

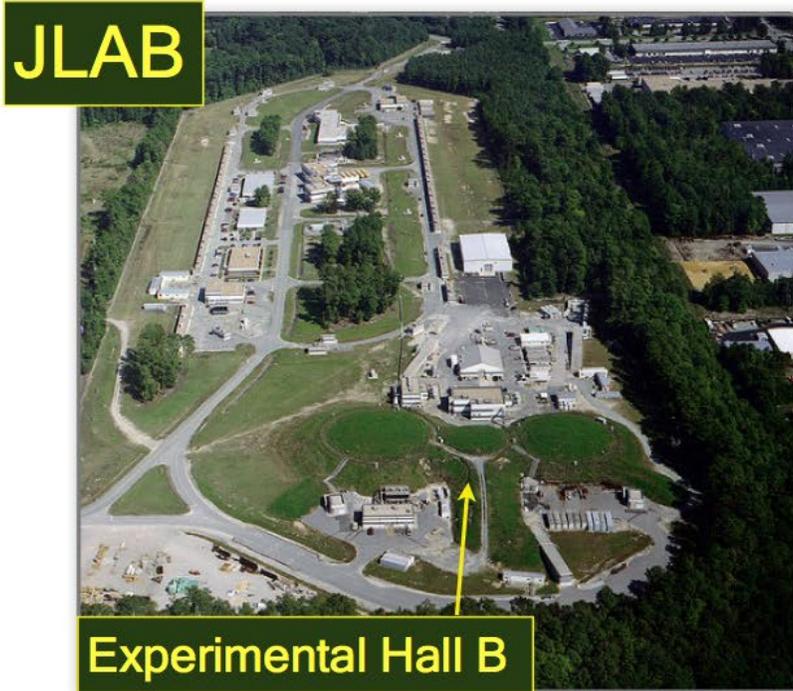
Attivita' JLab12

Marco Mirazita

Consiglio di Laboratorio – 6 luglio 2022

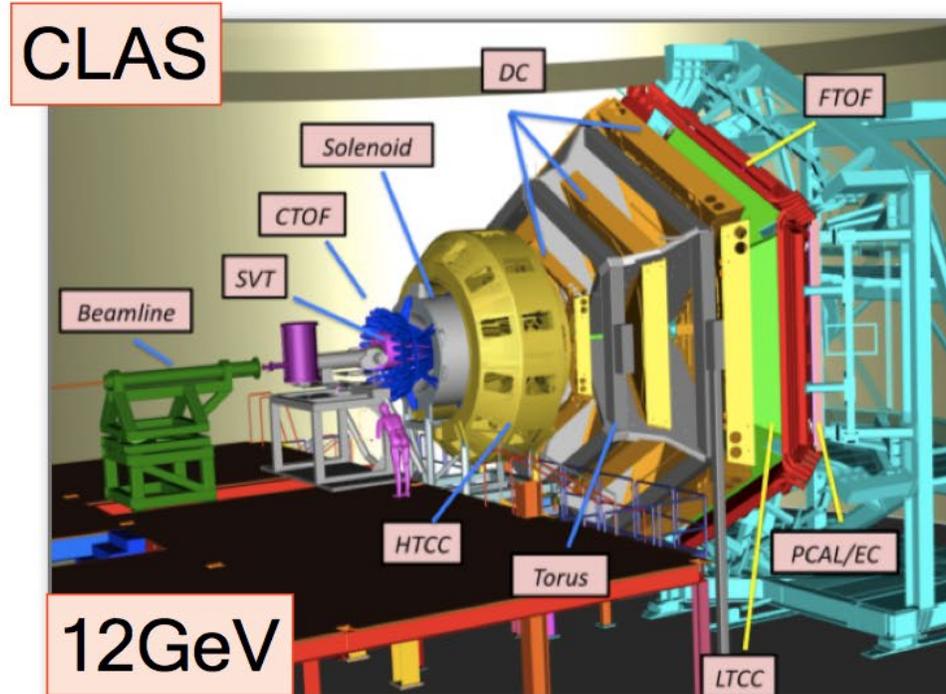
The CLAS12 spectrometer at JLab

The Thomas Jefferson National Accelerator Facility, Newport News, Virginia, USA



Continuos Electron Beam Accelerator Facility (CEBAF)

- **Beam delivered simultaneously in 4 Halls**
- **Max beam energy 12 GeV in Hall D**
- **high beam current $\sim 100 \mu\text{A}$**



CEBAF Large Acceptance Spectrometer (CLAS)

- **Luminosity up to $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$**
- **Max beam energy 10.6 GeV**
- **High polarization electron beam**
- **H and D targets (polarization), nuclear targets**
- **Wide acceptance**

The CLAS12 physics program in Hall B

2018-20 polarized electron beam on unpolarized H and D targets: **SIDIS, exclusive channels, hadron spectroscopy,...**

2020-21 polarized electron beam on D target (BONUS experiment): **free neutron structure functions**

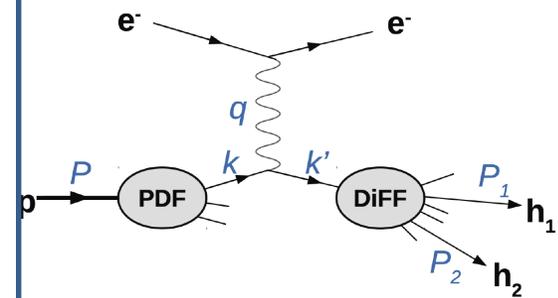
2021 polarized electron beam on nuclear targets (electrons for neutrinos exp.): **measurement of eA data**

2021 **First publications in SIDIS measurements with H target**

2022 **4 publications with CLAS12 data on DIS measurements, 2 under review, many more in advanced stage**

