The CLAS12 RICH project

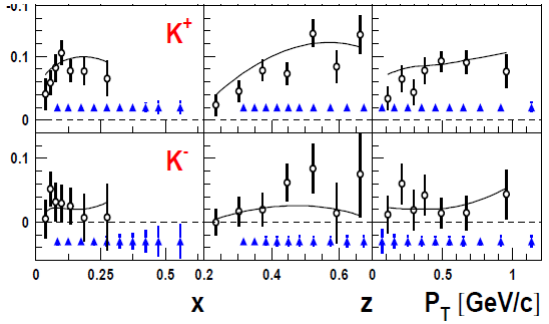
Marco Mirazita

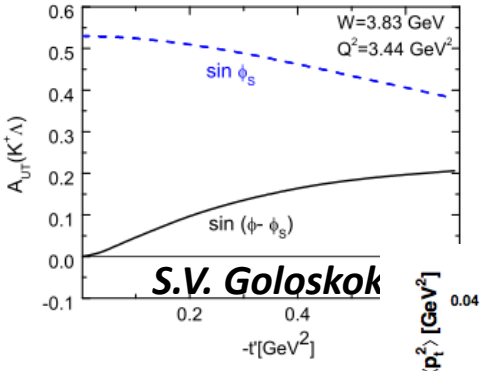
INFN – Laboratori Nazionali di Frascati

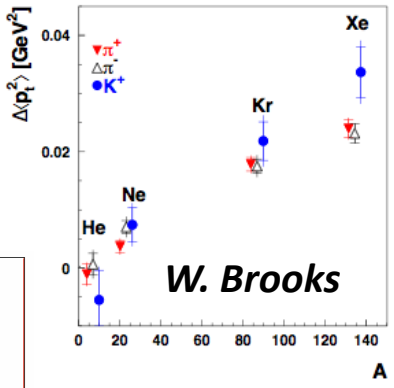
Kaon physics with CLAS12

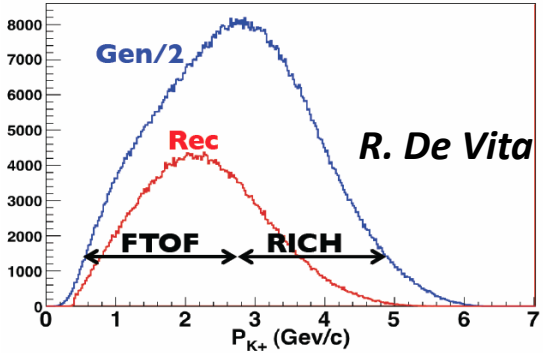
A broad program of measurements with kaons in the final state has already been approved

- **3D imaging of the nucleon through extraction of pion and kaon TMDs**
- **study the flavor dependence of the intrinsic transverse momentum**
- **study chiral-odd GPDs in hard exclusive pion and kaon production**
- **study the quark hadronization in cold nuclear matter**
- **study exotic mesons via kaon identification**

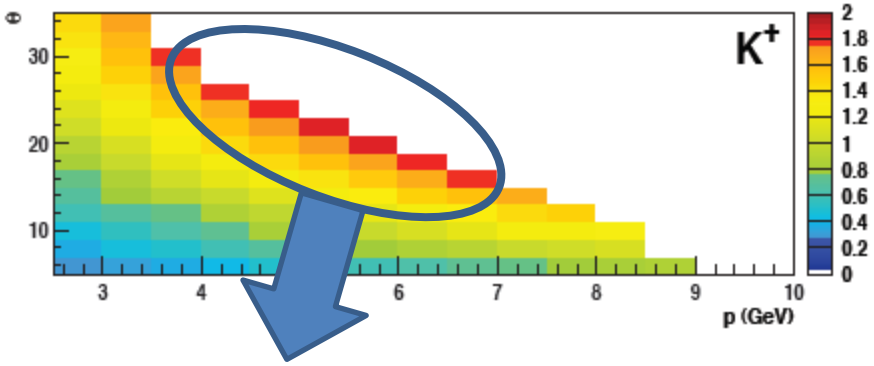






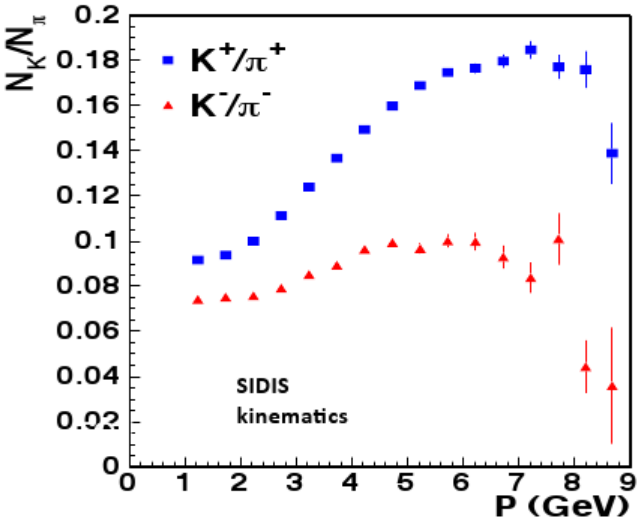


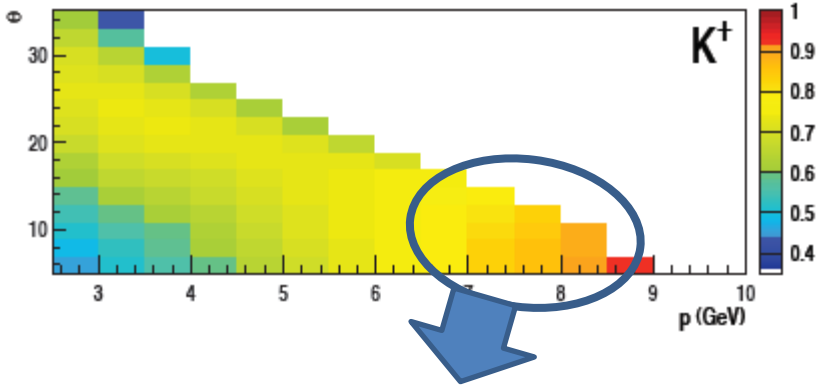
SIDIS kaons



color scale:
P_T values

Intermediate angular region important to reach high P_T





color scale:
z values

High momentum region important to study the transition to the hard semi-exclusive regime

Kaon ID requirements:

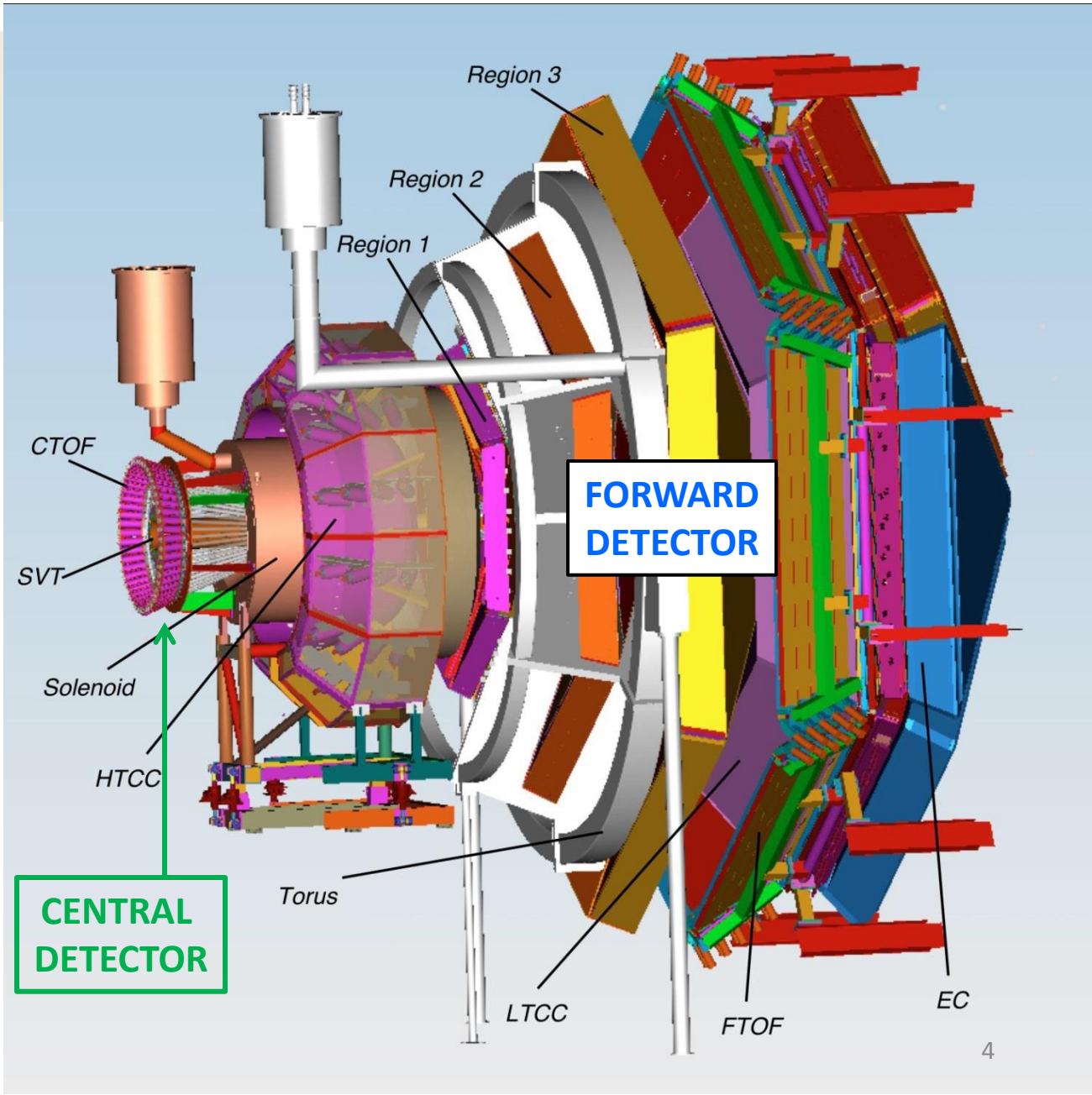
4σ π/K and p/K separation (rejection factor 1:500) in the 3-8 GeV/c momentum range and angular coverage 5-25deg

