Oak Ridge National Laboratory

August 11,2026| Oak Ridge, TN

MRA Interfaces

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U.S. DEPARTMENT of ENERGY

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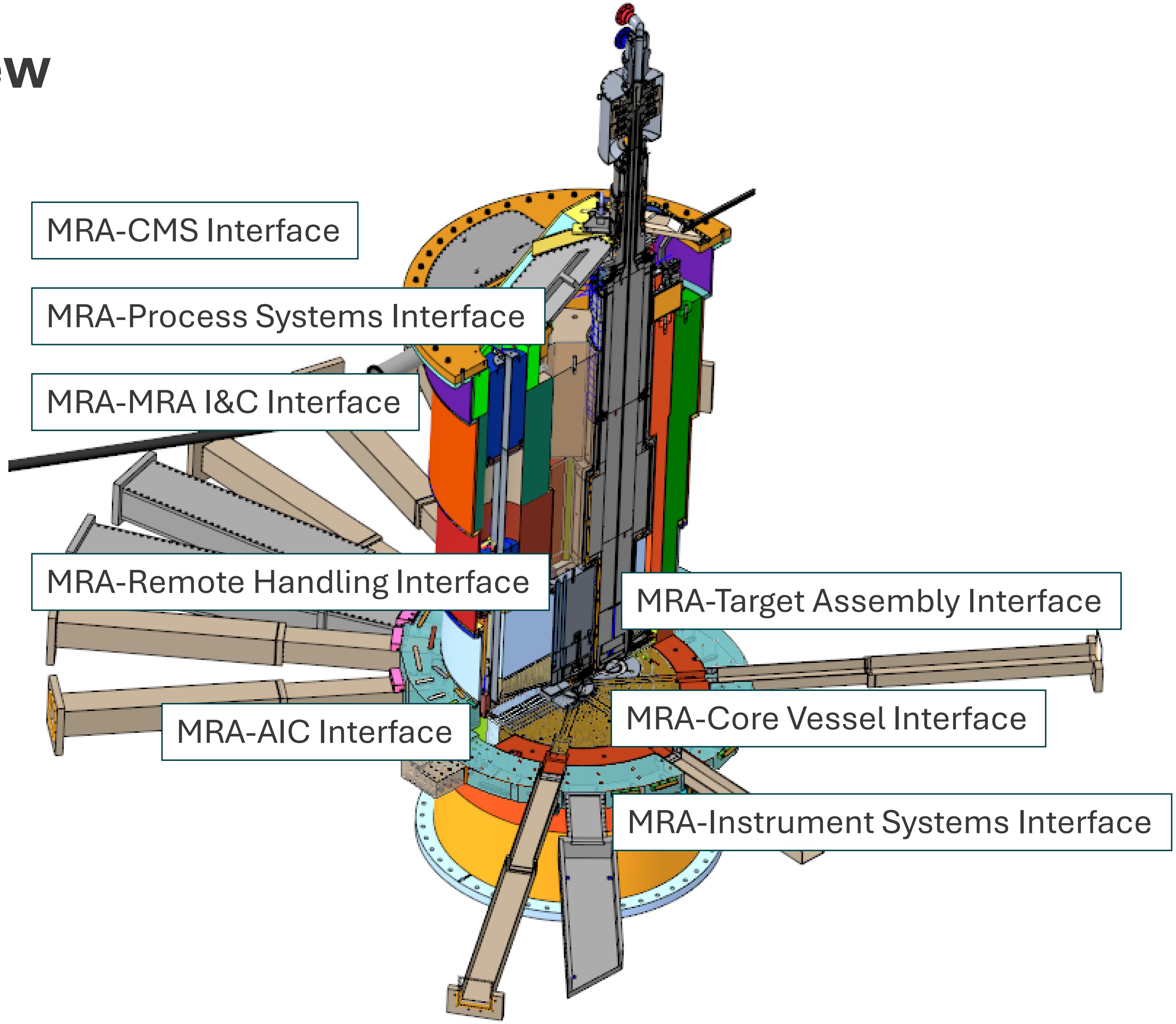
MRA Interface Overview

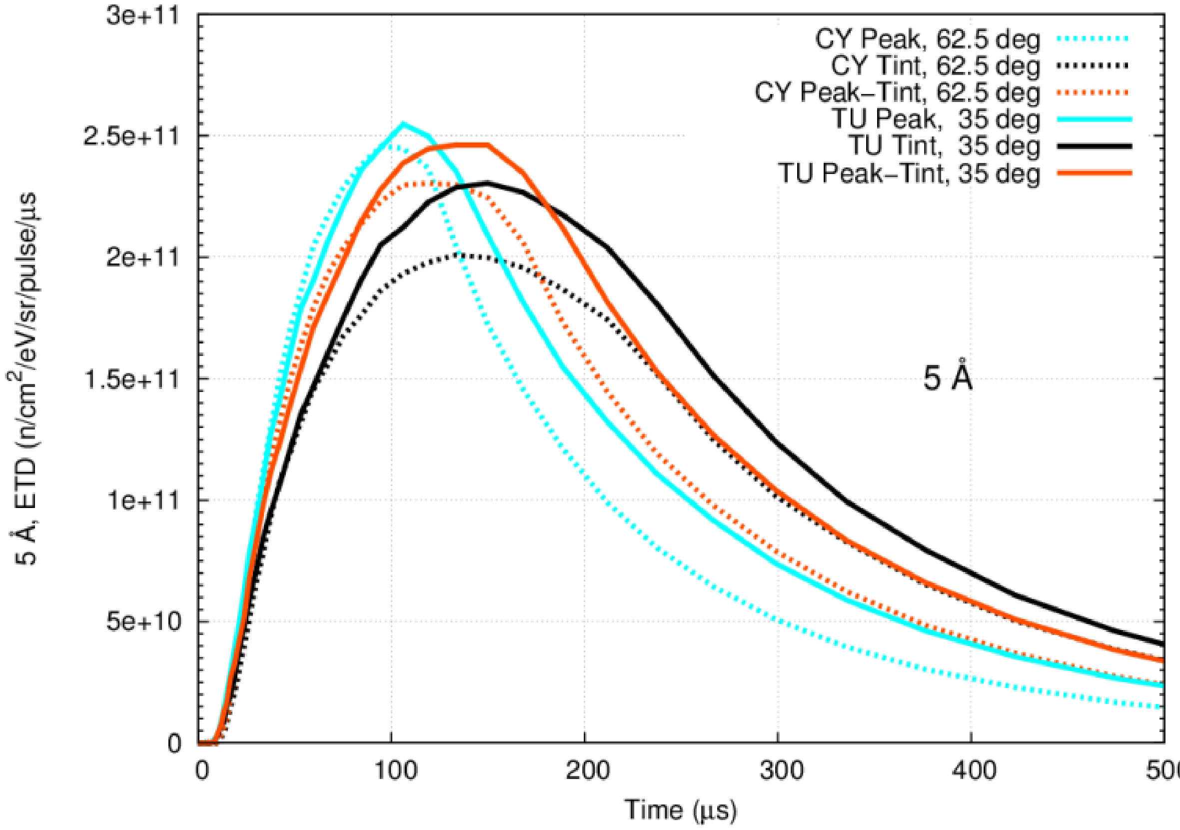
- MRA interfaces defined in 8 Interface Sheets
    - 6 Target Systems
    - 1 Instrument Systems
    - 1 ICS
- Interface sheets cover many aspects
    - Physical
    - Process
    - Clearance
    - Scope



