

# GP300 FEB Upgrade (PMO Prototype V2)

## -- Design & Test --

Xing Xu

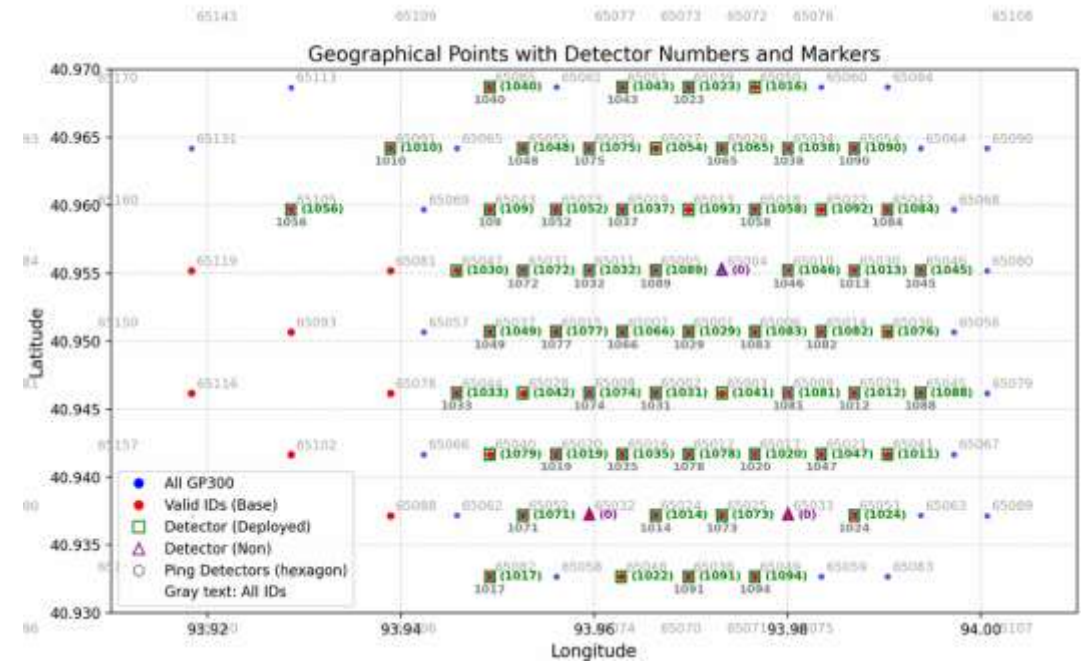
Purple Mountain Observatory, CAS

GRAND Collaboration Meeting    June, 2025

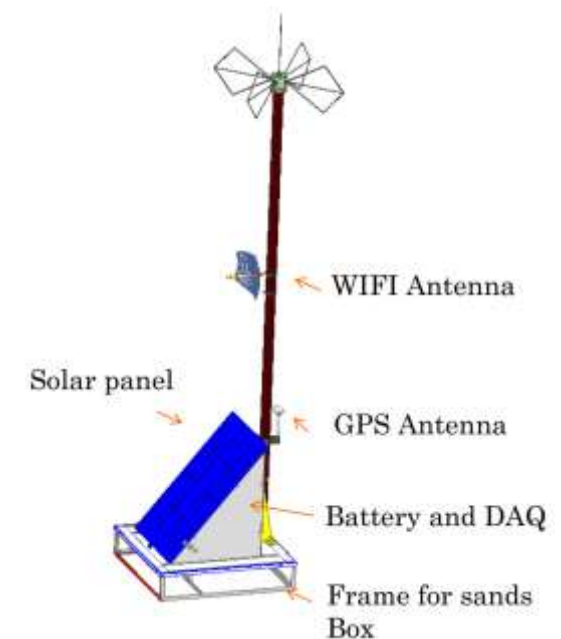
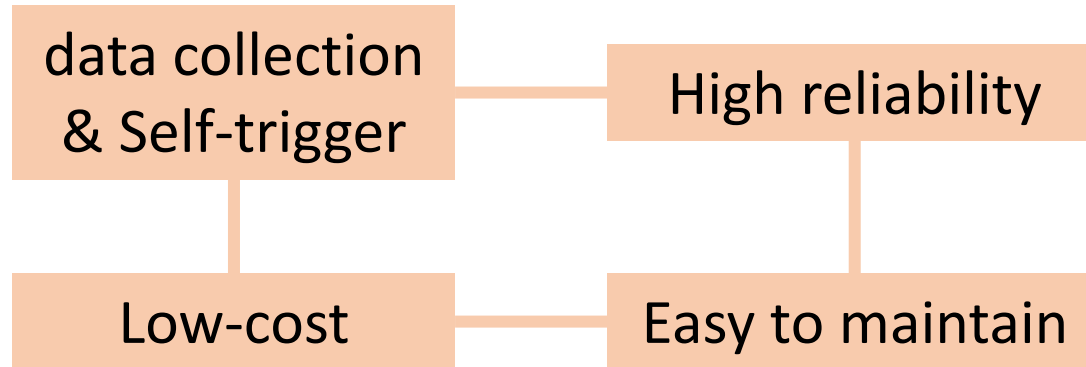
- Motivation
- Prototype V1
- Prototype V2
  - Hardware
  - Firmware
  - Software
  - Lab & Site Tests
- Summary and Future work

# What is GP300 ?

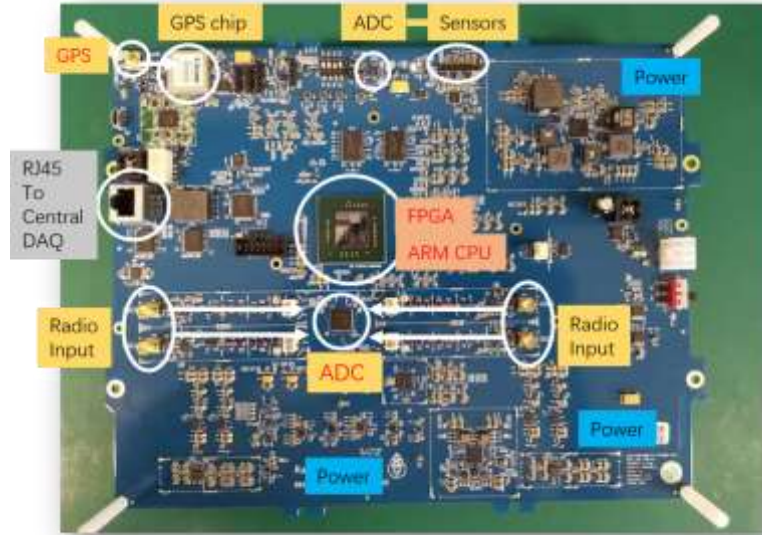
- Pathfinder of the GRAND10k
  - Detection strategy verification
- Targets
  - Collect event data of EAS events by UHECRs
  - Catch the typical event with Large zenith angle
  - Detection of solar bursts, FRB and other possible astronomical events



