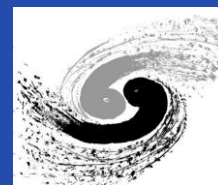
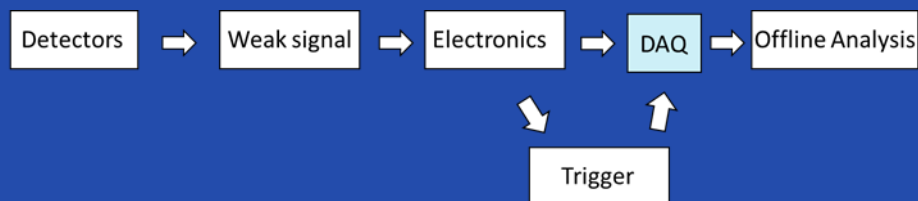


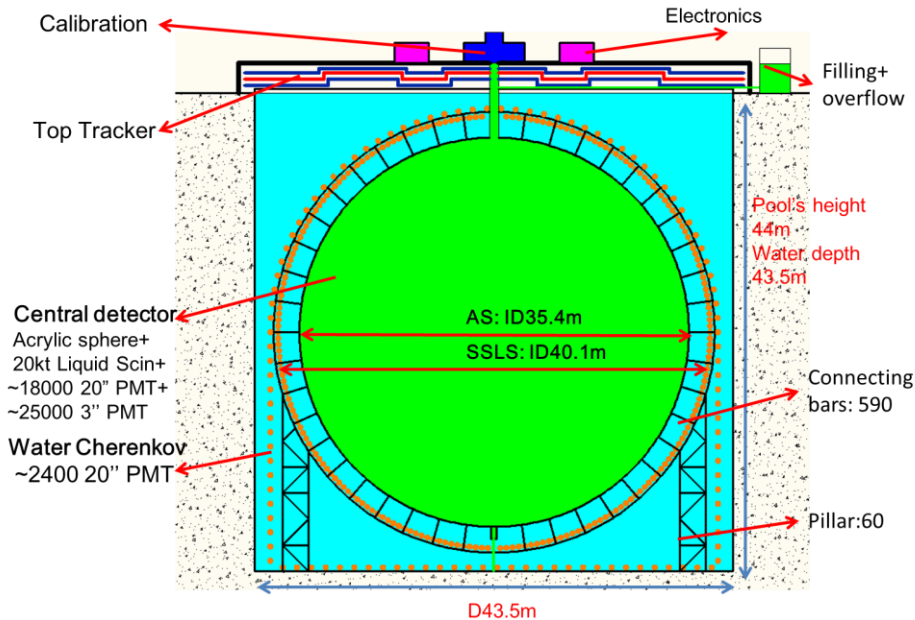
Research of Readout and Event Building Scheme of JUNO DAQ

Data Flow

By Tingxuan Zeng, Fei Li, Kejun Zhu
On Behalf of the JUNO Collaboration



Motivation and Main Content

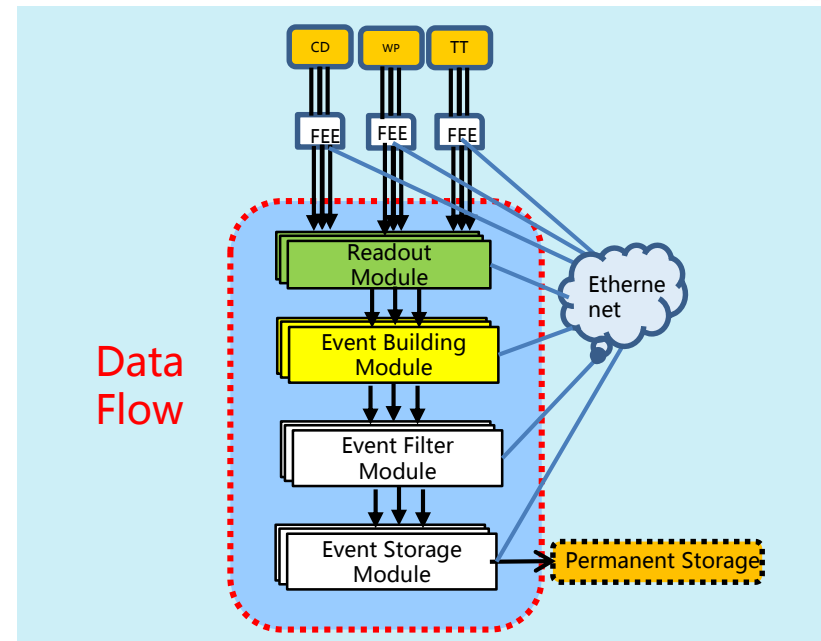


AS: Acrylic sphere; SSLS: stainless steel latticed shell

~ 20K 20" PMT 1GHz FADC waveform sampling

- each sampling point ~2Byte
- sampling window ~1us } 2KB fragment size
- After triggering, event rate will decrease to ~1KHz.
- Without compression, data rate ~ 40GB/s
- Most demanding 1-to-1 PMT and electronic connection scheme : 20K PMT => 20K connections

How to read out, assemble and process 20K connections of data fragments@2KB with 1KHz event rate ?



This poster is to give a solution.

