LIGO Laboratory / LIGO Scientific Collaboration

LIGO- T1000746-v1 *ADVANCED LIGO* 3/13/11

Viewports Subsystem
Final Design Document

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Abstract

This document will present the final design for the Viewports Subsystem. The Viewports subsystem provides optical viewports for the passage of all optical beams in and out of the vacuum region(s) of the IFO. The optical beams include the following: optical lever beams, CO2 laser beams for thermal compensation (TCS viewports are not part of this design), chamber illumination beams, video camera beams, and optical beams used for interferometer sensing and control.

1 Introduction

1.1 Scope and Introduction

The Viewports subsystem provides optical viewports for the passage of all optical beams in and out of the vacuum region(s) of the IFO. The optical beams include the following: optical lever beams, CO2 laser beams for thermal compensation, chamber illumination beams, video camera beams, and optical beams used for interferometer sensing and control.

TCS viewports are not part of this design.

1.2 Final Design Review Checklist

1.2.1 Final requirements – any changes or refinements from PDR?

Errors in some chamber and adapter flange viewport names were changed to reflect the LIGO naming convention.
The TCS CO2 laser viewports and the Hartmann viewports in HAM4 and HAM10 are the responsibility of the TCS subsystem.

1.2.2 Subsystem block and functional diagrams

See section **Error! Reference source not found.**.

1.2.3 Final Parts Lists and Drawing Package (assembly drawings and majority of remaining drawings)

1.2.4 Final specifications

The following viewports are standard catalog items with specifications guaranteed by the manufacturer:

2.7 DIA, MDC450004-AR635

5.4 DIA VP800/450009

5.4 DIA VP800-AR1064

5.4 DIA VP800-AR532

7.8 DIA, ISI 9722012-AR635

The dimensions and physical details can be found at the following web-site: MDC Vacuum Products. They require AR coatings at the specified wavelengths
The 6.0 in-AR800-900 and 6.0 in-AR1064/532 viewports are custom viewports purchased from a commercial vendor to the following specification: 6.0 inch Vacuum Viewport Specification

1.2.5 Final interface control documents

All viewports, except for the septum viewports, interface to standard conflat flanges that are attached to nozzles on the vacuum chambers, vacuum equipment connecting tubes and adapters. The details of these viewport attachment nozzles are described in the LIGO Vacuum Equipment drawings by GNB Corporation, and Process Systems International.

The septum viewports are sealed with o-rings around the openings of the septum plates.

1.2.6 Relevant RODA changes and actions completed

Not applicable

1.2.7 Signed Hazard Analysis

E1000890-v1 ACB Hazard Analysis

1.2.8 Final Failure Modes and Effects Analysis

Not Required

1.2.9 Risk Registry items discussed

None for this subsystem

1.2.10 Design analysis and engineering test data

See **Error! Reference source not found.** and **Error! Reference source not found.**.

1.2.11 Software detailed design

Not applicable, ISC will handle this.

1.2.12 Final approach to safety and use issues

No operational safety issues

1.2.13 Production Plans For Acquisition Of Parts, Components, Materials Needed For Fabrication

E1100247-v1_Viewport production plan.

1.2.14 Installation Plans and Procedures

This will be deferred until after FDR

1.2.15 Final hardware test plans

See E1000892-v1 Fabrication, Installation, and Test Plan

Suspended baffle balancing before installation

See E1000892-v1 Fabrication, Installation, and Test Plan

1.2.16 Final software test plans

Not applicable.

1.2.17 Cost compatibility with cost book

See E1000891-v1_ACB production plan.

1.2.18 Fabrication, installation and test schedule

See E1000892-v1 Fabrication, Installation, and Test Plan

1.2.19 Lessons Learned Documented, Circulated

TBD

1.2.20 Problems and concerns

TBD

1.3 Definitions

1.4 Acronyms

LIGO - Laser Interferometer Gravity Wave Observatory

IO - Input Optics

PRM, PR2, and PR3 – Power Recycling Mirrors

SRM, SR2, and SR3 – Signal Recycling Mirrors

BS - Beam Splitter

ITMx, ITMy - Input Test Mass in the interferometer ‘X’ or ‘Y’ arm

ETMx, ETMy - End Test Mass in the interferometer ‘X’ or ‘Y’ arm

AR - Antireflection mirror coating

HR – Hi-reflectance mirror coating

ppm - parts per million

ISC- Interferometer Sensing and Control

IFO - LIGO interferometer

HAM - Horizontal Access Module

WHAM – Hanford, Washington Horizontal Access Module

LHAM – Livingston, Louisiana Horizontal Access Module

BSC - Hanford, Washington Beam Splitter Chamber

WBSC - Hanford, Washington Beam Splitter Chamber

LBSC - Livingston, Louisiana Beam Splitter Chamber

TBD - To Be Determined

rms - root-mean-square

p-v, peak to valley

OPTLEV- optical lever

1.5 Applicable Documents

1.5.1 LIGO Documents

1. M950046-F LIGO Project System Safety Management Plan
2. L060068-00 ASC Vacuum Viewports
3. E960022-B LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures
4. D970211-B Video Imaging Assembly ASC Alignment
5. D970212-B Illuminator Assembly ASC Alignment
6. E080501 Enhanced LIGO TCS Hazard Analysis
7. E070253-A ELI Septum Window Assembly And Installation Procedure
8. D0901109 ZnSe Protector Plate Front View
9. D0901110 ZnSe Protector Plate Back
10. D0901477 Vacuum Chamber Designations for LHO aLIGO
11. D0901490 Vacuum Chamber Designations for LLO Aligo
12. D980227 Naming Conventions, BSC Ports
13. D980226 Naming Conventions for Ports on HAM Chamber
14. D980228 Naming Conventions for Ports on Adapter
15. E1000890-v1 ACB Hazard Analysis
16. E1000891-v1_ACB production plan
17. E1000892-v1 Fabrication, Installation, and Test Plan
18.
19.

1.5.2 Non-LIGO Documents

2 General description

Viewports are mounted to flanges in the nozzles of the vacuum chambers. The viewport material and the AR coatings on the viewport surfaces are chosen to maximize the transmissivity of the light passing through the viewport. Previous viewports from Initial LIGO and Enhanced LIGO may be re-used as appropriate.

3 Viewport Naming Conventions

3.1 BSC Chambers

3.1.1 D980227 - BSC Chamber Orientation for Viewport Names

The BSC orientation is shown in Figure 1. Ports are numbered clockwise from datum 0° distinguished by the Ion Pump Assembly location.

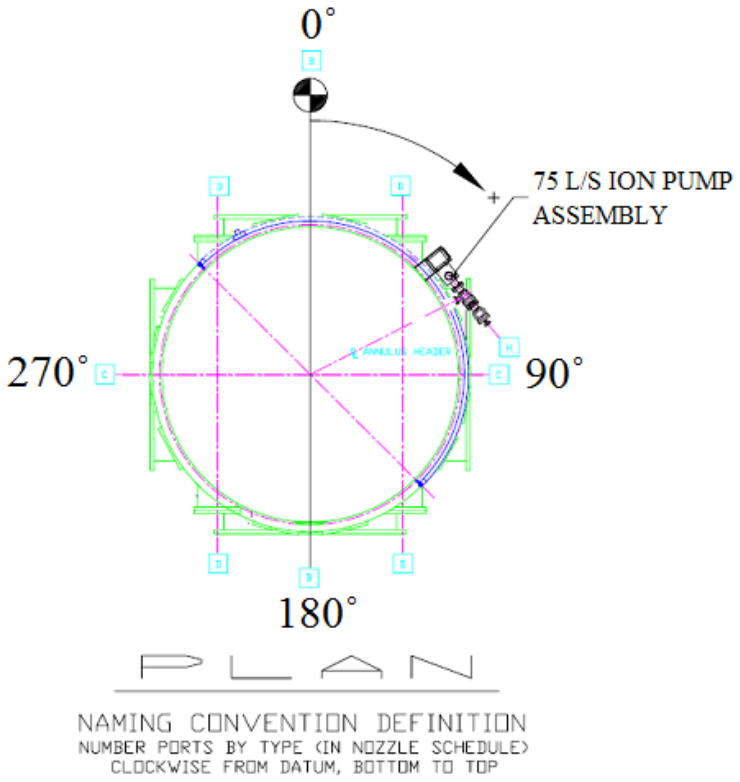

Figure 1: BSC orientation to reference viewport location

3.1.2 D980229 - BSC Viewport designation for Doors

The BSC Door Viewport Names are shown in Figure 2.

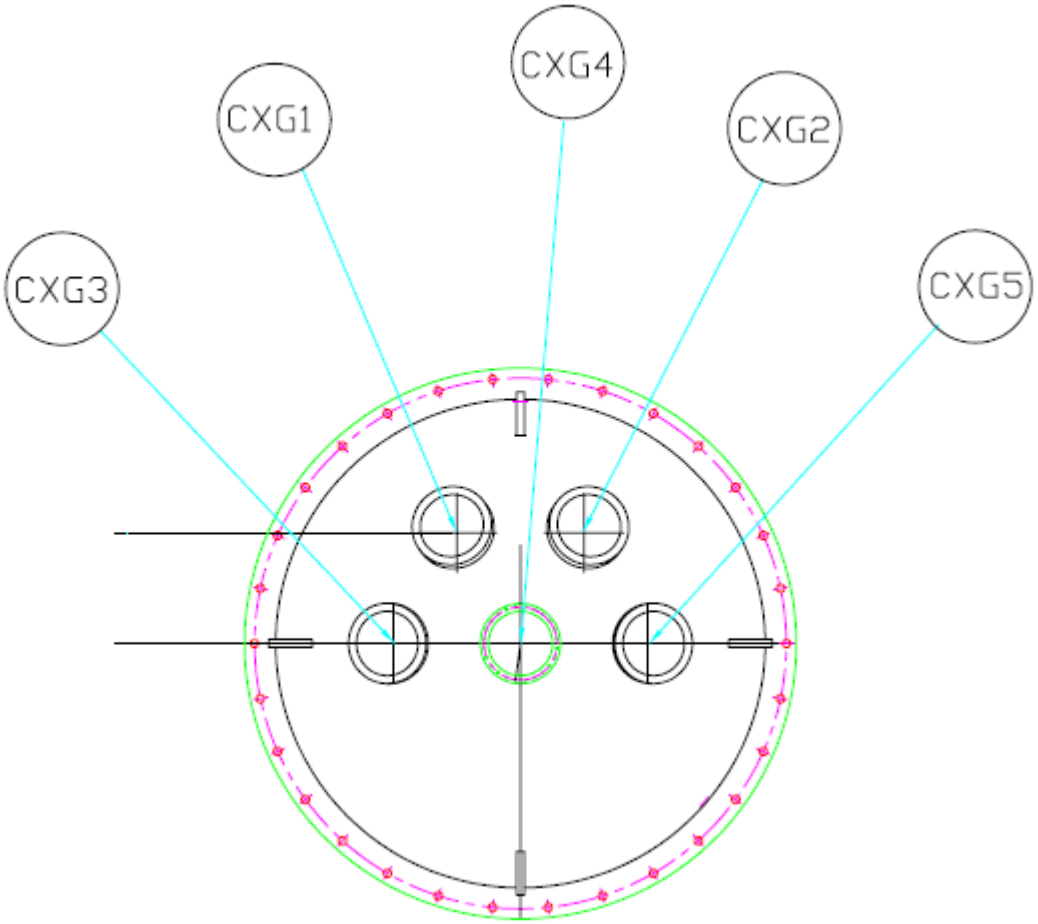

Figure 2: BSC Door Viewport Generic Names

3.1.3 BSC Viewport Door designations by Elevation

The BSC viewport names are shown in Figure 3, Figure 4, Figure 5 and Figure 6.

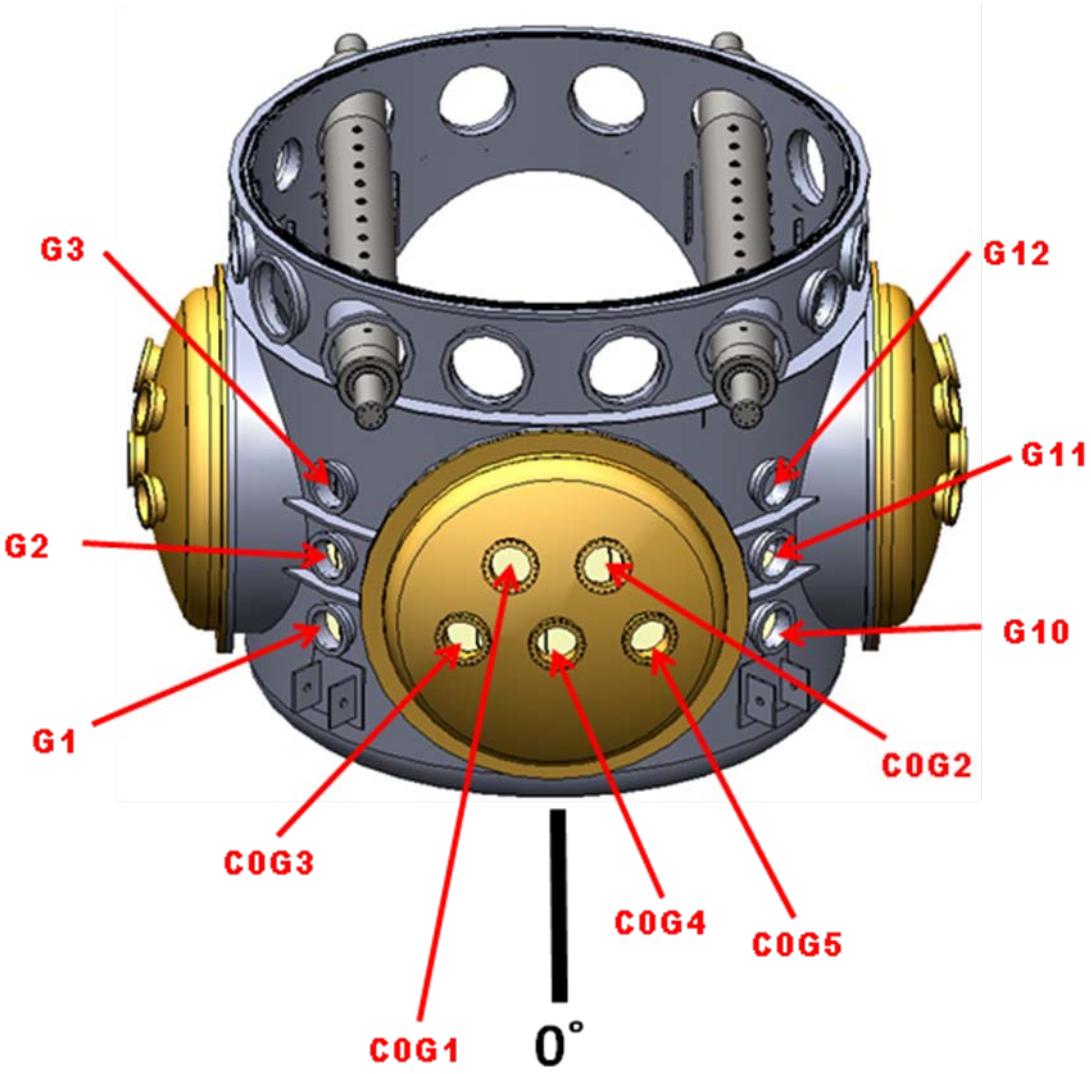

Figure 3: BSC viewport names, 0 deg elevation side

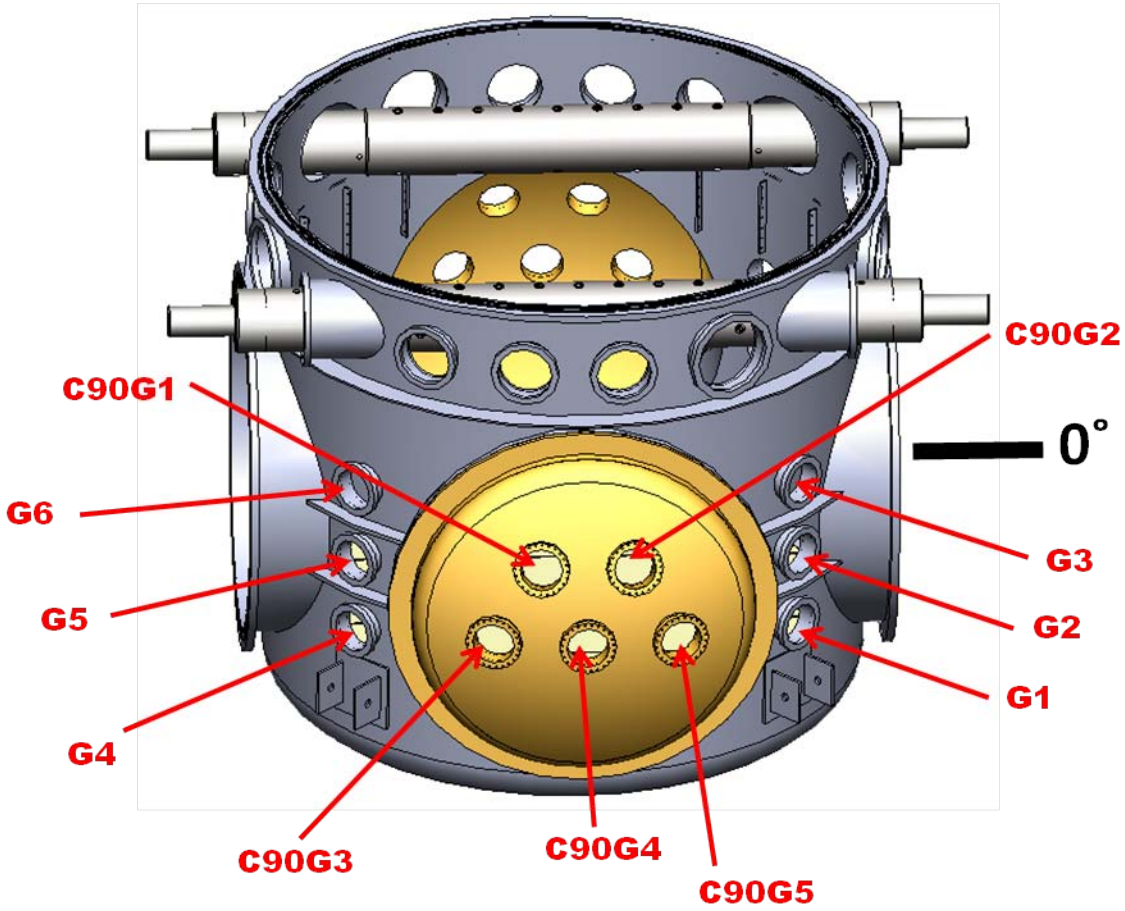

Figure 4: BSC viewport names, 90 deg elevation side

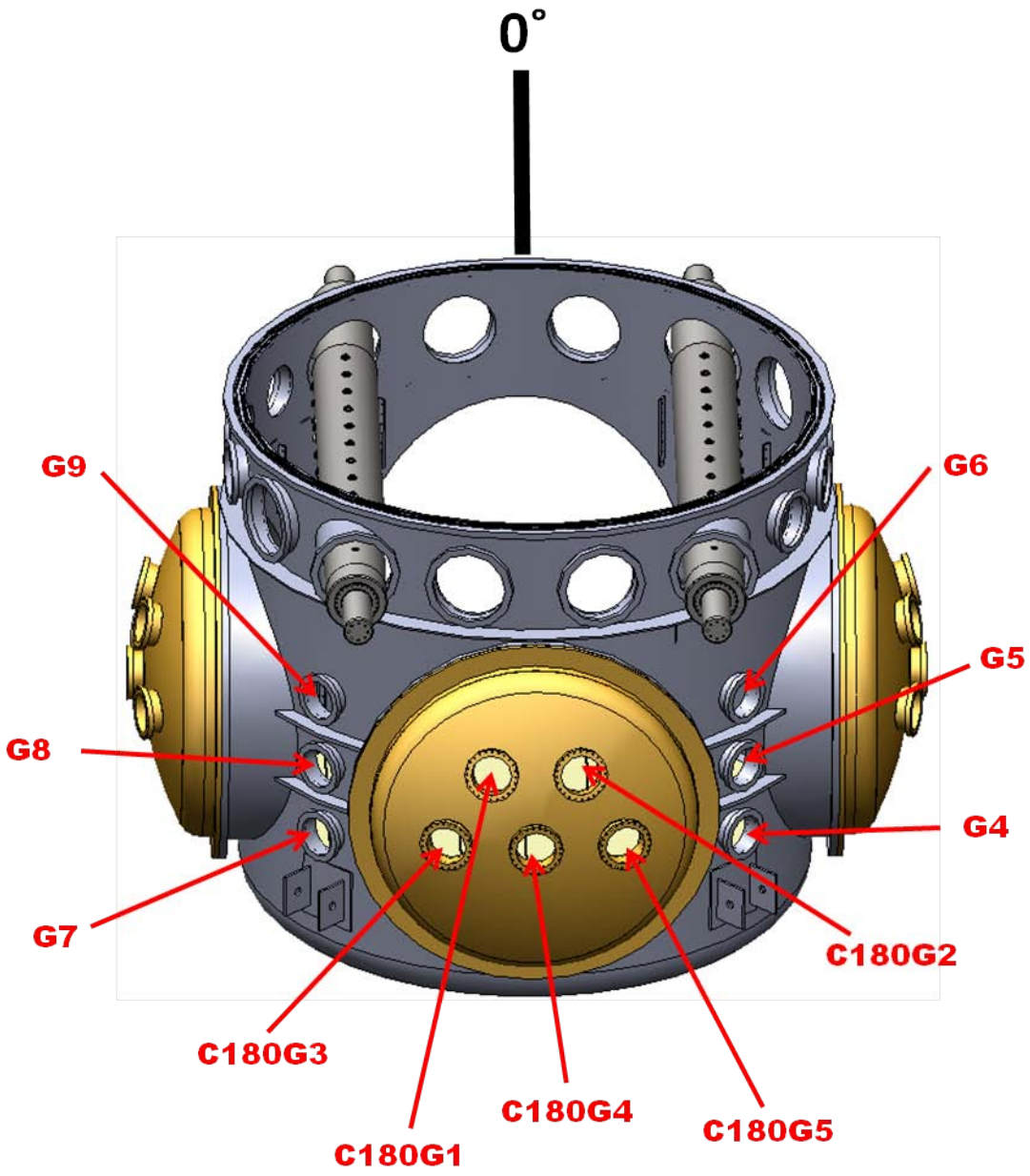

Figure 5: BSC viewport names, 180 deg elevation side

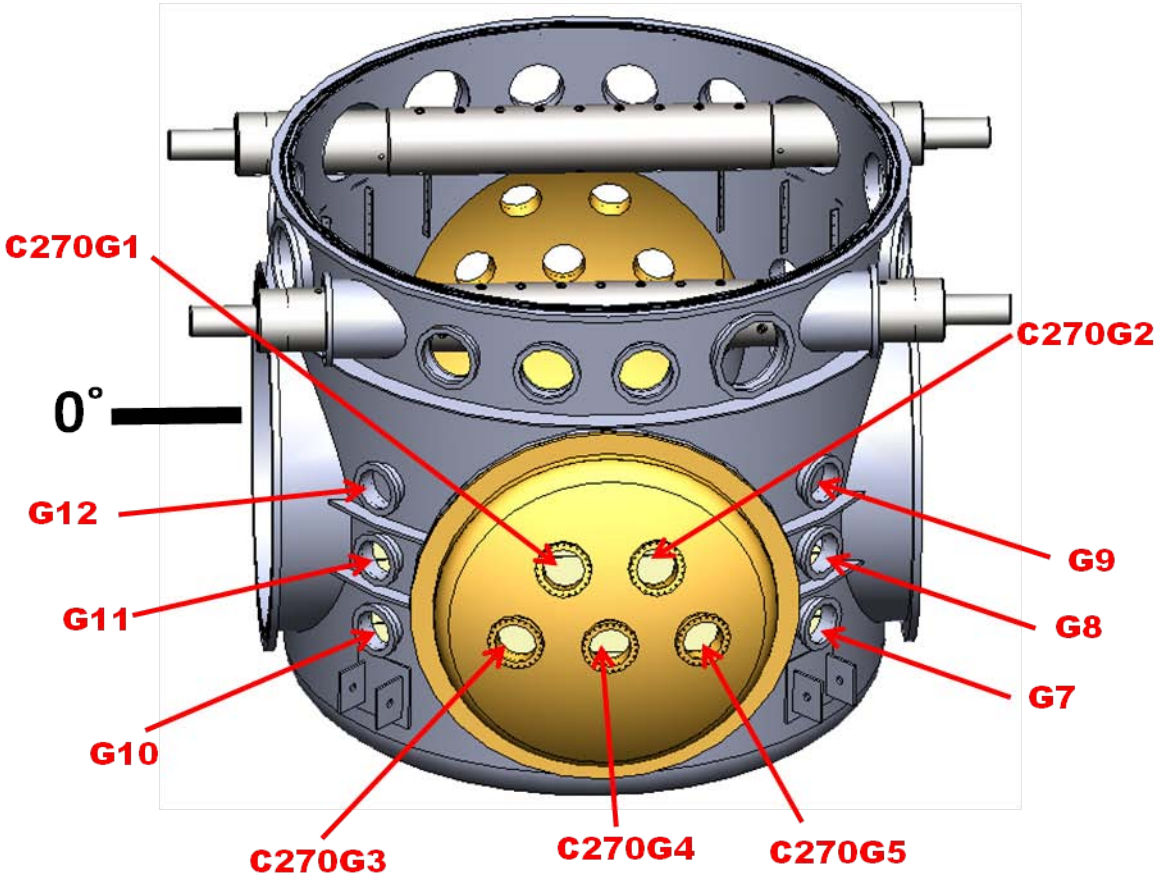

Figure 6: BSC viewport names, 270 deg elevation side

3.1.4 BSC Viewport designation for End Doors

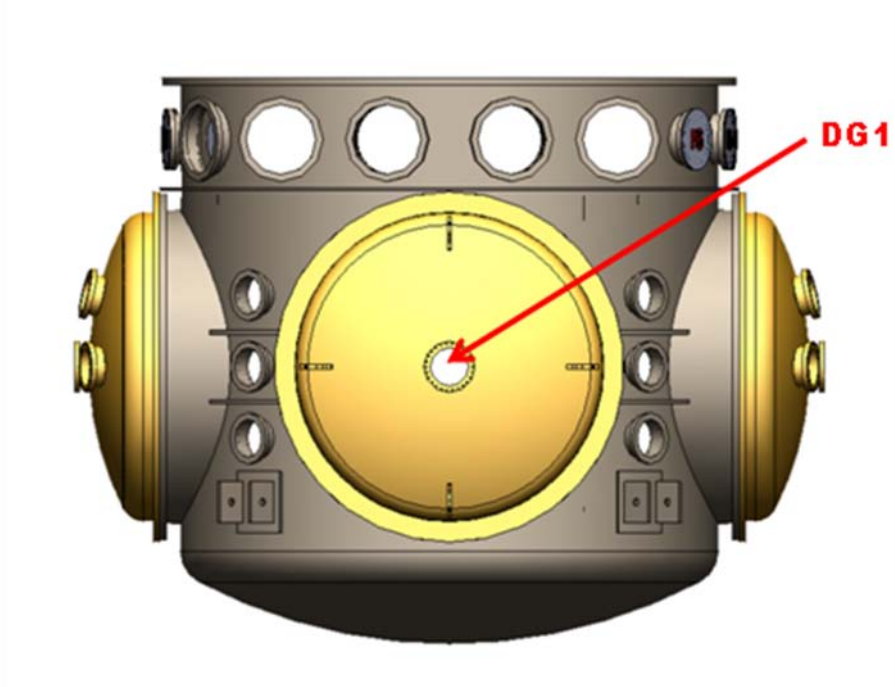

Figure 7: BSC End Door Viewport

3.2 HAM Chambers

3.2.1 D980226 - HAM Chamber Viewport Names

The HAM Chamber orientation and viewport names are shown in Figure 8.

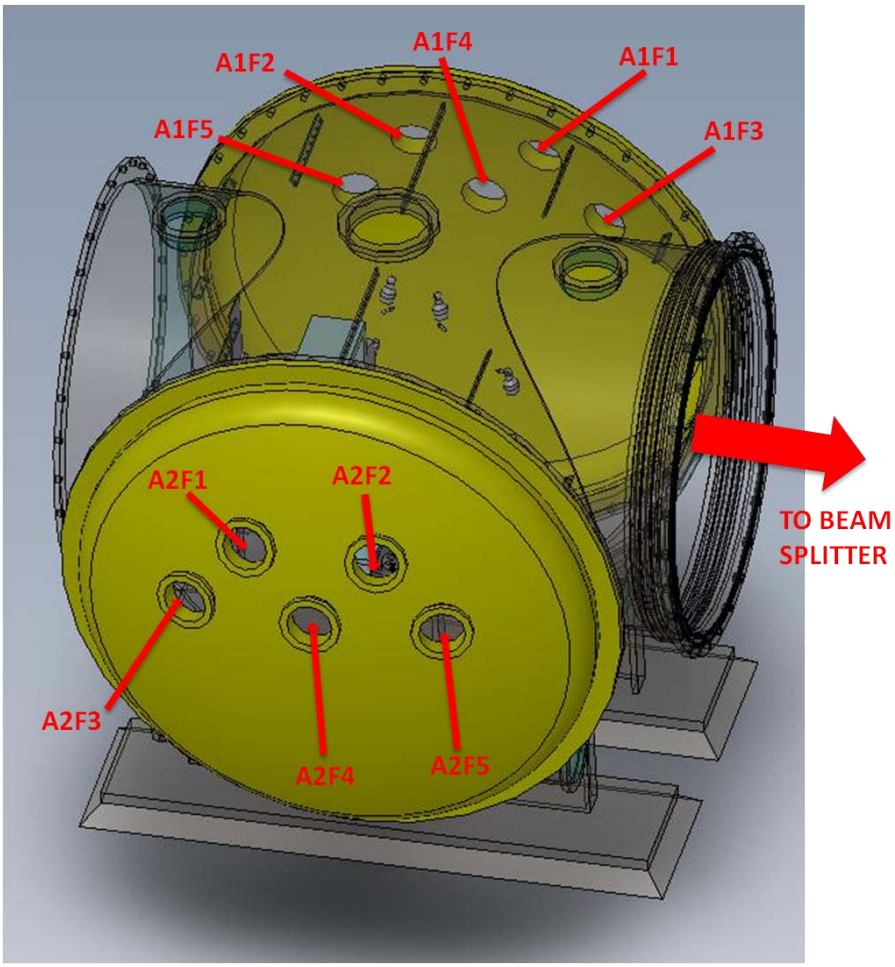

Figure 8: HAM Chamber Viewport Names

3.2.2 HAM Chamber End Door Viewport Names

The D060158 HAM Chamber Back Cover viewport names are shown in Figure 9.

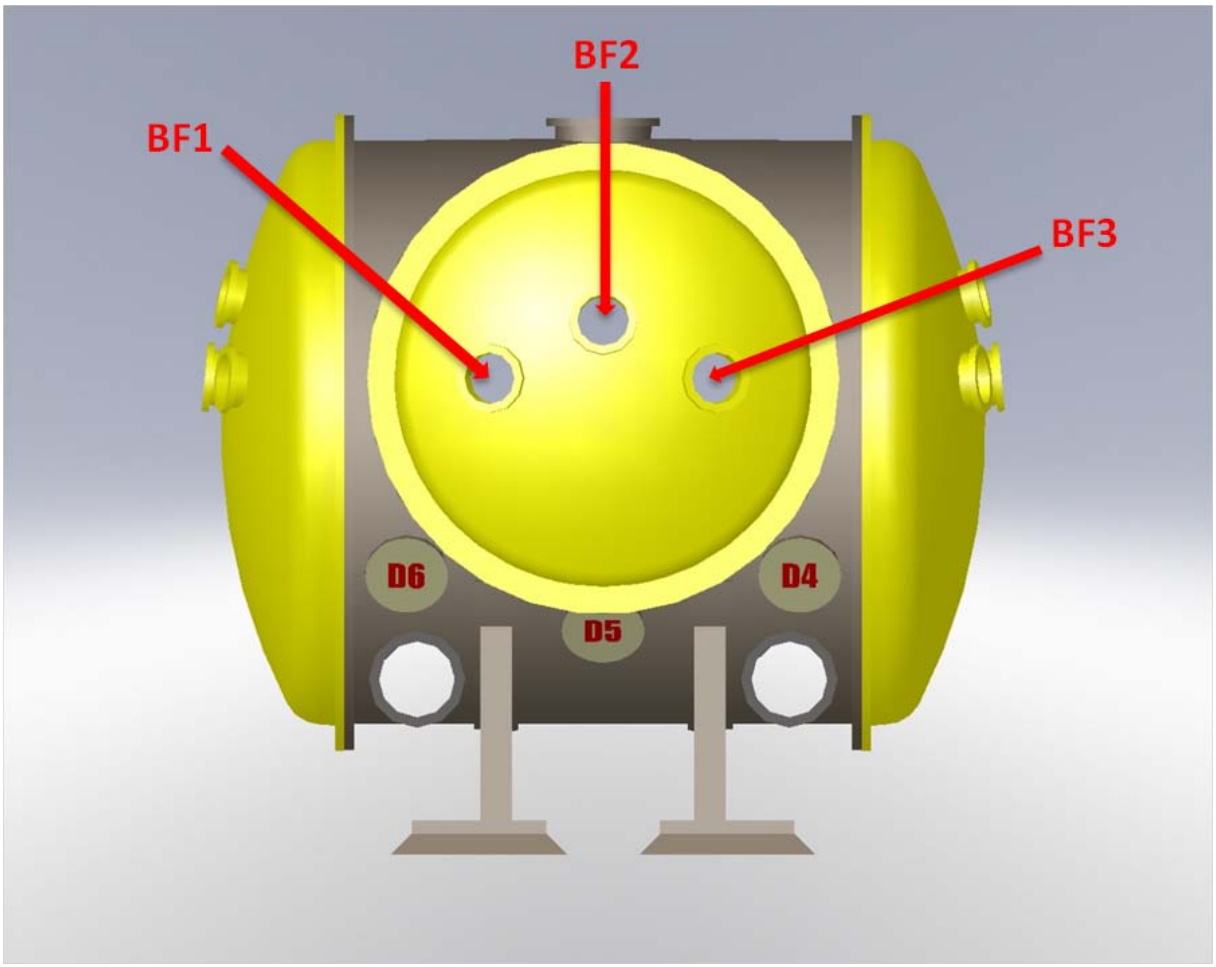

Figure 9: HAM Chamber Back Cover Viewport Names

3.3 Mode Cleaner Tubes

3.3.1 Mode Cleaner Tube Positions

The naming convention for the Mode Cleaner Tubes is shown in Figure 10.

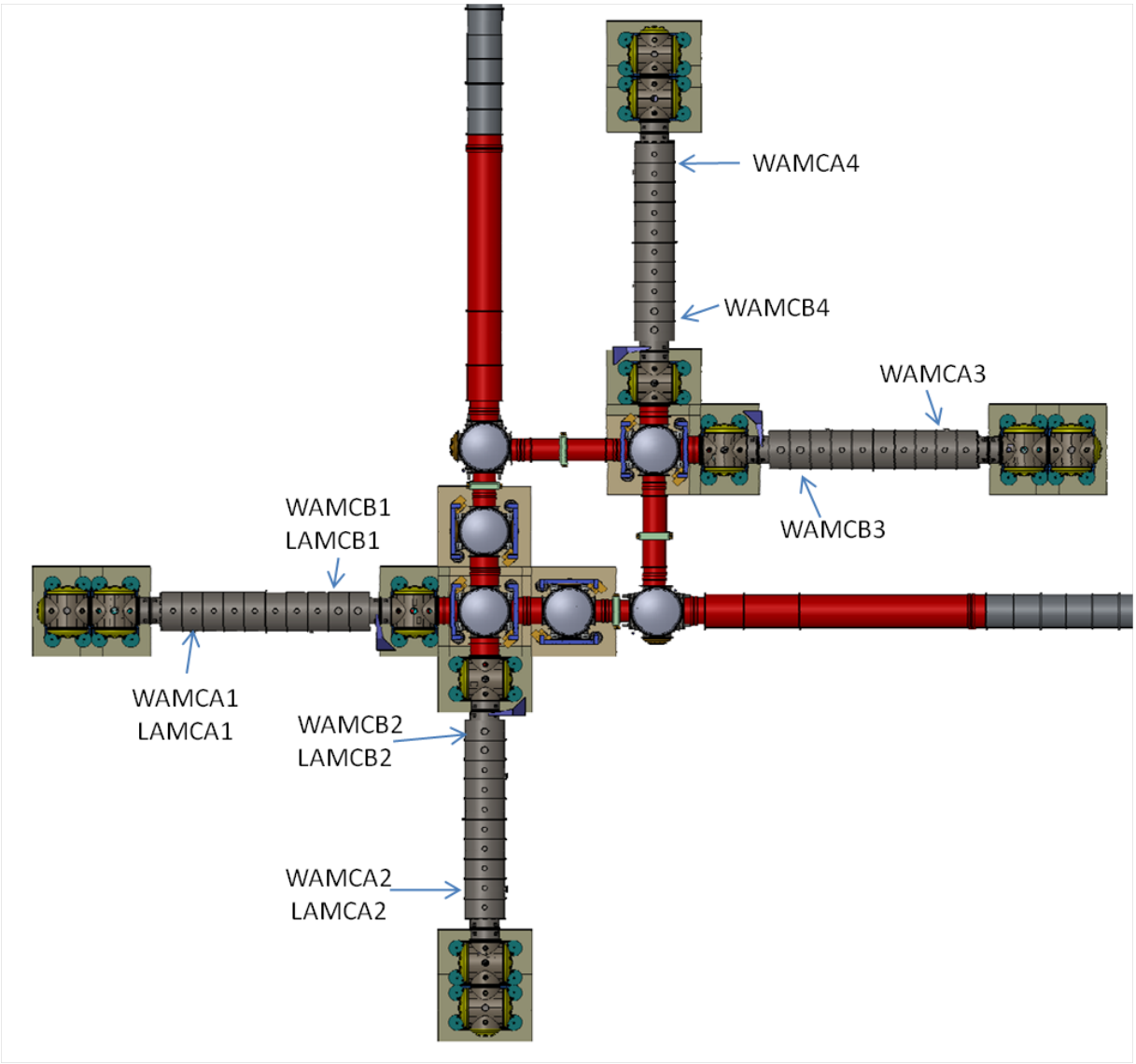

Figure 10: Mode Cleaner Tube Placement Naming Convention

3.3.2 D0902632 Mode Cleaner Tube A Viewports

The naming convention for the Mode Cleaner Tube A Viewports is shown in Figure 11.

