# Advancing Streaming Readout and Processing Architectures at JLAB

EICUG/EPIC Collaboration Meeting

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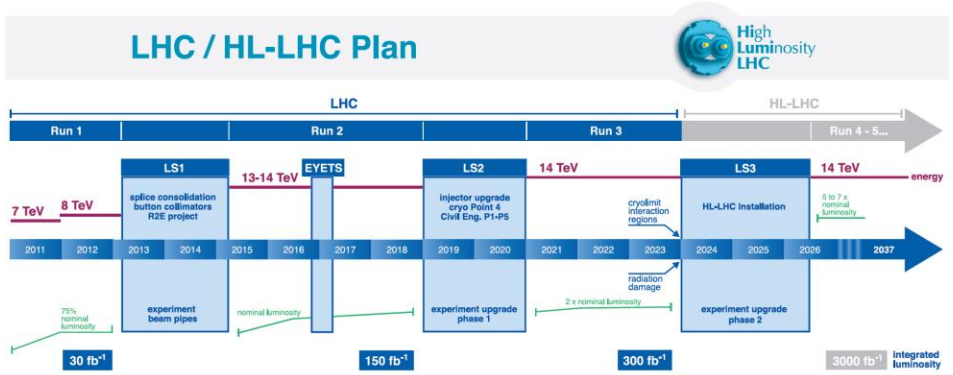
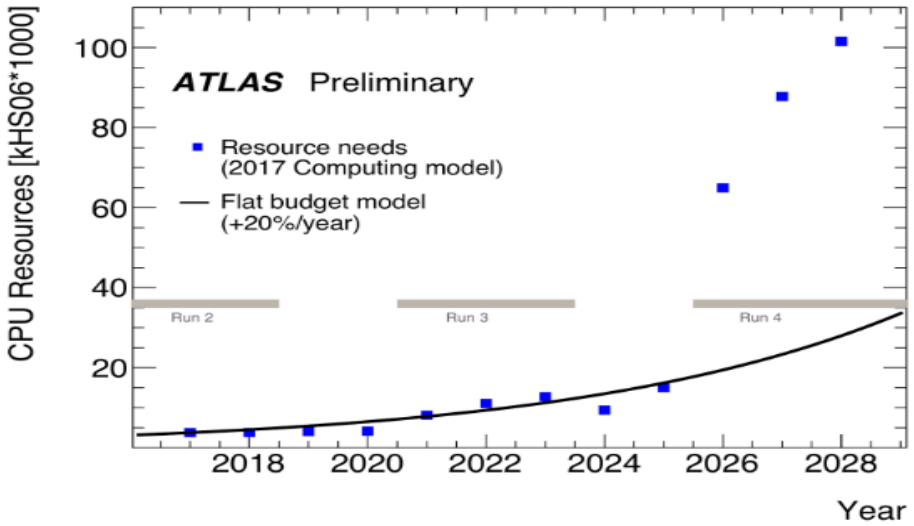
# Breaking the Limits: The Problems We Must Solve

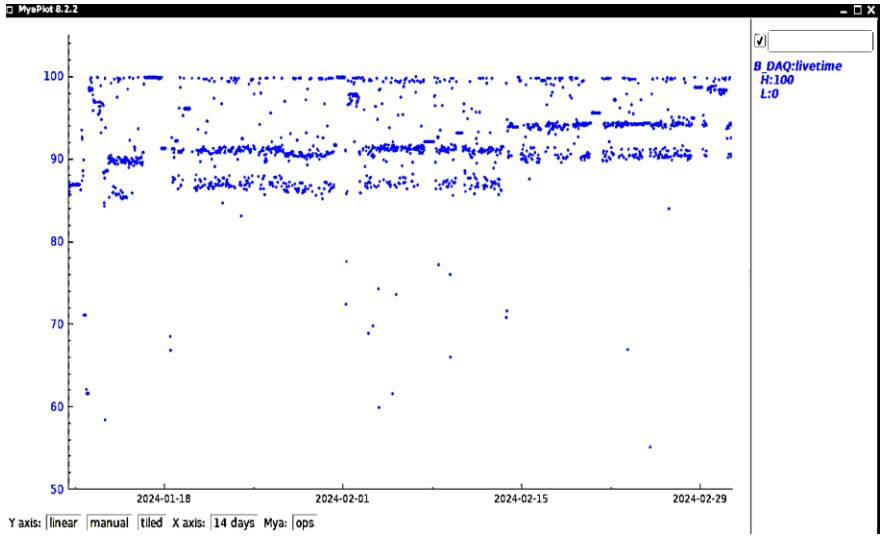
## Scientific Data Expansion




## Get more out of experiments

- Integration of all detectors into the event identification process.
- Increase science/$ ratio
- Preserve filtered, widely open trigger data for future physicist.




