

Slow Control, DCS

~Overview and Status~



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Belle II Trigger/DAQ Workshop 2025



Slow Control

What is Slow Control?

- We had a group named, slow control group; already been dissolved
- I'm assigned as the slow control contact person (coordinator?) now, but to be honest, I don't know the exact definition of slow control. It is "Common Sense".

In this talk, slow-control refers to

Non-time-critical systems used for, for example, configuration of the detector parameters and the environmental parameters, monitoring, and alarms that **don't require real-time and/or high-speed data acquisition.**

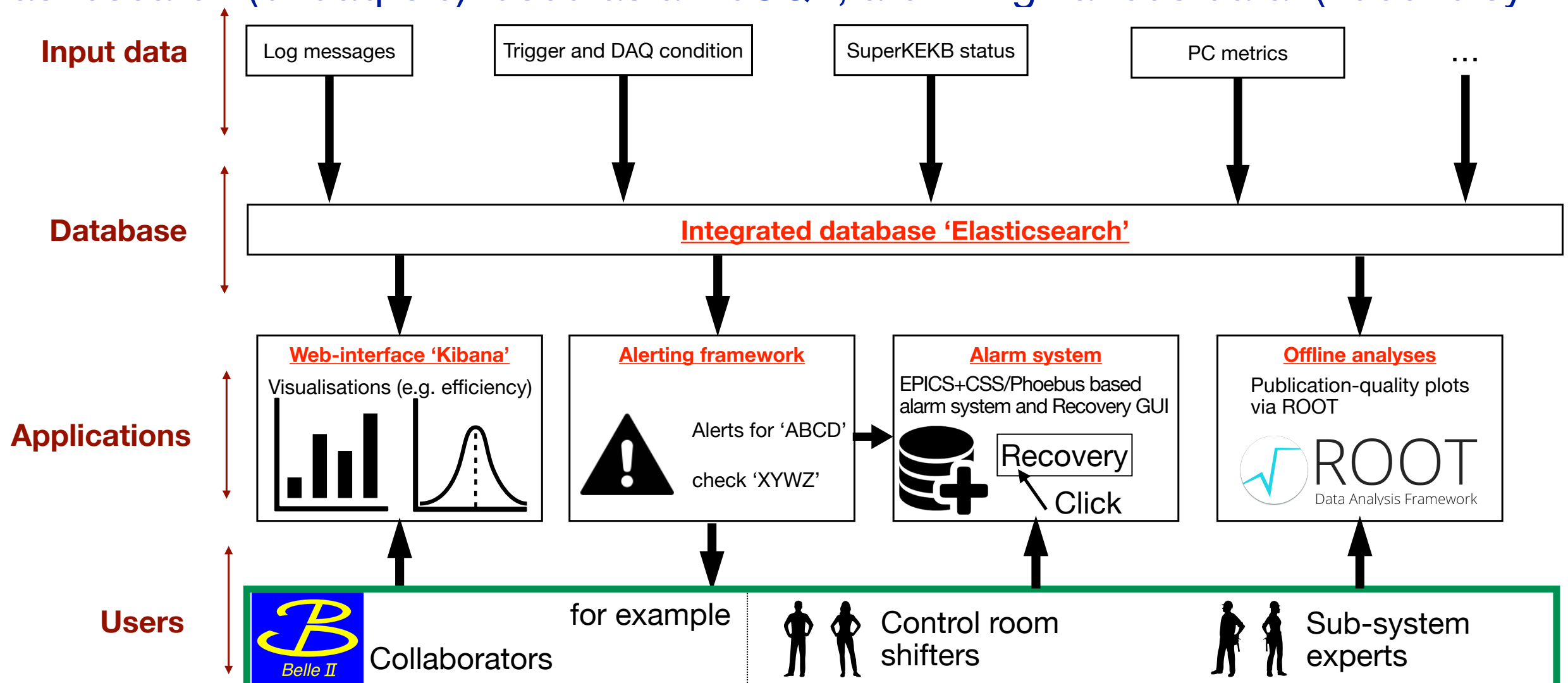
- High-Voltage (HV) setting can be slow-control, but in Belle II, HV system strongly couples with the accelerator's operation to ensure safety, and some features are time-critical, and hence not slow-control.
- To discuss, such kind of topics and issues across all the sub-system groups, we made a new group named, Detector Control System (DCS) in 2022.

