Detector control system / Slow control: Overview of KLM HV control

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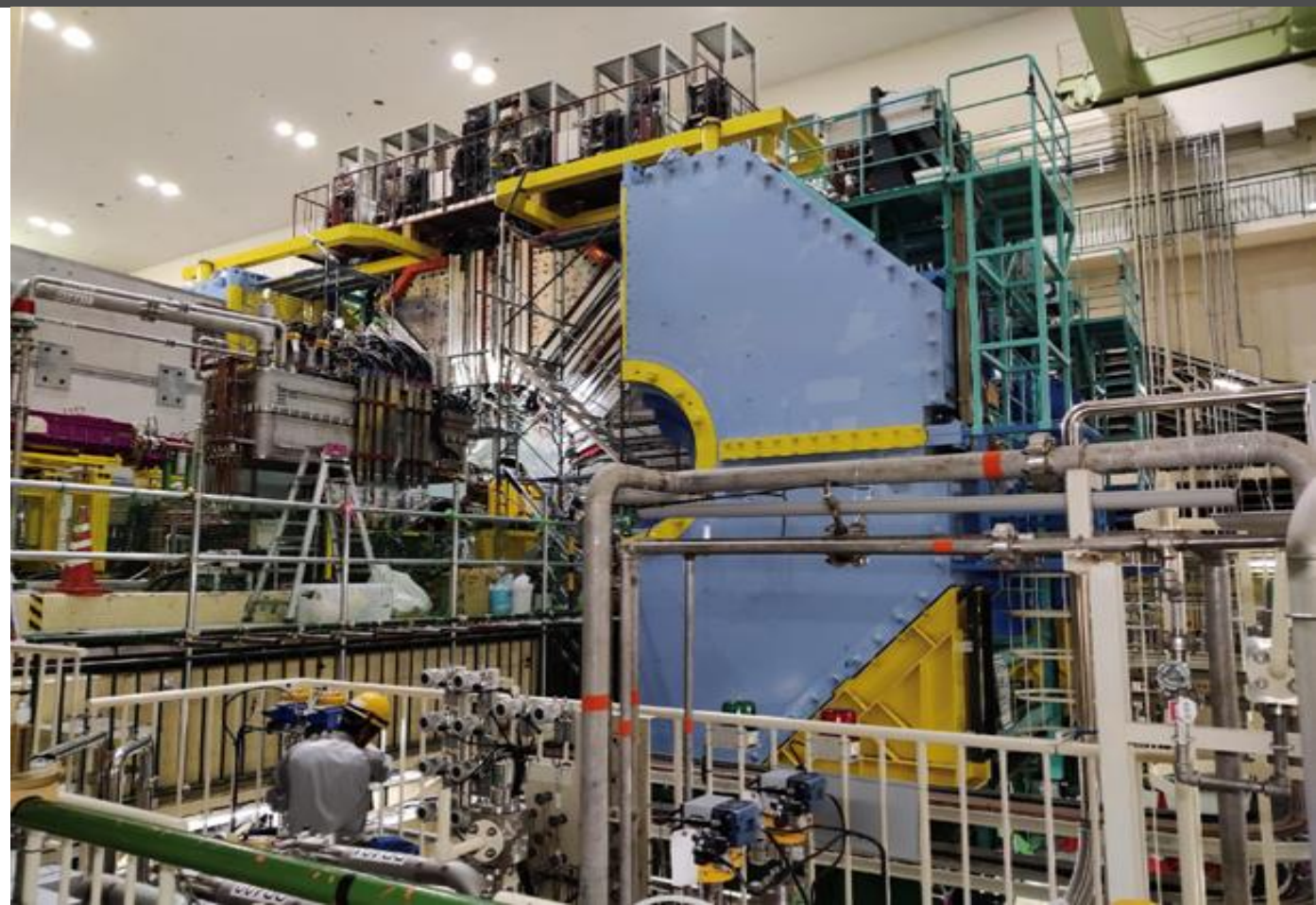
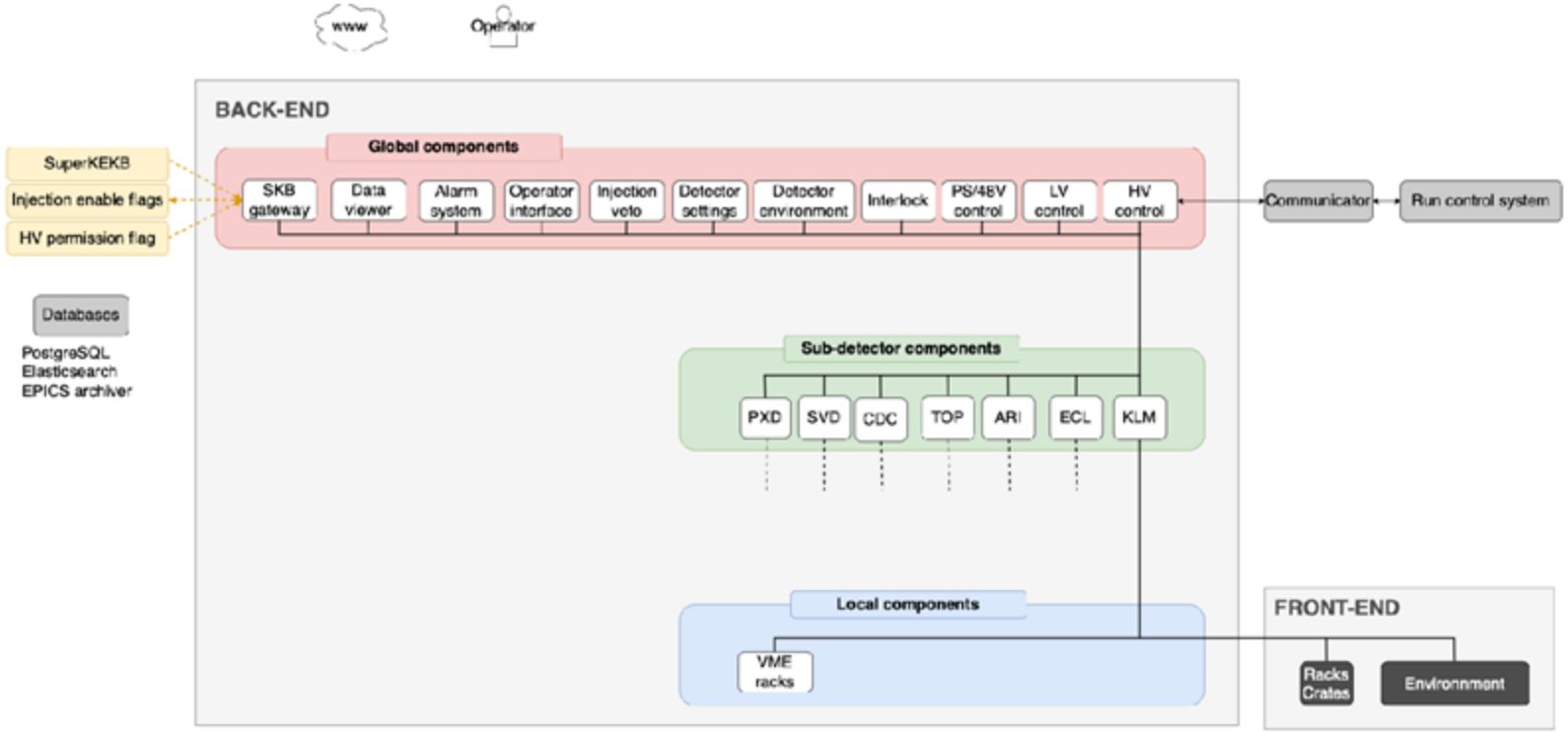
UNIVERSITY OF LOUISVILLE.



Introduction



➢ Detector Control System Courtesy:Kunigo-san @ KEK

- Derived from a common word: Industrial Control System
- To take data, sub-detector front end needs to be configured and initialized, and during data taking, also requires monitoring detector conditions like temperature, gas, and voltage. These operations are collectively referred to as **slow control**.
- and now the management of these detector-wide operations falls under the **DCS** group.

