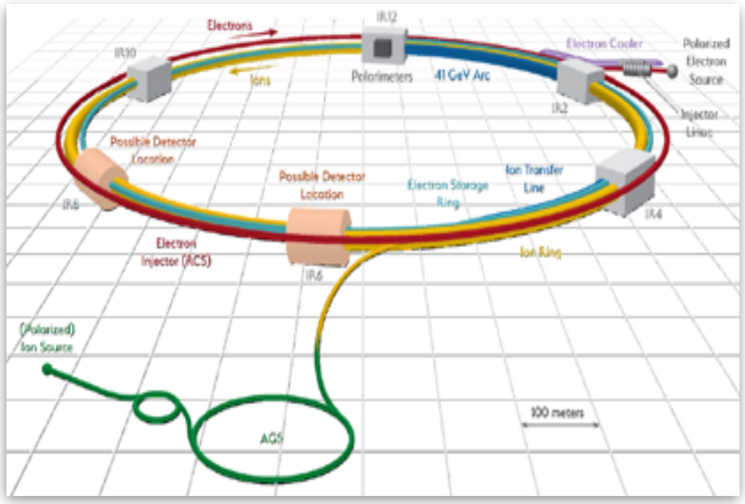
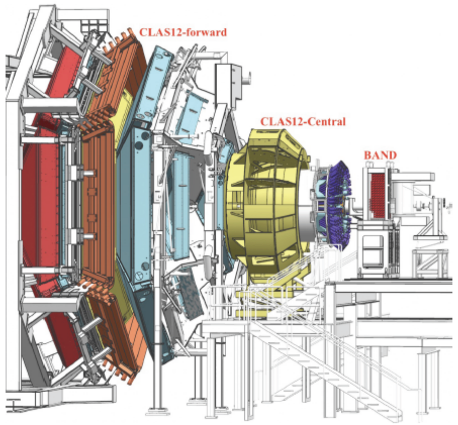
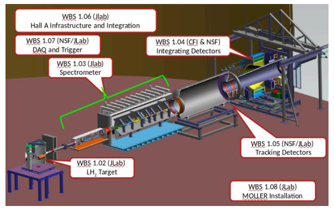
Jefferson Lab Scientific Computing Review

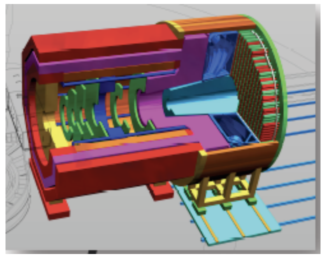
16 Dec 2021, 10:00 → 17 Dec 2021, 16:00 US/Eastern

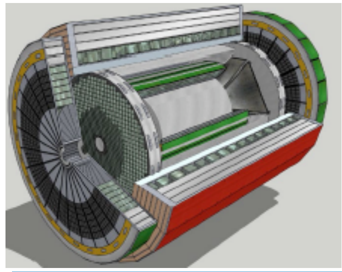
Amber Boehnlein (JLAB)

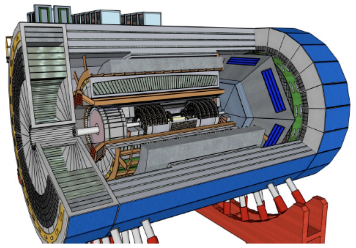


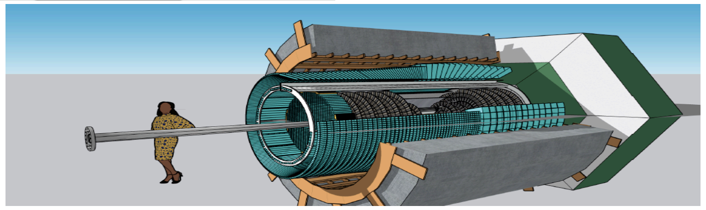












Streaming Readout

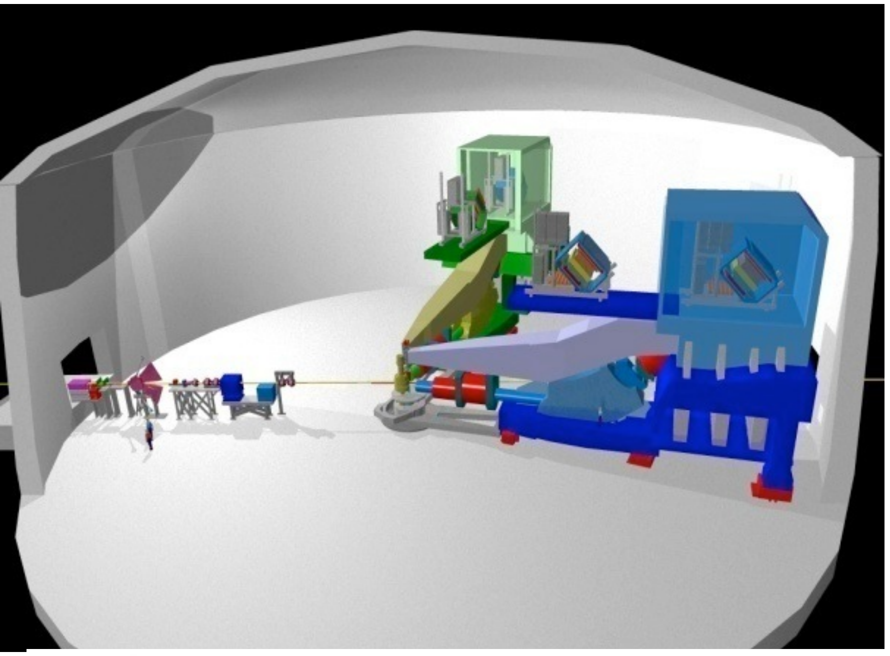
Marco Battaglieri
Jefferson Lab/INFN
(for JLab SRO Team)

Farnesina
Ministero degli Affari Esteri e della Cooperazione Internazionale

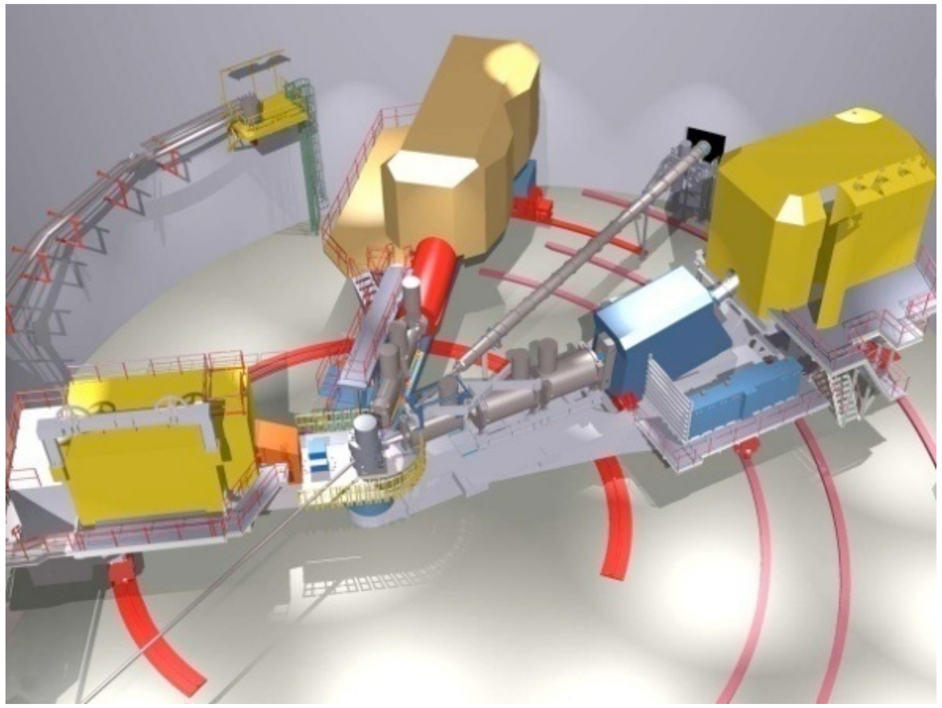
Supported by Italian Ministry of Foreign Affairs (MAECI) as Projects of great Relevance within Italy/US Scientific and Technological Cooperation under grant n. MAE0065689 - PGR00799

Present & future

Hall A – High Resolution Spectrometers and new multipurpose large acceptance detectors

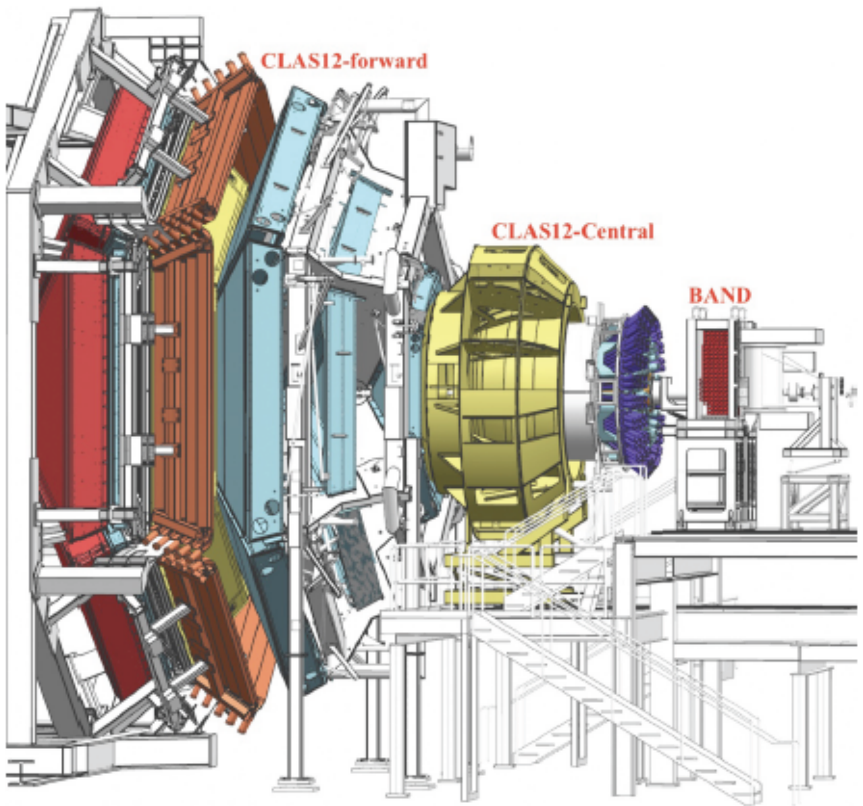


short range correlations, form factors, and future new experiments
current: SBS
future: MOELLER, SOLID



Hall C – Super High Momentum Spectrometer (SHMS)

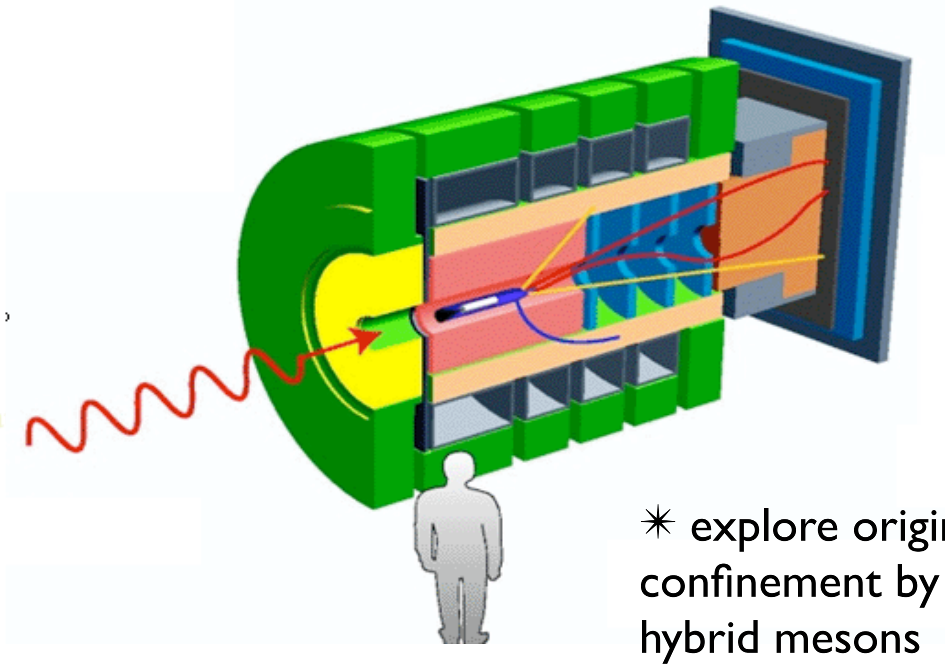
- ✳ precise determination of valence q properties in nucleons and nuclei, CPS



Hall B – Large acceptance detector CLAS12 for high luminosity measurements ($10^{35} cm^{-2} s^{-1}$)

- ✳ Understanding nucleon structure via GPDs and TMDs and hadron spectroscopy

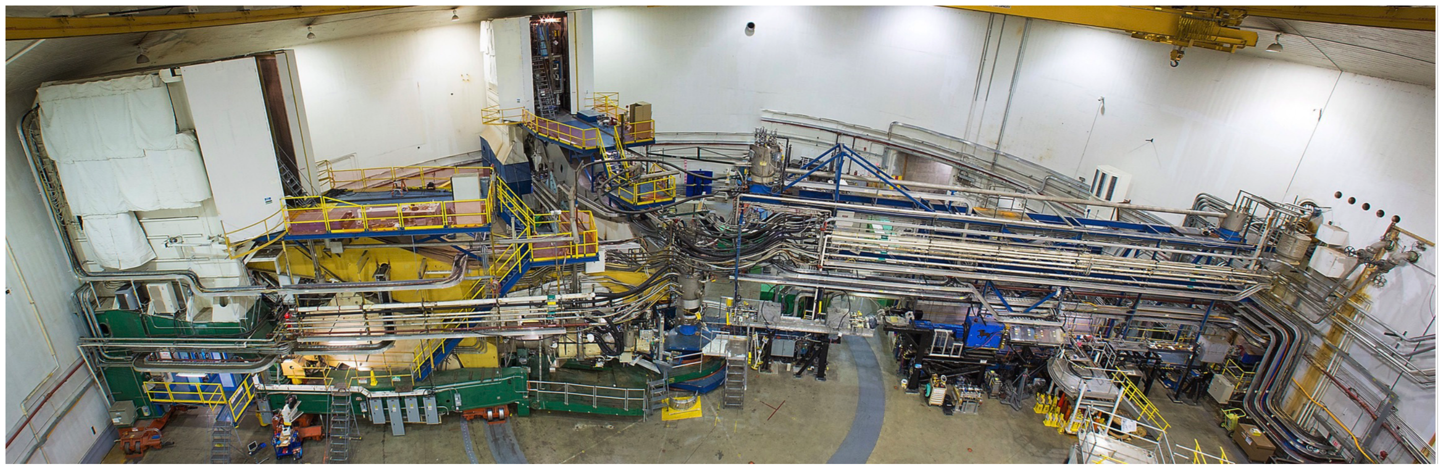
Hall D – GLUEx detector for photoproduction experiments



