

# Diamond-II Vacuum

M.P. Cox

Diamond-II SLS-2 Virtual Vacuum Worksop 7<sup>th</sup> July 2020

# Topics

- Vacuum vessel project overview M. Cox (10 Mins)
- Run through of Vessel CAD model A. Day (20 Mins)
- Thermal and structural simulation S. Hodbod (10 Mins)
- Vacuum simulation and impedance effects M. Cox / R.Fielder (15 Mins)
- Vessel manufacture and build M. Cox (15 Mins)

# Diamond-II Vacuum Project Overview



# Diamond-II overview

## Diamond

- 3<sup>rd</sup> generation light source UK
- 3 GeV 300 mA
- 562 m circumference 24-cell DBA lattice
- 2.7 nm.rad emittance
- Operating since 2007
- 35 beamlines

## Diamond-II

### Motivation

- Increase brightness
- 24 new mid-straight sections for additional insertion devices

## Summary

- In-place upgrade to storage ring
- 3.5 GeV 300 mA
- 160 pm.rad emittance as of CDR – lattice not finalised yet
- DTBA - modified 6BA lattice
- Many associated upgrades, e.g. RF, Diagnostics
- New booster ring
- Preserve existing beamline functionality with some new and upgraded beamlines
- Installation 2025-26 with  $\leq 18$  month disruption to user operations
- Main project funding – in work

# Requirements

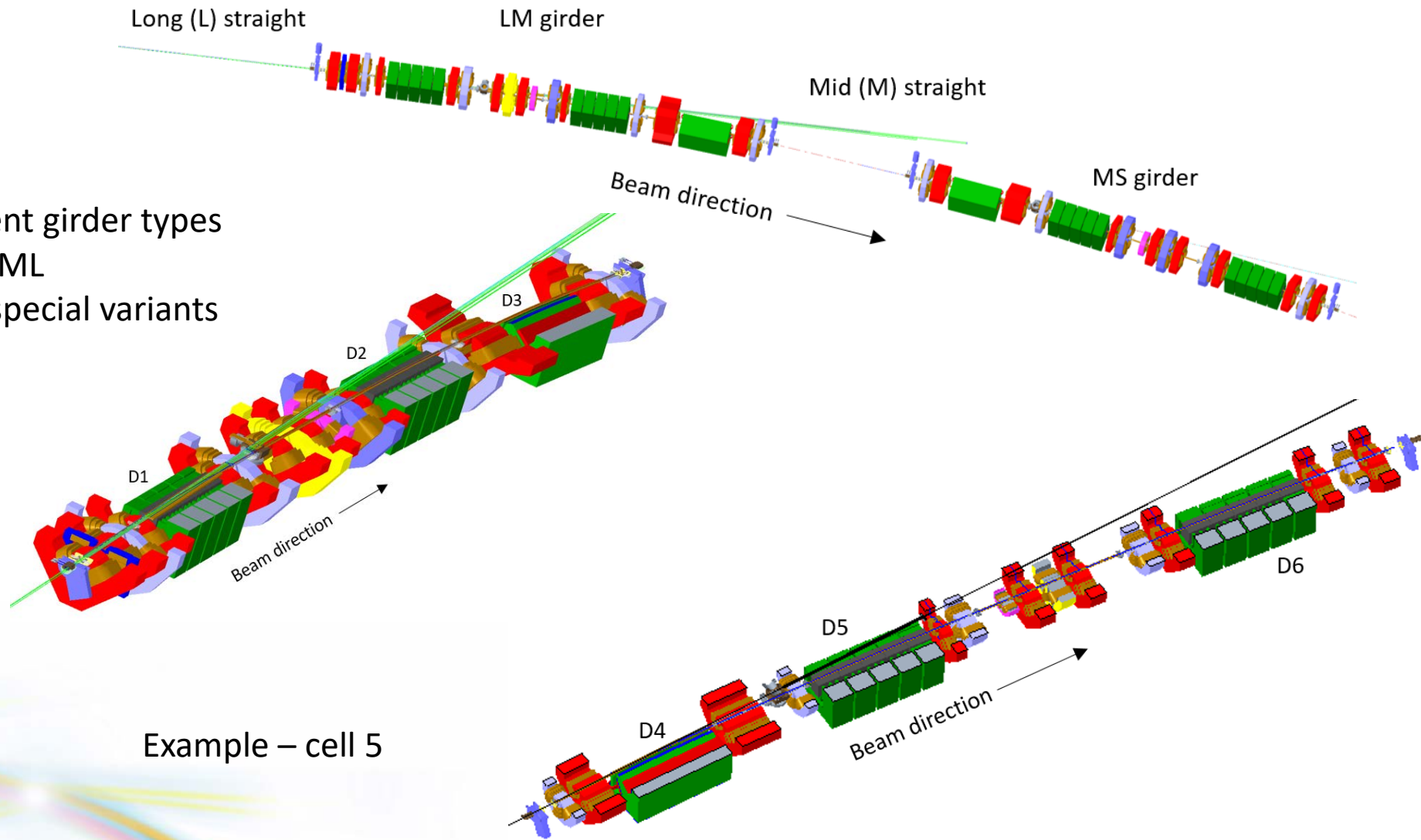
Vacuum performance	<ul style="list-style-type: none"><li>• Average pressure of <math>10^{-9}</math> mbar or better around the storage ring at 300 mA after 100 Ah of beam conditioning (gas lifetime studies in progress)</li></ul>
Machine impedance	<ul style="list-style-type: none"><li>• Geometric</li><li>• Resistive wall</li></ul>
Electron beam stay clear	<ul style="list-style-type: none"><li>• Respect minimum apertures</li></ul>
Magnet compatibility	<ul style="list-style-type: none"><li>• Respect magnet space envelopes</li><li>• No effect on field quality (AC and DC)</li><li>• In-situ bakeout compatible (no longer applicable)</li><li>• No effect on mechanical stability</li></ul>
Photon extraction	<ul style="list-style-type: none"><li>• Bending magnets and insertion devices</li></ul>
Heat load management	<ul style="list-style-type: none"><li>• Synchrotron radiation power loading</li><li>• RF beam heating</li></ul>
Operations	<ul style="list-style-type: none"><li>• Reliable, maintainable, energy efficient</li><li>• Control and monitoring</li><li>• Machine protection interlocks</li><li>• Radiation tolerant long term</li></ul>

# Diamond-II SR vacuum design history

- **Common features**
  - Typically 20 mm diameter vacuum pipes
  - Cu, SS and Al vessels and components (possibly some additive manufacturing for absorbers)
- **Option A (NEG coated based on MAX-IV, SIRIUS)**
  - Almost fully NEG-coated
  - No antechamber
  - Mainly distributed photon absorbers
  - Few discrete pumps
  - **Complex NEG coating challenge**
- **Option B (Uncoated based on ESRF-EBS)**
  - Little or no NEG coating
  - Full antechamber
  - Mainly discrete absorbers
  - Many discrete pumps
  - **Complex vessels. Many pumps needed ... difficult with tight magnetic lattice**
- **Option C (hybrid based on APS-U) – current working option**
  - Partial NEG coating (simple vessels only)
  - Antechamber in dipoles only
  - Mix of discrete and distributed absorbers
  - Some discrete pumps (most likely combined NEG/ion pumps)
  - **Generally simpler vessels (except for dipole and crotch vessels). Simple NEG coating geometry can be delivered by industry but we are also setting up a small coating rig in house (0.5 m vessels) to gain experience**
- **In situ bakeout or not**
  - We started out with the assumption of in-situ bakeout and NEG activation
  - However this has now been removed in the latest design iterations in favour of ex-situ bakeout, high purity Ne for interventions to preserve NEG coating and girder swap in case of major vacuum problem

# General layout – one cell (of 24)

Four different girder types  
LM MS SM ML  
plus some special variants



Example – cell 5

Hand over to Alan Day and Stephen Hodbod





# Vacuum simulations



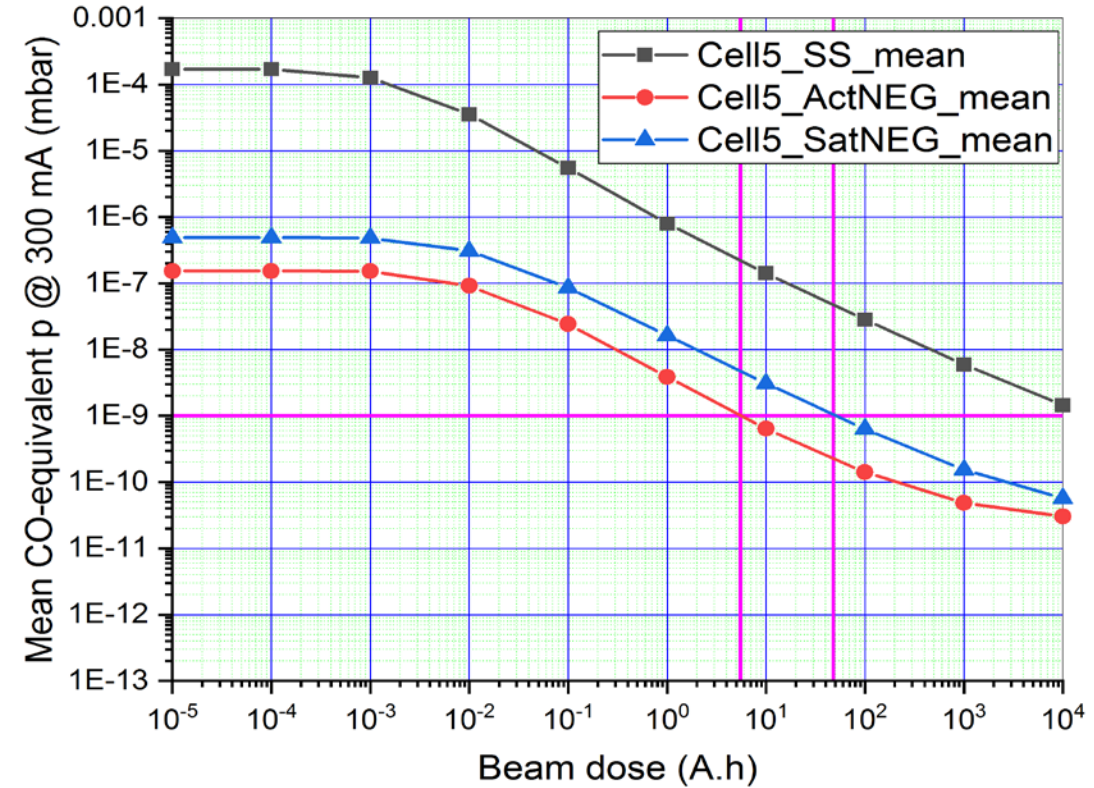
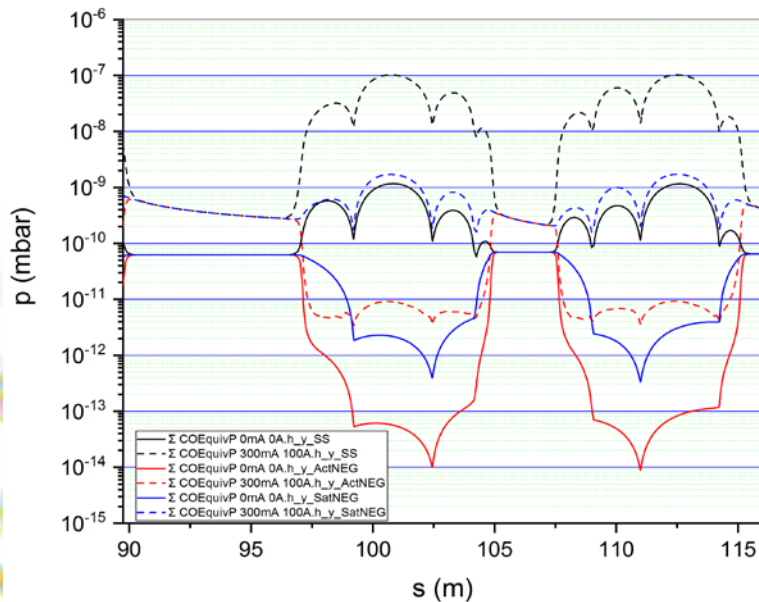
# Vacuum simulation process

- 1D
  - In-house Pressure Profile code
  - Needs pre-work to find out where SR hits the walls and gas is generated
  - Simple and quick and useful for long thin geometries but limited application to complex geometries
- 3D (1)
  - Synrad - SR ray tracing
    - Import vessel CAD geometry (usually too complicated and needs simplification / repair)
    - Define dipole sources using lattice file from Acc Phys (in-house code to translate and generate region files)
    - Define surface properties and meshes – 10% diffuse photon re-emission assumed
    - -> Molflow for pressure analysis
    - -> Ansys/Comsol for thermostructural analysis
  - Molflow – Monte-Carlo molecular gas flow
    - Convert Synrad data to outgassing map via material PSD curve
    - Define sticking probability, molecular mass, opacity
    - Calculate static pressure (no beam) and dynamic pressure (with beam)
    - Repeat for 4 main gases (H<sub>2</sub>, CO, CO<sub>2</sub> and CH<sub>4</sub>)
  - Matlab
    - Post-processing – weighted sums and average pressure, plots etc
  - Powerful, free, open source, well-optimised code (Synrad and Molflow)
  - Quirky user interface
  - Very labour intensive and prone to human error. Needs a lot of pre-processing and post-processing
  - Dipole and wiggler SR model correct, undulator model not correct
- 3D (2)
  - Comsol Multiphysics® can do ray tracing and molecular flow modelling in principle
  - Tricky to set up models with dipole sources etc and needs a powerful machine for larger models
  - Expensive commercial licensing and black box with hidden inner workings
  - Good for quick “what-ifs”

Synrad and Molflow courtesy of R. Kersevan/CERN

# 1D vacuum simulations (Option A – full NEG no A/C)

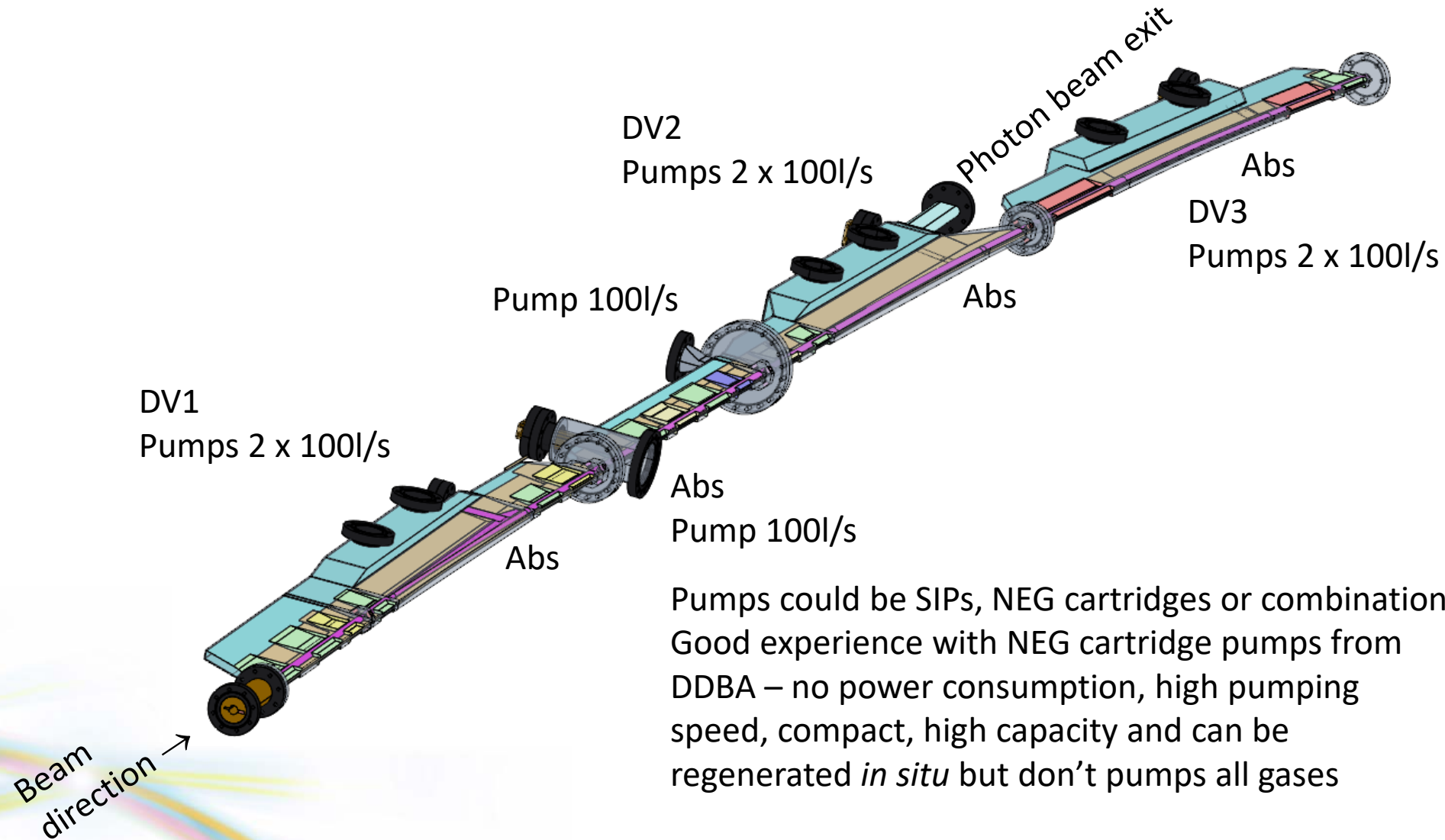
- Time to achieve  $10^{-9}$  mbar at 300 mA
  - Uncoated > 10000 A.h: (>7 years at 300 mA)
  - Fully-activated NEG coating: 6 A.h
  - Saturated NEG coating: 50 A.h
- Target < 100 A.h



