A RICH Detector for CLAS12

Contalbrigo Marco
INFN Ferrara

Workshop on Probing Strangeness in Hard Processes:
PSHP10

October 18-21, 2010 LNF INFN

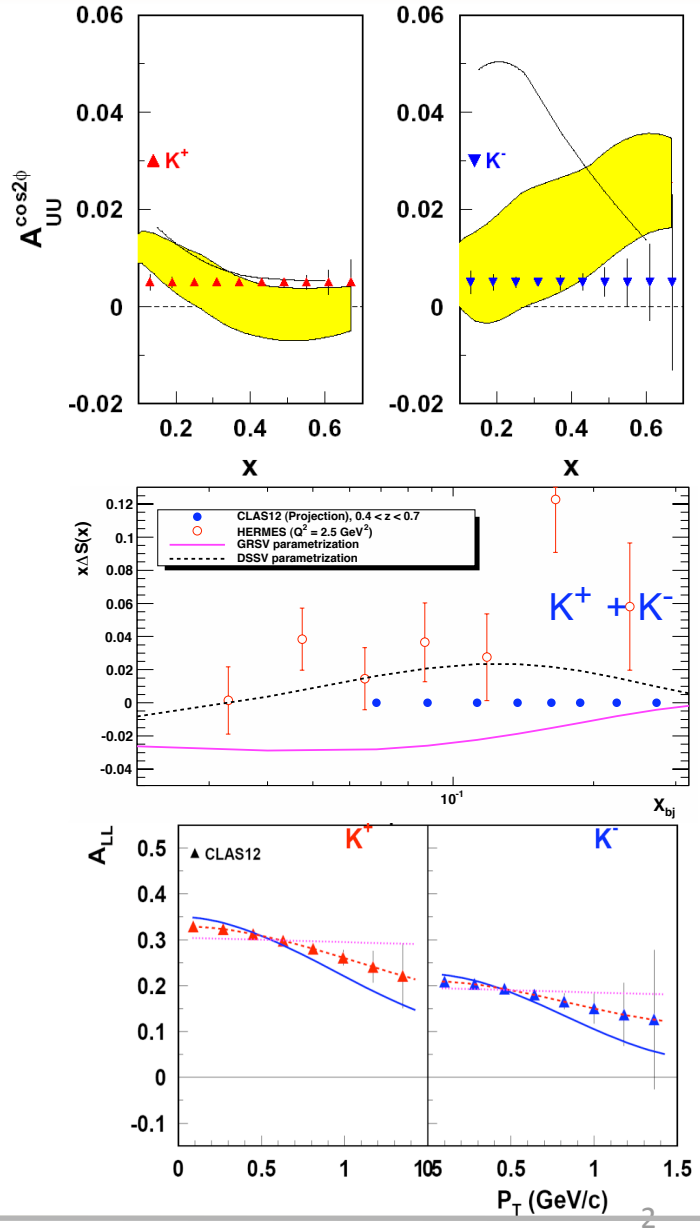
Kaon program @ CLAS12

Approved by PAC34:

PR12-09-08:
Studies of Boer-Mulders Asymmetry in Kaon Electroproduction with Hydrogen and Deuterium Targets

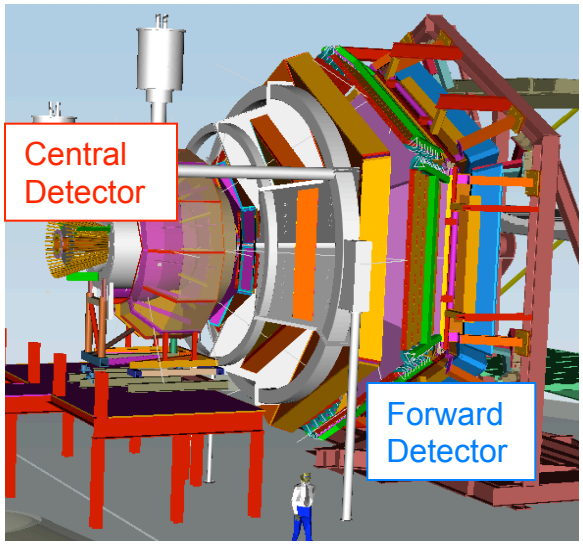
PR12-09-07:
Studies of partonic distributions using semi-inclusive production of Kaons

PR12-09-09:
Studies of Spin-Orbit Correlations in Kaon Electroproduction in DIS with polarized hydrogen and deuterium targets