# What kind of electronics is desired ?



# GP100 Design

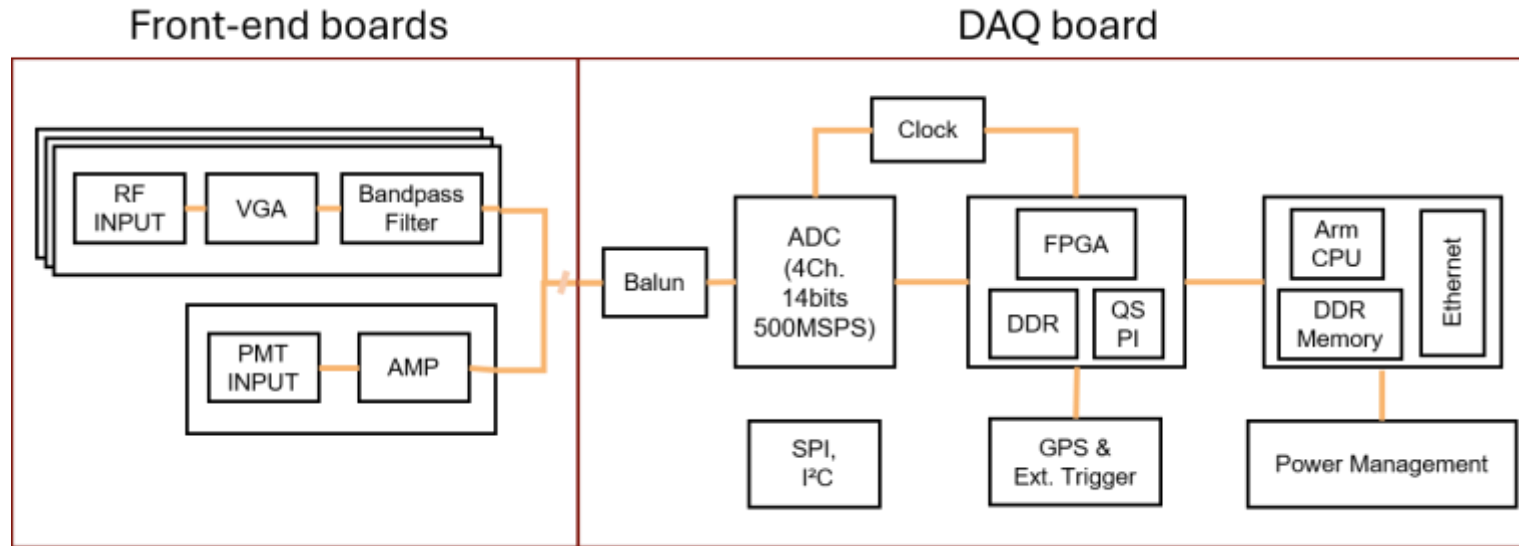


- ❑ Self-trigger & data collection (v)
    - ❑ 500MSPS, 14bits ADC
    - ❑ Xilinx ZYNQ MPSOC
    - ❑ Programmable trigger logic in firmware
    - ❑ GPS position and timing
- 

- ❑ High reliability
  - ❑ Heat dissipation
  - ❑ Housekeeping (self-recovery)
- ❑ Low-cost
  - ❑ Use cheaper chips to reduce cost furtherly
- ❑ Easy to maintain
  - ❑ Remote firmware update (v)
  - ❑ Modular design or integrated ?

➡ New design for GP300

# Prototype V1



- Separated FPGA and Arm CPU (Interacting through GPMC)
- Add readout for particle detector
- Verification of new GPS module (SKG172T)
- Works well on data collecting, digital filtering, and triggering

