High Voltage system for the Double Chooz experiment

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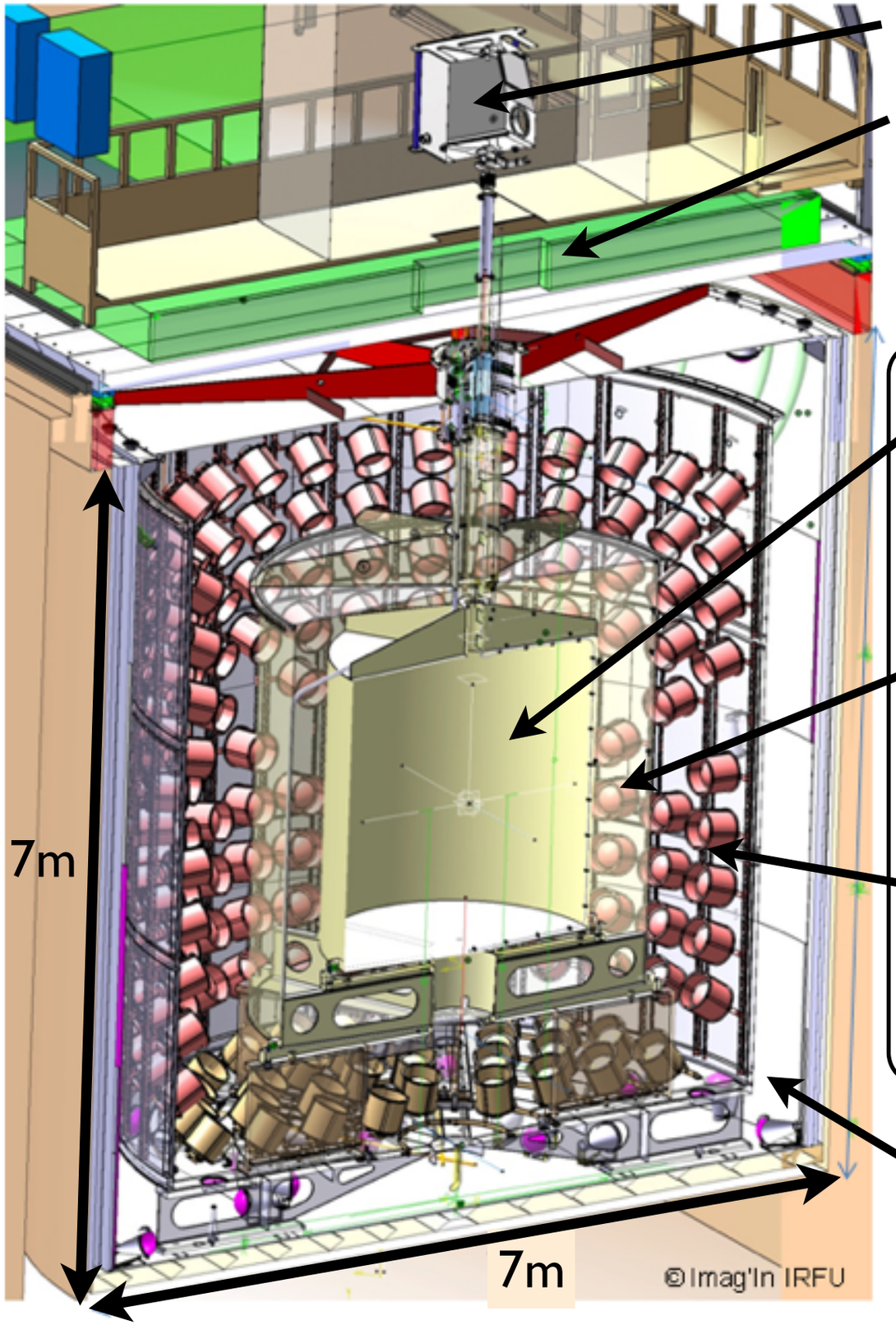
Double Chooz detector



Globe Box

Outer veto

Cosmic muon identify and veto

[plastic scintillator strip]

Inner detector (ID)

ν-target

Generate neutrino signal

[Gd doped(1g/ℓ) liquid scintillator(10.3m^3)]

γ-catcher

Capture escaping γ-ray from target region

[Liquid scintillator without Gd doping(22.3m^3)]

Buffer

Reduce fast neutron and accidental γ-ray

[Mineral oil (110m^3) + **10"PMT × 390**]

Inner veto (IV)

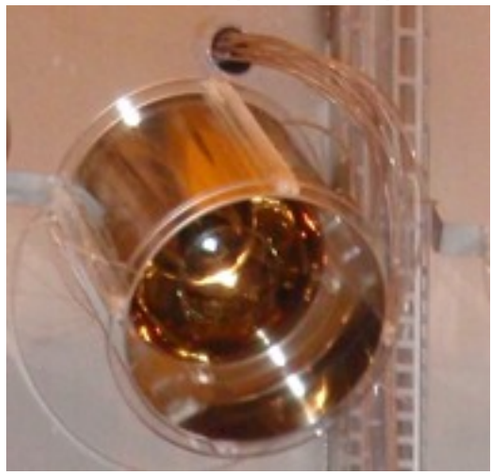
Back ground identify and veto

[Liquid scintillator (90m^3) + **8"PMT × 78**]

Readout system

Photomultiplier tubes

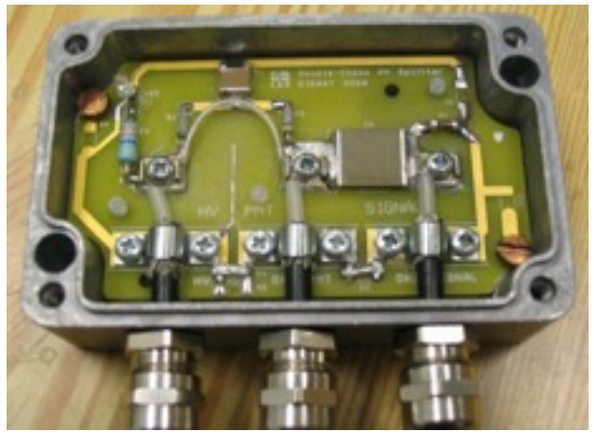
ID : 390 PMTs (R7081MOD)
IV : 78 PMTs (R1408)



Signal
HV

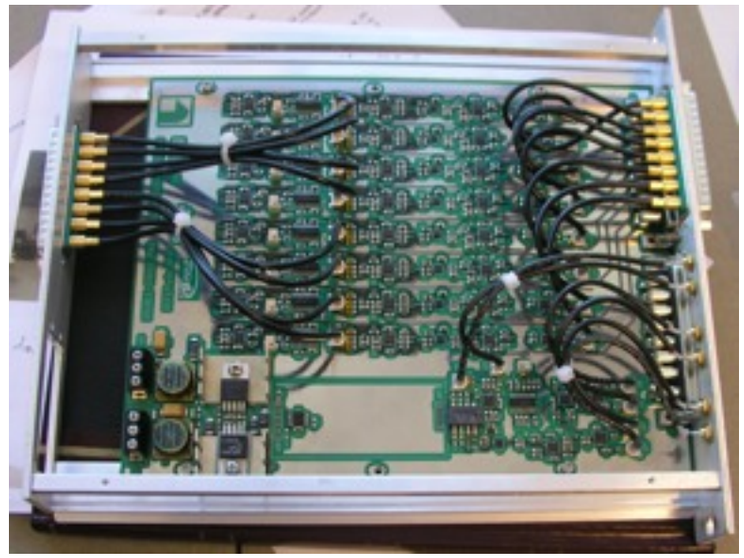
HV-Splitter

(by CIEMAT)



Signal

Frontend Electronics

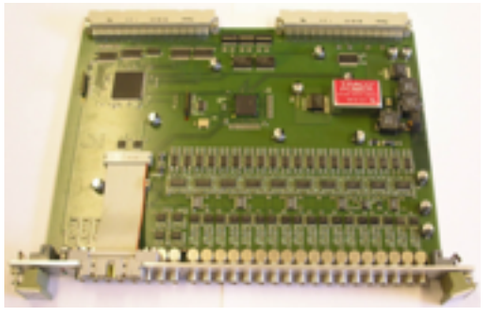


HV

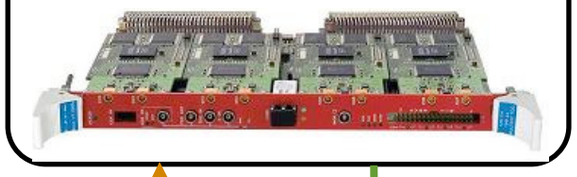
HV-Supply

SY1527LC & A1535P
(by CAEN)

Trigger & Clock



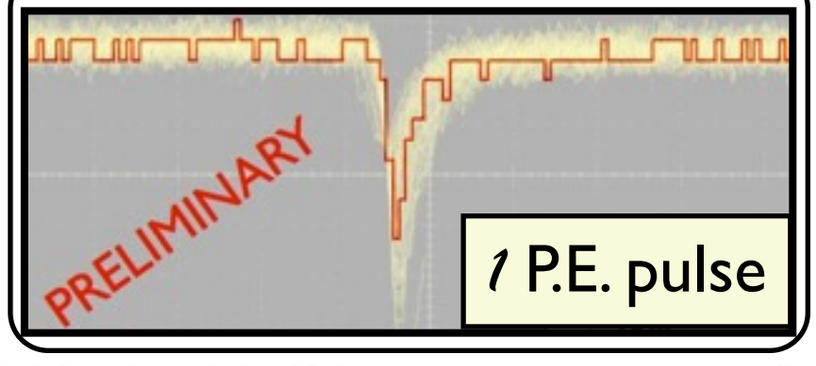
ν-FADC



μ-FADC

Trigger & clock

ν-DAQ



High Voltage system

- Hardware properties
- Module calibration
- Control software
- Status monitoring system

