OAK RIDGE National Laboratory

August 10, 2026, Target Assembly FDR

Core Vessel, Target, and MRA clearances

Aaron Jacques

Second Target Station

U.S. DEPARTMENT of ENERGY

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Charge Question 2: Has the design been shown to meet the requirements?

Charge Question 3: Do DACs and other supporting documentation adequately support the final design?

Question 5: Is the design sufficiently mature to proceed with finalizing the procurement package?

This presentation covers the following documents:

S03000000-CAC10000 – CALC Target Error Budget

And informs:

S03020000-SR0001 – Target Assembly Requirements

S03040000-SR0001 MRA System Requirements

S03060000-SR0001 - Core Vessel Requirements

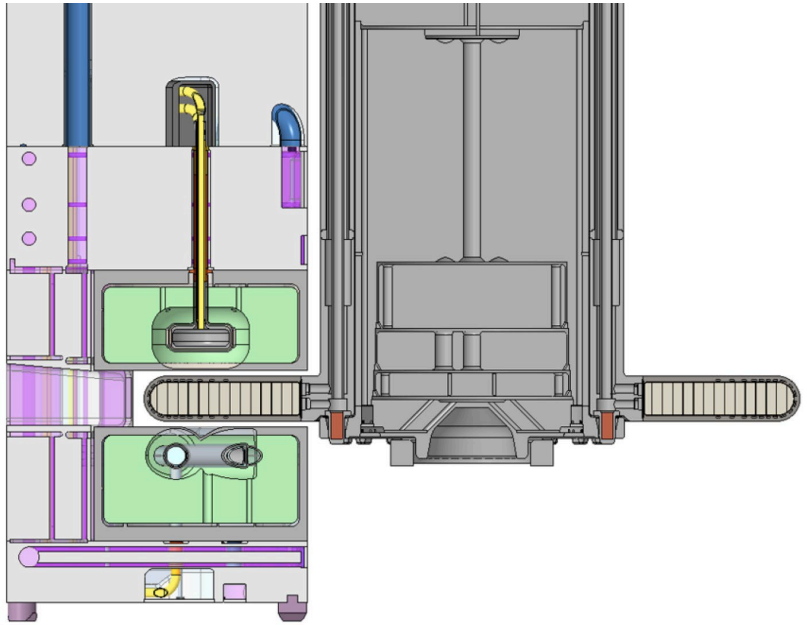
Key Parameters

Target Assembly

- Foot is biased 2mm “up”
- Target Installation tolerance: +/- 1mm (V&H)
- Seismic Acceleration=0.7g
- Snubber Installation tolerance:+/- 1mm (V&H)
- Snubber-shaft gap: 6mm (H) & 8mm (V)
- Segment Thermal expansion:1.75mm (down)
- Segment centripetal deflection: 4.5mm (radial)

MRA

- MRA Installation tolerance: +/- 0.5mm (V&H)
- Pressure deflection: 1mm (ea)
- Thermal: ~1mm



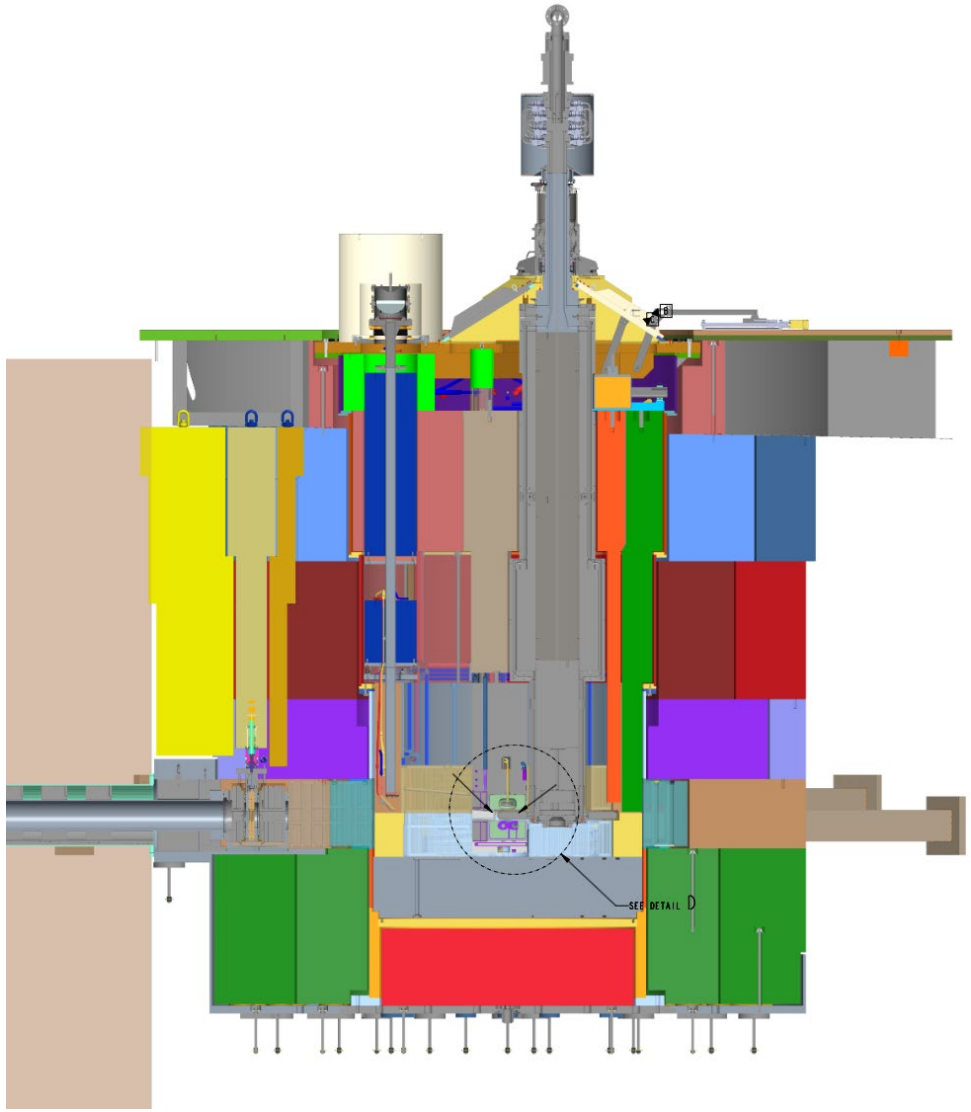
Core Vessel

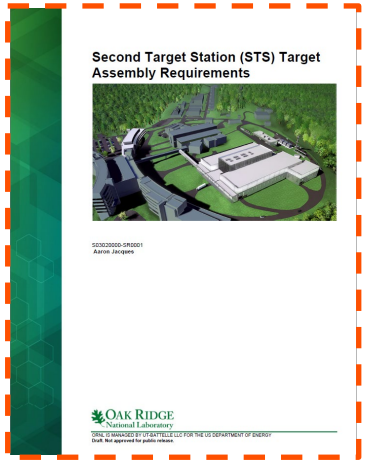
- Shield block install tolerance:+/- 2mm (V&H)
- Seismic motion: +/- 1mm
- Thermal expansion: 0.6mm
- Vacuum deflection: -1.5/+1.75(V/H)

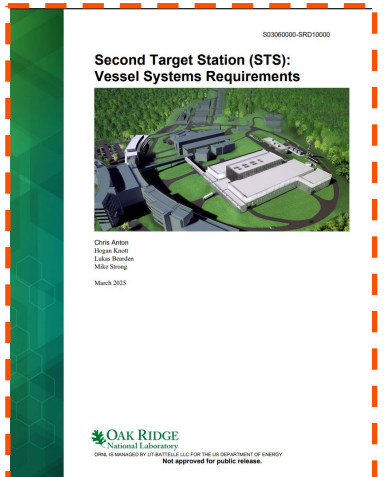
The clearance budget elaborates high level system requirements and functions into tractable L3 requirements

Some high-level requirements come from the Hazard Analysis (HA)

Some high-level requirements are risk reduction during normal operation “the target should not hit the shielding” but not captured formally







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Interaction related hazards are decomposed into component requirements primarily through the “Target Error Budget”

credited DF24

Building structures seismically qualified to prevent collapse, protect evacuation paths, and protect applicable confinement of hazardous material.

credited DF10

Target segment attachment points designed to withstand a design basis seismic event with a design margin of TBD.

SECOND TARGET STATION (STS) PROJECT
STS Bounding Accident Dose Estimates

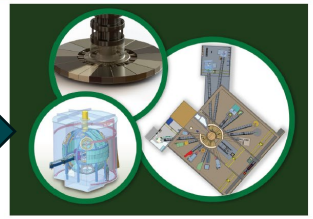
Thomas J. McManamy
Steven M. Trotter

Loss of cooling

Seismic - Detonation

SECOND TARGET STATION (STS) PROJECT

Preliminary Hazard Analysis Report



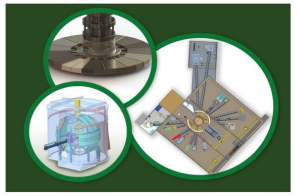
Thomas J. McManamy
Joe R. DeVore
R. Mike Harrington
James Eckroth
Max L. Gildner
Steven M. Trotter

Date April 30, 2019

Seismic

S03010000-SR0001 R02

Second Target Station: Target Systems Requirements



Peter Rosenblad
Mike Strong
Aaron Jacques
Lukas Bearden
Ethan Rummel

Approved for public release. Distribution is unlimited.

May 16, 2024

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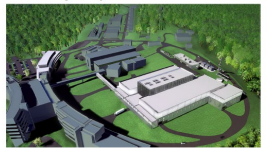
Error Budget

Linkage		From	To	LMC(-)	MMC(+)
A	Core Vessel Lower	1	99	-1	1
B	Core Vessel Upper	99	2	-1	1
C	Target Shaft Upper (Drive mounting to segment	3	4	-0.125	0.125
D	Target Shaft Lower	4	5	-0.75	0.75
E	Target Segment	5	7	-0.5	0.5
F	Foot	5	6	-0.1	0.1
G	Shield Block #1	8	9	-0.5	0.5
H	Shield Block #2	10	11	-0.5	0.5
I	Upper MRA	15	17	-0.5	0.5
J	Lower MRA	15	16	-0.5	0.5
K	Shield Block #3	13	14	-0.5	0.5
L	Shubber Gap	5	12	0	0
TA_{tgt}	Shaft Installation Accuracy	0	5	-1	1
TA_{MRA}	MRA Instalation Accuracy	8	0	-0.5	0.5
TA_{snub}	Snubber Installation Accuracy	12	0	-1	1
S_{GCS}	Worst case shim on Beam Guides (True positio	99	0	-1	1
TA_{SB1}	Shield Block 1 Installation Accuracy	11	0	-2	2
TA_{SB2}	Shield Block 2 Installation Accuracy	11	0	-2	2
TA_{SB3}	Shield Block 3 Installation Accuracy	11	0	-2	2

Second Target Station (STS) Target Assembly Requirements



S03020000-SR0001
Aaron Jacques

S03040000-SR0001 R01

SECOND TARGET STATION (STS) PROJECT

System Requirements Document for Target Systems Moderator Reflector Assembly (MRA)

Jim Janney
Mike Strong

March 18, 2024

S03060000-SRD10000

Second Target Station (STS): Vessel Systems Requirements

Chris Anton
Hegan Knott
Lukas Bearden
Mike Strong

March 2025

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Credited statements from the HAR are interpreted and agreed upon with ESH&Q as component & system requirements

Stress

Deflection

Table 3. HAR Requirement Matrix

Requirement [ac] / HAR Statement[b]	3006 Design Loads and Acceptance Criteria	1478[d] Hydrogen Boundary Interactions	1627 Isolation Jumper Position	1965 Segment Rotation Sensor	2078 Water Tube Spacing	1566 Hot Contact	1564 Max Temp without cooling & beam off	3727 Positive Engagement
TPS beam trip if target rotation stops or slows beyond limits. 9886				X				
TPS beam trip if target rotation increases beyond limits. 9887				X				
Target cooling system quick disconnects to all target segment cooling lines include an integral valve on each side of the connector that closes when it is disengaged, and a device that provides a visual indication that shows when the connector is properly engaged. 9969			X					
Target design interface with the target support system requires the target segment to be fully inserted and in the right position for the operator to insert the locking screw to attach the target. 9968								X
Building structures seismically qualified to prevent collapse, protect evacuation paths, and protect applicable confinement of hazardous material. 9947	X	X						
Target segment attachment points designed to withstand a design basis seismic event with a design margin of TBD. 9933	X							
Monolith concrete shielding and building steel structures seismically qualified to prevent gross displacement. Enough iron shielding is in place to provide a heat sink and keep the target below 800 C in all configurations. 9948						X	X	
Inlet screen in Loop 1 header to target segment. 9967					X			

[a] Statements taken directly from the HAR, reference (*S01030000-ESH10002, Second Target Station Hazards Analysis Report*) [67].