\* Details : ICRC2023 Proceeding <https://pos.sissa.it/444/1024/pdf>



# Timeline of upgrade design

V1 ADC Board



New ADC test



V2 FEB Board



V1 System test

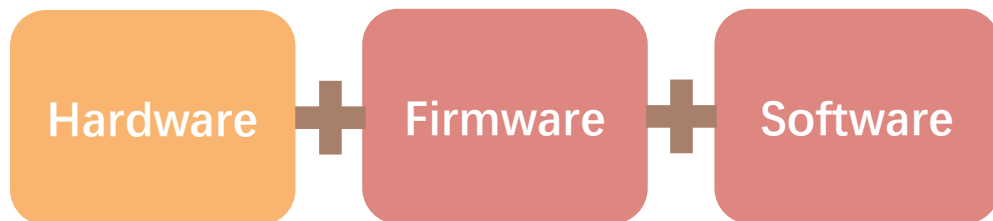


New Arm CPU test

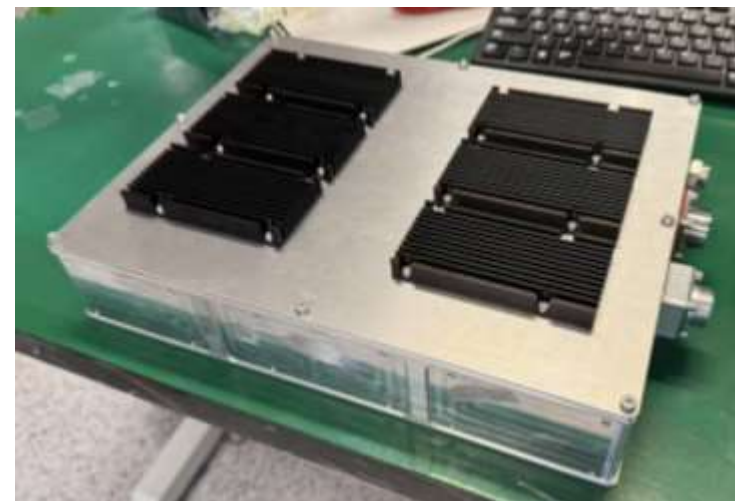


V2 System test

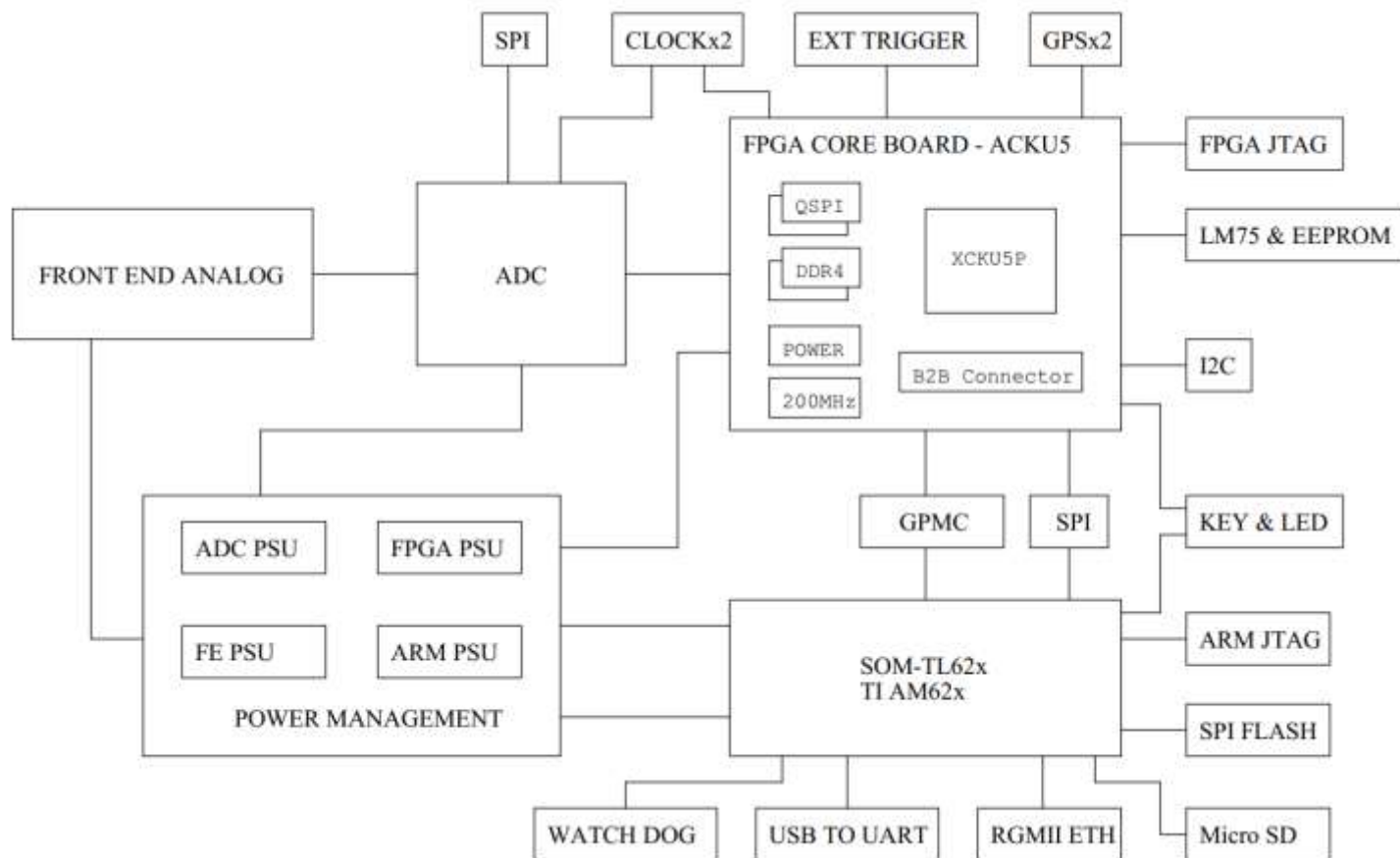
# Prototype V2



- Finished:
  - Chips soldering
  - Powers check
  - Clock config & check
  - GPS check
  - Arm Linux boot
  - Transfer cmd & data by GPMC
  - ADC Data collection
  - Simple ddaq & csdaq with GUI for lab/site test
  - New DAQ Box for site test



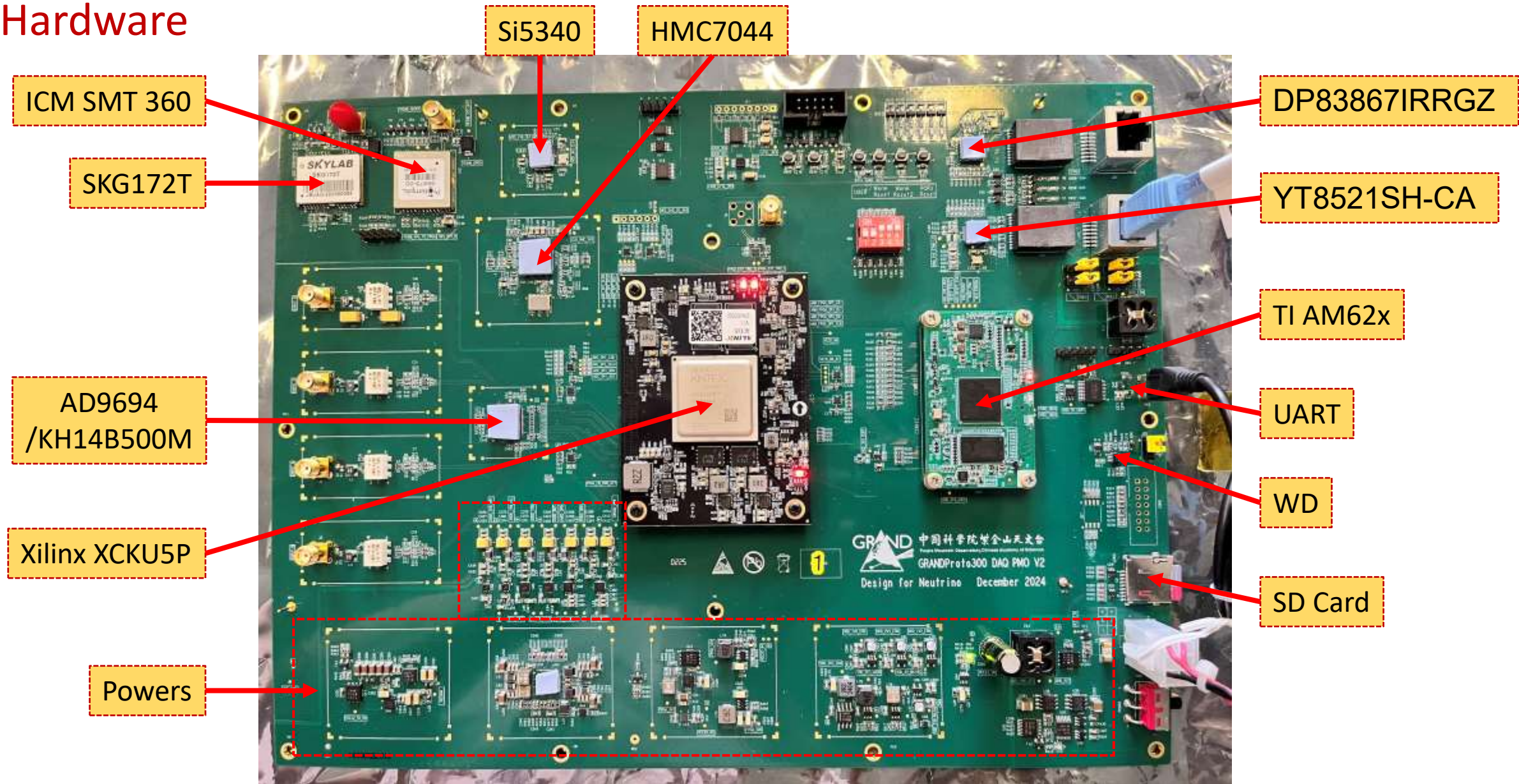
# Hardware



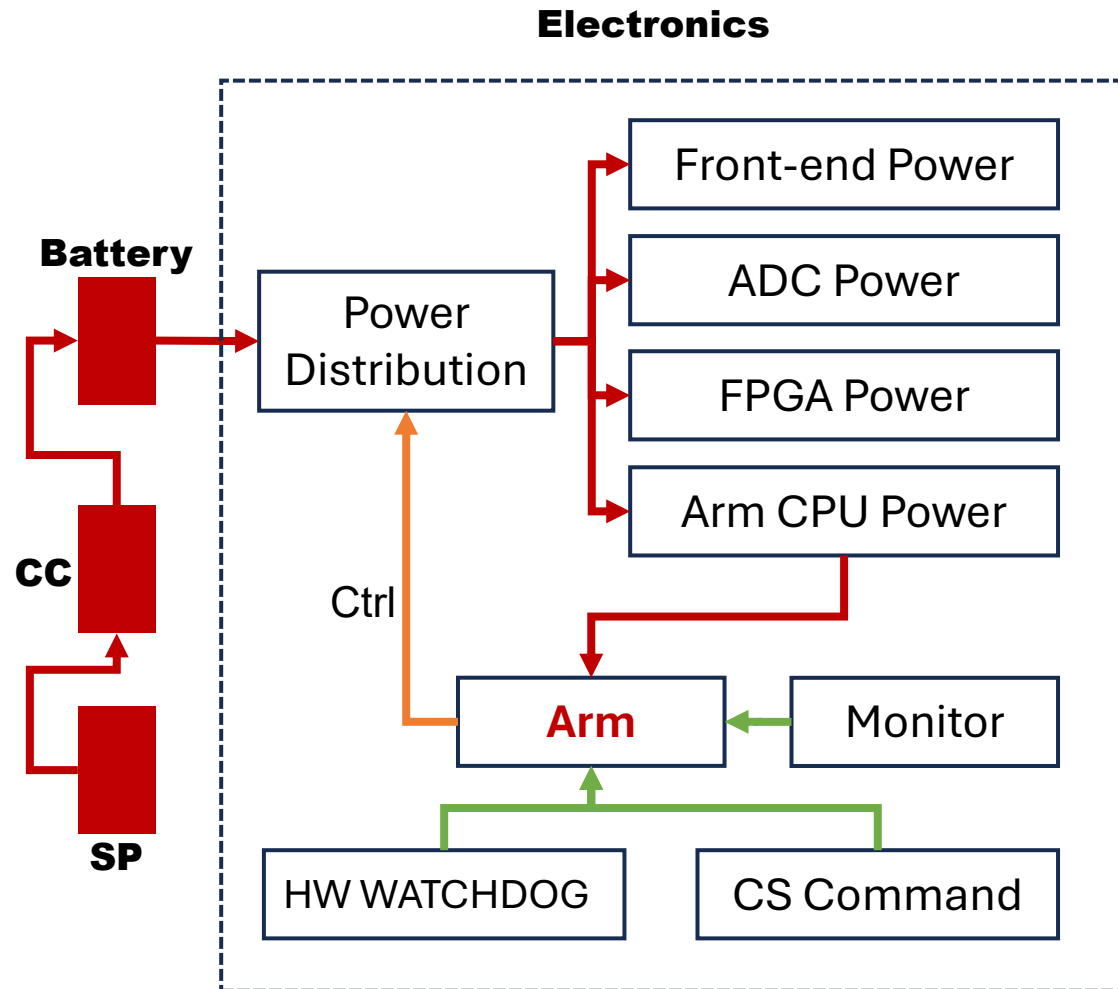
- Digitizing and Data Process
  - RF: Radio & Particle Detector
  - ADC: AD9694/KH14B500M
  - FPGA: Xilinx UltraScale+ XCKU5P
  - Arm: TI AM62x
- Timing
  - Clock: Si5340/HMC7044
  - GPS: TRIMBLE ICM SMT 360 /SKG172T
- Housekeeping
  - Power & temp monitor
  - Power management
  - Remote firmware update