CLAS12 DAQ dead-time

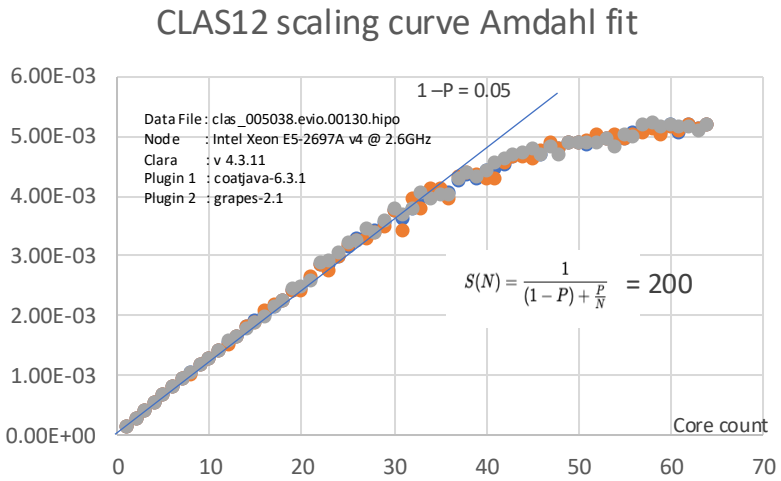
# Vertical and horizontal scaling and it's limitations

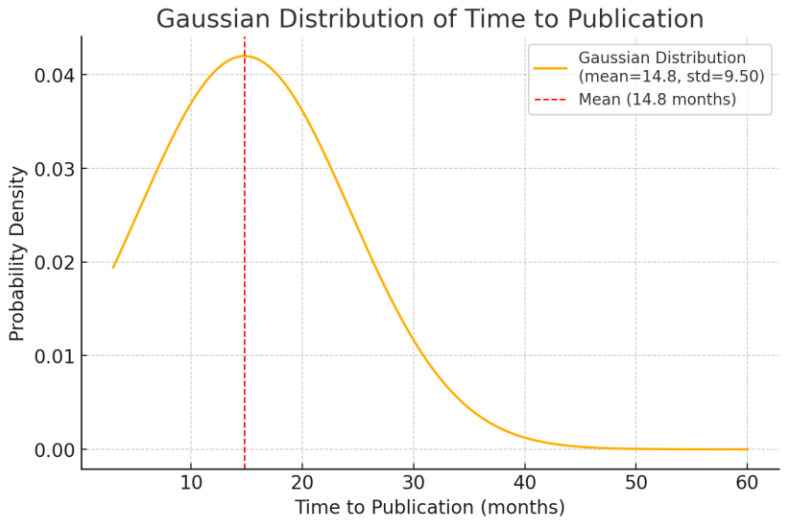
## Vertical scaling

- Some portion of the code remains serial
- Memory contention, leading to a plateau in performance.
- Concurrent accesses to CPU caches, increasing cache misses. If threads rely on disk or network I/O, and context switching.

## Horizontal (X) scaling

- Batch processing
  - Issues:
    - Limited local resources
    - Require data migration and temporal persistency (IO latency)