- ✓ Design a data flow scheme to read out and process FEE data(for 20" PMT).
- ✓ Verify the feasibility (3072 channels)
- ✓ Mainly focus on readout and event building module

Research of Readout and Event Building Scheme of JUNO DAQ Data Flow

Tingxuan Zeng^{1,2}, Fei LP¹, Kejun Zhu^{1,2}, On behalf of the JUNO collaboration

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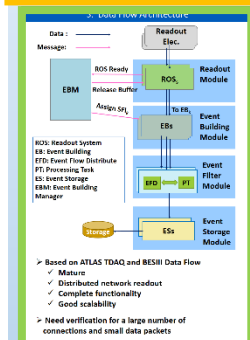
Introduction and Motivation

1. Introduction

In the JUNO experiment, the Data Acquisition (DAQ) system is an important part to read out and process data from the front-end electronics (FE). The performance requirements of DAQ depends on the design of detector and FE system.

- Electronics scheme is not yet fully determined, we choose the most demanding one for DAQ data flow.
 - Electronics scheme: 30 solution
 - DAQ and electronics connections: number of PMTs (for 20th PMT)
- 20K PMT (20K connections), 12 bit 10Gps ADC waveform sampling, 1 us sampling window
 - ① 38k 20th PMT, trigger data = 310G/s
 - ② 200 200 20th PMT, trigger data = 120G/s

Data Flow Software Architecture and research platform



4. Research and Test Platform

Hardware

Number of Blades	Lenovo Blade Server 28
CPU	Intel(R) Xeon(R) CPU E5-2620 v2 @ 2.10GHz
CPU cores	12
Hyper threading	On
Operating System	Scientific Linux CERN SLC release 6.6
Kernel version	2.6.32-554.el6.x86_64
28 Lenovo blades(nodes)	
56 6B/s NIC	

Software

- Software Simulated FEE (send data as fast as possible)
- DAQ Data Flow Software
- ipopt as a reference

- 5. References**
- [1] JUNO Collaboration, JUNO CDR, Beijing, China, March 14, 2015
 - [2] Xiaohua Jiang, Electronic Scheme[R], 2016.
 - [3] Xiaohua Jiang, One Electronics Box for Three PMTs[EPJ]R[2017].
 - [4] Fei Lu, JUNO DAQ Progress[R], 2017.

3. Objective

Number of Connections	Event Rate	Packet Length	Date Rate
20K	300K	318	400G/s

- Design a data flow scheme to read out and process raw data
- Verify the feasibility
- Mainly focus on Readout system and event building system

5. Readout Performance

(1) Single Node TCP Readout Performance

- ipopt send nodes vs recv nodes: 1, 2, 4, 8, 16, 32
- 1, 2, 4 threads reach max bandwidth (2700Mbps)
- 16, 32 threads reach max bandwidth (4000Mbps), recv node is the bottleneck.

(2) Multiple Readout Node vs Single Event Build Node

- 1 readout thread/ROS (128/1600) + 1000 channels
- ROS reach saturation 180Mbps, support for 1000 channels readout (100Mbps/ch)
- Performance doesn't increase when arranged more than 1000 channels, 128ch/thread.

6. Event Building Performance

(1) Single Readout Node vs Single Event Build Node

single FE node performance

- 800ch, Channel=128
- 800ch, Channel=16
- 800ch, Channel=16
- 800ch, Channel=16
- 800ch, Channel=16
- 800ch, Channel=16
- 800ch, Channel=16

(2) Multiple Readout Node vs Multiple Event Build Node

increase the number of readout nodes and event building nodes, the event rate decreases when the ratio of them becomes less than 1.

- to get enough event rate, enough 2400ch readout nodes + event building nodes should be 1:1.

(3) Readout Node + Event Building performance

Integrate the readout module and the event building module, with each module occupy 4 nodes, reaches 120000 event rate, which meets the designed event rate 100k.

(2) Multiple Node TCP Readout Performance

Extend 128 Channels TCP Readout Performance via 10Gbps network

- With ROS Buffer Management, 12 40Gbps per node > 160G/s
- With ROS Buffer Management, 12 40Gbps per node > 160G/s, can't meet the designed data rate (160Gbps per Channel)

7. Overall integration performance

Integrate all the modules to get the overall performance

process a total of 1536 Channels, deploy as follows:

- Simulated FEE Zener's 768 send process
- Readout 8 nodes * 100ch/node
- Event Building 4 nodes * 800ch/node
- Other modules 4 nodes
- Achieved event rate: 120k/s, almost meet the DAQ requirement

process a total of 2072 Channels, deploy as follows:

- Simulated FEE Zener's 128 send process
- Readout 8 nodes * 200ch/node
- Event Building 4 nodes * 800ch/node
- Other modules 4 nodes
- Achieved event rate: 1.88M/s, meet the DAQ requirement

8. Summary and Outlook

- With dummy event filter algorithm, and Xeon(R) CPU E5-2620 v2 @ 2.10GHz
- To process 20K channels, need:
 - 53 readout nodes, with 6.2Gb/s per node
 - Event building+event filter+storage: 40 nodes, with 6B/s/ each node.
 - 10Gb/s NIC can meet the requirement.

Research process and Testing Results

Summary and Outlook: With dummy event filter algorithm, To process 20K channels, need:

- ✓ 53 readout nodes
- ✓ Event building + event filter + storage 40 nodes
- ✓ 10Gb/s NIC can meet the requirement.