- ✳ explore origin of confinement by studying hybrid mesons

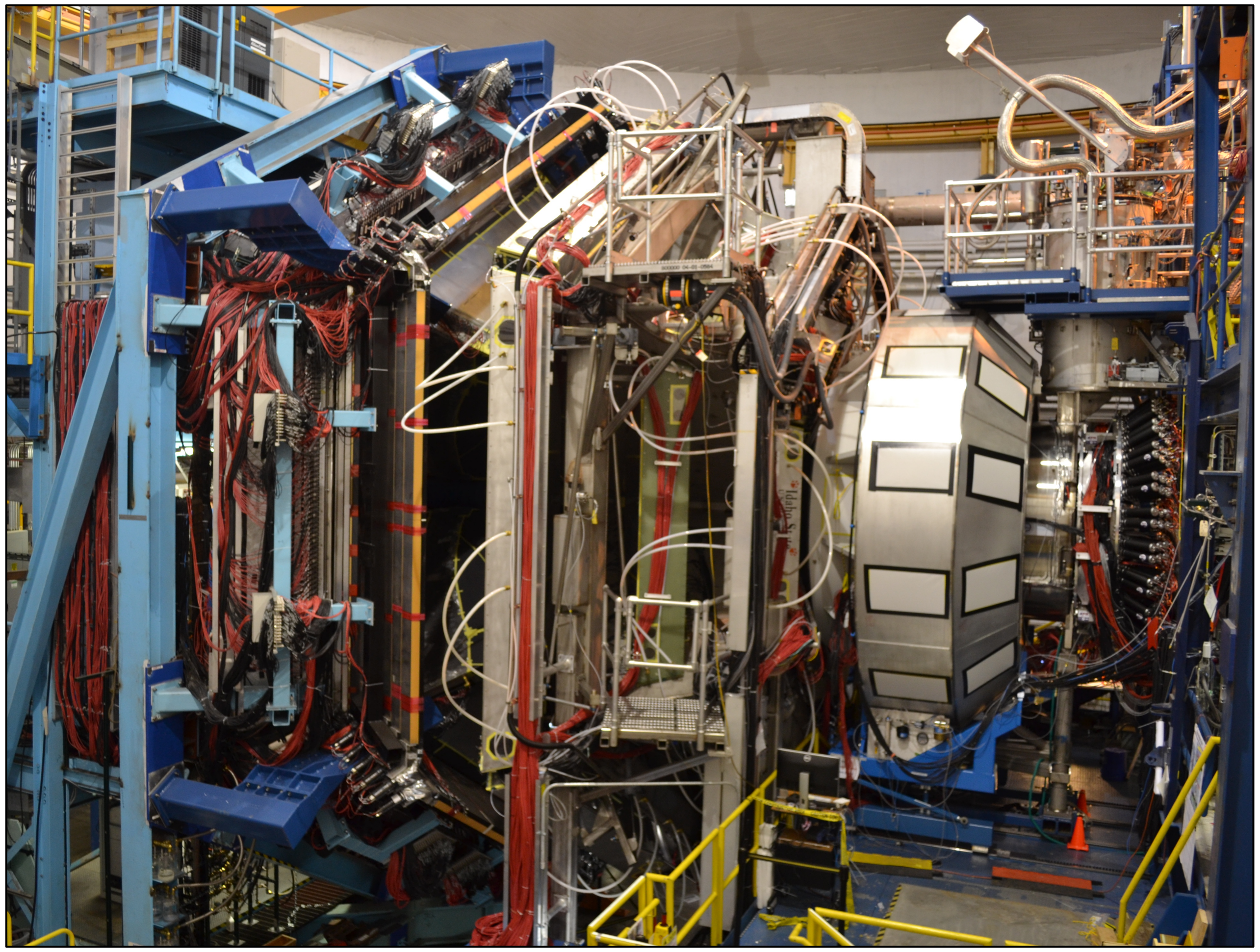
Present & future

Hall A

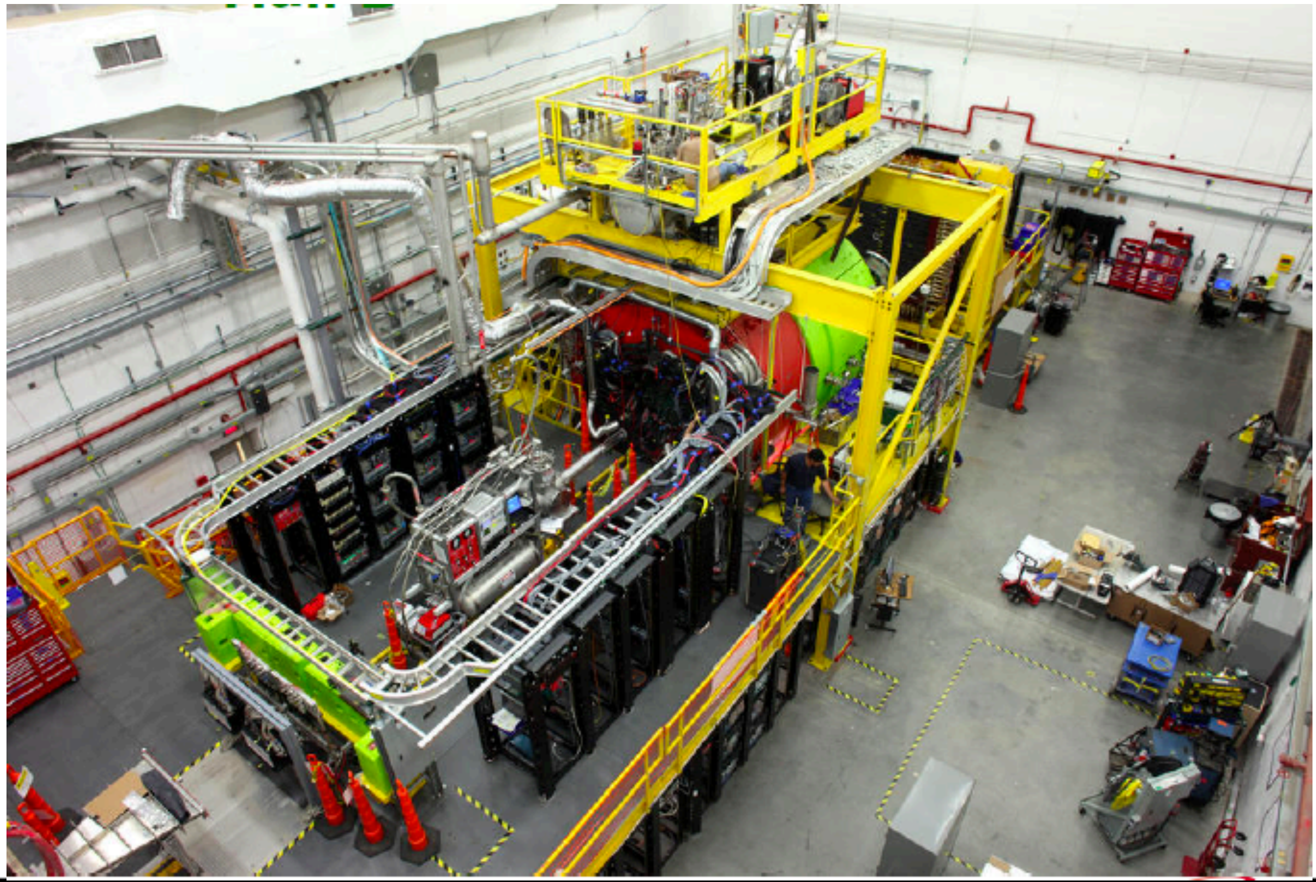


Hall C

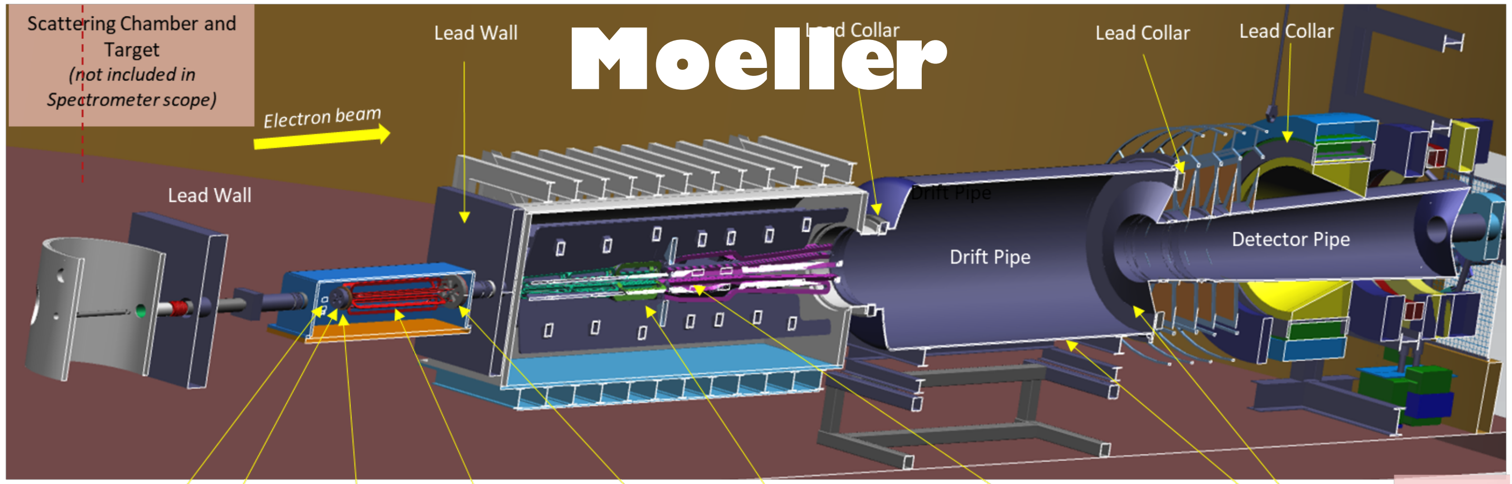
Hall B



Hall D

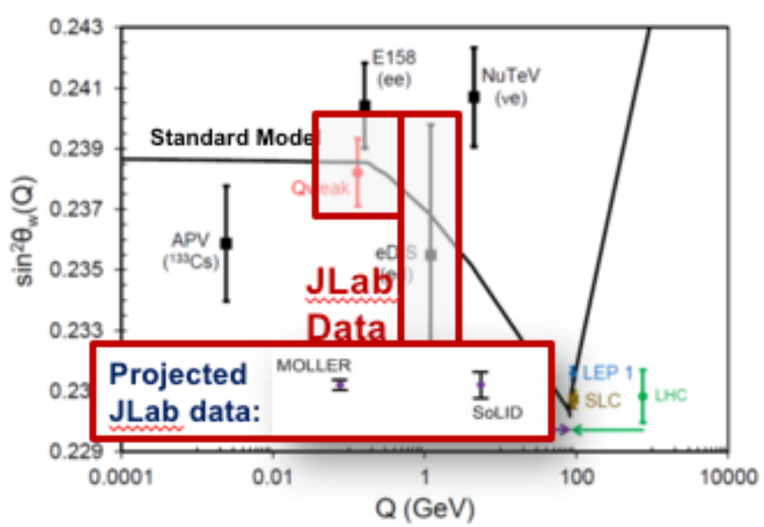


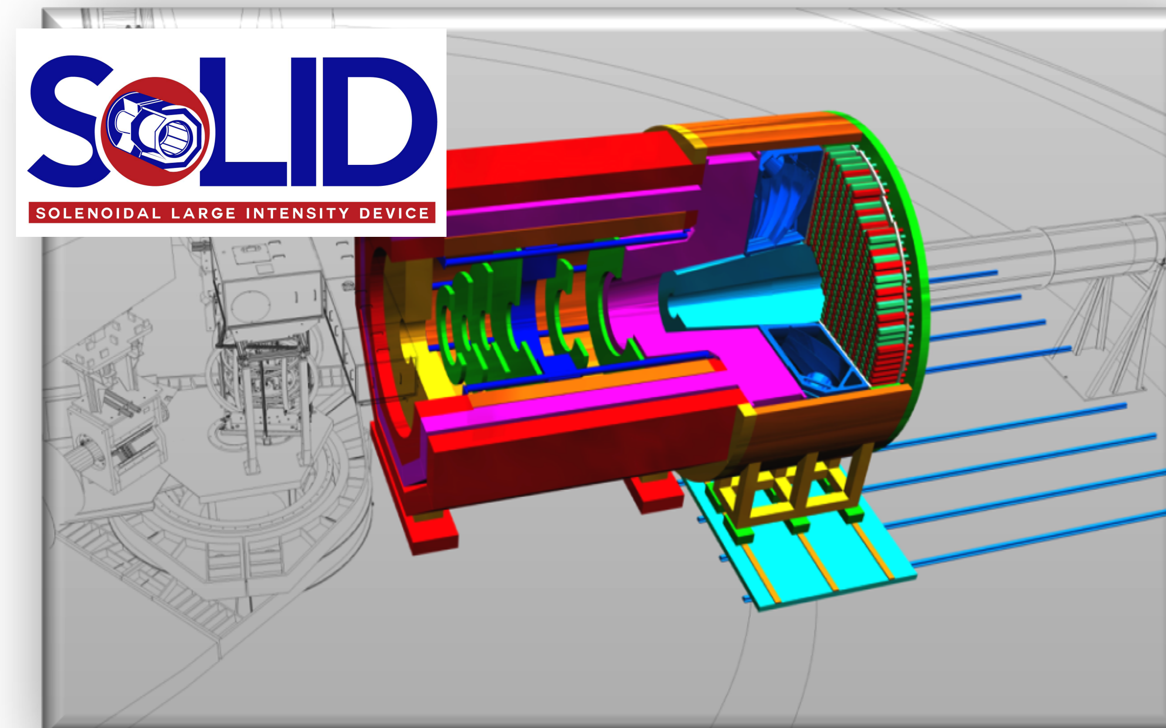
Present & future

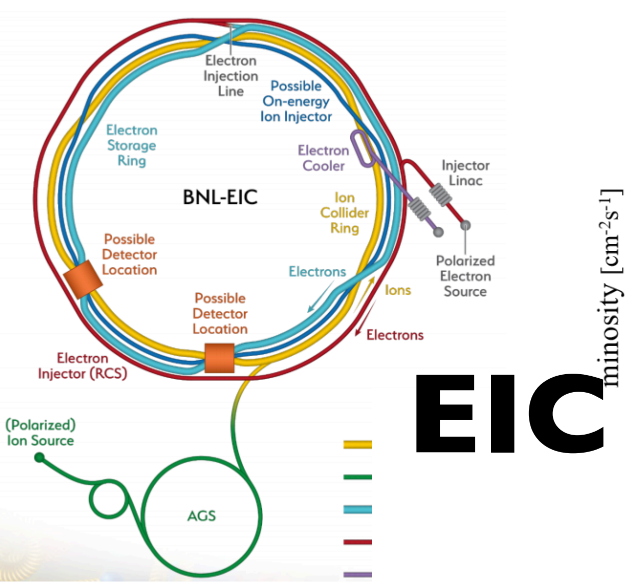


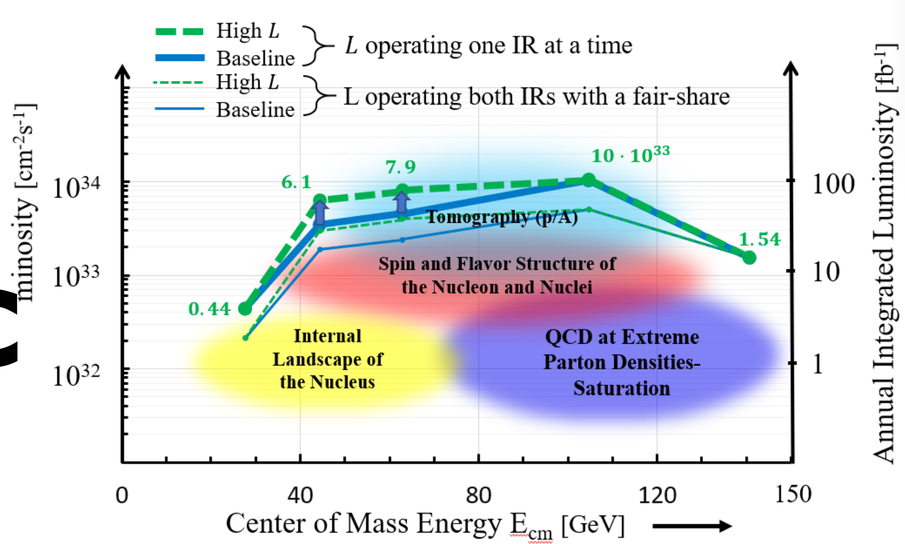
- Solenoidal Large Intensity Device – new multipurpose detector facility optimized for high luminosity and large acceptance, enabling very broad scientific program
- Unique capability combining high luminosity ($10^{37\text{-}39}$ / cm^2/s) (more than 1000 times the EIC) and large acceptance, with full ϕ coverage to maximize the science return of the 12-GeV CEBAF upgrade

- Unique discovery space for new physics up to 38 TeV mass scale, with a purely leptonic probe
- CD-1 approved Dec 2020
- Expected to operate in FY26









- Luminosity 100-1000 times that of HERA
- Polarized protons and light nuclear beams
- Nuclear beams of all A (p→U)
- Center mass variability with minimal loss of luminosity

- Large acceptance
- Frwrd/Bckw angles

- Precise vertexing
- HRes Tracking
- Excellent PID

Streaming RO

Traditional (triggered) DAQ

✳ All channels continuously measured and hits stored in short term memory by the FEE

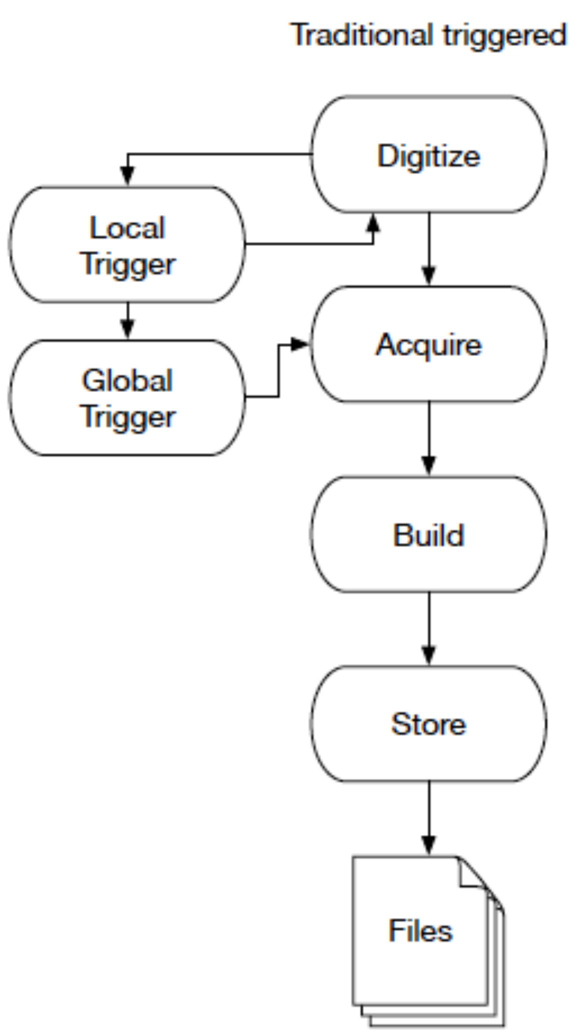
✳ Channels participating to the trigger send (partial) information to the trigger logic

✳ Trigger logic takes time to decide and if the trigger condition is satisfied:

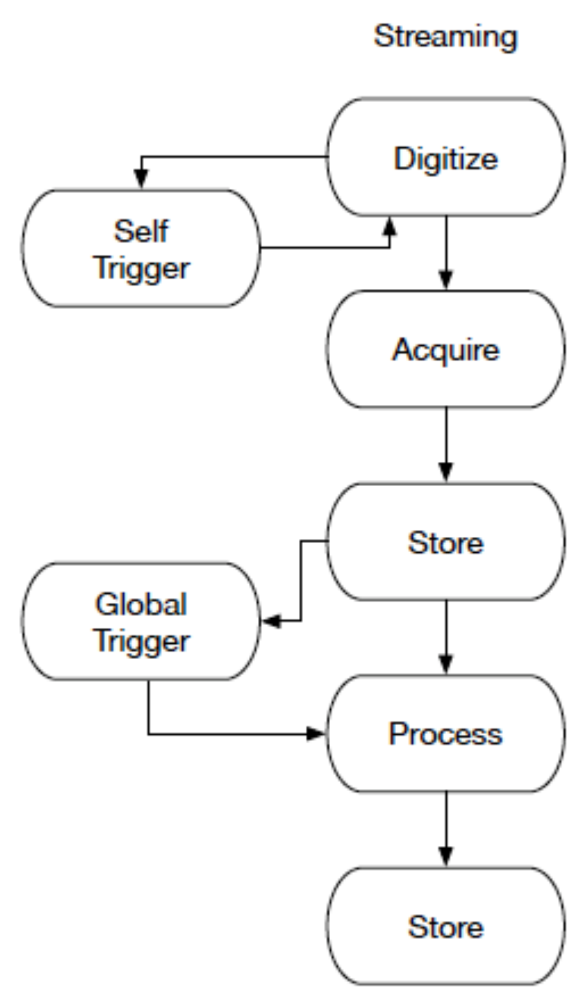
- a new 'event' is defined
- trigger signal back to the FEE
- data read from memory and stored on tape

✳ **Drawbacks:**

- only few information form the trigger
- Trigger logic (FPGA) difficult to implement and debug
- not easy to change and adapt to different conditions



Streaming readout



✳ All channels continuously measured and hits streamed to a HIT manager (minimal local processing) with a time-stamp

✳ A HIT MANAGER receives hits from FEE, order them and ship to the software defined trigger

✳ Software defined trigger re-aligns in time the whole detector hits applying a selection algorithm to the time-slice

- the concept of 'event' is lost
- time-stamp is provided by a synchronous common clock distributed to each FEE

✳ **Advantages:**

- Trigger decision based on high level reconstructed information
- easy to implement and debug sophisticated algorithms
- high-level programming languages
- scalability

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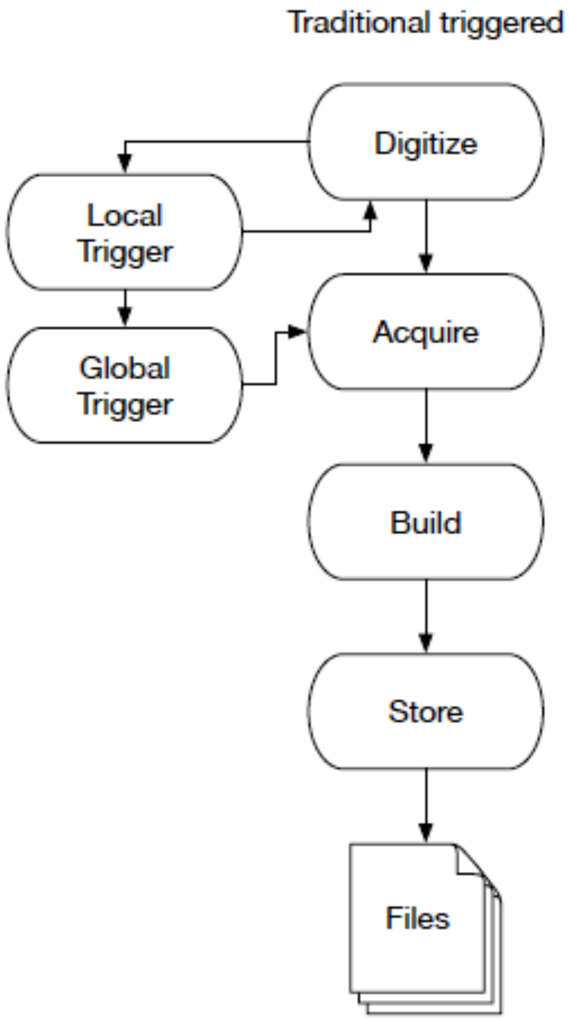
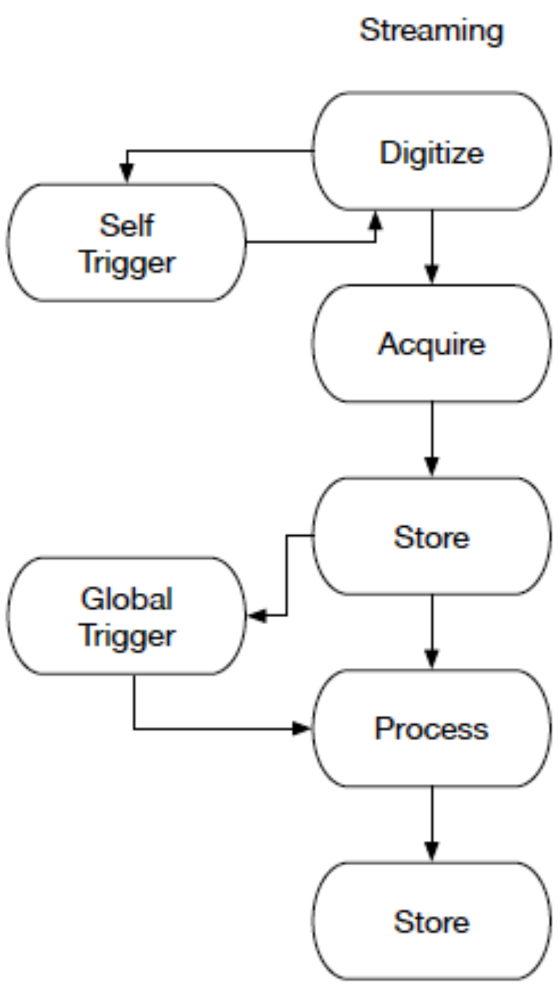


We know it works!

Streaming readout



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  - Trigger decision based on high level reconstructed information
  - easy to implement and debug sophisticated algorithms
  - high-level programming languages
  - scalability

We need to prove that it works!

Why SRO is so important???

✳ **To cope with high luminosity experiments**

- Current experiments are limited in DAQ bandwidth
- Reduce stored data size in a smart way (reducing time for off-line processing)

✳ **Shifting data tagging/filtering from the front-end (hw) to the back-end (sw)**

- Optimize real-time rare/exclusive channels selection
- Use of high level programming languages
- Use of existing/ad-hoc CPU/GPU farms
- Use of available AI/ML tools
- (future) use of quantum-computing

✳ **Scaling**

- Easier to add new detectors in the DAQ pipeline
- Easier to scale
- Easier to upgrade

Many NP and HEP experiments adopt the SRO scheme (with different solutions):

- CERN: LHCb, ALICE, AMBER
- FAIR: CBM
- DESY: TPEX
- BNL: sPHENIX, STAR, EIC
- JLAB: SOLID, BDX, CLAS12, …

SRO for EIC

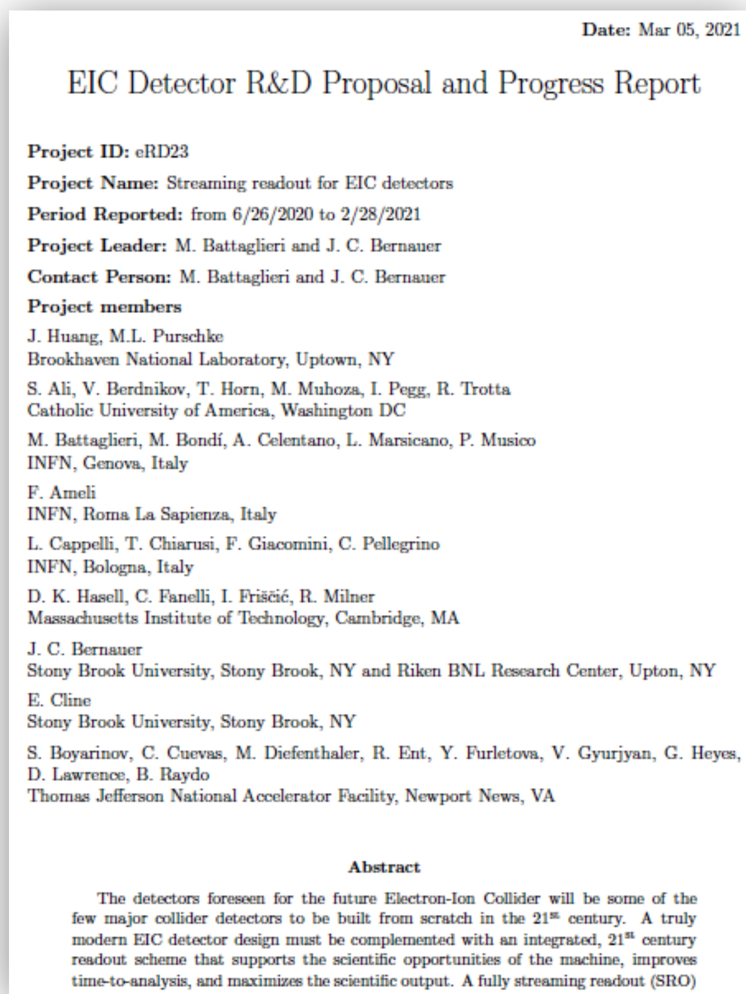
A Streaming Read-Out scheme for EIC requires:

- to identify and quantify relevant streaming-readout parameters
- to be implemented in realistic study cases
- to compare performances with traditional DAQ
- to evaluate the impact on EIC detector design

EIC R&D
Streaming Readout Consortium
eRD23

- 2 ws per year, (last: SRO VII was in April 2021)
- Ideal avenue to exchange ideas, progress across project.
- Contact with commercial enterprises: what is in the pipeline? What should be in the pipeline?
- Monthly phone conf. https://indico.mit.edu/category/1)
- Mailing list: eic_streaming_readout@mit.edu
- Not aligned with a particular proposal, and many non-EIC participants

Next workshop
- Organized by ORNL
- virtual, Dec 8-10 2021

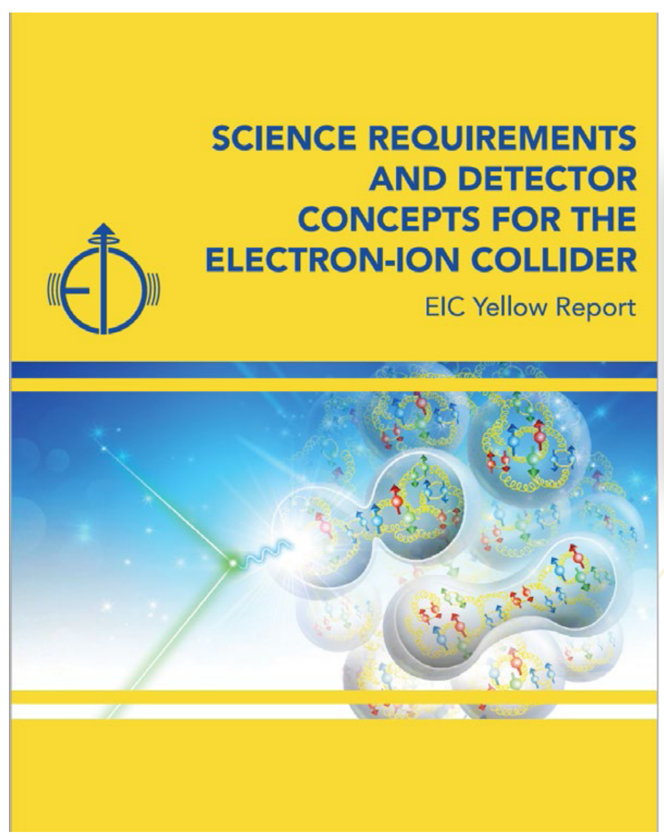

Date: Mar 05, 2021

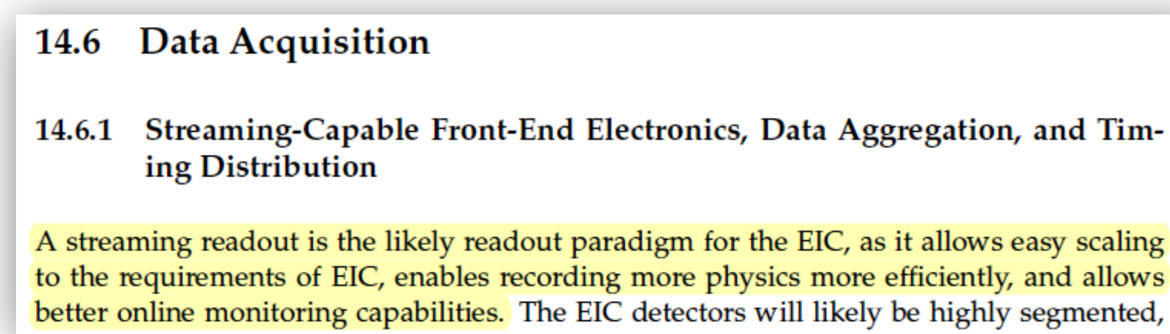
EIC Detector R&D Proposal and Progress Report

