PROGRESS OF JIANGMEN UNDERGROUND NEUTRINO OBSERVATORY (JUNO) DAQ SYSTEM

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On behalf of JUNO DAQ group
IHEP
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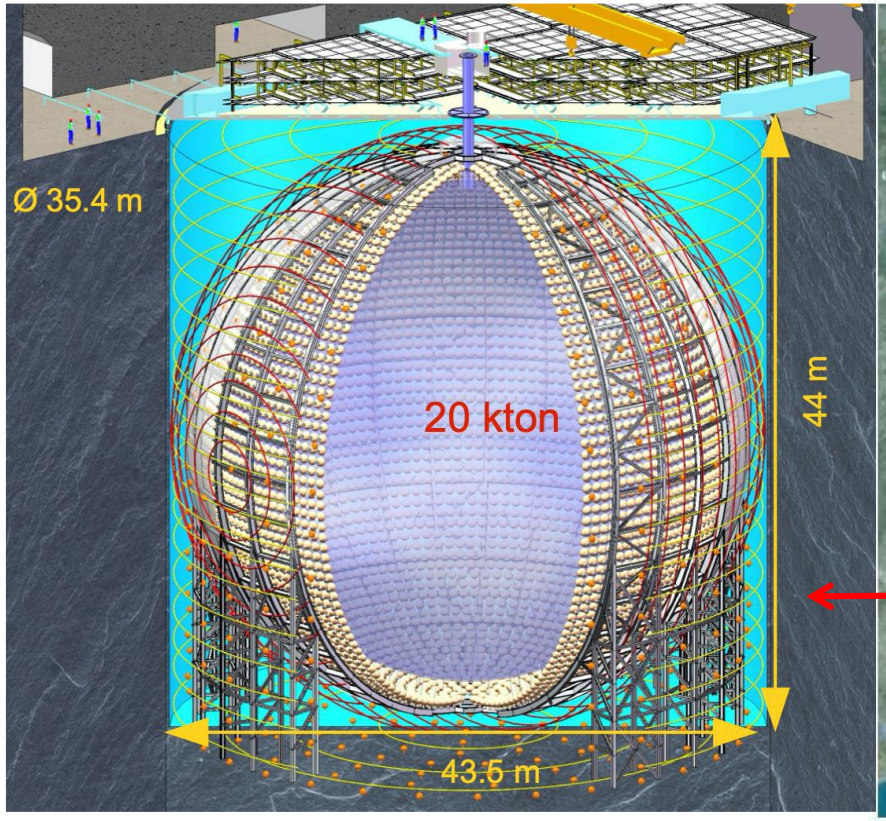
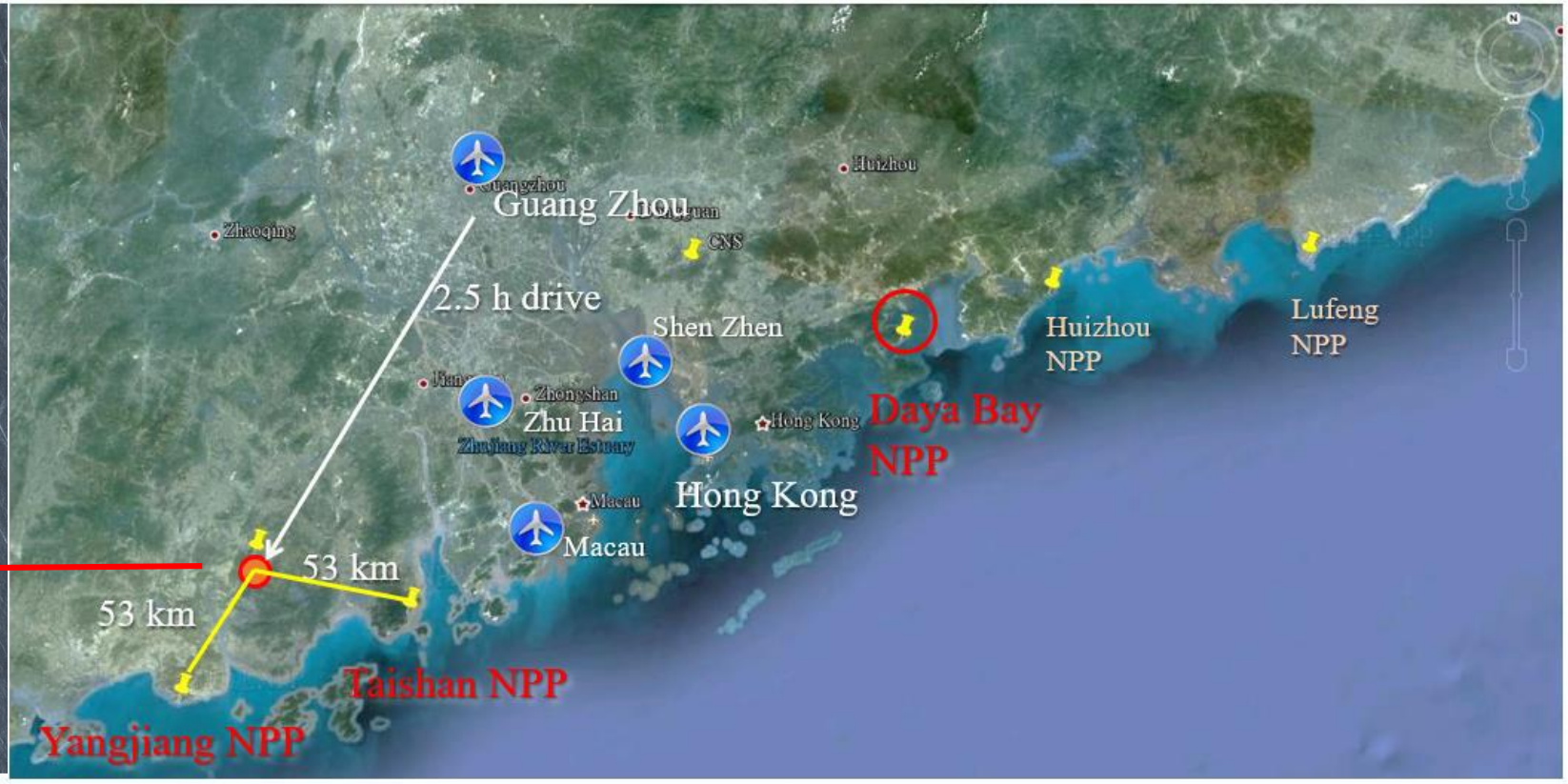
The 2023 international workshop on the high energy Circular Electron Positron Collider (CEPC) , Nanjing China

