



# OP view on the system performance and future improvement

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Session 4 : accelerator performance: LHC

# Availability in 2022

**We didn't expect this year to be easy:**

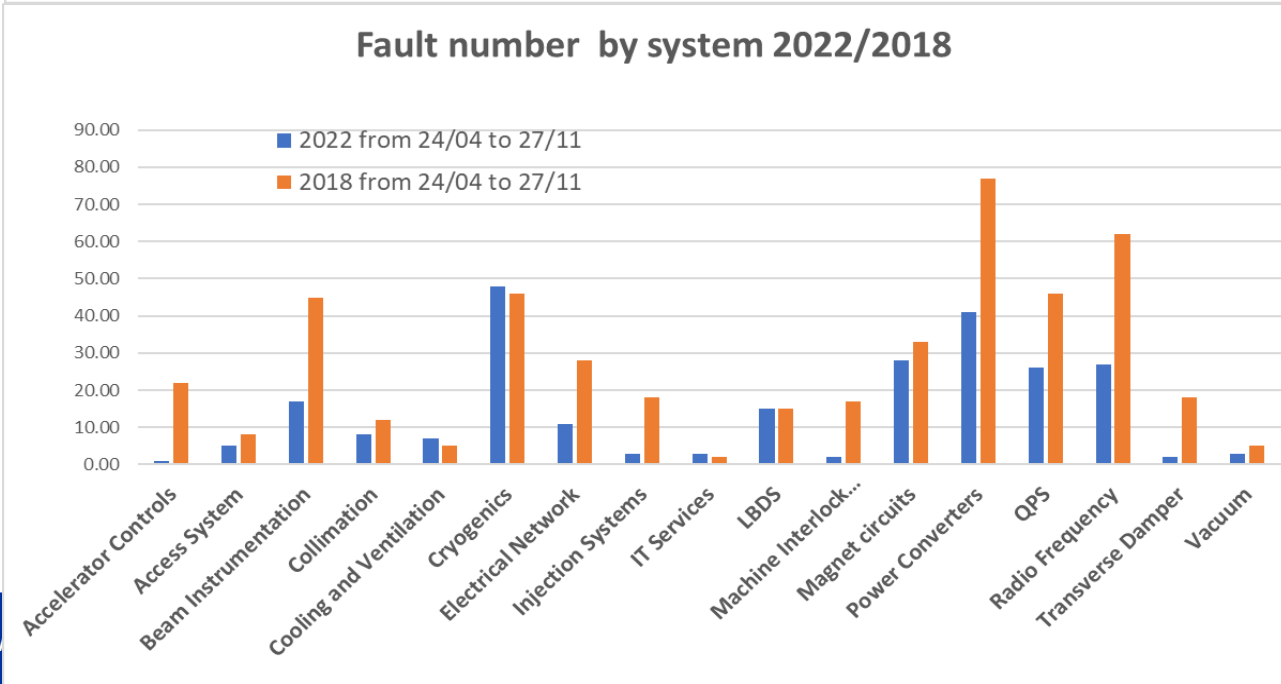
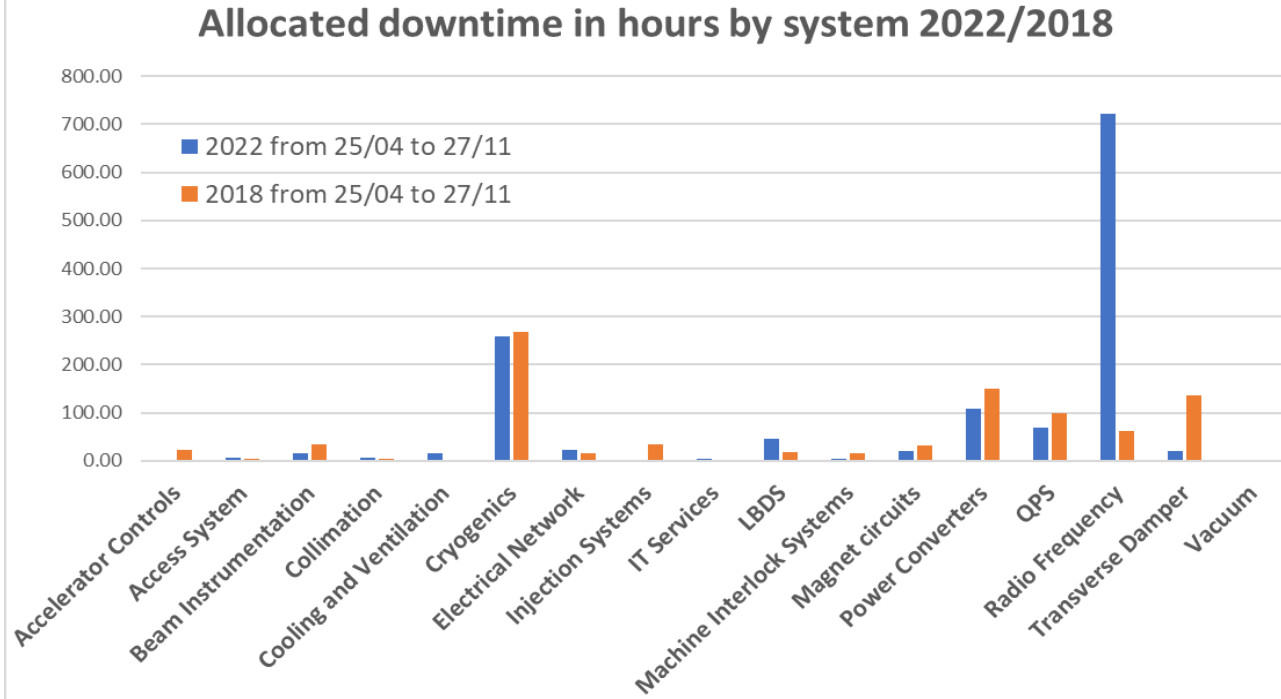
- Beam intensity and energy increased
- Very long stop of 3 years