Targets of the DCS

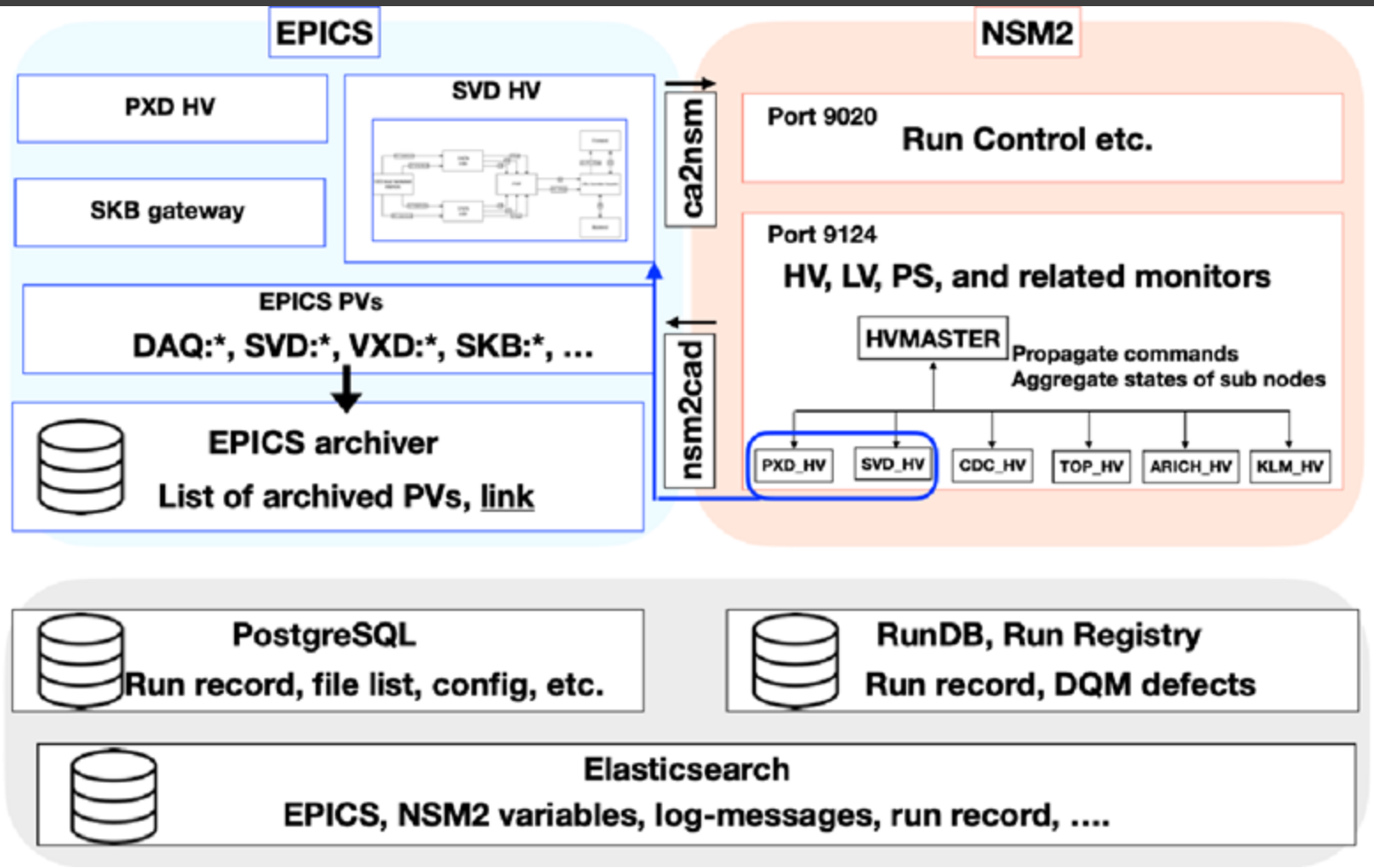
- **jobs related to detector control**
  - **High voltage control**
  - **Low voltage control**

- **detector setting**
  - **V-threshold**
  - **masking**
  - **interface to the database**

- **detector environment**
  - **thermal monitoring**
  - **gas monitoring**
  - **chiller**, etc

- **detector safety**
  - **HV permission (ARO)**
  - **interlock**
  - **cabling**, etc

B2NSM and B2EPICS



A gateway server (**daqnet**) links the two networks, allowing NSM2 daemons and EPICS IOCs to inter-operated.
– Operators control both networks via a single interface (e.g., Phoebus GUI).

Ref:[Trigger slow control system of the Belle II experiment]

HV control, permission, & ARO flag

- To have hand-shake between accelerator operations (SuperKEKB) and detector operations (Belle II), a mutual agreement is done based on SuperKEKB Injection status and Belle II HV Status for safe and smooth operations.

