

The CLAS12 Spectrometer

Ongoing upgrade of the CLAS detector.
First beam expected in 2016.

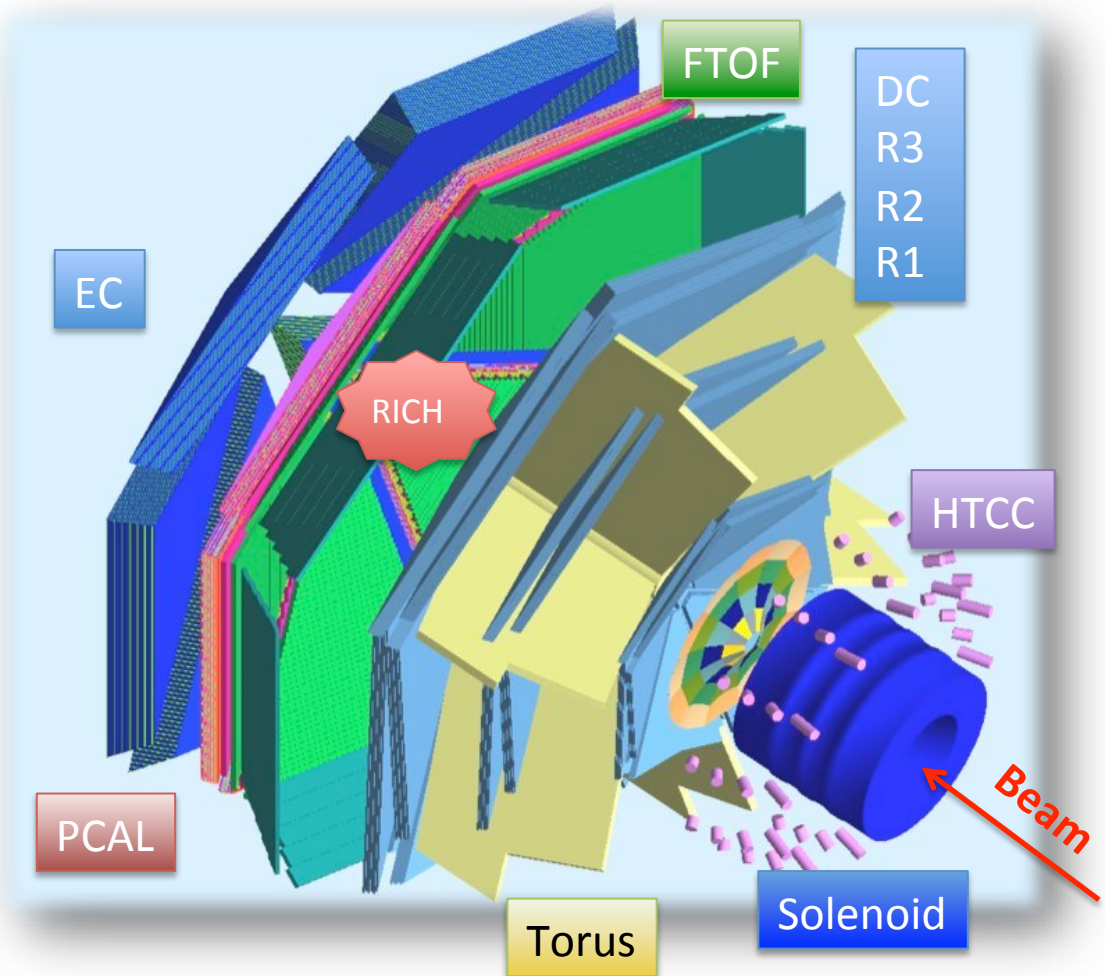
Highly polarized 12 GeV electron beam

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

H and D polarized targets

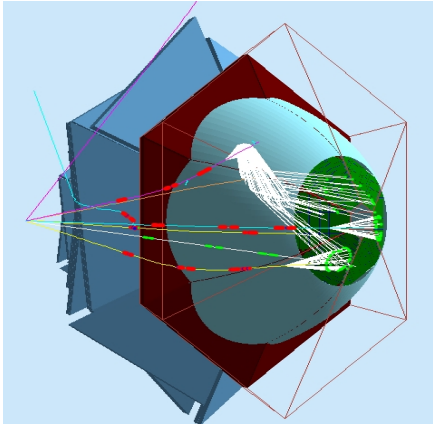
Broad kinematic range coverage
(current to target fragmentation)

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



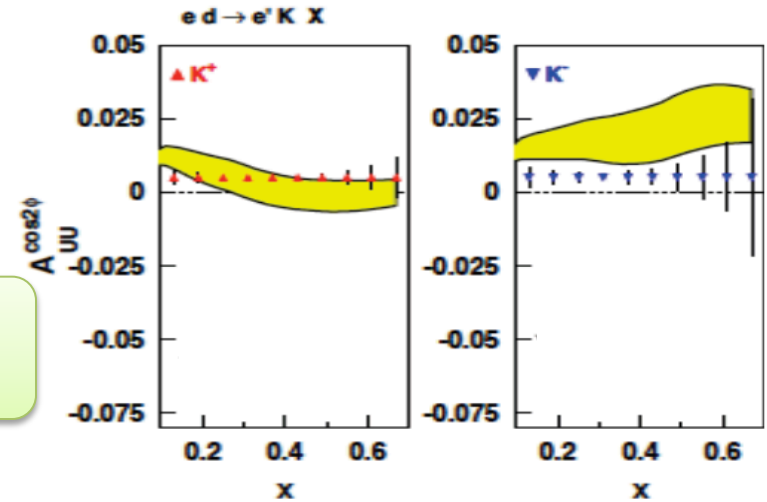
PAC30 report (2006): Measuring the kaon asymmetries is likely to be as important as pions The present capabilities of the present CLAS12 design are weak in this respect and should be strengthened.

