Update on the GeoSoilEnviroCARS (Sector 13) Canted Undulator Upgrade

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CARS
University of Chicago

History

2005

- **SAC Review**

"The SRP would like to encourage GSECARS to apply for canted undulators. ….. We suggest that their chances of success in acquiring canted undulators will be improved if they approach funding agencies at the same time that they approach APS management."

2006

- **GSECARS NSF and DOE Renewal**

A detailed canted upgrade plan was developed with the plan to seek additional funding.

- **Letter of Intent Submitted to the APS Scientific Advisory Committee**

2007

- **SAC Meeting and Letter from Murray Gibson**

"The APS will give high priority to providing and installing a second undulator in Sector 13–depending, of course, on other commitments and budget constraints at the time."

2008

- **An attempt to secure a University of Chicago slot for an NSF MRI proposal failed**
- **White Paper Submitted to DOE, NASA and NSF to share the beamline side of the upgrade**

Three equal cost sharing proposals were subsequently prepared and submitted.

- **NASA Funding Recommended**
- **NSF Funding Recommended (ARRA)**

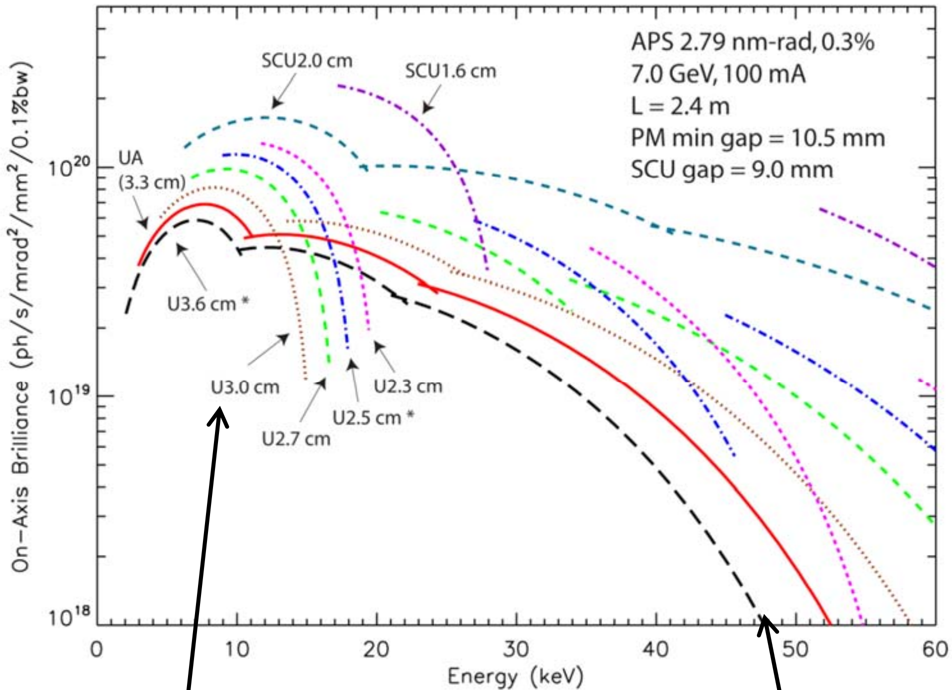
2009

- **DOE Single Investigator and Small Group Research " (SISGR) program was been selected for funding**
- **GSECARS Front End Canted upgrade funded through the APS request for stimulus funding (ARRA)**

History

2009

- **October - Undulator Design compete (U30 and U36) expected ready to install January 2012**



Ring Energy	7 GeV
Current	100 mA
Undulator Period	3.0 cm
Undulator K	2.123 @ 11 mm gap
Undulator Length	2.1 m
Undulator Periods	70
Horizontal Angular Size	117.9 µrad (3 mm @ 25.446 m)
Vertical Angular Size	78.6 µrad (2 mm @ 25.446 m)
Total Undulator Power	3.74 kW
Total Power passed by aperture	1.084 kW
Angular Peak Power Density	134.3 kW/mrad^2

Ring Energy	7 GeV
Current	100 mA
Undulator Period	3.6 cm
Undulator K	3.202 @ 11 mm gap
Undulator Length	2.1 m
Undulator Periods	58
Horizontal Angular Size	117.9 µrad (3 mm @ 25.446 m)
Vertical Angular Size	78.6 µrad (2 mm @ 25.446 m)
Total Undulator Power	5.87 kW
Total Power passed by aperture	1.163 kW
Angular Peak Power Density	141.6 kW/mrad^2

History

2010

- **May - Phase 1 Hutch modification**

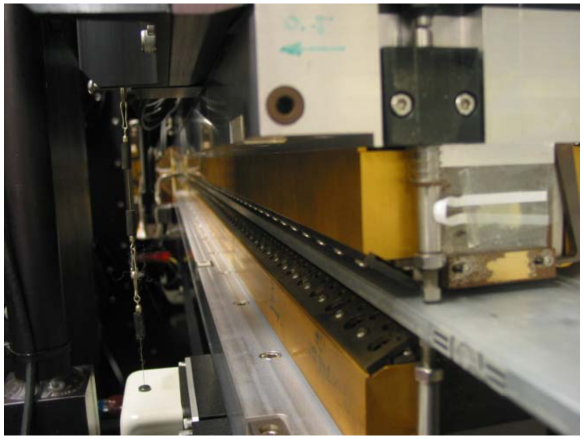
2011

- **January - Phase 2 Hutch modification**
- **November - FDR approved**
- **December – Relocate large KB mirrors to make way for SOE work starting March 2012.**

History

2012

- **January – U30 (downstream / inboard) undulator and new straight section installed**

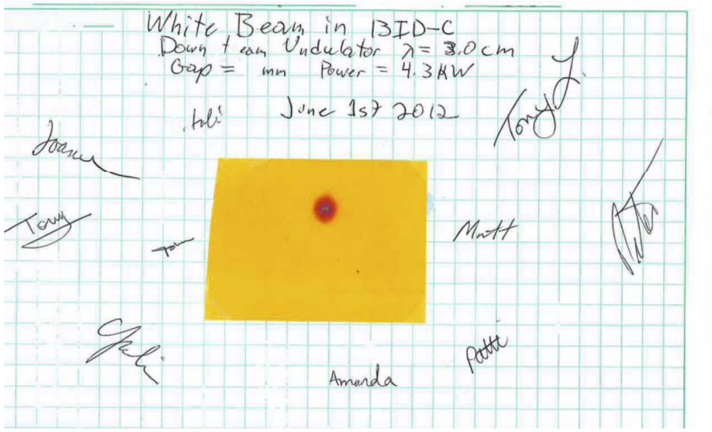


- **March 13 – ID goes global offline, GSECARS ID is Dark for last 7 weeks of run 2012-1. 12 week to gut and install**

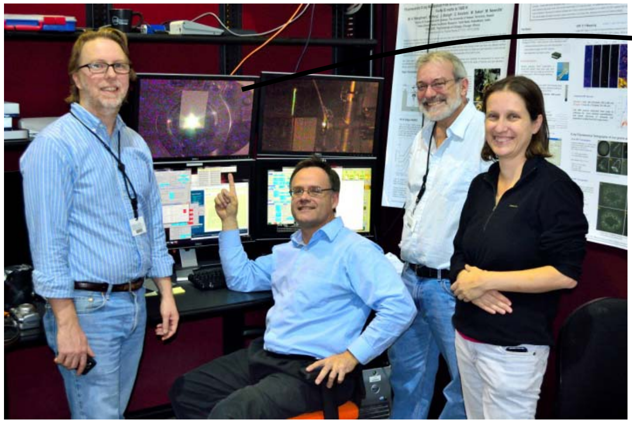
History

2012

- June 1st First beam to ID-C/D (Two Days Late due to vacuum policy confusion)



- June 6th - First Users Inboard Cant
- October 18th – First beam into IDE Outboard Cant



Entrance Port in 13-ID-E

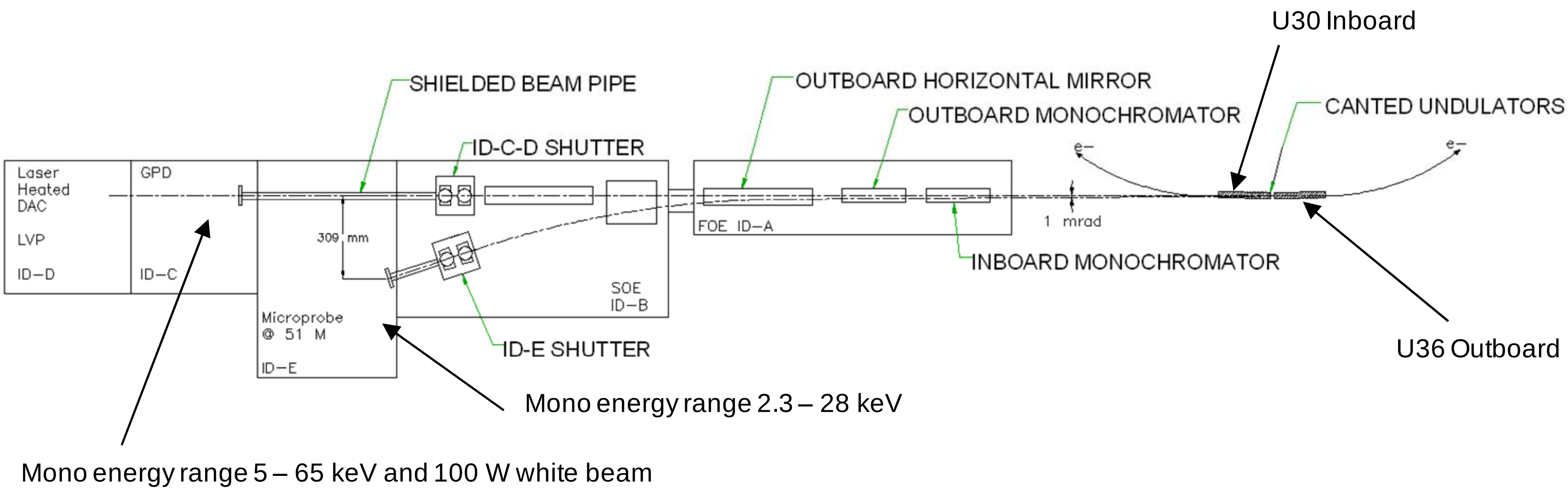
2013

- January 29 – Full user program on both beamlines

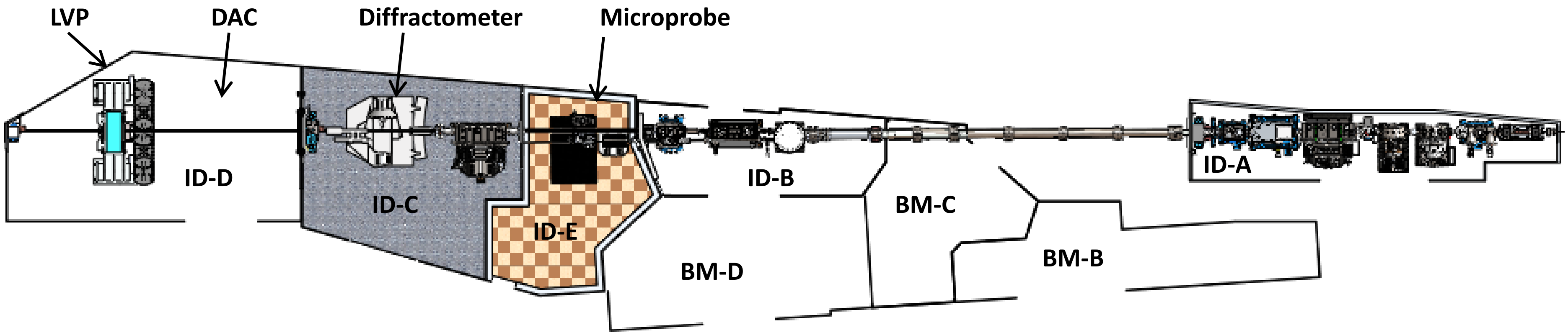
The Design

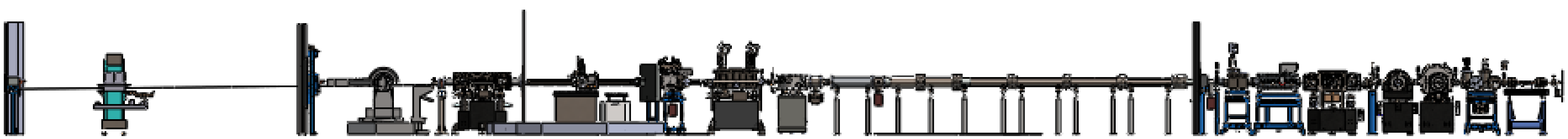
We needed to consider the existing layout and programs and put together an optics plan and layout that would allow us to:

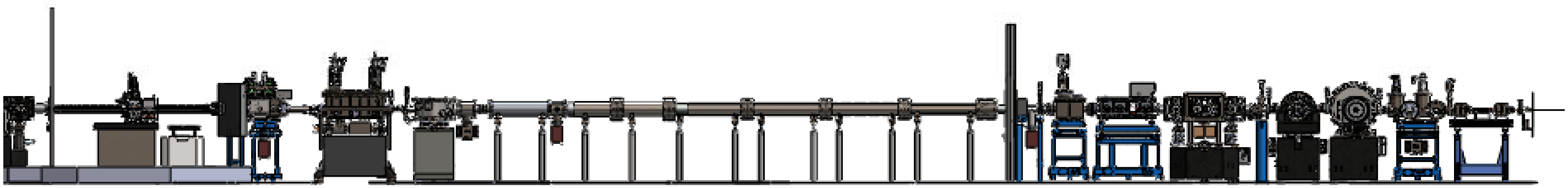
1. **Use to the greatest extent our existing optics and equipment,**
2. **Provide a substantial improvement in performance,**
3. **Provide new capabilities**
4. **Generate the experimental setup space needed for each end station given the tight space constraints inherent to a 1 mrad beam separation**

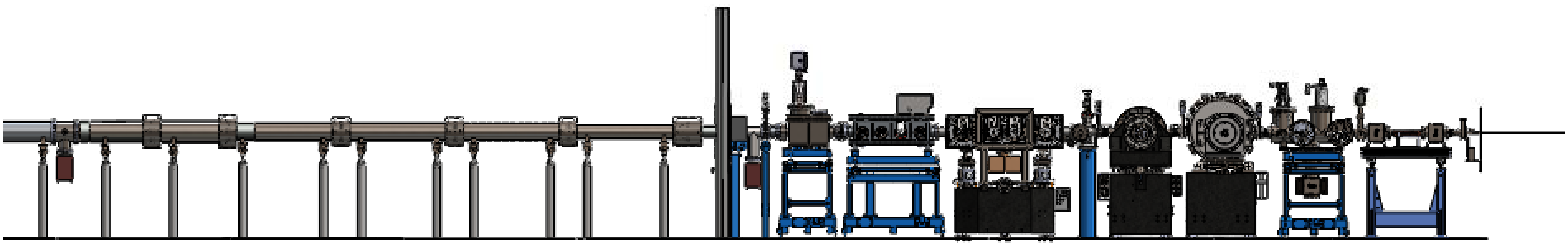


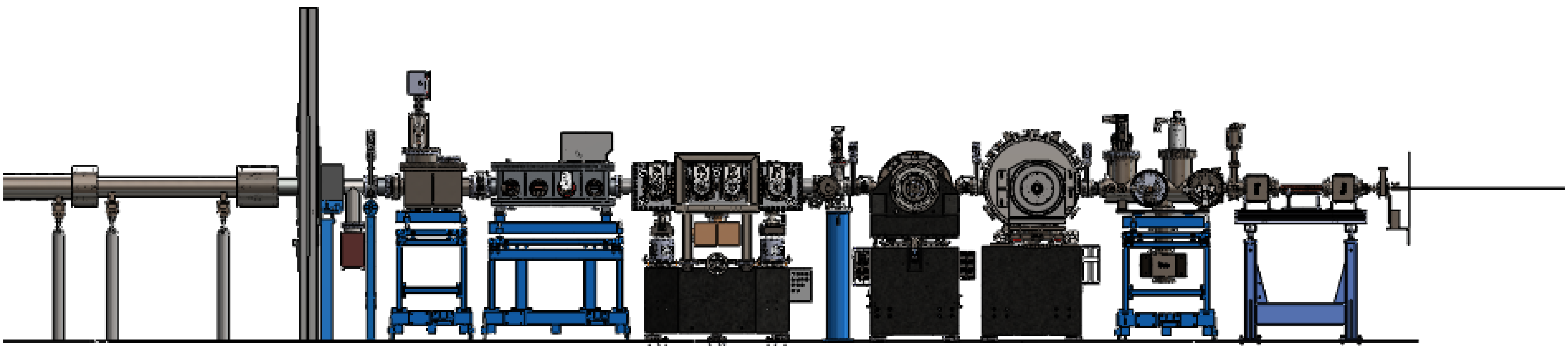
Sector 13


LVP
DAC
Diffractometer
Microprobe
ID-D
ID-C
ID-E
ID-B
BM-C
BM-D
BM-B
ID-A

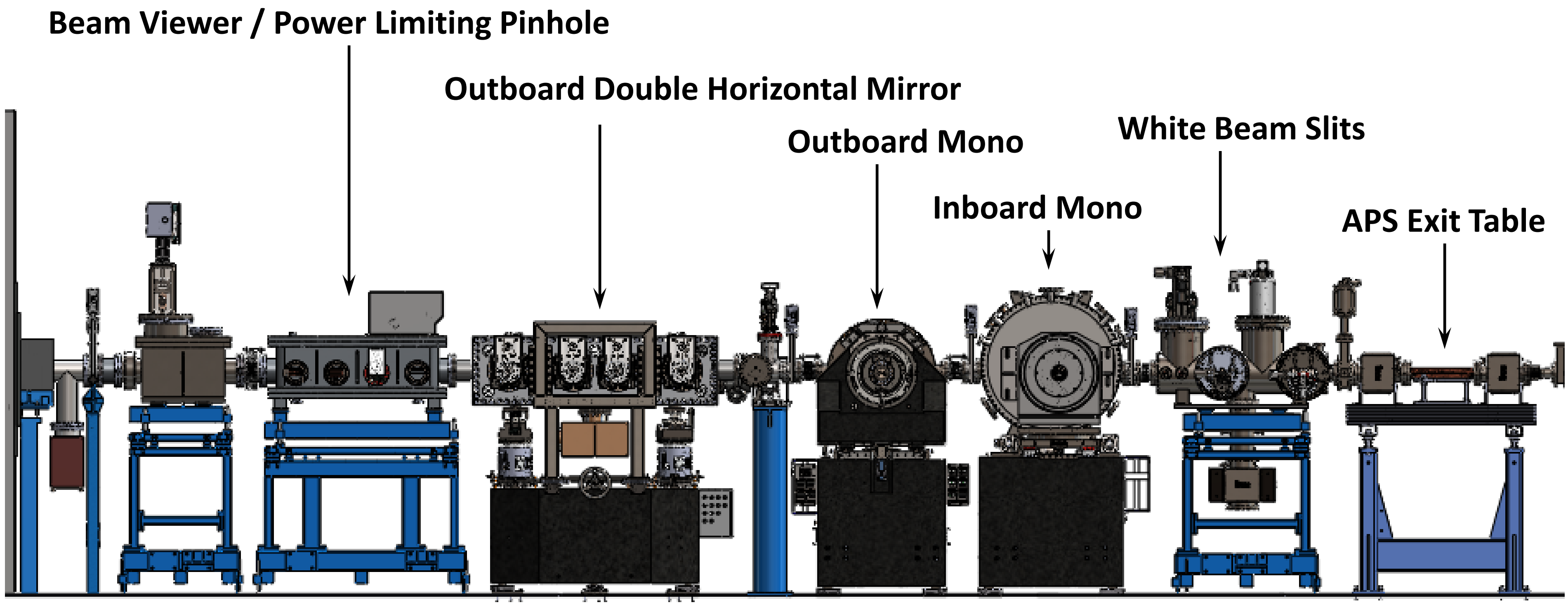




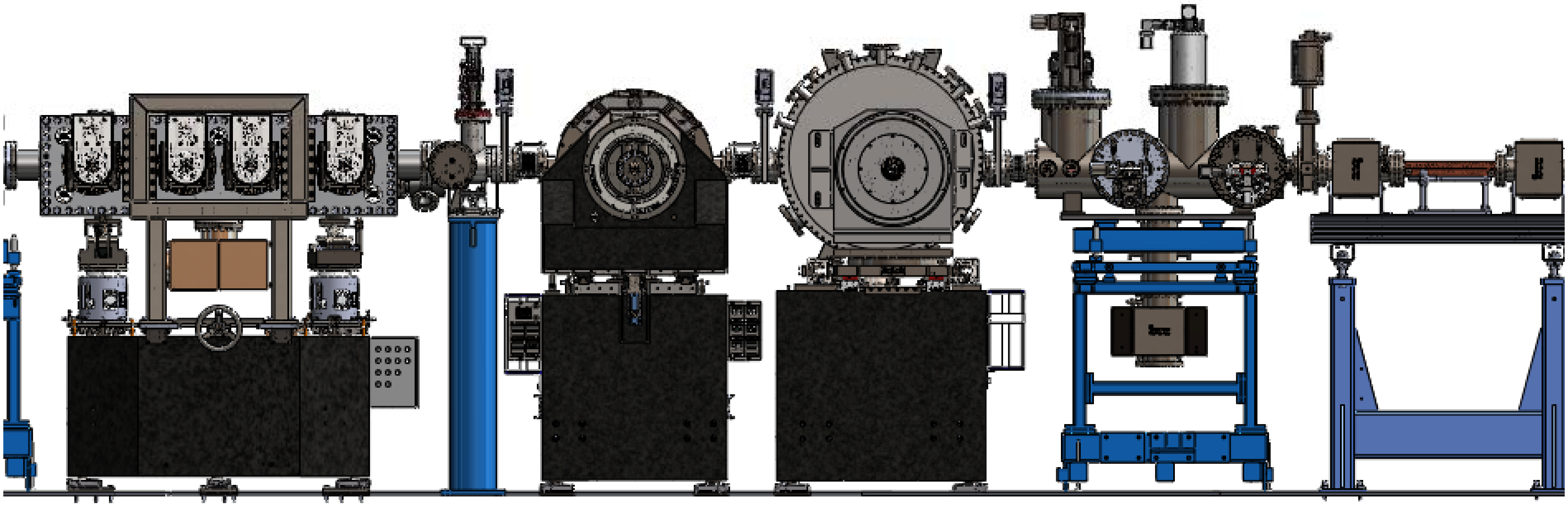


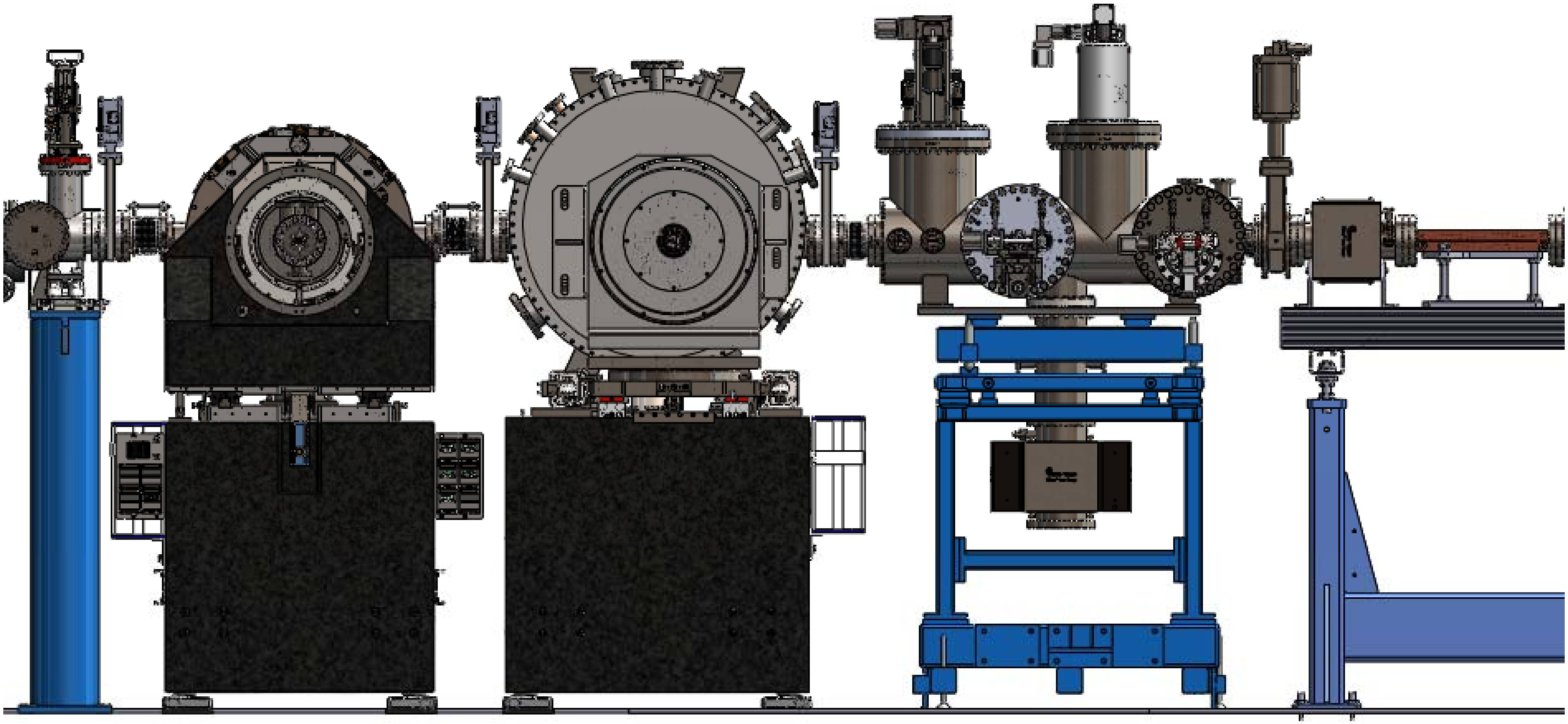


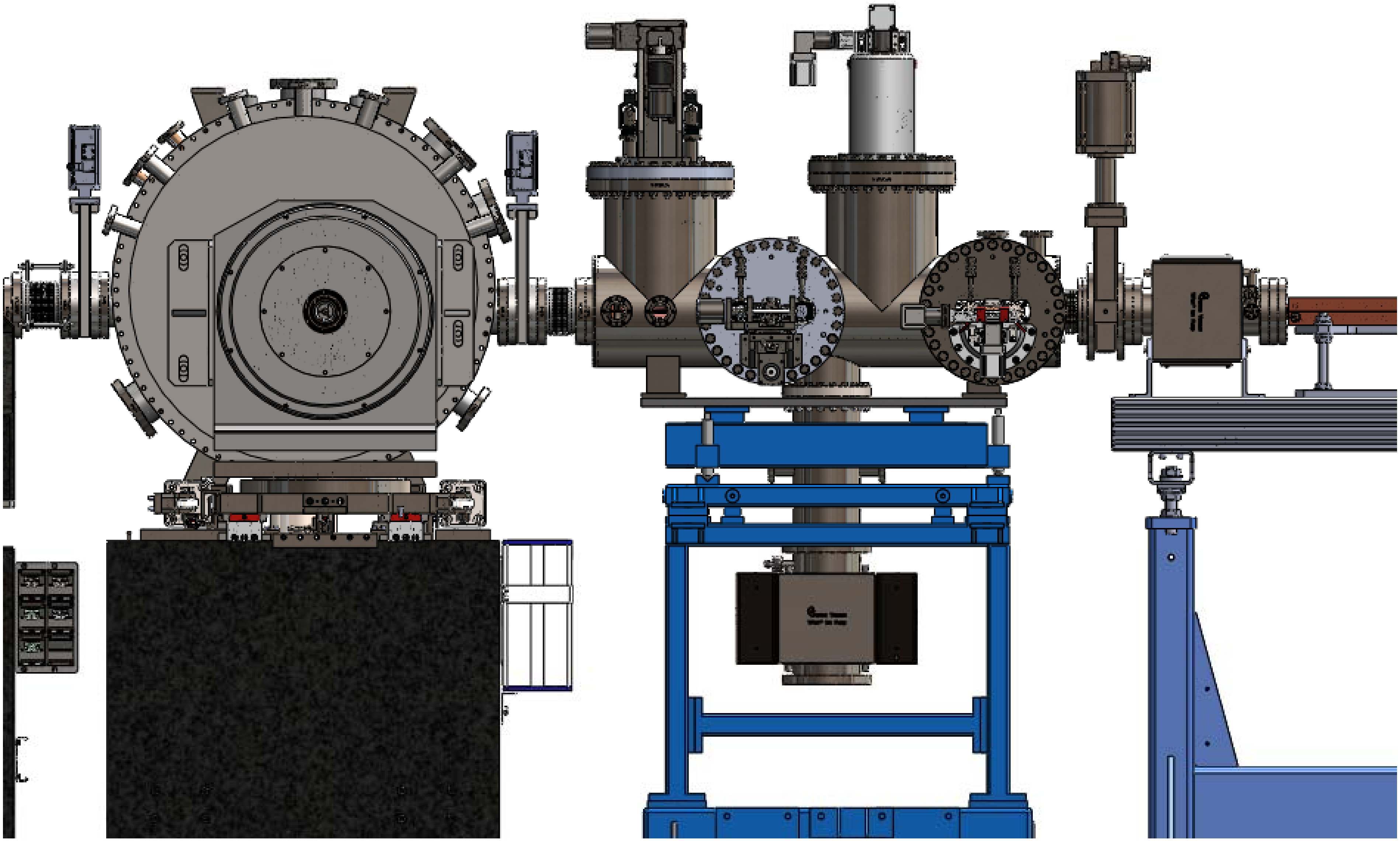
13-ID-A (FOE)

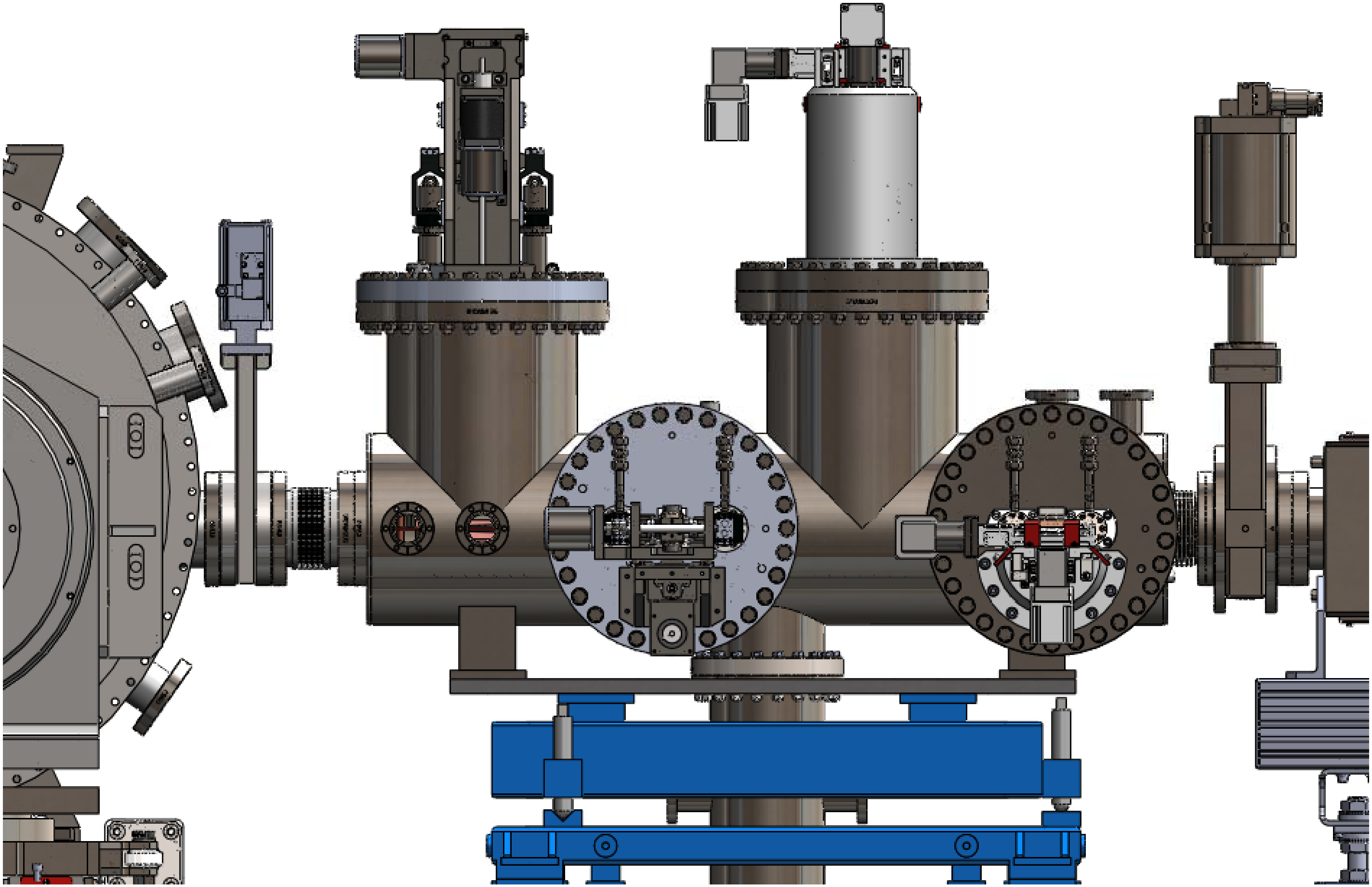


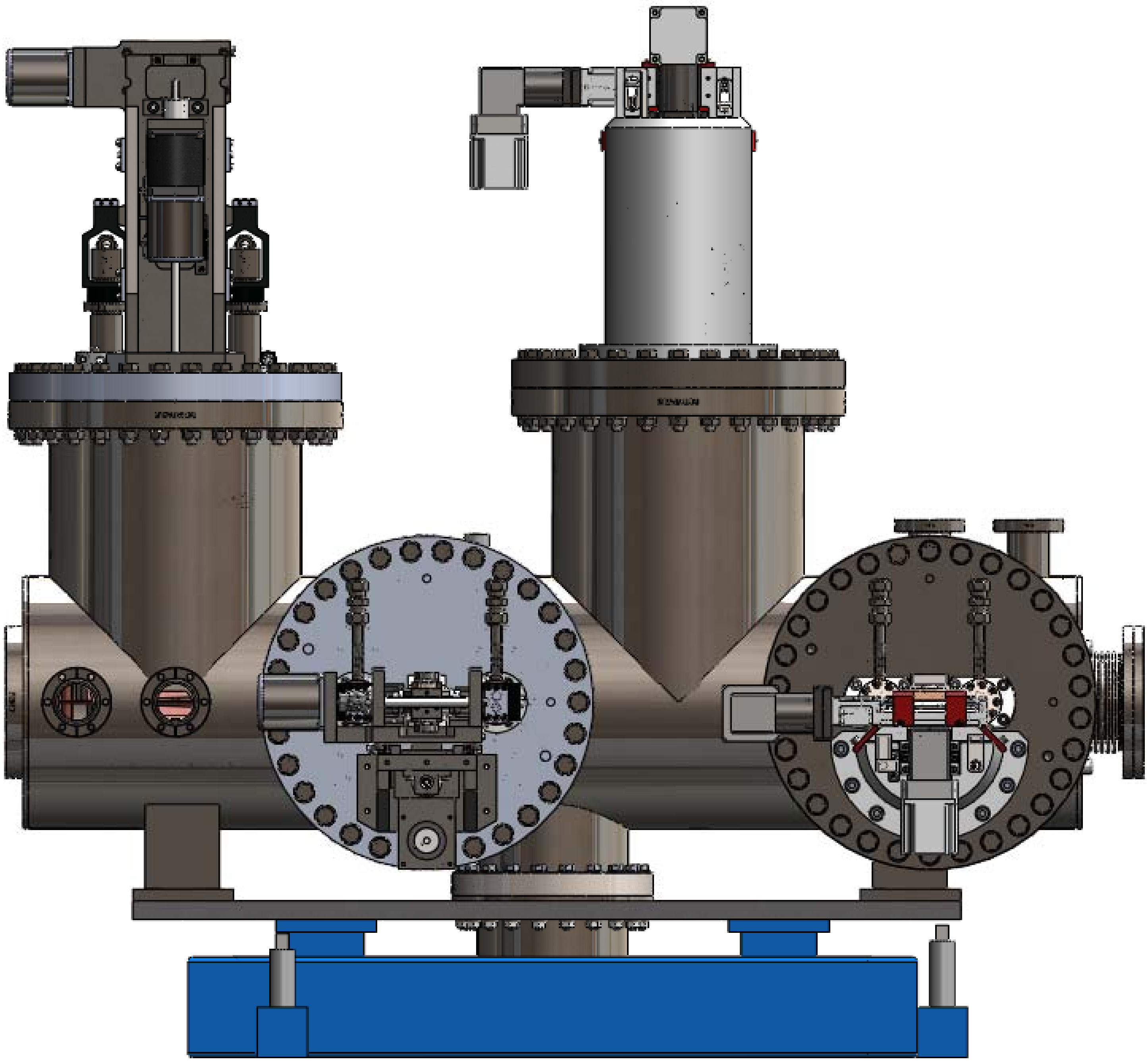
Beam Viewer / Power Limiting Pinhole
Outboard Double Horizontal Mirror
Outboard Mono
White Beam Slits
Inboard Mono
APS Exit Table

