Partial Return Yoke (PRY) Integration

29/07/13

Contents

Environment

Introduction

The MICE experimental environment has been built up within the constraints of the MICE Hall, R5.2 on STFCs Rutherford Appleton Laboratory site. The amount of space available in the Hall prior to the requirement for the magnetic field mitigation changes was adequate but not excessive. The magnetic field mitigation changes require extra space for the movement of sensitive equipment and the implementation of magnetic shielding.

For the Magnetic Shielding Partial Return Yoke (PRY) there are a significant number of environmental constraints based on structures, equipment and services that have already been installed or are planned to be installed for operation of the experiment. The following details highlight these constraints and show how they can be dealt with in each case, either by configuration of the PRY to fit with the constraint or a change to the environment to allow the PRY to fit in.

NOTE: DIMENSIONS ON FIGURE IN THIS DOCUMENT ARE FOR REFERENCE ONLY, REFER TO THE LATEST ISSUE OF THE DRAWING FOR FINAL DIMENSIONS.

Experimental Devices & Detectors

Spectrometer Solenoid (SS)

Drawings

TD-1189-1603, Step IV with Yoke (Mod)

TD-1189-1455, Upstream SS with Yoke

TD-1189-1xxx, Downstream SS with Yoke

Installation of PRY / SS Device

This relates to the fit between the PRY and the SS after installation rather than the procedure of installation. When both the PRY and the SS are in their final operational locations (prior to any services being connected) the fit is as shown in the figure below:

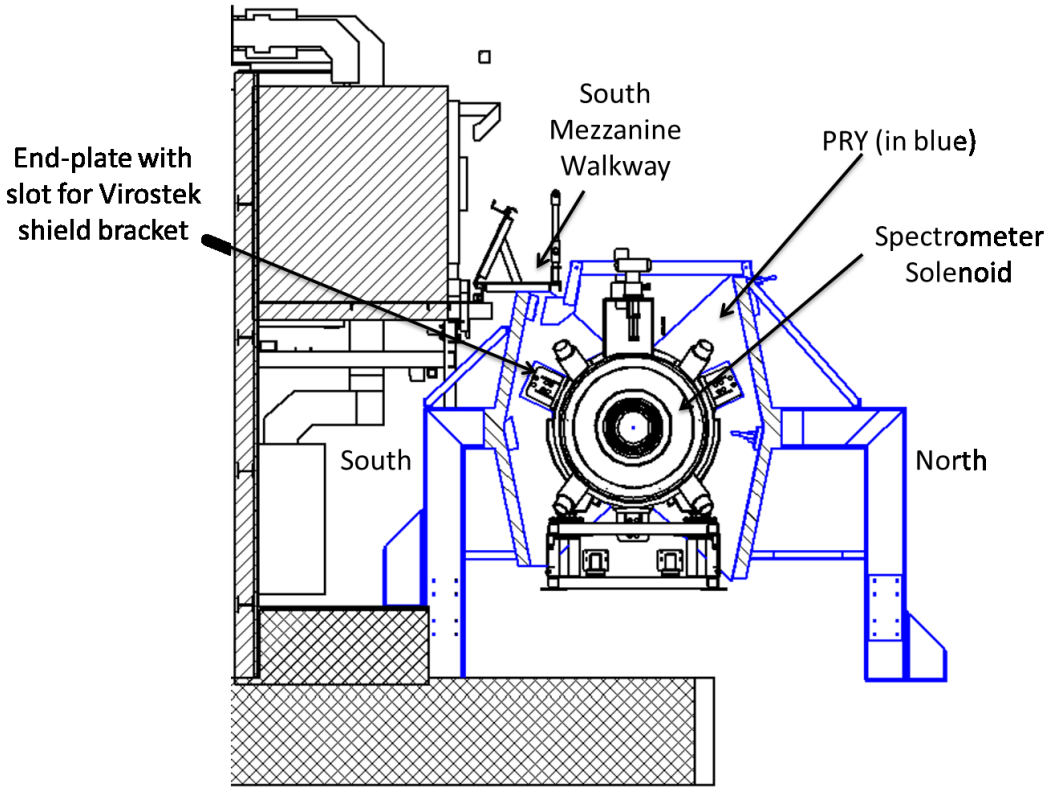


Fig xx: PRY, SS & South Mezzanine

It can be seen in the figure above that the PRY, SS & South Mezzanine are relatively interlocking in the vertical direction, i.e. when imagining installation via a crane. It is assumed for the purposes of this document that the downstream SS will arrive before the PRY, it is planned to install the SS in its final location upon delivery or after shortly after and acceptance testing. It is obvious from the above figure that the south side of the PRY will be impossible to install in any reasonable sized sections; even if it can be split down into smaller pieces it will still be risky being so close to the SS. There are moving platforms that are fixed to the floor on which the MICE Experiment Devices sit, these platforms allow the devices to be moved offline (northwards); the moving platform for the downstream SS has not currently been installed (July 2013). If the SS could be moved offline to the north during installation of the south side of the PRY the risk of damage to the SS would be reduced.

Alternatively if the SS is already in place it could be removed completely thus eliminating any risk of damage during the installation of the south side of the PRY. Removing the SS does not eliminate the need for the moving platform, as can be seen from the figure above the PRY wraps around the SS to some extent so it would be safest to mount the SS on an offline moving platform and slide it back into place once the south side PRY has been installed.

Note that in the figure above there are end plates that connect with the Virostek shields, in these endplates are slots to avoid the Virostek shield brackets. It can be seen that the Virostek bracket on the south side will clash with the edge of the diagonal slot as the SS is pulled out to the north, so this needs to be cut to clear; for symmetry this might need to be repeated on the north side end plate slot.

Recommendations

- **Install the moving platform at some stage before the PRY is delivered.**
- **Cut the top of the slot around the Virostek shield brackets horizontally to allow unrestricted sideways movement on the south and north sides at both the upstream and downstream SS positions.**

The other interlocking feature of this region is the walkway of the South Mezzanine Platform, this sits on the PRY and so will be removed during installation of the south side of the PRY.

Installation of ToF 1

ToF 1 is installed into a 'cage' on the upstream SS, this cage is formed by the Virostek shield and an opposing thinner plate which are both connected with crescent shaped edge pieces. One of the edge pieces is fitted with a hinge that acts as a door to the cage, the ToF1 is installed on temporary rails that protrude from the cage through this door. The cage is in line with the end of the PRY so that the ToF1 cannot be assembled when the PRY is in place; fortunately the assembly takes place on the north side, for this the north side of the PRY that aligns with the cage will be removed.

Recommendations:

- **Section of PRY on the north adjacent to the ToF1 cage will be removable independently to allow assembly of ToF1**

SS Tie Downs

Both SS devices have a tie-down assembly that fits around the SS base-frame and directly pulls it down to the ground. The purpose of this assembly is to prevent significant movement of the SS and due to the connection of the other devices to the SSs, should there be an imbalanced force during a quench the whole cooling channel will be restrained. The present designs of the tie-down assembly and the PRY mean there is a clash as shown below:

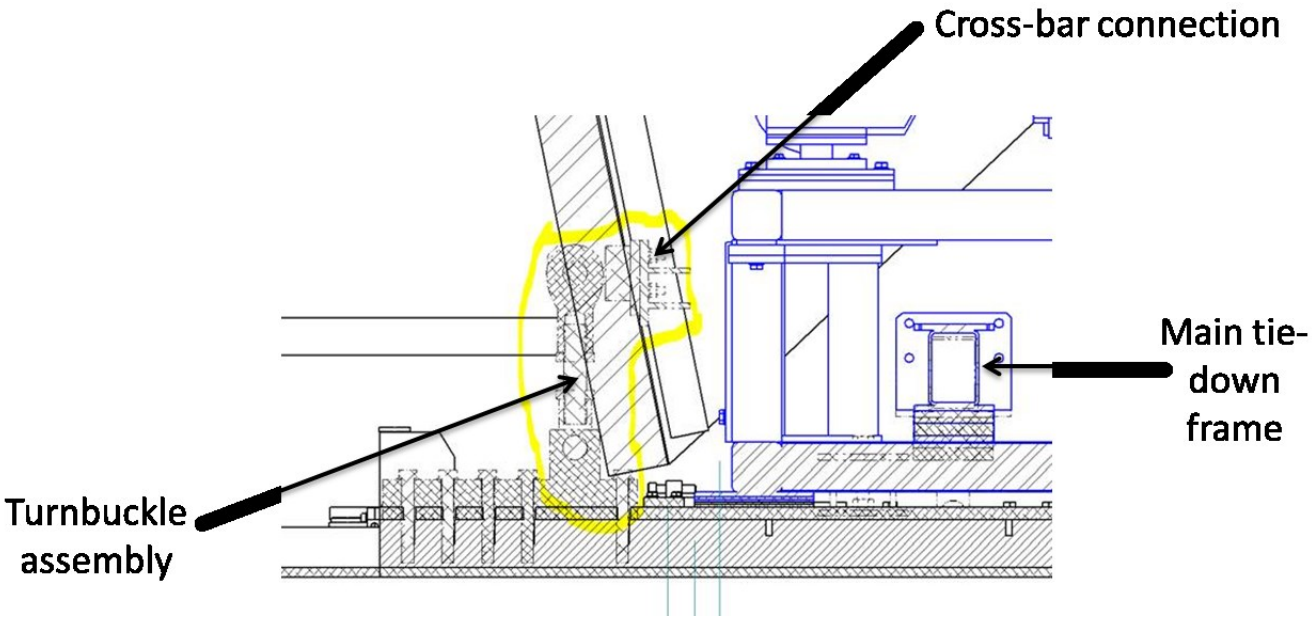


Fig XX: Clash between SS tie down assembly and the PRY, one half only

The tie-down frame has turnbuckle assemblies in the corners which are fastened to the end of a cross-bar on the frame, the turnbuckle assemblies have bolts that fasten through the moving platforms and into a bar fixed to the floor underneath; this of course locks the movement of the moving platforms. If the devices need to be moved offline the

turnbuckle assemblies are slackened and then unbolted from the floor, they can also be removed from the end of the cross-bar; this un-restrains the cooling channel and unlocks the moving platform. This means if the SS is to be slid offline then the tie-downs need to be accessible for removal which has implications for the turnbuckle ends, if the horizontal tie-down bar is shortened so the turnbuckle assembly is inside the PRY side-plate it will be almost impossible to reach them from the inside of the south side of the PRY. The turnbuckle assemblies should be on the outside of the PRY side-plate, this requires the cross-bar to be made longer so the turnbuckle assemblies sit further out. In this case the bar will need to penetrate the side-plate of the PRY. To minimise the size of the aperture for the cross-bar the way the turnbuckle assembly fixes on will need to be optimised as presently they use plates, these plates have a larger cross section than the cross-bar so would unnecessarily enlarge the aperture required for the side-plate to slide over the cross-bar when the device is pulled offline. The figure below shows the turnbuckle assembly further outside the PRY side-plates:

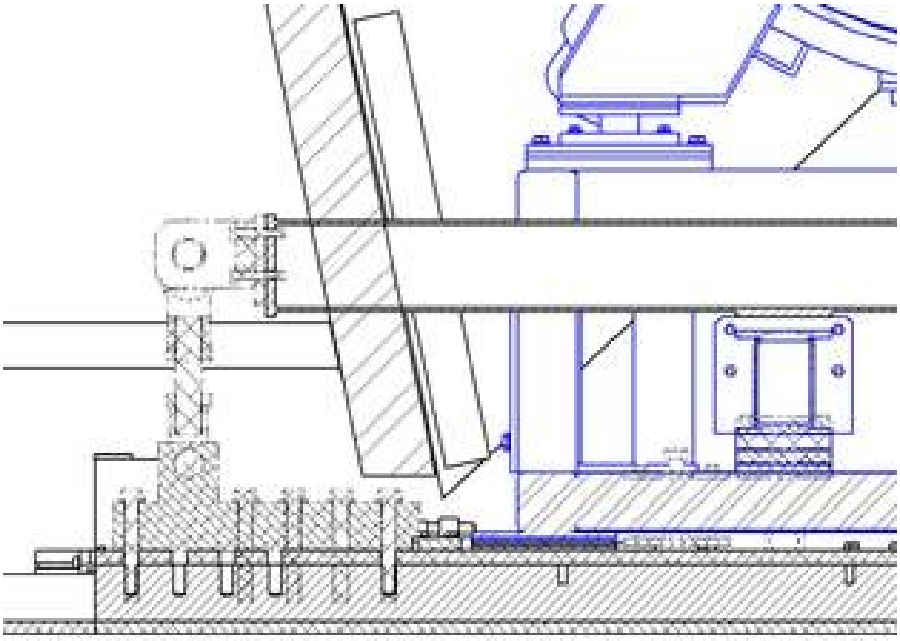


Fig XX: Extended horizontal tie-down bar and repositioned turnbuckle assembly, one half only

Recommendations:

- **Extend the horizontal tie-down bar**
- **Redesign the turnbuckle assembly fixing to match the cross section of the horizontal tie-down bar**
- **Place apertures in the PRY side plates (4 places) to accommodate the horizontal tie down bars (see figure below)**

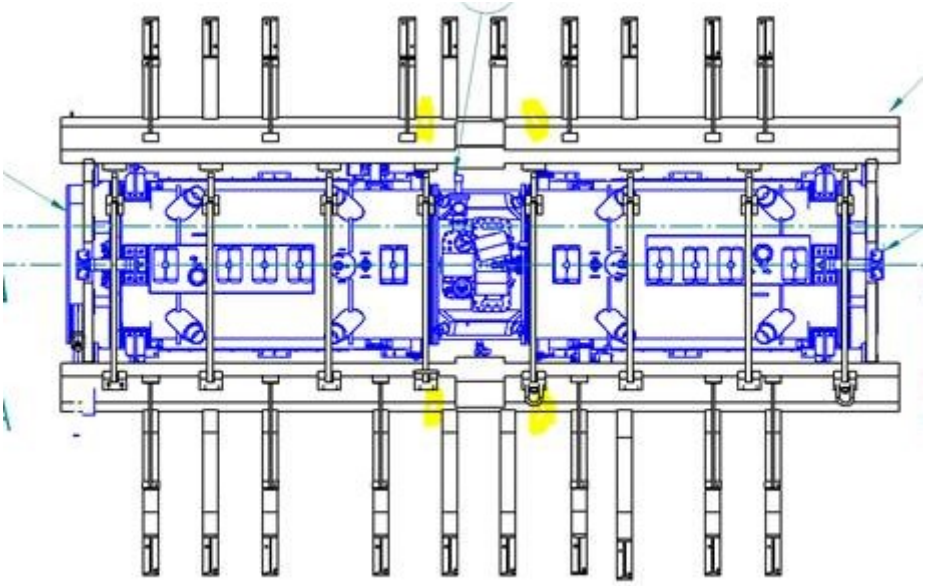


Fig XX: Positions for apertures (in yellow)

Vacuum connection

The vacuum connections on the SS are at the middle of the vessel, thus relatively inaccessible when the PRY is in place for connection of any pumping lines.

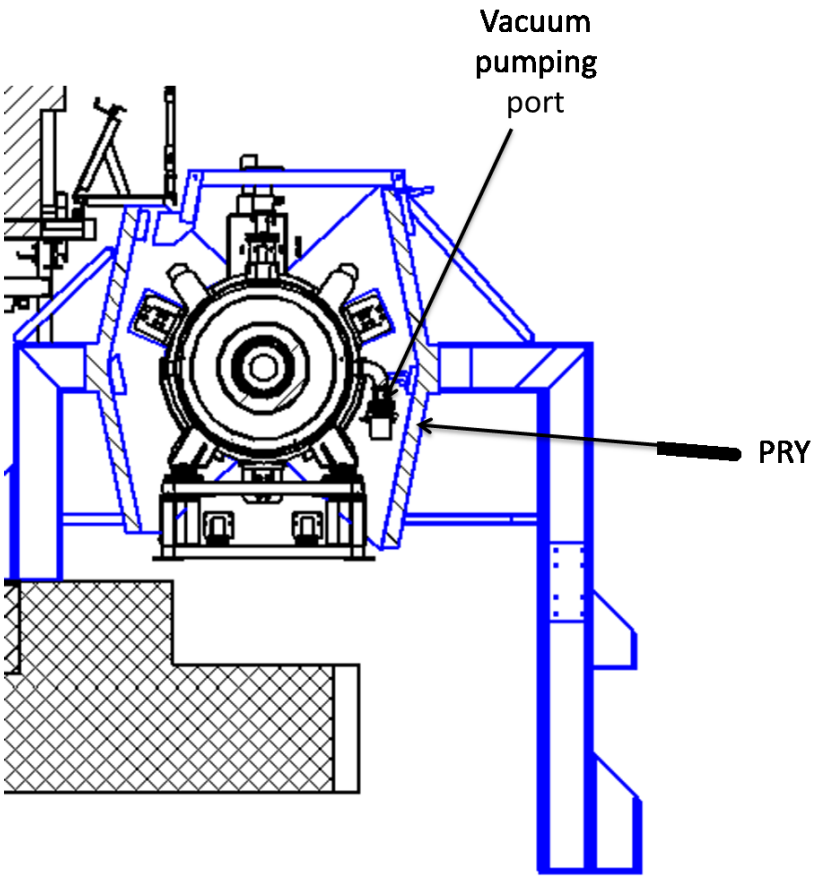


Fig XX: Position and proximity of the SS vacuum pumping port to the PRY

Recommendations:

- **Fit the pumping port with an extension piece that is compatible with the PRY whereby the end is easily accessible to connect to when the PRY is installed.**

Compressor Hose and Power Cable Connections

The compressors that supply the cryocooler cold heads are to be installed on the West Mezzanine. The compressor hoses and associated cold head power cables will be routed off of the West Mezzanine to floor mounted then PRY mounted hose 'tidies', these will be reconfigurable assemblies of non-magnetic Unistrut that will support the services. The hoses will be routed over the top edge of the PRY under the upper walkway of the South Mezzanine to the cold heads.