The CLAS12 spectrometer

- Luminosity up to 10^{35} cm^{-2} s^{-1}
- High polarization electron beam
- H and D polarized targets
- Wide acceptance

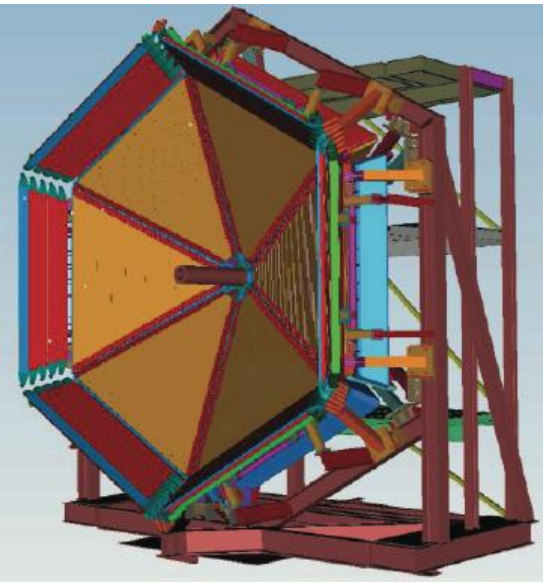
CENTRAL DETECTOR
- solenoidal field
- vertex tracker
- time-of-flight

FORWARD DETECTOR
- toroidal field
- 6 sector geometry
- vertex tracker
- three regions of drift chambers
- time-of-flight
- two threshold Cherenkov counters
- preshower
- EM calorimeter



PID in CLAS12

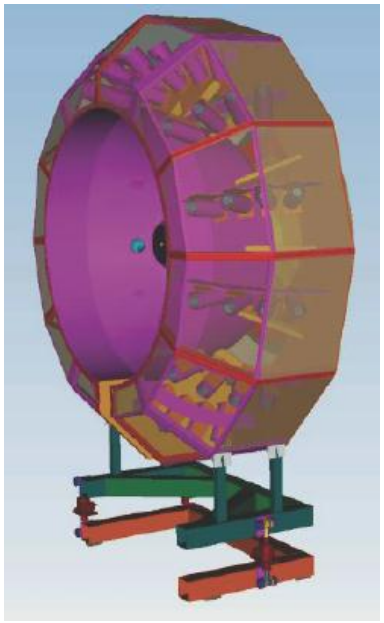
FTOF



- two panels of barrel scintillators
- combined resolution: 45-80 ps

➢ 4σ π/K and p/K separation below 3 GeV/c

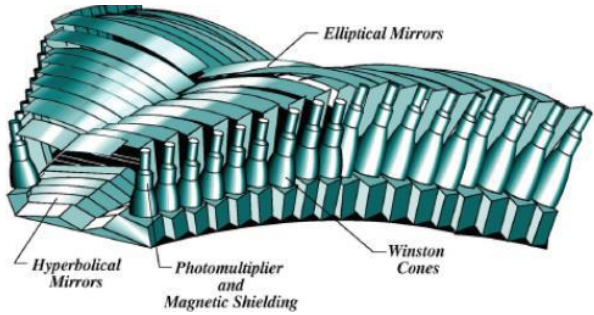
HTCC



- designed for electron ID
- CO_2 radiator
- N_{pe}~16 for electrons

➢ 4σ π/K separation above 7 GeV/c
➢ No p/K separation

LTCC

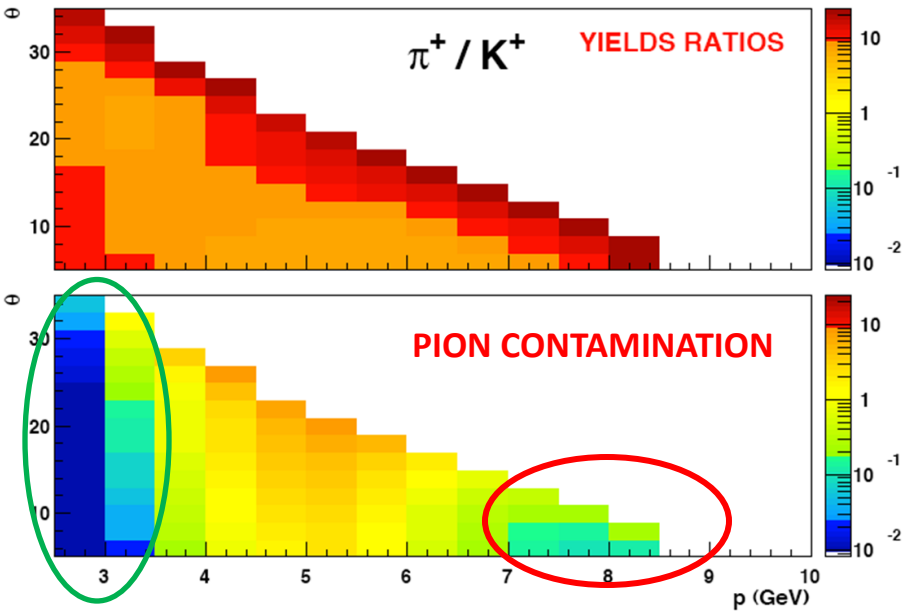


- designed for pion ID
- C_4F_{10} radiator
- complicated geometry, non uniform response

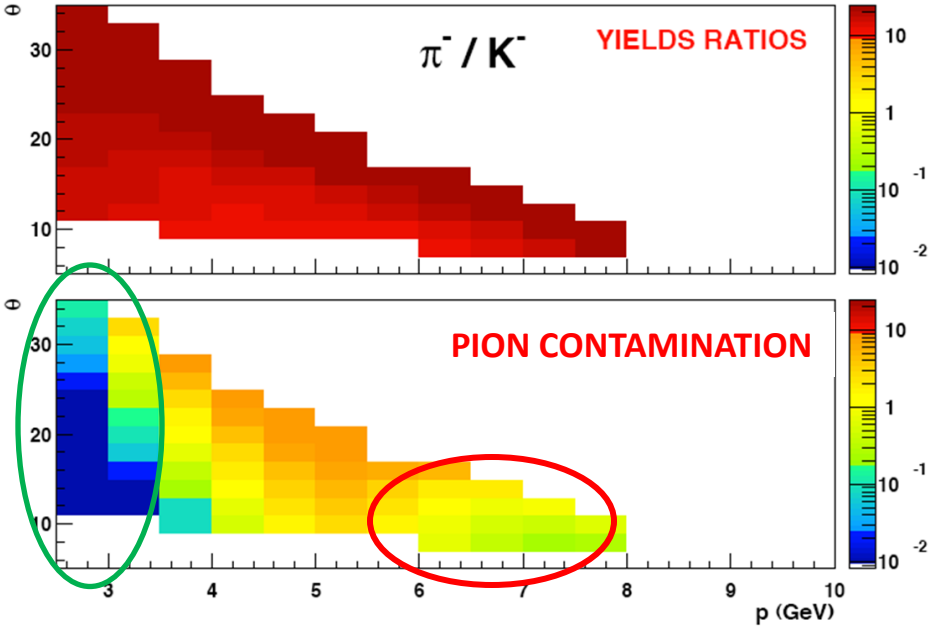
➢ 4σ π/K separation above 8 GeV/c
➢ No p/K separation

Hadron ID in CLAS12

Out-bending particles



In-bending particles



HTCC **FTOF**

SIDIS particle flux within the CLAS12 acceptance

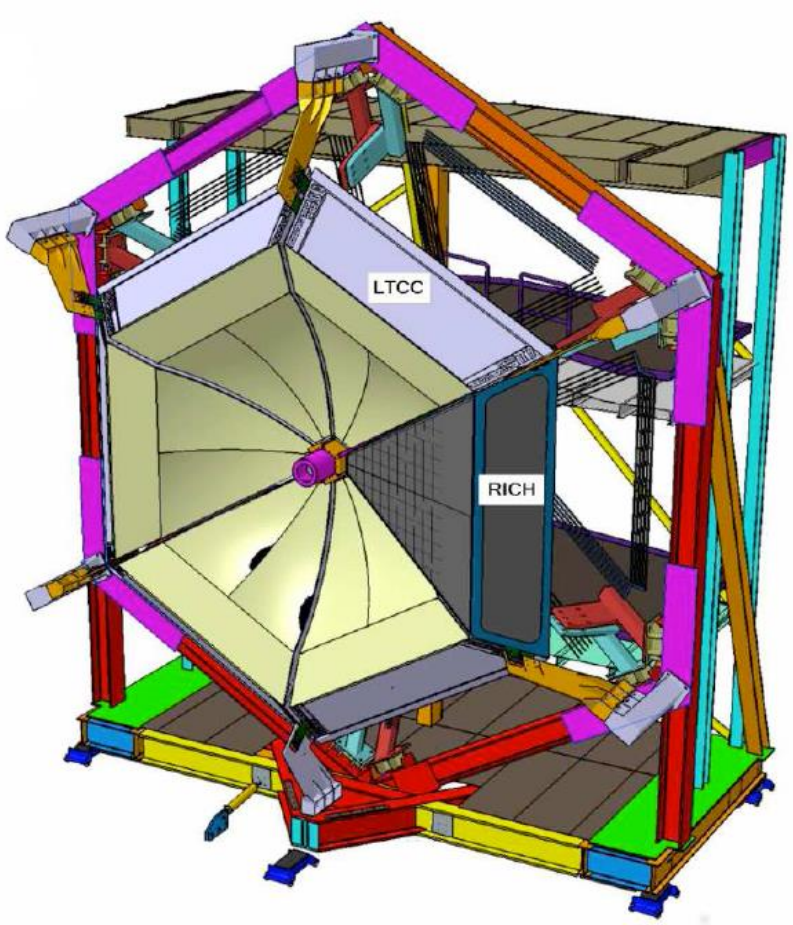
- pions >> kaons in the whole kinematical range

