S01020500-IST10064 R00

SECOND TARGET STATION (STS) PROJECT
Interface Sheet for the Vessel Systems and Target Station Shielding and Conventional Facilities

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Date: March 2025

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

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Date Published: March 2025

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, TN 37831-6283
managed by
UT-BATTELLE, LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

Approvals

Interface Sheet for the Vessel Systems and Target Station Shielding and Conventional Facilities		ISSUE DATE: Issue Date:3/25/2025
PREPARED BY Robert Malone & Chris Anton	PROJECT Second Target Station	DOCUMENT NUMBER: S01020500-IST10064

Approvals	Signature / Date					
Title	Rev. 00	Date	Rev. 01	Date	Rev. 02	Date
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Revision	Description
0	Initial Release

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1. PURPOSE

This document defines the interface between the Target Systems (TS) Monolith components and the cast-in-place concrete monolith structure by Conventional Facilities (CF). Specifically, this document addresses the following interfaces:

- Bulk Shielding Liner interface with cast-in-place Monolith
- Bulk Shielding anchorage and geometry interface with the Monolith and the Target Drive Room (TDR) structure
- Core Vessel Anchorage interface with cast-in-place Monolith
- Monolith Ports interface with cast-in-place Monolith
- Pipe Pan interface with cast-in-place Monolith

All common boundary conditions (i.e., geometric compatibility requirements, load transfer, etc.) shared between the interfacing parts will be detailed within this document or point the user to where the design data will be located.

2. SCOPE

The scope of this document is the complete interface definition for the interfaces detailed in the Interface Control Document (ICD) S01020500-IC0006 between Target Systems and Conventional Facilities. A list of these interfaces is provided in Section 2.1 of this document. The monolith structure in the table below includes both the concrete wall and floor.

2.1 INTERFACING PARTS OR COMPONENTS

No.	Components (Target Systems)		Components (Conventional Facilities)	
	Name	Functional reference Number	Name	Functional reference Number
1	Bulk Shielding Liner	HCK-TSS-BULK-LINER.PRT	Target & Instrument Building Level 1 – Structural Plan – Sector T1	8800-ST1113
2	Bulk Shielding Anchorage	N/A	Target & Instrument Building Wall Sections	8800-ST3050
3	Core Vessel Base Plate Anchorage	TBD	Target & Instrument Building Wall Sections	8800-ST3050
4	Standard Nozzle Extension	S03060200-M8U-8800-A10100.ASM		
5	QIKR Nozzle Extension	S03060000-CV-NE-QIKR-R2.ASM		

6	Dual Channel Nozzle Extension	PORT-15-NOZZLE.ASM		
7	Pipe Pan	CMA_PIPE-PAN.PRT	Target & Instrument Building Wall Sections	8800-ST3050
8	Core Vessel Base Plate	CMA-TSS-BASEPLATE.PRT	Target & Instrument Building Wall Sections	8800-ST3050
9	Monolith Port Interface Model	STS-MONOLITH-PORT-NOZZLES.ASM		

3. ACRONYMS AND DEFINITIONS

CF Conventional Facilities
ICD Interface Control Document
IS Instrument Systems
SSC Structure, System or Component
TDR Target Drive Room
TS Target System
CV Core Vessel
VS Vessel Systems
TSS Target Station Shielding

4. REFERENCES

4.1 DOCUMENTS APPLICABLE TO THE INTERFACING SSCS

Ref	Document Titles	Document Control System Location
[1]	Interface Control Document for Target Systems and Conventional Facilities	S01020500-IC0006
[2]	Target & Instrument Building Level 1 – Loading Diagram - Overall	8800-ST0010
[3]	Target Systems Monolith Concrete	S03060000-G8U-8800-A10000
[4]	Target Systems Monolith Port Nozzles	S03060000-G8U-8800-A10001
[5]	Bulk Shielding Base Plate Hole Locations	S03070000-G8U-8800-A10000
[6]	Bulk Liner V2 with Anchors and Spacers	S03070000-G8U-8800-A10001
[7]	Pipe Pan Cover Anchor Locations	S03070000-G8U-8800-A10002
[8]	Target and Instrument Building Level B1 Overall Mechanical Piping Floor Plan	8800-MP100000

5. INTERFACE DEFINITION

5.1 TECHNICAL DESCRIPTION OF THE INTERFACE & SCOPE DELINEATION

5.1.1 Scope Delineation of Interfaces

Target Systems (TS)

- Owner of TS components listed in Section 2.1
- Responsible for design, procurement, and installation of TS components listed in Section 2.1
- Responsible for delivery of TS components listed in Section 2.1.
- Responsible for design information and installation tolerance requirements of interfacing components listed in Section 2.1 for CF's design.

