



MRA PDR - Remote Handling Overview

Steve Schrick
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Objective – Show RH features to meet MRA requirements

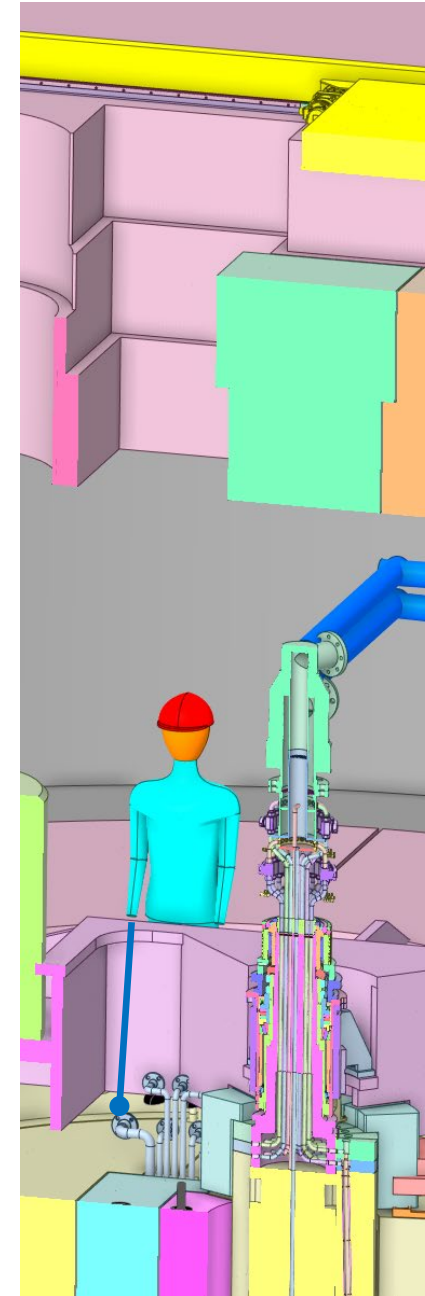
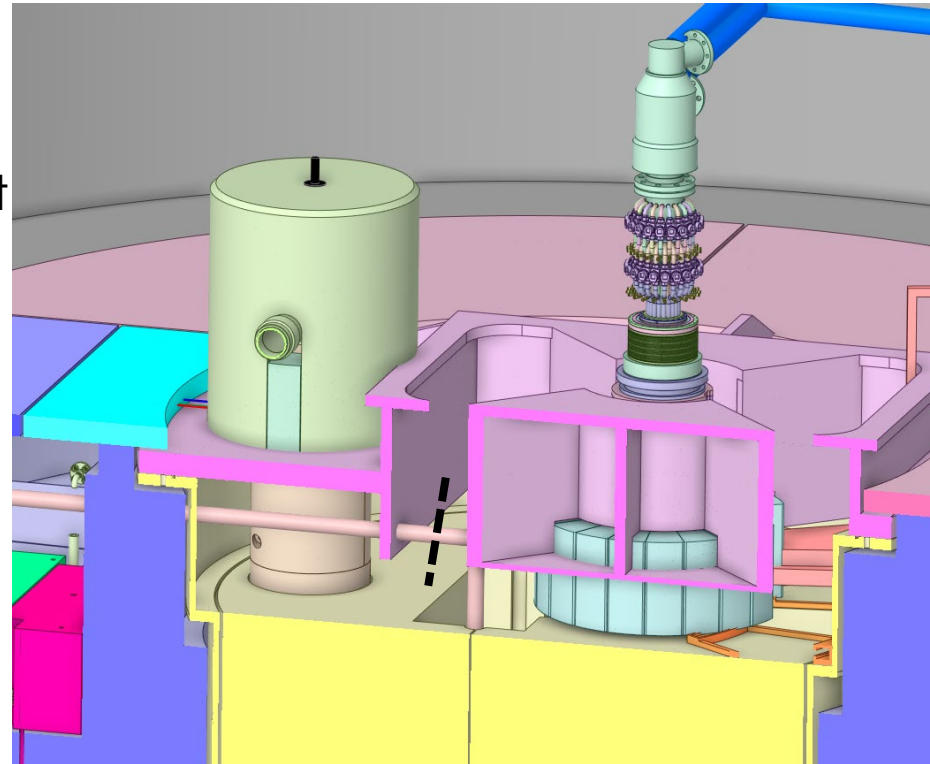
- Preliminary MRA removal scheme
 - Hands-on access
 - Pipe Cutting
 - Overall replacement time
- Preliminary MRA disposal planning
 - Size & weight limits
 - Classification

Preliminary MRA Removal Procedure

***Assumes core vessel lid is removed, but all other components in core vessel in place.**

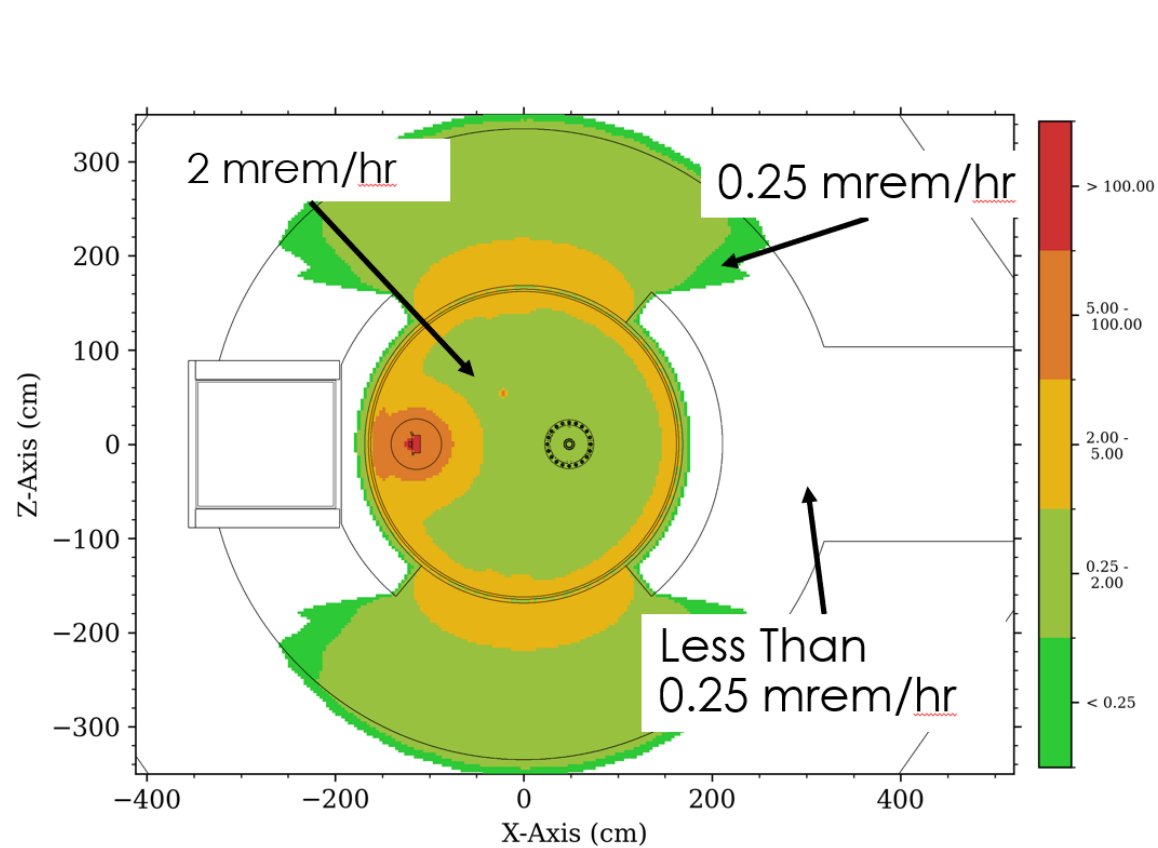
- Cut vacuum/transfer lines to MRA using rotary pipe cutter.
- Blowdown MRA and manually disconnect water lines
- Attach a lifting strap/lanyard to water pipes and transfer line

(All steps are hands-on)

