

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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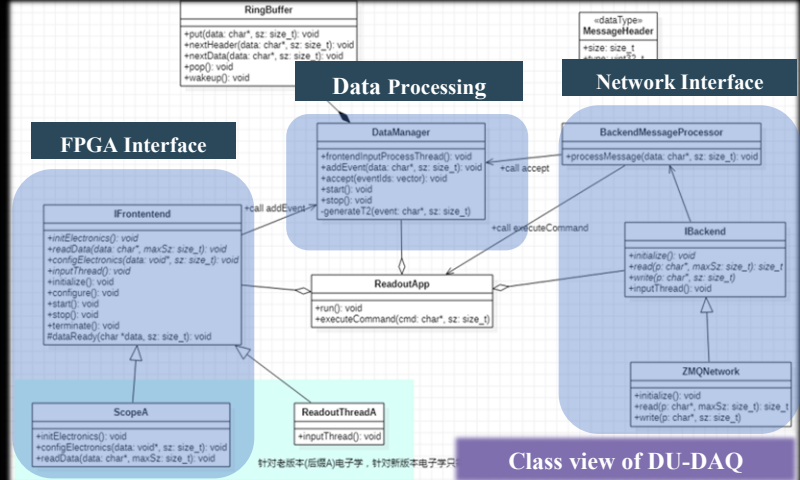
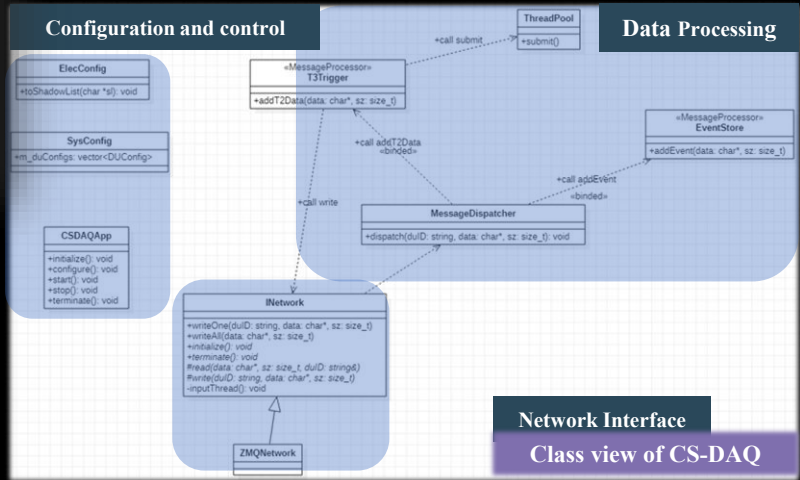
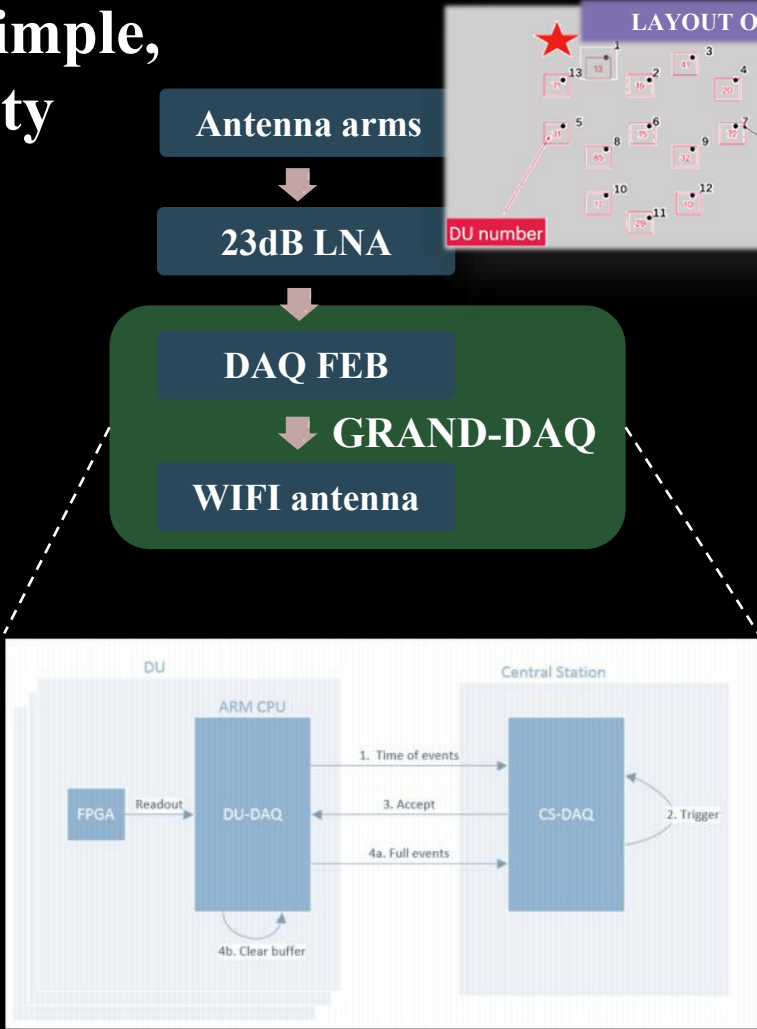
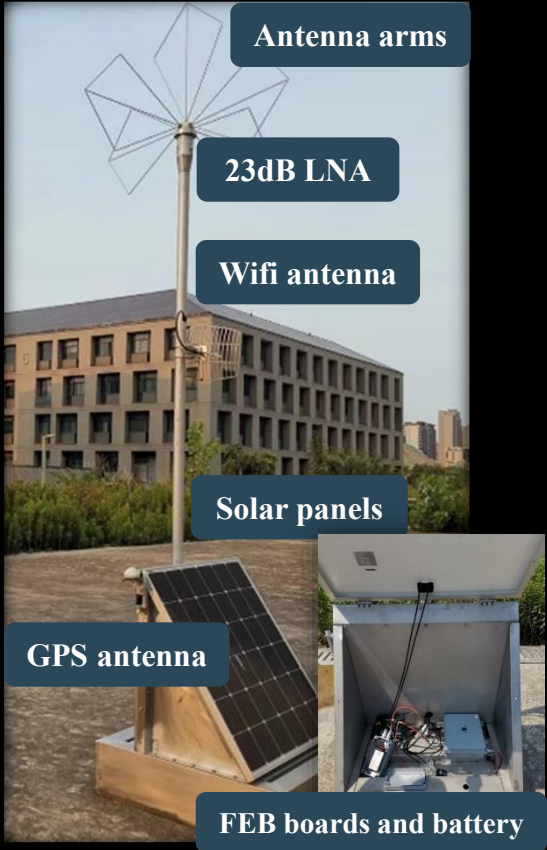
Warsaw, Poland