Current Scheme

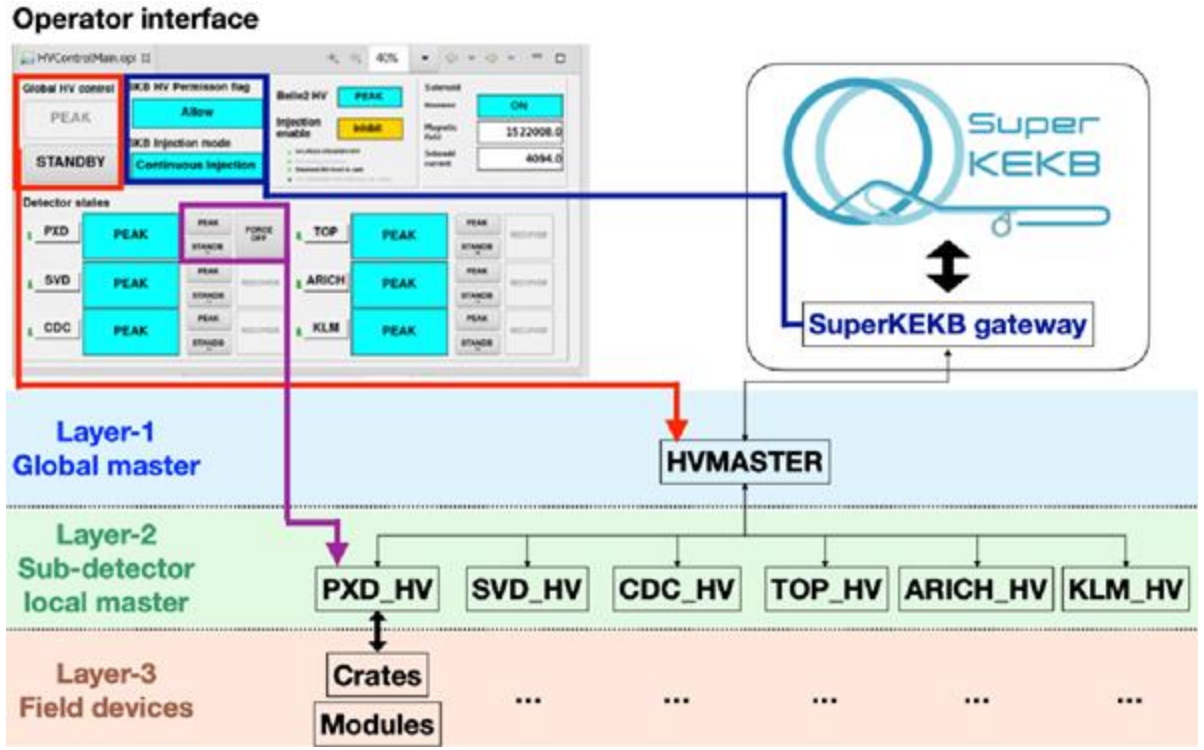
Beam Injection Signal

HV permission → Injection Enable — moderate and calm

HV permission → Injection Enable

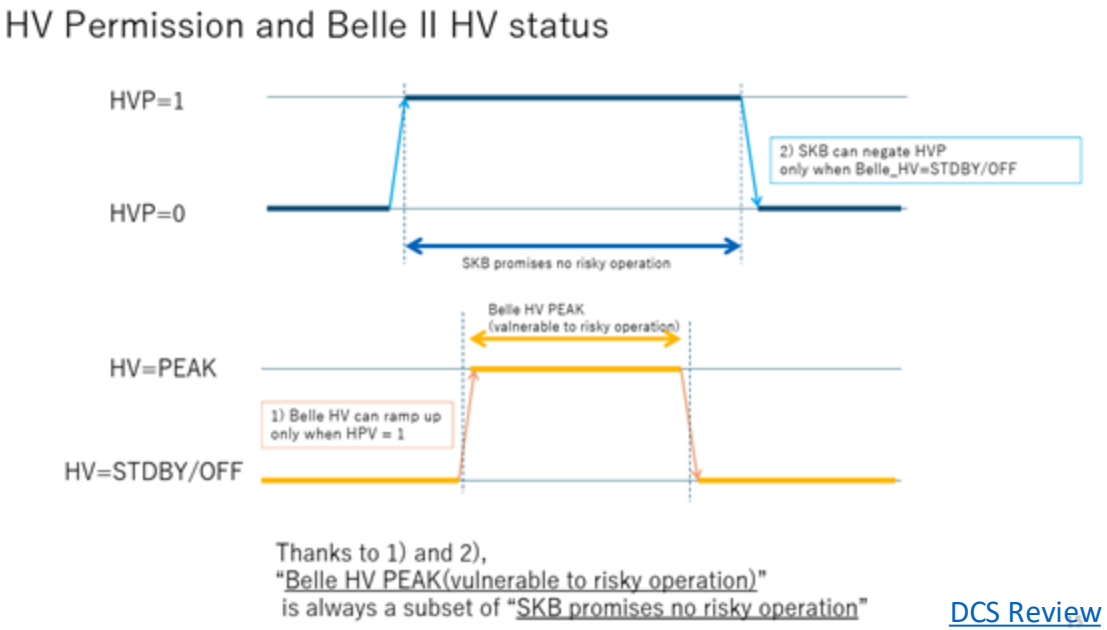
HV permission → Normal Enable — wild and dangerous

The global Belle II HV status is defined in HVMASTER, a module that takes into account the HV status of all sub-detectors.

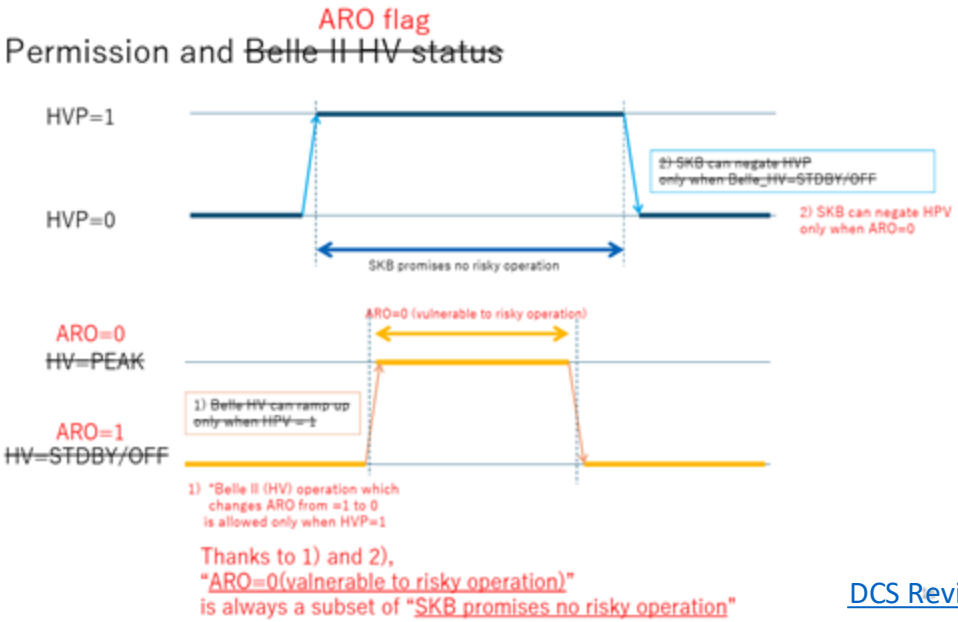


New Scheme: In the new system, **each subsystem can define its own injection enable signals** regardless of its HV status, based on its vulnerability to beam injections.

HV control, permission, & ARO flag



DCS Review

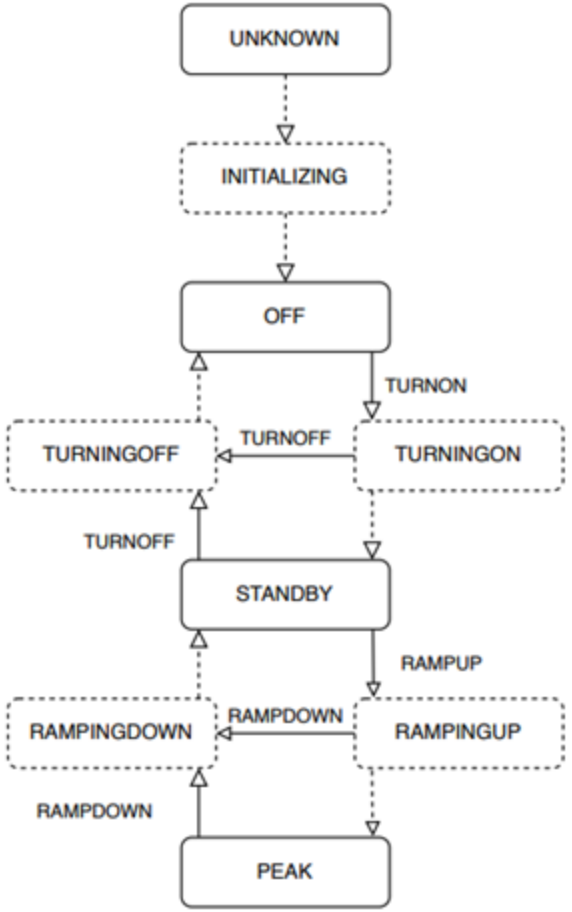


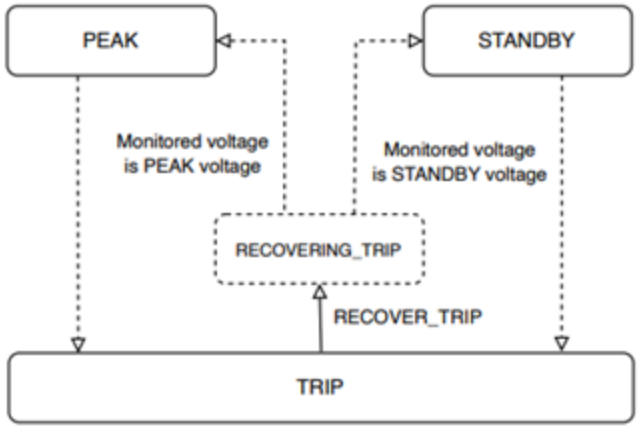
DCS Review

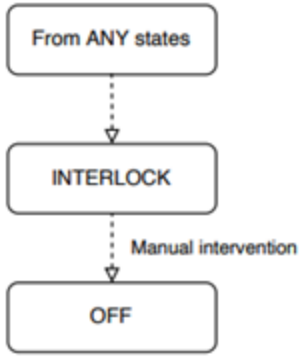
Current Status: Feedback and review of each sub-system scheme is in progress

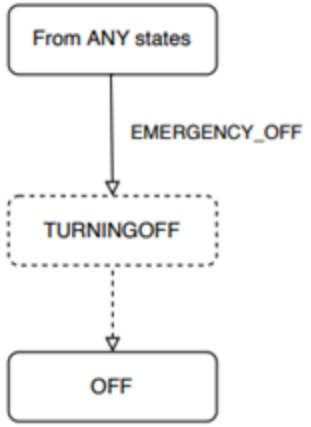
HV states and transitions

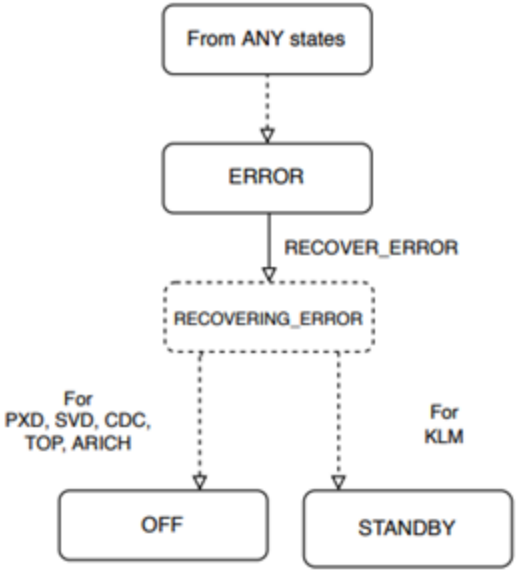
- Stable states
  - OFF
  - STANDBY
  - PEAK
- Transition states
  - TRANSITION
  - RAMPINGUP
  - RAMPINGDOWN
  - RECOVERING
  - TRUNINGON
  - TURNINGOFF
- Error states
  - ERROR
  - TRIP
  - INTERLOCK
  - MASKED











All states are defined in the source code here.