MRA-Instrument Systems Interface Overview

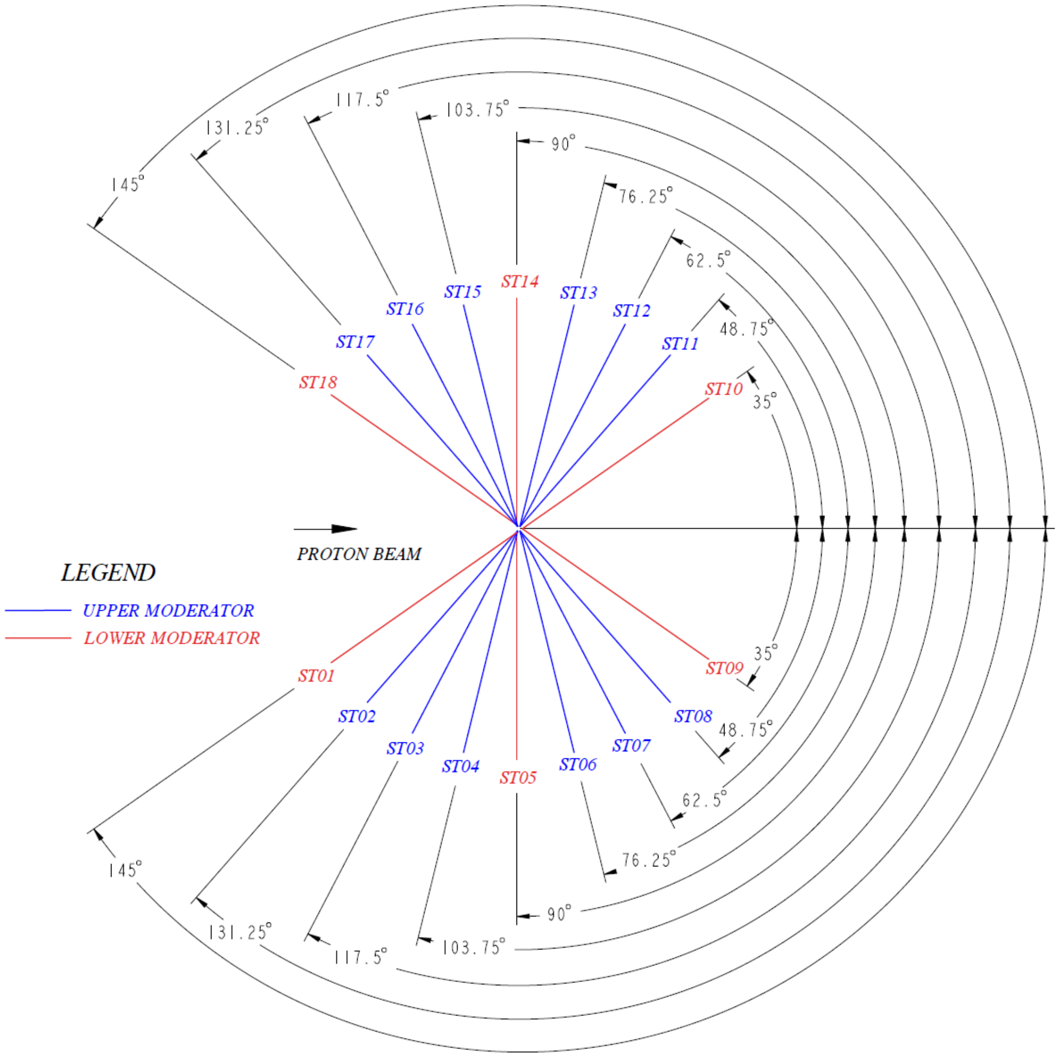
- Defines beamline layout and neutron beam characteristics for STS facility
  - Collaboration between Target Systems and Instrument Systems
- Characteristic moderator size chosen by Instrument Systems at 30 mm
  - Decision considered brightness, flux, guide illumination and sample size
- Instrument Systems chose preferred moderator optimization blend from peak, peak and time integrated, and time integrated optimizations
  - Peak and time integrated chosen

Emission Time Distribution for Peak, Peak and Time Integrated, and Time Integrated Optimized Moderators



MRA-Instrument Systems Interface Beamline Layout

- Beamline layout balances total number of beamlines, angular spacing between beamlines, and moderator design
  - Decisions made at a project level
  - Beamline layout fixed in 2024
  - Dual beamlines defined for ST02, ST15 and ST16



Final STS Beamline Layout

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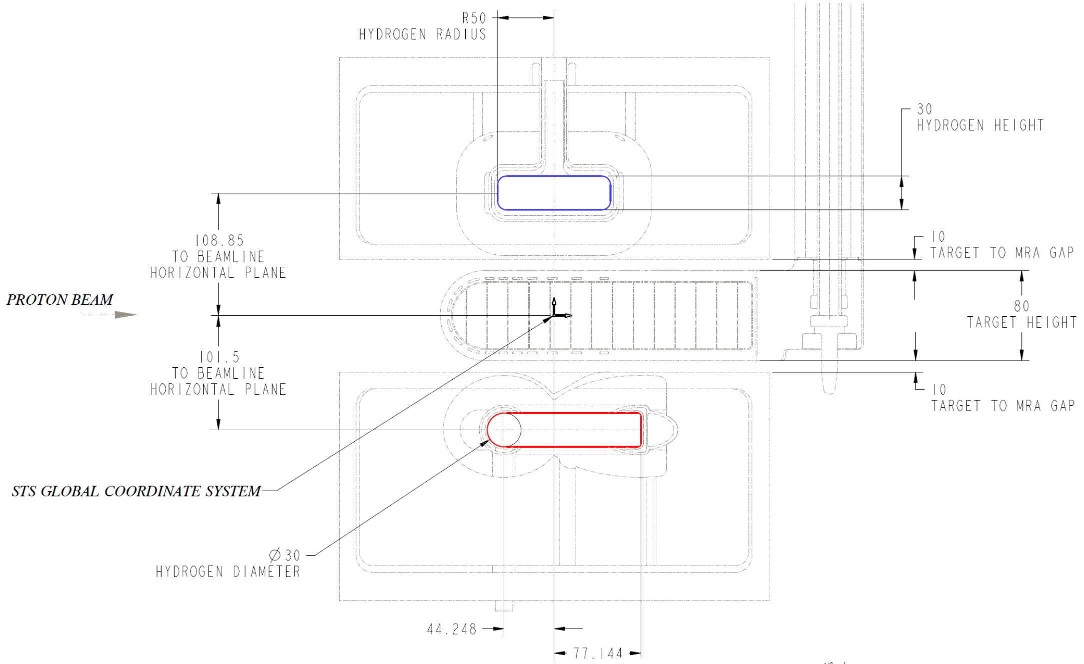
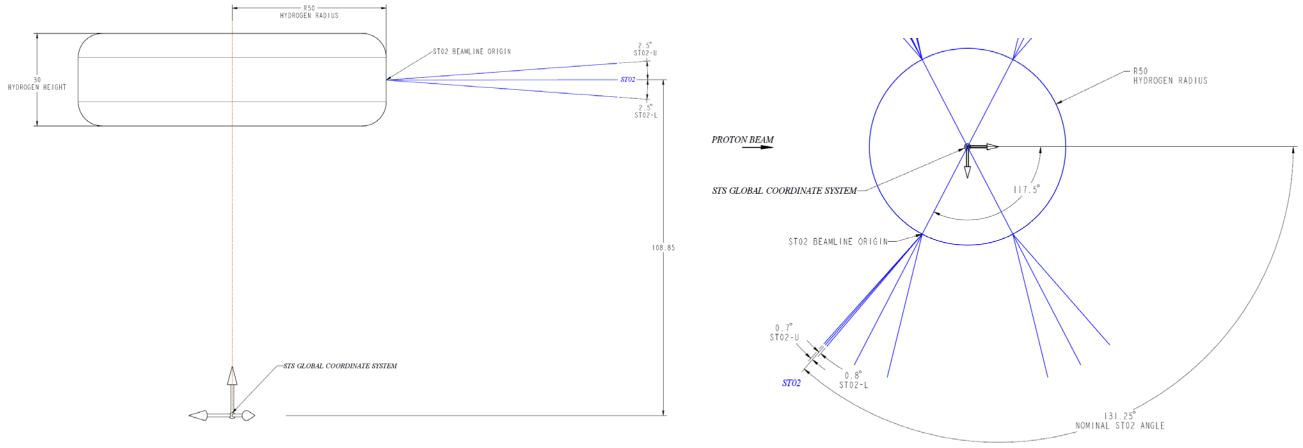
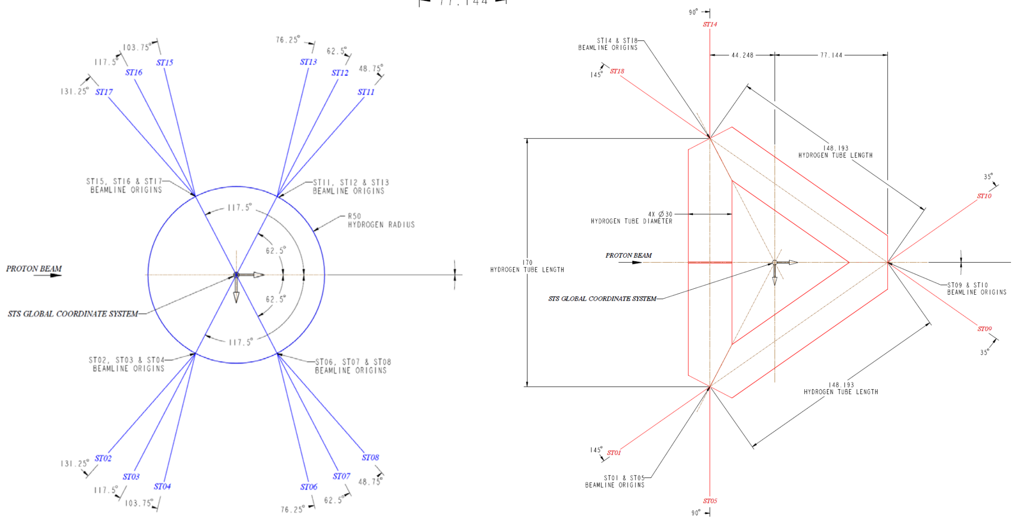
MRA-Instrument System Interface Moderator Layout

