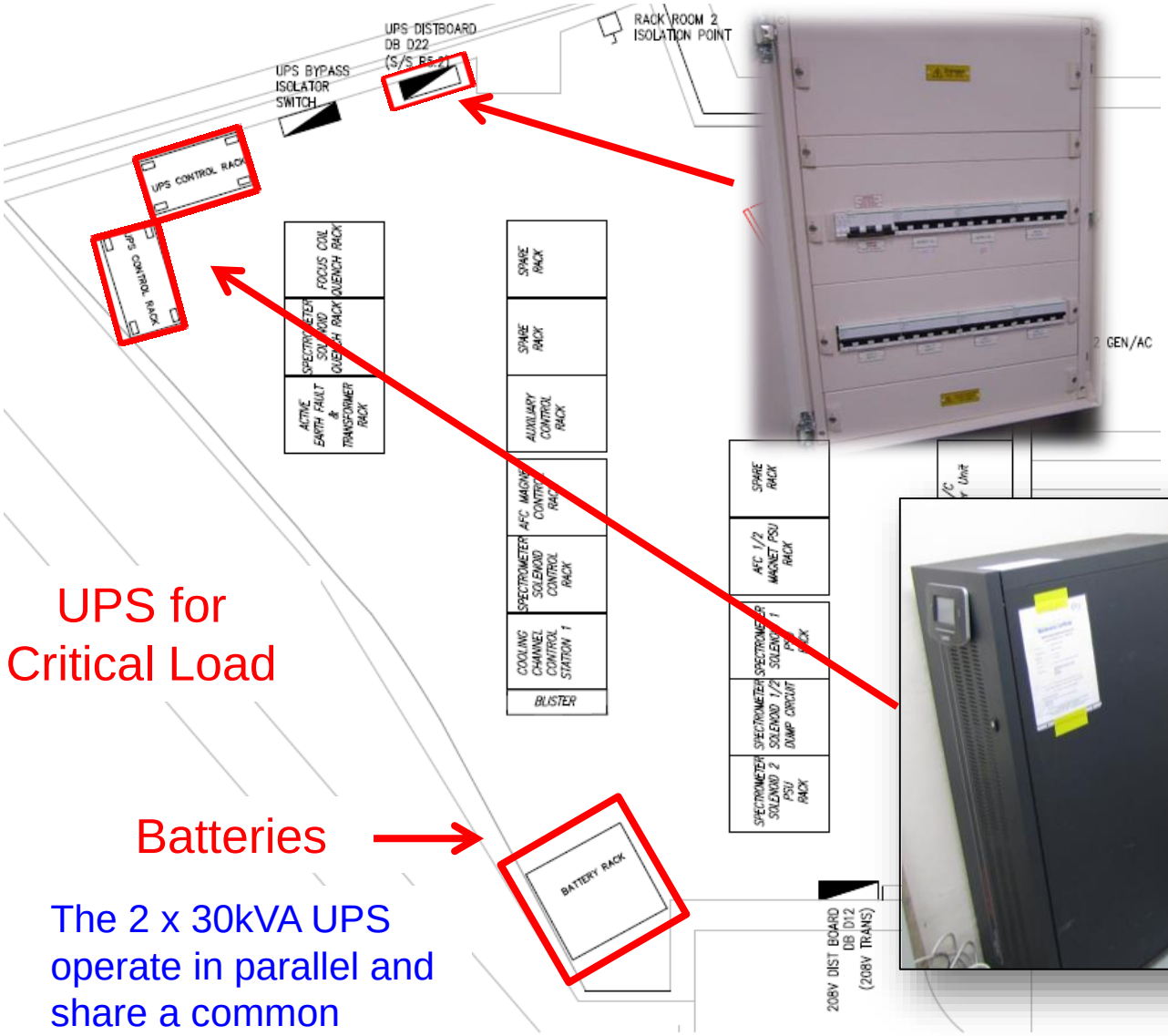
Electrical Integration

MPB October 2015

Rack Room 2 – UPS Inverter and Batteries



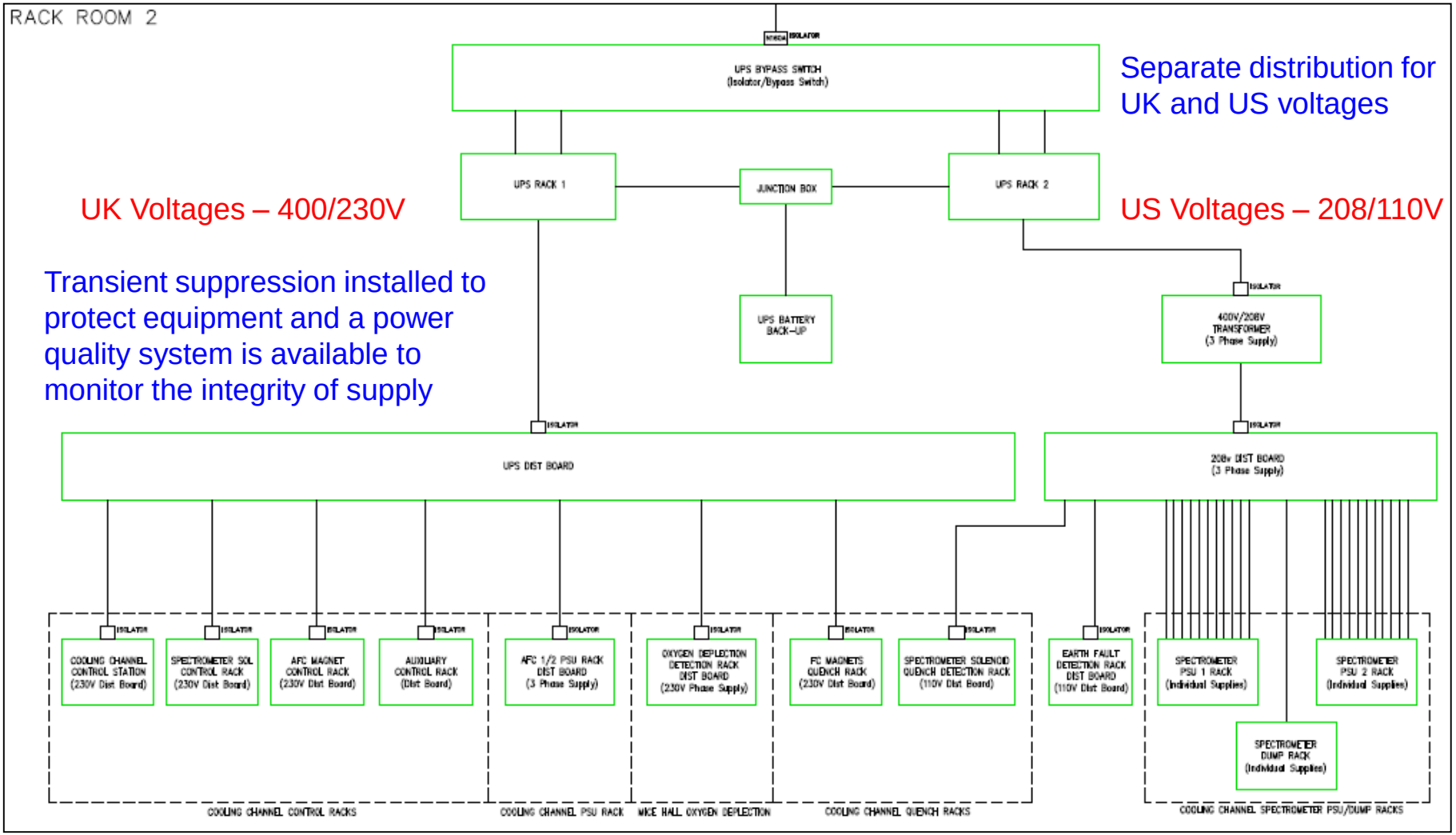
Two 30kVA UPS (inverter) including infrastructure have been installed and commissioned.
These support Control, Power Supplies, Vacuum and Instrumentation in RR2.

UPS for Critical Load

Batteries

The 2 x 30kVA UPS operate in parallel and share a common battery pack.