Kaon SIDIS Program @ CLAS12



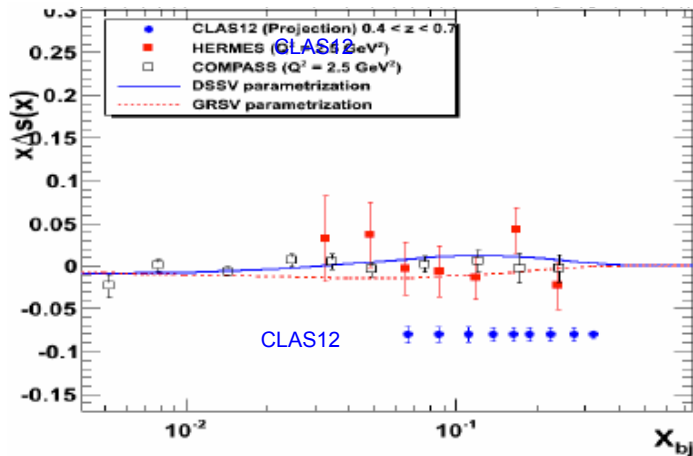
E12-09-08: Studies of Boer-Mulders Asymmetry in Kaon Electroproduction with Hydrogen and Deuterium Targets

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



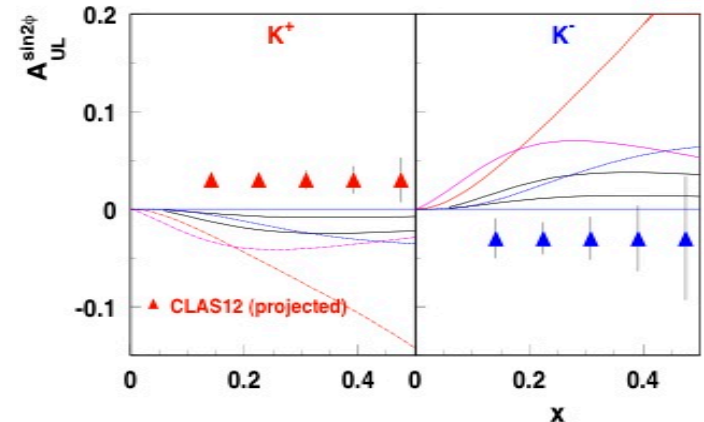
E12-09-09:

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



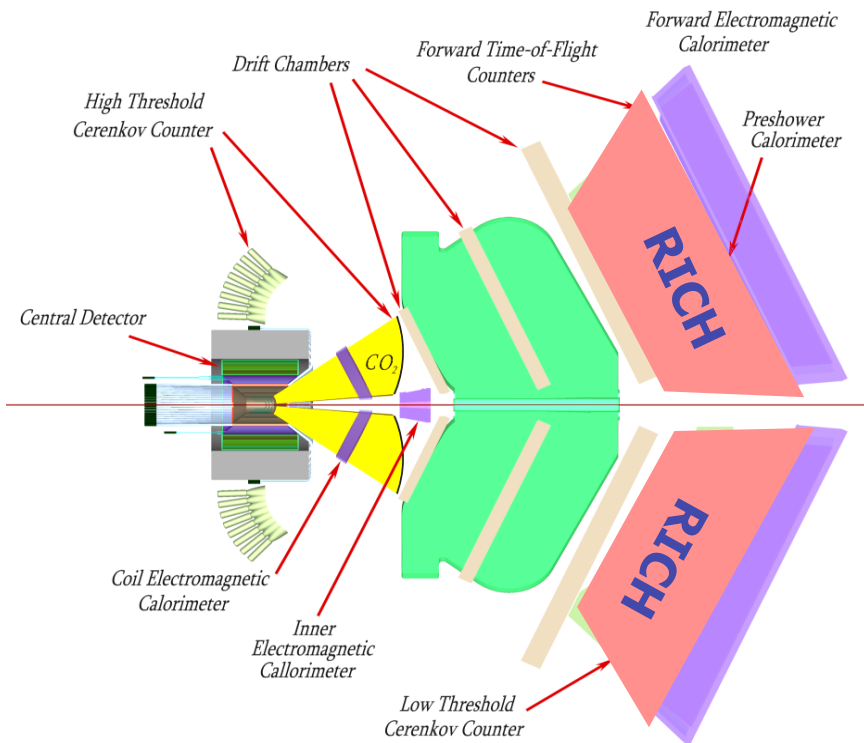
E12-09-07:

Studies of partonic distributions using semi-inclusive production of Kaons



The CLAS12 RICH Project

RICH goal: $\pi/K/p$ identification from 3 up to 8 GeV/c and 25 degrees
 $\sim 4\sigma$ pion-kaon separation for a pion rejection factor $\sim 1:500$



INSTITUTIONS
INFN (Italy) Bari, Ferrara, Genova, L.Frascati, Roma/ISS
Jefferson Lab (Newport News, USA)
Argonne National Lab (Argonne, USA)
Duquesne University (Pittsburgh, USA)
Glasgow University (Glasgow, UK)
J. Gutenberg Universitat Mainz (Mainz, Germany)
Kyungpook National University, (Daegu, Korea)
University of Connecticut (Storrs, USA)
UTFSM (Valparaiso, Chile)

