



Design and Development of JUNO DAQ Data Flow Software

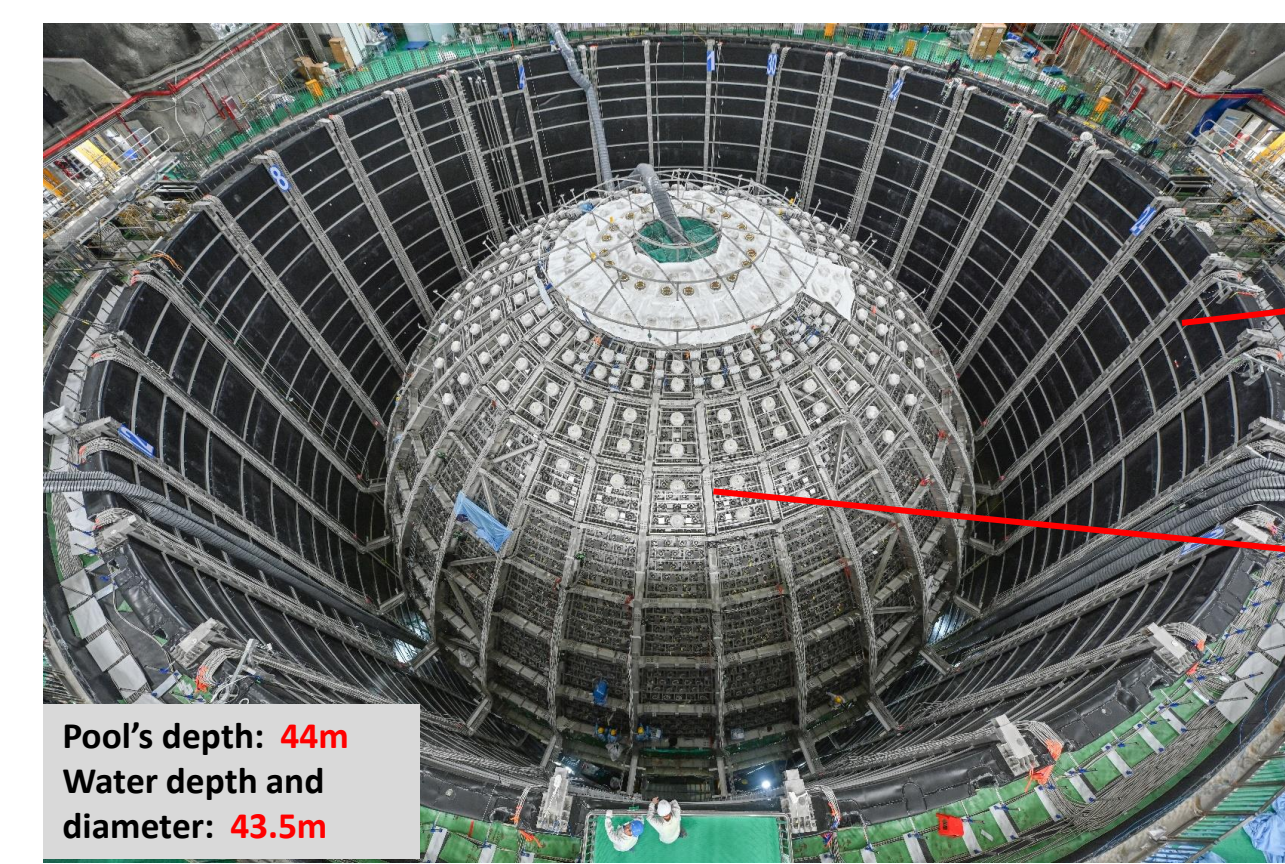