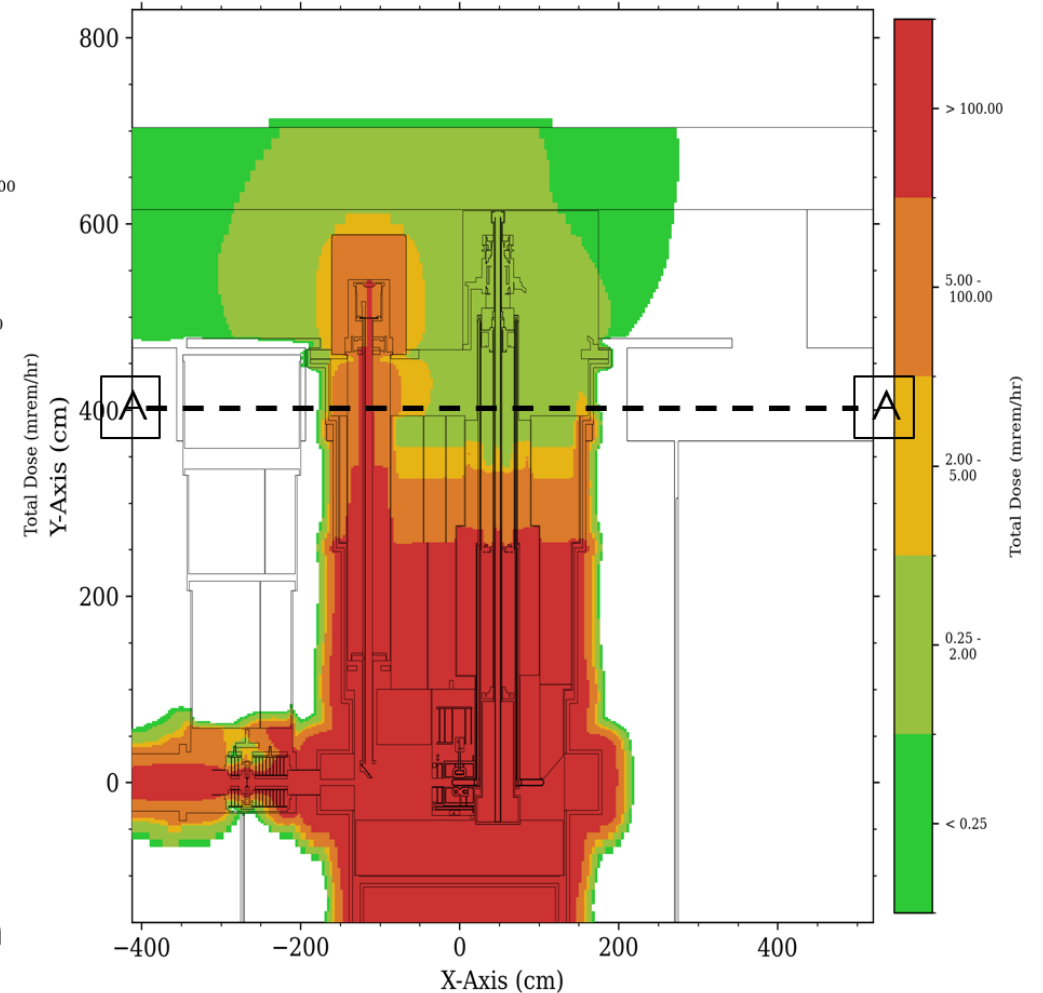


Preliminary MRA Procedure – Neutronics Analysis

Denovo Gamma Dose Rates after 8 Hours of Decay



Section A-A: Plan View at 4 m above beam elevation of Denovo Decay Gamma Dose Rates



Cross Section View of the Denovo Decay Gamma Doses after 8 Hours of Decay

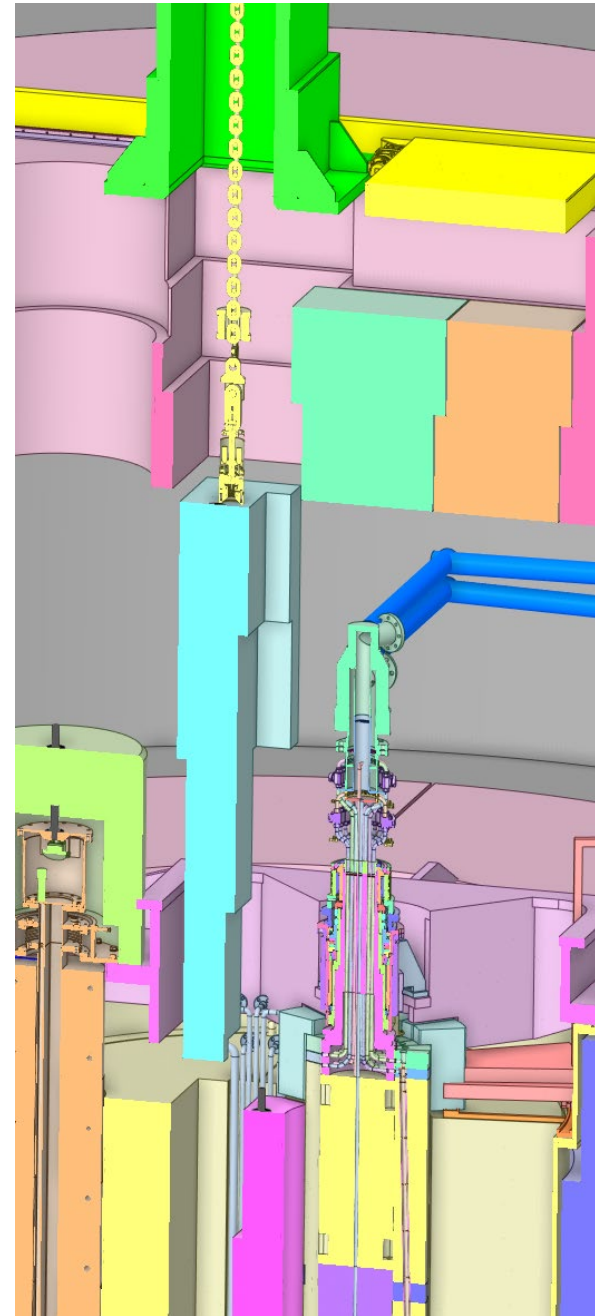
Nominal Operational Irradiation; 8 hours decay