Hardware

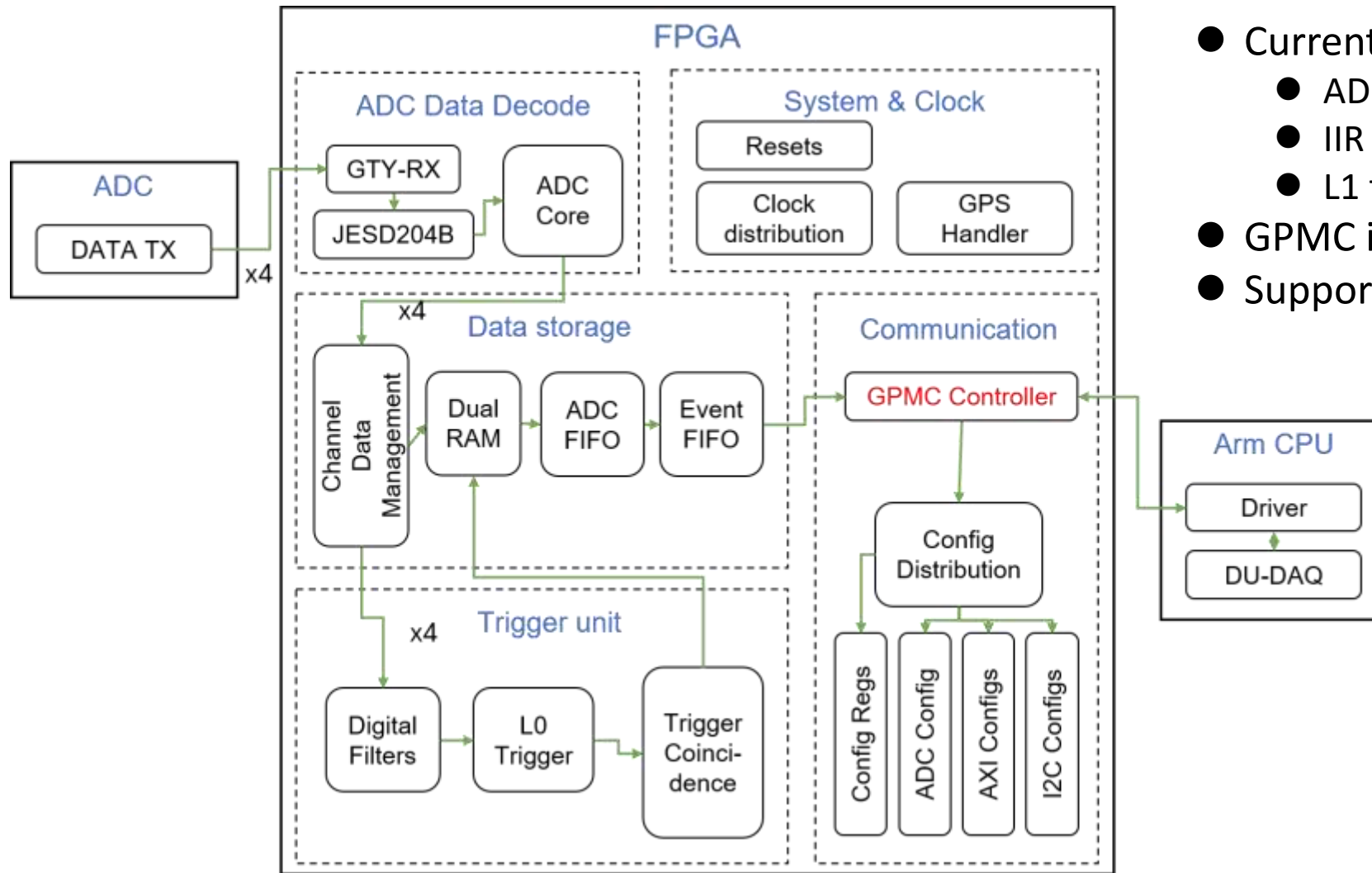


# Hardware



- Power Management
  - Separated powers control
  - Monitoring of temperatures and power voltage
  - Support HW Watchdog

