Status Report of the RICH Project

CLAS12 RICH Meeting, 20th November 2013, JLab

The CLAS12 Spectrometer

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

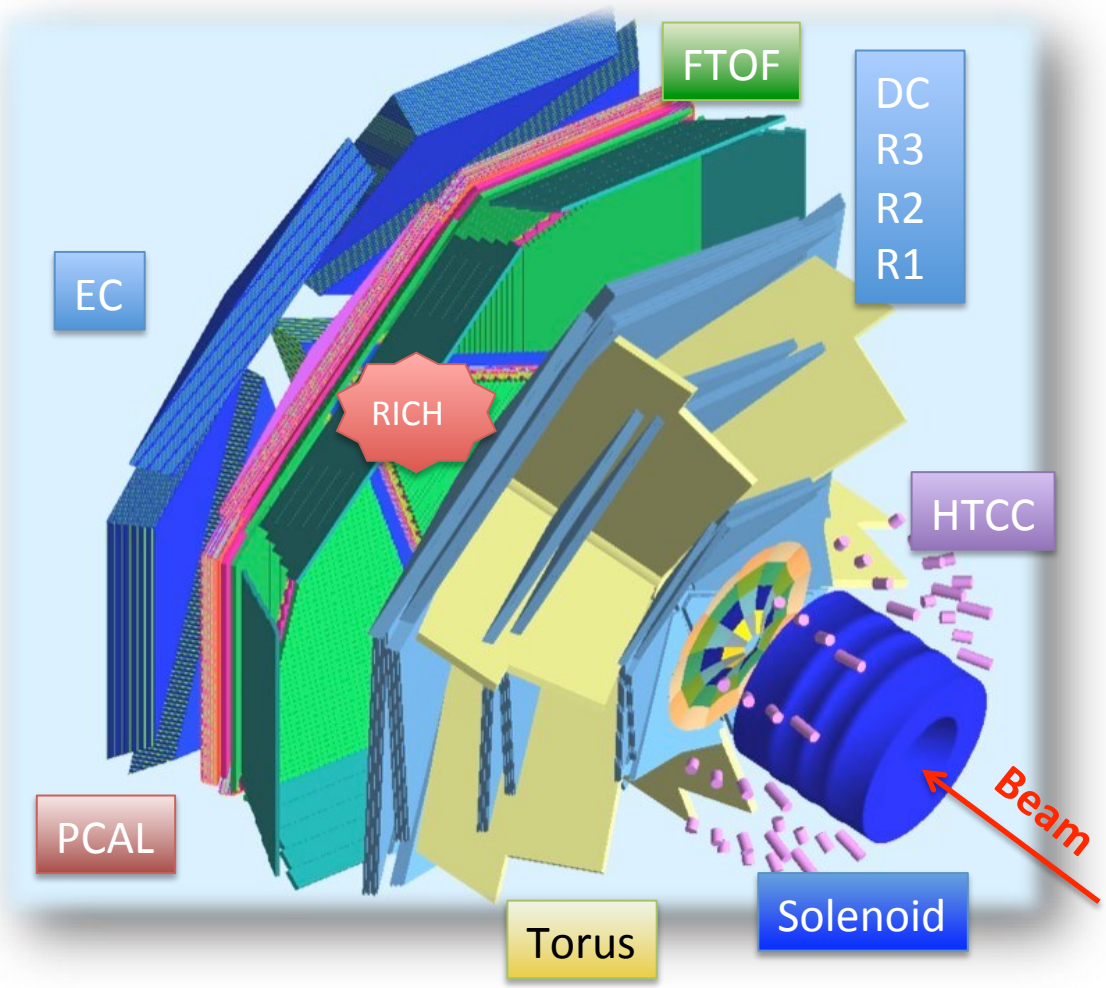
Highly polarized 12 GeV electron beam

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

H and D polarized targets

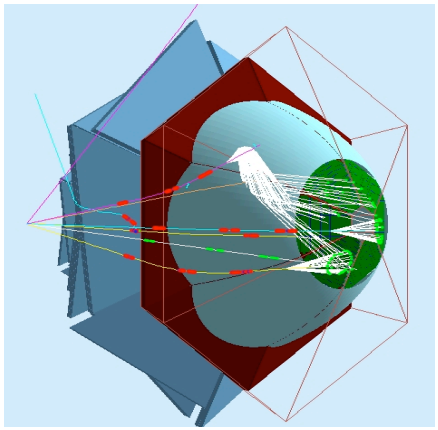
Broad kinematic range coverage
(current to target fragmentation)

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

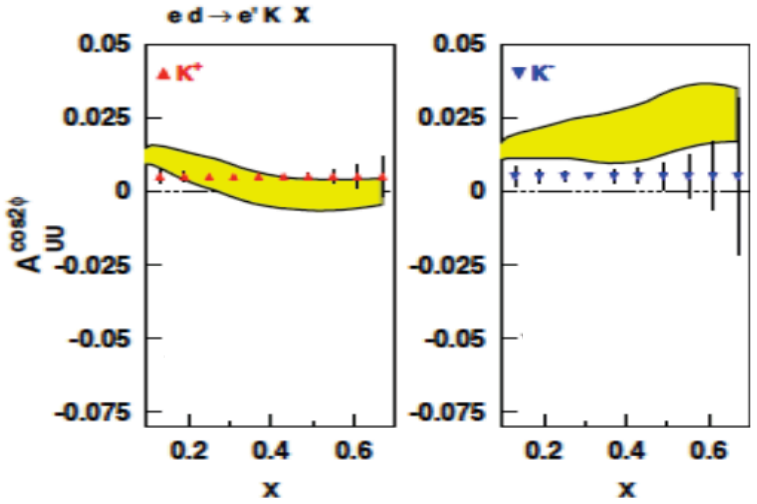


PAC30 report (2006): Measuring the kaon asymmetries is likely to be as important as pions …. The present capabilities of the present CLAS12 design are weak in this respect and should be strengthened.

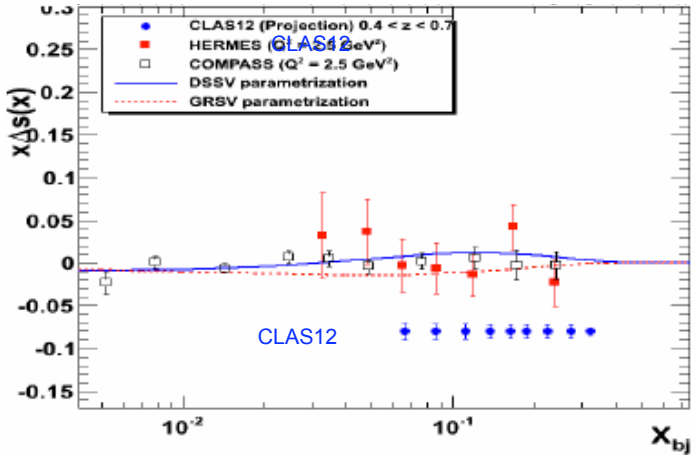
Kaon SIDIS Program @ CLAS12



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

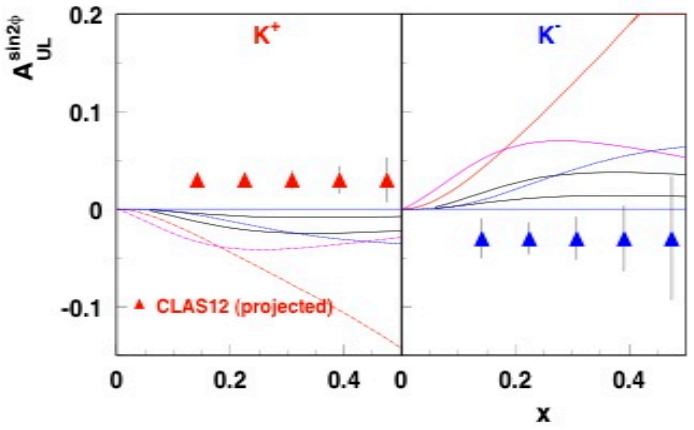


RICH detector for flavor separation of quark spin-orbit correlations in nucleon structure and quark fragmentation



E12-09-07:
Studies of partonic distributions using semi-inclusive production of Kaons

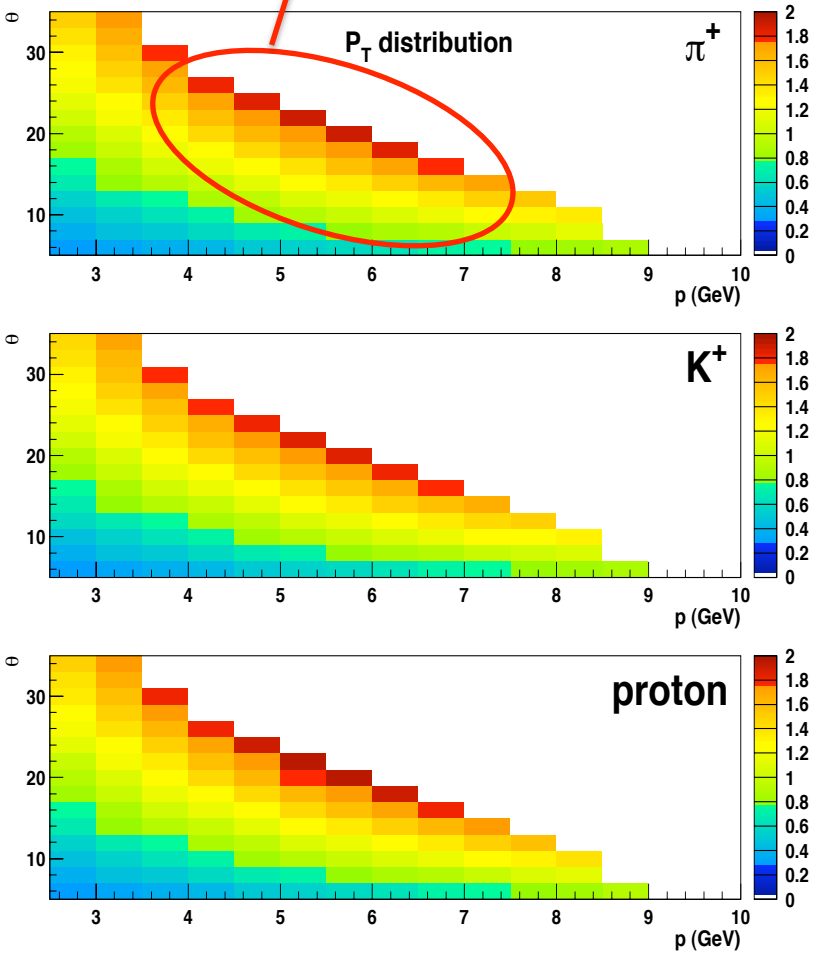
E12-09-09:
Studies of Spin-Orbit Correlations in Kaon Electroproduction in DIS with polarized hydrogen and deuterium targets



SIDIS Kinematics @ CLAS12

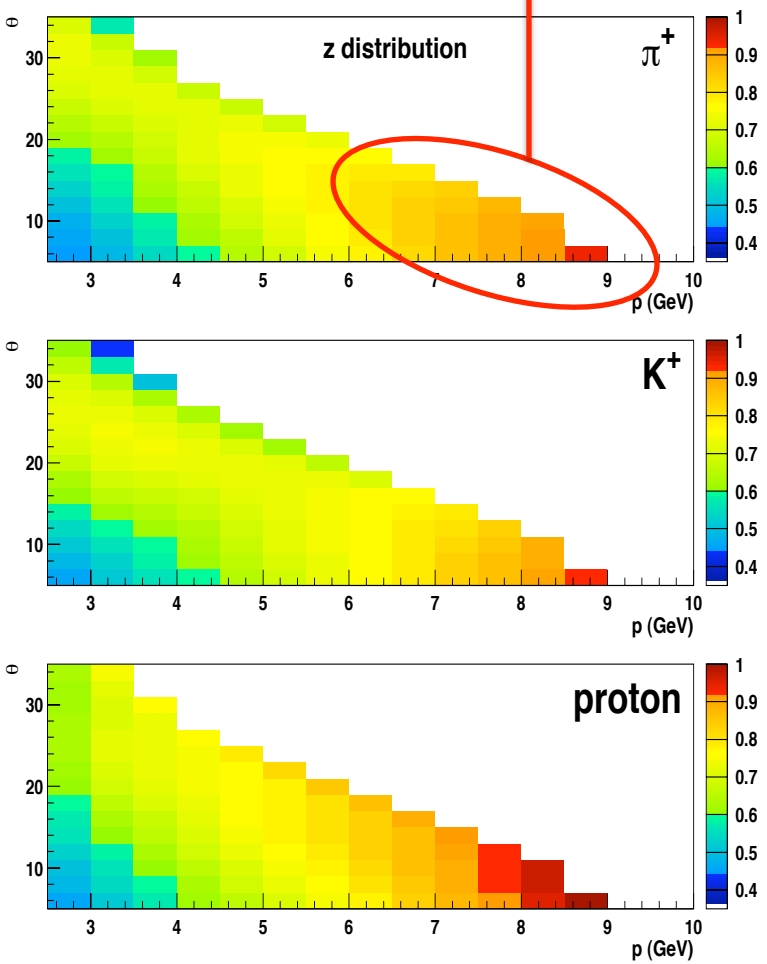
Intermediate angular range (15-25°) important to reach high P_T values

P_T: hadron transverse momentum



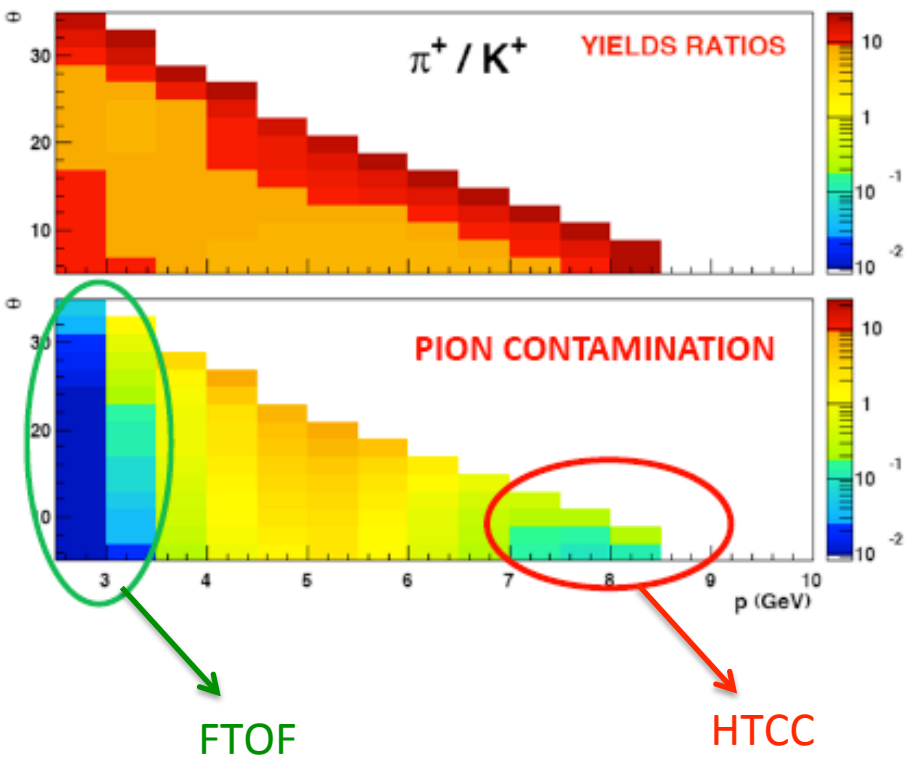
High Momentum region important as transient to hard semi-exclusive region

