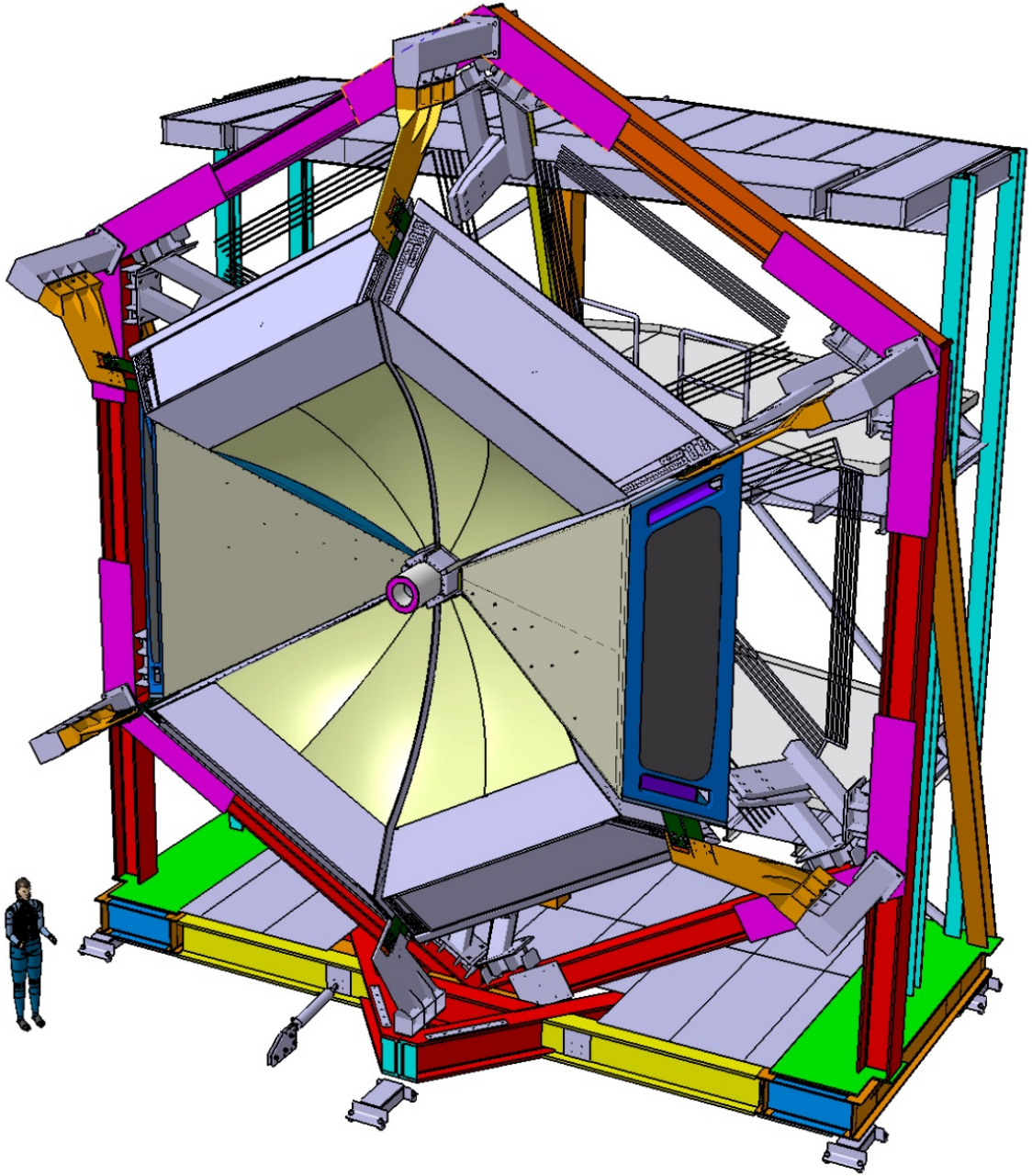


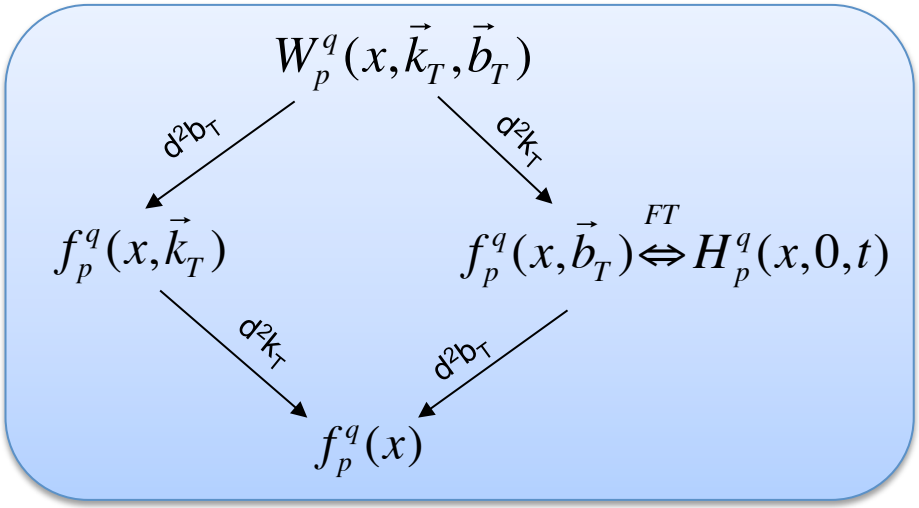
CLAS12-RICH

CLASMED

(progetto premiale)

July 13th 2015

The 3D Nucleon Structure



Confinement Scale

Transverse momentum

$\vec{k}_T$

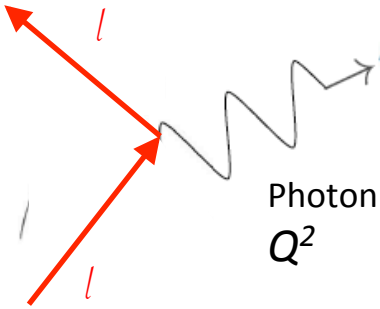
$\vec{b}_T$

Transverse position

Transverse plane

High Energy Probe
Hard Scale

Longitudinal momentum
$k^+ = xP^+$



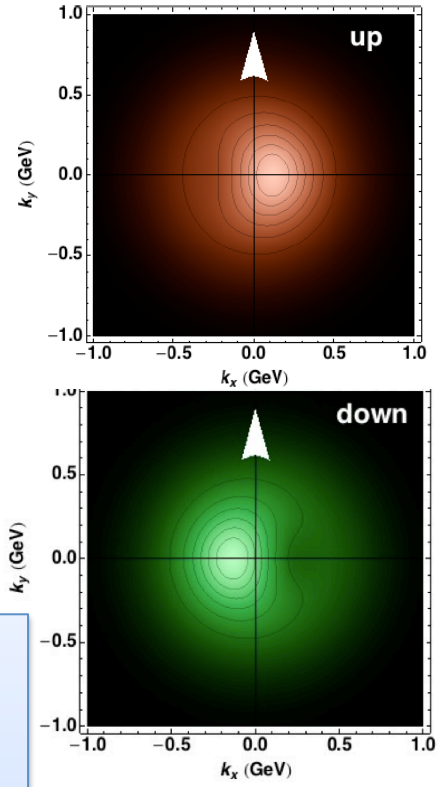
Photon Virtuality
Q^2

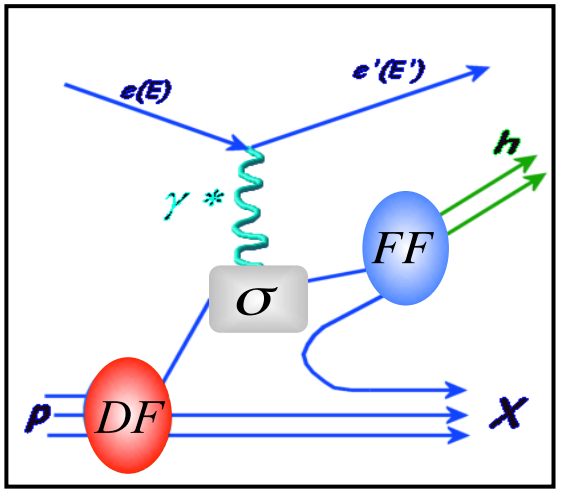
Transverse Momentum Dependent Distr.

quark polarisation

nucleon polarisation

N/q	U	L	T
U	f_1		$h_1^\perp$
L		g_1	$h_{1L}^\perp$
T	$f_{1T}^\perp$	$g_{1T}^\perp$	$h, h_{1T}^\perp$





Unpolarized elements:

Related to:

- ✓ Low-pT regime: precise xsec measurements
- ✓ Parton correlations: short range, MPI
- ✓ Low-x physics: color glass condensate
- ✓ Hadronization: parton dynamic in medium

Off-diagonal elements:

Related to:

- ✓ Parton Spin-Orbit effects: may explain pp SSA & DY Lam-Tung
- ✓ Parton Orbital motion

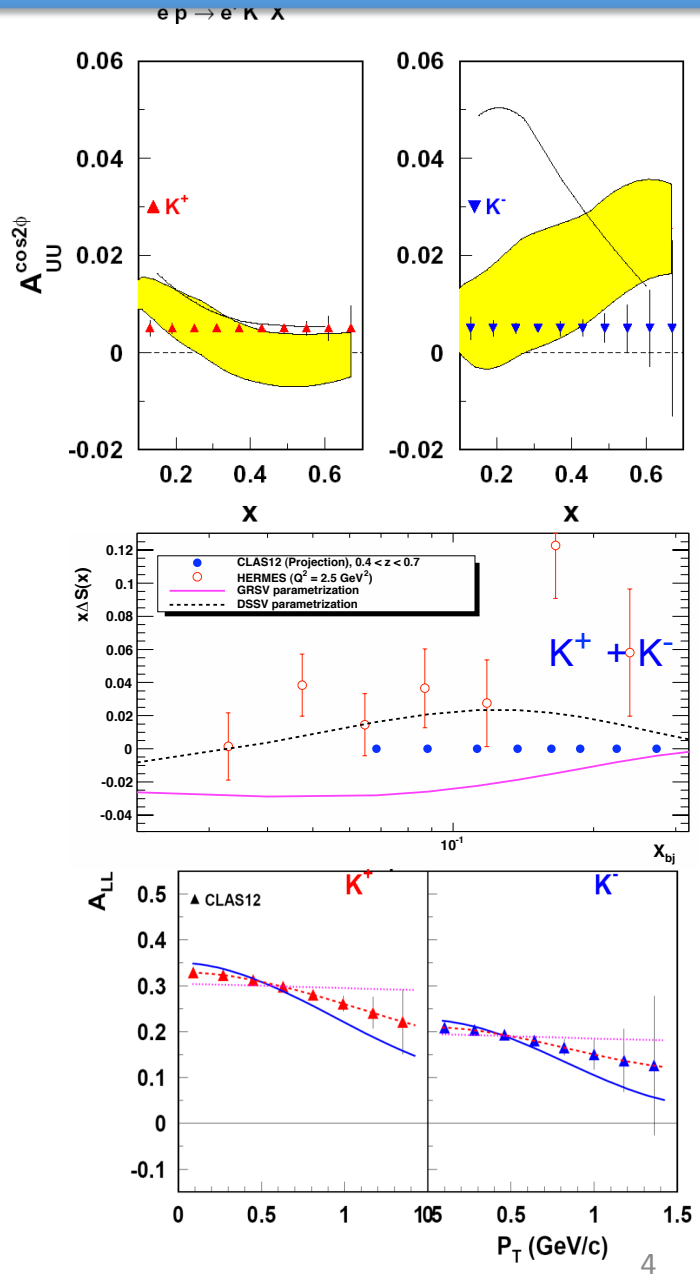
Kaon Program @JLab

Approved Experiments:

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

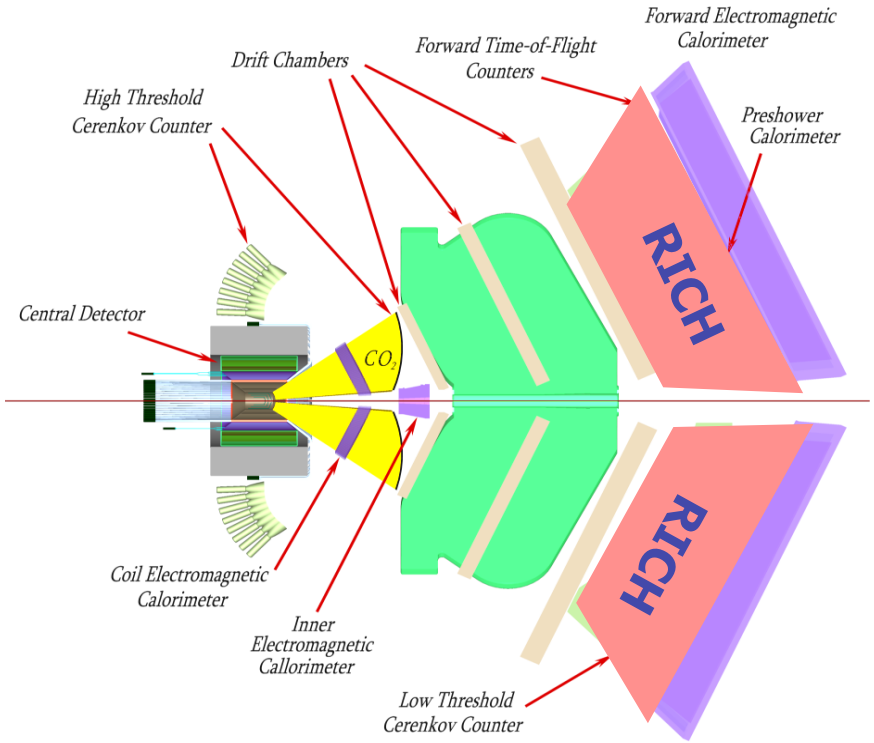
PR12-09-09:
Studies of Spin-Orbit Correlations in Kaon Electroproduction in DIS with polarized hydrogen and deuterium targets