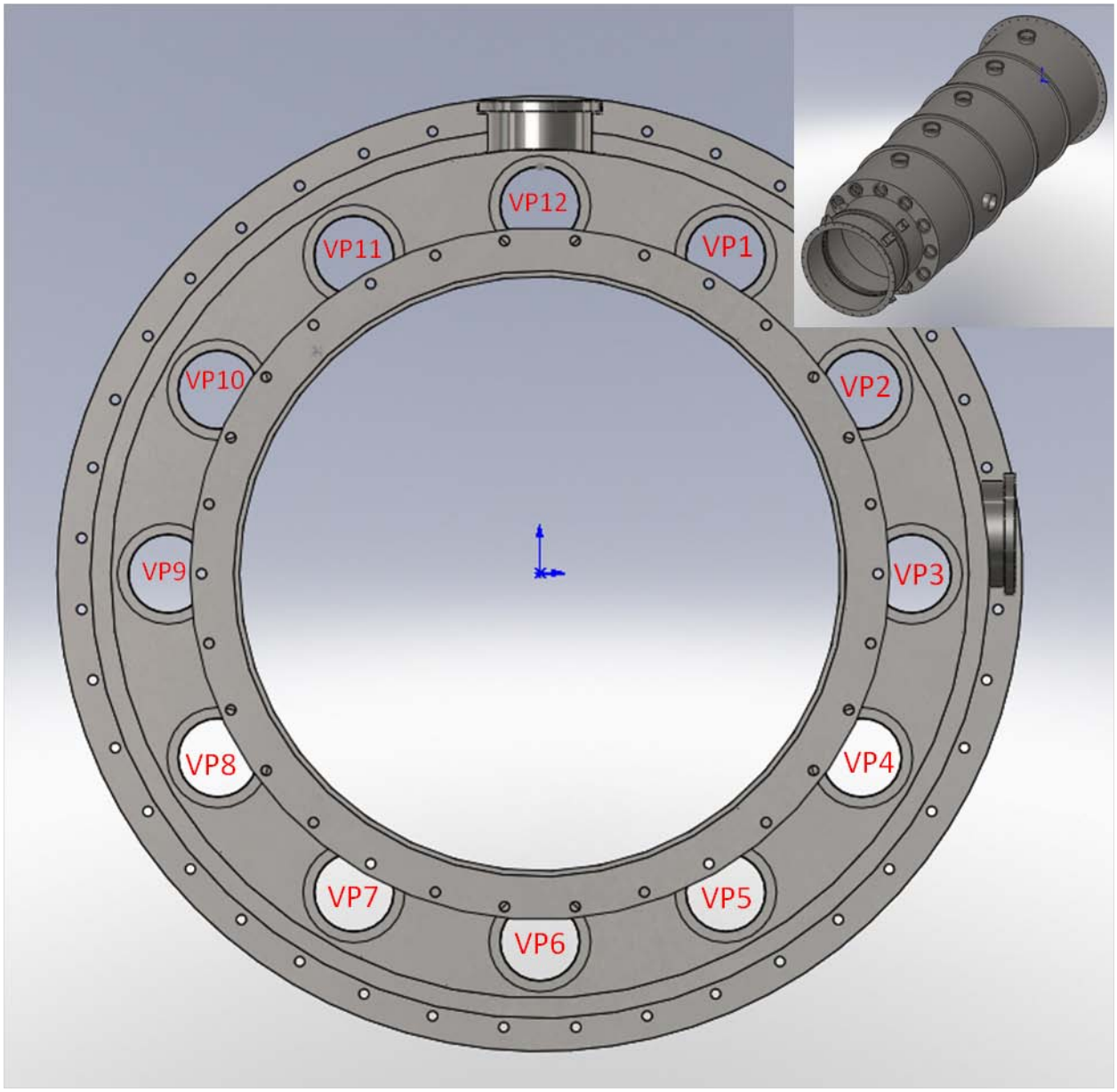

Figure 11: D0902632 Mode Cleaner Tube A Viewport Names

3.3.3 D0902631 Mode Cleaner Tube B Viewports

The naming convention for the Mode Cleaner Tube B Viewports is shown in Figure 12, see table for Hole Clock Positions.

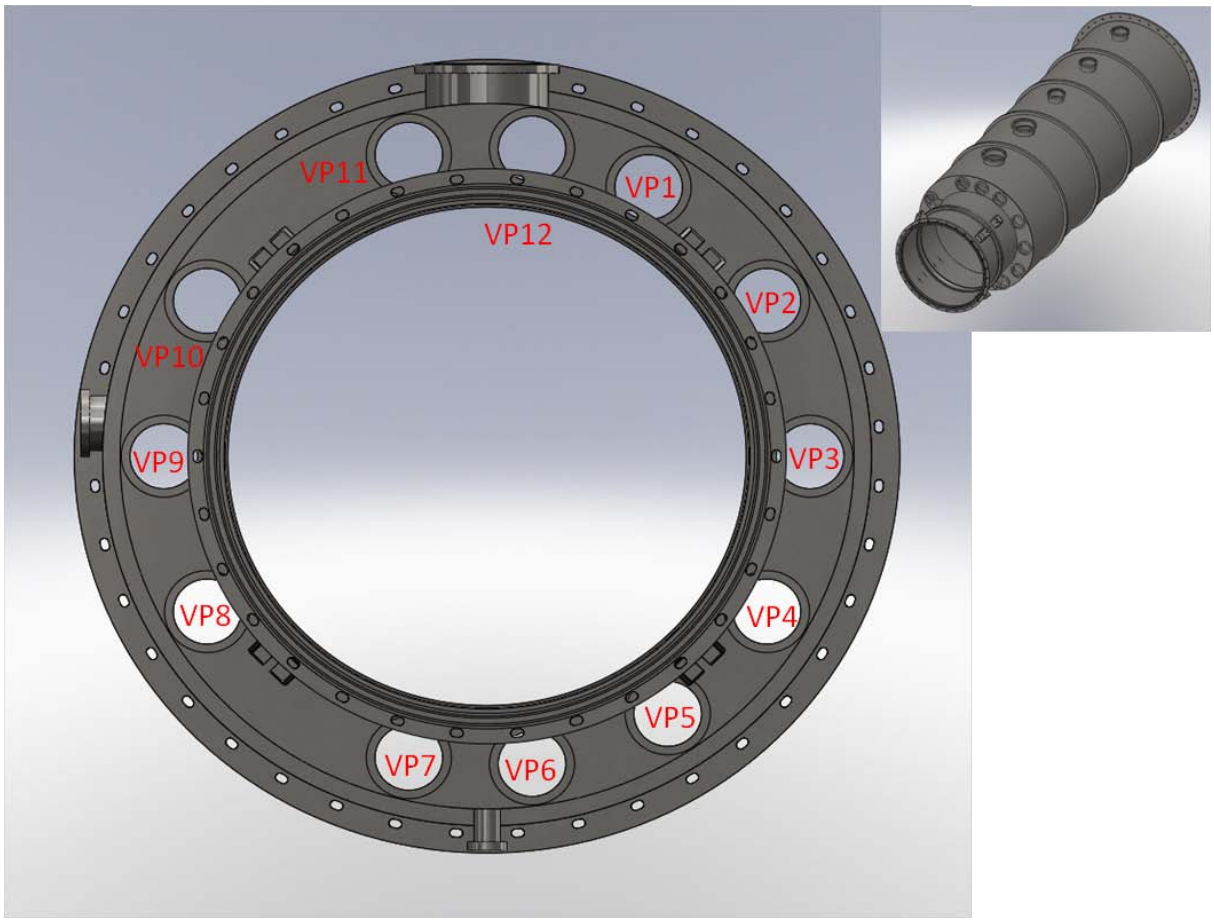

Table 2: Viewport Clocking
12 o'clock = 0°

Hole Clock Position	LAMCB1 WAMCB1	LAMCB2 WAMCB2	WAMCB3	WAMCB4
1	30°	23°	30°	30°
2	60°	60°	60°	60°
3	90°	90°	90°	90°
4	120°	120°	120°	120°
5	150°	157°	150°	146°
6	175°	180°	190°	172°
7	201°	210°	215°	194°
8	240°	240°	240°	240°
9	270°	270°	270°	270°
10	300°	300°	300°	300°
11	339°	330°	322°	346°
12	365°	360°	344°	368°

Figure 12: D0902631 Mode Cleaner Tube B Viewport Names and Clock Position

3.4 Adapter A-1 and Adapter A-17 Flanges

3.4.1 Spool B-9 - Adapter A-1, ITM-X and ITM-Y

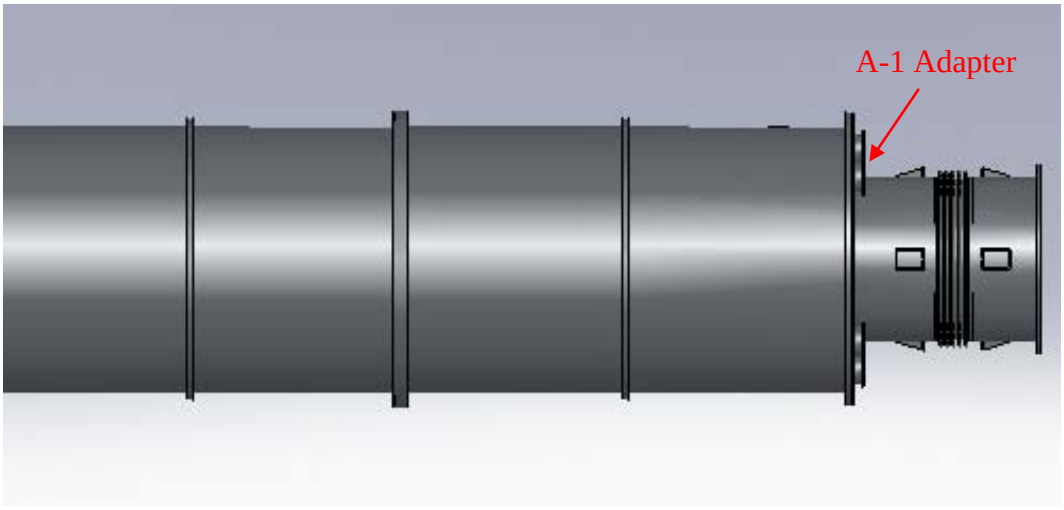

Figure 13: Spool B-9, Adapter A-1

3.4.2 L1 End - Adapter A-1, ETM-X and ETM-Y

Figure 14: L1 End - Adapter A-1

3.4.3 H1, H2 End - Adapter A-1 and Adapter A-17, ETM-X and ETM-Y

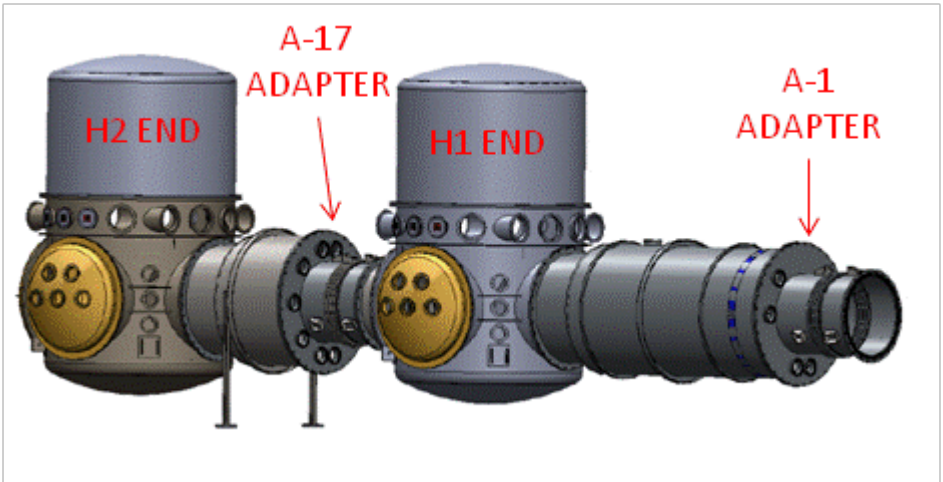

Figure 15: H1, H2 End - Adapter A-1 and Adapter A-17

3.4.4 D980228 Adapter A-1 Viewport Naming Convention

The Adapter A-1 viewport designators are shown in Figure 16.

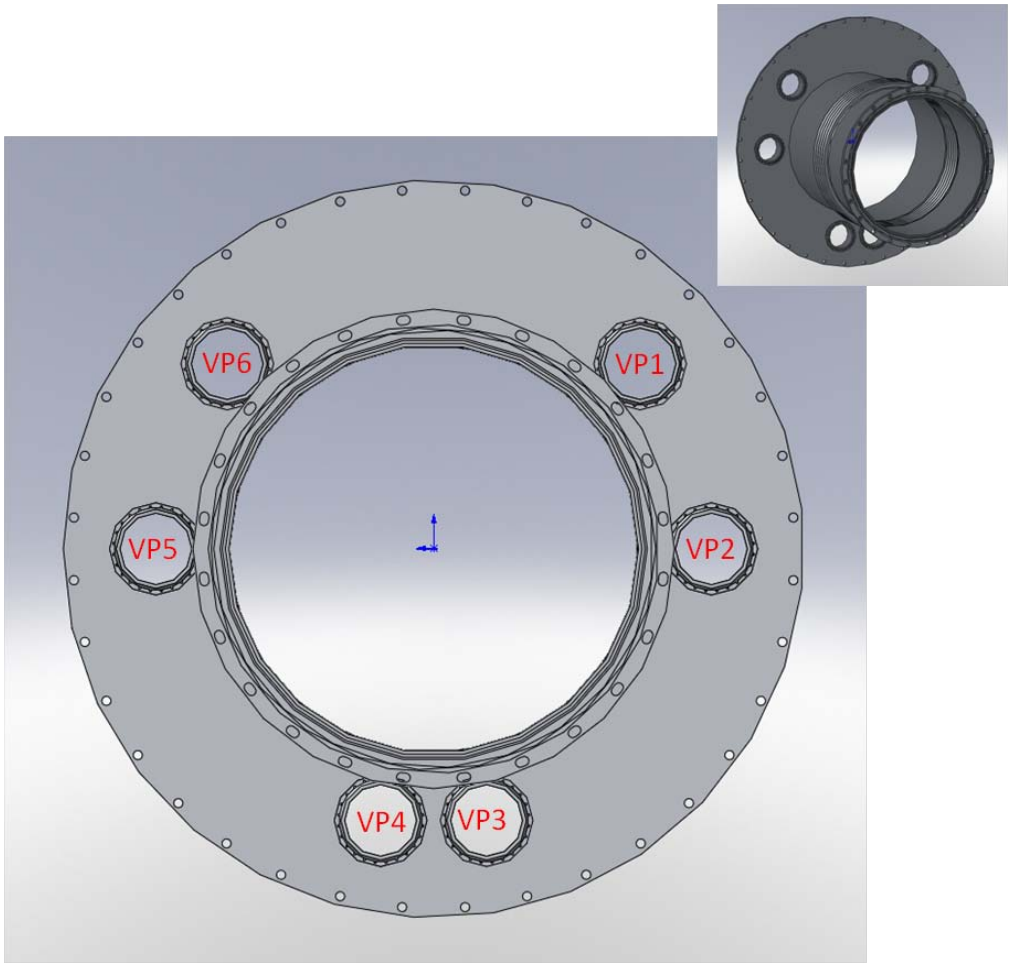

Figure 16: D980228 Adapter A-1

3.4.5 D0900947 Adapter A-17 Viewport Naming Convention

The Adapter A-17 viewport designators are shown in Figure 17

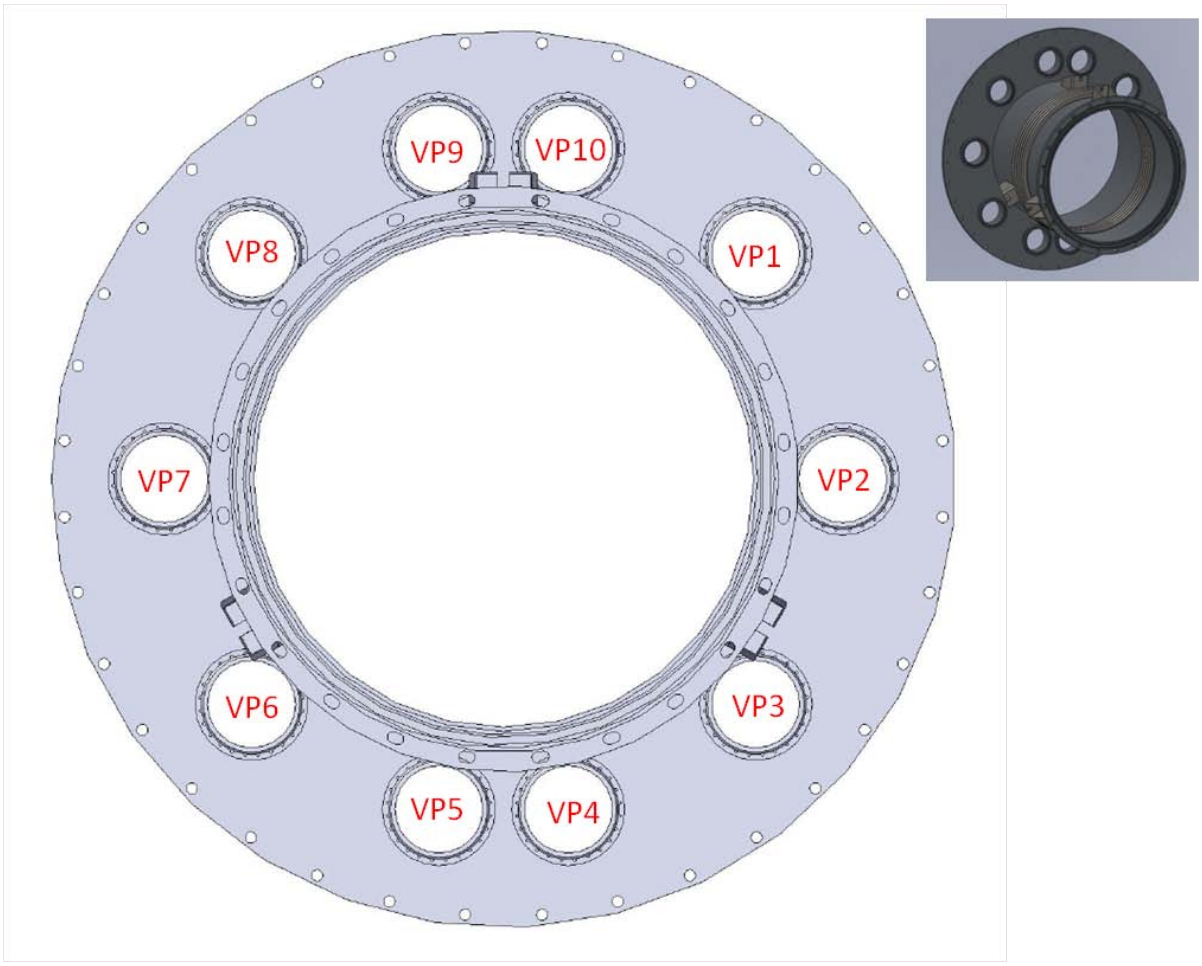

Figure 17: D0900947 Adapter A-17A

3.5 Septum Plates

3.5.1 H1, L1 Input Septum Plate Port Naming Convention

The H1, L1 Input Septum Plate Assembly D1002461 is shown in Figure 18.

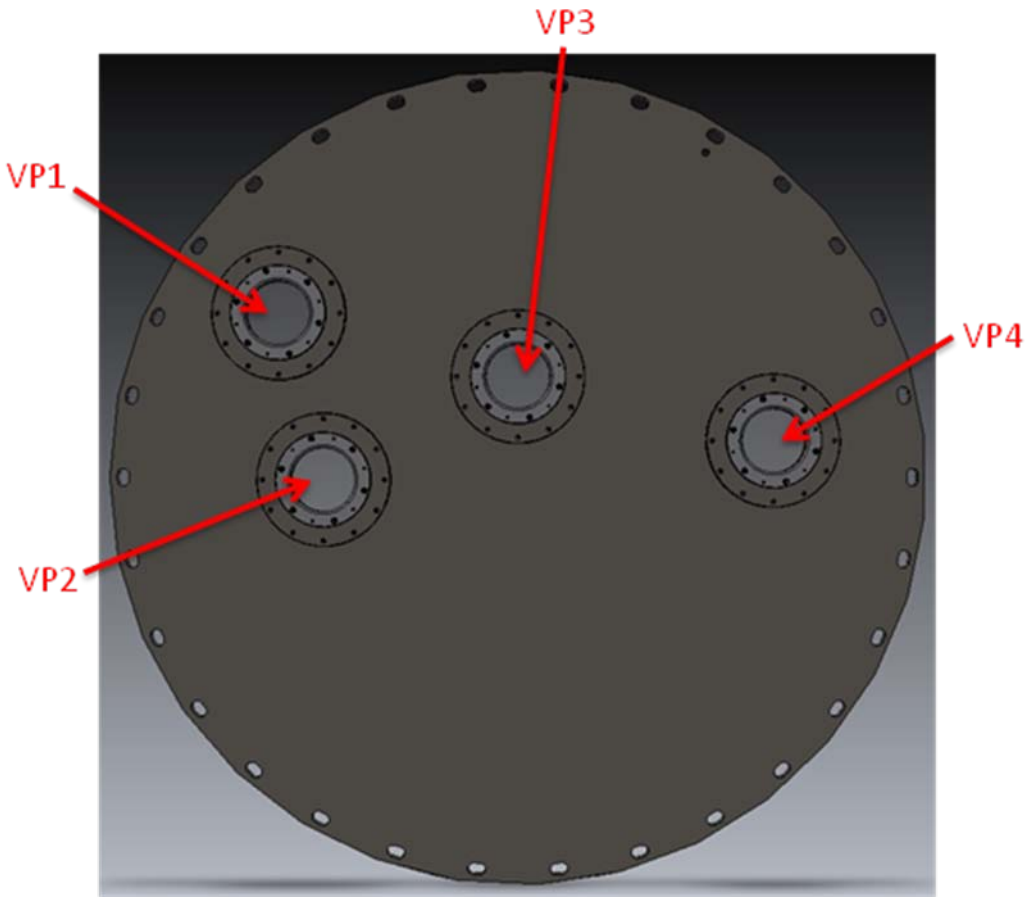

Figure 18: H1, L1 Input Septum Plate Port Naming Convention

3.5.2 H2 Input Septum Plate Port Naming Convention

The H2 Input Septum Plate Assembly D1002463 is shown in Figure 19.

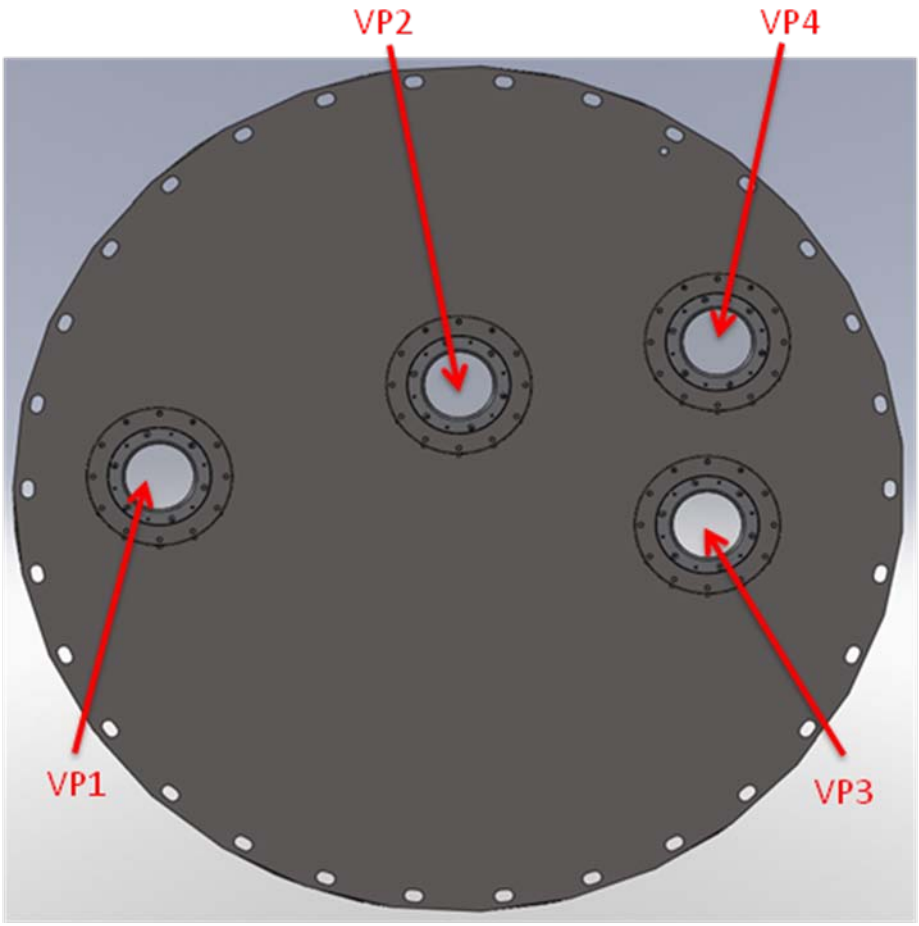

Figure 19: H2 Input Septum Plate Port Naming Convention

3.5.3 H1, L1 Output Septum Plate Port Naming Convention

The H1, L1 Output Septum Plate Assembly D1002462 is shown in Figure 20.

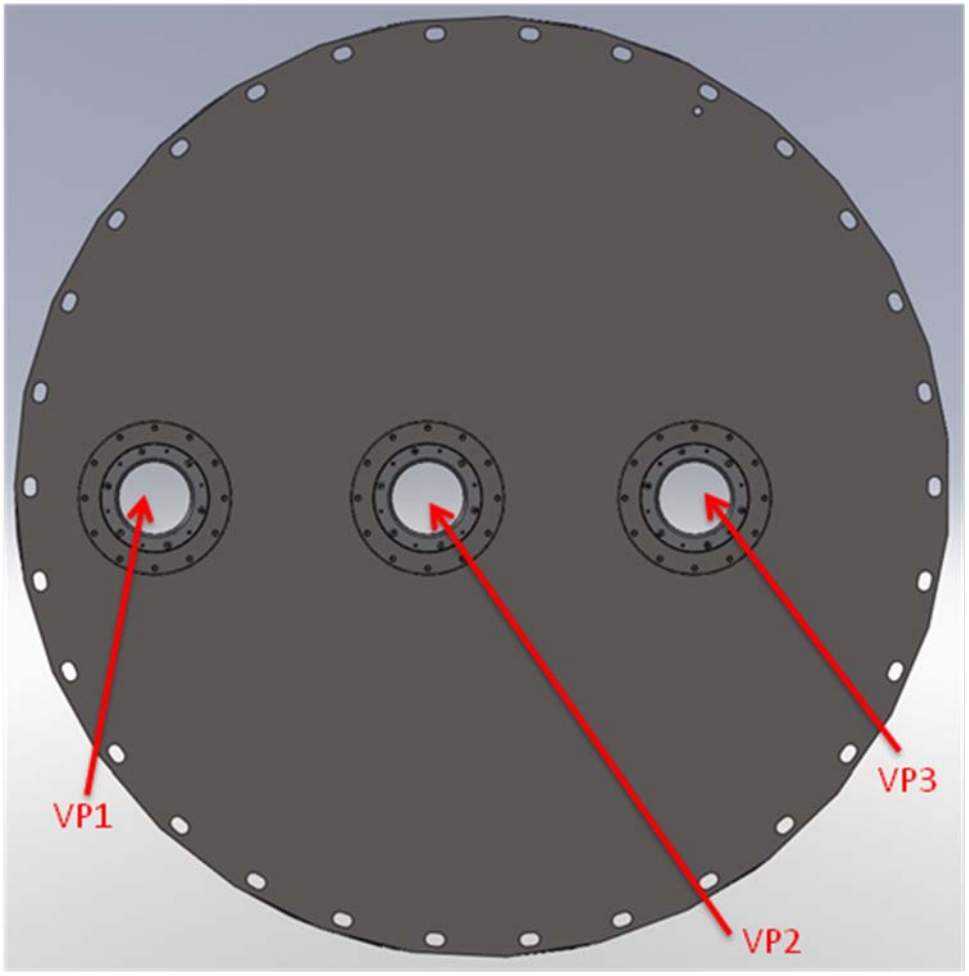

Figure 20: H1, L1 Output Septum Plate Port Naming Convention

3.5.4 H2 Output Septum Plate Port Naming Convention

The H2 Output Septum Plate Assembly D1002464 is shown in Figure 21.

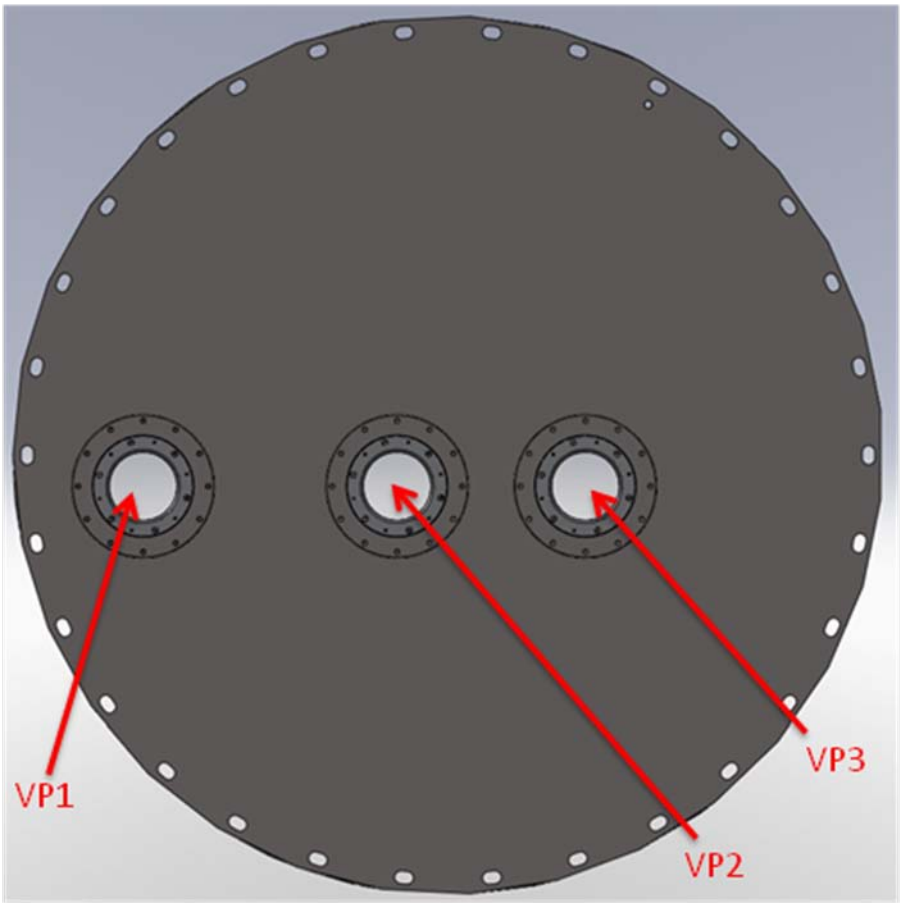

Figure 21: H2 Output Septum Plate Port Naming Convention

3.6 Temporary Septum Plates

3.6.1 H1, L1 Temporary PRC Septum Plate

See Section 6.1.26: D1003343 H1, L1 Temporary PRC Septum Plate Port Location

3.6.2 H2 Temporary PRC Septum Plate

See Section 6.2.21: D1003344 H2 Temporary PRC Septum Plate Port Location

4 Requirements and General Constraints

4.1 Refer to T1000022 Viewports Subsystem Requirements Document

5 Final Design

Various types of viewports are used for providing access to optical beams into and out of the IFO.

Video camera viewports are used to provide a visible access from outside the chambers for video cameras to view the IFO optics.

Optical lever viewports are used to provide entry and exit for optical lever beams from outside the chambers to measure the tilt of the IFO suspended optics.

Illumination viewports are used to provide illumination of the vacuum chambers with an outside illumination lamp.

TCS viewports are used to provide transmission of CO2 laser beams for heating certain core optics.

Hartmann viewports are used to provide entry and exit ports for the Hartmann wavefront sensing beams.

The Transmon viewports are used for entry and egress of the 532 nm arm length stabilization beam, the 532 nm Hartmann beam and the 1064 nm Transmon beam.

5.1 Protective Cover

All viewports will have a protective cover, similar to the one shown in Figure 22 which will cover the viewport whenever any physical activity occurs that might damage the viewport and cause a hazardous situation to nearby personnel.

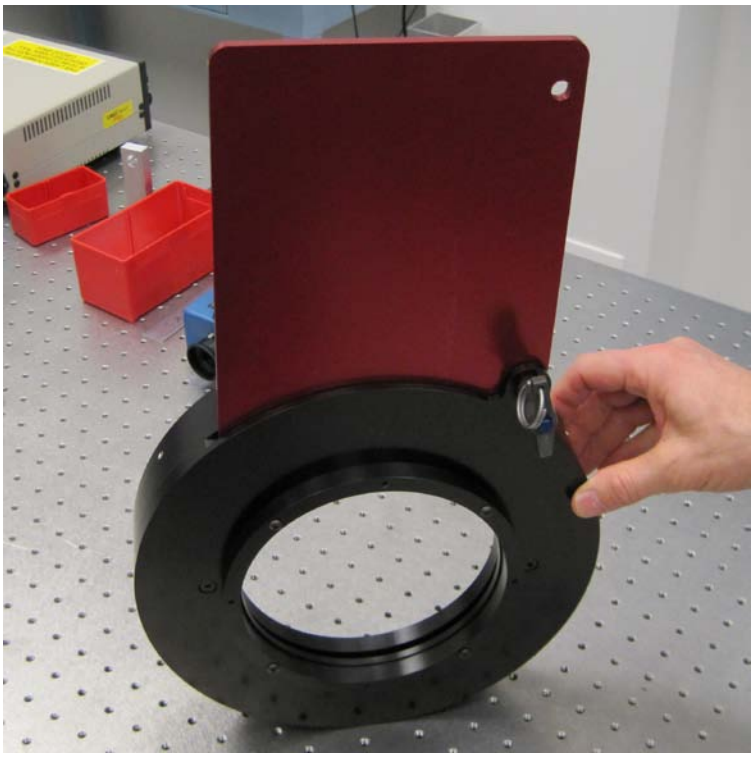

Figure 22: Viewport Protective Cover

6 Viewport Locations

6.1 H1, L1 IFO

6.1.1 WBSC2/LBSC2

The locations of the WBSC2/LBSC2 Chamber Viewports are shown in Figure 23.

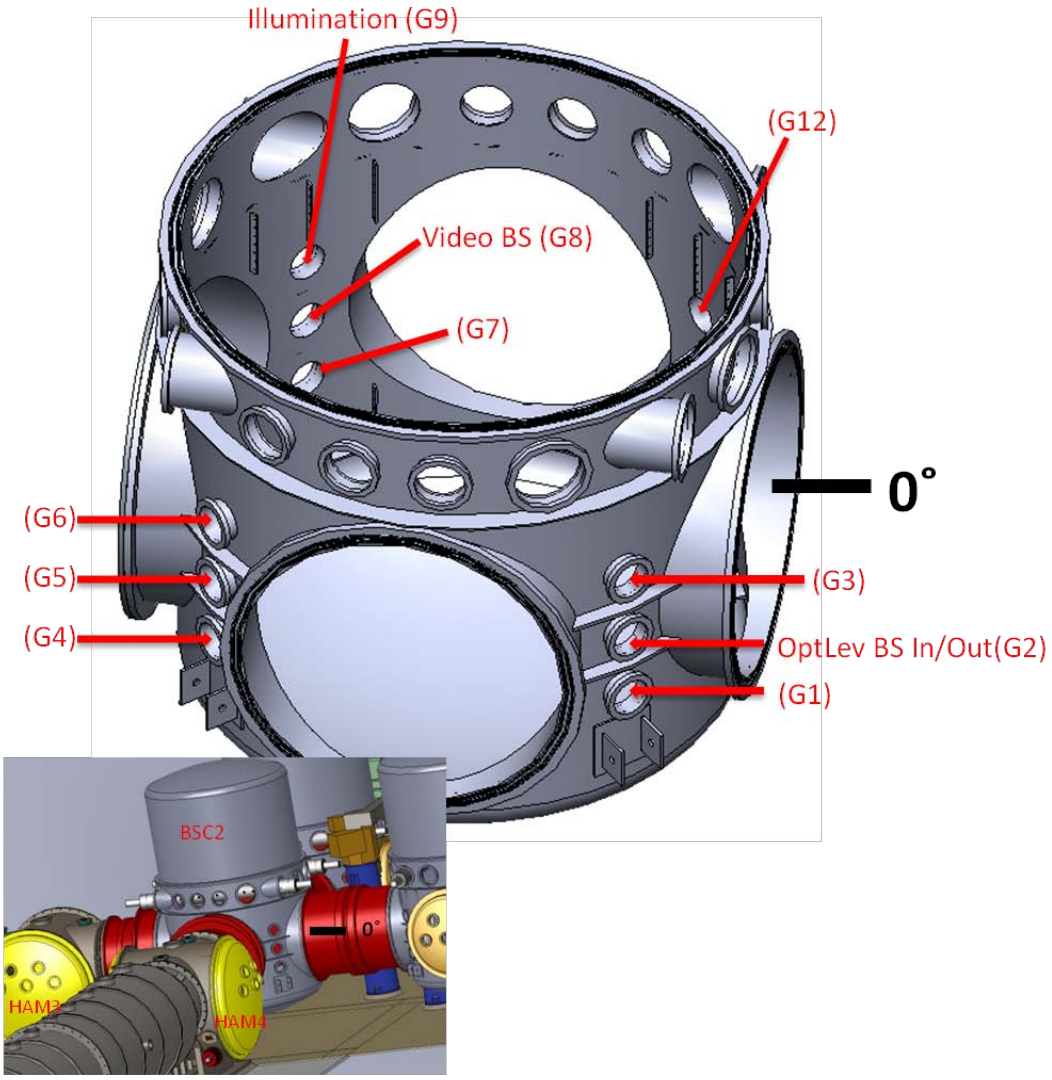

Figure 23: WBSC2/LBSC2 Viewports

6.1.2 WBSC1/LBSC1

The locations of the WBSC1/LBSC1 Chamber Viewports are shown in Figure 24.

