162.5 MHz Coupler for RFQ

Mechanical design

162.5 MHz Coupler for RFQ

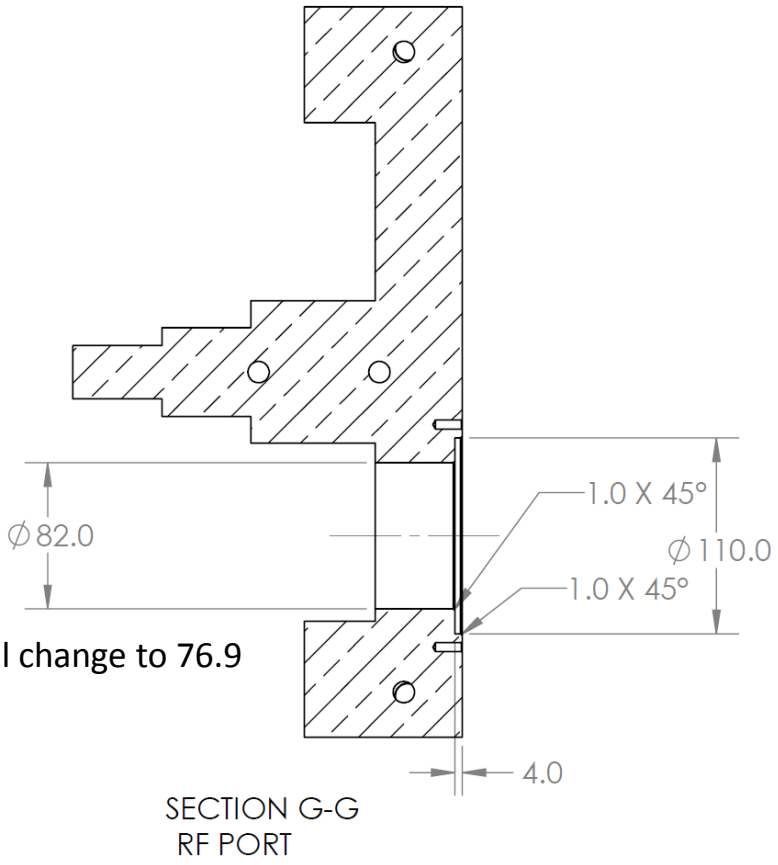
The PXIE RFQ power coupler includes all components necessary to transport up to 75kW (each) of RF power from a 50Ω source into the RFQ vacuum while maintaining the RFQ vacuum integrity.

Main features:

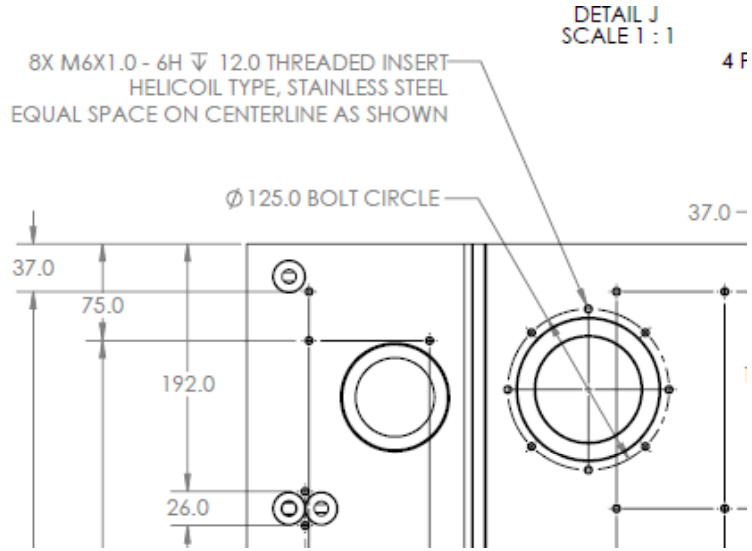
- Air cooled non grounded coupling loop
- HV bias
- Single Water cooled Ceramic window
- Compact design

According to Functional Requirement Specification for PXIE RFQ Coupler, clearance between the RFQ body and enclosure wall is 1.6 m on the shortest side. 1 m of space for is reserved for egress and 0.2m for RFQ component protection railings.

RFQ to Coupler interface



Will change to 76.9



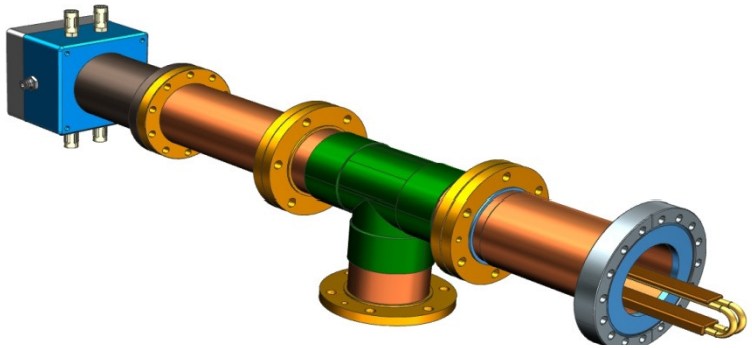
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN MM TOLERANCES: ANGULAR ±1° NO PLACE DECIMAL ±1 ONE PLACE DECIMAL ±0.3 TWO PLACE DECIMAL ±0.05	DRAWN	M. Hoff	2012/10/22
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
	COMMENTS: CAT CODE PX0010		
MATERIAL C101 COPPER			
FINISH 3.2			
DO NOT SCALE DRAWING			

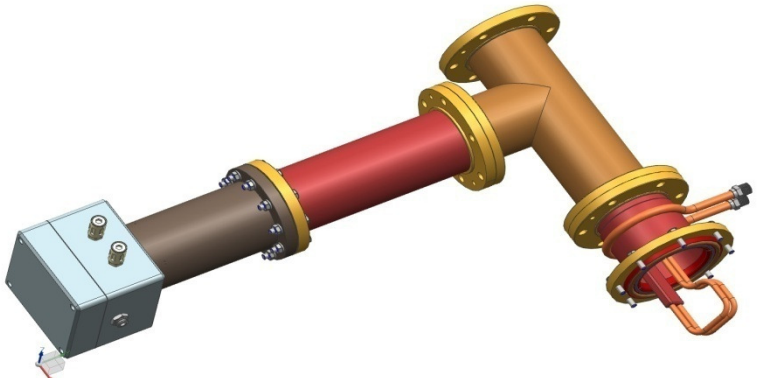
LAWRENCE BERKELEY NATIONAL LABORATORY		
TITLE: FNAL PXIE 162.5MHz RFQ ACCELERATOR CAVITY MODULE 2 HORIZONTAL VANE		
SIZE E	DWG. NO. 27J052	REV A
SCALE: 1:4	WEIGHT:	SHEET 3 OF 7

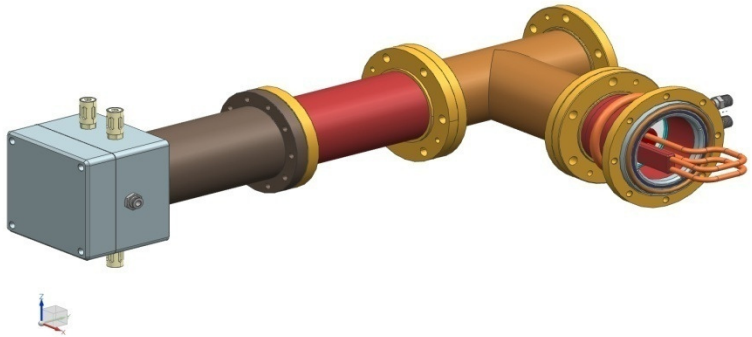
Most of the RF port dimensions are on sheet 3 of 27J052 Rev.A . See Sheet 3, Section G-G and zones B4 and B7 for port dimensions.

