

SESSION 4

STRATEGY FOR CONSOLIDATION TO AVOID INCIDENT AND LIMIT COLLATERAL DAMAGE

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Insulation vacuum and beam vacuum overpressure release – V. Parma

Improved anchoring of SSS with vacuum barrier to avoid displacement – O. Capatina

Bus bar joints stability and protection – A. Verweij

QPS Upgrade and Re-commissioning– R. Denz

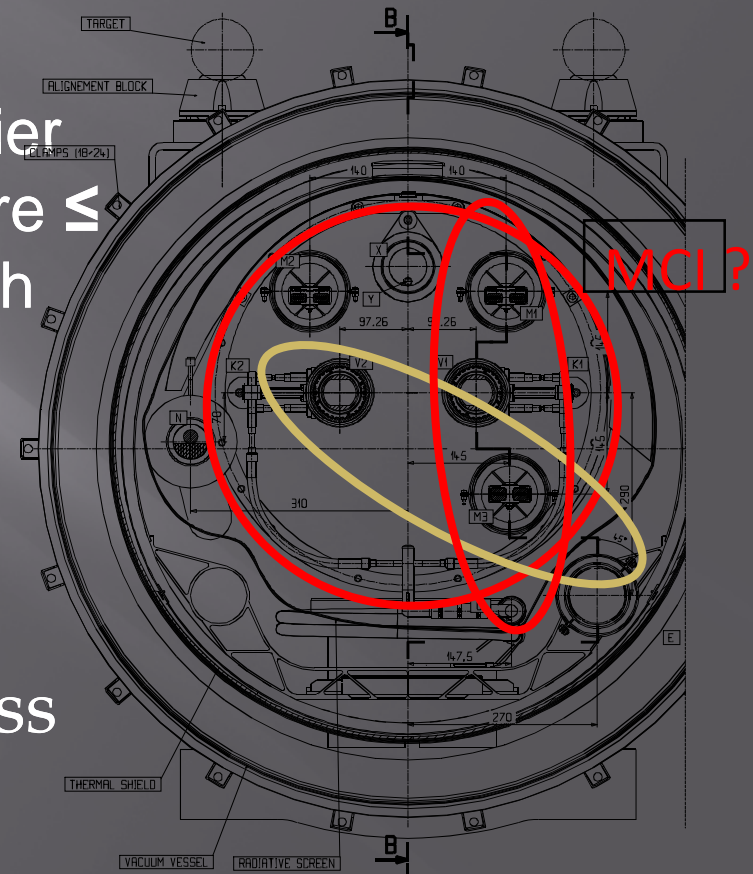
Risk Analysis for the Different Consolidation Proposals – J. Strait

Insulation vacuum and beam vacuum overpressure release

V. Parma

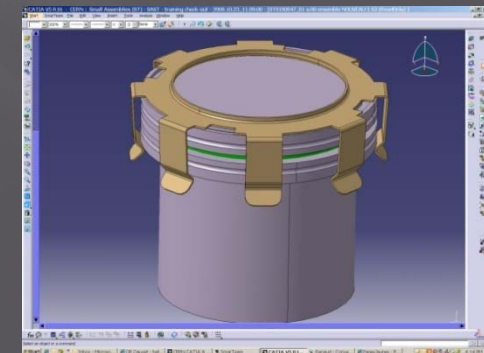
The problem

- Insufficient pressure relief devices in the current cryostats
 - Vacuum vessel and vacuum barrier designed to keep internal pressure ≤ 1.5 bars, for a helium release with mass flow ≤ 2 kg/s
 - Pressure estimated to 7 bars on September 19th. Peak mass flow 20kg/s.
- MCI could create a helium mass flow of 40kg/s



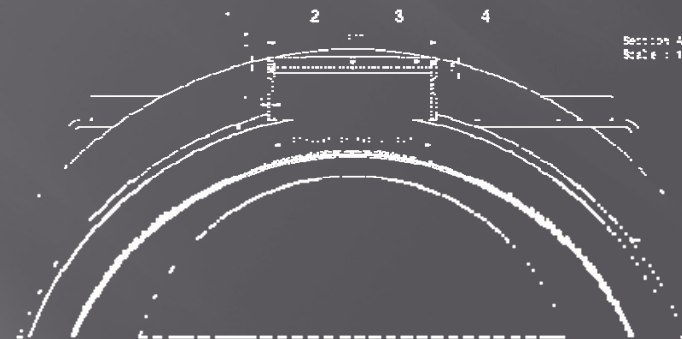
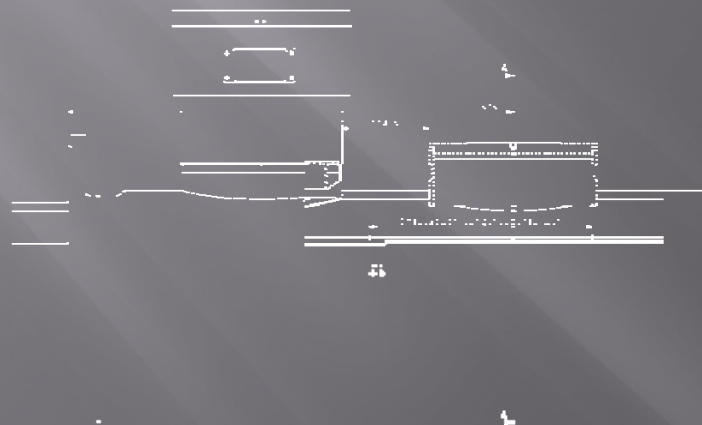
The solution (A)