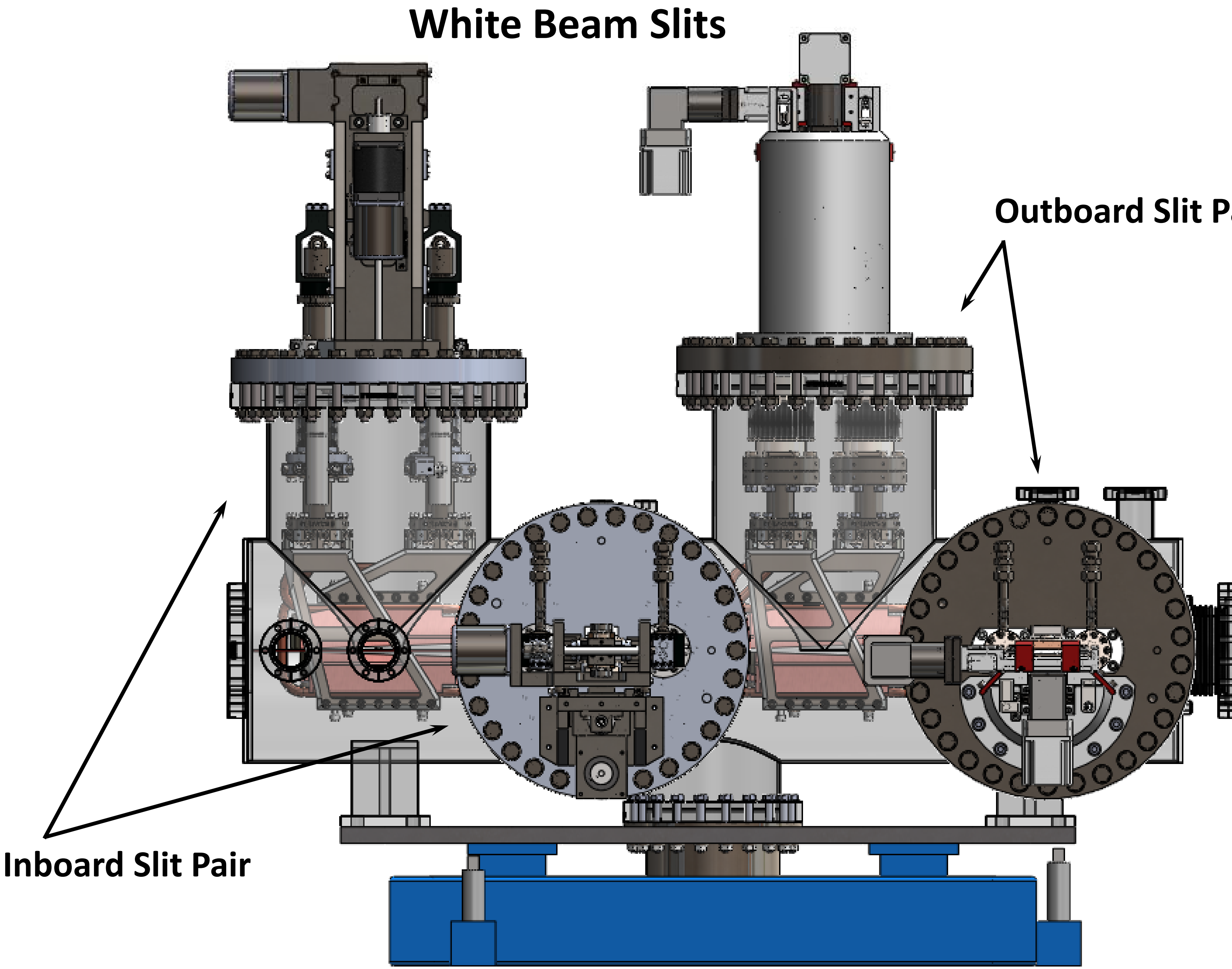


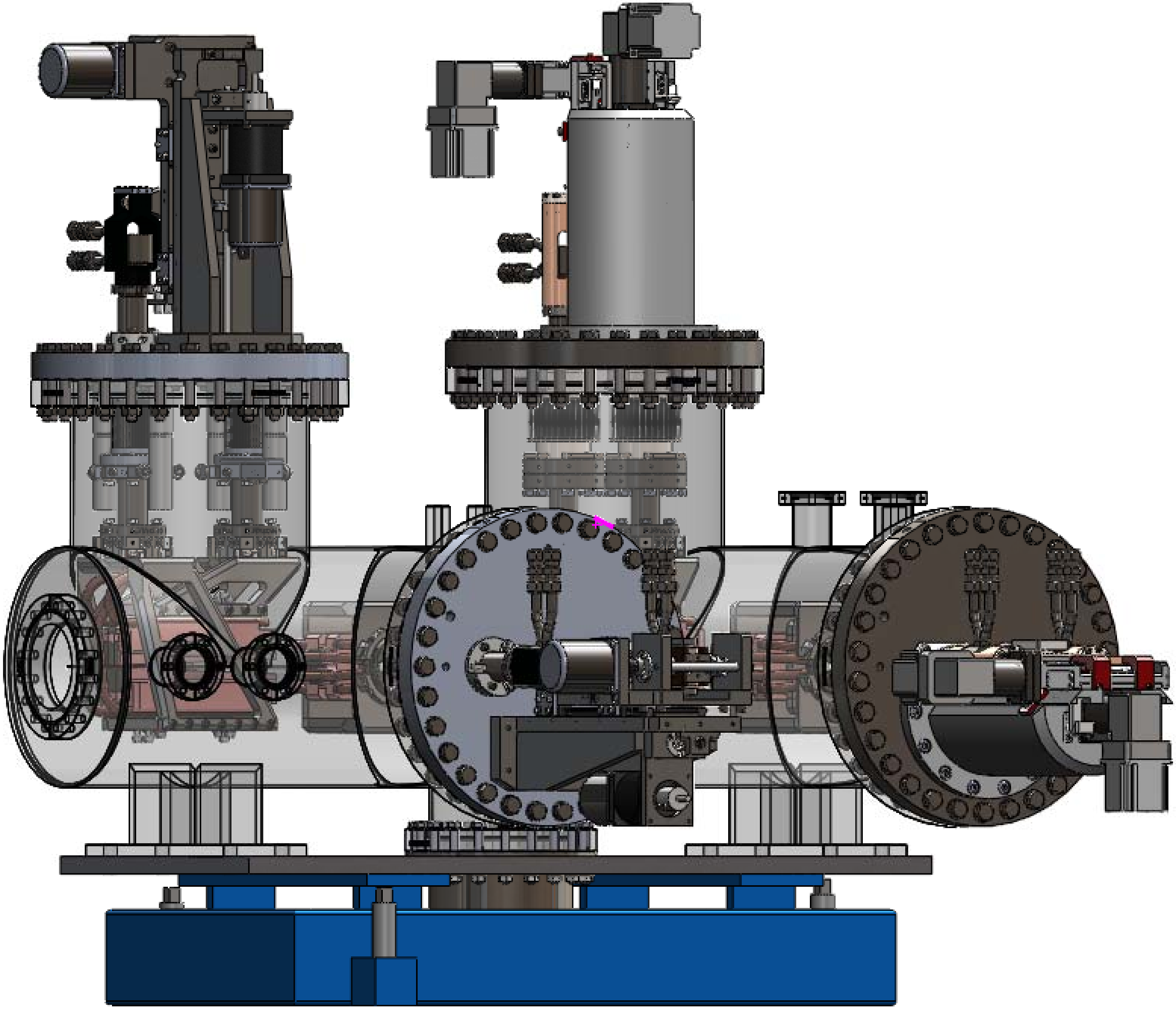


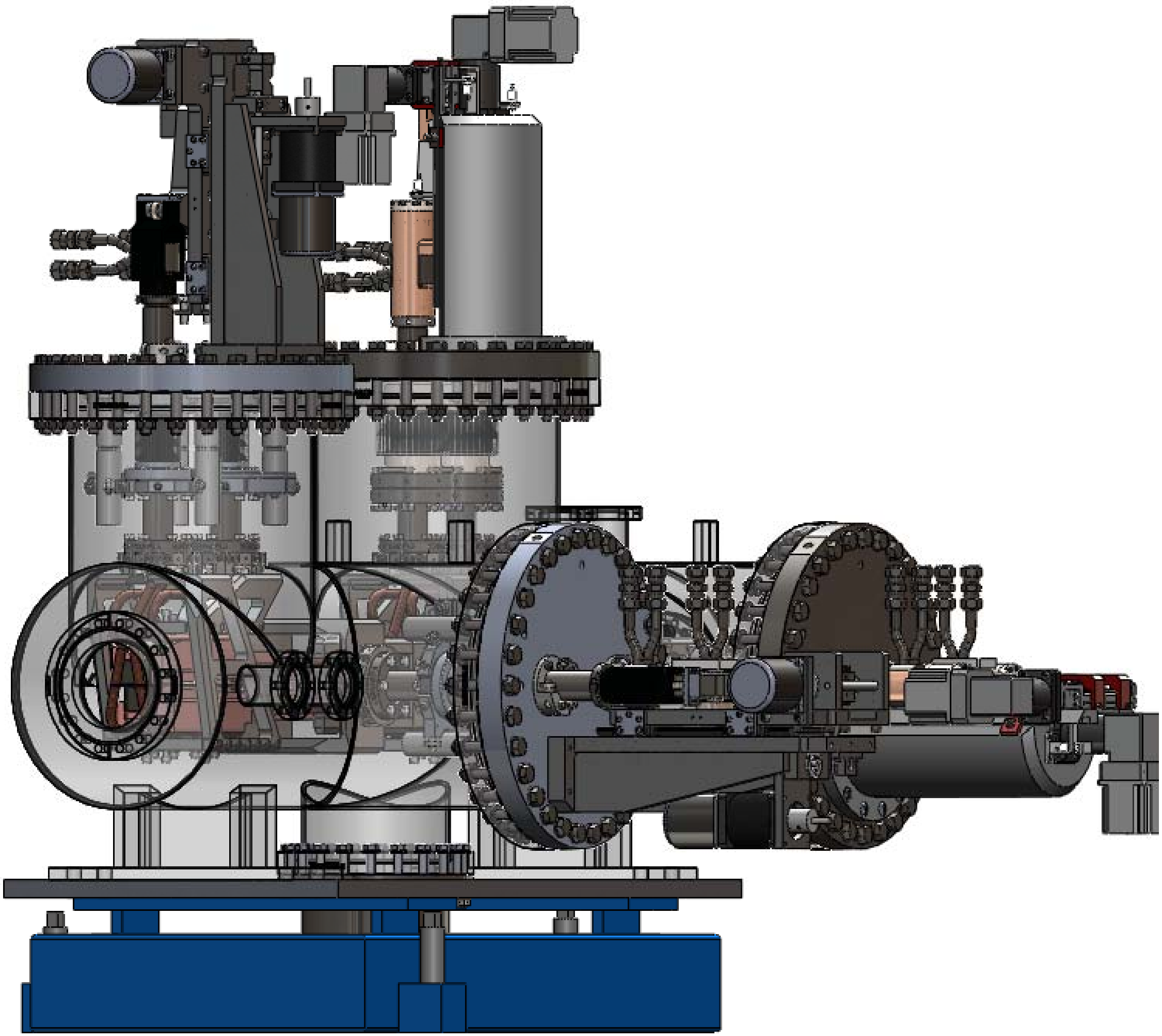


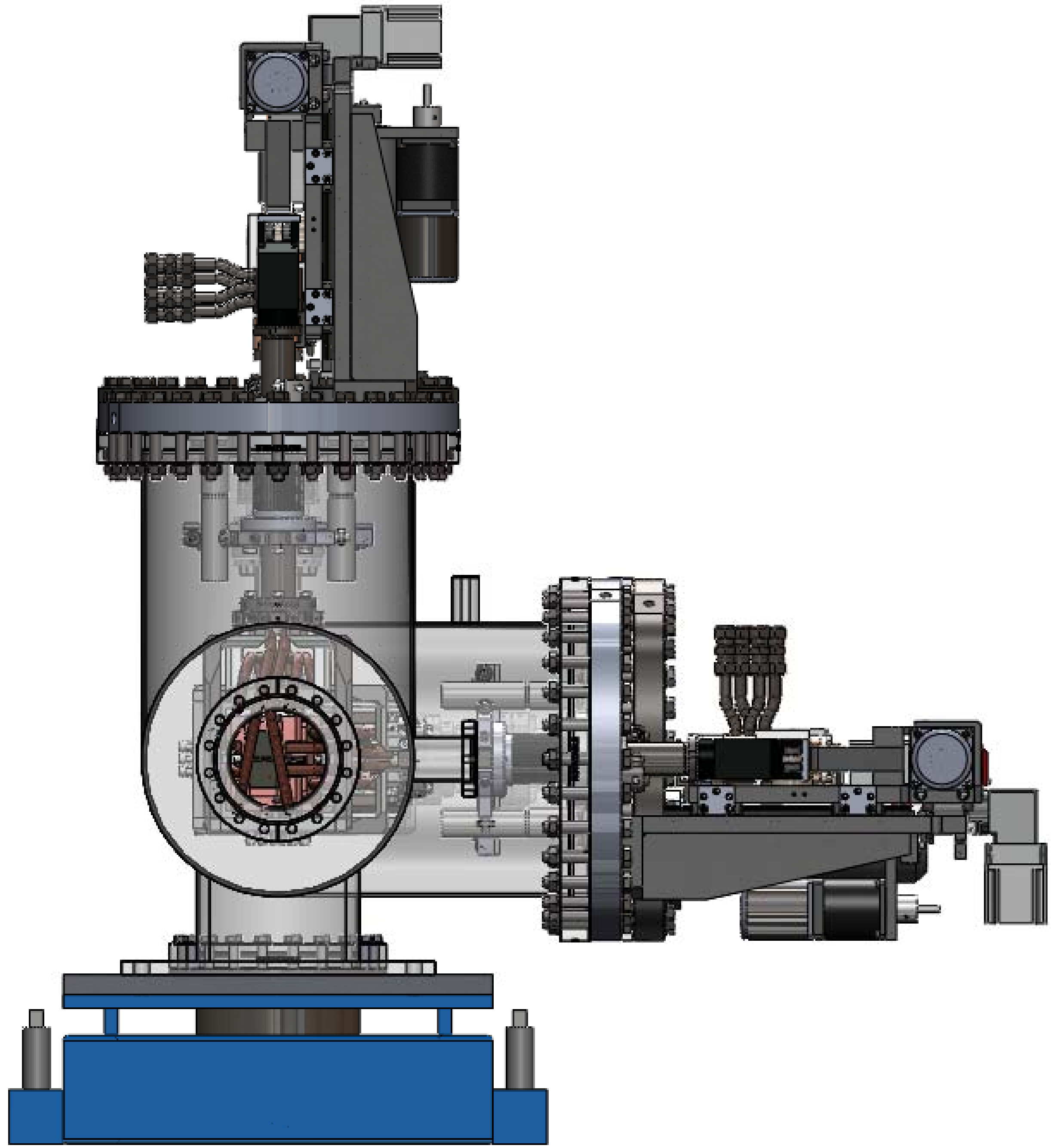


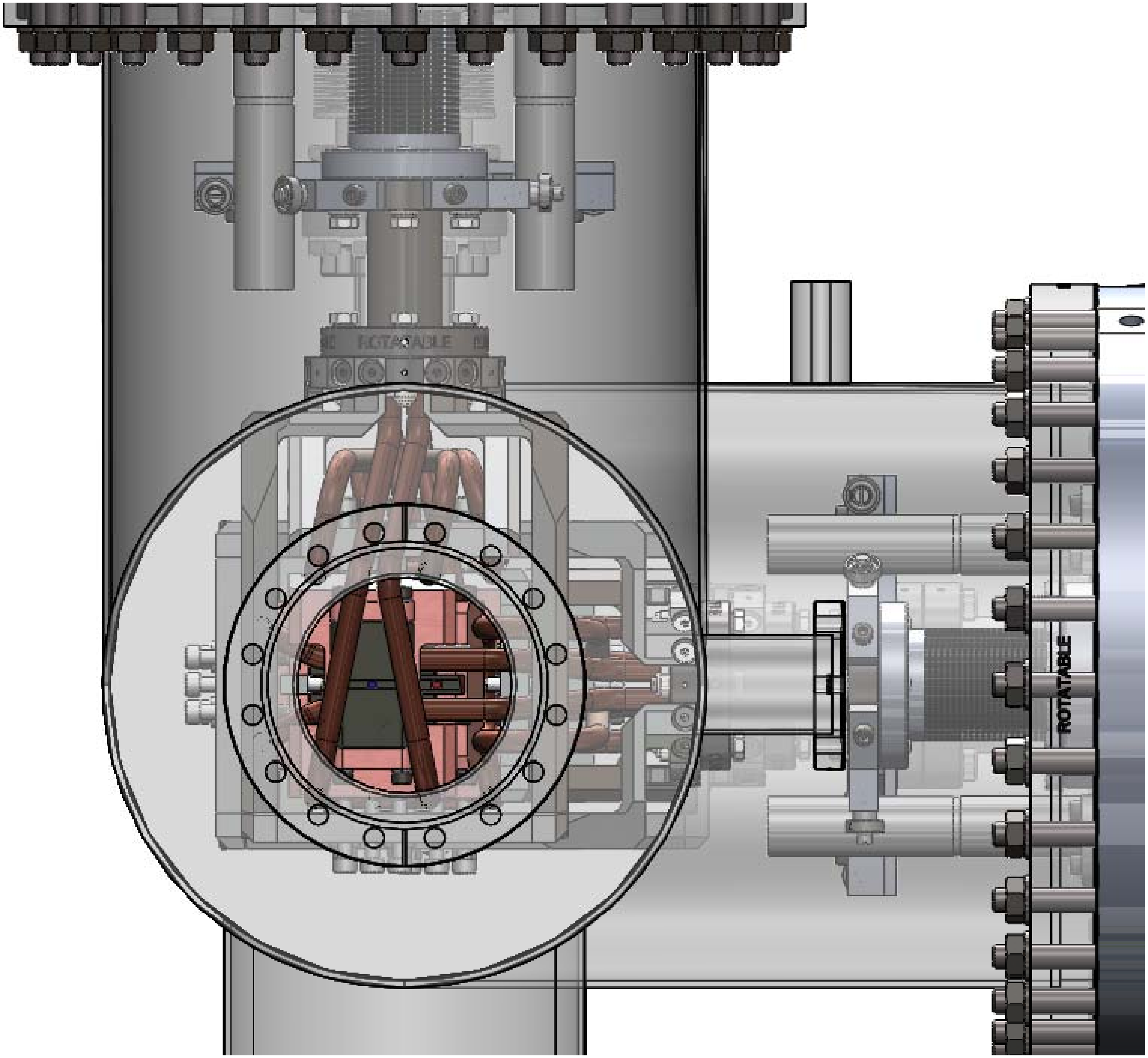


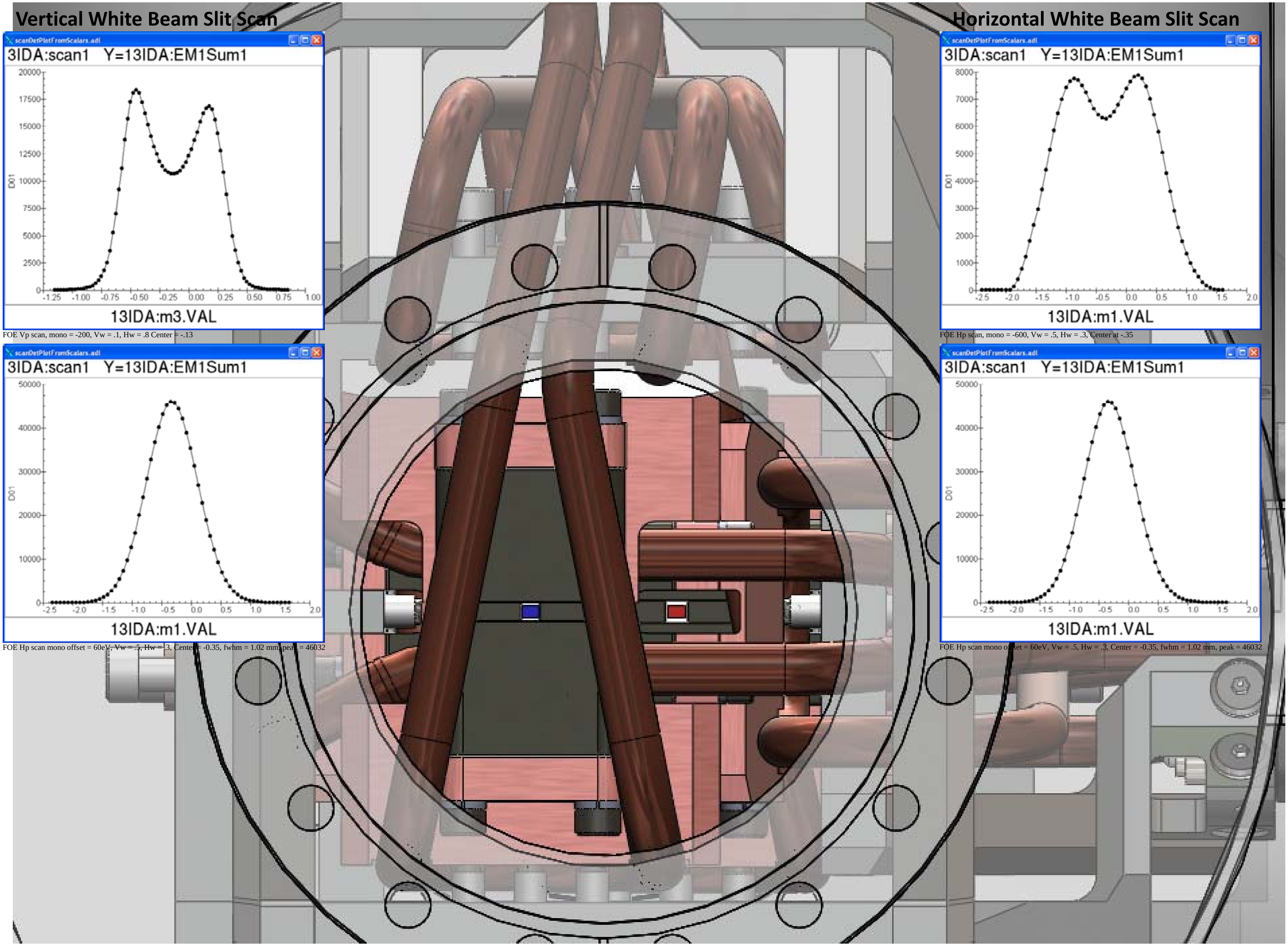

White Beam Slits
Outboard Slit Pair
Inboard Slit Pair



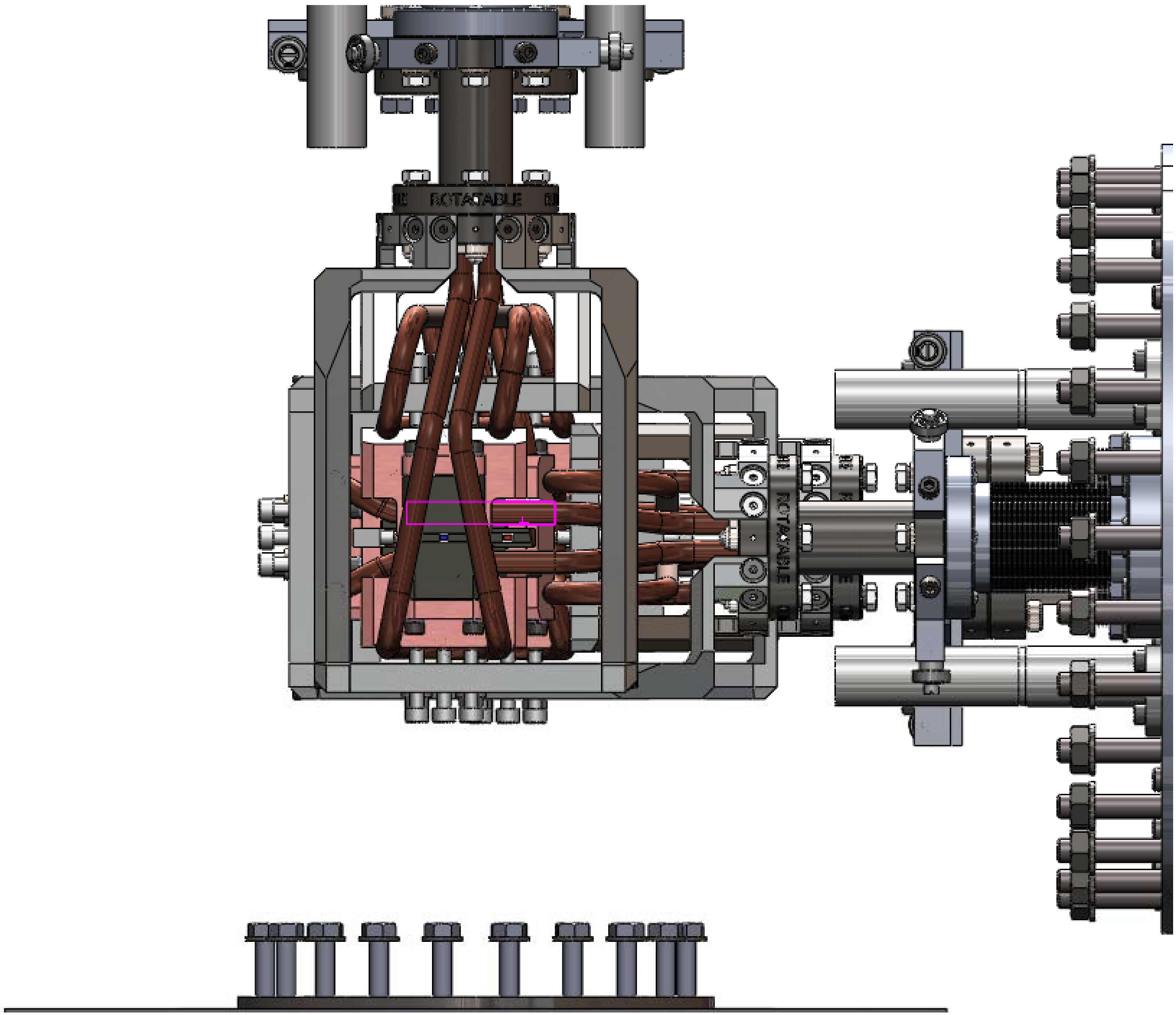


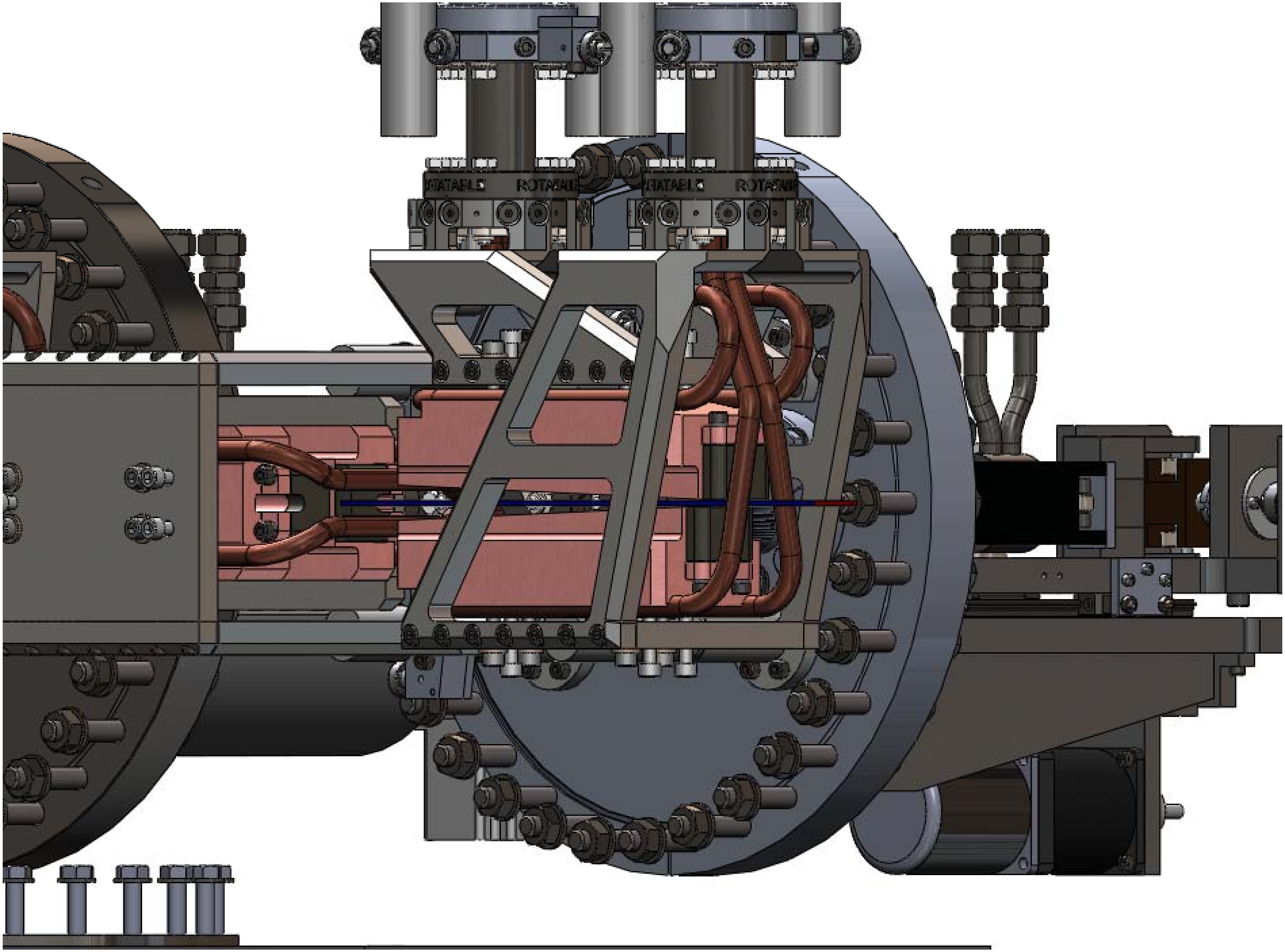


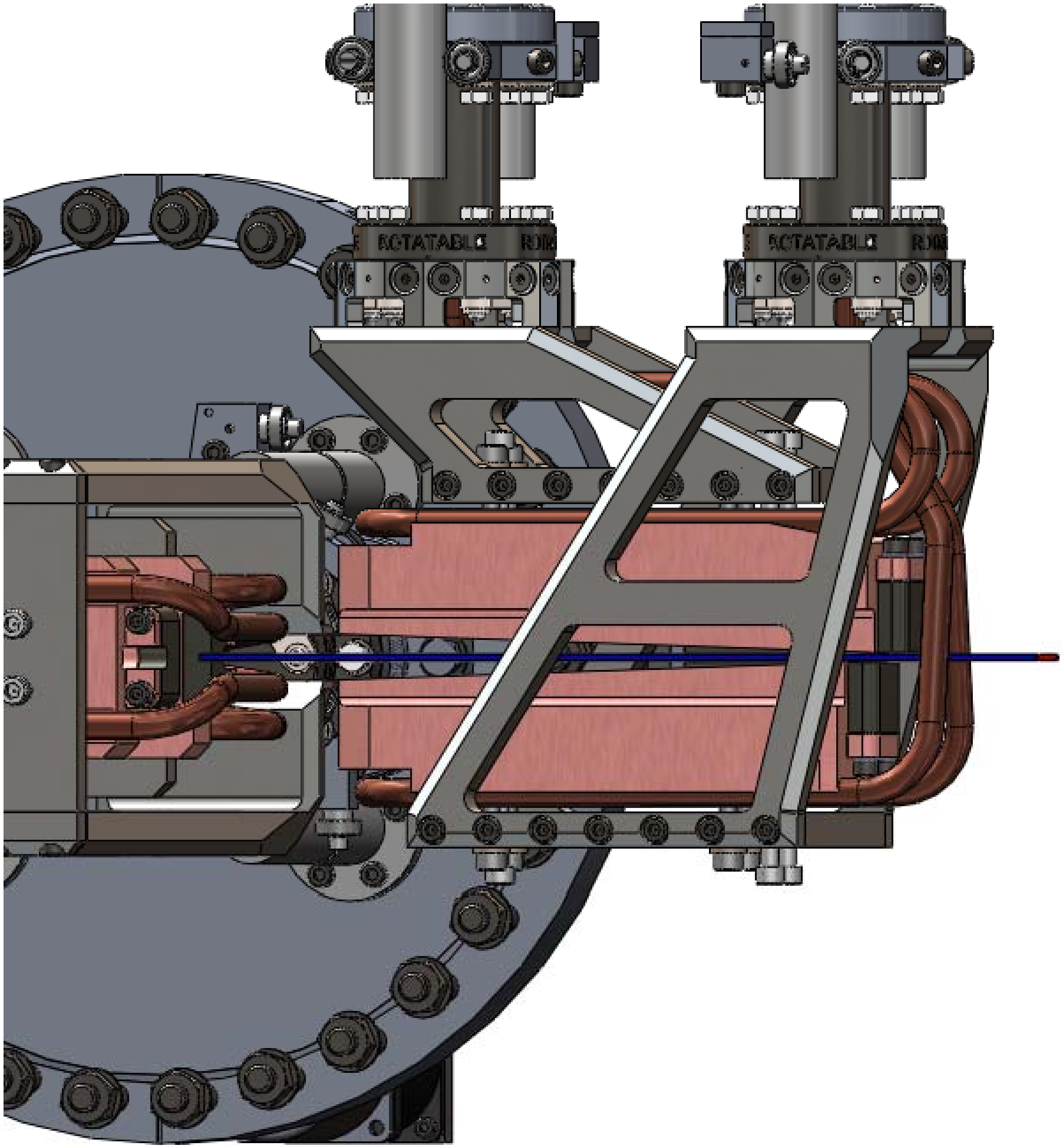

ROTATABLE
ROTATABLE

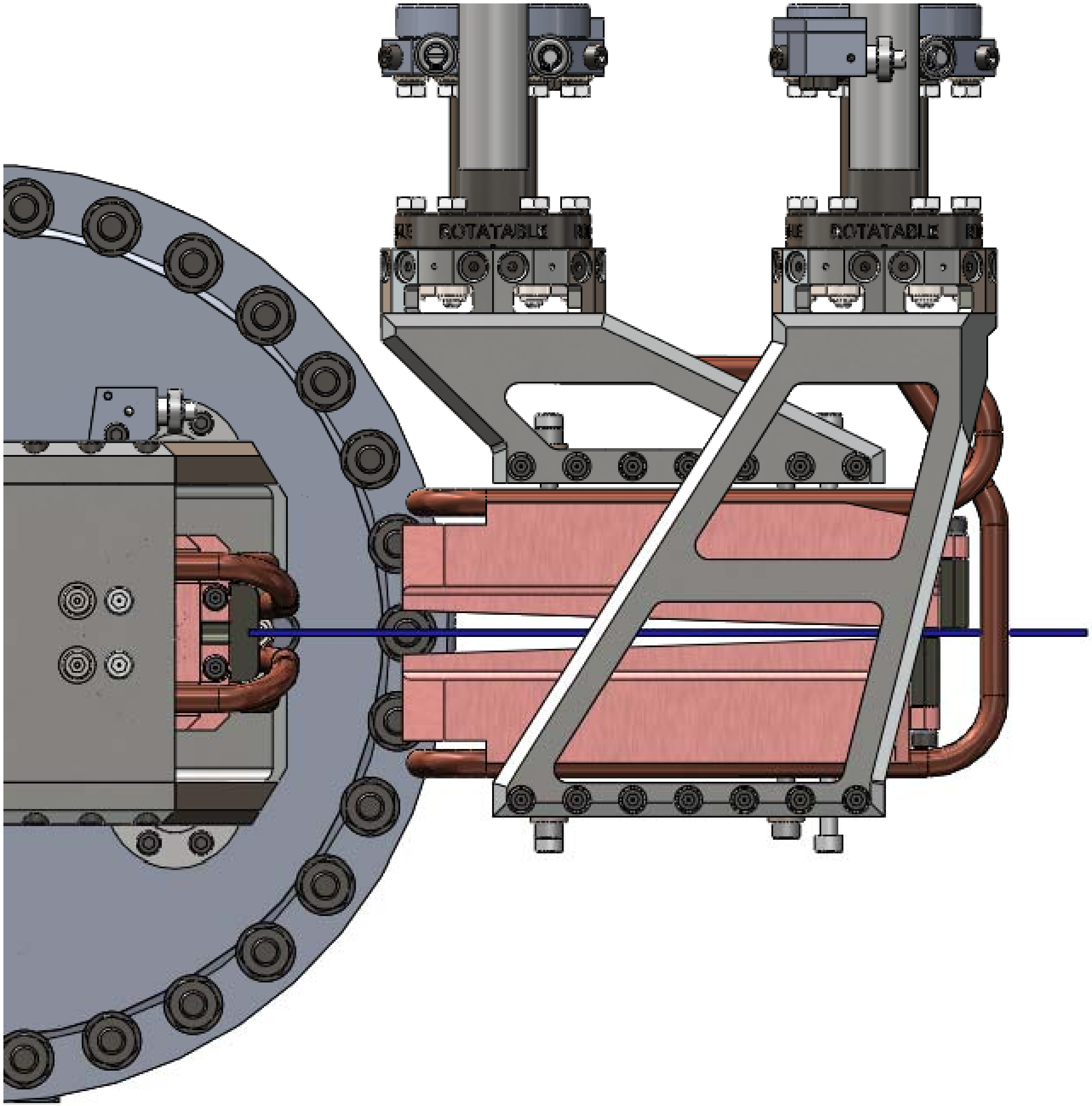


Vertical White Beam Slit Scan
Horizontal White Beam Slit Scan
3IDA:scan1 Y=13IDA:EM1Sum1
13IDA:m3.VAL
FOE Vp scan, mono = -200, Vw = .1, Hw = .8 Center = -.13
3IDA:scan1 Y=13IDA:EM1Sum1
13IDA:m1.VAL
FOE Hp scan, mono = -600, Vw = .5, Hw = .3, Center at -.35
3IDA:scan1 Y=13IDA:EM1Sum1
13IDA:m1.VAL
FOE Hp scan mono offset = 60eV, Vw = .5, Hw = .3, Center = -0.35, fwhm = 1.02 mm, peak = 46032
3IDA:scan1 Y=13IDA:EM1Sum1
13IDA:m1.VAL
FOE Hp scan mono offset = 60eV, Vw = .5, Hw = .3, Center = -0.35, fwhm = 1.02 mm, peak = 46032


ROTATABLE
ROTATABLE






ROTATABLE
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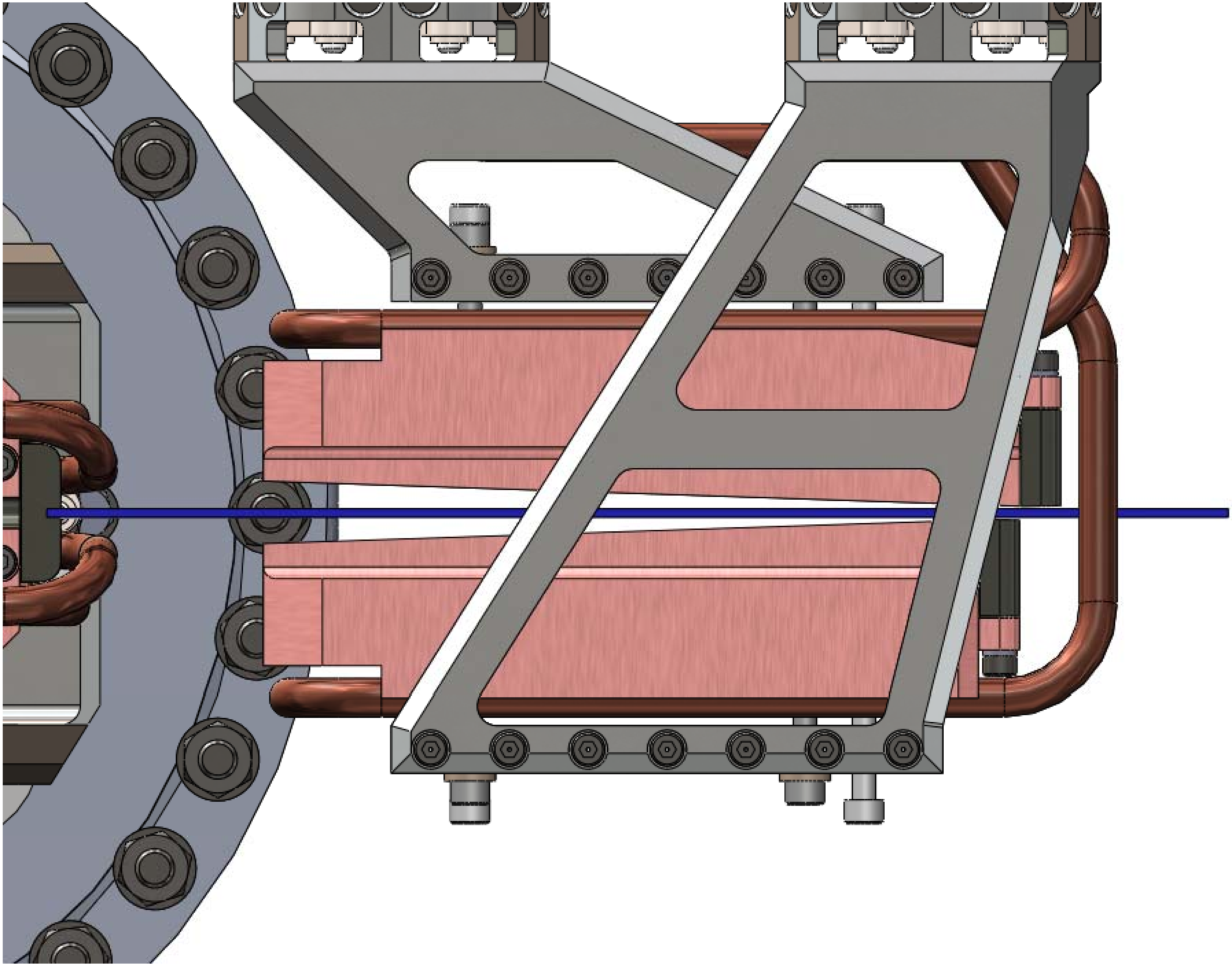
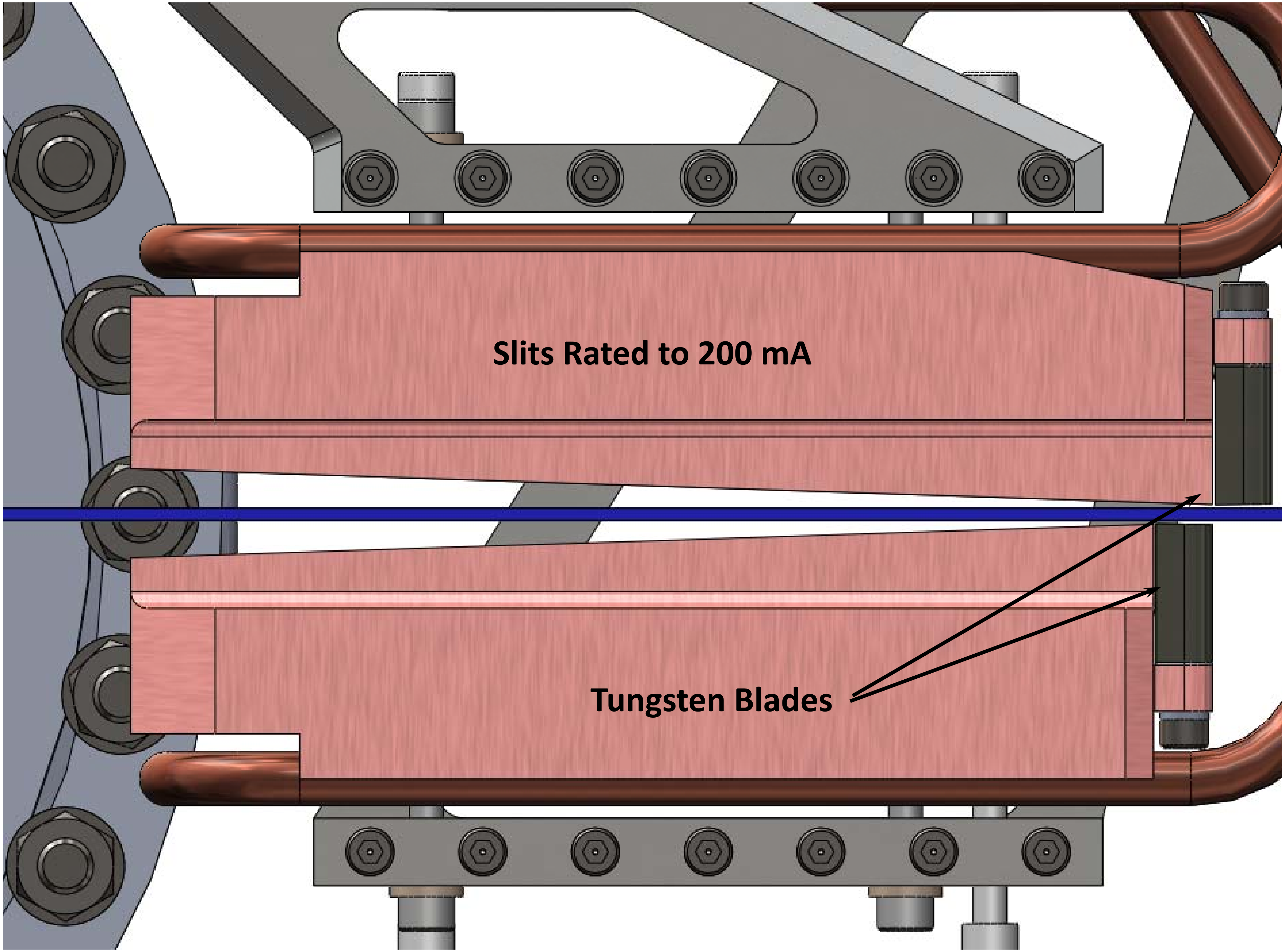
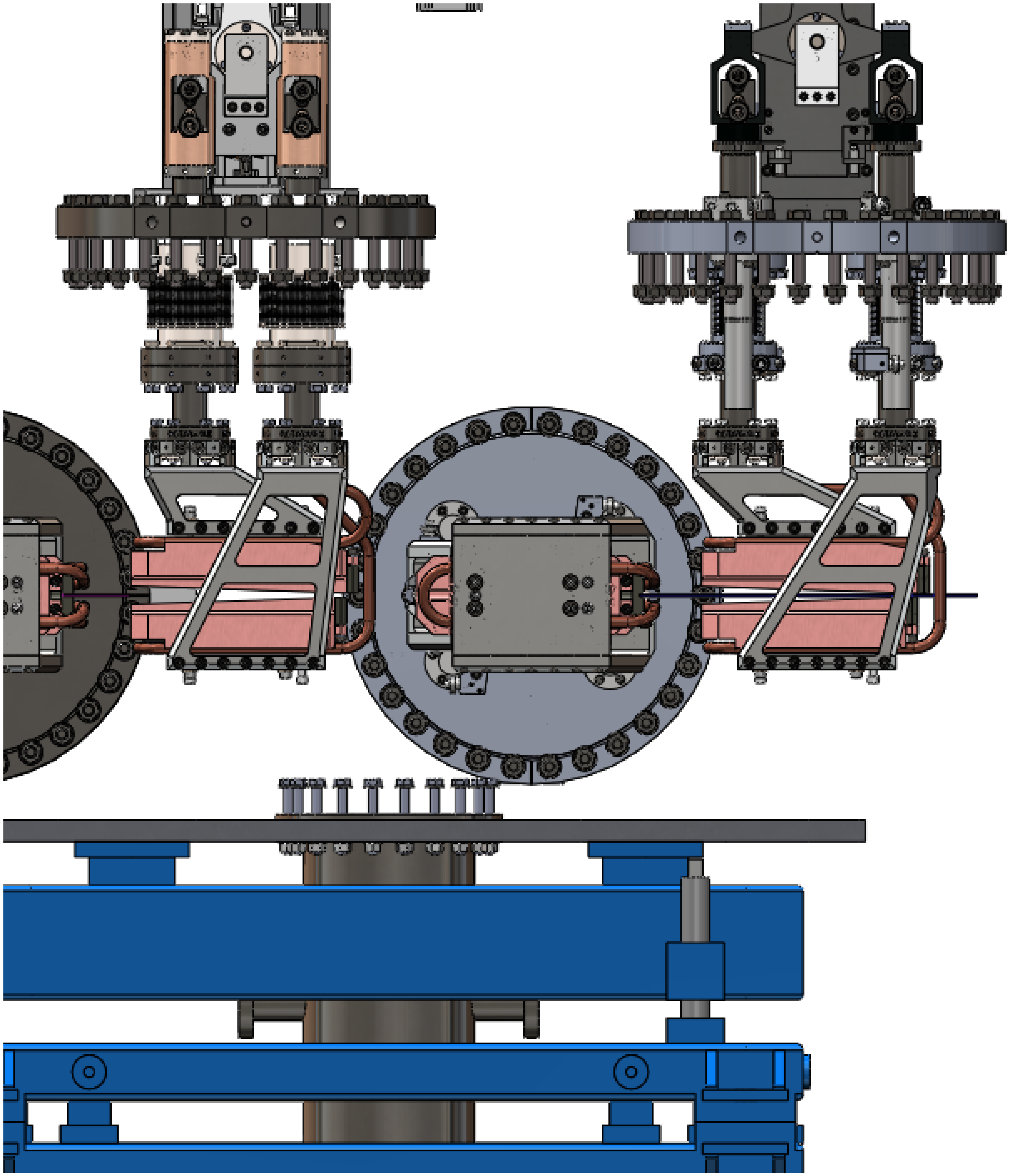
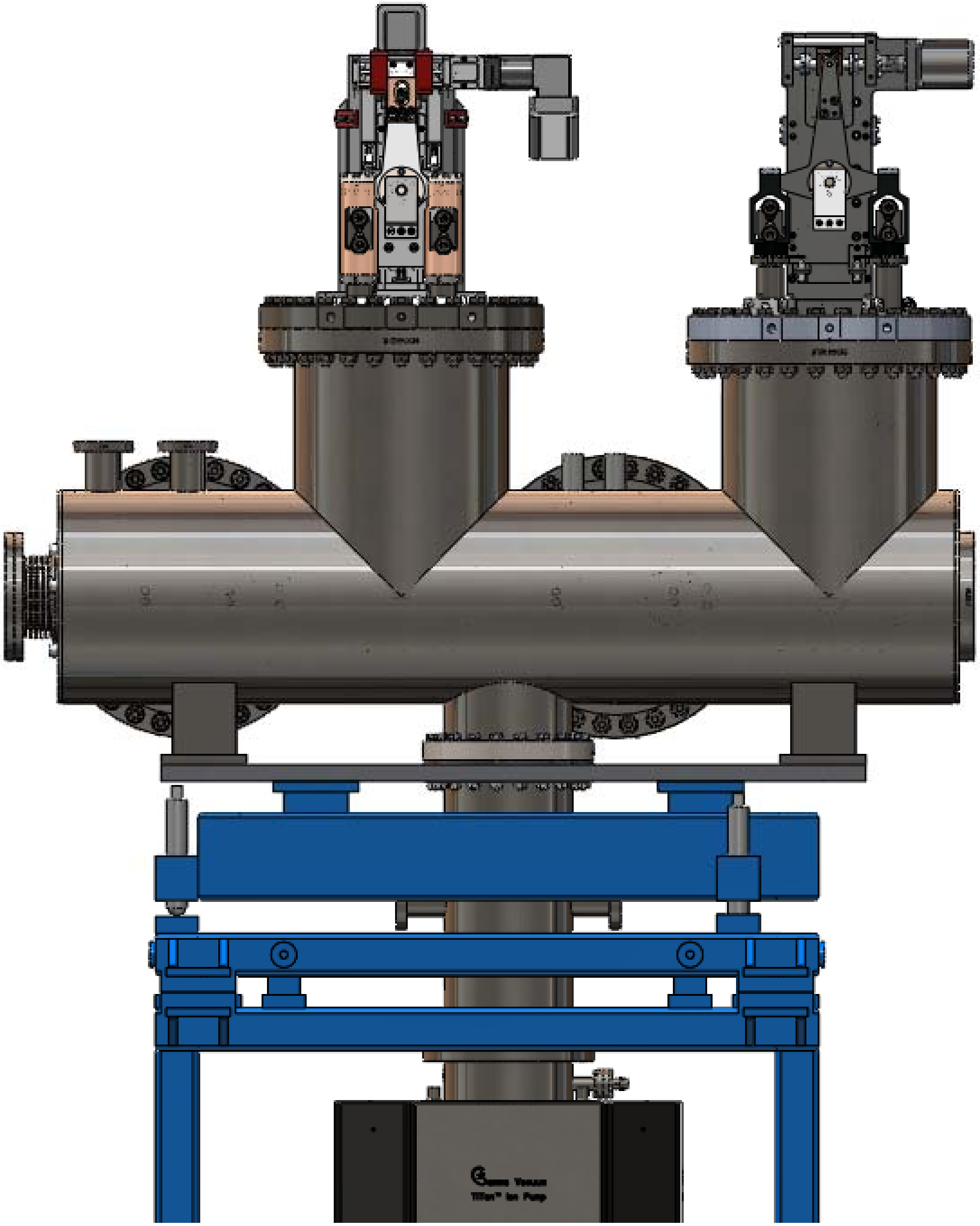
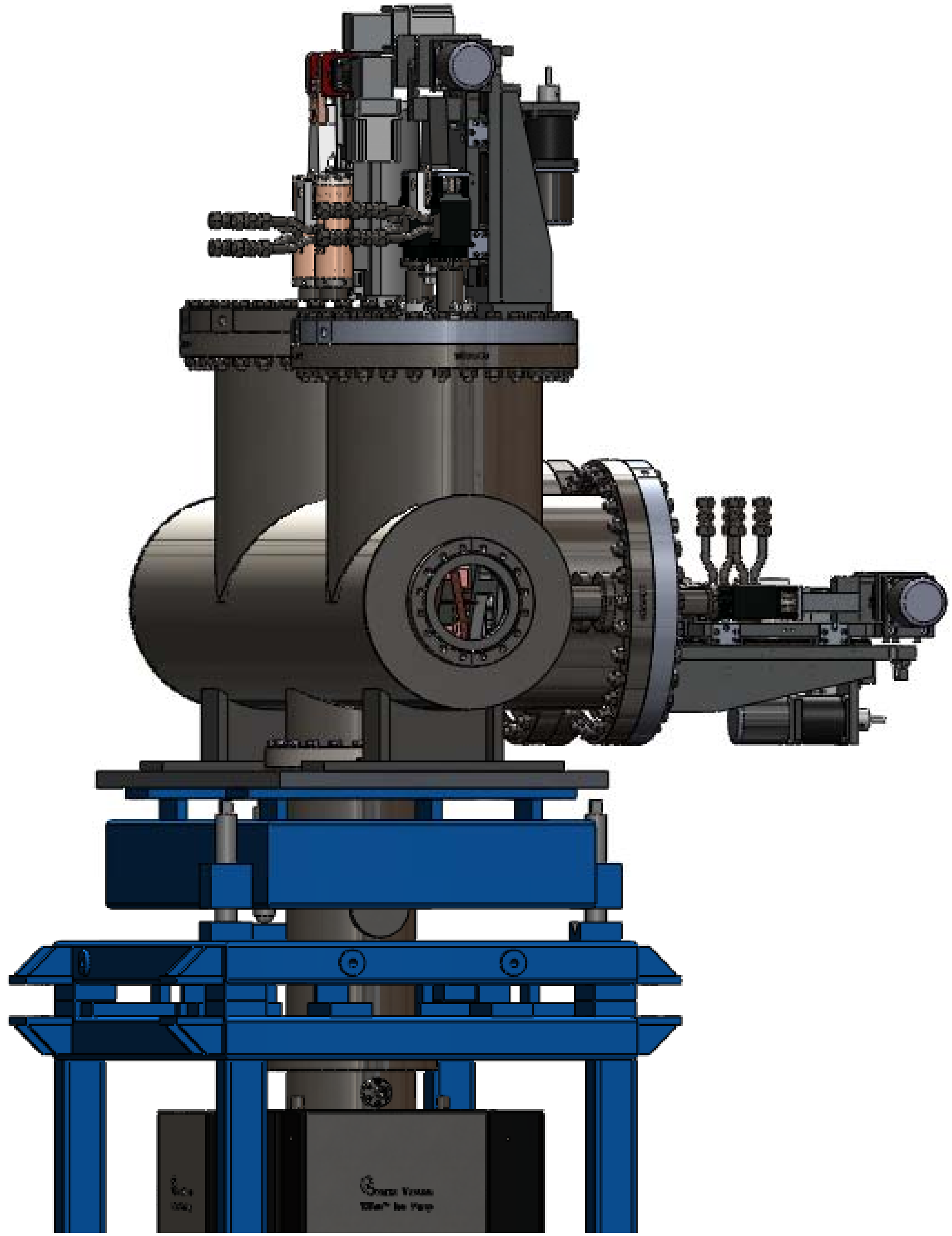
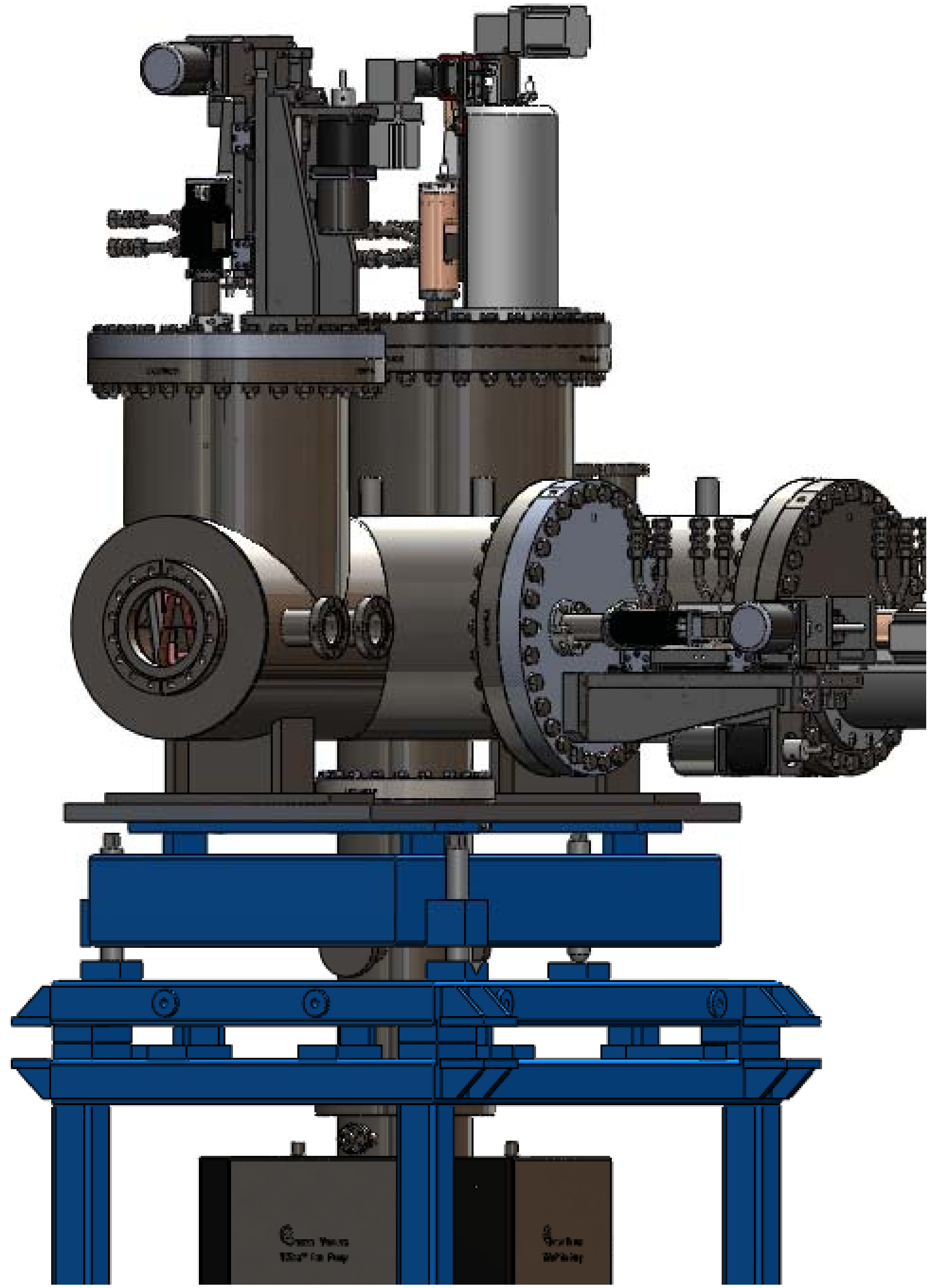


