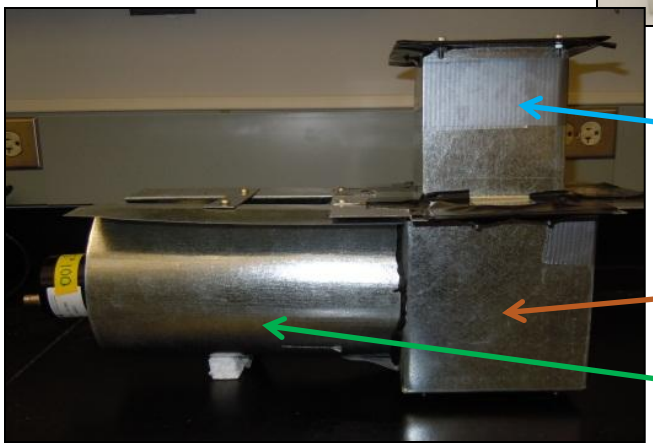
- Decide on lowest index
- Quality tests of aerogel material, e.g., transmission properties
- Refractive index, surface coating, etc.

Prototypes for aerogel tests

Construction of test setup/prototypes:

1st version of the prototype used in summer 2011



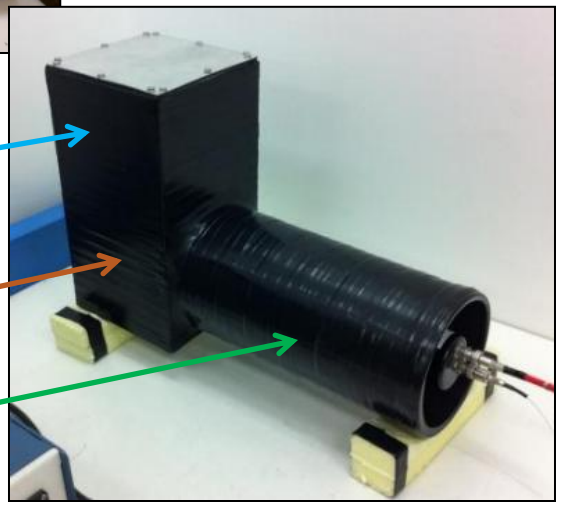


CUA prototype

Aerogel tray

Diffusion box

PMT



Yerevan prototype at JLab

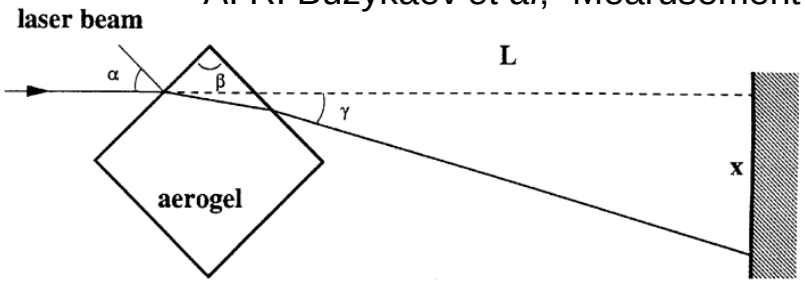
[see Arthur Mkrtchyan talk]

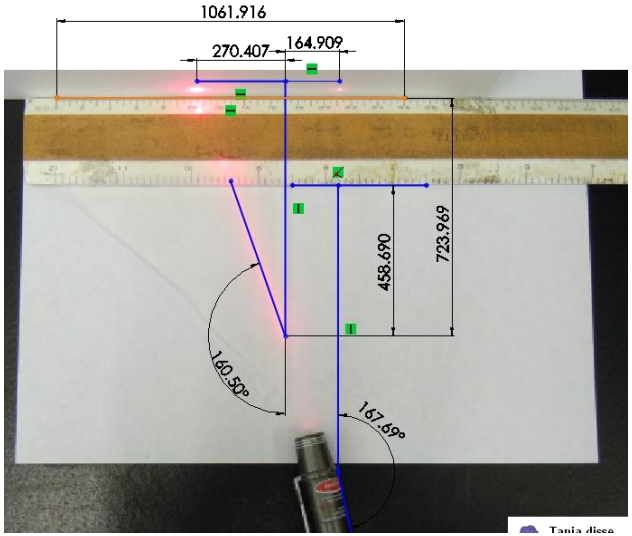
Aerogel material tests at CUA

Planned tests in spring 2012:

Refractive index analyzes

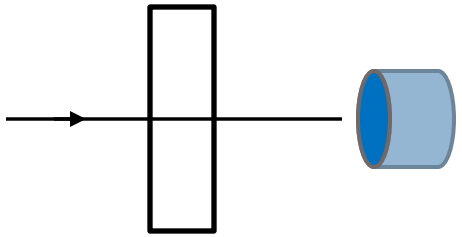
A. R. Buzykaev *et al*, “Mearusement of optical parameters of aerogel”, NIM-A (1999)





Analysis on the refractive index using a laser beam

Transmission analyzes



Surface coating analysis

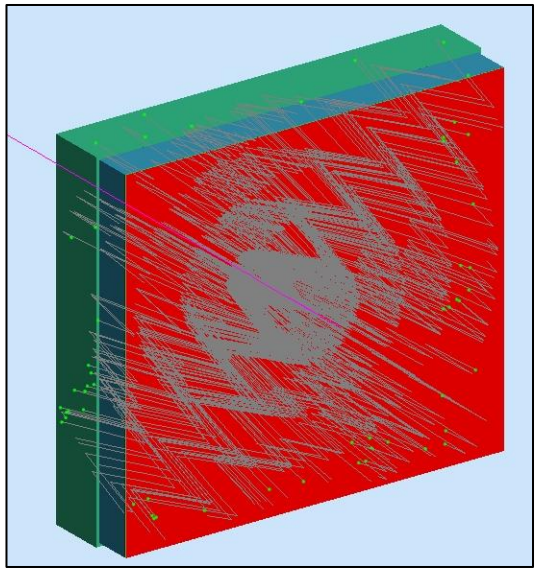
VSL materials science laboratories

GEANT4/GEMC simulations

GEMC:
https://gemc.jlab.org/gemc/Home.html

Aerogel detector in GEMC

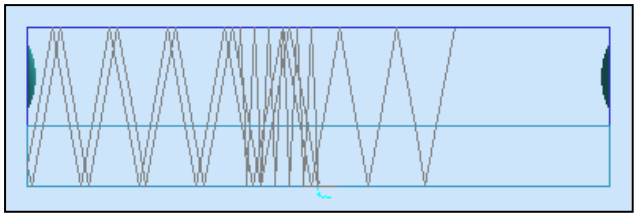
Detector construction in GEMC:

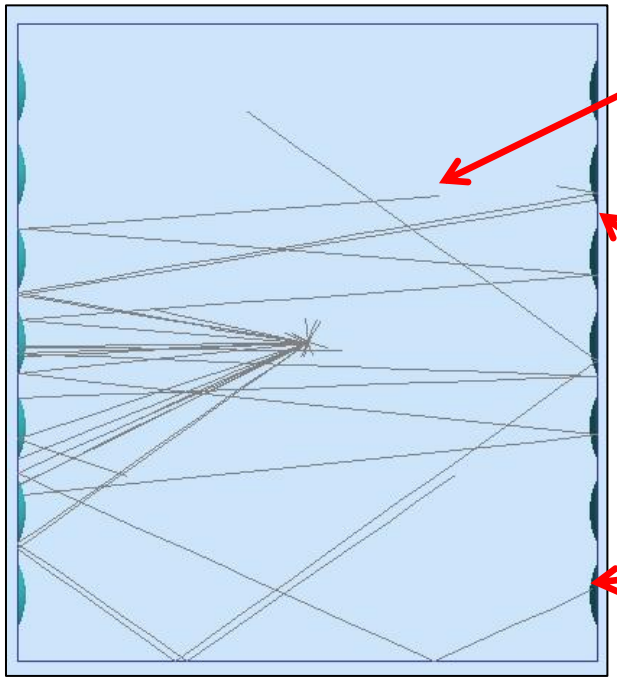


One Kaon passing through the detector and generating Cerenkov photons (gray lines)