CO-equivalent  $p$  at 300 mA vs distance and vs beam dose

Plan A design requires NEG coating due to small conductance of 20 mm diameter tube

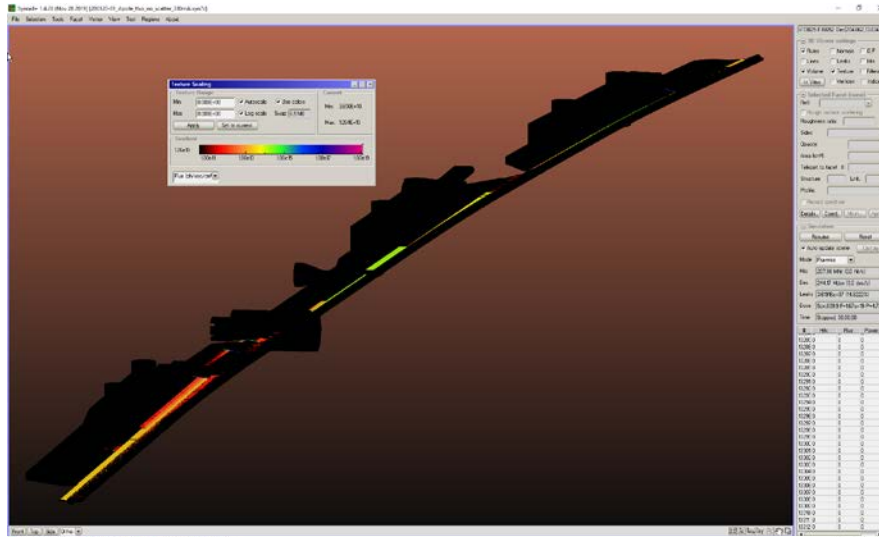
# 3D vacuum simulations (Option B - no NEG full A/C)



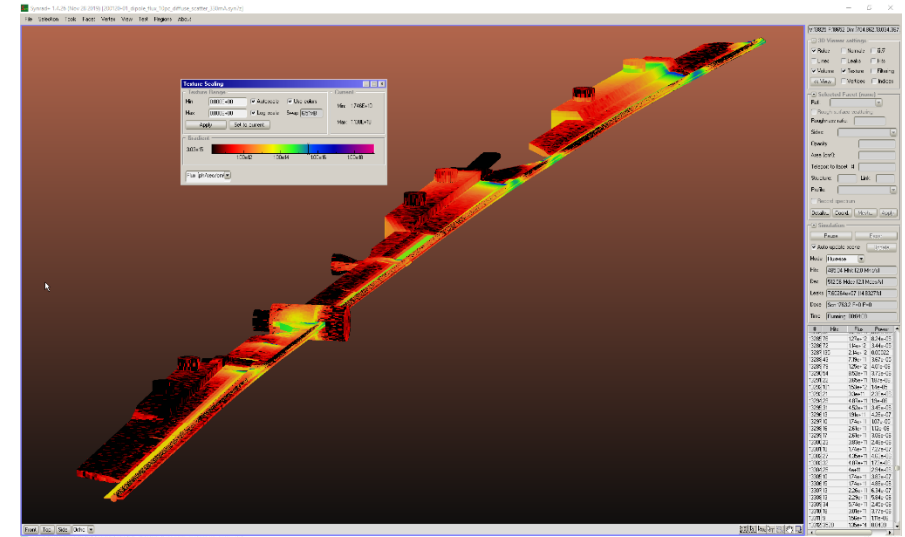
# Vacuum simulations (Option B) – photon flux on wall

Diffuse re-emission %

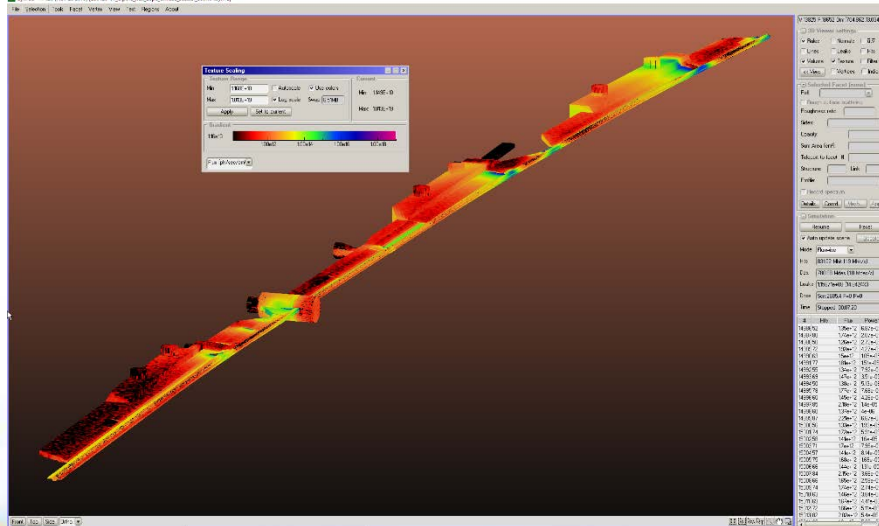
0%



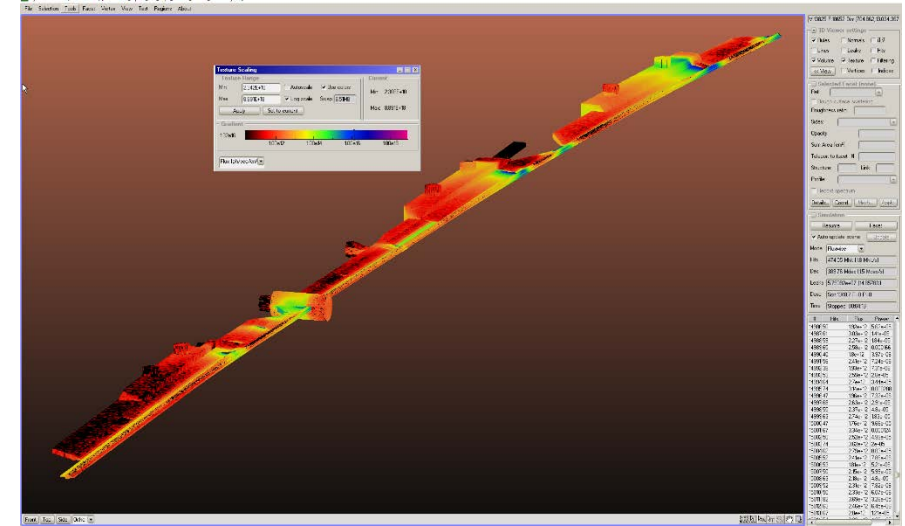
10%



20%

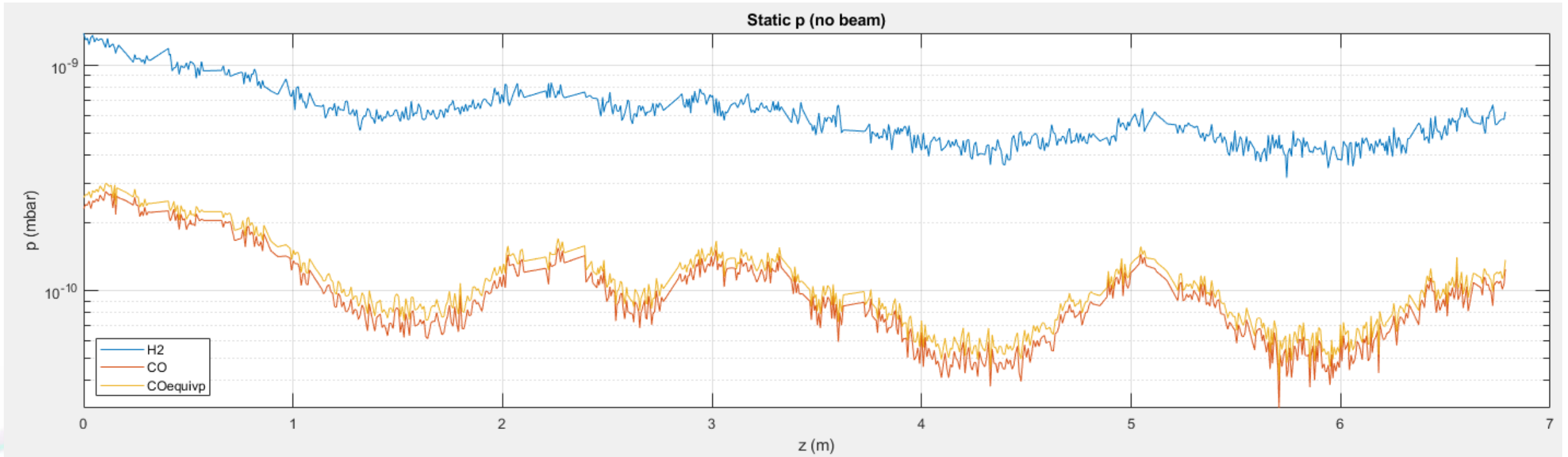
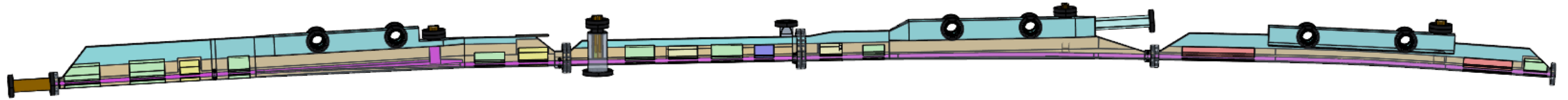


30%



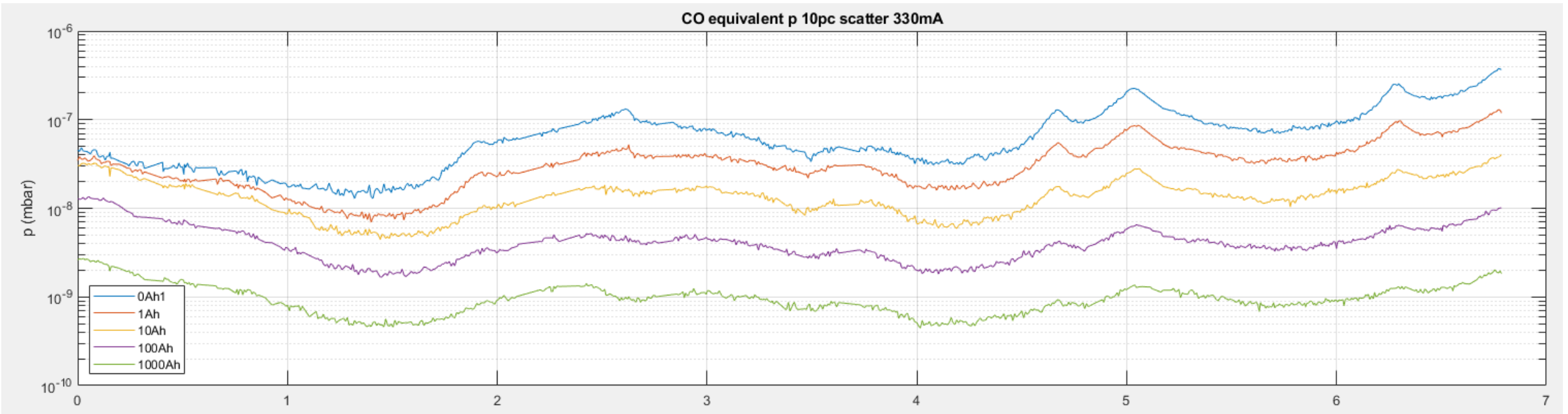
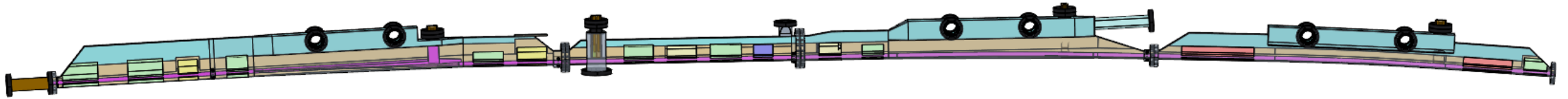
Synrad - most internal surfaces are significantly illuminated at a low level with 10% photon flux re-emission

# Vacuum simulations (Option B) – static pressure



Mean p: H<sub>2</sub>=6.3x10<sup>-10</sup>, CO=1.0x10<sup>-10</sup>, CO equiv p = 1.2x10<sup>-10</sup> mbar

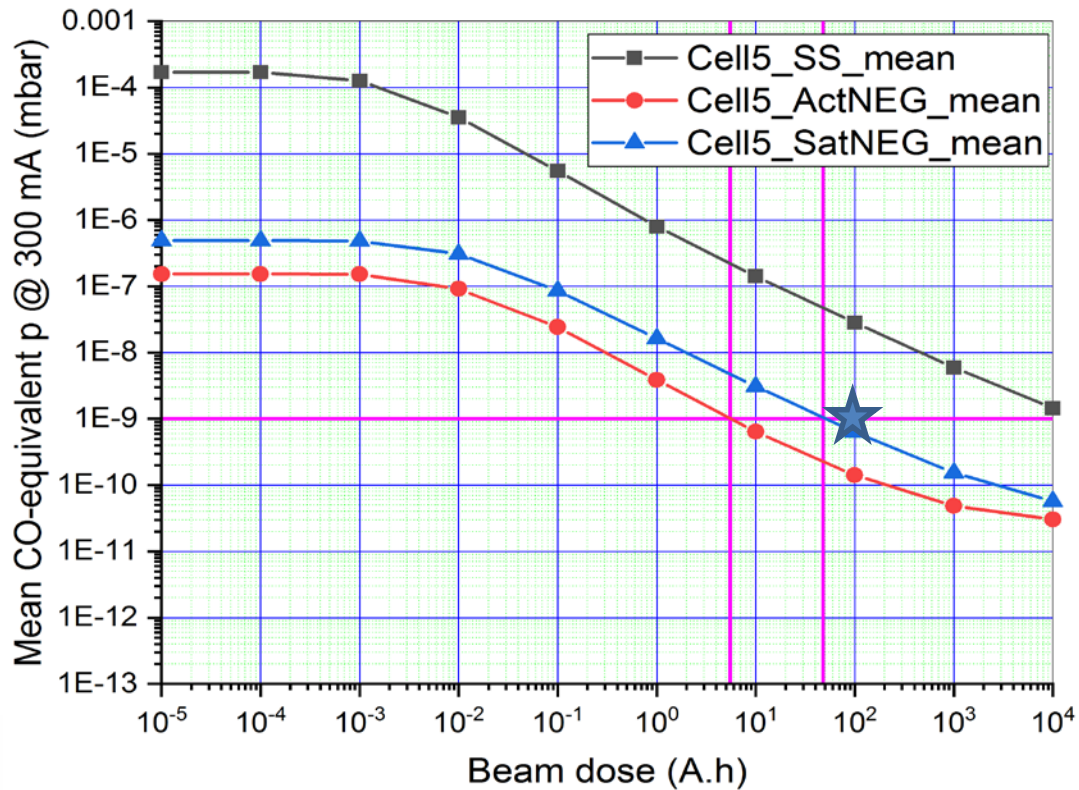
# Vacuum simulations (Option B) – dynamic pressure



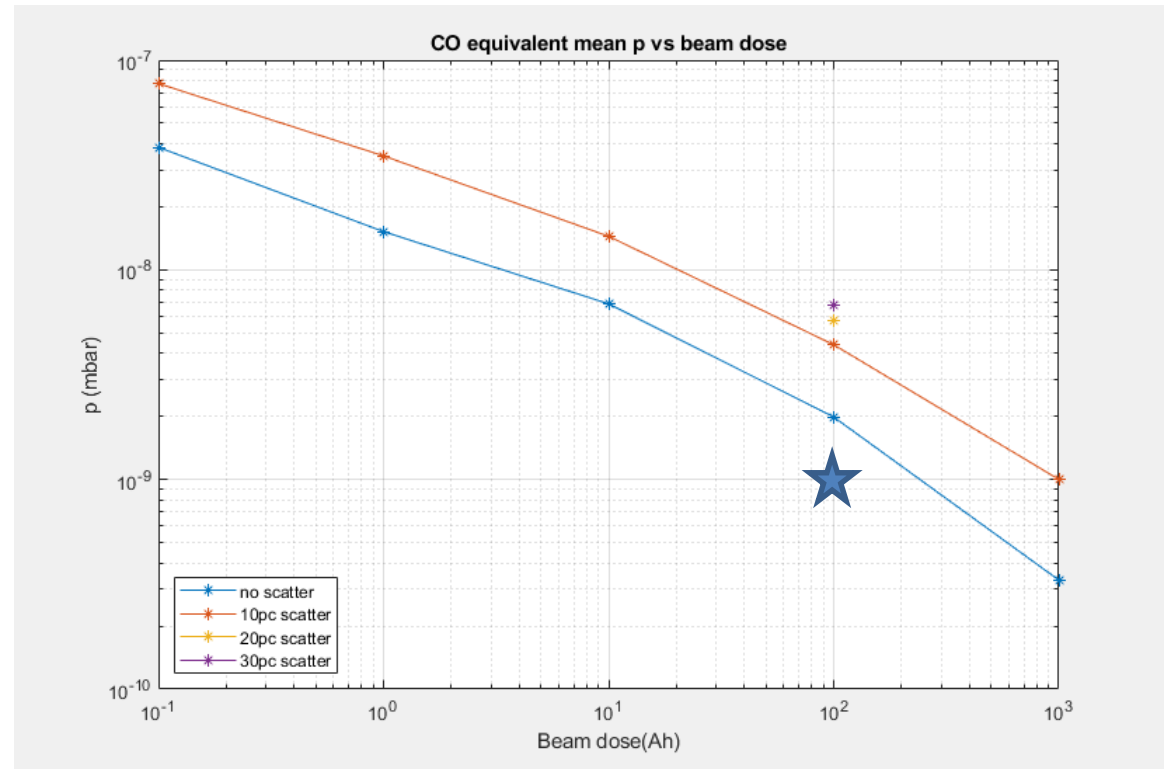
Mean p @ 330mA 100 Ah:  $H_2=1.8 \times 10^{-8}$ ,  $CO=4.0 \times 10^{-9}$ , CO equiv p =  $4.4 \times 10^{-9}$  mbar

