NEXT-100 Mechanical Overview

Derek Shuman

Lawrence Berkeley National Laboratory

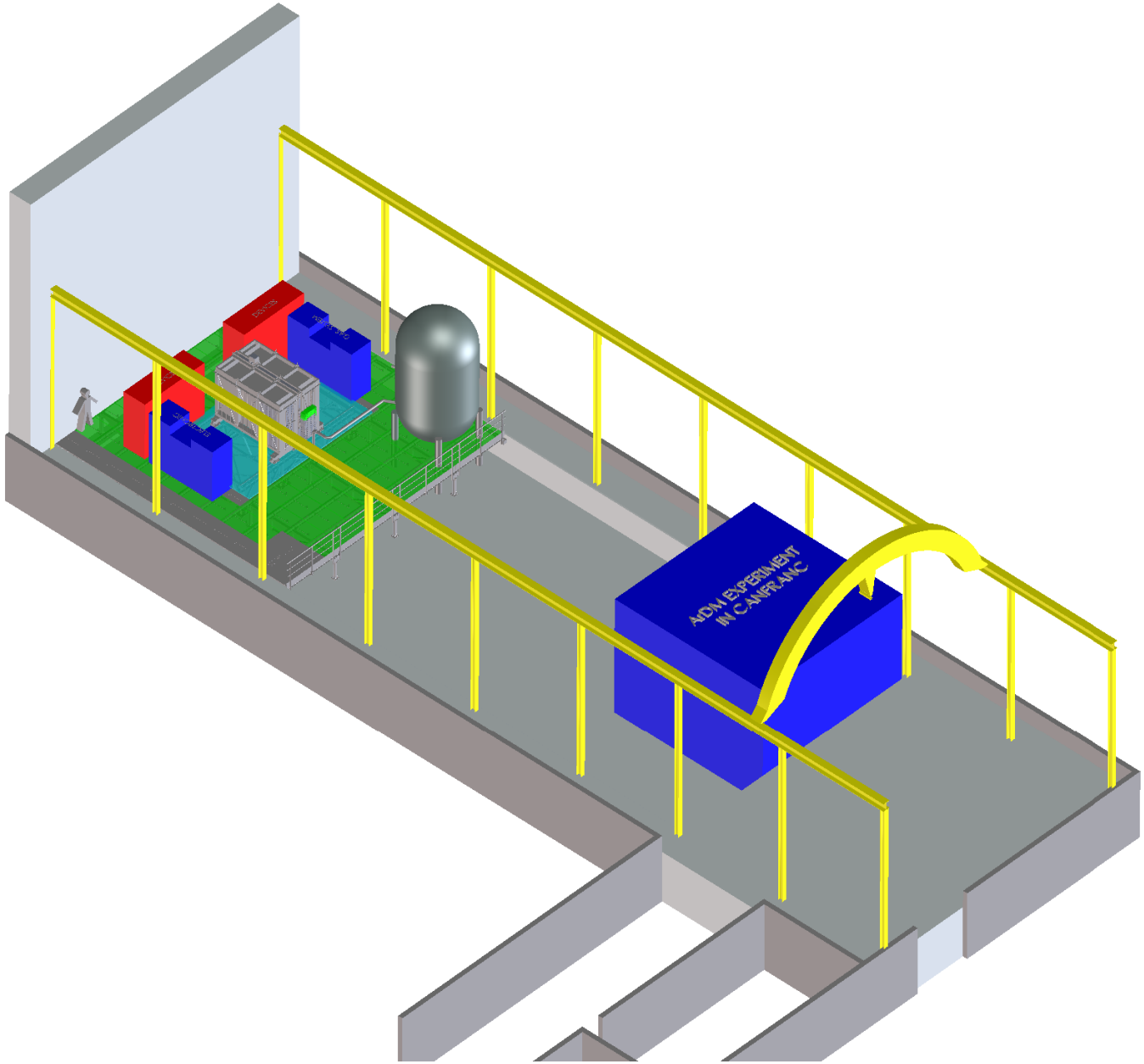
December 2, 2012

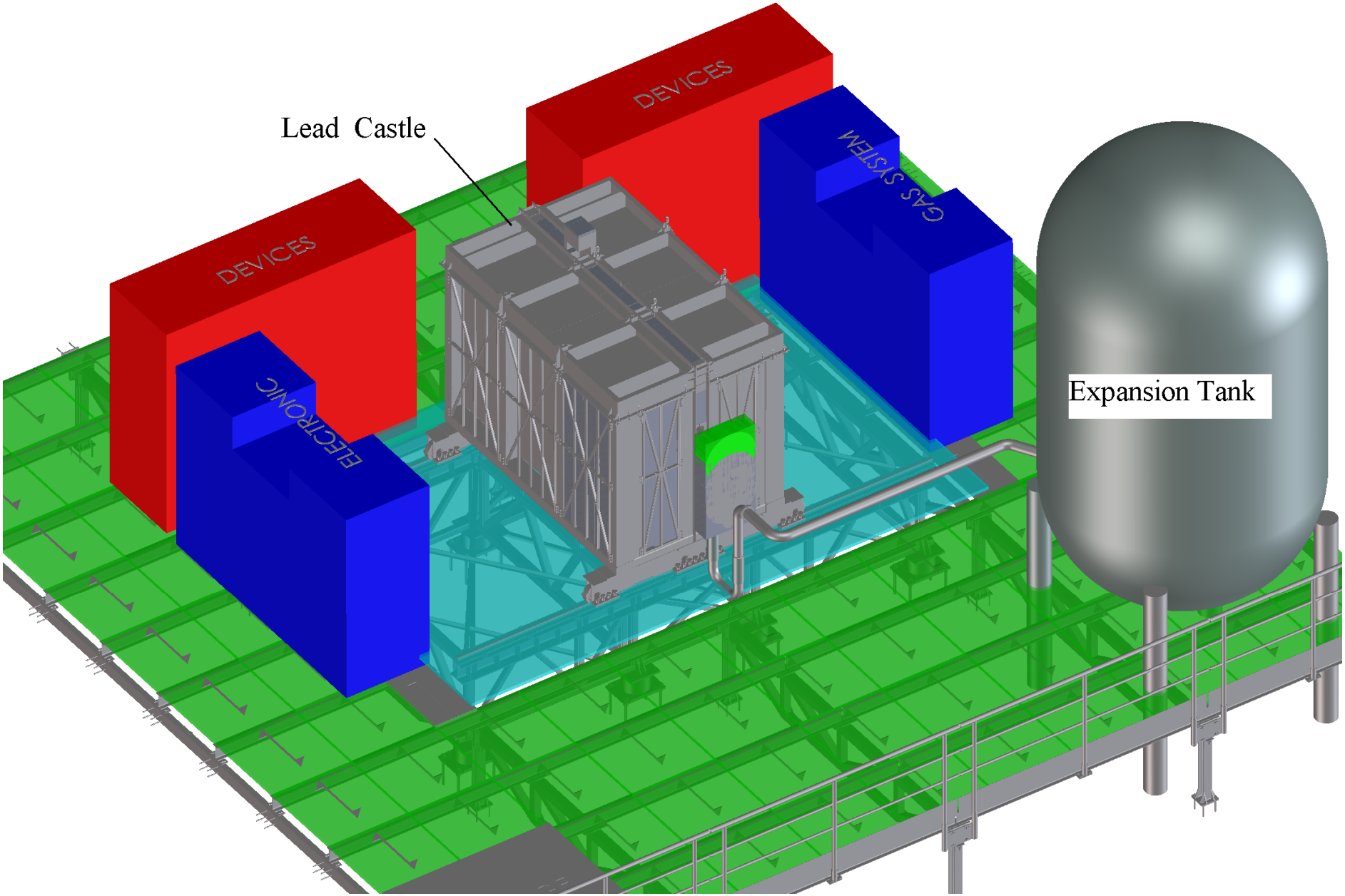
Mechanical

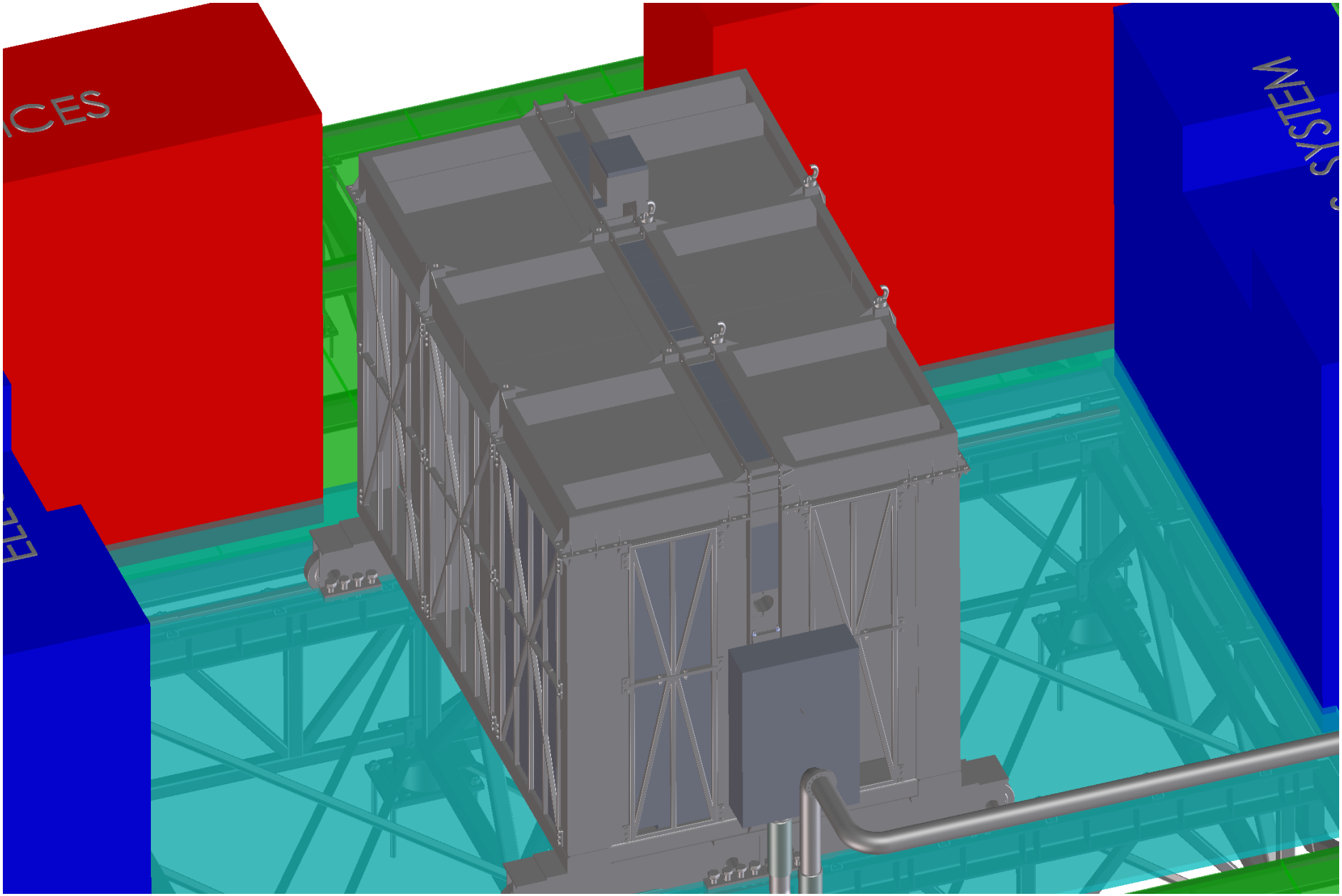
- Derek Shuman LBNL (lead, past)
- Sara Carcel, IFIC (lead, present)
- Alberto Martinez, IFIC

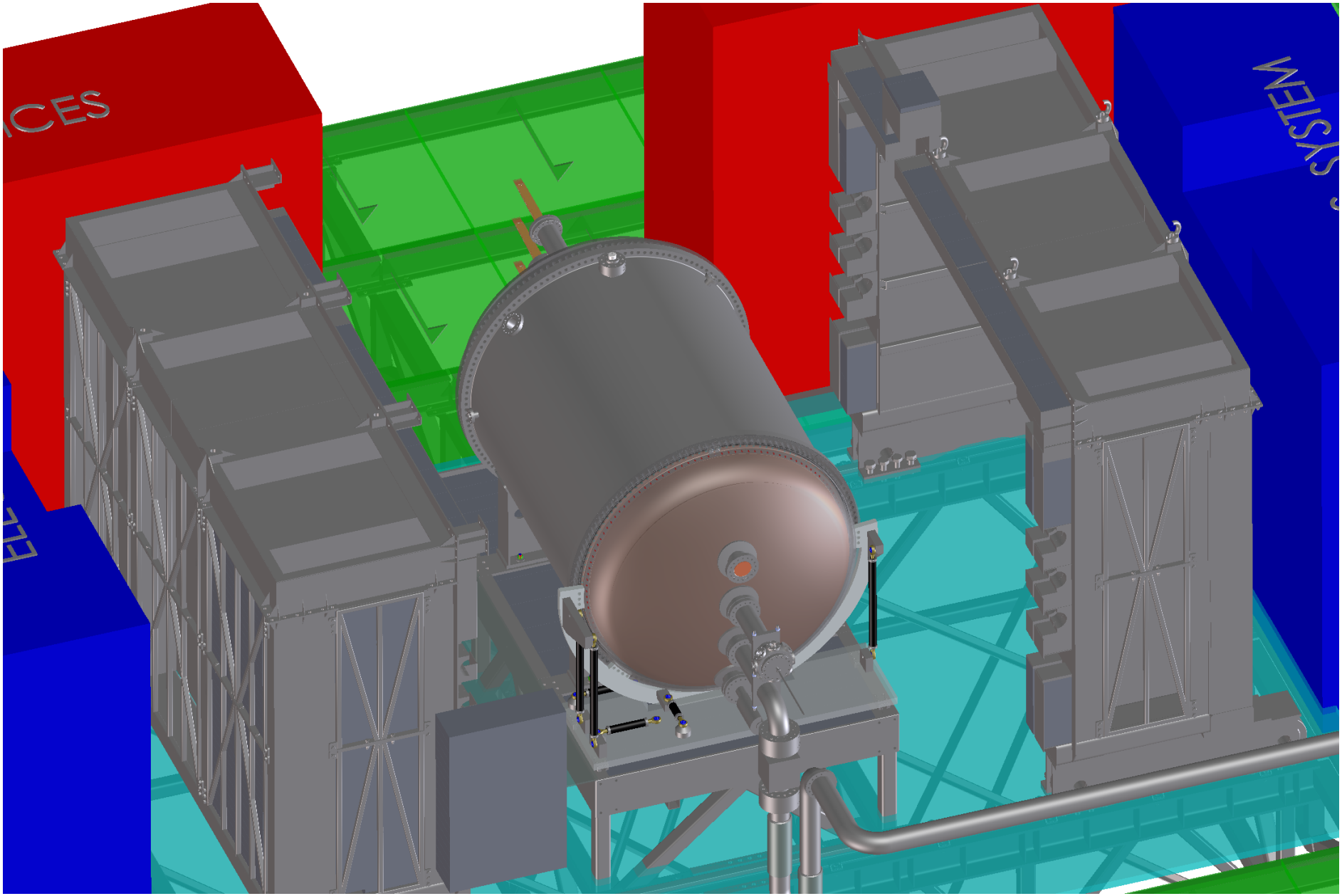
Civil

- Jose Luis Perez Aparicio, University Polytechnica de Valencia (lead)
- Jordi Torrent Collell, Escola Politechnica superior, University de Girona
- Roberto Palma, UPV