- ▣ Use all existing ports as pressure relief ports
 - BPM, vacuum and cryo-instrumentation ports in the SSS
 - x10 cross section
 - Maximum pressure reduced to about 3 bars
 - Vacuum barrier and cold posts still designed for 1.5 bars but may resist 3 bars
 - Critical now the floor and jack fixations
 - Pressure relief spring tested
 - **Can be implemented in cold sectors**



The solution (B)

- ▣ Adding new DN200 relief devices in dipoles
 - x33 cross section
 - Maximum pressure below 1.5 bars. All other systems are now conform
 - Special cases in the mid-arc and DS
 - Studied and feasible
 - **Can only be implemented in warm sectors**
 - **Implementation end of week 14 for four warm sectors**



Pending issues

- ▣ Testing vacuum barriers and cold posts
- ▣ Stand-alone magnets and inner triplets
- ▣ Beam insulation vacuum

From the discussion

- ▣ DFBs
- ▣ Derogations from safety in case of partial solution

Improved anchoring of SSS with vacuum barrier to avoid displacement

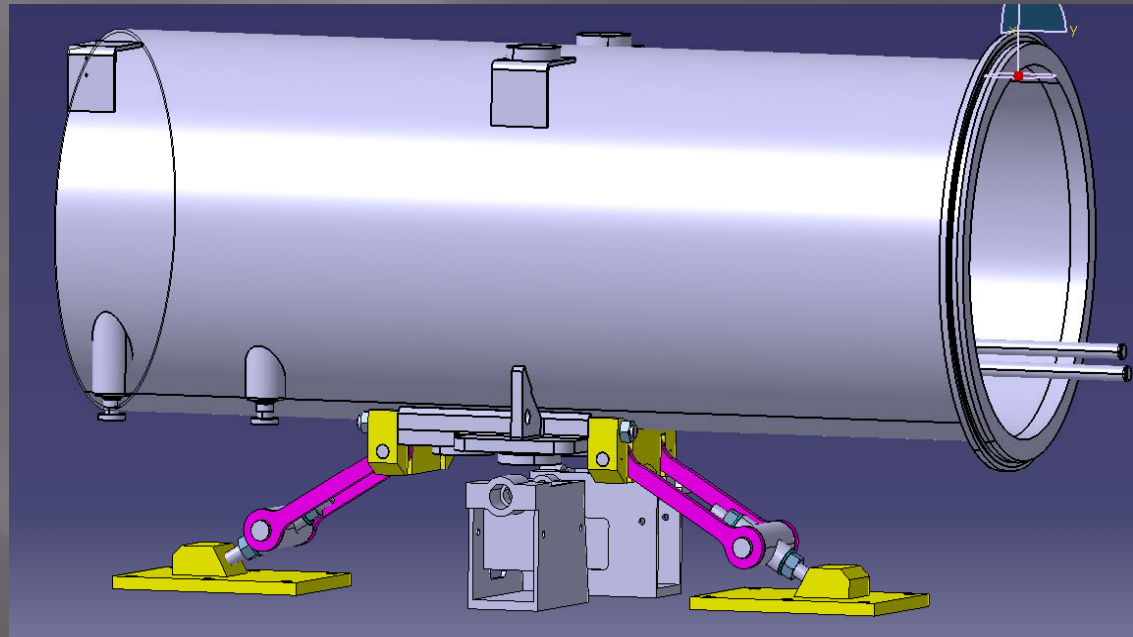
O. Capatina

The problem

- ▣ Failure of some supports of SSS in sector 3-4 due to longitudinal loads on September 19th.
- ▣ If internal pressure above 1.5 bars, support system is insufficient.
 - Nominal operation for supporting system 0.1MPa, exceptionally 0.15MPa (80kN, exceptionally 120kN)
 - Failure limit 150kN
 - Coherent system
 - ▣ vacuum barrier/cold post/jacks/floor
- ▣ New requirements 240kN

The solution

- ▣ Anchoring of the jacks
- ▣ Tested in the tunnel floor(SX4) up to 380kN
- ▣ Drilling authorised without liquid helium
- ▣ Installation ok with liquid helium
- ▣ 2 weeks per sector plus alignment. Total of 25 days.
- ▣ 867.000 CHF for all 8 sectors.



