RICH Project Overwiev

Contalbrigo Marco
INFN Ferrara

Rich Technical Review, 26th June 2013

The CLAS12 Spectrometer

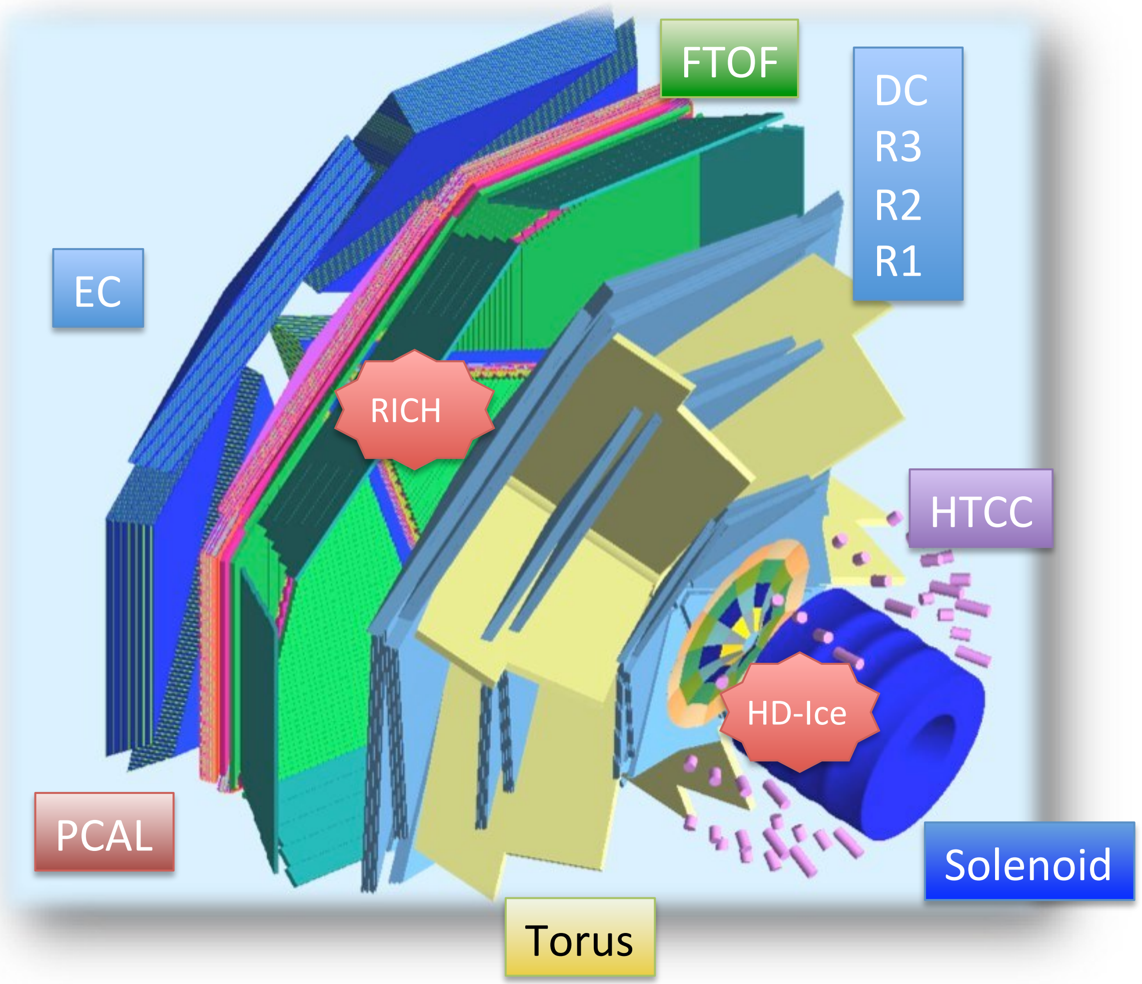
Luminosity up to 10^{35} cm^{-2} s^{-1}

Highly polarized electron beam

H and D polarized targets

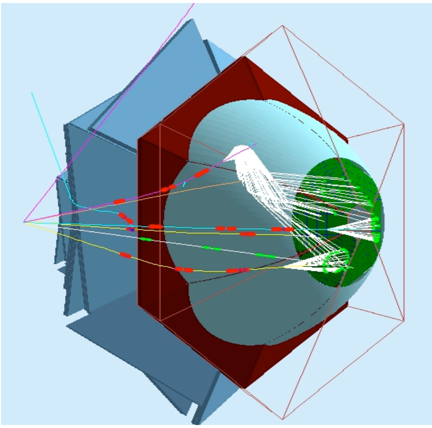
Broad kinematic range coverage
(current to target fragmentation)

RICH: Hadron ID
for flavor separation
(common to SIDIS approved exp.)

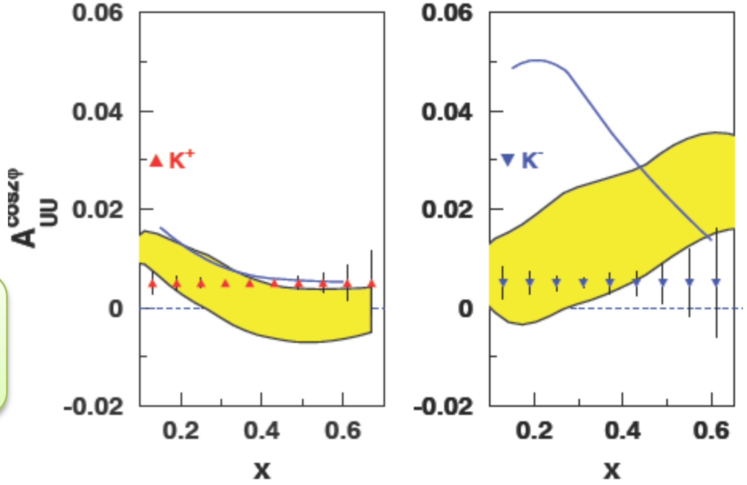


PAC30 report (2006): Measuring the kaon asymmetries is likely to be as important as pions …. The present capabilities of the present CLAS12 design are weak in this respect and should be strengthened.

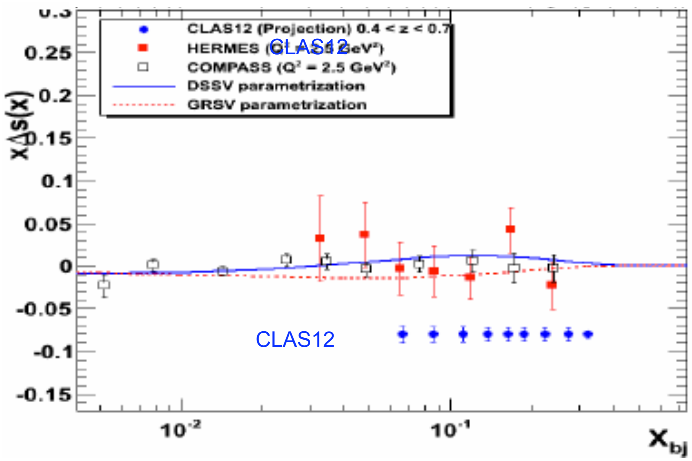
Kaon Program @ CLAS12



E12-09-08: Studies of Boer-Mulders Asymmetry in Kaon Electroproduction with Hydrogen and Deuterium Targets

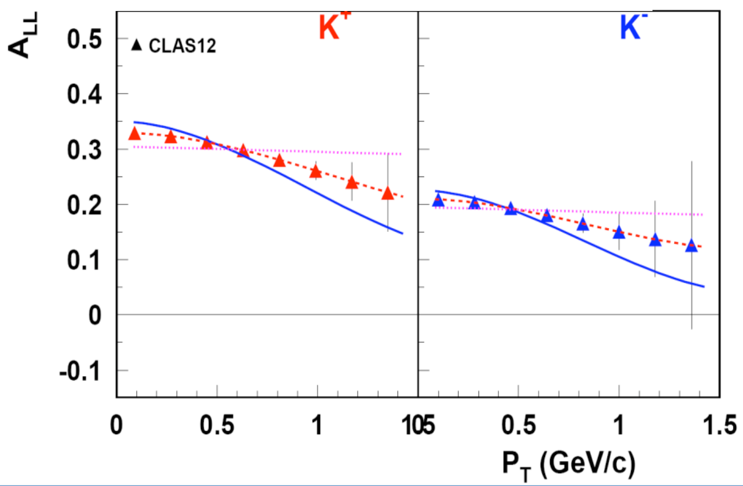


RICH detector for flavor separation of quark spin-orbit correlations in nucleon structure and quark fragmentation



E12-09-09:

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

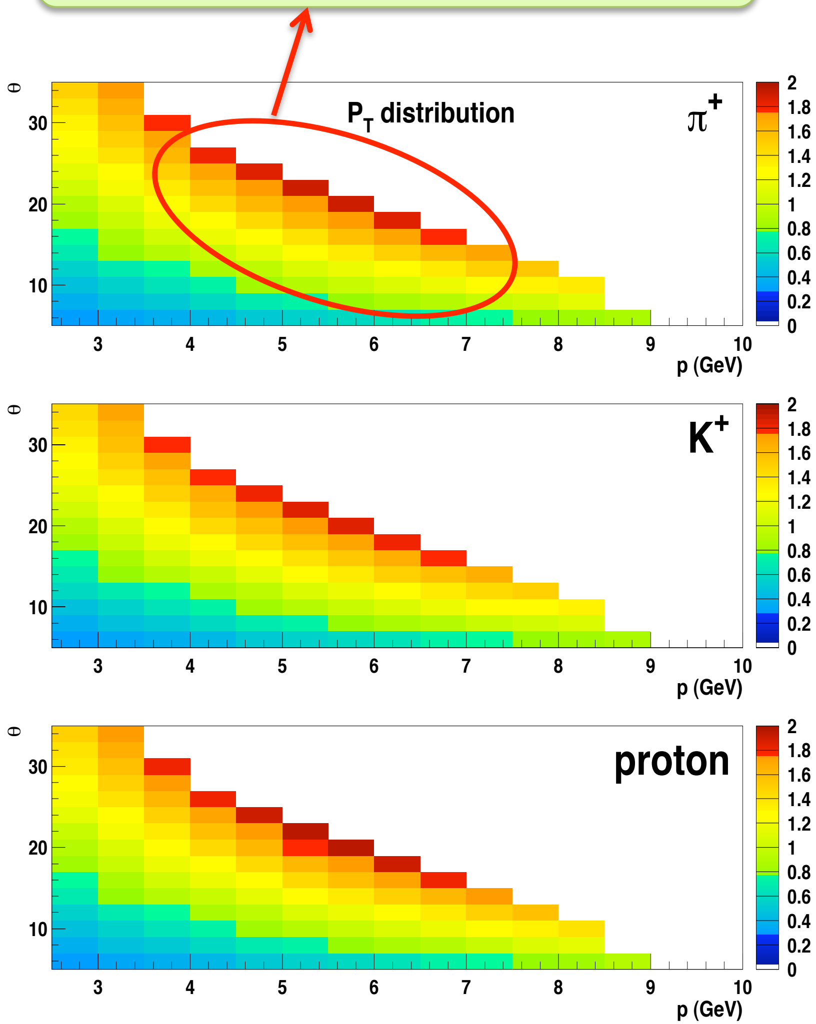


E12-09-07:

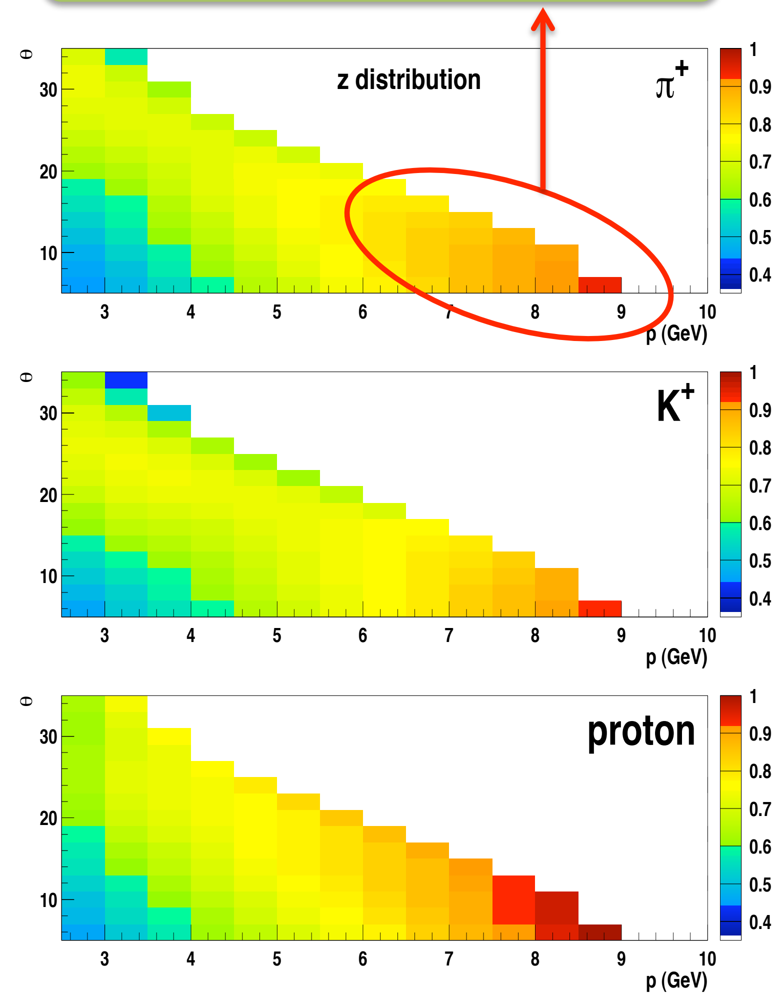
Studies of partonic distributions using semi-inclusive production of Kaons

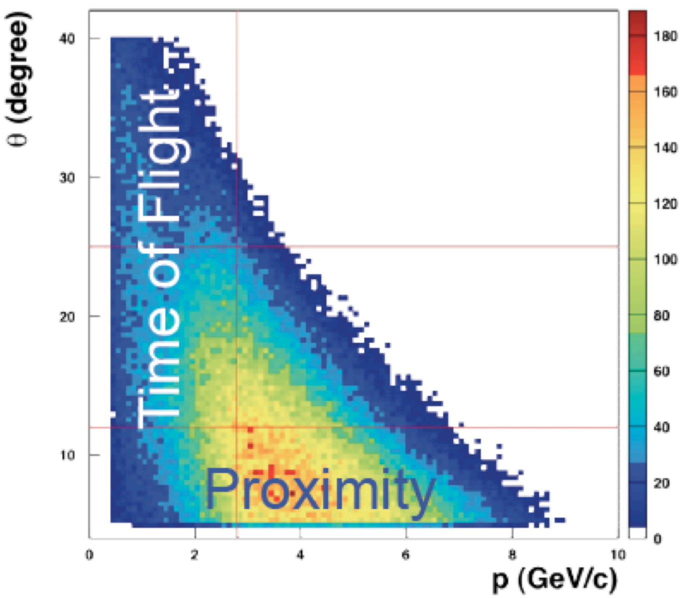
SIDIS Kinematics @ CLAS12

Intermediate angular range (15-30°) important to reach high P_T values

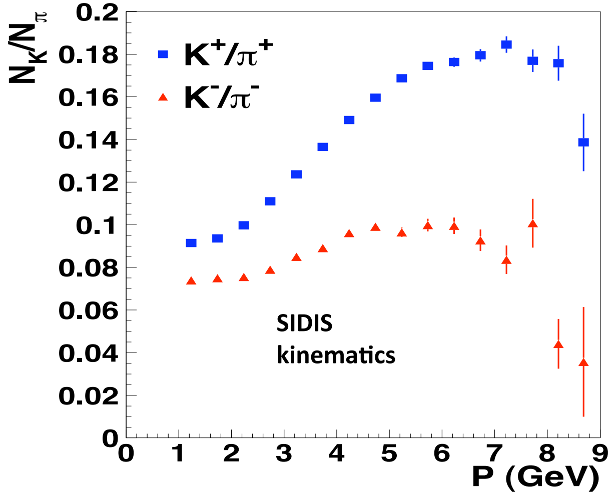


High Momentum region important as transient to hard semi-exclusive region

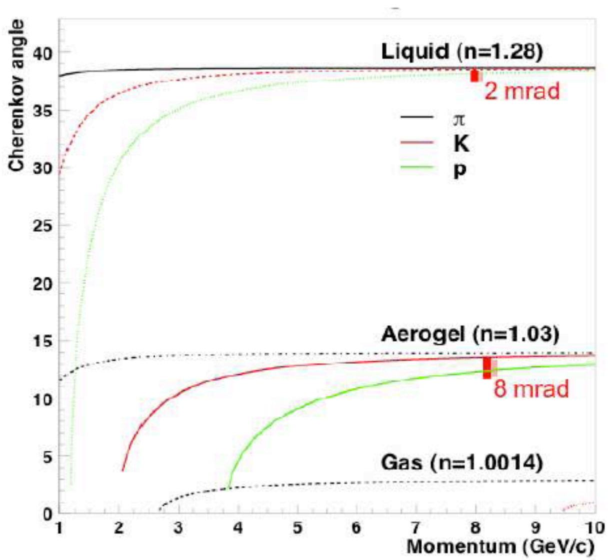




Ratio K/π ~ 0.1-0.15

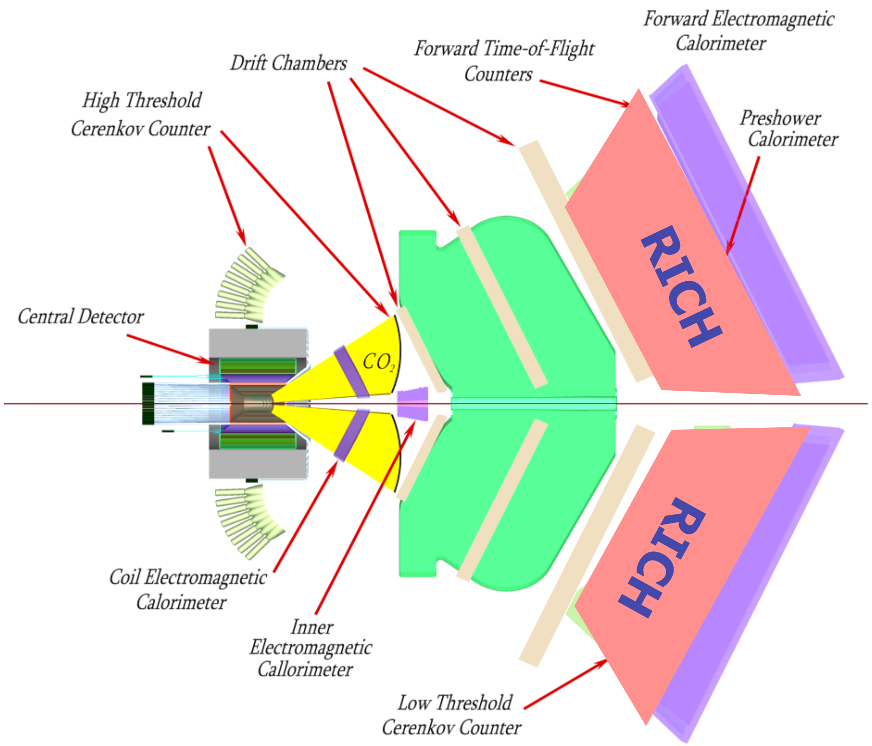


- **Aerogel** mandatory to separate hadrons in the 3-8 GeV/c momentum range with the required large rejection factors
  → collection of **visible Cherenkov light**
  → use of **PMTs**
- **Challenging project,** need **to** minimize detector area covered with expensive photodetectors



