

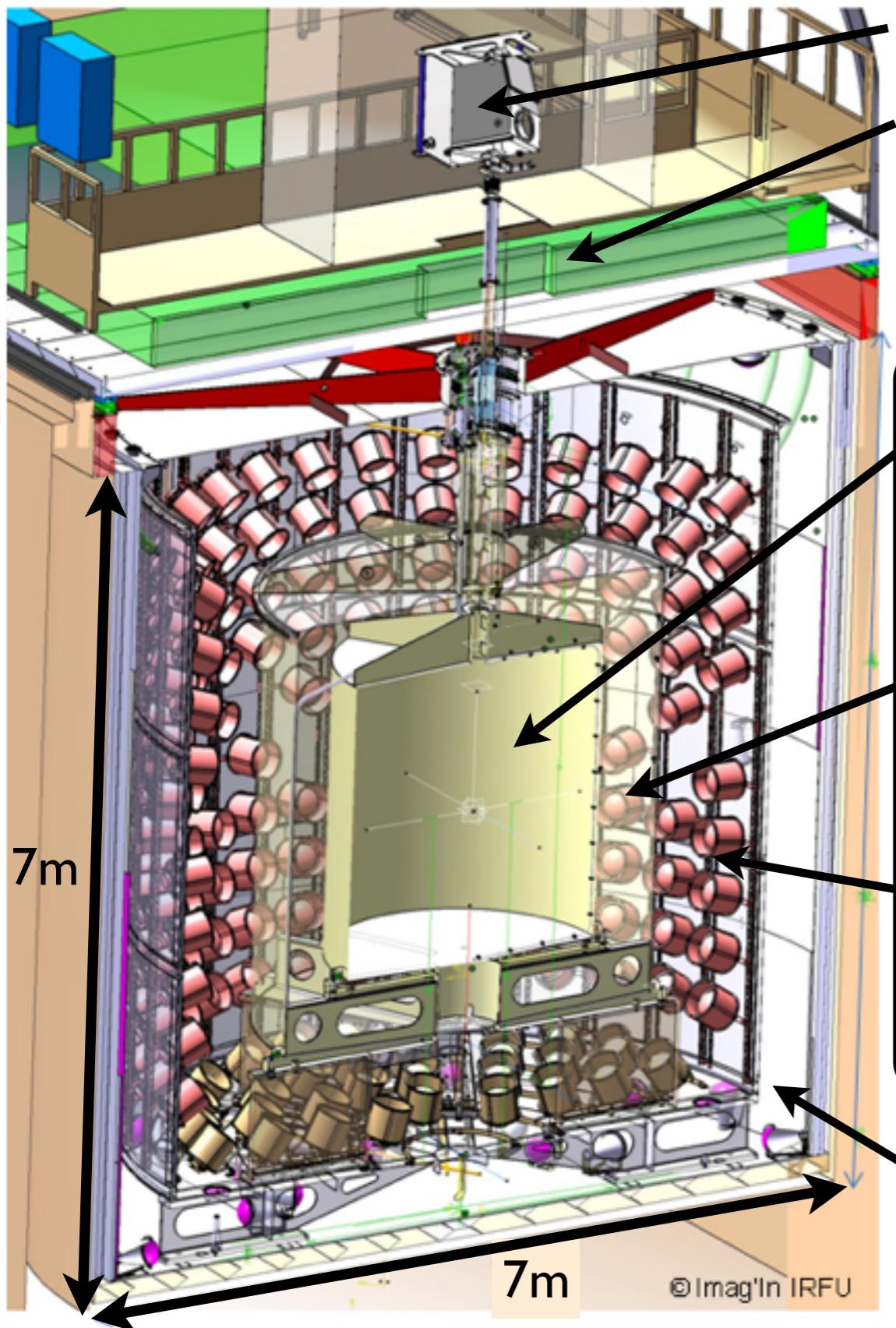


TOKYO METROPOLITAN UNIVERSITY

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)

v-target

Generate neutrino signal
[Gd doped(1g/l) liquid scintillator(10.3m³)]

γ-catcher

Capture escaping γ-ray from target region
[Liquid scintillator without Gd doping(22.3m³)]

Buffer

Reduce fast neutron and accidental γ-ray
[Mineral oil (110m³) + 10"PM^T × 390]

Inner veto (IV)

Back ground identify and veto
[Liquid scintillator (90m³) + 8"PM^T × 78]



Readout system

Photomultiplier tubes

ID : 390 PMTs (R7081MOD)

IV : 78 PMTs (R1408)



HV-Splitter

(by CIEMAT)



Signal
HV

Frontend Electronics



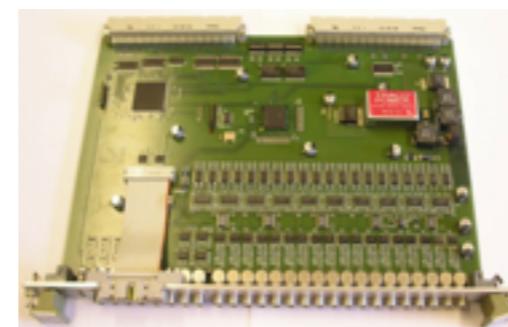
Signal

HV-Supply

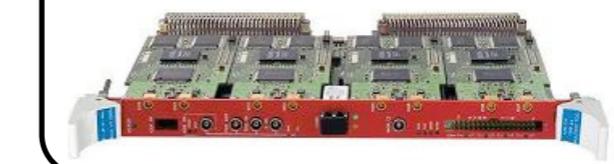
SY1527LC & A1535P
(by CAEN)



Trigger & Clock

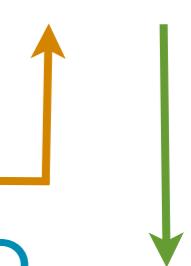


v-FADC

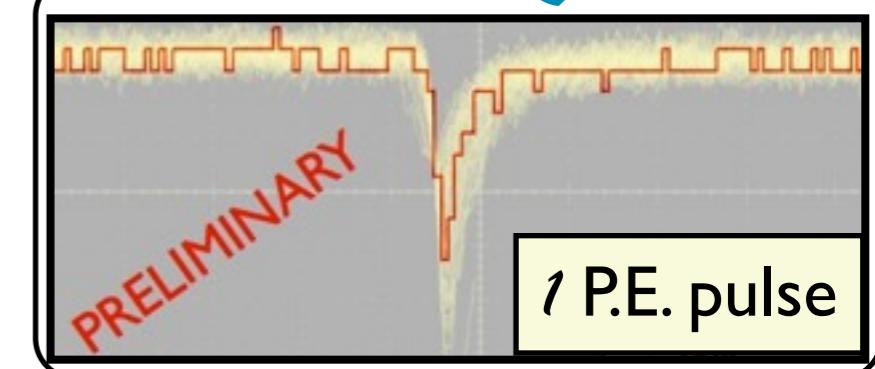


Trigger & clock

μ -FADC



v-DAQ





High Voltage system

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

• HV crate

Front view



Back view

SY1527LC crate

- 16 slots / crate
- size : 19-inch × 8U
- weight : 24 kg @ no module
- operating temperature : 0~40°C
- CPU and original OS are in itself
- Ethernet port interface is implemented
→ be able to operate remotely (TCP/IP)