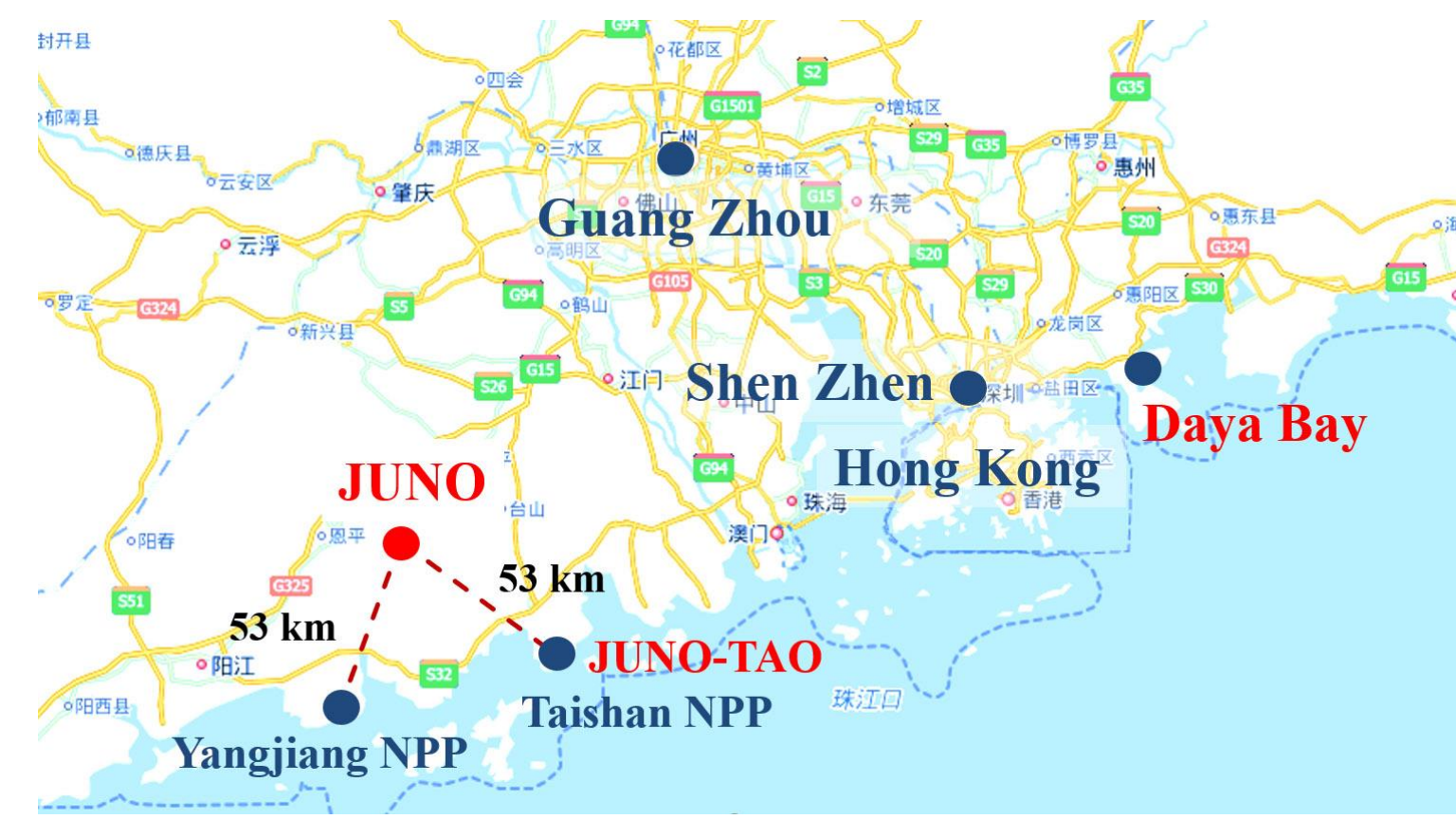
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1. Introduction

