CLAS12 First Experiment workshop
March 28 2017

The CLAS12 Forward Tagger

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… et (many) al.

Quark and gluon confinement: hybrids and exotics

We propose to study the light meson spectrum in a photoproduction experiment using CLAS12

★ Meson provide an easier access to inter-quark potential, strong interaction dynamics, and gluonic degrees of freedom

★ Photoproduction should be favorable to excite exotic quantum number and photon polarisation helps in extract the information suppressing the bg

JLab PAC41 granted A^- to MesonEx proposal

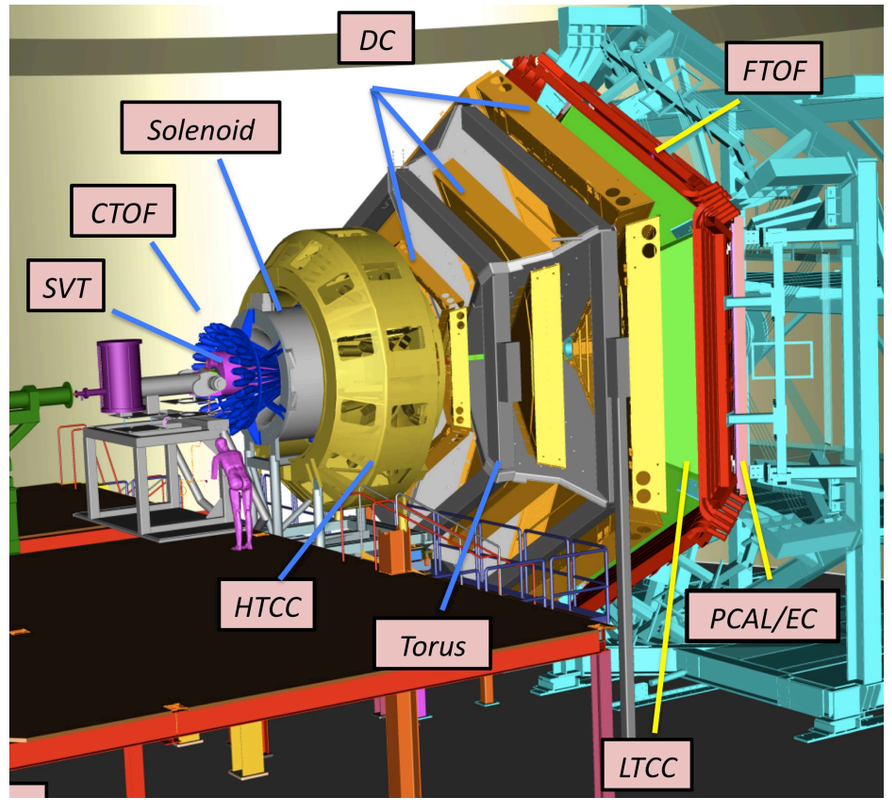
Requirements:

★ Large acceptance detector:

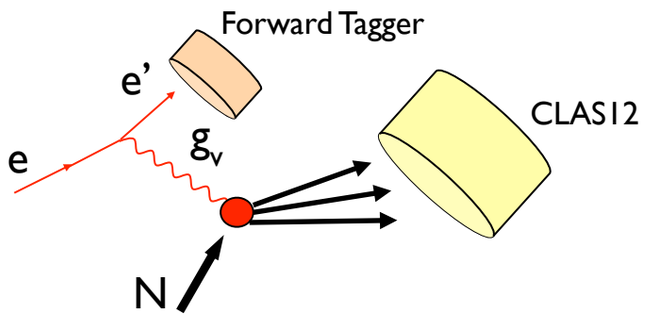
CLAS12

★ Intense, tagged, polarized photon beam in the energy range 5-10 GeV

CLAS12 Forward-Tagger



Quasi-real photoproduction with CLAS12 (Low Q^2 electron scattering)



$E_{scattered}$	0.5 - 4.5 GeV
θ	2.5^o - 4.5^o
ϕ	0^o - 360^o
ν	6.5 - 10.5 GeV
Q^2	0.01 - 0.3 GeV^2 ($< Q^2 > 0.1$ GeV^2)
W	3.6 - 4.5 GeV

★ Electron scattering at "0" degrees (2.5° - 4.5°)
low Q^2 virtual photon ⇔ real photon

★ Photon tagged by detecting the scattered electron at low angles
High energy photons $6.5 < E_g < 10.5$ GeV

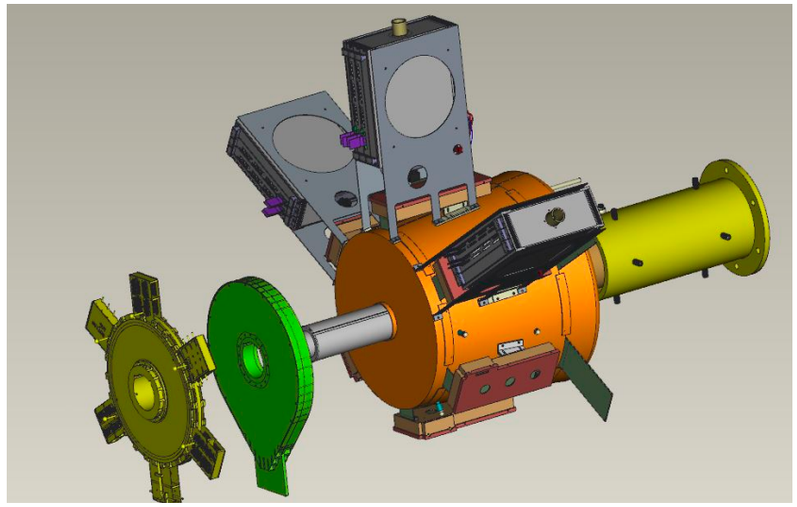
★ Quasi-real photons are linearly polarized
Polarization ~ 70% - 10% (measured event-by-event)

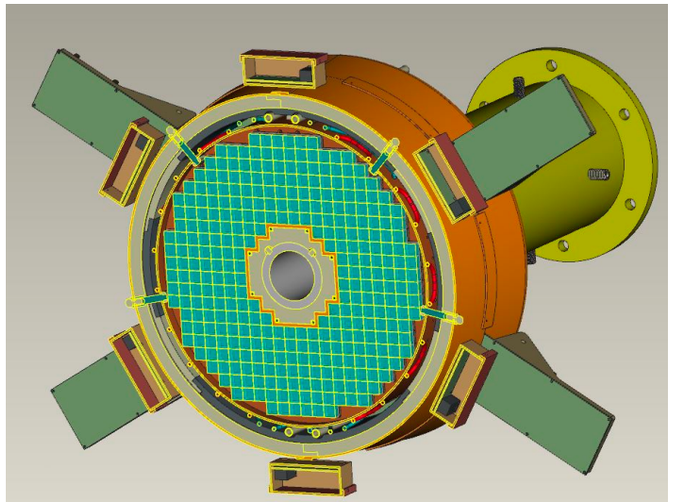
★ High Luminosity (unique opportunity to run thin gas target!)
Equivalent photon flux $N_\gamma \sim 5\ 10^8$ on 5cm H_2 ($L=10^{35}$ $cm^{-2}s^{-1}$)

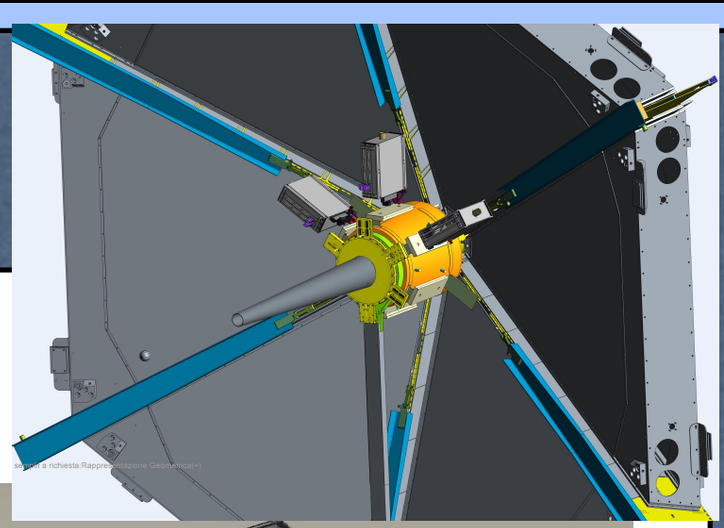
★ Multiparticle hadronic states detected in CLAS12
High resolution and excellent PID (kaon identification)

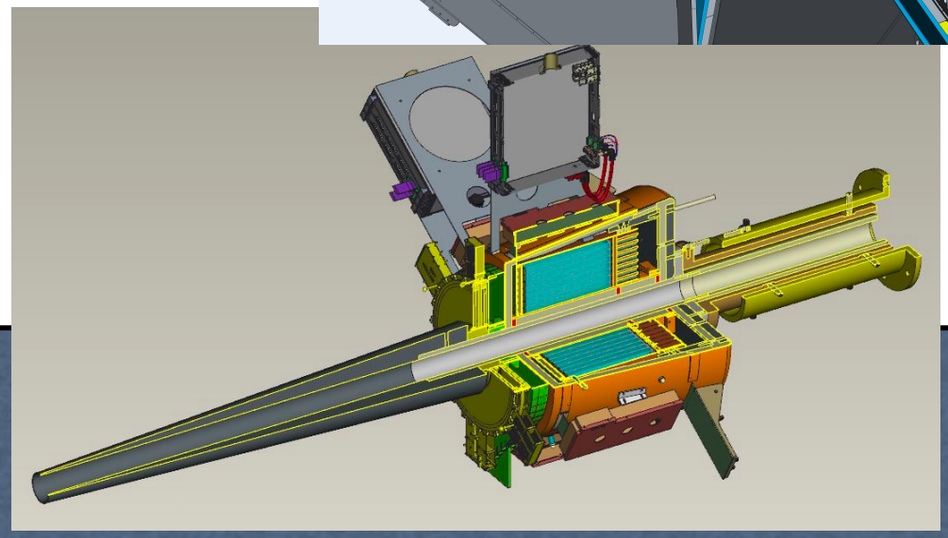
High energy low Q2 photon beam in CLAS12!

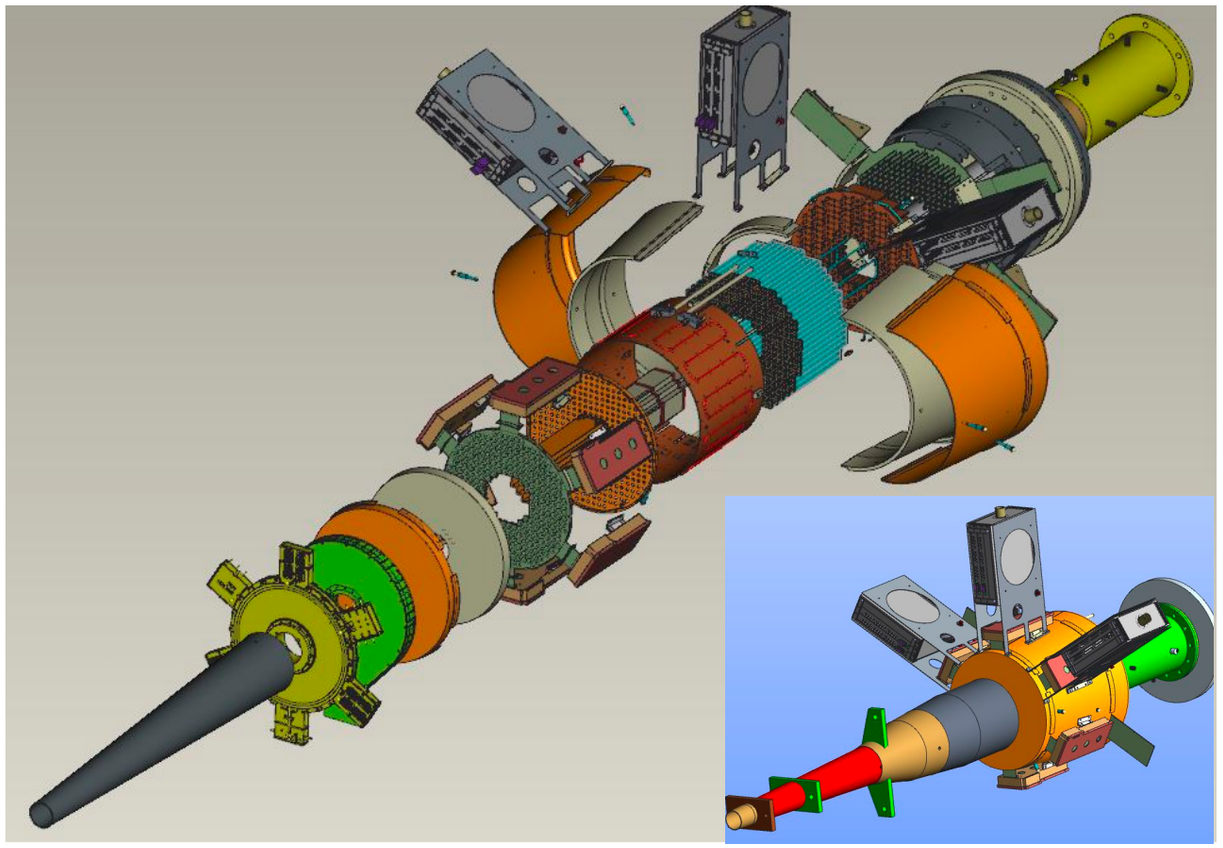
The Forward Tagger for CLAS12











FT-Cal: $PbWO_4$ calorimeter

electron energy/momentum

Photon energy (ν=E-E')

Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$

INFN-GE, INFN-RM2, INFN-TO

FT-Hodo: Scintillator tiles

veto for photons

EdinburghU+JMU+NSU

FT-Trck: MicroMegas detectors

electron angles and polarization plane

Saclay + OhioU

FT-Cal

Calorimeter + hodoscope + tracker

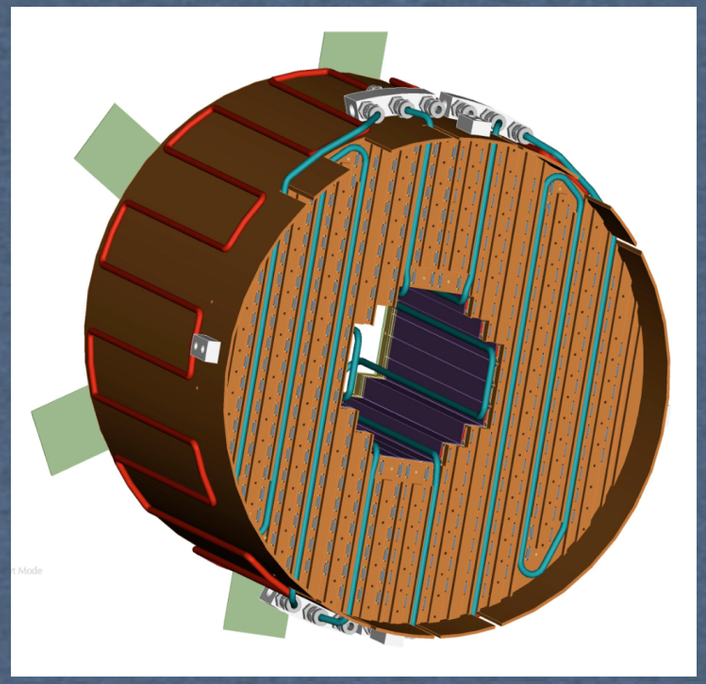
Electron energy/momentum

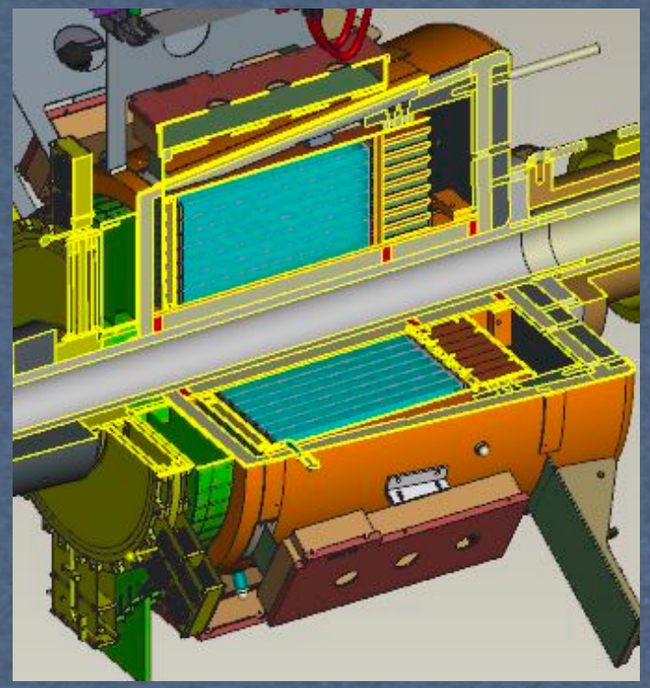
$\delta\nu/\nu = \delta E'/(E-E')$

Photon energy ($\nu=E-E'$)

