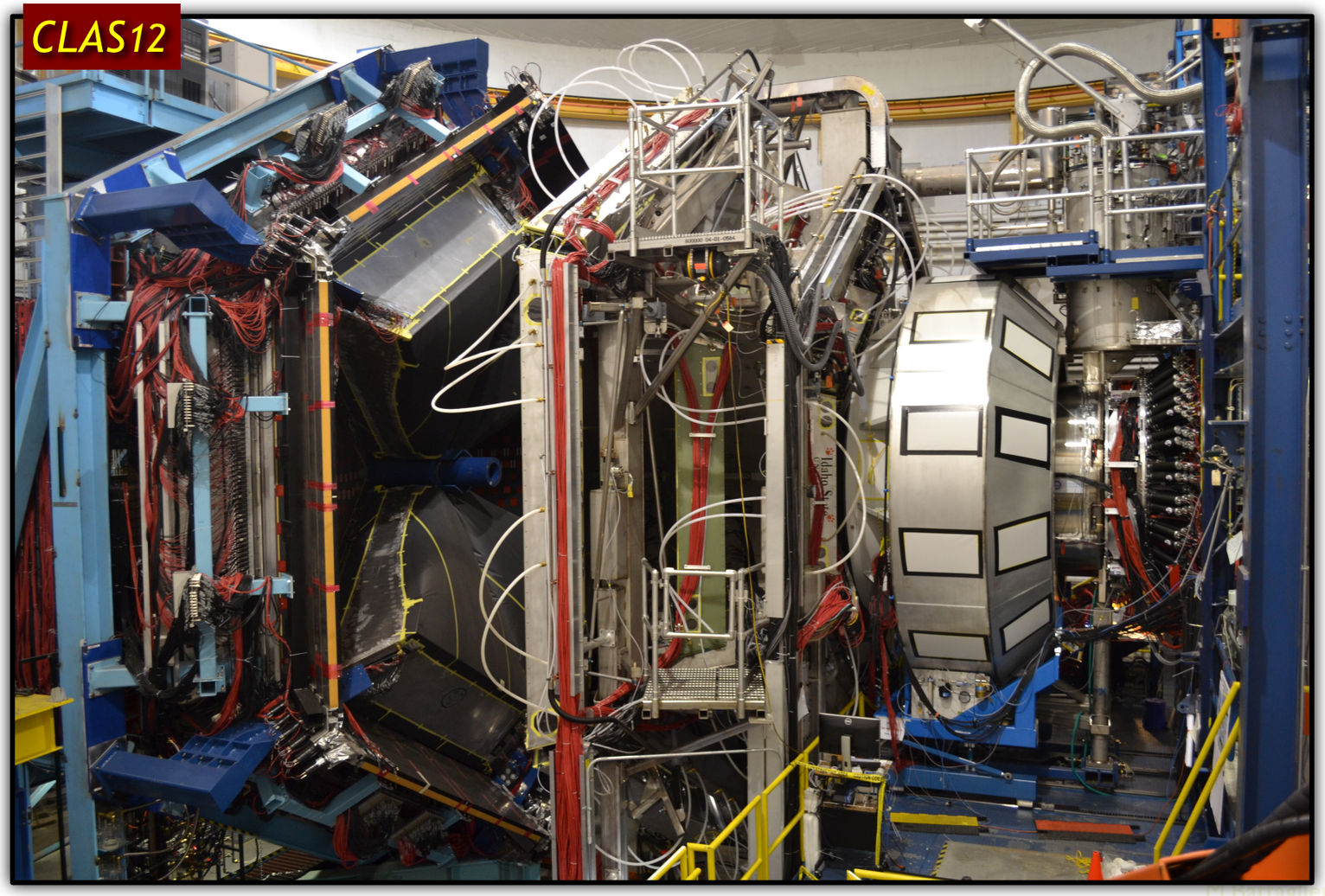
Streaming Readout VI

from Wednesday, 13 May 2020 at **08:30** to Friday, 15 May 2020 at **12:00** (US/Eastern)
at **Virtual Workshop**

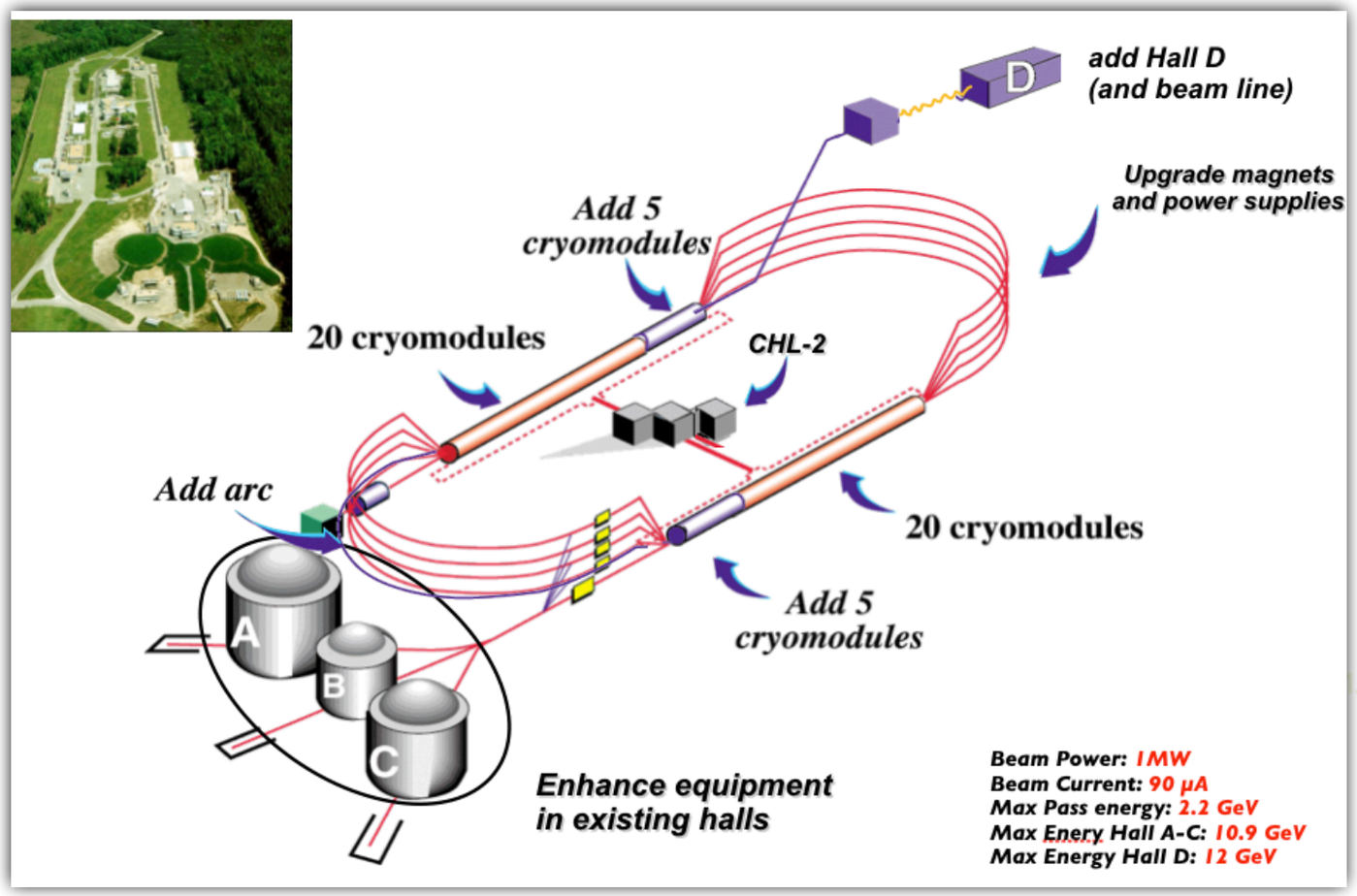


Recent Experience with Streaming ReadOut for Forward Tagger-CLAS12

Marco Battaglieri
Jefferson Lab/ INFN

Supported by Italian Ministry of Foreign Affairs (MAECI) as Projects of great Relevance within Italy/US Scientific and Technological Cooperation under grant n. MAE0065689 - PGR00799

Jefferson Lab

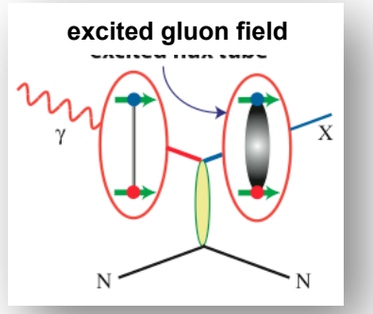


- ✳Primary Beam: Electrons
- ✳ Beam Energy: 12 GeV
  - 10 > λ > 0.1 fm
  - nucleon → quark transition
  - baryon and meson excited states
- ✳100% Duty Factor (cw) Beam
  - coincidence experiments
  - Four simultaneous beams
  - Independent E and I
- ✳ Polarization
  - spin degrees of freedom
  - weak neutral currents

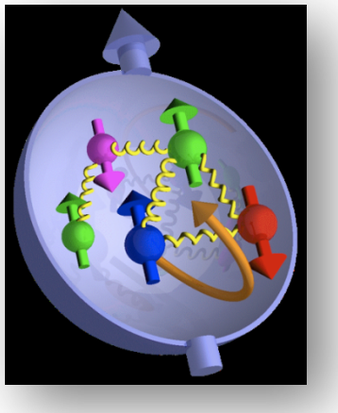
Luminosity > 10^7 -10^8 x SLAC
at the time of the original DIS experiments!

JLab Scientific mission

- What is the role of gluonic excitations in the spectroscopy of light mesons?

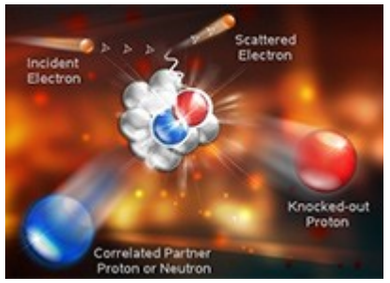


- Where is the missing spin in the nucleon? Role of orbital angular momentum?