Rack Room 2 – UPS and AC Infrastructure



Separate distribution for UK and US voltages

UK Voltages – 400/230V

US Voltages – 208/110V

Transient suppression installed to protect equipment and a power quality system is available to monitor the integrity of supply

All the electrical infrastructure for Step IV has been installed and Certified as compliant with Electrical Regulations

MICE Hall – Functional Earthing / Grounding

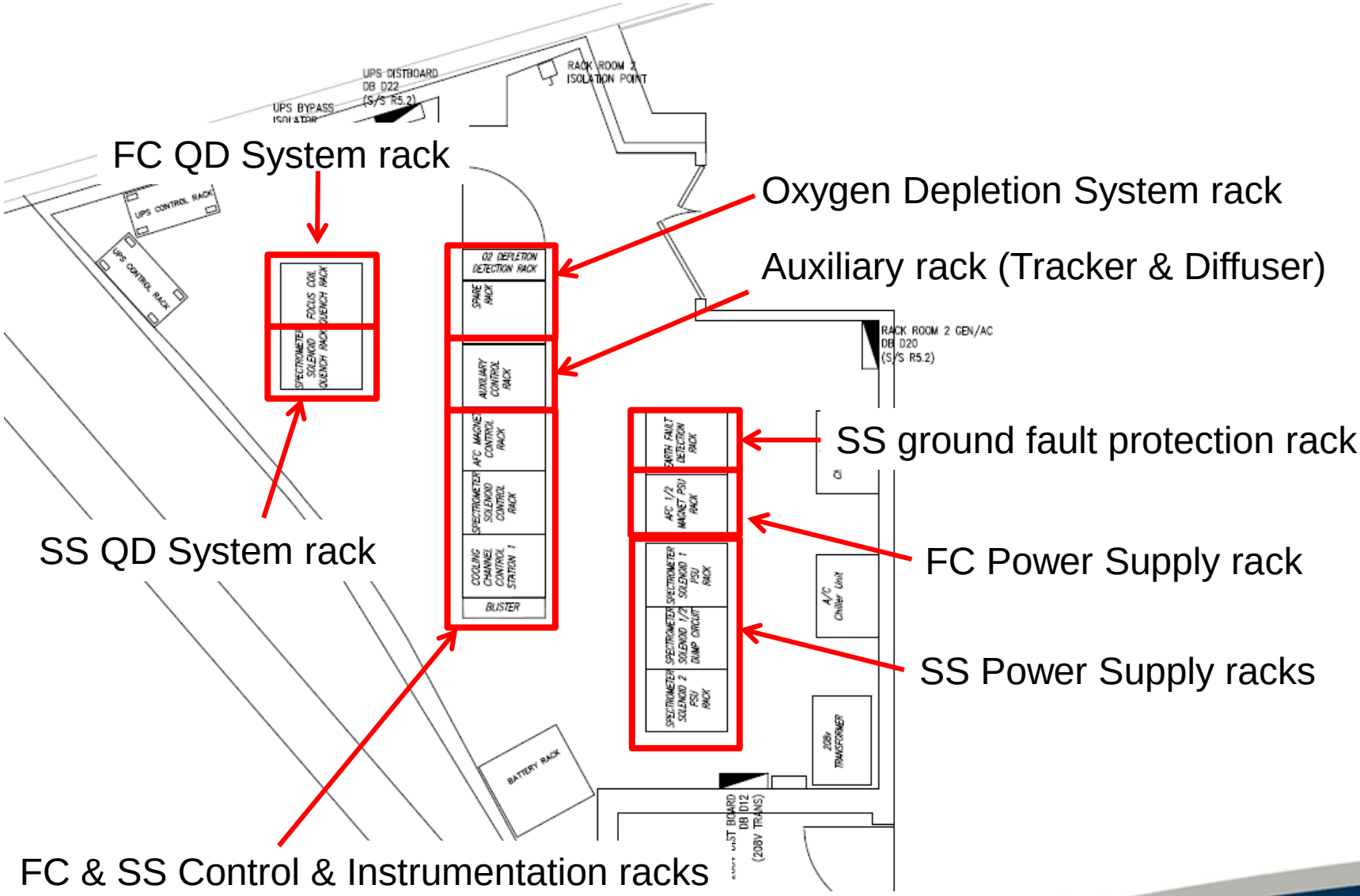
50mm x 6mm Busbar
North, South & West walls

