Summary of DCS

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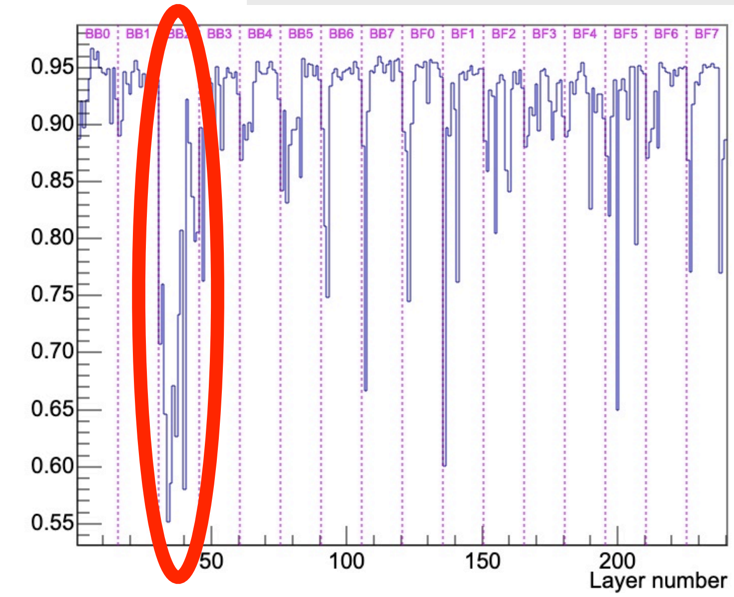
Belle II TRG/DAQ Workshop 2022

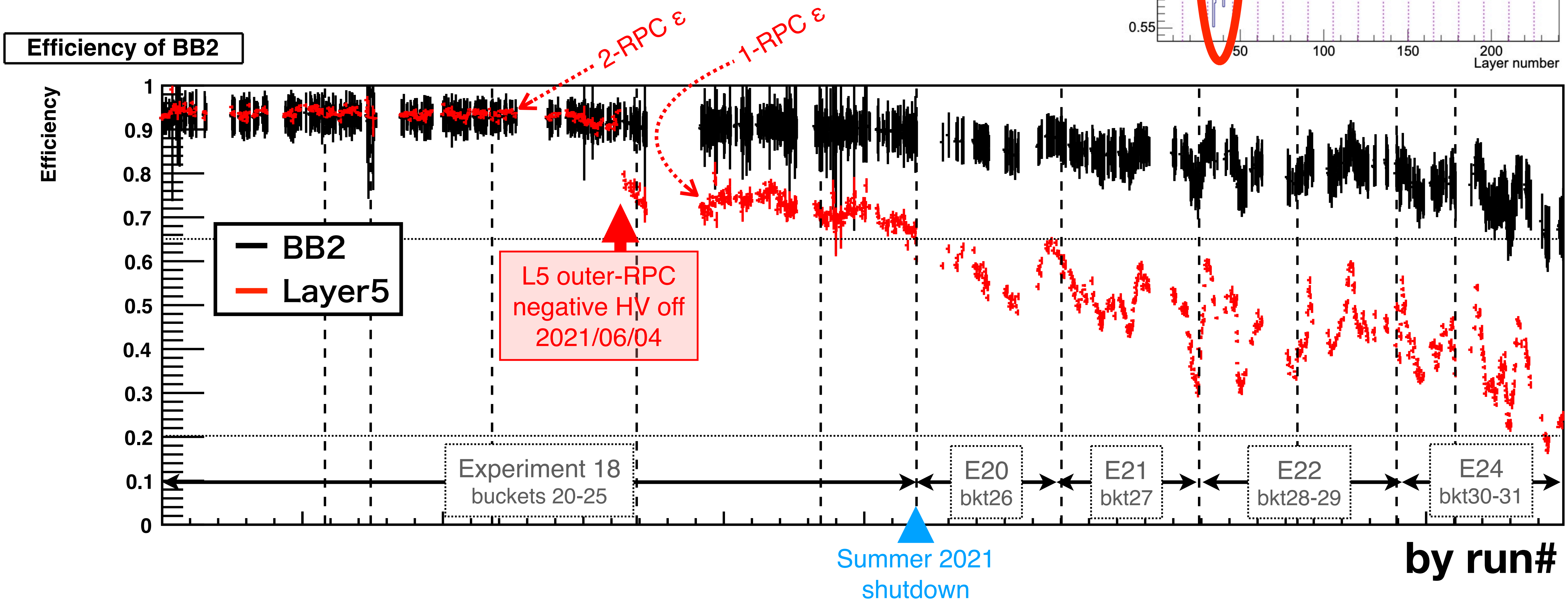
RPC BB2 low efficiency

- In April 2022, **Efficiency plots implemented in DQM**
  - ➡ We noticed low efficiency in BB2 RPC layers
    - Actually, this trend started in June 2021 confirmed by offline measurements