No Kaon ID in the 3 to 7 GeV/c range with baseline CLAS12 equipment

A RICH detector is mandatory for 4σ kaon ID

The CLAS12 RICH

Replace the LTCC with a RICH



Momentum range 3-8 GeV/c

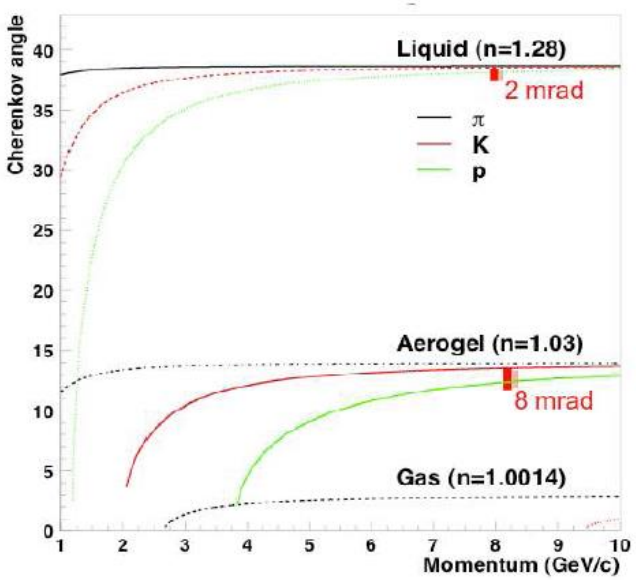
Aerogel radiator

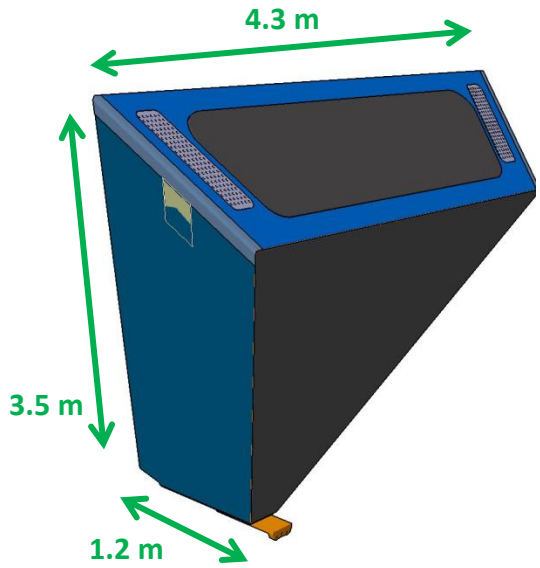
Visible (UV) light

Photomultiplier

Reduce the active area

Focalizing mirrors

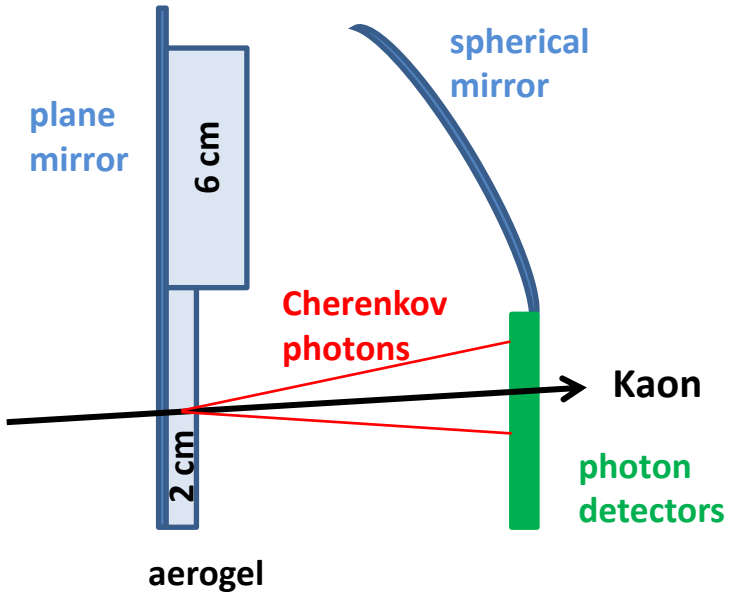




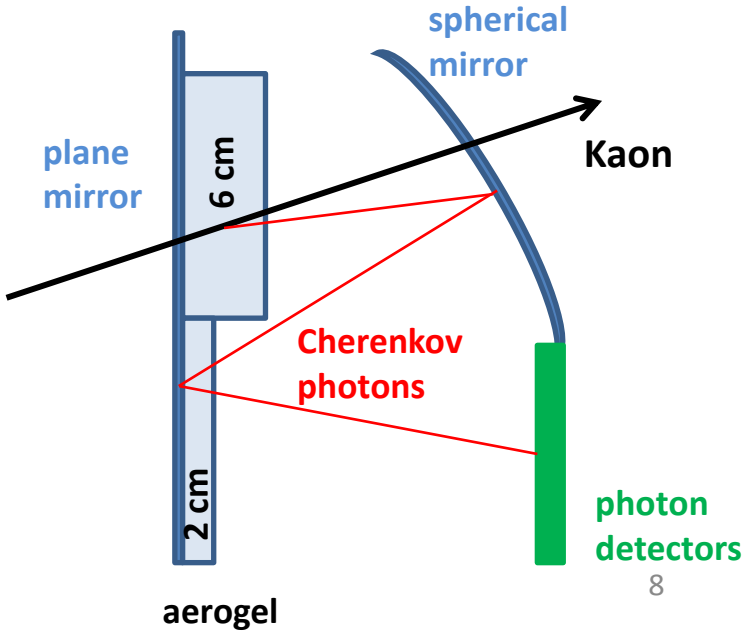
The RICH concept

Hybrid solution:
proximity gap plus mirror focusing

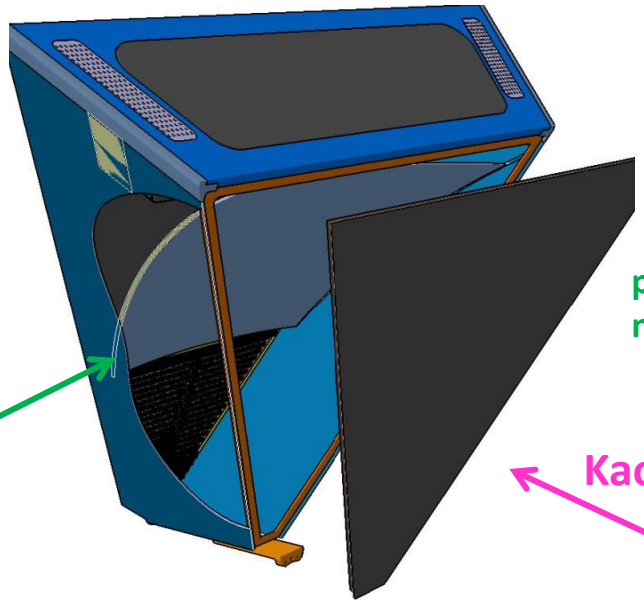
- **Small polar angle particles**
  - 1m gap
  - direct imaging of the Cherenkov photons
  - thin aerogel

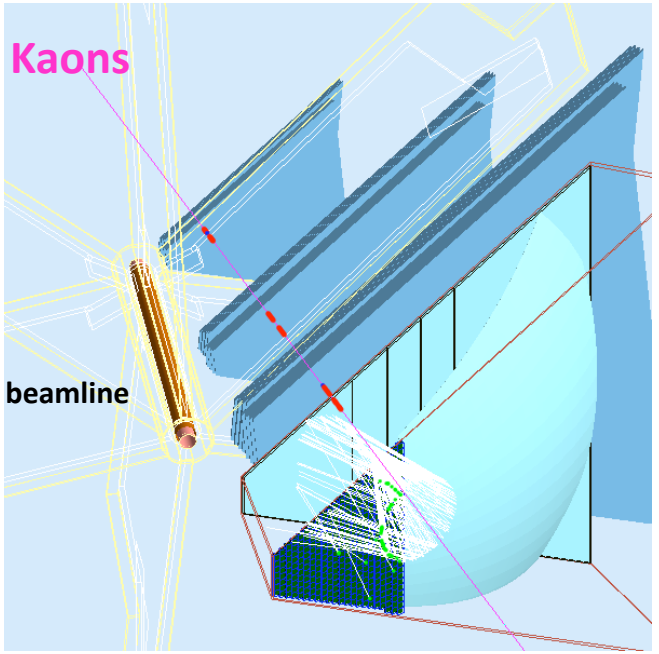


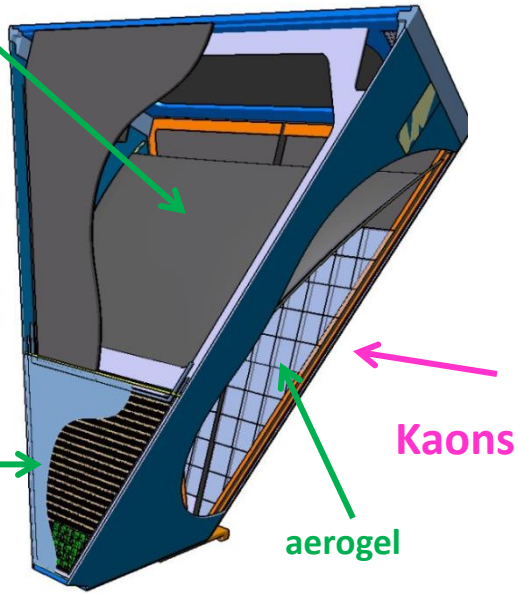
- **Large polar angle particles**
  - about 3m path length
  - multiple passage of Cherenkov photons in aerogel
  - thick aerogel radiator to compensate photon loss
  - Focalizing mirrors to reduce emission point uncertainty