OVERVIEW OF JUNO





Largest ever liquid scintillator detector

- 20 kton LS
- 78% photo-coverage

- Location optimized for neutrino mass ordering
- 700m rock overburden to suppress muon
- Expected to start data taking in 2024

JUNO DETECTOR

Global DAQ

Top Tracker(TT)

Standalone Local DAQ

Central Detector(CD)

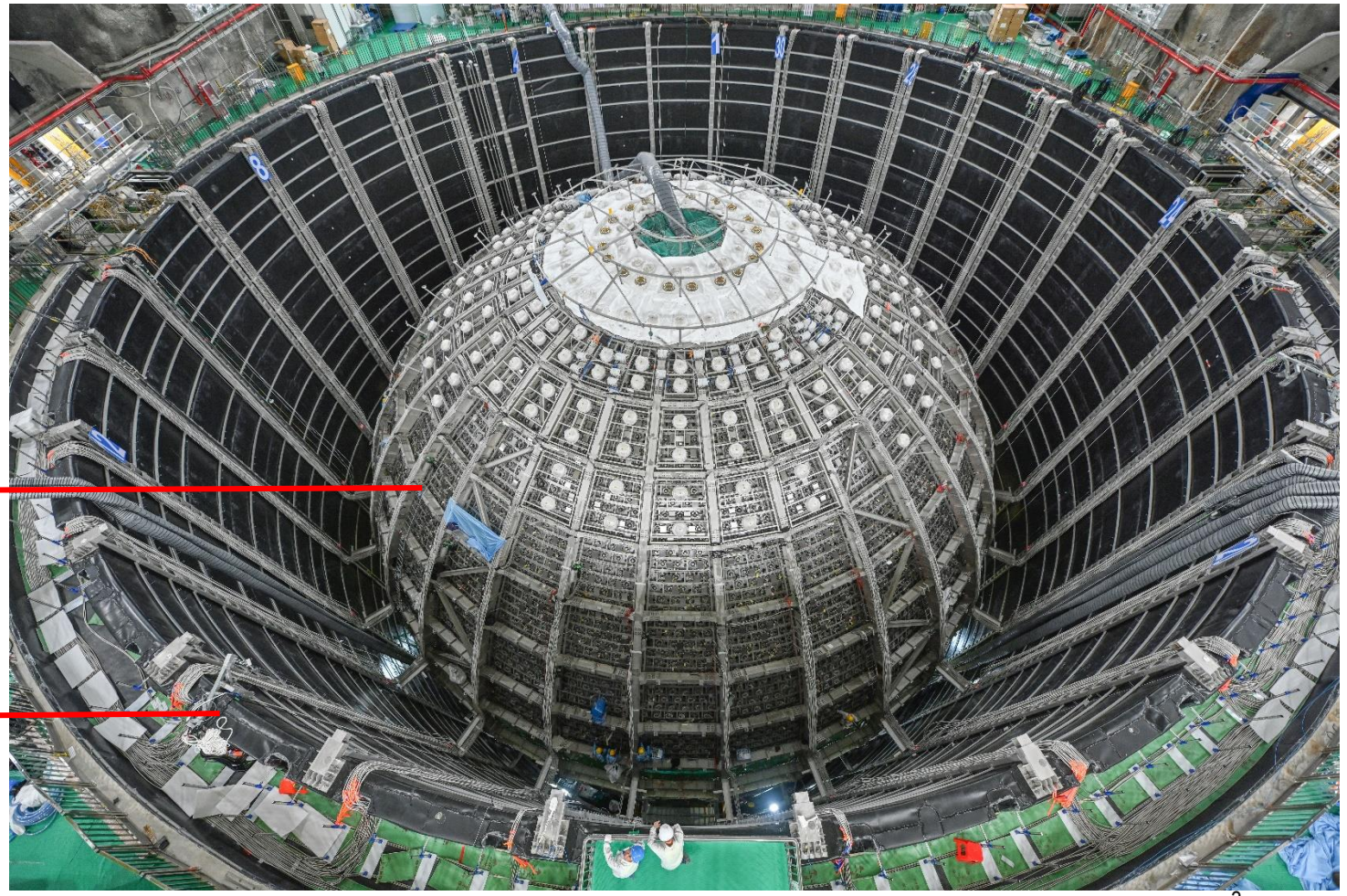
~18000 20" PMT(LPMT)

+

~25000 3'' PMT(SPMT)