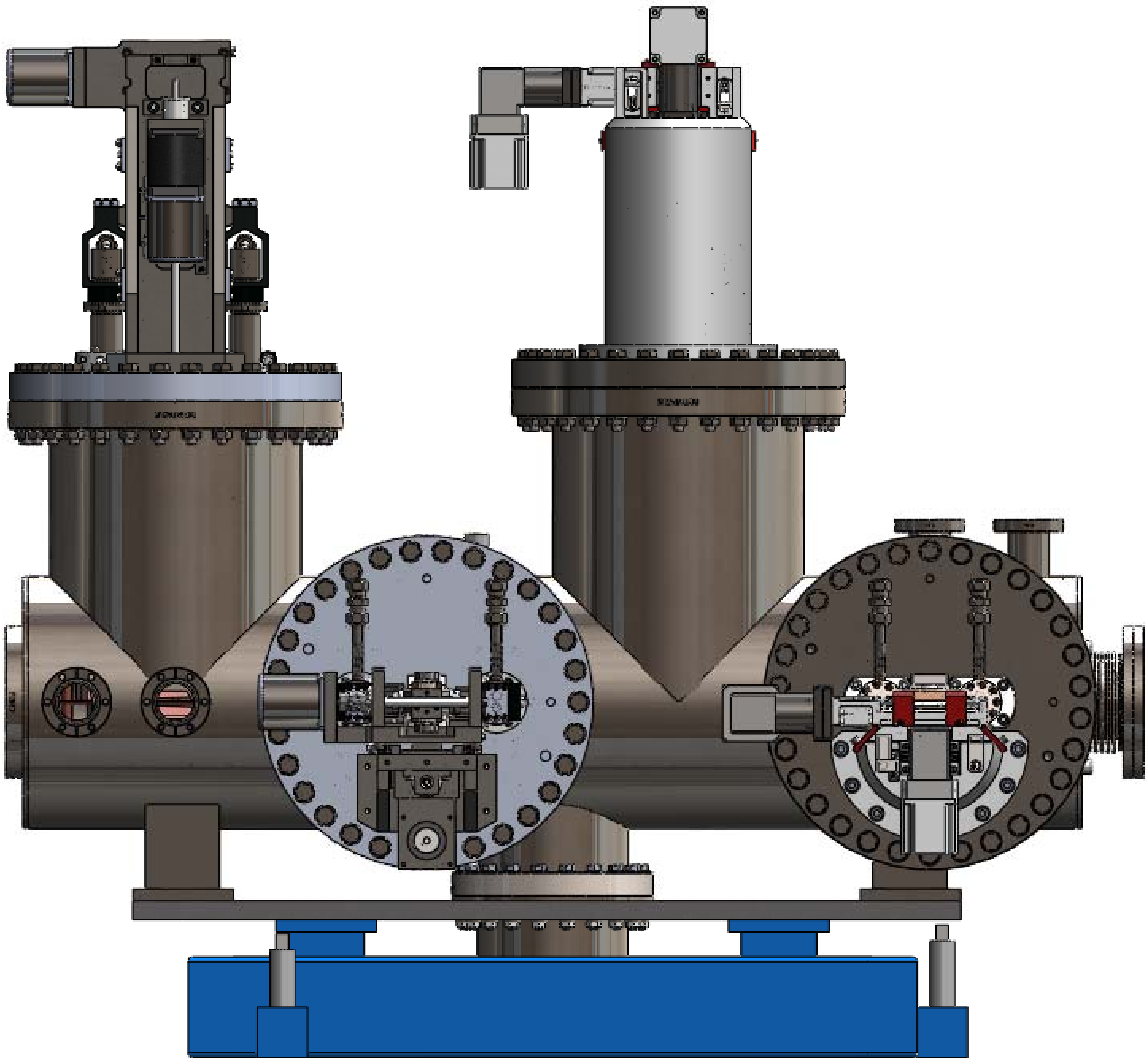

Slits Rated to 200 mA
Tungsten Blades

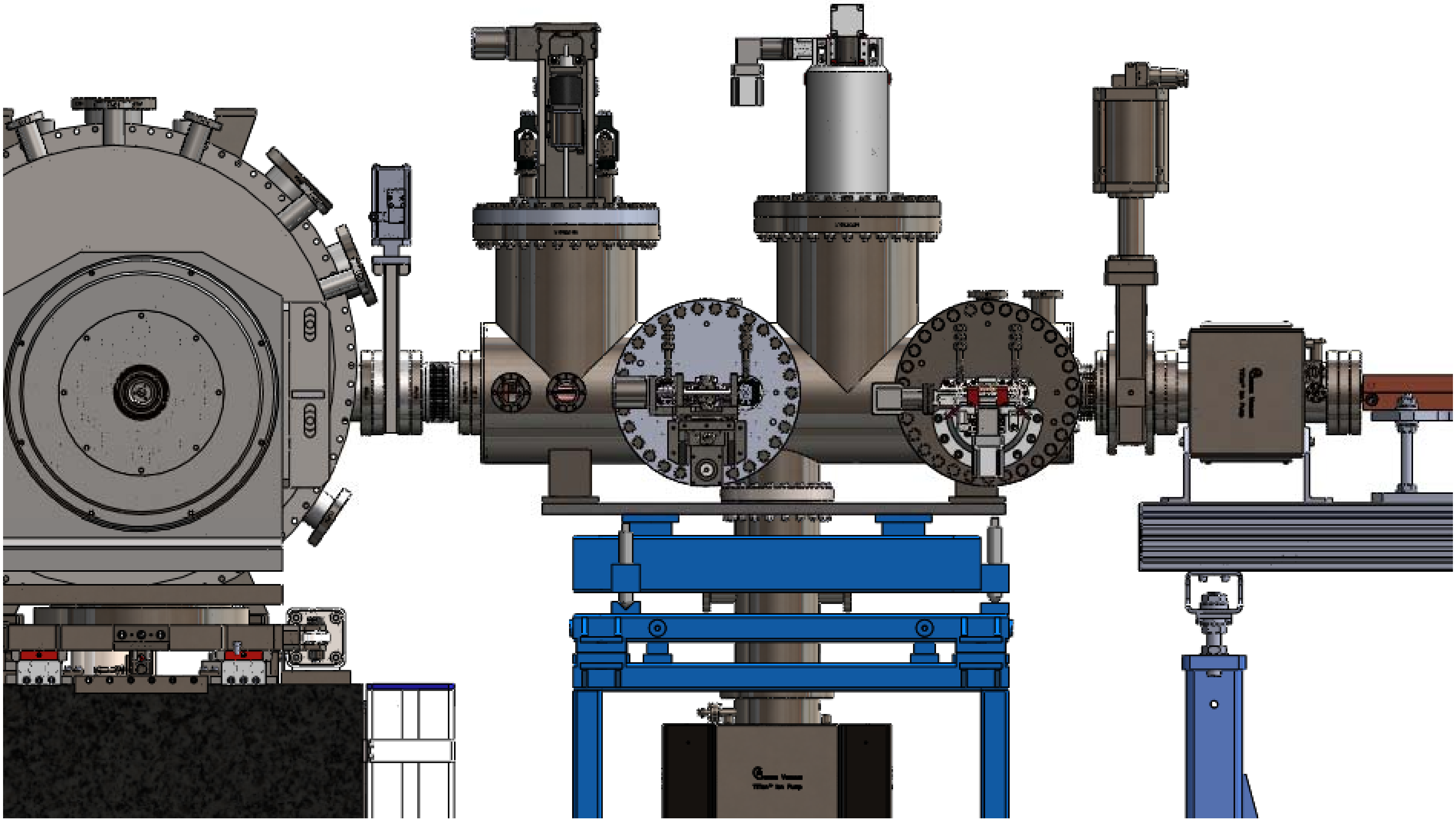


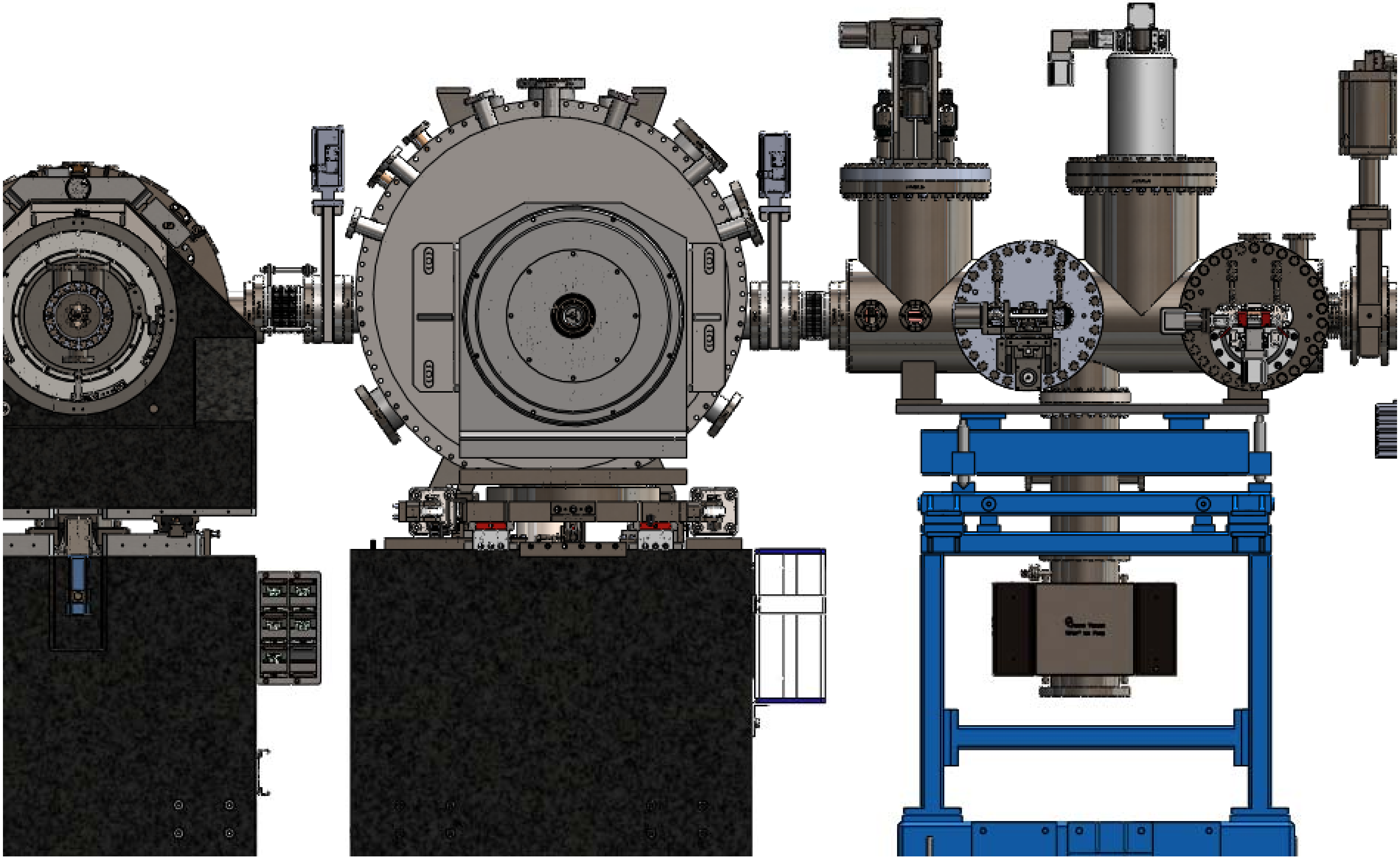


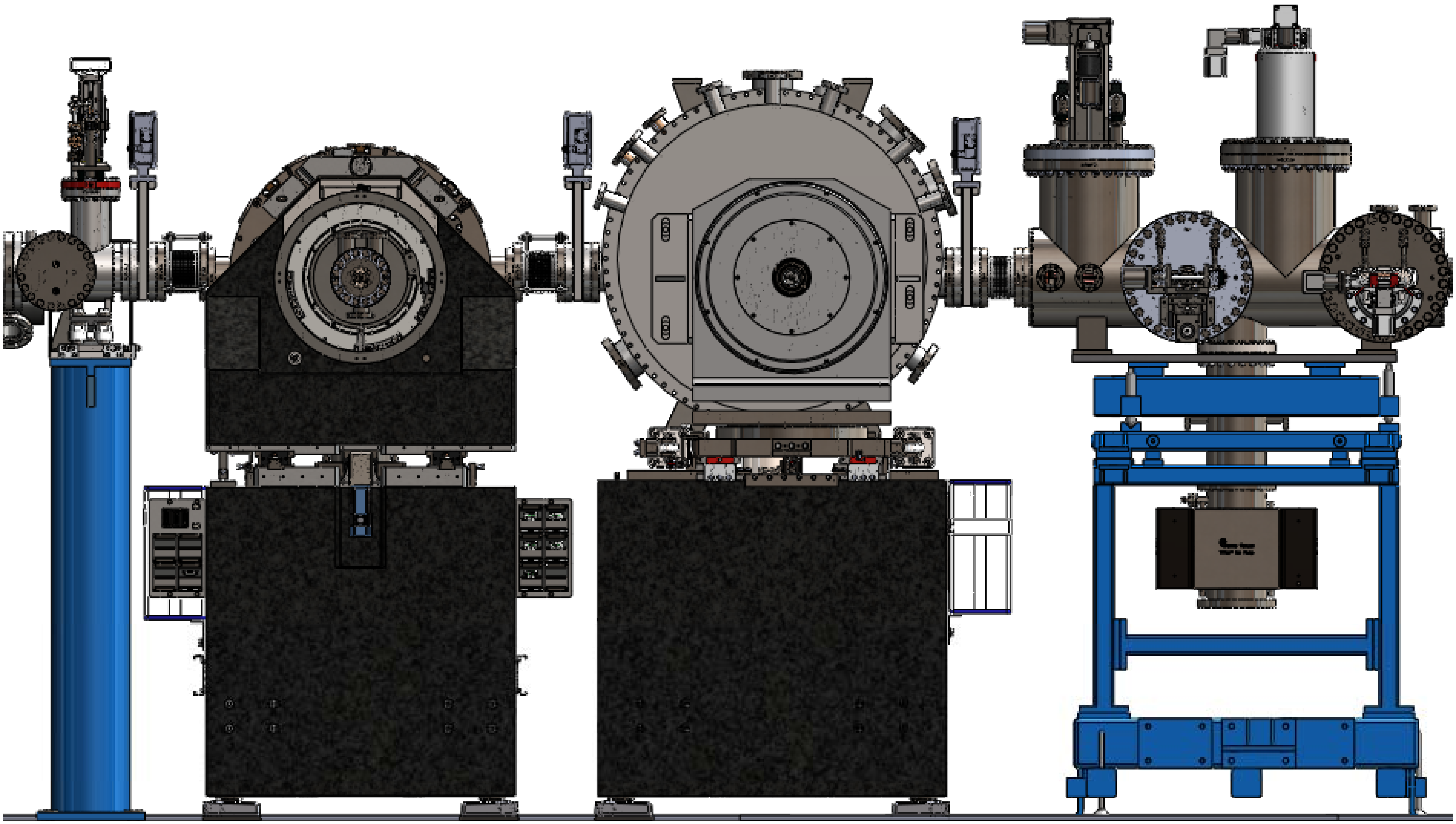




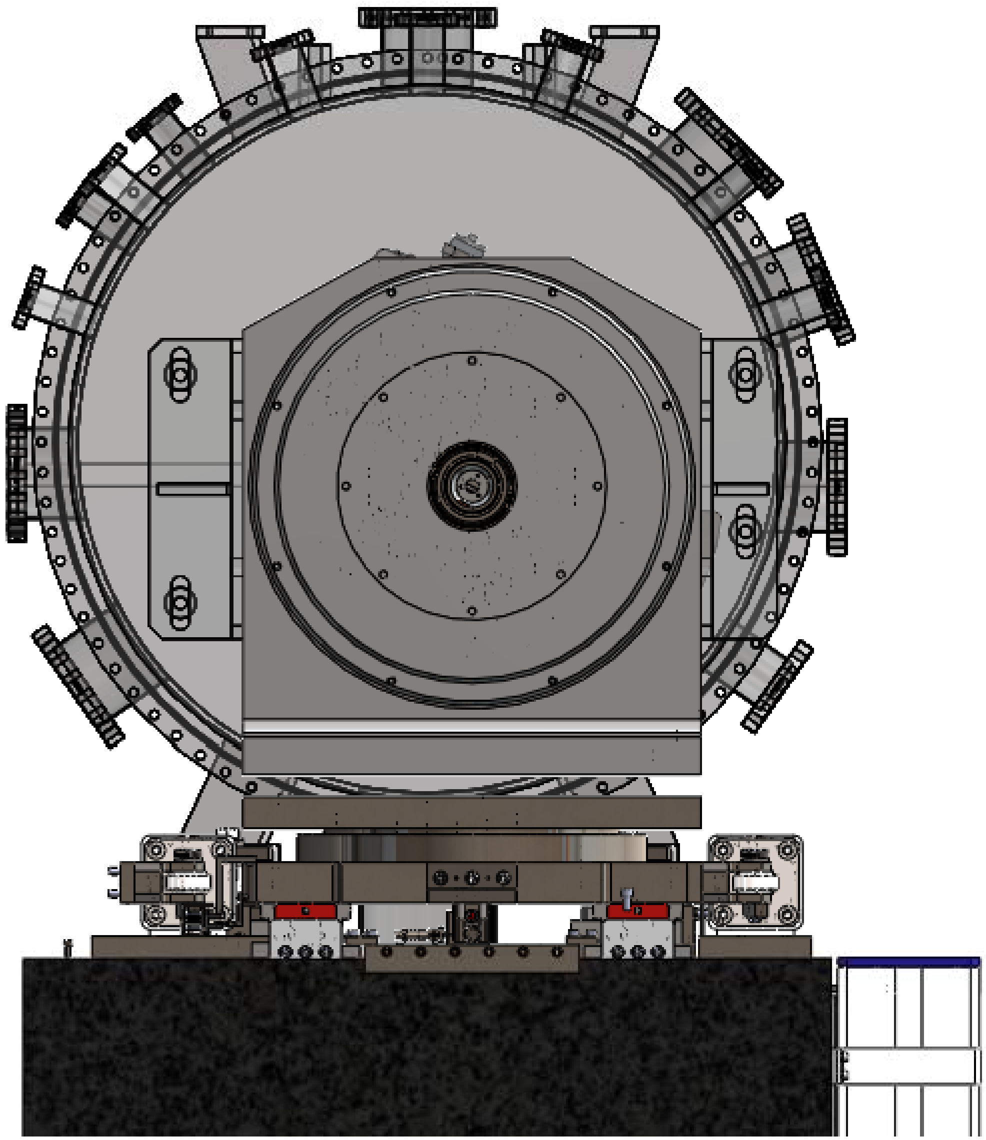


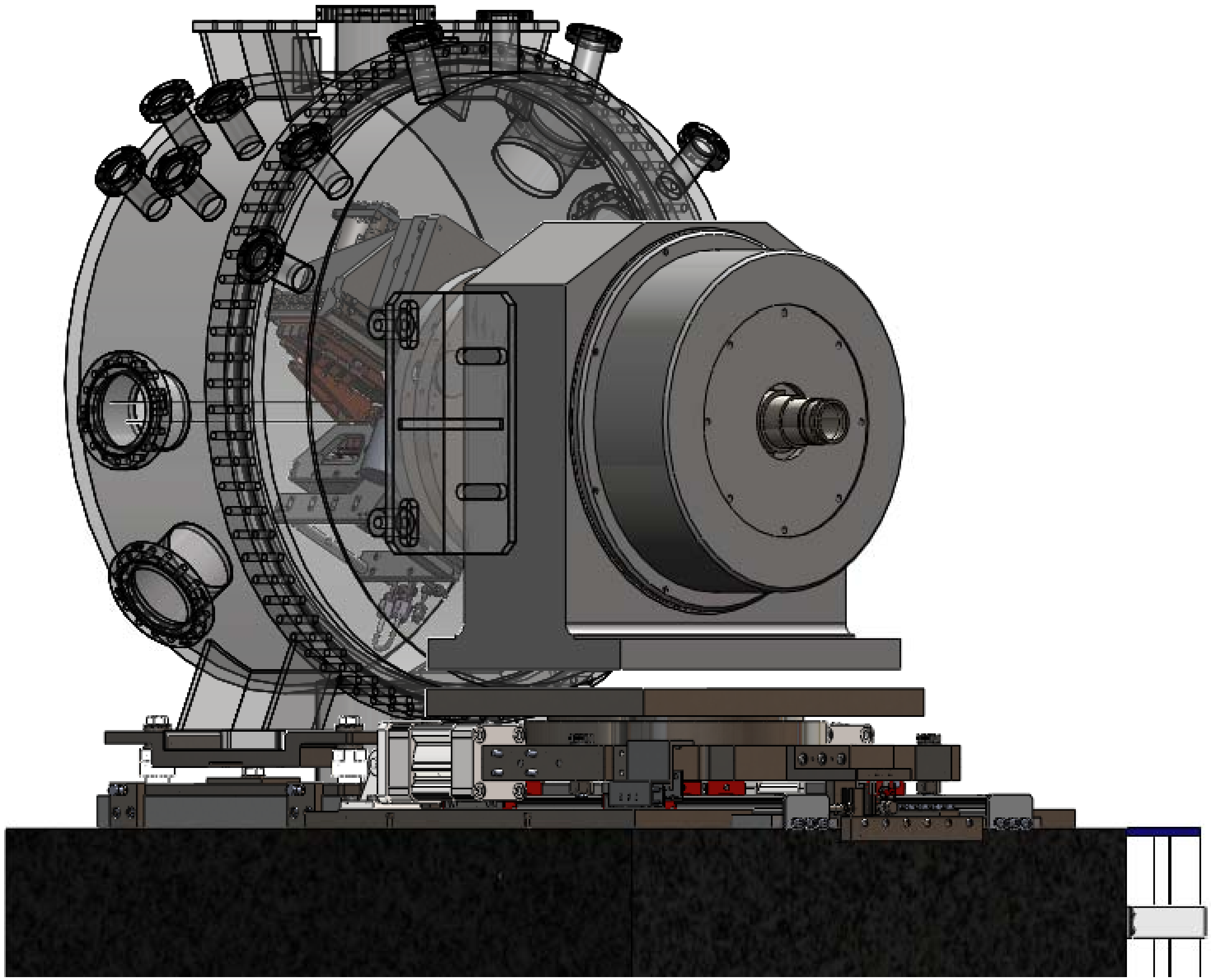


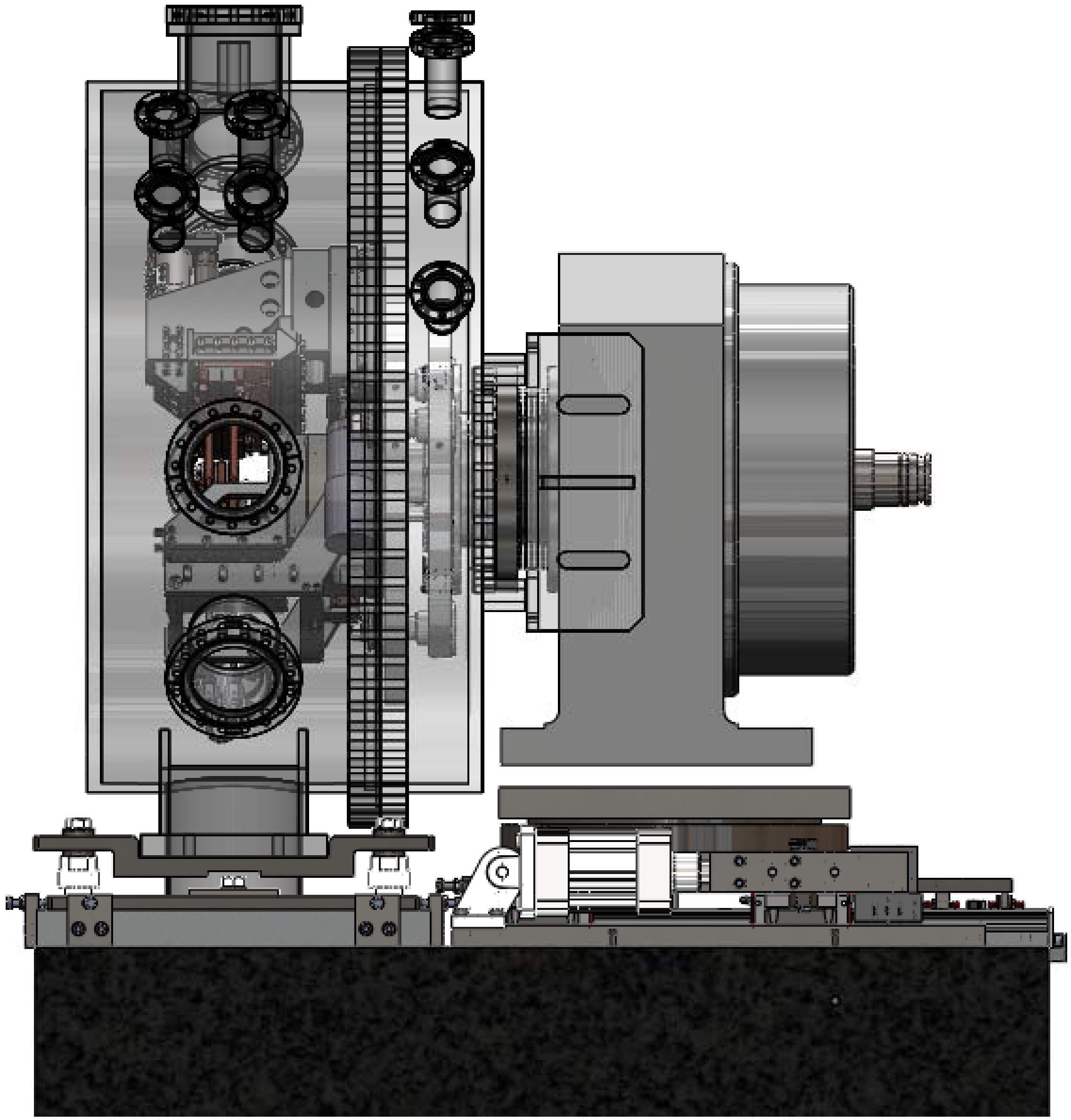


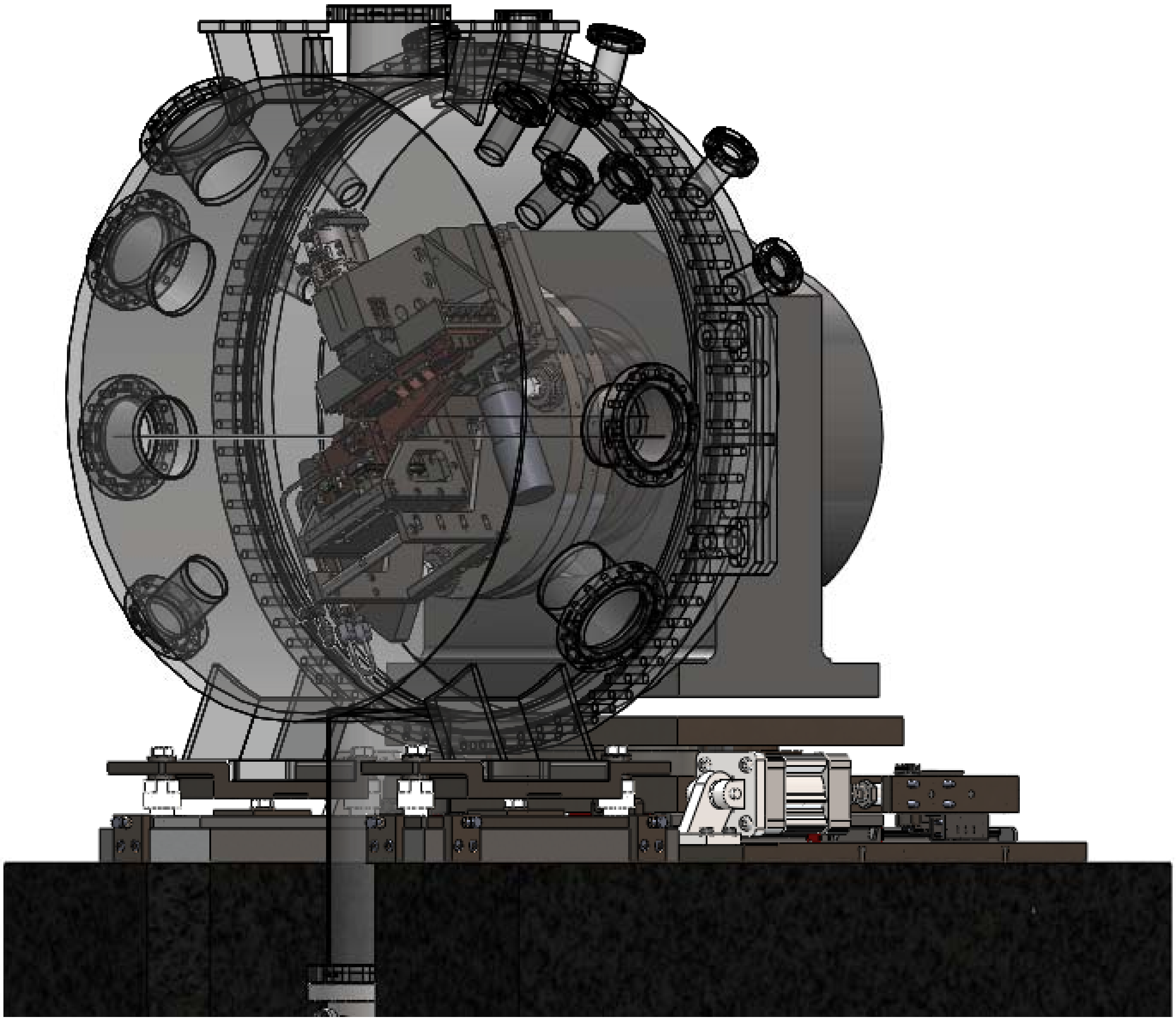


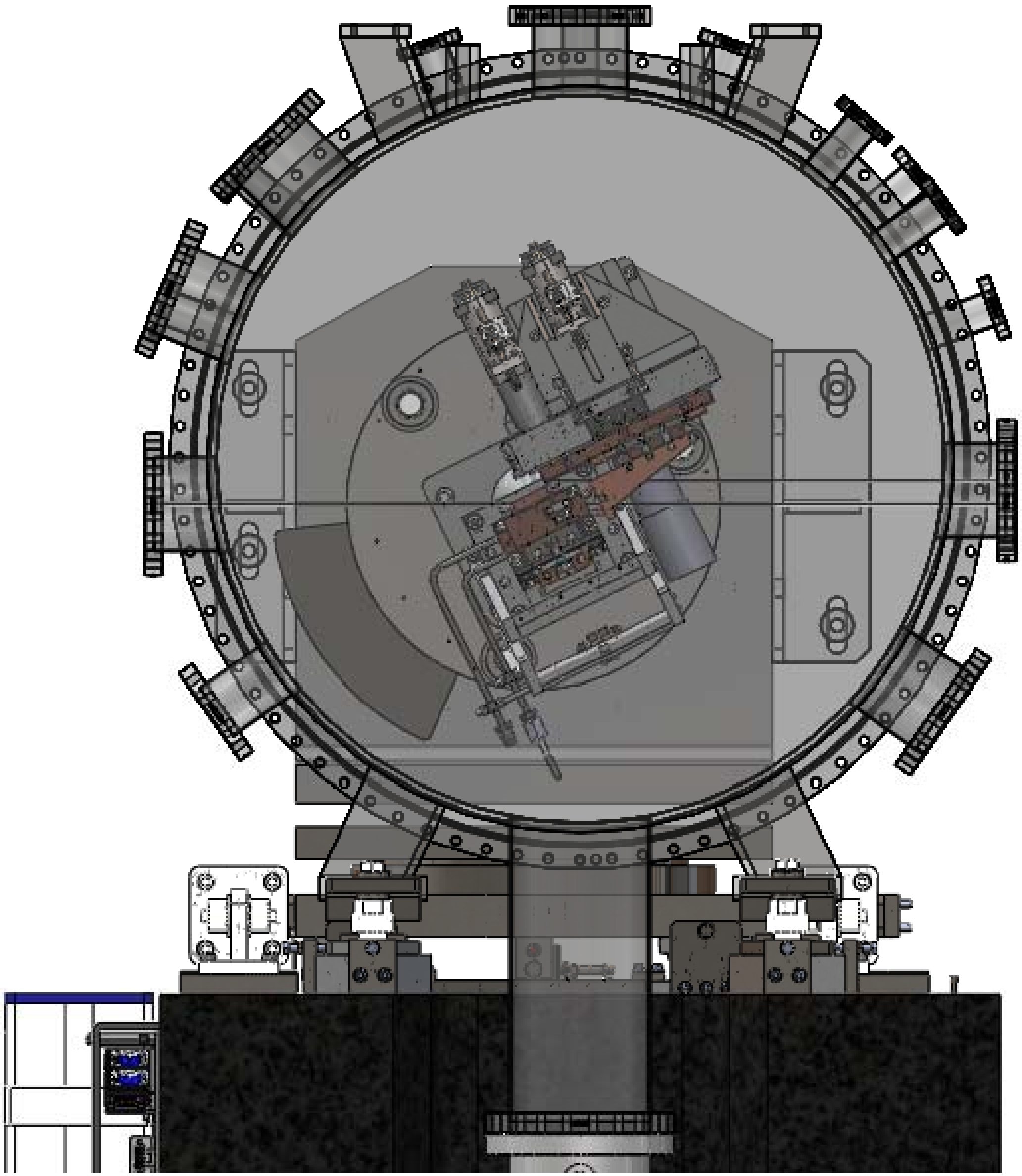
Inboard Mono
5 – 75 keV

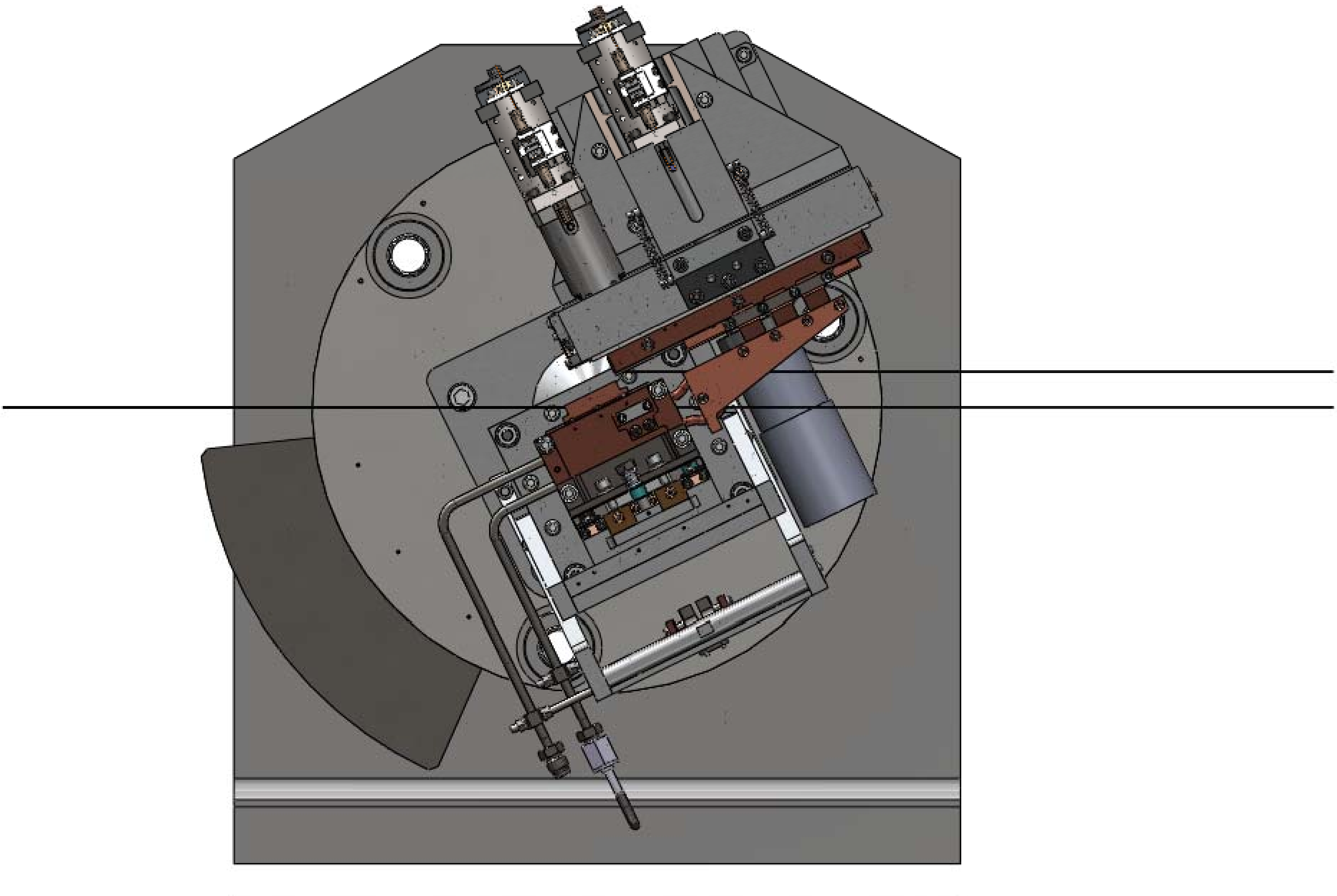


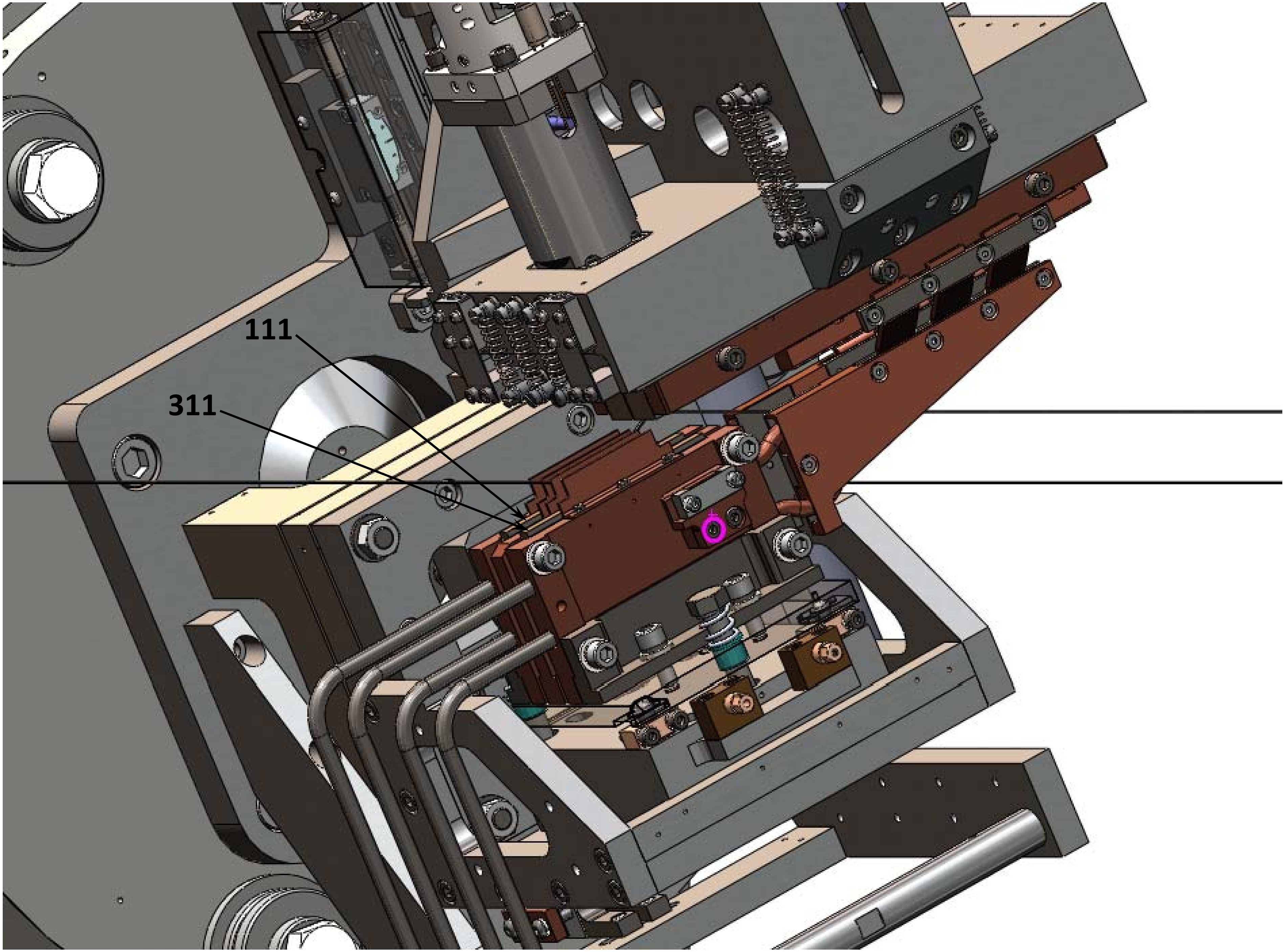








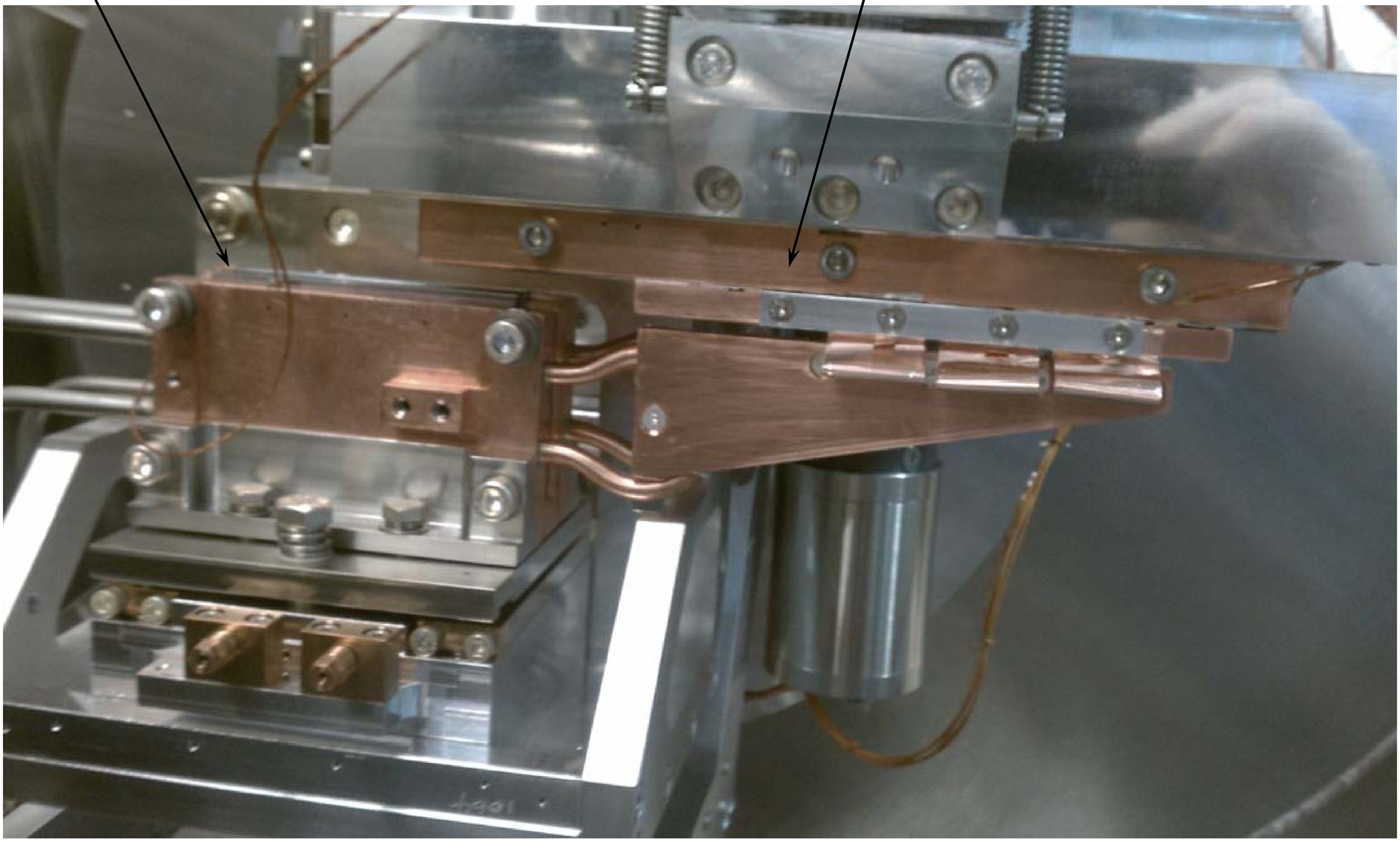



111
311

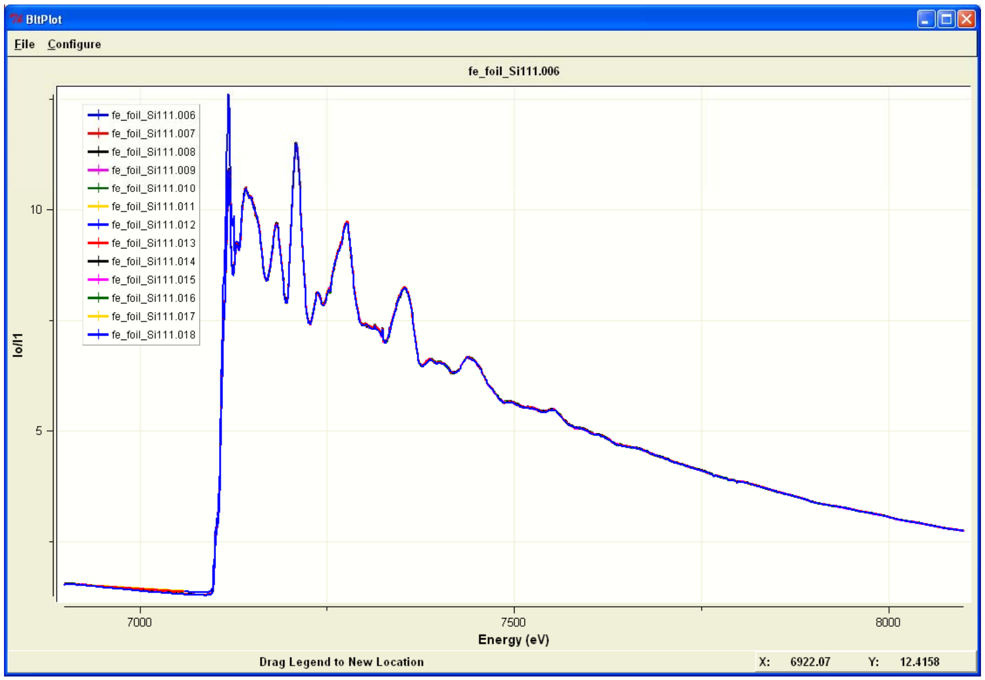
Tested to 150 mA

1st Crystal temperature = -197 C

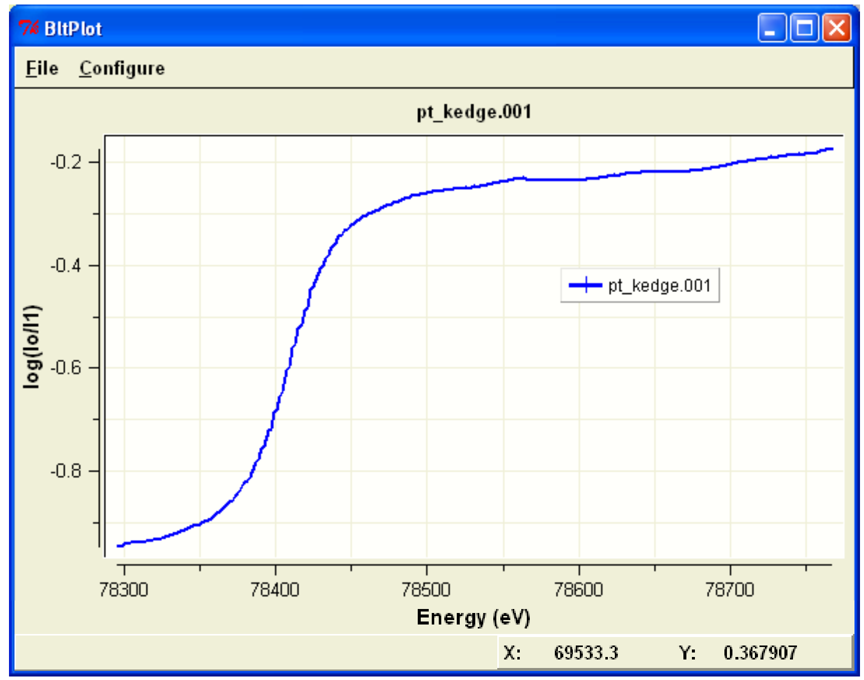
2nd Crystal temperature = -170 C

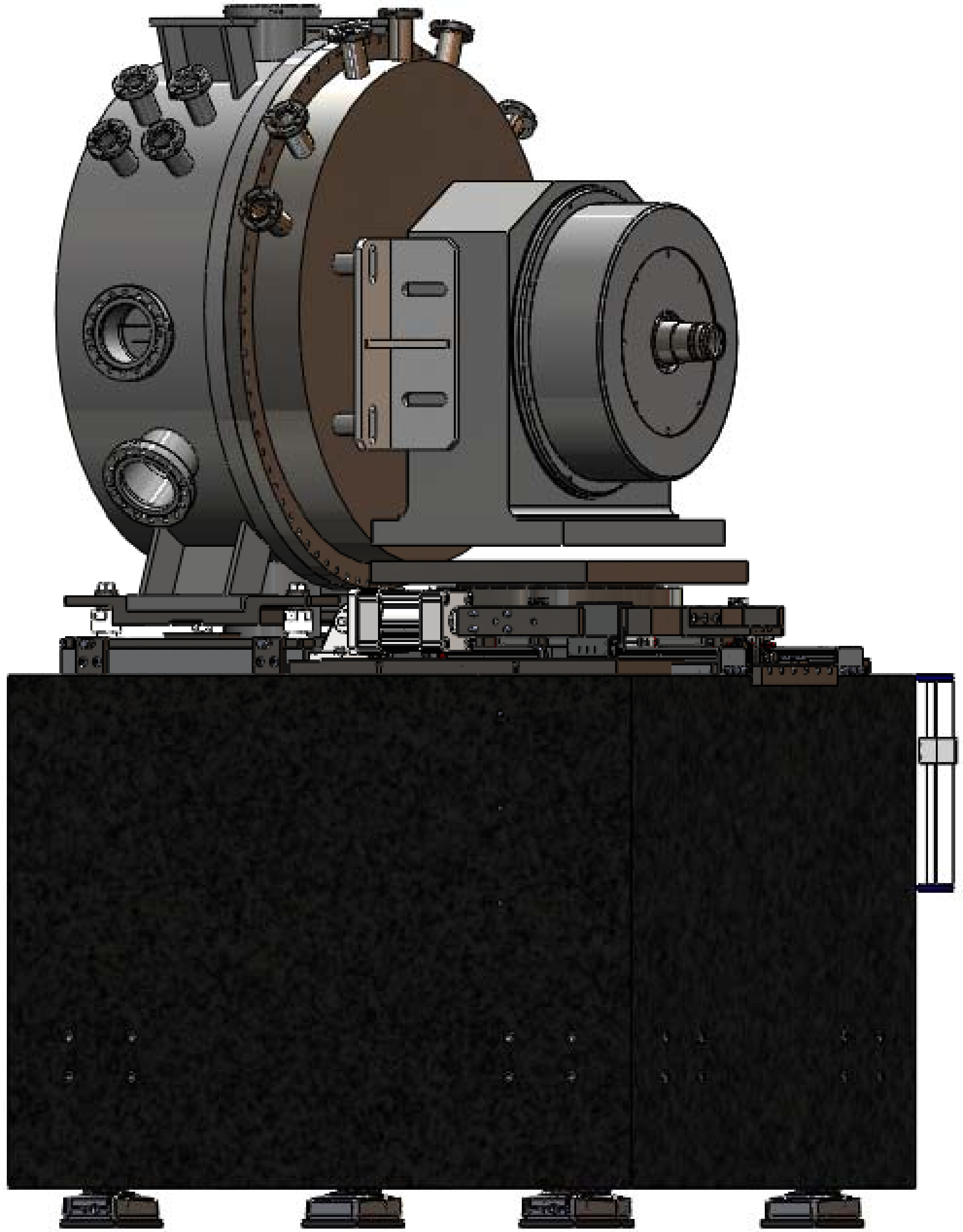


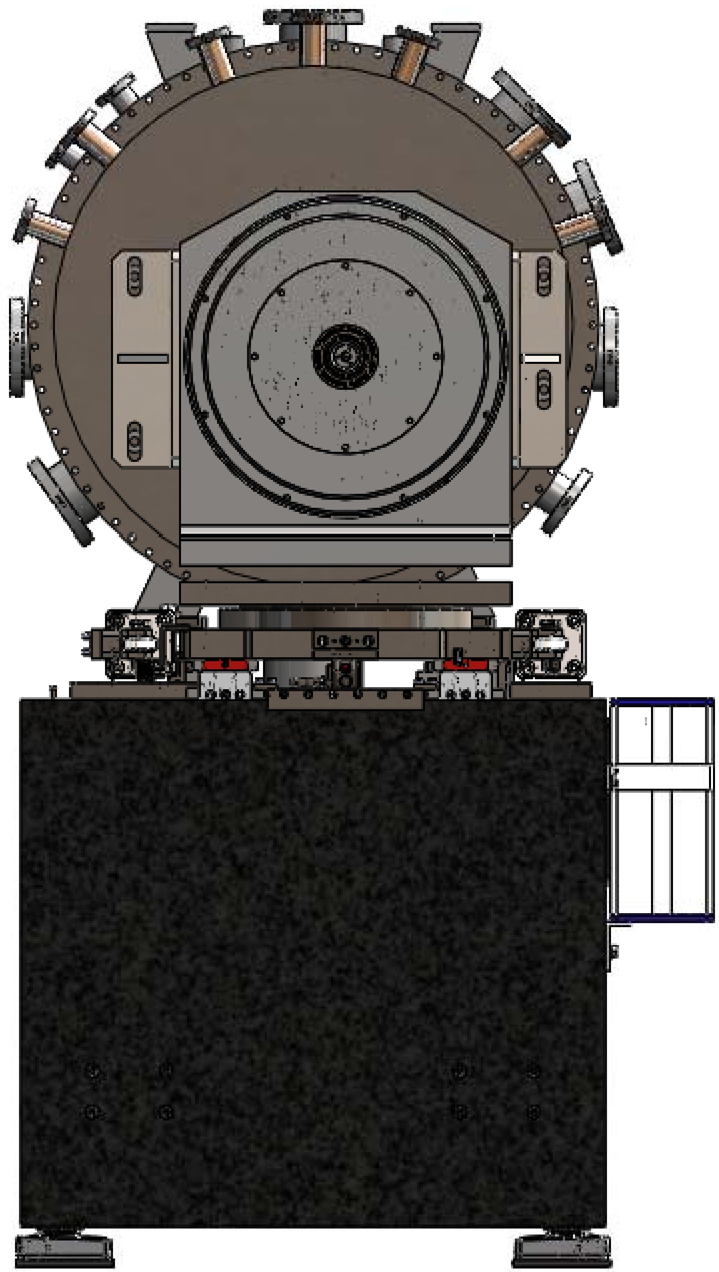
Fe k-edge, Si 111, Inboard Beamline
12 Scans