Monitoring and error diagnoses

Databases in Belle II

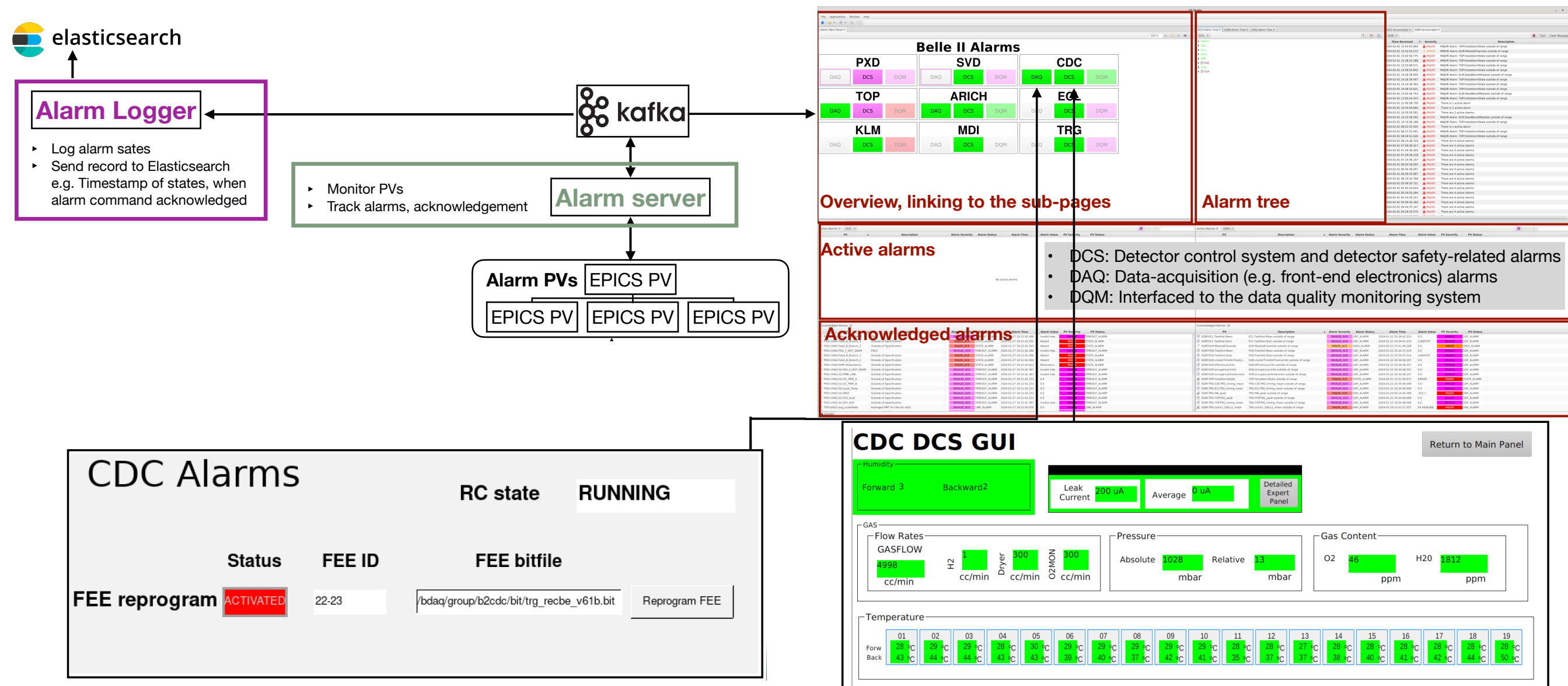
Monitoring is an analysis

- Many databases in the world: MySQL/MariaSQL, PostgreSQL, Oracle Database, Microsoft SQL Server, SQLite, Amazon Aurora, mongoDB, Redis, etc.
- PostgreSQL (b2db): used for datasets which matches exactly. (e.g. Exp+Run Number => Run setting, Recorded files, Detector setting, etc.) You just need to google SQL-queries syntax to use it.
- Elasticsearch (b2daq-slc): used as a NoSQL, archiving various data. (Lucene syntax)



Alarm System

- We have various types of EPICS Process Variables (PVs) to which alarm limits (condition to activate alarm) are defined (Alarm PVs, see next page for more detail)
- Alarm PVs monitored by the Alarm Server process; using the monitored data the Alarm GUI works