HV crate

Front view

※ 2 crates / one detector

Back view

SY1527LC crate

- 16 slots / crate
- size : 19-inch × 8U
- weight : 24 kg @ no module
- operating temperature : 0~40℃
- CPU and original OS are in itself
- Ethernet port interface is implemented

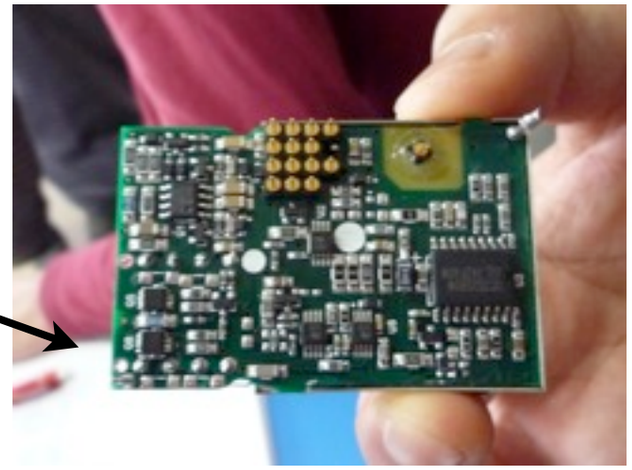
→ be able to operate remotely (TCP/IP)

HV module

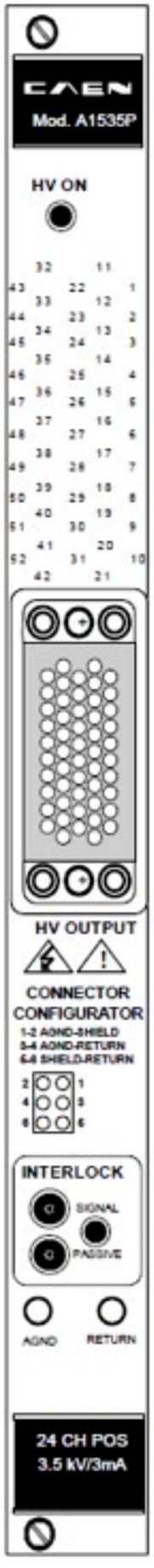
CAEN
Tools for Discovery

A1535P module

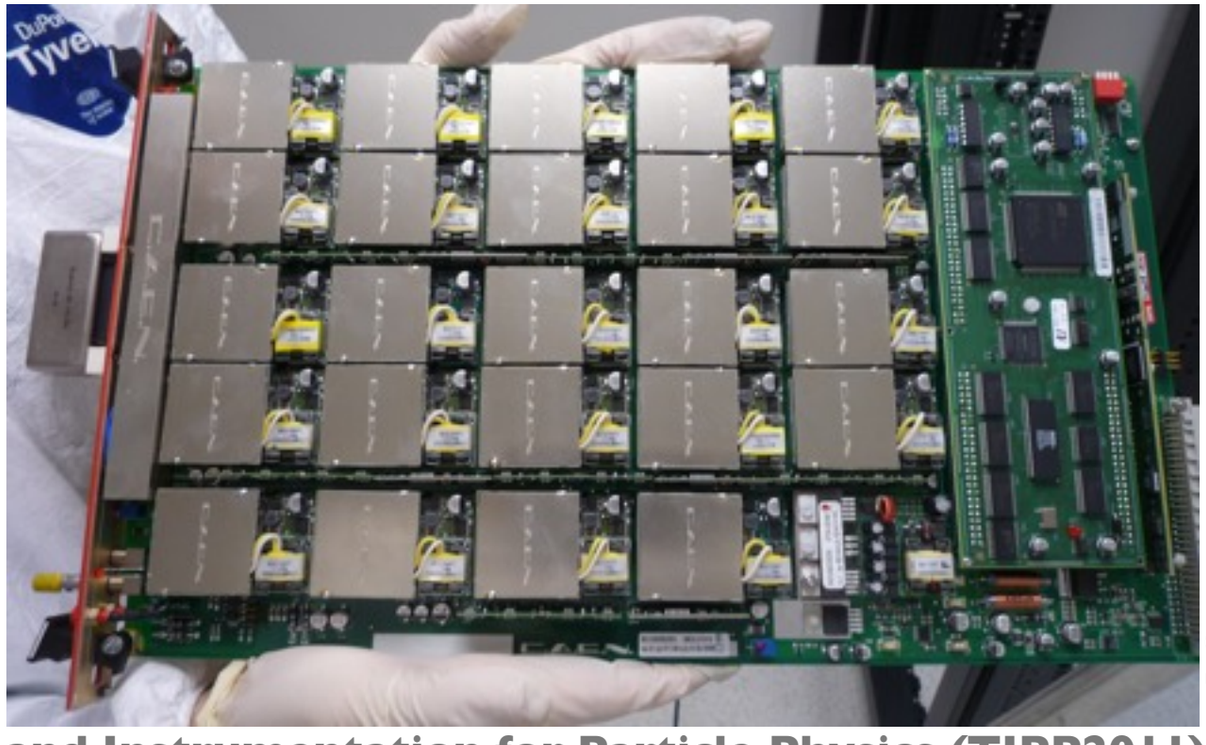
- 24 individual channels / module
- →can be replaced channel by channel
- Max voltage : 3500 V
- Max output current : 3 mA
- Voltage set/monitor resolution : 0.5 V
- Current set/monitor resolution : 0.5 µA
- Radial 52-pin connector



Channel chip

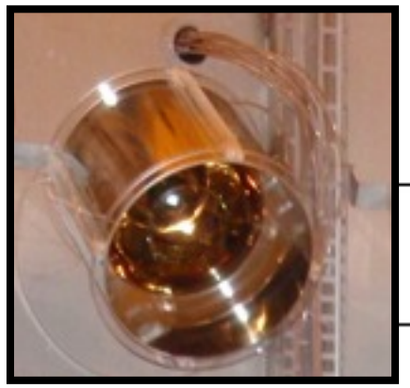


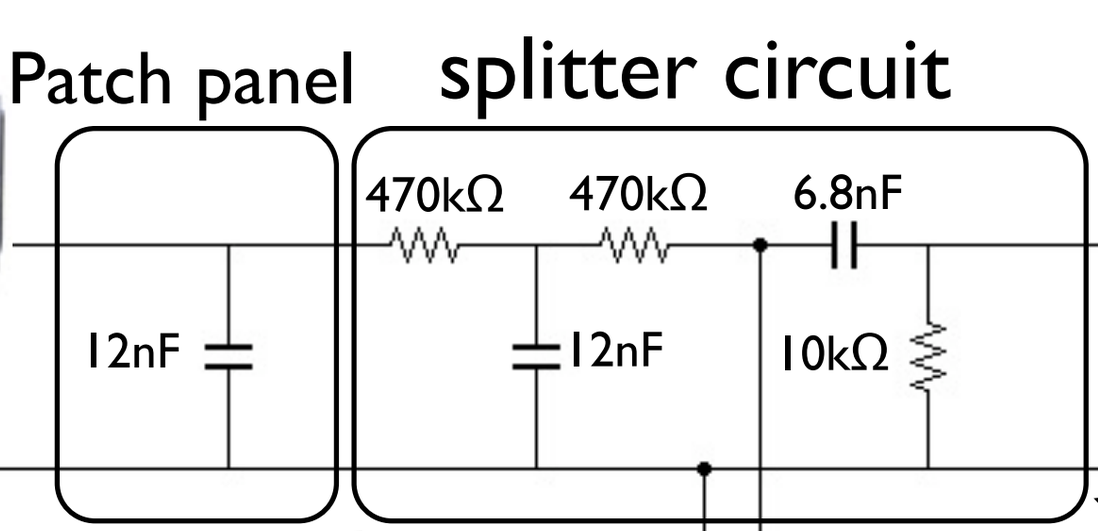
Front view



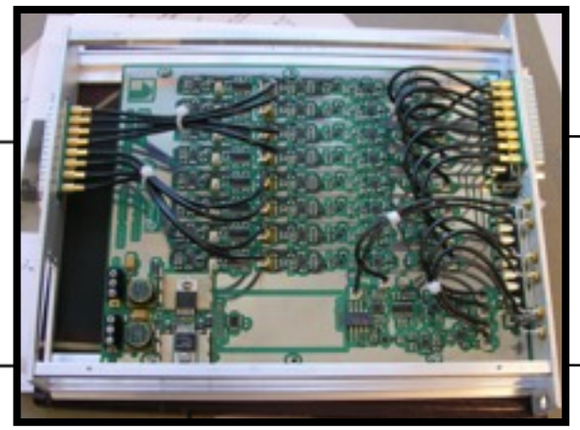
Side view

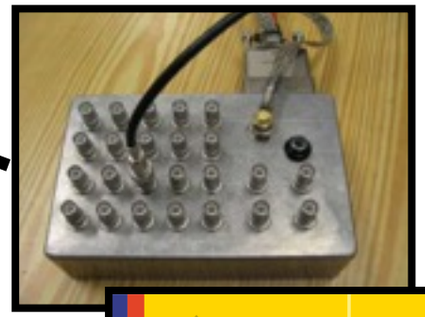
Splitter circuit for the PMT

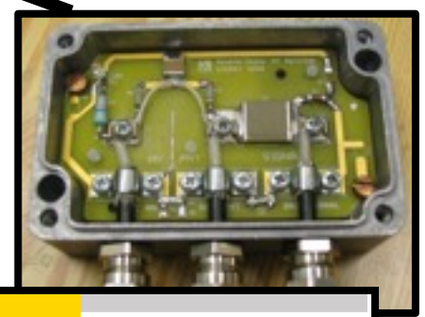




frontend







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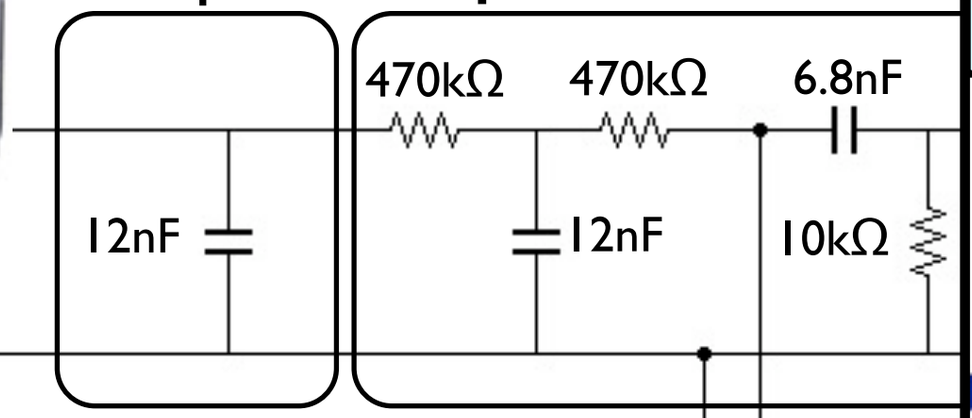
- Single cable is used to HV supply and signal output.