2025 06 03

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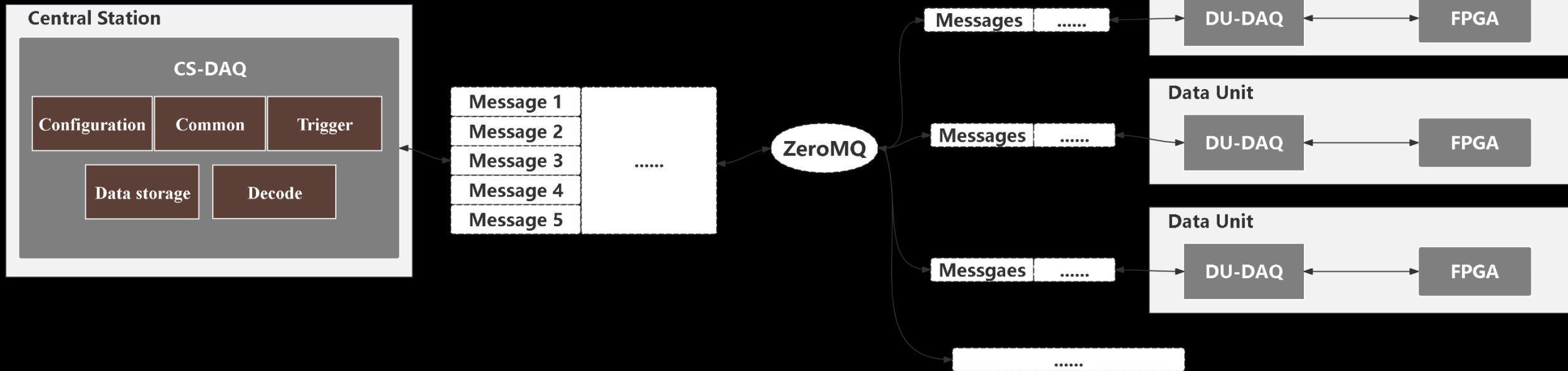
GRAND- DAQ	Grand Prototype 13	Grand Prototype 80	Data	Summary
01	02	03	04	05

