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Project	MACS			Revision ☐
Originator	T. D. Pike	If revision, provide the following:		
Date	December 20, 2003	Previous Submittal		
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Scope

Specification for the MACS Monochromator Cask

Purpose

To provide specifications for the MACS monochromator cask so the corresponding sub-project can proceed in parallel with development of the rest of MACS.
To submit solid body into One Space to represent bounding box.

Description

Text and images that specify the requirements for the monochromator cask and that define the interface with the rest of MACS. The mechanical interface is defined in terms of a hard bounding box to which there must be a specified internal clearance. The accompanying solid body included in this submission to the C-100 data base further describes this bounding box.
Search in MM for "macs_cask_bounding_box" part number 038-2487.

Filing	Change Process
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.	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)

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General Specification for Development of the DFM Cask

for the

Multi-Axis Crystal Spectrometer (MACS)

National Institute of Standards and Technology

Center for Neutron Research

Specification NG-0 –2 DFMC

Revision 5b

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1. Overall Specifications

The MACS monochromator cask contains all elements associated with controlling the neutron illumination and the location of the doubly focusing monochromator for MACS. The neutronic input is a diverging cold neutron beam with a circular cross section. The neutronic output is a converging, monochromatic neutron beam trimmed to a rectangular cross section and emanating in a specific direction from a specific location along the incident beam line.

1.1 Bounding box dimensions

The cask sub-project shall occupy the overall bounding box described in Figures 1, 2, 4, 7, and 8, and through the solid body in the accompanying IGES file. Clearance from the cask to the bounding box shall be at least 15 mm in horizontal directions and above the cask.

1.2 Materials and overall shielding requirements

There is an overall requirement that all volume within the cask 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. Hatched in red, Figure 4 and Figure 7 show a particularly important internal shielding element required by this stipulation. Materials types employed are listed below:

1. Structural Aluminum 6061-T6
2. Structural Steel
3. Pure Aluminum alloy 1100
4. Bulk shielding material:
    a. 55% (volume fraction) steel shot in 45% wax held in a closed steel containment vessel.
    b. B_4C powder backfilled with wax in a closed steel containment vessel
    c. Laminations of high density polyethylene and Steel
    d. Hot Isostatic Pressed (HIPD) B_4C
5. Void filling shielding material: 20%-50% B_4C loaded plastic materials such as polyurethane or polyethylene.
6. Shielding materials for cladding
    a. ^{10}B:Al (1mm or 6mm sheet stock)
    b. HIPD B_4C
7. Other specialty materials as required

Windows through which the neutron beam will propagate shall be made from 1100 aluminum and have a thickness that is to be minimized and that shall not exceed 1 mm.

1.3 Shielding & Construction Considerations

Six functional element types determine the Cask volume:

1. Helium containing shell
2. Neutronic devices (DFM, ICX, VBA)
3. Neutronic device swept volumes (DFM, ICX, VBA)
4. Beam path
5. Beam windows
6. Shielding

The Cask sides, top and bottom shall be fabricated from mild or stainless steel. The construction of the external surfaces of the helium liner shall be generally smooth and developed from primary solid volumes. External protrusions greater than 2 mm shall be minimized. Close to and within functional elements there will be complex voids that are challenging to fill with shielding for compliance with 1.2. As a general rule, individual and contiguous voids with volumes greater than 100 cm^3 shall be filled. However, additional cost or operational complexity must be balanced against the background reduction that can be achieved. In questionable cases Collin Broholm will decide whether or not to shield specific volumes>100 cm^3. All internal surface of the cask down stream of the variable beam aperture and where neutron transmission is not required shall be clad with non-hydrogen containing material that is highly absorbent to thermal neutrons. The default choice for cladding needed to satisfy this requirement shall be 1 mm thick ^{10}B:Al. The floor of the cask and the DTS are exempt from this overall requirement.

1.4 Attachment to MACS

The Cask shall be fully self-supporting on two horizontal contact pads with a vertical tolerance of $\pm$ 0.2 mm. The nominal distance from these surfaces to beam height shall be 817 mm. The dimensions and locations of, and the fixtures required on these surfaces, are to be defined by the cask sub-project and reported back to the project engineer. Installation and removal of the cask and its components shall be possible using an overhead crane.

1.5 Alignment process

The relative alignment of the ICX, VBA, and DTS within the cask shall be performed optically and/or mechanically to within the tolerances described below. Internal alignment and verification of such is the responsibility of the sub-project. The internal alignment shall remain true following removal and re-installation of the ICX, VBA, or DFM. Adjustment capabilities shall be devised so that the cask can be accurately aligned with respect to the incident beam line using standard optical techniques. The adjustment range required relative to the horizontal mounting surfaces on MACS will be $\pm$10 mm in the horizontal plane. Overall cask alignment with respect to MACS shall ensure that the cask central axis coincides with the MACS central axis to within $\pm$1 mm in the horizontal plane and $\pm$2 mm vertically. This alignment shall remain true upon removal and subsequent reinstallation of the cask. The process of removing the cask and then reinstalling it back to an aligned condition shall be as simple as reasonably achievable.

2. Internal 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/ . In the following we focus on internal cask interfaces.

2.1 Helium Containment

The cask shall hold a low positive pressure of helium to reduce neutron scattering losses and minimize radioactive argon production that would be incurred in an air environment. The cask is not intended to be a high integrity sealed vessel, rather it is a semi-permeable structure that presents a constant and relatively low <0.3 cuft/hr leak rate to C-100 internal helium source. There shall be two helium access ports at diagonally opposing corners of the top plate of the cask. Feed lines shall be detachable and the interfaces radiation hardened. The specifications for these interfaces shall be devised by the sub-project and provided to the project engineer.