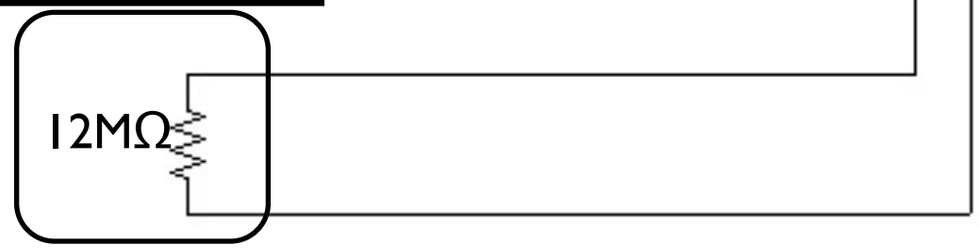
→Reduce cost and the volume for cables.

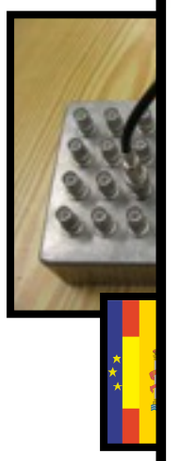
- Need the splitter circuit which separates signals from high voltage (by CIEMAT).
- High voltage noise would contaminate to signals from PMT?

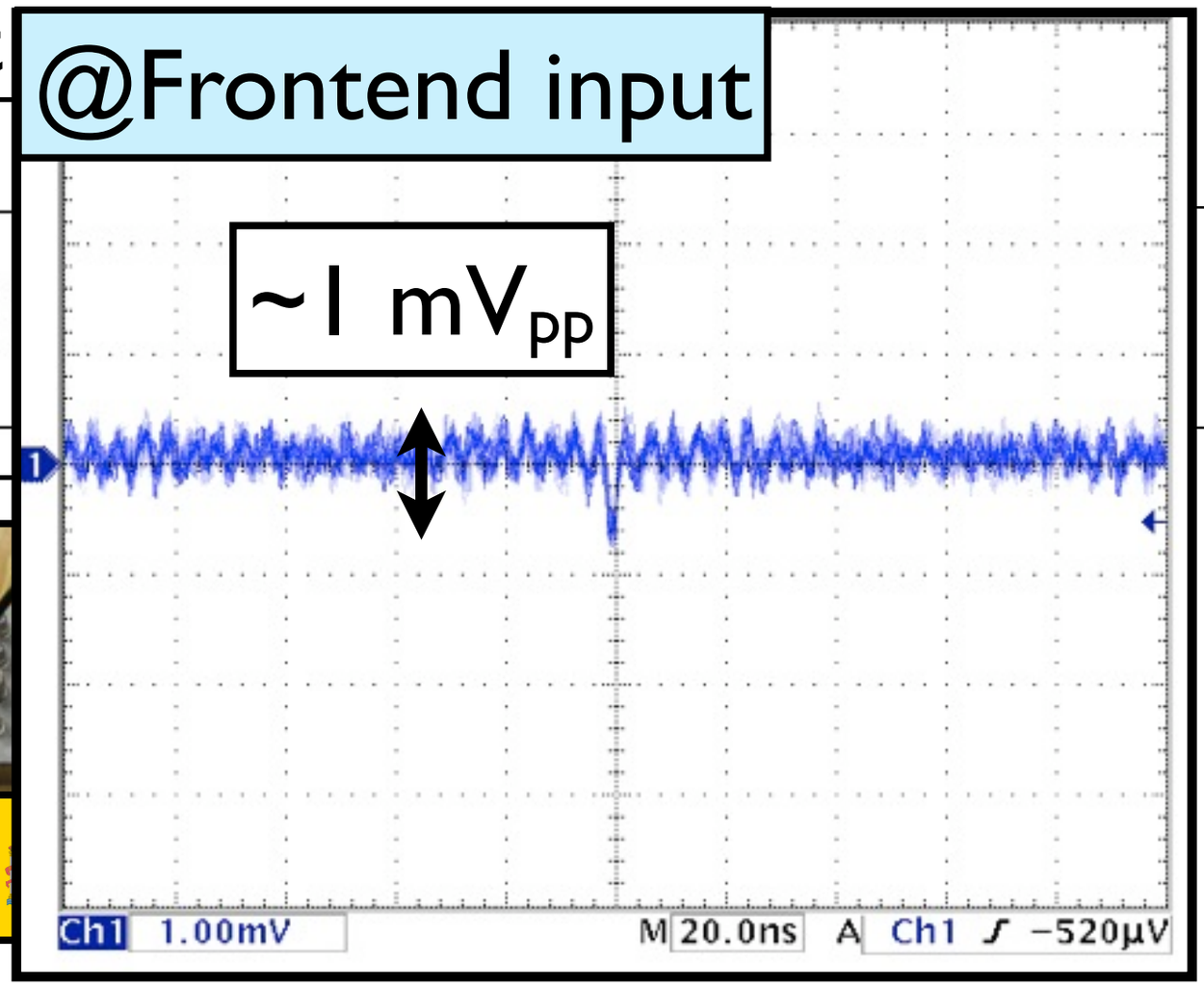
Splitter circuit for the PMT



Dummy load





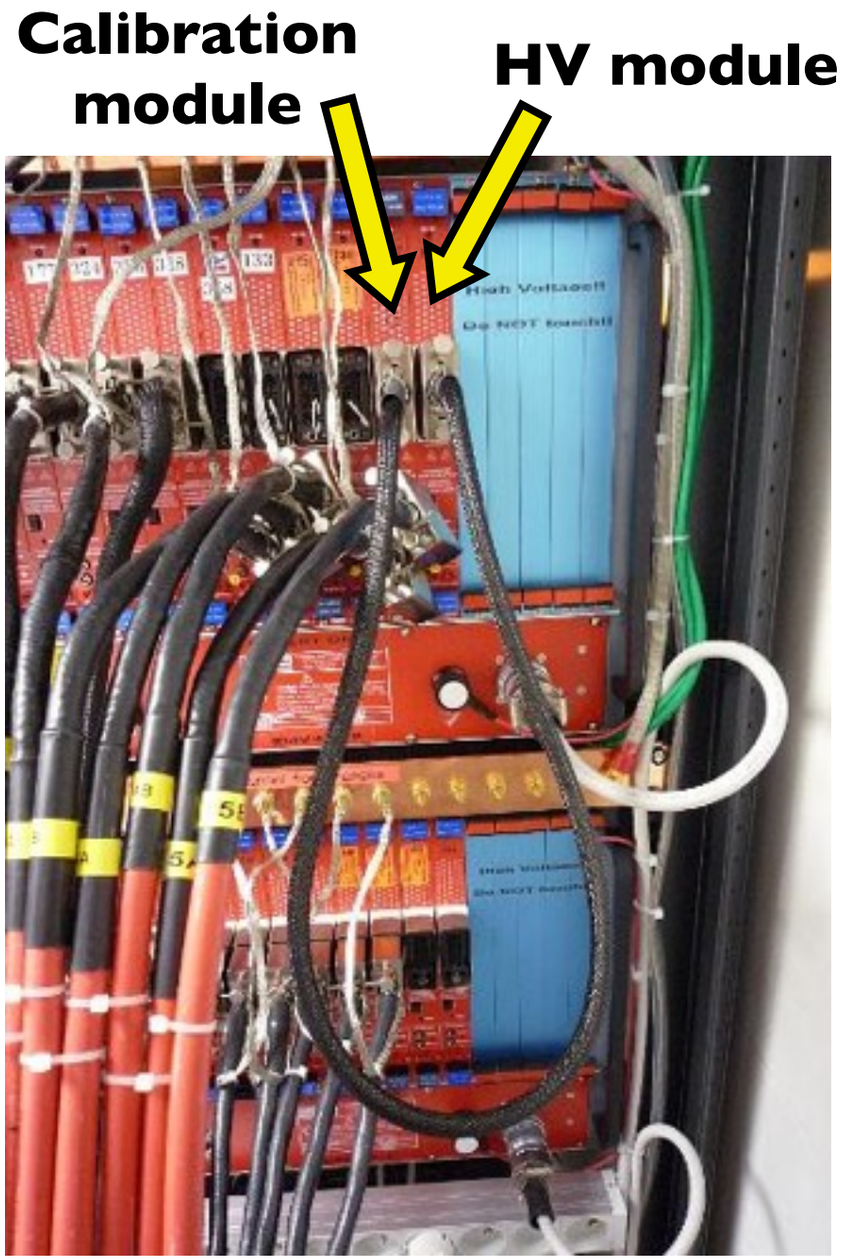


- Checked the noise from high voltage by oscilloscope.
- Noise from High Voltage can be reduced enough by splitter circuit.
  - Noise observed oscilloscope is about 1 mV_{pp}.