Polarization $\varepsilon^{-1} \sim 1 + \nu^2/2EE'$

Homogeneous, fast, dense, inorganic-crystals: PbWO4 Type-II

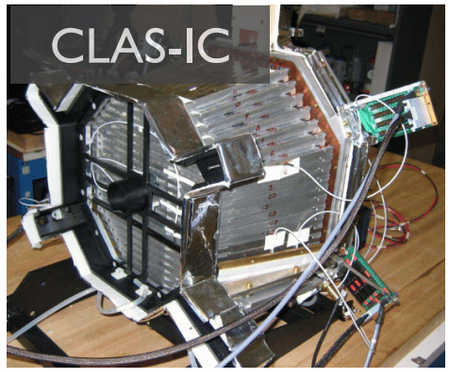




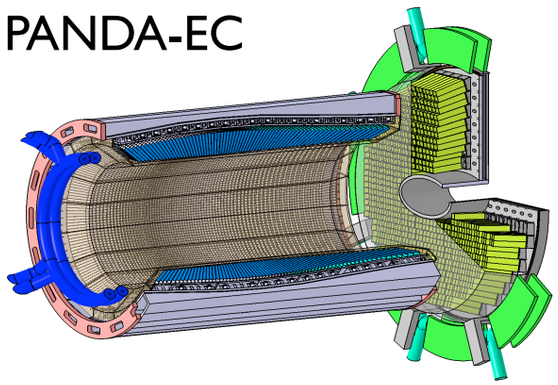
Requirements

- Radiation hard
- Good light yield
- Energy resolution
- Time resolution
- Light read-out (APD/SiPM)

CLAS-IC



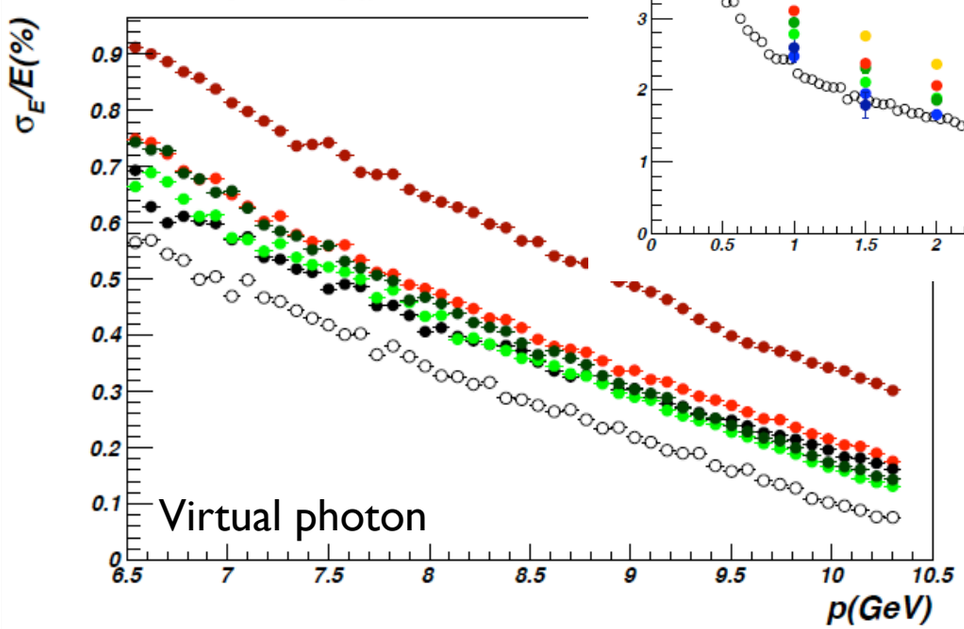
PANDA-EC



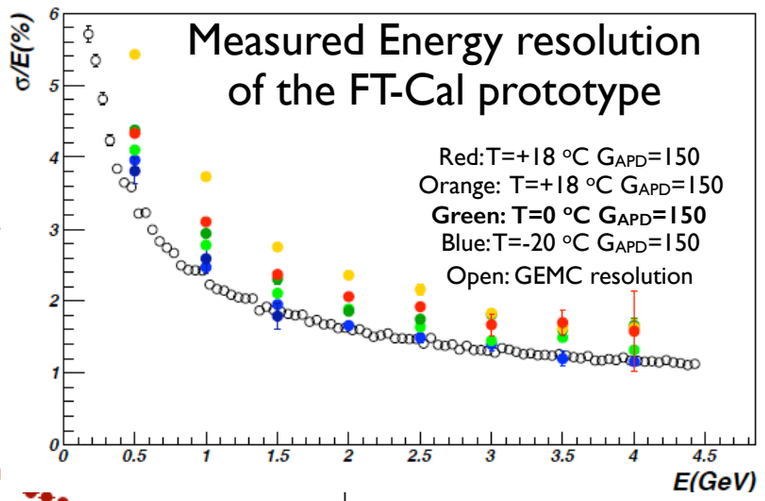
FT-Cal Specs

- Crystals: 332 15x15x200 mm3 BTCP/SICCAS PbWO4 Type II
- Light sensors: Hamamatsu LAAPD s8664-1010
- FE electronics: FT-Orsay preamps
- Working temperature: 0 °C, +18 °C
- Energy range: 5 MeV (Threshold on single crystal) to 8 GeV
- Energy resolution: 2.3%/√E(GeV) ⊕ 0.5%

Expected Energy resolution of FT-Cal



Measured Energy resolution of the FT-Cal prototype



FT-Hodo

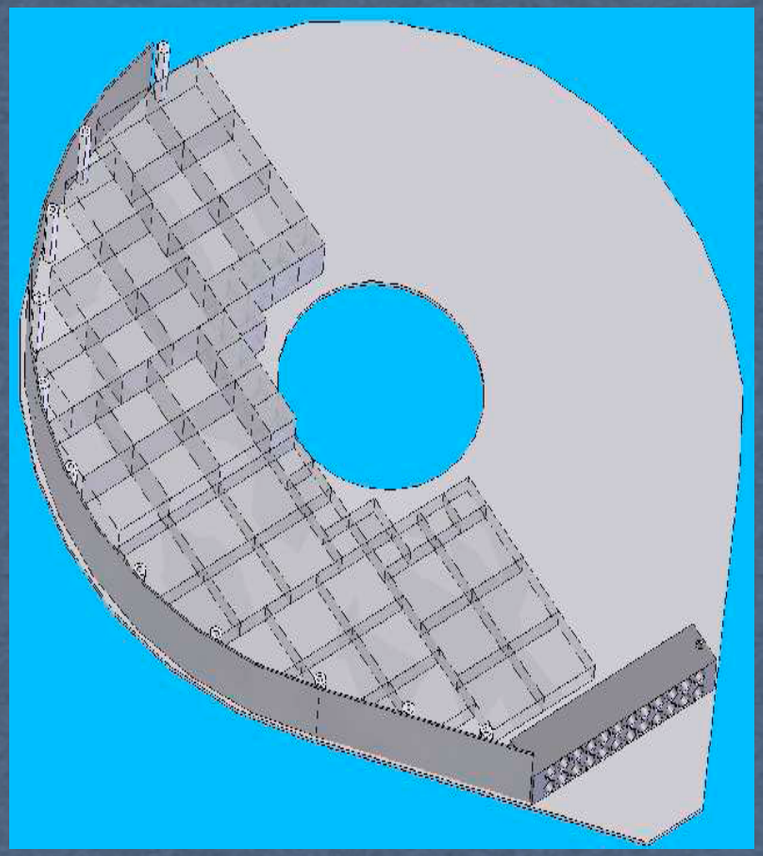
Calorimeter + **hodoscope** + tracker

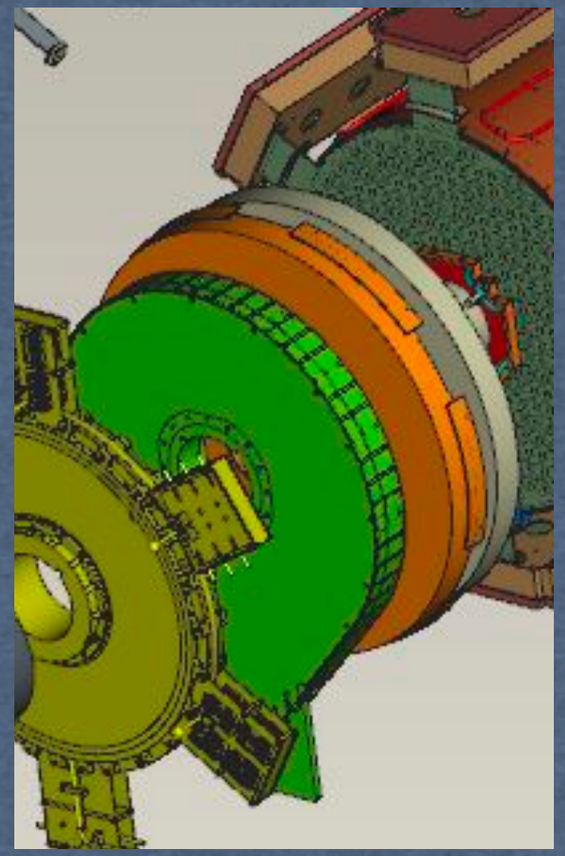
veto for photons

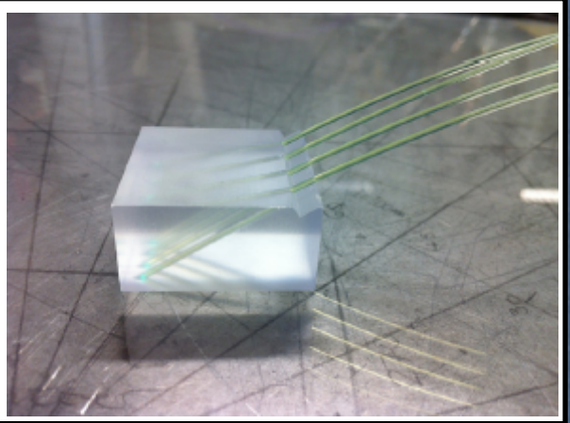
Plastic scintillators tiles with WLS fibres coupled to SiPM

Requirements

- Good timing (<ns) for MIPs
- High segmentation
- 100% efficient for charged particles



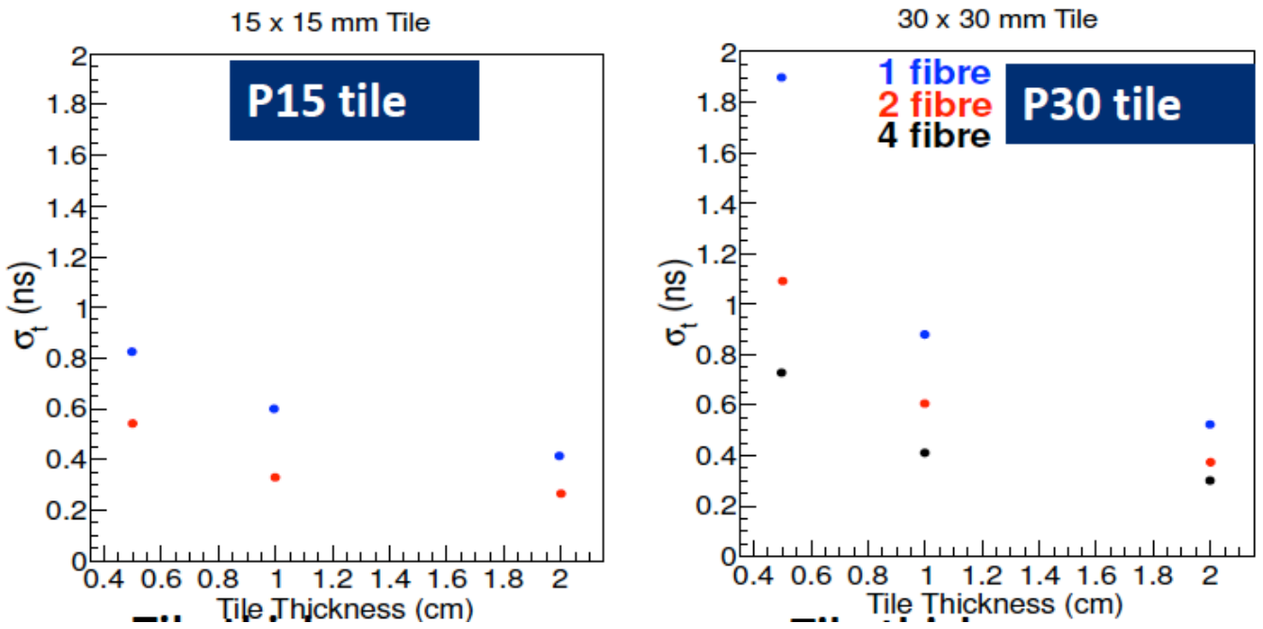




FT-Hodo Specs

- Segmented array, 2 layers of tiles to minimize photons misid
- Tiles: 74 30x30x15 mm2 + 42 15x15x7 mm3 EIJen 204 per layer
- WLS: (4x74 + 2x42)x2 = 380 d=1mm Kuraray K11
- Light sensors: Hamatsu S10362-33-100 3x3mm2, 100um SiPM
- FE electronics: 232 channels FTh-Orsay preamps
- Time resolution: <1ns

Expected time resolution of FT-Hodo



FT-Trck

Calorimeter + hodoscope + **tracker**

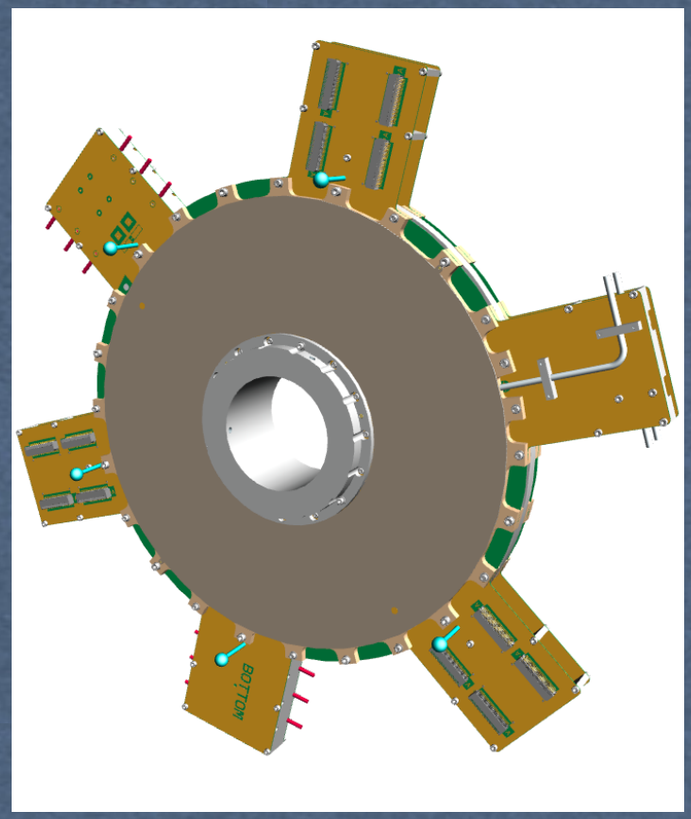
$Q^2 = 4\ E\ E'\ \sin^2 \vartheta/2$

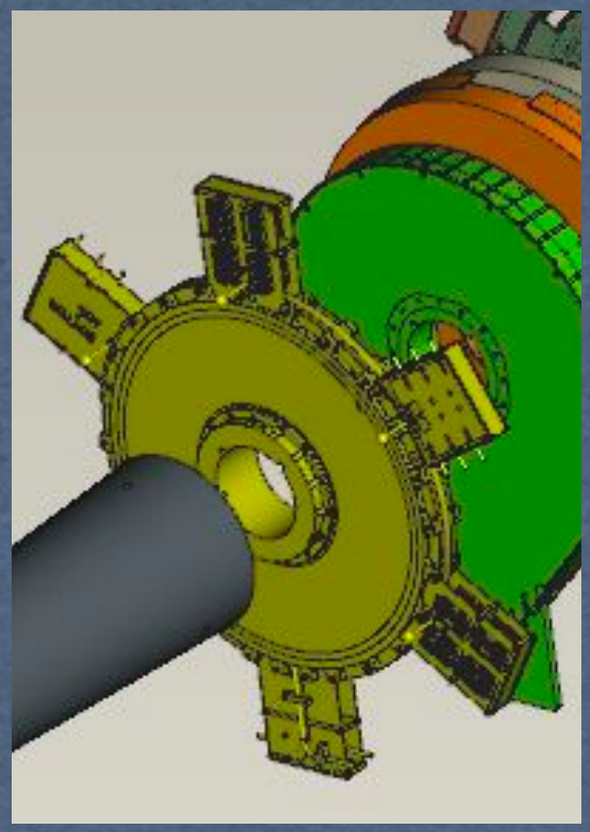
Scattering plane

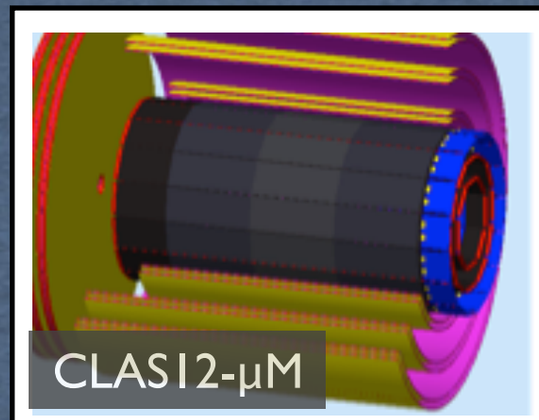
Requirements

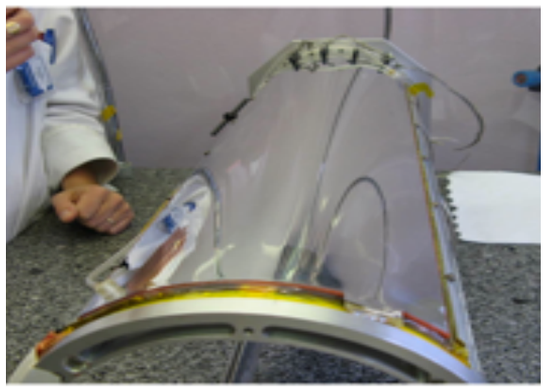
- ✳ High pixel density (FW)
- ✳ 100-300 μm resolution
- ✳ Integrated in the CLAS12 base equipment