**Nevertheless, for most of the systems, compare to 2018:**

- Downtime decreased or comparable
- Nbr of faults decreased or comparable

→ Great benefit of the 2021 Beam test.  
 → Systems well prepared for run3 challenges

Data from AFT from 25/04 to 25/11 in 2018 and 2022  
 \* For QPS and Power converter faults I compared only the faults >15 mins as I realized that in 2022 we didn't register faults for all little trips of the QPS or power converters as it was the case in 2018



# Scope

**This presentation is not an exhaustive report on each system performance**



**Focus on a few systems where OP experienced in 2022**

- Unusual faults and limitations
- Quality issue
- Operability that can be improved

**With a view on possible solutions**

# Instrumentation- BBQ

Quality of the measurement degraded by high chroma and high octupoles settings (necessary to stabilize the high intensity beam)

- New fit algorithm developed by OP and BI for a better peak detection of large peaks.
- Quality of the signal improved considerably

Bunch intensity increased → saturation issue

- Several options tested by BI : always a trade off with the signal quality
- OP/ BI need to decide on the best option for next start-up

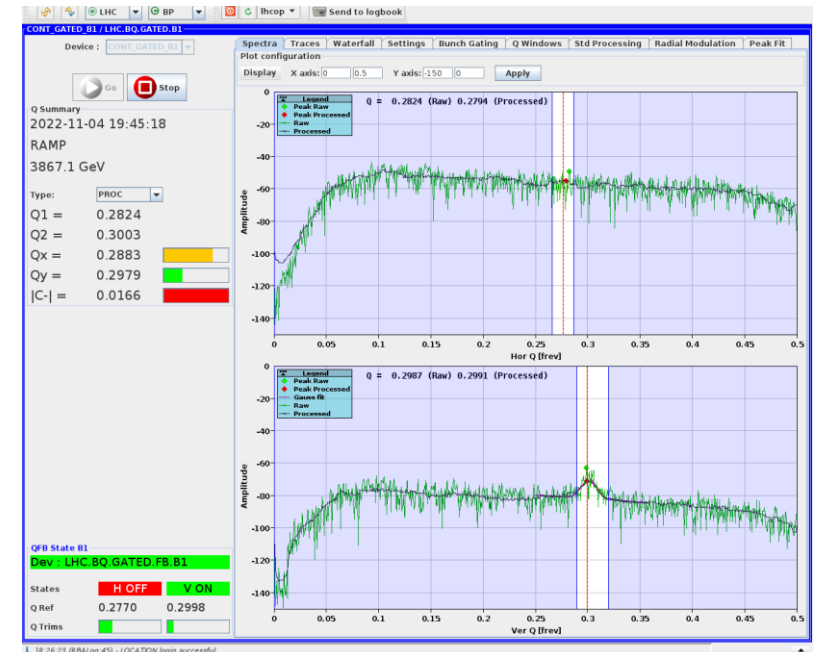
```
02-10-2022 20:03:03
BBQ signals at ~2 TeV

B2V peak disappeared on operational gated
it re-appeared at ~2.5 TeV

20-10-2022 04:00:00
Gated BBQ B1H spectrum oscillating a

10-07-2022 09:07:22
very bad tune signals, both on continuous an

Gated is a little bit better than continuous
```



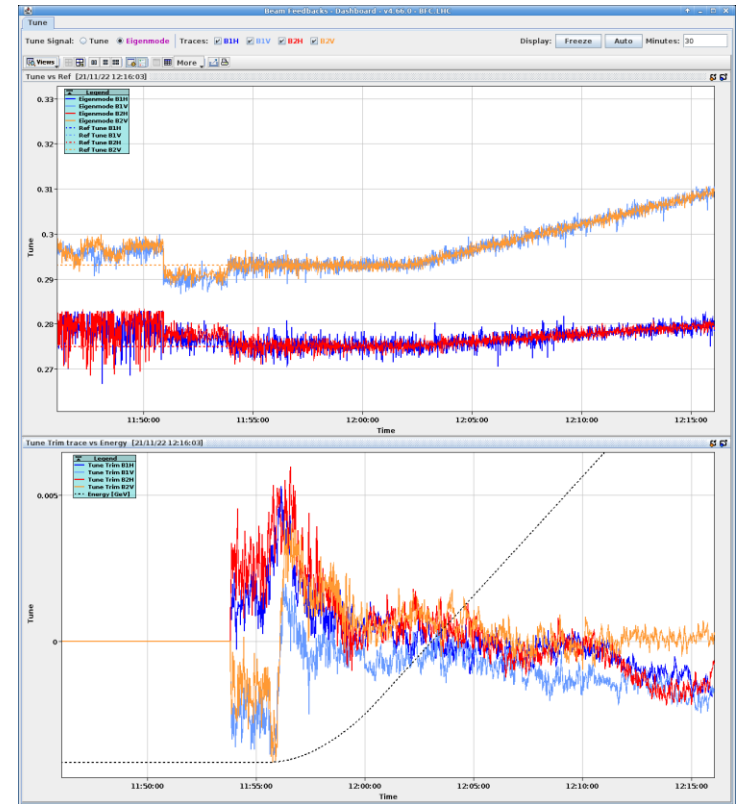
# Instrumentation : BBQ

## Consequences on the tune feedback :

- Tune feedback ON along the full cycle.
- Correcting on a noisy signal : stress the HW with many RT trims
- Could lock on a wrong peak : drive the real tunes away from ref