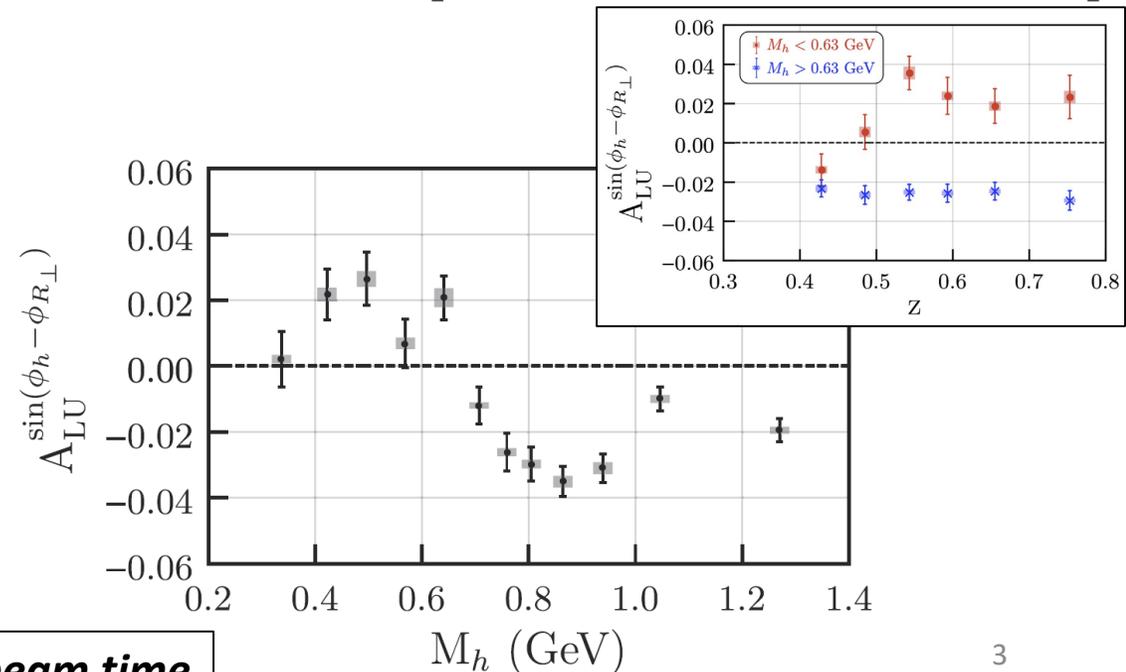
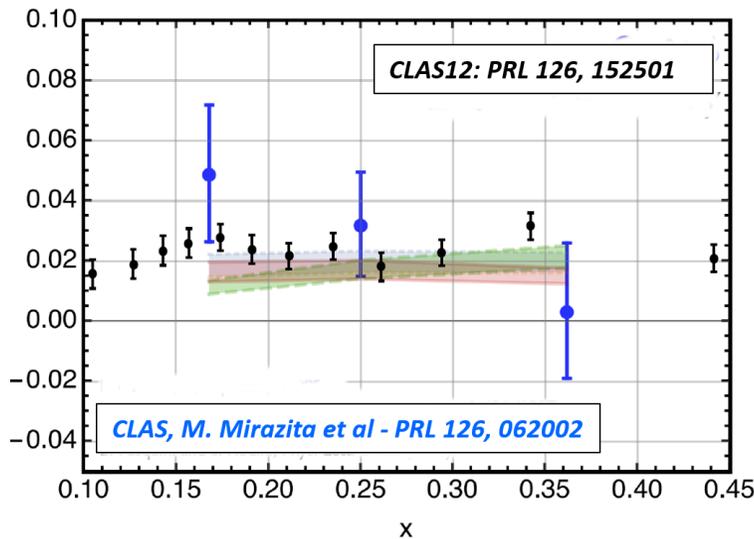
$e p \rightarrow e \pi^+ \pi^- X$

$d\sigma = d\sigma_{UU} + d\sigma_{LU} + \dots$



$$d\sigma_{LU} \propto C \lambda_e \sin(\phi_h - \phi_{R_\perp}) \mathcal{I}[f_1 G_1^\perp]$$

$$d\sigma_{LU} \propto W \lambda_e \sin(\phi_{R_\perp}) \left[x e(x) H_1^{\leftarrow}(z, M_h) + \frac{1}{z} f_1(x) \tilde{G}^{\leftarrow}(z, M_h) \right]$$



about 20% of the data collected so far and 10% of the approved beam time

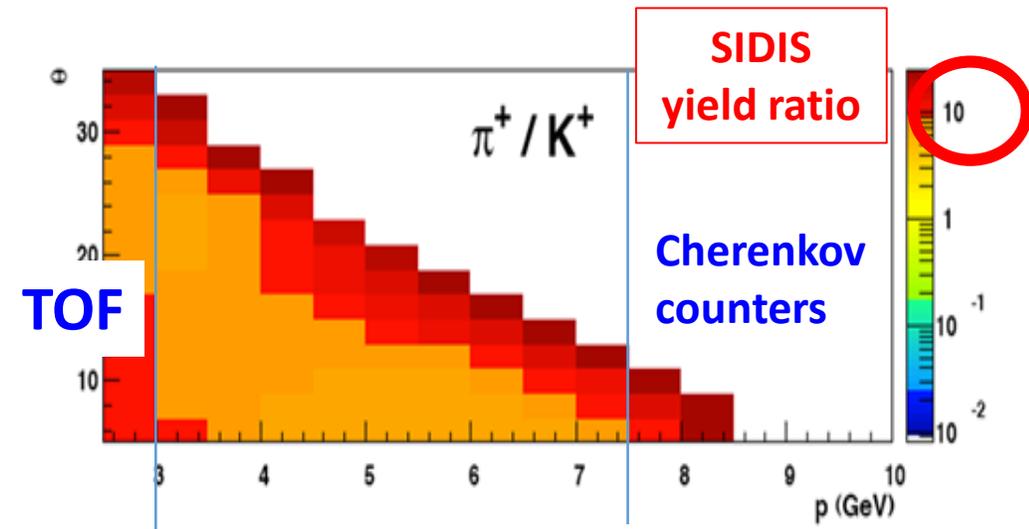
A Ring Imaging Cherenkov detector for CLAS12

A large fraction of the approved CLAS12 physics program requires good kaon identification

- flavor separation in SIDIS
- hard exclusive meson production
- exotic hybrid meson spectroscopy

CLAS12 provides good kaon ID only at low and high momentum regions

- pion production rate is one order of magnitude higher than kaon



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 $\sim 1:500$

The RICH project

- 2010** First studies initiated by Patrizia Rossi (LNF) and Evaristo Cisbani (RM1)
- 2011** First test beam at CERN
- 2012** Intensive campaign of test beam at CERN and LNF
- 2013** Technical Design Report
Project for 2 RICH modules approved by DOE and JLab
Premiale funding from MIUR for the construction of 2 RICH sectors
- 2014** Start construction of first module

- January 2018** First RICH module installed in CLAS12
CLAS12 start data taking at 11 GeV with unpolarized hydrogen target