162.5 MHz Coupler for RFQ

3 Variants

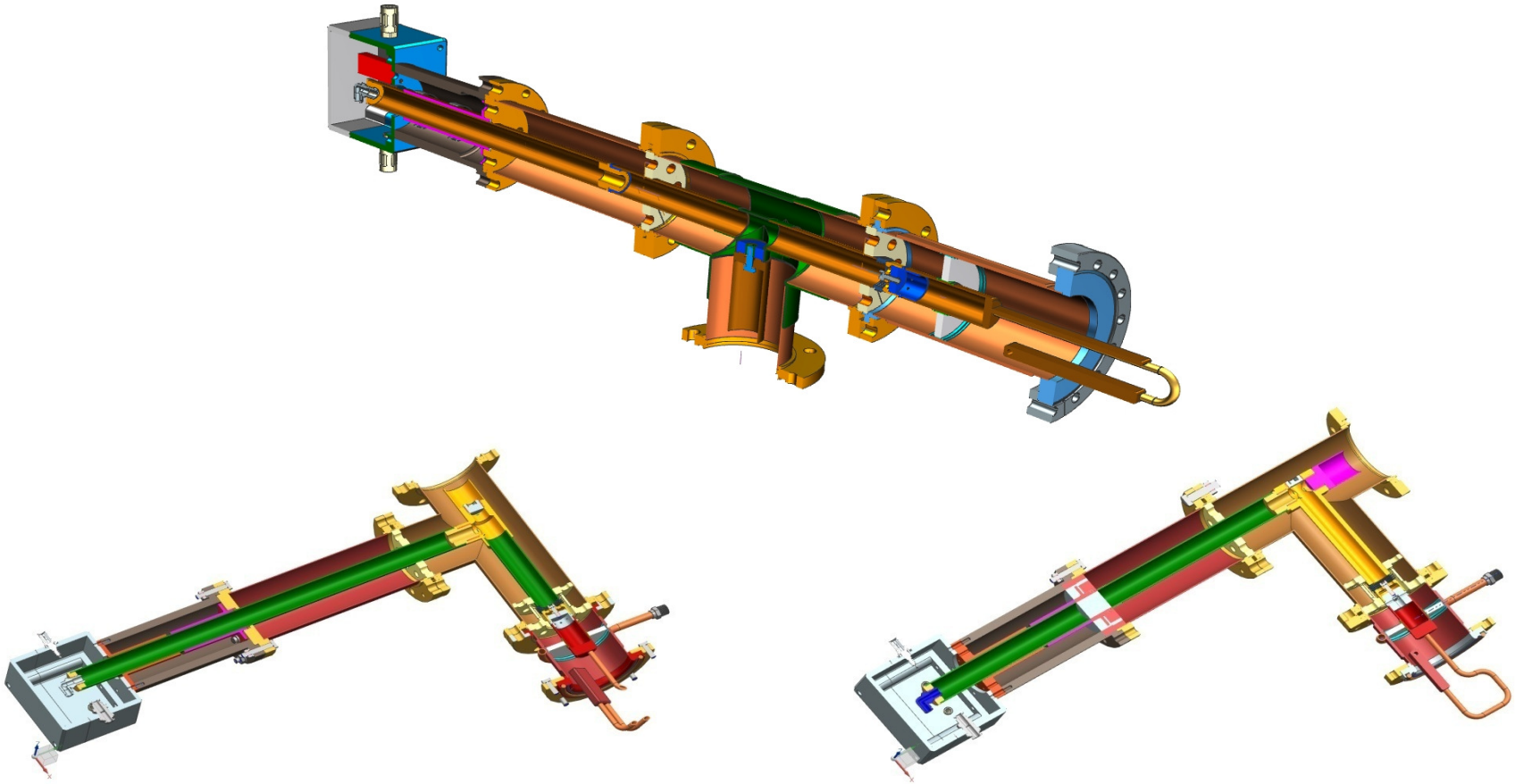




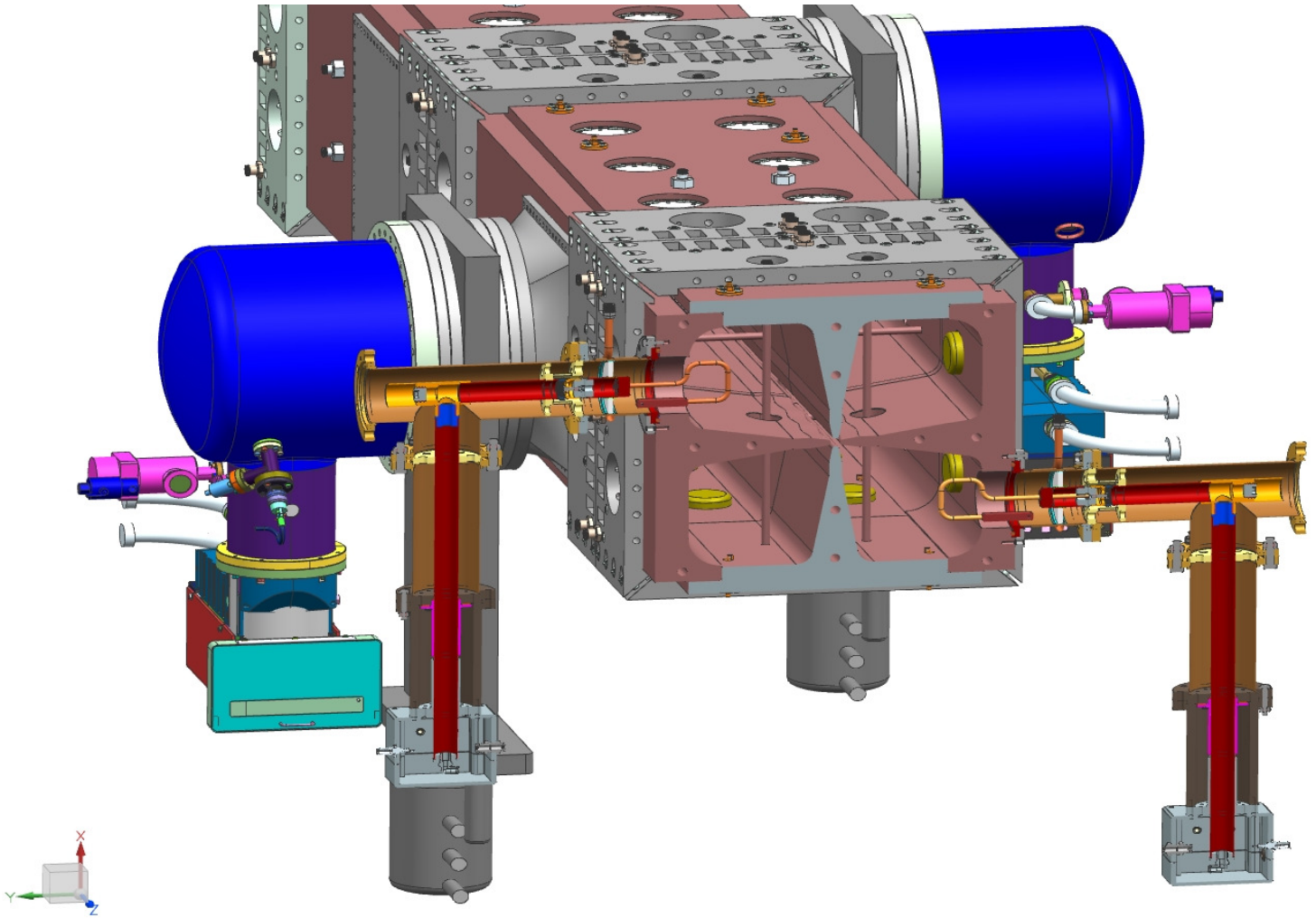


162.5 MHz Coupler for RFQ

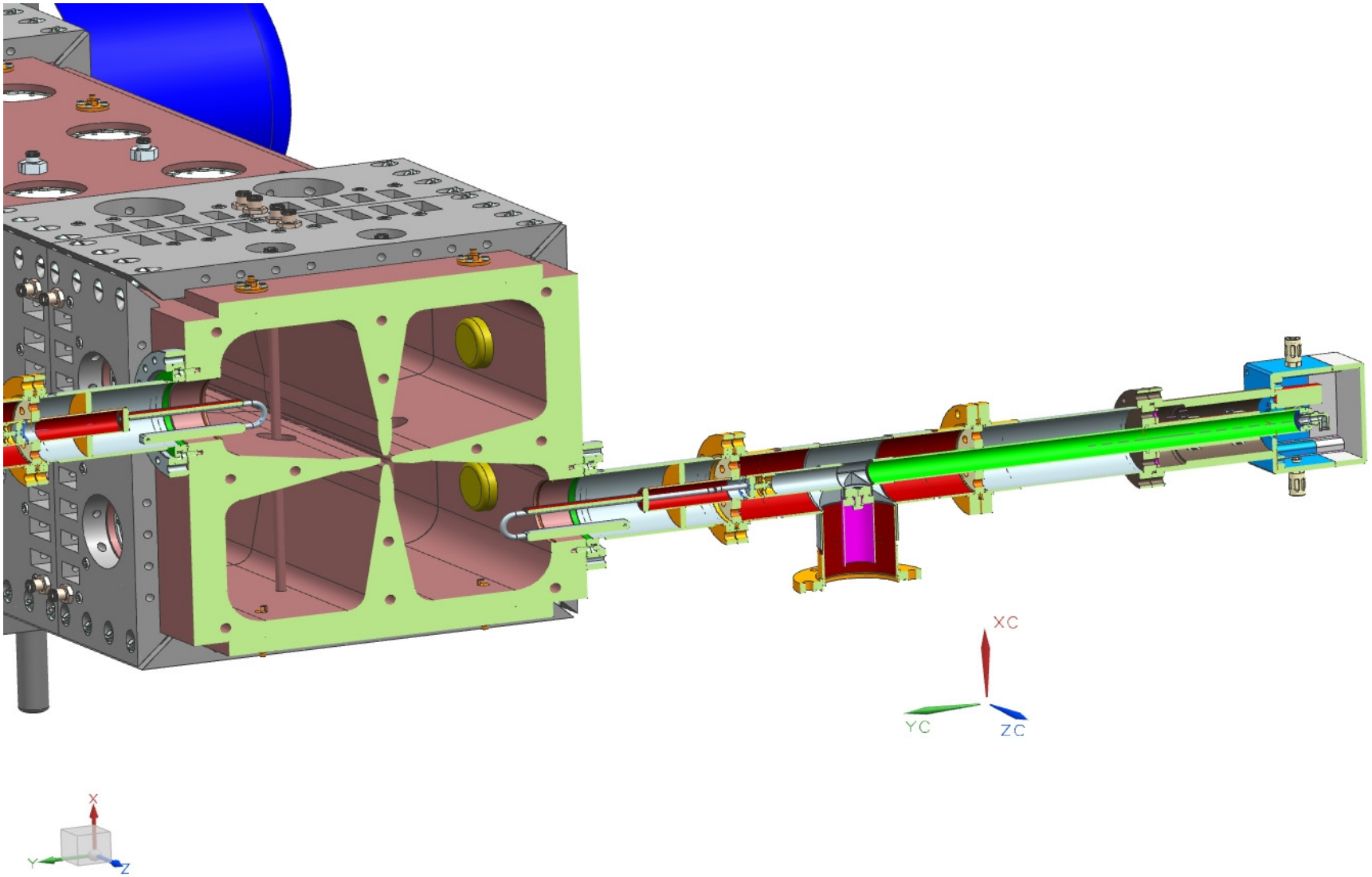
3 Variants



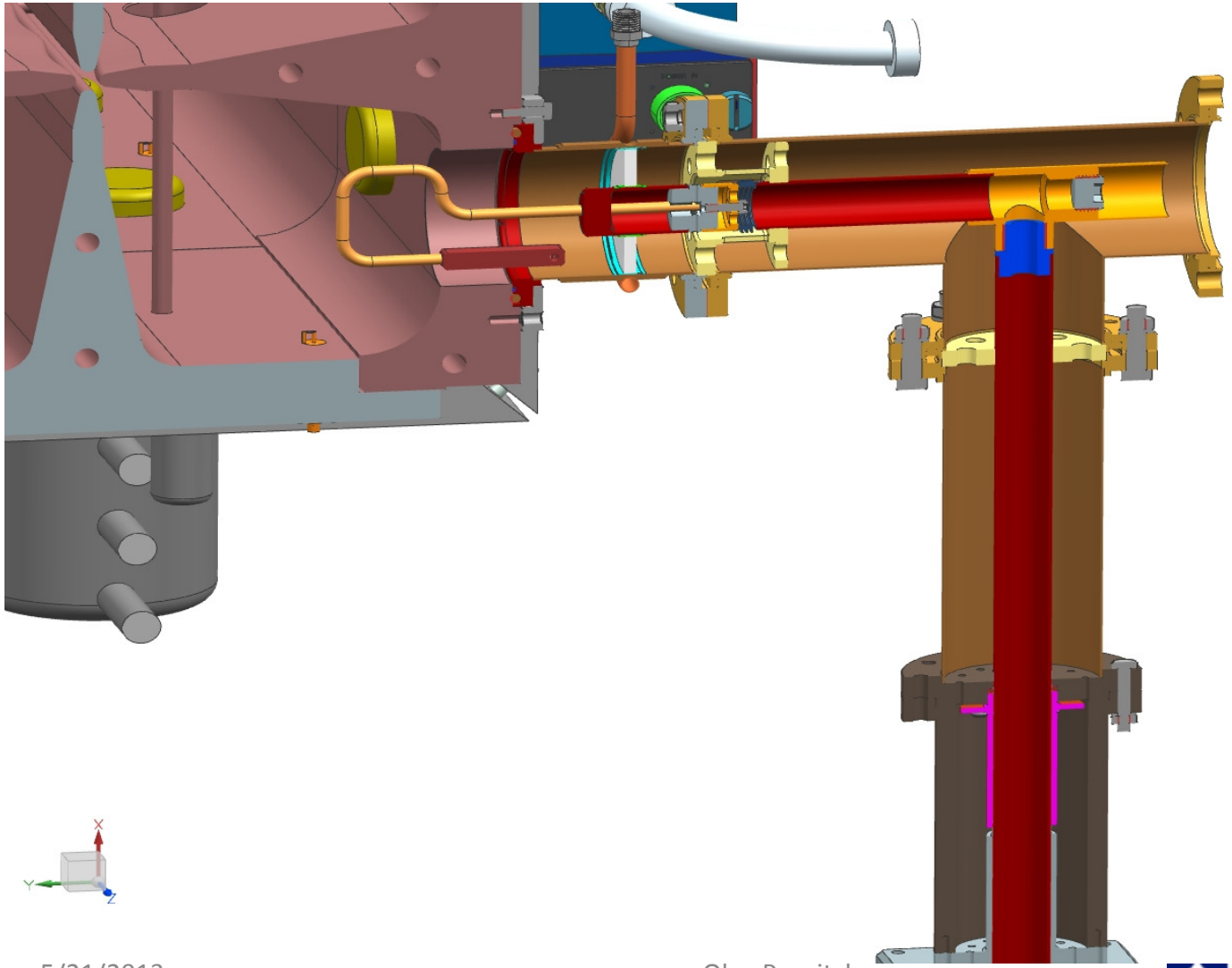
Couplers on RFQ



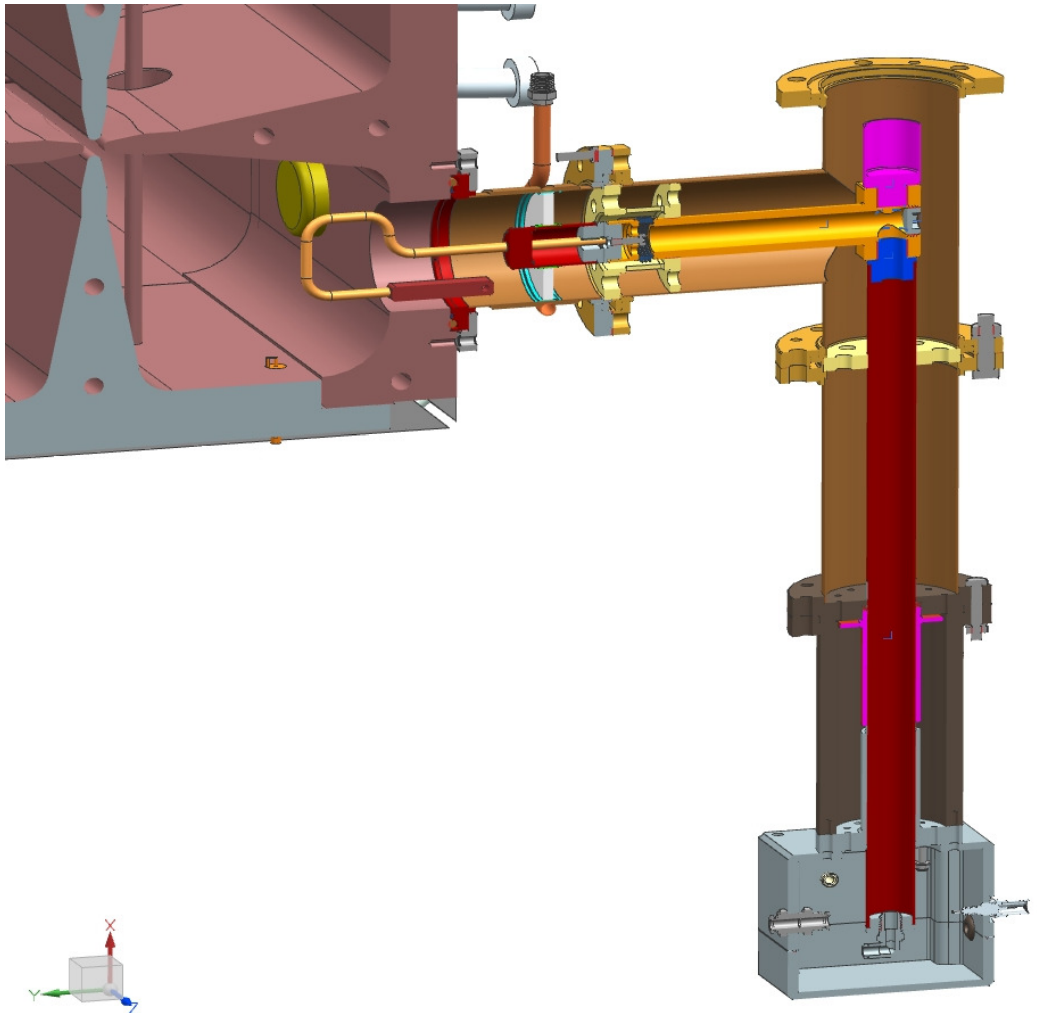
Variant 1 Coupler on RFQ



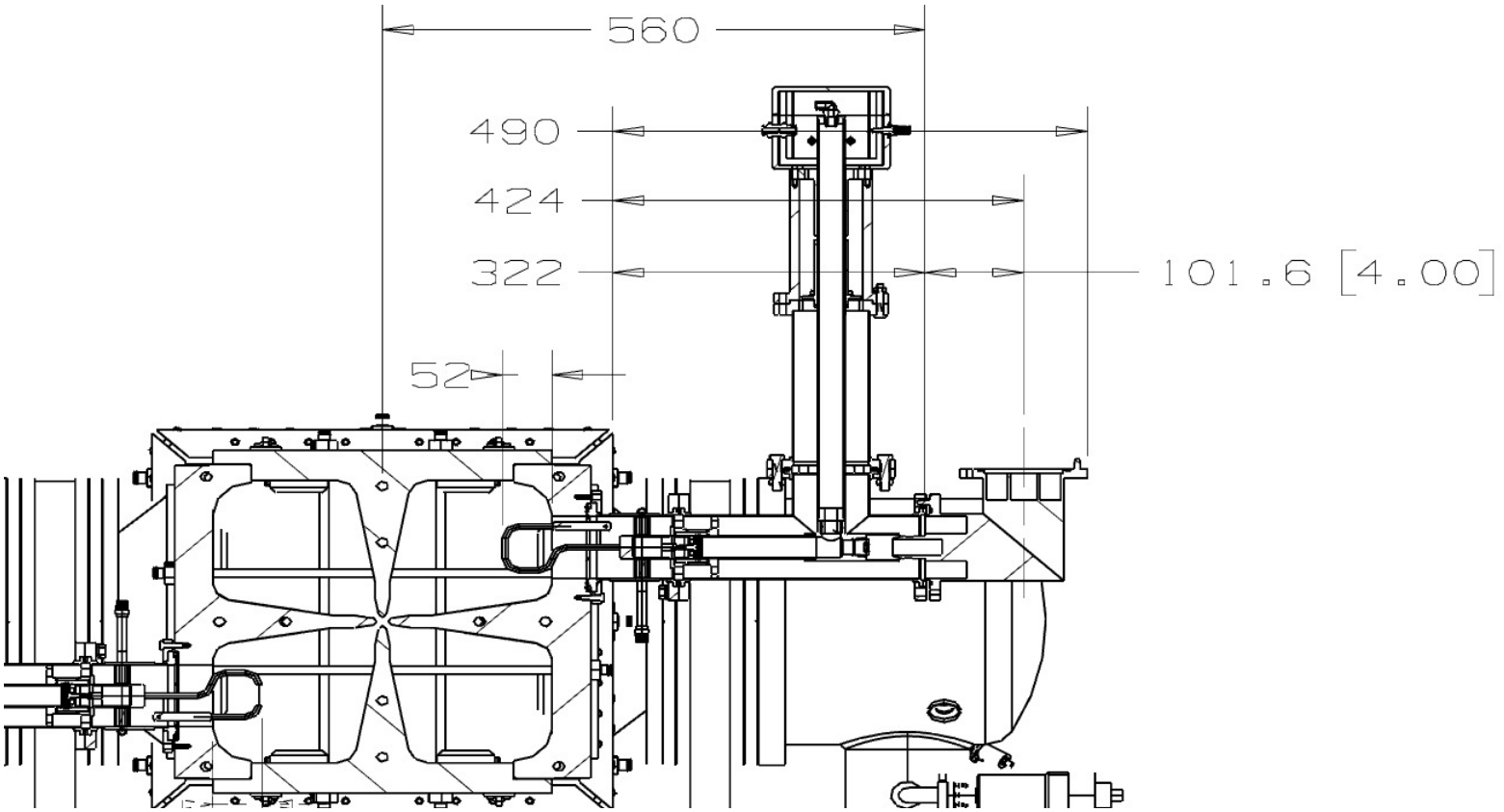
Variant 2 Coupler on RFQ



Variant 3 Coupler on RFQ