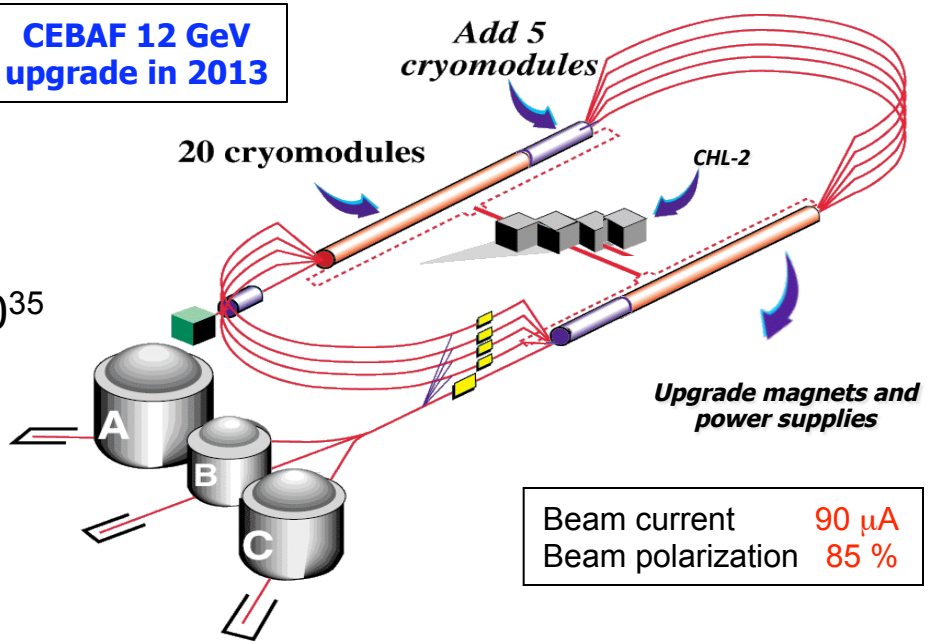


CLAS12 @ Hall-B

Hall-B @ L~10^{35} $cm^{-2}s^{-1}$ in 2015

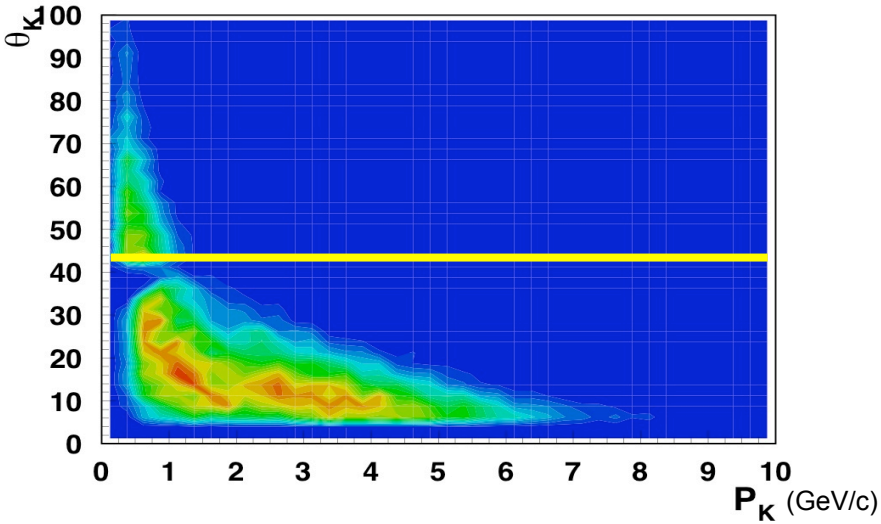


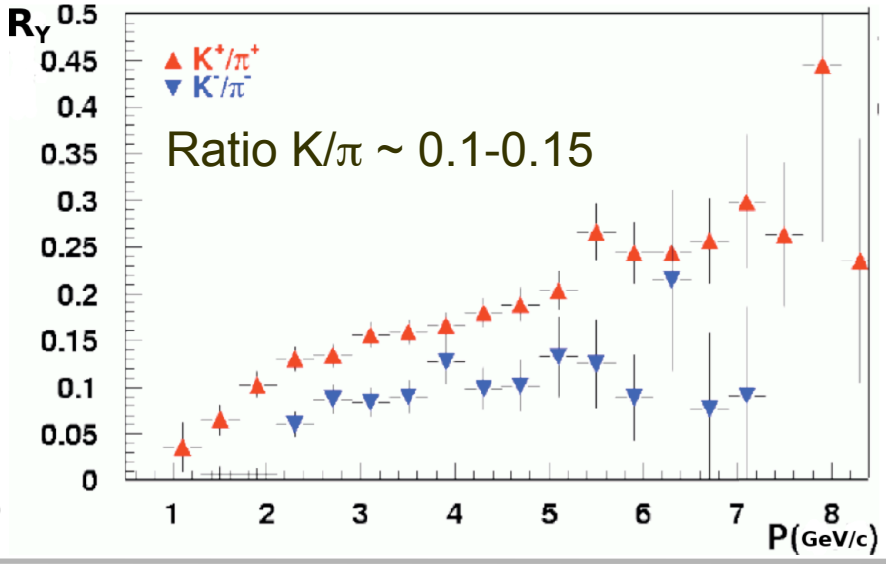
CEBAF 12 GeV upgrade in 2013



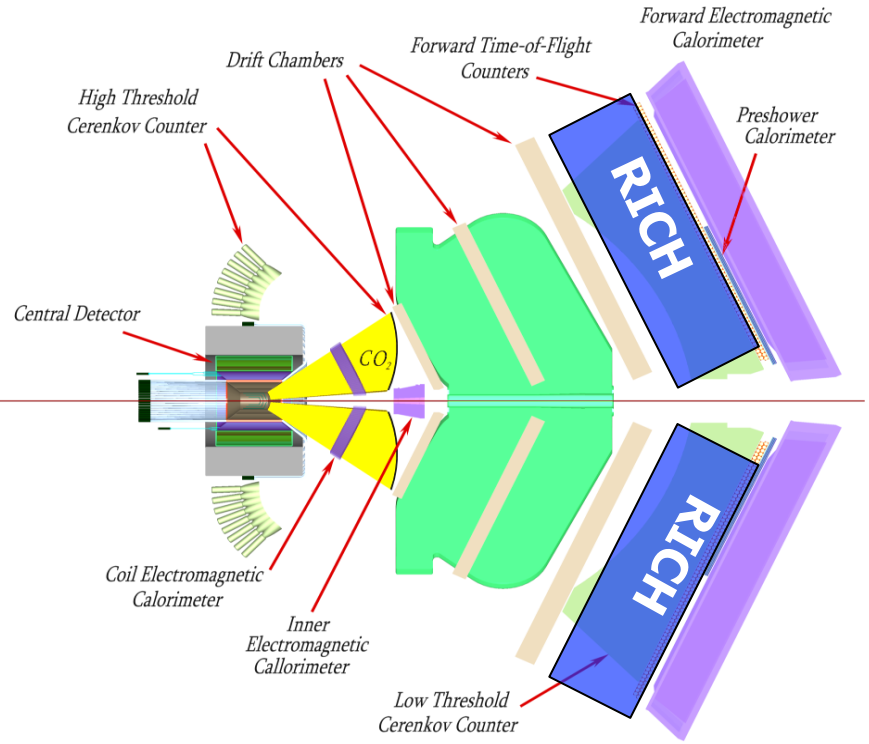
L=10^{35}

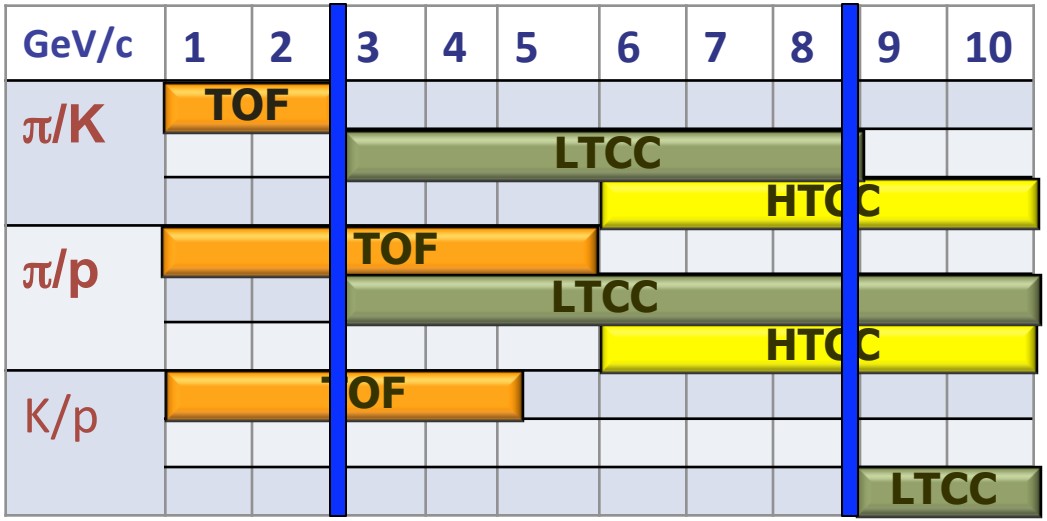
Beam current	90 μA
Beam polarization	85 %





A RICH detector for CLAS12





full pion / kaon / proton separation

over whole accessible momentum range of 2 – 8 GeV for SIDIS exp.

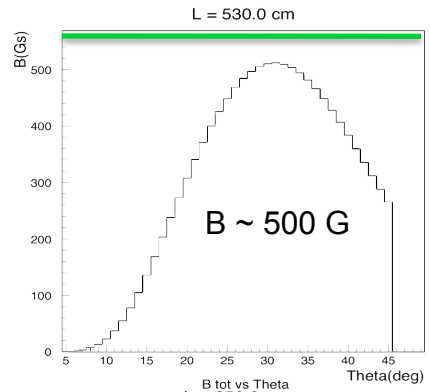
π/K separation of **4-5 σ @ 8 GeV/c** for a rejection factor **1:1000**

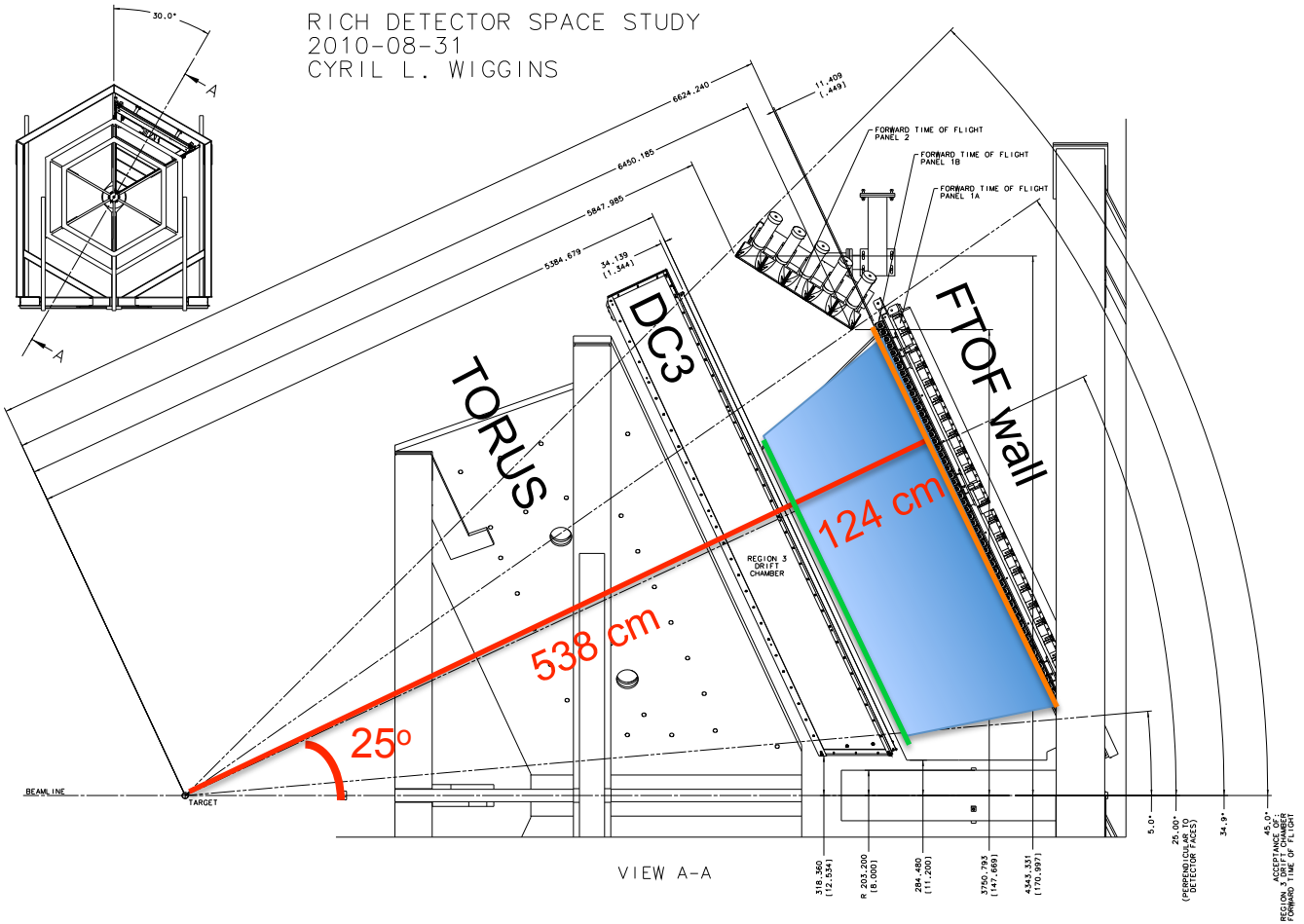
Ratio K/π ~ 0.1-0.15 for SIDIS experiments

A RICH detector for CLAS12

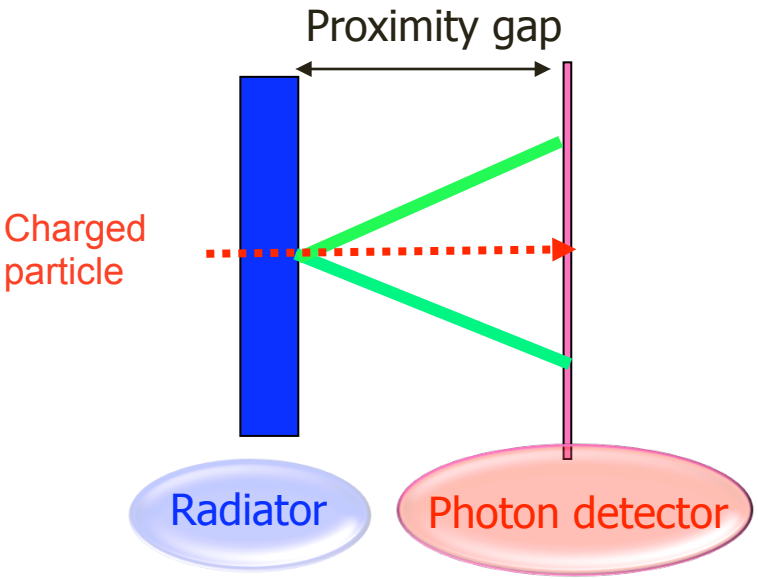
Projective geometry:

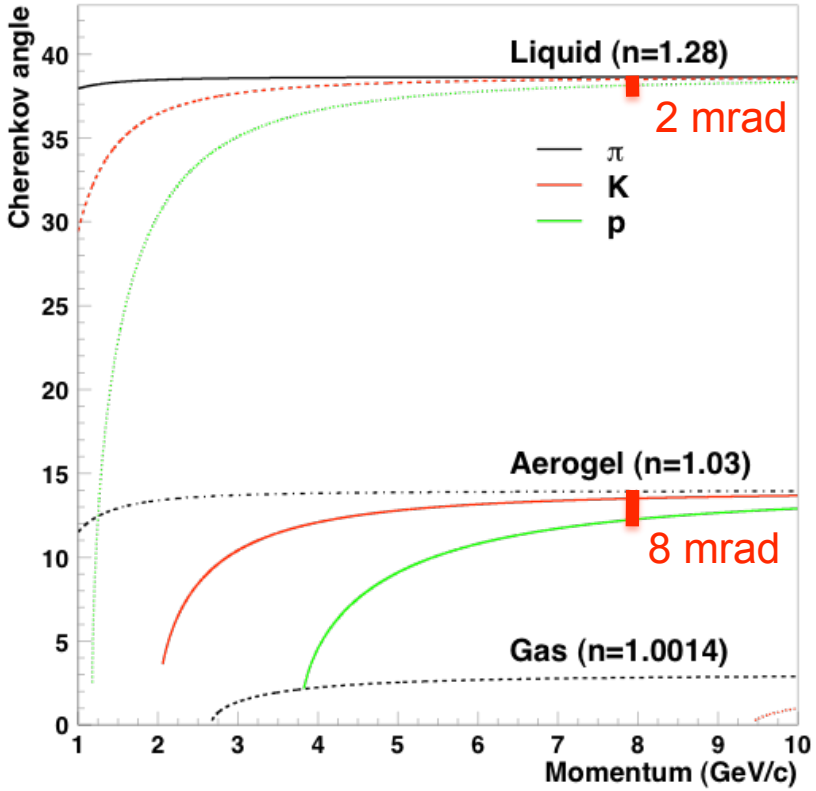
- 6 radial sectors
- 1.2 m gap
- ~ 3 m radius





The proximity focusing RICH





Freon+UV-light detection does not provide enough discrimination power in the 2-8 GeV/c momentum range (chromatic dispersion) → no cheap solution

Aerogel mandatory to separate hadrons in the 2-8 GeV/c momentum range

Collection of the **visible Cherenkov light**

A RICH detector for CLAS12

Simulations with stand alone Monte Carlo (from Hall-A):

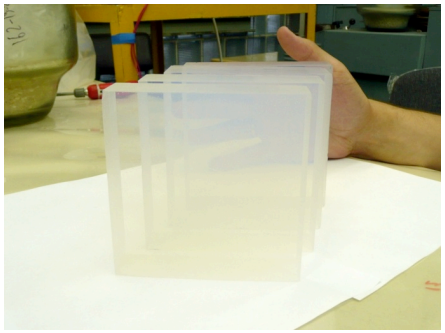
- GEANT3 toolkit
- Simplified geometry
- Ideal optical surfaces
- Rayleigh scattering treated as additional absorption
- No background accounted for

Preliminary studies of basic parameters:

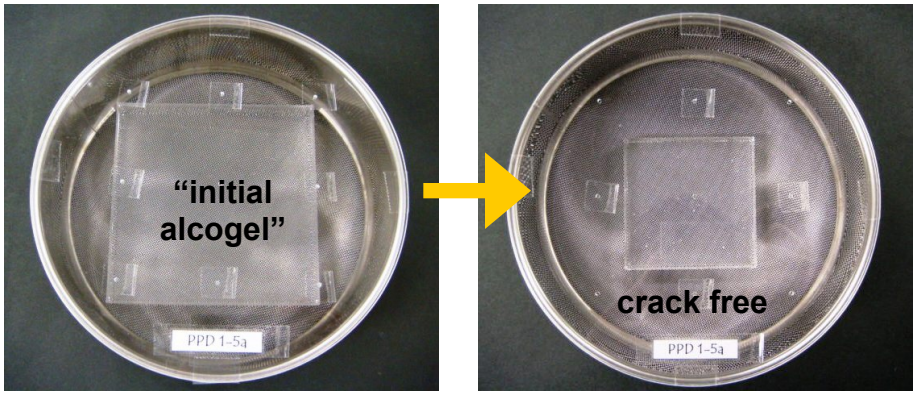
- Aerogel refractive index and thickness
- Photon detector pixel size
- Gap dimension

Aerogel Transmission length

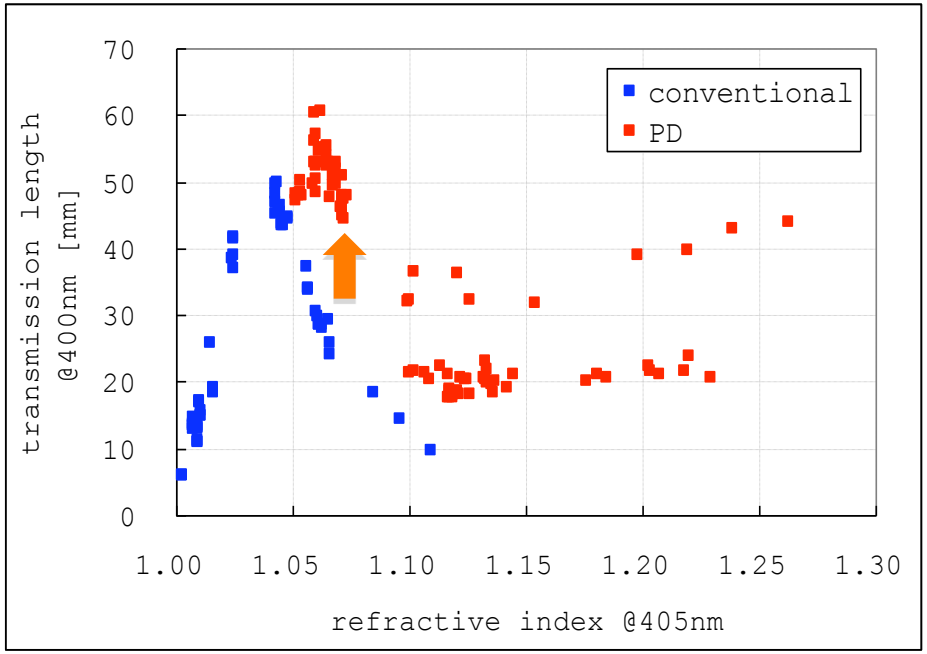
"Pinhole drying (PD)" method:
artificially shrinks alcogel to obtain high index
Transparency doubled for n>1.05 aerogel



M. Tabata @ RICH 2010



pinhole drying process

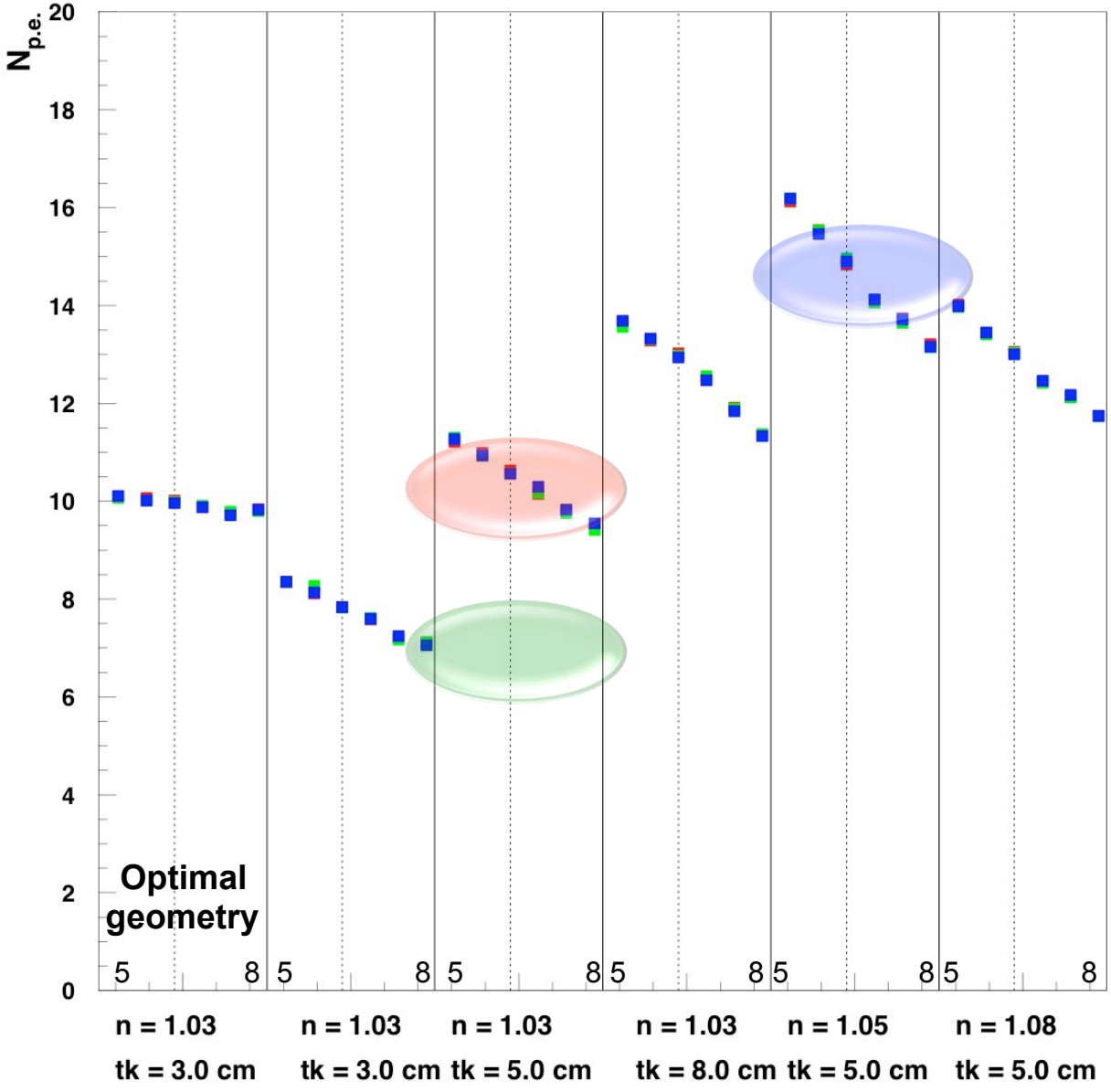


A.F. Danilyuk @ RICH 2010

Dens., g/cm^3	n	Lsc(400), mm
0.325	1.070	41.9
0.302	1.060	56.5

We assume 40 mm transmission length

Mean p.e. number (5-8 GeV/c)