## Major impact on beam avoided thanks to

- Feedback clever enough to detect bad quality input signal and switch off
- Good feedforward of the correction: the beam survives with feedback off (even if a bit rocky during the snapback.)



# Feedbacks

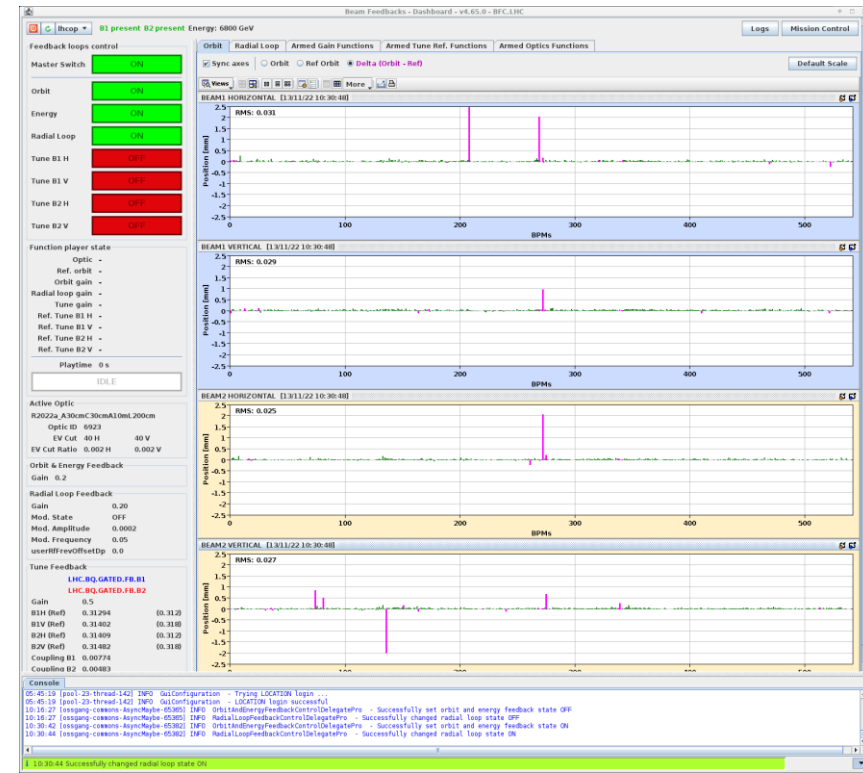
## Much more comprehensive and easier to operate

- Clearer interface on the system
- Settings all stored in LSA
- Sequencer task much simpler and faster

## Much faster Orbit feedback preparation

- Essential when using trim orchestration during B\* levelling

Small limitation of the orbit feedback on the max number of optics : will be updated for the 2023 configuration.



# XPOC

## Principle

- Each beam dump system trigger: dump event automatic analysis (i.e. kicker behavior, losses, vacuum...)
- If issue: operation blocked with SIS interlock, until expert or OP reset.

Since first beam : 500 resets in total

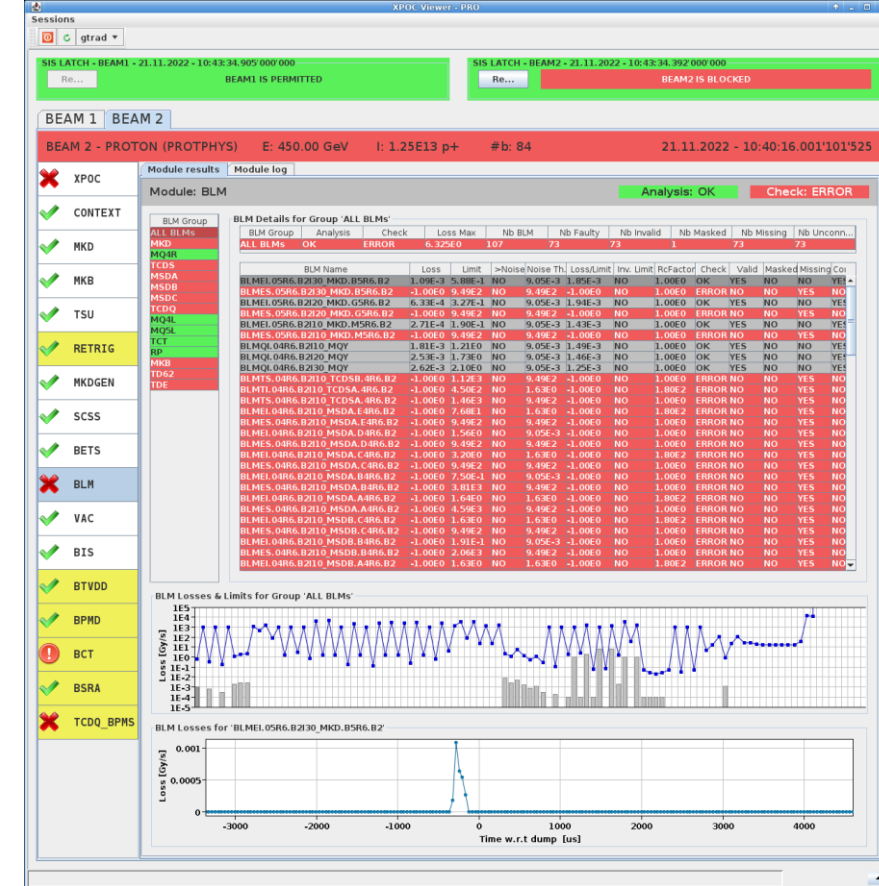
2 recurrent issues with XPOC system (15% of resets)