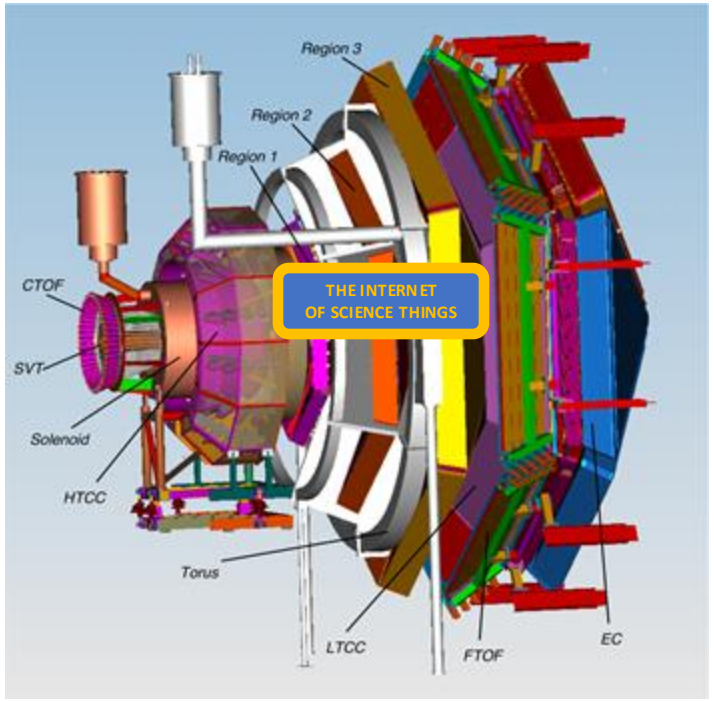



# Stream Data Workloads Require Scalable Processing

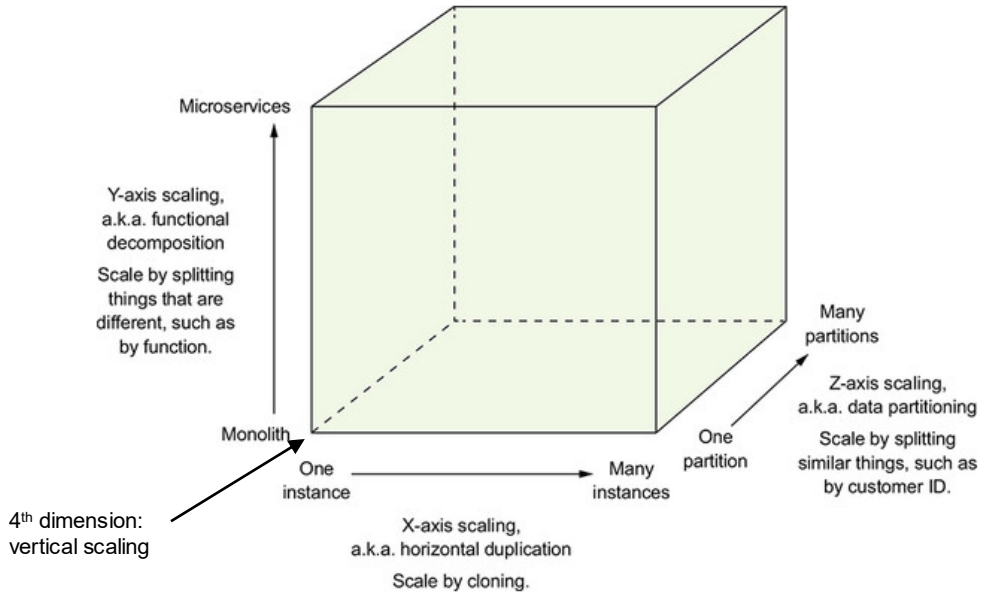
## Social media


IOT vs. IOST

## Science

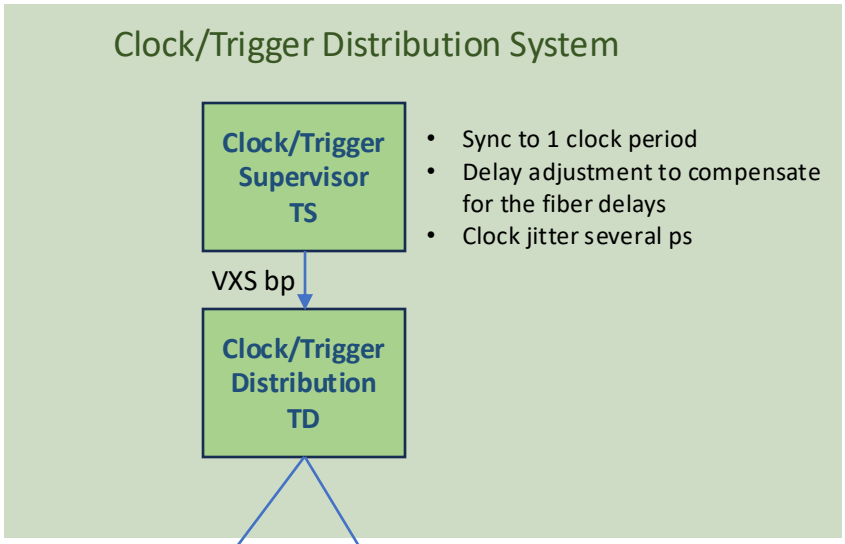



Precise genetic correlations between IOSTs

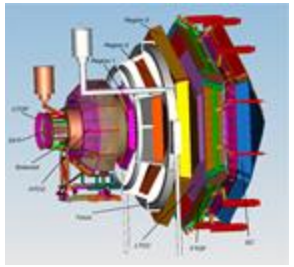