2.2 In Line Collimator Exchanger (ICX)

Overall requirements for the ICX are provided at http://www.pha.jhu.edu/~broholm/MACS/archive.htm. The development specification for the ICX will be provided under separate cover. The ICX shall be vertically actuated by means of pneumatic cylinders supplied with shop air (100 psi). Seals for the shaft penetration into the cask shall be radiation resistant and provide a 5-year nominal life. Cask wall segments shall be provided that will allow removal of the ICX along a vertical line of travel. Detachment and removal of the ICX vertically from the cask shall be possible without requiring that human body parts enter the cask. The central axis of the ICX shall coincide with the cask beam line axis to within $\pm 0.05^{o}$ and 1 mm at the location of the device. Tolerance for rotational alignment around the beam axis shall be $\pm 0.1^{o}$. The location of the ICX along the beam line shall be consistent with 1.1 and with the information in table 1 to within 1 mm translation along the beam axis. When the DFM is rotated to face the ICX, the central axis of the ICX shall intersect the center of the DFM to within ±0.5 mm horizontally and ±1 mm vertically. Specifications will be provided for the air cylinder manufacturer and model data used in other areas of MACS. Direct compatibility is very strongly encouraged.

2.3 Variable Beam Aperture (VBA)

Overall requirements for the VBA are provided at http://www.pha.jhu.edu/~broholm/MACS/archive.htm . The development specification for the VBA will be provided under separate cover. VBA actuation and position sensing shall be completely contained within the cask. The centerline of the VBA shall lie on the cask beam centerline to within 0.5 mm. The plane of the aperture shall be normal to the central axis of the cask to within $\pm 0.2^{o}$. Tolerance for rotational alignment around the beam axis shall be $\pm 0.2^{o}$. The location of the VBA along the beam line shall be consistent with 1.1 and with the information in table 1 to within 1 mm translation along the beam axis. Cask wall segments shall be provided that allow removal of the VBA along a vertical line of travel. Detachment and removal of the VBA from the cask shall be possible without requiring that human body parts enter the cask. VBA cables shall be combined with all other cask cables to exit the cask at a common bulkhead feature on the top plate.

2.4 DFM Transport System (DTS)

Overall specifications for the DTS and the DFM are available at http://www.pha.jhu.edu/~broholm/MACS/archive.htm . The DTS provides precision remote controlled translation of the DFM along the beam axis. As for all other elements within the cask, the DTS system shall be designed to minimize void space for maximum utilization of neutron shielding materials as specified in section 1.3. DTS cables shall be combined with all other cask cables to exit the cask at a common bulkhead feature on the top plate.

2.4.1 Actuation

The DTS shall be a direct drive mechanical system based on a ball-screw drive. The drive motor and position resolver and all associated hardware shall be completely contained within the Cask. The motor shall be placed to allow removal and replacement without requiring the removal of other major elements within the Cask. The drive motor and resolver shall be selected by the cask sub-project engineers in consultation with Nick Maliszewskyj.

2.4.2 Range, accuracy, and speed of travel

The range of travel shall be 20 mm beyond that which is required by table 1. This corresponds to 1127 mm up-stream (5073) and 670 mm down-stream (6870) from reference position (6200) for a full travel of at least 1797 mm. There shall be home switches within the cask that are activated at the reference location and at the extreme ranges of travel with $\pm$0.5 mm reproducibility. The DTS shall be capable of providing full travel of the DFM in less than 30 seconds. The positional accuracy for the DTS shall be $\pm$0.5 mm in all directions.

2.4.3 Cable management

A cable management system shall safely propagate cables attached to the mobile DFM system to a stationary bulkhead interface on the cask top plate. The cask and DTS shall be designed such that no crash condition involving the DFM or associated cables is possible when operating the DTS, the DFM rotation, and the DFM translation.

2.4.4 DFM Access

The DFM shall be removable and re-mountable from a specific location along the travel path. Cask access segments shall be provided that will allow removal of the DFM along a vertical line of travel. Detachment and removal of the DFM from the cask shall be possible without requiring that human body parts enter the cask. Electrical connections from the cask to the DFM shall be made via a blind mate connector that is readily detached and re-connected from above the cask.

2.4.5 Lifetime and Maintenance

The motive and bearing systems shall allow for 100,000 full travel cycles for the DFM over the anticipated device life of 20 years. Lubricants shall be selected to be unaffected by the high radiation environment for the life of the unit (or specific scheduled maintenance in not less than 3 year intervals).

2.5 Beam Entrance and Exit

The DFM cask receives the filtered “White” beam from the Cryo Filter Exchanger. The Monochromated beam is directed to the Super Mirror Guide, and the remaining neutrons pass on to the beam dump. To reduce losses and minimize scattering the beam windows shall be constructed from Pure Aluminum (Alloy 1100) and their thickness shall not exceed 1 mm.

2.5.1 Beam Entrance

The entering “White” Beam window shall be circular with a diameter of 325 mm $\pm$ 5mm at the 4094 mm position. Material surrounding the window is beam defining and shall be clad by or made from ^{10}B:Al or HIPD B_4C with the greatest possible thickness given external and internal constraints.

2.5.2 Beam Exit
Following the monochromator, the beam continues to the beam dump through a beam exit window. The diameter of the window shall be at least 575 mm at the 7450 mm position.