# Option B summary

Plan A (NEG) – average includes straights



Plan B (no NEG) – average excludes straights

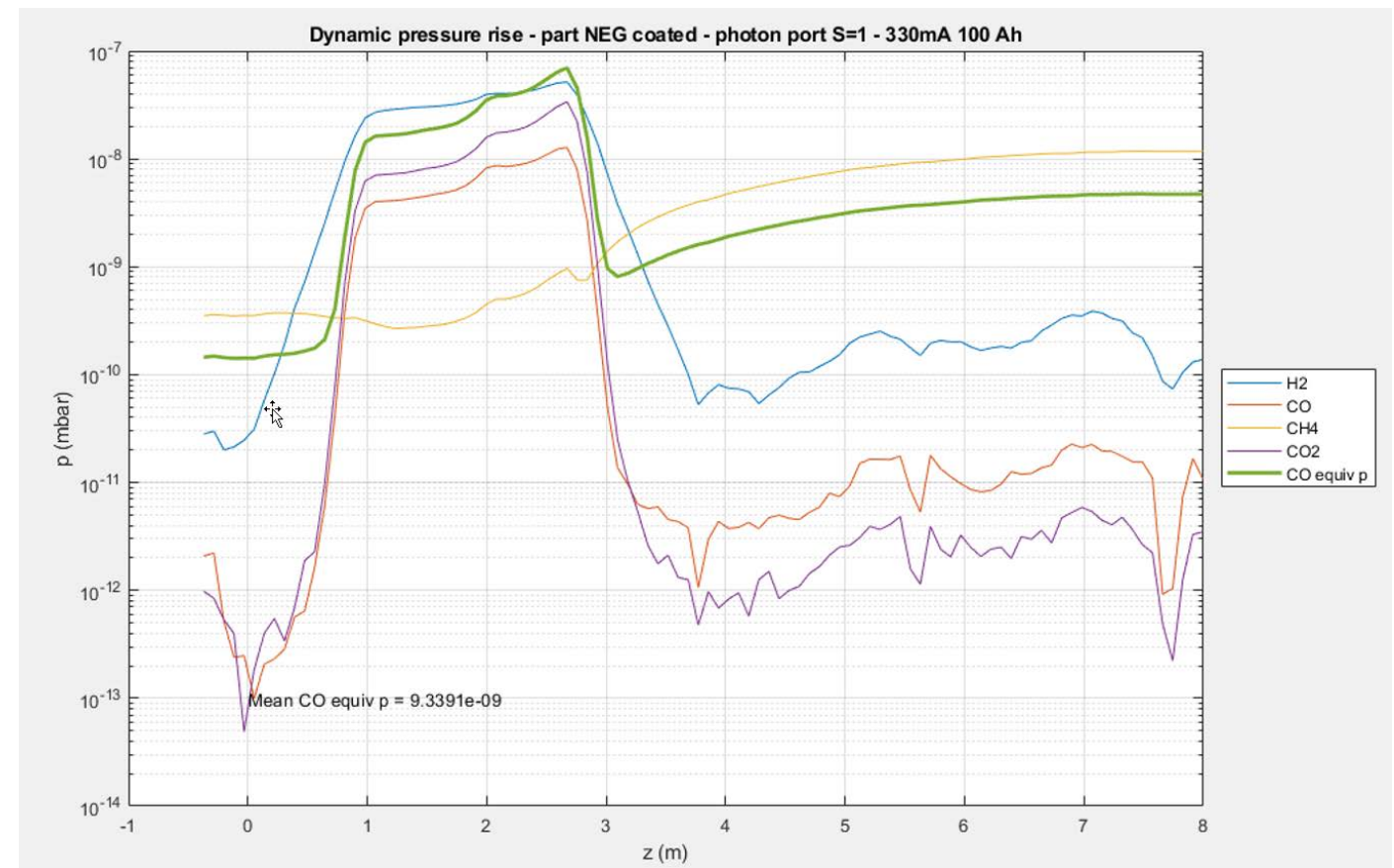
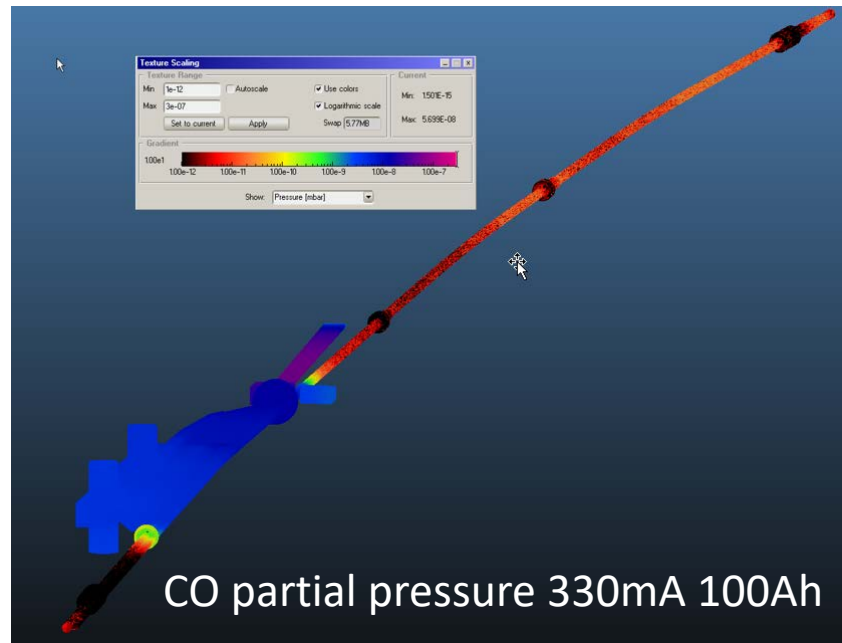
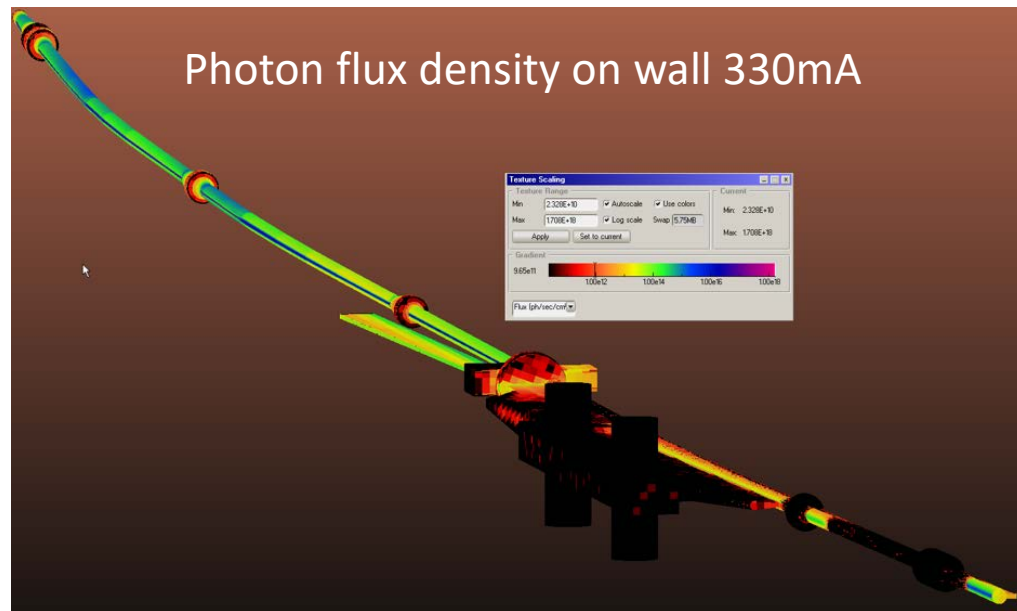


★ Target 10<sup>-9</sup> mbar at 100Ah conditioning

Plan A (narrow vessels – 20mm diameter tubes) requires distributed pumping (e.g. NEG coating) or the target 100h conditioning time is missed by >2 orders of magnitude. Plan B (antechamber design - iteration 0) misses the target 100h conditioning time by 1 order of magnitude but there is considerable scope for optimising the design.

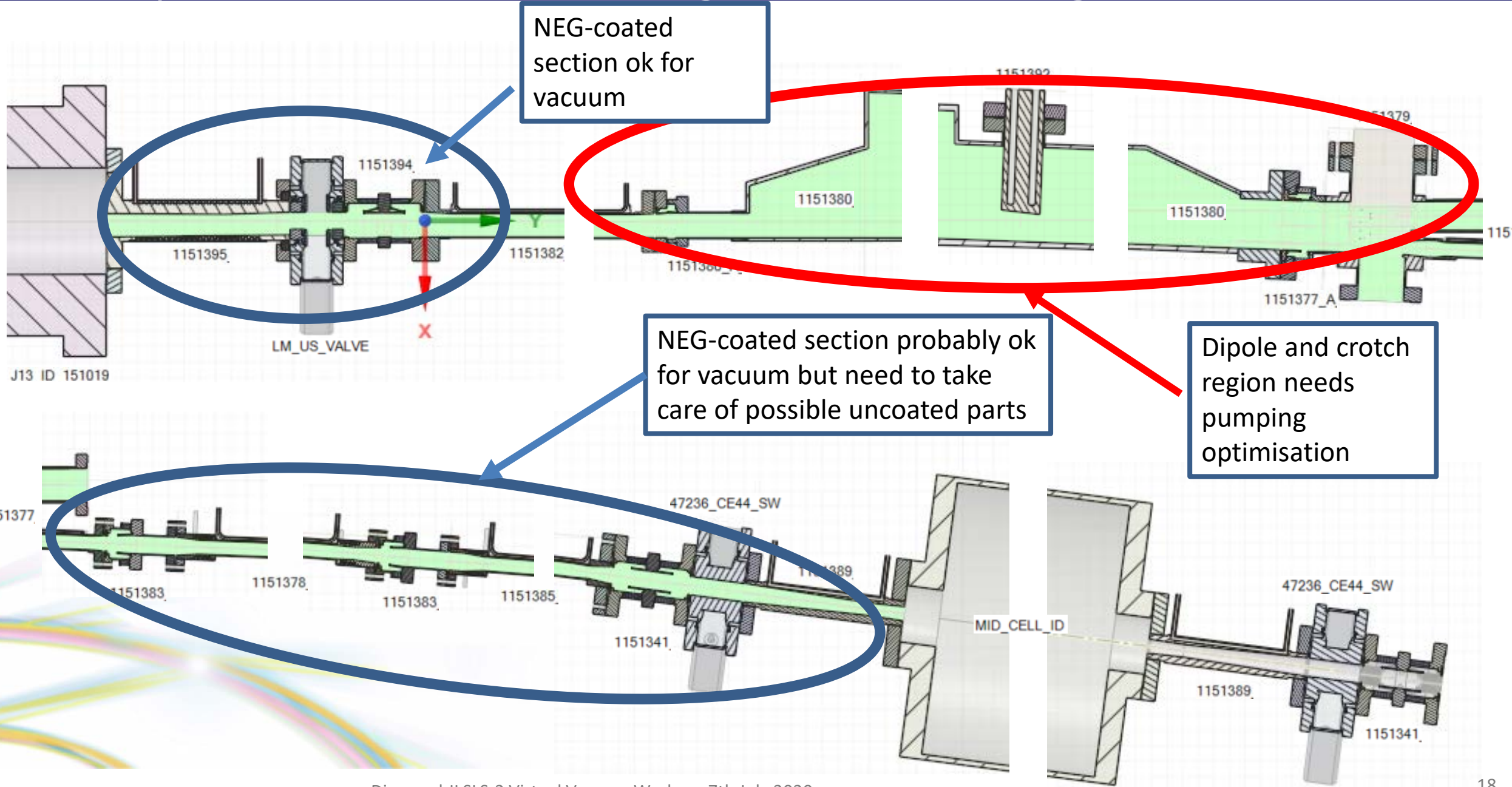


# 3D vacuum simulations (Option C - hybrid) Work in progress



- Design not yet optimised !!!!
- High active gas pressure in uncoated dipole/crotch region (high PSD yield of Aluminium + suboptimal pumping layout)
- High methane pressure in NEG-coated section (but neglects SR-induced wall pumping of NEG coating and end pumping from downstream section)

# Option C areas needing vacuum design iteration



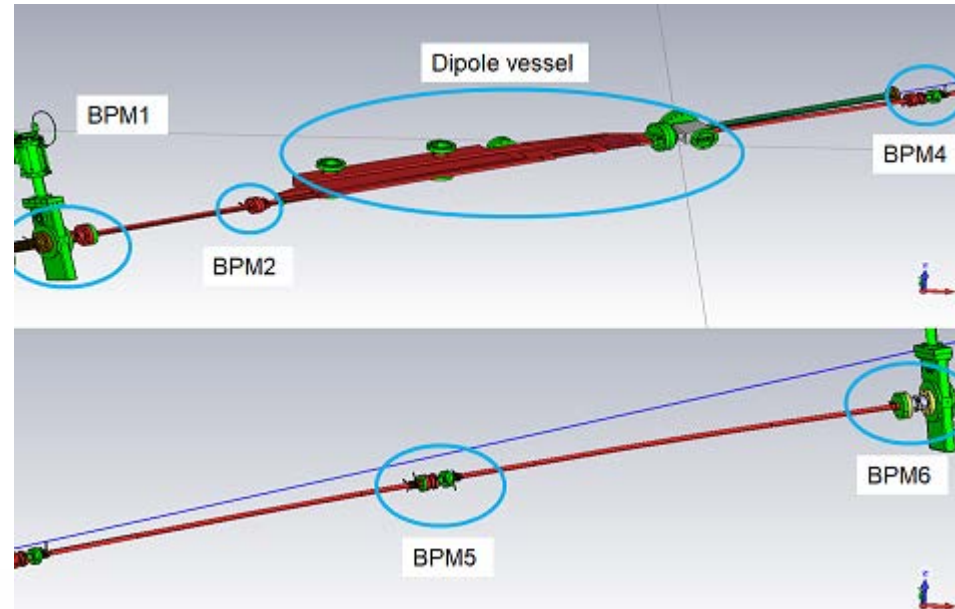
# Impedance effects

## Richard Fielder



# Impedance

- Component simulations using CST Studio
- 3 mm bunch length, 10 m wake calculated
- Identify main components for geometric impedance, plus resistive wall

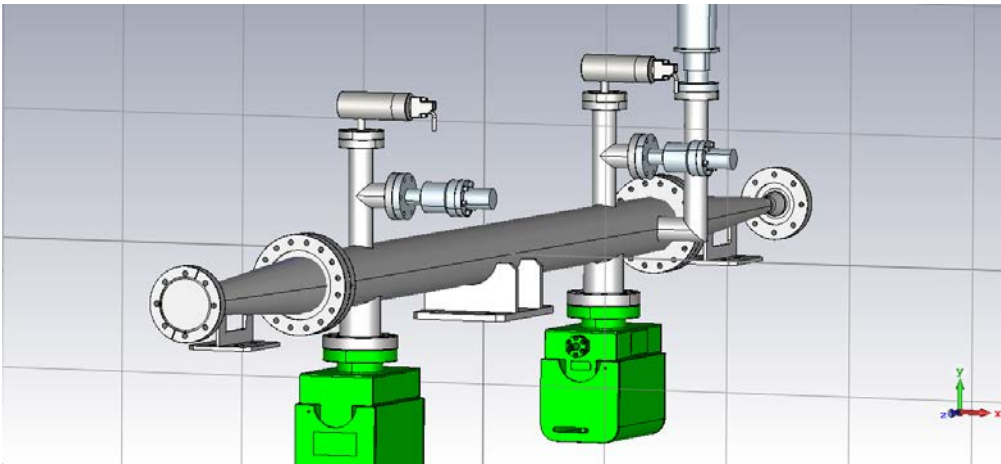


- Impedance used as input to mbtrack for instability tracking simulations
- No strict criteria for acceptance, need to calculate thresholds and iterate

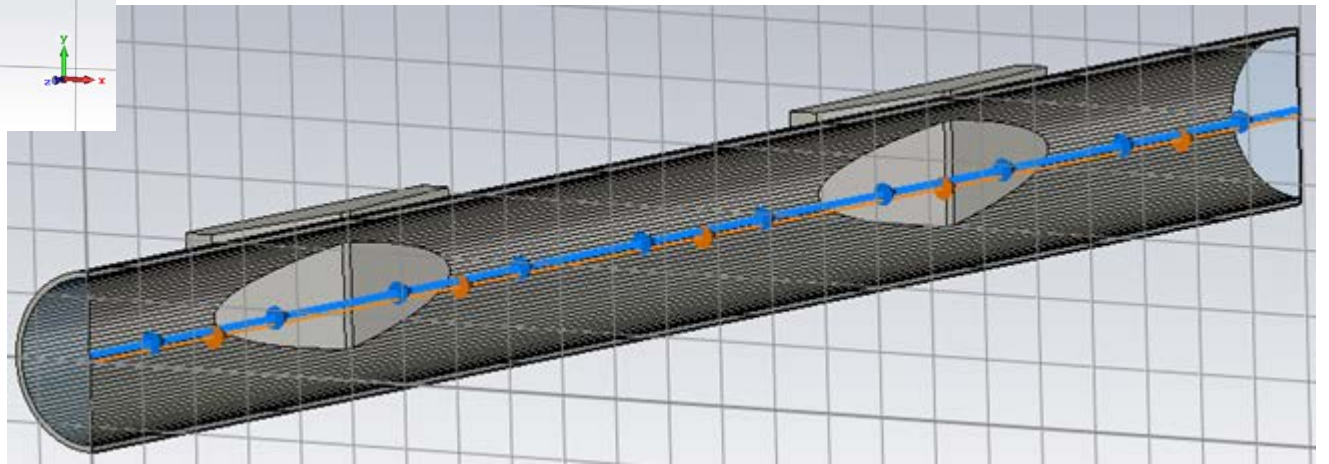
R. Fielder

# Mid-straight Makeup Vessel Impedance

- Constant radius pipe with shading bumps for synchrotron radiation.
- Much better than traditional large tapers and central vessel – factor  $\sim 20$  reduction in longitudinal even including increased resistive wall.
- Compared to cylindric tapers - factor of 2 worse in horizontal, but factor of 8 better in longitudinal and  $\sim 100$  in vertical.



