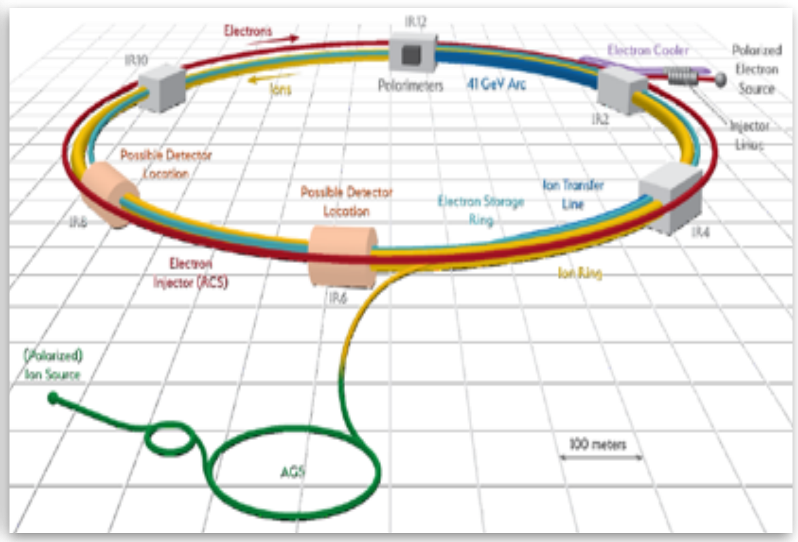
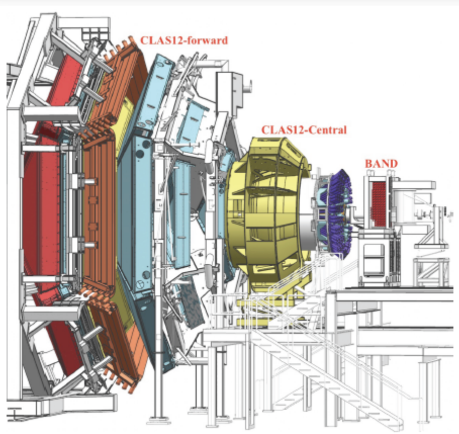
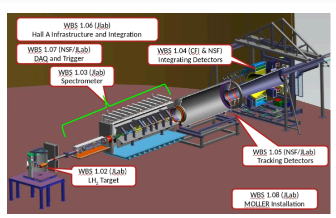
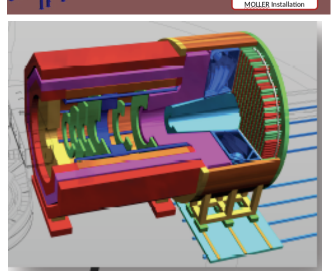
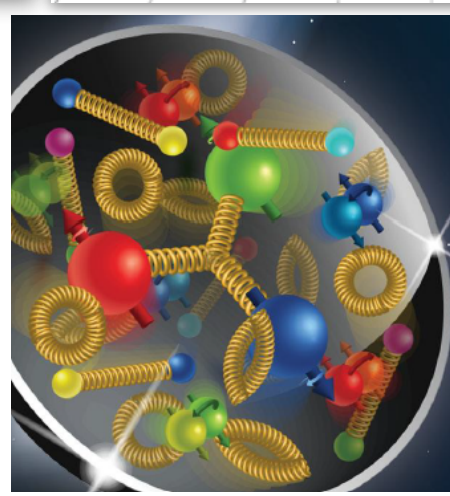
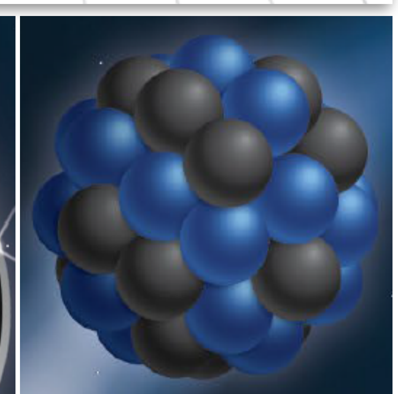








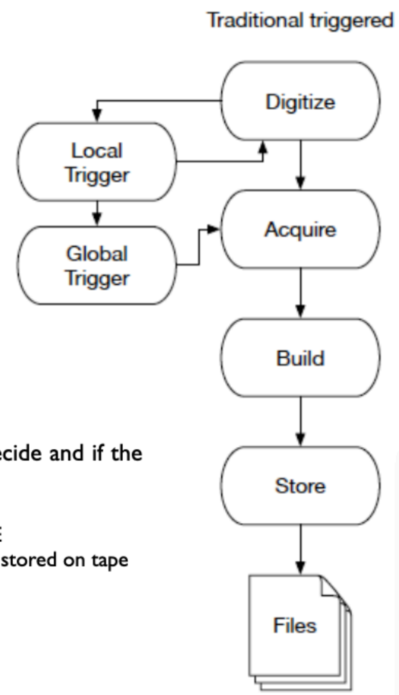
# *Streaming Readout @EIC*


Marco Battaglieri
INFN


M.Battaglieri - JLAB

# Streaming RO

## Traditional (triggered) DAQ




* (few) trigger Channels participating send (partial) information to trigger logic

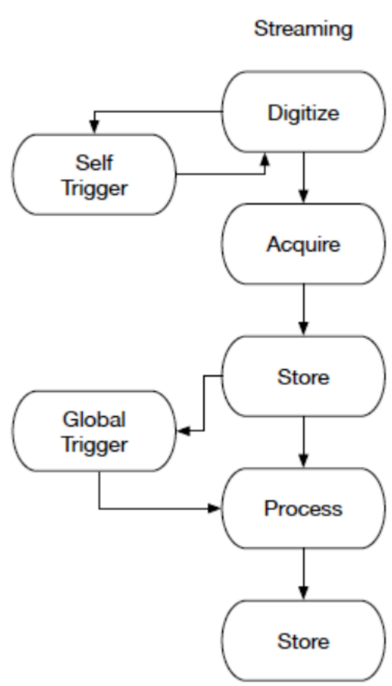
* All channels continuously measured, hits stored in short term memory

* 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

**Traditional triggered DAQ**

- **Pros**
  - we know it works reliably!
- **Drawbacks:**
  - only few information forms the trigger
  - Trigger logic (FPGA) difficult to implement and debug
  - not easy to change and adapt to different conditions

## Streaming read out (SRO)




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

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

* 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

**SRO DAQ**

- **Pros**
  - All channels can be part of the trigger
  - Sophisticated tagging/filtering algorithms
  - high-level programming languages
  - scalability
- **Drawbacks:**
  - we do not have the same experience as for TRIGGERED DAQ

## Why SRO is so important?

- **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

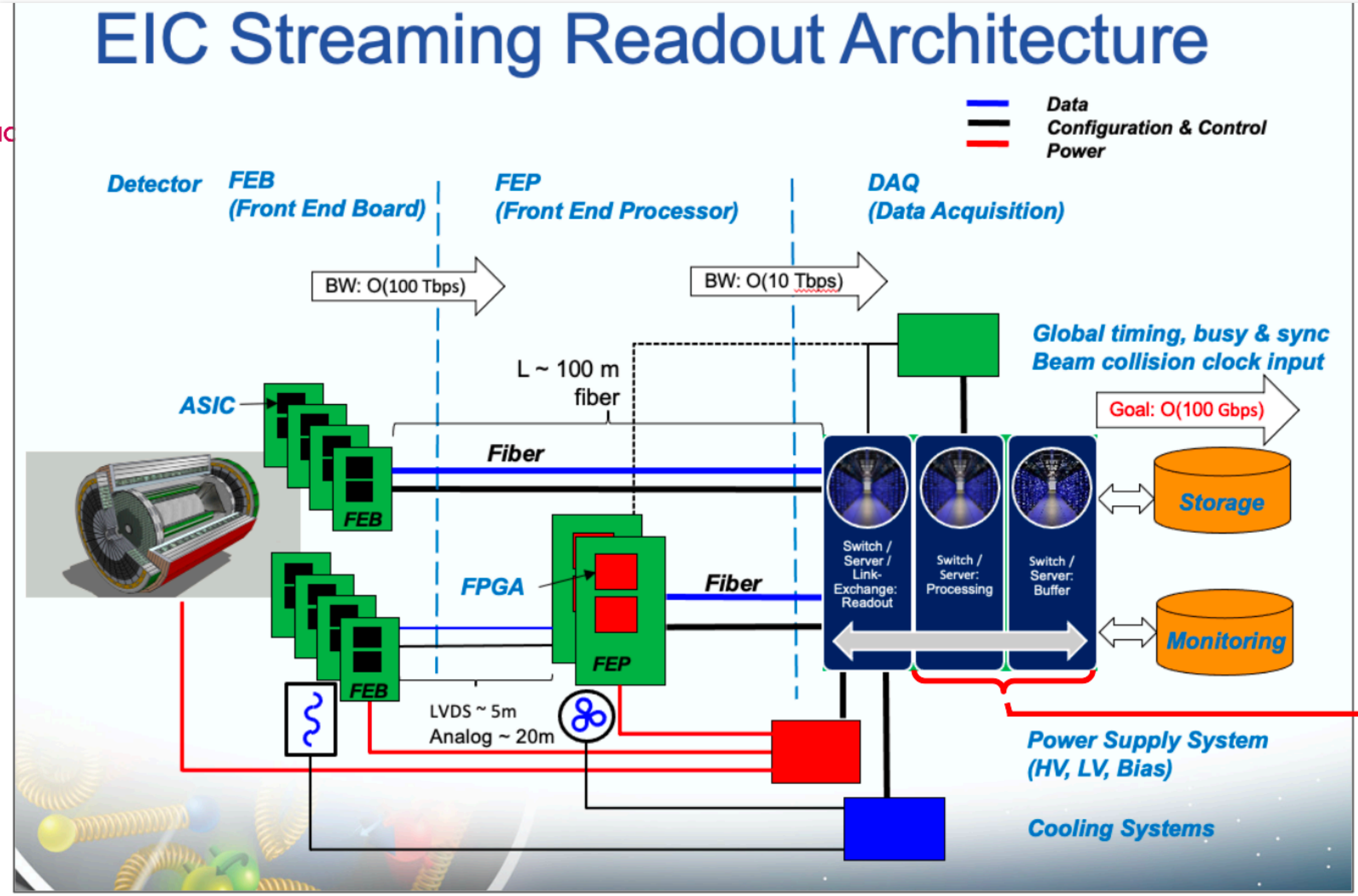
**Many NP and HEP experiments adopt the SRO scheme (with different solutions):**