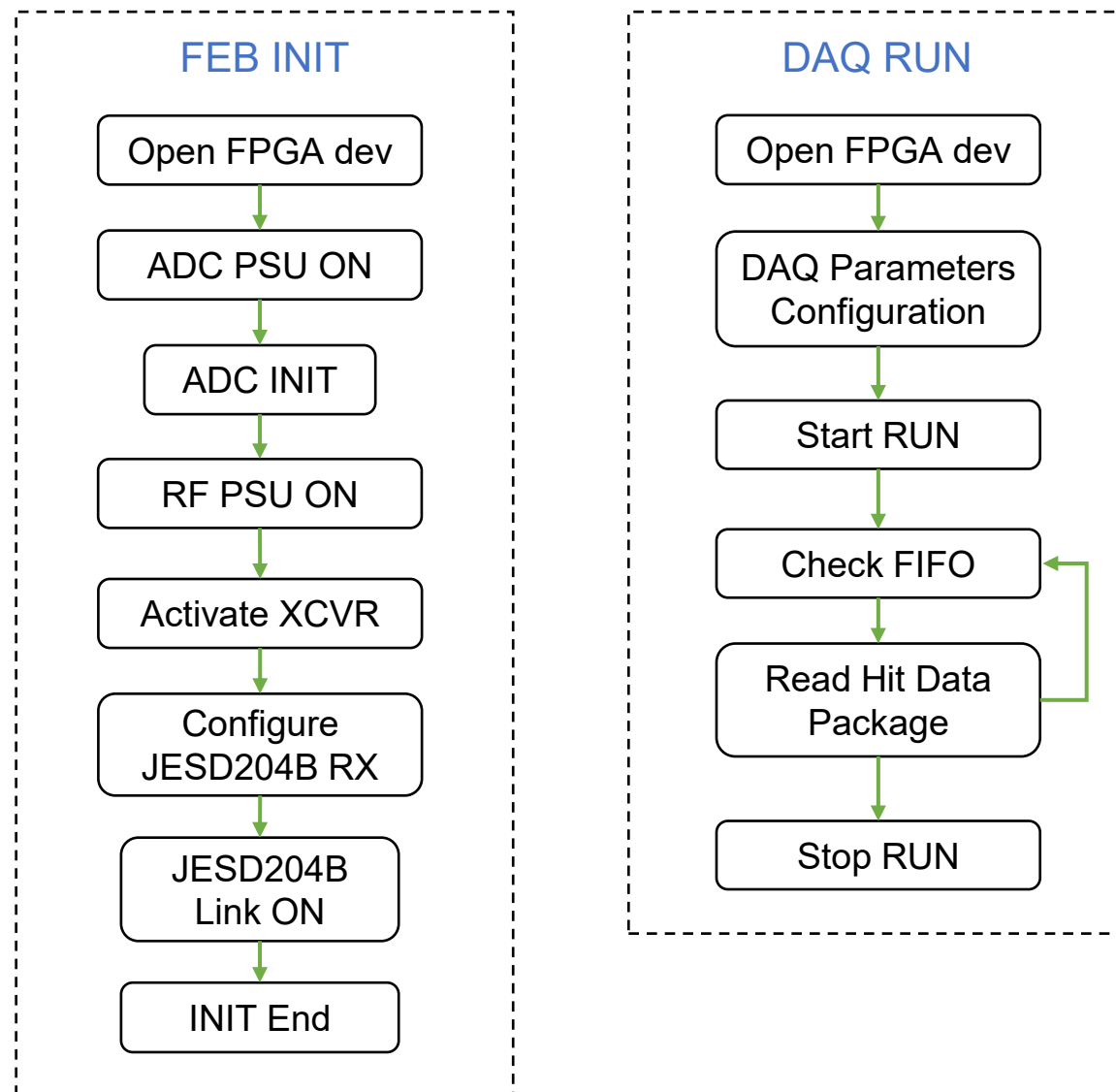
# Firmware



- Currently, similar implementation as V1B
  - ADC data transfer
  - IIR notch filter and FIR LP filter
  - L1 trigger algorithm
- GPMC interface between FPGA and CPU
- Supports two GPS modules

# Software

- Software on FEB side (dev by C)
- FEB initialization
- DAQ run task





# Software

Test of gp300 pmo v2 daq

DU ID  Brd ID

Brd IP  DU Alive

**DU Status**  
GPS Time   
Longitude  Latitude  Altitude   
Pwr Volt  Brd Temp  GPS Temp

**Power CTRL**  
☒ Arm Power ☒ LNA Power ☒ FPGA Power ☒ PD Power ☒ ADC Power

File Size  KB  
File Prefix   
RUN ID   
RUN Time  s  
  
24% Rcv File Num

**Sys Config**  
☐ Auto Reboot  
☐ Filter 1  
☐ Filter 2  
☐ Filter 3  
☐ Filter 4  
☐ Fake ADC  
☐ Enable 1PPS  
☒ Enable DAQ

**Trig Setting**  
☐ Chl 4  
☐ Chl 3  
☐ Chl 2  
☐ Chl 1  
☐ Chl 1 + Chl 2  
☐ Cali  
☐ 10s  
☐ Int P / Ext  
☐ Not Chl 1 + Chl 2  
☐ Red. Chl1 + Chl 2  
☐ Chl 3 + Chl 4  
Int Rate   
Trig Opt

chl 1 | chl 2 | chl 3 | chl 4

☒ Enable readout  
Input Source

Prev Time  Post Time  Integral Time  Base Adj Min  Base Adj Max

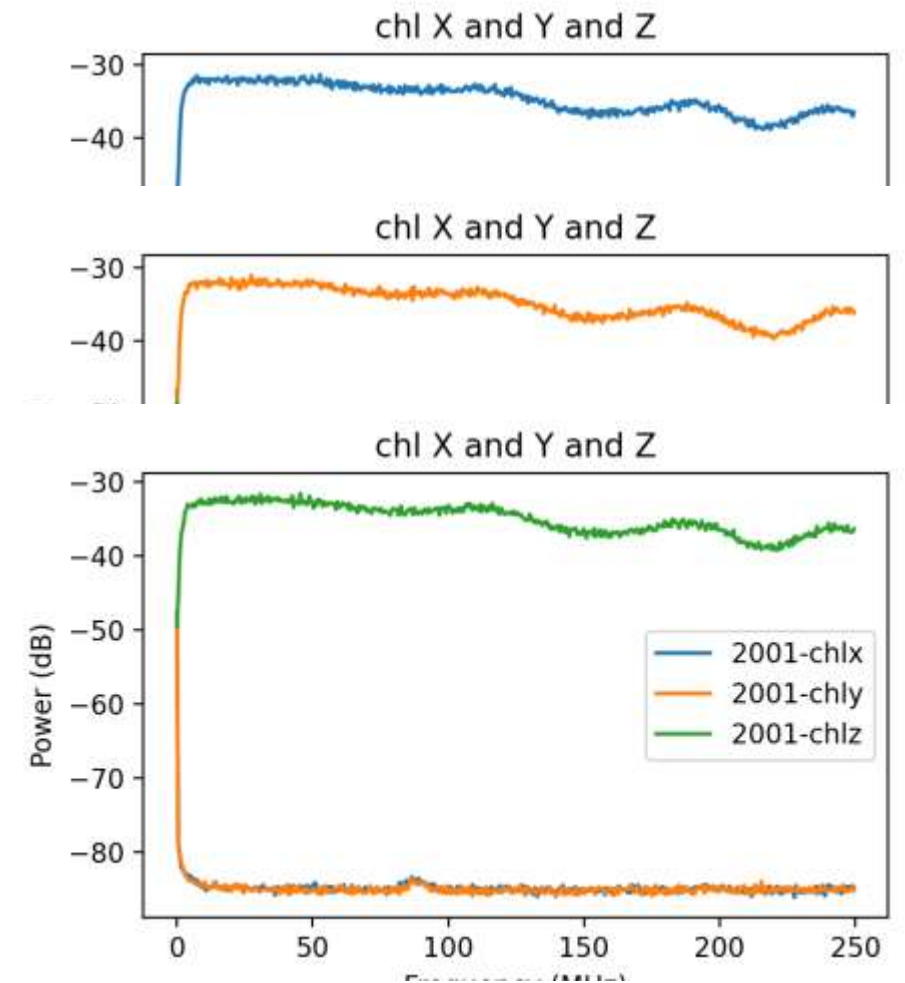
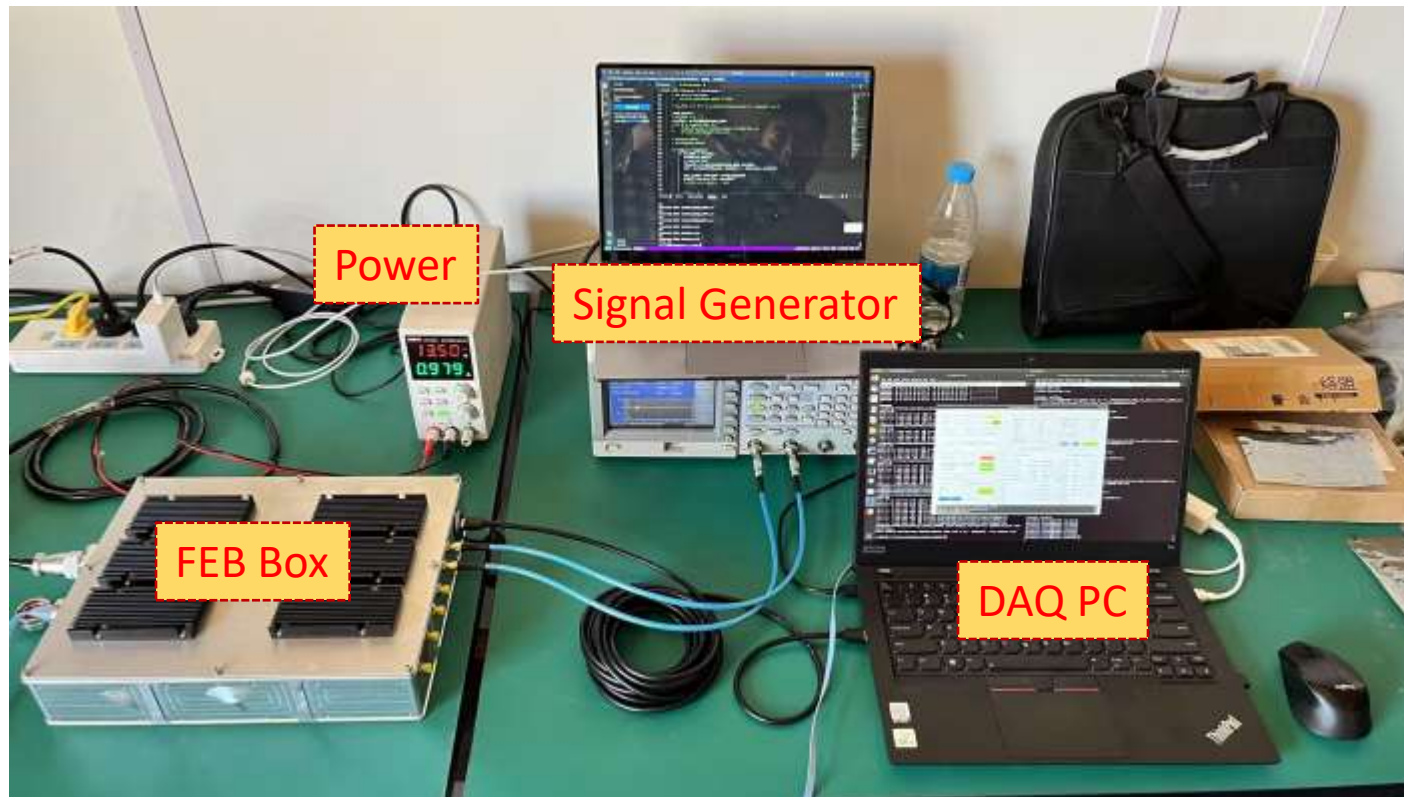
Signal Thr  Noise Thr  Quiet Time  Period Time  TC max  NC min  NC max  Q min  Q max