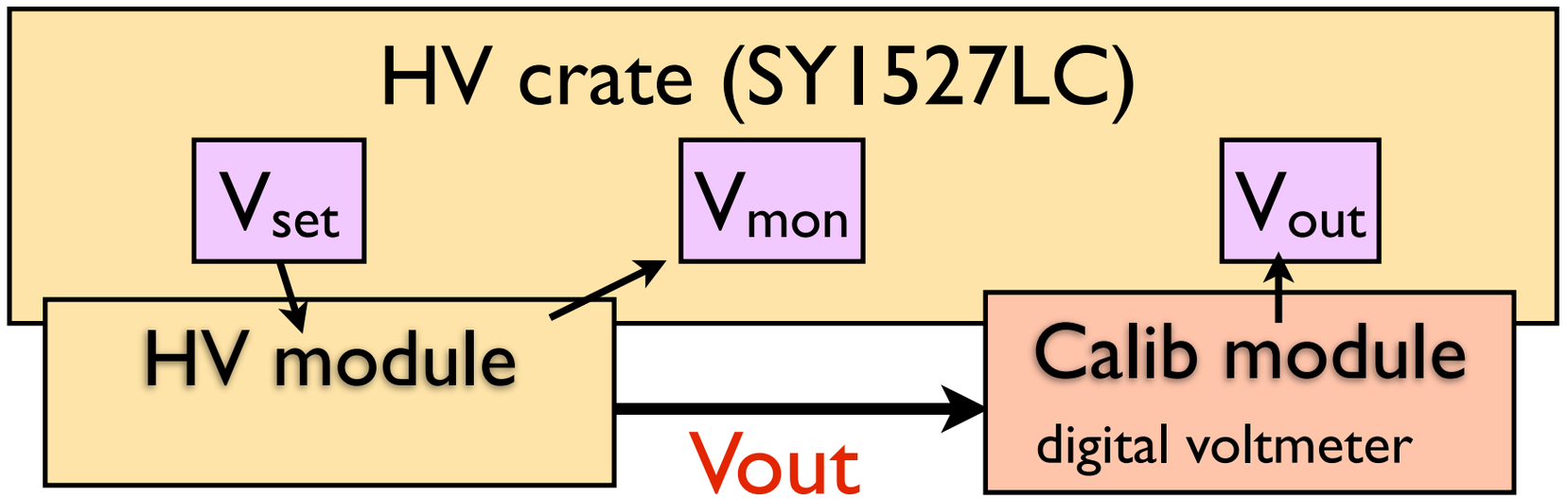
Module calibration

HV calibration system

HV output/monitor value is calibrated by a special calibration module.



- T1535P developed by CAEN.
- 24 digital voltmeters are placed on the calibration module to calibrate all channels, instead of HV chip.
- Calibration module reads the output voltage and send back to HV crate.

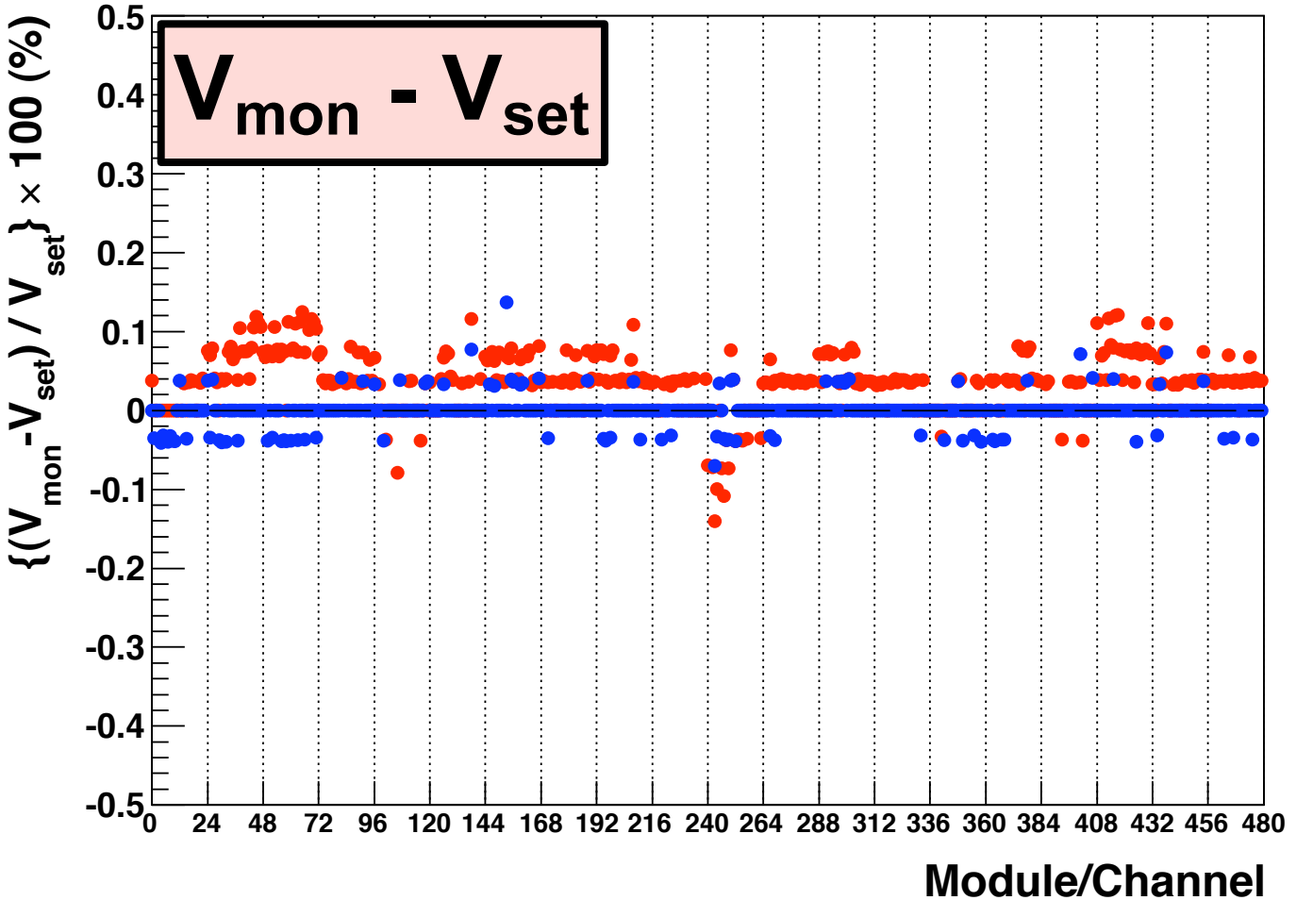


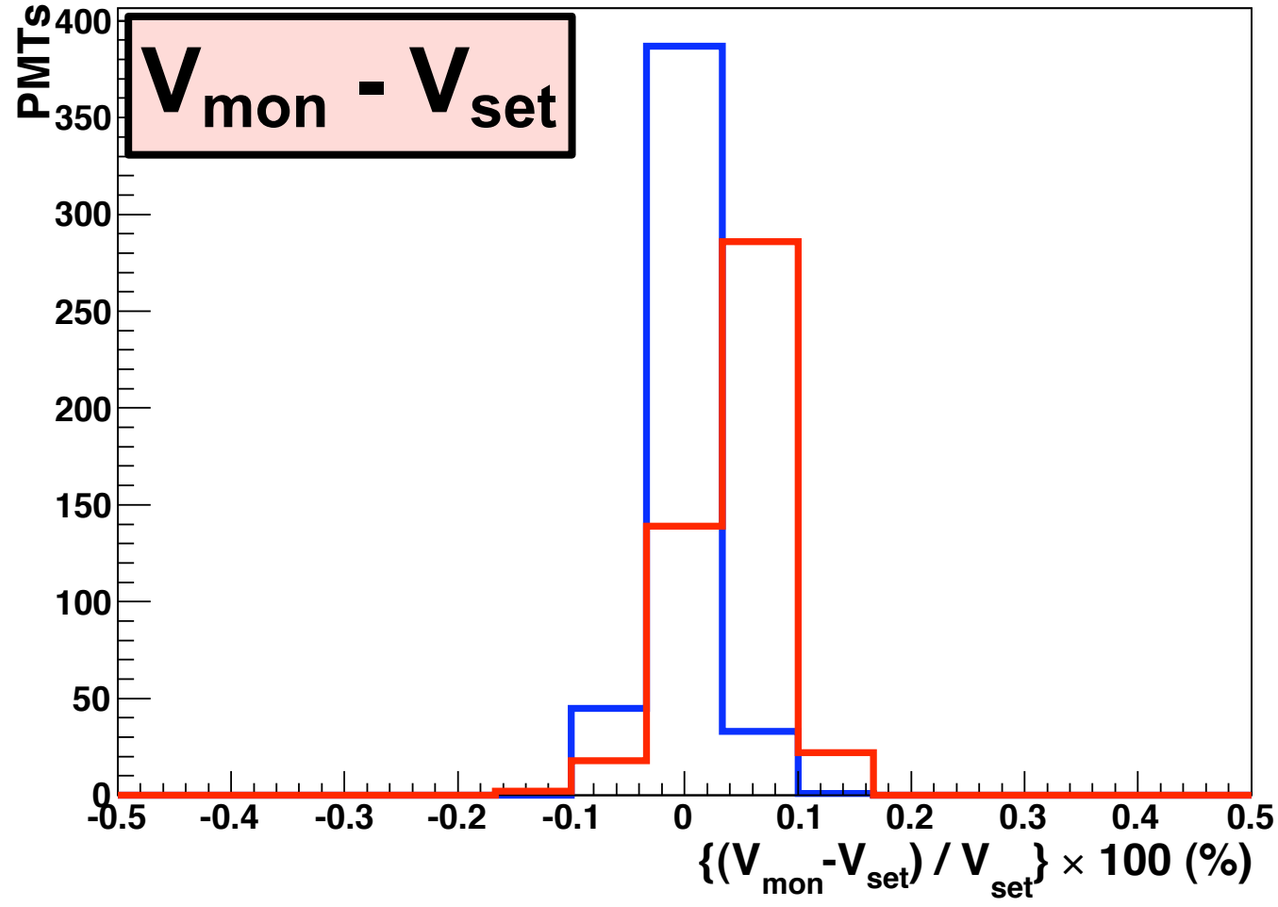
Vset : Setting voltage
Vmon : Voltage monitored by the HV module
Vout : Actual applied voltage