2.5.3 Monochromated Beam Exit
Between the DFM and the focal point of the DFM lies the Super Mirror Guide (SMG). The SMG resides within a drum of diameter 900 mm. The cask window conforms to the circular surface of the SMG. The Monochromated beam exit shall be the surface of a 940 mm diameter cylinder, 310 mm tall and traversing 55 degrees up beam and 40 degrees down beam. The center of the cylinder is located 775 mm from the transit axis of the DFM at the reference (90 degrees, 6200 mm) position of the DFM.

2.6 Computer control
All functional elements within the cask shall be controlled via the DFM computer. The DFM control computer in turn receives commands from the MACS instrument control computer via an RS232 interface. A communication interface shall be proposed by the cask sub-project and approved by project level review. To the extent possible all communication to and from the DFM control computer shall be in terms of the natural physical dimensions that are involved. For example the DTS should be addressed in terms of the distance from DFM to source as measured in mm.

The following commands shall be included as a minimum:

1. Abort all motion
2. Report the status of motion for any controlled actuator
3. Determine the setting of any actuator controlled by the DFM computer
4. Drive any actuator controlled by the DFM computer to a specified setting
5. Drive any actuator to any of its home positions and check against the encoder if applicable.
6. Select one of the four collimation options
7. Set up the monochromator for monochromatic focusing at a specified energy. The command translates the DFM to the required location, rotates the device, and sets the DFM blades and the vertical focusing as required.
8. Set up the monochromator for non-monochromatic focusing with a specified average scattering angle and overall DFM rotation angle. The command translates the DFM to the required location, rotates the device, and sets the DFM blades and the vertical focusing as required.

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

3. Additional Specifications

Additional specifications will be provided for the following:

- Paint & Finish
- Steel Shot & Wax
- Interfaces to other MACS elements
- Inspection & Test procedures

Project level approval is required for the following;

- Electrical Connectors
- Power & Communications Standards

Project Engineering Contacts

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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	43	150		**3518**	143.0	285.9	322
	7			**3668**	147.1	294.3	
Beryllium		100		**3675**	147.3	294.7	332
	7			**3775**	150.1	300.3	
Pyrolytic Graphite		100		**3782**	150.3	300.7	338
	43			**3882**	153.1	306.3	
				3925	154.3	309	347
	10						
Choke Entrance	120			**3935**	154.6	309.2	348
Exit				**4055**	158.0	315.9	355
	39						
Cask In				**4094**	159.0	318.1	358
	56						
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
	300						
Cask Out	2150		3356	**7450**	252.8	506	569
Beam Dump				**9600**	312.8	626	704

Table 1 1.600 Degree Divergence Beam Equation Rev. 5

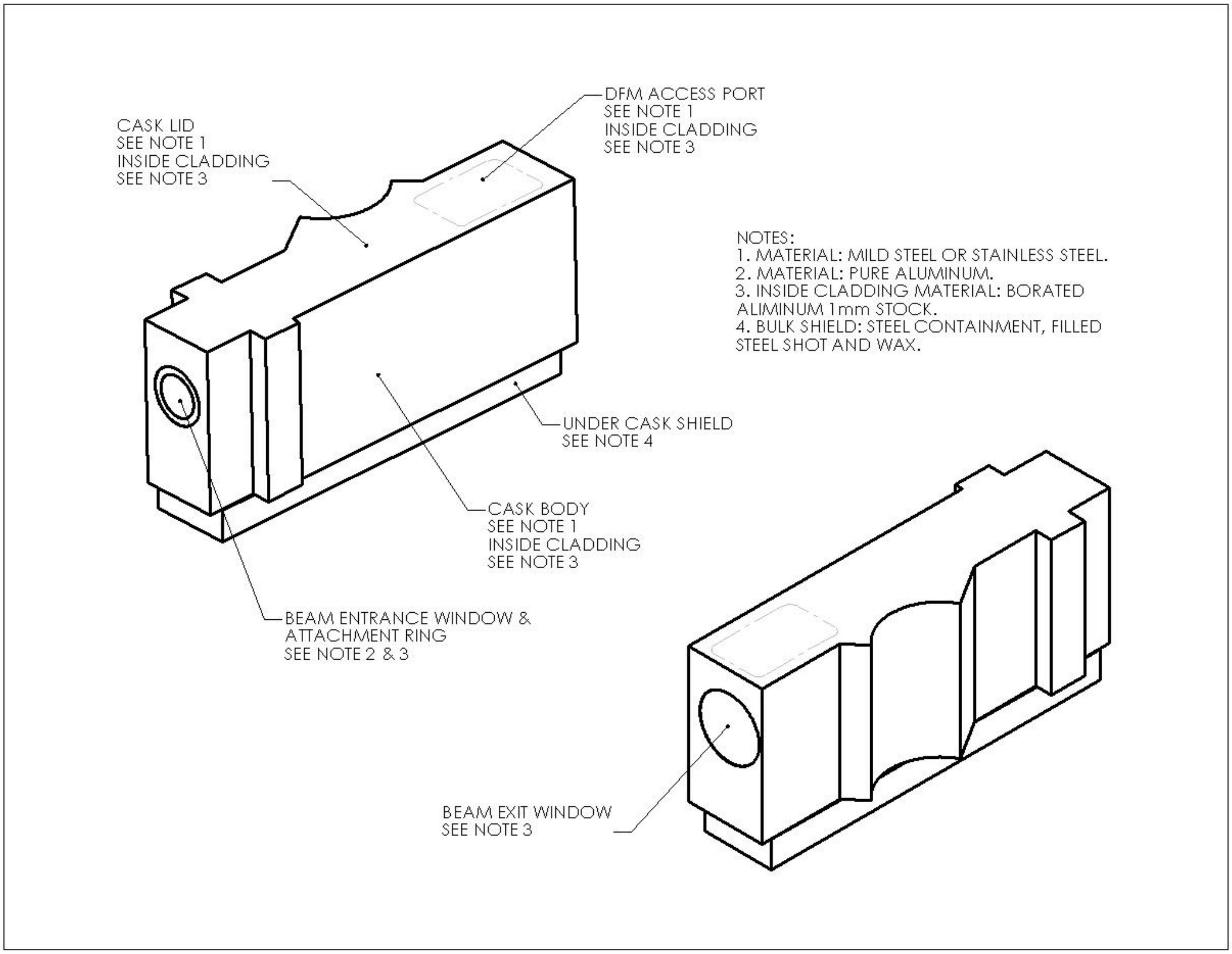

Figure 1 Perspective views of the cask bounding box and mounting surface with materials requirements