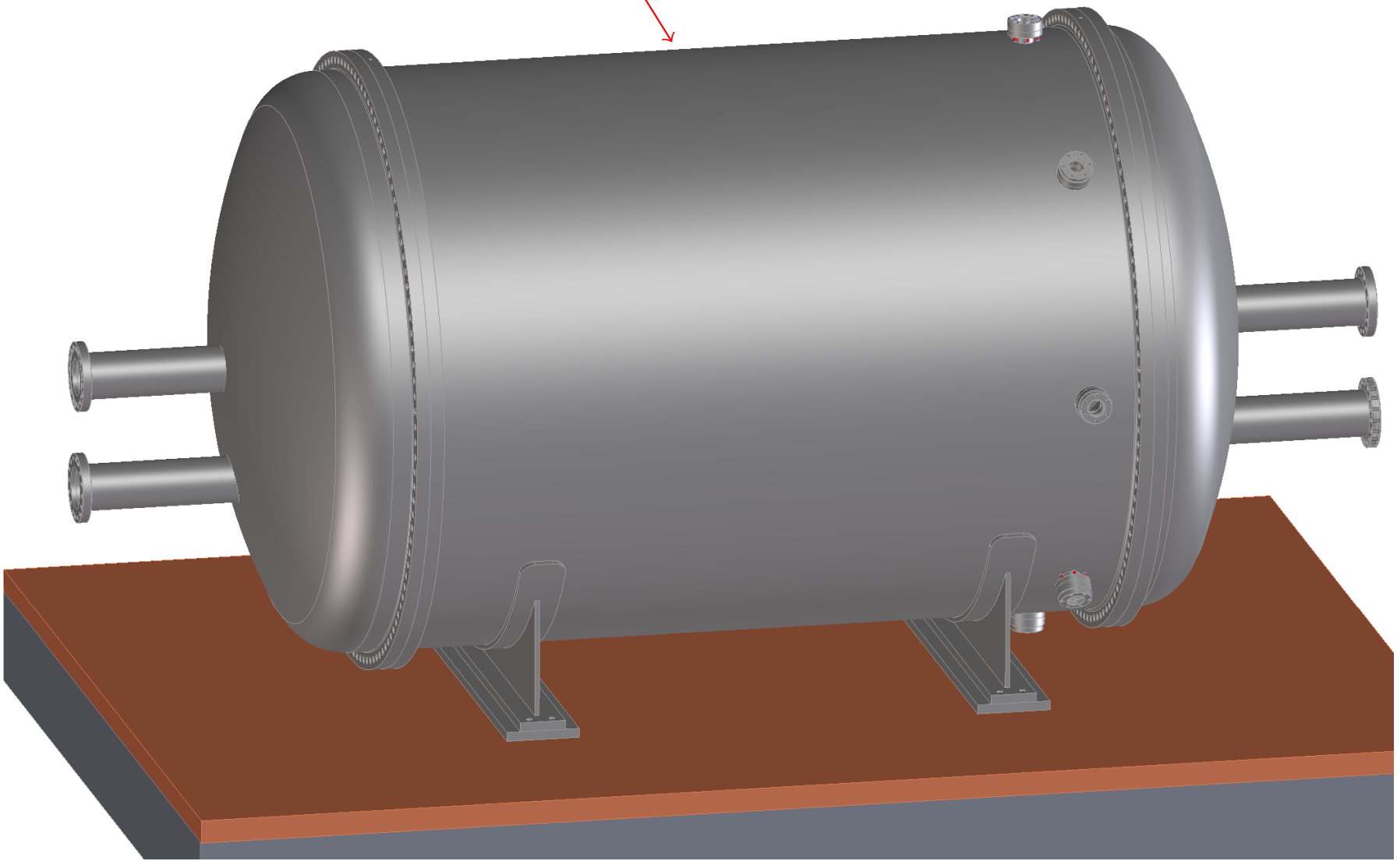

AIDM EXPERIMENT
IN CANFRANC

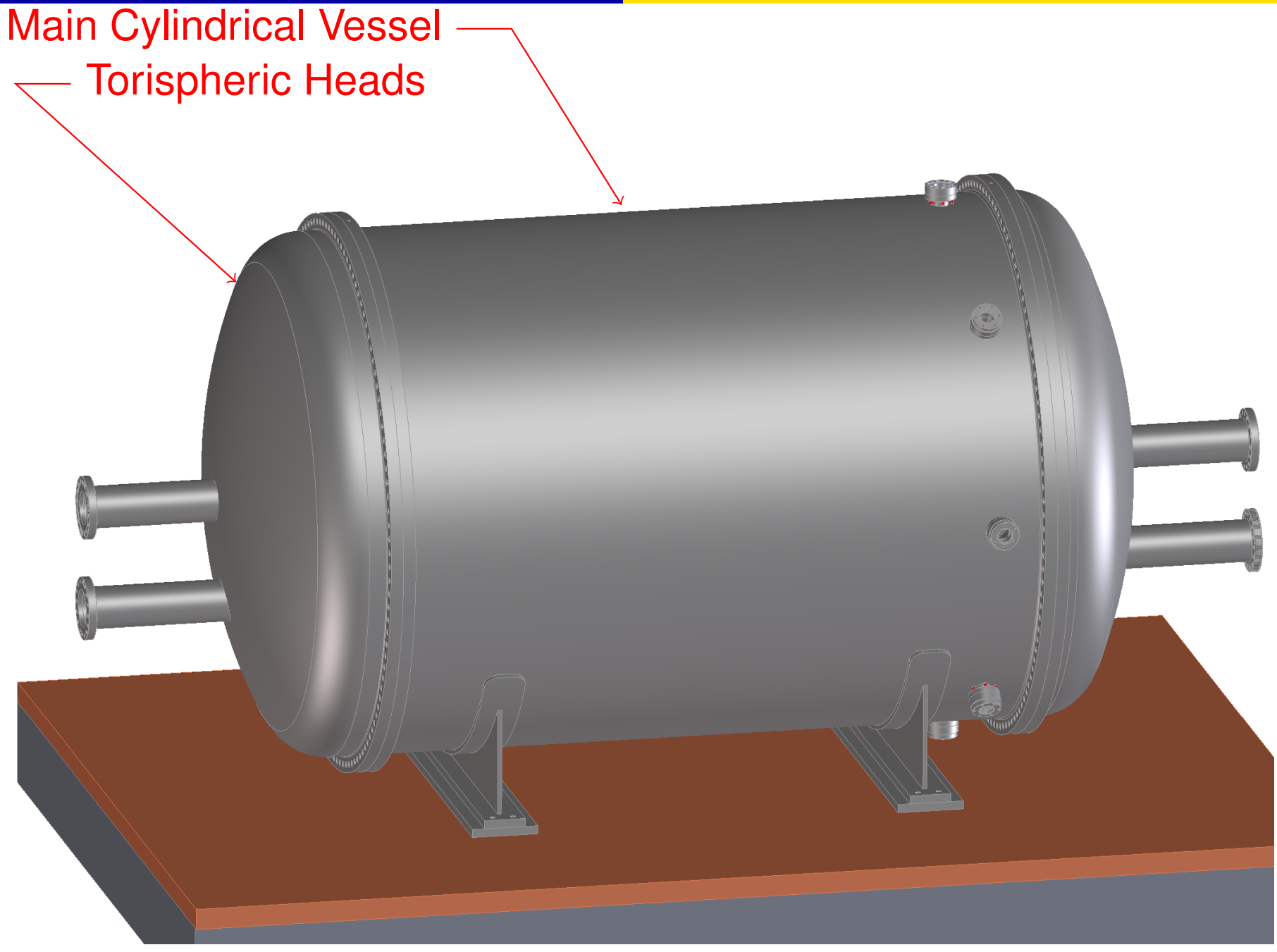

Lead Castle
DEVICES
DEVICES
GAS SYSTEM
ELECTRONIC
Expansion Tank

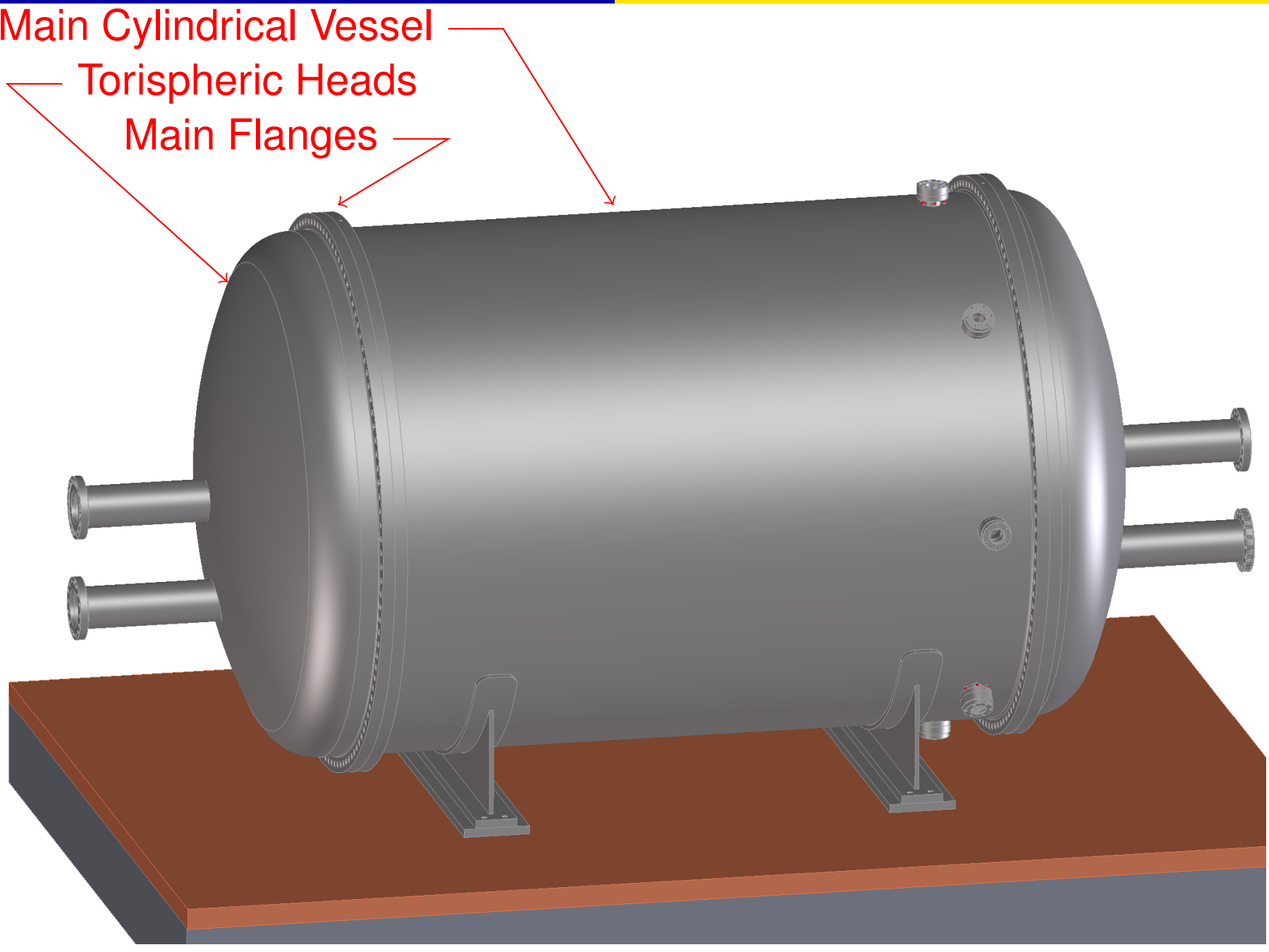

ICES
SYSTEM

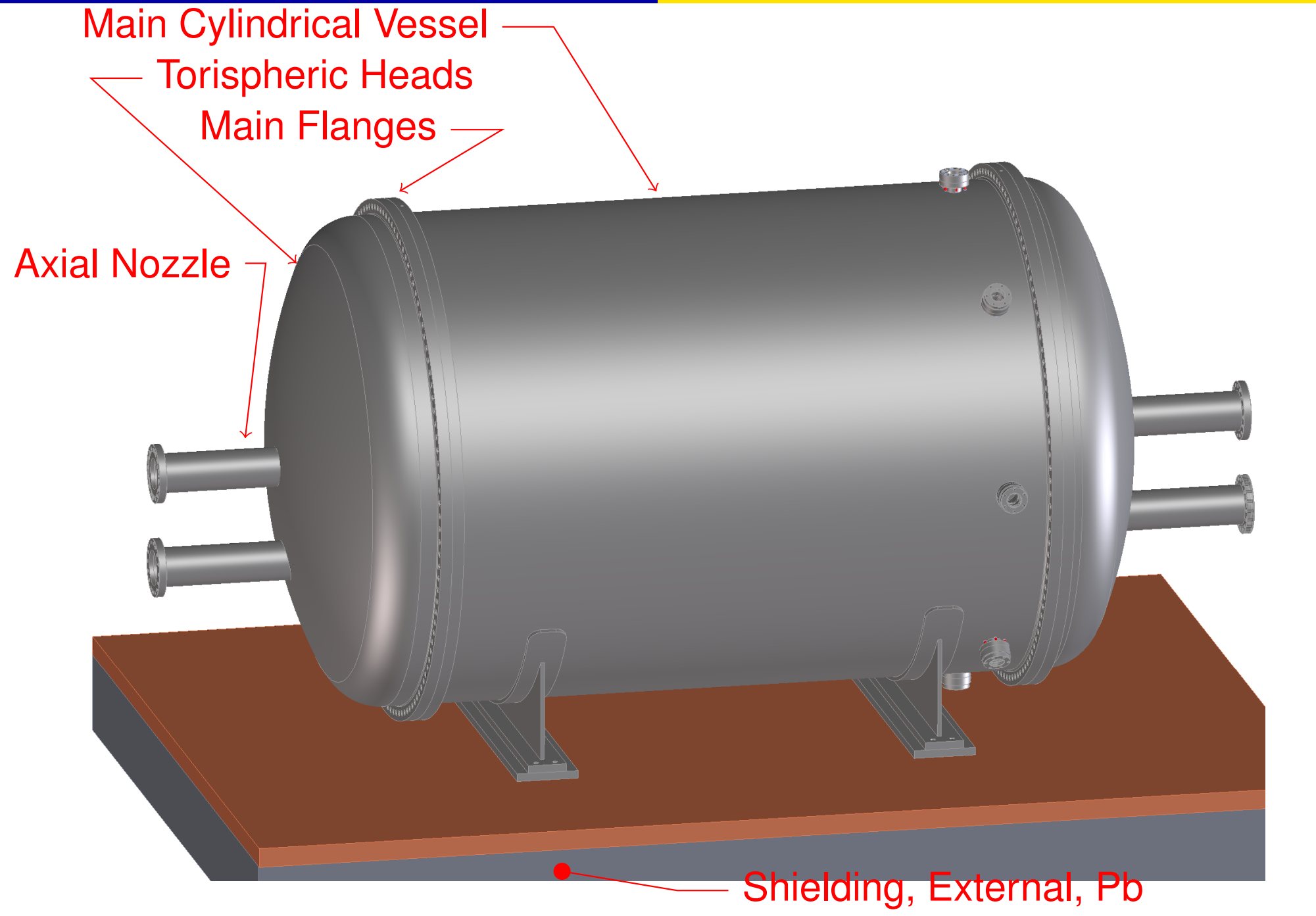

ICES
SYSTEM

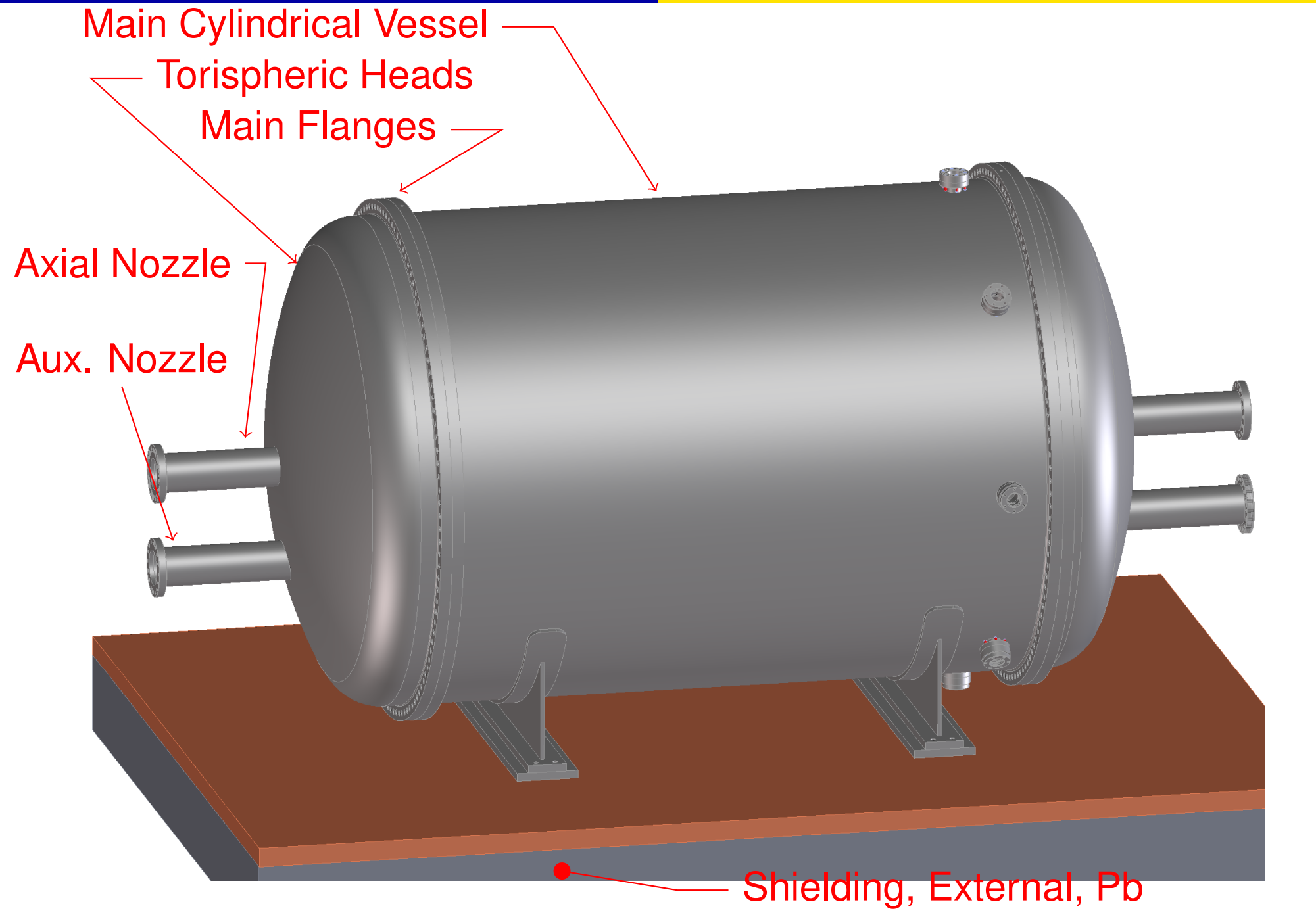
Main Cylindrical Vessel

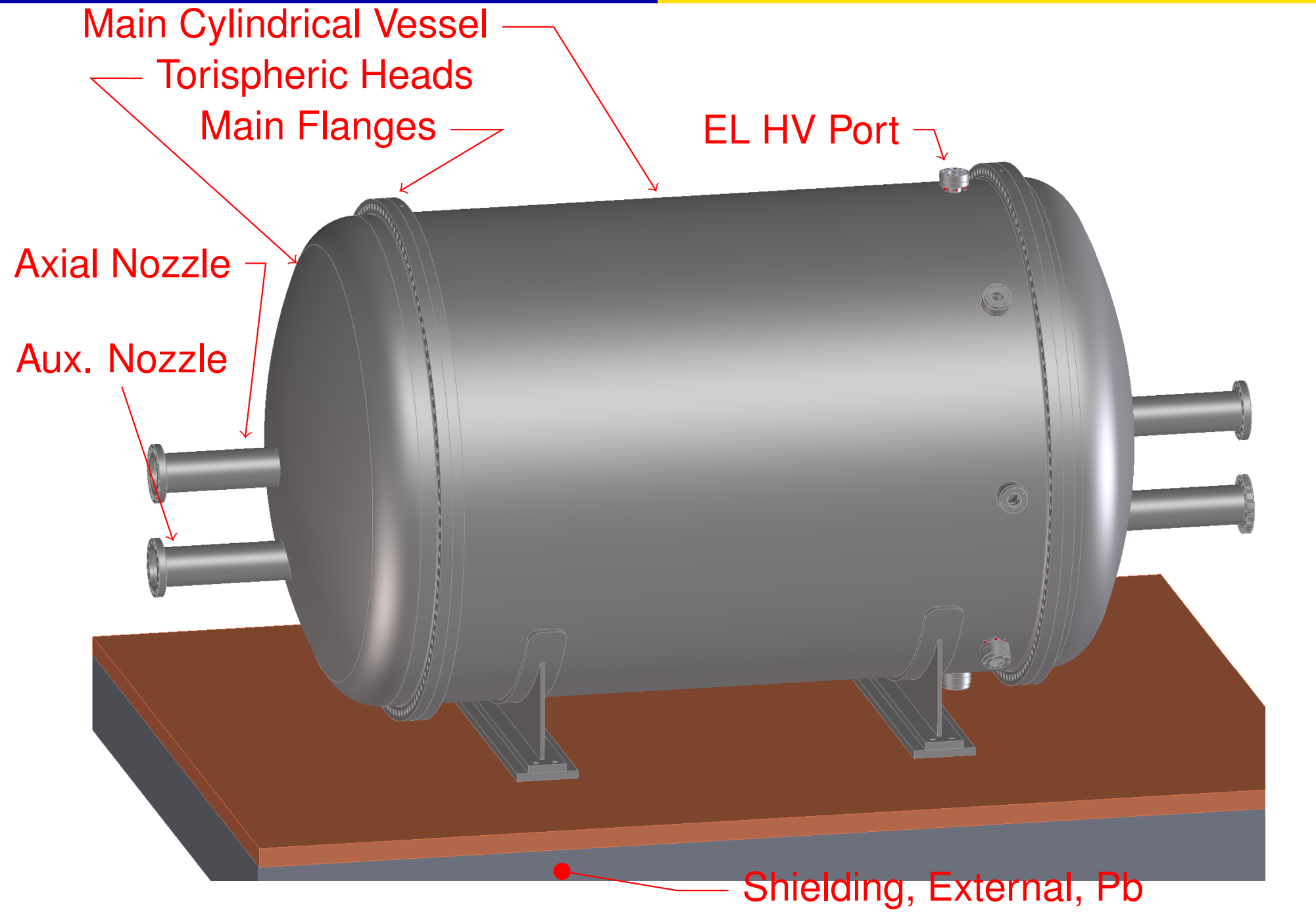


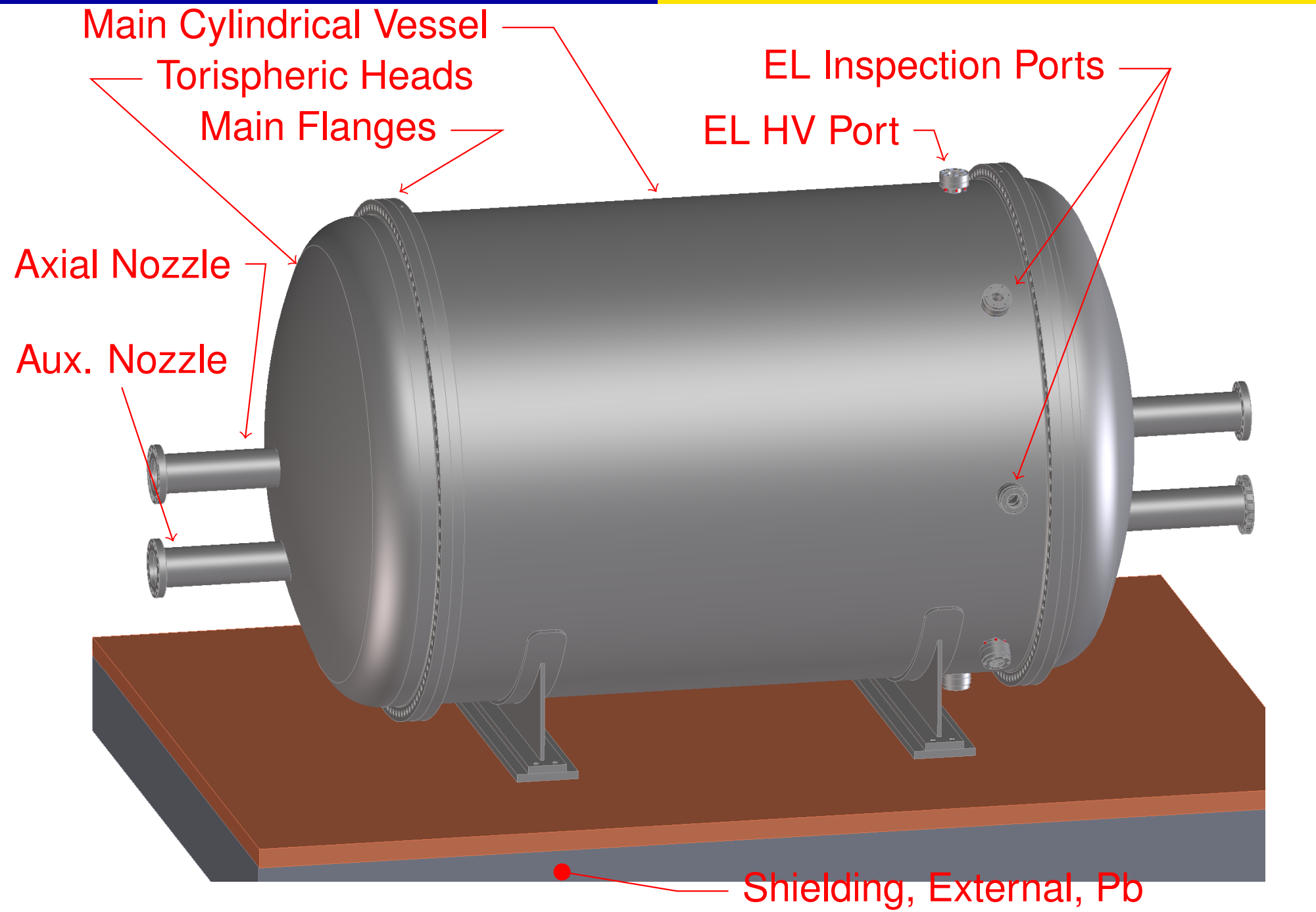

Main Cylindrical Vessel
Torispheric Heads

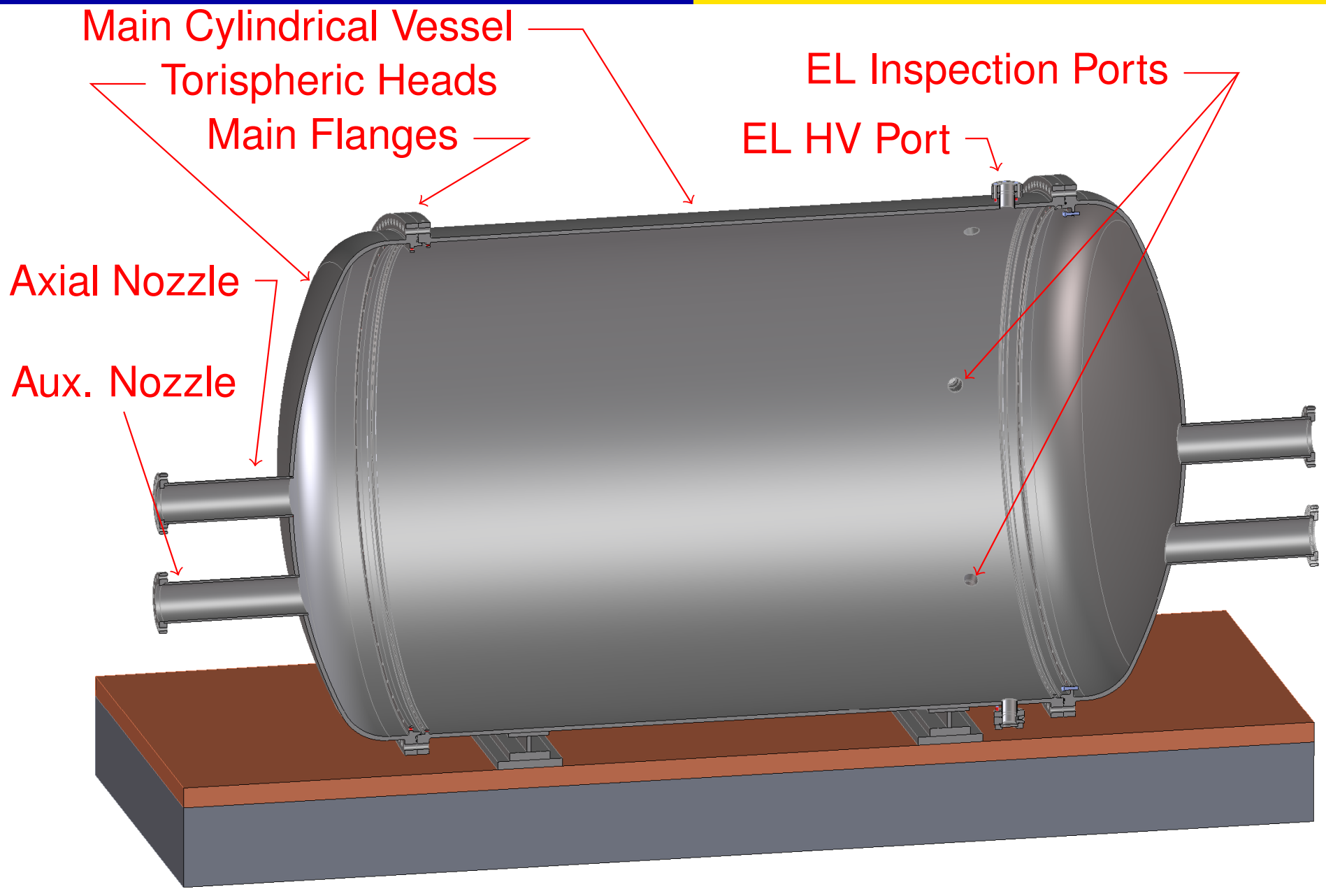

Main Cylindrical Vessel
Torispheric Heads
Main Flanges

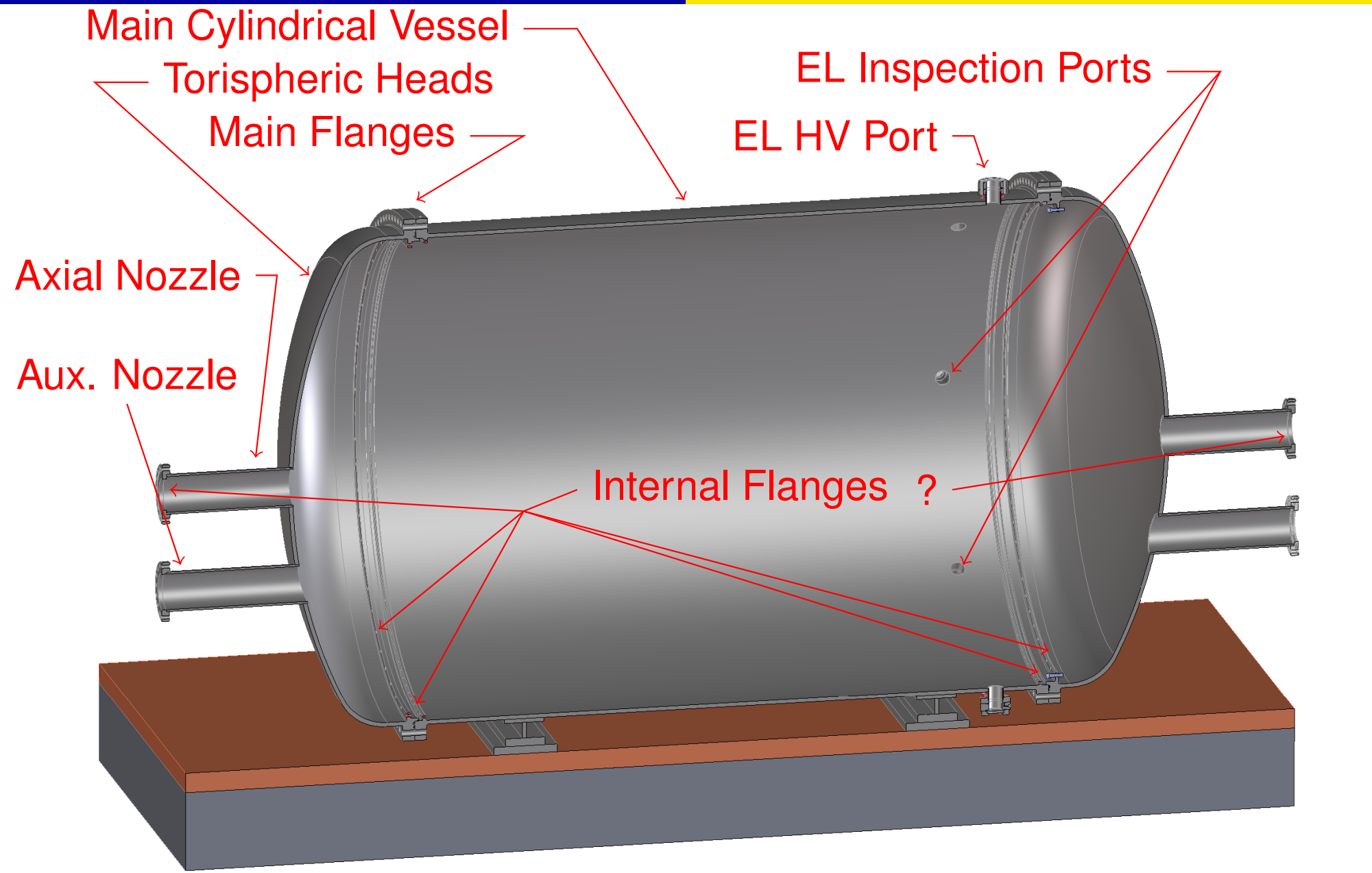

Main Cylindrical Vessel
Torispheric Heads
Main Flanges
Axial Nozzle
Shielding, External, Pb