HV calibration result

before calibration

after calibration



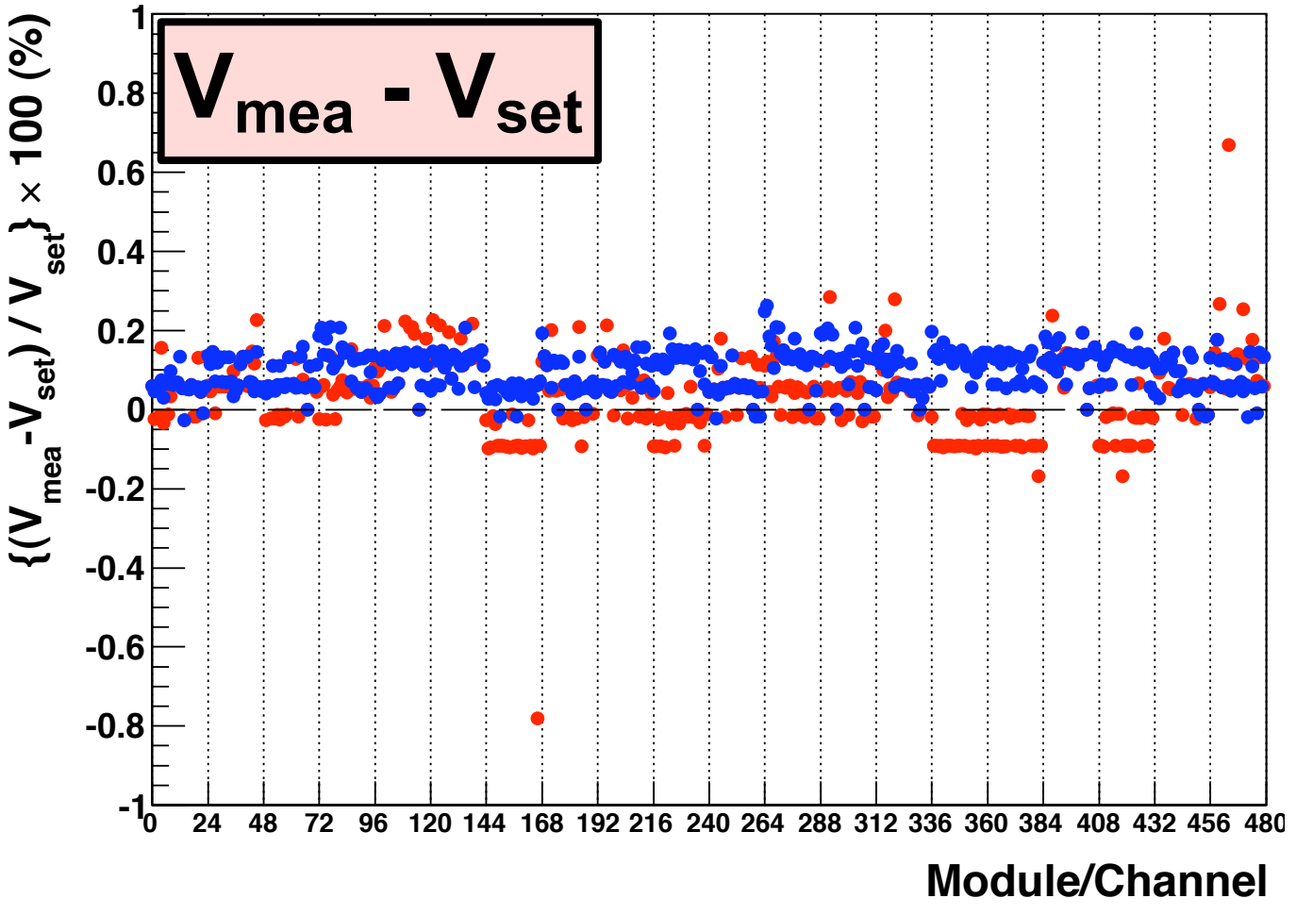


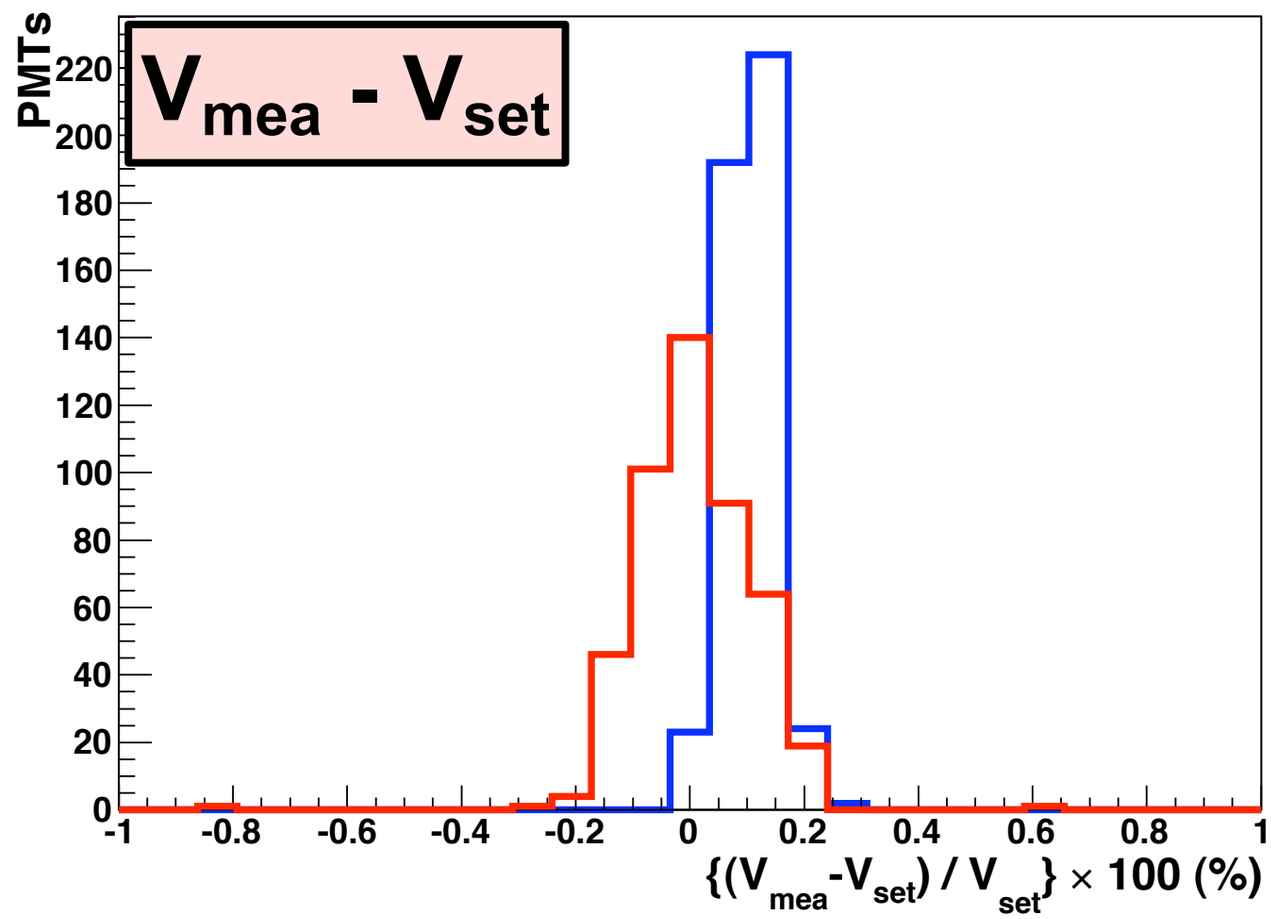
- Module dependency reasonably disappeared after calibration.
- V_{mon} are almost same value as V_{set} (within ~0.05%)

HV calibration result

before calibration

after calibration





- V_{mea} : the output value measured at dummy load($\fallingdotseq V_{out}$).
- V_{mea} has narrow distribution after the calibration.
  - still biased to positive side a little

