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Global Post-Mortem Analysis:
Results from First Meetings

Inputs mostly from

► Meeting of the July 21st, with AB/CO and driven by Andrzej
(attendees: B. Khomenko, P. Pugnat, A. Siemko, A. Vergara)
- From 1st ideas toward optimized practice.

► Meetings of August 1st(*) and 9th(#) driven by Félix
(attendees: R. Denz(*, #), K. Dahlerup-Petersen(*), P. Pugnat(*), F. Rodriguez-Mateos(*, #), A. Vergara(*, #) and M. Zerlauth(#))
- Discussions on local versus global analysis,
- Case of a Main Dipole Quench.

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Overview

- About the "Local" Analysis i.e. of signals coming from Main Systems
  ► How to integrate the knowledge acquired on test benches?
  - Expected quench performance of Superconducting Magnets
    ⇒ Impact of training quenches on the "1st Powering to Nominal"
  - Known failure modes inside Magnets i.e. electrical integrity of Quench Heater circuits, interturn shorts, breakdown of the insulation/ground,...
    ⇒ Look for precursors, clear diagnostic methods & tools; *for signal shape analysis recurrent problem concerning the optimum parameterization of "time dependant time constant"*
- From the "Local" Analysis to the Global one - *Inputs from the Meeting with AB/CO of the July 21st driven by Andrzej Siemko*
  - How to group, organize, introduce a hierarchy in signals?
  - Definition of a global event; global first specific for a given circuit of a sector, then globalization for all circuits of the sector, finally globalization to the entire machine,
  - Sequence of global events.
- Case of a main dipole quench - *Inputs from the Meeting of August 9th driven by Félix Rodriguez-Mateos.*

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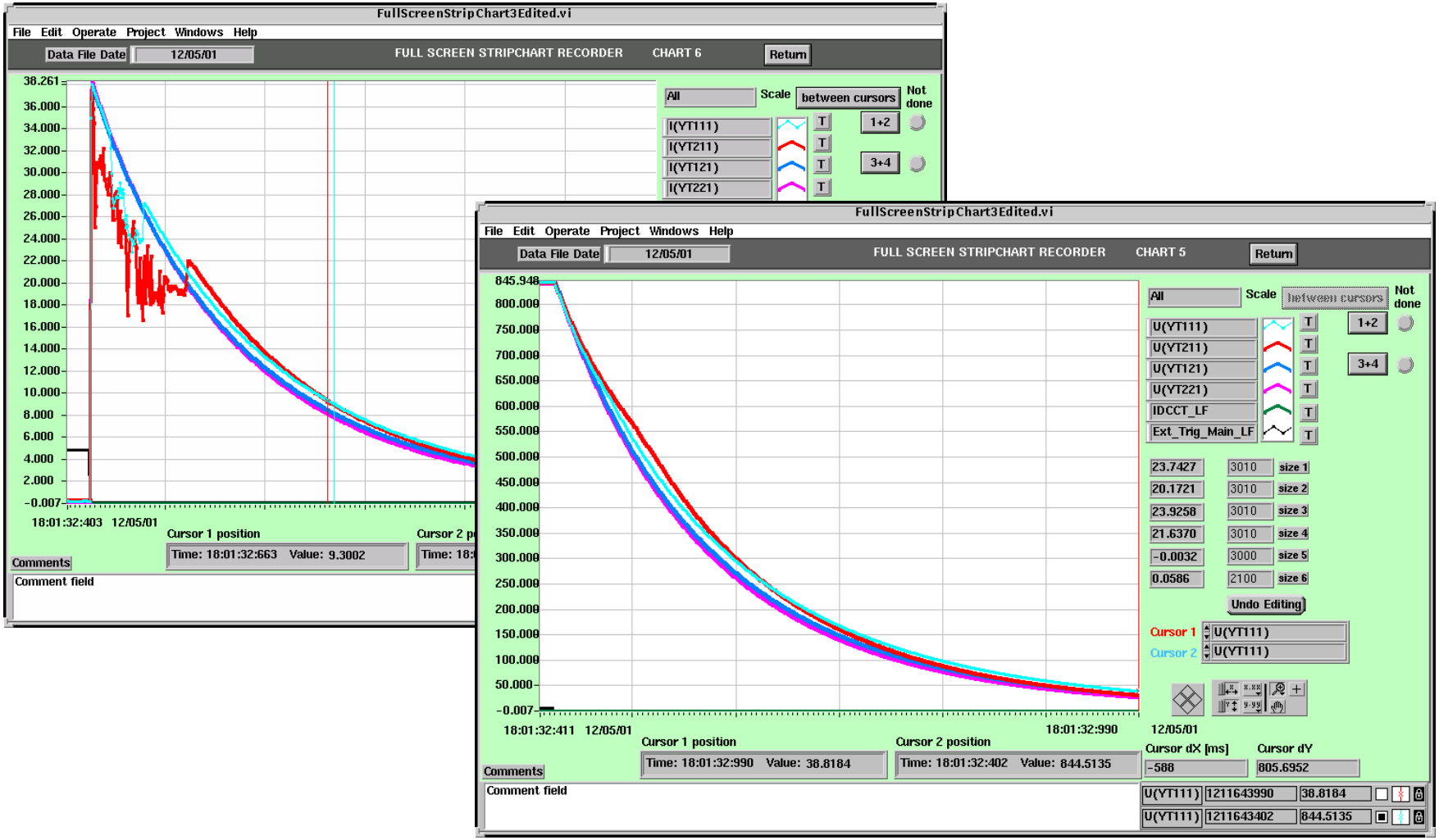
Example of a Known Failure Mode of QH circuits, not so visible in Voltage discharge curves, but...