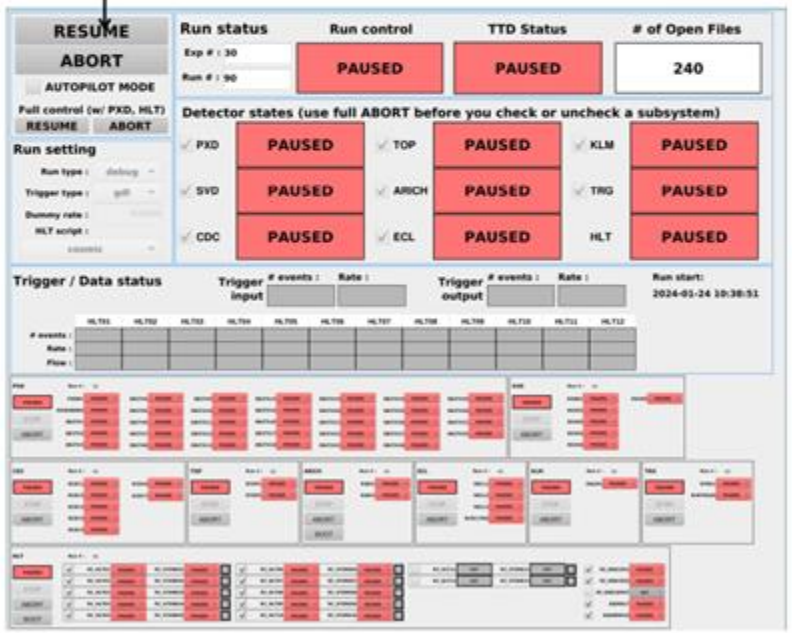
Monitoring by CR shifters

- ❑ To check the any errors are indicated in the HV control panel, in case of any error follow the RECOVERY procedures.
- ❑ To check if any interlock signals are indicated in the interlock panel.
- ❑ To check the mattermost chat notifications.

Belle II Shifter Operation Manual

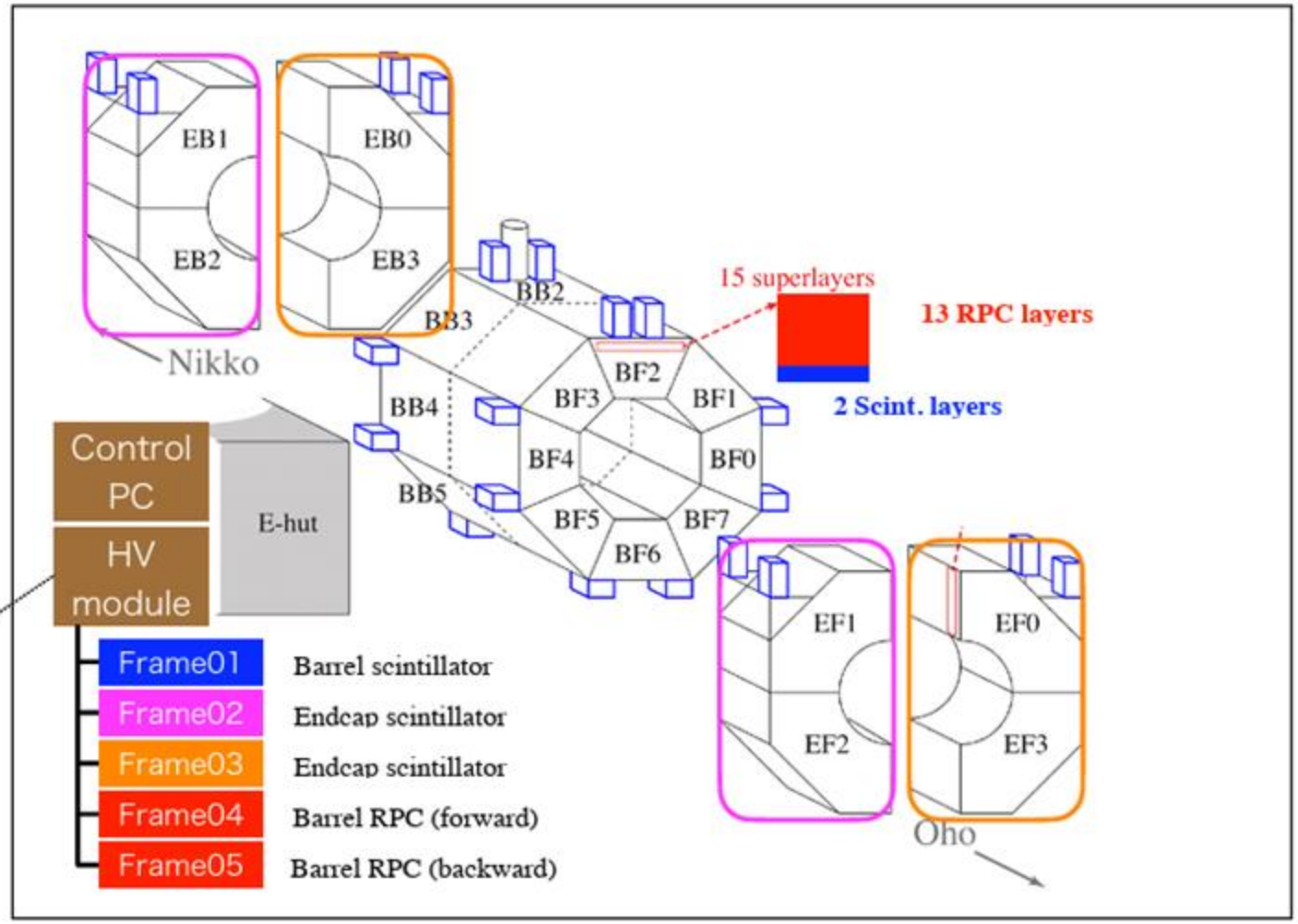
HV error states

- When HV goes to "ERROR", "TRIP", "INTERLOCK" or "UNKNOWN", the data taking is "PAUSED" in the RC panel. Do not "STOP" the current run.
  - ➢ "ERROR" and "TRIP" can be fixed by clicking the "RECOVER" button in the HV panel.
  - ➢ "INTERLOCK" and "UNKNOWN" need to be fixed by the subsystem experts.
- When the error state is gone, you can "**RESUME**" the run.