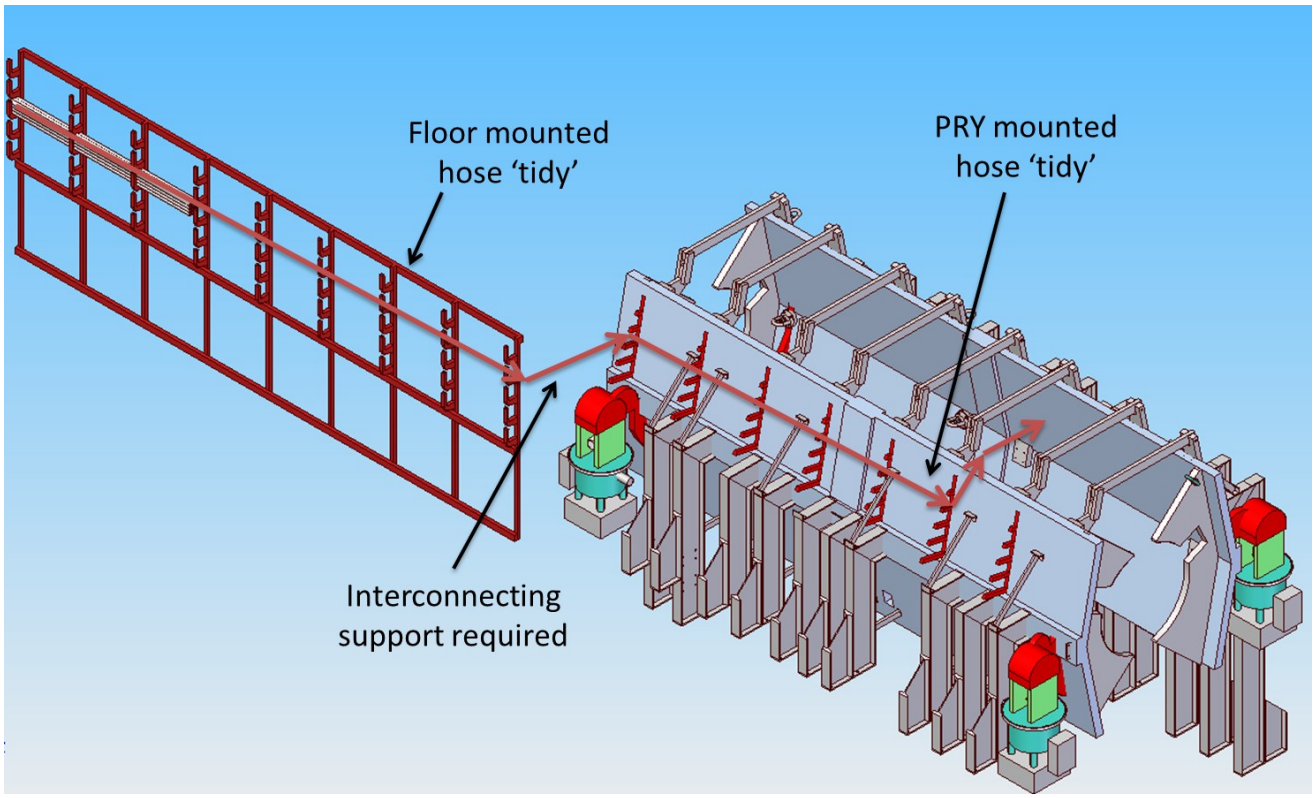


Fig XX: Compressor hose management with the PRY

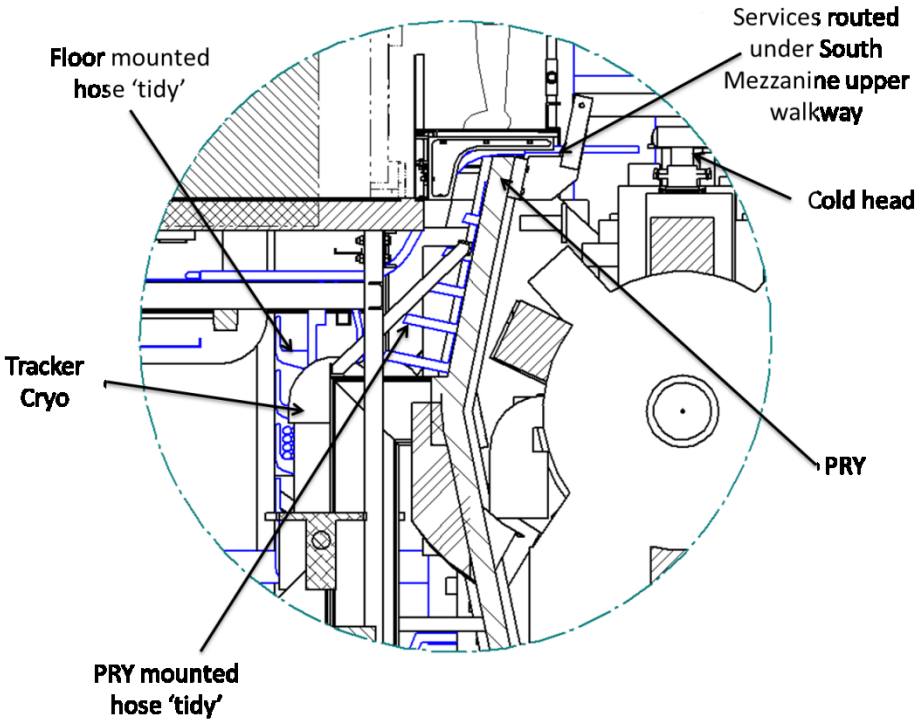


Fig XX: Compressor hose management & route to cold head

Magnet Power Cable Connections

Magnet power racks are being located outside of the MICE Hall; the cables are routed through the Hall wall and then through channels under the lower walkway of the south mezzanine; note that the channels are cut in the concrete below the steel shielding plates, these plates hence the current south shielding will remain mostly unchanged for Step IV. From here the most convenient routing would be over the top of the PRY using the PRY cross-bars for support. This has the advantage that the cable trays and the services they contain are accessible from the upper walkway of the south mezzanine.

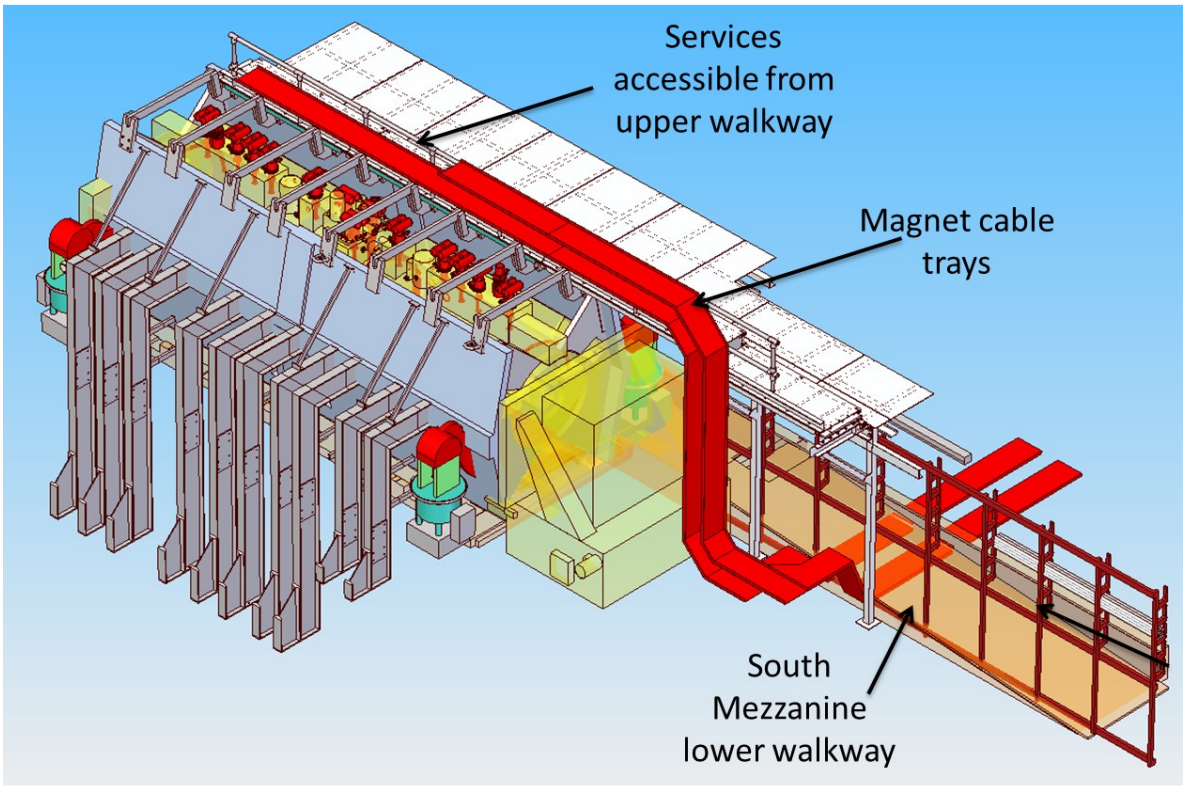


Fig XX: Magnet Power Cable Management with the PRY

Tracker Cryo

Drawings

TD-1189-1461 Tracker Cryo with PRY

It was expected that the Tracker Cryo would sit in close proximity to the cooling channel, actually on the moving platform, with this in mind the light guides are cut to optimised lengths. Work has been undertaken to determine how far from their original position they could be moved without causing a shortfall in the light guides:

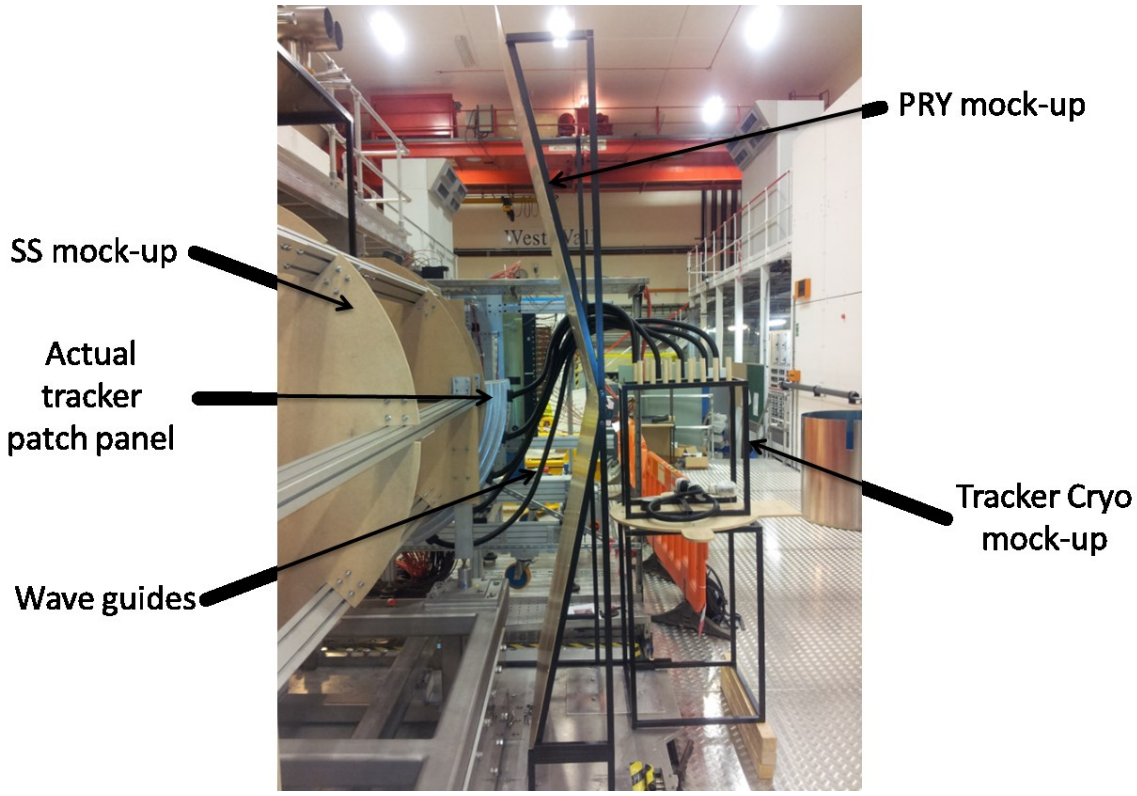


Fig XX: Tracker Cryo & PRY mock-up in MICE Hall

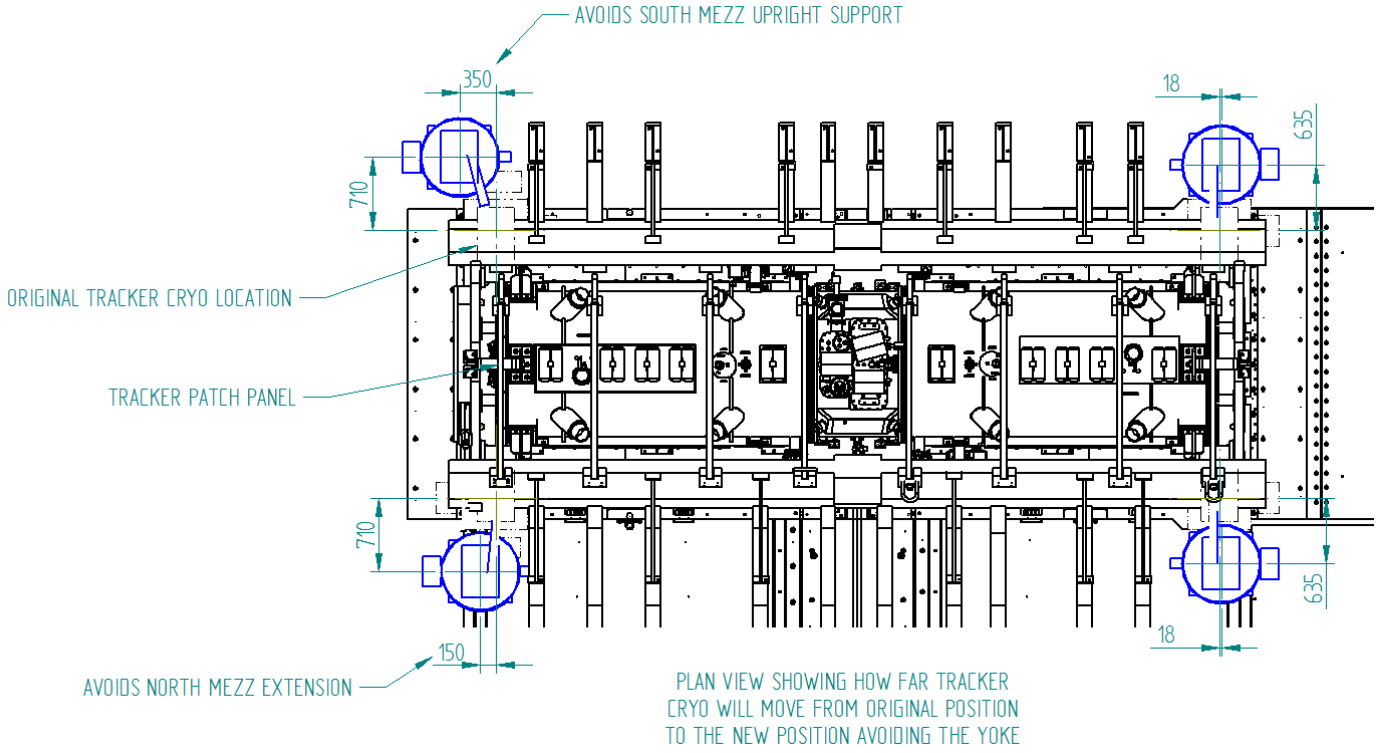


Fig XX: Required Tracker Cryo moves to avoid various features in the Hall

Absorber Focus Coil (AFC)

Drawings

TD-1189-1603, Step IV with Yoke (Mod)

TD-1189-1667, AFC with Yoke

Vacuum connection

As with the SS the vacuum connection for the AFC is at the vessels mid-level. Again an extension will be required to place a connection point in an accessible position when the PRY is in place.

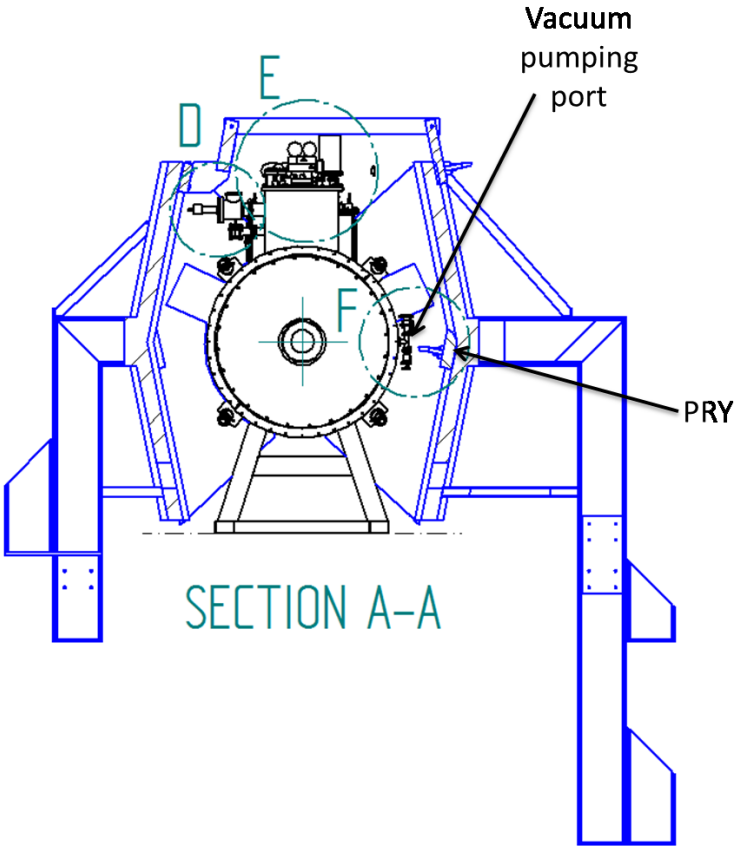


Fig XX: Position and proximity of the AFC vacuum pumping port to the PRY

Recommendations:

- **Fit the pumping port with an extension piece that is compatible with the fit of the PRY whereby the end is accessible to connect to when the PRY is installed.**

Compressor Hose and Power Cable Connections

As above with the SS

Magnet Cable Connections

As above with the SS

Kloe Light (KL) Chamber Trolley

Drawings

TD-1189-1671 KL & EMR with Yoke

The KL trolley sits at the downstream end of the MICE experimental devices and is braced off of the Virostek shield. Due to its position it is in close proximity to the PRY, the figure below shows there is a clash that needs to be addressed.

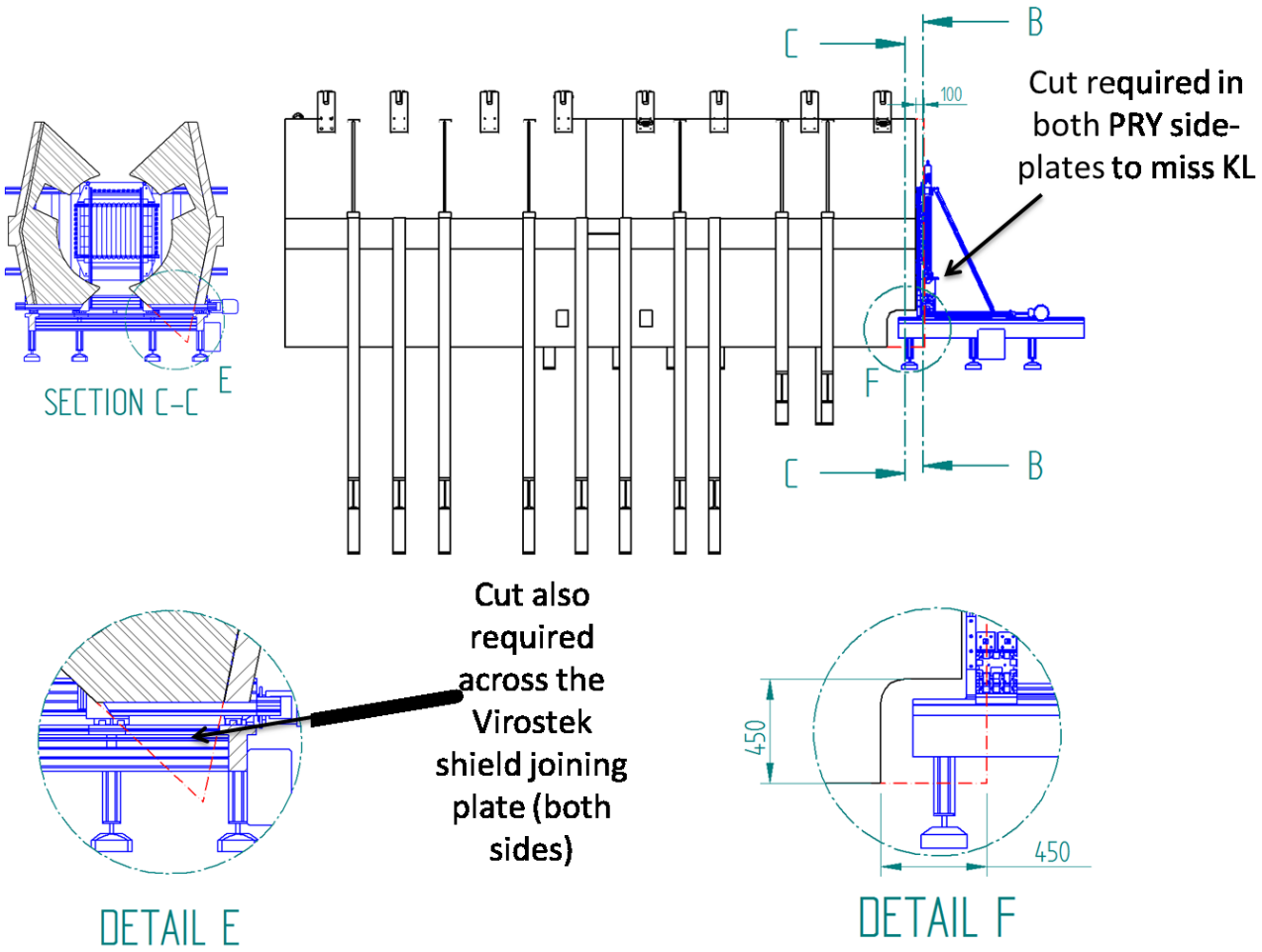


Fig XX: Clash avoided between KL Trolley and PRY by cut in downstream end of PRY

Recommendations:

- **PRY cut to accommodate the rails and supports of the KL trolley .**

Floor Connection

Drawings

TD-1189-1598 Floor Fit with Yoke (Mod)

Floor Loading

The requirement for the PRY is a compressive floor strength of 5000 Psi and a pull out force of 6000 lb using 1” diameter x 12” anchor bolts 9.5” deep and spaced 9.2” apart. (S Plate)

The Floor loading in the MICE Hall will take **250 kPa** which is **5221 lbf/ft^2** or **36 lbf/in^2**.

