Information-Request/Submittal/Release		Number	S	038-0008
Number of attached pages	0	New ☒		
Project	NCNR Instrument Project	Revision ☐		
Originator	NCNR Project Participant	If revision, provide the following:		
Date	November 10, 2003	Previous Submittal		038-xxxx
Database Reference	WorkManager reference	ECR/ECN		038-xxxx

Scope

Submittal of WBC General Specification for MACS

Purpose

Submit the "General Specification for Development of the White Beam Conditioning System" for MACS.

Description

"General Specification for Development of the White Beam Conditioning System" for MACS word document "NG-O-1 WBC" rev 2b.

Filing

When filed as a submittal, this form and the information attached to it transforms into a released document when it is signed by all parties named in it. The form with attachments is kept on file in the office of the NIST chief engineer. When attachments are electronic in nature (such as electronic CAD data) that information and its hierarchical position in the project design tree shall be identified in or under this submittal. Information Requests, Submittals and Releases are numbered separately, yet sequentially.

Change Process

Anyone can propose a change to documentation that is released under this form. To such end an Engineering Change Request (ECR) is filed. A priori, the change board is composed of the individuals that signed the submittal against which the ECR is drawn. Approval of the ECR turns it into an Engineering Change Notice (ECN), which gives authority to prepare a new submittal. The new submittal covers at least the fully executed ECN. Approval of the new submittal signifies close-out (full implementation) of the ECN.

Endorsements (list composition is part of release and determines Change Board for ECR/N's)

Submitted		Reviewed		S 038-0008
1	P. K. Hundertmark (signed)	1	D. J. Pierce (signed)	
2	T. D. Pike (signed)	2	Collin Broholm (signed)	
3		3		
4		4		
5		5		

General Specification for Development of the White Beam Conditioning System

for the

Multi-Axis Crystal Spectrometer (MACS)

National Institute of Standards and Technology

Center for Neutron Research

Specification NG-0 –1 WBC

Revision 2b

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Specification NG-0 –1 WBC

1 Overall Specifications

The MACS White Beam Conditioning System (WBC) includes the elements associated with delivering the neutron beam to the primary elements of the MACS optics system. The neutronic input is the C-100 Cold Source. The neutronic output is a diverging cold neutron beam with a circular cross section. Specific elements included in the WBC are:

1. Beam Tube
2. Shutter
3. Shutter Inserts (He liner and composite plug)
4. Beam Choke Box
5. Primary Shields (NG-0 beam enveloping)
6. NG-1 Shields (modifications & replacement elements)

1.1 General Dimensions

The WBC outside dimensions are defined by the adjacent instruments and equipment surrounding NG-0. The overall size of the WBC is shown in Figures 1-18 and through the solid body in the accompanying IGES files. The location of the internal elements of the WBC (Shutter, CFX Mount, Beam Choke Box, and DFM Cask Mount) is fully defined along the beam by Table 1.

1.2 General Materials Requirements

Construction of windows the neutron beam will pass through shall be made from 1100 aluminum and have a thickness that is to be minimized and each window shall not exceed 2 mm. There is an overall requirement that to the extent practical all volume within the instrument that is not occupied by fixed beam optics elements, required for moving optics travel, and that does not lie within exclusion zones defined in the 3D solid body shall be filled with bulk shielding material. Primary materials employed are:

1. Structural steel (10x0)
2. Pure Aluminum alloy 1100
3. 10B:Al (1mm or 6mm sheet stock)
4. Bulk shielding material: 55% (volume fraction) steel shot in 45% wax held in a closed steel containment vessel.
5. Laminations of high-density polyethylene and steel
6. Other Special Shielding Materials (e.g. Pb, Boral)

1.3 Construction Considerations

The construction of the internal and external surfaces that the shielding presents shall be generally smooth and developed from primary solid volumes. Protrusions greater than 2mm shall be minimized. Four functional element types determine the WBC volume:

1. Helium containing shells
2. Neutronic devices (Shutter, Beam Choke Box)
3. Beam windows
4. Shielding

1.4 Attachment Means

The WBC Rests on and is fully supported by the C-100 floor. Provisions for leveling elements can be performed individually or in groups. Adjacent Elements of shielding shall be toleranced to provide a maximum clearance of 15mm. Shielding element locations are maintained by the weight of the shield element either imposed directly on the C-100 floor or by resting directly on other shielding elements; fastening of shielding elements to one another shall generally not be required. Data for the mounting locations of the DFM Cask and the Cryo Filter Exchanger (CFX) appear in section 3.1

1.5 Alignment process

Allowances will be made within the Primary Shielding to allow for the motion required to align both the DFM Cask and the CFX. The adjustment range required relative to the horizontal mounting surface on MACS will be ±10 mm in all directions. Overall cask alignment with respect to MACS shall ensure that the cask central axis coincides with the MACS central axis to within ±1 mm in the horizontal plane and ±2 mm in the vertical plane. The nominal vertical axis of the cask shall coincide with the vertical direction to within ±0.1 degrees. Additional alignment specifications may be provided in the sub-project specifications for the cask and the CFX.

1.6 Transport Requirements

All sub elements shall have provisions to ensure safe transport from the manufacturing facility to the NCNR room C-100

2. Subsystem Functionality

Table 1 specifies the locations of neutronic components along the MACS beam line as well as the conical incident neutron beam profile. Details on the functionality of all beam line elements are provided in separate specifications that are or will be accessible via the project web site at http://www.pha.jhu.edu/~broholm/MACS/.

2.1 Beam Tube

The MACS Beam Tube directs neutrons from the Cold Source to the shutter. The inside of the tube diverges with a 1.600-degree angle from the central axis (3.200 degrees total). The theoretical inner diameter of the beam tube closest to the Source is 181.8mm.The theoretical diameter at the intersection of the beam centerline and the face of the biological shield is 225.4mm. For details of the assembly, see figure 1.

The Beam Tube is fully contained within and supported by the Beam Port Assembly. Adequate provisions shall be provided to allow the Beam Tube to be installed, aligned, and leveled within the Beam Port.

The beam tube is filled with helium. The inner surface of the Beam Tube is the actual surface that is exposed to the neutron beam and the helium. The Beam Tube is provided with a helium supply line and a pressure monitor.

2.3 Shielding

Shielding developed for NG-0 shall follow the NIST guidelines for instrument shielding. The top surface of the shielding which generally covers NG-0 is the same height as the existing NG-1 to NG-7 roof shields. Allowances are required above the Beam line for both additional shielding above the roof and for removal of the CFX, Beam Choke Box, DFM Cask and Super-mirror Drum. Details of the outer profile which mimics the plan view of the .iges files provided by the JHU MACS Staff are shown in figures 2 12 & 13.

2.4 Shutter

The recommended shutter principal for NG-0 is a rotating drum contained within a rectangular cross section shutter box. A pedestal and top shield of the same rectangular cross section lie above and below the shutter box. The pedestal is equipped with leveling devices for the shutter assembly, and the top shield has allowances for the shutter drive shaft and motor mounting. The basic shutter dimensions are given in figure 3.

2.4.1 Mechanical Performance

The shutter drum is penetrated by four tapered through holes. The axes of the through holes are parallel to the central axis of the drum. The first and third holes agree with the primary operational positions and are separated by 180 degrees. The other two holes are reserved for future use. The primary holes contain the helium liner and the shutter plug in positions one and three respectively. The holes reserved for future use contain plugs that are filled with the same material as the internal cavities of the shutter drum and shutter box. The arrangement of the primary and future use holes allows for clocking of the drum in 10 steps per rotation (36 degree increments) to align the shutter positions with beam axis.

2.4.2 Travel Range, accuracy & speed

The operation of the shutter requires 180 degrees of drum rotation between the primary opening and the fully closed position. The time to perform the 180 degree rotation shall be less than or equal to 15 seconds. Detents or other mechanical restraining devices shall limit the position of the selected bore to **1/4 degree** corresponding to a linear distance of **1.2mm** relative to the beam centerline.

2.4.3 Actuation

The shutter is driven by a two-stage speed reduction system. The first stage is a right angle commercial speed reducer directly coupled to the shutter drive motor. The output from the speed reducer is directly coupled to the second stage reduction. The second stage reduction is a chain and sprocket set. The driven sprocket is directly coupled to the shutter drum.

2.4.4 Motors & Encoders

The shutter drive motor is on a vertical axis directly above the first stage (commercial right angle) reduction. A drive shaft that passes through the top shield connects the motor to the first stage reduction. The position encoder system consists of redundant shutter home sensors mounted directly to the shutter drum and relative position encoders attached to the motor shaft. An additional sensor shall be applied to the detent device to ensure proper actuation in the home and other operational positions.

2.4.5 Shutter Position Indicator Telegraph
The Shutter design shall include an easy to read position indicator for the shutter drum. The indicator shall be positively connected to the shutter drum, and shall have provisions for verifying that the indicator telegraph is properly functioning with each actuation of the shutter.

2.4.6 Component Access
The shutter first stage (commercial right angle) reduction shall be located on the shutter box face downstream from the source. Access to the first stage (commercial right angle) reduction shall be possible by removing a shield block that is positioned adjacent to the CFX. With the above mentioned shield block removed, the first stage (commercial right angle) reduction shall be mounted to be removable and replaceable. Access to the drive motor shall be relatively unrestricted as the motor is mounted above the shutter top shield.

2.4.7 Lifetime and Maintenance
The MACS shutter shall be capable of performing a minimum of 100k operations without requiring access to the shutter box.

2.5 Beam Choke Box
The Choke Box is a highly absorbent neutron shield that further defines the beam following the CFX. The PI and The NIST Engineering Manager shall guide material selection for the choke box. The final dimensions of the CFX and the DFM Cask will fix the beam line dimension (150mm to 180mm) The bore is tapered and is 315 mm to 325 mm in diameter. The outer surfaces (shell) of the Choke Box shall be centered on the bore axis. The width and height of the outer shell of the box are 600mm x 600mm minimum, and larger if space within the NG-1 to NG-0 shields permits. Figure 4 and figure 5 show the details of the choke box design.