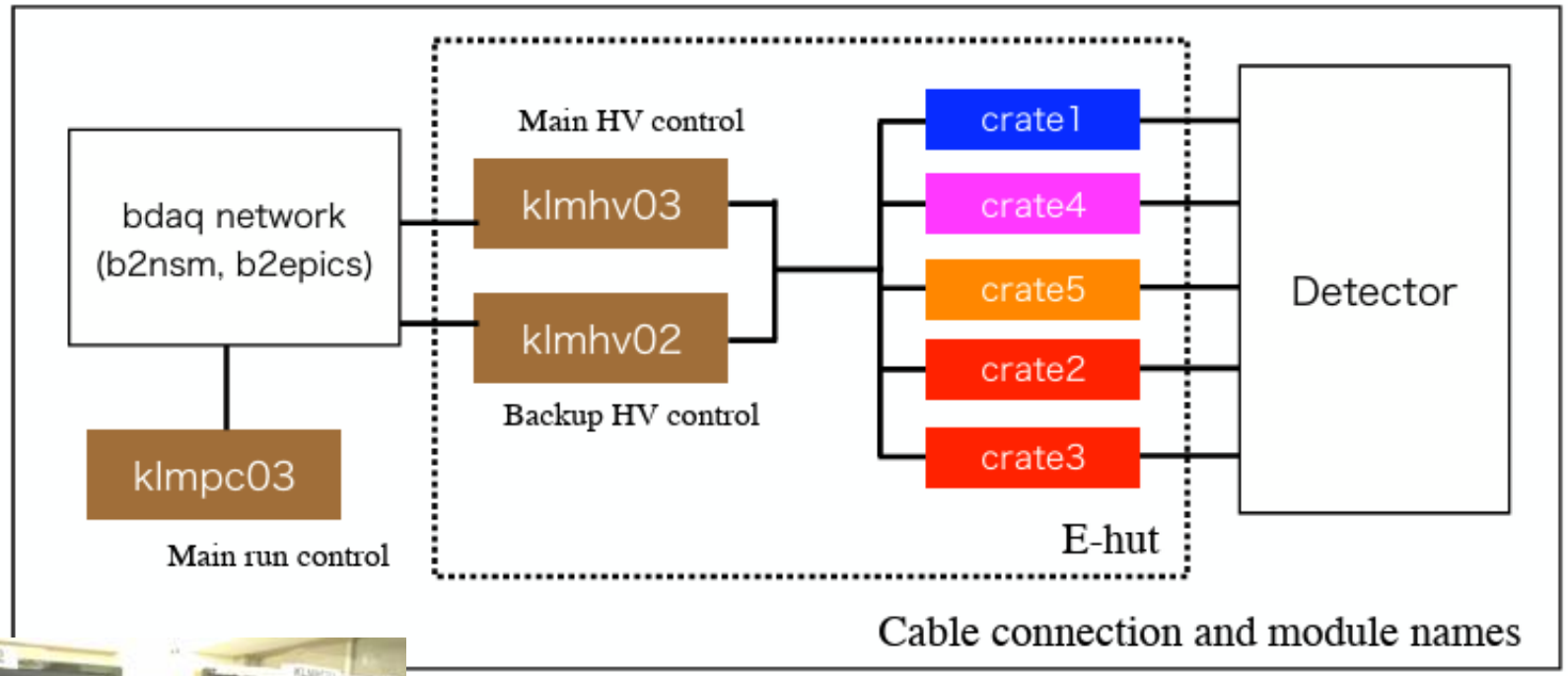
KLM HV control

- B/E-KLM need HV for operation. Scintillators need 75V, and RPCs need 8.2kV (-3.5kV & +4.7kV).
- There are 5 CAEN HV mainframes in E-hut. Each of them provides HV to KLM sectors.



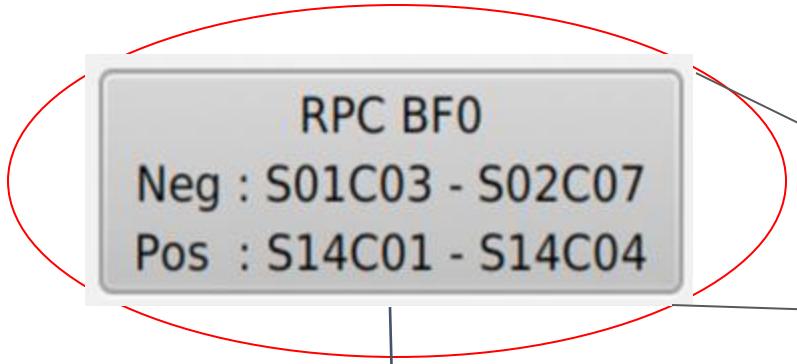
KLM HV Components

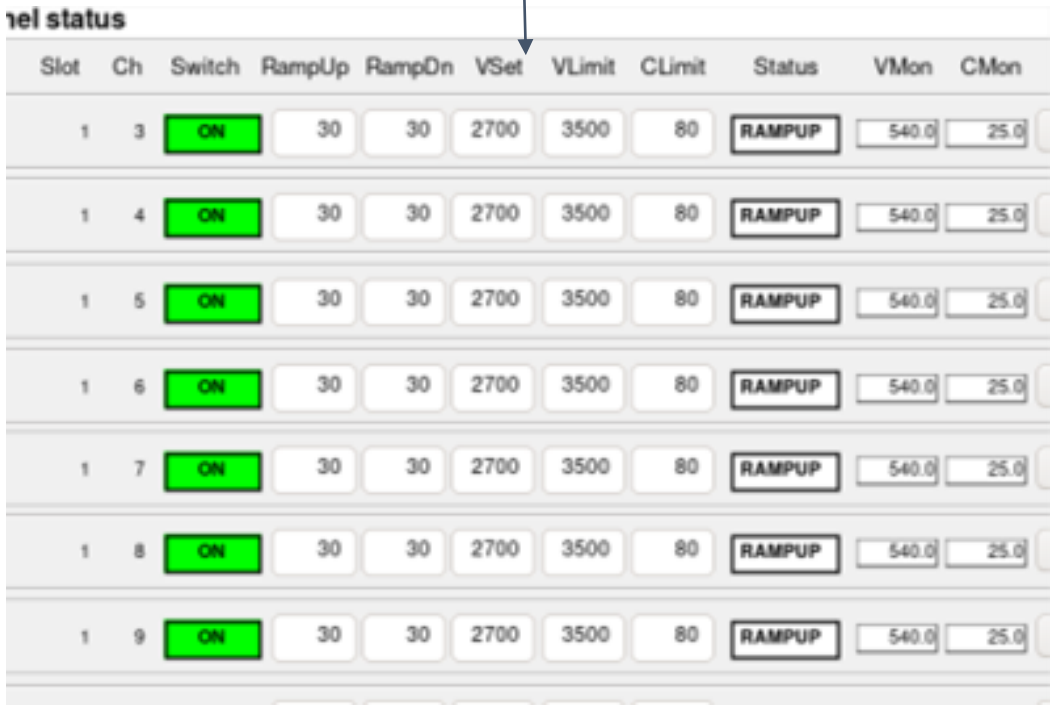
- All KLM HV components are in E-hut.
  - There are two HV control PC named klmhv03 and klmhv02.
  - They are controlled by the run control PC named klmpc03 via bdaq network.
  - In both HV PCs, same scripts are running and switching time is ~10 minutes.

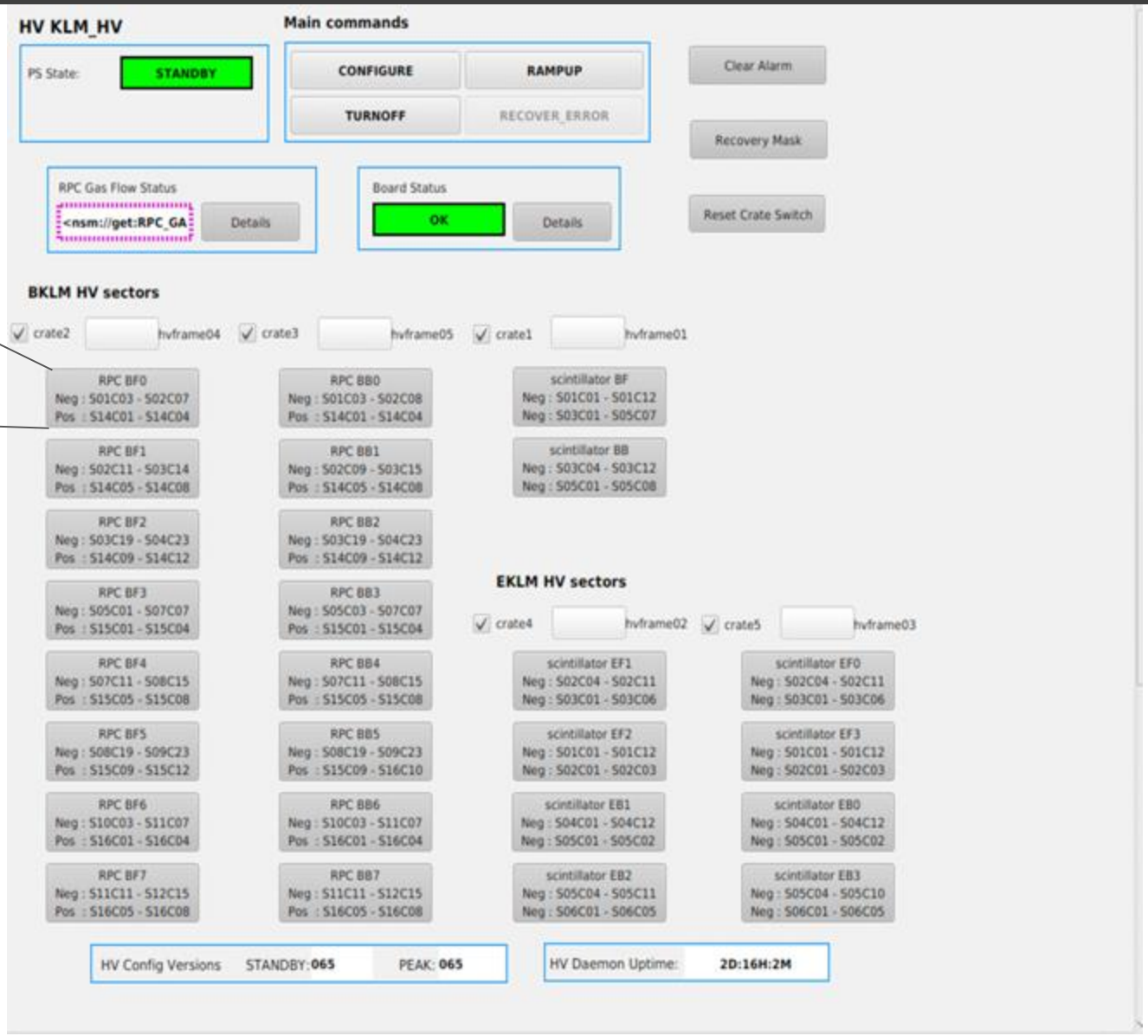


- During Run operations all task are managed through these PCs and a remote shifter can make access through bdaq account.