[b] For a detailed understanding and elaboration of the requirements, please see section 8 (Hyperlinks will take you directly to requirement statements within section 8)

[c] This table has been refined with several interactions between the design and ESH&Q team and represents the complete set of credited controls for the Target Assembly as required by (*S01030100-ES0001, Policy for Selection of Safety Related Credited Controls*) [59]

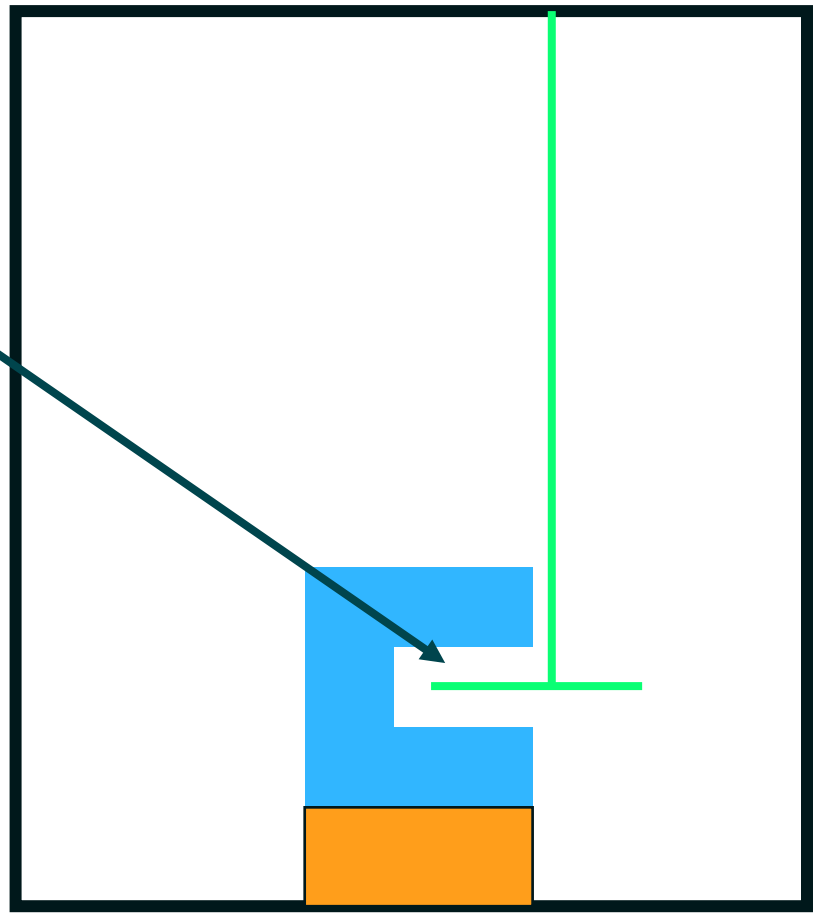
[d] This Target System requirement is decomposed into the following Target Assembly requirements: 3006, 10646, 10674, 10693, 10698, 10699, 10701, 10702, 10713, 10731, 10732, 10733, 10734, 10735, 10793.

Target Systems Requirement #1478 – Hydrogen boundary interactions – derived from the HAR

Components shall not damage (inadvertent contact) the hydrogen boundaries, regardless of load combination.
Note: This requirement specifically includes seismic loads

Who owns/controls this gap & requirement?

- Target
- Moderator
- Core Vessel
- Shielding



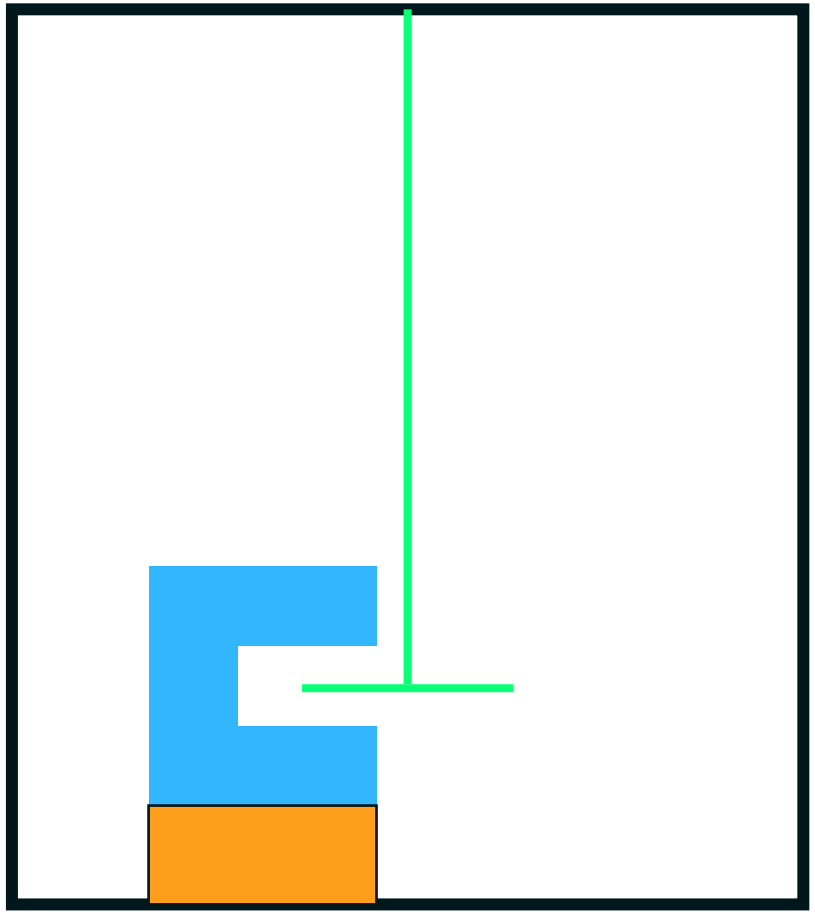
What component errors can produce a collision?

- Target
- Moderator
- Core Vessel
- Shielding

Coordinating loads, tolerances and stiffness across work packages and leads make this (already complicated) work more challenging