**The Art of Scalability.** by Martin L. Abbott and Michael T. Fisher. **ISBN-13:** 978-0134032801

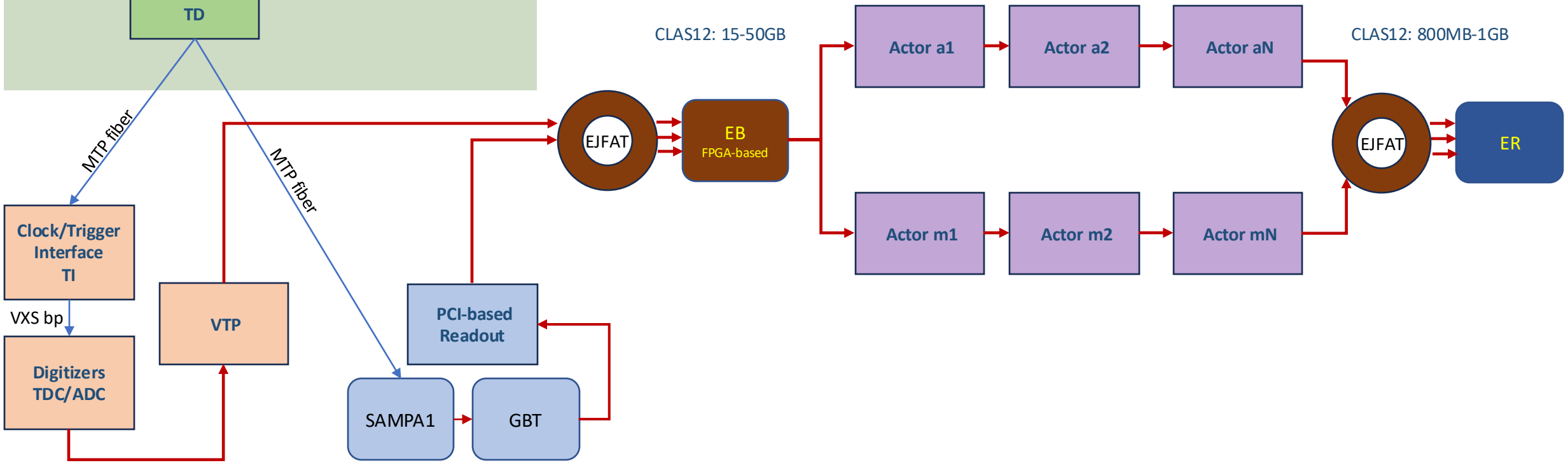
# End-to-End Streaming Data Acquisition




JLAB CLAS12 Detector

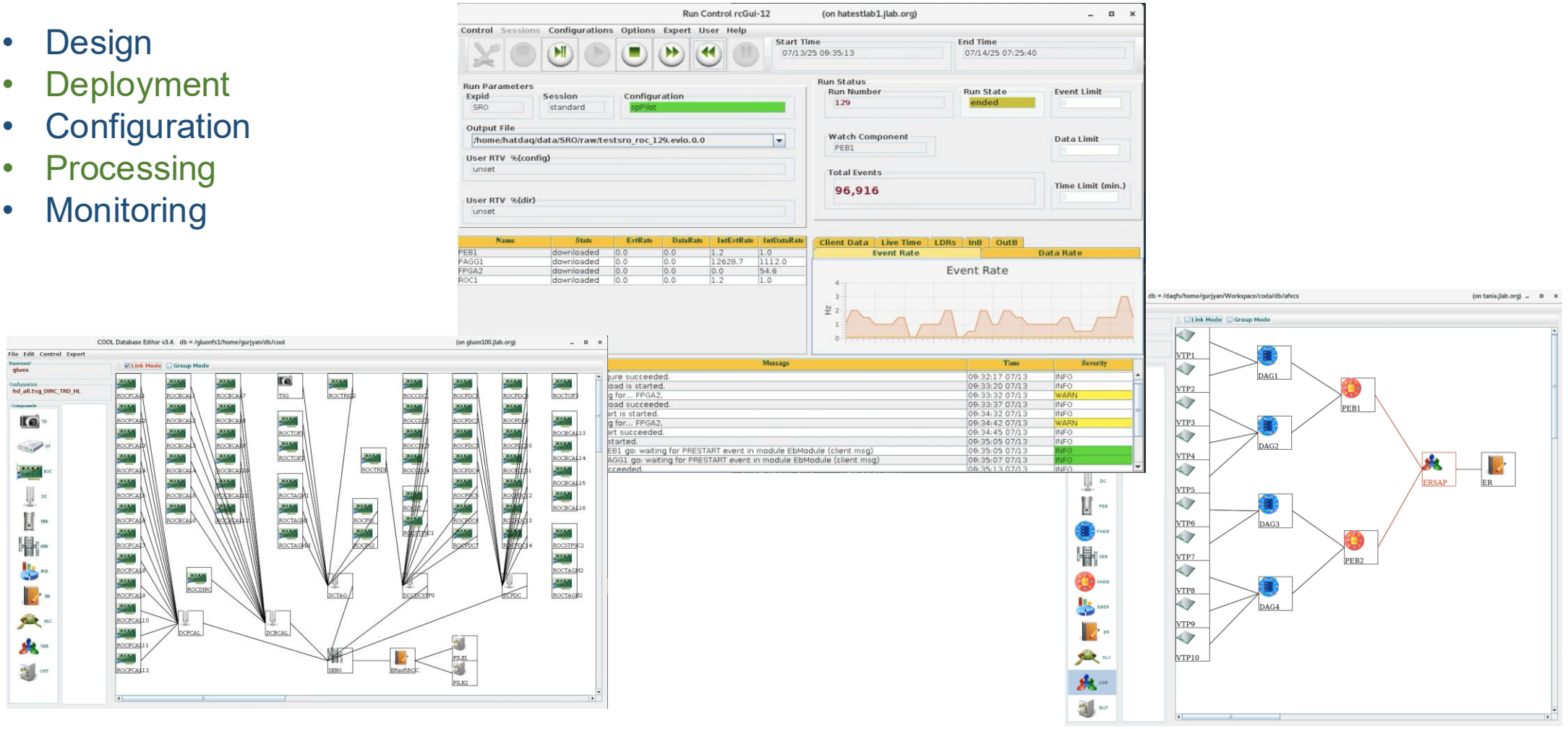


- Over 90 percent of the CLAS12 detector subsystems are SRO ready
- Expected data rates range from 15 GB/s to 50 GB/s depending on configuration

