Summary of Session VII

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- RF Commissioning - Andrew Butterworth (CERN)
- Machine Protection - Jorg Wenninger (CERN)
- Safe Beam Tests – Stefano Redaelli (CERN) on behalf of Ralph Assmann (CERN)
- Discussion, Phase I Commissioning

General summary

- Power system commissioning procedures will be well known if using existing power source (SPS type 800MHz)
- Controls and application software should be based on standard CERN controls infrastructure
- LHC low-level electronics has built-in conditioning and diagnostics facilities, and is already well integrated into the control system
- Powerful tools are being developed for LLRF setting-up which could equally be applied to the crab cavity system

LLRF: Summary

- It took almost 1 month to set up the Low-Level RF of the first cavity
- Once the procedures were well defined, the last few cavities took about 1 day each

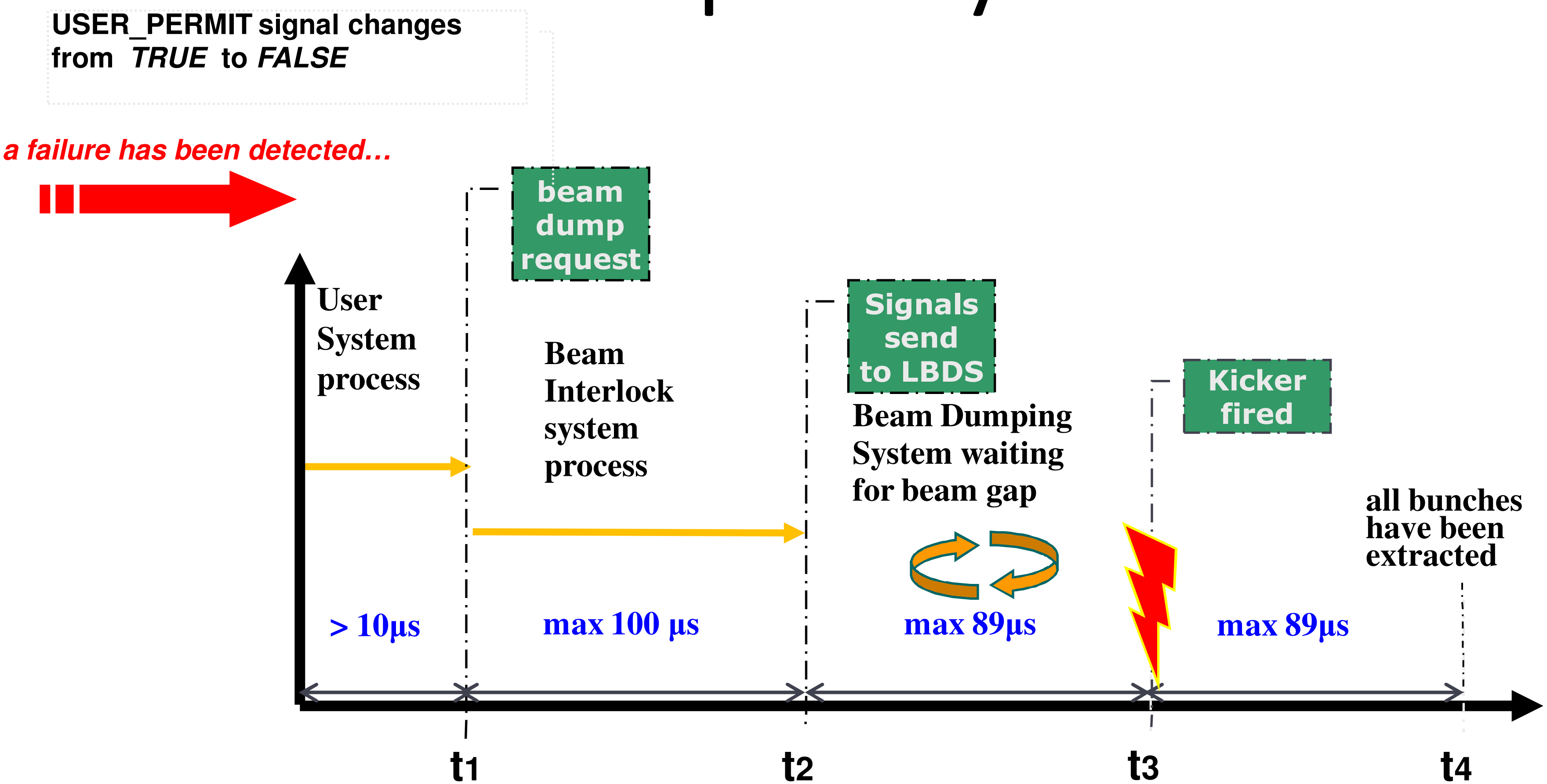
- New automated tools using MATLAB will save a lot of time