* 2 crates / one detector

HV module



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 μ A
- Radial 52-pin connector



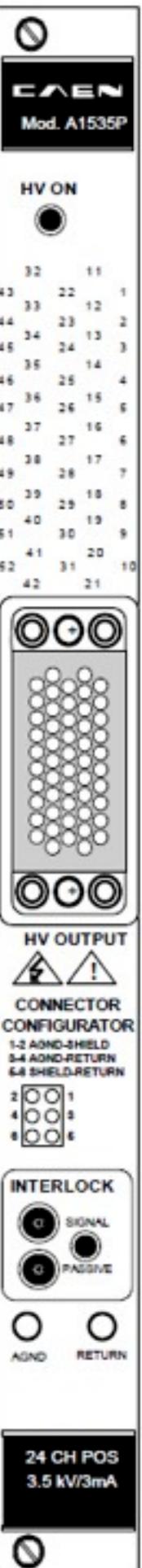
Channel chip



Front view

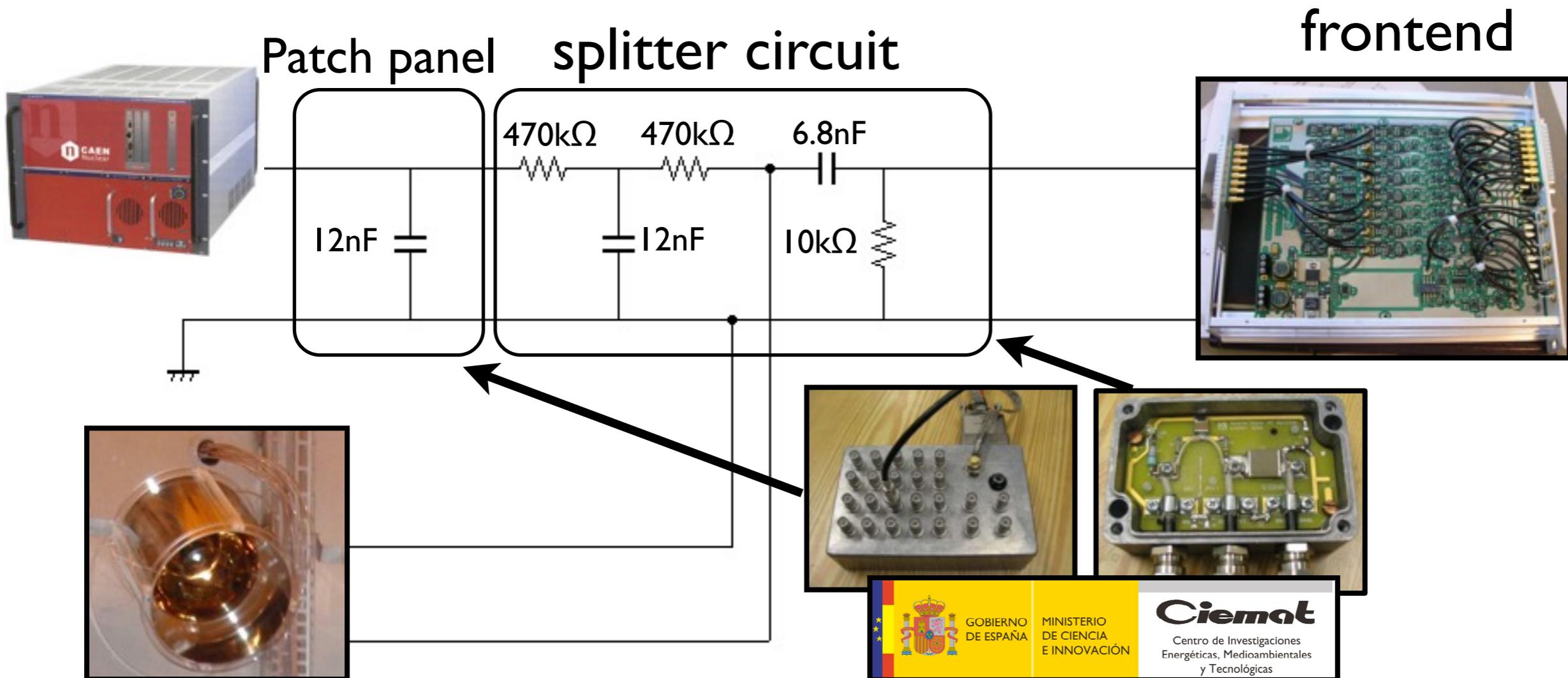


Side view





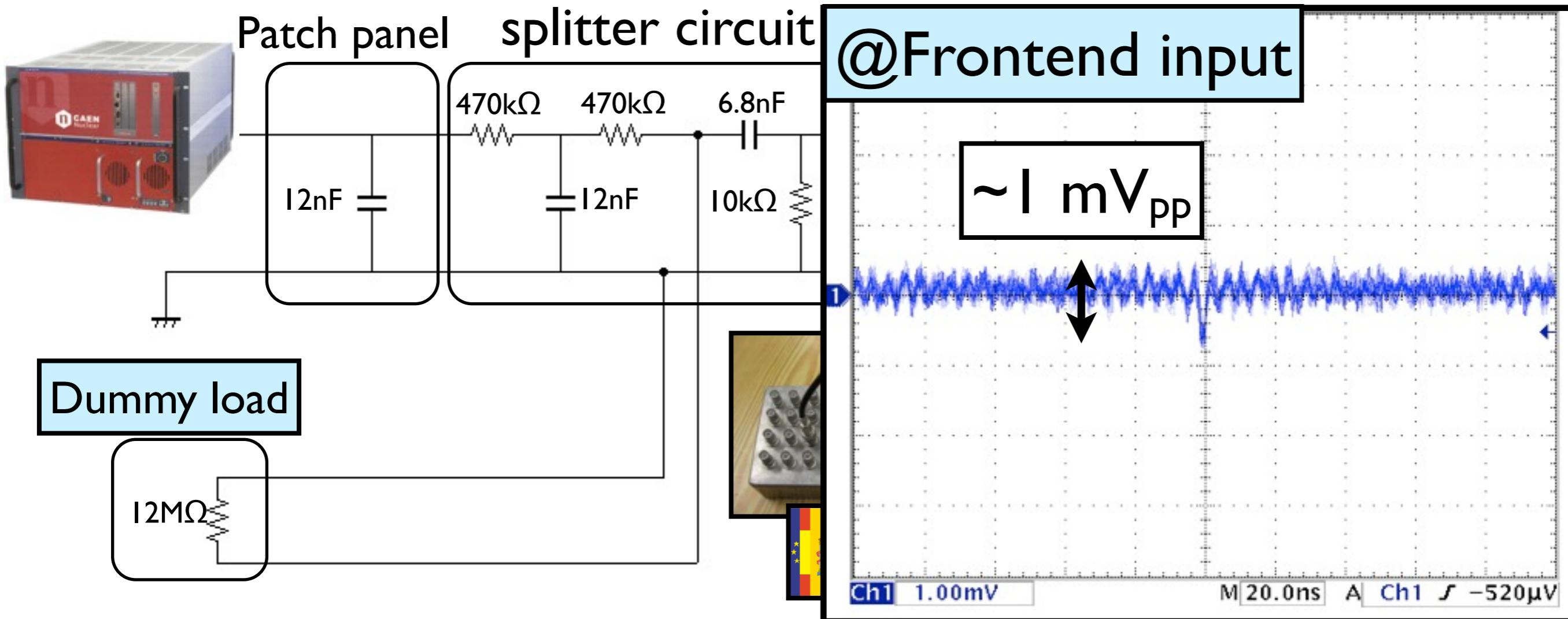