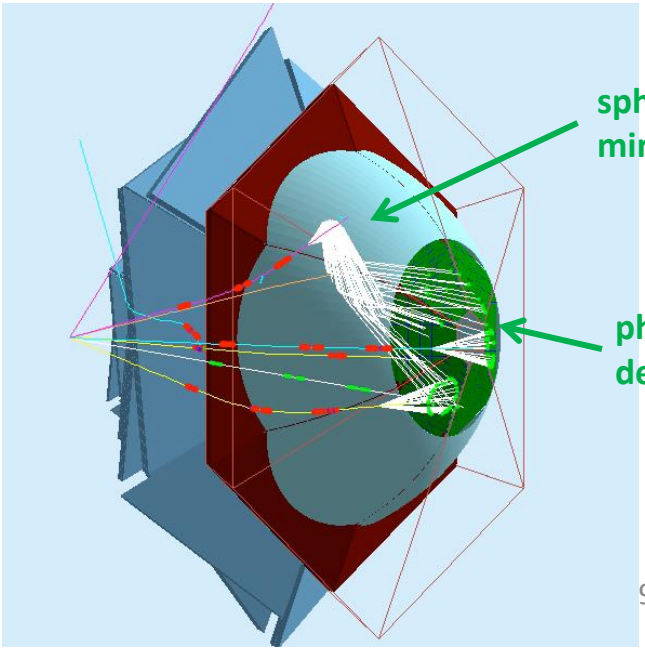


The RICH realization

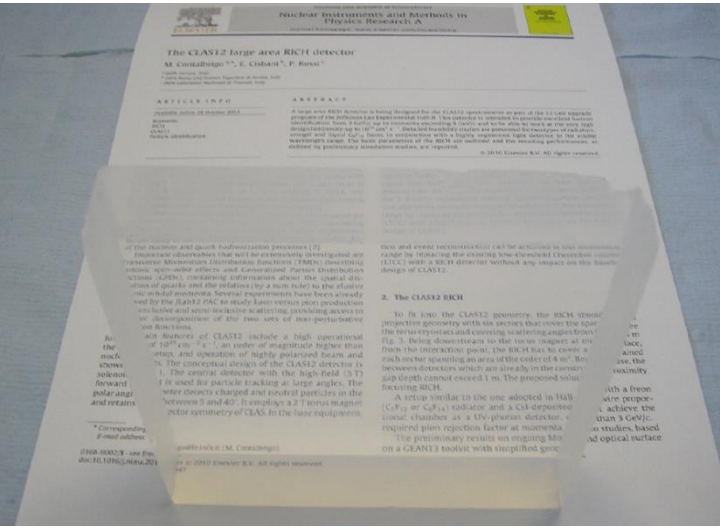




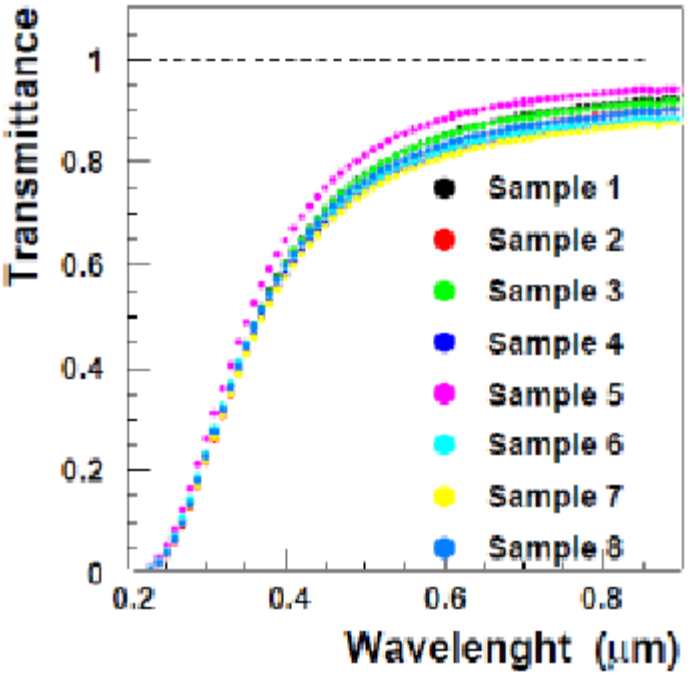


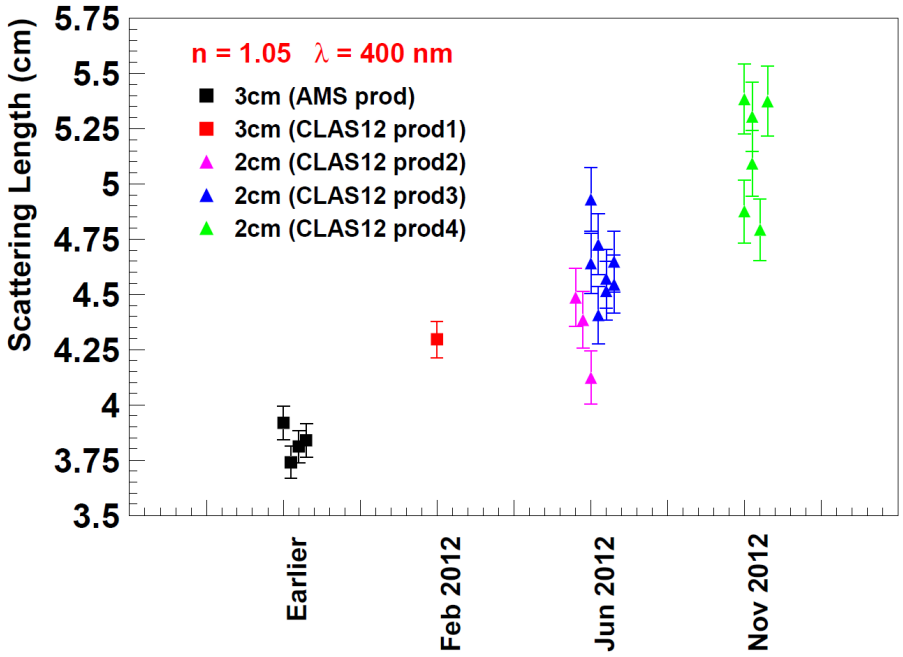


The aerogel radiator



Collaboration with Budker and Boreskov Institutes of Novosibirsk





For aerogel with n=1.05 achieved clarity

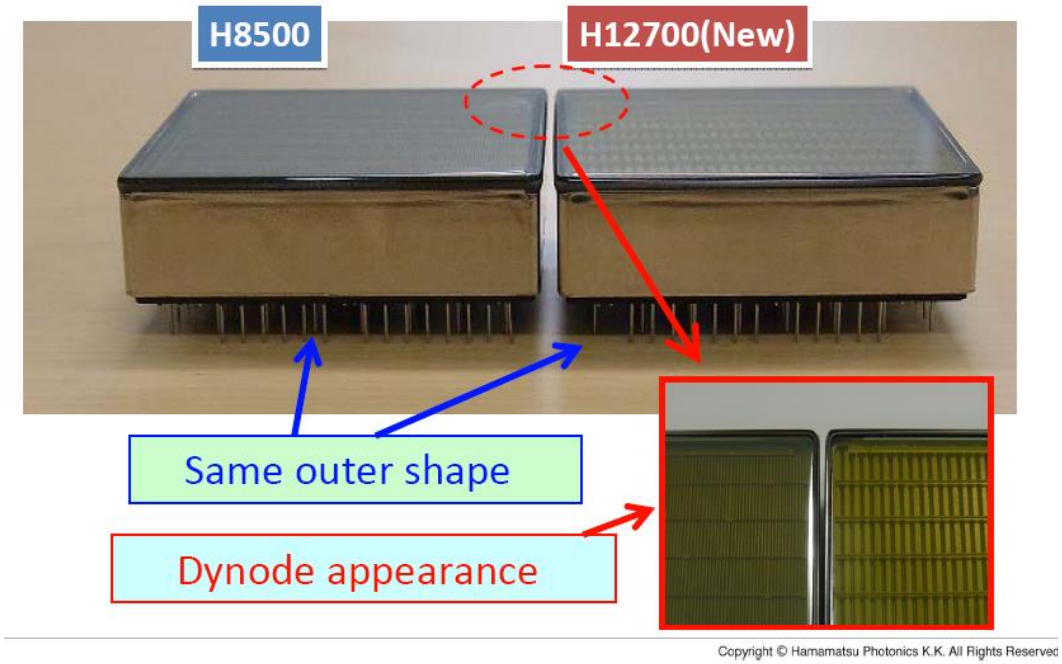
$$C \sim 0.00050\ \mu m_4\ cm^{-1}$$

LHCB: $C \sim 0.00064\ \mu m_4\ cm^{-1}$ with n=1.03

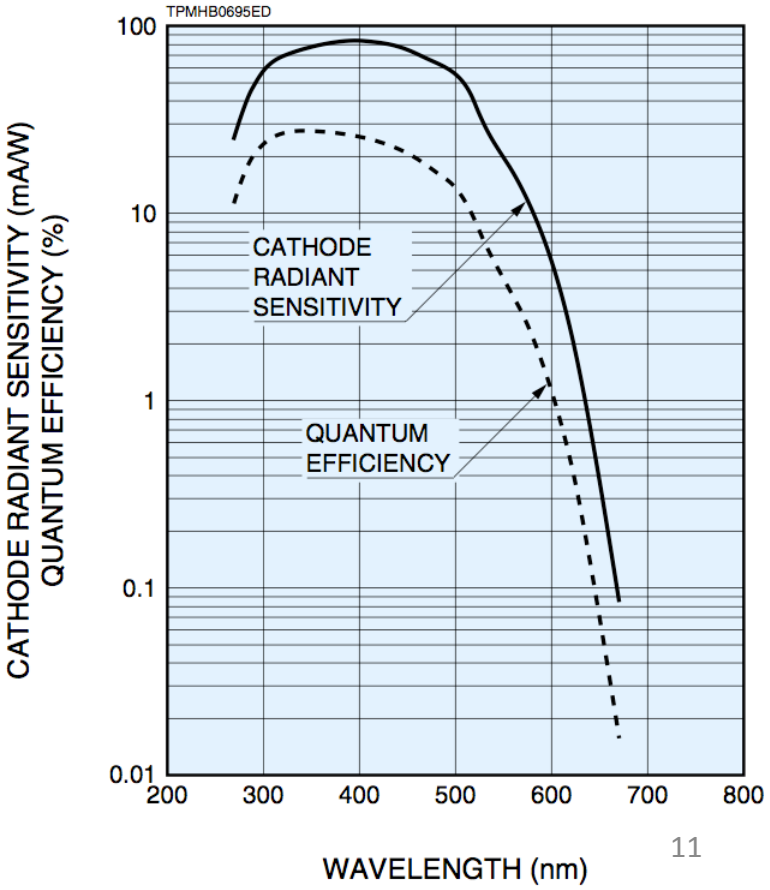
Photon detectors

The only way to keep the project on schedule is to use multi-anode photomultipliers

- **Hamamatsu H8500**
  - not optimized for SPE, but it works
- ***Hamamatsu H12700***
  - ***new device, better for SPE***

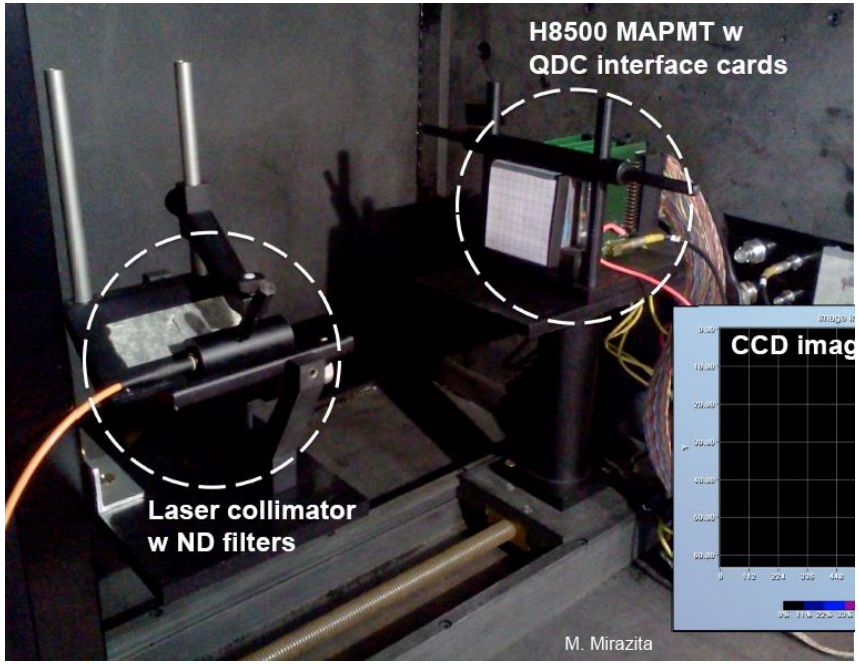


- mature technology
- large area (5x5 cm^2)
- high packing density (89%)
- 64 pixels, 6x6mm^2
- high sensitivity on visible to UV light
- fast response

