Information-Request/Submittal/Release		Number		038-0012
Number of attached pages	16	New ☒		
Project	MACS	Revision ☐		
Originator	T. D. Pike	If revision, provide the following:		
Date	January 13, 2003	Previous Submittal		
Database Reference	038-2489	ECR/ECN		

Scope

Specification for the MACS Beam Shutter

Purpose

To provide specifications for the MACS Beam Shutter to allow the corresponding sub-projects to proceed in parallel with general development of MACS.

Description

Text and images that specify the requirements for the Shutter 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. An accompanying solid body submission to the C-100 database further describes this bounding box.

P/N 038-2489 macs_shutter_bounding_box

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)

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NATIONAL SCIENCE FOUNDATION

NIST National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

General Specification for Development of the Beam Shutter

for the

Multi-Axis Crystal Spectrometer (MACS)

National Institute of Standards and Technology

Center for Neutron Research

Specification NG-0 –1 SHUT

Revision 2a

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1. Overall Specifications

The MACS beam shutter system contains all elements associated with turning the neutron beam off and on. The neutronic input and output is a diverging cold neutron beam with a circular cross section. The shutter uses rotary motion for selection of open and closed states.

1.1 Bounding box dimensions

The shutter is comprised of three primary components: shutter drum, shutter housing and shutter cap. The shutter shall occupy the overall bounding box described in figure 2, as well as the solid body in the accompanying IGES file. Dimensions for the Shutter Housing within the bounding box are shown in figures 3-5. Clearance from the shutter to the bounding box shall be at least 10 mm in the horizontal directions and above the Shutter Base by 80 mm.

1.2 Materials and overall shielding requirements

All volumes of the shutter drum, shutter housing and shutter cap that are not required for beam transmission or mechanical clearance shall be filled with shielding material. Typical materials employed are listed below:

1. A-36 mild steel (verify: low cobalt)
2. Bulk shielding material:
    a. 55% (volume fraction) steel shot in 45% wax held in a closed steel containment vessel.
    b. Laminations of high density polyethylene and Steel
3. Void filling shielding material: 20%-50% B_4C loaded plastic materials such as polyurethane or polyethylene.
4. HDPE (High density polyethylene)
5. Tungsten
6. HIP B4C (Hot isostatically pressed Boron Carbide)
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 0.5 mm.

1.3 Shielding & Construction Considerations

Six functional element types determine the shutter assembly volume:

1. Shutter housing
2. Shutter drum
3. Primary beam port
4. Primary beam plug
5. Auxiliary beam ports
6. Shutter Cap

The Shutter housing, drum and plug shells shall be fabricated from mild steel. The construction of the external surfaces of the housing shall be generally a vertical projection of the rectangular plan. The Shutter housing, drum and auxiliary beam plugs shall be filled with steel shot and wax as detailed above.

1.4 Attachment to MACS

The Shutter shall be fully self-supporting on three horizontal kinematic balls (NIST to provide) & mounting pads. The nominal distance from these surfaces to beam height shall be

750 mm, see figures 6 and 8 for dimensions. Threaded receivers for lifting eyes shall facilitate the installation and removal of the shutter and its components using an overhead crane. The Shutter Cap (NIST to provide) is in turn directly supported by the upper surface of the Shutter. Finally, the motor and primary gear reduction are supported by and mounted to the Shutter Cap.

1.5 Alignment

The central axis of the beam ports and the beam plug shall coincide with the shutter housing beam axis to within $\pm$ 1.3 mm when in the active position.

1.6 General dimensions

Shutter Housing, H x W x D	1270 x 1140 x 800 mm
Shutter Cap, H x W x D	650 x 1140 x 800 mm
Shutter Base, H x W x D	200 x 1140 x 800 mm
Drum diameter	960 mm
Drum thickness	750 mm
Beam tube entrance diameter, nominal	245 mm
Beam tube exit diameter, nominal	285 mm
Beam tube taper, nominal	1.600 degrees per side

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 shutter interfaces.

2.1 Helium Containing Primary Beam Tube

The beam tubes shall be hermetically sealed with approximately an atmosphere of helium to reduce neutron scattering losses and minimize radioactive argon production that would be incurred in an air environment. A helium leak can gradually evacuate the beam tube into the helium poor atmosphere. Design, fabrication, and tests shall therefore ensure that through 20 years the helium pressure in the beam tubes will remain constant to within the pressure differential that can be supported by the beam tube vessels. The tube walls shall be fabricated from aluminum or mild steel (A36). The north and south faces of the tube shall be fabricated to provide 0.5 mm thick 1100 alloy aluminum windows across the full face of the tube. The beam tube shall be removable by means of securing features that are fully accessible from the north face.

2.2 Neutron Blocking Plug

The functional requirement of the Neutron Blocking Plug is to efficiently absorb neutrons when placed in the beam. To this end, the following layered composition shall be contained within the 750 mm internal length of the steel shell:

1. HIP B4C 10 mm
2. Steel shot & wax, 55/45 215 mm
3. Tungsten 150 mm
4. HDPE 150 mm

5. Steel shot & wax, 55/45 215 mm
6. HIP B4C 10 mm

These materials shall be secured in such a way that shifting or moving within the tube is prevented.

2.3 Auxiliary Beam Plugs

Two removable Auxiliary Beam Plugs with the same shell construction as the Neutron Blocking Plug shall be filled with the shot and wax composition described in section 1.2. The auxiliary beam plugs shall define a vertical slit that has the height of the conical bore and fixed widths of 100 mm and 50 mm respectively. The slits shall be centered along the conical axis. The beam transmission portion of the tube shall be helium filled. The conditions for helium filling and beam windows of the auxiliary beam ports shall be the same as for the main beam port (section 2.1). The beam tubes shall be steel shells filled with steel shot and wax or alternatively it can be filled with axial laminations of steel and HDPE in approximate proportions 55% Fe to 45% HDPE by volume. The up and down stream faces of the bores shall be covered with 10 mm thick HIP B4C with appropriate openings for the beam. The auxiliary beam slits shall be vertical when engaged in the active position to within +/-0.5 degrees. The auxiliary beam tubes shall be removable by means of securing features that are fully accessible from the north face.

