BTL Collimators Mechanical Design

PIP II BTL Workshop

Vladimir Sidorov

December 1, 2022

PIP-II is a partnership of:
- US/DOE
- India/DAE
- Italy/INFN
- UK/STFC-UKRI
- France/CEA, CNRS/IN2P3
- Poland/WUST

Outline

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3. MARS simulations
4. Horizontal Collimator
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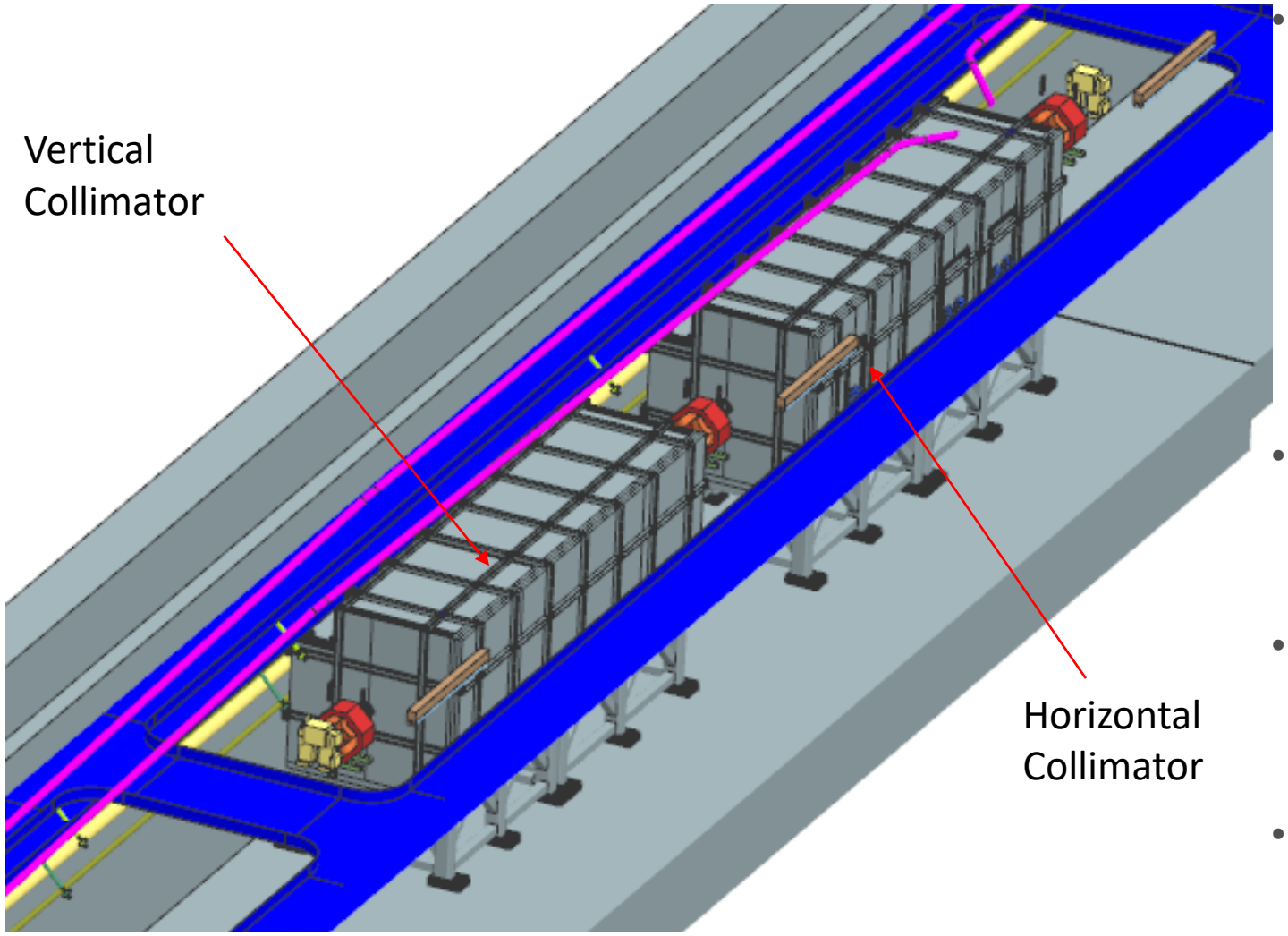
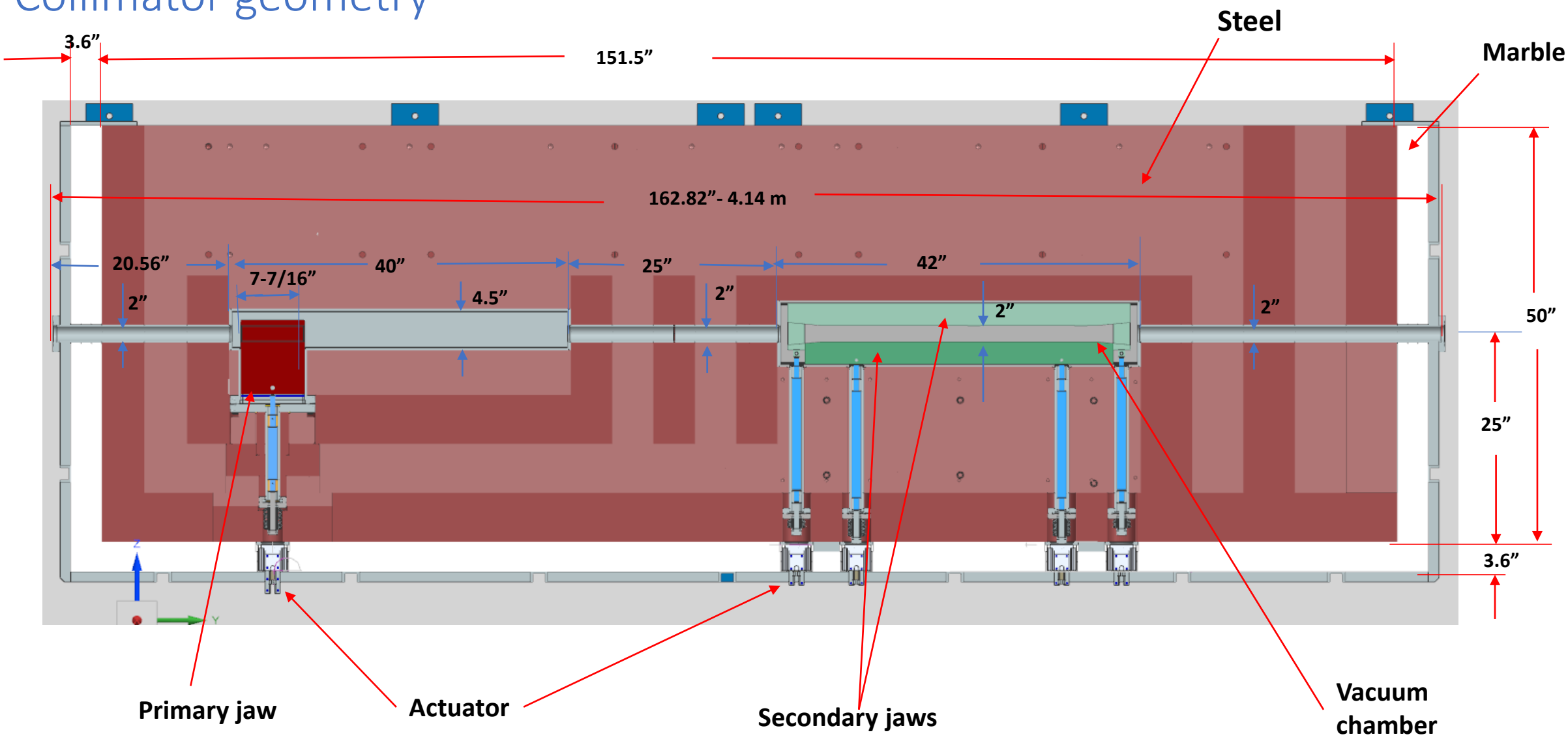
7. Primary collimator jaw design
8. Secondary collimator vacuum chamber assembly
9. Secondary collimation jaw design
10. Jaws thermal analyses
11. Collimators motion control
12. Collimator assembly procedure

Introduction



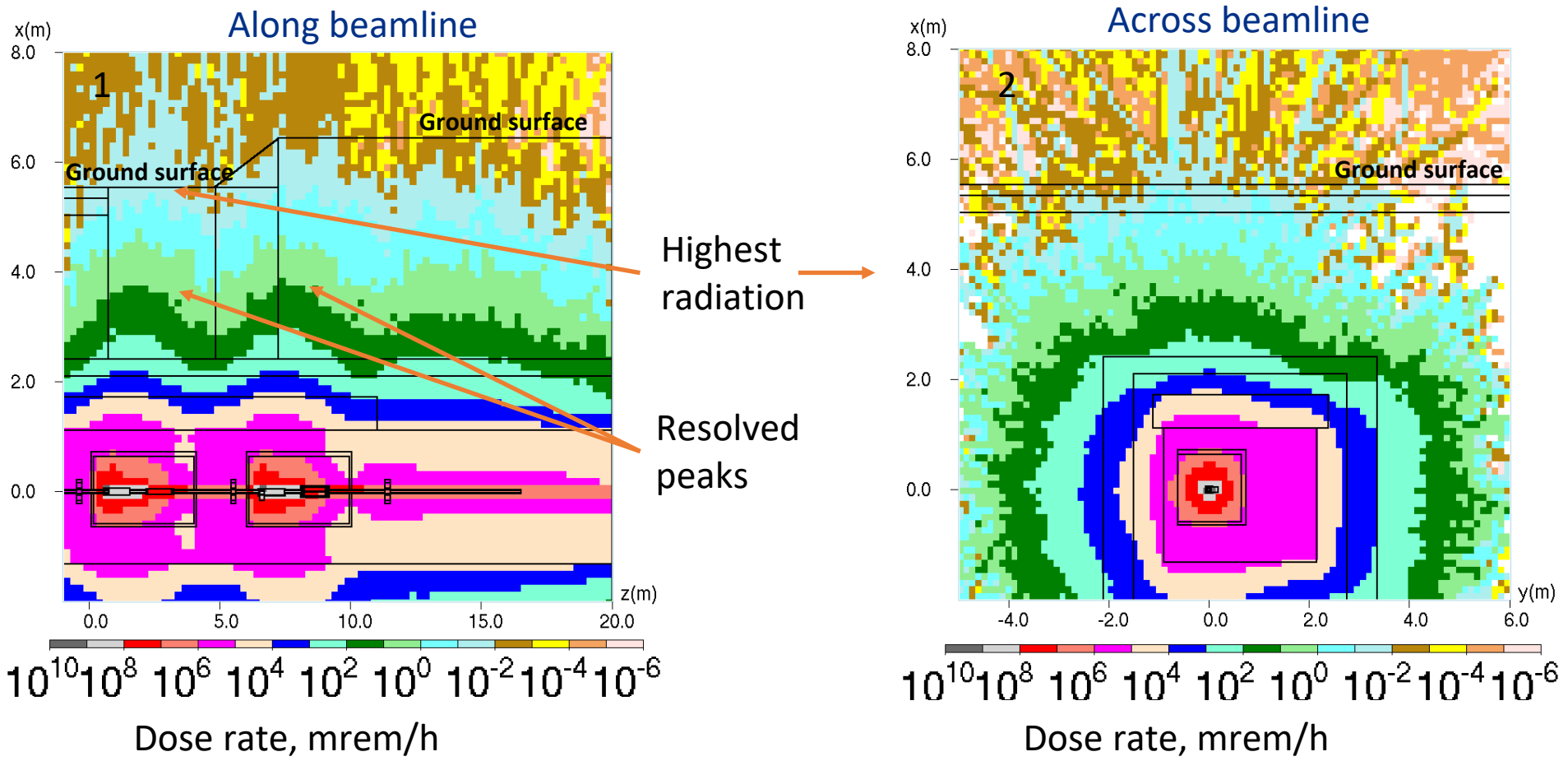
- Two collimation units, horizontal and vertical, will be installed in the PIP-II transfer line. Both systems have primary and secondary collimators and masks. Jaws are moved inside the vacuum chamber toward the center of the beam line. The travel of each jaw is +/- 1” for primary and one inch of each jaw for secondary. The aperture of the collimators is 2”x2”. The primary collimator jaw length is 7-7/16 ” , secondary collimator jaws length is 40”
- Collimators will intercept the beam in stainless steel vacuum chambers (part of the PIP II transfer line vacuum system), surrounded by steel absorbers with external marble shielding.
- The shielding is determined through an iterative process between the engineering design, radiological safety, MARS modeling, and PIP II group.
- The motion systems of the Primary and Secondary collimators are external of the entire collimation system.

Collimator geometry



Ground Surface Prompt Dose Rate Estimates

Dali Georgobiani



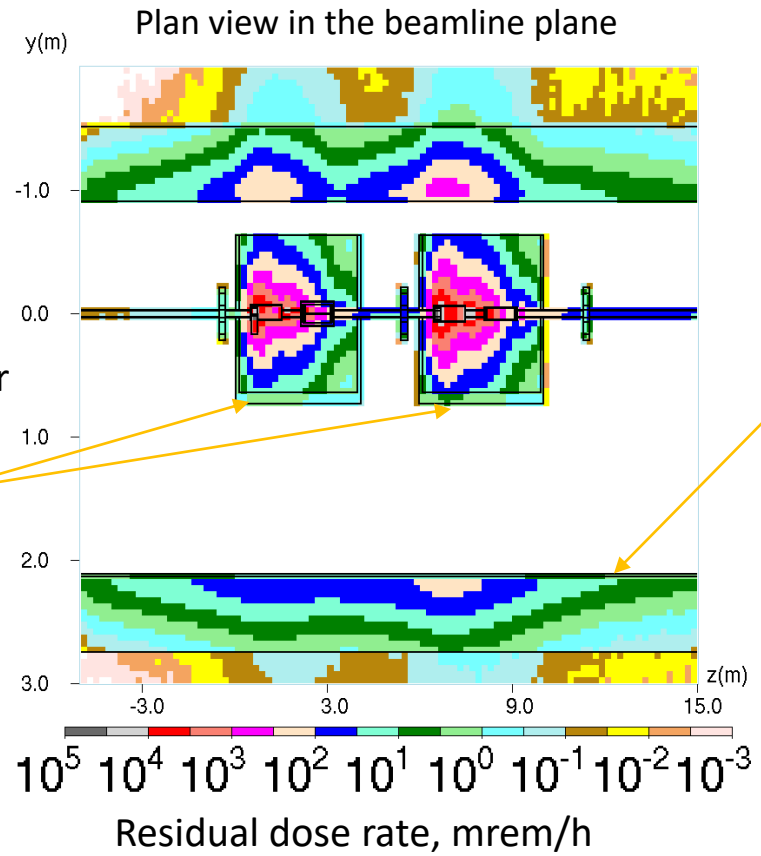
Prompt dose rate maps:
1. Along the beamline, centered at beamline
2. Across the beamline, location of the max radiation (forward peaked, approx. 2 m downstream of the source)

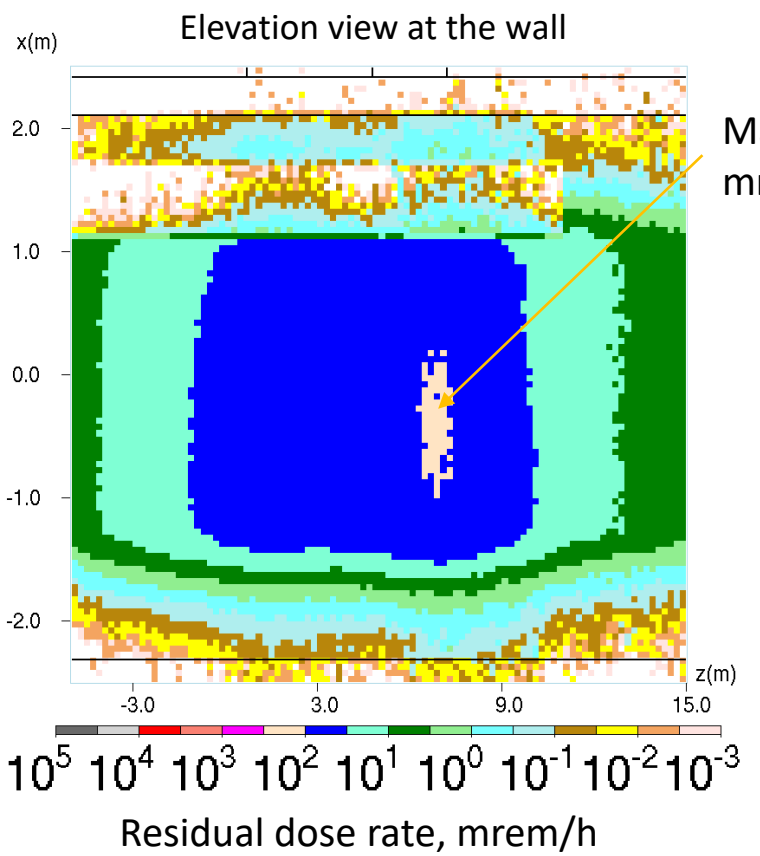
Transverse averaging: 60 cm in both cases

Requirement – below **5e-2 mrem/h**
Dose above the ground surface (averaged over 2 m human height & 60 cm by 60 cm horizontally): **1.4e-2 mrem/h**

Residual Dose Rates in the Beam Line Components & Tunnel Walls

Residual dose rates at surfaces of collimator shields are low, < 10 mrem/h





Max 120 mrem/h

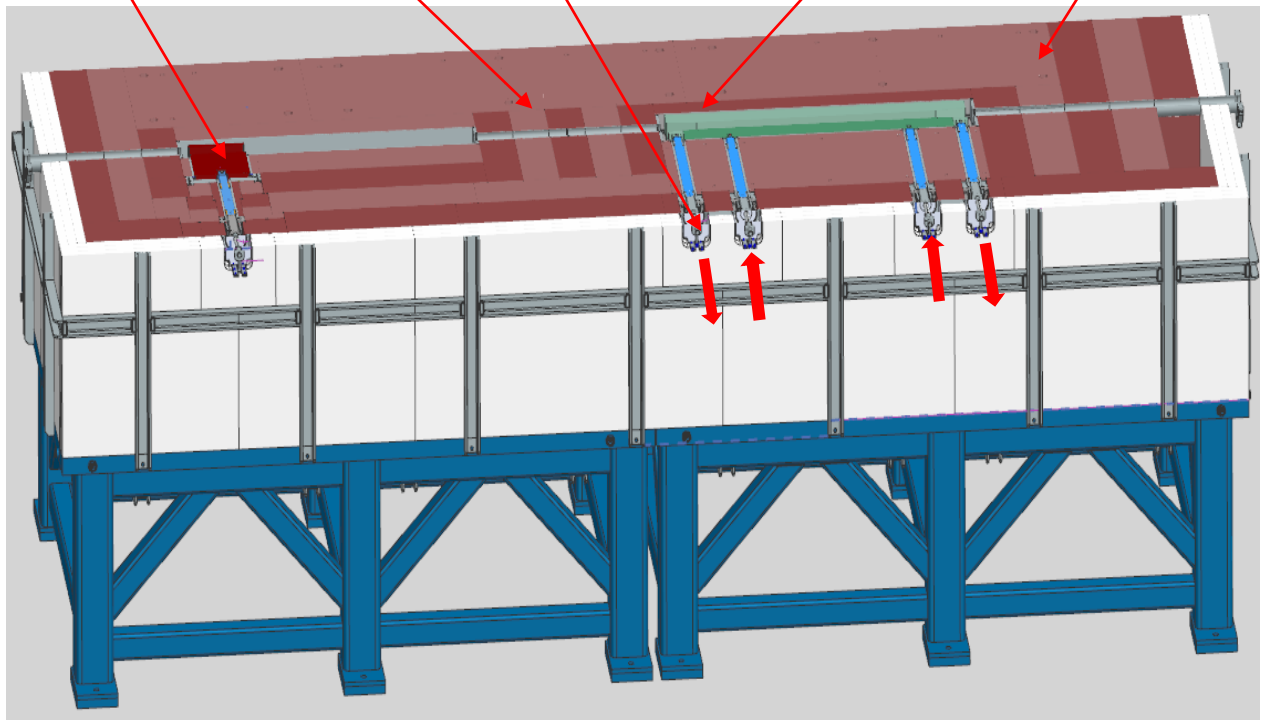
100 d irradiation,
4 h cooling time

Nominal hands-on limit is 100 mrem/h

Adding a 2.3 cm thick marble plate at the wall reduces doses on contact to < 5 mrem/h.
The extent of a marble plate can be deduced from the plan view of the dose rate map;
a few meters would be sufficient to shield the high dose area.

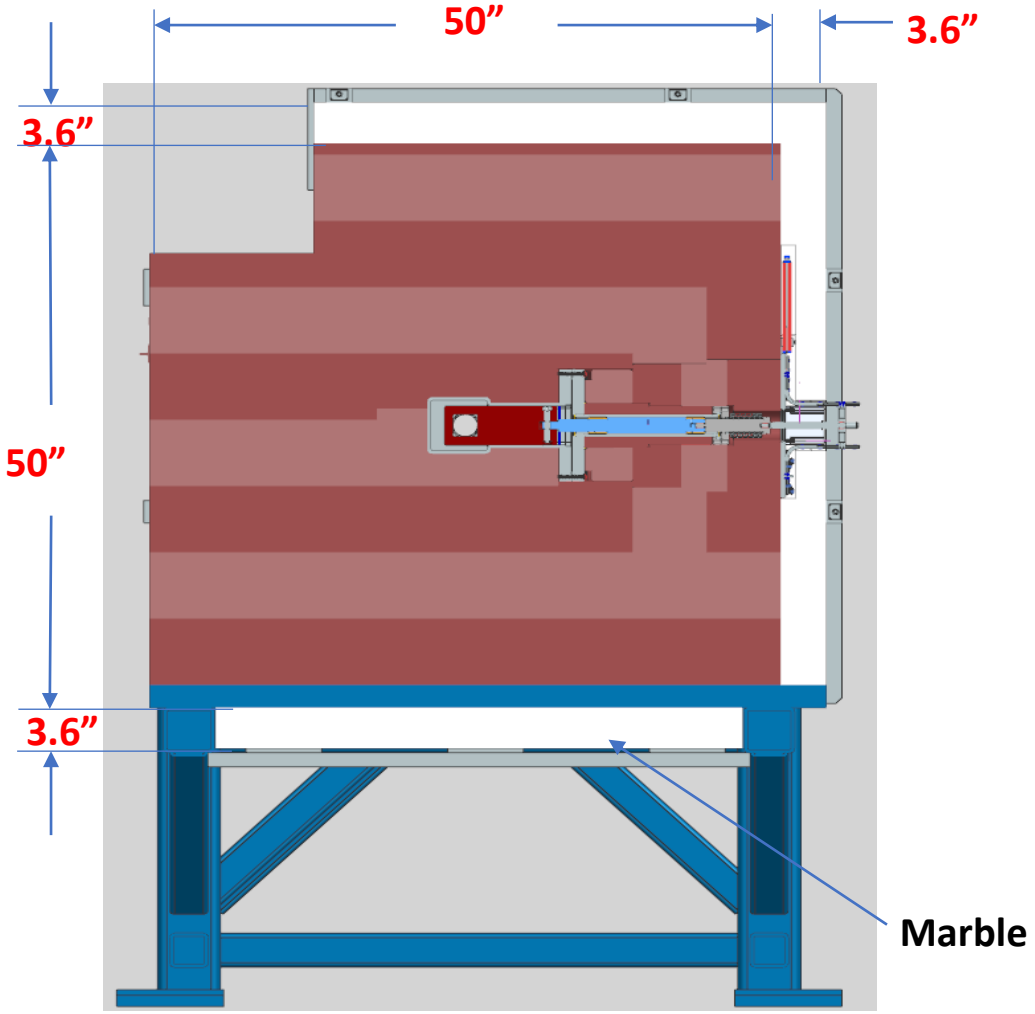
Horizontal Collimator

The Horizontal Collimator is scraping beam in the XY plane. Jaws are moved horizontally by actuators located on the aisle side of the collimator. The collimation unit weight is about 110,000lb.