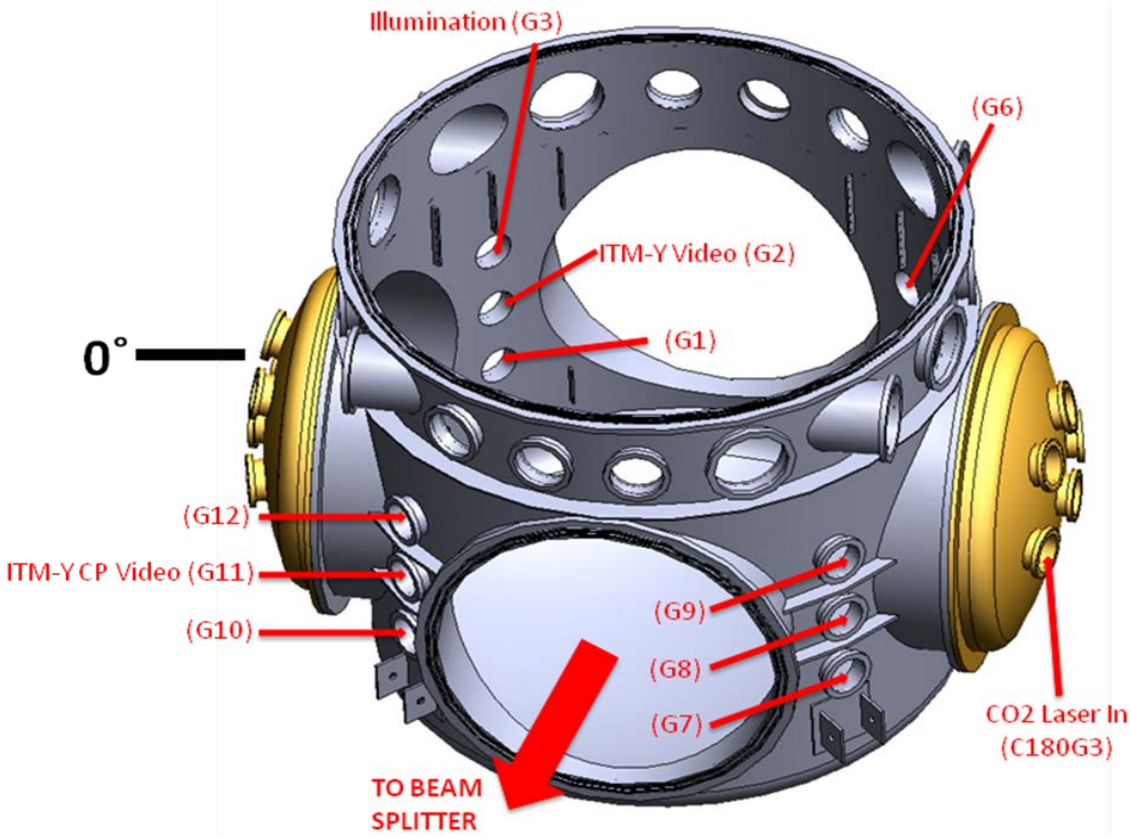

Figure 24: WBSC1/LBSC1 Viewports

6.1.3 WBSC3/LBSC3

The locations of the WBSC3/LBSC3 Chamber Viewports are shown in Figure 25.

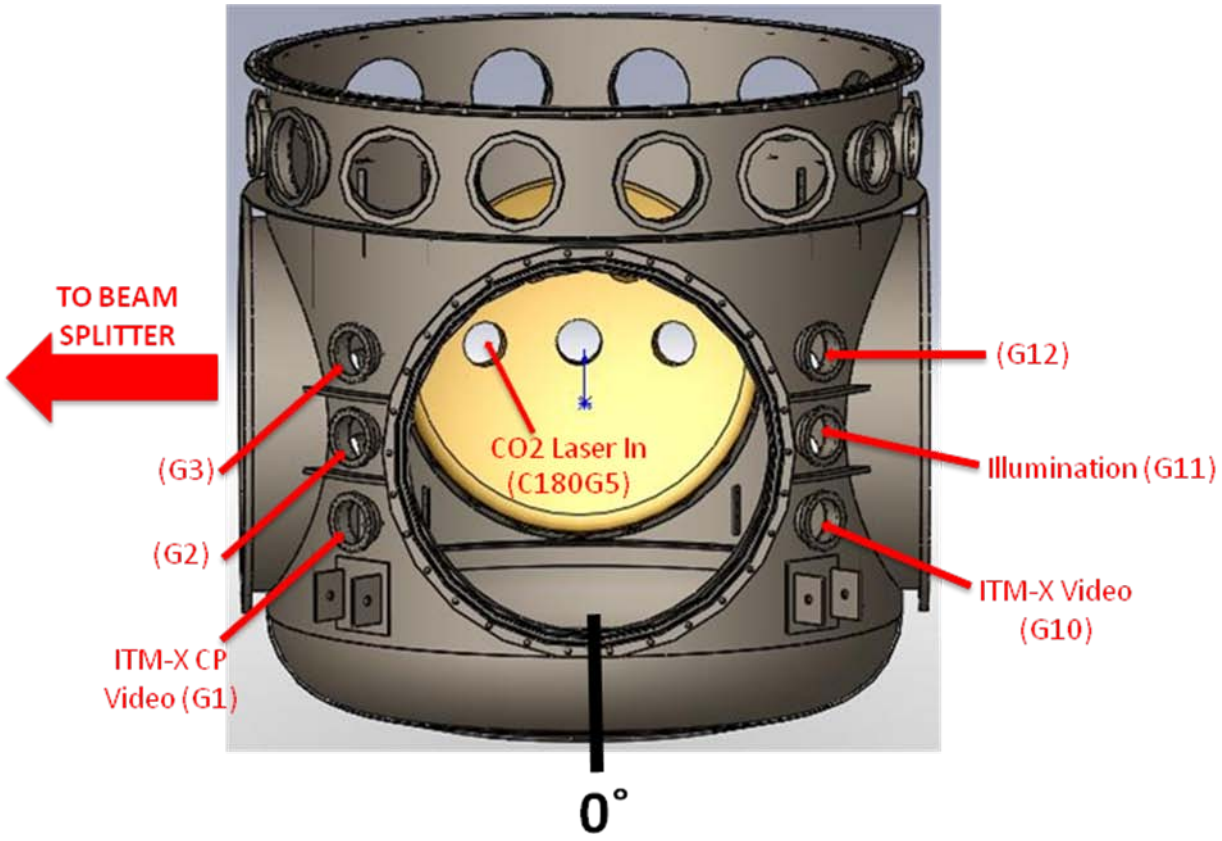

Figure 25: WBSC3/LBSC3 Viewports

6.1.4 WBSC9

The locations of the WBSC9 Chamber Viewports are shown in Figure 26.

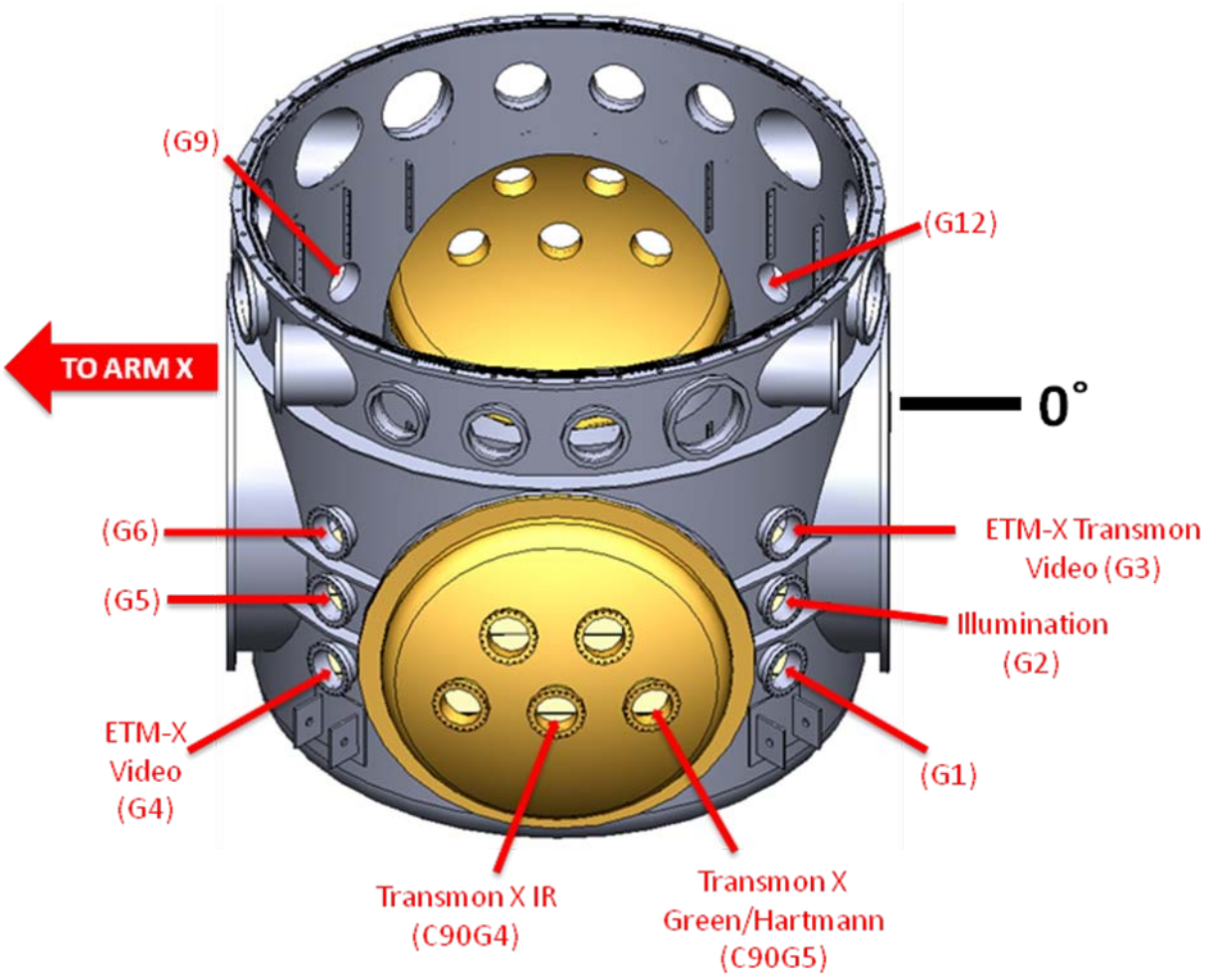

Figure 26: WBSC9 Viewports

6.1.5 LBSC4

The locations of the LBSC4 Chamber Viewports are shown in Figure 27.

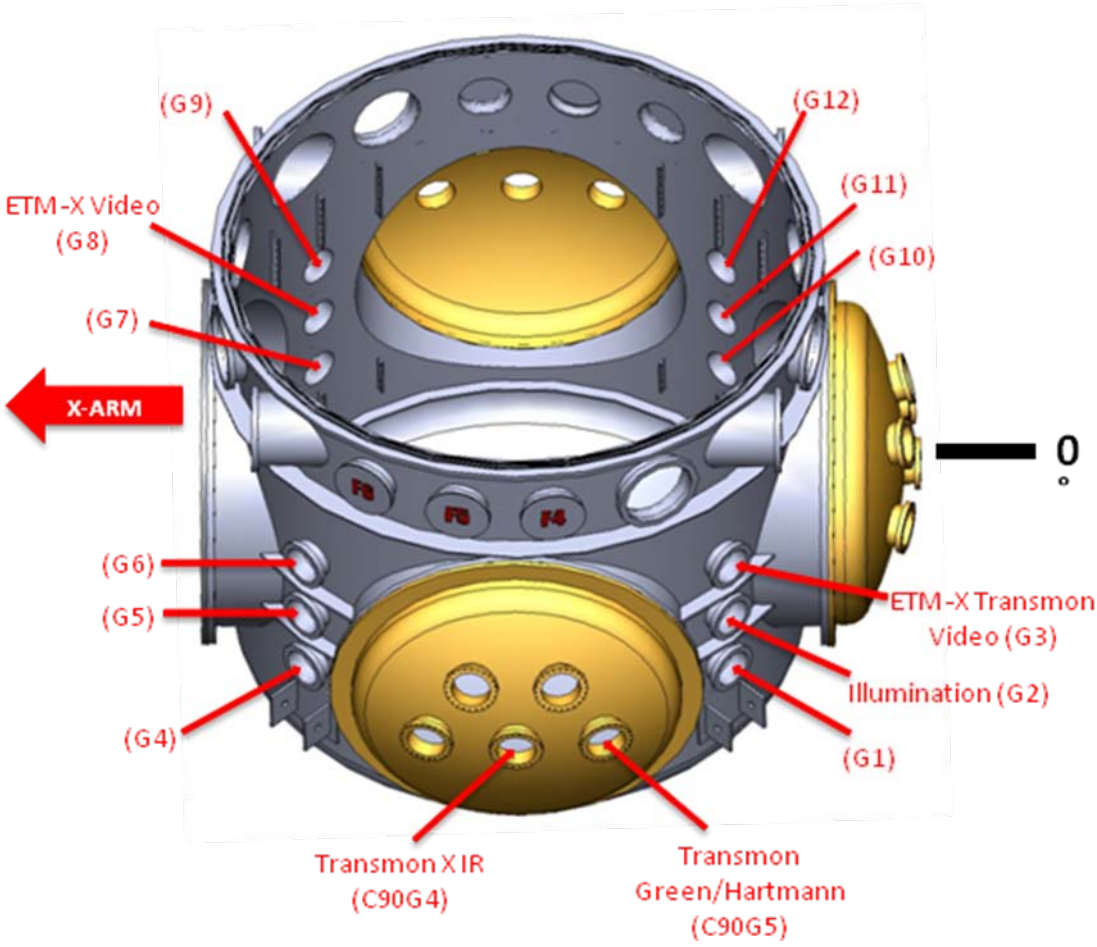

Figure 27: LBSC4 Viewports

6.1.6 WBSC10

The locations of the WBSC10 Chamber Viewports are shown in Figure 28

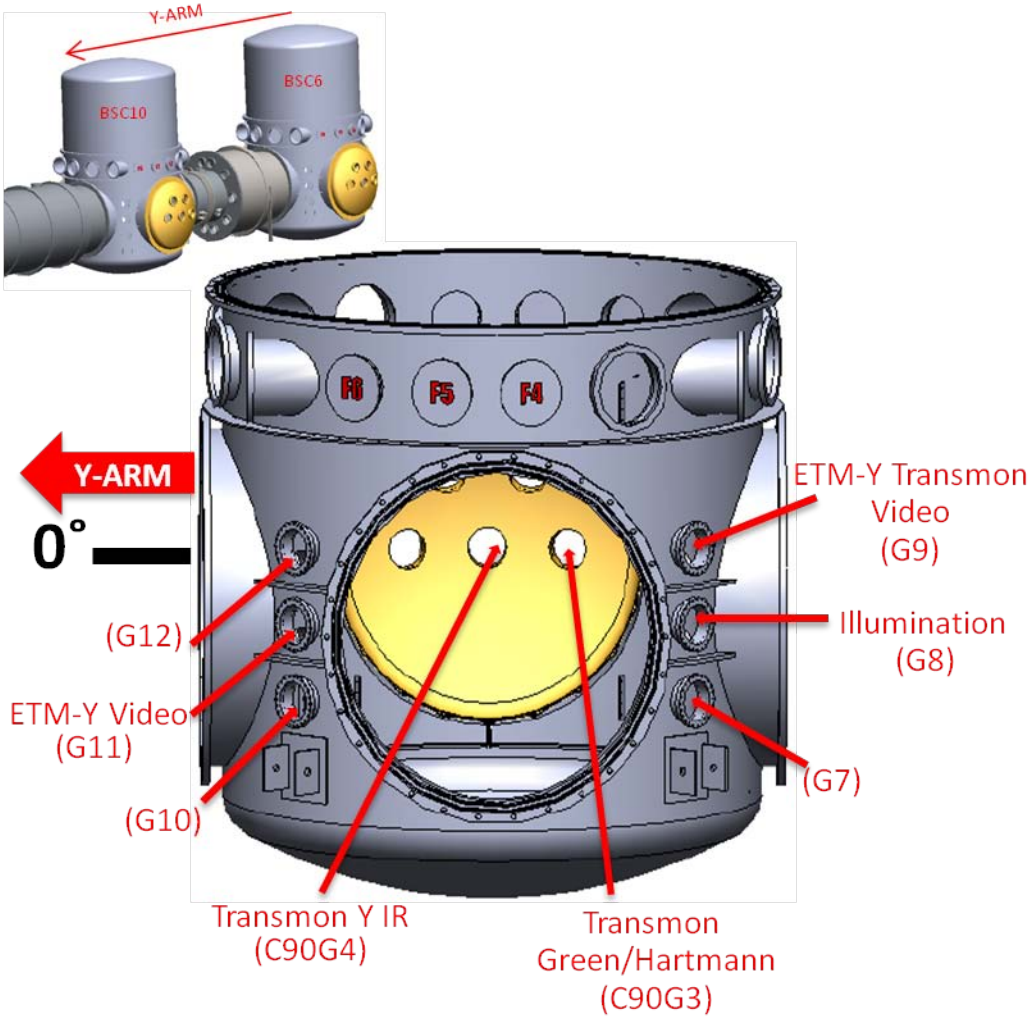

Figure 28: WBSC10 Viewports

6.1.7 LBSC5

The locations of the LBSC5 Chamber Viewports are shown in Figure 29.

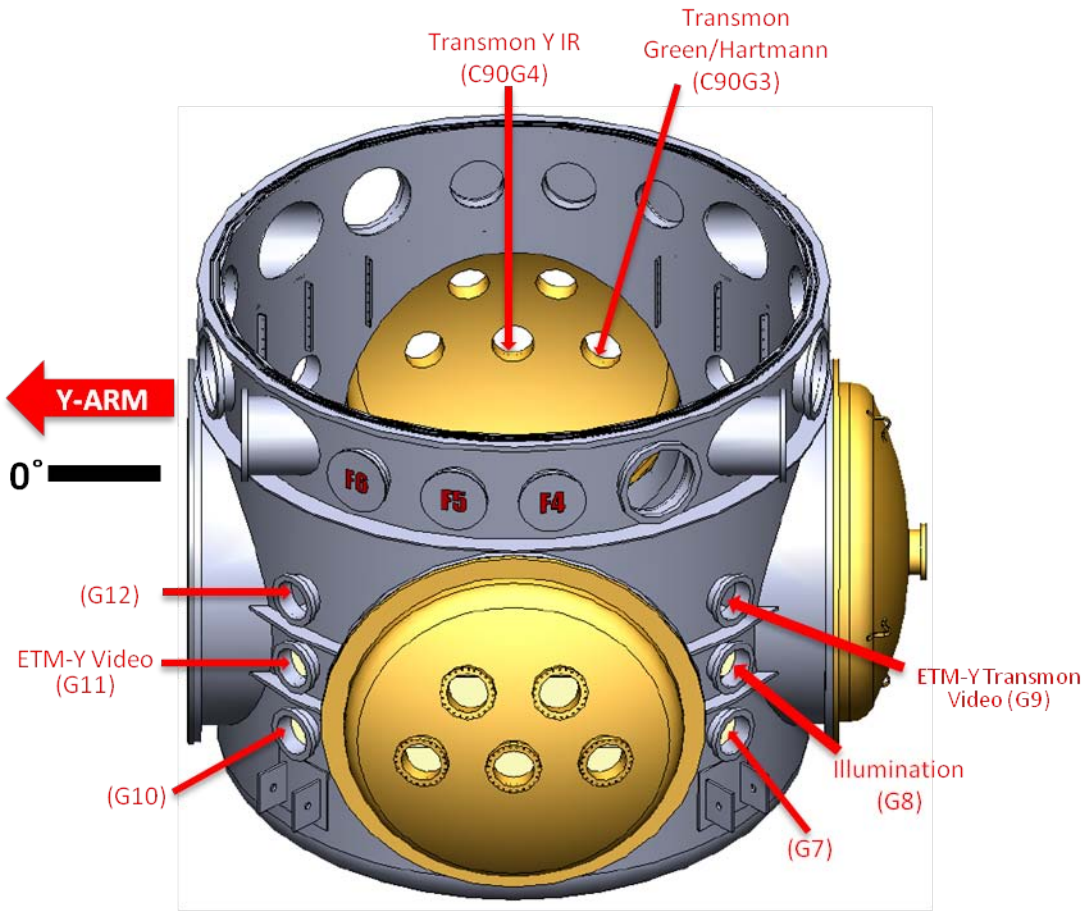

Figure 29: LBSC5 Viewports

6.1.8 WHAM1/LHAM1

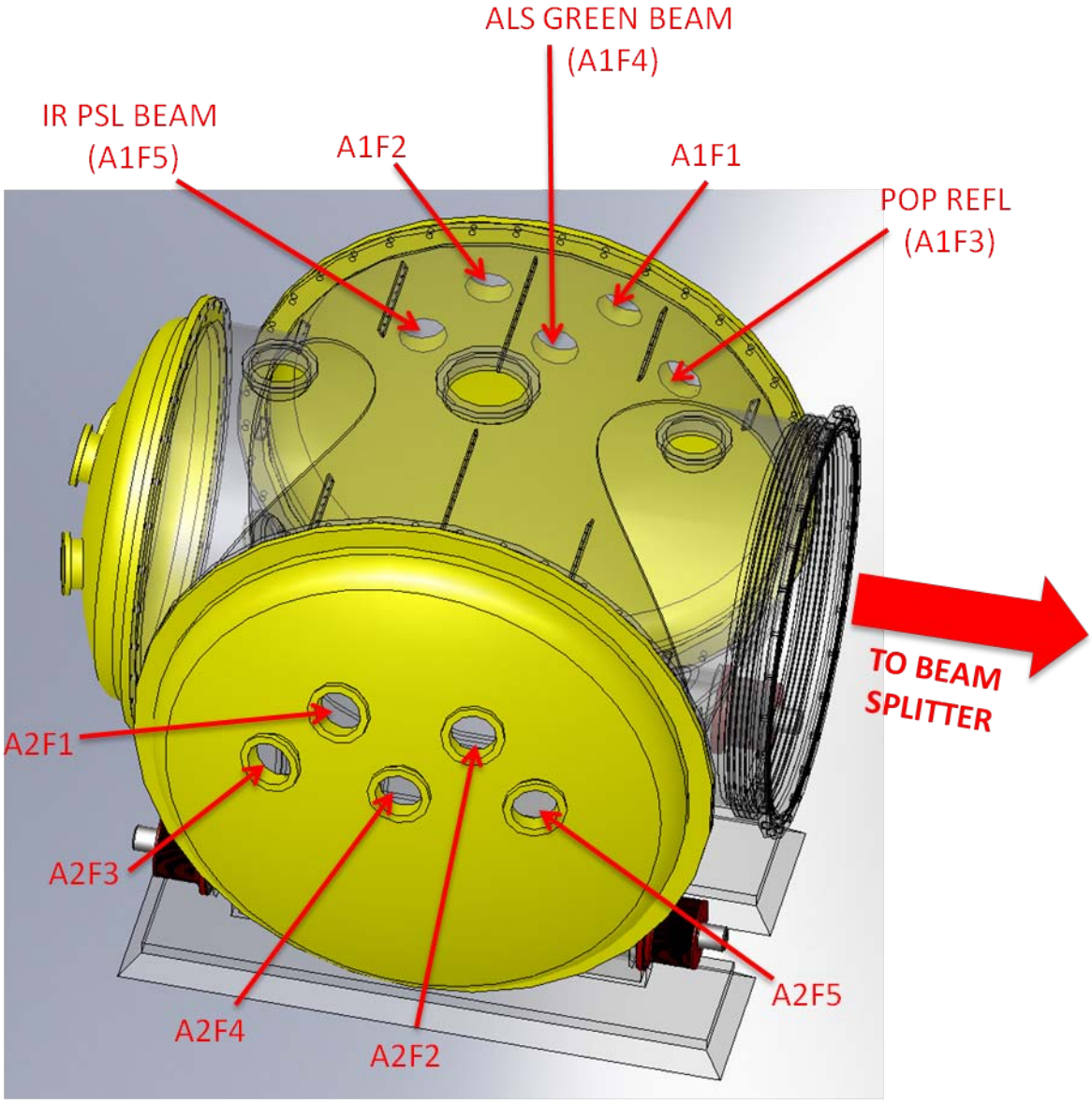

Figure 30: WHAM1/LHAM1

6.1.9 WHAM2/LHAM2

The locations of the WHAM2/LHAM2 viewports are shown in Figure 31.

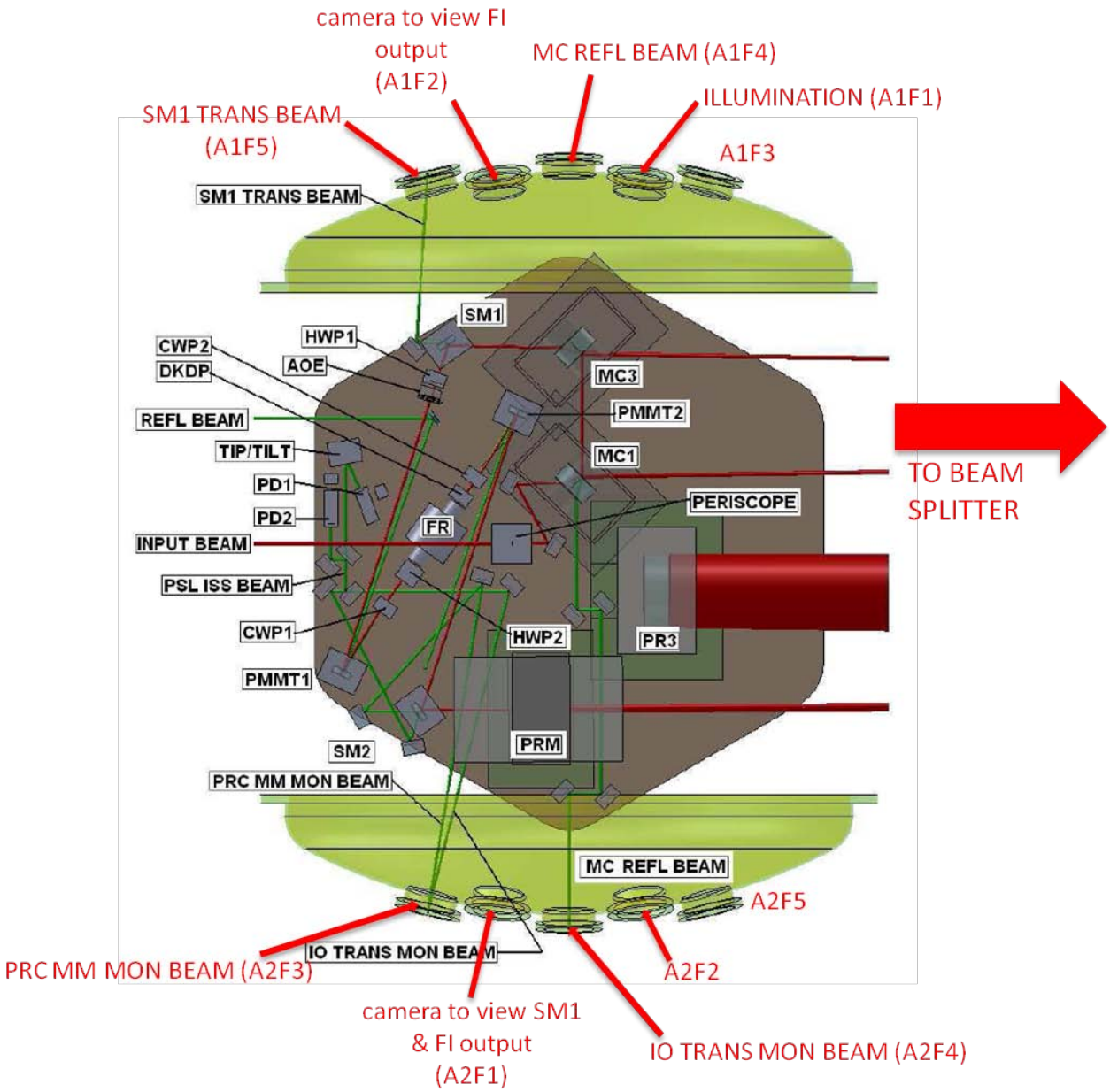

Figure 31: WHAM2/LHAM2 Viewports

6.1.10 WHAM3/LHAM3

The locations of the WHAM3/LHAM3 viewports are shown in Figure 32.

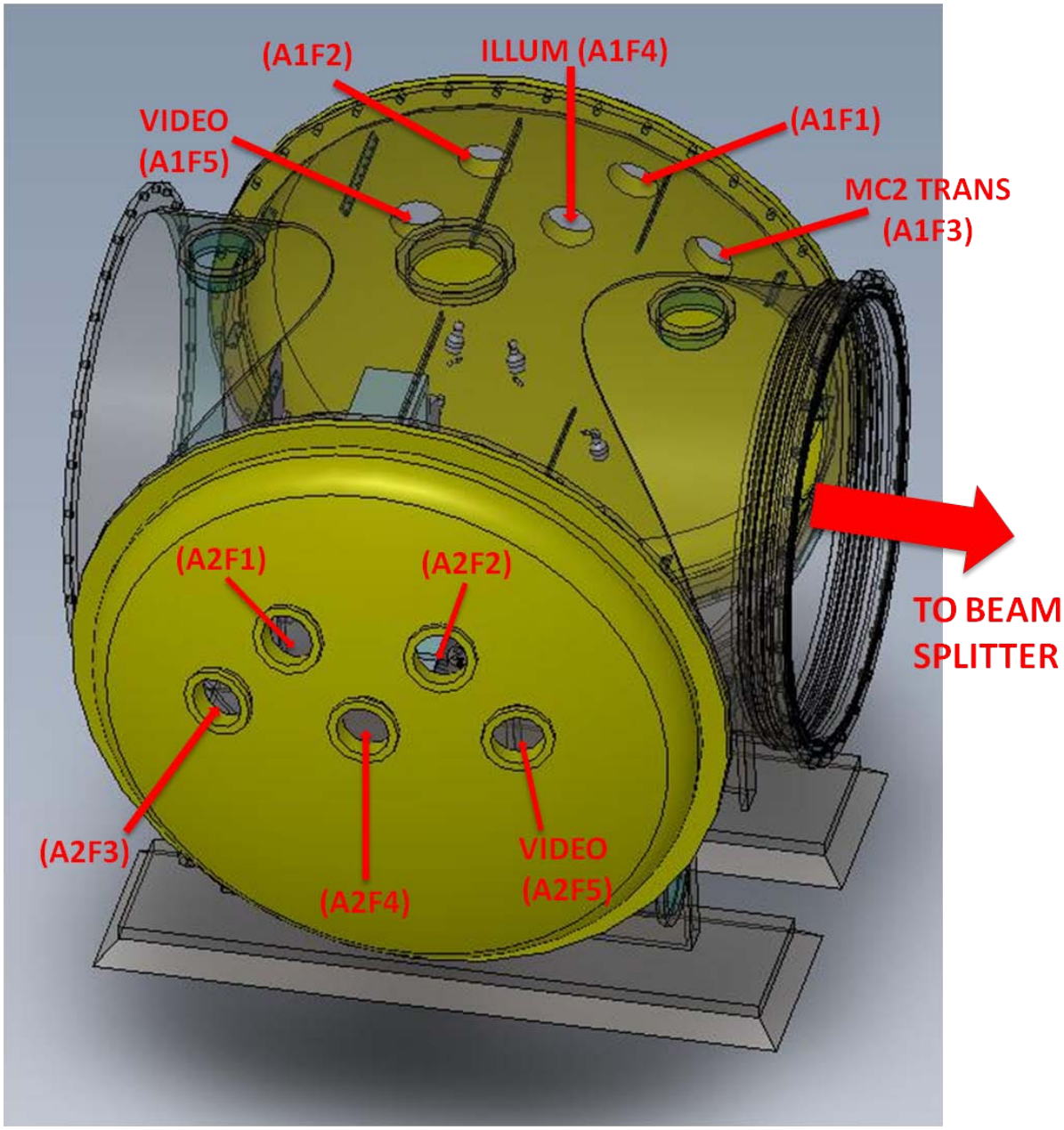

Figure 32: WHAM3/LHAM3 Viewports

6.1.11 WHAM4/LHAM4

The locations of the WHAM4/LHAM4 viewports are shown in **Figure 33**.

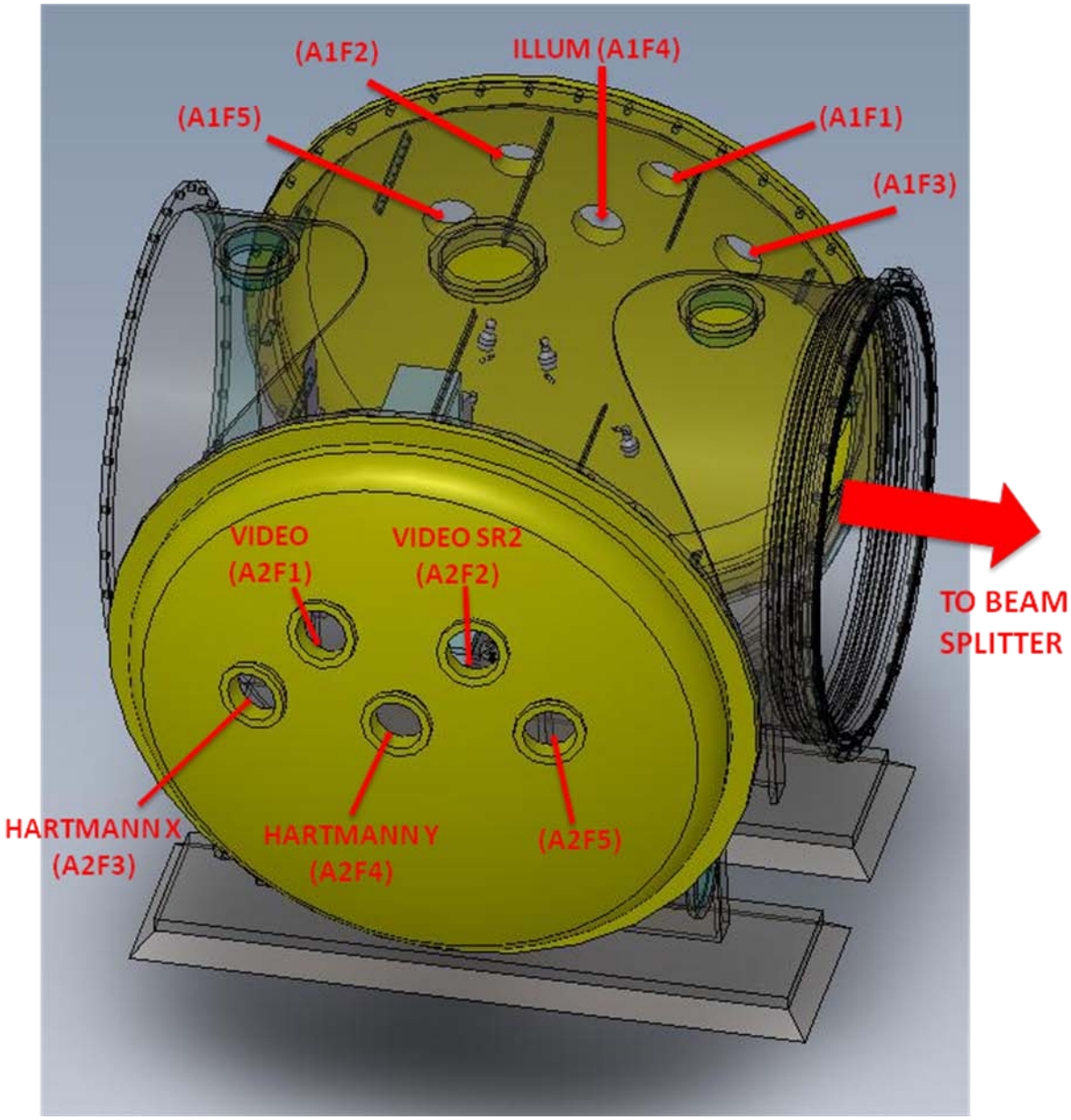

Figure 33: WHAM4/LHAM4 Viewports

6.1.12 WHAM5/LHAM5

The locations of the WHAM5/LHAM5 viewports are shown in **Figure 34**.