Splitter circuit for the PMT



- 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



- 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.

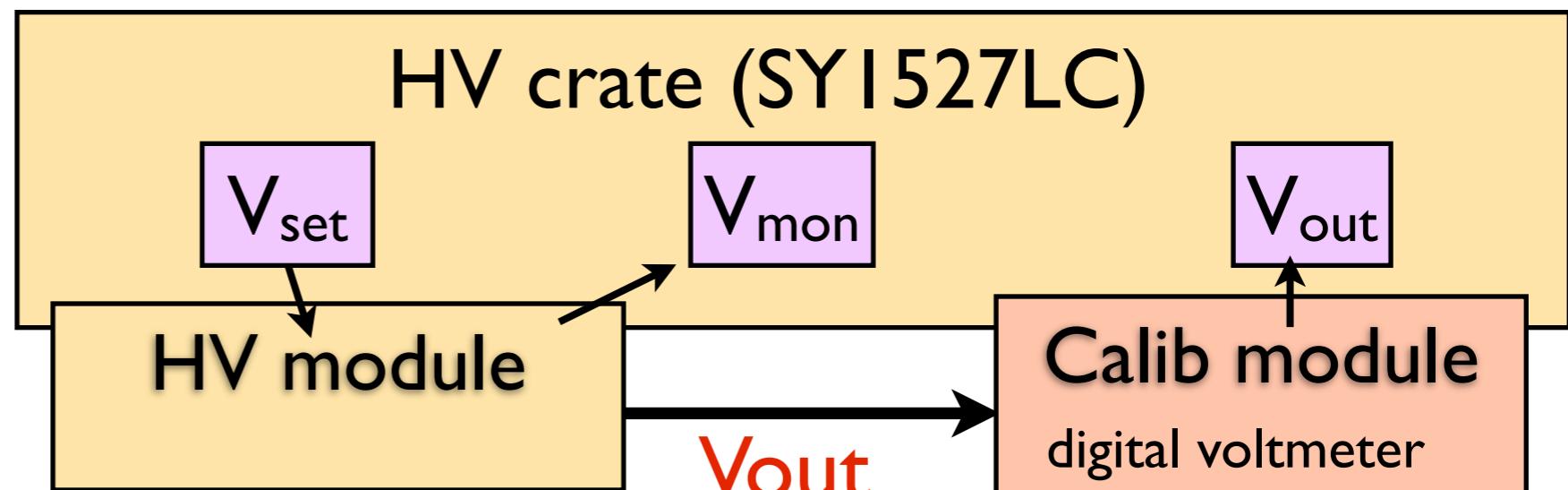
Calibration module



HV 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.