Credit: T. McClanahan

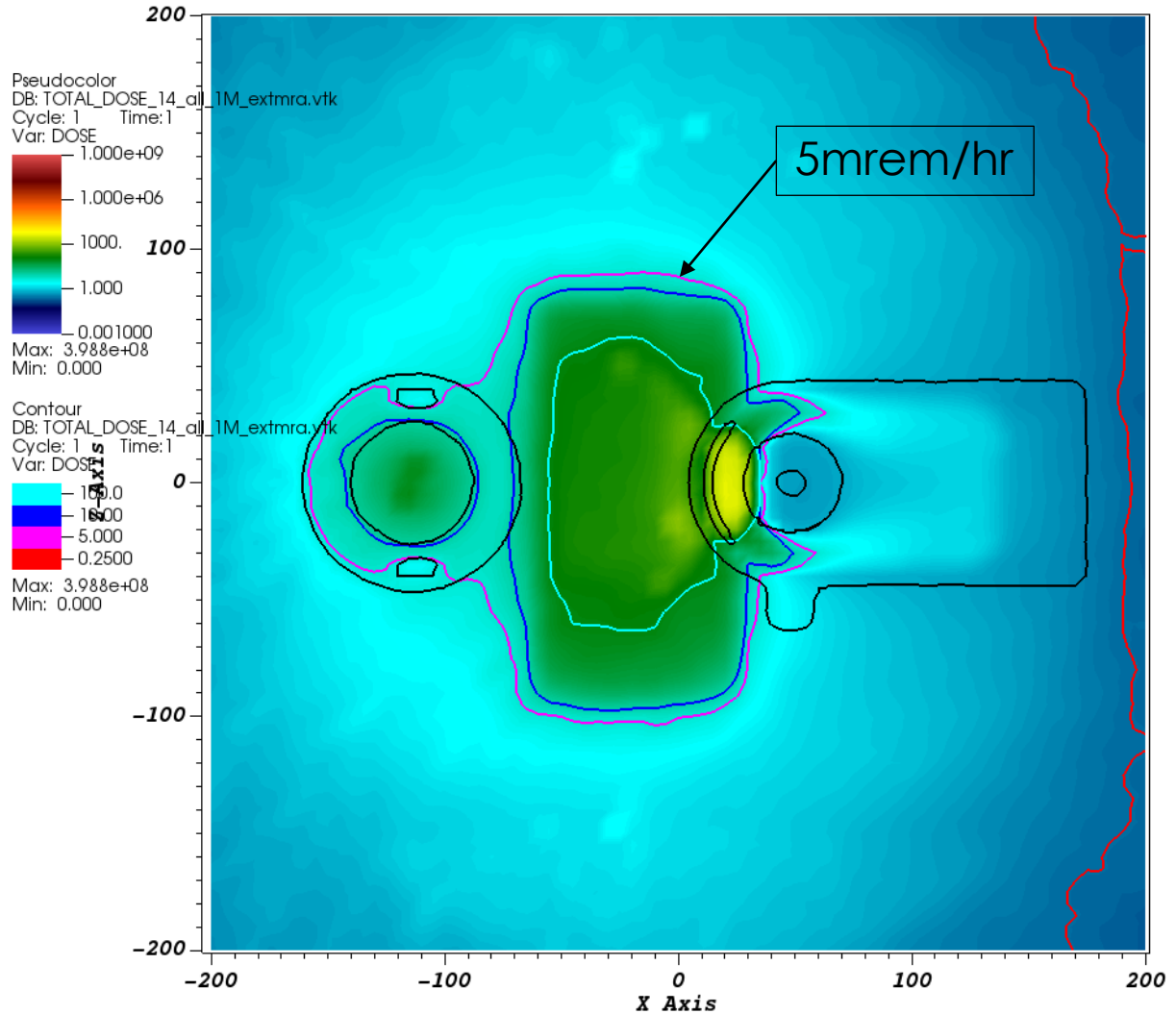
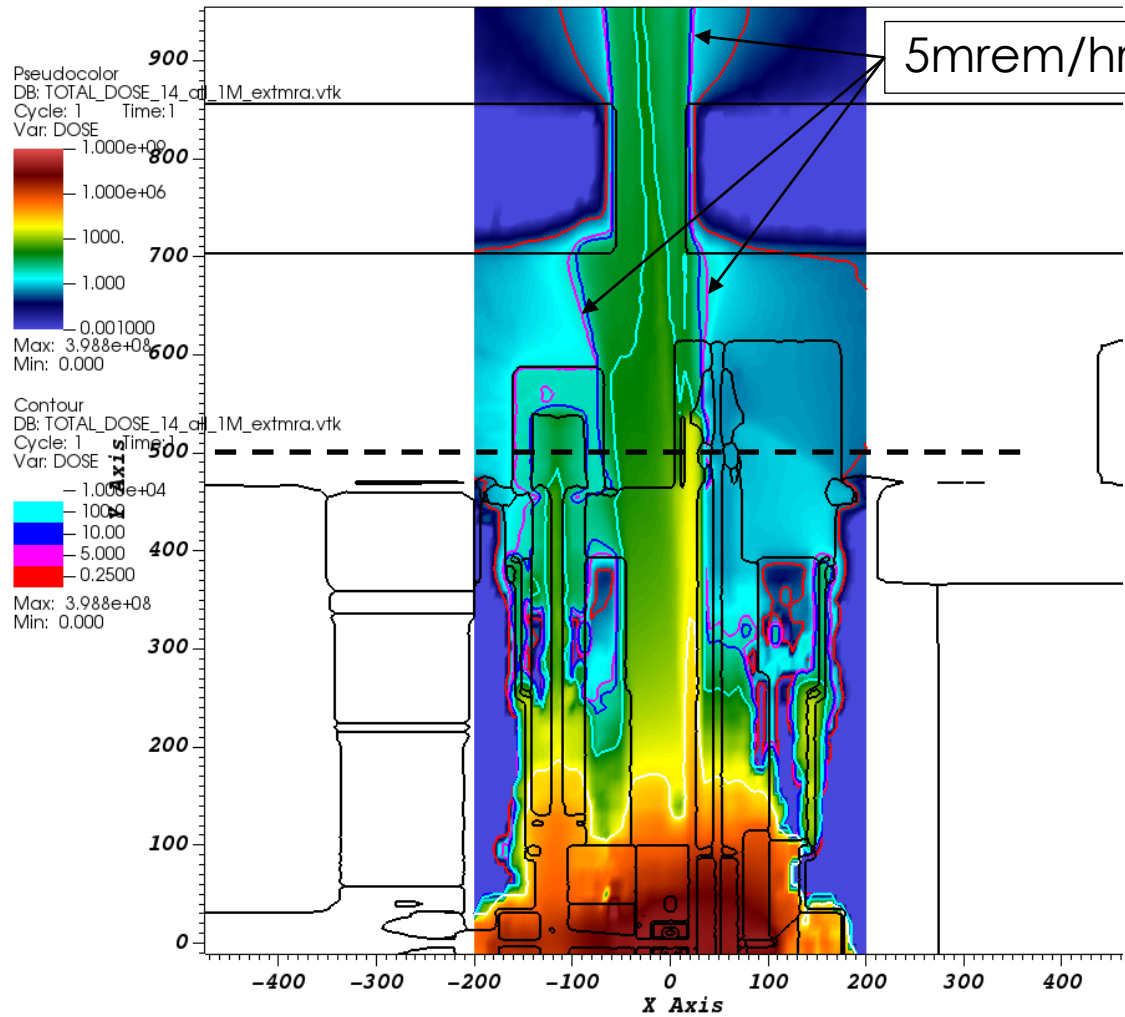
Preliminary MRA Procedure

***Assumes 3X target segment removal completed.**

- Remove roof plug to access MRA using high bay crane
- Rotate target drive shaft to align 3X segment void into MRA maintenance position.
- Fly in MRA shield block cask and then attach hoist to cask using high bay crane.
- Move sliding shield door out of the way
- Attach Ziplift grapple to shield block