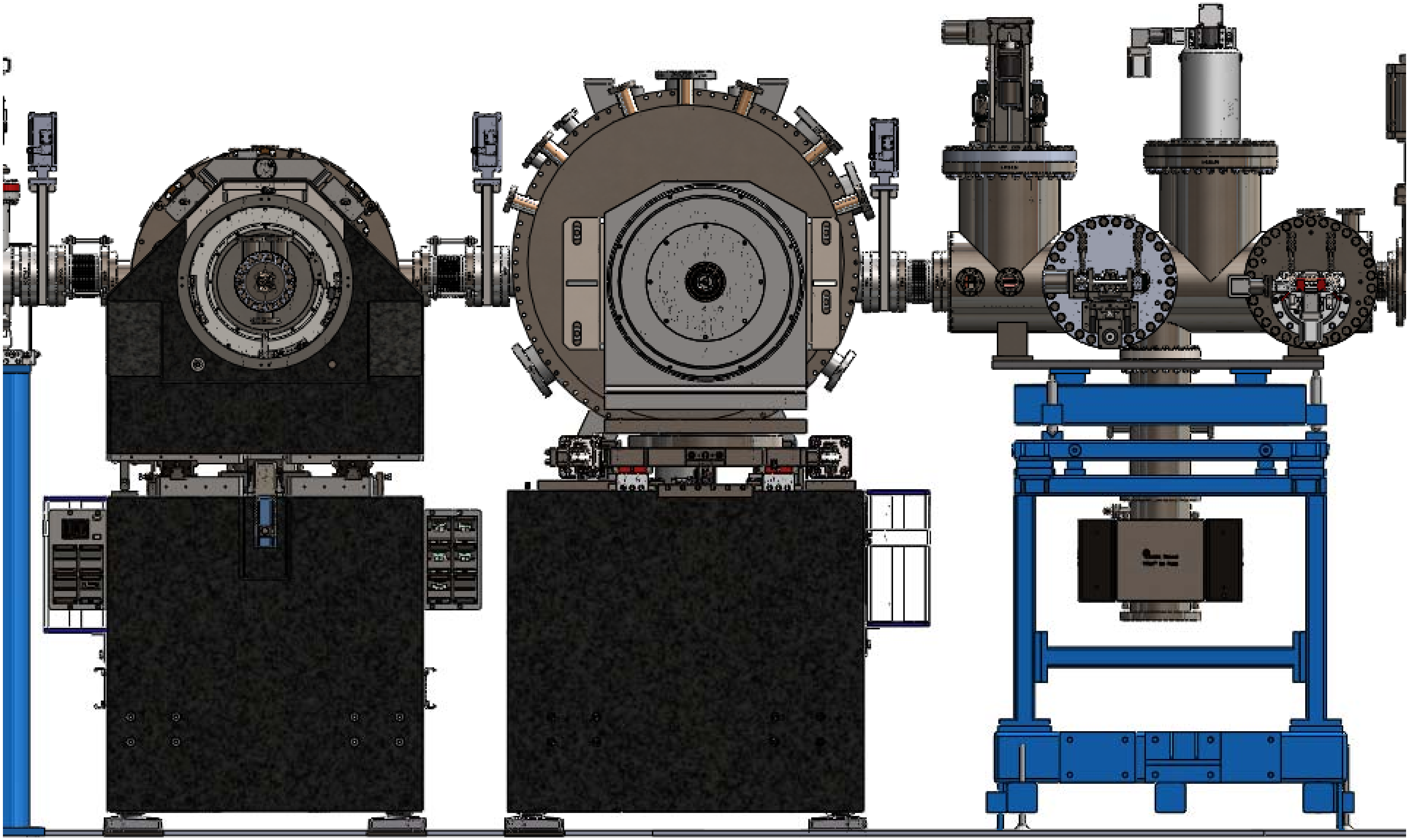


Pt k-edge, Si 311, Inboard Beamline

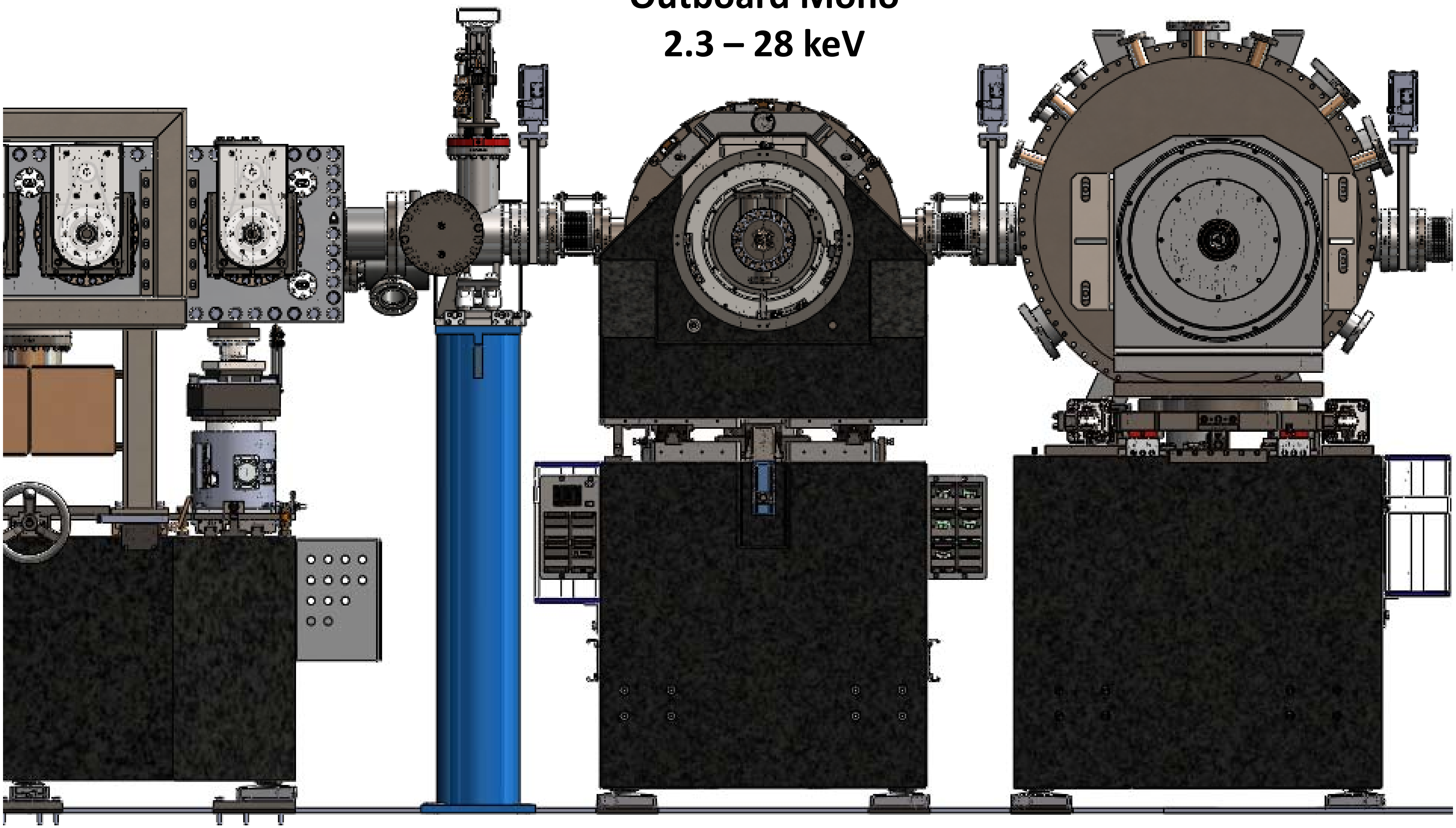




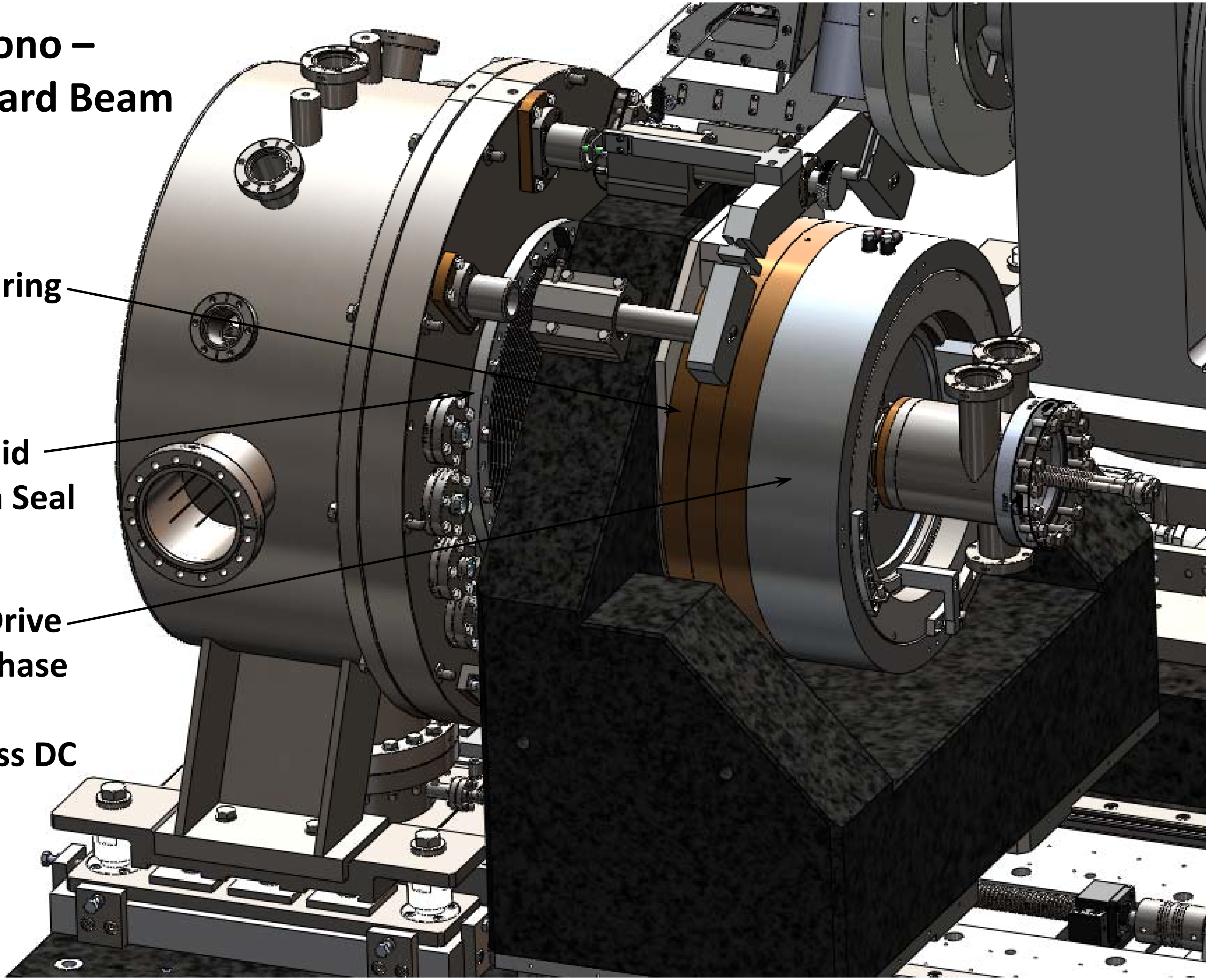




Outboard Mono
2.3 – 28 keV

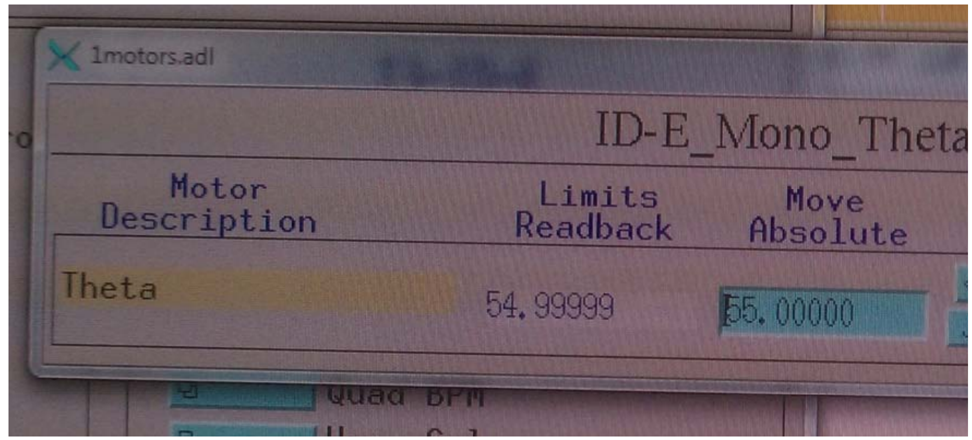


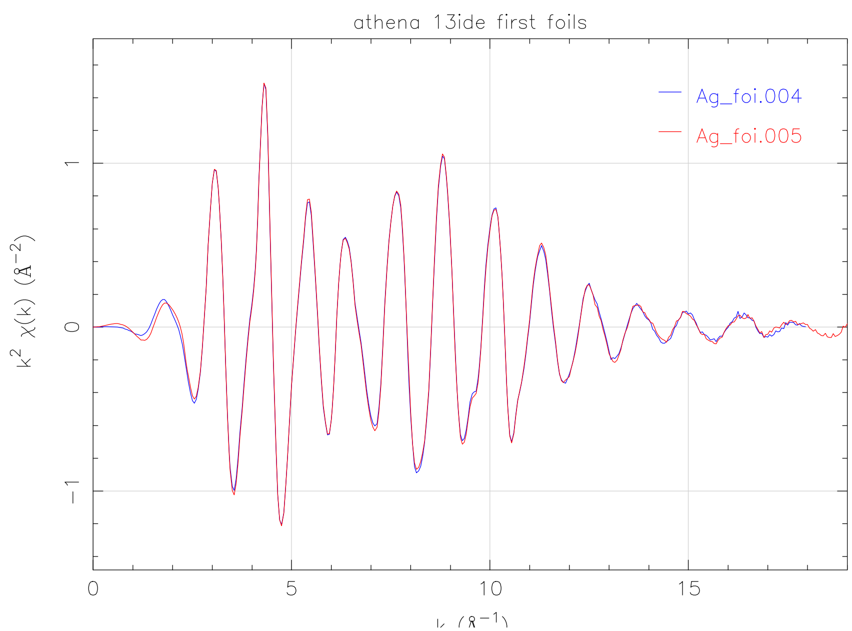
IDE Mono – Outboard Beam

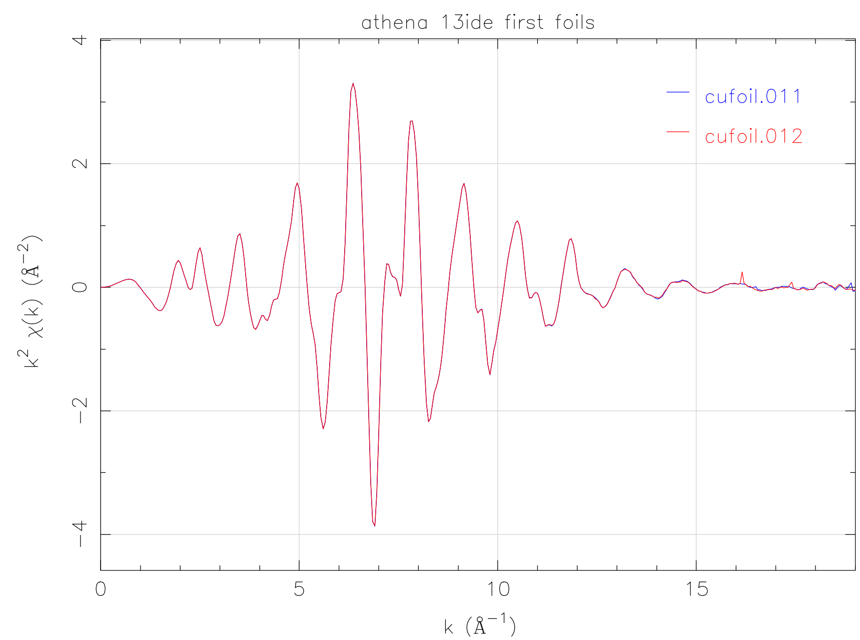


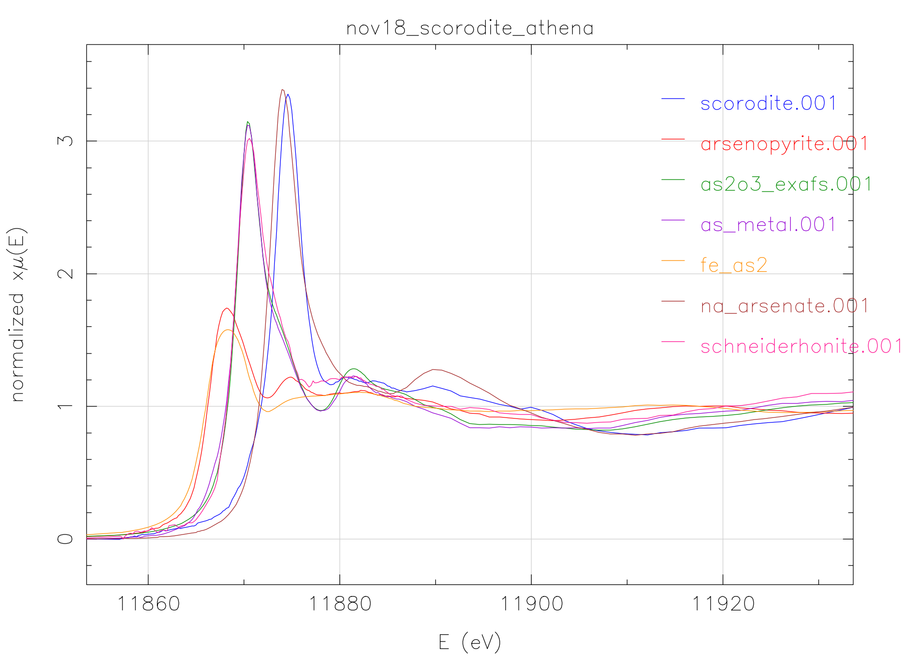
Fast > 10 deg/sec

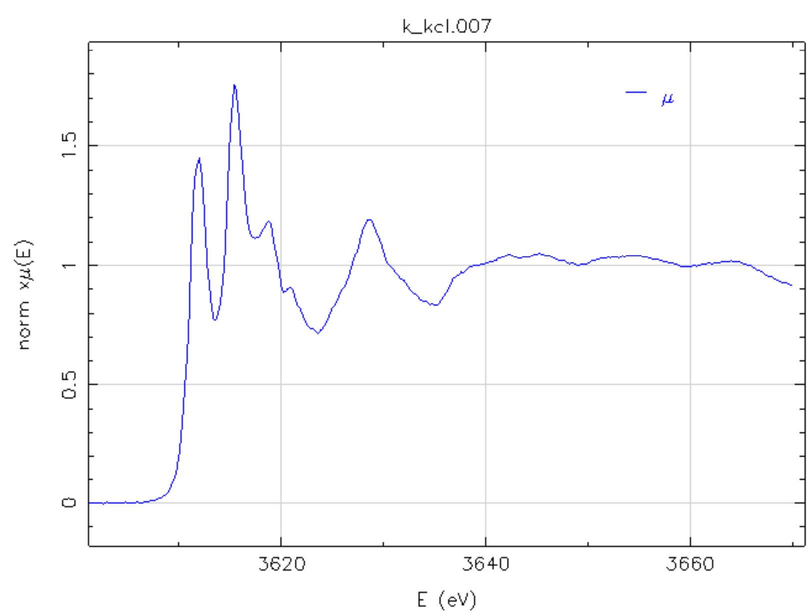
0.2 micro radian Encoder Resolution

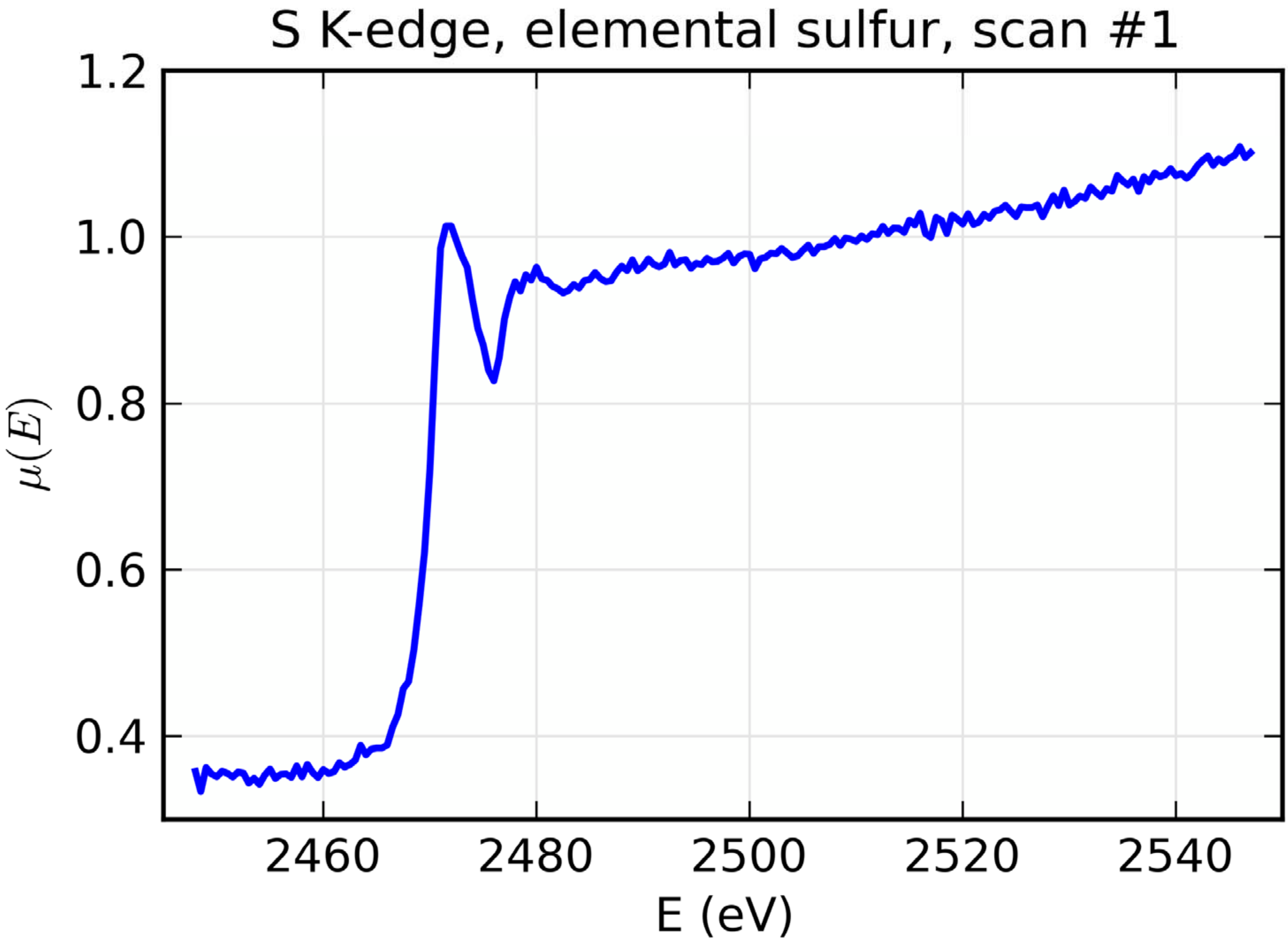


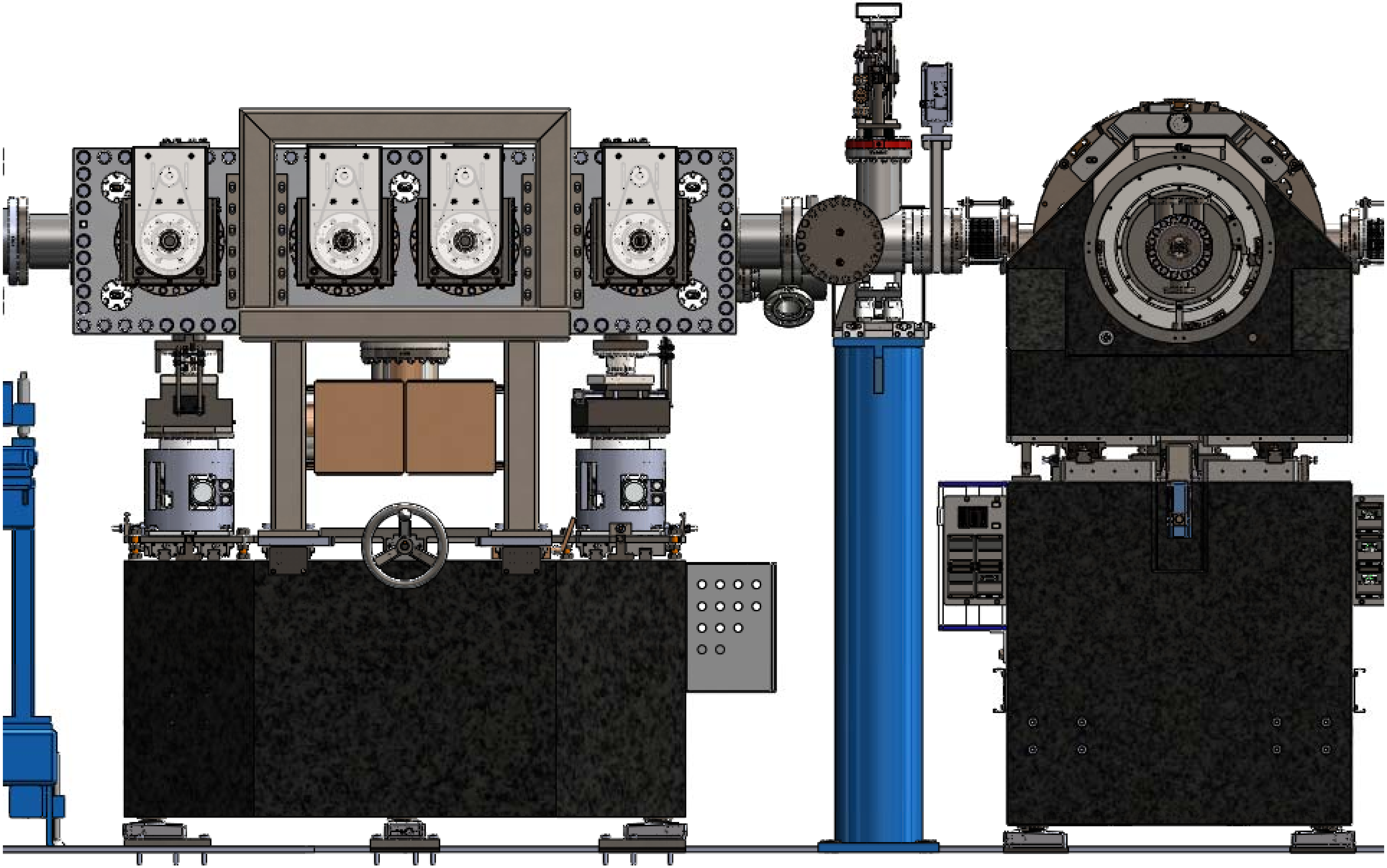

athena 13ide first foils
Ag_foi.004
Ag_foi.005
$k^2\chi(k)$ ($Å^{-2}$)
0
5
10
15
−1
0
1


athena 13ide first foils
cufoil.011
cufoil.012
$k^2\chi(k)$ ($Å^{-2}$)
k ($Å^{-1}$)
0
5
10
15
−4
−2
0
2
4

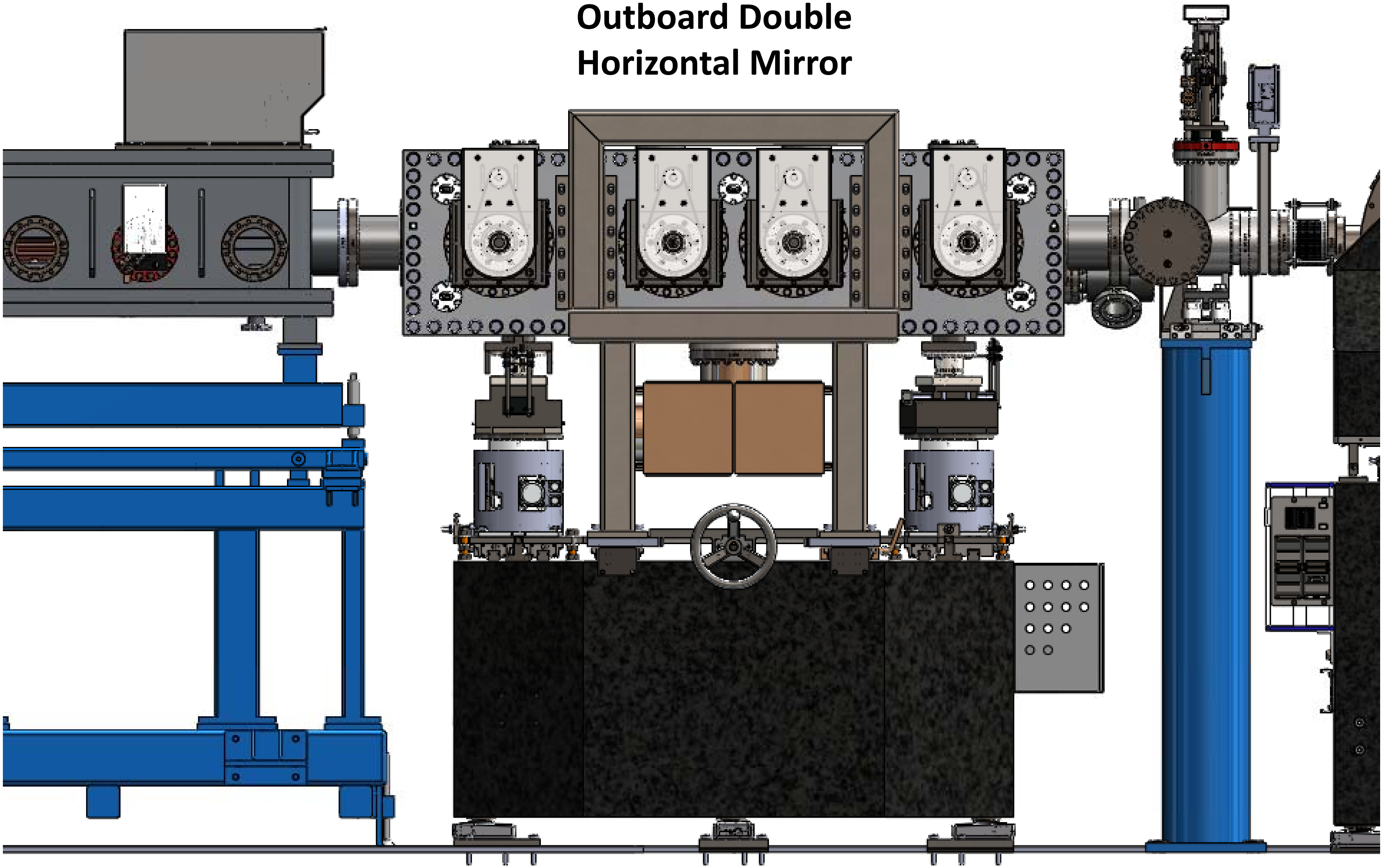

nov18_scorodite_athena
scorodite.001
arsenopyrite.001
as2o3_exafs.001
as_metal.001
fe_as2
na_arsenate.001
schneiderhonite.001
normalized xμ(E)
E (eV)
11860
11880
11900
11920
0
1
2
3

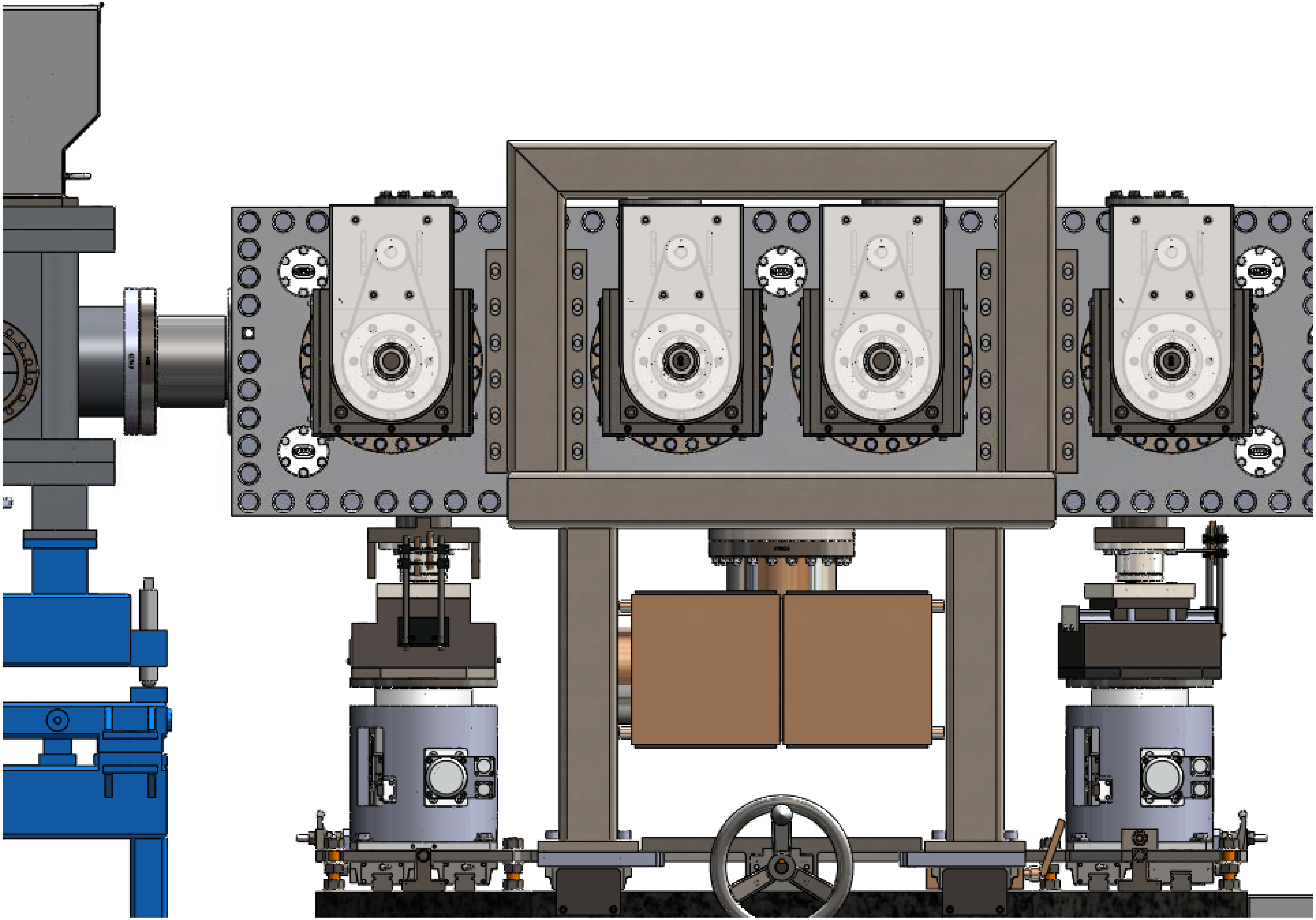

k_kcl.007
μ
norm xμ(E)
E (eV)
3620
3640
3660
0
0.5
1
1.5


S K-edge, elemental sulfur, scan #1
1.2
1.0
0.8
0.6
0.4
$\mu(E)$
2460
2480
2500
2520
2540
E (eV)