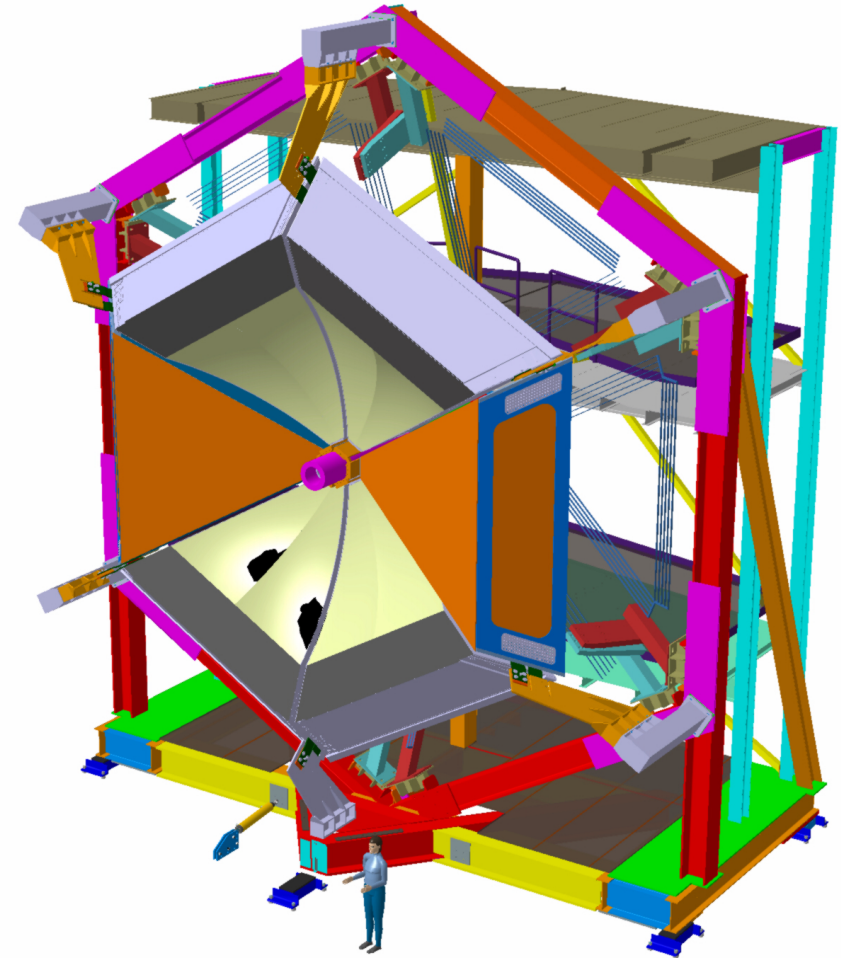
RICH Base Configuration

1st sector allows:

- ✓ to start physics with un-polarized and longitudinal polarized target
- ✓ full coverage of the relevant azimuthal angle ϕ (w.r.t virtual photon)

2nd sector allows:

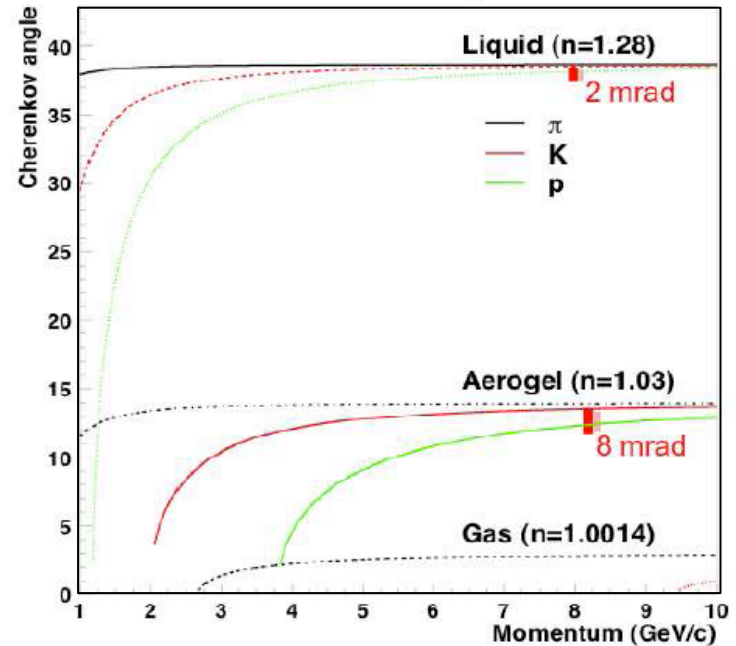
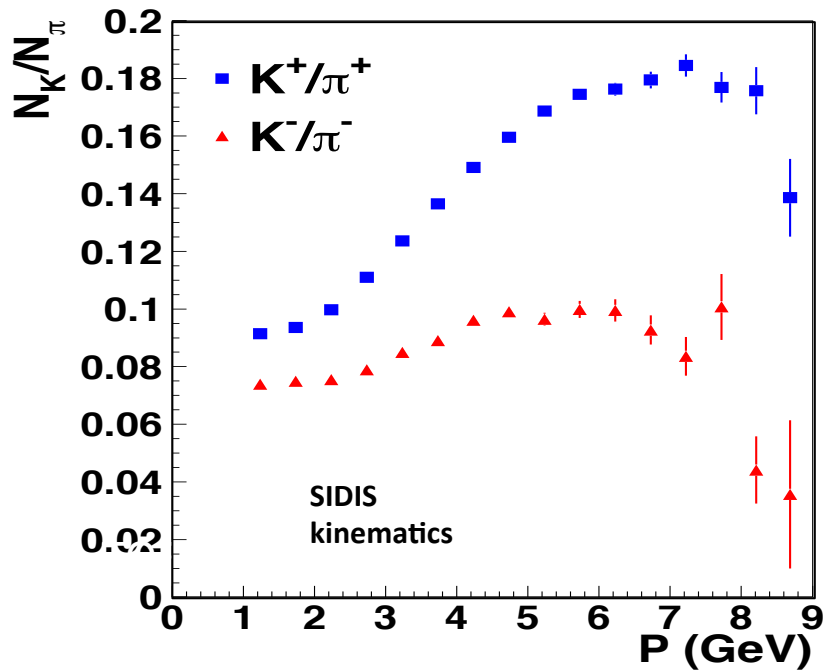
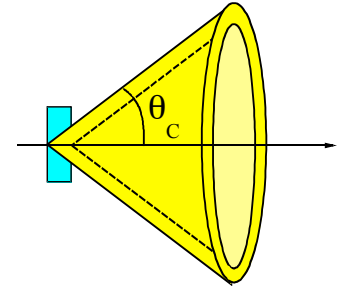
- ✓ to extend the kinematical coverage into the most interesting regions (high- Q^2 and high- P_T)
- ✓ the symmetric arrangement needed to control systematic effects in precision measurements with polarized targets (i.e. double ratio method)