- Retract shield block into the cask
- Move sliding shield door back to cover hatch
- Remove hoist and fly cask out of the way
- Repeat A/R for second shield block.



MRA Procedure–Neutronics Analysis–shield block removed



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Sun Mar 3 00:43:45 2024

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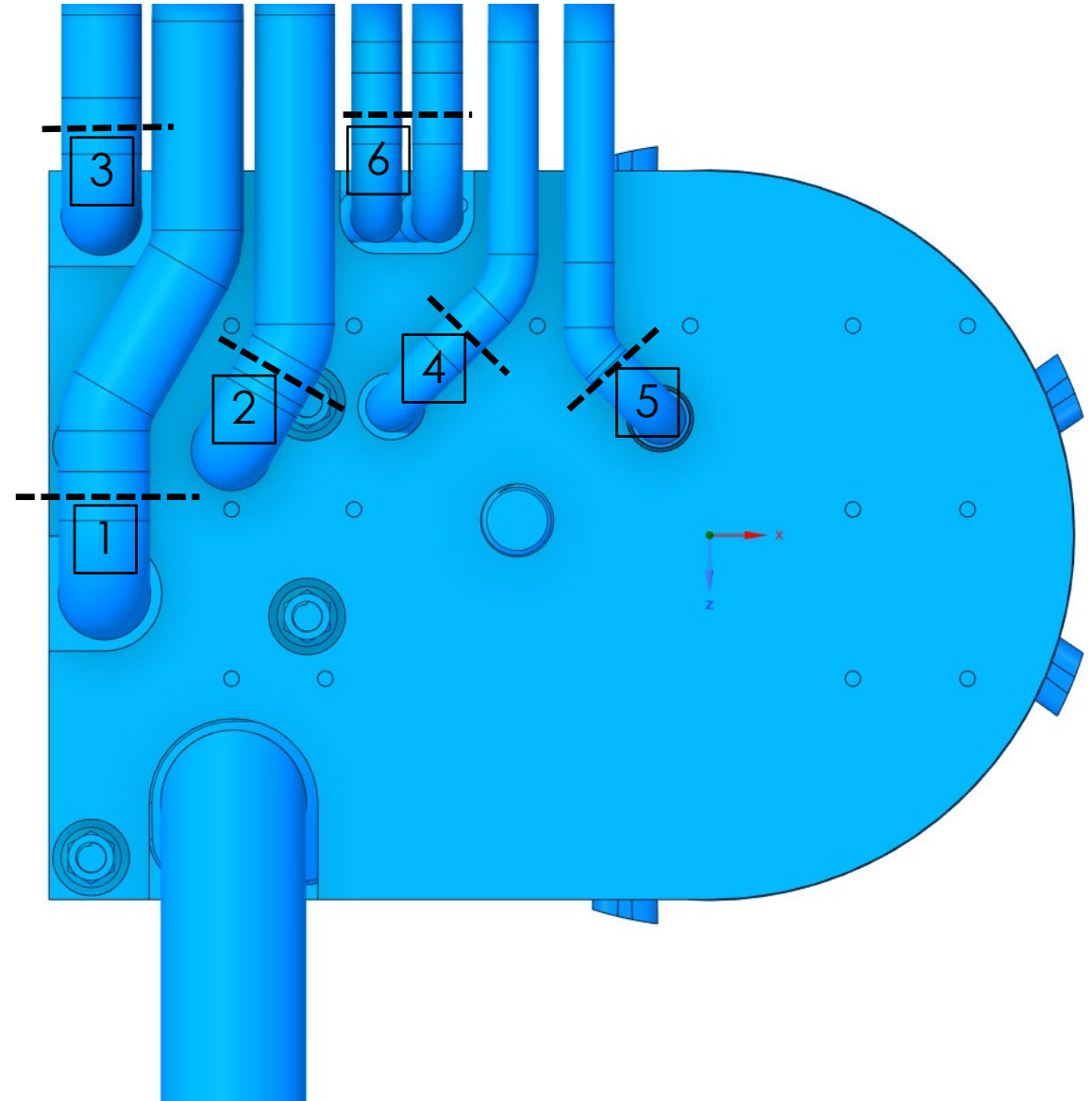
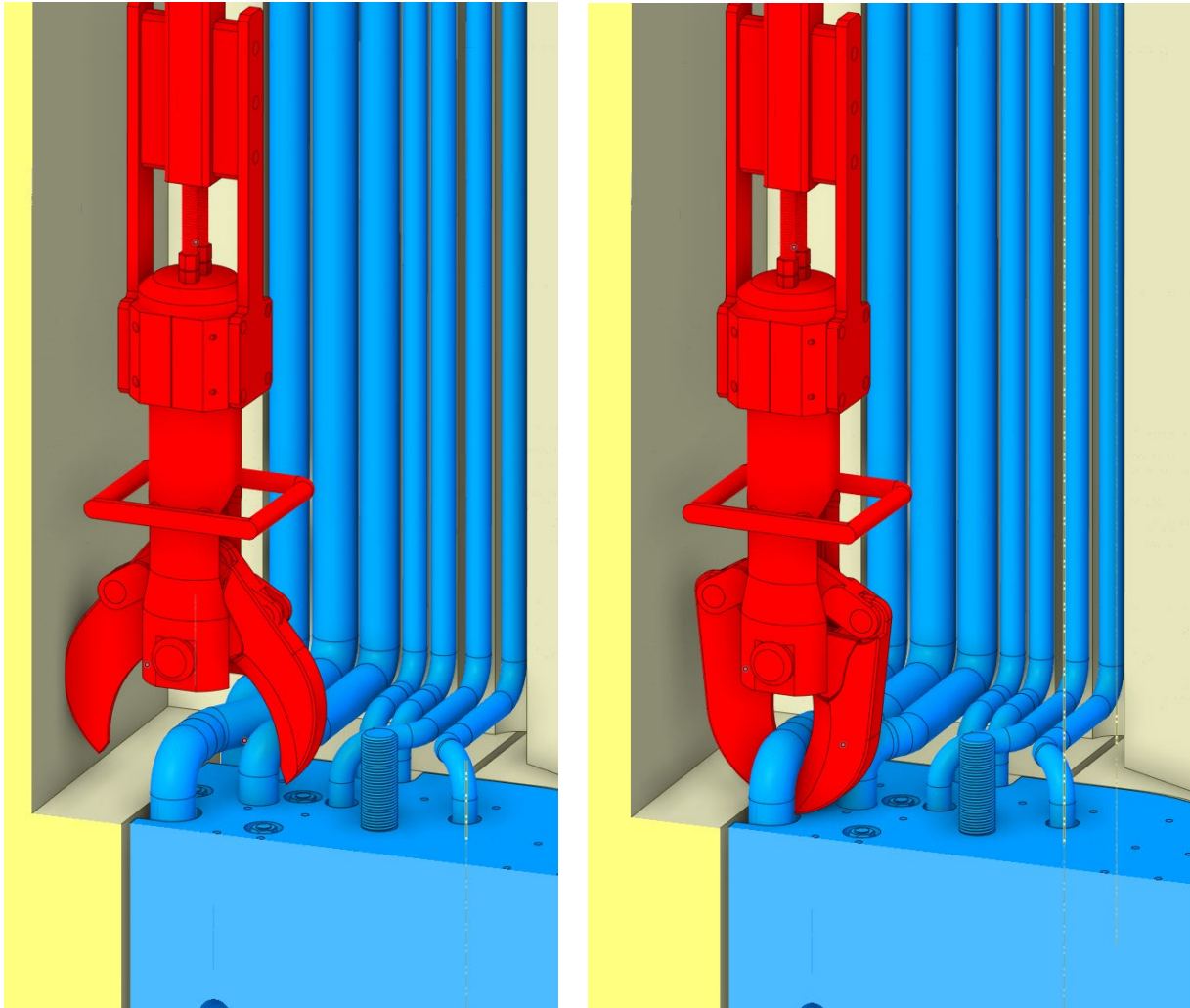
Nominal Operational Irradiation; 1 month decay