GRAND-DAQ: Robust, simple, reliable and modularity



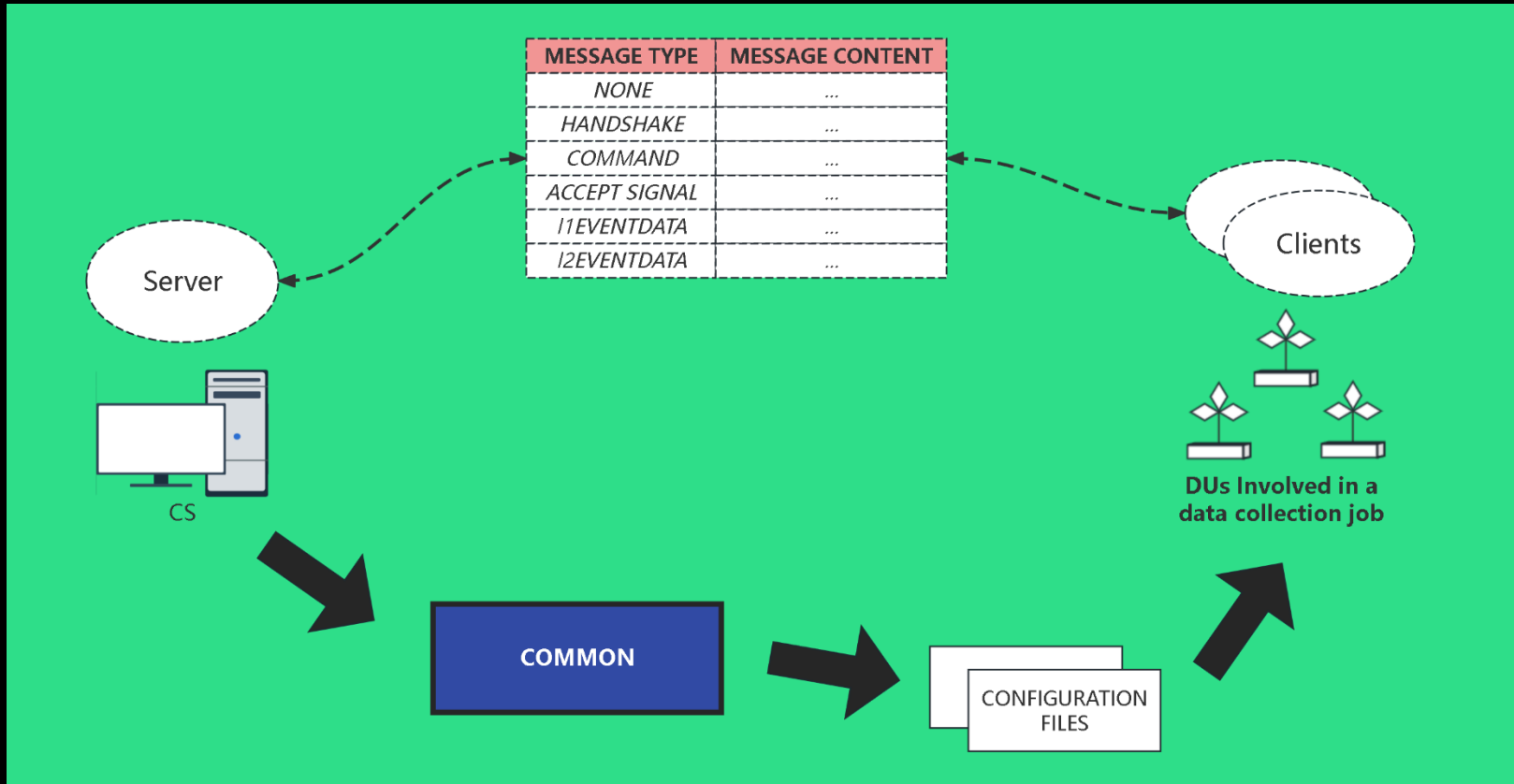
GRAND-DAQ consists of two parts: **DU-DAQ** and **CS-DAQ**. They are located at the central station (CS) of each detection unit (DU) and station respectively. The data stored in the central station is transmitted to PMO via the Internet

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

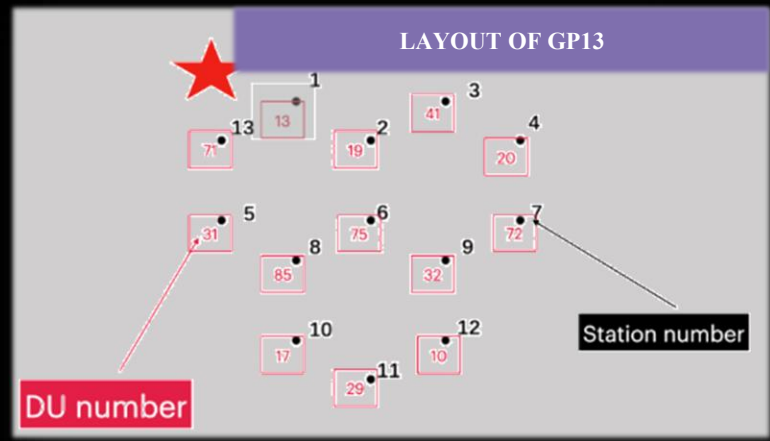
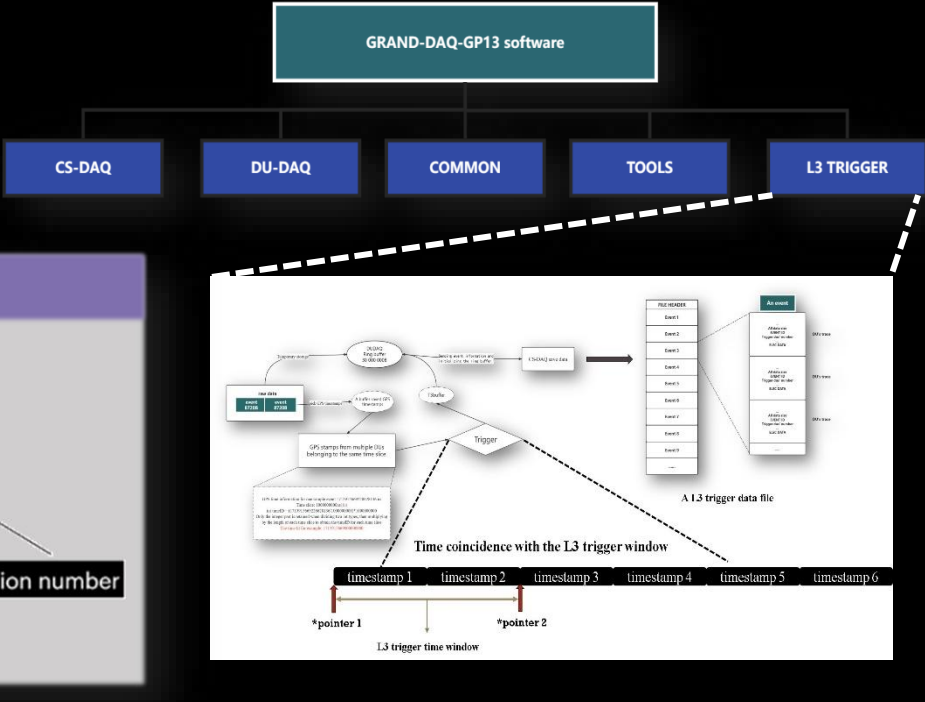