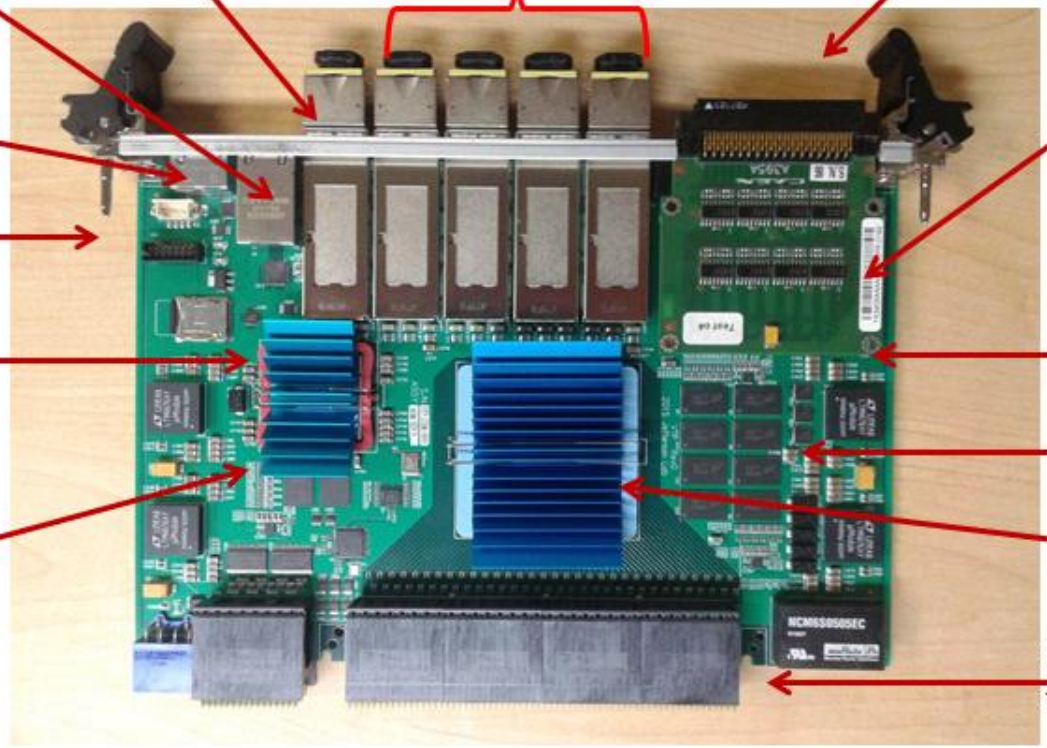


# CODA/ERSAP Role in Streaming DAQ

- Design
- Deployment
- Configuration
- Processing
- Monitoring



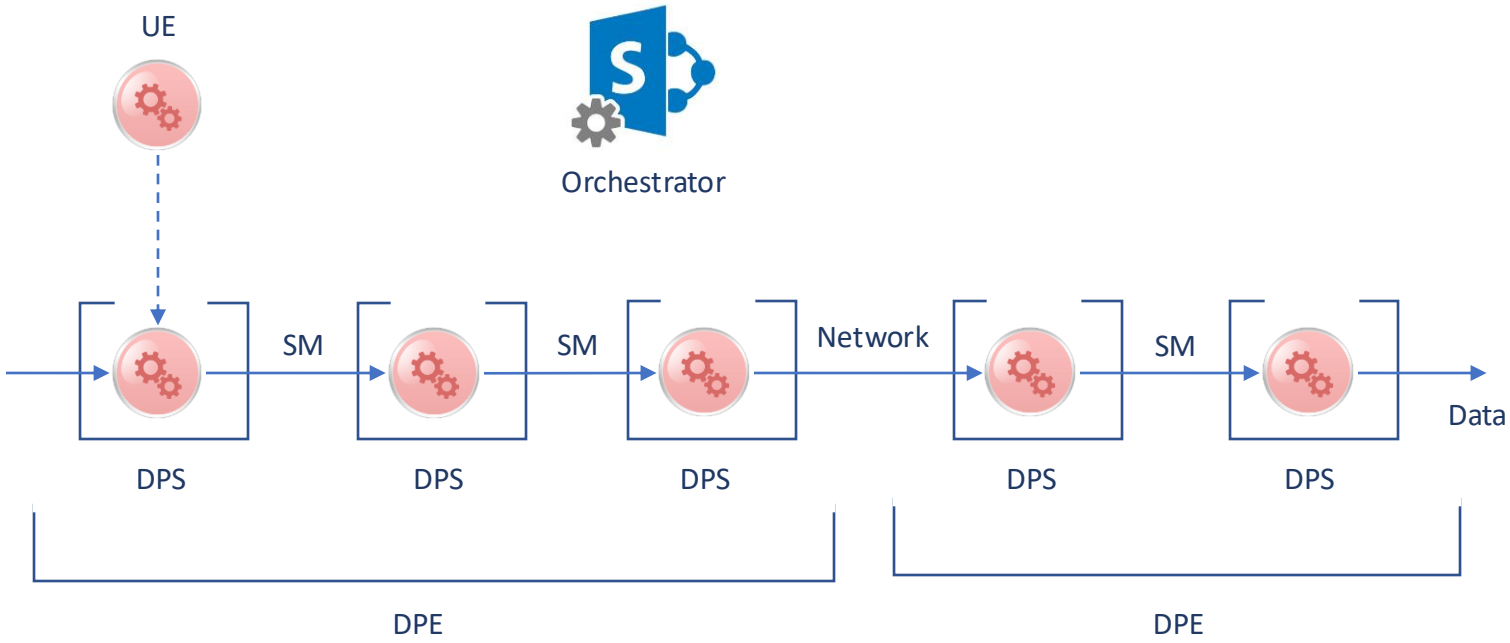
# DAQ stream source: VTP



# Y Scaling: Event Reactive Microservices Framework

- ERSAP is a software LEGO system
  - Easier to understand and develop
  - Reduced develop-deploy-debug cycle
  - Easy to migrate to data
  - Scales independently
  - Independent optimizations
- Improves fault isolation
- Easy to embrace hardware as well as software heterogeneity.
- Eliminates long term commitment to a single technology stack.