25mm x 3mm Busbar
NE corner

25mm x 3mm Busbar in main trench

- Electrical Functional / Safety Earthing has been enhanced in the MICE Hall with the installation of a 50mm x 6mm copper busbar.
- Additional busbar earthing has been installed under metal floor to improved equipotential bonding.
- Bonding to support structures, cable management and steel plates has been significantly improved.
- Earth bonding between the MICE Hall and RR2 has been enhanced with copper busbar connected between the 2 areas and the cable management is now appropriately bonded.
- 70mm^2 earth cables have been installed between each magnet and the main earth busbar located on South wall.

RR2 Layout – Rack allocation

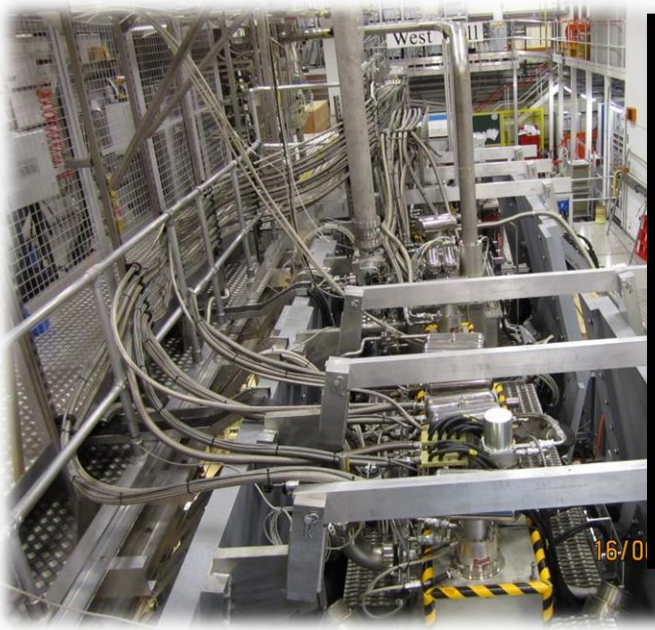


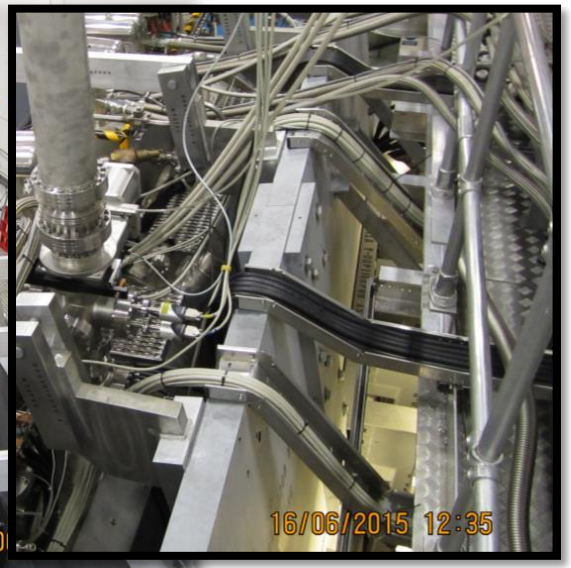
FC & SS Instrumentation & Control Racks

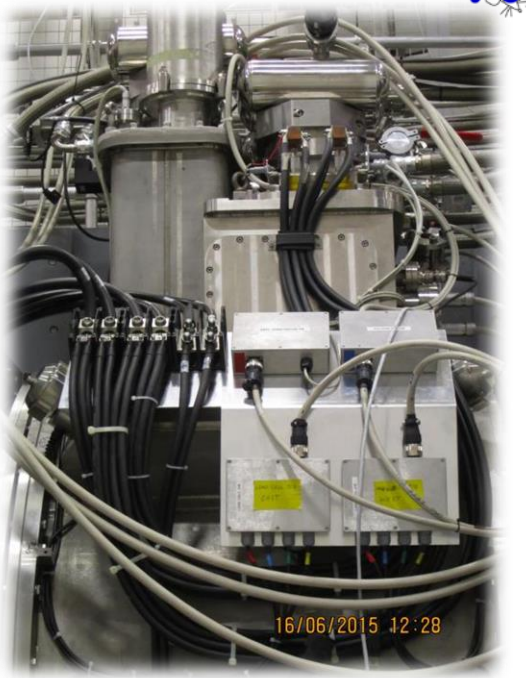
- All Instrumentation cables have been installed and terminated
- All magnet temperature sensors checked, some sensor issues have been identified on the SS magnets.
- Temperature curves programmed for FC.
- Temperature curves for SS still to be finalised – some issues sourcing the calibration data.
- Helium level sensors measured and checked for SS and FC.
- Anti-icing heater commissioned for FC – reliability issues need to be resolved
- Fans for anti-icing on SS fixed to magnet and terminated – reliability issues need to be resolved.
- Pressure heaters commissioned for FC.
- Pre-cool heaters for SS commissioned.
- Main pressure vessel regulation heaters for SS commissioned.

Racks installed in RR2

DC and Instrumentation cables







- 5 DC link boxes have been installed in MICE Hall.