1. Defines the server and client roles.

2. Defines the message types.

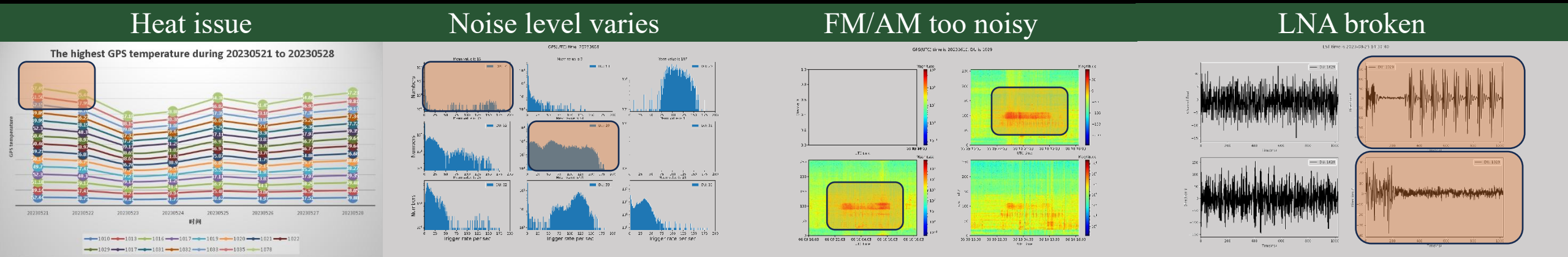
3. Implements structured management of data streams.

Grand Prototype 13



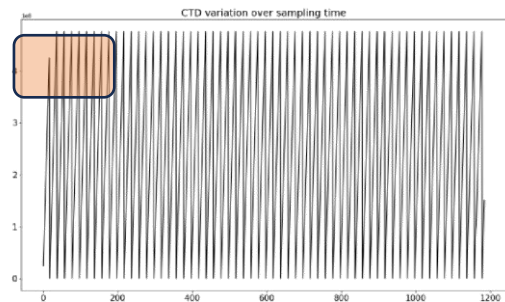
Two working modes are provided:

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

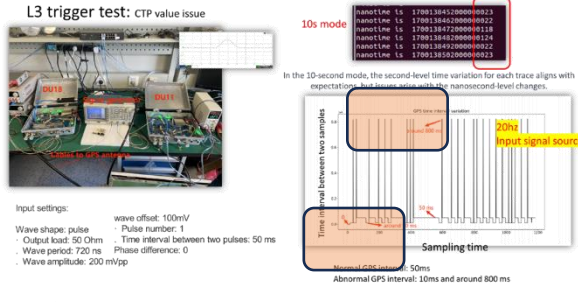


Grand Prototype 13

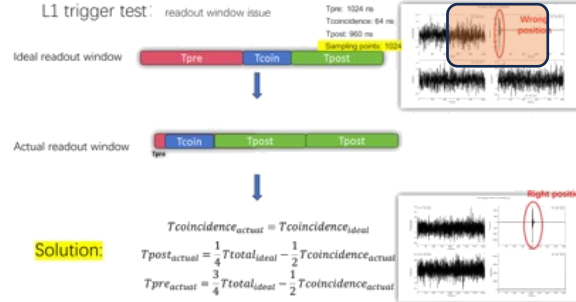
CTD issue



CTP issue



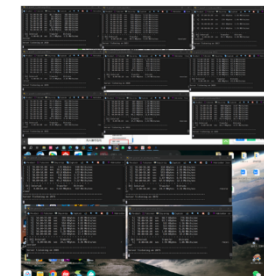
Readout position issue



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: 201Hz
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

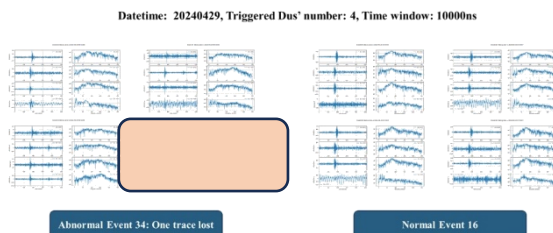
All operating modes are L1 mode

Aug 8th

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

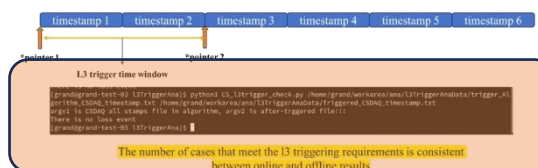
Create a time sliding window and use offline analysis to check for online T3 triggers