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



**EIC (from the YR effort to ePIC) choose a SRO DAQ**

# SRO for EIC




*EIC Streaming Readout (From Fernando Barbosa's talk at AI4EIC Sep. 9, 2021)*

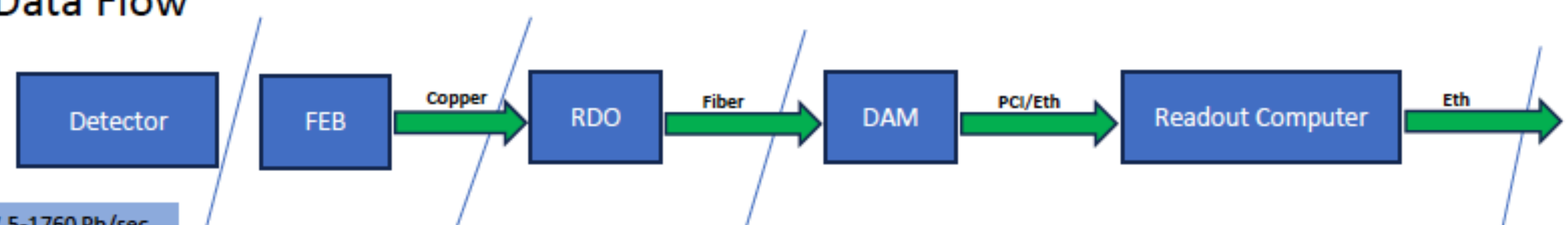
factor of 100 in data reduction

# SRO for EIC

## Summary of Channel Counts

| Detector Group | Channels | | | | | RDO | Fiber | DAM | Data Volume (RDO) (Gb/s) | Data Volume (To Tape) (Gb/s) |
|---|---|---|---|---|---|---|---|---|---|---|
| | MAPS | AC-LGAD | SiPM/PMT | MPGD | HRPPD | | | | | |
| Tracking | 36B | | | 202k | | 872 | 1744 | 24 | 27 | 26 |
| Calorimeters | 88M | | 123k | | | 258 | 556 | 10 | 502 | 27 |
| Far Forward | 300M | 2.3M | 170k | | | 178 | 492 | 5 | 15 | 8 |
| Far Backward | 146M | | 2k | | | 50 | 100 | 6 | 150 | 1 |
| PID | | 7.8M | 320k | | 140k | 241 | 523 | 39 | 2628 | 36 |
| TOTAL | 36.5B | 10.1M | 615k | 202k | 140k | 1599 | 3415 | 84 | 3,322 | 98 |

## Summary of Data Flow

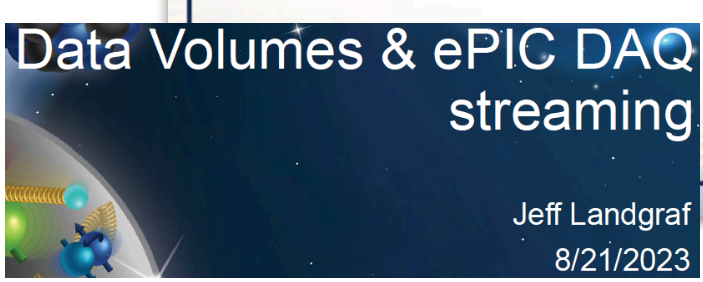



| | |
|---|---|
| 100% Occupancy | 27.5-1760 Pb/sec |

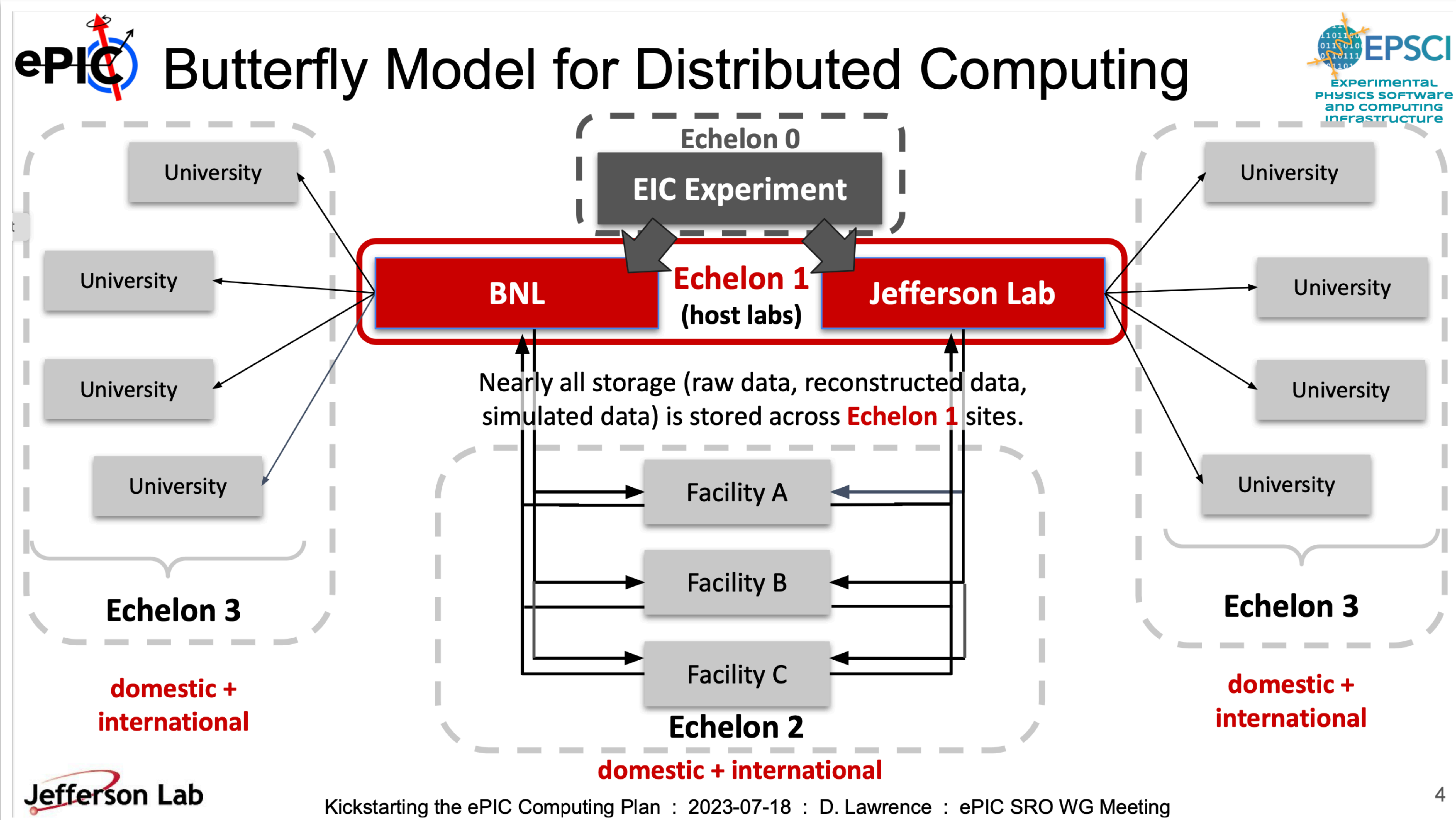
| | |
|---|---|
| Aggregate | 3.4 Tb/sec |
| Noise | 3 Tb /sec |
| Signal from Physics + Background | 400 Gb / sec |

| | |
|---|---|
| Aggregate | 3.4 Tb/sec |
| Per fiber (Avg) | 1.85 Gb/sec |

| | |
|---|---|
| Aggregate | 99 Gb/sec |
| Collision Signal | 38 Gb/sec |
| Synchrotron Rad | .01 Gb/sec |
| Electron Beam | 4 Gb/sec |
| Hadron Beam | 22 Gb/sec |
| Noise | 35 Gb/sec |



# SRO for EIC




✳Connections between on-line and off-line: LHC computing model investigation undergoing

# SRO for EIC

## SRO calls for a new computing model …

### ePIC Streaming Computing Model Working Group
Kick-off meeting - July 11, 2023

**Software and Computing Coordinator (Markus)**
+ Deputy Coordinator **Operations (Wouter)**
+ Deputy Coordinator **Development (Sylvester)**
+ Deputy Coordinator **Infrastructure (Torre)**

**Guiding Principles:** DE&I, Software Principles, Sustainability

**Operation WGs:**
- **Production (CD)**
- **User Learning**
- **Validation (CD)**

**Development WGs (CI):**
- **Physics and Detector Simulation**
- **Reconstruction**
- Analysis Tools

**Infrastructure WGs:**
- **Streaming Computing Model**
- Multi-Architecture Computing
- Distributed Computing

**Cross-cutting WG:**
- Data and Analysis Preservation

- Structure of Software and Computing in ePICS
- Presented by Markus on May 2nd 2023 kickoff-meeting

- ePIC SRO Computing Model WG belongs to 'infrastructure'
- Co-conveners: M.Battaglieri (INFN), J.Huang (BNL) + J.Landgraf (BNL)


**we are working on it!**

**… and tests to deploy a (working!) SRO pipeline form ePICS**

# Testing SRO for EIC

- ✳ 2020-21 test results published on Eur. Phys. J. Plus (2022)137:958 https://doi.org/10.1140/epjp/s13360-022-03146-z)

- ✳ New tests in spring 2023 (Feb15-March 20) to test JLab/EIC streaming readout framework using a 3x3 and a 5x5 SciGlass EIC EM bCal prototypes

  - ✳ Setups:
    - Cosmic rays (Hall-B): detector characterisation
    - Cosmic rays (Hall-D): during prod runs for calibration
    - EM shower (Hall-D): EM shower in SciGlass
  - ✳ Goals:
    - JLab SRO system performance profiling
    - (Quasi) real-time calibrations
    - Real-time AI-supported algorithms (clustering, calibration, …)
    - Data collected in 'dump-', 'tagging-' and 'filtering-' mode

Eur. Phys. J. Plus (2022) 137:958
https://doi.org/10.1140/epjp/s13360-022-03146-z

THE EUROPEAN PHYSICAL JOURNAL PLUS

Regular Article

**Streaming readout for next generation electron scattering experiments**

**Fabrizio Ameli[1], Marco Battaglieri[2,3], Vladimir V. Berdnikov[4], Mariangela Bondi[3,a], Sergey Boyarinov[2], Nathan Brei[2], Andrea Celentano[3], Laura Cappelli[5], Tommaso Chiarusi[6], Raffaella De Vita[3], Cristiano Fanelli[7,8], Vardan Gyurjyan[2], David Lawrence[2], Patrick Moran[7], Paolo Musico[3], Carmelo Pellegrino[5], Alessandro Pilloni[9,10], Ben Raydo[2], Carl Timmer[2], Maurizio Ungaro[2], Simone Vallarino[11]**

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Received: 3 February 2022 / Accepted: 4 August 2022


**Abstract** Current and future experiments at the high-intensity frontier are expected to produce an enormous amount of data that needs to be collected and stored for offline analysis. Thanks to the continuous progress in computing and networking technology, it is now possible to replace the standard 'triggered' data acquisition systems with a new, simplified and outperforming scheme. 'Streaming readout' (SRO) DAQ aims to replace the hardware-based trigger with a much more powerful and flexible software-based one, that considers the whole detector information for efficient real-time data tagging and selection. Considering the crucial role of DAQ in an experiment, validation with on-field tests is required to demonstrate SRO performance. In this paper, we report results of the on-beam validation of the Jefferson Lab SRO framework. We exposed different detectors (PbWO-based electromagnetic calorimeters and a plastic scintillator hodoscope) to the Hall-D electron-positron secondary beam and to the Hall-B production electron beam, with increasingly complex experimental conditions. By comparing the data collected with the SRO system against the traditional DAQ, we demonstrate that the SRO performs as expected. Furthermore, we provide evidence of its superiority in implementing sophisticated AI-supported algorithms for real-time data analysis and reconstruction.