2.4 Shutter Drum

The main functional unit of the shutter is the shutter drum. The beam tube, the beam block, and two auxiliary ports may occupy each of four possible positions. The functional positions are angularly spaced about the center of the drum at 0, 108, 180, 252 degrees, as shown in figure 5. By rotating the drum, the axis of the selected element is brought into alignment with the axis of the beam. Clearances between the drum and the housing shall not exceed 10 mm.

2.4.1 Actuation

Drum rotation shall be effectuated by a direct drive mechanical system based on a three-element reduction, conceptually shown in figure 1. The motor and primary reduction is installed on a vertical axis above the Shutter Cap. A vertical shaft connects the primary reduction to the right angle that is in turn connected to the secondary roller chain sprocket. The driven sprocket is attached directly to the shutter drum. Roller chain tensioning may be accomplished by allowing the right-angle drive to travel along the shaft axis, applying one or more idlers to the roller chain or by similar means. The contractor in consultation with Nick Maliszewskyj shall select the drive motor and resolver.

2.4.1 Shutter Position Detection

The position of the shutter shall be determined by the actuation of a series of switches driven by physical features on the outer surface of the Shutter Drum. A minimum of six switches are required as listed for each of the following: Primary beam port, 1 switch; Aux. port 1, one switch; Aux. port 2, one switch; in transit, one switch; Beam Plug (closed position) two switches. Access for the removal and replacement of the switches shall be from the top and West side only. Preference will be given to designs that allow switch removal and replacement without access below the surface of the Shutter cap.

2.4.3 Range, accuracy, and speed of travel
The shutter design shall allow continuous rotary motion. No preference is given to CW or CCW or reversible rotation. A positive detent system shall provide for positional location of each port to within $\pm$ 0.25 degrees corresponding to $\pm$ 1.3 mm at the beam port axis. Maximum time to rotate through 180 degrees shall be less than 15 seconds; preferred time is 5 seconds.

2.4.4 Cable management
Cables from drum position monitoring switches shall terminate within 300 mm of the motor shaft on the top surface of the Shutter Cap.

2.4.5 Shutter Drive Access
Access for removal and replacement of the right angle drive, drive sprocket and chain tensioning shall be possible from the top and West side only. The motor and primary reduction shall be mounted above the Shutter cap. Removal and replacement of the motor, primary reduction and drive shaft shall be accomplished without access below the surface of the Shutter cap.

2.4.5 Lifetime and Maintenance
The motive and bearing systems shall allow for 200,000 full travel cycles for the shutter 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 shutter receives the "White" beam directly from the Beam Tube. With the shutter open, the beam is then directed to the Cryo Filter Exchanger. The shutter bores are dimensioned and toleranced to assure an unimpeded beam path as listed in Table 1. The entering "White" Beam window shall be circular with a diameter of 245 mm $\pm$ 1.5 mm at the 2675 mm position. The exiting "White" Beam window shall be circular with a diameter of 285 mm $\pm$ 1.5 mm at the 3425 mm position.

2.6 Computer control
NIST shall take responsibility for the shutter control system logic. The contractor is responsible for position detection, drive motor and wiring to terminal blocks. The contractor is also responsible for a temporary control system to test the operation of the shutter.

2.6.1 General Electrical Requirements
Each of the position switches shall be wired Normally Open; that is, a given switch will indicate that the shutter is at the position, which that switch is to detect, by closing at that time and being open all other times. A common source of power (24 VDC) may be used for all the switches. The switch wires shall terminate at a separate terminal block from the motor wires, which shall also terminate at a terminal block. The switch wire shall be a minimum #20 AWG and the motor wire shall be a minimum #18 AWG. Additional requirements and information will be provided in a separate control interface specification.

3. Additional Specifications

Additional specifications will be provided by NIST for the following:

- Paint & finish
- Steel shot & wax
- Interfaces to other MACS elements

The contractor for the shutter shall develop specifications for the following:

- Inspection & test procedures
- Regular and preventive maintenance schedule

Project level approval is required for the following:

- Motor and power transmission elements
- Switches and 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
Shutter Drum (In)		25		**2675**	119.4	239	269
Shutter Drum (Out)		25		**3425**	140.4	281	316
Shutter Out		750	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			3356	**7450**	252.8	506	569
	2150						
Beam Dump				**9600**	312.8	626	704