Sustain high rate, moderate resolution, low material budget: Micromegas







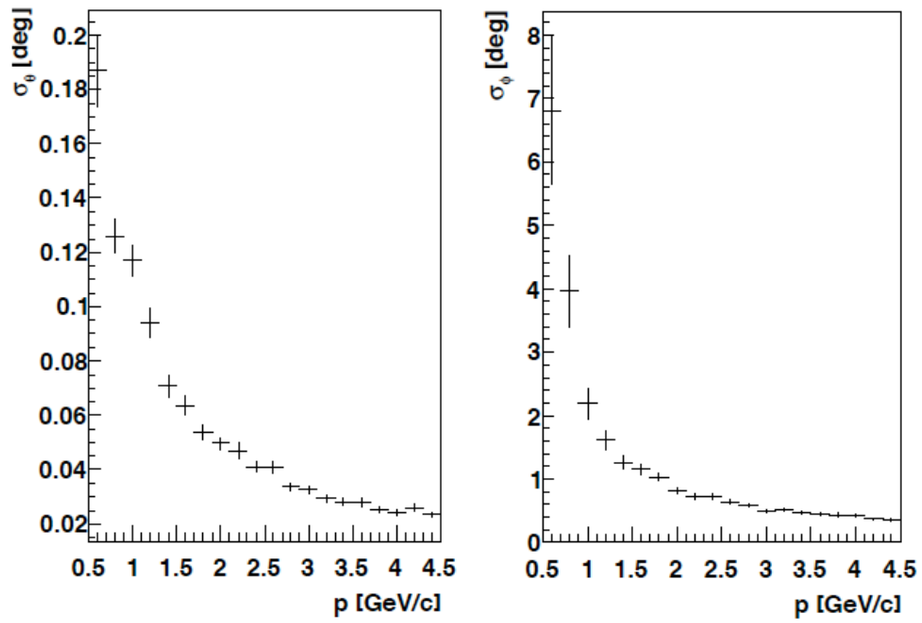


FT-Trck Specs

- ✳ Two double layers of bi-face bulk Micromegas
- ✳ Pitch: 500 μm
- ✳ FE electronics: 3392 channels, same FE used for MCT
- ✳ Services and slow controls shared with MCT
- ✳ Spatial resolution: < 150 μm

Expected angular resolution of FT-Trck

Exploiting the solenoid kick a single tracker close to the FT suffices

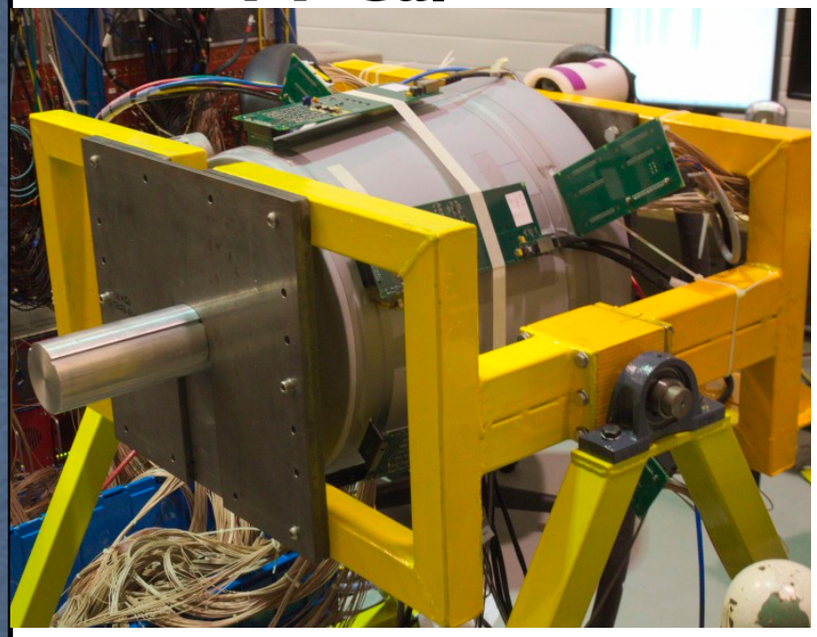


FT project timeline

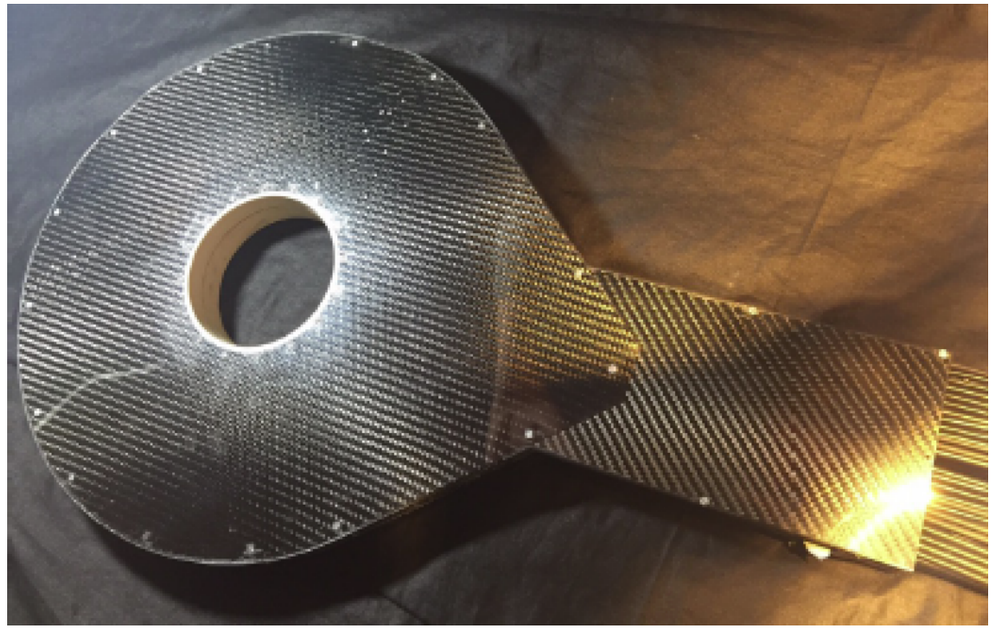
- 2011: MesonEx proposal presented to JLab PAC41 and approved
- 2011/12 Design and components R&D: crystals, APDs, plastic scintillators, sipm sensors and FE electronics, micromegas
- 2012 JLab review with 3 detectors layout (FT-Cal, FT-Hodo and FT-Trck)
- 2012/13 FT-Cal + FT Hodo prototype tested on e-beam at JLab and LNF, FT-Trck tested in Saclay
- 2014 Components procurement and test: PbWO crystals, LAAPD, SIPM, FE electronics, scintillator tiles, optical and WLS fibers WLS
- 2014 Ancillary systems design and procurement: LED monitoring system, mother boards
- 2015 FT subsystems assembled in Genova, Edinburgh and Saclay and tested with cosmic rays
- 2015/16 FT deployment to JLab (EEL), FT-Cal+FT-Hodo+FT-Trck assembly
- 2016 FT EER
- 2016 Commissioning with cosmic rays

FT current status

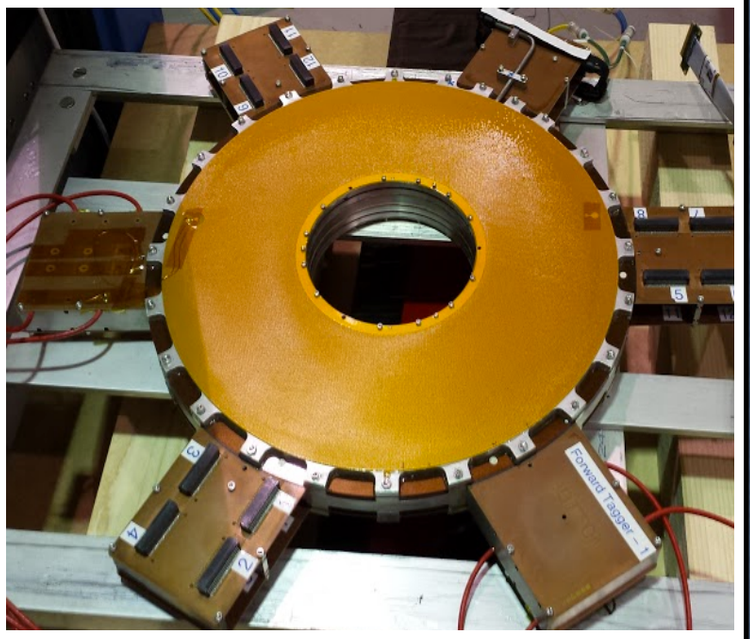
FT-Cal



FT-Hodo



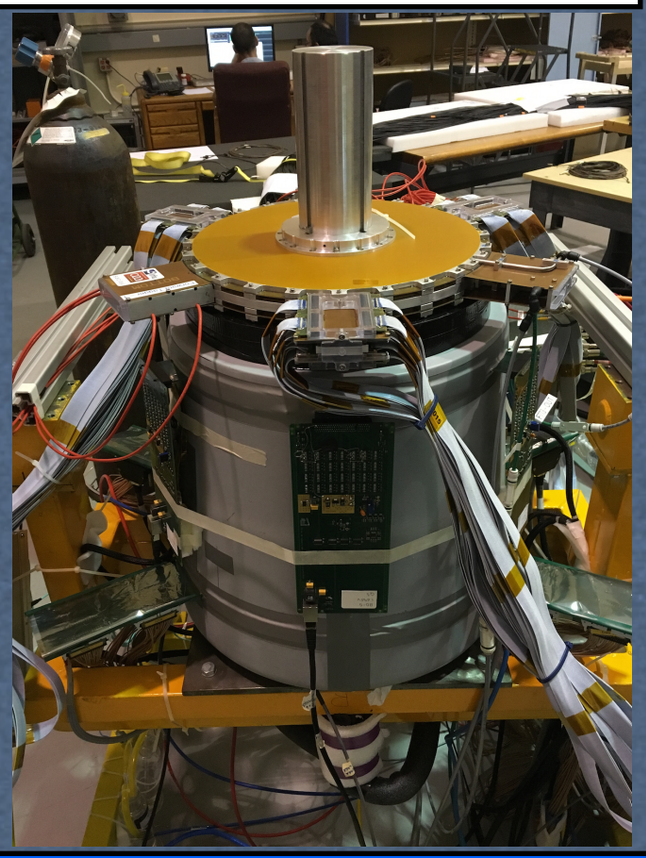
FT-Trck



JLab EEL building

- FT-Cal, FT-Hodo and FT-Trck assembled at JLab, cabled and connected to DAQ, taking cosmic data

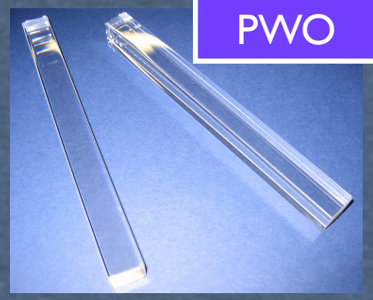
- FT-Cal + FT-Hodo implemented in the same DAQ configuration and taking cosmic data in vertical position

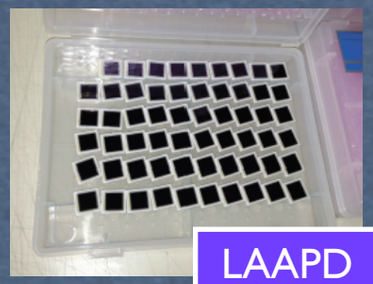


FT-Cal assembly and commissioning in Genova

PWO+APD assembly

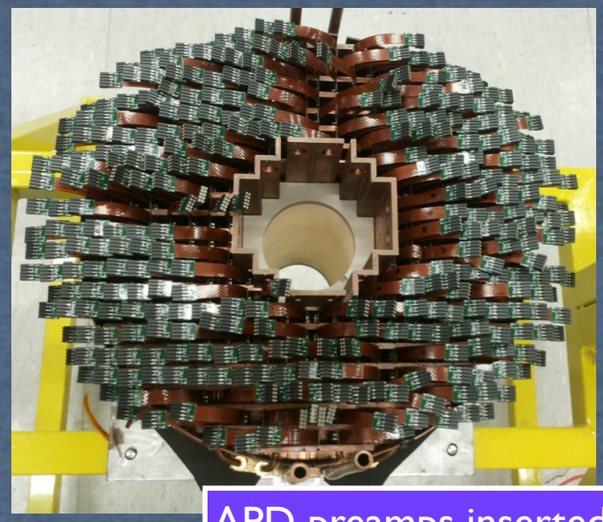
PWO





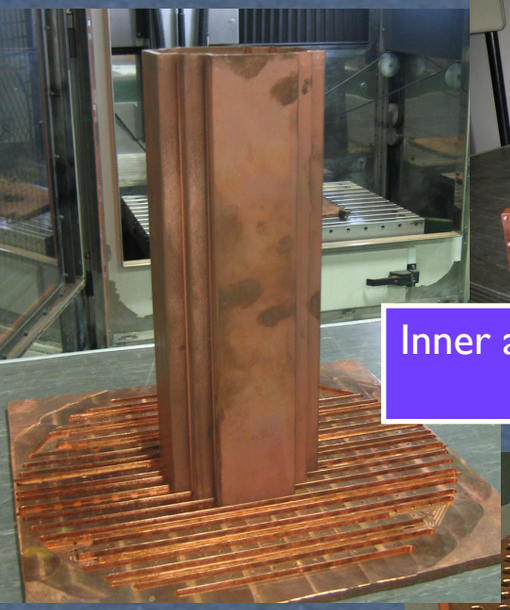
LAAPD

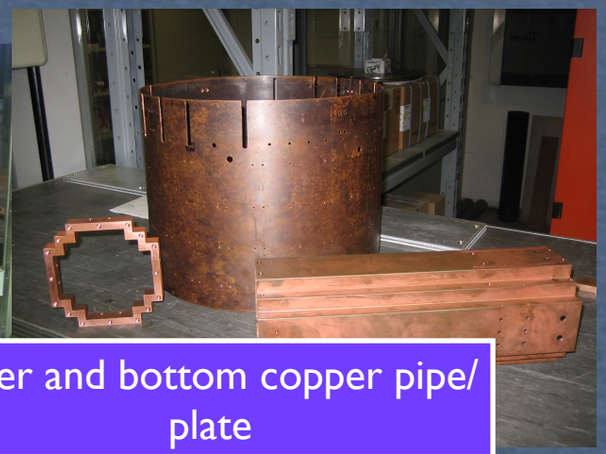
Carbon fiber skin



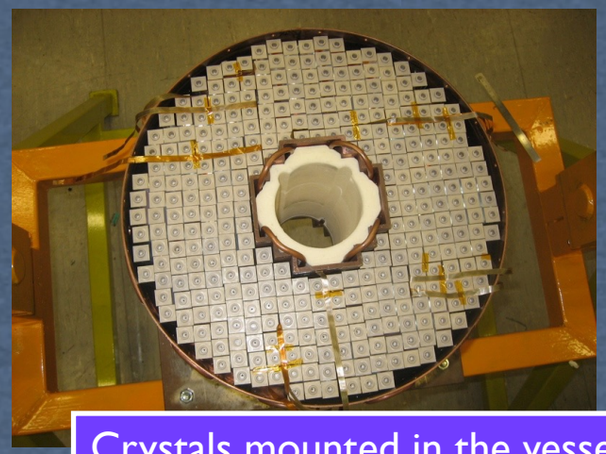
APD preamps inserted

RO electronics



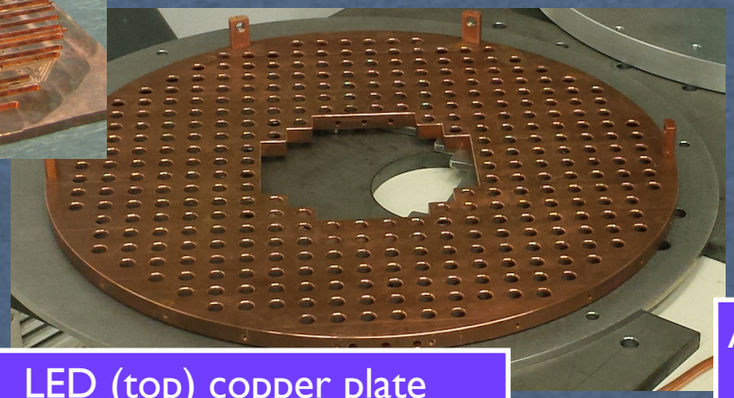


Inner and bottom copper pipe/ plate



Crystals mounted in the vessel

FT-Cal fully assembled on the stand



LED (top) copper plate

Assembly hall in Genova

FT-Cal assembly at JLab

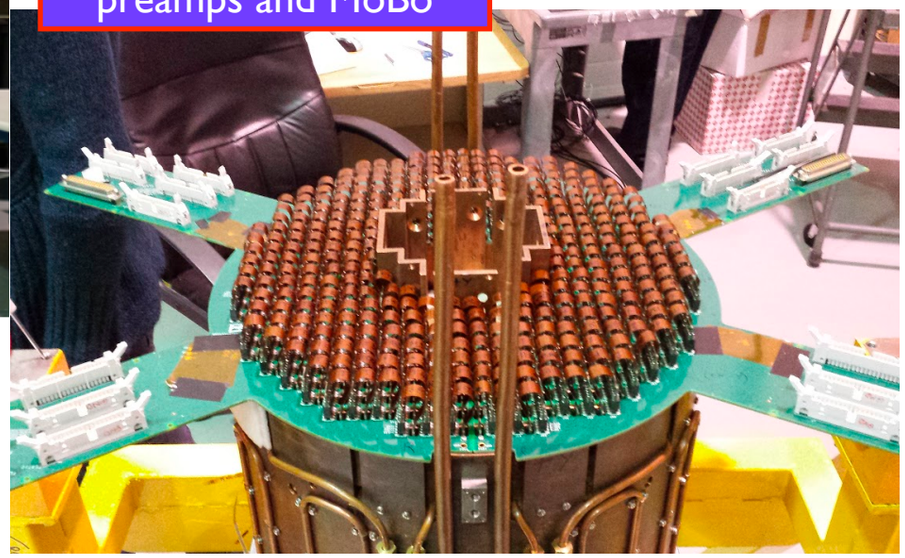
Assembly hall at JLab (EEL)