Project ID: eRD23
Project Name: Streaming readout for EIC detectors
Period Reported: from 6/26/2020 to 2/28/2021
Project Leader: M. Battaglieri and J. C. Bernauer
Contact Person: M. Battaglieri and J. C. Bernauer
Project members
J. Huang, M.L. Purschke
Brookhaven National Laboratory, Uptown, NY
S. Ali, V. Berdnikov, T. Horn, M. Muhoza, I. Pegg, R. Trotta
Catholic University of America, Washington DC
M. Battaglieri, M. Bondí, A. Celentano, L. Marsicano, P. Musico
INFN, Genova, Italy
F. Ameli
INFN, Roma La Sapienza, Italy
L. Cappelli, T. Chiarusi, F. Giacomini, C. Pellegrino
INFN, Bologna, Italy
D. K. Hasell, C. Fanelli, I. Friščić, R. Milner
Massachusetts Institute of Technology, Cambridge, MA
J. C. Bernauer
Stony Brook University, Stony Brook, NY and Riken BNL Research Center, Upton, NY
E. Cline
Stony Brook University, Stony Brook, NY
S. Boyarinov, C. Cuevas, M. Diefenthaler, R. Ent, Y. Furletova, V. Gyurjyan, G. Heyes, D. Lawrence, B. Raydo
Thomas Jefferson National Accelerator Facility, Newport News, VA

Abstract

The detectors foreseen for the future Electron-Ion Collider will be some of the few major collider detectors to be built from scratch in the 21st century. A truly modern EIC detector design must be complemented with an integrated, 21st century readout scheme that supports the scientific opportunities of the machine, improves time-to-analysis, and maximizes the scientific output. A fully streaming readout (SRO)

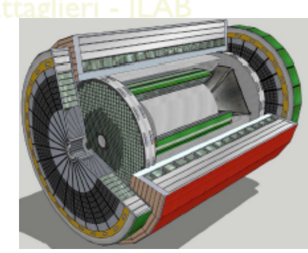
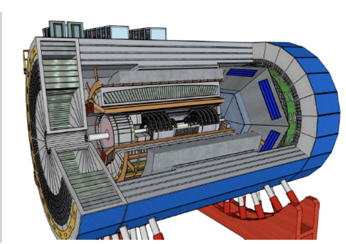
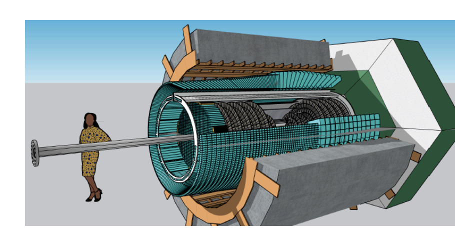



14.6 Data Acquisition

14.6.1 Streaming-Capable Front-End Electronics, Data Aggregation, and Timing Distribution

A streaming readout is the likely readout paradigm for the EIC, as it allows easy scaling to the requirements of EIC, enables recording more physics more efficiently, and allows better online monitoring capabilities. The EIC detectors will likely be highly segmented,

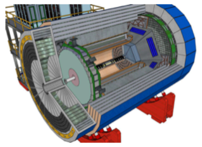
ECCE **ATHENA** **CORE**

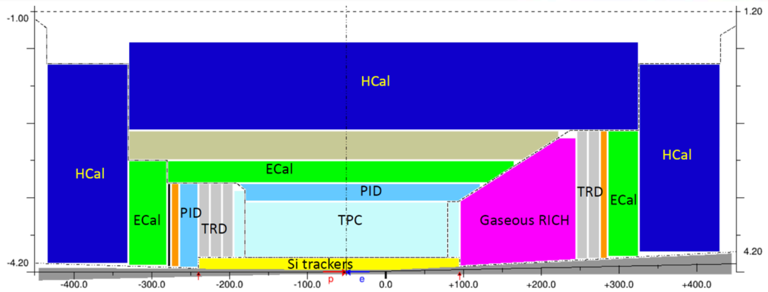
SRO for EIC

Some examples ...

Alexandre Camsonne, Jeffery Landgraf



ATHENA



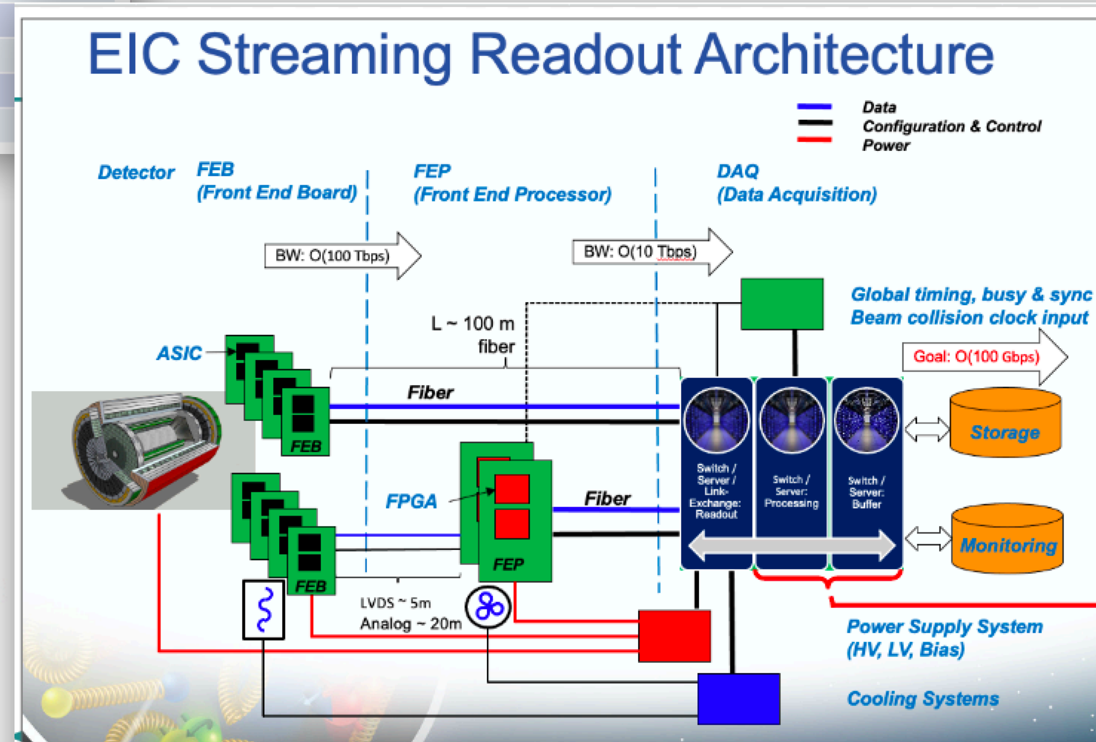
- Tracking: GEM + MPGD
- eCal-FW: PBWO + W_{powder} sci/fi, SiFi
- eCal-BR: SiFi
- hCal: Fe/Sci
- pld: mRICH, DIRC, DRICH
- pld: TOF LGAD
- FarFW: ZDC, RomanPot

- Collider parameters:
  - ~500KHz of collisions
  - ~60-100Gbps zero suppressed data
  - ~15 KB/event
  - ~100 bytes/bunch crossing
- Significant number of channels
- Challenging data compression scheme
  - Noise reduction
  - Zero suppression
  - Background elimination
- Keeping option of data selection before going to tape in case data volume too large to record all the streams

Detector	Readout Technology	Channel Count
Silicon Tracking	Si MAPS	37B
GEM/MMG Layer	GEM	217K
Cylindrical MPGD *	GEM	60M
HP-DIRC	MAP/MT	100-330k
ECAL	SiPM	1.7K
HCAL	SiPM	24K
HCAL imaging	Si MAPS	480M
dRICH	PMT/SiPM	350K
mRICH	PMT/SiPM	330K
B0	Si MAPS	32M + 320K
Off-Momentum	AC-LGAD (eRD24)	750K
Roman Pots	AC-LGAD (eRD24)	500K
ZDC	LGAD + ASIC eRD27	225+366
TOF	AC-LGAD	15M

We envision a triggerless streaming DAQ system following the outline described in the YR

- *Gets rid of many latency constraints*
- *Gets of the need for a hardware trigger*
- *Amplifies the need for robust zero-suppression / data compression*
- *No trigger allows for any physics process studies off-line*



ECCE

factor of 100 in data reduction

EIC Streaming Readout (From Fernando Barbosa's talk at AI4EIC Sep. 9, 2021)
David Lawrence -- ECCE Computing Model -- Dec. 9, 2021 -- Streaming Readout IX

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Streaming RO @ JLab

Streaming Read Out (RO) is one of the milestones of JLab Agenda

- **Streaming RO is necessary for a long-term HI-LUMI upgrade of CLAS12**
  - Running CLAS12 at higher luminosity (wrt the designed $10^{35}cm^{-2}\ s^{-1}$) has been declared as a milestone for the FY21 JLab Agenda
  - The appointed PhysDiv Task Force (S.Stepanyan) identified a staged approach with an increase of 2x (keeping ε_{Rec}>85%)in 2-3 years (Phase I) timeframe and a 100x in 5-7 years (Phase II)
  - An update of the R1 CLAS12 DC with more dense detector (e.g. GEM) is expected in Phase I. A Streaming RO DAQ upgrade is necessary for the Phase II
  - With the current triggered technology the maximum possible event acquisition rate for CLAS12 is ~100 kHz (R~30 kHz now) replacing MM and CAEN TDCs
- **Streaming RO can be tested in Hall-D using the PS hodoscope**
  - Hall-D PS can be used as a beam test facility (fully parasitic) for a tagged electron/positron beam
  - Unique opportunity to compare triggered/SRO results in a simple and well controlled setup
- **Streaming RO is recognised as the leading DAQ technology for the EIC project**
  - CLAS12 can be used to test and validate detector/DAQ solutions for the EIC in a realistic on-beam condition
  - Using VTP readout CLAS12 can reuse 3/4 of existing triggered boards (fADC250) in streaming mode
  - Part of a lab-wide effort (involving Hall-C and Hall-D) to test EIC calorimetry

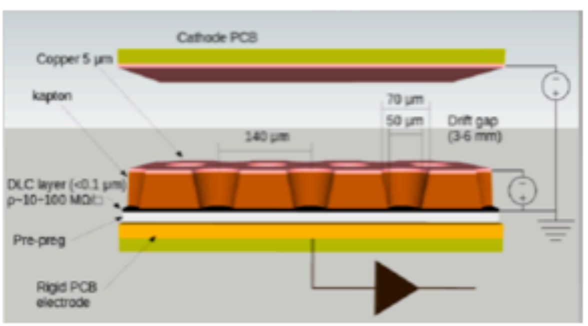
Unique opportunity of testing solutions in real (on-beam) conditions!

Streaming readout for CLAS12 HI-LUMI

Goal: double the current luminosity to operate CLAS12 at L~2 x 10^{35} cm^{-2} s^{-1} within the next 2-3 years

- CLAS12 High Luminosity operation has been included in the Lab Agenda
- Hall-B Task Forces (S.Stepanyan and S.Boyarinov)) conclusions: required a 1) new tracking detector & 2) new DAQ

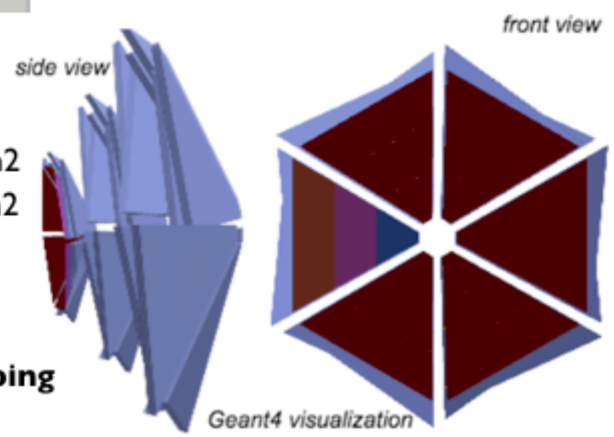
1) New CLAS12 tracking system: μ-Rwell



The μ-RWELL features:
- Compactness
- Easy assembly
- Easy powering
- Intrinsic spark quenching

Same technology proposed for EIC

The performance
- Gas gain: 10^4
- Rate capability HR version: 10 MHz/cm2
- Rate capability LR version: 100 kHz/cm2
- Spatial resolution: down to 60 μm
- Time resolution: 5-6 ns

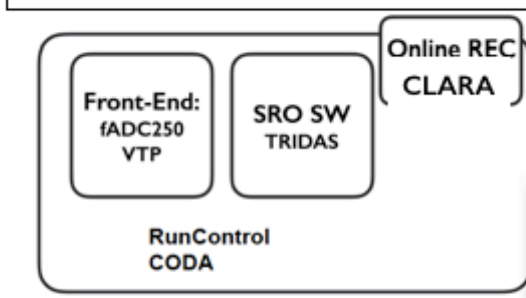


Status: CLAS12 μ-RWELL prototyping
- a prototype is being built by UVa
- full implementation in GEMC/REC software

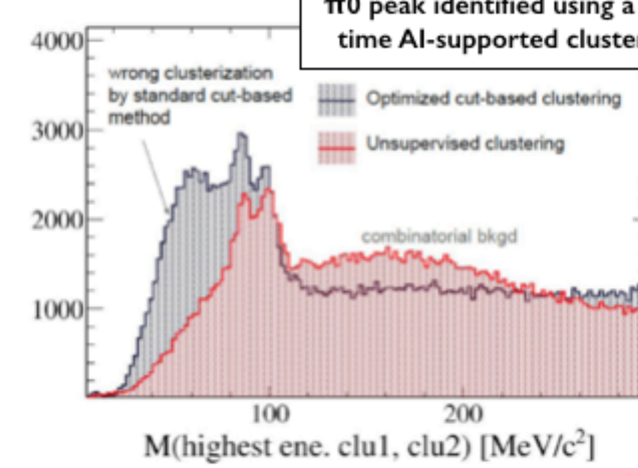
2) New CLAS12 Streaming Readout (SRO) DAQ

- current 'triggered' CLAS12 DAQ limited to 50 kHz acquisition rate
- working on a full streaming mode with 100kHz bandwidth
- Use of the current FE electronics (fADC250,VTP) and new backend software (TRIDAS)
- On-beam tests with CLAS12- FT are promising

Streaming RO CLAS12 FT tests: triggerless DAQ chain



CLAS12-FT SRO tests
π0 peak identified using a real-time AI-supported clustering



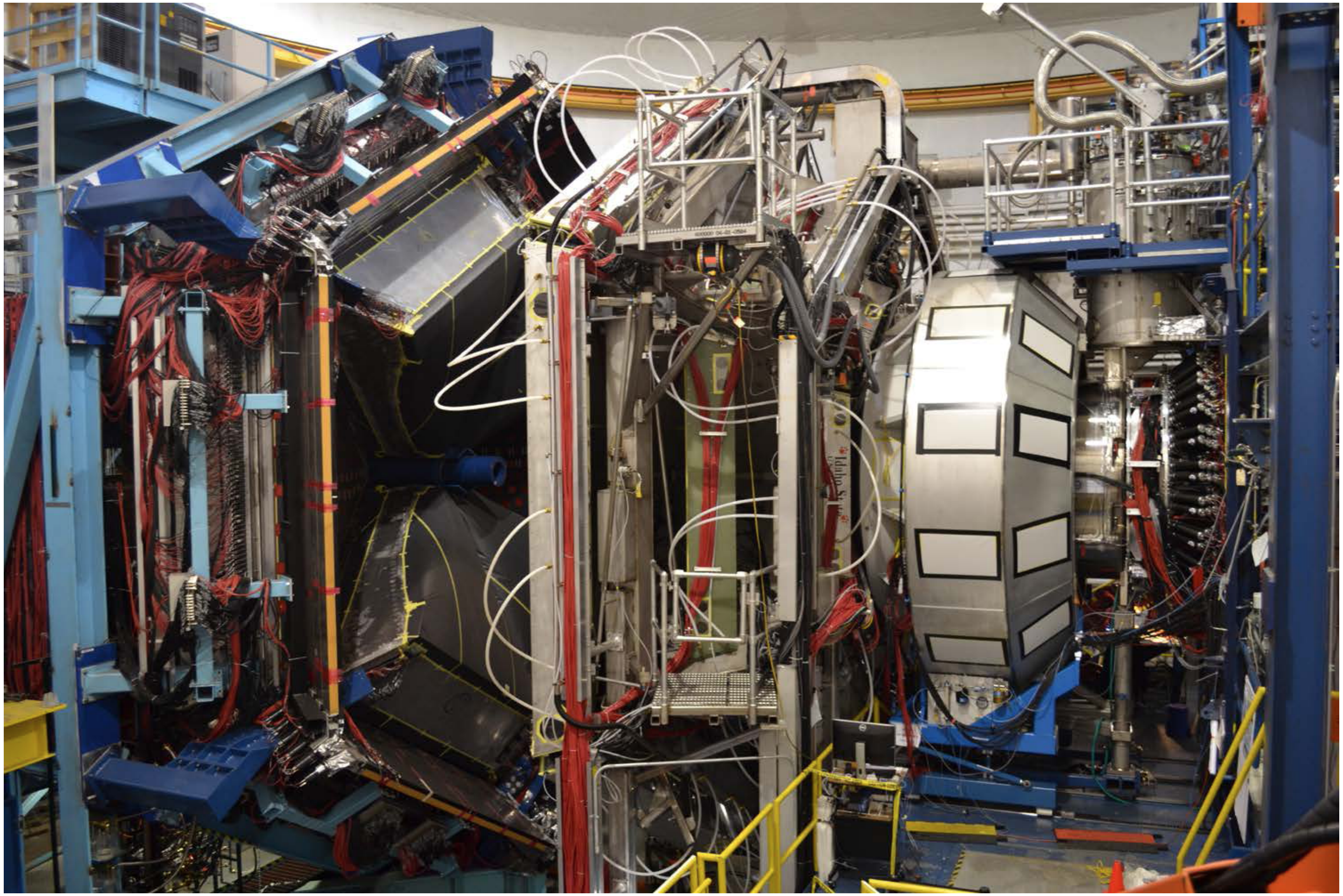
Options for μ-RWELL readout
- under test: SAMPA (ALICE) ,VMM3 (ATLAS) and FATIC2 LHCb)

Back to present: the CLAS12 detector

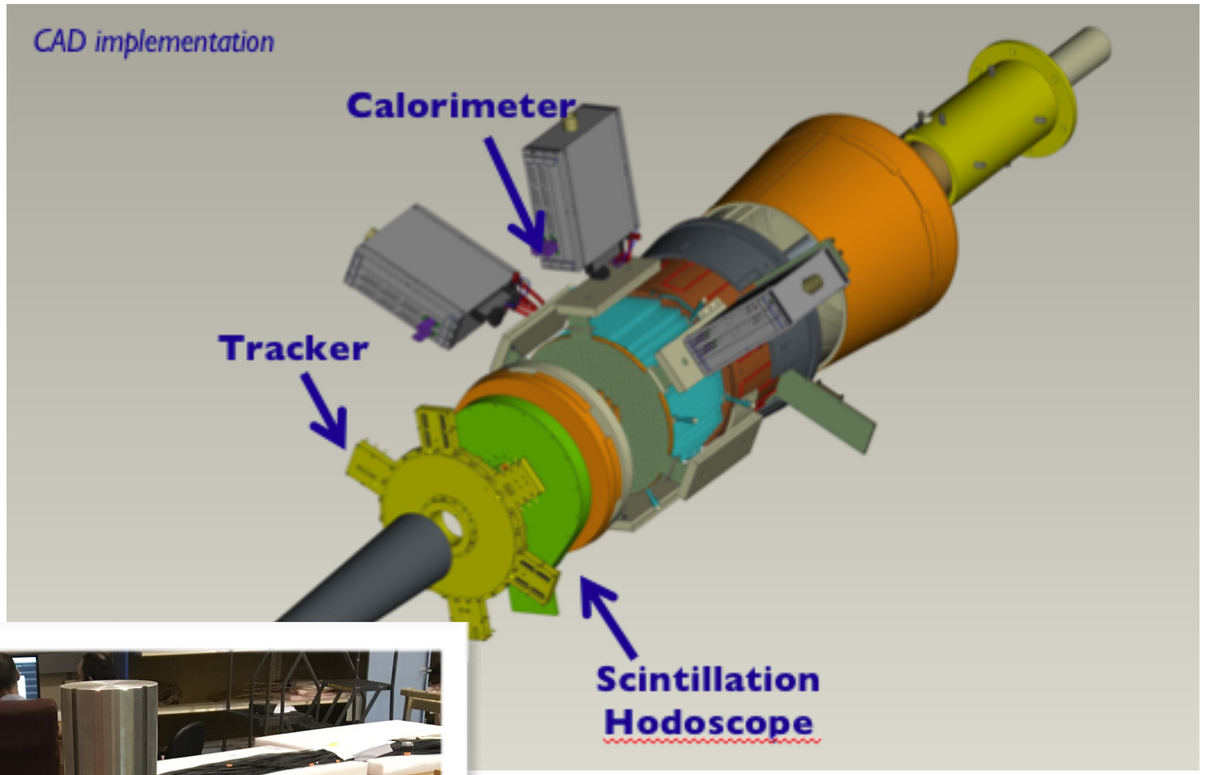
Forward Detector:
- *TORUS magnet*
- *HT Cherenkov Counter*
- *Drift chamber system*
- *LT Cherenkov Counter*
- *Forward ToF System*
- *Preshower calorimeter*
- *E.M. calorimeter (EC)*