Table 1 1.600-Degree Divergence Beam Equation Rev. 5c

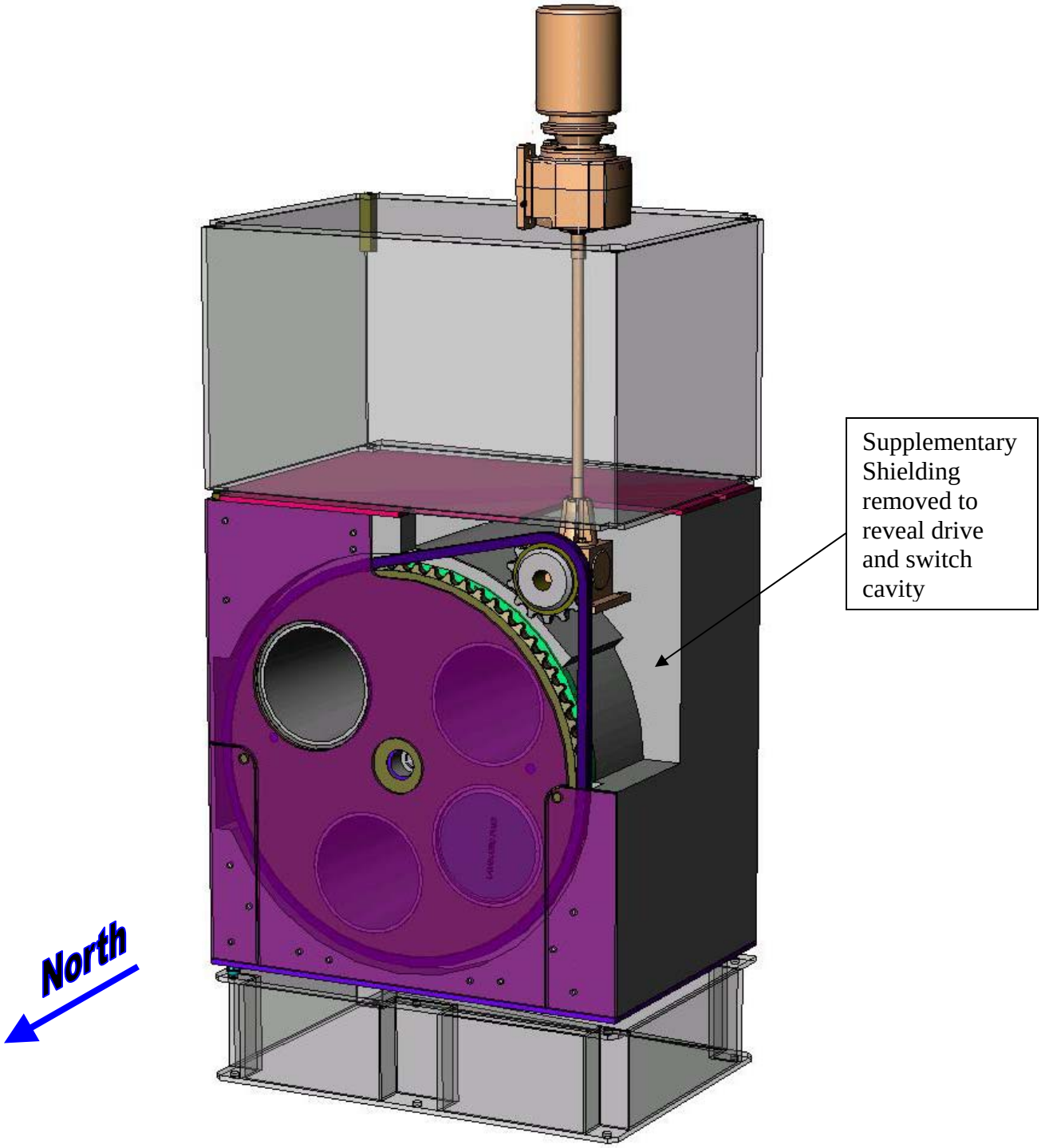

Figure 1 Perspective view of the Shutter.
Shutter Cap & Shutter Base provided by NIST