- 2018** Start construction of second module

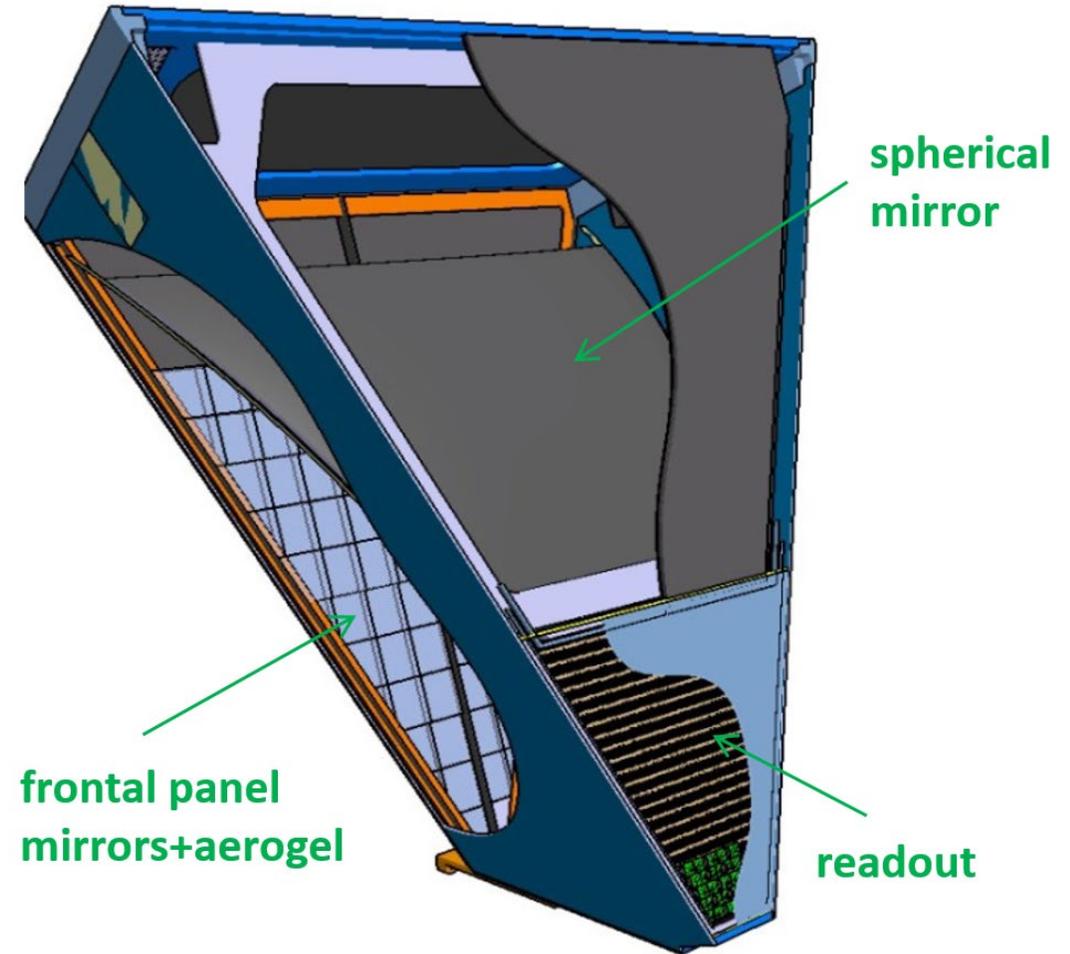
- June 2022** Second RICH module installed in CLAS12
CLAS12 start data taking with polarized targets

Institutions
INFN: LNF, Fe, RM1/ISS, Ge, Ba
Glasgow U. (UK)
Gutemberg U. (Mainz, Ge)
Jefferson Lab (USA)
Argonne Lab (USA)
Duke, Duquesne, GWU, UConn (USA)
UTFSM (Valparaiso, Chile)
Kyungpook U. (Korea)

The two RICH modules were both installed as planned in the JLab data taking schedule

The CLAS12 RICH

- **very light mechanical structure in aluminum and carbon fiber**
 - 4.2 m high, 4 m wide, 1.2 m deep
- **102 aerogel tiles, mostly 20x20 cm², thickness 2 and 3 cm**
 - assembled in 3 layers
- **7 planar glass mirrors**
 - 2 frontal, 5 lateral
 - total about 7 m² surface
- **10 spherical mirrors in carbon fiber**
 - assembled on a carbon fiber frame
 - total about 4 m² surface
- **391 Multi-Anode PMT Hamamatsu H12700**
 - 25k independent pixels
- **138 readout units**
 - adapter+MAROC+FPGA per unit
 - binary readout, TDC information (leading and trailing edges)
 - adjustable preamp gain and thresholds