**1 Introduction**

A new generation of electron scattering experiments is underway at the world-leading QCD facilities such as Brookhaven National Lab (BNL) and Jefferson Lab (JLab). New projects include the Electron Ion Collider (EIC) [1] at BNL, SOLID [2] and Moller [3] at JLab, and upgrades of the existing detectors in the two labs, sPHENIX [4] and CLAS12 [5], respectively.

All these experiments are characterized by modern detectors with millions of active readout channels and by an unprecedented data rate produced by high-luminosity operations of the accelerators. The ambitious scientific program at the *intensity frontier* of nuclear physics calls for a data acquisition system (DAQ) that can record the interesting events and filter out the unnecessary background. Advances in data manipulation algorithms, e.g., artificial intelligence (AI) and machine learning, open up new possibilities for (quasi-)real-time data processing, by providing an efficient tool to calibrate the detector while running and at the same time intelligently select and reconstruct the final state particles. To fully exploit this progress, it is necessary to leave the triggered DAQ paradigm and move toward a more flexible software-based framework. In this scheme, all data is streamed from the detector to a data center where the entire detector's information can be analyzed and used for efficient data tagging and filtering. This framework is called *triggerless* or *streaming readout (SRO)* DAQ.

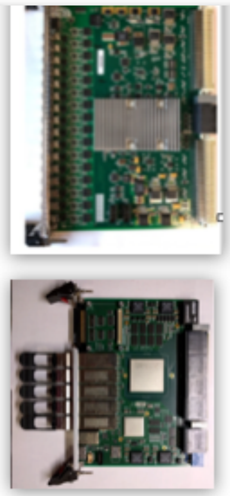
[a] e-mail: mariangela.bondi@ge.infn.it (corresponding author)

Published online: 24 August 2022 Springer

# SRO DAQ

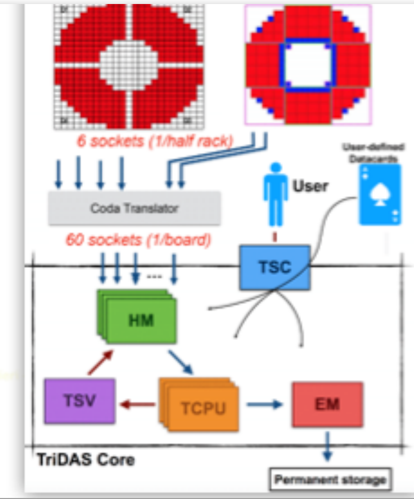
**FrontEnd**
D.Abbott, F.Ameli, C.Cuevas, P. Musico, B.Raydo

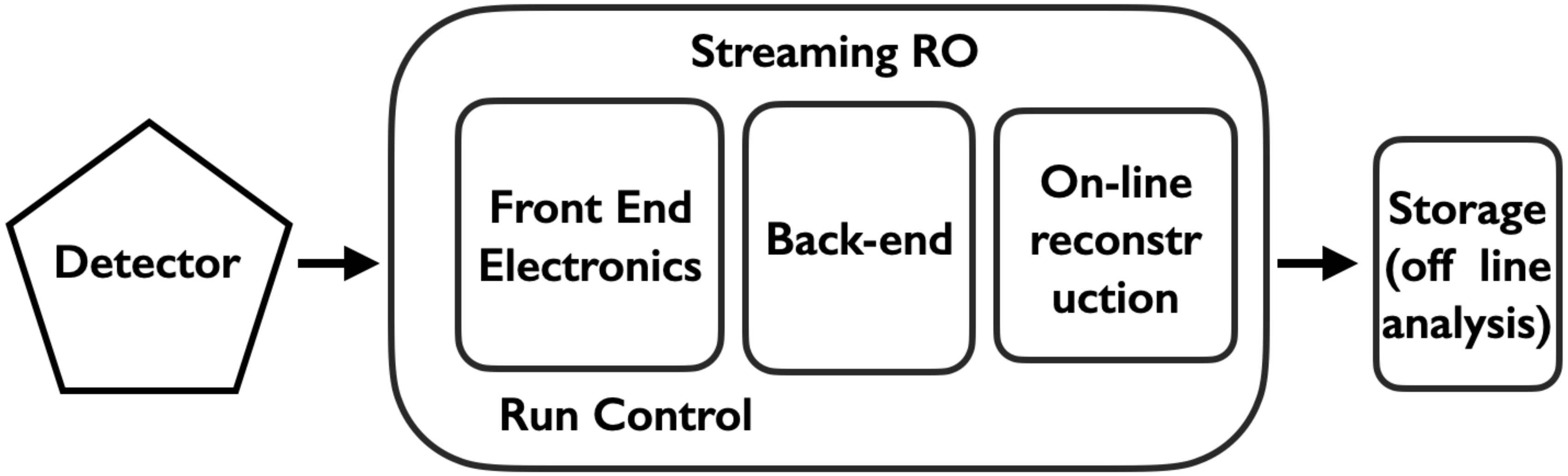
✴ JLab fADC250 + VTP bord
- JLab 250 MHz flash ADC digitizer currently used in many experiments
- Overcome VXS limitations (<24 Gb/s) using JLab VTP board (<40 Gb/s)
- Not optimised but reuse of existing boards: ready-to-go solution while waiting for fADC250.v2



**BackEnd**
L.Cappelli, T.Chiarusi, F.Giacomini, C.Pellegrino

✴ TRIggerless Data Acquisition System (TriDAS)
- Developed for KM_3NET
- Installed on Hall-B DAQ cluster
- Multi CPUs, rate up to 20-30 MHz

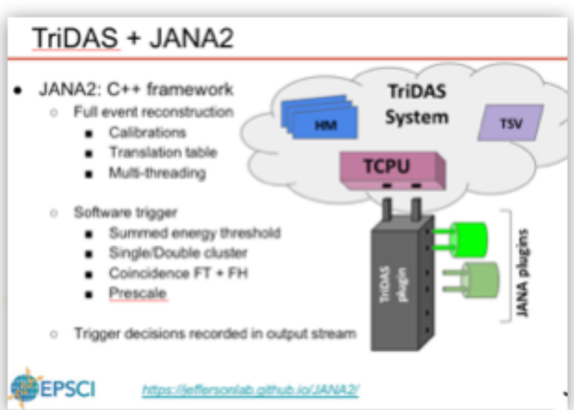



**SRO concept validation**
1) Assemble SRO components
2) Test SRO DAQ in lab
3) Test SRO DAQ on-beam

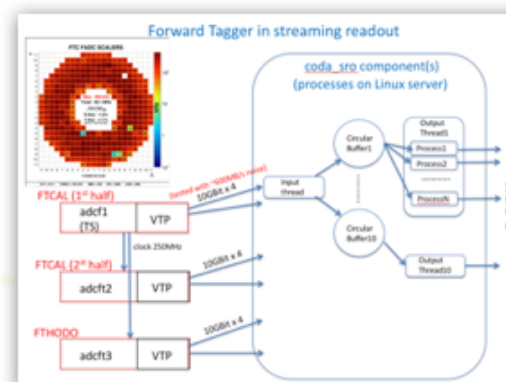
**Jana2 + reconstruction**
N.Brei, D.Lawrence,
M.Bondi', C.Fanelli, A. Fulci, M.Spreafico

✴ JANA2 + TriDAS
- Integration between On-line and off-line
- Real-time tagging/filtering data
- Offline algorithm development immediately available for use in Software Trigger
- Level 1 "minimum-bias": at least one crystal with E> 2 GeV
- Level 2 plugins (*tagging* and *filtering*)
  - "standard" FT-CAL clustering ($N_{cluster} \geq 1, 2, 3$)
  - cosmic tracking
  - AI clustering algorithm: at least two cluster in the FT-CAL

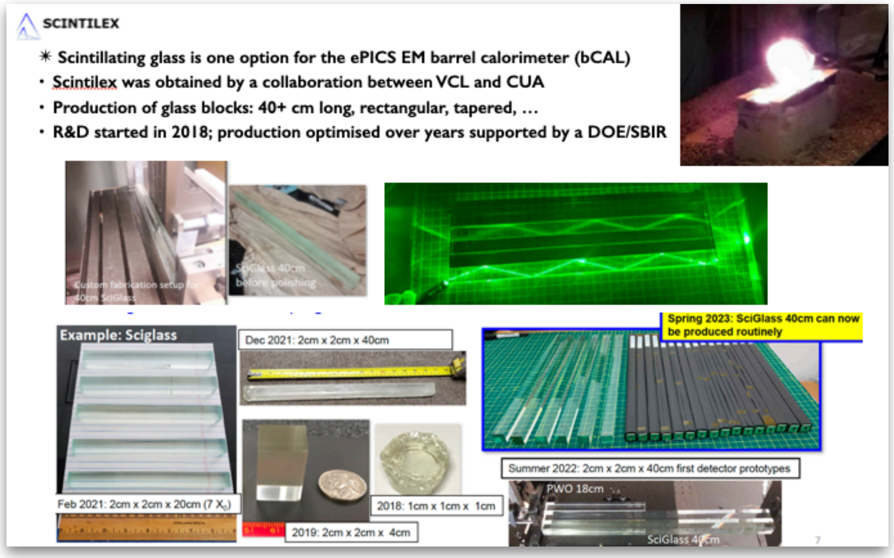


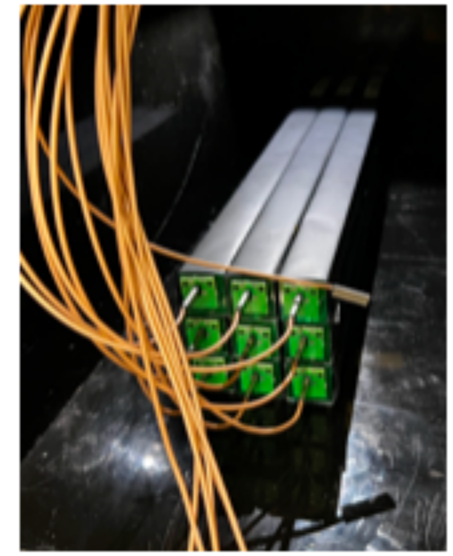

**Cebaf Online Data Acquisition (CODA)**
S.Boyarinov, B.Raydo, G.Heyes

- Originally designed for trigger-based readout systems
- Controllers (ROCs) and VXS Trigger Boards (VTPs)
- The Trigger Supervisor (TS) synchronizes components using clock, sync, trigger and busy signals.-time tagging/ filtering data
- CODA adapeted to the SRO
  - Replaced EB to use timestamp)
  - ROC communication via VTP (not VXS bus)



