中國科學院紫金山天文台

Purple Mountain Observatory,Chinese Academy of Sciences

2025 Annual Meeting

Updates and progress of GRAND-DAQ

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GRAND-DAQ: Robust, simple, reliable and modularity

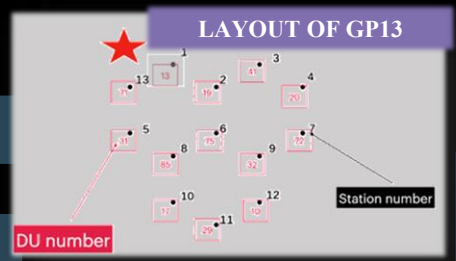
Antenna arms

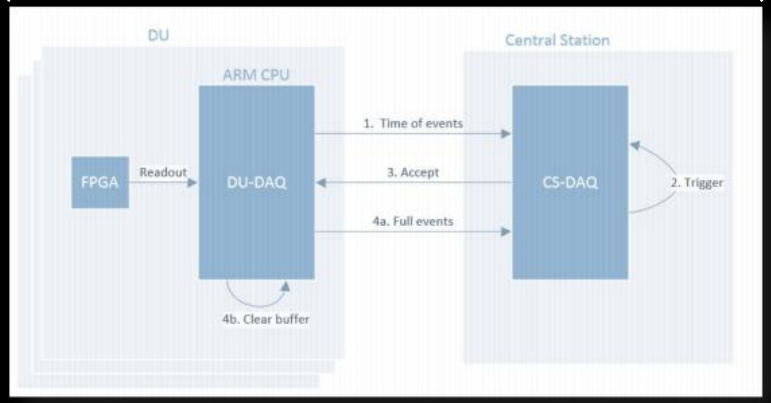
23dB LNA

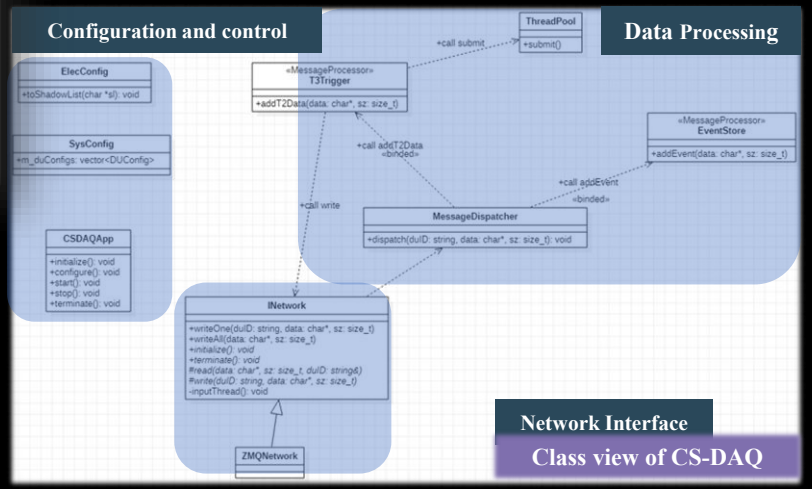
DAQ FEB