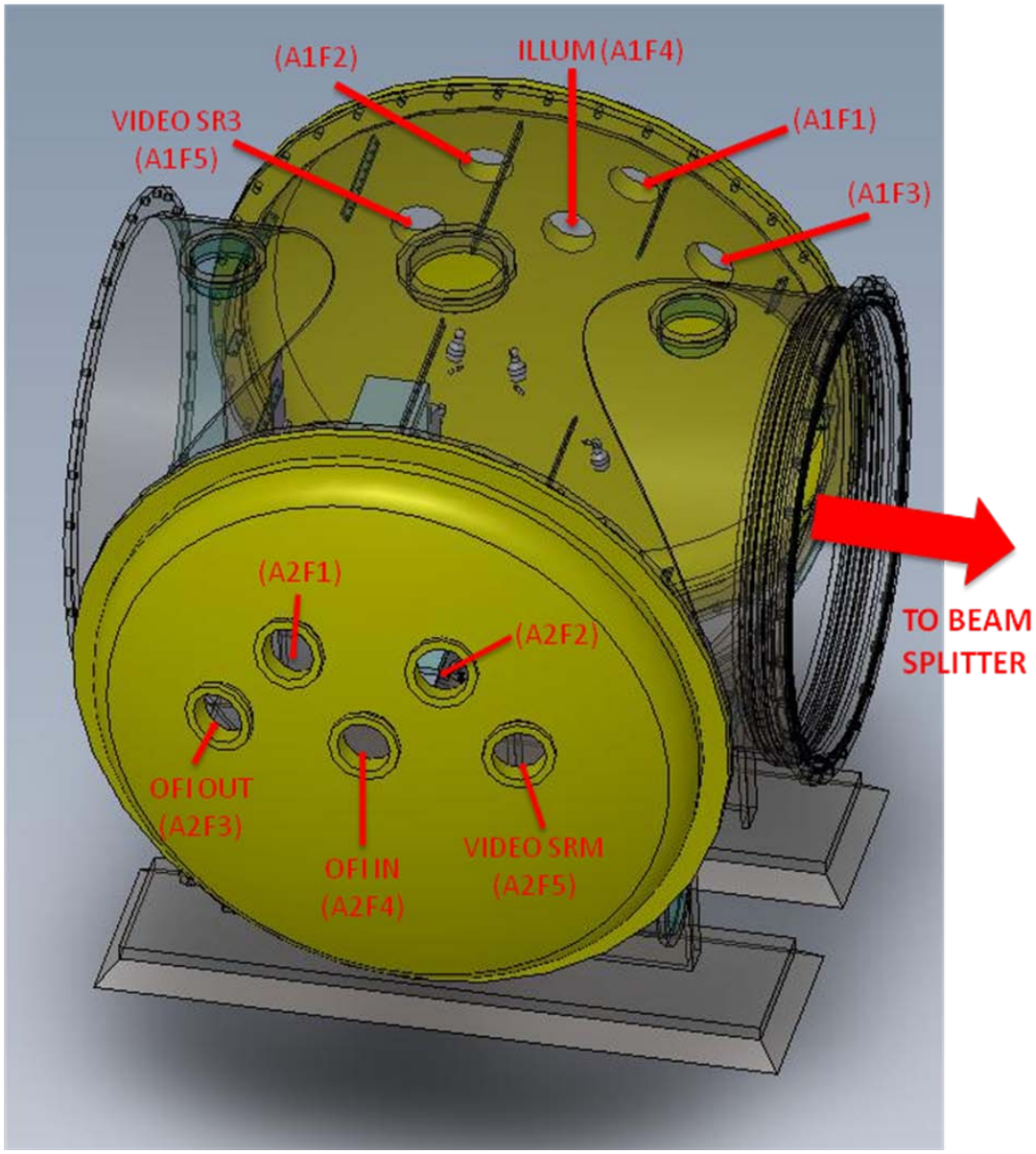

Figure 34: WHAM5/LHAM5 Viewports

6.1.13 WHAM6/LHAM6

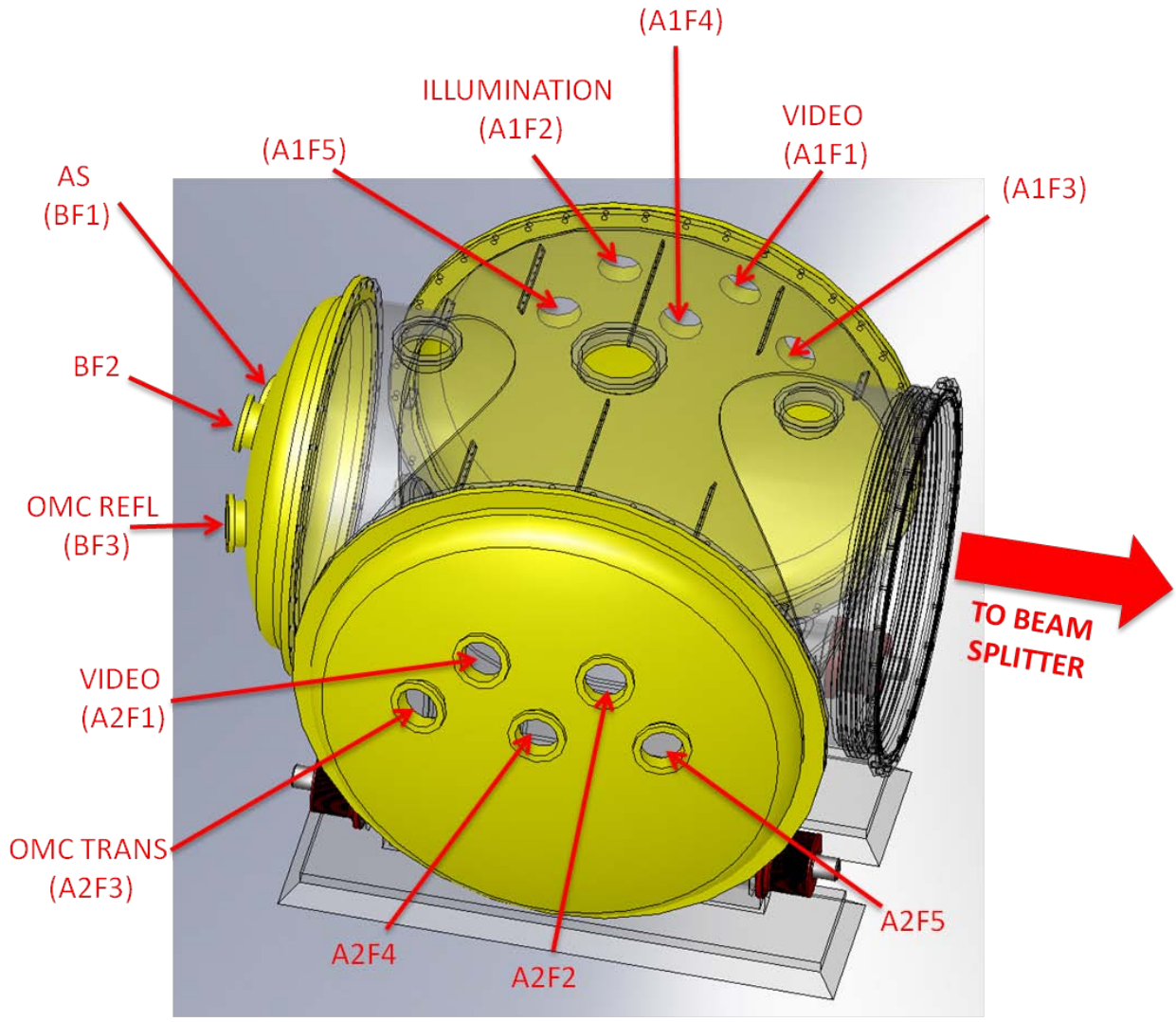

Figure 35: WHAM6/LHAM6

6.1.14 WAMCA1/LAMCA1

The locations of the WAMCA1/LAMCA1 viewports are shown in Figure 36.

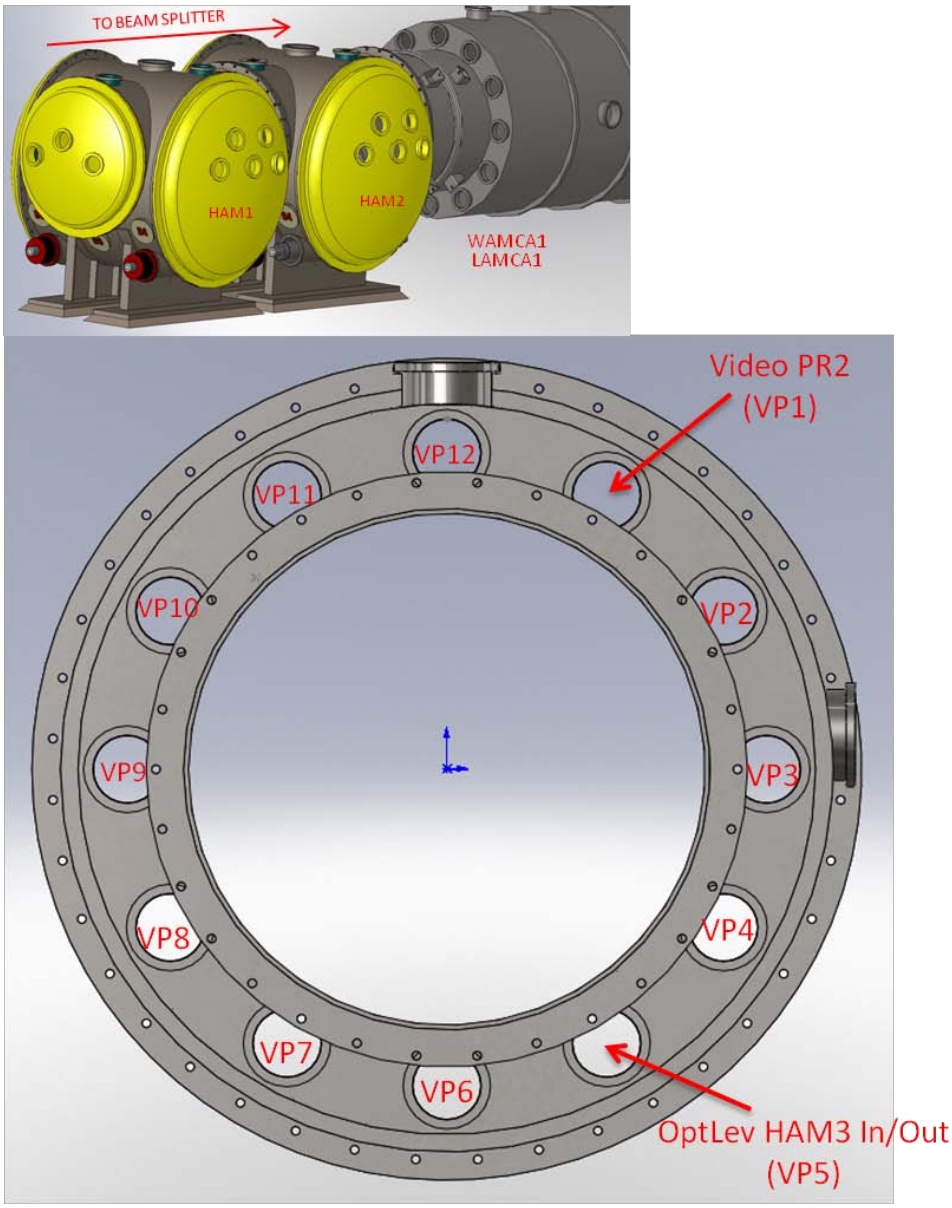

Figure 36: WAMCA1/LAMCA1 Viewports

6.1.15 WAMCB1/LAMCB1

The locations of the WAMCB1/LAMCB1 viewports are shown in Figure 37.

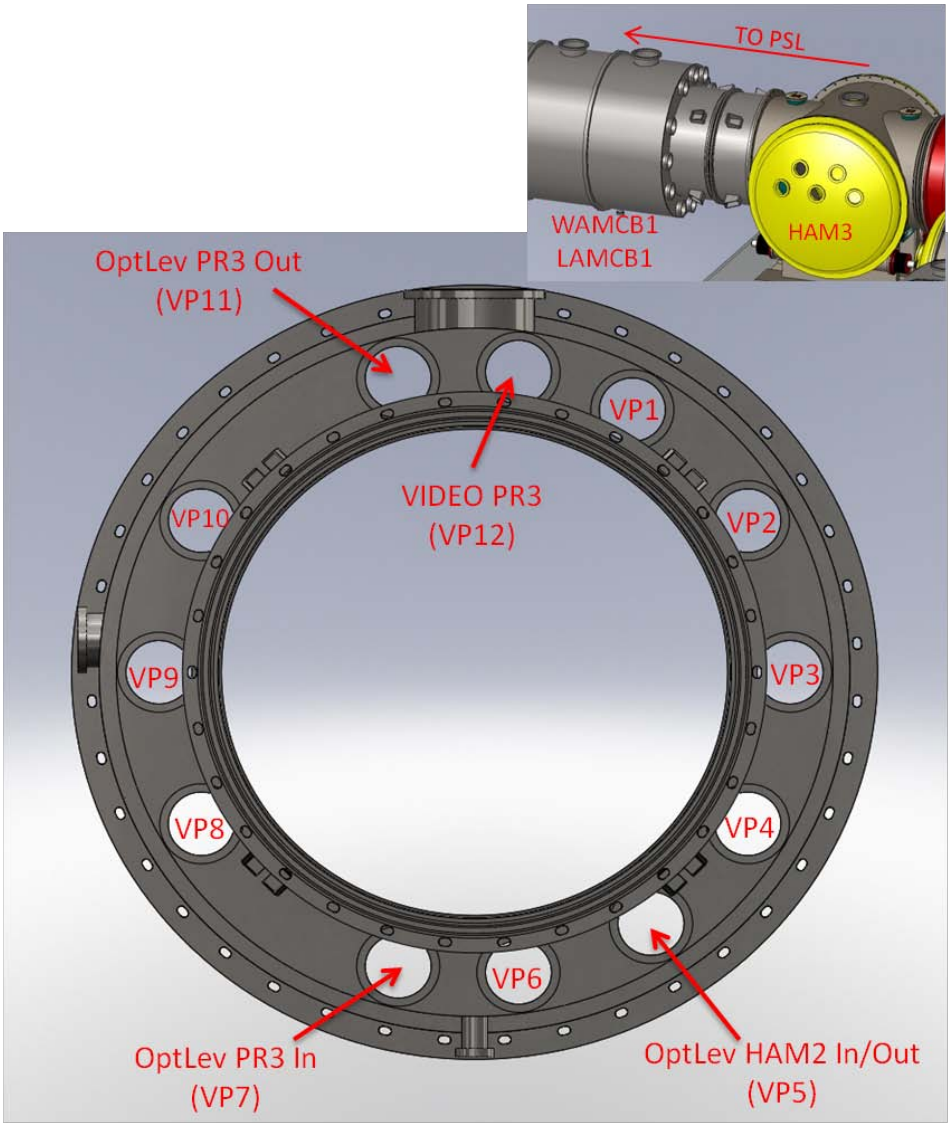

Figure 37: WAMCB1/LAMCB1 Viewports

6.1.16 WAMCA2/LAMCA2

The locations of the WAMCA2/LAMCA2 viewports are shown in Figure 38.

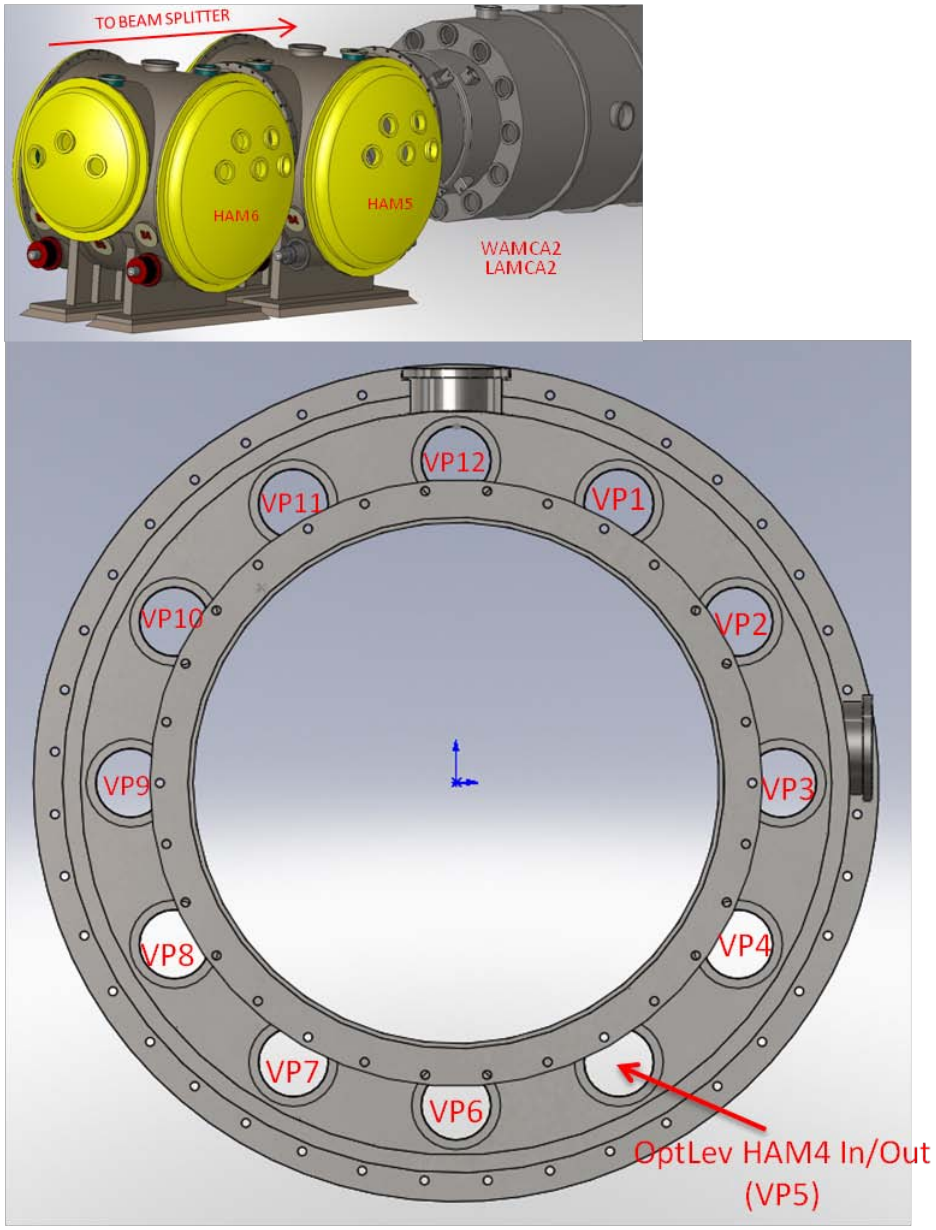

Figure 38: WAMCA2/AMCA2 Viewports

6.1.17 WAMCB2/LAMCB2

The locations of the WAMCB2/LAMCB2 viewports are shown in Figure 39.

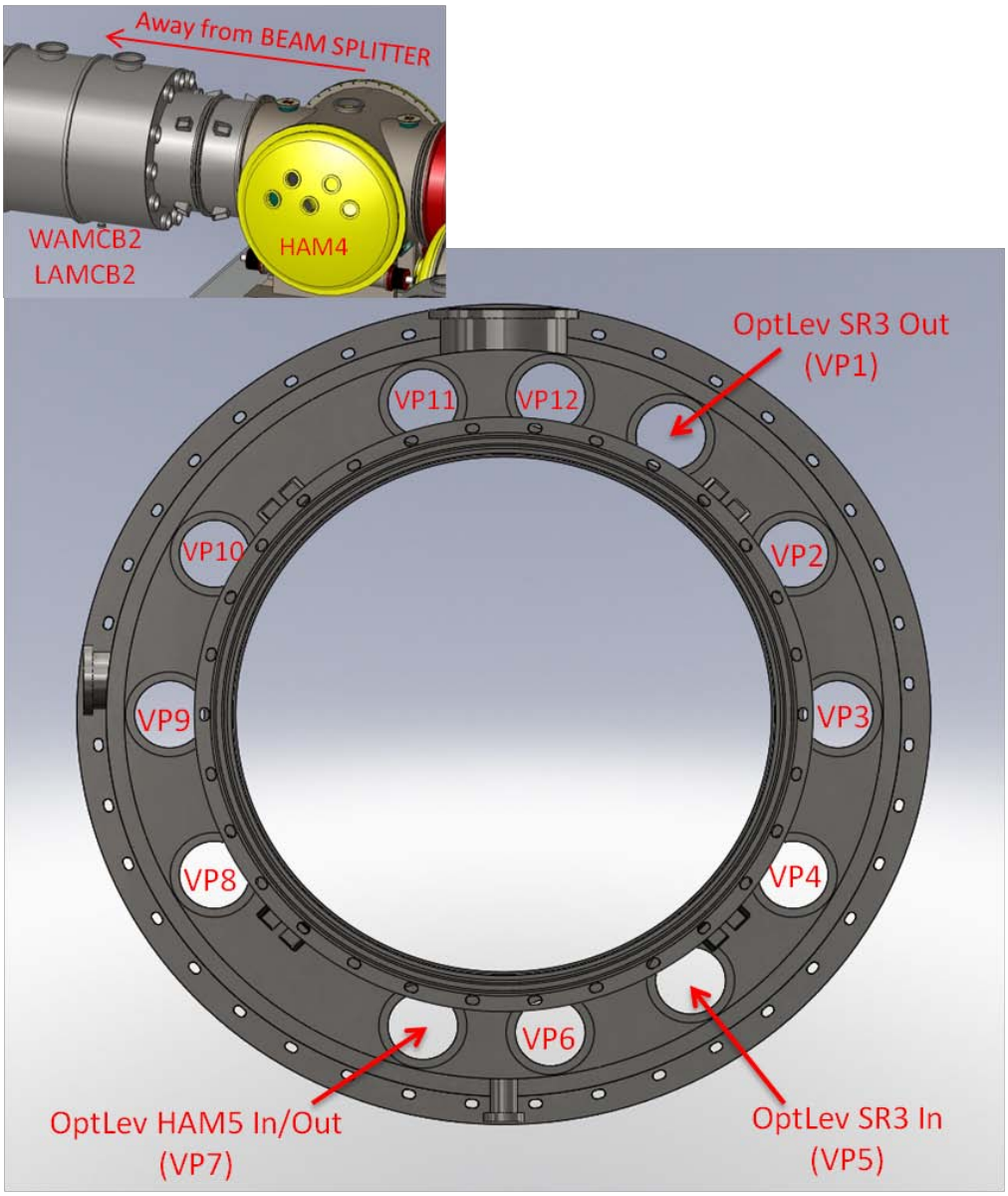

Figure 39: WAMCB2/LAMCB2 Viewports

6.1.18 ITM-X Adapter A-1 FLANGE

The locations of the ITM-X Adapters WA-1C and LA-1A Viewports are shown in Figure 40.

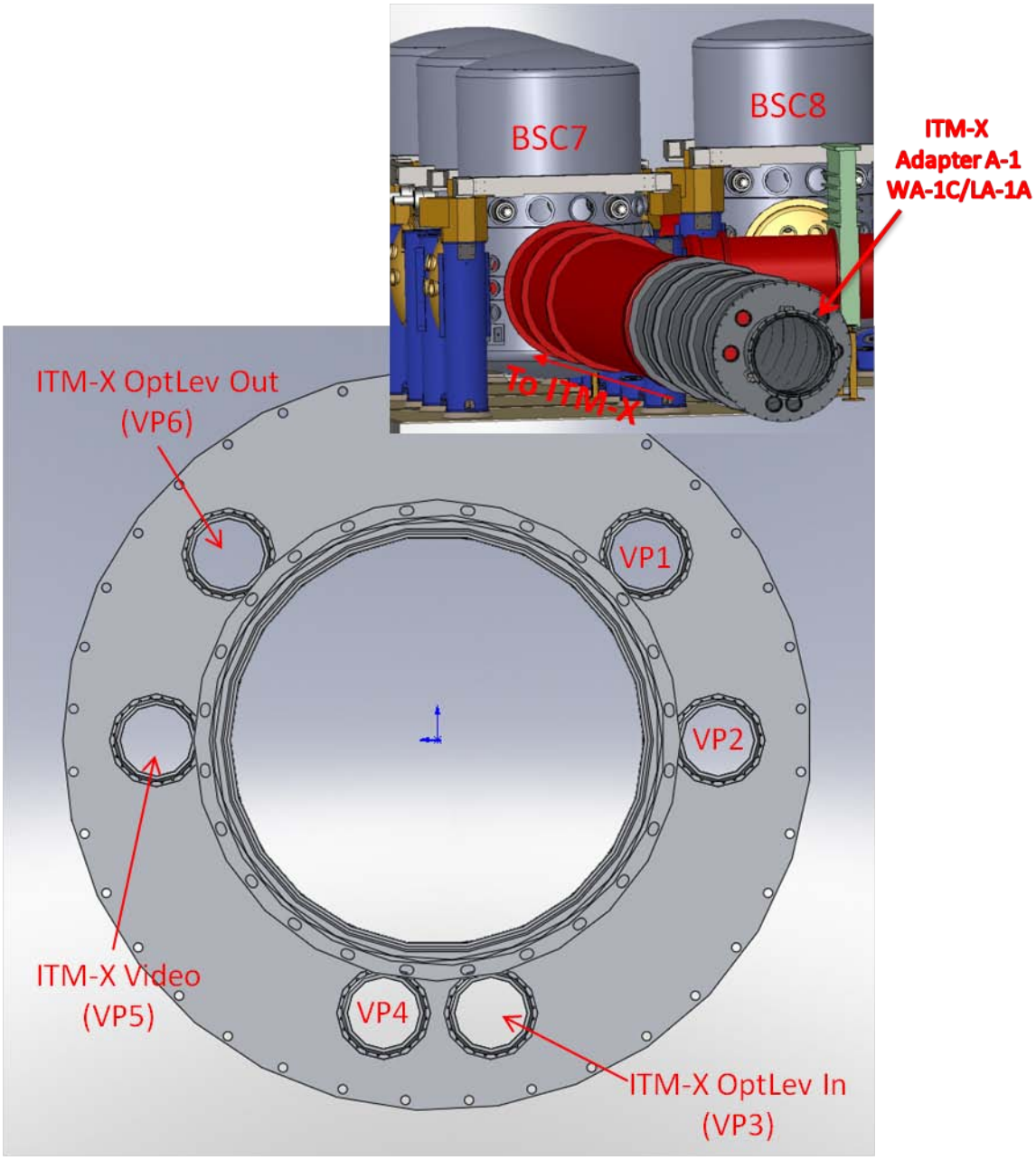

Figure 40: ITM-X Adapter WA-1C and LA-1A Viewports

6.1.19 ITM-Y Adapter A-1 FLANGE

The locations of the ITM-Y Adapters WA-1F and LA-1B Viewports are shown in Figure 41.

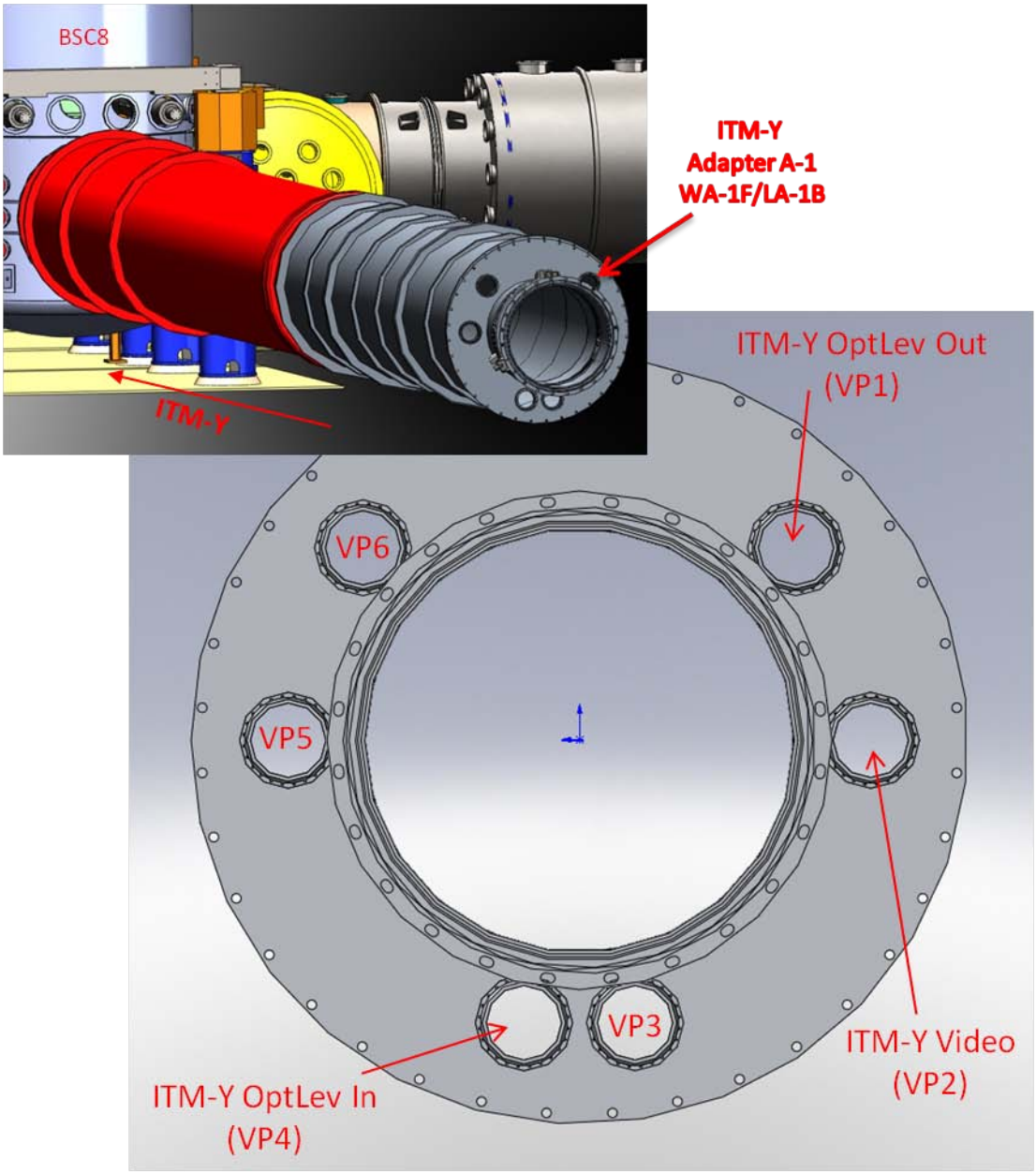

Figure 41: ITM-Y Adapter WA-1F and LA-1B Viewports

6.1.20 H1, H2 ETM-X Adapter A-1 FLANGE

The locations of the H1, H2 ETM-X Adapter A-1 WA-1E Viewports are shown in Figure 42.

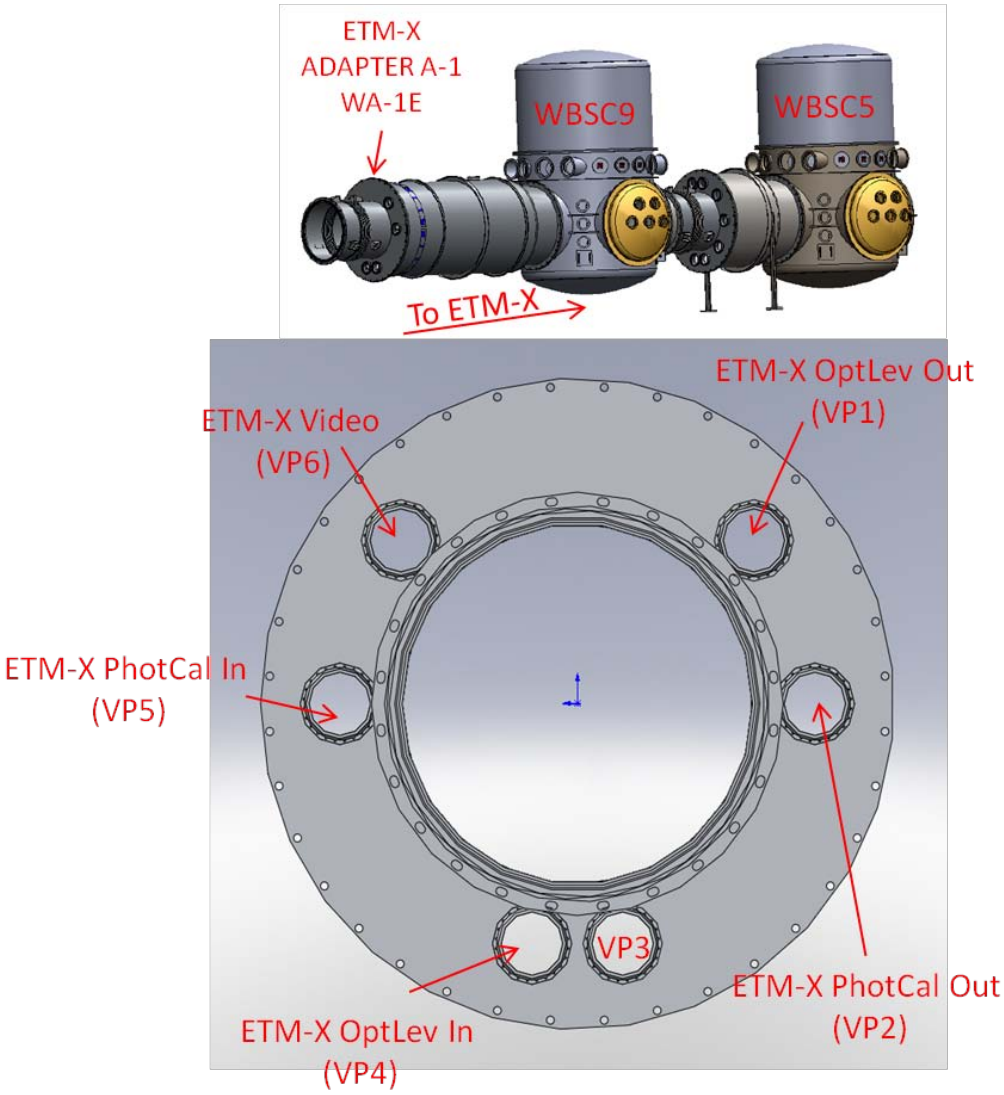

Figure 42: H1, H2 ETM-X Adapter A-1 WA-1E

6.1.21 L1 ETM-X Adapter A-1 FLANGE

The locations of the L1 ETM-X Adapter A-1 LA-1C Viewports are shown in Figure 43.

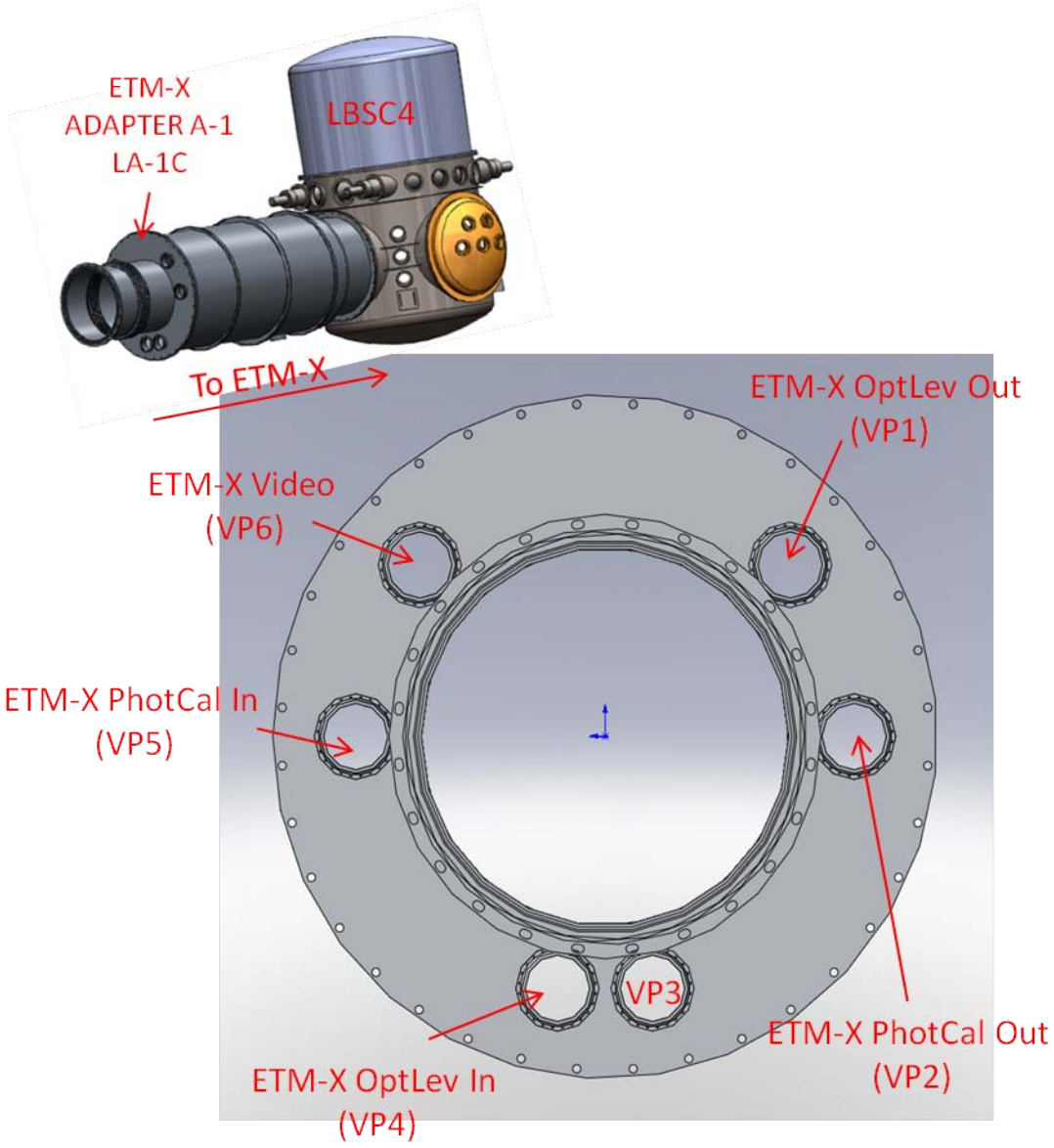

Figure 43: L1 ETM-X Adapter A-1 LA-1C

6.1.22 H1, H2 ETM-Y Adapter A-1 FLANGE

The locations of the H1, H2 ETM-Y Adapter A-1 WA-1B Viewports are shown in Figure 44.

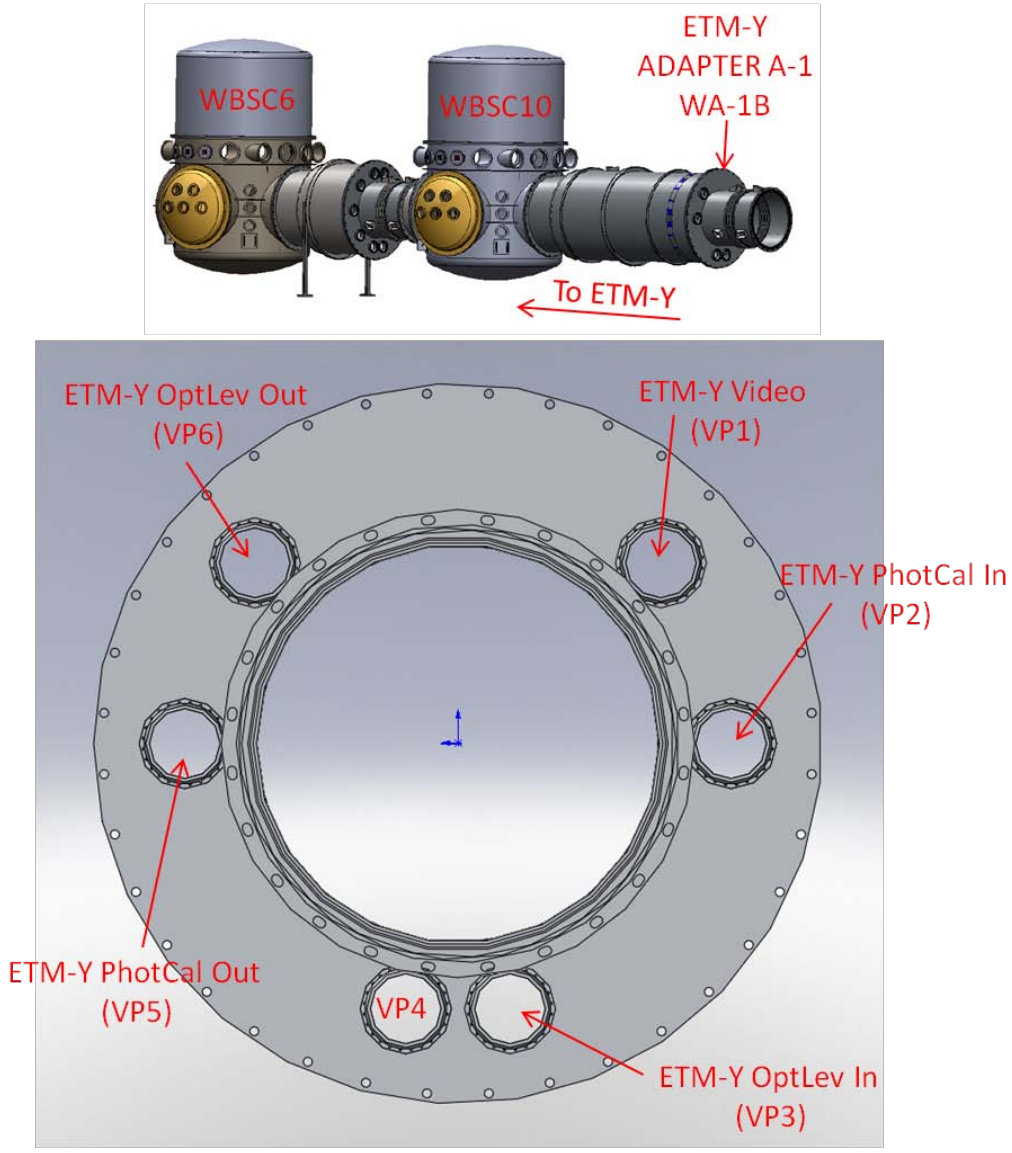

Figure 44: H1, H2 ETM-Y Adapter A-1 WA-1B

6.1.23 L1 ETM-Y Adapter A-1 FLANGE

The locations of the L1 ETM-Y Adapter A-1 LA-1D Viewports are shown in Figure 45.