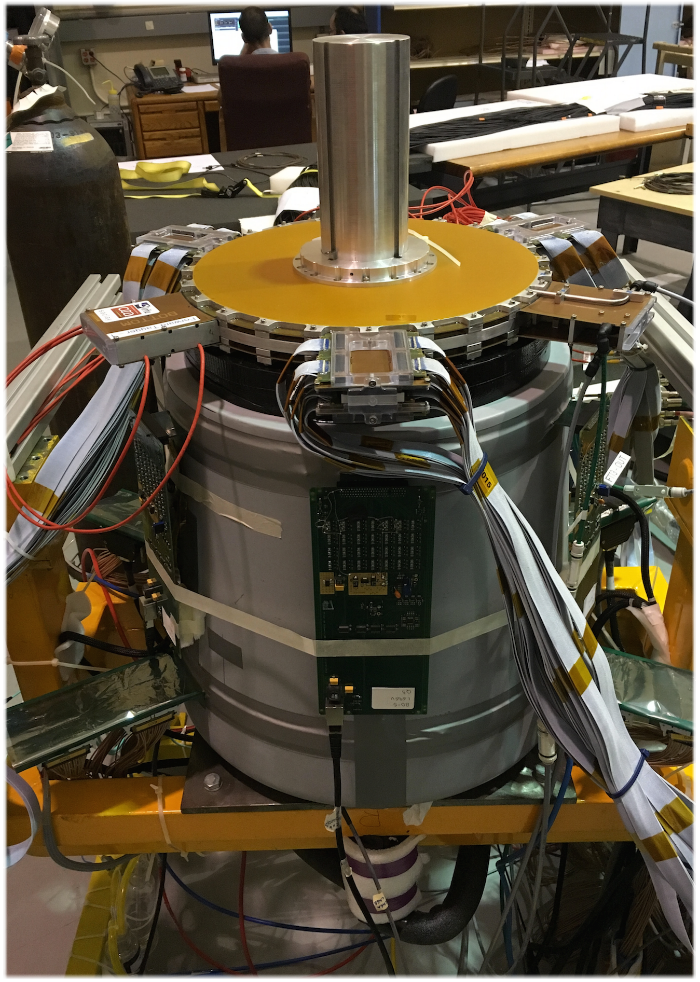
Central Detector:
- *SOLENOID magnet*
- *Barrel Silicon Tracker*
- *Central Time-of-Flight*

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



CLAS12 and the Forward Tagger (FT)

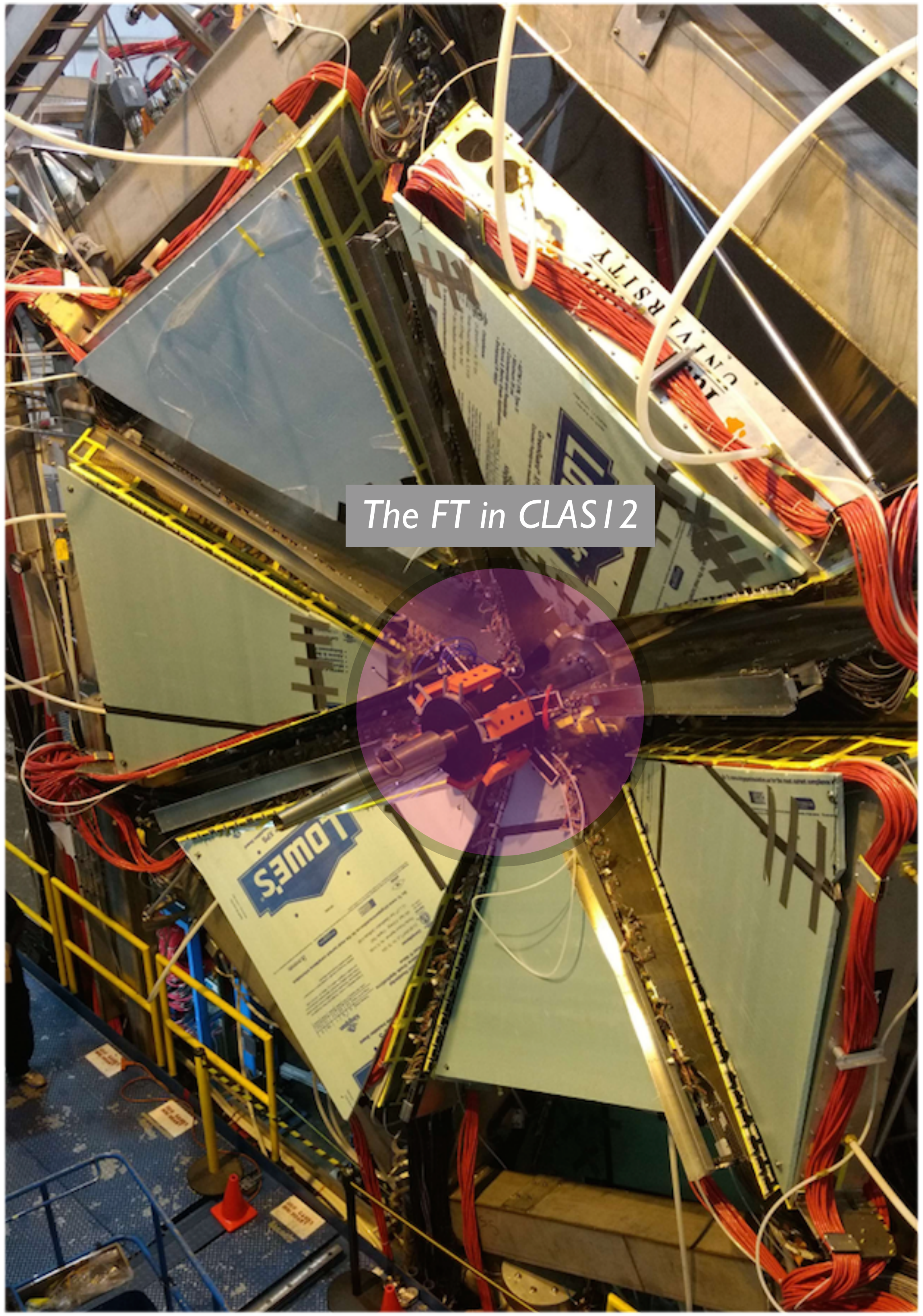




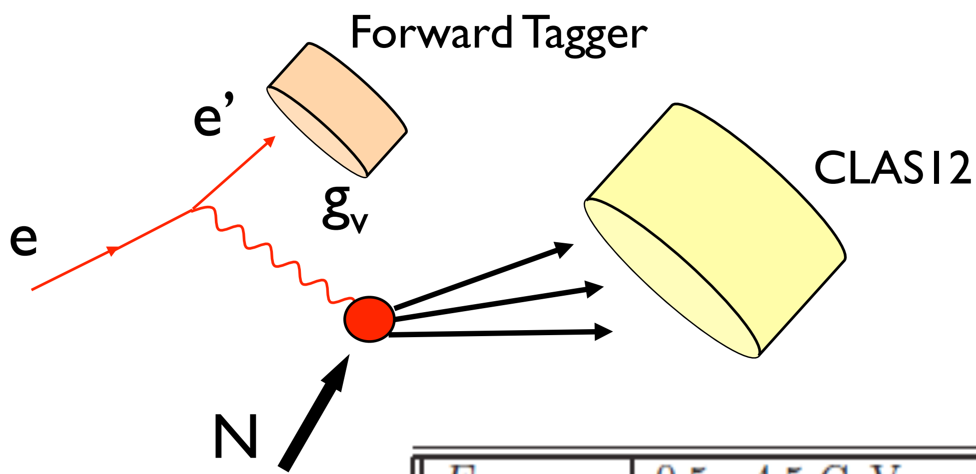
FT-Trck: MicroMegas
- electron angles and polarization plane

FT-Hodo: Scintillator tiles
- veto for photons

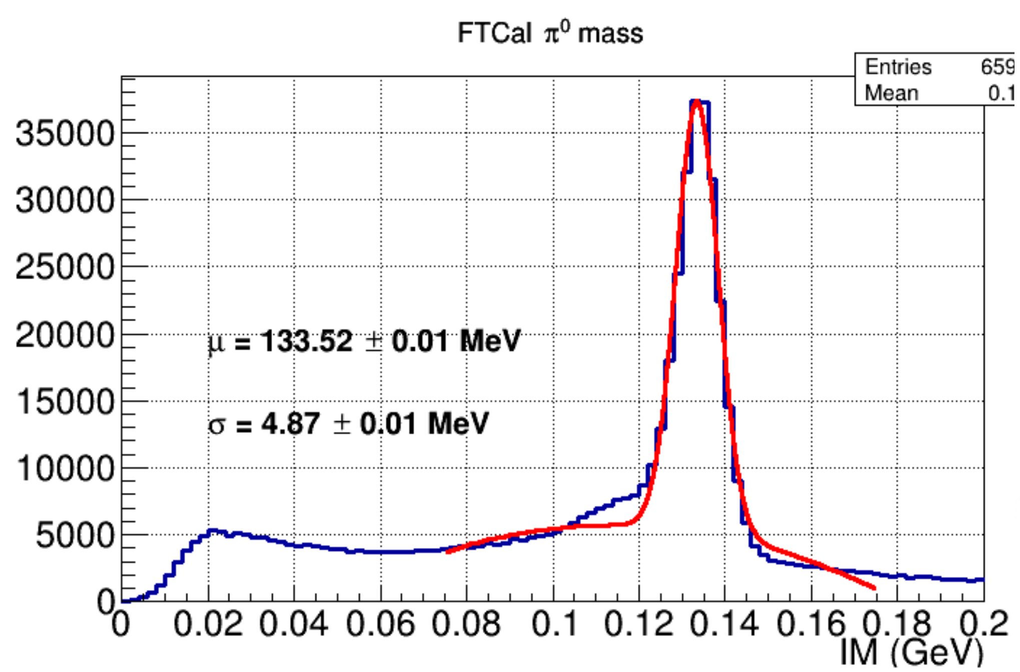
FT-Cal: $PbWO_4$ calorimeter
- electron energy/momentum
- Photon energy (ν=E-E')
- Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$



FT performance

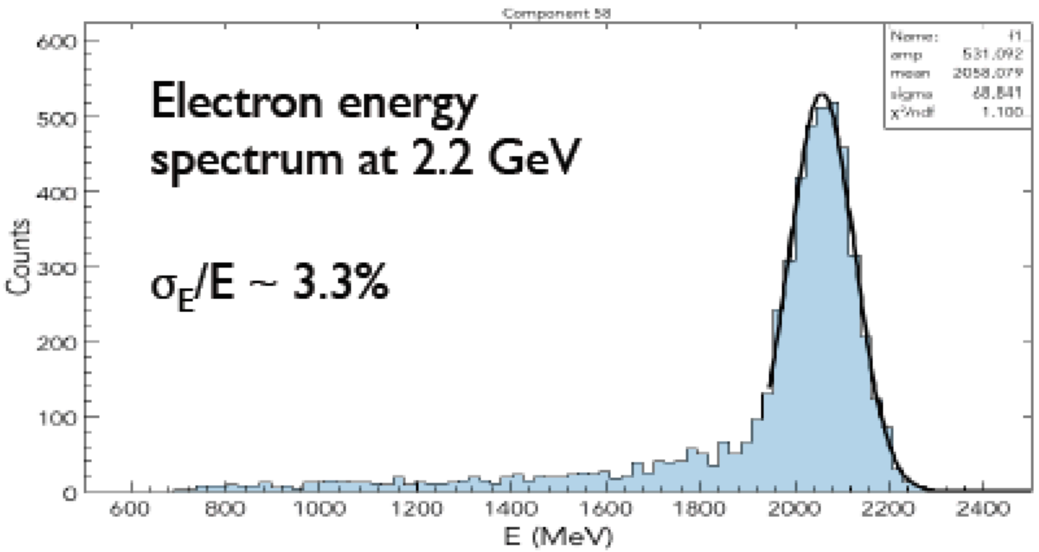


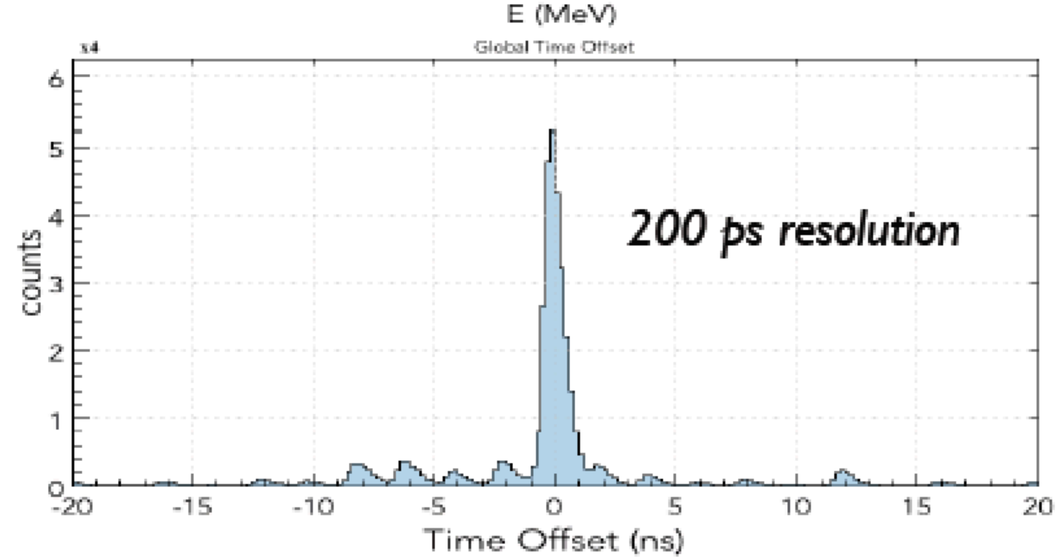
$E_{scattered}$	0.5 - 4.5 GeV
θ	2.5^o - 4.5^o
ϕ	0^o - 360^o
ν	6.5 - 10.5 GeV
Q^2	0.01 - 0.3 GeV^2 ($< Q^2 >$ 0.1 GeV^2)
W	3.6 - 4.5 GeV



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

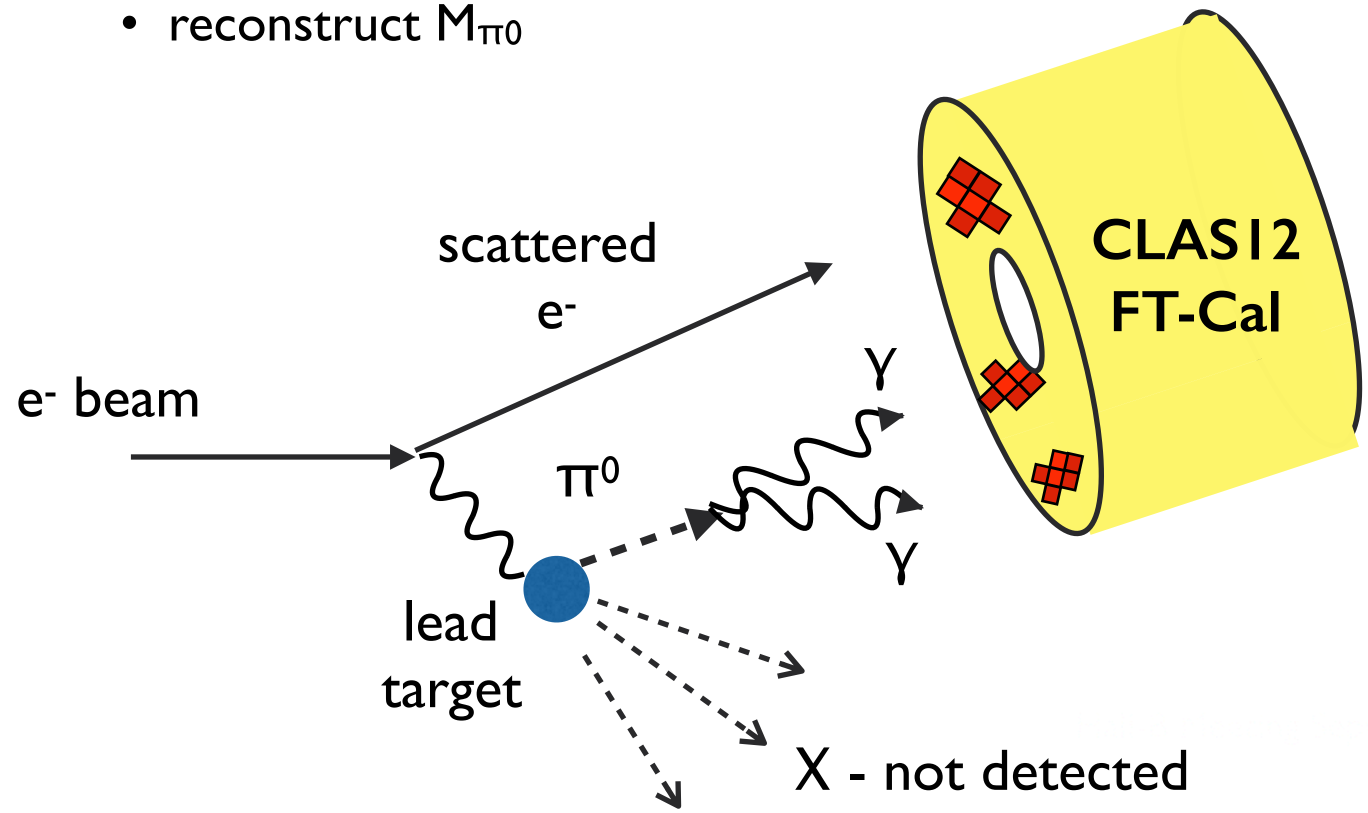
- **SRO DAQ full chain test: FE + RunControl + Streaming ROsw + Rec**
- **On-beam tests**
  - **Run1: 10.4 GeV electron beam on Pb target in Jan/Feb 2020**
  - **Run2: 10.4 GeV electron beam on H2 and D2 targets in Aug/Sept 2020**
- **Hall-B CLAS12 Forward Tagger: Calorimeter + Hodoscope + (Tracker)**

Goal:

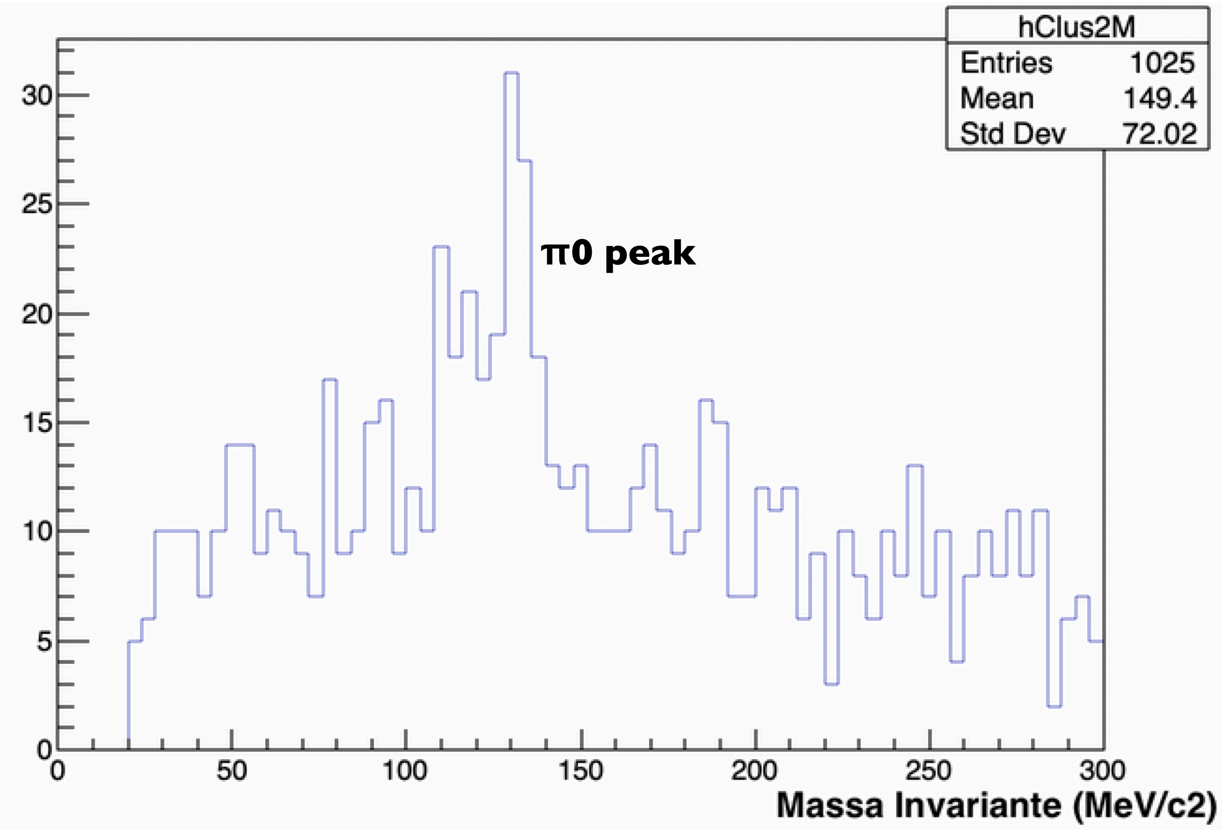
- collect data with 1-2-3 clusters in FT-CAL
- Identify the reaction
  e H/D2/Al/Pb → (X) e' π^0 →(X) e' γ γ
- reconstruct $M_{\pi 0}$

Test equipment

- FT-Cal: 332 PbWO crystals (APD)
- 10+12 fADC250 boards + 2 VTPs (in 2 crates/ROCs)
- FT-Hodo: 232 plastic scintillator tiles (SiPM)
- 15 fADC250 boards

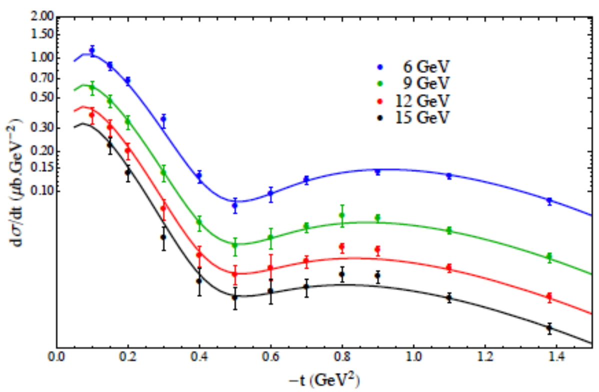


double-clusters (π0) mass obtained from FT-Cal RG-A data fed to TRIDAS



Realistic inclusive π⁰ photoproduction model

- Multi π0 detection suppressed by FT acceptance
- Physics model of π^0 real photoproduction from JPAC (arXiv:1505.02321)
- Electroproduction simulated as quasi-real ph.prod. as in Tsai
- $2 < k_\gamma < 10$ GeV
- Acceptance $2^\circ < \theta_{\pi^0} < 6^\circ$, quite larger than the real one;
- Real acceptance (different for each target) from GEANT
- Other cuts from GEANT



Internal production (Tsai 4.16, 4.24):

$$\frac{1}{\log E_{beam}/k_{min}} \int_{k_{min}}^{E_{beam}} \sigma(k)_{4\pi} \frac{dk}{k} = 0.924\,\mu b$$

$$\frac{1}{\log E_{beam}/k_{min}} \int_{k_{min}}^{E_{beam}} \sigma(k)_{FT} \frac{dk}{k} = 0.182\,\mu b$$

Radiated from Pb:

$$\left[\int_{k_{min}}^{E_b} f(k)dk\right]^{-1} \int_{k_{min}}^{E_b} \sigma(k)_{4\pi} f(k)dk = 0.964\,\mu b$$

$$\left[\int_{k_{min}}^{E_b} f(k)dk\right]^{-1} \int_{k_{min}}^{E_b} \sigma(k)_{FT} f(k)dk = 0.177\,\mu b$$

with $f(k) = \left[\frac{4}{3}\left(\frac{1}{k} - \frac{1}{E_b}\right) + \frac{k}{E_b^2}\right]$ (Tsai 3.84)