Preliminary MRA Procedure

- Fly in long reach hydraulic pipe cutter using high bay crane/aux hoist. Keep HPU staged at high bay floor. Route hoses as required.
(Personnel Accessible)

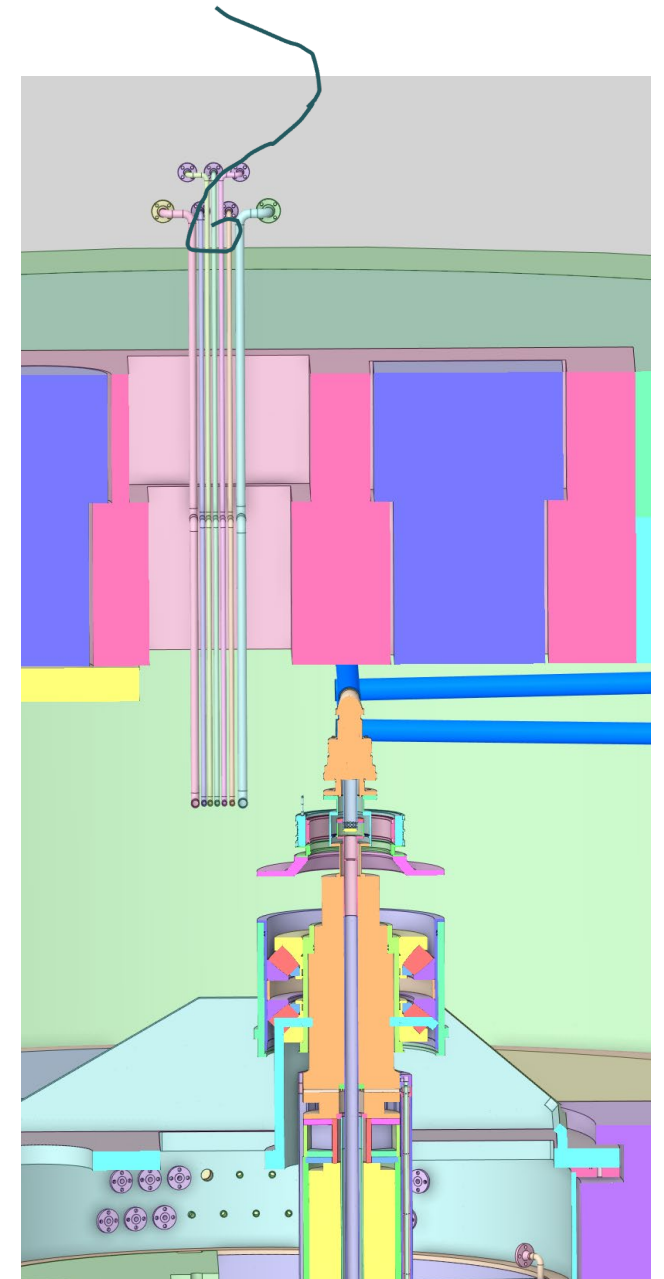


Preliminary MRA Procedure – Pipe Cutting Sequence

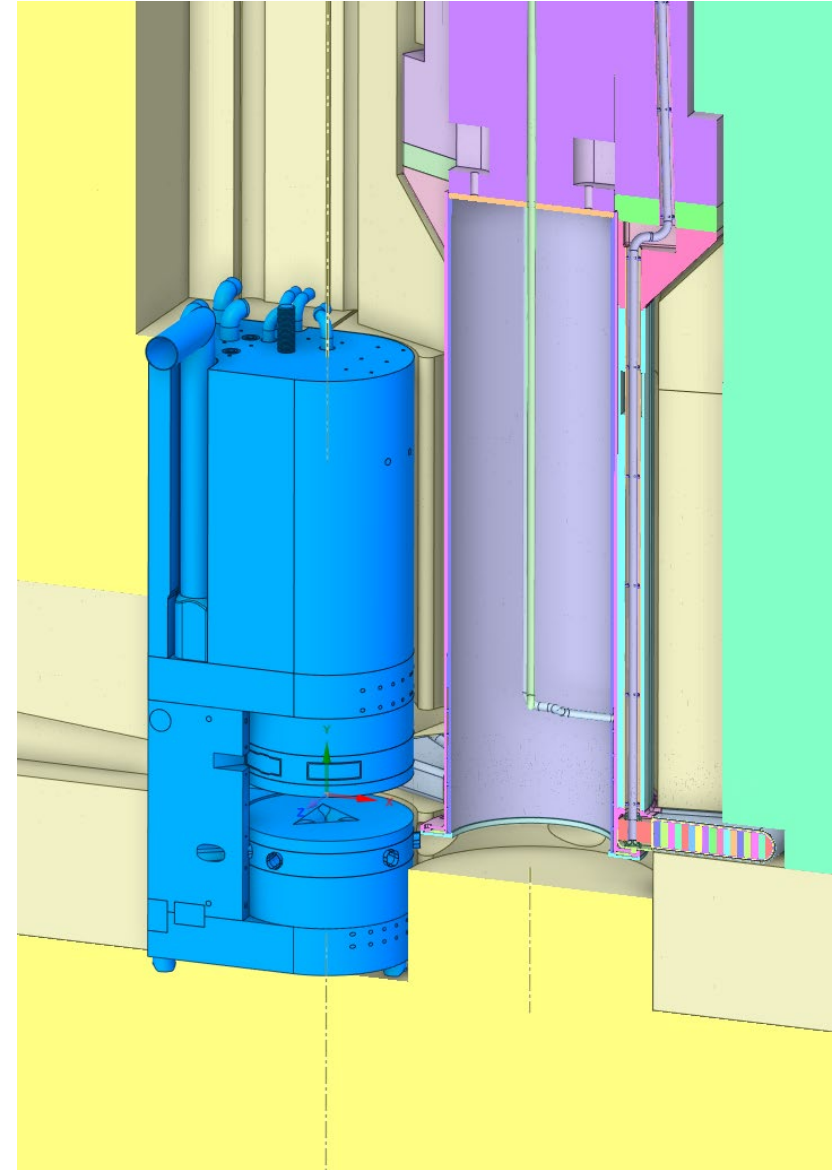
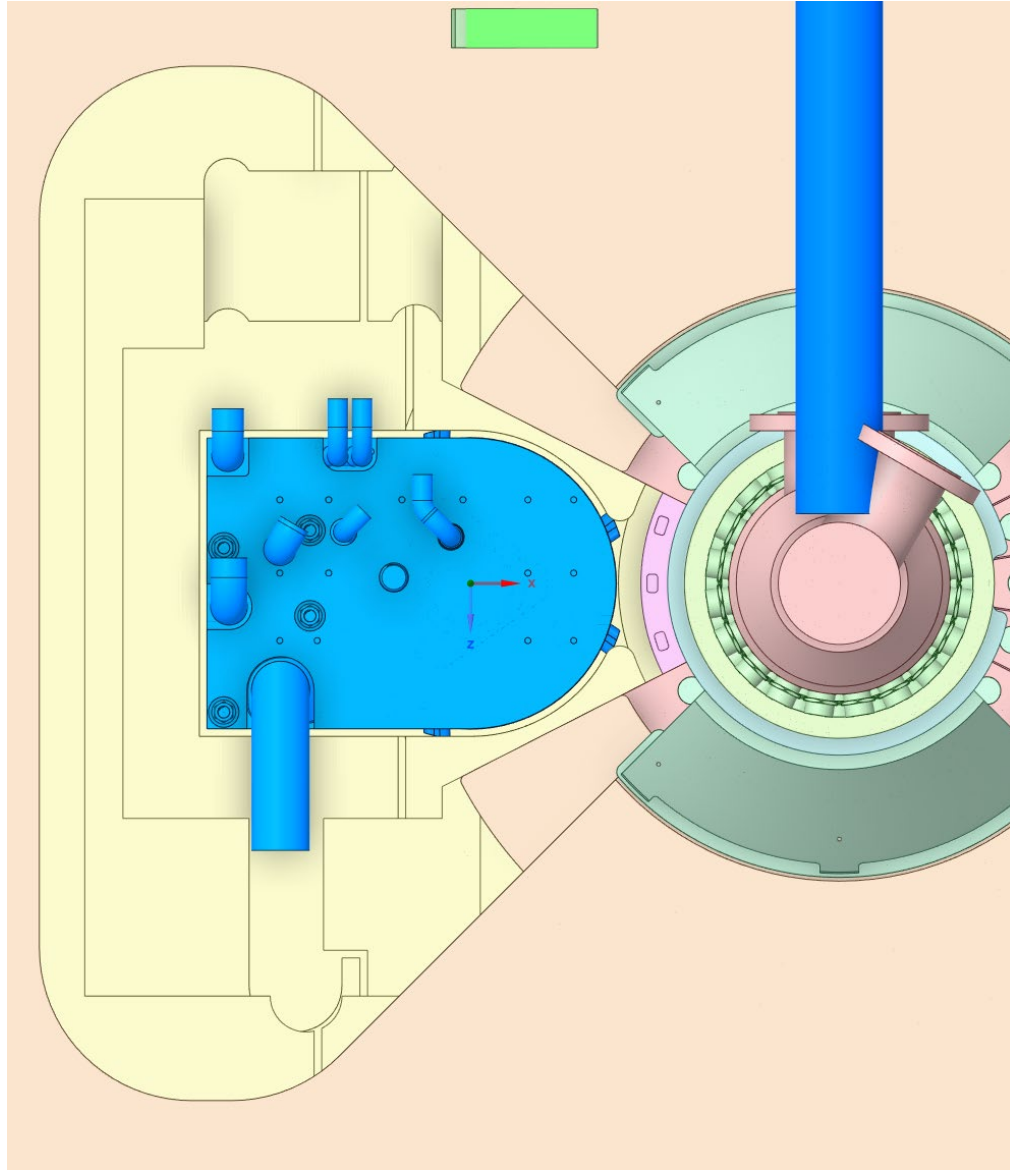


Preliminary MRA Procedure

- Cut water pipes and transfer lines and retract out of core vessel via previously attached strap/lanyard; using aux hoist on high bay crane (~30lbs ea water lines, ~30lbs transfer lines).
(Personnel Accessible)
- Retract long reach pipe cutter out of core vessel