***Agile framework that makes easy software evolution over time!***




DPE : Data Processing Environment

SM : Shared Memory

DPS : Data Processing Station

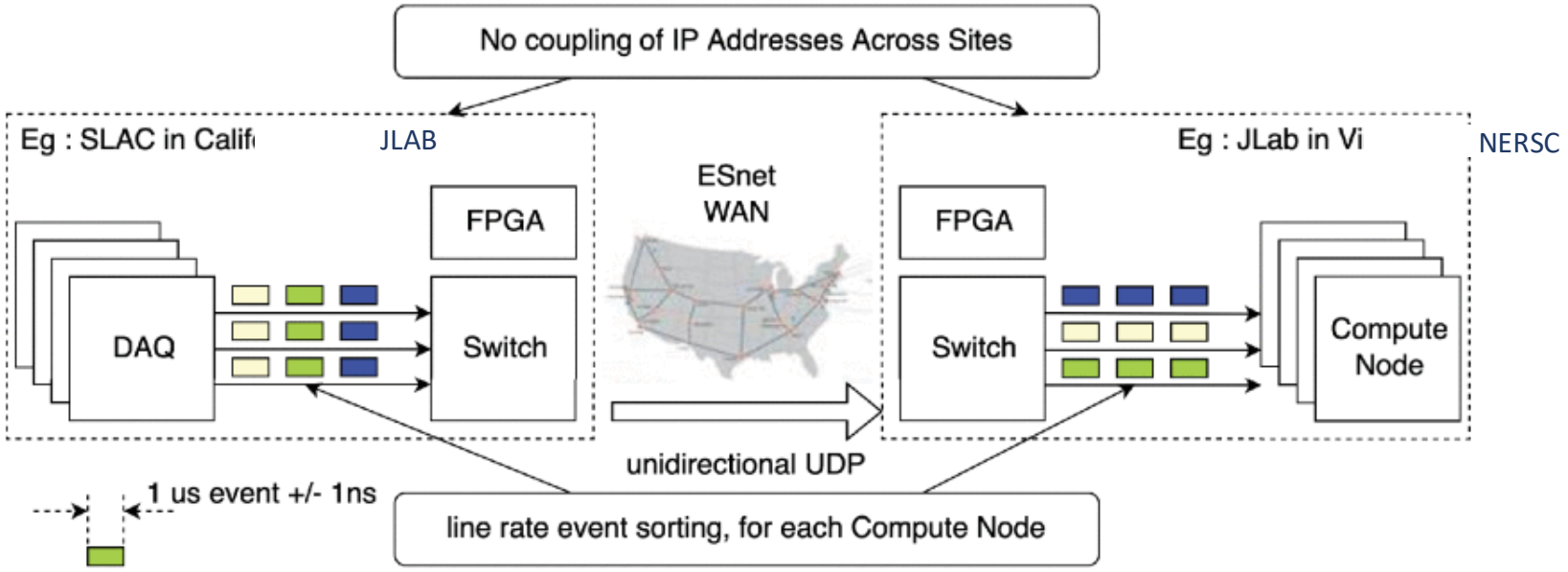
UE : User Engine

***ERSAP: Towards Better NP Data-Stream Analytics with Flow-Based Programming*** V. Gyurjyan, D. Abbott, N. Brei, M. Goodrich, G. Heyes, E. Jastrzembski, D. Lawrence, B. Raydo, C. Timmer
Published at: IEEE Xplore
DOI: https://doi.org/10.1109/TNS.2023.3242548

ERSAP provides event level parallelization. Supports arbitrary fragmented data (Z scaling).