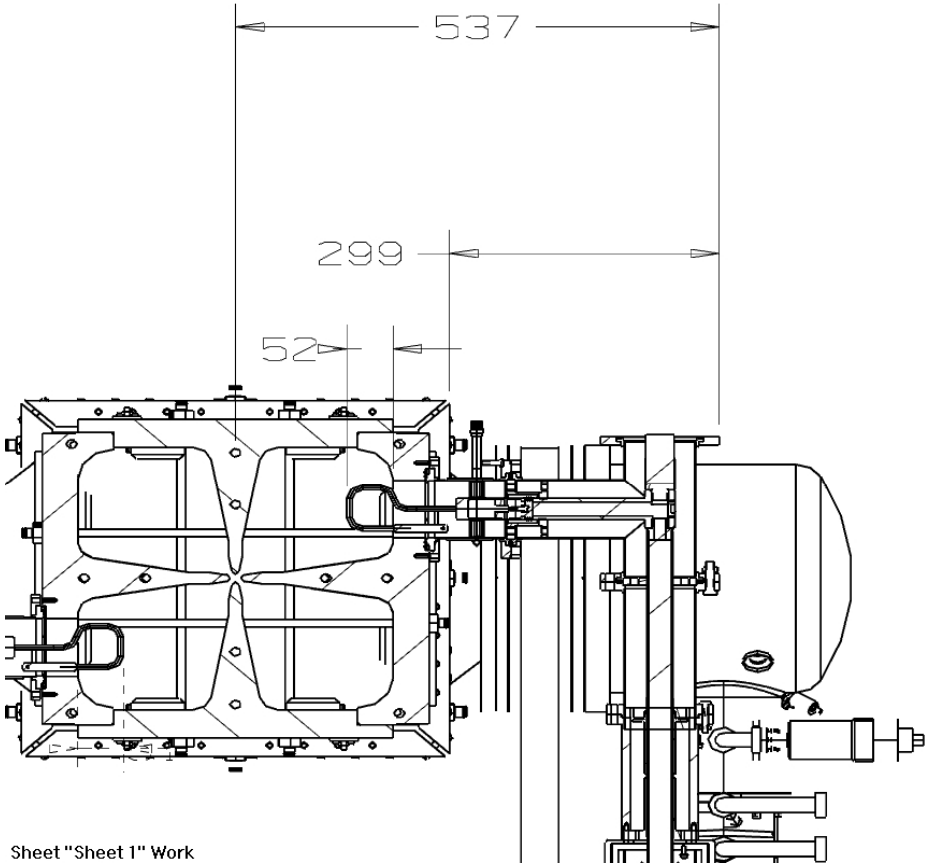


Coupler, variant 2 on RFQ



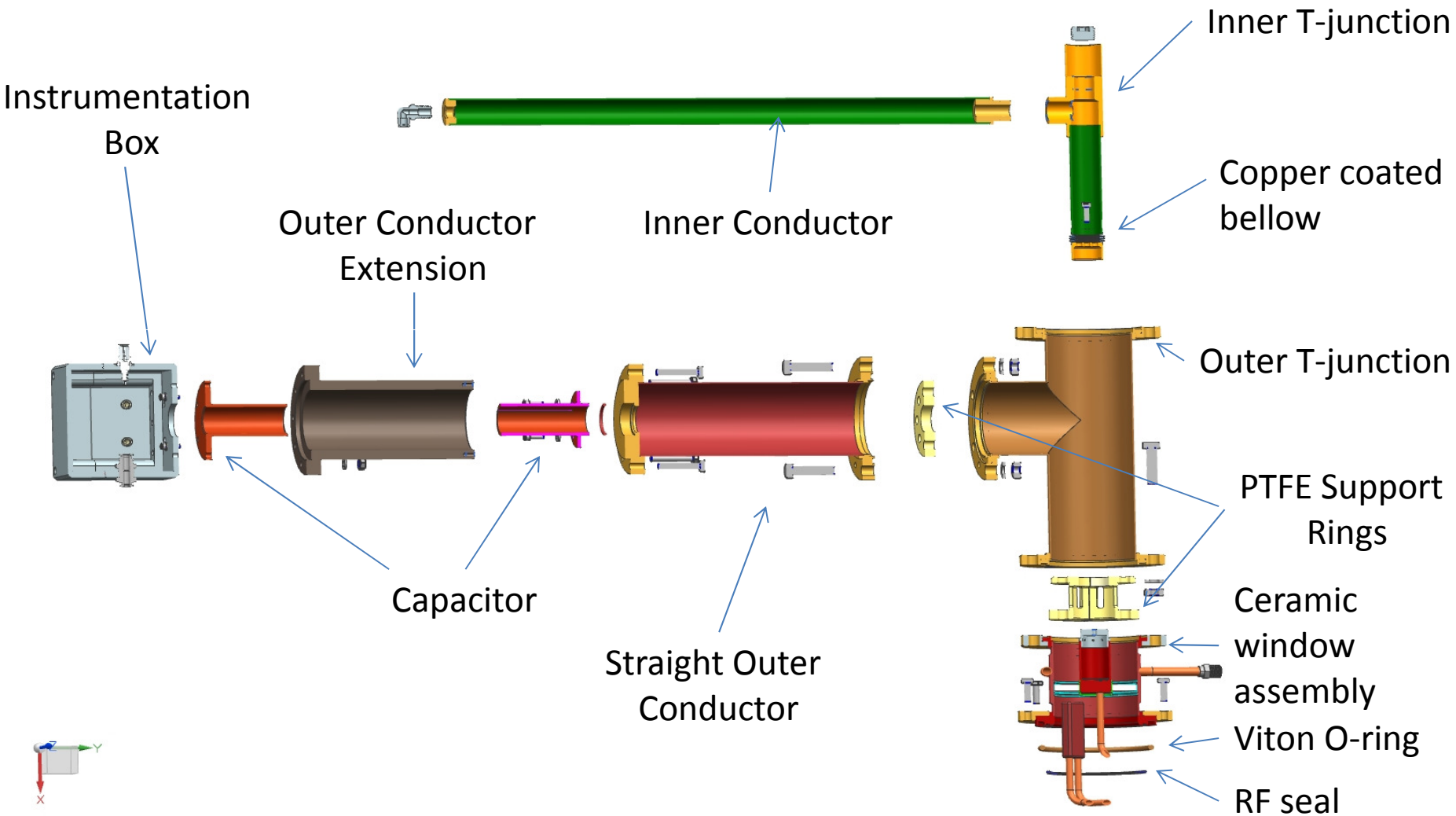
Variant 2 Coupler will use 322 mm. Shortest 90 degree coaxial 3 1/8 elbow is 4". Distance from RFQ body to the side of the elbow attached to the coupler will be 490 mm. Can we use thinner railing? This variant provide better flexibility for coaxial line connection.

Coupler, variant 3 on RFQ