The Jiangmen Underground Neutrino Observatory (JUNO) is a neutrino experiment under construction with a broad physics program in southern China. The primary physics goal of JUNO is to measure the order of neutrino mass. The JUNO DAQ data flow software is responsible for the readout, online processing, and storage of more than 40GB/s raw data generated by the front-end electronics(FEE) in various formats.



JUNO Detectors

VETO system
Top Tracker
Water Cherenkov with 2400 20" PMT
Earth Magnetic Field shielding coils

Central detector
• Steel structure (SSS)
• Acrylic sphere (AS) + 20kt Liquid scintillator
• 17612 20" PMT (LPMT)
• 25600 3" PMT (SPMT)

2. Requirement

Data volume from each detector

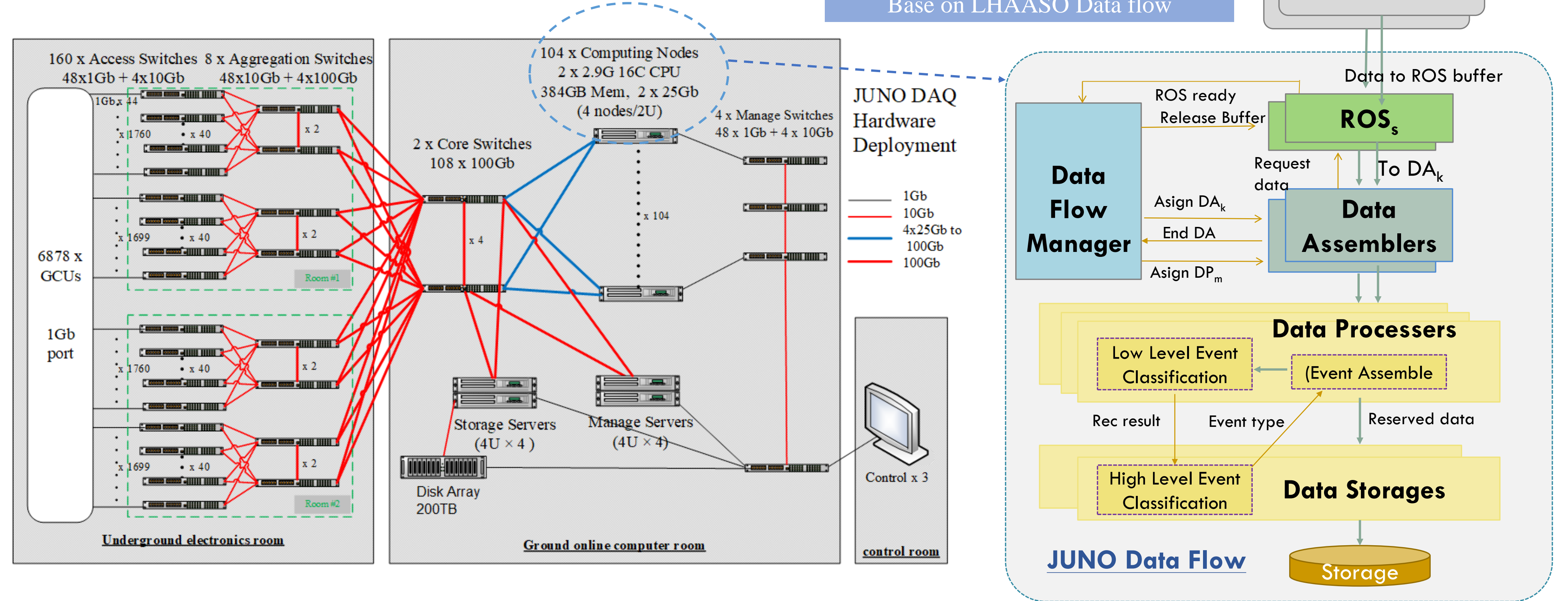
Detector	Channel	Data Size (Byte)	Rate	Data Volume
CD LPMT	17612	2032	1 kHz	35.8 GB/s
CD LPMT-T/Q	17612	16	30 kHz	8.5 GB/s
CD SPMT	25600	30	500 Hz	375 MB/s
CD Calibration	17612	2032	200 Hz	7.2GB/s
WP LPMT	2400	2032	205 Hz	984 MB/s
WP Calibration	2400	2032	200 Hz	960 MB/s
TT				1 MB/s

Non-detector data

- Global trigger data (CD/veto)
- Multi-messenger(MM) trigger data

Readout requirement of 40GB/s, with 50% performance redundancy

3. Architecture



4. Implementation

I. Pipeline architecture of ROS

Readout threads:

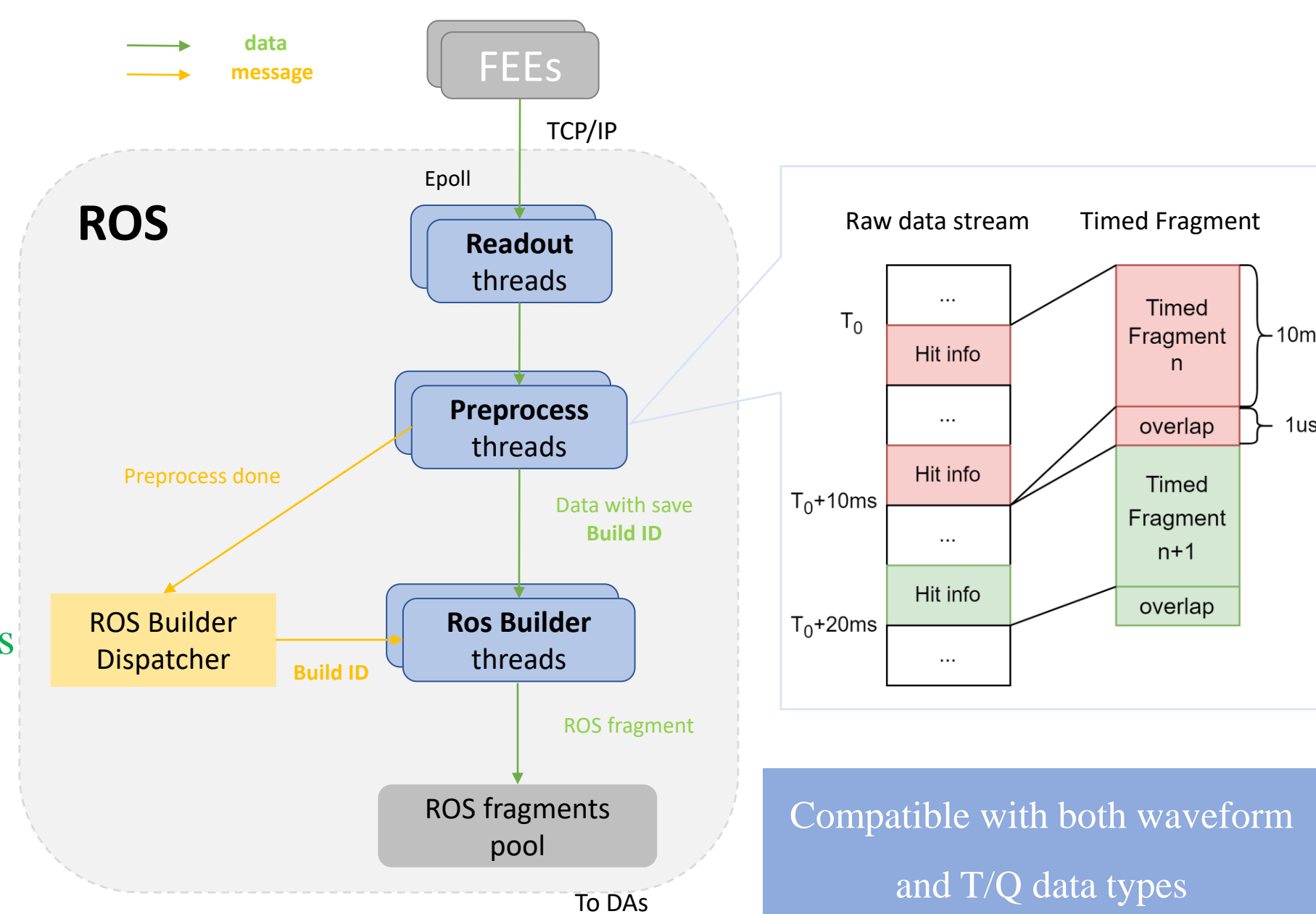
- Readout of all channel data
- 1-thread to multi-channels

Preprocess threads:

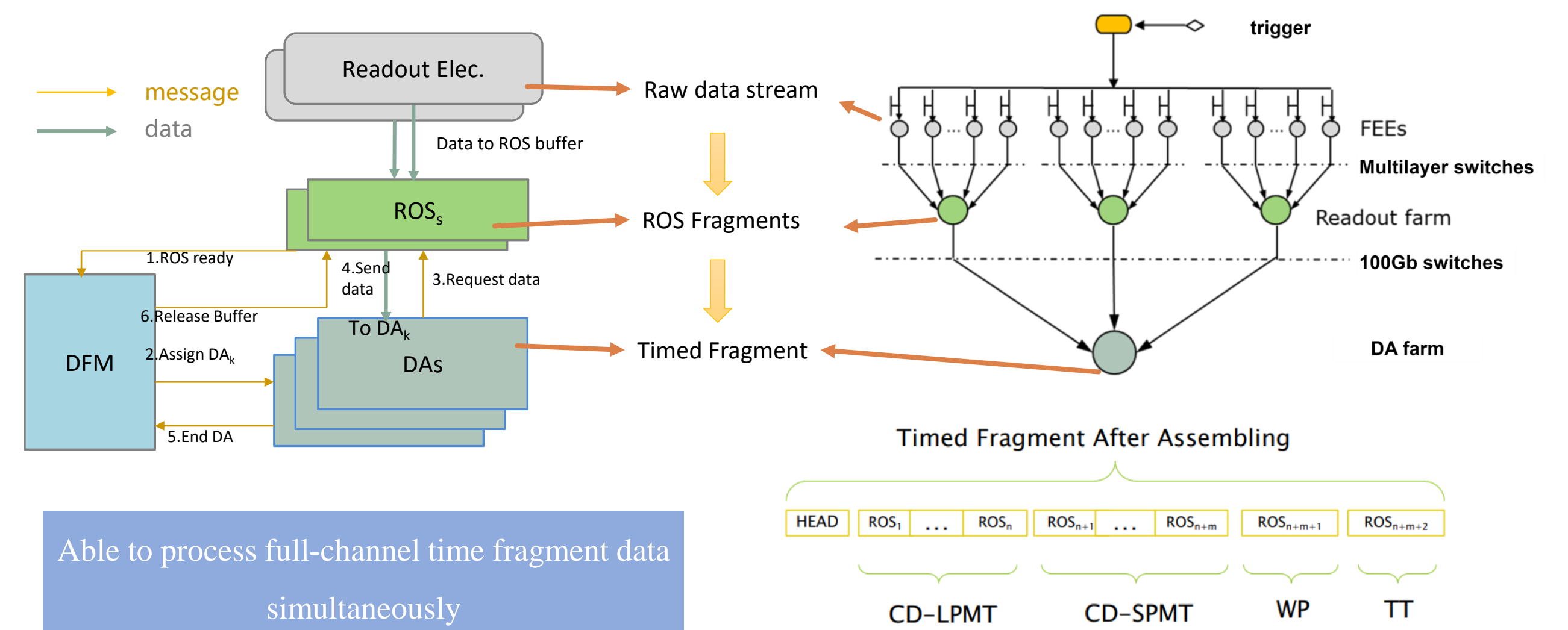
- Data format check
- Generate time fragment based on timestamps