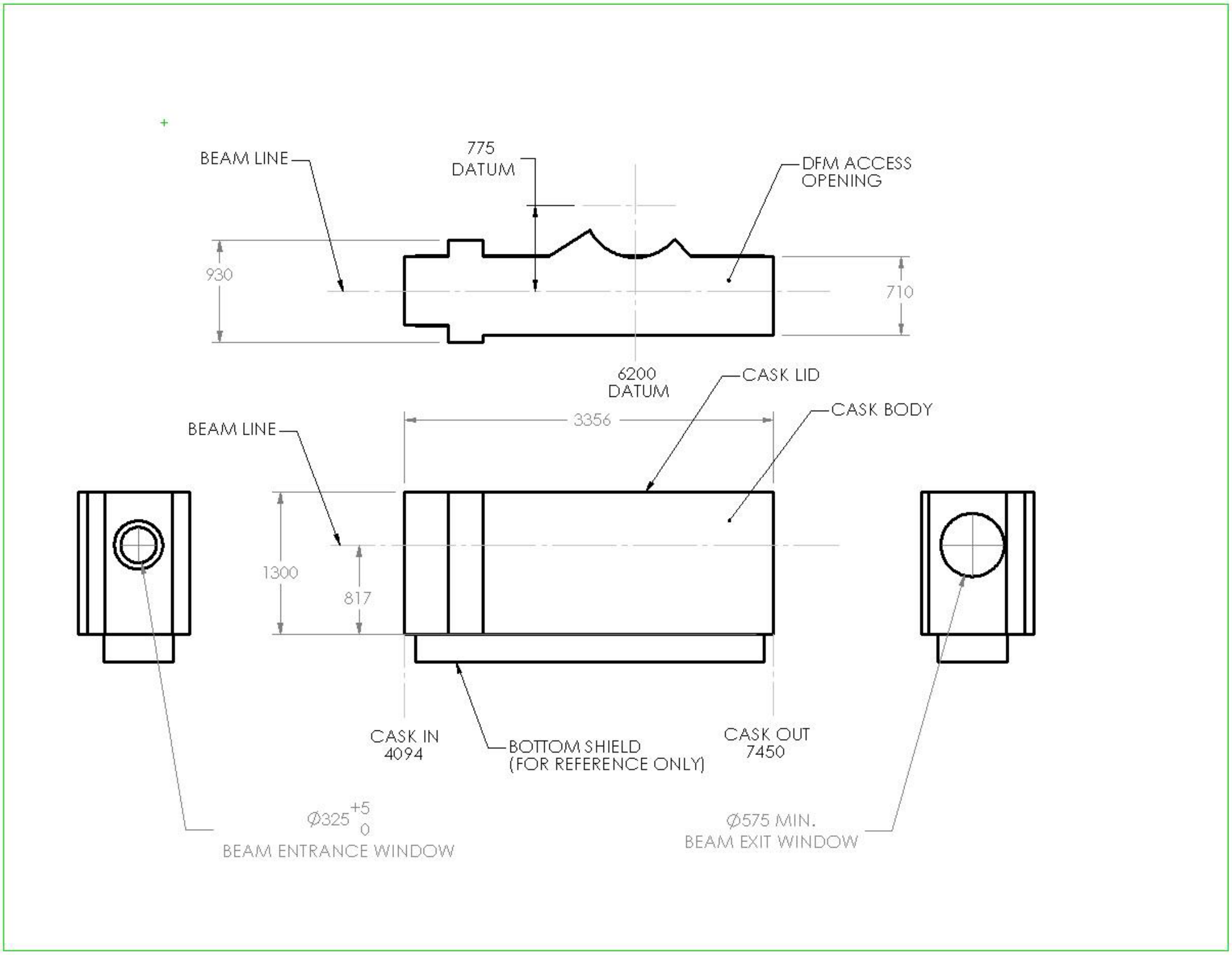

Figure 2 Cask over-all dimension

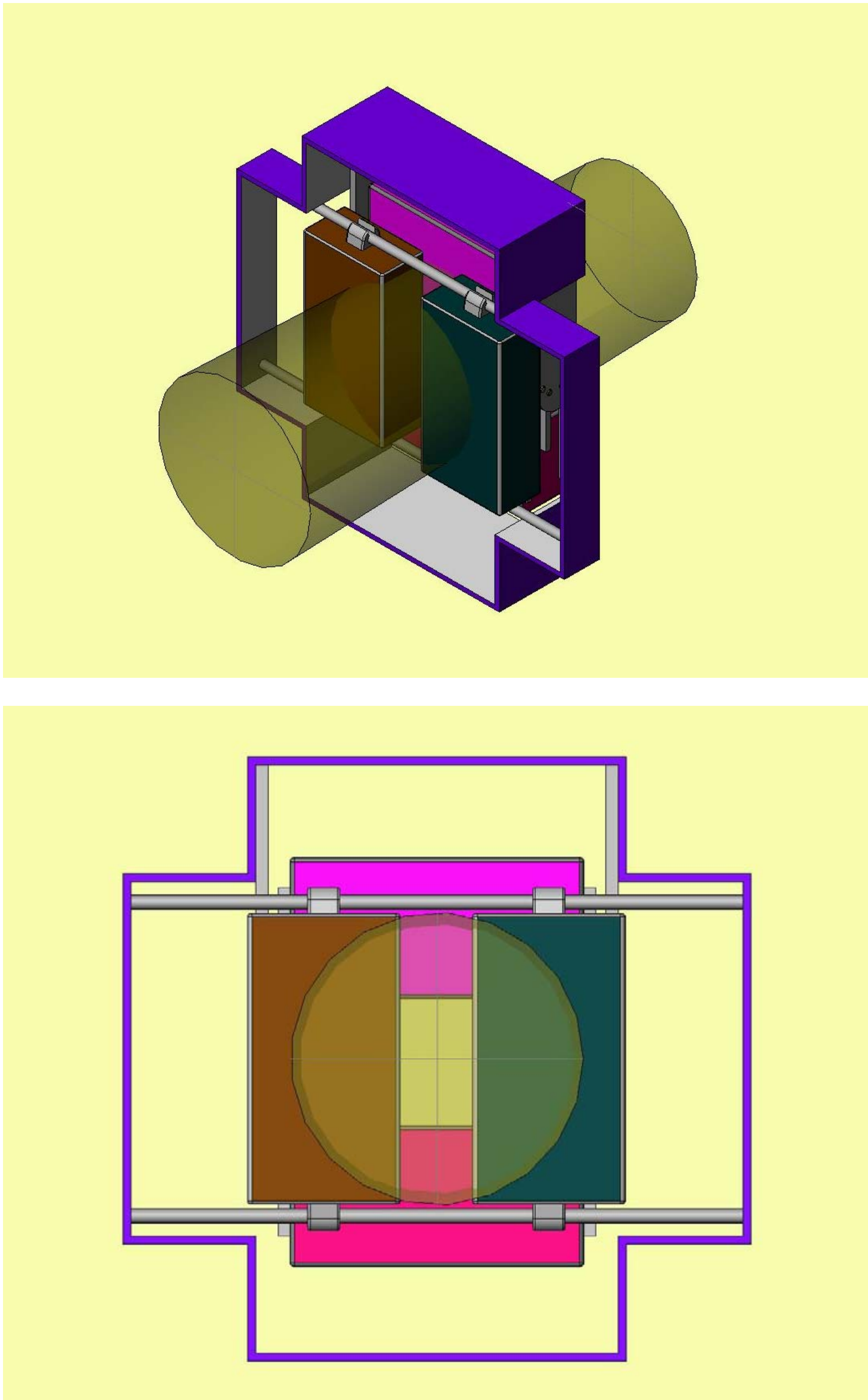

Figure 3 Partially open VBA
Perspective view and in front view towards source.