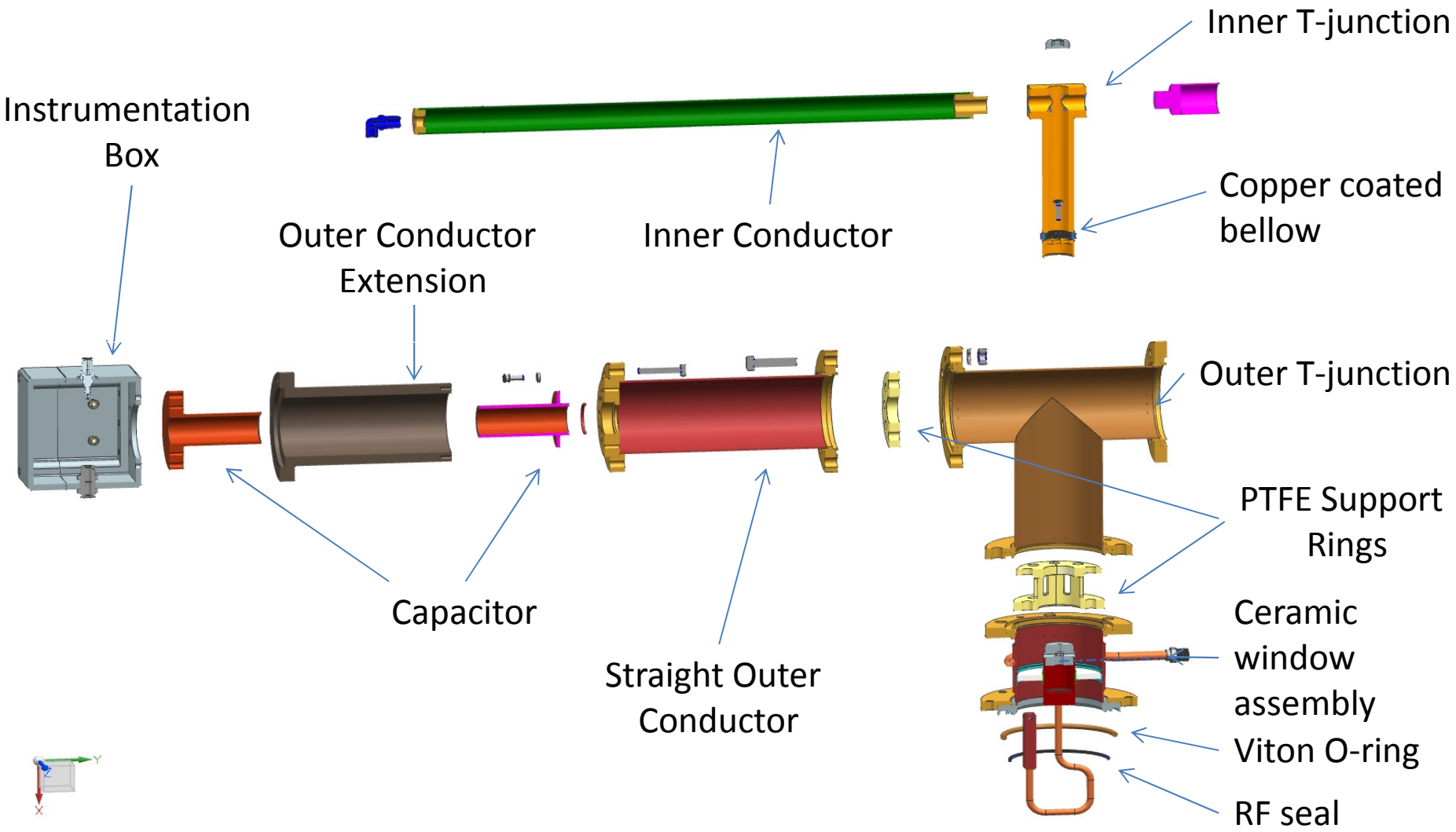


According to Functional Requirement Specification
PXIE RFQ Coupler, Clearance between the RFQ body and enclosure wall is 1.6m on the shortest side. We will need 1m of space for egress and 0.2m for RFQ component protection railings. Variant 3 Coupler will use 299 mm. This variant is more compact.

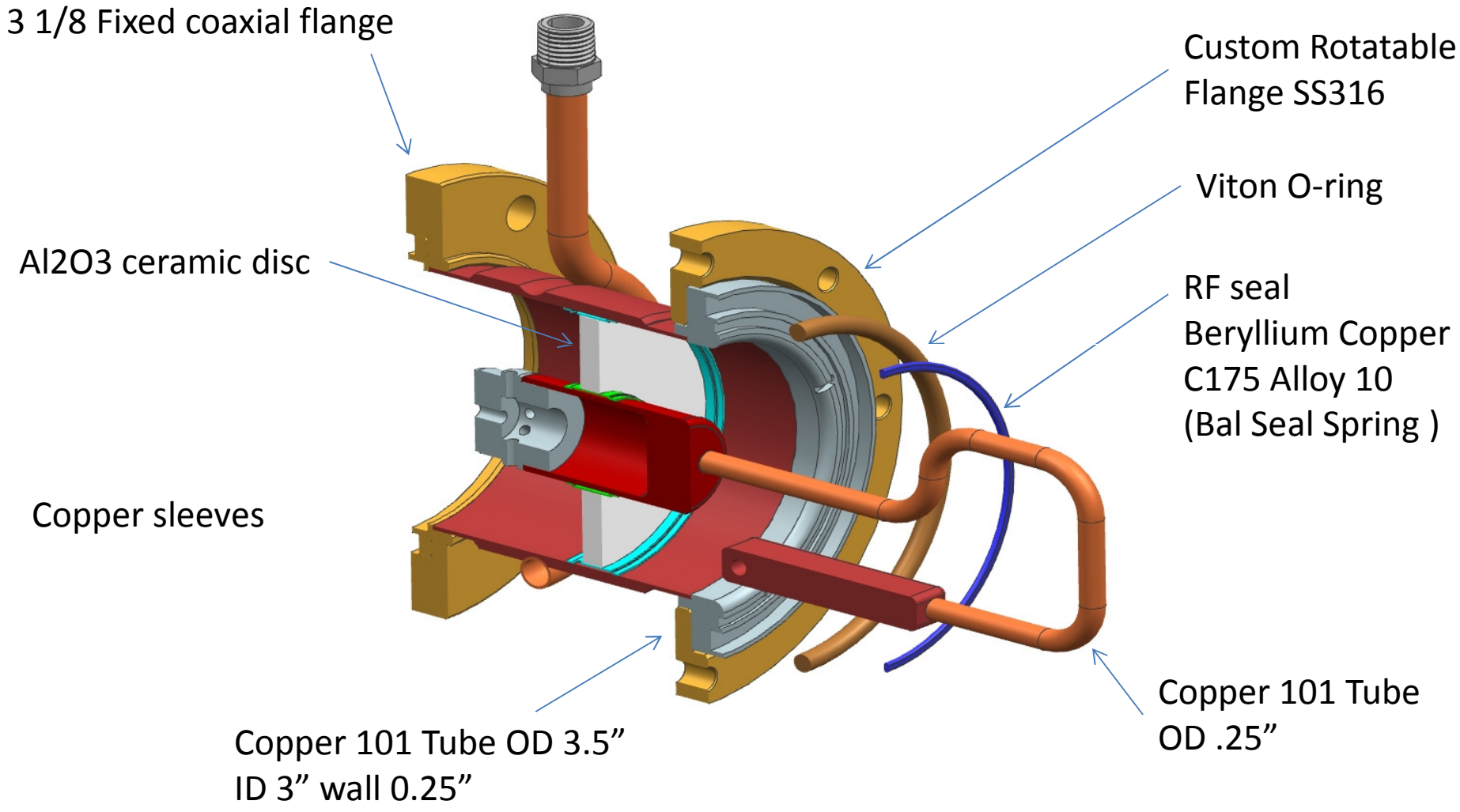
162.5 MHz Coupler for RFQ Variant 2
Main components