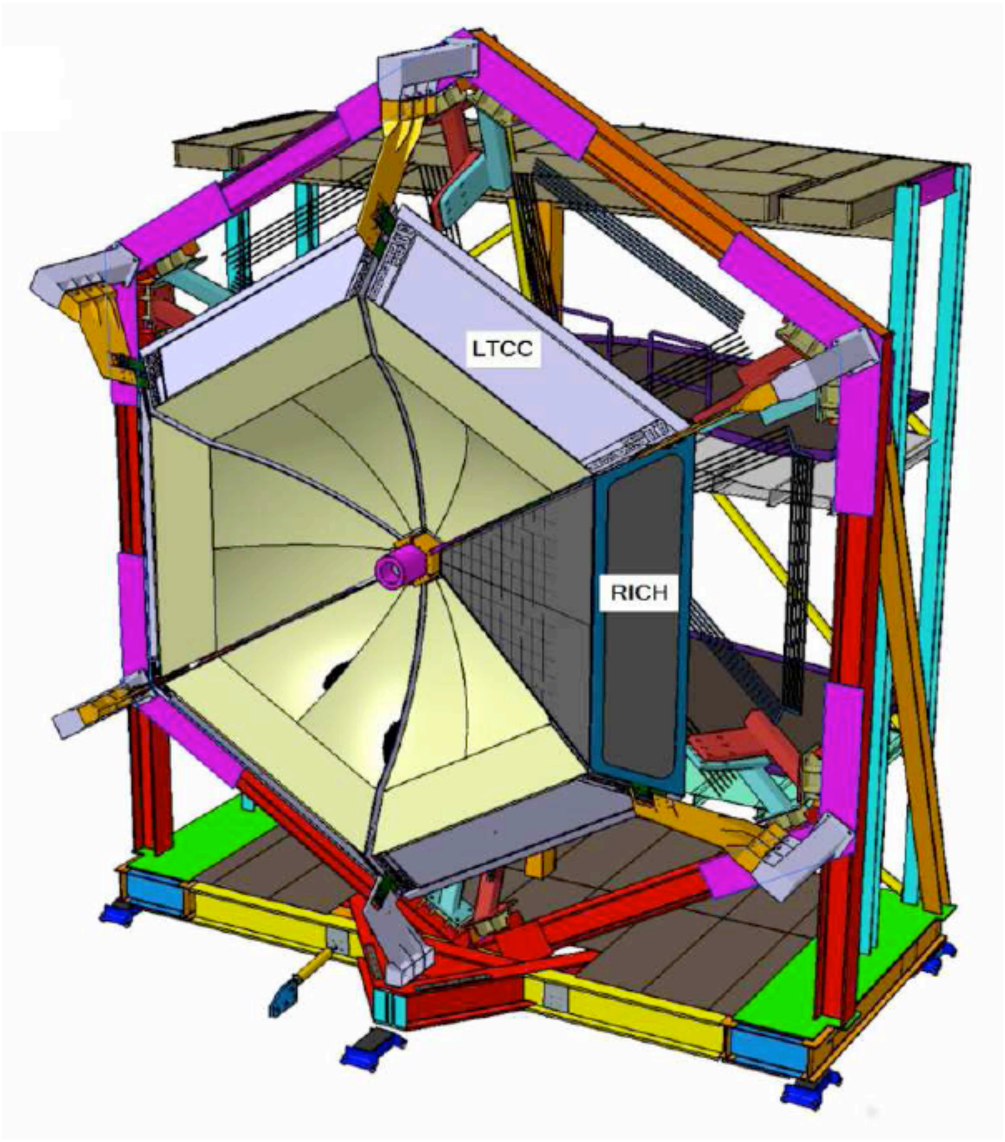
The CLAS12 RICH

RICH goal: **π/K/p separation of ~4 σ up to 8 GeV/c**
for a pion rejection factor ~ **1:500**



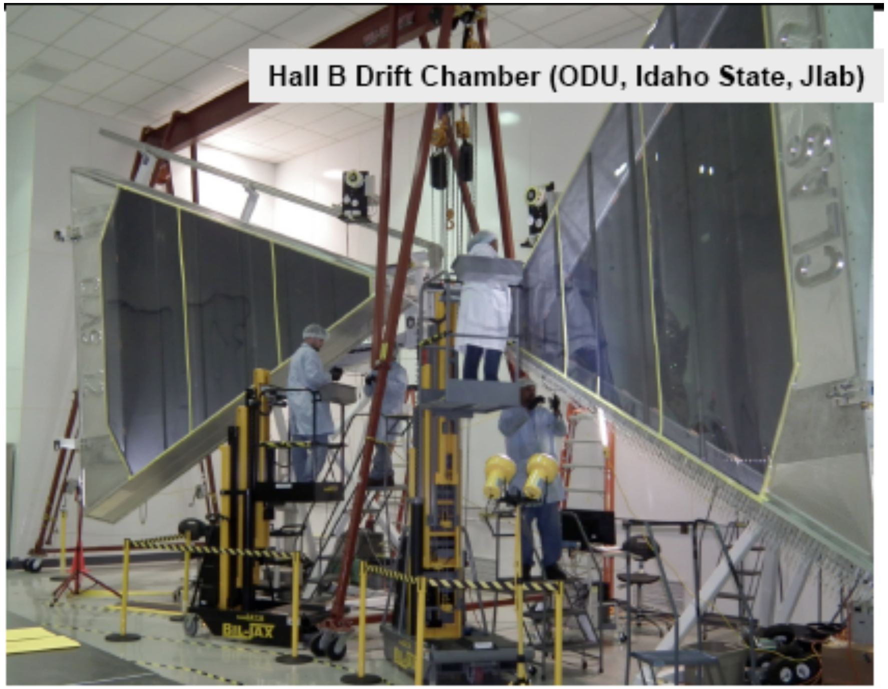
INSTITUTIONS
Jefferson Lab (USA)
INFN (Italy) Bari, Ferrara, Genova, L.Frascati, Roma/ISS
Argonne National Lab (USA)
Duquesne University (USA)
Glasgow University (UK)
Mainz Institut fur Kernphysik (Germany)
University of Connecticut (USA)
UTFSM (Chile)

Base Configuration



1st sector in time for physics run
(unpolarized and longitudinal polarize targets)

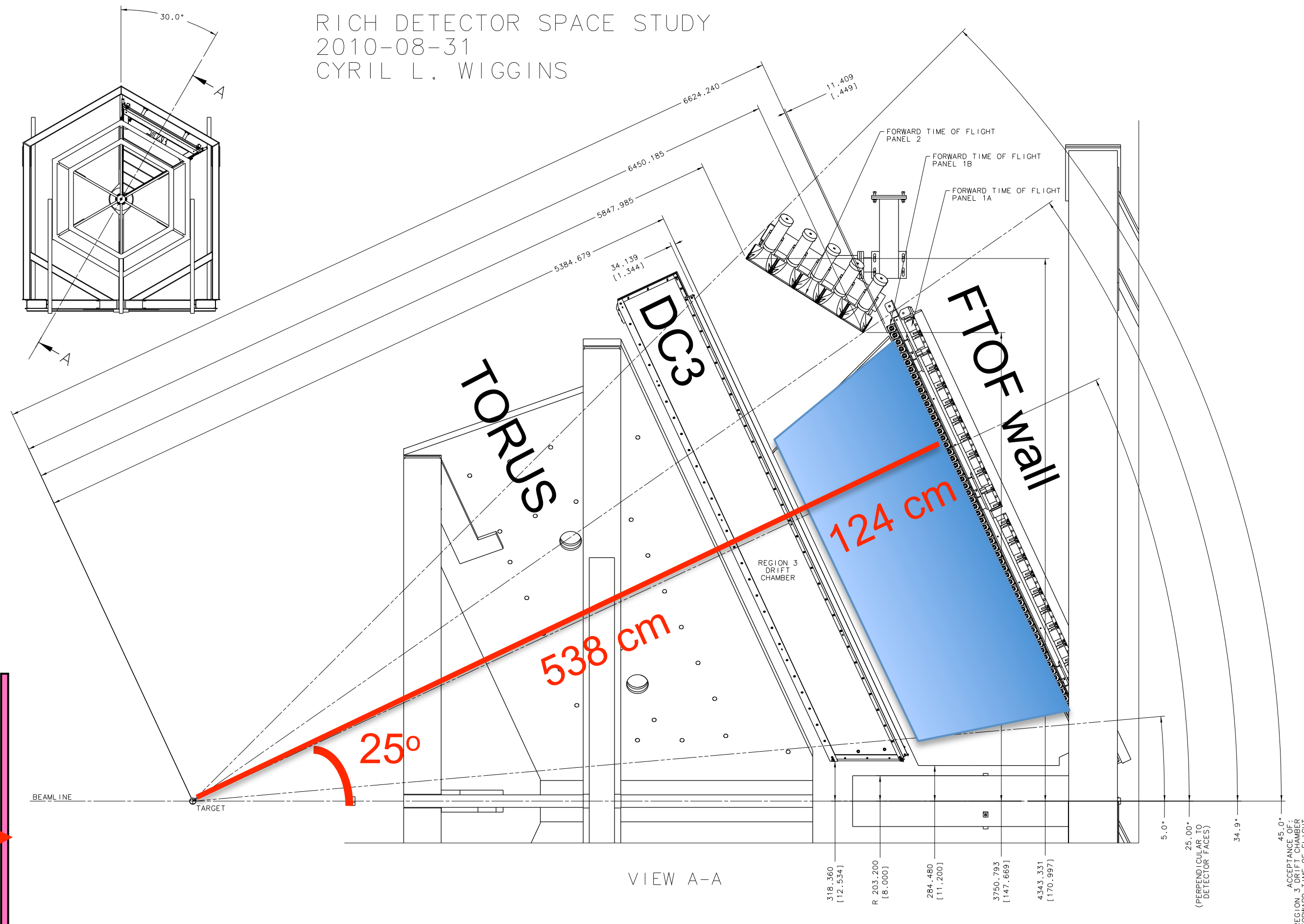
2nd++ sector for transverse target
(left-right symmetry and statistics)