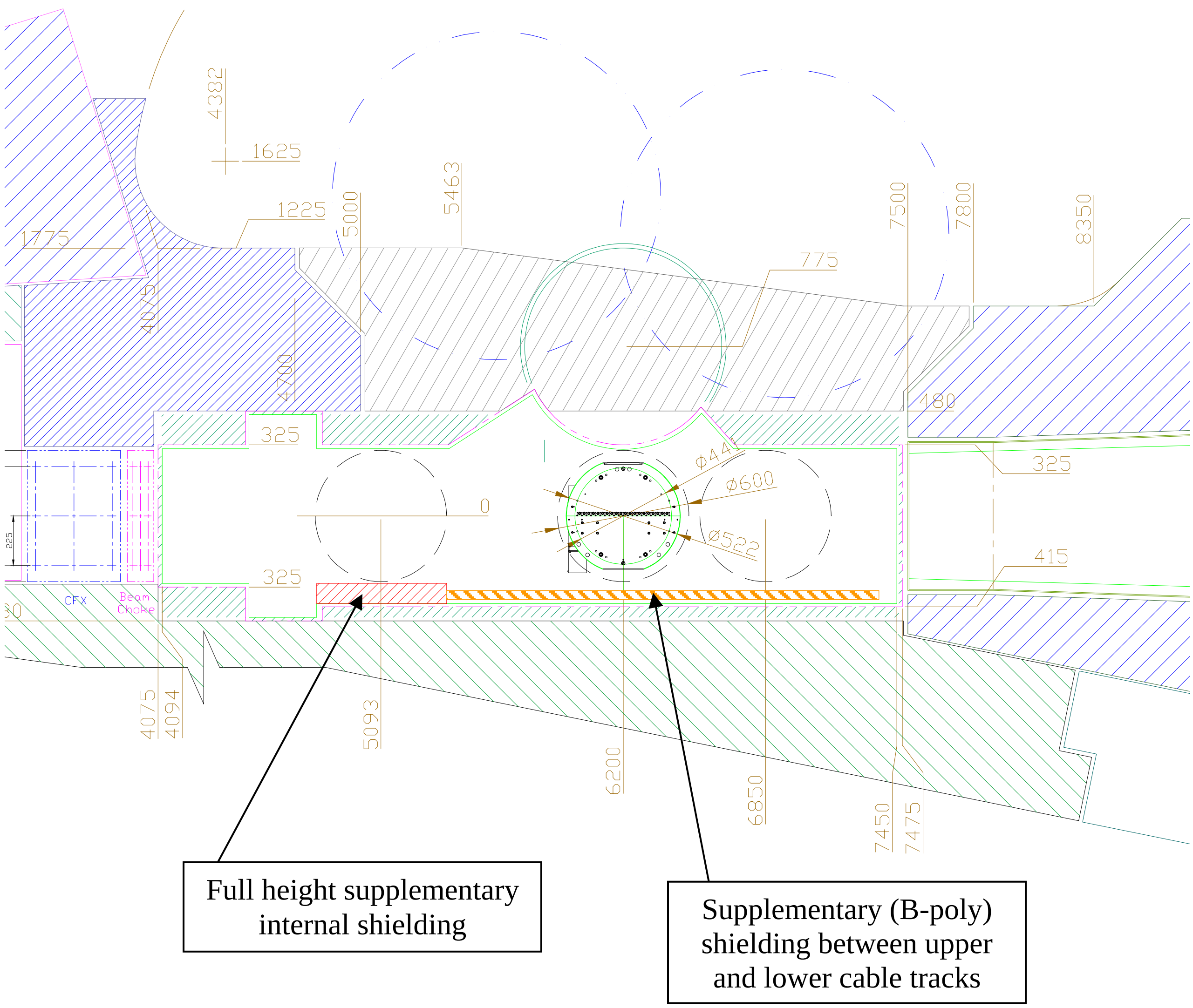

Figure 4 Cask plan view