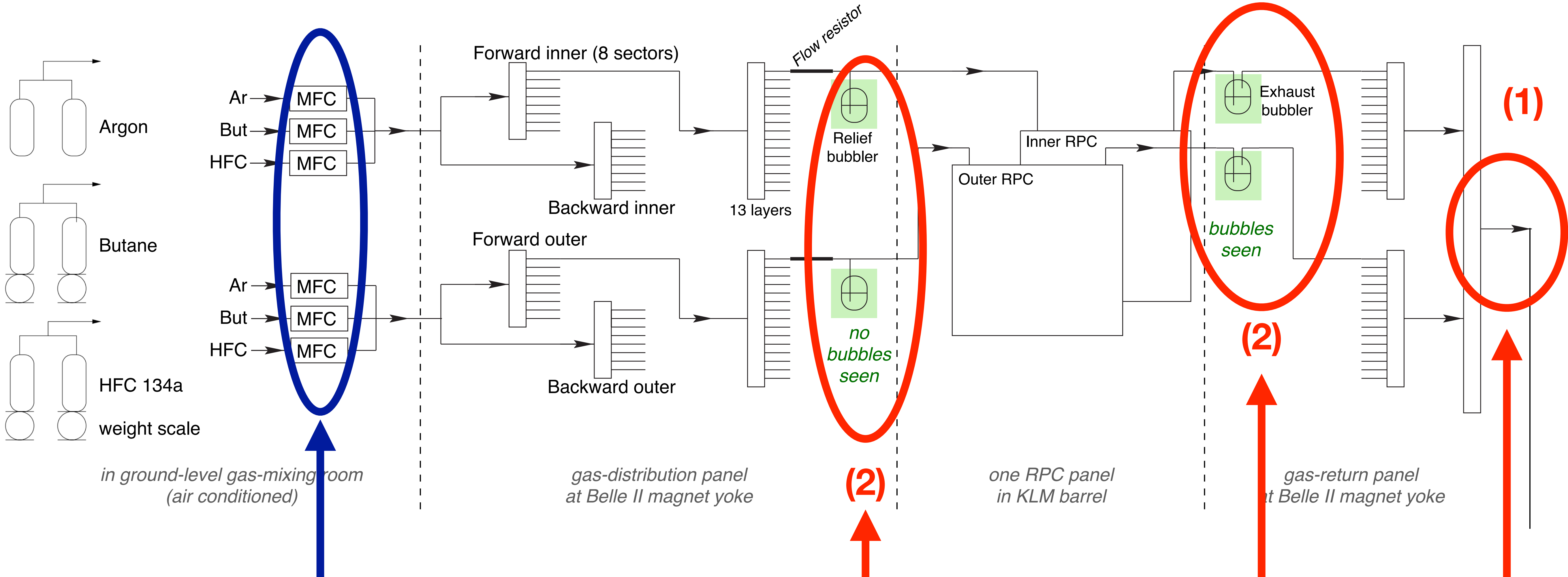
RPC dedicated talk by Leo Piilonen



Need to clarify why the low efficiency not noticed for ~10 months?



RPC gas system



- Current monitoring system
  - Inner/Outer x Ar/But/HFC = Six monitored value

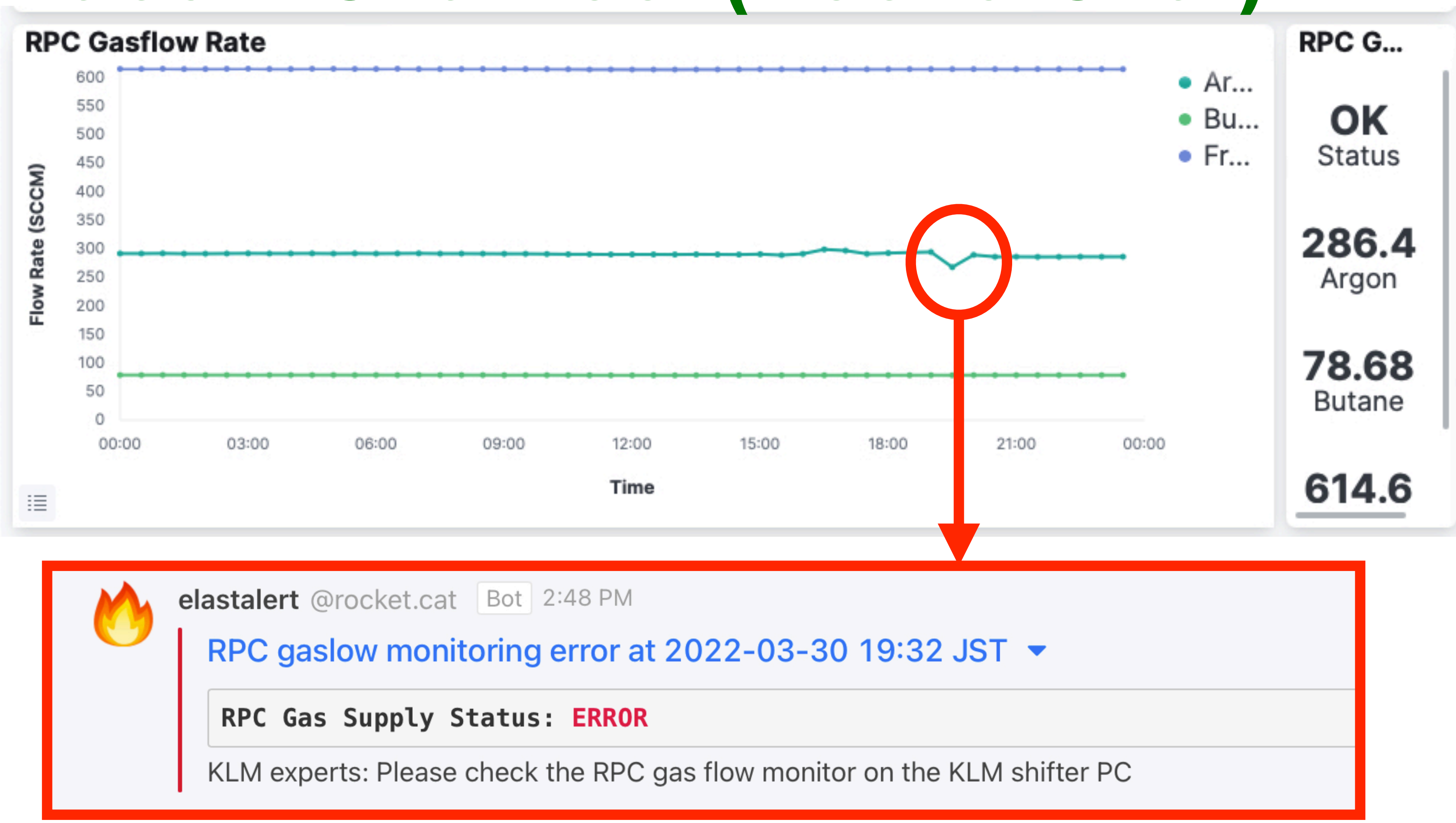
    ➡ **Not enough monitoring** information
- Upgrade plan

(1) Mass flow monitor to be added at output

(2) Bubbler monitoring

Current alarm handling

Interface = Chat tool (RocketChat)



- Analyse data
- Implement in Elastalert (alert rule= ~30l yaml file)
- Automatic notification on a chat tool