S.03.02 – Target Assembly

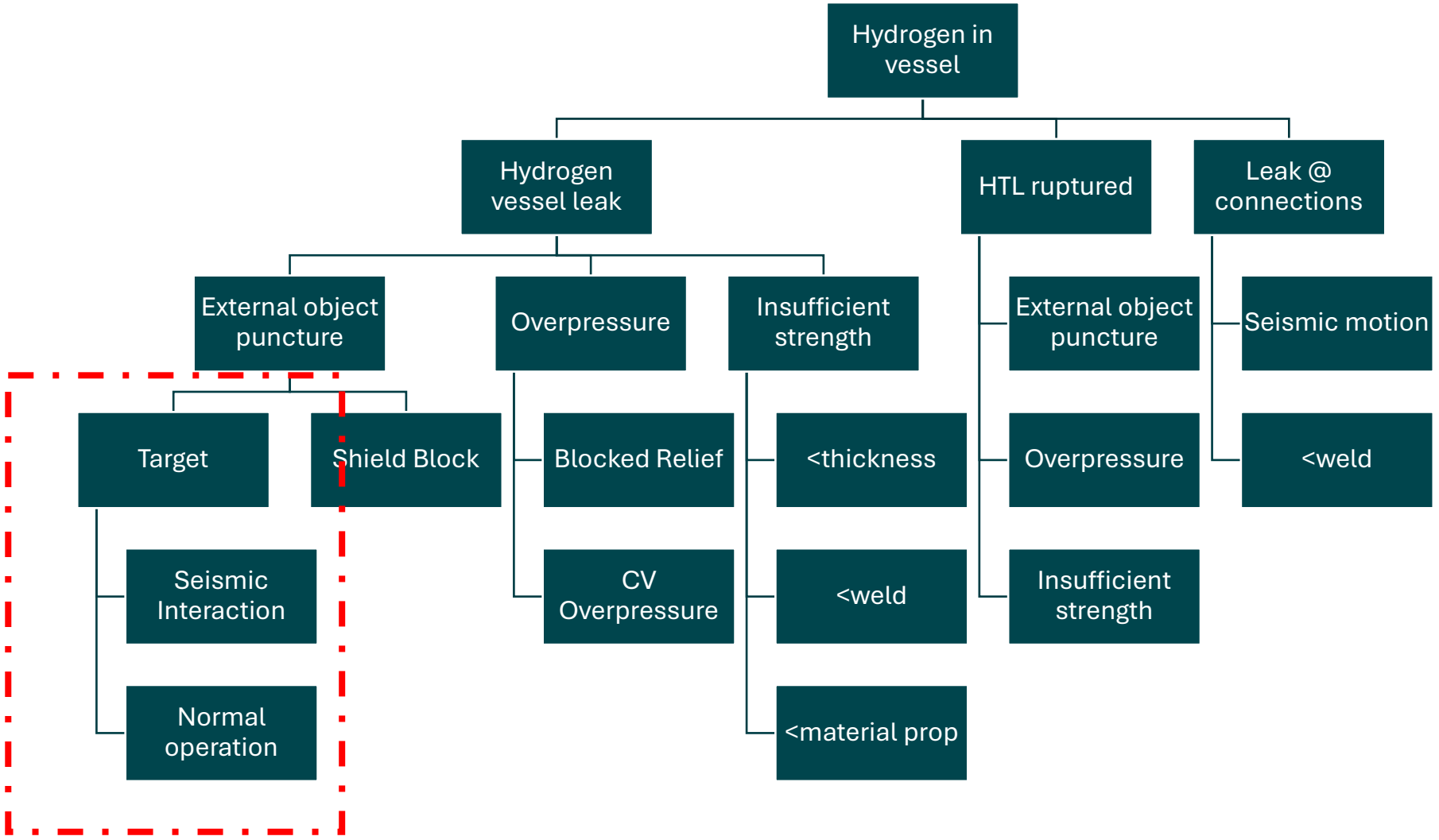
S.03.03 – Moderator & Reflector



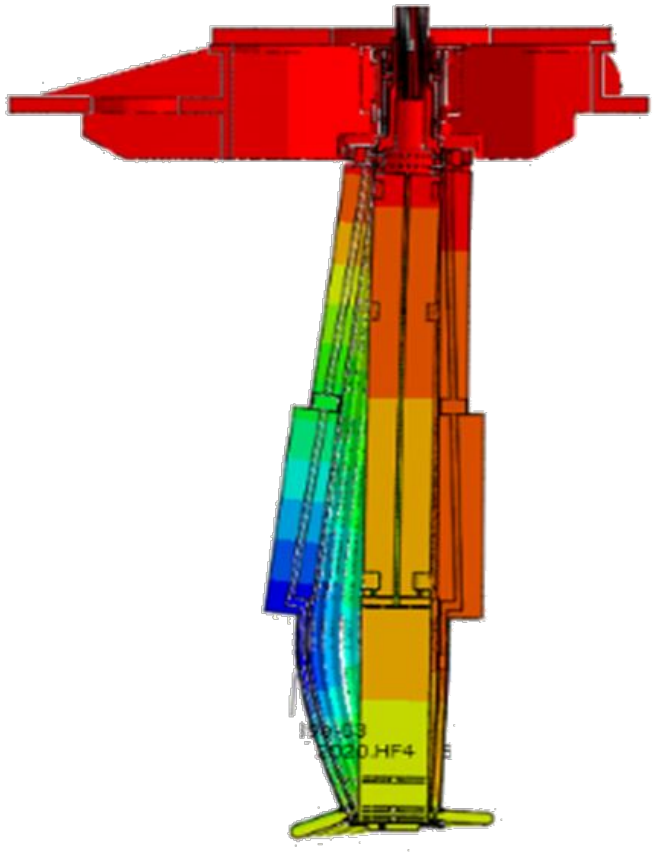
S.03.06 – Vessel Systems

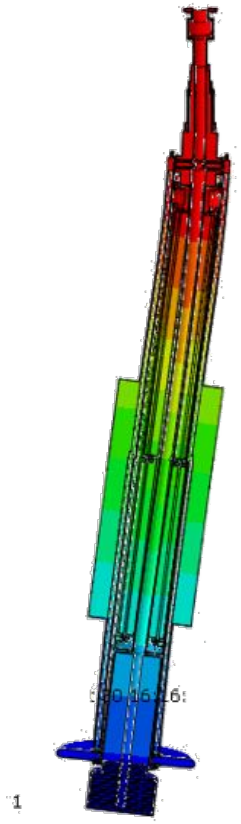
S.03.06 – Vessel Shielding

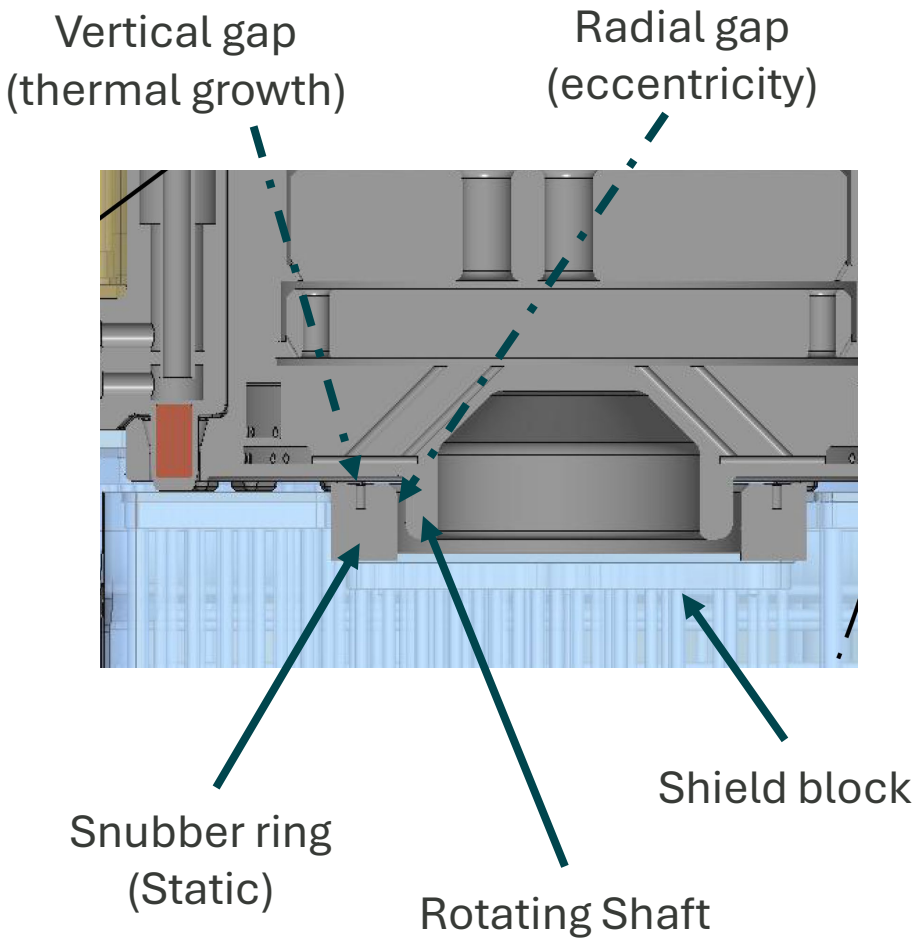
Clearance objective 1: Prevent free hydrogen in the core vessel due to target-MRA collision



The target is a large pendulum suspended from a flexible lid; a snubber was added early in the project to limit seismic motion



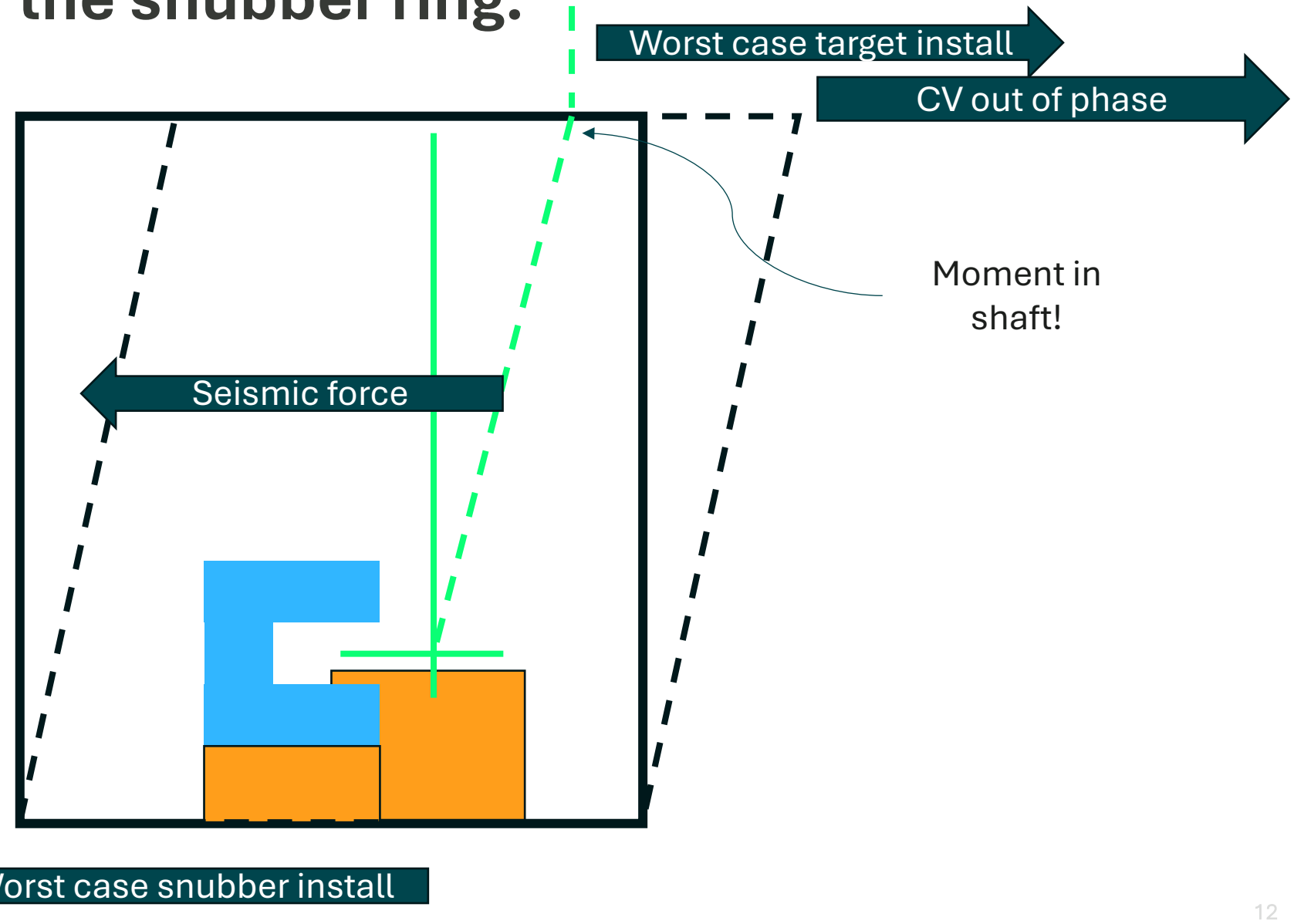




The seismic interaction problem was fixed – now we have a more complex operational clearance problem to solve with tighter clearances!

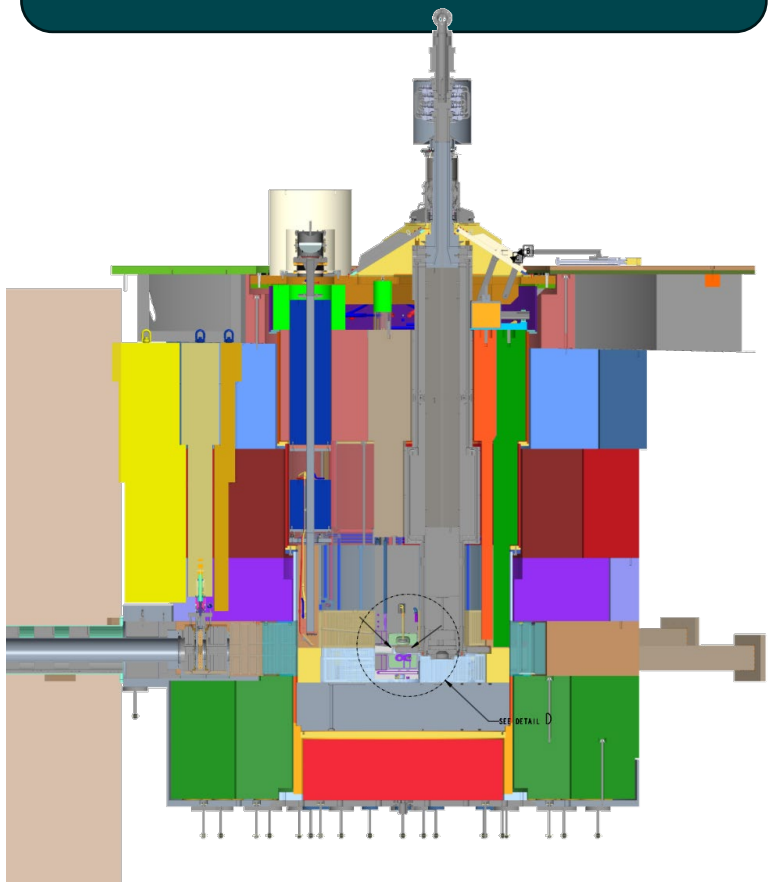
The target must survive the relative motion between the top of the core vessel and the snubber ring.

Seismic motion may be out of phase



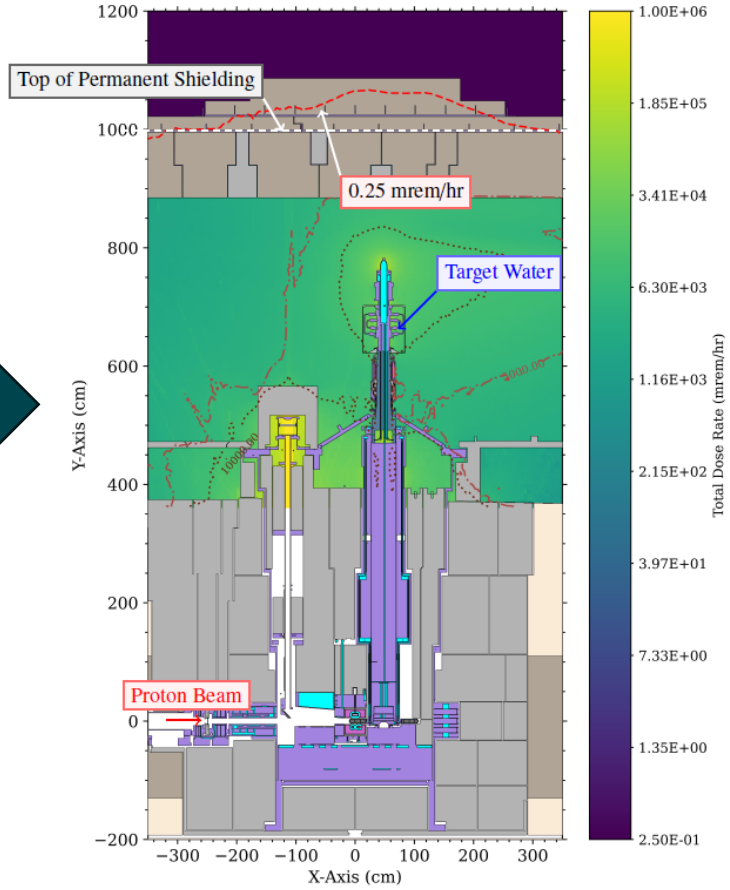
Target Clearance objective #2: Prevent target from contact with any object during normal operation (more stringent)

The rotating target should not contact anything stationary!