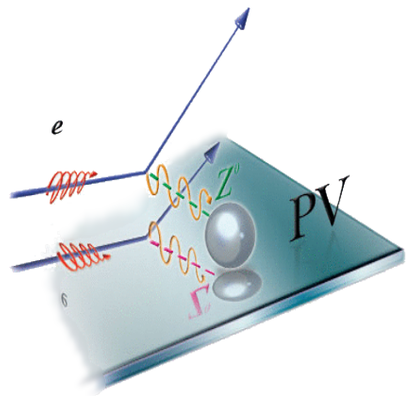


- Can we reveal a novel landscape of nucleon substructure through 3D imaging at the femtometer scale?

- What is the relation between short-range N-N correlations, the partonic structure of nuclei, and the nature of the nuclear force?



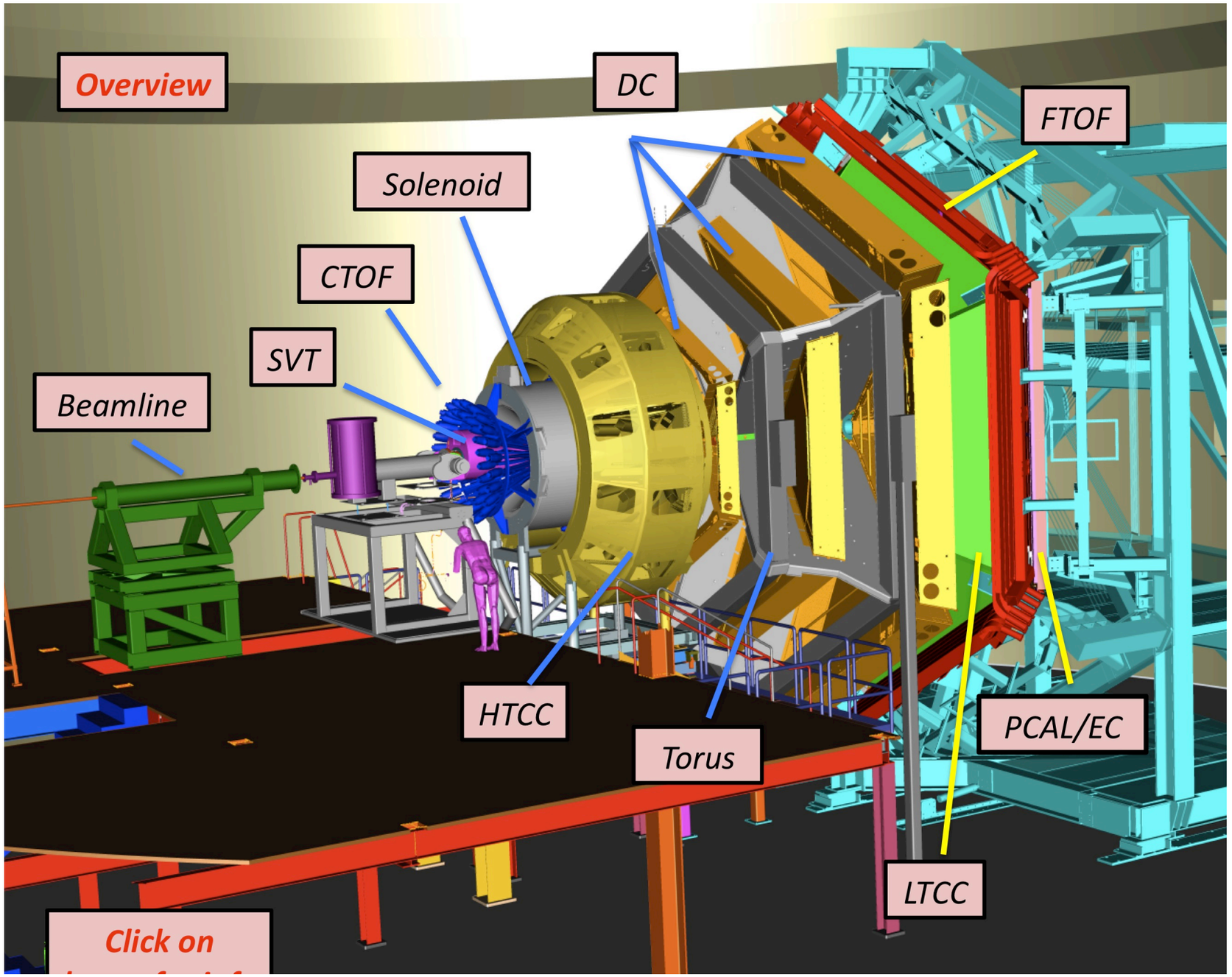
- Can we discover evidence for physics beyond the standard model of particle physics?



Hall-B: the CLAS12 detector

Forward Detector:
- *TORUS magnet*
- *HT Cherenkov Counter*
- *Drift chamber system*
- *LT Cherenkov Counter*
- *RICH detector*
- *Forward ToF System*
- *Pre-shower calorimeter*
- *E.M. calorimeter (EC)*
- *Forward Tagger*

Central Detector:
- *SOLENOID magnet*
- *Barrel Silicon Tracker*
- *Micromegas*
- *Central ToF system*
- *Neutron detector*
- *Backward Angle Neutron detector*



The CLAS12 detector

Forward Detector:

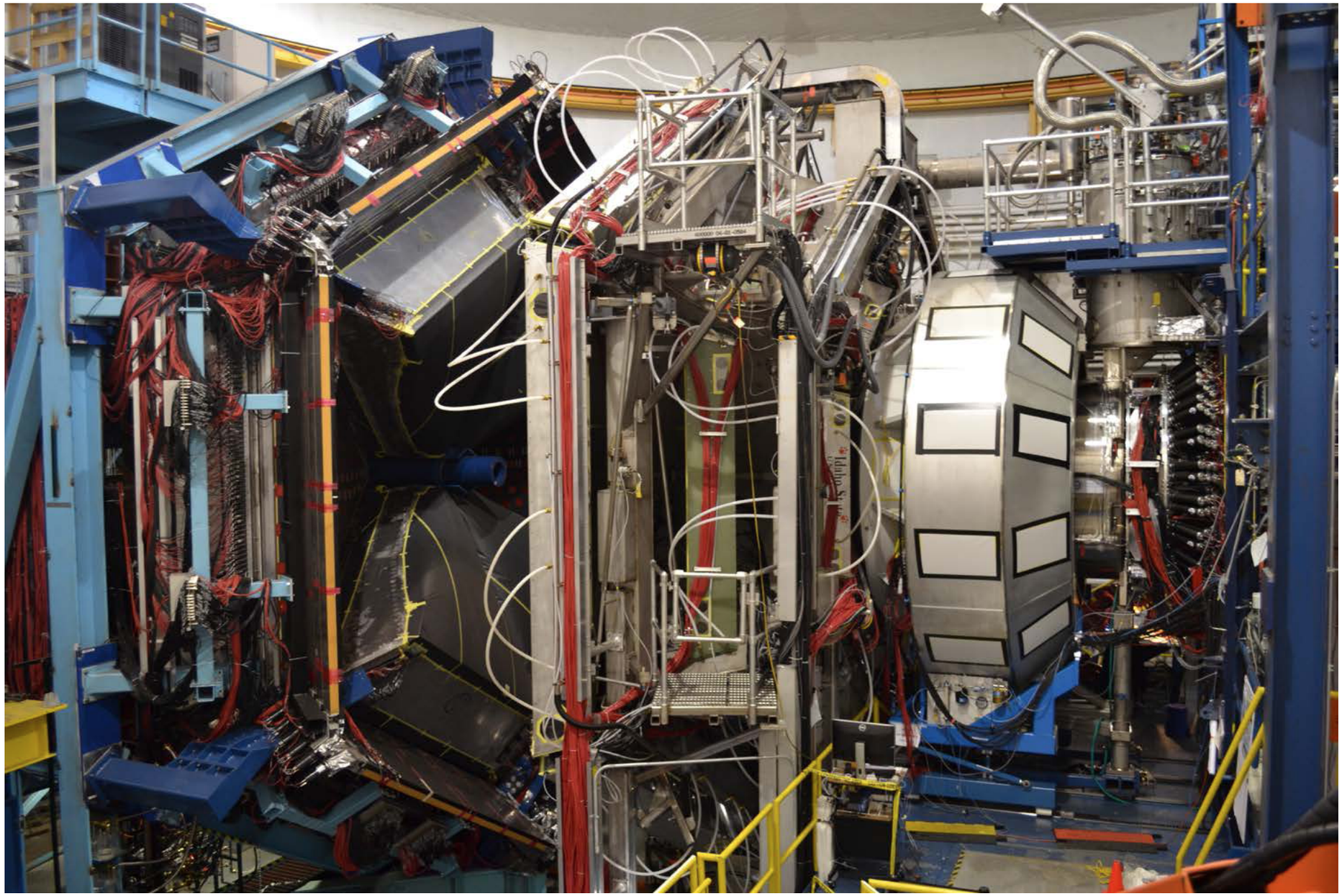
- *TORUS magnet*
- *HT Cherenkov Counter*
- *Drift chamber system*
- *LT Cherenkov Counter*
- *Forward ToF System*
- *Preshower calorimeter*
- *E.M. calorimeter (EC)*

Central Detector:

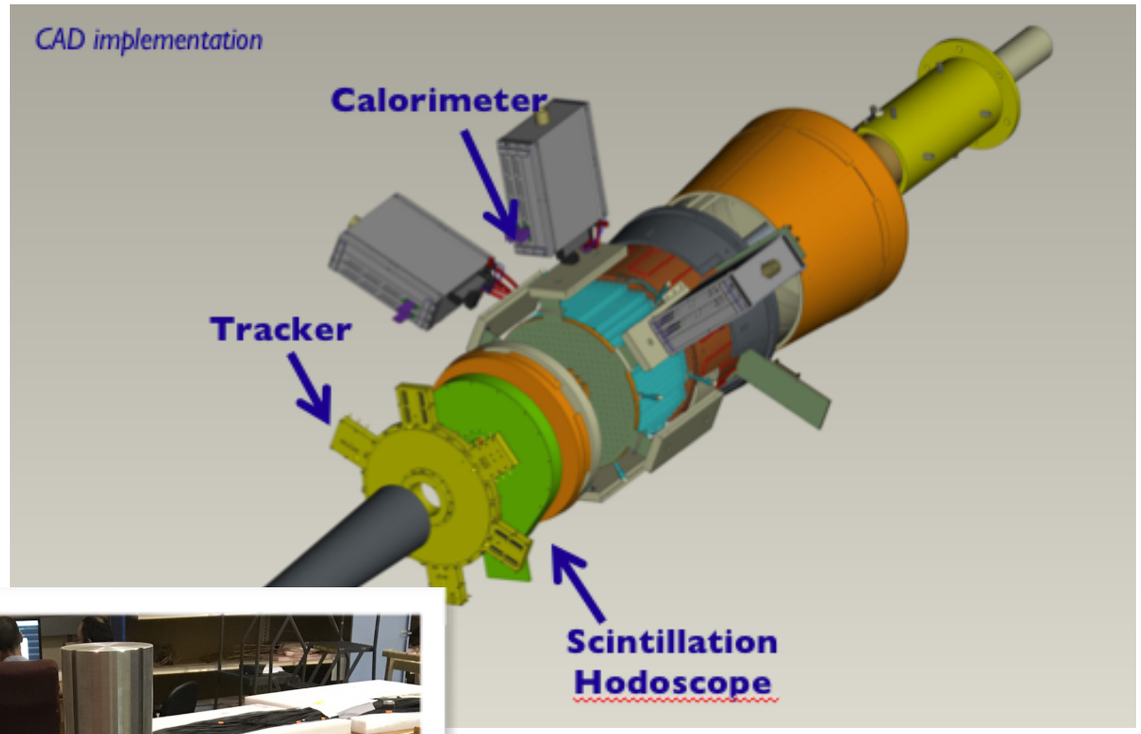
- *SOLENOID magnet*
- *Barrel Silicon Tracker*
- *Central Time-of-Flight*

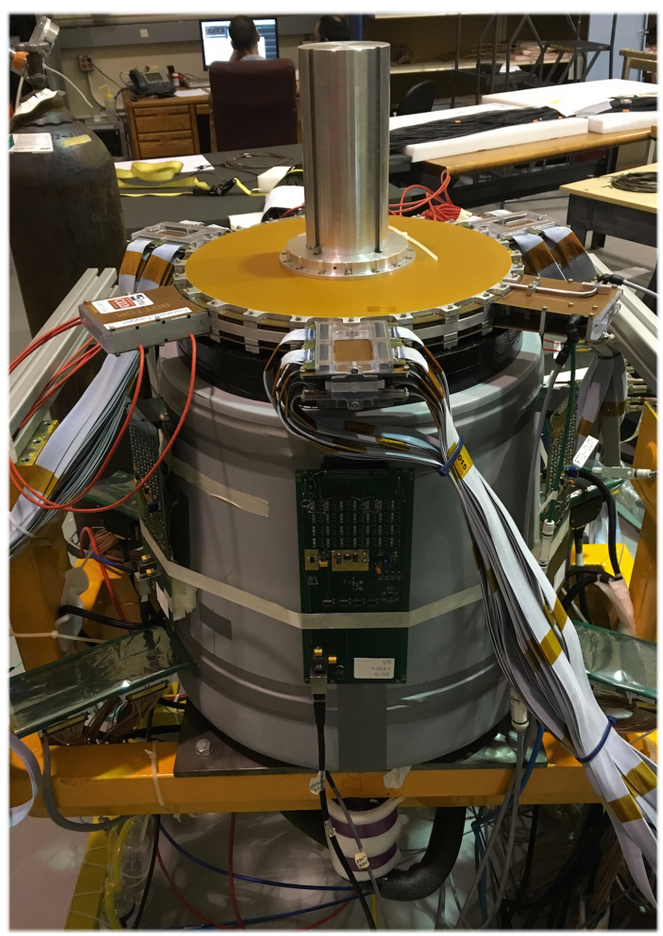
Upgrades:

- *Micromegas (CD)*
- *Neutron detector (CD)*
- *RICH detector (FD)*
- *Forward Tagger (FD)*



CLAS12 and the Forward Tagger (FT)

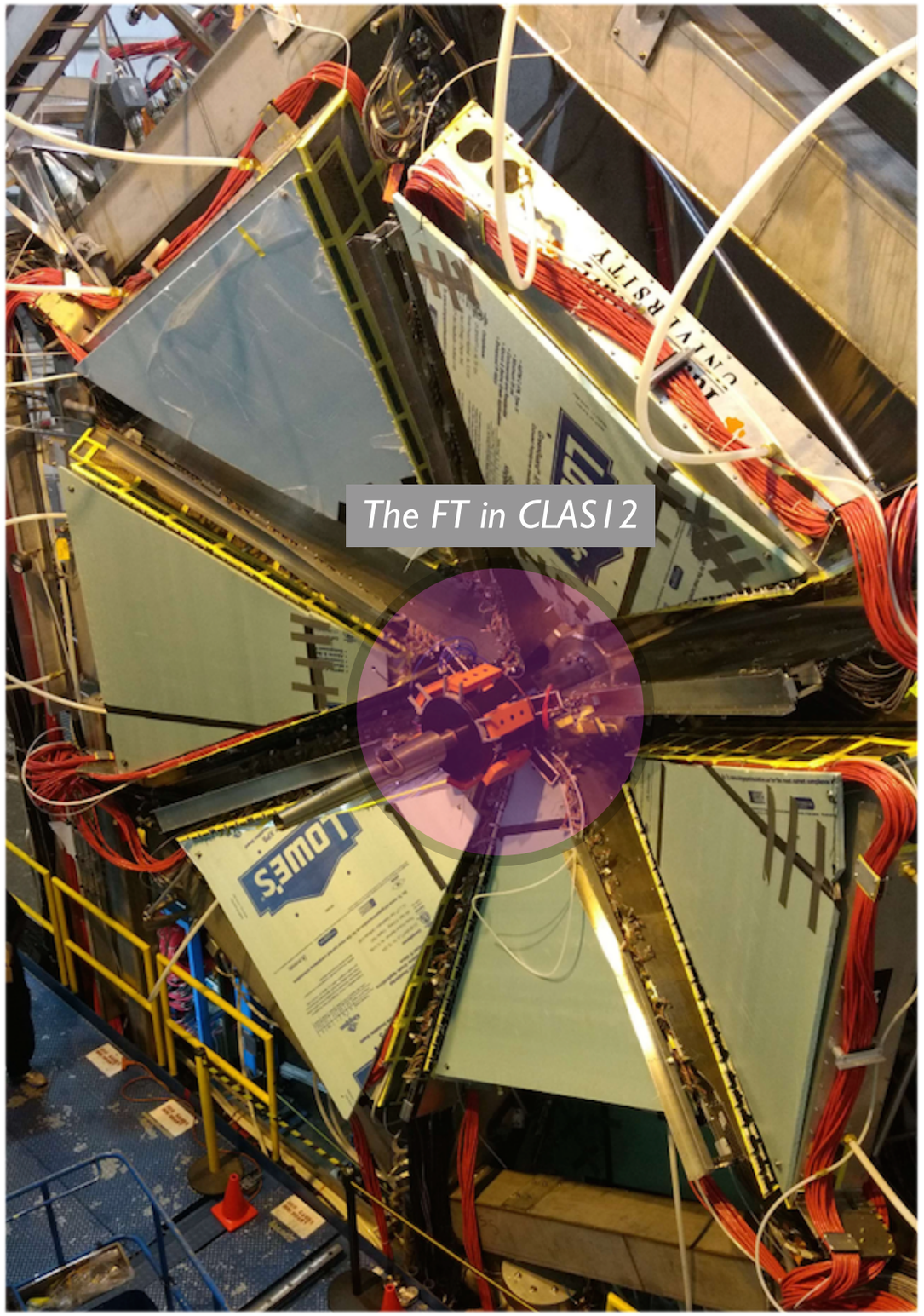




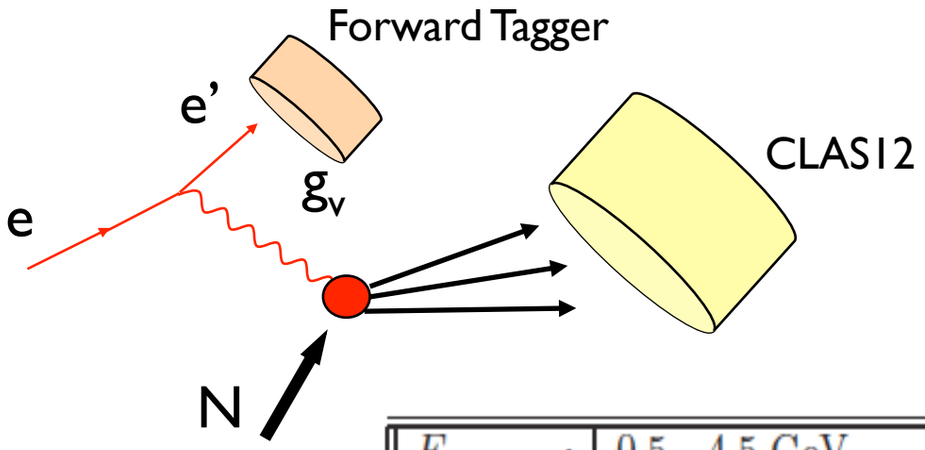
FT-Trck: MicroMegas
- electron angles and polarization plane