1. Generate two files on the PC end

1. trigger_algorithm_timestamp.txt

All timestamps from two DUs before triggering

2. Offline T3 trigger



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



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



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

New rockets and FEB boards are deployed

About the updates of throughput,

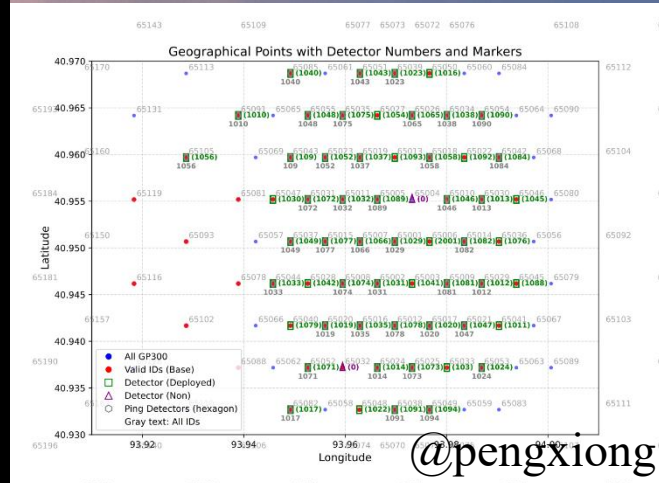
1. Trigger rate can reach **around 2000Hz** for L1 data collection in total, when the length of each trace is **8.7KB**
2. Main updates for the whole systems are:
 - Change the **priorities of all Bullets** to the base level, so there is no difference for the transfer rate.
 - I have changed the **options for ZeroMQ** in network control of data transmission



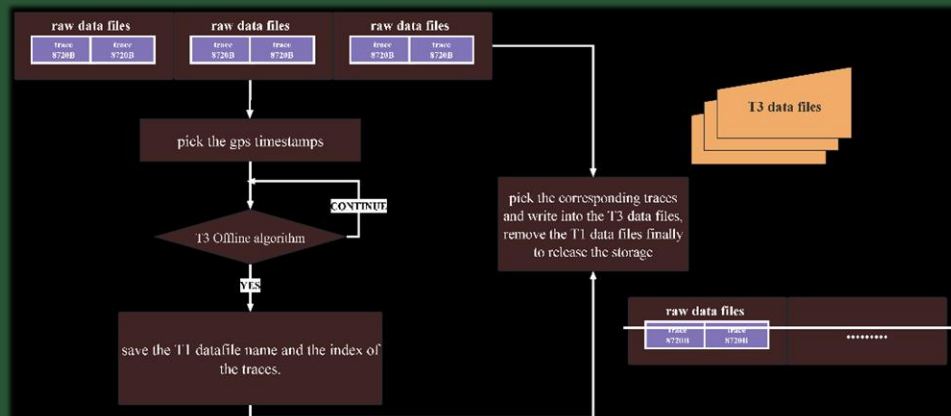
Optimized network throughput:
It can **reach about 2000Hz**, with
a single data length of **8720B**

Balance the status of bullets

Choose the proper ZMQ parameter



Grand Prototype 80: GP35

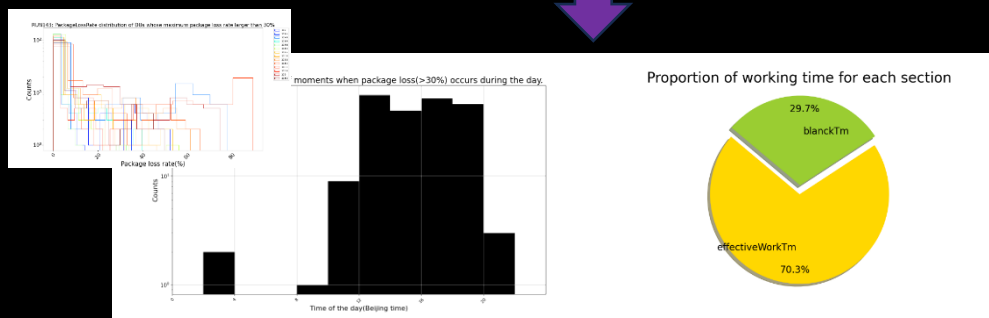


T3 offline Nov 2024, optimized by Lech March 2025

Trigger rate

Package Loss

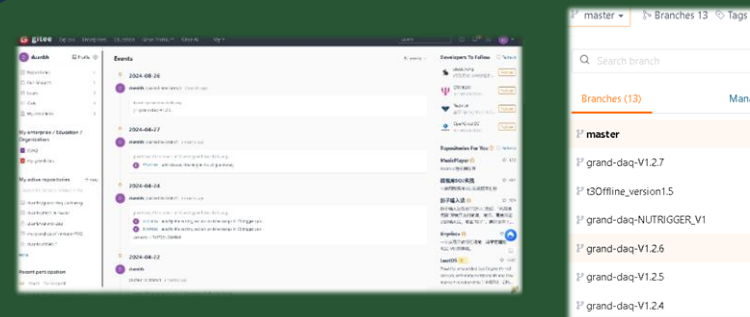
LOG info



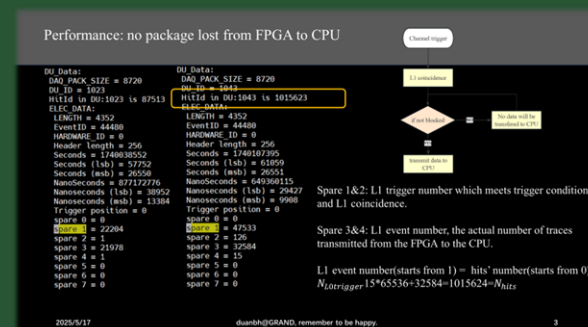
If Nevent > 1Hz Or watch dog operates: 4 dus'
trigger rate > 300Hz