Competing goals

Gaps should be small to prevent streaming



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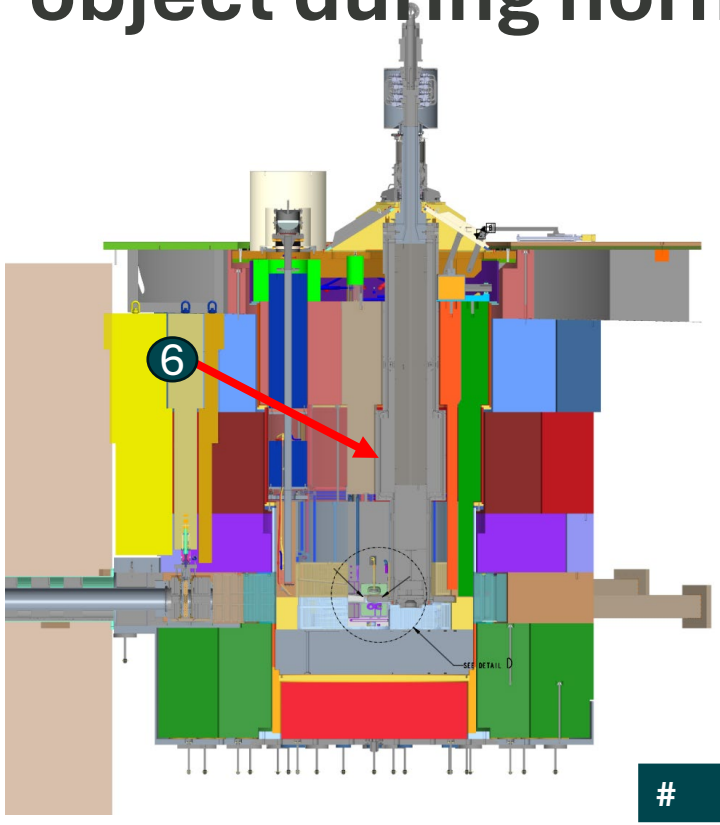
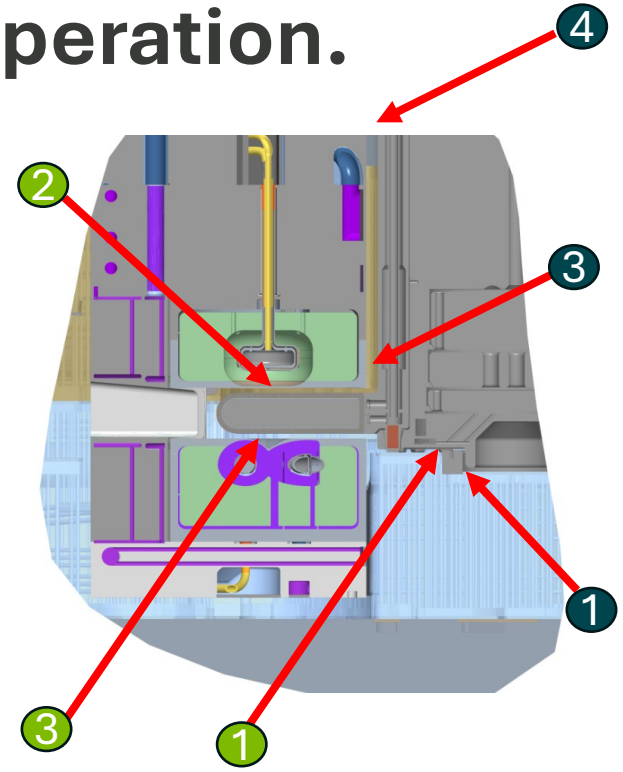
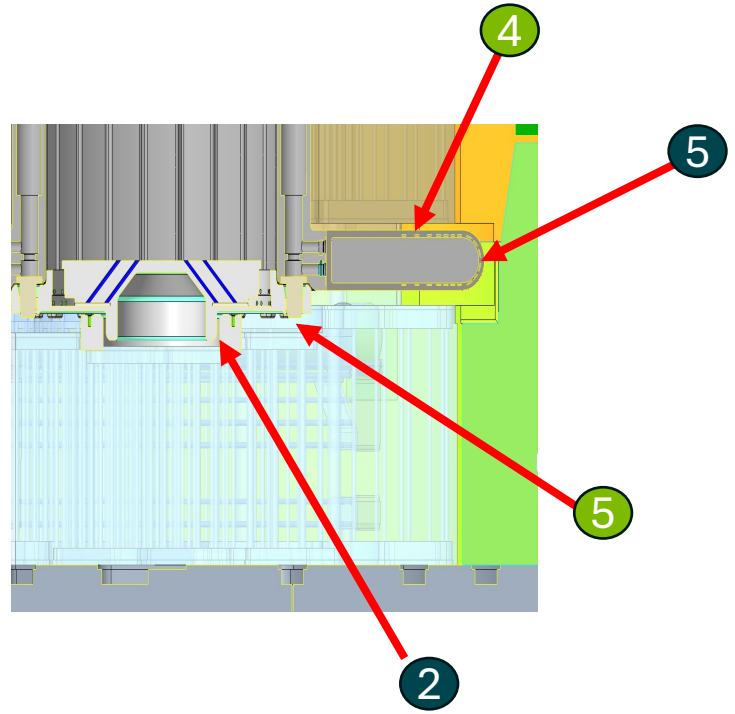
Target Clearance Goal #2: Prevent target from contact with any object during normal operation.







#	Horizontal	Nom	Vertical	Nom
1	Snubber-Shaft (upstream)	6	Snubber - Shaft	8
2	Snubber-Shaft (downstream)	6	Top of Target - Upper MRA	10
3	Target segment – MRA (Beam el.)	21.5	Bottom of Target - MRA	10
4	Target Segment- MRA upper shield	22.5	Top of Target - Bottom SB#3	9
5	Target Foot - SBL#3	20	Segment Pin - Neutron flight path	4.9
6	Donut – Shield block	20		

Methodology

Sources of deviations from nominal CAD include fabrication tolerances, deflections, and installation tolerances

Fabrication tolerances

* Relative to:
-Installation (Dead loads only)
-Room temperature everything
-Core vessel filled with ambient air

Linkage		Node From	Node To	Tolerances LMC (-)	Tolerances MMC (+)	LMC: Design Offset D_{offs}	LMC: Rotation + L_{rot}	LMC: 3 Segments Removed (D_{maint})	LMC: Pressure - Operation P_{op}	LMC: Pressure - MAWP P_{MAWP}	LMC: Thermal - Beam On T_{op}	LMC: Core Vessel MAWP CVP_{MAWP}	LMC: Core Vessel - Helium Mode CVP_{He}	LMC: Core Vessel - Vacuum Mode CVP_{vac}	LMC: Seismic E-	LMC: Bearing Replacement Mbrg	MMC: Design Offset D_{offs}	MMC: Rotation + L_{rot}	MMC: 3 Segments Removed (D_{maint})	MMC: Pressure - Operation P_{op}	MMC: Pressure - MAWP P_{MAWP}	MMC: Thermal - Beam On T_{op}	MMC: Core Vessel MAWP CVP_{MAWP}	MMC: Core Vessel - Helium Mode CVP_{He}	MMC: Core Vessel - Vacuum Mode CVP_{vac}	MMC: Seismic E	MMC: Bearing Replacement Mbrg
A	Core Vessel Lower	1	99	-1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0	0	0	0
B	Core Vessel Upper	99	2	-1	1	0	-0.1	-0.1	0	0	0	0	0	-1.8	-0.3	0	0	0.1	0.1	0	0	0.3	0.5	0	0	0.3	0
C	Target Shaft Upper (Drive mounting to segment attachment bolts)	4	3	-0.125	0.125	0	-0.1	0	0	0	0	0	0	0	0	-2	0	0.1	0	0	0	0	0	0	0	0	2
D	Target Shaft Lower	4	5	-0.5	0.5	0	-0.1	0	0	0	0	0	0	0	-0.1	0	0	0.1	0	0	0.1	1.8	0	0	0	0.1	0
E	Target Segment	4	6	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	-2	0	0	0	0	1.8	0	0	0	0	0
F	Foot	6	7	-0.1	0.1	0	0	0	0	0	0	0	0	0	-0.3	0	0	1.5	0	0	0	0	0	0	0	0.3	0
G	Shield Block #1	15	11	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.5	0	0	0	0	0
H	Lower MRA	8	9	-0.5	0.5	0	0	0	0	0	0	0	0	0	-0.3	0	0	0	0	1	1.3	0.3	0	0	0	0.3	0
I	Upper MRA	8	10	-0.5	0.5	0	0	0	-1	-1.3	-0.3	0	0	0	-0.3	0	0	0	0	0	0	1	0	0	0	0.3	0
J	Shield Block #2	11	12	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.5	0	0	0	0	0
K	Shield Block #3	12	14	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.5	0	0	0.25	0	0
IA_{tgt}	Shaft Installation Accuracy	0	5	-0.5	0.5																						
IA_{MRA}	MRA Installation Accuracy	8	0	-0.5	0.5																						
IA_{snub}	Snubber Installation Accuracy	12	0	-0.5	0.5																						
S_{GCS}	Worst case shim on Beam Guides (True position within beam tube set)	99	0	-1	1																						
IA_{SB1}	Shield Block 1 Installation Accuracy	11	0	-0.5	0.5																						

LMC

MMC

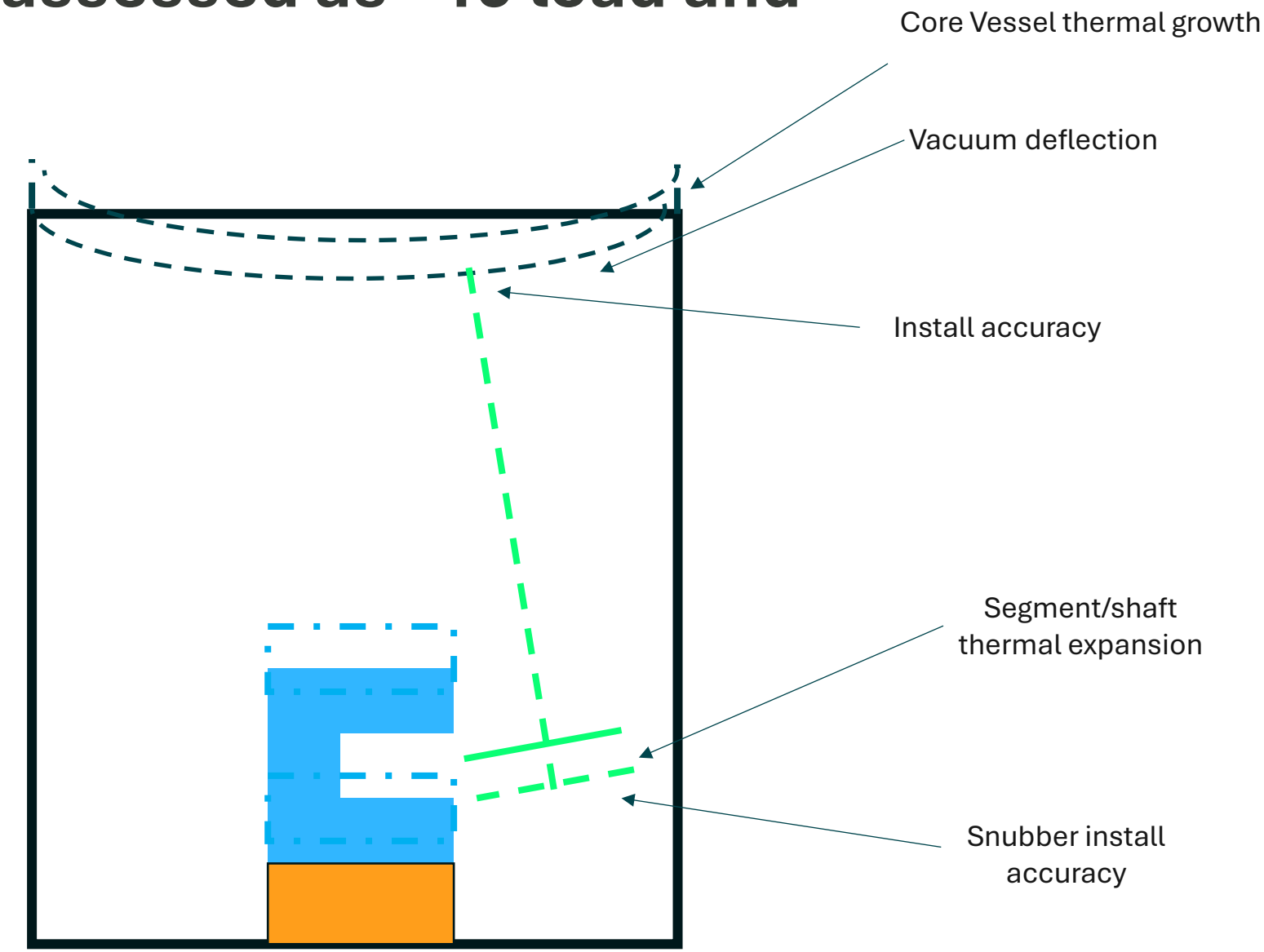
Install tolerances

Deflections of isolated effects

!!Core Vessel deflections are in mm of target motion!!