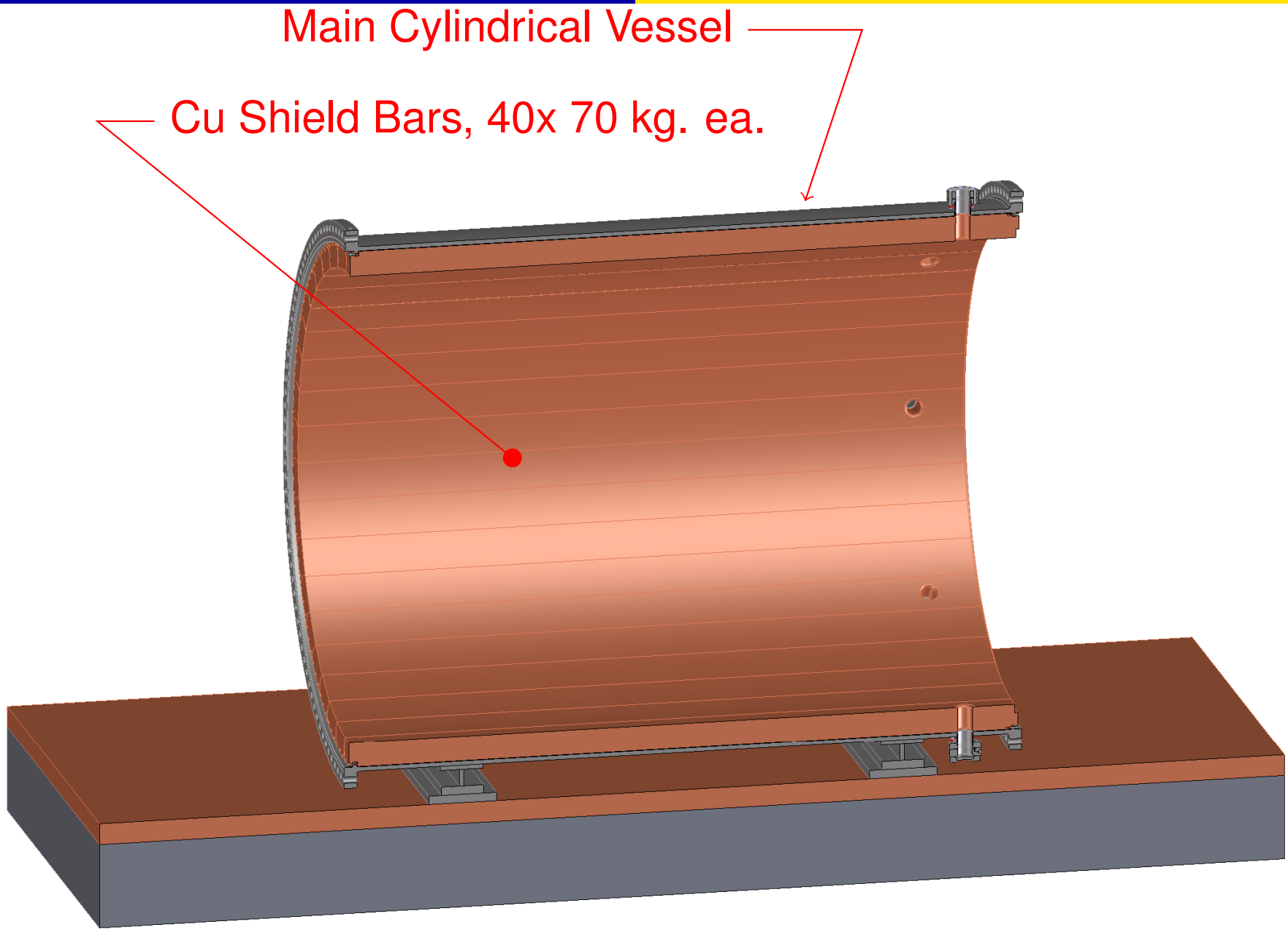

Main Cylindrical Vessel
Torispheric Heads
Main Flanges
Axial Nozzle
Aux. Nozzle
Shielding, External, Pb

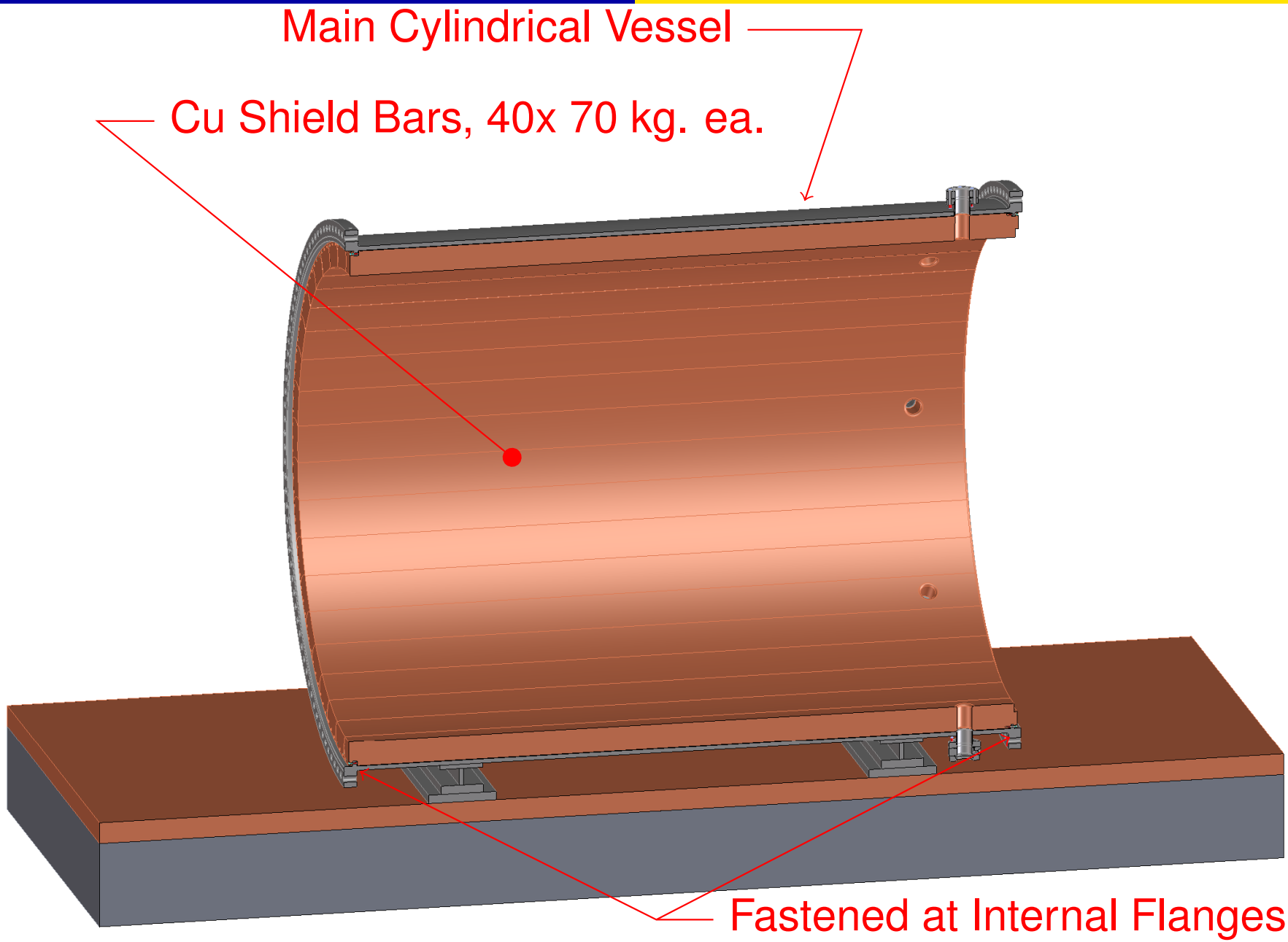

Main Cylindrical Vessel
Torispheric Heads
Main Flanges
EL HV Port
Axial Nozzle
Aux. Nozzle
Shielding, External, Pb


Main Cylindrical Vessel
Torispheric Heads
Main Flanges
EL Inspection Ports
EL HV Port
Axial Nozzle
Aux. Nozzle
Shielding, External, Pb


Main Cylindrical Vessel
Torispheric Heads
Main Flanges
EL Inspection Ports
EL HV Port
Axial Nozzle
Aux. Nozzle

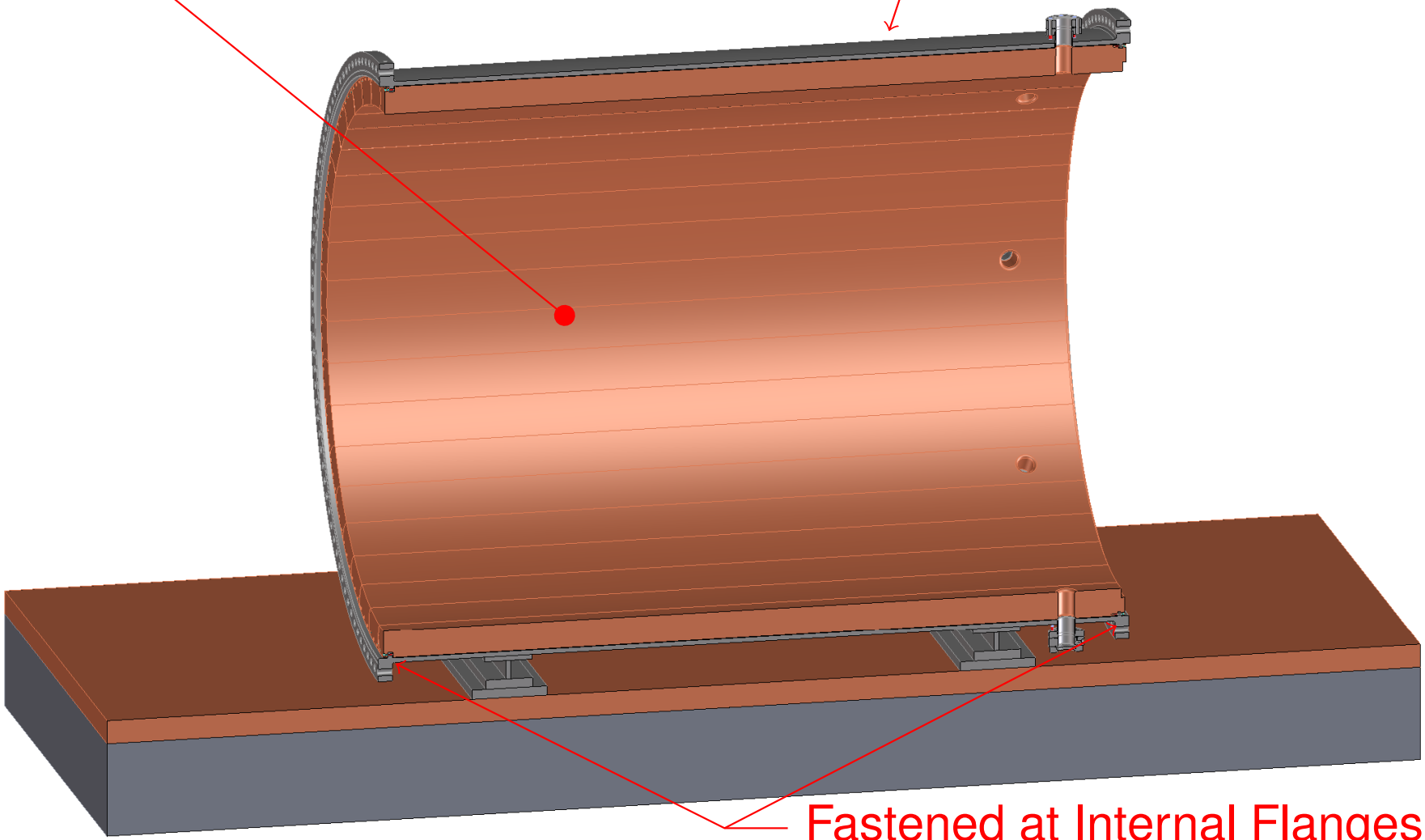

Main Cylindrical Vessel
Torispheric Heads
Main Flanges
EL Inspection Ports
EL HV Port
Axial Nozzle
Aux. Nozzle
Internal Flanges ?