KLM HV GUI

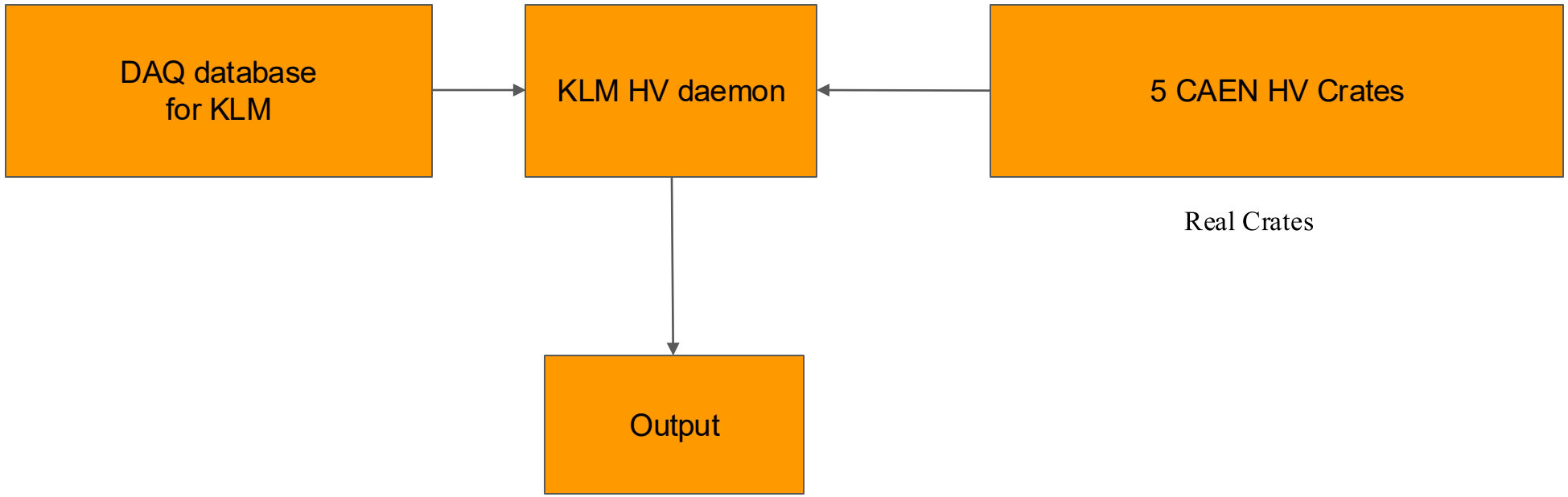

RPC BF0
Neg : S01C03 - S02C07
Pos : S14C01 - S14C04


Slot Ch Switch RampUp RampDn VSet VLimit CLimit Status VMon CMon
1 3 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0
1 4 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0
1 5 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0
1 6 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0
1 7 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0
1 8 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0
1 9 ON 30 30 2700 3500 80 RAMPUP 540.0 25.0


HV KLM_HV
PS State: STANDBY
Main commands
CONFIGURE
RAMPUP
TURNOFF
RECOVER_ERROR
Clear Alarm
Recovery Mask
Reset Crate Switch
RPC Gas Flow Status
Details
Board Status
OK
Details
BKLM HV sectors
crate2 hvframe04 crate3 hvframe05 crate1 hvframe01
RPC BF0 Neg : S01C03 - S02C07 Pos : S14C01 - S14C04
RPC BB0 Neg : S01C03 - S02C08 Pos : S14C01 - S14C04
scintillator BF Neg : S01C01 - S01C12 Neg : S03C01 - S05C07
RPC BF1 Neg : S02C11 - S03C14 Pos : S14C05 - S14C08
RPC BB1 Neg : S02C09 - S03C15 Pos : S14C05 - S14C08
scintillator BB Neg : S03C04 - S03C12 Neg : S05C01 - S05C08
RPC BF2 Neg : S03C19 - S04C23 Pos : S14C09 - S14C12
RPC BB2 Neg : S03C19 - S04C23 Pos : S14C09 - S14C12
RPC BF3 Neg : S05C01 - S07C07 Pos : S15C01 - S15C04
RPC BB3 Neg : S05C03 - S07C07 Pos : S15C01 - S15C04
EKLM HV sectors
crate4 hvframe02 crate5 hvframe03
RPC BF4 Neg : S07C11 - S08C15 Pos : S15C05 - S15C08
RPC BB4 Neg : S07C11 - S08C15 Pos : S15C05 - S15C08
scintillator EF1 Neg : S02C04 - S02C11 Neg : S03C01 - S03C06
scintillator EF0 Neg : S02C04 - S02C11 Neg : S03C01 - S03C06
RPC BF5 Neg : S08C19 - S09C23 Pos : S15C09 - S15C12
RPC BB5 Neg : S08C19 - S09C23 Pos : S15C09 - S16C10
scintillator EF2 Neg : S01C01 - S01C12 Neg : S02C01 - S02C03
scintillator EF3 Neg : S01C01 - S01C12 Neg : S02C01 - S02C03
RPC BF6 Neg : S10C03 - S11C07 Pos : S16C01 - S16C04
RPC BB6 Neg : S10C03 - S11C07 Pos : S16C01 - S16C04
scintillator EB1 Neg : S04C01 - S04C12 Neg : S05C01 - S05C02
scintillator EB0 Neg : S04C01 - S04C12 Neg : S05C01 - S05C02
RPC BF7 Neg : S11C11 - S12C15 Pos : S16C05 - S16C08
RPC BB7 Neg : S11C11 - S12C15 Pos : S16C05 - S16C08
scintillator EB2 Neg : S05C04 - S05C11 Neg : S06C01 - S06C05
scintillator EB3 Neg : S05C04 - S05C10 Neg : S06C01 - S06C05
HV Config Versions STANDBY: 065 PEAK: 065
HV Daemon Uptime: 2D:16H:2M

KLM HV Test Bench

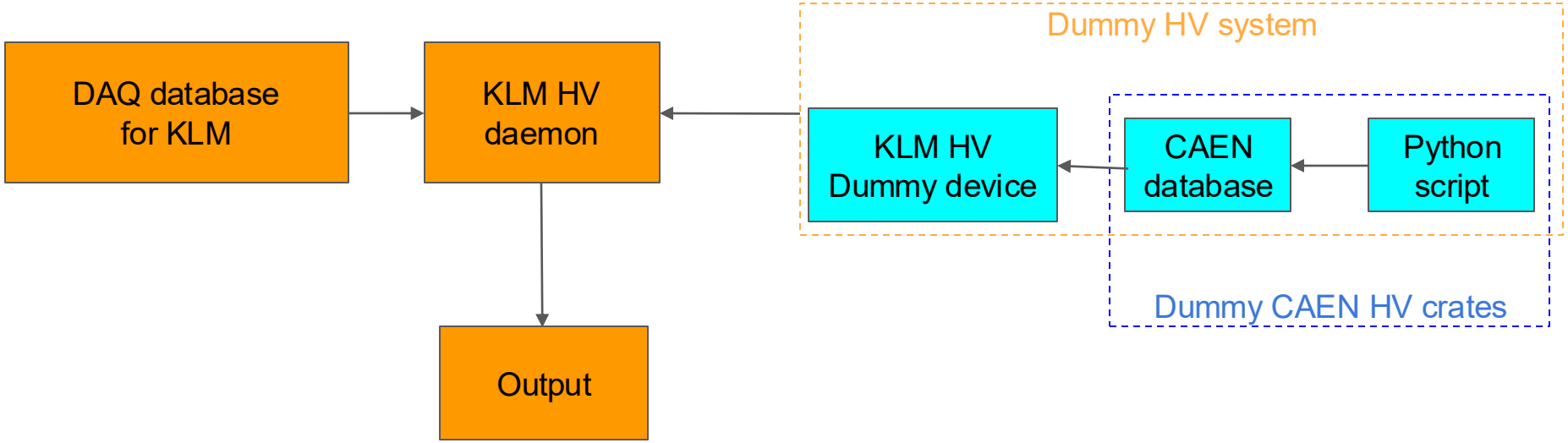
Real System



Real Crates

KLM HV Test Bench

- A **CAEN HV crate simulator** was developed by the UofL group to address issues in KLM HV control.
  - The **daq_slc** setup was successfully installed and compiled on a standalone PC (not connected to DAQNet or B2NSM)
  - A dedicated DAQ database was prepared and configured to support the KLM HV daemon.
  - Details:
    - A **Python script** interfaces with the CAEN database to mimic basic HV crate behavior.
    - It simulates key HV states: **RAMPING UP, RAMPING DOWN, ON, OFF**.
    - The simulator can be extended to include various error message scenarios.