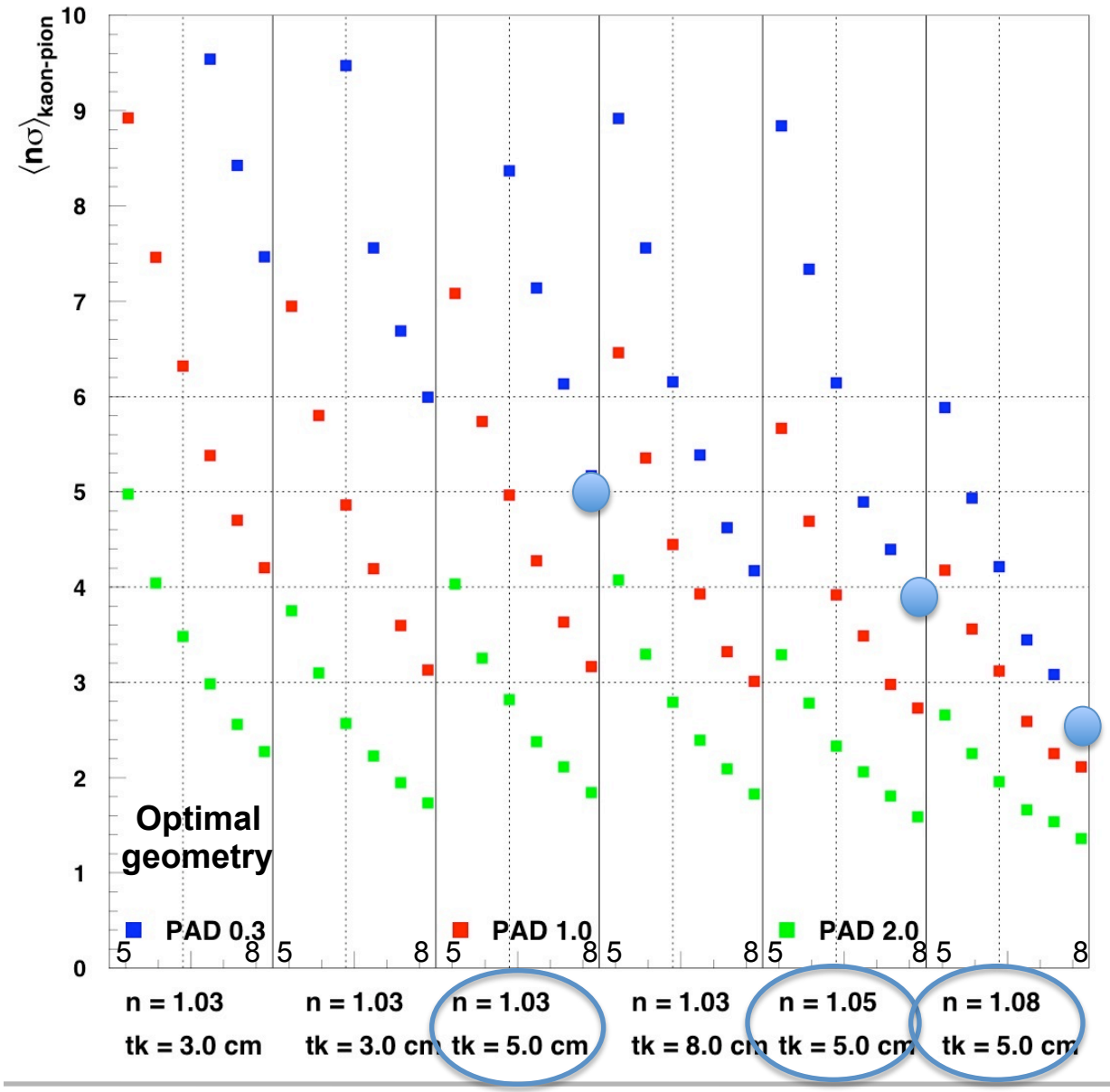


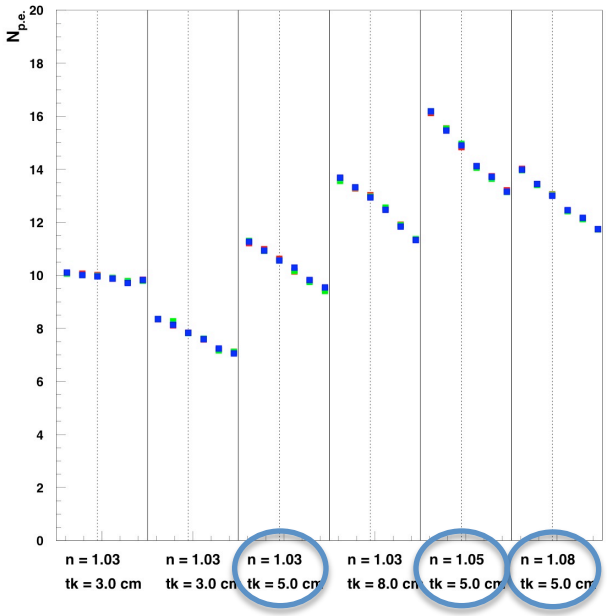
BELLE II test-bench
15 p.e. with aerogel of n ~ 1.05 refractive index and 4 cm thickness

HERMES experiment
10 p.e. with aerogel of n ~ 1.03 refraction index and 5 cm thickness but lower transmittance

LHC-B
7 p.e. with aerogel of n ~ 1.03 refraction index and 5 cm thickness but 64% packing factor

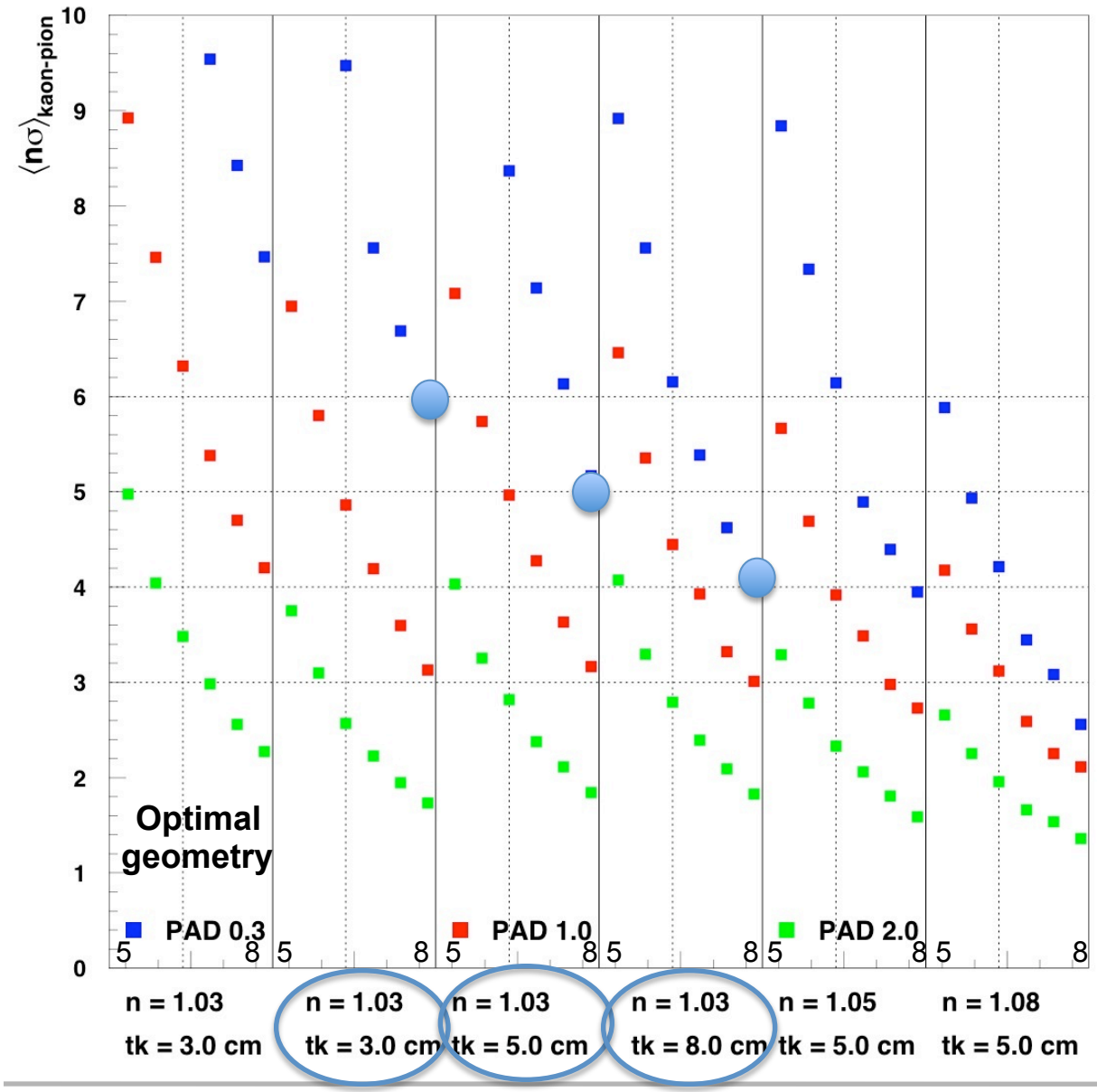
Mean π/K separation (5-8 GeV/c)

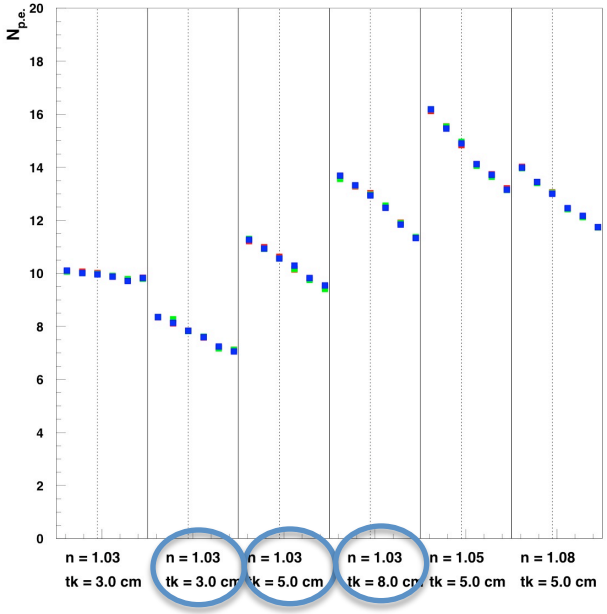




P (GeV/c)