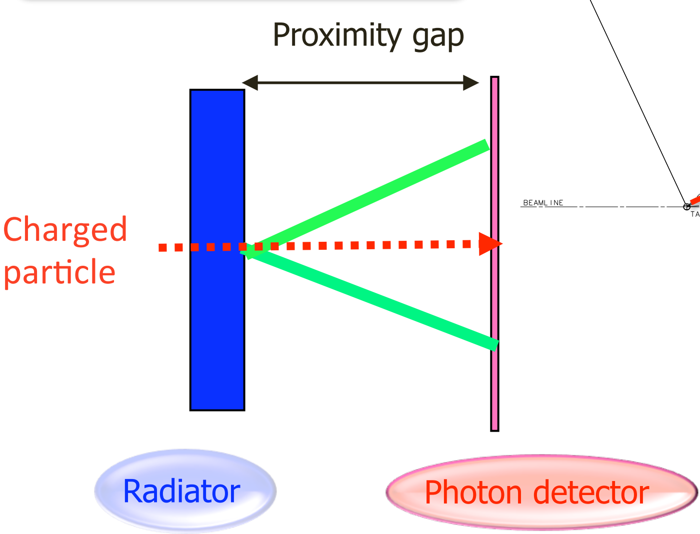
CLAS12 Geometry Constraints

Base Numbers

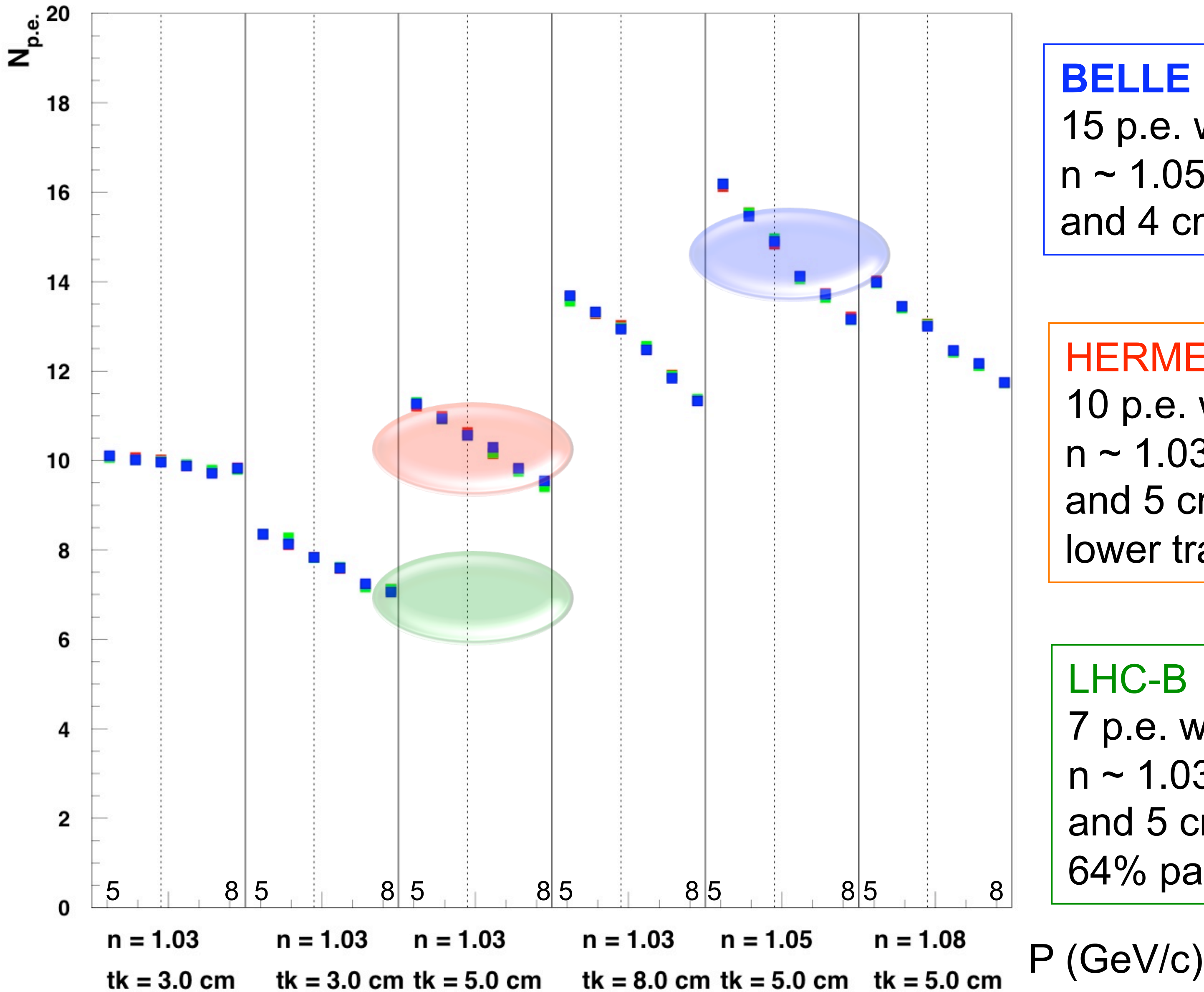
- 5 m from IP
- ~ 1 m gap
- Several m² surface



Proximity RICH



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

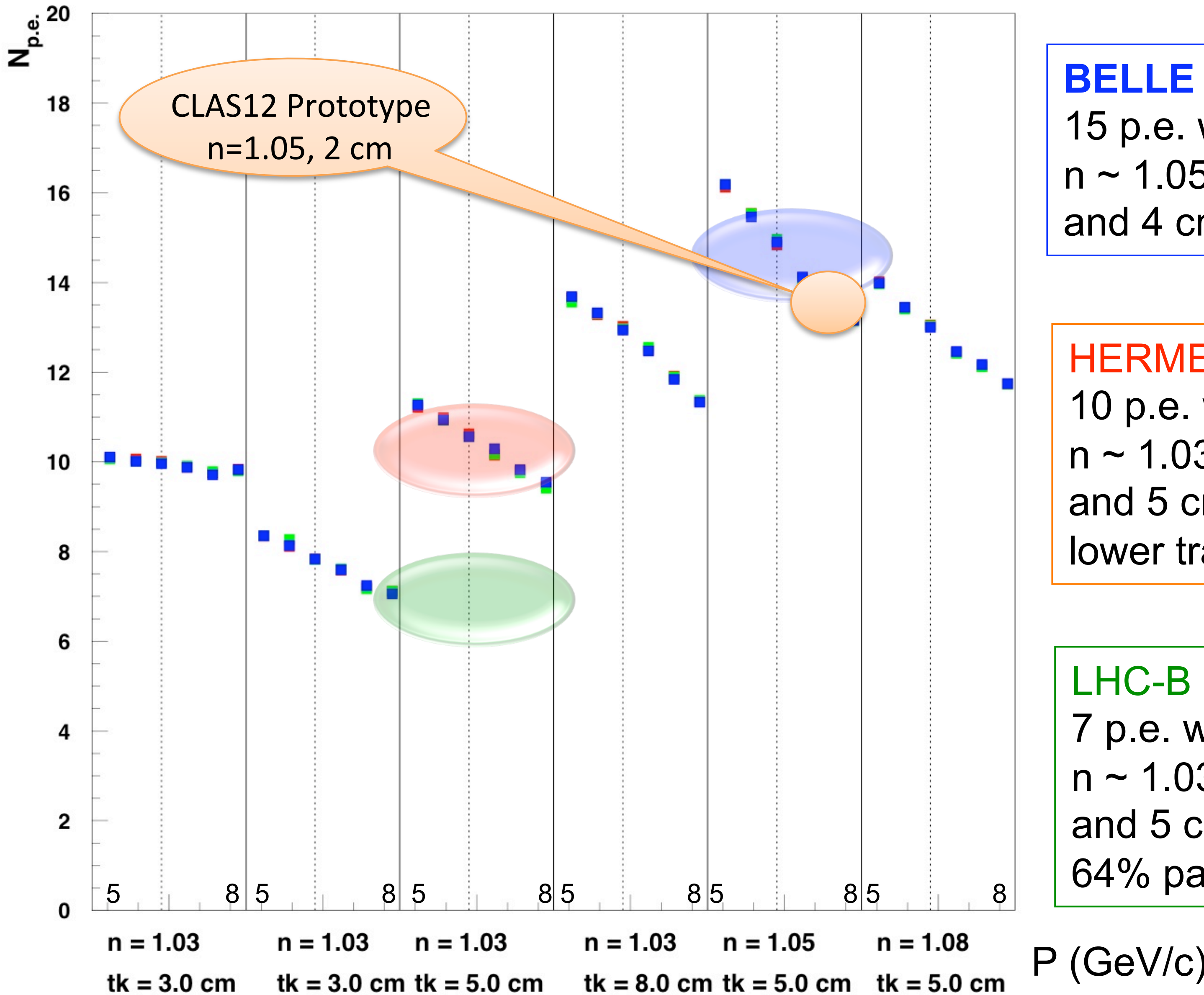


BELLE II test-bench
15 p.e. with aerogel of
n ~ 1.05 refractive index
and 4 cm thickness

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 p.e. Number (5-8 GeV/c)