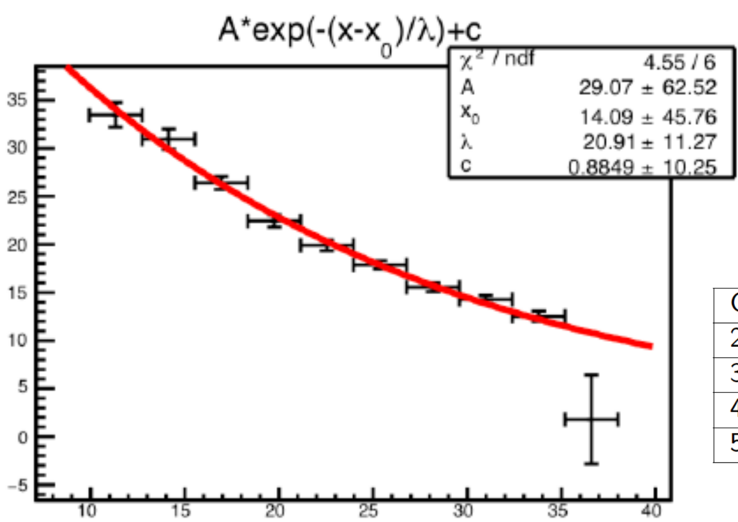
# The detector: scintillating glasses

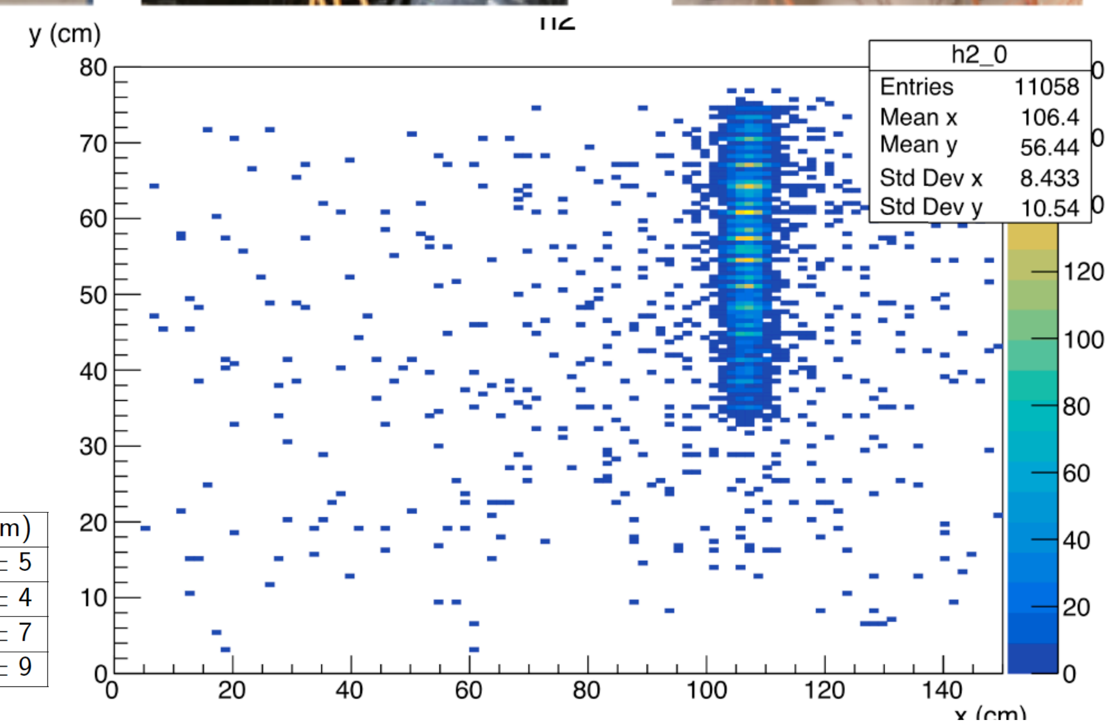


## ✳ Scintillating glass characterisation at INFN-GE

- A telescope of three large area (80x150 cm2) RPCs (ALICE-TOF like) to measure the att. length




✳ **Attenuation length ~ (15± 5) cm**

| Glass | $\lambda$ (cm) |
|---|---|
| 2 | $19 \pm 7$ |
| 3 | $14 \pm 4$ |
| 4 | $18 \pm 6$ |
| 5 | $21 \pm 11$ |

| Glass | $\lambda$ (cm) |
|---|---|
| 6 | $16 \pm 4$ |
| 7 | $16 \pm 6$ |
| 8 | $20 \pm 7$ |
| 9 | $10 \pm 2$ |

| Glass | $\lambda$ (cm) |
|---|---|
| 10 | $12 \pm 3$ |
| 11 | $14 \pm 4$ |
| 13 | |
| 14 | $13 \pm 6$ |

| Glass | $\lambda$ (cm) |
|---|---|
| 15 | $18 \pm 5$ |
| 16 | $13 \pm 4$ |
| 18 | $17 \pm 7$ |
| 19 | $22 \pm 9$ |

✳ **LY ~ (4 ± 0.5) pe/MeV**

| Glass | LY (pe/MeV) |
|---|---|
| 2 | $4.29^{+0.425}_{-0.3}$ |
| 3 | $4.07^{+0.447}_{-0.3}$ |
| 4 | $3.6^{+0.446}_{-0.3}$ |
| 5 | $3.92^{+0.47}_{-0.4}$ |

| Glass | LY |
|---|---|
| 6 | $3.46^{+0.408}_{-0.3}$ |
| 7 | $4.05^{+0.534}_{-0.4}$ |
| 8 | $3.64^{+0.403}_{-0.3}$ |
| 9 | $4.25^{+0.7}_{-0.5}$ |

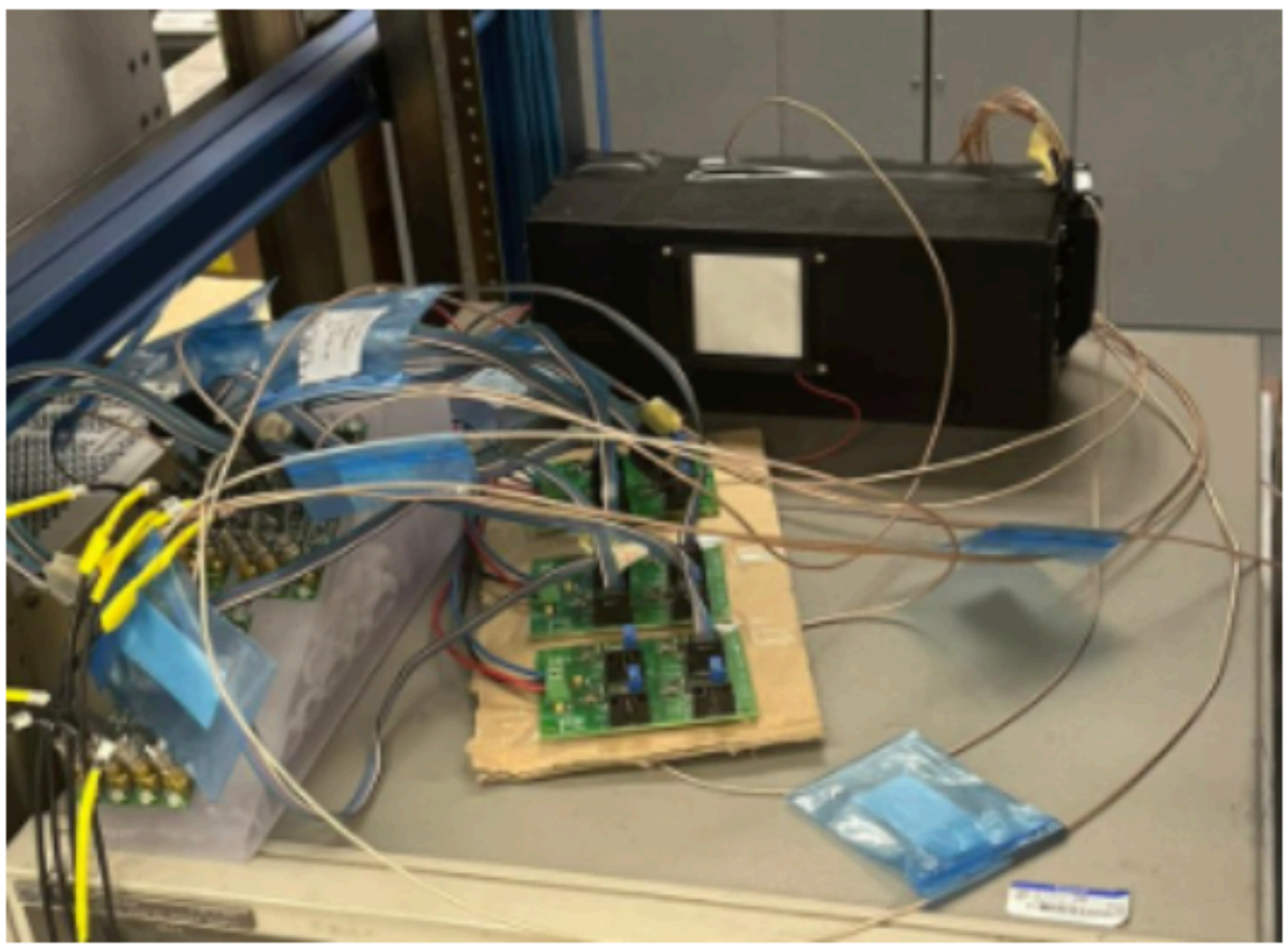
| Glass | LY |
|---|---|
| 10 | $4.32^{+1}_{-0.8}$ |
| 11 | $4.34^{+0.5}_{-0.4}$ |
| 13 | $3.76^{+0.5}_{-0.3}$ |
| 14 | $3.41^{+0.5}_{-0.4}$ |