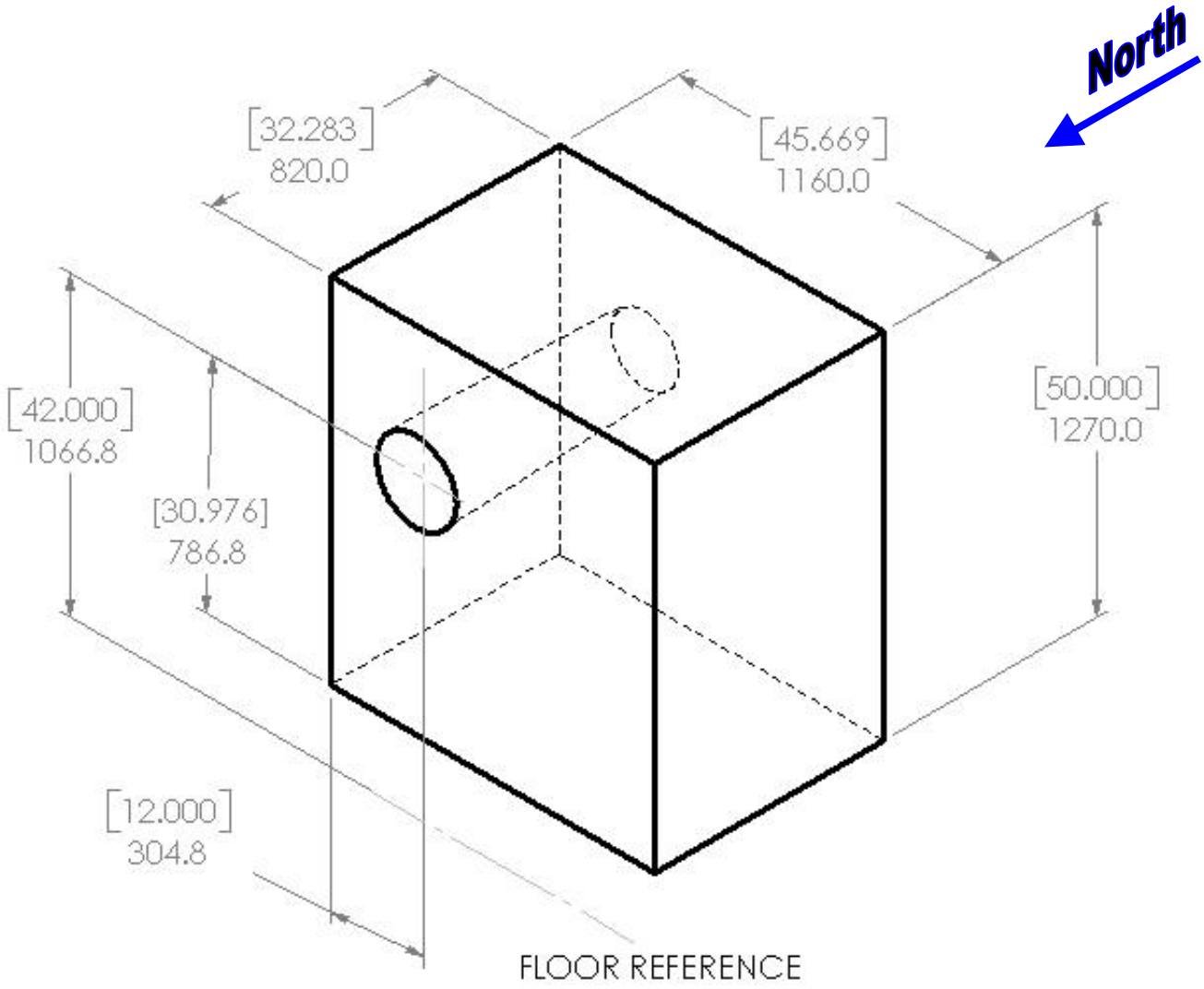

Figure 2 Shutter bounding box dimensions.

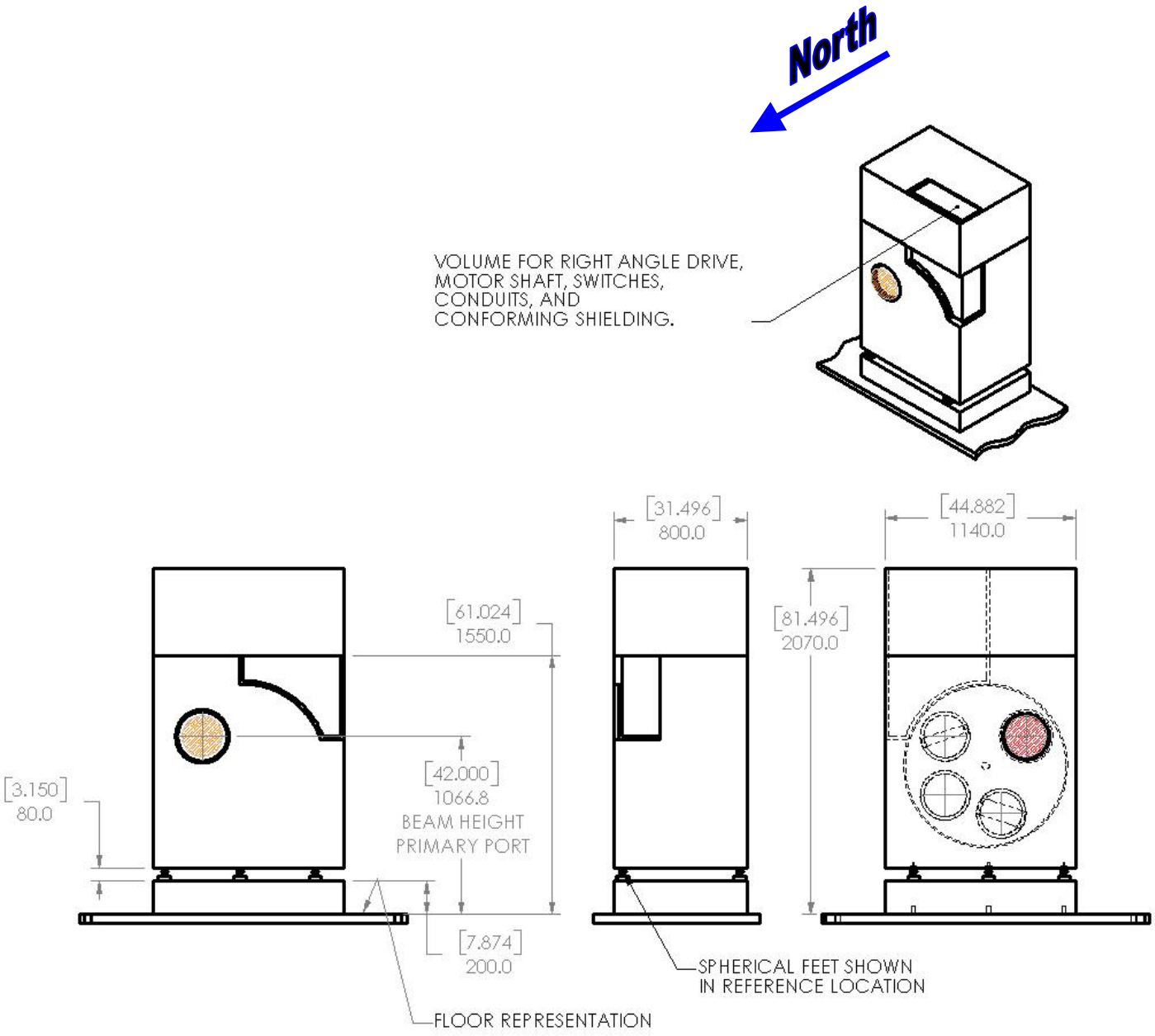

Figure 3 Shutter elevations and perspective view with reference dimensions. The Shutter is shown mounted on the Shutter Base, which is provided by NIST.