2.5.1 Mechanical Performance
The Choke Box is a fully passive device. The only requirement for performance is that powdered material enclosed within the Beam Choke Box shell shall be adequately confined to prevent the material from escaping.

2.5.2 Mechanical Positioning
The WBC general shields shall be designed to allow the Choke Box to be easily extractable. The Choke Box rests on an element of the WBC shielding directly in front of the CFX. Nominal clearance between the shield walls and the Choke Box with the Choke Box installed is10mm. The Choke Box is kinematically mounted with a minimum total adjustment range of 12 mm along each axis. The Choke Box kinematic mounting locations are shown in figure 6.

2.5.3 Neutron absorbing Materials

The materials contained within the Beam Choke Box shall have neutron-absorbing qualities. The specific materials and the corresponding thicknesses are as follows:

Item	Material	Thickness
1	B4C	5 mm
2	Steel Shot & Wax	(L-10 mm)/2
3	B4C Powder & Wax	(L-10 mm)/2
4	B4C	5 mm
Total		L

2.5.4 Beam Choke Box Access

Access to the Choke Box shall be accomplished through an access lid located in the top face of the primary shielding roof. The shielding lid shall be constructed to allow easy assess to the Choke Box and provide sufficient radiation protection when installed while keeping the weight and size of the lid as low as is reasonable. Design details are shown in figure 7.

2.6 Get Lost Pipe

The Get Lost Pipe is an extension of the WBC general shields. The get lost pipe is designed to be sufficiently long to reduce the reflection of the neutron beam from the inner surface of the beam dump. The beam dump shields on the Guide hall tube side of NG-0 are a continuation of the WBC general shields. The rear face of the Get-lost pipe is positioned at the 10600mm datum, with the inner surface of the beam dump at the 9600mm datum. Accommodations within the Beam dump shall be made for a removable helium liner. The rear of the Beam Dump shall have a removable “Sighting Plug” for instrument alignment. The interlocking sighting plug shall be designed to minimize the Neutron Flux at the rear external face of the Beam Dump. Design details are shown in figure 8.

2.6.1 Mechanical Performance

The Get Lost Pipe is a fully passive device. The only requirement for performance is that helium leak rate is less than **0.04 cuft/hr.**

2.6.2 Access and Mechanical Positioning

The Get Lost Pipe rests on an element of the WBC shielding directly beyond the DFM Cask. The Get Lost Pipe is kinematically mounted with a minimum total adjustment range of 12 mm along each axis. The Get Lost Pipe kinematic mounting locations are shown in figure 9.

3 System Interfaces

The following are guidelines for the location, attachment and securing of MACS elements associated with, adjacent to, or enclosed within the WBC.

3.1 CFX Interface

The CFX rests on an element of the WBC shielding directly in front of the Shutter. Nominal clearance between the shield walls and the CFX with the CFX installed is10mm. Shielding above the CFX will provide the necessary clearances for the pneumatic filter actuators. Raceways will be provided for vacuum lines and signal and sense cabling. The CFX is kinematically mounted with a minimum total adjustment range of 12 mm along each axis. The CFX kinematic mounting locations are shown in figure 10.

3.1.1 CFX Access

Access to the CFX shall be accomplished by removing the shielding elements surrounding the CFX on the top face of the primary shielding roof. The shielding elements shall be constructed to allow easy assess to the CFX and providing sufficient radiation protection when installed while keeping the total weight and size of the shielding elements as low as is reasonable. Design details are shown in figure 11.

3.2 Primary Shield Interface

The WBC shielding shall be placed directly against the reactor biological shield face and the BT-6 and BT-7 near-reactor shielding, allowing only for minimal installation clearance. Shields shall be segmented appropriately to allow access to specific maintenance areas of the Biological shield such as the shim arm cabinet and features of BT-7 (or BT-6) that may require access. See Figure 12.

3.3 MBT (Monochromatic Beam Transport) Interface

The MBT consists of the elements associated with the location, support and operation of the super mirror guides. There is no direct interface between the moving portions of the MBT and the WBC. The WBC interfaces to the MBT on the BT-7 side of NG-0 at two places along the primary shield. The MBT shields shall be removable by translation in the BT-7 direction only, or vertical translation only. The MBT shields shall not require a combination of vertical and horizontal translation for removal. Nominal clearance between the shield walls and the MBT with the MBT installed is15mm. The WBC shields and the MBT shields shall be designed to interlock to minimize the Neutron Flux at the external shield face. Interface design details are shown in figure 13.

3.4 DFM Cask Interface

The DFM Cask is contained completely within a closed volume created by the inner surfaces of the WBC shields, the MBT shields, and the Get Lost Pipe shields. Access to the Cask is required over the entire top surface. This access shall take the form of a removable section or sections of the roof shields. A smaller opening in the roof shields shall allow access and removal of the DFM from within the DFM Cask. Nominal clearance between the shield walls and the DFM Cask with the DFM Cask installed is20mm (10 mm nominal clearance and 10 mm space for adjustment). Design details are shown in figures 14.

3.4.1 DFM Access Port

Access to the DFM shall be accomplished through an access port located in the top face of the DFM Cask. This port shall be easily accessible by removing a shielding lid that is somewhat larger than the corresponding access port. The shielding lid shall be constructed to allow easy assess to the DFM port and provide sufficient radiation protection when installed while keeping the weight and size of the lid as low as is reasonable. Design details are shown in figure 15.

3.5 NDS (Neutron Detection System) Interface

To function properly, the NDS requires clearance to the WBC at the extreme travel positions of the NDS. Abundant clearances are available for the distance between the reactor biological shield and the shielding along the BT-6 direction. Shielding has been optimized normal to Choke Box exit datum at 4105mm to produce a shield outer surface to beam line thickness of **1065 mm.** Similarly, shielding has been optimized normal to the Get Lost Pipe datum at 8000mm to produce a shield outer surface to beam line thickness of **600 mm**. Nominal clearance between the NDS and the WBC is 25mm at the extreme travel locations of the NDS. Design details are given in figure 16.

3.6 Top Shield Interface Summary

As stated in section 2.3 the MACS – NG-0 shields shall be constructed with the top surface of the shields above NG-0 coinciding with the top surface of the shields above NG-1 to NG-7 guides. In the previous sections details of the specific access requirements for each of the elements have been given. The details of the access requirements for the roof shields are summarized in figure 17.

4 Primary Sub-element Specifications

The following are secondary devices associated with the construction and are to be considered as deliverable items by the team associated with the WBC construction:

4.1 Kinematic Mounting System

The kinematic mounting systems associated with the location dimensions of the Shutter, CFX, Choke Box and Beam Dump Liner shall use a common system of ball-studs and supports. Details of the proposed kinematic mount system are shown in figure 18.

5. Computer Control

All functional elements within the WBC shall be controlled and monitored by the MACS instrument control computer. Specific elements are the Shutter (Position Monitoring), Beam Tube Insert (Monitor), and CFX (Control & Monitor). Raceways for cabling shall be integral with the shielding wherever possible.

The following commands shall be included as a minimum:

1. Abort all motion
2. Determine the setting of any actuator controlled by the MACS computer
3. Drive any actuator controlled by the MACS computer to a specified setting
4. Drive any actuator to any of its home positions and check against the encoder if applicable.

Additional requirements and information will be provided in a separate control interface specification.

6. Cryogenic Systems

Cryogenic systems for MACS shall employ closed cycle refrigeration systems. Connections for the cold head hookup will pass through the WBC shielding. Although insulation is not a requirement, raceways for refrigeration plumbing as well as CFX monitor cabling shall be integral with the shielding wherever possible.

7 Compressed Gas Systems and Vacuum Systems

7.1 Compressed Air

Actuation of the CFX is performed using standard air cylinders. Raceways for compressed air supply lines shall be integral with the shielding wherever possible.

7.2 Compressed Helium

Compressed helium will be required to maintain a helium atmosphere in the DFM Cask and Super Mirror Guide Drum and the Get Lost Pipe. Compressed helium may be required to maintain a helium atmosphere in the Beam Tube. Raceways for compressed helium supply lines shall be integral with the shielding wherever possible.

7.2 Vacuum Systems

The CFX and MCFX require High Vacuum for proper performance. A centralized Vacuum pump will provide vacuum to these devices. Raceways for vacuum lines shall be integral with the shielding wherever possible.

8 Additional Specifications

The following additional specifications apply to the construction of the WBC:

8.1 Commercial Hardware

Where ever possible, metric threads and fasteners shall be utilized. Exceptions will be treated on a case-by-case basis. The lifting eye receivers are a notable exception; inch threads shall be used.

8.2 Custom Components

Off the shelf components shall be the standard. Exceptions will be made on a case-by-case basis.

8.1.3 Electrical Connectors

TBD (Nick Maliszewskyj)

8.1.4 Power & Communications

TBD (Nick Maliszewskyj)

8.1.5 Shielding

TBD (Colin L. Broholm & Paul Brand)

8.1.6 Cable Management

Accommodations for cables and gas lines shall be provided to permit removal of the roof shields with out requiring disconnection. Where ever possible cables shall be routed through raceways integral to the primary shielding.