Control software

Structure

TCP/IP

TCP/IP

HV server

TCP/IP

database (MySQL)
-Setting table
-Monitor table
-Voltage
-Current

TCP/IP

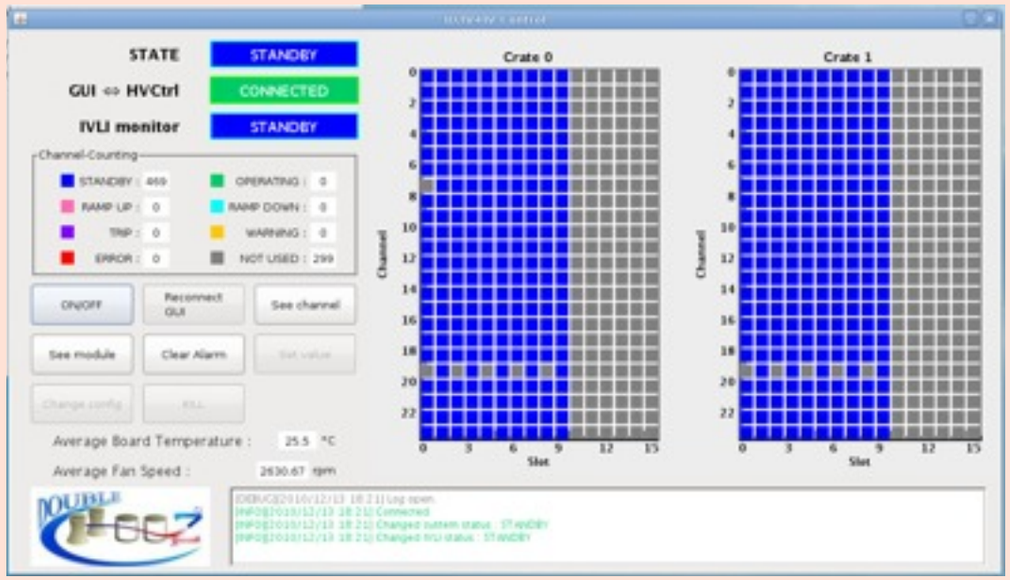
TCP/IP

Monitor server

Laboratory

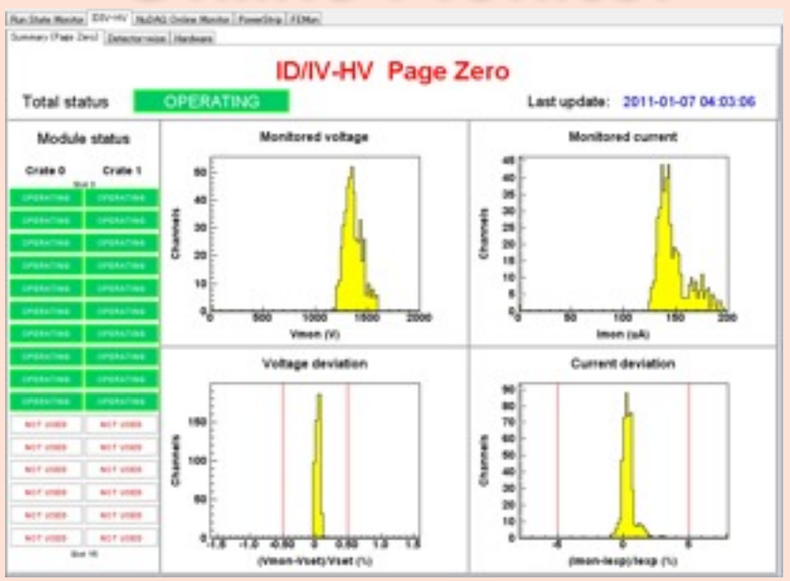
TCP/IP

Control GUI



Shifter

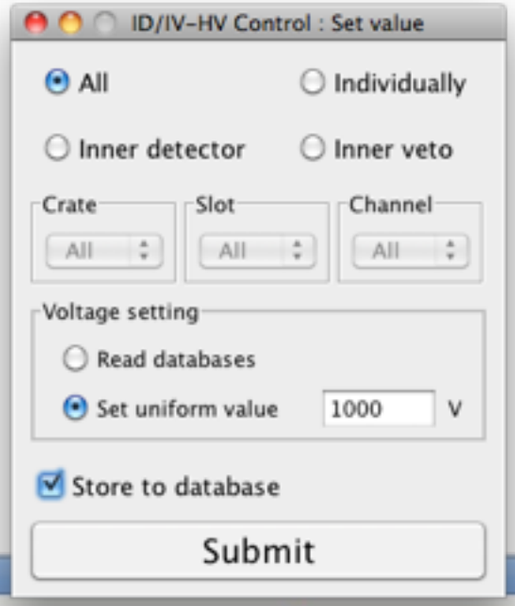
Online Monitor

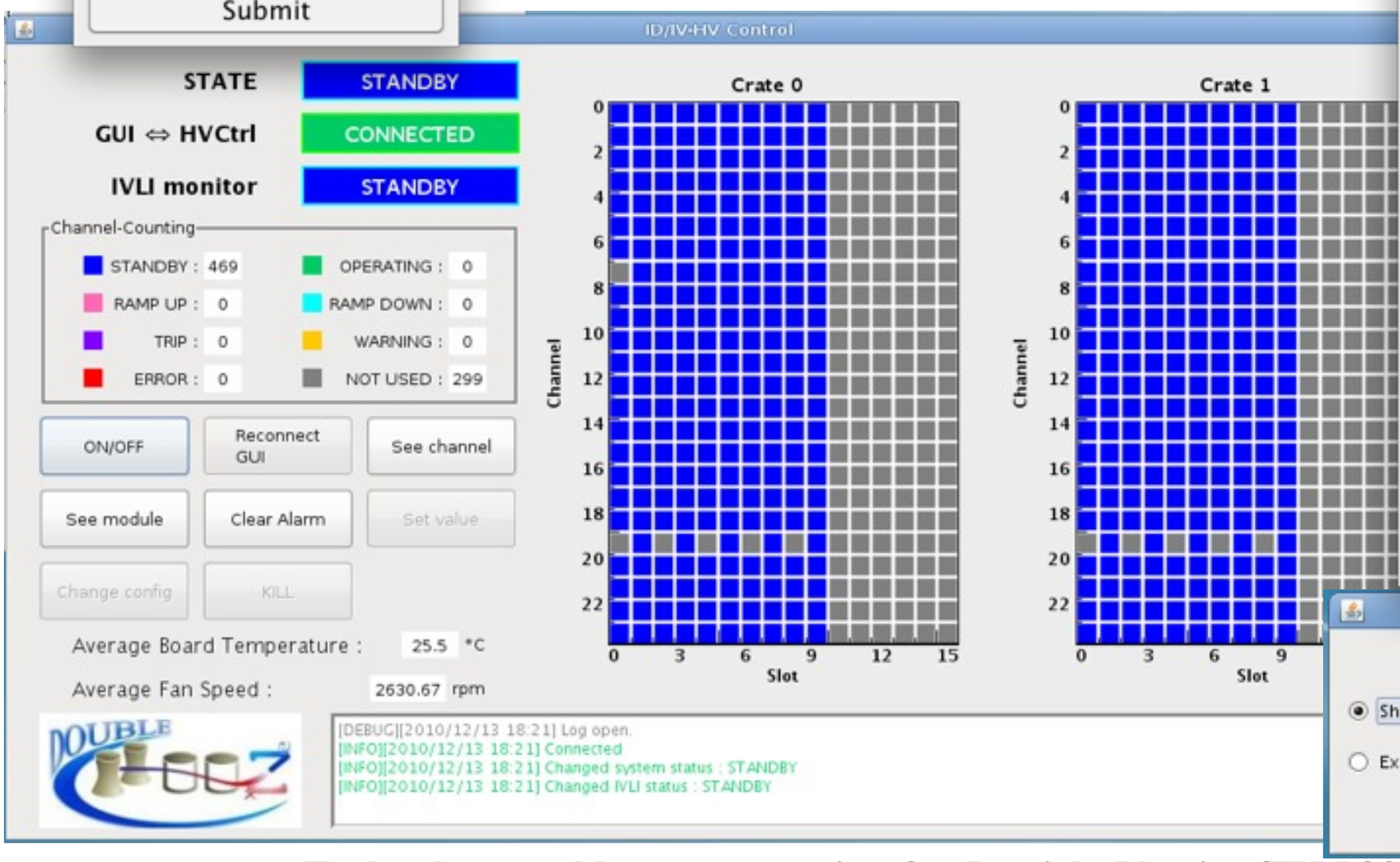


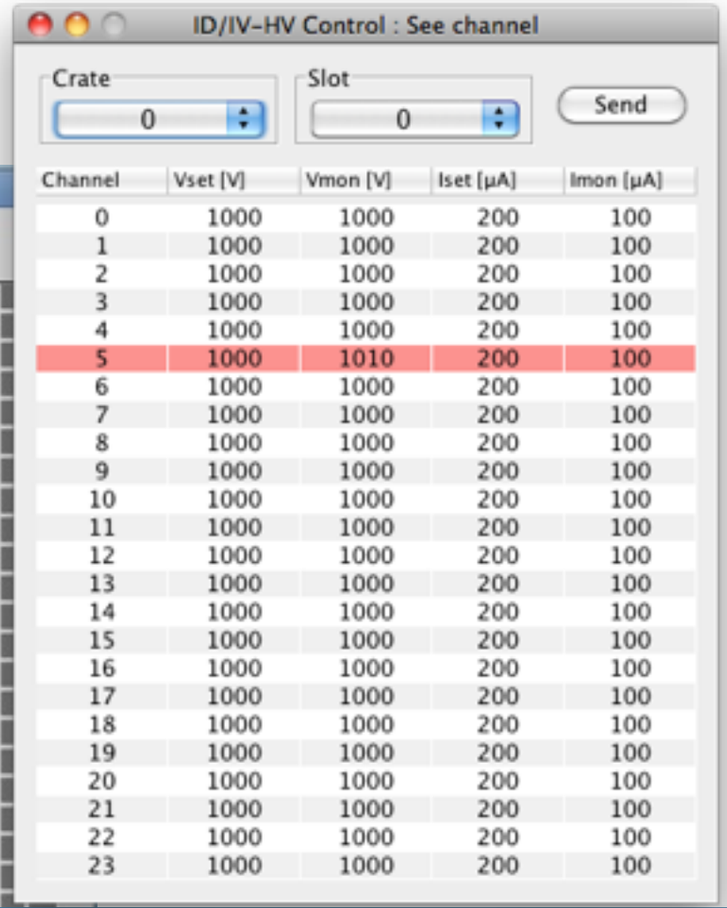
Control room

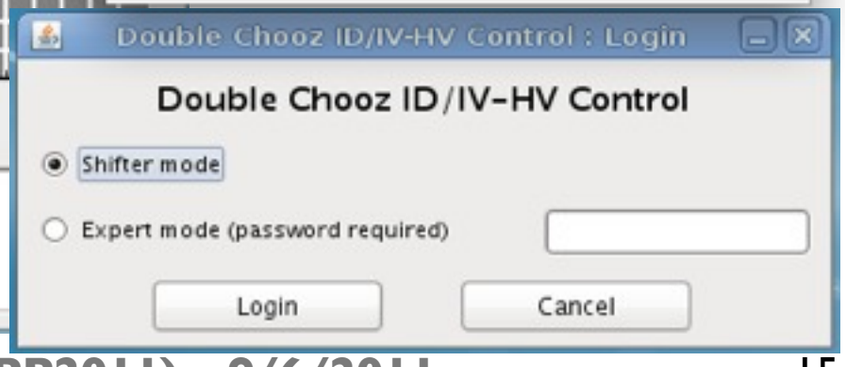
HV control

- On/Off
- Set Value
  - directly
  - from database
- Store the status to database
- Check the status