- Beamline origin locations defined for all beamlines
    - Locations based on MRA and Target engineering
- Dual beamlines defined for ST02, ST15, and ST16





ST02 Dual Beamline Definition



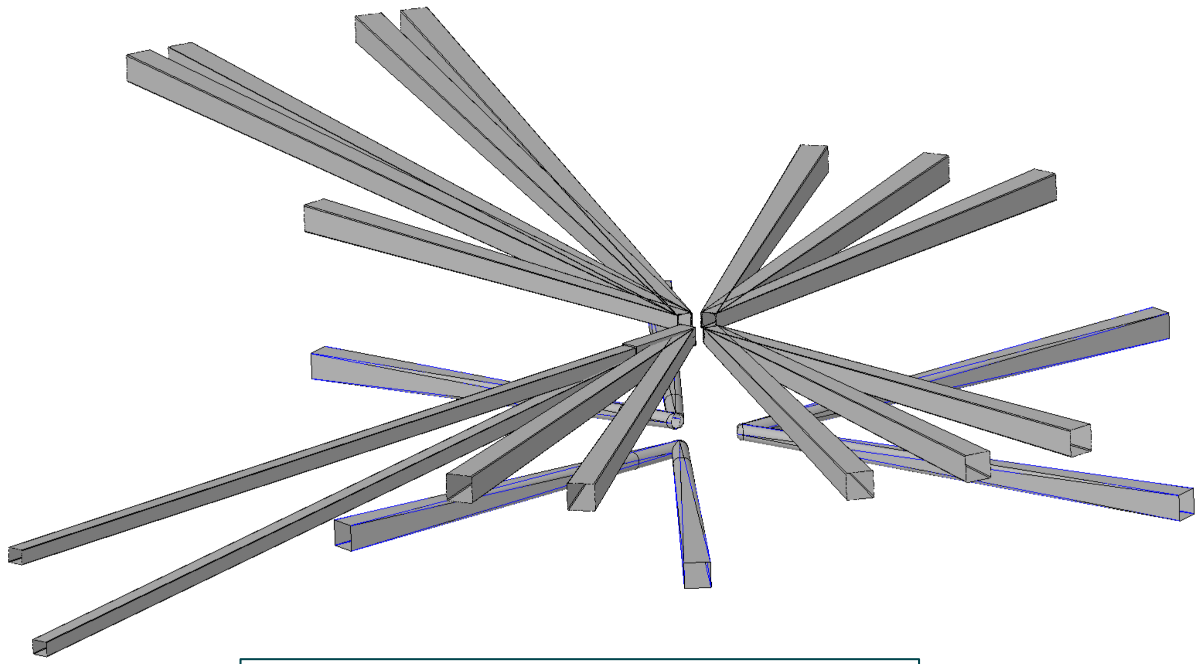
Final Beamline Origin Definitions

MRA-Instrument Systems Beamline Flight Path Definition

- Beamline guide entrance sizes and distances determine nominal flight paths from moderators to the guide entrances

Guide Entrance Geometry Table

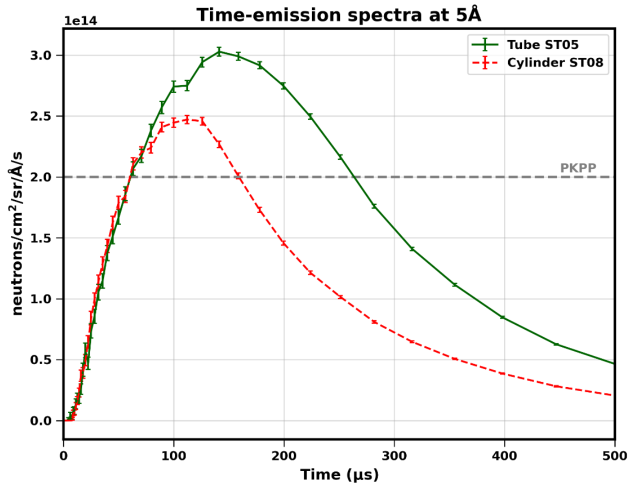
Beamline	Angle from Proton Beam	Moderator	Viewed Area Geometry	Nominal Guide Entrance Geometry	Nominal Guide Entrance Distance
ST01	-145°	Lower	Ø30mm Circle	50mm Square	805.6mm
ST02	-131.25°	Upper	30mm Square	See 5.2.2.1	2000mm
ST03	-117.5°	Upper	30mm Square	50mm Square	1018mm
ST04	-103.75°	Upper	30mm Square	50mm Square	1018mm
ST05	-90°	Lower	Ø30mm Circle	50mm Square	805.6mm
ST06	-76.25°	Upper	30mm Square	50mm Square	1018mm
ST07	-62.5°	Upper	30mm Square	50mm Square	1018mm
ST08	-48.75°	Upper	30mm Square	50mm Square	1018mm
ST09	-35°	Lower	Ø30mm Circle	50mm Square	1003mm
ST10	35°	Lower	Ø30mm Circle	50mm Square	1003mm
ST11	48.75°	Upper	30mm Square	50mm Square	1018mm
ST12	62.5°	Upper	30mm Square	50mm Square	1018mm
ST13	76.25°	Upper	30mm Square	50mm Square	1018mm
ST14	90°	Lower	Ø30mm Circle	50mm Square	805.6mm
ST15	103.75°	Upper	30mm Square	50mm Square	2000mm
ST16	117.5°	Upper	30mm Square	50mm Square	2000mm
ST17	131.25°	Upper	30mm Square	50mm Square	1018mm
ST18	145°	Lower	Ø30mm Circle	50mm Square	805.6mm