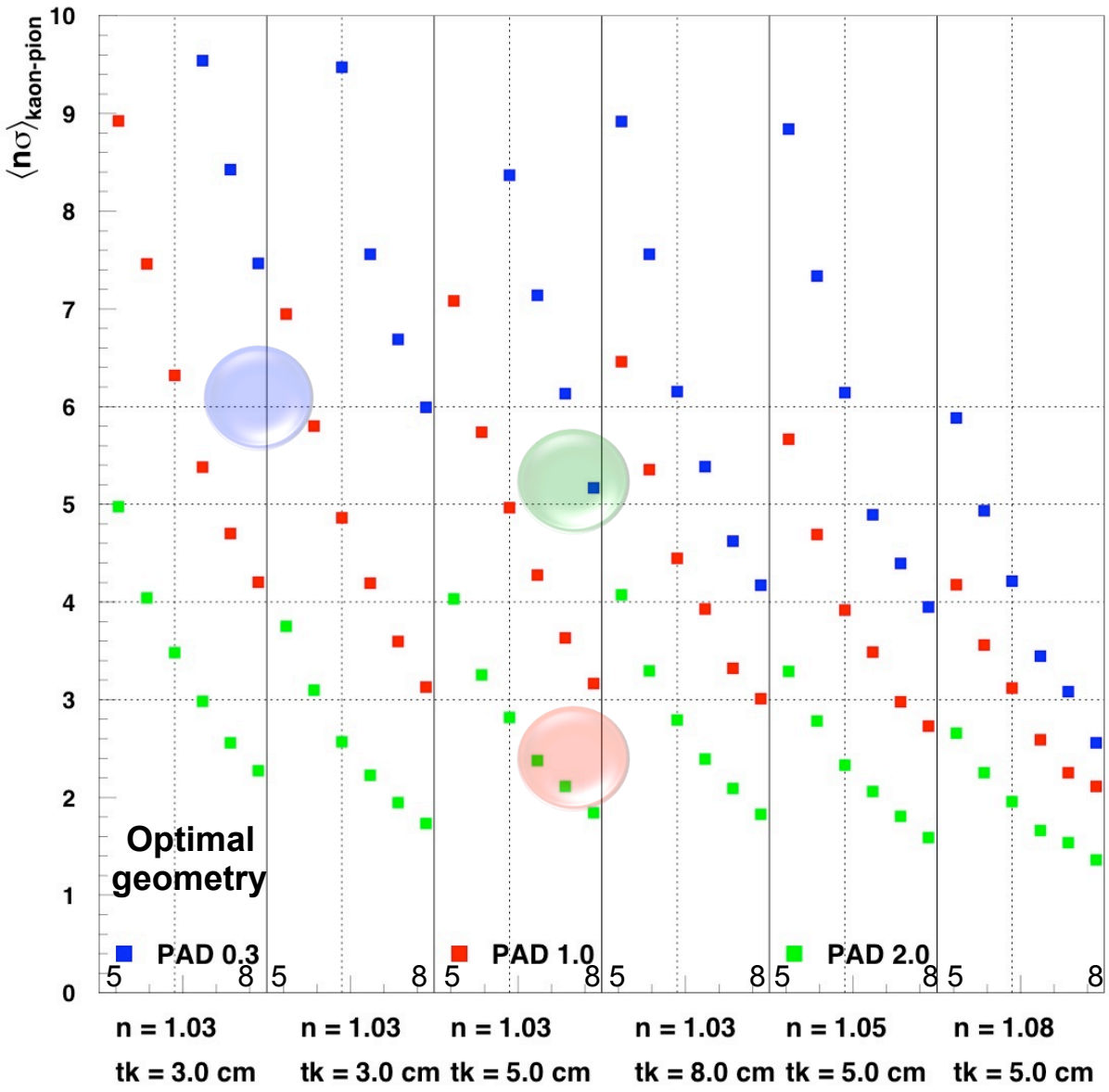
Mean π/K separation (5-8 GeV/c)

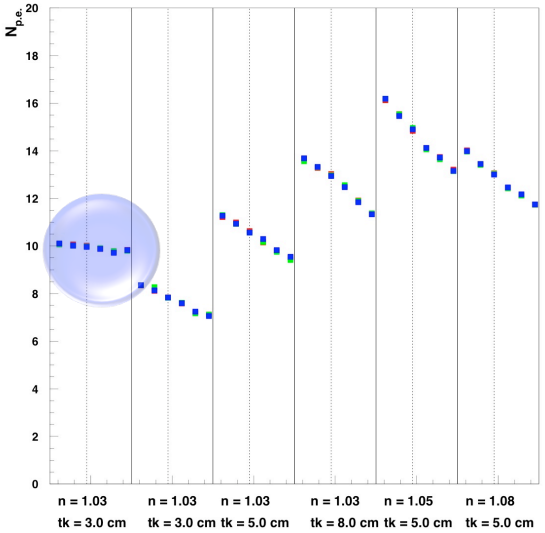




P (GeV/c)

Mean π/K separation (5-8 GeV/c)





LHC-B
3 mrad single photon resolution with ~ 3 mm comparable pixel size

HERMES experiment
7.6 mrad single photon resolution, dominated by the ~ 2 cm pixel size

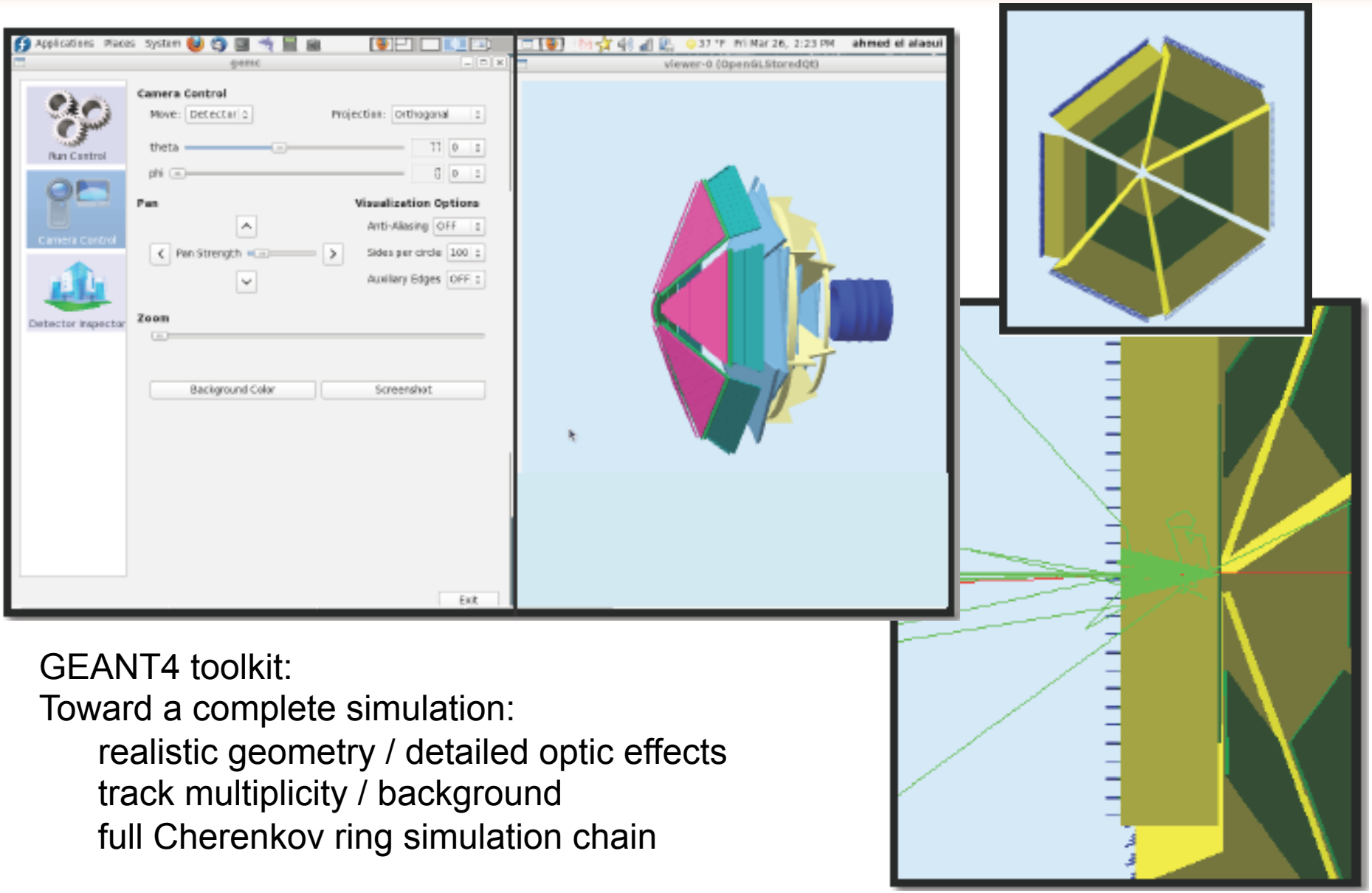
P (GeV/c)

A RICH detector for CLAS12

Ongoing activities:

- Improve simulation → Geant 4 (Argonne, ….) + GEMC (JLab…)

A RICH detector for CLAS12: GEMC



GEANT4 toolkit:

Toward a complete simulation:

- realistic geometry / detailed optic effects
- track multiplicity / background
- full Cherenkov ring simulation chain