2025/6/4

duanbh@GRAND, remember to be happy



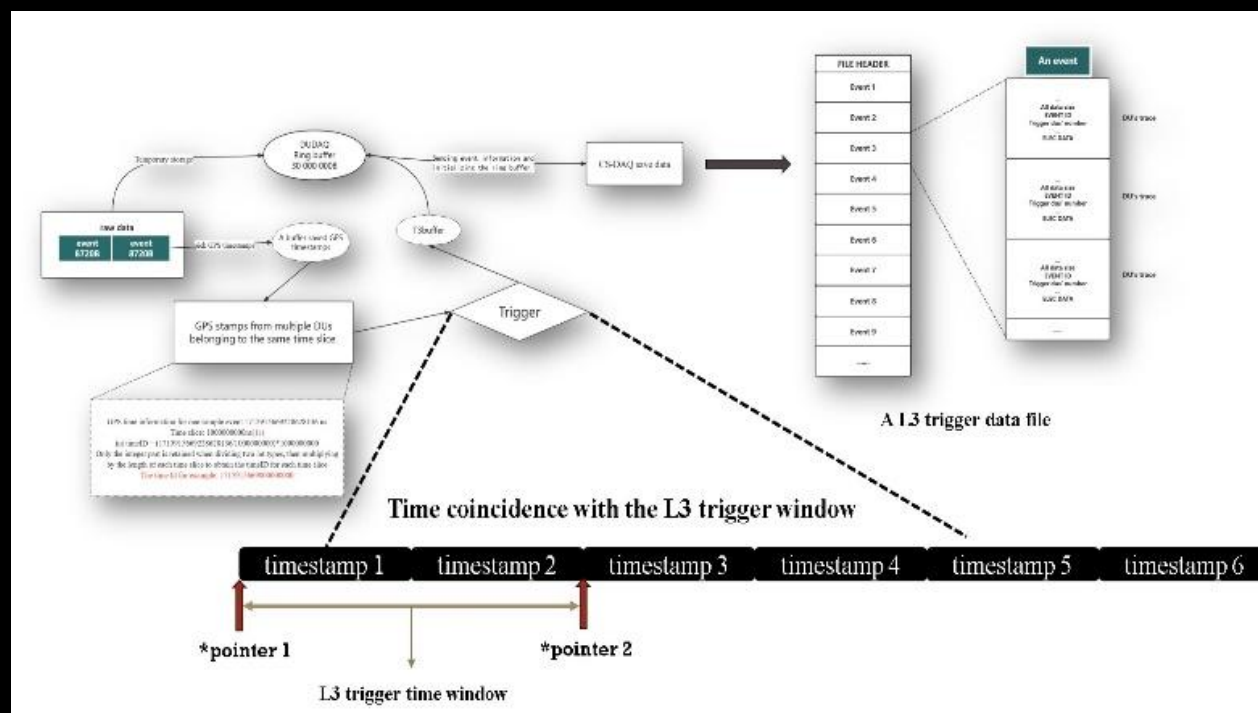
- Integrated the L2 module into GRAND-DAQ and released it on Gitee.
- The optimized GRAND-DAQ will continue to be uploaded here.