Crucial for the study of parton dynamics related to angular momentum and spin-orbit effects with flavor sensitivity.

CLAS12 Momentum Range

- ◆ Kaon flux 1 order of magnitude lower than $\pi \rightarrow \pi$ rejection 1:500 required
- ◆ **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 the detector area covered with expensive photo-detectors



Aerogel Radiator



The CLAS12 large area RICH detector

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ABSTRACT

A large area RICH detector is being designed for the CLAS12 spectrometer as part of the 12 GeV upgrade program of the Jefferson Lab Experimental Hall-B. This detector is intended to provide excellent hadron identification from 3 GeV/c up to momenta exceeding 8 GeV/c and to be able to work at the very high design luminosity up to $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$. Detailed feasibility studies are presented for two types of radiators, aerogel and liquid C_6F_{14} freon, in conjunction with a highly segmented light detector in the visible wavelength range. The basic parameters of the RICH are outlined and the resulting performances, as defined by preliminary simulation studies, are reported.

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doi:10.1016/j.nima.201

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...with
...The major focus of
...starting in 2014, will
...imaging

...are
...describing
...reproduction

...the study of the structure of nucleons and the hadronization of
the nucleon and quark hadronization processes [2].
Important observables that will be extensively investigated are
transverse Momentum Distribution functions (TMDs) describing
partonic spin-orbit effects and Generalized Parton Distribution
functions (GPDs), containing information about the spatial distri-
bution of quarks and the relation (by a sum rule) to the elusive
partonic orbital momenta. Several experiments have been already
performed by the JLab12 PAC to study kaon versus pion production
in exclusive and semi-inclusive scattering, providing access to
the decomposition of the two sets of non-perturbative
distribution functions.

Main features of CLAS12 include a high operational
luminosity of $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$, an order of magnitude higher than
the CLAS setup, and operation of highly polarized beam and
target. The conceptual design of the CLAS12 detector is
shown in Fig. 1. The central detector with the high-field (5 T)
solenoid is used for particle tracking at large angles. The
RICH detector detects charged and neutral particles in the
momentum range between 5 and 40 GeV/c. It employs a 2 T torus magnet
with a dipole symmetry of CLAS. In the base equipment,

...rejection factor
...sigma pion kaon
...detectors do not
...the 5-8 GeV momentum interval, improved particle identifica-
tion and event reconstruction can be achieved in this momentum
range by replacing the existing low-threshold Cherenkov counter
(LTCC) with a RICH detector without any impact on the baseline
design of CLAS12.

tion and event reconstruction can be achieved in this momentum
range by replacing the existing low-threshold Cherenkov counter
(LTCC) with a RICH detector without any impact on the baseline
design of CLAS12.

2. The CLAS12 RICH

To fit into the CLAS12 geometry, the RICH should
have a projective geometry with six sectors that cover the space
between the torus cryostats and covering scattering angles from
Fig. 3. Being downstream to the torus magnet at the interaction
point, the RICH has to cover a large area between detectors
which are already in the constraining geometry. The gap
depth cannot exceed 1 m. The proposed solution is a
solute focusing RICH.

A setup similar to the one adopted in Hall-B (C₅F₁₂ or C₆F₁₄) radiator and a CsI-deposited
silicon chamber as a UV-photon detector, is required to achieve
the required pion rejection factor at momenta up to 8 GeV/c.

The preliminary results on ongoing Monte Carlo studies, based
on a GEANT3 toolkit with simplified geometry, show that the
design of CLAS12