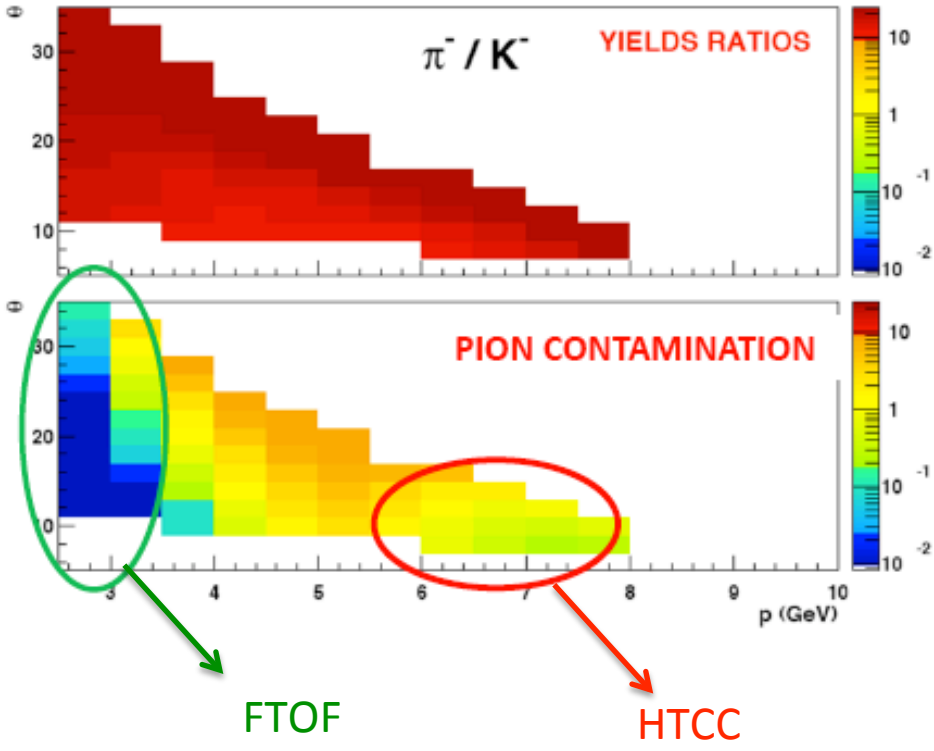
z: hadron fractional energy



PID @ CLAS12

RICH is mandatory to reach few % pion contamination in the full kinematics

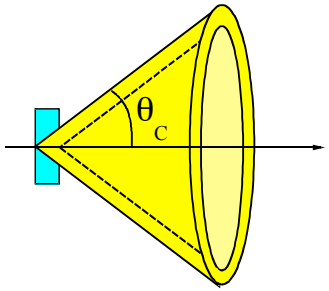


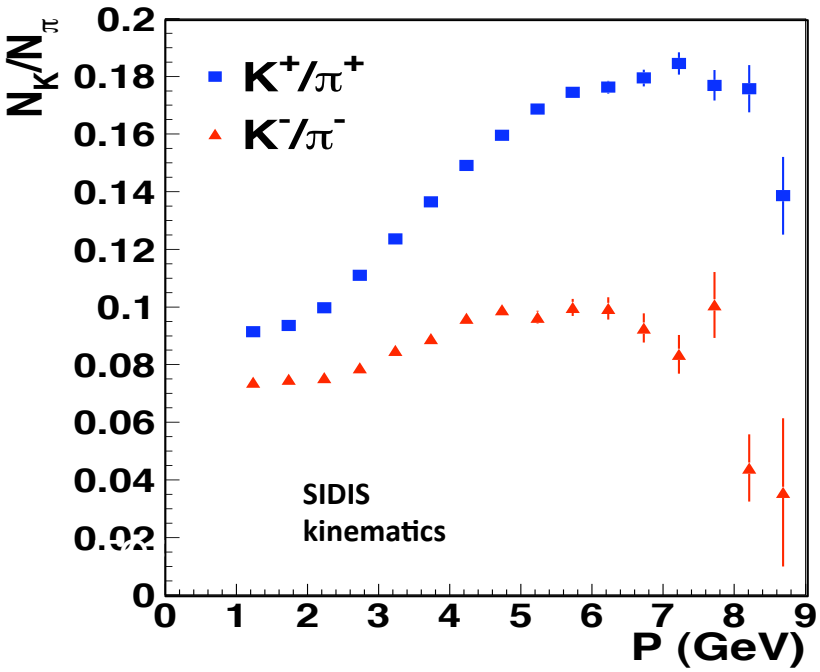


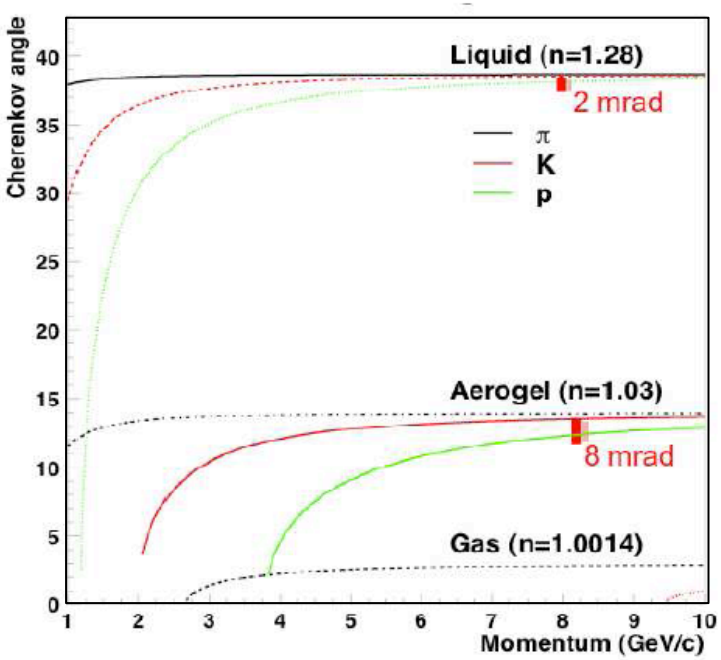
CLAS12 Momentum Range

- Kaon flux 1 order of magnitude lower than π → **π 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







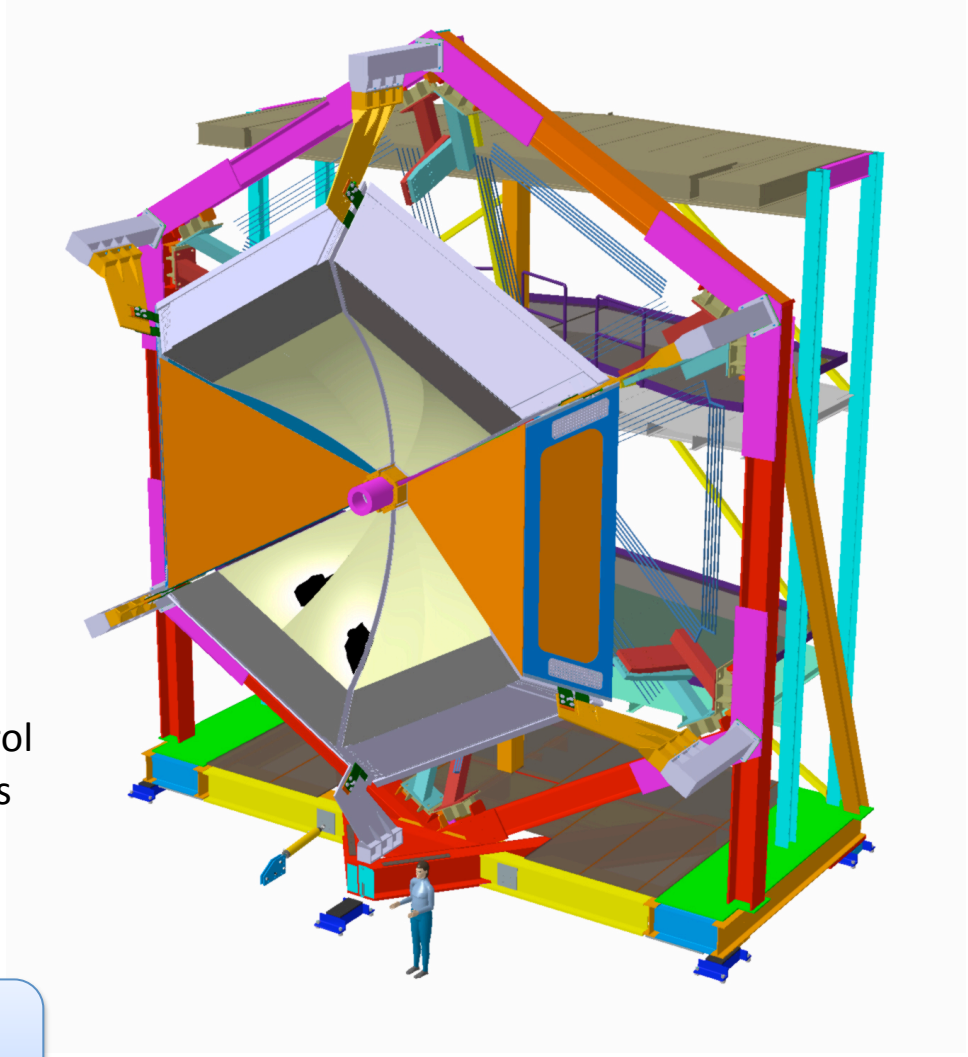
RICH Base Configuration

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)

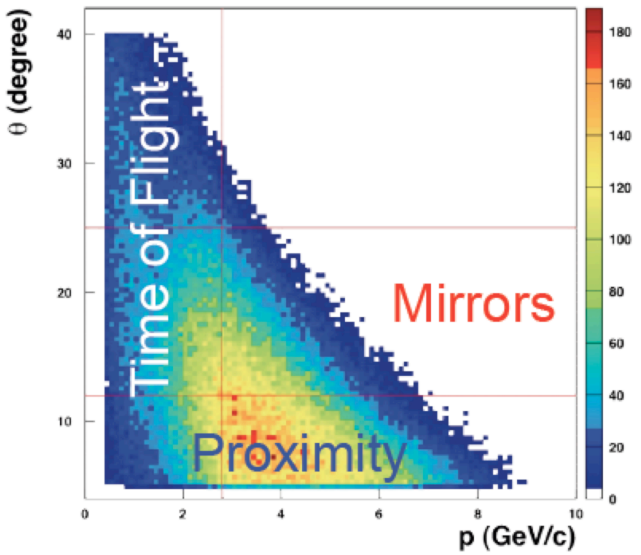
2nd sector allows:

- ✓ 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)

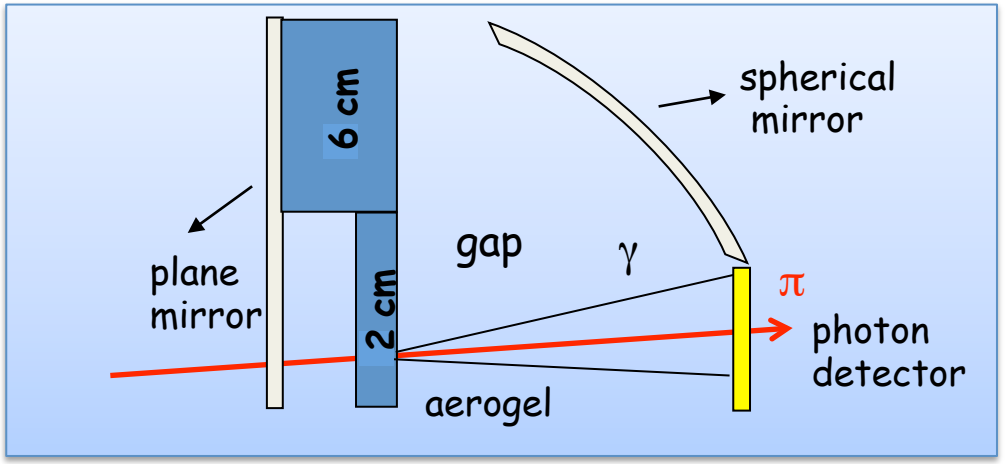


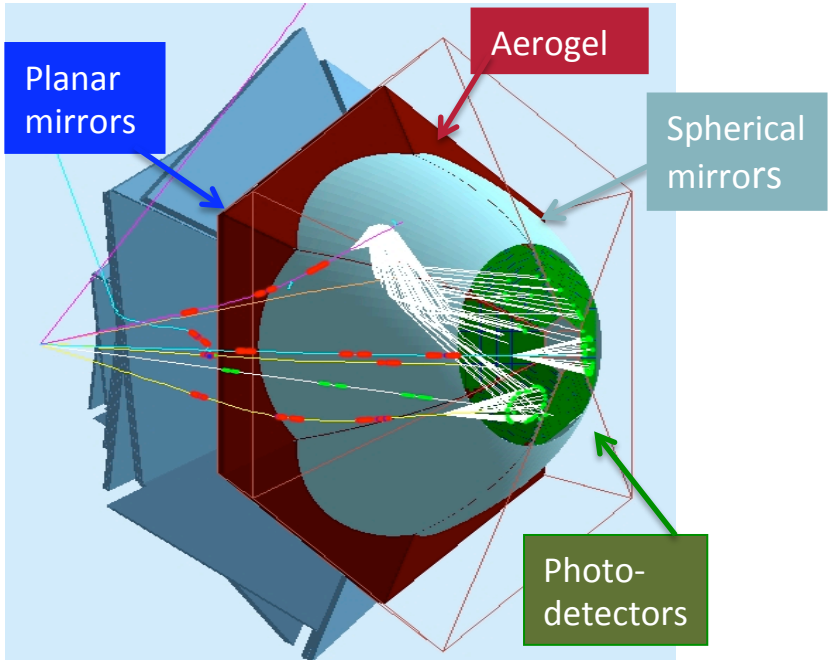
Crucial for the study of parton dynamics related to angular momentum and spin-orbit effects with flavor sensitivity.