Ros builder threads:

- Level-1 data assemble



II. 2 level data assemble by time fragments



III. Processing of different types of data in DP

4 Event Stream: (online processing, in the same DP)

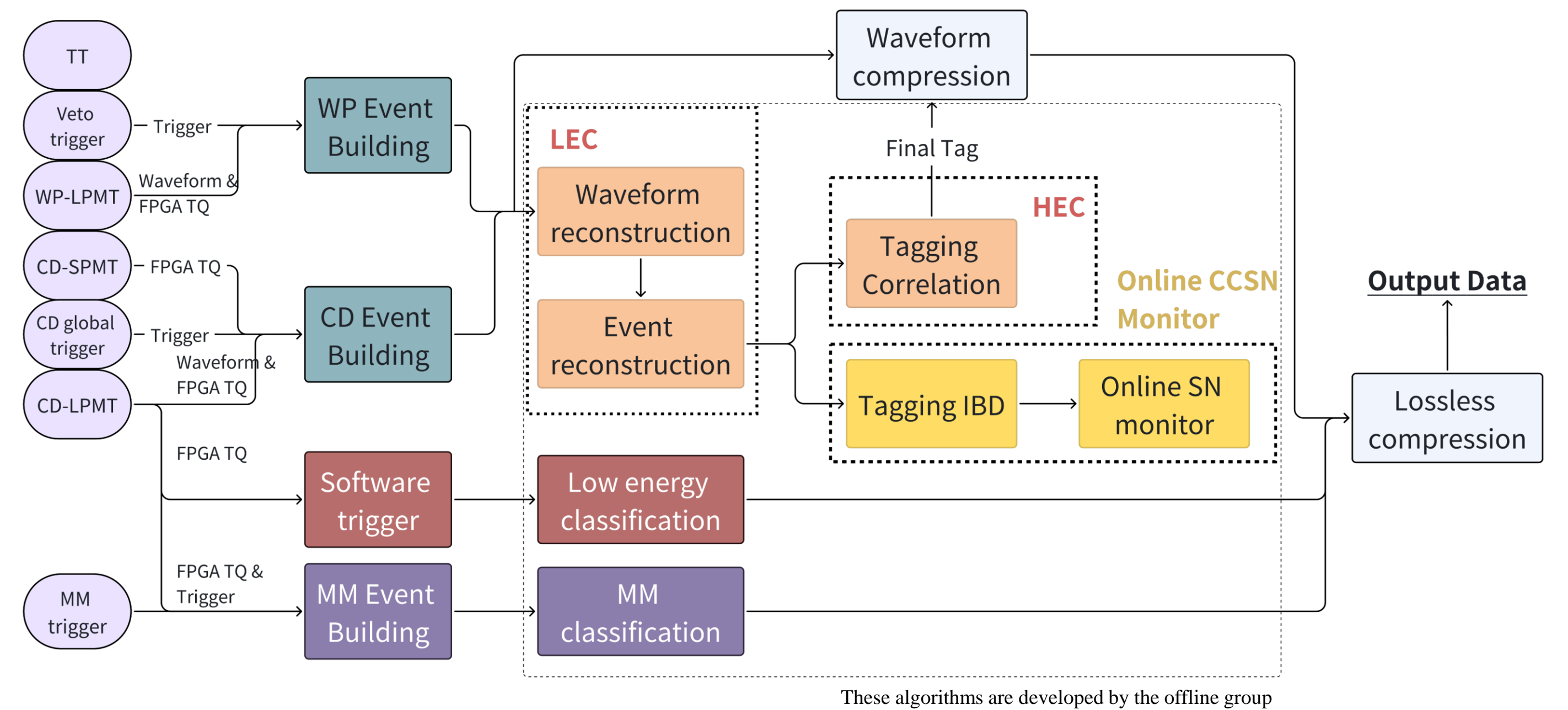
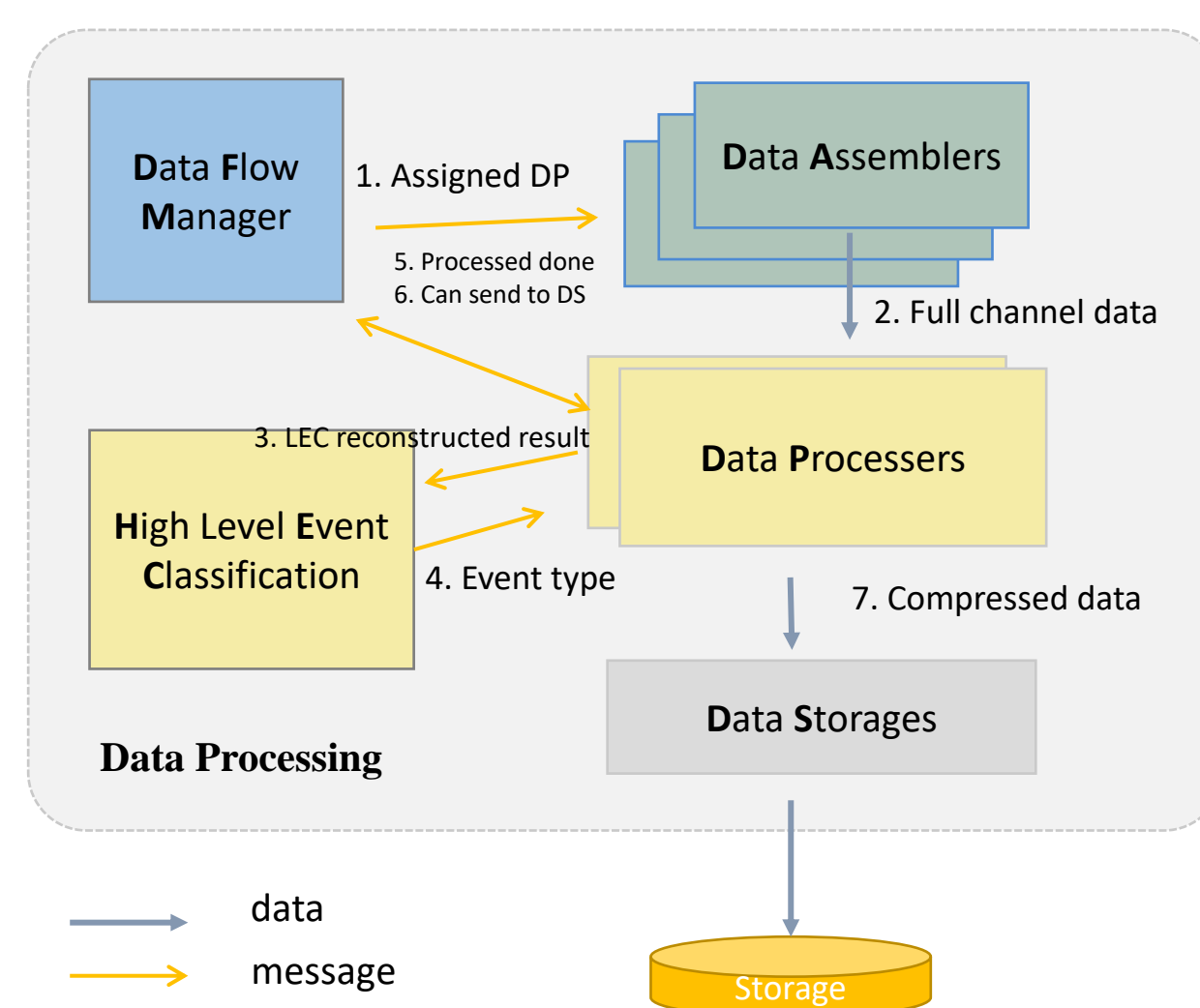
Waveform event (hardware trigger)