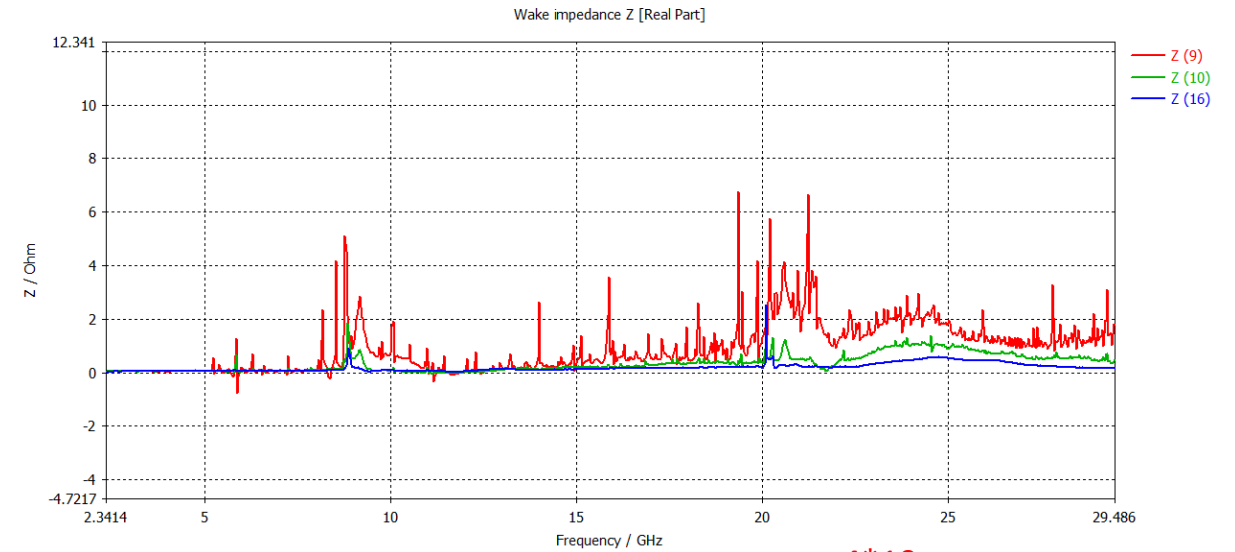
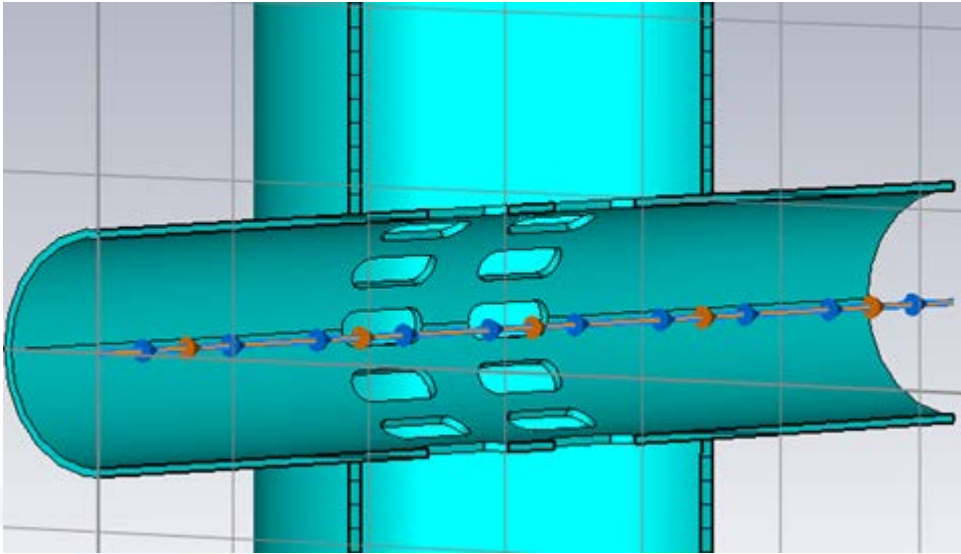
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# Mid-straight Pump Impedance

- Large reduction in impedance possible by making holes longer and thinner while keeping area constant.
- $k_z = 0.0116$  V/pC
- $k_z = 0.0042$  V/pC
- $k_z = 0.0026$  V/pC

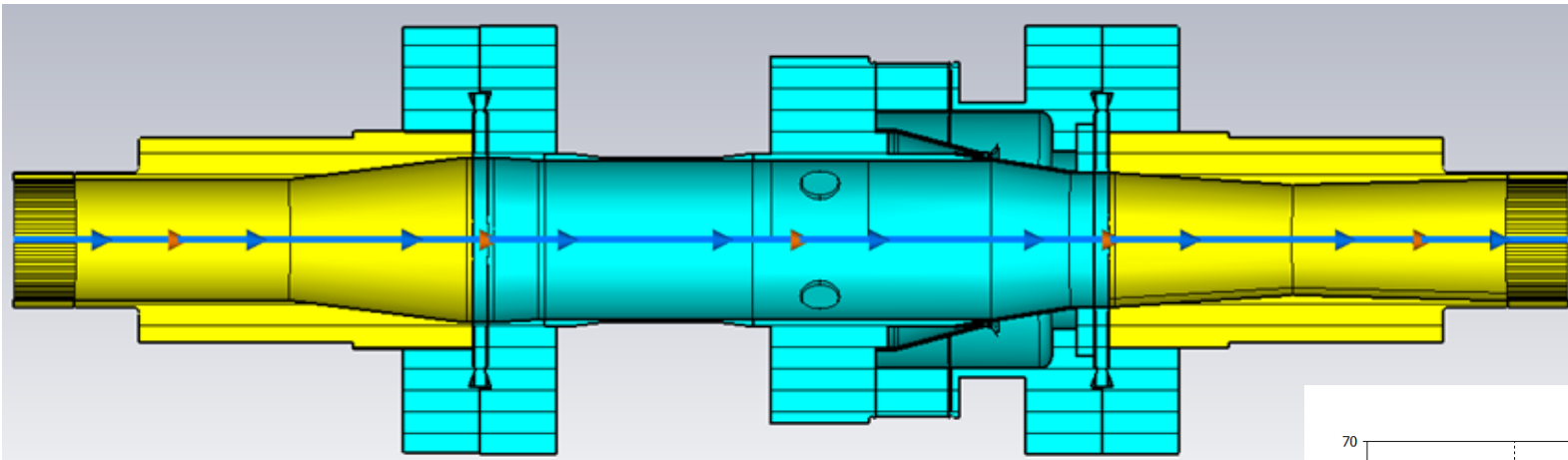
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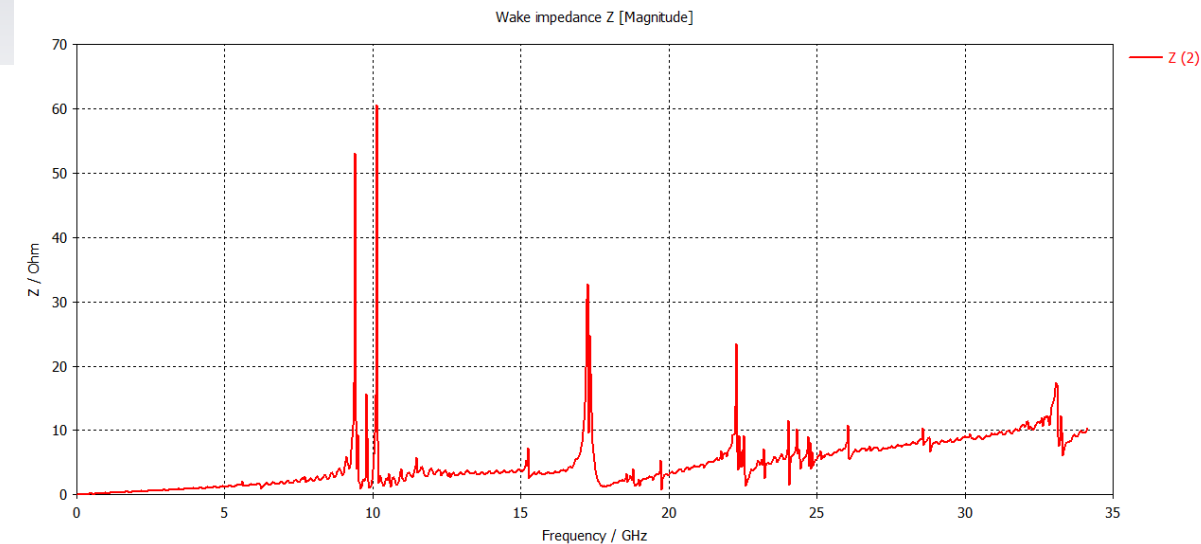
4\*10 mm  
3\*13.3 mm  
2.35\*17 mm

# BPM Impedance

- BPMs inside tapered section to avoid synchrotron radiation.
- Impedance factor of  $\sim 10$  worse than BPM block in isolation.
- 5 BPM assemblies with different taper and bellows details + 1 included in dipole vessel assembly.



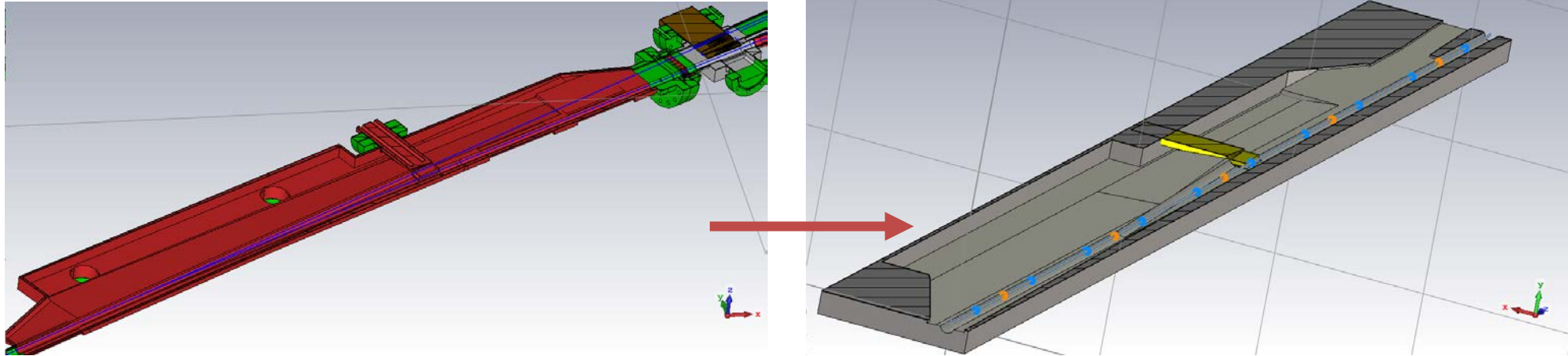
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# Dipole Vessel Impedance

- Large model, impossible to simulate curved particle beam.
- Create simplified model to assess impact of adding/removing each component
- Antechamber pumps, absorber, bellows, crotch absorber, BPM, pumping port

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- Large chamber and many transitions not good for impedance, but required for vacuum and radiation.

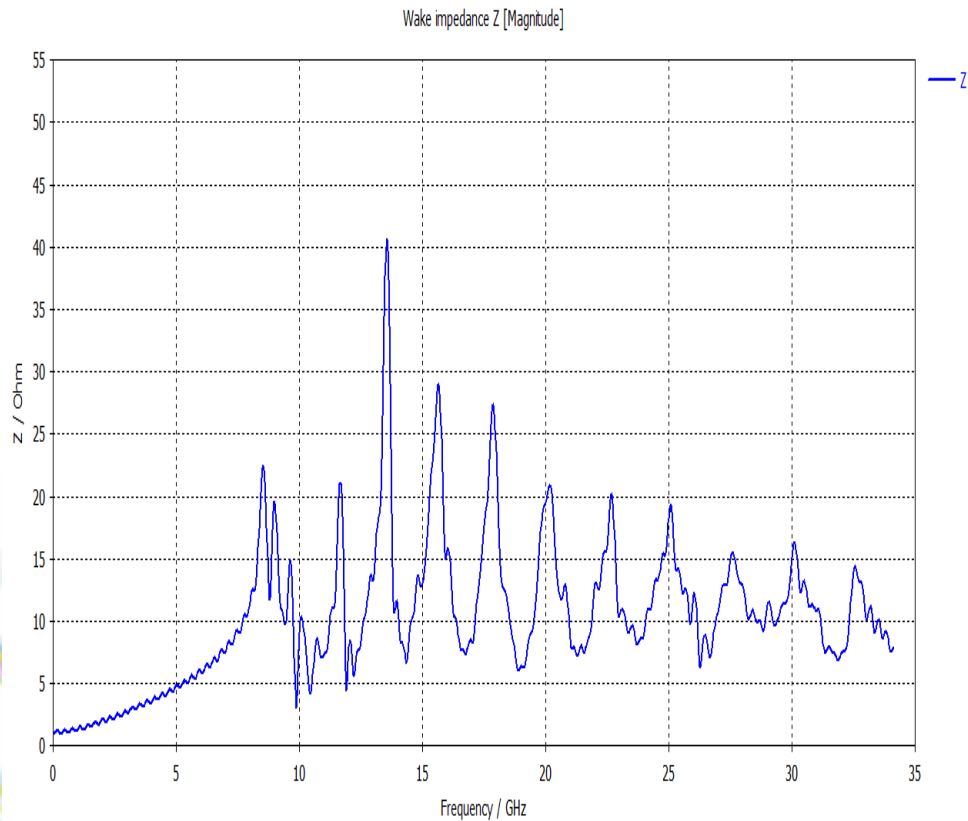


# Dipole Vessel Impedance

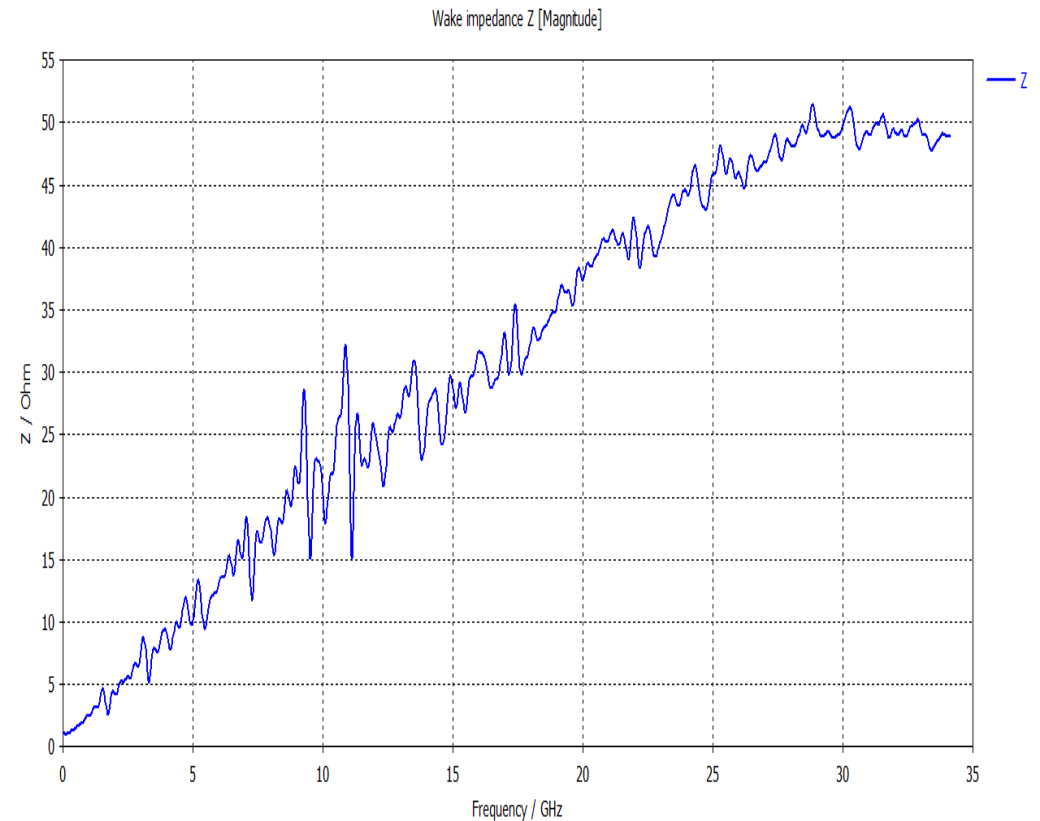
- Loss factor  $k_z = 0.09$  V/pC for bare vacuum vessel, PEC.
- $k_z = 0.10$  V/pC with copper absorber.