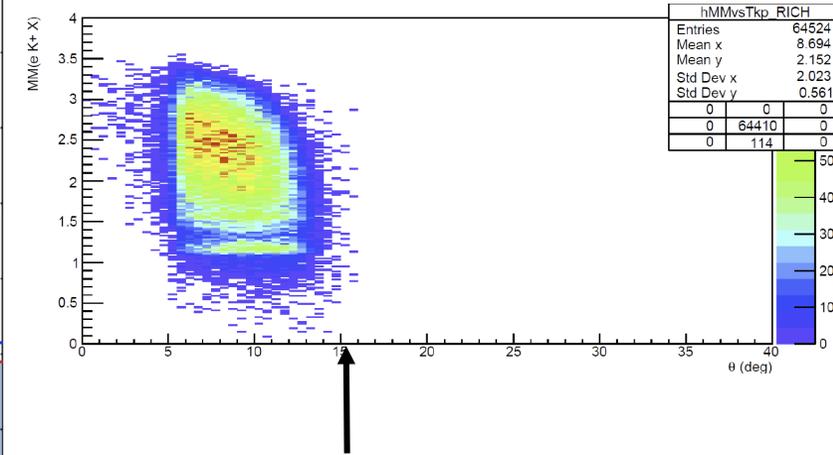
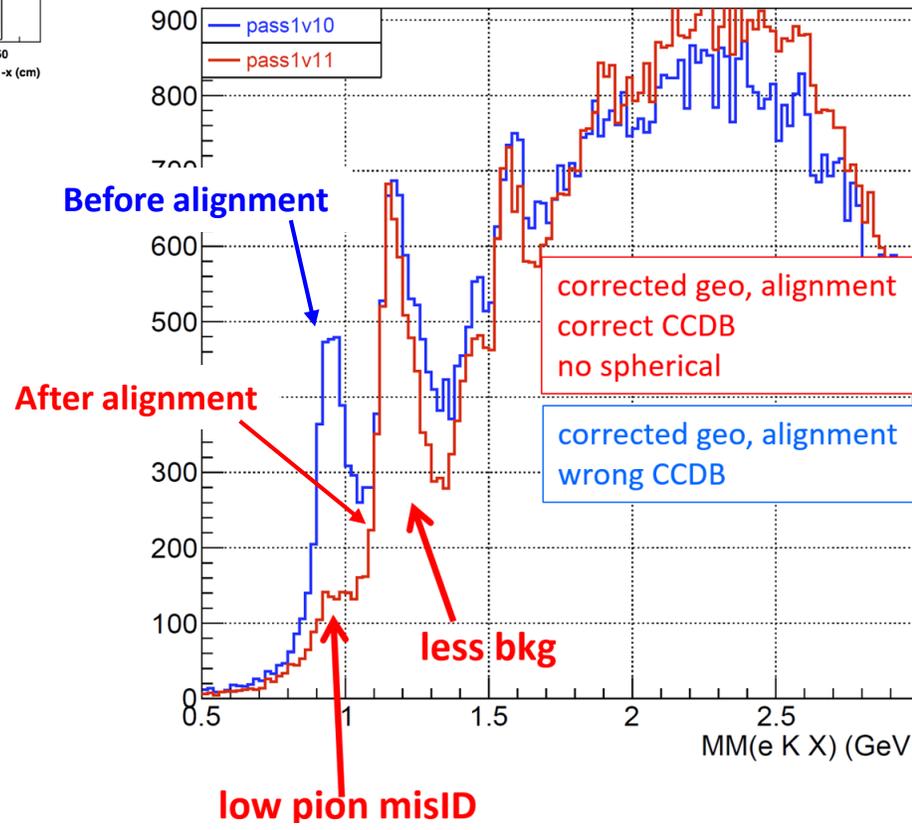
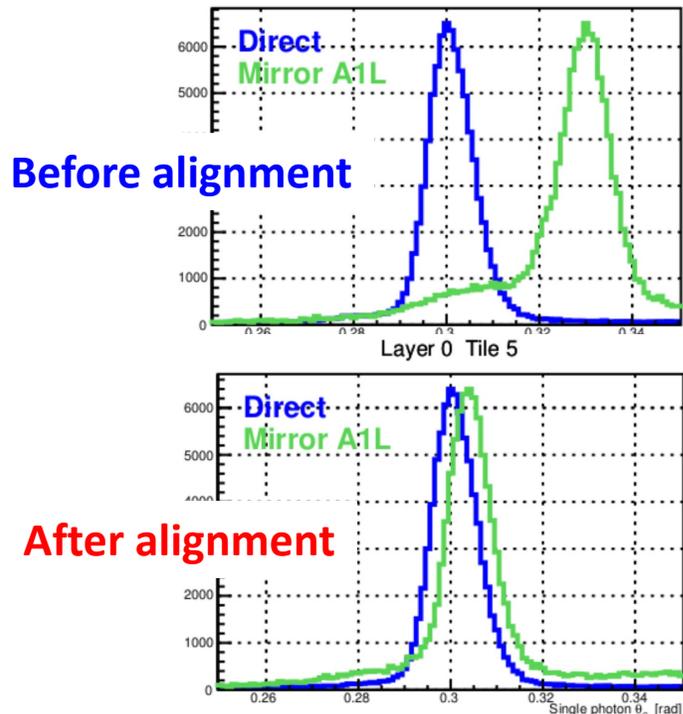
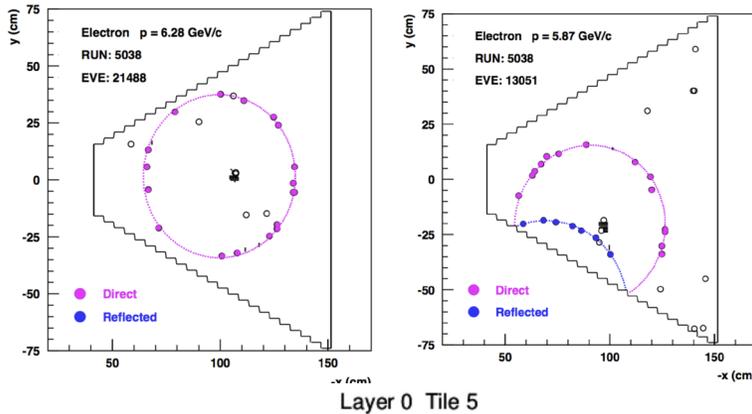
PID with RICH-1

RICH Particle ID performance improved after first run of alignment of the internal elements with “brute force” approach:

- move and rotate each element at once
 - choose the set of alignment parameter that minimizes Cherenkov angle differences
- works for simple topologies (no spherical mirrors)

Selecting events $e p \rightarrow e K^+ X$ and looking at the missing mass

- X can be Λ , Σ^0 , ... but not a nucleon



Kinematic acceptance limited at 15 deg

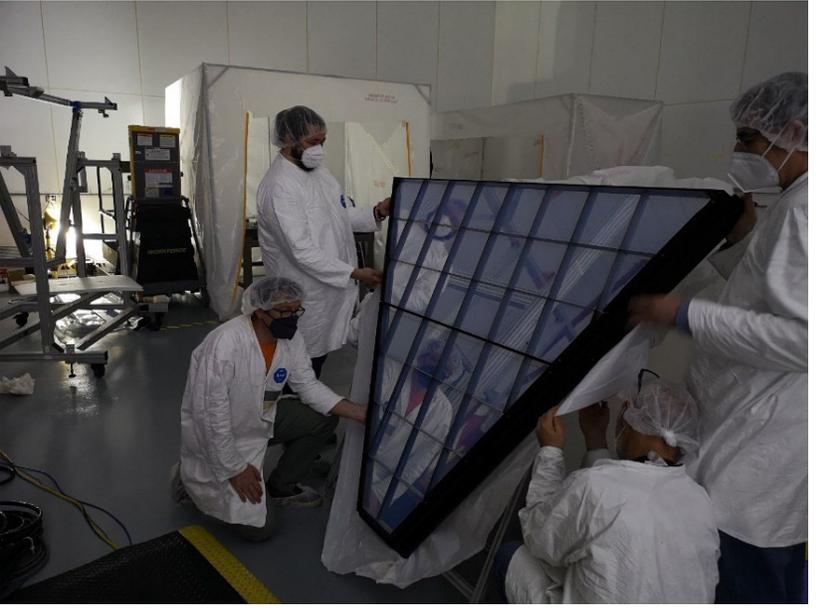
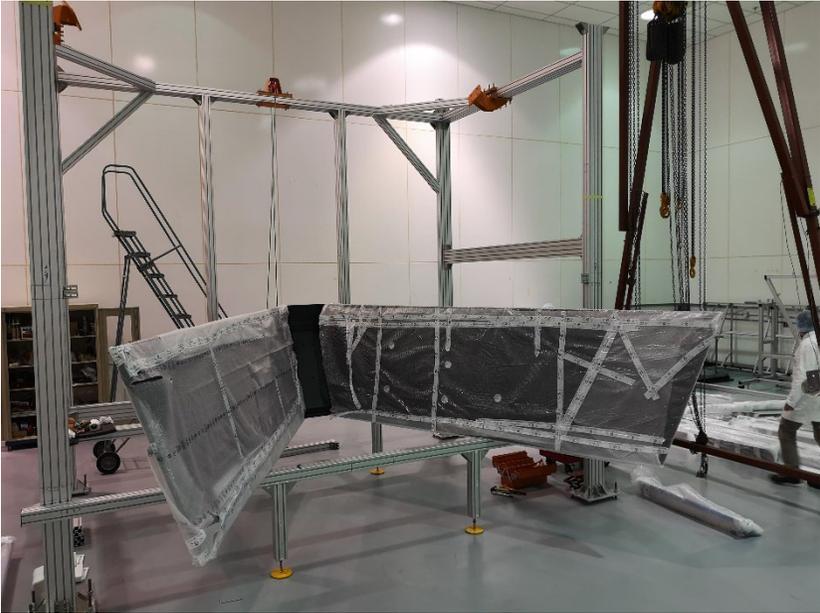
RICH-2 construction and assembly timeline