- Internal in Lead
  - Real $N_e \frac{N_A X_{Pb0}}{A} \frac{T_{Pb}^2}{2} \log\frac{E_{beam}}{k_{min}} = 2.84 \times 10^5\,\mu b^{-1}$
  - Virtual $N_e \frac{N_A X_0}{A} T_{Pb}\, t_{eq} \log\frac{E_{beam}}{k_{min}} = 4.33 \times 10^5\,\mu b^{-1}$
- Internal in Alluminum
  - Real 1: $N_e \frac{N_A X_{Al0}}{A} \frac{T_{Al1}^2}{2} \log\frac{E_{beam}}{k_{min}} = 244\,\mu b^{-1}$
  - Real 2: $N_e \frac{N_A X_{Al0}}{A} \frac{T_{Al2}^2}{2} \log\frac{E_{beam}}{k_{min}} = 680\,\mu b^{-1}$
  - Virtual 1: $N_e \frac{N_A X_{Al0}}{A} T_{Al1} t_{eq} \log\frac{E_{beam}}{k_{min}} = 2.47 \times 10^4\,\mu b^{-1}$
  - Virtual 2: $N_e \frac{N_A X_{Al0}}{A} T_{Al2} t_{eq} \log\frac{E_{beam}}{k_{min}} = 4.11 \times 10^4\,\mu b^{-1}$
- Real photons radiated from Pb, target Al
  - $N_e \frac{N_A X_{Al0}}{A} T_{Pb} T_{Al1} \left[\int_{k_{min}}^{E_b} f(k)dk\right] = 3.13 \times 10^4\,\mu b^{-1}$
  - $N_e \frac{N_A X_{Al0}}{A} T_{Pb} T_{Al2} \left[\int_{k_{min}}^{E_b} f(k)dk\right] = 5.23 \times 10^4\,\mu b^{-1}$

Contributions considered

- Internal in Lead
  - Real (brehemstraalung)
  - Virtual (electroproduction)
- Internal in Alluminum
  - Real (brehemstraalung)
  - Virtual (electroproduction)
- Real photons radiated from Pb, target Al

CLAS12-FT acceptance/efficiency

- From Lead, $z = -4$ cm, 1.4%
- From Al1, $z = 25.5 - 4$ cm, $x = 1$ cm, 0.8%

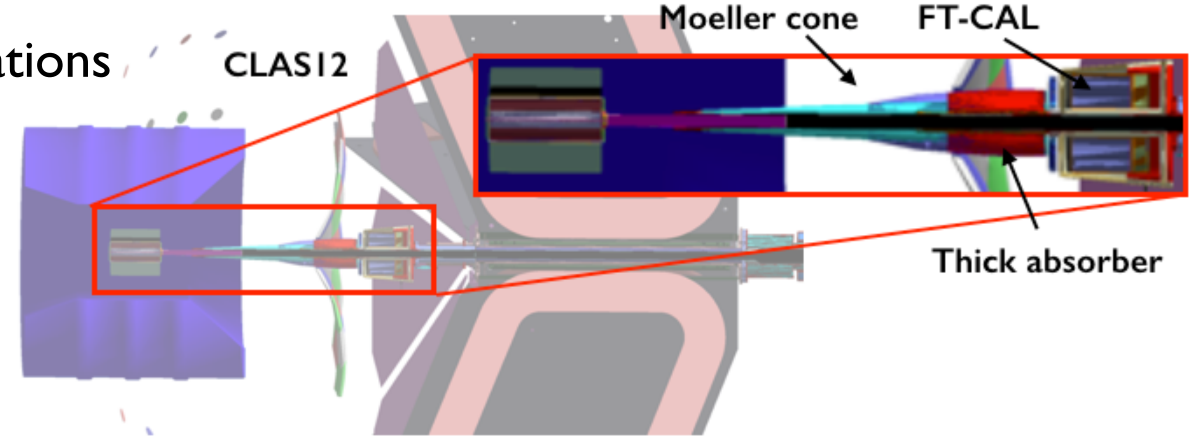
Expected yield (20mn run L=1e^{35} cm^{-2} s^{-1})

- From Lead ~1800
- From 160μm Al+glue ~420

Hall-B Tests

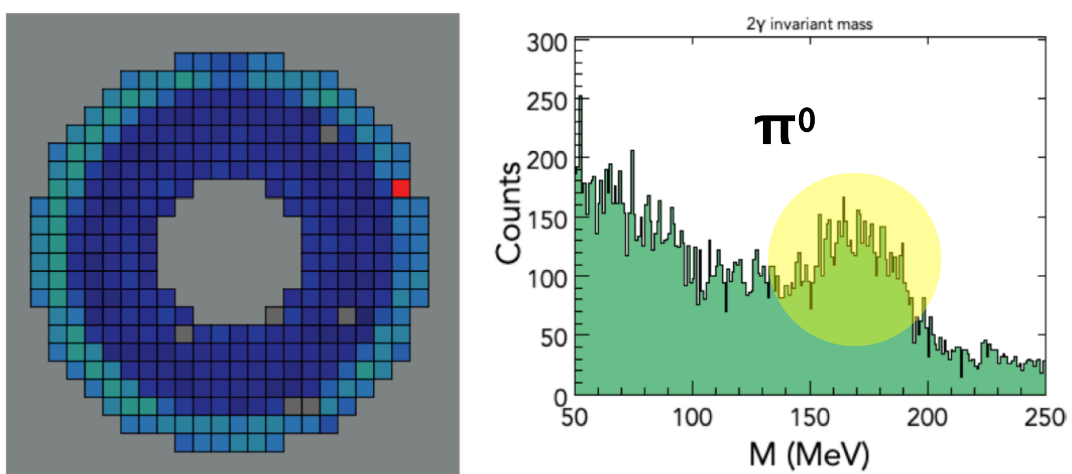
M.Bondí, P.Moran, S.Vallarino

- Full GEANT4 simulations for the different experimental configurations
- Run1: no Moeller cone, nuclear (thin) target
- Run2: Moeller cone, longer target



2-gamma events assuming z=-32cm

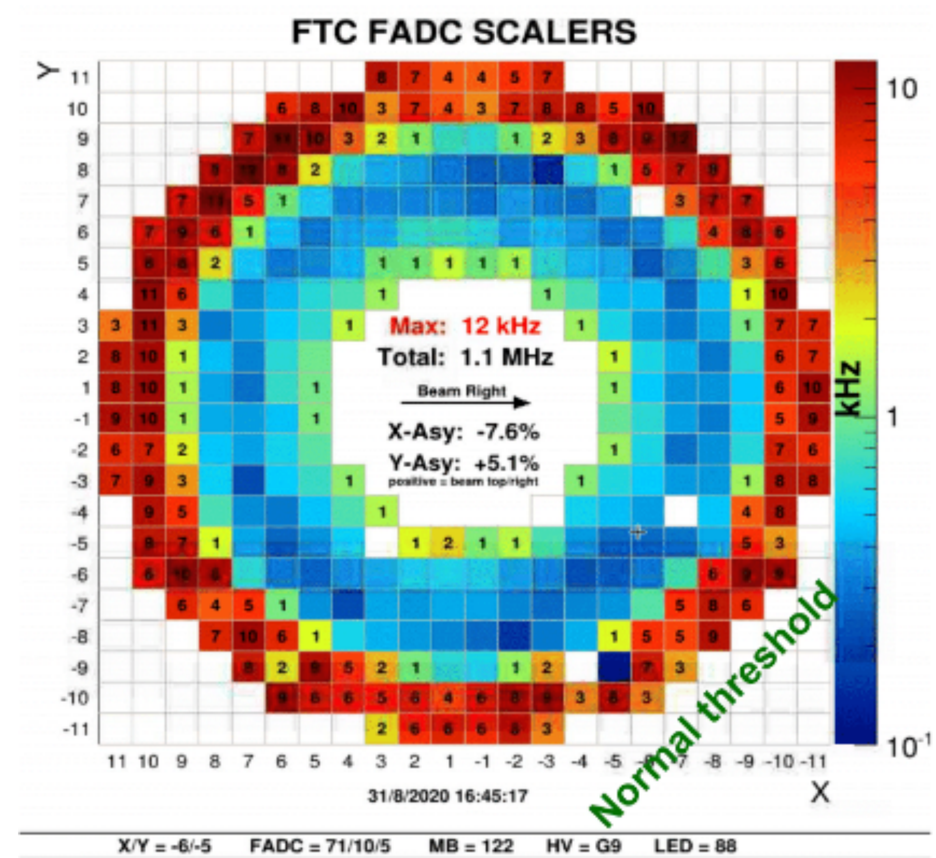
D2 target run 12509



R.De Vita

- As a reference, data taken both in 'triggered' and SRO mode

- On-line scalers during Run2



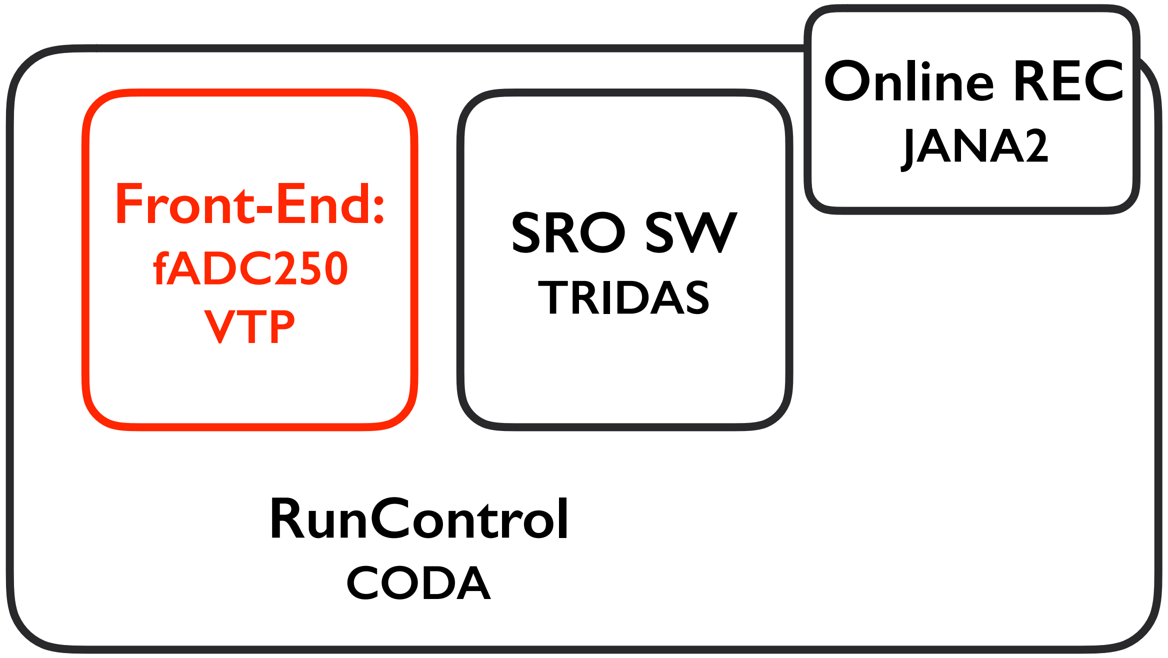
SRO mode:

- L1 "minimum-bias": at least one crystal with energy > 2 GeV
- several L2 conditions in "tagging-mode" and "filtering-mode"
  - "standard" clustering algorithm: at least 2 clusters in FT-CAL
  - cosmic tracking
  - AI clustering algorithm: at least two cluster in the FT-CAL

Goal:

- study SRO performance: memory + cpu use, trigger eff., …
- Collect data for physics analysis: pi0 production on target
- Demonstrate t SRO s outperforms vs. a triggered DAQ

Streaming RO - CLAS12-FT tests



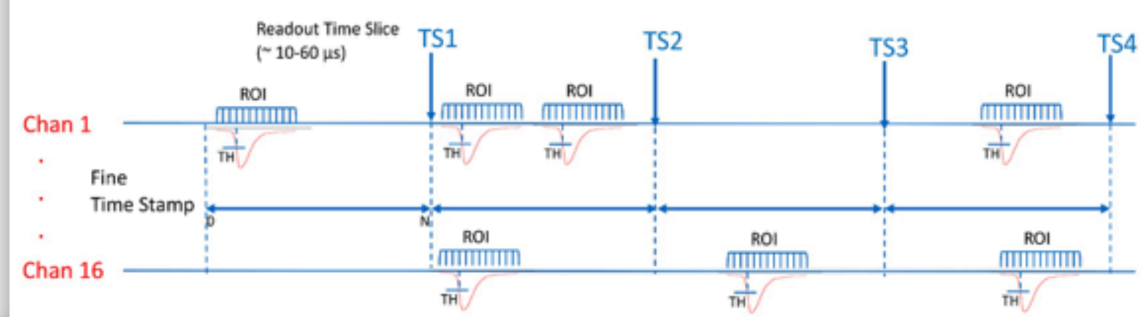
FrontEnd

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

JLAB FADC in "Streaming Mode"

Streaming data can be thought of as Triggered mode where the trigger is a fixed pulser and you keep all the data for a single channel generated from the last pulse.

A 250 MHz FADC generates a 12 bit sample every 4ns. That's 3 Gb/s for one channel. A 16 channel module is 48 Gb/s. That is over twice the available VXS bandwidth. But we don't need ALL the data.



Within the FPGA we keep only the data around a Region of Interest (ROI) from each channel, along with a fine time stamp in each time slice window.

Depending on hit rates and available bandwidth , We can keep the individual samples or just compute a sum.

Jefferson Lab

Streaming DAQ Through the VXS Trigger Processor

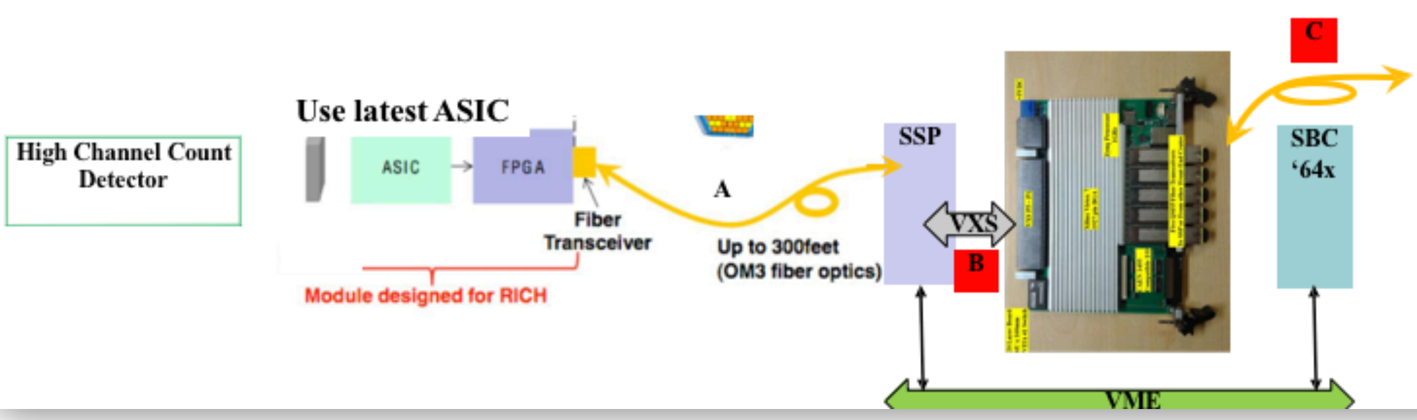
Bypassing '64x Example

A 1 SSP manages 32 LC fiber @2.5Gbps

B 16 SSP/crate @20Gbps to VTP [4 lanes/@5Gbps]

- Streaming bandwidth 320Gpbs to VTP
- 40Gbe from VTP "CODA ROC"

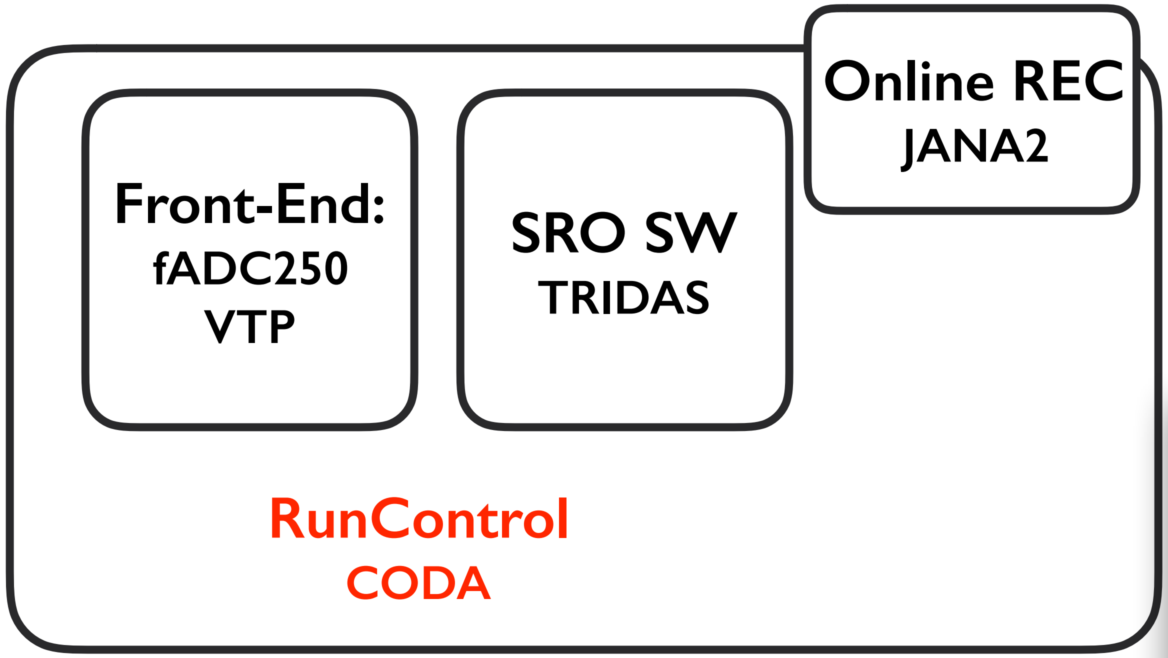
C VTP can perform significant data processing
192 channels for FPGA front end so,
Single VXS crate could stream
$192_{FPGA} * 32_{Links} * 16_{SSP} == 98304$ Chs



During tests:

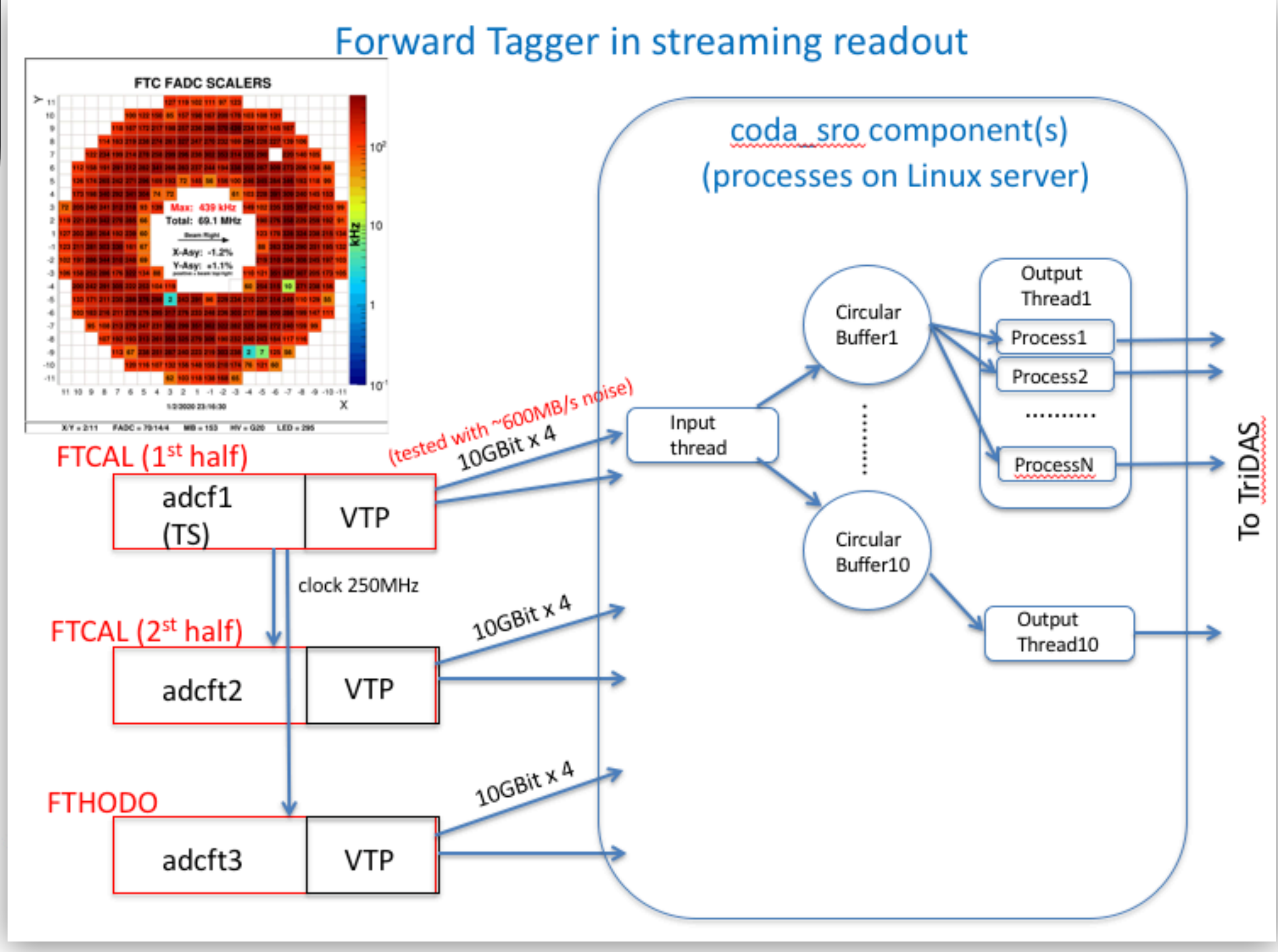
- Peak data rates ~150MBytes total
- Current VTP limit ~2GByte/sec
- Max: 10GBytes/sec

Streaming RO - CLAS12-FT tests



CODA

S.Boyarinov, B.Raydo, G.Heyes



Cebaf Online Data Acquisition (CODA)

- Designed for trigger-based readout systems
- The Event Builder (EV) collects data from 100+ Readout Controllers (ROCs) and VXS Trigger Boards (VTPs)
- The Trigger Supervisor (TS) synchronizes components using clock, sync, trigger and busy signals.

CODA adapted to SRO mode:

- EB replaced with new SRO component and back-end software capable of gluing ROC information based on timestamp instead of event number.
- ROCs not send data on VME bus (only initial configuration)
- Readout performed by VTP boards over serial lines
- 20GBit/s per crate (up to 40GBit/s if needed.)