→ Many thanks to our US-LARP colleagues from SLAC

Conditioning: Summary

- Typical conditioning time to full power and voltage for an LHC cavity was a few days to 1 week
- Highly automated, but still requires regular human supervision to adjust parameters
- Integrated conditioning system in LLRF hardware has proved very efficient, and allows conditioning of multiple cavities in parallel
- Main power coupler DC bias switched on only after conditioning

Dump Delays

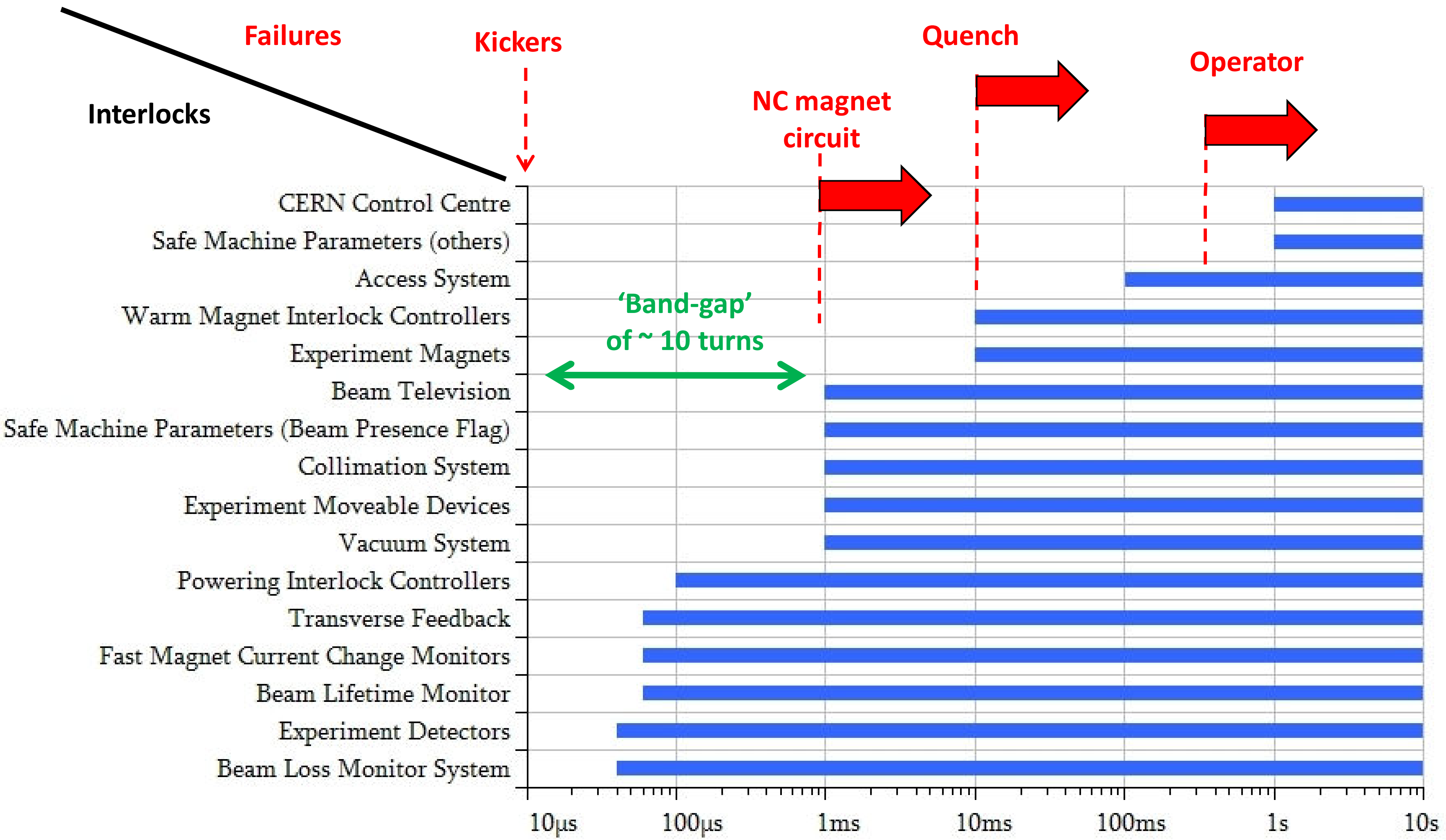


Achievable response time ranges between 100 µs and 270 µs.

>> Triggering a dump is not the end of the story,

must be able to survive up to another 3 turns.

Times Scales



Best failure detection time = 40 us = half turn

Particle Excursions

- Global crab (test) : $\beta^* = 0.55$ m, $\theta_C = 0.3$ mrad