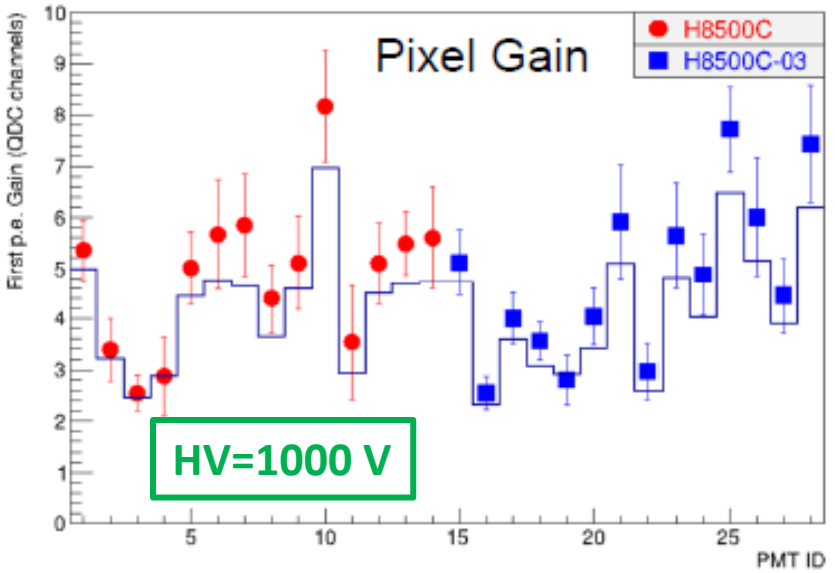


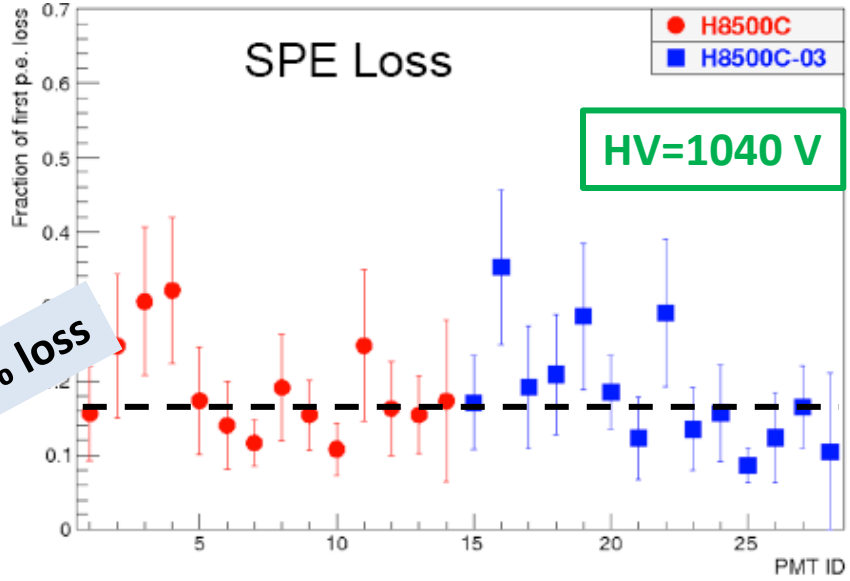
SPE response

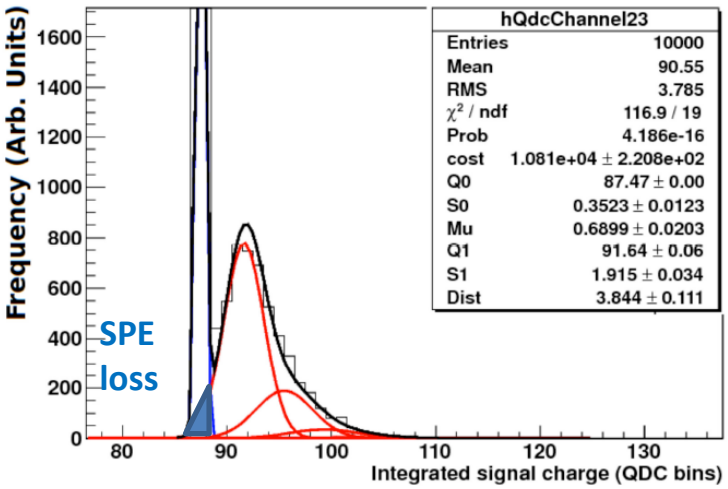
MAPMT characterization with laser setup



64 channels averages and RMS





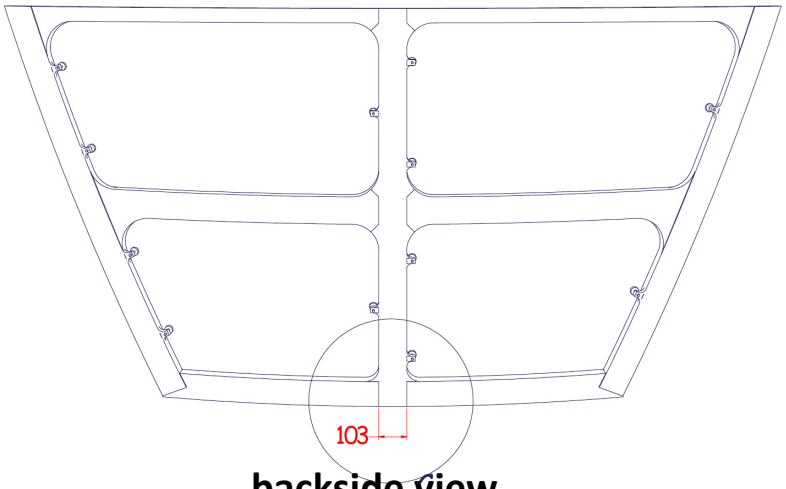


~15% loss

The mirror system

SPHERICAL MIRROR

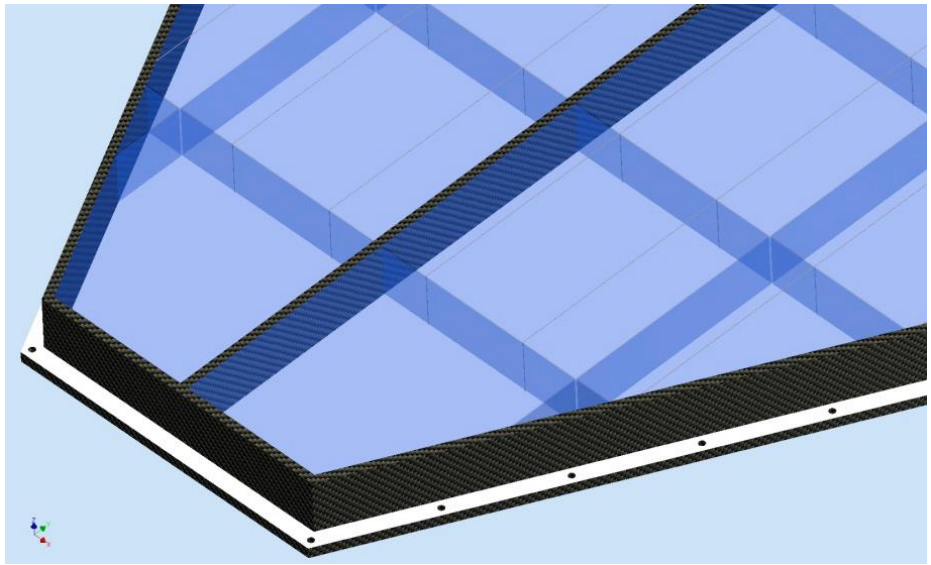
- composite mirror
- four independent sections
- supporting mount allowing relative alignment
- curvature radius 4m
- total surface about $3m^2$



backside view

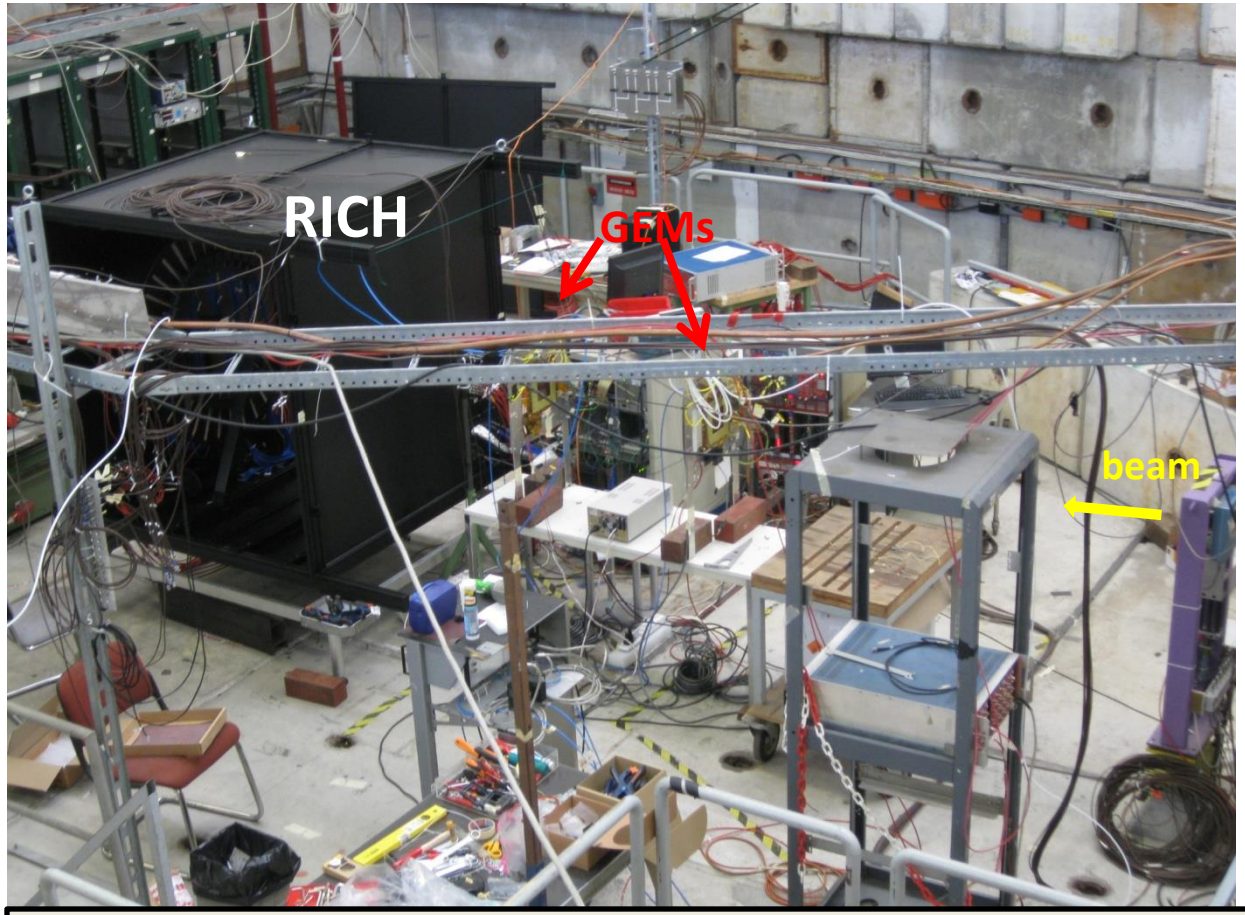
PLANE MIRROR

- sandwich of two thin (0.7mm) skins of glass
- four independent sections
- supporting mount allowing relative alignment
- will support also the aerogel tiles
- total surface about $3m^2$

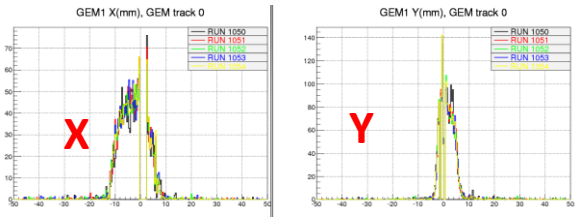


- Total thickness of the mirror system $<0.1X_0$
- Required optical characteristics comparable to LHCb mirrors