Filter 1 - f  Filter 1 - r  Filter 2 - f  Filter 2 - r  Filter 3 - f  Filter 3 - r  Filter 4 - f  Filter 4 - r

- DAQ software (dev by PYQT5)
- DU status monitoring
- FEB power mode control
- DAQ running parameters configuration
- DAQ run task



## Site test – Test use AFG3252

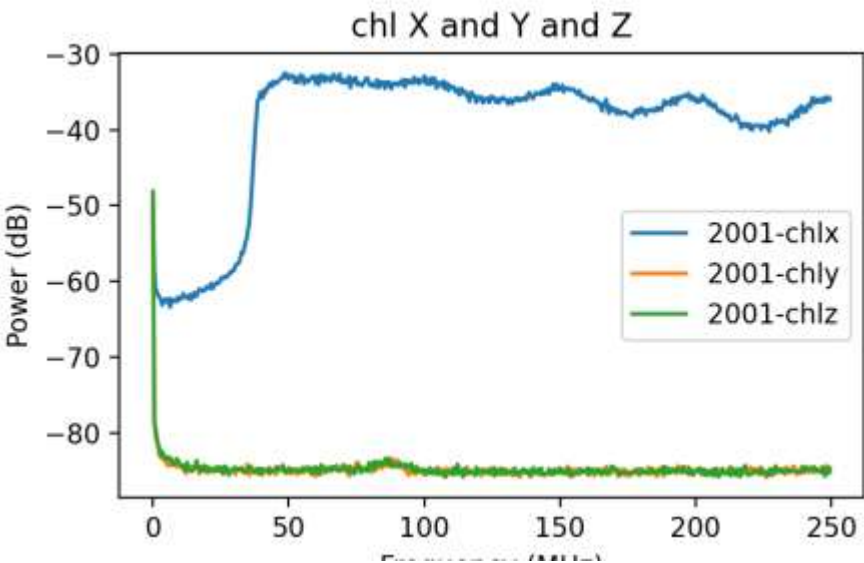
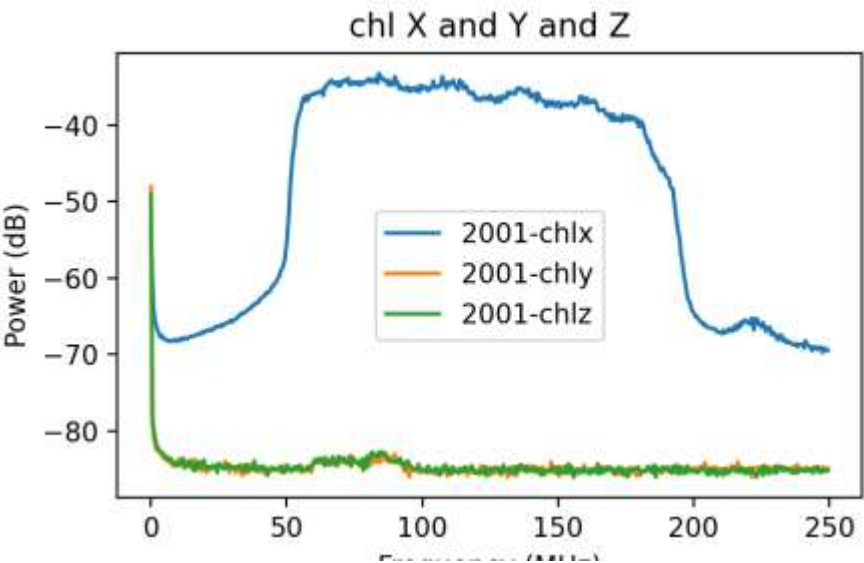