- 240mm^2 and 70mm^2 cables have been installed from RR2 to link boxes.
- 95mm^2 and 70mm^2 cables have been installed between DC link boxes and magnet local termination point.
- DC link boxes will enable the FC and SS to be changed from Solenoid to Flip mode and vice versa.
- All control interfaces for FC have been relocated to the top of the North side for convenient access.
- Cables have been installed and commissioned for the FC Load cells and are being monitored.

Quench Detection System

SS - QD system rack

- SS QD system rack has been installed in RR2 and commissioned with the control system.
- SS voltage tap cables were installed, but there are still quality issues with the connectors.
- SSU has been fully trained to 285A and the QD system has operated reliably.
- SSD has been partially trained, but there has been issues with a broken voltage tap wire and magnet component failure.
- FC QD system rack has been installed in RR2 and calibrated with magnet.
- The FC magnet has been operated at 10A, the circuit still needs to be optimised before ramping to nominal current.
- A full systems check was performed on both QD systems before powering magnets.

FC & SS Power Converter Racks

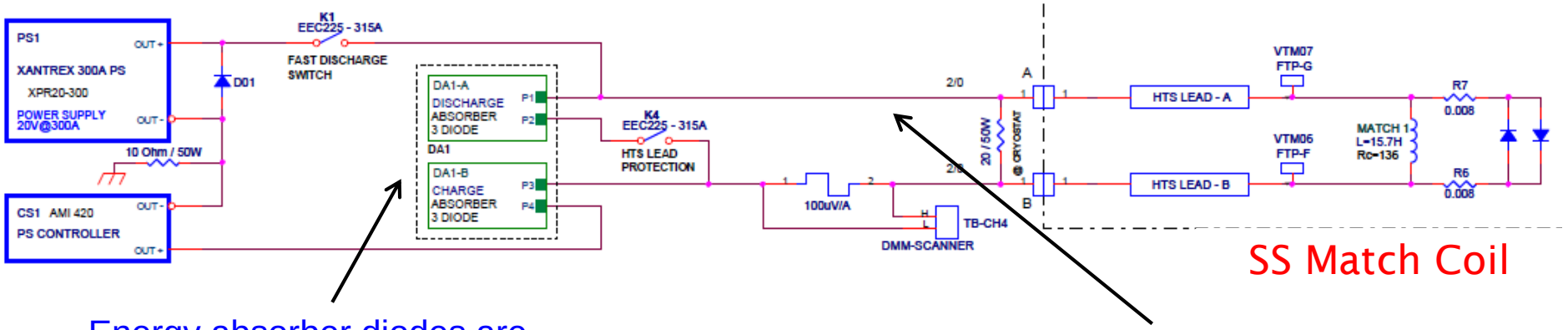
- SS power supplies have been fully commissioned with control system.
- Full electrical sign off of all interlocks and controls checked and signed off.
- Power supplies have successfully provided power for full training of SSU, and partial training of SSD.
- Solenoid valves fitted to transfer cooling to towns water in case of a fault with the chiller/ air blast unit.