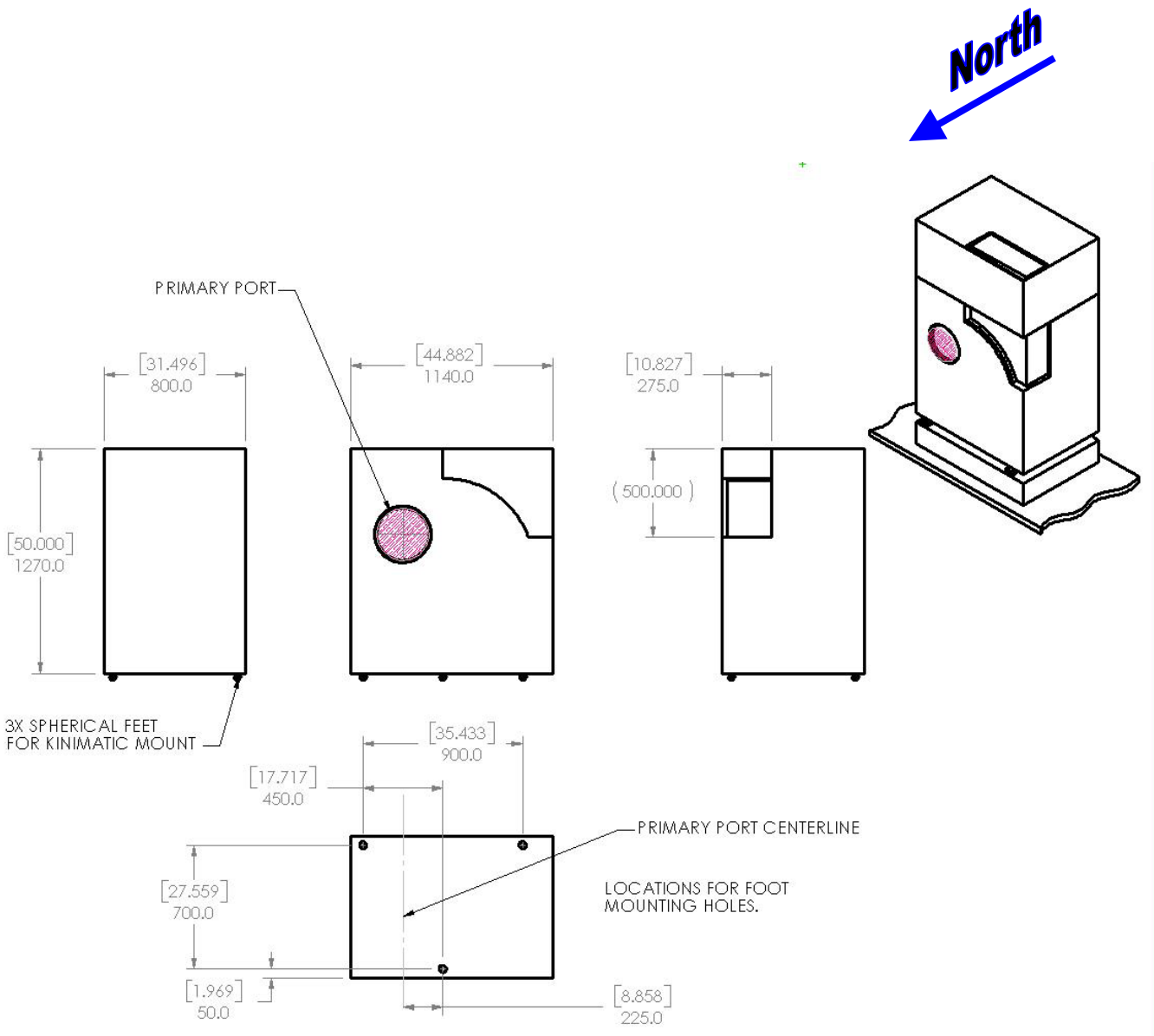

Figure 4 Shutter enclosure dimensions.

