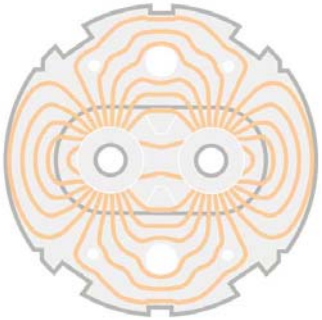


Session on circuit commissioning

Post-Mortem requirements

F. Rodríguez-Mateos on behalf of the SACEC sub-Working Group

Outline

- Setting the scene
- Purpose of PM
- A reliable system
- Data sent to the PM database
- Other data required for the analysis of an event
- The three facets of analysis
- IST requirements
- HC requirements
- Final remarks

Setting the scene

- I will concentrate on the superconducting magnet circuits since it is there that major efforts are necessary and provided

- These slides are the result of many discussions at SACEC*, among colleagues from many groups and not least, our experience in String 1 and 2 facilities over a few years

- Post-Mortem in the title of this talk refers to:
  - PM database
  - PM client interface
  - The data sent by the clients
  - Data retrieval and browser
  - Analysis tools (manual and automatic)

* Sub-Working Group of HCWG which deals with the Software Applications for the Commissioning of Electrical Circuits; http://lhc-hcwg.web.cern.ch/LHC-HCWG/SACECSubwgHome.htm

Purpose of PM (1/2)

Which system triggered first?

Why did it trigger?

Which systems were subsequently triggered and why (crosstalk, dependencies)?

What are the effects to the first triggering system?

What are the effects to the other systems triggered?

- Diagnostic tool
- Improve efficiency (rapid analysis, anticipation of misbehavior of equipment, etc)

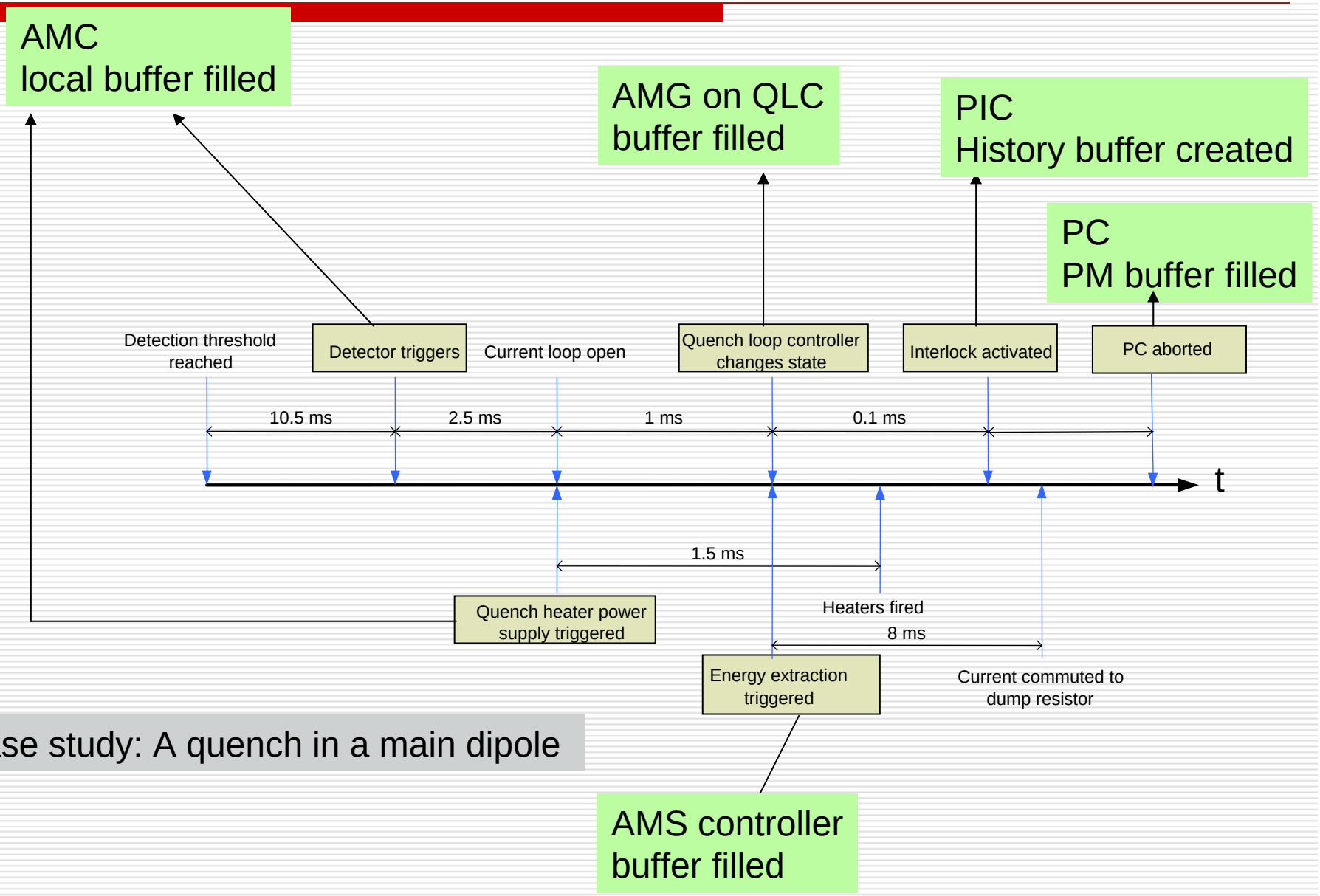
Purpose of PM (2/2)