Racks installed in RR2

- FC power supply has been commissioned and tested.
- FC power supply has been ramped successfully to 10A, further testing of the magnet is ongoing (114A solenoid mode???)

SS Power Supply Instabilities

SS Power Supply Rack



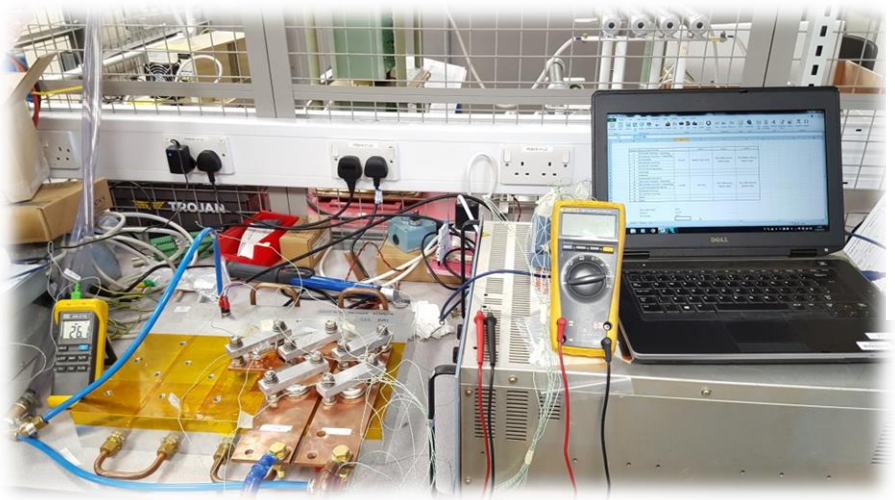
Energy absorber diodes are configured to conduct bidirectional