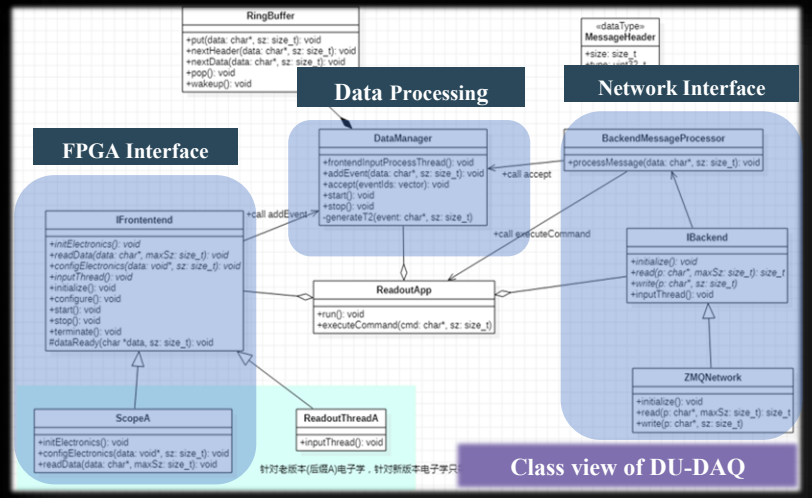
GRAND-DAQ

WIFI antenna



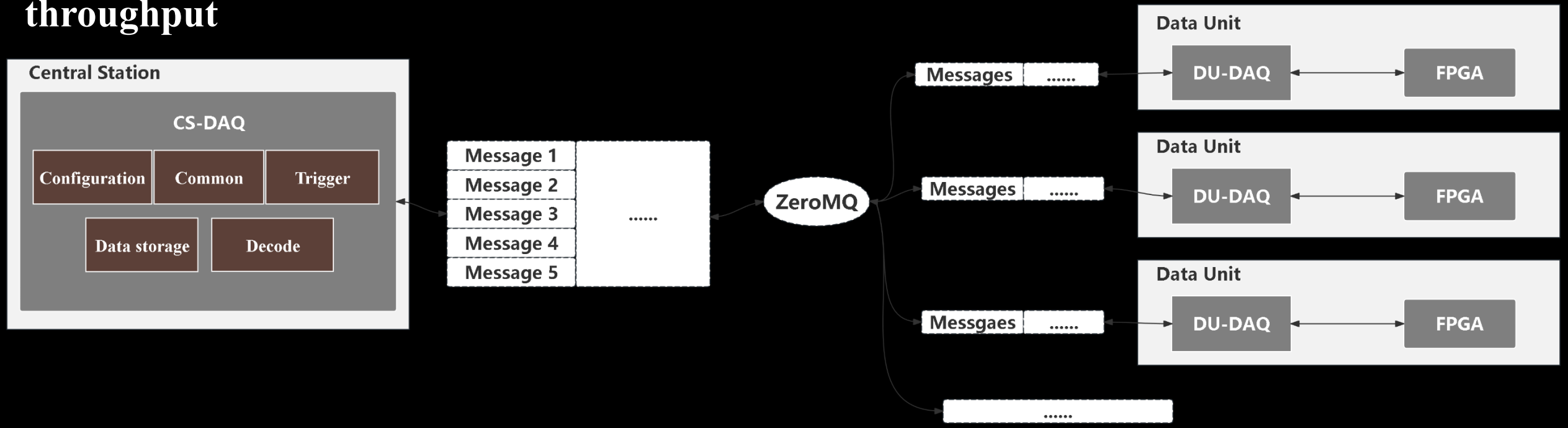






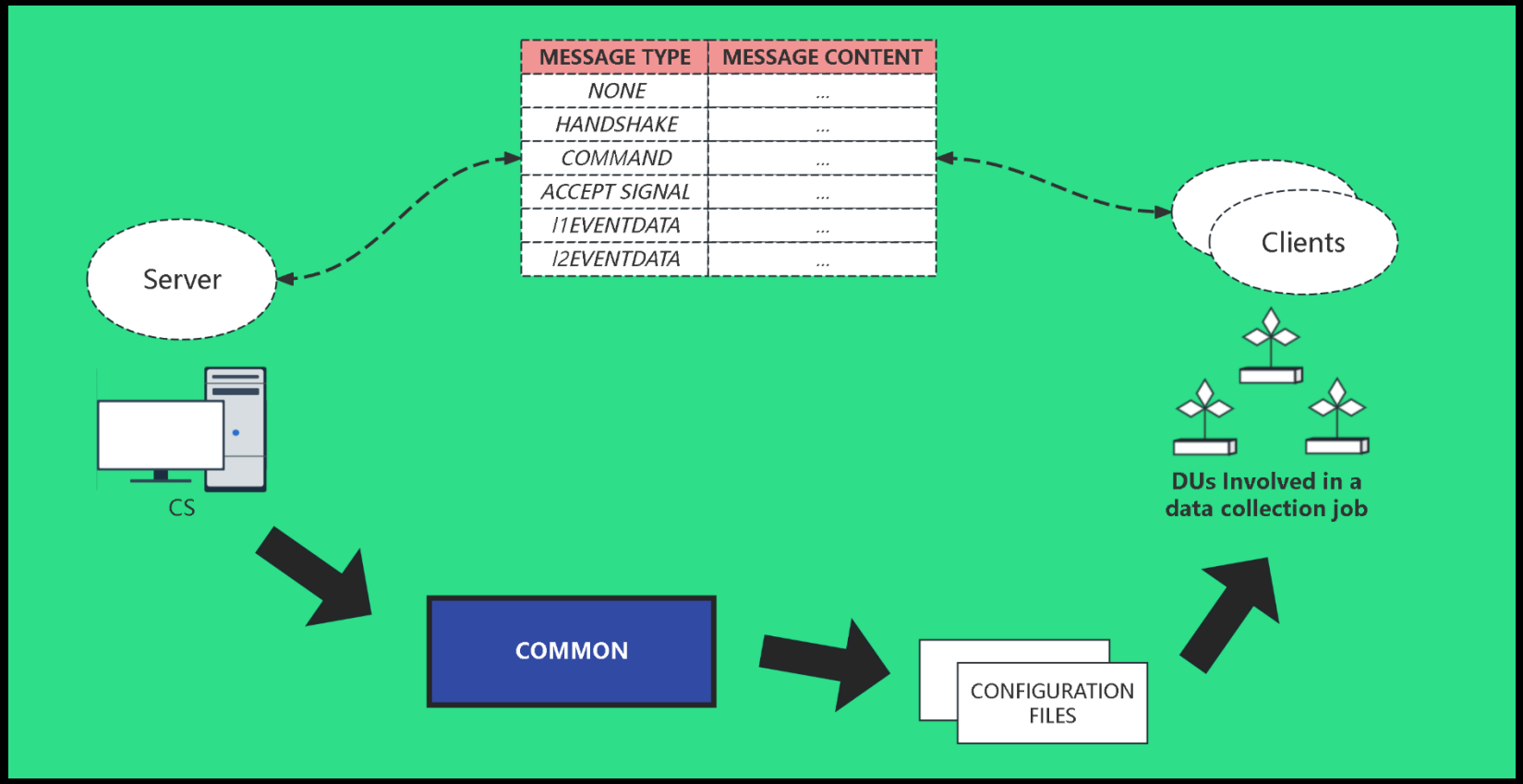
GRAND-DAQ consists of two parts: **DU-DAQ** and **CS-DAQ**. They are located at the central station (CS) of each detection unit (DU) and station respectively. The data stored in the central station is transmitted to PMO via the Internet