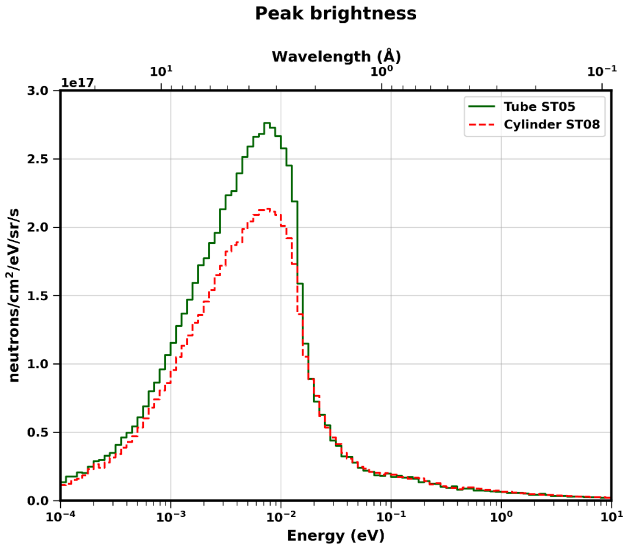


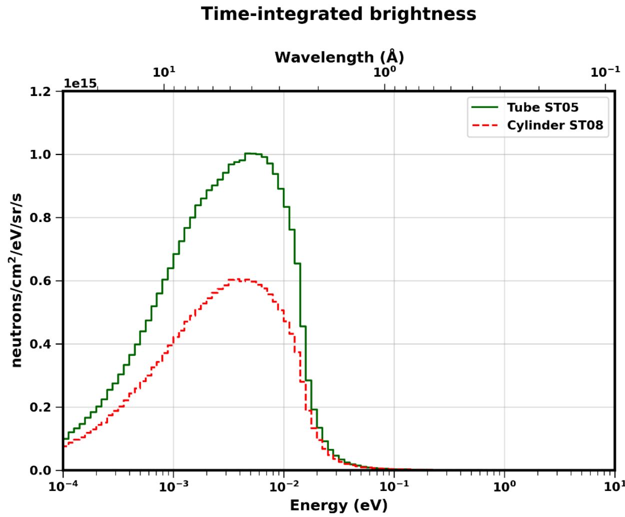
Beamline Nominal Flight Paths

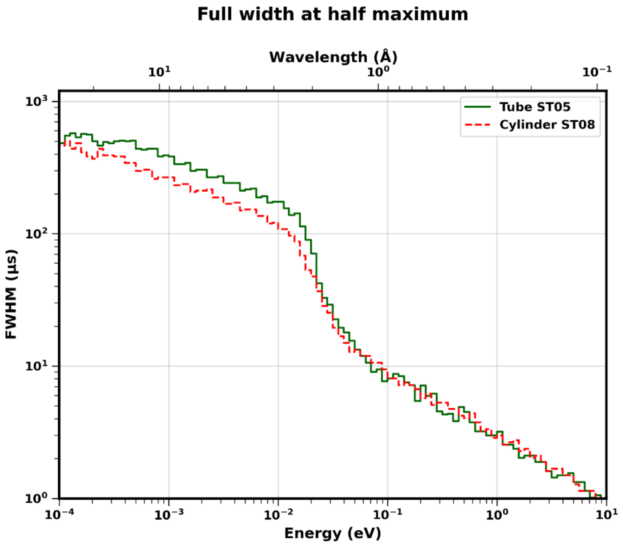
MRA-Instrument System Neutron Beam Characteristics

- Plots provided to described characteristics of neutron beams to be delivered to Instrument Systems
  - Time emission spectra (2-10Å)
  - Peak brightness plots
  - Time averaged brightness plots
  - FWHM of ETD plots

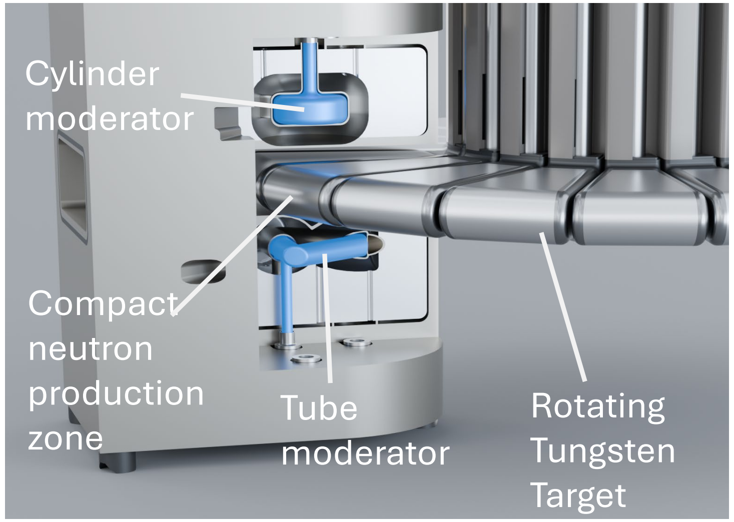




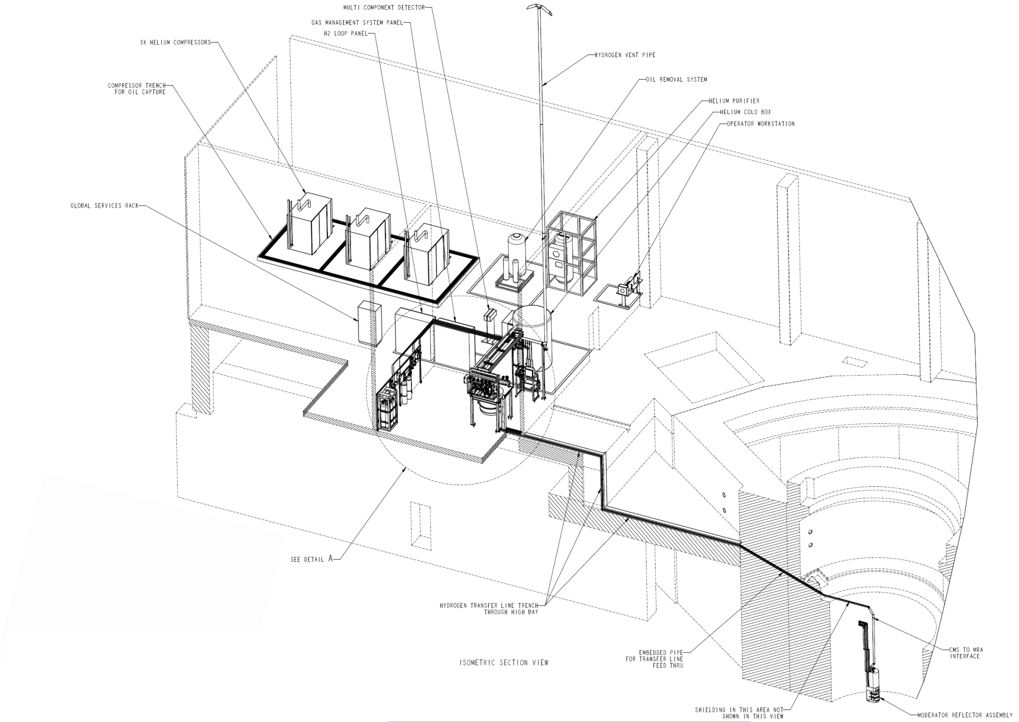




MRA-Cryogenic Moderator System Interface



- CMS purpose is to supply liquid hydrogen to the 2 moderators such that the hydrogen state within the moderators is maintained for acceptable neutronics performance given the neutronic heating of the hydrogen and surrounding structures by the proton beam
- Defines expected hydrogen properties, required hydrogen properties, physical interface, and scope assignment of shared analyses
    - Approved by neutronics to verify defined hydrogen properties
- Moderator hydrogen properties determined by both CMS delivered hydrogen and MRA design
    - Requires close coordination



MRA-CMS Layout

MRA-CMS Hydrogen Properties Requirements

Expected Hydrogen Properties Table

Location	Inlet Temperature (K)	Inlet Pressure (bara)	Hydrogen Flowrate (g/s)	Inlet Parahydrogen Fraction	Average Temperature (K)	Average Density (kg/m3)	Average Parahydrogen Fraction
Supply to MRA	18.34	14.09	37.35	0.99947			
Upper, Cylinder					19.56	73.185	0.99946
Lower, Tube					20.38	72.353	0.99944
Return to CMS	21.03	13.98	37.35	0.99943			

Required Hydrogen Properties Table

Location	Maximum Inlet Temperature (K)	Minimum Inlet Pressure (bara)	Minimum Hydrogen Flowrate (g/s)	Minimum Inlet Parahydrogen Fraction
Supply to MRA	20.0	14.0	37.0	0.998