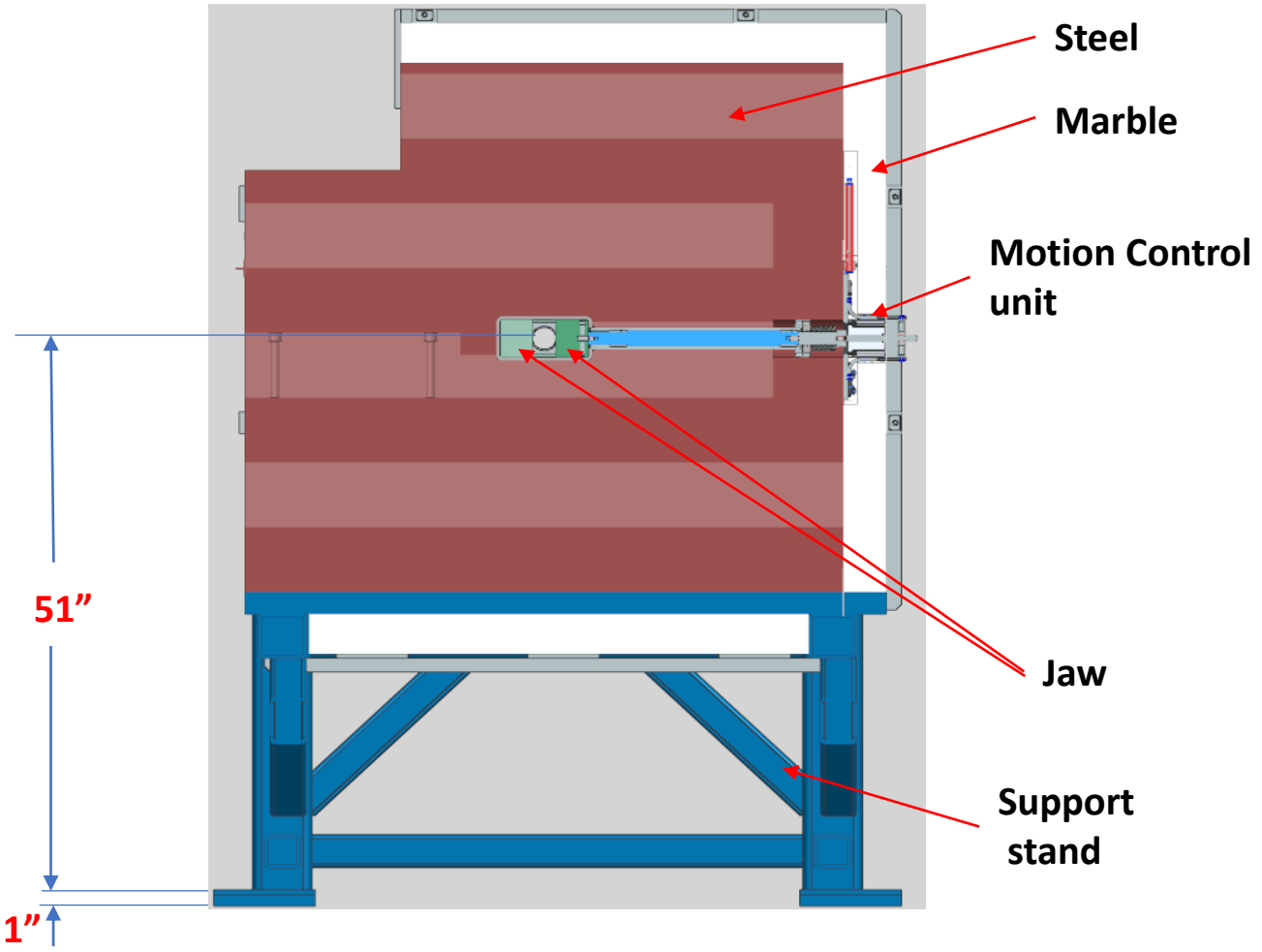


Primary and Secondary Horizontal Collimators sections

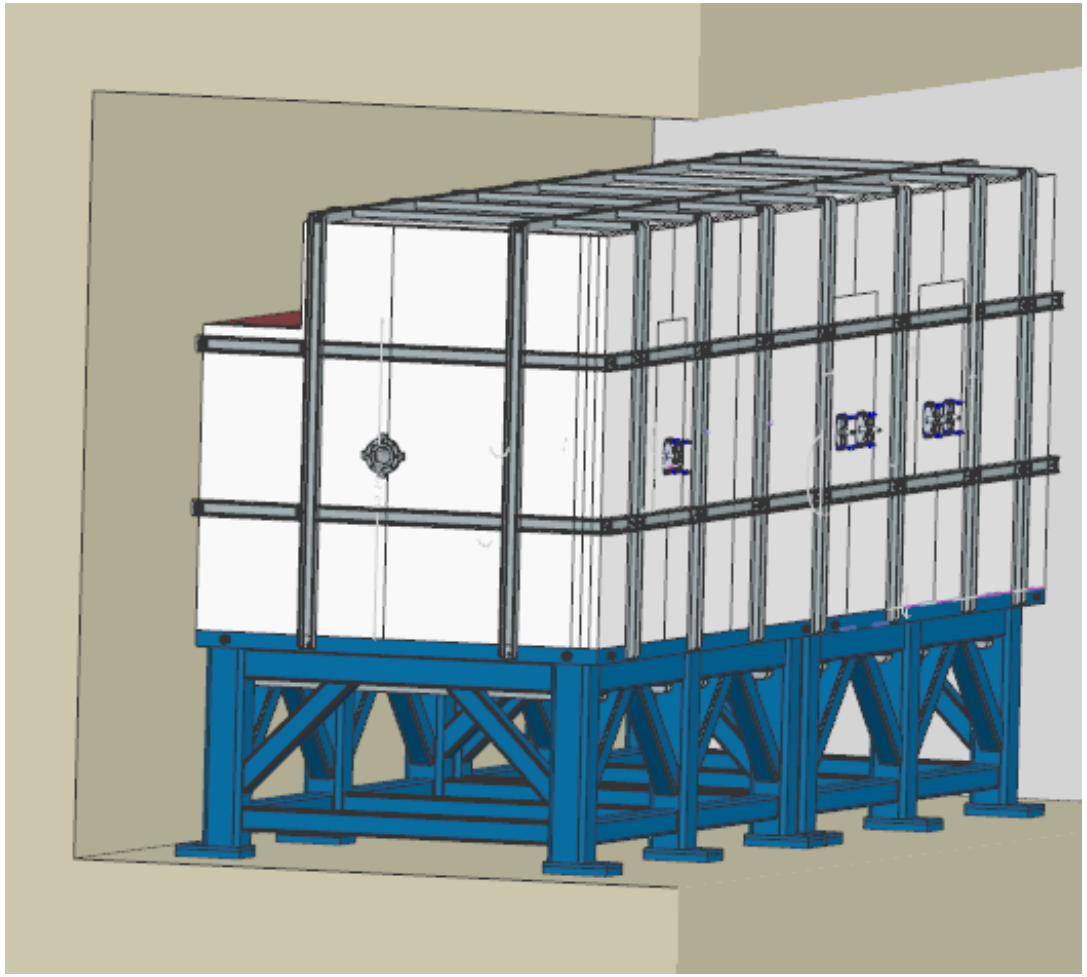
Primary collimator

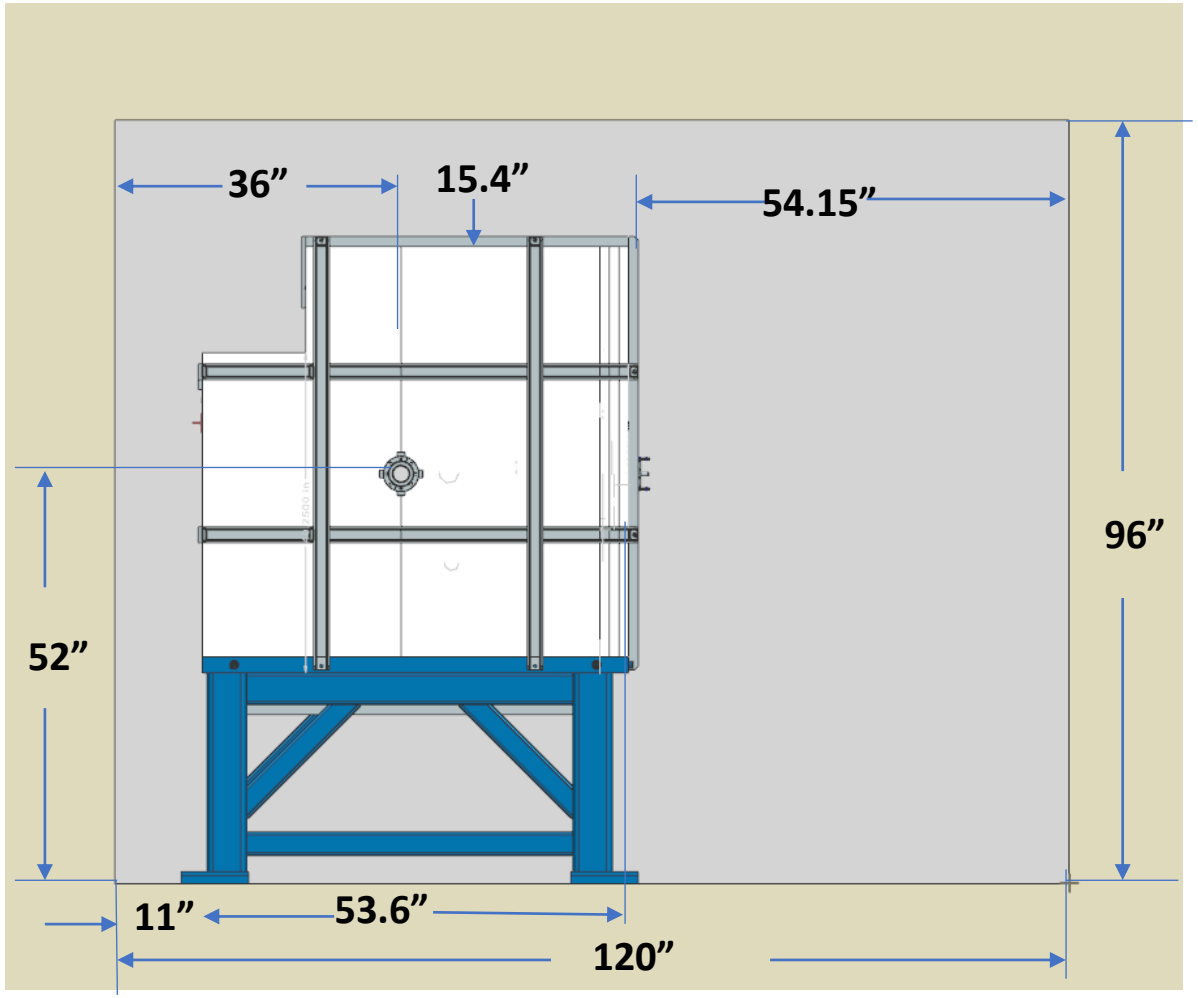


Secondary collimator



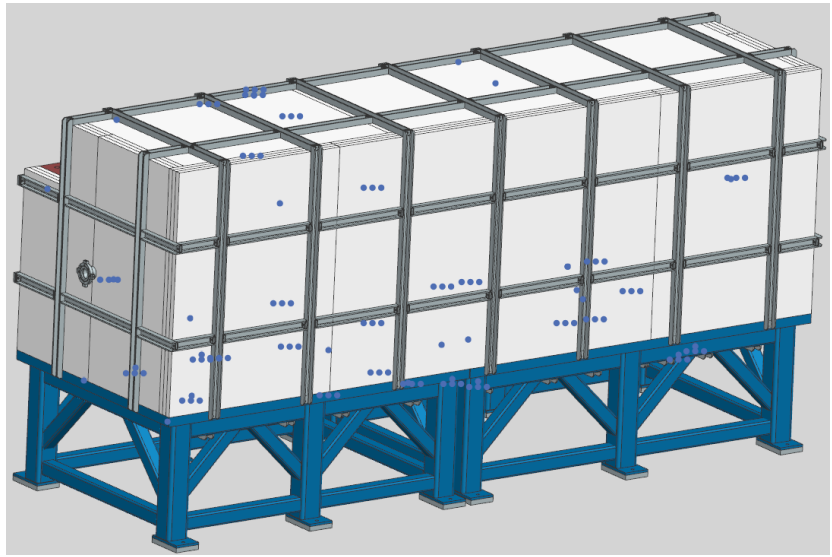
Horizontal Collimation Unit in the Tunnel

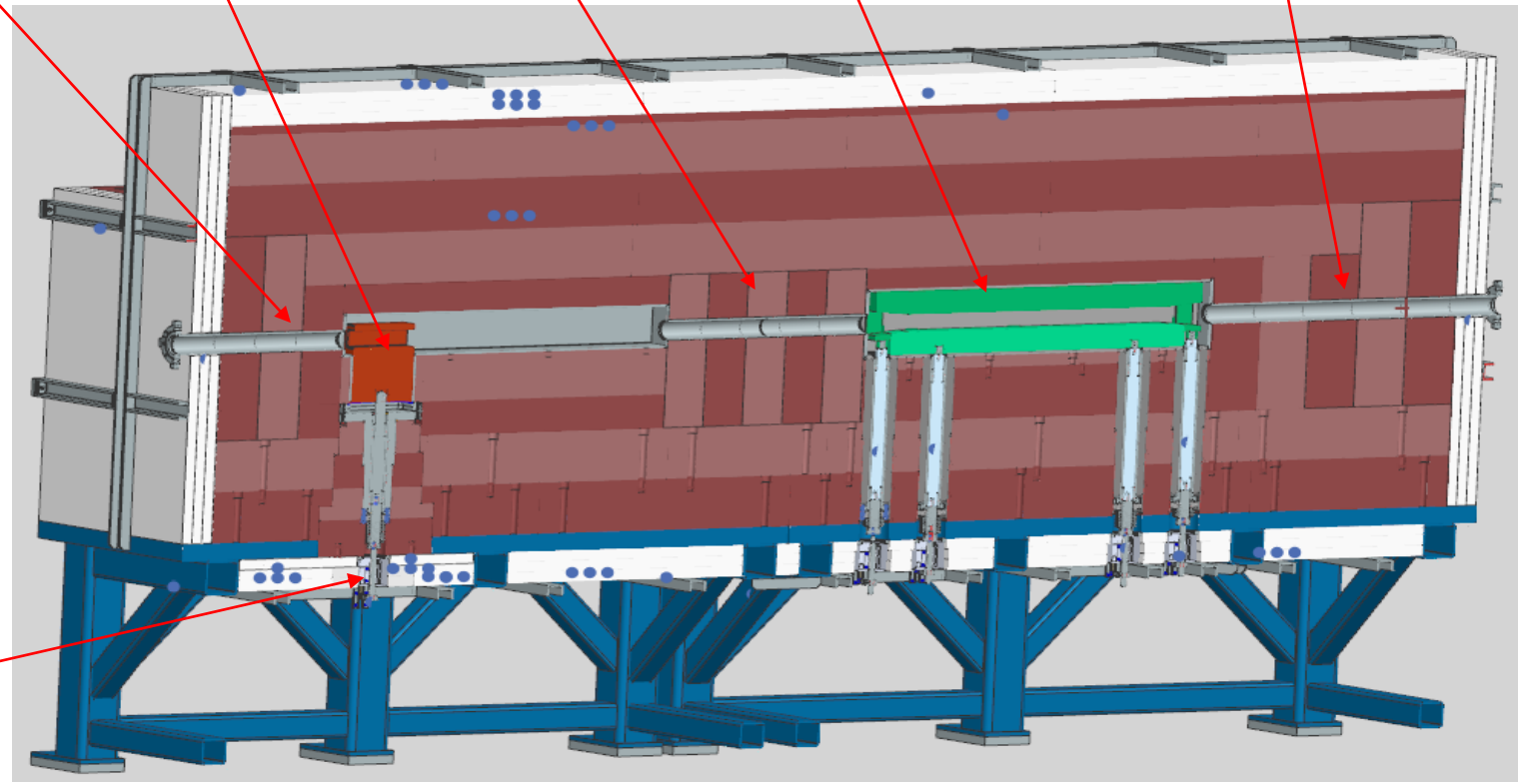




Vertical Collimator

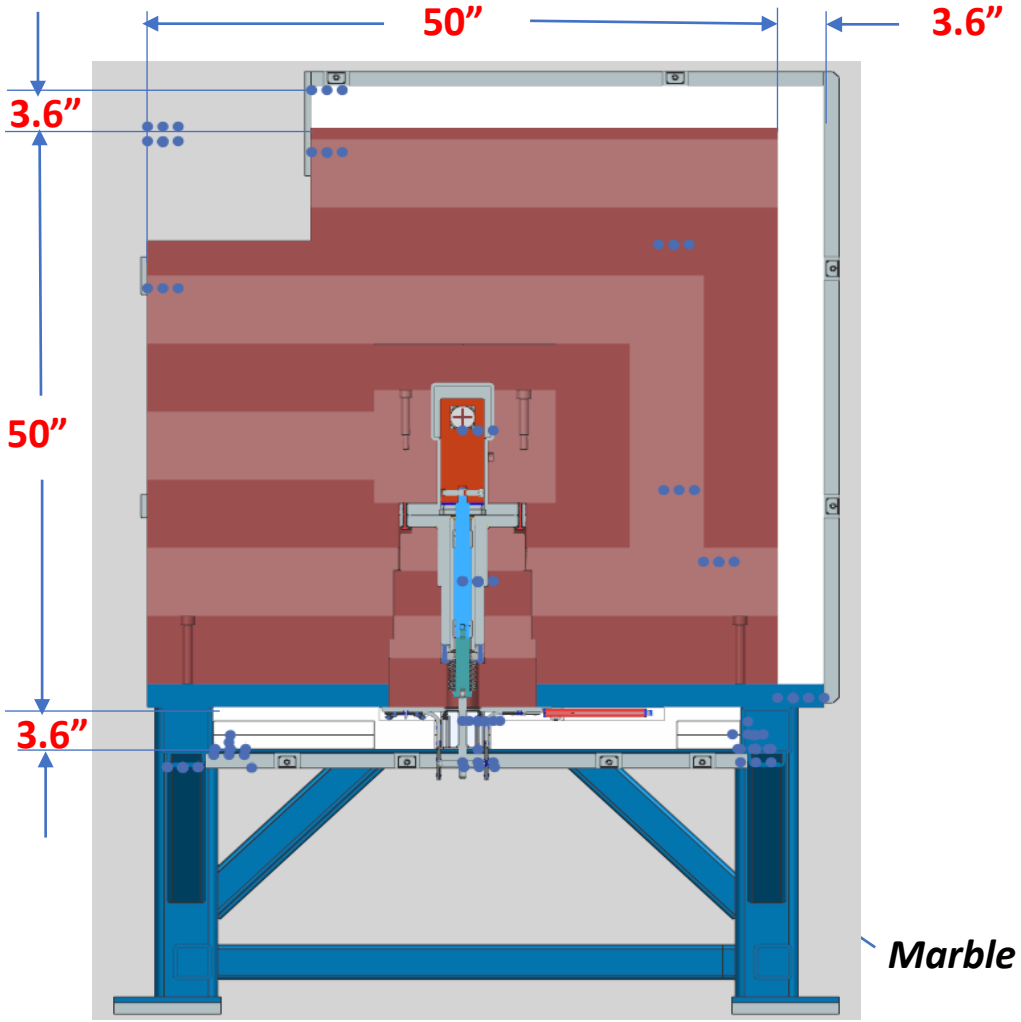
The vertical collimator design is similar with Horizontal collimator. Jaws are moved vertically in the YZ plane .