Main Cylindrical Vessel
Cu Shield Bars, 40x 70 kg. ea.


Main Cylindrical Vessel
Cu Shield Bars, 40x 70 kg. ea.
Fastened at Internal Flanges

Main Cylindrical Vessel

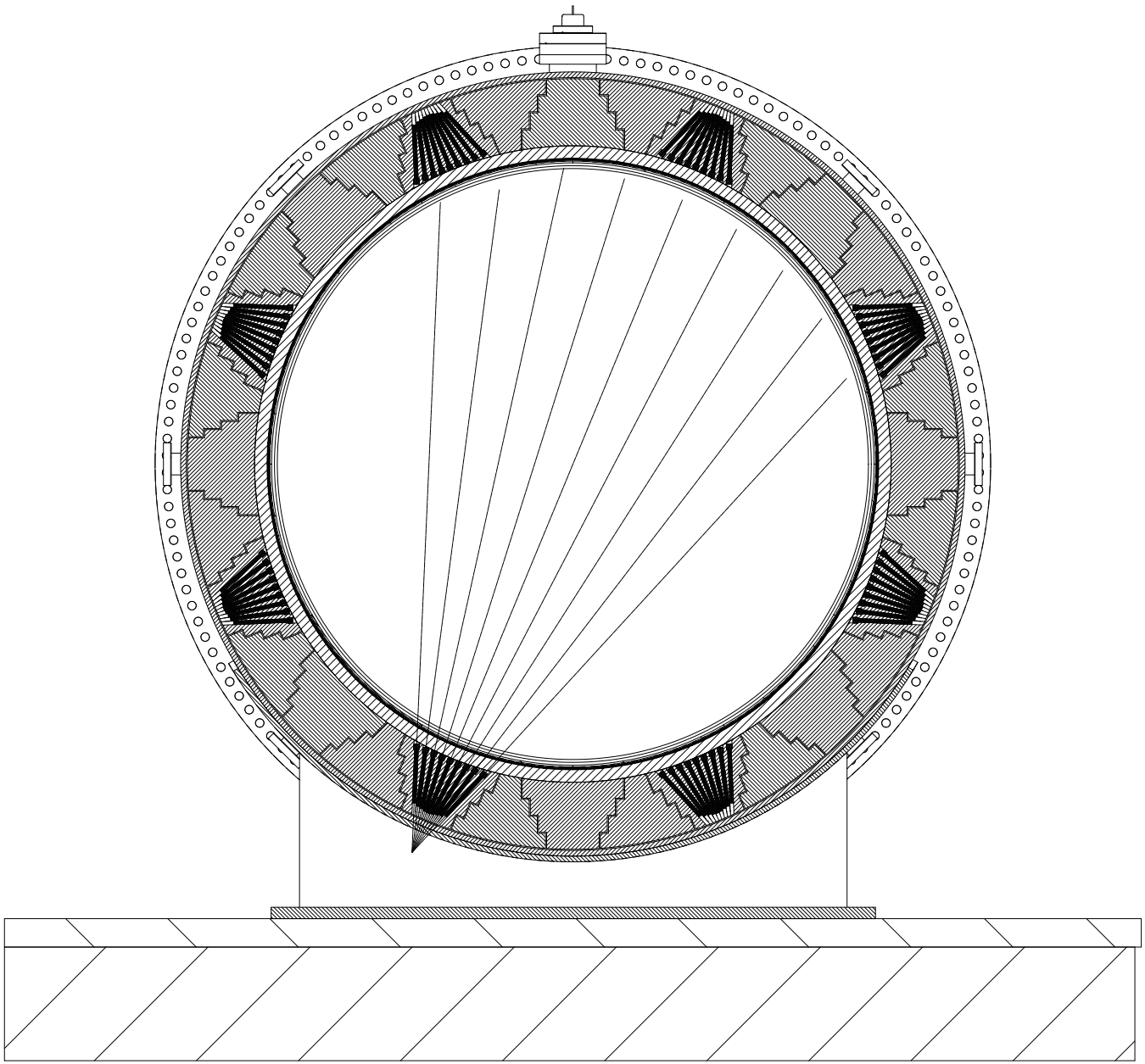
Cu Shield Bars, 40x 70 kg. ea.

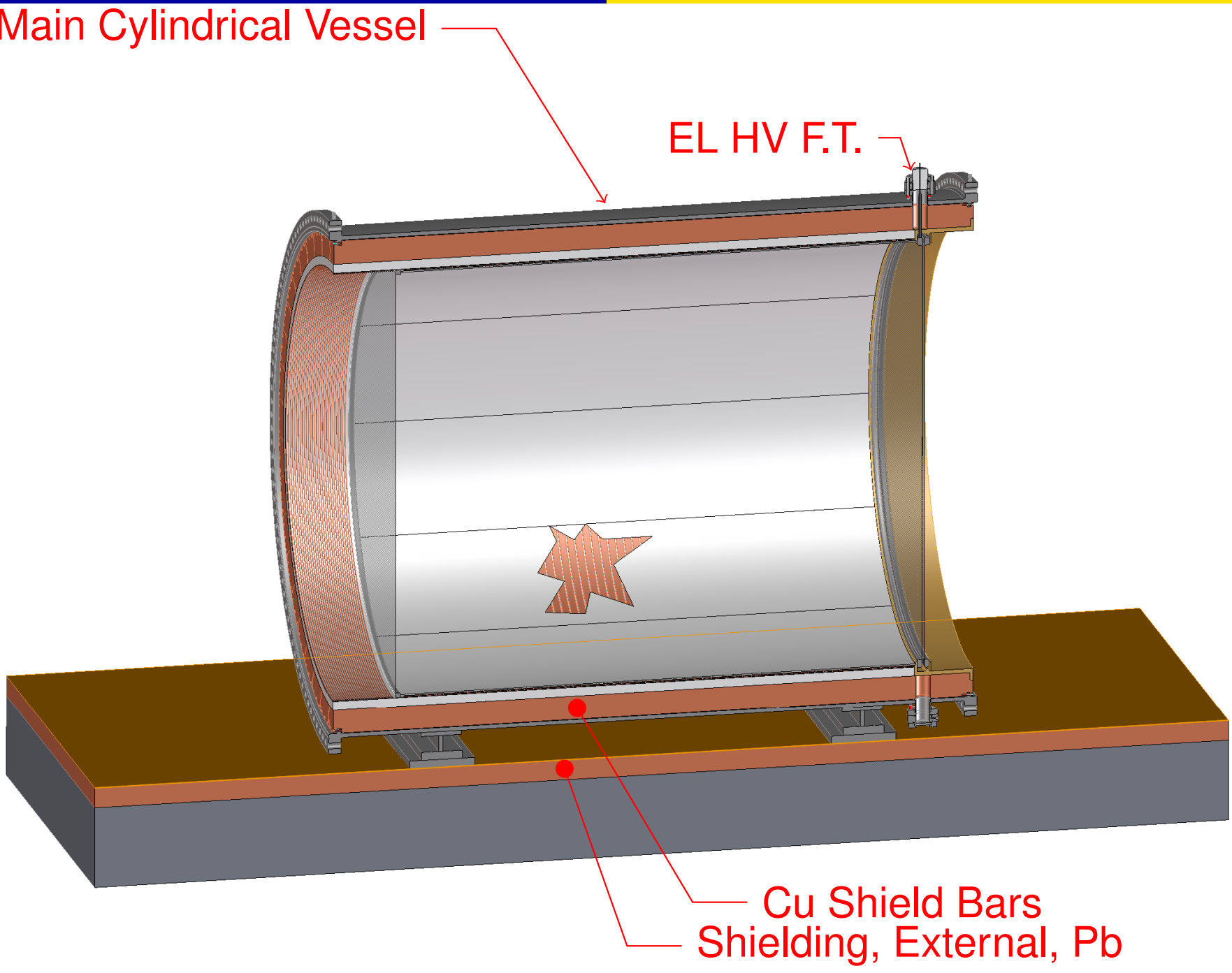


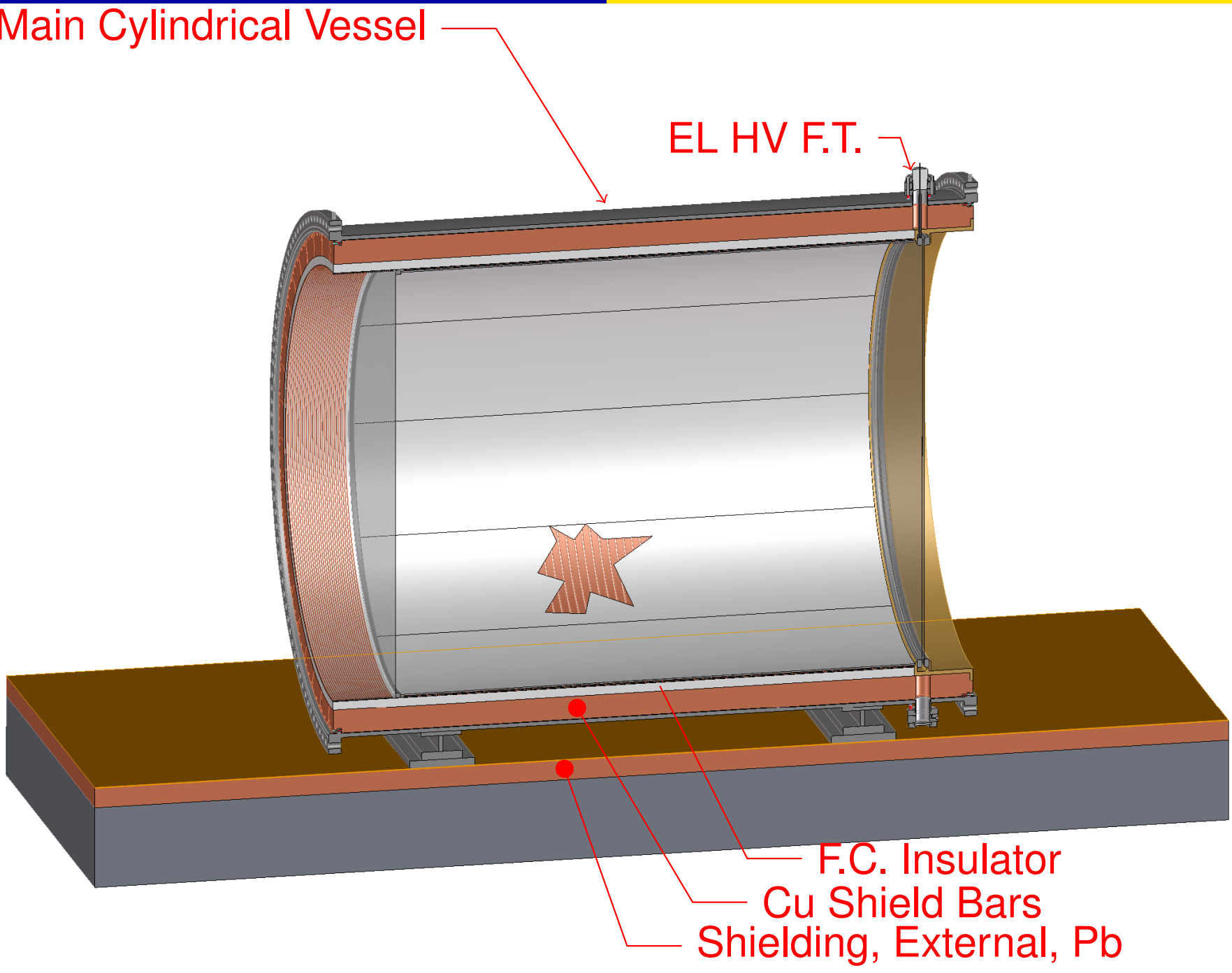
Fastened at Internal Flanges

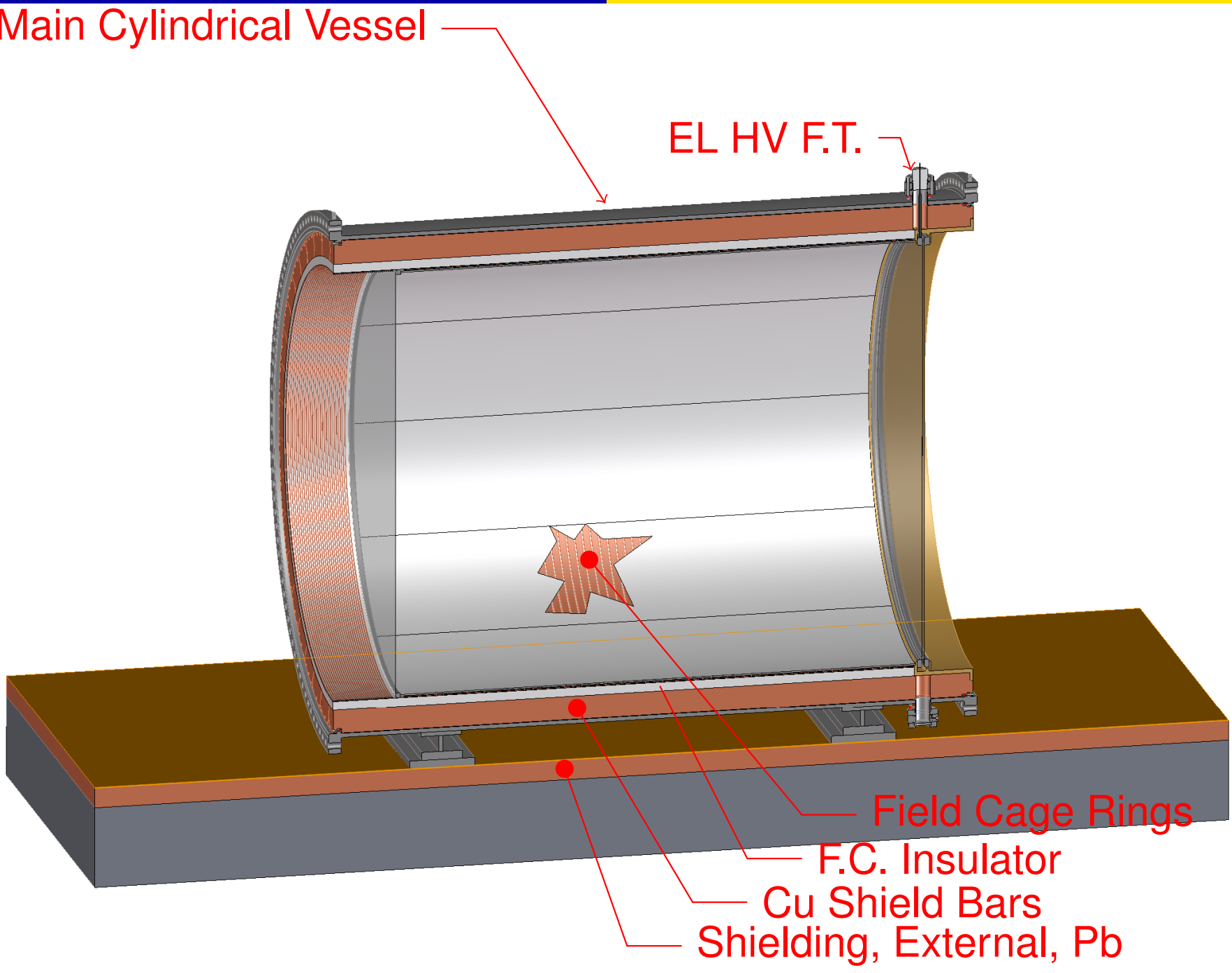
Supported on Ends, low stress, no vessel contact

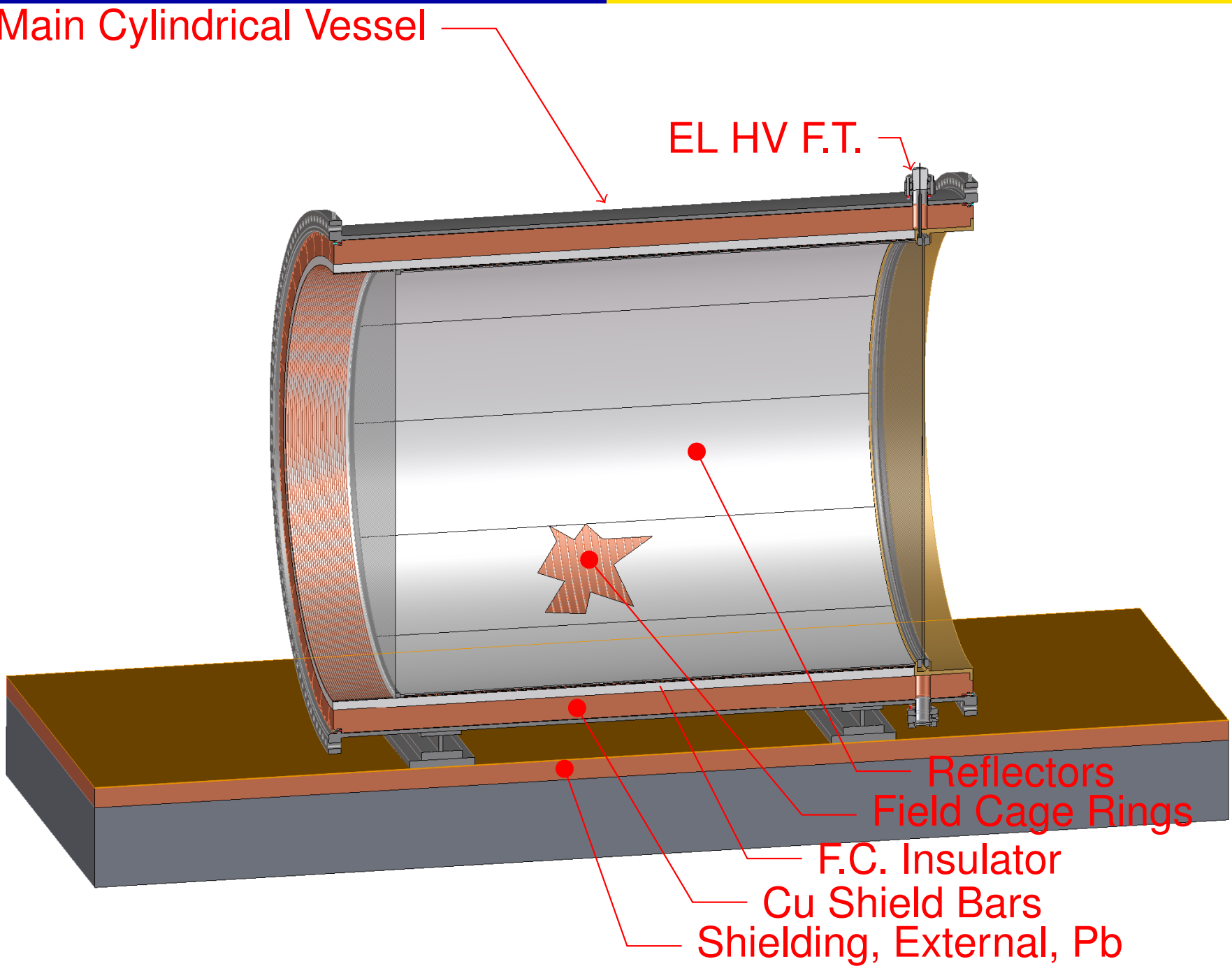
End view of ICS bars showing possible external source collimators