V_{set} : Setting voltage

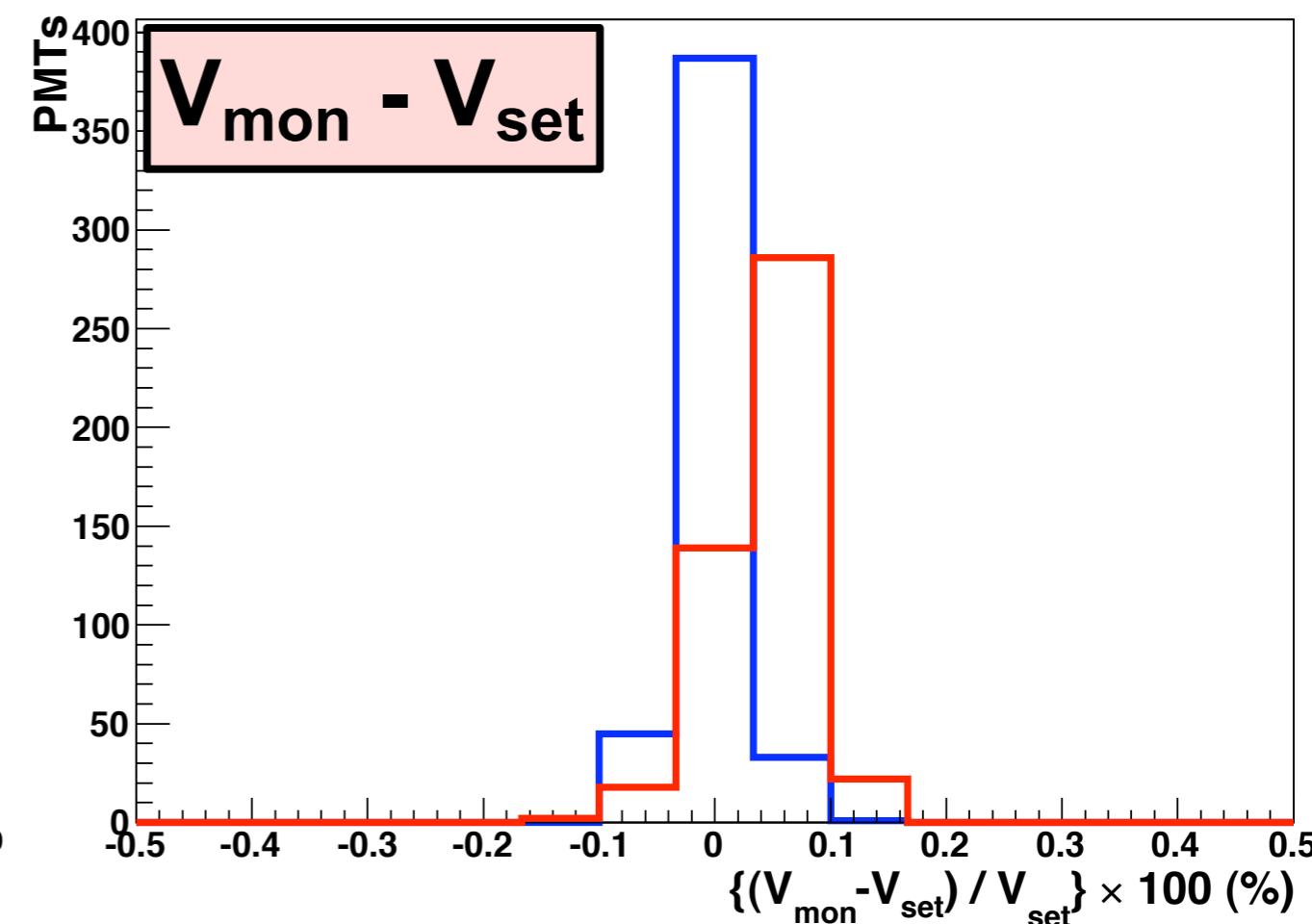
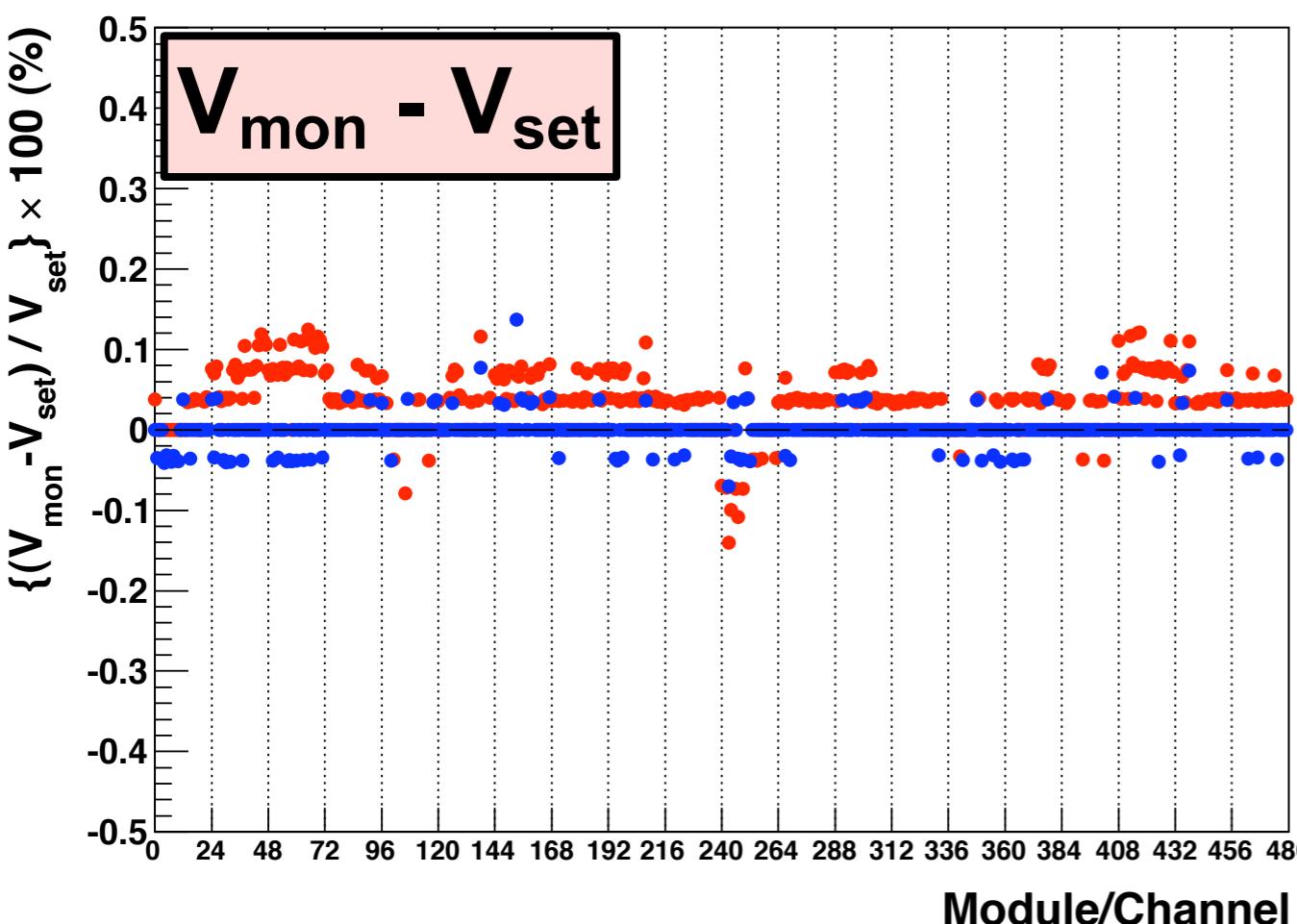
V_{mon} : Voltage monitored by the HV module