Chat tool is not a proper interface for alarm handling

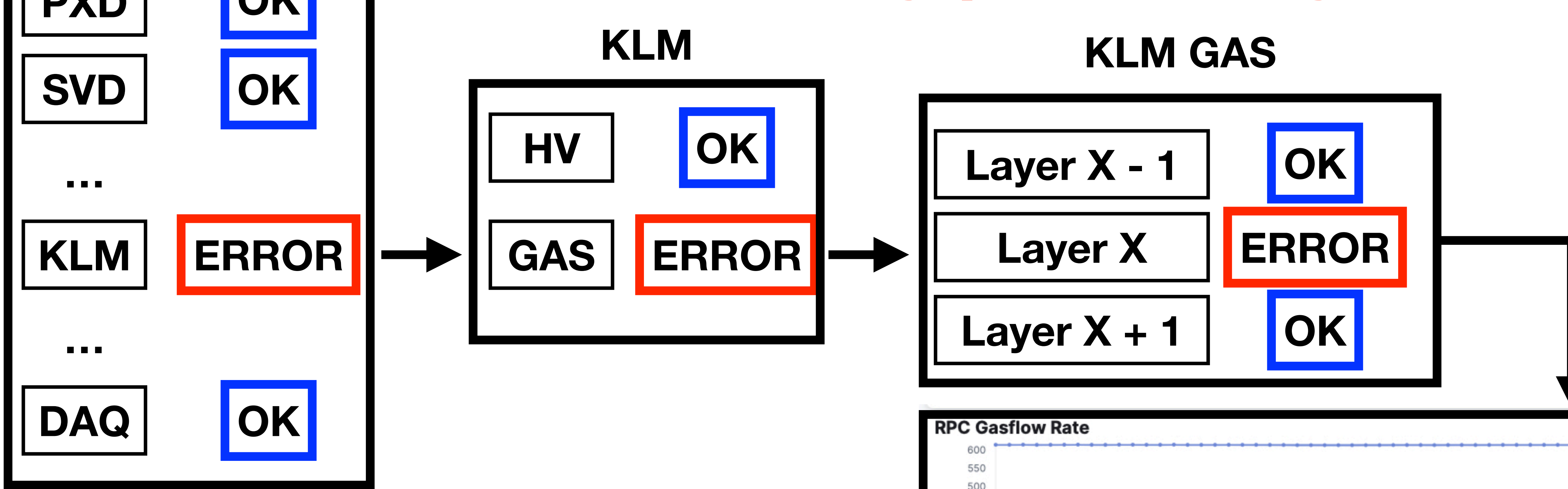
Alarm interface

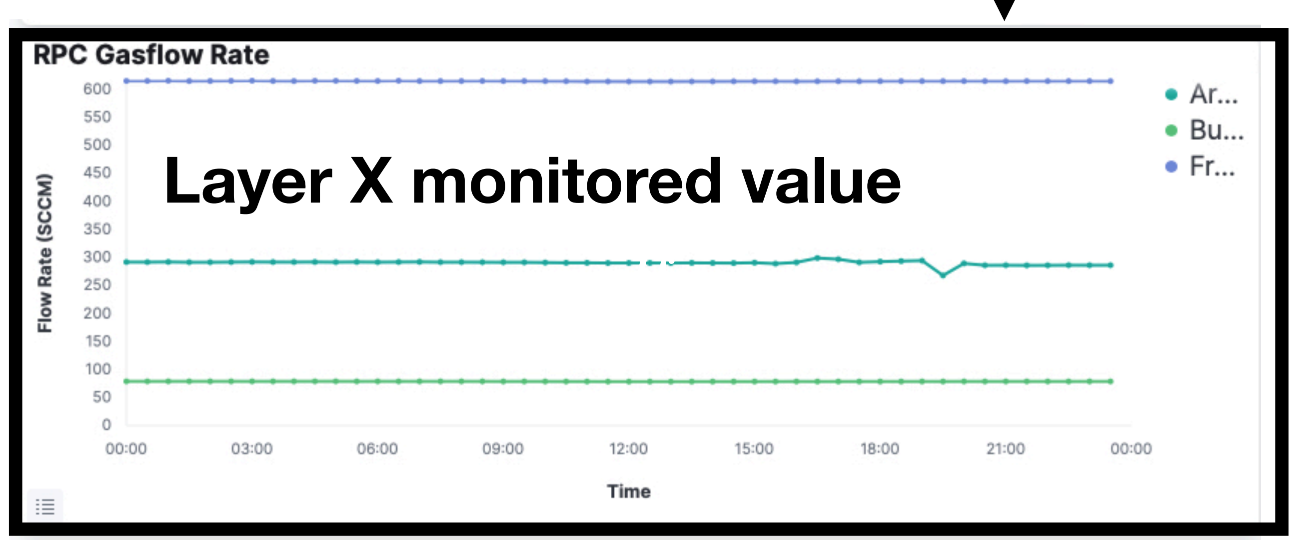
Graphical user interface via CSS opi

Activated alarms	Activated at
KLM gas flow Layer X	2022-11-01T09:00:00 JST

Very preliminary structure

DCS Main



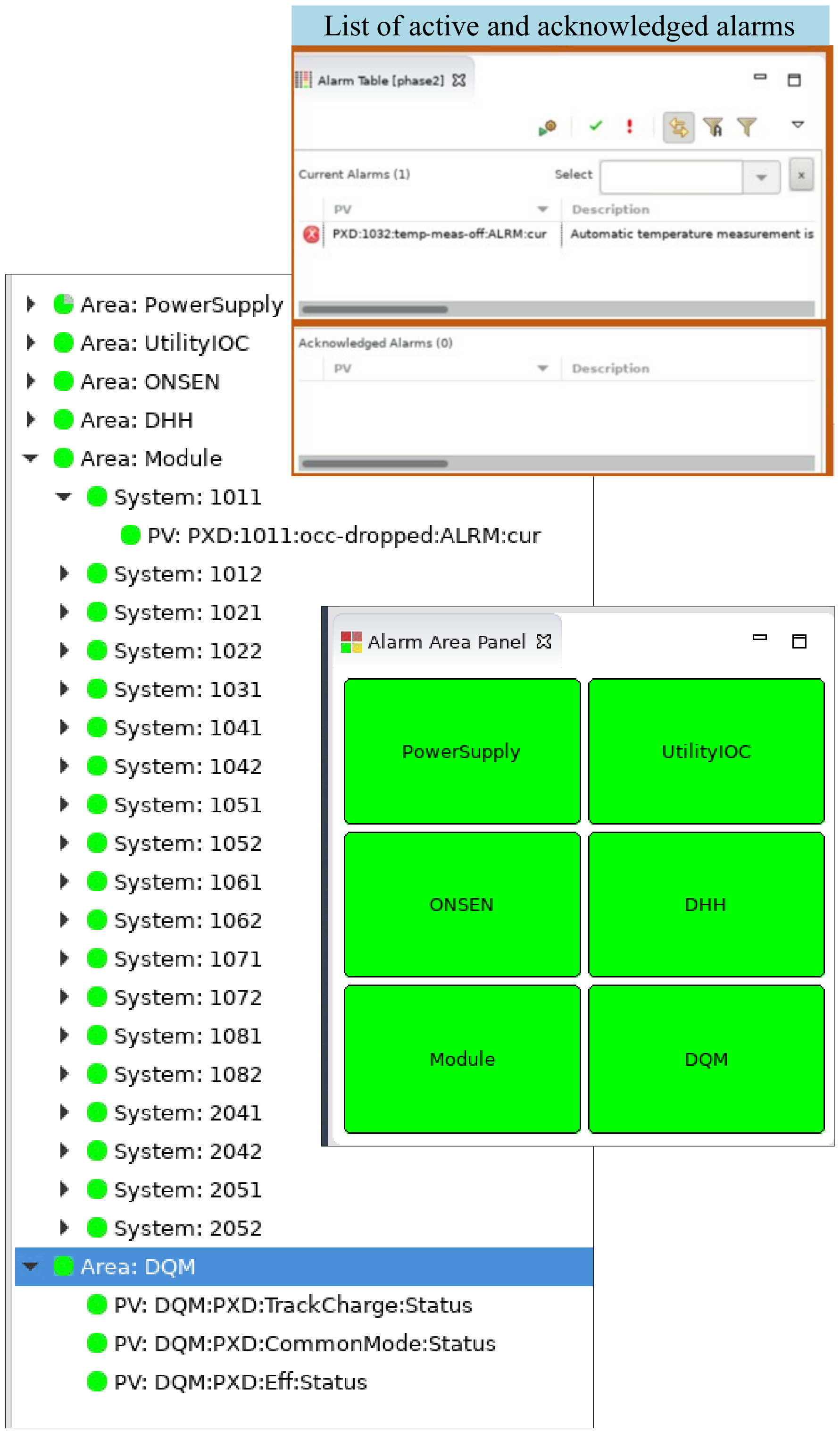


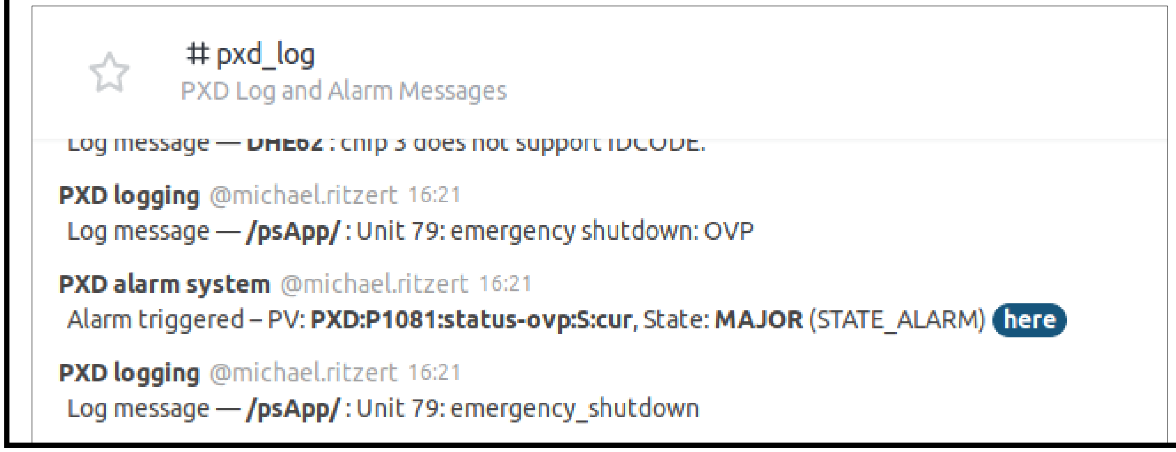
- All the information accessible
- Non-experts navigated on GUI

PXD Alarm System

- PXD used the BEAST alarm system integrated in CSS (Control System Studio)
- Alarm panel, table & hierarchical alarm tree
  - Latching alarms
  - Required shifter acknowledge
  - Embedded actions (buttons) & guidance text
  - Acoustic voice announcements
  - Database for configuration
    - Allow complex condition for alarms
      - e.g. n times within given times
- Alarm messages (together with other log messages) pushed to ElasticSearch database and RocketChat

https://github.com/ControlSystemStudio/cs-studio/wiki/BEAST





Slide by Björn Spruck

- Need to extend the target