Streaming RO - CLAS12-FT tests

Front-End:
fADC250
VTP

SRO SW
TRIDAS

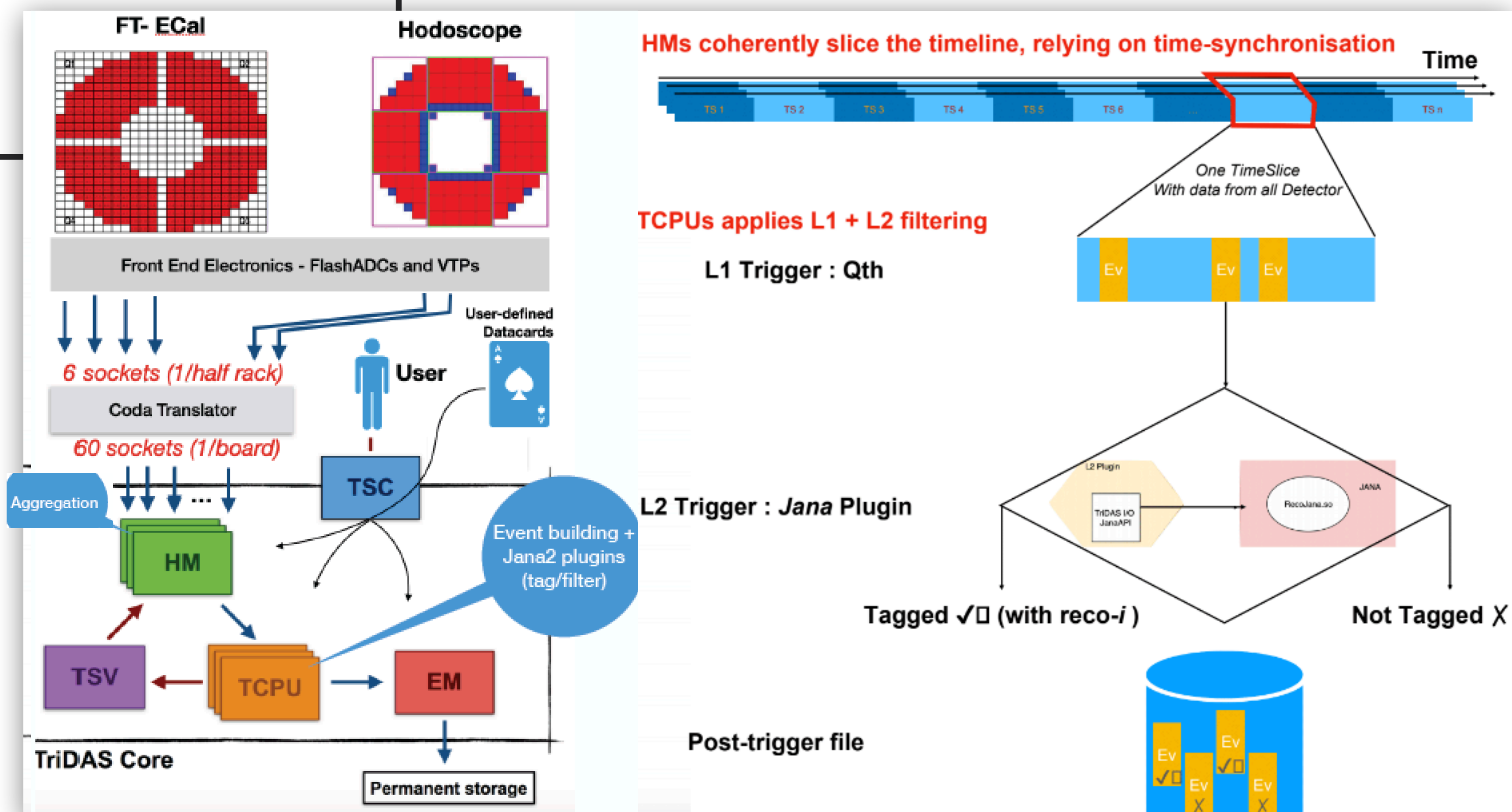
Online REC
JANA2

RunControl
CODA

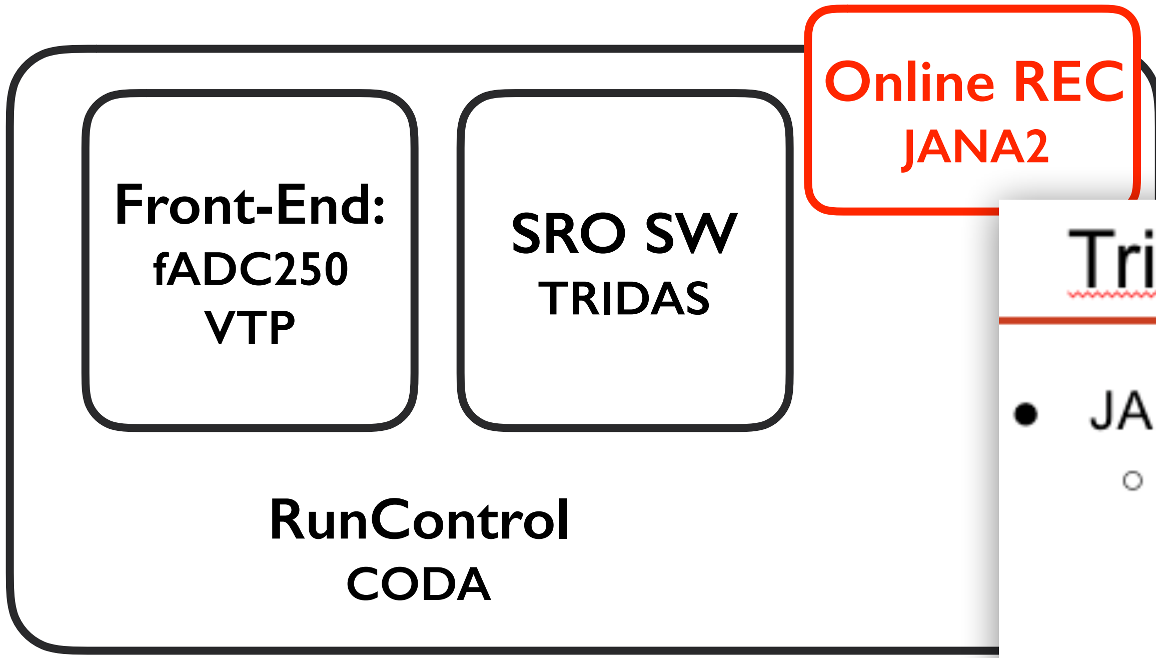
TRIDAS

T.Chiarusi, C.Pellegrino

- TriDAS: backend SRO sw framework
- developed for KM3_NET
- installed on Hall-B cluster
- Tested on multiple CPUs
- FT-Cal rate: 20-30 MHz
- Few hot-channels > 1 MHz
- Dta rate ~50MB/s
- Tests performed with different parameters (thresholds, HM, TCPUs)
- Profiling and performance



Streaming RO - CLAS12-FT tests

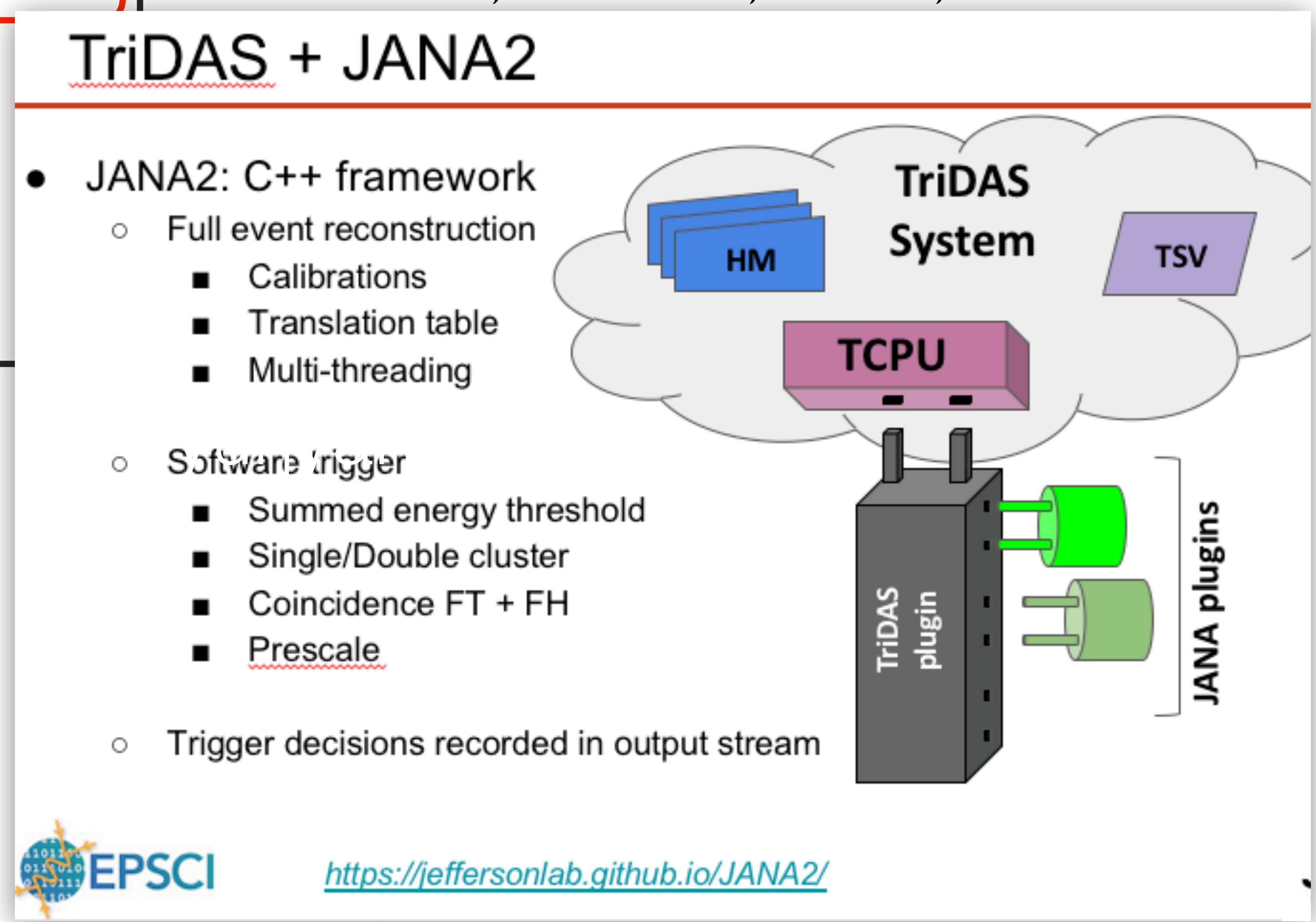


FE setup:
- FT-Cal only
- TET (on fADC250)=15/50,
- L1 threshold: 2000 (MeV)
- L1 time window: 400 ns

JANA2:
- L1 "minimum-bias": at least one crystal with energy > 2 GeV
- scaler (all L1 to diskS
- L2 plugins (*tagging* and *filetring*)
  - "standard" FT-CAL clustering ($N_{cluster} \geq 1, 2, 3$)
  - cosmic tracking
  - AI clustering algorithm: at least two cluster in the FT-CAL

JANA2 + REC

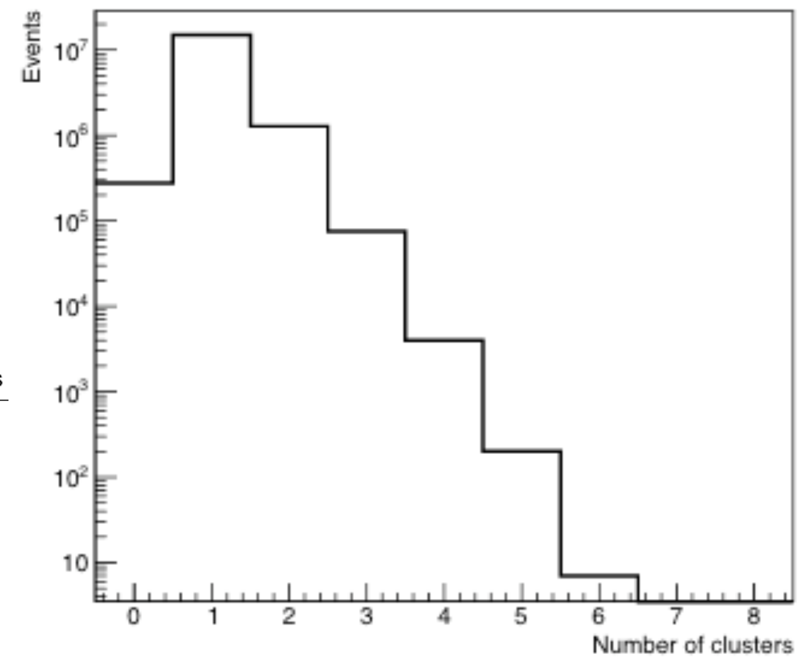
N.Brei, D.Lawrence,
M.Bondi', A.Celentano, C.Fanelli, S.Vallarino

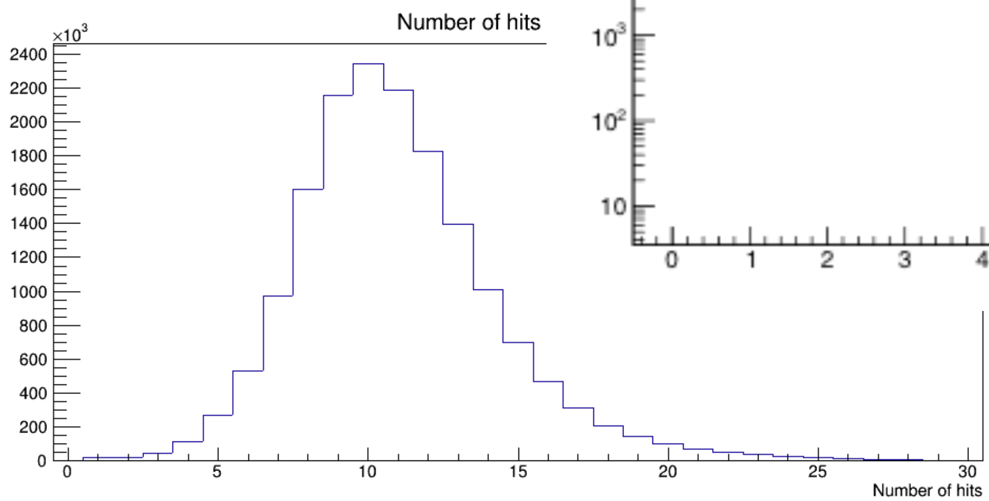


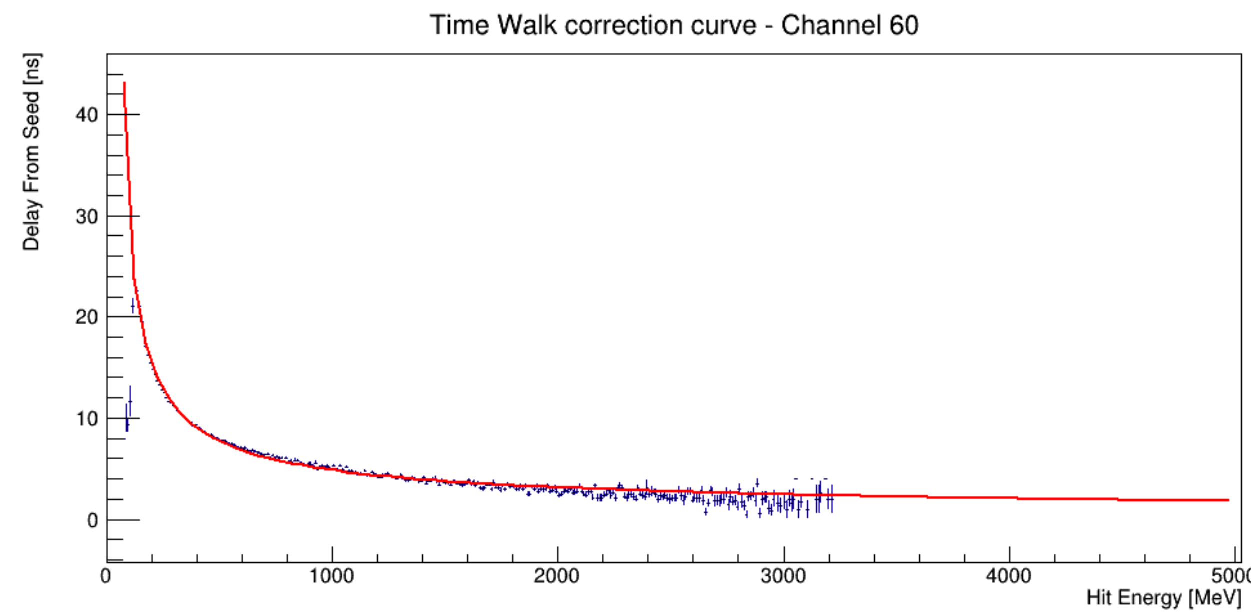
JANA Event Source plugin
- Read TriDAS file.pt files for offline analysis
- Offline algorithm development immediately available for use in Software Trigger
- Strong integration between online and offline

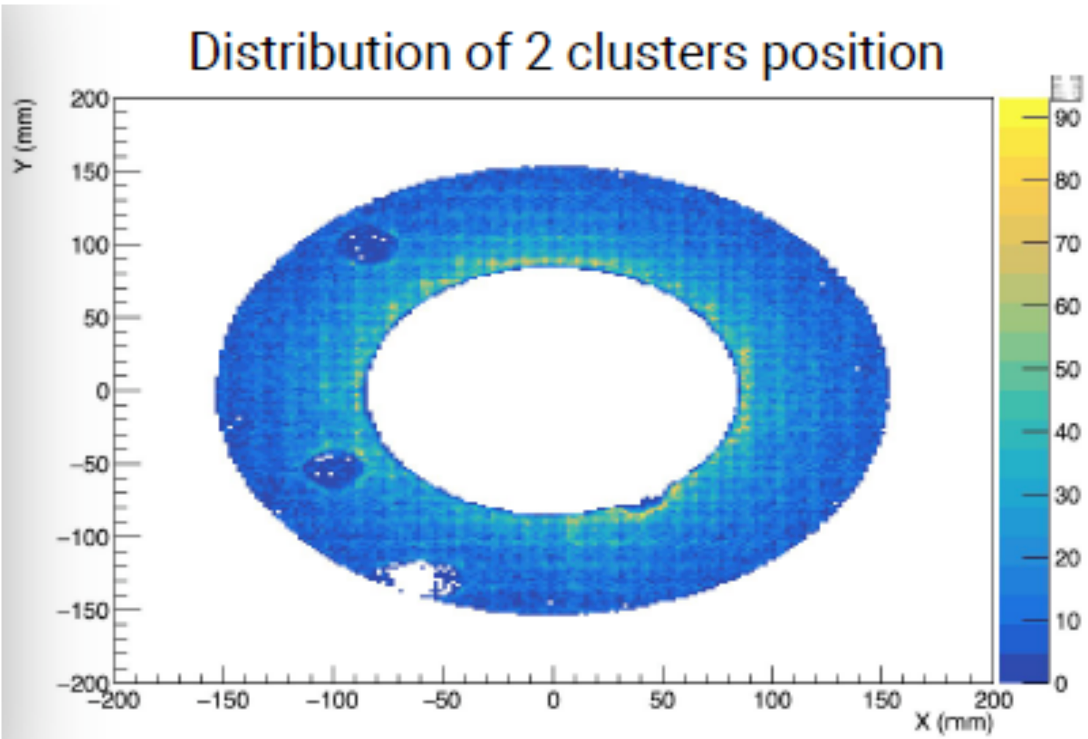
Run1 Data analysis

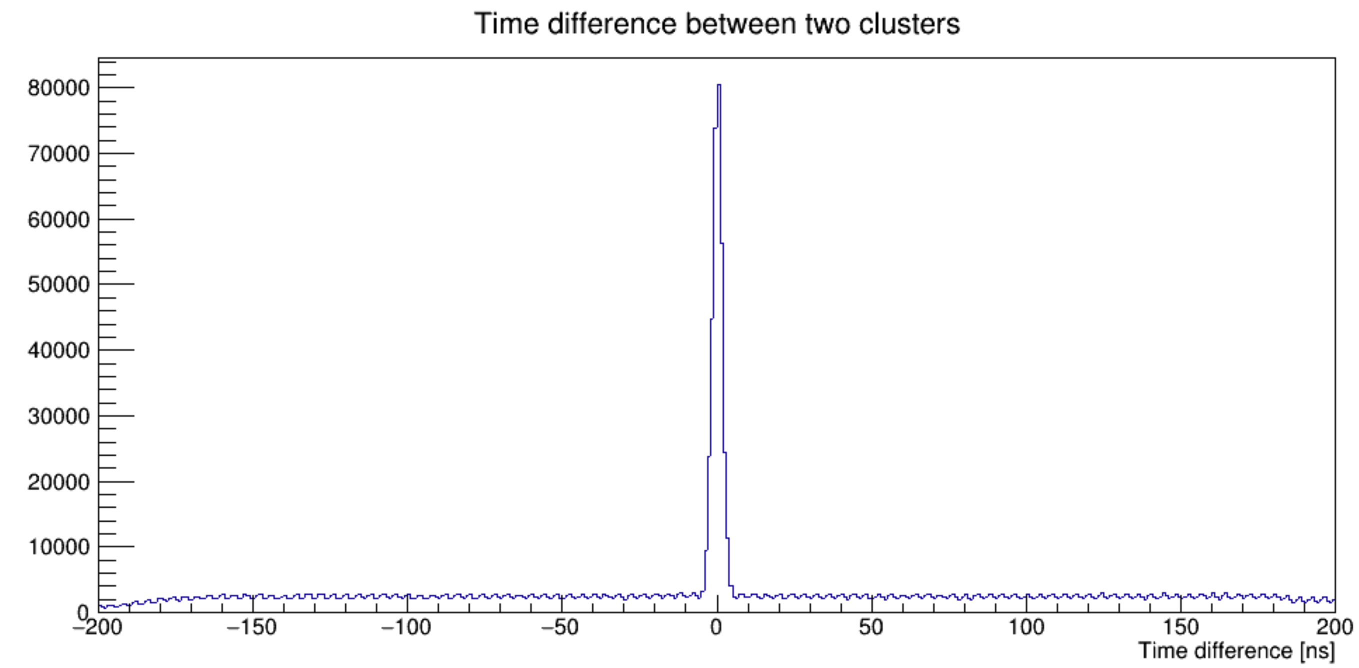
M.Bondi, S.Vallarino, A.Celentano









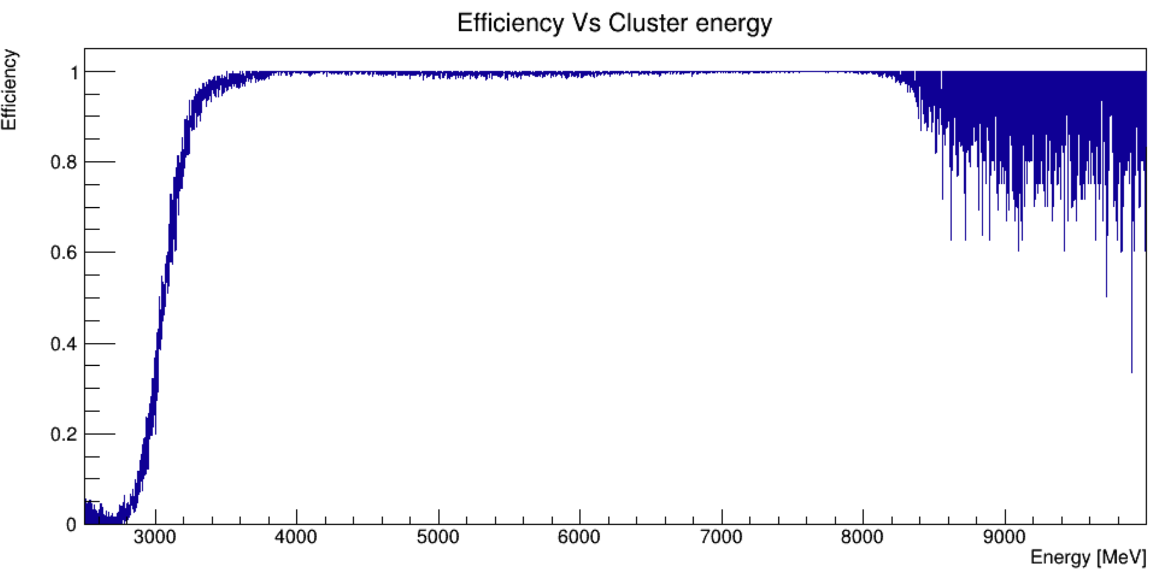


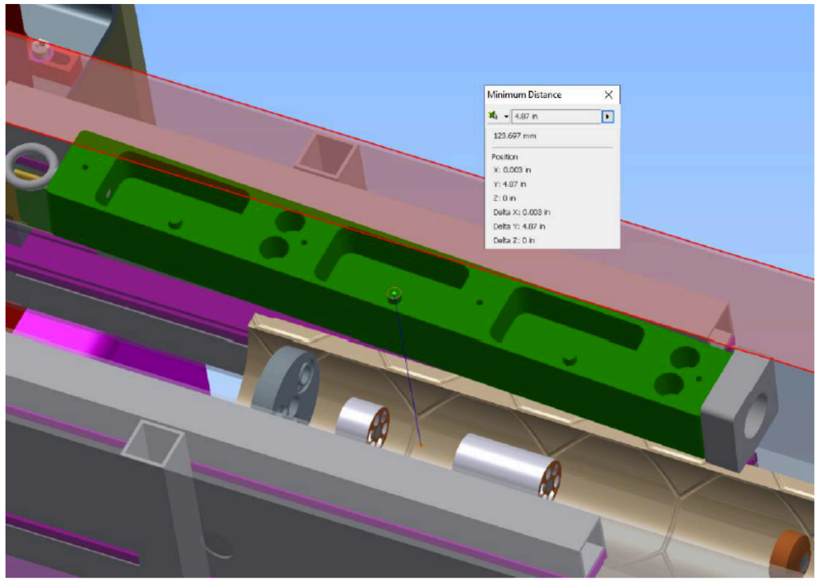
- **Time-walk (time) and calibration (energy)**
- **SRO data behaves as expected (N_{hits}, $N_{clusters}$, $XY_{cluster}$, ΔT)**