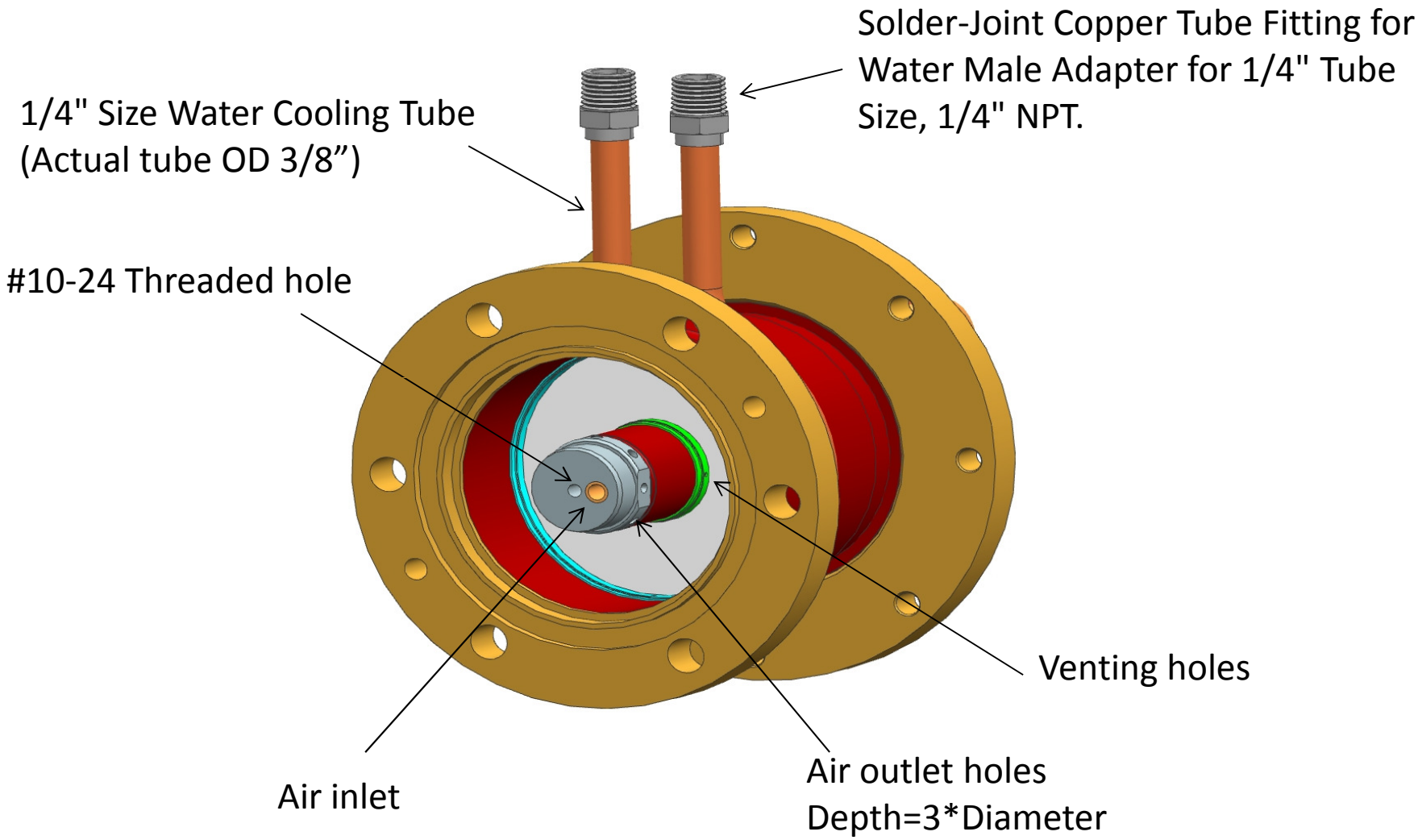
162.5 MHz Coupler for RFQ Variant 3
Main components