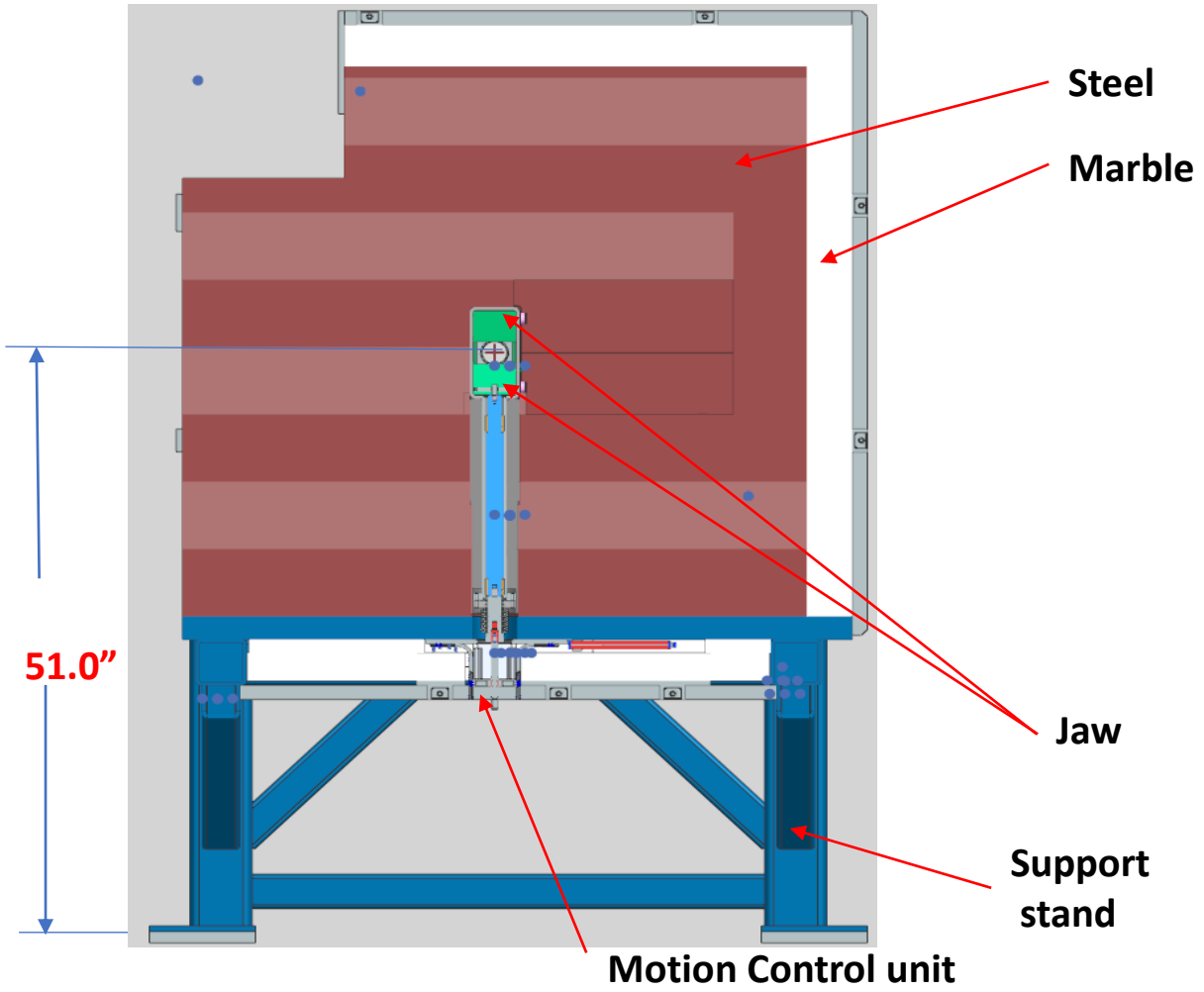


Primary and Secondary Vertical Collimators sections

Primary collimator

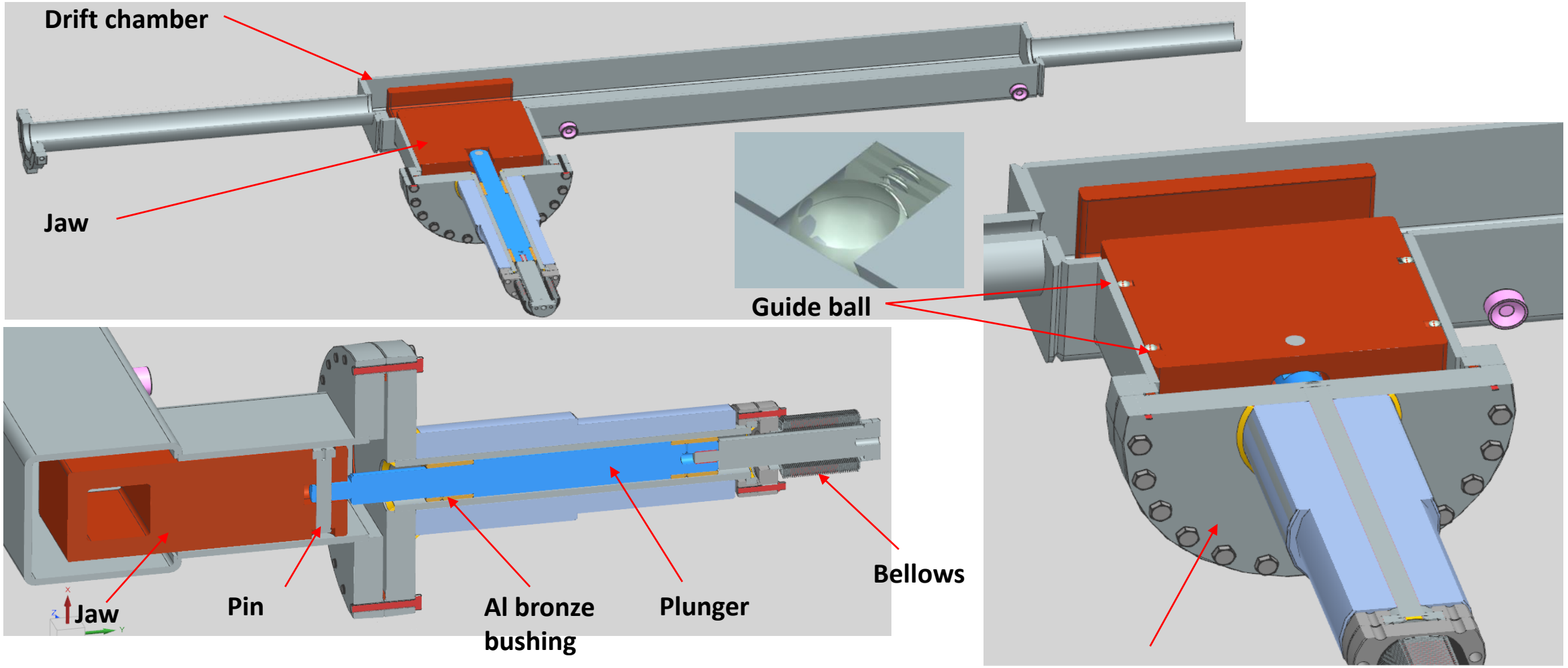


Secondary collimator



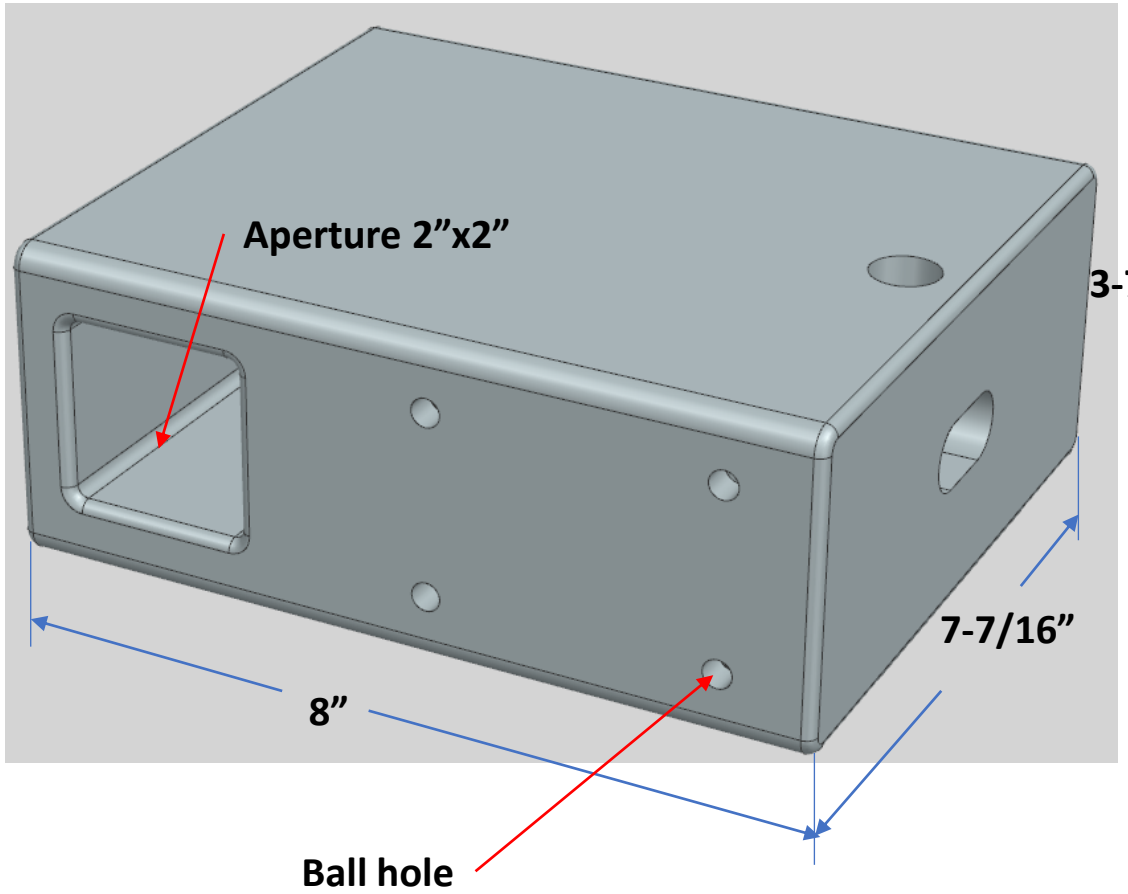
Primary Collimator vacuum chamber assembly

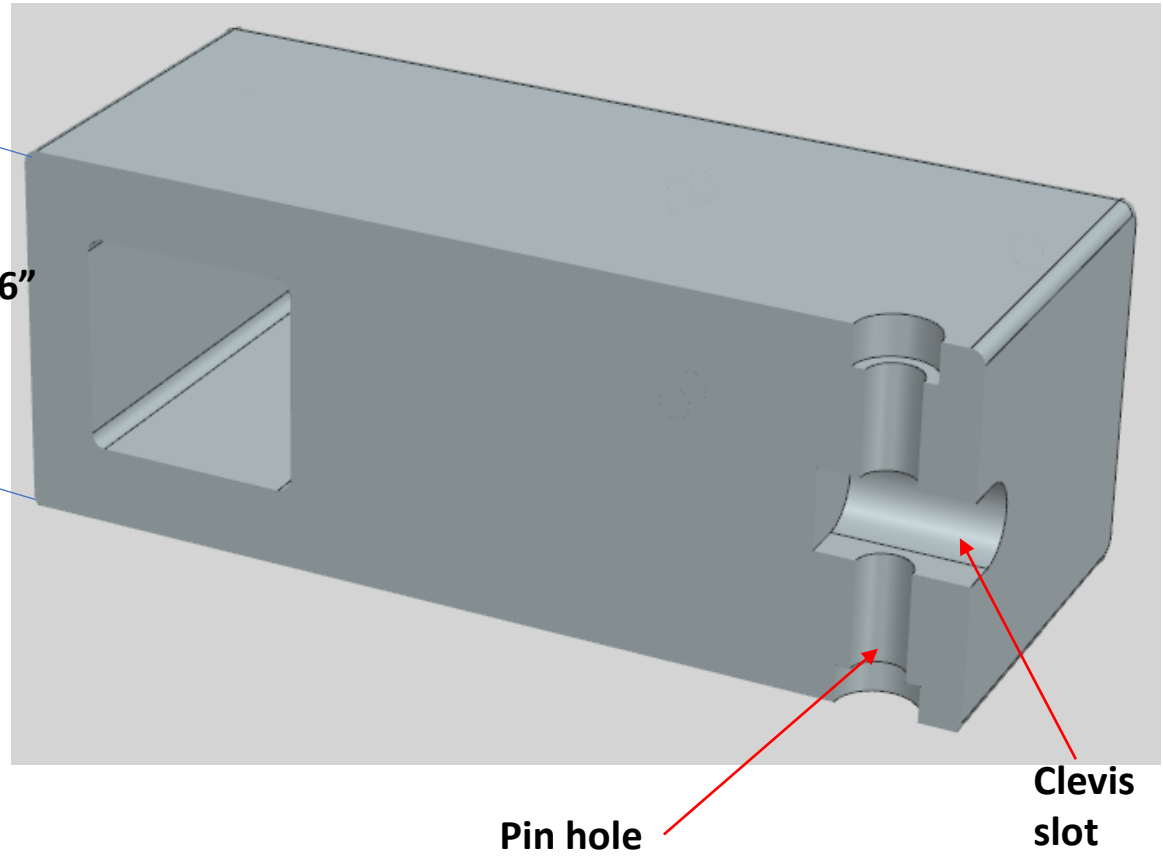
The Jaw is inserted into the 4”x8” tube and sliding to the beam line. The jaw is guided inside the tube by stainless steel balls. The plunger is connected to the jaw and to the actuator through the bellows weldment rod .



Primary Collimator Jaw

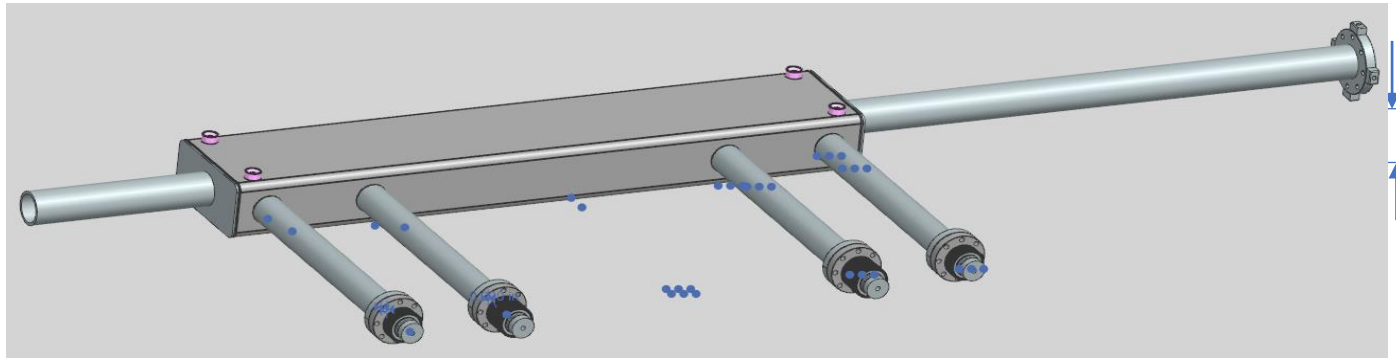
The primary collimator jaw is made from copper. The aperture of the jaw is 2”x 2”.

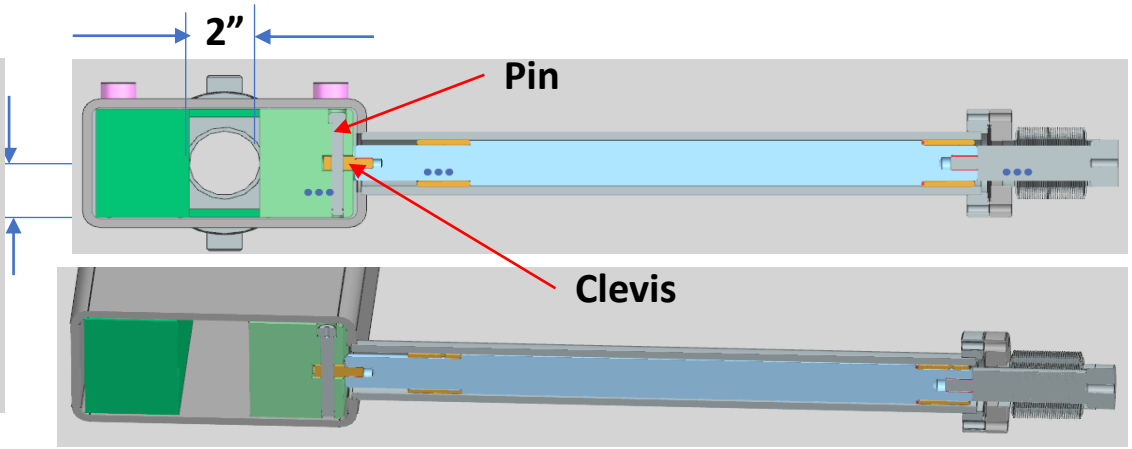


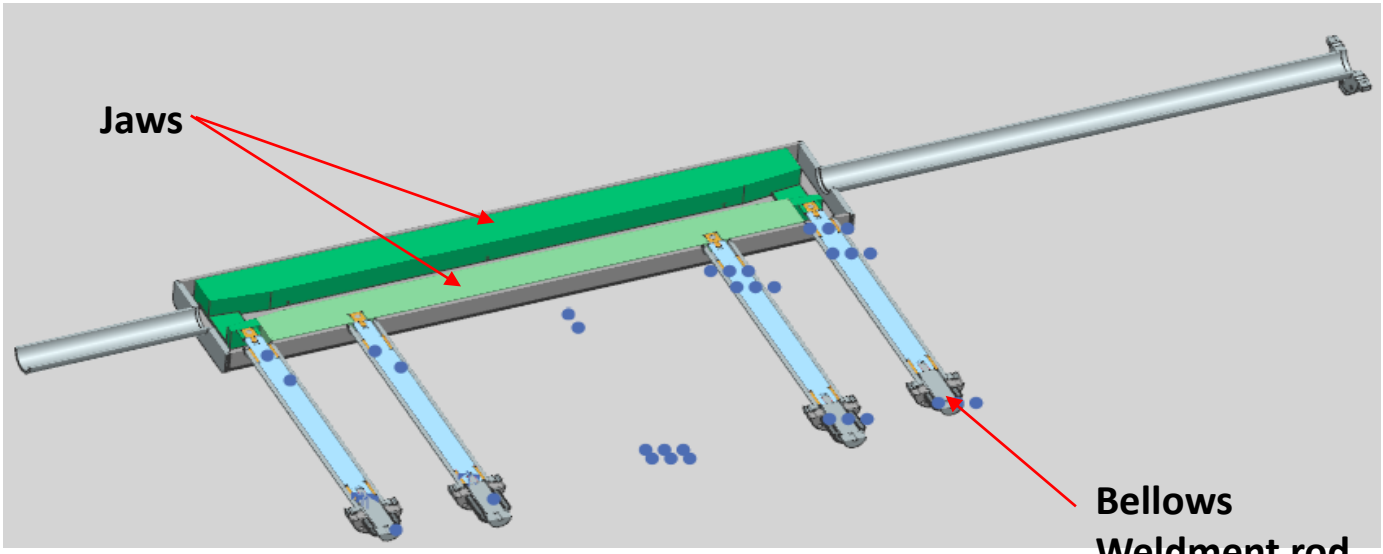


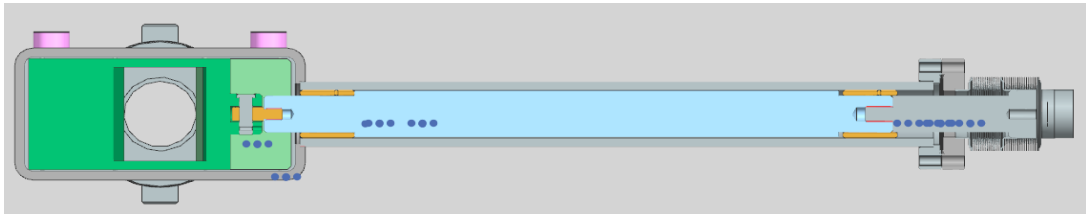
Secondary Collimator vacuum chamber assembly

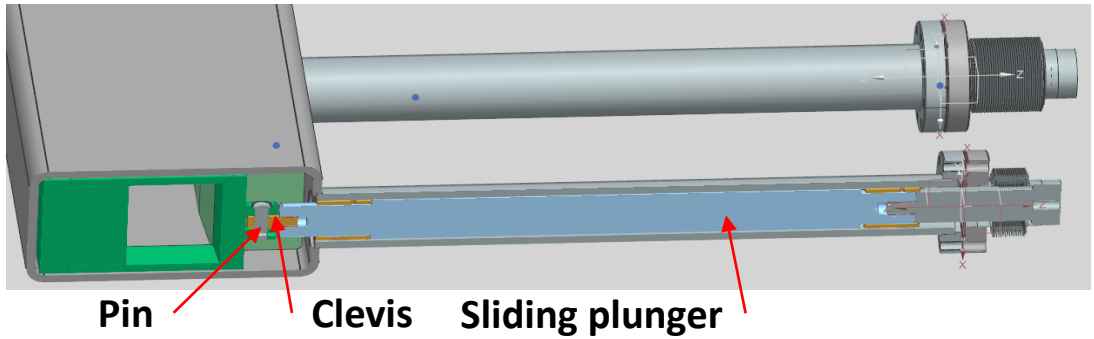
- Both jaws are connected to the sliding plungers with pin-clevis joint. The sliding plunger is joint with bellows weldment rod.





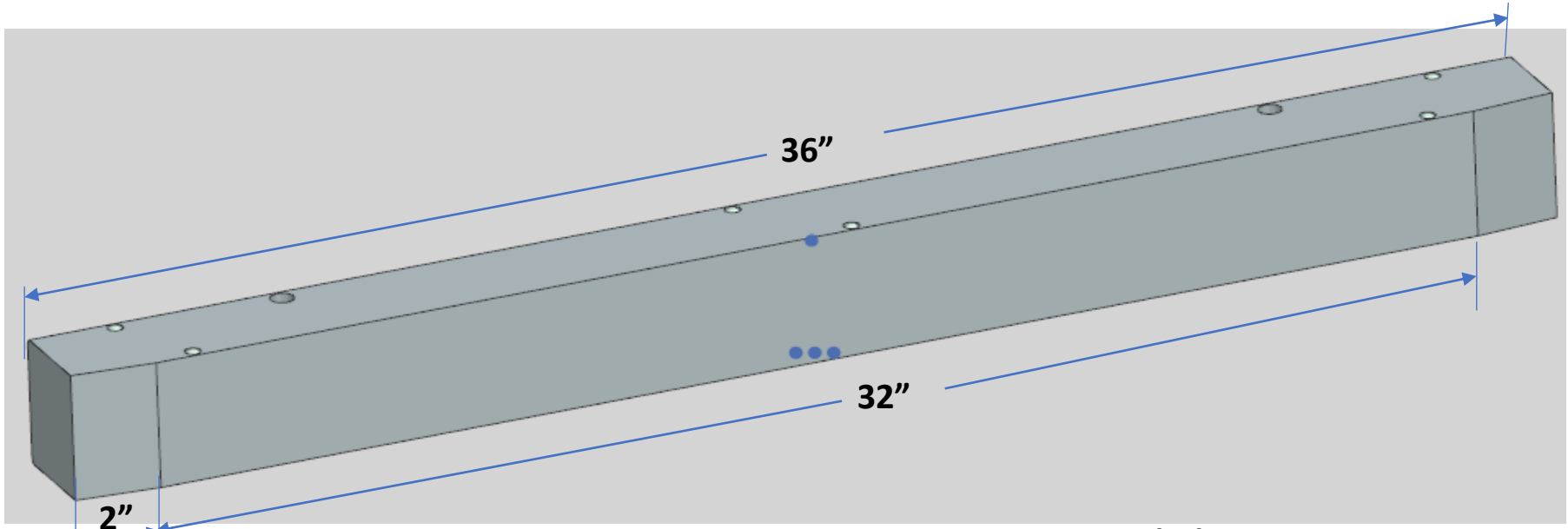


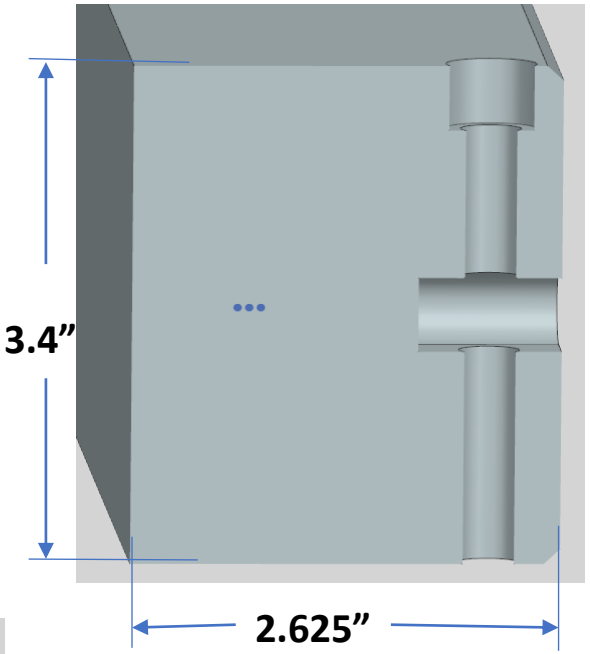


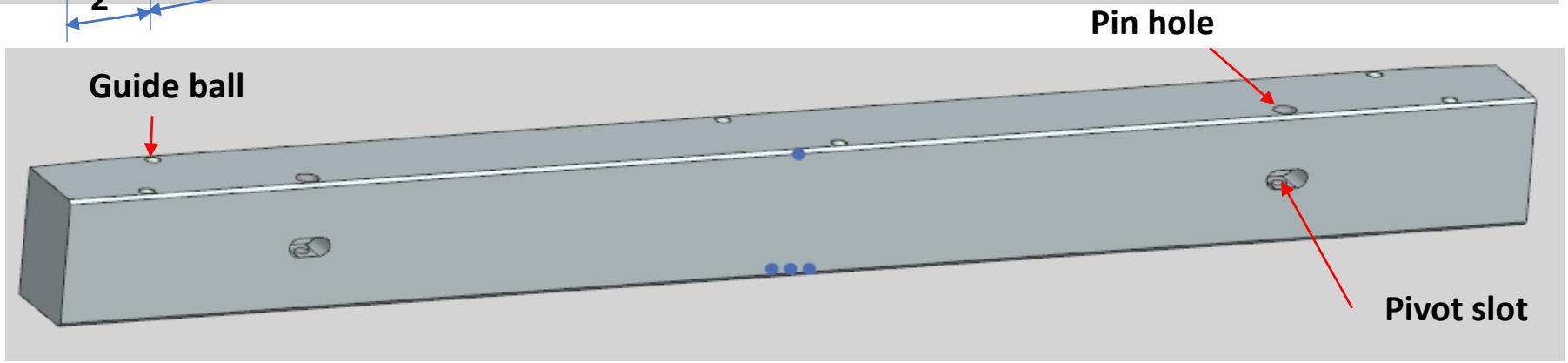


Secondary Collimator aisle side Jaw

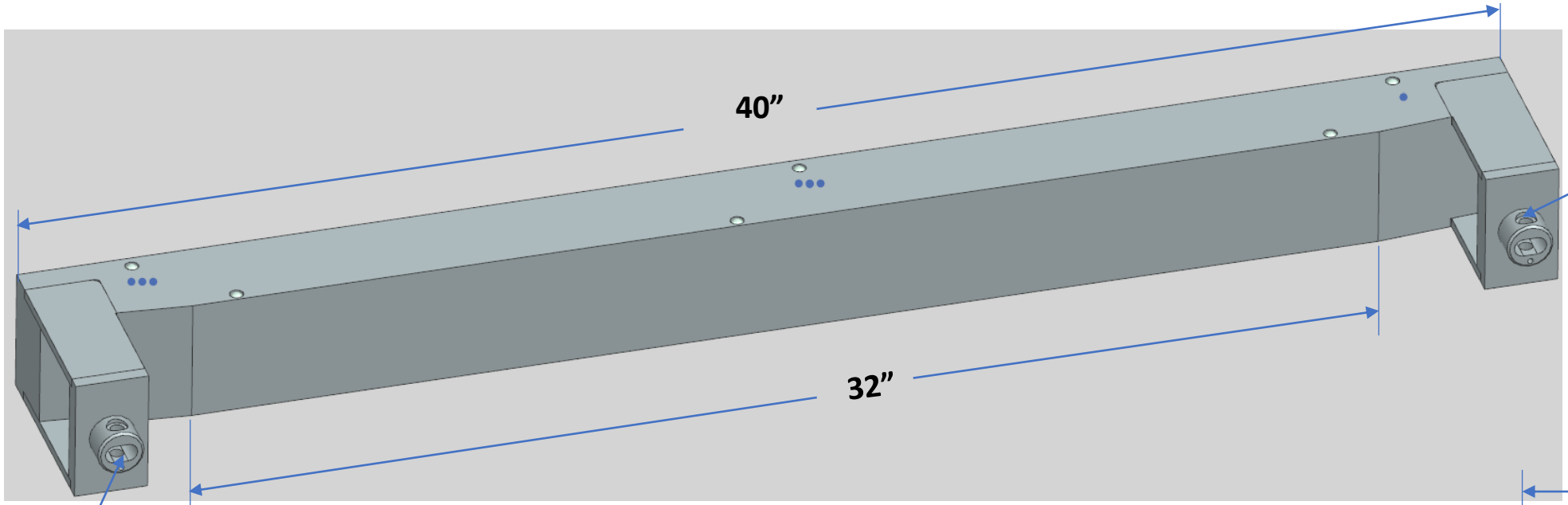
Secondary collimator jaws are made from stainless steel.