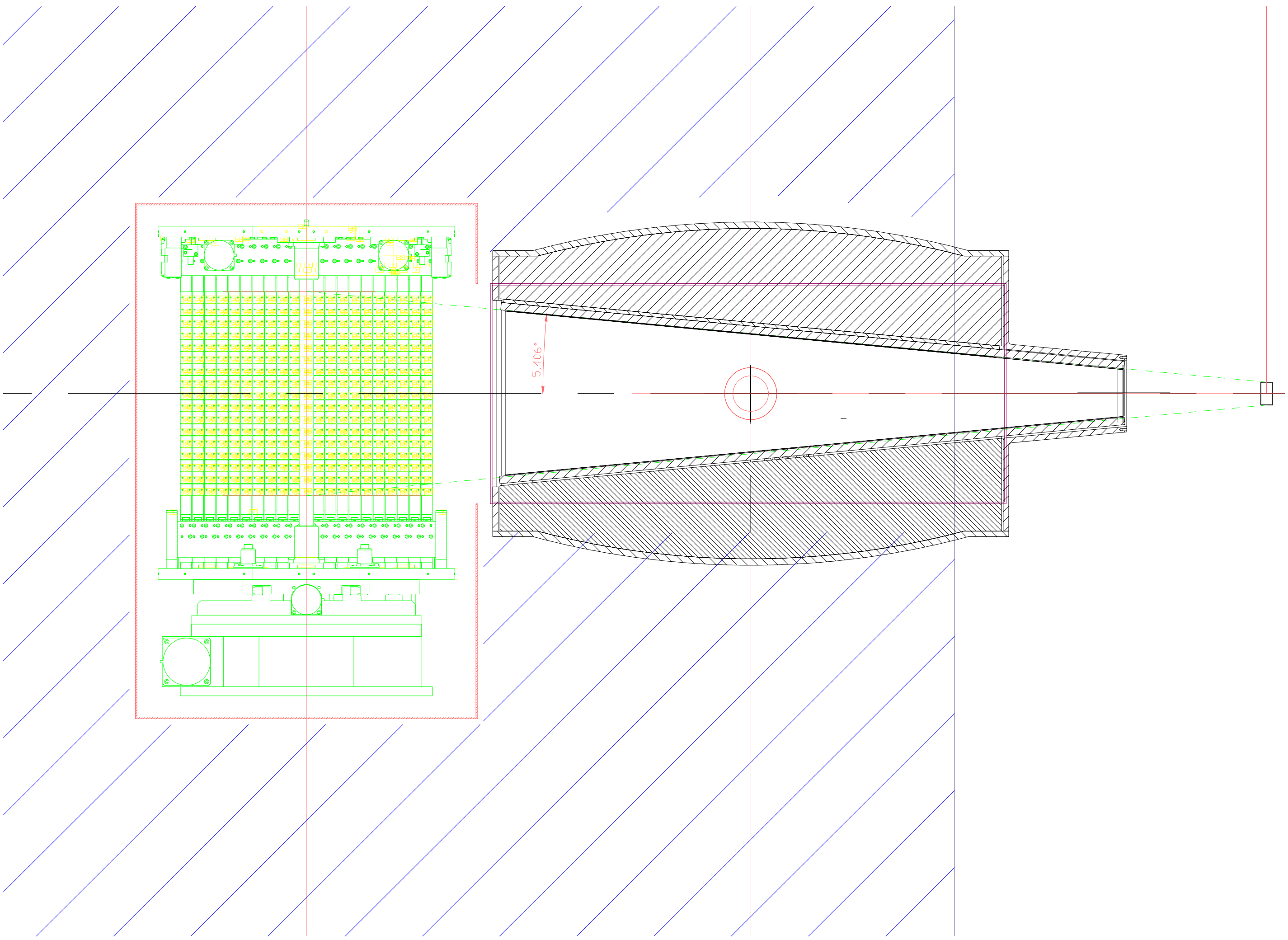

Figure 5 Rear elevation.