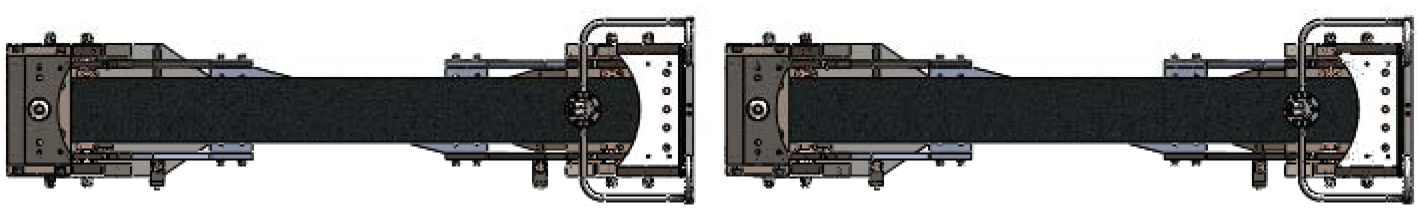


Outboard Double Horizontal Mirror

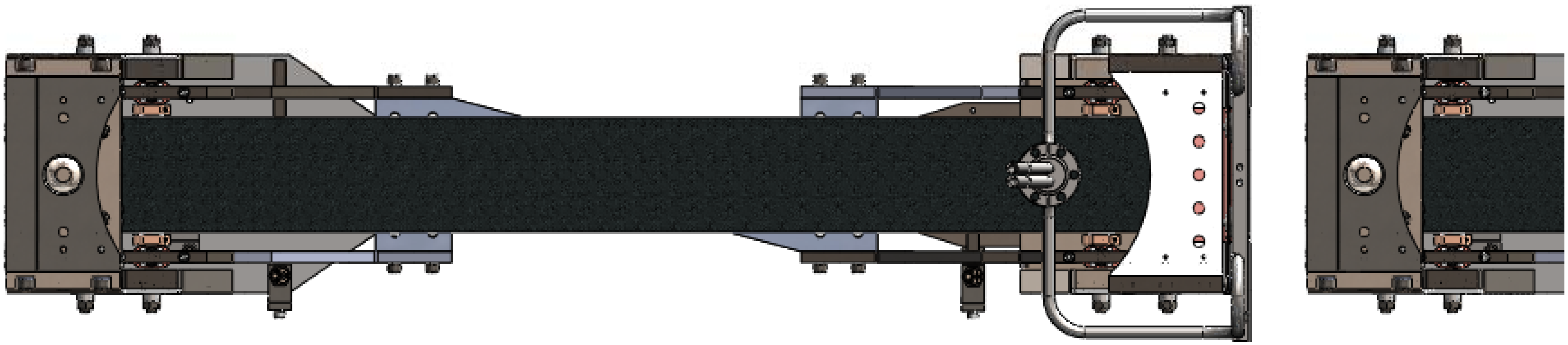


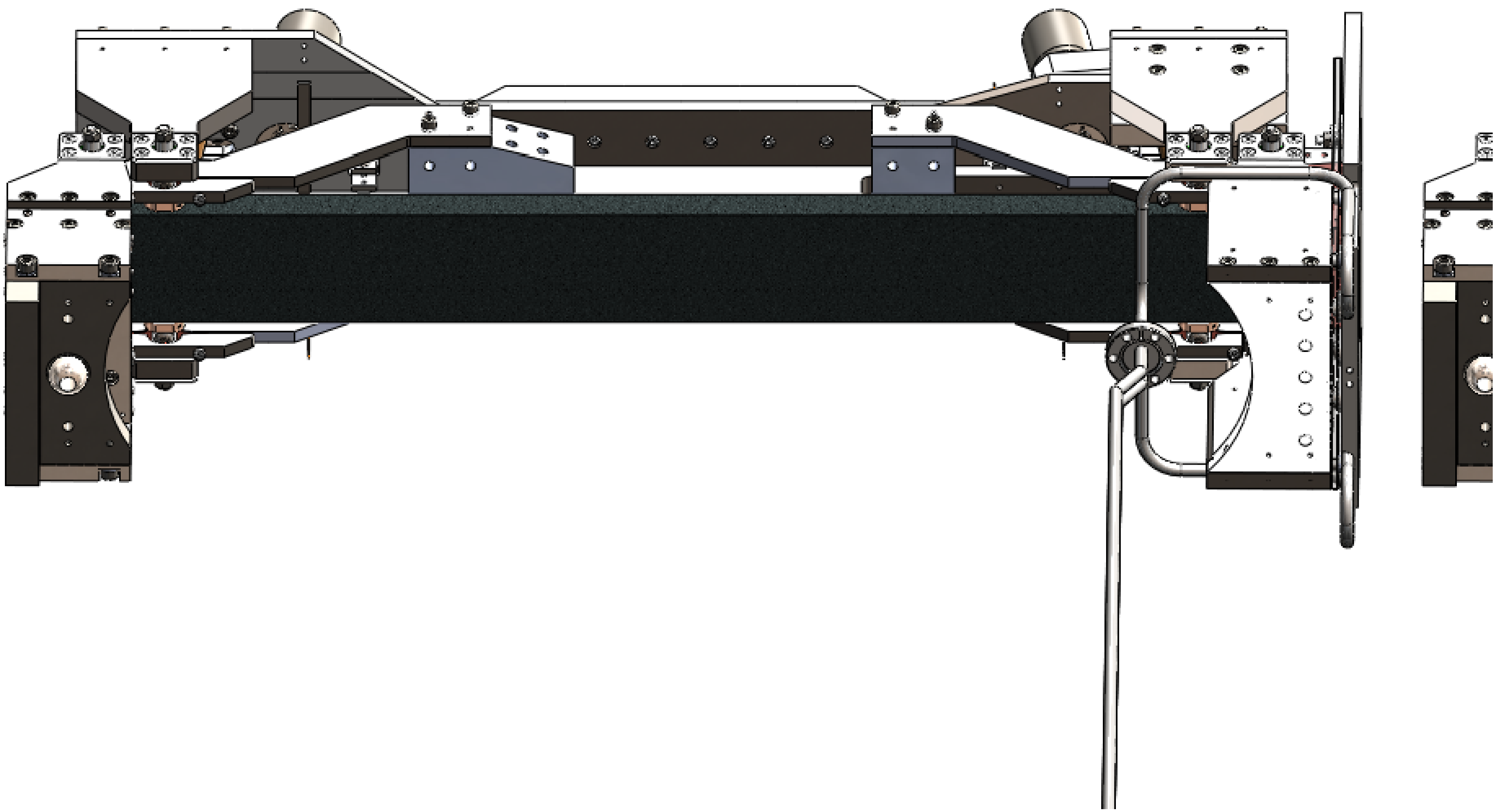


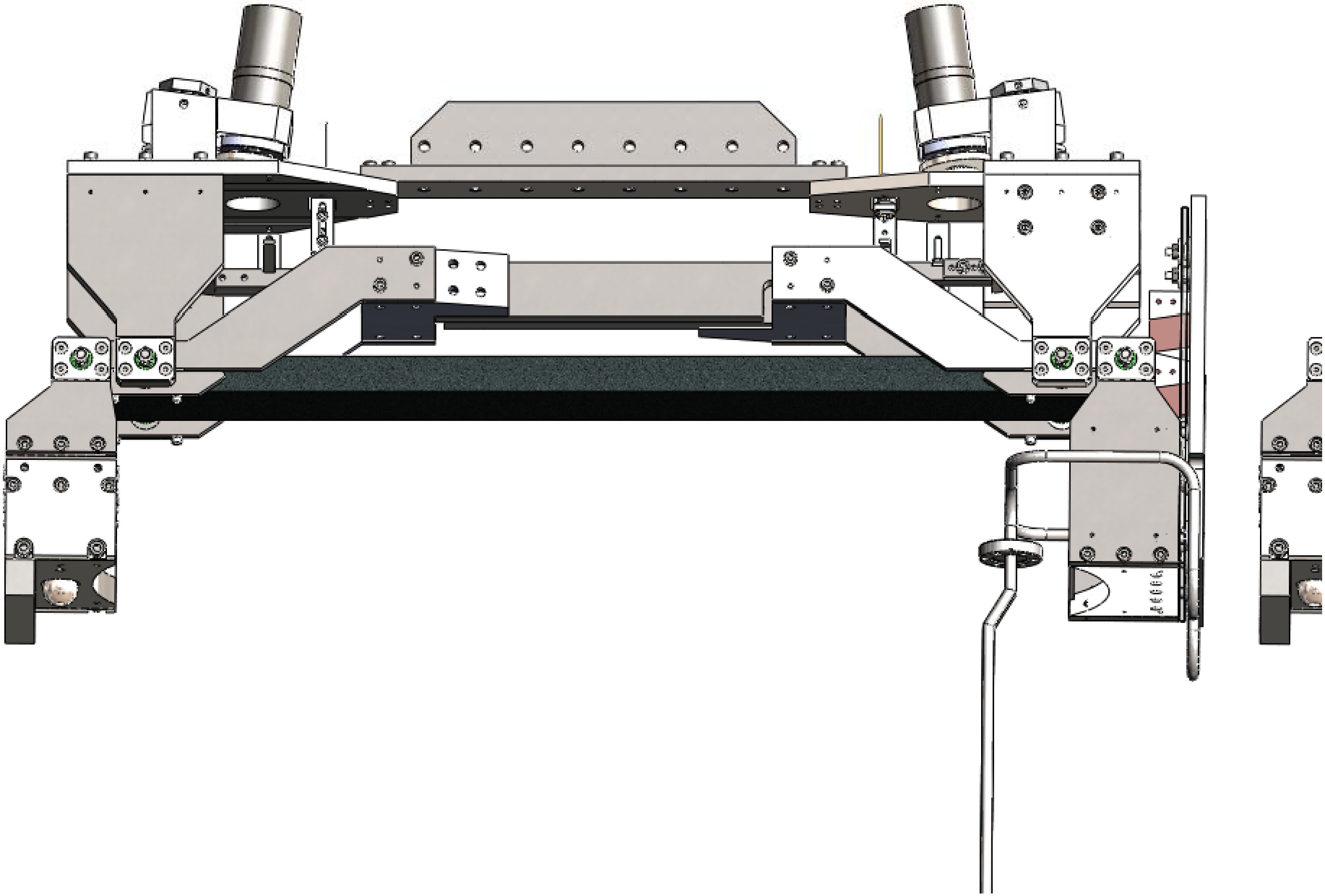
Two Inline Mirrors Each 500 mm long

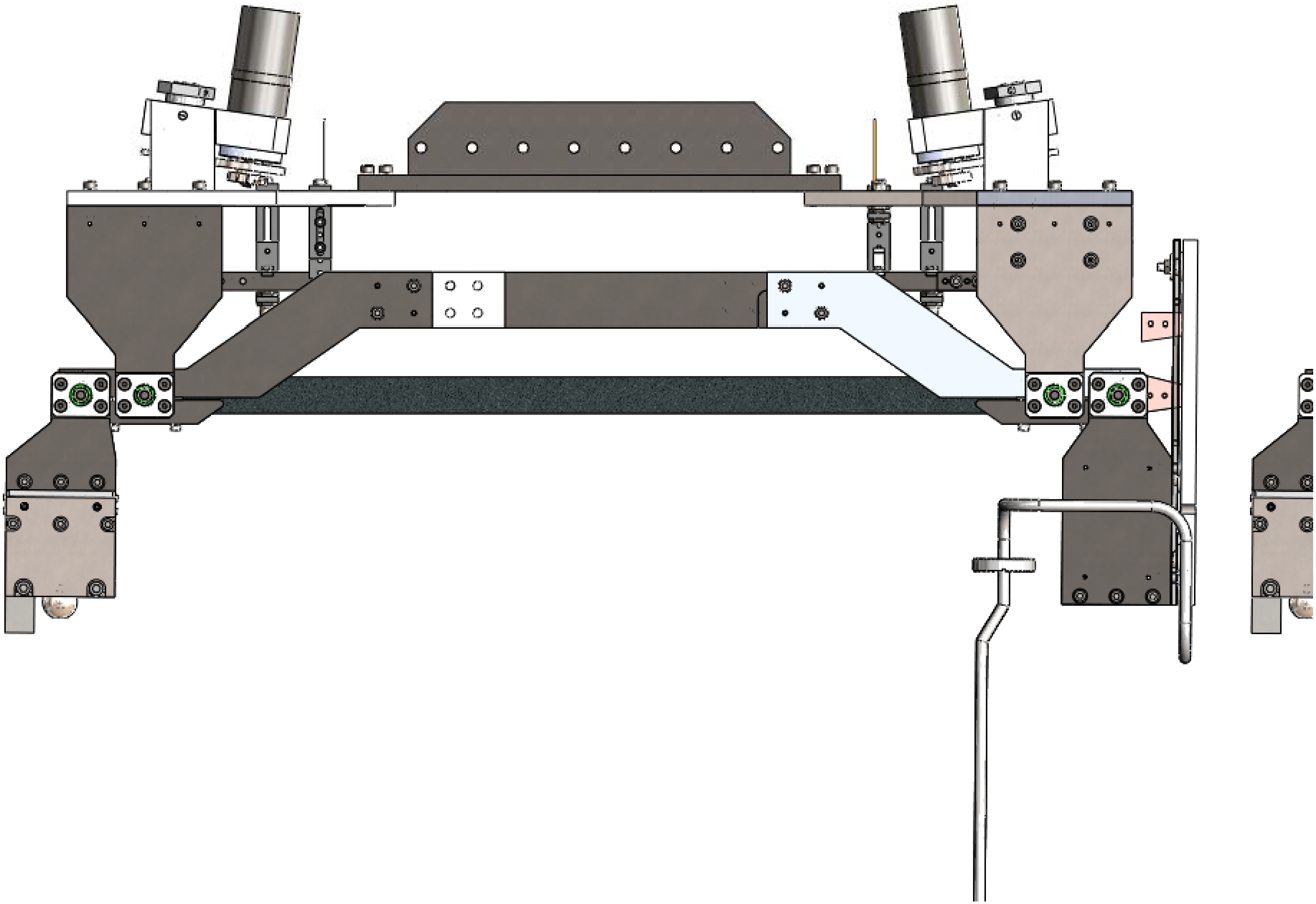


Dynamically Bent Si substrate, with Rh, Pt, Si Stripes

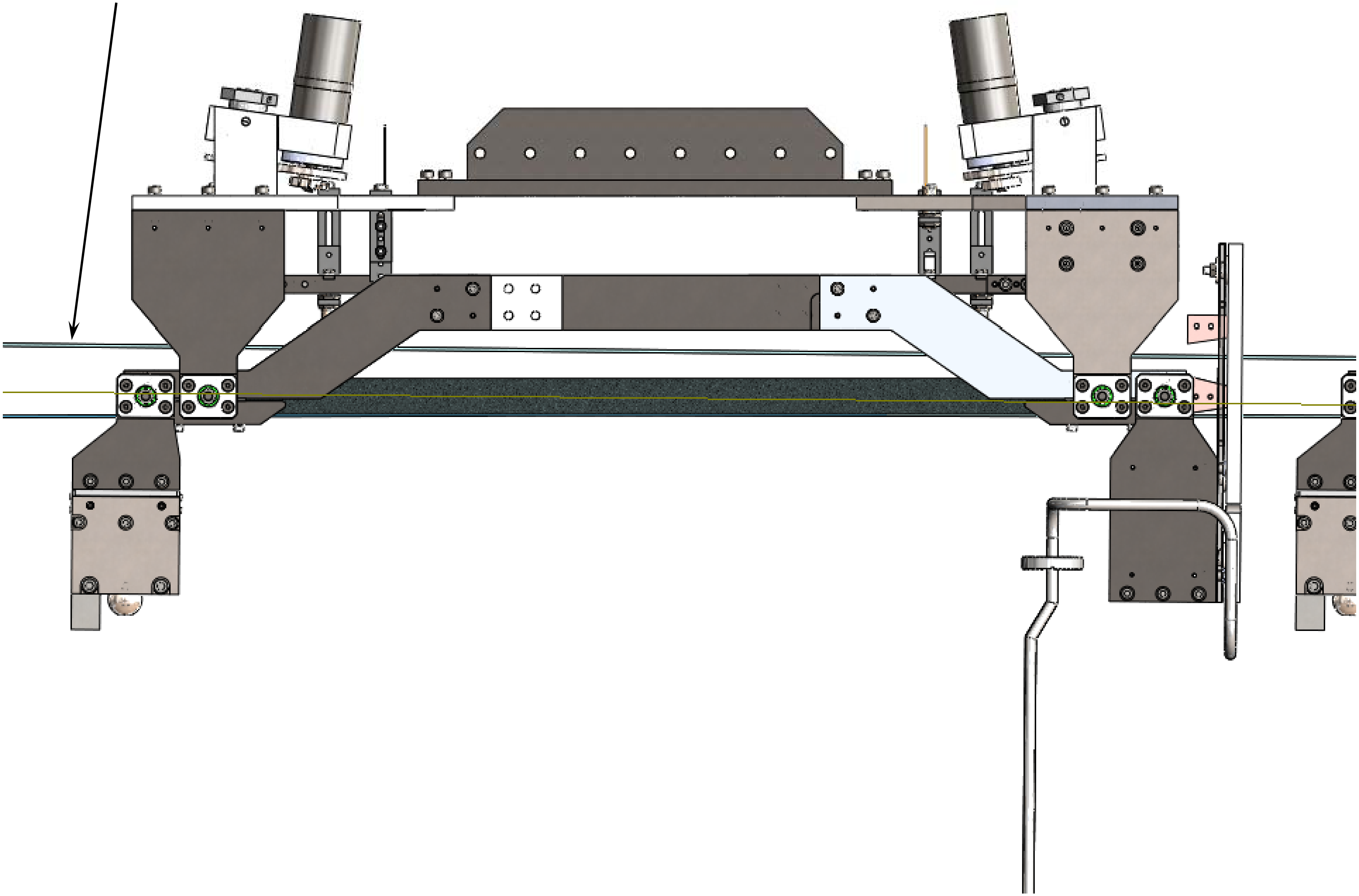


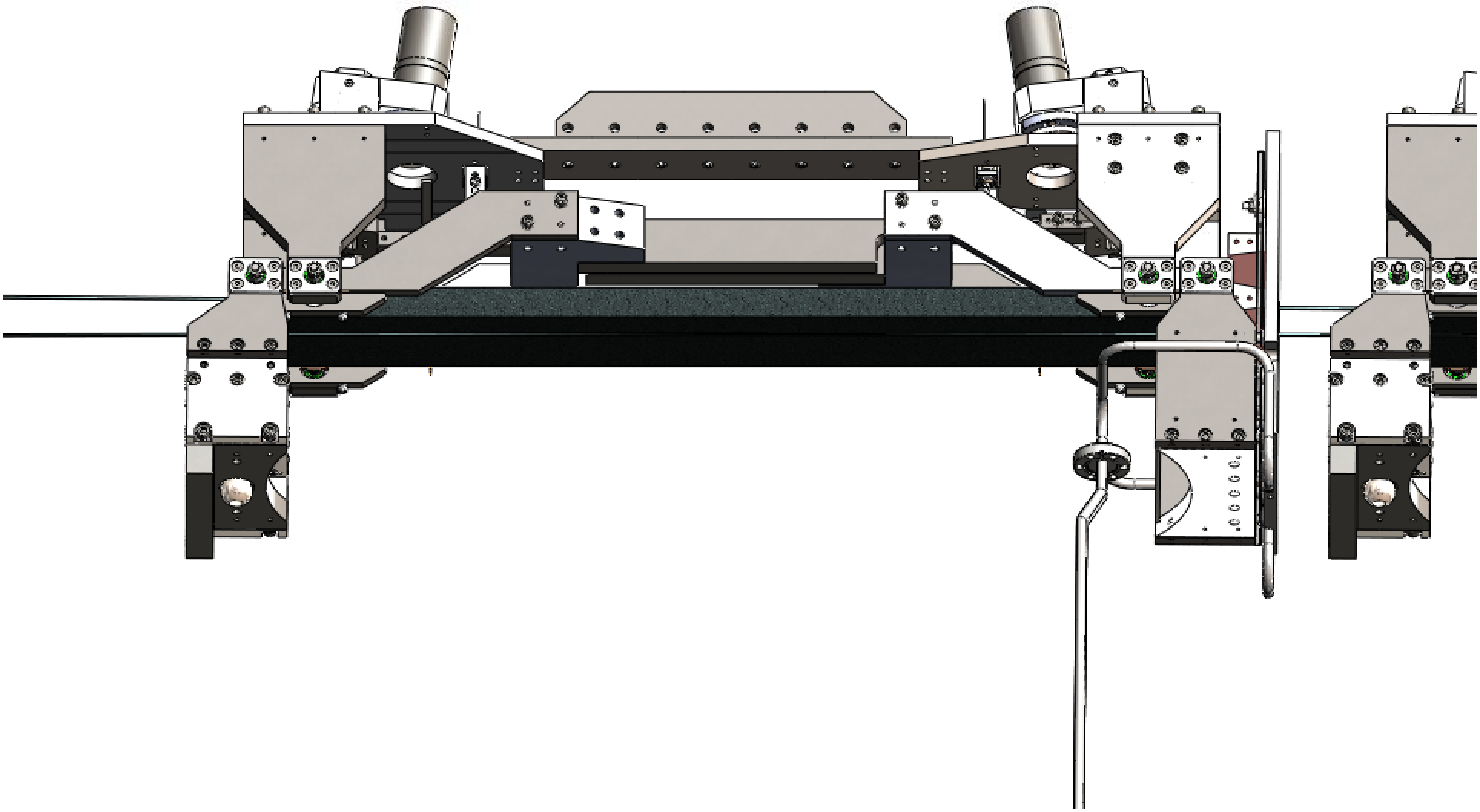


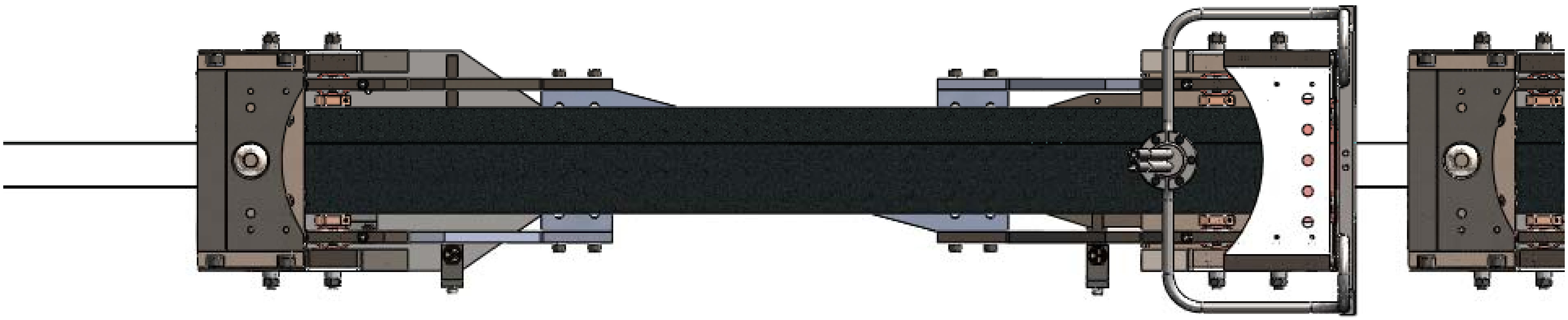


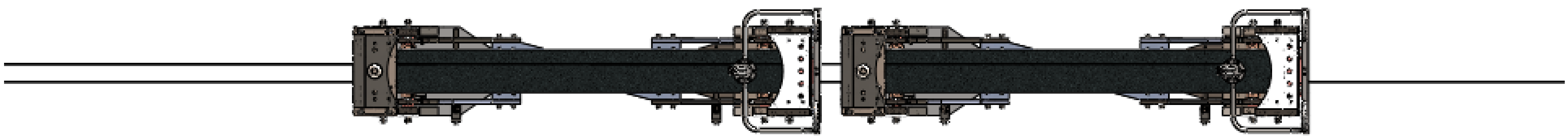


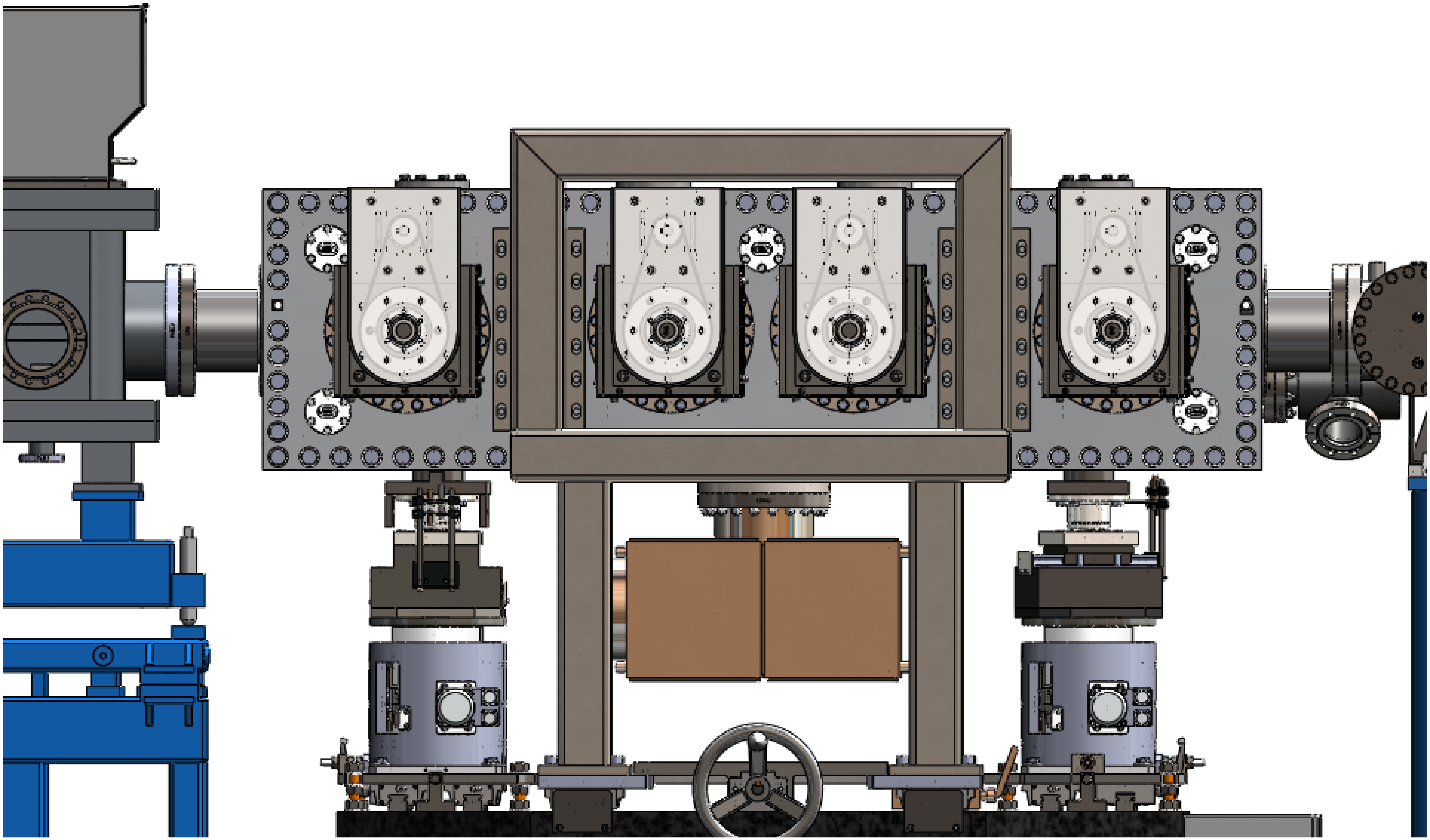
Inboard Beam Passes Through Aperture in the Bender, allowing the outboard canted beam to be outboard deflected by the mirrors

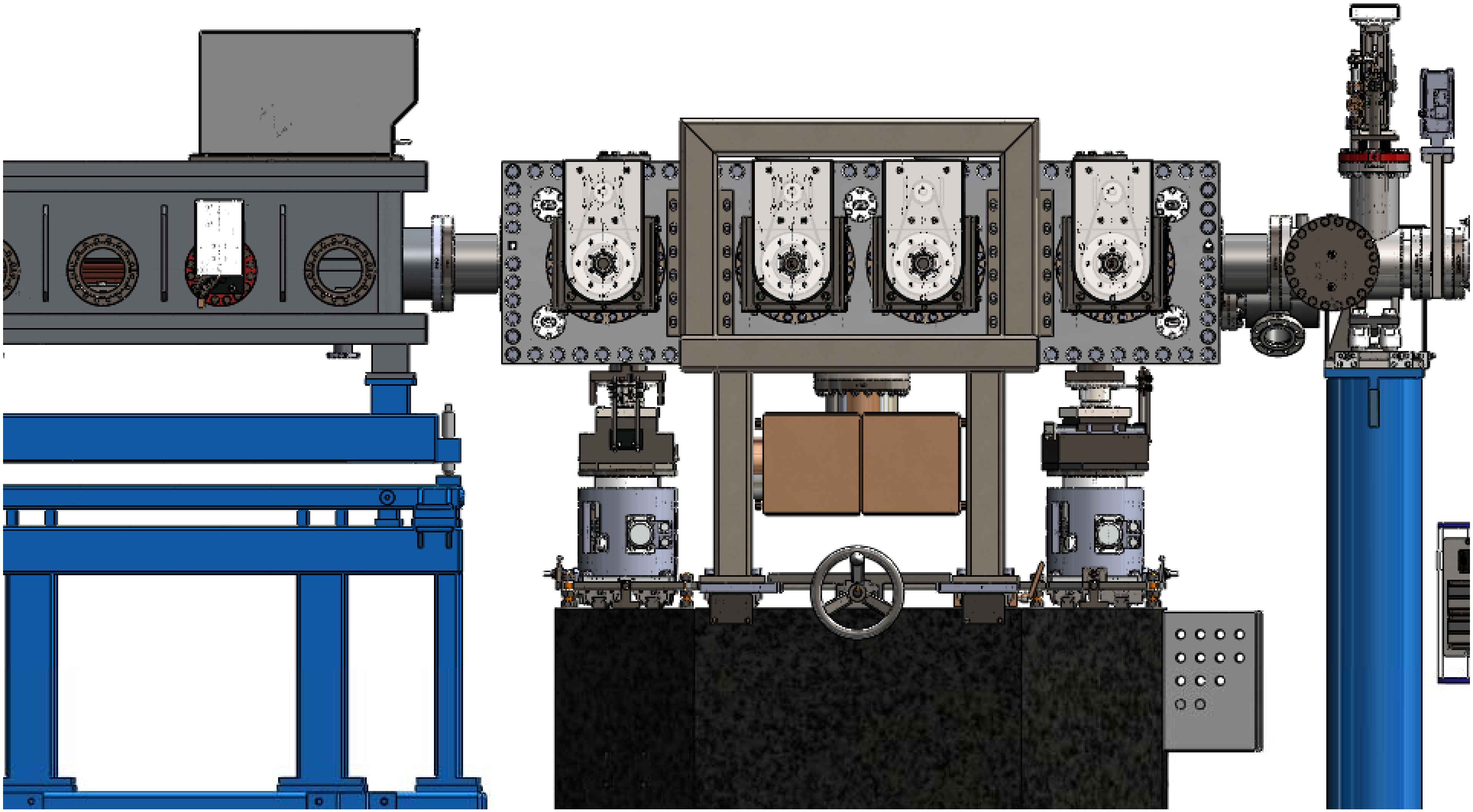


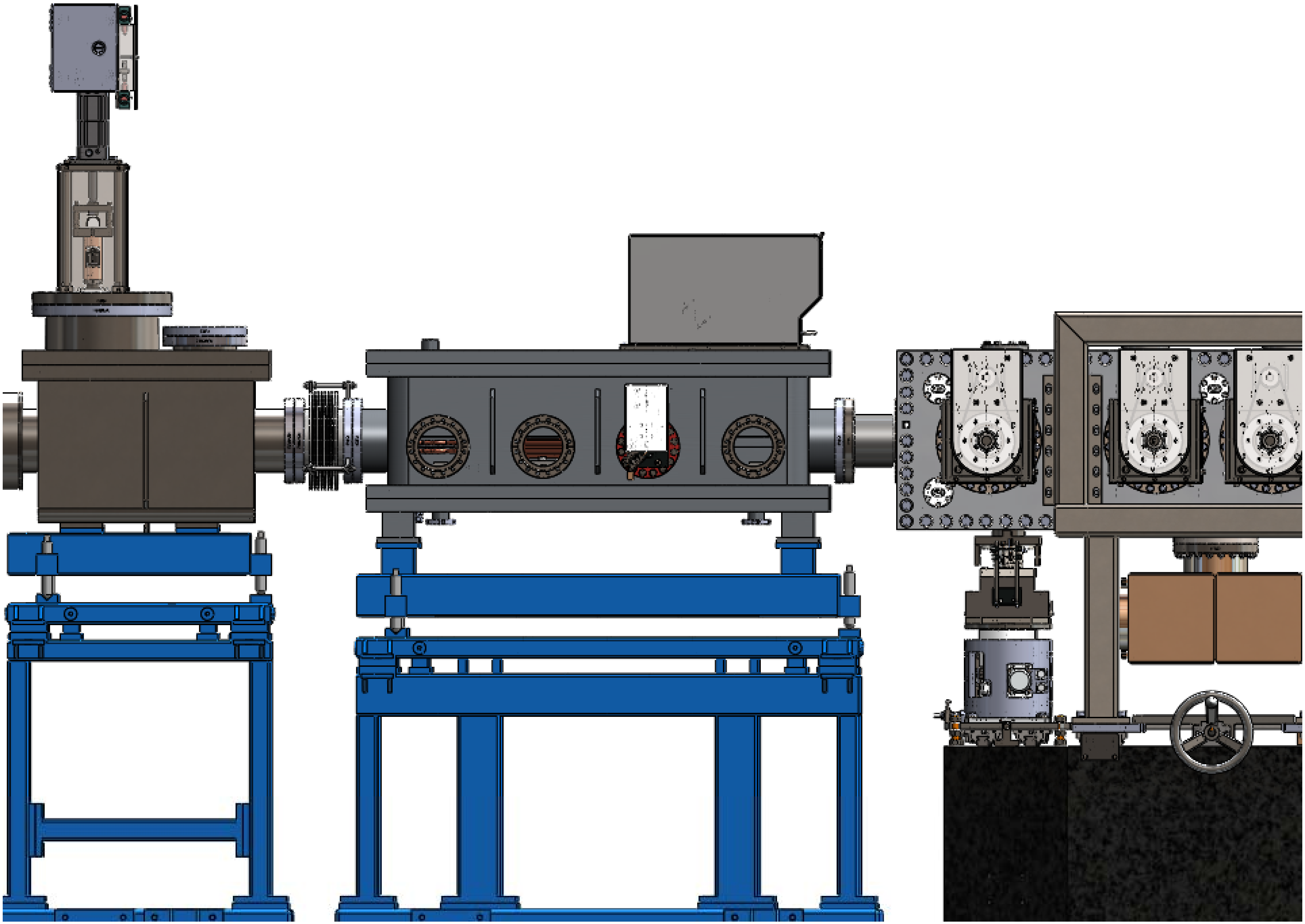


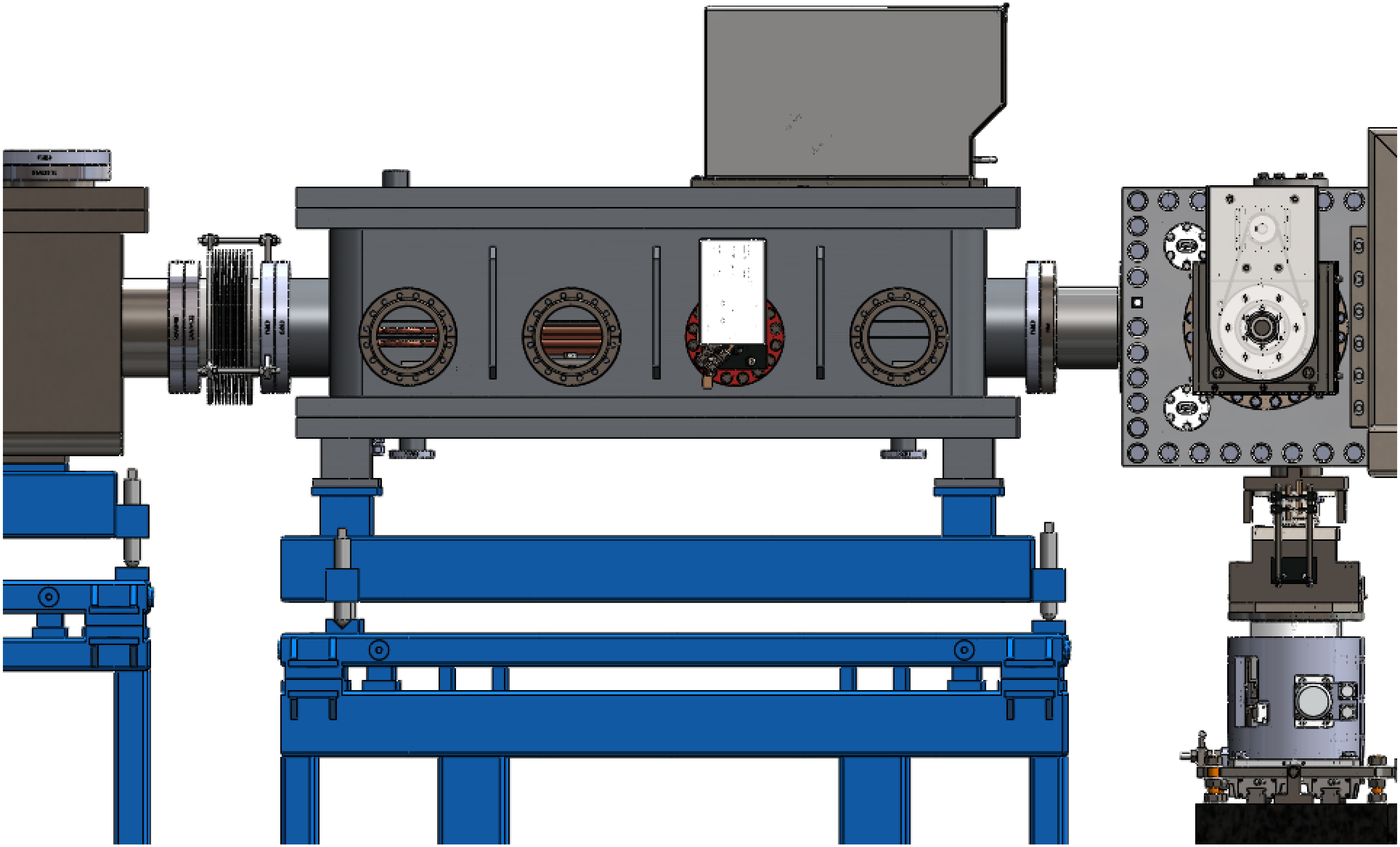


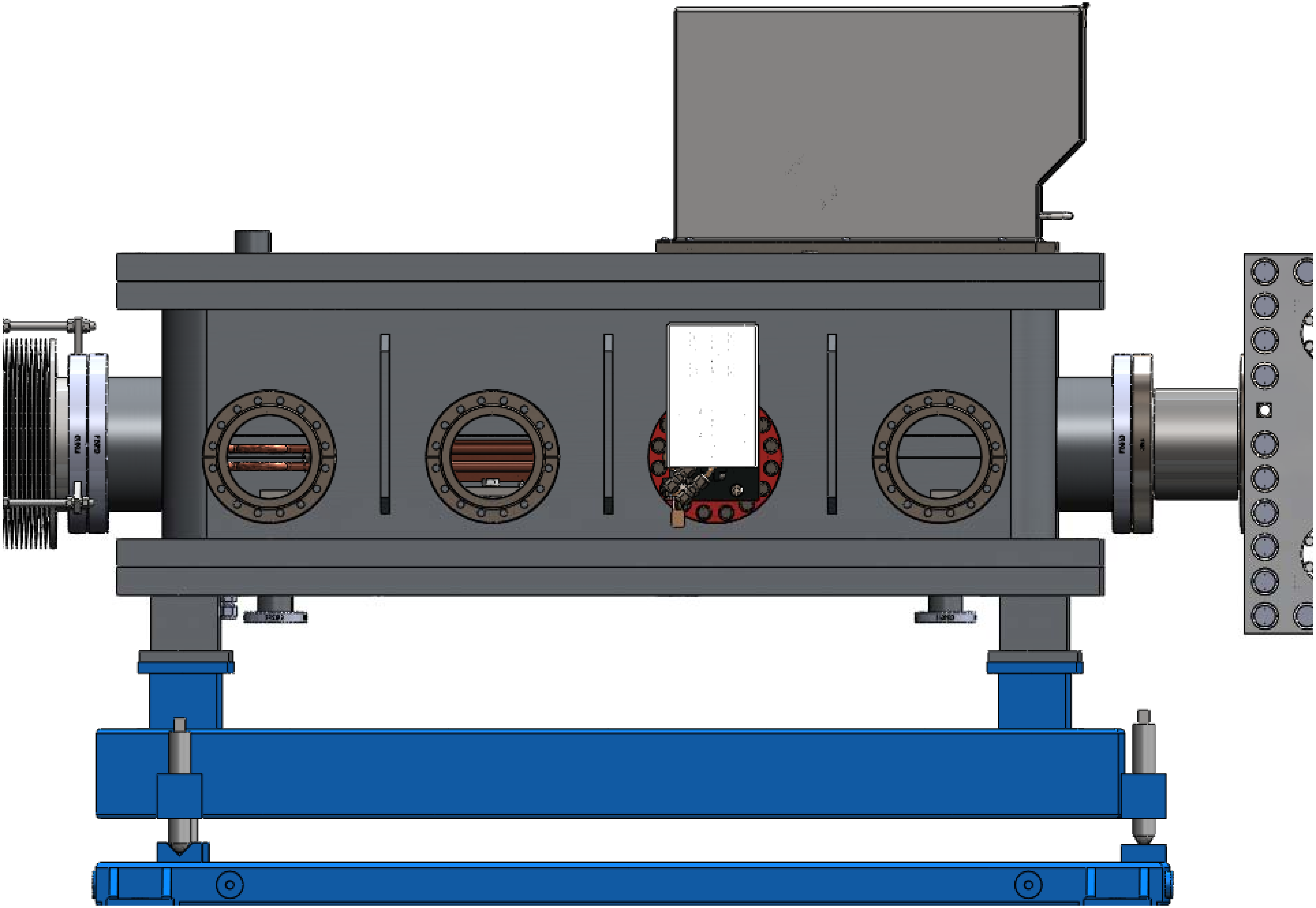




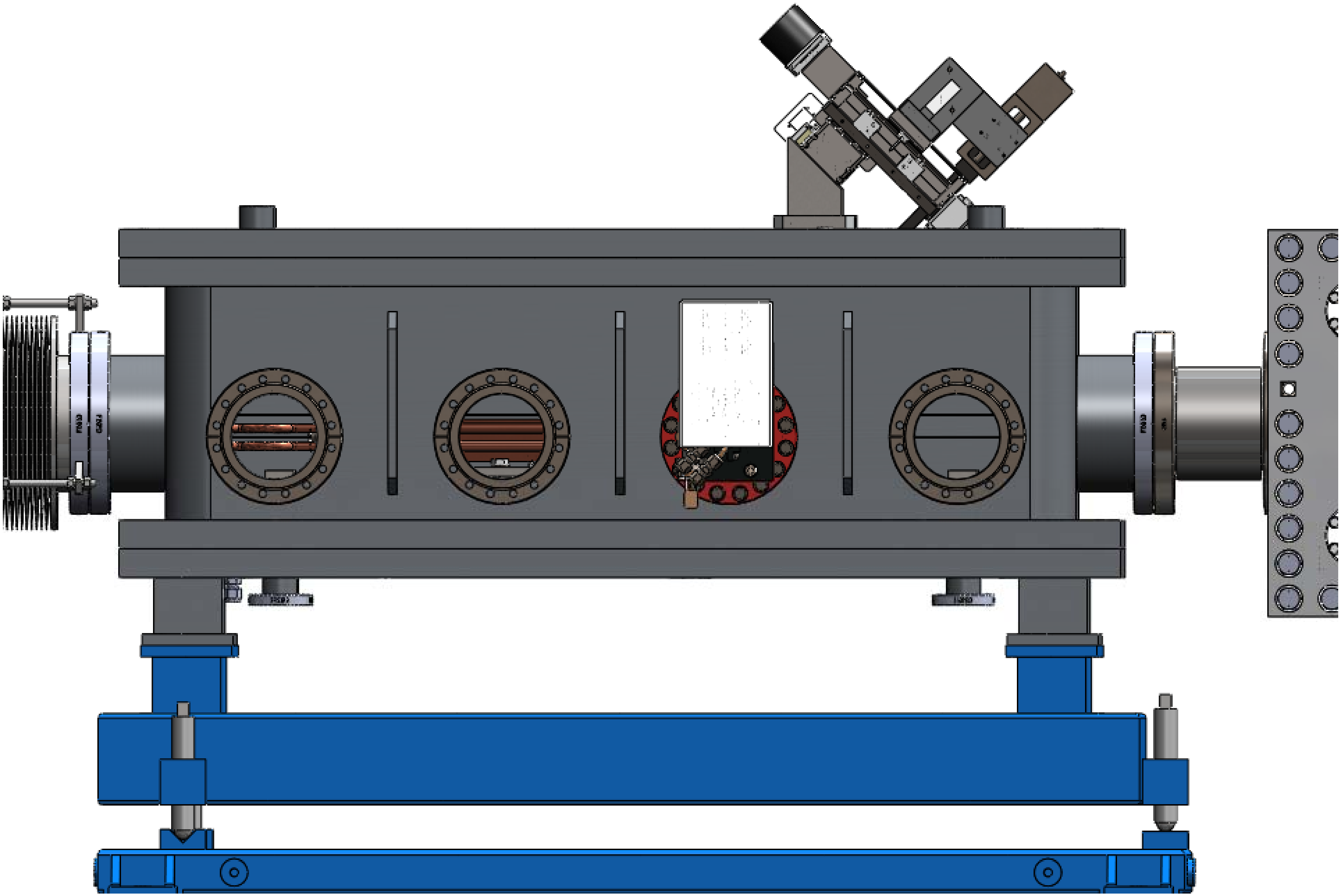


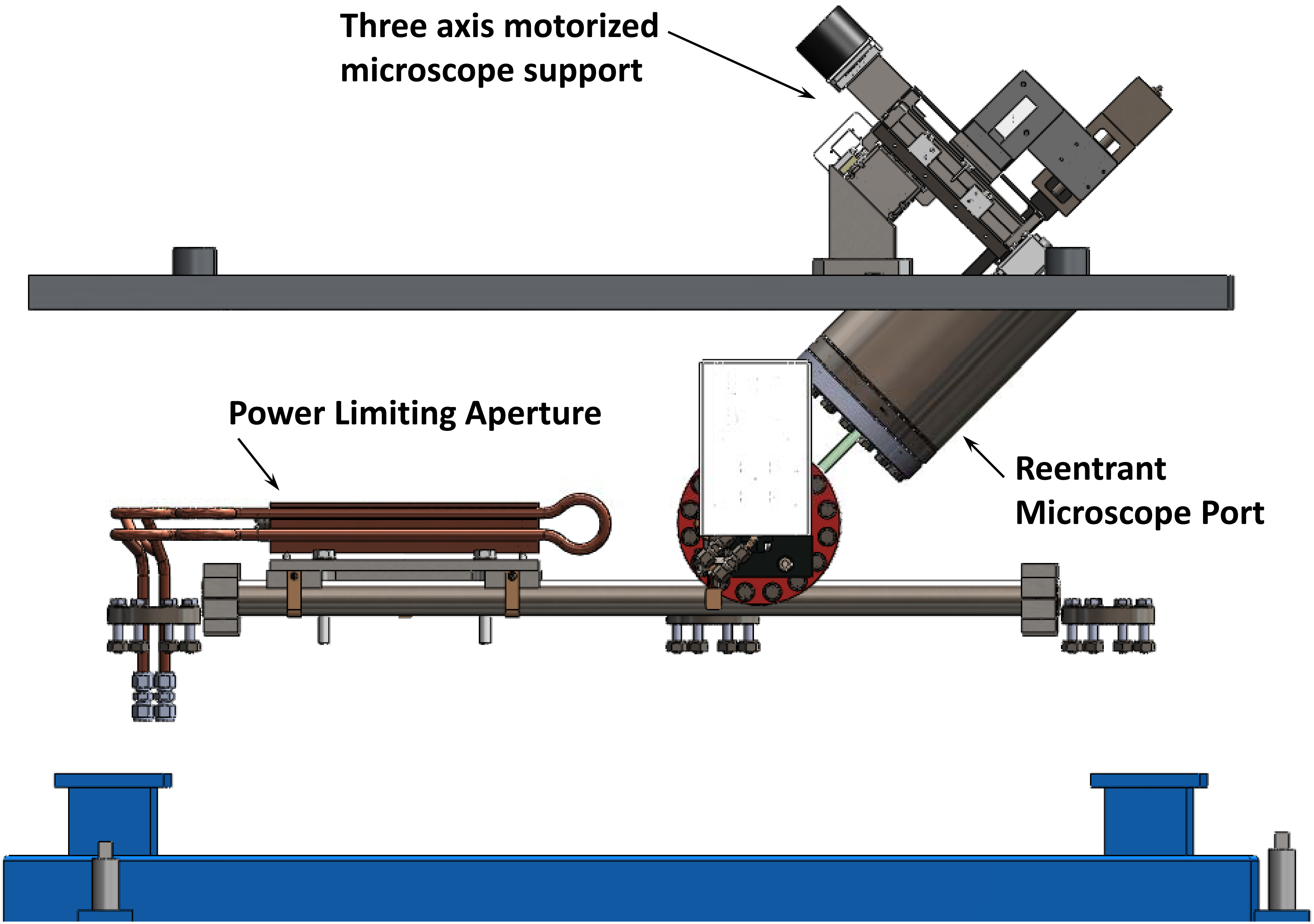


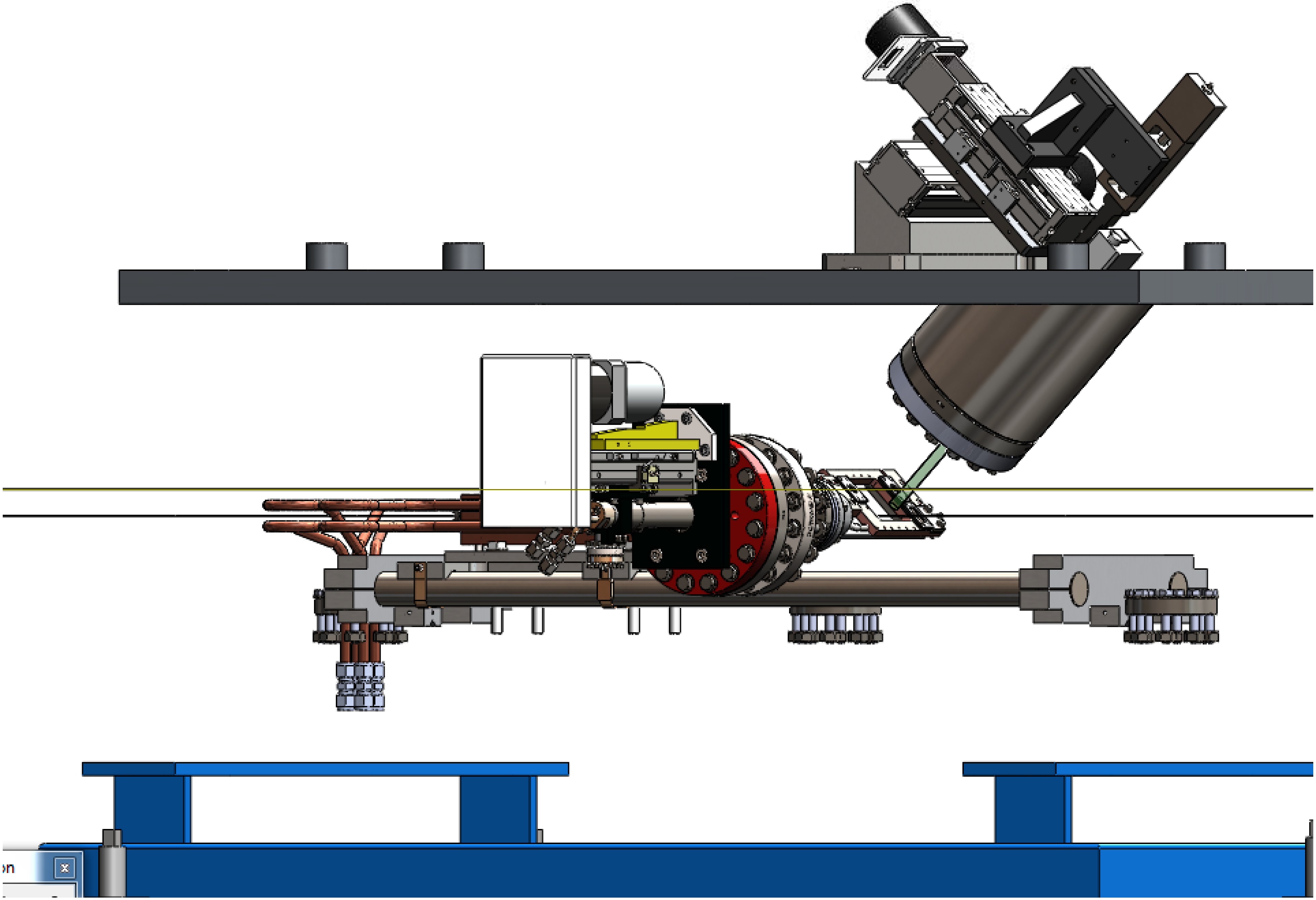


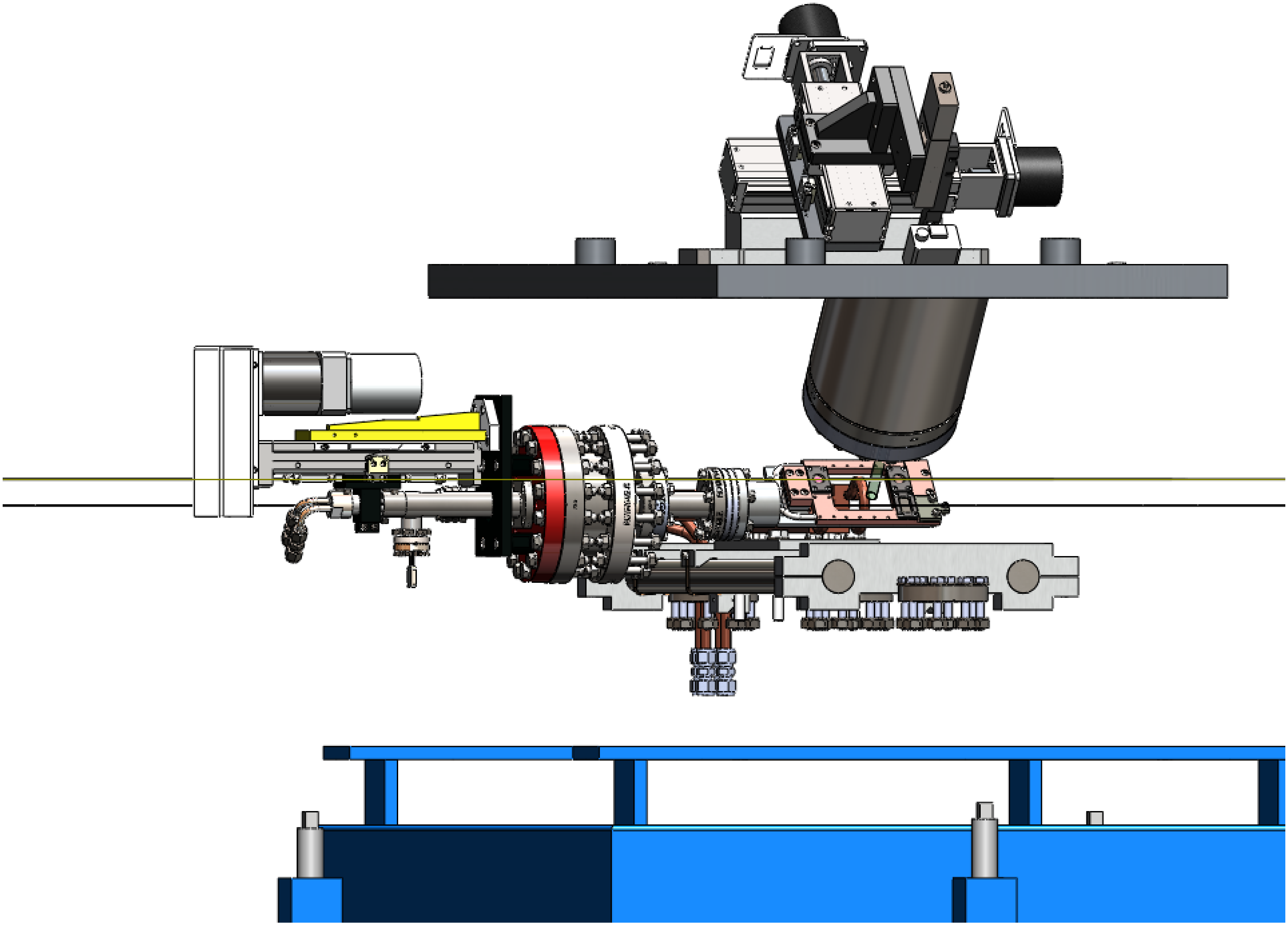


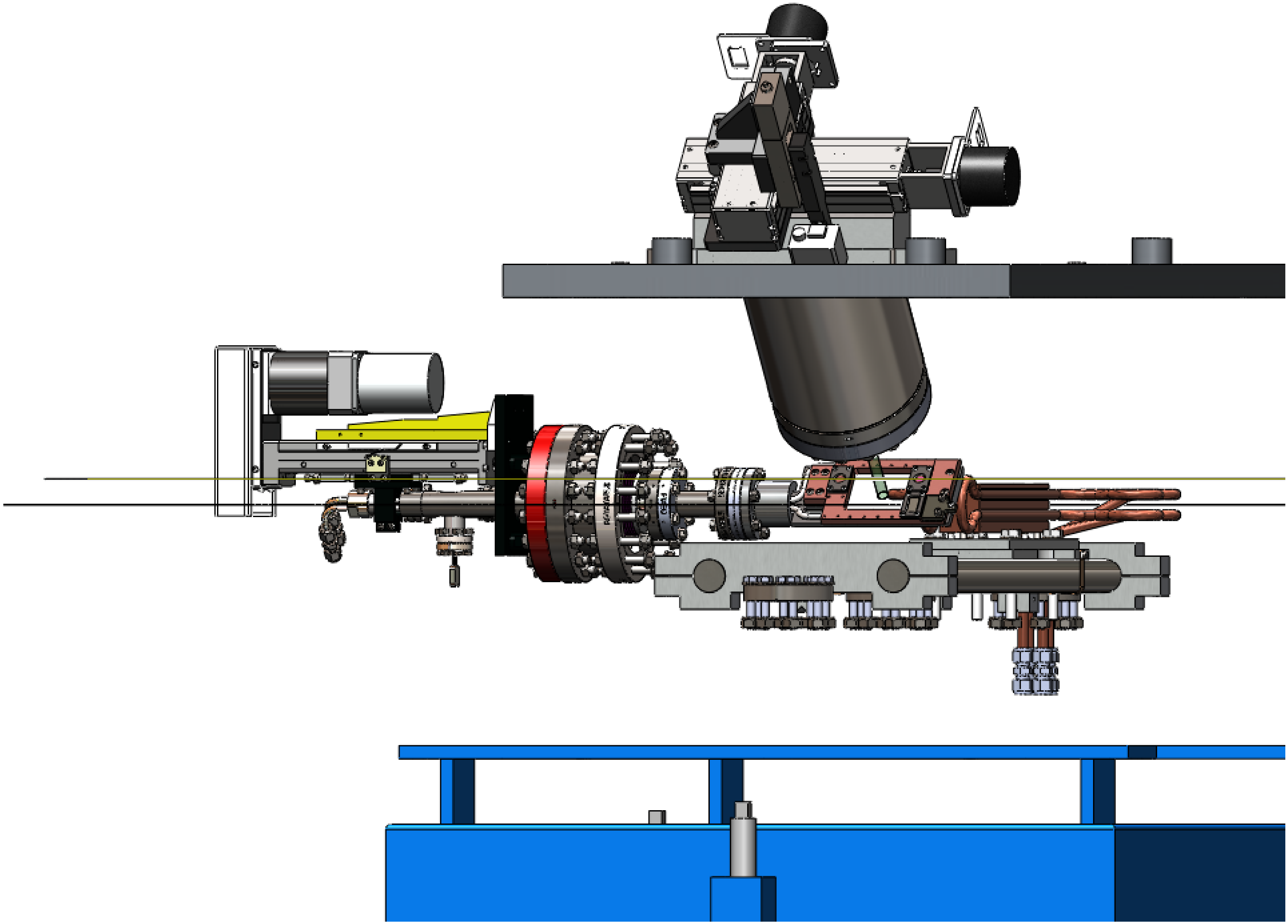
High Resolution Beam Viewer and Power Limiting Aperture