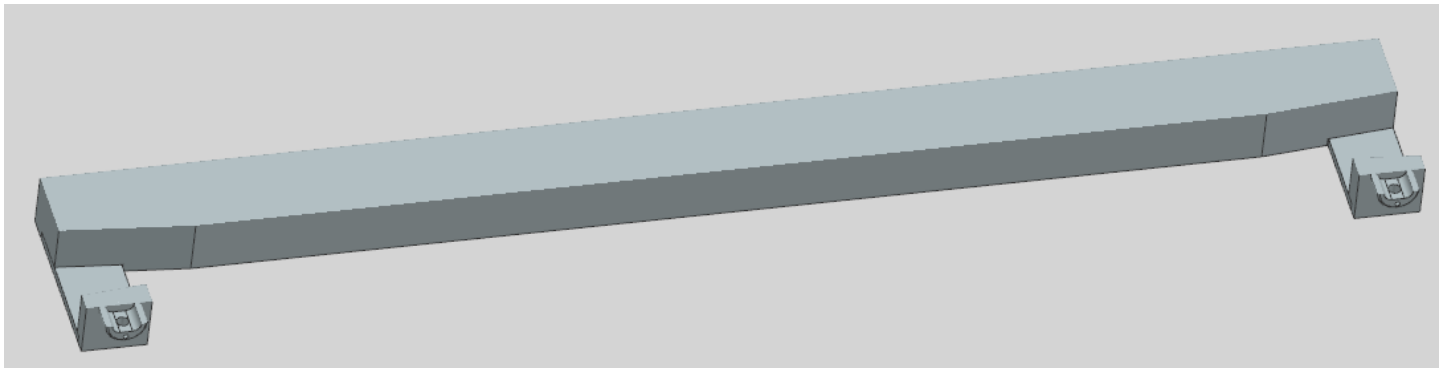


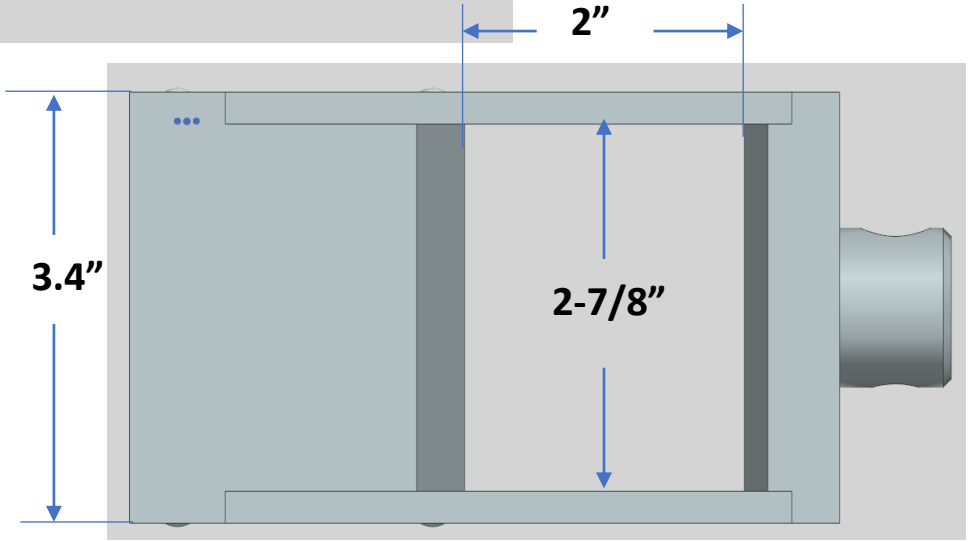




Secondary Collimator wall side Jaws

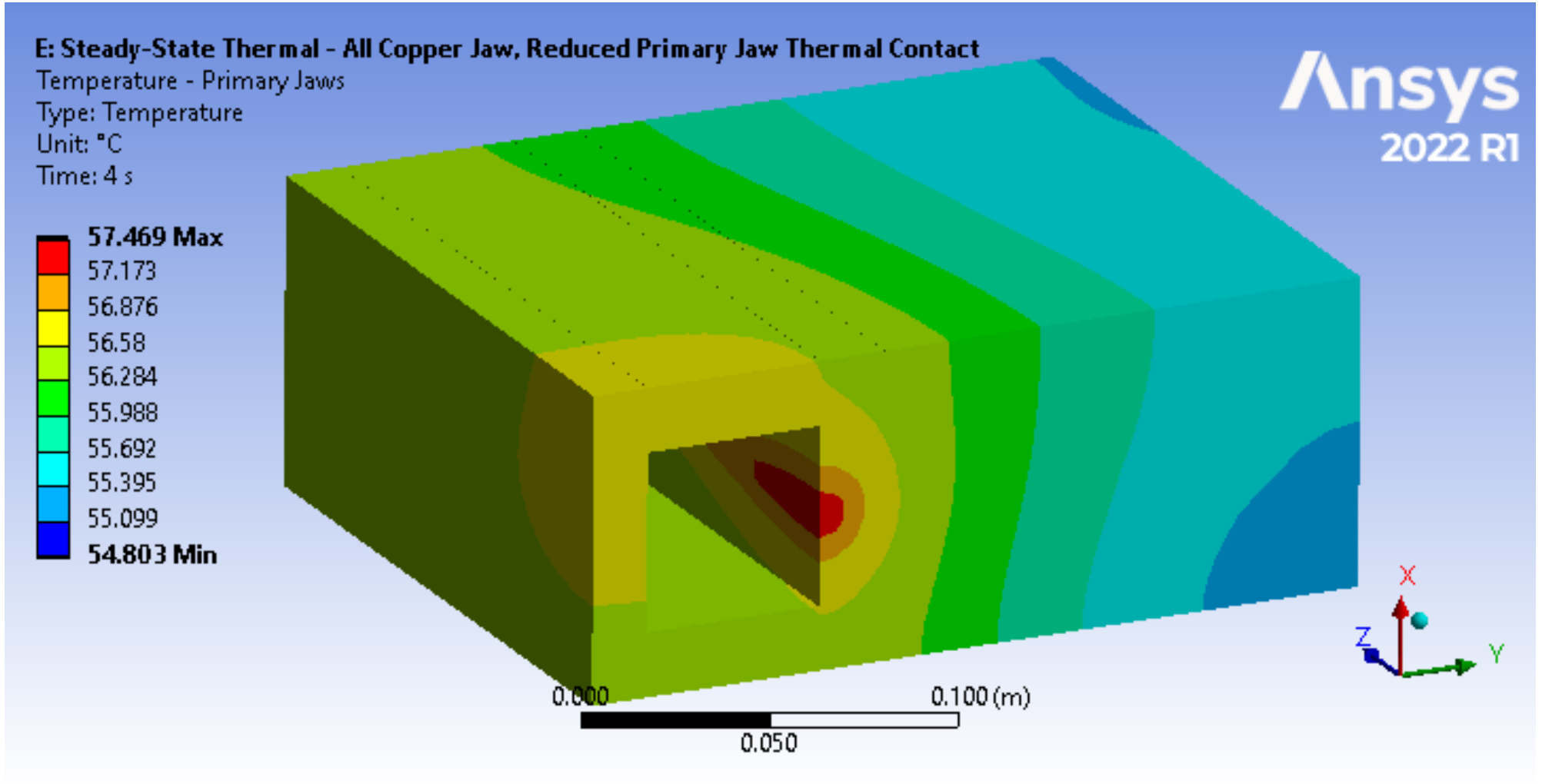




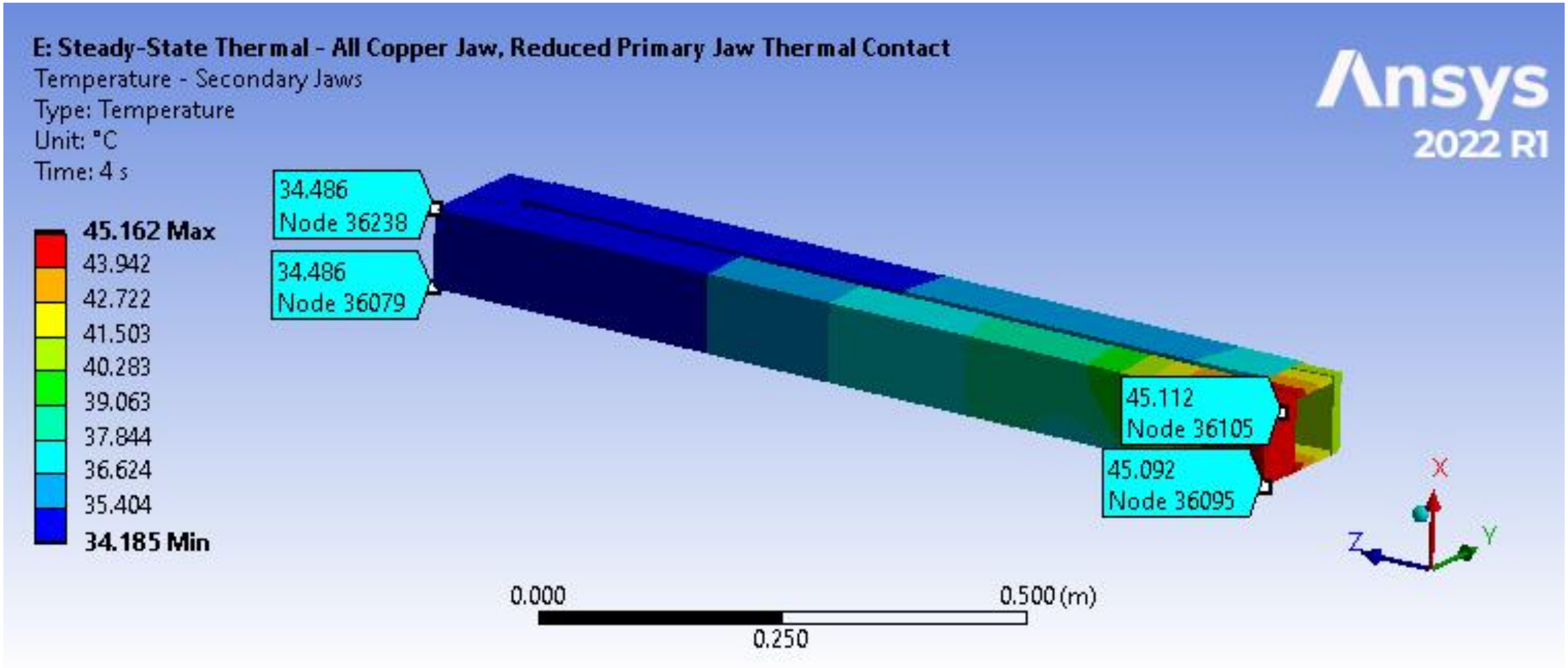


Temperature Results – Primary Jaw

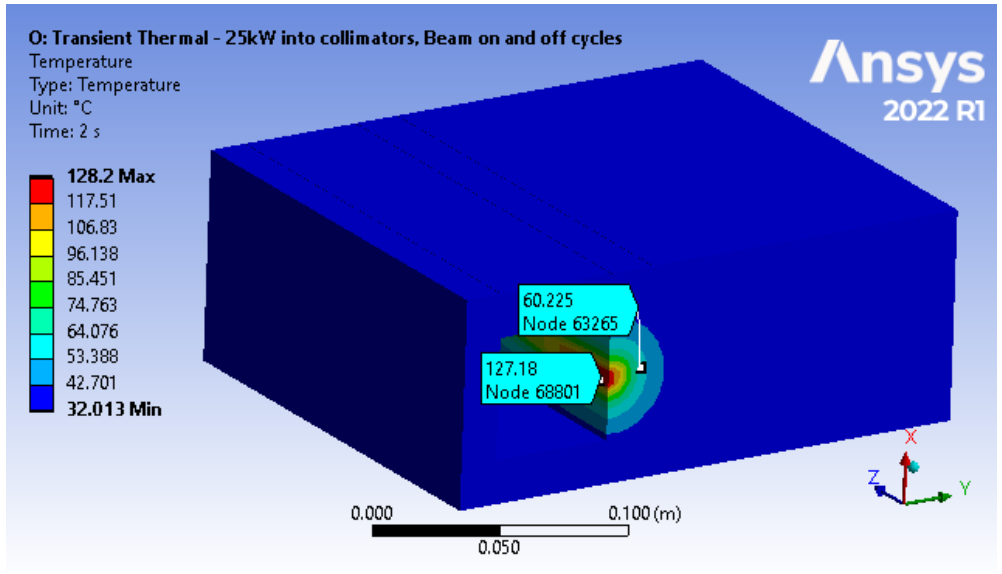
Raul Campos

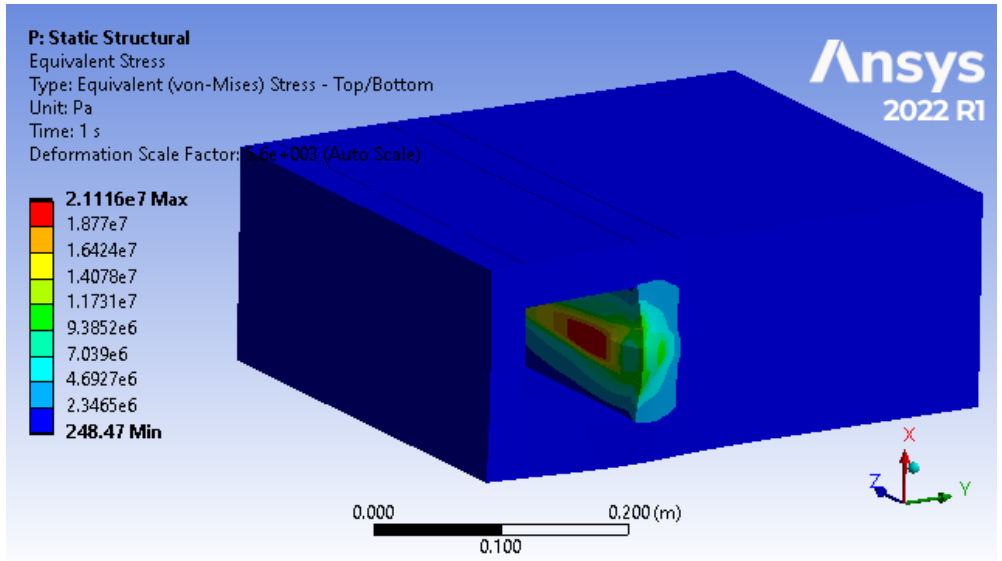


Temperature Results – Secondary Jaw



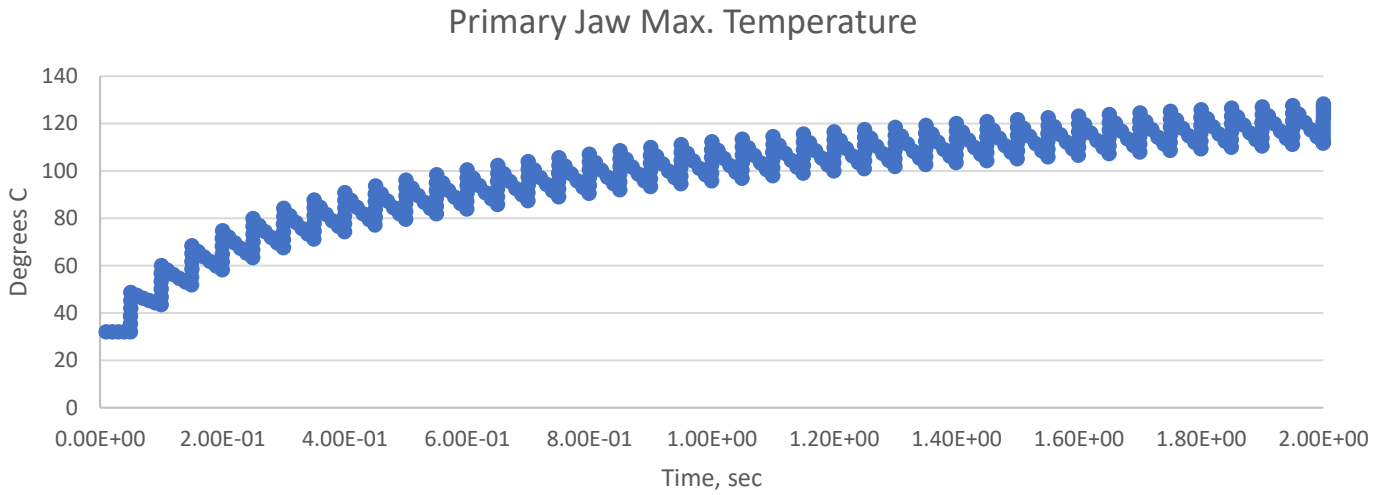
Accident scenario – 25kW energy deposition





25kW accident scenario energy deposition scaled from normal operation (250W energy deposition distribution), with baseline contacts and boundary conditions

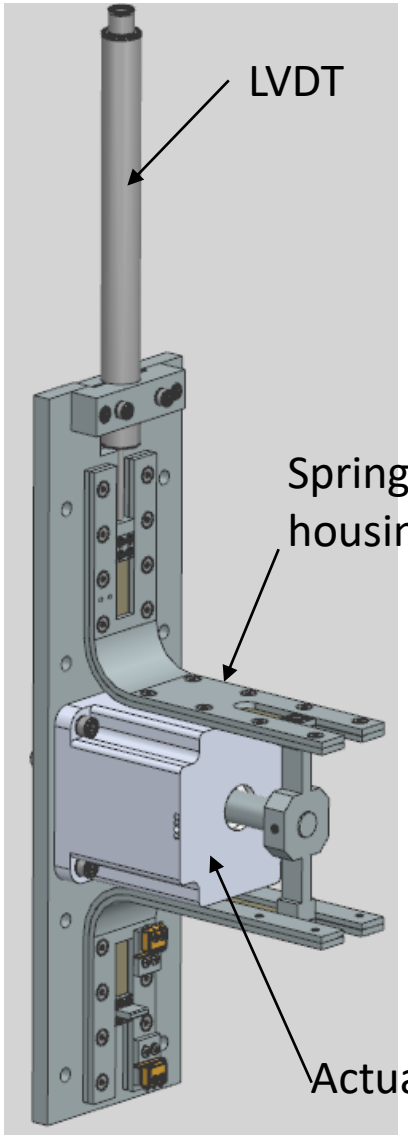
pulse length	0.00055	sec
Rep rate	20	pulses/sec
beam off between pulses	0.04945	sec

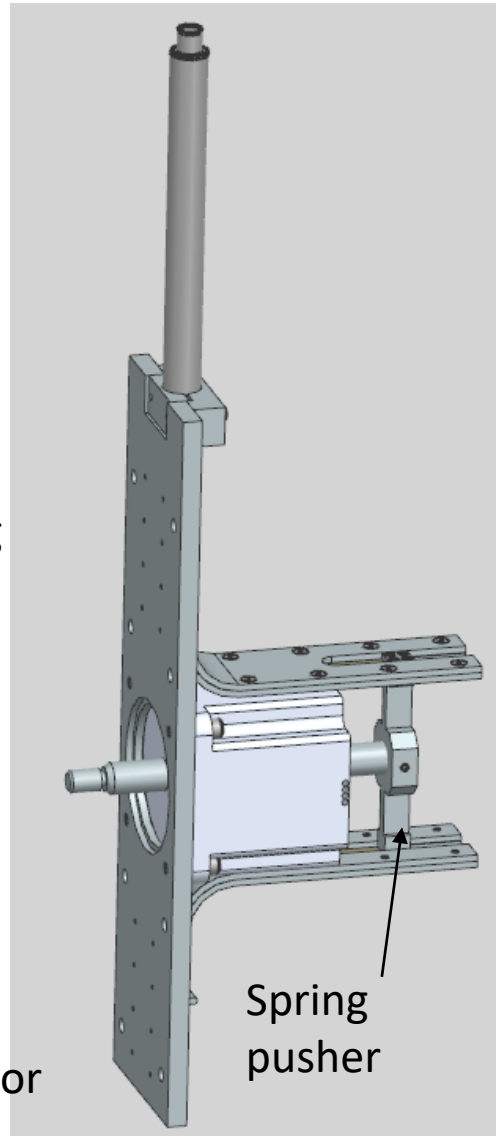


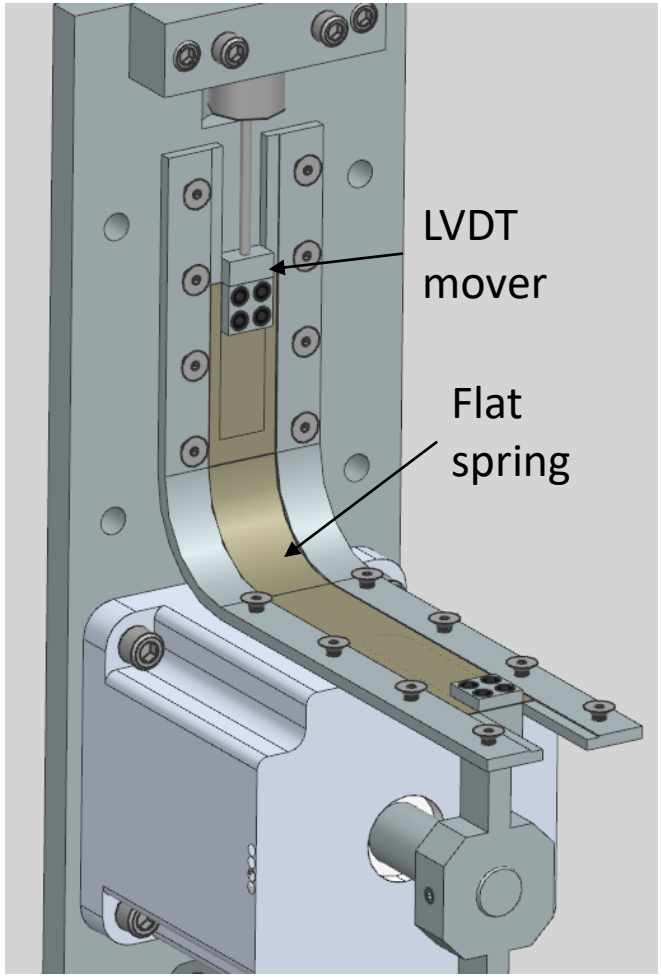
- Maximum temperature is not an issue with analyzed contacts and boundary conditions for the initial seconds of accident scenario, but could be for longer duration of 25kW energy deposition
- 21 MPa stresses due to temperature gradient below endurance limit (50 MPa for assumed annealed copper) so there is no risk of thermo-mechanical fatigue failure

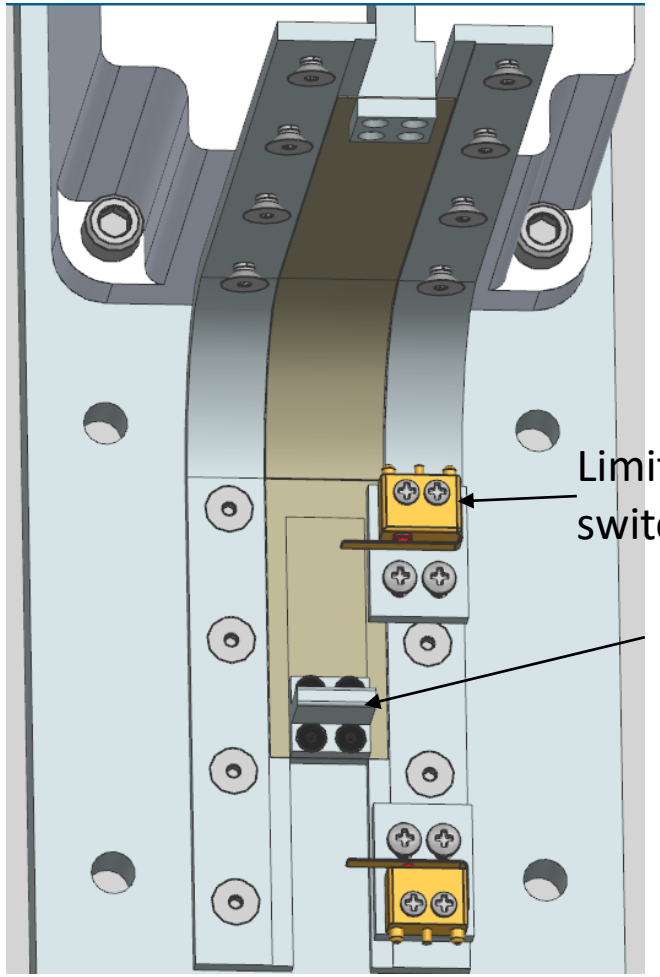
Collimators motion control unit

Special motion control unit is designed for collimators jaws movement.