FT-Hodo: Scintillator tiles
- veto for photons

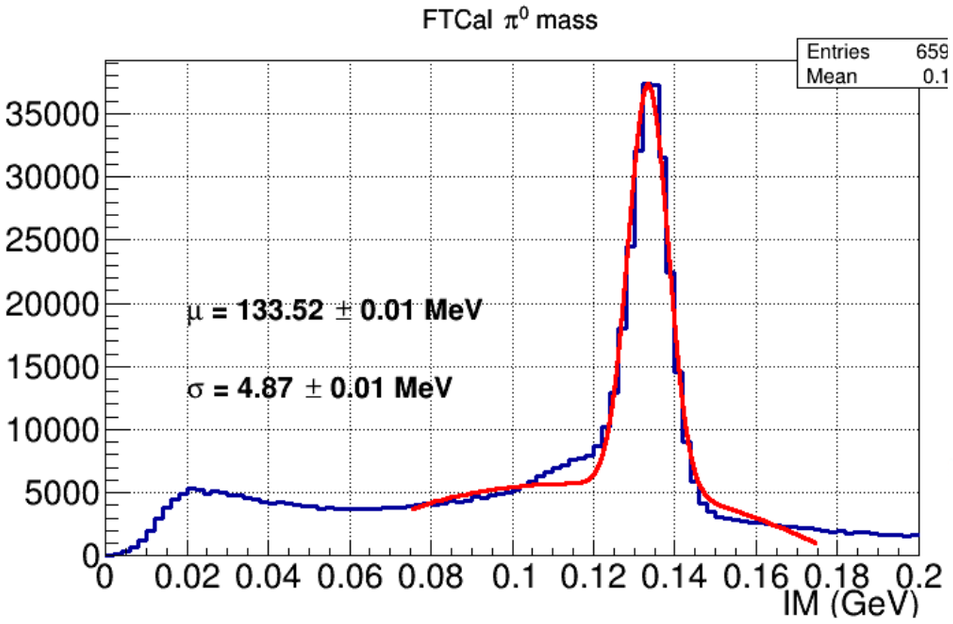
FT-Cal: $PbWO_4$ calorimeter
- electron energy/momentum
- Photon energy (ν=E-E')
- Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$



FT performance

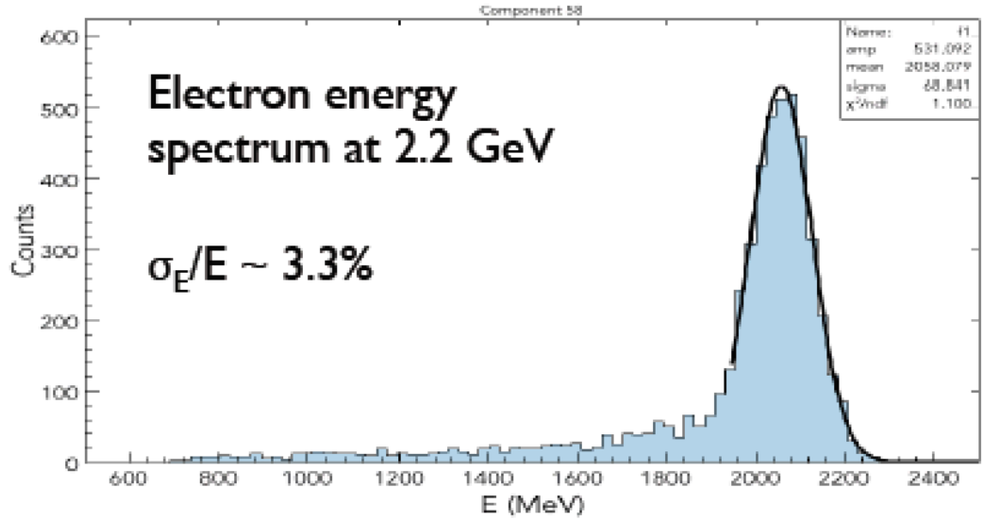


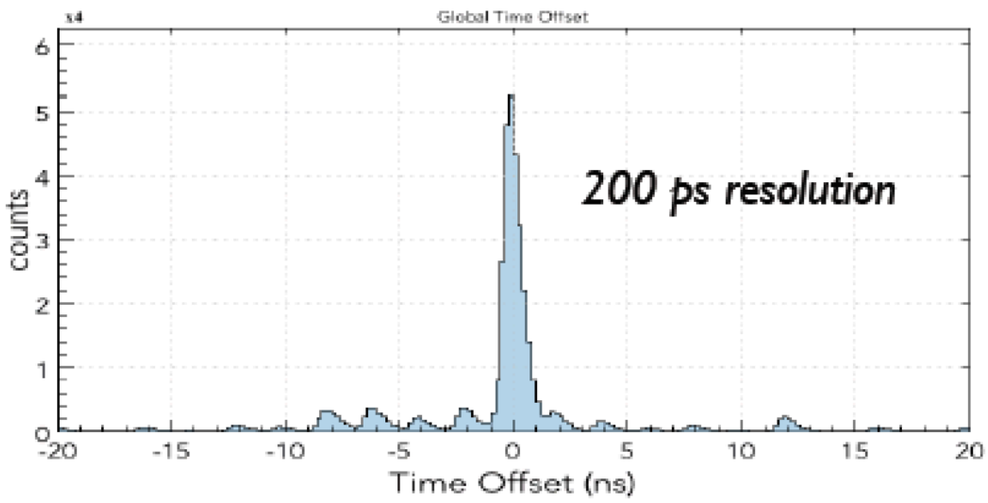
$E_{scattered}$	0.5 - 4.5 GeV
θ	2.5^o - 4.5^o
ϕ	0^o - 360^o
ν	6.5 - 10.5 GeV
Q^2	0.01 - 0.3 GeV^2 ($< Q^2 > 0.1$ GeV^2)
W	3.6 - 4.5 GeV



Final calorimeter calibration based on real data:

- Energy calibration based on elastic data at 2.2 GeV and 6.4 GeV
- Timing calibration based on coincidence with forward CLAS12 detector





Streaming RO - CLAS12-FT tests

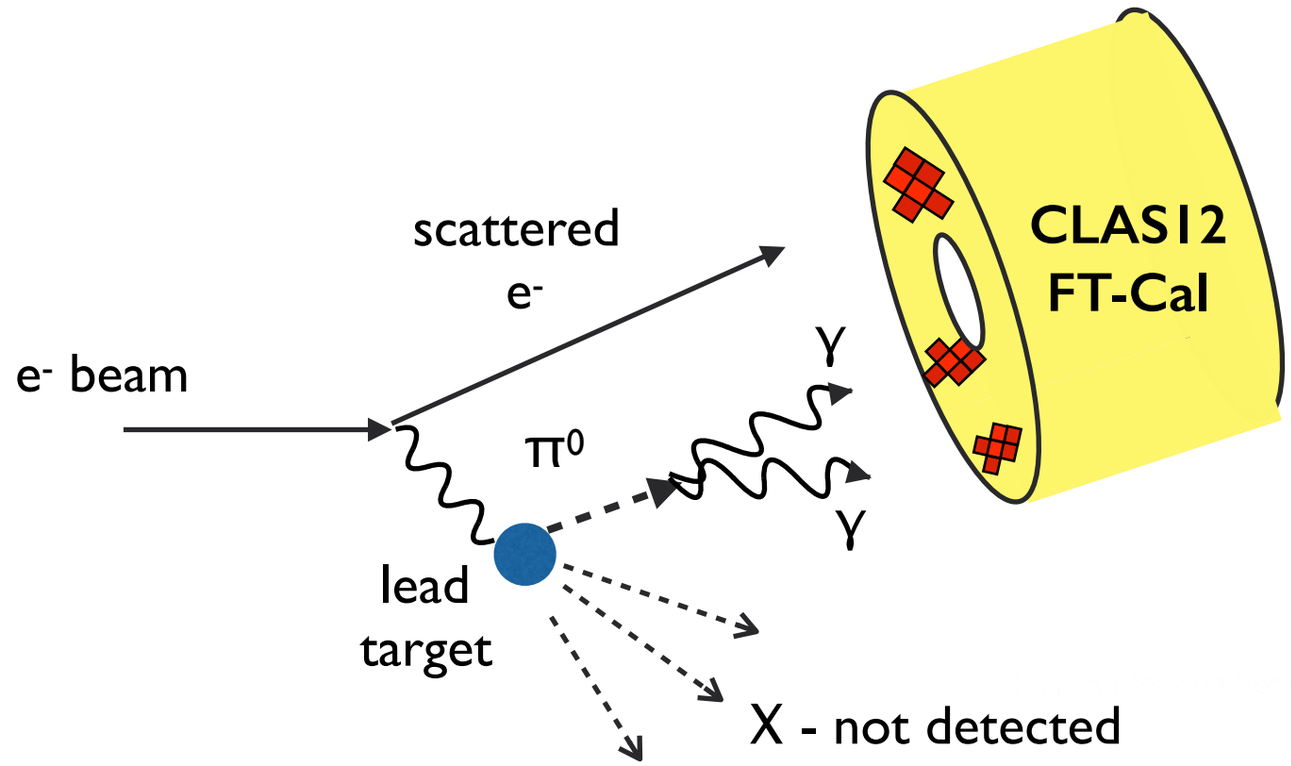
- **SRO DAQ full chain test: FE + RunControl + Streaming ROsw + Rec**
- **On-beam test (10.4 GeV electron beam on Pb target) in Jan/Feb 2020**
- **Hall-B CLAS12 Forward Tagger: Calorimeter + Hodoscope + Tracker**

Goal:

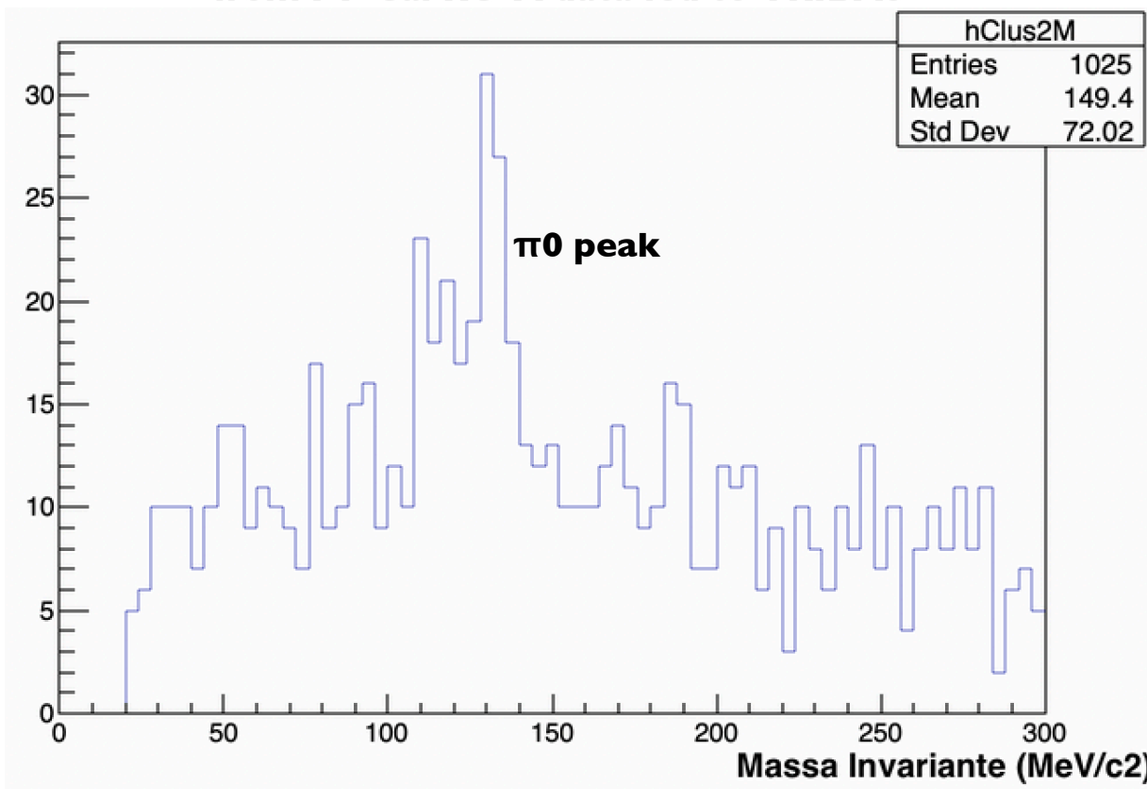
- collect data with 1-2-3 clusters in FT-CAL
- Identify the reaction e Pb → (X) e' π^0 →(X) e' γ γ
- reconstruct $M_{\pi 0}$

This test:

- FT-Cal only
- 332 PbWO crystals (APD)
- 10+12 fADC250 boards + 2 VTPs (in 2 crates/ROCs)



double-clusters (π0) mass obtained from FT-Cal RG-A data fed to TRIDAS



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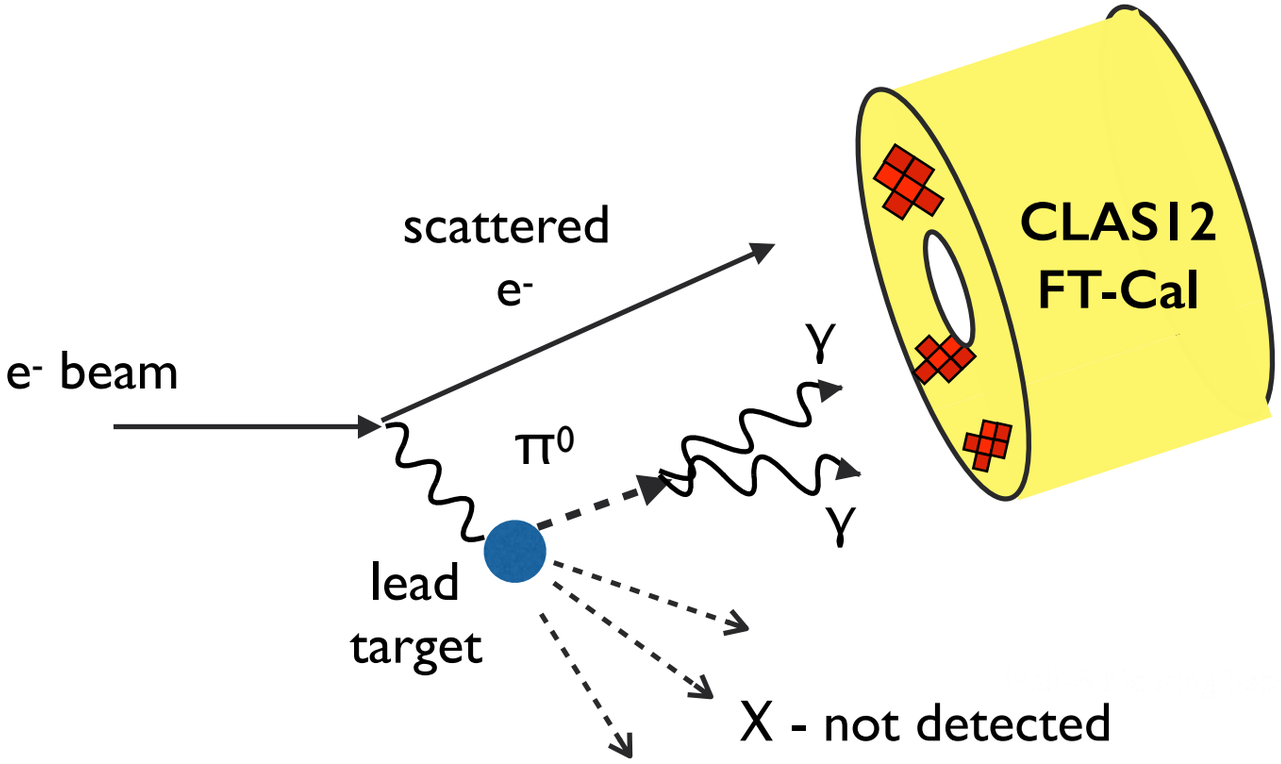
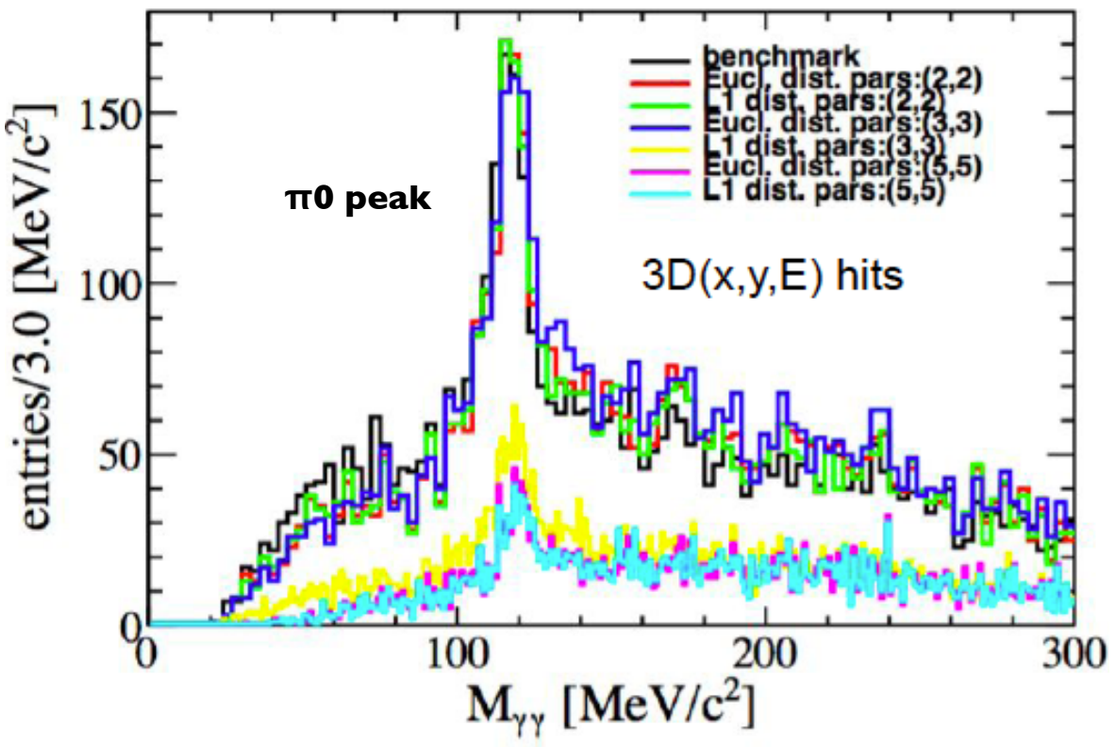
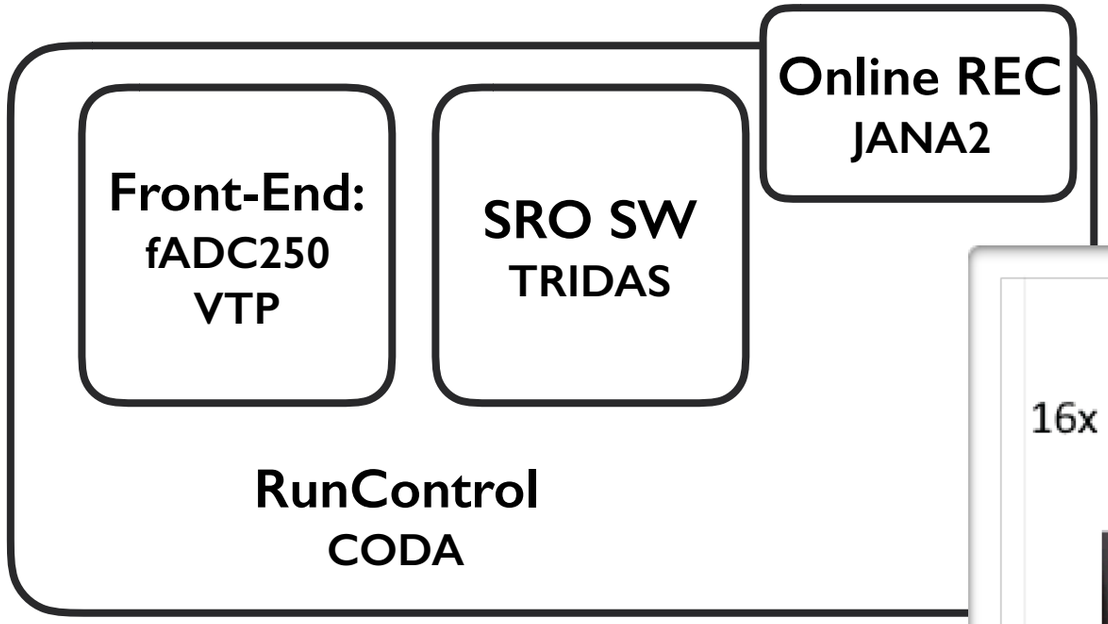