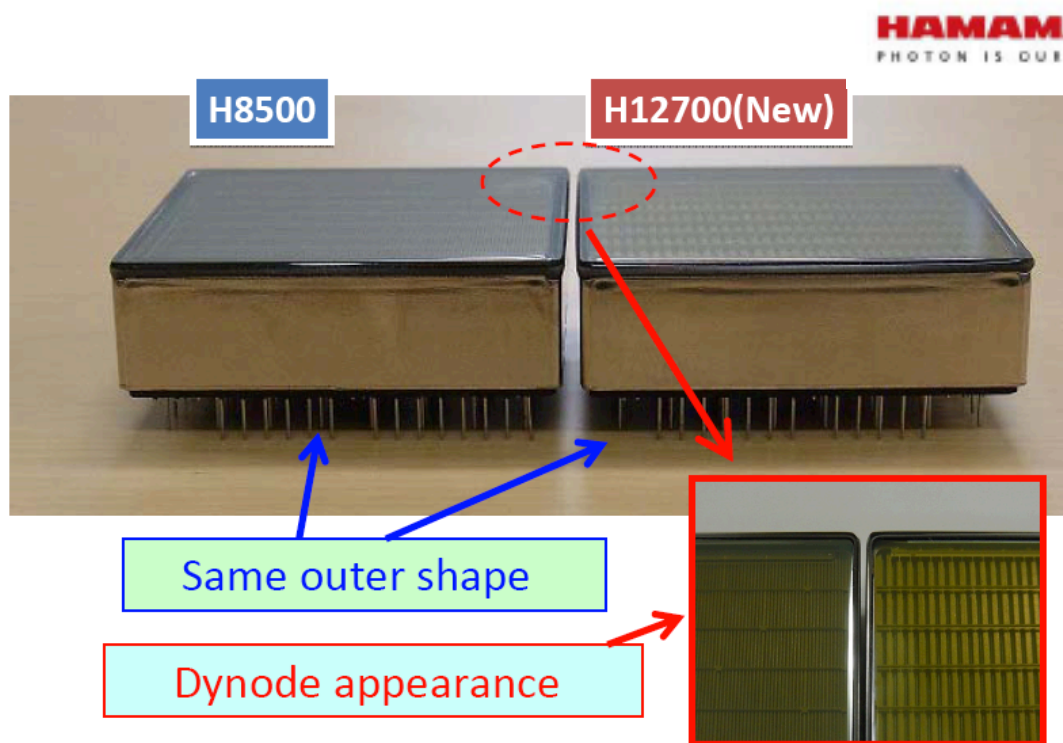
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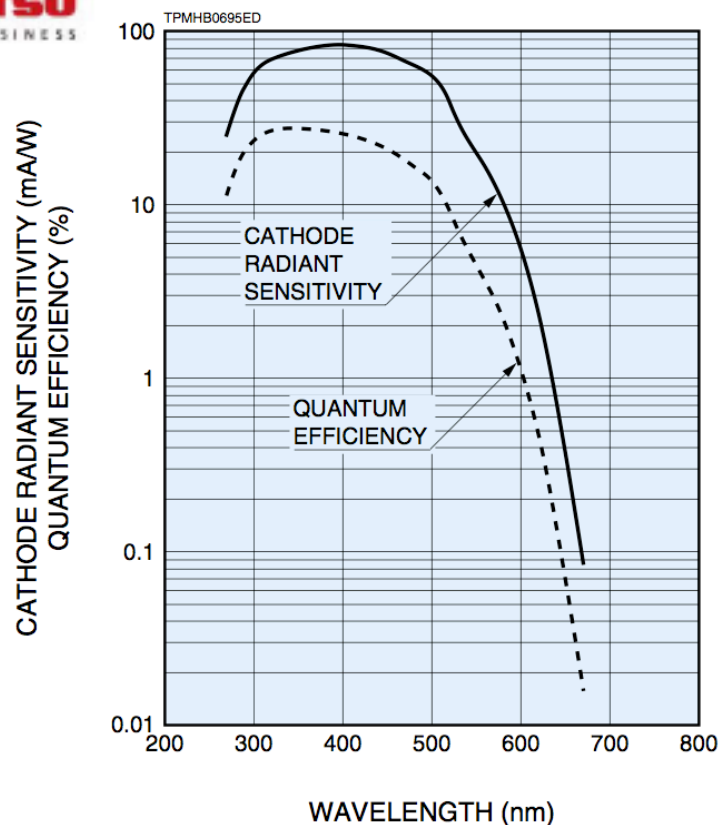
Photon Detectors: MA-PMT

The only option to keep the schedule is the use of multi-anode photomultipliers (we consider the promising SiPM technology as the alternative)

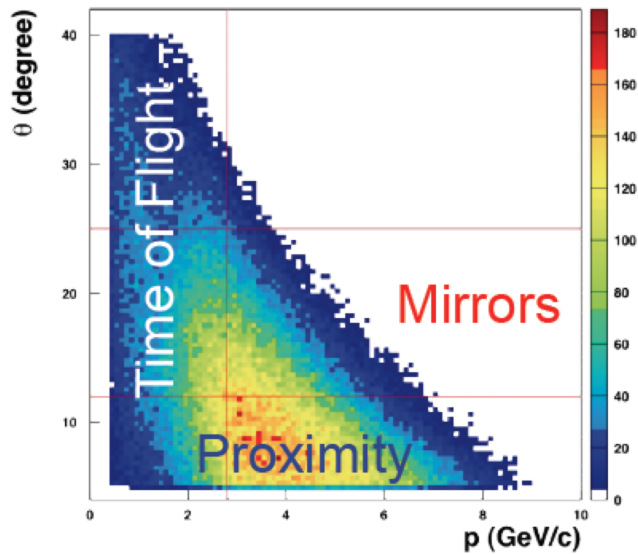
- ✓ Mature and reliable technology
- ✓ Large Area ($5 \times 5 \text{ cm}^2$)
- ✓ High packing density (89 %)
- ✓ 64 $6 \times 6 \text{ mm}^2$ pixels cost effective device
- ✓ High sensitivity on visible towards UV light
- ✓ Fast response