2017	First aerogel tiles
2021	Completion of the mechanical structure Completion of planar mirrors Completion of the MAPMT production Completion of aerogel production
2/2022	Completion of the readout electronics
4/2022	Completion of the spherical mirror frame
May 23, 2022	Spherical mirrors at JLab → The final assembly started

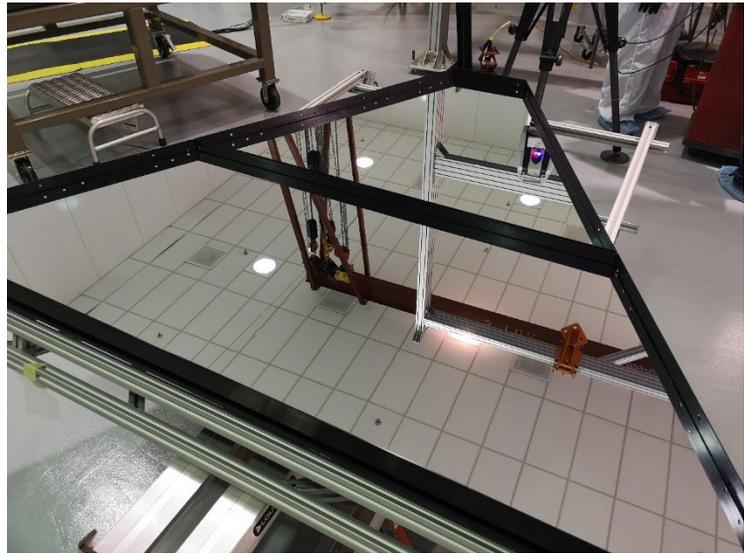
Main assembly works carried out during 3 visits of INFN personnel

- **January** **Mechanical structure assembly**
- **March-April** **Start assembly and test of the electronics**
Assembly test of various components
- **May**
May 30 **Detector sealed, final tests**
June 1 **Detector transported in the experimental hall**
June 2 **Installation in Hall B**
June 3 **Commissioning completed**
June 8 **First data with 2 RICH modules**

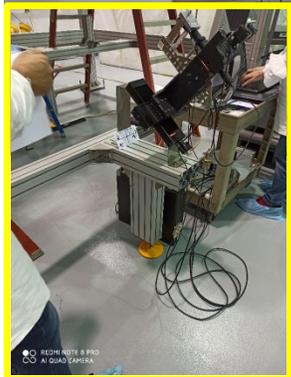
RICH-2 assembly and installation in pictures



RICH-2 assembly and installation in pictures



● ○ REDMI NOTE 8 PRO
AI QUAD CAMERA

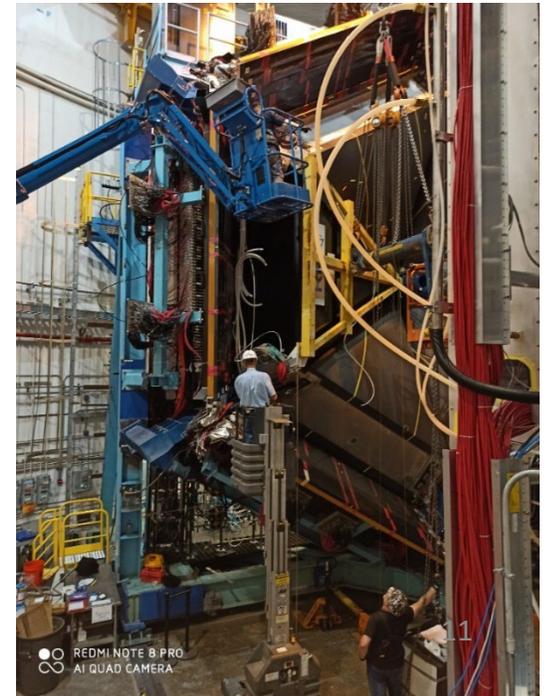
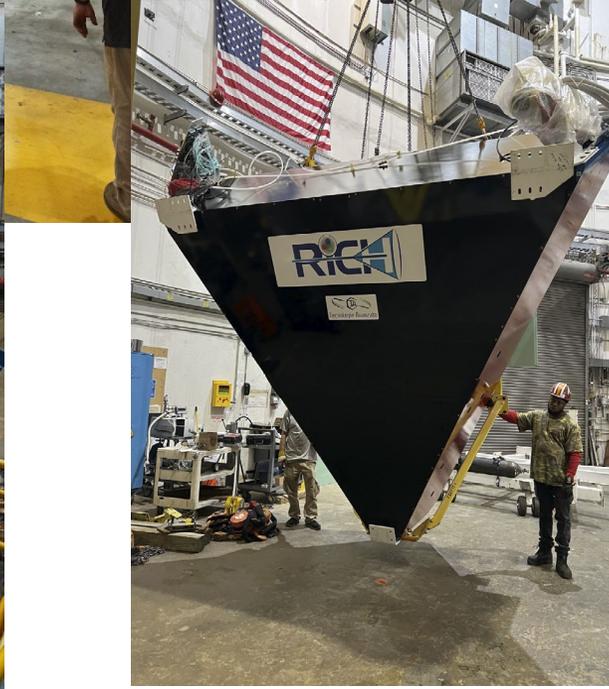