# Site test – Test with Filters

50-200MHz  
BP Filter



40MHz  
LP AM Filter

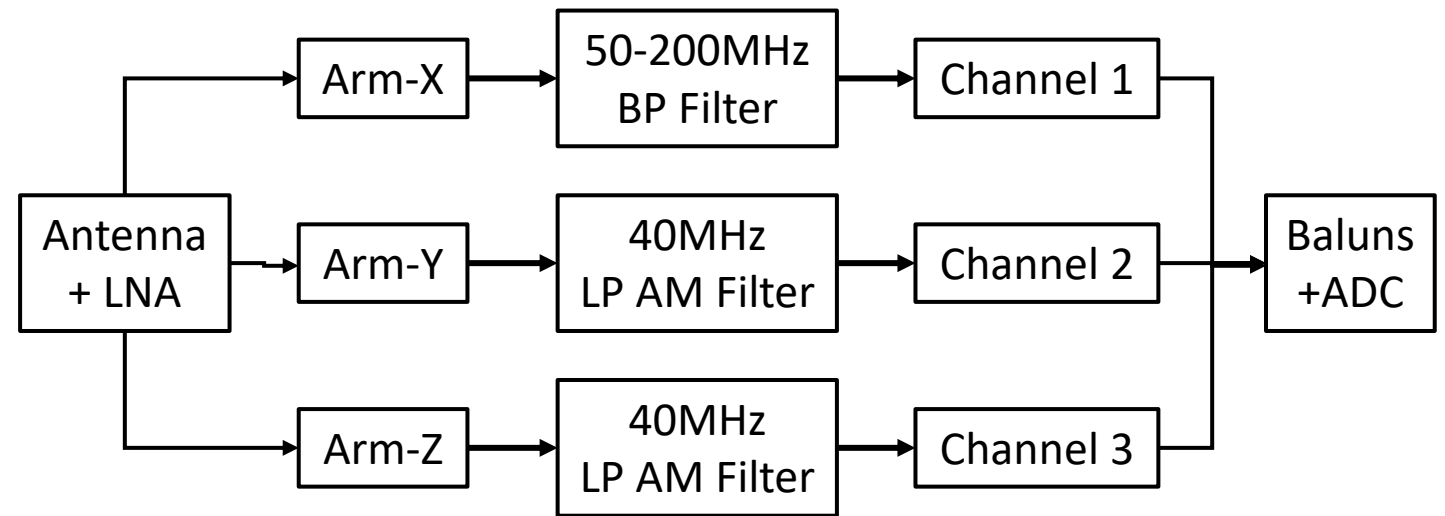


## Site test – Deploy to Station 6



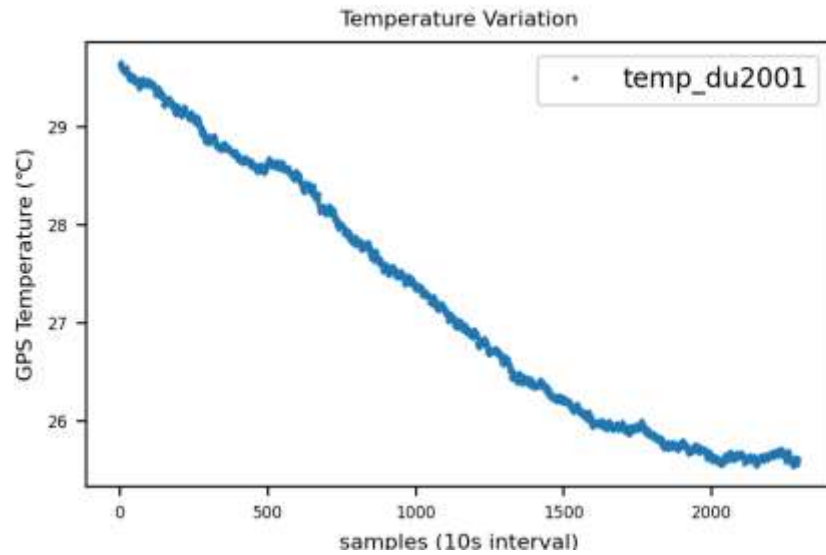


## Site test – Front-end Connection

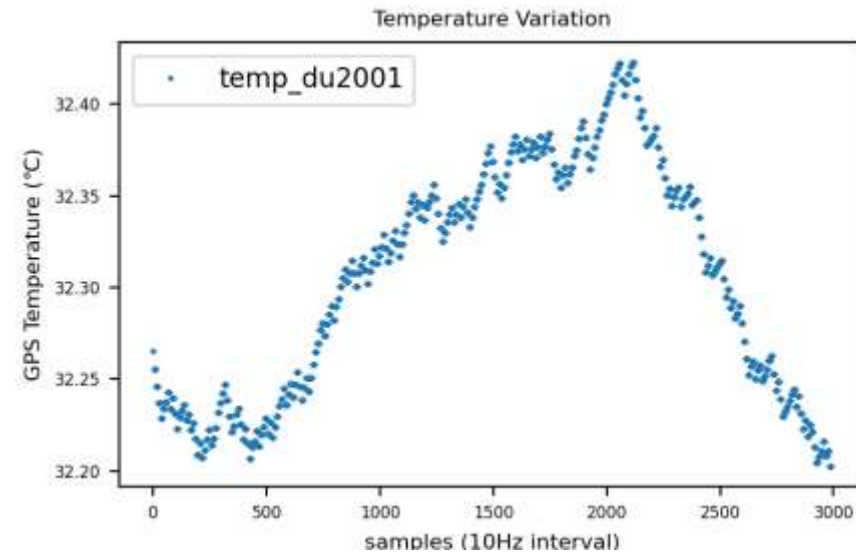


\* But the EMC shield is not very good.

# Site test – GPS Temperature



Time : 2025.04.22 Night  
Mode : 10s  
Period : ~6 hours



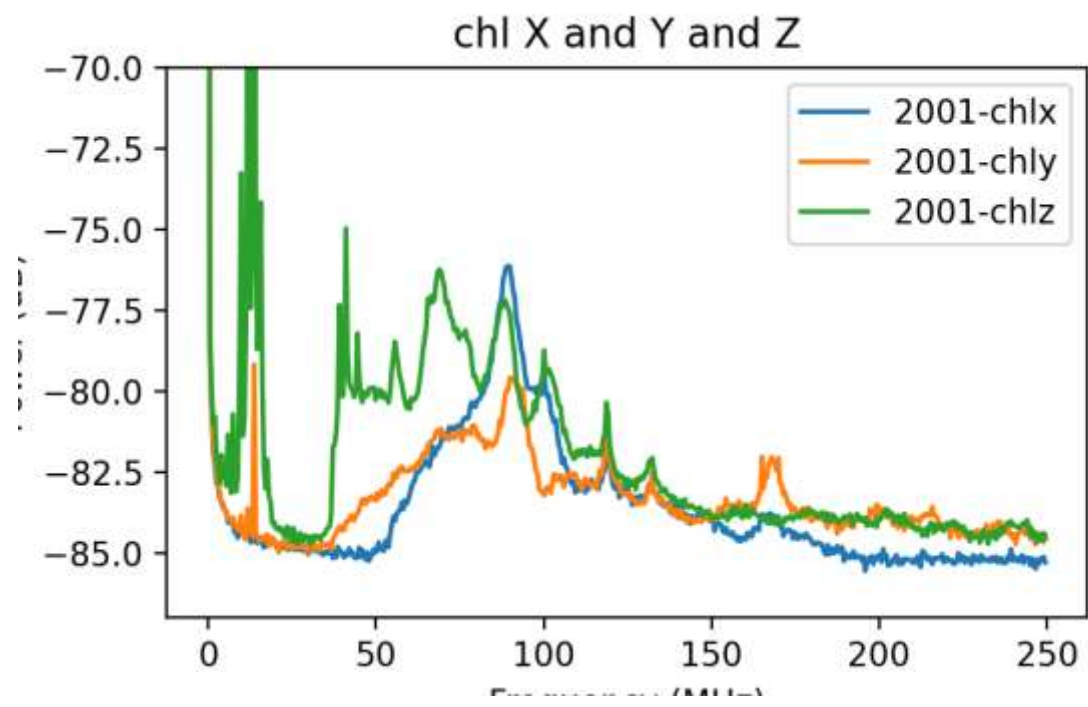
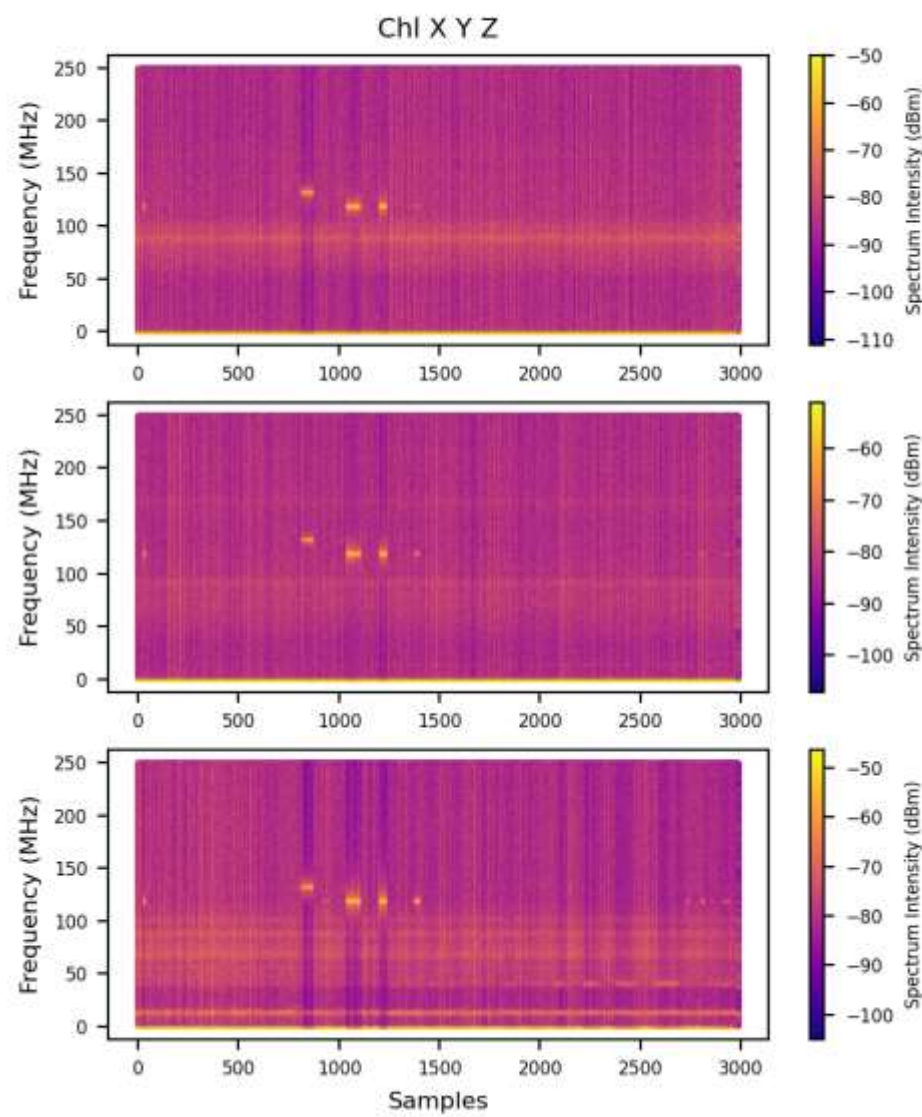
Time : 2025.04.24 Evening  
Mode : 10Hz  
Period : 300s