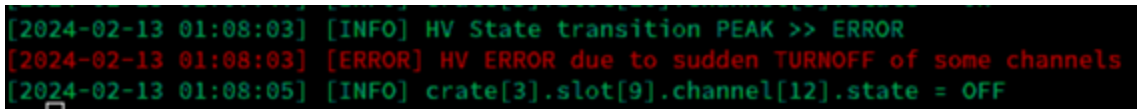


Main Advantage: Allows testing and validation of HV control scripts before deploying them to the real KLM system, improving reliability and reducing downtime.

Recent Issues

- KLM HV Sudden turn off
  - Certain negative KLM HV modules randomly turn off without entering RAMPDOWN or TRIP states, causing the corresponding positive modules to OVP trip.
  - First observed on Jan 24, 2024 (Crate 3, Slot 15), with similar incidents later seen across other slots of Crate 3.
  - The firmware of the crate 3 has already been changed. But, the problem is still existing.

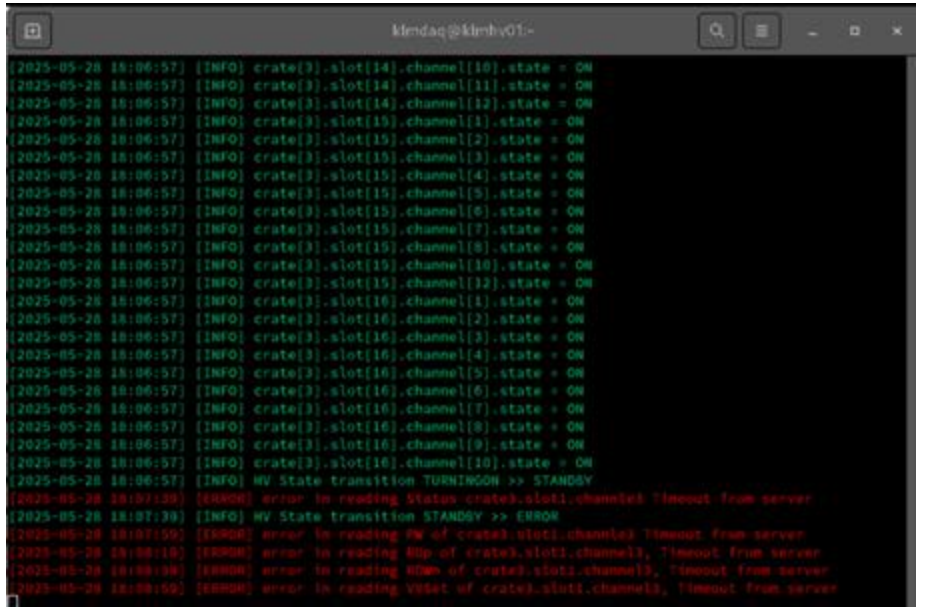
  - Temporary fix:
    - The HV daemon is now modified to detect this behavior, if it occurs during STANDBY/PEAK, it enters ERROR state, recoverable via RECOVER_ERROR → STANDBY.

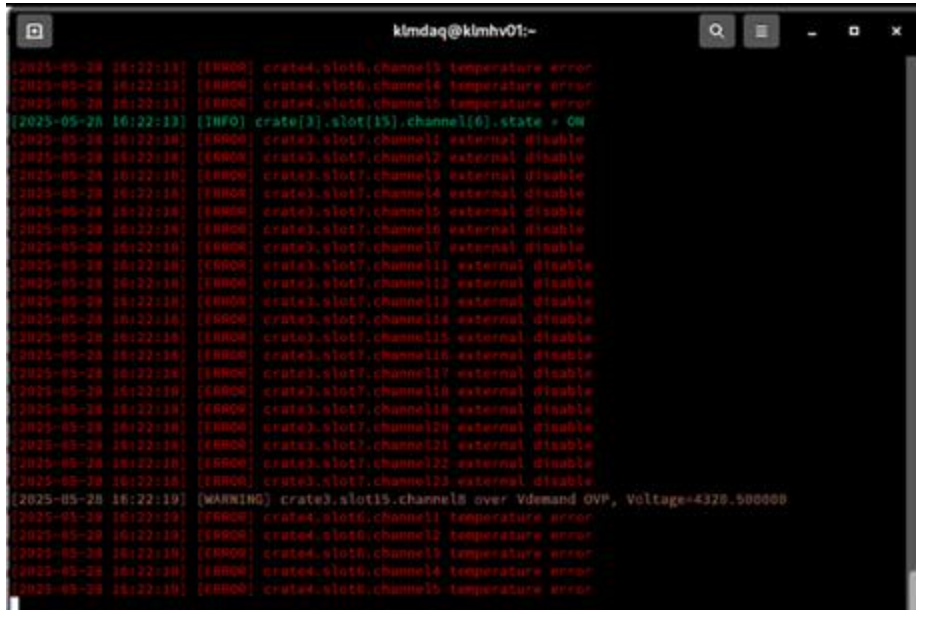


Recent Issues

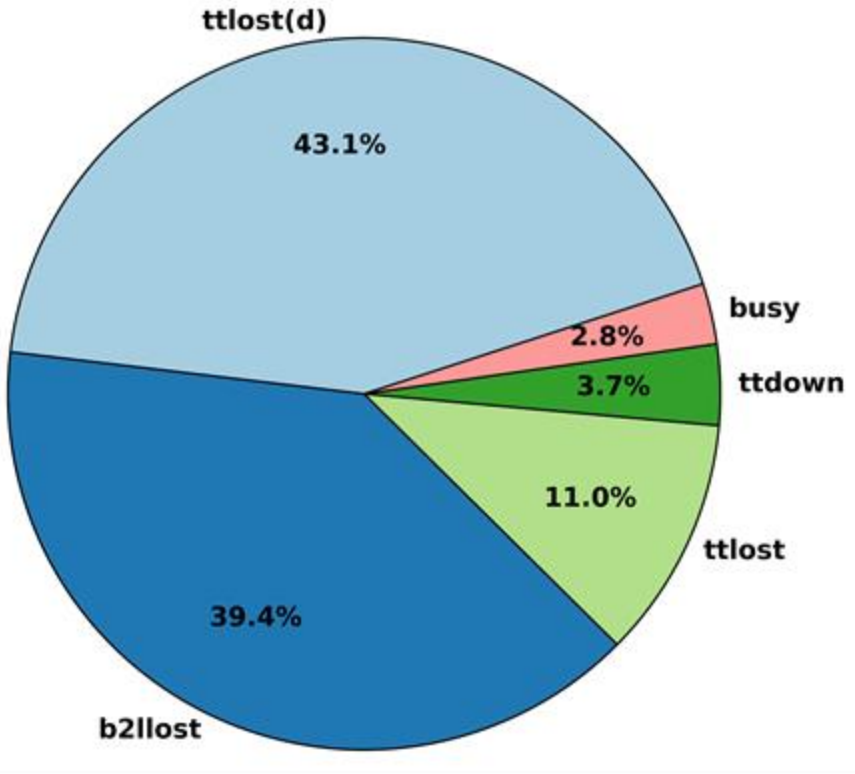
- Issue with UNKNOWN state
  - Caused by B2NSM network failures leading to unresponsive CAEN HV API, leaving KLM HV stuck in its last known state.
  - Issue was often missed by shifters, despite being logged, due to delayed API responses.
  - Fix: Now, the system triggers an ERROR signal within 25 seconds to promptly flag the issue.