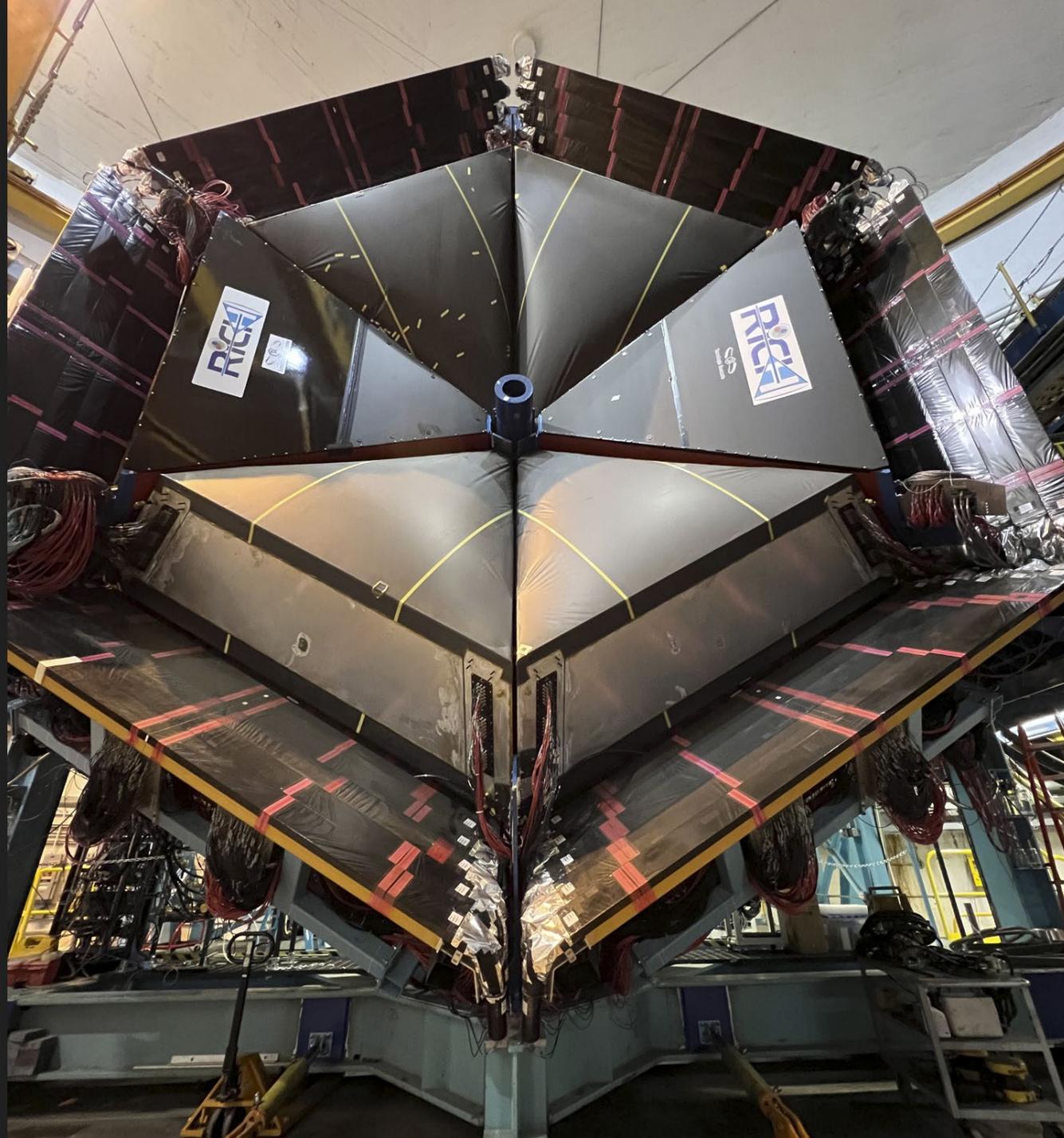
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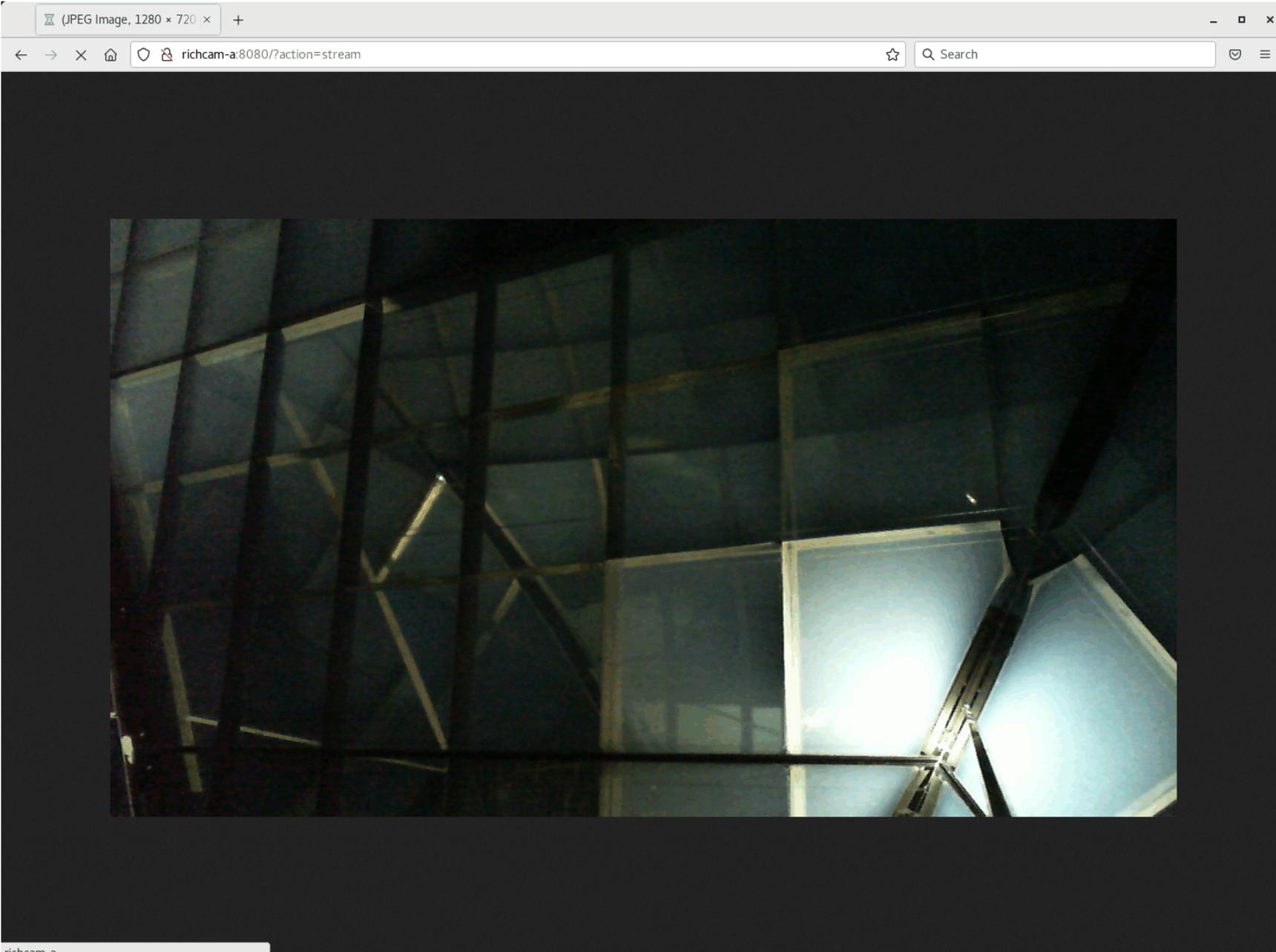
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RICH-2 assembly and installation in pictures