The CLAS12 RICH Project

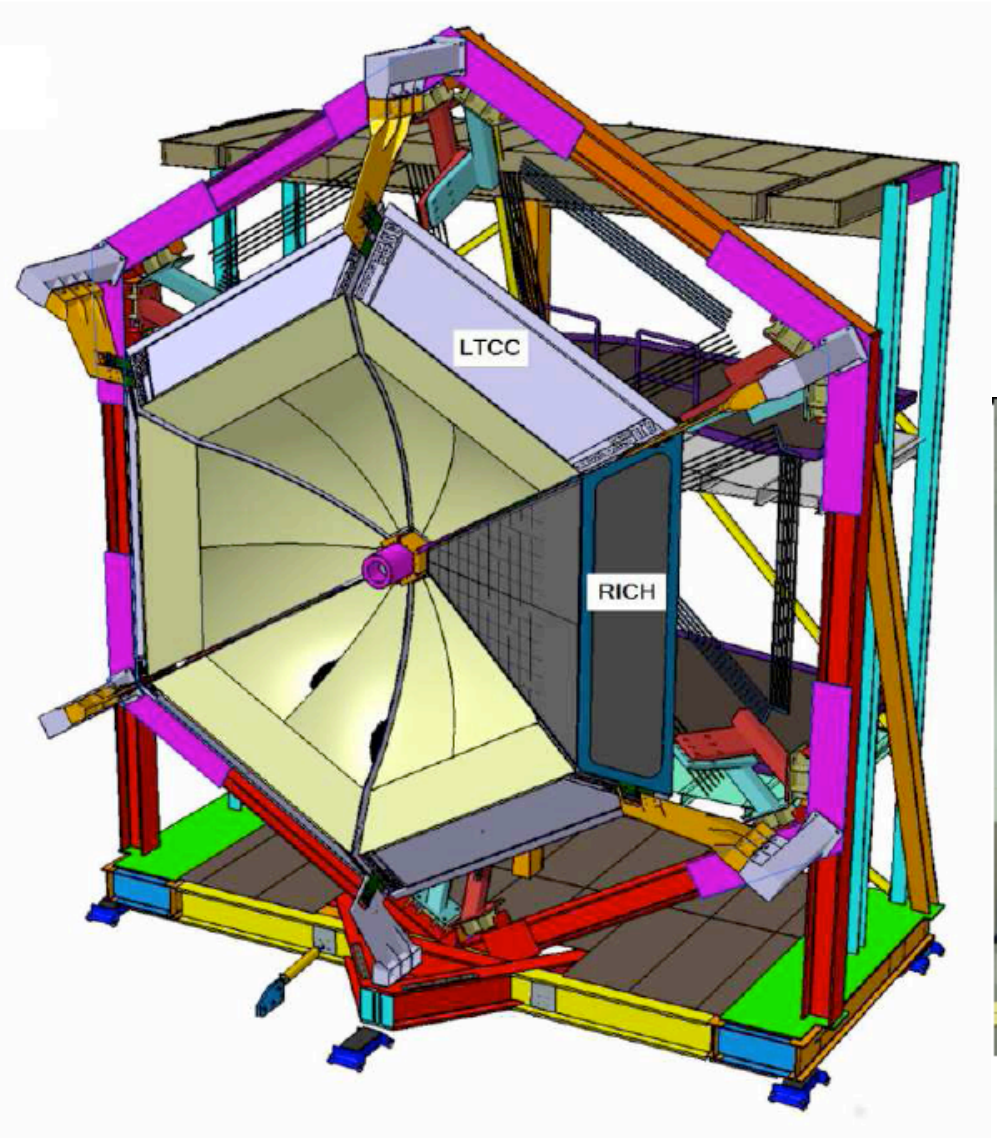
RICH goal: **π/K/p identification from 3 up to 8 GeV/c and 25 degrees**

~4σ pion-kaon separation for a pion rejection factor ~ 1:500



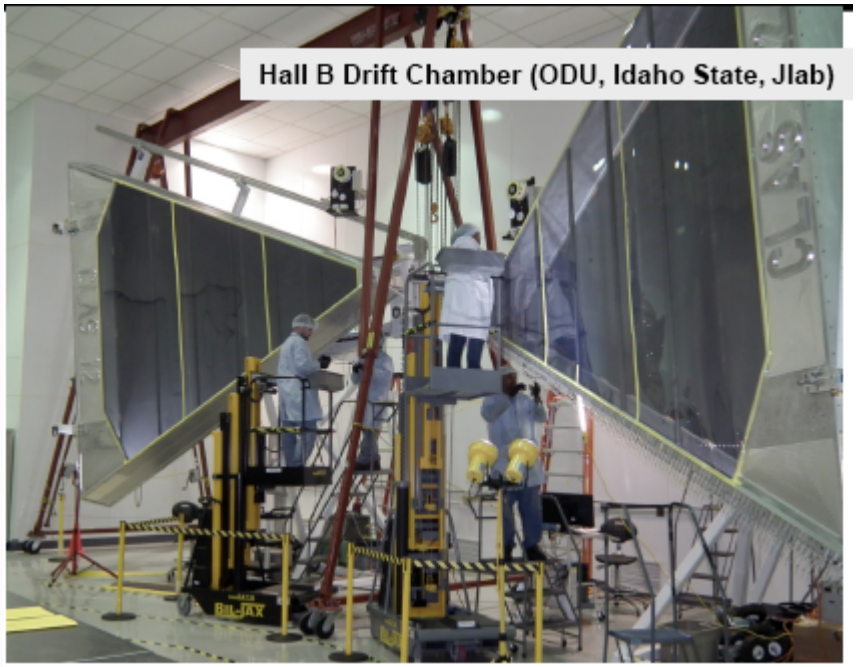
INSTITUTIONS
INFN (Italy) Bari, Ferrara, Genova, L.Frascati, Roma/ISS
Jefferson Lab (Newport News, USA)
Argonne National Lab (Argonne, USA)
Duquesne University (Pittsburgh, USA)
Glasgow University (Glasgow, UK)
J. Gutenberg Universitat Mainz (Mainz, Germany)
Kyungpook National University, (Daegu, Korea)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

Base Configuration



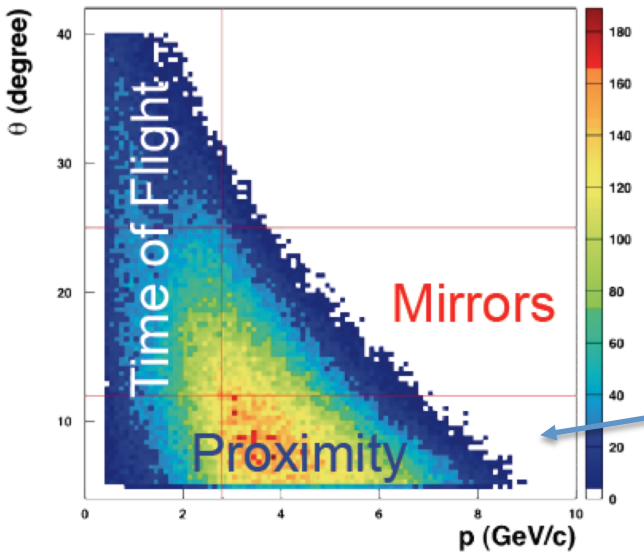
1st sector in time for physics run
(unpolarized and longitudinal polarize targets)

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

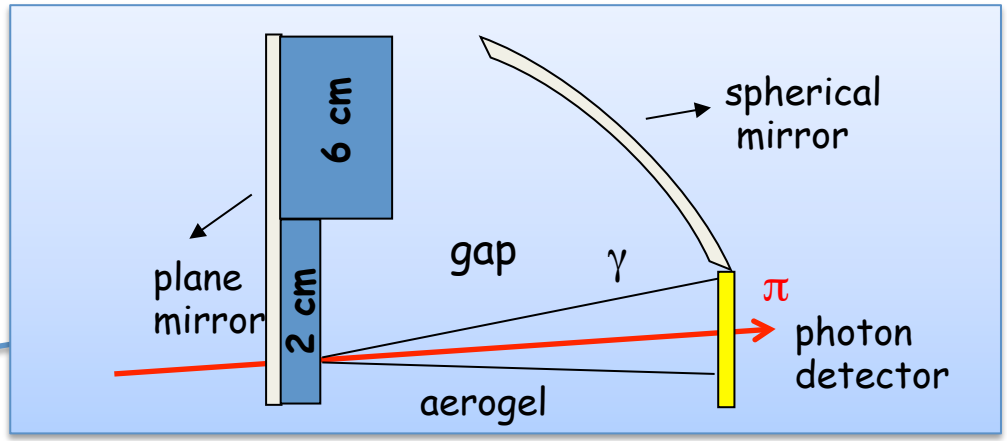


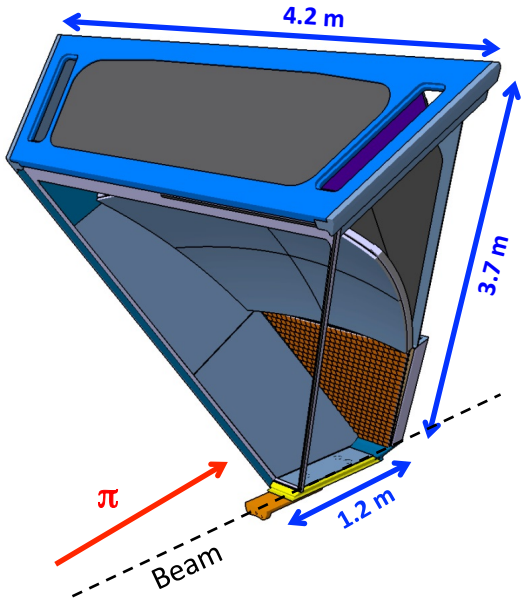
2nd++ sector for transverse target
(left-right symmetry and statistics)

The Hybrid Optics Design

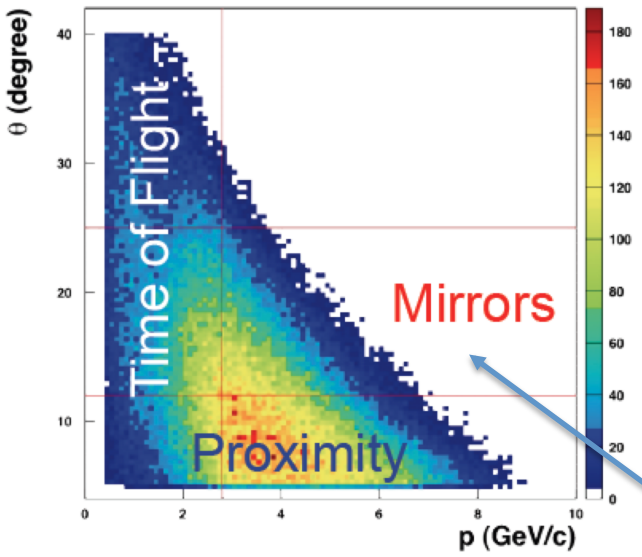


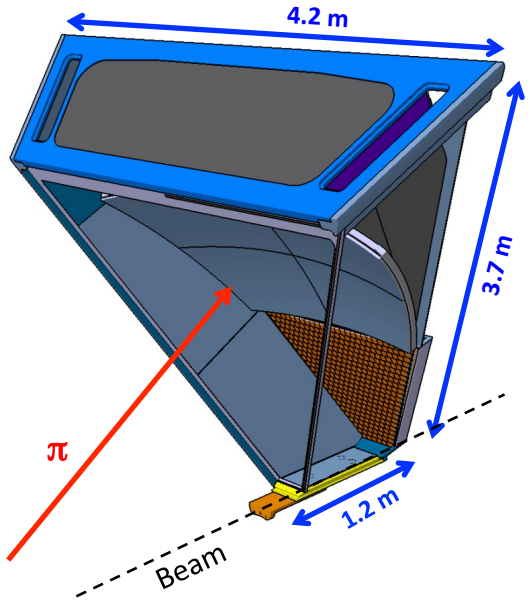
Direct rings and best performance for high momentum particles



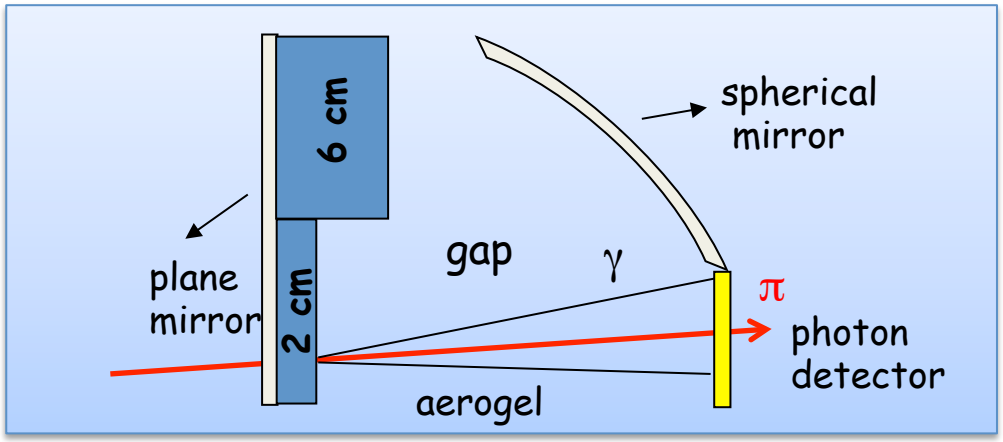


The Hybrid Optics Design

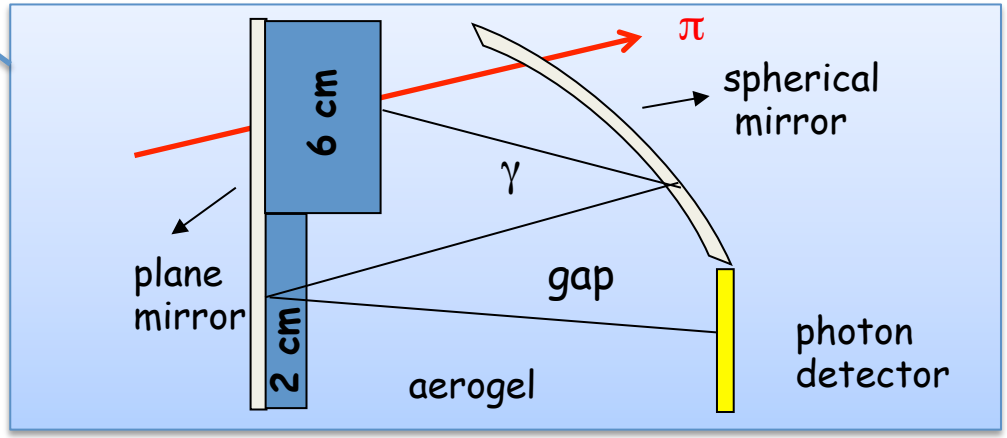




Direct rings and best performance for high momentum particles



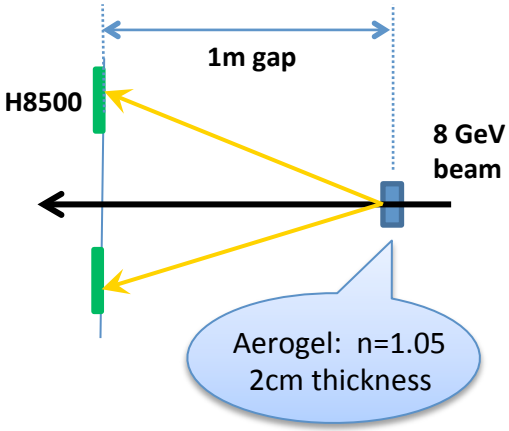
Reflected rings for less demanding low momentum particles