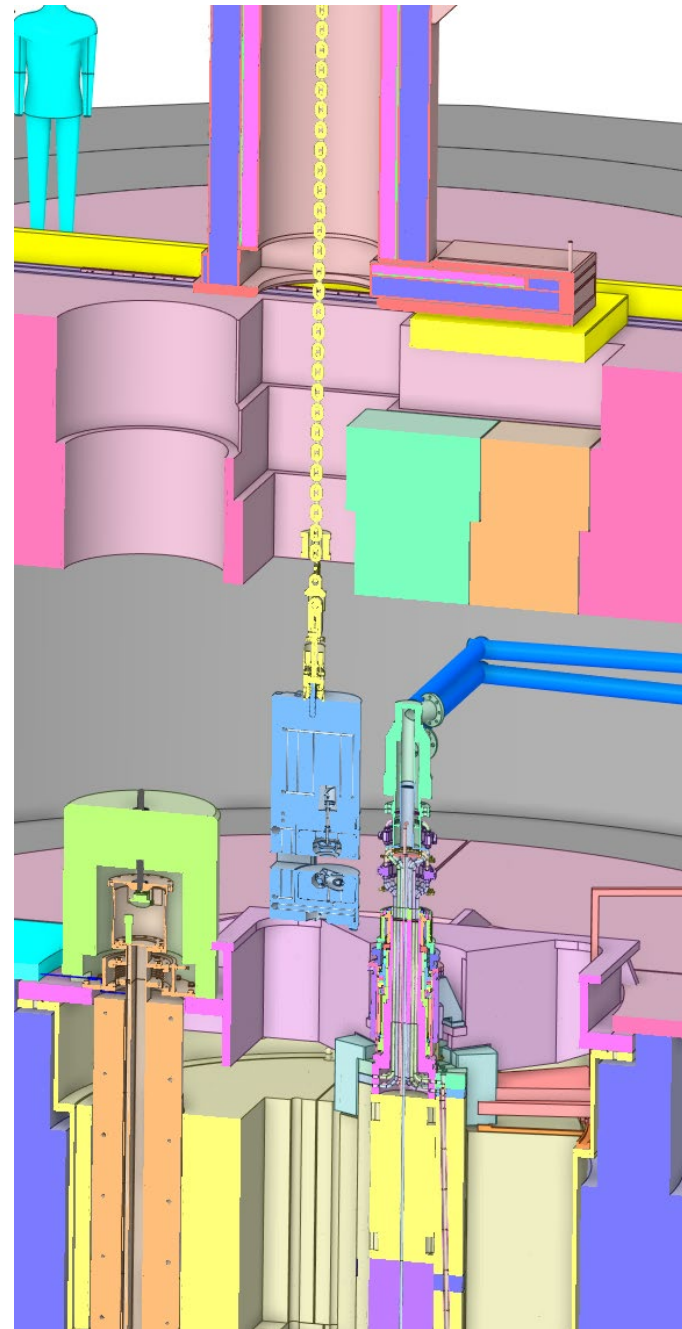


Preliminary MRA Procedure



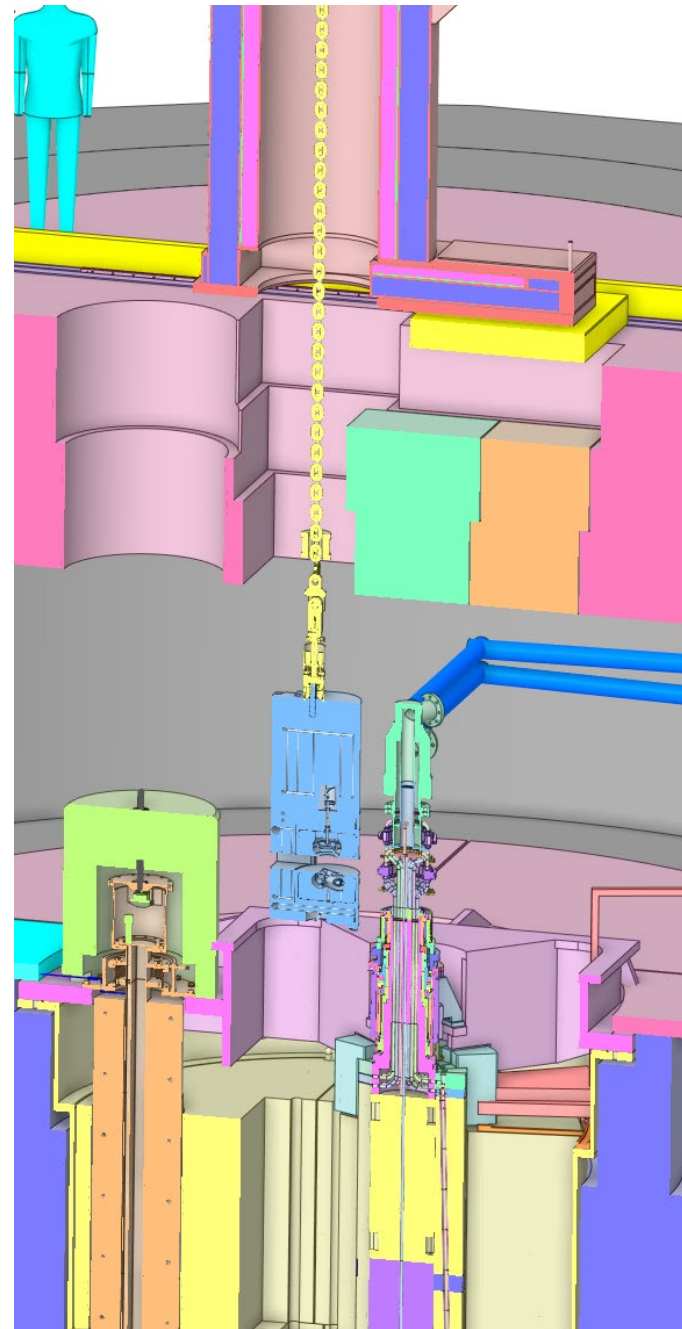
Preliminary MRA Procedure

- Move sliding shield door to cover opening
- Fly in MRA cask and attach hoist via high bay crane
- Open sliding shield door
- Raise MRA into the cask
- Close the sliding shield door
- Disconnect hoist and fly MRA cask away
- Repeat similar steps for new MRA installation

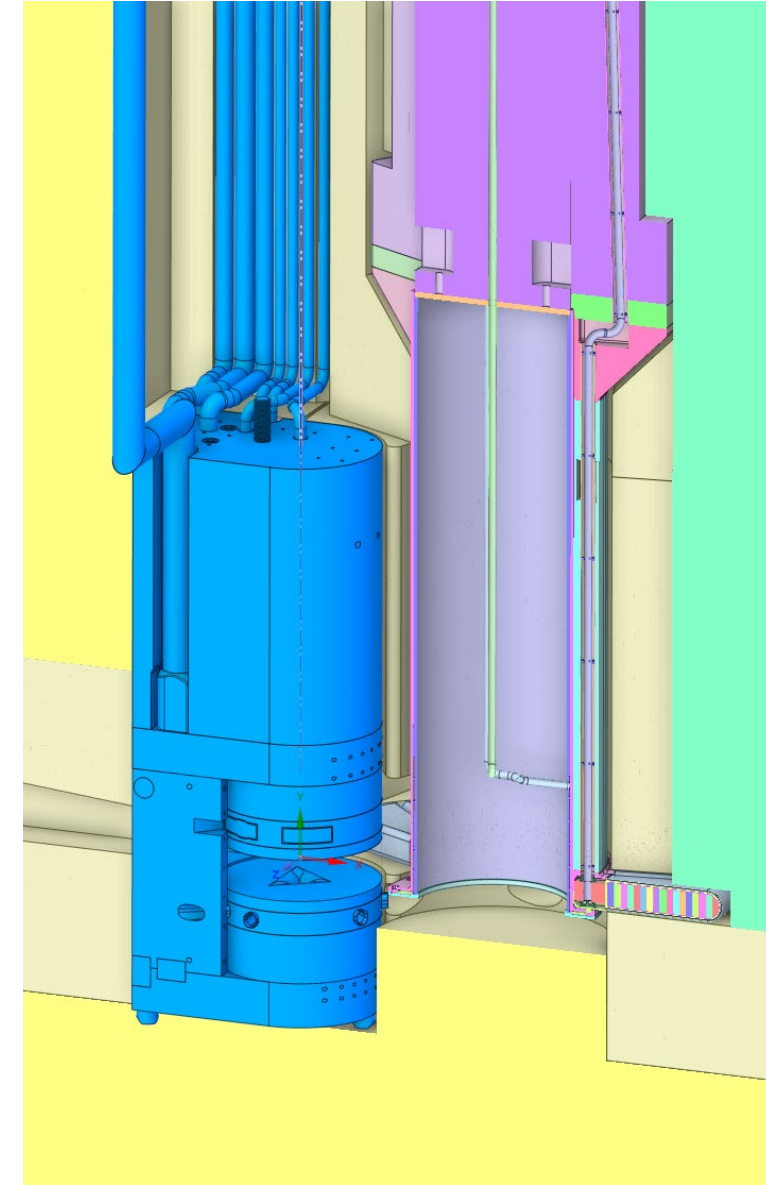
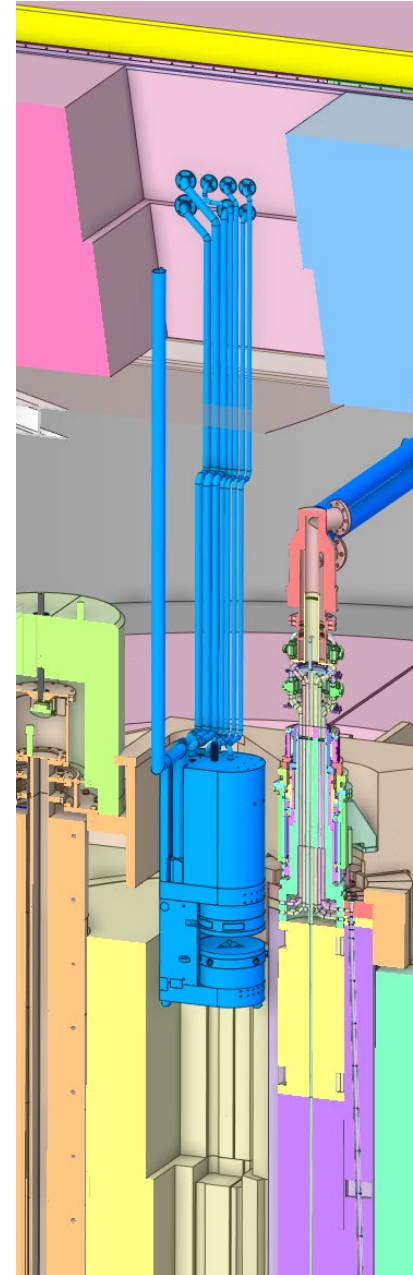
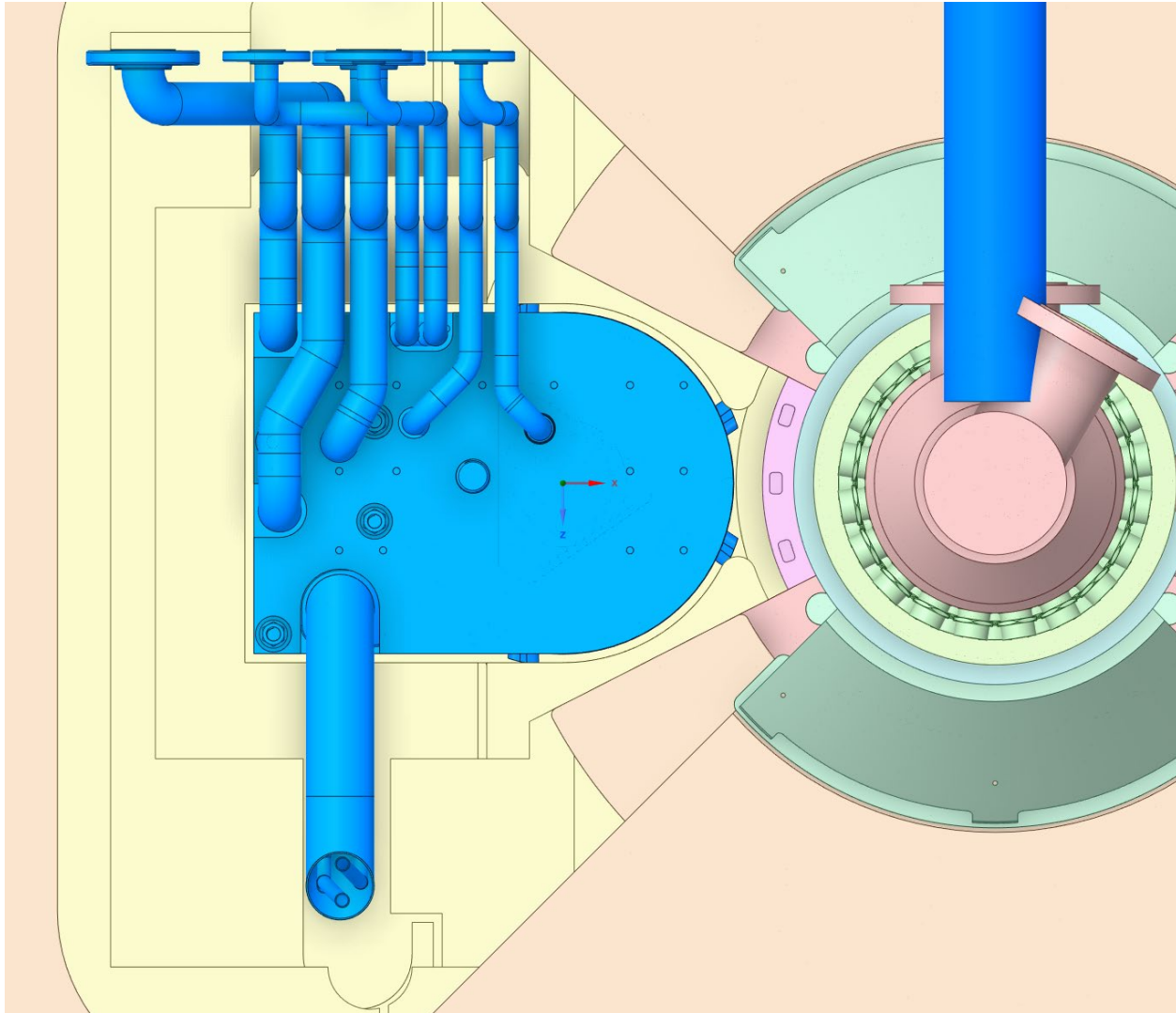