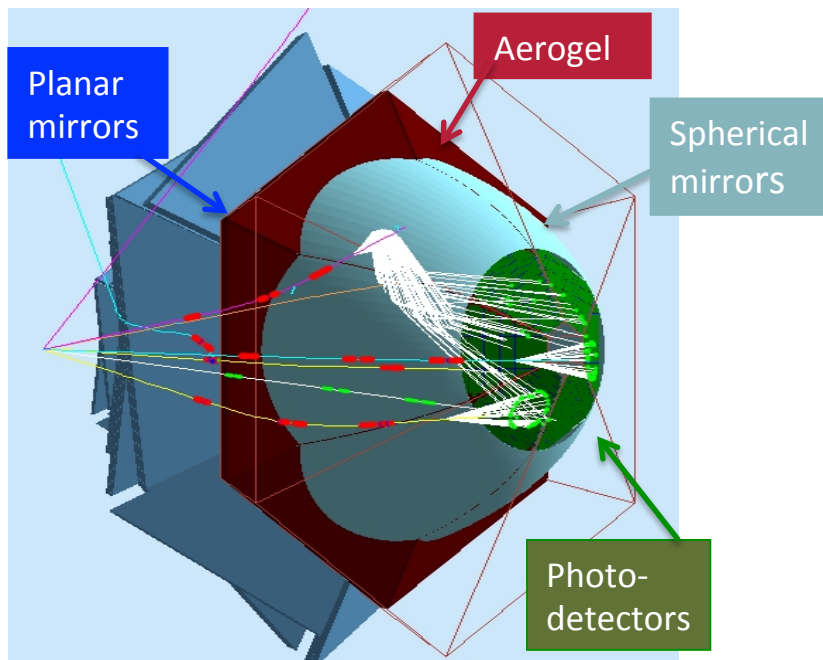
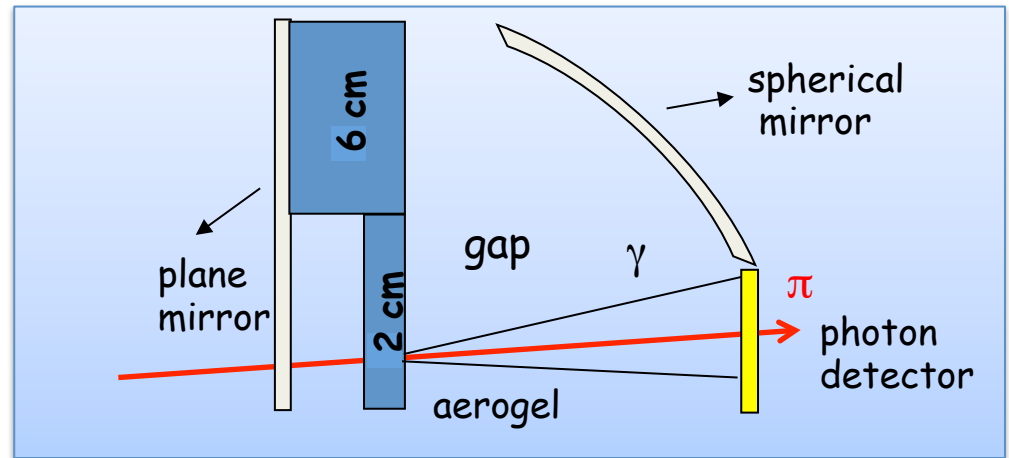
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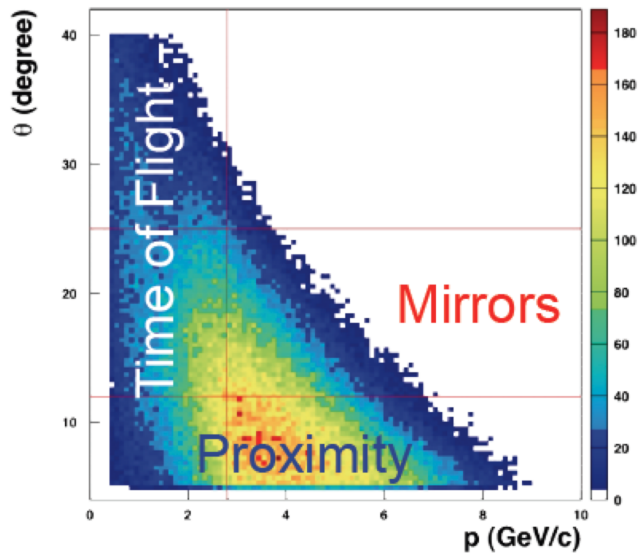
The Hybrid Optics Design



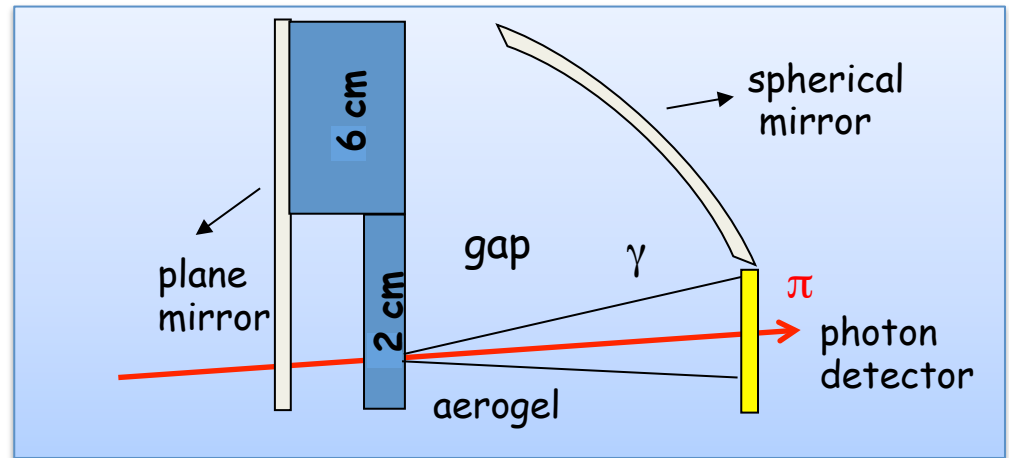
Direct rings/best performance for high momentum particles