GRAND-DAQ: communication, 150Mbps in total for wireless throughput



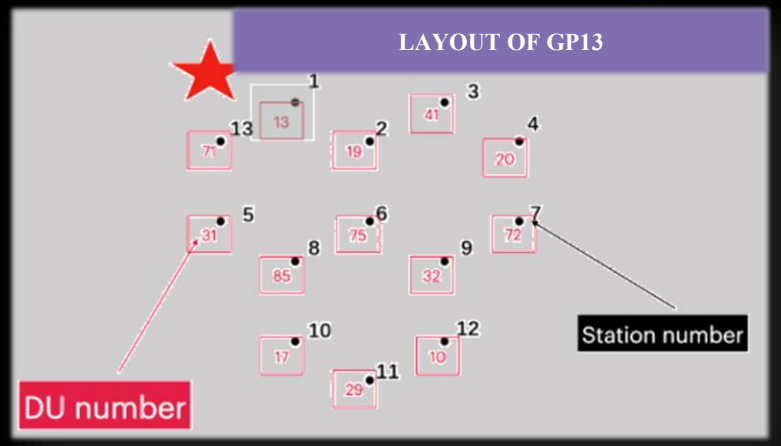
1. Easier to operate and handle communication errors
2. Provides multiple communication patterns: PUSH-PULL, ROUTER-DEALER
3. Supports non-blocking and async messaging

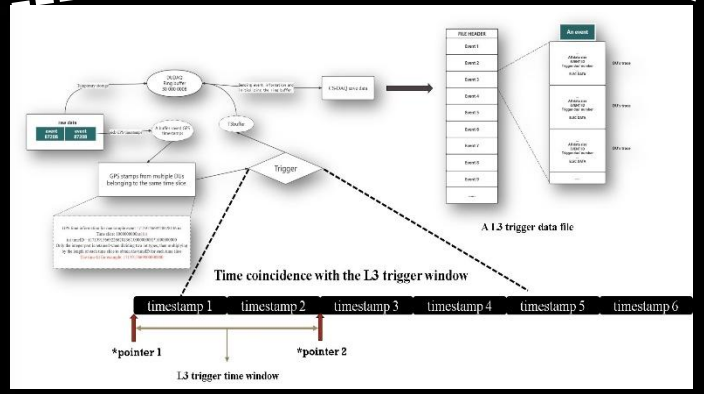
GRAND-DAQ: common module to manage the data flow



1. Defines the server and client roles.
2. Defines the message types.
3. Implements structured management of data streams.

Grand Prototype 13

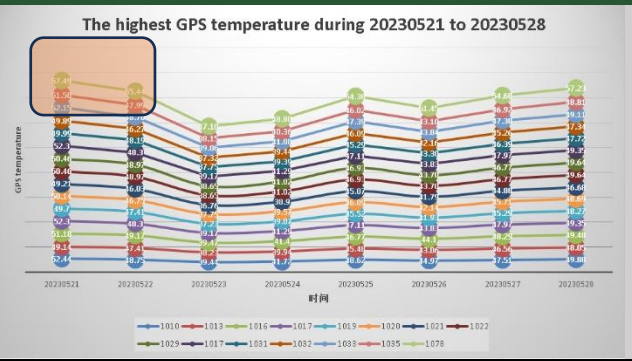




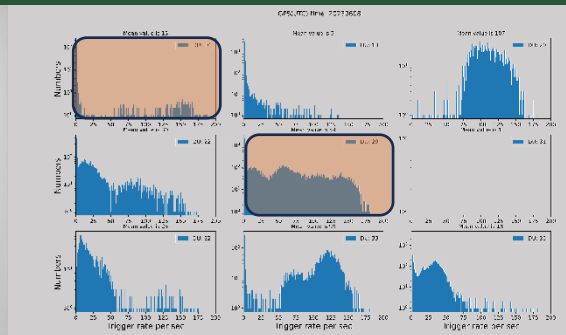
Two working modes are provided:

1. **T1 trigger:** CS directly collects data that meets the triggering conditions for a single DU
2. **T3 trigger:** CS only collects data that meets the online algorithm requirements