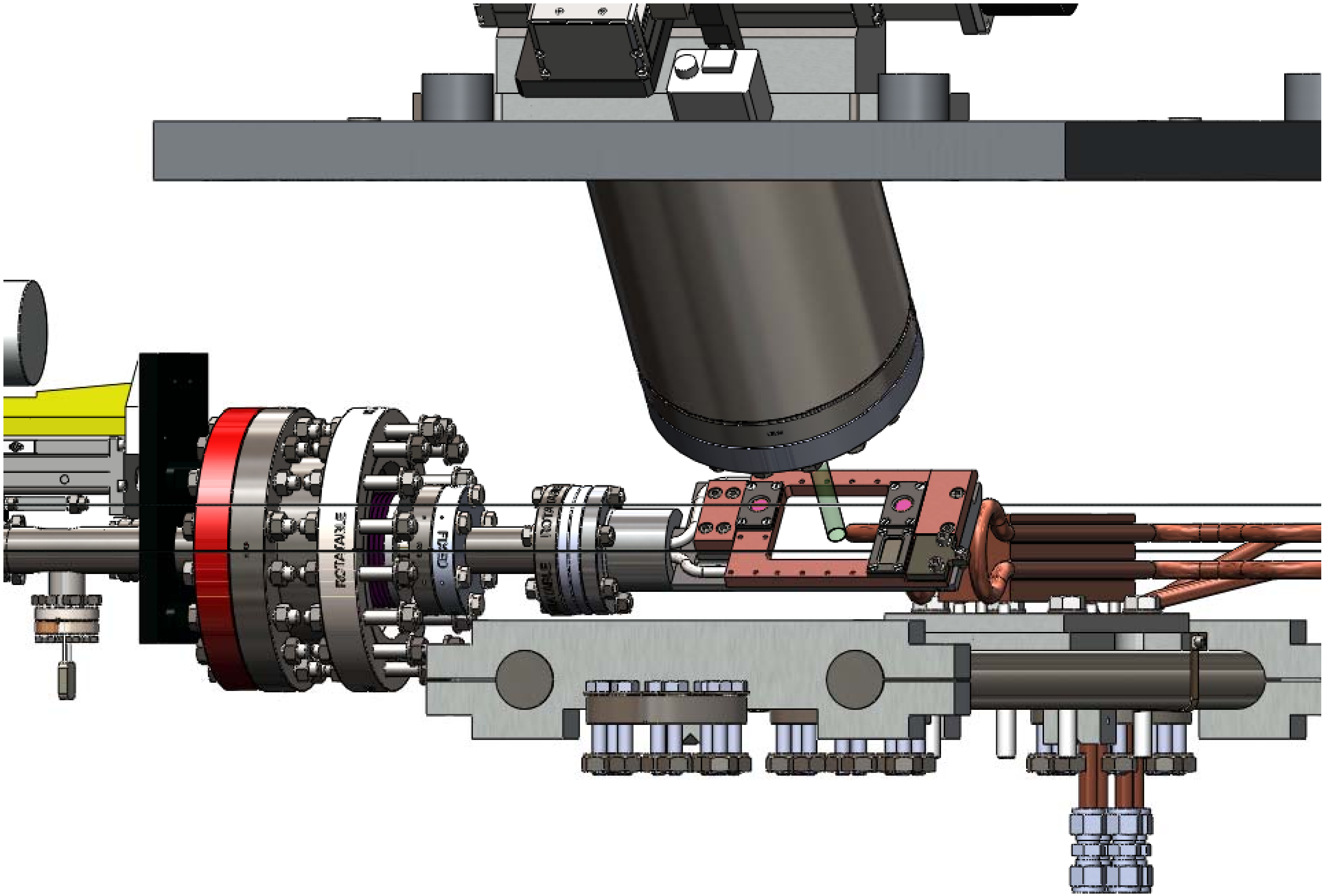


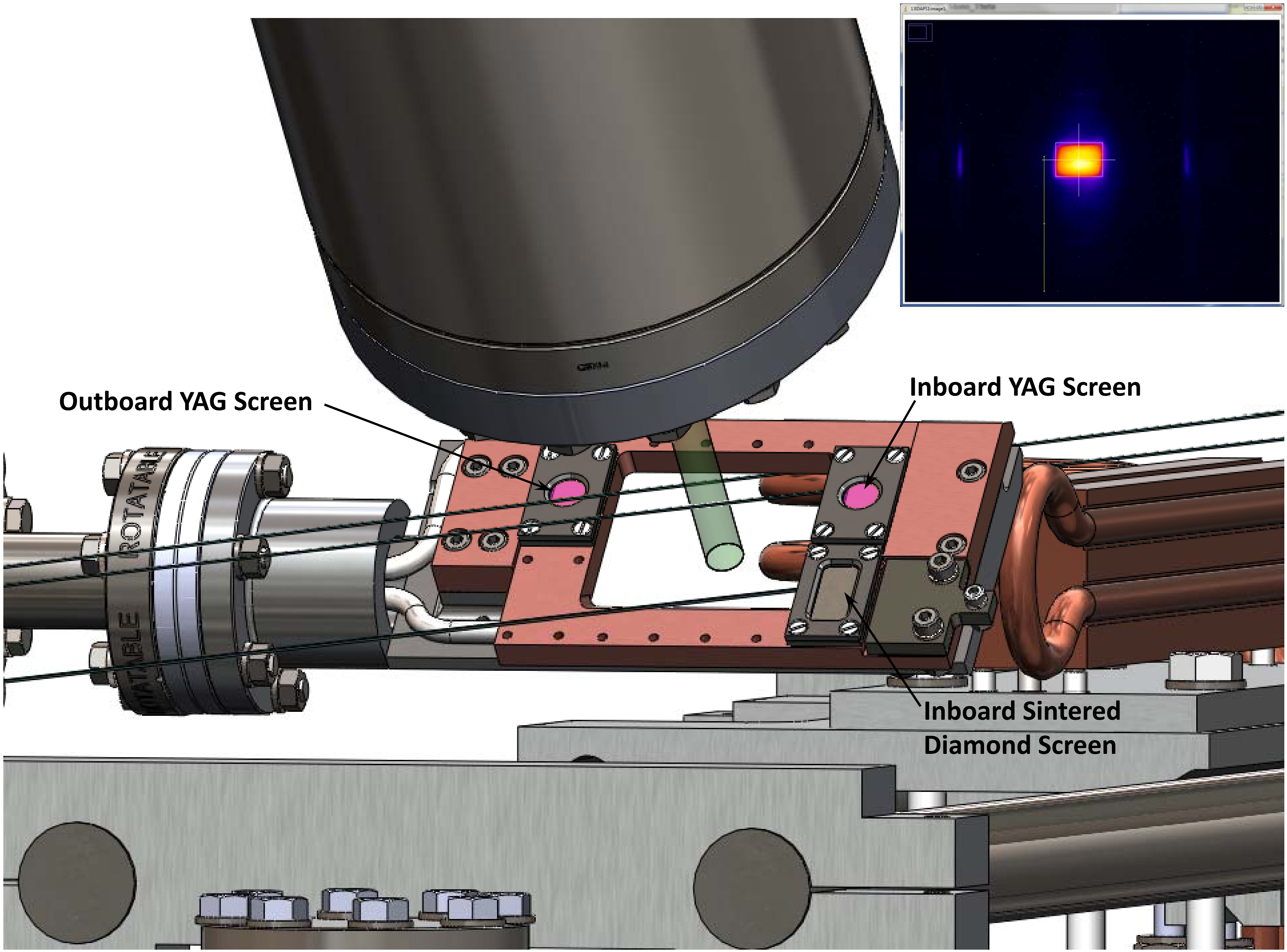

Three axis motorized microscope support
Power Limiting Aperture
Reentrant Microscope Port



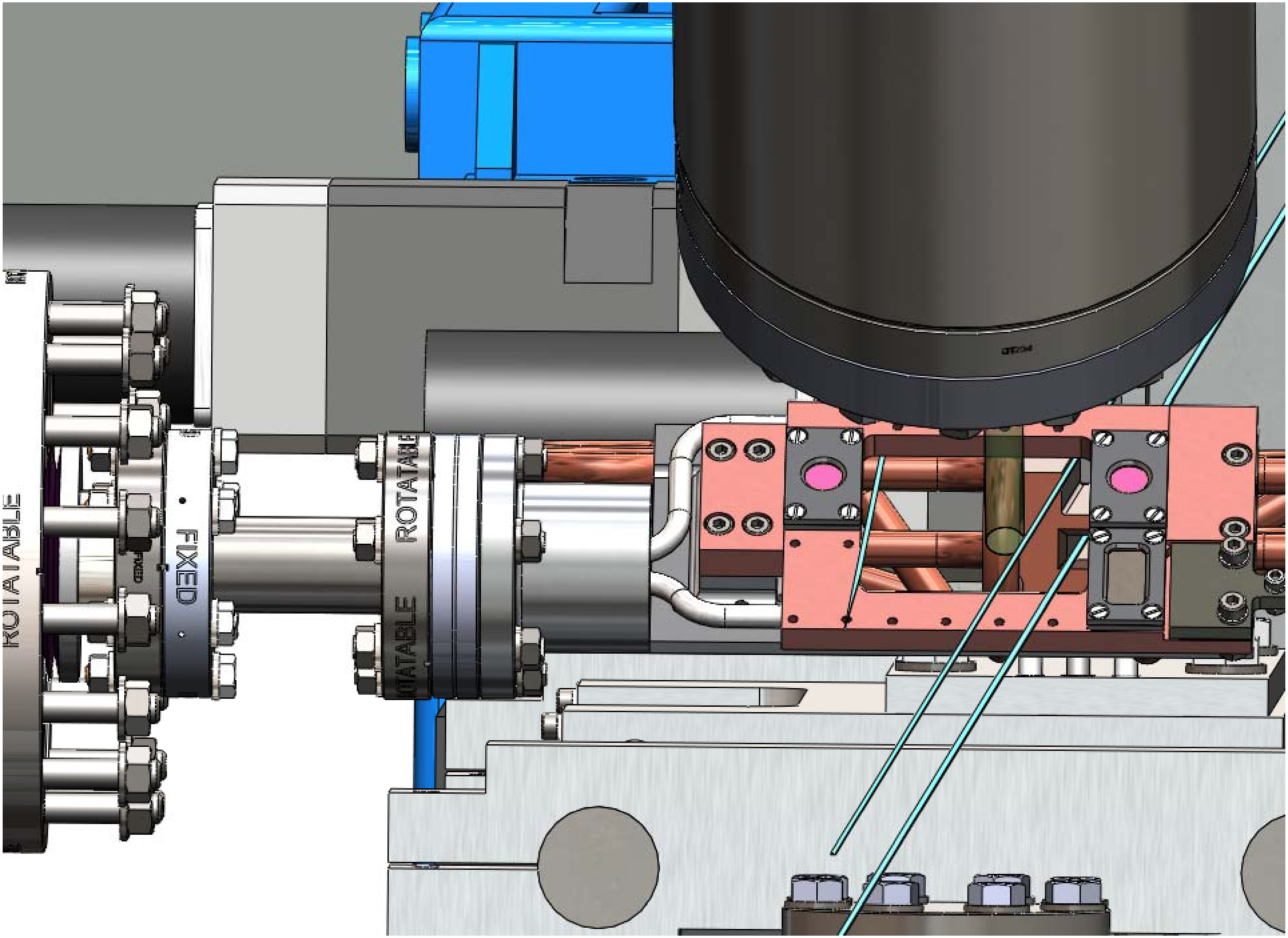




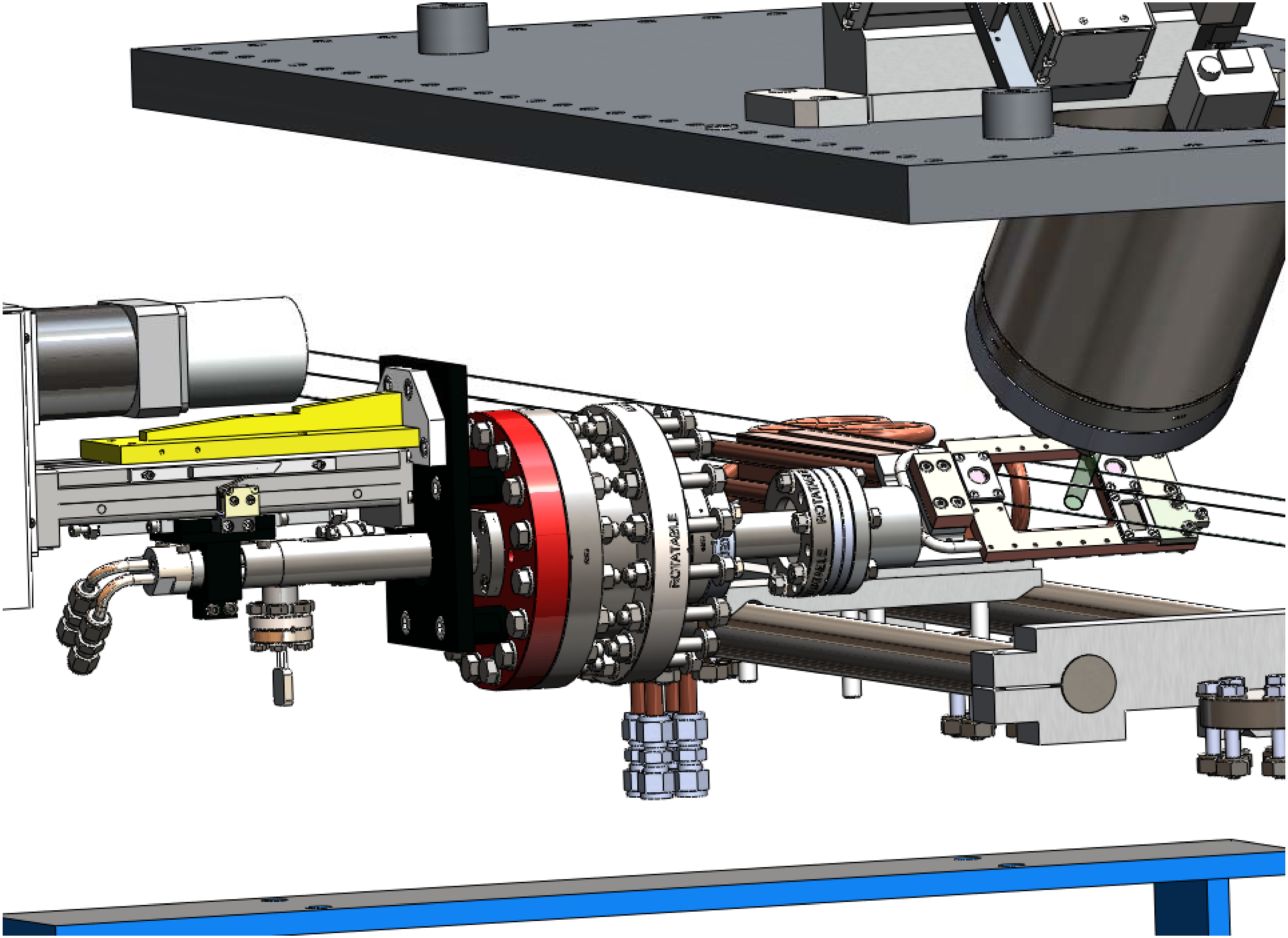


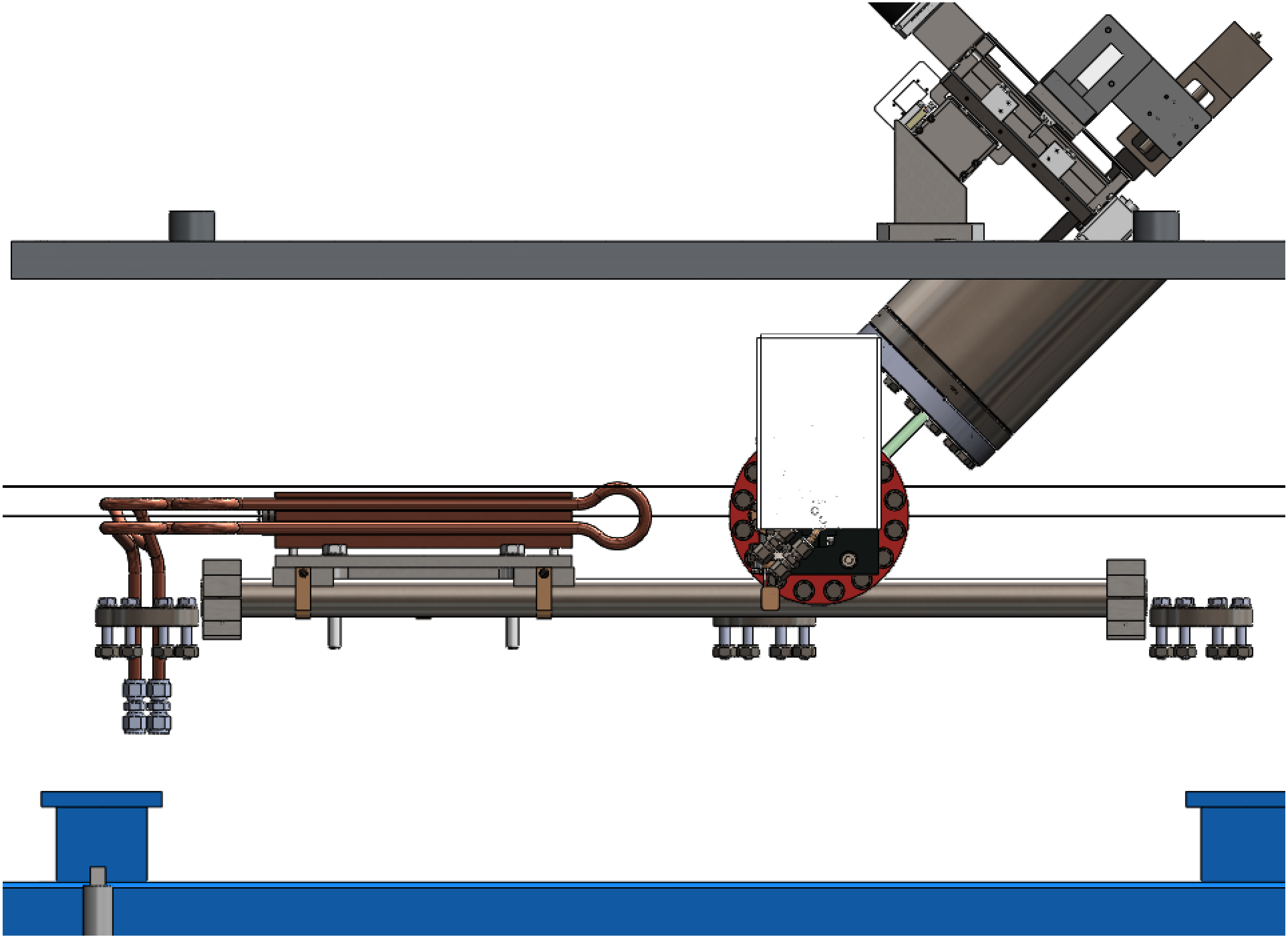


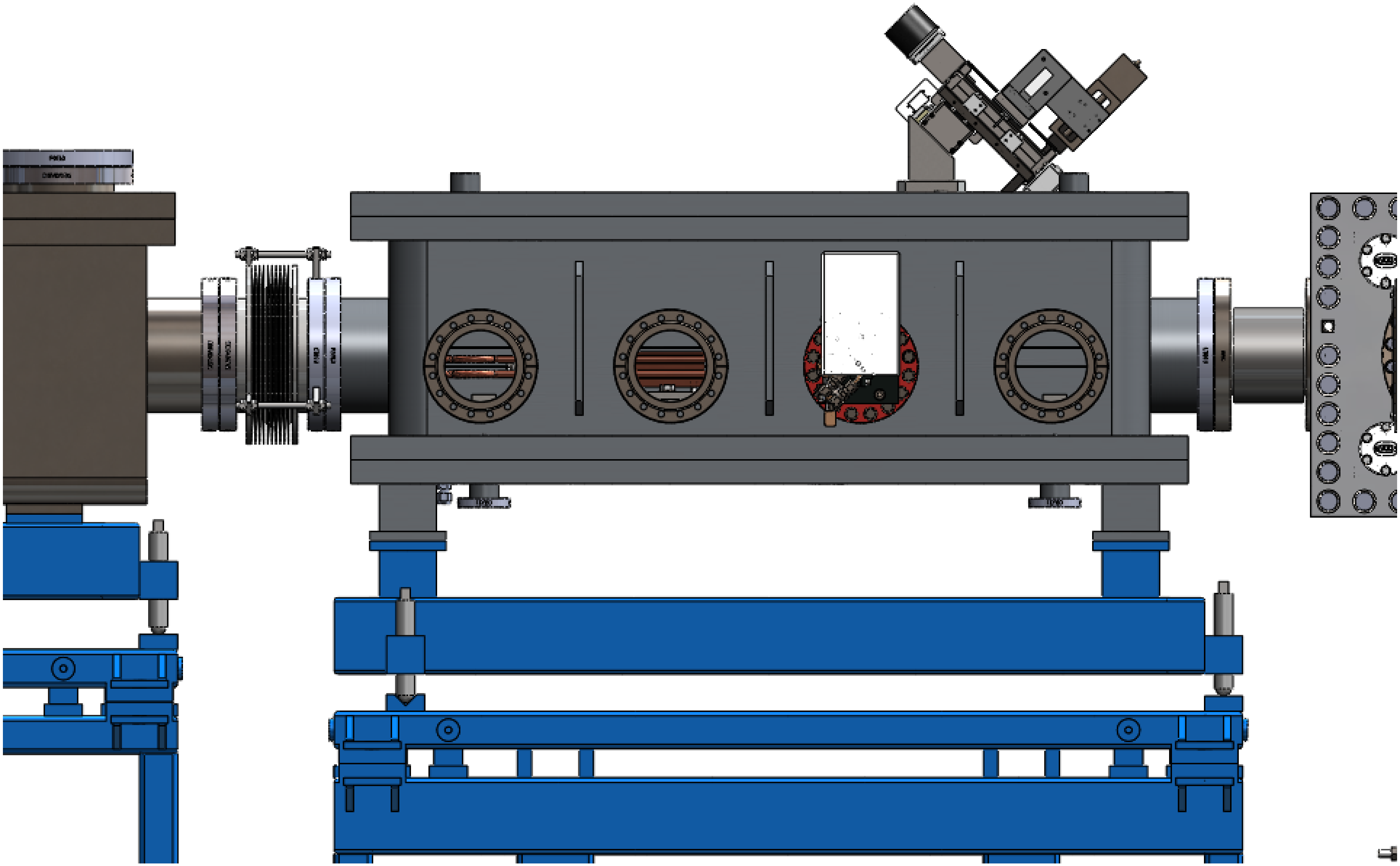
Outboard YAG Screen
Inboard YAG Screen
Inboard Sintered
Diamond Screen

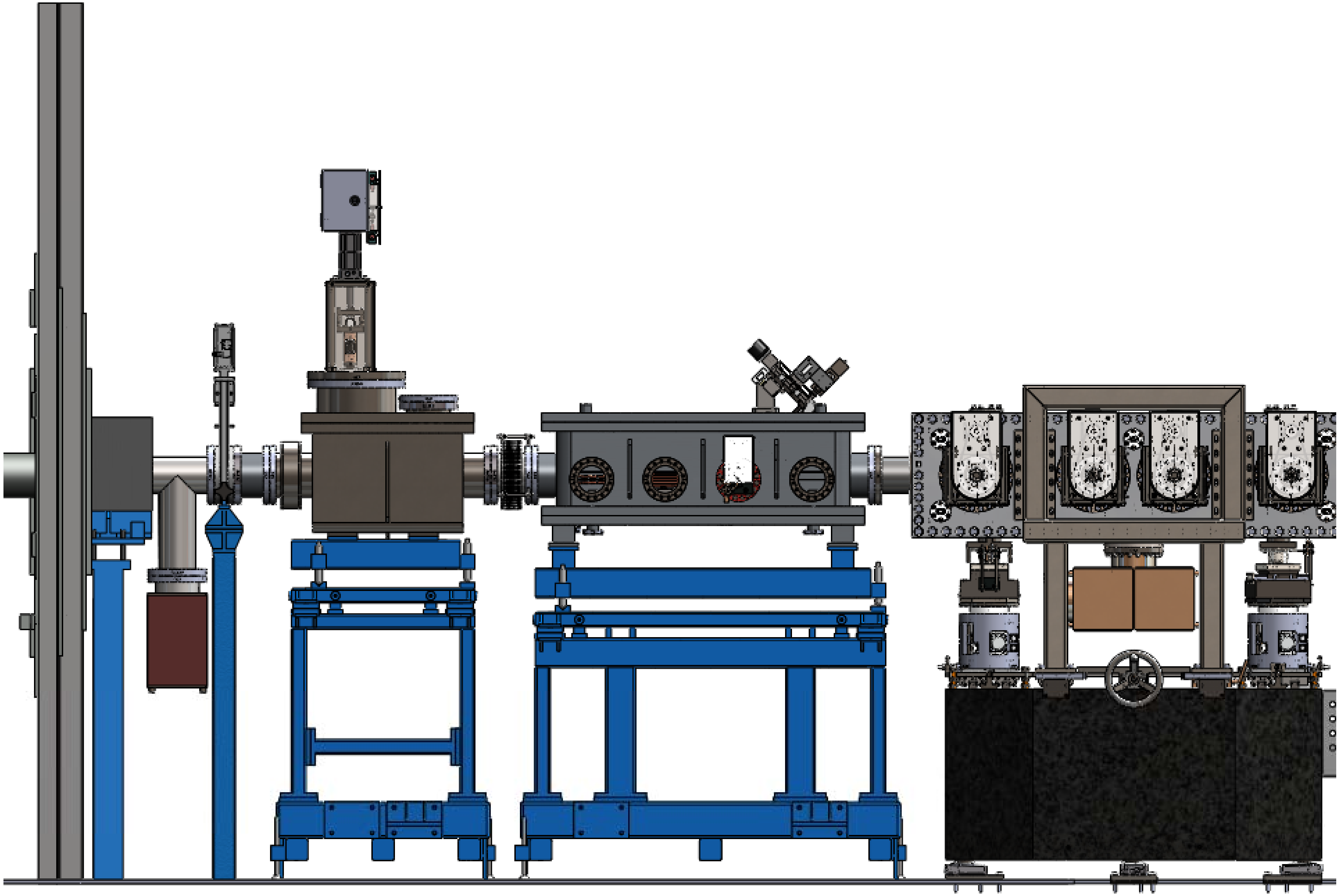


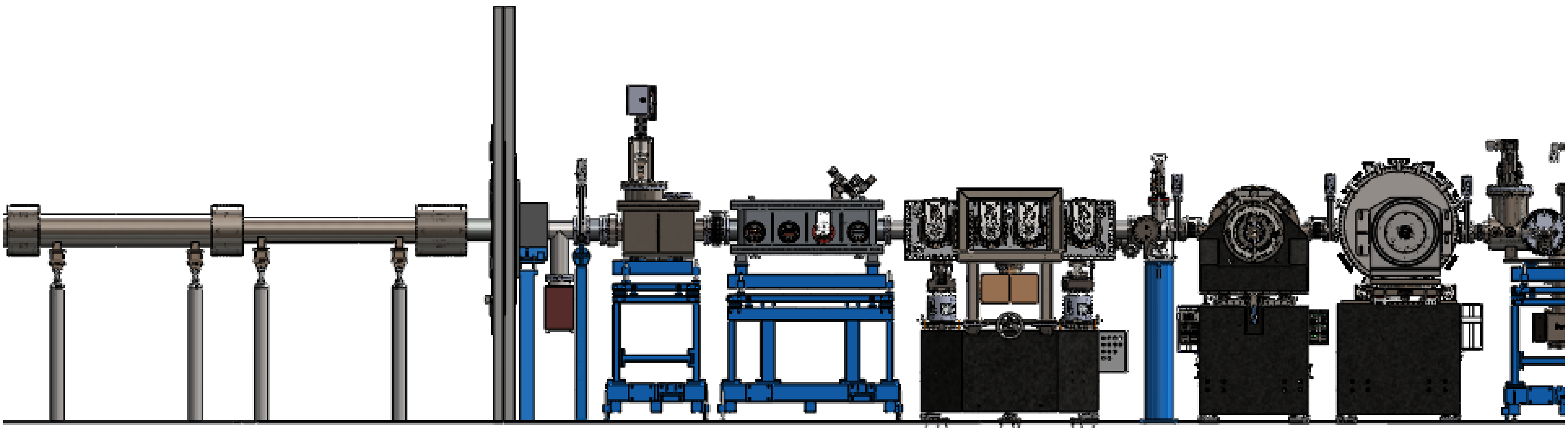
ROTATABLE
FIXED
ROTATABLE
ROTATABLE

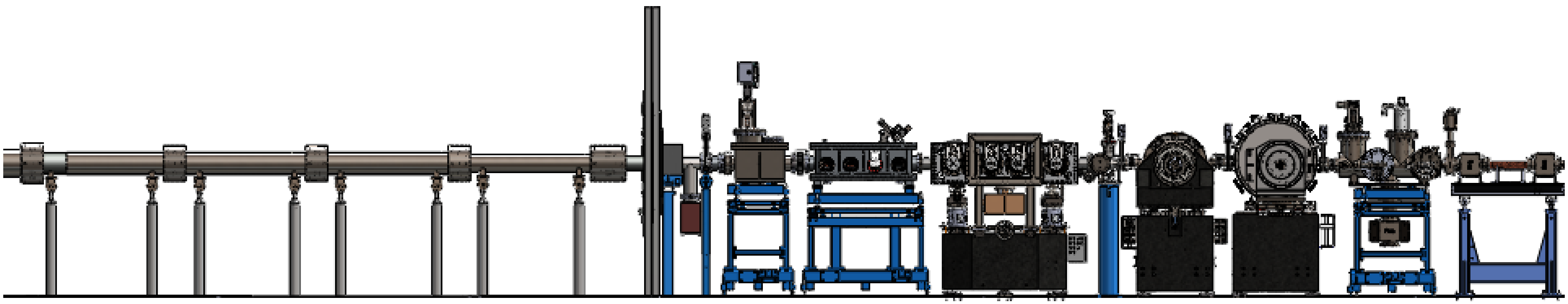

ROTATABLE



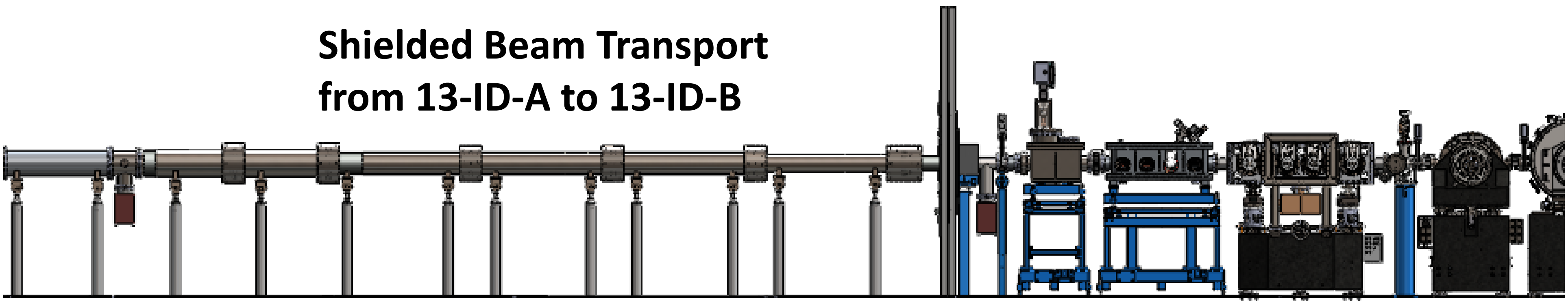


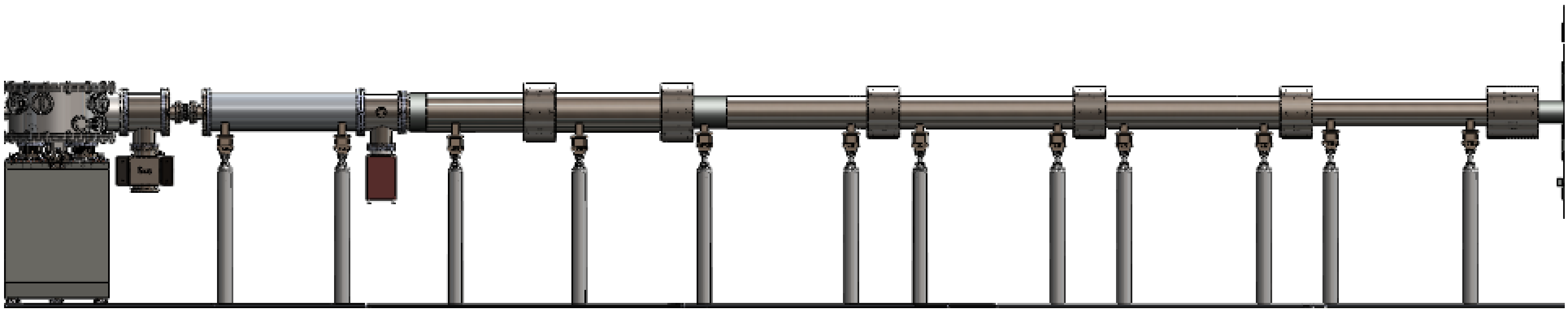




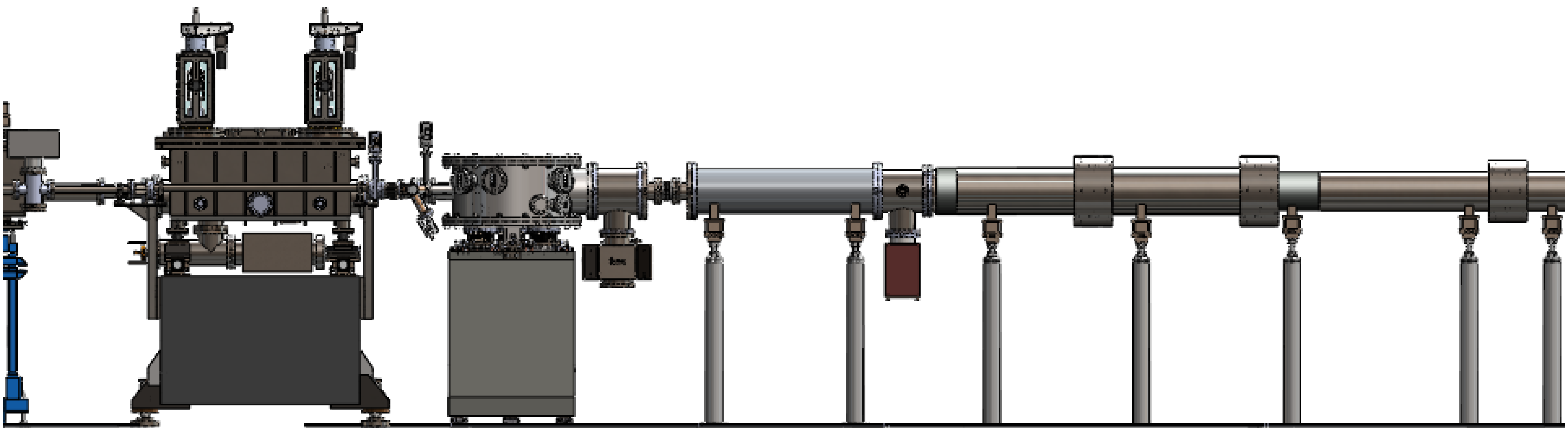


Shielded Beam Transport from 13-ID-A to 13-ID-B

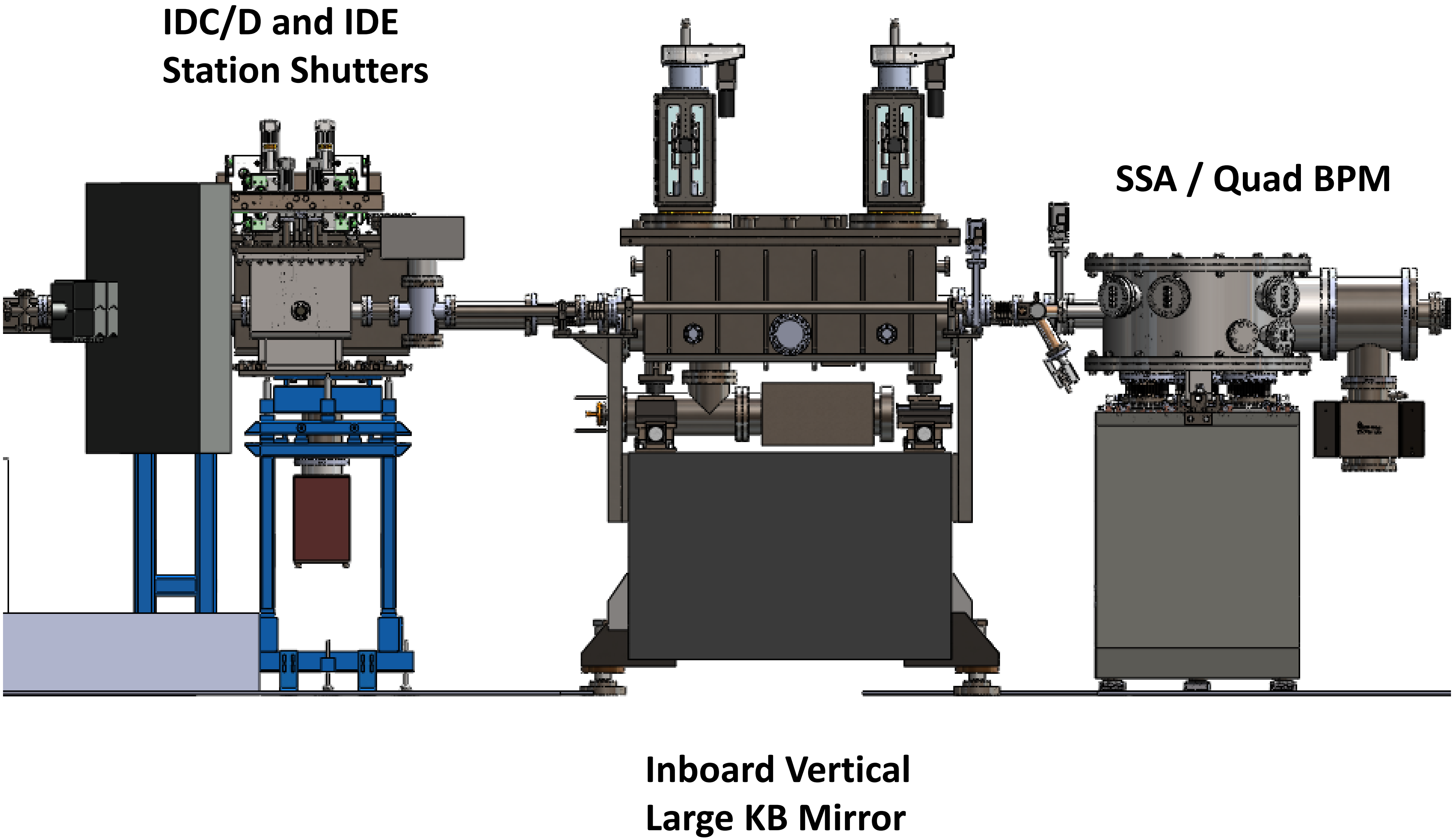


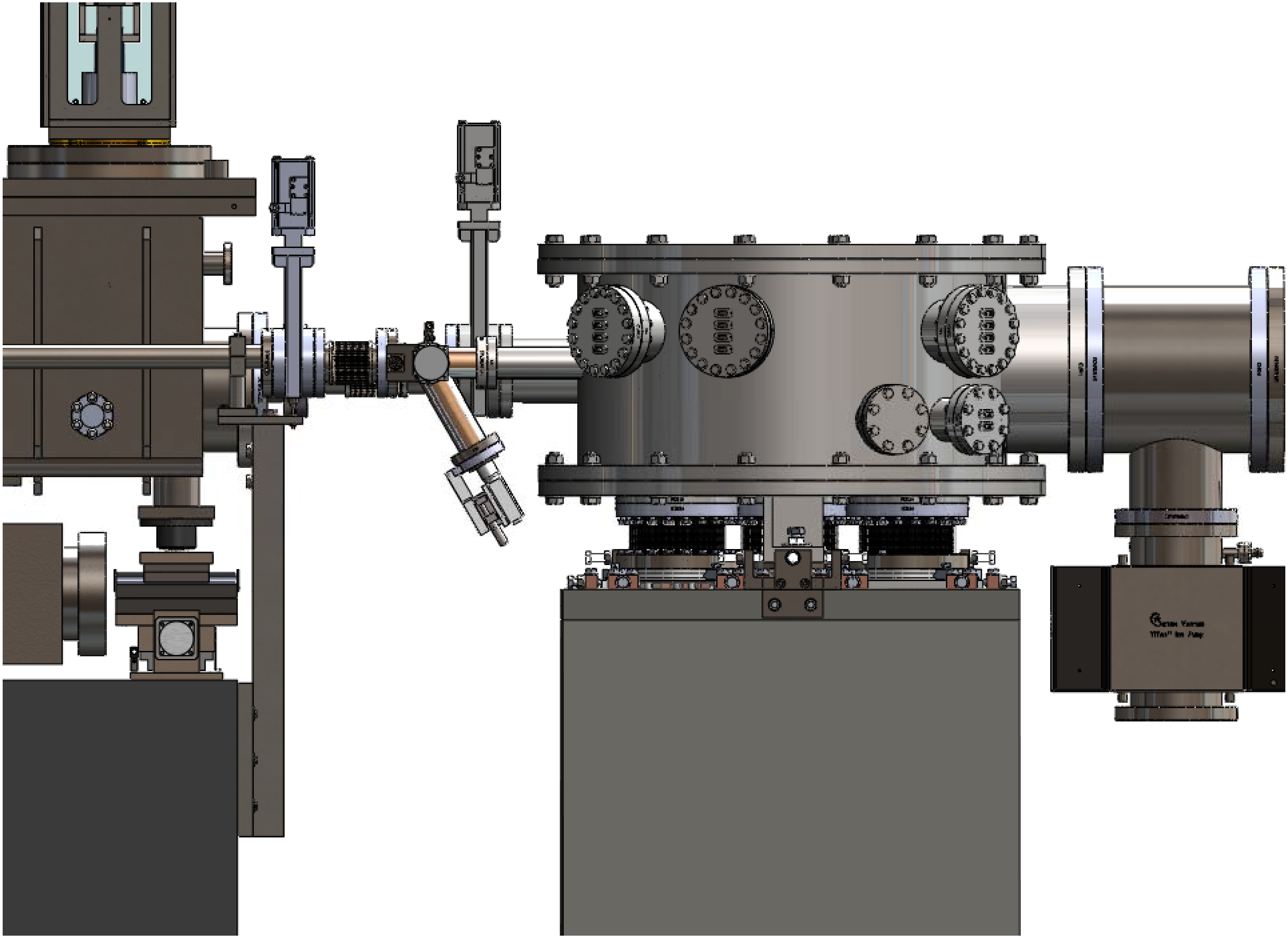


13-ID-B (SOE)

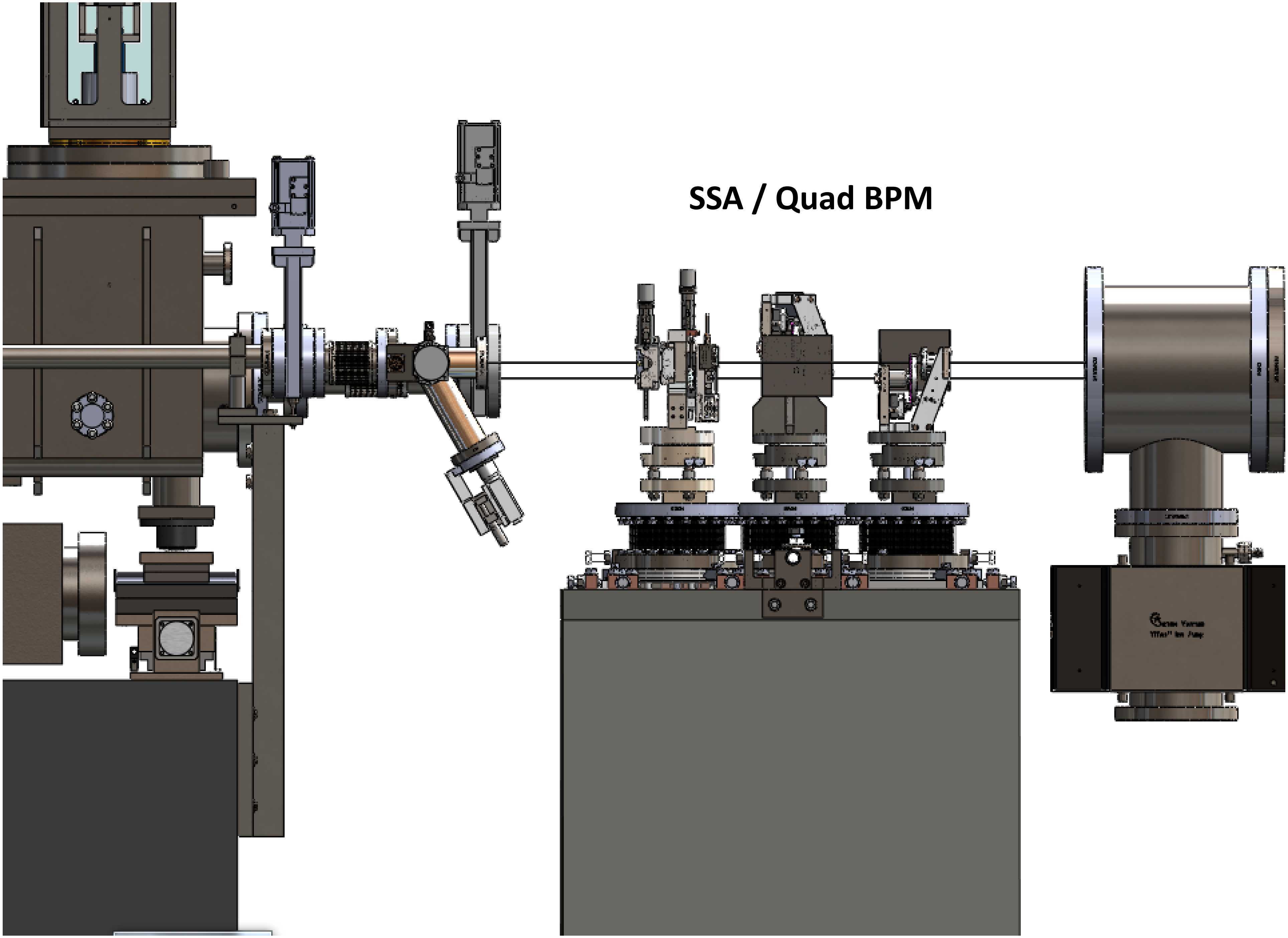


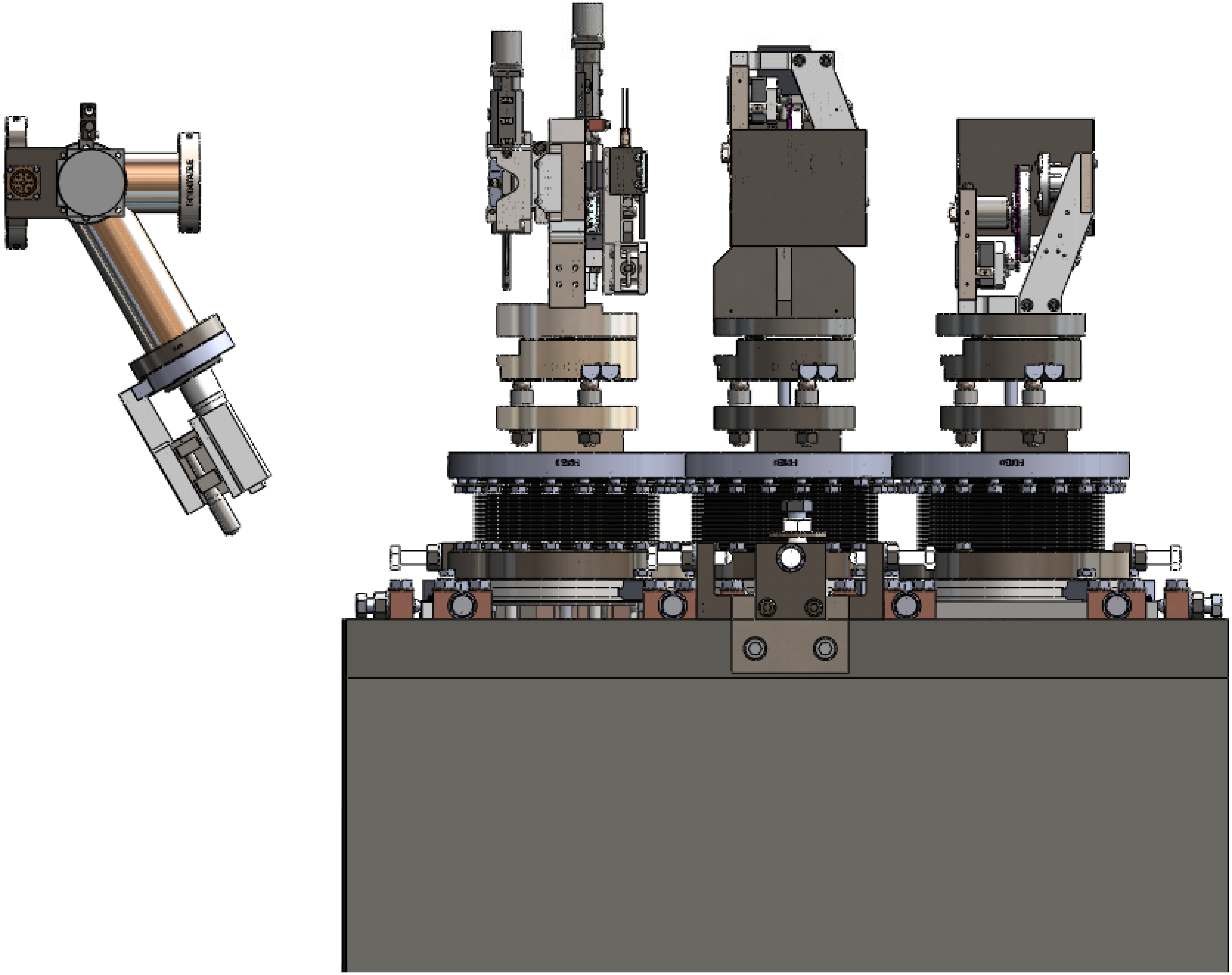
13-ID-B (SOE)