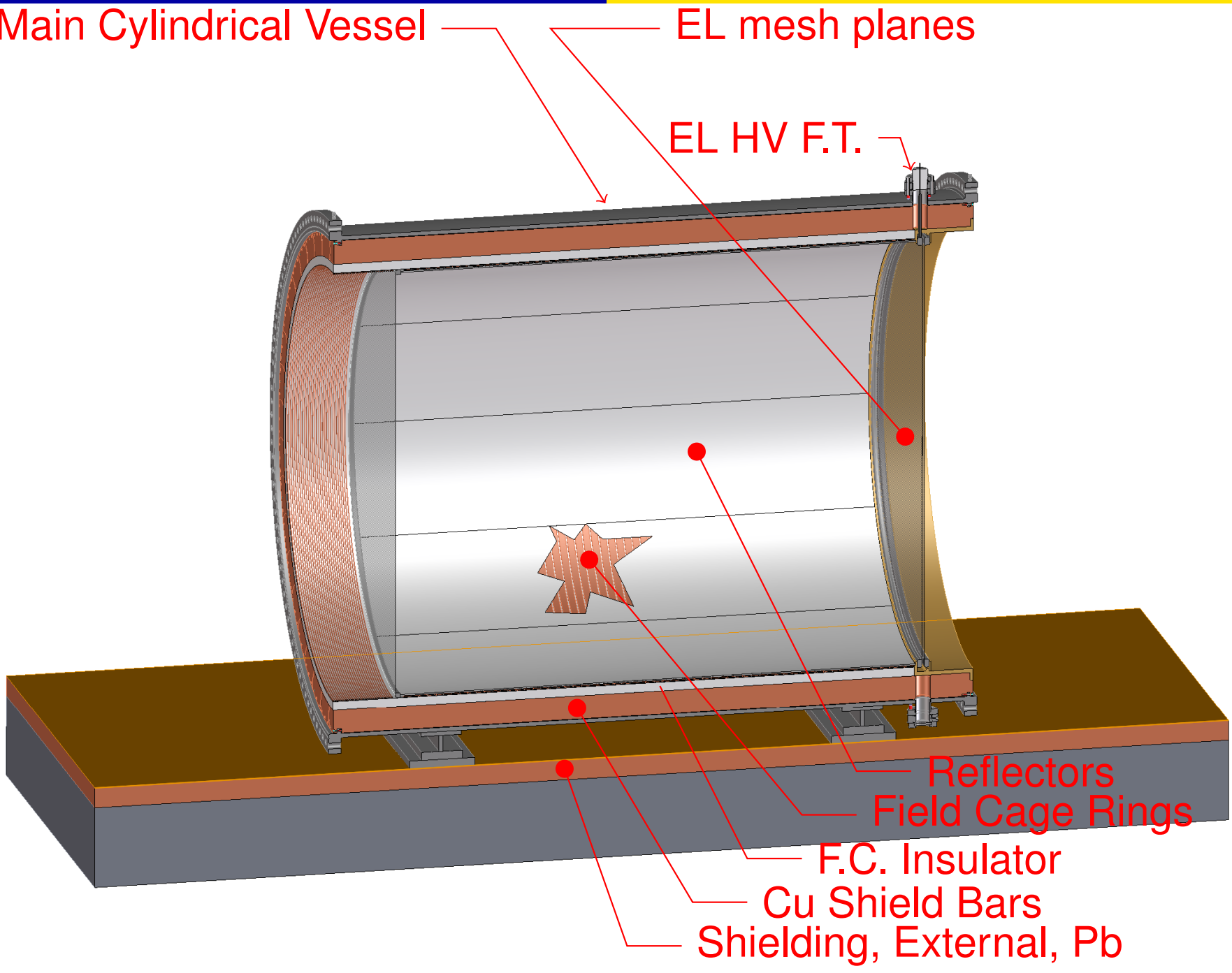


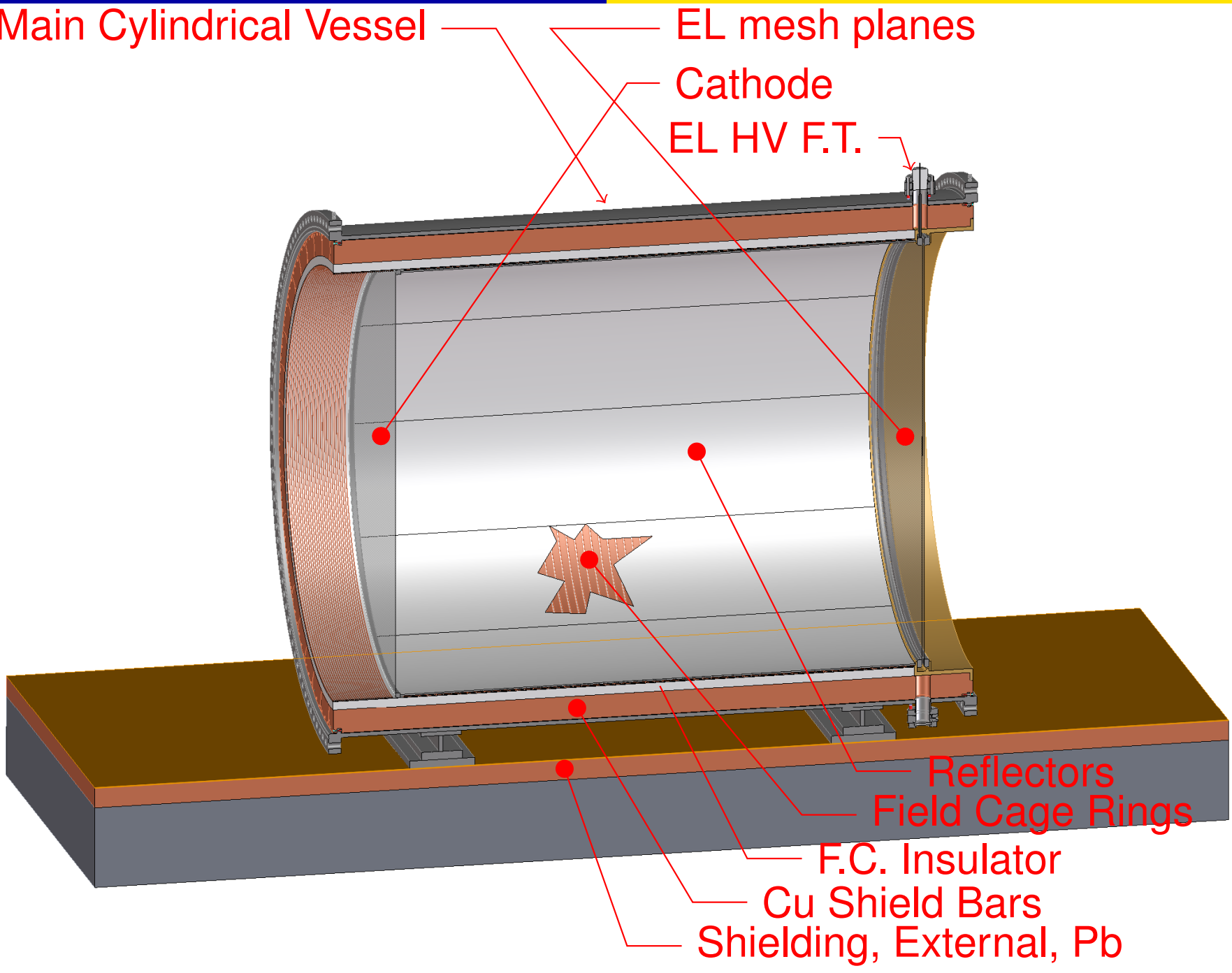

Main Cylindrical Vessel
EL HV F.T.
Cu Shield Bars
Shielding, External, Pb

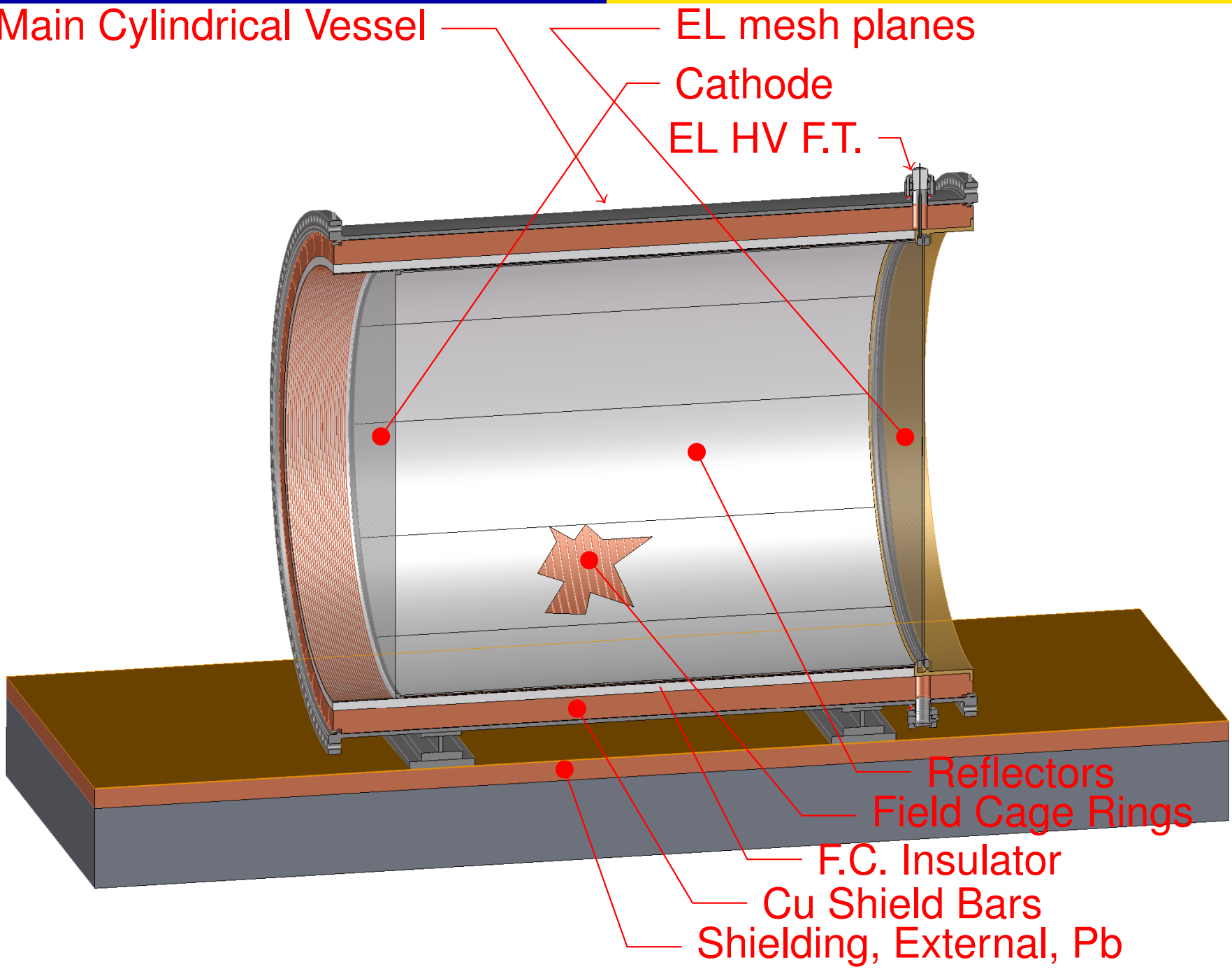

Main Cylindrical Vessel
EL HV F.T.
F.C. Insulator
Cu Shield Bars
Shielding, External, Pb

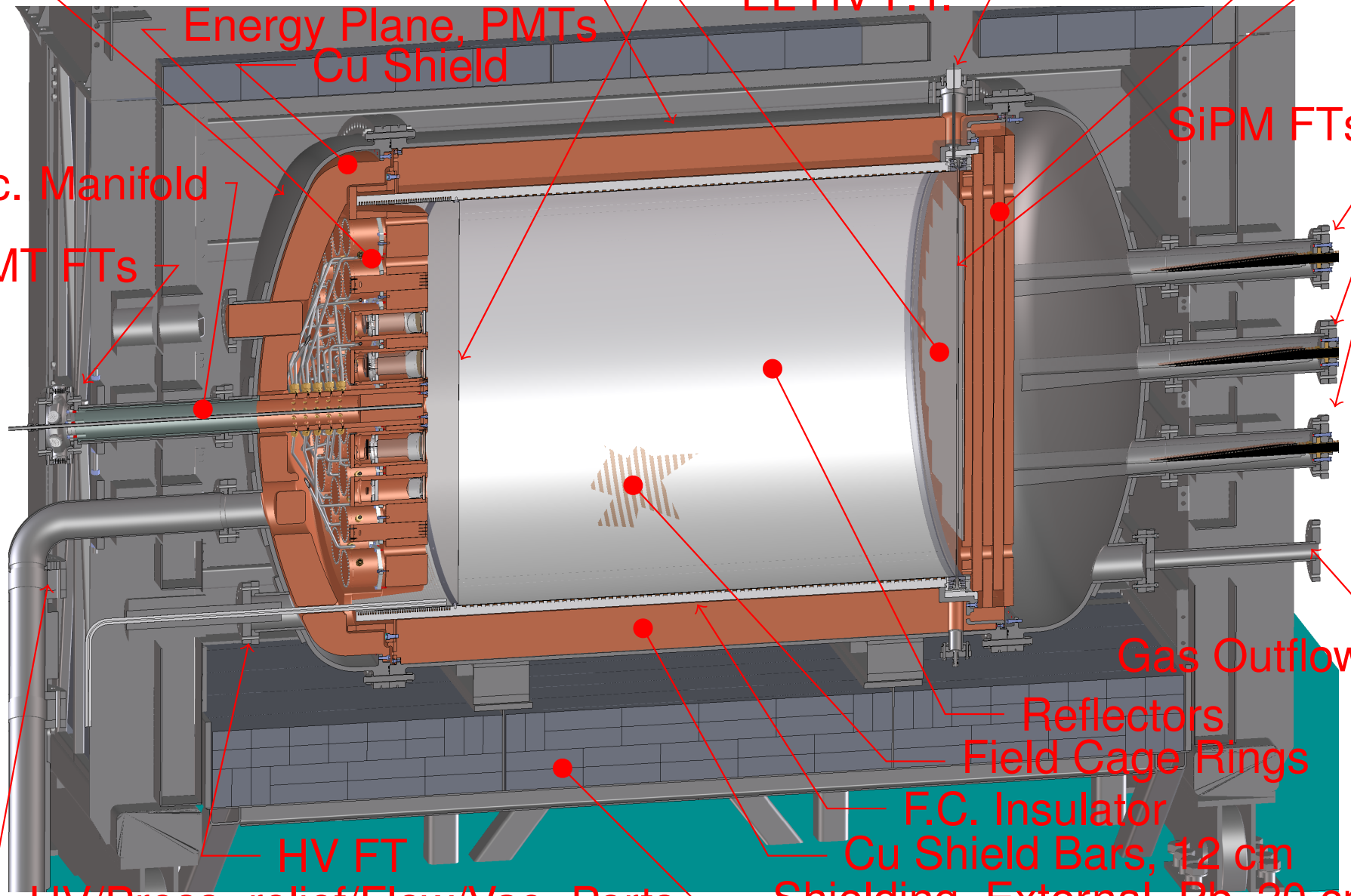

Main Cylindrical Vessel
EL HV F.T.
Field Cage Rings
F.C. Insulator
Cu Shield Bars
Shielding, External, Pb


Main Cylindrical Vessel
EL HV F.T.
Reflectors
Field Cage Rings
F.C. Insulator
Cu Shield Bars
Shielding, External, Pb

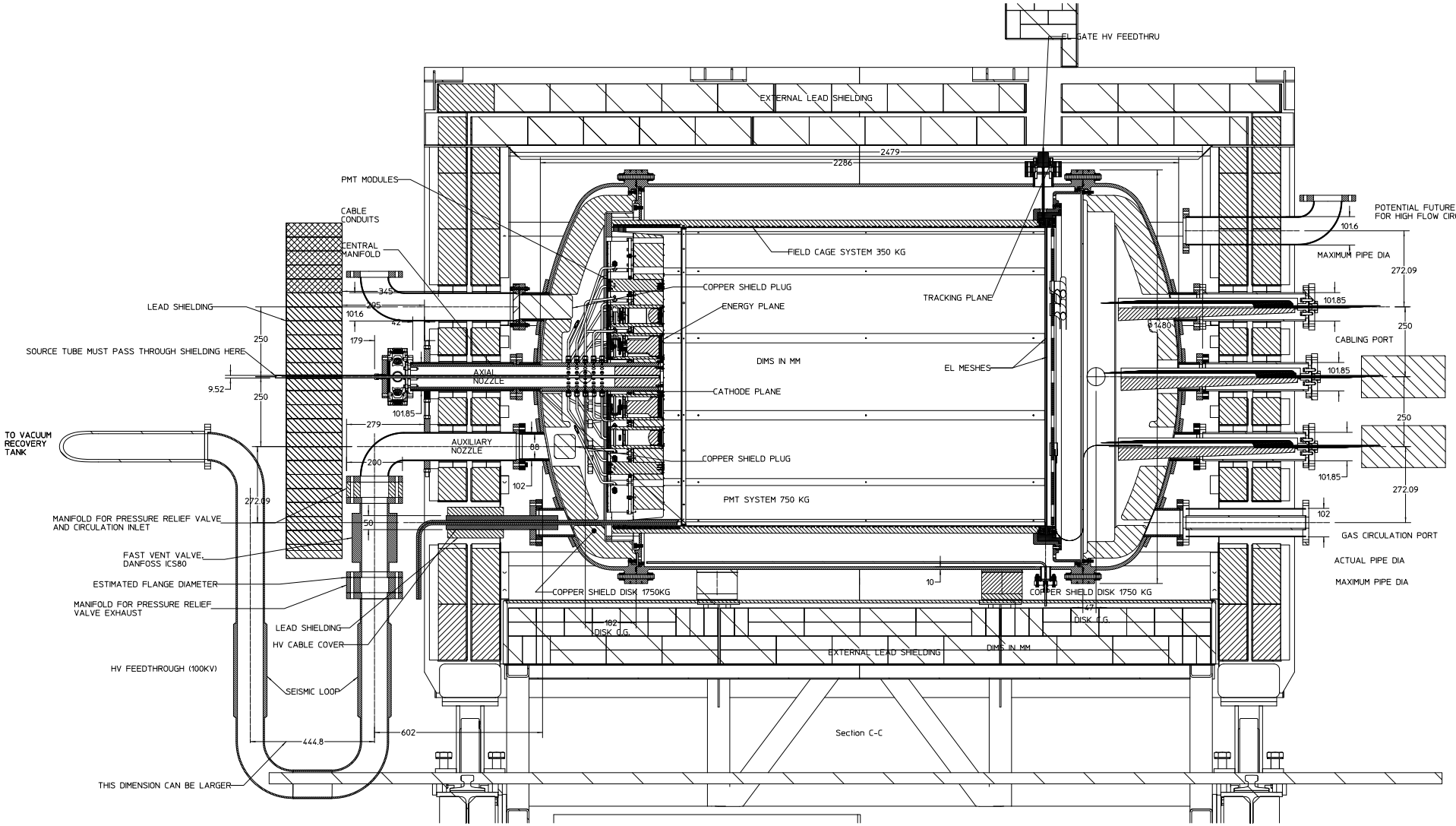

Main Cylindrical Vessel
EL mesh planes
EL HV F.T.
Reflectors
Field Cage Rings
F.C. Insulator
Cu Shield Bars
Shielding, External, Pb


Main Cylindrical Vessel
EL mesh planes
Cathode
EL HV F.T.
Reflectors
Field Cage Rings
F.C. Insulator
Cu Shield Bars
Shielding, External, Pb