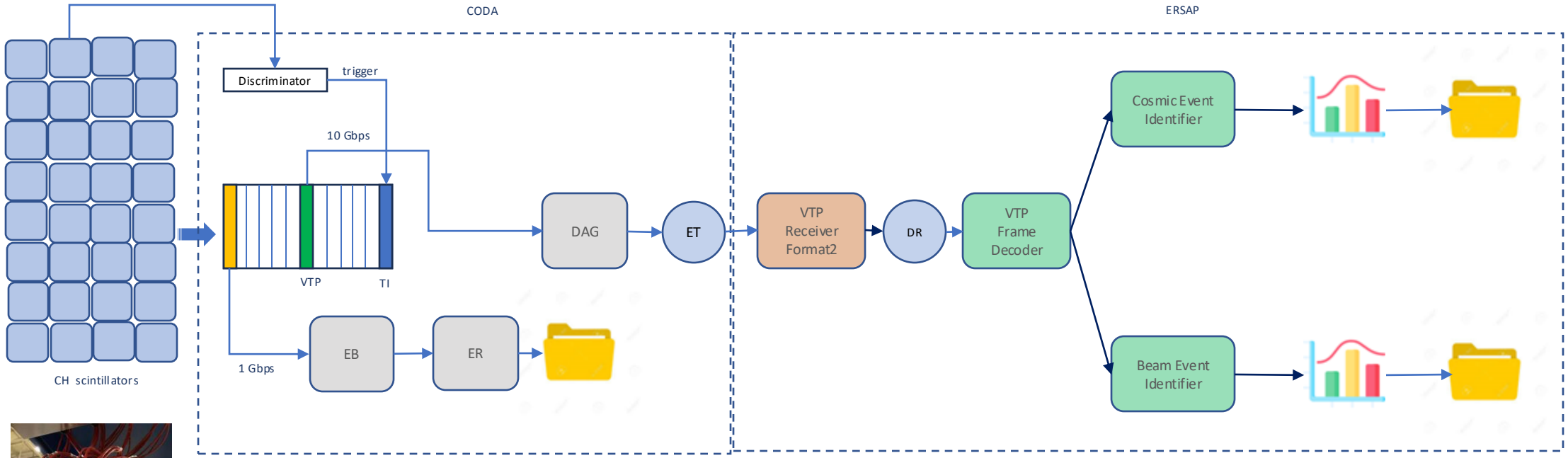
# Efficient X and Z scaling for streaming experiments

- We need network solutions that recognize experiment unique markers
- Shape, sort, and forward data based on experiment-specific markers.
- Dynamic load balancing to ensure optimal and efficient use of computational resources.




***EJ-FAT Joint ESnet JLab FPGA Accelerated Transport Load Balancer***
Stacey Sheldon, Yatish Kumar, Michael Goodrich, Graham Heyes
arXiv:2303.16351 **[cs.NI]**

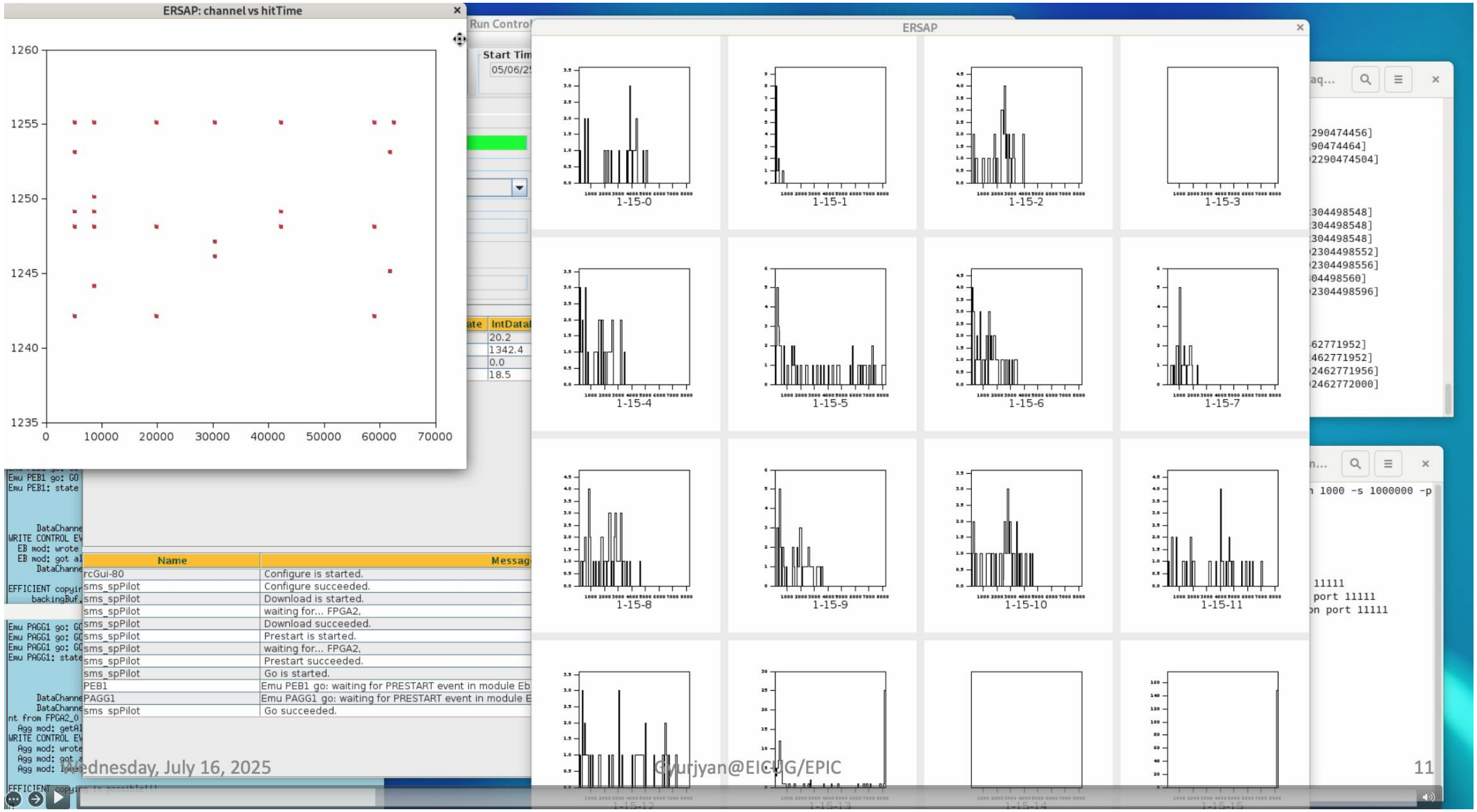
# 4x8 CH Scintillator SRO pipeline at JLAB Test Lab