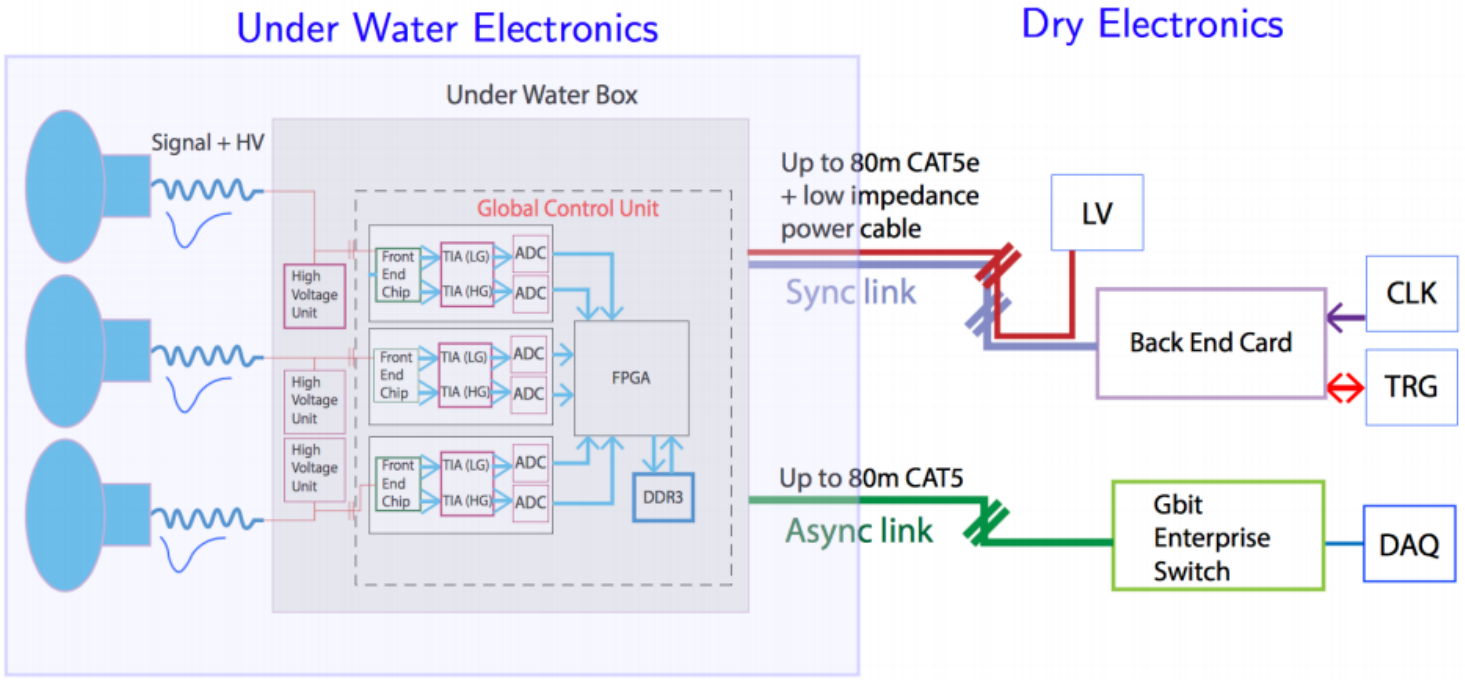
Water Cherenkov(WP)