Conventional Facilities (CF)

- Owner of the cast-in-place concrete Monolith structure and monolith ports listed in Section 2.1.
- Responsible for design of the cast-in-place concrete Monolith structure in accordance with the TS requirements.
- Responsible for placement of embeds, anchorage, or connections needed for the TS components listed in Section 2.1

The TS team will be responsible for the design, procurement, installation procedures, assembly and detailed drawings, and delivery of the components identified herein to the CF team. Installation and construction tolerance requirements will be developed by the TS team and coordinated between the TS and the CF teams. Any deviation from the construction drawings must be documented and evaluated by both teams and corrective measures be determined. The anchorage system shall be designed and provided by the CF team and anchorage positions specified by the TS team. Also, the TS team will provide the details, requirements, and governing loads for the connection between the TS components and the CF structure. CF shall evaluate the impact on the structure and coordinate with the TS team accordingly. The CF team is responsible for the design of concrete monolith structure to verify it is adequate for all sustain and operating loads imposed by the anchorage of the equipment. The anchorage adequacy will be evaluated by the TS team.

The corresponding members working within the Vessel Systems WBS (Work Breakdown Structure) within Target Systems are responsible for the design and procurement of the core vessel and core vessel internal shielding. The corresponding members working within the Target Station Shielding WBS within Target Systems are responsible for the design and procurement of the bulk shielding, bulk shielding liner, core vessel baseplate, pipe pan and removable shielding. Conventional Facilities is responsible for the concrete portion of the monolith that separates the Target Systems components inside the monolith from the Instrument Bunker beyond the outside diameter of the monolith structure, as well as the monolith ports and all of the imbedded anchors within the concrete portion of the monolith

5.1.2 Technical Description

In the STS design, a pulsed proton beam is transported from the Accelerator to a rotating Tungsten Target to produce Neutrons through spallation. The generated neutrons pass through a Moderator Reflector Assembly that produces the desired cold neutrons that radiate along specific paths as they exit the moderator. The cold neutrons then pass through clearance paths within the Core Vessel shielding, through the front window of the Monolith Inserts and into the optical guides contained within the Monolith Inserts. The neutrons are transported along the beamlines to the end stations within each individual instrument.