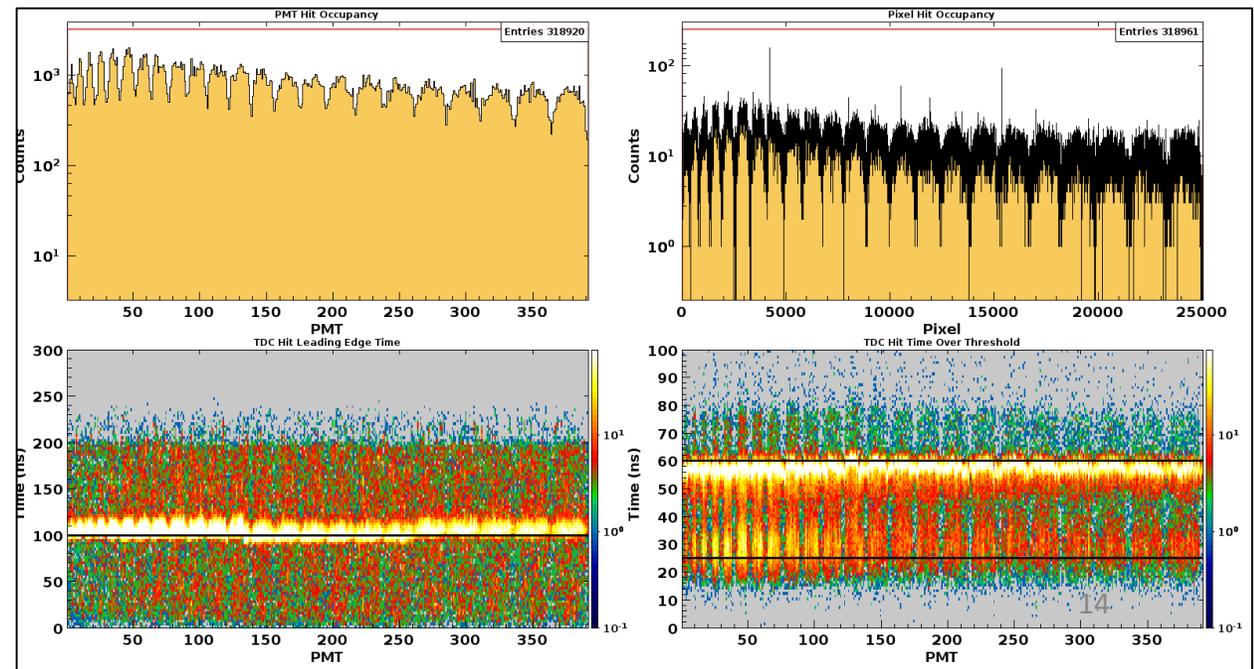
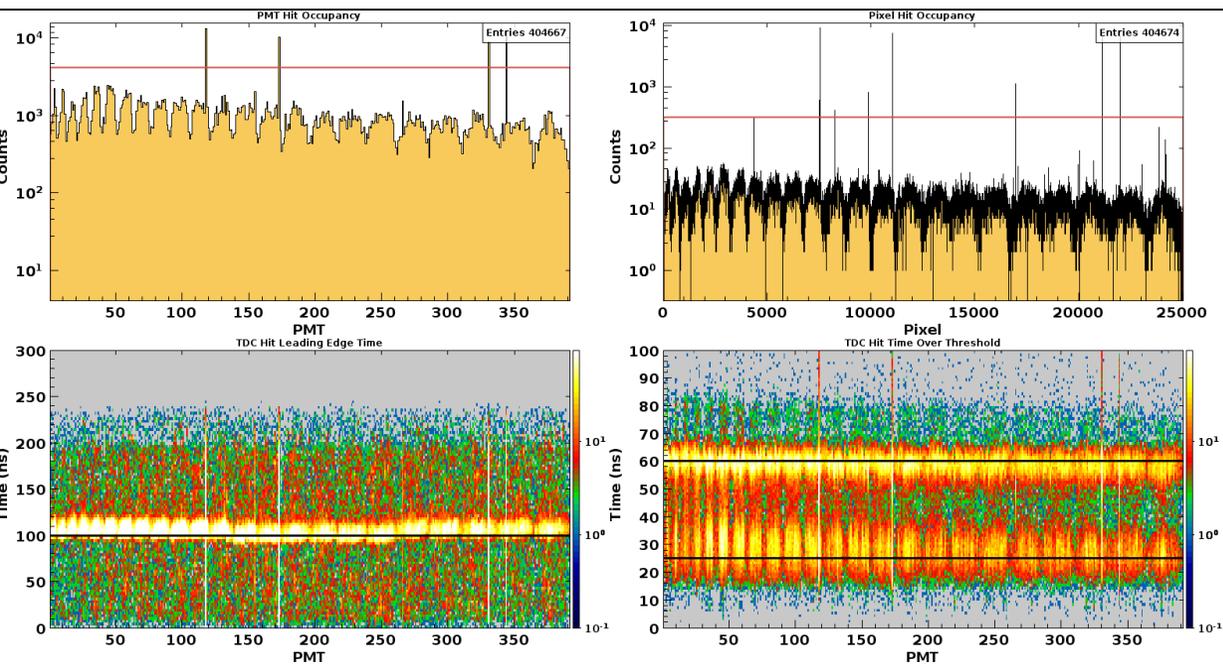
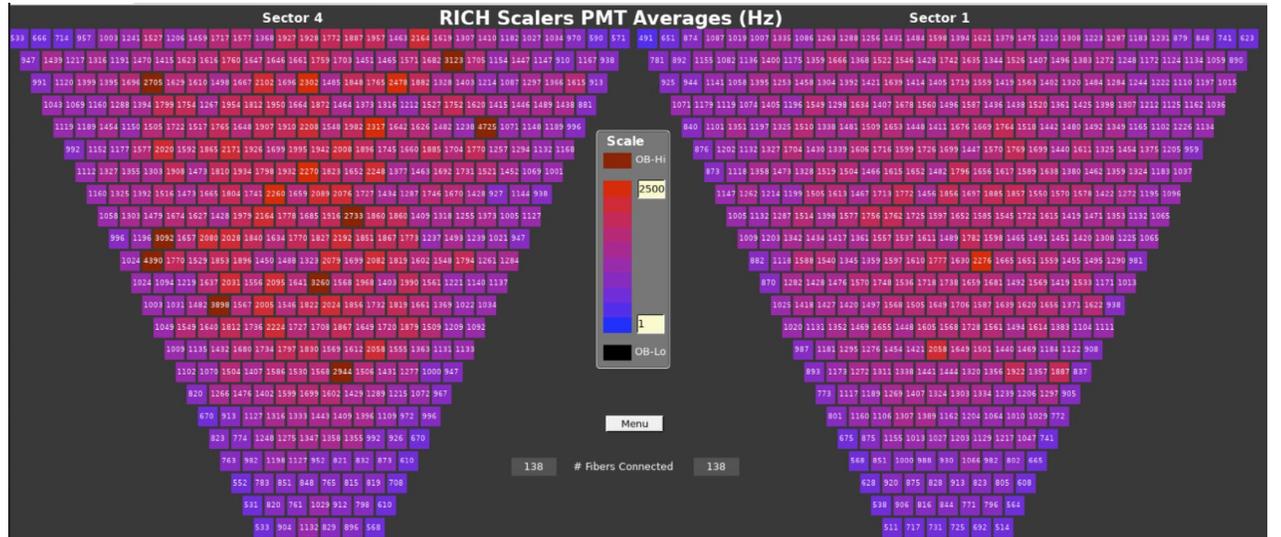
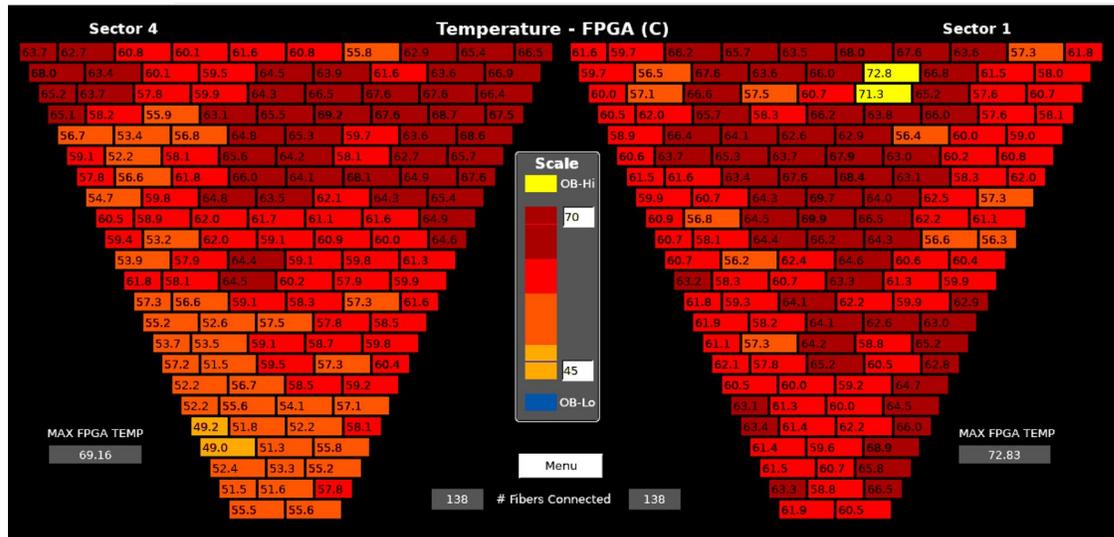