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About $\tau(t)$ of decaying signals, a required recurrent analysis

- Example of the powering of Quench Heaters (QH)
  - A generic definition of the inverse time constant for a decaying signal is $\tau_V(t)^{-1}$ = - dV/Vdt = - dlnV/dt
  - Use in AQA to detect precursors of the identified failure mode of QH circuits, but $\tau_I(t)$ and its time derivative are the most sensitive $\Rightarrow$ the physical parameterization of $\tau_V(t)$ can also allow a diagnostic

$$V(t) = V_{max} \exp\left\{ - \int \underbrace{\left(\frac{1}{R(t)C(t)} + \frac{d \ln C}{dt} \right)}_{\tau_V(t)^{-1}} dt \right\}$$

with

. C(t), containing the information about the integrity of the QH power supplies and,

. R(t), the integrity of the QH circuits.

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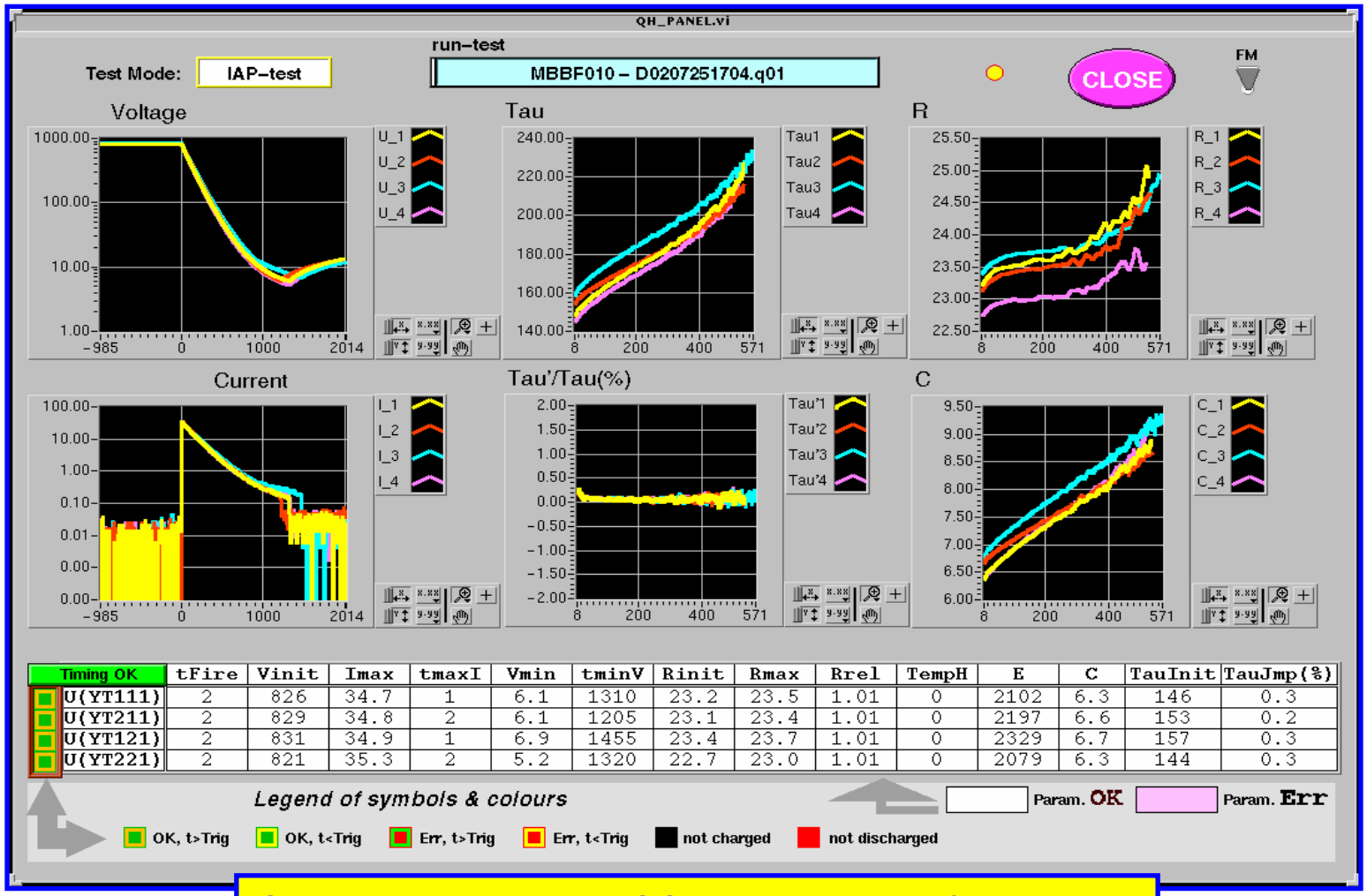
Electrical integrity of MBs