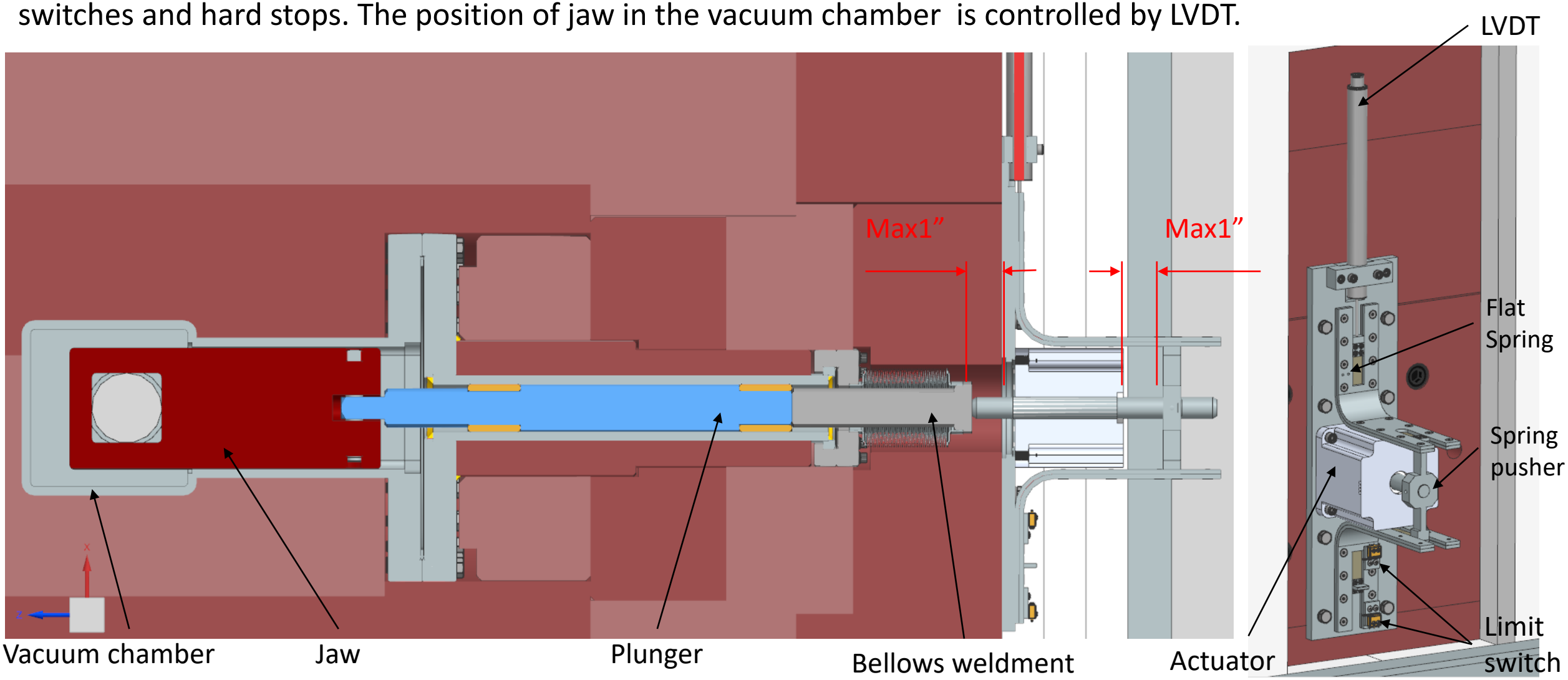






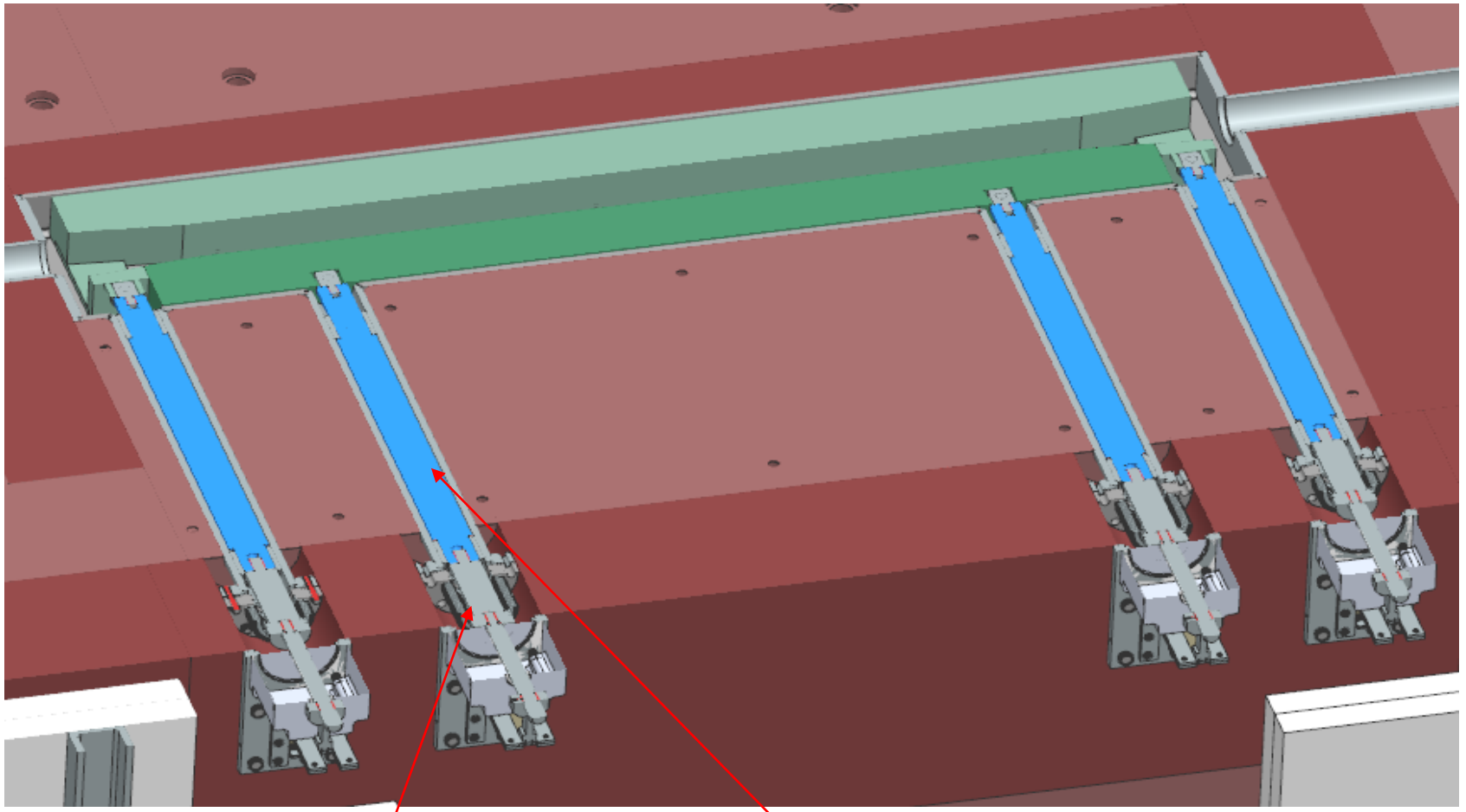
Primary horizontal collimator drive and control

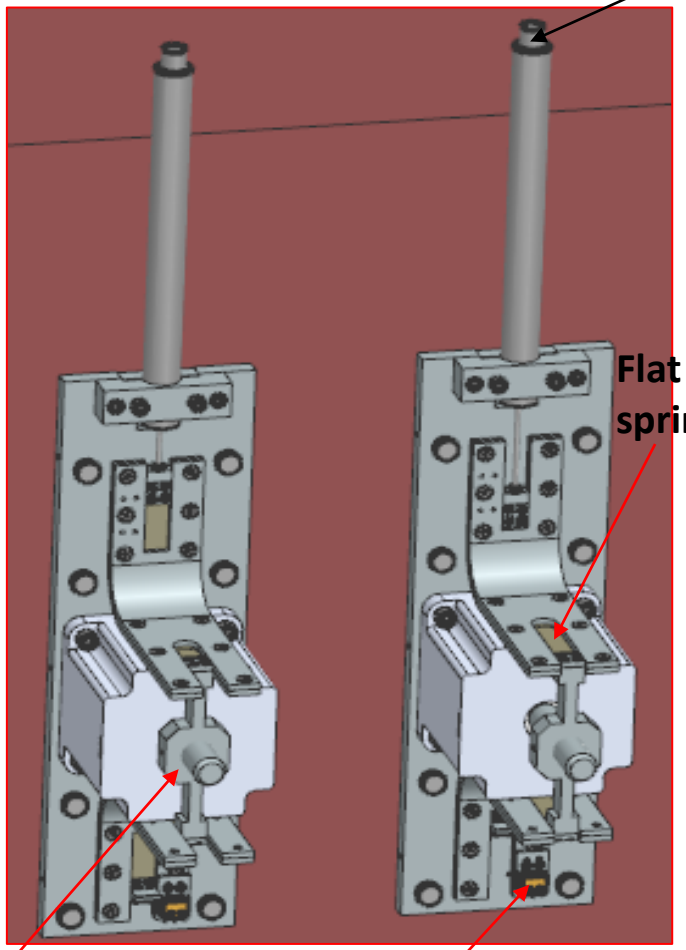
The jaw movement is provided by the actuator. The actuator bracket base plate is bolted to the collimator steel shielding and the actuator screw is connected to bellows weldment rod . The travel +/- 1” is limited by limit switches and hard stops. The position of jaw in the vacuum chamber is controlled by LVDT.



Secondary collimator drives and controls

The actuator is connected to the bellows weldment rod and providing the push-pull acting force. Both actuators of each jaw are synchronized. Limit switches are limited the jaws travel. LVDTs control the jaws position inside the vacuum chamber. The bellows weldment rod and spring pusher stops jaws movement if Limit switch will be destroyed.





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Anaheim Automation :: Stepper :: :: Hybrid Linear Actuators :: 34AW

34AW - Hybrid Linear Actuators

- *NEMA Size 34*
- *Motor Winding Options Available*
- *Custom Lead Screw Lengths*
- *Stepper Motor with Internal Nut*
- *Self Contained Package with Ball Bearings*
- *1.8° Step Angle*
- *0.0127mm Per Full Step*
- *CE Certified*

3D PDF
.STEP File (.RAR File)
Spec Sheet (PDF)
Get a Quote

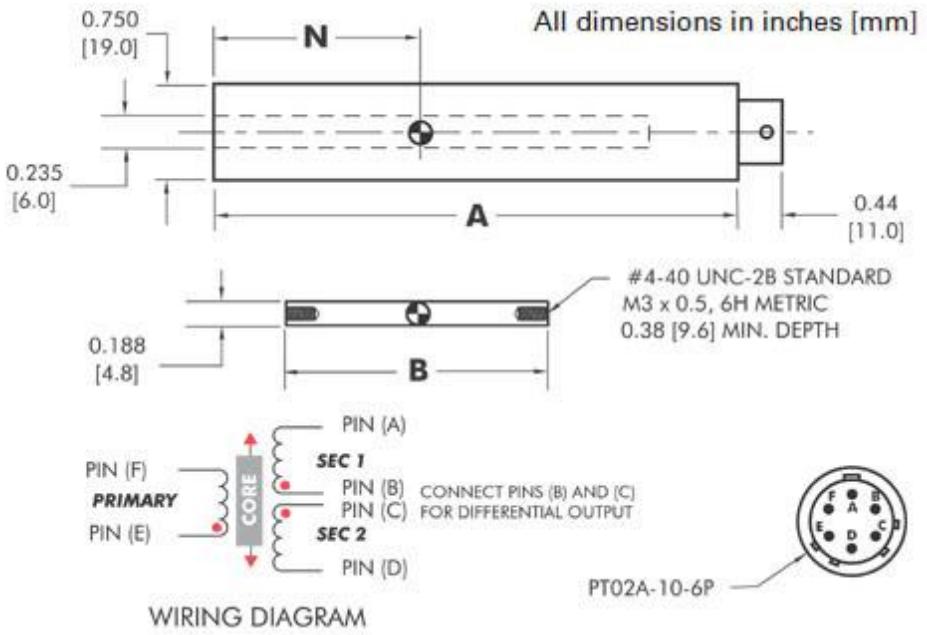
The 34AW Linear Stepper Motors are designed to be the most versatile linear positioning motors on the market. Based on the NEMA 34 Hybrid Stepper Motor, it has a 1.8° single step. These hybrid non-captive and external linear actuators are robust and can be easily configured to solve some of the most difficult application problems. Integration of a lead screw with a motor saves space, eliminates components, and reduces cost. While many standard configurations are available, custom modifications for OEM customers are welcome.

Item	Bipolar RMS Current (A)	Bipolar RMS Voltage (V)	Travel Per Step (mm)	# of Lead Wires	Weight (lbs)	Maximum Force (lbs)	Motor Length (mm)	Screw Length (in(mm))	Price (USD)	$AVE Quantity Discounts	Stock Status	Add To Cart
34AW1063X18-LW8-EL	3	4.5	0.0127	8	6.40	528	78.56	18 (457.2)	$378.00	view here	7 in Stock	
34AW1063X18-LW8-NC	3	4.5	0.0127	8	5.90	528	78.56	18 (457.2)	$376.00	view here	7 in Stock	

LVDT

HSA/HSAR 750 Series

•Macro Sensors' HSA and HSAR 750 Series of 3/4 inch (19 mm) diameter AC-operated LVDTs are designed for a wide range of position measurement applications. These are rugged **hermetically sealed sensors**, constructed entirely of stainless steel, and intended for general industrial use. The coil windings are sealed against hostile environments to IEC standard IP-68 and electrical termination is through a sealed axial (HSA) or radial (HSAR) connector.



Input Voltage	**3.0 Vrms (nominal)**
Input Frequency	**2.5 to 3.0 kHz**
Linearity Error	**< ±0.25% of FRO**
Repeatability Error	**< 0.01% of FSO**
Hysteresis Error	**< 0.01% of FSO**
Operating Temperature	**-65 °F to +220 °F** **-55 °C to +105 °C**
Thermal Coefficient of Sensitivity	**-0.01%/°F (nominal)** **-0.02%/°C (nominal)**
Vibration Tolerance	**20 g to 2 kHz**
Shock Survival	**1000 g, 11 ms**

Parameter	Unit of Measure	HSA 750-050	HSA 750-125	HSA 750-250	HSA 750-500	HSA 750-1000	HSA 750-2000	HSA 750-3000	HSA 750-4000	HSA 750-5000	HSA 750-7500	HSA 750-10000
Nominal Range	inches	± 0.050	± 0.125	± 0.25	± 0.50	± 1.00	± 2.00	± 3.00	± 4.00	± 5.00	± 7.50	± 10.00
	mm	± 1.3	± 3.0	± 6.3	± 12.5	± 25	± 50	± 75	± 100	± 125	± 190	± 250
Sensitivity	mV/V/.001 in	6.1	3.9	2.4	0.63	0.61	0.37	0.25	0.17	0.12	0.11	0.07
	mV/V/mm	240	154	96	25	24	15	9.8	6.7	4.9	4.3	2.8
Primary Impedance	ohms	325	735	1400	1200	1250	2150	2150	420	600	775	620
Dimension "A"	inches	2.01	2.64	3.35	5.92	7.38	10.91	13.65	16.17	18.65	23.85	31.66
	mm	51.1	67.1	85.1	150.4	187.5	277.1	346.1	411	473.7	606	804
Dimension "B"	inches	0.80	1.25	1.65	3.45	3.45	5.30	6.20	6.20	6.20	7.00	9.50
	mm	20.3	31.7	41.9	87.6	87.6	134.6	157.5	157.5	157.5	177.8	241.3
Dimension "N"	inches	0.63	0.94	1.32	2.57	3.32	5.07	6.29	7.65	8.94	11.52	15.42
	mm	16	24	33	65	84	129	160	194	227	293	392
Weight - Body	ounces	1.6	2.1	2.5	3.3	4.3	6.2	8.2	9.2	10.0	14.2	18.3
	grams	45	59	71	93	122	176	232	260	283	402	519
Weight - Core	ounces	0.08	0.12	0.18	0.40	0.40	0.65	0.80	0.80	0.80	0.90	1.20
	grams	2.4	3.7	4.8	11.6	11.6	18	22	22	22	25.5	34

Limit Switch

Sealed Super-Ultra-Small Basic Switch D2JW

OMRON

Ultra compact seal type.

[Features]
· Protection structure is JIS immersion type IEC IP67 compatible; (terminal parts not included).
· Peripheral temperature of -40 to +85°C can be used.
· High durability, high contact durability due to gold alloy cross bar contact and coil spring.

Configure here

Reset

Completed

Movement After the Operation OT(mm)

0.7

Operating Position OP(mm)

8.4±0.8

Part Number **D2JW-01K1A1**

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Configured Specifications

Detector Shape	Lever Shape (push)	Plunger Shape Type	-
Lever Shape Type	-	DC rated operating voltage(V)	30
Operating Temperature Range(℃)	-40 ~ 85	Protection Structure	IP67
Force Required for Push Side O.F.(N)	~2	Motion to Switching P.T.(mm)	5.4
Contact Type	Single Pole Double Throw	Contact Point Type	[Crossbar] Crossbar
Contact Material	Gold alloy	Mechanical Life(A million times)	100

Show More

Price $7.01

Total $7.01

Ship Date Mon. Jul 11, 2022
Valid until 8PM, EST

Qty. 1 Add to Cart

Quantity	Price	Ship Date
1-26	$7.01	Jul 11, 2022
27-	$7.01	TBD

NOTE : Ship Dates above are subject to change depending upon availability.