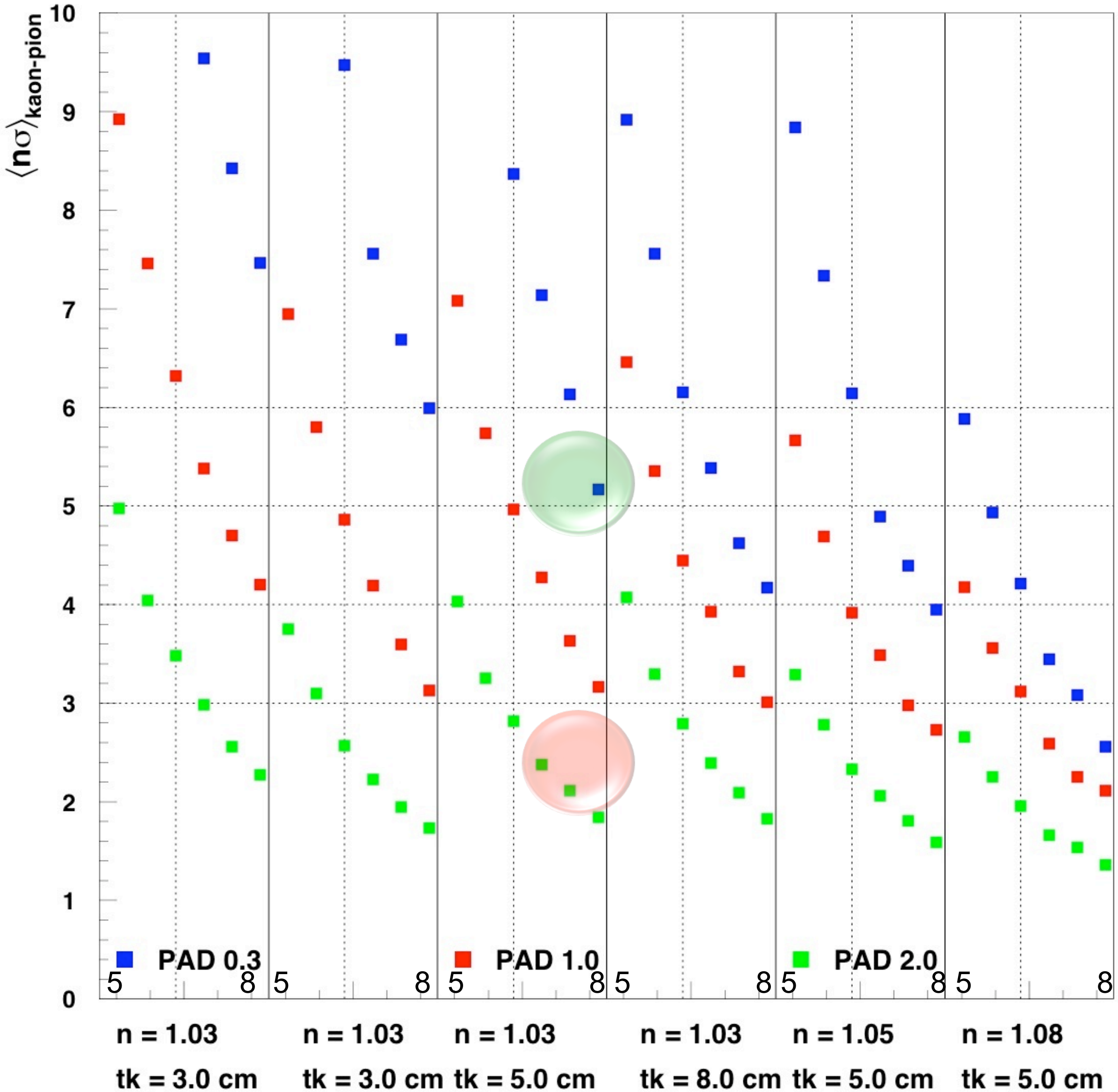


BELLE II test-bench
15 p.e. with aerogel of n ~ 1.05 refractive index and 4 cm thickness

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

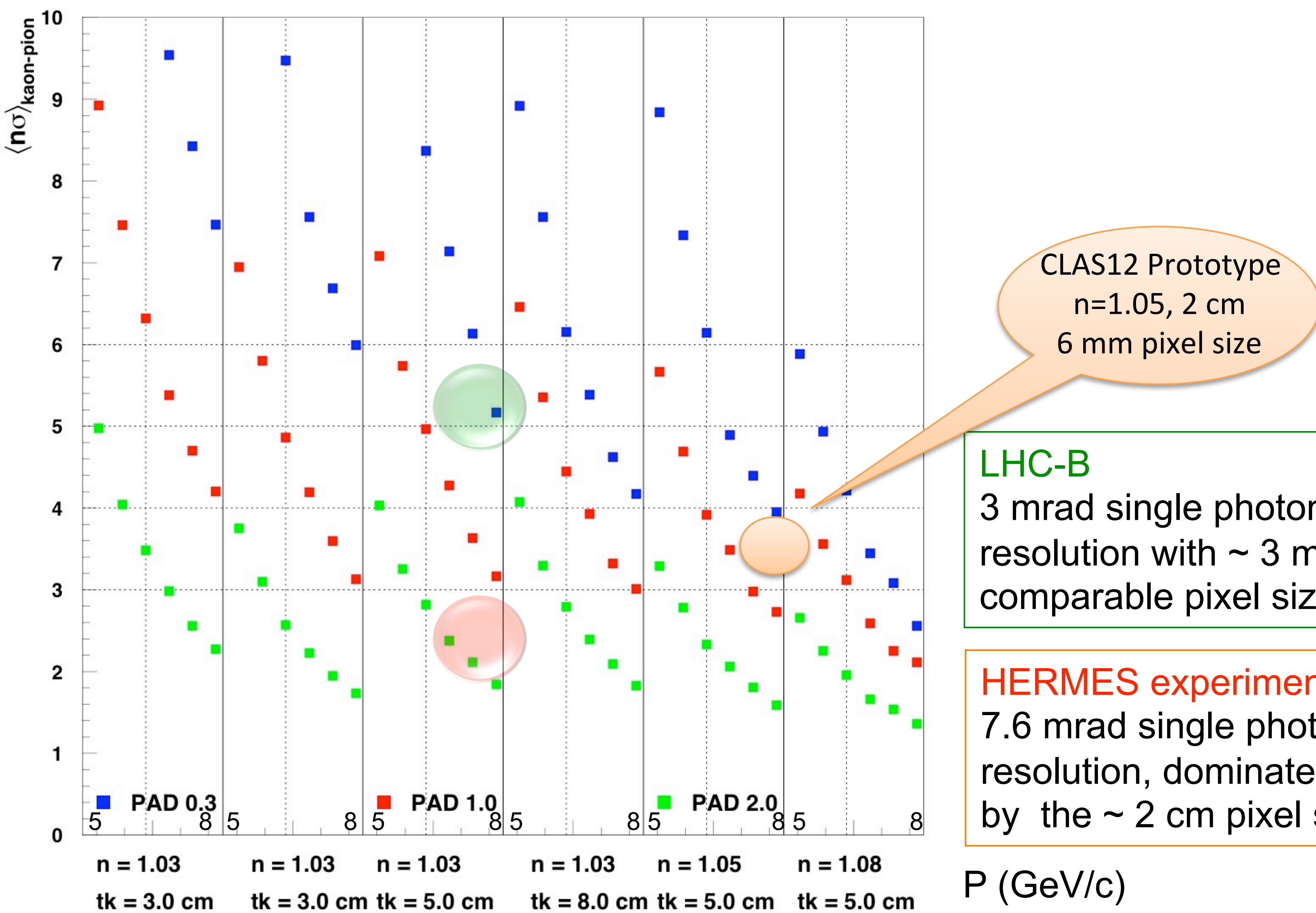
Mean π/K Separation (5-8 GeV/c)



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

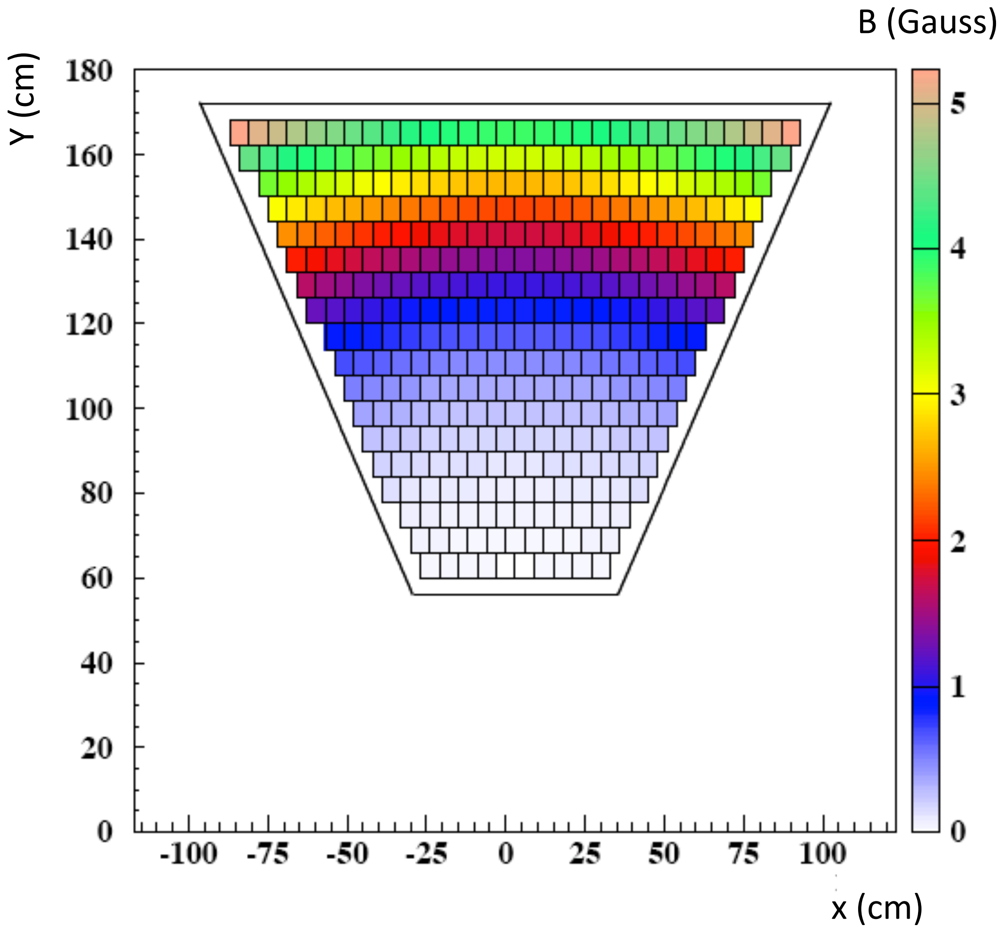
Mean π/K Separation (5-8 GeV/c)



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

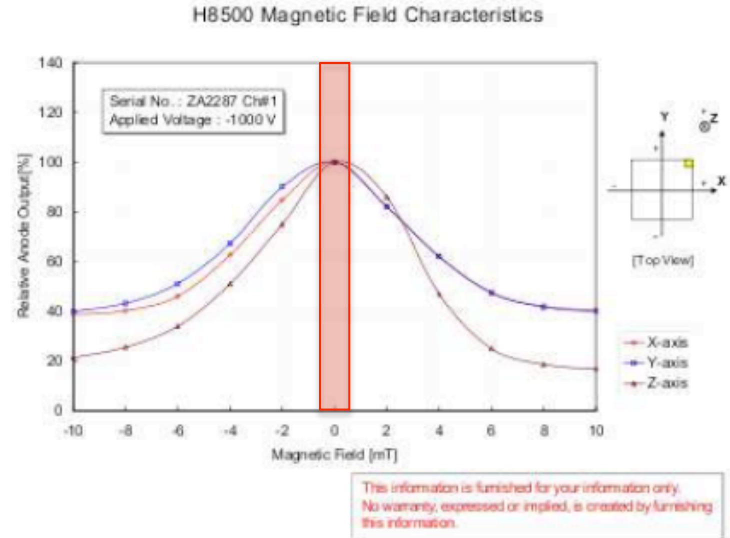
HERMES experiment
7.6 mrad single photon resolution, dominated by the ~ 2 cm pixel size