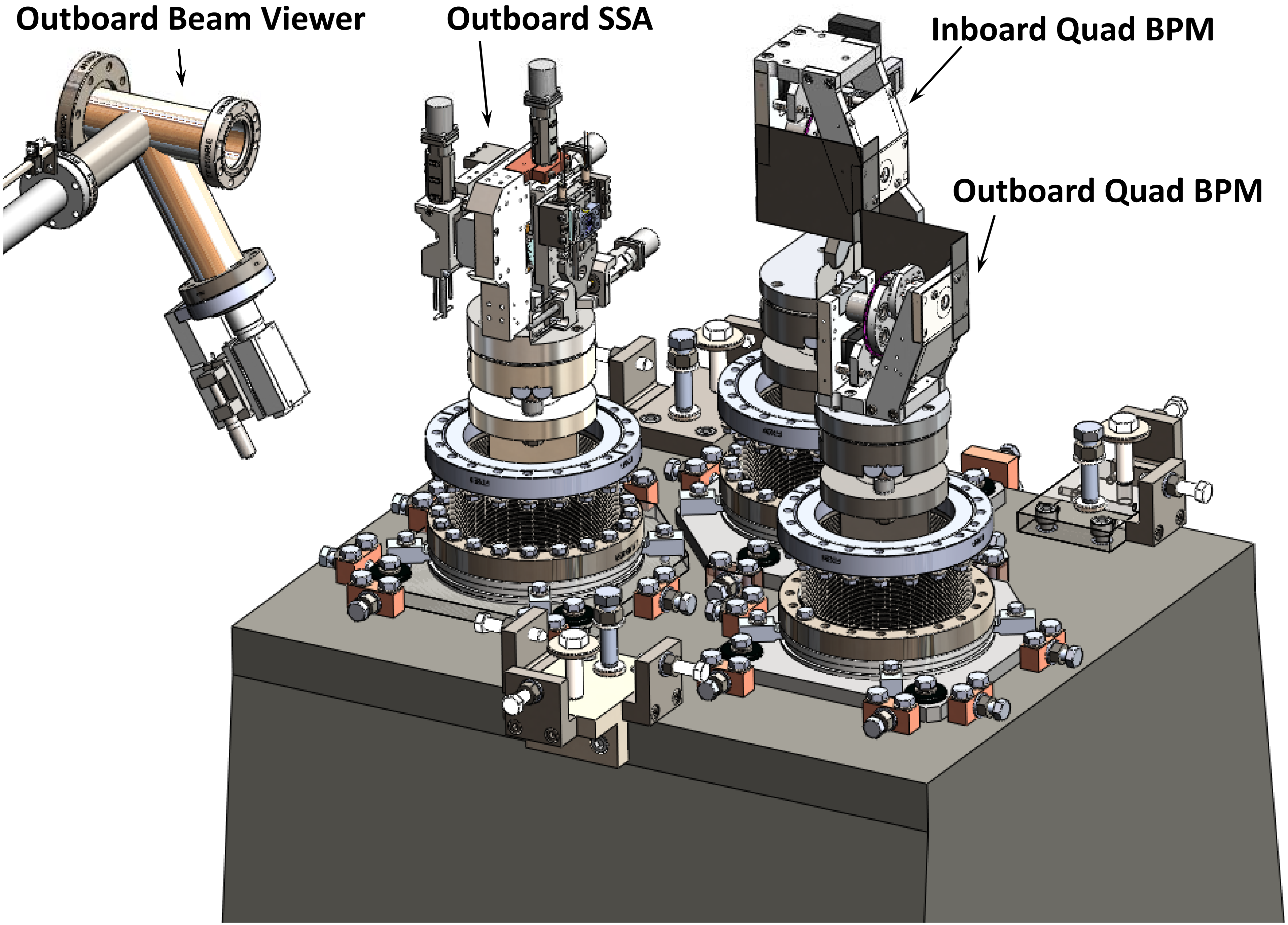

IDC/D and IDE
Station Shutters
SSA / Quad BPM
Inboard Vertical
Large KB Mirror

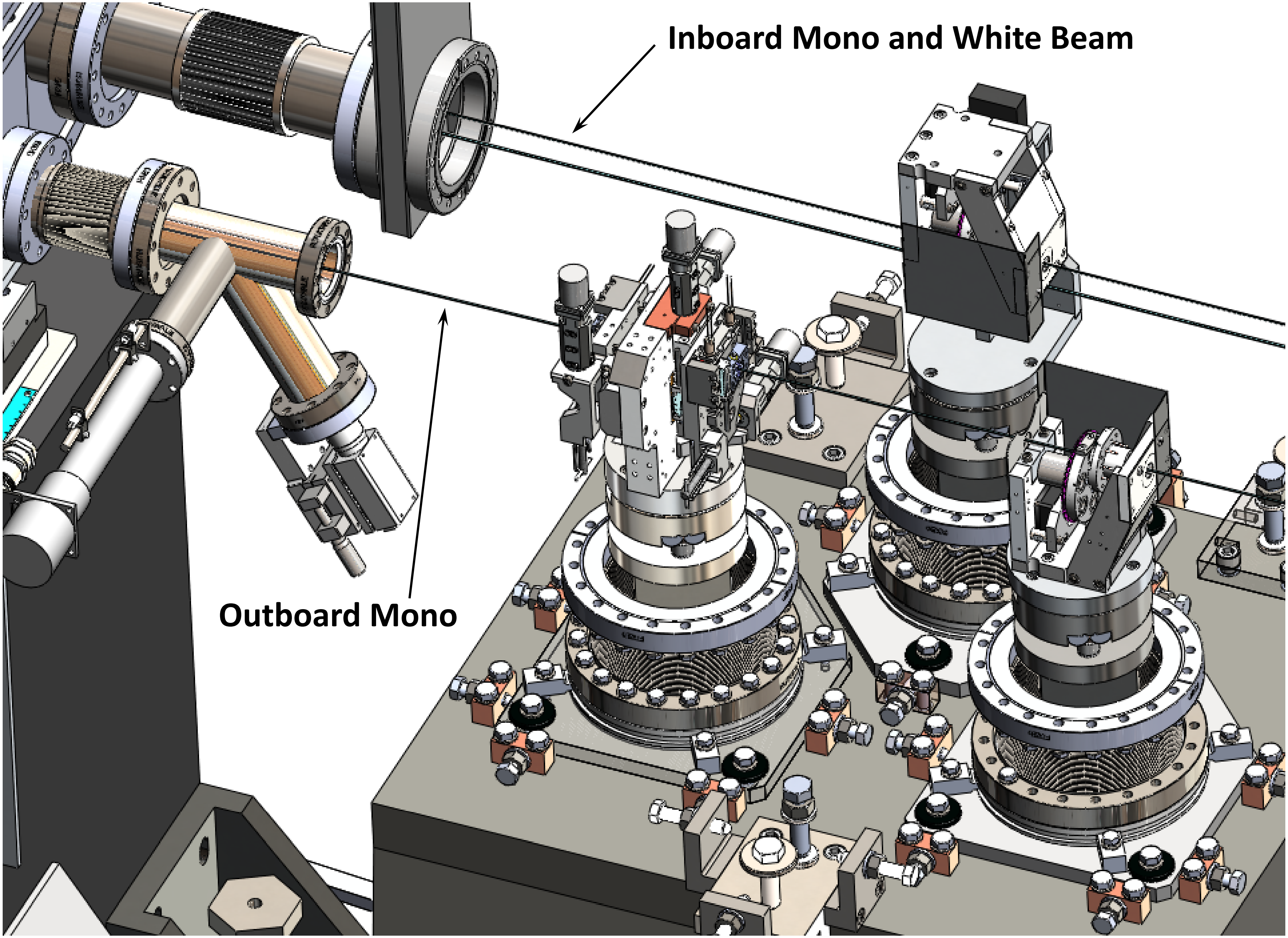


SSA / Quad BPM

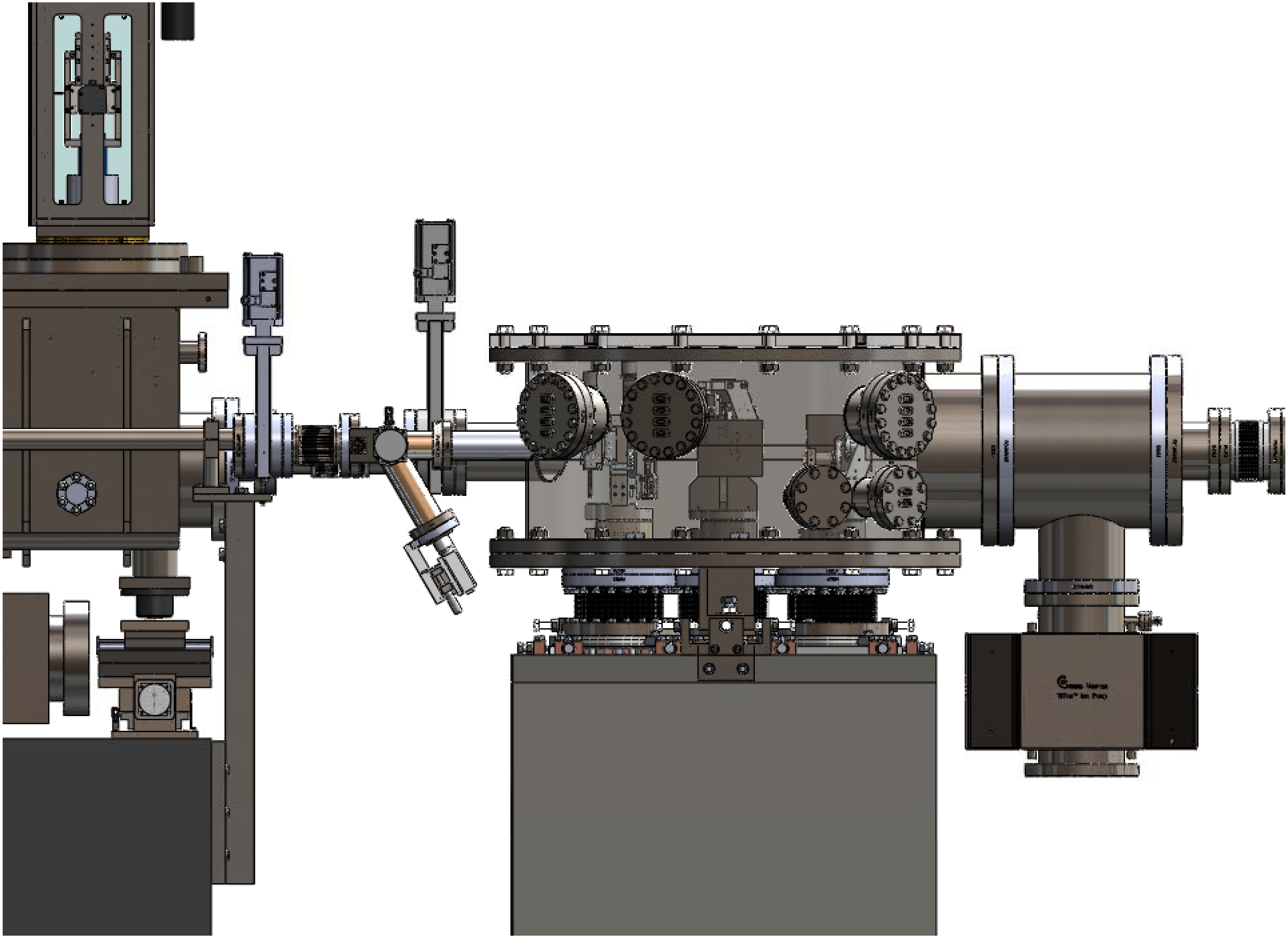


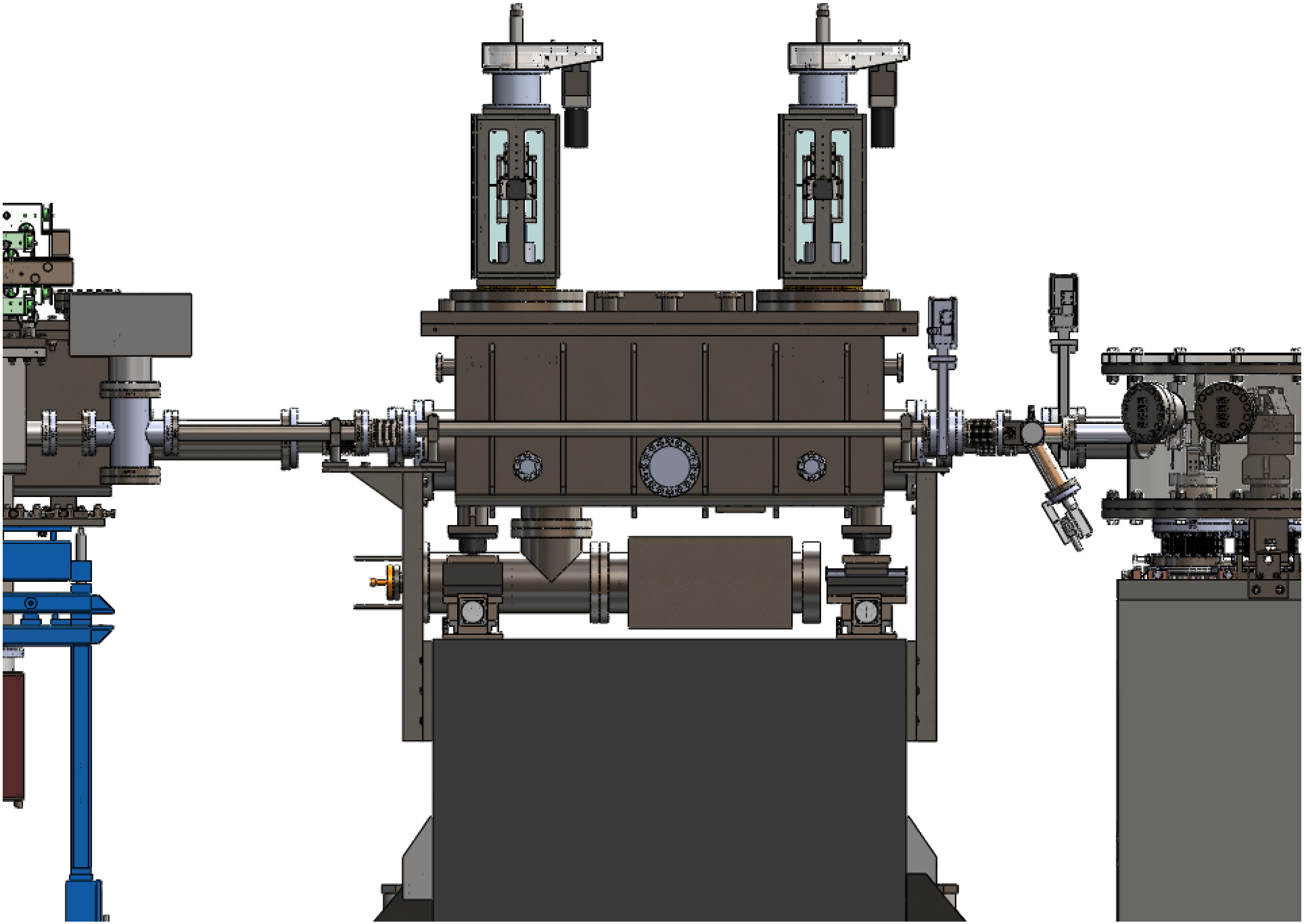


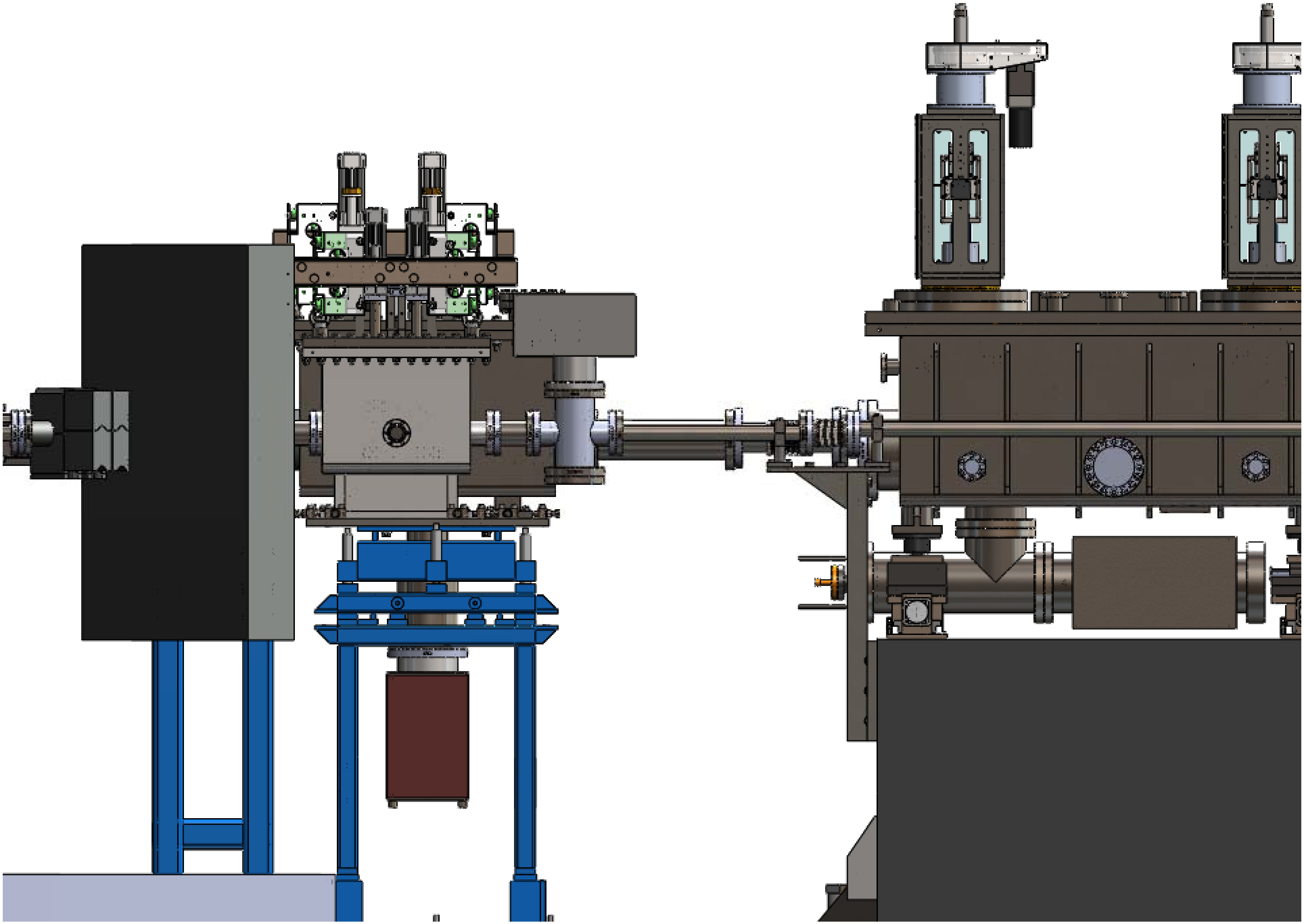

Outboard Beam Viewer
Outboard SSA
Inboard Quad BPM
Outboard Quad BPM

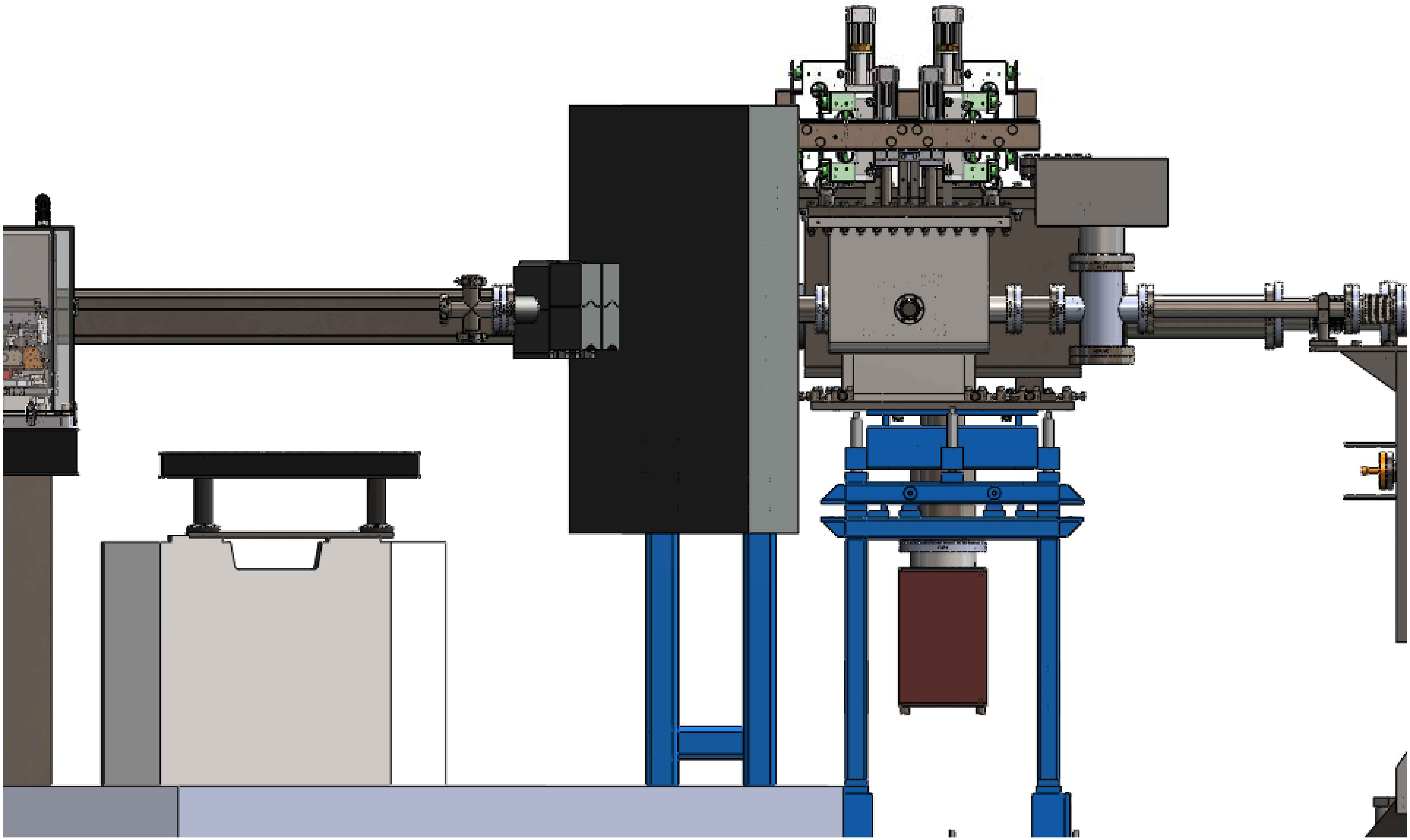


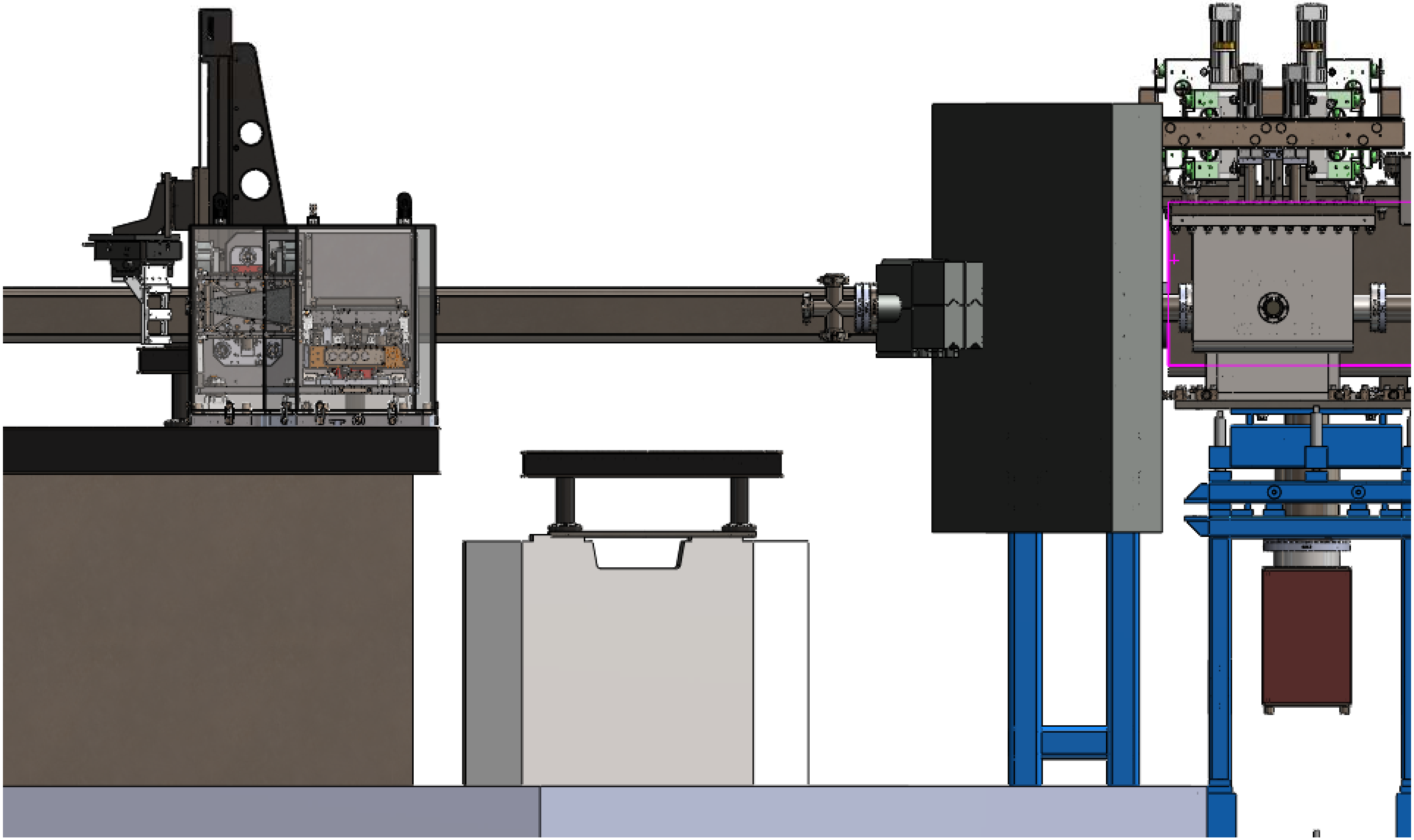
Inboard Mono and White Beam
Outboard Mono



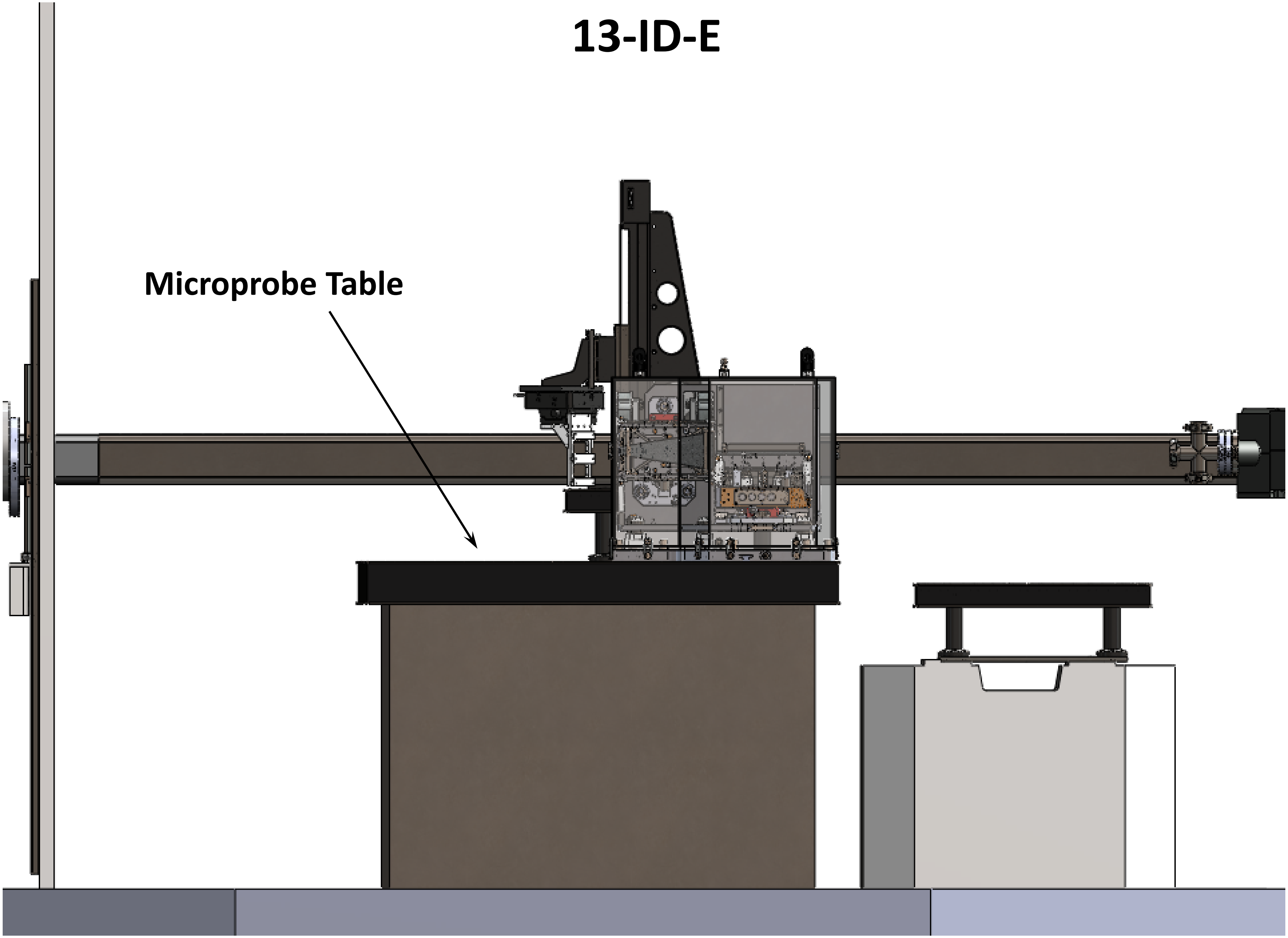


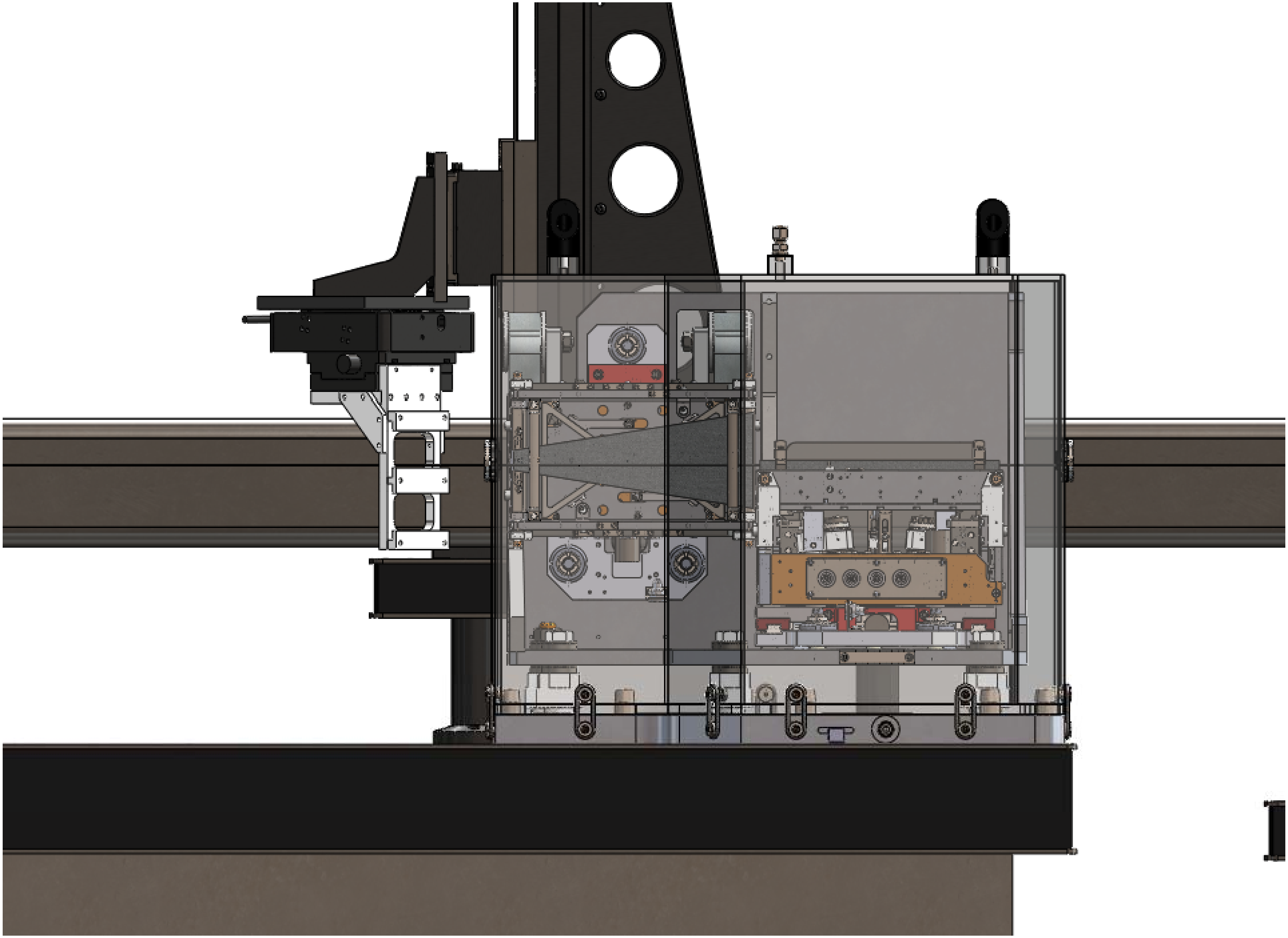


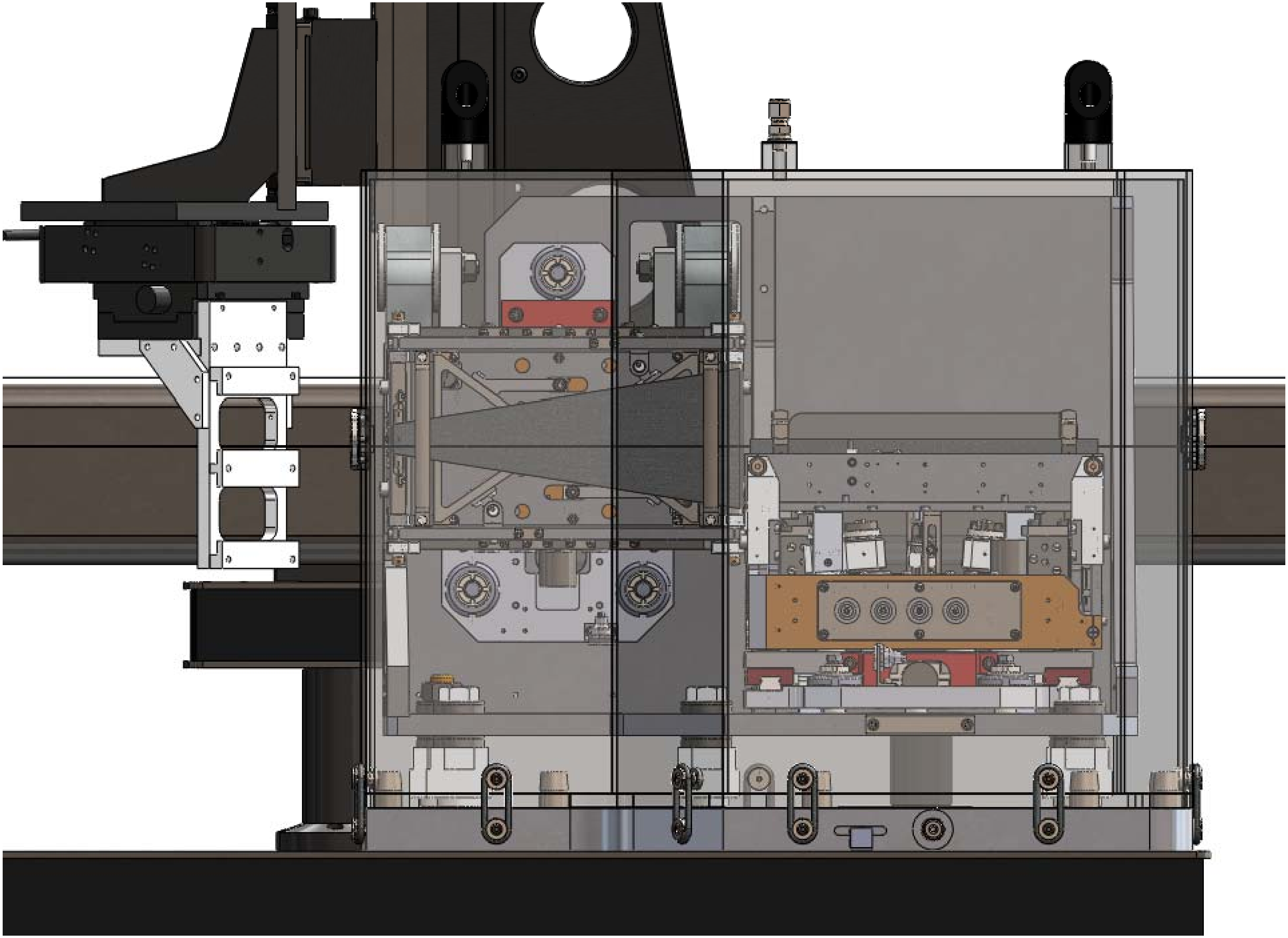


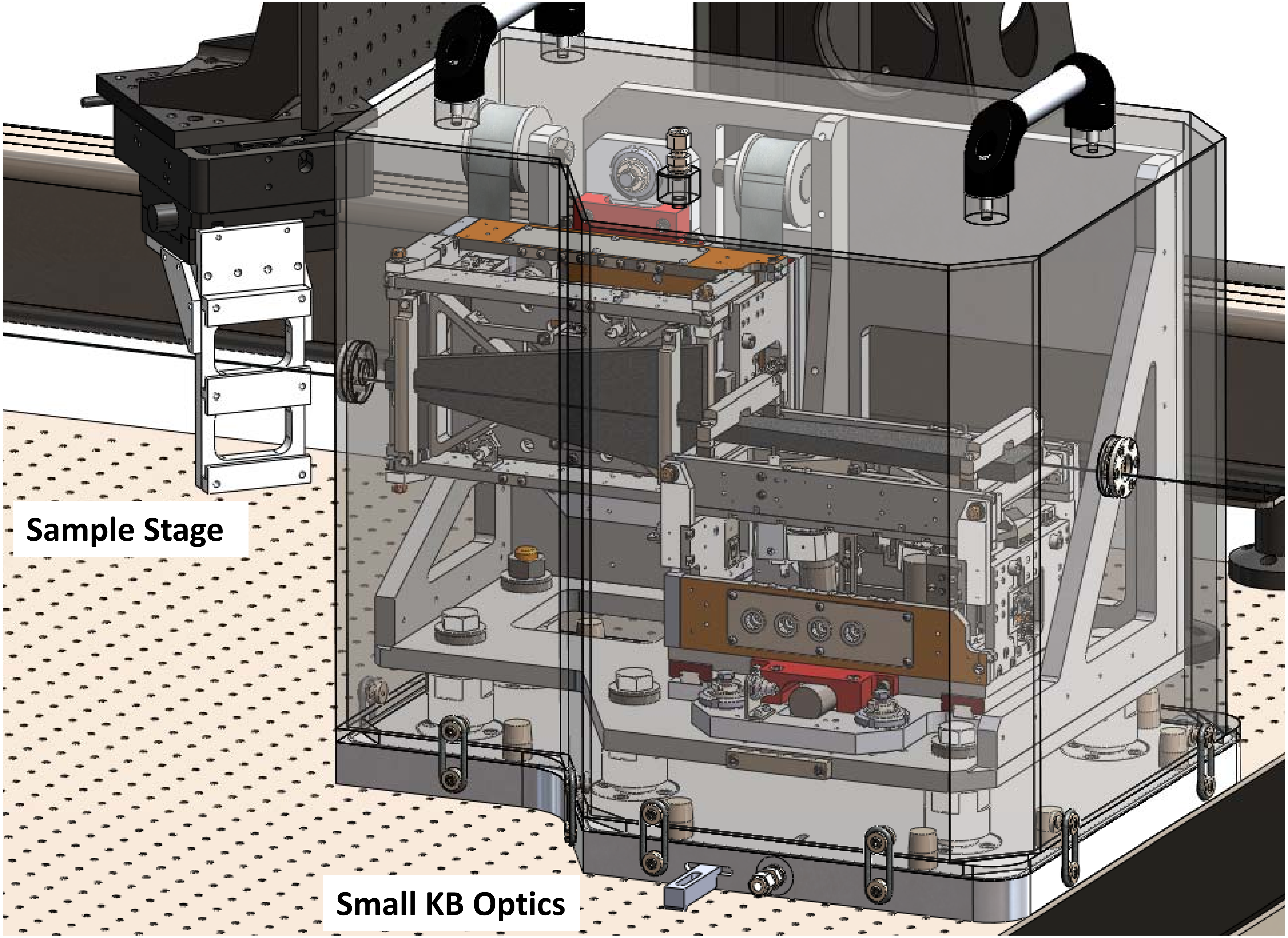


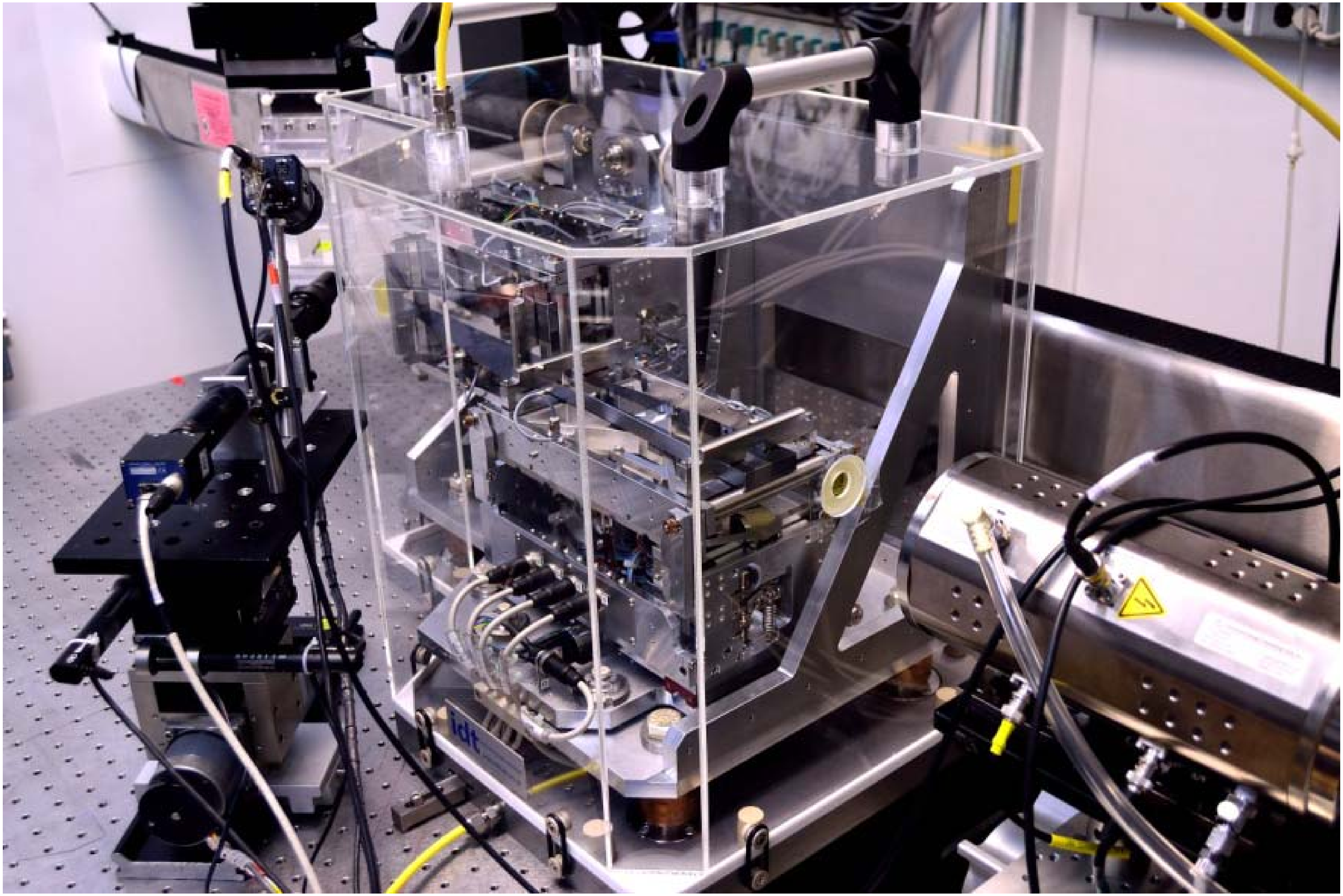
13-ID-E

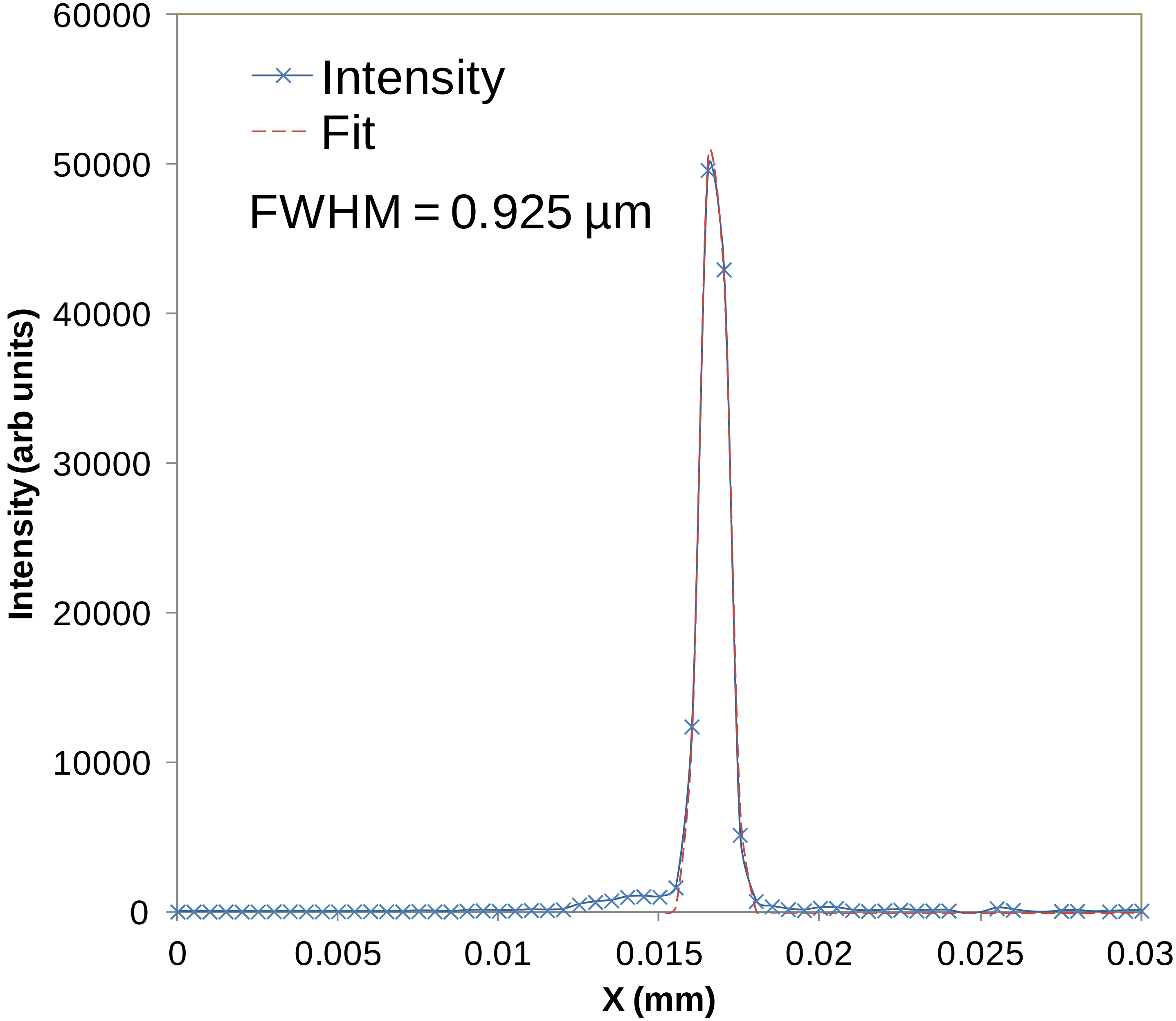






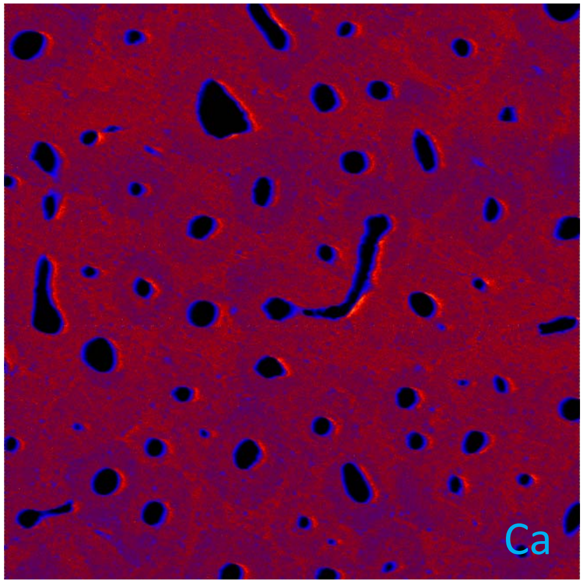

Sample Stage
Small KB Optics


idt



Intensity
Fit
FWHM = 0.925 µm
60000
50000
40000
30000
20000
10000
0
Intensity (arb units)
0
0.005
0.01
0.015
0.02
0.025
0.03
X (mm)

MegaPixel Map
IDE Mono Si 111, No Feedback, Non-Top Up Mode

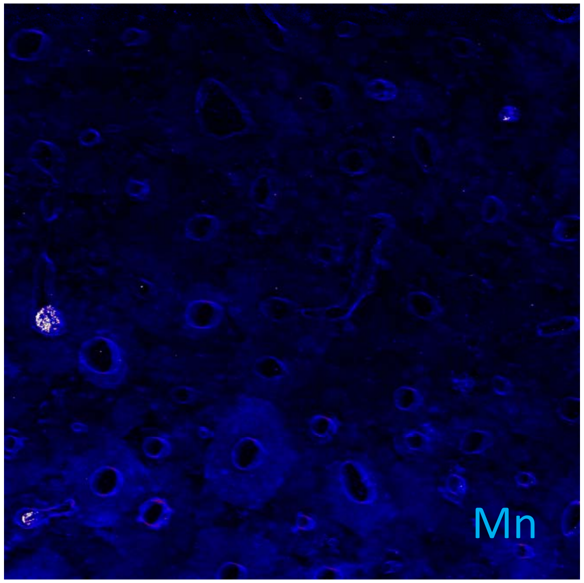


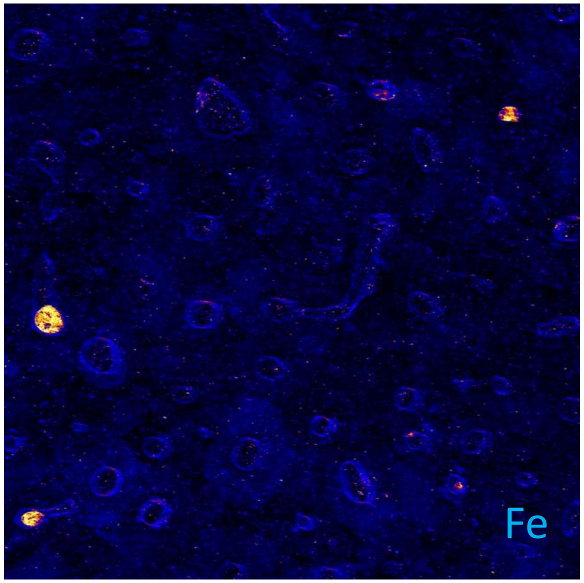
Wooly Mammoth bone cross-section

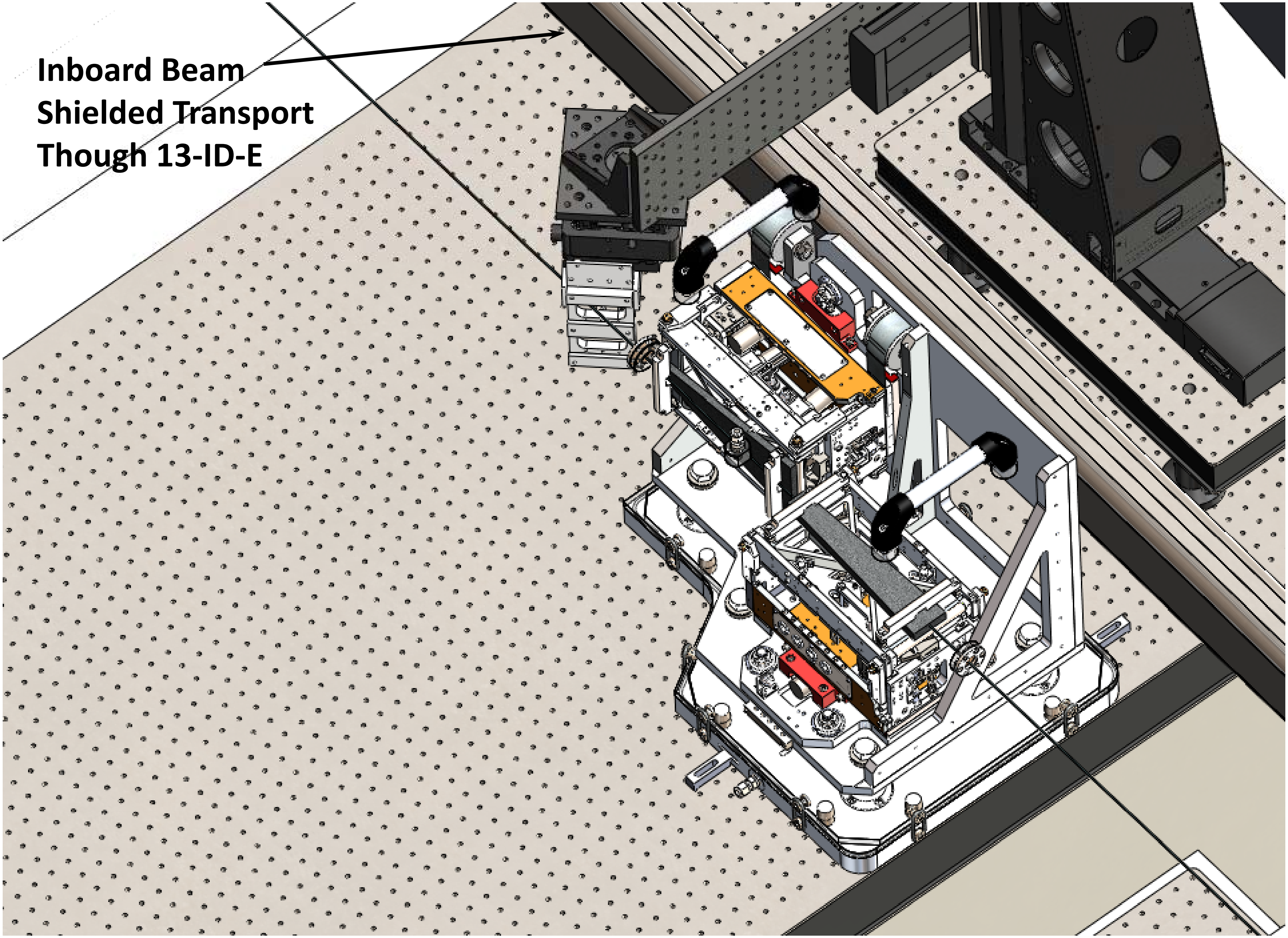
Mammoth preserved in permafrost, Yukagir, Siberia, ca. 20,000 years old