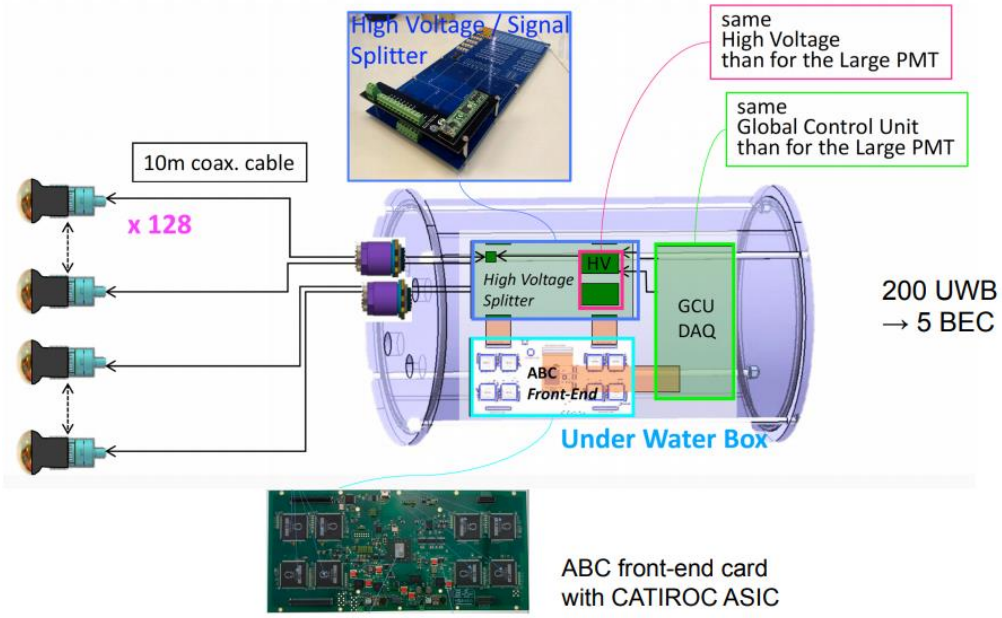
~2400 20'' PMT



JUNO experiment hall

READOUT ELECTRONICS



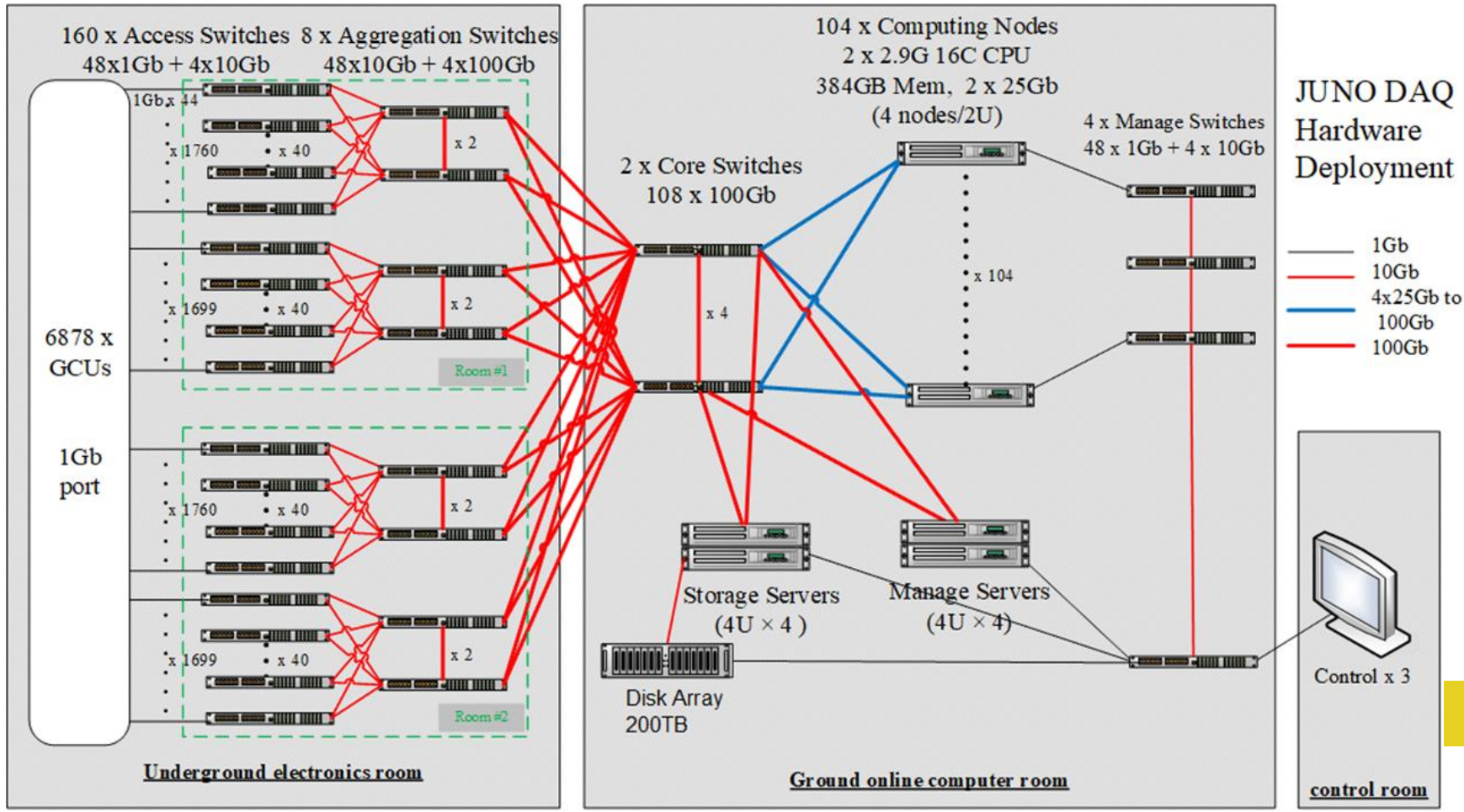


3 channels/UWB for LPMTs of CD and WP : ~6800 UWBs
CD waveform data rate with hardware trigger:
18000 * 1GHz sample * 2 Bytes *1us window *1kHz trigger rate = 36GB/s
CD trigger-less TQ data rate: 18000 * 30kHz dark rate * 10 Bytes = 5.4GB/s

128 channels/UWB for SPMTs: 200 UWBs
Trigger-less TQ data rate:
500Hz dark rate * 25000 * 30 Bytes = 375MB/s

~7000 links, readout interface: 1Gbps Ethernet + TCP protocol , ~40GB/s data rate

JUNO DAQ HARDWARE



Total physical cores: 3328

Node parameters:

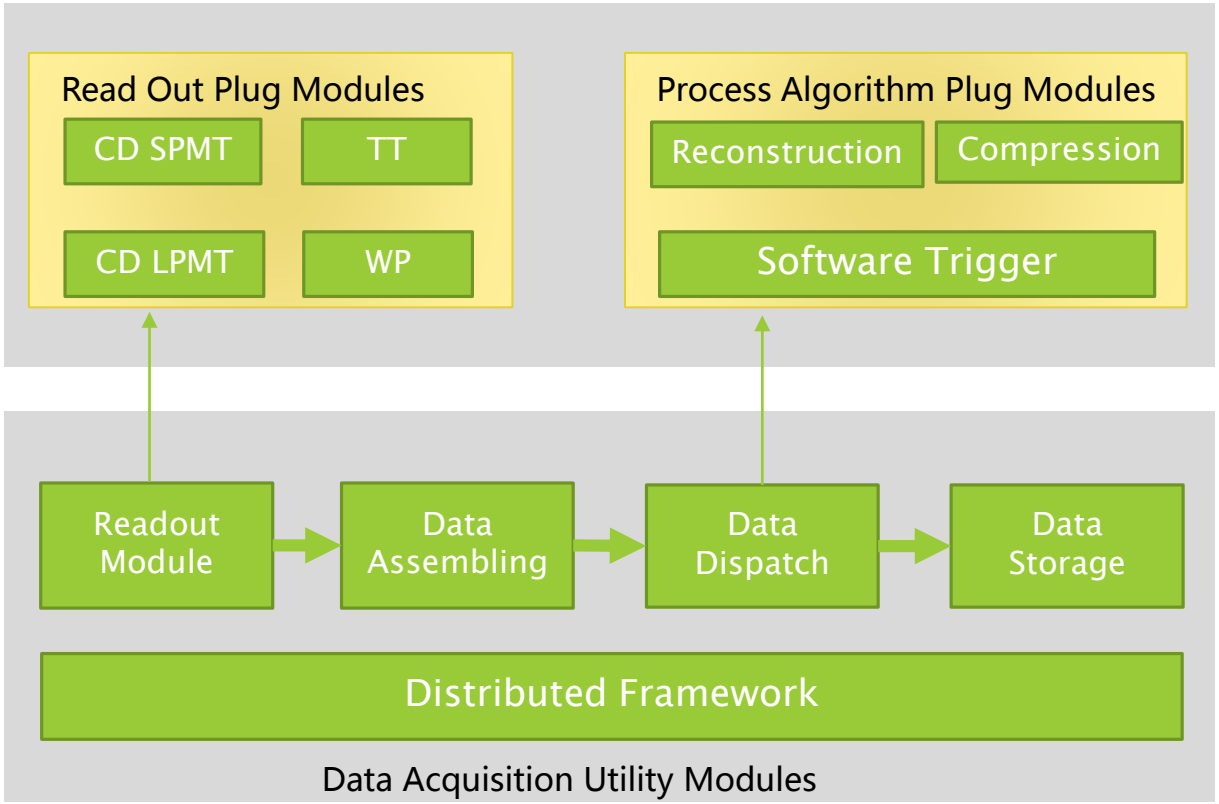
- CPU model: Intel(R) Xeon(R) Gold 6226R CPU(16 cores) @ **2.90GHz x 2**
- Memory: **384GB**
- Network: **50Gb/s** uplink

Most installed onsite.

JUNO DAQ SOFTWARE ARCHITECTURE

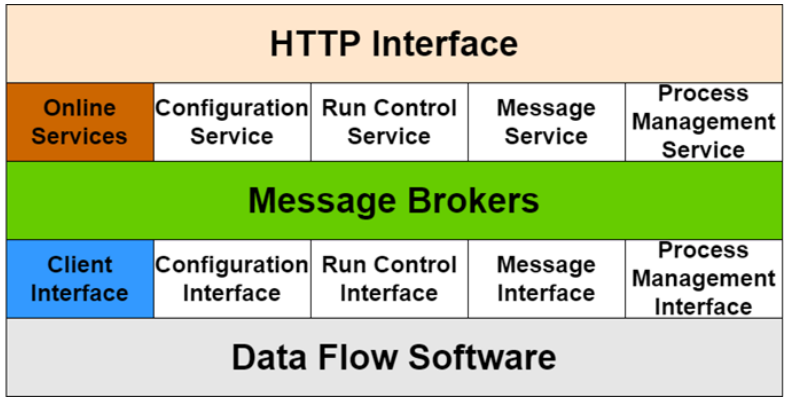
- Developing for JUNO and LHAASO
  - Same data flow design
  - Simplified framework and functions
- Generic distributed framework
  - Transport layer
    - Zero Message Queue
  - Redis based online service
- Plug-in modules design
  - Different electronics modules readout
  - Different online processing algorithms

- LHAASO was data taking since 2019.
- Continues to upgrade for JUNO.