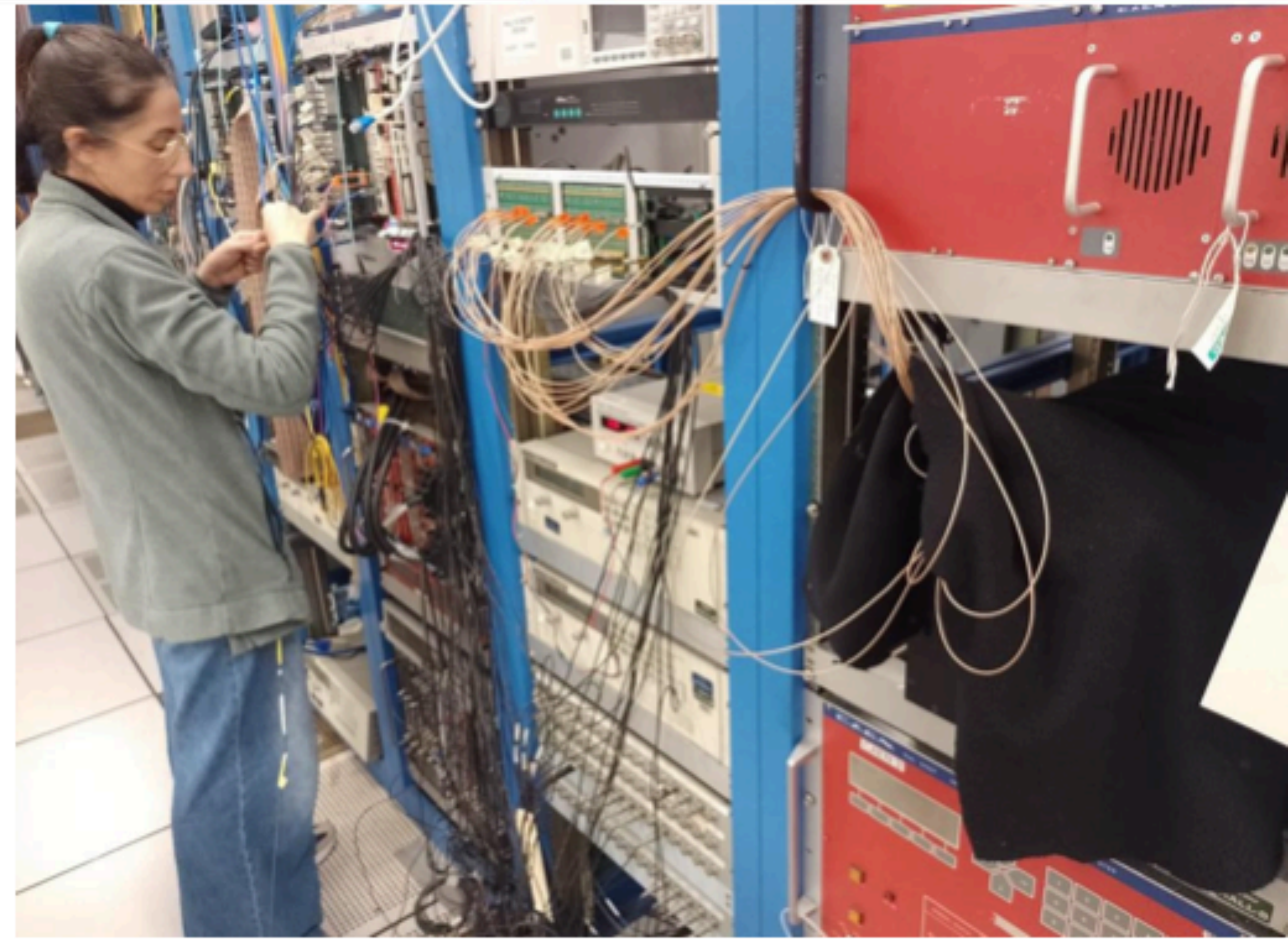
| Glass | LY |
|---|---|
| 15 | Not measured |
| 16 | $4.19^{+0.4}_{-0.3}$ |
| 18 | $3.28^{+0.3}_{-0.3}$ |
| 19 | $3.13^{+0.3}_{-0.3}$ |

# EM bCAL prototype(s)

✳ Proto I

- 3x3 2x2x20 cm3 blocks
- SiPM: 1x 6x6 mm2, 100um,  Hamamatsu
- Currently installed in Hall-B Counting Room

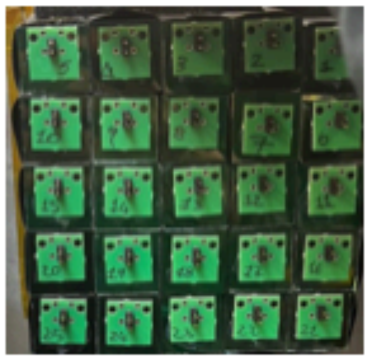


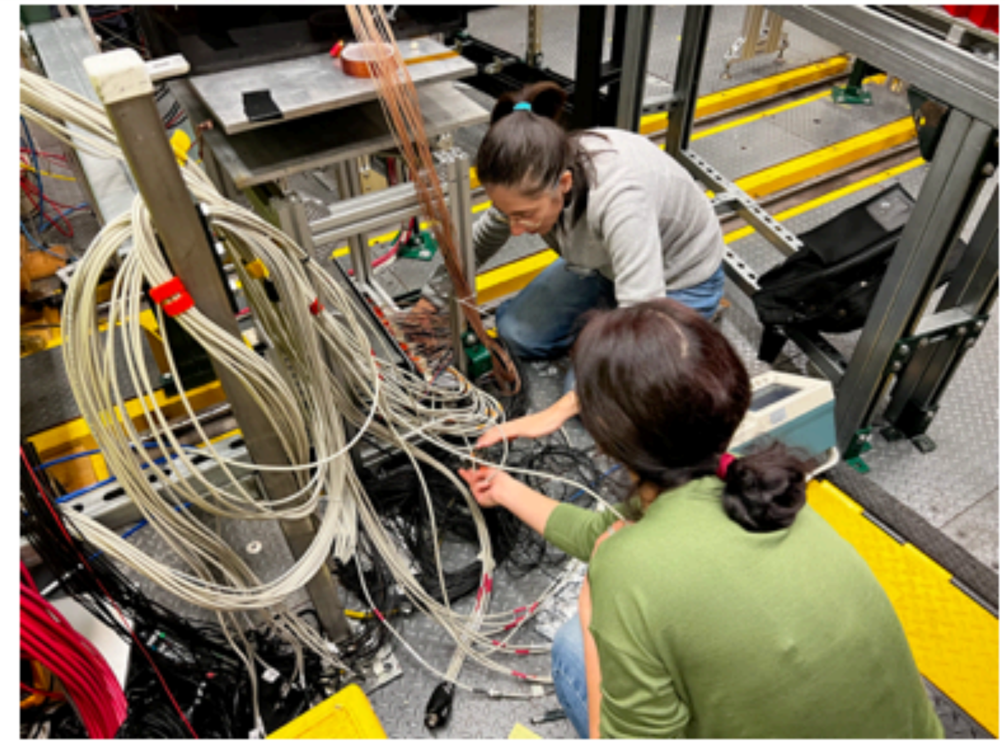
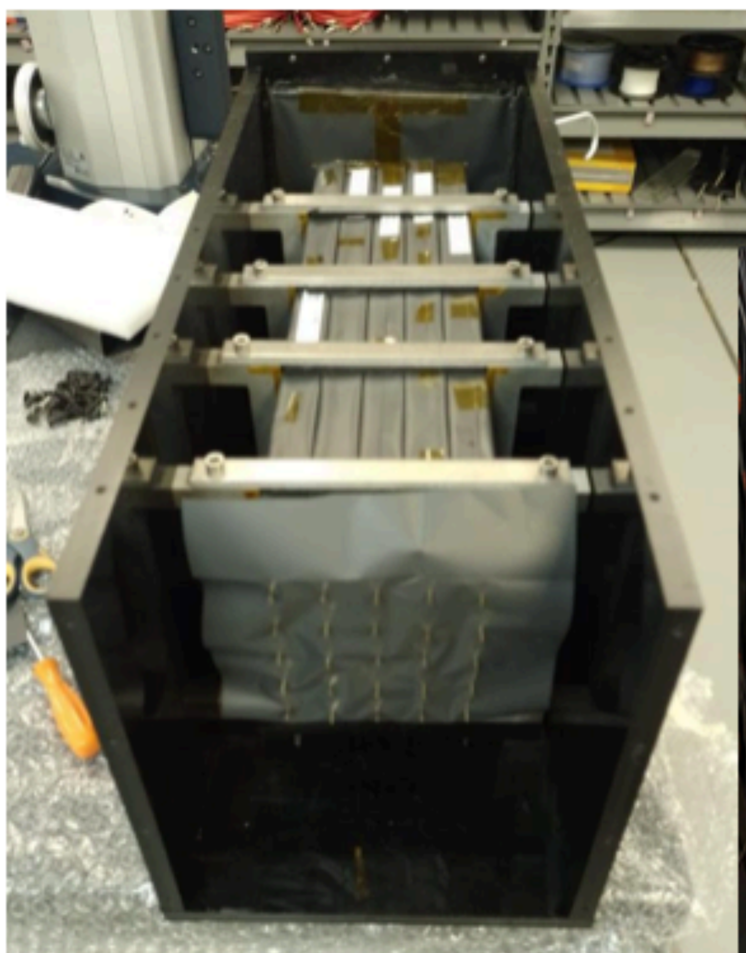


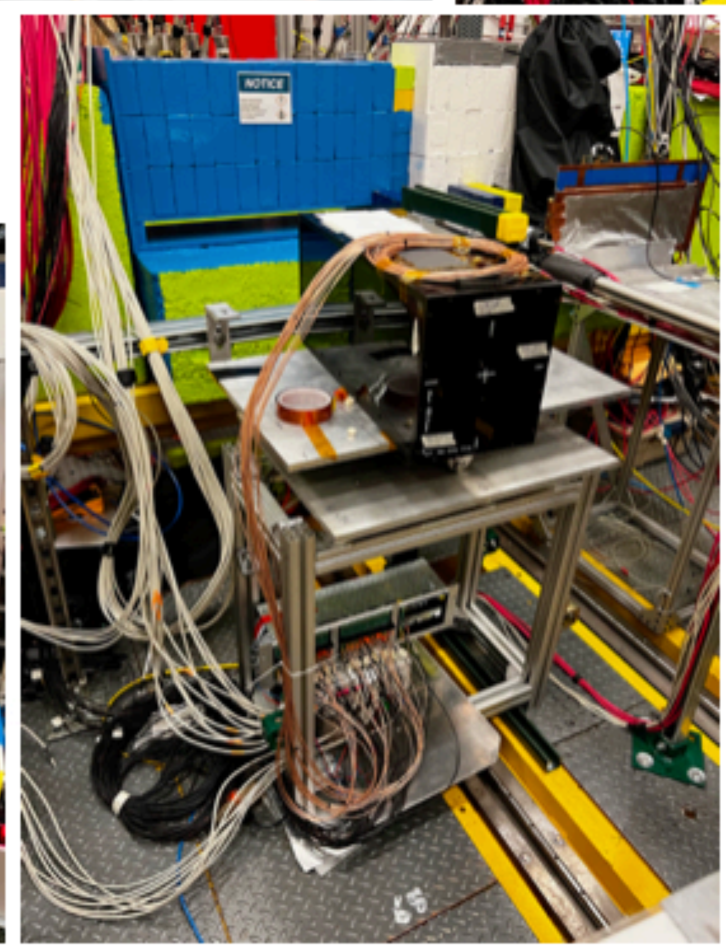
# EM bCAL prototype(s)