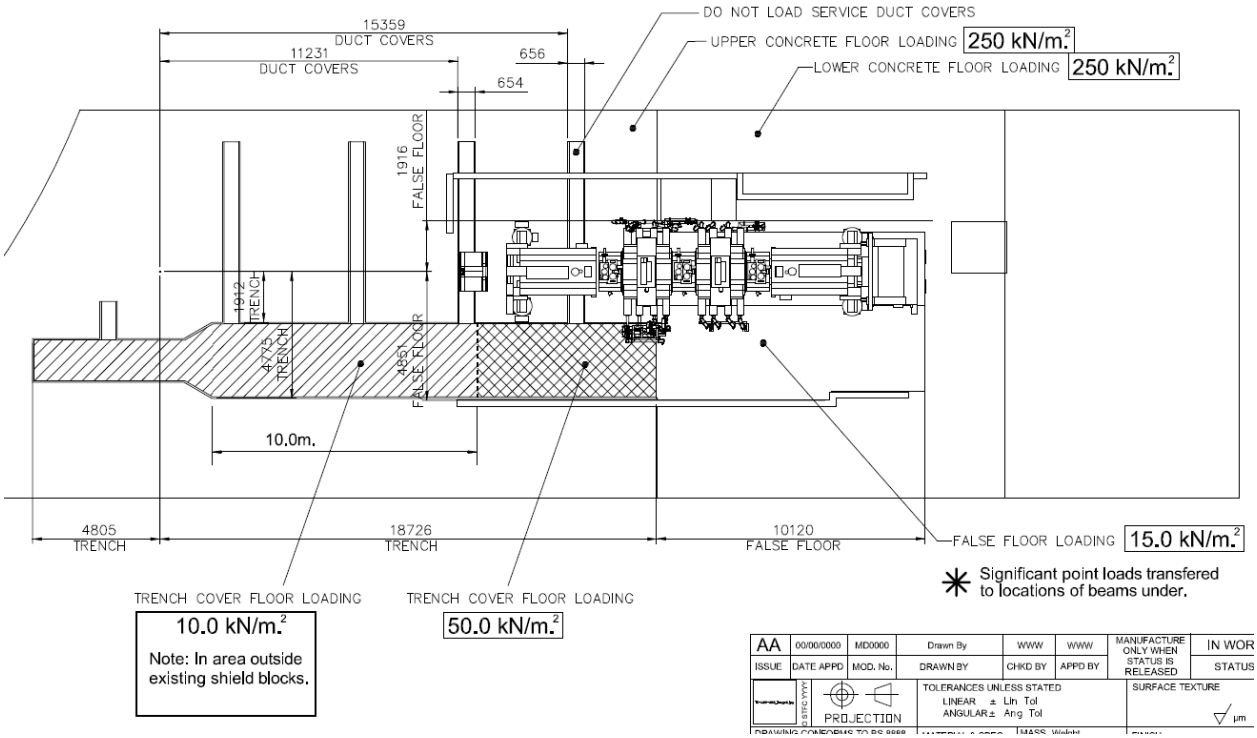


Fig xx : Floor loading in the MICE Hall including trench roof

Pressure on floor

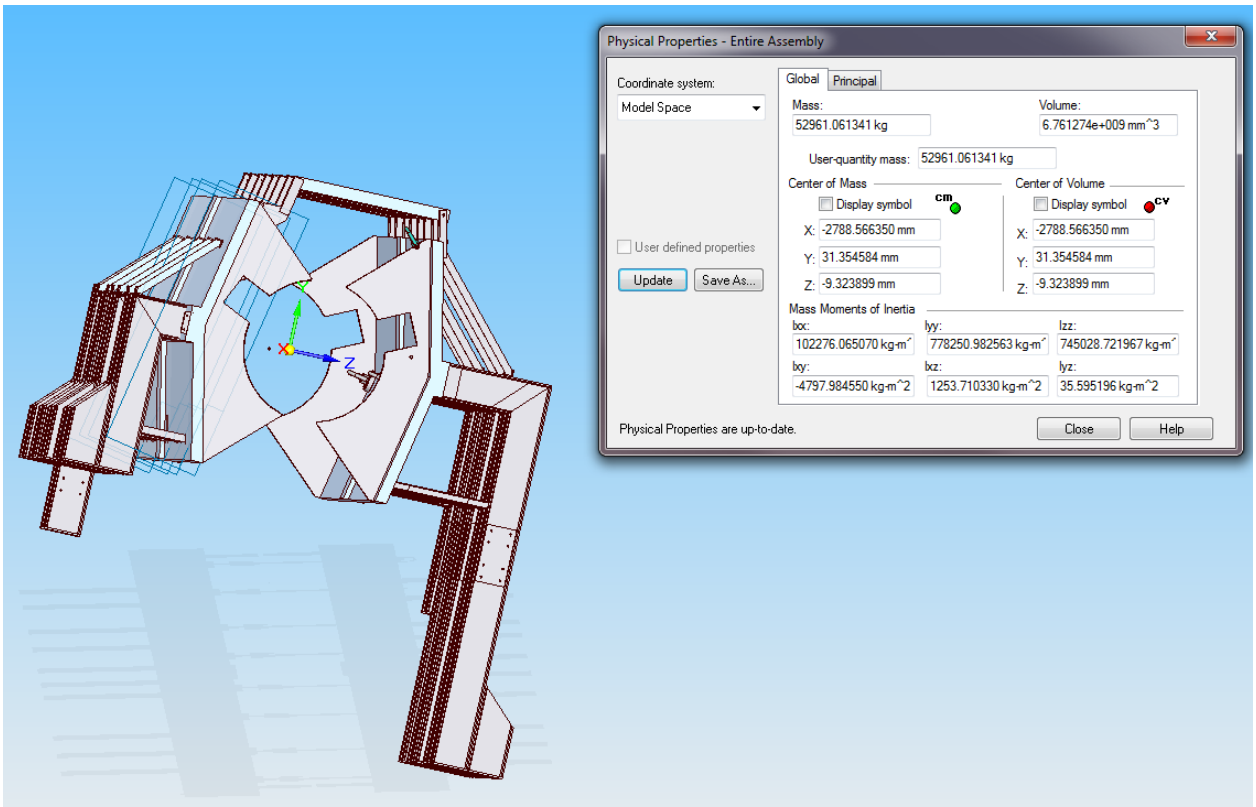


Fig XX: Mass of PRY with 120 mm steel side plates

$$mass := 53000 \cdot kg$$

$$load := mass \cdot g$$

$$load = (5.198 \cdot 10^5)\ N$$

load taken on leg footplate
of 762 x 143 mm x 20 legs

$$area := 0.762 \cdot 0.143 \cdot 20 \cdot m \cdot m$$

$$area = 2.179\ m^2$$

$$pressure := \frac{load}{area}$$

$$pressure = (2.385 \cdot 10^5)\ Pa$$

$$pressure = (4.981 \cdot 10^3)\ \frac{lbf}{ft^2}$$

The pressure on the concrete is about 240 kPa (~5000 lbf/ft^2), the maximum compressive force specified for the concrete floor in the MICE Hall is 250 kPa. However this loading assumes:

1. All legs are in contact
2. The footprint is in full contact
3. The load is evenly distributed over the 20x legs

Assumptions 1 & 2 might be realised by grouting in the footplates or using shims to ensure all footplates are in contact with the ground, or ensuring there is enough adjustment in fitting of the legs to the PRY side-plates that all footplates can be in contact with the ground. Assumption 3 is probably false as the north side is marginally heavier than the south and the legs are not evenly spaced, for this it might mean marginally larger footplates to spread the load or that the areas where those legs sit are locally reinforced before installation of the Yoke, the latter being a little more difficult due to the work involved in removing the asbestos loaded bitumen before undertaking any reinforcement.

Recommendations:

- **Grout, shim or fit legs such that all footplates are in full contact with the ground**
- **Use bigger footplates on the legs**

25/07/13 Emailed David Pyke re 6000 lb pull out anchor points – awaiting reply

Moving Platforms

Each of the MICE Experimental devices, the SS, AFC and the Radio Frequency Coupling Coil (RFCC) used at Steps V & VI, can be fitted with a moving platform, this allows the device to be slid offline (to the north in the MICE Hall). These platforms have only been design with the load of the device, therefore the PRY cannot make any unsupported mechanical connection to them. To give maximum coverage the PRY needs to cover the region right down to the moving platform; for this it must avoid features on the moving platforms.

Fit with Moving Platforms

Not only does the fit between the PRY and the moving platform need to be made in the static online (operational) position, also the south side of the PRY must not clash with the moving platforms features when it is slid offline.

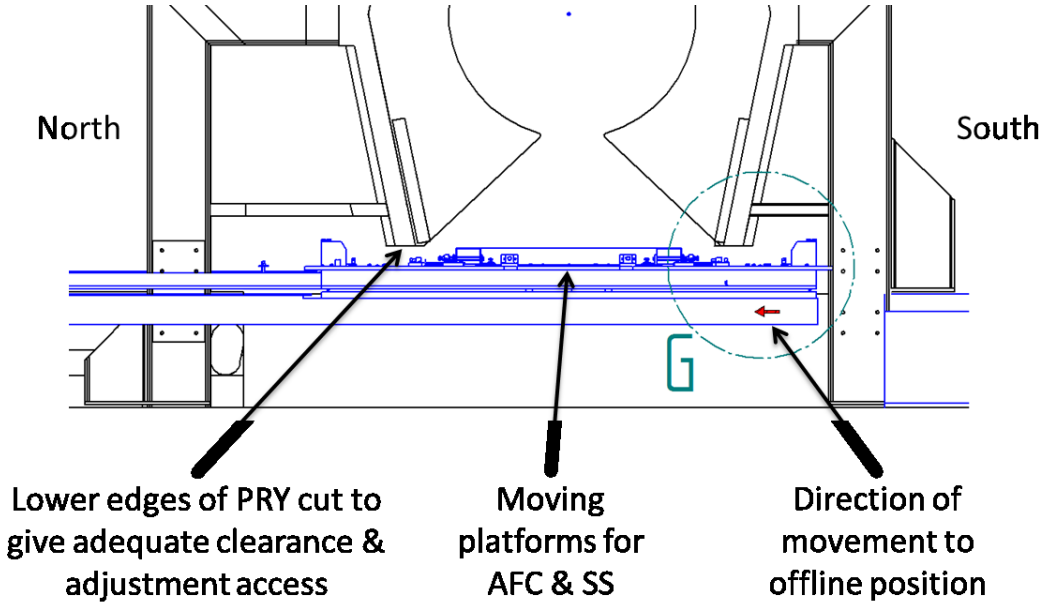
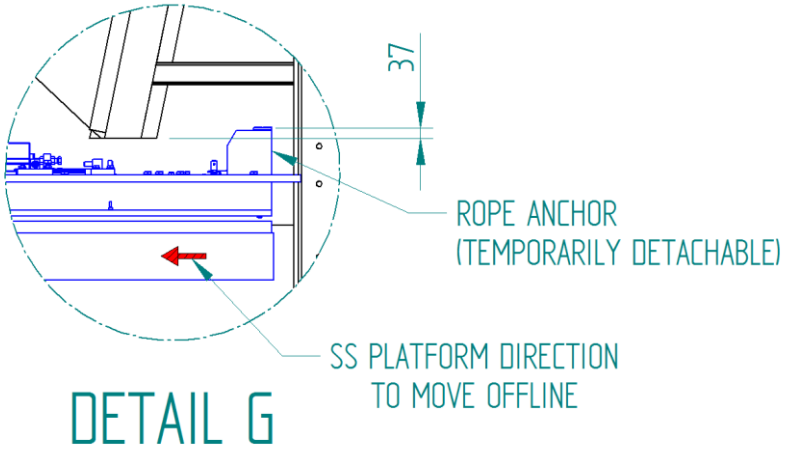


Fig XX: Fit of moving platforms with PRY in static operational position



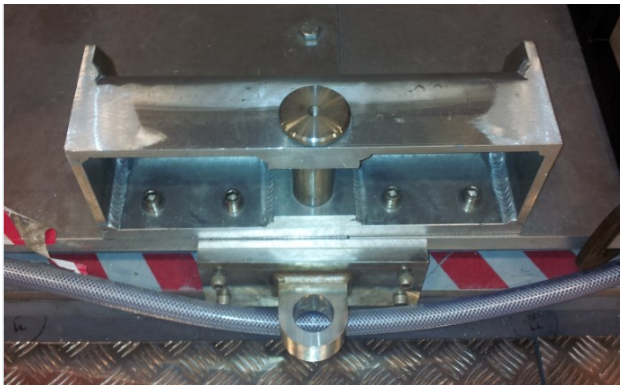


Fig xx: Rope anchor feature would clash when moving offline but is temporarily removable

In addition to the fixed features on the moving platforms, when the devices are placed on top they will need to be finely adjusted into position. If the south side of the PRY is in place then extended tooling will need to be used to gain access through the gap between the PRY and the moving platform to reach the adjustment points at the base of each device. By cutting the lower edge of the PRY an adequate gap is formed to gain access to the adjustment points.