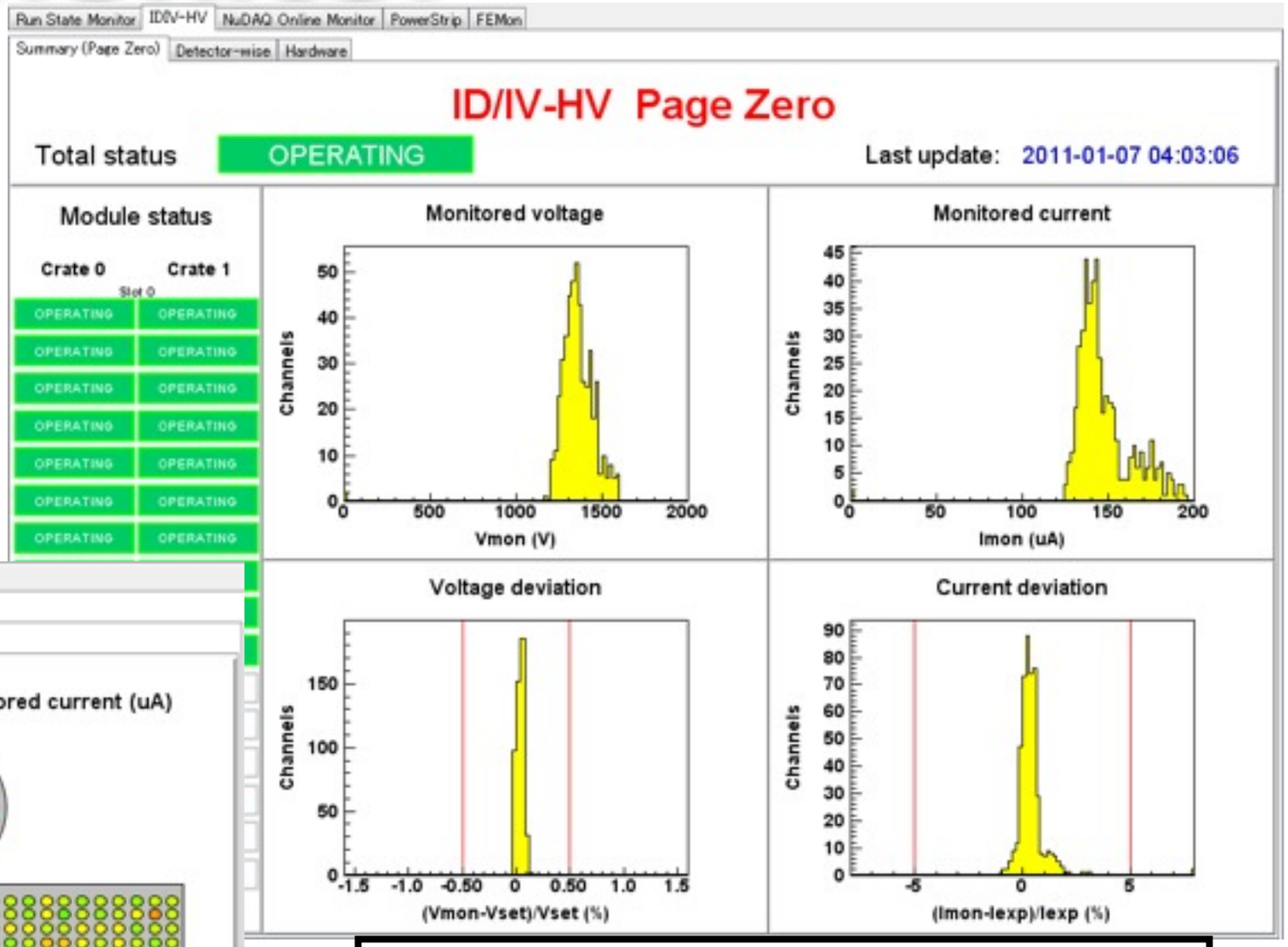




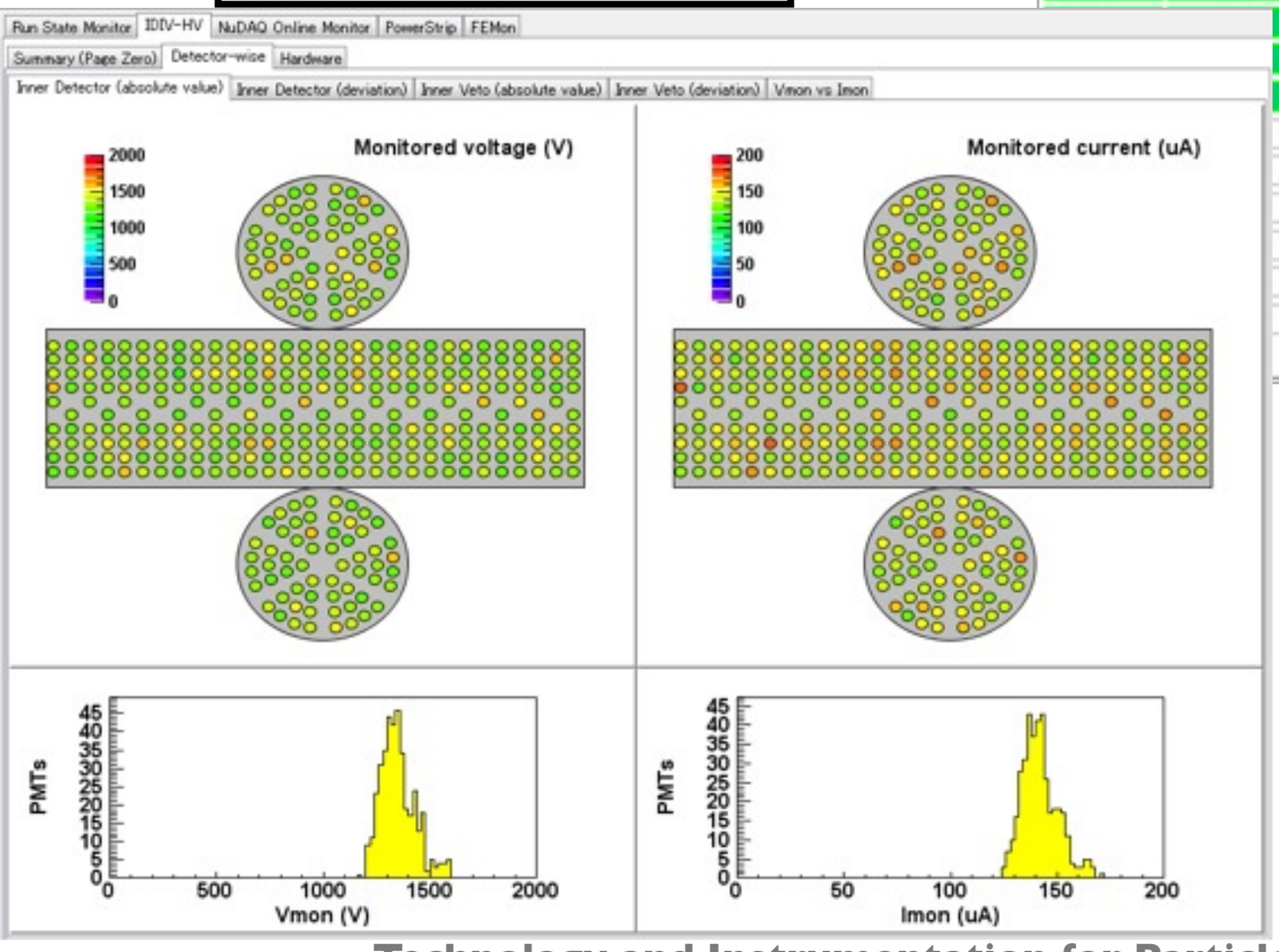




HV Online monitor



Detector map



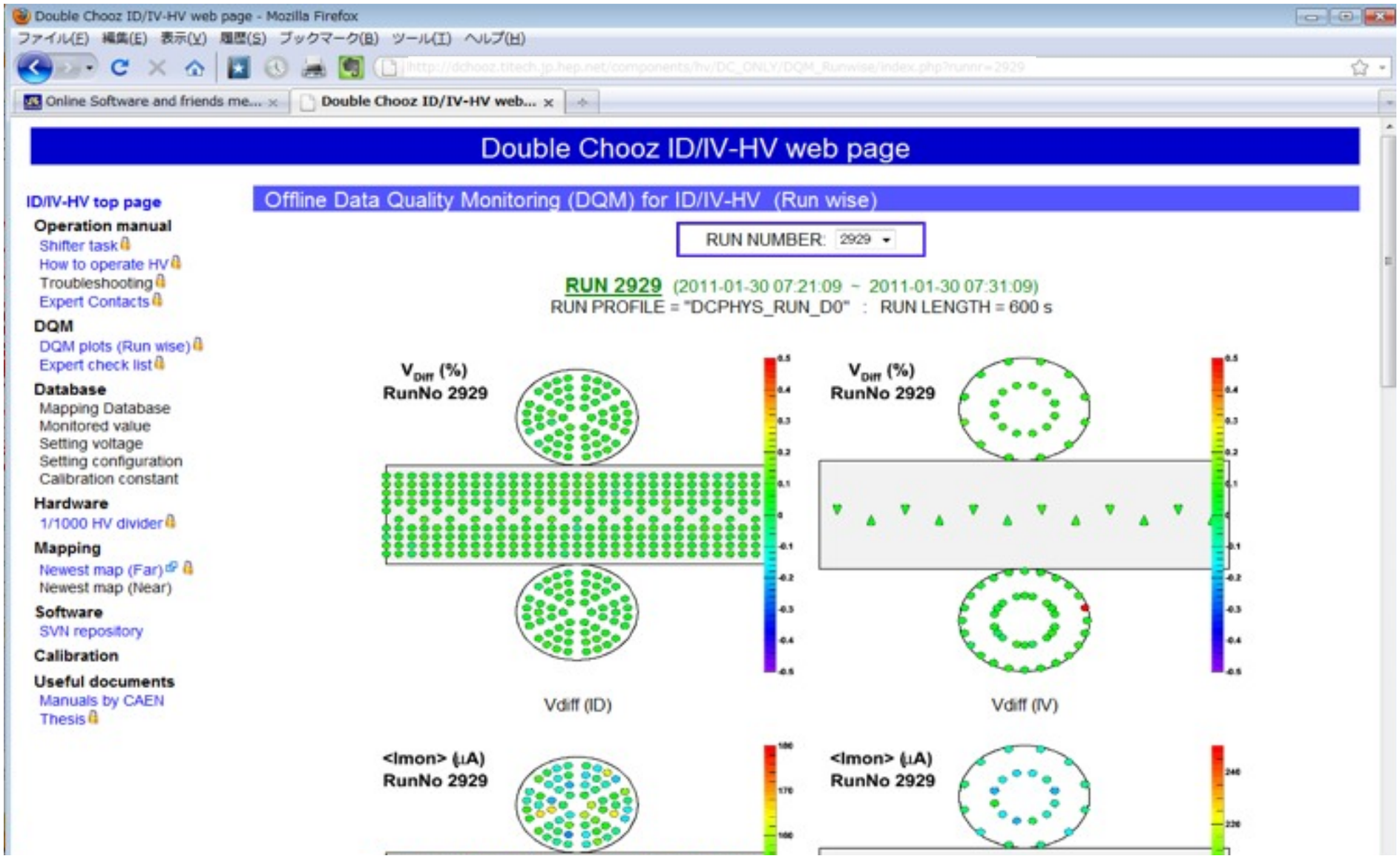
HV value distribution

poster presentation by T.Konno

Status monitoring system

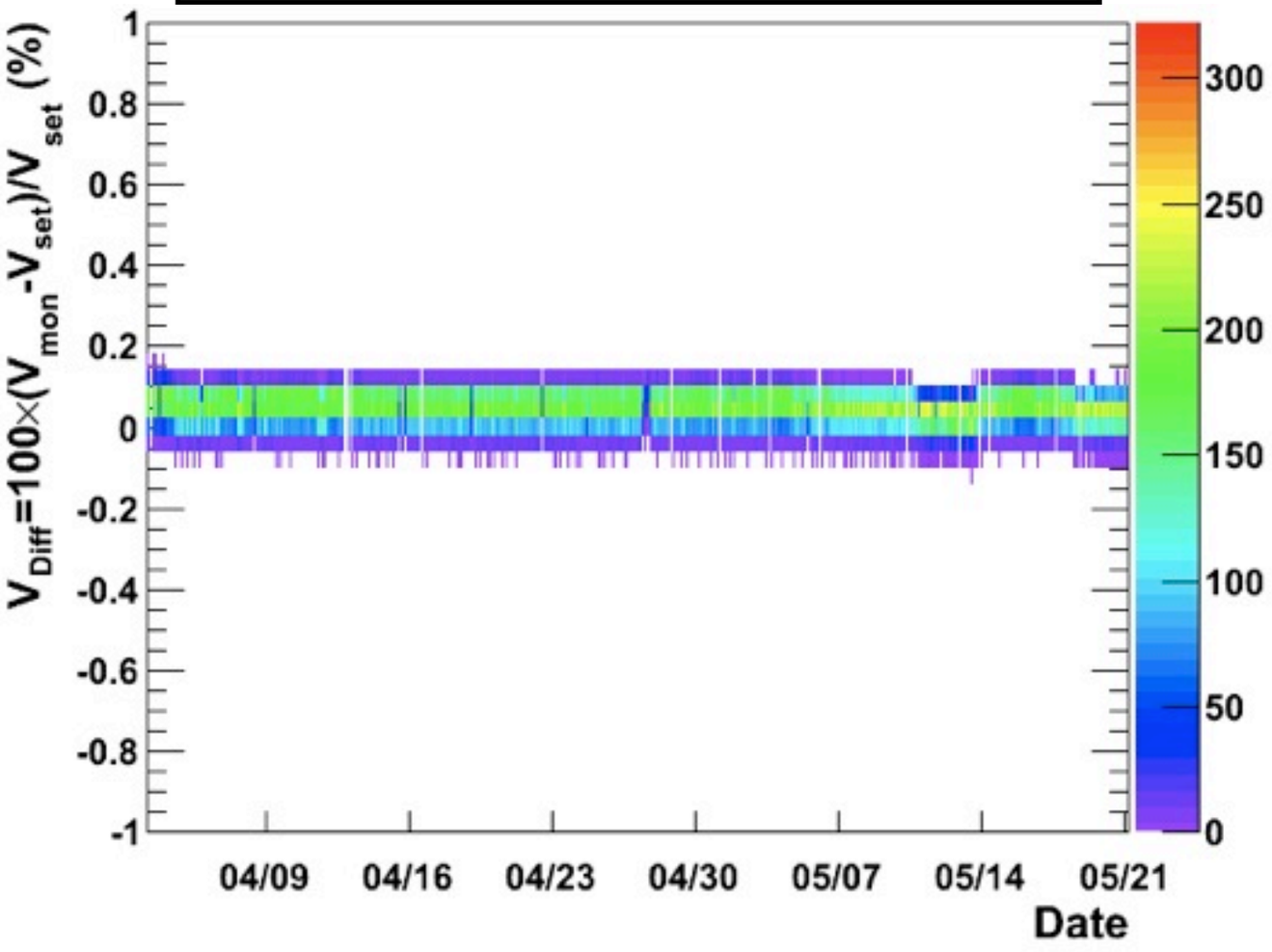
Status monitoring system

- Offline status monitoring system is developed.
- MySQL database for HV and run information is used for this system.
- Two kinds of plots are created.
  - run-wise : can check HV status in each run.
  - HV-wise : can check status in the HV system.

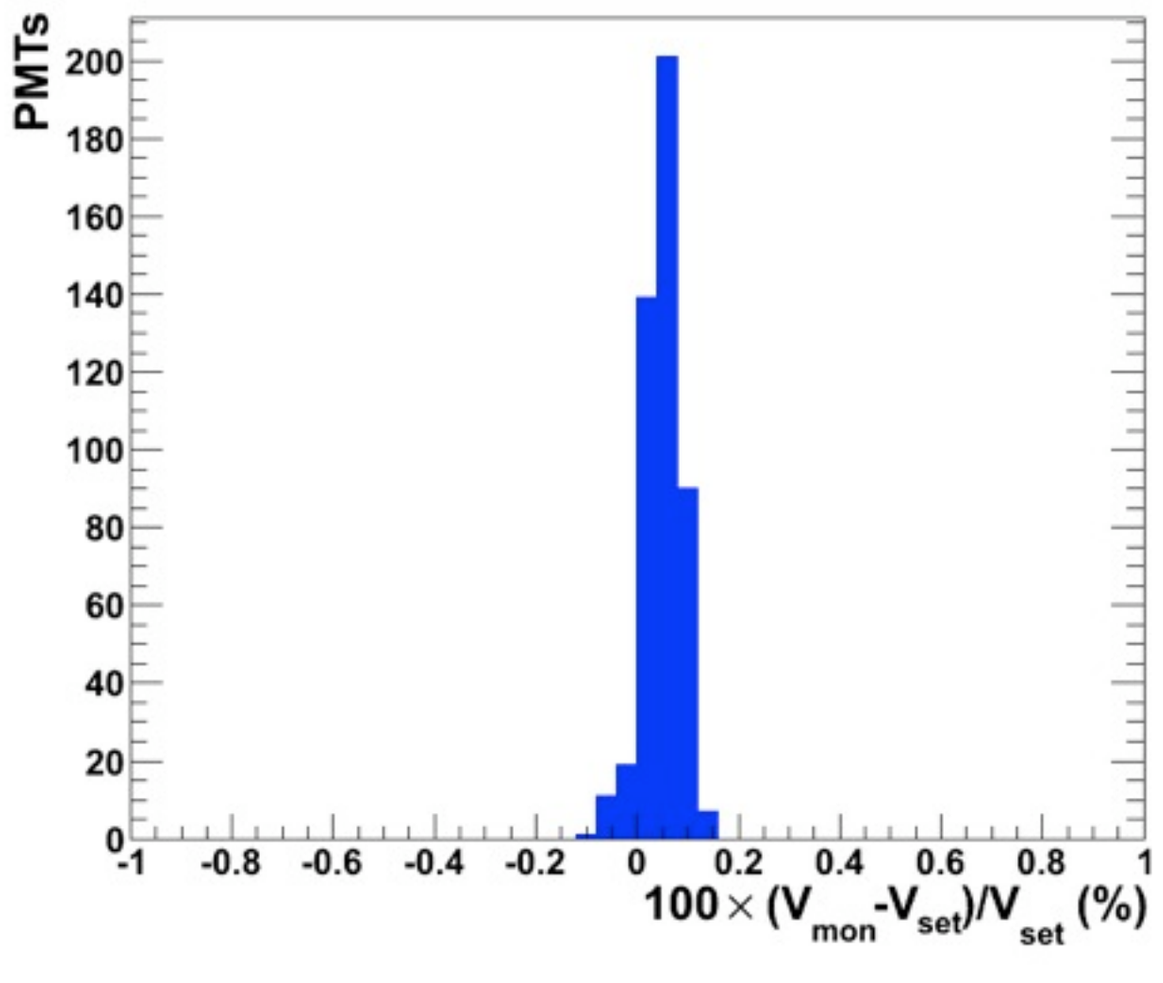


Current performance

Voltage deviation vs Date



max deviation during two month



- Check the stability of HV for about two months.
- High voltage deviation is within ~0.1% for about two months.

→ ~0.8% gain deviation of PMT.

Summary

- High Voltage system for 468 PMTs of the Double Chooz detector was constructed.
  - Splitter circuit was developed and succeeded to reduce noise from HV.
  - Control and monitoring software is working properly.
- HV calibration was done and succeeded to reduce module dependency.
- Data quality monitoring system is also developed.
  - HV was very stable in two months.
- All the high voltage system for the Double Chooz experiment is stably working.