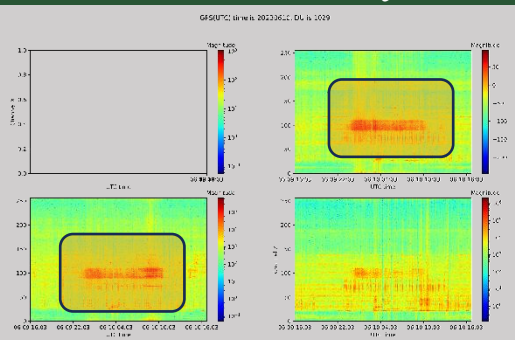
Heat issue



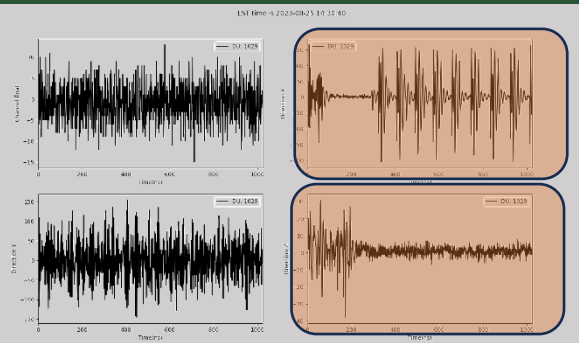
Noise level varies



FM/AM too noisy

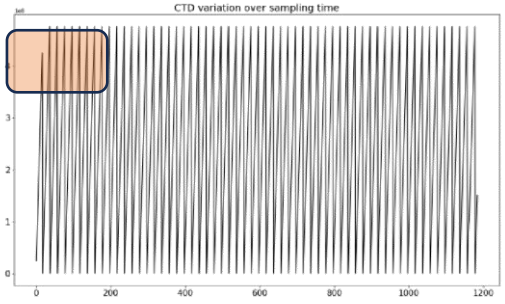


LNA broken

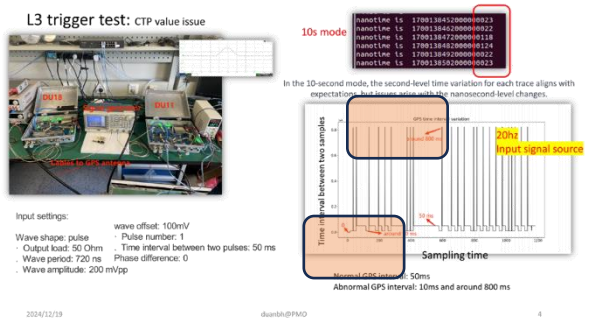


Grand Prototype 13

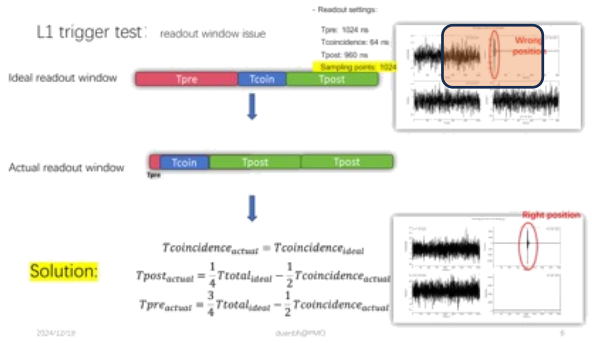
CTD issue



CTP issue



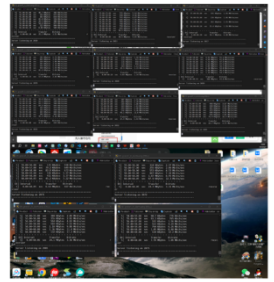
Readout position issue



Throughput issue

P2MP throughput test 1:13

1. The lowest average throughput is DU 31 at 639Kbps, and the highest is DU 29 at 43MbpsThe lowest average throughput is DU 31 at 639Kbps, and the highest is DU 29 at 43MbpsThroughput is obviously not balanced
2. Average trigger rate: 20HZ
3. Total trigger rate: around 300Hz
4. Far below the top limit allowed by the system



T1 Package Loss

total traces：Select all the traces that the data should have on that day (taking into account the situation where the hitid is less than the last hitid of the old task when restarting a new task on that day)

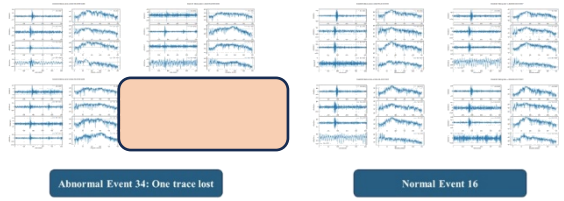
count traces: Actually, the number of traces recorded

Loss package rate

All operating modes are L1 mode

Summary:
Before August 4th, packet loss occurred when only the 29th DU was a new firmware
On August 8th, all units experienced varying degrees of packet loss, with the most severe being DU17, with a packet loss rate of 44.37%
On August 15th, there was a small probability of packet loss, DU29: 5.49%, DU 19: 0.39%No packet loss occurred on other dates

T3 Package Loss



T3 online trigger test

Create a time sliding window and use offline analysis to check for online T3 triggers

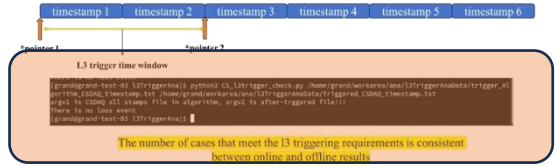
500hz!! L3 trigger window 1000ns, ignition DU number>=2

1. Generate two files on the PC end

1. trigger_Algorithm_CSDAQ_timestamp.txt
All timestamps from two DUs before triggering

2. Triggered_CSDAQ_timestamp.txt
The timestamps of two DUs from the same instance after triggering are provided online by the triggering algorithm