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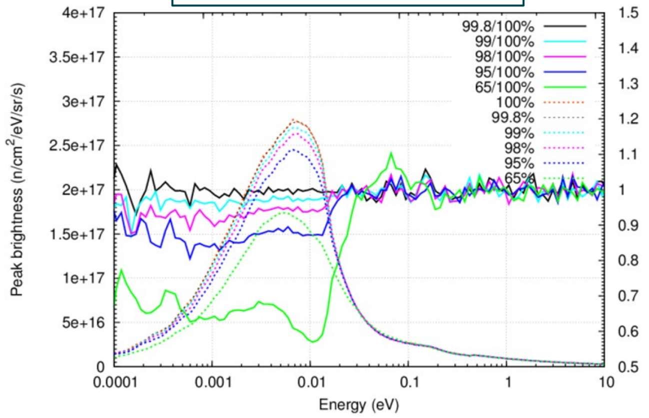
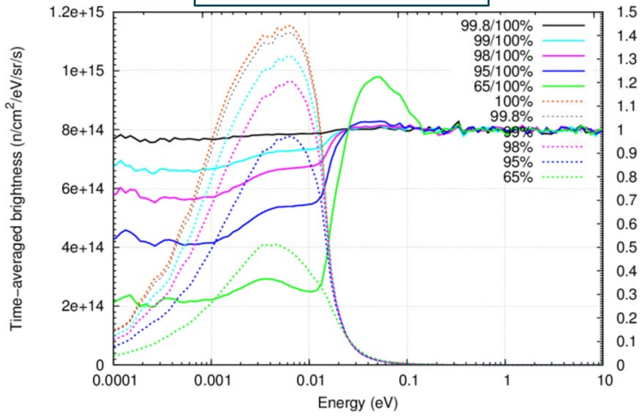
MRA-CMS Hydrogen Parafraction Requirements

- STS moderator performance relies on high parahydrogen fraction
  - 10-50% performance loss from 95% para compared to 100%
- Parahydrogen fraction primarily determined by CMS design
  - Specifically, by O/P converter design and temperature
- STS CMS O/P converter design is borrowed from SNS, where its performance has been demonstrated at prototypic STS conditions

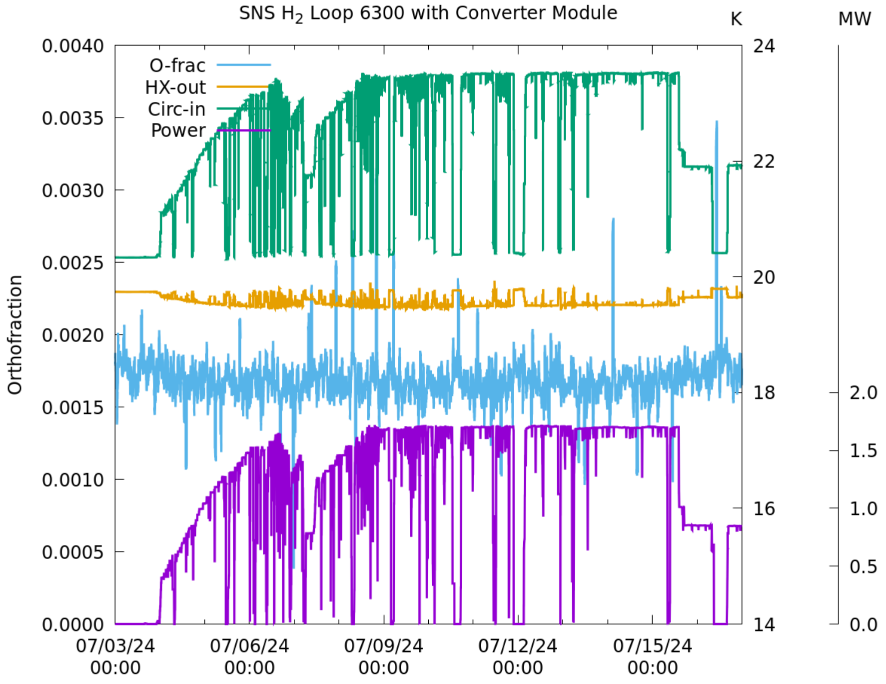
Cylinder Moderator



Tube Moderator



Orthohydrogen Fraction at Prototypic STS Conditions



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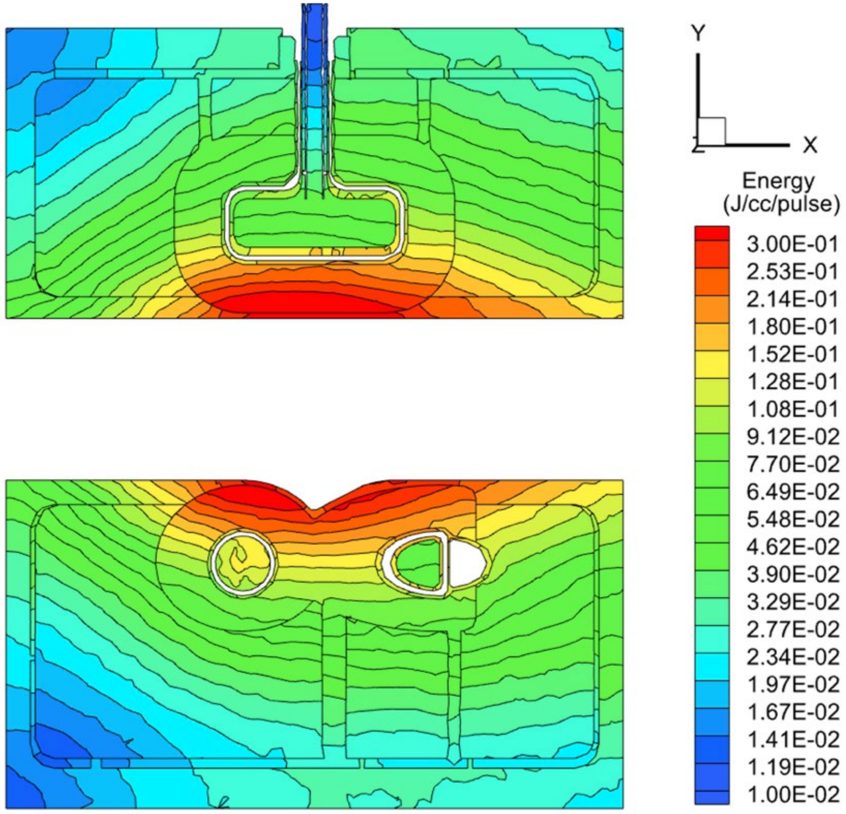
MRA Neutronic Heat Loads

- MRA neutronic heat loads determined for hydrogen and hydrogen boundary structures
  - Moderators and transfer lines included
- Total heat load must be removed by CMS
  - Hydrogen heating separated from structure heating as only hydrogen heating drives backconversion to ortho hydrogen