Thermocouple

Thermocouples Probes with Connectors - Quick Disconnect - Standard Size Molded Connector

$ -- Item# --

Volume discounts availab

Qty

1

ADD TO CART

CONFIGURE NOW

--

Please note new lead times for out-of-stock items between May 18th and 29

★★★★★ 4.8 (4) Write a review

- Male Connector Permanently Molded to Probe Sheath adds Strength and Durability
- Standard Size Thermocouple Connectors, Color-Coded with Thermocouple Type
- Choice of 304SS, 321SS or Inconel Sheath
- High Strength Bendable Design
- Withstands Vibration, High Temperature, and High Pressure
- Connector Body Rated to 180°C (356°F)
- Made with Special Limits of Error Material
- Mating Connector & clamp & other accessory Sold Separately

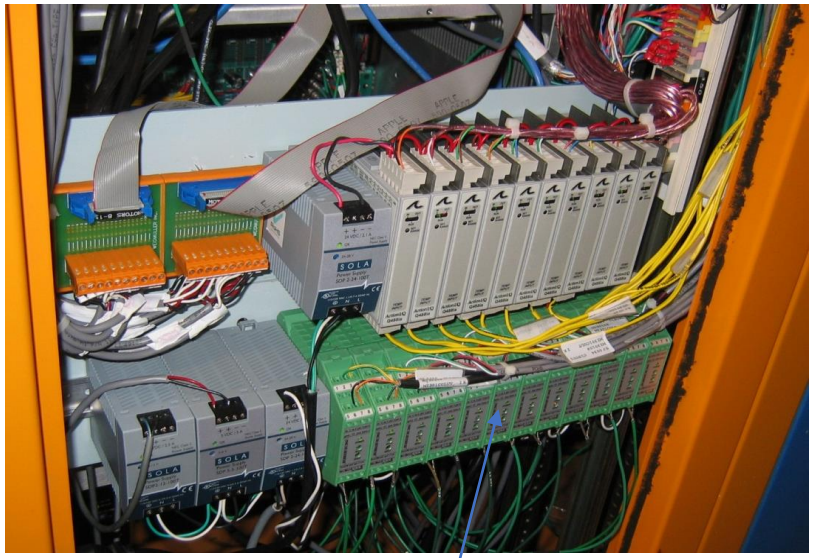
Standard Dimension - Standard Quick Disconnect Probes

Alloy/ANSI Color Code	Sheath Dia. in.	Model No. 12" Length	Model No. 18" Length	Model No. 24" Length
J Iron- Constantan Inconel Sheath	1/16	JQIN-116(*)-12	JQIN-116(*)-18	JQIN-116(*)-24
	1/8	JQIN-18(*)-12	JQIN-18(*)-18	JQIN-18(*)-24
	3/16	JQIN-316(*)-12	JQIN-316(*)-18	JQIN-316(*)-24
	1/4	JQIN-14(*)-12	JQIN-14(*)-18	JQIN-14(*)-24
J Iron- Constantan 304 SS Sheath	1/16	JQSS-116(*)-12	JQSS-116(*)-18	JQSS-116(*)-24
	1/8	JQSS-18(*)-12	JQSS-18(*)-18	JQSS-18(*)-24
	3/16	JQSS-316(*)-12	JQSS-316(*)-18	JQSS-316(*)-24
	1/4	JQSS-14(*)-12	JQSS-14(*)-18	JQSS-14(*)-24
K CHROMEGA™-ALOMEGA™ Inconel Sheath	1/16	KQIN-116(*)-12	KQIN-116(*)-18	KQIN-116(*)-24
	1/8	KQIN-18(*)-12	KQIN-18(*)-18	KQIN-18(*)-24
	3/16	KQIN-316(*)-12	KQIN-316(*)-18	KQIN-316(*)-24
	1/4	KQIN-14(*)-12	KQIN-14(*)-18	KQIN-14(*)-24
K CHROMEGA™- ALOMEGA™ 304 SS Sheath	1/16	KQSS-116(*)-12	KQSS-116(*)-18	KQSS-116(*)-24
	1/8	KQSS-18(*)-12	KQSS-18(*)-18	KQSS-18(*)-24
	3/16	KQSS-316(*)-12	KQSS-316(*)-18	KQSS-316(*)-24
	1/4	KQSS-14(*)-12	KQSS-14(*)-18	KQSS-14(*)-24
K CHROMEGA™-ALOMEGA™ Super OMEGACLAD™ XL Sheath	1/16	KQXL-116(*)-12	KQXL-116(*)-18	KQXL-116(*)-24
	1/8	KQXL-18(*)-12	KQXL-18(*)-18	KQXL-18(*)-24
	3/16	KQXL-316(*)-12	KQXL-316(*)-18	KQXL-316(*)-24
	1/4	KQXL-14(*)-12	KQXL-14(*)-18	KQXL-14(*)-24
N OMEGA-P™-OMEGA-N™ Super OMEGACLAD™ XL Sheath	1/16	NQXL-116(*)-12	NQXL-116(*)-18	NQXL-116(*)-24
	1/8	NQXL-18(*)-12	NQXL-18(*)-18	NQXL-18(*)-24
	3/16	NQXL-316(*)-12	NQXL-316(*)-18	NQXL-316(*)-24
	1/4	NQXL-14(*)-12	NQXL-14(*)-18	NQXL-14(*)-24
E CHROMEGA™- Constantan Inconel Sheath	1/16	EQIN-116(*)-12	EQIN-116(*)-18	EQIN-116(*)-24
	1/8	EQIN-18(*)-12	EQIN-18(*)-18	EQIN-18(*)-24
	3/16	EQIN-316(*)-12	EQIN-316(*)-18	EQIN-316(*)-24
	1/4	EQIN-14(*)-12	EQIN-14(*)-18	EQIN-14(*)-24
E CHROMEGA™- Constantan 304 SS Sheath	1/16	EQSS-116(*)-12	EQSS-116(*)-18	EQSS-116(*)-24
	1/8	EQSS-18(*)-12	EQSS-18(*)-18	EQSS-18(*)-24
	3/16	EQSS-316(*)-12	EQSS-316(*)-18	EQSS-316(*)-24
	1/4	EQSS-14(*)-12	EQSS-14(*)-18	EQSS-14(*)-24
T	1/16	TQIN-116(*)-12	TQIN-116(*)-18	TQIN-116(*)-24

The OMEGA type-K thermocouple 1/16 diameter is used for jaws temperature control.
The thermocouple is inserted into grove and touched the vacuum chamber. The heat from jaws is transferred through the vacuum chamber body to thermocouples.

Power supply and controls rack assembly

Mike Coburn



LVDTs Controllers

Motors Controllers

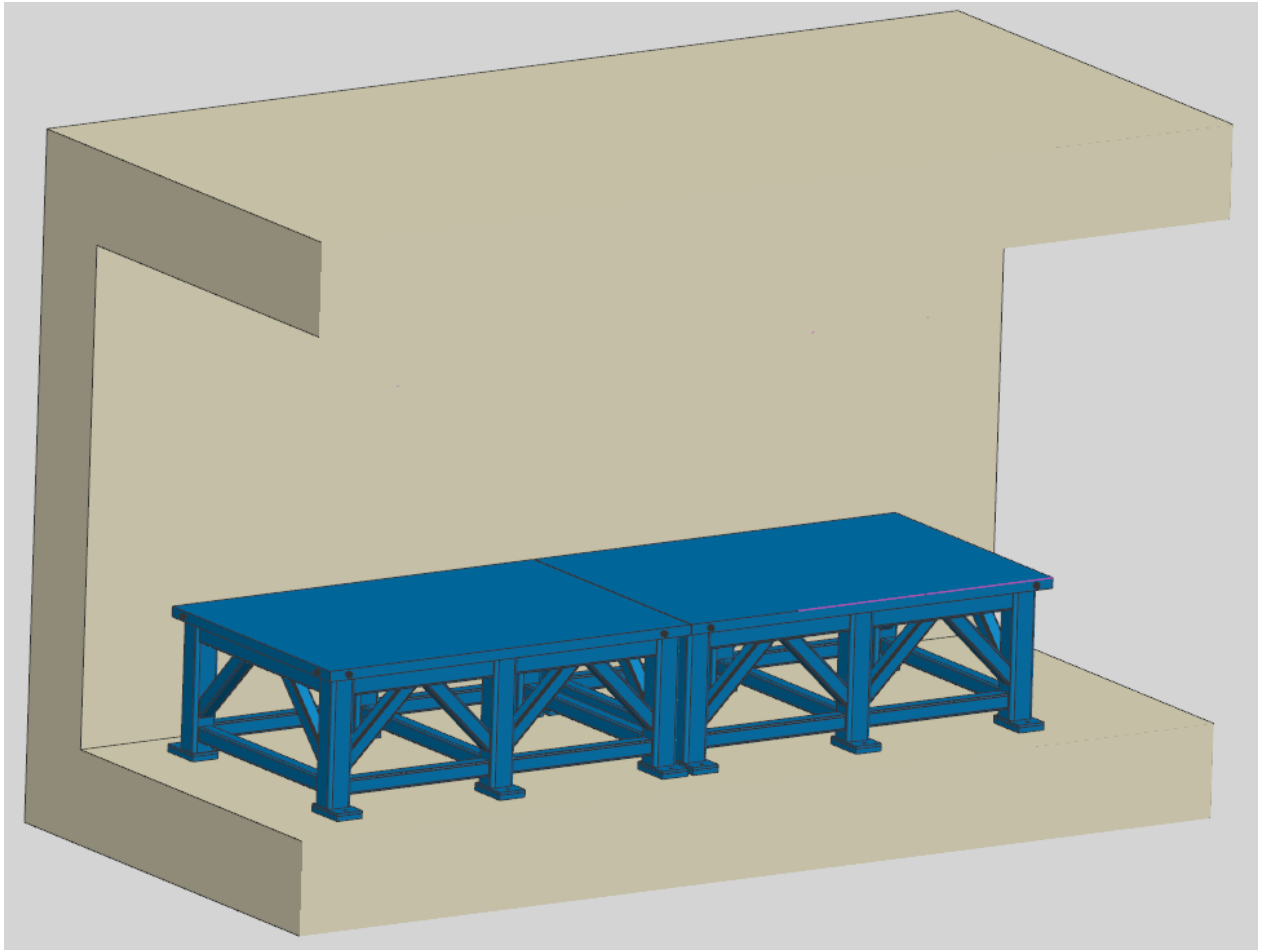
Power Supply

- Cables will be procured and pulled from the racks to the element.

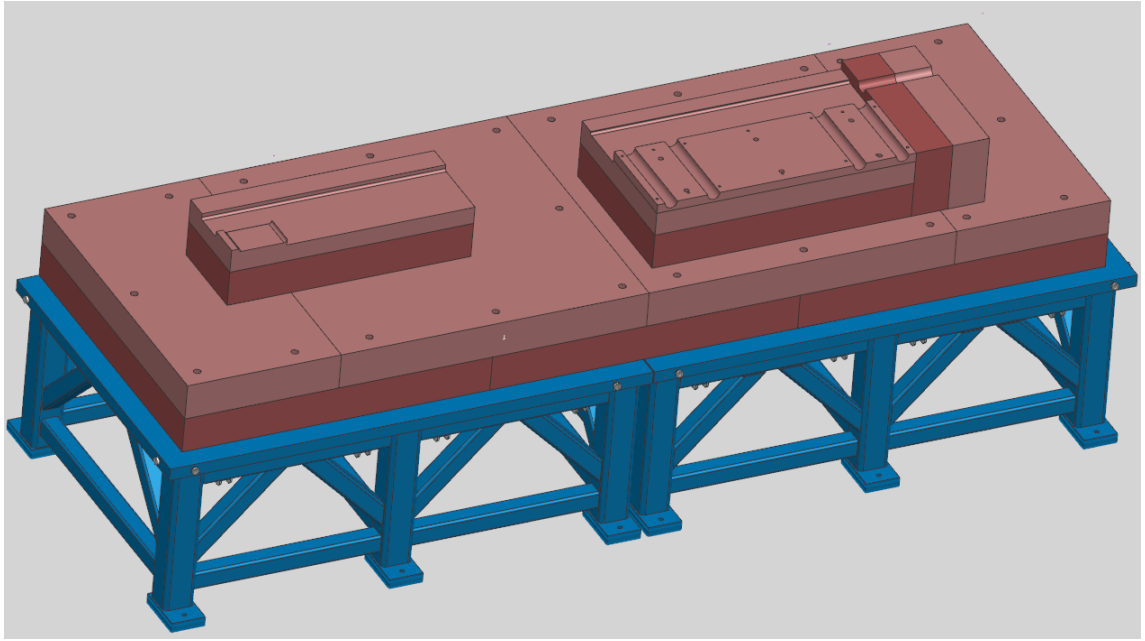
(4) 5 conductor 18 AWG Alpha Cable MFR. # 1898/5C For Motor Control
(4) 3 conductor 20 AWG Alpha Cable MFR. # 1896C/3C For Limit Switches
(4) 2 Pair 22 AWG Alpha Cable MFR. # 2466C For LVDT Position Sensors

Collimator Assembly Procedure

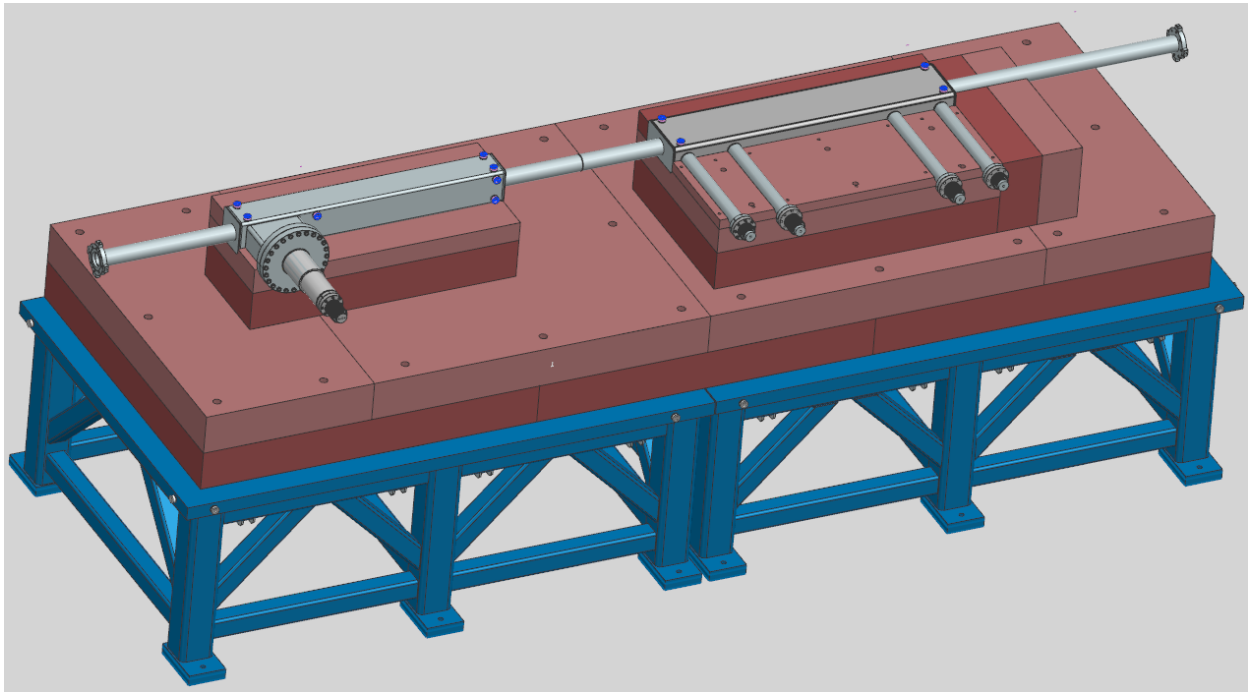
1. Two collimator support tables are delivered to the collimator location and aligned with the beam line by the alignment group. Table weight: 4000lb

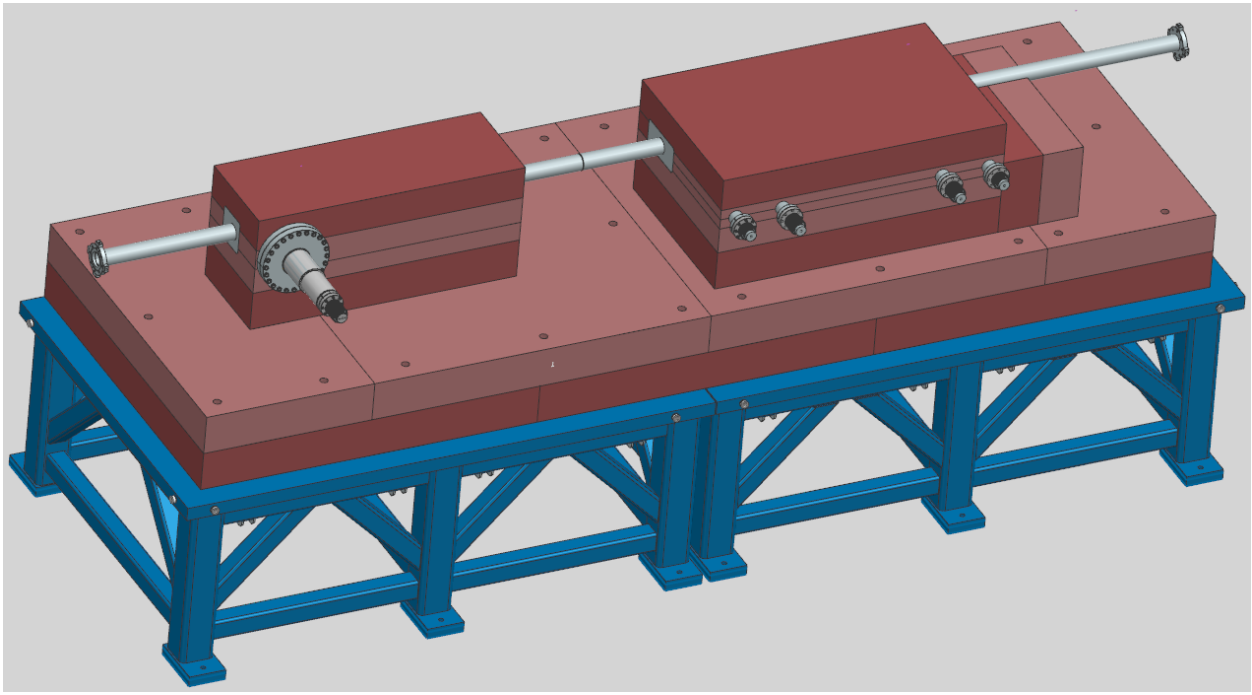


2. Primary and secondary collimators vacuum chambers support blocks are assembled in the middle of tables.

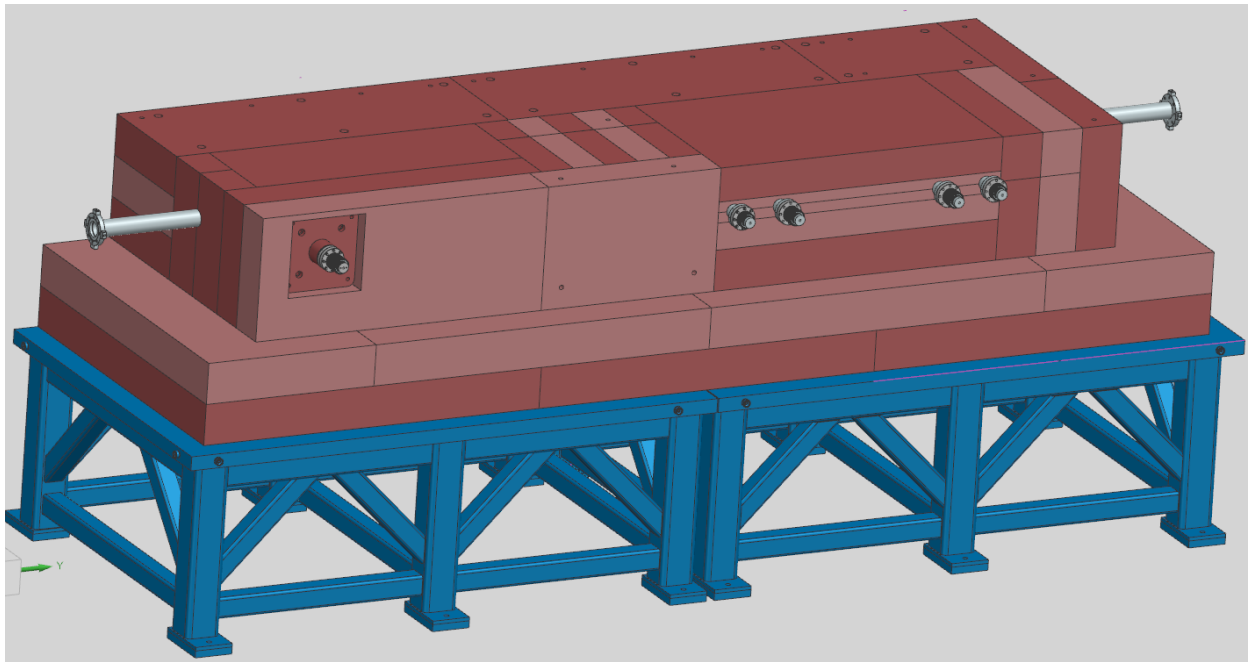


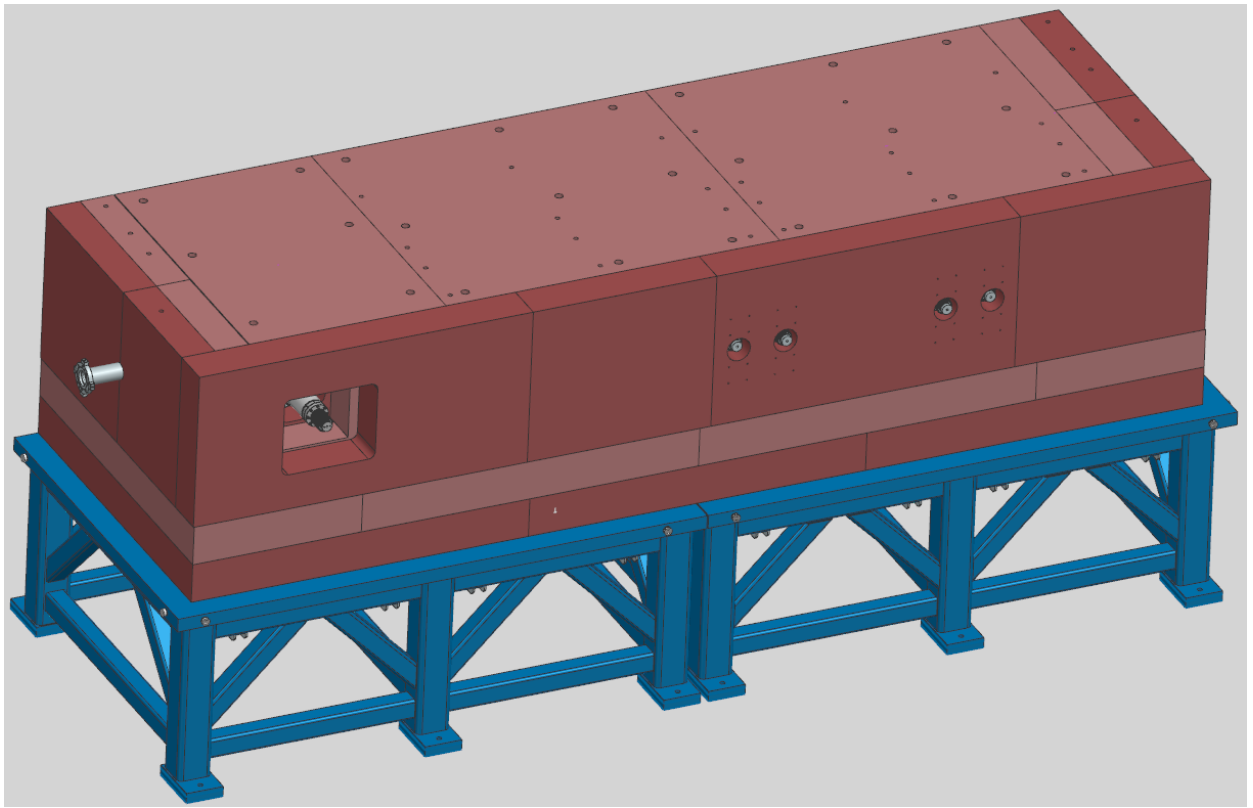
3. Both collimators vacuum chambers are placed on the support blocks, aligned with the beam line center, welded together and covered with top shielding plates.