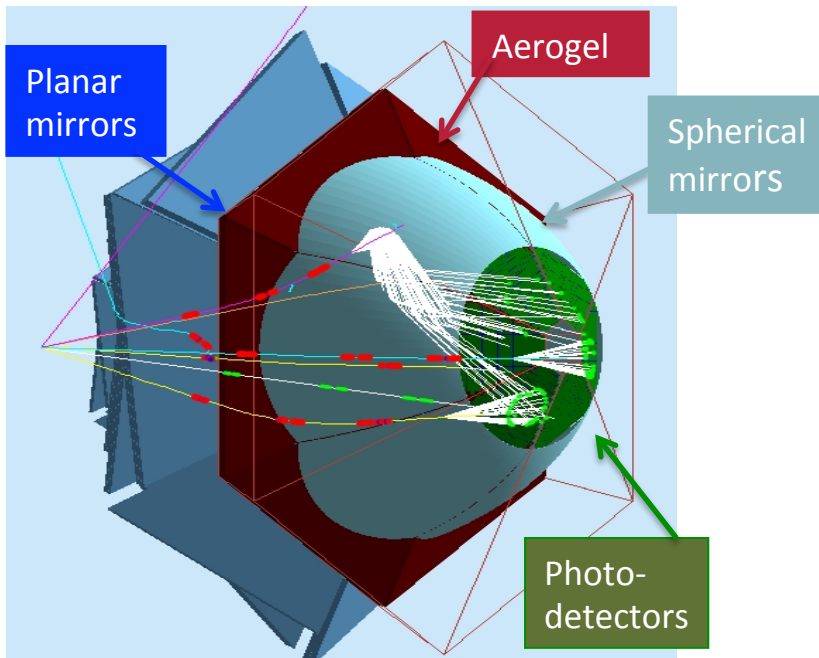
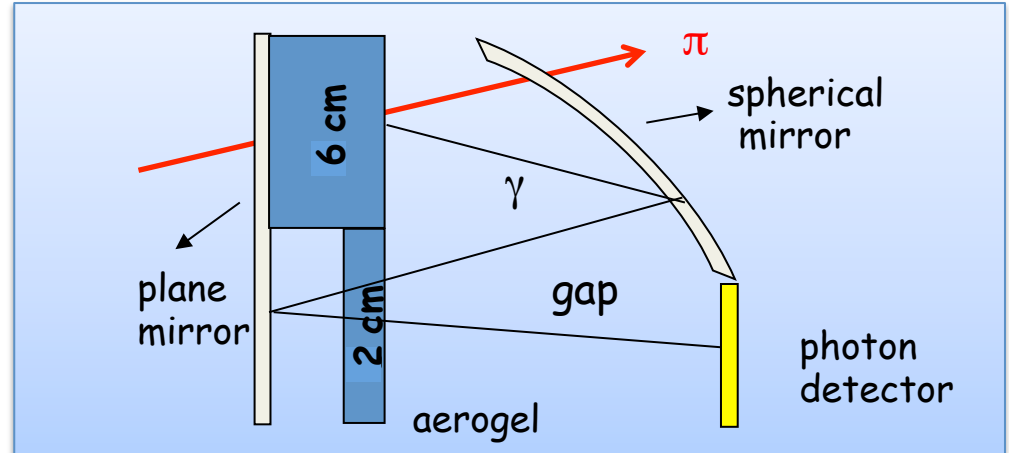
The Hybrid Optics Design



Direct rings/best performance for high momentum particles



Reflected rings for less demanding low momentum particles



- Minimize active area (cost) to about 1 m²
- Material budget concentrated where TOF is less effective
- Focalizing mirrors allow thick radiator for good light yield

Mirror Technology

Metalized Carbon Fiber substrate
for spherical mirror

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

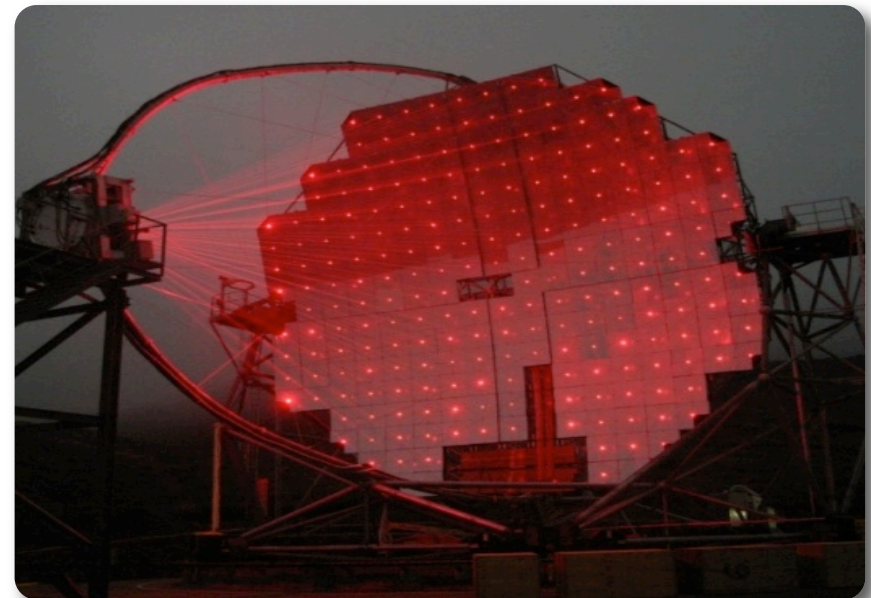
Thin glass skin on a flat support
for planar mirrors