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

Grand Prototype 80

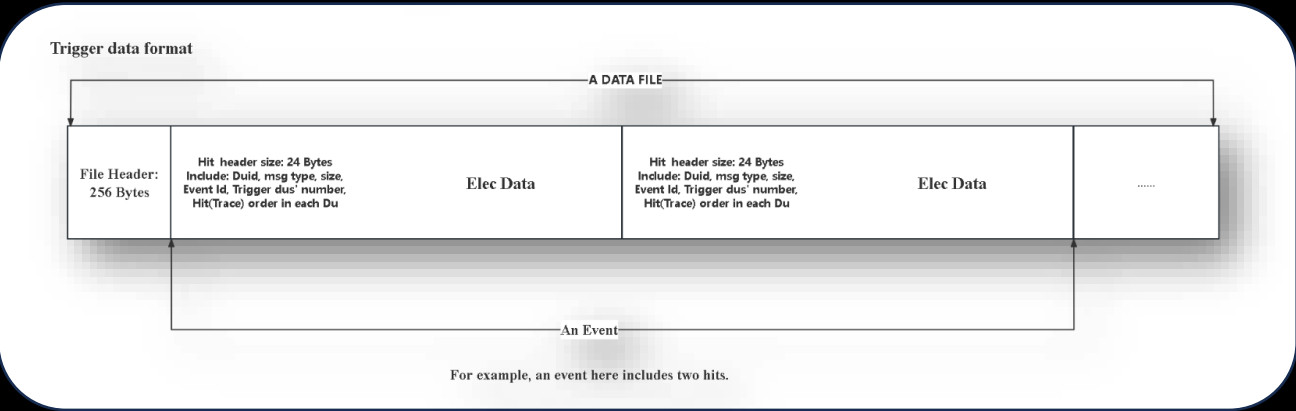
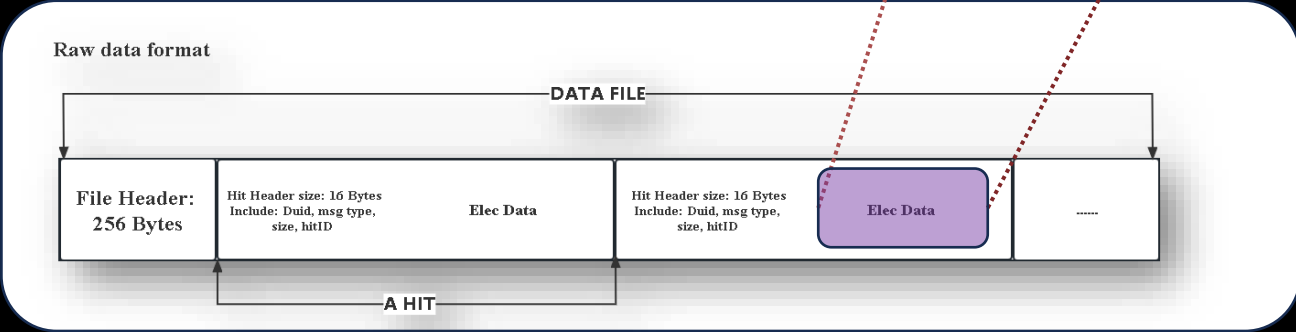
Updates Online CD with the help of Lech!



- 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.

2.2.1 Hit Header and Event Header

1. Hit Header size: 16 Bytes	1. Hit Header size: 16 Bytes
2. Hit Header size: 16 Bytes	2. Hit Header size: 16 Bytes
3. Hit Header size: 16 Bytes	3. Hit Header size: 16 Bytes
4. Hit Header size: 16 Bytes	4. Hit Header size: 16 Bytes
5. Hit Header size: 16 Bytes	5. Hit Header size: 16 Bytes
6. Hit Header size: 16 Bytes	6. Hit Header size: 16 Bytes
7. Hit Header size: 16 Bytes	7. Hit Header size: 16 Bytes
8. Hit Header size: 16 Bytes	8. Hit Header size: 16 Bytes
9. Hit Header size: 16 Bytes	9. Hit Header size: 16 Bytes
10. Hit Header size: 16 Bytes	10. Hit Header size: 16 Bytes
11. Hit Header size: 16 Bytes	11. Hit Header size: 16 Bytes
12. Hit Header size: 16 Bytes	12. Hit Header size: 16 Bytes
13. Hit Header size: 16 Bytes	13. Hit Header size: 16 Bytes
14. Hit Header size: 16 Bytes	14. Hit Header size: 16 Bytes
15. Hit Header size: 16 Bytes	15. Hit Header size: 16 Bytes
16. Hit Header size: 16 Bytes	16. Hit Header size: 16 Bytes
17. Hit Header size: 16 Bytes	17. Hit Header size: 16 Bytes
18. Hit Header size: 16 Bytes	18. Hit Header size: 16 Bytes
19. Hit Header size: 16 Bytes	19. Hit Header size: 16 Bytes
20. Hit Header size: 16 Bytes	20. Hit Header size: 16 Bytes
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27. Hit Header size: 16 Bytes	27. Hit Header size: 16 Bytes
28. Hit Header size: 16 Bytes	28. Hit Header size: 16 Bytes
29. Hit Header size: 16 Bytes	29. Hit Header size: 16 Bytes
30. Hit Header size: 16 Bytes	30. Hit Header size: 16 Bytes
31. Hit Header size: 16 Bytes	31. Hit Header size: 16 Bytes
32. Hit Header size: 16 Bytes	32. Hit Header size: 16 Bytes
33. Hit Header size: 16 Bytes	33. Hit Header size: 16 Bytes
34. Hit Header size: 16 Bytes	34. Hit Header size: 16 Bytes
35. Hit Header size: 16 Bytes	35. Hit Header size: 16 Bytes
36. Hit Header size: 16 Bytes	36. Hit Header size: 16 Bytes
37. Hit Header size: 16 Bytes	37. Hit Header size: 16 Bytes
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86. Hit Header size: 16 Bytes	86. Hit Header size: 16 Bytes
87. Hit Header size: 16 Bytes	87. Hit Header size: 16 Bytes
88. Hit Header size: 16 Bytes	88. Hit Header size: 16 Bytes
89. Hit Header size: 16 Bytes	89. Hit Header size: 16 Bytes
90. Hit Header size: 16 Bytes	90. Hit Header size: 16 Bytes
91. Hit Header size: 16 Bytes	91. Hit Header size: 16 Bytes
92. Hit Header size: 16 Bytes	92. Hit Header size: 16 Bytes
93. Hit Header size: 16 Bytes	93. Hit Header size: 16 Bytes
94. Hit Header size: 16 Bytes	94. Hit Header size: 16 Bytes
95. Hit Header size: 16 Bytes	95. Hit Header size: 16 Bytes
96. Hit Header size: 16 Bytes	96. Hit Header size: 16 Bytes
97. Hit Header size: 16 Bytes	97. Hit Header size: 16 Bytes
98. Hit Header size: 16 Bytes	98. Hit Header size: 16 Bytes
99. Hit Header size: 16 Bytes	99. Hit Header size: 16 Bytes
100. Hit Header size: 16 Bytes	100. Hit Header size: 16 Bytes