Long cable length between RR2 and SS magnets

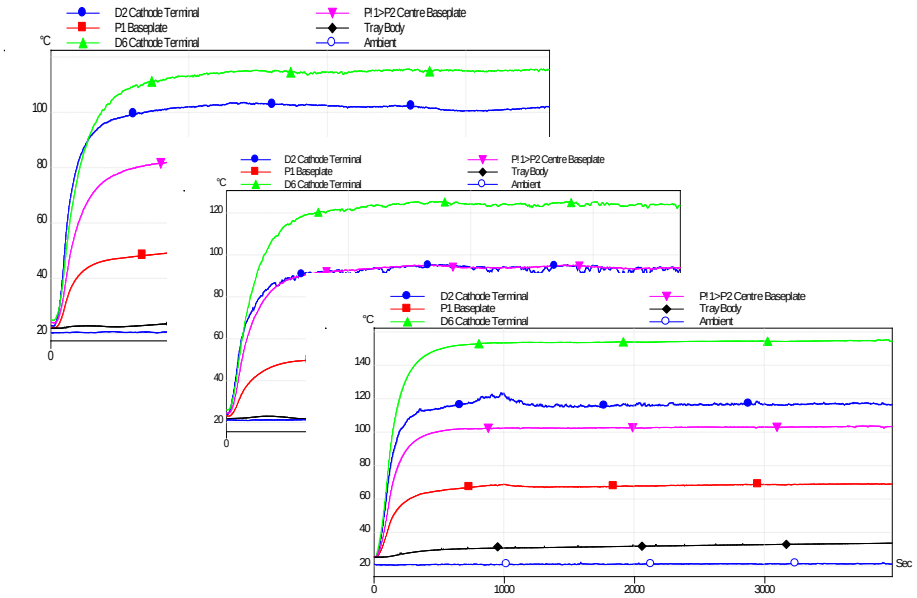
SS Match Coil

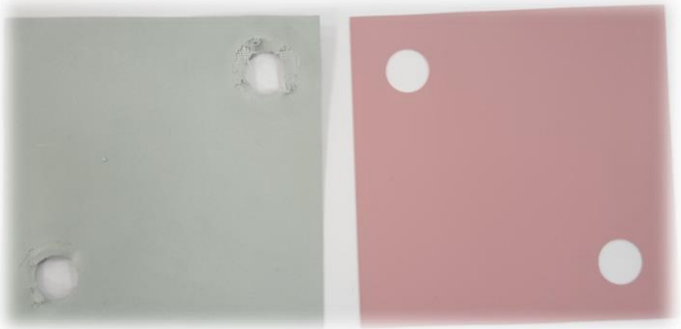
- Due to the long cable lengths and the bidirectional diode configuration the power supply became unstable once the forward conduction voltage of the diodes was reached.
- This varied between SSU and SSD due to the difference in cable length, but could be seen at approx. 200A.
- This was resolved by removing the energy discharge absorber diodes from the circuit as these primary discharge paths are provided by the power supply.
- The series energy absorber diodes remain in circuit as these maintain a linear discharge rate.

Upgrade to SS Energy Absorber Diodes



SS Diode absorbers under test





Samples of Silicon Pads tested

Original silicon pads utilised caused earth leakage failures due to pressure rupturing of the silicon pockets

- Kapton tape used solely as an electrical insulator causes the diode to operate at unreliable temperatures.
- Adding silicon pads improves both electrical insulation and thermal conductivity, allowing the diodes to operate at a lower temperature.
- Using only Silicon pads offers the best thermal conductivity, but the Kapton provides added electrical insulation.

Emergency Off Procedure

Emergency Off buttons installed on SS racks

- Emergency Off buttons have been installed on the SS power supply racks.
- These buttons open the DC contactors and artificially quench the magnet if pressed.

  Currently there is **no** alternative way of discharging the magnet energy without software reliance.
- A report detailing the emergency off procedure hierarchy has been issued and is awaiting agreement.
- There are options available to remove the reliance on software, which include replacing the AMI 420 with AMI 430 controllers.
- An emergency off button will also be installed on the FC power supply rack, but this can ramp the current to zero via the AMI 430 controller without quenching the magnet.
- The natural discharge rate set by the SS circuit parameters will quench the magnet, so the power supplies cannot be disabled.
- The FC natural discharge rate needs to be investigated to see if it will quench the magnet, additional cable could be installed.

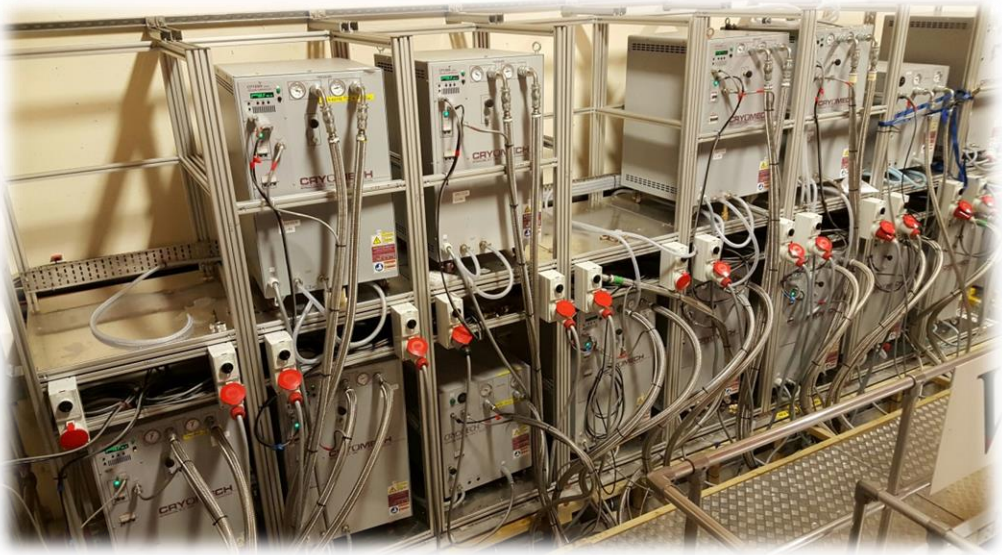
Auxiliary (Diffuser and Tracker) Control Rack

- The tracker control rack has been installed in RR2 to allow ease of access.
- 2 Control crates have been manufactured for housing in RR2 rack and containing the Canbus modules.
  - Both crates is are completed, tested and in position in RR2.
- Full system commissioned and verified tracker can be controlled from RR2.
- However some rack modification required to control AC power to the WIENER cryostat.