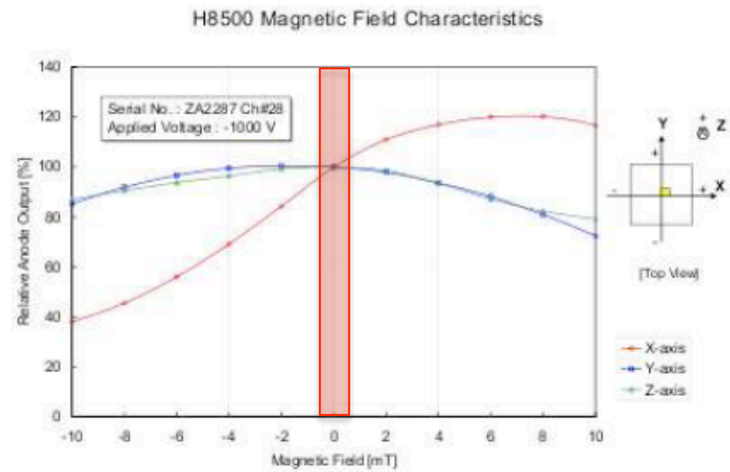
Magnetic Field



The torus fringe-field allows the use of Multi-Anode Photomultipliers

HAMAMATSU

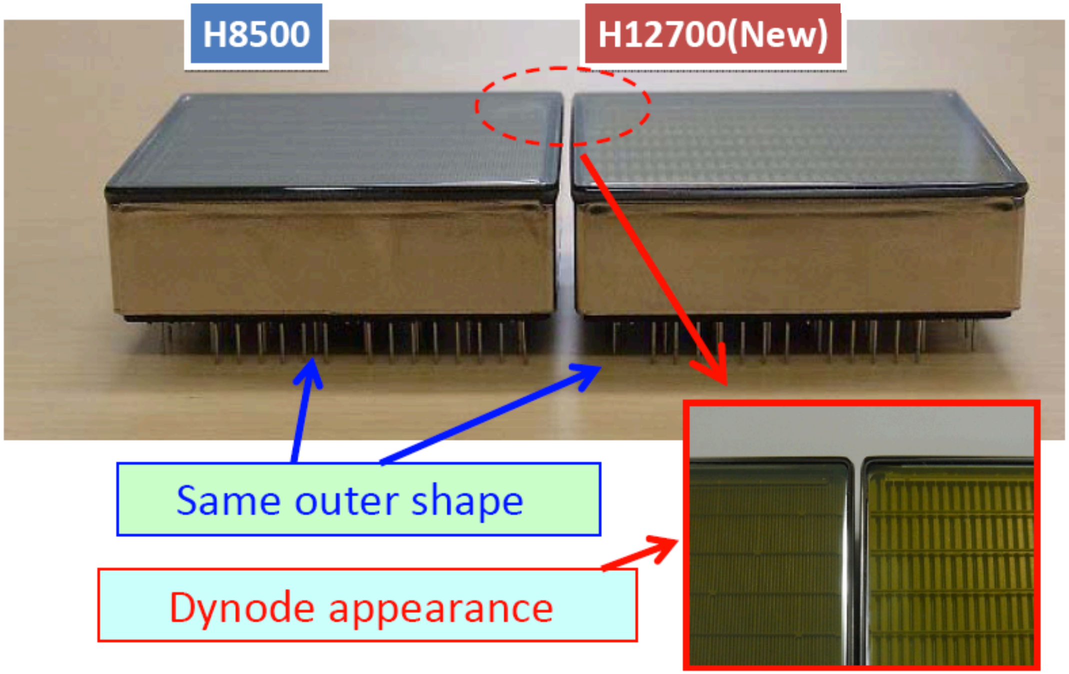


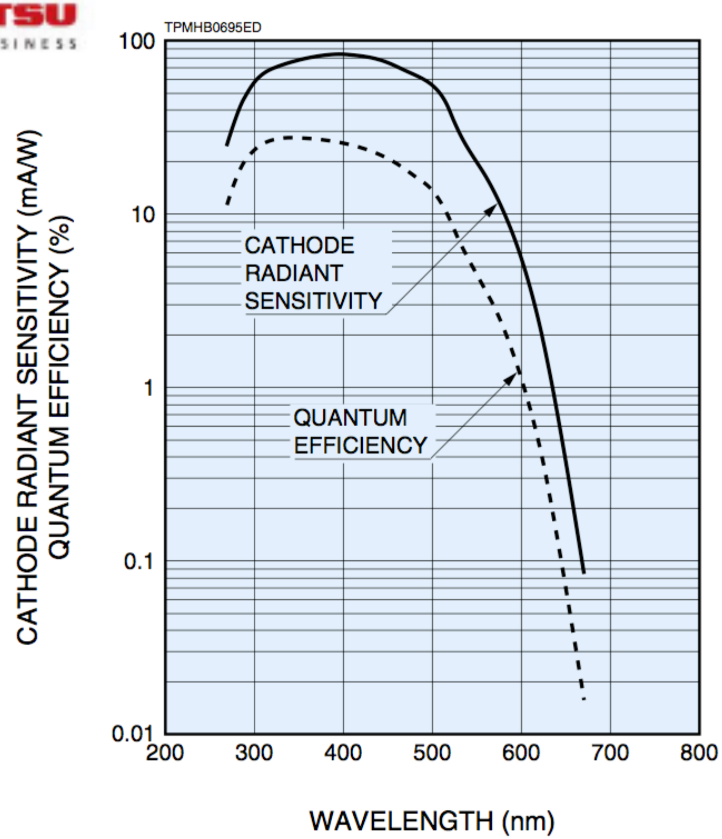


Photon Detectors: MA-PMT

Multi-Anode Photomultipliers: Large Area (5x5 cm^2)
Cost-Effective Devices (~2.3 k$ each)
High packing density (89 %)

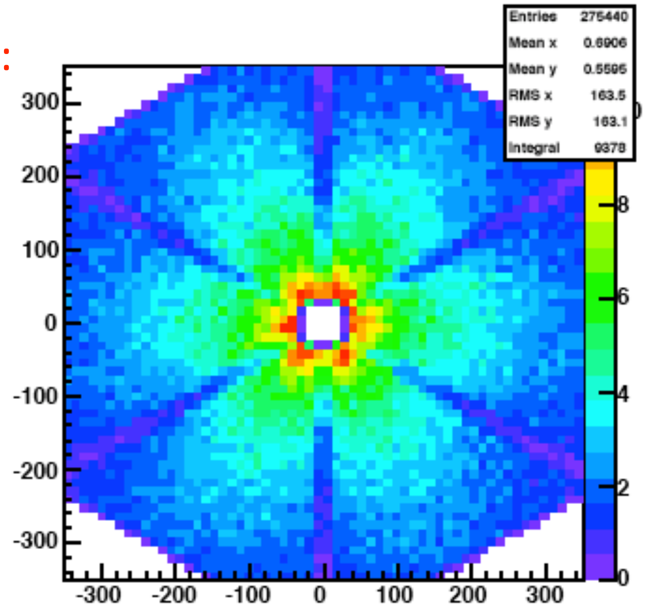
HAMAMATSU
PHOTON IS OUR BUSINESS



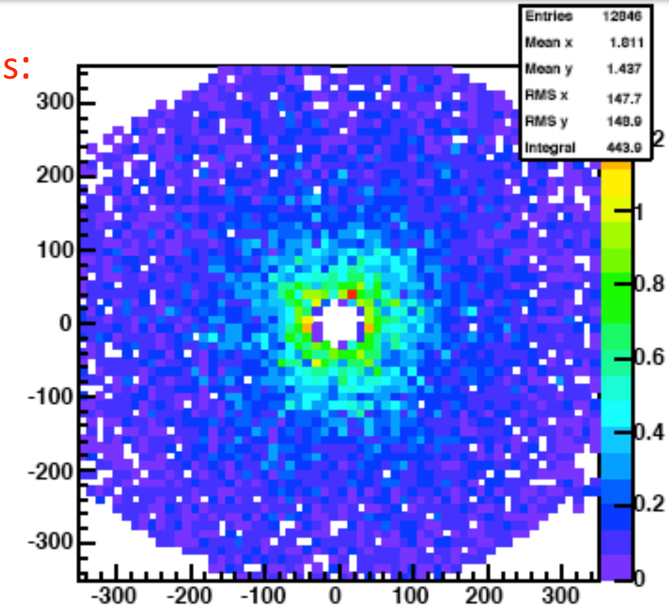


Radiation Damage

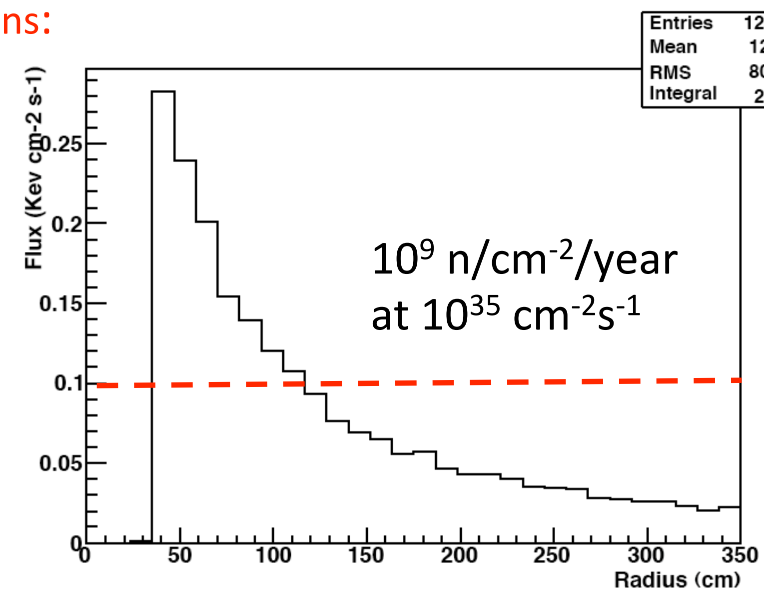
Gammas:

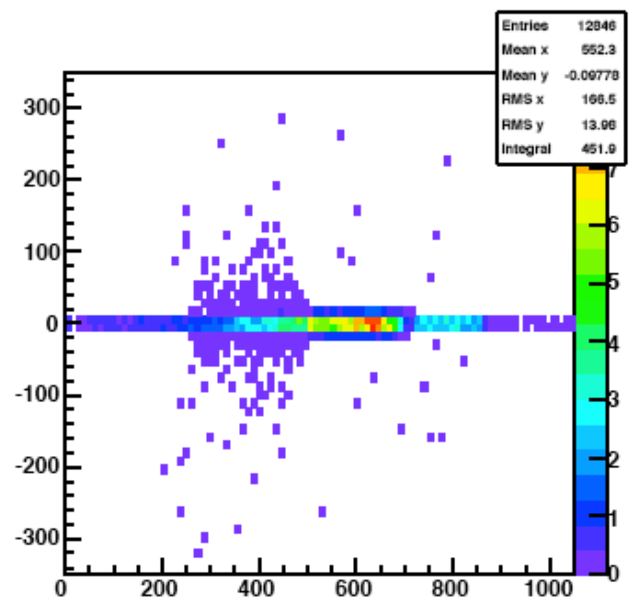


Neutrons:



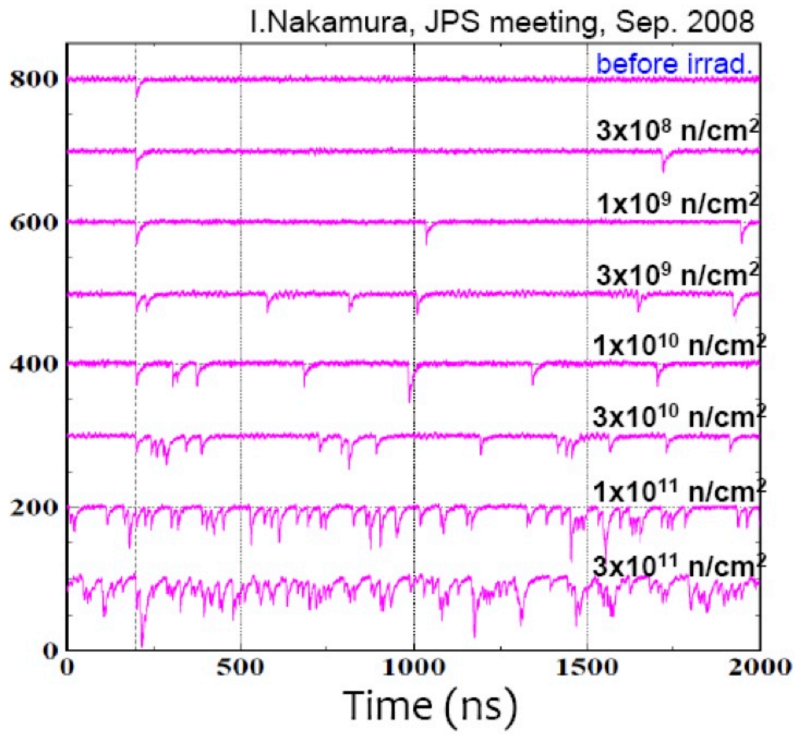
Neutrons:





Photon Detectors: SiPM

Expected neutron damage inside the BelleII spectrometer

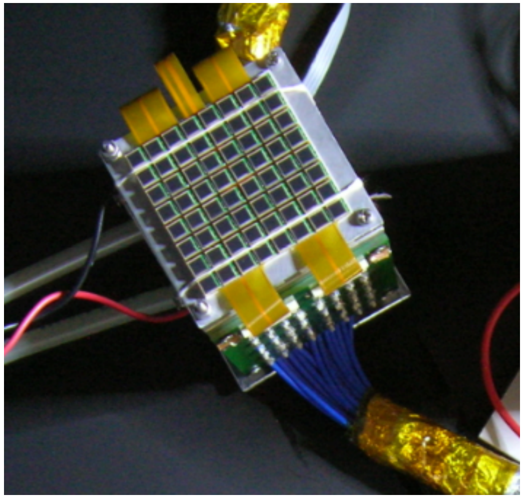


Measured fluence @ Belle:
90/fb → 1-10 10^9 n/cm^2

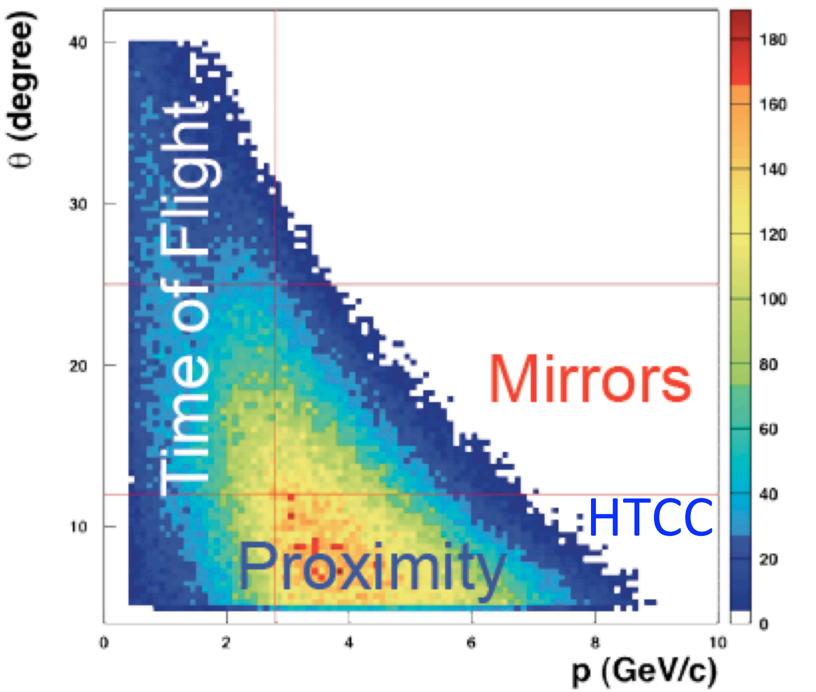
Expected fluence @ Belle-2:
50/ab → 2-20 10^{11} n/cm^2

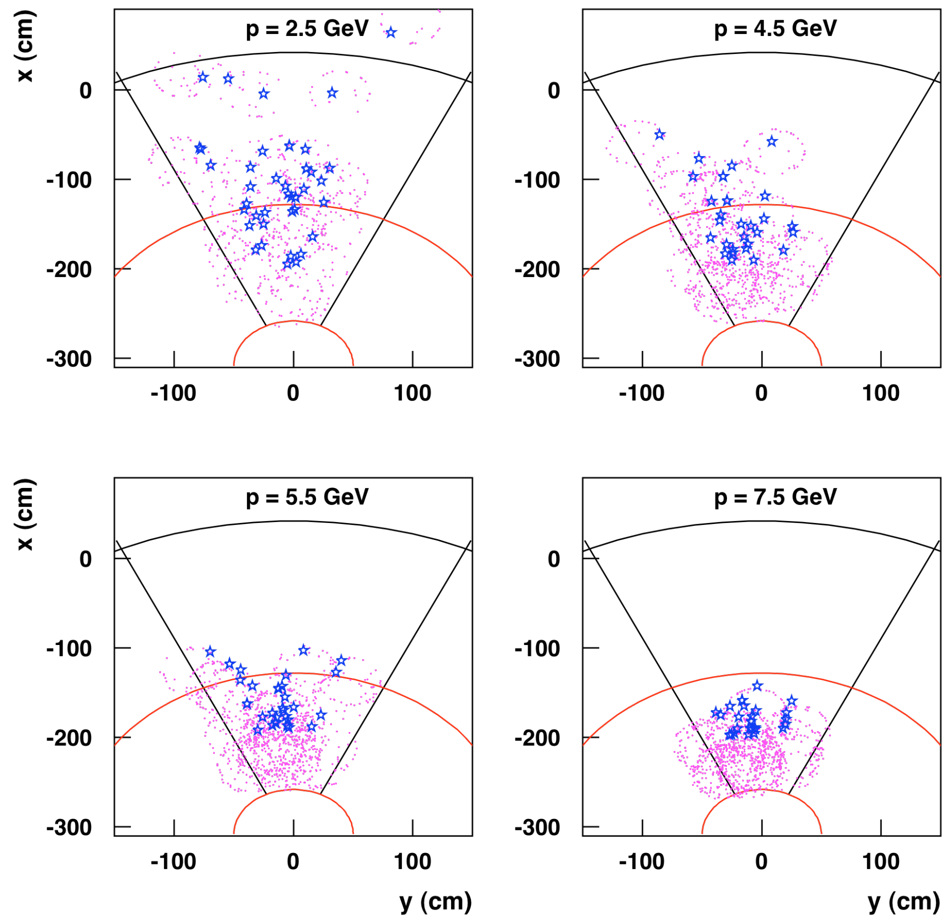
Expected fluence @ LHCB-2:
1 year → 6 10^{11} n/cm^2

Fluence at CLAS12 allows the use of SiPM for future upgrades:
- fast develop in performances
  - (dark count ~ 1 Mhz for 3x3 mm^2 devices)
- fast reduction in price
  - (already comparable with MA-PMTs over 1 m^2)