- Requires the interface to all the databases (PostgreSQL, EPICS archiver, Elasticsearch)

Centralised detector control and monitoring

- Sub-detector components maintained by each sub-detector group
- Some components neither Belle II-wide reviewed nor officially documented
- Each sub-system component is (almost) independent
  - Some sub-system already have an alarm interface (and independent system), but no central alarm interface

Need to gather information, skills, and experience, and to brush up and unify our system

Detector control system

- where we discuss all the DCS topics as a Belle II matter
- 1st task is to summarise and document the current system in each sub-system
- then, we improve up each component one by one

Detector control system

Target of the detector control system

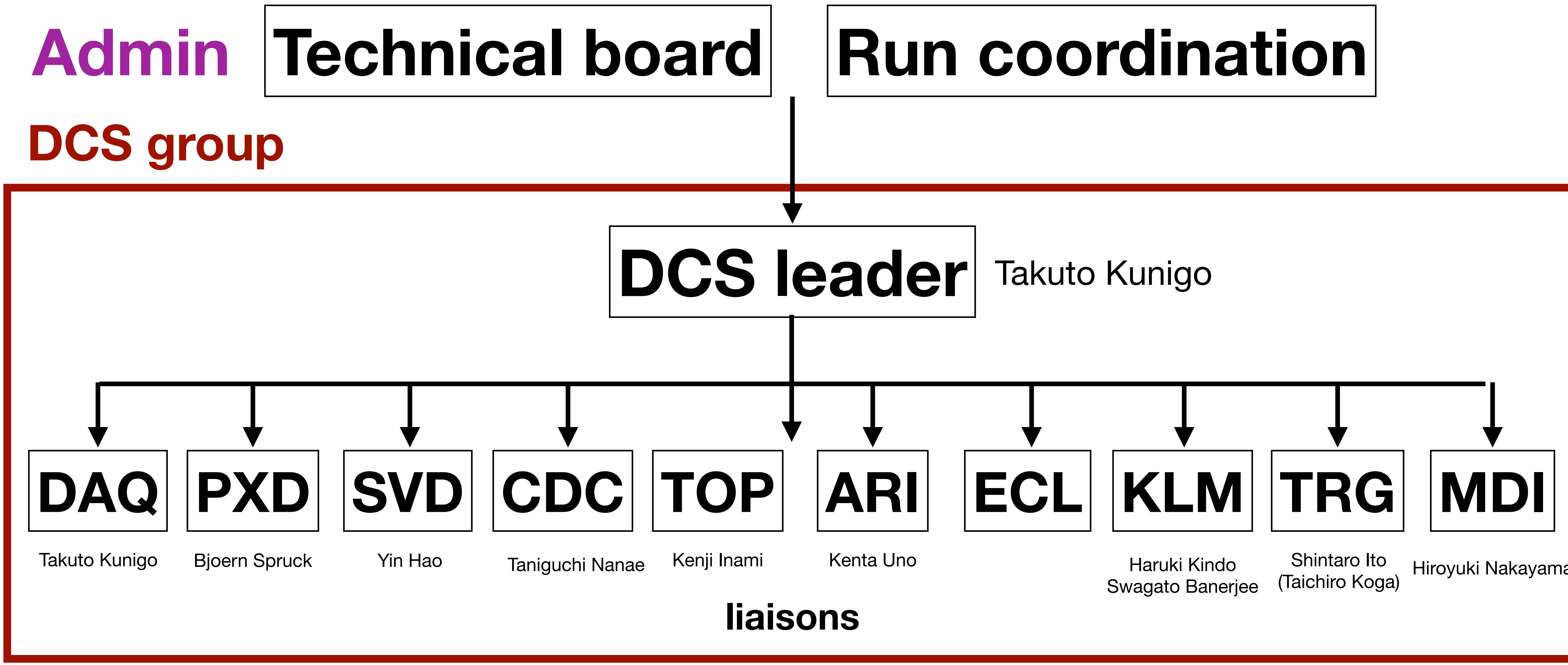
- High voltage control
- Low voltage control
- Power supply
- SKB gateway
- Interlock
- Detector environment (Gas, heating, chiller, etc)
- Detector setting parameters (V-threshold, masking, etc)
- + Operator interfaces (with interfaces to the databases)