V_{out} : Actual applied voltage



HV calibration result

before calibration
after calibration

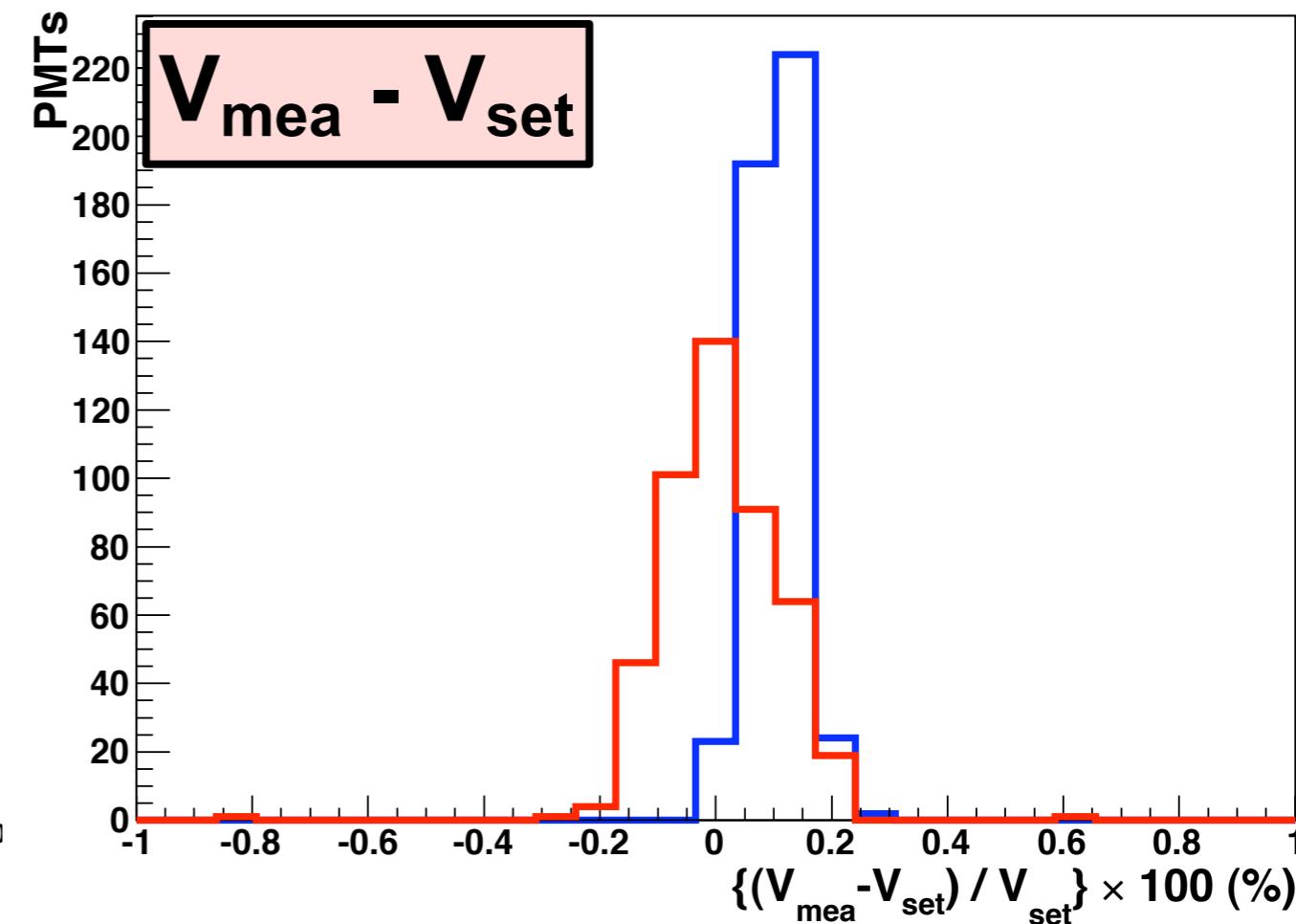
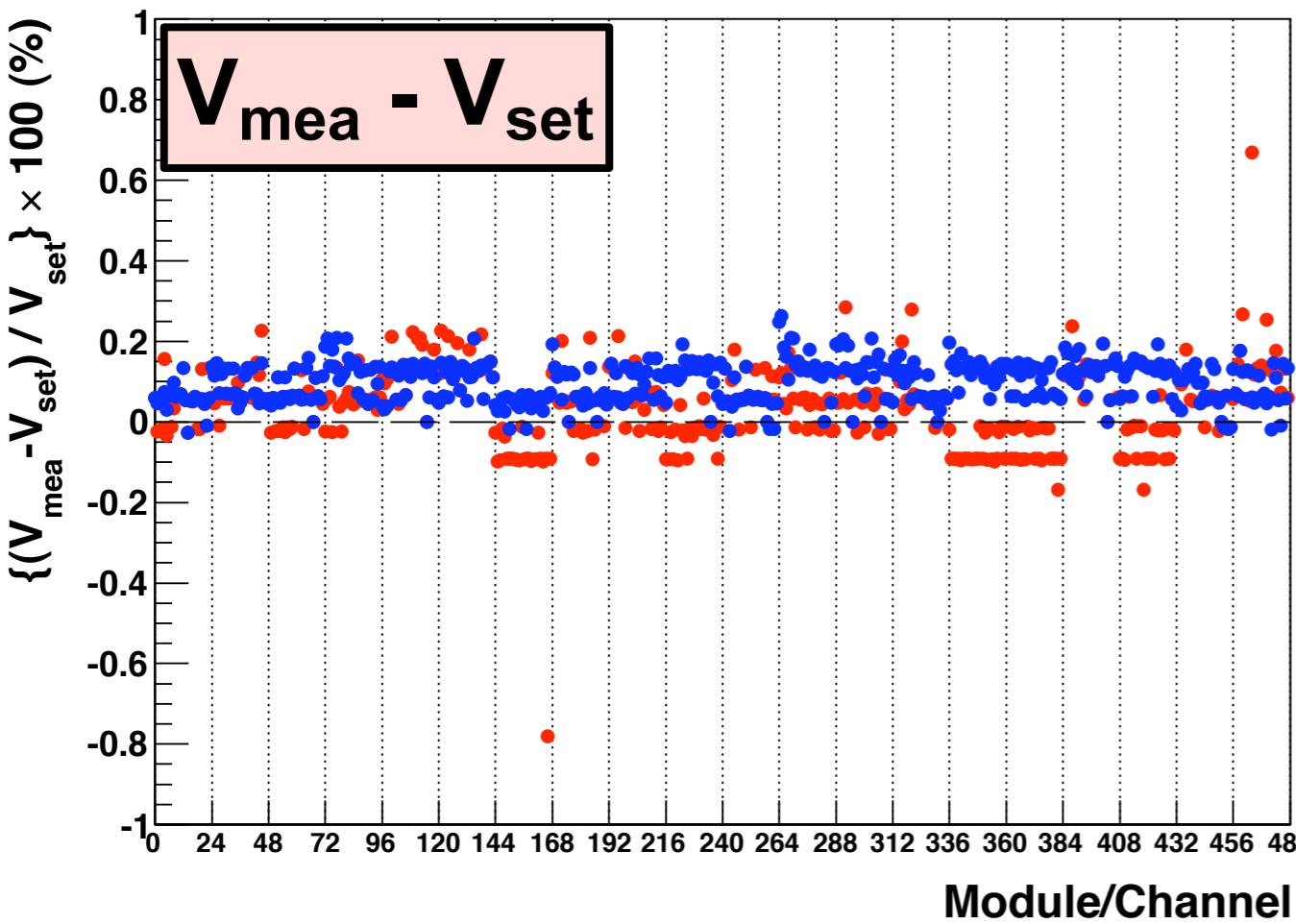