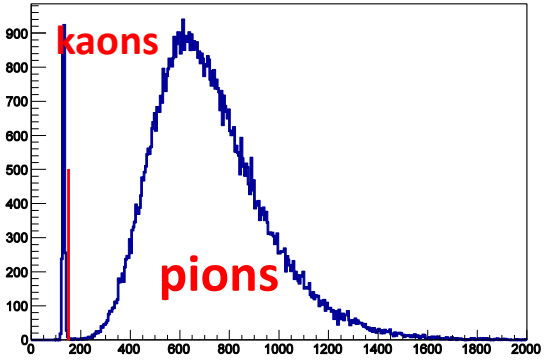
RICH prototype testbeam

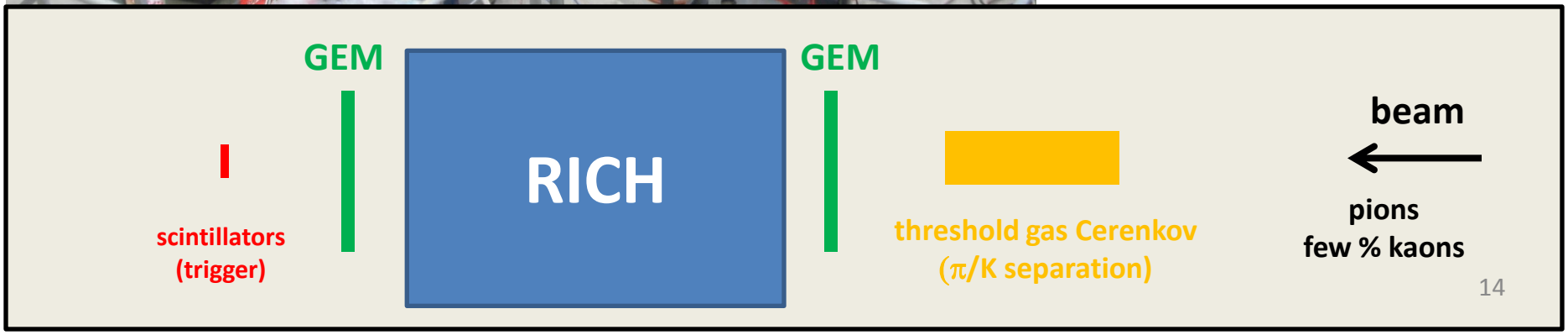


GEM profile

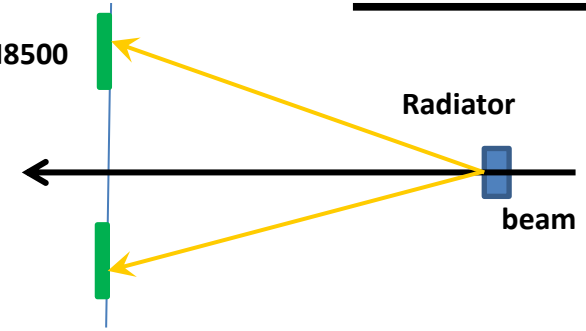


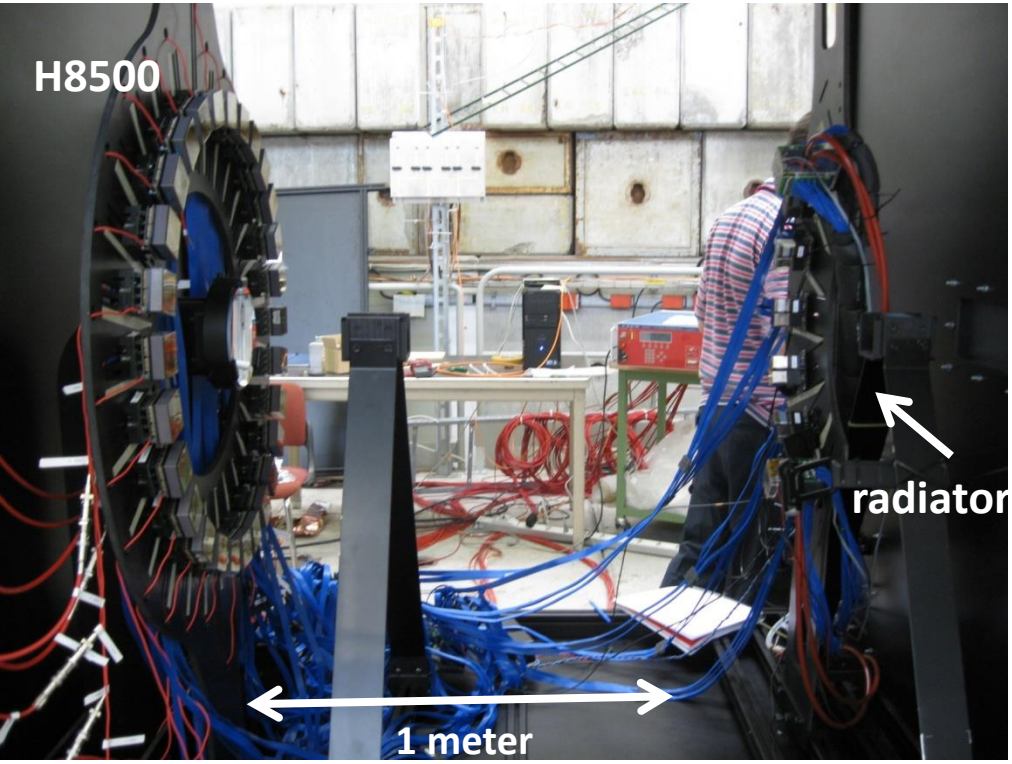
Threshold Cherenkov

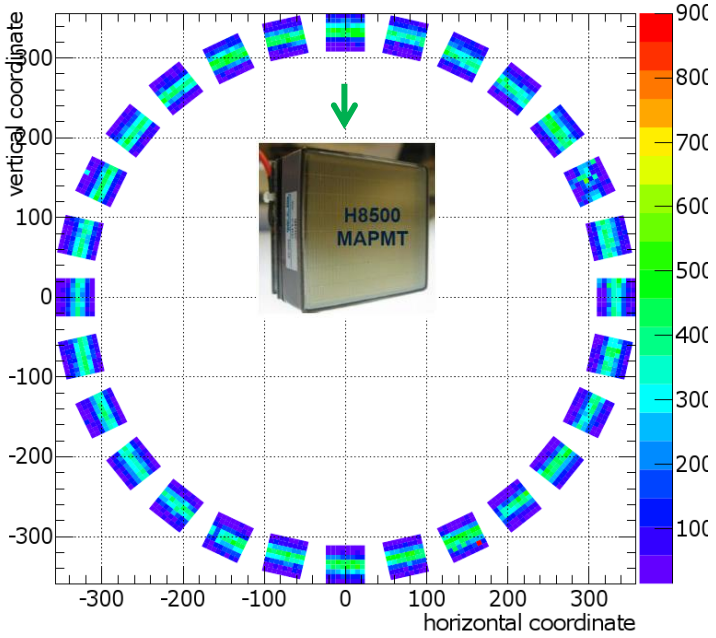


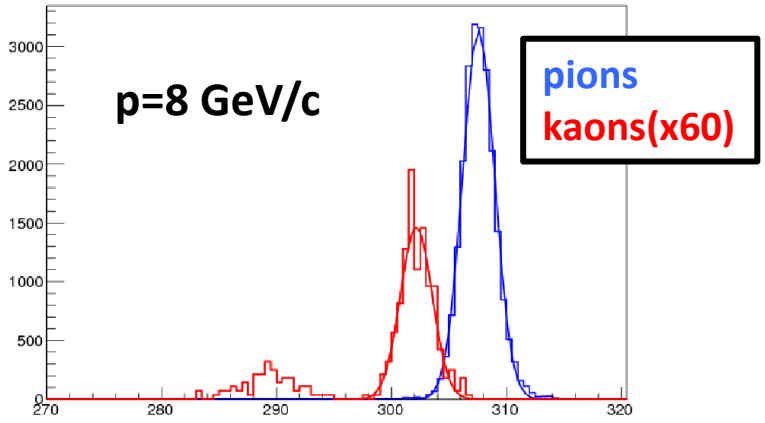


Direct light results

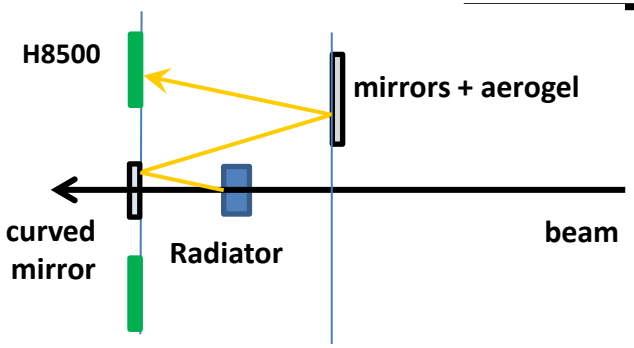


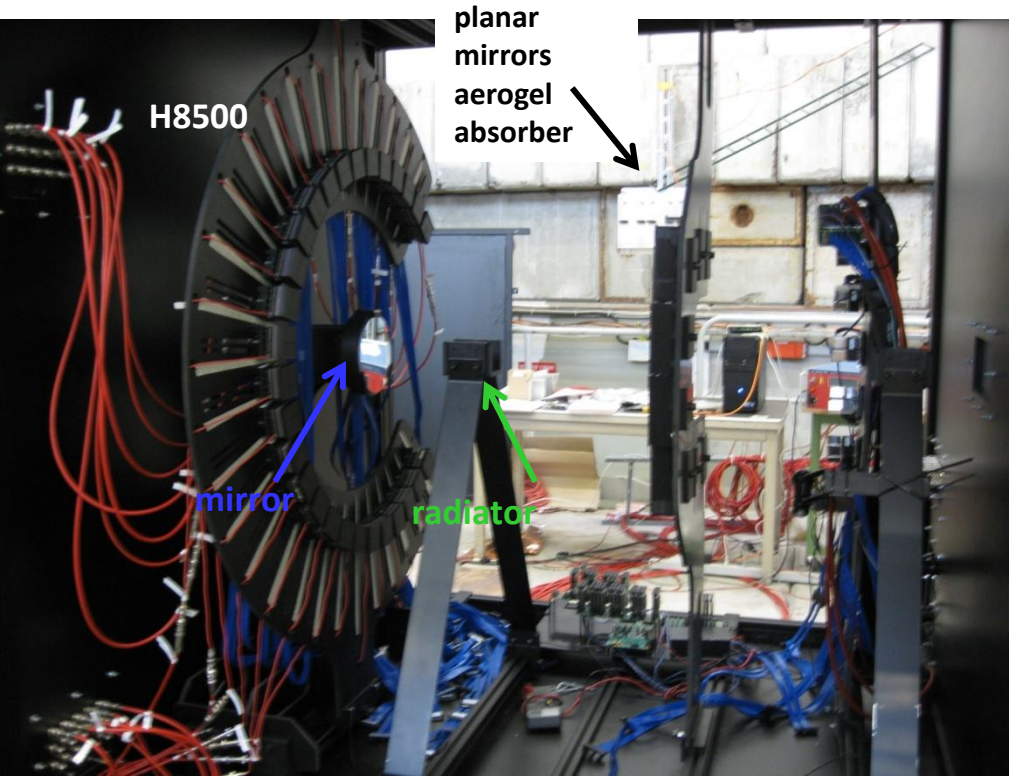


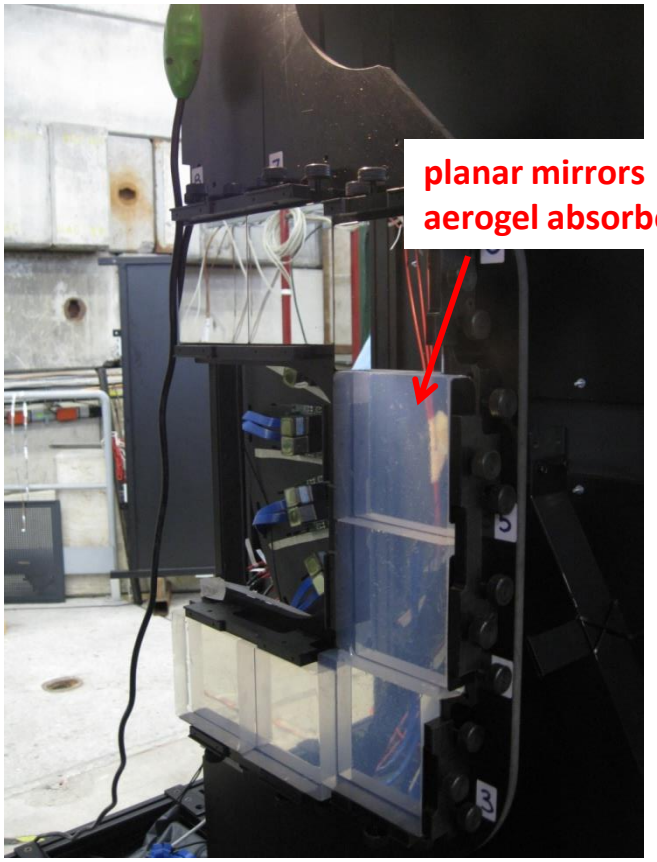




Reflected light setup

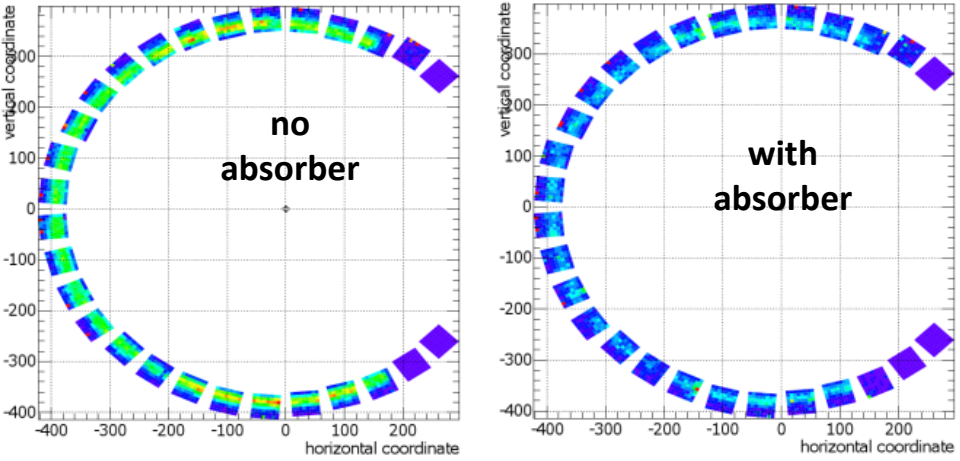


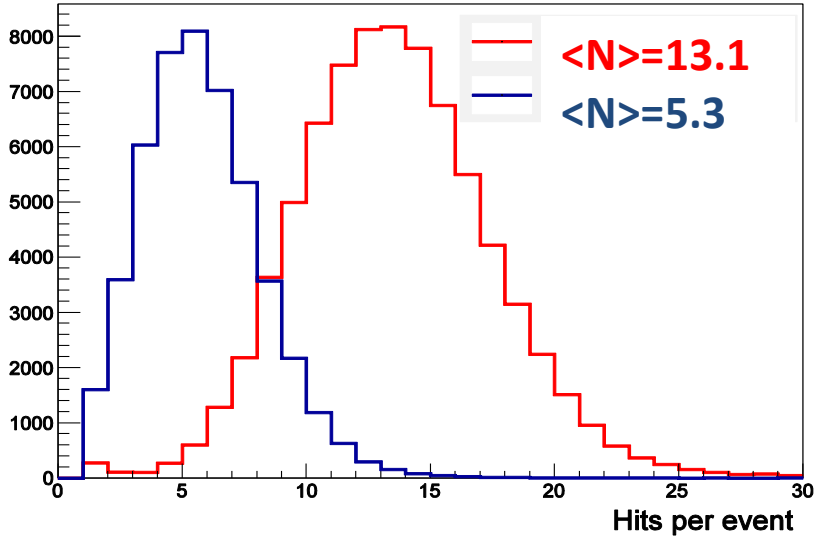




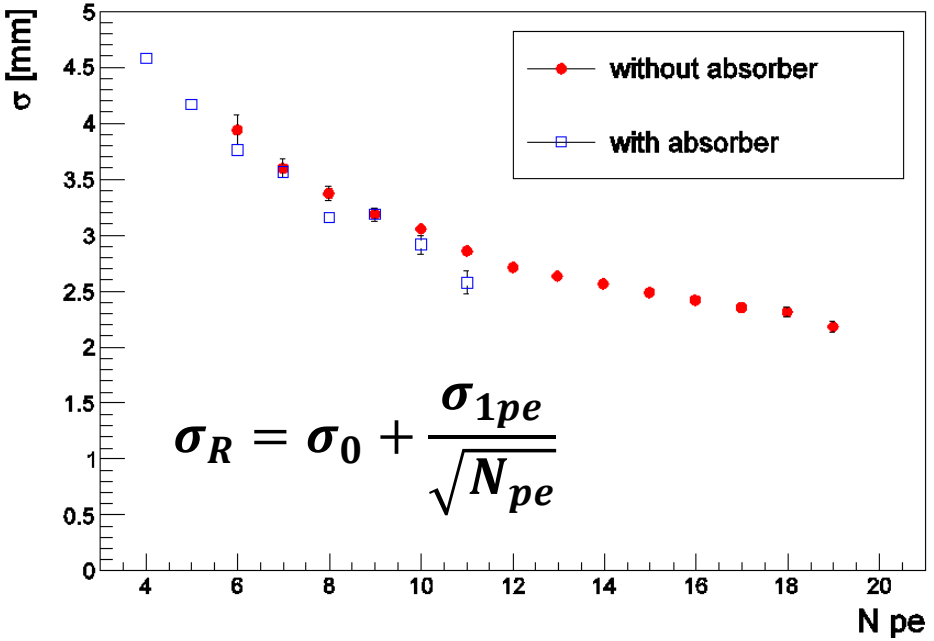