- CD/WP event assemble based on hardware triggers
- Online Event Classification(OEC)

Trigger-less T/Q (software trigger)

- T/Q process flow for CCSN monitor
- T/Q process flow for low energy event

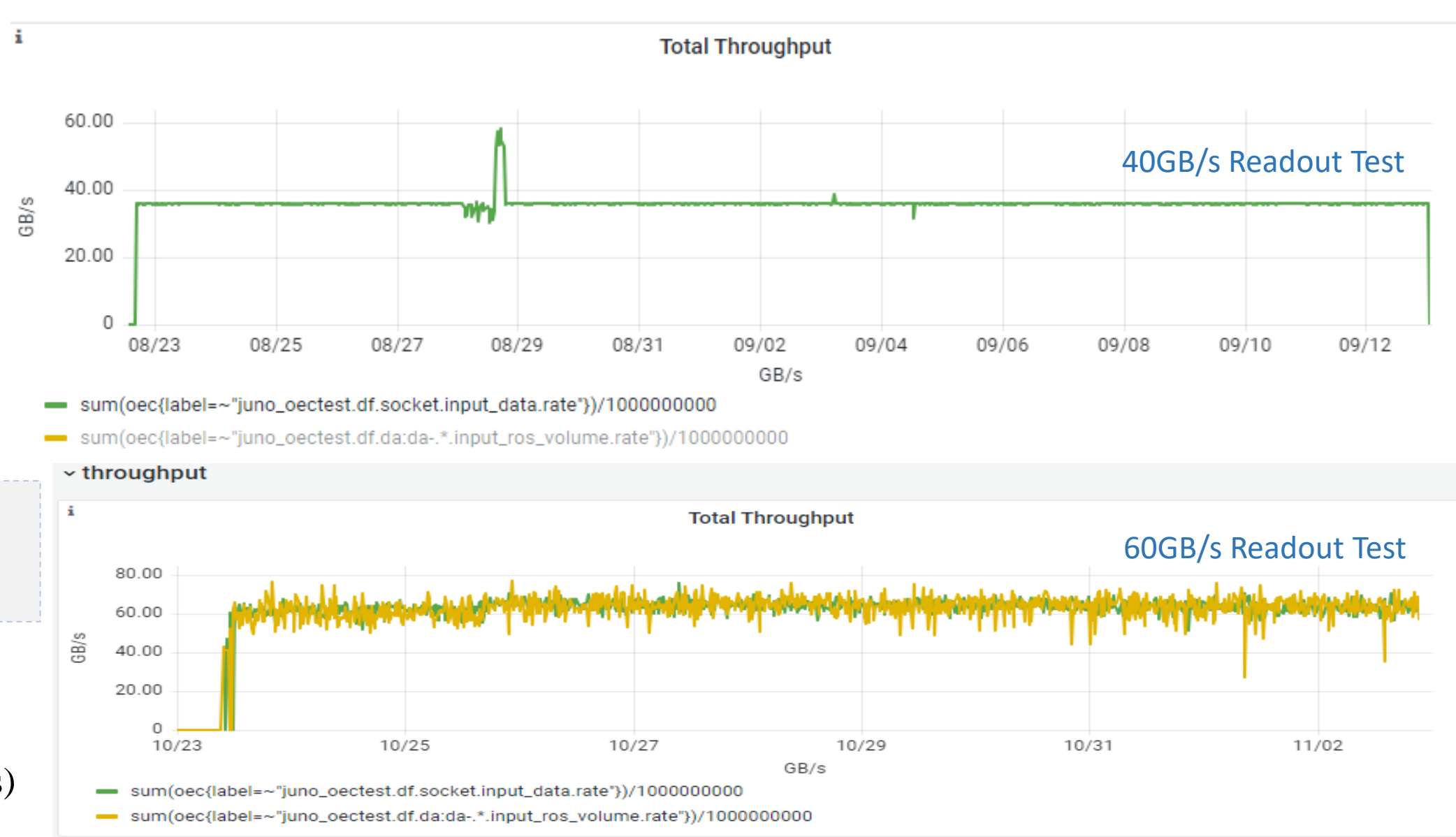
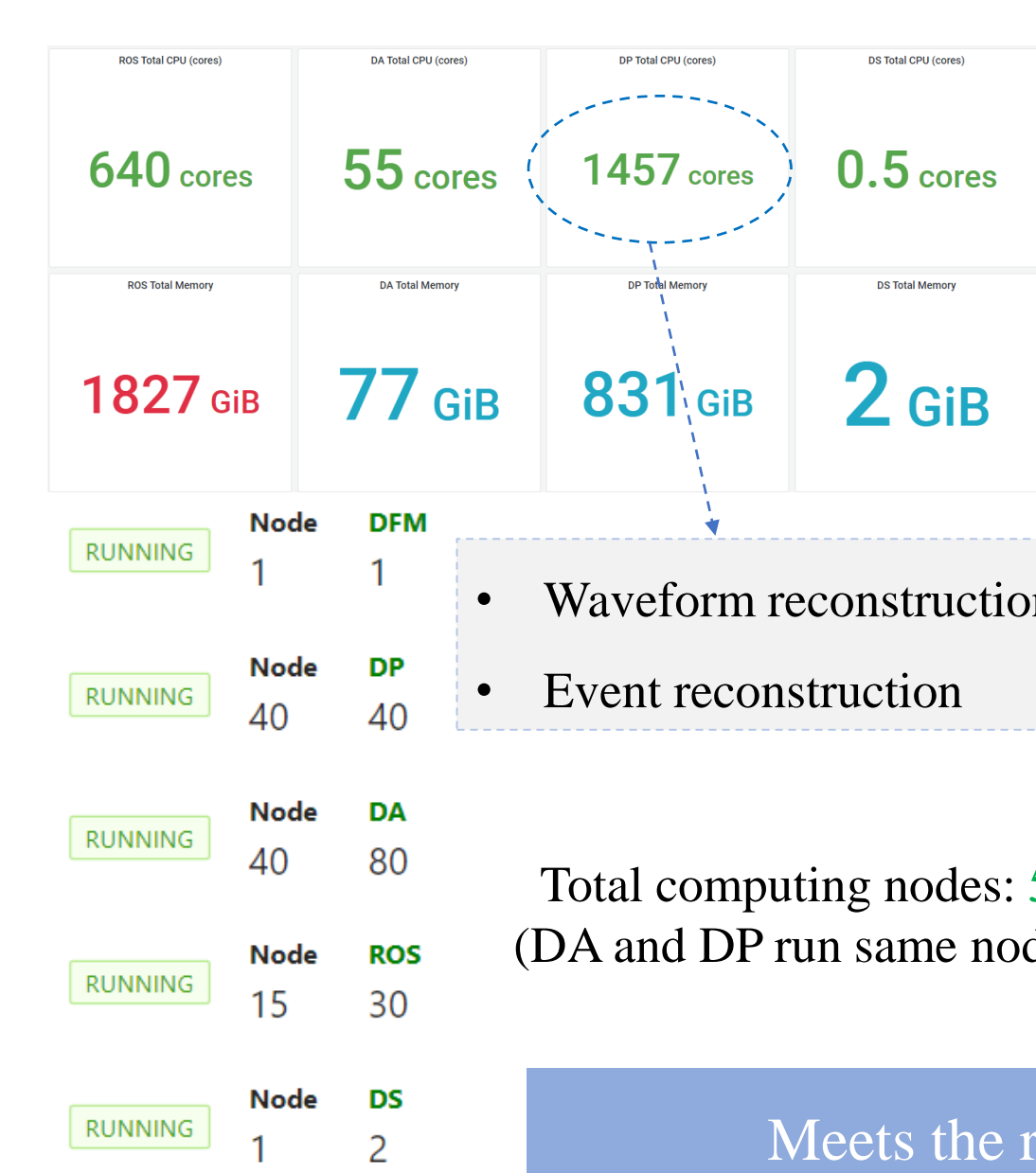
Multi-Message data stream (hardware trigger)



5. Performance

Containerized running by Kubernetes

Dummy waveform data source test



Meets the requirement for 40GB/s data acquisition and 50% redundancy performance

Mixed dummy data source test

3 types of data:

- 1kHz CD waveform data
- 30kHz CD T/Q data
- 400Hz WP waveform data

Totally run time(no continuously run)
More than 2 month

JUNO onsite test



6. Conclusion

The current version of JUNO data flow software supports readout and processing of waveform and T/Q data for both CD and WP detectors, as well as global trigger data. The on-site detector integration has begun, and the software is currently able to support trial operation.

The main focus of the subsequent work is the upgrade of high availability for the data stream.