- BLM PM data missing (solved by BI but still happens..)
- PM database issue, fully solved by MPE

Beam availability not impacted

- Amazing availability of the expert (54 calls to N.Magnin any time of day, night and week-ends)
- Some non-critical modules can be reset by OP

During YETS: review the BLM thresholds to reduce the number of resets.

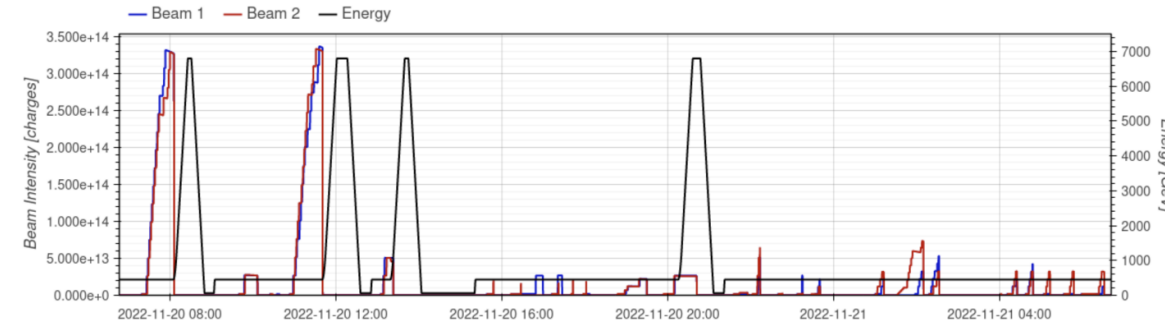


## Difficult year on the HW point of view

- But comparable to 2018 if we remove the long fault end of August

## Long downtime after the ions run :

- Was pure HW issue, unrelated to switching particle
- Highlighted that diagnostic would be easier with more settings in LSA, to be reviewed during YETS.



## Expected improvement in 2023

- New diagnostic: machine learning tomography, b/b tomography.
- Operational pre-detuning (reduce the transient at first nominal injection) : becomes useful with the increase of bunch intensity!



## Operational application could be improved to better display the active settings

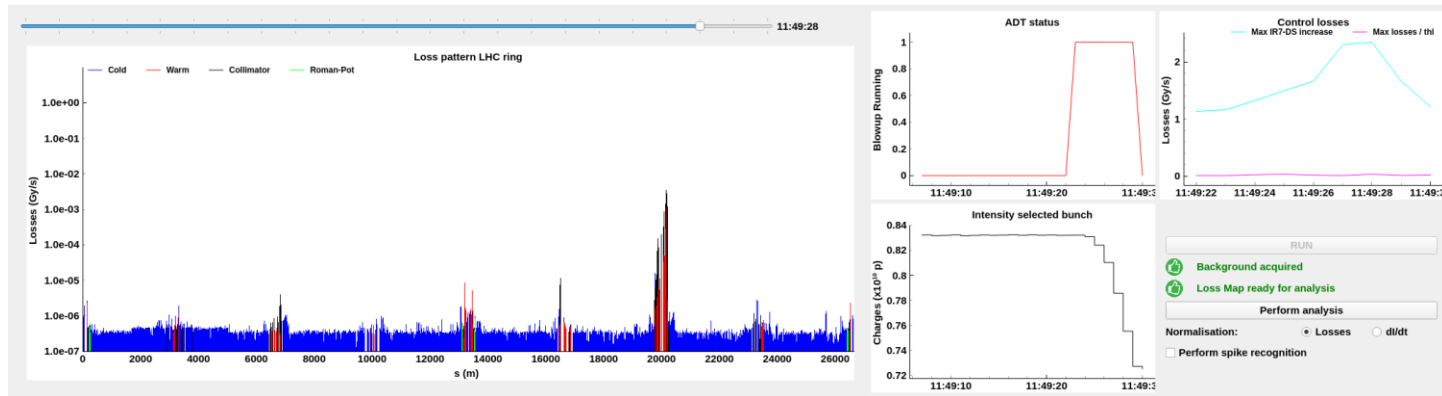
- Already the Abort gap check application is being redone.

## Missing diagnostic

- Position settings set according to the expected intensity (SIS interlock): no monitoring what is set.
- Missing a measurement of the ADT signal (like the one in the expert scope) that would confirm if ADT is active and on which bunches.
- Obs box not always available for expert during MDs

# Collimators

Huge amount of time saved for OP thanks to the new loss map app.