FT boxes just arrived

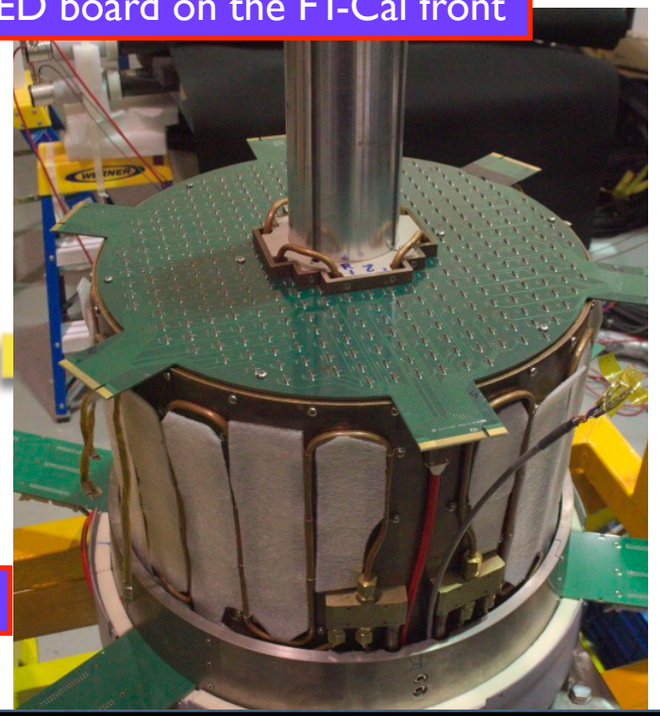
FT-Cal mounting stand

Vessel+cooling pipes

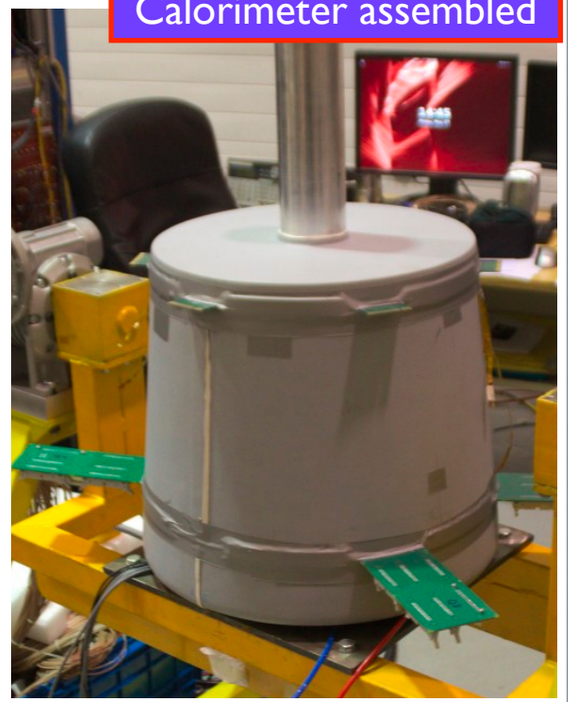
preamps and MoBo



LED board on the FT-Cal front

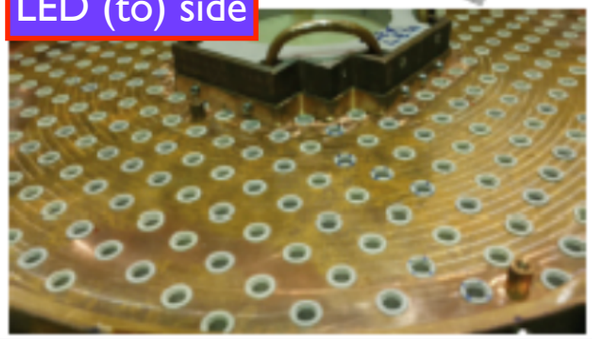


Calorimeter assembled

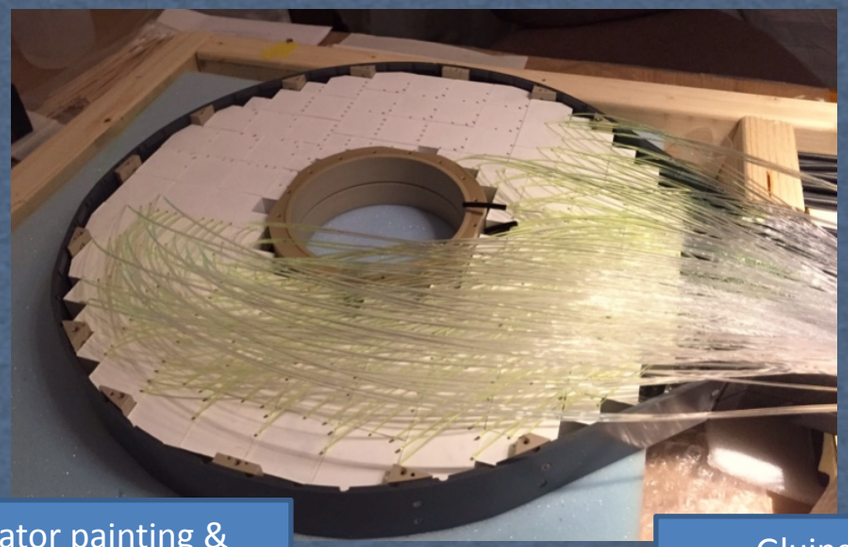


Kapton thin PT100

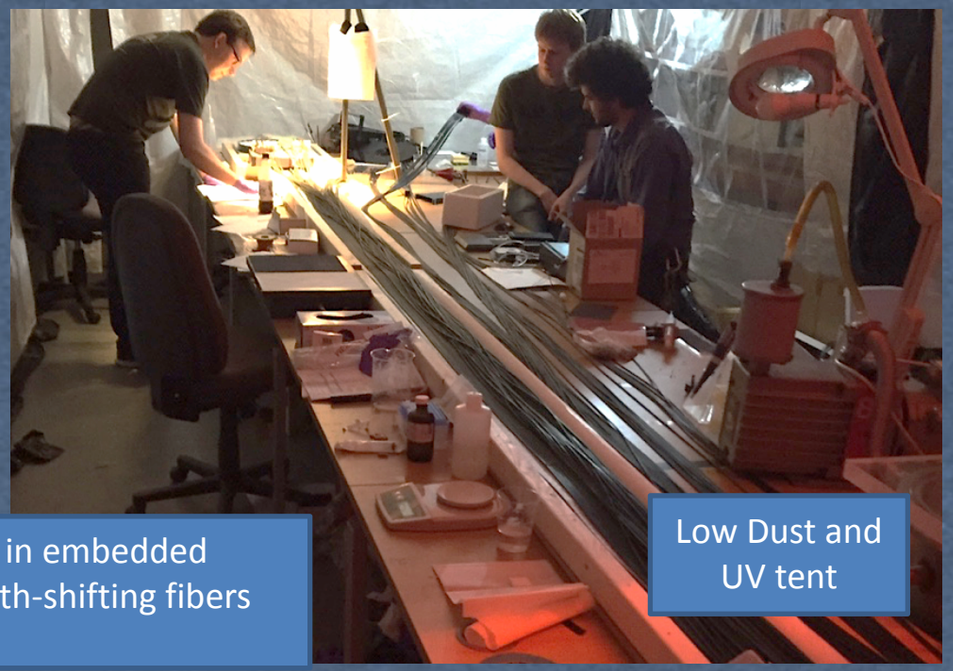
LED (to) side



FT-Hodo assembly and commissioning (Edinburgh)

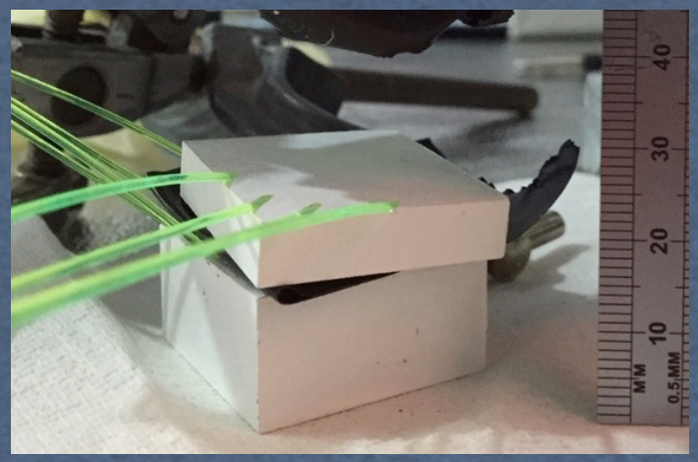


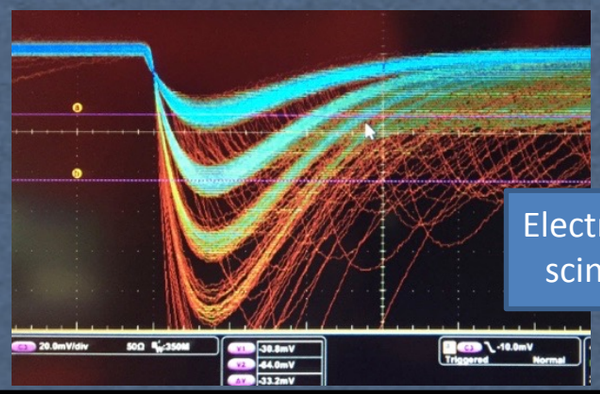
Scintillator painting & assembly



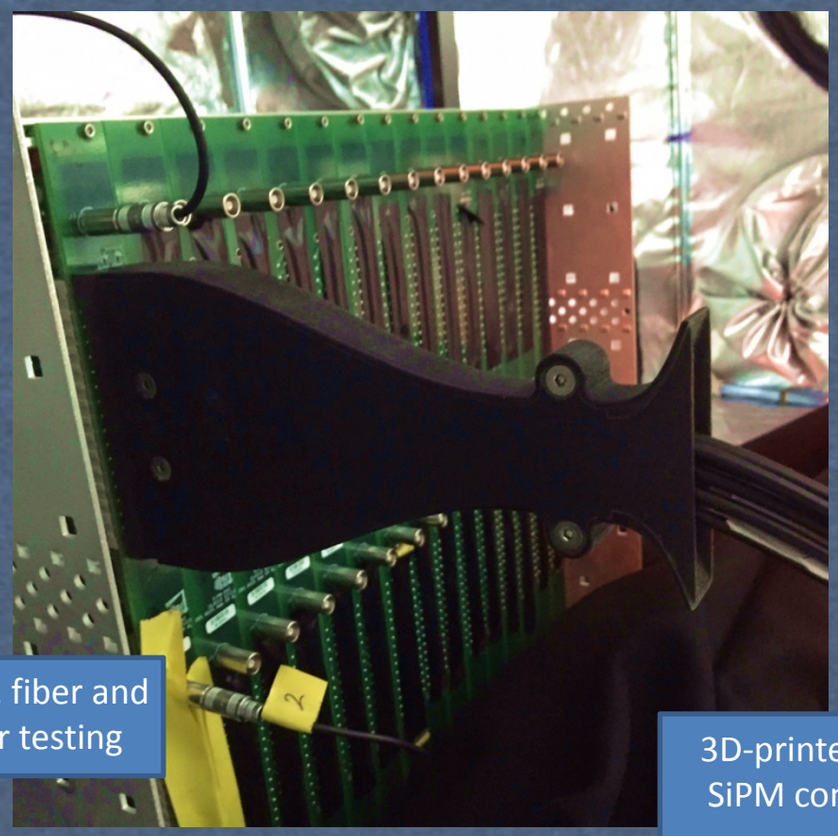
Gluing in embedded wavelength-shifting fibers