Pending issues

Basically the same as in previous presentation

- ▣ DFB's stand alones, inner triplet
- ▣ Testing of the vacuum barrier and cold post

From the discussion

- ▣ Do we need this if DN200 is implemented in all magnets? 1.5 bars could be marginal for the current solution

Bus bar joints stability and protection

A. Verweij

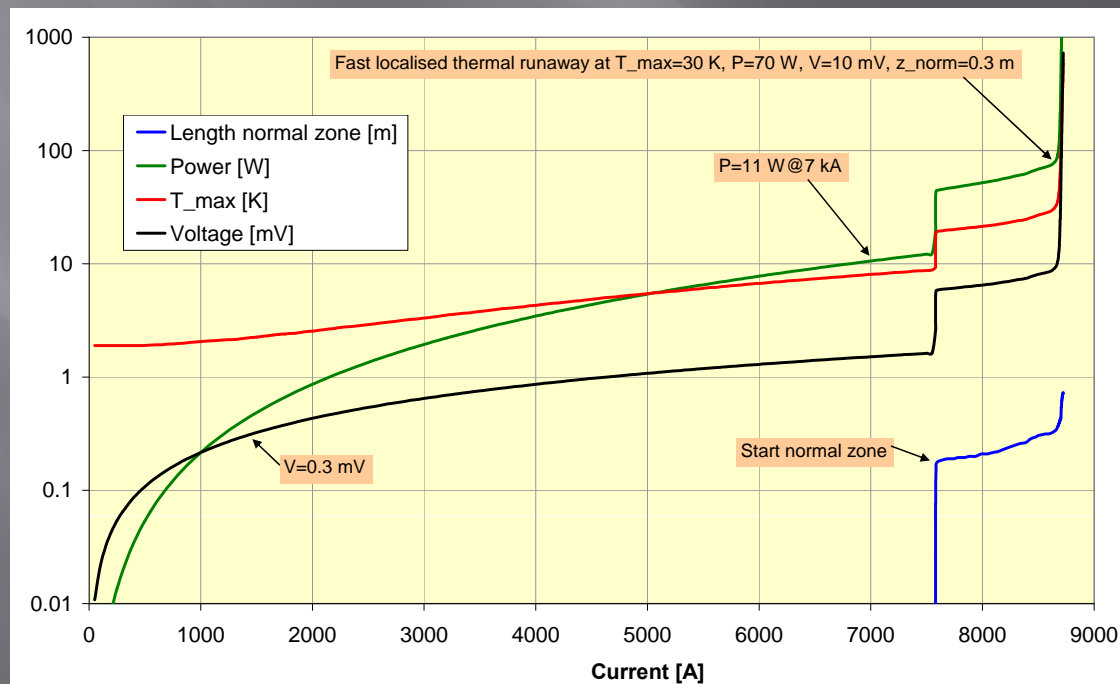
The problem

- ▣ An interconnection opened on September 19th.
- ▣ Probably a bad splice. Two potential scenarios
 - Bad electrical and thermal contact
 - ▣ Between joint, u-shape and wedge
 - ▣ Between u-shape and wedge and bus-bar (longitudinally)
 - Resistive cable plus longitudinal discontinuity