Isolated deflections are assessed as ~19 load and error combinations

1	Installation - Target Assembly
2	Rotation Test, Target Assembly
3	Component Pressure Test
4	Core Vessel Vacuum, No Beam
5	Core Vessel Vacuum, Beam on
6	Core Vessel Vacuum, No Beam, Seismic
7	Core Vessel Vacuum, Beam On, Seismic
8	CV Vac, Component MAWP, No Beam
9	CV Vac, Component MAWP, Beam On
10	CV Helium Mode, No Beam
11	CV Helium Mode, Beam On
12	CV Helium Mode, No Beam, Seismic
13	CV Helium Mode, Beam On, Seismic
14	CV He, No Beam, Component MAWP
15	CV He, Beam On, Component MAWP
16	CV MAWP, No Beam
17	CV MAWP, Beam On
18	Target Change Out
19	Bearing Change Out (Shaft on lid)



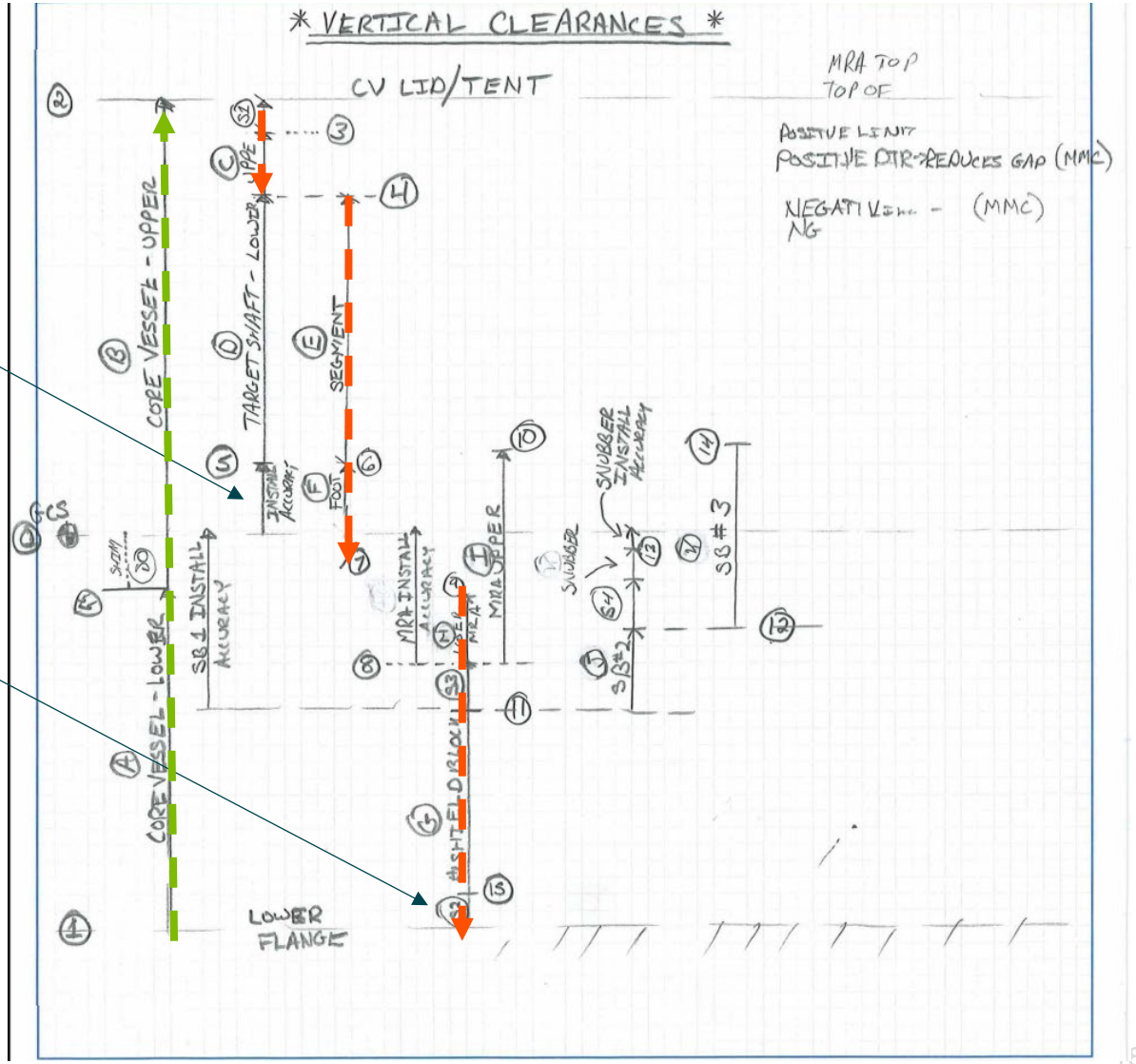
Gaps are computed systematically by tracing linkages & nodes with assigned MMC/LMC conditions relative to World Center

Many objects are installed relative to STS GCS –eliminates some fab tolerances

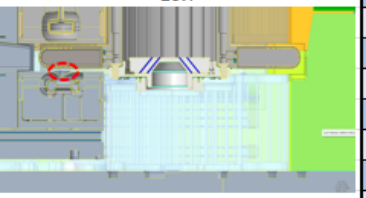
Deflection paths skip shims/install tolerance elements

Sign Convention

+ -



The linkages for fabrication errors, install errors, and deflection are captured carefully and systematically (0,1,-1)

		ASCE/ASME LOAD COMBINATION?	Node		Clearance				Linkages -Tolerances														Linkages - Deflections										
			From	To	CAD	Max	Min	Trave	A	B	C	D	E	F	G	H	I	J	K	IA_{tgt}	IA_{MRA}	IA_{snub}	S_{GCS}	IA_{SB1}	A	B	C	D	E	F	G	H	I	J	K
Bottom of Target - MRA	1	Installation - Target Assembly	9	7	10	11.7	8.3						1	1		1				1	-1				1	1	-1		-1	-1	-1	-1			
Nominal (CAD) Gap	2	Rotation Test, Target Assembly			10	11.9	8.6		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
10	3	Component Pressure Test			10	11.7	8.8		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
Minimum Gap	4	Core Vessel Vacuum, No Beam			10	11.9	5.6		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
2.3	5	Core Vessel Vacuum, Beam on			10	12.5	3.1		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
Maximum Gap	6	Core Vessel Vaccuum, No Beam, Seismic			10	12.7	4.8		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
13.7	7	Core Vessel Vaccuum, Beam On, Seismic			10	13.3	2.3		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	8	CV Vac, Component MAWP, No Beam			10	11.9	5.3		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	9	CV Vac, Component MAWP, Beam On			10	12.5	2.8		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	10	CV Helium Mode, No Beam			10	11.9	7.3		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	11	CV Helium Mode, Beam On			10	12.5	4.8		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	12	CV Helium Mode, No Beam, Seismic			10	12.7	6.5	X	0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	13	CV Helium Mode, Beam On, Seismic			10	13.3	4.0		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	14	CV He, No Beam,Component MAWP			10	11.9	7.1		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	15	CV He, Beam On, Component MAWP			10	12.5	4.6		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	16	CV MAWP, No Beam			10	12.5	9.1		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	17	CV MAWP, Beam On			10	13.1	6.6	X	0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	18	Target Change Out			10	11.8	9.0		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0
	19	Bearing Change Out (Shaft on lid)			10	13.7	8.3		0	0	0	0	1	1	0	1	0	0	0	1	-1	0	0	0	1	1	-1	0	-1	-1	-1	-1	0	0	0

Sign Convention

+ -

0) Trace path of interest
-tolerance
-deflection

Tolerance Linkages

Deflection Linkages

1	Installation - Target Assembly
2	Rotation Test, Target Assembly
3	Component Pressure Test
4	Core Vessel Vacuum, No Beam
5	Core Vessel Vacuum, Beam on
6	Core Vessel Vaccuum, No Beam, Seismic
7	Core Vessel Vaccuum, Beam On, Seismic
8	CV Vac, Component MAWP, No Beam
9	CV Vac, Component MAWP, Beam On
10	CV Helium Mode, No Beam
11	CV Helium Mode, Beam On
12	CV Helium Mode, No Beam, Seismic
13	CV Helium Mode, Beam On, Seismic
14	CV He, No Beam,Component MAWP
15	CV He, Beam On, Component MAWP
16	CV M
17	CV M
18	Targ
19	Bea

1) Enter path of interest & load combinations (build the equation)

2) Lookup magnitudes

* Relative to:
-Installation (Dead loads only)
-Room temperature everything
-Core vessel filled with ambient air

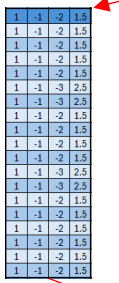
Linkage		Node From	Node To	Tolerances LMC (-)	Tolerances MMC (+)	Design Offset D_{offs}	Rotation + L_{rot}	3 Segments Removed (D_{mint})	Pressure - Operation P_{op}	Pressure - MAWP P_{MAWP}	Thermal - Beam On T_{op}	Core Vessel MAWP Core Vessel - Helium Mode CVP MAWP	Core Vessel - Helium Mode CVP He	Core Vessel - Vacuum Mode CVP_v	Seismic E_{ac}	Bearing Replacement Mbrg
A	Core Vessel Lower	1	99	-1	1	0	0	0	0	0	0	0	0	0	0	0
B	Core Vessel Upper	99	2	-1	1	0	-0.1	-0.1	0	0	0	0	0	-1.8	-0.3	0
C	Target Shaft Upper (Drive mounting to segment attachment bolts)	4	3	-0.125	0.125	0	-0.1	0	0	0	0	0	0	0	0	-2
D	Target Shaft Lower	4	5	-0.5	0.5	0	-0.1	0	0	0	0	0	0	0	-0.1	0
E	Target Segment	4	6	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0
F	Foot	6	7	-0.1	0.1	0	0	0	0	0	0	0	0	0	-0.3	0
G	Shield Block #1	15	11	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0
H	Lower MRA	8	9	-0.5	0.5	0	0	0	0	0	0	0	0	0	-0.3	0
I	Upper MRA	8	10	-0.5	0.5	0	0	0	-1	-1.3	-0.3	0	0	0	-0.3	0
J	Shield Block #2	11	12	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0
K	Shield Block #3	12	14	-0.1	0.1	0	0	0	0	0	0	0	0	0	0	0
IA_{tgt}	Shaft Installation Accuracy	0	5	-0.5	0.5											
IA_{MRA}	MRA Instalation Accuracy	8	0	-0.5	0.5											
IA_{snub}	Snubber Installation Accuracy	12	0	-0.5	0.5											
S_{GCS}	Worst case shim on Beam Guides (True position within beam tube set)	99	0	-1	1											
IA_{SB1}	Shield Block 1 Installation Accuracy	11	0	-0.5	0.5											

Linkage		Design Offset D_{offs}	Rotation + L_{rot}	3 Segments Removed (D_{mint})	Pressure - Operation P_{op}	Pressure - MAWP P_{MAWP}	Thermal - Beam On T_{op}	Core Vessel MAWP Core Vessel - Helium Mode CVP MAWP	Core Vessel - Helium Mode CVP He	Core Vessel - Vacuum Mode CVP_{vac}	Seismic E	Bearing Replacement Mbrg
A	Core Vessel Lower	0	0	0	0	0	0	0.3	0.3	0	0	0
B	Core Vessel Upper	0	0.1	0.1	0	0	0	0.3	0.5	0	0	0
C	Target Shaft Upper (Drive mounting to segment attachment bolts)	0	0.1	0	0	0	0	0	0	0	0	2
D	Target Shaft Lower	0	0.1	0	0	0	0	0.1	1.8	0	0	0
E	Target Segment	-2	0	0	0	0	0	1.8	0	0	0	0
F	Foot	0	1.5	0	0	0	0	0	0	0	0	0.3
G	Shield Block #1	0	0	0	0	0	0	0.3	0.3	0.5	0	0
H	Lower MRA	0	0	0	0	0	0	1	1.3	0.3	0	0.3
I	Upper MRA	0	0	0	0	0	0	0	0	1	0	0.3
J	Shield Block #2	0	0	0	0	0	0	0.3	0.3	0.5	0	0
K	Shield Block #3	0	0	0	0	0	0	0.3	0.3	0.5	0	0.25

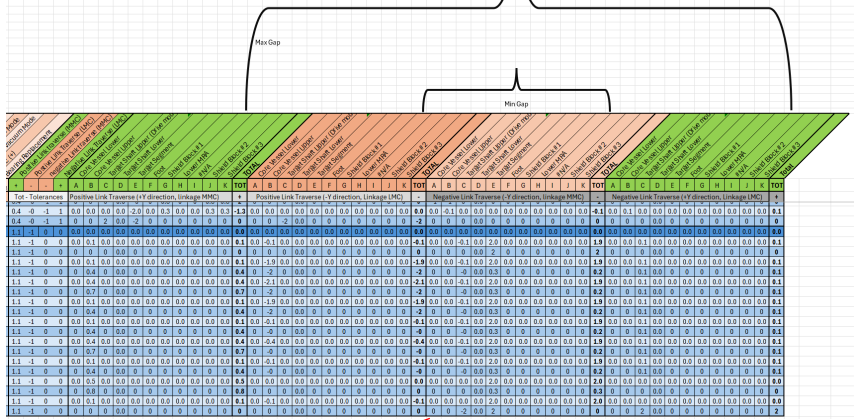
LMC

MMC

Capturing all combinations of paths and linkage conditions ensures complete coverage of situations



3) Expand LMC and MMC to all combinations (+/- paths)