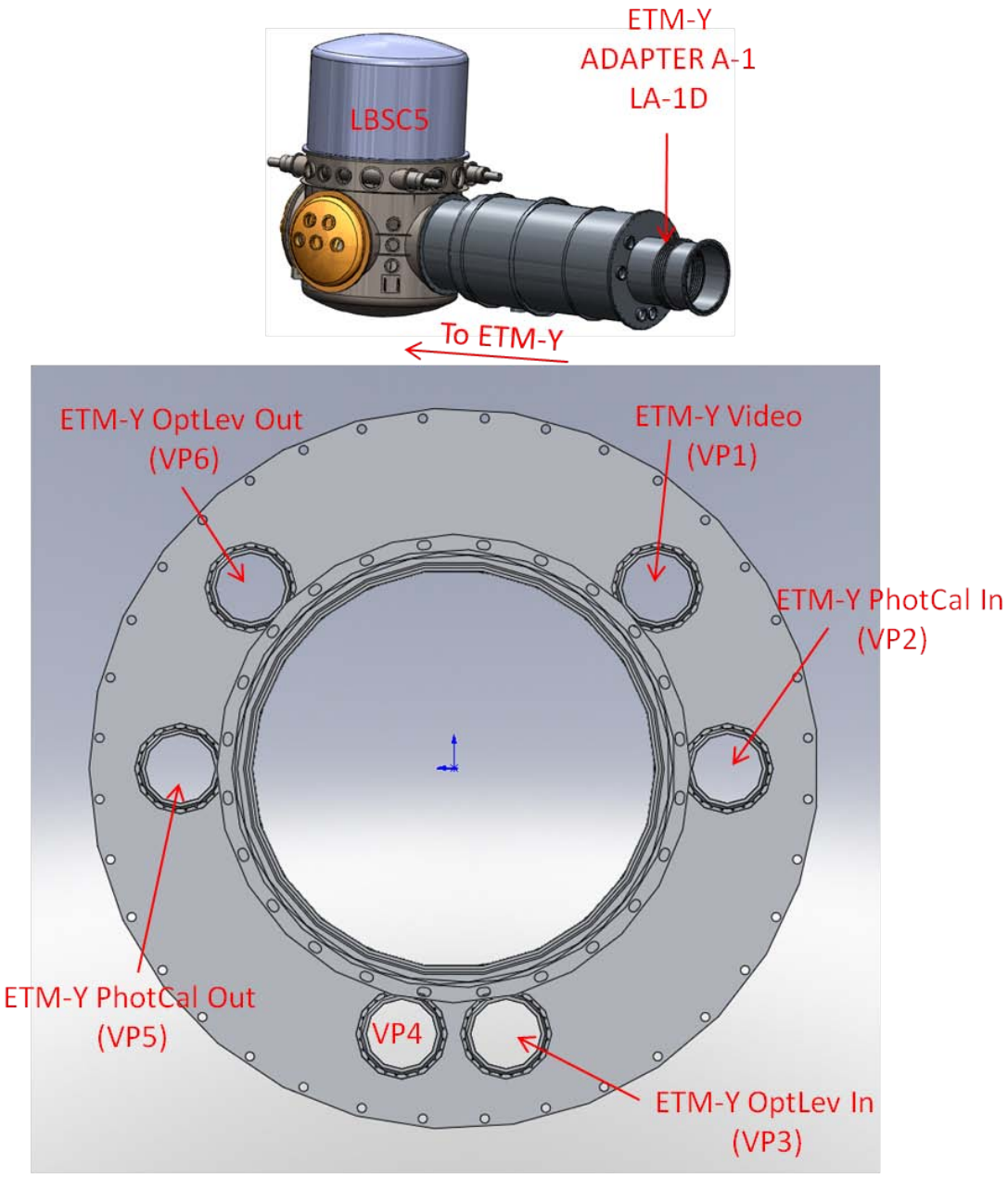

Figure 45: L1 ETM-Y Adapter A-1 LA-1D

6.1.24 D1001661 - H1, L1 Input Septum Plate Port Locations

The septum viewports between HAM1 and HAM2 allow passage of 1) PSL input beam, 2) REFL beam, 3) POB reference beam, and 4) the Arm Length Stabilization beam.

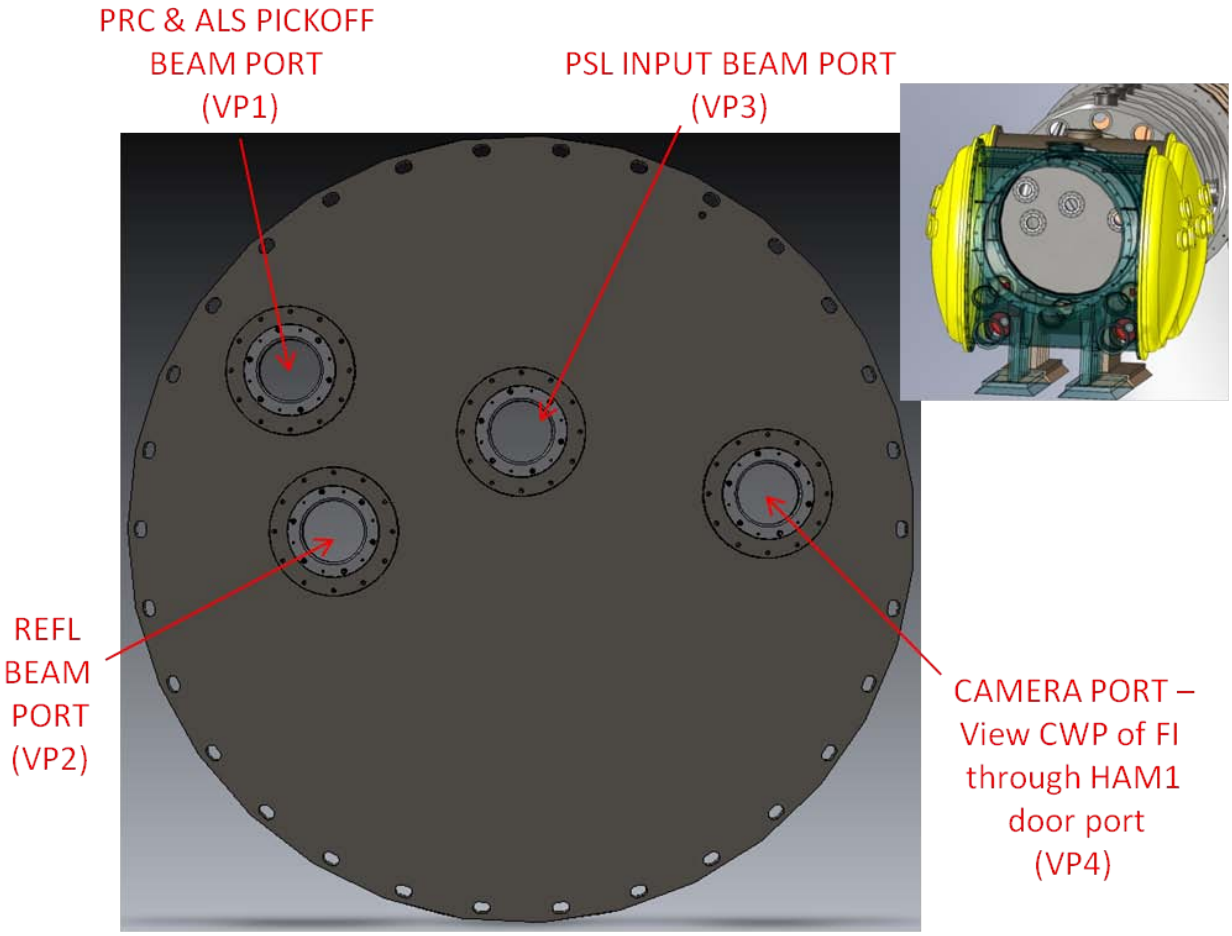

Figure 46: H1, L1 Input Septum Plate Port Locations

6.1.25 D1001662 H1, L1 Output Septum Plate Port Locations

The septum viewports between HAM5 and HAM6 allow passage of the 1) Signal beam, 2) TBD beams.

The septum plate viewports that were installed in Enhanced LIGO will be re-used for Advanced LIGO.

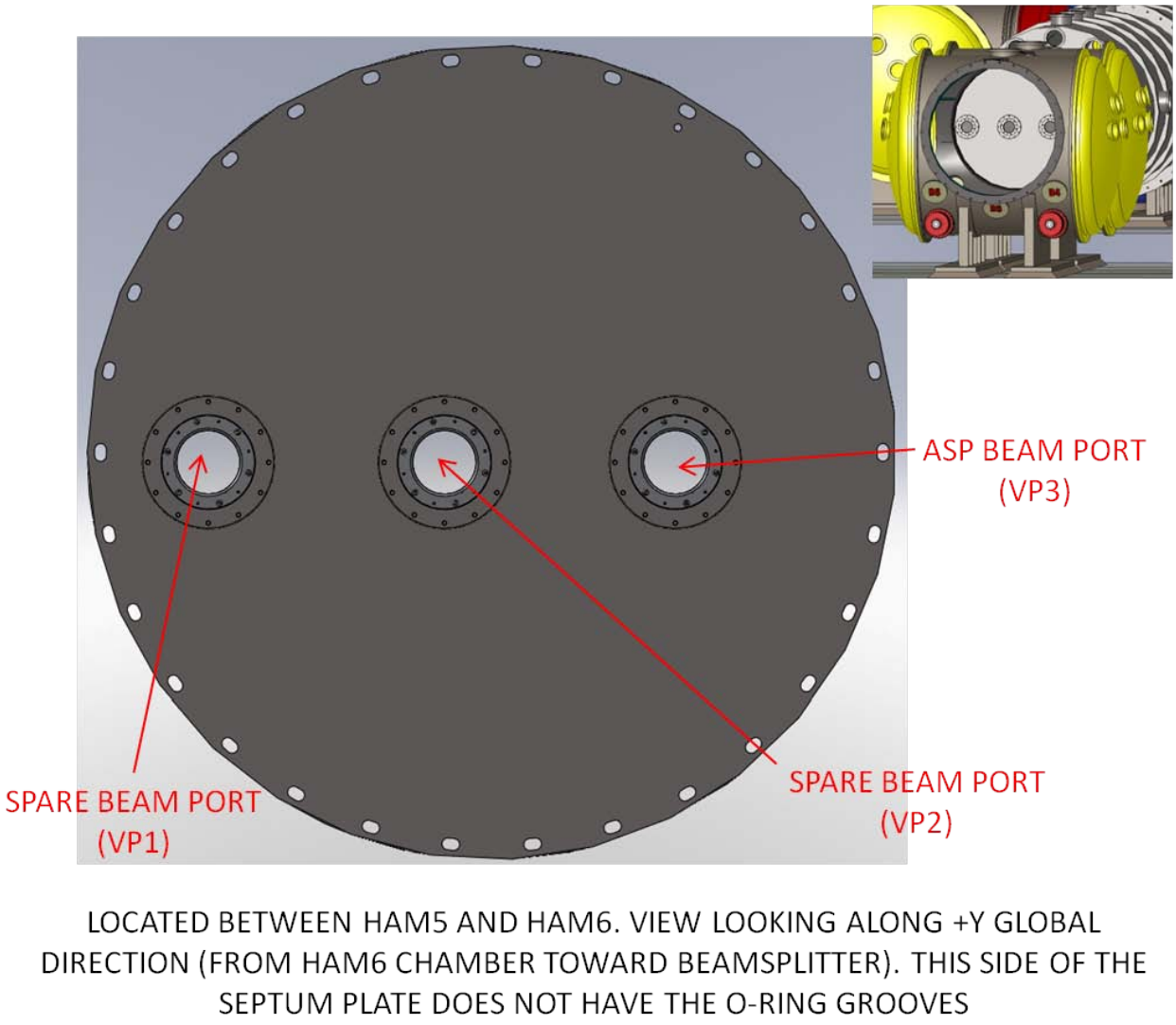

Figure 47: H1, L1 Output Septum Plate Port Locations

6.1.26 D1003343 H1, L1 Temporary PRC Septum Plate Port Location

This power recycling cavity (PRC) Septum Plate will be installed at the beam tube flange of HAM3 that faces BSC2. The H1, L1 PRC Septum Plate viewport name and location is shown in Figure 48.

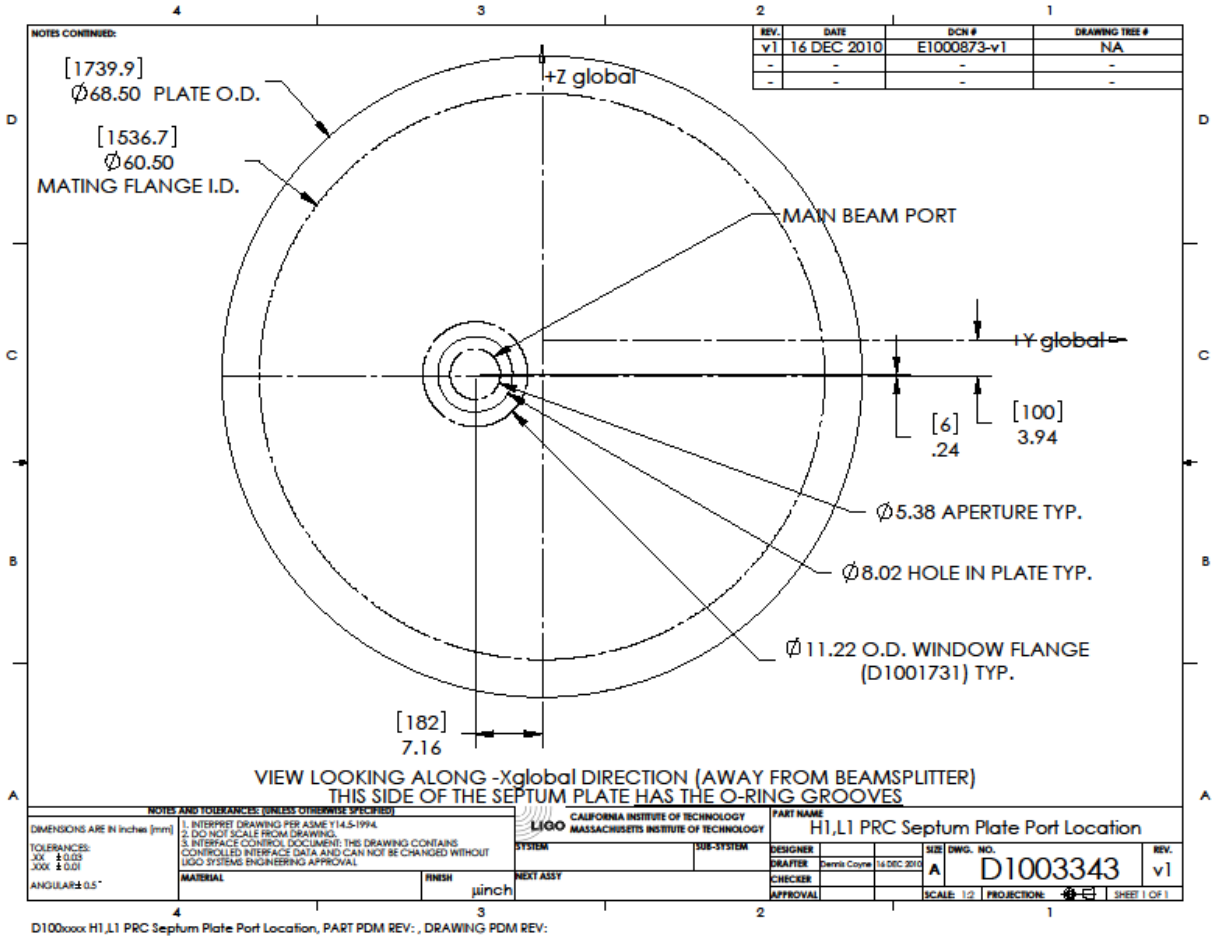

Figure 48: H1, L1 Temporary PRC Septum Plate Port Location

6.2 H2, Folded IFO

6.2.1 WBSC4

The locations of the WBSC4 viewports are shown in Figure 49.

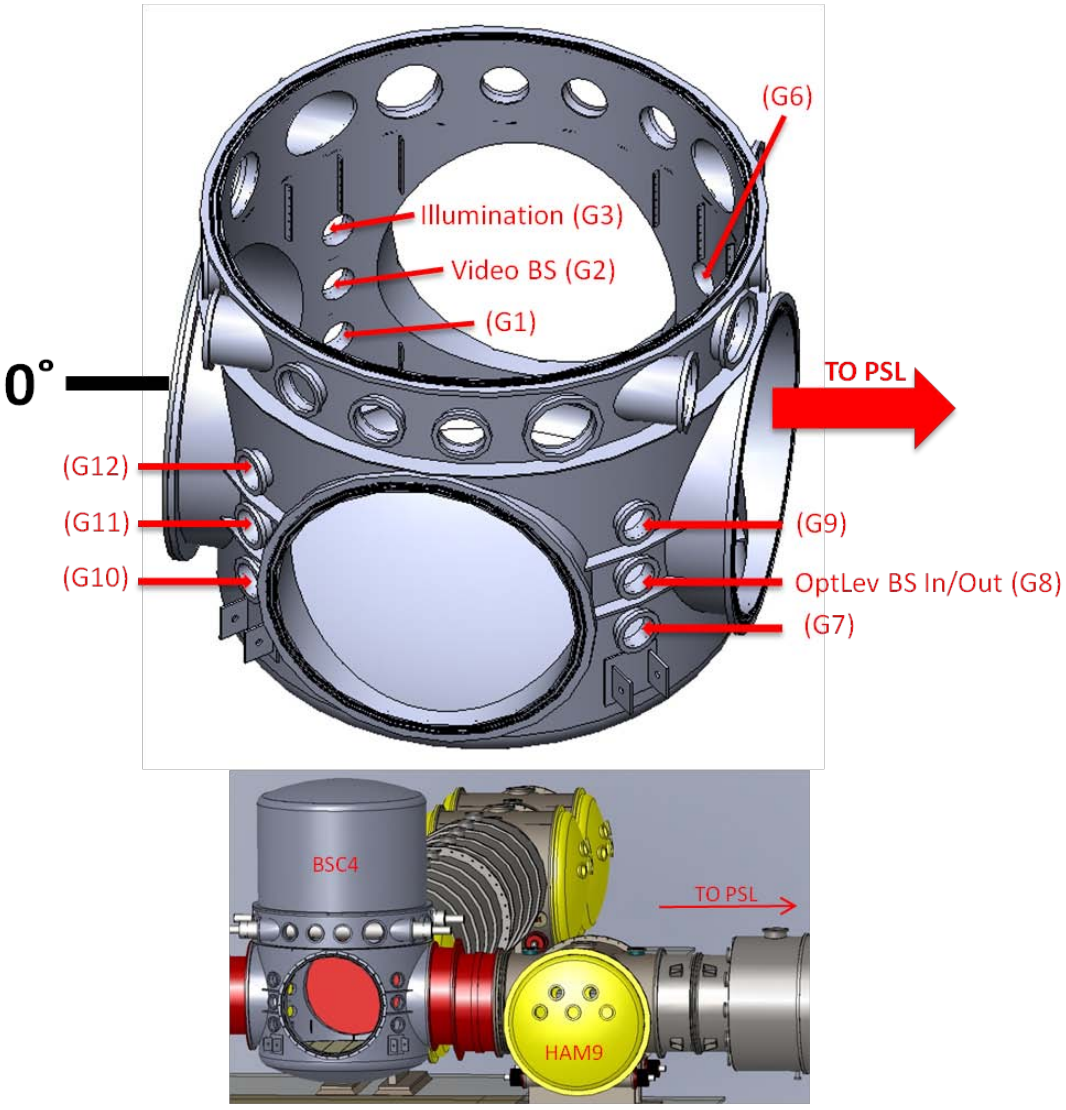

Figure 49: WBSC4 Viewports

6.2.2 WBSC7

The locations of the WBSC7 viewports are shown in Figure 50.

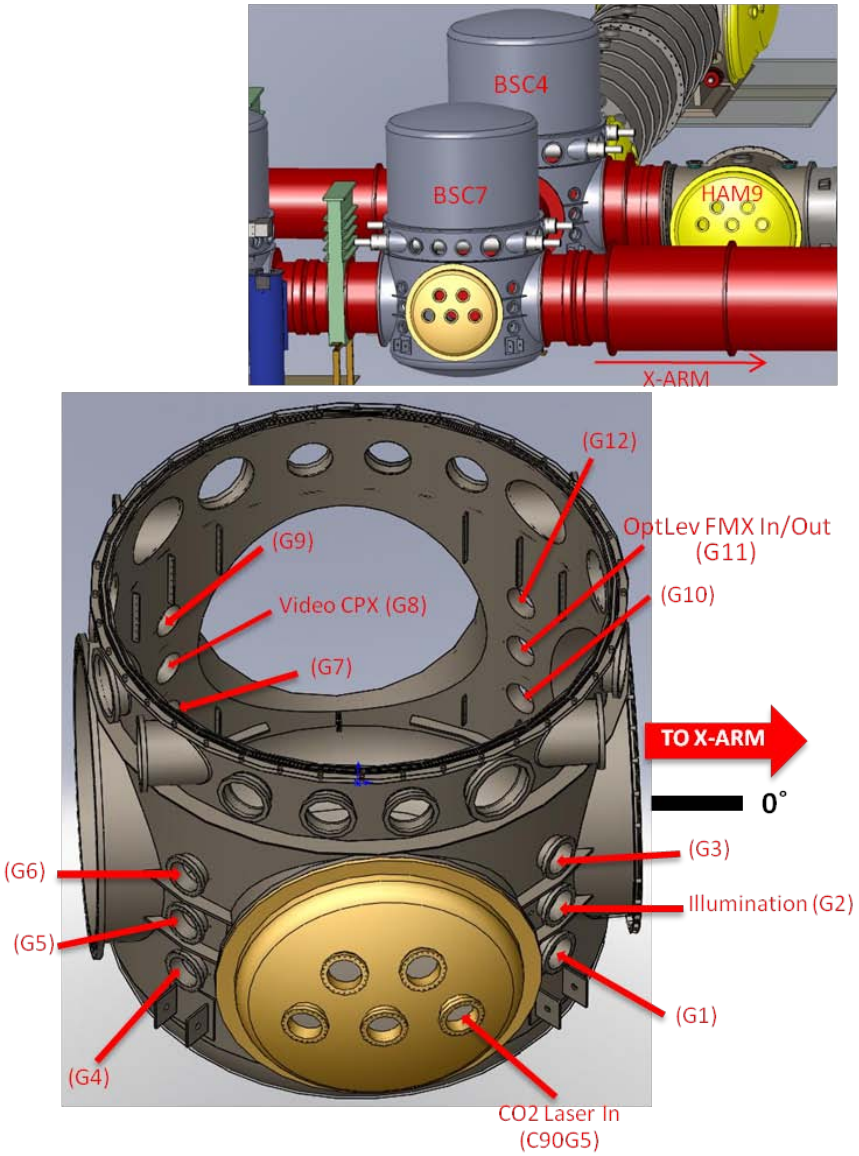

Figure 50: WBSC7 Viewports

6.2.3 WBSC8

The locations of the WBSC8 viewports are shown in Figure 51.

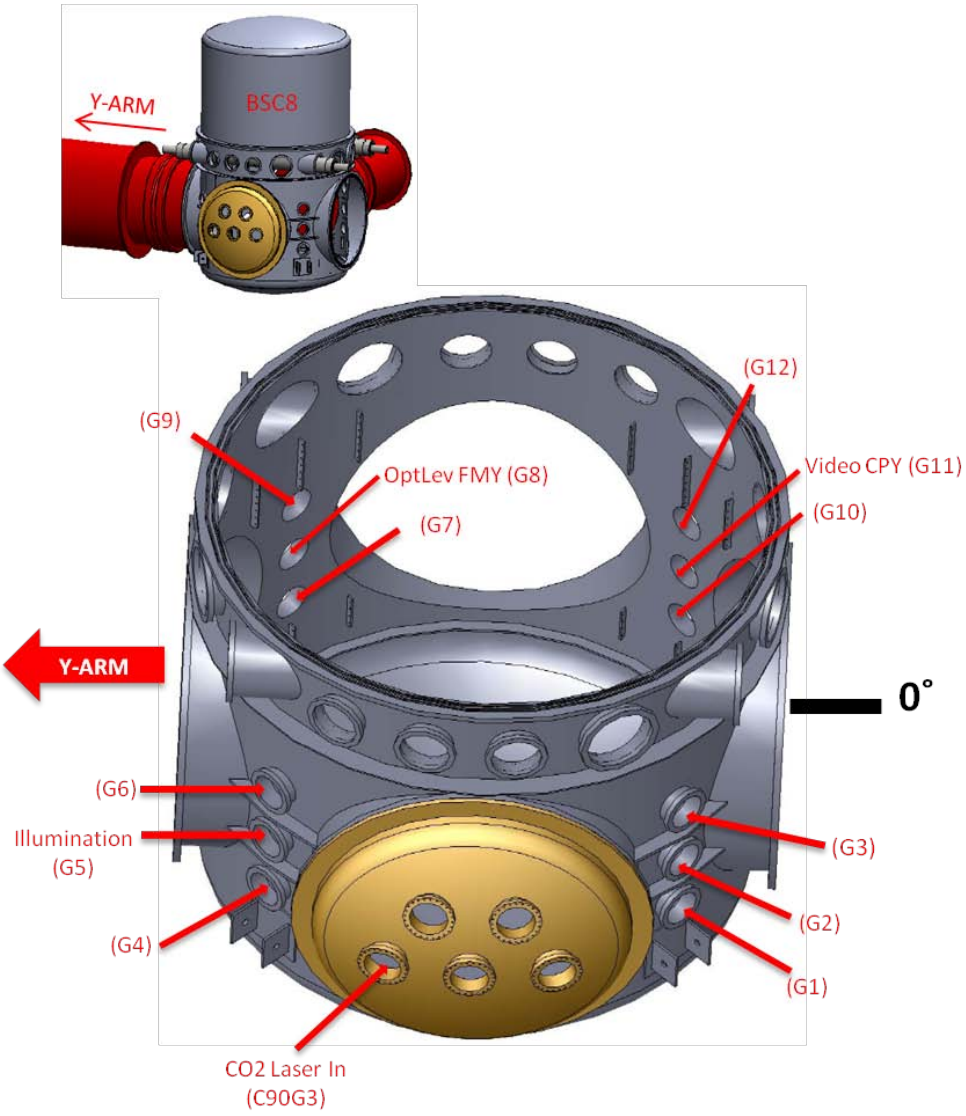

Figure 51: WBSC8 Viewports

6.2.4 WBSC5

The locations of the WBSC5 viewports are shown in Figure 52.

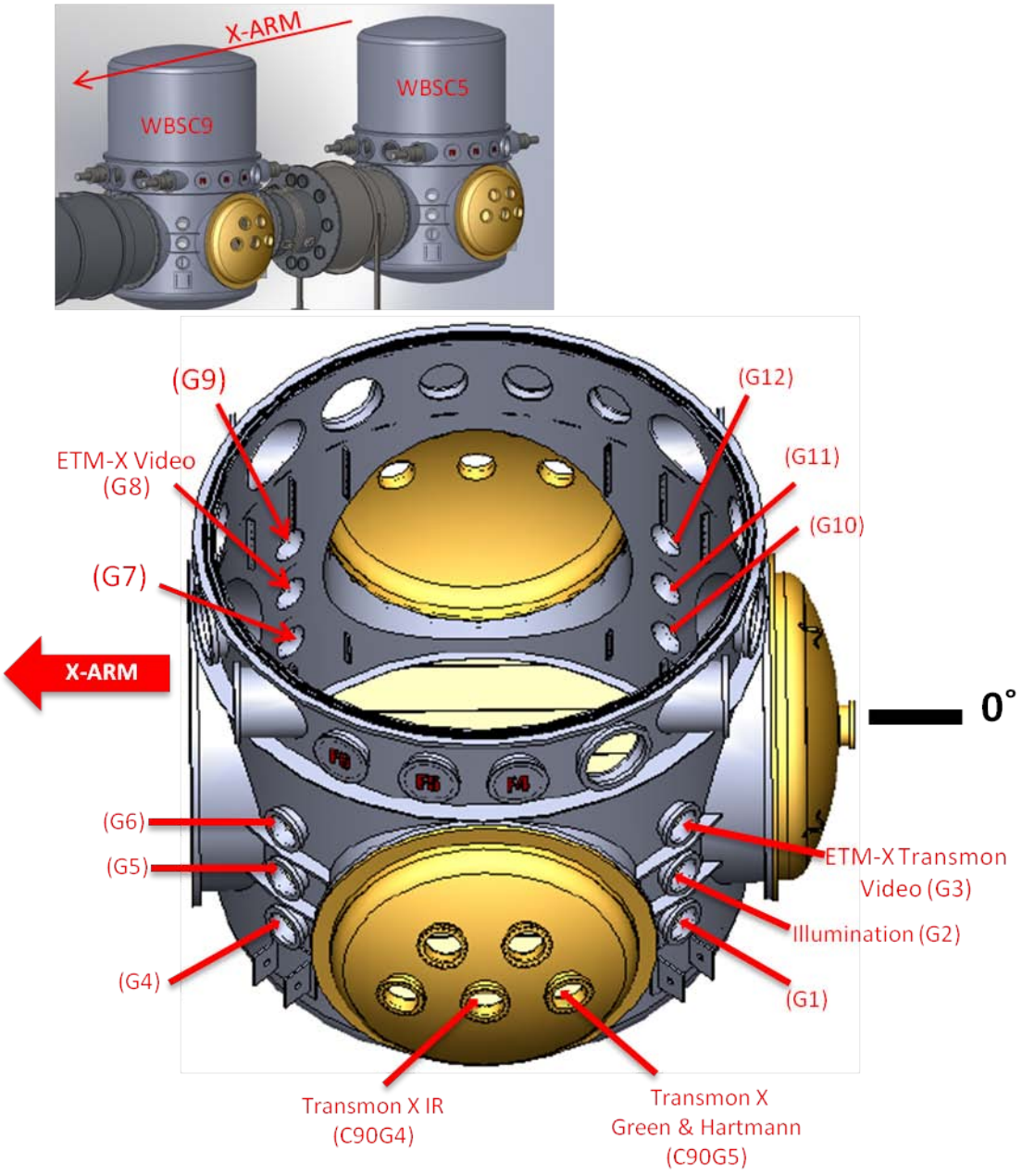

Figure 52: WBSC5 Viewports

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6.2.5 WBSC6

The locations of the WBSC6 viewports are shown in Figure 53.

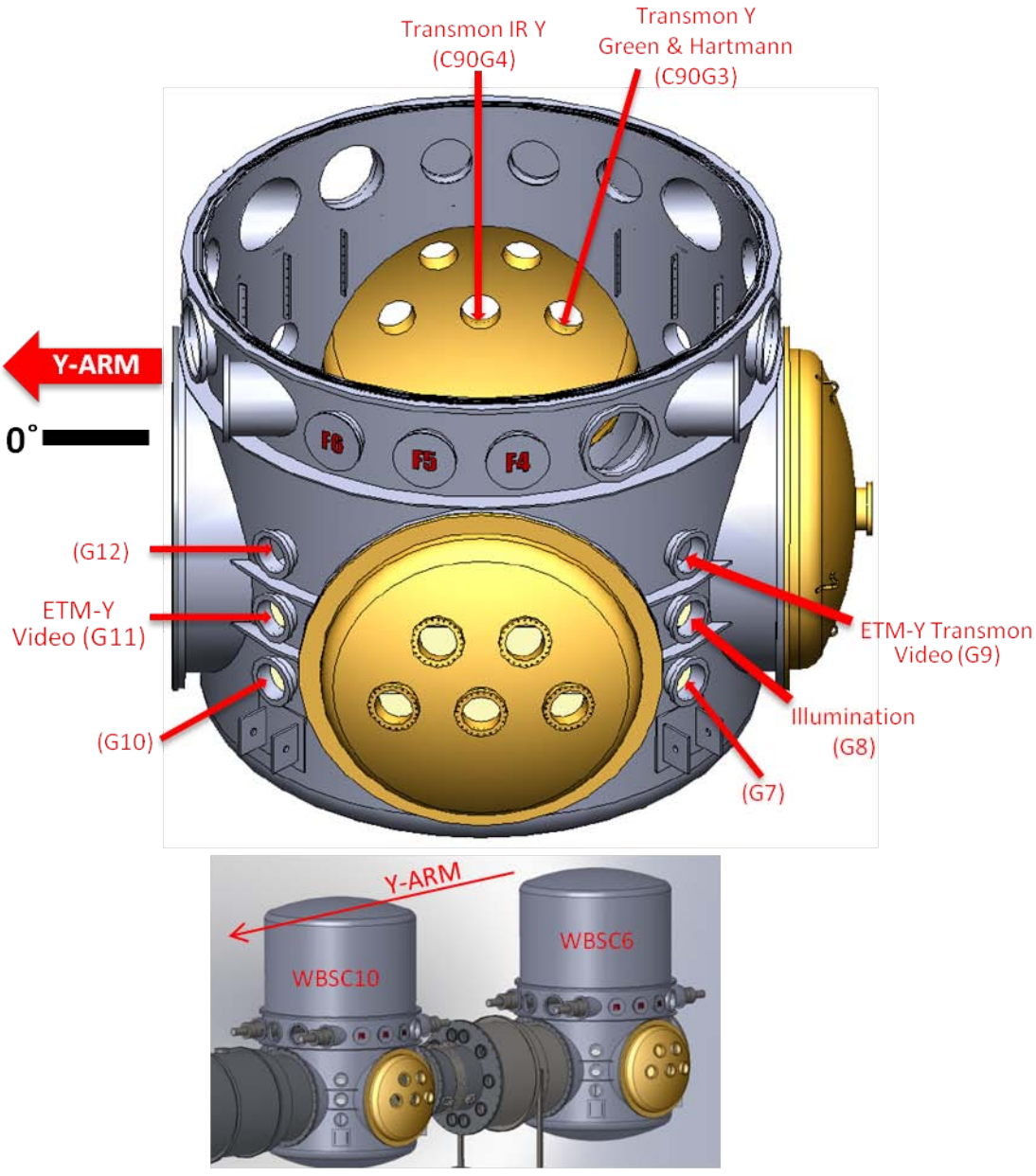

Figure 53: WBSC6 Viewports

6.2.6 WHAM7

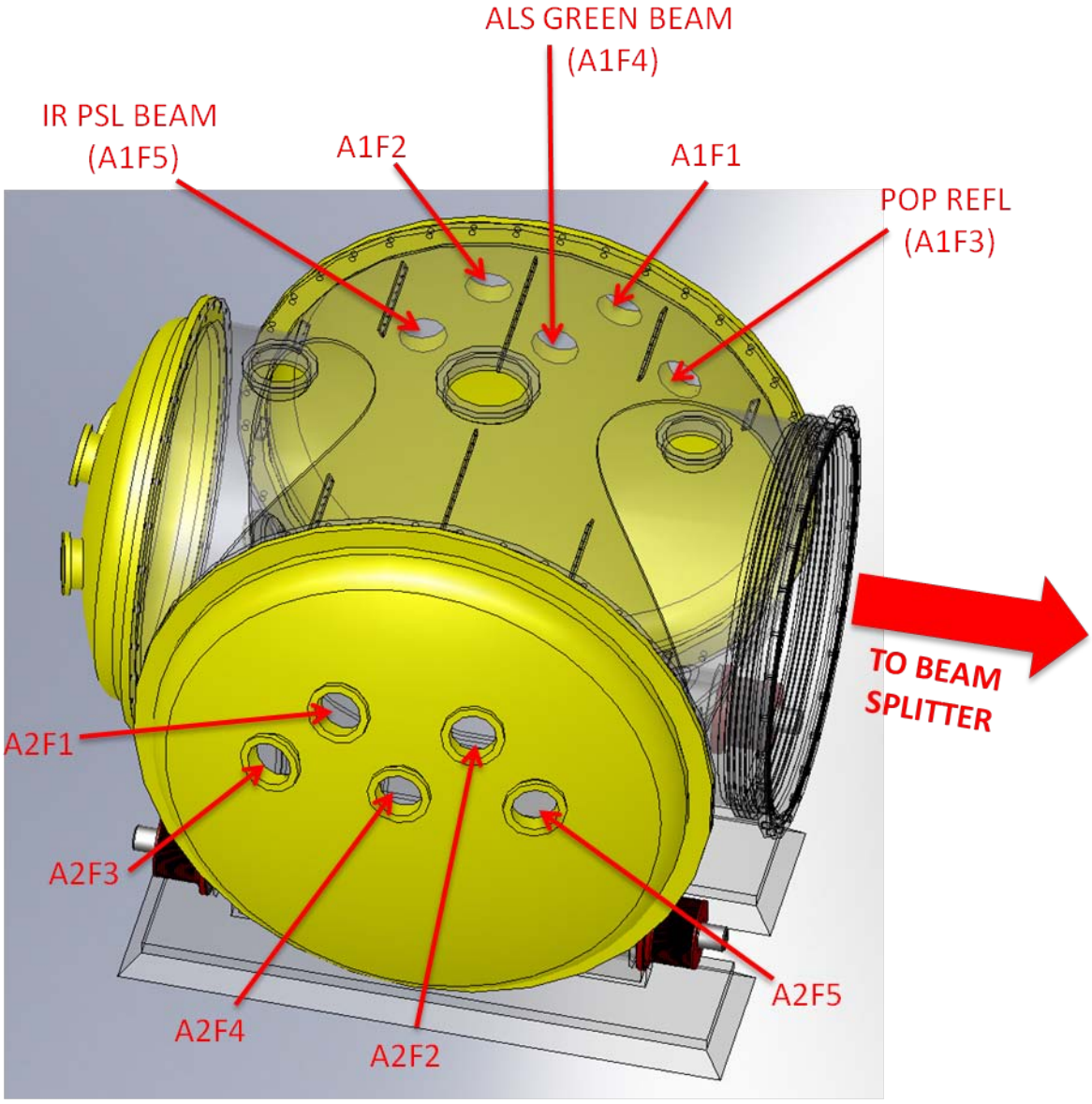

Figure 54: WHAM7

6.2.7 WHAM8

The locations of the WHAM8 viewports are shown in Figure 55.