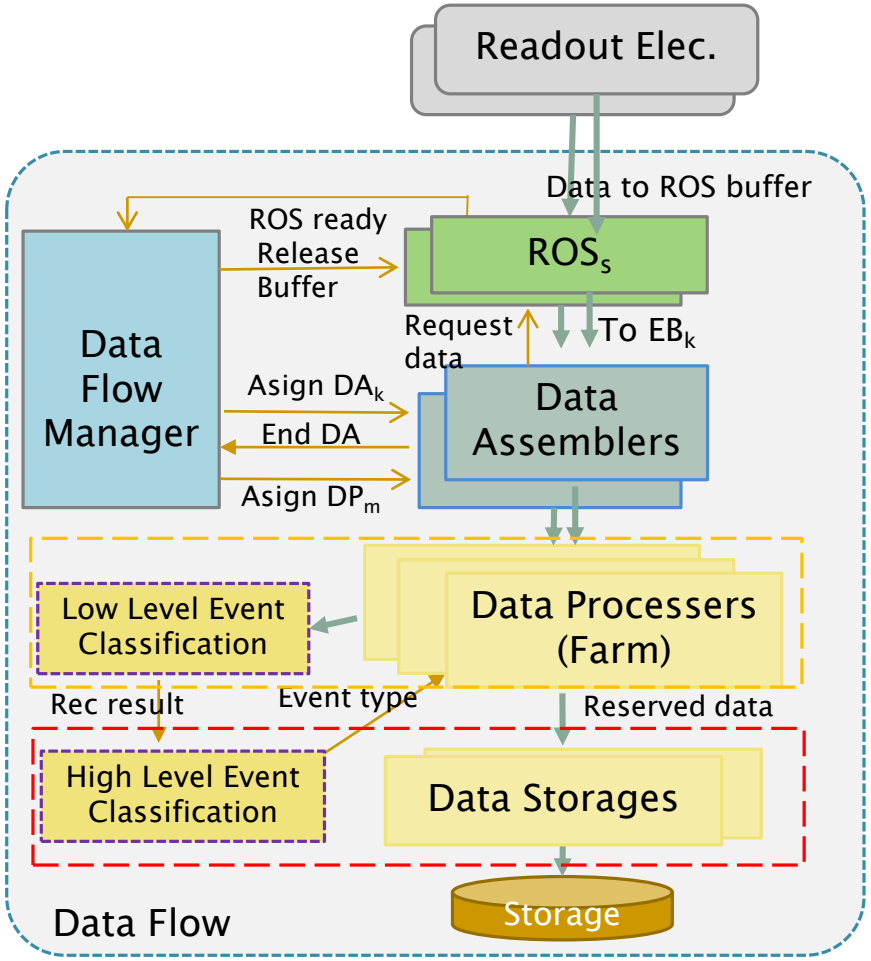


JUNO DAQ SOFTWARE DEVELOPING

- **Online Software:**
  - Configuration Services
  - Run Control
  - Process Management
  - Message Services
  - Info Share Services(Redis)
- **Data Flow Software (DF):**
  - Data Read out system(ROS)
  - Data Assembly(DA)
  - Data Processing(DP)
  - Data Storage(DS)

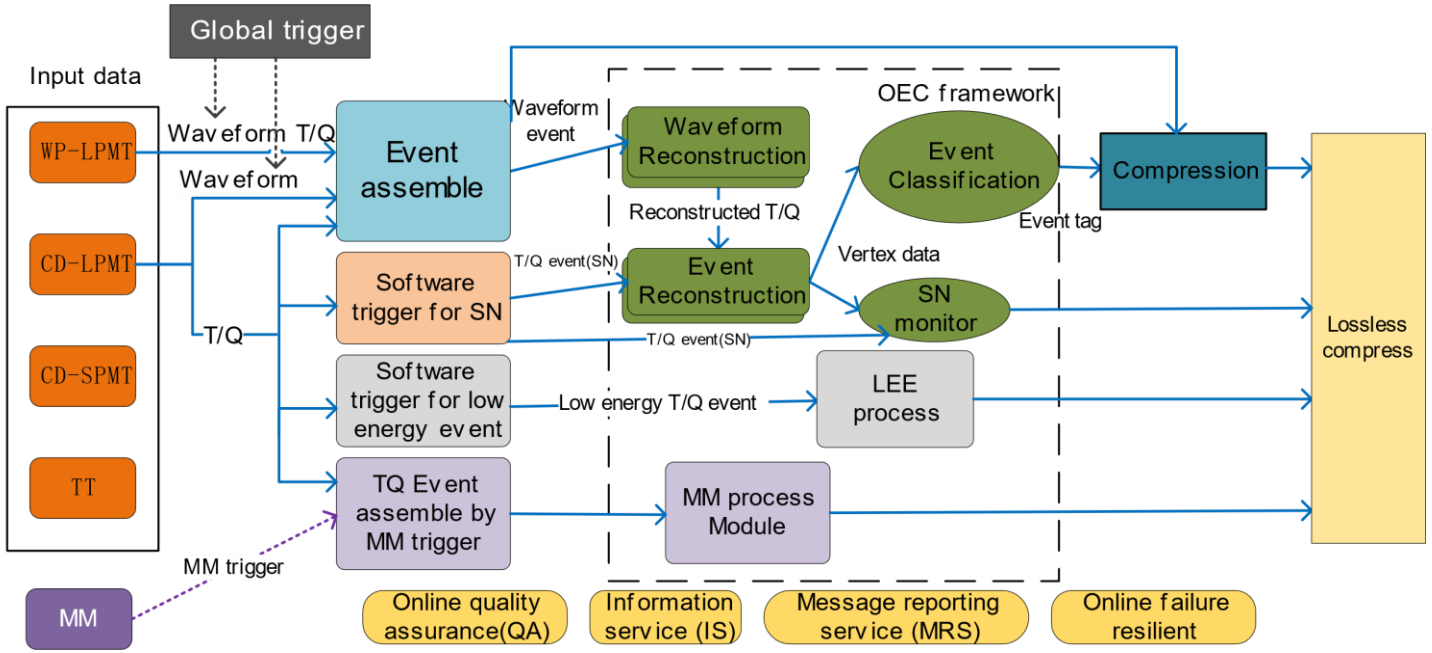


New online services based on Kafka and zookeeper



- Upgraded online software for high availability(HA) .
- Containerized running of all processes by Kubernetes(K8S).
- Data flow software still under upgrading for HA