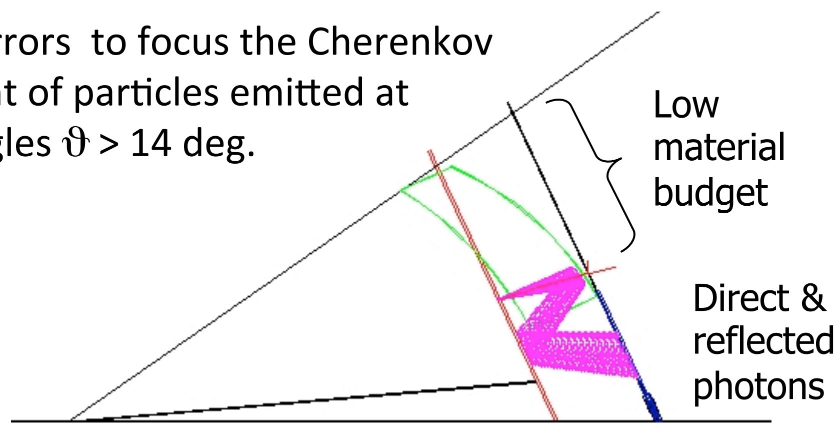


The Mirror System





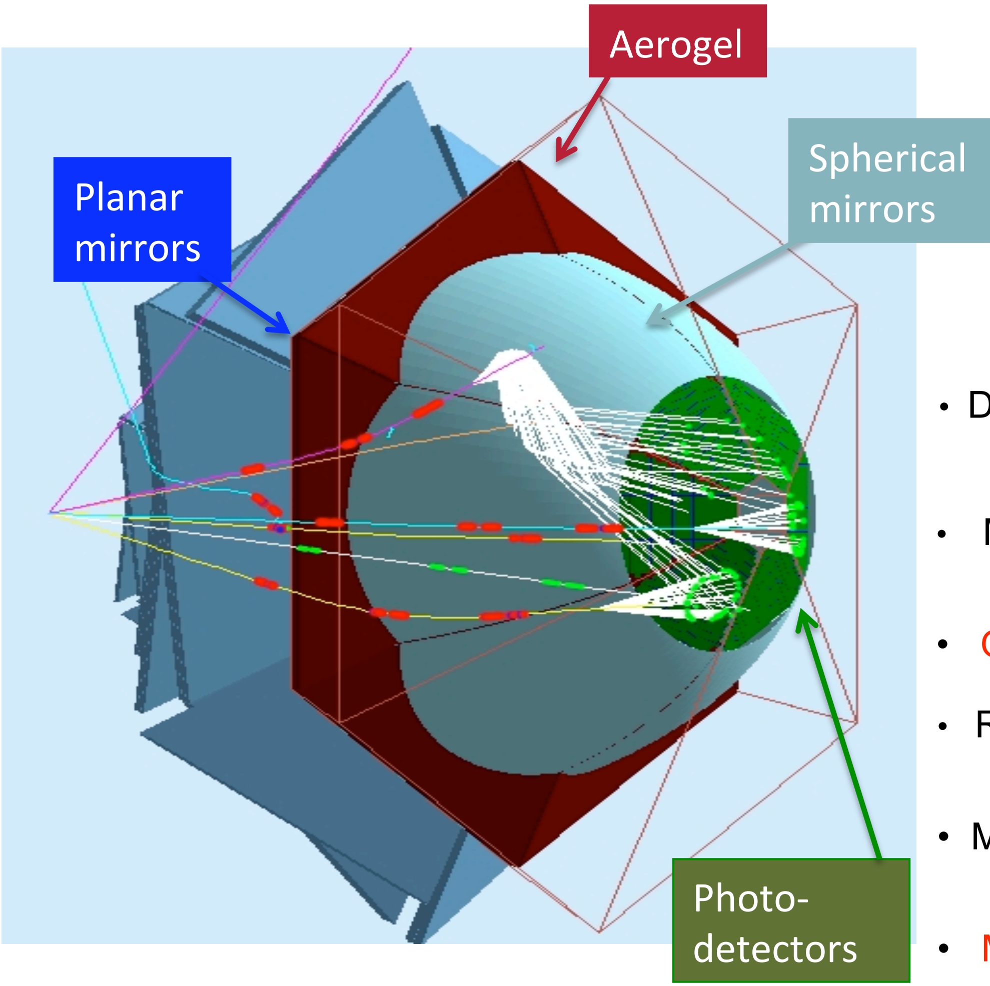
Mirrors to focus the Cherenkov light of particles emitted at angles ϑ > 14 deg.

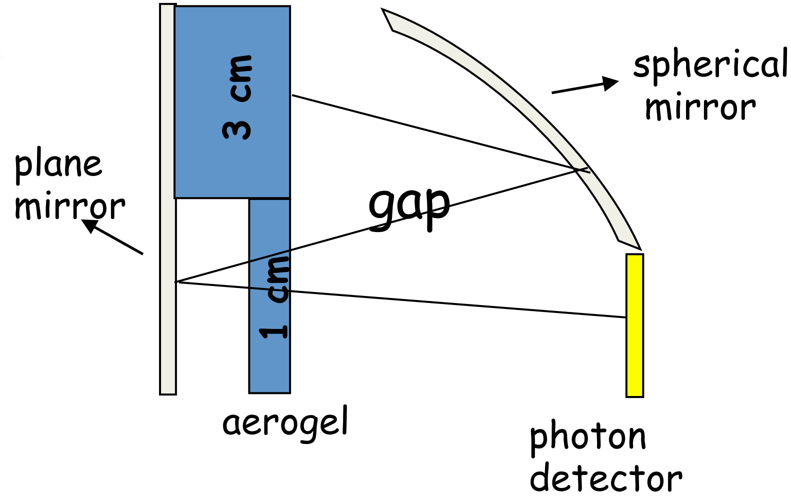


Goals:

- instrument only forward region
- reduce active area (~1 m^2/sect)
- minimize interference with TOF system

Proximity Focusing RICH + Mirrors



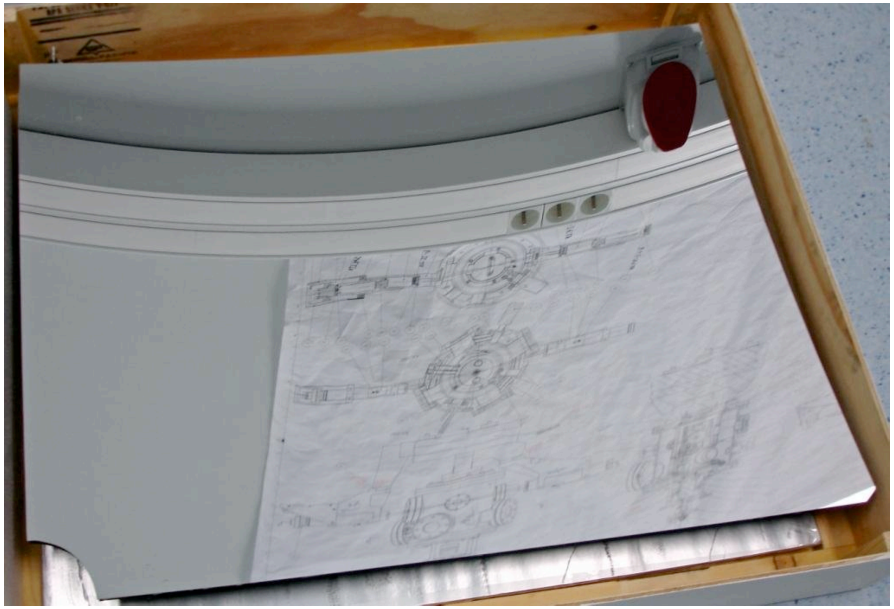


- Direct rings for high momentum particle → best performance !
- Minimize photon detector area → cost !
- Open detector close to beam line → background !
- Reflected rings for low momentum particle → less demanding
- Minimum interference with TOF
- Multiple passages within aerogel → photon losses
- Focalising mirrors allow for thicker aerogel (to partly compensate the loss of photons)

Mirror Technology

Metalized Carbon Fiber substrate

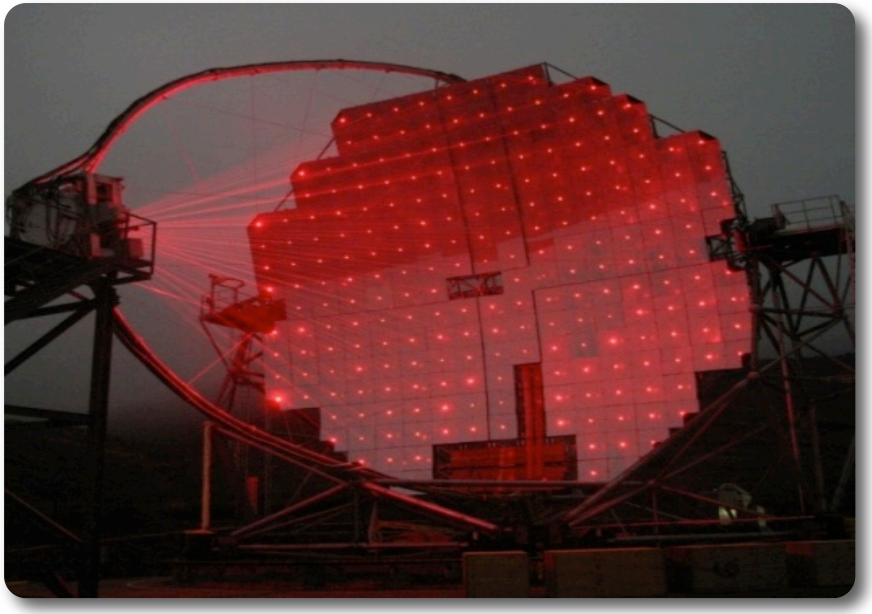
Self-supporting structure with
minimal material budget
(applications in physics experiments)



LHCB mirror

Thin glass skin embracing a honeycomb core

Cost-effective technology for precise
large area mirrors
(applications in terrestrial telescopes)



MAGIC telescope

RICH Project Achievements

2010:

- ✔ Concept of Design and Technology

2011:

- ✔ Tests of components and small prototype

2012:

- ✔ July: Test-beam with Electrons (Frascati)
- ✔ July: Test-beam with Hadrons (CERN)
- ✔ December: Test-beam with Hadrons (CERN)

2013:

- ✔ February: Start Engineering Phase
- ✔ June: Conclusion Test-beam Data Analysis
- ✔ 26-27 June: Technical Review

RICH outlook

Summer 2013:

- ✔ July: Finalize Test-beam Data Analysis (MC tuning)
- ✔ July: Test-beam Dedicated to Electronics
- ✔ August: Finalize CLAS12 RICH Project (TDR)
- ✔ 5-6 September: Project Review with DOE
- ✔ September: Start Procurement

GOAL: 1st sector ready for physics run in 2016