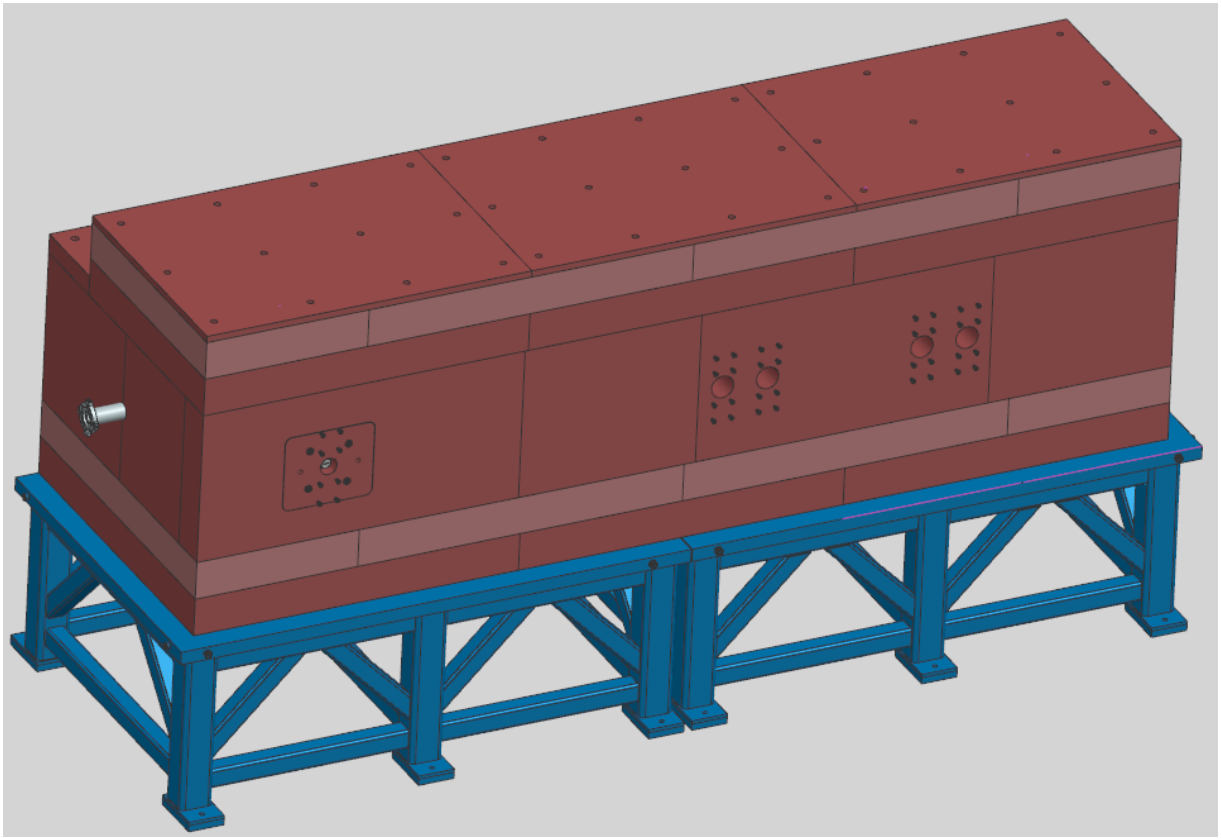


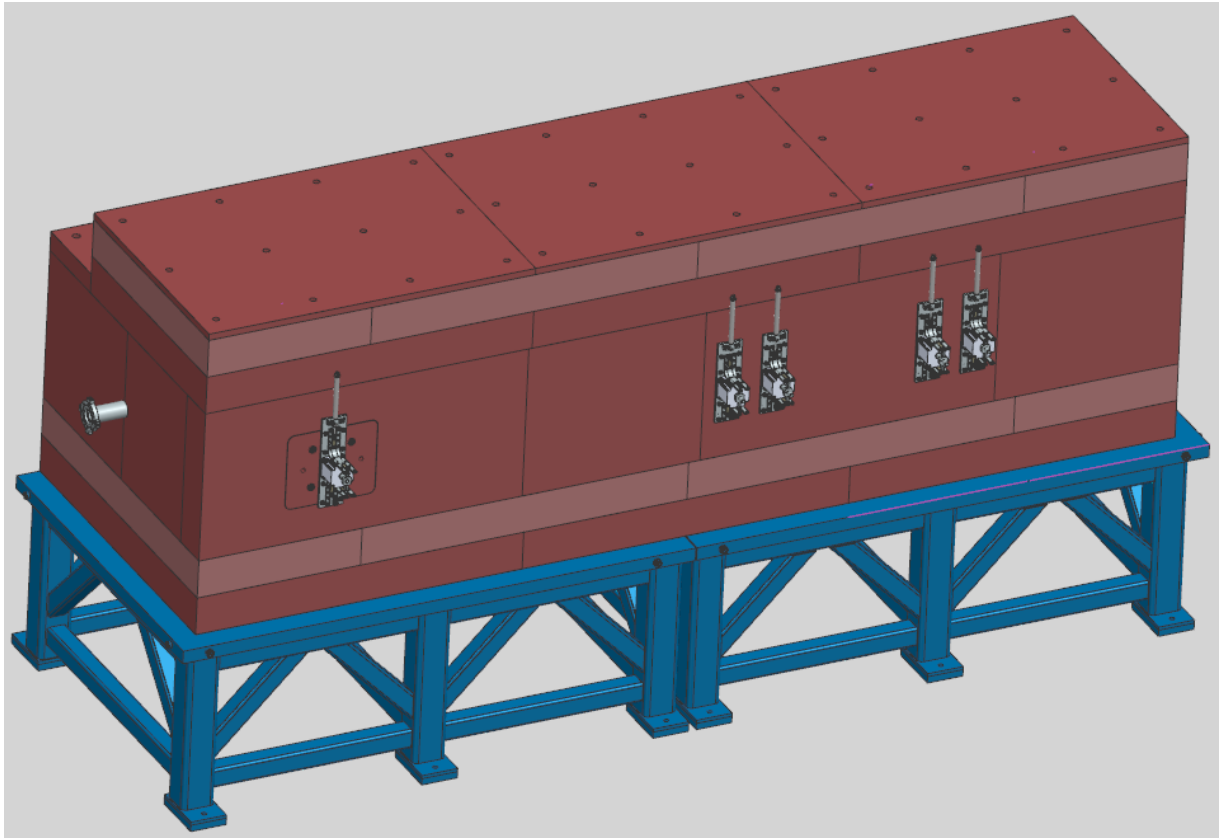
4. Vacuum chambers surrounding steel shielding installation is continued.



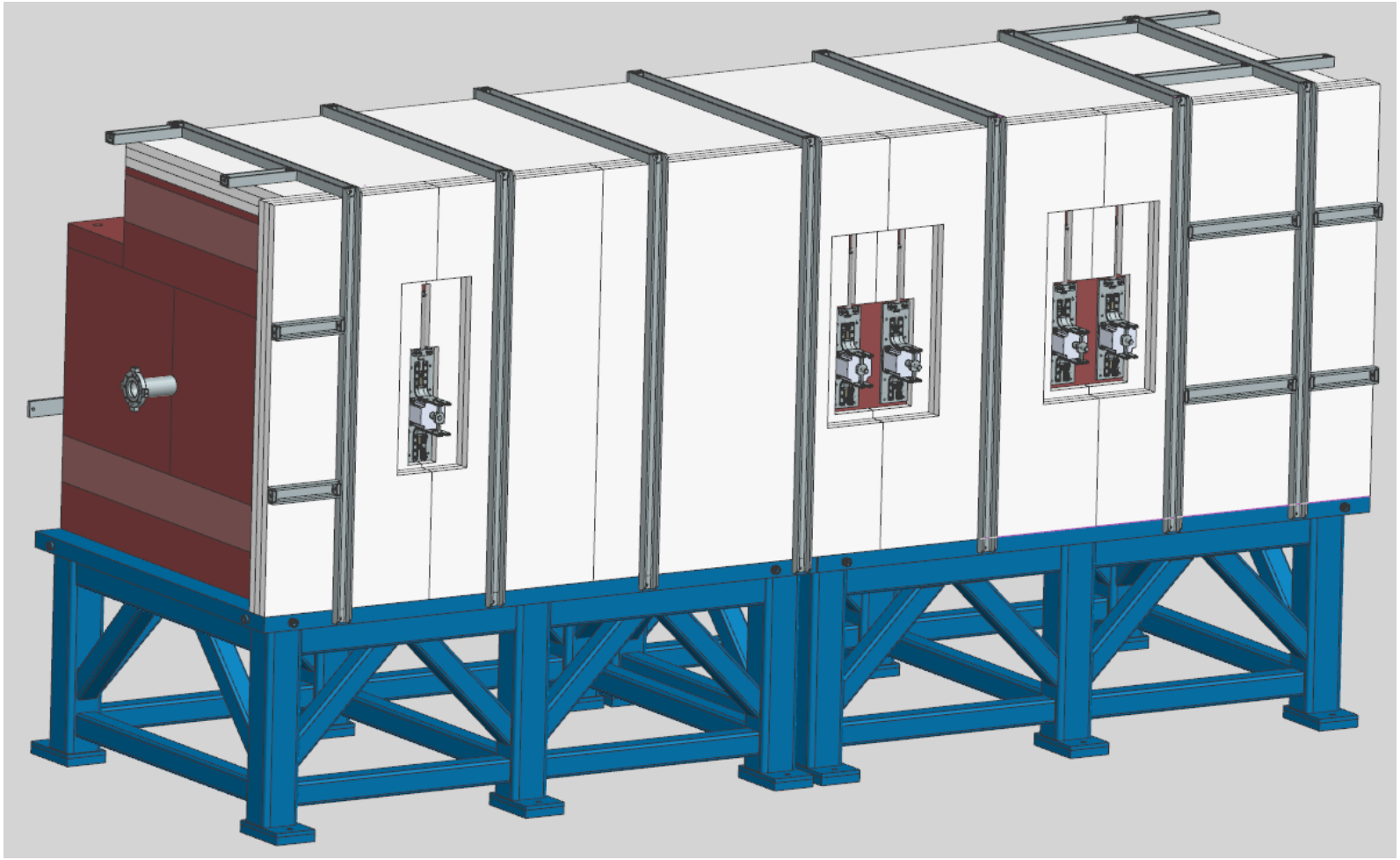


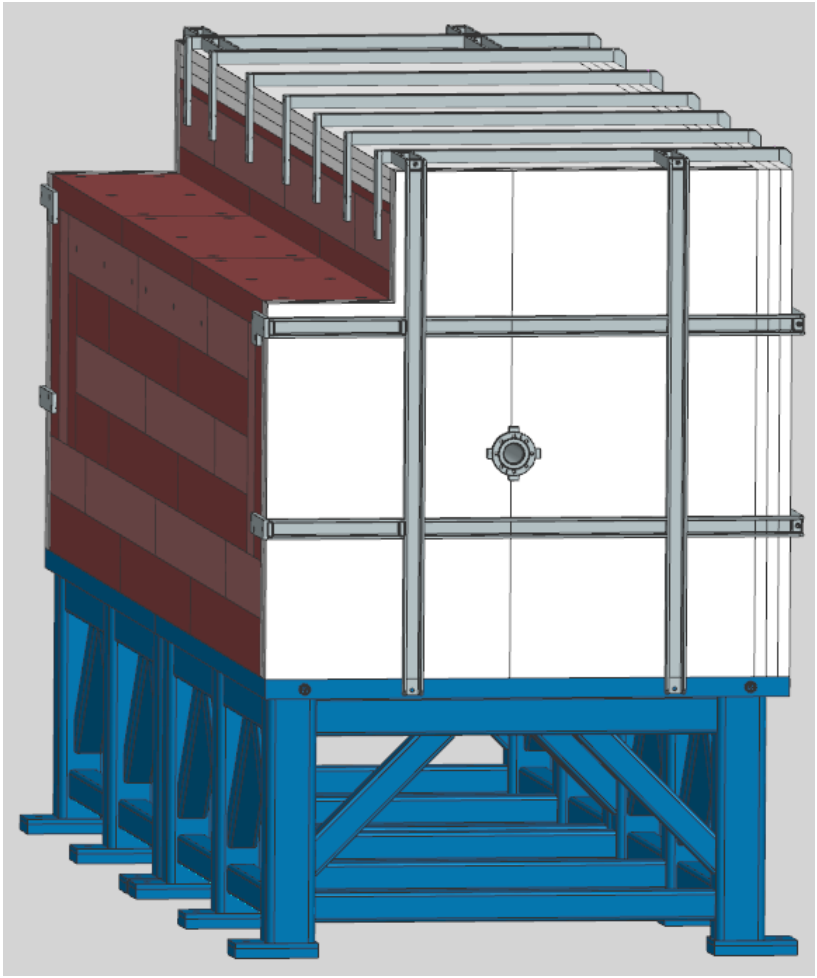
5. Steel shielding installation is completed. Motor control units are installed



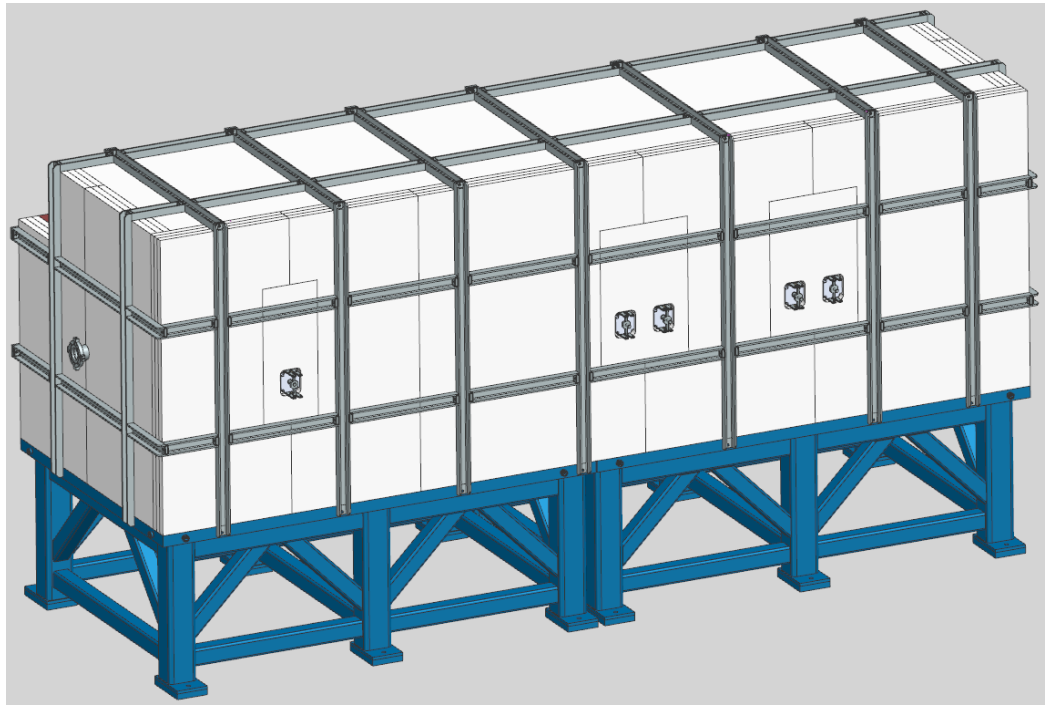


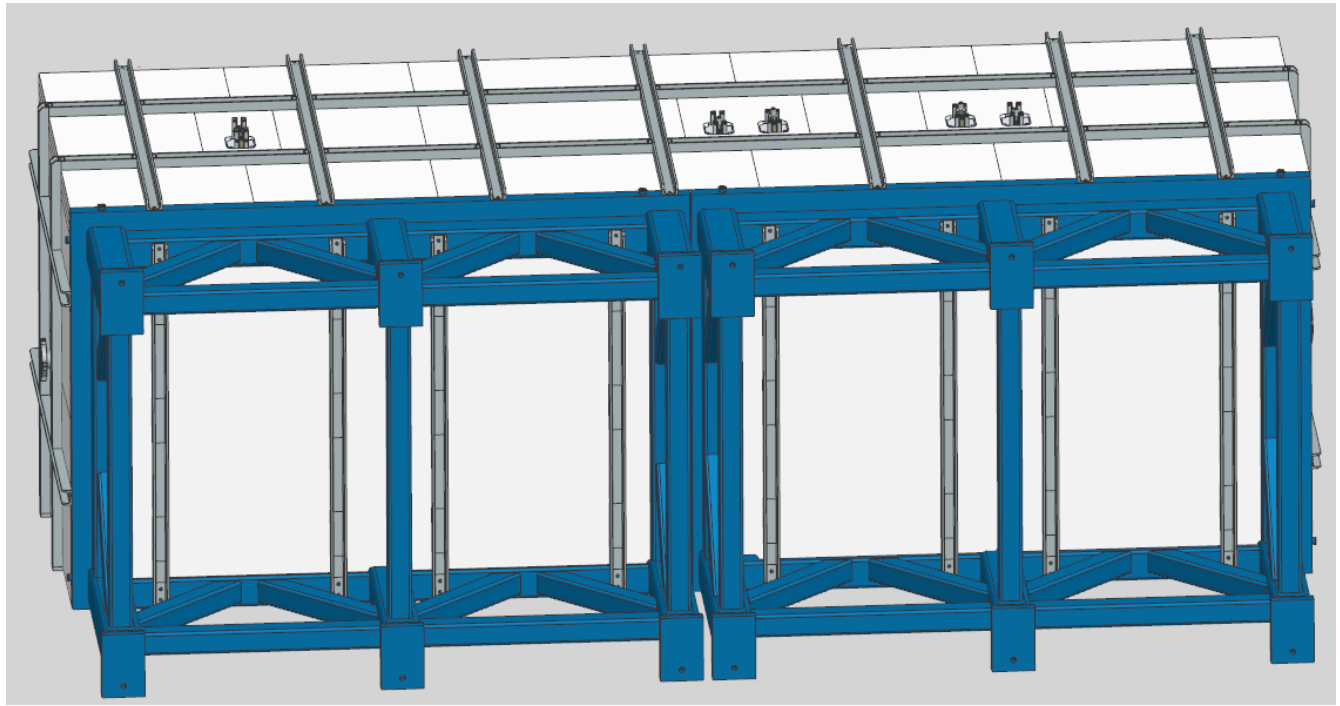
6. All steel shielding surfaces are covered with marble except the wall side. The marble is held by aluminum frame.



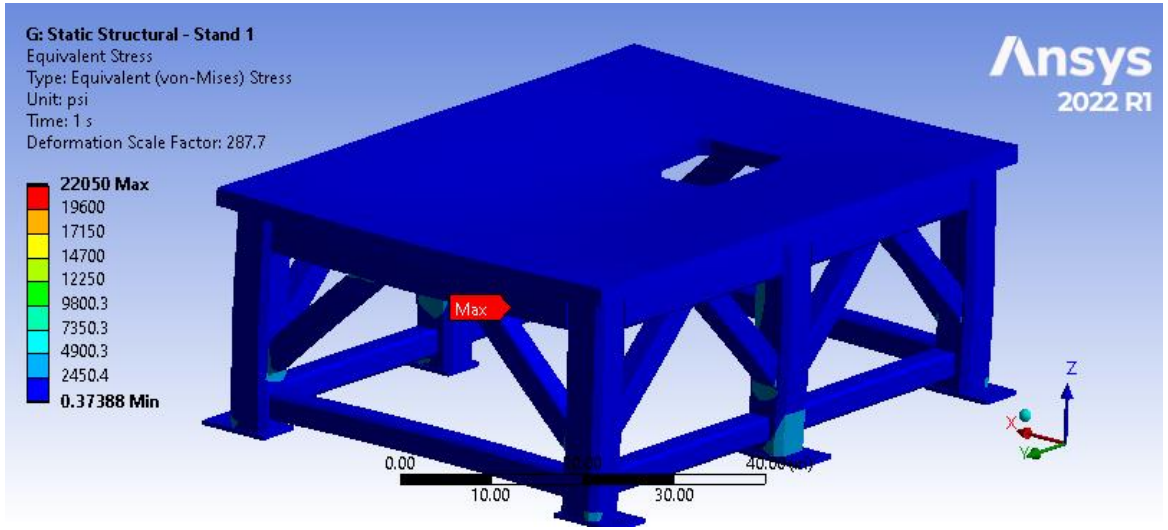


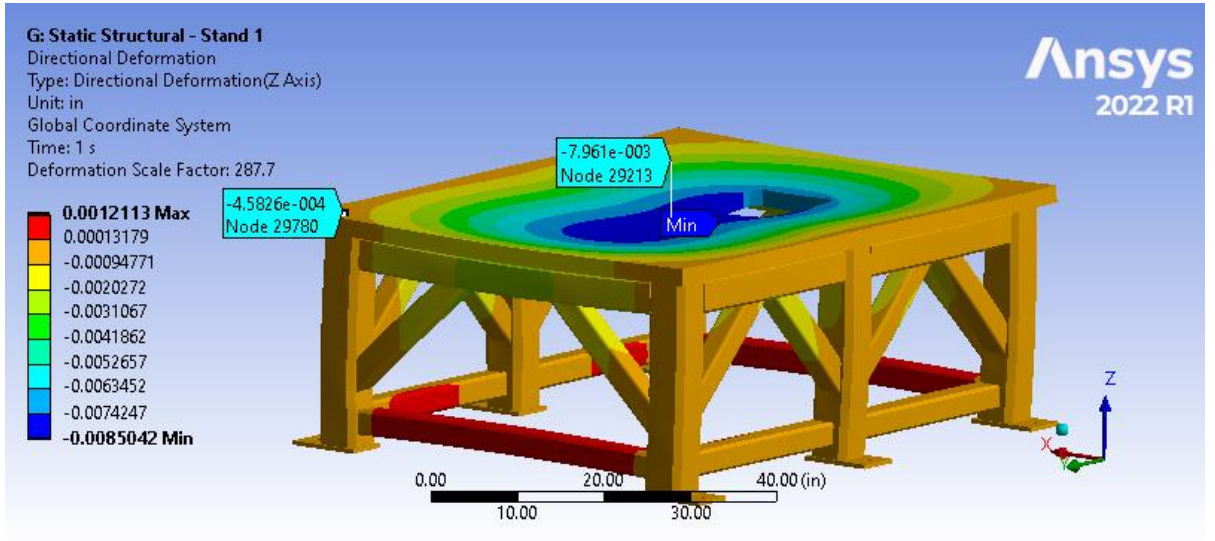
7. The support table is covered with marble. The marble is supported by aluminum channels.