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Without absorber



With absorber

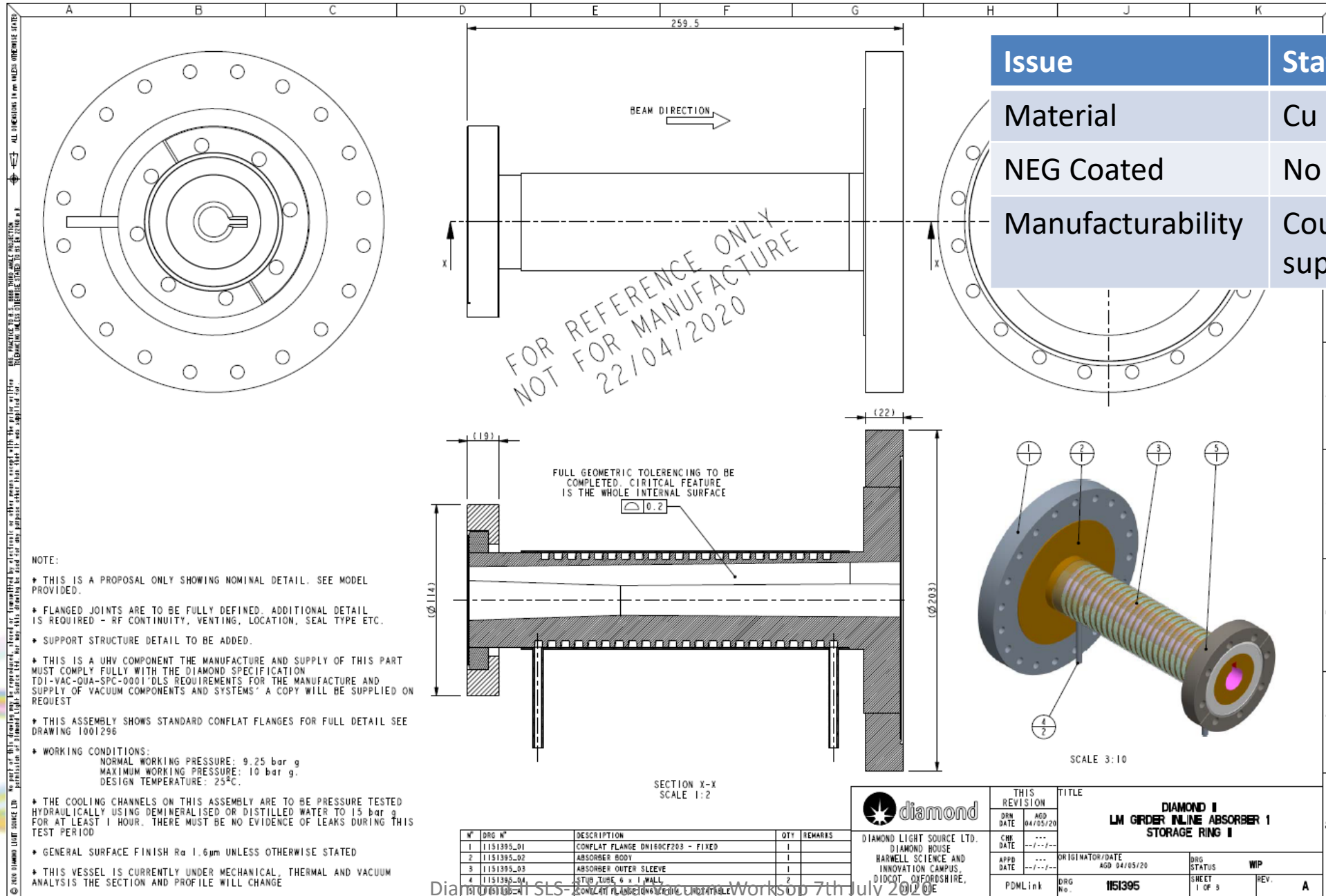


# Vessel manufacture and build

# Time plan: Vacuum vessels (constantly under review)

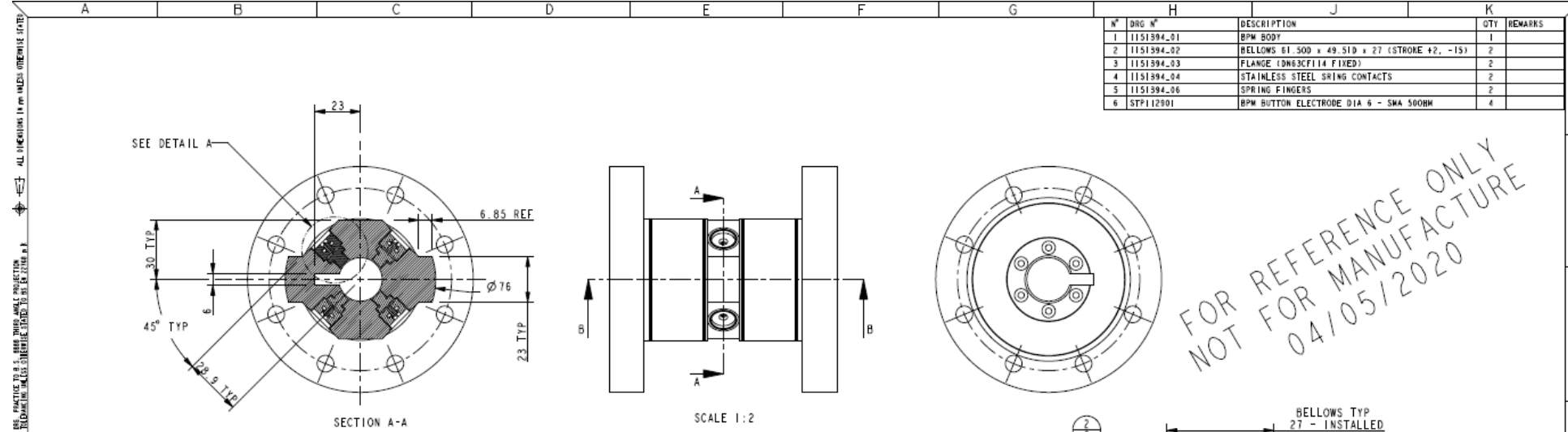
1 <sup>st</sup> Call for Tender for LM girder prototype vessels	Nov 2020
LM girder prototype vessels delivered including NEG coating	Oct 2021
LM girder prototype vessel evaluation complete	Jan 2022
1 <sup>st</sup> Call for Tender for series vessels (longest delivery items)	Mar 2022
1 <sup>st</sup> orders placed for series vessels	May 2022
Pre-series delivered	Dec 2023
Pre-series SATs complete	Feb 2024
Start to install pre-series vessels on the mock-up	Apr 2024
Start main girder assembly	Sep 2024
End of girder assembly	Sep 2025
Start of dark period	Dec 2025

# InLine Absorber 1 - 1151395



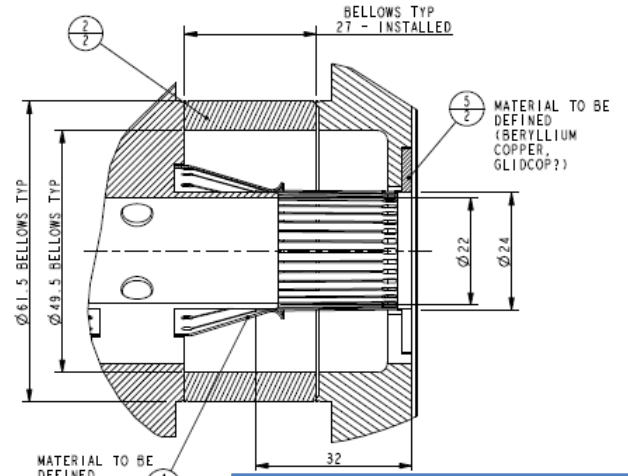
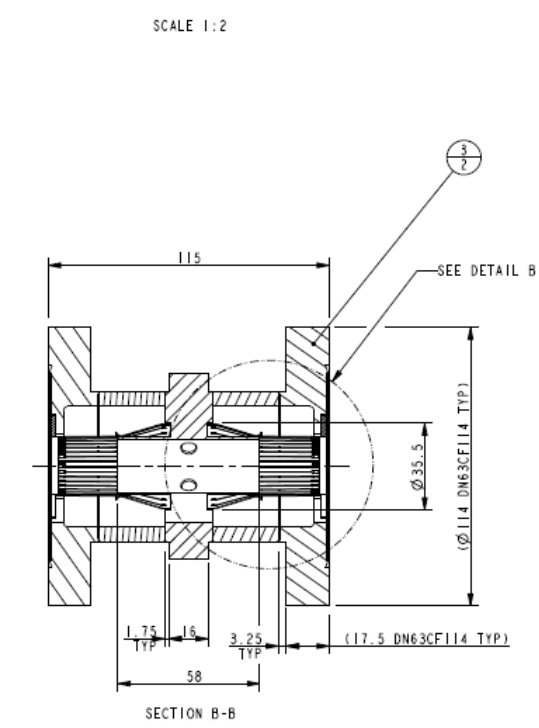
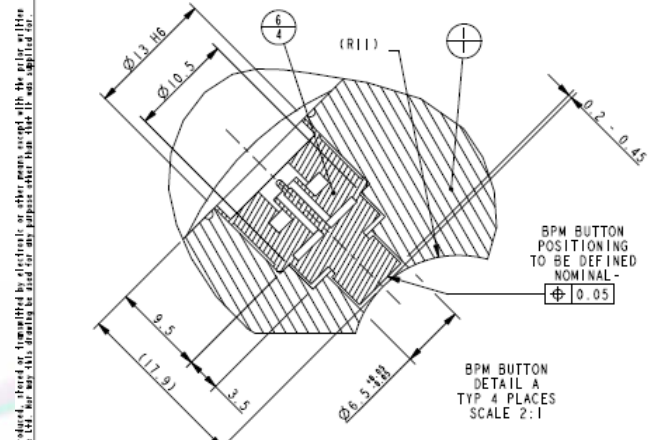
Issue	Status
Material	Cu OFS (Silver) or CuCrZr
NEG Coated	No
Manufacturability	Could be built by a range of suppliers

# PBPM Assy - 1151394



#	DRG #	DESCRIPTION	QTY	REMARKS
1	1151394_01	BPM BODY	1	
2	1151394_02	BELLOWS 61.500 x 49.510 x 27 (STROKE +2, -15)	2	
3	1151394_03	FLANGE (DN63CF114 FIXED)	2	
4	1151394_04	STAINLESS STEEL SPRING CONTACTS	2	
5	1151394_06	SPRING FINGERS	2	
6	STP12901	BPM BUTTON ELECTRODE DIA 6 - SKA 500HM	4	

FOR REFERENCE ONLY  
NOT FOR MANUFACTURE  
04/05/2020



- NOTE:
- THIS IS A PROPOSAL ONLY SHOWING NOMINAL DETAIL. SEE MODEL PROVIDED.
  - FLANGED JOINTS ARE TO BE FULLY DEFINED. ADDITIONAL DETAIL IS REQUIRED - RF CONTINUITY, VENTING, LOCATION, SEAL TYPE ETC.
  - SUPPORT STRUCTURE DETAIL TO BE ADDED.
  - THIS IS A UHV COMPONENT THE MANUFACTURE AND SUPPLY OF THIS PART MUST COMPLY FULLY WITH THE DIAMOND SPECIFICATION TD1-VAC-QUA-SPC-0001 'DLS REQUIREMENTS FOR THE MANUFACTURE AND SUPPLY OF VACUUM COMPONENTS AND SYSTEMS' A COPY WILL BE SUPPLIED ON REQUEST
  - THIS ASSEMBLY SHOWS STANDARD CONFLAT FLANGES FOR FULL DETAIL SEE DRAWING 1001296.
  - GENERAL SURFACE FINISH Ra 1.6µm UNLESS OTHERWISE STATED
  - THIS VESSEL IS CURRENTLY UNDER MECHANICAL, THERMAL AND VACUUM ANALYSIS THE SECTION AND PROFILE WILL CHANGE

Issue	Status
Material	St Steel with CuBe fingers
NEG Coated	No
Manufacturability	Concept design only

**diamond**  
DIAMOND LIGHT SOURCE LTD.  
DIAMOND HOUSE  
HARWELL SCIENCE AND INNOVATION CAMPUS  
OXFORDSHIRE, OX11 0DE

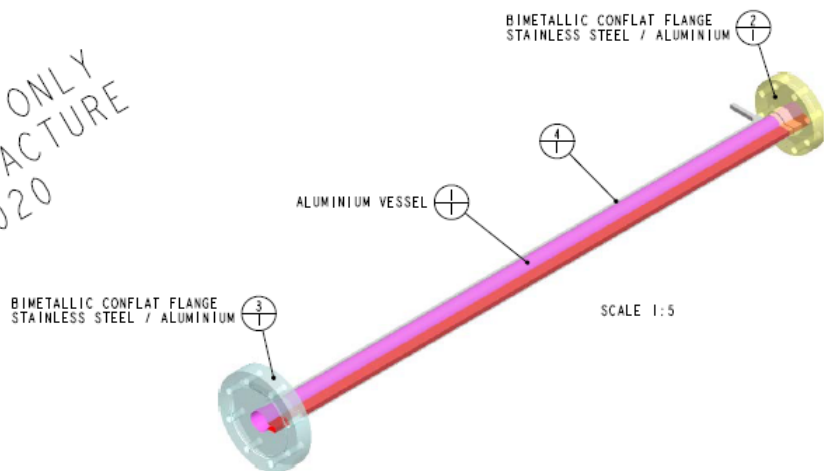
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APP DATE: [ ]

PDMLink No: **1151394**

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# Vessel 1 - 1151382

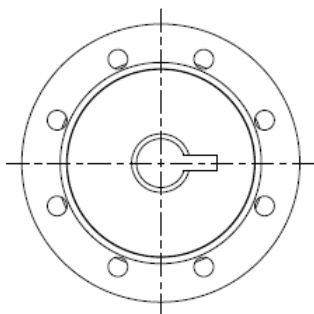
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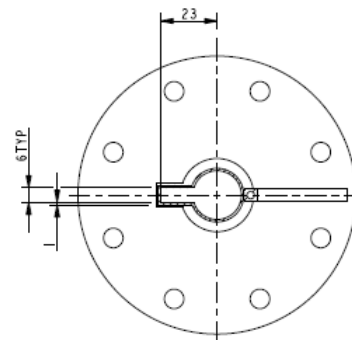
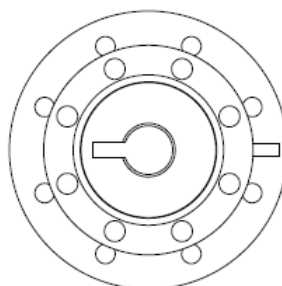
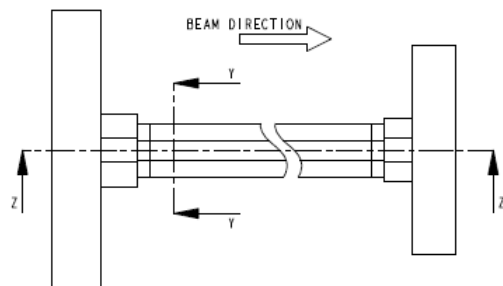
N°	DRG N°	DESCRIPTION	QTY	REMARKS
1	1151382.01	ALUMINIUM KEYHOLE VESSEL	1	
2	1151382.02	BIMETALLIC CONFLAT DN40CF70 FIXED	1	
3	1151382.03	BIMETALLIC CONFLAT DN63CF114 FIXED	1	
4	1151382.04	COOLING TUBE	1	

NOTE:

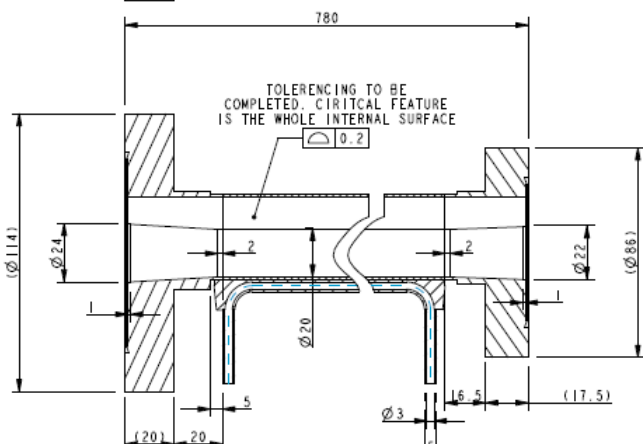
- THIS IS A PROPOSAL ONLY SHOWING NOMINAL DETAIL. SEE MODEL PROVIDED.
- FLANGED JOINTS ARE TO BE FULLY DEFINED. ADDITIONAL DETAIL IS REQUIRED - RF CONTINUITY, VENTING, LOCATION, SEAL TYPE ETC.
- SUPPORT STRUCTURE DETAIL TO BE ADDED.
- THIS IS A UHV COMPONENT THE MANUFACTURE AND SUPPLY OF THIS PART MUST COMPLY FULLY WITH THE DIAMOND SPECIFICATION TD1-VAC-DUA-SPC-0001 'DLS REQUIREMENTS FOR THE MANUFACTURE AND SUPPLY OF VACUUM COMPONENTS AND SYSTEMS' A COPY WILL BE SUPPLIED ON REQUEST
- THIS ASSEMBLY SHOWS STANDARD CONFLAT FLANGES FOR FULL DETAIL SEE DRAWING 1001296.
- GENERAL SURFACE FINISH  $R_a 1.6\mu m$  UNLESS OTHERWISE STATED
- THIS VESSEL IS CURRENTLY UNDER MECHANICAL, THERMAL AND VACUUM ANALYSIS THE SECTION AND PROFILE WILL CHANGE