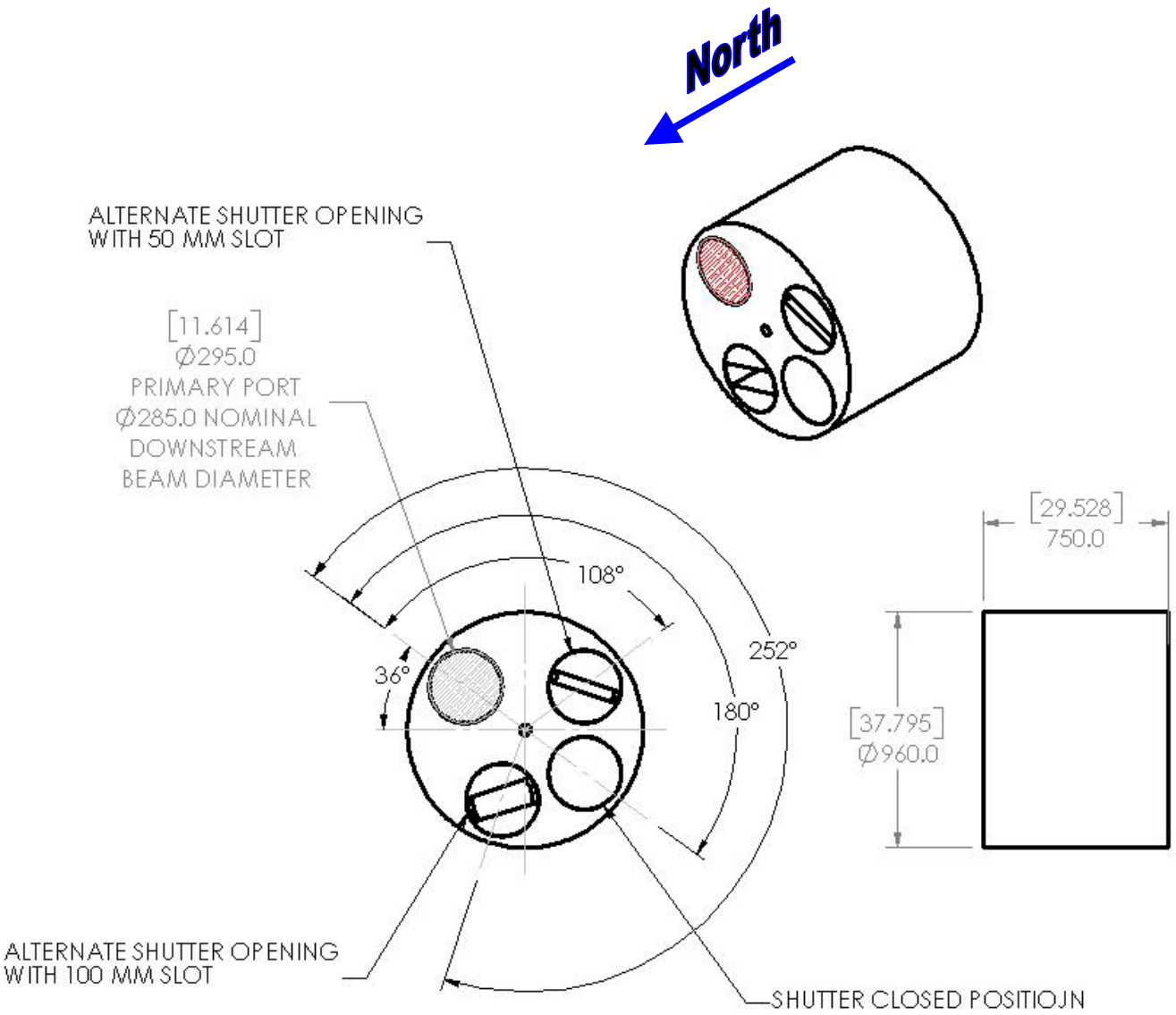

Figure 5 Shutter Drum dimensions.