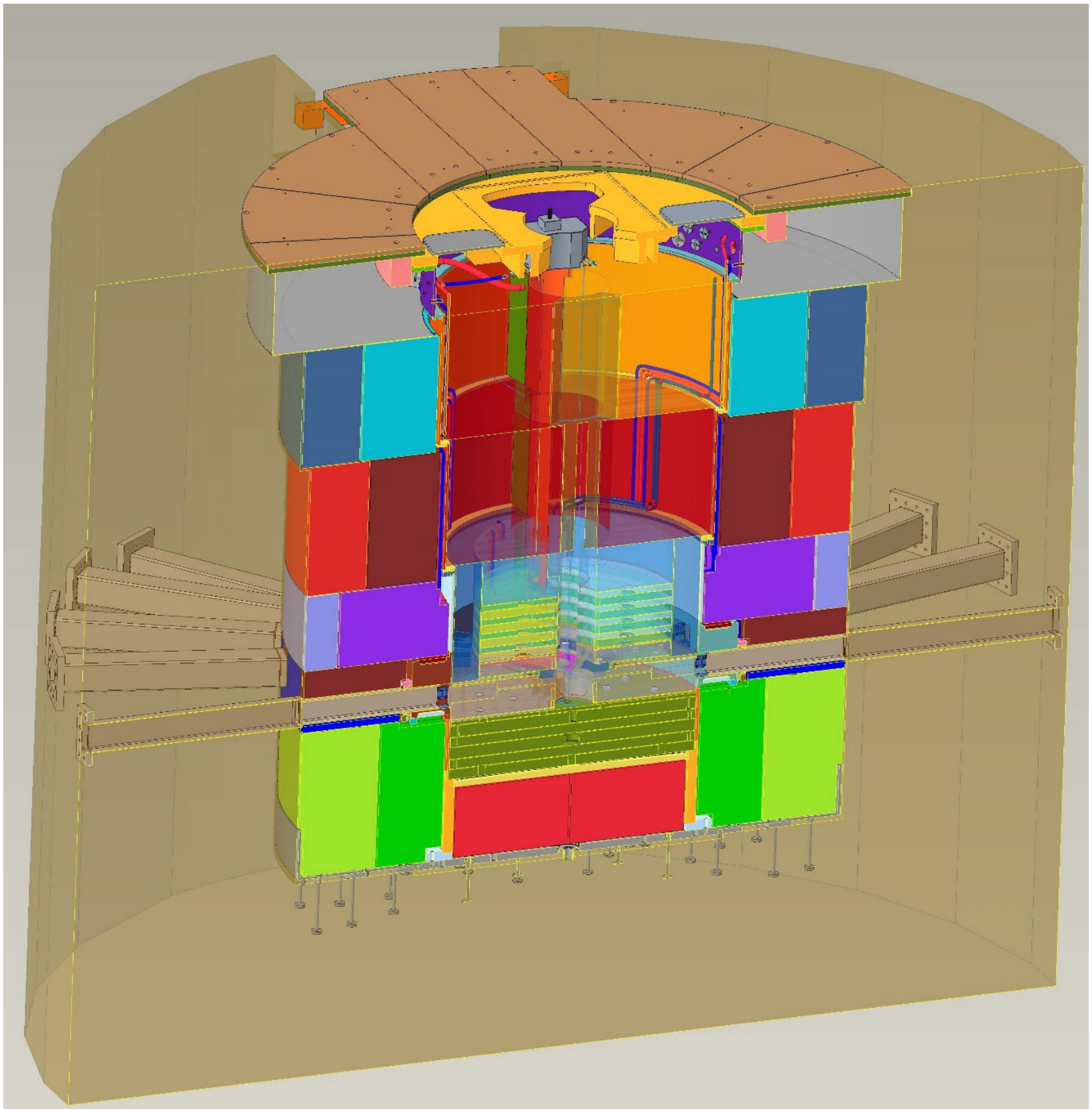

Figure 1: STS Monolith Section Cut Along Beamline # 5

A total of 18 beamlines would originate from two Moderators located above and below the rotating Tungsten Target. Each beamline will utilize an individual Monolith Insert containing guide optics to direct the beam out of the monolith and towards the individual instruments. The Monolith Inserts are centred in plan and in elevation on the (18) neutron beamlines. While only (8) instruments will be designed and constructed during the capital project, all (18) monolith inserts will be installed and aligned to facilitate future additions to the facility's instrument suite. Each monolith insert is housed within a Nozzle Extension that attaches to the Core Vessel and extends through the monolith concrete to the outside diameter of the monolith. Penetrations in the monolith concrete will be formed by (18) Monolith Ports. A section view of the current STS monolith design can be seen in **Figure 1** above.

Proper alignment between the Moderator Reflector Assembly within the Core Vessel and the instrument beamline optics is of critical importance to the overall performance of the Second Target Station. Small deviations in alignment both during construction as well as during operation can have a negative impact on the performance of Second Target Station instruments. Because of this, the accurate positioning of the Target System within the monolith as well as the maintenance of this position over time must be accomplished. The following interfaces exist between Conventional Facilities and Vessel Systems / Target Station Shielding:

- **Monolith concrete floor to Core Vessel Baseplate**

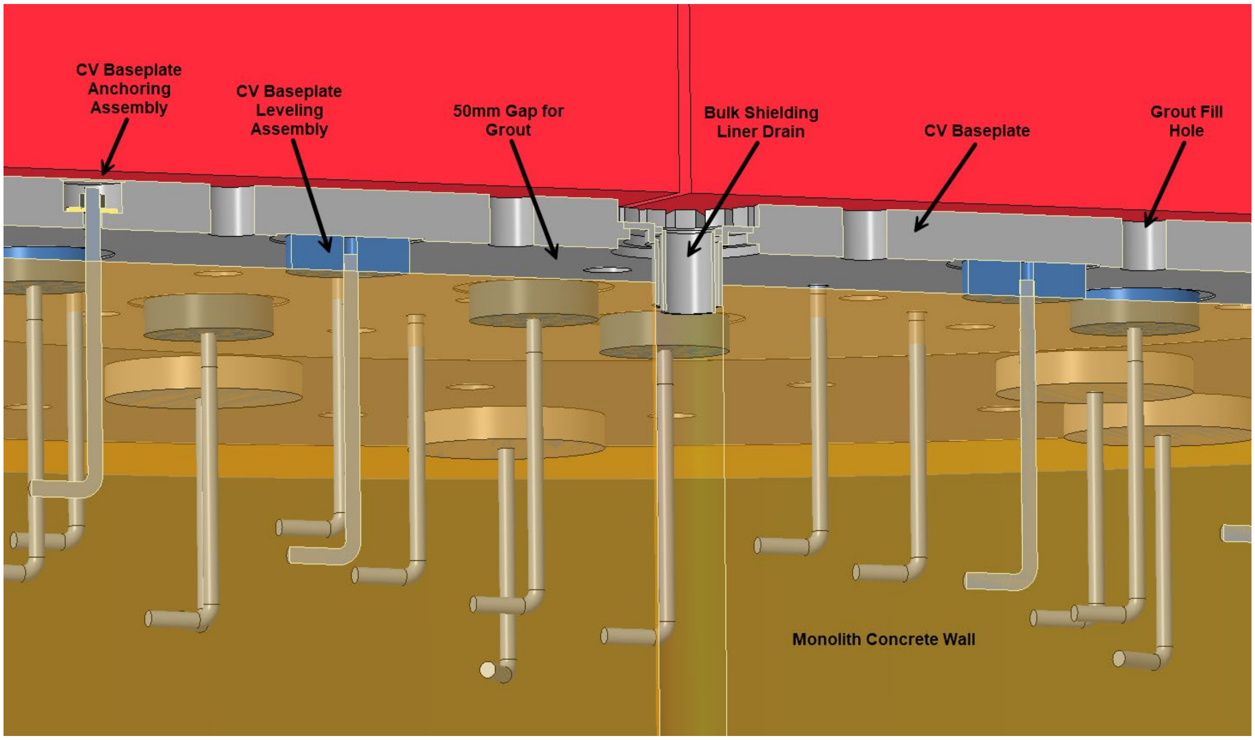

Figure 2: Cross sectional view showing Core Vessel Baseplate to monolith concrete floor interface. Note: anchor geometry is notional and will be determined by CF team.