Low Dust and UV tent

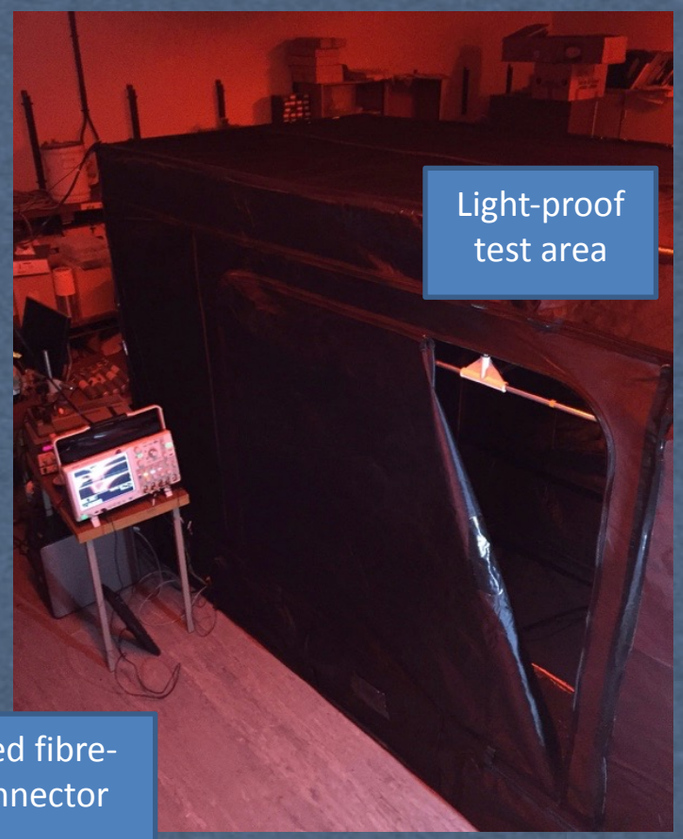




Electronics, fiber and scintillator testing

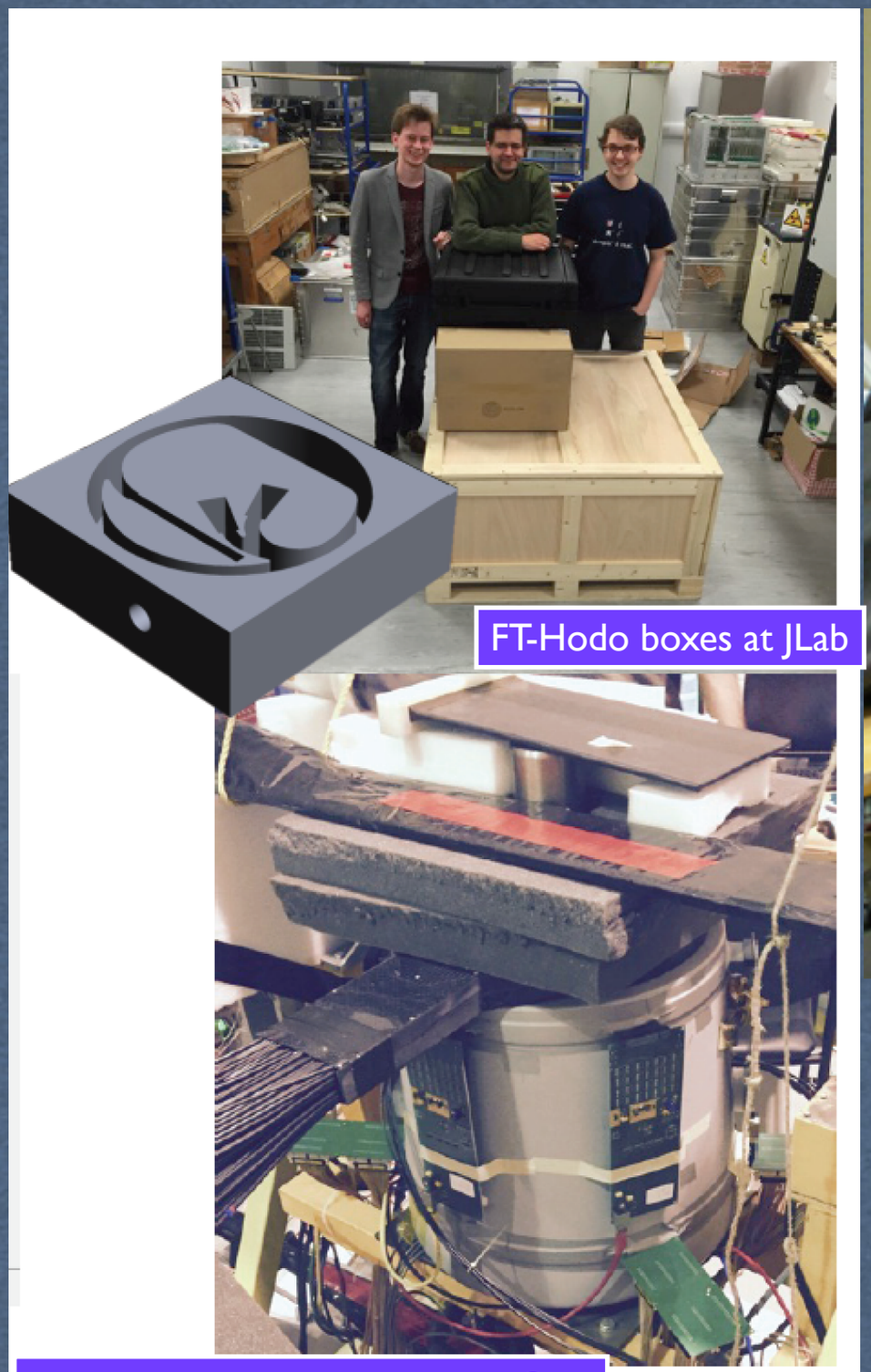


3D-printed fibre-SiPM connector



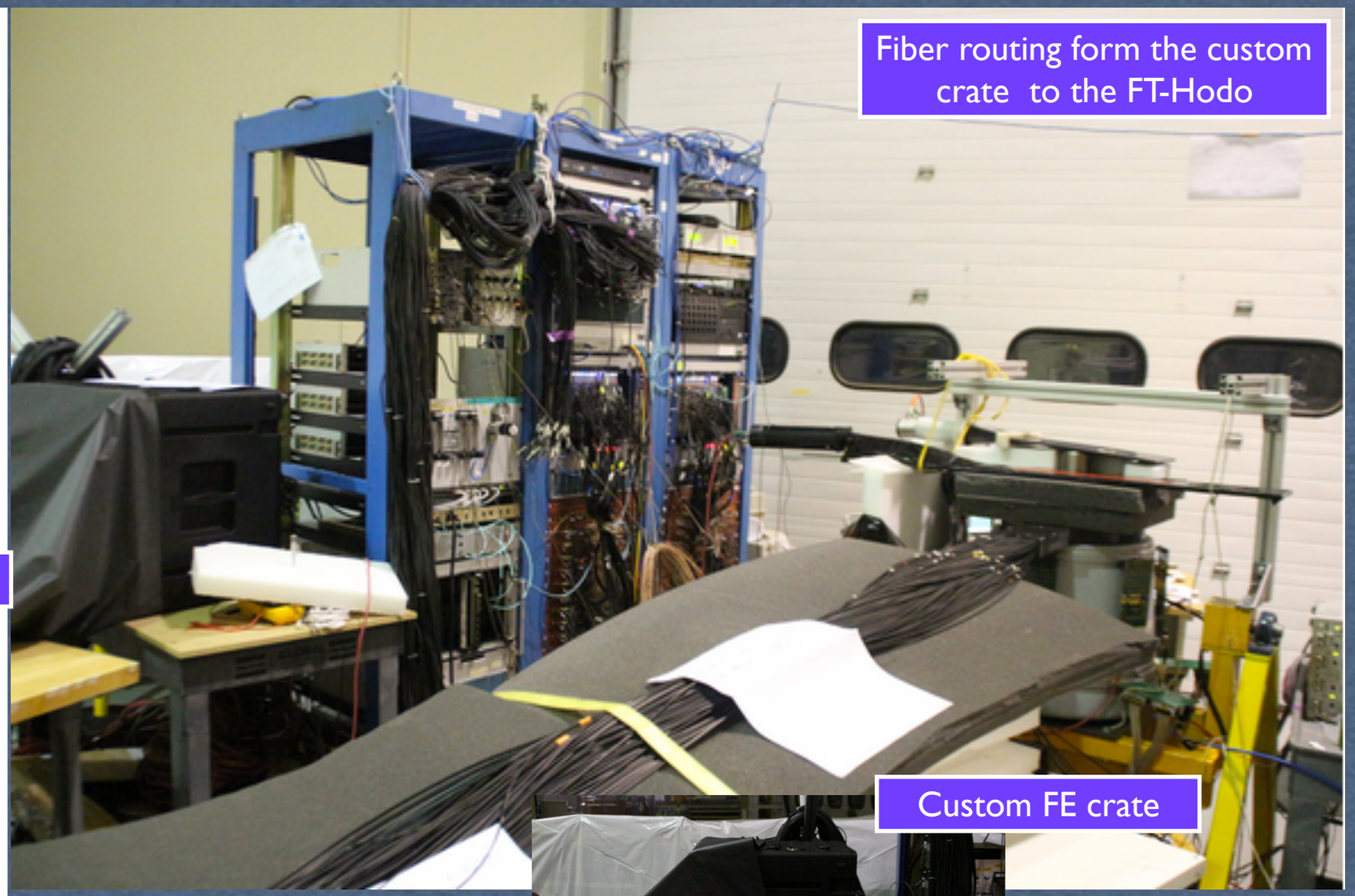
Light-proof test area

FT-Hodo assembly and commissioning (JLab)



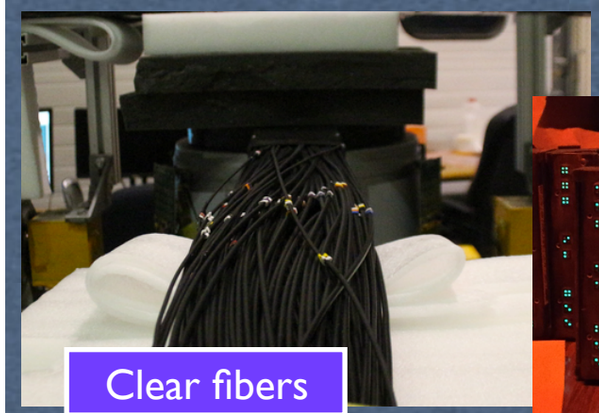
FT-Hodo boxes at JLab

FT-Hodo mounted on the FT-Cal

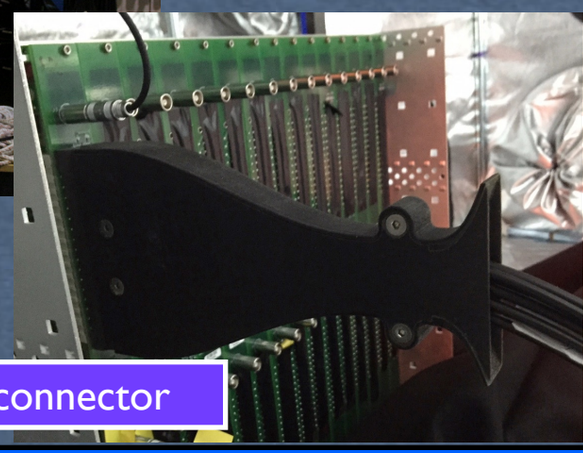


Fiber routing form the custom crate to the FT-Hodo

Custom FE crate



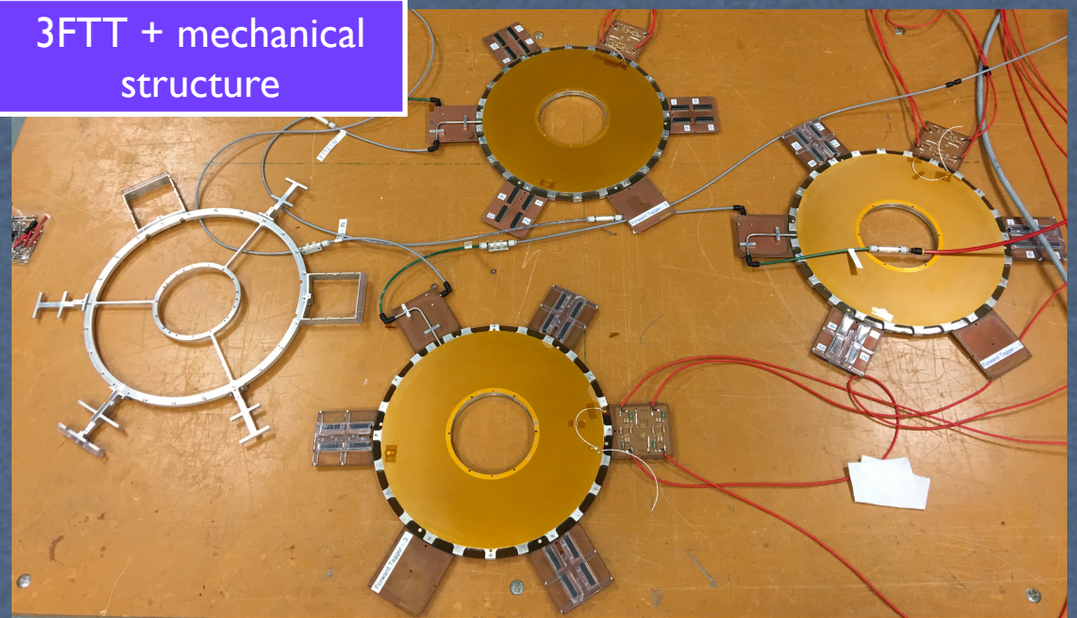
Clear fibers



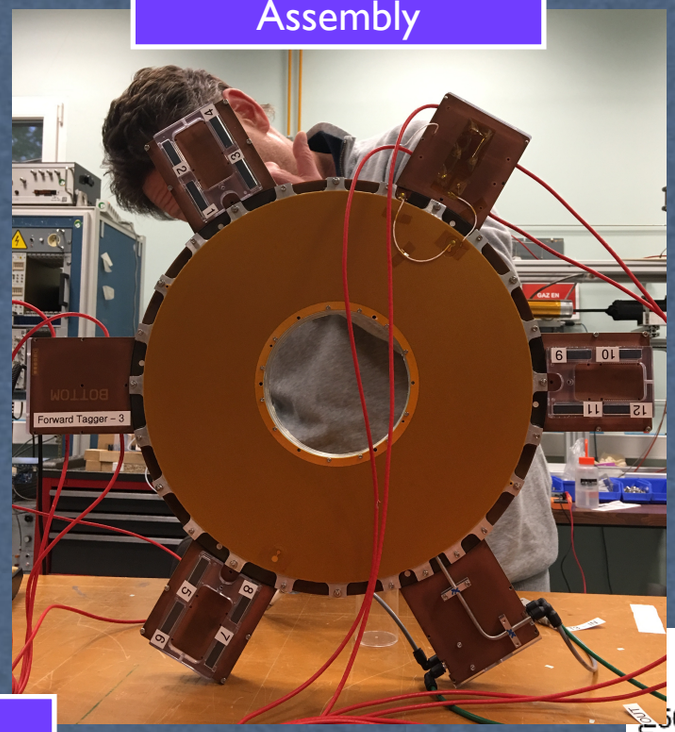
Fiber connector

FT-Trck assembly and commissioning (Saclay)