The Hybrid Optics Design



Direct rings/best performance for high momentum particles





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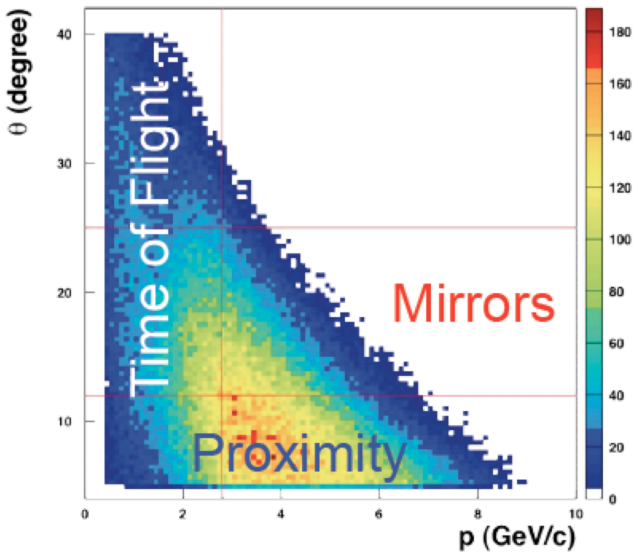

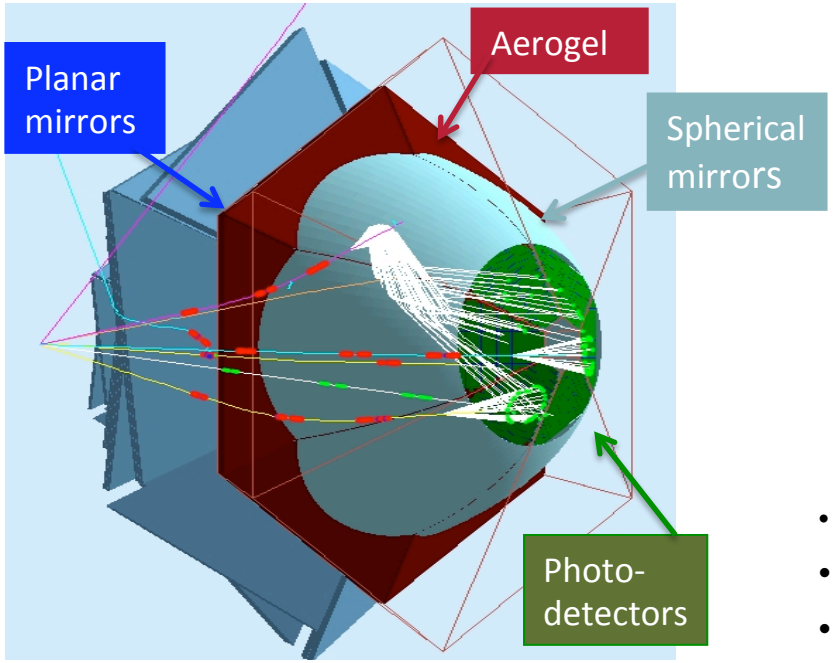

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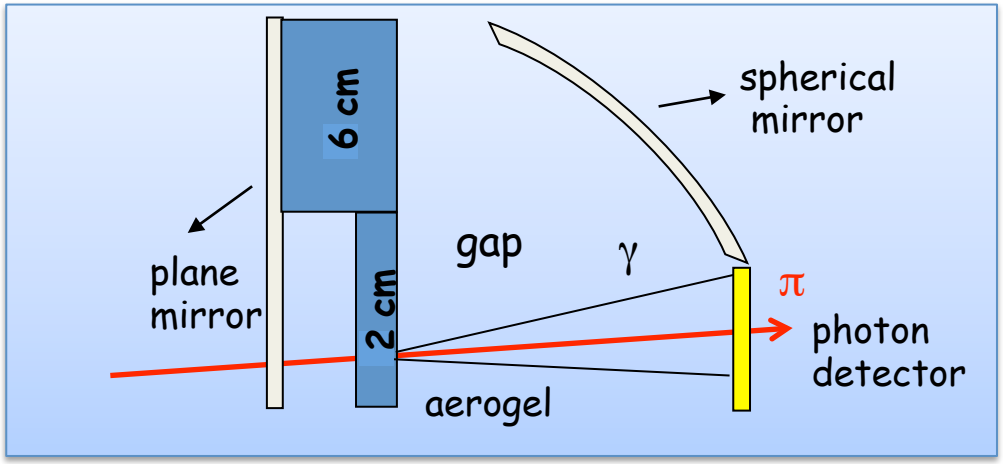
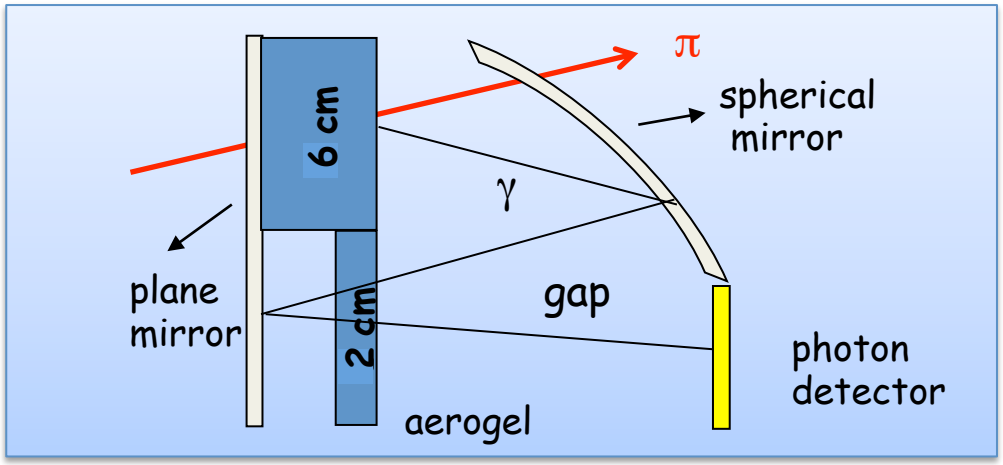


Reflected rings for less demanding low momentum particles



- Minimize active area (cost) to about 1 m^2
- Material budget concentrated where TOF is less effective
- Focalizing mirrors allow thick radiator for good light yield

RICH Project Achievements

2010:

- ✔ Concept of Design and Technology

2011:

- ✔ Tests of components and small prototype

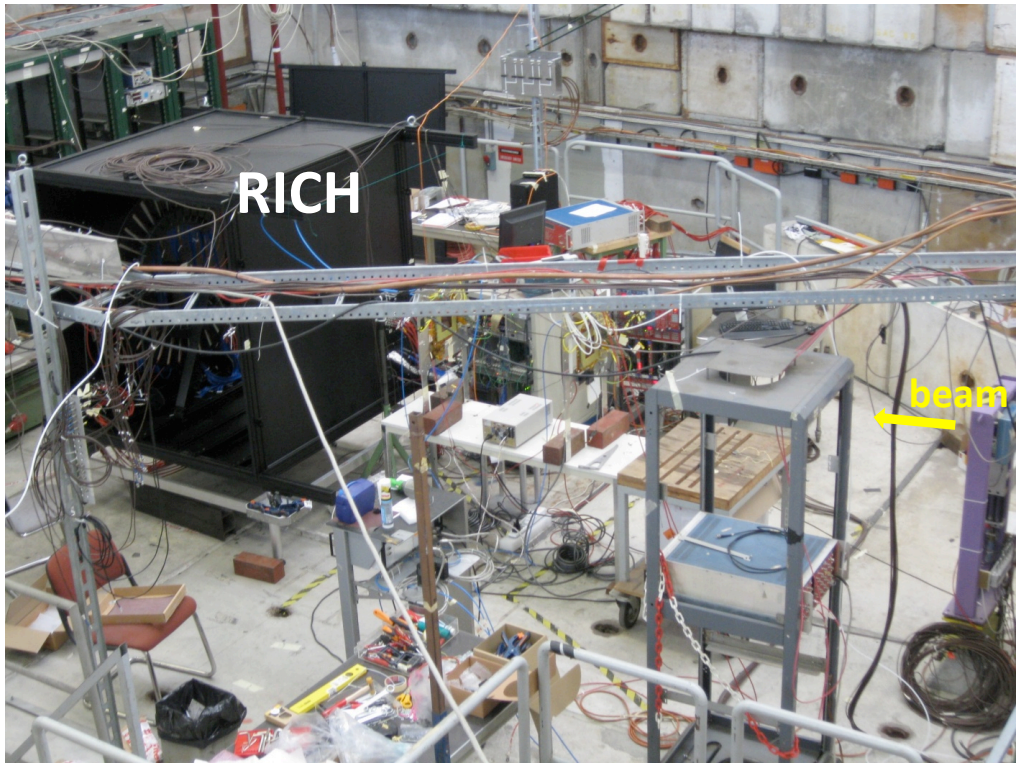
2012:

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

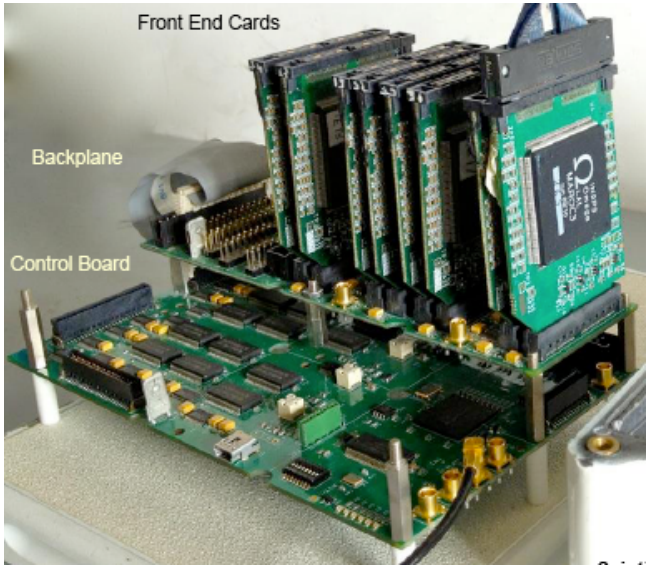
2013:

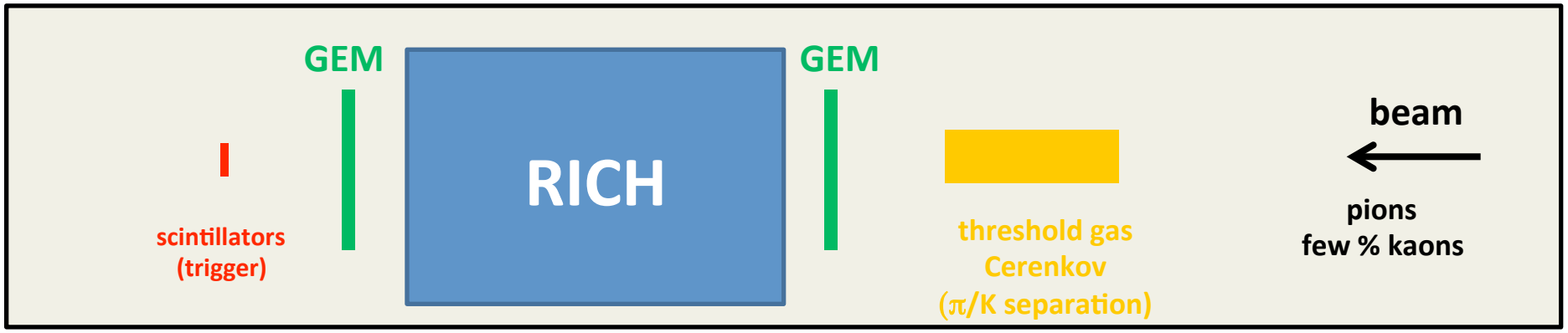
- ✔ February: Start Engineering Phase
- ✔ 26-27 June: Technical Review

RHIC Prototype at CERN-T9

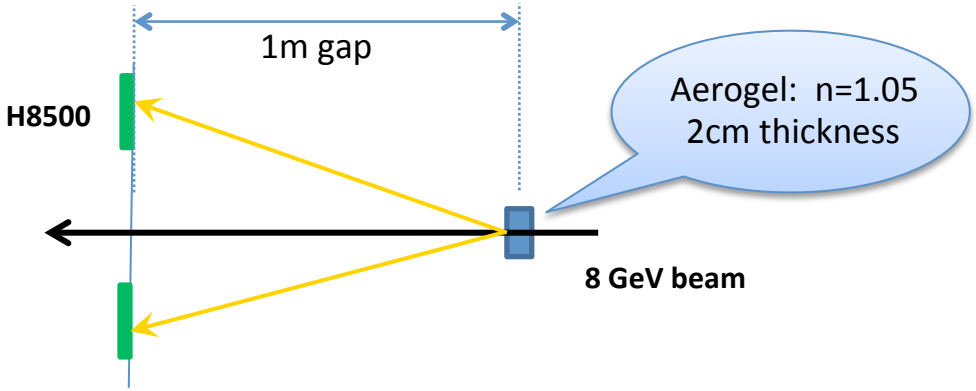


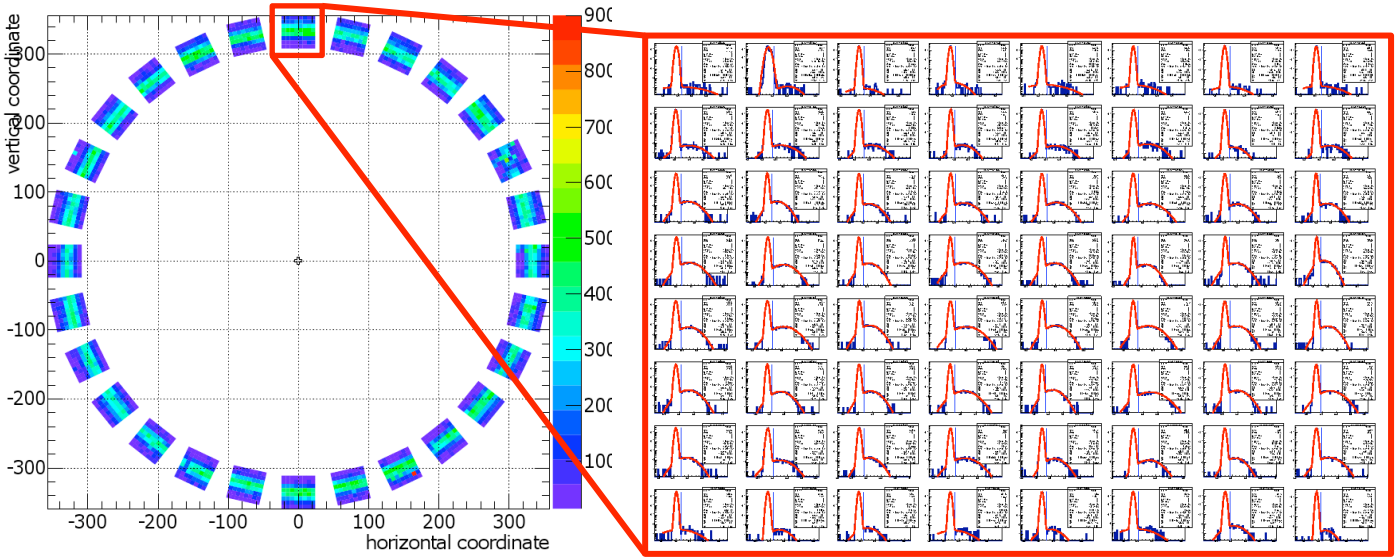
Readout Electronics based on MAROC3 chip and derived from Medical Imaging