Preliminary MRA Procedure

- Current estimated cycle time for MRA removal and replacement: ~200-250 hours
 - Maintenance Prep, Remove CV lid: ~20hrs
 - Disconnect hydrogen & water lines: ~10hrs
 - Target Segments (3X) removal: ~30hrs
 - Shield blocks and MRA removal: ~40hrs
- MRA and shield blocks install: ~30hrs
- Connecting Hydrogen and water lines: ~24hrs
- Target Segments (3X) install: ~40hrs
- Button up CV: ~20hrs

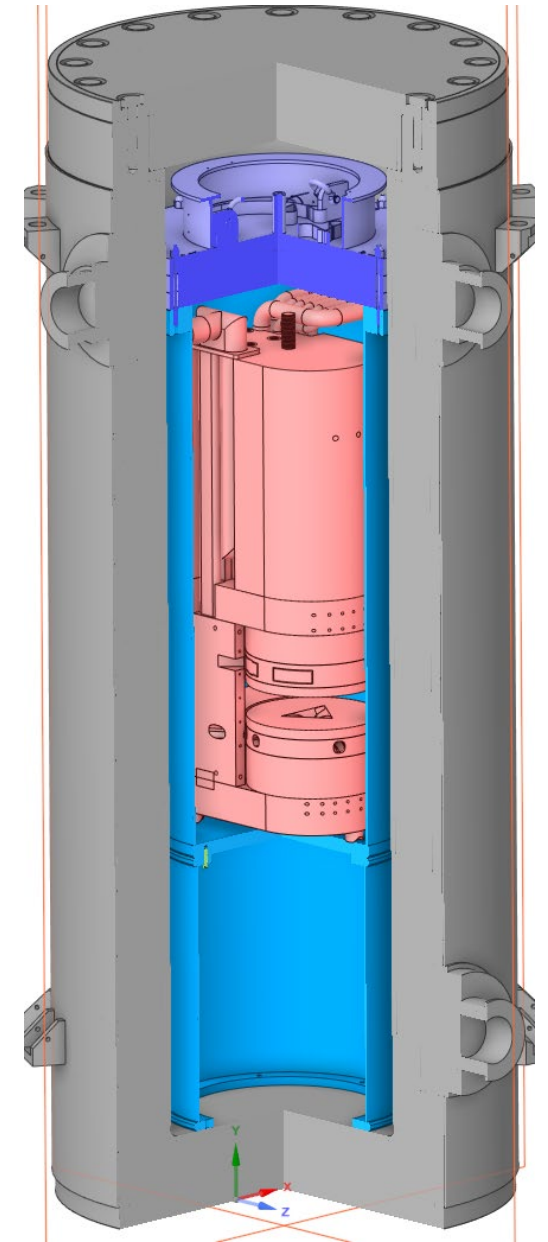


Preliminary MRA Procedure – Installation



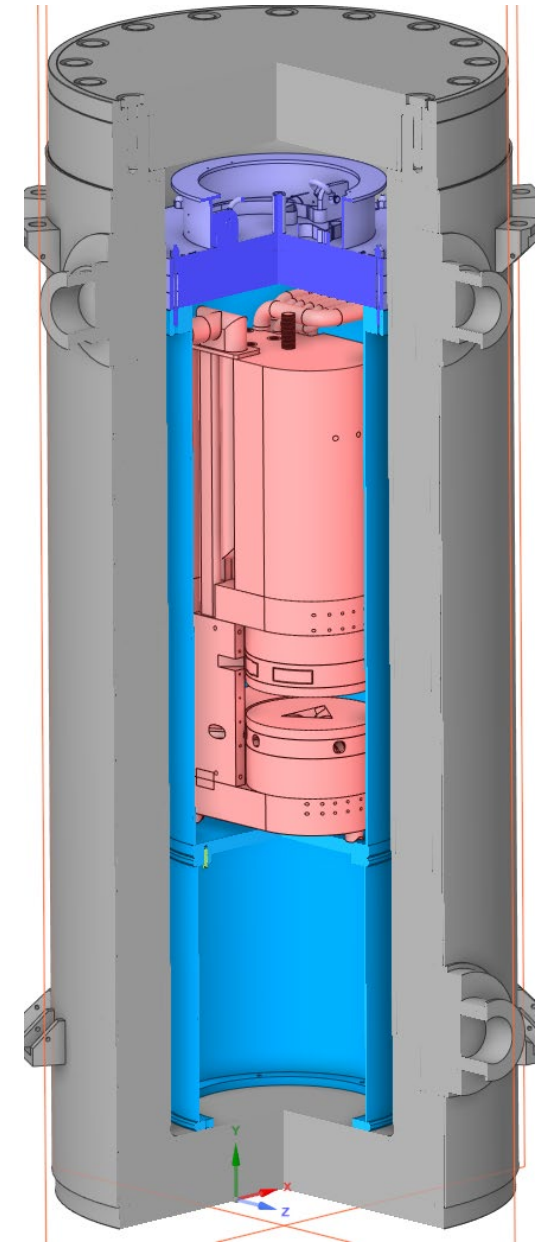
Preliminary MRA Disposal

- Plan to package spent MRA into a steel liner and then package liner into TN-RAM shipping cask
 - TN-RAM cavity size: $\text{Ø}35'' \times 111''$
 - Liner + lid size: $\text{Ø}34'' \times 107''$ to meet disposal site criteria
 - TN-RAM Payload Capacity: 9500lbs
 - Total activity $<30\text{kCi}$ of Co-60 or equiv
 - A2 fraction <3000
 - Avg Specific activity $<10\text{Ci/kg}$
 - Decay heat $<500\text{W}$
- Dose rate $<200\text{mrem/h}$ on TN-RAM surface
- Dose rate $<10\text{mrem/h}$ @ 1m from surface
- Dose rate $<2\text{mrem/h}$ @ truck cab



Preliminary MRA Disposal

- MRA characteristics for disposal assuming 1 year of decay time.
 - Class C-like waste per 10CFR61.55
 - MRA Weight ~ 5000lbs
 - Liner weight ~2900lbs
 - Total activity ~25kCi (not Co-60 or equiv)
 - Decay Heat <150W
- Dose rates on cask exterior for DOT shipment are achieved after ~12-16 weeks of decay