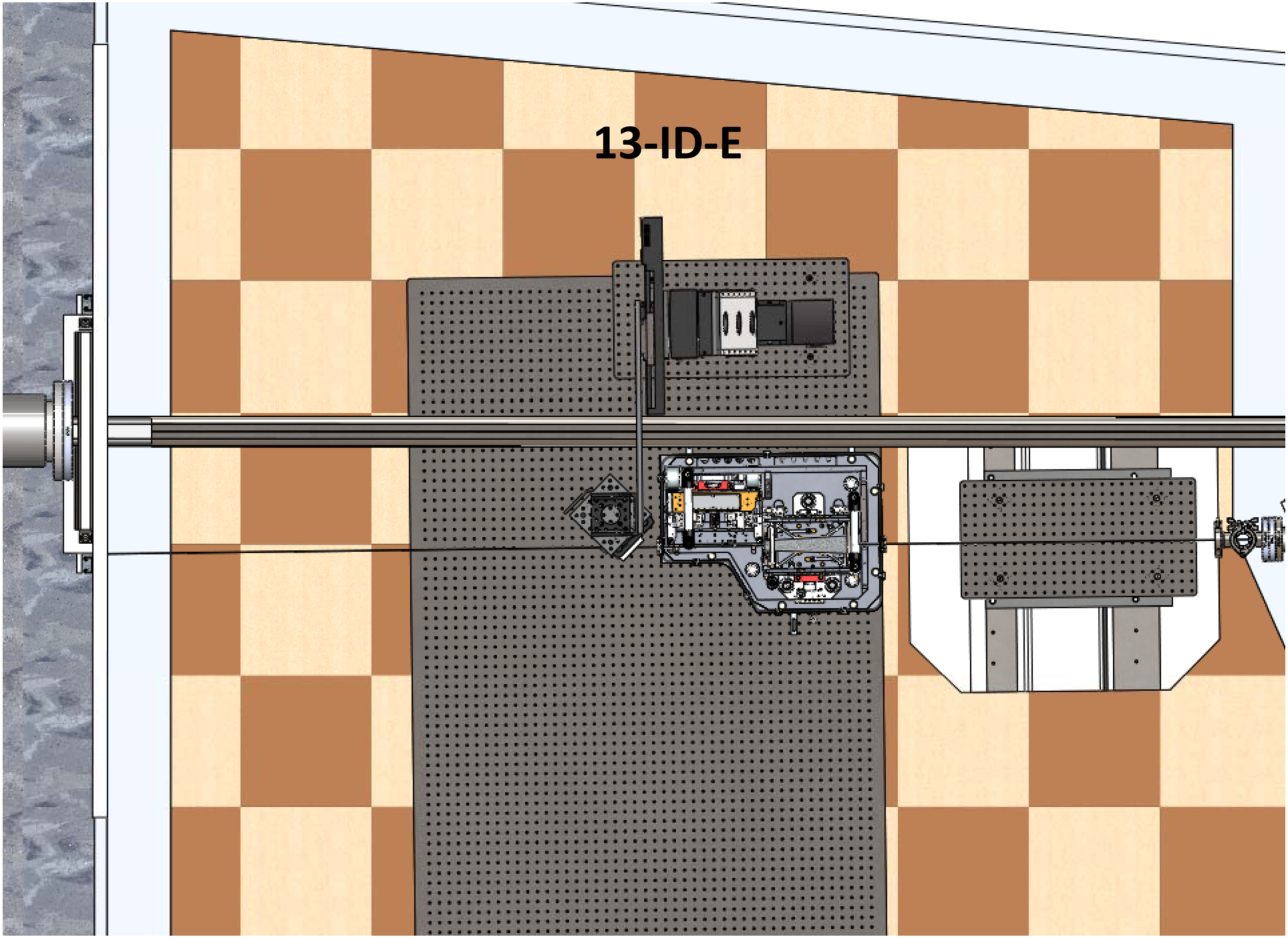
2 mm x 2mm, 2 μm pixels
(1000 x 1000 pixels)

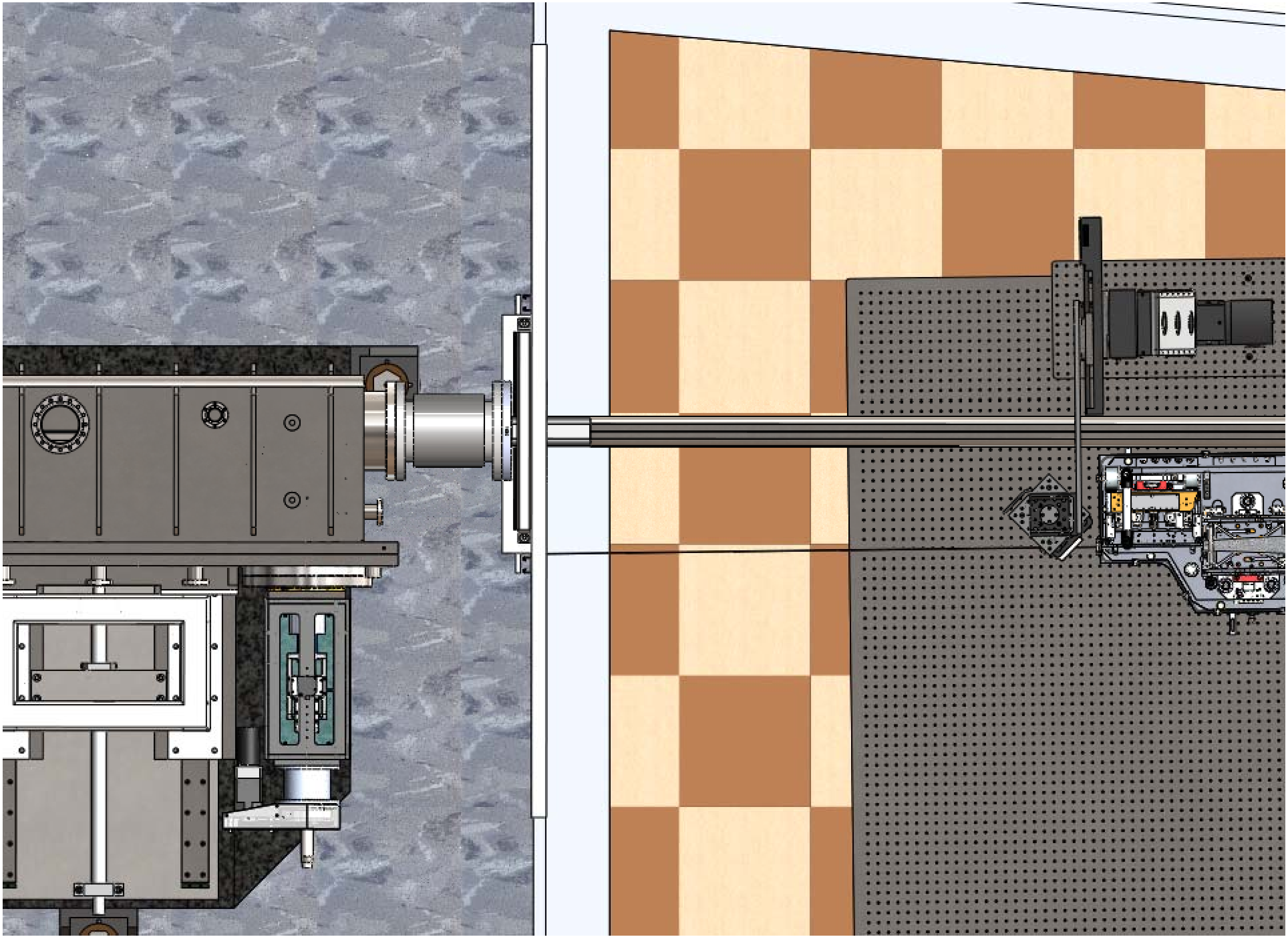
30ms dwell time per pixel
Total acquisition time: 9 hours

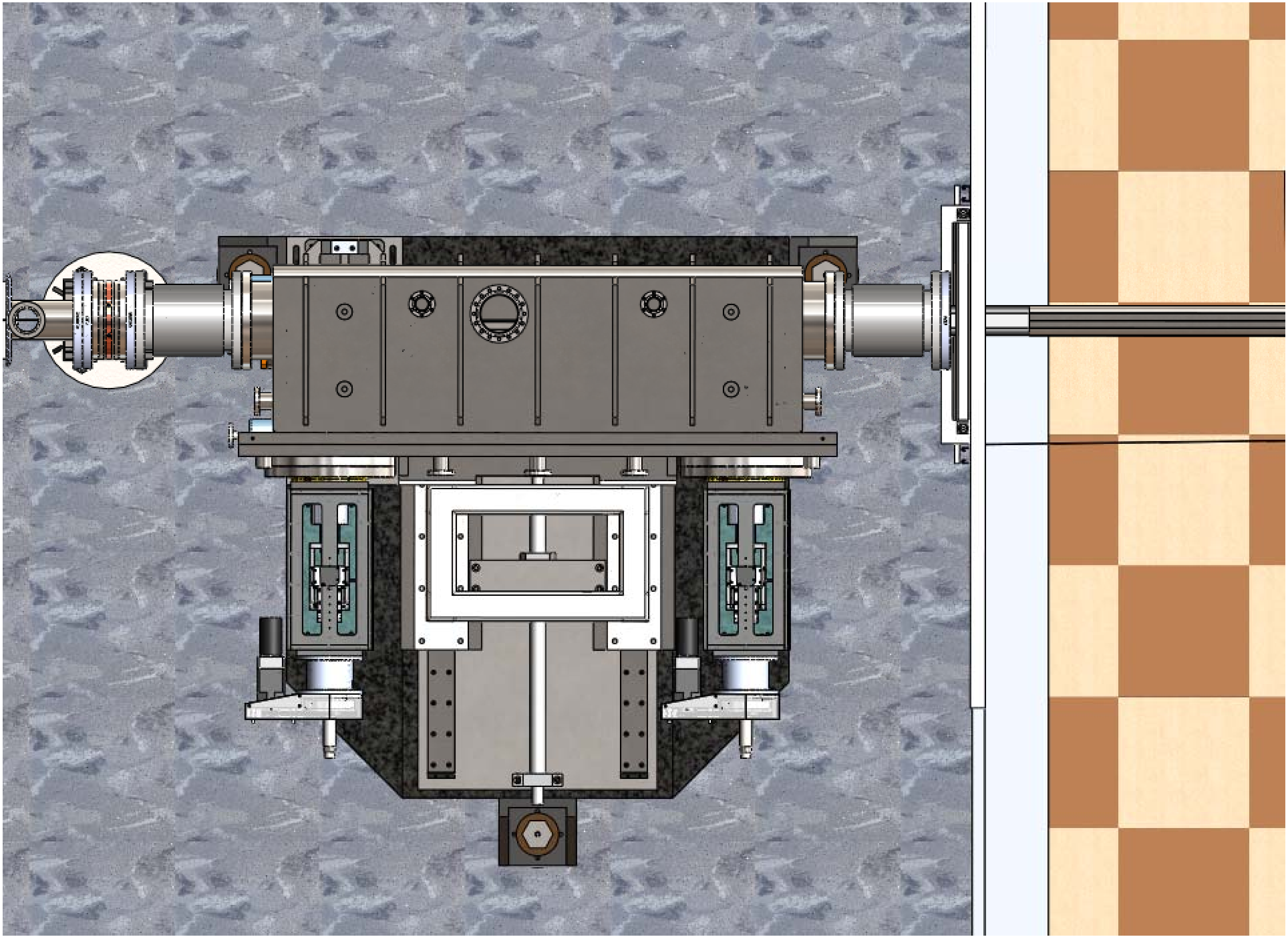


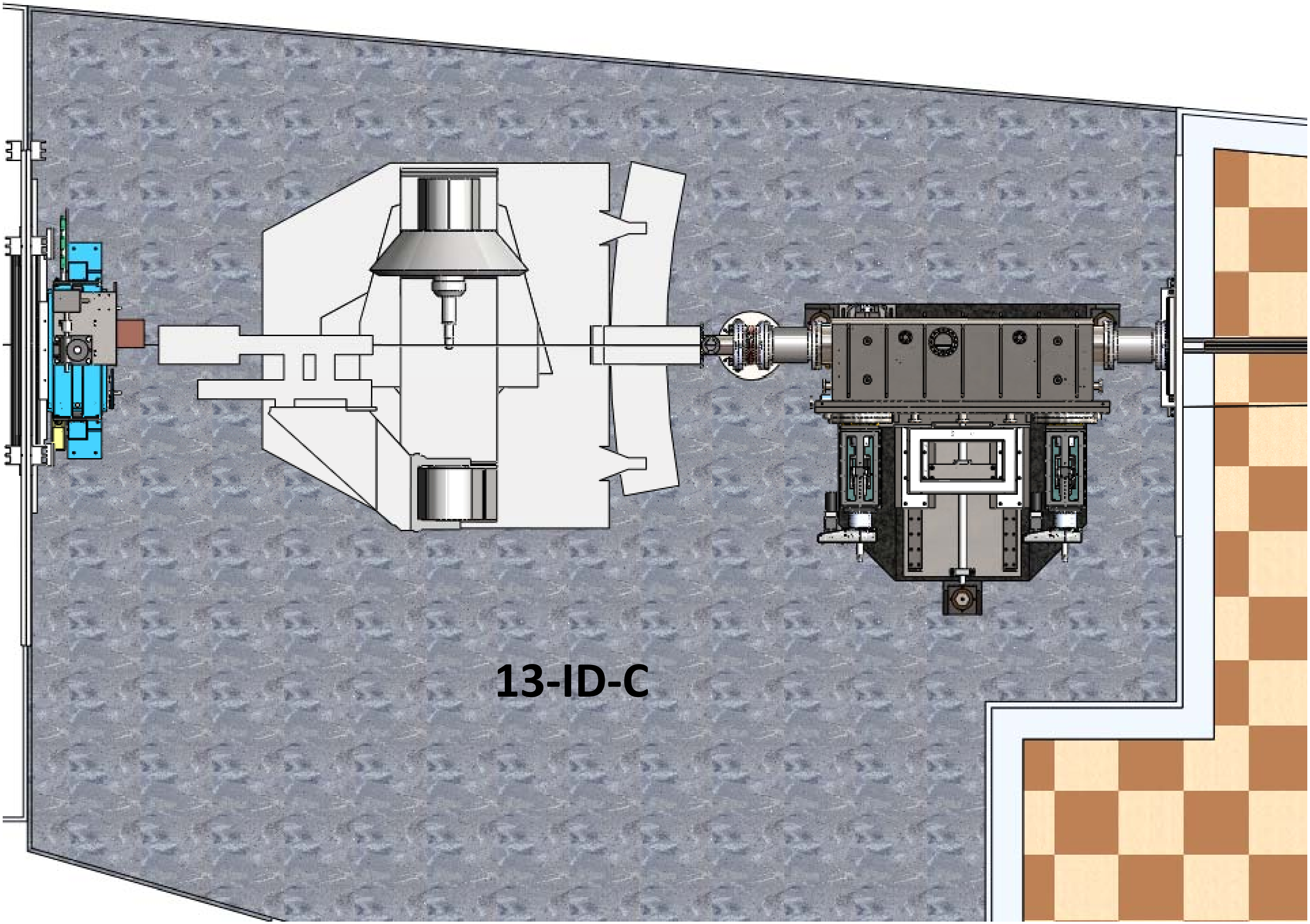


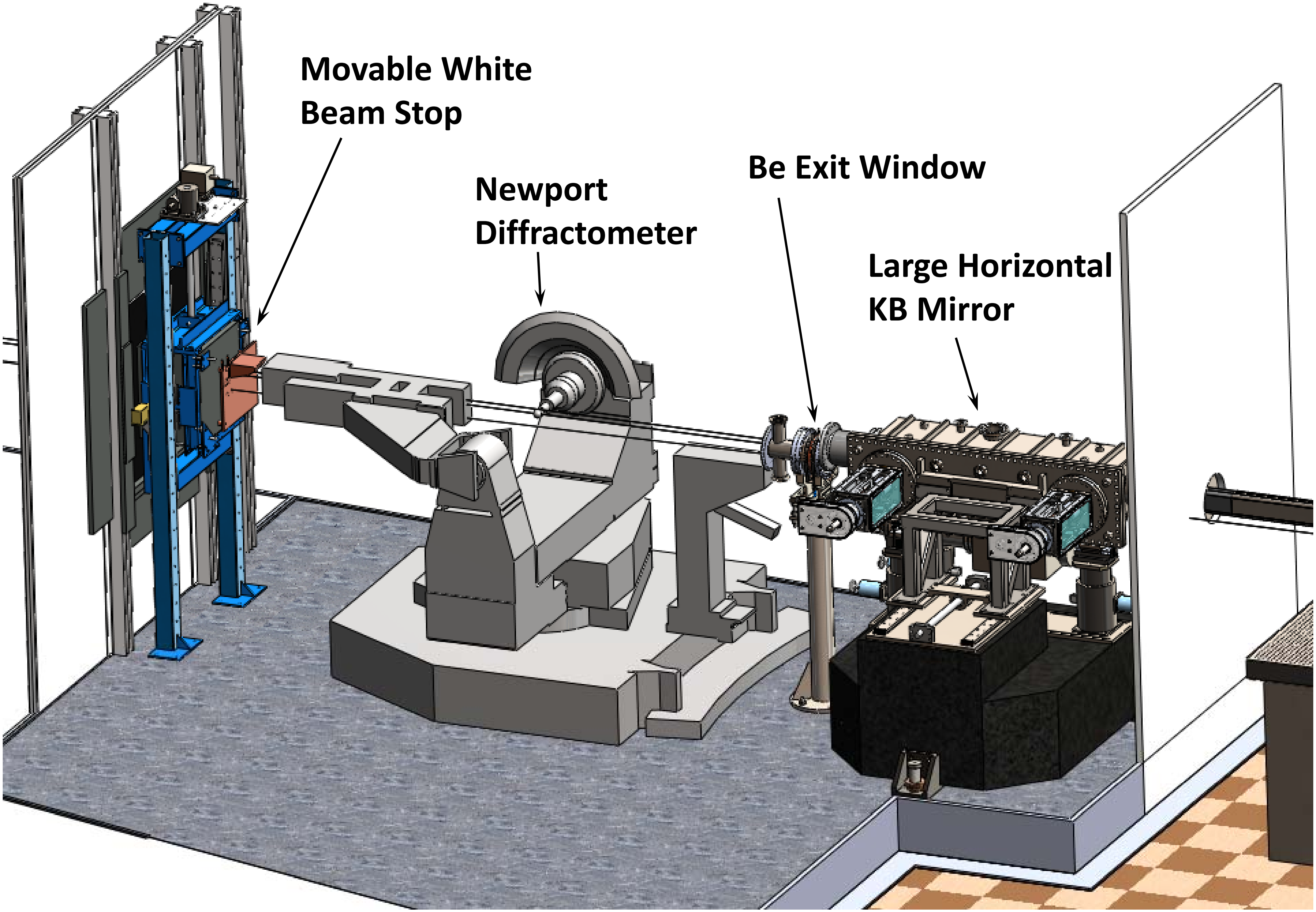

Inboard Beam
Shielded Transport
Though 13-ID-E

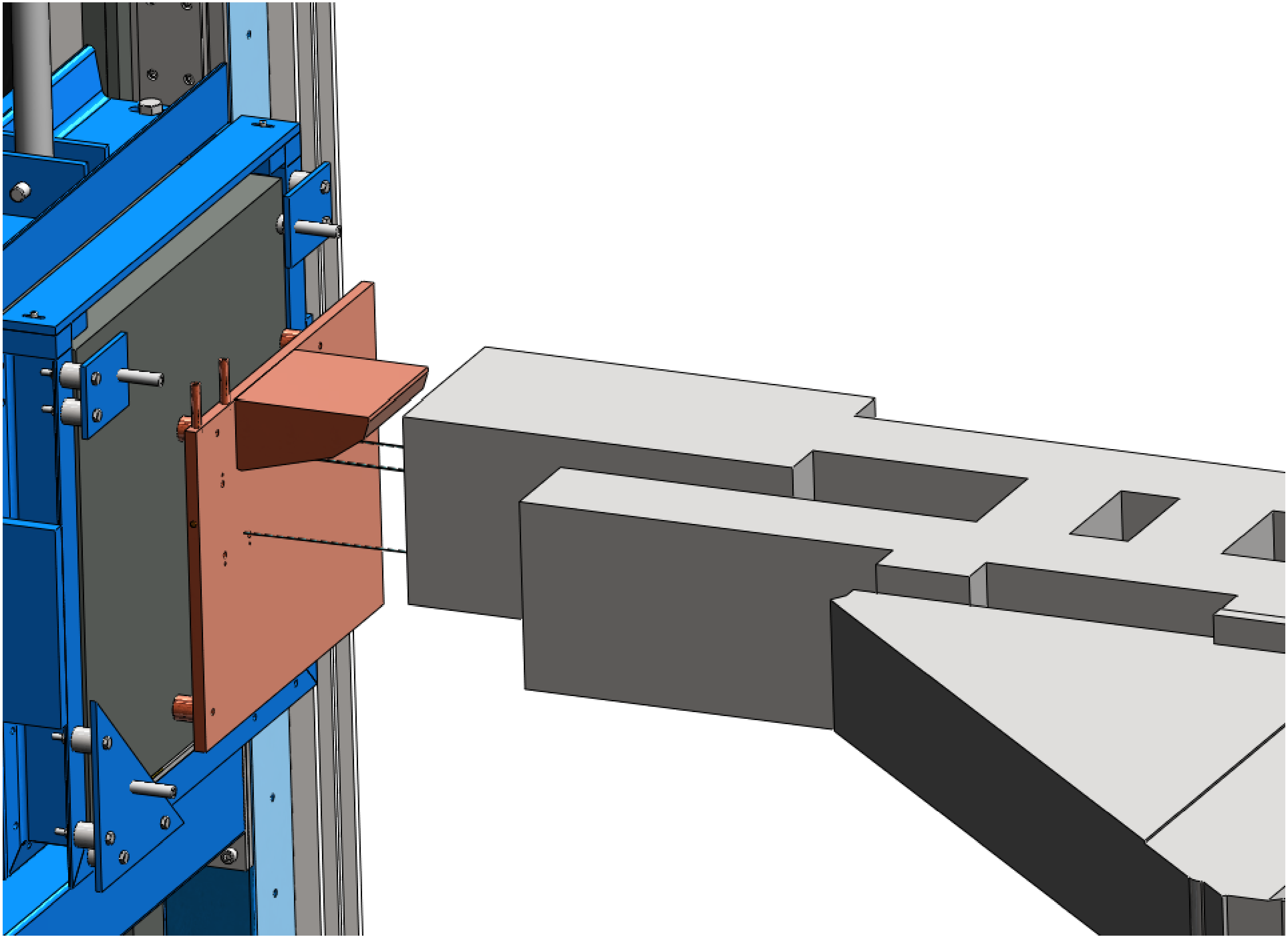

13-ID-E

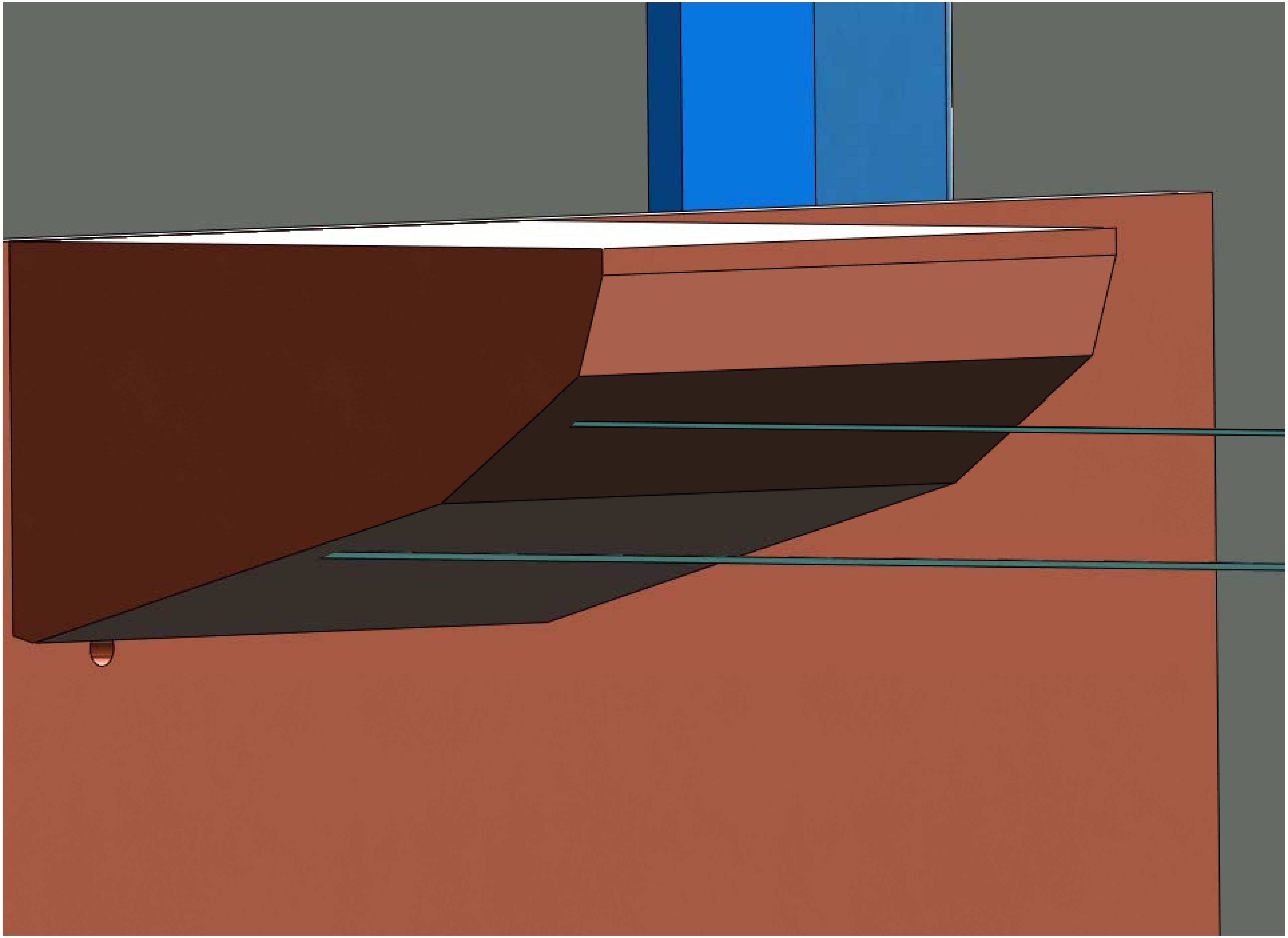




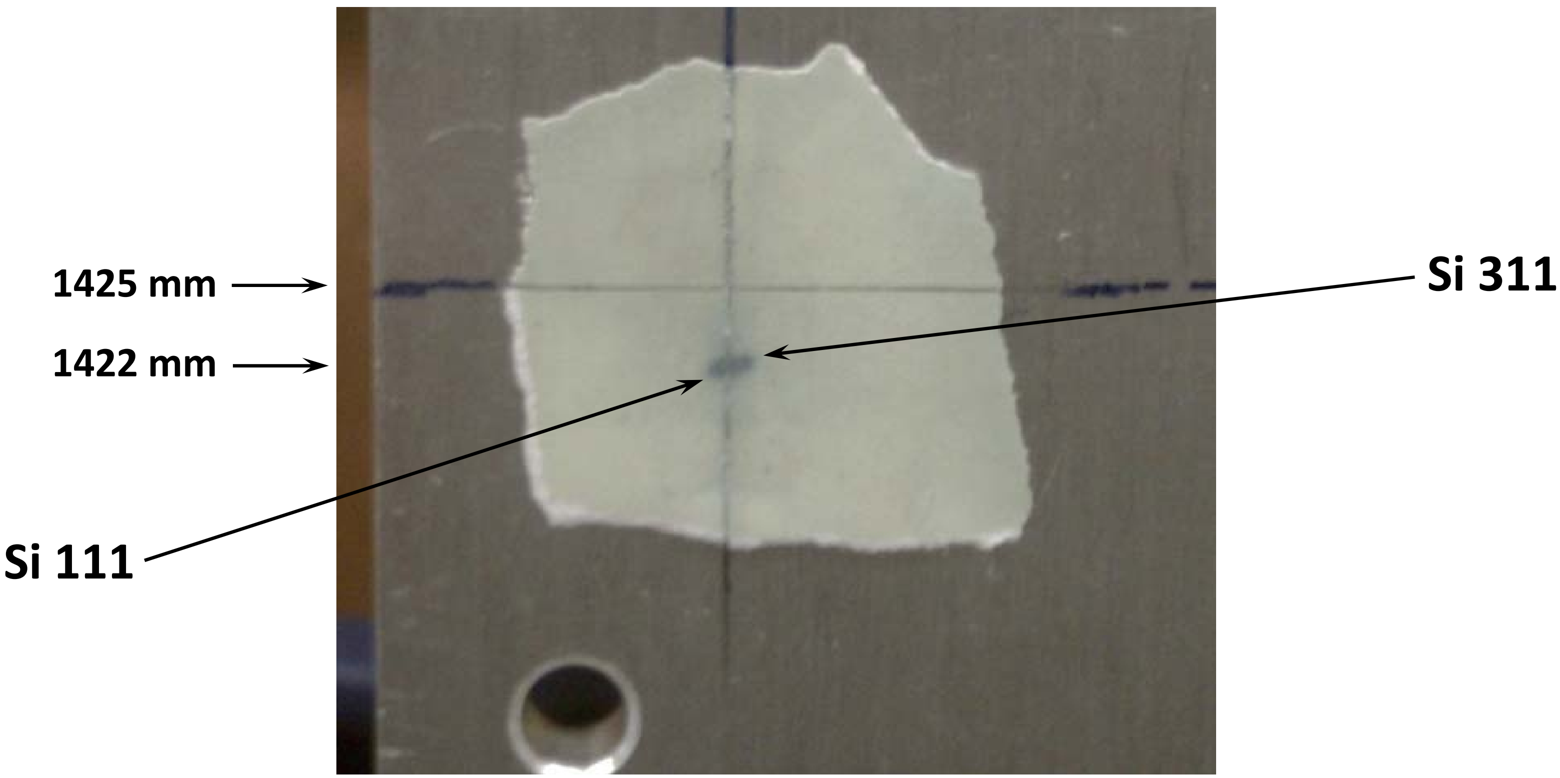

13-ID-C

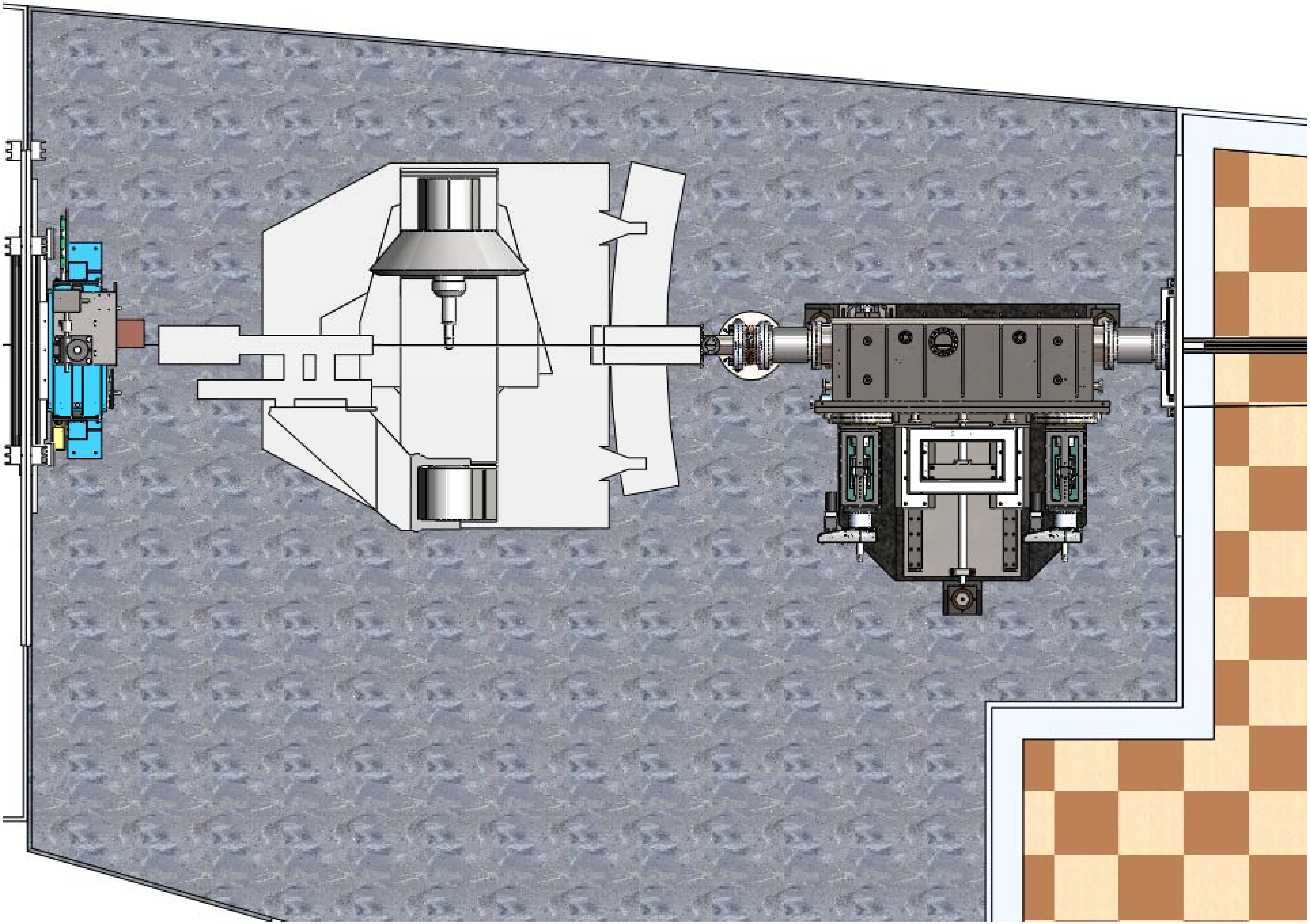

Movable White
Beam Stop
Newport
Diffractometer
Be Exit Window
Large Horizontal
KB Mirror



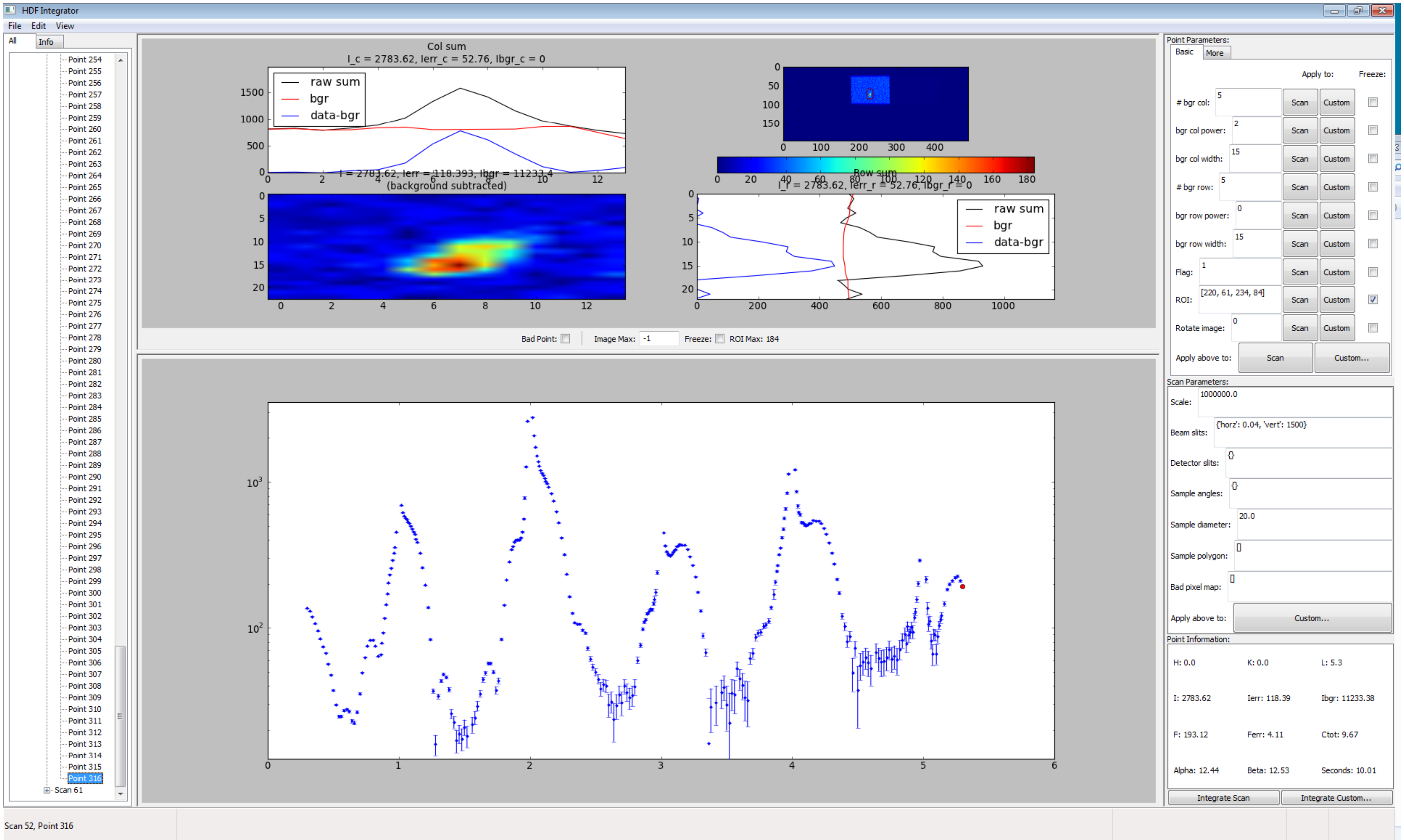


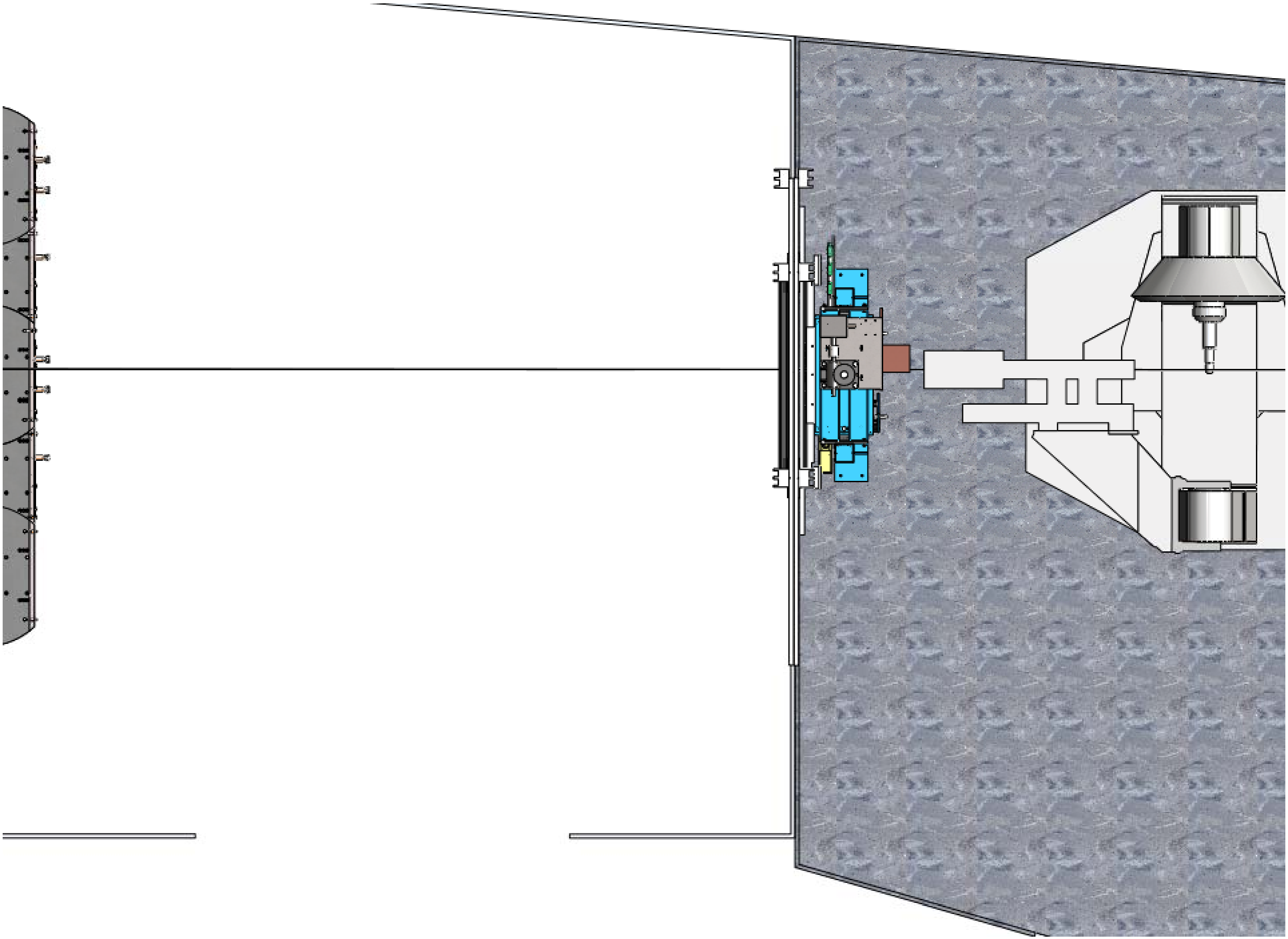
IDC/D Mono Beam Burn on back wall of 13-ID-C

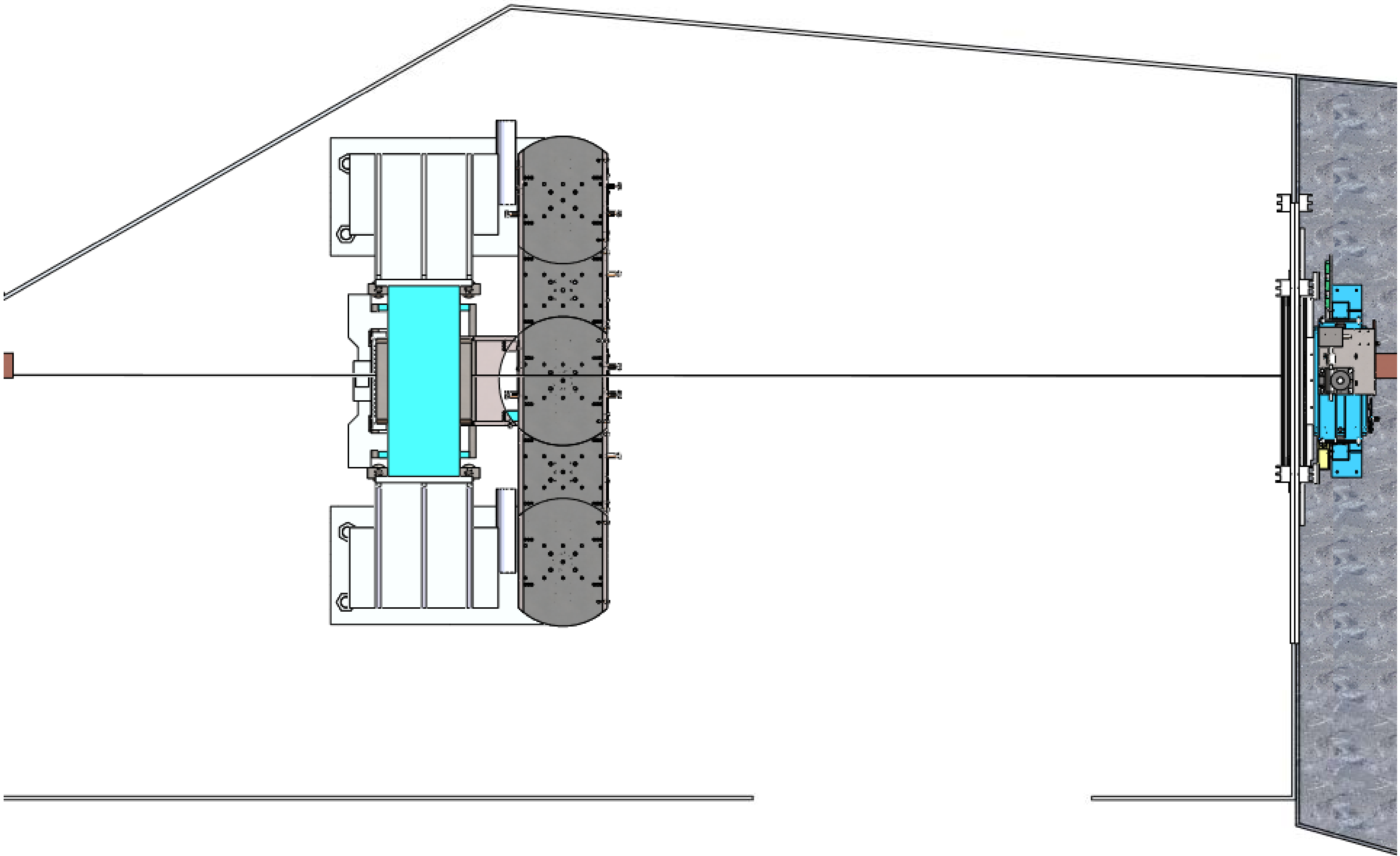


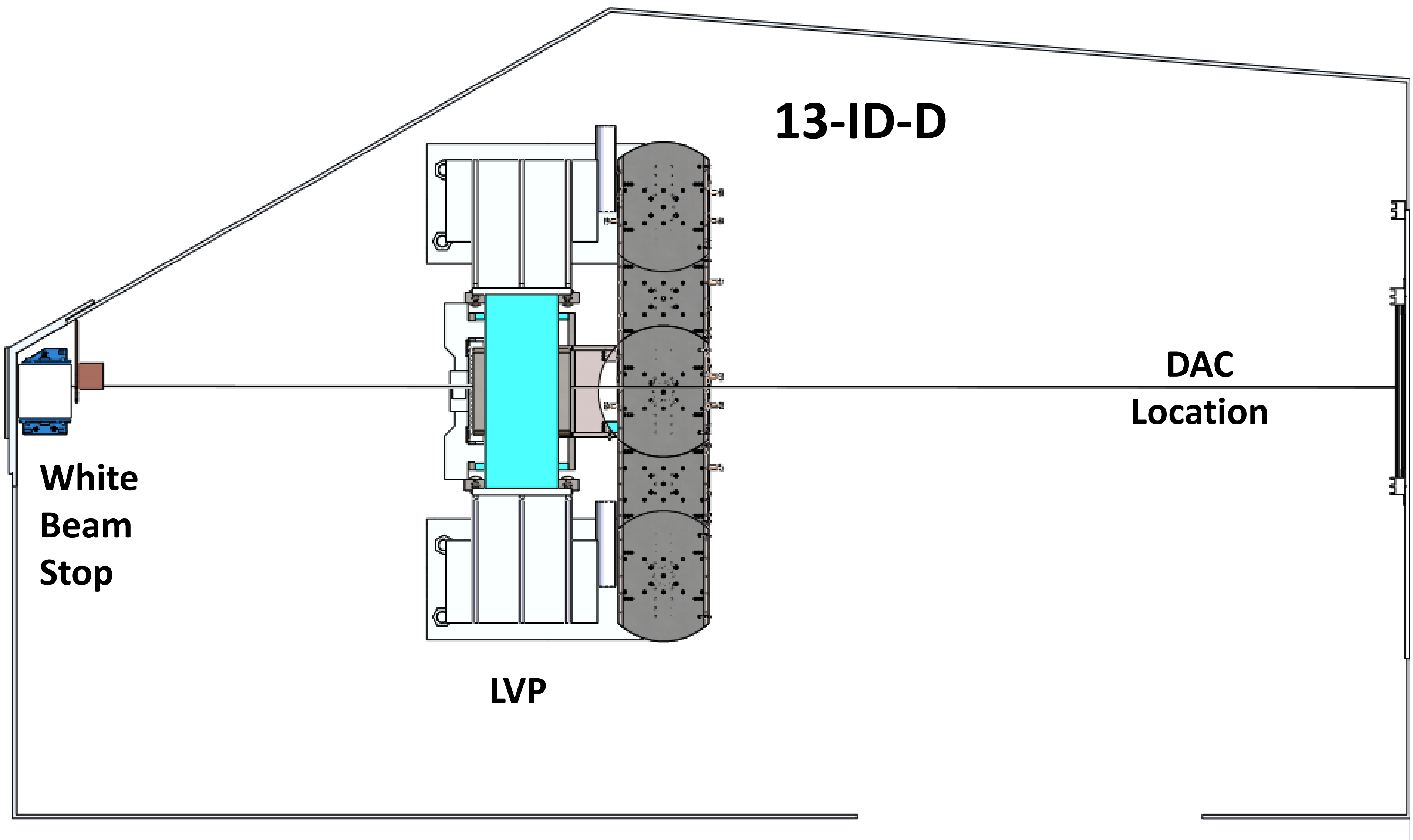


5 Monolayers of LAO on STO
Specular Rod, E = 39 keV








13-ID-D
DAC
Location
White
Beam
Stop
LVP

Thank the APS for exceptional service and support throughout our upgrade process

Acknowledge the CARS beamline staff for being the muscle behind the upgrade

Acknowledge Instruments Design Technologies - IDT - for their willingness to be collaborative and innovative and deliver high quality instruments