RHIC Prototype: Direct Light Case





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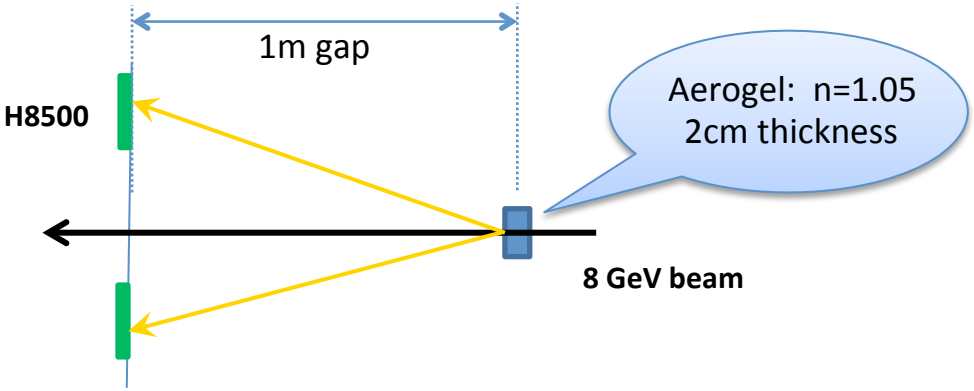
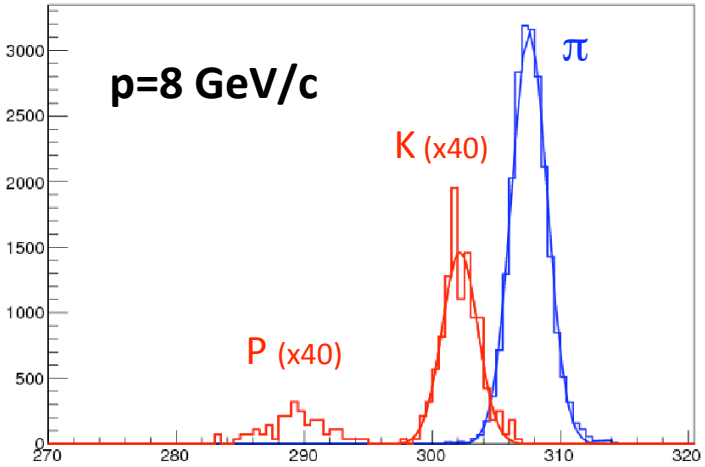
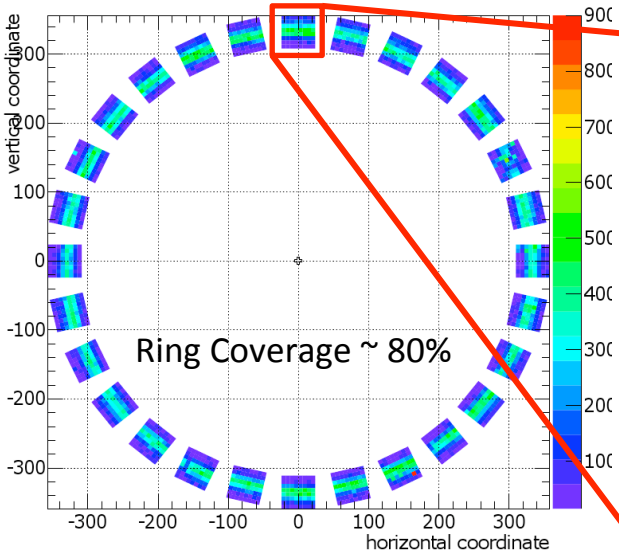
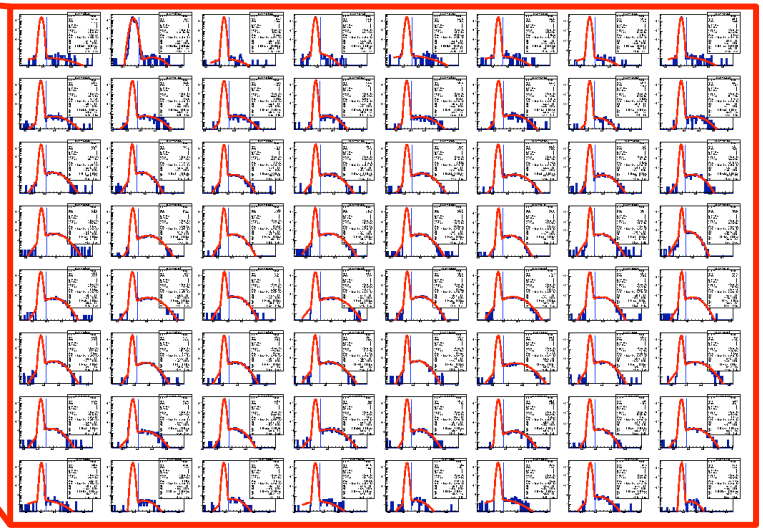


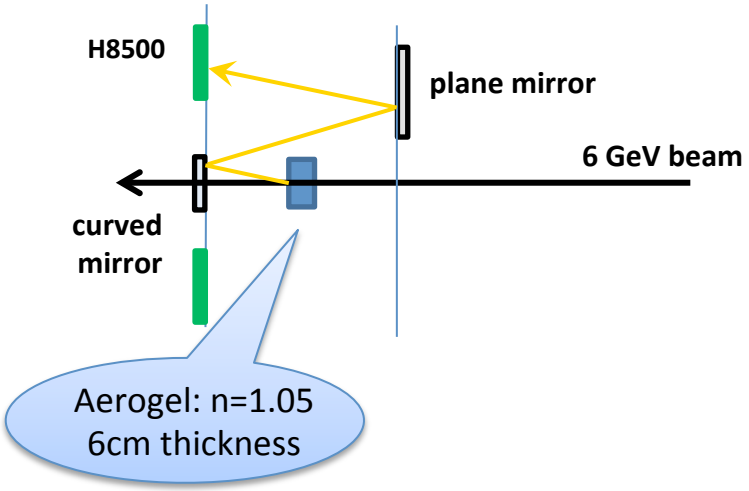
Clear hadron separation up to the CLAS12 maximum momentum

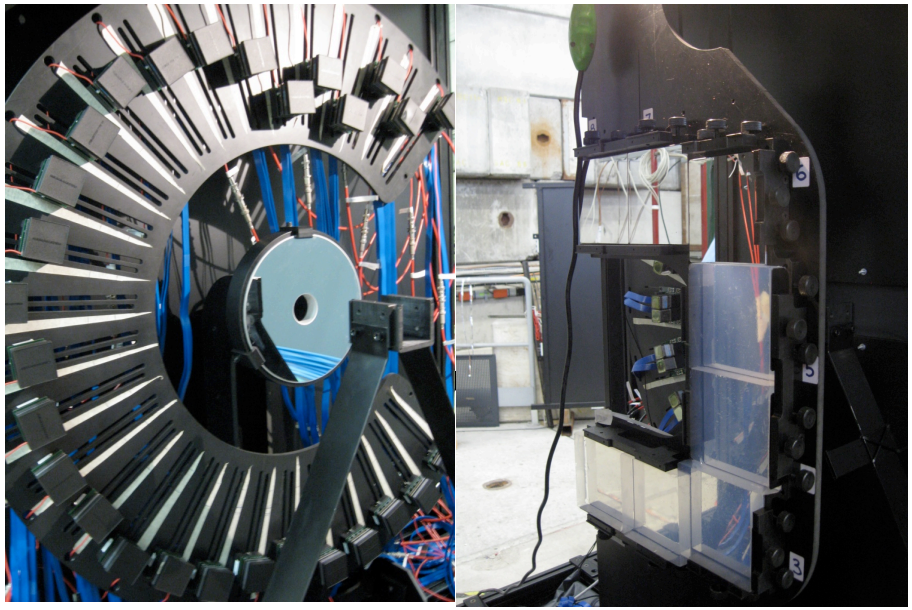






RHIC Prototype: Reflected Light Case





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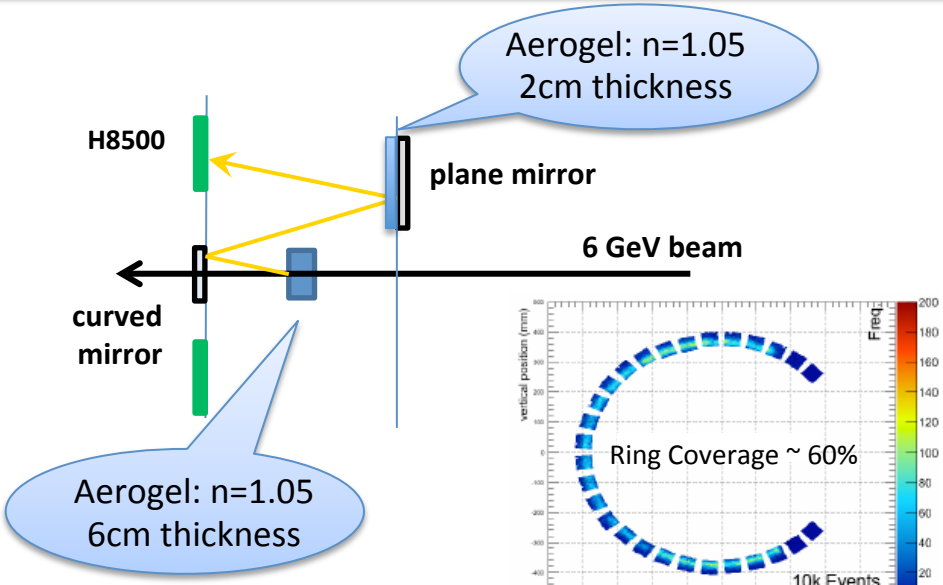
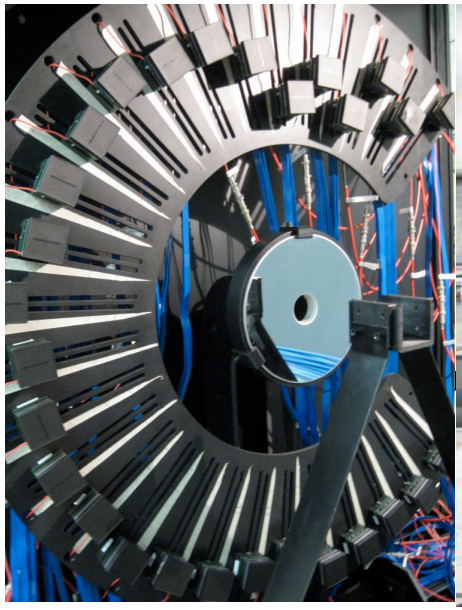
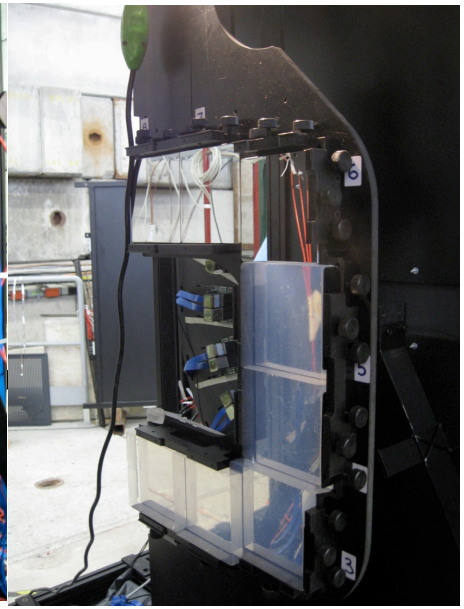
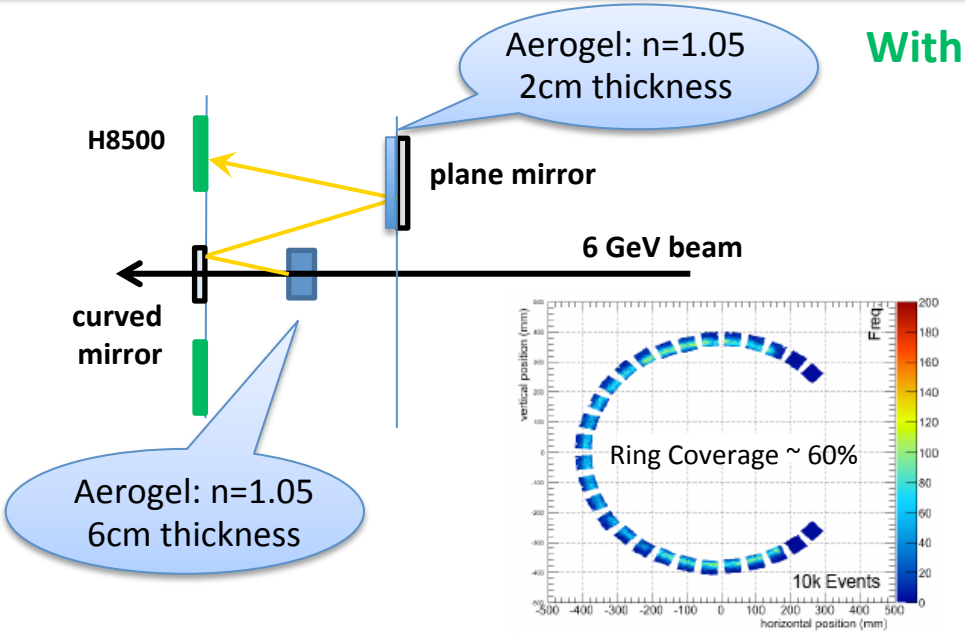