Motivation

- Each system is independent
- Each system is (mostly) assigned to single person and little people understand the system

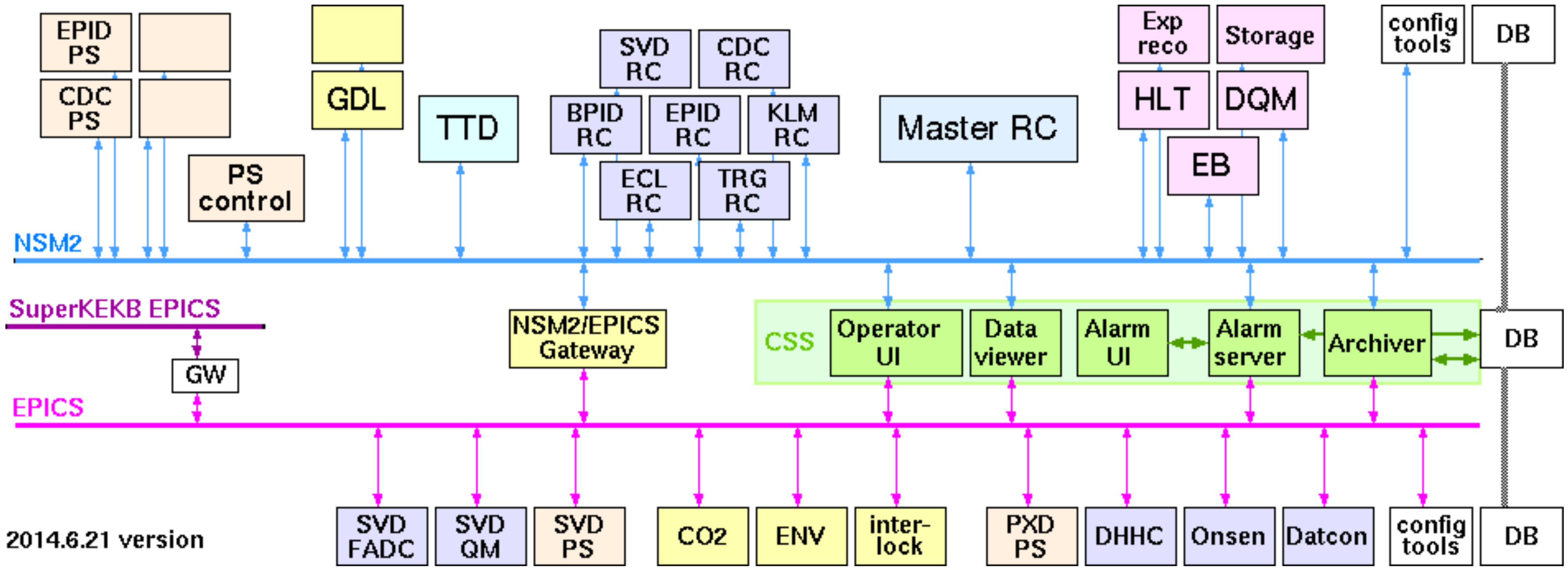
➡**Establish a system which is capable to control and monitor the whole Belle II detector (i.e. Belle II DCS)**

Organisation



- Liaison is assigned to each sub-system including TRG, MDI
- **DCS leader coordinates the system**
- Final decision is always done by TB or RC

Slow control



- Until ~2year ago there was the **Slow control group**
  - Slow-control group already dissolved
- Motivation of slow-control group is similar to DCS, but there are several different points
  - Definition of “Slow-control” is not clear or too wide-ranging
    ➡DCS focuses on detector-control
  - Procedures to make a decision is not clear
    ➡Agreement among the sub-systems in DCS then request an approval to admin (TB/RC)

HV control

1st priority given to HV control

- because it influences SKB injection
- We revisit definitions one by one
- Actual implementation to be done by the end of 2022