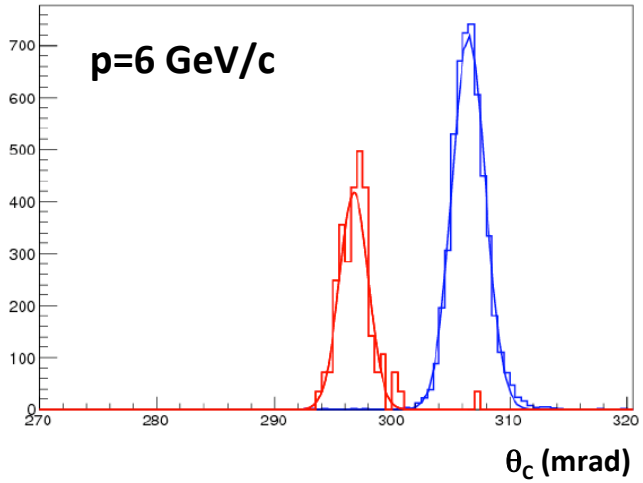


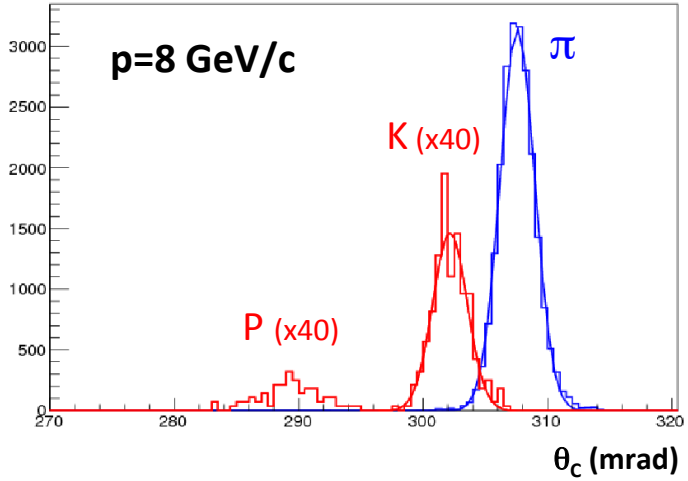
- Minimize active area (cost) to about 1 m^2
- Material budget concentrated where TOF is less effective
- Focalizing mirrors allow thick radiator for good light yield
- Time resolution < 1 ns to distinguish direct and reflected patterns

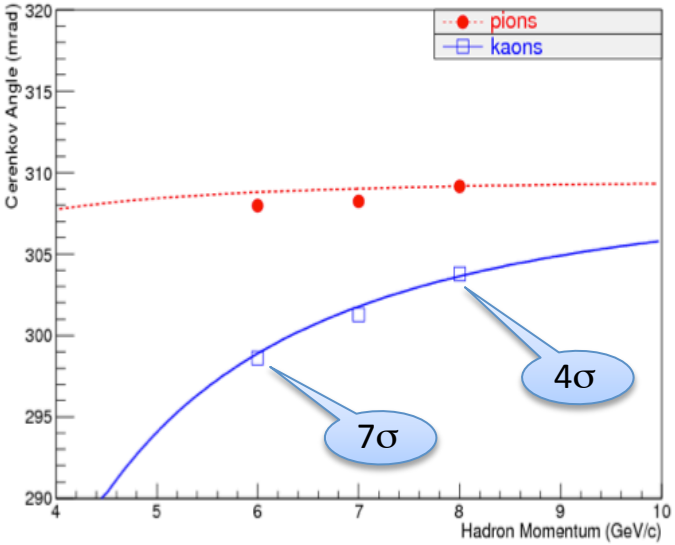
RHIC Prototype: Direct Light Case

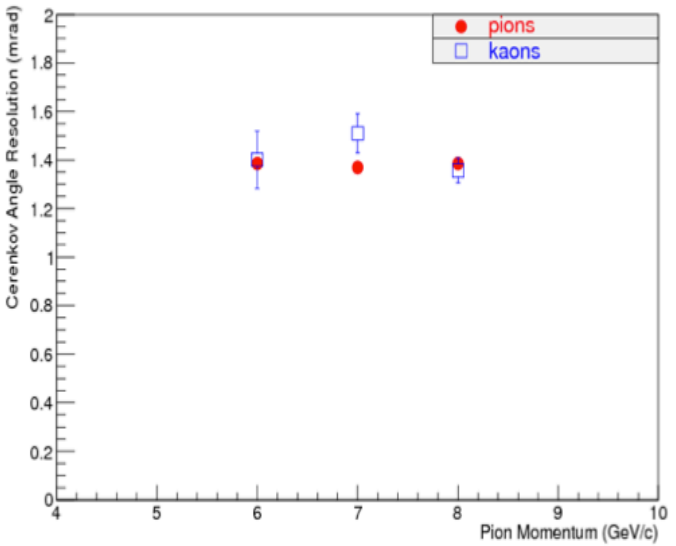
Clear hadron separation up to the CLAS12 maximum momentum



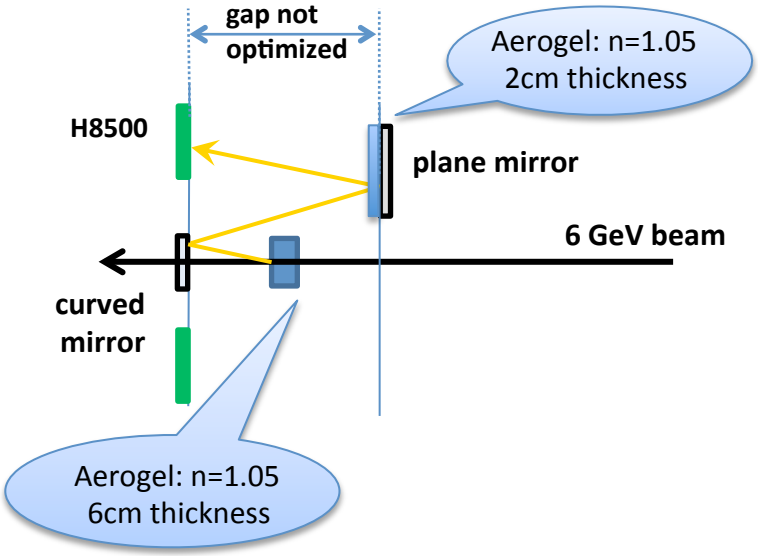


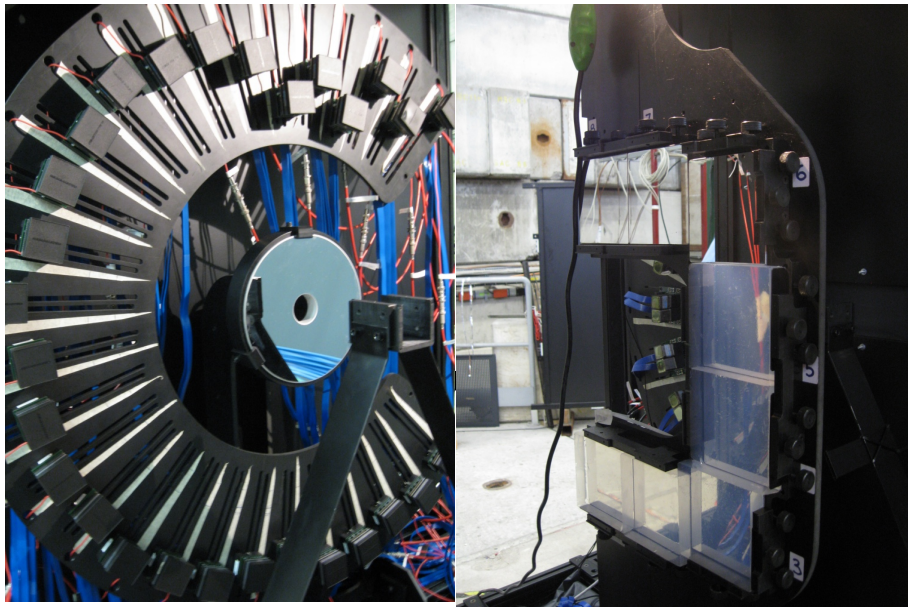




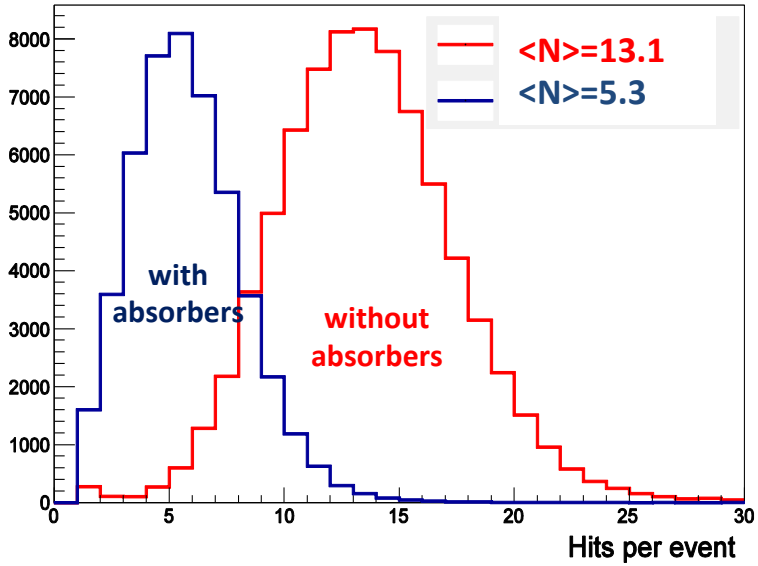


RHIC Prototype: Reflected Light Case

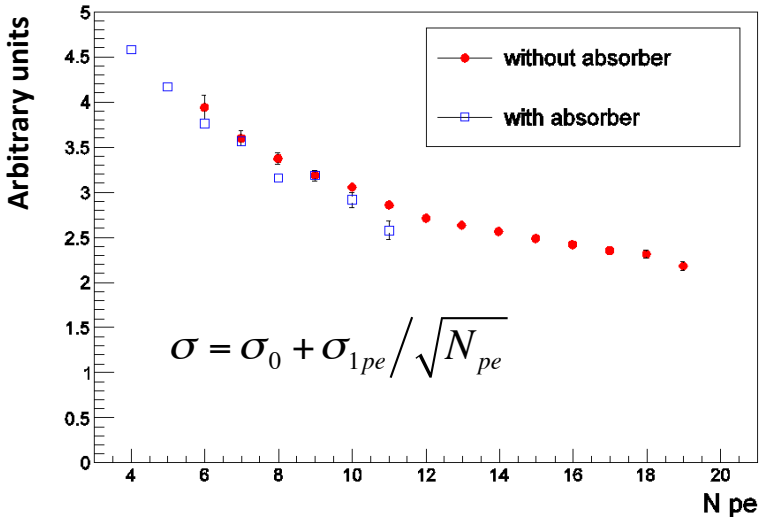




With absorbers: sizeable fraction of light survives



and resolution is not significantly degraded



CLAS12 RHIC

TIMELINE:

2013/09: Project Review with DOE
First contract awarded: MA-PMTs

2014/06: Mechanical Review
10: Start of Aerogel production

2015/05: Contract awarded for Mechanics
07: Start Mirror Production
10: Mid-term Project Review
10: Start Electronics Production

2017/06: RICH Installation

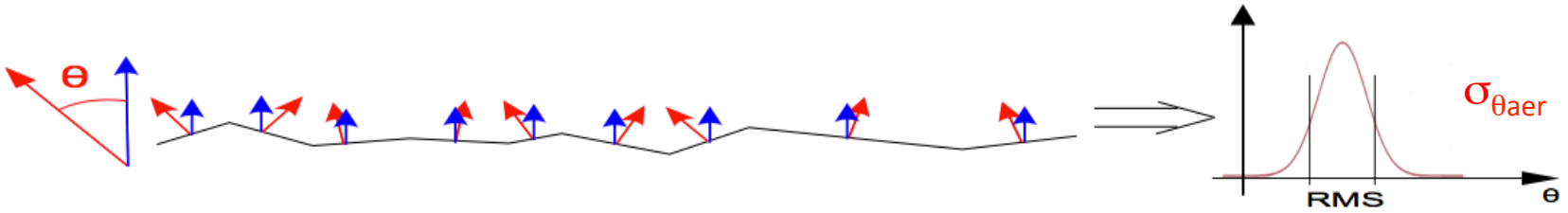
PUBBLICATIONs:

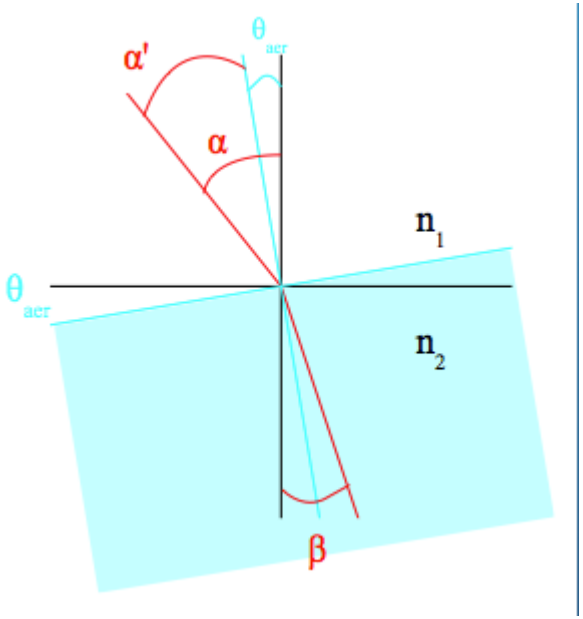
Tests of innovative photon detectors and integrated electronics for the large-area CLAS12 ring-imaging Cherenkov detector
Nucl.Instrum.Meth. A787 (2015) 224-228

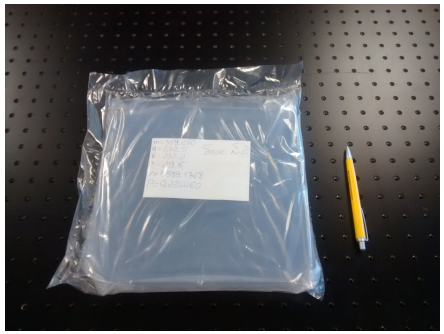
Investigation of Hamamatsu H8500 phototubes as single photon detectors
Nucl.Instrum.Meth. A790 (2015) 28-41

The large-area hybrid-optics CLAS12 RICH detector: Tests of innovative components
Nucl.Instrum.Meth. A766 (2014) 22-27