8.1.6 Paint & Surface Finishes

TBD (Paul Brand)

8.1.7 Inspection & Test

TBD (T. D. Pike & Paul Brand)

9 Project Contacts

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Electrical & Software	Nick Maliszewskyj	301.975.3171	nickm@nist.gov

Element		ΔX	ΔXi	ΣΔXi	x	y	2y	2Y
						Radius	Diameter	Clearance
Theoretical Beam Convergence Point					**-1600**	0		Diameter
Cold Source Face					0	44.7	89	101
Beam Hol	184 ref				1654	90.9	182	205
Face of Bio Shield @		781			2435	112.7	225	254
Forward Edge of Bio Shield					2600	117.3	235	264
Shutter In					**2650**	118.7	237	267
Anti-Streaming Dome (In)			50		**2700**	120.1	240	270
Anti-Streaming Dome (Out)			50		**3400**	139.7	279	314
Shutter Out			700	800	**3450**	141.1	282	317
Cryo Filter Exchanger			CFX	450	**3475**	141.8	284	319
Sapphire	in	43	150		**3518**	143.0	285.9	322
	out	7			3668	147.1	294.3	
Beryllium	in		100		**3675**	147.3	294.7	332
	out	7			3775	150.1	300.3	
Pyrolytic Graphite			100		**3782**	150.3	300.7	338
	out	43			3882	153.1	306.3	
					3925	154.3	309	347
		10						
Choke	Entrance	170			**3935**	154.6	309.2	348
	Exit				4105	159.4	318.7	359
		20						
Cask In					**4125**	159.9	319.8	360
		25						
In-line Collimator Exchanger			ICX	355	**4150**	160.6	321	361
			140		4290	164.5	329	370
		5			**4295**	164.7	329	371
			210		4505	170.5	341	384
		45						
Variable Beam Aperture			VBA	205	**4550**	171.8	344	387
			100		4650	174.6	349	393
		5			**4655**	174.7	349	393
			100		4755	177.5	355	399
Monochromator			DFM					
eading Edge		38			**4793**	178.6	357	402
Axis	35°	300			**5093**	187.0	374	421
Axis	90°		Total Travel		**6200**	217.9	436	490
Axis	105.4°		1757		**6413.5**	223.8	448	504
Axis	130°				**6850**	236.0	472	531
railing Edge					**7150**	244.4	489	550
		125						
Cask Out				3150	**7275**	247.9	496	558
		2325						
Beam Dump					**9600**	312.8	626	704