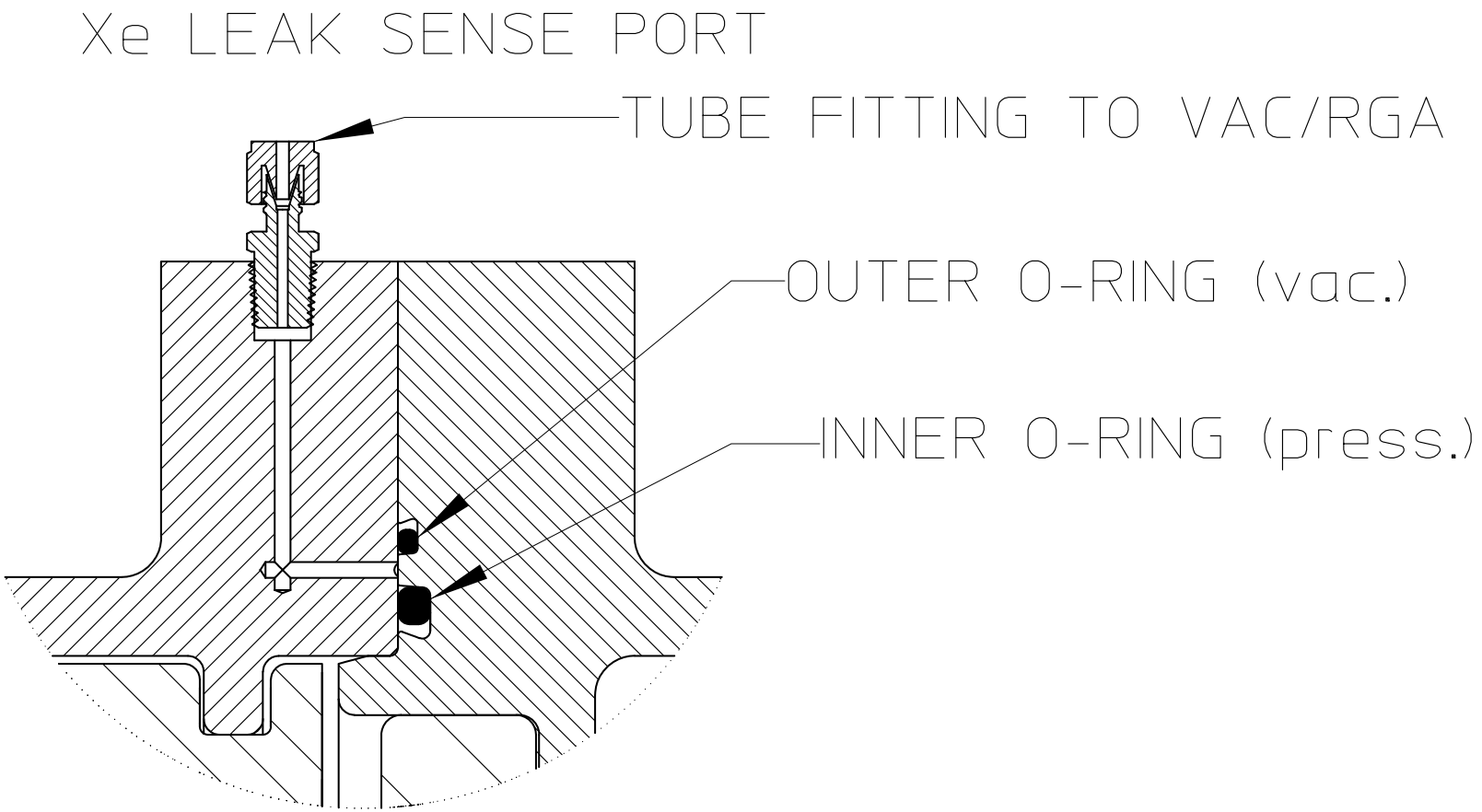

Main Cylindrical Vessel
EL mesh planes
Cathode
EL HV F.T.
Reflectors
Field Cage Rings
F.C. Insulator
Cu Shield Bars
Shielding, External, Pb


Main Cylindrical Vessel
Torispheric Head
Energy Plane, PMTs
Cu Shield
Vac. Manifold
PMT FTs
EL mesh planes
Cathode
EL HV F.T.
Tracking Plane
Cu Shield
SiPM FTs
Gas Outflow
Reflectors
Field Cage Rings
F.C. Insulator
Cu Shield Bars, 12 cm
Shielding, External, Pb, 20 cm
HV FT
HV/Press. relief/Flow/Vac. Ports

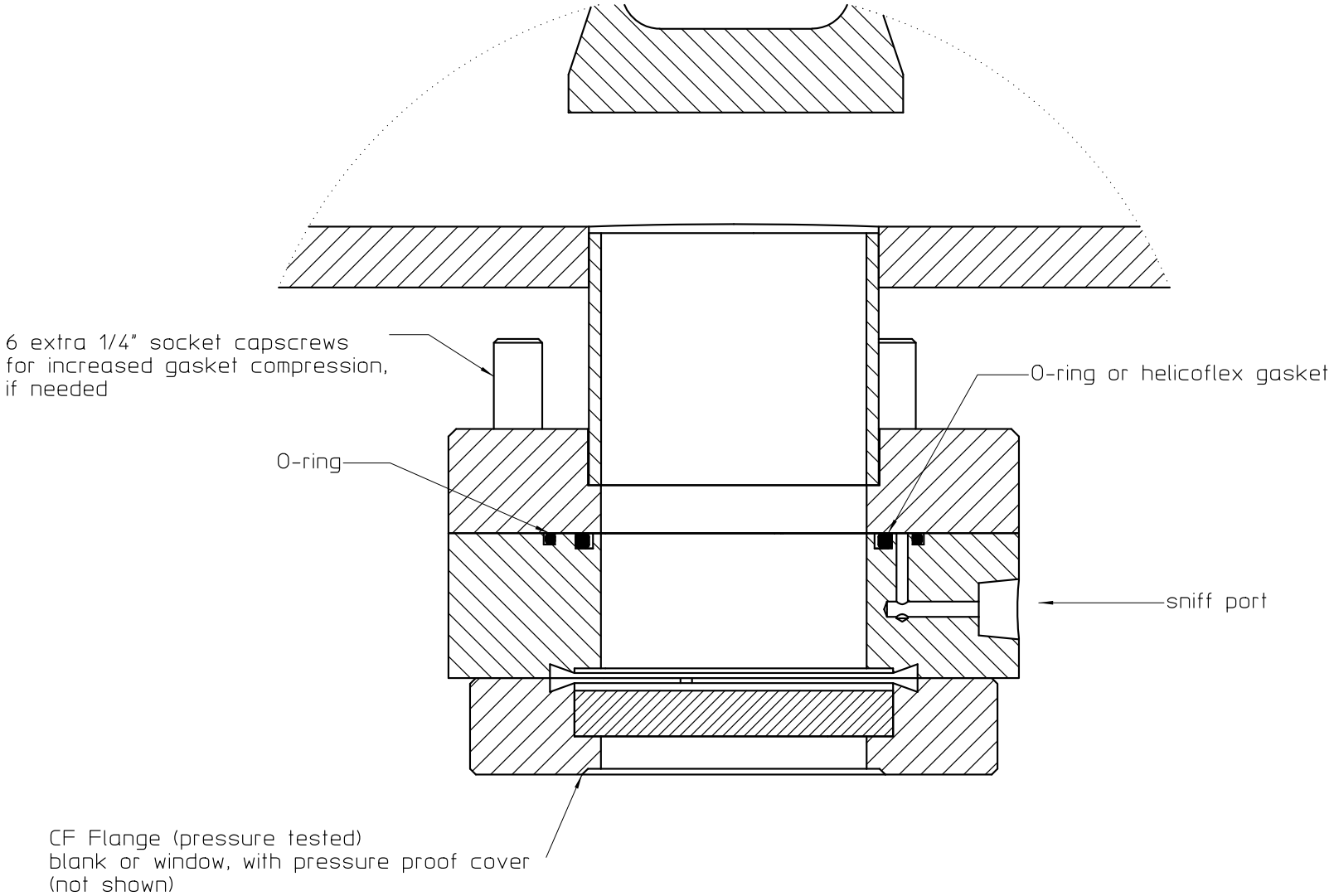
Parameter	qty	units
Maximum Operating Pressure (MOP)	15.0	bar (abs)
Maximum Allowable Working pressure (MAWP)	16.4	bar (abs)
Minimum Allowable Pressure (external)	1.5	bar (abs)
Material, stainless steel, alloy	316Ti	
Inner diameter	136	cm
Outer Diameter, Flanges	148	cm
Length, inside shielding	2.22	m
Vessel and head wall thickness	10	mm
Flange thickness, head to vessel (both)	4.1	cm
Bolt Diameter (Inconel 718), head to vessel flanges	16	mm
Number of Bolts, each head to vessel flange	132	
Mass, Vessel and both heads	1100	kg
Mass, Internal copper shielding	8500	kg
Total Weight	12000	kg

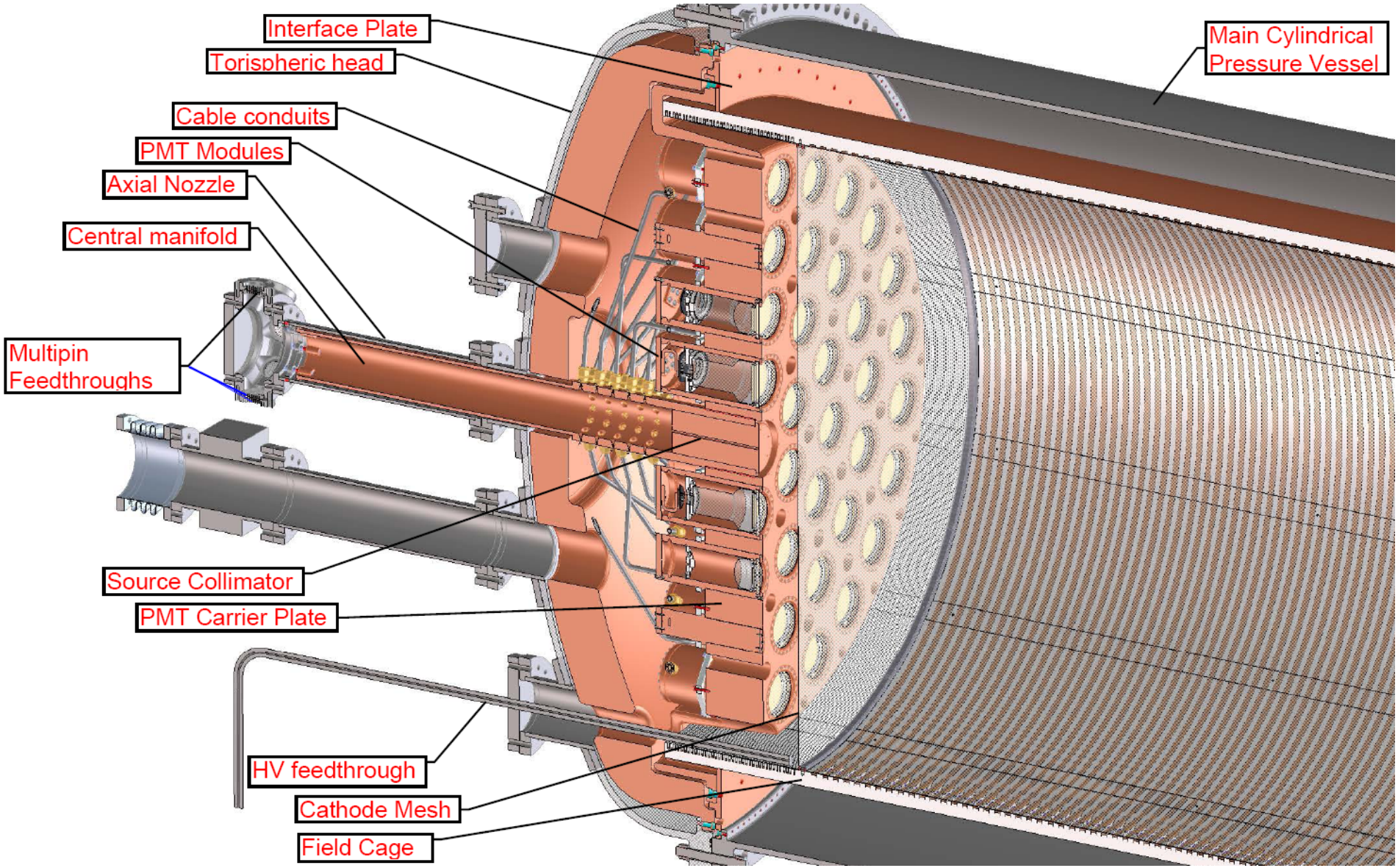

EL GATE HV FEEDTHRU
EXTERNAL LEAD SHIELDING
2479
2286
PMT MODULES
CABLE CONDUITS
CENTRAL MANIFOLD
FIELD CAGE SYSTEM 350 KG
COPPER SHIELD PLUG
ENERGY PLANE
TRACKING PLANE
LEAD SHIELDING
SOURCE TUBE MUST PASS THROUGH SHIELDING HERE
AXIAL NOZZLE
DIMS IN MM
EL MESHES
CATHODE PLANE
TO VACUUM RECOVERY TANK
AUXILIARY NOZZLE
COPPER SHIELD PLUG
PMT SYSTEM 750 KG
MANIFOLD FOR PRESSURE RELIEF VALVE AND CIRCULATION INLET
FAST VENT VALVE, DANFOSS ICS80
ESTIMATED FLANGE DIAMETER
MANIFOLD FOR PRESSURE RELIEF VALVE EXHAUST
LEAD SHIELDING
HV CABLE COVER
HV FEEDTHROUGH (100KV)
SEISMIC LOOP
COPPER SHIELD DISK 1750KG
COPPER SHIELD DISK 1750 KG
DISK O.D.
DISK O.D.
EXTERNAL LEAD SHIELDING
DIMS IN MM
Section C-C
444.8
602
THIS DIMENSION CAN BE LARGER
POTENTIAL FUTURE FOR HIGH FLOW CIRC
MAXIMUM PIPE DIA
CABLING PORT
GAS CIRCULATION PORT
ACTUAL PIPE DIA
MAXIMUM PIPE DIA