New application to simplify the settings generation

LHC Collimator Settings App v0.4.2 connected to server LHC

| Parameter Group  | Property        | Device/Property     |
|------------------|-----------------|---------------------|
| COLLIMATORS      | COLL_BBParam    | TCDD.4L2/BBParam    |
| COLLIMATORS      | COLL_BBOptics   | TCDD.4L2/BBOptics   |
| COLLIMATORS      | COLL_NSIGMA     | TCDD.4L2/NSIGMA     |
| COLLIMATORS      | COLL_NSIGMA_TOL | TCDD.4L2/NSIGMA_TOL |
| TEST COLLIMATORS | ~NONE           | ~NONE               |

Generate settings for selected parameters

# Collimators

Still complicated management of the settings and sequences:

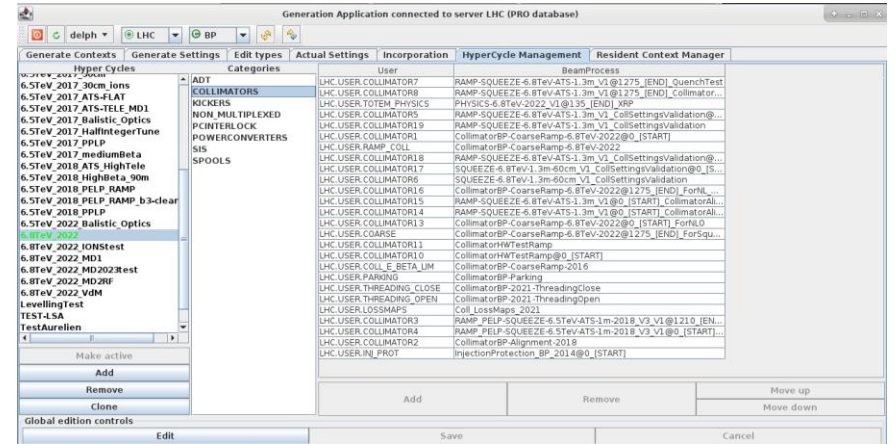
- Several dedicated BP + the main function BP
- We move different coll groups at each phases

Many sequences to maintain and adapt to present machine configuration

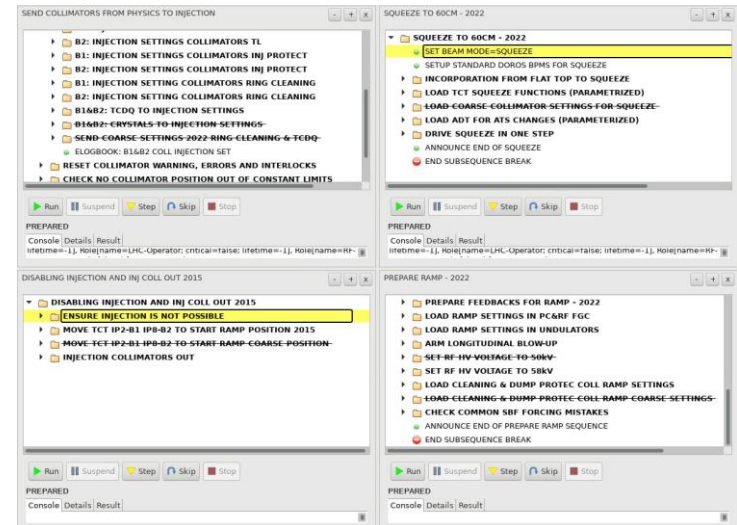
- Would really benefit from **more flexibility in the sequencer** (but no major upgrade foreseen...)

**YETS** : attempt to further optimize the settings and sequences management in order to

- Reduce the workload of the expert (namely Daniele)
- Reduce the mistake possibilities



The many collimator beam processes in the nominal hypercycle



Up to now no better solution found than skip - unskip sequences when configuration changes

# Circuits

## Cause of circuit trips often difficult to analyze

- Can be triggered by QPS, Power converter or PIC failure
- Several app to open and information to put together
- Paper procedure to find out what to be done
- sometime still unclear, both QPS and EPC piquet called to check