  - Crab excursions extend over entire ring.
  - Crab excursions must be compatible with collimation.

$$\Delta\hat{x}[\sigma_x] \cong 0.6\,\Delta s[\sigma_s] \quad \Longrightarrow \quad |\Delta\hat{x}_{\max}| \cong 1.2\,\sigma_x$$

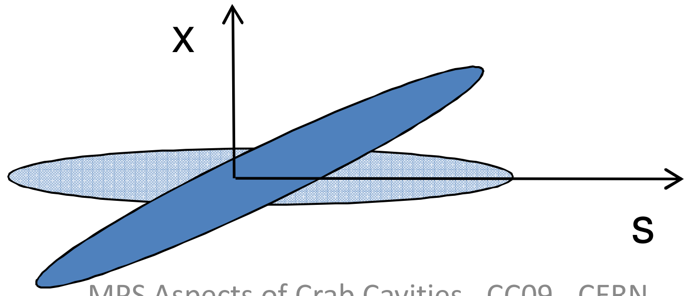
Assuming a full length of $\pm 2\,\sigma_s$

- Local crabs : SLHC-I, $\beta^* = 0.25$ m, $\theta_C = 0.4$ mrad
  - Nominal crab excursions only local around IR1 & IR5.
  - Collimation does not see the crab when cavities are at nominal setting.

$$\Delta\hat{x}[\sigma_x] \cong 1.2\,\Delta s[\sigma_s] \quad \Longrightarrow \quad |\Delta\hat{x}_{\max}| \cong 2.5\,\sigma_x$$

Assuming a full length of $\pm 2\,\sigma_s$

Even larger excursions for more extreme θ_c…



Failure Time Constants

Possible failure modes:

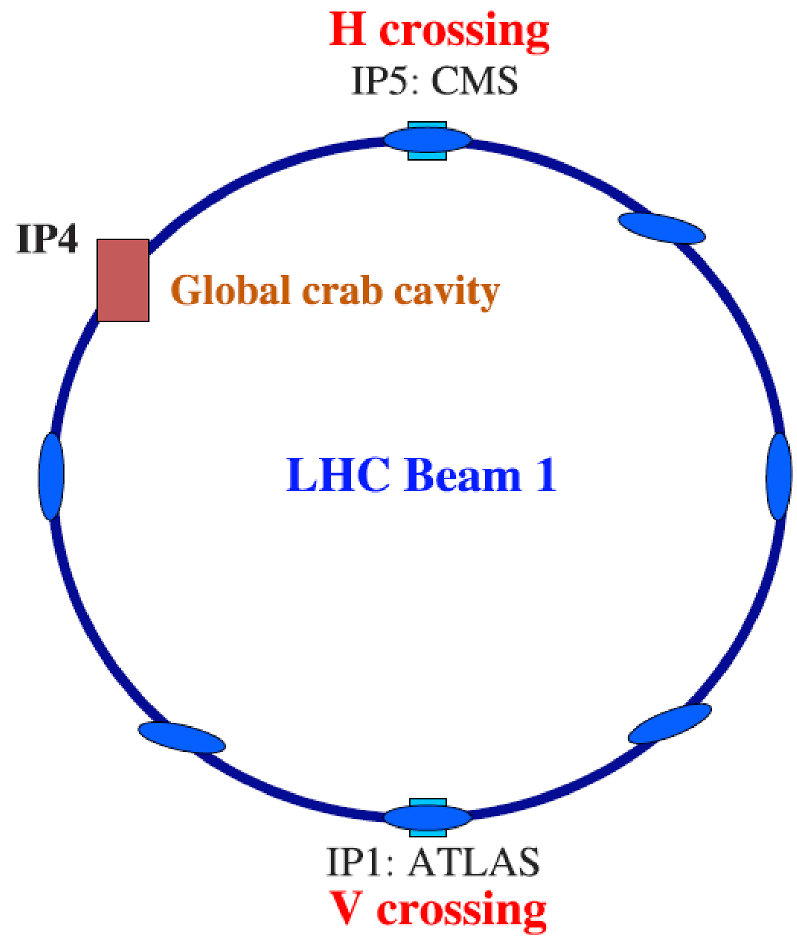
- Cavity trips.
- Cavity phase changes or jumps.
- 'Controlled' cavity voltage changes.
- …

From a discussion with J. Tückmantel, it seems that the those failures or changes may occur over time scales of **less than 1 LHC turn**.

If confirmed, this could make protection against Crab cavity failures very difficult.

The Global Crab Cavity in IR4

- Explained before in detail…
- Meant as a demonstration experiment. Goals:
  - **Show that crab cavities do not disturb the beam.**
  - **Show that the predicted gain is really achieved.**
- Some price to be paid:
  - Not closed solution, so beam changed all around the ring.
  - Have to address issues that would be no problem for a closed solution, e.g. collimation and MP.
  - Additional issues can cause problems…



Safe Beam Tests

- Safe → **Minimize intensity during tests as much as possible and proceed very systematically**.
- Propose three categories of beam tests:
  1. **Beam tests before installation of the IR4 crab cavity**
  2. **Beam tests after installation of the IR4 crab cavity, before squeeze and with low intensity**
  3. **Beam tests with crab cavity in collision**
- Some major machine changes can be tested without crab cavities and should be tested to avoid later failure.

Beam Tests with Crab Cavity in Collision

- Beam parameters depend on the luminosity measurement resolution for various intensities, …. To be defined later.
- **This crucial test will aim at measuring between 4% and 14% of improvement in luminosity in IP5.**
- Careful previous beam tests and optimizations must have resulted in maintaining the beam quality with the crab cavity at 2.3 MV.
- A 4% gain in luminosity seems a priori small to be measured.
- However, we could do it for LEP why not for LHC?
  Crab cavities provide well controlled parameters that can be changed back and forth.
- See **LEP examples on next slides on measured luminosity…**
- Would worry more about machine changes than measuring luminosity at the few % level.

Summary

- RF: major re-use of hardware/tools/procedures from commissioning of other systems.

- MPS: potential danger of single-turn CC failure. To be addressed in detail. Data from KEKB CC trips might be useful.

- Safe beam tests: a systematic set of beam measurements proposed. Luminosity measurement seems particularly challenging for Hadrons machines (extrapolation from Lepton machines not completely appropriate). BB transfer function measurements should help. List of key instruments/techniques required is needed.