Aerogel Surface

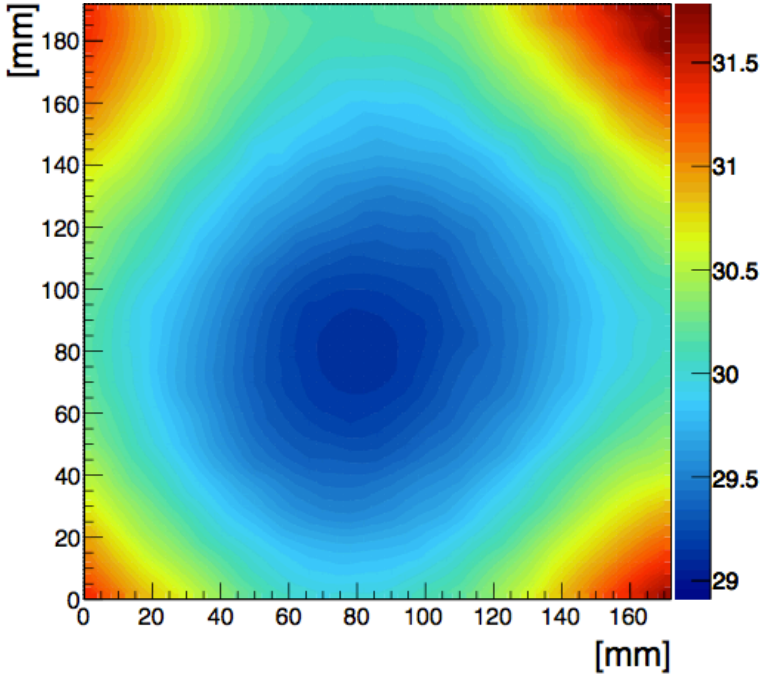






Initial delay due to lack of chemicals

25 % ready for delivery



Refraction from a surface with local normal deviation θ

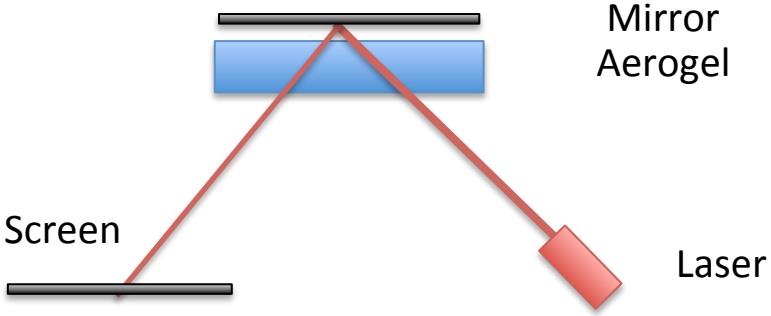
$$\beta = \vartheta_{aer} + \arcsin\left(\frac{1}{n}\sin(\alpha - \vartheta_{aer})\right)$$

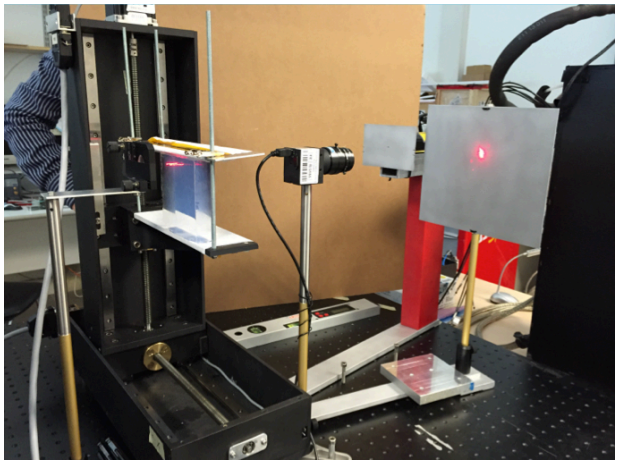
Contribution on light dispersion at small incident angles

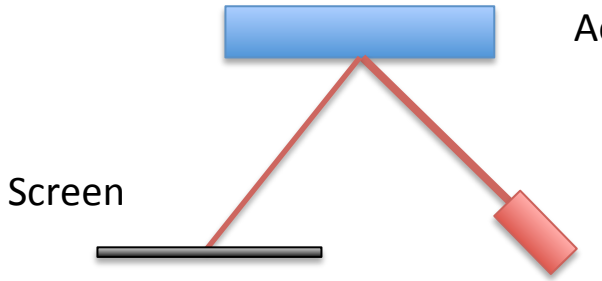
$$\sigma_{\vartheta_{light}} = \left(1 - \frac{1}{n}\right) \cdot \sigma_{\vartheta_{aer}} \approx 0.05 \cdot \sigma_{\vartheta_{aer}}$$

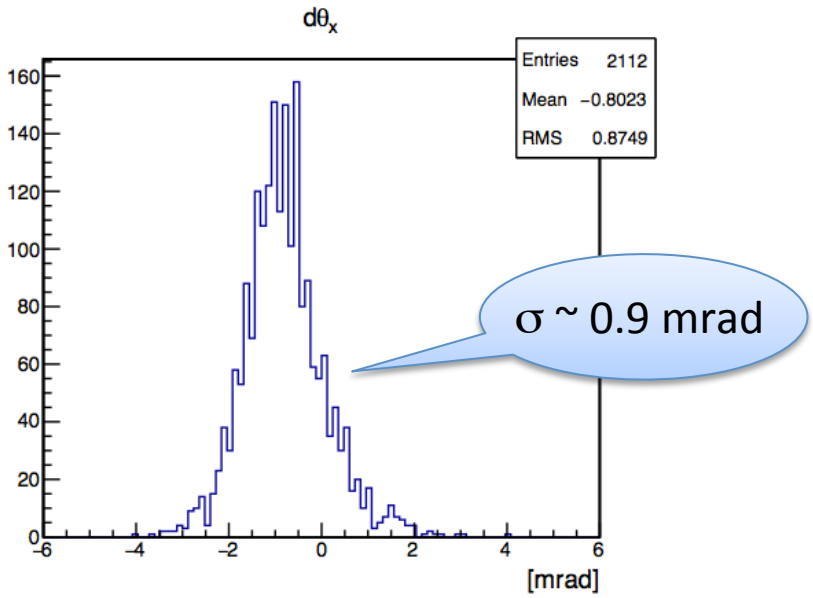
Aerogel Surface

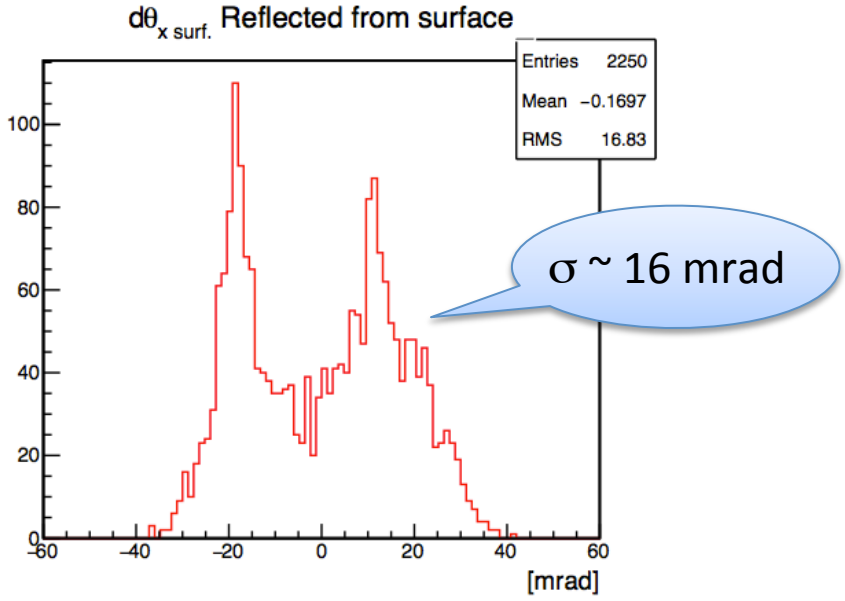
INFN-FE









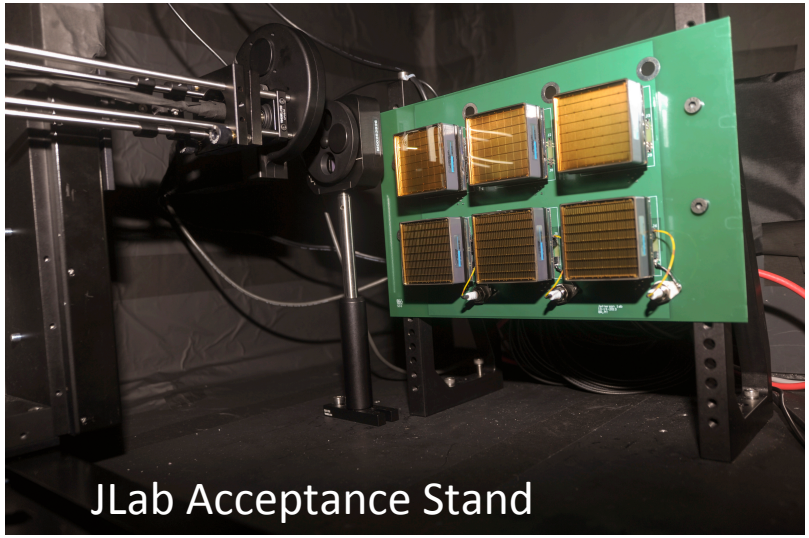


MA-PMT Photon Detector

110 Hamamatsu MAPMT out of 430 delivered and tested at JLab

- 80 H8500
- 130 H12700 with enhanced SPE spectrum

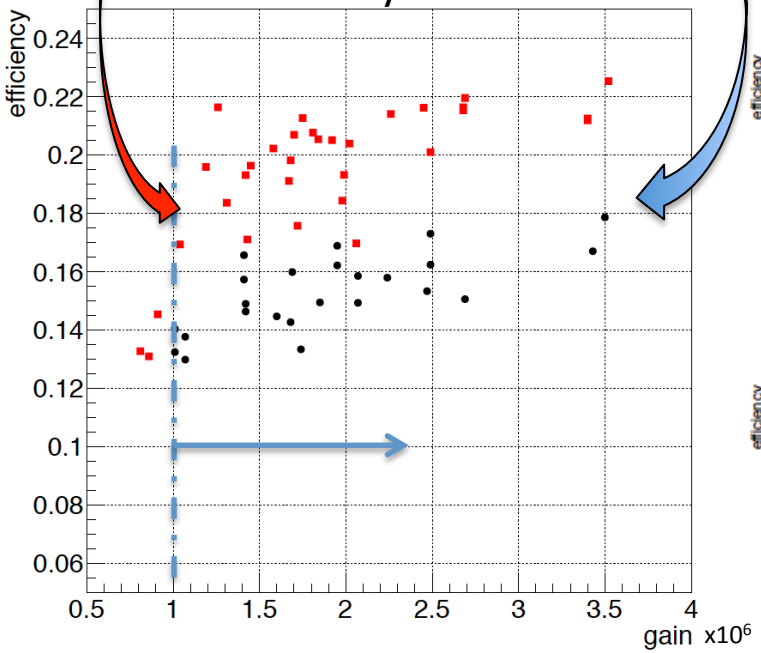
Procurement secured for new H12700 PMTs



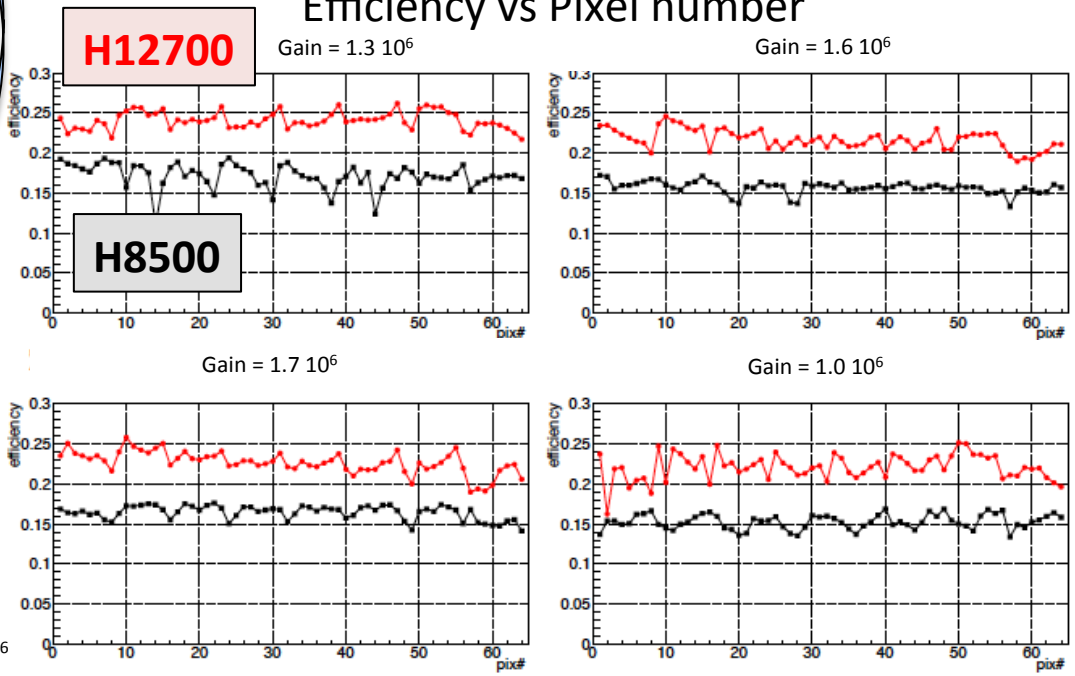
PMT Efficiency Comparison:

H12700 ⟷ **H8500**

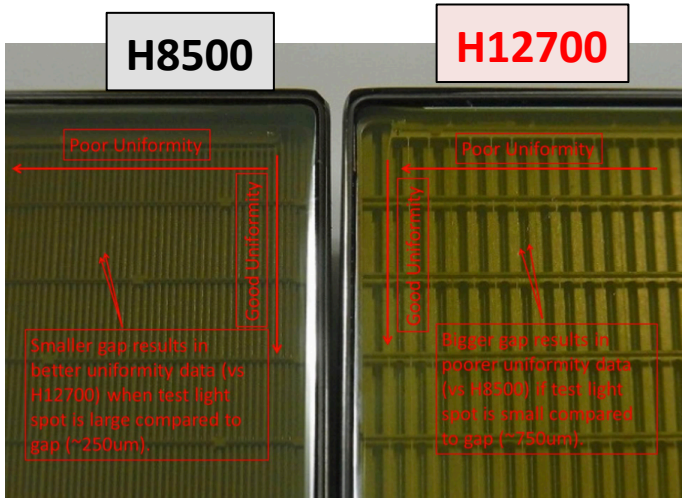
Efficiency vs Gain

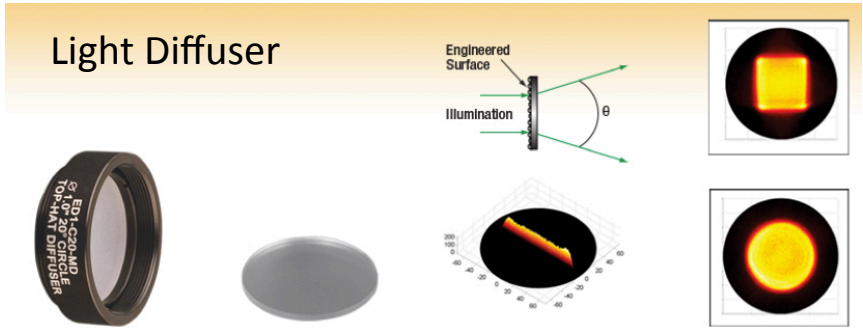


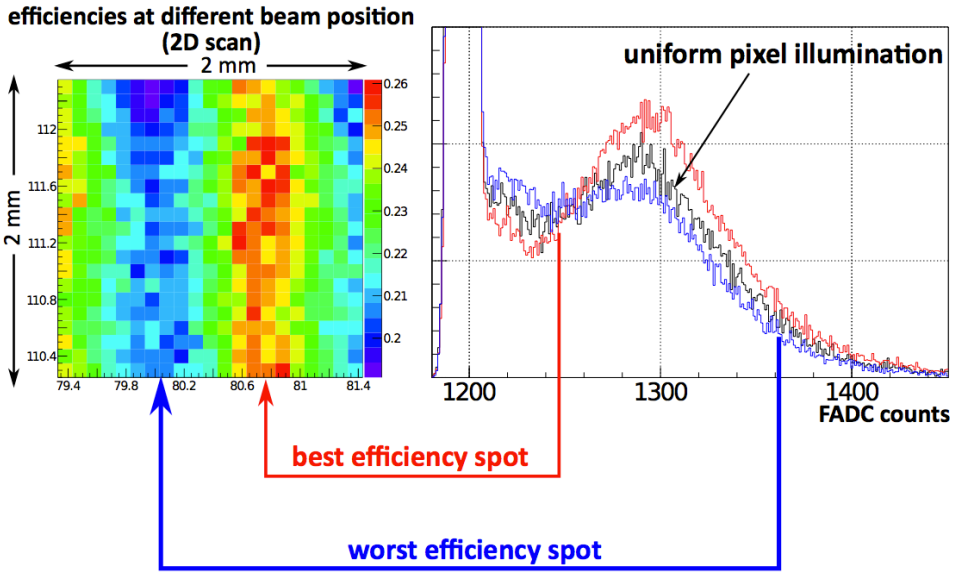
Efficiency vs Pixel number



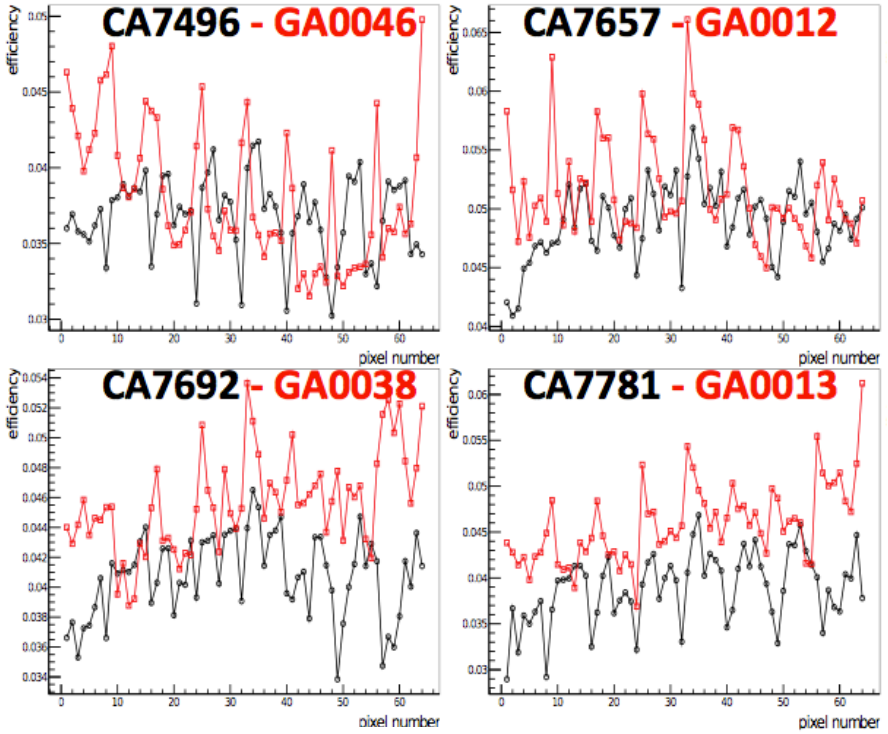
MA-PMT Photon Detector





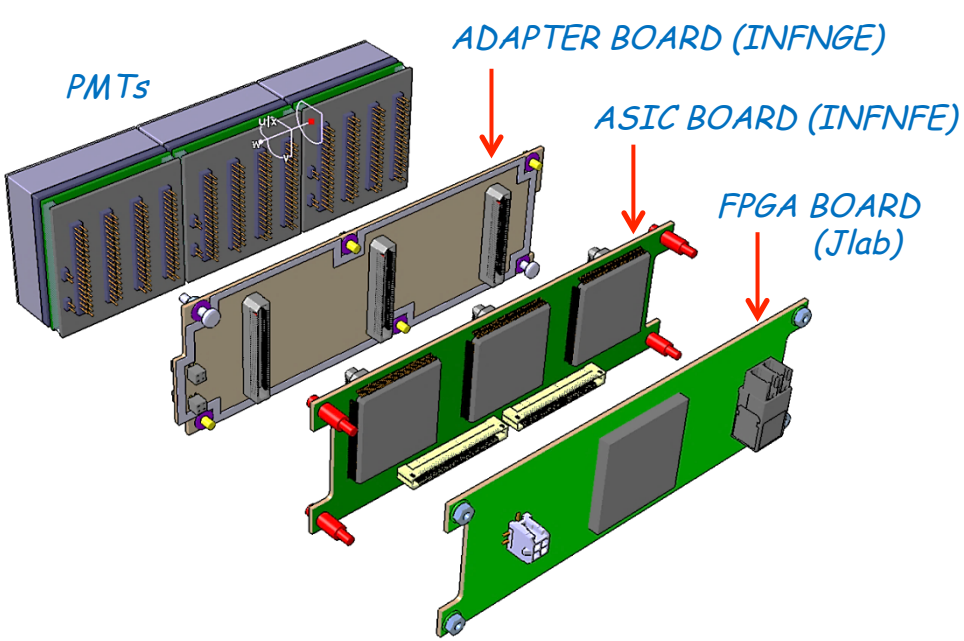


Efficiency with full pixel illuminated

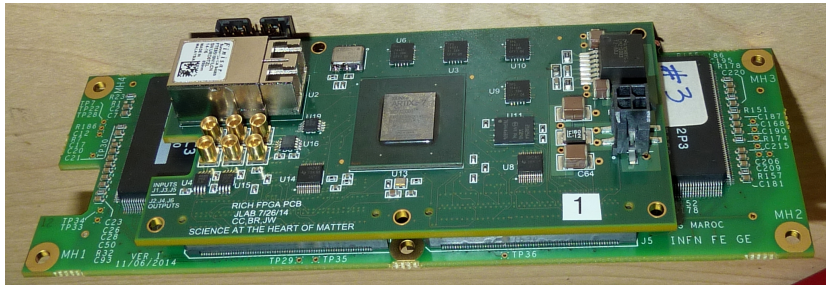


Front-End Electronics

INFN-GE/FE/LNF

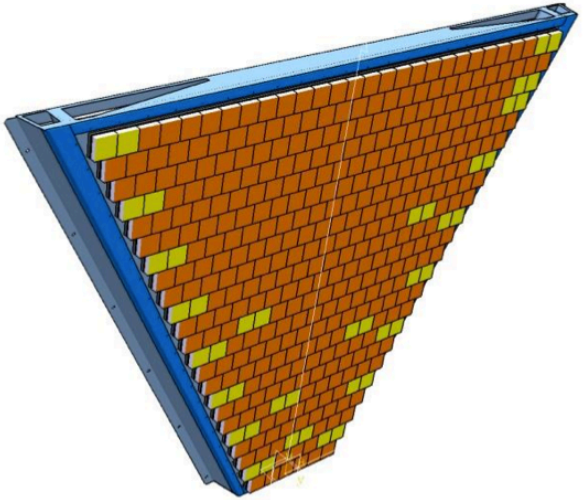


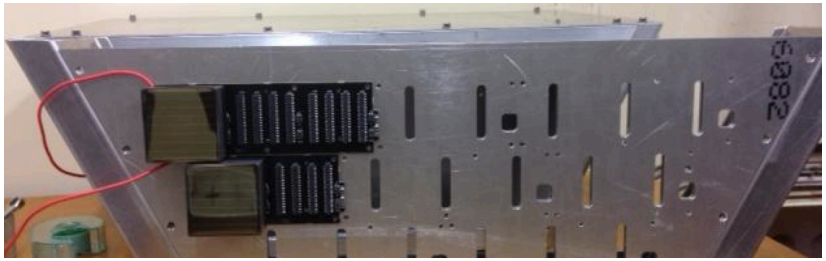
3 x ASIC BOARD (INFN) matching the



Universal FPGA BOARD (JLab)

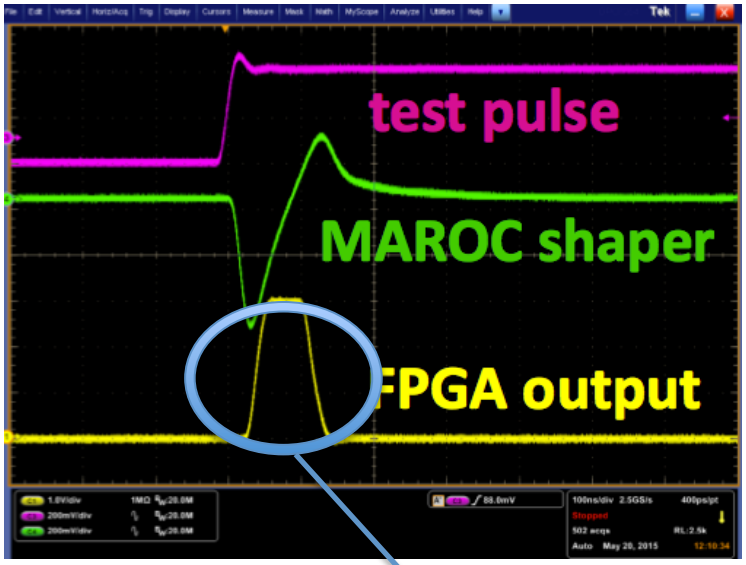
Possible applications @ JLab: Hall-D, SOLID, EIC, PET

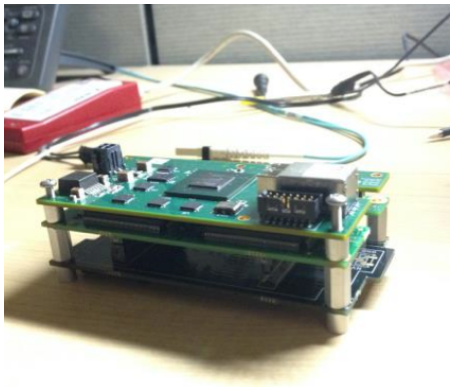




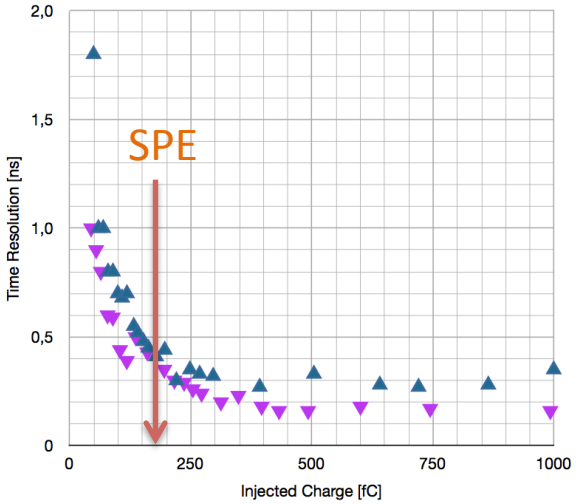
Assembling Tests (Frascati)