On the north side of the MICE Experiment are the offline components of the moving platforms. These consist of accurately levelled floor plates that are fitted with temporary rails that guide the moving platforms to their offline resting places. The legs of the PRY need to be placed carefully on the north side to avoid clashing with features or fixings of these offline components.

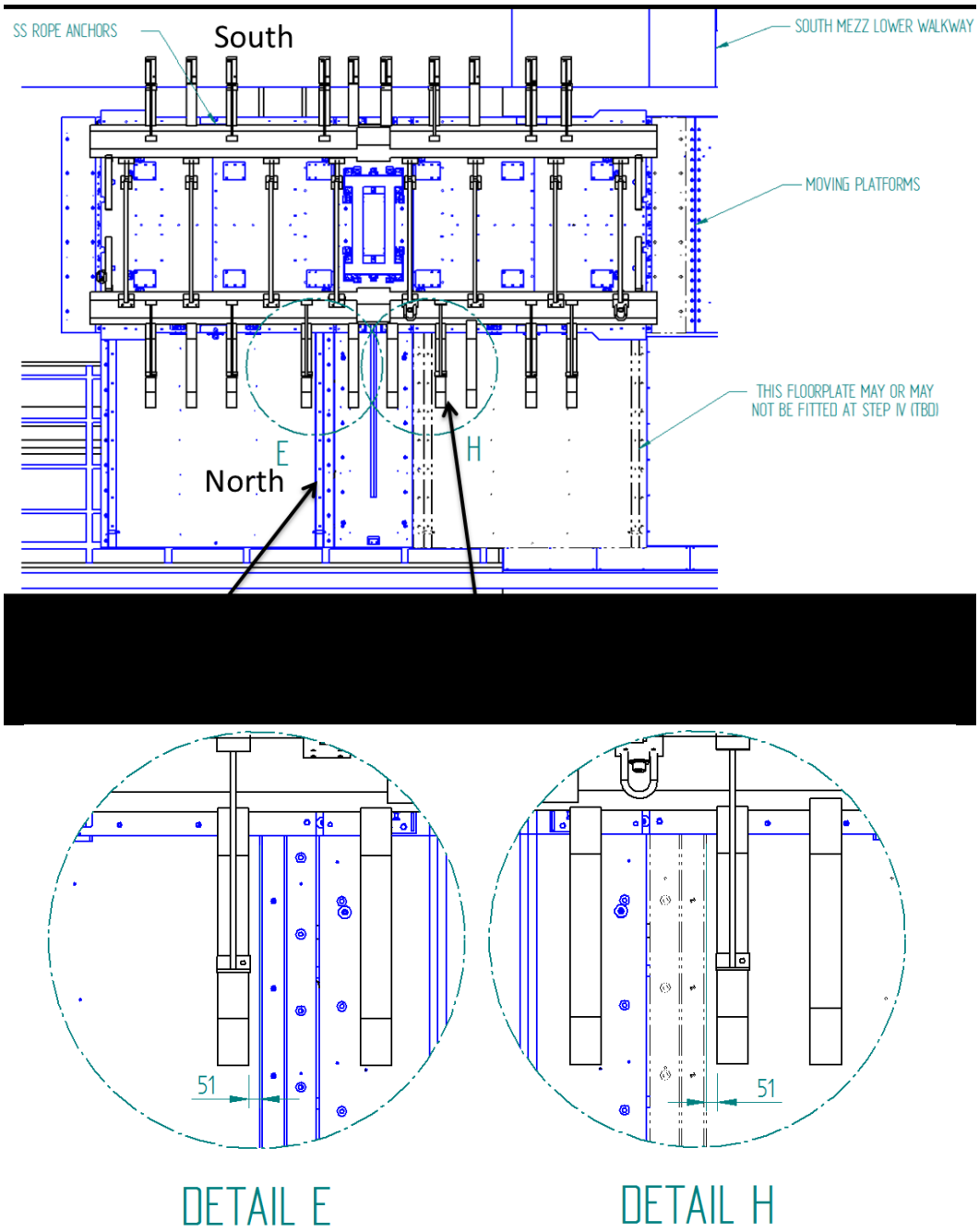


Fig XX: Adjustments required to original PRY design to avoid rail positions in offline moving platform sections

The rails can be removed when the north side of the PRY is assembled however there will need to be holes cut through the levelled plates for the PRY legs to pass through so it is best that the legs miss the rail positions. The legs are to be sectioned at a position just slightly below the levelled offline plates so that the lower section of leg can remain in place bolted to the floor of the trench, or the main north side floor. The holes cut in the moving platform offline plates will need to be cut carefully to prevent any distortions, this is particularly important for the SS air-lift platforms. The SS air-lift platforms also need close fitting in-fill sections as the SS devices are lifted on a cushion of air, if the offline plate is not level or has a hole then the air cushion can be lost and the lift will be lost causing the moving platform to fail.

Recommendations:

- **Lower edge of PRY is cut as shown in the figures above to give adequate clearance from moving platform features.**
- **Moving platforms to be cut where the legs pass through and fitted with cover plates when the legs are removed to prevent failure of the air cushioned platforms and for general safety.**
- **Move the legs of the PRY longitudinally to avoid rail features on the offline sections of the moving platforms.**

- **Rope anchor is temporarily removed to pull SS moving platforms offline.**

Trench

The trench in the MICE Hall is adjacent to the upstream devices in the MICE Experiment, as such interaction with the PRY is relatively unavoidable. The trench roof will not support the weight of the PRY so the legs of the PRY have to pass through the roof to the concrete floor below.

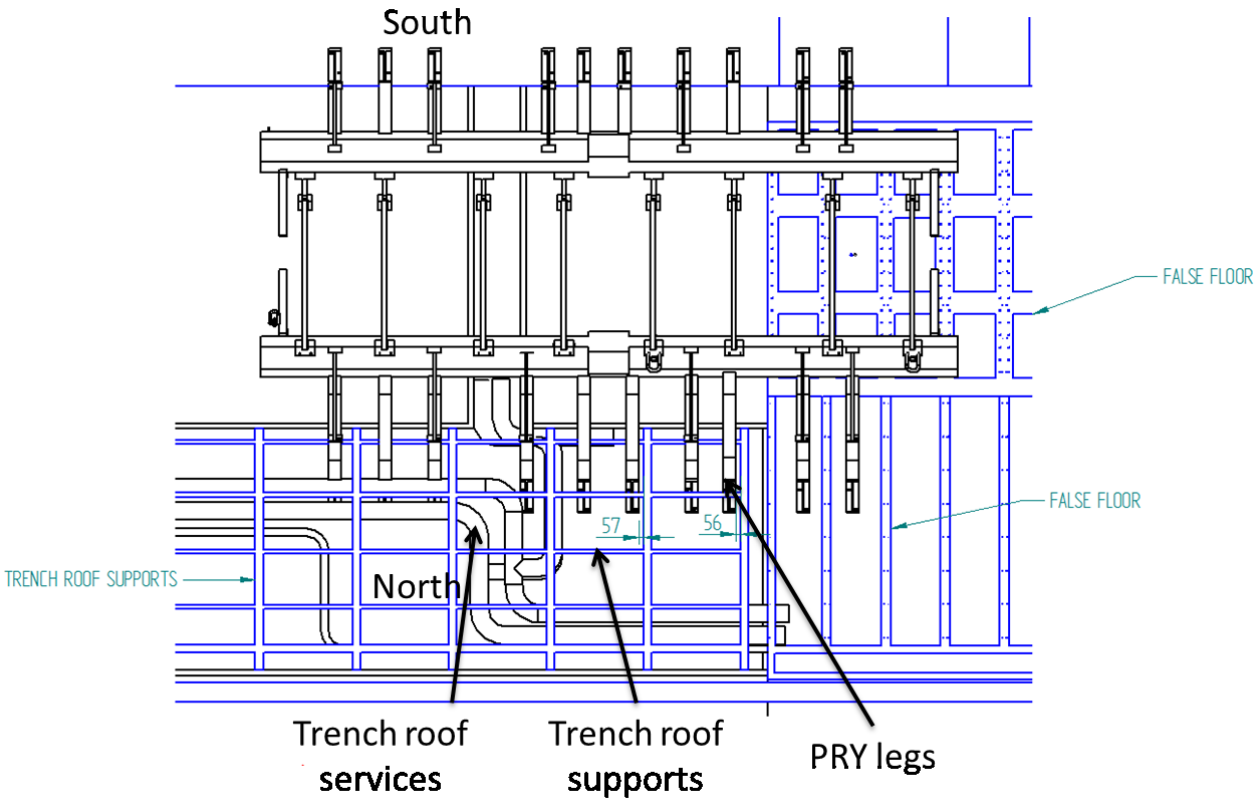


Fig XX: Yoke leg fit optimised for trench roof supports and services

In addition to the fit of the legs with the trench roof supports there are already a number of services installed in the trench that need to be avoided, some of these are shown in the figure above. The others are dealt with in the later section "*Trench Services*"

South Mezzanine Lower Walkway & False Floor

On the south side of the PRY the legs will connect to the South Mezzanine lower walkway. This is a concrete section ramped at one and covered with metal magnetic shielding plates that form part of the south shield wall. The legs that connect to the lower walkway in the vicinity of the ramped section will require some of the ramp to be cut to allow them to connect fully to the lower floor rather than be overhanging the ramp further up.