SCALE 1:2



NOMINAL VESSEL SECTION



TOLERANCING TO BE COMPLETED. CRITICAL FEATURE IS THE WHOLE INTERNAL SURFACE

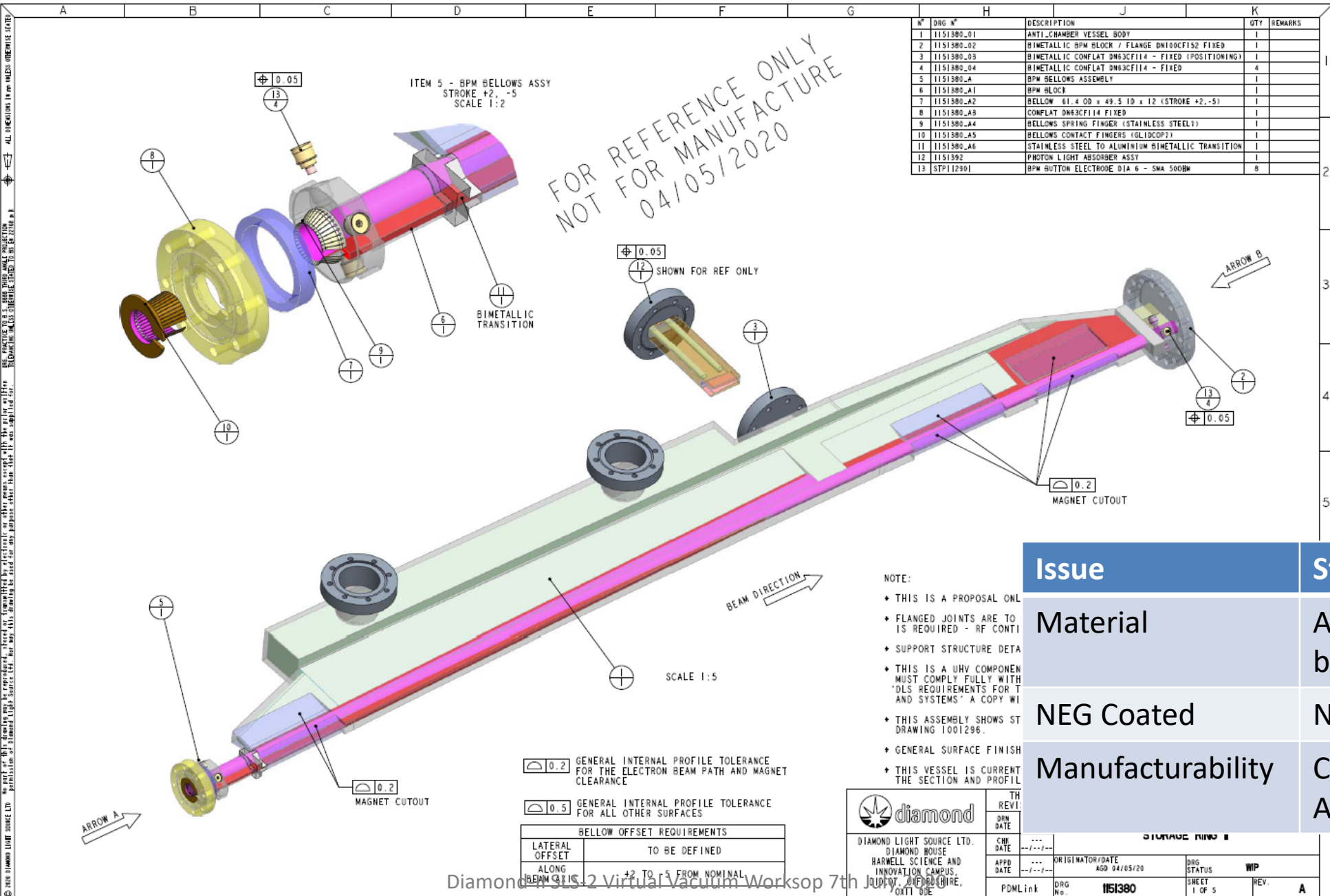


Issue	Status
Material	Aluminium / Cu TBD
NEG Coated	Yes probably
Manufacturability	Could be built by a range of suppliers

DATE	AGD 04/05/20	STATUS	WIP
PDMLink	DRG No. 1151382	SHEET 1 OF 1	REV. A



# Vessel 2 (DL Dipole 1)- 1151380



Issue	Status
Material	Aluminium with explosion bonded flanges
NEG Coated	No
Manufacturability	Could be built by specialist Aluminium vessel suppliers

**diamond**

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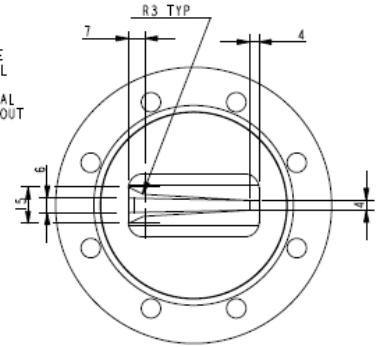
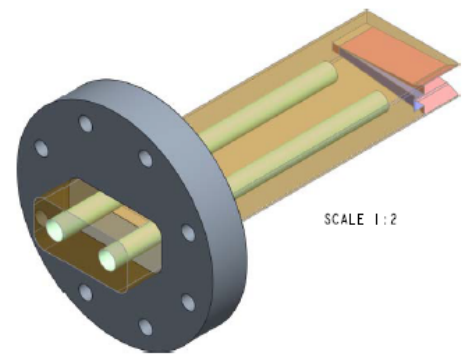
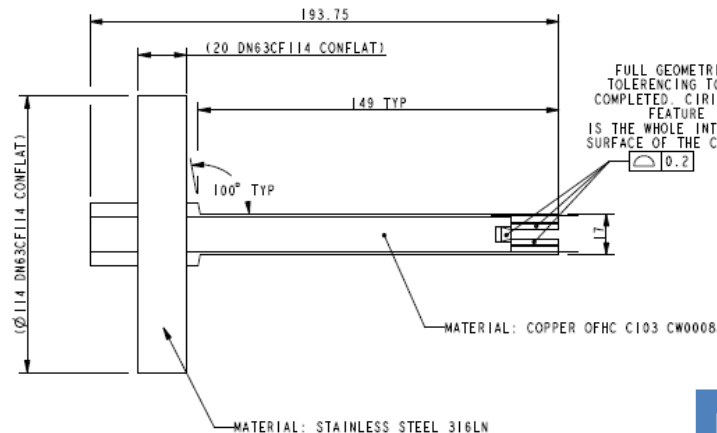
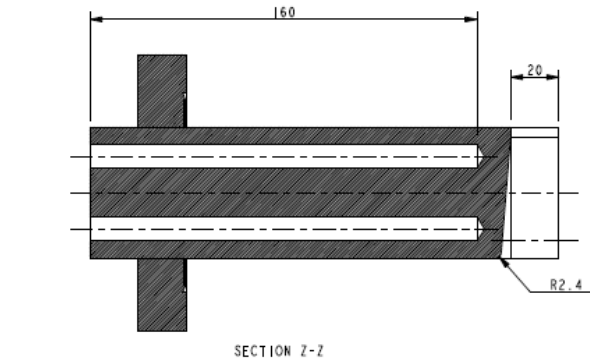
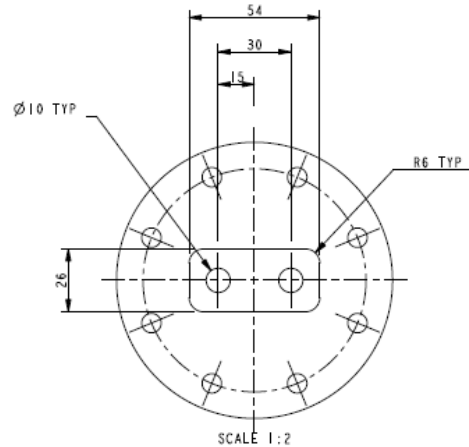
TH REV: 1  
DRN DATE: 04/05/20  
CHG DATE: 04/05/20  
APPD DATE: 04/05/20

ORIGINATOR/DATE: AGD 04/05/20  
DRG STATUS: WIP  
SHEET 1 OF 5  
REV: A

PDMLink: DRG No. 1151380

# Photon Light Absorber - 1151392

FOR REFERENCE ONLY  
NOT FOR MANUFACTURE  
12/05/2020



N°	DRG N°	DESCRIPTION	QTY	REMARKS
1	1151392_01	ABSORBER BLOCK - STRAIGHT 13	1	
2	1151392_02	CONFLAT FLANGE DN63CF114 - FIXED	1	

- NOTE:
- THIS IS A PROPOSAL ONLY SHOWING NOMINAL DETAIL. SEE MODEL PROVIDED.
  - FLANGED JOINTS ARE TO BE FULLY DEFINED. ADDITIONAL DETAIL IS REQUIRED - RF CONTINUITY, VENTING, LOCATION, SEAL TYPE ETC.
  - SUPPORT STRUCTURE DETAIL TO BE ADDED.
  - THIS IS A UHV COMPONENT THE MANUFACTURE AND SUPPLY OF THIS PART MUST COMPLY FULLY WITH THE DIAMOND SPECIFICATION TDI-VAC-QUA-SPC-0001 DLS REQUIREMENTS FOR THE MANUFACTURE AND SUPPLY OF VACUUM COMPONENTS AND SYSTEMS. A COPY WILL BE SUPPLIED ON REQUEST.
  - THIS ASSEMBLY SHOWS STANDARD CONFLAT FLANGES FOR FULL DETAIL SEE DRAWING 1001296
  - WORKING CONDITIONS:
    - NORMAL WORKING PRESSURE: 9.25 bar g
    - MAXIMUM WORKING PRESSURE: 10 bar g.
    - DESIGN TEMPERATURE: 25°C.
  - THE COOLING CHANNELS ON THIS ASSEMBLY ARE TO BE PRESSURE TESTED HYDRAULICALLY USING DEMINERALISED OR DISTILLED WATER TO 15 bar g FOR AT LEAST 1 HOUR. THERE MUST BE NO EVIDENCE OF LEAKS DURING THIS TEST PERIOD
  - GENERAL SURFACE FINISH Ra 1.6µm UNLESS OTHERWISE STATED
  - THIS VESSEL IS CURRENTLY UNDER MECHANICAL, THERMAL AND VACUUM ANALYSIS THE SECTION AND PROFILE WILL CHANGE

Issue	Status
Material	CuOFS (Silver) or CuCrZr
NEG Coated	No
Manufacturability	Could be built by a range of suppliers

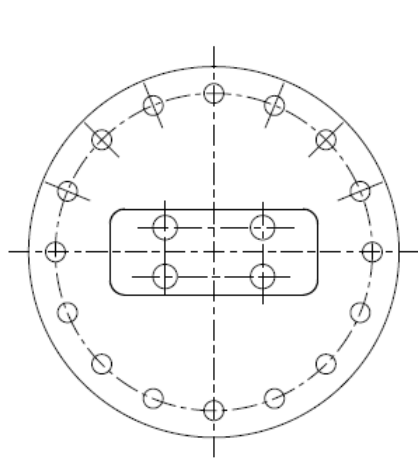


DATE	AGD 12/05/20	STATUS	WIP
PDMLink	DRG No. 1151392	SHEET	1 OF 1
		REV.	A

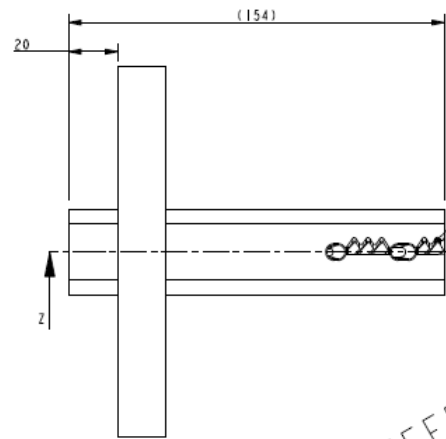




# Cell 13 Crotch absorber - 1151379

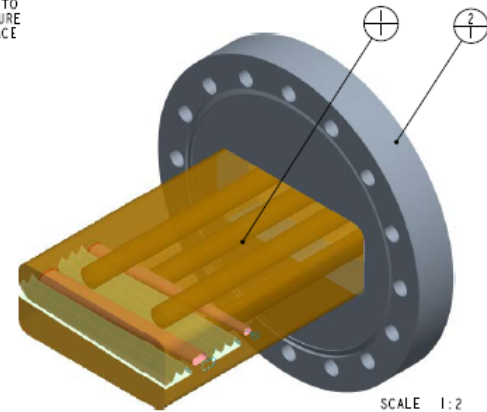


SCALE 1:2



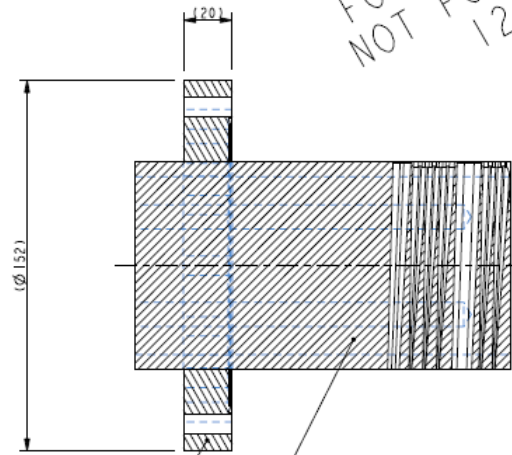
FULL GEOMETRIC TOLERANCING TO BE COMPLETED. CRITICAL FEATURE IS THE WHOLE INTERNAL SURFACE OF THE CUT OUT

0.2



SCALE 1:2

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NOT FOR MANUFACTURE  
12/05/2020



MATERIAL: STAINLESS STEEL 316LN  
MATERIAL: COPPER OFHC C103 CW0008A

NOTE:

- THIS IS A PROPOSAL ONLY SHOWING NOMINAL DIMENSIONS
- FLANGED JOINTS ARE TO BE FULLY DEFINED INCLUDING VENTING, LOCATION, SEAL TYPE ETC.
- SUPPORT STRUCTURE DETAIL TO BE ADDED.
- THIS IS A UHV COMPONENT THE MANUFACTURE TO BE TO THE DIAMOND SPECIFICATION TD1-VAC-QUA-SPC-00 VACUUM COMPONENTS AND SYSTEMS' A COPY WILL BE PROVIDED
- THIS ASSEMBLY SHOWS STANDARD CONFLAT JOINTS
- WORKING CONDITIONS:  
NORMAL WORKING PRESSURE: 9.0E-5 mbar  
MAXIMUM WORKING PRESSURE: 1.0E-4 mbar  
DESIGN TEMPERATURE: 25°C.
- THE COOLING CHANNELS ON THIS ASSEMBLY WILL BE MINERALISED OR DISTILLED WATER TO 15 BAR
- GENERAL SURFACE FINISH Ra 1.6µm UNLESS OTHERWISE SPECIFIED
- THIS VESSEL IS CURRENTLY UNDER MECHANICAL DESIGN

N°	DRG N°	DESCRIPTION	QTY	REMARKS
1	1151379_1	ABSORBER BLOCK - STRAIGHT 13	1	
2	1151379_2	CONFLAT FLANGE DN100CF132	1	

Issue	Status
Material	CuOFS (Silver) or CuCrZr
NEG Coated	No
Manufacturability	Design may change to vertical flange above Could be built by a range of suppliers

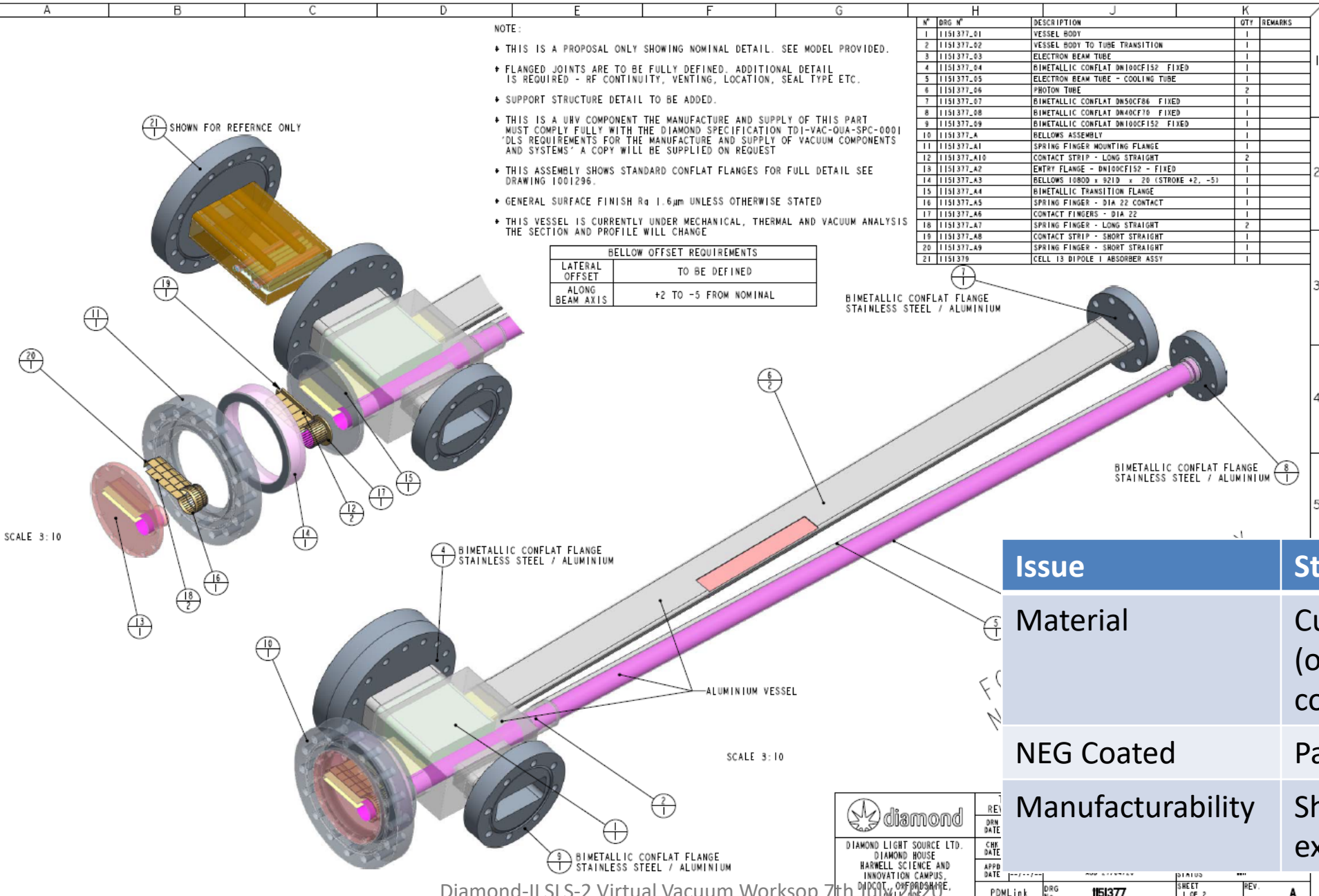


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DIDCOT, OXFORDSHIRE,  
OX11 0DE

DATE	---	ORIGINATOR/DATE	AGD 12/05/20	DRG STATUS	WIP
APPD DATE	---				
PDMLink		DRG No.	1151379	SHEET	1 OF 4
				REV.	A

# Vessel 3 (Crotch) - 1151377

ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED  
 THIS DRAWING IS THE PROPERTY OF DIAMOND LIGHT SOURCE LTD. IT IS TO BE USED ONLY FOR THE PROJECT AND NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM.