Double cluster π0 mass as obtained by an unsupervised hierarchical clustering algorithm implemented in JANA framework by C.Fanelli



Streaming RO - CLAS12-FT tests



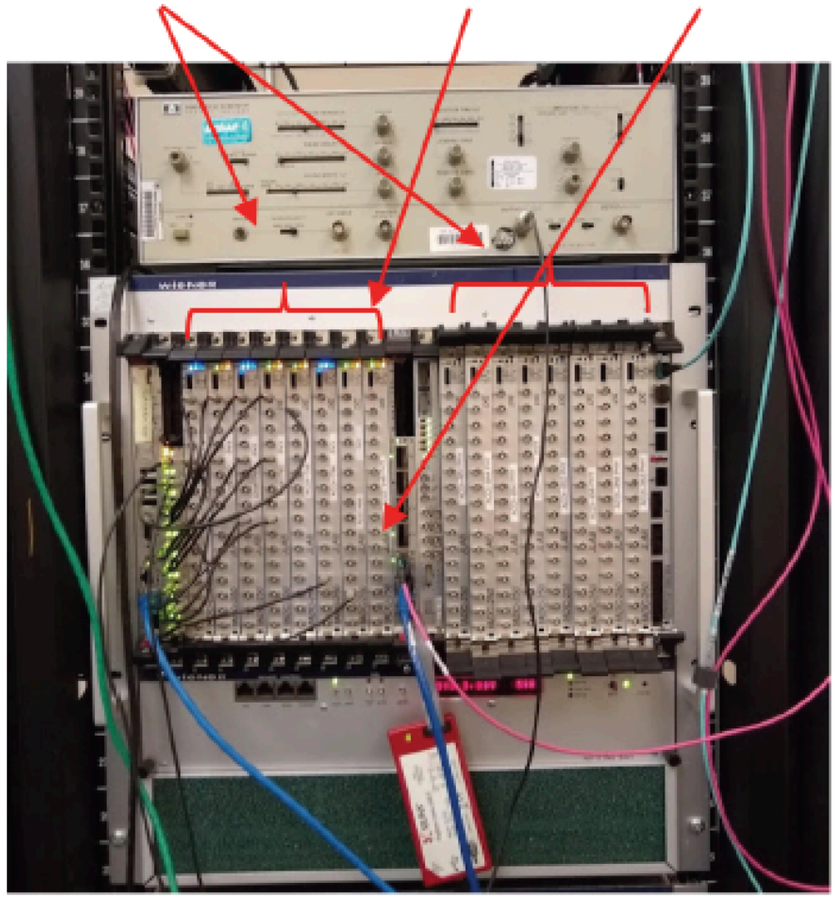
- Peak data rates ~150MBytes total (from both VTPs)
- Current VTP limit ~2GByte/sec
- Max: 10GBytes/sec
- VTP 10GbE ethernet links showed stability problems,
- TCP/IP stack found to be responsible
- Working on fixing it

FrontEnd

D.Abbott, F.Ameli, C.Cuevas, P. Musico, B.Raydo

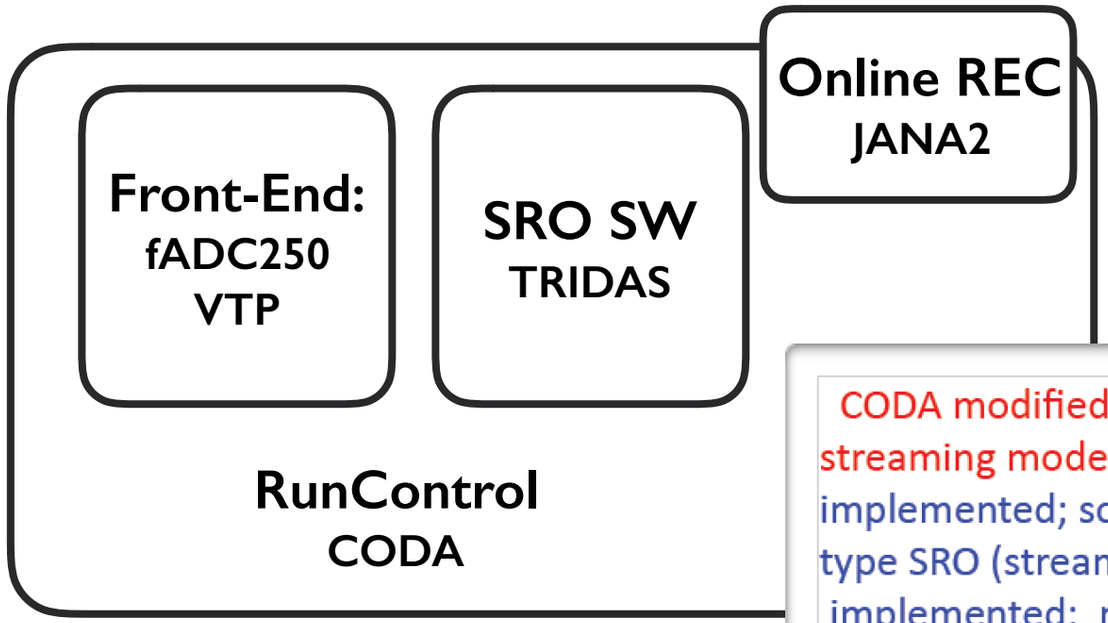
Streaming FADC250 Setup

16x FADC250 Modules -> VTP -> 2x 10Gbps Ethernet -> PC



Pretty much the same configuration FADC250 present throughout much of Hall B already