1. Each Hit size: This value represents the length of each Hit sent from DU, and can be modified

2.2 Hit Header and Event Header

2 Description of each part

2.1 f

GRAND-DAQ data format V1.1.0

If necessary, you can reach me at the email address duanh@pmo.ac.cn.

We currently have two data formats: RAW-DATA-FORMAT and TRIGGER-DATA-FORMAT. In the following section, we will outline the differences between the two. At the current testing stage, we are using two sets of data formats. Once the DAQ system becomes stable, however, for the sake of simplifying data processing, we may plan to merge the two data formats in the future.

1 Diagrams of two formats

The data in the File header and Elec Data are identical in both data formats, only the data in the Hit Header and Event Header differ.

Raw data format

Trigger data format

2.2 1.1 trigger

1. Why I need this document for naming data files?

2024.11.07 by duanh,

If necessary please contact with me by email: duanh@pmo.ac.cn

Now we have 2 GRAND Prototypes arrays for detection. When I run a job, there comes a data file automatically so it's necessary for me to copy some rules to management all data files' name. I could use the name to do fast selection and get the info easier.

2. Data collection jobs

2.1 L1 trigger

The datafile should be as followed, the underscored part should not be changed, it is the decision from the Collaboration.

- Internal level: Raw filenames should follow the pattern: `[site][job].[time].PUN[run_number].[mode].data`
- Personal level (Bohao): An example first: `GP100_20241107_074802_HUN125_MD_160V-ChanXVZ-2008-GP100-10p-35DUu-YZFLOAT_XZZ-0001.dat`
 - GP100: name of phase of GRAND
 - 20241107_074802: date, time
 - HUN125: RUN[run_number]
 - MD: [mode]
 - external comment: RAW-ChanXVZ-2008-GP100-10p-35DUu-YZFLOAT_XZZ-0001.dat
 - RAW: no operations from my software, if NOT TRIGGER or L1 works, it should be changed;
 - ChanXVZ-2008: ADC gain for channels;
 - GP100: Which prototype array;
 - 10p: The detailed mode for L1L2L3;
 - 35DUu: Number of included DUs;
 - YZFLOAT_XZZ: Values to save data for 4 channels;
 - 0001: Order of the data files.

I have released two data structures:

- T1 mode
- T3 mode

And I created a document on naming data files.

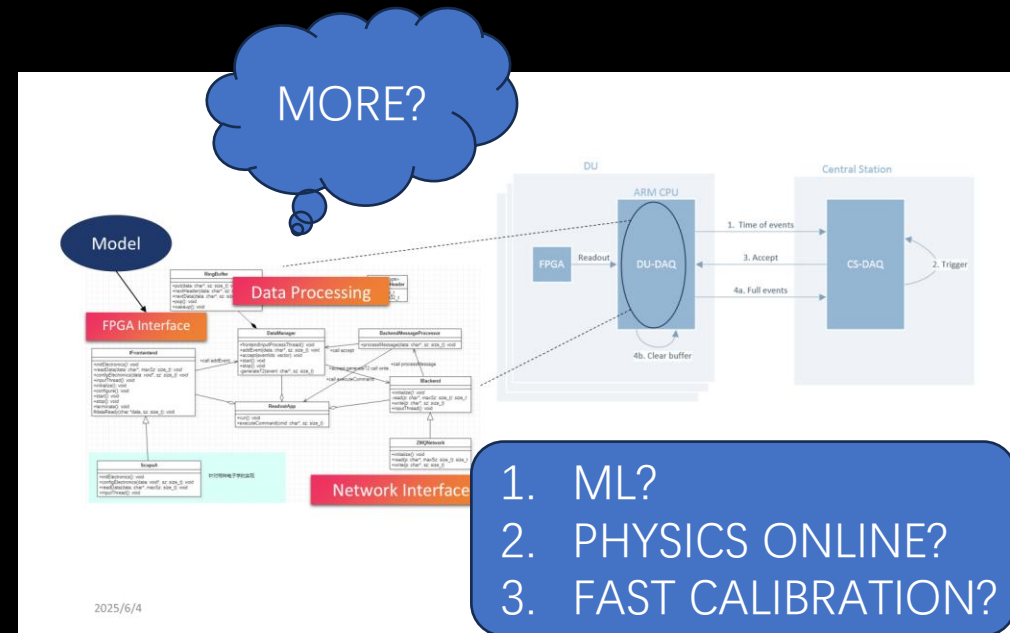
Summary

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.