DATA PROCESS FLOW IN DP



Readout data
~ 40GB/s

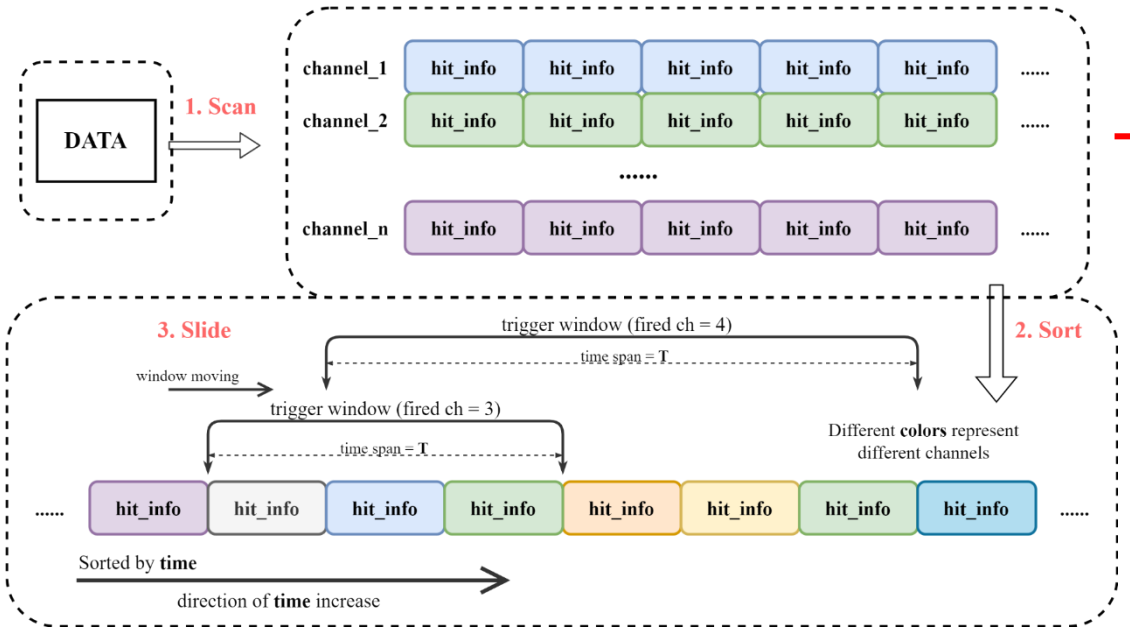
Storage data
~ 60MB/s (physics, only waveform)

Event Stream: (**4 separate streams**)

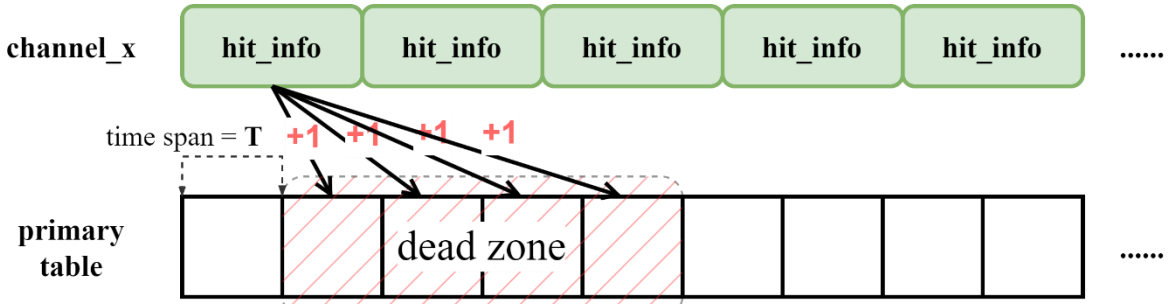
- **Waveform event** (hardware trigger)
- **Trigger-less T/Q** (software trigger)
  - T/Q process flow for CCSN monitor
  - T/Q process flow for low energy event
- **Multi-Message data stream** (hardware trigger)

- Online event classification(OEC) to suppress waveform data for offsite data transmission
- Save T/Q data stream only with SN trigger

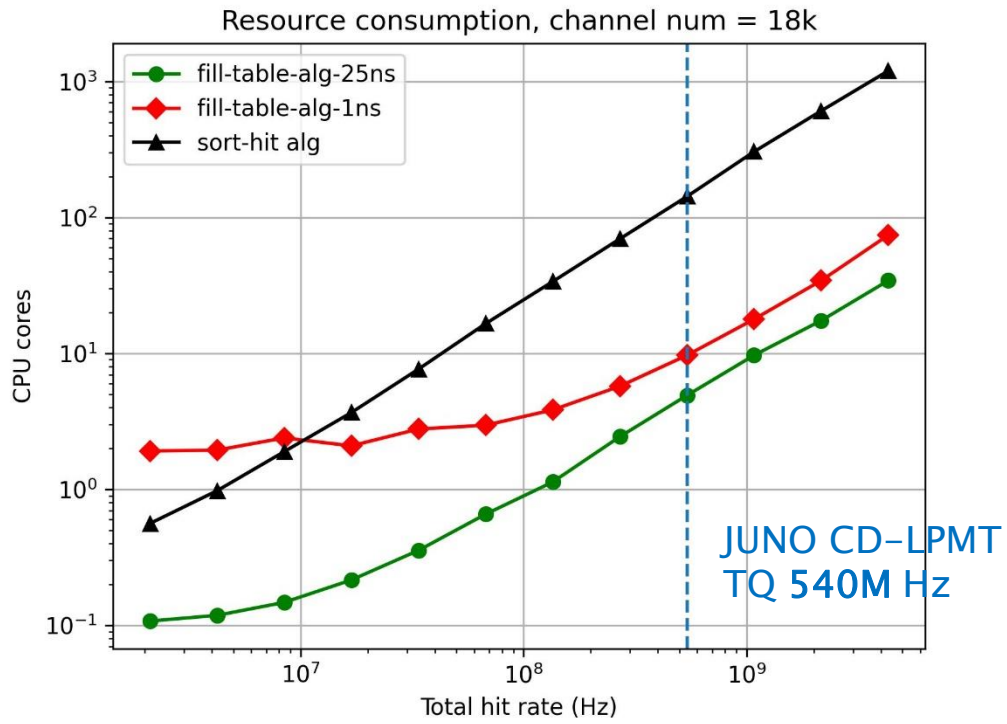
SOFTWARE TRIGGER



LHAASO sort-hit algorithm



JUNO fill-table algorithm



JUNO CD-LPMT
TQ **540M** Hz

A reserve software trigger algorithm using n-PMT method has been implemented, required CPU cores reduce by 10 times