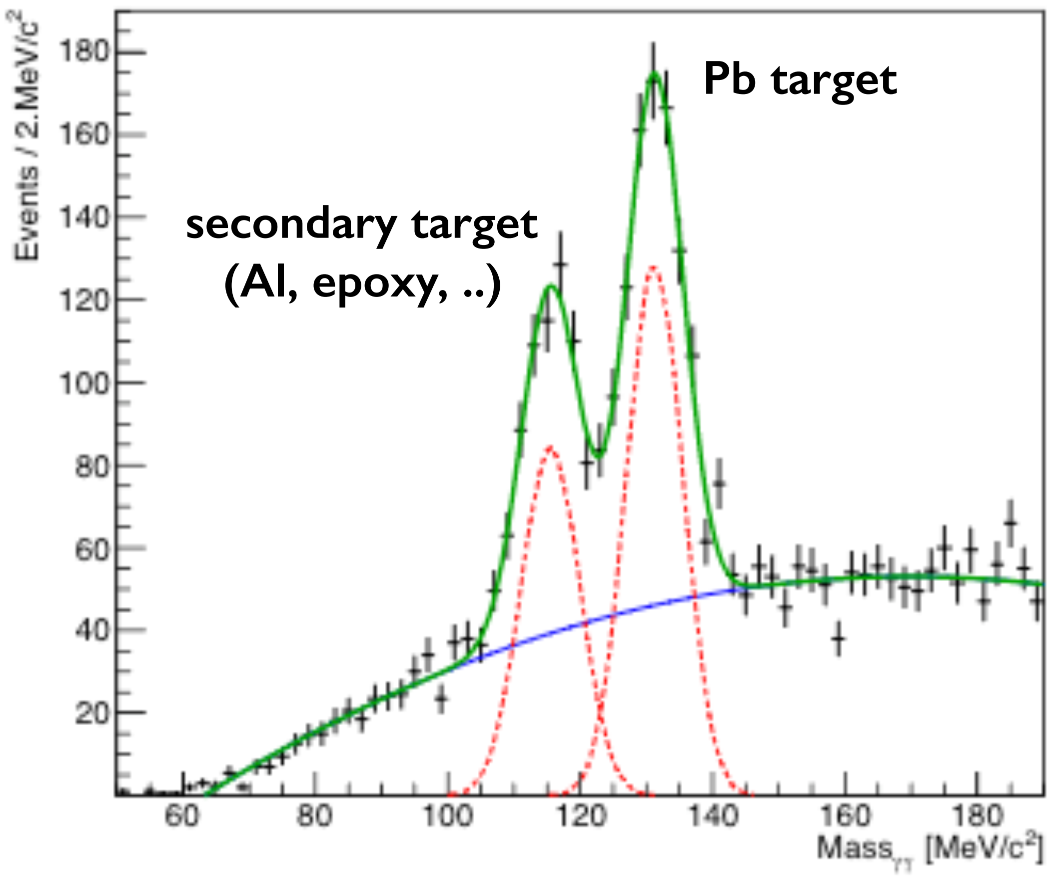
Run1 Data analysis

M.Bondi, S.Vallarino, A.Celentano

- Efficiency: comparison between online/offlin clustering







Two pi0 peaks corresponding to two vertices (and a wrong assumption on the vertex position)

- Measured (expected) pi0 yield

  Peak1 = 1365+-140 (~1800)

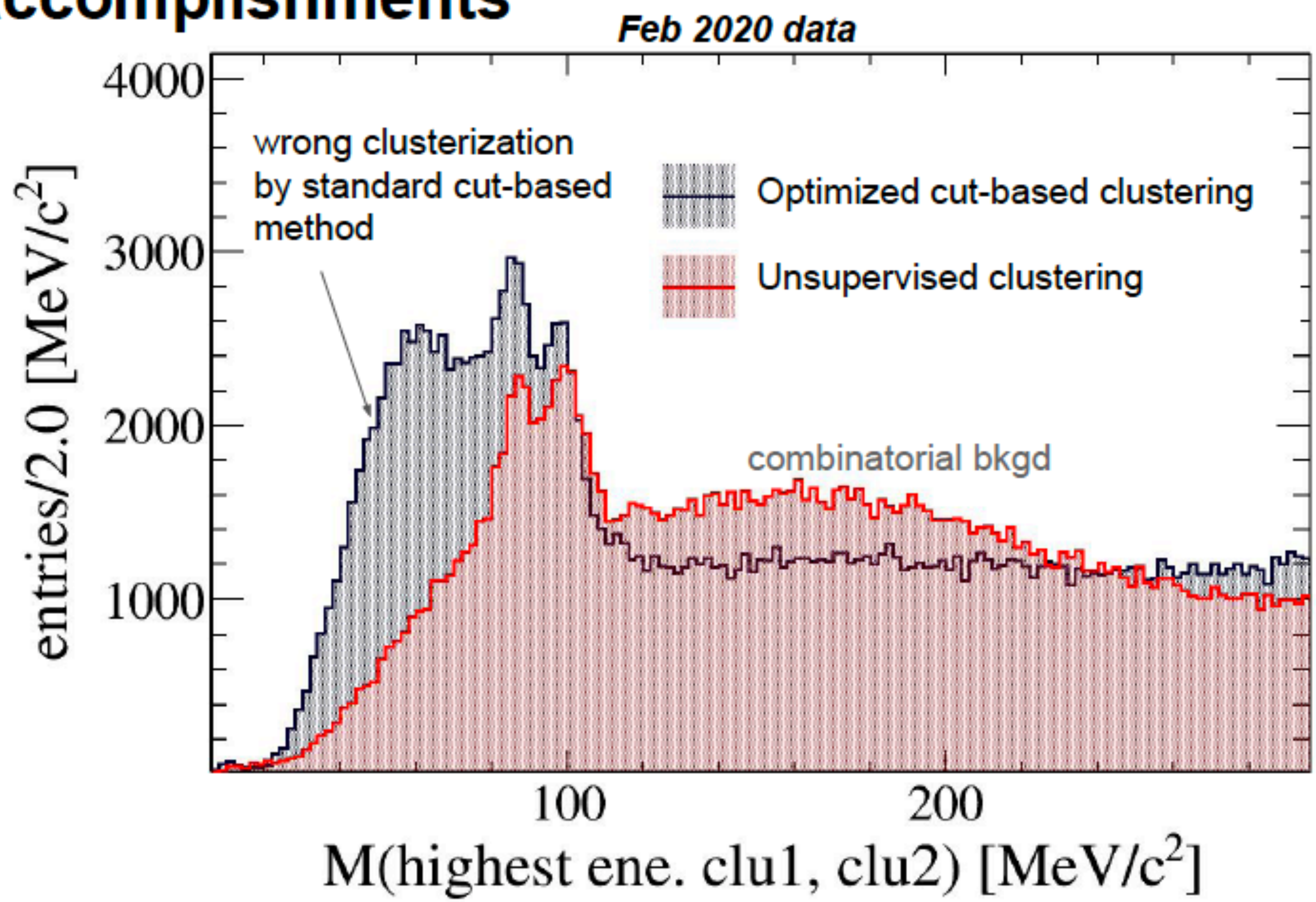
  Peak 2 = 930+-100 (~420)

Run2 data analysis in progress

Run1 Data analysis (AI-supported)

C.Fanelli

Accomplishments



*The cut-based clustering seems to assign more hits to the highest energy seed cluster.

- Implementation of AI supported L2 reconstruction algorithms for SRO: offline and online tests accomplished
- Unsupervised (no cuts required) hierarchical clustering generally robust against variations in experimental conditions
- AI tolerates larger hits multiplicities

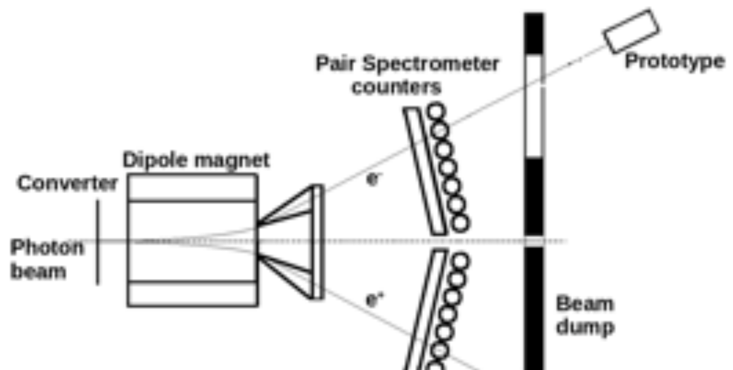
- Run1: off-line only
- Run2: real time!

Data analysis in progress

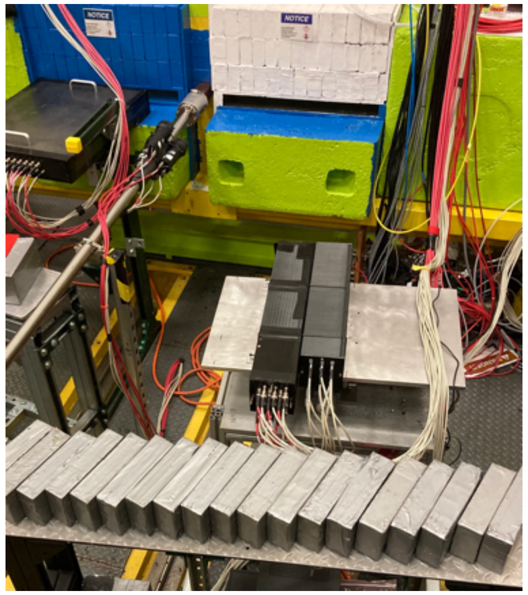
Streaming RO - Hall-D tests

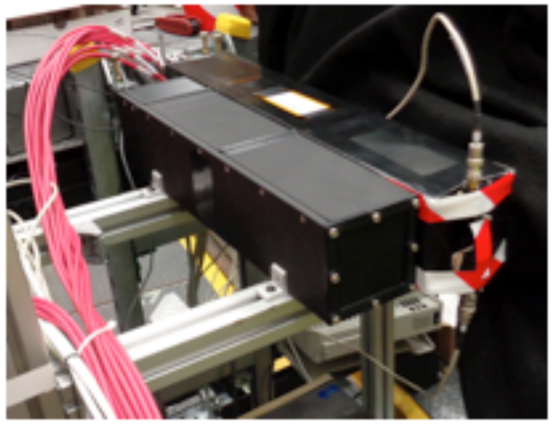
V.Berdnikov, T.Horn

- HallD parasitic test beam area, secondary e+/e- beam: E range (3-6) GeV
- *Triggered* DAQ with NPS and FCALII prototypes (baseline)
- New prototypes PbWO/SciGlass SiPM or PMT photosensors (3x3 matrix)
- SRO: preamps, fADC or WaveBoard digitizers



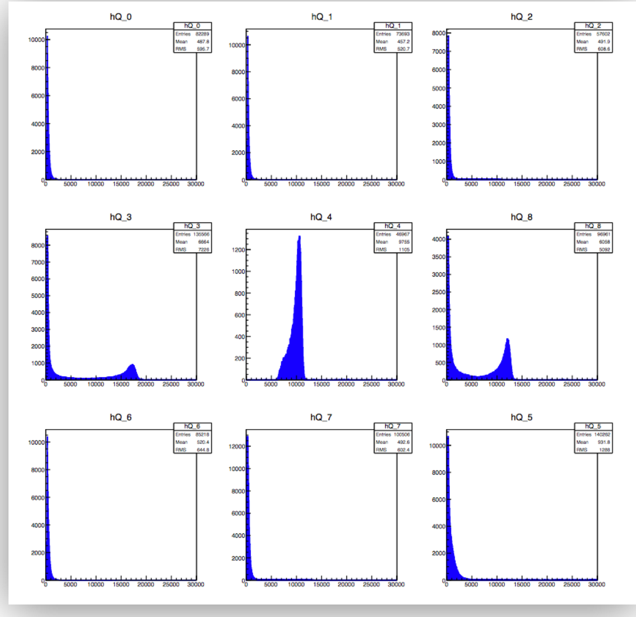
Setup scheme




SiPM(left) & PMT(right) cal. prot.

Waveboard

ECAL proto: 9ch SRO-mode



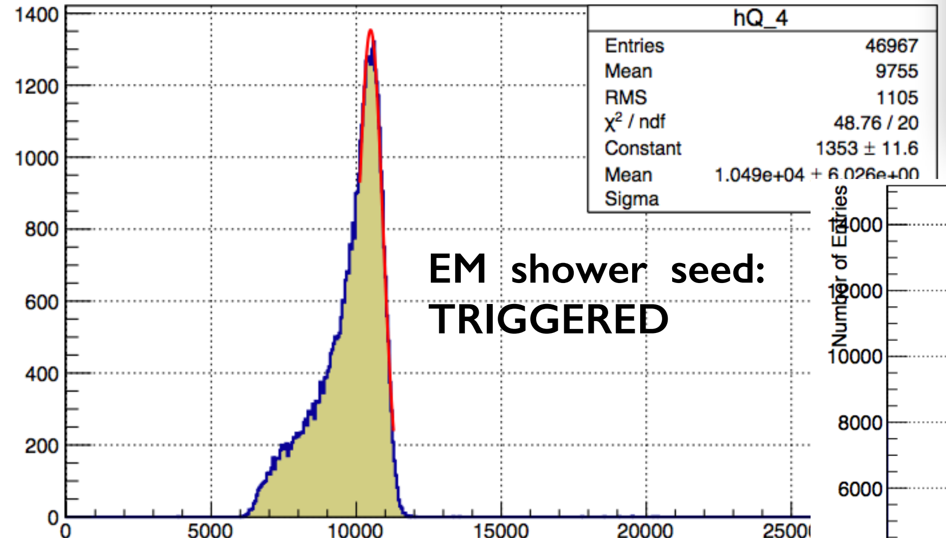
Spring/summer run 2020 HallD tests:

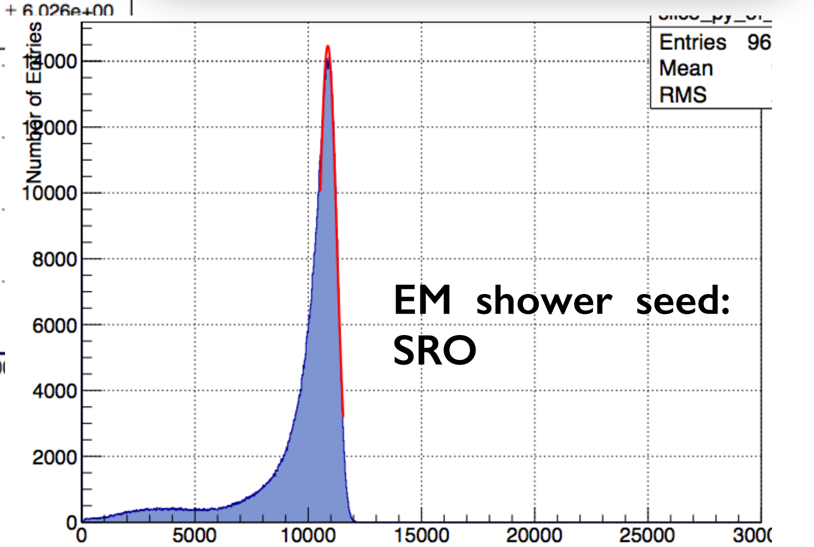
- 3x3 PMT PWO prototype installed
- Baseline performance established with GlueX triggered DAQ (parasitic mode)
- Central cell events hits (PS tile 59) correspond to ~ 4.5GeV lepton
- INFN WaveBoard fADC for SRO tests
- Scintillator pads in front of central cell installed for software L2 trigger
- SRO DAQ cabled/connected and tested

Data analysis in progress

New tests planned for Dec 21:

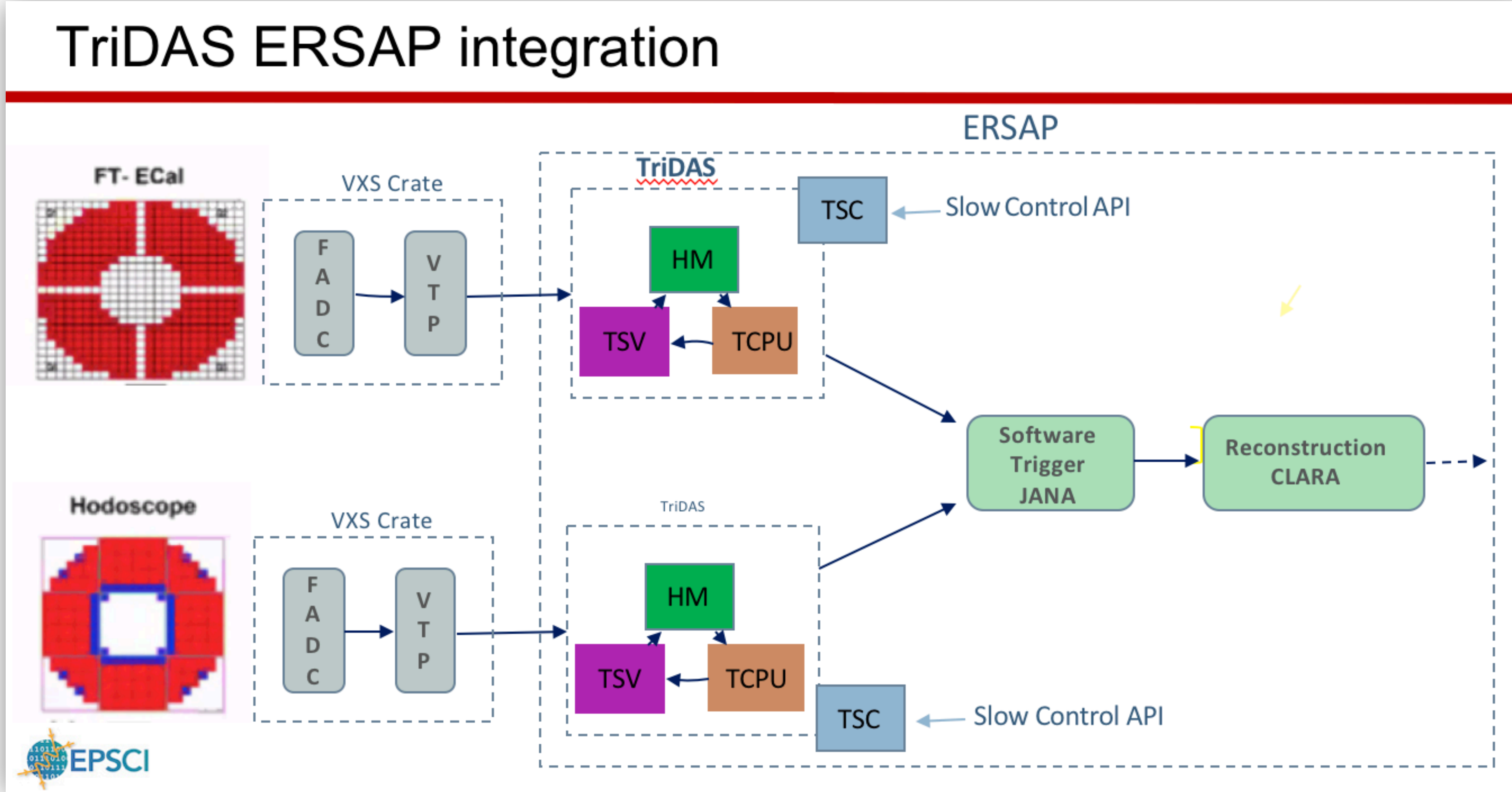
- 3x3 PMT PWO prototype (SiPM + preamps)
- fADC250 + VTP
- Cosmic muon tests undergoing
- TriDAS (Hall-B remote installation), ERSAP, …





Streaming RO - ERSAP

V.Gyurjyan, T.Chiarusi



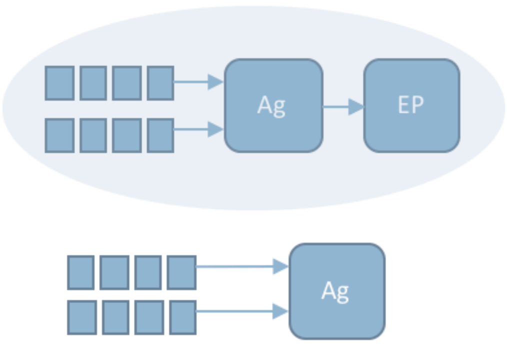
- **Reactive, event-driven data-stream processing framework that implements micro-services architecture**

- Provides basic stream handling services (stream aggregators, stream splitters, etc.)
- Implements tiered memory architecture (stream cooling: hierarchical ring buffers, data lakes, etc.)
- Defines streaming transient-data structure
- Provides service abstraction to present user algorithm (engine) as an independent service.
- Defines service communication channel (data-stream pipe) outside of the user engine.
- Stream-unit level workflow management system and API
- Adopts design choices and lessons learned from TRIDAS, JANA, CODA and CLARA

Streaming RO - ERSAP

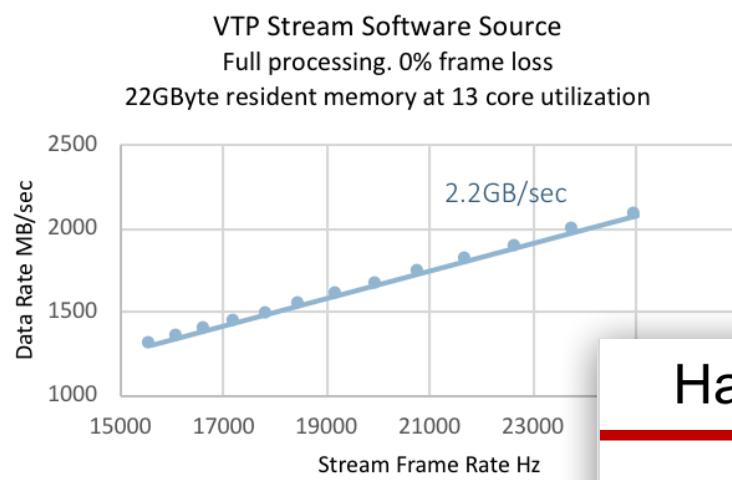
V.Gyurjyan, T.Chiarusi

VTP source engine (INDRA SRO test setup)



CPU 600%
Resident memory 5.4GByte
Throughput **5.3** GB/sec

EPSCI

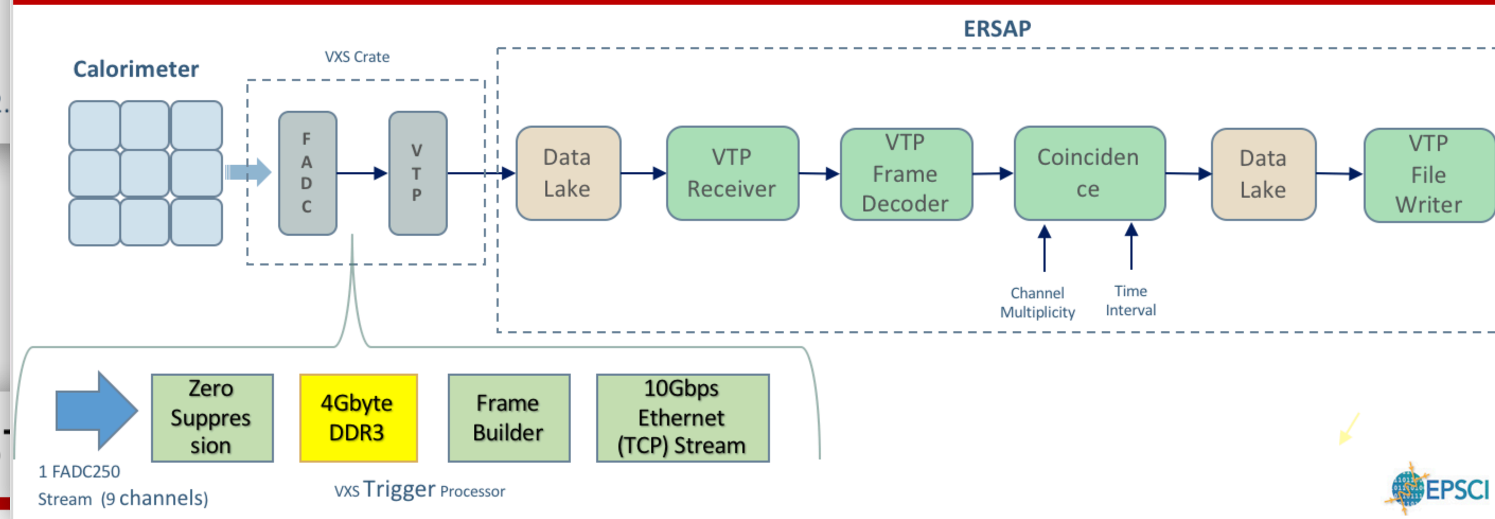


Intel Xeon (R) Gold 5218 @ 2.