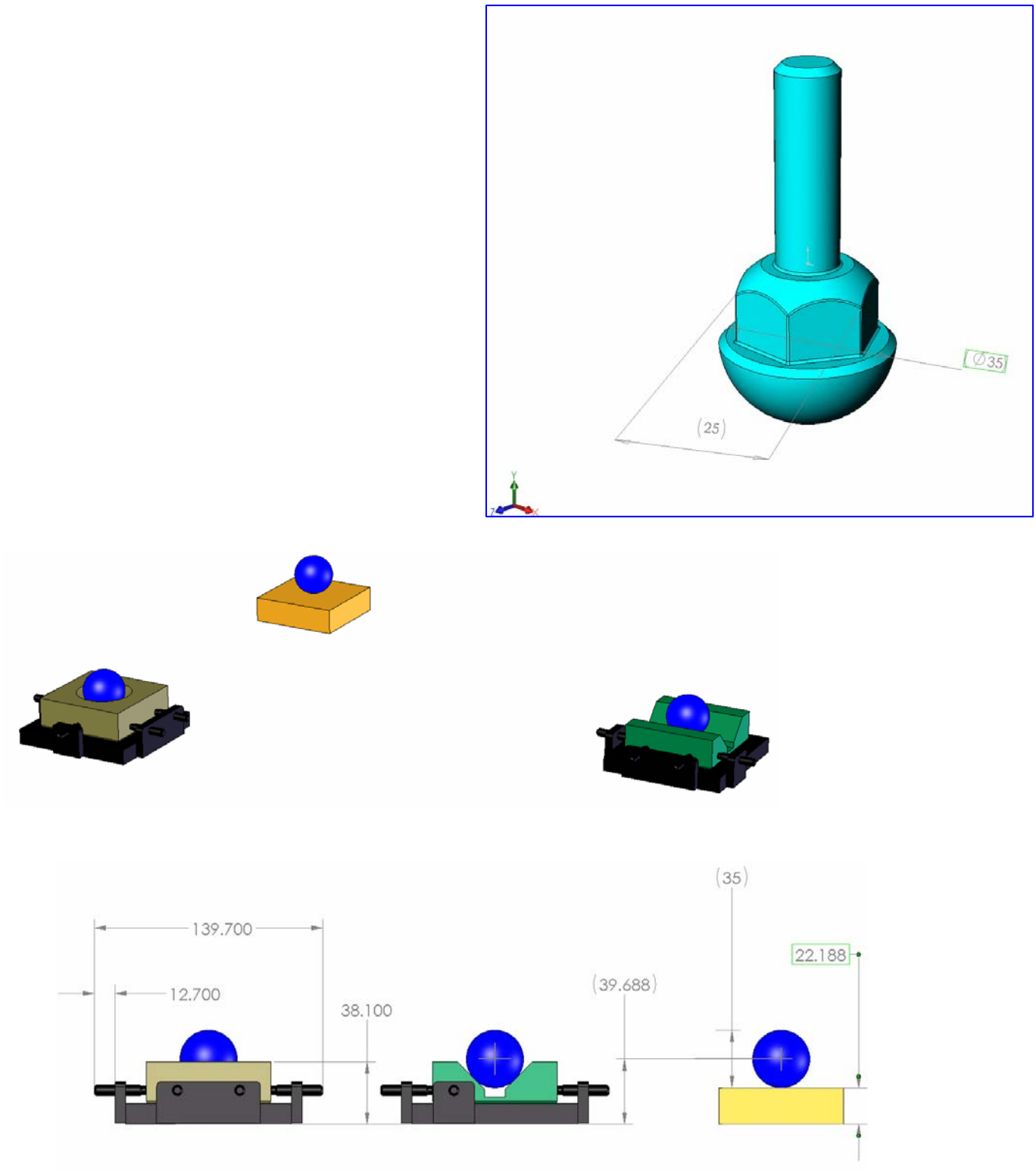

Figure 6 Kinematic Mounting Systems

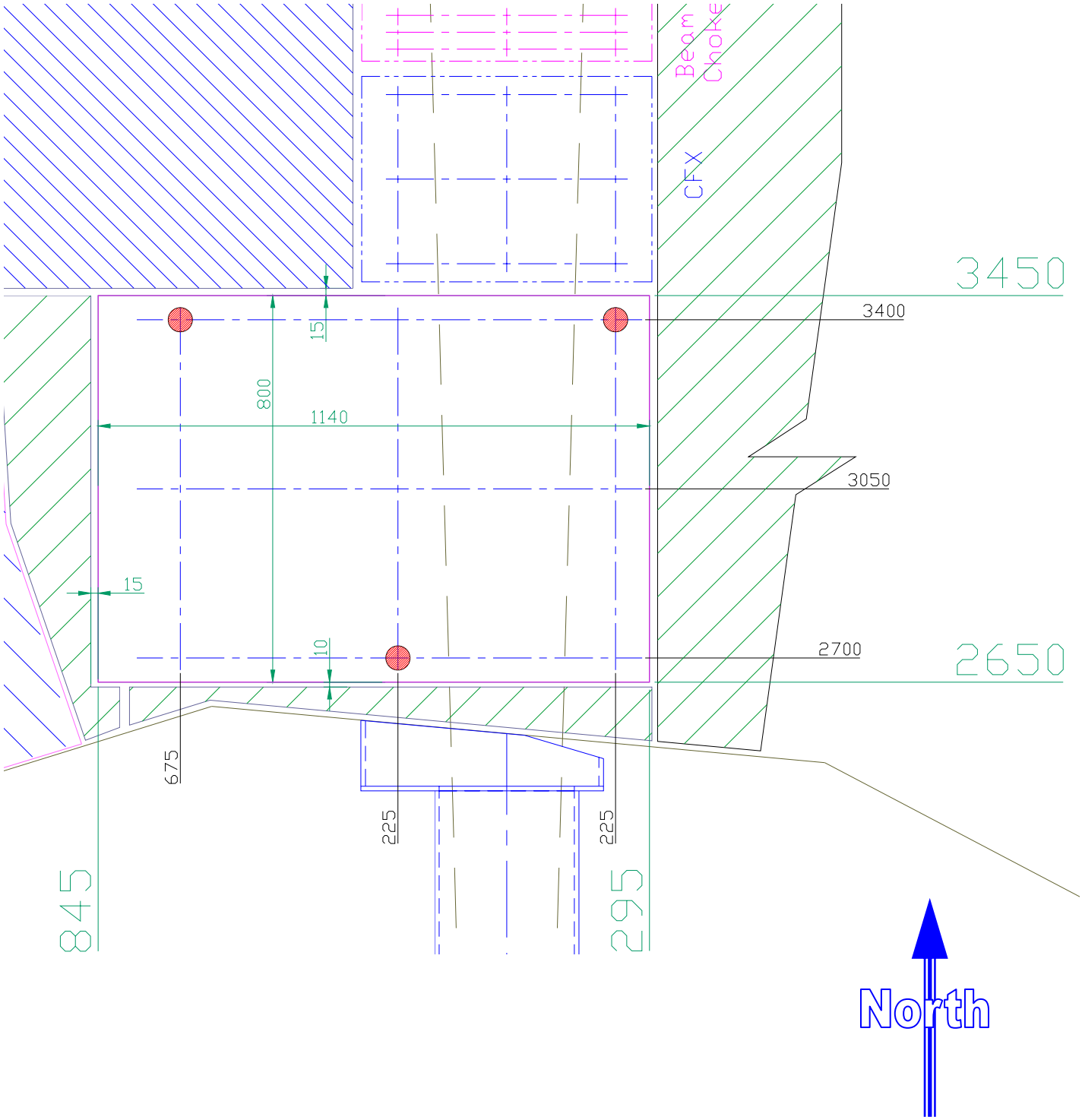

Figure 7 Shutter plan view A