Alarm PVs

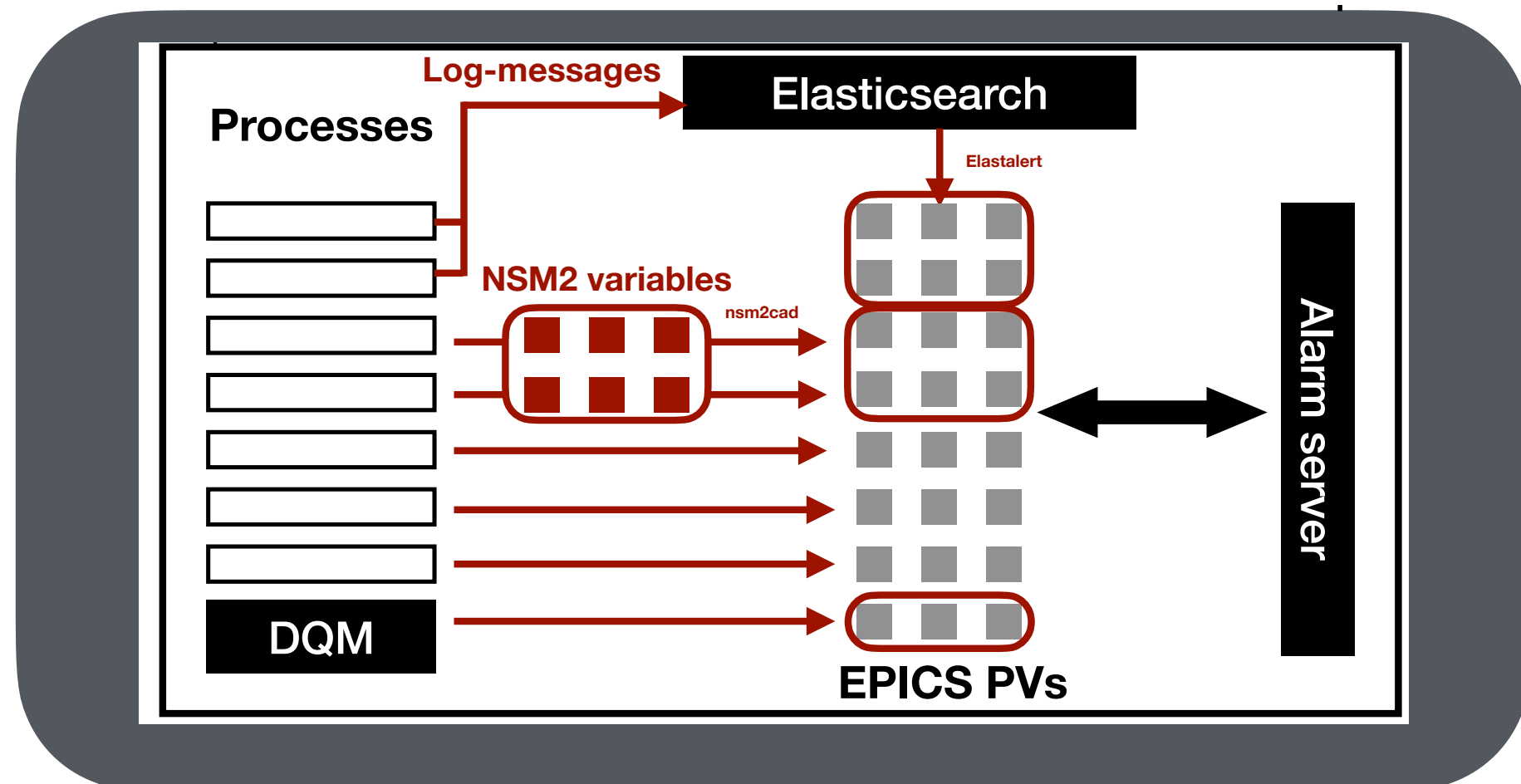
- We have not only native EPICS PVs, but also the nsm2cad-converted PVs, moreover we also need a feature to enable an alarm if a log-message is found

```
dbLoadRecords("db/nsmvget_text.db", "name=ARICH_HV, val=crate[1]:slot[0]:channel[0]:state")
dbLoadRecords("db/alarm_nsmvget_float_deadband.db", "name=ARICH_HV, val=crate[1]:slot[0]:channel[0]:vmon, adel=0.5, mdel=0.5, lololo=-100, low=-100, high=500, hihi=600")
dbLoadRecords("db/alarm_nsmvget_float_hihi_high_low_lolo.db", "name=ARICH_HV, val=crate[1]:slot[0]:channel[0]:cmon, lololo=-30.0, low=-15.0, high=15.0, hihi=30.0")
dbLoadRecords("db/nsmvget_int.db", "name=ARICH_HV, val=crate[1]:slot[0]:channel[1]:channel")
dbLoadRecords("db/nsmvget_int.db", "name=ARICH_HV, val=crate[1]:slot[0]:channel[1]:slot")
dbLoadRecords("db/nsmvget_text.db", "name=ARICH_HV, val=crate[1]:slot[0]:channel[1]:switch")
```