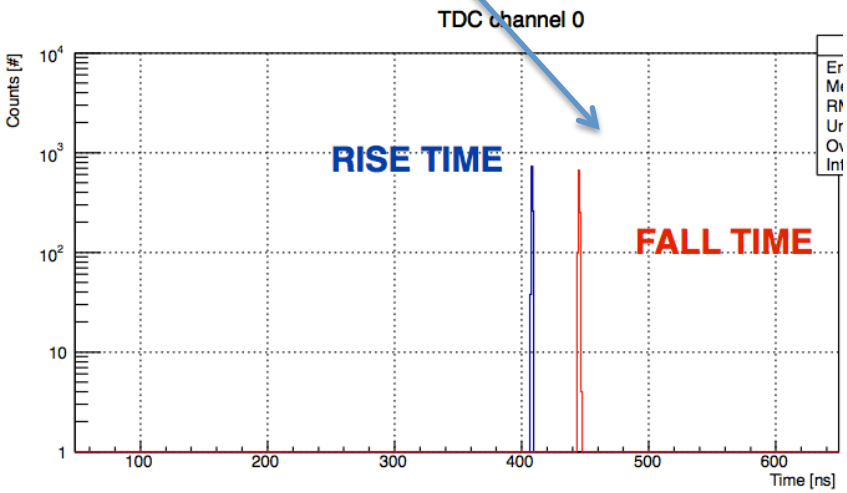
Front-End Electronics



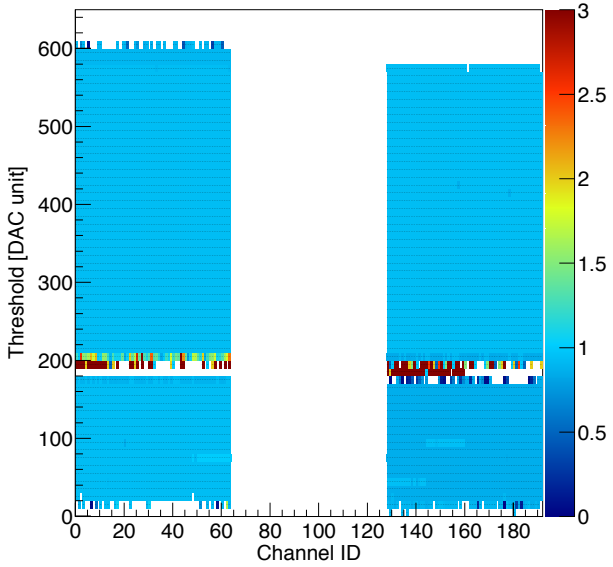


Fast shaper time jitter



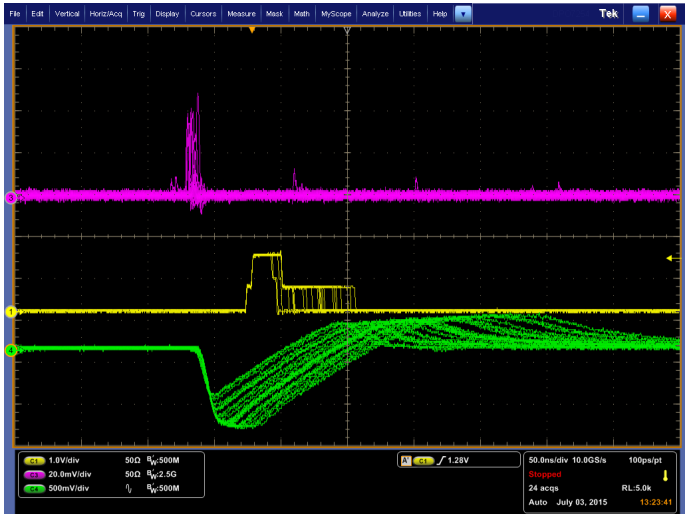


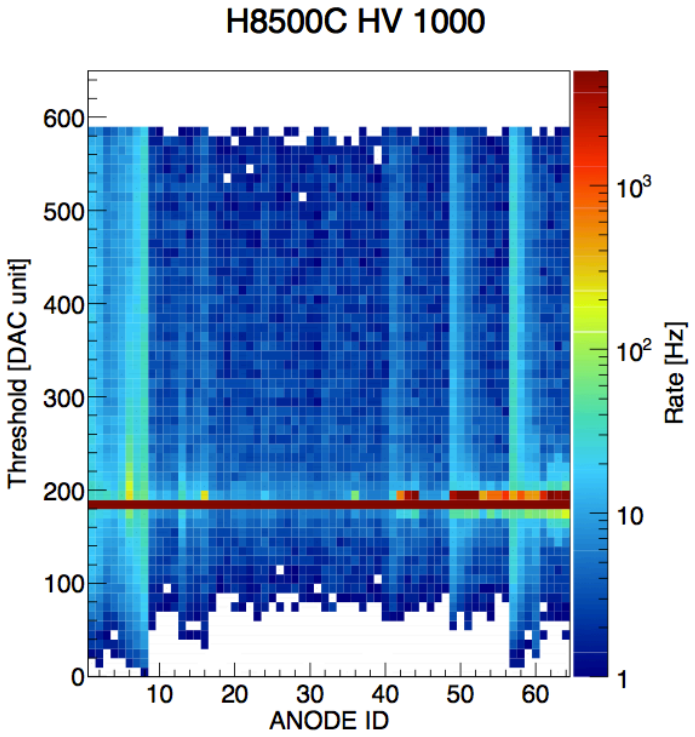
TDC Efficiency All channels



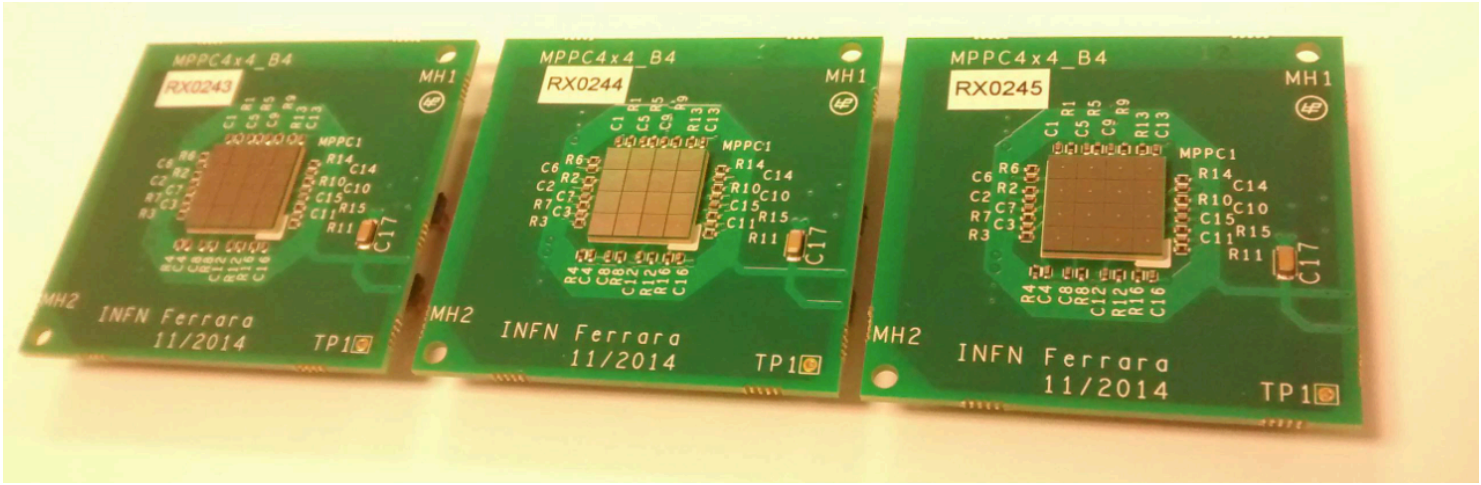
Front-End Electronics

MA-PMTs: Measured Dark Counts
in line with expectations

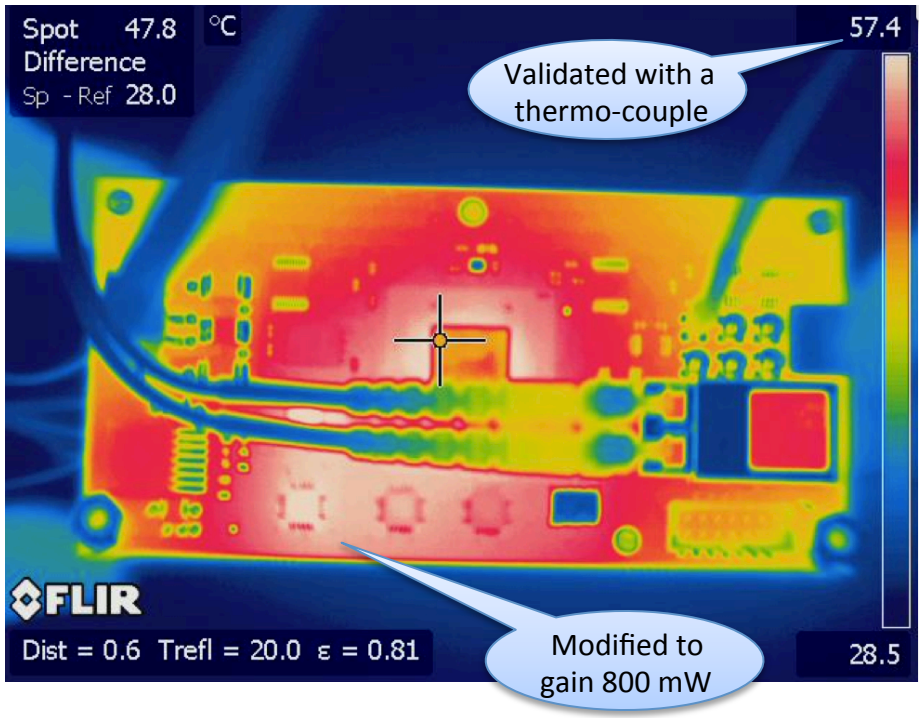




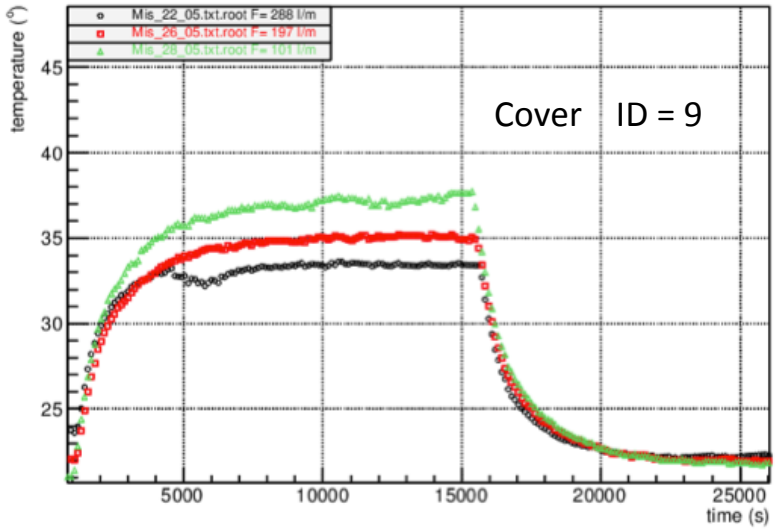
Next Step:



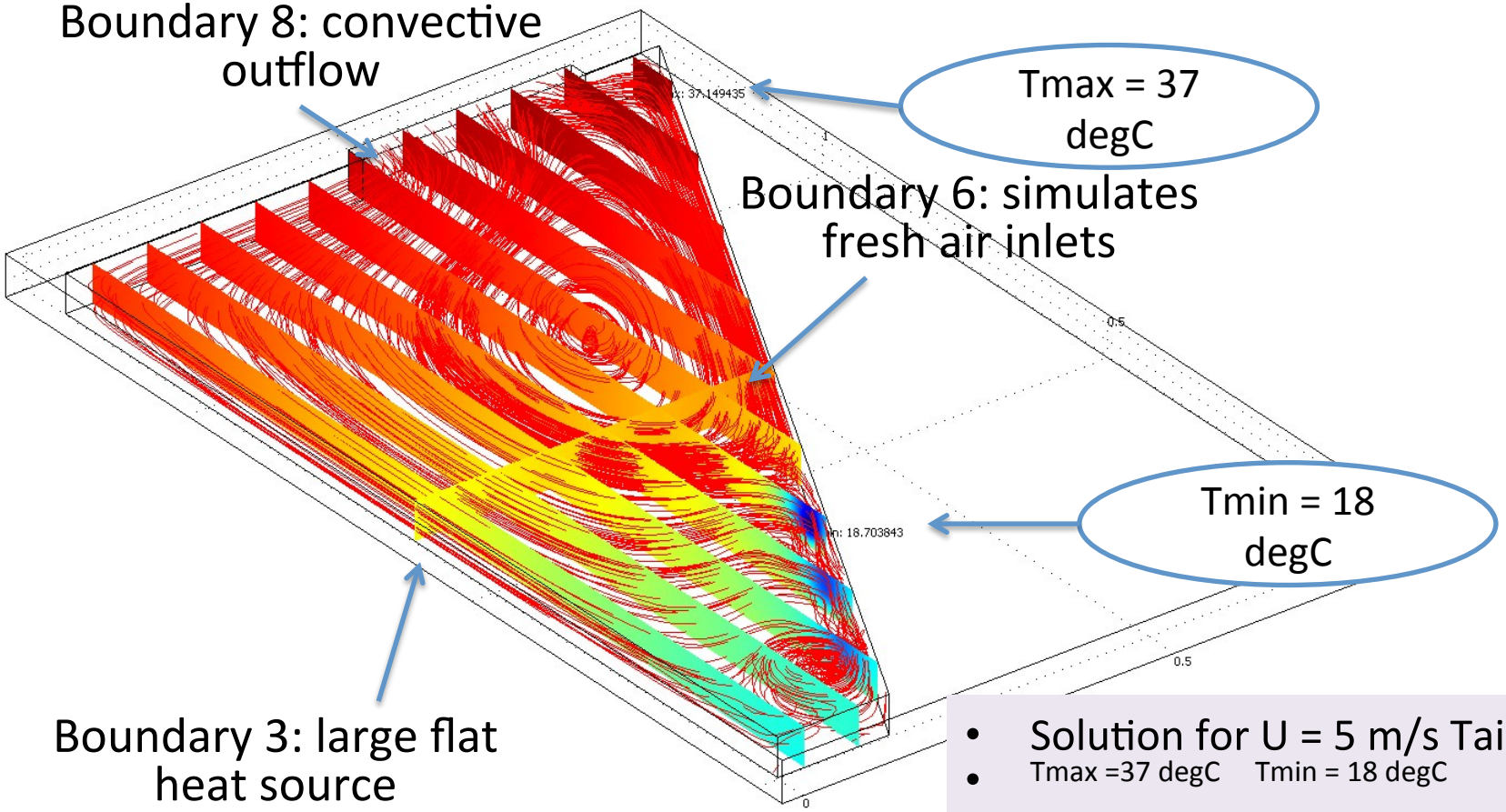
Tile power dissipation ~ 4 W



FTOF requirement: T < 100 F = 38 C



Only three inlets are considered – Inlets size to be tuned (here ∅~5 mm)