Ground Fault Protection

- FermiLab designed and assembled the ground fault protection crates.
- The 2 crates have been installed and tested with the SS circuits.
- They were used to identify the earth leakage issues on the energy absorber diodes.
- The system did initially suffer from over sensitivity issues and caused spurious trips. The topology used only works when connected to a circuit which has a relatively high impedance to ground.
- Unfortunately for the FC magnet the centre of the energy dump circuit is referenced to ground, to minimise the voltages generated during a quench.
- An alternative solution was designed and implemented for the FC magnet.

Compressors and Vacuum Rack

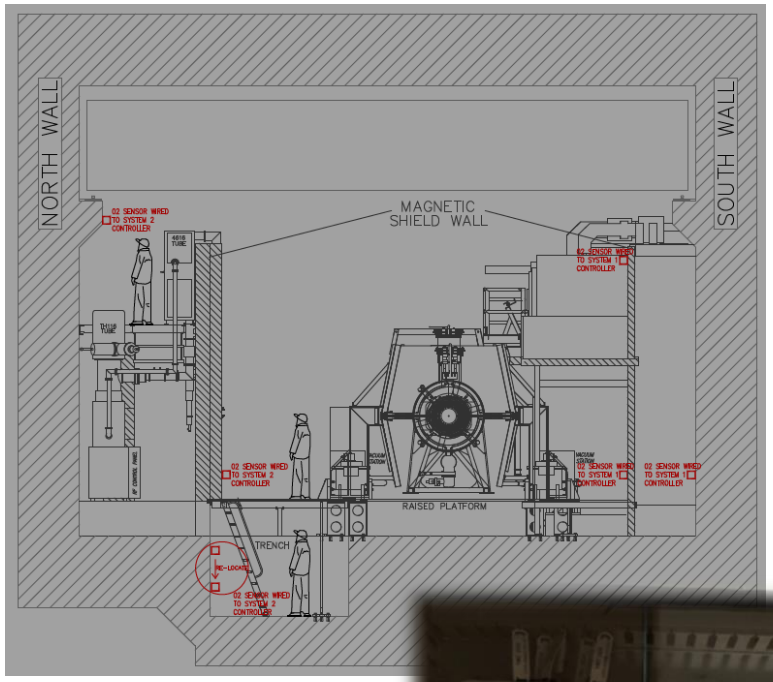


Some of the FC compressors moved closer to improve cooling efficiency

- Vacuum / compressor rack has been installed and commissioned in North / West corner
- Extra shut off valves were requested for the SS turbo pumps, these are now operational.
- Control philosophy for backing line scroll pumps has been finalised and implemented.
- Hard wired vacuum status provided to RR2.
- RS232 controls interface for compressors commissioned and operational.

Oxygen Depletion System

Position of new and existing O_2 sensors



Controllers mounted in blister in RR2

- Additional O_2 sensors have been installed at agreed locations.
- A second controller has been installed to interface with additional sensors.
- Cable management and cables installation and terminated from RR2 to MICE Hall.
- ODS rack designed, assembled, installed and commissioned in RR2
- The OD System has been checked, sign off and is fully operational.

Resource Summary

- The electrical budget estimates for the end of September were £73k staff and £25k non -staff (contract effort)
- To the end of September staff costs have been £116k and £50k non staff
- Non staff costs are twice the expected level as contract effort has been retained.
- Staffing levels are 38% higher than originally estimated as electrical support during magnet training has been higher than expected.
- Expected staff budget was £135k however with current cost levels and further scope creep this is expected to rise by £50k.

Questions?