**NOTE:**

- THIS IS A PROPOSAL ONLY SHOWING NOMINAL DETAIL. SEE MODEL PROVIDED.
- FLANGED JOINTS ARE TO BE FULLY DEFINED. ADDITIONAL DETAIL IS REQUIRED - RF CONTINUITY, VENTING, LOCATION, SEAL TYPE ETC.
- SUPPORT STRUCTURE DETAIL TO BE ADDED.
- THIS IS A UHV COMPONENT THE MANUFACTURE AND SUPPLY OF THIS PART MUST COMPLY FULLY WITH THE DIAMOND SPECIFICATION TD1-VAC-OVA-SPC-0001 'DLS REQUIREMENTS FOR THE MANUFACTURE AND SUPPLY OF VACUUM COMPONENTS AND SYSTEMS' A COPY WILL BE SUPPLIED ON REQUEST
- THIS ASSEMBLY SHOWS STANDARD CONFLAT FLANGES FOR FULL DETAIL SEE DRAWING 1001296.
- GENERAL SURFACE FINISH  $R_a$  1.6  $\mu\text{m}$  UNLESS OTHERWISE STATED
- THIS VESSEL IS CURRENTLY UNDER MECHANICAL, THERMAL AND VACUUM ANALYSIS THE SECTION AND PROFILE WILL CHANGE

BELLOW OFFSET REQUIREMENTS	
LATERAL OFFSET	TO BE DEFINED
ALONG BEAM AXIS	+2 TO -5 FROM NOMINAL

N°	DRG N°	DESCRIPTION	QTY	REMARKS
1	1151377_01	VESSEL BODY	1	
2	1151377_02	VESSEL BODY TO TUBE TRANSITION	1	
3	1151377_03	ELECTRON BEAM TUBE	1	
4	1151377_04	BIMETALLIC CONFLAT DN100CF152 FIXED	1	
5	1151377_05	ELECTRON BEAM TUBE - COOLING TUBE	1	
6	1151377_06	PHOTON TUBE	2	
7	1151377_07	BIMETALLIC CONFLAT DN50CF86 FIXED	1	
8	1151377_08	BIMETALLIC CONFLAT DN40CF70 FIXED	1	
9	1151377_09	BIMETALLIC CONFLAT DN100CF152 FIXED	1	
10	1151377_A	BELLOWS ASSEMBLY	1	
11	1151377_A1	SPRING FINGER MOUNTING FLANGE	1	
12	1151377_A10	CONTACT STRIP - LONG STRAIGHT	2	
13	1151377_A2	ENTRY FLANGE - DN100CF152 - FIXED	1	
14	1151377_A3	BELLOWS 1000 x 9210 x 20 (STROKE +2, -5)	1	
15	1151377_A4	BIMETALLIC TRANSITION FLANGE	1	
16	1151377_A5	SPRING FINGER - DIA 22 CONTACT	1	
17	1151377_A6	CONTACT FINGERS - DIA 22	1	
18	1151377_A7	SPRING FINGER - LONG STRAIGHT	2	
19	1151377_A8	CONTACT STRIP - SHORT STRAIGHT	1	
20	1151377_A9	SPRING FINGER - SHORT STRAIGHT	1	
21	1151377_B	CELL 13 DIPOLE 1 ABSORBER ASSY	1	

Issue	Status
Material	Currently Aluminium (option all copper or copper/stainless )
NEG Coated	Partly
Manufacturability	Should be makeable by experienced suppliers

REV. DATE	STATUS
CHK. DATE	REV. A
APPD. DATE	
PDNLink	DRG No. 1151377
	SHEET 1 OF 2

# Vessel 3 (Dipole 2) - 1151378

N°	DRG N°	DESCRIPTION	QTY	REMARKS
1	1151378_01	ELECTRON BEAM TUBE	1	
2	1151378_02	COOLING CHANNEL	1	
3	1151378_A	DOWNSTREAM COOLED TAPER	1	
4	1151378_A1	COOLED COPPER TAPER	1	
5	1151378_A2	CONFLAT DN40CF70 FIXED	1	
6	1151378_A3	OUTER TUBE	1	
7	1151378_A4	STUB TUBE 5 OD x 0.75 WALL	2	
8	1151378_B	UPSTREAM COOLED TAPER	1	
9	1151378_B1	COOLED COPPER TAPER	1	
10	1151378_B2	CONFLAT DN40CF70 FIXED	1	
11	1151378_B3	OUTER TUBE	1	
12	1151378_B4	STUB TUBE 5 OD x 0.75 WALL	2	

NOTE:

- THIS IS A PROPOSAL ONLY SHOWING NOMINAL DETAIL. SEE MODEL PROVIDED.
- MATERIAL:
  - VESSEL: COPPER
  - FLANGES: INCONEL
  - STUB TUBES: INCONEL
- FLANGED JOINTS ARE REQUIRED - RF
- SUPPORT STRUCTURE
- THIS IS A UHV COMPONENT MUST COMPLY FULLY WITH 'DLS REQUIREMENTS FOR UHV AND SYSTEMS' A CO
- THIS ASSEMBLY SHOWS DRAWING 1001296.
- GENERAL SURFACE FINISH
- THIS VESSEL IS CUT TO THE SECTION AND PI

SCALE 1:5

DETAIL A SEE SHEET 2 FOR DETAIL SCALE 1:1

DETAIL B SEE SHEET 2 FOR DETAIL SCALE 1:1

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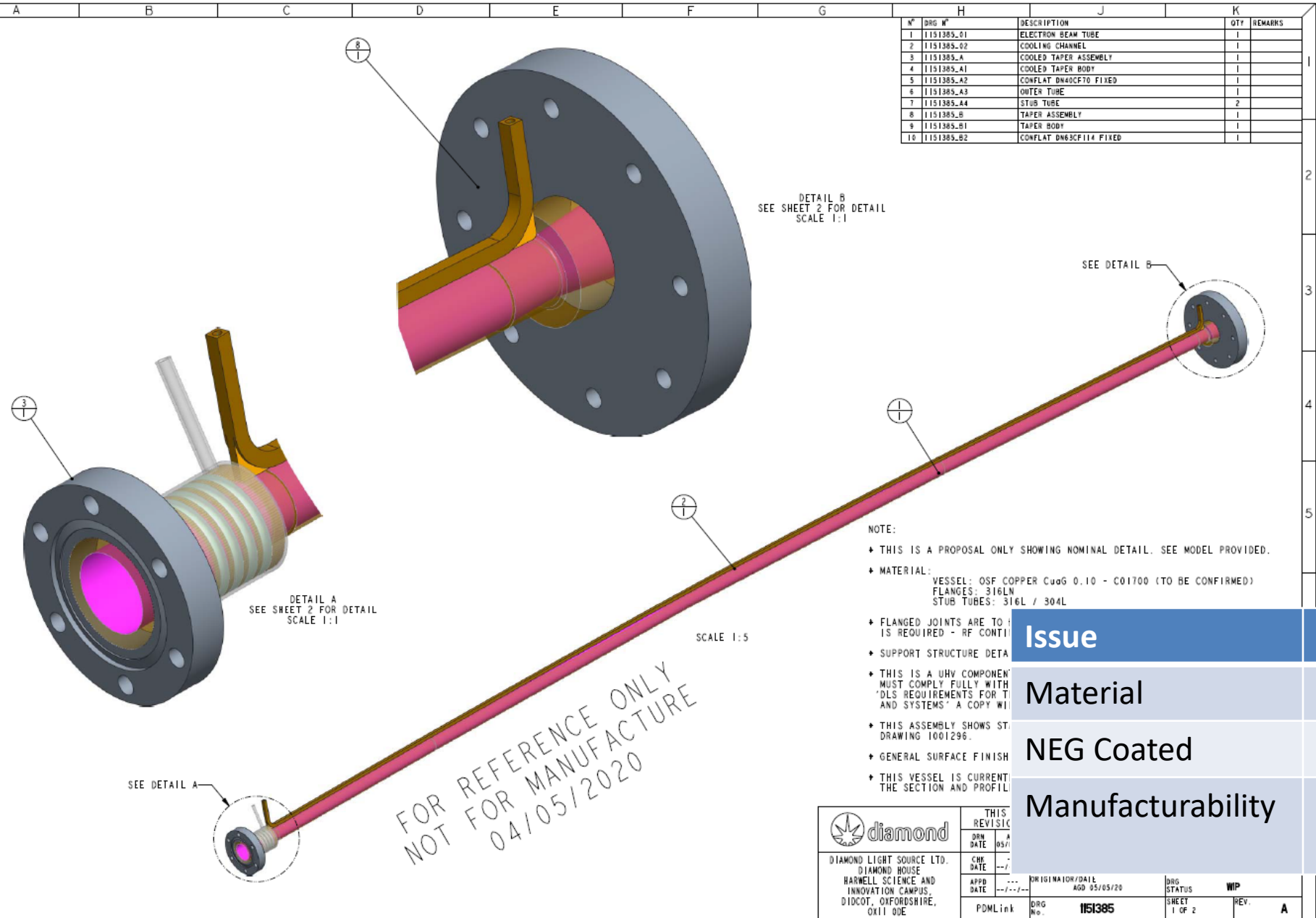
Issue	Status
Material	Copper
NEG Coated	Yes
Manufacturability	Could be built by a range of suppliers

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DATE	04/05/20	DRG NO.	1151378
CHK DATE	---	ORIGINATOR/DATE	AGD 04/05/20
APPD DATE	---	DRG STATUS	WIP
PDMLink		SHEET	1 OF 2
		REV.	A

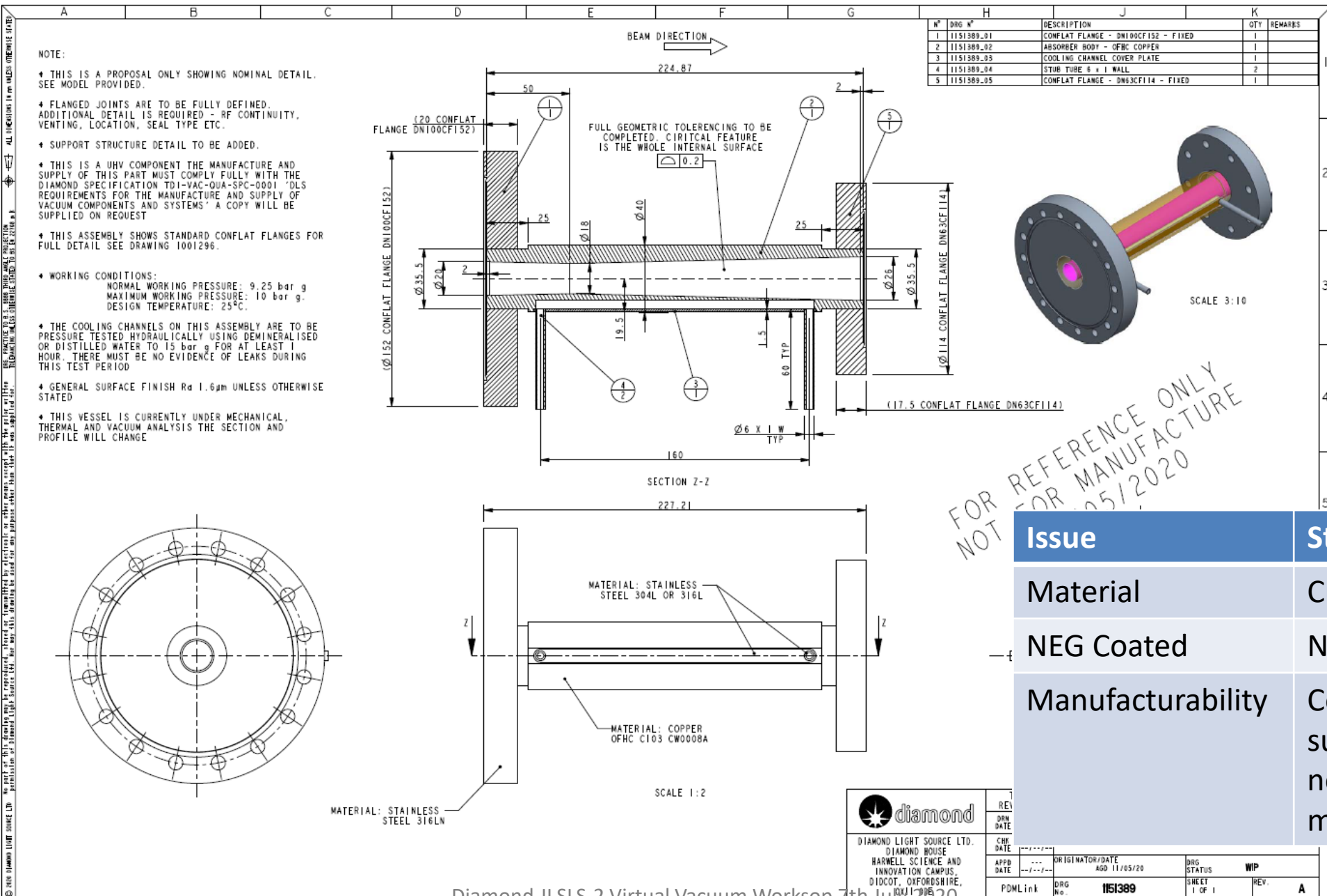
# Vessel 5 (Diploe 3) - 1151385

ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED  
 USE PRACTICE TO A 3.000 THIRD ANGLE PROJECTION  
 DIMENSIONS IN THIS DRAWING SHALL BE TO THE CENTERLINE UNLESS OTHERWISE STATED TO AN EDGE OR SURFACE



Issue	Status
Material	Copper
NEG Coated	Yes
Manufacturability	Could be built by a range of suppliers