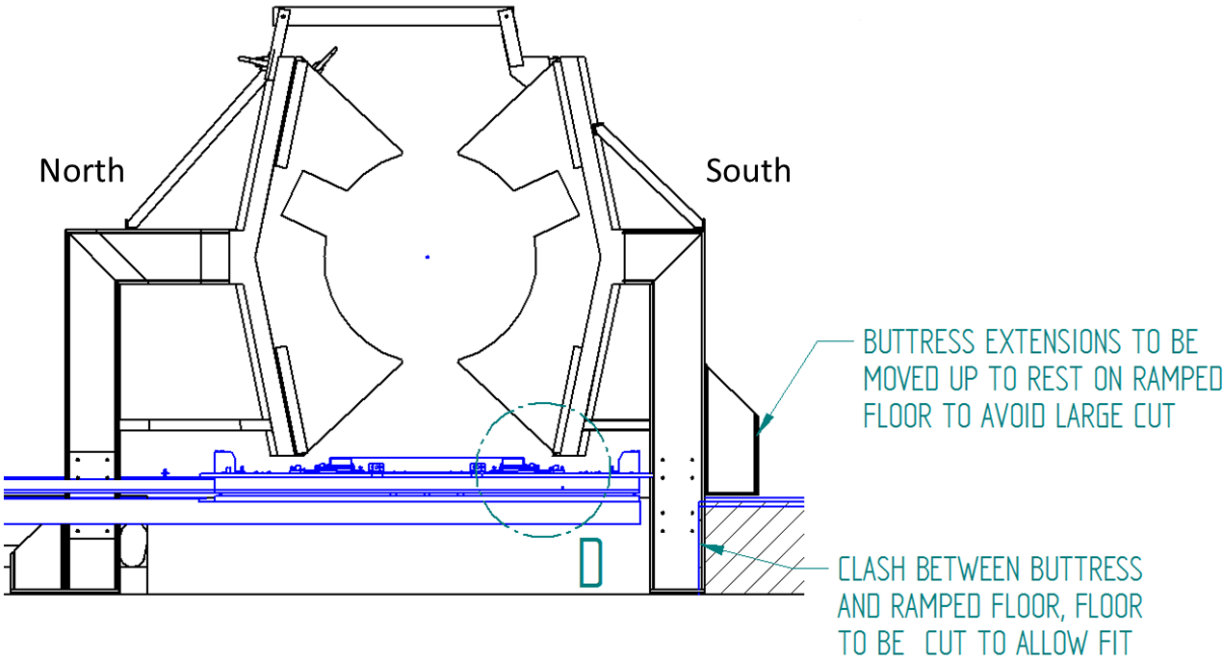


Fig xx: Cut for main leg section in the ramped floor

It can also be seen from the above figure that to avoid a much bigger cut in the concrete and metal plated ramp the buttress extension of the leg could be moved up to connect on top of the ramp, this will of course need to connect through angled shims that match the fall of the ramp.

Recommendations:

- **South Mezzanine lower walkway ramp (concrete and metal top plates) are cut to fit PRY legs to lower floor.**
- **PRY buttress extensions are raised and fitted to ramp, angled shims will be required to match the fall of the ramp.**

South Mezzanine

Drawings

TD-1189-1601 South Mezz with Yoke (Mod)

Upper Walkway & Front of South Mezzanine

The upper walkway of the South Mezzanine is hinged to allow them to be lifted to give extra clearance to devices that ware being craned in to the location on the beamline. This capability is mainly required to devices not fitted with moving platforms, e.g. KL, EMR and other detectors, as the main experimental devices can be craned onto the moving platforms in the offline position and then moved into place online. The fit of the upper walkway is quite tight to the main experimental devices, mainly due to the position of the shield wall and the hydrogen system in relation to the experimental devices, this only leaves a small strip for the walkway. To allow the PRY maximum coverage the upper walkway would need to be raised by 200 mm; to further avoid clashes the support beams of the South Mezzanine upper walkway would need to be cut back so the walkway would need resting points on the PRY itself, this is shown in the figure below:

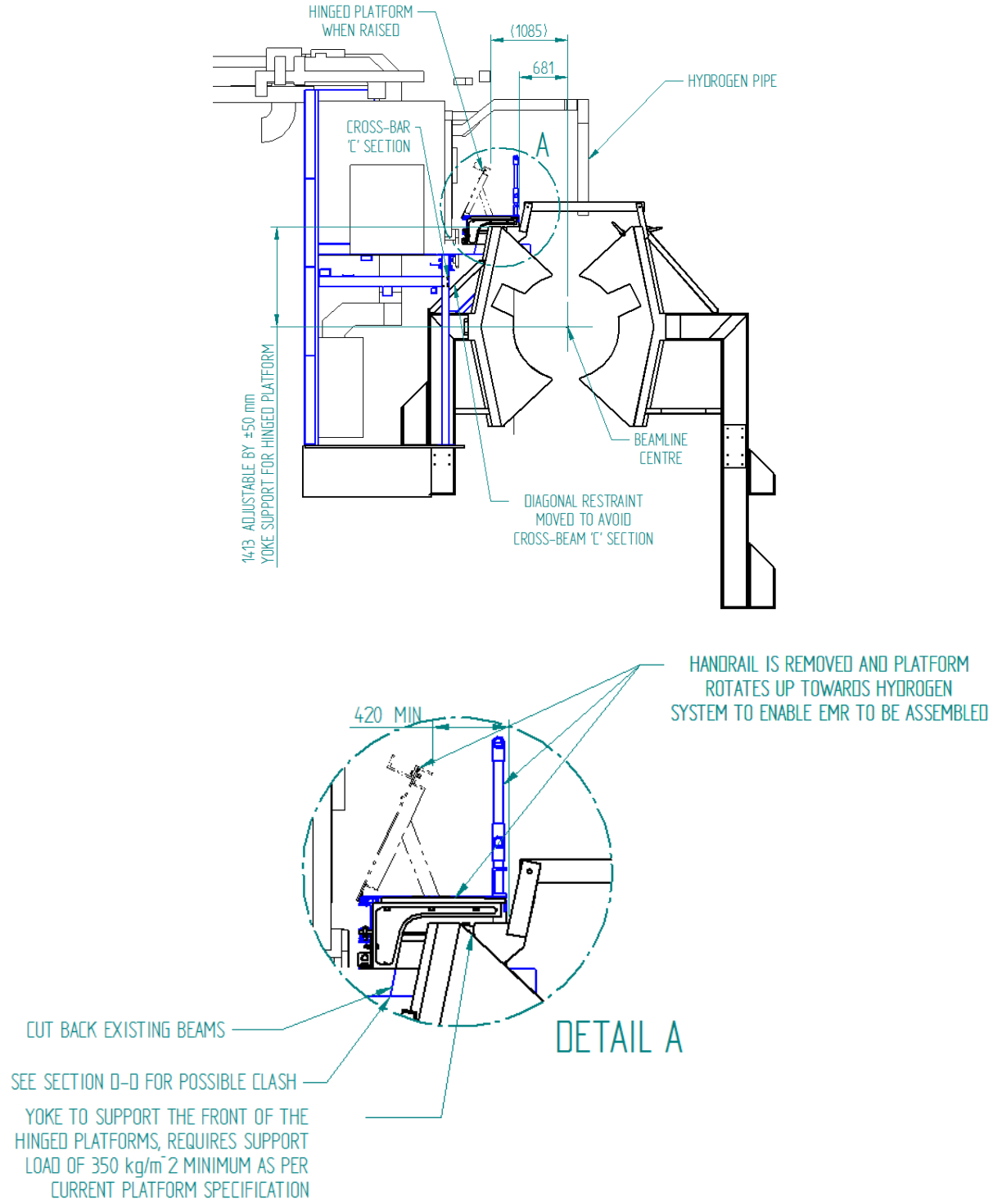


Fig xx: Fit of PRY with South Mezzanine

It can be seen in the figure above that the diagonal restraints on the south side of the PRY also need to be moved to ensure they does not clash with the cross-bar 'C' section that supports the lower set of horizontal bars. To move the cross-bars would be a major modification for the South Mezzanine.

Services

Drawings

TD-1189-1466 Services with Yoke

Compressor Lines & power

Dealt with in previous section "Spectrometer Solenoid (SS)", "Compressor Hose and Power Cable Connections"

Magnet Cables

Dealt with in previous section “Spectrometer Solenoid (SS)”, “Magnet Power Cable Connections”

Vacuum

The connection into the individual experimental devices is dealt with above in the “Vacuum Connection” sections. The Vacuum system is currently under review; it is expected to change but will be reconfigured to fit around the PRY and existing MICE Hall environment.

Trench Services

Drawings

TD-1189-1668 Trench Services with Yoke (MOD)

ISIS Cables

There are a number of ISIS cables in the trench that cannot be moved far as there is a risk they may be damaged and this would impact on the running of ISIS. In this case they need to be reconfigured so they are tight to the south trench wall then the legs of the PRY need to avoid them. This requires the legs of the PRY to be spaced away from the south side trench wall by 200 mm.