Table 1 1.600 Degree Divergence Beam Equation

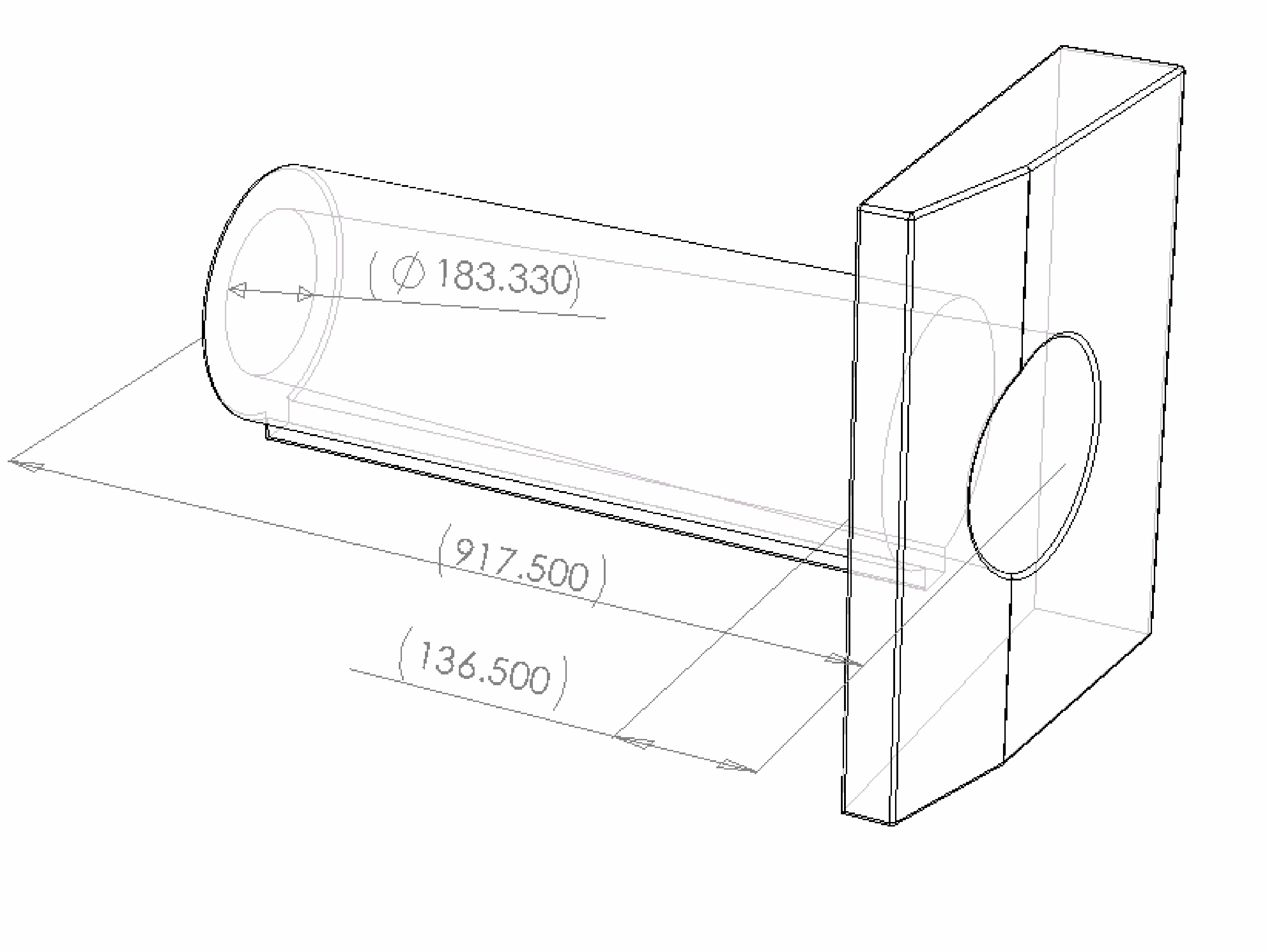


Figure 1. Beam Tube and Helium Liner

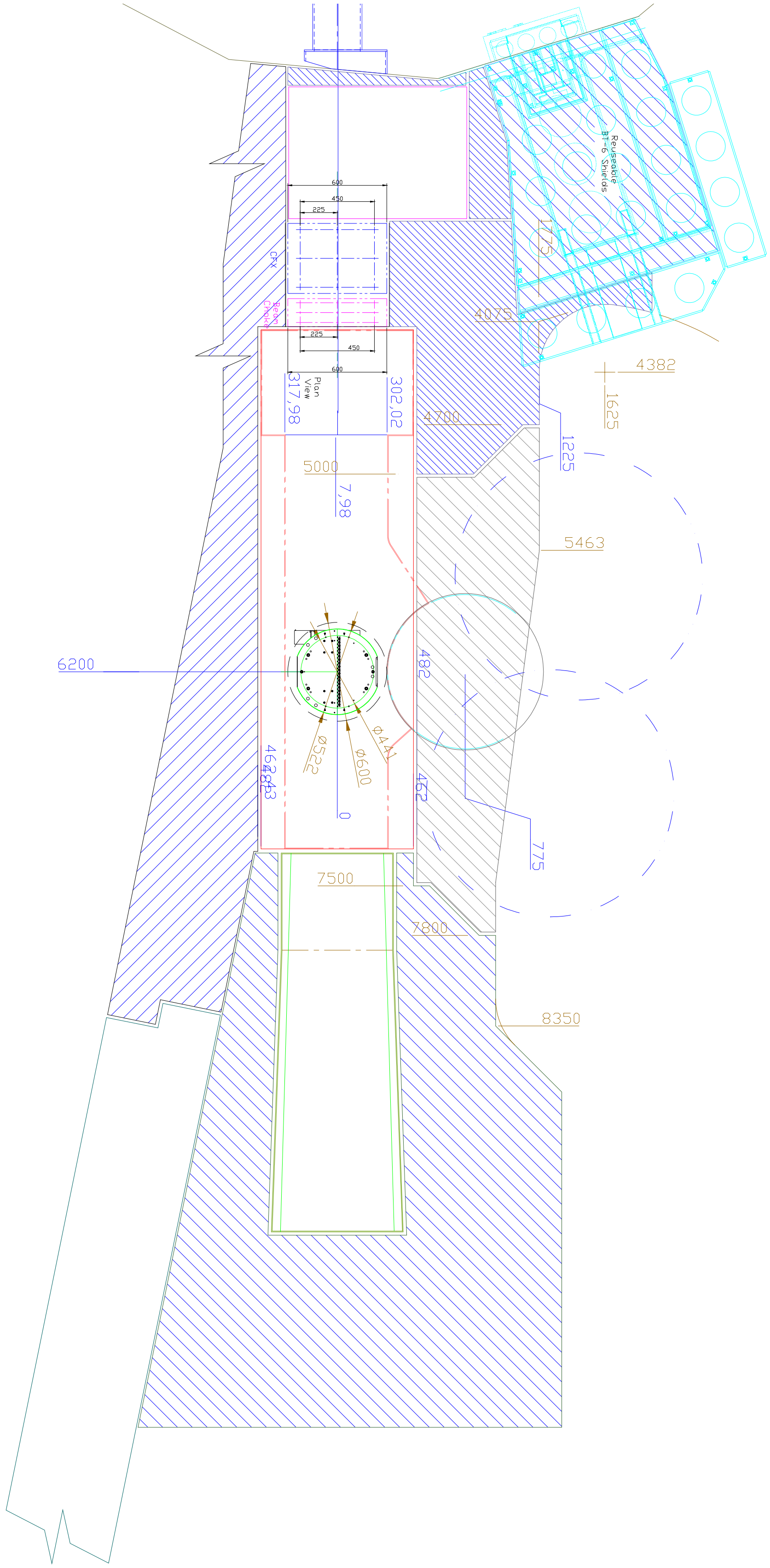


Figure 2. General Layout of Shielding

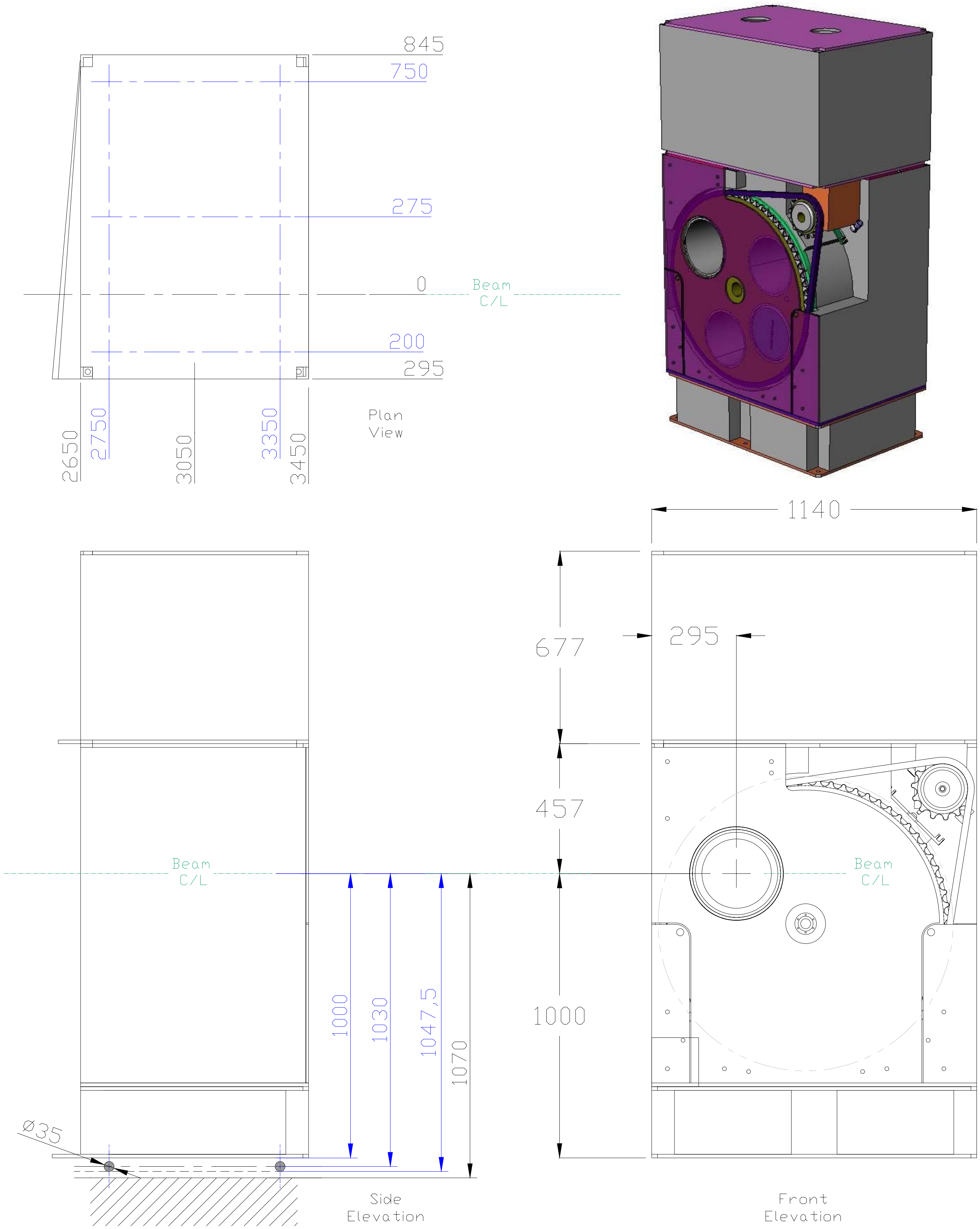


Figure 3. Shutter and Shutter Kinematic Mounting

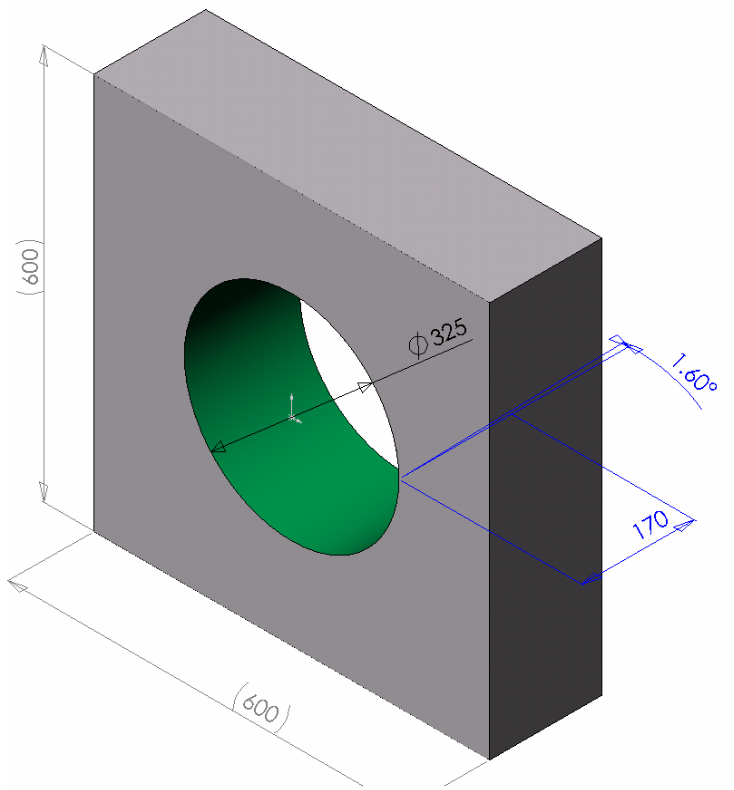


Figure 4. Beam Choke Box General Dimensions

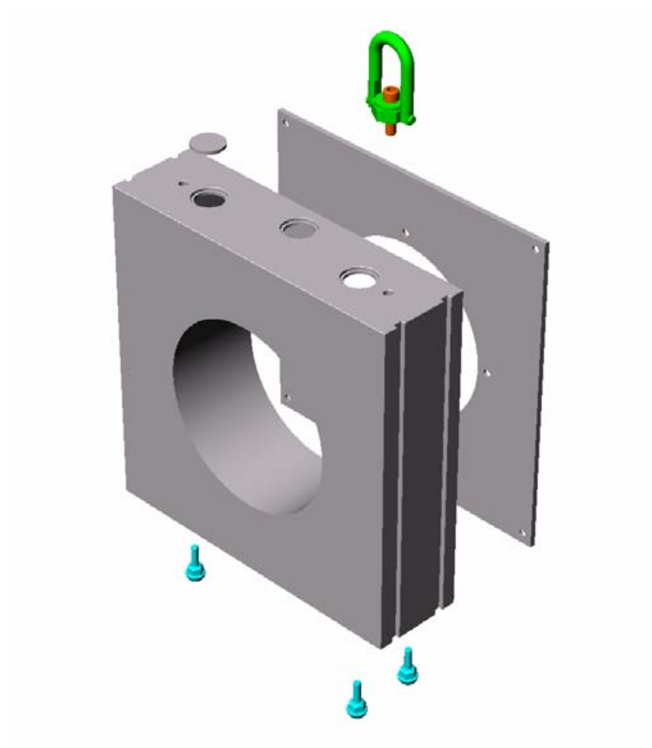
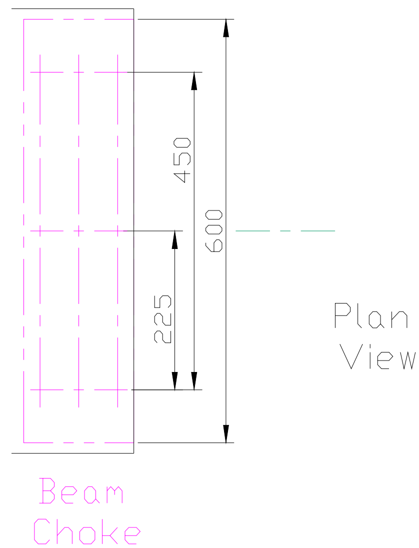