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

Standard technologies already in use and commercially available



LHCB mirror



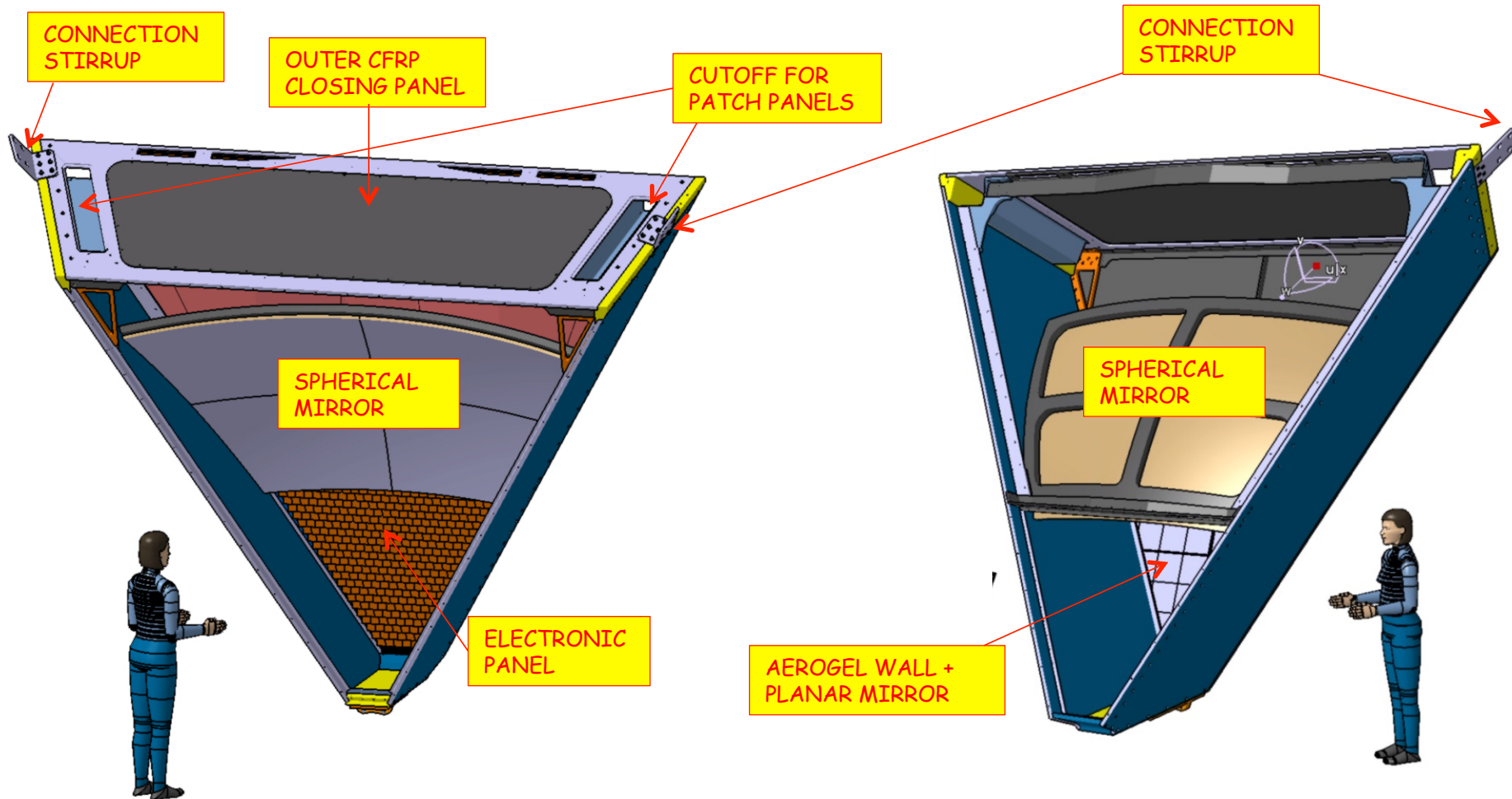
MAGIC-II telescope

RICH Module General Assembly

RICH module designed to be as much as possible close to the existing LTCC sector layout

RICH MODULE BACKWARD VIEW (OPENED)

RICH MODULE FORWARD VIEW (OPENED)



RICH Construction Schedule

Milestone	Date
Concept of Design and Technology	2010
Tests of components and small prototype	2011
Test-beam with electrons (Frascati) and hadrons (CERN)	2012-2013
Start Engineering Phase	Feb. 2013
Hall-B review	June 2013
TDR	Aug. 2013
Physics Division review with DOE observers	Sep. 2013
Hamamatsu contract awarded	30 Sep. 2013
Electronics boards completed	July 2015
MA-PMT production completed	Dec. 2015
Mirror production completed	Sep. 2015
Start RICH assembly	Oct. 2016
Aerogel production completed	Dec. 2016
RICH project completed	June 2017

Conclusions

RICH construction phase started in September 2013

Goal: 1st sector ready by the June 2017

RICH module external layout modeled as LTCC



D. Orecchini talk

Structure lighter than LTCC validate by stress FEA model analysis



S. Tomassini talk

Waiting validation before starting procurement and optimizing internal elements

Gas system Design Parameters have been identified



R. Perrino talk

N₂ flux to preserve aerogel performances

Air cooling for electronic box

Waiting Hall-B constraints before starting technical design and prototyping