Looking inside the detector



Monitoring plots with beam



RICH-II

Despite the delays, pandemic ... the detector was assembled, tested and installed right on time for the RG-C run!

Congratulations to the whole team!



See M. Mirazita's talk

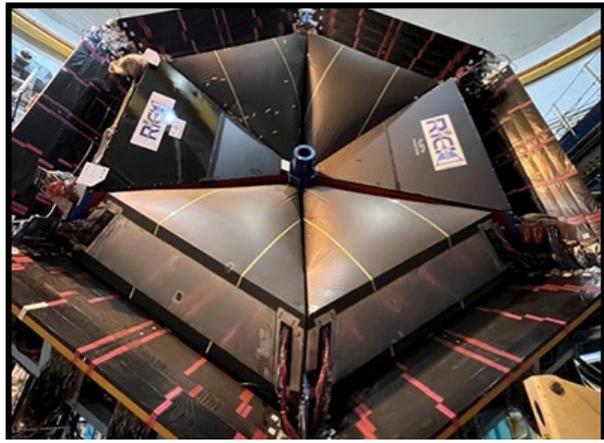




June 15, 2022

S. Stepanyan, Hall B leader
CLAS Collaboration meeting, June 21-24

... prior milestone. A group of scientists from Istituto Nazionale Fisica
 ... Lab and Jefferson Lab, with the help of detector support,
 ... groups, completed the construction, installation and
 ... counter for the CLAS12 detector. The
 testing
 group plans to ...
 and have it integrated into ...
 undertaking for the CLAS collabora...
 second RICH module will significantly enhance
 ring imaging Cherenkov counters of the CLAS12 detector.
 identification capabilities for high momentum charged hadrons. It ...
 physics reactions with strangeness production, such as semi-inclusive and ...
 with charged kaons.





Summary

Nonostante le complicazioni dovute al COVID-19 degli ultimi 2 anni, l'installazione del secondo modulo RICH e' stata completata il 2 giugno, come previsto in vista dell'inizio della presa dati con bersaglio polarizzato longitudinalmente.

Il merito di questo successo va a tutto il personale che ha lavorato al progetto del RICH:

- i colleghi INFN passati e presenti, in particolare delle sezioni dei LNF e di Ferrara
- il personale del JLab e degli altri istituti americani
- l'amministrazione e i servizi dei LNF

Ma il mio ringraziamento particolare va a Dario e Sandro per la passione e l'impegno che ci hanno messo in questi 10 anni di lavoro