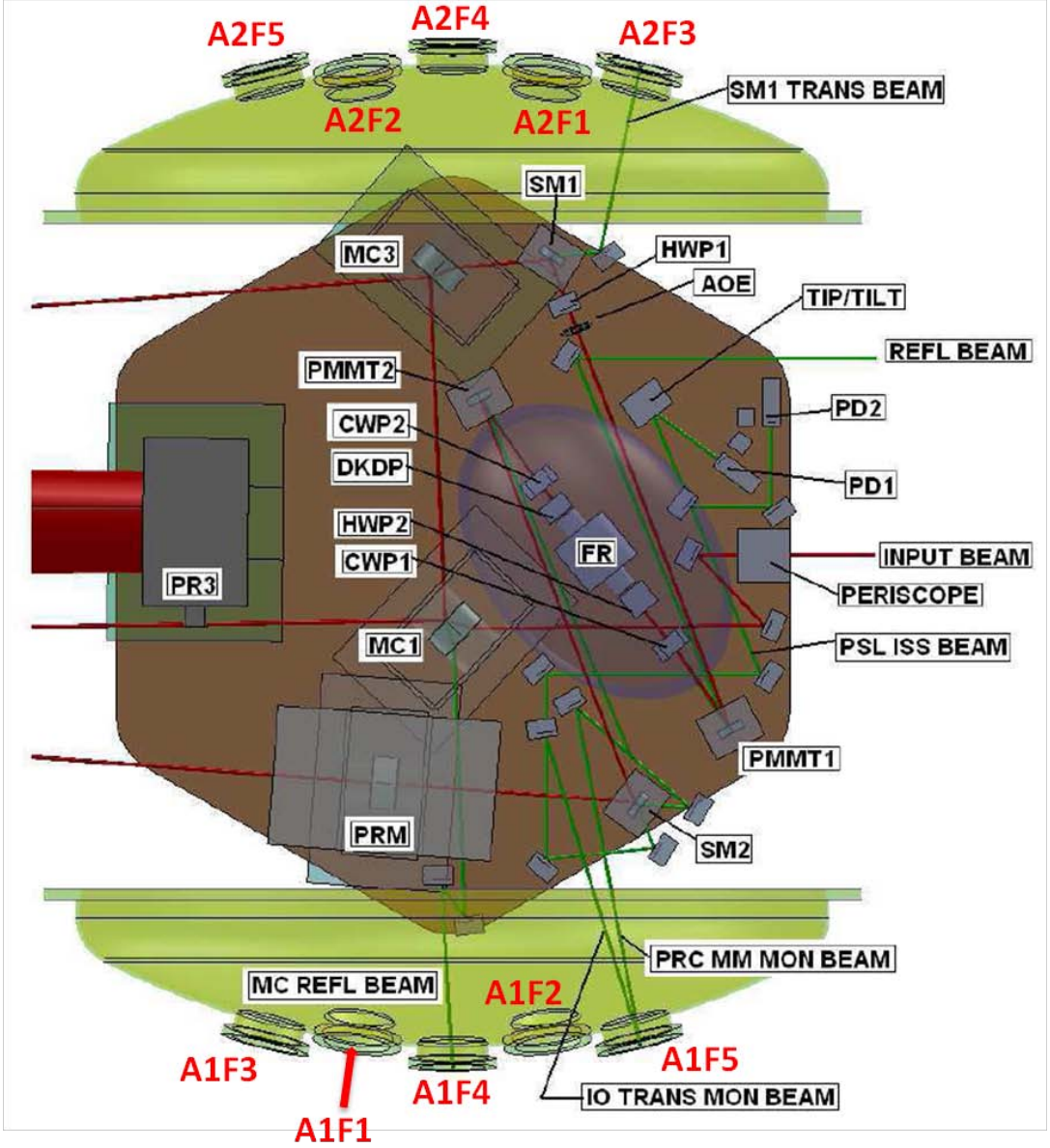

Figure 55: WHAM8 Viewports

6.2.8 WHAM9

The locations of the WHAM9 viewports are shown in Figure 56.

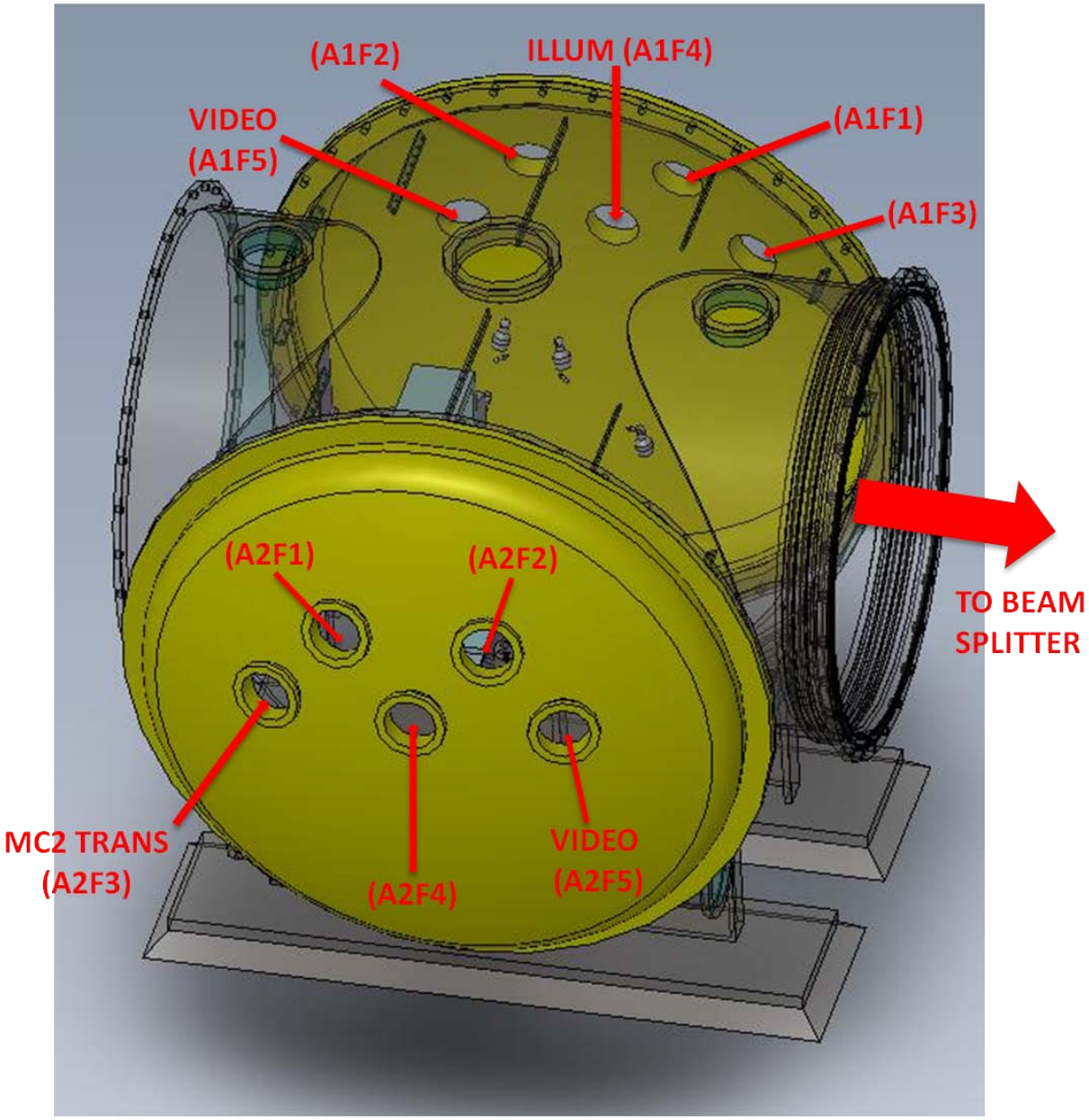

Figure 56: WHAM9 Viewports

6.2.9 WHAM10

The locations of the WHAM10 viewports are shown in Figure 57.

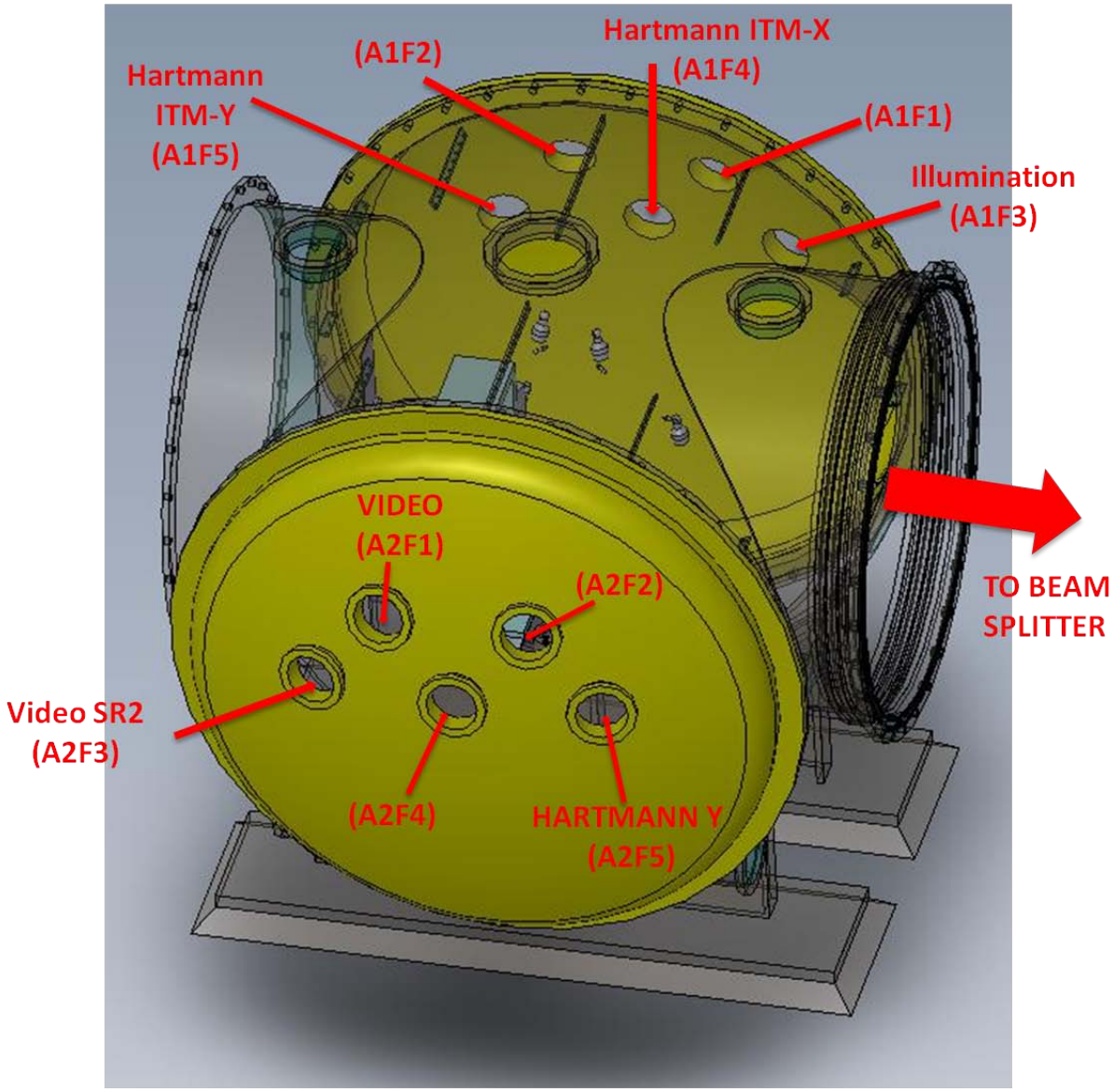

Figure 57: WHAM10 Viewports

6.2.10 WHAM11

The locations of the WHAM11 viewports are shown in Figure 58.

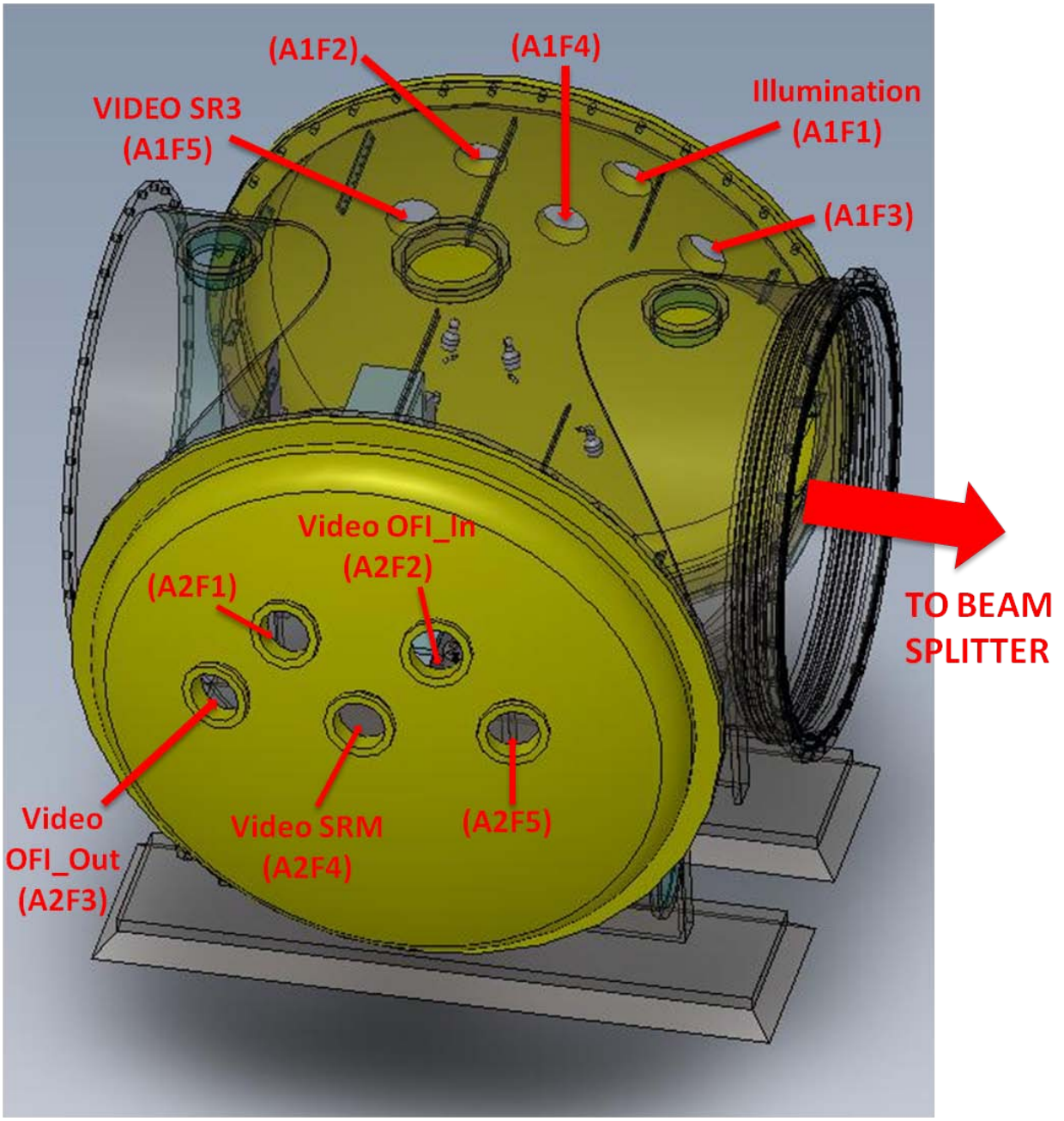

Figure 58: WHAM11 Viewports

6.2.11 WHAM12

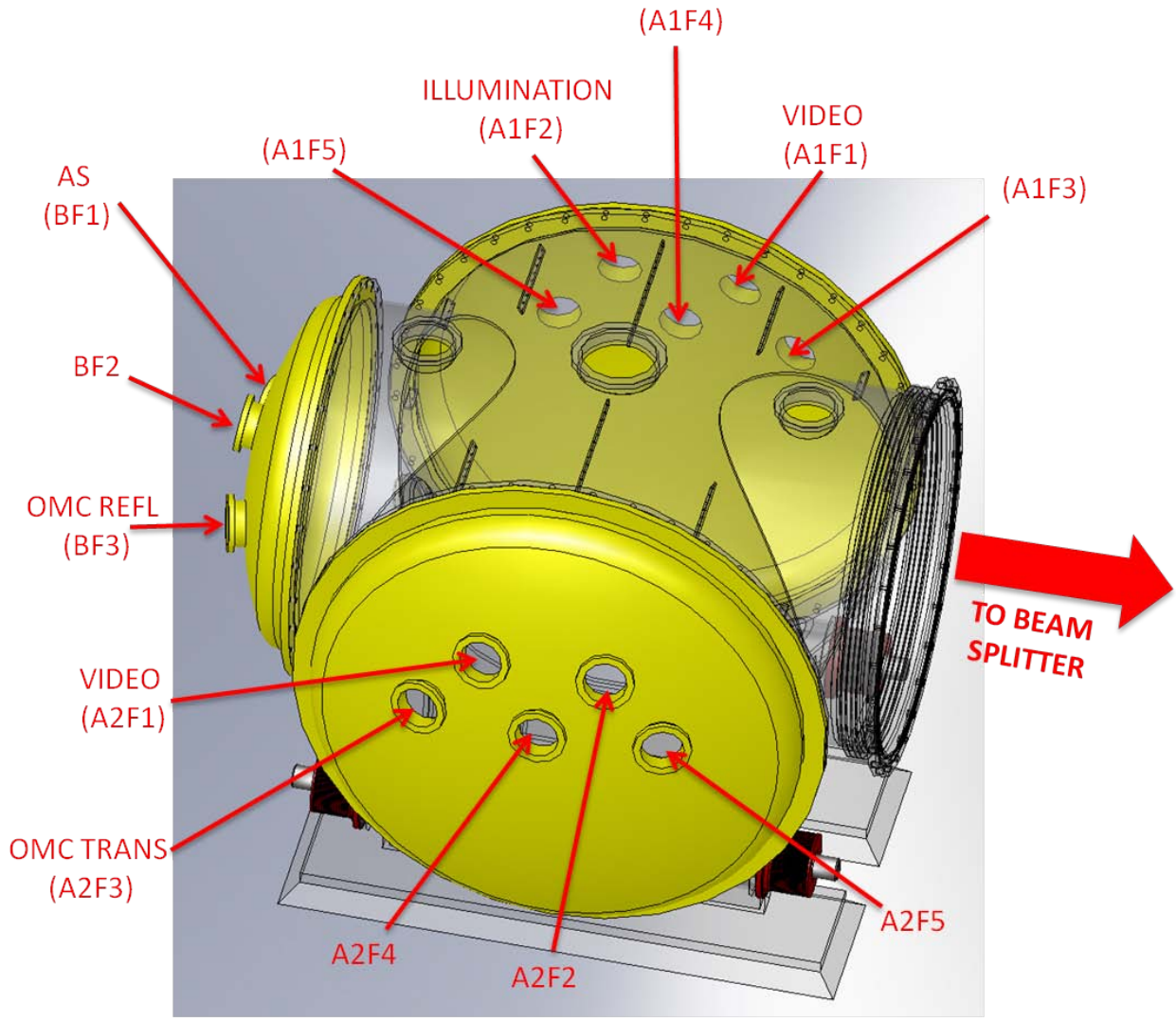

Figure 59: WHAM 12

6.2.12 WAMCA3

The locations of the WAMCA3 viewports are shown in Figure 60.

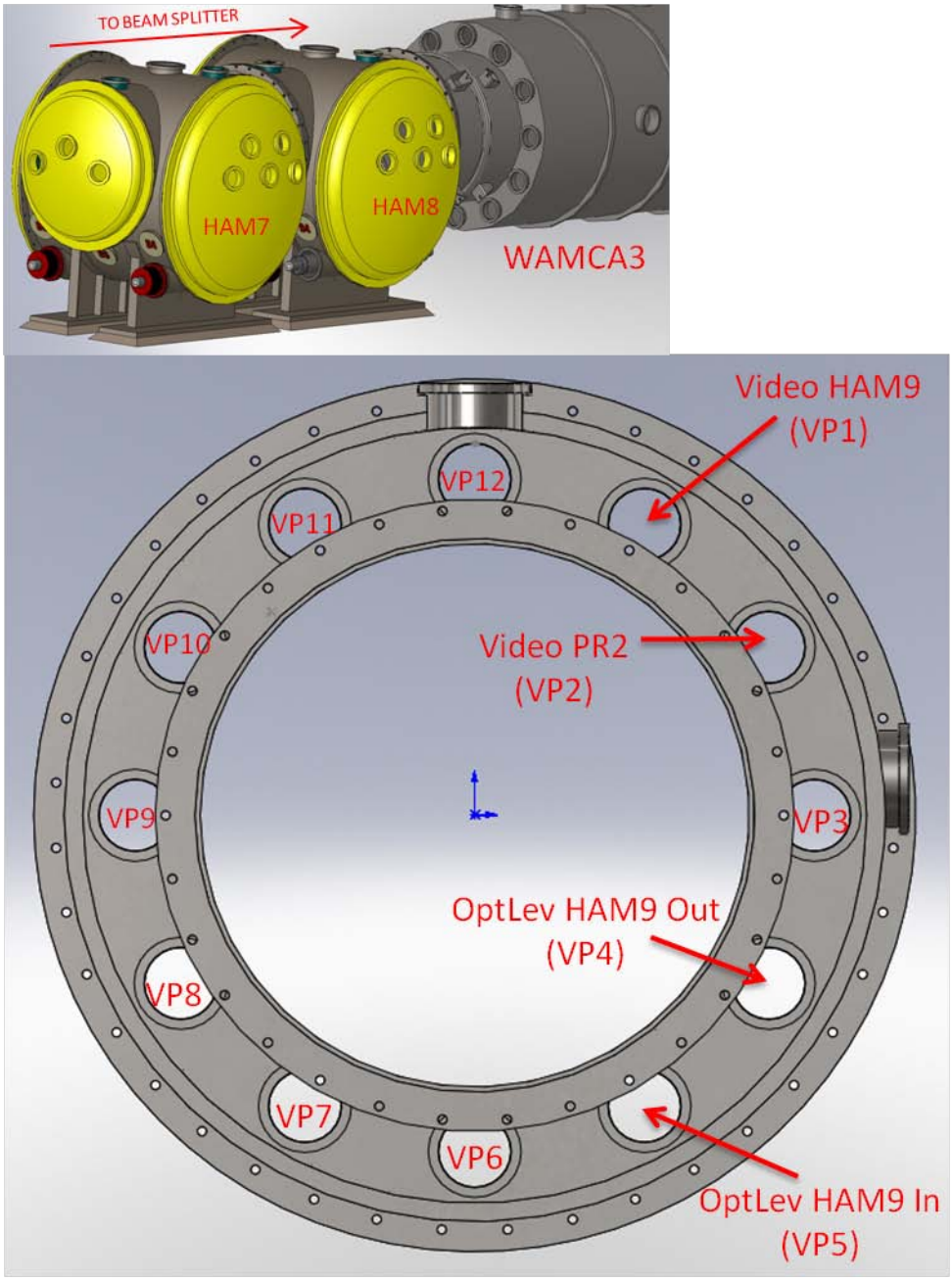

Figure 60: WAMCA3 Viewports

6.2.13 WAMCB3

The locations of the WAMCB3 viewports are shown in Figure 61.

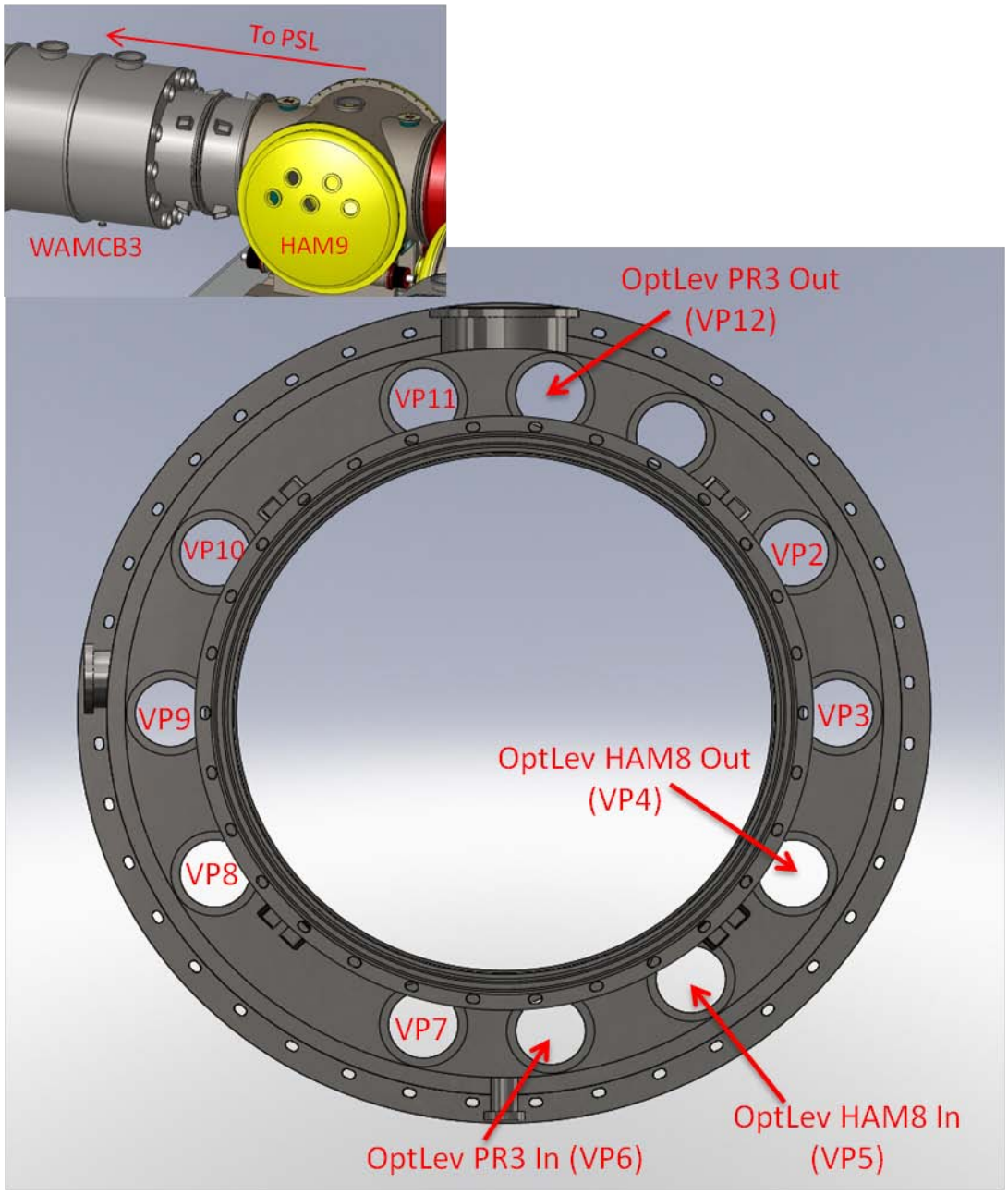

Figure 61: WAMCB3 Viewports

6.2.14 WAMCA4

The locations of the WAMCA4 viewports are shown in Figure 62.

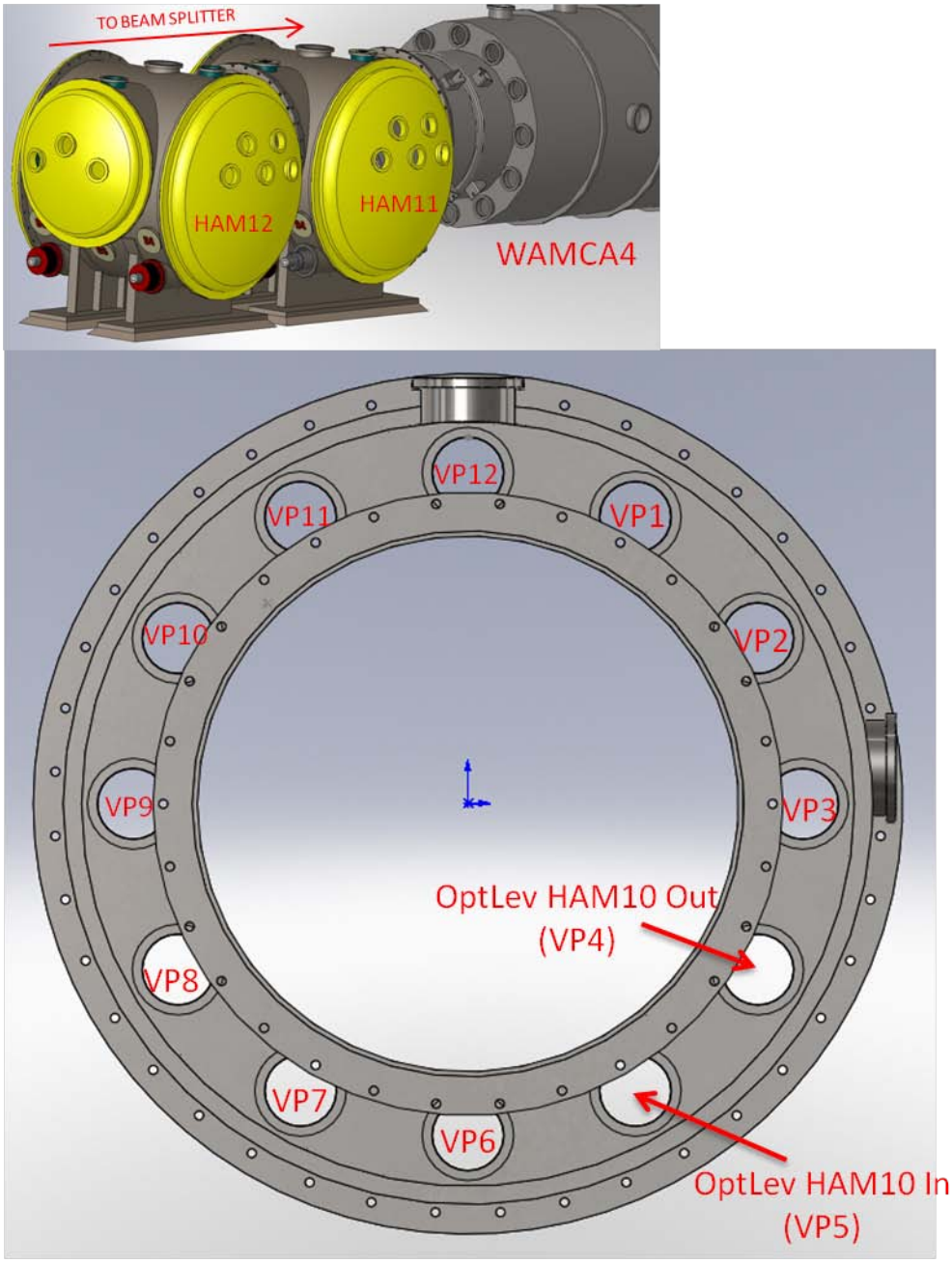

Figure 62: WAMCA4 Viewports

6.2.15 WAMCB4

The locations of the WAMCB4 viewports are shown in Figure 63.

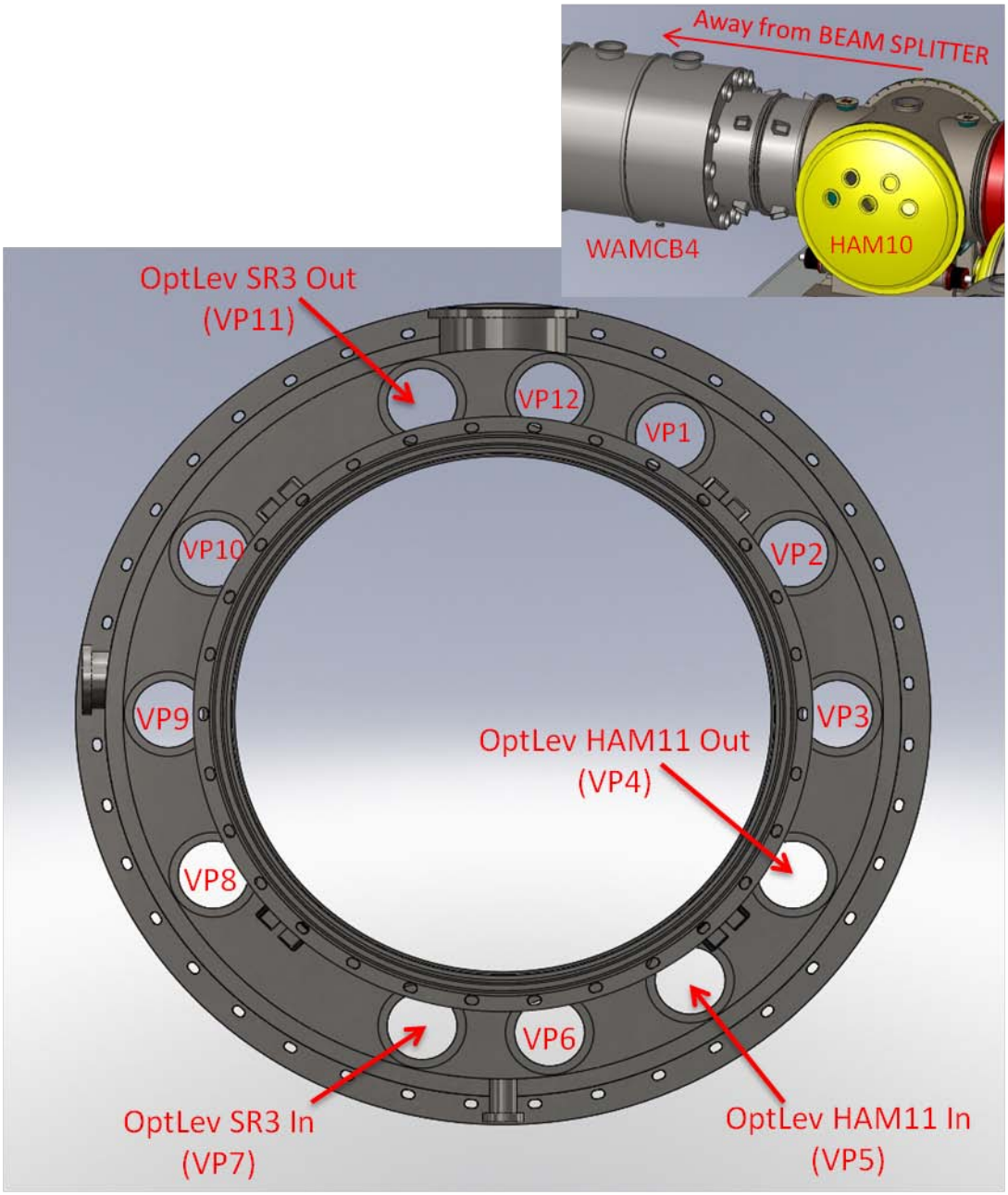

Figure 63: WAMCB4 Viewports

6.2.16 H2 Adapter A-1 FLANGE Viewports

H2 ETM-X Adapter A-1 viewports are identified in Section 6.1.20.

H2 ETM-Y Adapter A-1 viewports are identified in Section 6.1.22.

6.2.17 H2 ETM-X Adapter A-17A

The locations of the H2 ETM-X Adapter A-17A viewports are shown in Figure 64.