Figure 5. Beam Choke Box Detail Elements



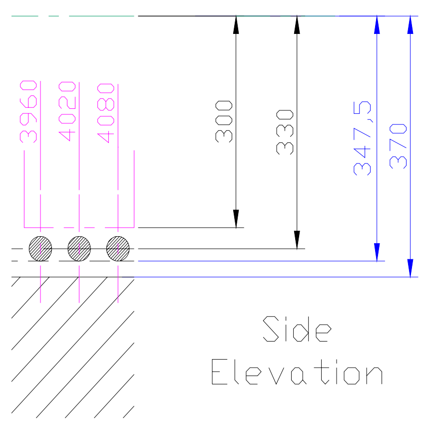


Figure 6. Choke Box Kinematic Mounting

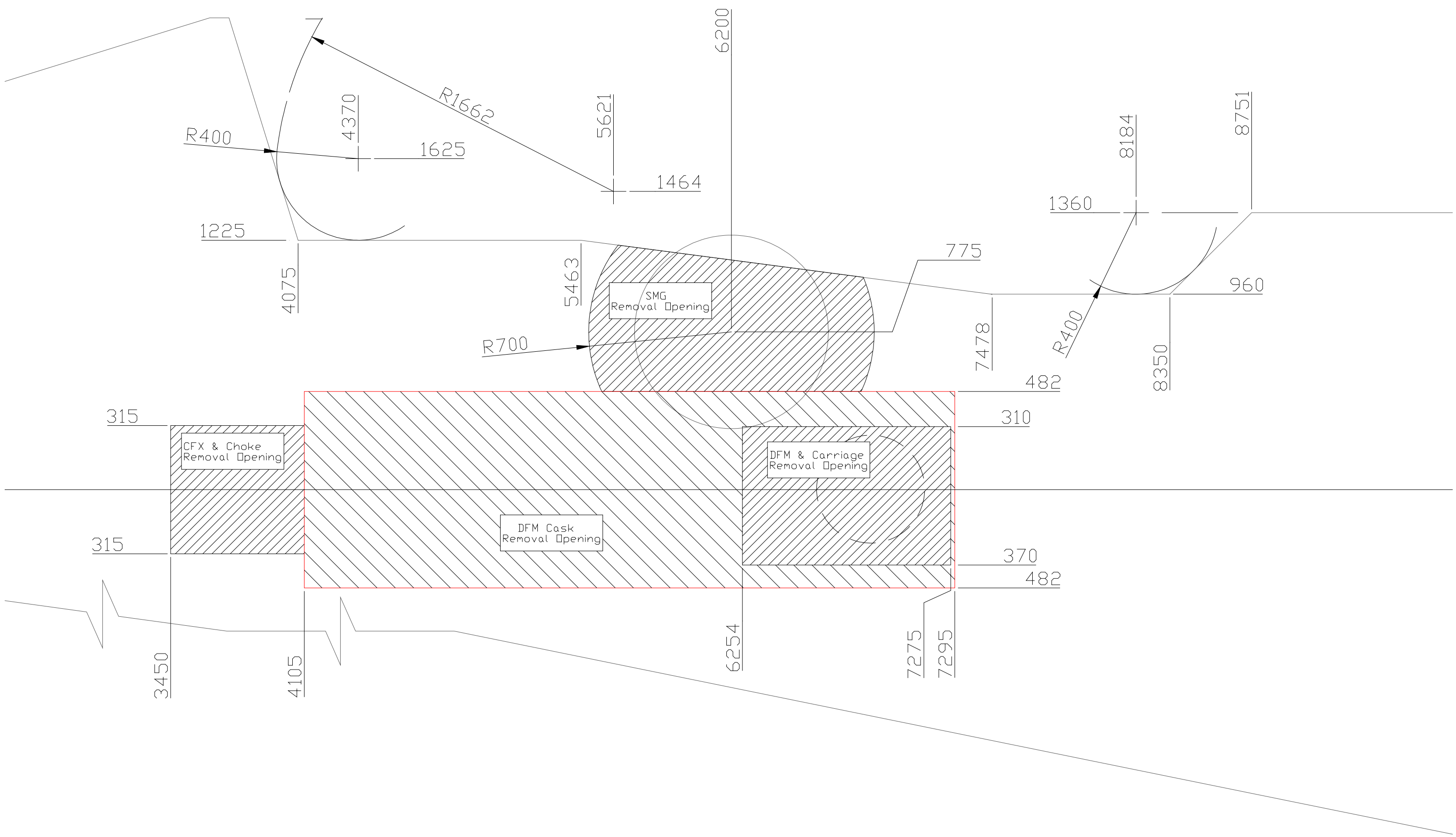


Figure 7. Shield Access Areas

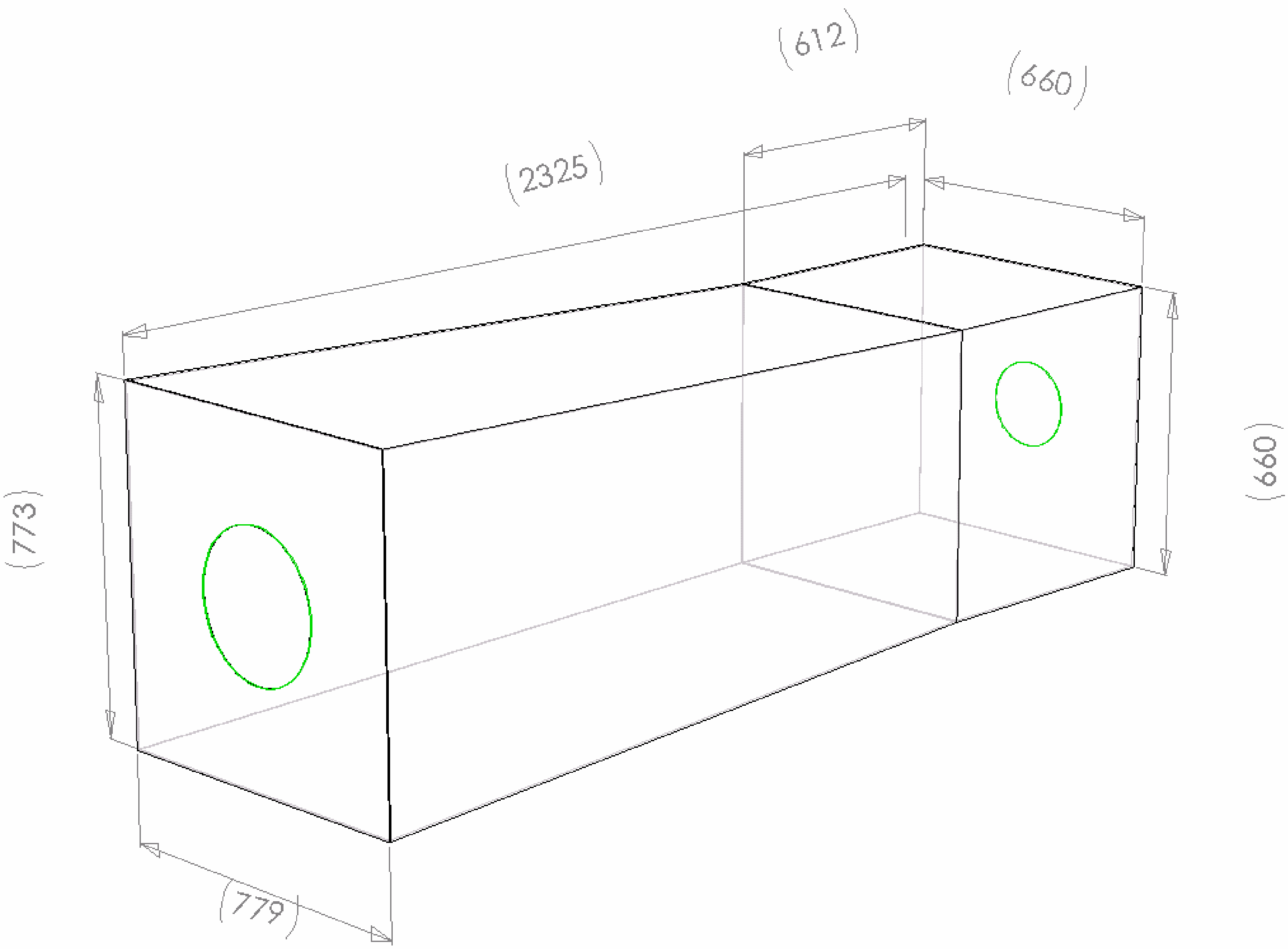


Figure 8. Get Lost Pipe Interface

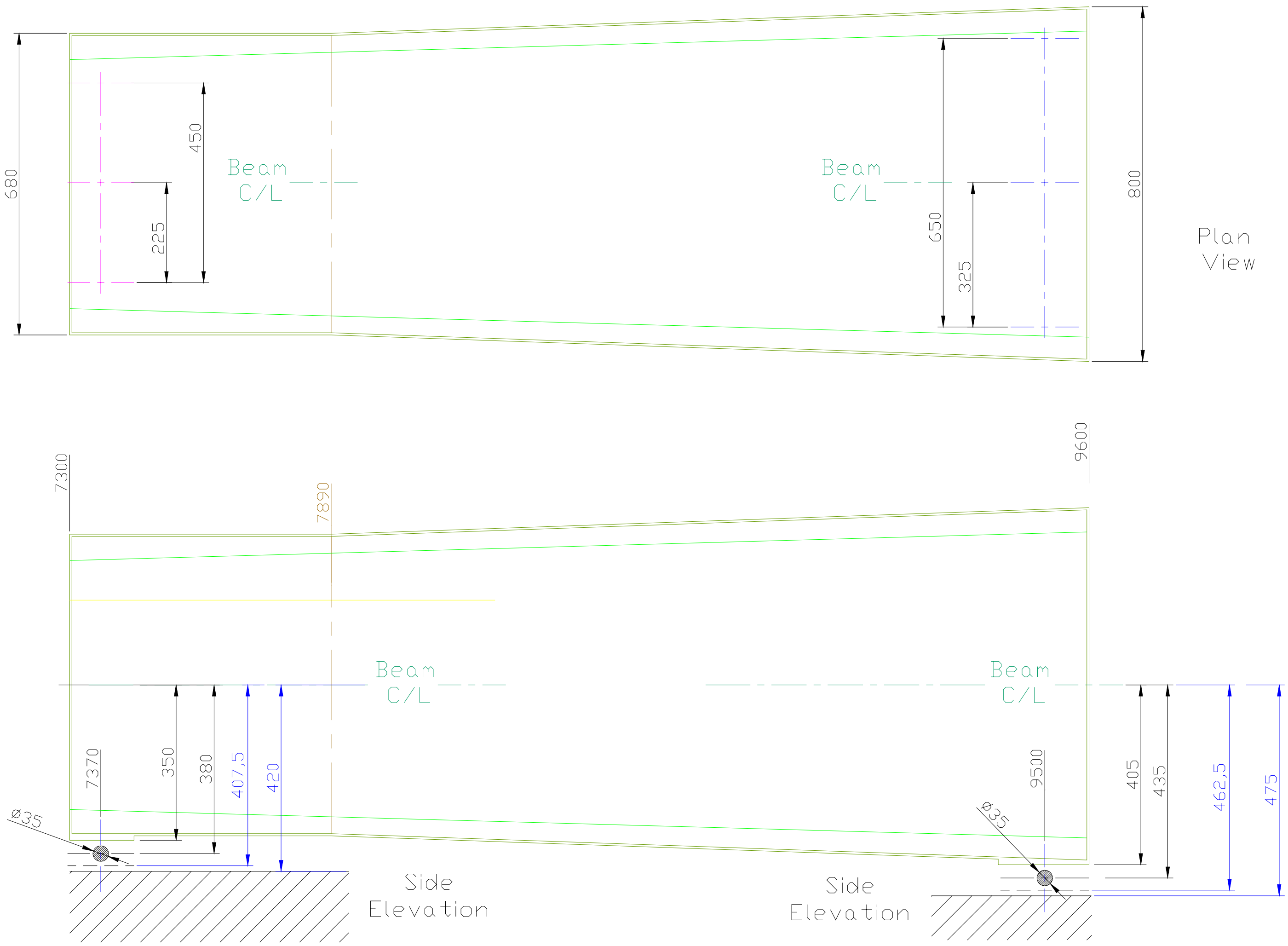
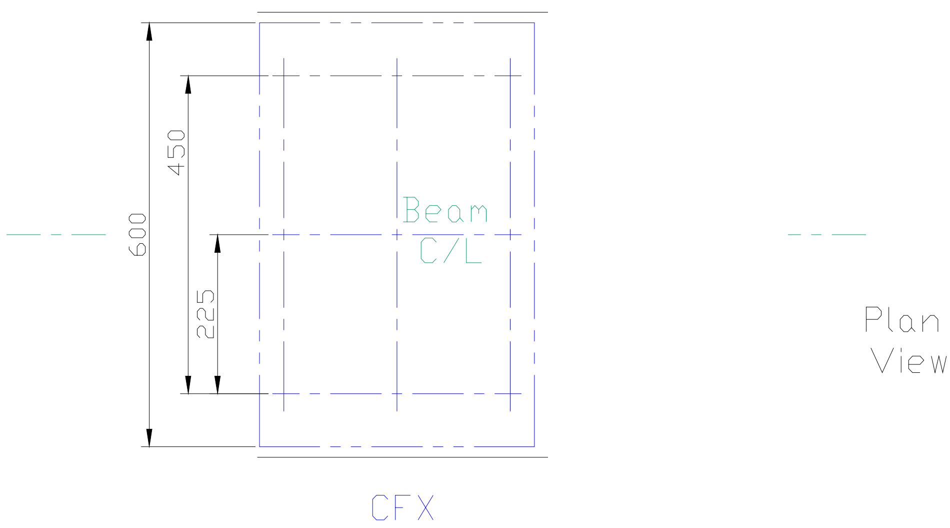