4) Max gap = + path MMC – path LMC
Min gap = +path LMC – path MMC

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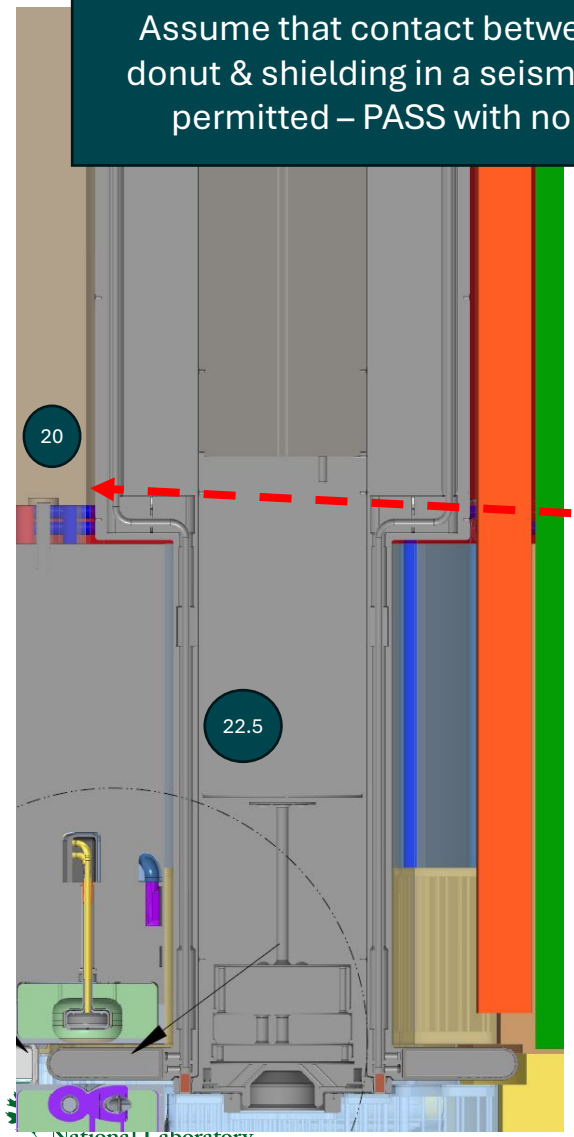
The minimum clearances are tight, but estimated in a very conservative approach (worst case stack up)

Assume that contact between target donut & shielding in a seismic event is permitted – PASS with no margin



Vertical Gaps	Operation	Seismic
Snubber - Shaft	1.575	1.315
Top of Target - Upper MRA	4.475	3.925
Bottom of Target - MRA	2.825	2.275
Top of Target - Bottom SB#3	5.275	4.725
Segment Pin - Neutron Beam guide	2.075	1.825
Horizontal Gaps		
Snubber - Shaft (upstream)	2.25	N/A
Snubber Shaft - Downstream	0.875	N/A
Target Foot - MRA lower	15.5	7.25
Target Segment- MRA upper shield	13.625	2.75
Target Donut- Shield Block	10.38	0.13
Target Foot - SBL#3	13.275	5.15

Design intent achieved for order of contact (seismic)

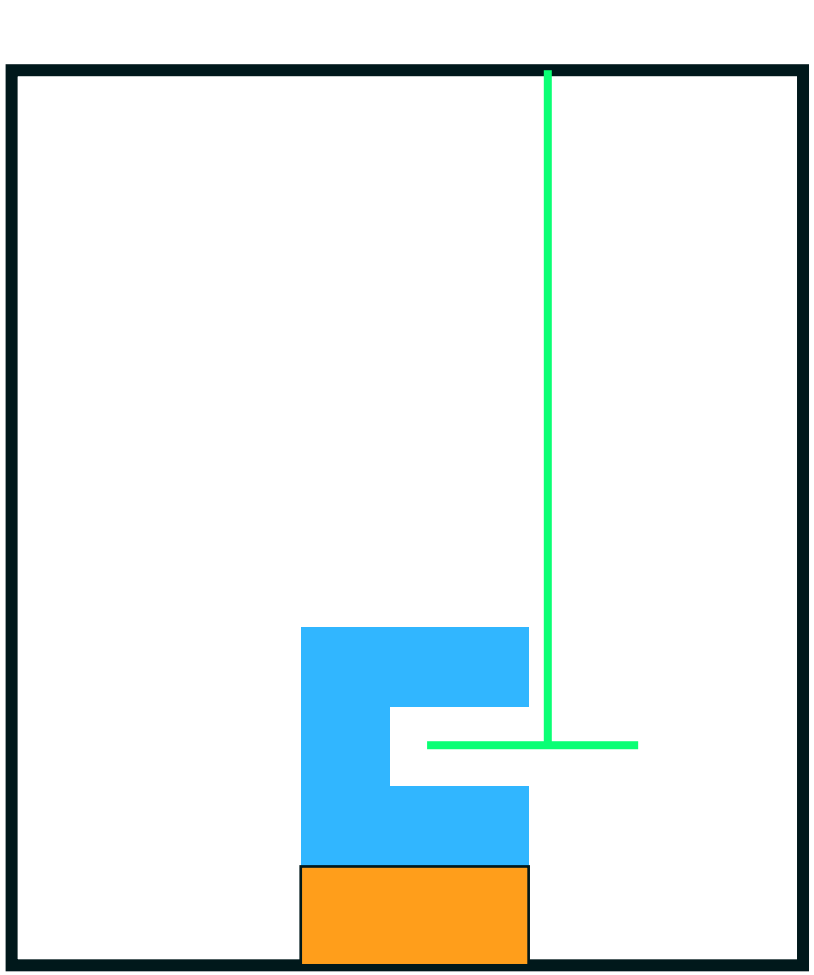
1. Snubber
2. Shielding
3. Moderator (never)

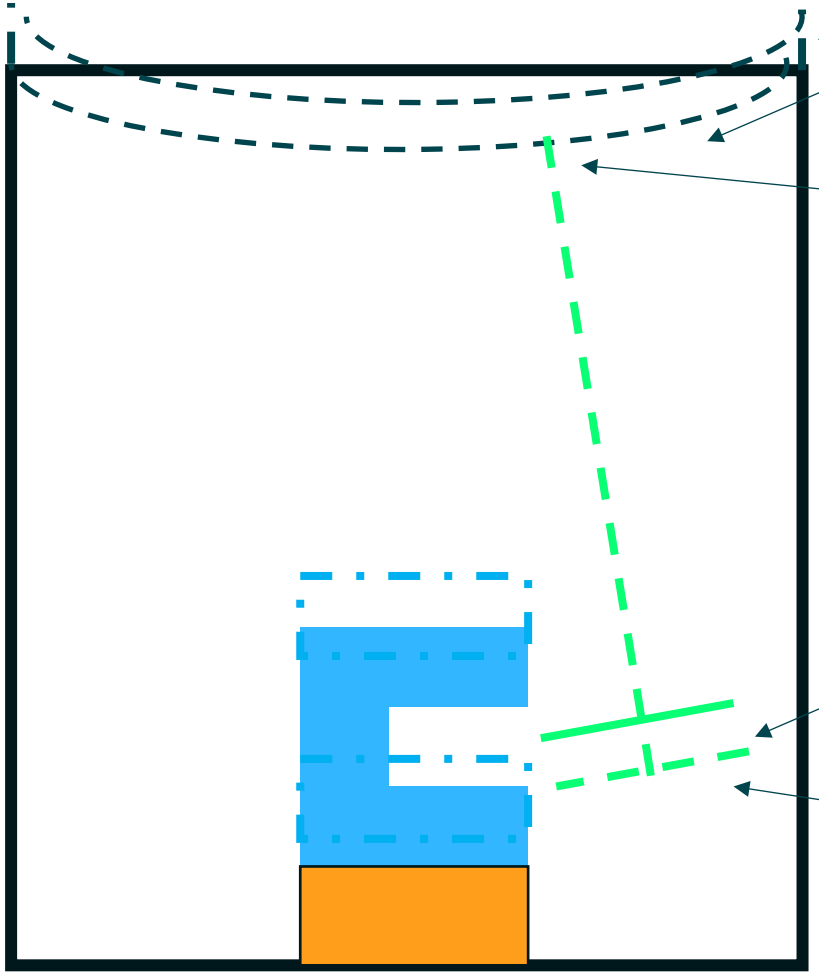
No collisions occur if all requirements are met by sub-components

1	Installation - Target Assembly	4	12	8	9.0	7.0
2	Rotation Test, Target Assembly			8	9.3	6.7
3	Component Pressure Test			8	9.0	6.4
4	Core Vessel Vacuum, No Beam			8	9.3	4.4
5	Core Vessel Vacuum, Beam on			8	9.9	1.7
6	Core Vessel Vacuum, No Beam, Seismic			8	9.7	4.1
7	Core Vessel Vacuum, Beam On, Seismic			8	10.3	1.3
8	CV Vac, Component MAWP, No Beam			8	9.3	4.3
9	CV Vac, Component MAWP, Beam On			8	9.9	1.6
10	CV Helium Mode, No Beam			8	9.3	6.2
11	CV Helium Mode, Beam On			8	9.9	3.4
12	CV Helium Mode, No Beam, Seismic			8	9.7	5.8
13	CV Helium Mode, Beam On, Seismic			8	10.3	3.1
14	CV He, No Beam, Component MAWP			8	9.3	6.1
15	CV He, Beam On, Component MAWP			8	9.9	3.3
16	CV MAWP, No Beam			8	9.8	6.5
17	CV MAWP, Beam On			8	10.4	3.7
18	Target Change Out			8	9.1	6.4
19	Bearing Change Out (Shaft on lid)			8	11.0	5.0

1	Installation - Target Assembly	6	17	20	23.5	16.5
2	Rotation Test, Target Assembly			20	28.6	11.4
3	Component Pressure Test			20	23.5	16.5
4	Core Vessel Vacuum, No Beam			20	30.1	11.4
5	Core Vessel Vacuum, Beam on			20	31.1	10.4
6	Core Vessel Vaccuum, No Beam, Seismic			20	40.4	1.1
7	Core Vessel Vaccuum, Beam On, Seismic			20	41.4	0.1
8	CV Vac, Component MAWP, No Beam			20	30.1	11.4
9	CV Vac, Component MAWP, Beam On			20	31.1	10.4
10	CV Helium Mode, No Beam			20	28.6	11.4
11	CV Helium Mode, Beam On			20	29.6	10.4
12	CV Helium Mode, No Beam, Seismic			20	38.9	1.1
13	CV Helium Mode, Beam On, Seismic			20	39.9	0.1
14	CV He, No Beam,Component MAWP			20	28.6	11.4
15	CV He, Beam On, Component MAWP			20	29.6	10.4
16	CV MAWP, No Beam			20	23.5	15.8
17	CV MAWP, Beam On			20	24.5	14.8
18	Target Change Out			20	23.8	16.3
19	Bearing Change Out (Shaft on lid)			20	23.5	16.5

What are the drivers of tight vertical clearances to the snubber (<1mm min clearance)?





Core Vessel thermal growth (V=0.6mm)

Vacuum deflection (V=1.8mm)

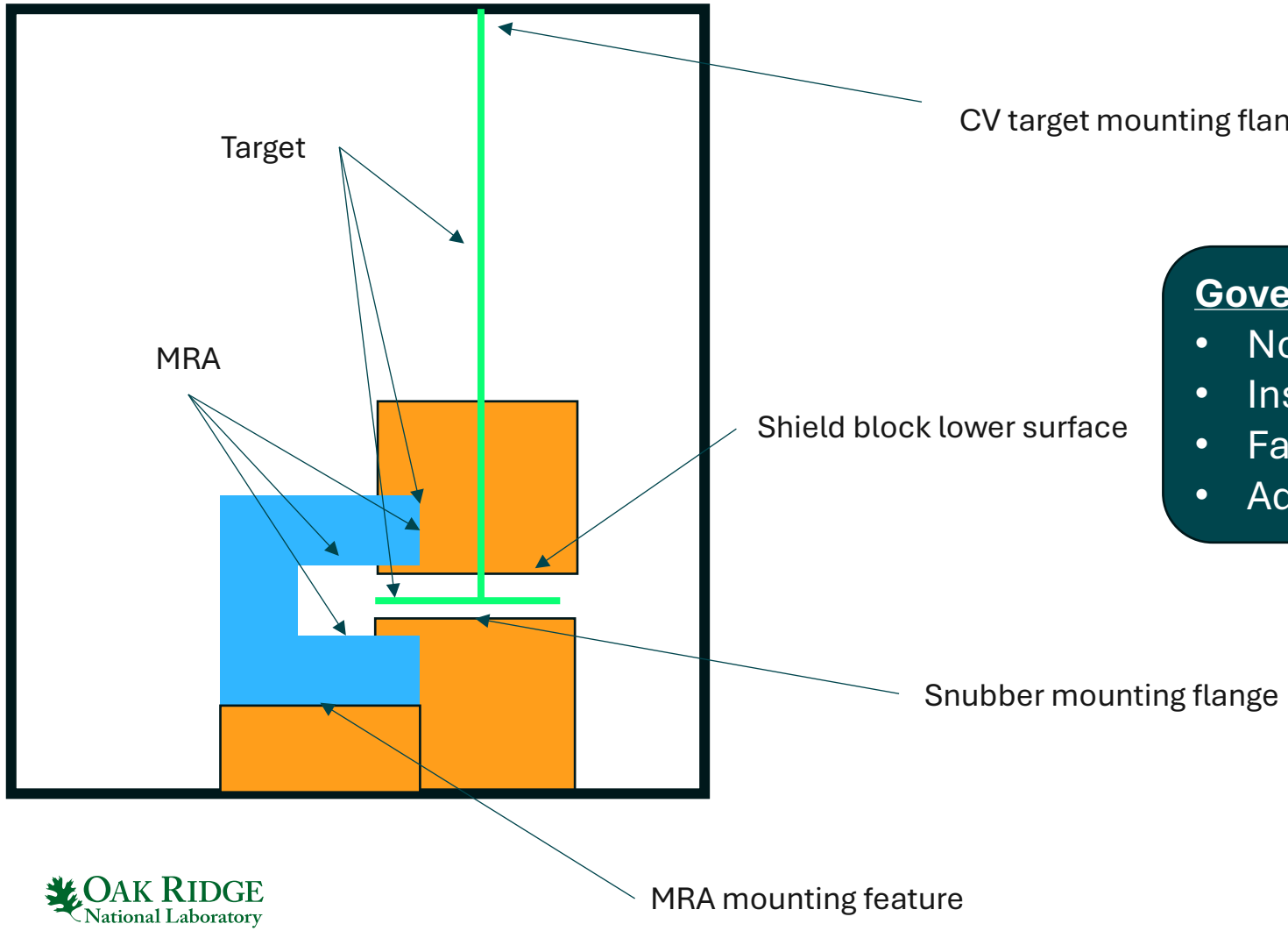
Install accuracy (+/- 1mm)

Segment/shaft thermal expansion (1.8mm)

Snubber install accuracy (+/-1mm)

Manufacturing tolerances & smaller effects (1.4mm)

Inputs to the analysis that satisfy “no contact” solutions are captured as requirements for each L3 system at areas of concern.