- Mixed Error & Interlock state issue
  - Occasionally, scintillator crates show ERROR while RPC crates show INTERLOCK, causing the KLM HV state to oscillate between the two.
  - To fix this, ERROR and soft TRIP signals are suppressed when INTERLOCK is active.
  - Fix: The solution has been successfully tested using dummy interlock signals on the real system, ensuring a stable INTERLOCK-only status.





KLM Errors



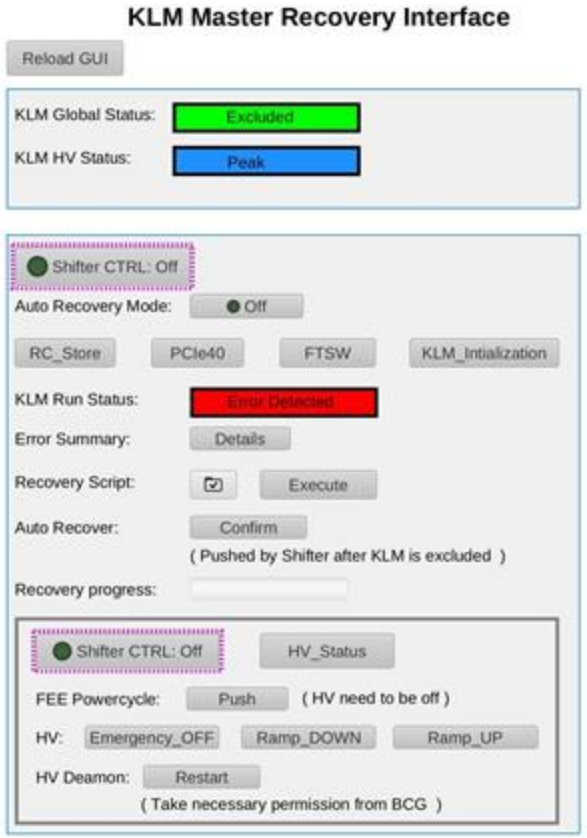
Error distributions in 2024.

- These errors fall into two main categories:
  - **HV errors** (e.g., sudden turn-offs, unknown/error states in HV crates), and
  - **DAQ errors** (e.g., link issues, FEE errors, tag/time mismatches).

- The most frequent causes of these errors are:
  1. `TTLOST` and `TTDOWN`: These occur due to miscommunication between the DC and the FTSW.
  2. `B2LLOST` and `B2LDOWN`: These arise from miscommunication between the DC and the PCIe40.

Future Plans

- Master recovery GUI

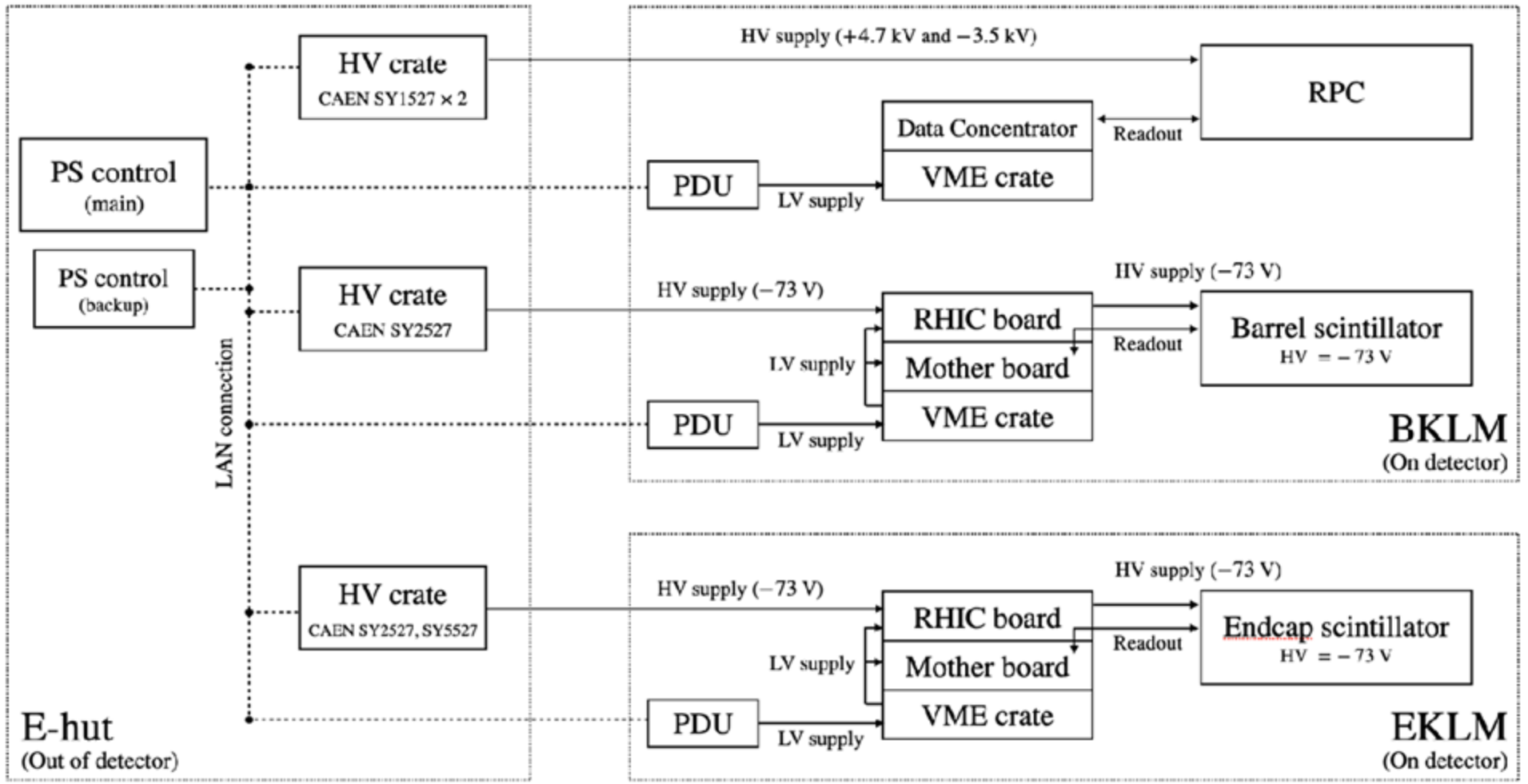


- Low voltage monitoring
  - Monitor stability of ±12V low voltage power supply to KLM FEE

Thanks to D. Biswas and S. Patra for helping me get up to speed with all this stuff.

Backup

KLM Power supply



KLM CAEN HV Database

crate	slot	ch	pw	v0set	vmon	imon	i0set	rup	rdwn	svmax	status
2	11	20	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
5	4	3	1	73.000000	73.000000	25.0	180.000000	5.000000	5.000000	100.000000	1
3	5	6	0	0.000000	20	3.5	80.000000	30.000000	30.000000	3500.000000	0
3	9	22	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	10	4	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	5	5	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
1	5	5	1	73.000000	73.000000	25.0	180.000000	5.000000	5.000000	100.000000	1
3	8	1	0	2700.000000	20	3.5	80.000000	30.000000	30.000000	3500.000000	0
5	5	6	1	73.000000	73.000000	25.0	180.000000	5.000000	5.000000	100.000000	1
3	10	3	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	5	9	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	11	7	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
1	5	6	1	73.000000	73.000000	25.0	180.000000	5.000000	5.000000	100.000000	1
2	9	12	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	8	20	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	8	7	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	9	16	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	5	17	0	0.000000	20	3.5	80.000000	30.000000	30.000000	3500.000000	0
3	9	15	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
1	5	4	1	73.000000	73.000000	25.0	180.000000	5.000000	5.000000	100.000000	1
2	9	15	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	10	22	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	9	19	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	5	21	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	9	4	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	10	7	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
3	7	22	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
1	3	1	1	73.000000	73.000000	25.0	180.000000	5.000000	5.000000	100.000000	1
3	10	8	1	2700.000000	2700.000000	25.0	80.000000	30.000000	30.000000	3500.000000	1
2	15	7	1	3900.000000	3900.000000	25.0	200.000000	30.000000	30.000000	6000.000000	1

A PostgreSQL database has been prepared, which contains detailed information about the KLM HV crates.