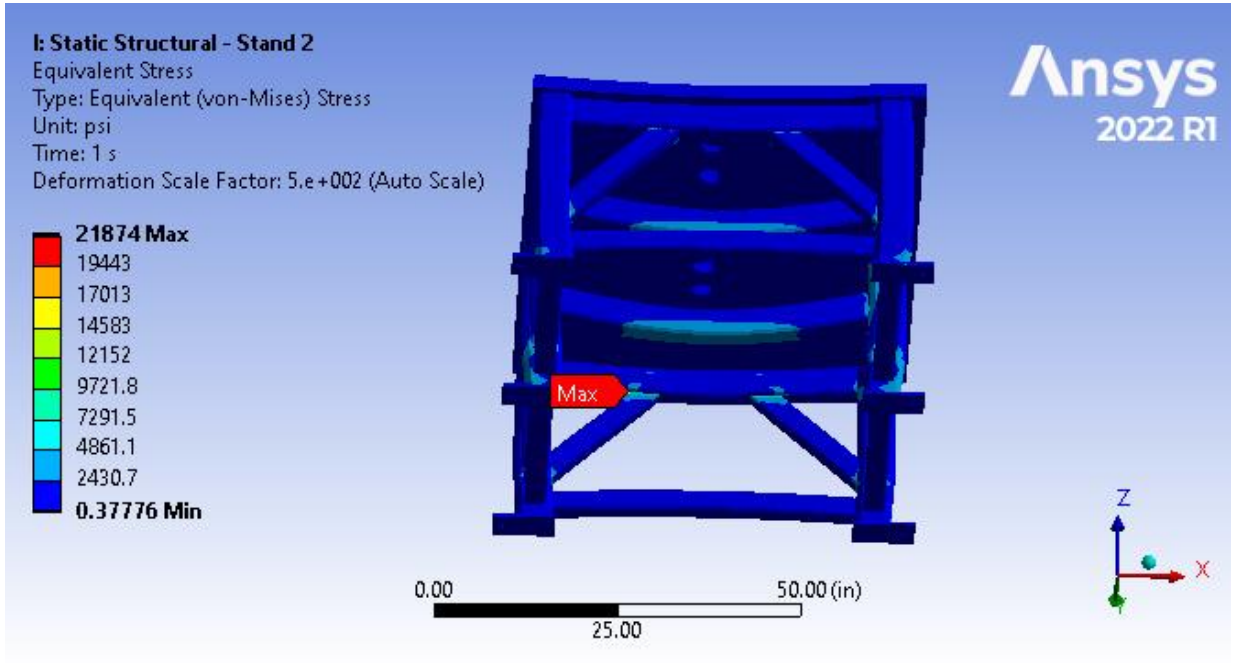


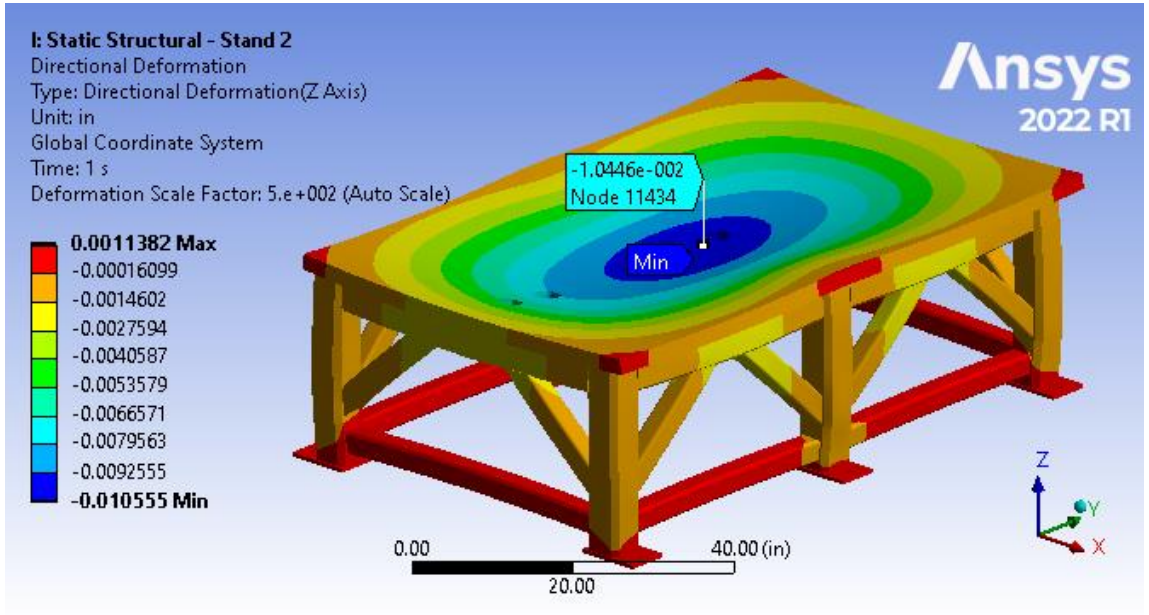


Vertical Support Collimator Stands

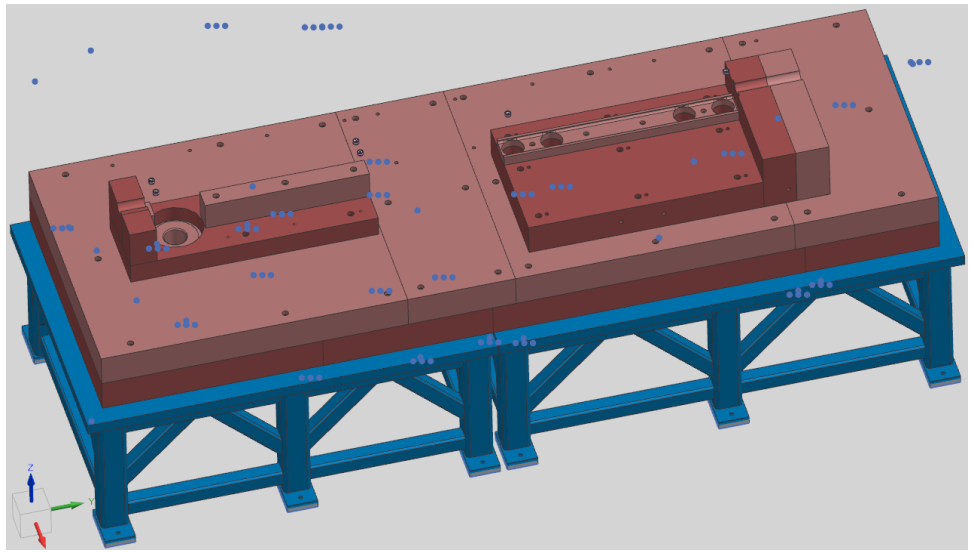


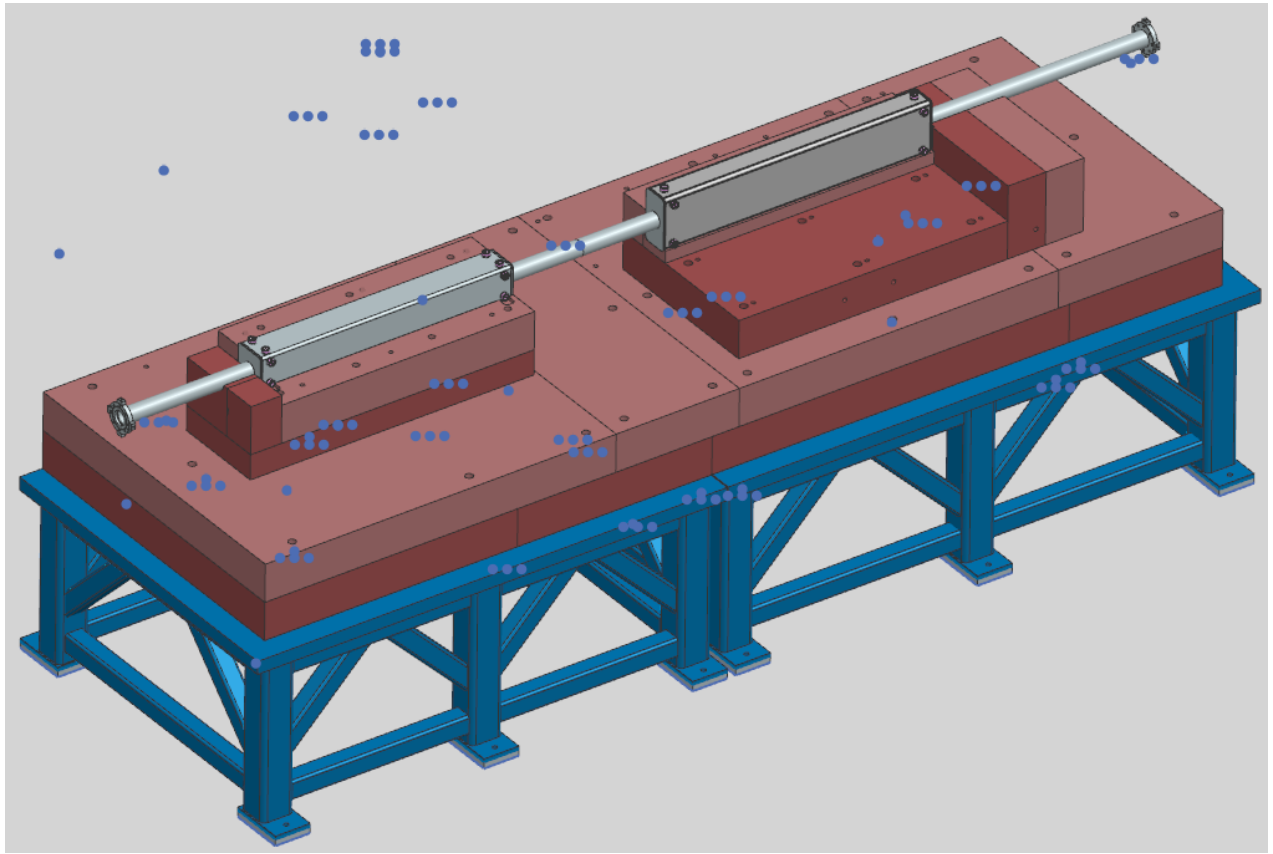




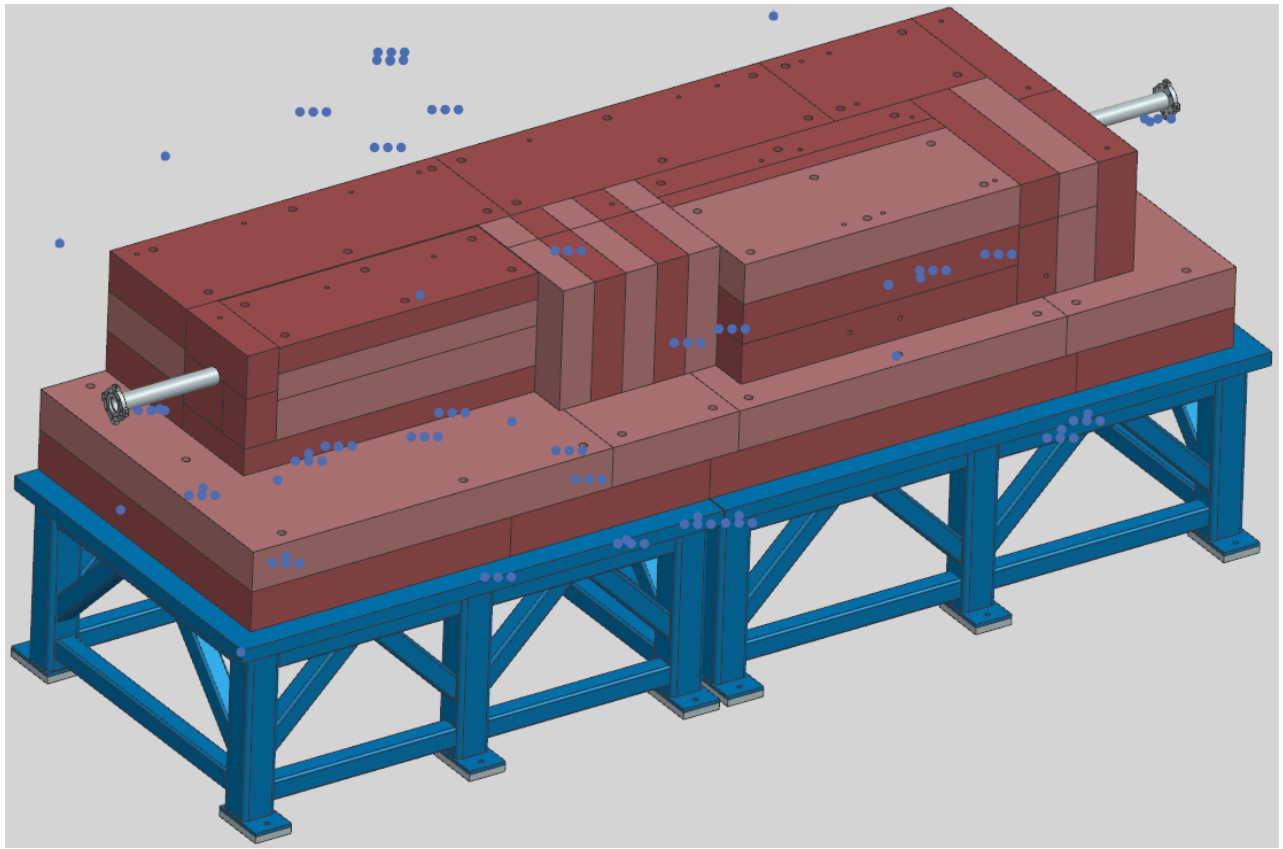


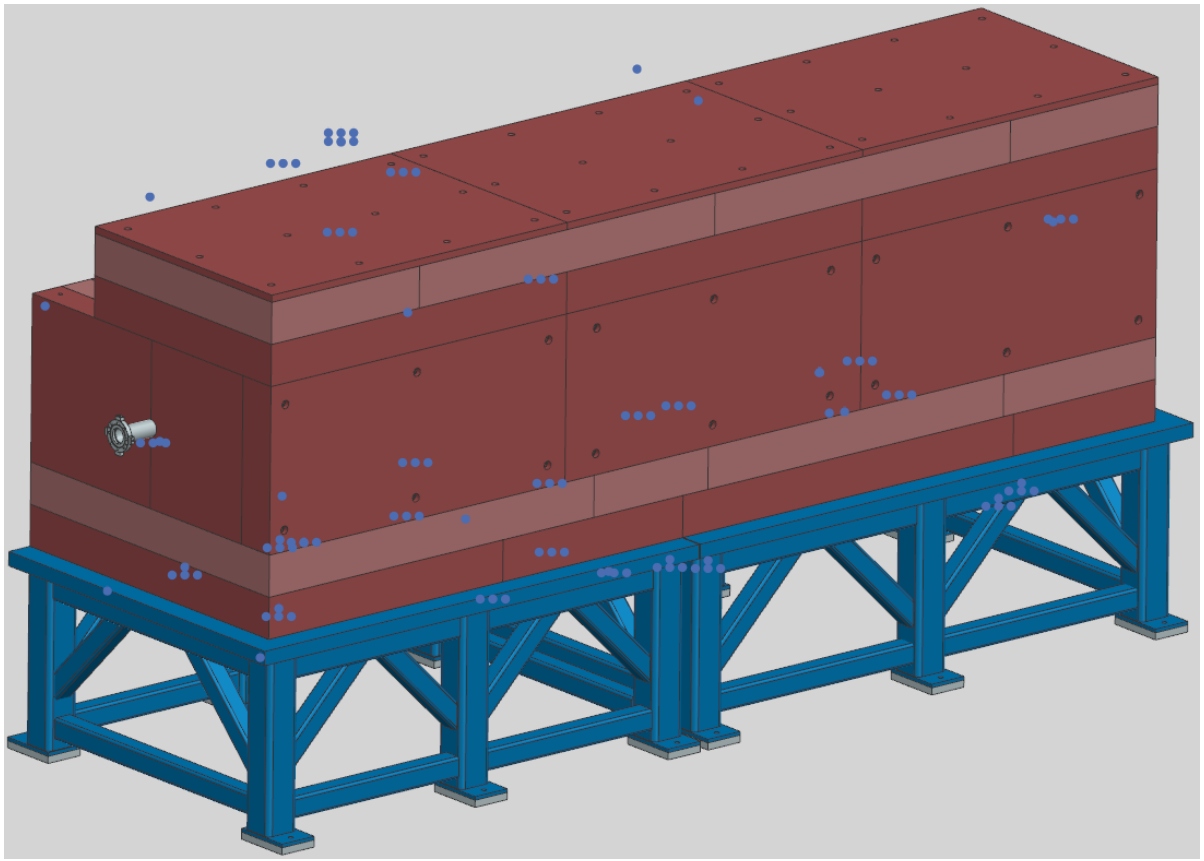
8. Vertical collimators shielding has holes on the bottom. Vacuum chambers are placed on the support blocks, aligned with beam center line, secured and welded together.



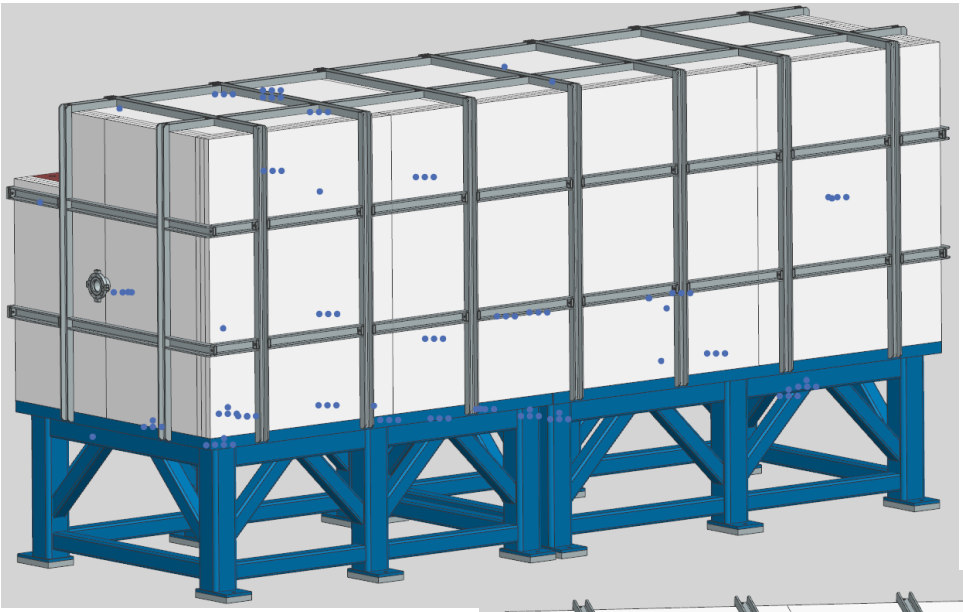


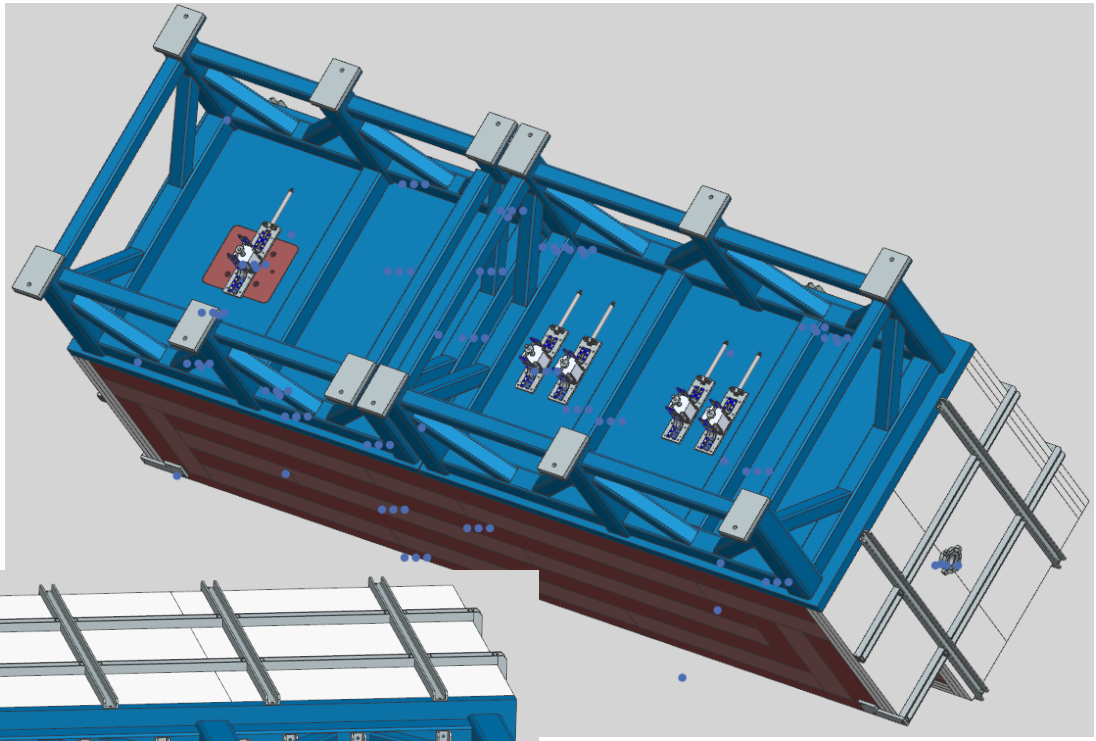
9. Surrounding steel shielding installation.

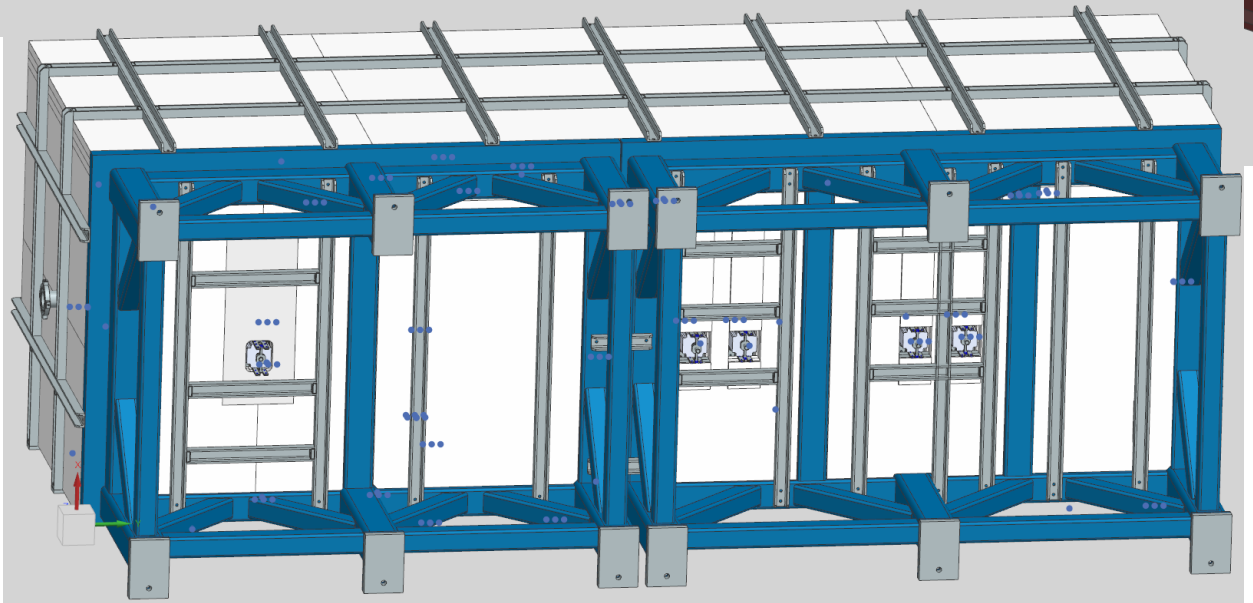




10. All collimator surfaces are covered with marble except the wall side . Motion controls are installed under the table and table bottom surface is covered with marble.



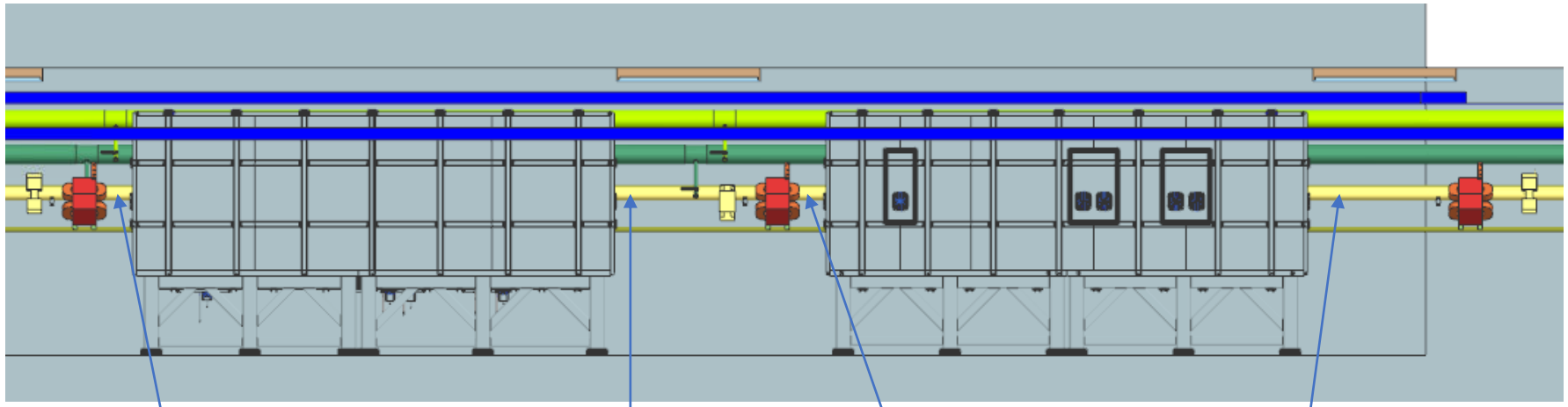


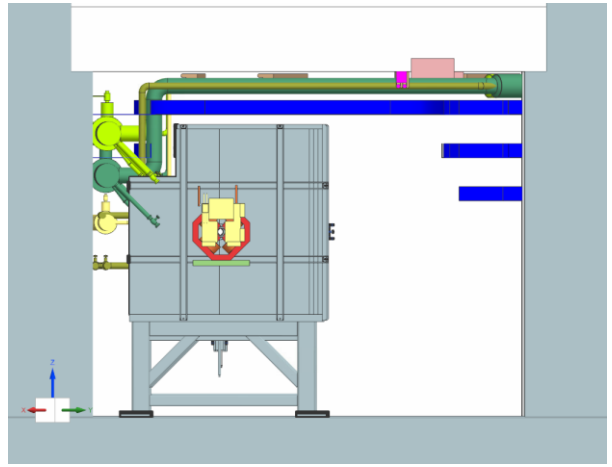


11. After collimators assembly in the tunnel , the collimators vacuum chambers are connected to the transfer line beam pipe.

Vertical Collimator

Horizontal Collimator






Thank you for your Attention
Questions?