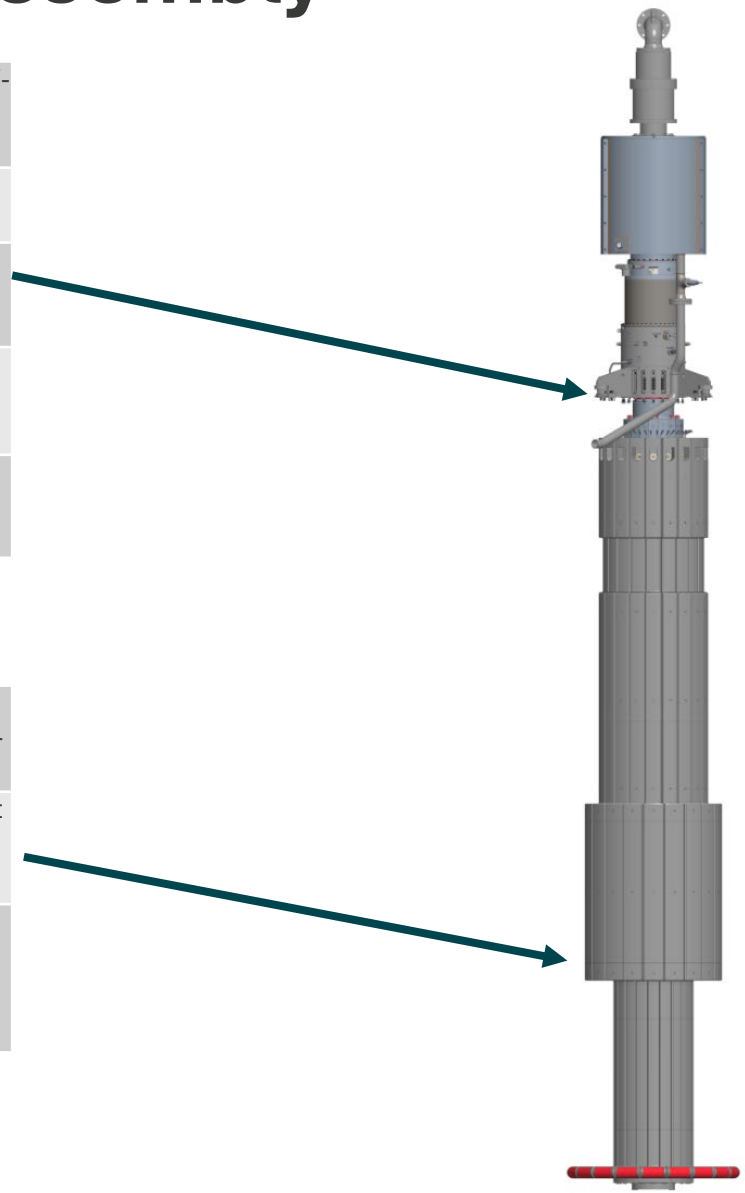
47 requirements generated
- -27 to Vessel systems
- -2 for MRA
- -18 for Target Assembly

Governing Tolerances
- Nominal Gaps
- Installation tolerance
- Fabrication tolerances
- Adjustment capacity

Deflection load cases simplified to:
- Normal operation and overpressure
- Deflections during seismic events
- Maximum relative displacement

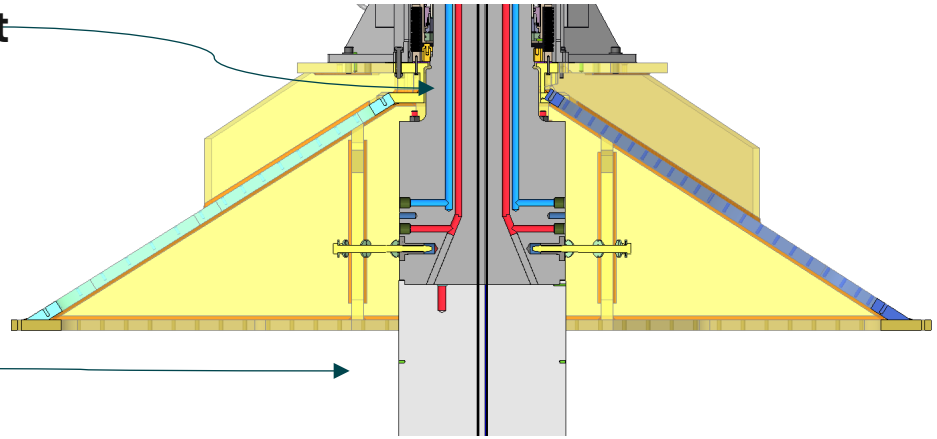
Requirements allocated to the target assembly

10646	Upper mounting point - Horizontal Installation tolerance	S.03.02-10646	The target assembly (the axis of rotation) shall be located within +/- 1mm~, of the global (master) coordinate system in the horizontal direction.
10793	Upper Mounting point - Vertical Installation tolerances	S.03.02-10793	The target assembly shall be located within +/- 0.5mm~, of the global (master) coordinate system in the vertical direction.
10735	Lower restraint - adjustment allowance	S.03.02-10735	The lower restraint or the target assembly shall be able to withstand adjustment relative to the shield mounting points of: Horizontal: +/-3.5mm & Vertical: +/- 1.5mm
10699	Upper mounting point adjustment allowance	S.03.02-10699	The target assembly shall permit adjustment relative to the core vessel lid of: Horizontal: +/- 5mm & Vertical: +/-1.5mm
10698	Structural capacity during relative motion	S.03.02-10698	The target assembly shall be capable of maintaining structural integrity under a horizontal relative motion between base and lower extremity (snubber ring) of up to: 13mm.
10734	Mid-height location - Profile tolerance	S.03.02-10734	The vertical surfaces of the target assembly (above the target foot) shall have a profile tolerance~, when assembled, not to exceed +/- 0.5mm relative to the installed axis of the shaft.
10733	Mid-Height locations - Horizontal deflections during normal operations	S.03.02-10733	The outer profile of the target assembly (above the target) shall not deflect in the horizontal direction more than +/-4.5mm during normal operation and pressure testing operations.
10693	Mid-height locations - Horizontal deflections during seismic operation	S.03.02-10693	Any portion of the target assembly shall not deflect in the horizontal direction more than 7mm during a seismic lateral force; displacement is that beyond relative displacement between mounting flange and lower extremity.



How can there possibly be 13 mm of relative motion between the target drive and the bottom of the snubber with a 6mm gap?

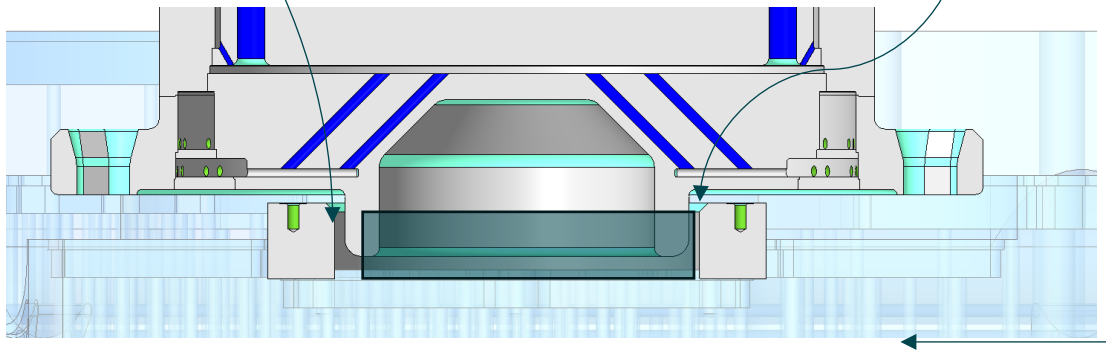
Max Moment



1mm CV seismic

<u>Target Assembly</u>
1mm install accuracy
6mm nom gap
1mm snubber install accuracy
1.75mm vac motion
0.875mm geometric runout
<u>0.5mm imbalance</u>
Total: 11.125mm

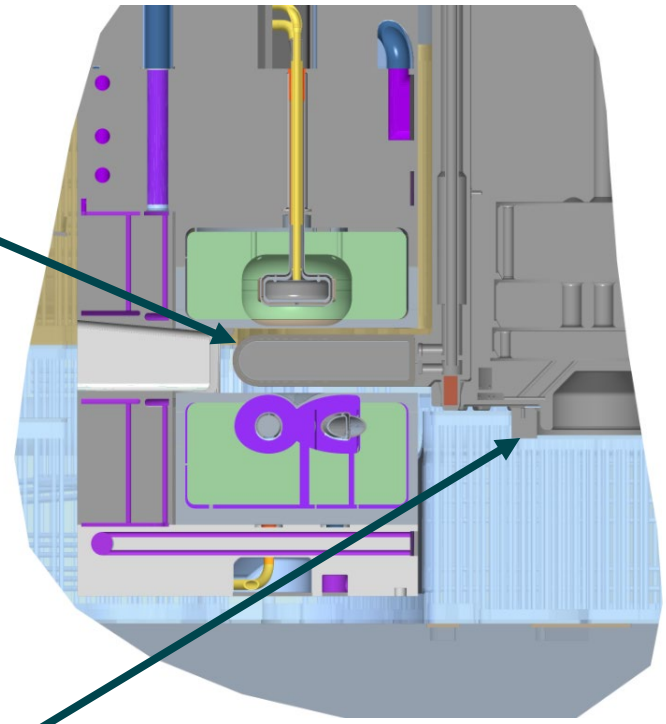
Min Gap: 0.875mm



<u>Shield block</u>
0.25mm CV seismic
<u>0.5mm Thermal</u>
Total 0.75mm

Target Assembly Requirements

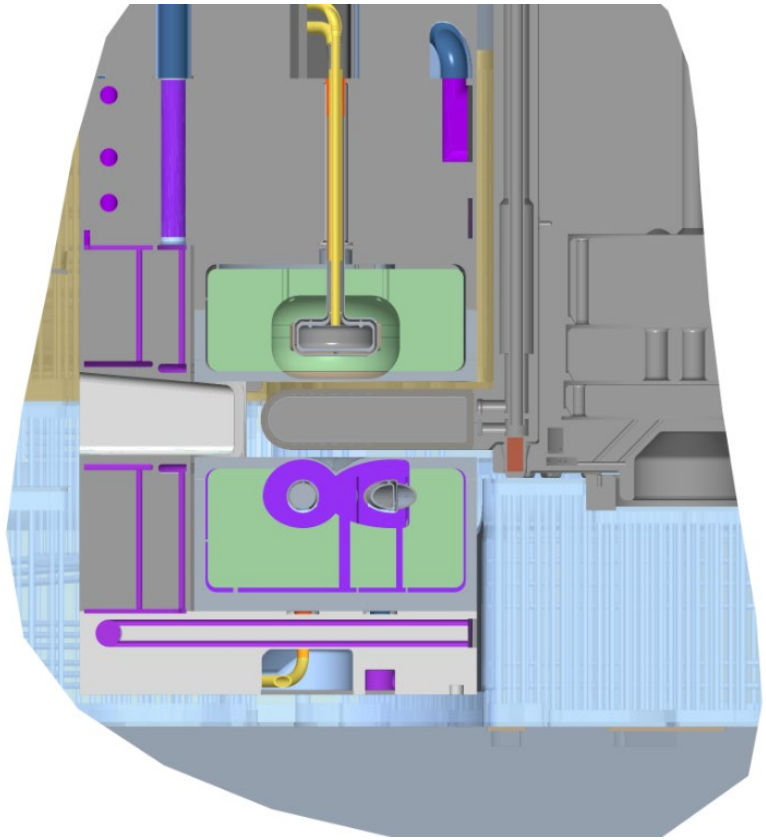
10701	Foot location - Profile	S.03.02-10701	The target shall have a profile within +/~- 0.2mm of the nominal CAD boundary (at installation)
10732	Foot location - Horizontal deflections during normal operations	S.03.02-10732	The outer boundary of the target assembly at the foot elevation shall deflect <0.5mm horizontally during the worst case combination of:
10702	Foot location - Vertical Deflections During Normal Operations	S.03.02-10702	The outer boundary of the target assembly at the foot elevation shall not deflect in the vertical direction more than 3.25mm (down) or more than 0.25mm (up) during the worst case combination of:.''
10713	Foot location - Horizontal Deflections During Seismic Event	S.03.02-10713	The outer boundary of the target assembly at the foot elevation shall deflect in the horizontal direction <0.25mm beyond any imposed displacements between mounting flange and lower extremity.
10731	Foot location - Vertical Deflection during seismic event	S.03.02-10731	The outer boundary of the target assembly at the foot elevation shall deflect in the vertical direction < 3.65mm (down) and <0.55mm (up) during a seismic vertical force.