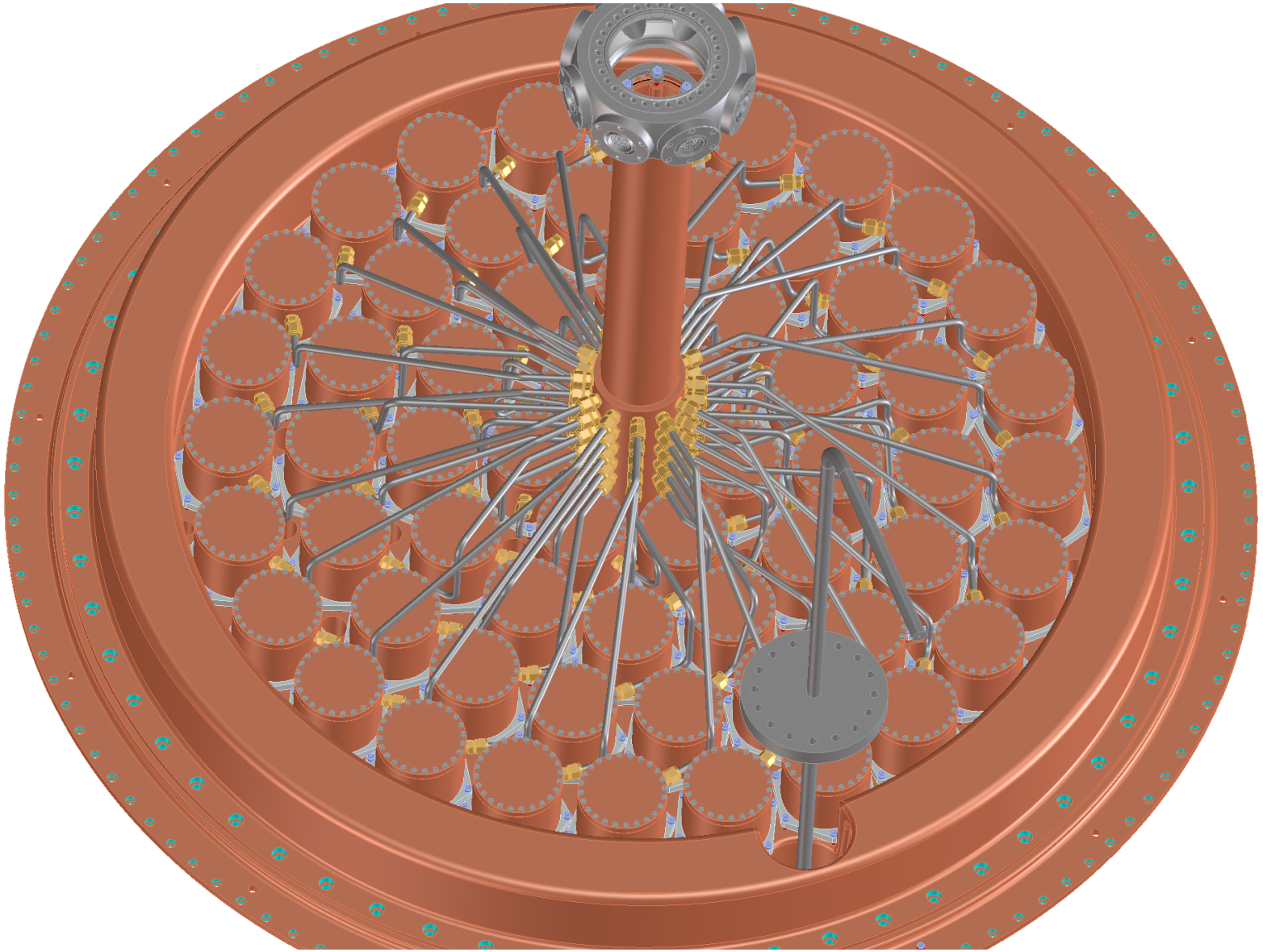
Double seal detail with leak sense port

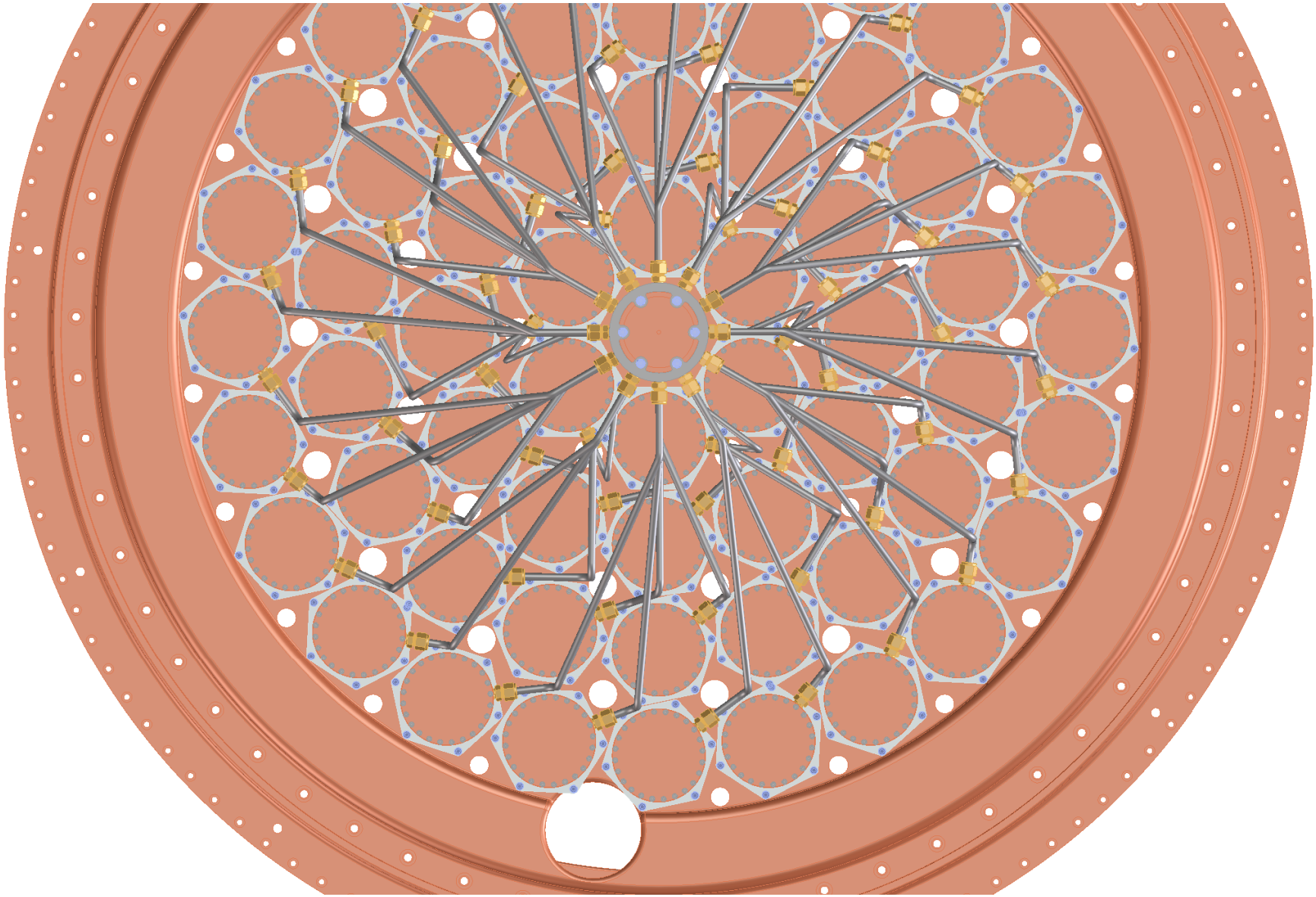


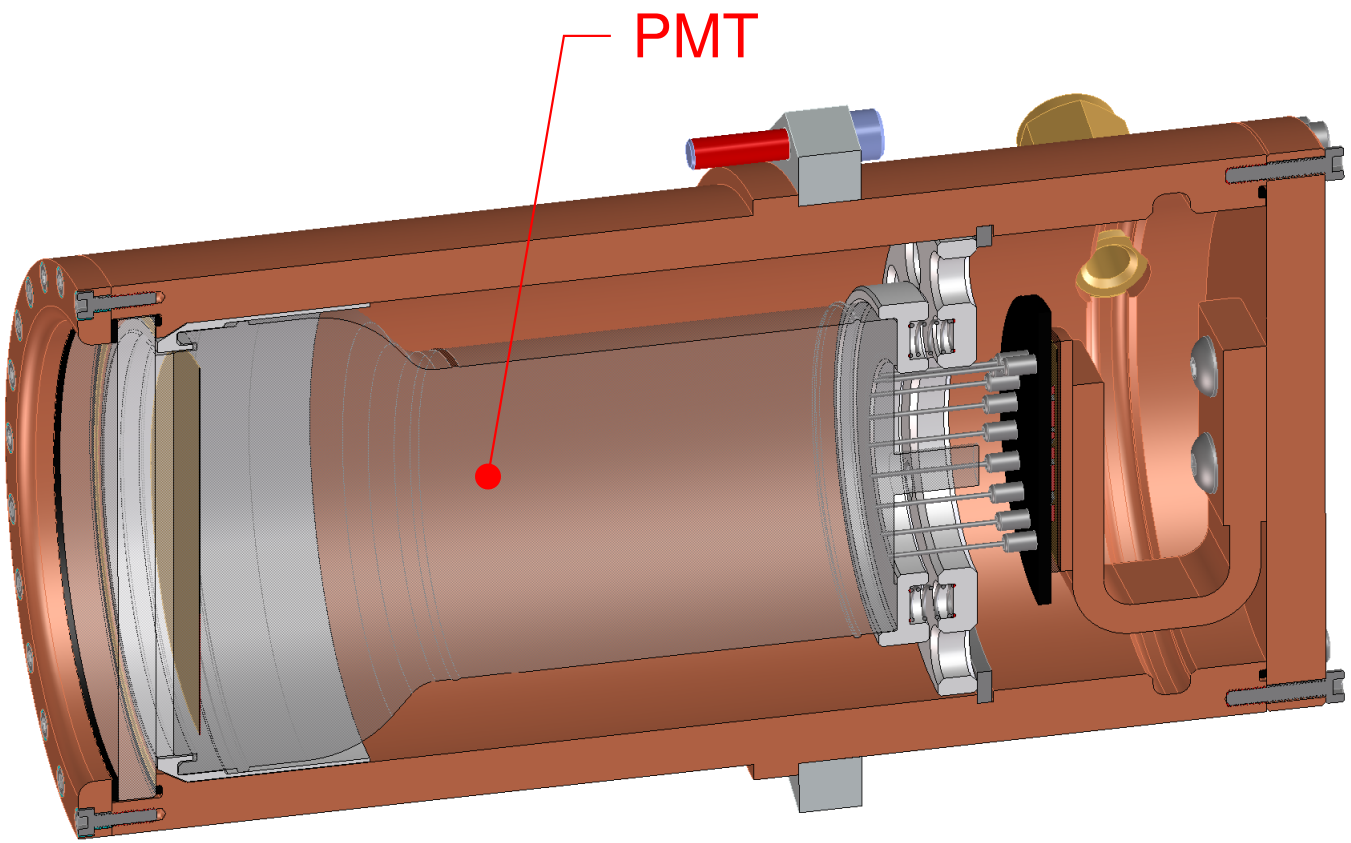
Interface flange detail

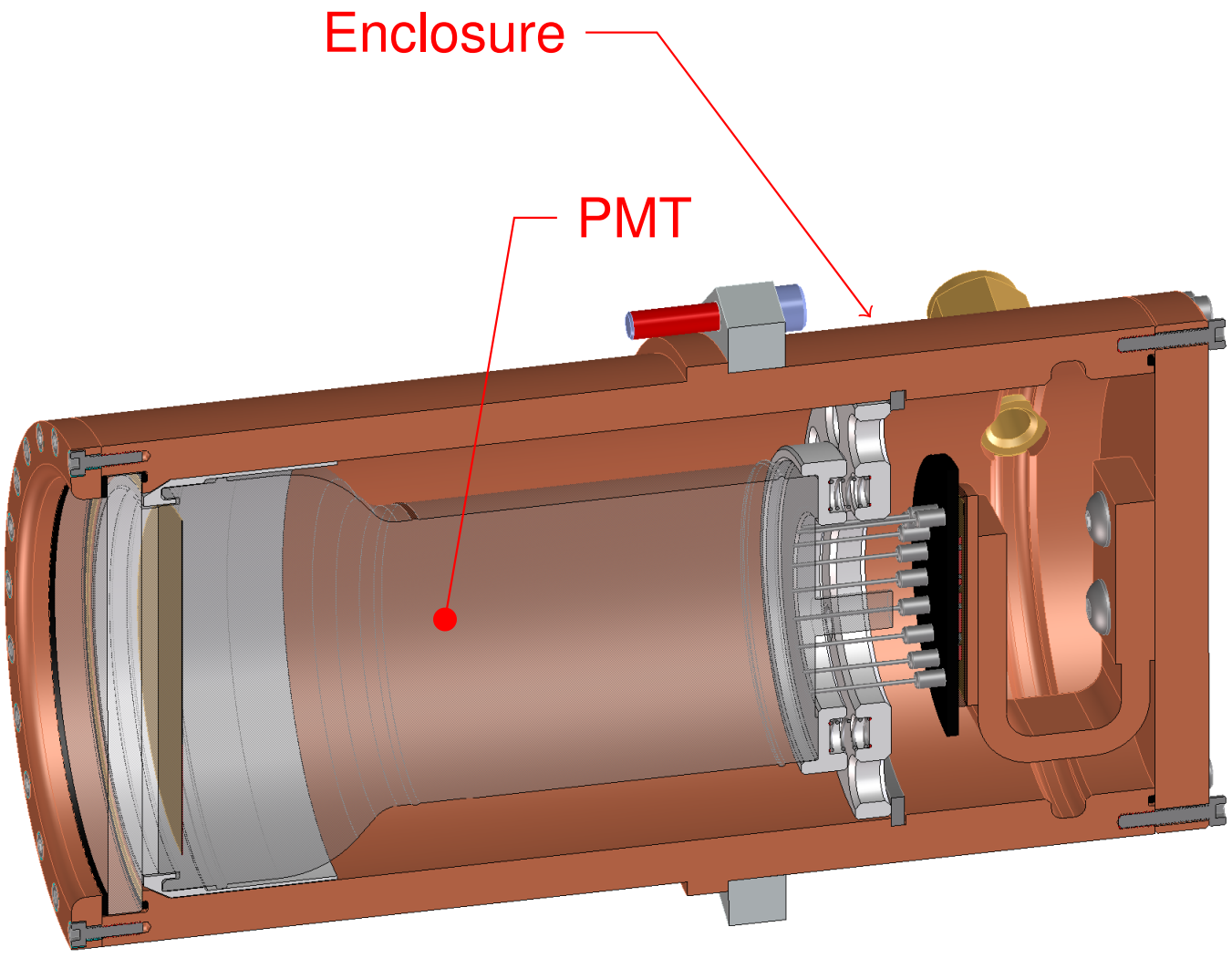


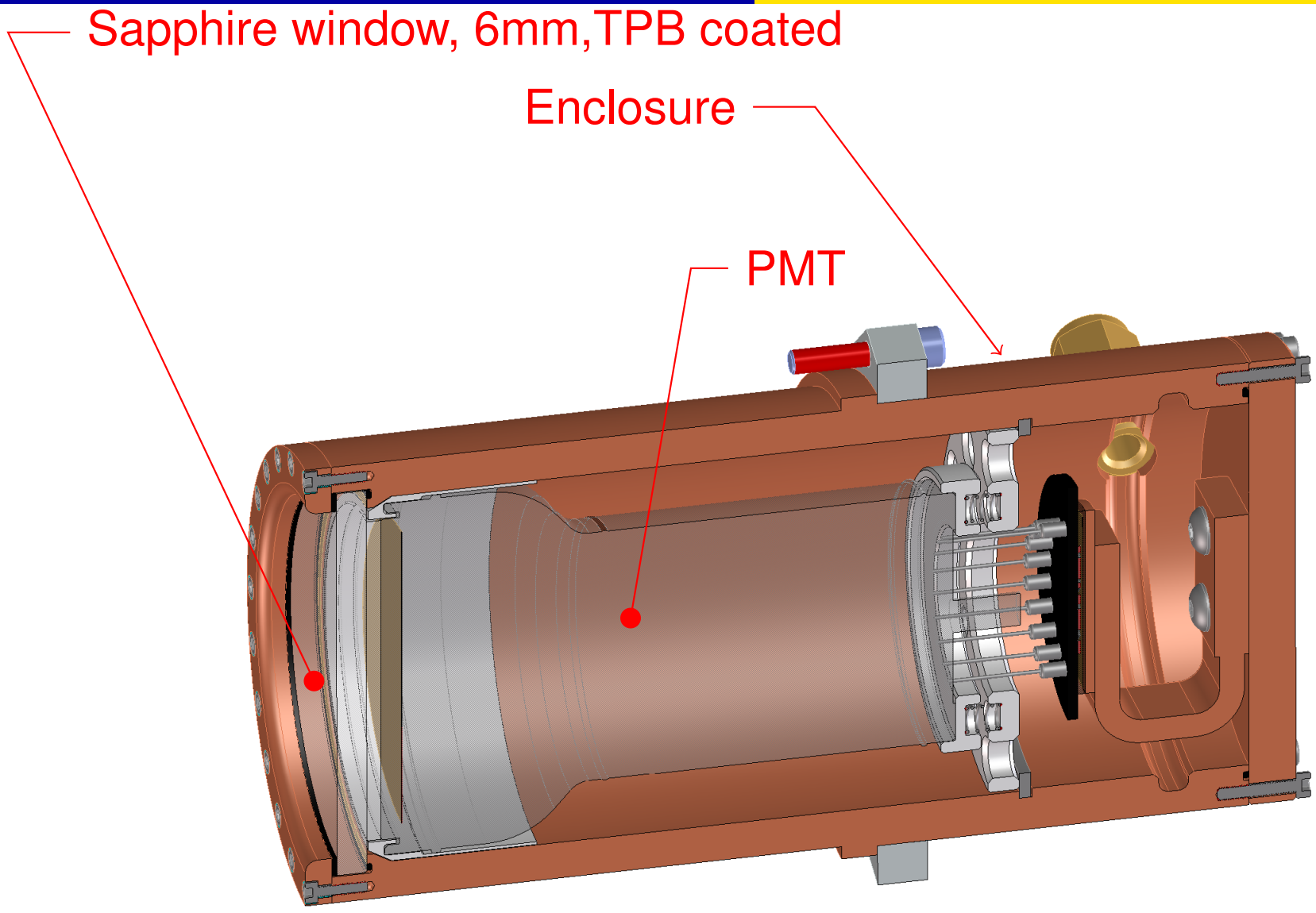

Interface Plate
Torispheric head
Cable conduits
PMT Modules
Axial Nozzle
Central manifold
Multipin Feedthroughs
Source Collimator
PMT Carrier Plate
HV feedthrough
Cathode Mesh
Field Cage
Main Cylindrical Pressure Vessel