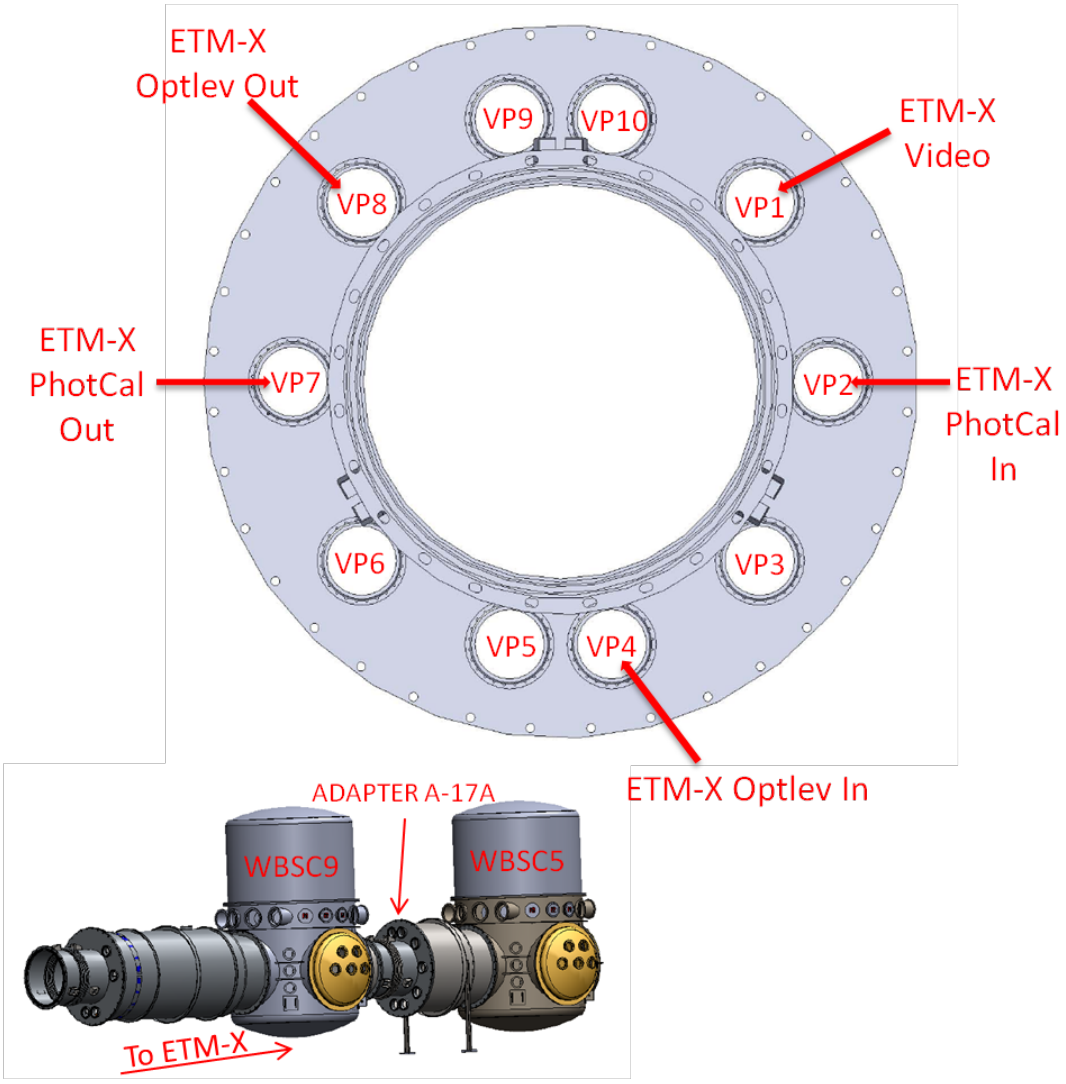

Figure 64: H2 ETM-X Adapter A-17A

6.2.18 H2 ETM-Y Adapter A-17B

The locations of the H2 ETM-Y Adapter A-17B viewports are shown in Figure 65.

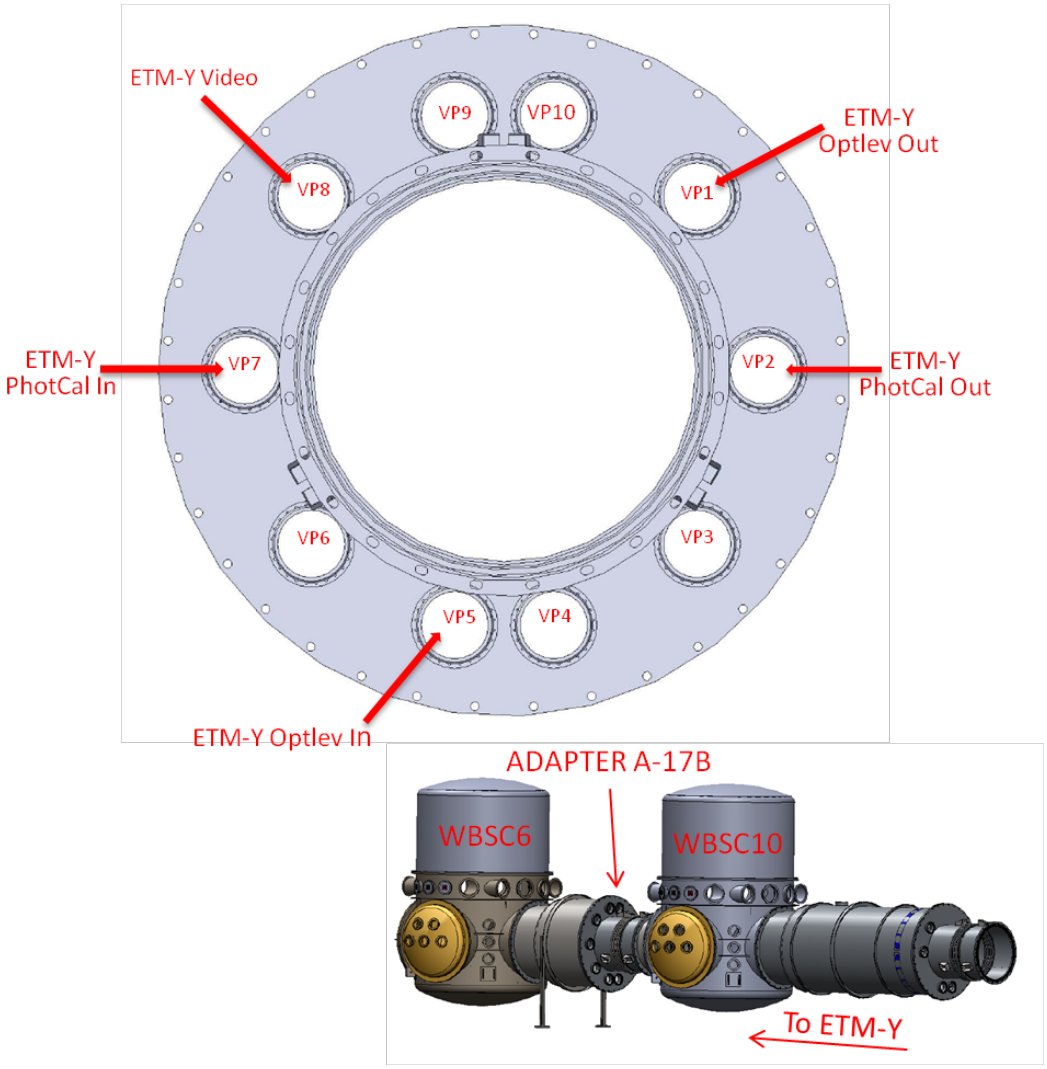

Figure 65: H2 ETM-Y Adapter A-17B

6.2.19 D1001665 H2 Input Septum Plate Port Locations

The septum viewports between HAM7 and HAM8 allow passage of 1) PSL input beam, 2) REFL beam, 3) POB reference beam, and 4) the Arm Length Stabilization beam.

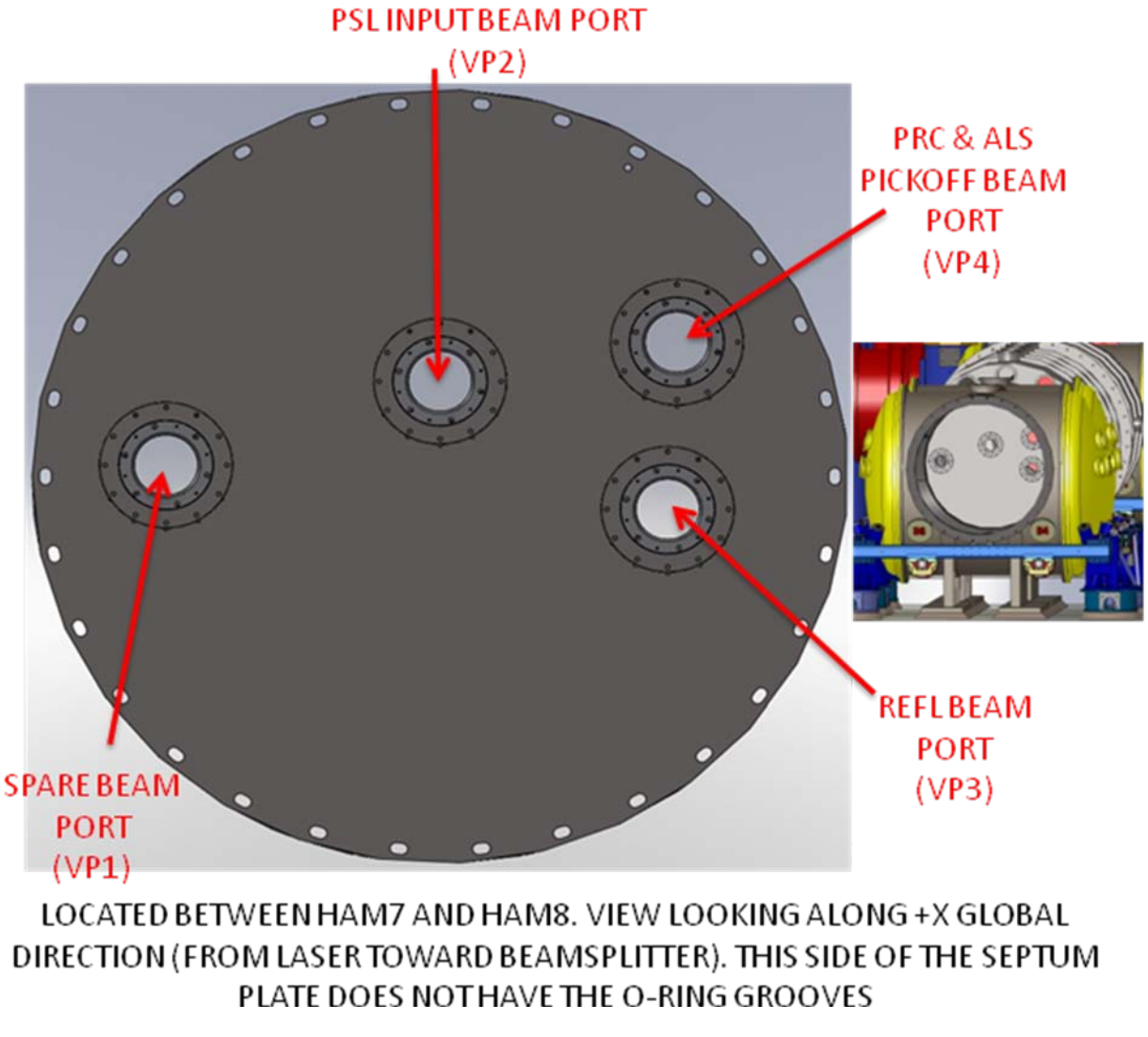

Figure 66: H2 Input Septum Plate Port Locations

6.2.20 D1001666 H2 Output Septum Plate Port Locations

The septum viewports between HAM11 and HAM12 allow passage of the 1) Signal beam, 2) TBD beams.

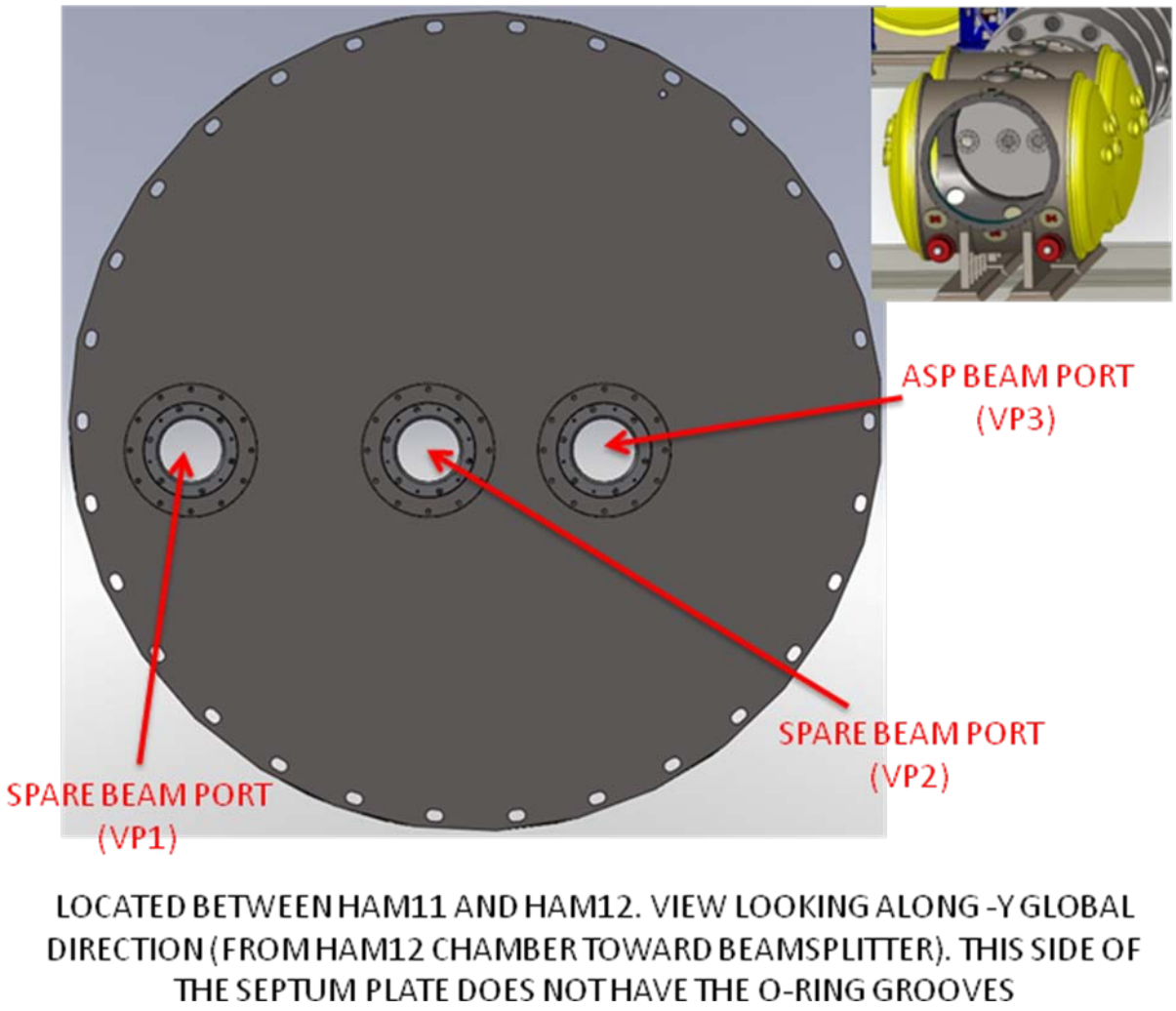

Figure 67: H2 Output Septum Plate Port Locations

6.2.21 D1003344 H2 Temporary PRC Septum Plate Port Location

This PRC Septum Plate will be installed at the beam tube flange of HAM9 that faces BSC4. The H2 PRC Septum Plate viewport name and location is shown in Figure 68.

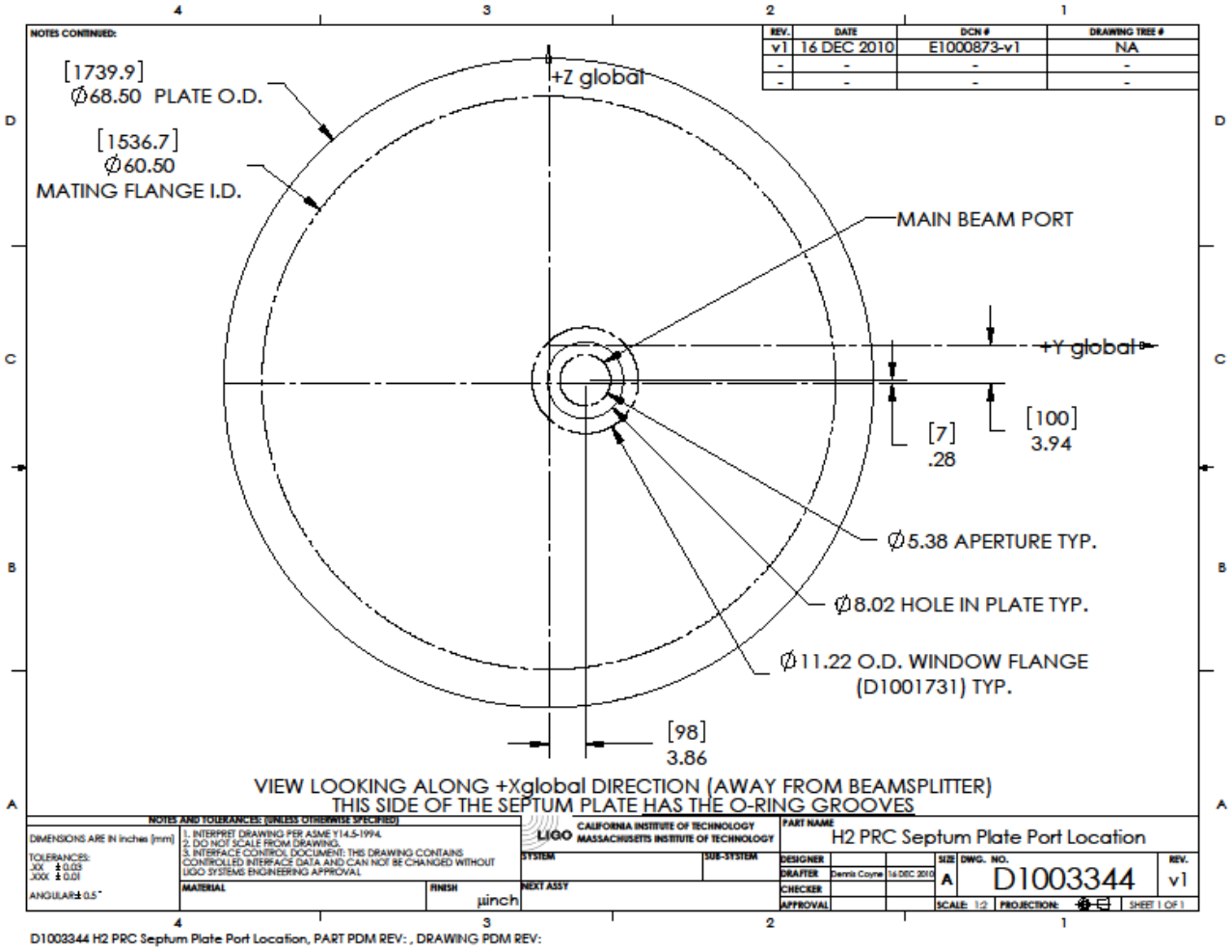

Figure 68: H2 Temporary PRC Septum Plate Port Location

7 Summary of Viewports

The viewport descriptions for H1, H2, and L1 interferometers are presented in the following tables.

Table 1: H1 Viewports

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H1	A1-B	VP2	PHOTCAL1-2	ETMY-IN	6.0 in-AR1064/532
H1	A1-B	VP5	PHOTCAL1-2	ETMY-OUT	6.0 in-AR1064/532
H1	A-1B	VP3	OPTLEV	ETMY-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A-1B	VP6	OPTLEV	ETMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP1	OPTLEV	F-ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP3	OPTLEV	ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP4	OPTLEV	F-ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP5	VIDEO	ITMX	5.4 DIA VP800/450009
H1	A1-C	VP6	OPTLEV	ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-E	VP1	OPTLEV	ETMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-E	VP2	PHOTCAL1-2	ETMX-OUT	6.0 in-AR1064/532
H1	A1-E	VP4	OPTLEV	ETMX-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-E	VP5	PHOTCAL1-2	ETMX-IN	6.0 in-AR1064/532
H1	A1-F	VP1	OPTLEV	ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-F	VP2	VIDEO	ITMY	5.4 DIA VP800/450009
H1	A1-F	VP3	OPTLEV	F-ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-F	VP4	OPTLEV	ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-F	VP6	OPTLEV	F-ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	BSC1	G11	VIDEO	ITMY-CP	5.4 DIA VP800/450009
H1	BSC1	G2	VIDEO	ITMY	5.4 DIA VP800/450009
H1	BSC1	G3	ILLUMINATION		5.4 DIA VP800/450009

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H1	BSC10	G11	VIDEO	ETMY	5.4 DIA VP800/450009
H1	BSC10	G8	ILLUMINATION		5.4 DIA VP800/450009
H1	BSC10	G9	VIDEO	TRANSMONY	5.4 DIA VP800/450009
H1	BSC10-S	C90G3	DIAGNOSTIC	TRANSMONY GREEN-HARTMANN	6.0 in-AR1064/532
H1	BSC10-S	C90G4	DIAGNOSTIC	TRANSMONY-IR	5.4 DIA VP800-AR1064
H1	BSC1-S	C180G3	CO2-LASER	ITMY-IN	TCS
H1	BSC2	G2	OPTLEV	BS-IN/OUT	2.7 DIA, MDC450004-AR635
H1	BSC2	G8	VIDEO	BS	5.4 DIA VP800/450009
H1	BSC2	G9	ILLUMINATION		5.4 DIA VP800/450009
H1	BSC3	G1	VIDEO	ITMX-CP	5.4 DIA VP800/450009
H1	BSC3	G10	VIDEO	ITMX	5.4 DIA VP800/450009
H1	BSC3	G11	ILLUMINATION		5.4 DIA VP800/450009
H1	BSC3-S	C180G5	CO2-LASER	ITMX-IN	TCS
H1	BSC9	G2	ILLUMINATION	RMX	5.4 DIA VP800/450009
H1	BSC9	G3	VIDEO	TRANSMONX	5.4 DIA VP800/450009
H1	BSC9	G4	VIDEO	ETMX	5.4 DIA VP800/450009
H1	BSC9-S	C90G4	DIAGNOSTIC	TRANSMONX-IR	5.4 DIA VP800-AR1064
H1	BSC9-S	C90G5	DIAGNOSTIC	TRANSMONX GREEN-HARTMANN	6.0 in-AR1064/532
H1	HAM1	VPA1F3	DIAGNOSTIC	POP-REFL	5.4 DIA VP800-AR1064
H1	HAM1	VPA1F4	DIAGNOSTIC	ALS-GREEN-BEAM	5.4 DIA VP800-AR532
H1	HAM1	VPA1F5	DIAGNOSTIC	IR-PSL-BEAM	5.4 DIA VP800-AR1064
H1	HAM1	VPA2F4	ILLUMINATION		5.4 DIA VP800/450009
H1	HAM2	VPA1F1	ILLUM		5.4 DIA VP800/450009

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H1	HAM2	VPA1F2	VIDEO	FI-OUT	5.4 DIA VP800/450009
H1	HAM2	VPA1F4	DIAGNOSTIC	MC-REFLBEAM	5.4 DIA VP800-AR1064
H1	HAM2	VPA1F5	VIDEO	SM1-TRANSBEAM	5.4 DIA VP800/450009
H1	HAM2	VPA2F1	VIDEO	SM1_FI-OUTPUT	5.4 DIA VP800/450009
H1	HAM2	VPA2F3	DIAGNOSTIC	PRC-MM-MONBEAM	5.4 DIA VP800-AR1064
H1	HAM2	VPA2F4	DIAGNOSTIC	IO-TRANS-MONBEAM	5.4 DIA VP800-AR1064
H1	HAM3	VPA1F3	DIAGNOSTIC	MC2-TRANS	5.4 DIA VP800-AR1064
H1	HAM3	VPA1F4	ILLUM		5.4 DIA VP800/450009
H1	HAM3	VPA1F5	VIDEO	MC2	5.4 DIA VP800/450009
H1	HAM3	VPA2F5	VIDEO	PR2	5.4 DIA VP800/450009
H1	HAM4	VPA1F4	ILLUM		5.4 DIA VP800/450009
H1	HAM4	VPA2F2	VIDEO	SR2	5.4 DIA VP800/450009
H1	HAM4	VPA2F3	DIAGNOSTIC	HARTMANN_ITMX	6.0 in-AR800-900
H1	HAM4	VPA2F4	DIAGNOSTIC	HARTMANN_ITMY	6.0 in-AR800-900
H1	HAM5	VPA1F4	ILLUM		5.4 DIA VP800/450009
H1	HAM5	VPA1F5	VIDEO	SR3	5.4 DIA VP800/450009
H1	HAM5	VPA2F3	SQUEEZE		6.0 in-AR1064/532
H1	HAM5	VPA2F4	VIDEO	OFI-IN	5.4 DIA VP800/450009
H1	HAM5	VPA2F5	VIDEO	SRM	5.4 DIA VP800/450009
H1	HAM6	VPA1F1	VIDEO	OMC-2	5.4 DIA VP800/450009
H1	HAM6	VPA1F2	ILLUMINATION		5.4 DIA VP800/450009
H1	HAM6	VPA2F1	VIDEO	OMC-1	5.4 DIA VP800/450009
H1	HAM6	VPA2F3	DIAGNOSTIC	OMC-TRANS	5.4 DIA VP800-AR1064

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H1	SEPTUM	VP4	DIAGNOSTIC	CAMERA PORT	SEPTUM VP
H1	SEPTUM-IO	VP1	DIAGNOSTIC	PRC & ALS PICKOFF BEAM PORT	SEPTUM VP
H1	SEPTUM-IO	VP2	DIAGNOSTIC	REFL BEAM PORT	SEPTUM VP
H1	SEPTUM-IO	VP3	DIAGNOSTIC	PSL INPUT BEAM PORT	SEPTUM VP
H1	SEPTUM-OUT	VP1	OUT	SPARE BEAM PORT	SEPTUM VP
H1	SEPTUM-OUT	VP2	OUT	SPARE BEAM PORT	SEPTUM VP
H1	SEPTUM-OUT	VP3	OUT	ASP BEAM PORT	SEPTUM VP
H1	A1-B	VP2	PHOTCAL1-2	ETMY-IN	6.0 in-AR1064/532
H1	A1-B	VP5	PHOTCAL1-2	ETMY-OUT	6.0 in-AR1064/532
H1	A-1B	VP3	OPTLEV	ETMY-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A-1B	VP6	OPTLEV	ETMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP1	OPTLEV	F-ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP3	OPTLEV	ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP4	OPTLEV	F-ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-C	VP5	VIDEO	ITMX	5.4 DIA VP800/450009
H1	A1-C	VP6	OPTLEV	ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-E	VP1	OPTLEV	ETMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-E	VP2	PHOTCAL1-2	ETMX-OUT	6.0 in-AR1064/532
H1	A1-E	VP4	OPTLEV	ETMX-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-E	VP5	PHOTCAL1-2	ETMX-IN	6.0 in-AR1064/532
H1	A1-F	VP1	OPTLEV	ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	A1-F	VP2	VIDEO	ITMY	5.4 DIA VP800/450009
H1	A1-F	VP3	OPTLEV	F-ITMY-IN	7.8 DIA, ISI 4.9722012-AR635

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H1	A1-F	VP4	OPTLEV	ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
H1	A1-F	VP6	OPTLEV	F-ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H1	BSC1	G11	VIDEO	ITMY-CP	5.4 DIA VP800/450009
H1	BSC1	G2	VIDEO	ITMY	5.4 DIA VP800/450009
H1	BSC1	G3	ILLUMINATION		5.4 DIA VP800/450009
H1	BSC10	G11	VIDEO	ETMY	5.4 DIA VP800/450009
H1	BSC10	G8	ILLUMINATION		5.4 DIA VP800/450009

Table 2: H2 Viewports

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H2	A-17A	VP3	PHOTCAL	FETMX-IN	6.0 in-AR1064/532
H2	A-17A	VP5	OPTLEV	FETMX-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A-17A	VP8	PHOTCAL	FETMX-OUT	6.0 in-AR1064/532
H2	A-17A	VP9	OPTLEV	FETMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A-17B	VP2	OPTLEV	FETMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A-17B	VP3	PHOTCAL	FETMY-OUT	6.0 in-AR1064/532
H2	A-17B	VP6	OPTLEV	FETMY-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A-17B	VP8	PHOTCAL	FETMY-IN	6.0 in-AR1064/532
H2	A1-C	VP1	OPTLEV	FITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A1-C	VP2A	C02-LASER	FITMX-IN	TCS
H2	A1-C	VP2B	VIDEO	FITMX	TCS
H2	A1-C	VP3	OPTLEV	ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A1-C	VP4	OPTLEV	FITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A1-C	VP6	OPTLEV	ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A1-F	VP1	OPTLEV	ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A1-F	VP3	OPTLEV	FITMY-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A1-F	VP4	OPTLEV	ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A1-F	VP5A	C02-LASER	FITMY-IN	TCS
H2	A1-F	VP5B	VIDEO	FITMY	TCS
H2	A1-F	VP6	OPTLEV	FITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	BSC4	G2	VIDEO	BS	5.4 DIA VP800/450009
H2	BSC4	G8	OPTLEV	BS_IN/OUT	2.7 DIA, MDC450004-AR635
H2	BSC5	G2	VIDEO	RMX	5.4 DIA VP800/450009
H2	BSC5	G3	VIDEO	ETMX_TRANSMON	5.4 DIA VP800/450009

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H2	BSC5	G4	VIDEO	ETMX	5.4 DIA VP800/450009
H2	BSC5	G8	ILLUMINATION		5.4 DIA VP800/450009
H2	BSC5-S	C90G4	DIAGNOSTIC	TRANSMONX-IR	5.4 DIA VP800-AR1064
H2	BSC5-S	C90G5	DIAGNOSTIC	TRANSMONX-GREEN-HARTMANN	6.0 in-AR1064/532
H2	BSC6	G11	VIDEO	ETMY	5.4 DIA VP800/450009
H2	BSC6	G8	ILLUMINATION		5.4 DIA VP800/450009
H2	BSC6	G9	VIDEO	TRANSMONY	5.4 DIA VP800/450009
H2	BSC6-S	C90G3	DIAGNOSTIC	TRANSMONY-GREEN-HARTMANN	6.0 in-AR1064/532
H2	BSC6-S	C90G4	DIAGNOSTIC	TRANSMONY-IR	5.4 DIA VP800-AR1064
H2	BSC7	G11	OPTLEV	FMX-IN/OUT	2.7 DIA, MDC450004-AR635
H2	BSC7	G2	ILLUMINATION		5.4 DIA VP800/450009
H2	BSC7	G8	VIDEO	CPX	5.4 DIA VP800/450009
H2	BSC8	G11	VIDEO	CPY	5.4 DIA VP800/450009
H2	BSC8	G5	ILLUMINATION		5.4 DIA VP800/450009
H2	BSC8	G8	OPTLEV	FMY_IN/OUT	2.7 DIA, MDC450004-AR635
H2	HAM1	VPA1F3	DIAGNOSTIC	POP-REFL	5.4 DIA VP800-AR1064
H2	HAM1	VPA1F4	DIAGNOSTIC	ALS-GREEN-BEAM	5.4 DIA VP800-AR532
H2	HAM1	VPA1F5	DIAGNOSTIC	IR-PSL-BEAM	5.4 DIA VP800-AR1064
H2	HAM1	VPA2F4	ILLUMINATION		5.4 DIA VP800/450009
H2	HAM10	VPA1F3	ILLUMINATION		5.4 DIA VP800/450009
H2	HAM10	VPA1F4	DIAGNOSTIC	HARTMANN_ITMX	6.0 in-AR800-900
H2	HAM10	VPA1F5	DIAGNOSTIC	HARTMANN_ITMY	6.0 in-AR800-900
H2	HAM10	VPA2F1	VIDEO		5.4 DIA VP800/450009
H2	HAM10	VPA2F3	VIDEO	SR2	5.4 DIA VP800/450009
H2	HAM11	VPA1F1	ILLUMINATION		5.4 DIA VP800/450009

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H2	HAM11	VPA1F5	VIDEO	SR3	5.4 DIA VP800/450009
H2	HAM11	VPA2F1	SQUEEZE		6.0 in-AR1064/532
H2	HAM11	VPA2F2	VIDEO	OFI_IN	5.4 DIA VP800/450009
H2	HAM11	VPA2F3	VIDEO	OFI_OUT	5.4 DIA VP800/450009
H2	HAM11	VPA2F4	VIDEO	SRM	5.4 DIA VP800/450009
H2	HAM12	VPA1F1	VIDEO	OMC2	5.4 DIA VP800/450009
H2	HAM12	VPA1F2	VIDEO	OMC3	5.4 DIA VP800/450009
H2	HAM12	VPA1F3	VIDEO	OMC4	5.4 DIA VP800/450009
H2	HAM12	VPA1F4	VIDEO	OMC5	5.4 DIA VP800/450009
H2	HAM12	VPA2F1	VIDEO	OMC1	5.4 DIA VP800/450009
H2	HAM12	VPA2F3	VIDEO	OMC_REFL	5.4 DIA VP800/450009
H2	HAM12	VPA2F4	DIAGNOSTIC	OMC_REFL	5.4 DIA VP800-AR1064
H2	HAM12	VPA2F5	DIAGNOSTIC	OMC_TRANS	5.4 DIA VP800-AR1064
H2	HAM6	VPBF1	DIAGNOSTIC	AS	5.4 DIA VP800-AR1064
H2	HAM6	VPBF3	DIAGNOSTIC	OMC-REFL	5.4 DIA VP800-AR1064
H2	HAM8	VPA1F1	VIDEO		5.4 DIA VP800/450009
H2	HAM8	VPA1F2	VIDEO		5.4 DIA VP800/450009
H2	HAM8	VPA1F3	DIAGNOSTIC	SM1_TRANS	5.4 DIA VP800-AR1064
H2	HAM8	VPA1F4	VIDEO		5.4 DIA VP800/450009
H2	HAM8	VPA1F5	ILLUMINATION		5.4 DIA VP800/450009
H2	HAM8	VPA2F1	VIDEO		5.4 DIA VP800/450009
H2	HAM8	VPA2F2	VIDEO		5.4 DIA VP800/450009
H2	HAM8	VPA2F3	VIDEO		5.4 DIA VP800/450009
H2	HAM8	VPA2F4	DIAGNOSTIC	MC_REFL	5.4 DIA VP800-AR1064
H2	HAM8	VPA2F5	DIAGNOSTIC	IO_TRANSMON	5.4 DIA VP800-AR1064

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H2	HAM8	VPA2F5	DIAGNOSTIC	PRC_MM_MON	5.4 DIA VP800-AR1064
H2	HAM9	VPA1F4	ILLUMINATION		5.4 DIA VP800/450009
H2	HAM9	VPA1F5	VIDEO	MC2	5.4 DIA VP800/450009
H2	HAM9	VPA2F3	DIAGNOSTIC	MC2-TRANS	5.4 DIA VP800-AR1064
H2	HAM9	VPA2F5	VIDEO	PR2	5.4 DIA VP800/450009
H2	WAMCA3	VP2	VIDEO	PR2	5.4 DIA VP800/450009
H2	WAMCA3	VP5	OPTLEV	HAM9_IN/OUT	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCA4	VP5	OPTLEV	HAM10-IN/OUT	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCB3	VP12	OPTLEV	PR3_OUT	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCB3	VP5	OPTLEV	HAM8_IN/OUT	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCB3	VP6	OPTLEV	PR3_IN	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCB4	VP11	OPTLEV	SR3-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCB4	VP12	VIDEO	SR3	5.4 DIA VP800/450009
H2	WAMCB4	VP5	OPTLEV	HAM11-IN/OUT	7.8 DIA, ISI 4.9722012-AR635
H2	WAMCB4	VP7	OPTLEV	SR3-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A-17A	VP3	PHOTCAL	FETMX-IN	6.0 in-AR1064/532
H2	A-17A	VP5	OPTLEV	FETMX-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A-17A	VP8	PHOTCAL	FETMX-OUT	6.0 in-AR1064/532
H2	A-17A	VP9	OPTLEV	FETMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A-17B	VP2	OPTLEV	FETMY-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A-17B	VP3	PHOTCAL	FETMY-OUT	6.0 in-AR1064/532
H2	A-17B	VP6	OPTLEV	FETMY-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A-17B	VP8	PHOTCAL	FETMY-IN	6.0 in-AR1064/532
H2	A1-C	VP1	OPTLEV	FITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	A1-C	VP2A	C02-LASER	FITMX-IN	TCS

IFO	CHAMBER	VIEWPORT	FUNCTION	DESCRIPTION	VIEWPORT P/N
H2	A1-C	VP2B	VIDEO	FITMX	TCS
H2	A1-C	VP3	OPTLEV	ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A1-C	VP4	OPTLEV	FITMX-IN	7.8 DIA, ISI 4.9722012-AR635
H2	A1-C	VP6	OPTLEV	ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
H2	SEPTUM	VP4	DIAGNOSTIC	PRC & ALS PICKOFF BEAM PORT	SEPTUM VP
H2	SEPTUM-IO	VP1	DIAGNOSTIC	SPARE BEAM PORT	SEPTUM VP
H2	SEPTUM-IO	VP2	DIAGNOSTIC	PSL INPUT BEAM PORT	SEPTUM VP
H2	SEPTUM-IO	VP3	DIAGNOSTIC	REFL BEAM PORT	SEPTUM VP
H2	SEPTUM-OUT	VP1	OUT	SPARE BEAM PORT	SEPTUM VP
H2	SEPTUM-OUT	VP2	OUT	SPARE BEAM PORT	SEPTUM VP
H2	SEPTUM-OUT	VP3	OUT	ASP BEAM PORT	SEPTUM VP

Table 3: L1 Viewports

IFO	CHAMBER	VIEWPORT	DESCRIPTION		VIEWPORT P/N
L1	A1-A	VP1	OPTLEV	F-ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-A	VP3	OPTLEV	ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-A	VP4	OPTLEV	F-ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-A	VP5	VIDEO	ITMX	5.4 DIA VP800/450009
L1	A1-A	VP6	OPTLEV	ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP1	OPTLEV	ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP2	PHOTCAL1-2	ETMY-IN	6.0 in-AR1064/532
L1	A1-B	VP2	VIDEO	ITMY	5.4 DIA VP800/450009
L1	A1-B	VP3	OPTLEV	F-ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP3	OPTLEV	ETMY-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP4	OPTLEV	ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP5	PHOTCAL1-2	ETMY-OUT	6.0 in-AR1064/532
L1	A1-B	VP6	OPTLEV	F-ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP6	OPTLEV	ETMY-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-E	VP1	OPTLEV	ETMX-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-E	VP2	PHOTCAL1-2	ETMX-OUT	6.0 in-AR1064/532
L1	A1-E	VP4	OPTLEV	ETMX-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-E	VP5	PHOTCAL1-2	ETMX-IN	6.0 in-AR1064/532
L1	BSC1	G11	VIDEO	ITMY-CP	5.4 DIA VP800/450009
L1	BSC1	G2	VIDEO	ITMY	5.4 DIA VP800/450009
L1	BSC1	G3	ILLUMINATION		5.4 DIA VP800/450009
L1	BSC1-S	C180G3	CO2-LASER	ITMY-IN	TCS
L1	BSC2	G2	OPTLEV	BS-IN/OUT	2.7 DIA, MDC450004-AR635