- The Core Vessel will require a baseplate within the concrete monolith floor to support the Core Vessel weight as well as provide precise alignment features and bolting locations suitable for all anticipated mechanical/structural loads
- Anchor locations will be provided in drawings by TS team
- Anchor loadings will be provided by the TS team
- The CF team will provide a pocket in the monolith concrete floor for the imbedded plate to rest within
- The CF team will procure and install anchors in the locations specified by the TS team.
- The baseplate will be leveled using leveling anchor assemblies, and bolted to the concrete via embed anchors
- The CF team will procure and install the leveling anchors and the threaded top portion of the leveling anchor assemblies
- Bulk shielding liner drain pipes will be installed in the concrete prior to CV baseplate installation. CF will field fit and weld the inner and outer drain pipes to the baseplate using adapter rings provided by VS. The adapter rings can be seen over the bulk shielding liner drain in Figure 2 above.
- After the baseplate is leveled and secured, the assembly will be grouted in place with a 50mm thick layer of free-flowing grout via grout holes in the baseplate

- Baseplate grout holes will be 75mm in diameter and no more than 600mm (center to center) away from the next closest grout hole

- **Monolith concrete floor and wall to Bulk Shielding Liner**

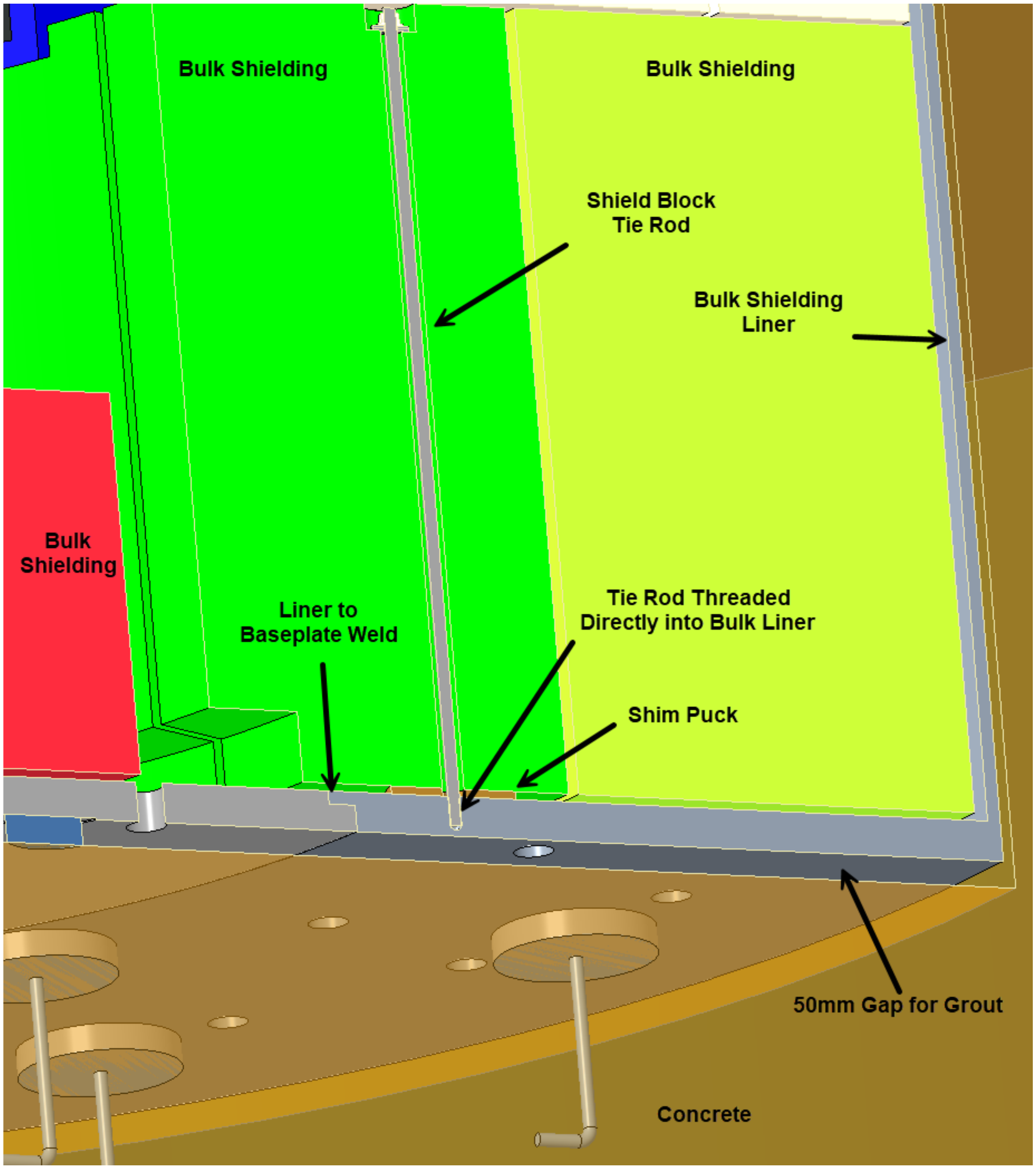

Figure 3: Cross sectional view showing bulk shielding liner and anchor system.