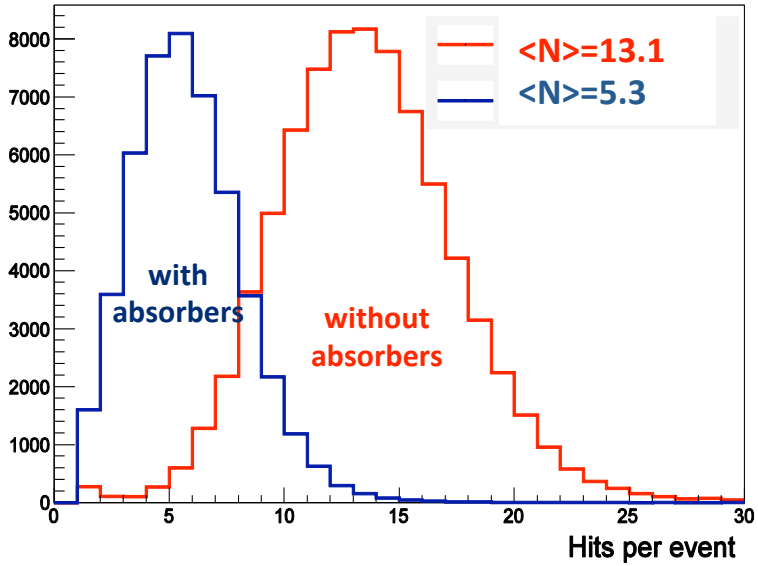


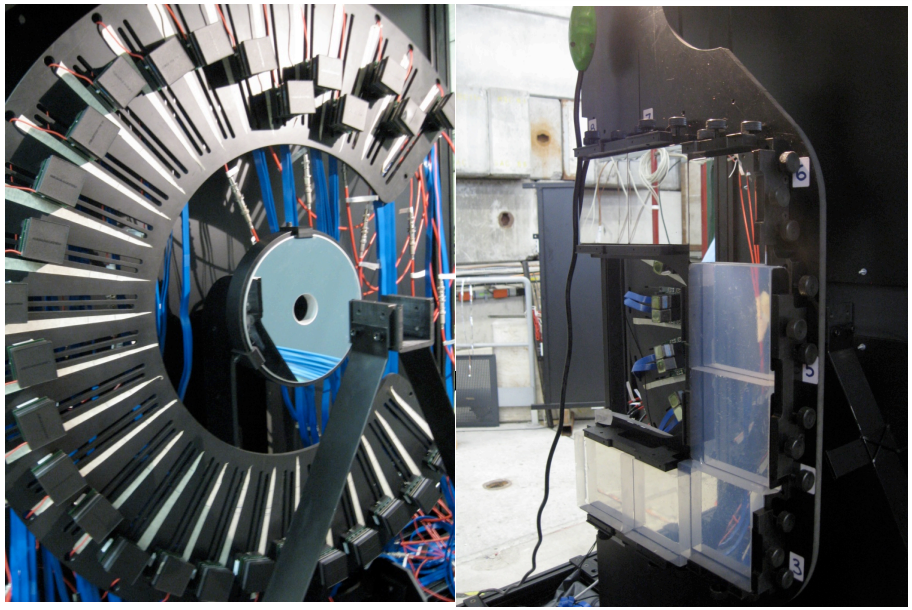


RHIC Prototype: Reflected Light Case

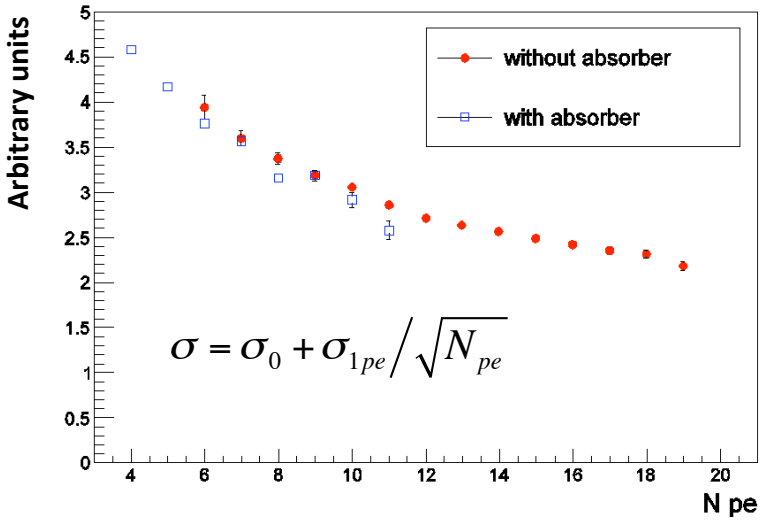


With absorbers: sizeable fraction of light survives





and resolution is not significantly degraded



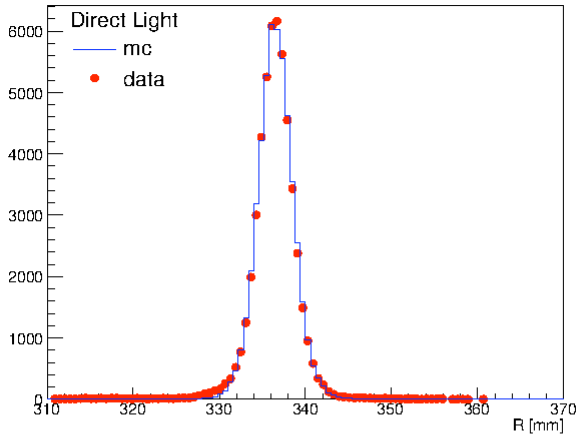
RICH Simulations

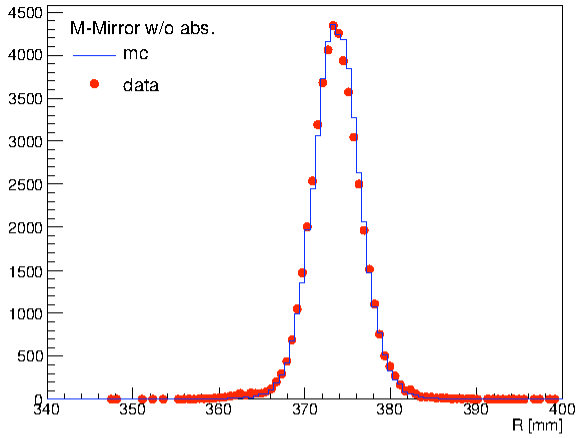
reflected light setup

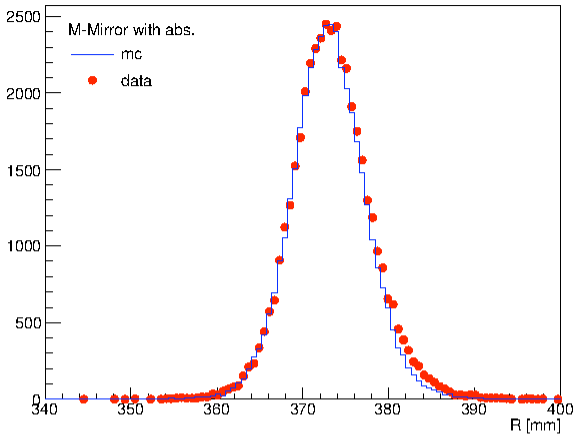
direct light setup

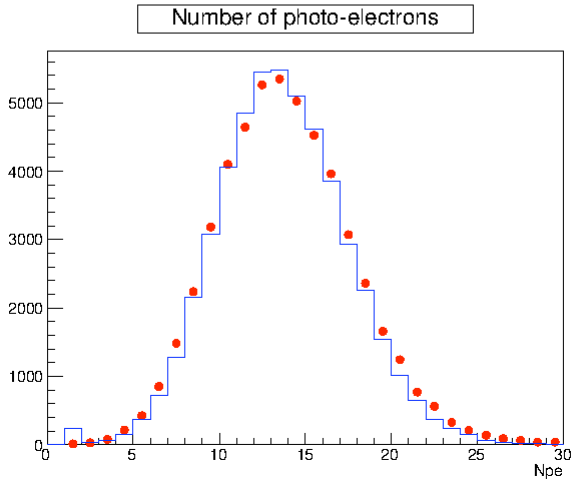
without absorbers

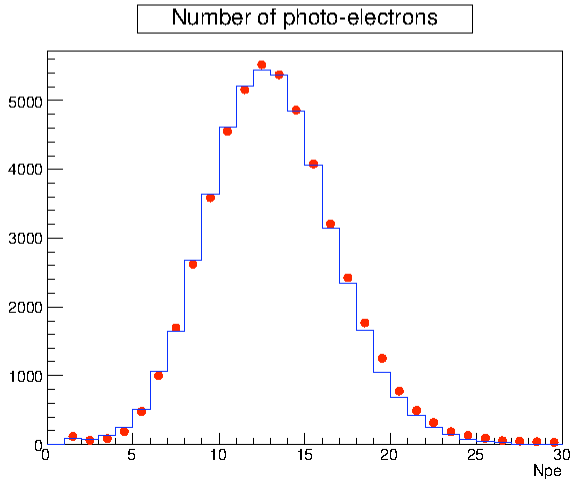
with absorbers

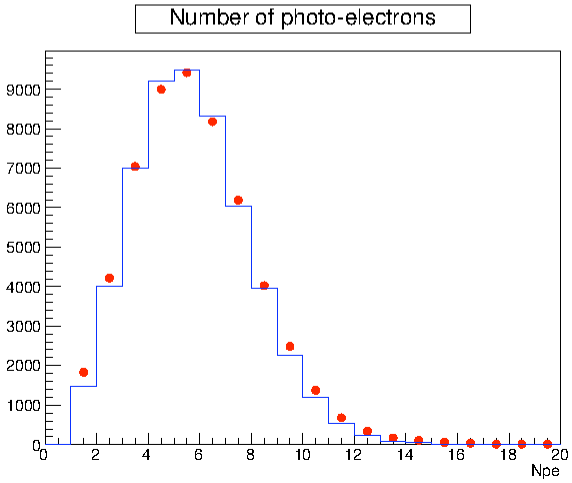








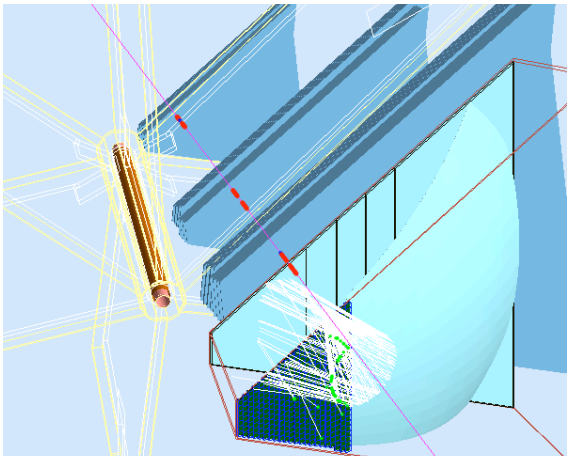




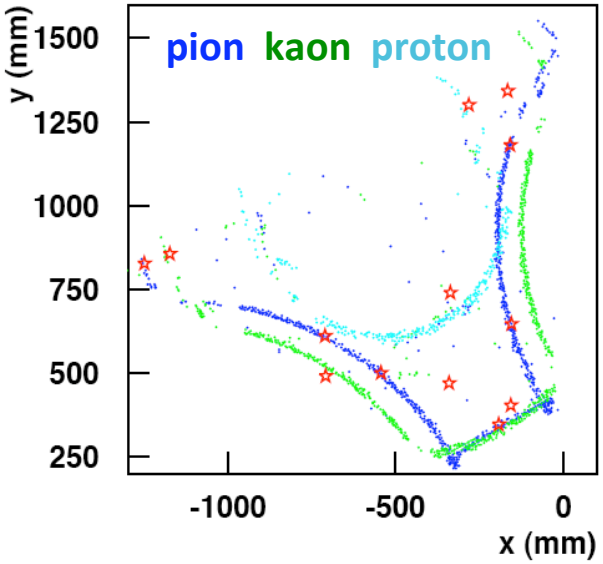
Based on measured optical characteristics and validated with RICH prototype data

The CLAS12 Hadron ID

One charged particle per sector in average:



Non trivial RICH light patter due to reflections:
patter recognition and likelihood ID required



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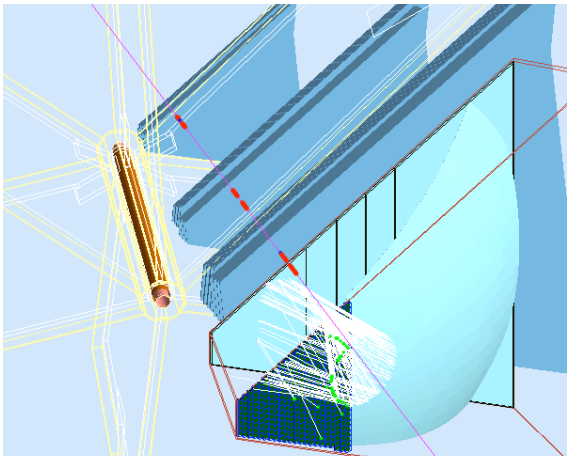

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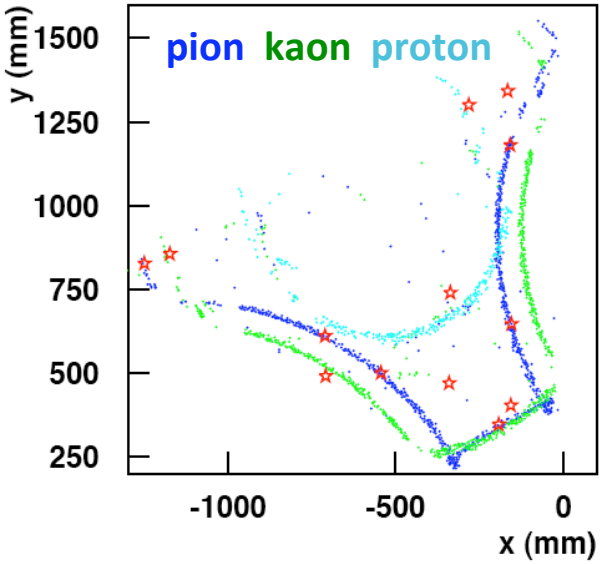