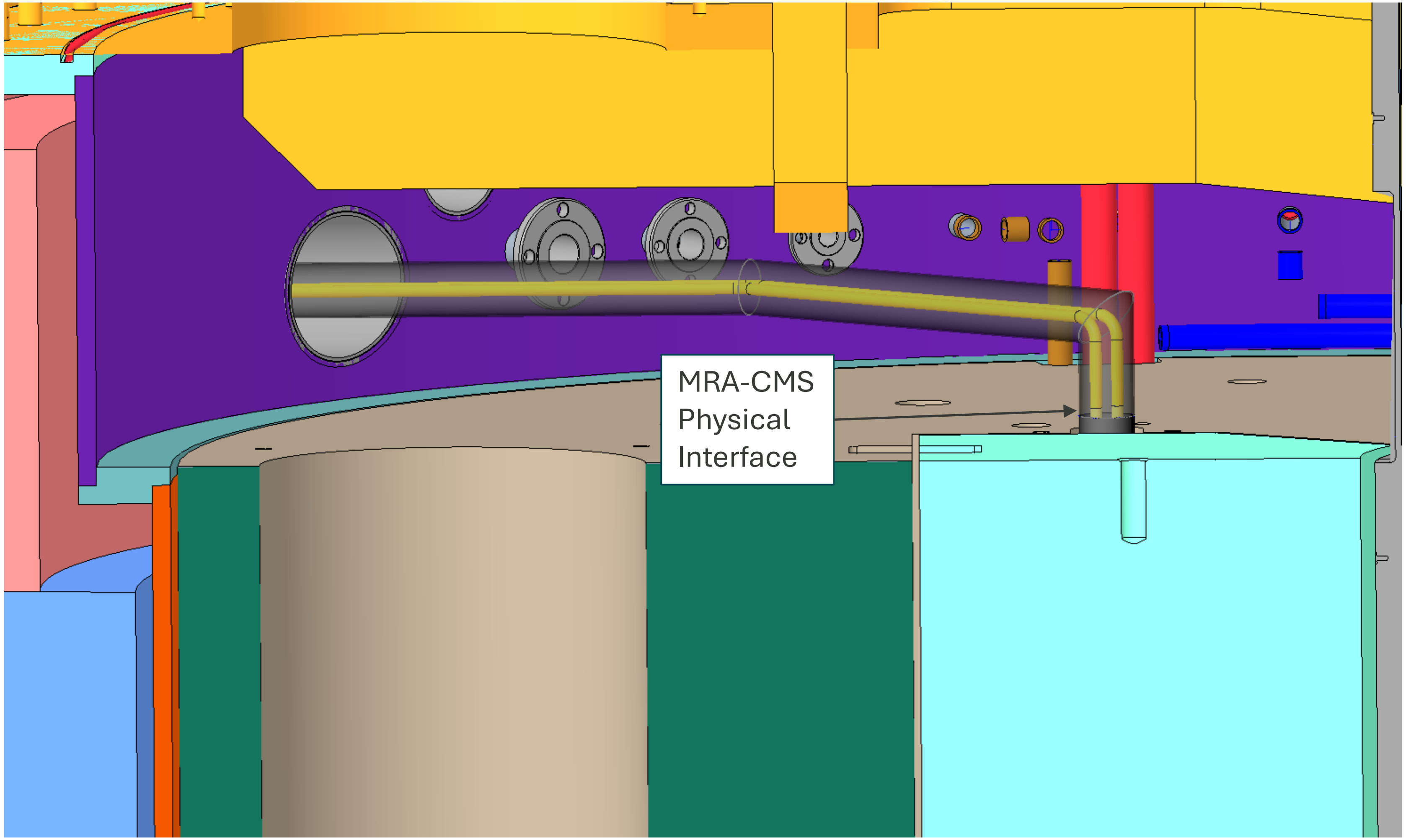
Reflector Vessel Energy Deposition Profile

MRA Neutronic Heat Loads to CMS Table

Moderator	Hydrogen Heat Load (W)	Structure Heat Load (W)	Total Heat Load (W)
Upper, Cylinder	183.95	248.62	432.57
Lower, Tube	235.56	216.28	451.84

MRA-CMS Physical Interface

- Welded interface between MRA and CMS transfer line sections
  - 2 15.9mm x 0.9 mm (5/8” x 0.035”) Invar tubes
  - 1 76.2 mm x 1.65 mm (3” x .065”) 316L tube
- Will need to be cut and rewelded at least 6 times over the 40 year expected STS lifetime

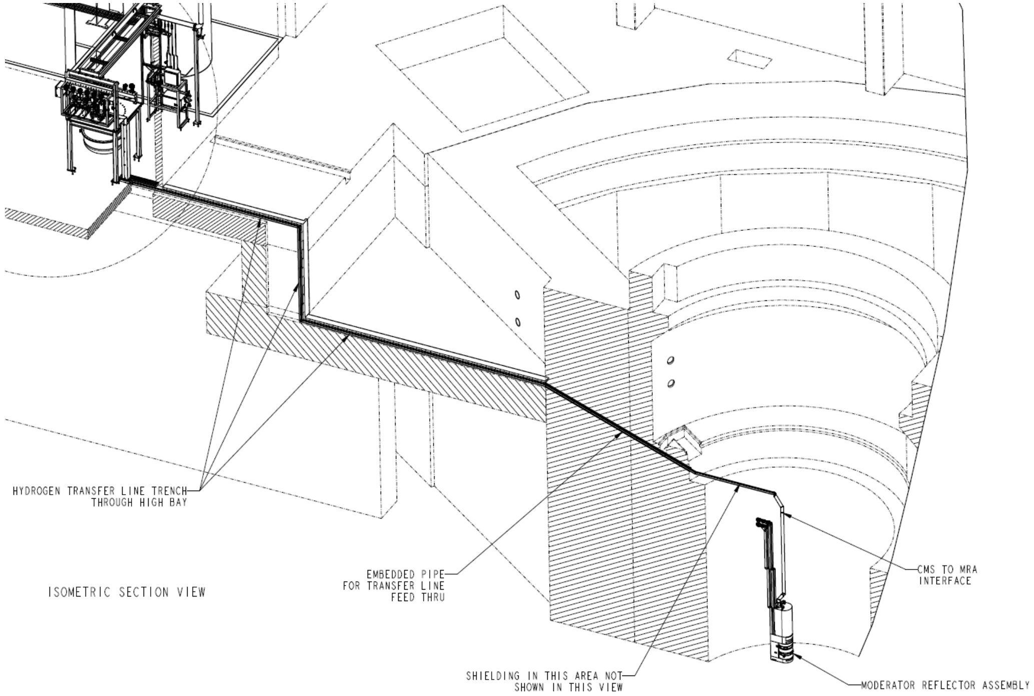


MRA-CMS Shared Analyses

- MRA and CMS each contains portions of the hydrogen transfer line
- There are several critical functions of the hydrogen transfer line which must be analyzed
    - Structural piping analysis (HAR credited)
    - Hydrogen venting in loss of vacuum event without exceeding MAWP
    - Vacuum space venting of potential hydrogen leaks with exceeding MAWP (HAR credited)
- These analyses will consider hydrogen transfer line as a whole
- Analyses will be performed within CMS project scope as CMS provides overpressure protection