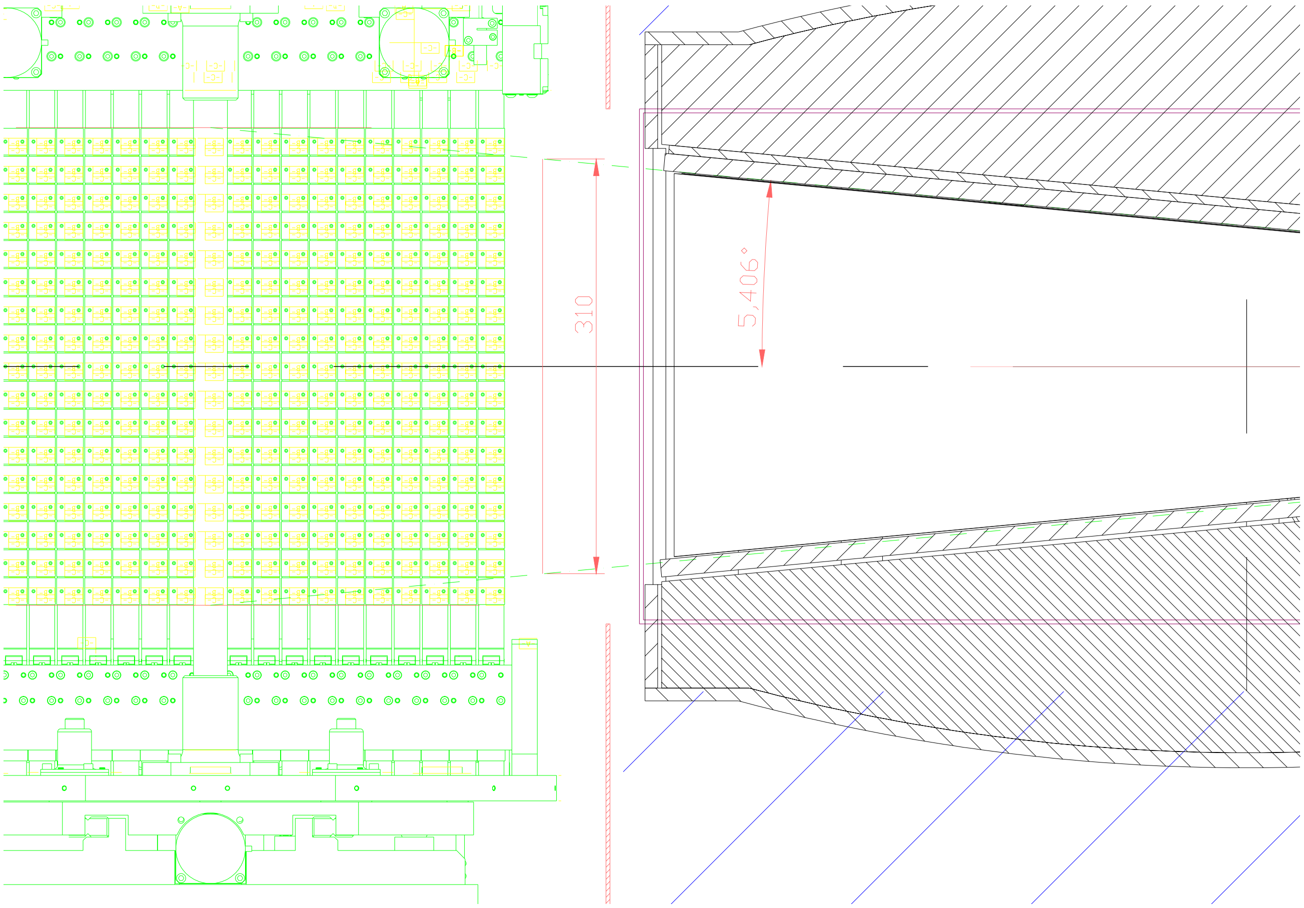

Figure 6 Rear elevation
View shows DFM and SMG window details

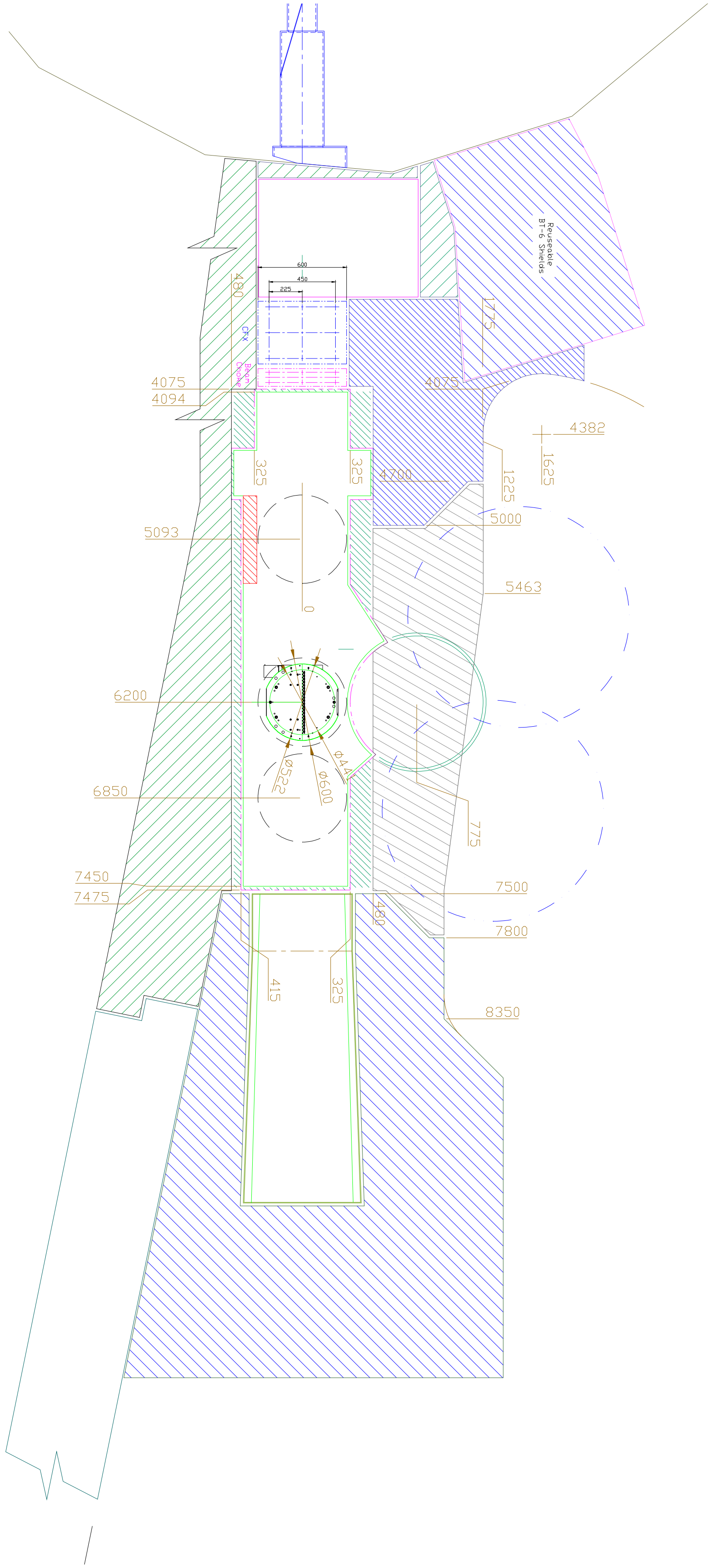