✳ Proto II

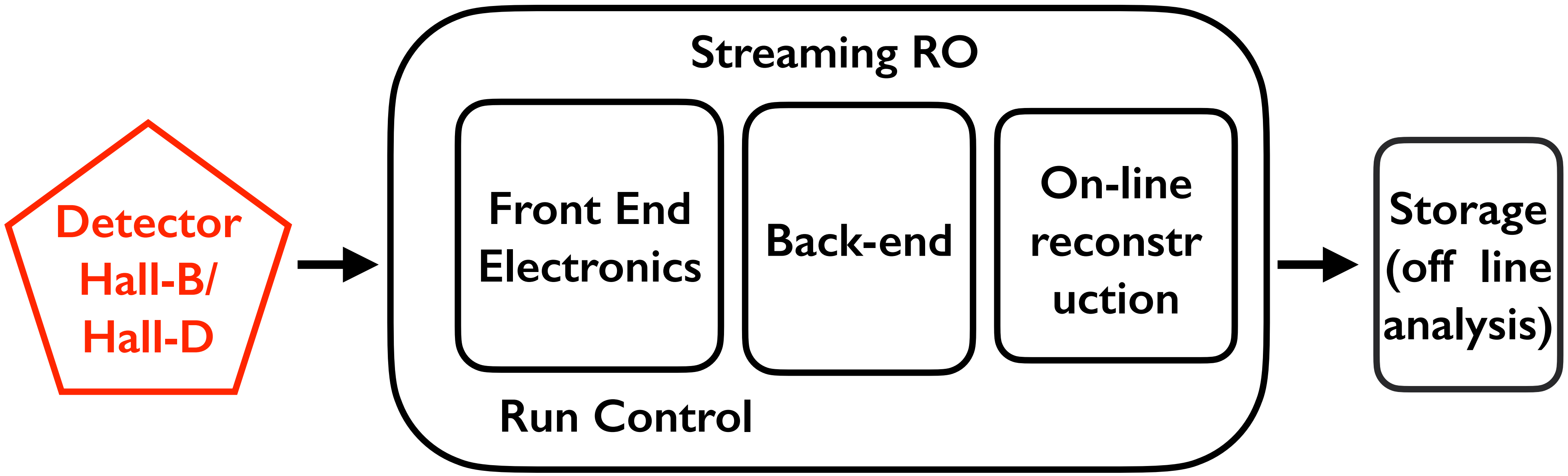
- 5x5 2x2x40 cm3 blocks
- SiPM: 2x 6x6 mm2, 50um, Hamamatsu, mounted on a PCB
- Installed in Hall-B CR and on Hall-D PS e+/e- beam




# EM bCAL prototype(s)



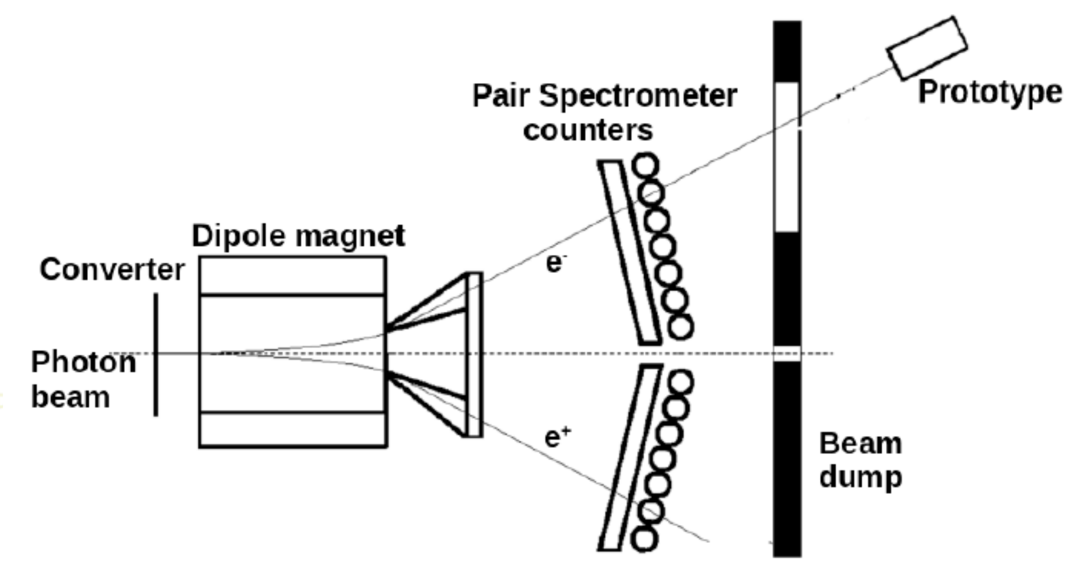

**SRO concept validation**
1) Assemble SRO components
2) Test SRO DAQ in lab
3) Test SRO DAQ on-beam

## SRO validation @ JLab

V.Berdnikov, S.Boiarinov, M.Bondi, J. Chrafts, C. Fanelli, A. Fulci, Y. Ghandilyan, D. Lawrence, S. Grazzi, T.Horn, A. Somov, M.Spreafico

✳ **EIC EM bCal Sciglass prototype**

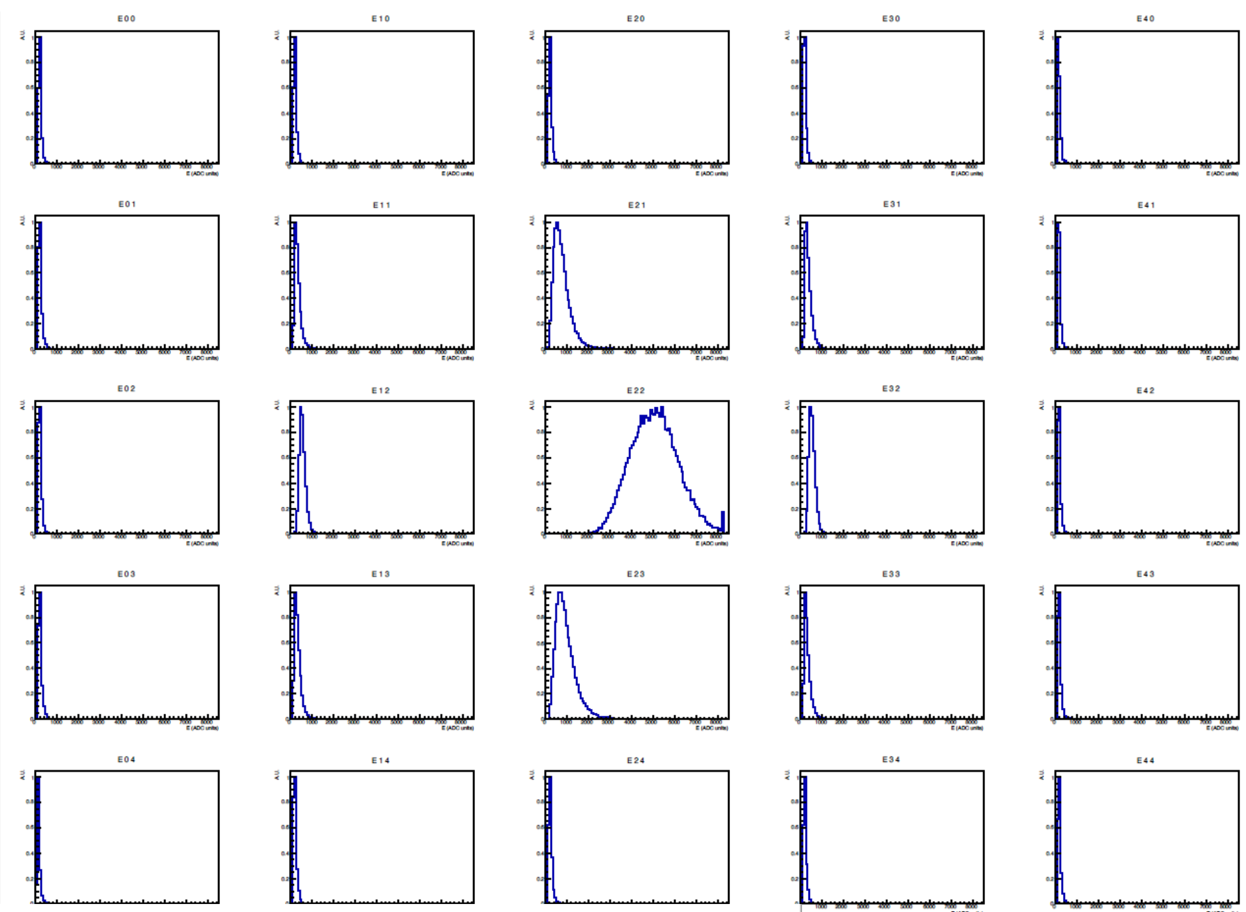
- Use the Hall-D Pair Spectrometer setup
- Secondary e+/e- beam: E range (3-6) GeV
- Simple setup to compare TRIGGERED to TRIGGERLESS
- 5x5 Sciglass blocks, SiPM readout
- fADC250+VTP front end