## Not more user friendly to restart circuits

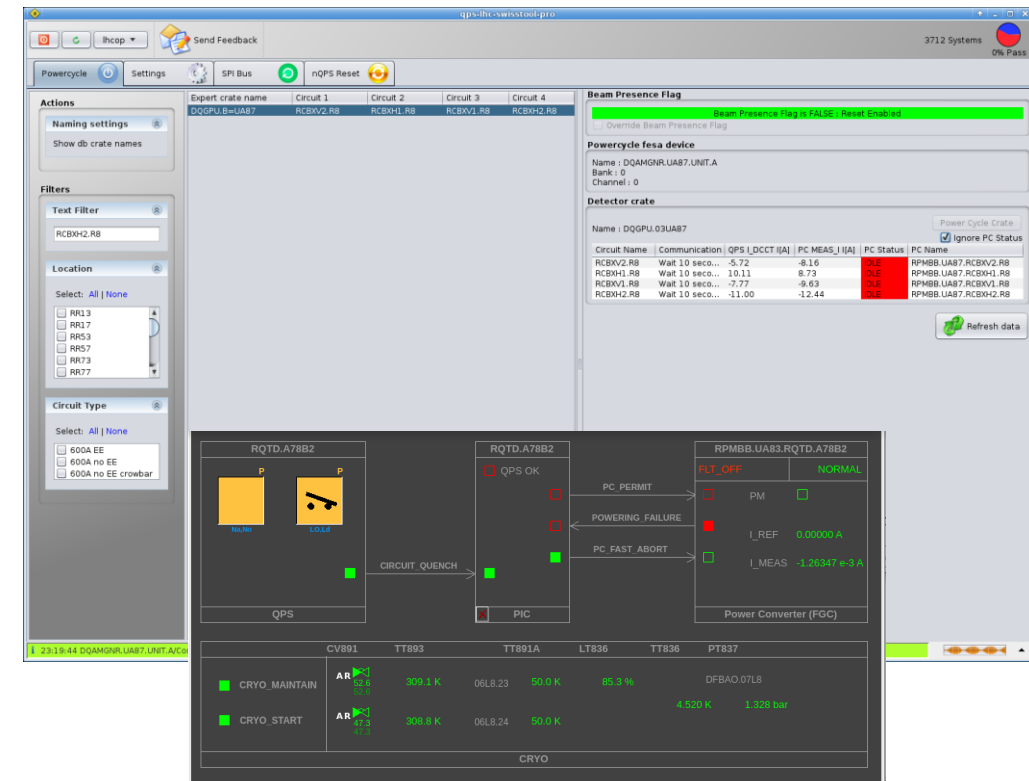
- Many reset and actions necessary in different apps
- Sequencer task : takes too much time, should be re-optimized

| Unnamed: 0 | source | datetime      | circuit_type | circuit_name | analysis_result |
|------------|--------|---------------|--------------|--------------|-----------------|
| 0          | A12R2  | 2022-10-30... | RB           | RB.A23       | FAILED          |
| 1          | A15R4  | 2022-10-30... | RB           | RB.A45       | FAILED          |
| 2          | A12L7  | 2022-10-30... | RB           | RB.A67       | FAILED          |

# Circuits

## QPS tools

- Very expert oriented, i.e. : no way to do reset on many QPS boards, only one by one
- Diagnostic not easy, sometime many reset necessary
- QPS reset macros: from time to time, it trips the 600A circuits (RB macros issue solved)



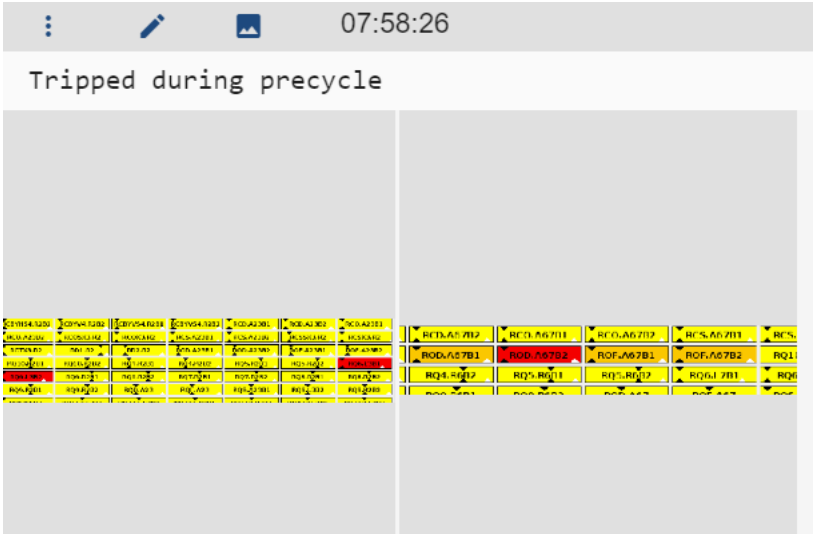
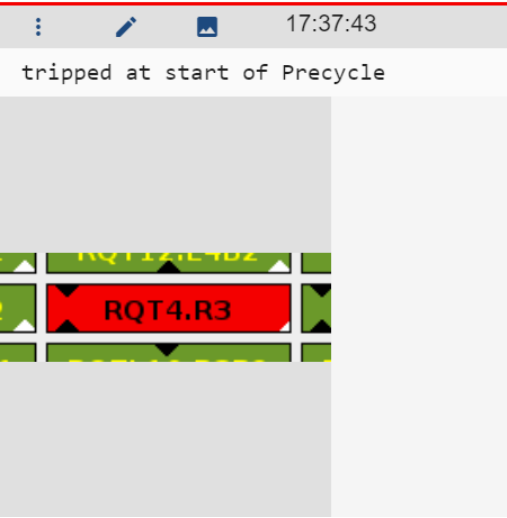
## Clearly missing an operational tool for circuits

- We need global diagnostic and control including QPS, PIC, Power converters
- That would also give a better understanding of the possible actions and their consequences.

# Circuits

## Regular trips of power converters when precycling or ramping down.

- No downtime as usually a powerconverter reset is enough to restart the circuits
- But very annoying and worth investigating





# Circuits : DFB chimney heaters

On several occasion , Cryo operator informed EIC that temperature too low on one of the current lead.