nsm2cad dbs

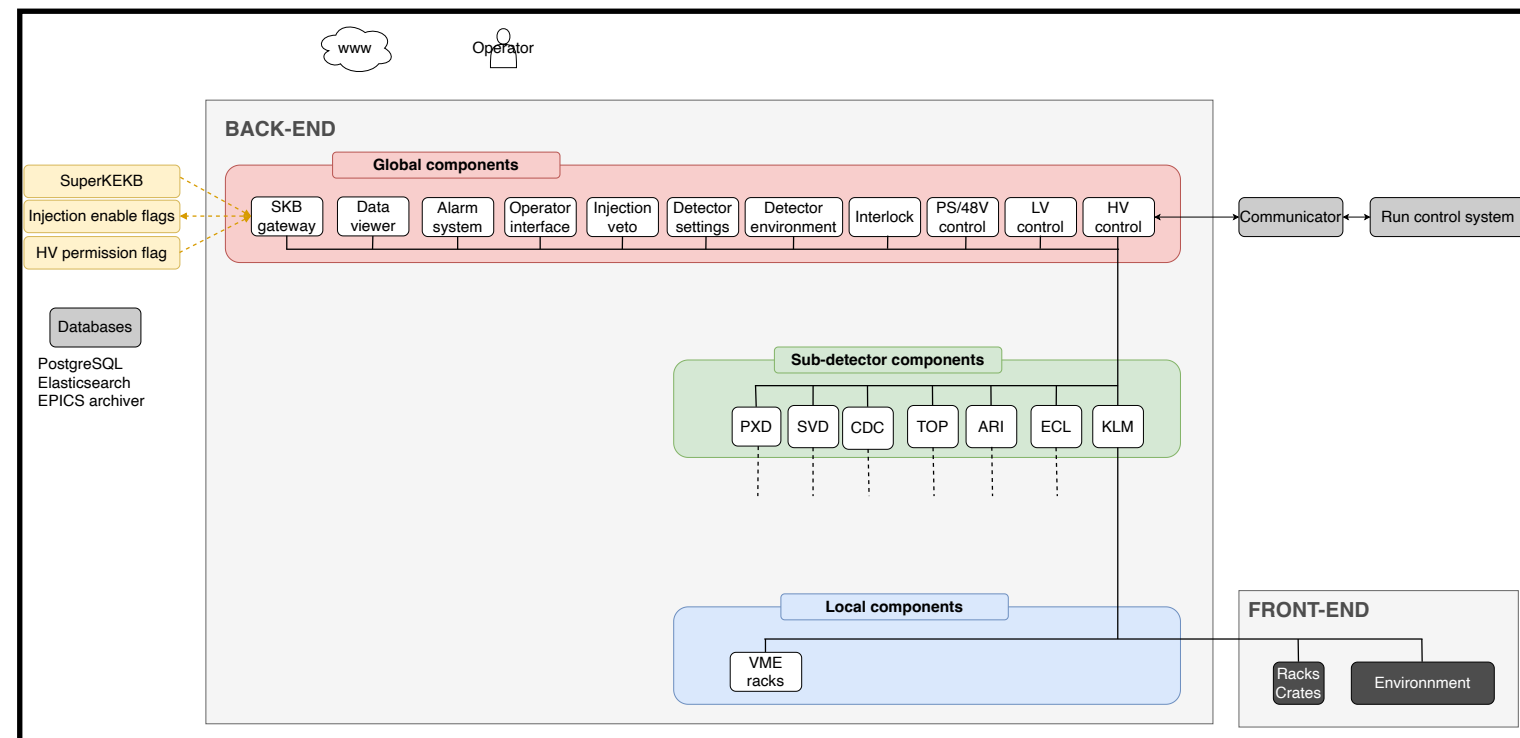
```
command: ["/home/vagrant/bin/caput.py", "B2_alarm:CDC:FEEREPROGRAM:ID", "{FEES}"]
recovery_command:
  host: "ttd11"
  user: "b2shift"
  rcrequests_before_recovery: "STOP-ABORT"
  command: "cd scripts/cdc_config && ./config_parallel.py --ID caget(B2_alarm:CDC:FEEREPROGRAM:ID)"
```

ElastAlert rules



Detector Control System

- Derived from a common word: Industrial Control System, [Wikipedia](#)
(Not Distributed Control System)
- In Belle II, the place where:
 - any topics related to detector control (HV, LV, PS, ...), detector setting (Vth, masking, database, ...), detector environment (thermal monitoring), detector safety (HV permission, ARO), interlock, cabling, etc. to be reported and to be discussed
 - to make a consensus among the sub-systems (incl. MDI, TRG, DAQ) discussing also technical details before bringing the topic to TB meeting
- Regular meeting alternating two time slot: Wednesday 13:00 JST, 21:00 JST
 - Each sub-system group should attend either of the slot
 - Lack of activity from some sub-systems
 - DCS review committee and TCs encourage assigning person power to the activity



DCS note

If you would like to know about DCS, please first read through the DCS note, [link](#)

1 Introduction

Belle II is a next generation B-physics experiment, started data taking in 2019 at the SuperKEKB at KEK, Tsukuba, Japan. The Belle II detector consists of seven sub-detectors. To control the complex sub-detectors, containing a large number of individual detector elements, is a challenging task. For effective data-taking, we redesign and implement the system Detector Control System (DCS) for Belle II.