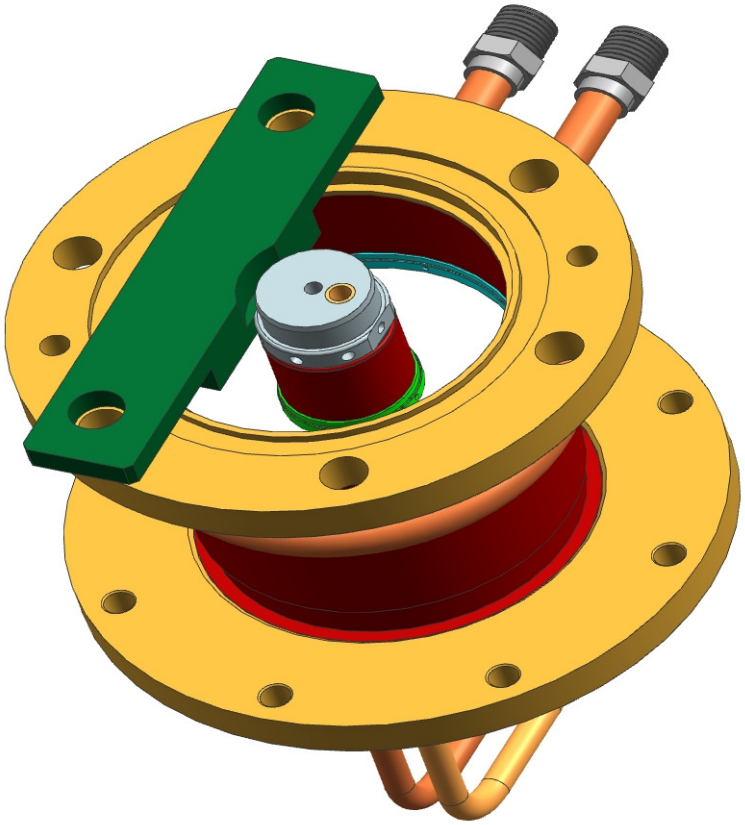
Ceramic window assembly

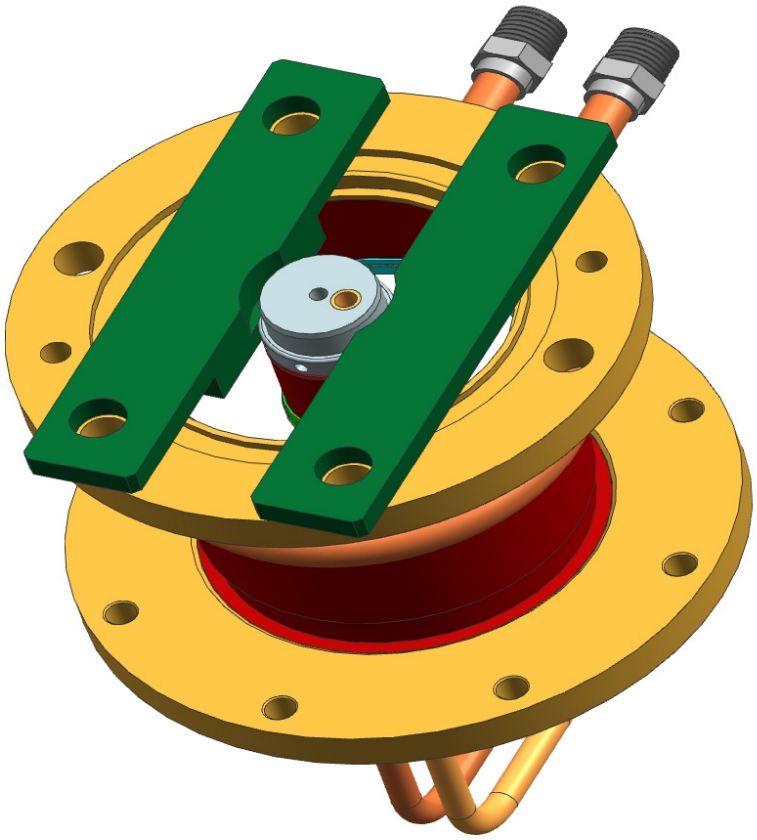


Ceramic window assembly

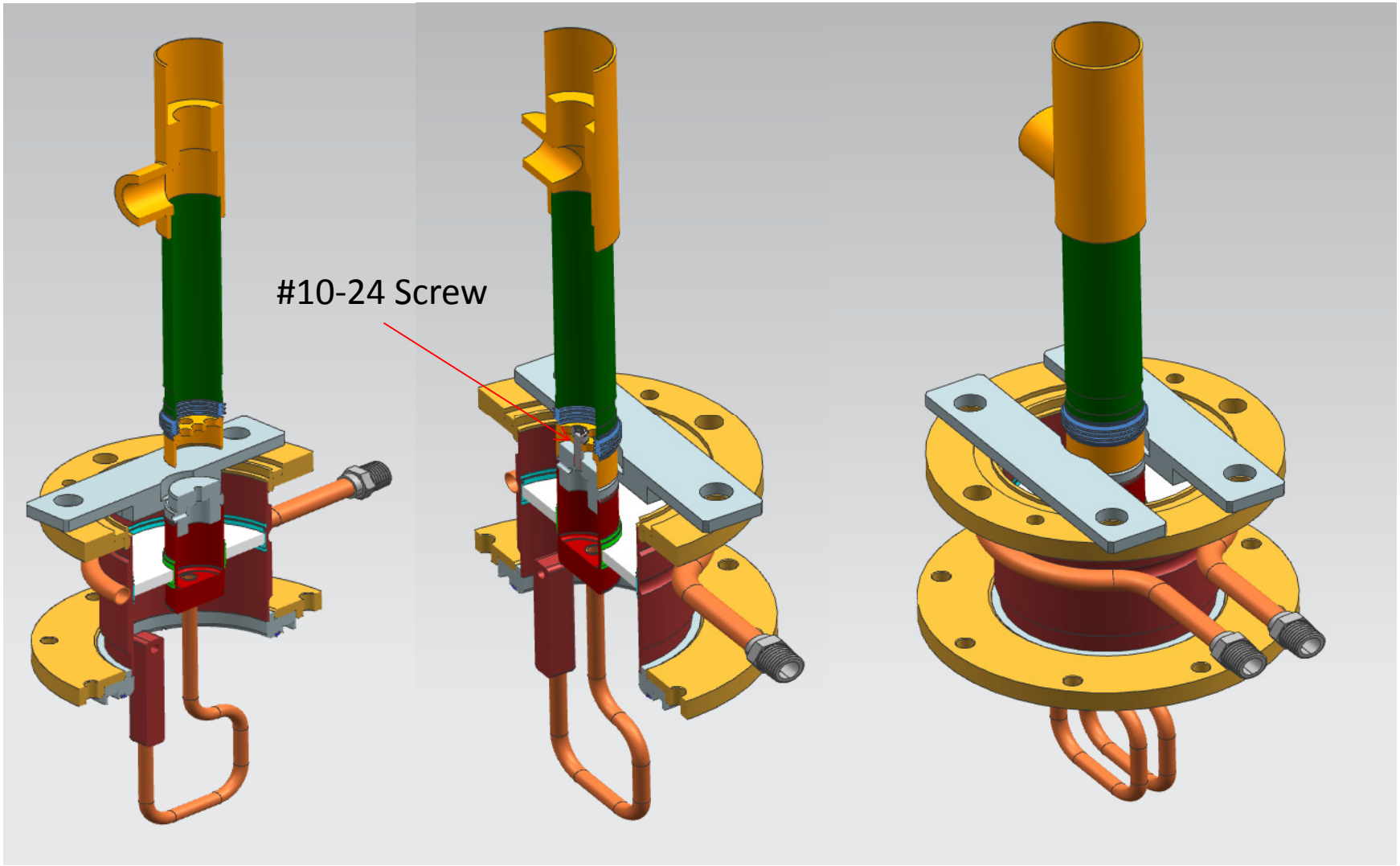


162.5 MHz Coupler for RFQ
Ceramic joint protection

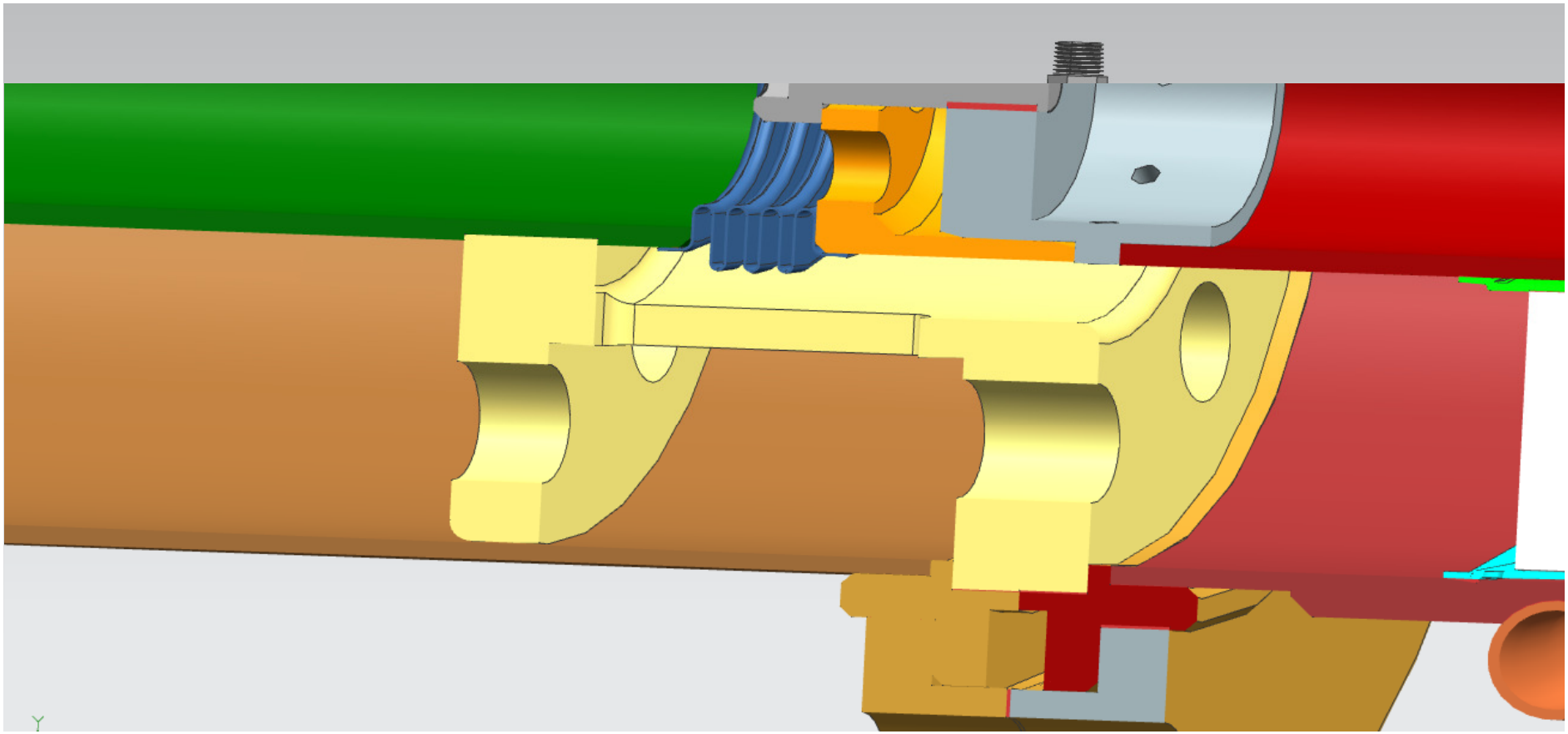




162.5 MHz Coupler for RFQ
Inner T-junction installation

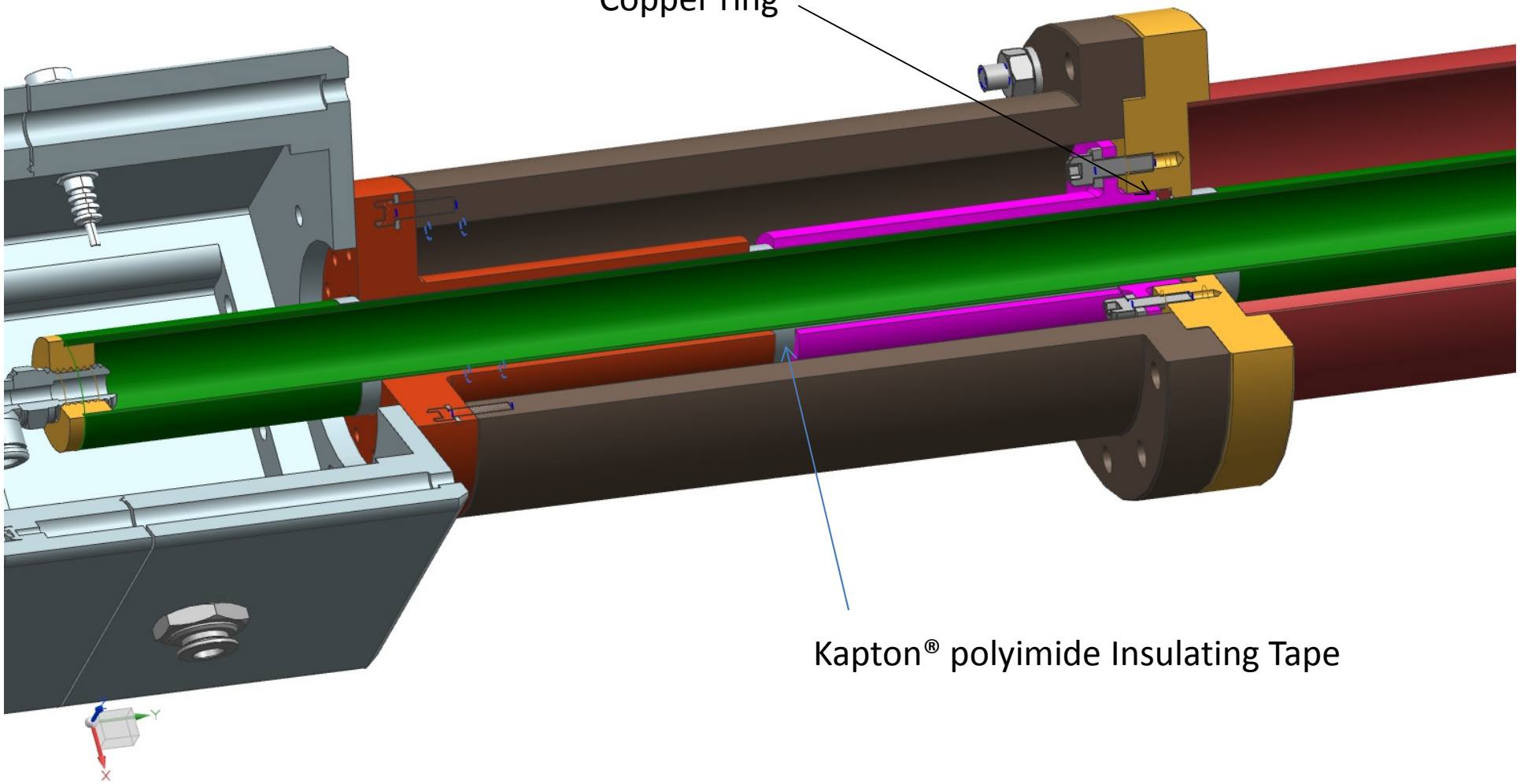


162.5 MHz Coupler for RFQ, Variant 2