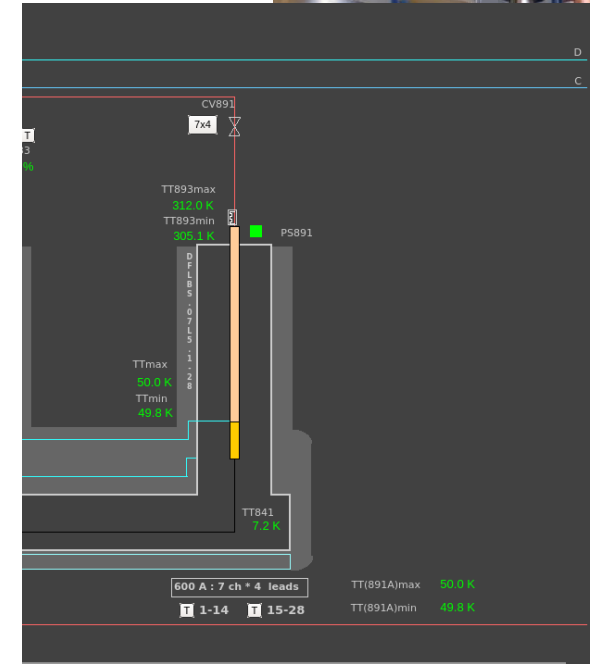
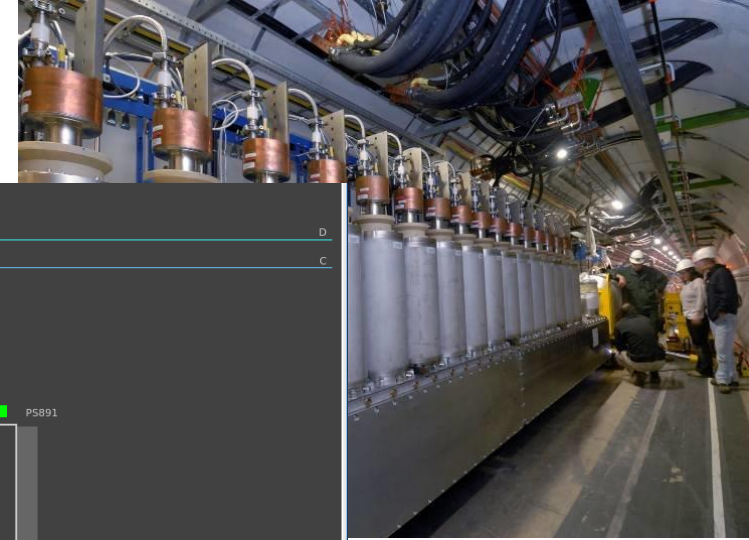
## Requires urgent access

- if the temperature can't be stabilized by cryo, dump beams for immediate intervention.

16 occurrences during operation (14 in RRs)

This recurrent problem is due to single event upset on the temperature regulators in the RRs

During YETS an upgrade of the regulator is foreseen that should solve the issue.



- DFB = Current lead of the superconducting magnets, regulated from ambient temp to cryo temp.
- If a temp regulator fails, the top of the current lead starts freezing with a risk to damage equipment

# Access

## Complicated system with many details to know:

- Diagnostic not always easy.
- Many documentation and procedures, also many extra little details and tricks to know

## Recovering from access

- Quite often we realized too late:
  - key missing or not plugged properly
  - Ventilation door left opened, or with bad contact
- Difficult to spot before everybody has left
- Sometime required to re-enter the machine
- Especially a nightmare when mixing access and commissioning activities