=> Similar capability on heat dissipation compared to the GP100 FEB.



# Site test – MD Spectrum

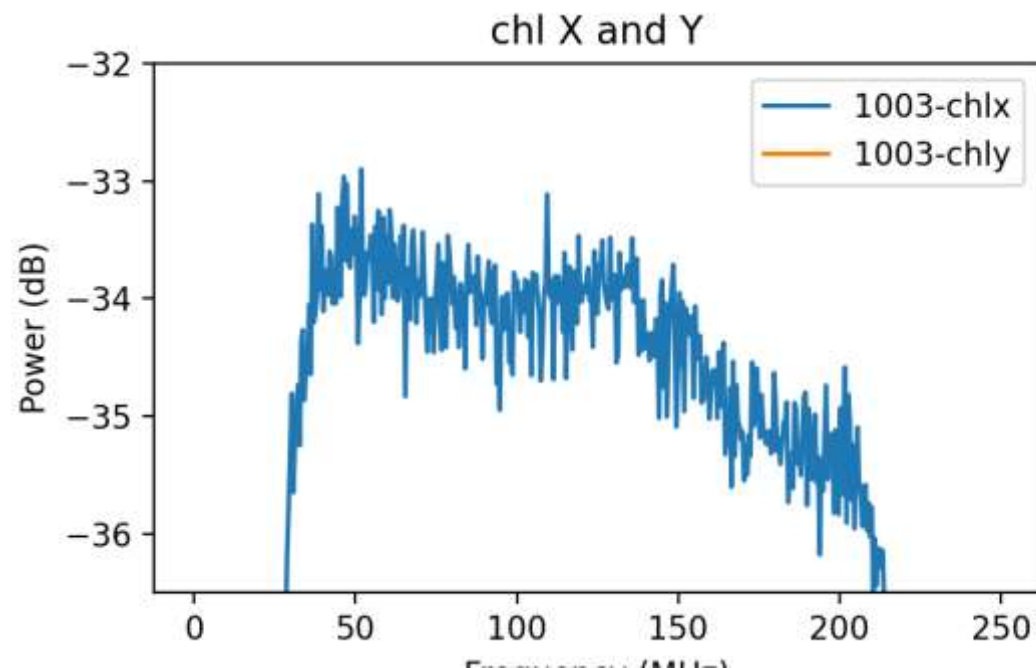
Time : 2025.04.24 Evening  
Mode : 10Hz  
Period : 300s



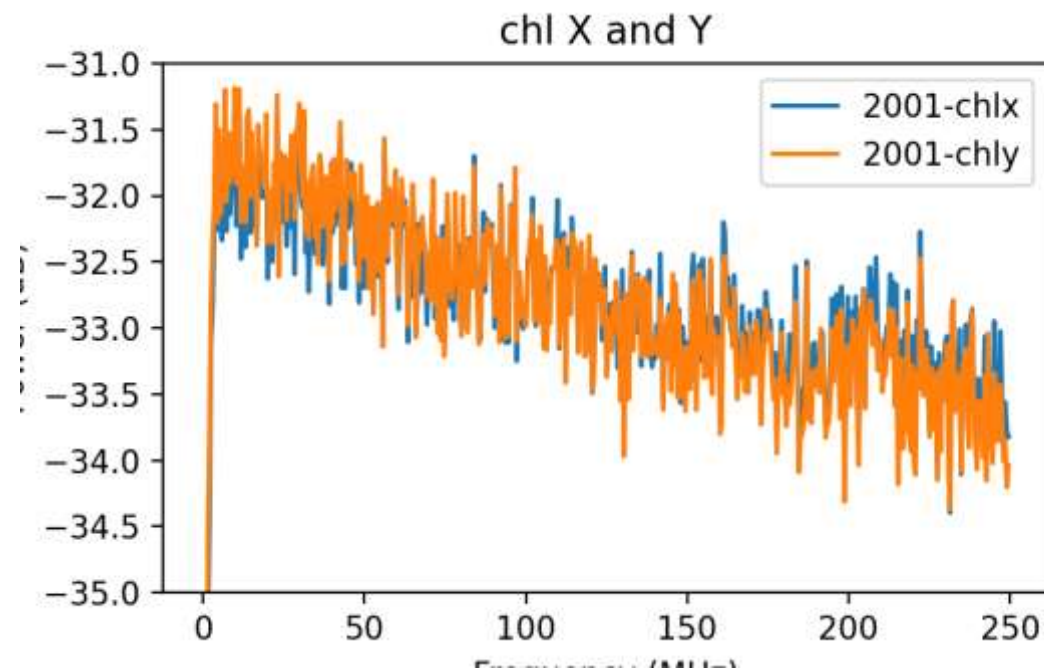
## Lab test -- Test use AFG31000

- GP100 FEB

\* VGA set to 0dB



- New FEB



=> It seems the abnormal on noise spectrum is caused by AFG device

## Summary and future work

- The new FEB for GP300 has good capability for collecting data, communication and power management;
- It needs more time for going to the next version;
- More tests need to do:
  - New GPS test on V2
  - New ADC & Clock chip verification
  - Trigger test using simulation data
  - Long-term stability test
  - ... ..
- The coming June trip provides an opportunity for further site test.
  - Using new LNA
  - Better EMC shield