Streaming RO - CLAS12-FT tests

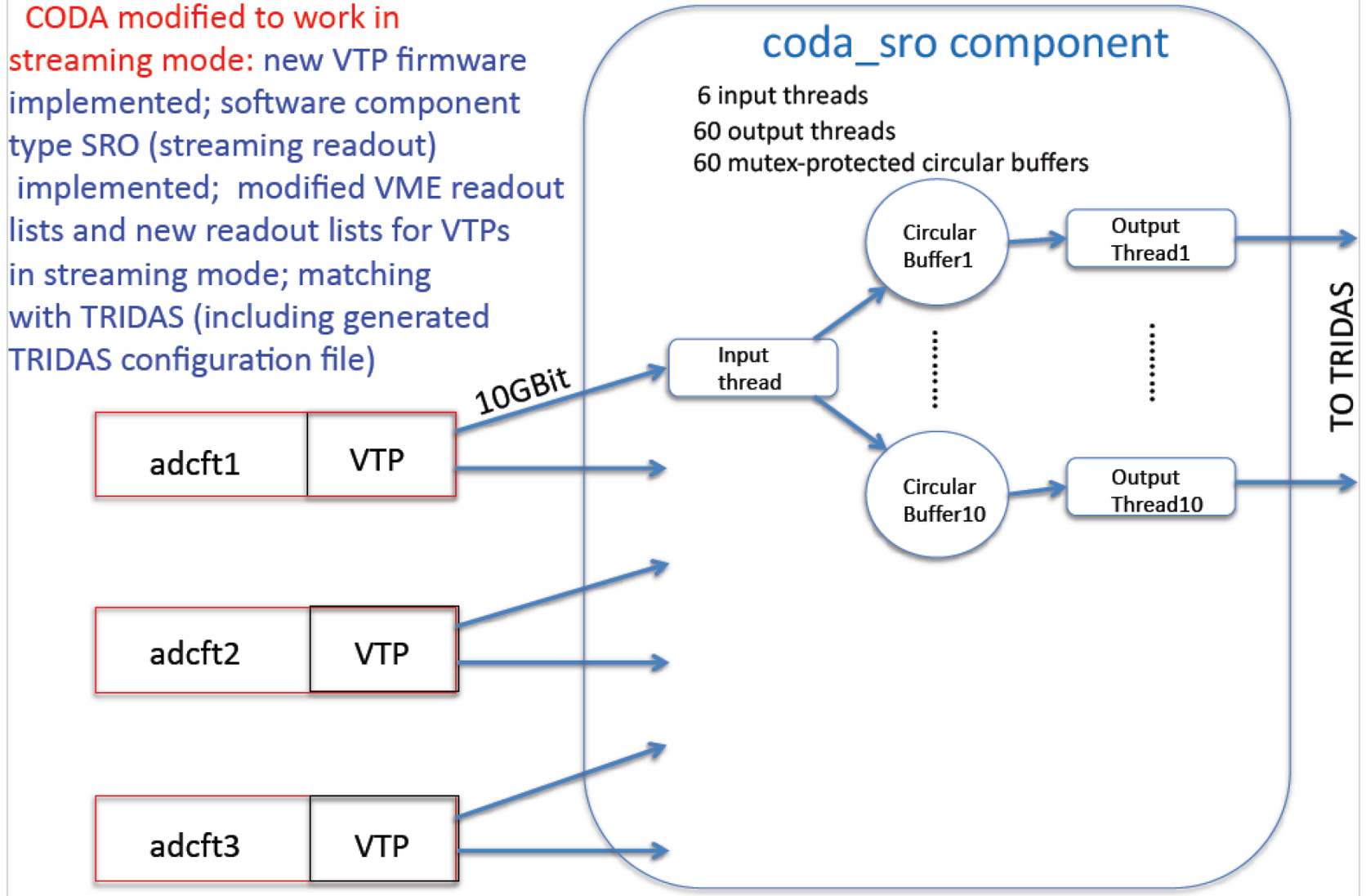


CODA

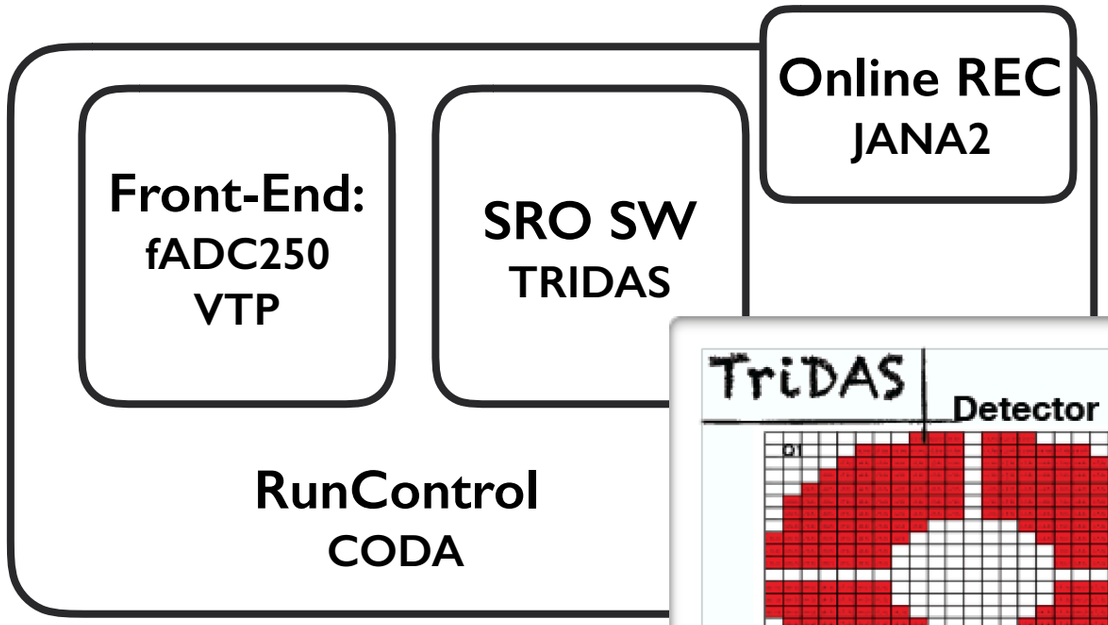
S.Boyarinov, B.Raydo

- Peak data rates ~150MBytes total (from both VTPs)
- Current VTP limit ~2GByte/sec
- Max: 10GBytes/sec
- VTP 10GbE ethernet links showed stability problems,
- TCP/IP stack found to be responsible
- Now fixed

CODA modified to work in streaming mode: new VTP firmware implemented; software component type SRO (streaming readout) implemented; modified VME readout lists and new readout lists for VTPs in streaming mode; matching with TRIDAS (including generated TRIDAS configuration file)