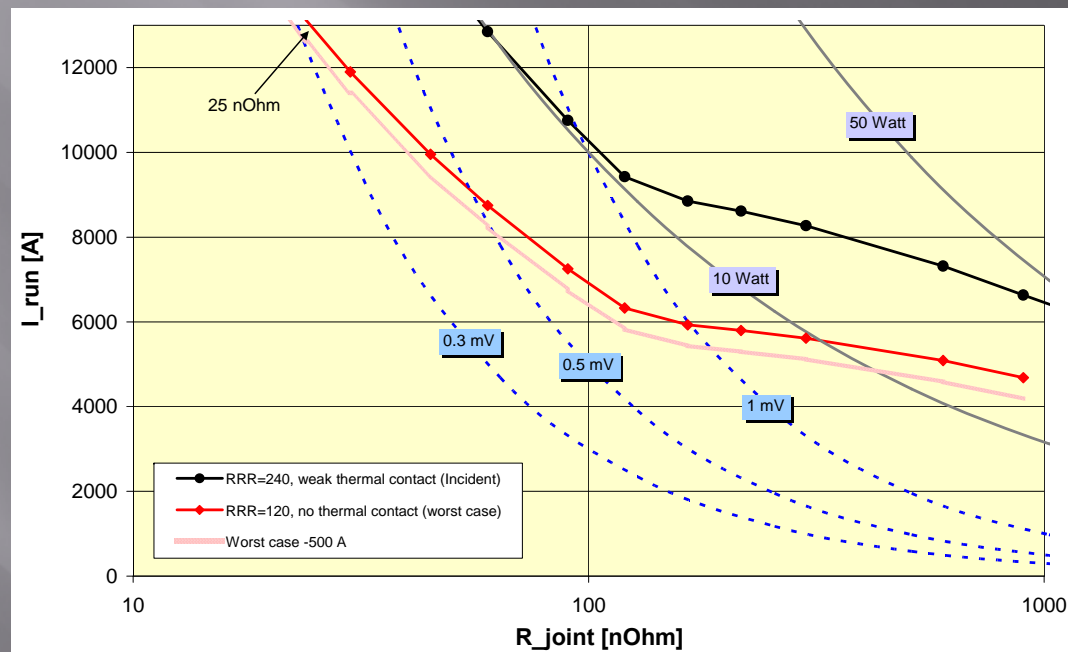
The problem

- ▣ Fast localised thermal runaway
 - Stable resistive heating below 7.5kA. Slow voltage increase much below QPS threshold (mV)
 - Fast normal zone development
 - Temperature increases rapidly above melting point



The solution

- QPS threshold of 0.3 mV. Integration time 10s
 - Detects any resistance larger than 25 nOhms up to nominal current



- Avoid bad splices
 - Excessive longitudinal gap, Lack of solder
 - Clamping

Pending issues

- ▣ QPS system cannot protect the circuit in case of a sudden mechanical opening of the joint
- ▣ Other bus-bar types (6 kA, pigtails...)

From the discussion

- ▣ Operability
- ▣ Clamping

QPS Upgrade and Re-commissioning

R. Denz

The problem

- ▣ Symmetric quenches between apertures went unnoticed for more than half a second
- ▣ Local bus-bar protection capable of detecting bad splices
 - Threshold 0.3mV, integration time 10s

The solution

- ▣ Detection of symmetric quenches:
 - Compare consecutive magnets
 - New card design
 - Not in the baseline for 2009 before Chamonix mtg. ($E < 5\text{TeV}$)
- ▣ Splice detection
 - Uses existing voltage taps in the diode
 - Uses protection cards for HTS leads
 - Regular scans during operation
- ▣ Both solutions require additional cabling (240Km)

Pending issues

- ▣ Radiation hardness of the electronics
- ▣ Verifying the cabling
- ▣ Commissioning of the new system
- ▣ In the critical path

From the discussion

- ▣ Beam induced symmetric quenches
- ▣ Spurious triggers

Risk Analysis for the Different Consolidation Proposals

J. Strait

Solutions planned

- ▣ Improved QPS system for detection of bad splices in bus-bars
- ▣ Added procedures
 - Calorimetric measurements
 - Snapshot on individual magnets
 - Snapshot in bus-bars
- ▣ Avoid collateral damage
 - Additional DN200 ports in dipoles in half of the machine
 - Additional pressure relief ports in SSS in all LHC
 - Improved anchoring for SSS with vacuum barrier

Solutions recommended

- ▣ Pressure relief in vacuum system
- ▣ Improve pressure relief in DFBs, stand alone magnets and inner triplet
- ▣ Anchoring of the DFBA supports
- ▣ Intelligent reaction to quenches in bus-bars and other sensible equipment
 - opening of the quench release valves at a lower pressure
 - Firing more quench heaters to speed up current decay

Scenarios

- ▣ Add DN200 ports in all dipoles in the machine (warm-up other 4 sectors)
 - Not recommended if prevents running this year
- ▣ Add burst disks in the vacuum system
 - Recommended at least for warm sectors
 - Adding DN200 in DFB
 - Recommended at least for warm sectors
- ▣ Intelligent reaction to quenches
 - Should be studied carefully
 - not mandatory

Scenarios

- ▣ What if additional bad splices in the magnets are found?
- ▣ When machine is cold
 - Other mitigation measures will minimize the risk of an accident
 - Limited damage to one or two dipoles
 - Leave it and change it in the next shutdown
- ▣ By analysis of the already taken data (snapshots and cold tests)
 - Change the magnet as soon as possible

Scenarios

- ▣ What if additional splices are found in the bus-bars?
- ▣ It will be detected when cold
- ▣ Warm up and repair the splices

- ▣ What energy should we run in 2009
5 +5 TeV is achievable, safe AND useful

Conclusions

- ▣ The incident in sector 34 revealed needs of enhanced:
 - Early spotting of possible origins of faults
 - Enhanced prevention of initial faults
 - Mitigation of consequences

- ▣ Means were developed and implementation scenarios proposed to a happy landing wherever we're falling to with the electrical splices of magnet circuits

Thanks to all speakers