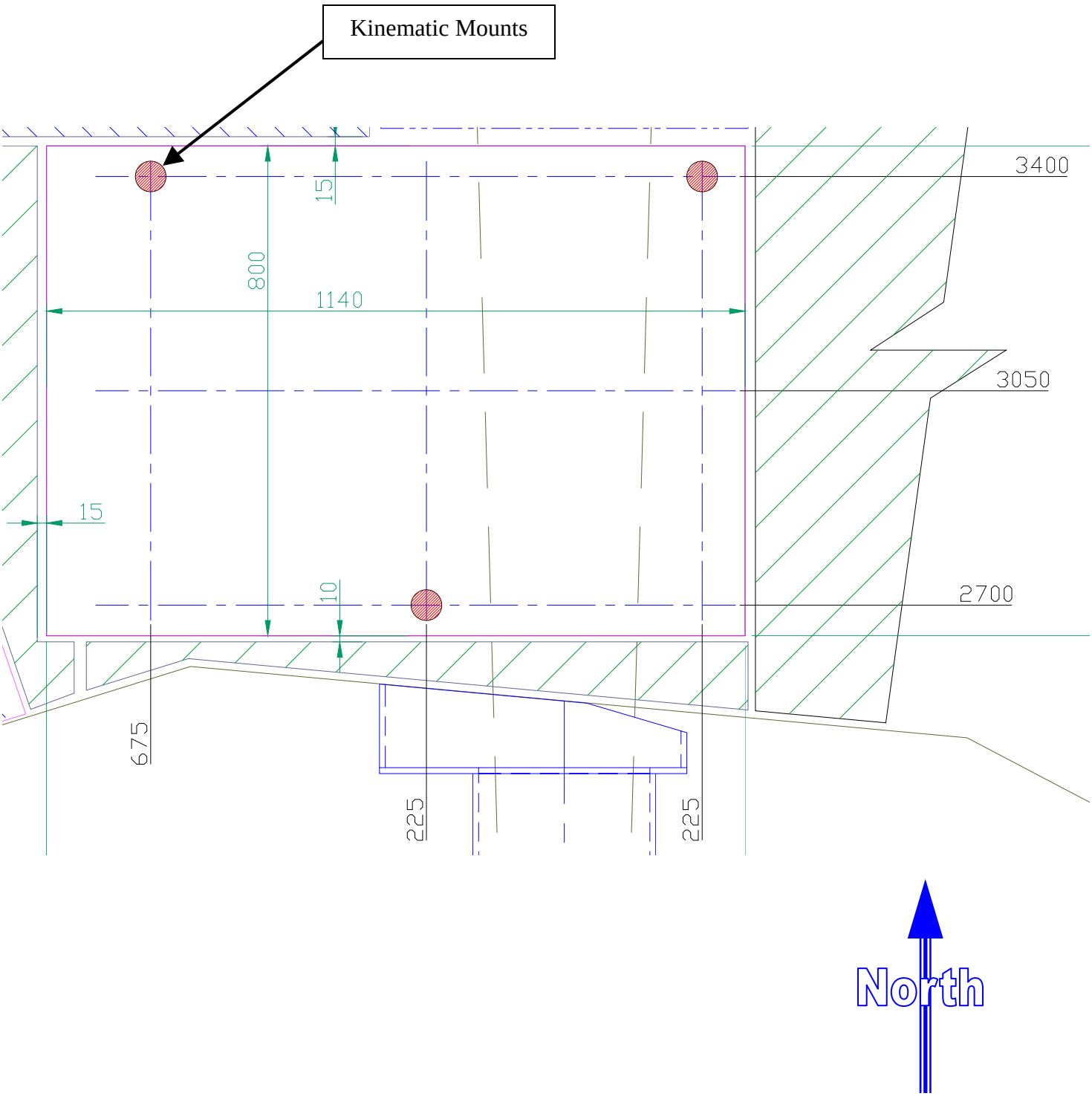

Figure 8 Shutter plan view B

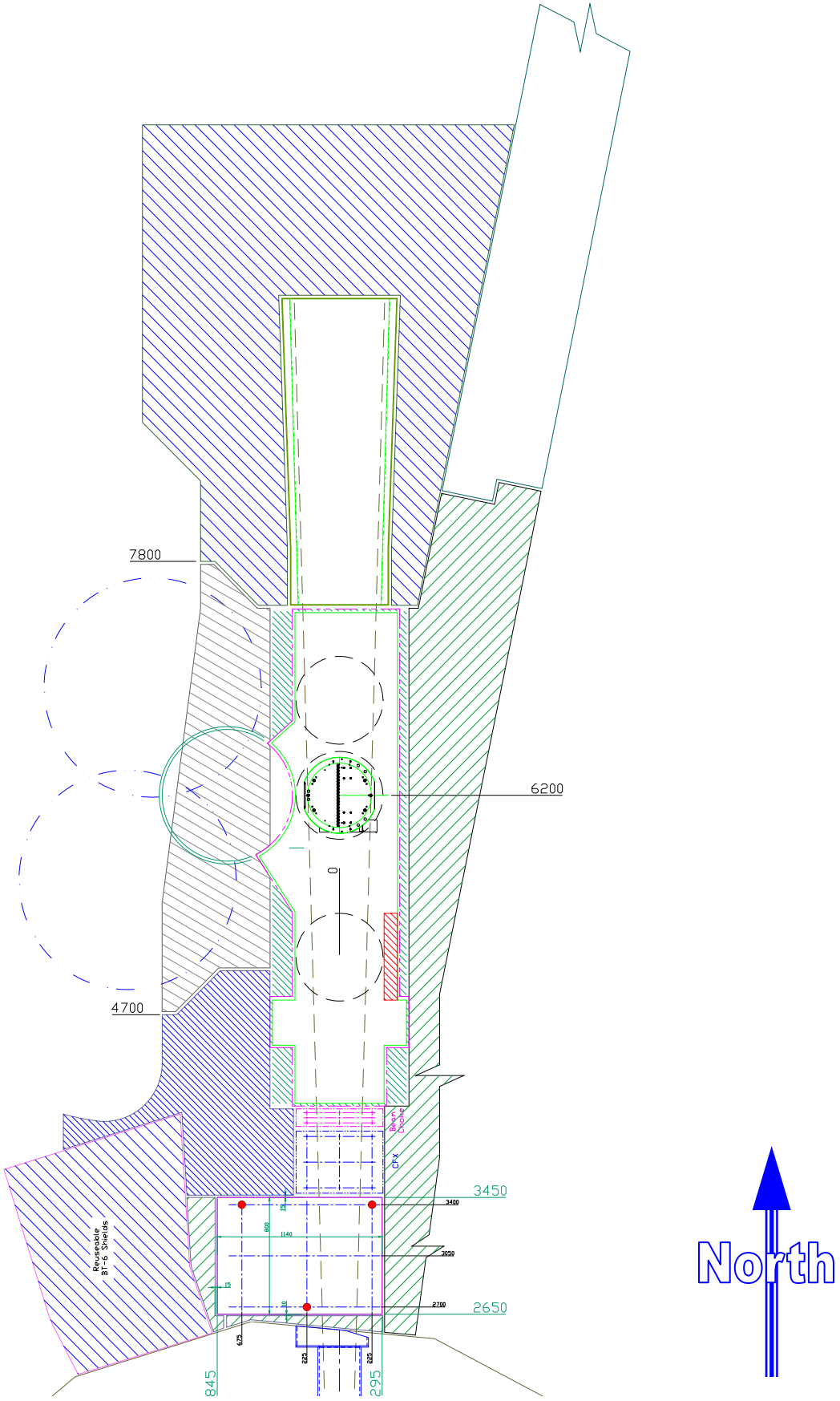

Figure 9 MACS General Layout.