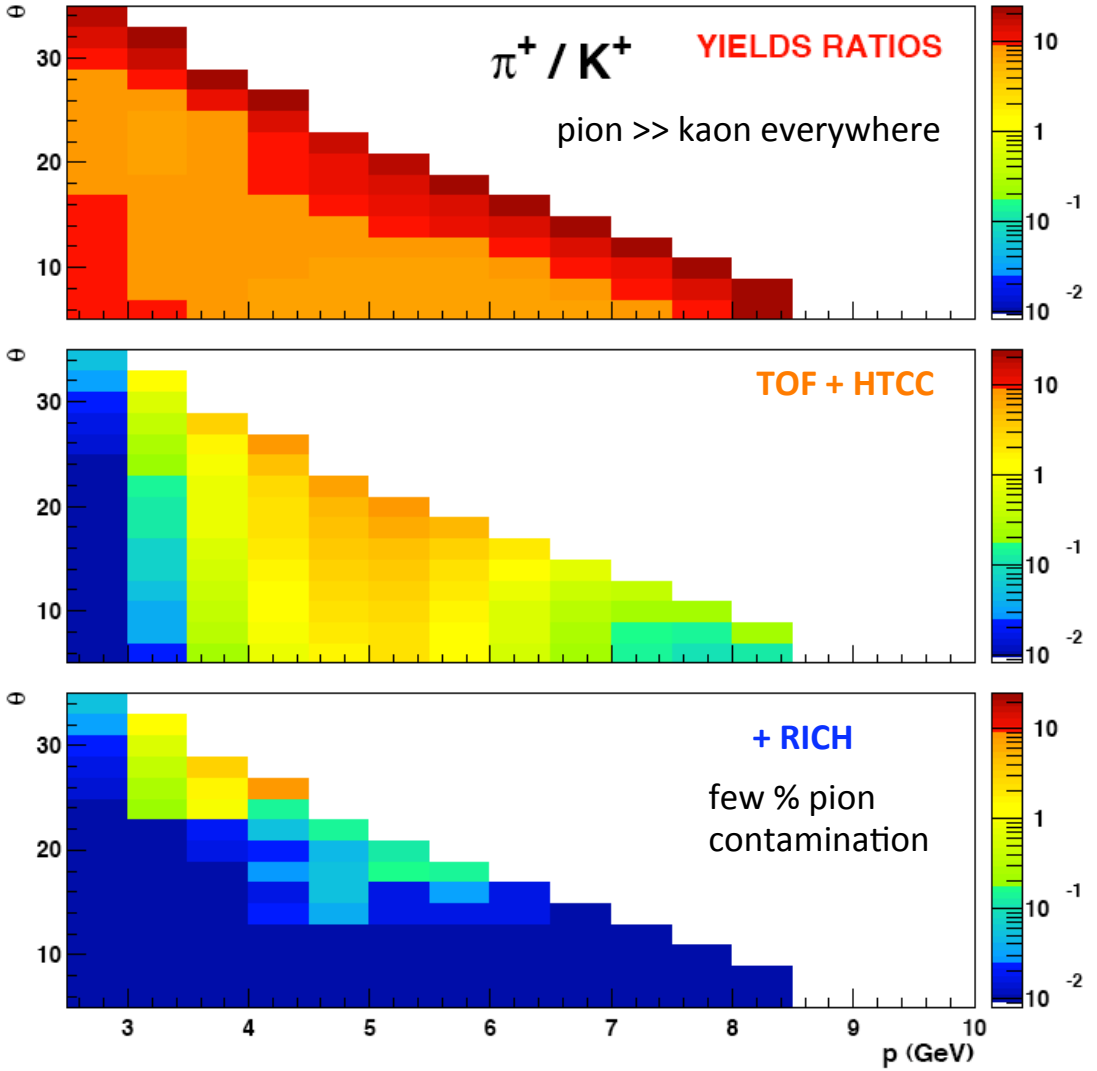

Even with a not yet optimized tuning of pattern recognition and likelihood ID, the π contamination is of the order of 1%

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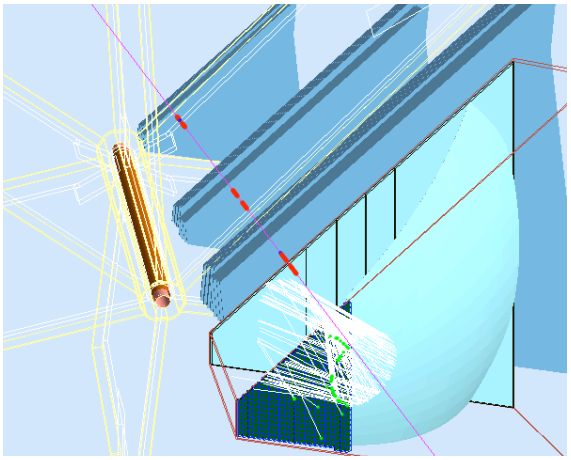

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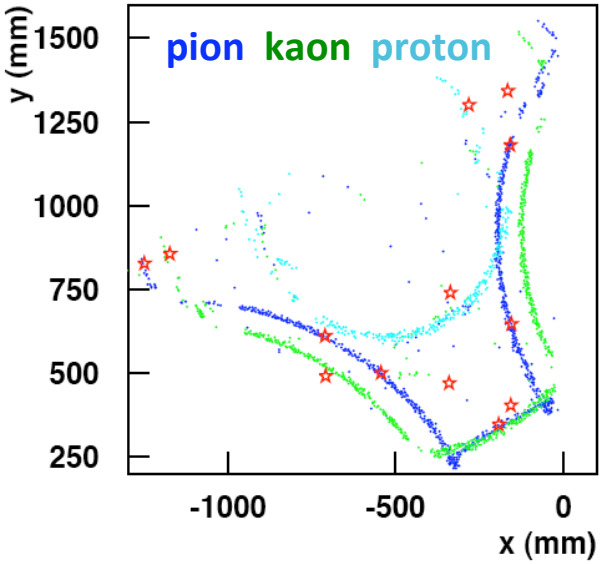
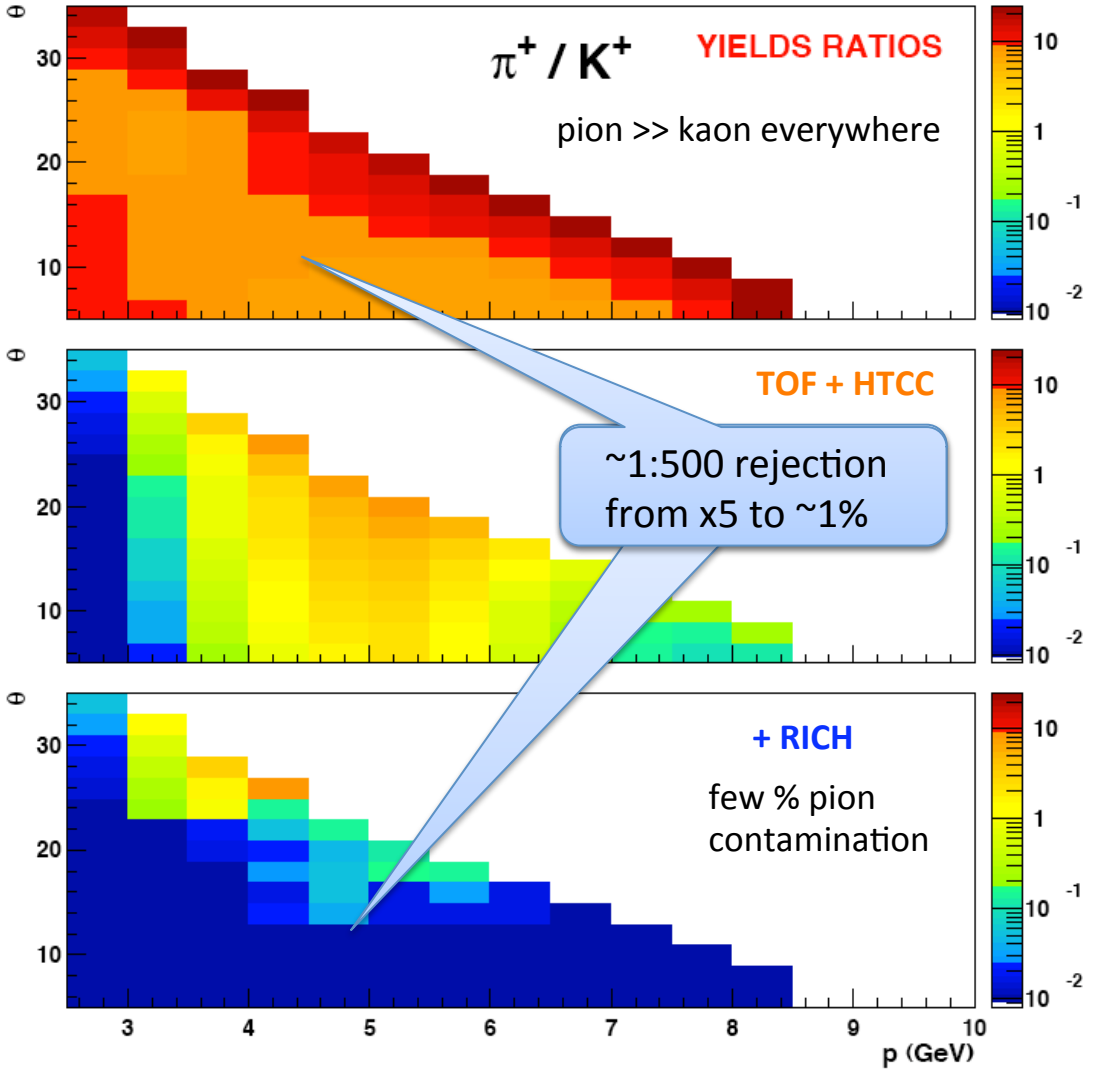




Even with a not yet optimized tuning of pattern recognition and likelihood ID, the π contamination is of the order of 1%

Technical Review Outcome

Very fruitful discussion and positive response:

"A talented and dedicated collaboration is aggressively pursuing the development of a detector that would significantly enhance the capabilities of the CLAS-12 baseline design. Retrofitting a detector into predetermined constraints is always a challenge. Much progress has already been made. Although several challenges remain, the panel offers their strong encouragement to continue. The potential gain is high."

14 valuable recommendations:

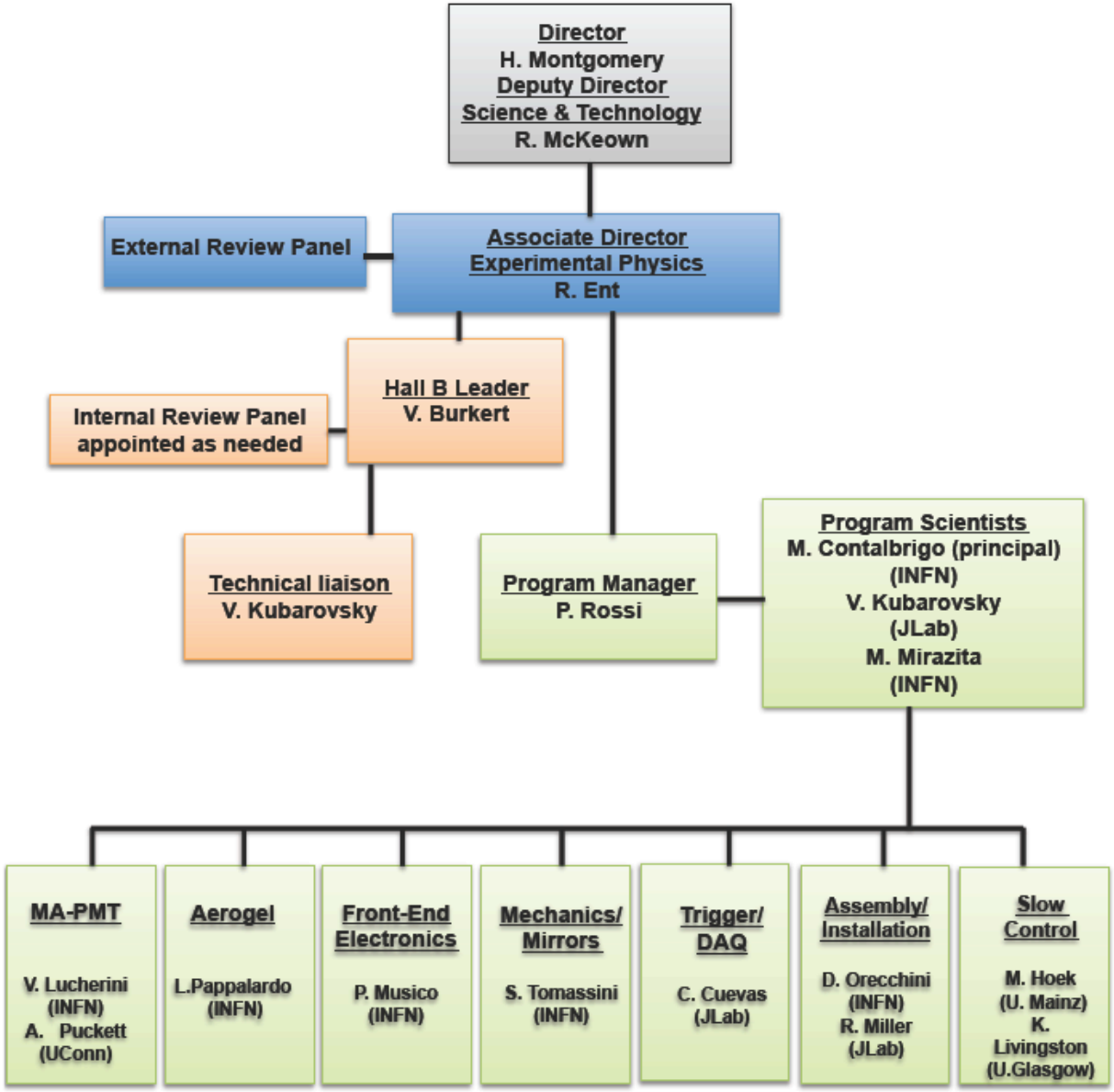
We implement actions for all.
Many are addressed already in the TDR under finalization.