The DCS has the task to permit coherent and safe operation of Belle II, to serve a user-friendly interface to all the sub-detectors, and monitoring and logging them. The DCS must be able to bring the detector into any desired operational state, to continuously monitor and archive the operational parameters, to signal any abnormal behaviour to the operator, and to allow manual or automatic actions to be taken. In order to synchronise the state of the detector with the operation of the physics data acquisition system, bi-directional communication between DCS and run control is provided. Finally, the DCS has to communicate with the other systems which are controlled independently, such as the SuperKEKB accelerator, detector interlock system.

This paper focuses on the DCS architecture, hardware components, and the design and implementation of the DCS back-end software. The paper is structured as follows: after a summary of the previous system in section 2, the requirements on the new system is summarised in section 3. blabla...

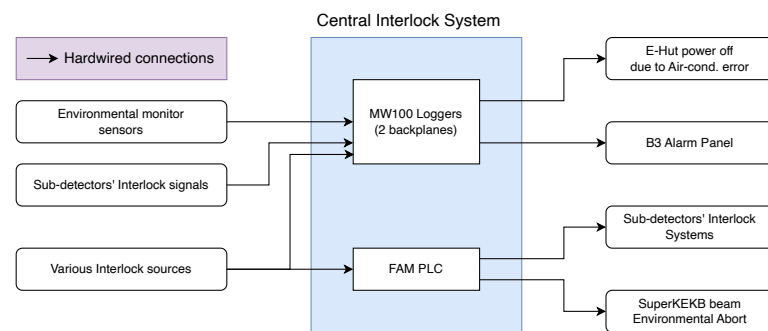


Figure 23: Schematic view of the central interlock system

2.15 Interlock

2.15.1 Overview

“MW100 Loggers” and “FAM PLC” work as programmable logic controllers among many hardwired connections, consisting of analog or digital input modules and digital output modules. MW100 Logger is analog/digital-measurement-oriented; digital discrimination for a measurement item can issue a digital output as an “alarm”. FAM PLC is logical-sequence oriented; a micro-program (called ladder) composes an Input/Output matrix (similar to FPGA). Logger (1 loop takes $\mathcal{O}(ns)$) is slower than PLC ($\mathcal{O}(10\ ms)$).

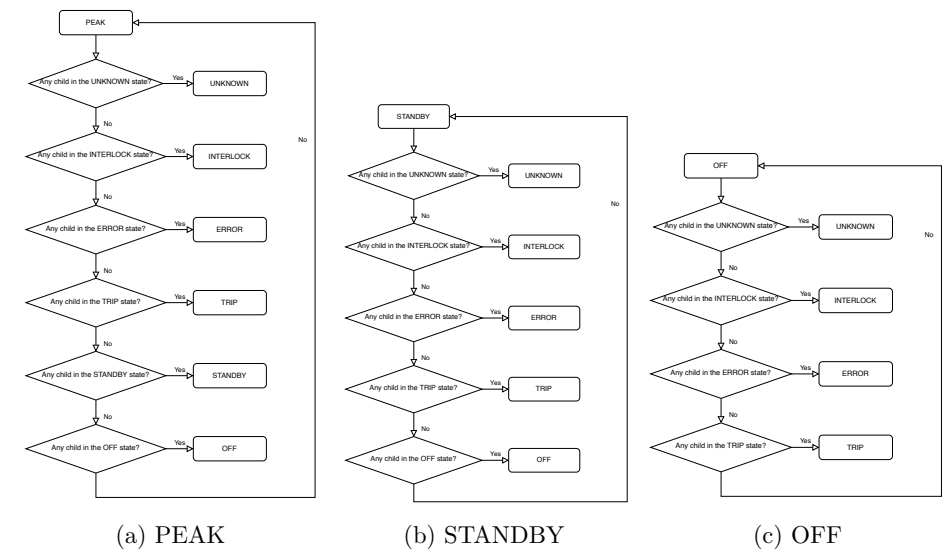


Figure 30: Example of state rule

3.2.3 State transition

State transitions can be initiated for every FSM objects by commands in the NSM2 framework. The higher level node propagate the commands to their lower level nodes (children). The state transitions are summarised in Figure 31.

There is no major change on the nominal transitions, while we have added a few transition states, and renamed the HV commands. Concerning the error handling, we applied many changes.