- The bulk shielding liner assembly interfaces with the concrete floor of the monolith.
- The bulk shielding liner will extend up the inside diameter side wall of the monolith concrete 500 mm to provide leak capturing for the monolith cooling loops.
- The Bulk Shielding Liner will be anchored only to the monolith floor and proton beam ledge. Anchorage of the liner to the monolith wall is not required.
- Bulk Shielding Liner anchorage will be provided by the CF team.

- Shim pucks (Supplied by TS) will be placed at all anchor points between the bulk shielding liner and the concrete floor in order to level the bulk shielding liner
- The bulk shielding liner will be welded to the core vessel baseplate prior to grouting in place
- The bulk shielding liner will be grouted in place with 50mm of free-flowing grout at the same time the core vessel base plate is grouted in place
- 75mm grout holes spaced 600mm apart or less will be provided in the bulk shielding liner as a part of the TS design of the liner
- The bulk shielding liner will be installed after the monolith concrete is poured and set

- **Monolith Ports**

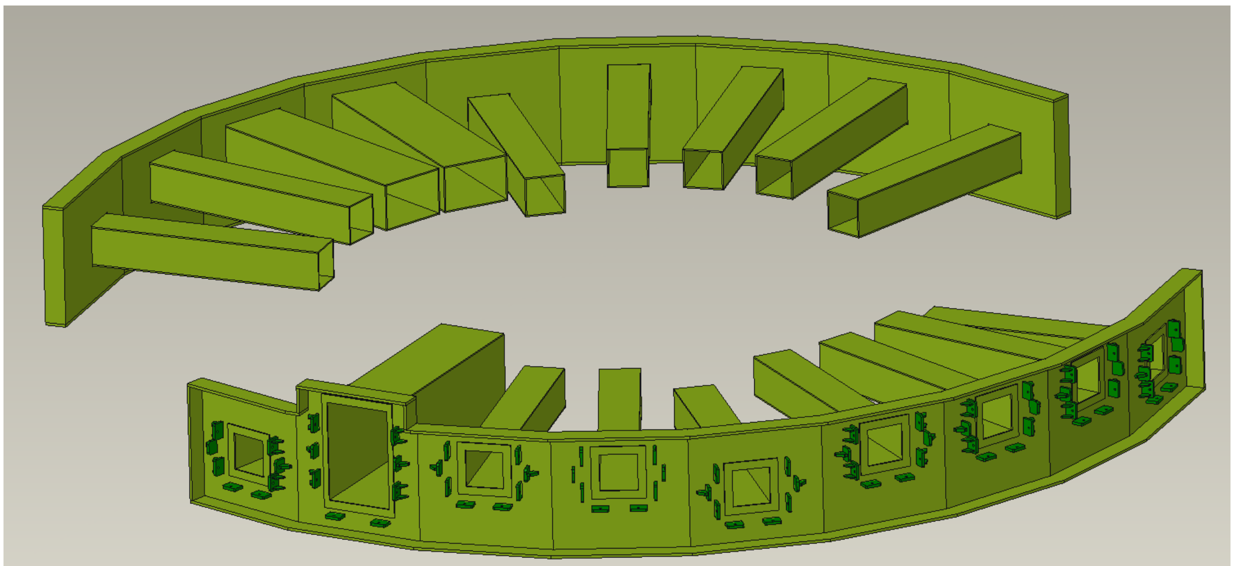

Figure 4: Conceptual design of monolith ports used to define inside dimensions required by TS

- The (18) monolith ports [4] will be embedded into the concrete monolith wall to provide clearance and support for the nozzle extensions, as well as mechanical support for the instrument shutters.
- Monolith ports will be accurately located to allow alignment of the instrument optics within the monolith. Placement shall meet the American Concrete Institute standard, ACI 117, specifies +/- 1/2"inch (12.7mm) of horizontal and vertical placement.
- Monolith port interior profile shall not deviate more than +/- 5 mm due to out of squareness and localized deflections due to concrete loading
- TS will provide the nominal inside profile and tolerance bands for the interior openings of the monolith ports
- Bunker-side details of the monolith port geometry will be provided by Instrument Systems
- Detailed design of the monolith ports is by CF.
- CF team will be responsible for designing, overseeing, and providing adequate shoring and support for the ports to meet the requirements established by TS.
- Port locations are by TS team and are provided on interface drawings [4] to the CF team.