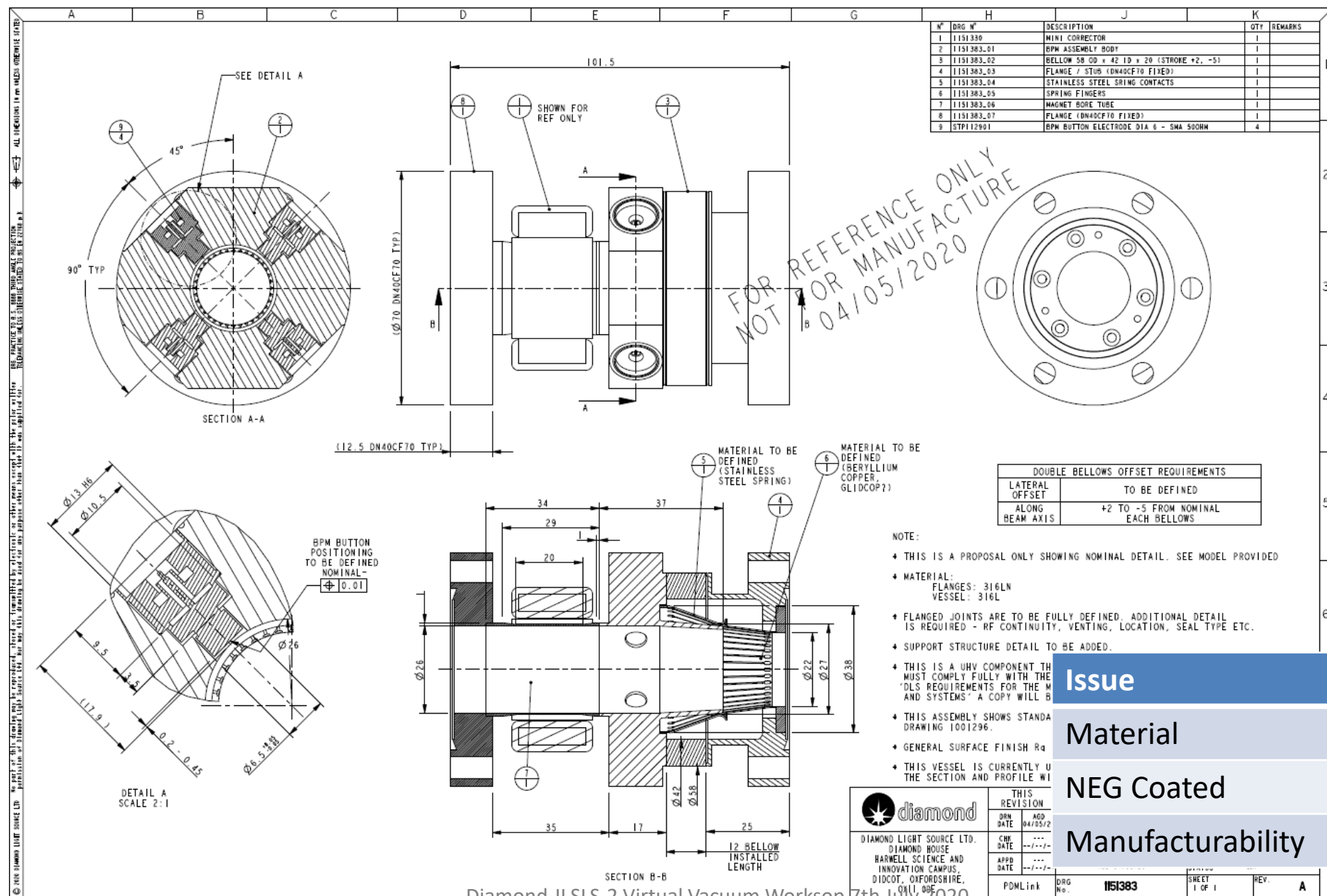
# InLine Absorber 2 - 1151389



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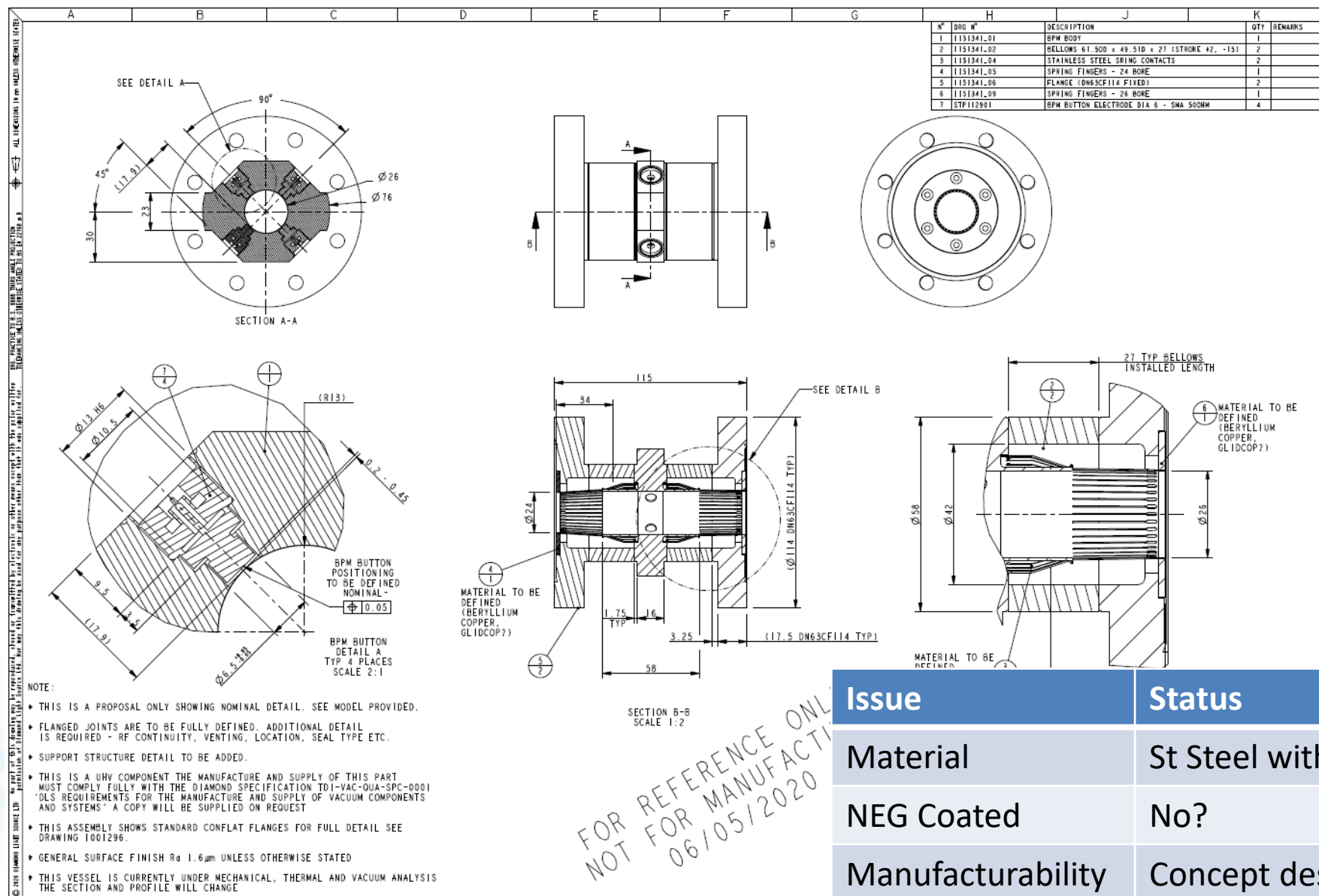
Issue	Status
Material	CuOFS (Silver) or CuCrZr
NEG Coated	No
Manufacturability	Could be built by a range of suppliers (Water cooling may need changing to help manufacture)

# BPM and Mini Corrector Bellows - 1151383



Issue	Status
Material	St Steel with CuBe fingers
NEG Coated	No?
Manufacturability	Concept design only

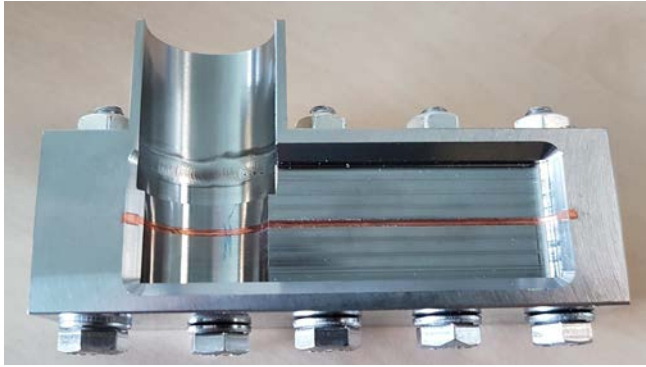
# PBPM Bellows - 1151341



Issue	Status
Material	St Steel with CuBe fingers
NEG Coated	No?
Manufacturability	Concept design only

# RF flanges being evaluated (1)

MO type

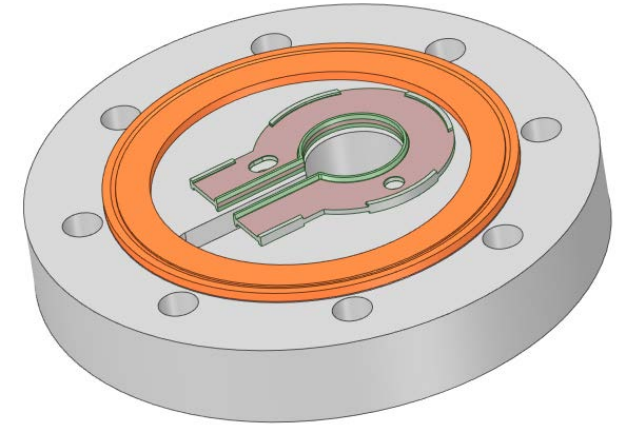


Baked out, vacuum tested, cut up to assess interface

Flat seal

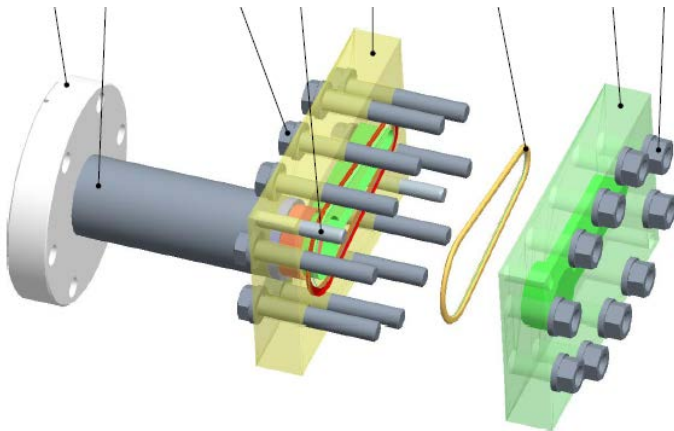


CF + RF continuity piece (ESRF-EBS inspired)



Also looking at clamp flanges for difficult-to-access areas – SIRIUS type plus several commercial types

Helicoflex®

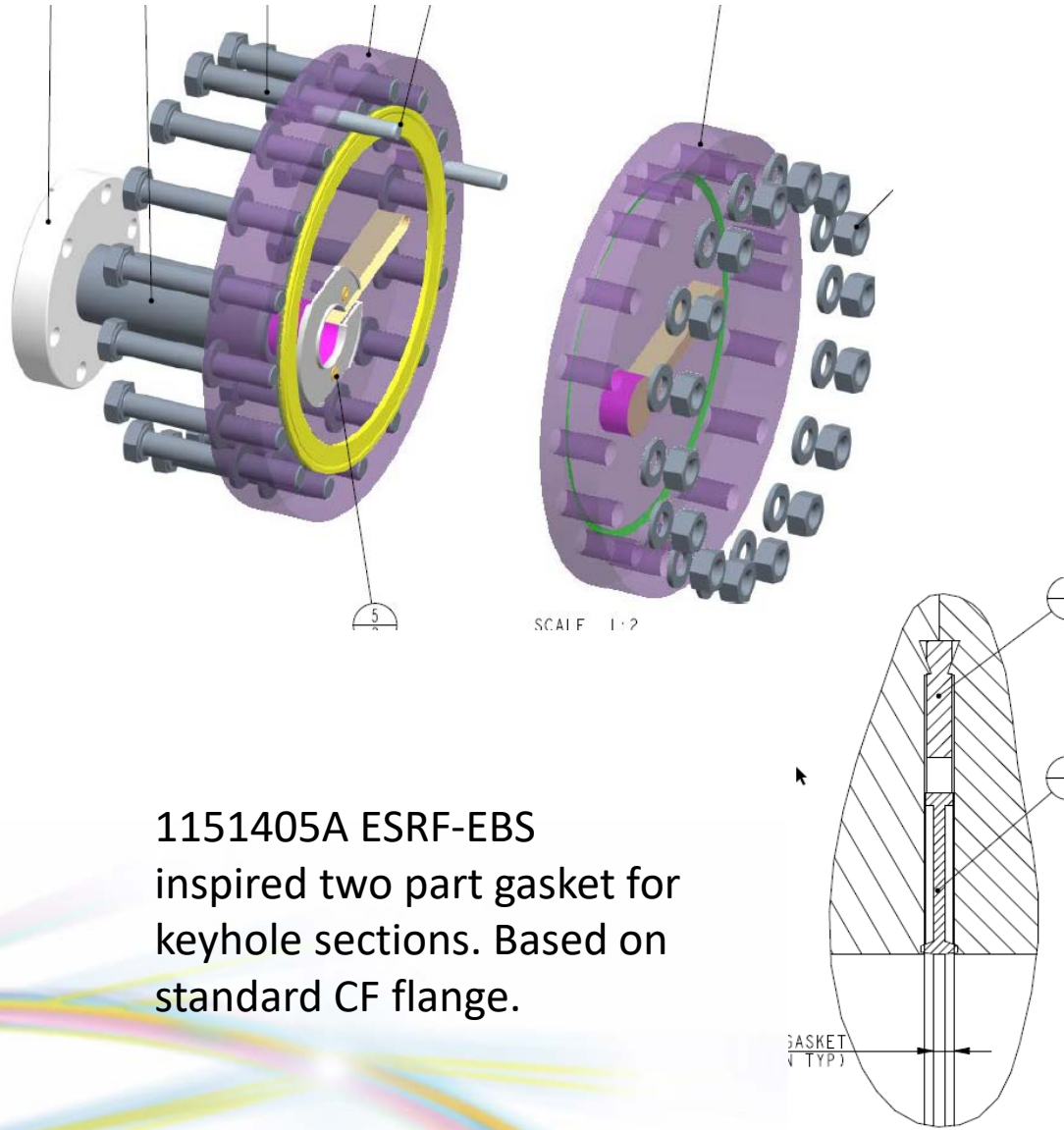


Prototyping several different types with representative aperture geometry for Diamond-II. Expecting more than one solution to work technically. Leak tightness, bakeout, gap and alignment, practicality

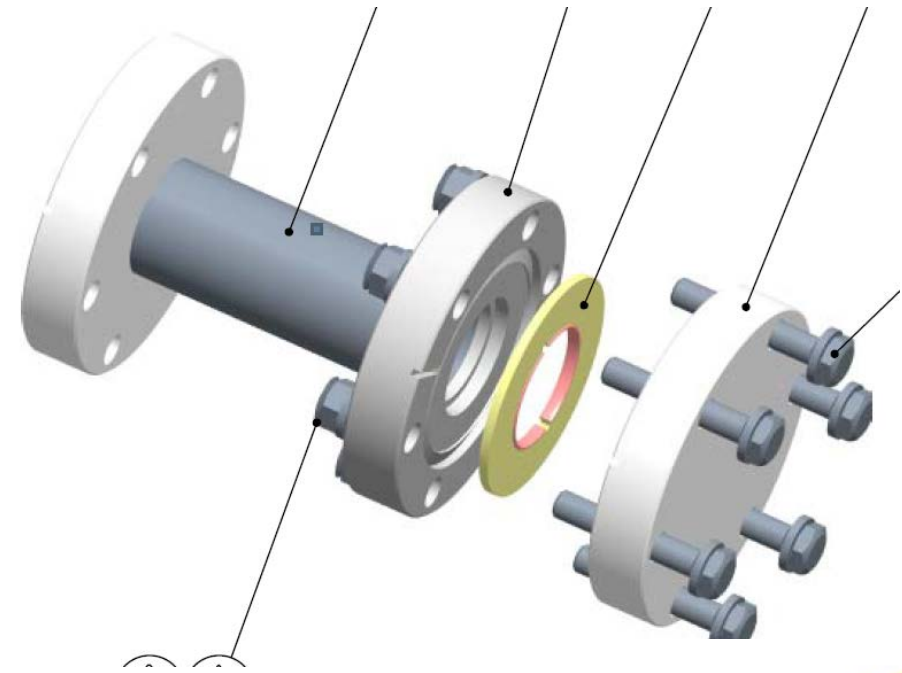




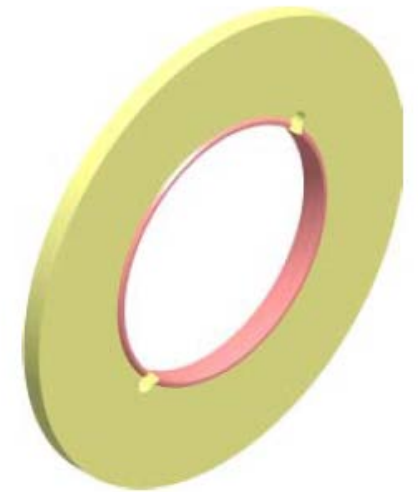
# RF flanges being evaluated (2)



1151405A ESRF-EBS  
inspired two part gasket for  
keyhole sections. Based on  
standard CF flange.



1151401A APS-U inspired  
single gasket for circular  
sections. Based on  
standard CF flange.



# Other components

- **BPMs**
  - See Diagnostics workshop
- **Pumps**
  - Probably combination NEG/ ion pumps – evaluating possibilities
  - Plus NEG coating
- **Valves**
  - In discussion with VAT about using the upgraded series 47 RF gate valves as supplied to ESRF-EBS (CuBe RF fingers rather than stainless steel as Diamond's existing valves)
- **Instrumentation**
  - Total pressure gauges (at least one set per vacuum section)
  - Residual gas analysers
  - Temperature monitoring

# Build sequence

- Assemble and align vacuum vessels on build trolley, pump down and vacuum test. After this stage, remains under vacuum without venting.
- Build up oven panels, bake and activate the NEG coating and degas the vacuum instrumentation. Top plate of assembly trolley forms base of oven.
- Transfer vacuum string under vacuum to the pre-aligned magnet halves on the girder
- Reassemble magnet tops
- Move into position in the storage ring
- Make vacuum connections to the adjacent vacuum sections, pump these down and bake if necessary
- Open the gate valves to the adjacent vacuum sections once clean ultra-high vacuum conditions have been achieved and verified in these adjacent sections.

# Acknowledgements

- Diamond Vacuum Group: Andy Miller, Hugo Shiers, Toby Lockwood, Chris Burrows, Neil Warner
- Diamond Engineering Group: Alan Day, Nigel Hammond, Stewart Scott, Stephen Hodbod
- Diamond Acc Phys Group: Richard Fielder
- Diamond Diagnostics Group: Alun Morgan
- + apologies to the many others I haven't mentioned