ERSAP framework currently being tested in different configurations:

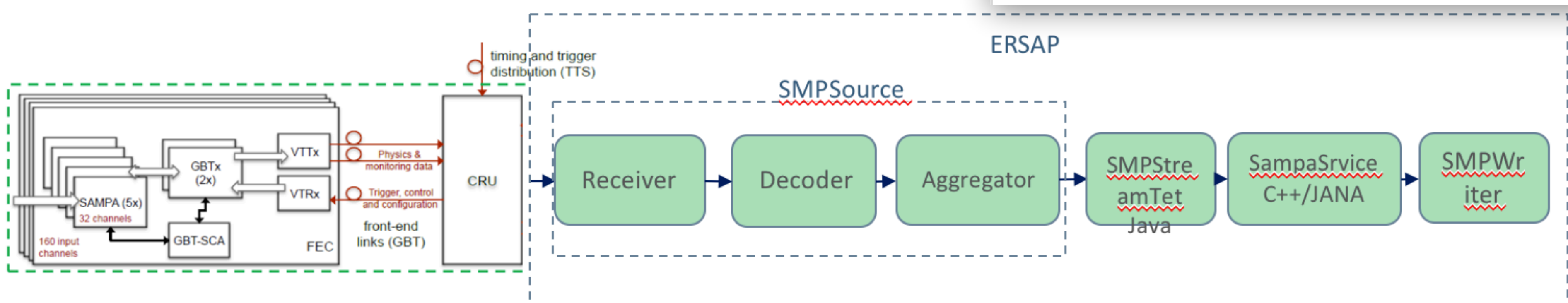
- INDRA lab
- EIC-ECAL prototype (Hall-D tests)
- EIC-GEM prototype (INDRA-ASTRA)

Hall-D prototype calorimeter SRO



EPSCI

GEM prototype detector SRO (INDRA-AS



- 5 SAMPA based front end card (FEC) was fabricated at the JLAB for GEM (prototype) detector readout.
  - FEC has 5 SAMPA chips: 160 ADC channels per FEC
- CRU (common readout unit. Provided by the ALICE collaboration)
  - Multiplexes data from front-end links
  - Control and configuration data for FECs
  - Xilinx Virtex-6 FPGA , can be used for data processing and formatting
  - 12 fast serial links

EPSCI

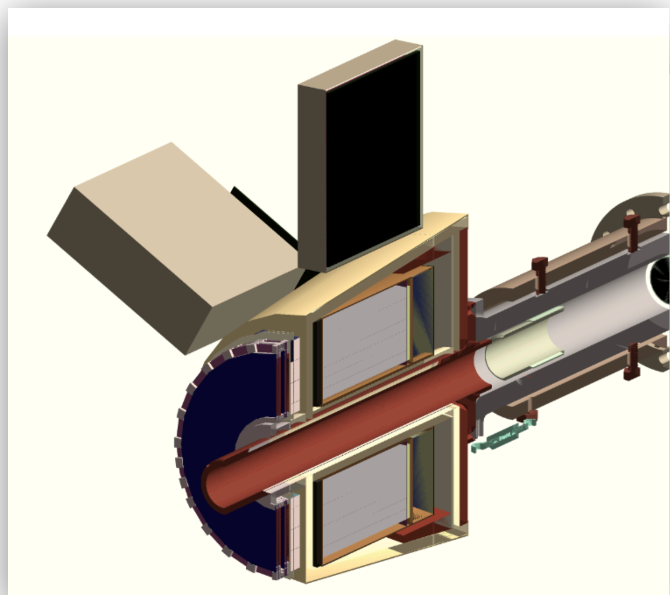
Streaming RO - ERSAP

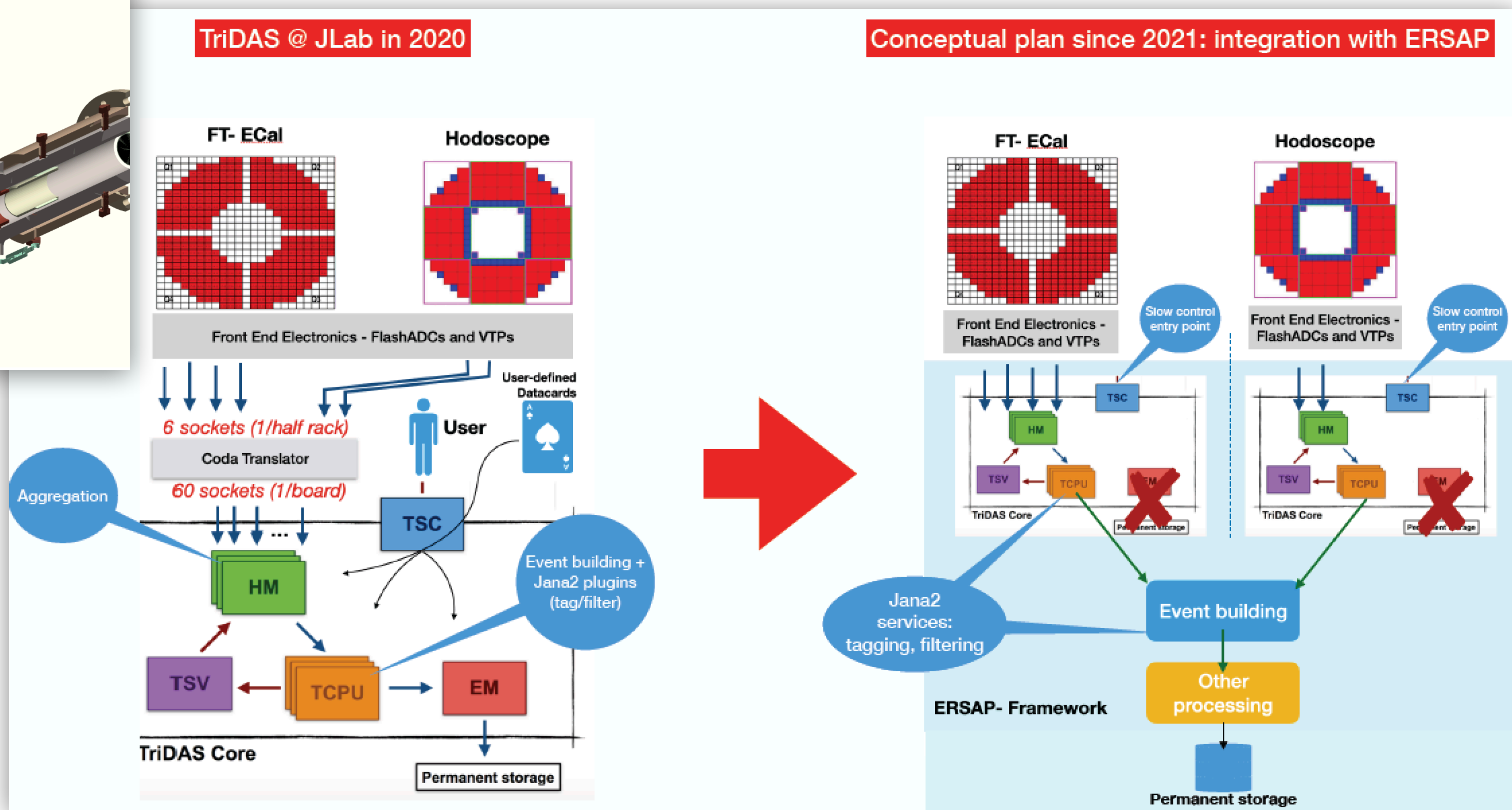
V.Gyurjyan, T.Chiarusi, L.Cappelli, C.Pellegrino, F.Giacomini

Hall-B tests Dec21/Jan22

- Same hw configuration used bin 2020
- Take adfvantage of c current run with solid targets(defined vertex)
- Implementation of different components in ERSAP framework
- VTP data format matching
- Backend deployed and running in Hall-B CLONE

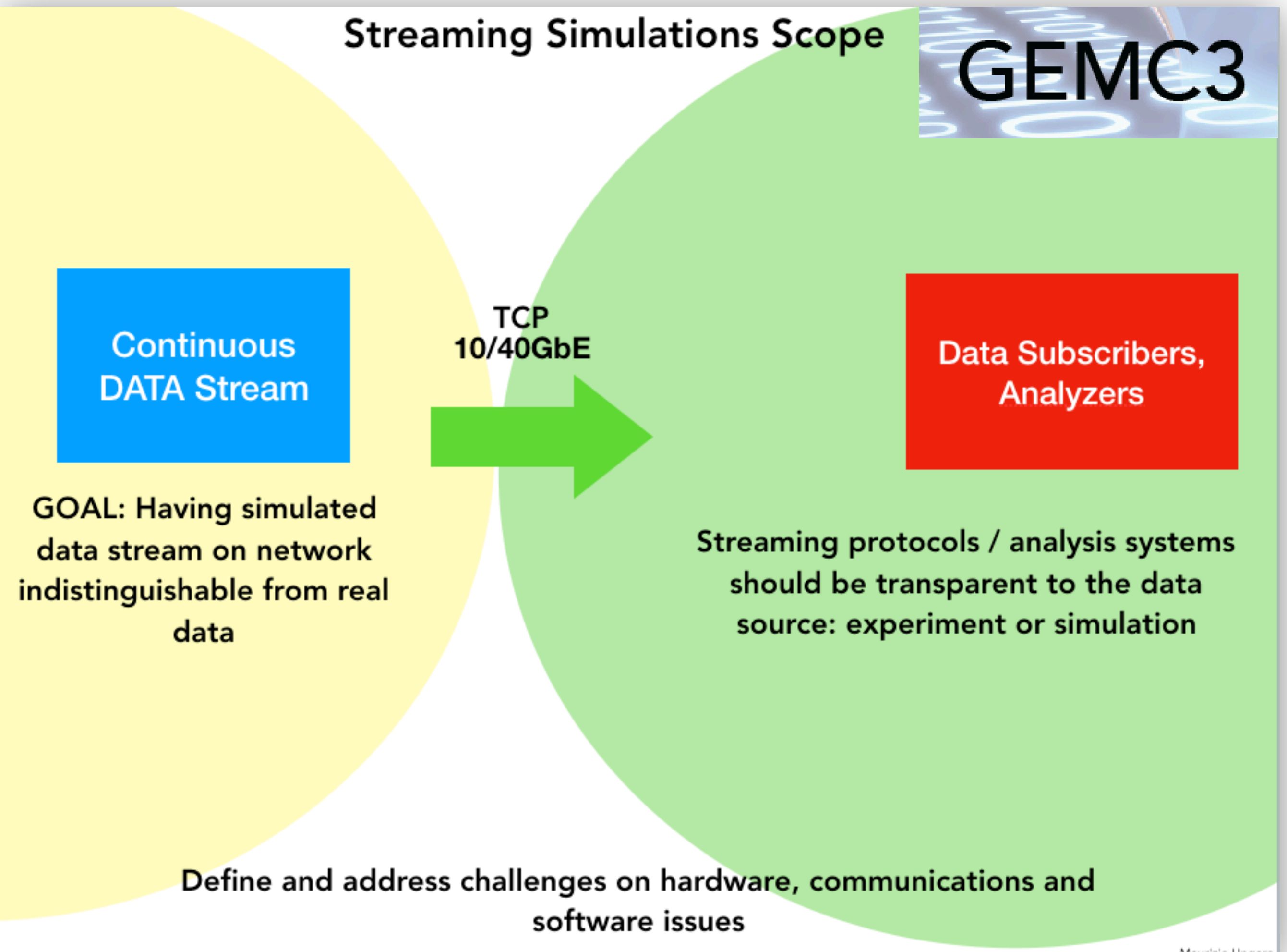
- Test with pulser
- Data from FT-CAL and FT-HODO
- Different clustering algorithms in JANA
- AI/ML real-time test
- FE+BE performance assessment
- Test-bench for future CLAS12 HI-LUMI ops





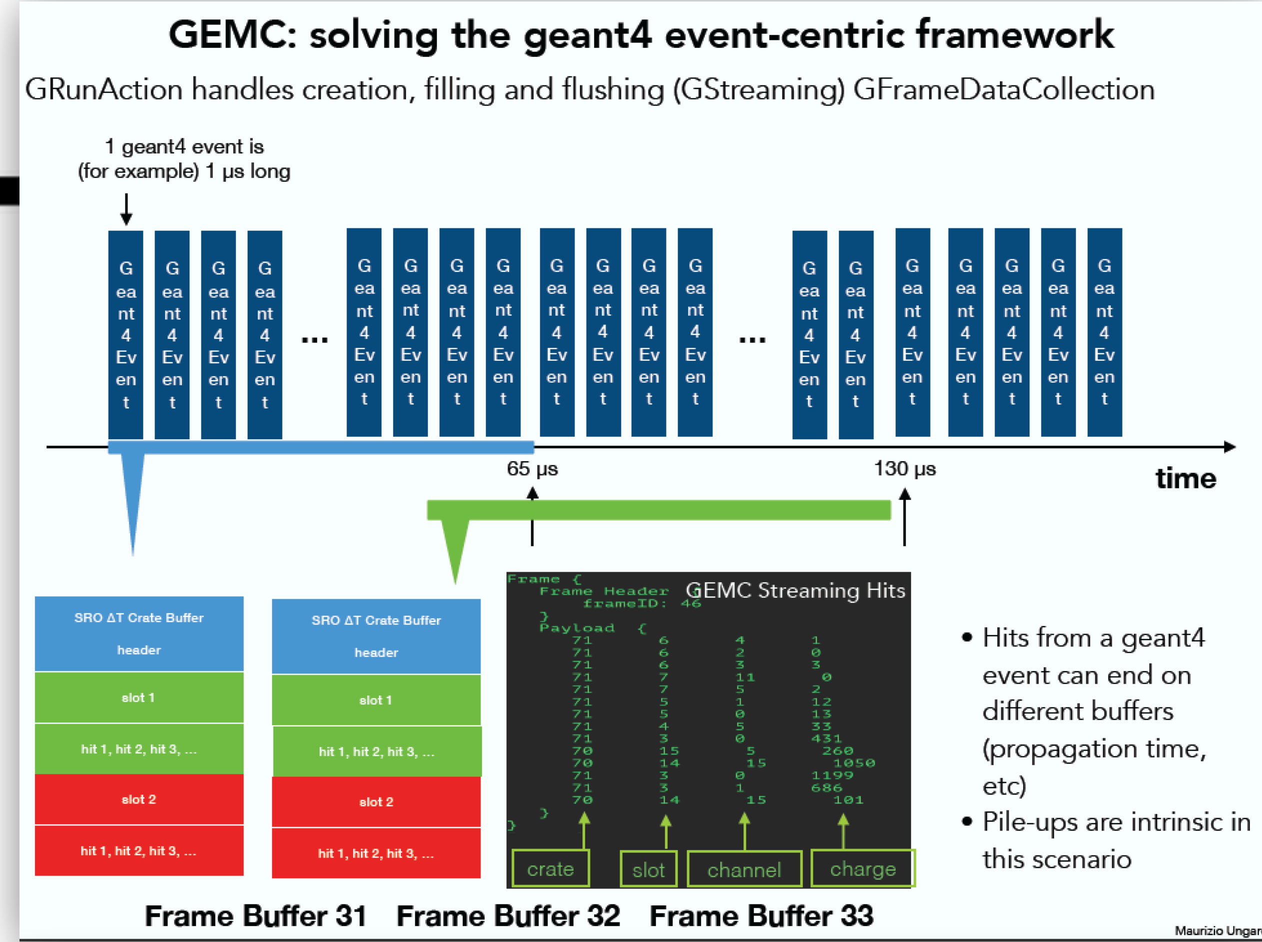
GEMC3: SRO GEANT4 MC

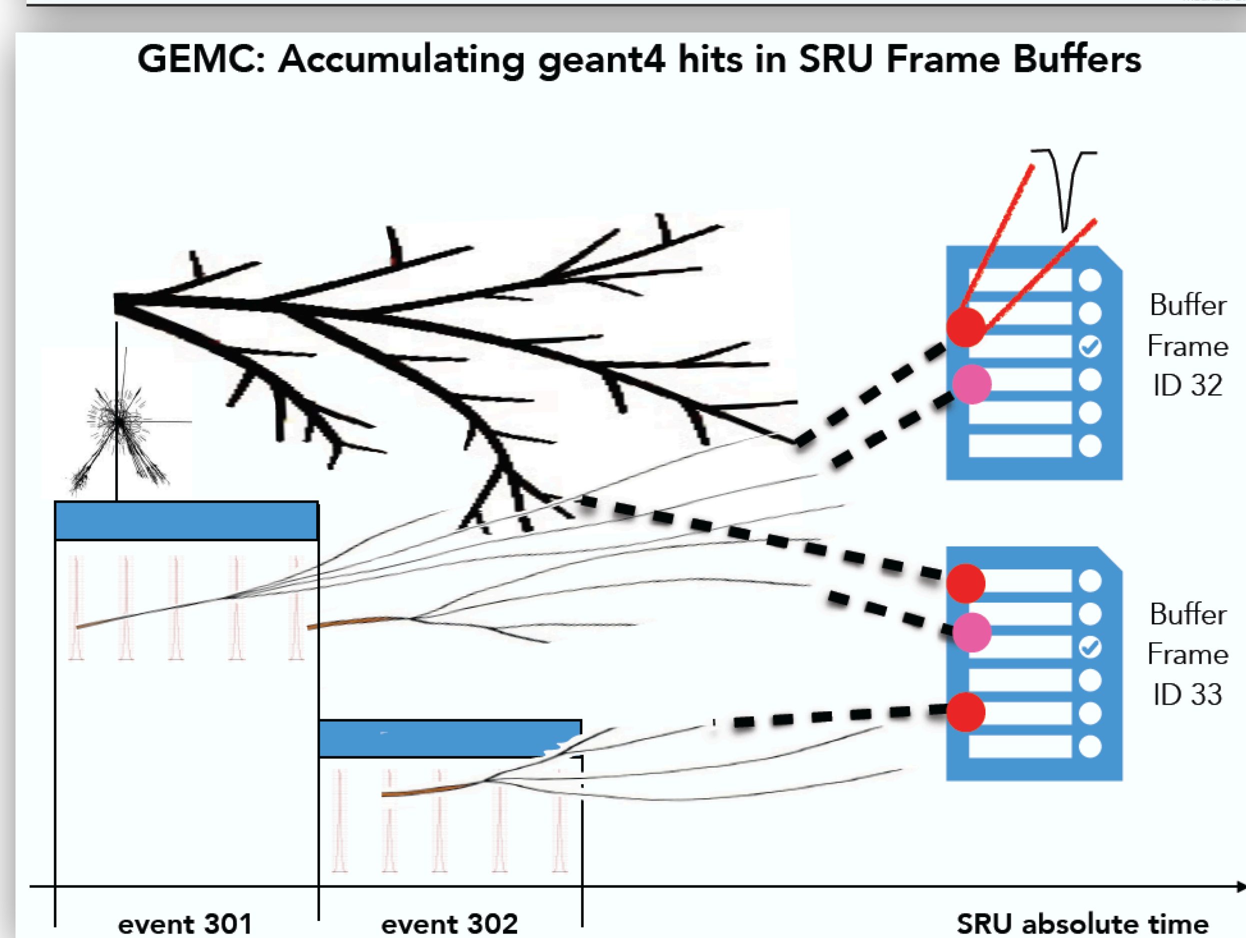
Development of a MC GEANT-based toolkit to implement SRO in detector simulations



- Transform event-based to stream-based G4 logic
- Develop libraries share same on-line data format
- Emulate TCP output te feed to ERSAP

M.Ungaro, P.Moran, L.Cappelli





Summary

- Streaming RO is 'THE' option for future electron beam experiments
- Take advantage of the full detector's information for an optimal (smart) tagging/filtering
- So many advantages: performance, flexibility, scaling, upgrading …

  … but, has to demonstrate to be as effective (or more!) than triggered systems
- Streaming Readout on-beam tests performed using the CLAS12-FT-Cal at JLab
- The full chain (FE + SRO sw + ON-LINE REC) tested with existing hw
- Data taken in full streaming mode, analysis in progress (traditional and AI-supported)
- Parallel activity in a more controlled situation (Hall-D PS test e^-/e^+beam)
- New tests planned at JLab in winter 2021/22
- Development of a SRO G4 MC (GEMC3)
- Deployment of JLab SRO framework based on micro-services architecture
- SRO prototype to be tested in view of a massive implementation of full CLAS12 SRO
- Built a real SRO prototype and a work team!

M.Battaglieri - JLAB

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