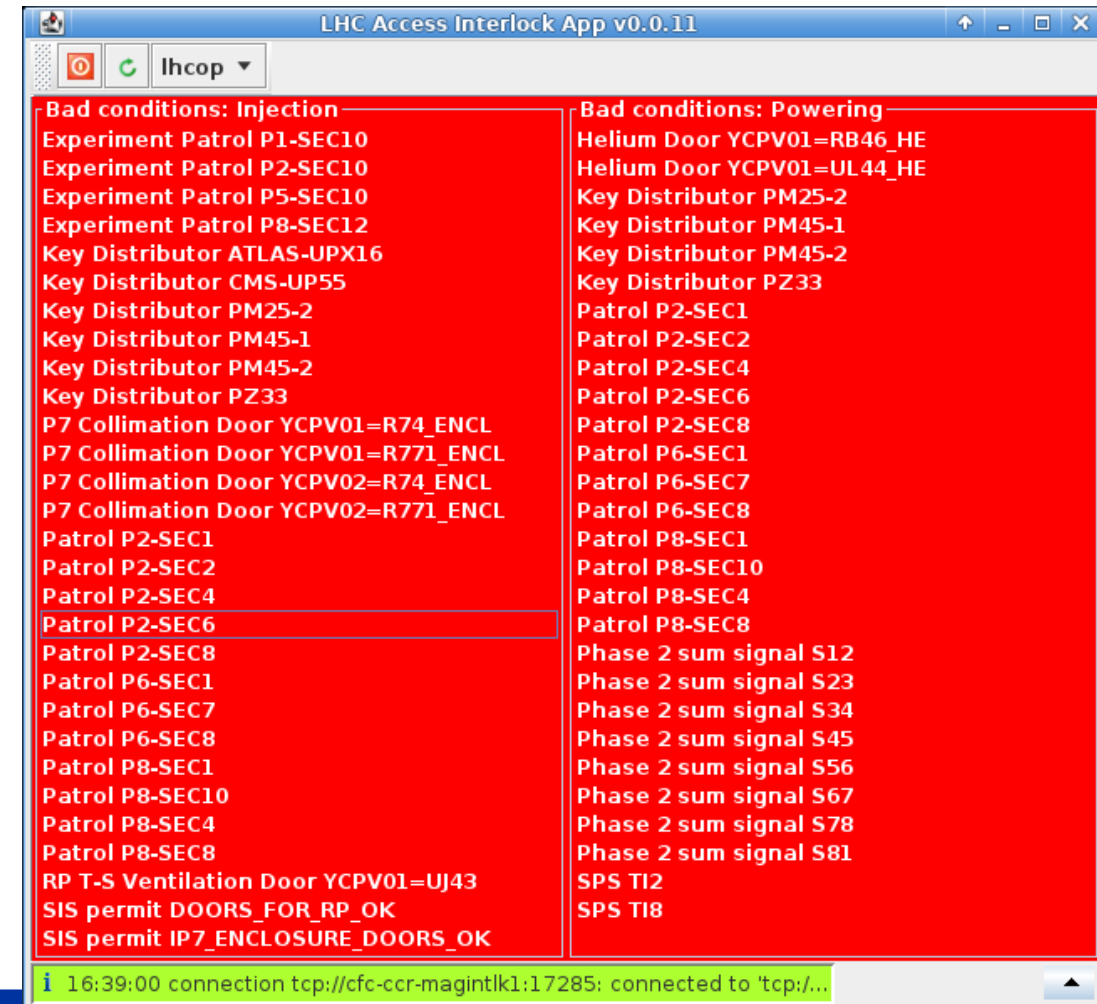
# Access

## Could we be helped by software?

- Existing user interface are outsourced and difficult to modify.
- simple application developed by OP: summary of all access interlock, immediate spot of remaining issue.
- In addition, announcer messages, i.e. in case of lost patrol

**OP: gather requirement to improve the situation**

**Check with access control team what can be done.**



The screenshot shows a window titled "LHC Access Interlock App v0.0.11" with a menu bar containing "lhcop". The main content area is a red background with white text, divided into two columns. The left column is titled "Bad conditions: Injection" and the right column is titled "Bad conditions: Powering".

| Bad conditions: Injection            | Bad conditions: Powering   |
|--------------------------------------|----------------------------|
| Experiment Patrol P1-SEC10           | Helium Door YCPV01=RB46_HE |
| Experiment Patrol P2-SEC10           | Helium Door YCPV01=UL44_HE |
| Experiment Patrol P5-SEC10           | Key Distributor PM25-2     |
| Experiment Patrol P8-SEC12           | Key Distributor PM45-1     |
| Key Distributor ATLAS-UPX16          | Key Distributor PM45-2     |
| Key Distributor CMS-UP55             | Key Distributor PZ33       |
| Key Distributor PM25-2               | Patrol P2-SEC1             |
| Key Distributor PM45-1               | Patrol P2-SEC2             |
| Key Distributor PM45-2               | Patrol P2-SEC4             |
| Key Distributor PZ33                 | Patrol P2-SEC6             |
| P7 Collimation Door YCPV01=R74_ENCL  | Patrol P2-SEC8             |
| P7 Collimation Door YCPV01=R771_ENCL | Patrol P6-SEC1             |
| P7 Collimation Door YCPV02=R74_ENCL  | Patrol P6-SEC7             |
| P7 Collimation Door YCPV02=R771_ENCL | Patrol P6-SEC8             |
| Patrol P2-SEC1                       | Patrol P8-SEC1             |
| Patrol P2-SEC2                       | Patrol P8-SEC10            |
| Patrol P2-SEC4                       | Patrol P8-SEC4             |
| Patrol P2-SEC6                       | Patrol P8-SEC8             |
| Patrol P2-SEC8                       | Phase 2 sum signal S12     |
| Patrol P6-SEC1                       | Phase 2 sum signal S23     |
| Patrol P6-SEC7                       | Phase 2 sum signal S34     |
| Patrol P6-SEC8                       | Phase 2 sum signal S45     |
| Patrol P8-SEC1                       | Phase 2 sum signal S56     |
| Patrol P8-SEC10                      | Phase 2 sum signal S67     |
| Patrol P8-SEC4                       | Phase 2 sum signal S78     |
| Patrol P8-SEC8                       | Phase 2 sum signal S81     |
| RP T-S Ventilation Door YCPV01=UJ43  | SPS TI2                    |
| SIS permit DOORS_FOR_RP_OK           | SPS TI8                    |
| SIS permit IP7_ENCLOSURE_DOORS_OK    |                            |

At the bottom of the window, a status bar shows: "i 16:39:00 connection tcp://cfc-ccr-magintk1:17285: connected to 'tcp://...'"

# Access

## Several unusual issues related to access in the machine

- Access maintenance during operation
  - Saves a lot of time during technical stops and YETS
  - [3 dumps in 2022](#) during the switch to/from maintenance mode (then maintenance was stopped)
  - Problem is now understood
    - Extra sanity checks added in the procedure to switch to maintenance mode
    - Should be solved during YETS
- Stuck elevators
  - 6 times during operation: access delayed of several hours due to elevator problems
  - Corrective action foreseen during YETS.



# Conclusions

**All systems worked very well**

**Some unusual problems, most of them already solved or being addressed during the YETS**

**For some cases reported here, a better interface with the operation team would be beneficial**

- Better and faster diagnostic
- More comfortable and intuitive to operate
- May save some calls to experts and piquets (and reduce downtime)

**Amazing experts' availability much appreciated by OP**