- **Monolith concrete wall to shield stack**
  - A nominal gap of 20mm has been designed between the concrete wall and the outside diameter of the target station shielding stack and bulk shielding liner

- All shielding will be installed after the monolith concrete is poured and cured

- **Monolith concrete to proton beam window bump-out**

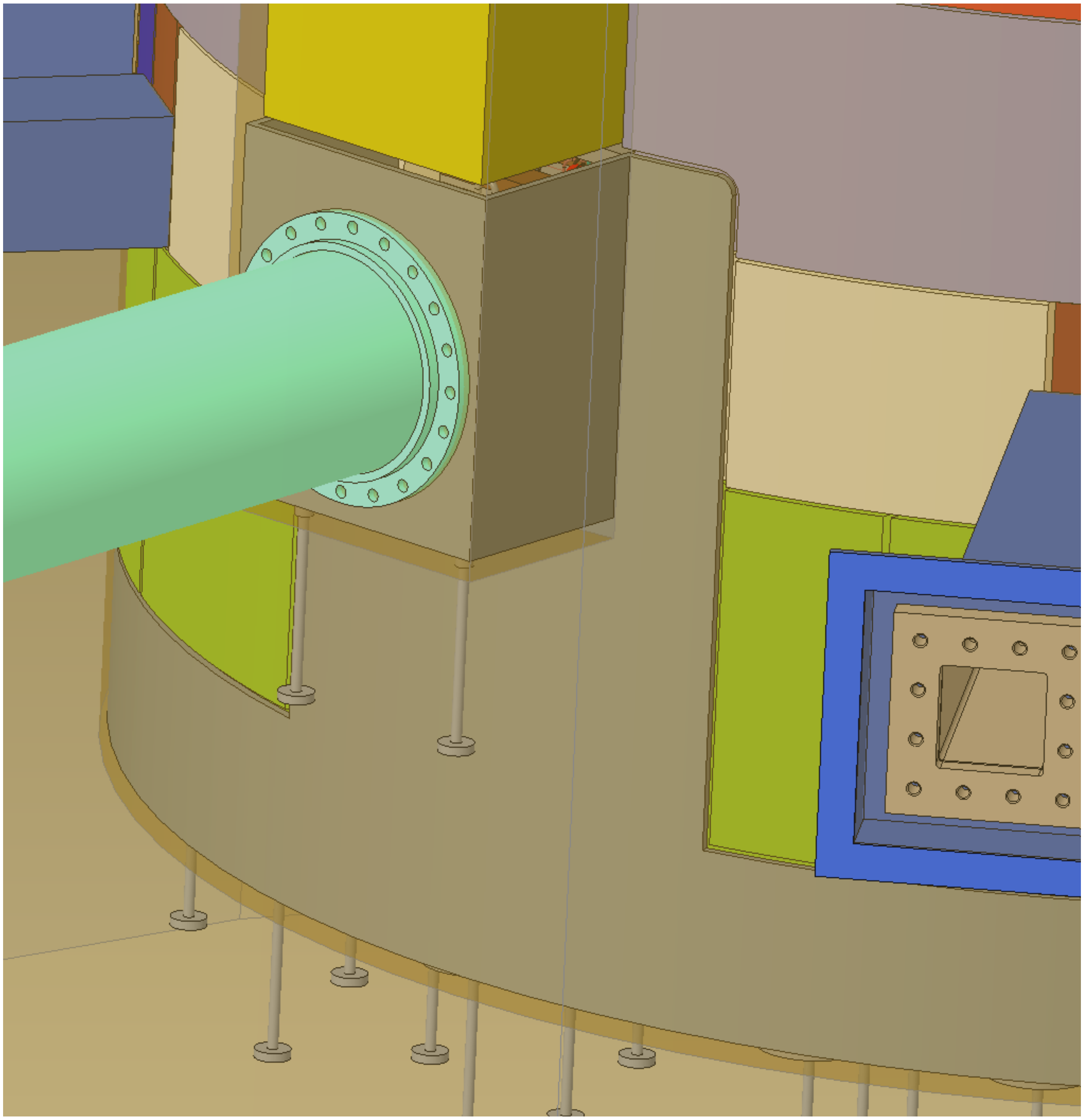

Figure 5: Exterior view of bulk shielding liner proton beam window bump-out

- A small portion of the bulk shielding liner extends up the wall of the monolith and forms a containment box around the proton beam window landing zone
- The horizontal surface of the bump-out will be leveled using shim pucks for leveling and grouted in place
- Embedded anchors in the horizontal floor section are required to secure the proton beam window base plate