Figure 9. Get Lost Pipe Interface



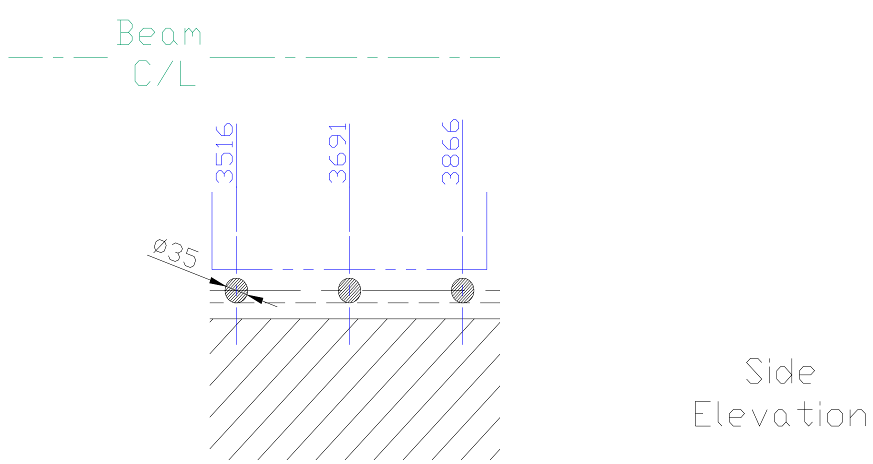


Figure 10. CFX Kinematic Mounting

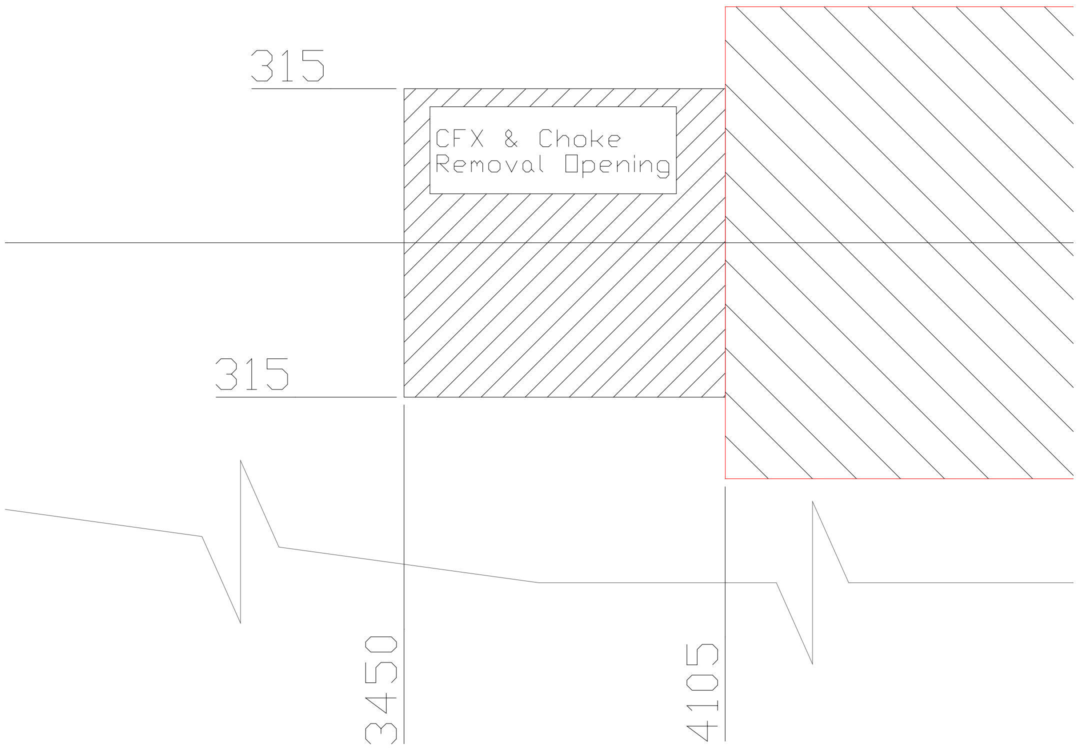


Figure 11. CFX Access Area

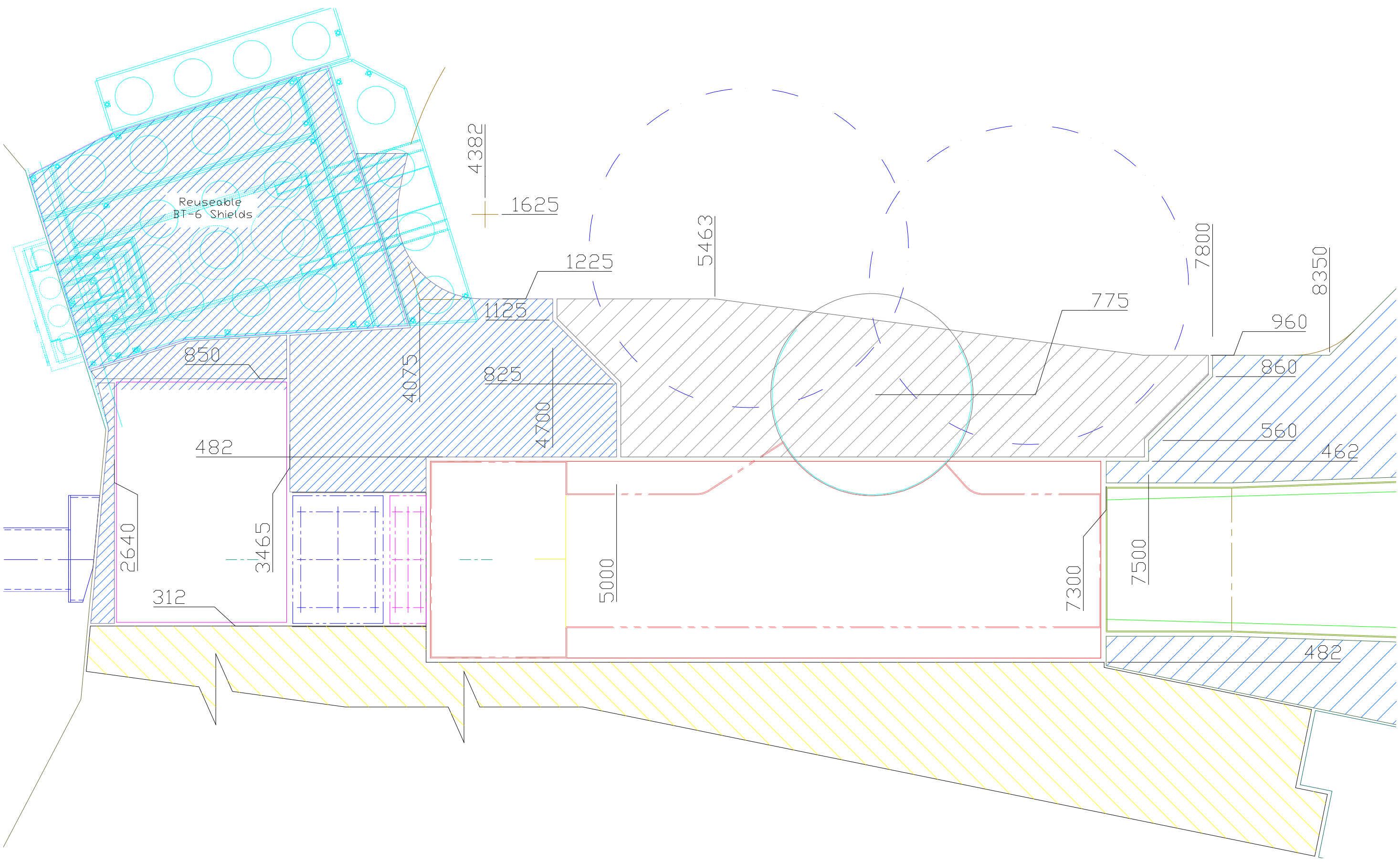


Figure 12. Primary Shielding Interfaces