Inner T-junction installation

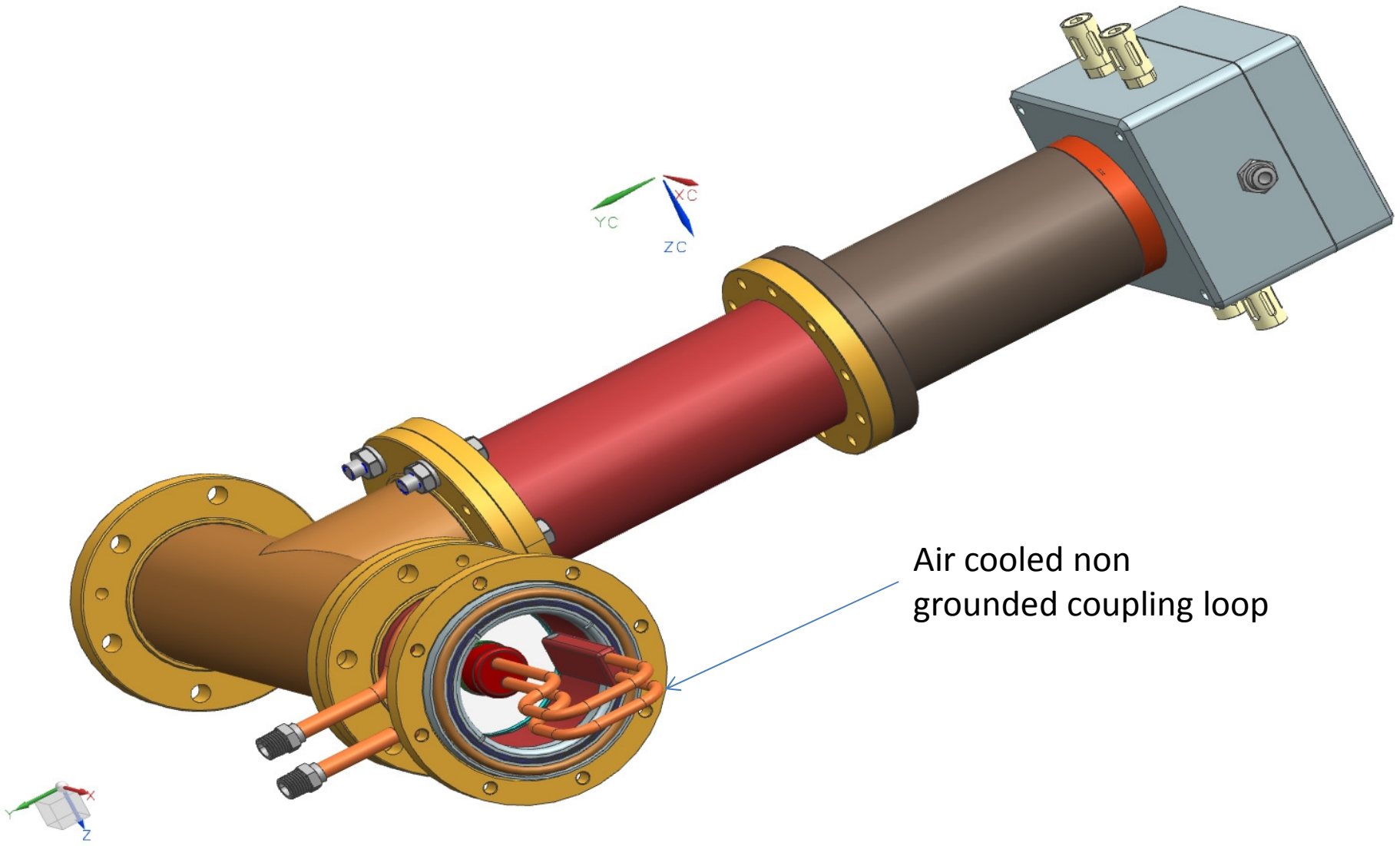


•Copper coated bellow will protect ceramic window
•Notch on inner conductor and special PTFE support will isolate bellow during coaxial line installation

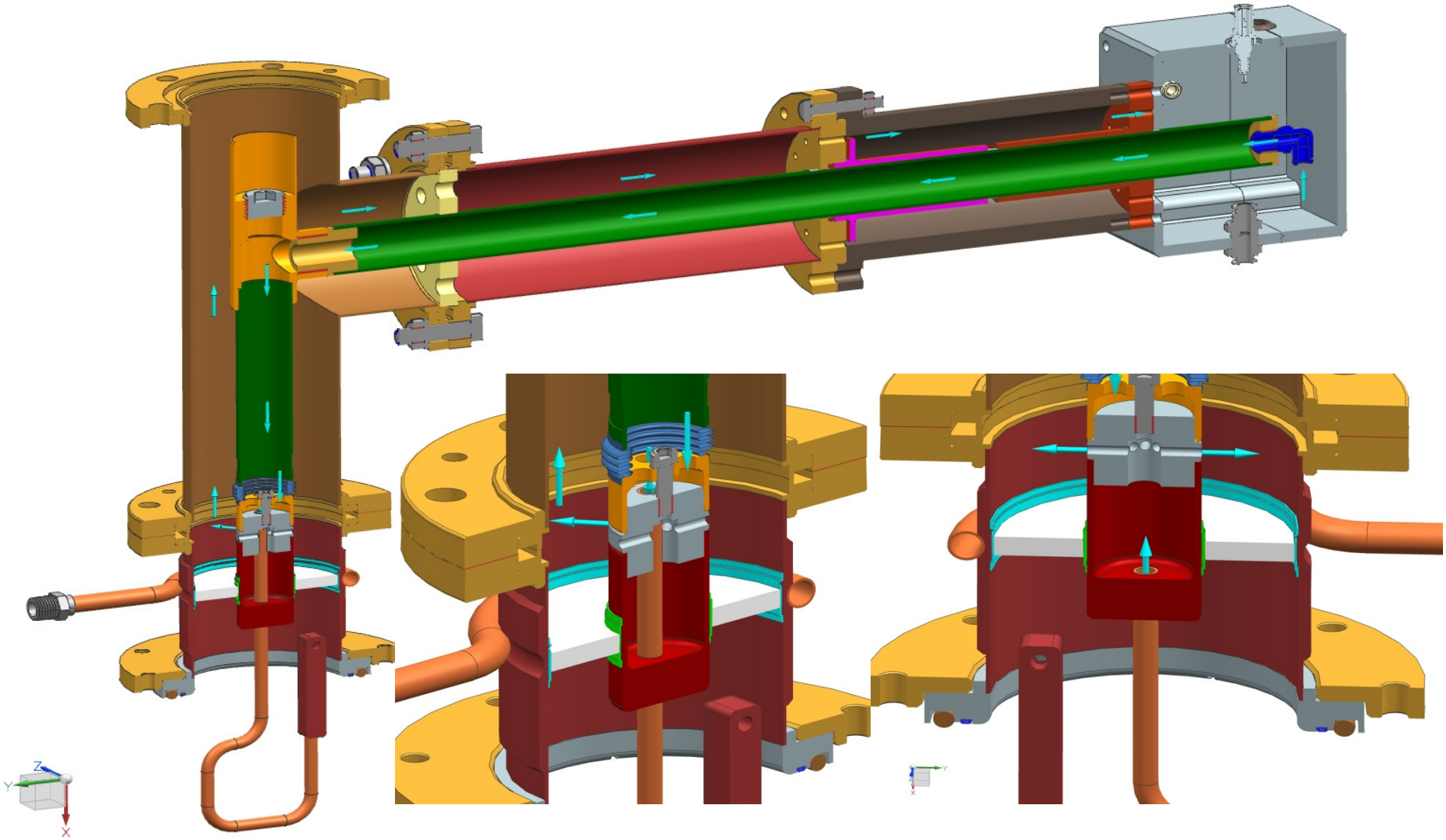
162.5 MHz coupler for RFQ
Capacitor



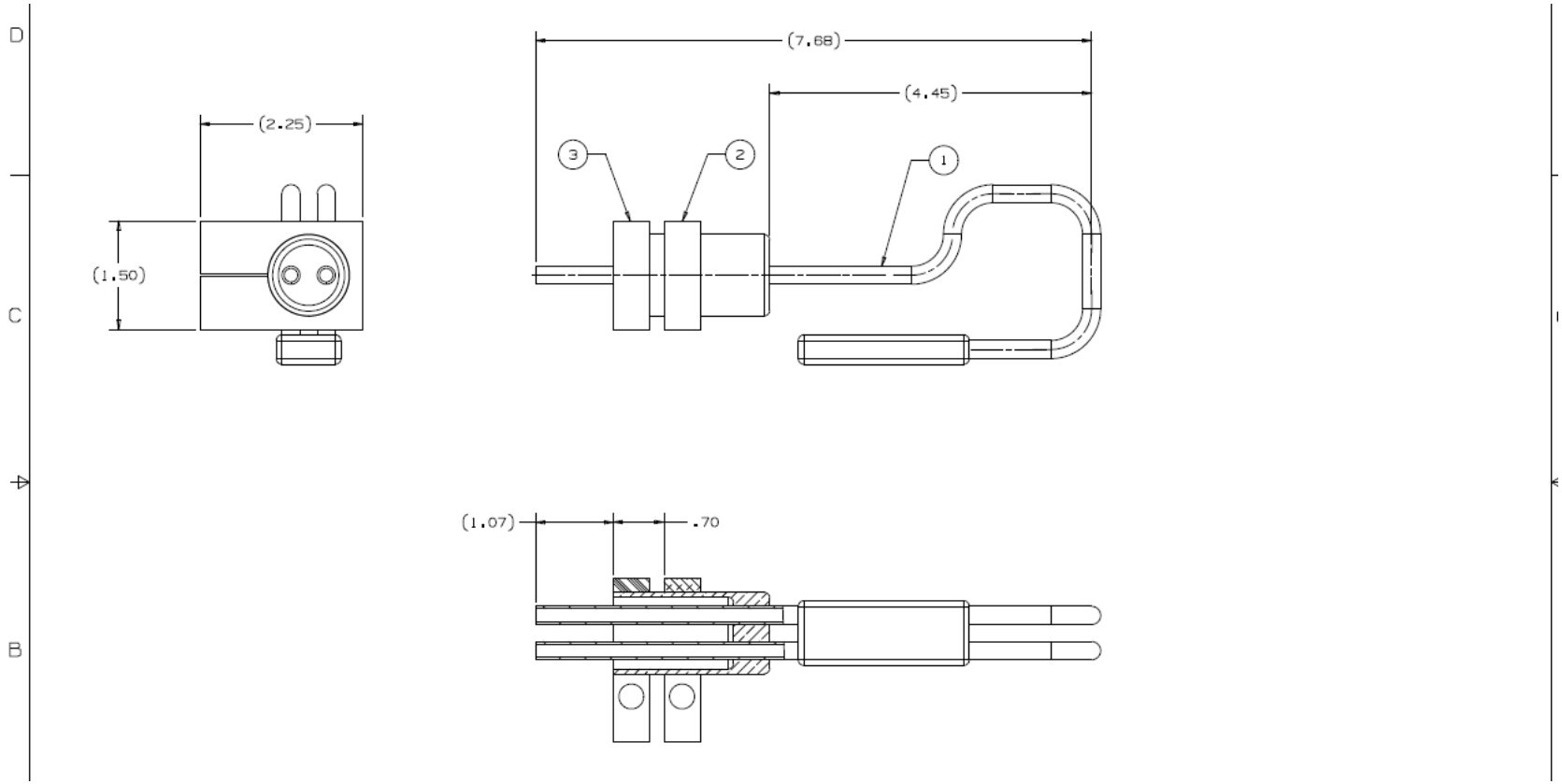
162.5 MHz coupler for RFQ
Cooling air flow