- We explicitly define INTERLOCK state, which was not defined in the old definition.
- We define a new command, EMERGENCY_OFF, as a countermeasure against, e.g. unknown errors by which we cannot ensure detector safety
- We define a pair of recovery commands, RECOVER_ERROR, RECOVER_TRIP. In the old definition, TRIP was defined as an error state, which should be fixed automatically. However, in the real operation, some sub-detectors prefer fixing TRIP by a manual request. To satisfy this requirement, we define different recovery commands against ERROR and TRIP, and leave it as an option to execute RECOVER_TRIP command automatically or not.
- We allow from PEAK or STANDBY state; while in the old definition, the transition to TRIP is allowed only from PEAK. After the RECOVER_TRIP command, it should recover to the original state, by checking the monitored voltage.
- OFF to STANDBY transition for KLM requires a long time, thus after recovery from ERROR, KLM is changed to STANDBY voltage.

Allow Risky Operation

- HV permission is an agreement between SuperKEKB and Belle II
 - Without HV permission, Belle II should not ramp up HV
 - While HV permission is allowed, SuperKEKB do not do risky operation (if HV permission = inhibited, there can be risky operation)

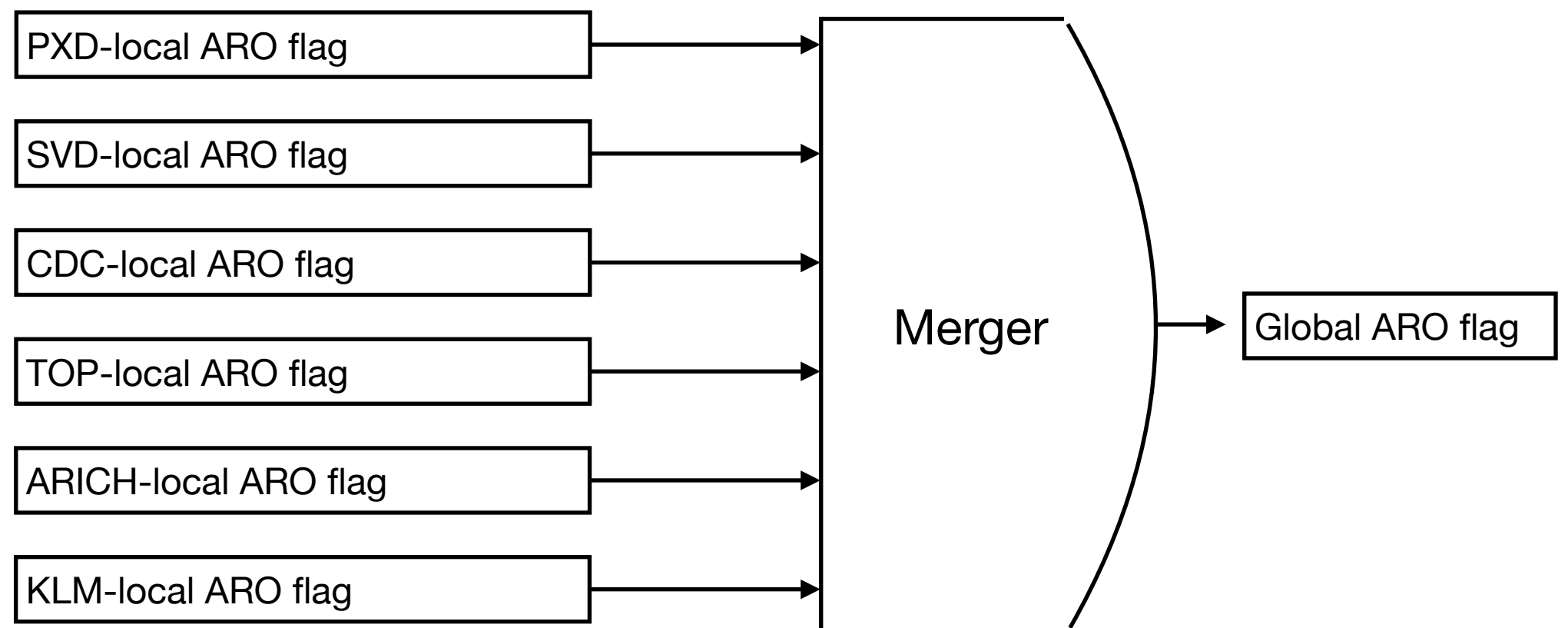
Situation

- HV_PERMISSION flag can be negated when HVMASTER's hvstate is OFF or STANDBY
- However, this implementation is not good;
 1. HVMASTER's hvstate does not represent the safety of Belle II
 2. Excluded sub-detector is ignored from HVMASTER's state (Little risks though)
 3. e.g. in case of CLAWS abort, PXDPS is OFF, and should be TURNedON but it inhibits negating HV_PERMISSION
(In Phase-3 Run-1, PXDPS's TURNINGON was hidden)
- Thus, we plan to properly define the condition in which Belle II is safe and hence SuperKEKB can revoke the HV permission, using a new signal “Allow Risky Operation” flag (ARO)
- See further information in Hiro's slides: [link](#)