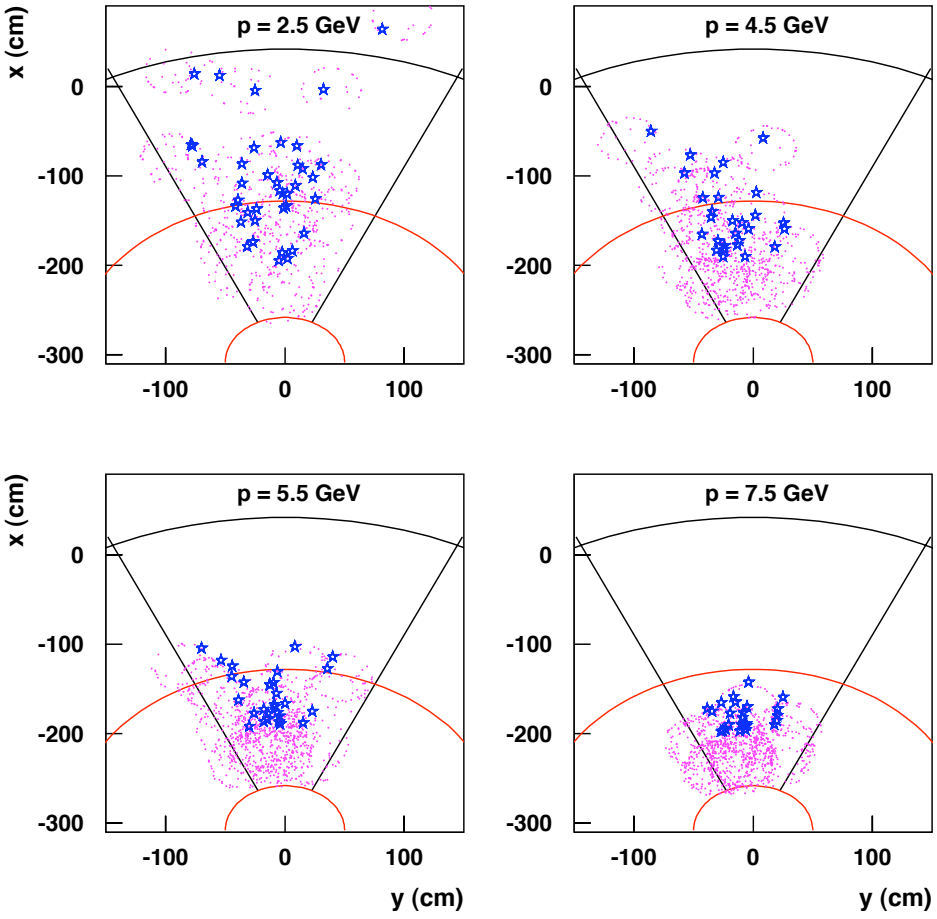
A RICH detector for CLAS12

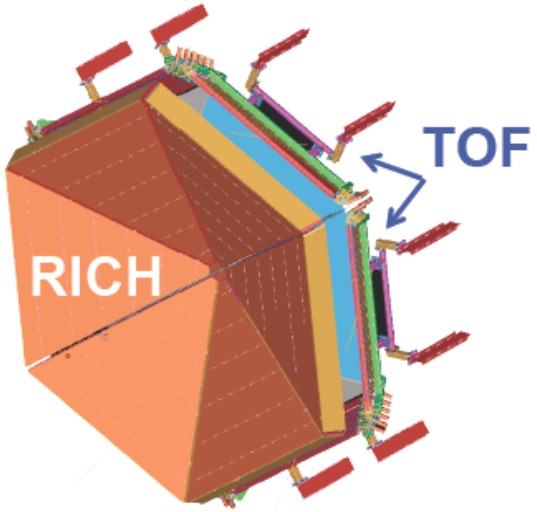
Ongoing activities:

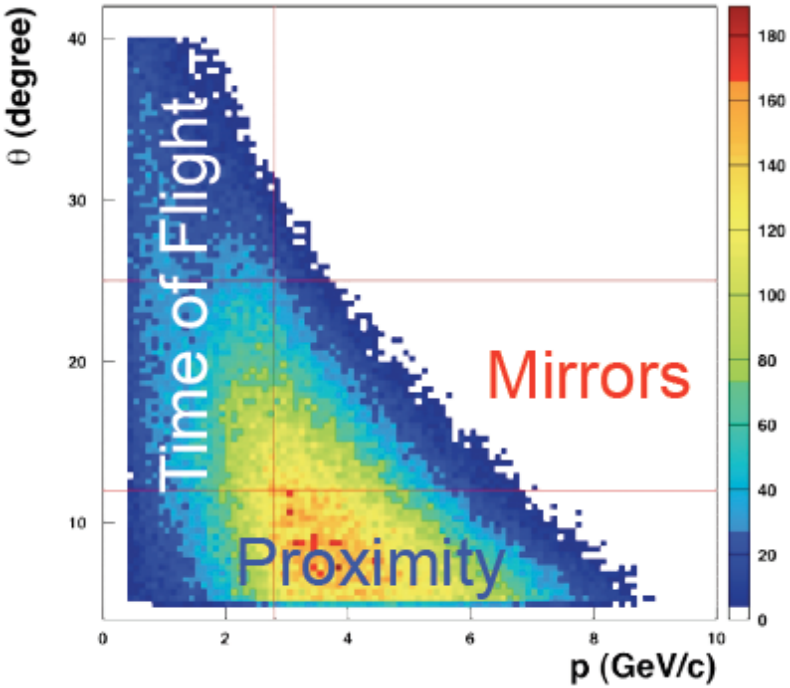
- Improve simulation → Geant 4 (Argonne, ….) + GEMC (JLab…)
- Reduce costs → mirrors and light concentrators

The focusing mirror system

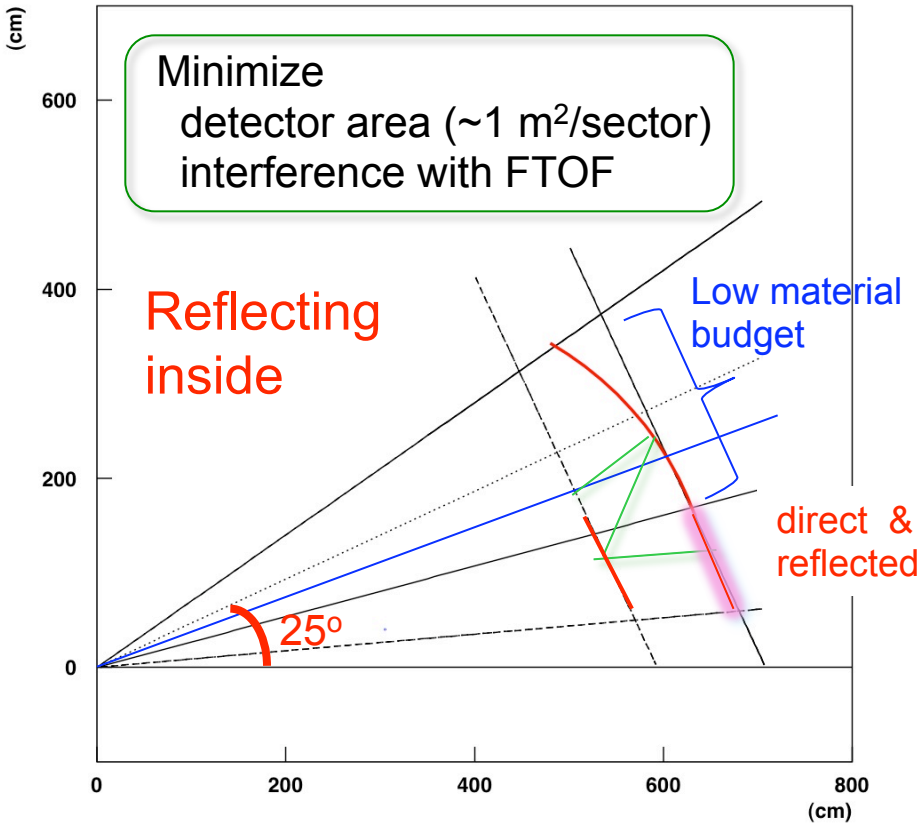
Goals: reduce active area
minimize interference with TOF system
allow larger aerogel thickness

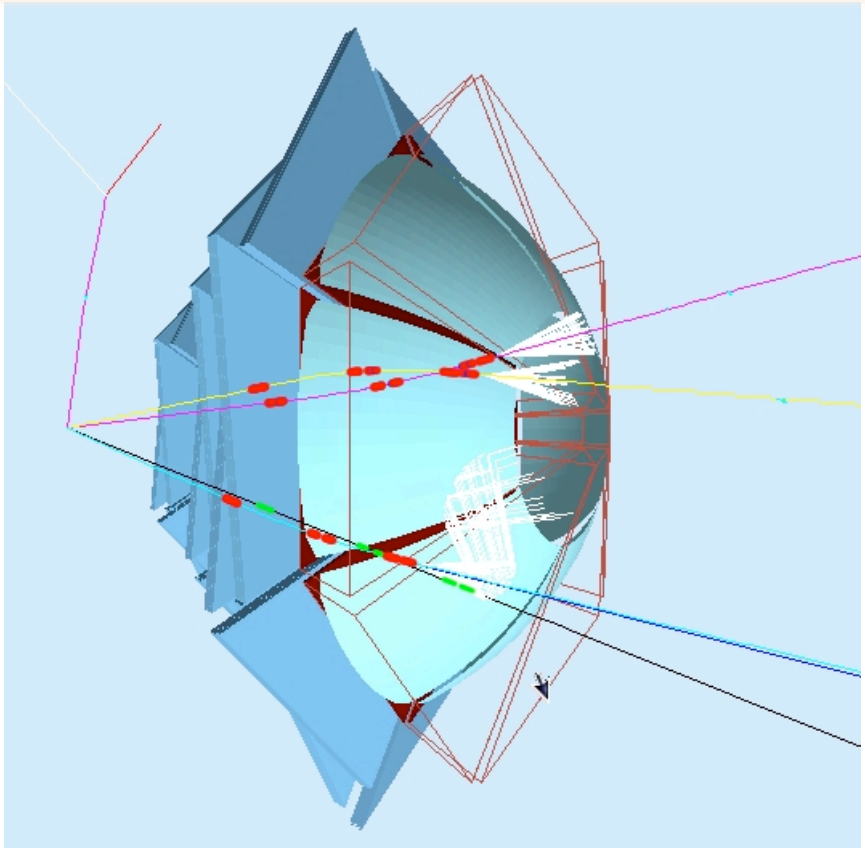






The focusing mirror system





High density of hits and background: high segmentation / narrow in-time coincidence

High absorption in aerogel: semi-reflective mirror inside the gap

Reduced collection efficiency: compensated by ultra bialkali / thick aerogel for focalized light

A RICH detector for CLAS12

Ongoing activities:

- Improve simulation → Geant 4 (Argonne, ….) + GEMC (JLab…)
- Reduce costs → mirrors and light concentrators
- Validate simulations and check performances

  Test components (Glasgow, ….)