Preliminary MRA Removal & Installation Time Study

Normal Remove			Time Duratic
	Beam Off - Decay Time		8
Parallel	Vent CV, A/R.		4
	Remove hydrogen and make MRA inert	standard (hands-on) rigging	4
	Perform radiological survey		
	Lay Herculite on TDR floor and around Target Segment opening, A/R		2
	Disconnect sensors/wiring from outer target drive shroud		1
	Unbolt and remove shroud in two pieces		0.5
	Remove supplemental shielding from water pipes & other, A/R		2
	Perform radiological survey		
	Disconnect bellows from drive shaft and top plate		0.5
	Disconnect top plate from support structure		0.5
	Turn off main water supply to Loop 1		0
	Drain and partially blow down water supply down into crown		0.75
	Disconnect water supply and return jumper lines from target crown.		1
Parallel	Attach lifting apparatus to bellows assembly. Secure to TDR hoist		0.5
	Lift bellows over crown and transfer within TDR for storage		0.5
	Attach lifting apparatus to top plate. Secure to TDR hoist		0.5
	Lift top plate over crown and transfer with TDR for storage		0.5
	Reconnect main water supply and return jumper lines to crown. Re-establish water flow		1.5
	Remove high bay floor plugs, A/R		2
	Drain Loop 2 and perform partial blow down of target shield blocks and MRA water circuit		2
	Perform radiological survey		
	Manually disconnect target shield block water joint flange connection below CV lid		1
	Manually disconnect MRA water joint flange connections below CV lid		2
	Cut hydrogen transfer lines	rotary pipe cutter	2
	Attach lifting sttaps/lanyard to water pipes and transfer line		2
	Perform removal of 3X target segments		32.5
	Re-install target segment shield block into CV, A/R		4
	removal MRA roof plug		1
	Rotate drive shaft to position segment void for MRA removal		0.5
	Position shielded cask 1 adjacent to floor hatch	Overhead crane (50T), shackles, slings	1
	Unbolt cask bottom plate.		0.25
	Lift cask and transfer above floor hatch.		0.5
	Attach portable hoist to shielded cask		1
	Lower chain from hoist and attach Ziplift grapple to lifting stud on fixture	remote tooling	0.5
	Retract Shield Block 1 into cask	Hoist Assy (13T), Ziplift	0.5
	Manually engage cask support pins		0.25
	Disconnect Ziplift from shield block. Unrig and remove hoist.		0.5
	Install Cask lid	Overhead crane (50T), hoist rings	0
	Rig cask to overhead crane		0.5
	Lift cask and position on bottom plate. Secure together		0.5
	Transfer cask-shield block to laydown area in high bay	Overhead crane (50T), Ziplift	0.5
	Repeat steps above to remove 2nd shield block		6
	Perform radiological survey		
	Rig long reach hydraulic pipe cutter to crane		0.25
	Make all hydraulic pipe cutter/HPU connections. Position HPU in high bay		0.5
	Transfer pipe cutter and lower into core vessel.		0.5
	Cut hydrogen transfer line		1
	Extract cut transfer line out of core vessel to TDR or high bay		0.5
	Cut water pipes in prescribed sequence. Remove section after each cut. (6X)		8
	Retract pipe cutter out of core vessel/TDR. Disconnect HPU.		0.5
	Transfer pipe cutter to storage in high bay		0.5
	Position MRA shielded cask above floor hatch	Overhead crane (50T), shackles, slings	1

Normal Install			
	Prep MRA in vertical orientation in high bay		1
	Perform radiological survey		
	Rig to MRA. Attach Ziplift		
	Lower MRA into core vessel		1
	Perform survey & alignment of new MRA		8
	Disconnect Ziplift from MRA. Unrig and remove XXXX		0.5
	Position shield block cask 2 adjacent to floor hatch	Overhead crane (50T), shackles, slings	1
	Unbolt cask bottom plate.		0.5
	Lift cask and transfer above floor hatch.		0.5
	Remove Cask lid	Overhead crane (50T), hoist rings	0
	Attach portable hoist to shielded cask		1
	Lower chain from hoist and attach Ziplift grapple to lifting stud on shield block		0.25
	Slightly raise Shield Block 2 inside cask	Hoist Assy (13T), Ziplift	0.25
	Manually disengage cask support pins		0.25
	Lower shield block 2 into core vessel		0.75
	Disconnect Ziplift from shield block. Unrig and remove hoist.		0.5
	Rig cask to overhead crane		0.5
	Lift cask and position on bottom plate. Secure together		0.5
	Transfer cask to laydown area in high bay	Overhead crane (50T), Ziplift	0.5
	Repeat steps above to install other shield block		6
	Rotate drive shaft to position segment void for new segment install		0.5
	Perform radiological survey		
	Perform install of 3X target segments		
	Manually connect water supply and return flange connections beneath CV lid		4
	Leak test each connection joint		4
	Manually connect transfer lines via welding		8
	Leak test welded joints		8
	Turn on main water supply to Loop 2; fill MRA circuit		0.5
	Turn on hydrogen supply; fill MRA		0.5

Preliminary Waste Disposal Data

					10 year operation, 1250 (~2mo) decay				10 year operation, 1 year decay					
Table 1					10CFR61.55 Limits									
		Ci/m3	0.1Ci/m3		Activity	Total	Concentration	Waste						
						Ci	Ci/m3*	Class						
C-14 in activated metal		80	8		C-14	6.76E-03	8.76E-03	A	A	A	C-14	6.76E-03	8.76E-03	A
Ni-59 in activated metal		220	22		Ni-59	2.66E+00	3.44E+00	A	C	B	Ni-59	2.66E+00	3.44E+00	A
Nb-94 in activated metal		0.2	0.02		Nb-94	3.03E-03	3.93E-03	A			Nb-94	3.03E-03	3.93E-03	A
Tc-99		3	0.3		Tc-99	7.68E-02	9.94E-02	A			Tc-99	7.68E-02	9.94E-02	A
I-129		0.08	0.008		I-129	0	0.00E+00				I-129	0	0.00E+00	
Total alpha >5y t1/2	nCi/g	100	10		Tot alpha	5.16E-02	2.19E+01	C			Tot alpha	5.80E-02	2.46E+01	C
Pu-241	nCi/g	3500	350		Pu-241	2.64E+00	1.12E+03	C			Pu-241	2.53E+00	1.07E+03	C
Cm-242	nCi/g	20000	2000		Cm-242	9.29E-01	3.94E+02	A			Cm-242	2.45E-01	1.04E+02	A
Table 2					Activity				Activity					
		Ci/m3	Ci/m3	Ci/m3	Total	Concentration	Waste	Total	Concentration	Waste	Total	Concentration	Waste	
		col 1 (A)	col 2 (B)	col 3 (C)	Ci	Ci/m3*	Class	Ci	Ci/m3*	Class	Ci	Ci/m3*	Class	
Total < 5y t1/2		700	no limit	no limit	Total	1.89E+04	2.45E+04	B	Total	9.07E+03	1.17E+04	B	Total	
H-3		40	no limit	no limit	H-3	7.77E+03	1.01E+04	B	H-3	7.41E+03	9.59E+03	B	H-3	
Co-60		700	no limit	no limit	Co-60	9.71E+03	1.26E+04	B	Co-60	8.68E+03	1.12E+04	B	Co-60	
Ni-63 in activated metal		35	700	7000	Ni-63	3.17E+02	4.11E+02	B	Ni-63	3.16E+02	4.09E+02	B	Ni-63	
Sr-90		0.04	150	7000	Sr-90	4.43E-03	5.73E-03	A	Sr-90	4.34E-03	5.61E-03	A	Sr-90	
Cs-137		1	44	4600	Cs-137	0	0.00E+00		Cs-137	0	0.00E+00		Cs-137	
					Total decay heat =	175.125 W	*uses waste form volume (liner volume)		Total decay heat =	140.167 W	*uses waste form volume (liner volume)			
					Total activity =	36731.5 Ci			Total activity =	25502.4 Ci				

Preliminary Waste Disposal Data

Table 6. MRA Cask Lead Thickness to Achieve 10.00 mrem/hr

Decay Time (weeks)	Lead Thickness for 10.00 mrem/hr					
	Negative X cm	Positive X cm	Negative Y cm	Positive Y cm	Negative Z cm	Positive Z cm
1	15.54	14.08	15.12	8.50	13.17	13.29
2	15.24	13.77	14.82	8.22	12.85	12.93
3	15.05	13.59	14.66	8.06	12.70	12.77
4	14.93	13.43	14.53	7.95	12.57	12.64
5	14.84	13.27	14.39	7.85	12.44	12.51
6	14.75	13.12	14.26	7.77	12.31	12.37
9	14.50	12.82	13.93	7.54	11.97	12.00
12	14.24	12.58	13.71	7.30	11.76	11.78

TN-RAM cask contains 5.88" thick lead walls encased by ¾" steel plate on the interior and 1.5" steel plate on the exterior.

Max lead thickness required to shield to 10mrem/hr on contact after 12 weeks of decay time is 14.24cm (5.61").