RICH Project Achievements

Summer 2013:

- ✔ August: CLAS12 RICH Project (TDR)
- ✔ August: Project Management Plan
- ✔ 5-6 September: Project Review with DOE

RICH US Scope Management



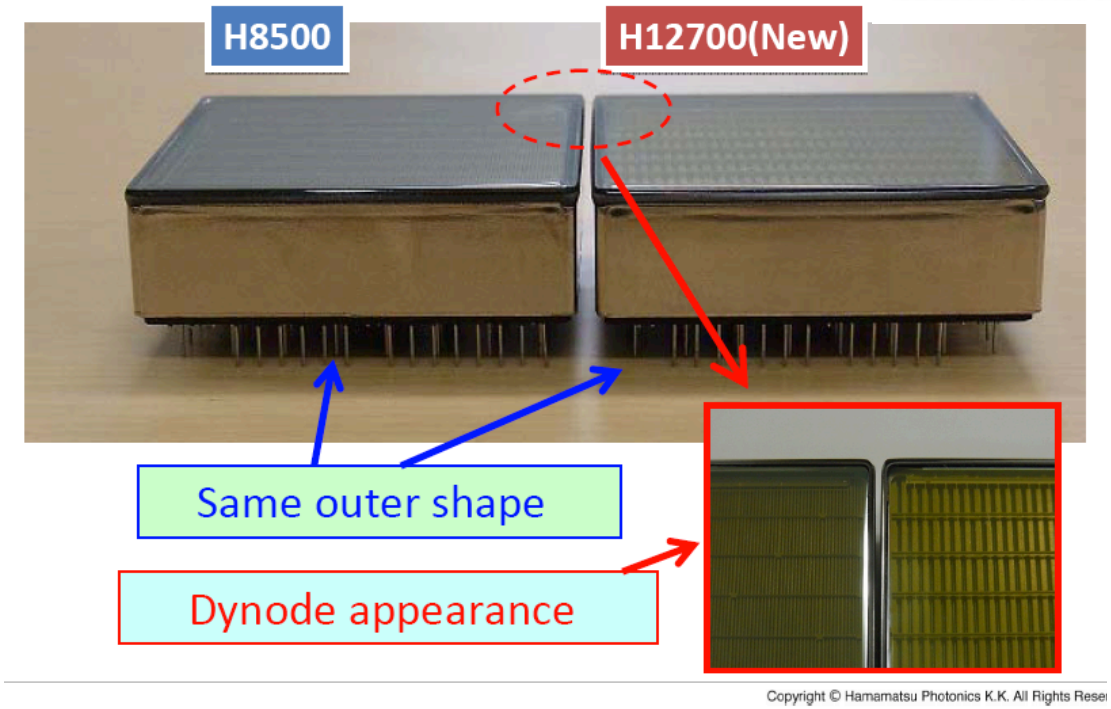
Photon Detectors: MA-PMT

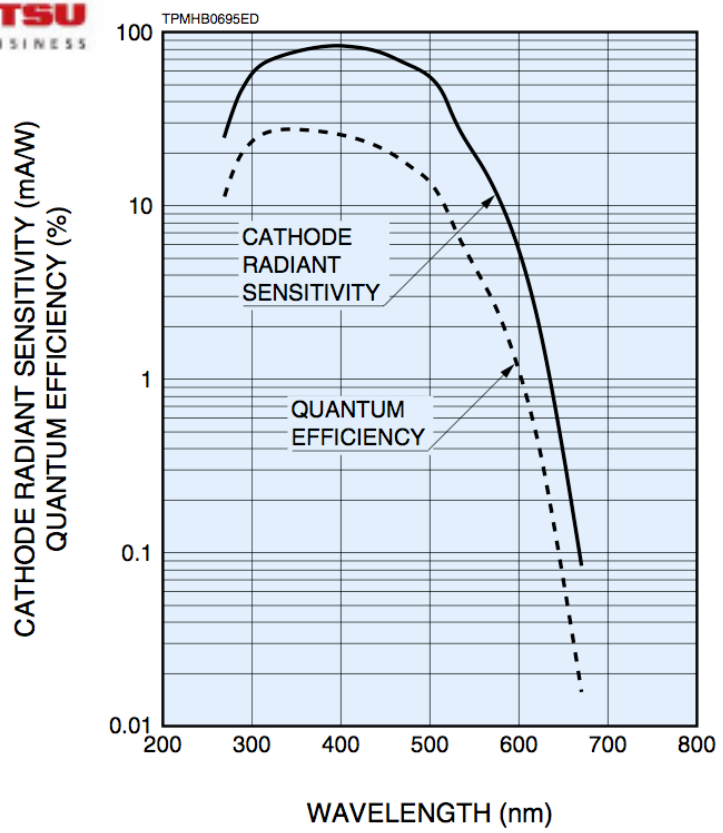
The only option to keep the schedule is the use of multi-anode photomultipliers: start with H8500, keep option for H12700

⇨ Contract Awarded by JLab on 30 September 2013

- ✓ Mature and reliable technology
- ✓ Large Area (5x5 cm^2)
- ✓ High packing density (89 %)
- ✓ 64 6x6 mm^2 pixels cost effective device
- ✓ High sensitivity on visible towards UV light
- ✓ Fast response

HAMAMATSU
PHOTON IS OUR BUSINESS





RICH Project Achievements

Summer 2013:

- ✔ August: CLAS12 RICH Project (TDR)
- ✔ August: Project Management Plan
- ✔ 5-6 September: Project Review with DOE
- ✔ 30 September: 1st contract awarded (MA-PMTs)

Construction phase has been started

GOAL: 1st sector ready by the end of FY16

Aerogel Radiator

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

The CLAS12 large area RICH detector

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Keywords:
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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^{35} cm^{-2} 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.

of the nucleon and quark hadronization processes [2].

Important observables that will be extensively investigated are Transverse Momentum Distribution functions (TMDs) describing ...rtonic spin–orbit effects and Generalized Parton Distribution ...ctions (GPDs), containing information about the spatial dis... ...ution of quarks and the relation (by a sum rule) to the elusive ...nic orbital momenta. Several experiments have been already ...ved by the JLab12 PAC to study kaon versus pion production ... exclusive and semi-inclusive scattering, providing access to ... or decomposition of the two sets of non-perturbative ...on functions.

...ain features of CLAS12 include a high operational ... of 10^{35} cm^{-2} s^{-1}, an order of magnitude higher than ...etup, and operation of highly polarized beam and ...s. The conceptual design of the CLAS12 detector is ...1. The central detector with the high-field (5 T) ...t is used for particle tracking at large angles. The ...eter detects charged and neutral particles in the ...between 5 and 40°. It employs a 2 T torus magnet ...ector symmetry of CLAS. In the base equipment.

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 baseli... design of CLAS12.

2. The CLAS12 RICH

To fit into the CLAS12 geometry, the RICH should ... projective geometry with six sectors that cover the spac... the torus cryostats and covering scattering angles from ... Fig. 3. Being downstream to the torus magnet at mo... from the interaction point, the RICH has to cover a ... each sector spanning an area of the order of 4 m^2. Be... between detectors which are already in the constr... gap depth cannot exceed 1 m. The proposed solut... focusing RICH.

A setup similar to the one adopted in Hall-... (C_5F_{12} or C_6F_{14}) radiator and a CsI-deposited ... tional chamber as a UV-photon detector, ... required pion rejection factor at momenta ...

The preliminary results on ongoing Mo... on a GEANT3 toolkit with simplified geor...

lu... the nucl... shown solenoi... forward ... polar angl... and retains ...

* Corresponding... E-mail address: ...go@fe.infn.it (M. Contalbrigo).

0168-9002/$ - see fro...
doi:10.1016/j.nima.201...

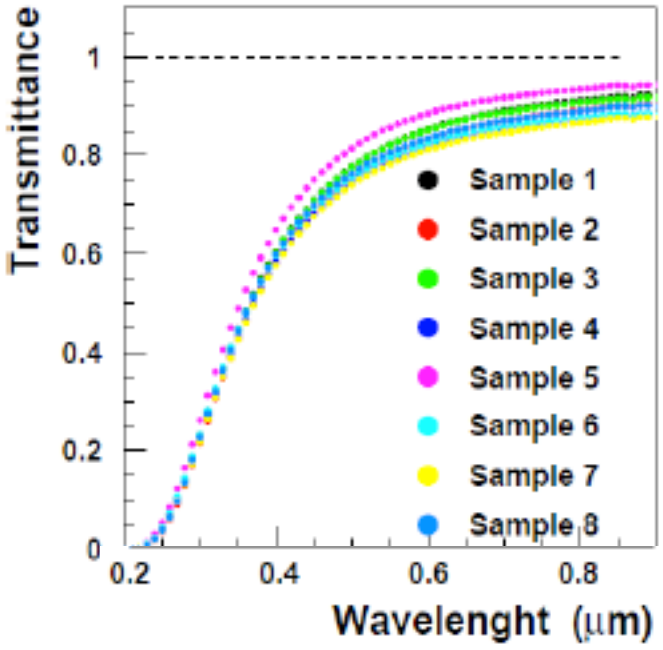
...ee ... m ...face, ...ained ...ase, the ...roximity ...ith a freon ...vire propor... ...achieve the ...than 3 GeV/c. ...o studies, based ...nd optical surface

Aerogel Transmittance

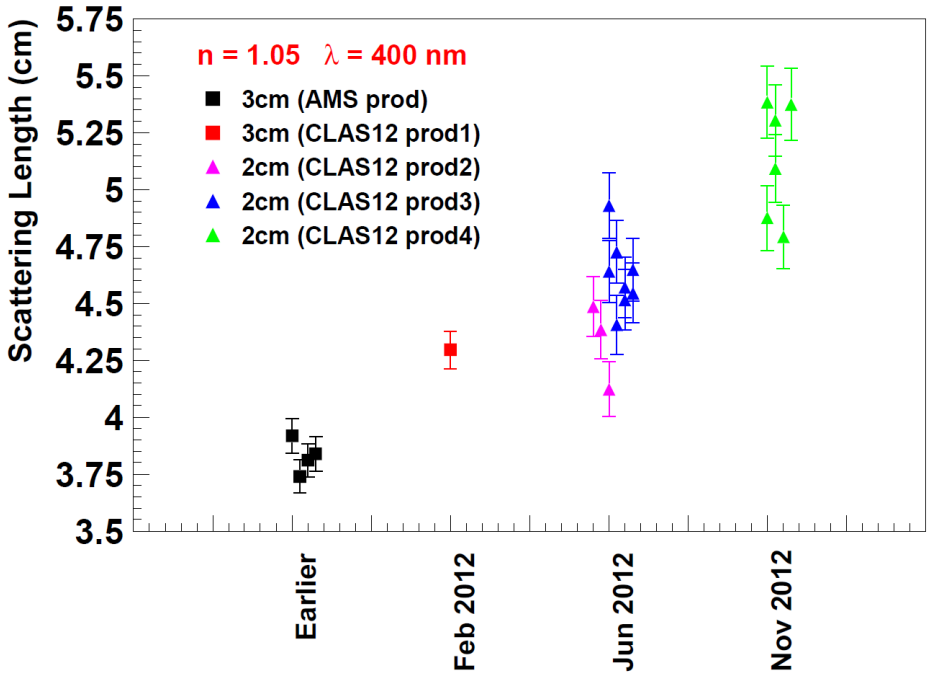
Achieved clarity for large tiles at n=1.05

~ 0.00050 $\mu m^4\ cm^{-1}$

(LHCB has 0.0064 $\mu m^4\ cm^{-1}$ for n=1.03)



In collaboration with Budker and Boreskov Institutes of Novosibirsk



Aerogel Production

Aerogel Manufacture Engineering:

- maximize production rate for large scattering lengths (>50 mm)
- minimize edge effects (large area tiles)
- improve bottom surface accuracy

⇨ Under negotiation (INFN)

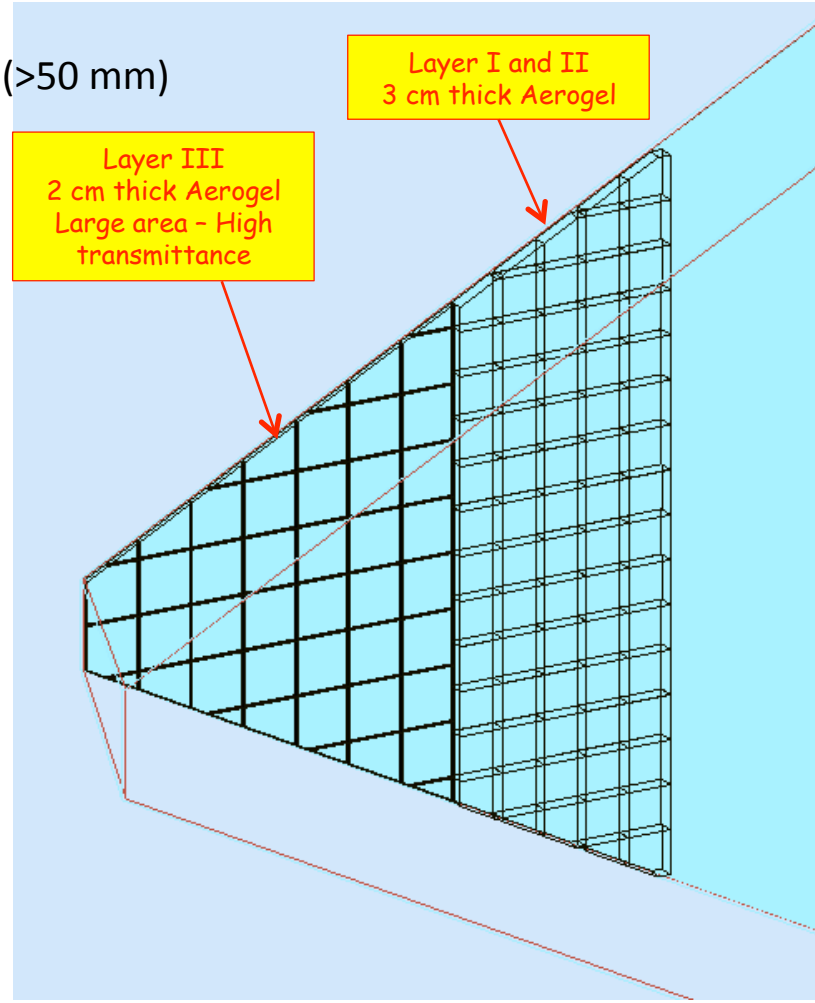
Aerogel Production Phases:

I) First layer of the tick radiator ~ 2 m^2 by March 2015
   - minimum requirement on optical quality

⇨ 1st m^2 under negotiation (INFN)

II) Second layer of the tick radiator
   - medium requirement on optical quality

III) Thin radiator layer
   - maximum requirement on optical quality



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Mirror Technology

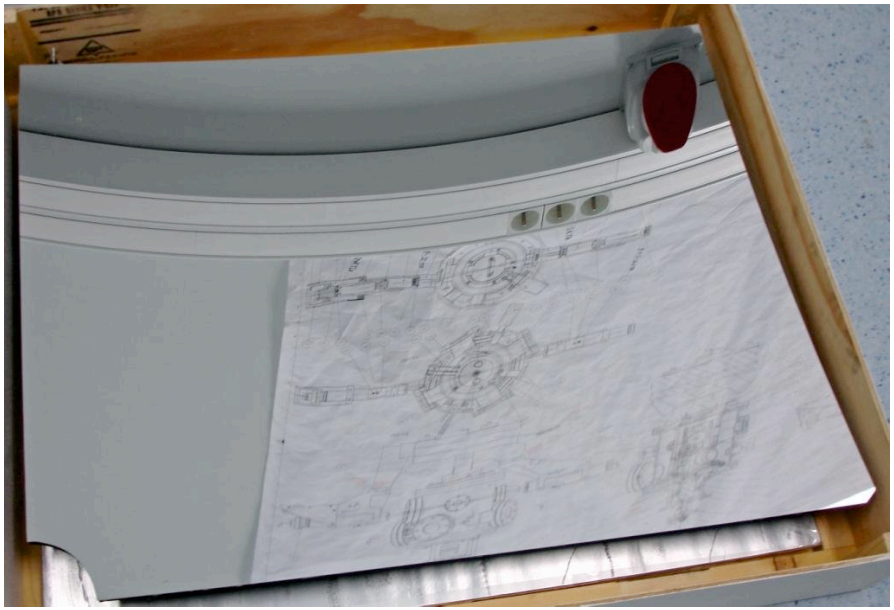
Metalized Carbon Fiber substrate
for spherical mirror