State definition

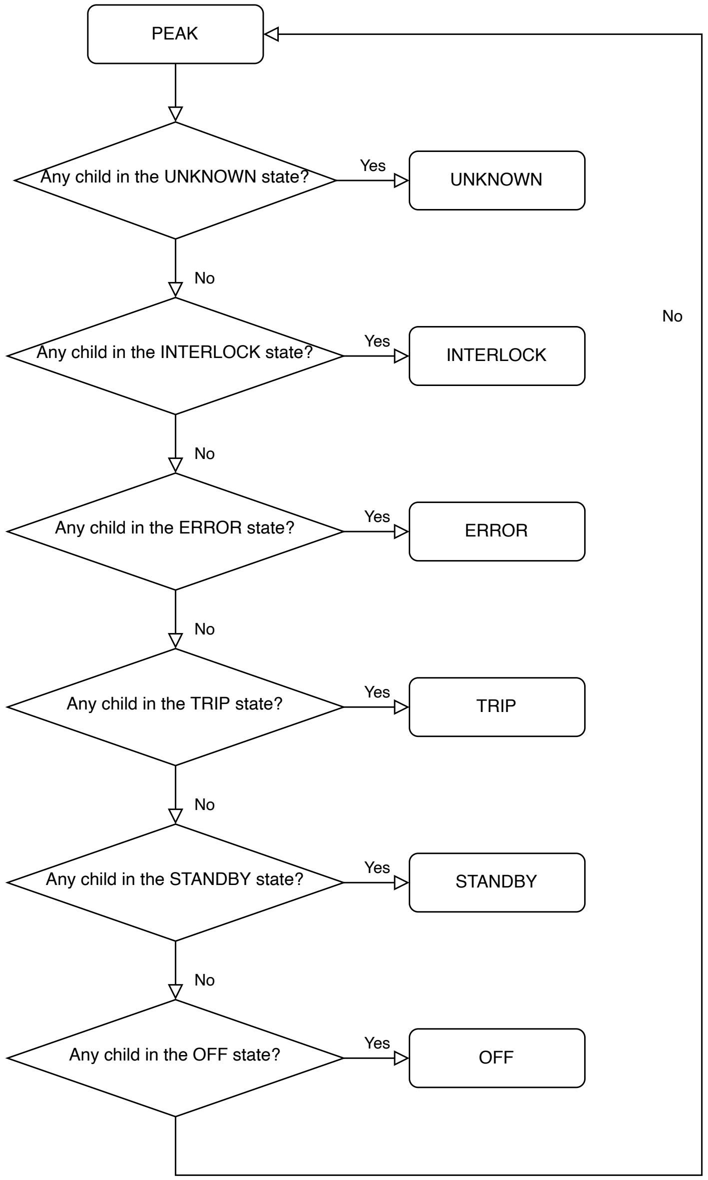
Each sub-detector HV process works as a finite-state machine (FSM), and thus has its state (HV state). For logical objects, the mandatory HV states are PEAK and OFF, reflecting conditions for which data taking is possible or impossible, respectively. The state UNKNOWN is used in case the condition cannot be verified. Other possible states are 1) ERROR, which indicates that normal operation not possible or will become impossible very soon, and 2) TRIP, which is due to over-current or over-voltage of the children modules. The actual state of these logical objects is determined by the states of the associated lower level objects (children) via state rules, an example of the state rule is figure 1.

During beam operations, all sub-detectors ramp HV to nominal values ("PEAK") only when stable beams has been declared by SuperKEKB, implying no more manipulations/adjustments are done on the beams. Outside stable beams, HV is set to a lower STANDBY value. Stable beams is indicated to Belle II by the HV permission flag, which is sent from the SuperKEKB group via the EPICS network. Current Standby settings are summarised in table 1.

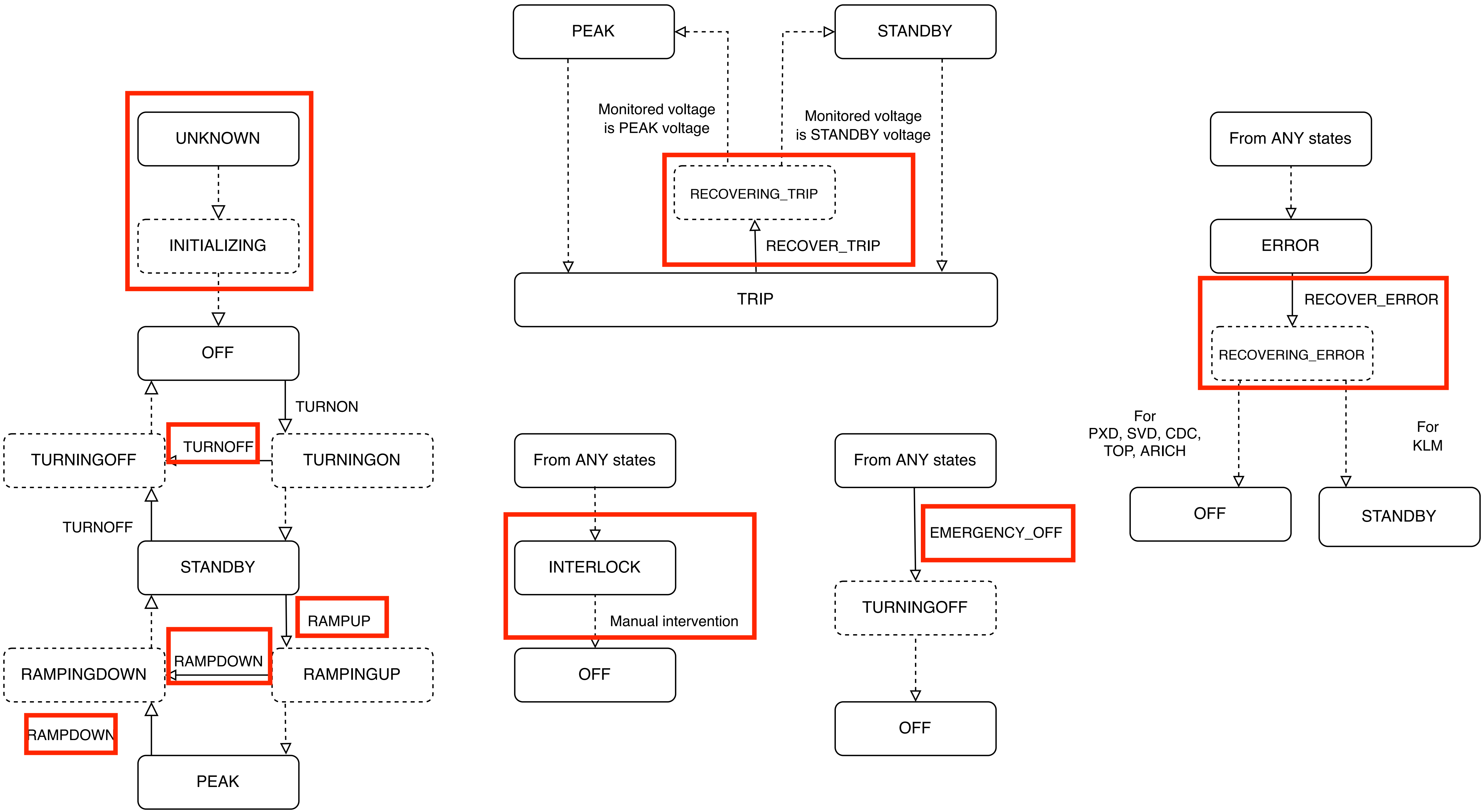
The master node of Belle II HV nodes (HVMASTER) aggregates each sub-detector HV state. The aggregated HV state is treated as the global HV state, which is directly coupled with the SuperKEKB injection blocking algorithm. The coupling between the global HV state and injection blocking is summarised in table 2. The detail of the injection blocking algorithm is described in the MDI section.

State transitions. 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 2.