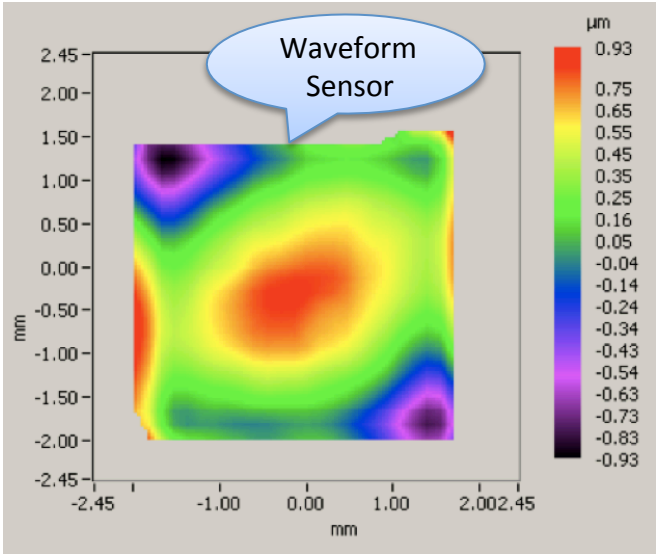


- Solution for U = 5 m/s Tair=20 degC
- Tmax =37 degC Tmin = 18 degC

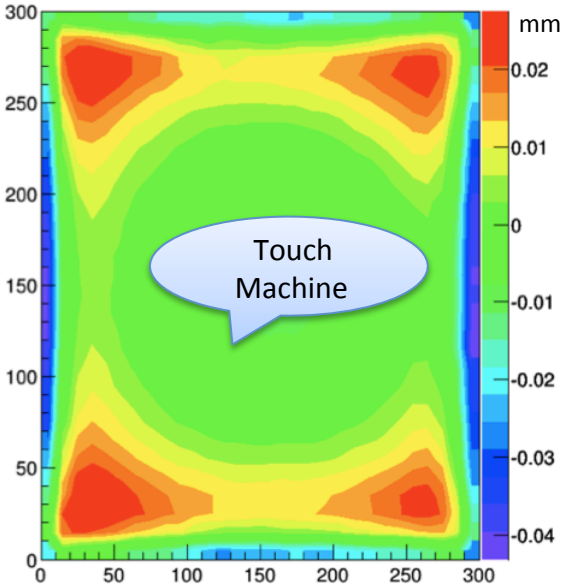
CFRP Spherical Mirror: Demo-1

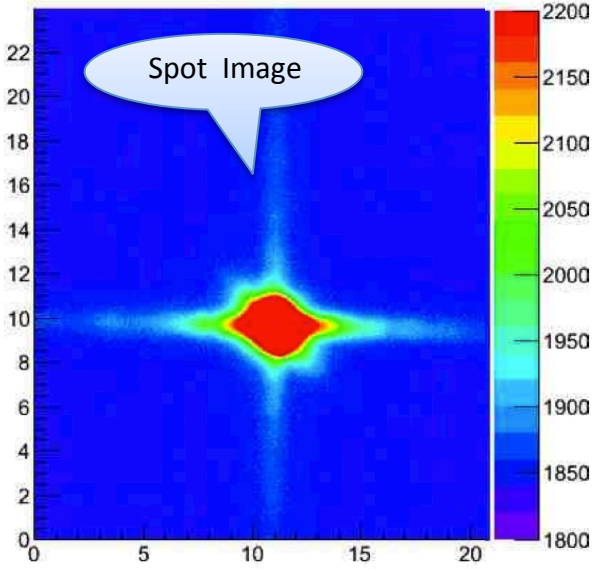
INFN-LNF/FE

CMA Report, April 2014

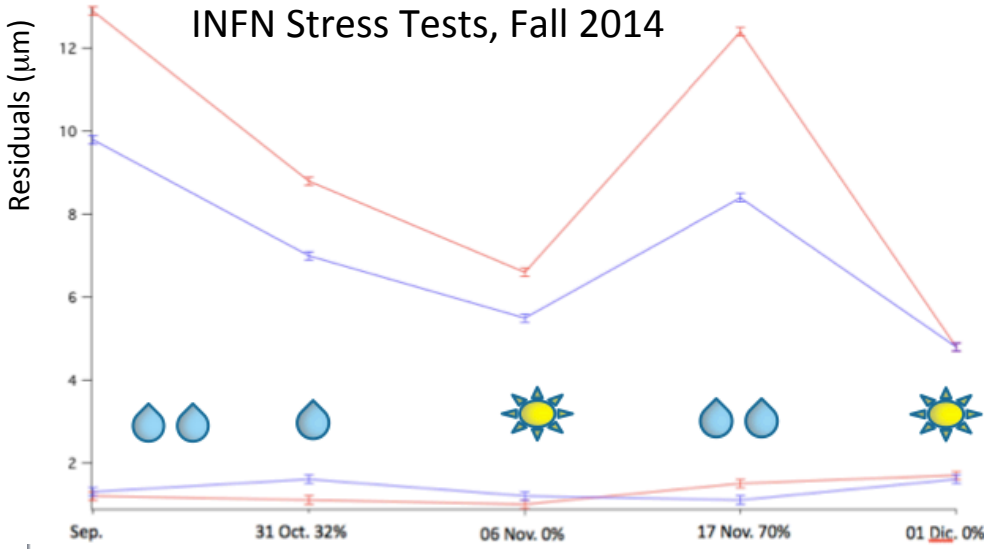


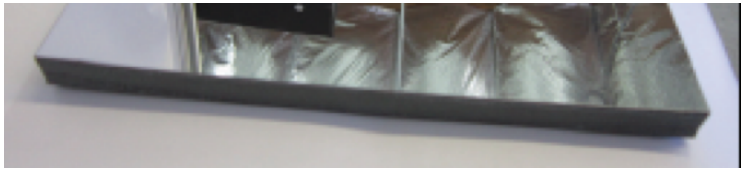
INFN Measurement, September 2014





INFN Stress Tests, Fall 2014



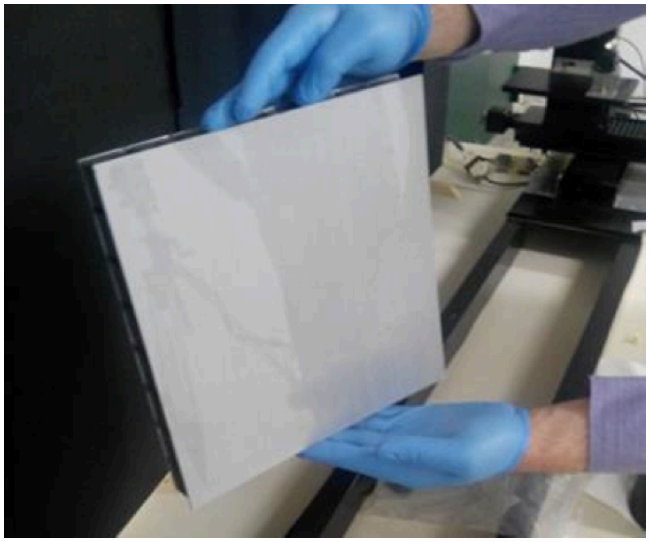


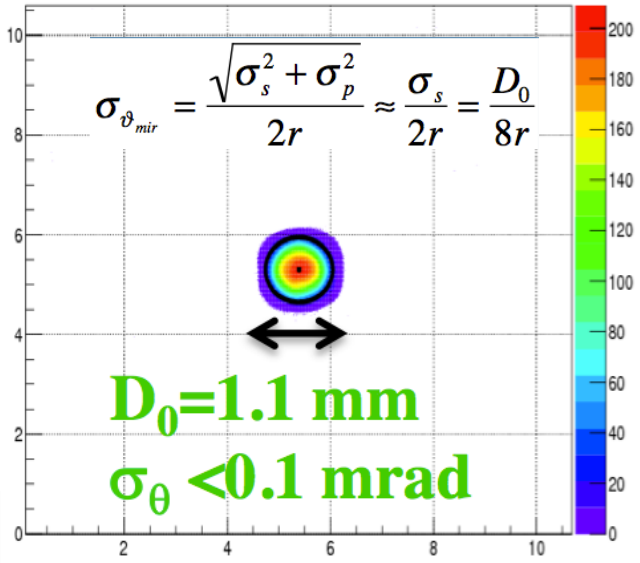
Foam core

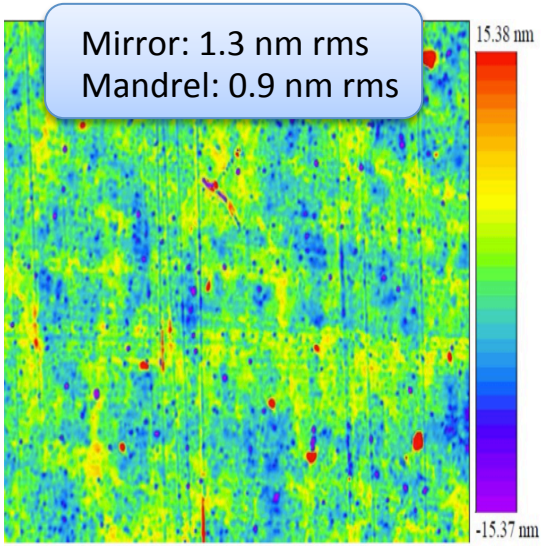
CFRP core

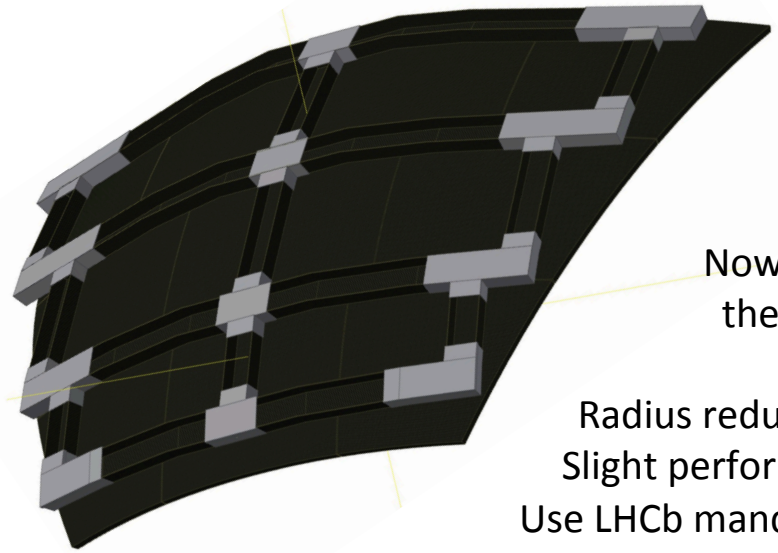
CFRP Spherical Mirror: Demo-2

INFN-LNF/FE



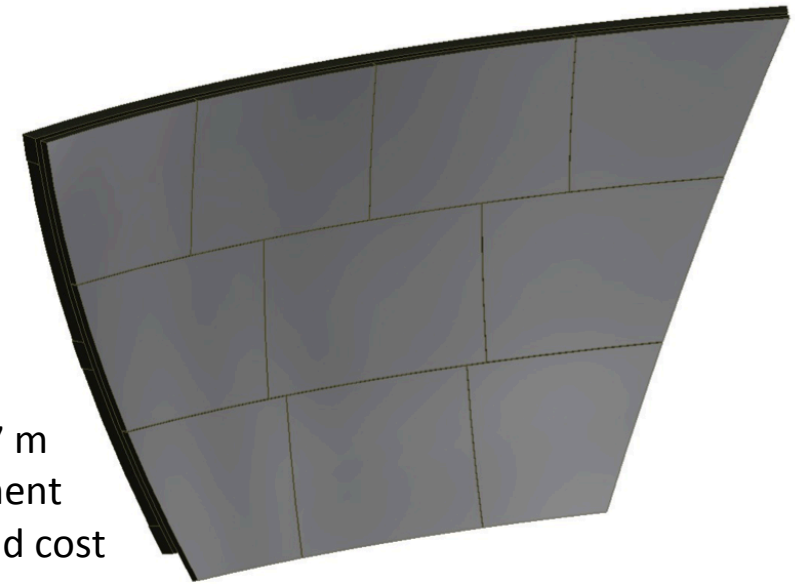






Now engineering
the production

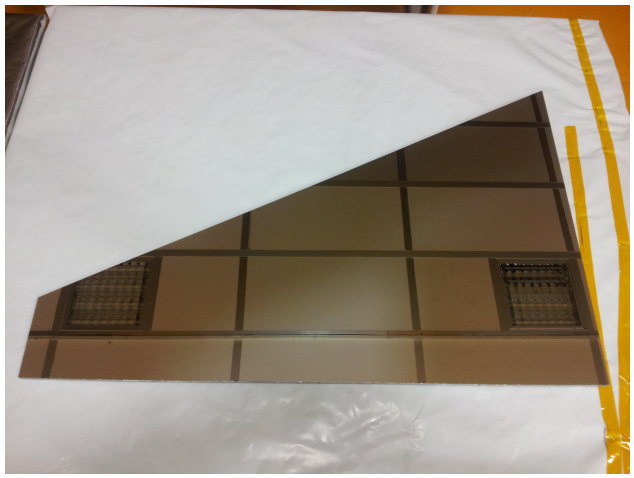
Radius reduced from 4 to 2.7 m
Slight performance improvement
Use LHCb mandrel: save time and cost