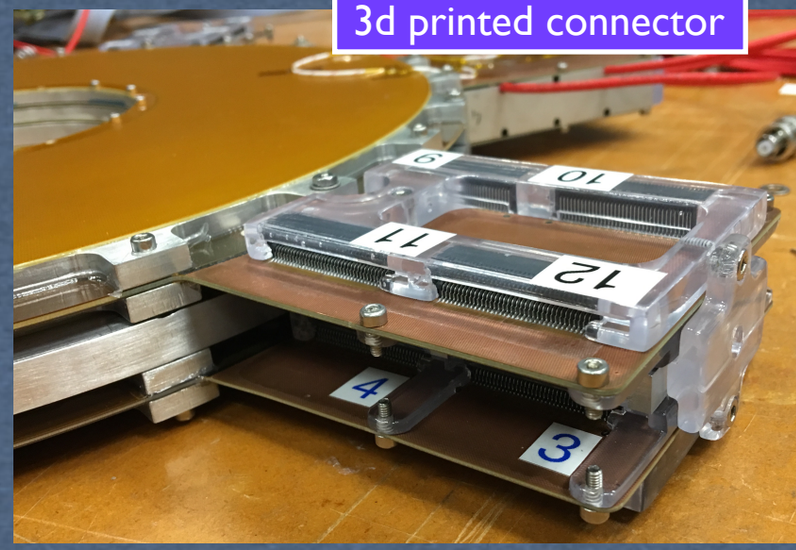
3FTT + mechanical structure

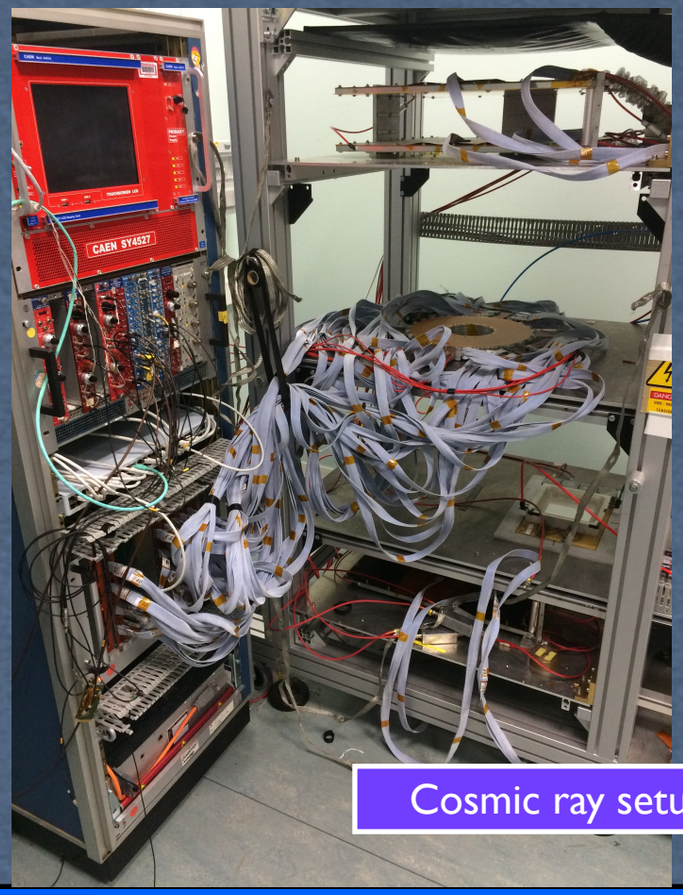


Assembly



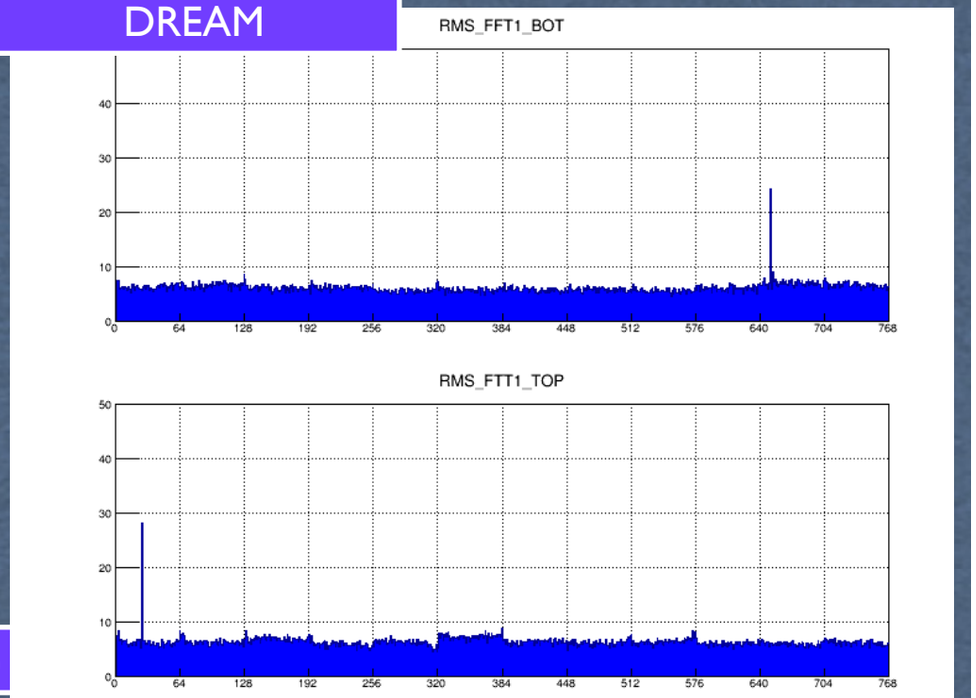
3d printed connector

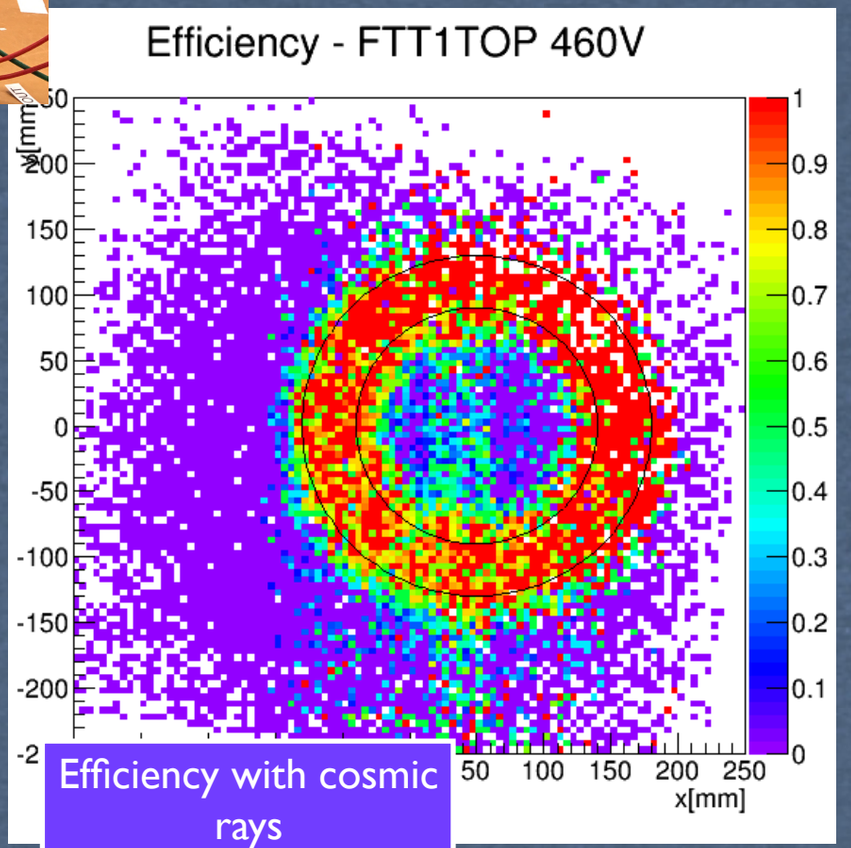




Cosmic ray setup

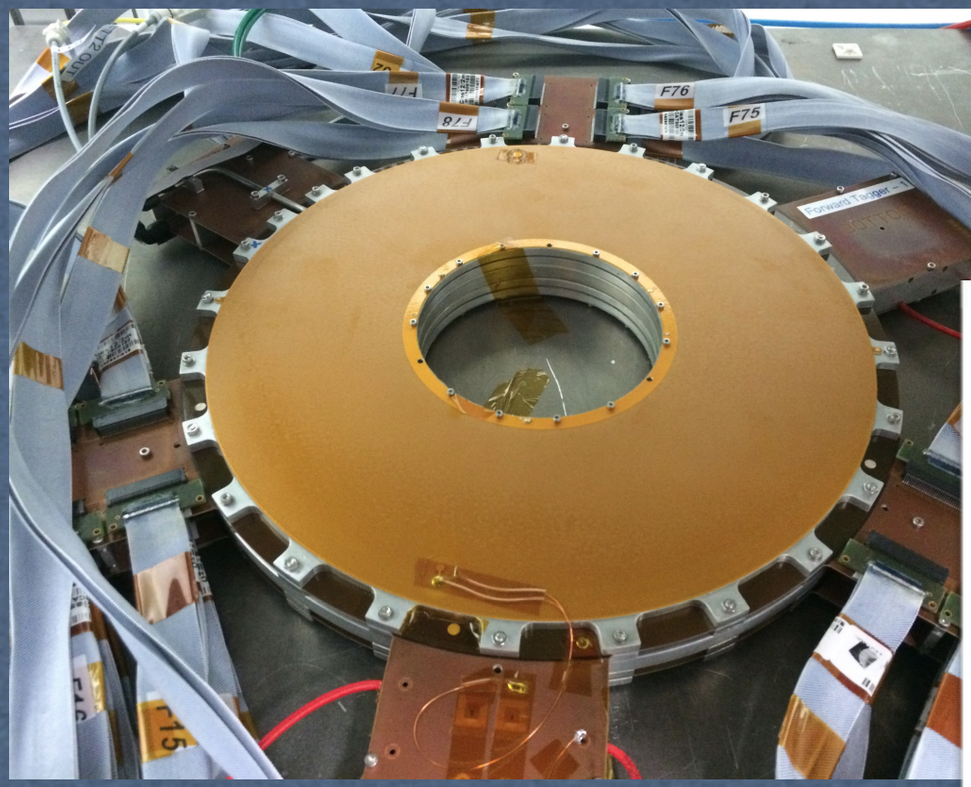
Noise level with DREAM





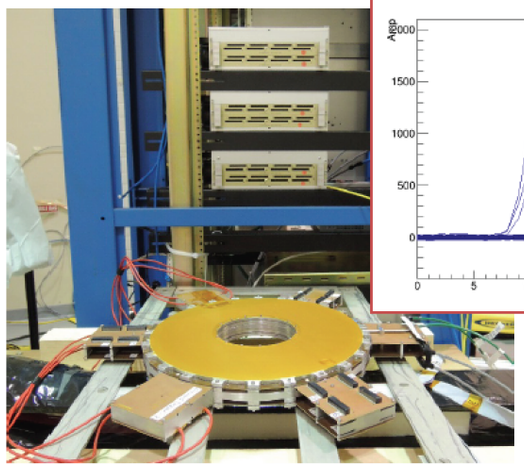
Efficiency with cosmic rays

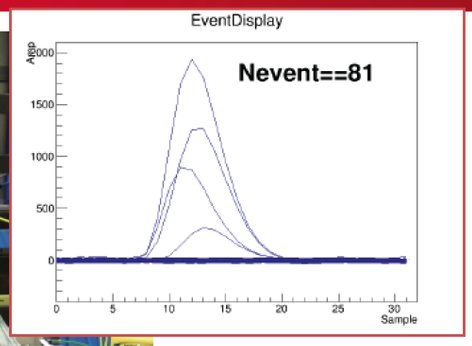
FT-Trck assembly and commissioning (JLab)

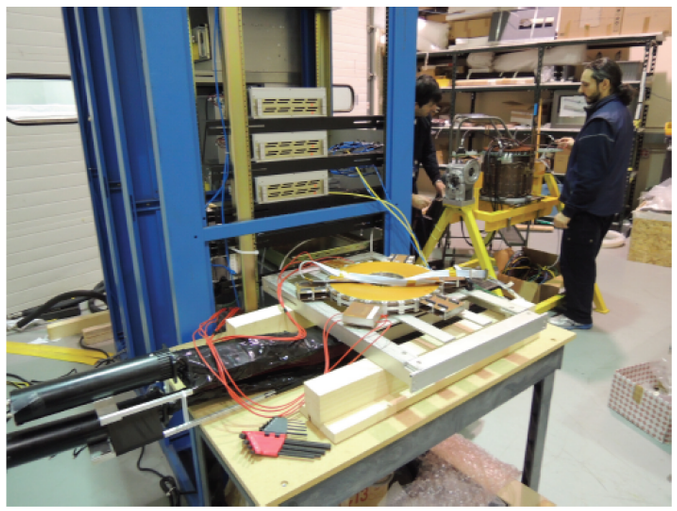


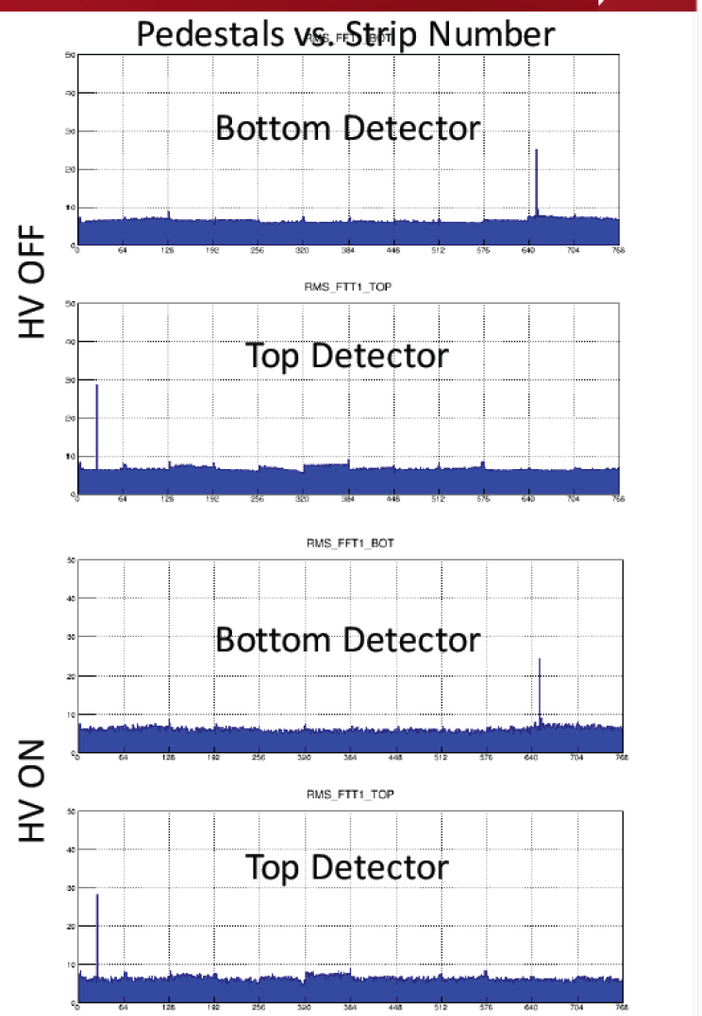
- FT-Trck deployed at JLab in Dec 2105
- RO electronics and gas system ready
- Cosmic tests showed issues
- New detector (spare) manufactured at CERN and assembled at Saclay
- FT-Trck deployed at JLab in June

Forward Tagger Tracker – A few pictures & results





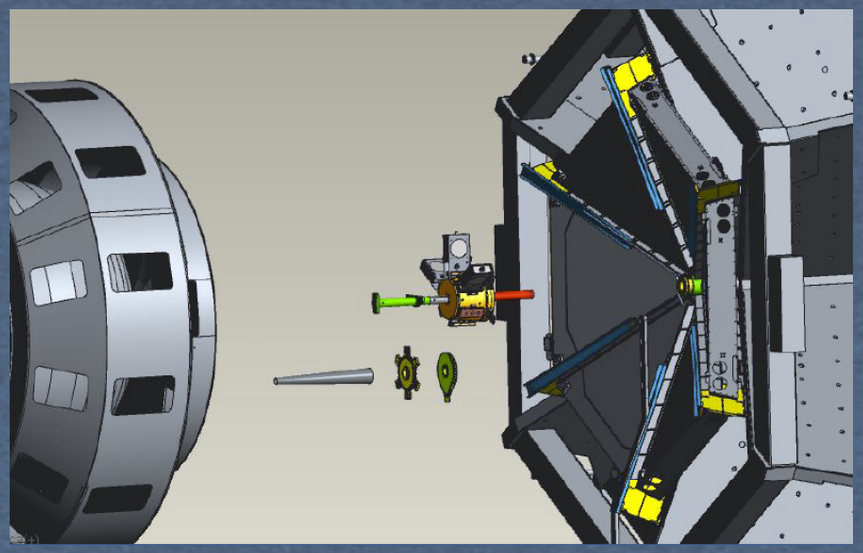




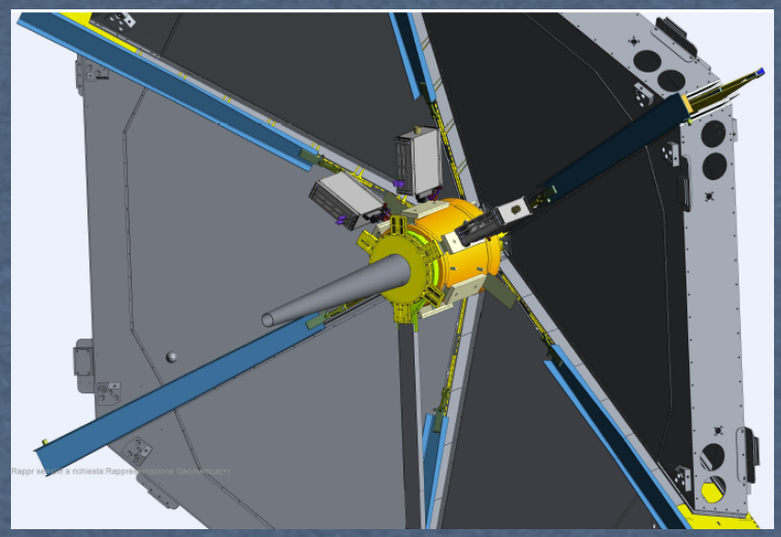
CEA-Saclay F. Sabatié Forward Tagger Tracker Status Report 02/25/2016

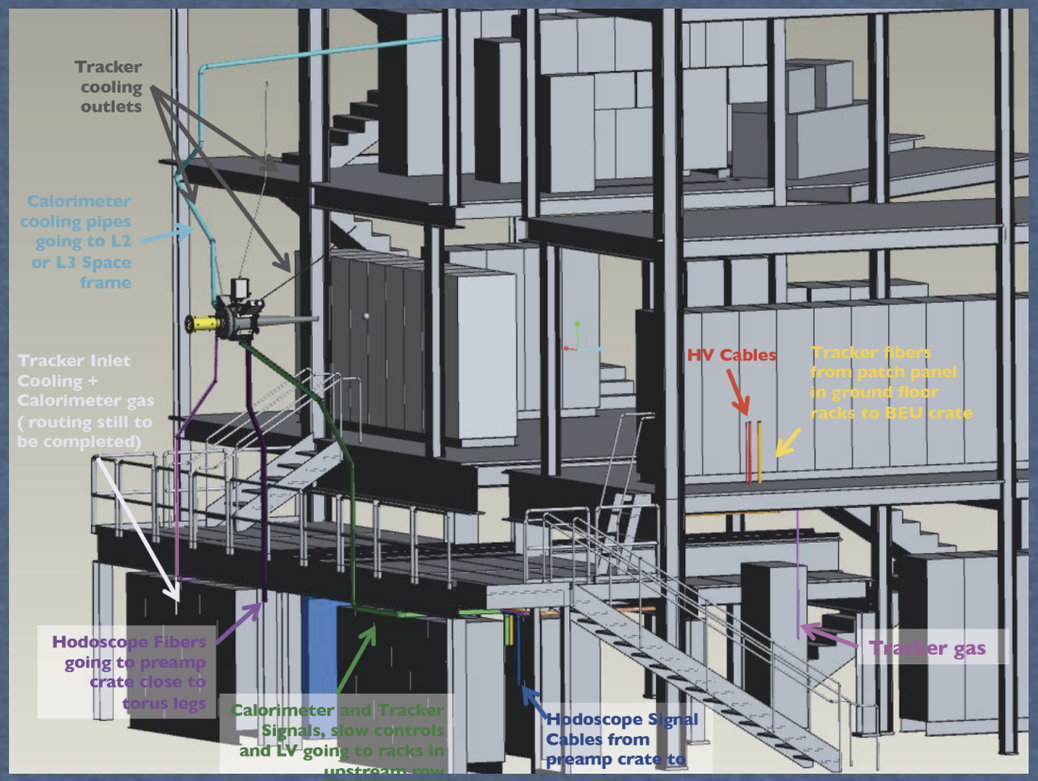
FT installation and integration in CLAS12

Installation procedure sketched with Hall-B engineering team



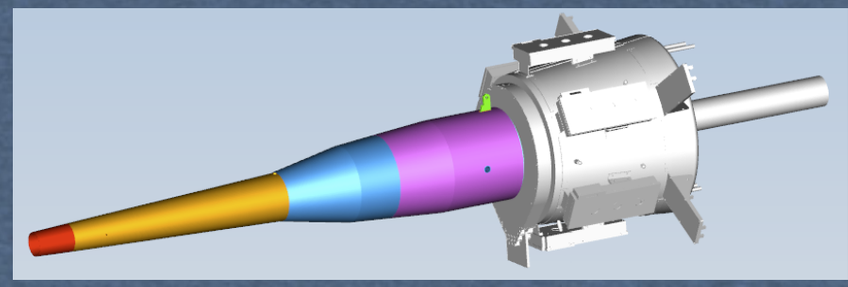
- FT cables and service routing
- Electronics position defined