2. Offline T3 trigger



The number of cases that meet the l3 triggering requirements is consistent between online and offline results

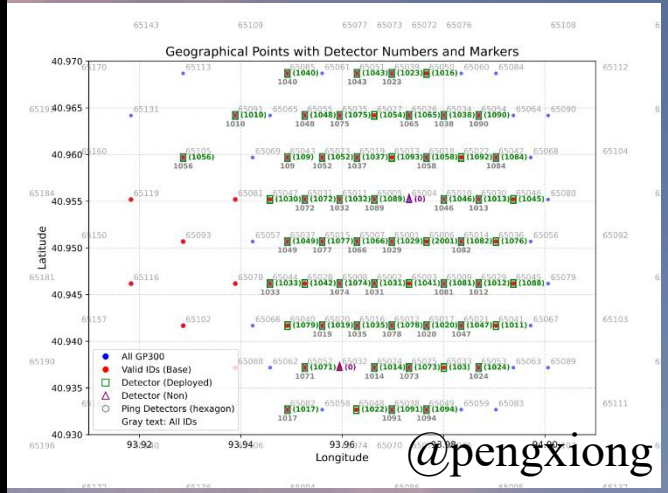
Prepare for GP80

For a year and a half, we have continuously optimized the links and enhanced our understanding of the whole system, constantly solving problems that arise in actual construction. So far, most of the challenges have been resolved, but we still need to reduce the impact of links and background noise, so that the system has the ability to capture cosmic rays and enhance its robustness and reliability. With the continuous expansion of the array, more demands need to be met, and optimization work is still ongoing.

Grand Prototype 80

Complete FEB board testing before GP35 installation at Xi'an University of Electronic Science and Technology in **August 2024**

Quick checks before installing



@pengxiong

35 DUs were installed by the end of **October 2024**

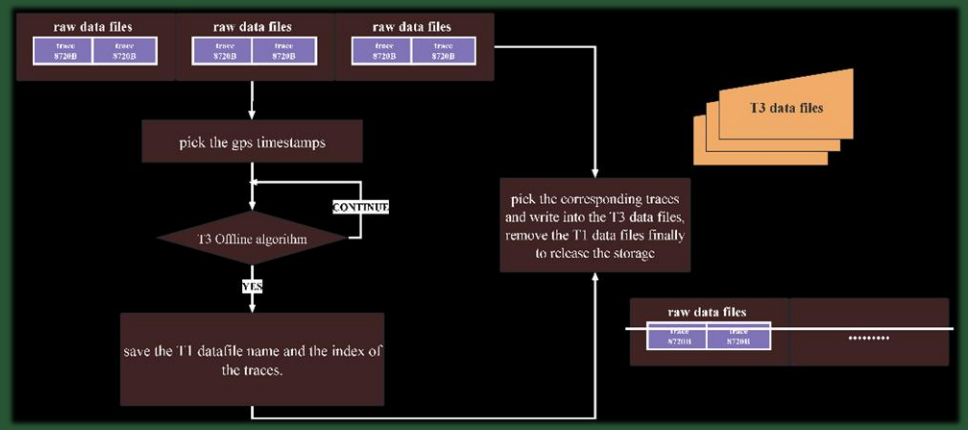
New rockets and FEB boards are deployed

Preliminary testing of GP35 was conducted in **November 2024**, and some issues on the links were resolved

Optimized network throughput: It can **reach about 2000Hz**, with a single data length of **8720B**

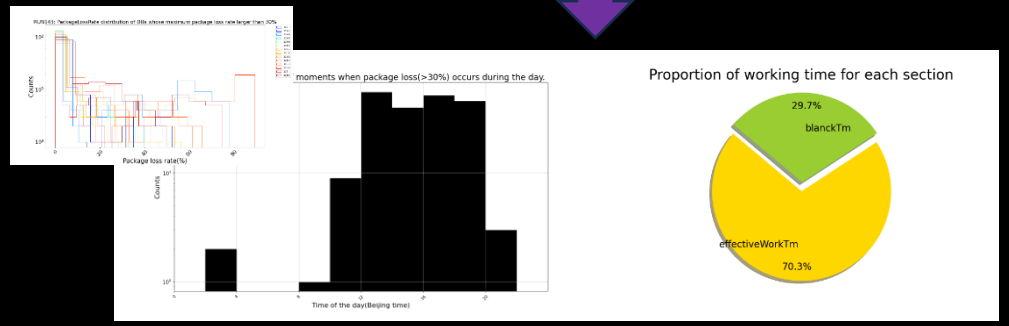
Balance the status of bullets
Choose the proper ZMQ parameter