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

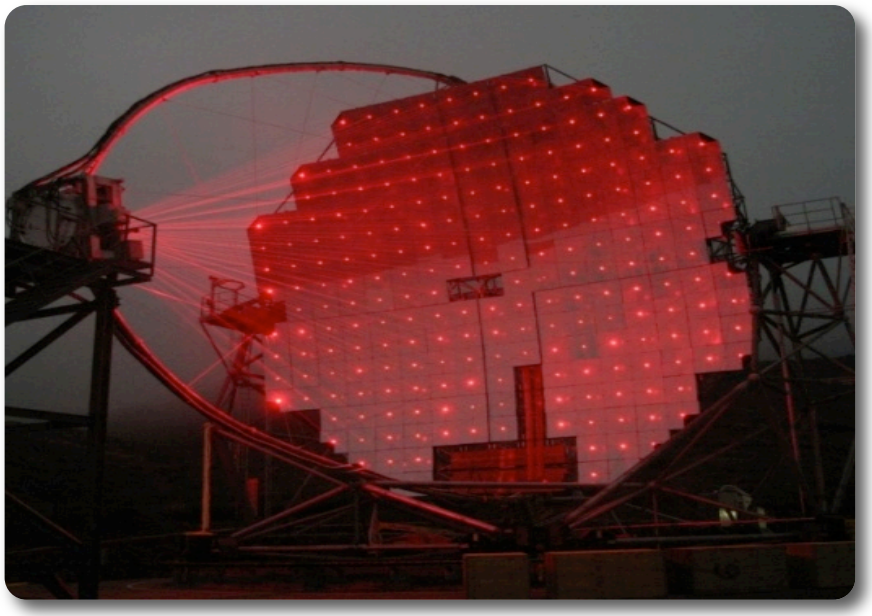
Thin glass skin on a flat support
for planar mirrors

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

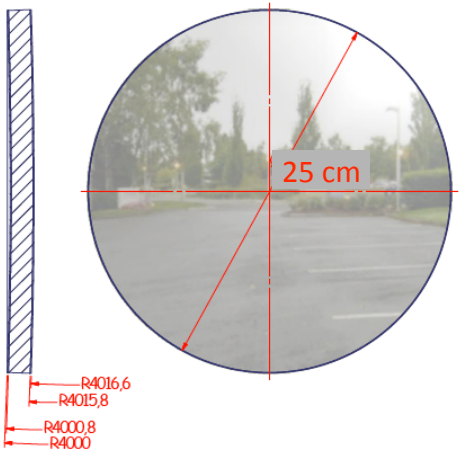
CFRP Mirror

Mirror Manufacture Engineering:

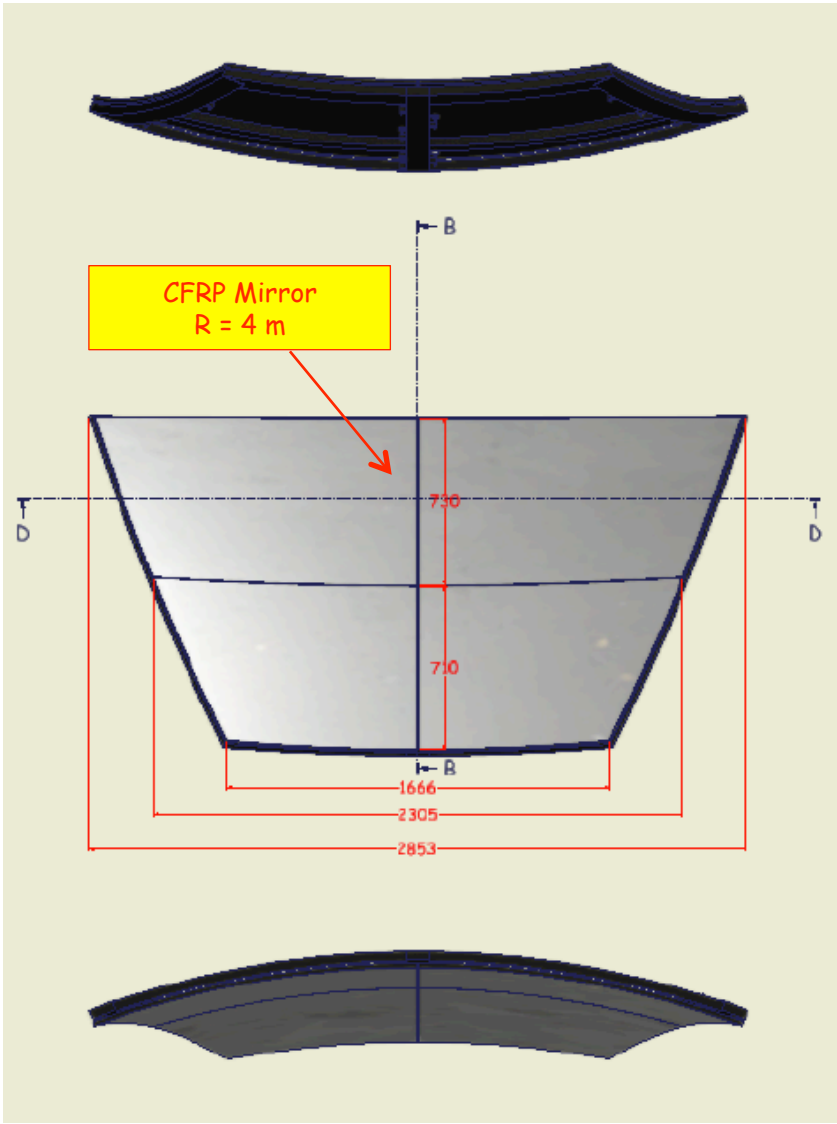
- pyrex mold (Marcon, CMA)
- small size CFRP prototype (CMA, Riba, Alenia)
- reflective coating (CMA)

- surface accuracy & reflectivity (CERN Lab)
- point-like source image < pixel size
- rigidity/stiffness

⇨ Under negotiation (INFN)



dR/R ~ 1 %
Surface accuracy ~ few μm
Surface roughness ~ few nm



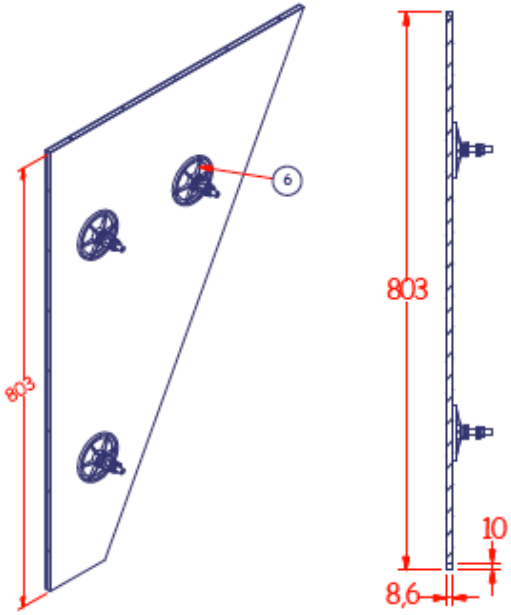
Glass Skin Mirror

Mirror Manufacture Engineering:

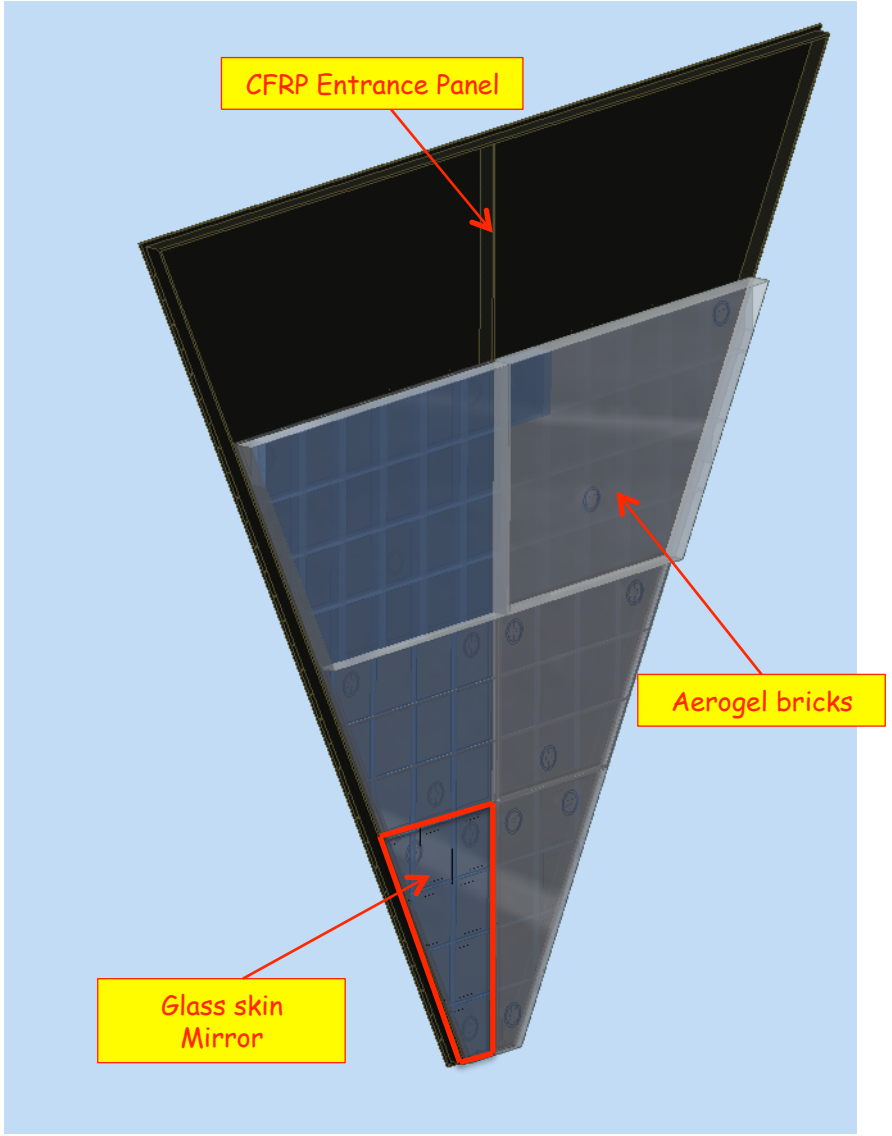
- small size prototype (Media-Lario)
- reflective coating

- surface accuracy & reflectivity
- aerogel holding test
- rigidity/stiffness

➡ Under negotiation (INFN)



Al honeycomb core
<1 mm glass skin



RICH Project Latest's

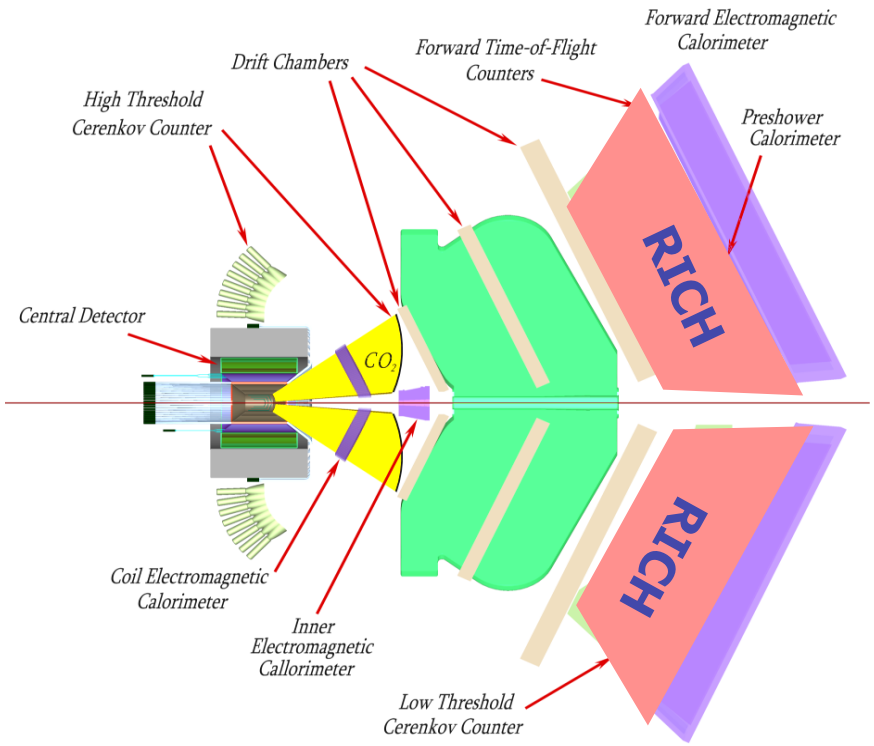
RICH Project Latest's

- ✔ September: MA-PMTs Neutron Irradiation Tests
- ✔ 14-18 October: DREAM chip readout test
- ✔ 11-13 November: PSHP Workshop
- ✔ November: H12700 characterization
- ✔ 18-22 November: MAROC + NINO chip readout test
- ✔ November: start aerogel + Mirror Manufacture Engineering Phase

The CLAS12 RICH Project

From DOE review report:

"All presentations were of excellent quality and reflected an impressive body of work. It is clear that the collaboration is talented, enthusiastic, and hard working. "



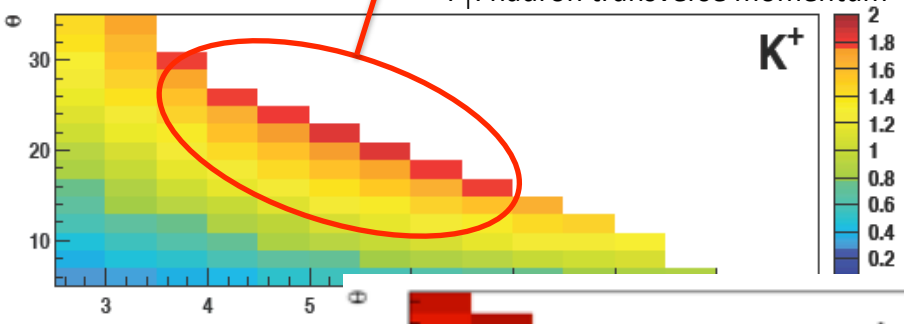
INSTITUTIONS
INFN (Italy) Bari, Ferrara, Genova, L.Frascati, Roma/ISS
Jefferson Lab (Newport News, USA)
Argonne National Lab (Argonne, USA)
Duquesne University (Pittsburgh, USA)
Glasgow University (Glasgow, UK)
J. Gutenberg Universitat Mainz (Mainz, Germany)
Kyungpook National University, (Daegu, Korea)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

THANKs EVERYBODY FOR THE HARD WORK AND SUCCESSFULLY REVIEWS !!!

SIDIS Kinematics @ CLAS12

Intermediate angular range (15-25°) important to reach high P_T values

P_T: hadron transverse momentum



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

z: hadron fractional energy