CMS Pressure Table

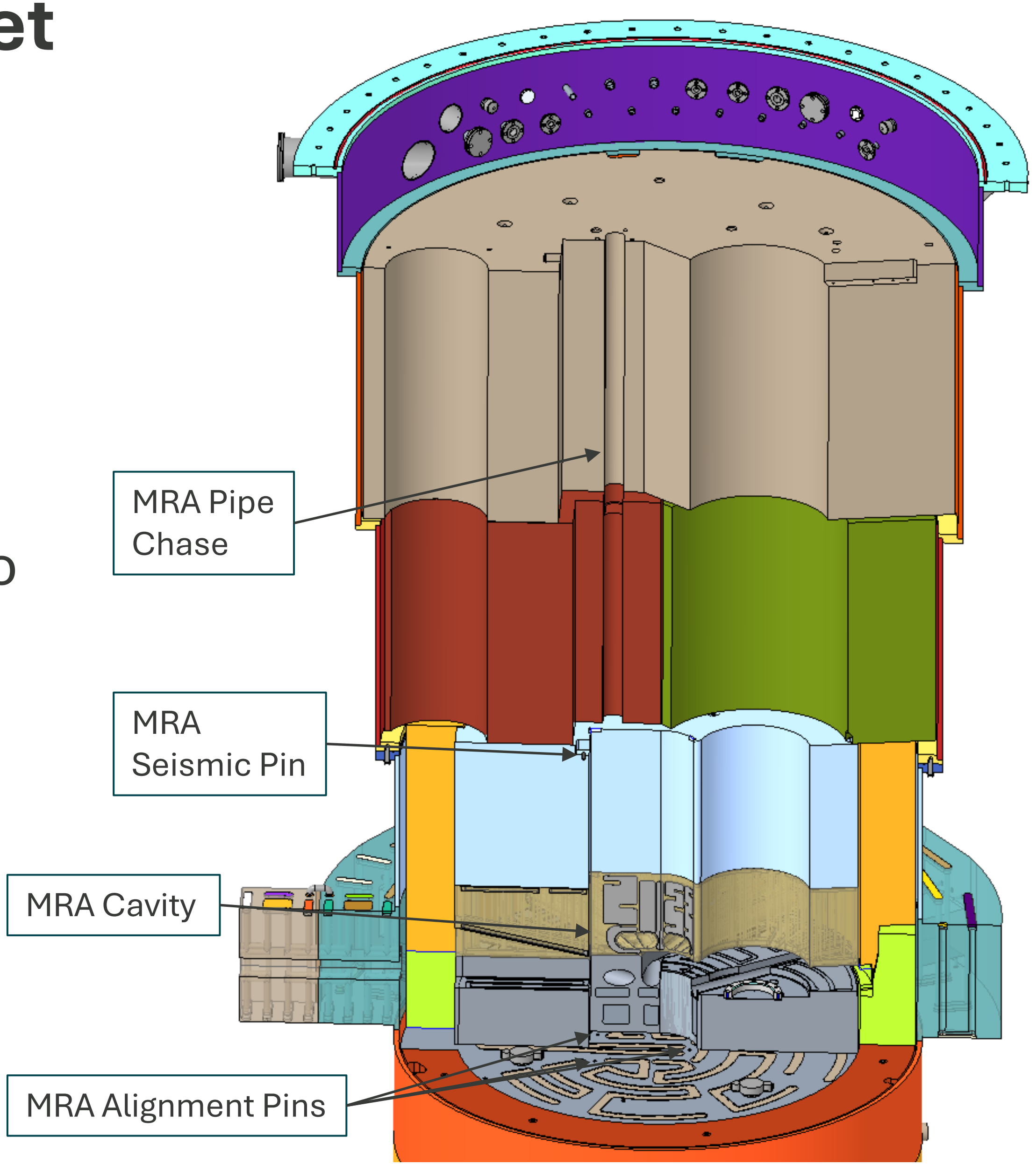
	Pressure (bara)	
	Operating	**MAWP**
Hydrogen	14	19
Vacuum	$<1 \times 10^{-11}$	2



Hydrogen Transfer Line Layout

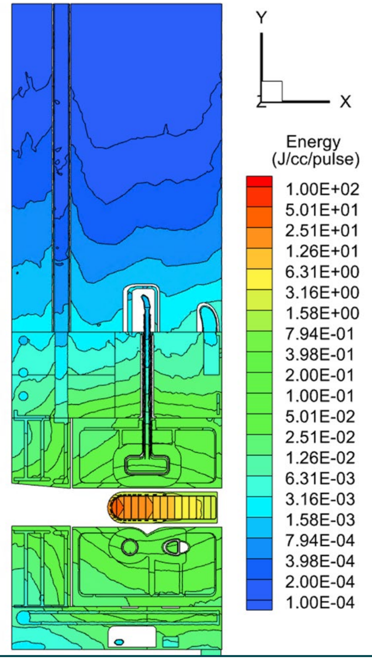
MRA-Core Vessel Interface Sheet

- Defines physical interface
    - MRA-CV alignment pins/blocks
    - MRA-CV seismic pin/block
    - MRA-CV water flanges
    - MRA-CV pipe supports (details still to be developed within CMS scope)
    - MRA-CV thermocouple terminations
- Defines clearance interface
    - MRA-CV clearances defined consistent with Clearance Budget Calculation



MRA-Process Systems Interface

- Process Systems provides 5 cooling water supplies, 1 return, and associated overpressure protection to MRA
- MRA defines energy deposition (total and in water) and pressure drop for Process System design

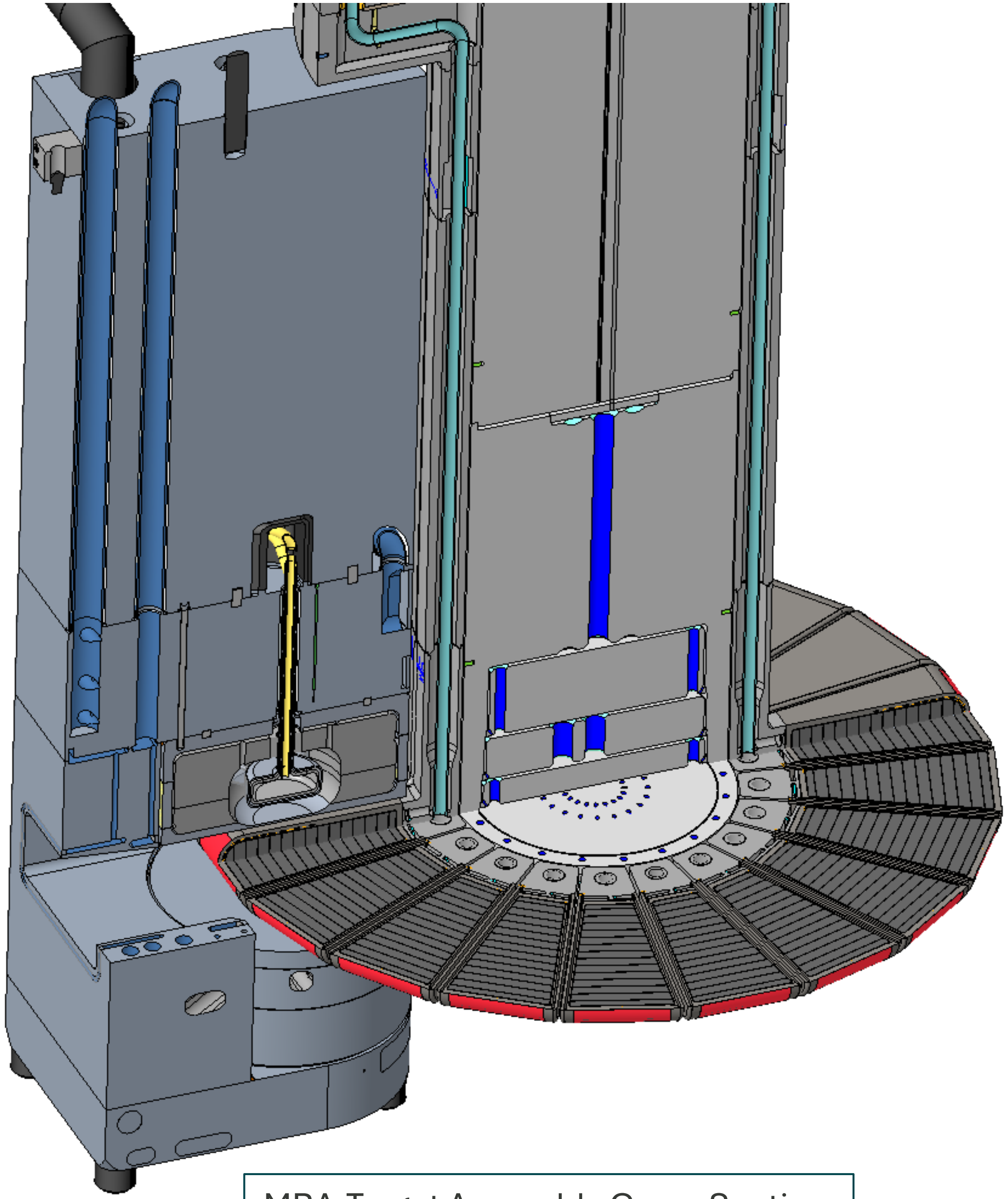


MRA Energy Deposition Profile

STS Process Systems Design Basis 2.8 MW Beam / 700 KW @ 15 Hz to STS										
	Technical Component Design Values						Primary Cooling Loop			
Target Systems Energy Deposition	STS Design Basis Heat Load, Watts	Energy Deposited In Water Watts	Component Water Volume, cm^3	Component Pressure Drop, PSI	Component MAWP, PSIA	Component Material of Construction	Design Basis Flow GPM	Design Basis ΔT °F	Primary T Inlet °F	Supply Pipe Size, Inches	Return Pipe Size, Inches
Upper Premoderator	9,009	3,400	5,096	5.20	75.0	Al, Be, SS	7.5	10.7	90	1	
Upper Reflector	9,894	470	4,590	9.65	75.0	Al, Be, SS	7.5	11.8	90	1	
Lower Premoderator	11,020	4,746	5,350	6.86	75.0	Al, Be, SS	7.5	13.1	90	1	2
Lower Reflector	10,725	434	4,363	9.55	75.0	Al, Be, SS	7.5	12.8	90	1	
MRA Backbone	16,547	153	11,313	4.29	75.0	316L SS	15.0	9.9	90	1.5	