Overview

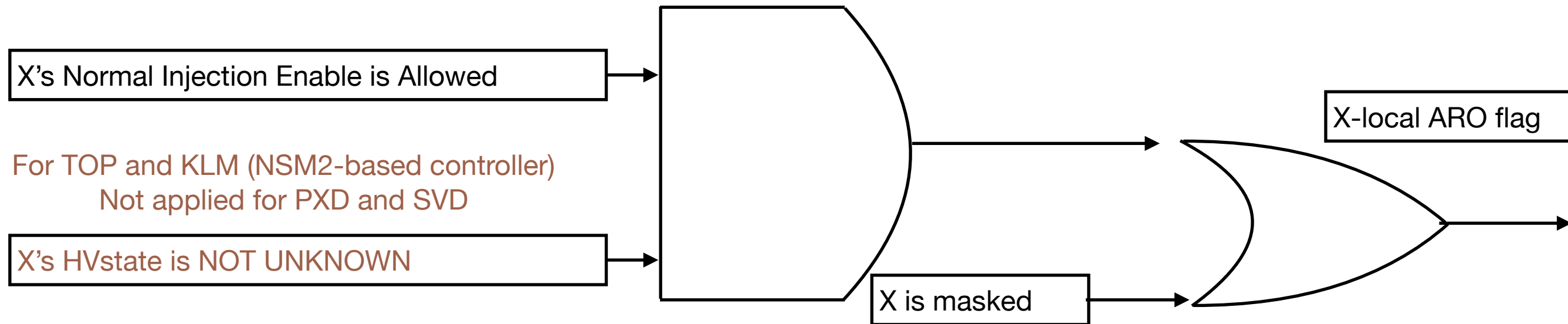
Scheme

- We take a similar/same scheme with the Injection Enable flags

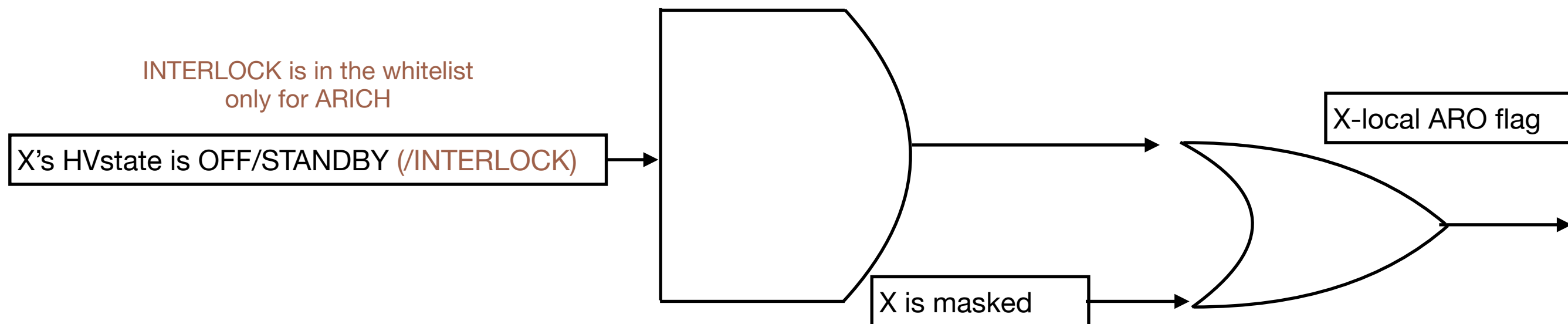


Overview of local AROs

- Two types of sub-detectors:
 - NE (Normal injection enable) flag based: PXD, SVD, TOP, KLM



- Local HV state based: CDC, ARICH



Status of implementation

- Logic implemented in the EPICS-style and tested; test results are included in the corresponding the MR, [daq_slc!780](#)
 - Checked by all the sub-detector groups, approved by MDI
- Lost heartbeat alarms added in the MR, [daq_slc!848](#)
 - Implemented following the suggestions by PXD, SVD experts, approved by MDI
- In case of the lost heartbeat problems, injection-enable flags must be negated, this is implemented in the MR, [daq_slc!849](#)

NORMAL_INJECTION:ENABLE	Used	ARO
1	1	1
0	1	0
1	0	1
0	0	1

Disconnection of input PVs

```

TEST:PXD:HV_PERMISSION:CTRL:ENABLE 2024-11-06 12:44:51.620555 1
TEST:Used 2024-11-06 12:44:44.270314 1
TEST:NORMAL_INJECTION:ENABLE 2024-11-06 12:44:51.620312 1
CA.Client.Exception.....
TEST:NORMAL_INJECTION:ENABLE 2024-11-06 12:45:02.740342 *** disconnected
Warning: "Virtual circuit disconnect"
Context: "daqslc-elk.b2epics.kek.jp:46217"
Source File: ../cac.cpp line 1238
Current Time: Wed Nov 06 2024 12:45:02.740311200
.....
TEST:PXD:HV_PERMISSION:CTRL:ENABLE 2024-11-06 12:45:02.740293 0