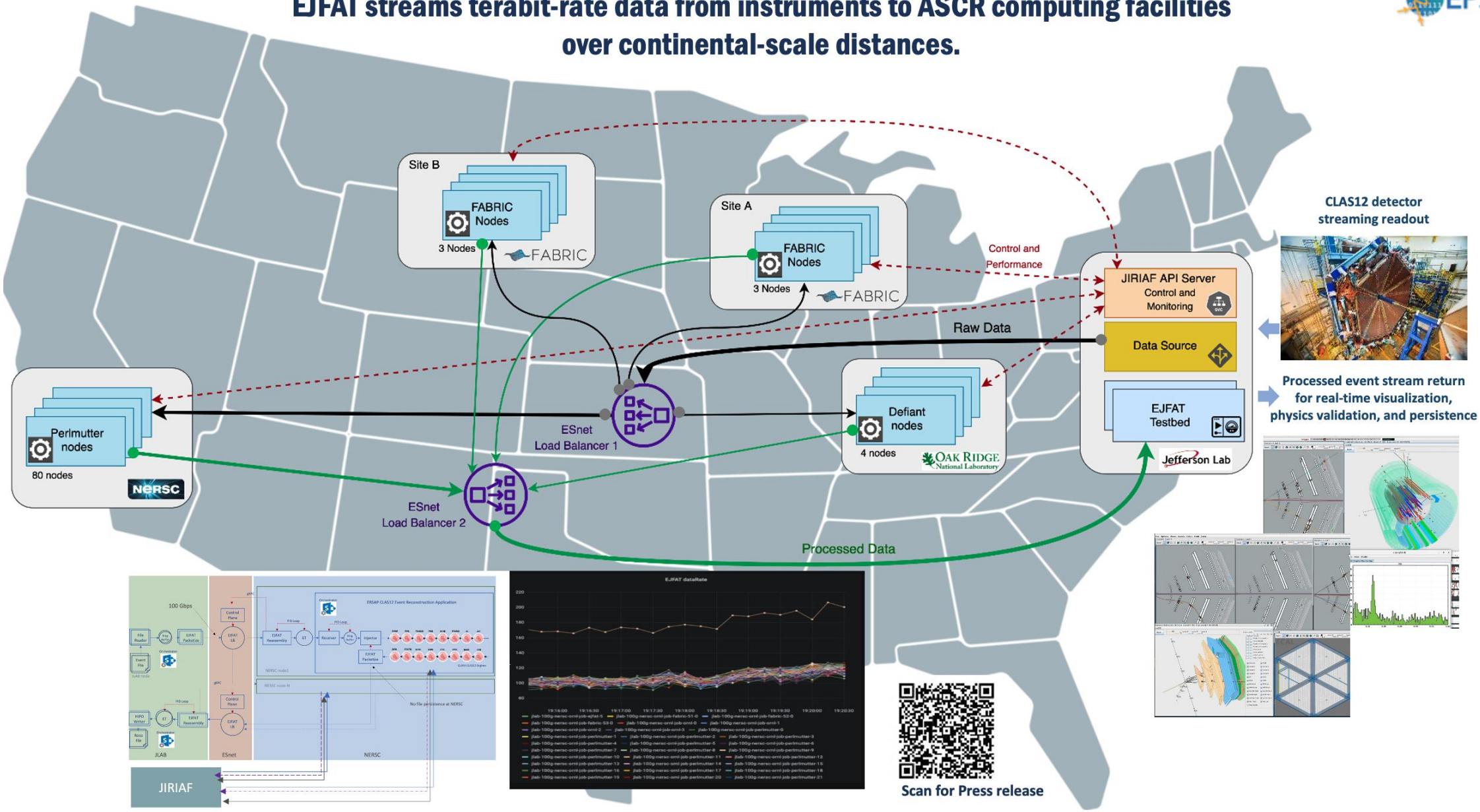

Photos courtesy of Hanjie Liu

Triggered data are waveforms read out over the VME bus.
Stream data are integrated sums and times of all hits over a threshold in the calorimeter regardless of the trigger status.

# SRO and data processing in action



# EJFAT streams terabit-rate data from instruments to ASCR computing facilities over continental-scale distances.



# Conclusion

- We have successfully carried out several streaming readout campaigns, including beam tests that demonstrated the feasibility of the streaming readout approach.  The Streaming CODA and ERSAP frameworks are at the forefront of the SRO effort at the JLAB
- The first time, a fully remote, distributed data stream processing workflow has been successfully demonstrated using production-level physics data across DOE computing facilities using EJFAT and ERSAP. This marks a significant milestone in our efforts to enable real-time, cross-site data curation and analysis at scale.

# Thank you