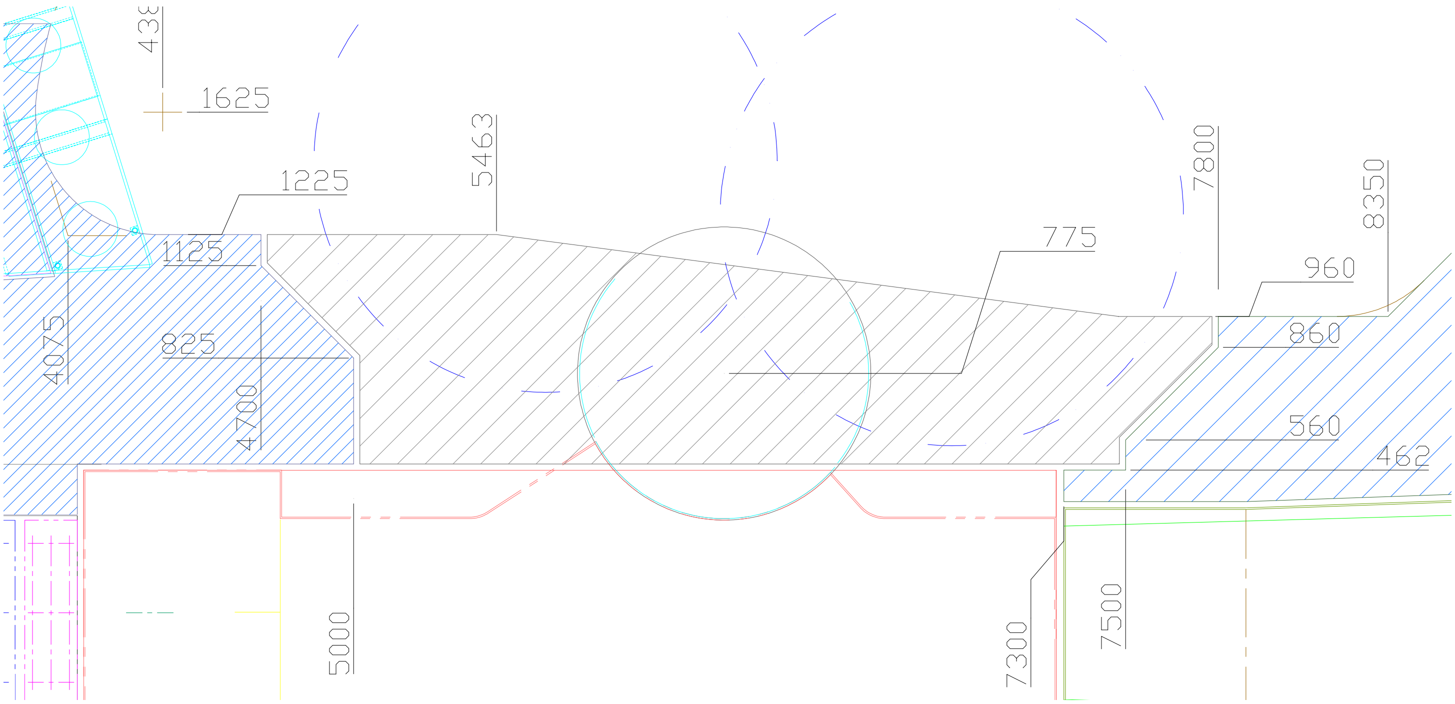


Figure 13. MBT (Monochromatic Beam Transport) Interface

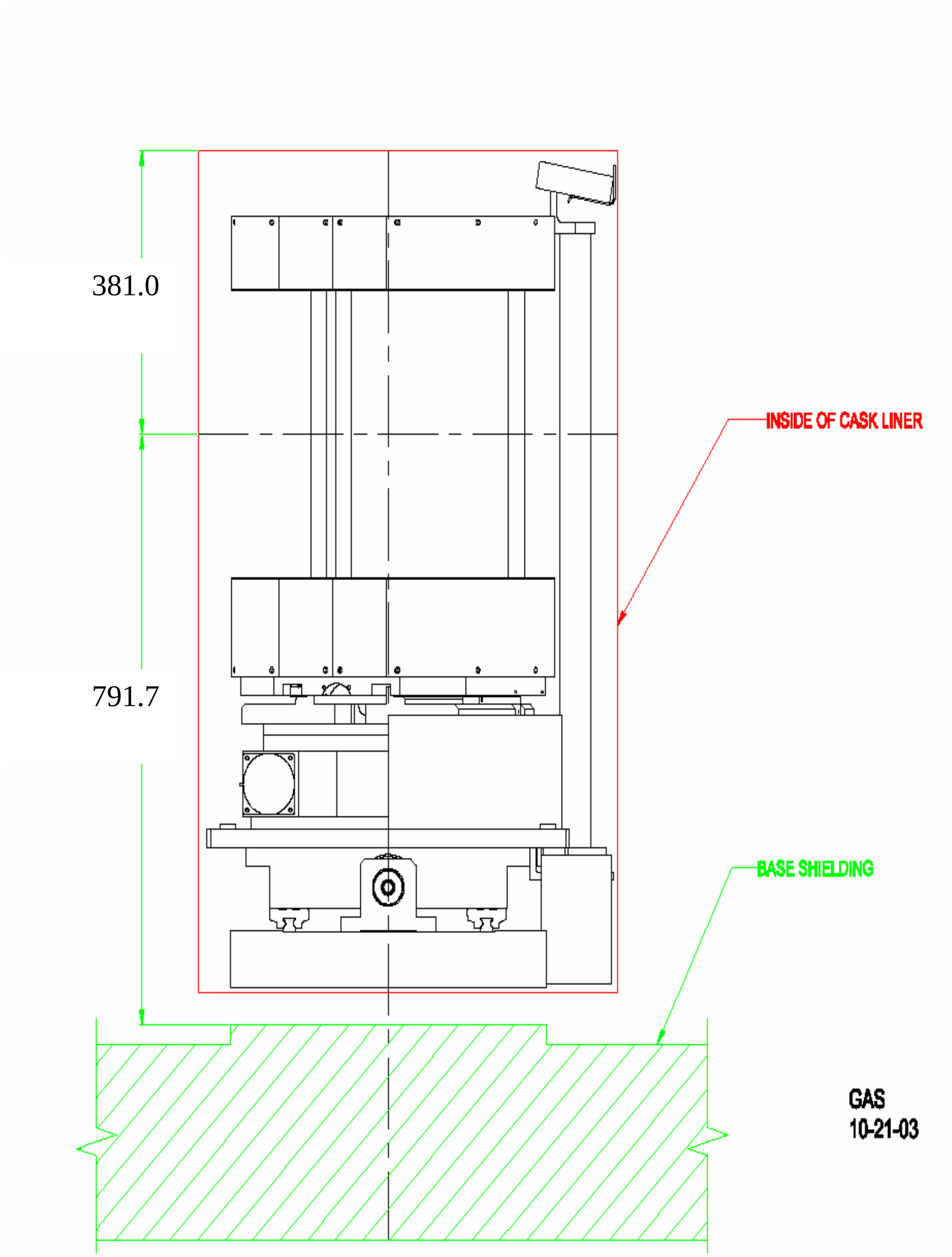


Figure 14. DFM Cask Interface

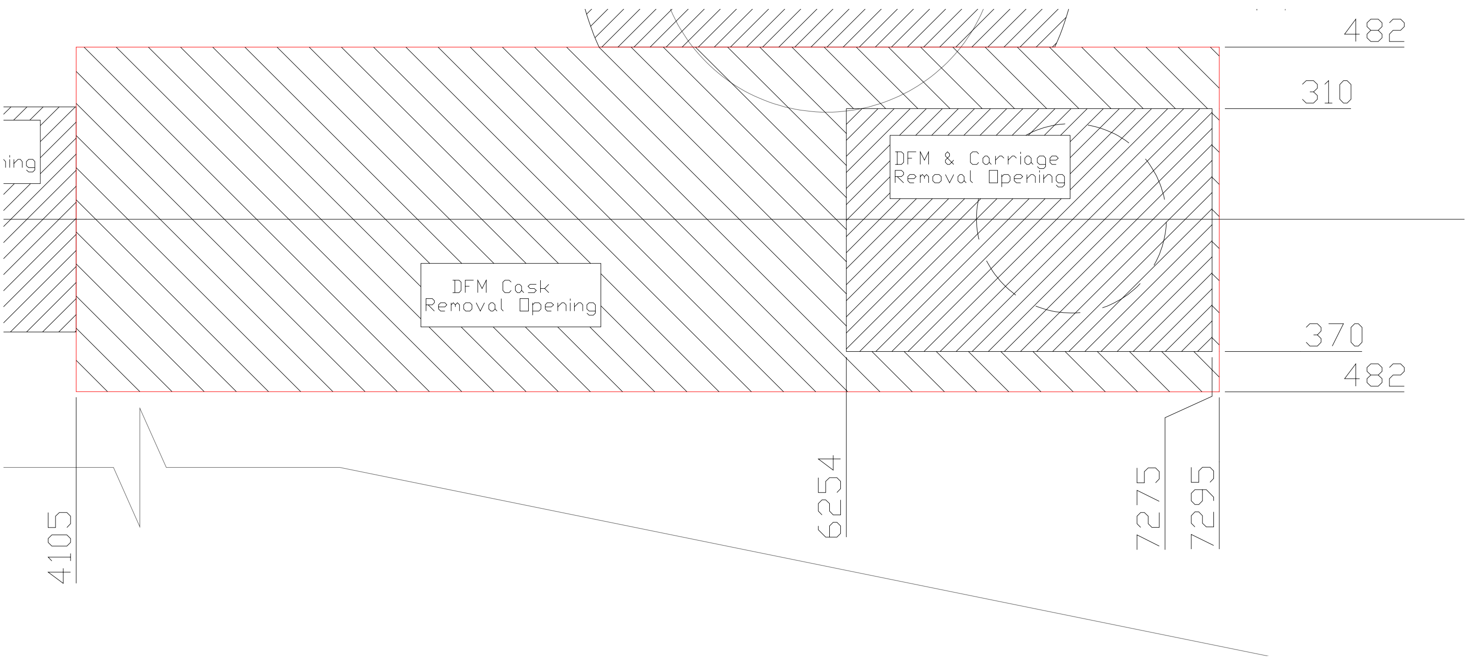


Figure 15. DFM Cask Access

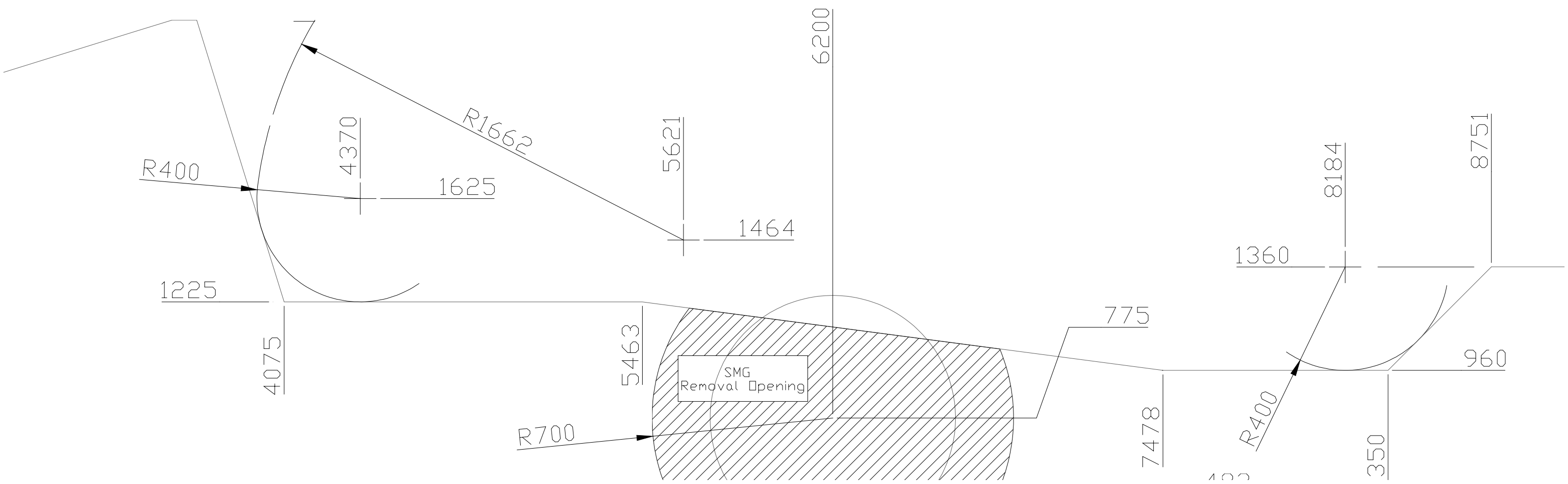