```

We are very close to the final green light
=> ARO will be deployed in 2025c

Special issue for next

- Special issue; whether we should implement HV permission guard in the local sub-detector's HV controller
 - ▶ Discussions on several recommendations; most of them have clear solutions, which all sub-detector groups agree
 - ▶ One issue which requires more discussion in offline
 - ▶ KLM disagreed with implementing the safe guard but after some discussion, we understood that there is misunderstanding, and KLM agrees with the feature
 - ▶ CDC: under discussion

Target: next-to-next run (in 2026)
(not the beginning of the next run)

HV permission guard in the Local sub-detector's HV controller

Open Issue created 6 days ago by Takuto Kunigo

1. Introduction

HVMaster rejects HV requests (TURNON/TURNOFF/RAMPUP/RAMPDOWN) when the HV permission is 0 (OFF). On the other hand, it is allowed to make local HV requests to a local sub-detector's HV controller; this allows the flexibility to the sub-detector experts, while there can be mis-operation and this feature can be a potential risk to our detector. **Note that from the CR shifters this feature is not allowed**; the HV permission guard is implemented in the GUI-level. Some sub-detectors still prefer this feature. (Local HV requests can be used ignoring HV permission). In this issue, we'd like to track the detail of the discussion.

2. Discussion in the past

There were discussions in the DCS meetings a few times. (The oldest one was when we define the HV features in 2022, and the latest one was we discussed on the answers to the recommendations on August 27) In the latest discussion, the sub-detector groups' opinion are as follows.

- PXD and SVD: This feature should be added to the other sub-detector group's HV controllers
- CDC: (Yu Nakazawa) requires a discussion with Nanae (if needed, Takuto will be invited to the discussion)
- TOP and ARICH: For flexibility, would like to use the rule as `HV permission=1 OR Transitions between HV states with ARO=1`, so that, for example, TOP_HV can be TURNedOFF with HV permission=0.
- KLM: Don't like to implement HVP guard. GUI-level protection (e.g. confirmation message by a pop-up window) should be added to the KLM shifter's GUI, but for flexibility, KLM would like to keep this feature. (i.e. Try to add a protection to mis-operation in the GUI level, but it is still possible from the GUI, and no protection at the CLI level)

3. Discussions

- Should we divide sub-detectors to two groups? 1) Group requires HV permission, 2) Group do NOT require HV permission => Should be NO. For simplicity, To avoid confusion. (comment by Takuto KUNIGO)
- If we don't implement the HV permission guard to the local HV controller, how we should protect our detector?
- How about ignoring the HV permission guard, only when the sub-detector is masked?

4. Technical implementation

- To retrieve the HV permission from HVMaster (to use it in the local HV controller)
- If the HV permission is 0, then rejects the HV requests.
- If we add other constraints (e.g. if ARO=1 or if masked), it is also need to be added.

Edited 6 days ago by Takuto Kunigo

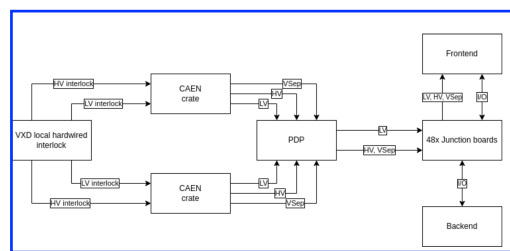
NSM2 and EPICS

EPICS

PXD HV

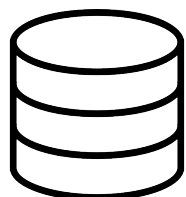
SKB gateway

SVD HV



EPICS PVs

DAQ:*, SVD:*, VXD:*, SKB:*, ...



EPICS archiver

List of archived PVs, [link](#)

NSM2

Port 9020

Run Control etc.

Port 9124

HV, LV, PS, and related monitors

HVMMASTER

Propagate commands
Aggregate states of sub nodes

PXD_HV

SVD_HV

CDC_HV

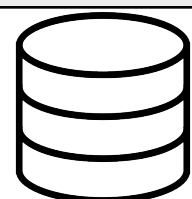
TOP_HV

ARICH_HV

KLM_HV

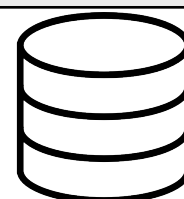
ca2nsm

nsm2cad



PostgreSQL

Run record, file list, config, etc.



RunDB, Run Registry

Run record, DQM defects

Elasticsearch

EPICS, NSM2 variables, log-messages, run record,