Continuity Test: Monitoring of QH circuits



Collaboration with AB-CO, B. Khomenko & A. Rijllart

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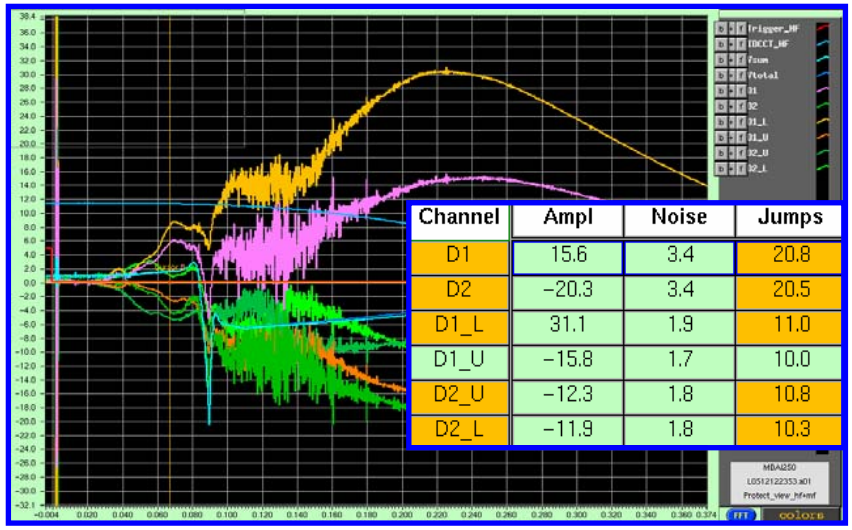
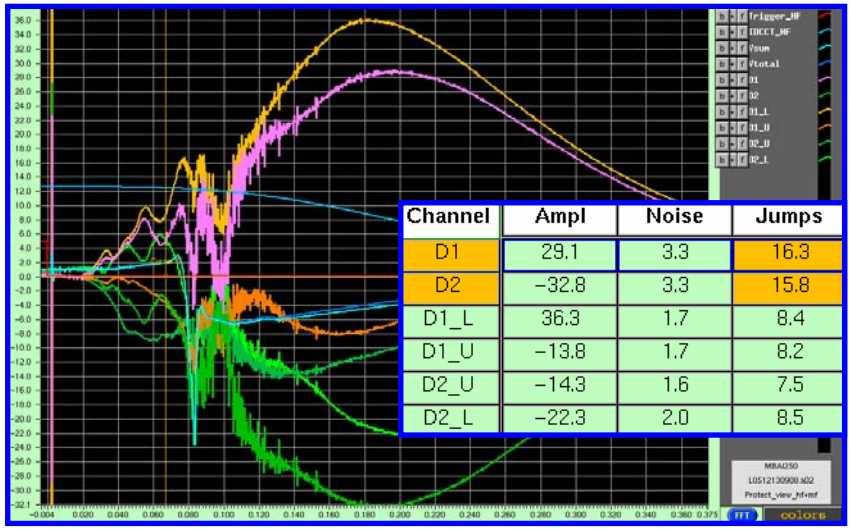
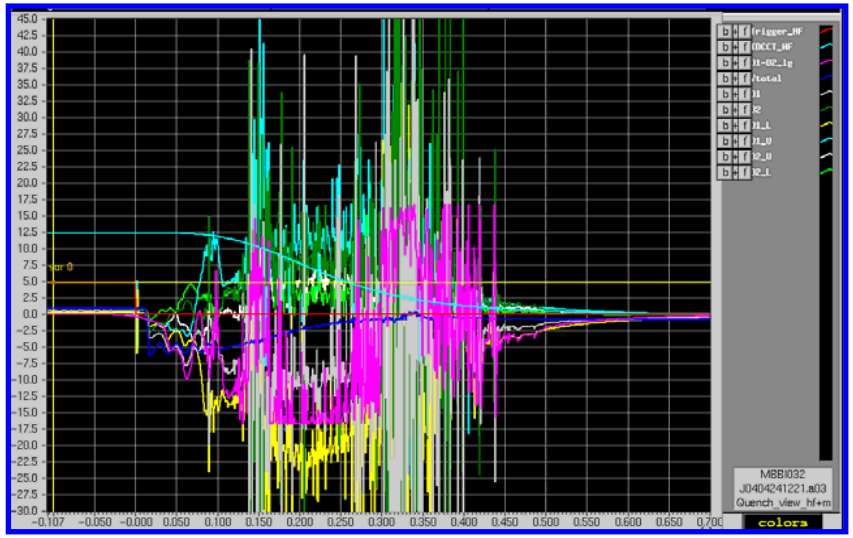
Another Failure Mode of MBs during quenches: High Frequency V-signals



Channel	Ampl	Noise	Jumps
D1	15.6	3.4	20.8
D2	−20.3	3.4	20.5
D1_L	31.1	1.9	11.0
D1_U	−15.8	1.7	10.0
D2_U	−12.3	1.8	10.8
D2_L	−11.9	1.8	10.3



Channel	Ampl	Noise	Jumps
D1	29.1	3.3	16.3
D2	−32.8	3.3	15.8
D1_L	36.3	1.7	8.4
D1_U	−13.8	1.7	8.2
D2_U	−14.3	1.6	7.5
D2_L	−22.3	2.0	8.5



and the MB seems Ok,…

For other cases, an interturn short develops,…

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From "Local" to Global Analysis - *Inputs from the 1st Meeting driven by Andrzej*

$$\text{Global Analysis} > \sum_i \{\text{"Local" Analysis}\}_i$$

With i = QPS, PC, PIC, Cryo, Vac, Sequencer ...
and also BLM

From "Local" Analysis to Global one

How to proceed? How to Manage the Complexity?

- The final solution is not yet completely known and has to be developed, but the way to proceed was already experienced (AQA, Spike Analysis)