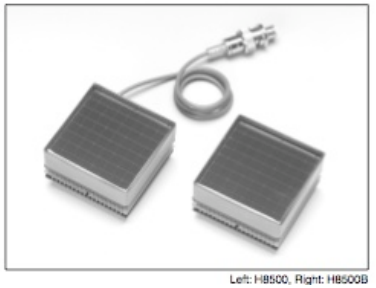
  Prototype (INFN groups, JRA-WP3)

A RICH detector for CLAS12: MA-PMTs

Requests:
- visible light detection
- compact
- single p.e. detection
- small pad size

- Multi-anode PMTs
- SiPM

MAPMT	Dimentional outline (mm^3)	Effective area (mm^2)	Pixel size (mm^2)
H8500	52x52x28	49x49	5.8x5.8 (8x8)
H9500	52x52x33.3	49x49	2.8x2.8 (16x16)

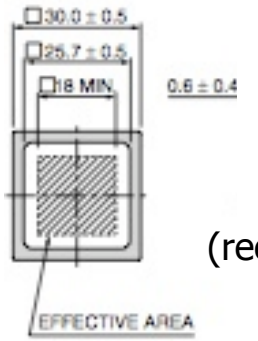


- Pros: excellent packing factor (89%)
- Cons: non optimized for single p.e. detection (**not recommended** by Hamamatsu)

R7600

R7600
R7600-M4
R7600-M16
R7600-M64

- Pros: optimized for single photon detection
- Cons: quite sizeable dead area (324/660 = 49%)

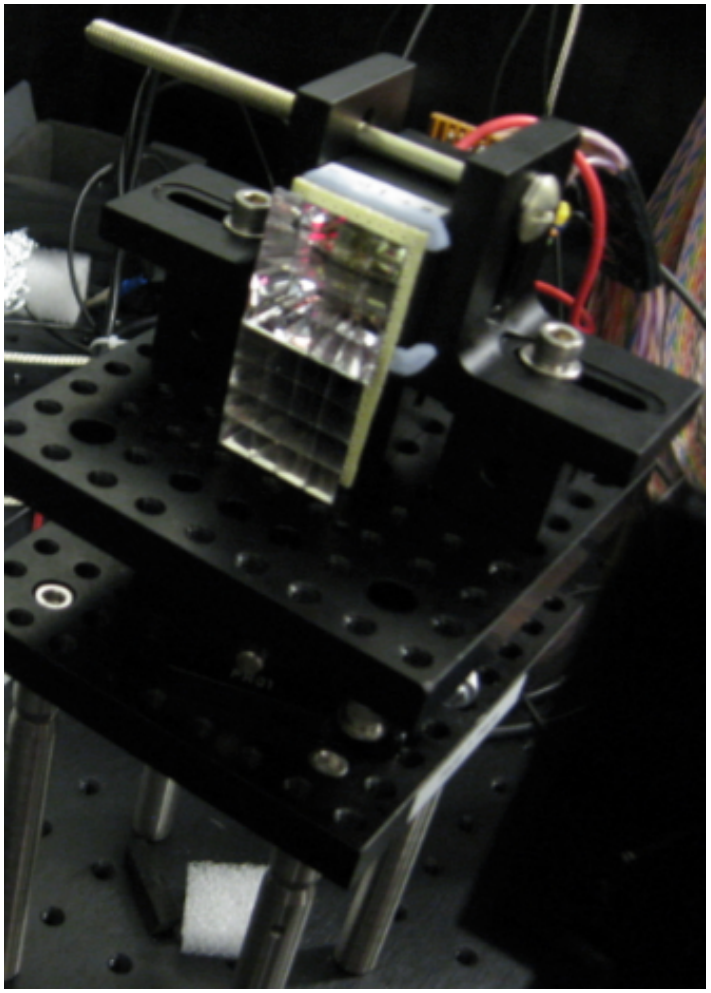


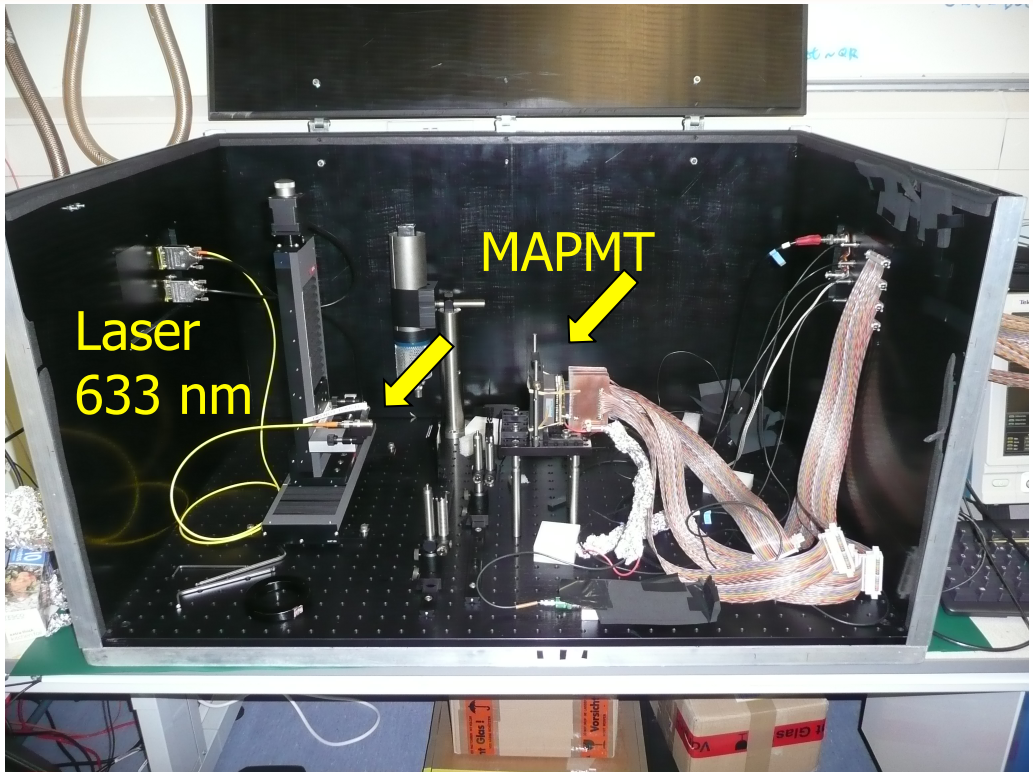
(recommended by Hamamatsu)

A RICH detector for CLAS12: MA-PMT tests

TESTS at Glasgow Un. Sep 13-16, 2010

http://nuclear.gla.ac.uk/~rachel/

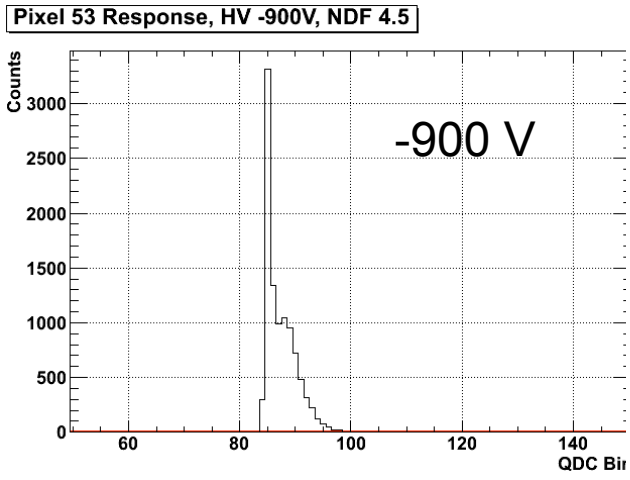


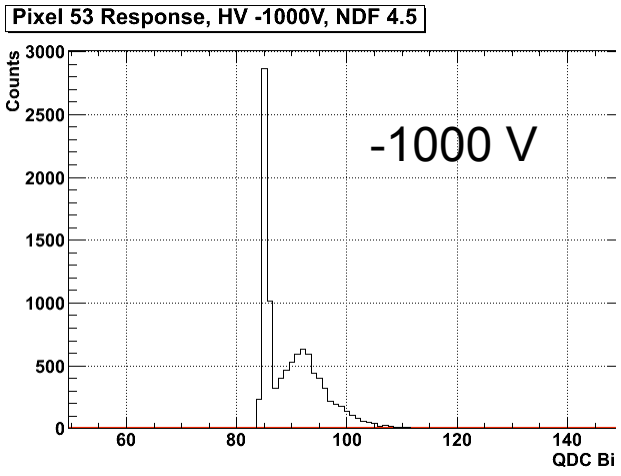


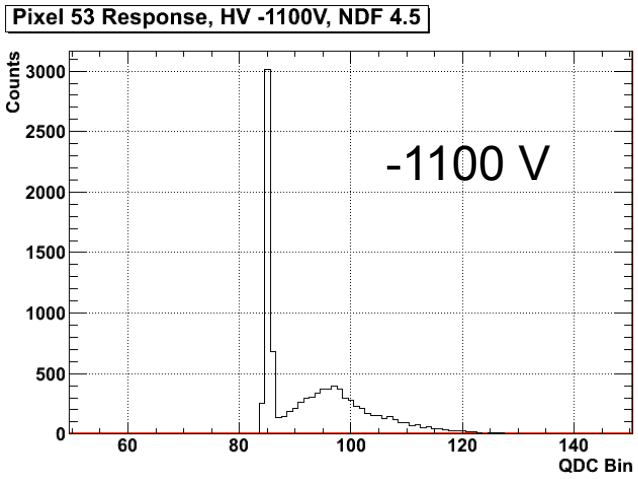
- Laser: 633 nm
- HV: -900, -950, -1000 V
- Scan 5x5 cm – 64 pixels in 1mm step
- Scan 1 pixel (6mm) in 0.5 mm step
- Scan at # incident angle with respect to the beam direction: 0°, 10°, 20°, 30°
- Scan with light catchers