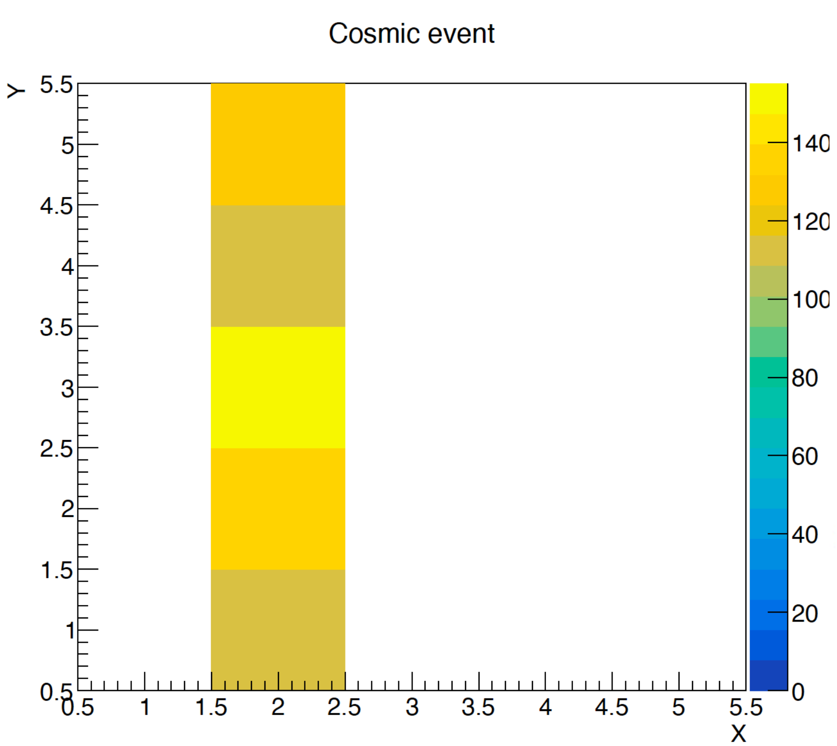


# Test results

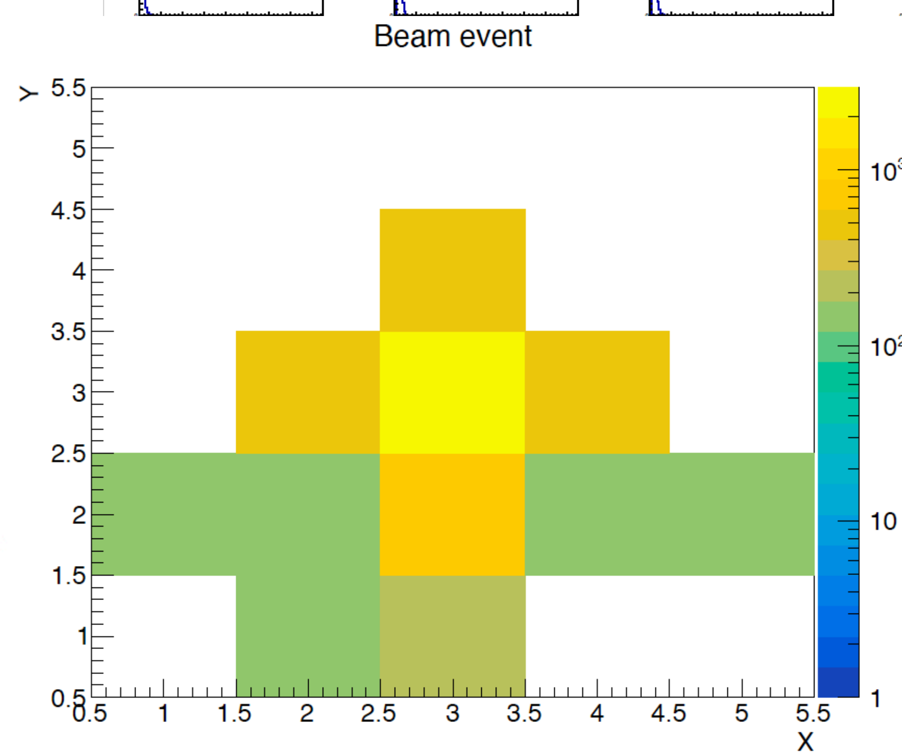
✳ Triggered/SRO comparison:

- SRO data analysis:
  - TRIDAS+JANA2-based analysis
- Triggered DAQ data analysis
  - Part of the standard Gluex DAQ






JANA2 plugin cosmic



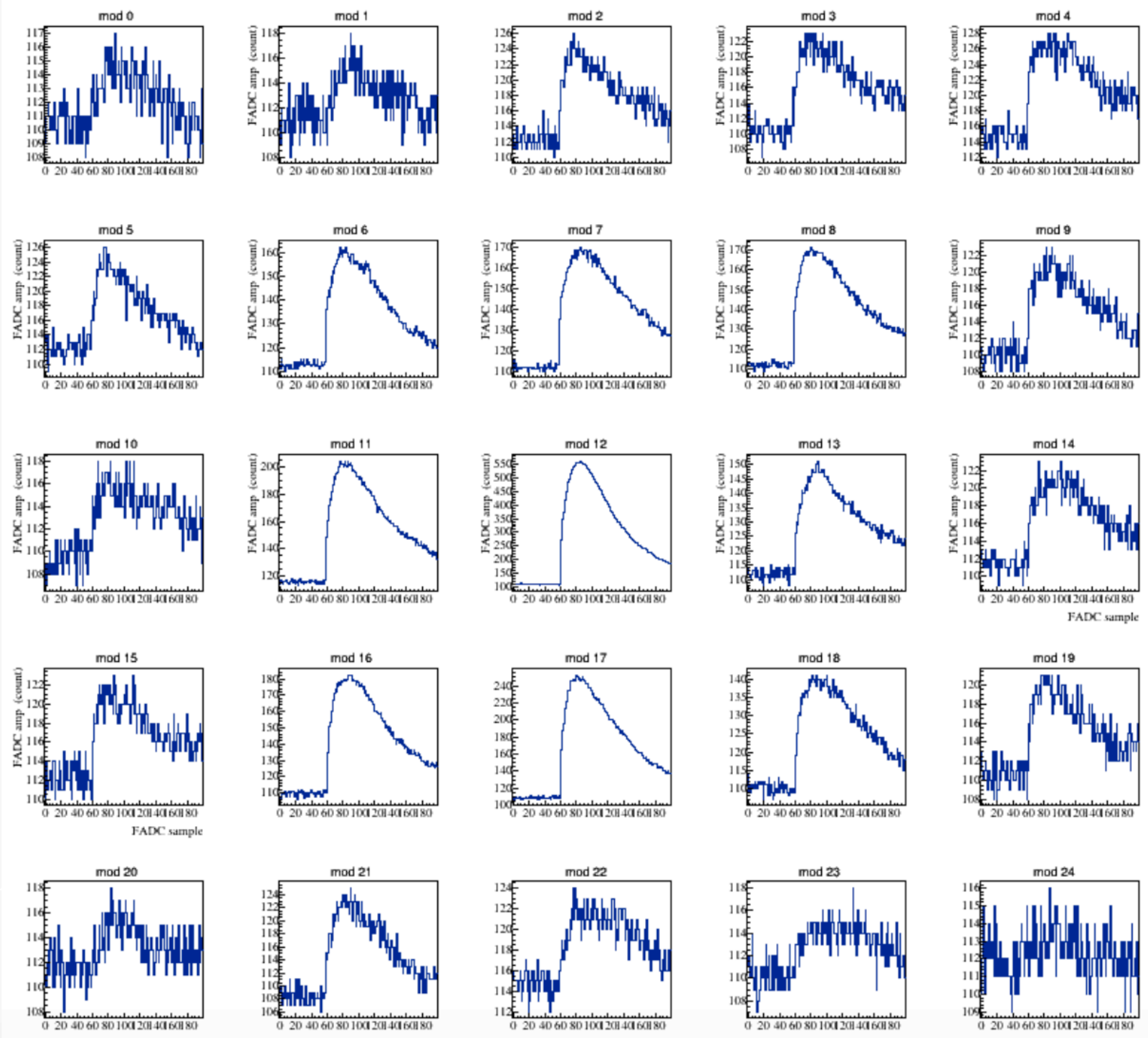

JANA2 plugin clustering

M.Spreafico

# Test results

✳ Triggered/SRO comparison:

- SRO data analysis:
  - TRIDAS+JANA2-based analysis
- Triggered DAQ data analysis
  - Part of the standard Gluex DAQ



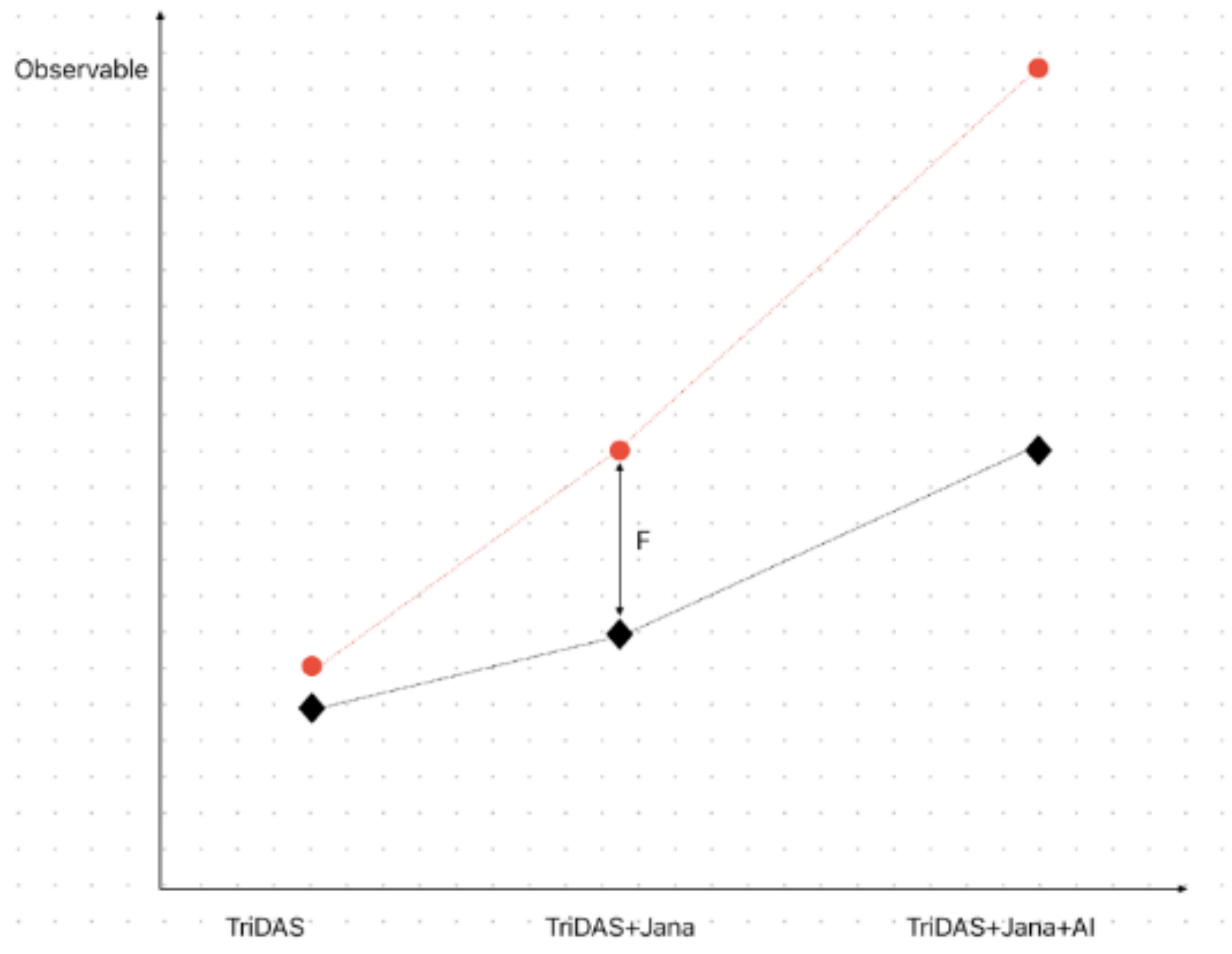

Waveforms collected by Glue DAQ branch

*Y.Ghandilyan*

# Test results

✳ JLab-SRO profiling:

- Real-time measure of:
  - CPU load per TRIDAS process
  - RAM usage per TRIDAS process
  - Time per timeslice processing
- to characterise SRO DAQ performance in different configs:
  - TRIDAS alone
  - TRIDAS+ JANA2 (conventional plugin for clustering and cosm rays tagging/filetr)
  - TRIDAS+ JANA2 (AI plugin for clustering)
  - with and w/o beam, with different fADC TET, ro window, anc G, different TRIDAS-L1Q threshold
- during runs, information was reported in sqlite .db fil and ain a network stat file
- Data analysis is undergoing






✳ Meeting with RN and CNAF Director to support SRO, unfortunately inconclusive

✳ INFN-BO (KM3_NET) dropped its support (TriDAS) to ePIC SRO

✳ ePIC SRO development will rely on BNL and JLab support

# Streaming RO R&D plans

✳ **Synergic activities:**

- EIC Generic R&D: Generic Glass Scintillator R&D

| FY24 Request | CUA | IJCLab-Orsay | INFN-GE | AANL | TOTAL |
|---|---|---|---|---|---|
| Student Support | 14,000 | 8,000 | 8,000 | 5,000 | 35,000 |
| Fringe | 1,071 | 0 | 0 | 0 | 1,071 |
| Materials | 3,000 | 3,000 | 11000 | 3,000 | 20,000 |
| Optimization of FEE boards (preamp/biasing: custom and commercial + LED or LASER system for SiPM tests)<br>Mechanical supports, reflectors, optical components | | | | | |
| Travel | 0 | 2,000 | 8,000 | 8,000 | 18,000 |
| Indirect Cost | 10,662 | 2,600 | 5,000 | 3,000 | 21,262 |
| **TOTAL** | 28,733 | 15,600 | 32,000 | 19,000 | **95,333** |

**Title of the Project:** Generic glass scintillators for EIC Calorimeters (ScintCalEIC) R&D
**Date of Submission:** 7/14/2023
**Contact Person:** Tanja Horn, CUA (hornt@cua.edu)
**List of all proponents and institutions:**

Marco Battaglieri, INFN-GE
Vladimir Berdnikov, JLab
Julien Bettane, IJCLab-Orsay
Mariangela Bondi, INFN-CT
V. Chaumat, IJCLab-Orsay
A. Fulci, INFN-CT
Josh Crafts, CUA
Stefano Grazzi, INFN-GE
Yeran Ghandilyan, CUA
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Noemie Pilleux, IJCLab-Orsay
A. Riggio, INFN-CT
Alex Somov, JLab
Marco Sprefico, INFN-GE
Avnish Singh, CUA
Richard Trotta, CUA
Vardan Tadevosyan, AANL
S. Vallarino, INFN-FE
H. Voskanyan, AANL
P.K. Wang, IJCLab-Orsay

**Abstract:**

Detecting the scattered electron with high precision is essential at the EIC. This requires high-resolution EM Calorimeters, which for any EIC general purpose detectors, will require good energy resolution and efficiency over a large dynamic range of photon energies. Crystals have been used in many homogeneous precision calorimeters, but they are expensive, their production is slow and complex, and there is only one viable vendor worldwide. The development of scintillating glasses has shown excellent promise to become an alternative to crystals. However, detailed characterizations of the glass properties are needed to demonstrate glass as a viable cost-effective solution as EIC calorimeter technology, particularly in the most demanding conditions. Furthermore, glass and any homogeneous calorimeters consist of relatively large-area modules making light-collection with small-size modern silicon-based devices far from trivial. If the high-precision homogeneous EIC EMCals are to achieve the desired resolution performance over the full dynamic range it must be demonstrated that glass (or crystal) can be matched to silicon-based

**Waiting for feedback**

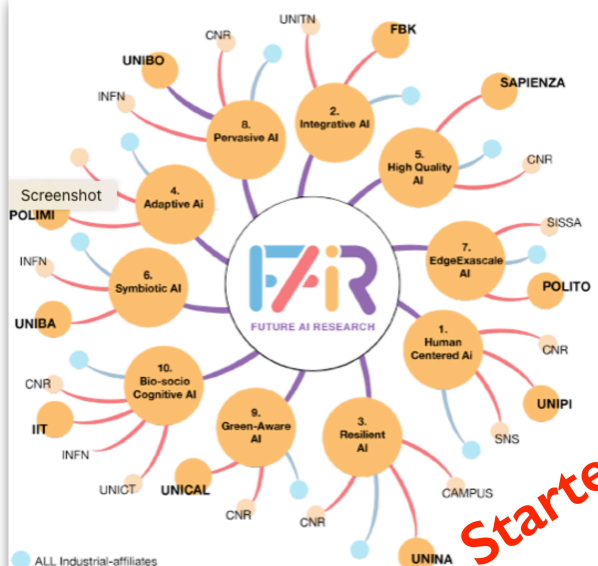
- JLAB12: SRO tests at Jefferson Lab and FY 2024 LDRD
  - *Streaming Readout Real-Time Development and Testing Platform*

**FY 2024 LDRD Proposal**
**Program: DRD**
**Proposal Title**: Streaming Readout Real-Time Development and Testing Platform
**Principal Investigator, Division:** David Lawrence , CST
**Co-Investigator:**
**Contributors:** Vardan Gyurjyan, CST
Xinxin "Cissie" Mei, CST
**Advisors/consultants:** Marco Battaglieri, INFN
Markus Diefenthaler, ENP
Sergey Furletov, ENP
Sergey Boyarinov, ENP

| Budget ($K) | Total | FY24 | FY25 | FY26 |
|---|---|---|---|---|
| | $545k | $271k | $274k | N/A |

**AWARDED!**

- PNRR: FAIR
  - *Development of AI-supported algorithms for real-time big data processing: streaming readout (SRO) DAQ*

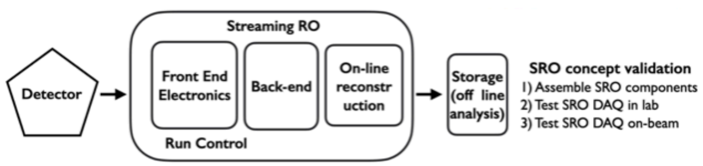



In collaboration with INFN-BA and INFN-PI and INFN_ML (
INFN-GE role:
- Leader of real-time data processing WG
- Dedicated personnel:
  F. Rossi (Tecnologo)

FUTURE AI RESEARCH

## WP 6.7
## Infrastructure and large scale solutions

**Goal:**
**Development of AI-supported algorithms for real-time big data processing: streaming readout (SRO) DAQ**




Why SRO?
- Current experiments are limited in DAQ bandwidth (intensity frontier)
- 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 and existing/ad-hoc CPU/GPU farms
- Use of available AI/ML tools and (future) use of quantum-computing
- Easier to add new detectors in the DAQ pipeline, to scale, to upgrade

SRO is the new DAQ paradigm in Nuclear and High Energy physics exps at at CERN, FAIR, BNL, JLab, ...

**Deployment of an auto-encoder for data compression between the FEE and the backend**

**Started !**

# Streaming RO R&D plans

✳ Synergic activities:

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Vardan Tadevosyan, AANL
S. Vallarino, INFN-FE

Waiting for feedback

✳ **dRICH SRO to start**

- postdoc position tom be awarded in Fall22 (*AI for real-time applications*), candidate identified, call preparation
- the candidate will spend 6m in RM-TV and 6m in GE
- implementation of AI algorithms on FPGAs with a specific target of reducing dRICH rate
- work with dRICH electronic group to use ALCOR in streaming mode
- possible use in EIC Cal (similar sipm readout)

Hopefully starting soon !

Advisors/consultants: Marco Battaglieri, INFN
Markus Diefenthaler, ENP
Sergey Furletov, ENP
Sergey Boyarinov, ENP

AWARDED!

| Budget (\$K) | Total | FY24 | FY25 | FY26 |
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- PNRR: FAIR
  - *Development of AI-supported algorithms for real-time big data processing: streaming readout (SRO) DAQ*



Started !

In collaboration with INFN-BA and INFN-PI and INFN_ML (
INFN-GE role:
- Leader of real-time data processing WG
- Dedicated personnel:
  F. Rossi (Tecnologo)

Infrastructure and large scale solutions

Goal:
Development of AI-supported algorithms for real-time big data processing: streaming readout (SRO) DAQ



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Deployment of an auto-encoder for data compression between the FEE and the backend

# Streaming RO R&D plans

## ✳ Goals for 2024

- Contribute to shaping the Streaming Computing and Software model of ePIC (CT,GE)
- Test SRO pipeline with an EIC EMCal made by 5x5 40x2x2 cm3 SCIGlass blocks at JLab (CT,GE)
  - Optimization of photosensor readout
  - Optimization of FEE for high-rate/large-signals
  - Cosmic ray and on-beam test and characterization of the prototype
    - **SRO set up in Catania based on WB+Tridas+Jana2 (duplicating INFN-GE system)**
    - **Cosmic and on-beam (JLab) tests of EIC Cal prototype with AI-supported tagging/filtering (implemented in Jana2)**
    - **Existing solutions assessment for multiple channels readout (eg ALCOR ASIC)**
    - **Smart tagging/filtering algorithms on GPU/CPU farms (off-line)**
    - **Smart tagging/filtering algorithms on FPGA (real-time)**
- Development of an auto-encoder to reduce the data payload in fADC to backend streaming (GE)
  - Algorithms deployment on CPU/GPU
  - Optimization for real-time applications on fast hw (FPGA)
- Development of AI-supported algorithms to reduce the ePIC dRICH rate (dominated by single pe dark noise) (RM2,RM)
  - APEIRON/NA62 AI-supported framework
  - Time and geographical matching
  - Pre-filtering

## ✳ Funding requests:



**GE: INV 10k** **FPGA 4k (VCK5000-AIE-ADK) + Server/GPU (Nvidia GeForce RTX 2080 Ti) 5k + Networking Switch 1k**

**CT: INV 5k WaveBoard 2.0 (INFN) for Streaming Readout (EEE MRPC at UniME)**

**[RM2/RM: (22k within dRICH requests) B.Benkel (postdoc), equipment in RM2 already procured]**