Grand Prototype 80: GP35

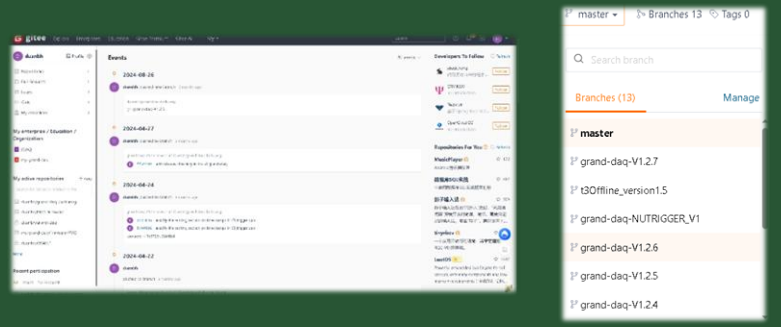


T3 offline Nov 2024, optimized by Lech March 2025

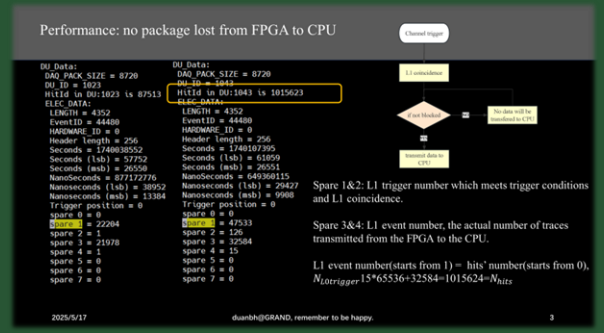
Trigger rate | Package Loss | LOG info



If Nevent > 1Hz Or watch dog operates: 4 dus' trigger rate > 300Hz



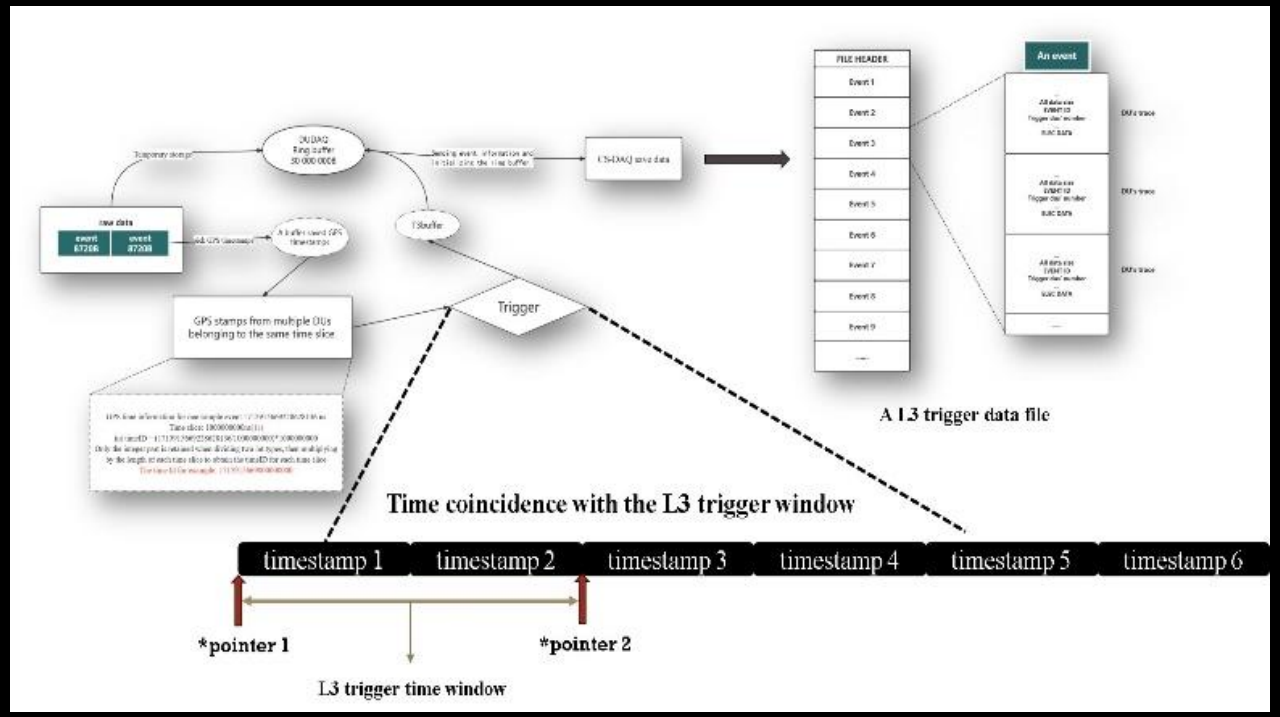
- Integrated the L2 module into GRAND-DAQ and released it on Gitee.
- The optimized GRAND-DAQ will continue to be uploaded here.



Firmware updates and tests: On the FPGA-to-CPU link, the software can achieve 100% packet capture.