IFO	CHAMBER	VIEWPORT	DESCRIPTION		VIEWPORT P/N
L1	BSC2	G8	VIDEO	BS	5.4 DIA VP800/450009
L1	BSC2	G9	ILLUMINATION		5.4 DIA VP800/450009
L1	BSC3	G1	VIDEO	ITMX-CP	5.4 DIA VP800/450009
L1	BSC3	G10	VIDEO	ITMX	5.4 DIA VP800/450009
L1	BSC3	G11	ILLUMINATION		5.4 DIA VP800/450009
L1	BSC3-S	C180G5	CO2-LASER	ITMX-IN	TCS
L1	BSC4	G2	ILLUMINATION	RMX	5.4 DIA VP800/450009
L1	BSC4	G3	VIDEO	TRANSMONX	5.4 DIA VP800/450009
L1	BSC4	G4	VIDEO	ETMX	5.4 DIA VP800/450009
L1	BSC4-S	C90G4	DIAGNOSTIC	TRANSMONX-IR	5.4 DIA VP800-AR1064
L1	BSC4-S	C90G5	DIAGNOSTIC	TRANSMONX GREEN-HARTMANN	6.0 in-AR1064/532
L1	BSC5	C90G4	DIAGNOSTIC	TRANSMONY-IR	5.4 DIA VP800-AR1064
L1	BSC5	G11	VIDEO	ETMY	5.4 DIA VP800/450009
L1	BSC5	G8	ILLUMINATION		5.4 DIA VP800/450009
L1	BSC5	G9	VIDEO	TRANSMONY	5.4 DIA VP800/450009
L1	BSC5-S	C90G3	DIAGNOSTIC	TRANSMONY GREEN-HARTMANN	6.0 in-AR1064/532
L1	HAM1	VPA1F3	DIAGNOSTIC	POP-REFL	5.4 DIA VP800-AR1064
L1	HAM1	VPA1F4	DIAGNOSTIC	ALS-GREEN-BEAM	5.4 DIA VP800-AR532
L1	HAM1	VPA1F5	DIAGNOSTIC	IR-PSL-BEAM	5.4 DIA VP800-AR1064
L1	HAM1	VPA2F4	ILLUMINATION		5.4 DIA VP800/450009
L1	HAM2	VPA1F1	ILLUM		5.4 DIA VP800/450009
L1	HAM2	VPA1F2	VIDEO	FI-OUT	5.4 DIA VP800/450009
L1	HAM2	VPA1F4	DIAGNOSTIC	MC-REFLBEAM	5.4 DIA VP800-AR1064
L1	HAM2	VPA1F5	VIDEO	SM1-TRANSBEAM	5.4 DIA VP800/450009
L1	HAM2	VPA2F1	VIDEO	SM1_FI-OUTPUT	5.4 DIA VP800/450009

IFO	CHAMBER	VIEWPORT	DESCRIPTION		VIEWPORT P/N
L1	HAM2	VPA2F3	DIAGNOSTIC	PRC-MM-MONBEAM	5.4 DIA VP800-AR1064
L1	HAM2	VPA2F4	DIAGNOSTIC	IO-TRANS-MONBEAM	5.4 DIA VP800-AR1064
L1	HAM3	VPA1F3	DIAGNOSTIC	MC2-TRANS	5.4 DIA VP800-AR1064
L1	HAM3	VPA1F4	ILLUM		5.4 DIA VP800/450009
L1	HAM3	VPA1F5	VIDEO	MC2	5.4 DIA VP800/450009
L1	HAM3	VPA2F5	VIDEO	PR2	5.4 DIA VP800/450009
L1	HAM4	VPA1F4	ILLUM		5.4 DIA VP800/450009
L1	HAM4	VPA2F2	VIDEO	SR2	5.4 DIA VP800/450009
L1	HAM4	VPA2F3	DIAGNOSTIC	HARTMANN_ITMX	6.0 in-AR800-900
L1	HAM4	VPA2F4	DIAGNOSTIC	HARTMANN_ITMY	6.0 in-AR800-900
L1	HAM5	VPA1F4	ILLUM		5.4 DIA VP800/450009
L1	HAM5	VPA1F5	VIDEO	SR3	5.4 DIA VP800/450009
L1	HAM5	VPA2F3	SQUEEZE		6.0 in-AR1064/532
L1	HAM5	VPA2F4	VIDEO	OFI-IN	5.4 DIA VP800/450009
L1	HAM5	VPA2F5	VIDEO	SRM	5.4 DIA VP800/450009
L1	HAM6	VPA1F1	VIDEO	OMC-2	5.4 DIA VP800/450009
L1	HAM6	VPA1F2	ILLUMINATION		5.4 DIA VP800/450009
L1	HAM6	VPA2F1	VIDEO	OMC-1	5.4 DIA VP800/450009
L1	HAM6	VPA2F3	DIAGNOSTIC	OMC-TRANS	5.4 DIA VP800-AR1064
L1	SEPTUM	VP4	DIAGNOSTIC	CAMERA PORT	SEPTUM VP
L1	SEPTUM-IO	VP1	DIAGNOSTIC	PRC & ALS PICKOFF BEAM PORT	SEPTUM VP
L1	SEPTUM-IO	VP2	DIAGNOSTIC	REFL BEAM PORT	SEPTUM VP
L1	SEPTUM-IO	VP3	DIAGNOSTIC	PSL INPUT BEAM PORT	SEPTUM VP
L1	SEPTUM-OUT	VP1	OUT	SPARE BEAM PORT	SEPTUM VP
L1	SEPTUM-OUT	VP2	OUT	SPARE BEAM PORT	SEPTUM VP

IFO	CHAMBER	VIEWPORT	DESCRIPTION		VIEWPORT P/N
L1	SEPTUM-OUT	VP3	OUT	ASP BEAM PORT	SEPTUM VP
L1	A1-A	VP1	OPTLEV	F-ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-A	VP3	OPTLEV	ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-A	VP4	OPTLEV	F-ITMX-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-A	VP5	VIDEO	ITMX	5.4 DIA VP800/450009
L1	A1-A	VP6	OPTLEV	ITMX-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP1	OPTLEV	ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP2	PHOTCAL1-2	ETMY-IN	6.0 in-AR1064/532
L1	A1-B	VP2	VIDEO	ITMY	5.4 DIA VP800/450009
L1	A1-B	VP3	OPTLEV	F-ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP3	OPTLEV	ETMY-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP4	OPTLEV	ITMY-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP5	PHOTCAL1-2	ETMY-OUT	6.0 in-AR1064/532
L1	A1-B	VP6	OPTLEV	F-ITMY-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-B	VP6	OPTLEV	ETMY-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-E	VP1	OPTLEV	ETMX-OUT	7.8 DIA, ISI 4.9722012-AR635
L1	A1-E	VP2	PHOTCAL1-2	ETMX-OUT	6.0 in-AR1064/532
L1	A1-E	VP4	OPTLEV	ETMX-IN	7.8 DIA, ISI 4.9722012-AR635
L1	A1-E	VP5	PHOTCAL1-2	ETMX-IN	6.0 in-AR1064/532
L1	BSC1	G11	VIDEO	ITMY-CP	5.4 DIA VP800/450009
L1	BSC1	G2	VIDEO	ITMY	5.4 DIA VP800/450009
L1	BSC1	G3	ILLUMINATION		5.4 DIA VP800/450009
L1	BSC1-S	C180G3	CO2-LASER	ITMY-IN	TCS
L1	BSC2	G2	OPTLEV	BS-IN/OUT	2.7 DIA, MDC450004-AR635

7.1 Viewport System Characteristics

7.1.1 Viewport Performance Characteristics

The viewports will have antireflection coatings to provide high transmissivity at the appropriate wavelengths. The optical quality of the viewports will not significantly degrade the resolution of the video cameras and of the TCS heating pattern. The Septum plate viewports will have low scattering and reflection losses @ 1064 nm wavelength.

7.1.2 Viewport Physical Characteristics

7.1.2.1 Video Camera Viewport

The video camera viewport will be the same as was used for Initial LIGO (see D970211-B Video Imaging Assembly ASC Alignment), MDC VP-800, 5.4 in clear viewing diameter, zero-length 10.0 in diameter flange, Kovar-sealed viewport, made of Corning 7056 glass.

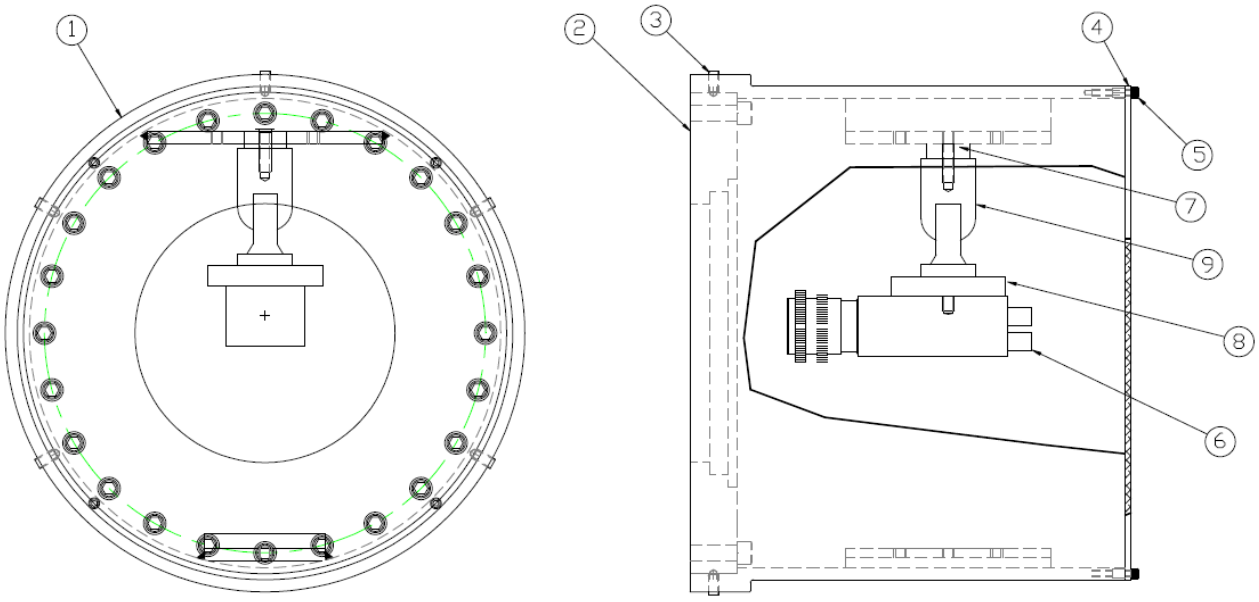

Figure 69: Video Imaging Assembly ASC Alignment

The experience of Initial LIGO showed that these video camera viewports maintained the resolution of the video cameras > 250 TV lines vertical and horizontal. This resolution was adequate for measuring the beam centroid with respect to the rim of the COC mirrors to a precision < 1 mm.

The viewport will be AR coated for minimum reflection @ 1064 nm (specified R<0.25% per surface at normal incidence).

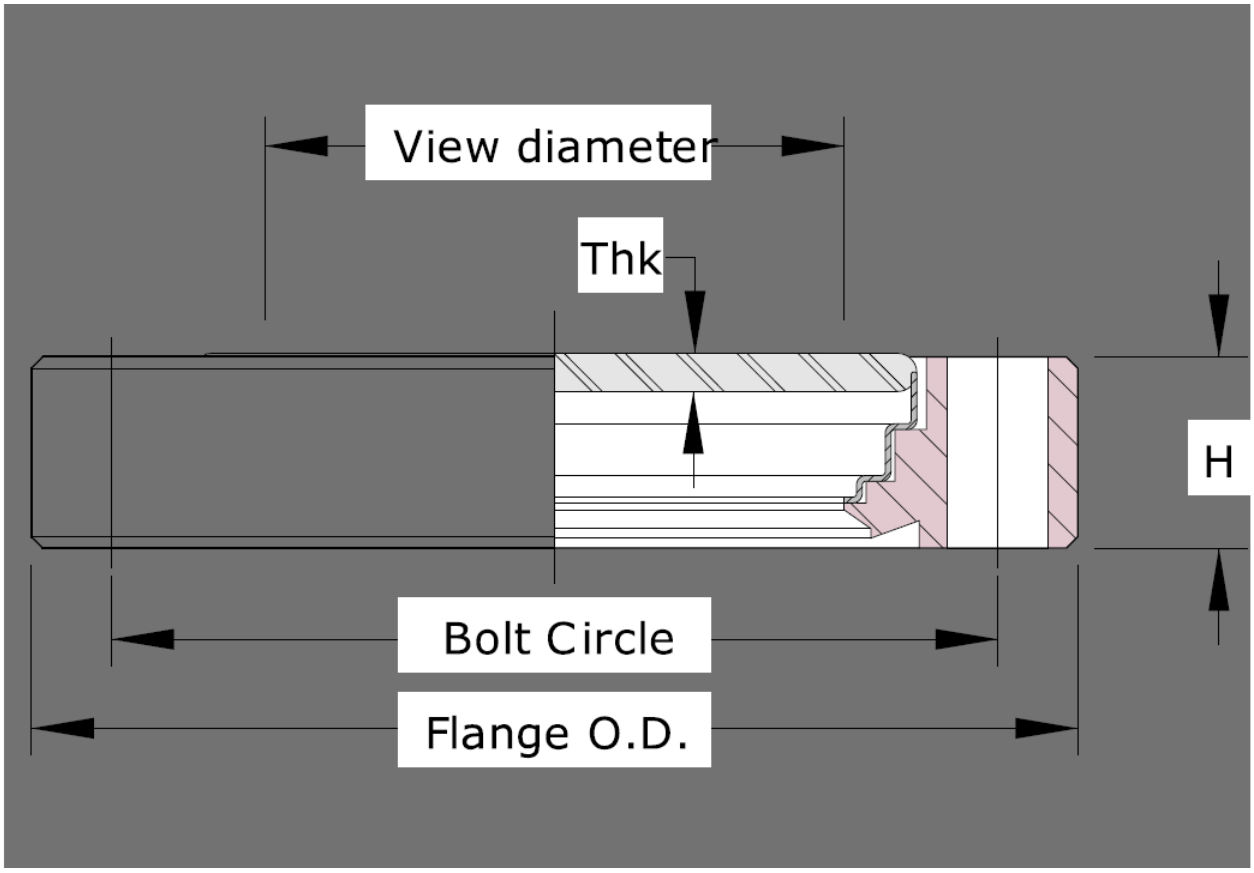

Figure 70: MDC series VPxxx Kovar-sealed viewport

7.1.2.2 Illuminator Viewport

The chamber illuminator assemblies from Initial LIGO will be re-used for aLIGO. (See D970212-B Illuminator Assembly ASC Alignment).

The illuminator viewport will be the same as the camera viewport, without any AR coating.

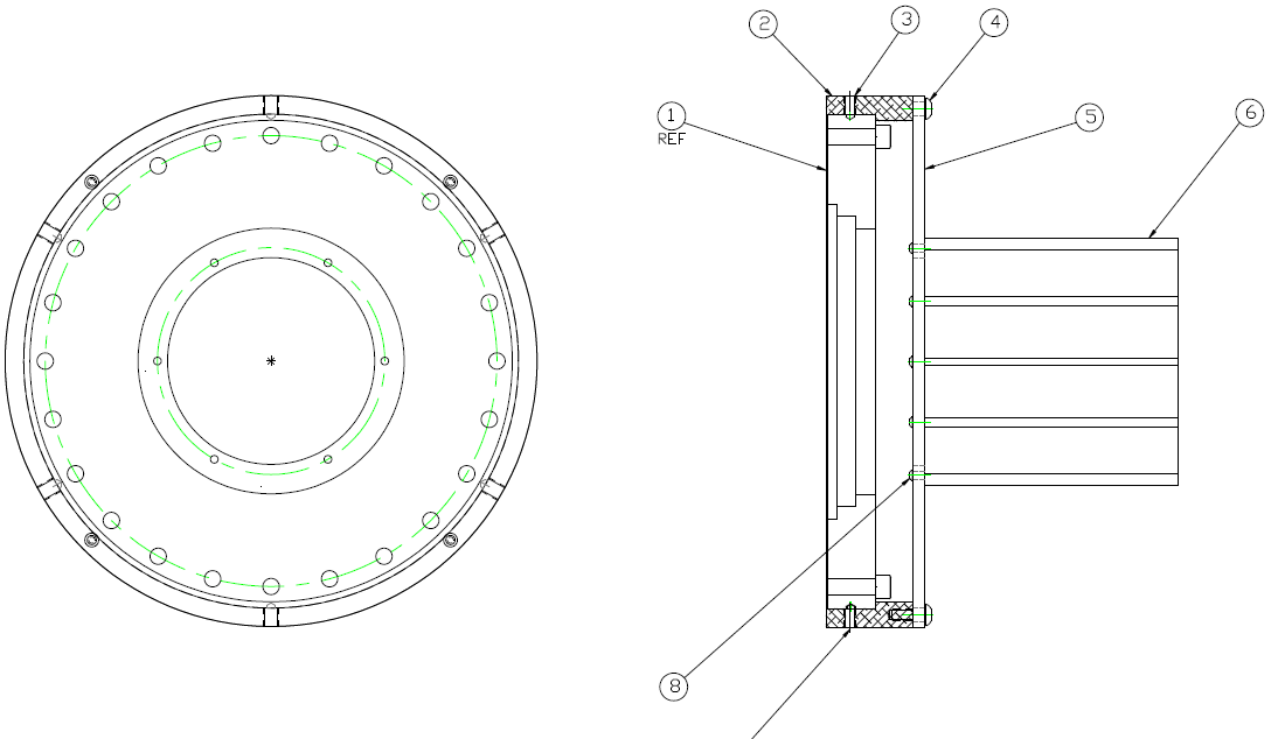

Figure 71: Illuminator Assembly

7.1.2.3 Optical Lever Viewport

The 2.7 in and 5.4 in viewing diameter viewports will be of the MDC series VPxxx Kovar-sealed, viewport designed for vacuum sealing, made of Corning 7056 glass.

The 7.8 diameter viewports will be fused silica viewports made by Insulator Seal, P/N ISI 4.9722012 designed for vacuum sealing, shown in Figure 72.

The 6.0 in viewing diameter viewports will be fused silica viewports, sealed with o-rings into conflat flange adapters similar to the septum viewports, as shown in Figure 73

The surface finish will be the same as specified in E070069 for enhanced LIGO.

All Optical Lever viewports will have an AR coating @ TBD nm wavelength, normal incidence with a specified total reflectivity < 0.5%.

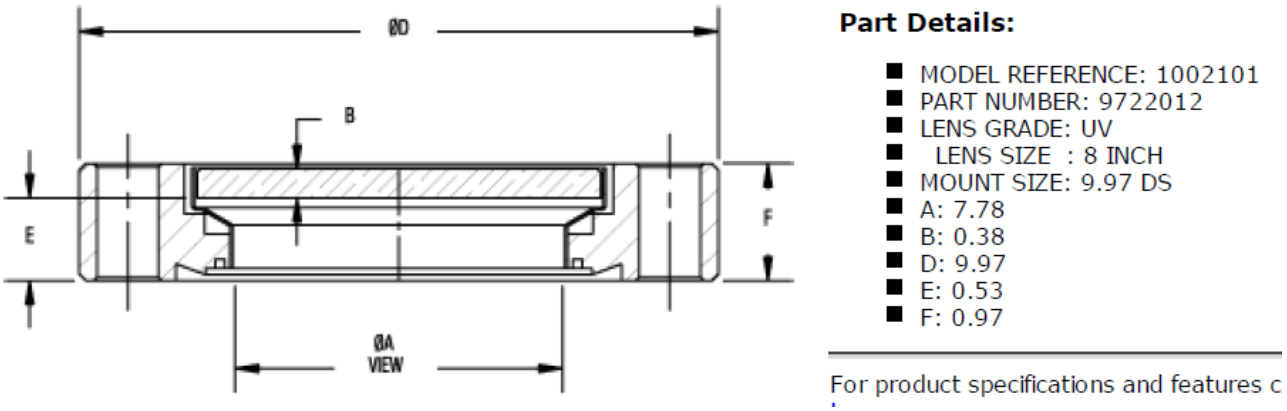

Figure 72: 7.8 Diameter Viewport

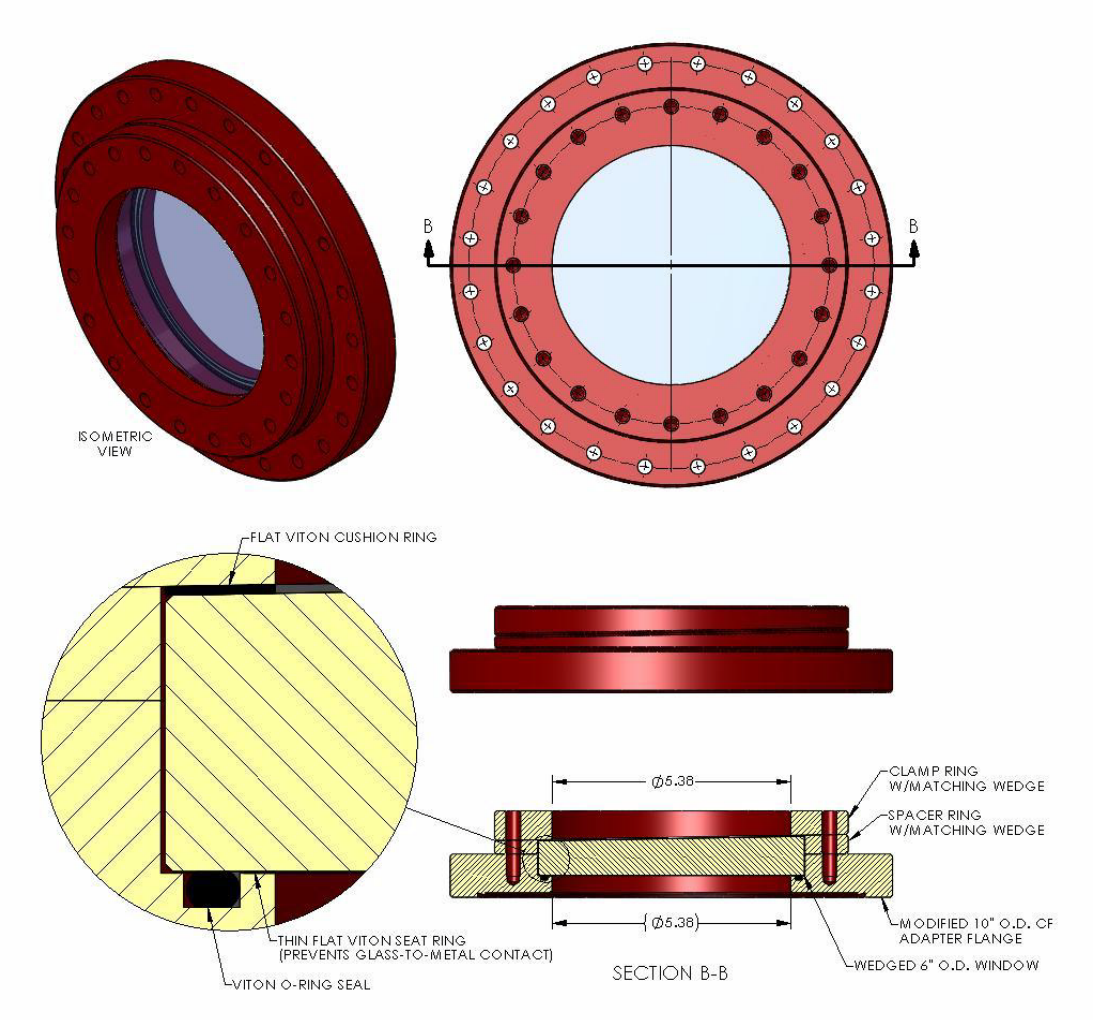

Figure 73: 6.0 in Optical Lever Viewport

7.1.2.4 Septum Viewport

The septum viewports will have a viewing diameter of 6.0 in, and will be made from fused silica, sealed with o-rings into conflat flange adapters as shown in Figure 74.

The polishing for the Septum viewport substrate, shown in Figure 75, is specified in LIGO E070069.

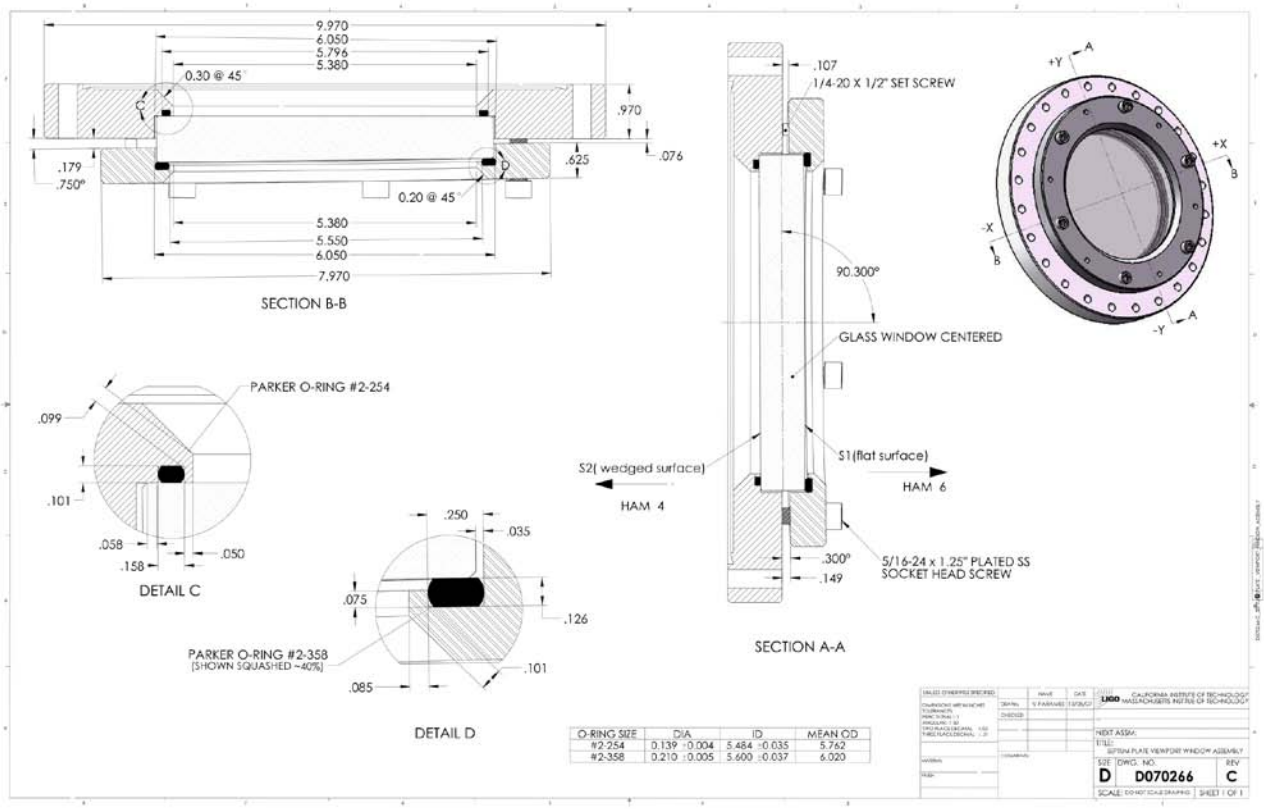

Figure 74: Septum Window Flange Assembly

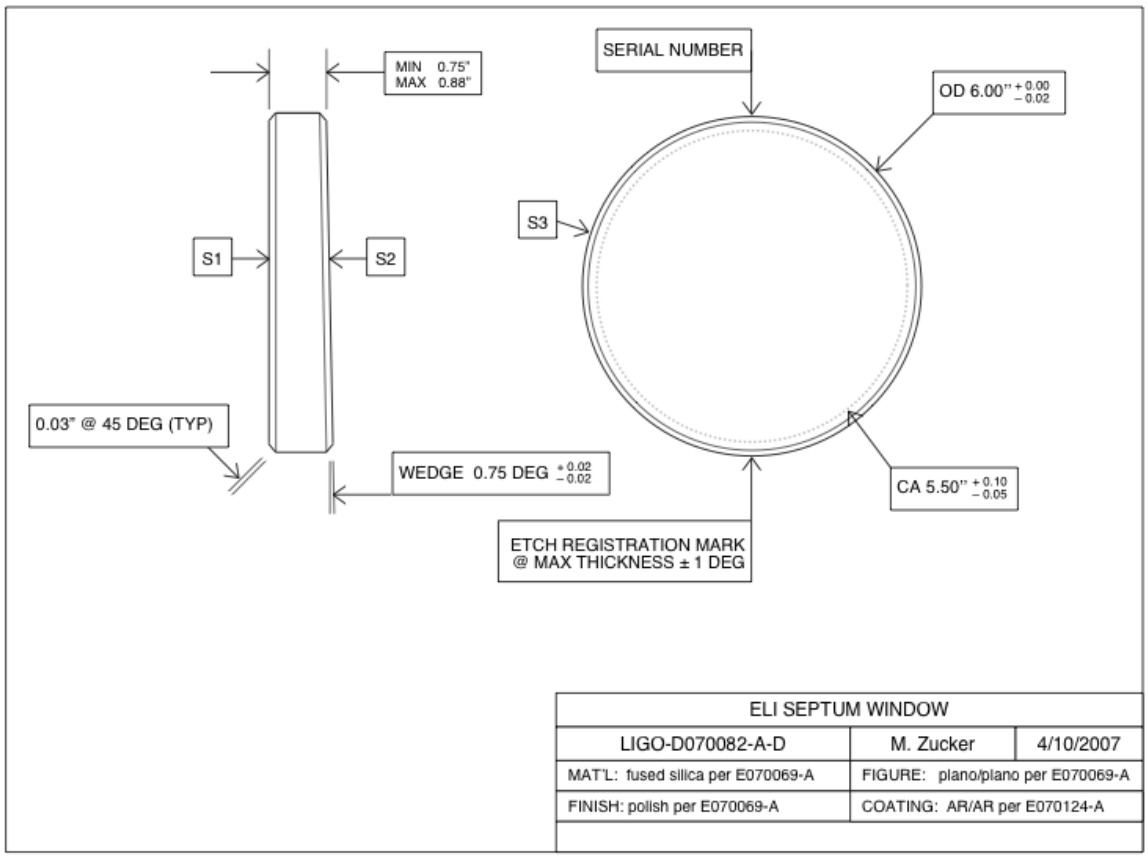

Figure 75: Septum Window

7.1.2.5 TCS Viewport

This is not part of this scope.

7.1.2.6 Hartmann Viewport

This is not part of this scope.

7.1.2.7 Transmon Viewport

The Transmon IR viewport will be the 5.4 in viewing diameter MDC series VP800 Kovar-sealed, viewport designed for vacuum sealing, made of Corning 7056 glass with an AR coating for 1064 nm

The Transmon Green Hartmann viewport will be a special 6.0 in viewport with AR coating for two wavelengths, 1064 nm and 532 nm per the specification 6.0 inch Vacuum Viewport Specification.

7.1.3 Viewport Interface Definitions

7.1.3.1 Interfaces to other LIGO detector subsystems

The viewports are mounted to vacuum flanges that mount to the existing nozzles on the HAM and BSC chambers, and to the viewport adapters that are attached to the various manifolds and vacuum tubes between vacuum chambers.

7.1.3.1.1 Septum Plate Installation

The septum window assembly and installation procedure is described in E070253.

7.1.3.1.2 Stay Clear Zones

Viewport safety covers - the optical path of the light beams passing from the optical lever transmitters and receivers, and to the video cameras will be enclosed by a suitable means to define the stay clear zone.

7.1.4 Viewport Reliability

7.1.4.1 Mean Time before Failure

Viewports are durable optical components that have an essentially unlimited lifetime.

7.1.4.2 Viewports Maintainability

The viewports will be handled and maintained using the E960022-B LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures cleaning procedures and protocols. The viewports will be replaced if they fail.

7.1.4.3 Viewports Environmental Conditions

7.1.4.3.1 Natural Environment

7.1.4.3.1.1 Temperature and Humidity

The viewports are designed to function with vacuum conditions on the inside surface, and with the humidity and temperature controlled environment of the enclosed LIGO LVEA on the outer surface.

Table 4 Environmental Performance Characteristics

Operating	Non-operating (storage)	Transport
+20C to +25C, 20-70% RH, non- condensing	0C to +60C, 10-90% RH, non-condensing	0C to +60C, 10-90% RH, non- condensing

7.1.4.3.1.2 Atmospheric Pressure

The viewports are designed to function with a differential pressure between faces of one atmospheric pressure.

7.1.5 Viewport Transportability

All items will be transportable by commercial carrier without degradation in performance. As necessary, provisions will be made for measuring and controlling environmental conditions (temperature and accelerations) during transport and handling. Special shipping containers, shipping and handling mechanical restraints, and shock isolation will be utilized to prevent damage. All containers shall be movable by forklift.

7.2 Viewport Design and Construction

7.2.1 Materials and Processes

The in-vacuum materials and processes used in the fabrication of the viewports will be compatible with the LIGO approved materials list.

7.2.1.1 Materials

A list of currently approved materials for use inside the LIGO vacuum envelope can be found in E960022-B LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures. All materials used inside the vacuum chamber will comply with LIGO-E960022-00-D.

7.2.1.2 Processes

7.2.1.2.1.1 Cleaning

All materials used inside the vacuum chambers will be cleaned in accordance with Specification Guidance for Seismic Component Cleaning, Baking, and Shipping Preparation (LIGO-L970061-00-D).

7.2.1.3 Component Naming

All components will be identified using the LIGO naming convention. This will include identification (part or drawing number, revision number, serial number) physically stamped on all components, in all drawings and in all related documentation. The flange edges of the glass-to-metal sealed viewports will be marked to indicate the AR coating.

7.2.2 Workmanship

All components will be manufactured according to good commercial practice.

7.2.3 Interchangeability

Viewports with like dimensions and like coatings will be interchangeable.

7.2.4 Safety

This item will meet all applicable NSF and other Federal safety regulations, plus those applicable State, Local and LIGO safety requirements.

7.2.5 Human Engineering

Viewport Safety Covers, similar to the one shown in Figure 22, will cover the viewport whenever any physical activity occurs that might damage the viewport and cause a hazardous situation to nearby personnel.

7.2.6 Assembly and Maintenance

TBD

7.3 Documentation

7.3.1 Specifications

Manufacturer's specifications for standard MDC VP-xxx series viewports, and Insulator Seal 9722012 series viewports, as well as special specifications published by LIGO for custom viewports, will apply.

7.3.2 Design Documents

Same as 7.3.1

7.3.3 Engineering Drawings and Associated Lists

Same as 7.3.1

7.3.4 Technical Manuals and Procedures

Not applicable.

7.3.5 Documentation Numbering

All documents will be numbered and identified in accordance with the LIGO documentation control numbering system LIGO document TBD

7.3.6 Test Plans and Procedures

A test plan and procedure will be developed for testing those viewports that use an o-ring for vacuum sealing to assure that the vacuum leak rate is acceptable.

7.4 Logistics

7.4.1 Spare Parts

The spare viewports are included in the Viewport Production Plan.

7.4.2 Special Test Equipment

TBD

7.5 Precedence

7.6 Qualification

8 Quality Assurance Provisions

This section includes all the examinations and tests to be performed for ascertaining that the viewports conform to the requirements in section 3.

8.1 General

8.1.1 Responsibility for Tests

AOS will conduct tests to verify the as-delivered performance specifications of the viewports.

8.1.2 Special Tests

8.1.2.1 Engineering Tests

TBD

8.1.2.2 Reliability Testing

8.1.2.2.1 Viewports

The reliability of the viewports that will be used in aLIGO was evaluated during Initial LIGO. Therefore, no further reliability testing will be conducted.

8.1.3 Configuration Management

Configuration control of specifications and designs will be in accordance with the LIGO Detector Implementation Plan.

8.2 Quality conformance inspections

Design and performance requirements identified in this specification and referenced specifications shall be verified by inspection, analysis, demonstration, similarity, test or a combination thereof per the Verification Matrix, Appendix 1 (See example in Appendix). Verification method selection shall be specified by individual specifications, and documented by appropriate test and evaluation plans and procedures. Verification of compliance to the requirements of this and subsequent specifications may be accomplished by the following methods or combination of methods:

8.2.1 Inspections

Manufactured parts with LIGO identification numbers or marks will be inspected to determine conformity with the procurement specification.

A witness sample will be acceptable proof of the properties of anti-reflection coatings applied to viewports

8.2.2 Demonstration

A demonstration of the visual quality of the video camera image of the optics in the chamber will be acceptable as verification of the resolution characteristics of the video camera and the acceptable intensity level of the illumination lamp.

8.2.3 Test

TBD

9 Safety

9.1 Hazard Analysis

A hazard analysis for the TCS viewports is presented in **E1100246-v1**

9.2 Working Covers

Protective covers for all viewports will be provided to protect personnel from possible implosion hazards of the viewport.

10 Preparation for Delivery

Packaging and marking of equipment for delivery will be in accordance with the Packaging and Marking procedures specified herein.

10.1 Preparation

- Vacuum preparation procedures as outlined in E960022-B LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures will be followed for all components intended for use in vacuum. After wrapping vacuum parts as specified in this document, an additional, protective outer wrapping and provisions for lifting shall be provided.
- Electronic components will be wrapped according to standard procedures for such parts.

10.2 Packaging

Procedures for packaging will ensure cleaning, drying, and preservation methods adequate to prevent deterioration, appropriate protective wrapping, adequate package cushioning, and proper containers. Proper protection will be provided for shipping loads and environmental stress during transportation, hauling and storage. The shipping crates used for large items will use for guidance military specification MIL-C-104B, Crates, Wood; Lumber and Plywood Sheathed, Nailed and Bolted. Passive shock witness gauges will accompany the crates during all transits.

For the viewports, the shipping preparation will include double bagging with Ameristat 1.5TM plastic film (heat sealed seams as practical, with the exception of the inner bag, or tied off, or taped with care taken to insure that the tape does not touch the cleaned part). The bag will be purged with dry nitrogen before sealing.

10.3 Marking

Appropriate identification of the product, both on packages and shipping containers; all markings necessary for delivery and for storage, if applicable; all markings required by regulations, statutes, and common carriers; and all markings necessary for safety and safe delivery will be provided.

Identification of the material will be maintained through all manufacturing processes. Each component will be uniquely identified. The identification will enable the complete history of each component to be maintained (in association with Documentation “travelers”). A record for the optical lever support structures will indicate all weld repairs and fabrication abnormalities.

The specification for marking the viewports will state that marking fluids, die stamps and/or electro-etching is not permitted. A vibratory tool with a minimum tip radius of 0.005" is acceptable for marking on surfaces that are not hidden from view. Engraving and stamping are also permitted.

11 Notes

Appendix A Quality Conformance Inspections

Appendix A contains a table that lists the requirements and the method of testing requirements. TBD

Table 5 Quality Conformance Inspections

Paragraph	Title	I	A	D	S	T
	Performance Characteristics					
	Controls Performance					
	Timing Performance‘					