MRA-Target Assembly Interface

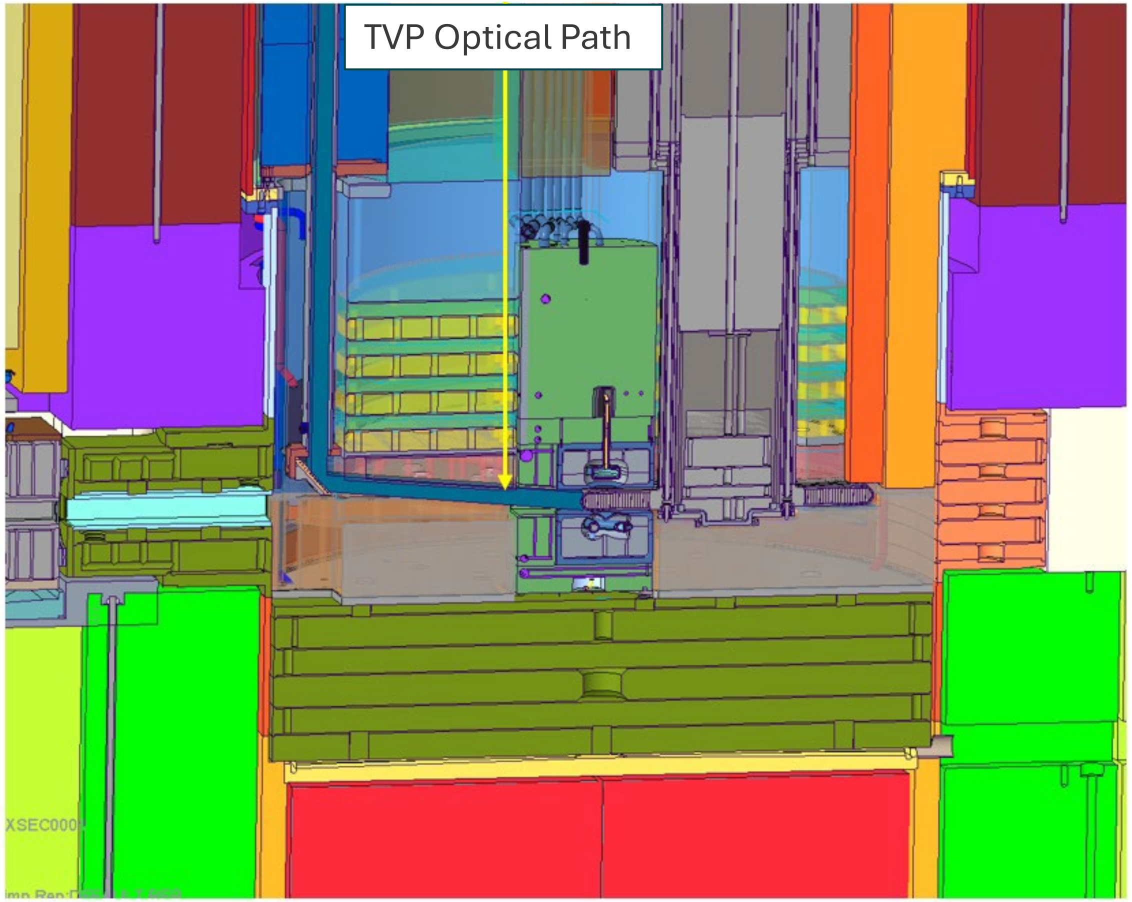
- Neutronic interface is managed at Target Systems level rather than separation of Target and MRA functions
    - No requirements for neutrons produced by the target, just what is delivered to beamlines
- Describes clearance interface
    - MRA-CV clearances described consistent with Clearance Budget Calculation
- Describes target segmentation to allow MRA removal



MRA-Target Assembly Cross Section

MRA-Accelerator Interface Components Interface

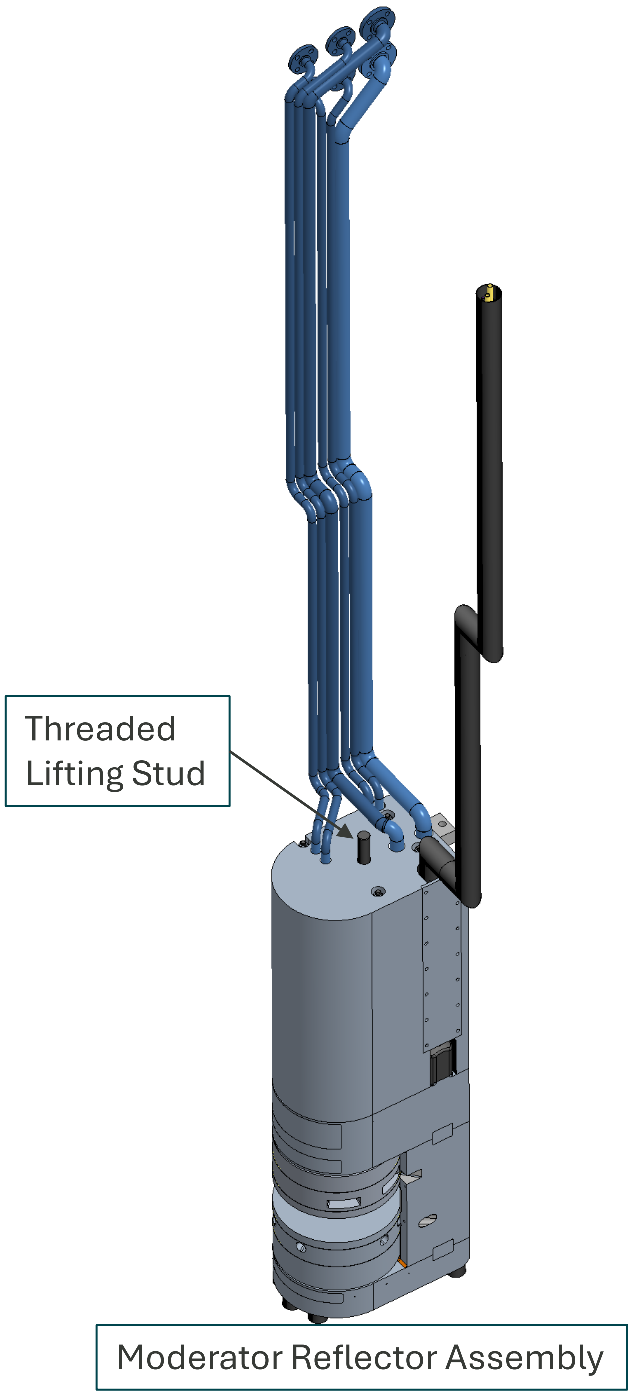
- Defines optical path from Target Viewing Periscope first mirror to the target front face



TVP Optical Path Within Core Vessel

MRA-Remote Handling Interface

- Describes MRA Size and Mass
- Describes MRA Lifting Interface
- Describes MRA guiding and alignment features
- Defines steps for MRA removal from core vessel after operation
    - Blowdown
    - Pipe cutting
- Defines MRA preparation for disposal
    - Vacuum drying



MRA-MRA Instrumentation and Controls Interface

- MRA supplies thermocouples and installs them on MRA
- MRA I&C supplies cabling to core vessel feedthrough and to PLC cabinet and associated installation
- MRA I&C provides system testing
- Process Systems will provide P&ID and PCD for MRA thermocouples
    - MRA thermocouples are intended for information only

Thank You