- PM is NOT only used when something goes wrong!
- It is regularly used during:
  - The Individual System Tests (IST) of the QPS
  - The Hardware Commissioning Procedure (HCP) for the interlocks (PIC and interfaces)
  - The tests at different current levels taking place during the powering-to-nominal phase
- A condition to power is that **all the transient recorders in the equipment** are ON and that **the PM database** and **the PM client interface** are operational (same applies to Logging)

A reliable system…

- If PM data are lost:
  - Tremendous difficulty to make any diagnostic in a superconducting magnet chain
  - All the commissioning sequence must be repeated before powering the circuit again
- Hence the need for a secured and reliable data …
  - Collection
  - Transmission
  - Storage
  - Retrieval

Data sent to the PM database (1/3)



A case study: A quench in a main dipole

Data sent to the PM database (2/3)

A case study: quench in a main dipole for the QPS

- All post mortem buffers will be received by the corresponding gateways and shipped to the post mortem database
  - Up to 4 gateways are involved (at least 3)
  - In parallel, logging continues when filling the post mortem buffer
    - Important for 13 kA EE systems
  - All QPS/EE systems are blind while shipping the buffer to the gateway
- Amount of data and transmission rate
  - Size of typical QPS post mortem buffer: 61 kByte
  - Transmission rate per agent (independent of number of agents sending buffers): 480 Byte/s
  - 50 buffers for a typical case : 3 MByte @ 24 kByte/s within 3 min

Data sent to the PM database (3/3)

- There are three main systems sending transient data buffers to the Post-Mortem database
- QPS …
  - Will be the largest PM client
  - About 45’000 signals are included in c… uffers stopping in case of quench or other event (see F… t. no. 356568)
  - Signals generated by about 2000 c… s with internal trigger and “local” time stamp with ±1 m… on wrt to UTC time
  - Maximum sampling rate around…
- Power Converters …
  - Internal trigger (also extern… g-)
  - I_{ref}, V_{ref}, I_{meas}, V_{meas} are re… t 100 Hz over 40 s
  - I_{meas} is recorded at 1 kH… 6 s
  - There is a buffer runni… sampling rate of 50 Hz over 5 min
  - State transitions are… amped at ±1 µs precision wrt UTC
- PIC …
  - Internal trigger
  - History buffers… changes with ±1 ms precision wrt to UTC time

Time stamp precision across systems is **fundamental** for the reconstruction of an event

Other data required for the analysis of an event

- Besides the "fast" data from the three systems above, other signals coming from systems with no transient recorders are required. This implies the need for importing into the event analysis data from the Logging Database
- Cryogenics (ref. L. Serio, AT/ACR)
  - Sector Cryo Ok
  - Cell T_{max}
  - Cell pressure
  - Quench valve position
  - Pressure in line D
  - P, T and position of discharge valve to quench buffer
- Vacuum (ref. P. Cruikshank, AT/VAC)
  - Beam vacuum total pressure
  - Sector valves status
  - Ion pumps current
  - Insulation vacuum total pressure
- Other signals
  - -Under study-

The three facets of analysis

We have identified three major axis where the work is being focused:

① A data viewer (interactive browser) with standard features that are well known since the String days:

- easy data retrieval
- view data y=f(t) in engineering units
- several curves from different systems on same plot, in different scales
- several plots per page, several pages
- zooming, cursors, highlighting of signals, ...

② Analysis of the sequence of events

- Verification that the chronological order is what it is expected

③ Analysis of waveforms

- Verification that deduced parameters are within the expected range

② and ③ lead to the way of automation
(pattern recognition for sequences and curves)

… automatic analysis: sequence

- at magnet level
  - quench detection
  - heater firing
  - all heaters fired
  - coherency flag ok
- at circuit level
  - quench detection in other elements (magnets, bus bars, current leads)
  - opening of the quench loop
  - opening of energy extraction
  - change of status in PIC
  - switching the power converter off
- at sub-sector level
  - switching other power converters off
  - opening of energy extraction in other circuits
  - quench detection in other magnets
  - heaters fired in other magnets

… automatic analysis: waveforms

Analysis software must be capable to…

- calculate
  - extraction voltage and its time constant
  - circuit current time constant
  - heater discharge and time constants
  - dV_r/dt at quench
- measure
  - maximum magnet voltage at quench
  - maximum circuit voltage
- detect
  - time to exceed a threshold
  - diode conducting/blocking
- check coincidence of multiple curves
  - voltage across magnets

IST requirements

- QPS
  - For their IST in LSS8L, end of November 2005, the QPS team needs
    - the PM database and interface operational
    - data viewer operational
  - Later, for IST in the arc in April 2006,
    - the automatic analysis tools with reduced functionality (to be defined)
- PIC
  - No special needs during ISTs
  - For the check of interlocks in LSS8L (PIC1), PM must be operational at the same level as for QPS in February 2006
- Power Converters
  - No special requests during ISTs

HC requirements

- For the first powering in LSS8L (February 2006) PM should be fully operational by mid January 2006 for dry runs
  - First validation and refinement of the automatic analysis during the tests

a quasi permanent evolution

Final remarks

- Lists of signals with right naming (w.r.t. the naming conventions) and attributes have been completed by the responsible groups
- The browser is well advanced
- Discussions to define automatic analysis features have started
- Automatic analysis
  - … does not mean:
    - "We don't need to look at the curves, the software says it is ok"
    - "Automatic green light for next powering"
  - … is a fundamental tool to help and do calculations for us