MA-PMT Test: H8500

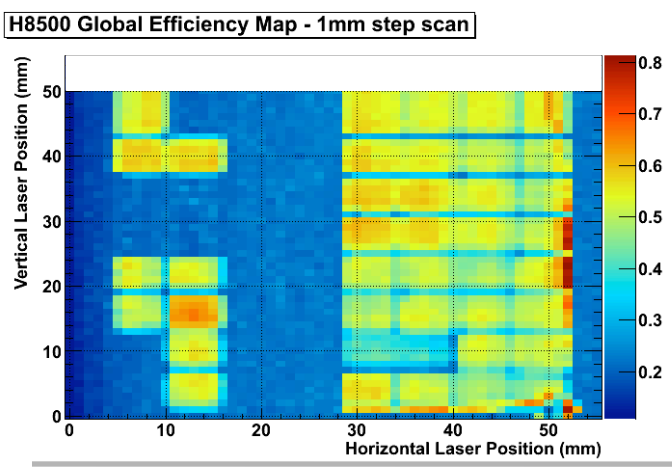
"Single p.e. spectrum" for a good pixel



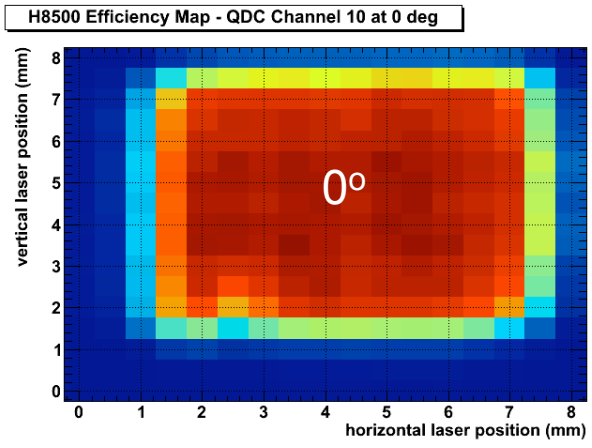


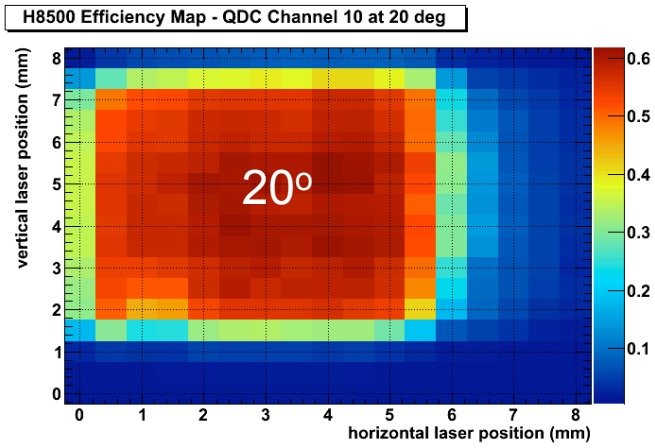


Global scan at 1 mm step
Not really uniform



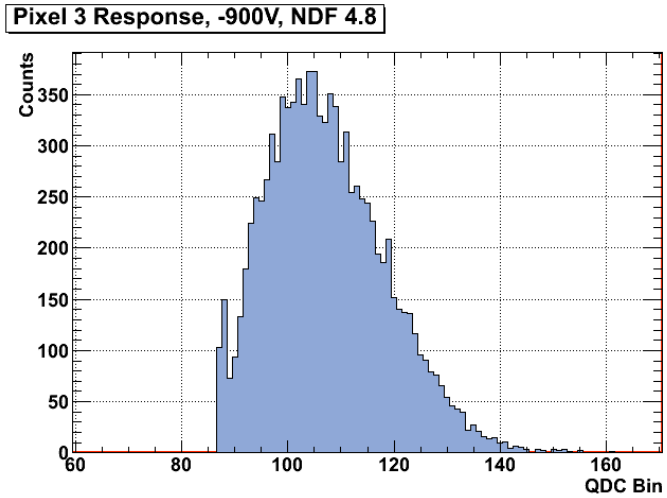
0.5 mm scan on a single (good) pixel
Almost insensitive to the photon incident angle



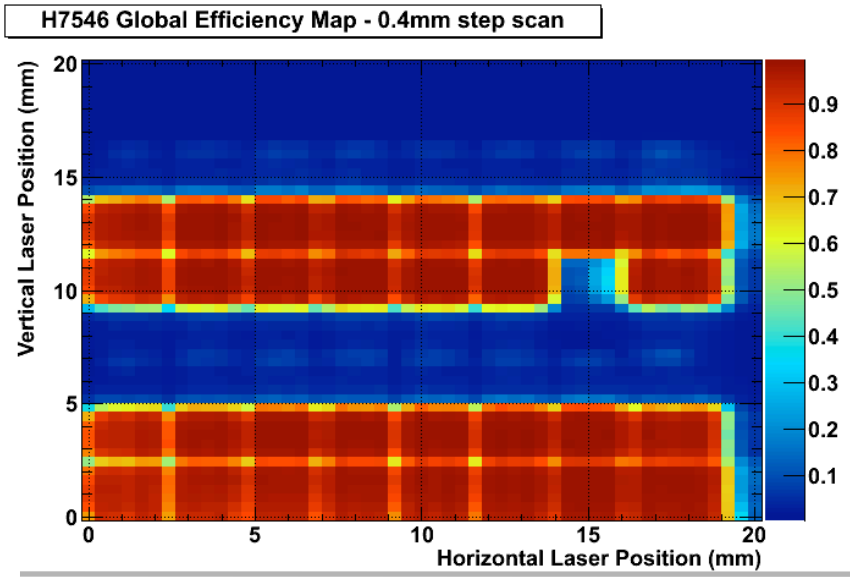


MA-PMT Test: R7564 SBA

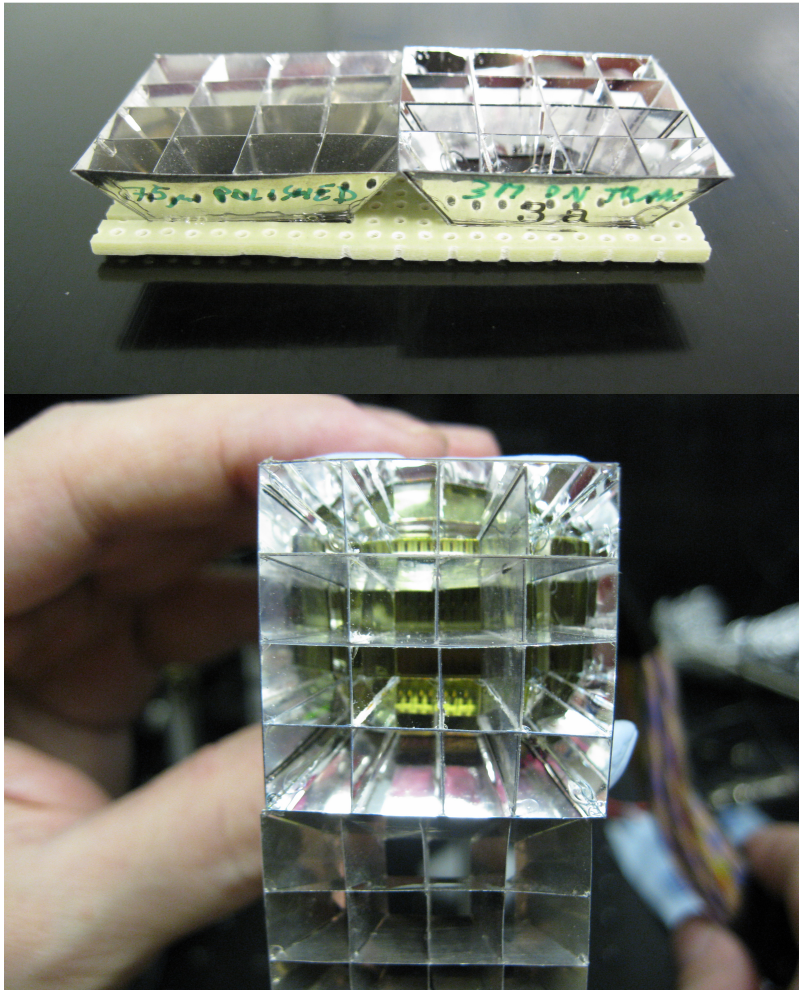
"Few p.e. spectrum" for a standard pixel



Global scan at 0.4 mm step
Uniform !



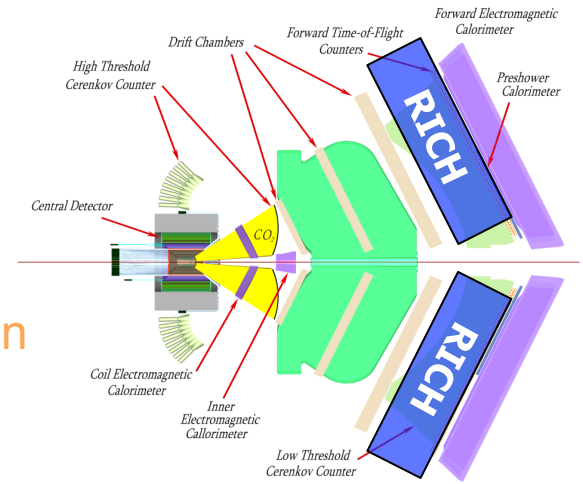
To reduce dead area / active area:
Light concentrators: grid of plastic foils covered by 3M DF200MA high-reflective film



A RICH detector for CLAS12: SiPMs

JRA WP3: 3D-Mom
the three-dimensional momentum structure of hadrons

the challenges:



- geometrical restrictions:
  small gap (~1 m), large surface

➔ aerogel radiator in *proximity focusing* configuration

- experimental conditions:
  high intensity electron beam, presence of magnetic fields

➔ highly segmented and fast photo-detection system based on *SiPMs*

the task:

R&D for final RICH detector design with optimized performance to cost ratio; prototype construction & test

Conclusions

Flavor separation accessible only with good hadron ID:

- CLAS12 has an approved physics program requiring a RICH
- Preliminary studies show aerogel plus visible light detection can match the RICH requirements
- Work is in progress to validate simulations and check performances by testing components and building a prototype