Figure 16. NDS (Neutron Detection System) Interface

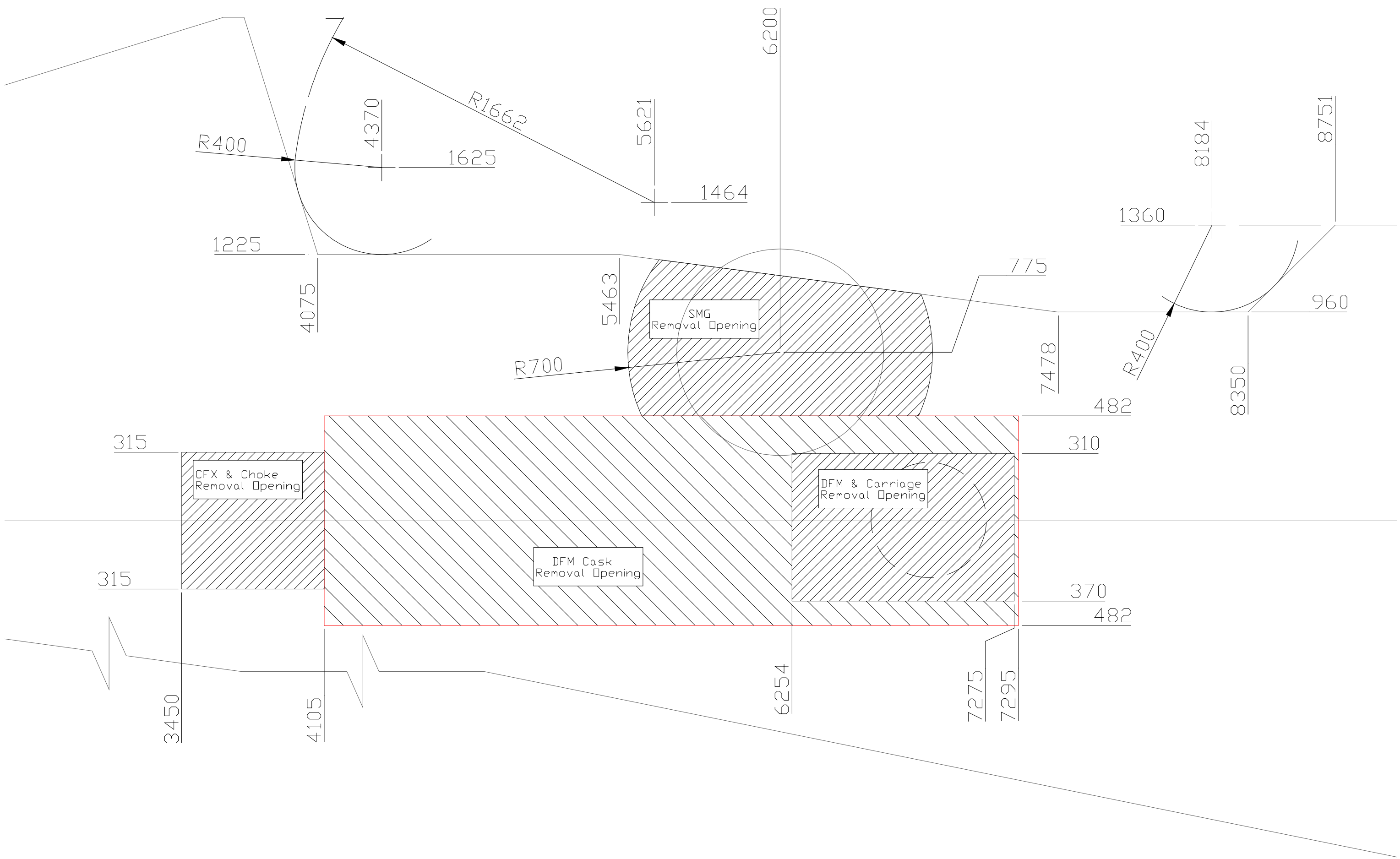
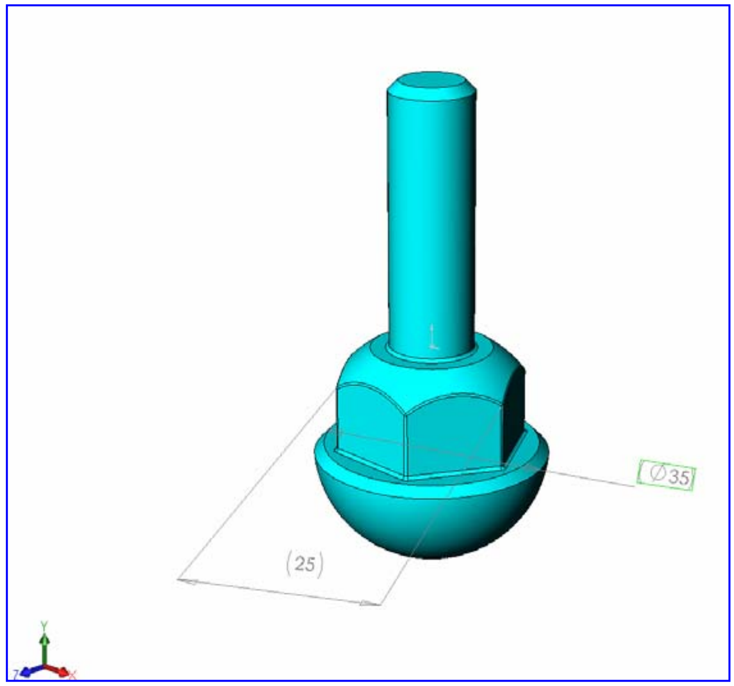
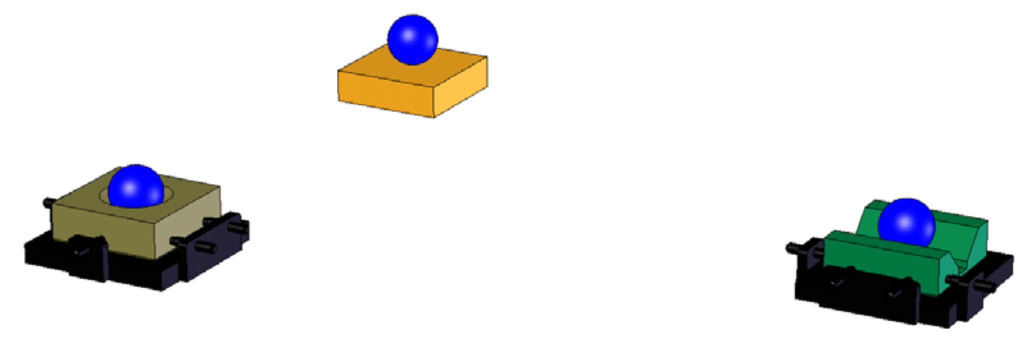


Figure 17. Top Shield Interfaces





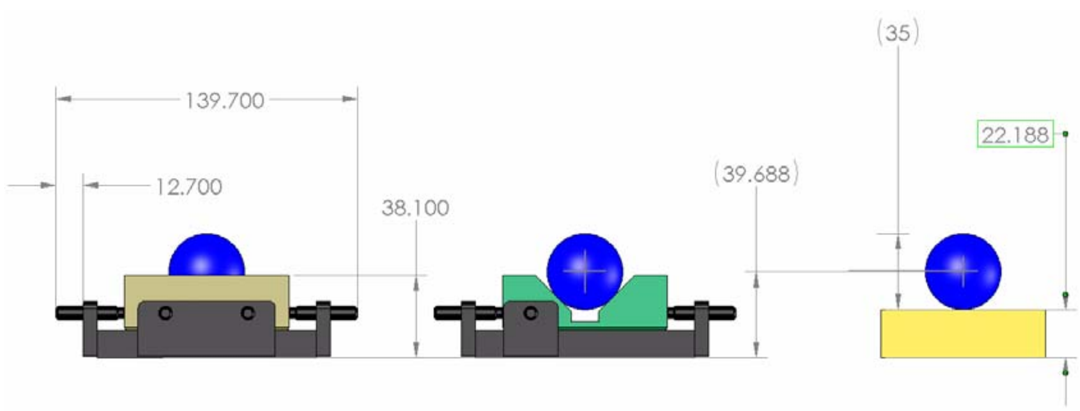


Figure 18. Kinematic Mounting System