Runs with absorbers in/out to study Cherenkov photon loss

Reflected light results



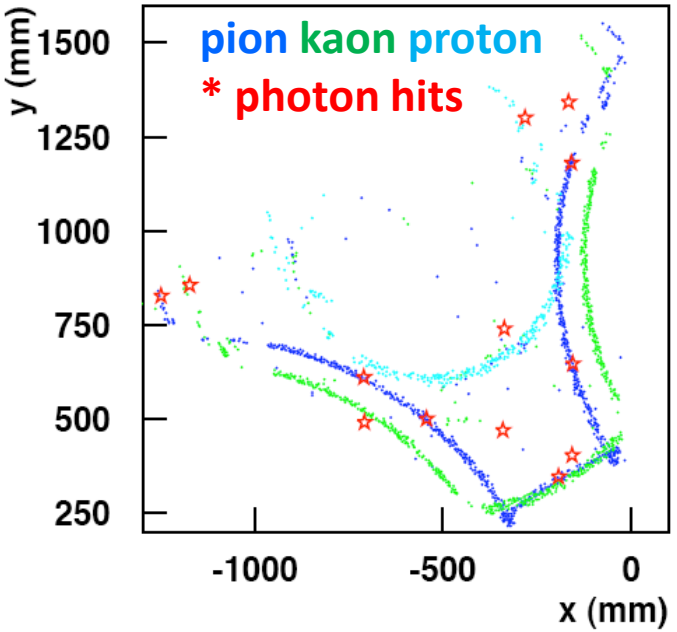


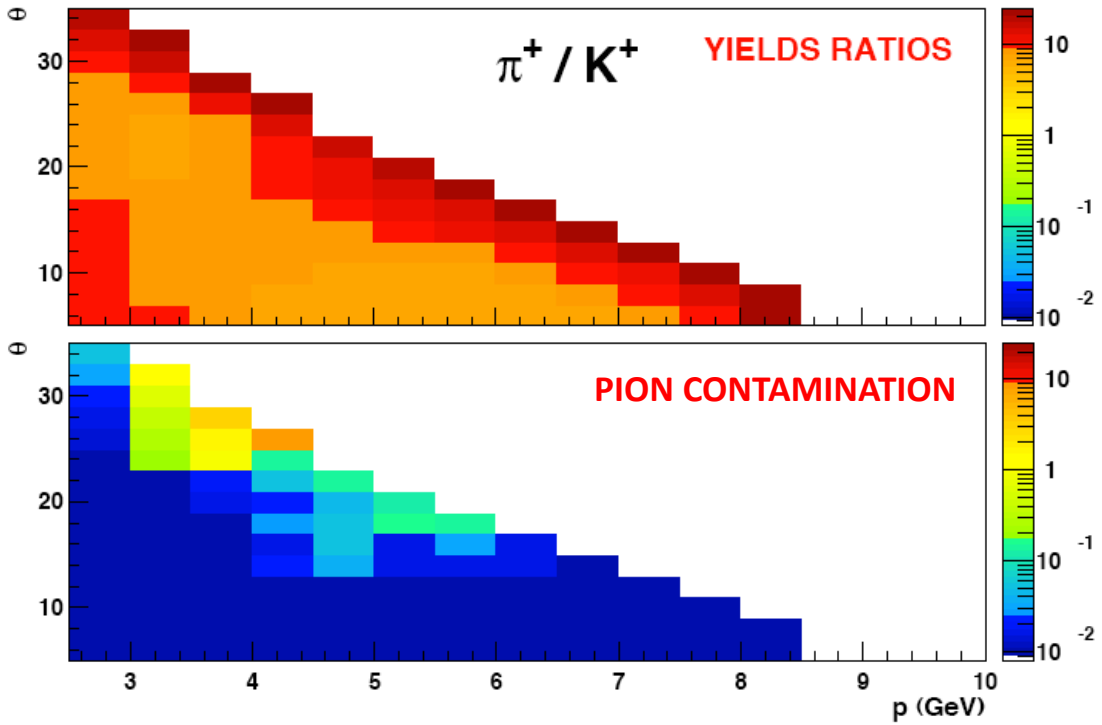
- About 40% of the Cherenkov photons survive after the double pass through the aerogel
- Resolution not significantly degraded besides the loss of photons



Kaon ID in the CLAS12 RICH

- Low multiplicicty, one charged particle per sector in average
- Complicated photon patterns due to reflections
- Pattern recognition algorithm based on Likelihood fit





Even with not yet optimized tuning of the pattern recognition algorithm, the π contamination is at few % level

The RICH project

The RICH project is an international collaboration between institutions from many countries

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)

The goal is to provide CLAS12 with one RICH sector by the beginning of the physics operations (end of 2016)

A second sector is foreseen for the physics with transversely polarized target

- The project has been approved by JLab and DOE by two reviews committees in september
  - the RICH is now part of CLAS12 equipment
- INFN funding on schedule
  - Procurement of the main components already started
  - Construction of the first module will begin in 2014