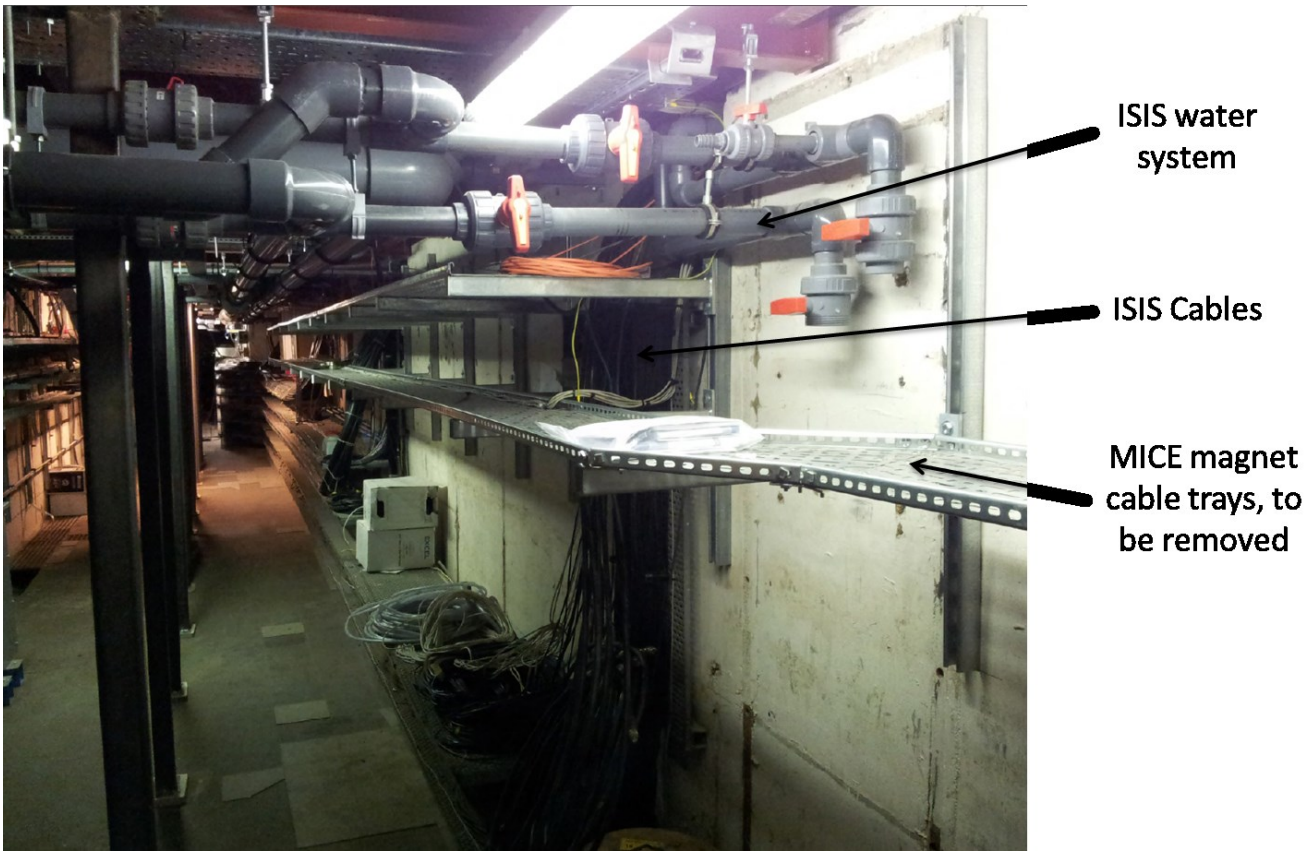


Fig XX: Trench (looking east) and existing services

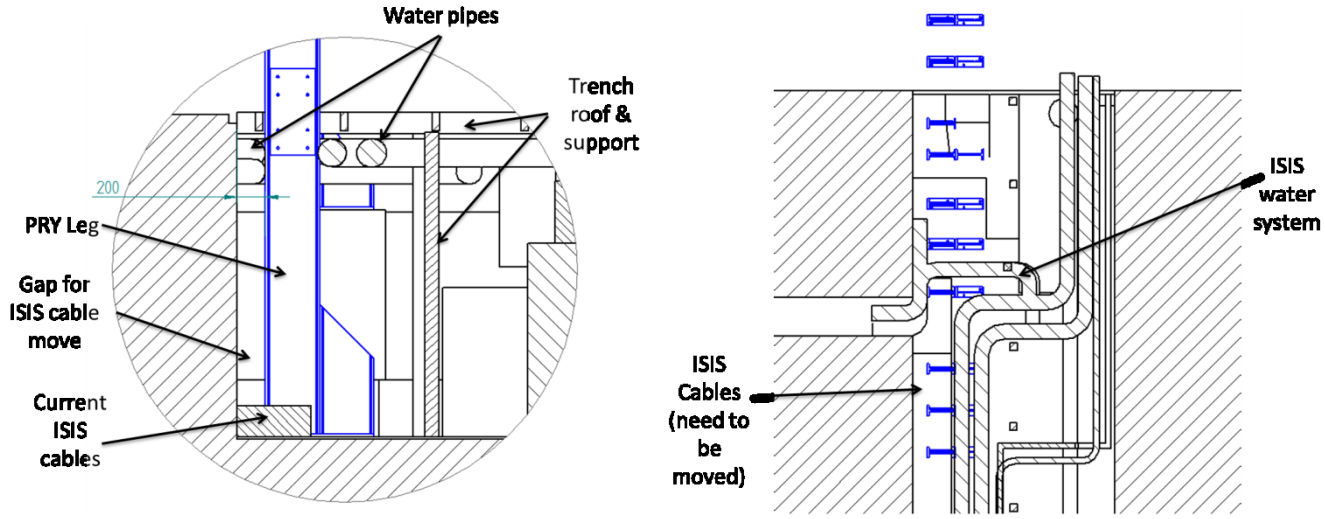


Fig XX: PRY legs and ISIS trench services

Water

The water system for compressor feed is currently situated in the trench; there is a plan to move this outside of the Hall but some of the water feeds will remain for ISIS as shown in the figure above. As with the ISIS cables the PRY legs shall avoid these to prevent any disruption to ISIS.

Hydrogen system

The hydrogen system that is currently installed will remain mostly unchanged due to the investment and time penalties that would be incurred. On part of the hydrogen system that is impacted by the PRY indirectly is the hydrogen fill station that is located on the lower walkway of the South Mezzanine. Due to the size of the PRY the Tracker Cryo units have to be moved out further south, this then reduces the access around the fill station. This will be resolved by moving the hydrogen fill station to the end of the lower walkway, this is shown in the figure below:

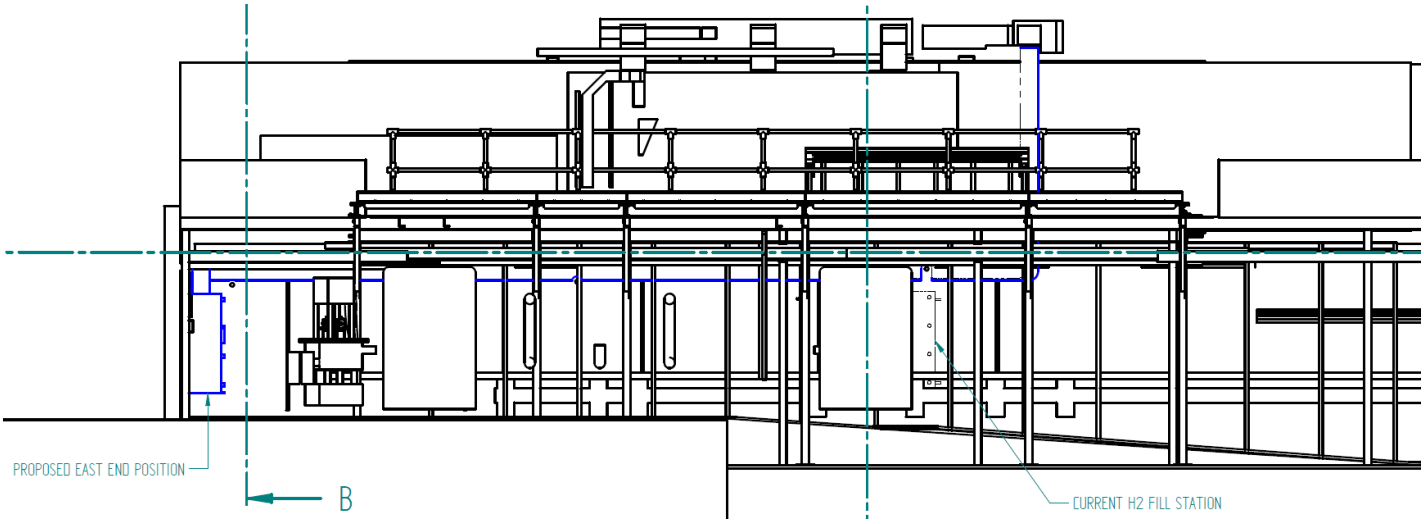


Fig XX New hydrogen fill station position

Step V & Beyond

Drawings

TD-1189-3471 Step V Yoke & South Mezz

At Step V the PRY design is complicated by the large size of the RFCC devices that are introduced to the MICE Experiment. The RFCCs are bigger than the SS & AFC and also the RF waveguides that attach are large, rigid and attach to the mid-level of the vessel.

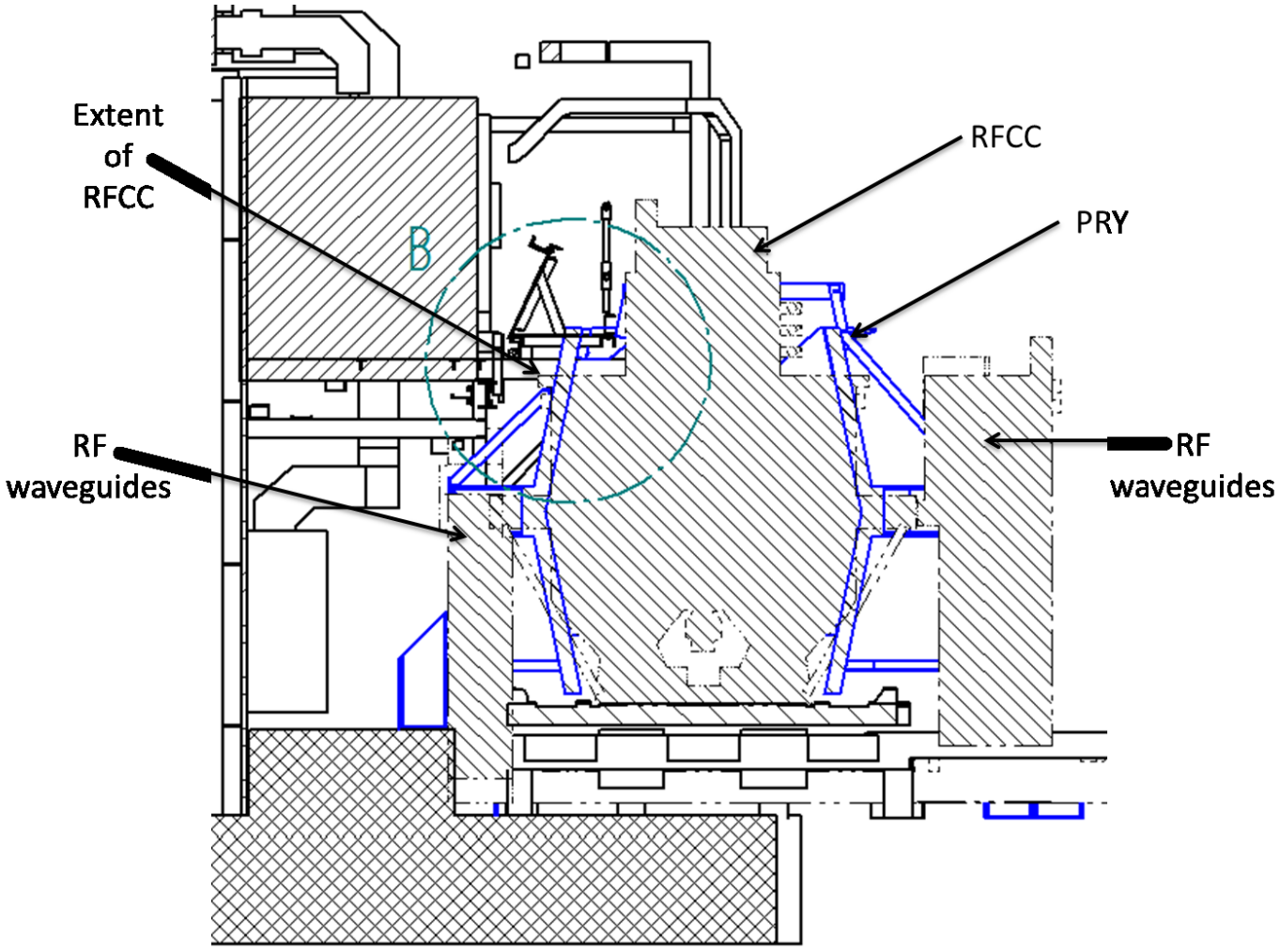


Fig XX: RFCC superimposed on Step IV PRY

The design of PRY for the RFCC is likely to require more significant alterations to the South Mezzanine, this might entail removal of some or all of the hydrogen system to whilst the South Mezzanine alterations take place or maybe even modification of the Step IV hydrogen system.

Cost & Schedule