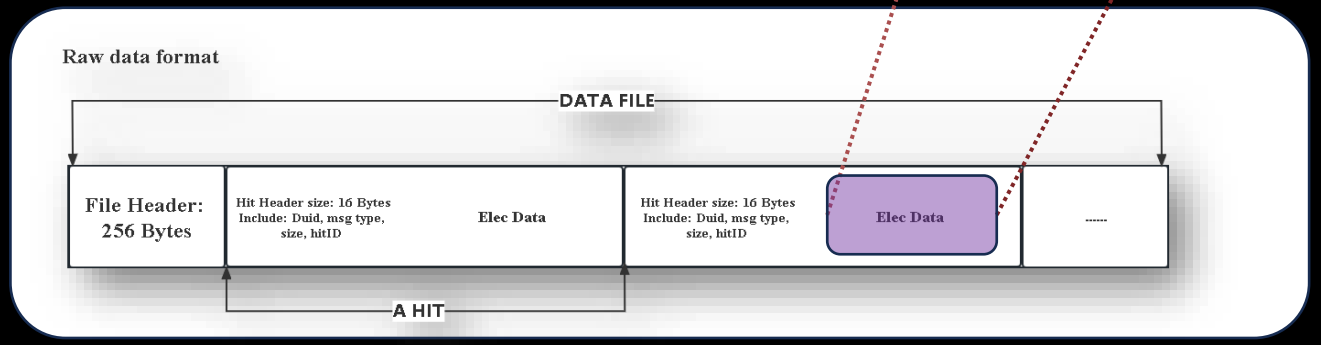
Grand Prototype 80

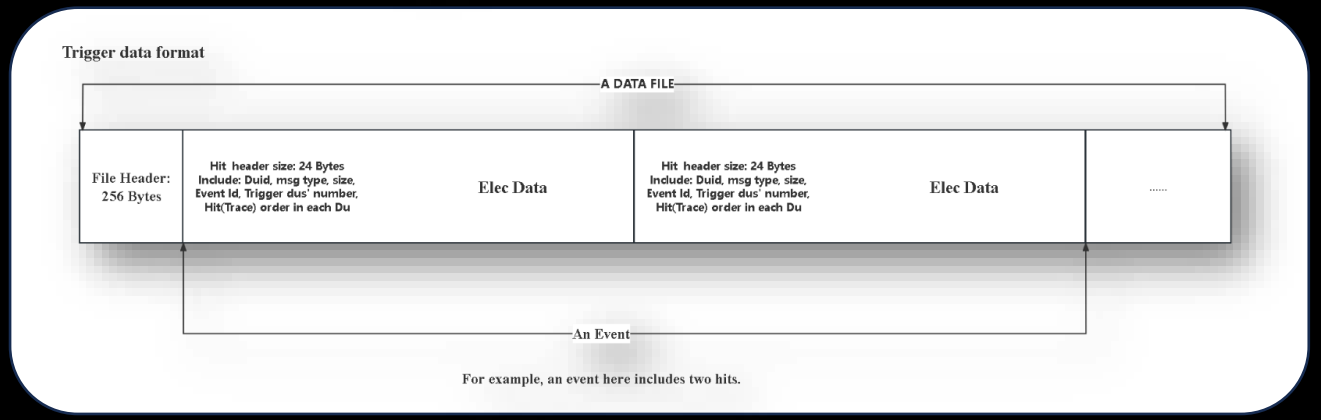
Updates Online CD with the help of Lech!

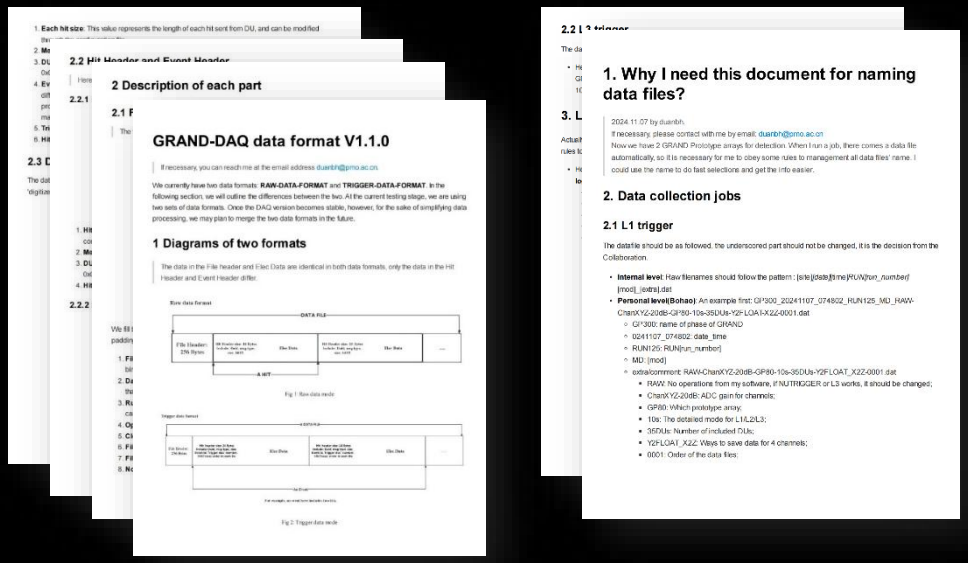


- Restructure the data storage format to reduce the number of iterations and minimize redundant data copying.
- An active window mechanism was used.
- Temporarily avoided potential resource allocation conflicts caused by high CPU usage.
- Implemented port monitoring in the communication module, thereby preventing port blockage issues caused by unexpected DU-side exits.