10792	Snubber Nominal Gap - Horizontal	S.03.02-10792	The restraint ring at the bottom of the target shall have a nominal radial gap of 6mm between rotating and static faces.
10791	Snubber Nominal Gap -Vertical	S.03.02-10791	The restraint ring at the bottom of the target shall have a nominal vertical gap of 8mm between rotating and static faces.
10674	Profile Tolerance	S.03.02-10674	The profile tolerance of the lower target extremity (snubber) shall be radially within +/~-0.875mm from nominal.
10676	Horizontal Deflections During Normal Operation	S.03.02-10676	The lower extremity (snubber) shall not deflect in the horizontal direction more than +/~-0.5mm during the worst case combination of
10677	Vertical Deflections During Normal Operation	S.03.02-10677	The lower extremity shall deflect in the vertical direction <2mm (down) and< 0.2mm (up) during the worst case combination of:

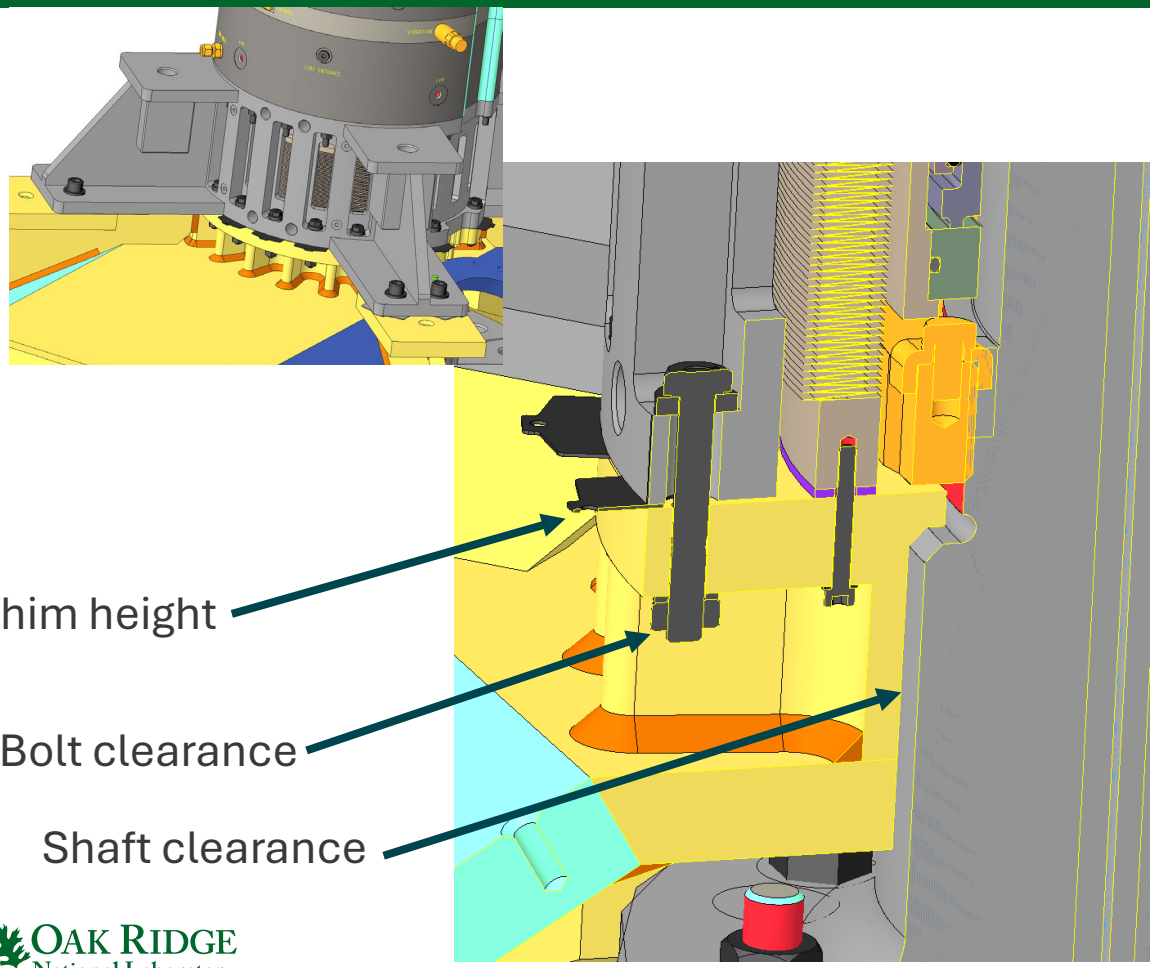
MRA requirements

2374	MRA Boundary Requirement	The MRA nominal boundary shall match the boundary defined in the MRA-Target Assembly-Core Vessel Clearance Budget Document.
2995	MRA profile tolerance requirement	The MRA shall have an overall profile tolerance of +/- 1mm to the ideal boundary after installation
2994	MRA deflections	The MRA outside surfaces shall not deflect more than +/- 1.5mm from their installed locations under any expected loading conditions.

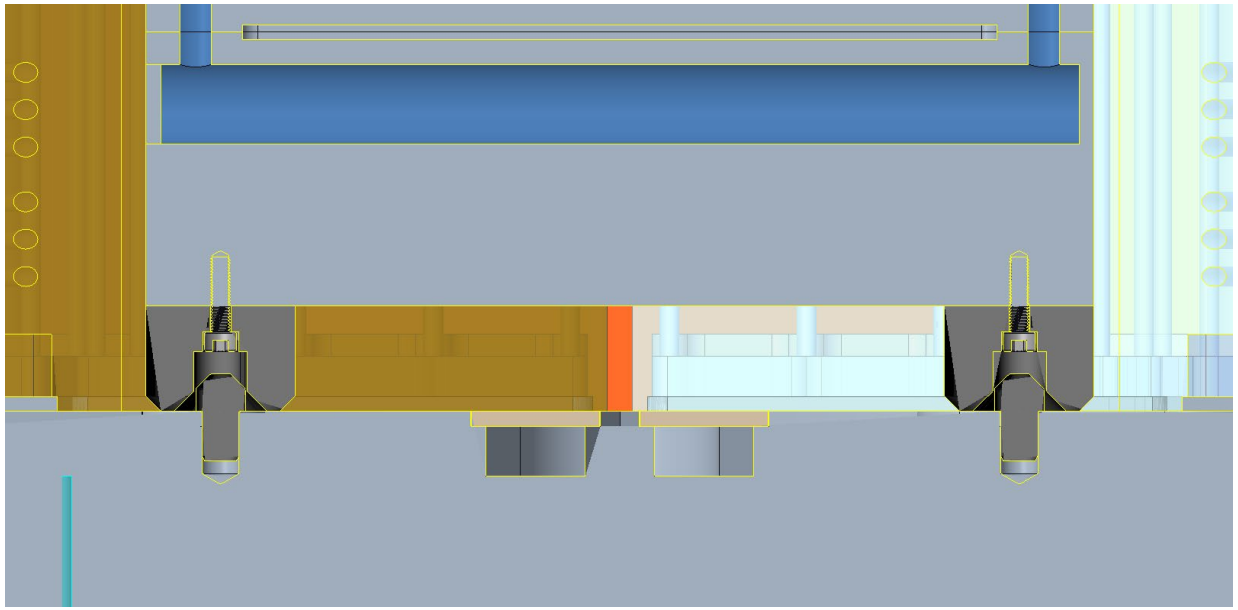


The error budget clarifies the adjustment needed to achieve reasonable fabrication tolerances and shim heights

Target Assembly

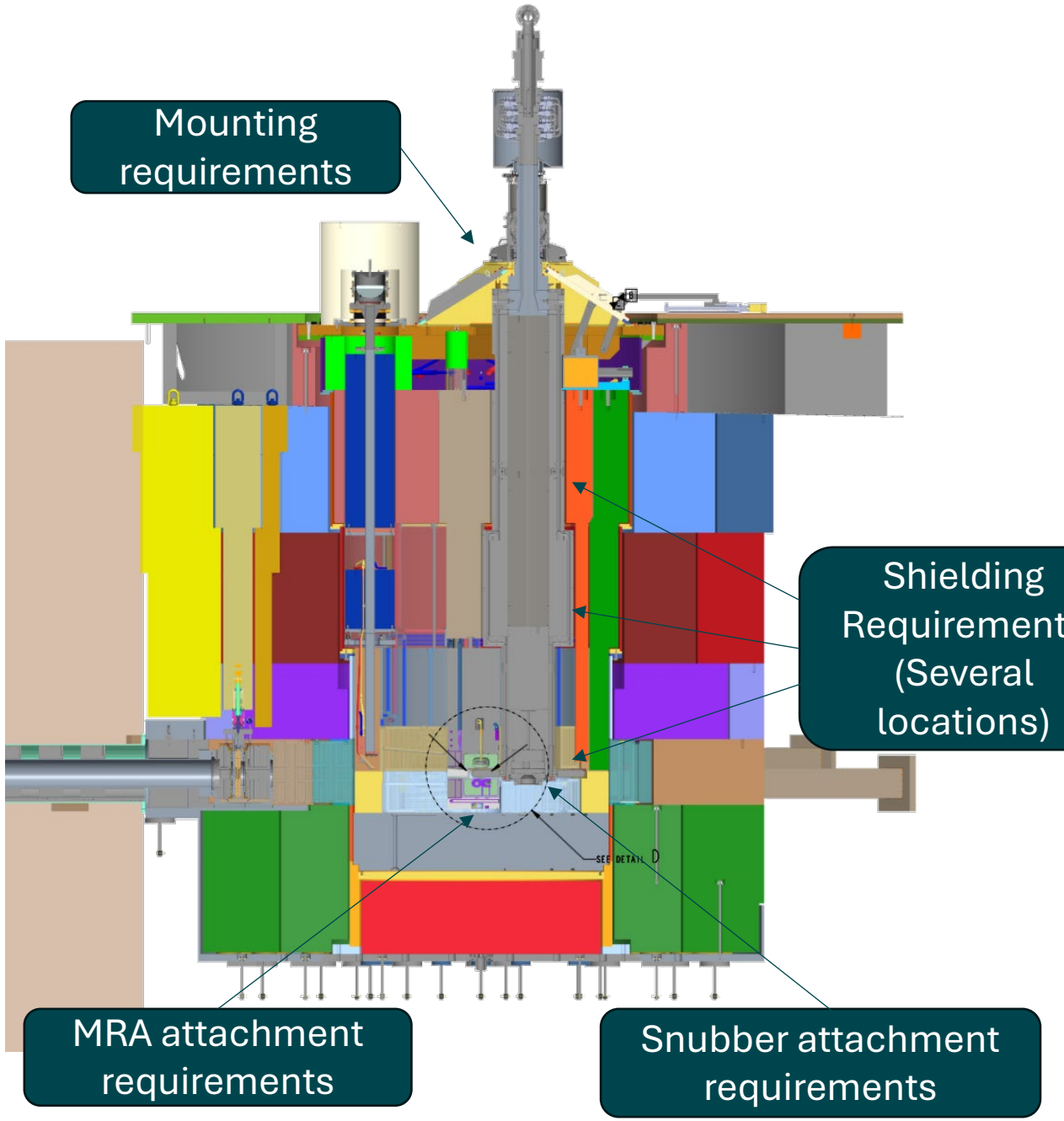


MRA



Core Vessel requirements

To be reviewed during S.03.06 FDR– details are in Clearance budget calculation package (S03000000-CAC10000)



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