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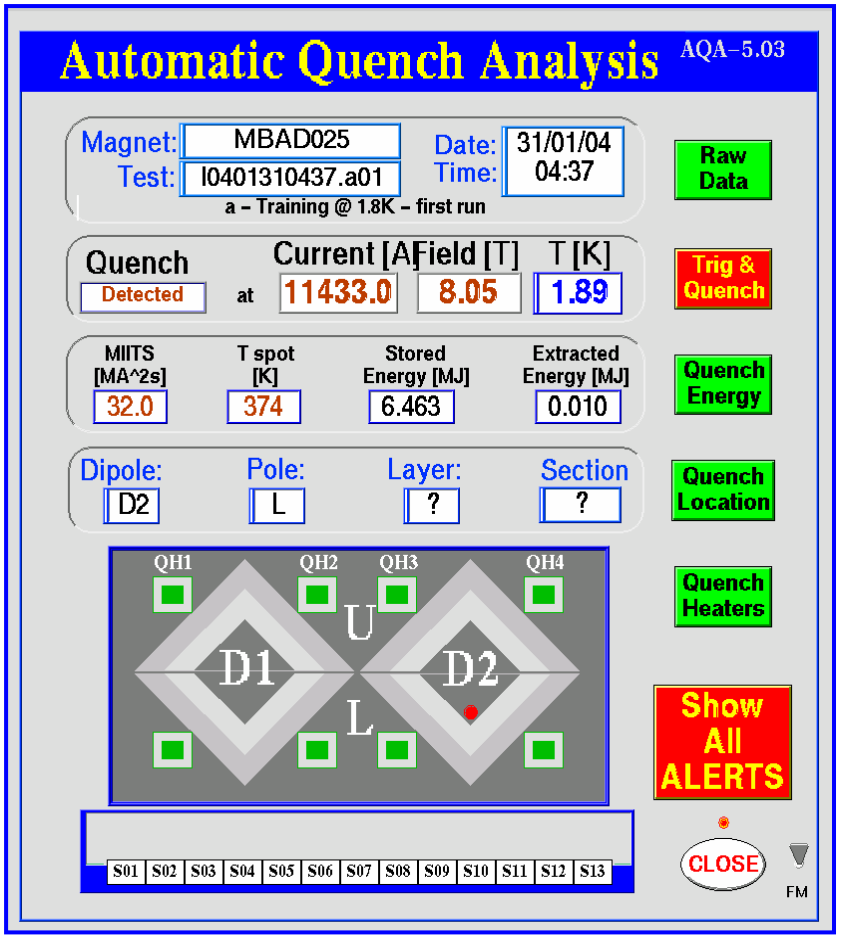
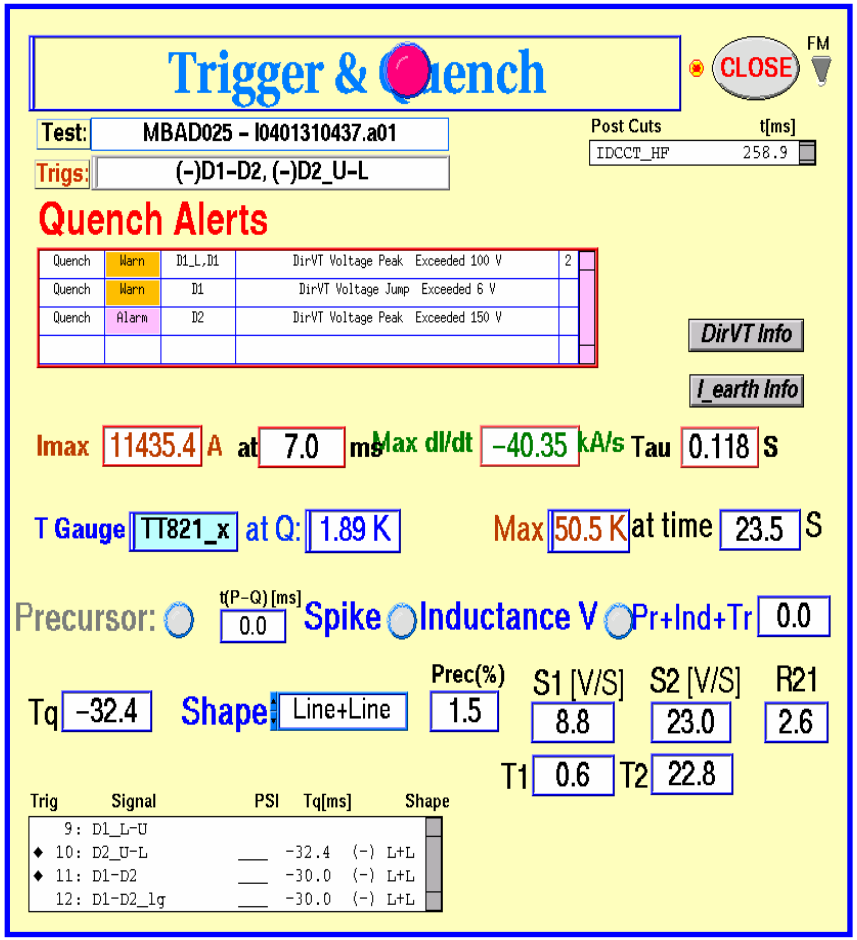
Example of AQA used on Test Benches and Anticipating Main Failures Modes