Data







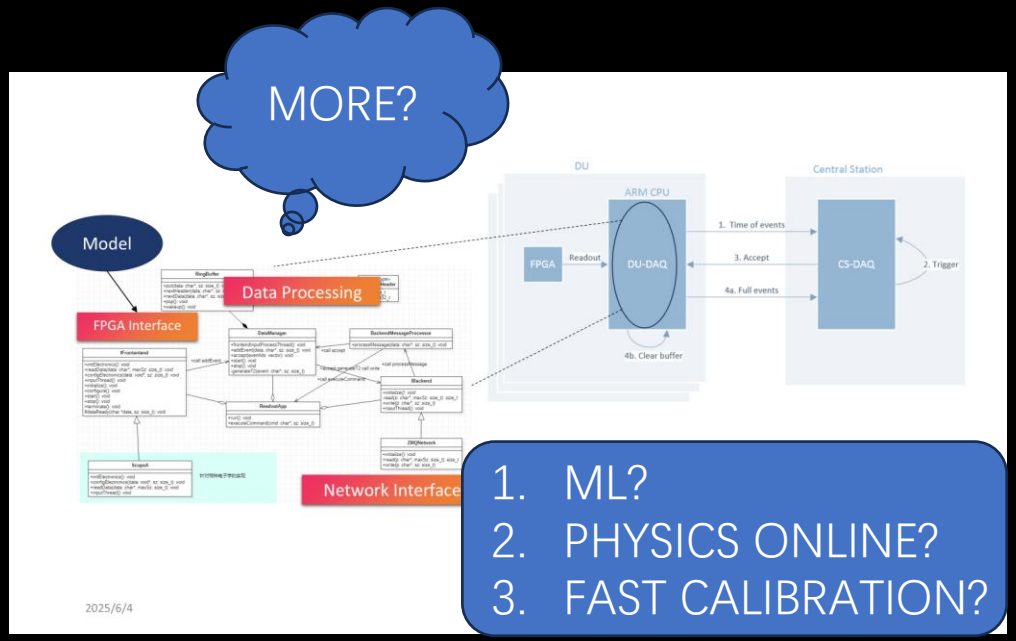
I have released two data structures:
- T1 mode
- T3 mode

And I created a document on naming data files.

Summary

Achievements:

1. T1 and T3 trigger
2. Multi-terminal control
3. Storing different types of data as needed
4. Monitoring of trigger rate and packet loss rate
5. Integration of external modules
6. Dealing with communication issues
7. State switching under high trigger rates, etc



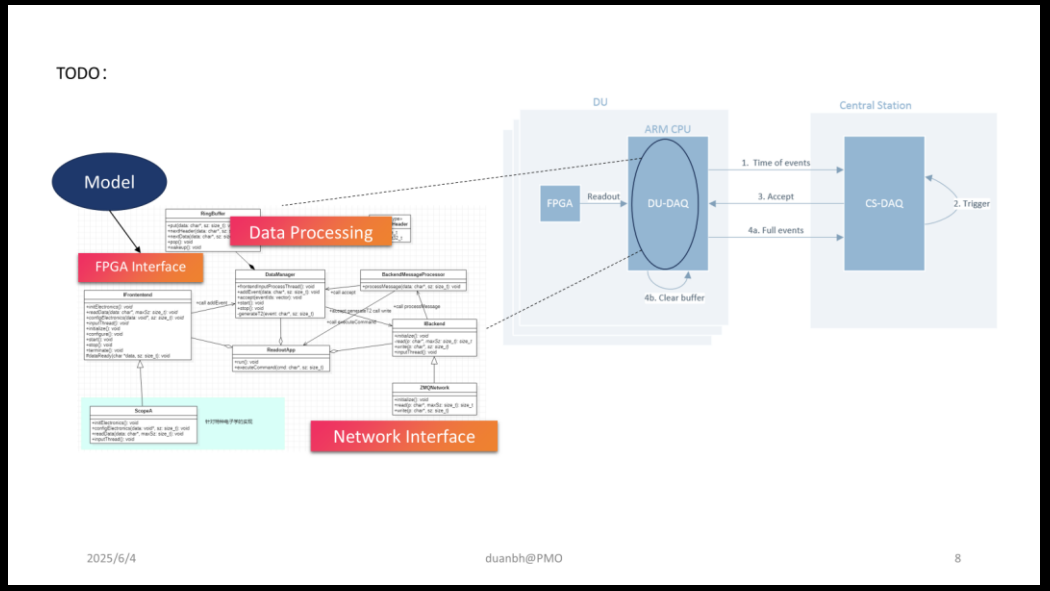
TODO list:

1. Free memory occupied by redundant pointers to reduce CPU load (Simple)
   - Redefine data types within the software.
   - Balance the consumptions of different modules to fully use the CPU resource
2. Automatically re-establish the software connection when the FEB board CPU restarts.
   - It is now possible to avoid runtime exceptions caused by DU exits and attempt to restore the socket connection(Robust and Reliable)
3. Meet more requirements(Modularity)
   - Data save requirement
   - Modules integrated
   - Updates and tests

Summary

At present, we have accomplished full-process acquisition of data streams, leading to a deeper understanding of the data. Iterative improvements are ongoing, and our objectives are well-defined.

In my view, the software is inherently rich in functionality and provides interfaces at multiple levels. I hope to incorporate new elements into it, enabling us to obtain more results during the online phase — or even assist in initial decision-making or calibration.



Working with interesting people is a wonderful thing