Figure 7 MACS General Layout.

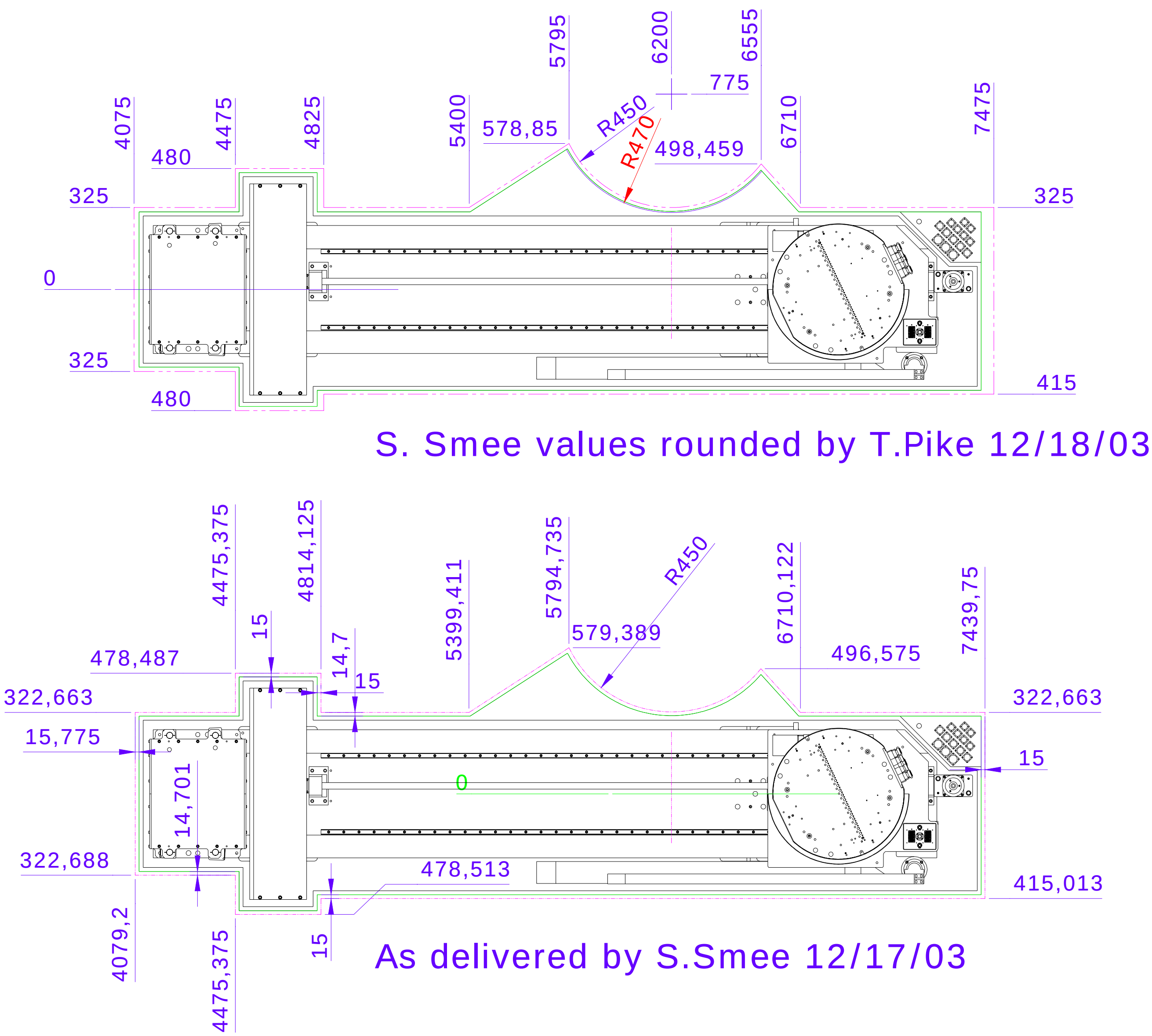

Figure 8 MACS Cask bounding box dimensions.