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Main Dipole Quench – Global PM Analysis From Meeting driven by Félix

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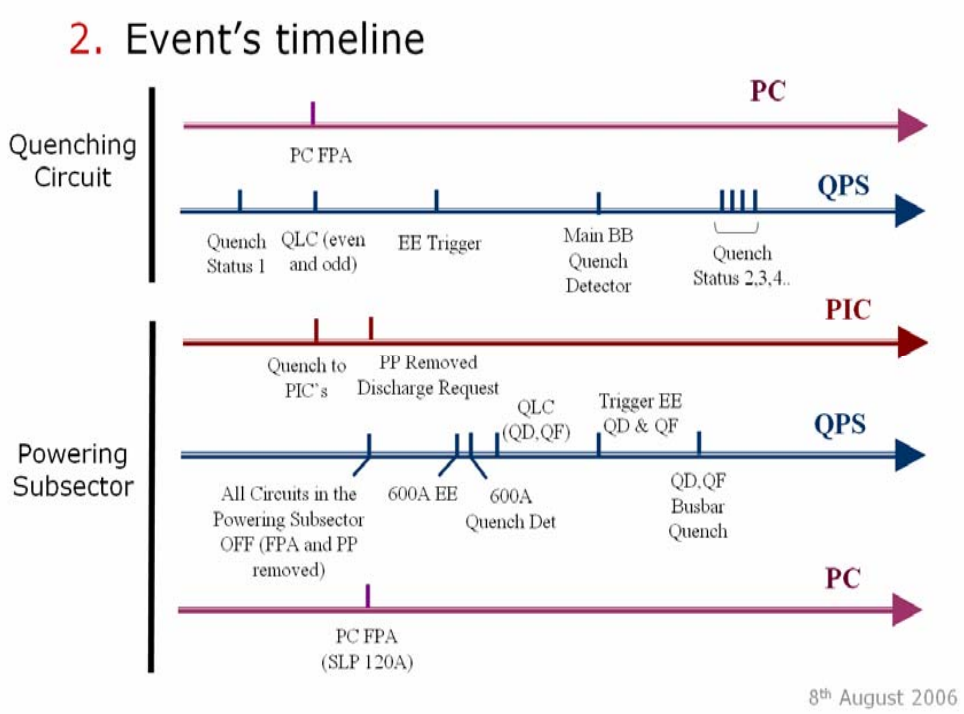
Analysis Steps:

1. Define relevant data blocks
   - Specify Concerned equipments & buffers which are concerned

2. Event's timeline



3. Post-Mortem (automated) analysis run for all the data blocks (buffers) by the owner of each equipment.
4. Plot analogue signals (viewer)
   - Per Quenched Magnet
     . Voltage (aperture + detector)
     . Heater firing + "time constant"
     . Cryo parameters (logging)
     . Sequence of events
   - Per Circuit:
     . Discharge voltage (EE)
     . IDCCT's & PC Voltage output
     ...
   - Per Powering Subsector:
     . Sequence
   - Event General Information
     . Provoked or not (Sequencer data)
     . Vacuum (logging)
     . Other Alarms

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Summary

- The “Local” Analysis should contain tools to anticipate Main Known Failure Modes
  - Not mandatory for the Hardware Commissioning but would be useful; Software developments require anticipations to let “some doors open”...
  - **Required recurrent analysis concerning decaying signals with** $\tau(t)$ *i.e QH discharge, current decay during energy extraction,...*
  - Waveform analysis: Information is also contained in noise.

- The Global Analysis requires 1st, a functional specification
  - **Signals coming from BLMs are one of the key elements** of the Global Analysis,
  - The Logic of “Globalization” has also to be discussed & specified,
  - The architecture should be urgently defined,

  ► *Key points: Modular, open and evolutive software tools like AQA for example,…*

- A first version of Global PM Analysis should be available asap; due to time constraint a minimal version should be targeted which is compatible with the architecture of the more ambitious one.