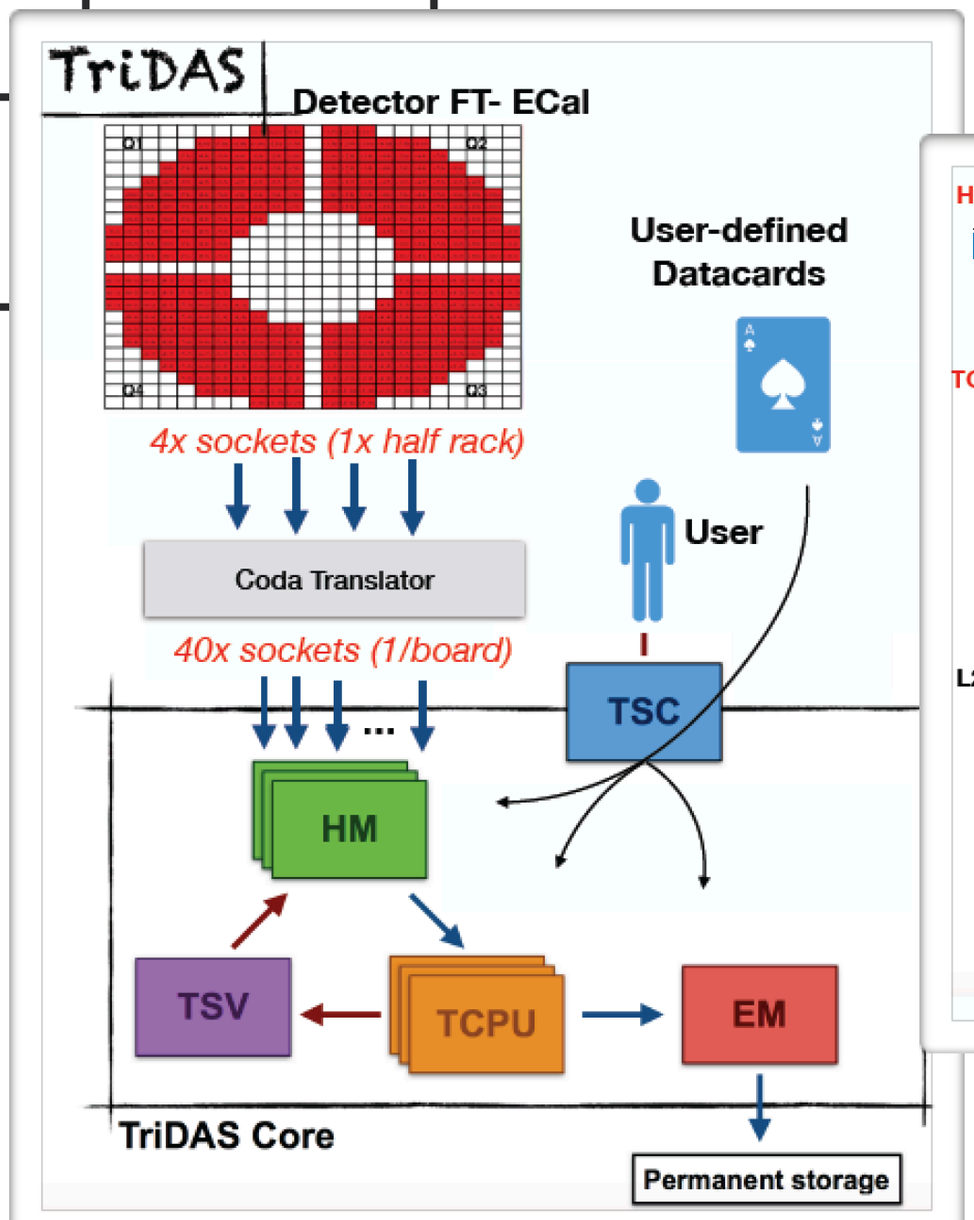
Streaming RO - CLAS12-FT tests

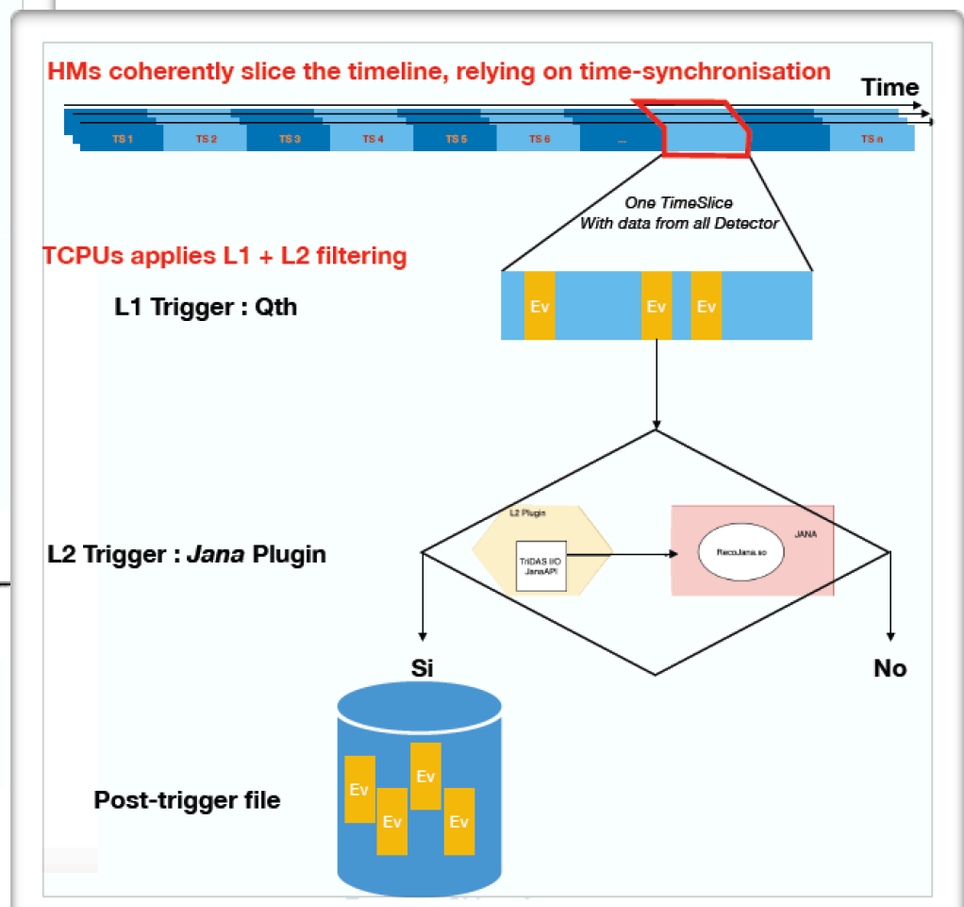


TRIDAS

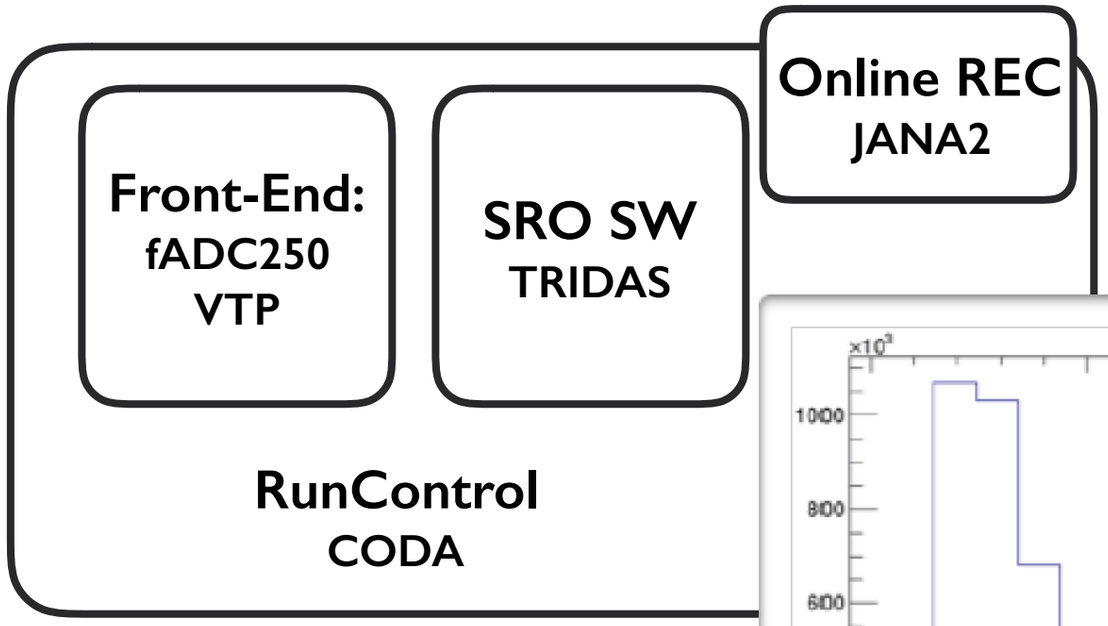
T.Chiarusi, C.Pellegrino

- TriDAS installed on Hall-B cluster
- Tested on multiple CPU: clonfarm1,2,3 and clondaq 4,5,7
- FT-Cal rate: 20-30 MHz
- Few hot-channels > 1 MHz



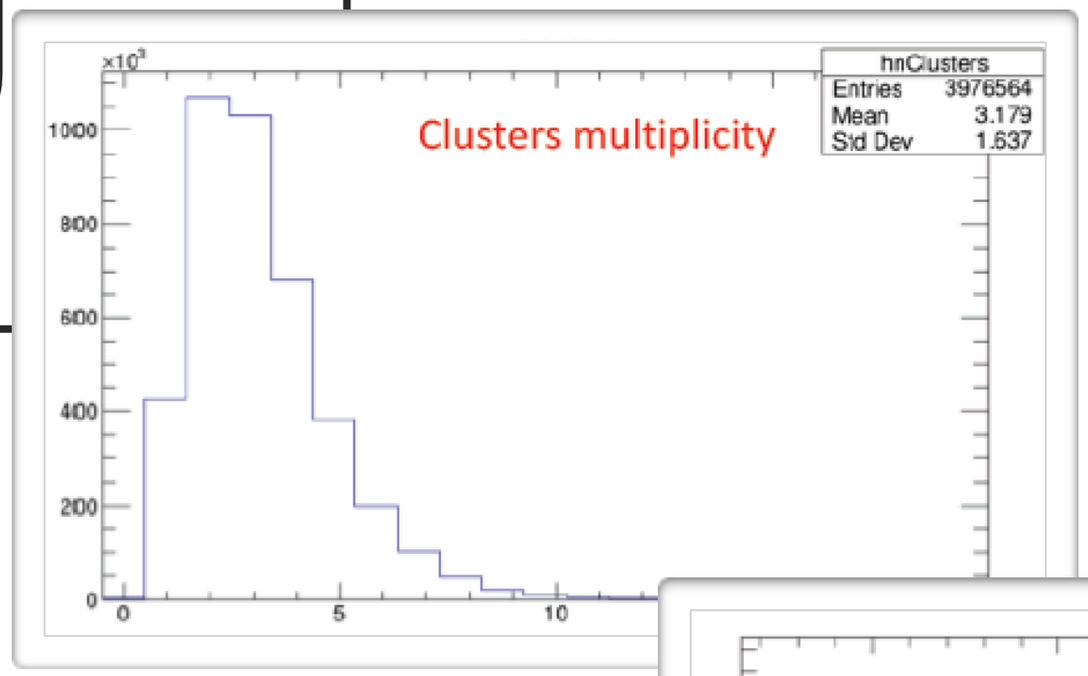


Streaming RO - CLAS12-FT tests

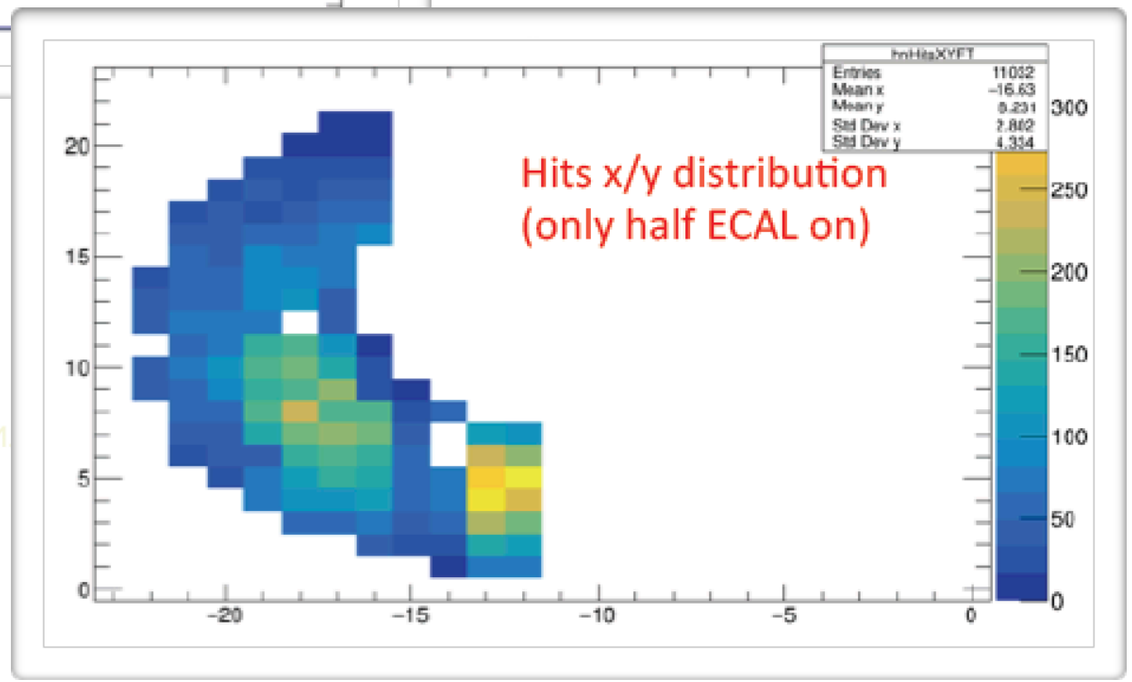


JANA2 + REC

N.Brei, D.Lawrence,
M.Bondi', A.Celentano, C.Fanelli, S.Vallarino



- FE setup:
  - FT-Cal only
  - TET (on fADC250)=15/50,
  - L1 threshold: 2000 (MeV)
  - L1 time window: 400 ns
- Tridas+JANA2+monitoring
- JANA2:
  - single-thread
  - L2 plugins: scaler (write all L1 to disk) + JANA2 (tag L1 events)
  - Online clustering enabled
  - Different runs taken with >=1 cluster, >=2 clusters, >=3 clusters
- AI-supported algorithms
  - Semi-supervised: k-mean
  - Unsupervised: hierarchical clustering



Streaming RO - CLAS12-FT tests

CLAS12-FT preliminary tests

- Data analysis in progress
- Future tests with:
  - FT-Hodo: cluster geometrical matching
  - FT-Trck: ~3k channels, digital RO
  - Cosmic muons
  - Beam-on

In progress

- TRIDAS optimisation
- JANA2 test & development
- Performance assessment
- Full online reconstruction
- AI-supported algorithms for cluster recognition
- Online self-calibration procedure using cosmic

Next step: Hall-D tests

- 3x3 PbWO2 cal prototype
  - Electron beam: Pair Spectrometer (PS)
  - Photosensors: SiPM/PMT readout
  - FE electronics: fADC250/WaveBoard digitizers
- Standard and Streaming RO DAQ comparison
- Tests planned for summer 2020
- Same configuration used in Hall-B: CODA+TRIDAS+JANA2
- Distributed system: run on Hall-B/CC servers
- Systematic performance assessment
- Development of a MC to simulate FE data stream

Conclusions

- Streaming Readout on-beam tests performed using the CLAS12-FT-Cal at JLab
- First step towards a full implementation for EIC
- The full chain (FE + SRO sw + ON-LINE REC) tested on existing hw
- Data taken in full streaming mode, analysis in progress (traditional and AI-supported)
- Fixed some issues to have a stable working chain
- Ready for systematic check and performance assessment
- Planned new tests with cosmic muons and on-beam reaction tagging
- Parallel activity in a more controlled situation (Hall-D PS test e^-/e^+beam)
- Implementing the FT model in a SRO G4 MC to check the full chain
- SRO prototype to be tested in view of a massive implementation of full CLAS12 SRO
- Built a real SRO prototype and a work team!