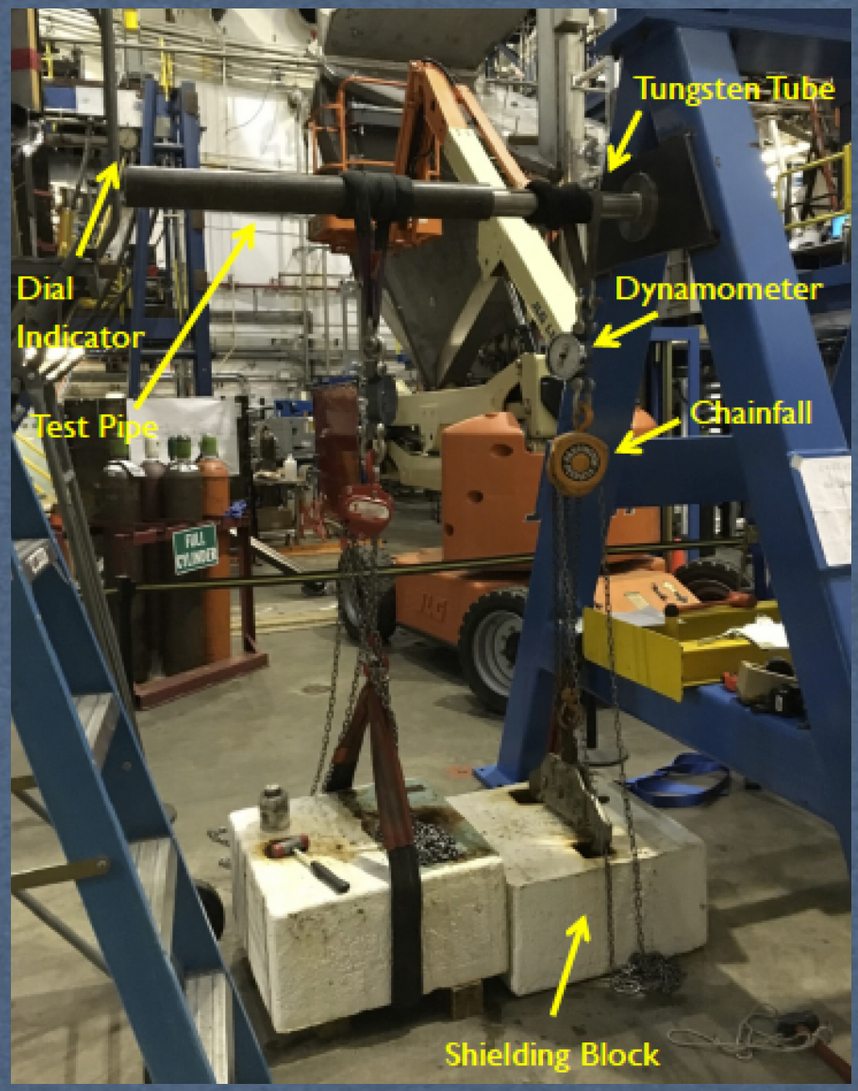




FT support pipe load tests

- nominal FT configuration
- shielded FT configuration

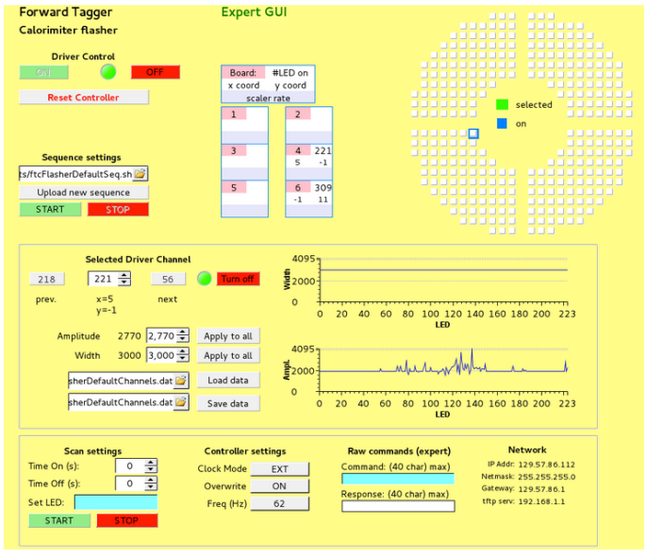


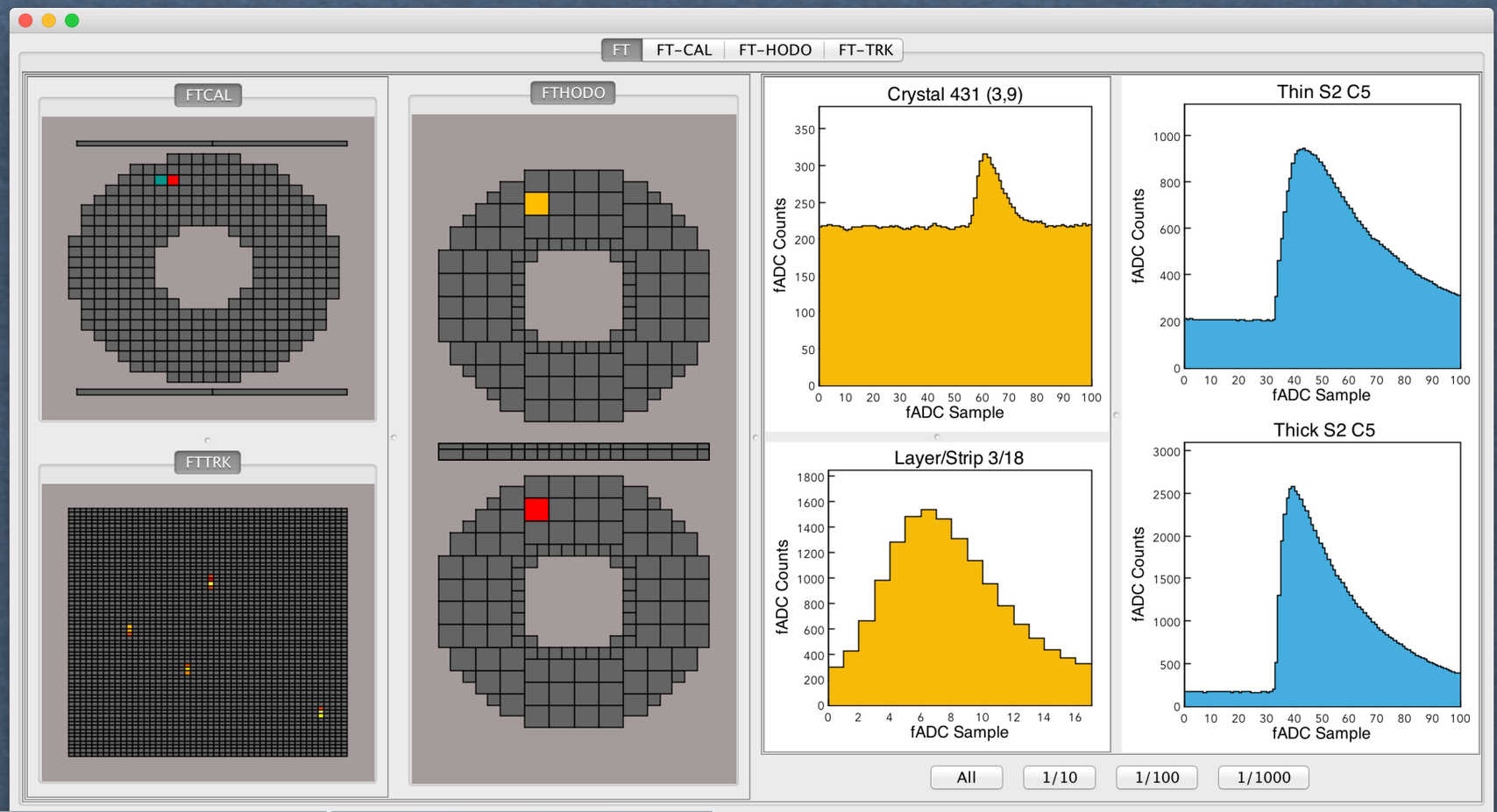


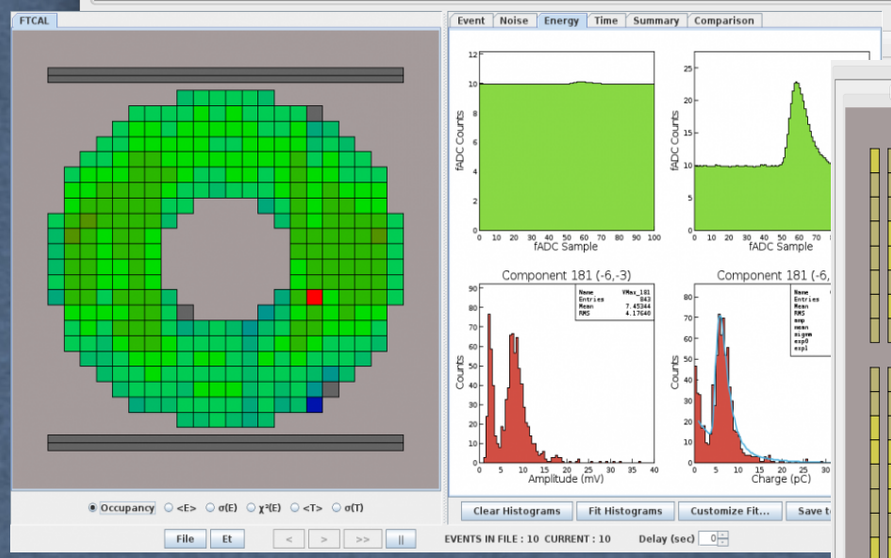
FT DAQ, Slow Controls and monitoring

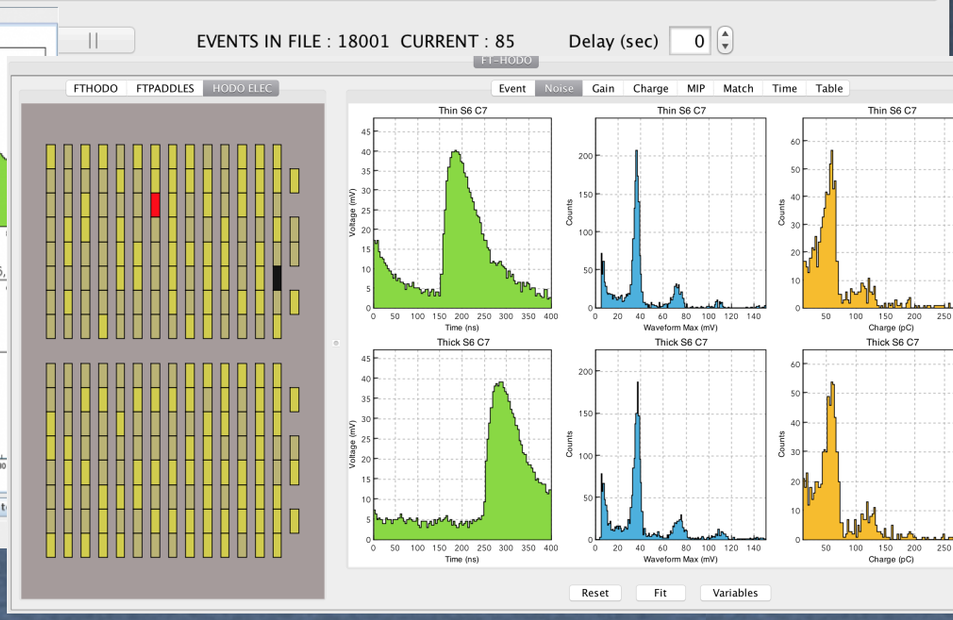
HV/LV/T Chiller GUI

LED Monitoring GUI



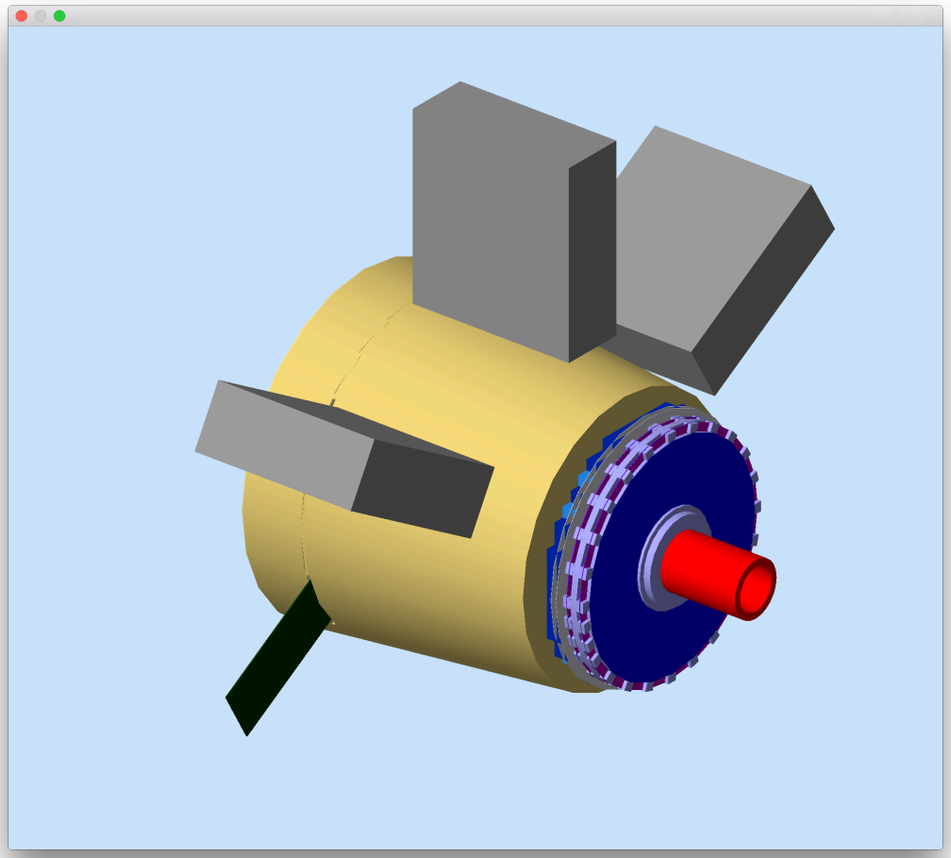


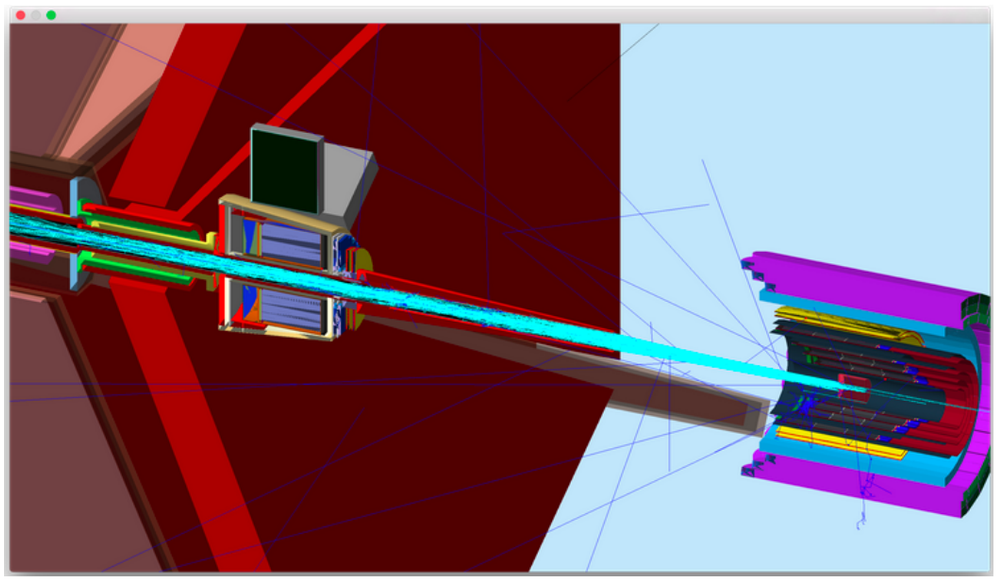




- FT-Cal slow controls and monitoring
- Combined Cal+Hodo+Trck monitoring GUI
- Now upgrading to COATJAVA 3.0

FT in GEMC





FT simulations

Simulations:

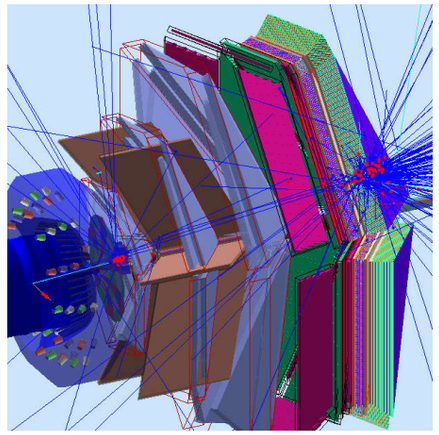
Geometry
- correct z position
- correct FT-cal insulation and FT-Trk crates position
- Full FT-Hodo geometry (Edinburgh+Genova)
- Full FT-Trk geometry (M. Garcon)

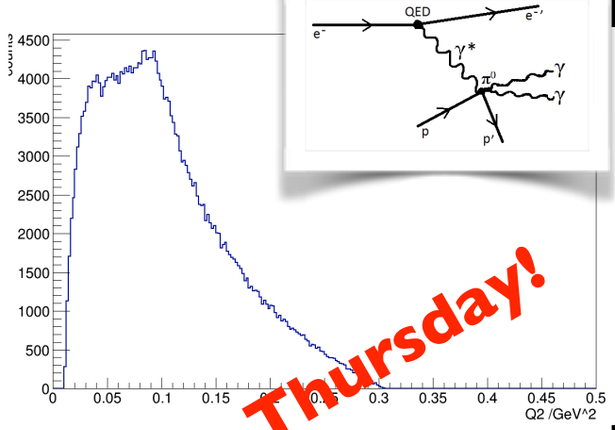
FT hitprocess
- Digitization based on calibration constants read from CCDB
- FT-Cal and FT-Hodo tuned to match cosmic ray calibration data
- FT-Trk update in progress (M. Defurne)

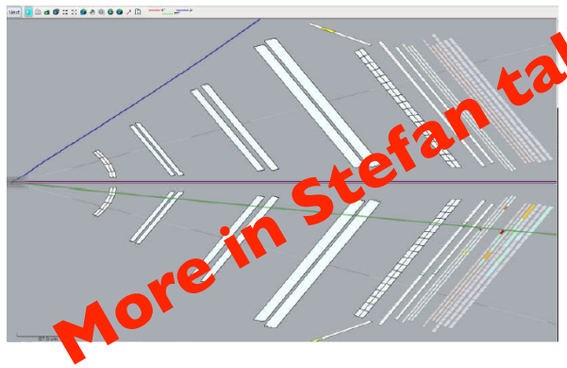
FT reconstruction

e p → e' p π0 (γ p → p π0)

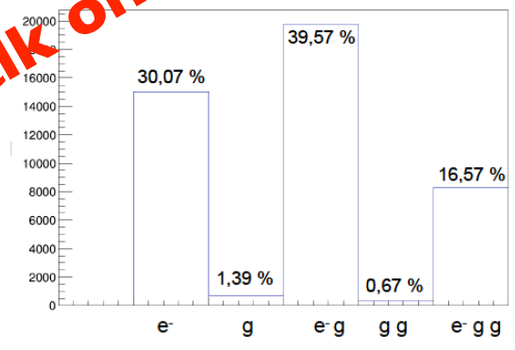
- S.Diehl (U Giessen)
- Full CLAS12 (+FT) GEANT4 sim/rec
- JPAC e-production amplitudes (V.Mathieu)
- AMPTOOLS

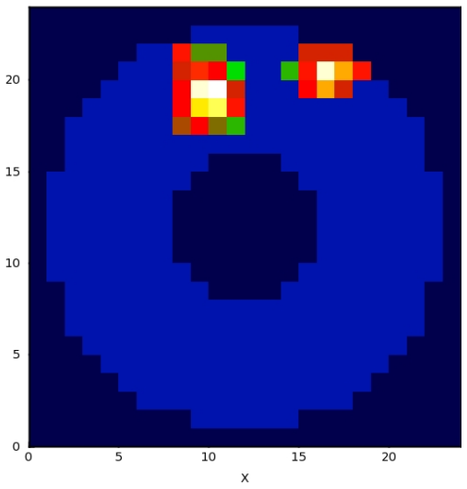


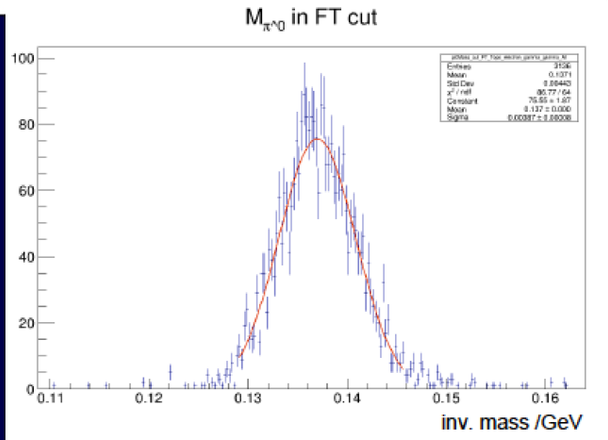




More in Stefan talk on Thursday!