162.5 MHz coupler for RFQ
Cooling air flow

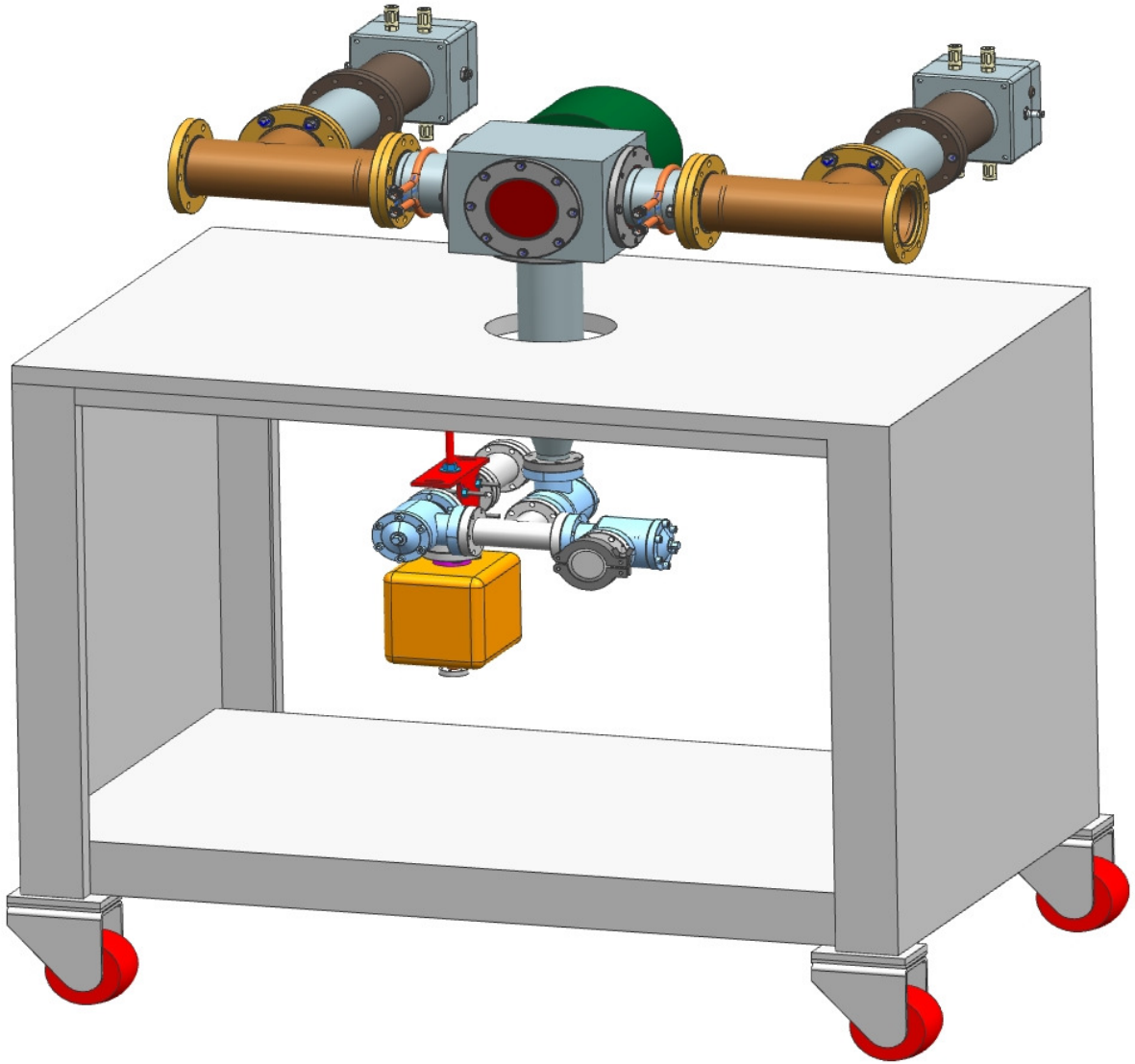


Test coupler

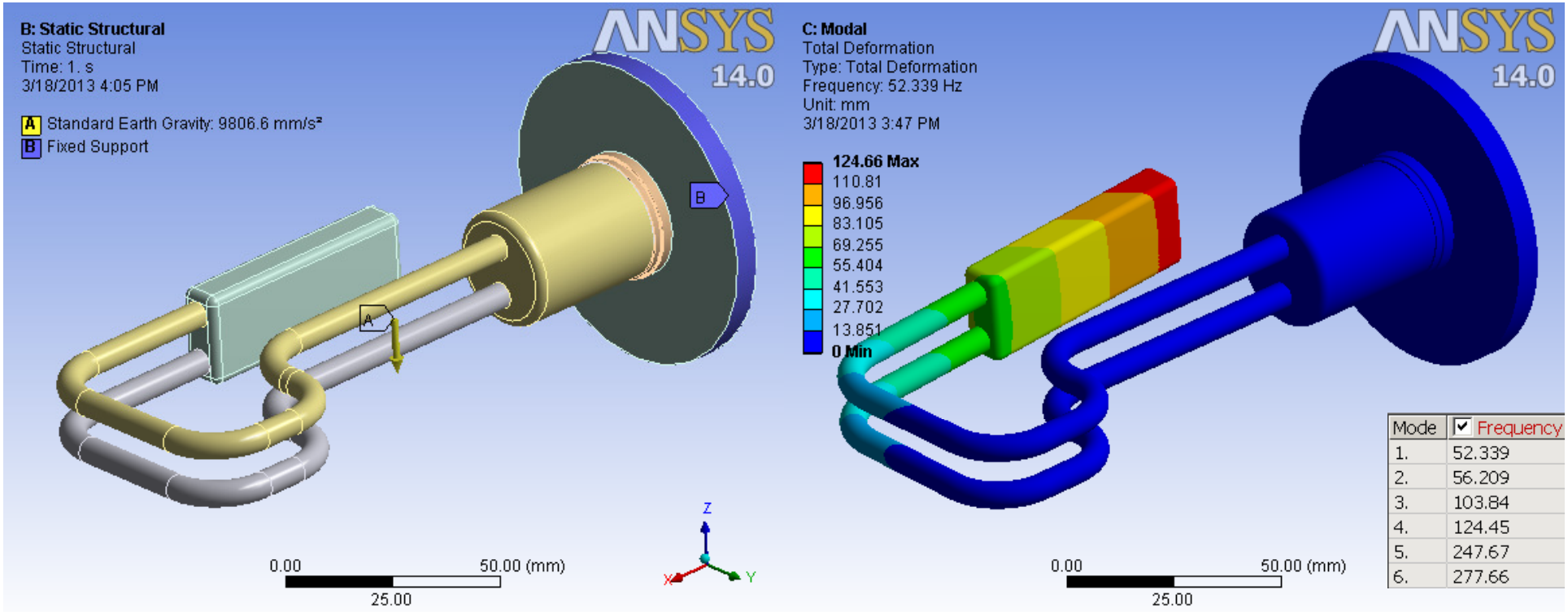


To verify air cooling and modal calculations we designed and ordered test coupler.
Expected delivery – end of May from VMS.

Preliminary design of Test Stand for RFQ Couplers



Antenna Loop Modal analyses



Al2O3 Ceramic Properties Standard

CoorsTek
Amazing Solutions.®

	Properties*		Units	Test	AD-998 Min. 99.8% Al_2O_3
MECHANICAL	Density		gm/cc	ASTM-C20	3.92
	Crystal Size	Average	MICRONS	THIN-SECTION	6
	Water Absorption		%	ASTM-373	0
	Gas Permeability		–	–	0
	Color		–	–	IVORY
	Flexural Strength (MOR)	20° C	MPa (psi x 10^3)	ASTM-F417	375 (54)
	Elastic Modulus	20° C	GPa (psi x 10^6)	ASTM-C848	370 (54)
	Poisson's Ratio	20° C	–	ASTM-C848	0.22
	Compressive Strength	20° C	MPa (psi x 10^3)	ASTM-C773	2500 (363)
	Hardness		GPa (kg/mm²)	KNOOP 1000 gm	14.1 (1440)
			R45N	ROCKWELL 45 N	83
	Tensile Strength	25° C	MPa (psi x 10^3)	ACMA TEST #4	248 (36)
	Fracture Toughness	K(I c)	Mpa $m^{1/2}$	NOTCHED BEAM	4 - 5
THERMAL	Thermal Conductivity	20° C	W/m K	ASTM-C408	30.0
	Coefficient of Thermal Expansion	25-1000° C	1X 10^{-6}/°C	ASTM-C372	8.2
	Specific Heat	100° C	J/kg*K	ASTM-E1269	880
	Thermal Shock Resistance	ΔTc	°C	❶	200
	Maximum Use Temperature		°C	NO-LOAD COND.	1750
ELECTRICAL	Dielectric Strength	6.35mm	ac-kV/mm (ac V/mil)	ASTM-D116	8.7 (220)
	Dielectric Constant	1 MHz	25° C	ASTM-D150	9.8
	Dielectric Loss (tan delta)	1 MHz	25° C	ASTM-D150	< 0.0001
	Volume Resistivity	25° C	ohm-cm	ASTM-D1829	> 10^{14}
		500° C	ohm-cm	ASTM-D1829	2 x 10^{10}
		1000° C	ohm-cm	ASTM-D1829	2 x 10^7
WEAR	Impingement		–	❷	0.47
	Rubbing		–	❷	–

KYOCERA

ITEMS	UNIT	CUSTOMER' s REQUEST	PROPOSED CERAMIC MATERIAL	
KYOCERA MATERIAL No.	--	--	A479B	AH100A
APPLICATION	–	--	RF EQUIPMENT	HIGH VOLTAGE
METALLIZATION	–	Mo/Mn + Ni Plating	Mo/Mn+ Ni Plating Ag-Cu-Ti + Ni Plating	Ag-Cu-Ti +Ni Plating
BRAZING ATMOSPHERE	–	NO REQUEST	N2/H2 VACUUM	VACUUM
BRAZING MATERIAL	–	NO REQUEST	Ag-Cu / Cu / Au-Cu	Ag-Cu
Al2O3 PURITY	%	99.5MIN.	99.8	97
SEE Coefficient (Max.)	—	NO REQUEST	11.5	5.7
FLEXUAL STRENGTH	*MPa*	NO REQUEST	300	359
YOUNG'S MODULUS	*GPa*	NO REQUEST	370	386
POISSON'S RATIO	—	NO REQUEST	0.23	0.25
VOLUME RESISTIVITTY	*Ohm*cm*	NO REQUEST	$>10^{14}$	$>10^{14}$
DIELECTRIC CONSTANT (1MHz)	—	9.8 +0.2/-0.4	9.9	10.9
Tan Delta (@1MHz)	*($\times 10^{-4}$)*	*$<10^{-4}$ at R.oom Temperature*	0.4 (@8GHz) **circular cavity**	2X (10GHz)
CTE	*$\times 10^{6}$/deg C*	NO REQUEST	7	7.4
THERMAL CONDUCTIVITY	*W/(mK)*	NO REQUEST	29	24

SEE Coefficient : Secondary Electron Emission Coefficient
These are reference value taken from material measurement data.
The failure mode in brazing process is ceramic crack.
Tensile strength for Ag(72%)-Cu(28%) material itself: 32-40kgf/mm2. Bonding strength after brazing: 10-15kgf/mm2

Summary of RFQ Coupler Design Status

- ✓ Engineering design nearly complete, see F10003120.
- ✓ Thermal, stress, deflection and modal analysis complete
- ✓ Test coupler designed, fabrication drawings released to procurement, expected delivery end of May 2013 from VMS

Remaining Tasks and Plans

- Make groove mock-up of Coupler to RFQ flange to test the groove/spring fit
- Fabrication drawings
- Procurement of RFQ Coupler
- Finish Design and order Coupler Test Stand
- Design and order Coupler Support