State rule



State transition



Injection inhibit Current/Old

2.11 MDI

Due to its short beam life time, SuperKEKB adopts "top-up" injection scheme to keep the target stored beam currents. To avoid unwanted beam injections when Belle II detector is not ready, Belle II sends two injection enable signals to SuperKEKB to limit when beam injection can happen. The two signals are available as EPICS PVs in the Belle II network:

- a) B2_MDI:INJ:INJECTION:ENABLE
- b) B2_MDI:INJ:NORMAL:ENABLE

The ttd module in the E-hut checks those PVs and convert them into hardware signals, and send them to the SuperKEKB side via optical fibers between the E-hut and SuperKEKB control room. Then the signals are converted to EPICS PVs in SuperKEKB network (note that PV names are different from those in the Belle II network) and used in their injection control system.

The injection enable signals sent from Belle II to SuperKEKB are used in the following way to control beam injections.

- While HV permission is given, beam injection should be moderate and calm except for unexpected sudden troubles. In this case, SuperKEKB requires only a) to perform beam injections.
- While HV permission is NOT given, during Main Ring start up for example, beam injection could be wild and dangerous. In this case, SuperKEKB requires both a) and b) to perform beam injections.

In the current DCS system, the global Belle II HV status is defined in HVMASTER module taking into account the HV status of all sub-detectors. And the global HV status is used for injection control in the following way:

- When the global Belle II HV status is OFF or STANDBY or PEAK we assume Belle II is safe for moderate injections and enable a).
- When the global Belle II HV status is OFF or STANDBY (not PEAK), we assume Belle II is safe for even wild injections and enable both a) and b).
- When the global Belle II HV status is in other states (transition, error, unknown, etc.), we do not enable any of a) and b).

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. Then the sub-detector injection enables signals (prepared as EPICS PVs) collected from all sub-detectors are summed up on a IOC to prepare global injection enable signal PVs.

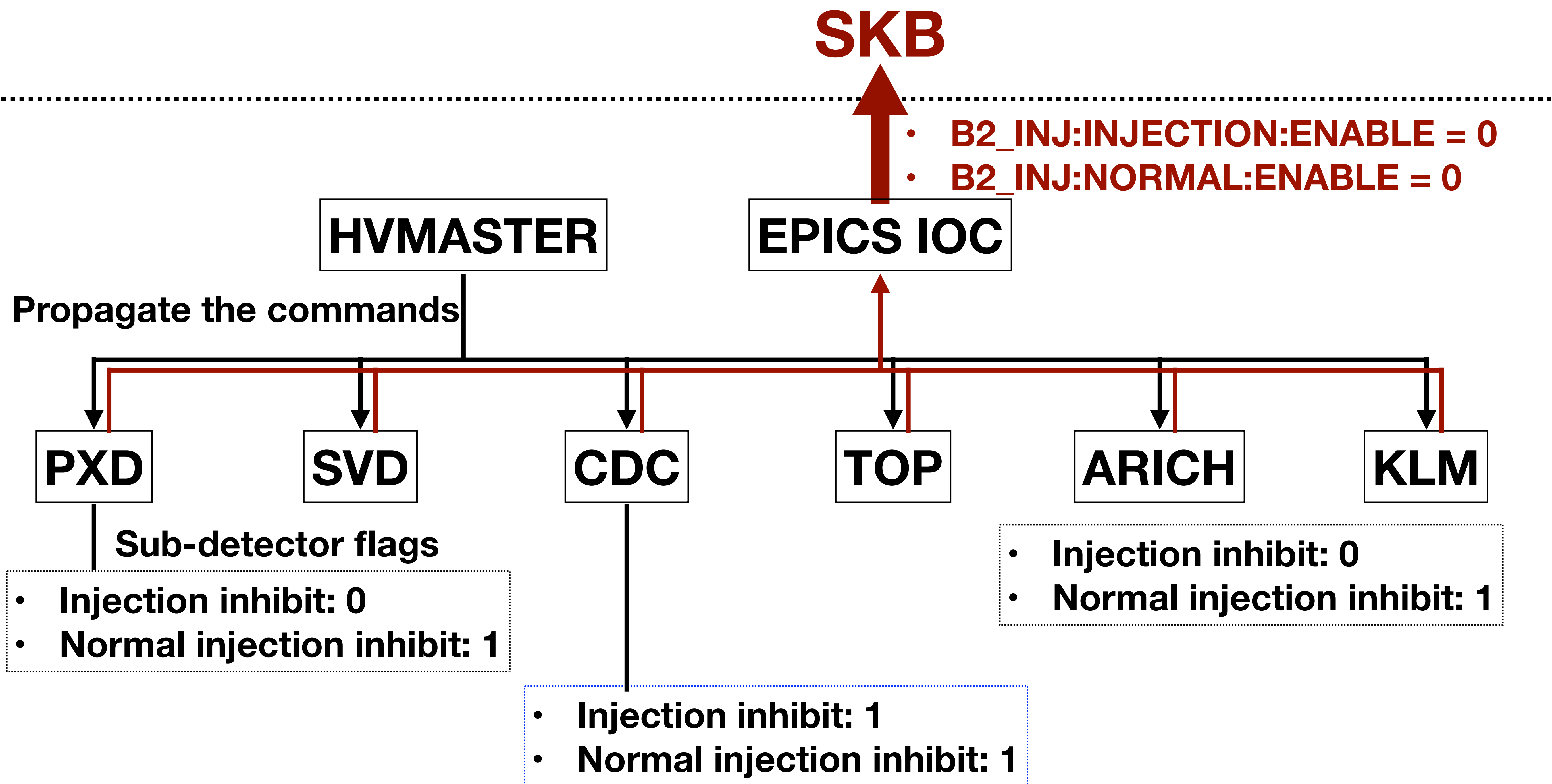
For PXD and SVD, whose run control system is based on EPICS, it is easy to prepare new EPICS PVs for injection enable signals. However, for other sub-detectors whose run control system is based on NSM2, they need to prepare a nsm2cad IOC to convert their NSM variables for injection enable signals into EPICS PVs. Such conversion IOCs could fail during beam operation, especially when they restarted the DAQ system but forgot to reboot the IOCs. We need to implement some "heartbeat" features to detect such failures, to avoid unwanted interruption of beam operation due to missing injection enable signals from sub-detectors. It is also important to prepare a CSS OPI panel showing which sub-detector is blocking beam injection, so that BCG and CR shift can know the issue immediately and contact relevant sub-detector experts.

Table 2: Coupling between the global HV state and injection blocking flags. The definition of continuous and normal injections are explained in the MDI section.