137 MeV/c² reconstrcuted (lit.: 134,98 MeV/c²)

Resolution: 3.9 MeV/c²

Reconstruction

FT-Cal:
- Read raw hits from hipo bank
- Read calibration constants from DB
- Create hits, converting from digitized info to E and T
- Reconstruct cluster and determining cluster E, T and pos

FT-Hodo:
- Read raw hit from evio bank
- Read calibration constants from DB
- Create hits, converting from digitized info to E and T
- Match hits in the hodoscope layers

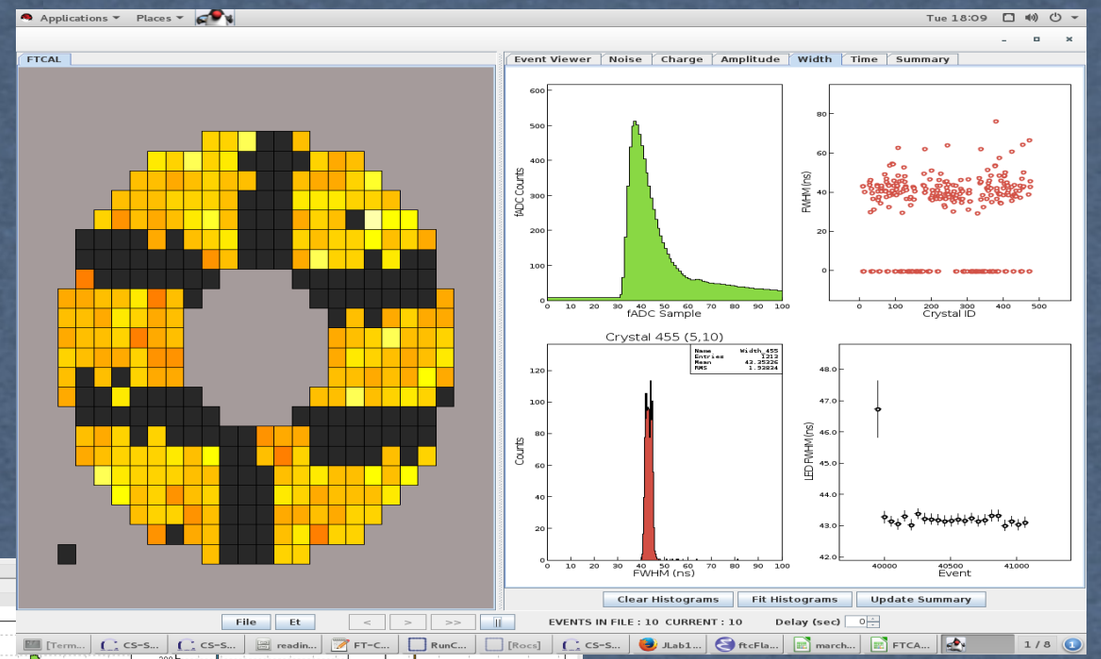
FT-Track:
- started based on algorithm developed by G. Charles

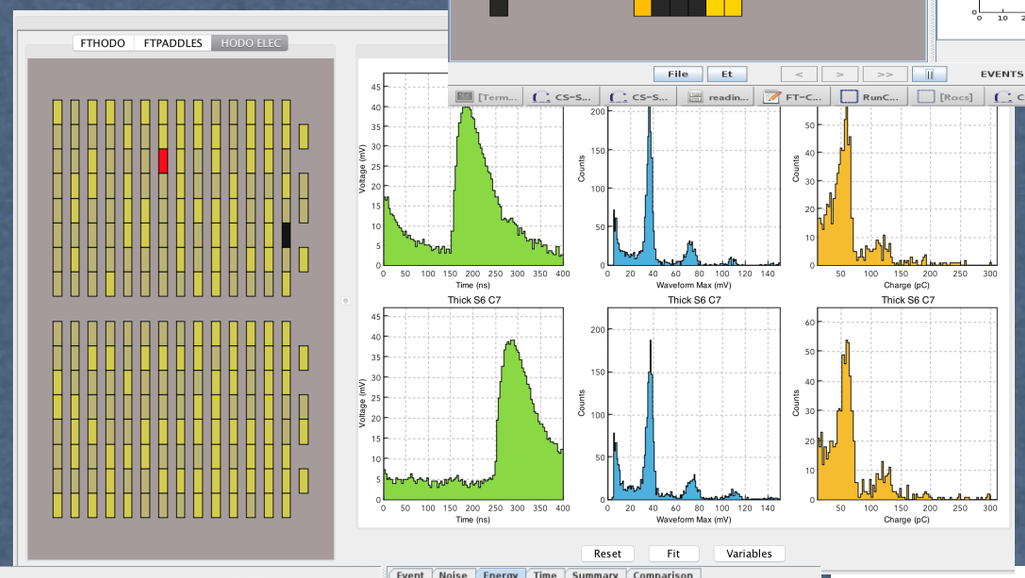
FT-Match:
- Match reconstructed clusters with hits in hodoscope
- Output of final reconstructed particles

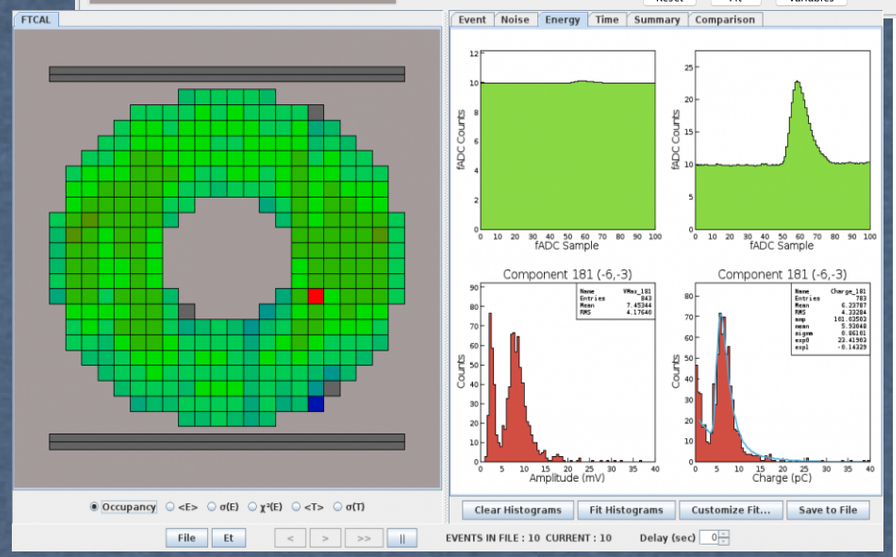
Code available in present COATJAVA distribution

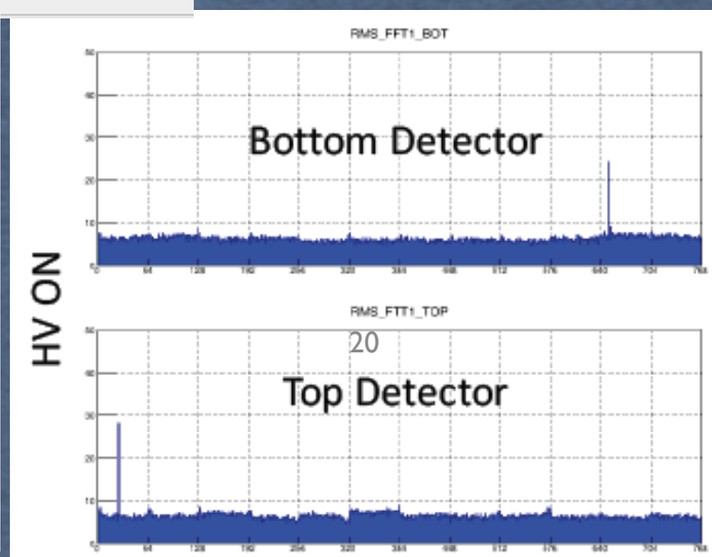
FT Commisioning w/o beam

- Calorimeter:
  - Noise measurement to test individual channel functionality
  - Response to LED signals
  - Cosmic ray energy calibration
- Hodoscope:
  - Noise measurement to test individual channel functionality
  - Cosmic ray energy calibration
- Tracker:
  - Pedestal/noise measurement and FEE diagnostic runs









FT Calibration Challenge results

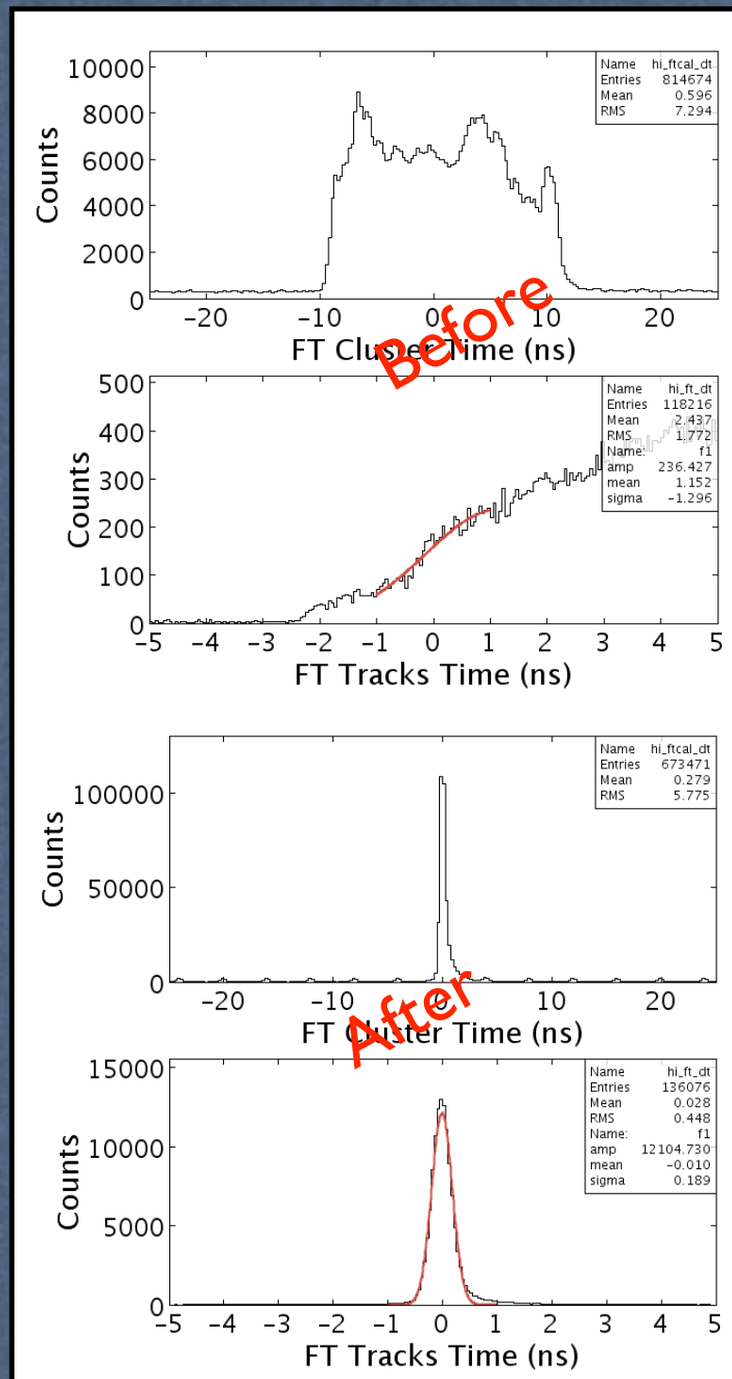
FT participated into Dec16 Calibration Challenge to test the effectiveness of the calibration procedures using MC data with background

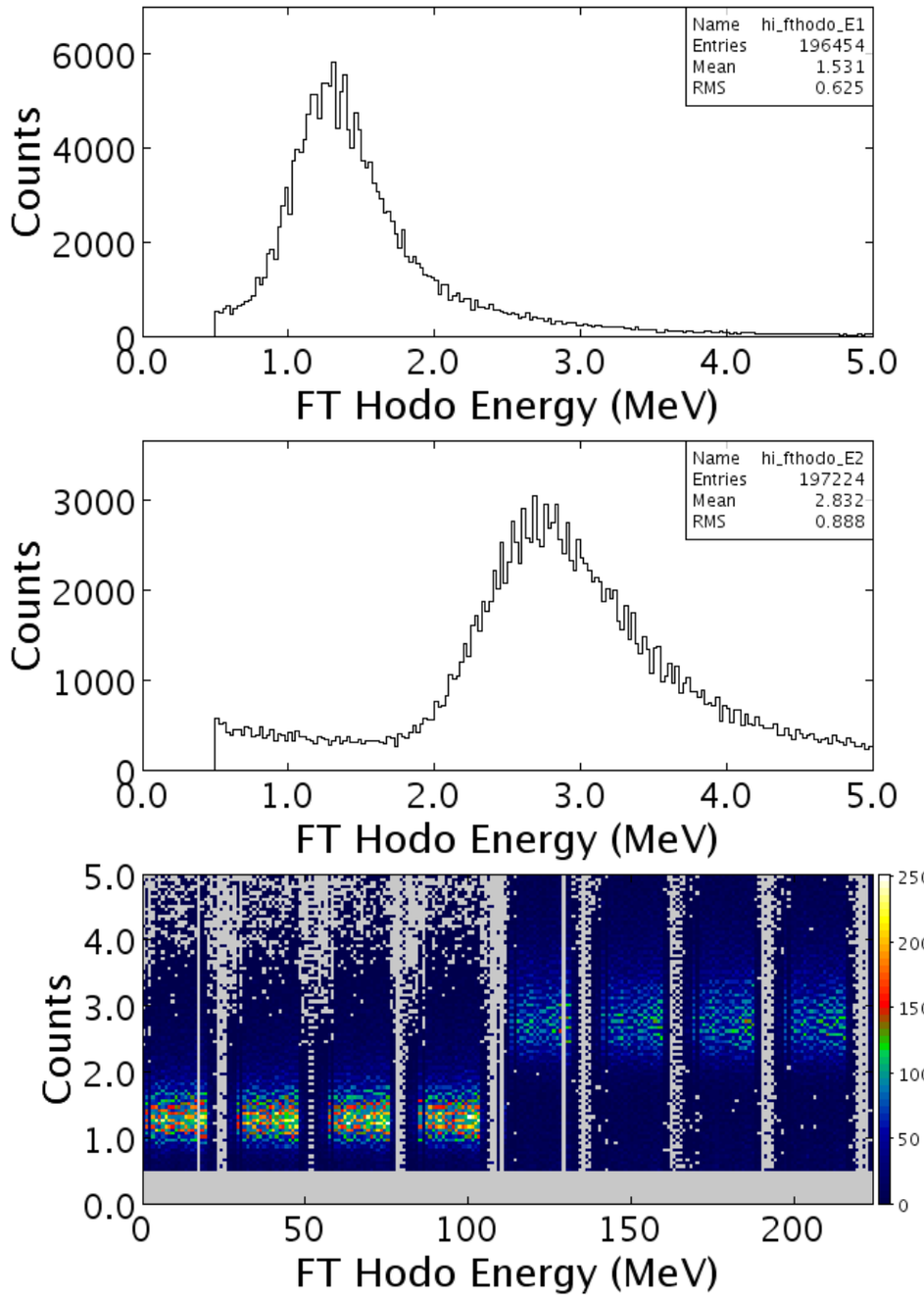
Tested procedures include:

- FT-Cal timing calibration (E.Fanchini)
- FT-Hodo energy calibration (G.Smith)

Successful results for both sub-detectors at first iteration:

- FT timing resolution after calibration consistent within simulated value
- FT-Hodo charge2energy constants consistent with simulated ones with small systematics (3%) due the Landau parameterization





Schedule of remaining tasks

FT final assembly and test in the EEL building

- FT-Cal sealing
- FT-Cal + FT-Hodo ready for cosmic checkout
- Interlocks + Gas system tested in EEL building
- FT-Trck integration (interlocks + gas system)
- FT final check with cosmic

JLab EEL building

May

June

FT detector ready to be installed in CLAS12

FT installation in CLAS12

- Move the electronics to the Hall
- Move the FT to the Hall and integrate in CLAS12
- Take cosmic data to check the final configuration

JLab Hall-B

July

August/ September

FT detector ready to take data