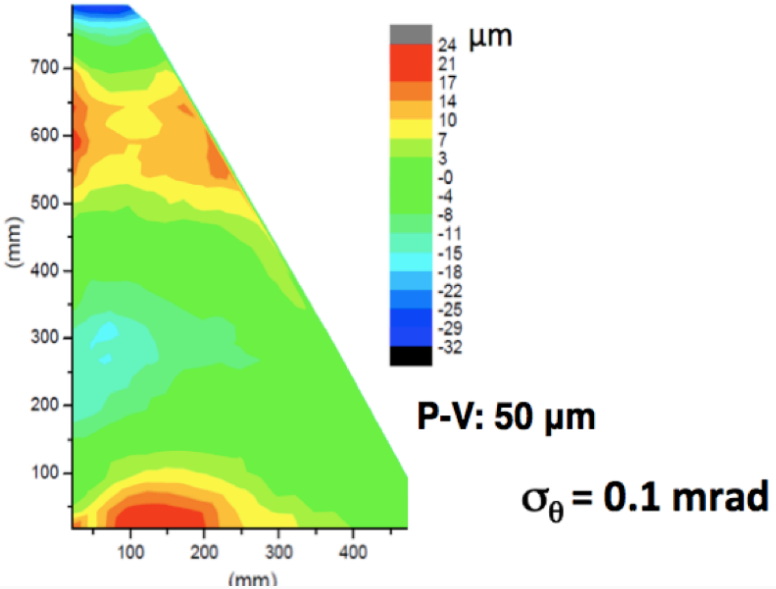
Glass-skin Planar Mirror

INFN-LNF

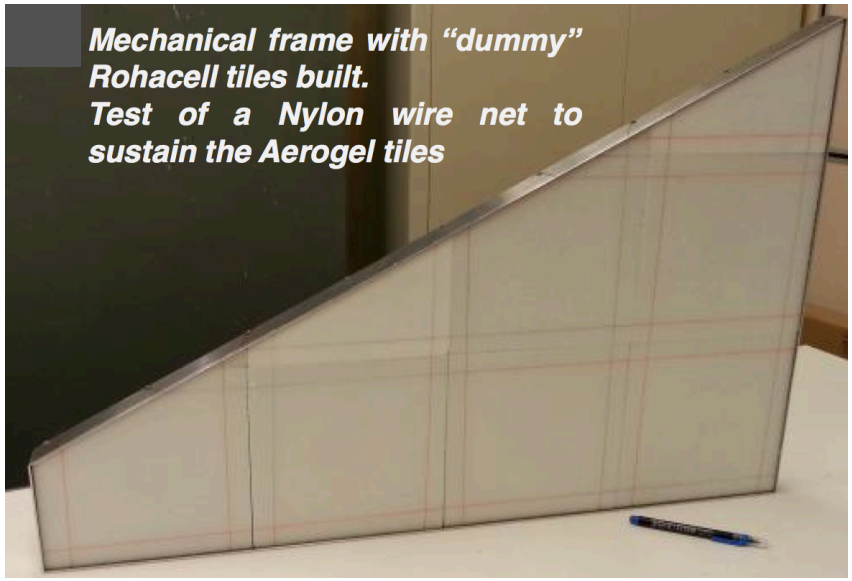
Demo delivered in spring 2014

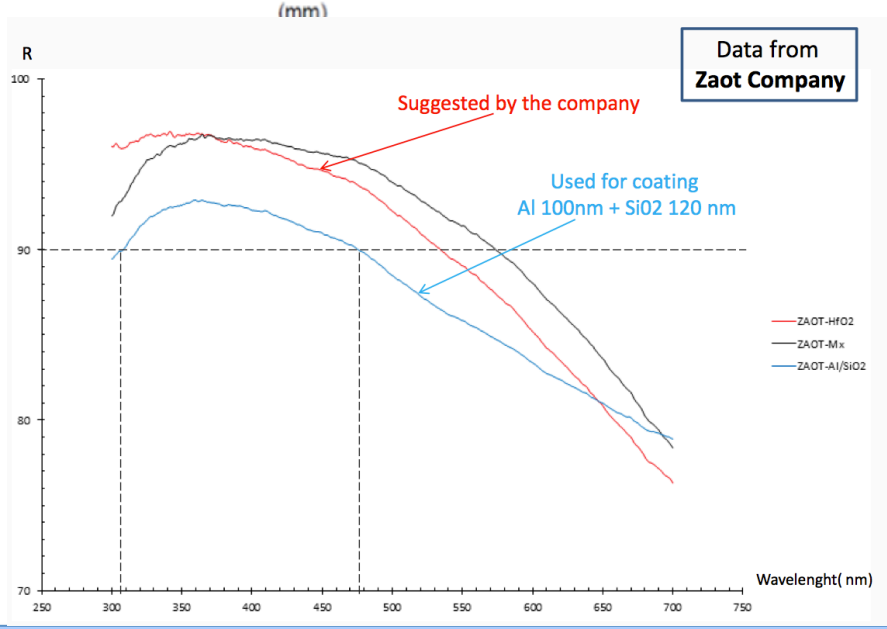


Production started in April 2014



Validation of aerogel holding scheme



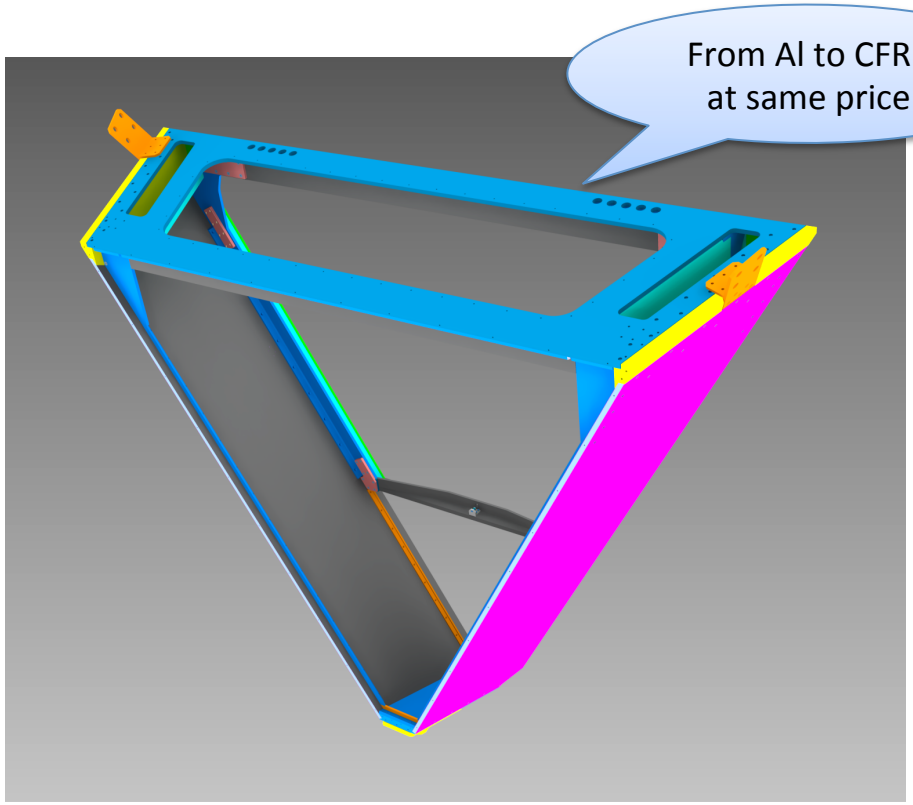


External Frame

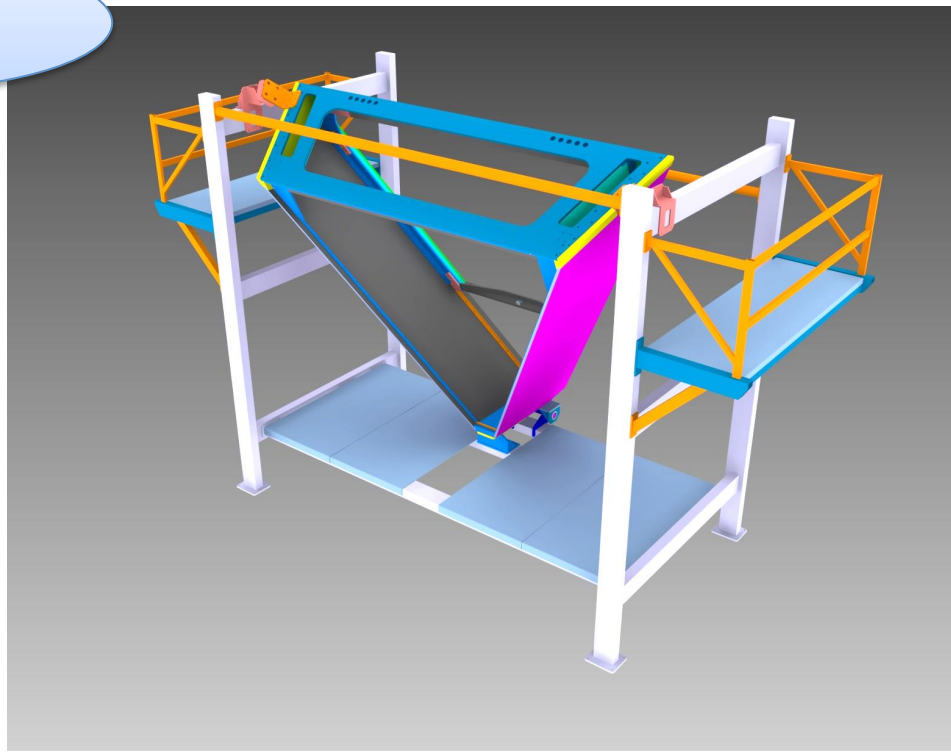
Contract awarded to aerospace company TecnaVan (Italy)
Delivery expected at the end of the year

Specialized in large area, light and stiff composites for aeroplanes.

RICH External Frame



RICH Assembling Structure



CLAS12 RICH Project Midterm Status

- ✔ Mechanics
- ✔ Electronics
- ✔ Photodetector

  - In line or better vs the project

- ✔ Mirrors

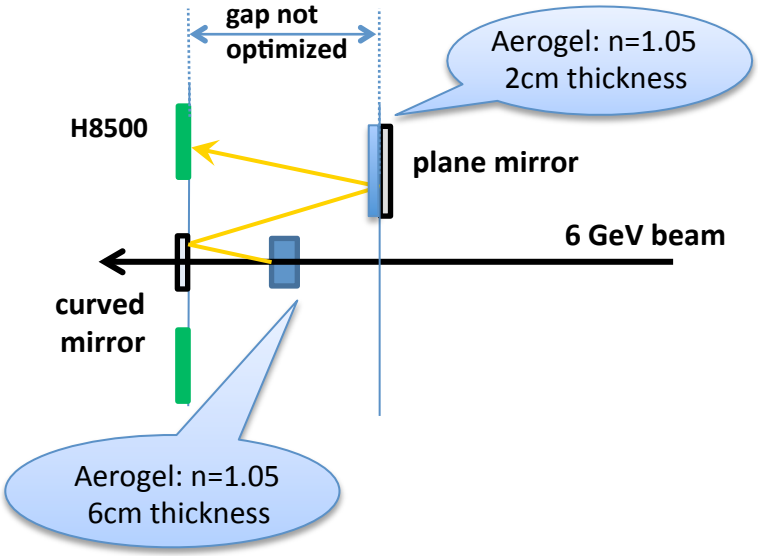
  - Technological issue identified and overcame
  - Initial delay is being recovered

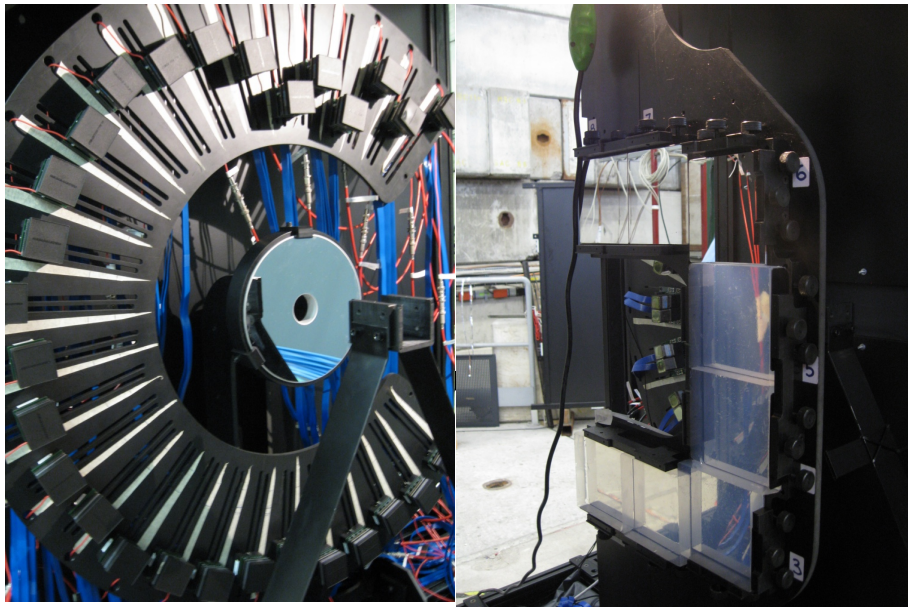
- ✔ Aerogel

  - Most critical part
  - Slow production start, should improve with time
  - Working to optimize specifications vs production efficiency

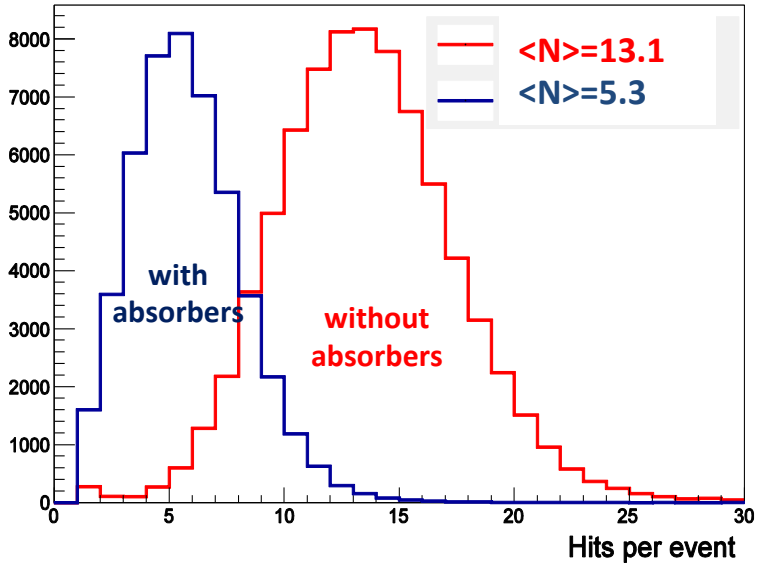
Ge: P. Musico, S. Minutoli
Fe: M. Contalbrigo, A. Movsisyan, M. Turisini, I. Balossino, P. Lenisa, L. Barion, R. Malaguti
LNF: M. Mirazita, V. Lucherini, D. Orecchini, S. Tomassini, G. Angelini, S. Pisano, R. Montgomery
ISS: E. Cisbani
Ba: R. Perrino

RHIC Prototype: Reflected Light Case

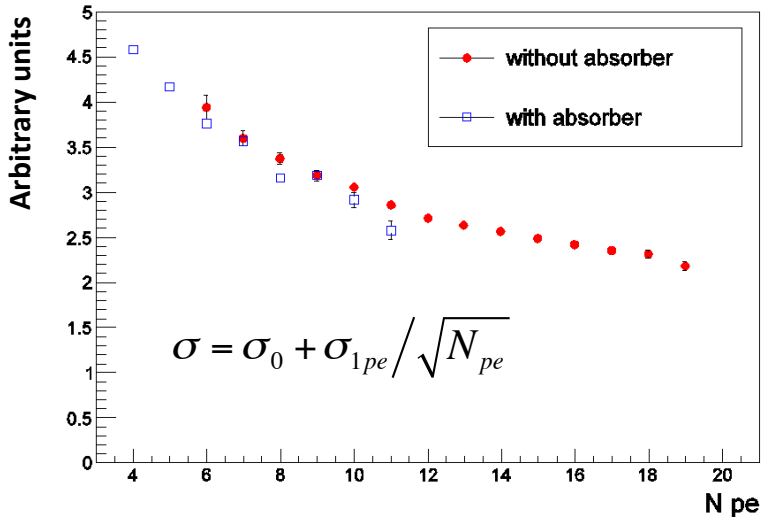




With absorbers: sizeable fraction of light survives



and resolution is not significantly degraded



CLAS12 RHIC: Resolution

Resolution	Direct (mrad)	Reflected (mrad)
Emission Point	1.7	1.7
Readout Accuracy	2.1	1.0
Chromatic Aberration	3.0	2.5
Aerogel Optical Prop.	≤ 1	≤ 2
Mirror System		≤ 1
σ_θ (1 p.e.)	4.2	3.9
Requirements	Direct	Reflected
Max. momentum	8 GeV/c	6 GeV/c
σ_θ (4σ separation)	1.4 mrad	2.5 mrad
Np.e. Yield	≥ 10	≥ 3

$$\sigma_{\vartheta_{Ch}} = \sqrt{\sum_i \frac{\left(\sigma^i_{\vartheta_{Ch}}\right)^2}{N_{p.e.}}}$$

RHIC Prototype: Direct Light Case

Resolution	Direct (mrad)
Emission Point	1.7
Readout Accuracy	2.1
Chromatic Aberration	3.0
Aerogel Optical Prop.	≤ 1
Mirror System	
σ_θ (1 p.e.)	4.2
Requirements	Direct
Max. momentum	8 GeV/c
σ_θ (4σ separation)	1.4 mrad
Np.e. Yield	≥ 10