Global HV state	Continuous injection	Normal injection
OFF	Allowed	Allowed
STANDBY	Allowed	Allowed
PEAK	Allowed	Inhibited
TURNINGON	Inhibited	Inhibited
TURNINGDOWN	Inhibited	Inhibited
RAMPINGUP	Inhibited	Inhibited
RAMPINGDOWN	Inhibited	Inhibited
TRIP	Inhibited	Inhibited
ERROR	Inhibited	Inhibited
UNKNOWN	Inhibited	Inhibited
INTERLOCK	Inhibited	Inhibited

Injection inhibit

New



Documentation

Everything need to be documented officially

Publication number: TBD
Authors: DCS group
Referees: TBD
Intended journal: TBD
KEK preprint: TBD
Belle II preprint: TBD
Deadline: TBD

The detector control system of the Belle II experiment

Draft version 0.0.0
October 20, 2022

Abstract

The Belle II experiment seeks physics beyond the standard model of particle physics exploiting the data provided from the SuperKEKB accelerator, an asymmetric energy e^+e^- collider located at KEK, Tsukuba, Japan. The Belle II detector consists of seven sub-detectors; (1) pixel detector and (2) silicon vertex detector for tracking and vertex reconstruction, (3) central drift chamber for reconstruction of charged particle trajectories, (4) time-of-propagation counter and (5) aerogel ring-imaging-cerenkov counter for charged hadron identification, (6) electromagnetic calorimeter for photon detection and electron identification, and (7) KL and muon detector. During 2022-2023, the scheduled long shutdown (LS1) was took place. During LS1, we complete the installation of the second layer of the pixel-based vertex detector. At the commissioning phase, the individual detector components are developed and maintained by each sub-detector experts. During LS1, we unified them in to the common system, Detectro Control System (DCS). The DCS enables equipped with [illegible] and communicates with the data acquisition system via a communicator. We deploy the DCS during the LS1, the DCS is being used successfully.

Work in progress

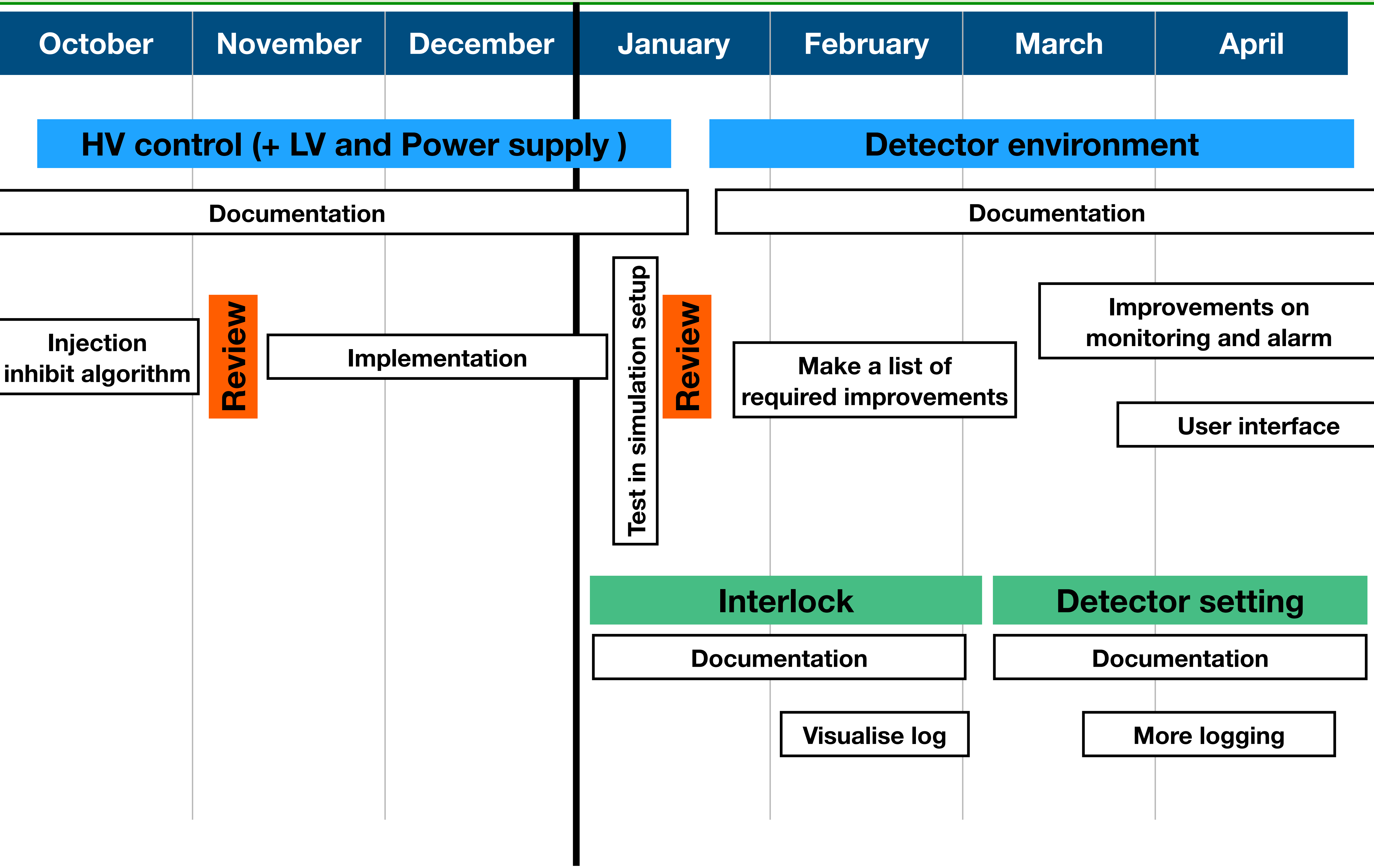
helpful for new Belle II members, HEP community, and Belle II (old) members

Summary

Detector control system group

- We plan some upgrades on, for example, gas flow monitoring
- For detector control components, we need to
  - **review** the components as a Belle II operation matter
  - make an **official document** of the signed-off items
- Now focusing on the HV control upgrade
  - Actual implementation to be done by the end of 2022
  - to be tested in early 2023
- LS1 is the (almost) only opportunity to apply changes on DCS

Schedule


October
November
December
January
February
March
April
HV control (+ LV and Power supply)
Detector environment
Documentation
Documentation
Injection inhibit algorithm
Review
Implementation
Test in simulation setup
Review
Make a list of required improvements
Improvements on monitoring and alarm
User interface
Interlock
Detector setting
Documentation
Documentation
Visualise log
More logging