[MAPC]

Side view of a simulation, showing just a few Cerenkov photons





Photon absorption in aerogel or Millipore

Photon reflection on the walls

Photon detected by this PMT

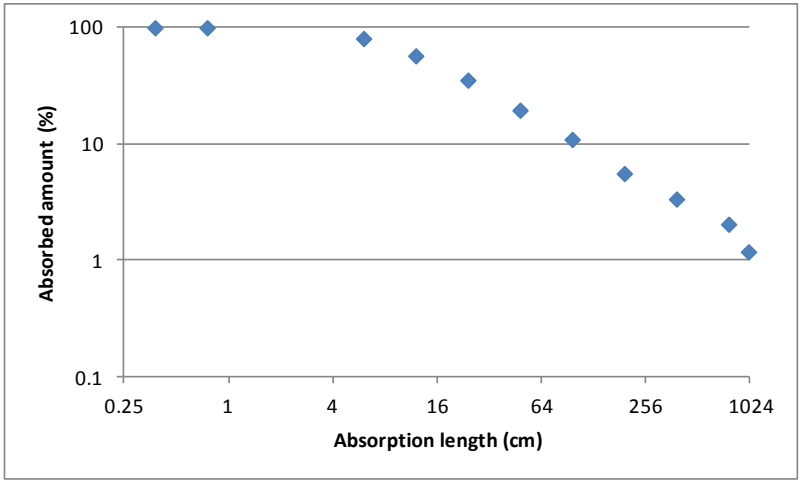
Upper view of the simulation

Aerogel detector in GEMC

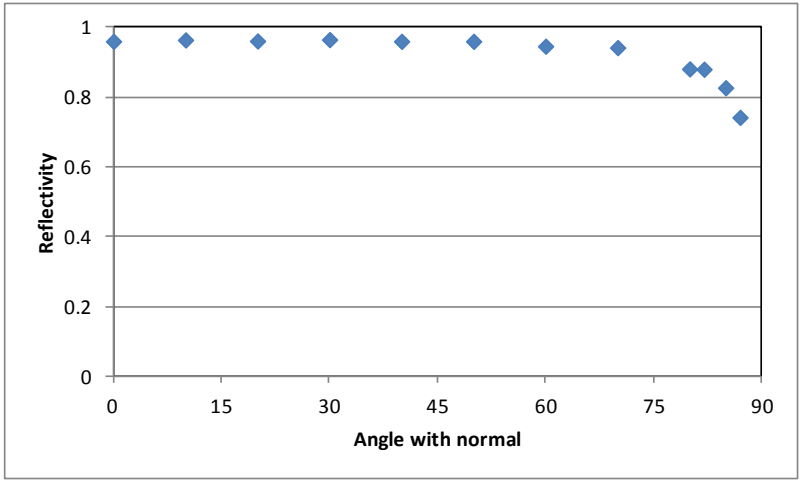
Configuring simulation parameters recompiling GEMC:

- ❑ Definition of the walls reflectivity
- ❑ Definition of the aerogel characteristics (refractive index, absorption length, Cerenkov photons generation)
- ❑ PMT detection efficiency

Absorption in aerogel (controlling its absorption length parameter)



Walls reflectivity to optical photons



Summary and Outlook

- Detector box materials procurement complete and machining ongoing
- Aerogel and PMTs have been procured from MIT/Bates experiment
- DAQ system built at CUA for PMT and aerogel tests
- Quality tests of PMTs and aerogel will continue this spring and summer
  - Prototypes have been built at Jlab and CUA
  - Modification of PMT HV bases and addition of amplifiers
  - Decision on third refractive index
- GEANT4 simulations of detector have started

More details on simulation and experimental tests in the next talks:

SHMS Shower Counter – Arthur Mkrtchyan

SHMS Aerogel Construction Details – Laura Rothgeb and Nathaniel Hlavin

Acknowledgments

All the people that are collaborating
to this project

Jefferson Lab Staff and Users