- Module dependency reasonably disappeared after calibration.
- V_{mon} are almost same value as V_{set} (within $\sim 0.05\%$)



HV calibration result

before calibration
after calibration



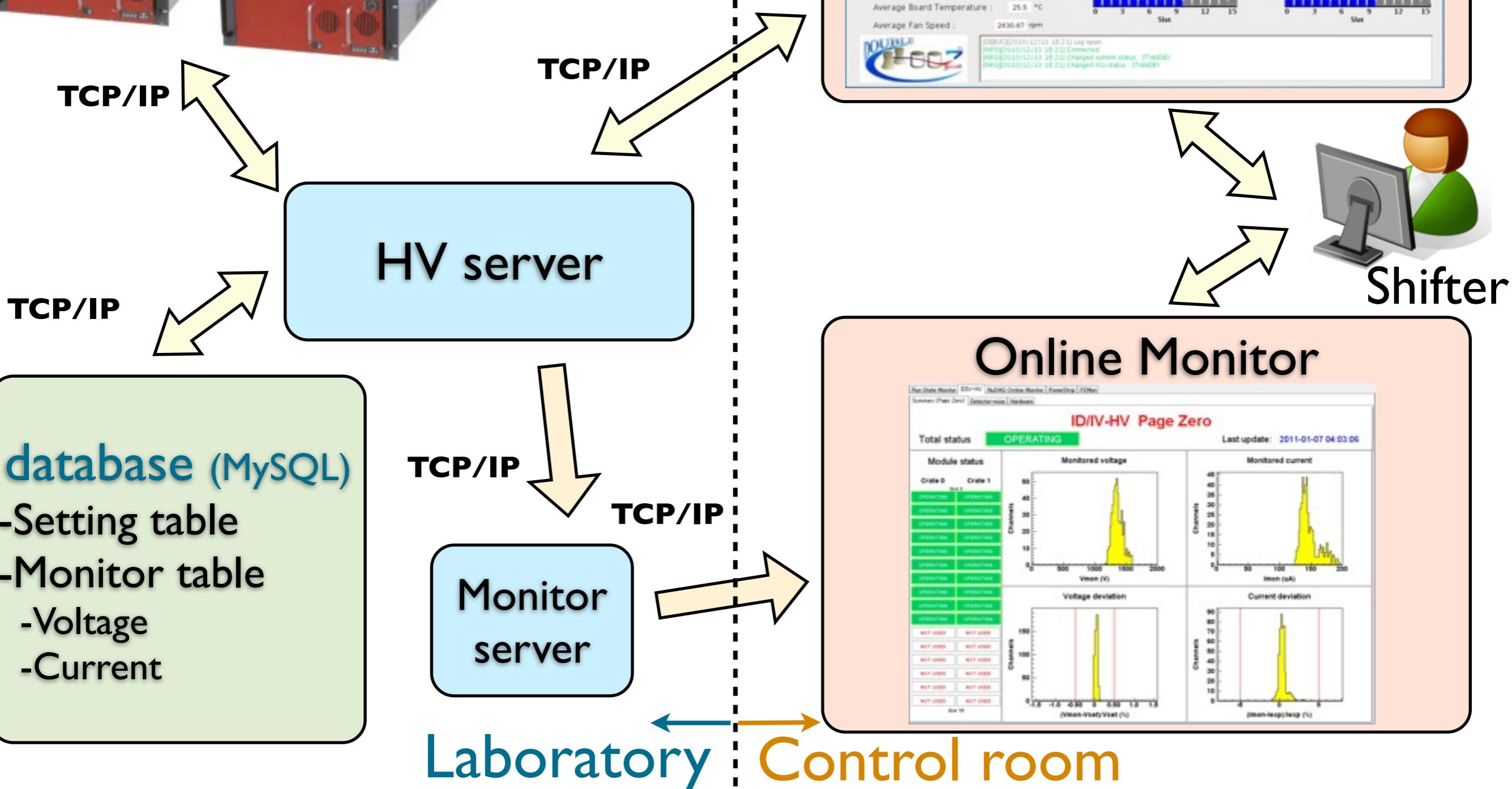
- V_{mea} : the output value measured at dummy load ($\div V_{\text{out}}$).
- V_{mea} has narrow distribution after the calibration.
- still biased to positive side a little



Control software



Structure



HV control

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

The screenshot shows the main control window titled "ID/IV-HV Control". It includes several sub-windows:

- ID/IV-HV Control : Set value**: A dialog for setting voltage values, with "All" selected. It has dropdowns for Crate (All), Slot (All), and Channel (All). Options include "Read databases", "Set uniform value" (set to 1000 V), and a checkbox for "Store to database". A "Submit" button is at the bottom.
- ID/IV-HV Control : ON/OFF**: A dialog for turning HV on or off. It has "All" selected. It has dropdowns for Crate (All), Slot (All), and Channel (All). It shows two radio buttons: "ON" and "OFF", and a "Submit" button.
- ID/IV-HV Control**: The main monitoring window. It displays two heatmaps: "Crate 0" and "Crate 1". The y-axis is "Channel" (0-22) and the x-axis is "Slot" (0-15 for Crate 0, 0-9 for Crate 1). Blue indicates operating status, grey indicates not used.
- GUI ⇔ HVCtrl**: Status indicator showing "CONNECTED".
- IVLI monitor**: Status indicator showing "STANDBY".
- Channel-Counting**: A table of counts for various states:

STANDBY : 469	OPERATING : 0
RAMP UP : 0	RAMP DOWN : 0
TRIP : 0	WARNING : 0
ERROR : 0	NOT USED : 299
- Buttons**: ON/OFF, Reconnect GUI, See channel, See module, Clear Alarm, Set value, Change config, KILL.
- Average Board Temperature**: 25.5 °C.
- Average Fan Speed**: 2630.67 rpm.
- Log window**: Displays system logs including connection and status changes.
- DOUBLE logo**: The Double Chooz logo.