FARM TEST

ROS Total CPU (cores)	DA Total CPU (cores)	DP Total CPU (cores)	DS Total CPU (cores)
640 cores	55 cores	1457 cores	0.5 cores
ROS Total Memory	**DA Total Memory**	**DP Total Memory**	**DS Total Memory**
1827 GiB	77 GiB	831 GiB	2 GiB

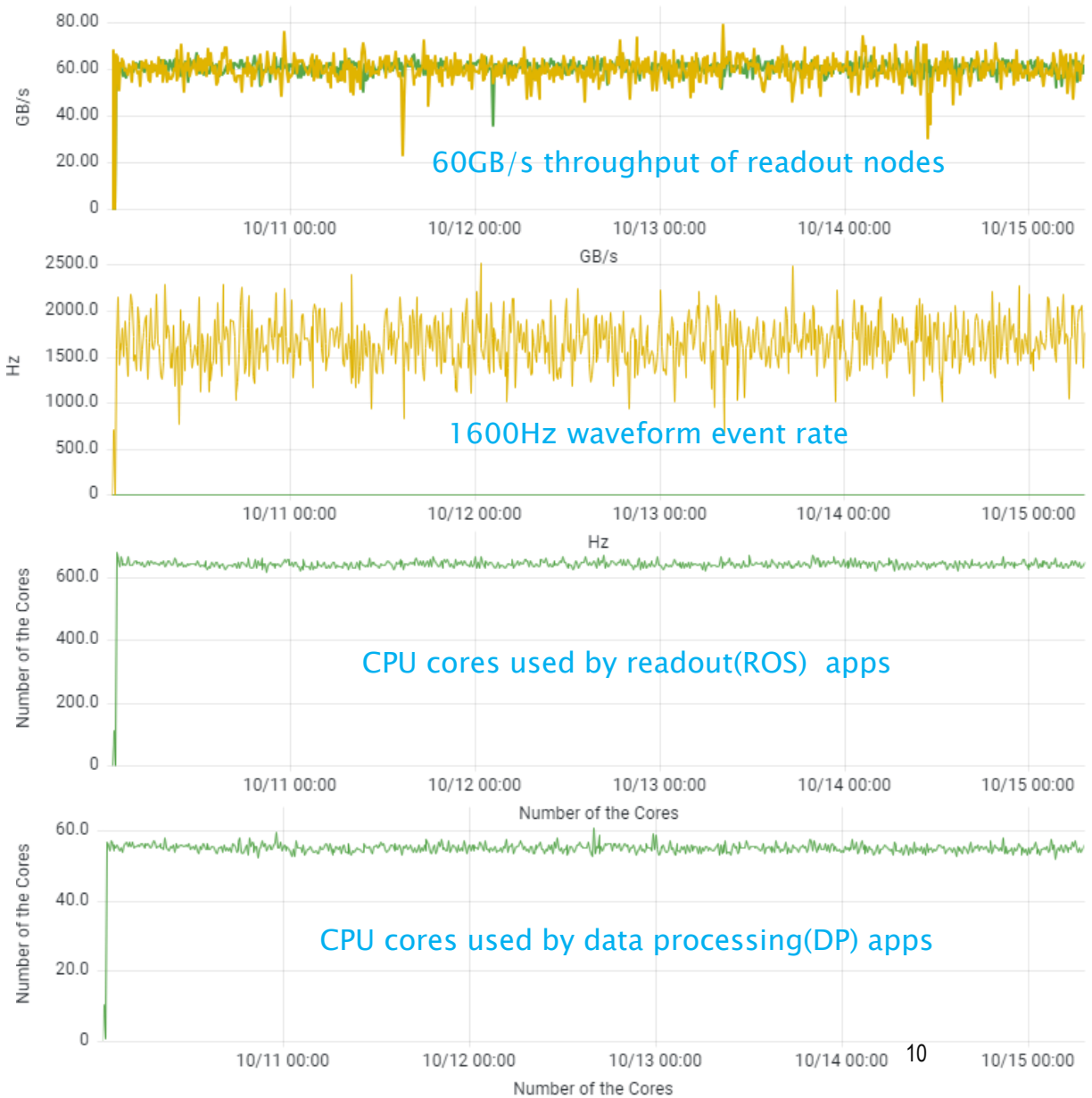
- Onsite farm test throughput: 60GB/s
- Total computing nodes: 55 (DA and DP run same nodes)
- Whole data flow functions with baseline OEC algorithms and simulated waveform data

	Node	DP
RUNNING	40	40

	Node	DA
RUNNING	40	80

	Node	ROS
RUNNING	15	30

	Node	DS
RUNNING	1	2



SUMMARY

JUNO DAQ software is under upgrading based on LHAASO DAQ.

The software data flow performance already reach design requirements.

A high performance nPMT algorithm was developed for JUNO trigger-less data.

Online computer room

Thanks for your attention!

Online computer room