- A 50mm grout gap is to be filled by CF during installation, with a grout dam used to keep grout from flowing down the vertical face of the bulk shielding liner
    - Grout holes will be 75mm in diameter and no more than 600mm away from the next closest grout hole
    - Static and seismic loading data for these anchors will be provided by the Accelerator Interface Components group within Target Systems
- **Monolith Concrete to proton beam window removable shielding**
    - PBW removable shielding is supported on a ledge in both the target station shielding and the concrete
    - Alignment pins in the target station shielding and concrete will properly locate the shielding and maintain its position during a seismic event
    - TS will provide the concrete anchor locations as well as the static and seismic loading conditions
- **Monolith concrete to Pipe Pans**
    - Pipe pans will be run under the cooling lines entering and leaving the Core Vessel
    - Sections of the pipe pans will run on top of the concrete monolith side walls and extend both upstream and downstream to the vertical pipe chases
    - Routing and geometric requirements of the pipe pans is by TS
    - All pipe pans will be installed after completion of the monolith concrete pour
- **Monolith support**
    - The monolith concrete floor must be designed to support the full mechanical/structural loading of the Target System components housed within the monolith.
    - Differential settlement within the monolith can negatively impact component alignment and should be kept below 5mm. It has been determined that the deep foundation supported concrete mat foundation system selected by the project team can support the structure and anticipated loads without undergoing excessive differential settlements after component alignment. It is understood that the optical components within the Monolith have very limited adjustment capabilities.
- **Monolith Concrete Coating**
    - In order to contain leaks within the monolith, a waterproof coating shall cover all concrete surfaces below the TDR floor and extend 500 mm up the target drive room side walls where practical
- **Monolith concrete radiation protection**
    - Radiation shielding provided by Vessel Systems and Target Station Shielding must be sufficient to protect the concrete from excessive heating that would compromise the strength of the concrete. A maximum concrete temperature below 65C will be maintained during steady state operation
    - Preliminary Neutronics heating analysis of the concrete directly below the Core Vessel showed a peak concrete temperature of 47 degrees Celsius during steady state operation. The CF team will ensure that the CF structure is adequate when subjected to this thermal loading
- **Ground water radiation protection**
    - The combination of Vessel Systems, Target Station Shielding and Conventional Facilities concrete radiation shielding must be sufficient to protect ground water present under the concrete from becoming contaminated during facility operation. TS is responsible for meeting this requirement.
- **Core Vessel Hatch Clearance**
    - The CV upper weldment is currently the largest assembled component that will be transported through the loading hatches and into the high bay prior to installation in the monolith

- The current size of the CV upper weldment is 3282 mm tall and 3745 mm in diameter
- CF will ensure that the hatch clearance is sufficient for movement of the CV from the truck loading bay to the high bay
- Vessel Systems will inform CF of any changes to the physical size of the CV

5.2 INTERFACE DATA

The basic mechanical layout of the Core Vessel, Target Station Shielding and Monolith Concrete can be seen in figure 6 below. The concrete floor interfaces with the embedded plate below the Core Vessel, the bulk shielding liner, and the bulk shielding anchors. The Monolith floor shall be designed to support the full weight of the Target Systems monolith components. While some degree of monolith settlement is expected, differential settling within the monolith structure itself and relative to the bunker is minimized by the foundation system selected for this project. The concrete Monolith walls interface with both the bulk shielding liner as well as the (18) Monolith Ports [4].