The screenshot shows a login dialog for "Double Chooz ID/IV-HV Control". It contains the following fields:

- Mode Selection**: Radio buttons for "Shifter mode" (selected) and "Expert mode (password required)".
- Login**: A text input field for the password.
- Cancel**: A button to cancel the login process.



HV Online monitor

Run State Monitor ID/V-HV NuDAQ Online Monitor PowerStrip FEMon
Summary (Page Zero) Detector-wise Hardware

ID/IV-HV Page Zero

Total status

OPERATING

Last update: 2011-01-07 04:03:06

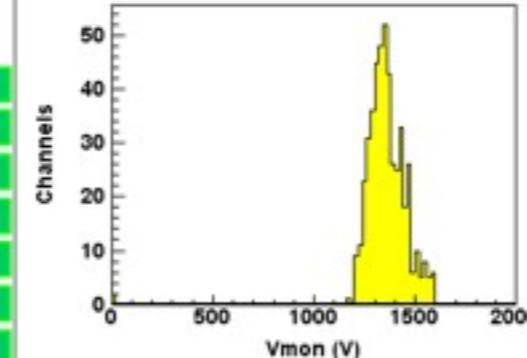
Module status

Crate 0 Crate 1

Slot 0

OPERATING OPERATING

Monitored voltage

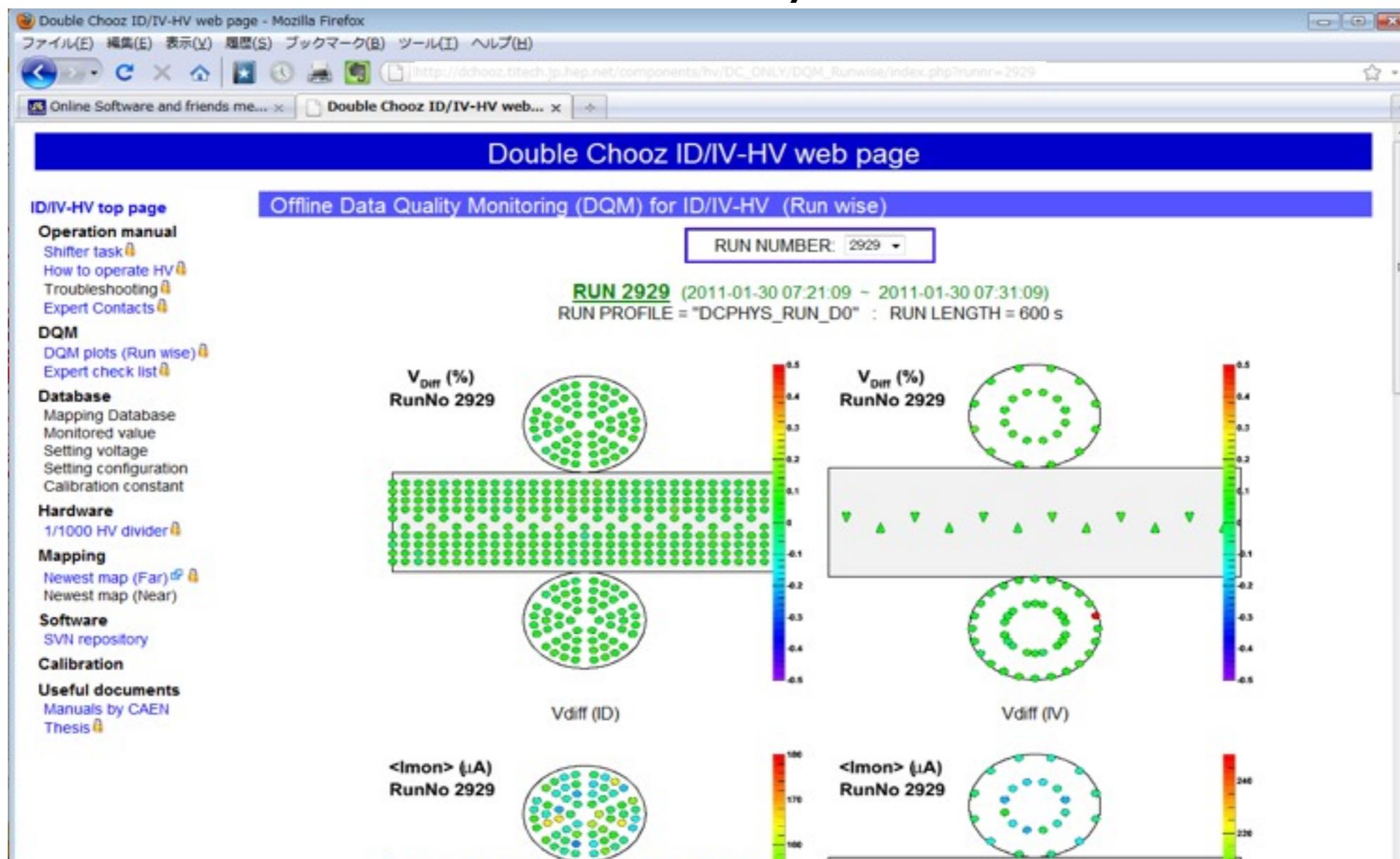




Status monitoring system

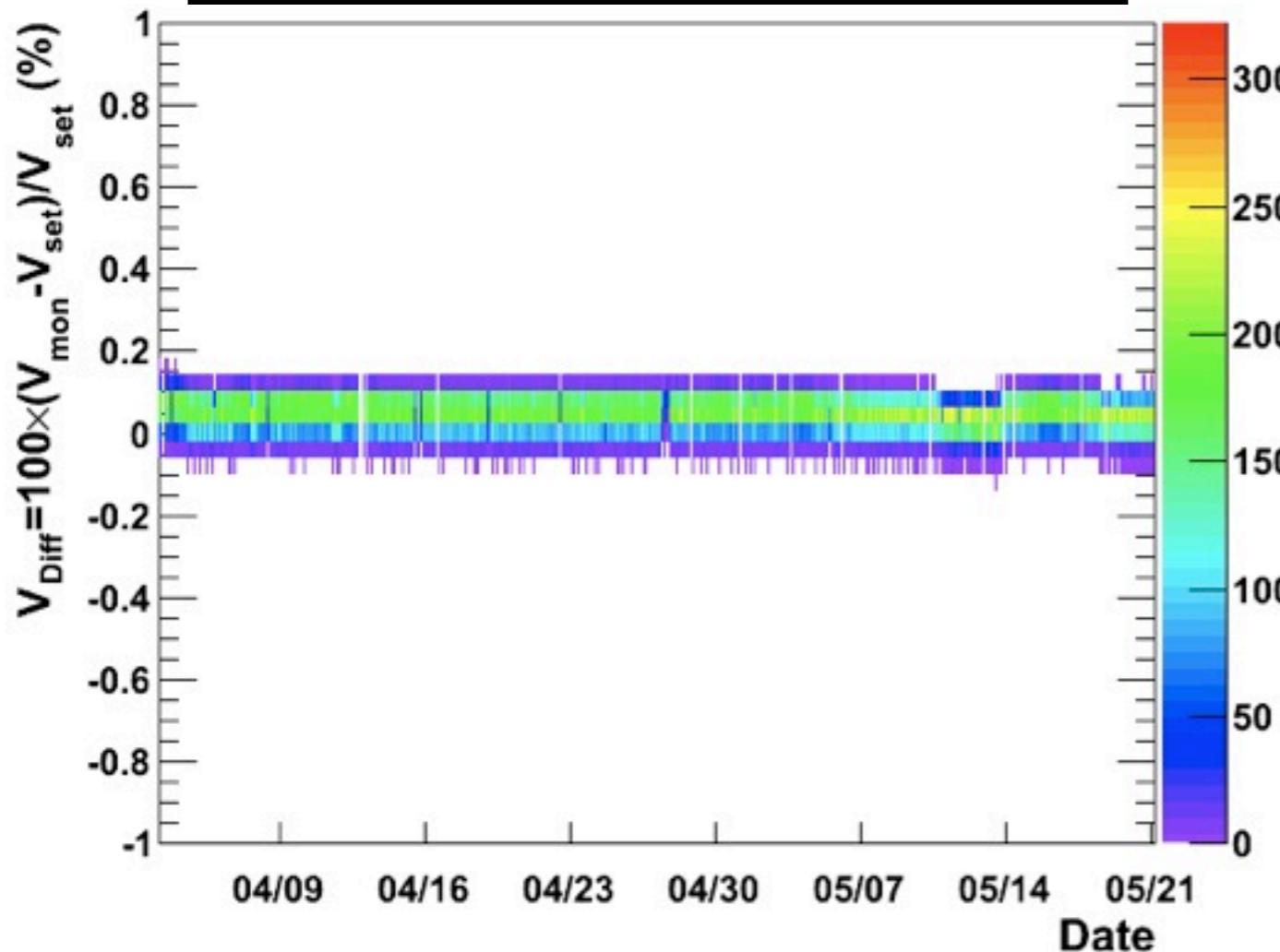
>Status monitoring system

- 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.

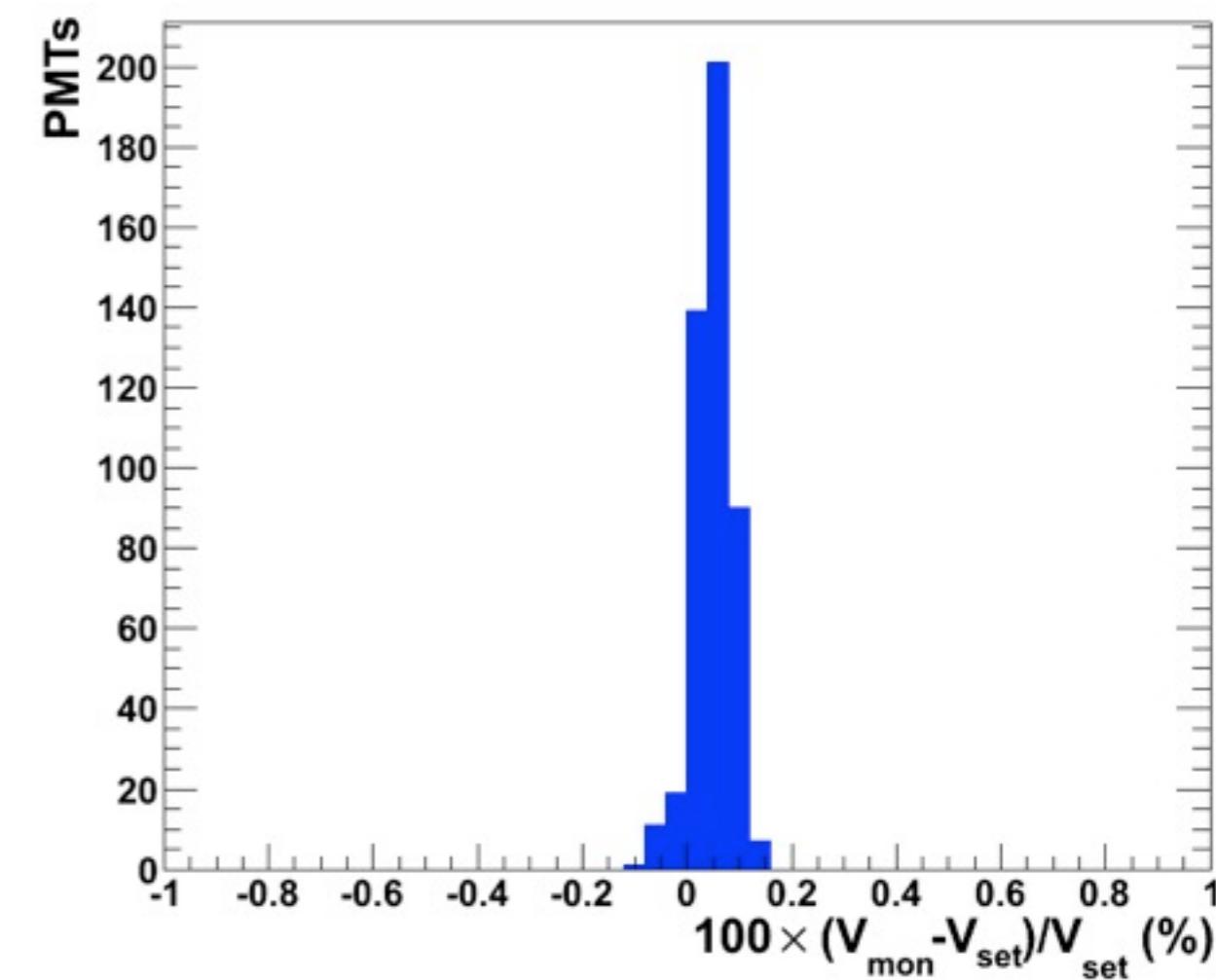


Current performance

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.