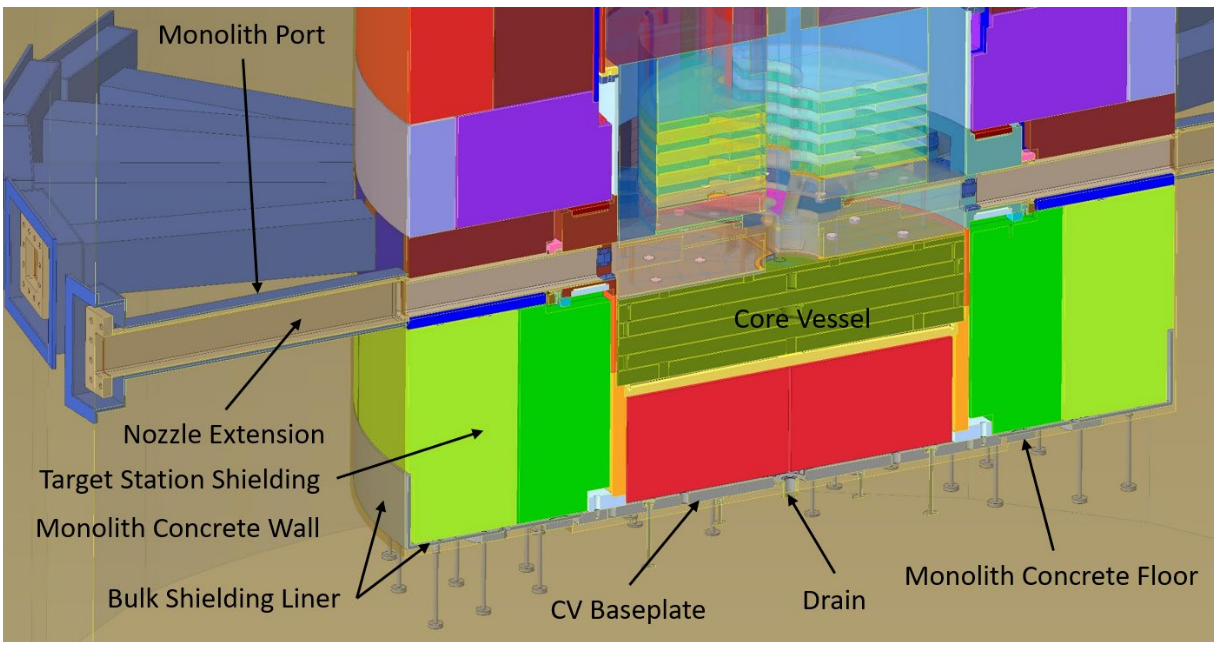

Figure 6: Detailed view of STS Monolith design section cut along Beamline #5

5.2.1 Internal monolith concrete geometry

- See drawing S03060000-G8U-8800-A10000 [3] for nominal dimensions of the monolith internal concrete relative to Target Systems global center
- Concrete tolerance = +/- 10mm

5.2.2 Monolith port internal geometry and position

- See drawing S03060000-G8U-8800-A10001 [4] for nominal dimensions of the monolith port internal shape and locations relative to the instrument beamline centers
- Monolith port positional tolerance = +/- 10mm

5.2.3 Core Vessel Baseplate concrete anchor details

- See drawing S03070000-G8U-8800-A10000 [5] for anchor dimensional details
- Anchor type: M24 female threaded anchor
- Expected anchor pull-out load
    - Bolt Preload = Minimal, sufficient to lock plate position and resist uplift during grouting
    - Max seismic vertical load = TBD
    - Maximum total pull-out load = TBD
- Expected anchor lateral load (seismic loading): TBD
- Required positional accuracy: Each anchor position aligns to oversized holes in the corresponding shield block with 10mm of radial clearance. Embedded anchors must remain within this positional envelope after the concrete has been cast and settled.

5.2.4 Bulk shielding liner concrete anchor details

- See drawing S03070000-G8U-8800-A10001 [6] for anchor dimensional details
- Anchor type: M24 female threaded anchor
- Expected anchor pull-out load
    - Bolt Preload = Minimal, sufficient to lock plate position and resist uplift during grouting
    - Max seismic vertical load = TBD
    - Maximum total pull-out load = TBD
- Expected anchor lateral load (seismic loading): TBD
- Required positional accuracy: Each anchor position aligns to oversized holes in the corresponding shield block with 10mm of radial clearance. Embedded anchors must remain within this positional envelope after the concrete has been cast and settled.

5.2.5 Pipe pan cover anchor details

- See drawing S03070000-G8U-8800-A10002 [7] for anchor dimensional details
- Anchor type: M16 female threaded anchor
- Expected anchor pull-out load
    - Bolt Preload = N/A
    - Max seismic vertical load = TBD
    - Maximum total pull-out load = TBD
- Expected anchor lateral load (seismic loading): TBD
- Required positional accuracy: Each anchor position aligns to oversized holes in the corresponding pipe pan cover with 7mm of radial clearance. Embedded anchors must remain within this positional envelope after the concrete has been cast and settled.

5.2.6 Imposed Gravitational and Seismic Loads

The total weight load imposed on the monolith concrete by the Target Systems monolith components is estimated to be 1,219,882 kg. This includes the target station shielding, bulk shielding liner, pipe pan, core vessel with internal shielding, proton beam tube, proton beam window assembly, target viewing periscope, target assembly and moderator. Utility piping outside of the core vessel is not included but it is not expected to have a substantial effect on the total weight. Monolith ports are not included in the weight too.

The following data may be used to calculate the seismic load effects related to the Target Systems monolith components:

- Combined center of gravity (C.G.) in the X, Y, Z in relation to the STS datum
    - X = -72.7988 mm
    - Y = 1310.1 mm
    - Z = 16.7555 mm
- The total effective seismic weight is equal to 1,219,882 kg
- Seismic Coefficients from Table 13.6-1, ASCE 7-16
    - $a_p = 1$
    - $R_p = 1.5$
    - $\Omega = 2$
- The importance factor, I_e, shall be 1.5

Note: Based on preliminary calculations, the core vessel anchorage does not experience any uplift or shear related to seismic loads. Shear resistance is provided by two available mechanisms. The confinement provided by the monolith itself at the interface between the grouted in liner and the inner wall of the monolith. As well as the frictional resistance between the CV liner and the base mat. Preliminary calculations show that the frictional resistance is more than enough to restrain the CV under seismic loads. To provide a redundant means of shear resistance, the AE shall design the monolith wall to resist 100% of the seismic load at the interface between the grouted in liner and the lower portion of the monolith wall.

5.2.7 Concrete temperature during beam-on operations

The peak concrete temperature has been estimated at 47 degrees Celsius based on the current shielding layout and corresponding Neutronics and thermal analysis conducted in May 2023.

5.2.8 Core Vessel Hatch Clearance

The CV upper section is currently the largest assembled component that will be transported through the loading hatches and into the high bay prior to installation in the monolith. The current size of the CV upper weldment is 3282 mm tall and 3745 mm in diameter.