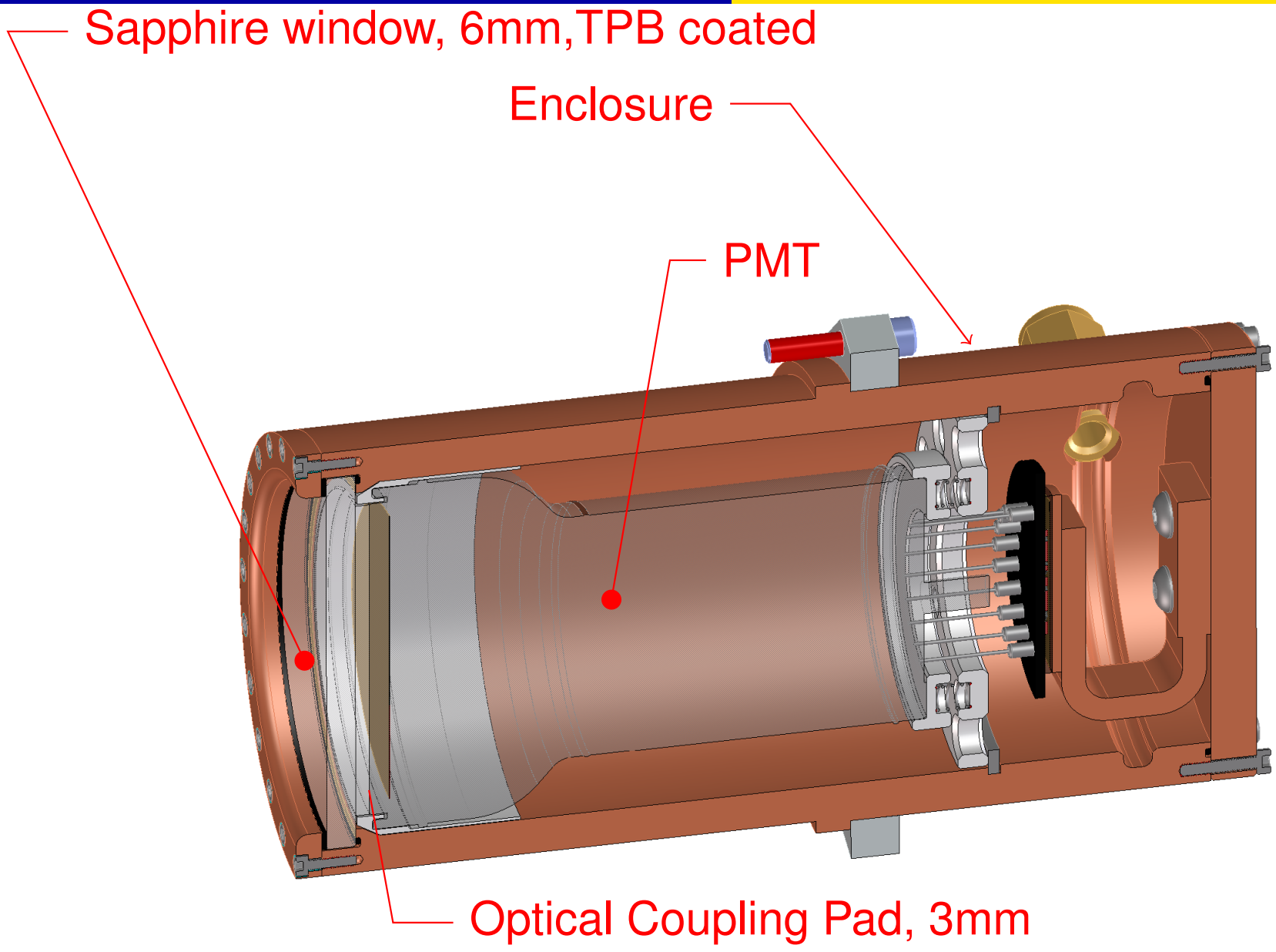


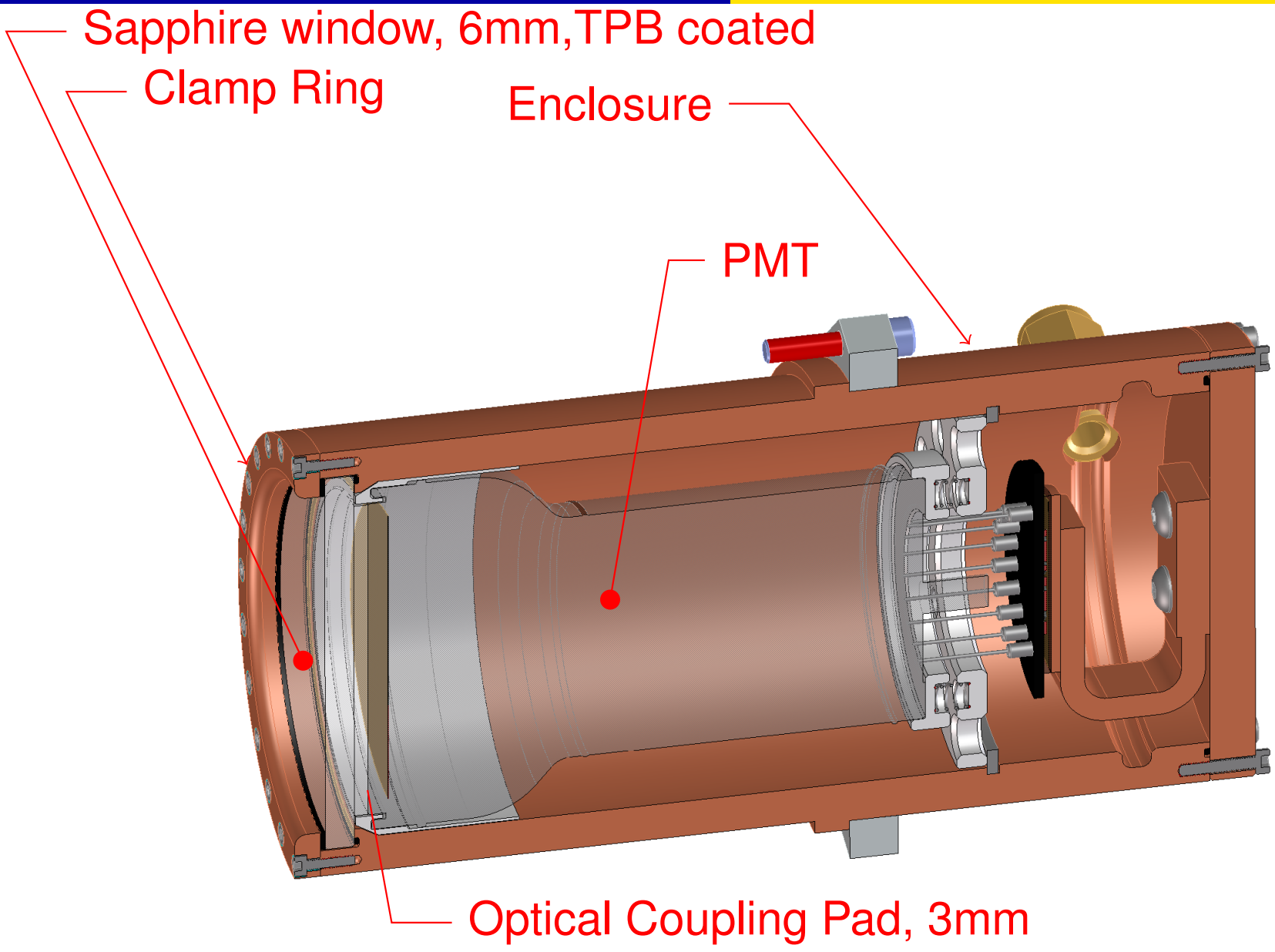


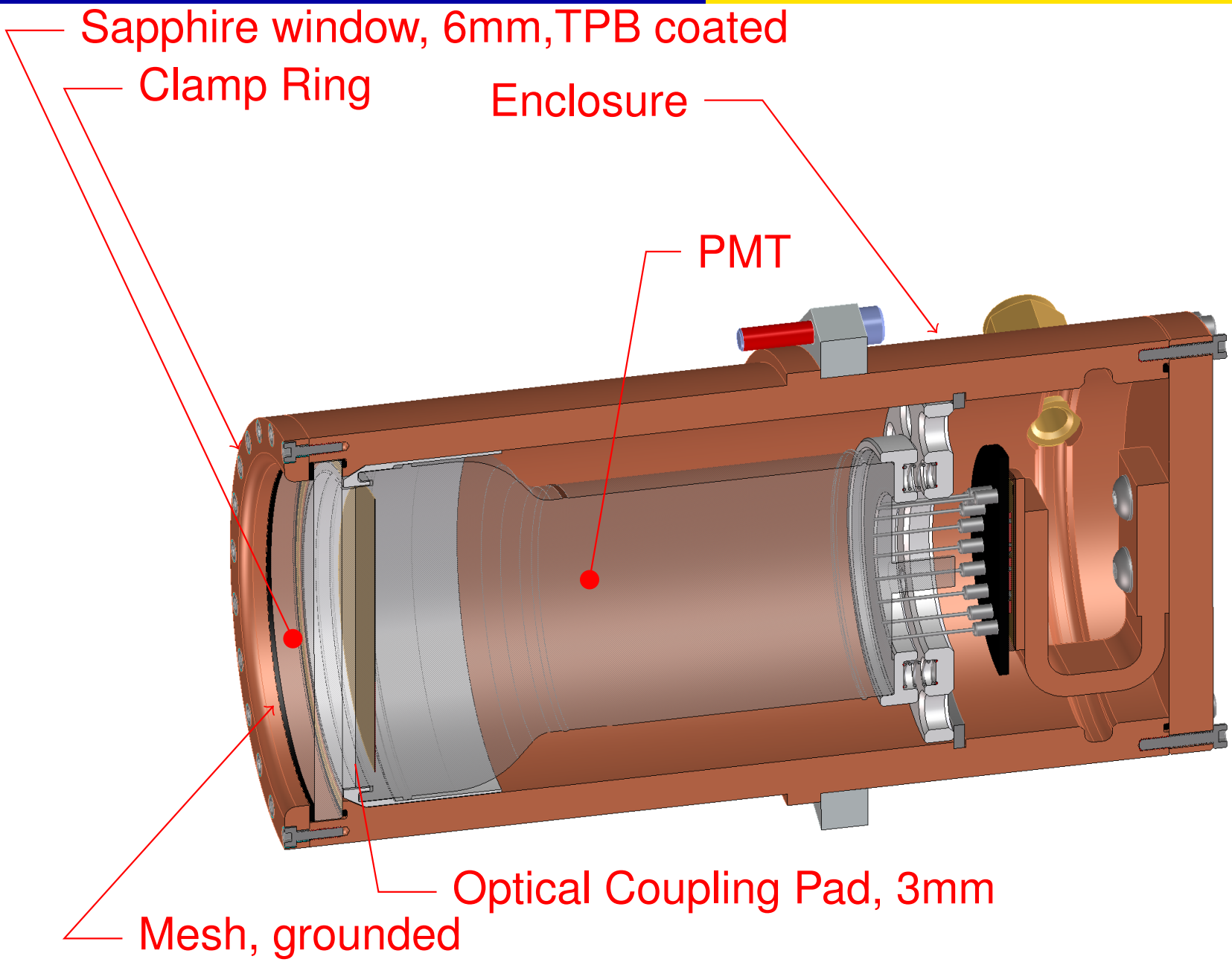

PMT

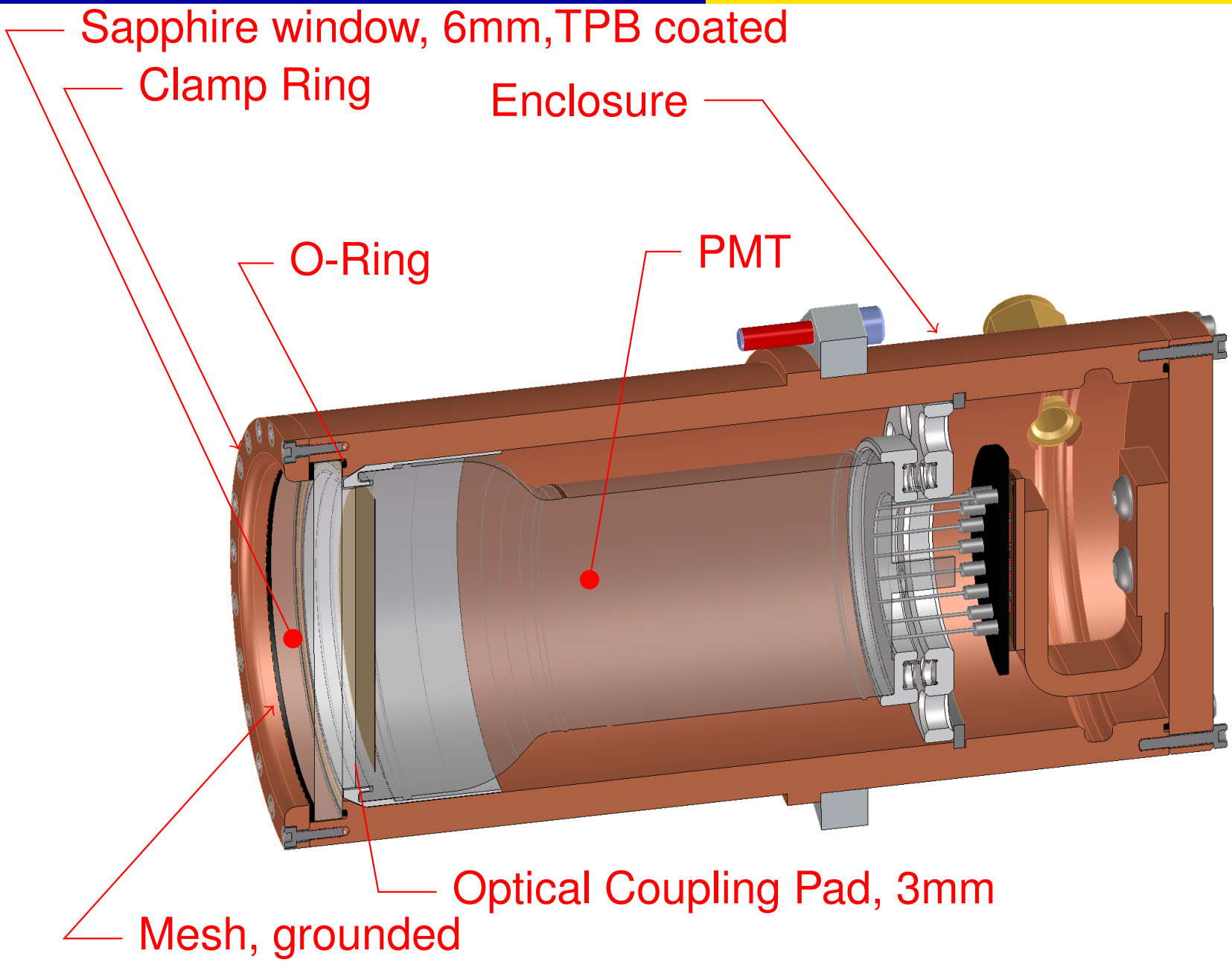

Enclosure
PMT

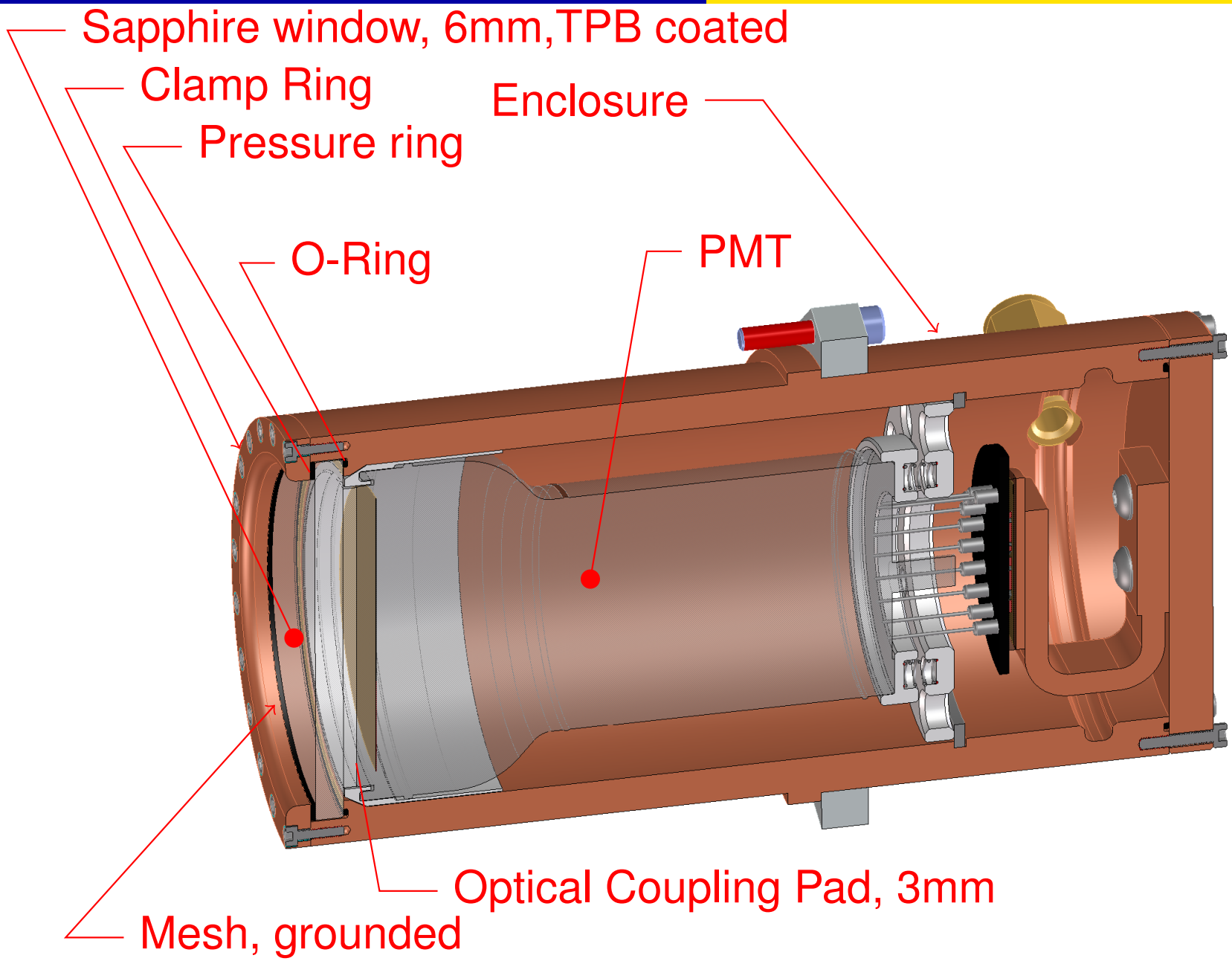

Sapphire window, 6mm,TPB coated
Enclosure
PMT

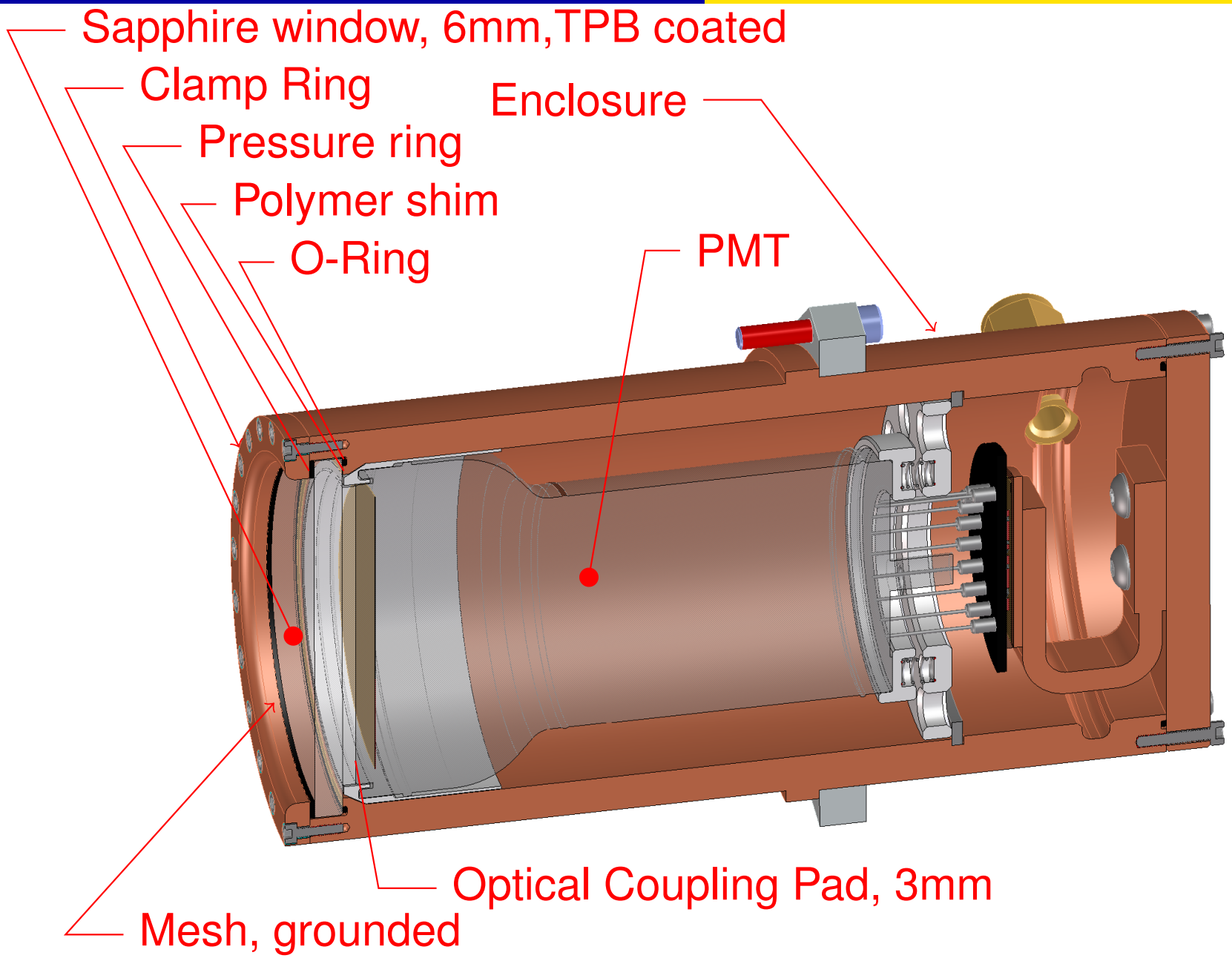

Sapphire window, 6mm,TPB coated
Enclosure
PMT
Optical Coupling Pad, 3mm

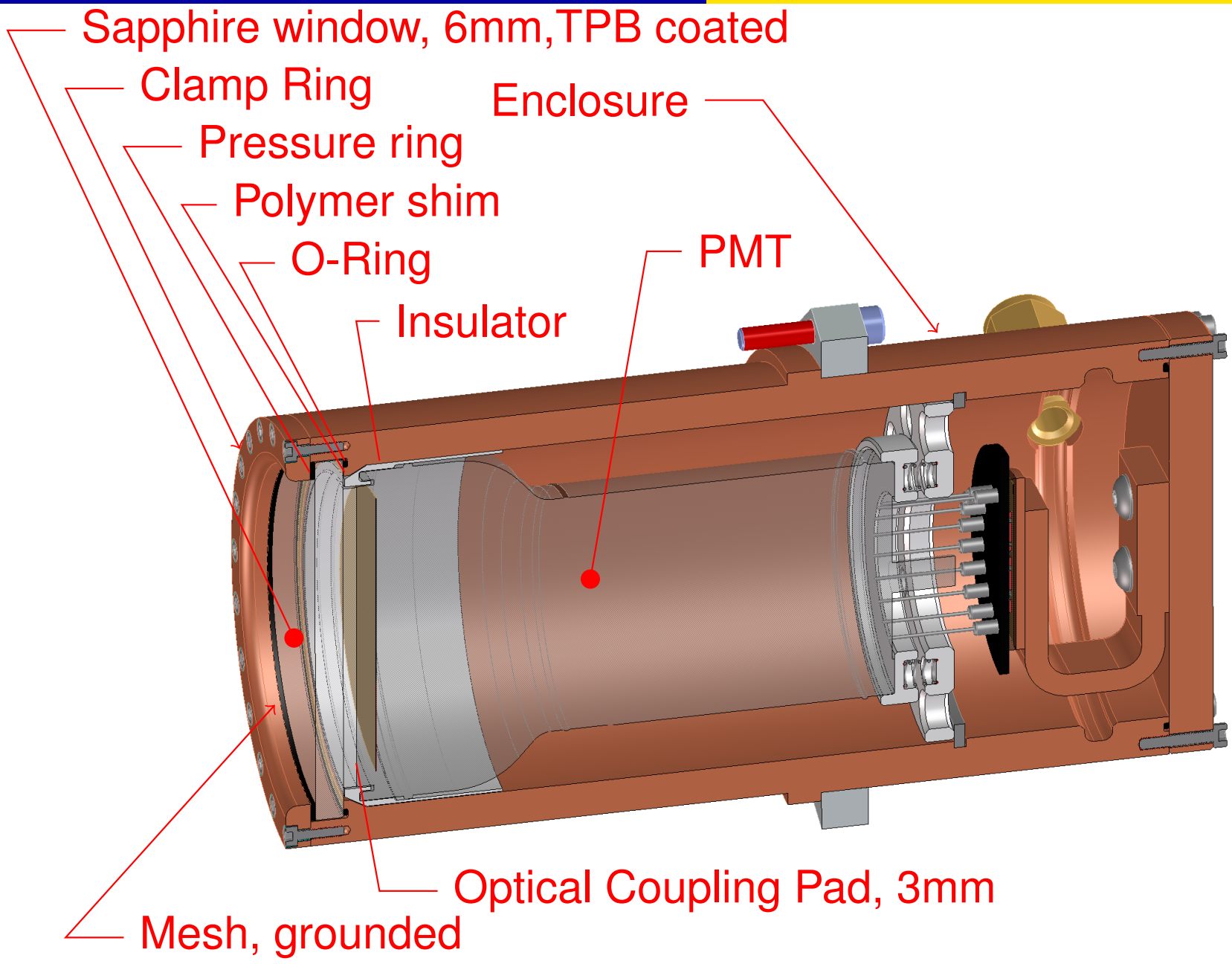

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
PMT
Optical Coupling Pad, 3mm

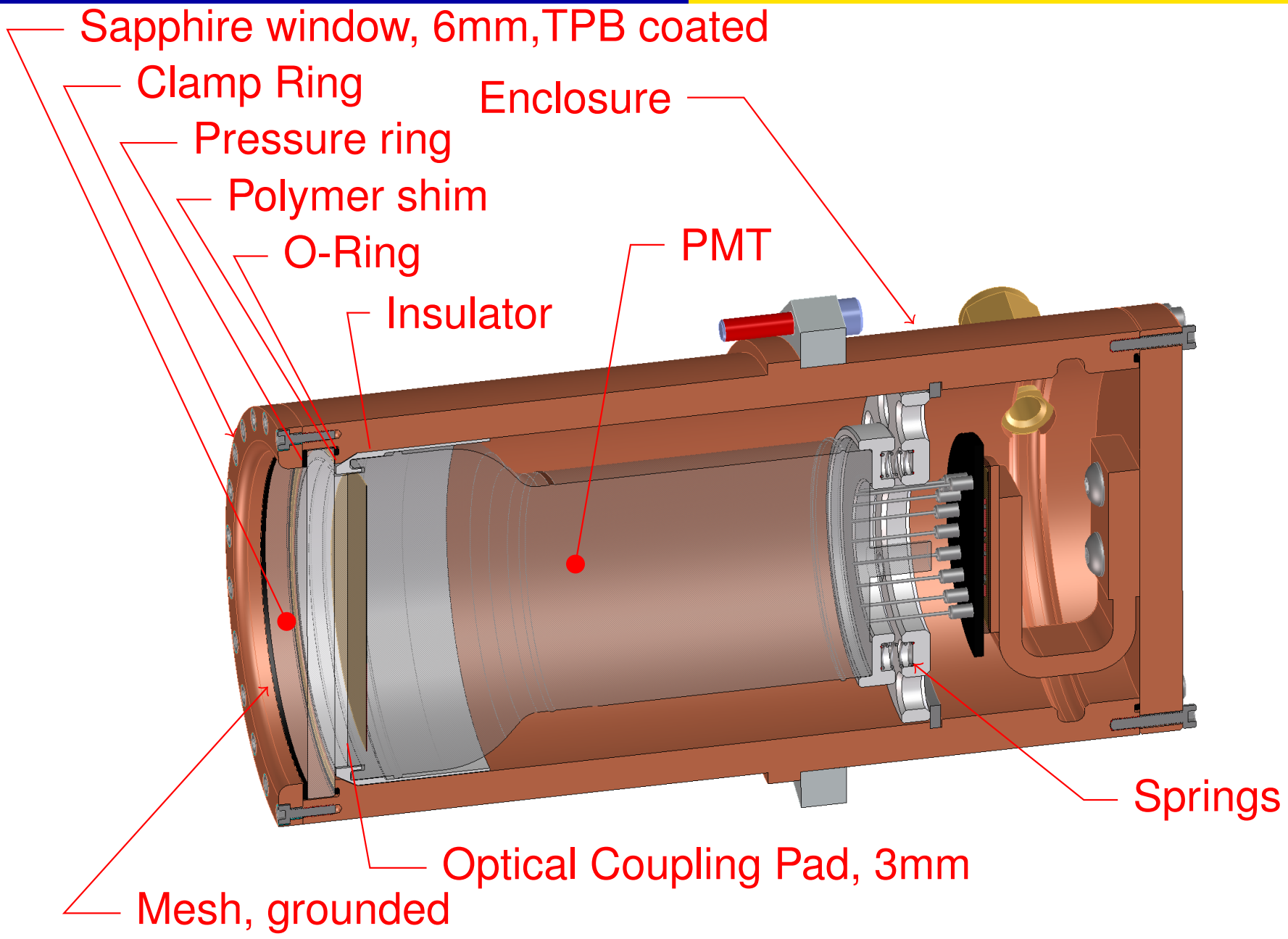

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
PMT
Optical Coupling Pad, 3mm
Mesh, grounded

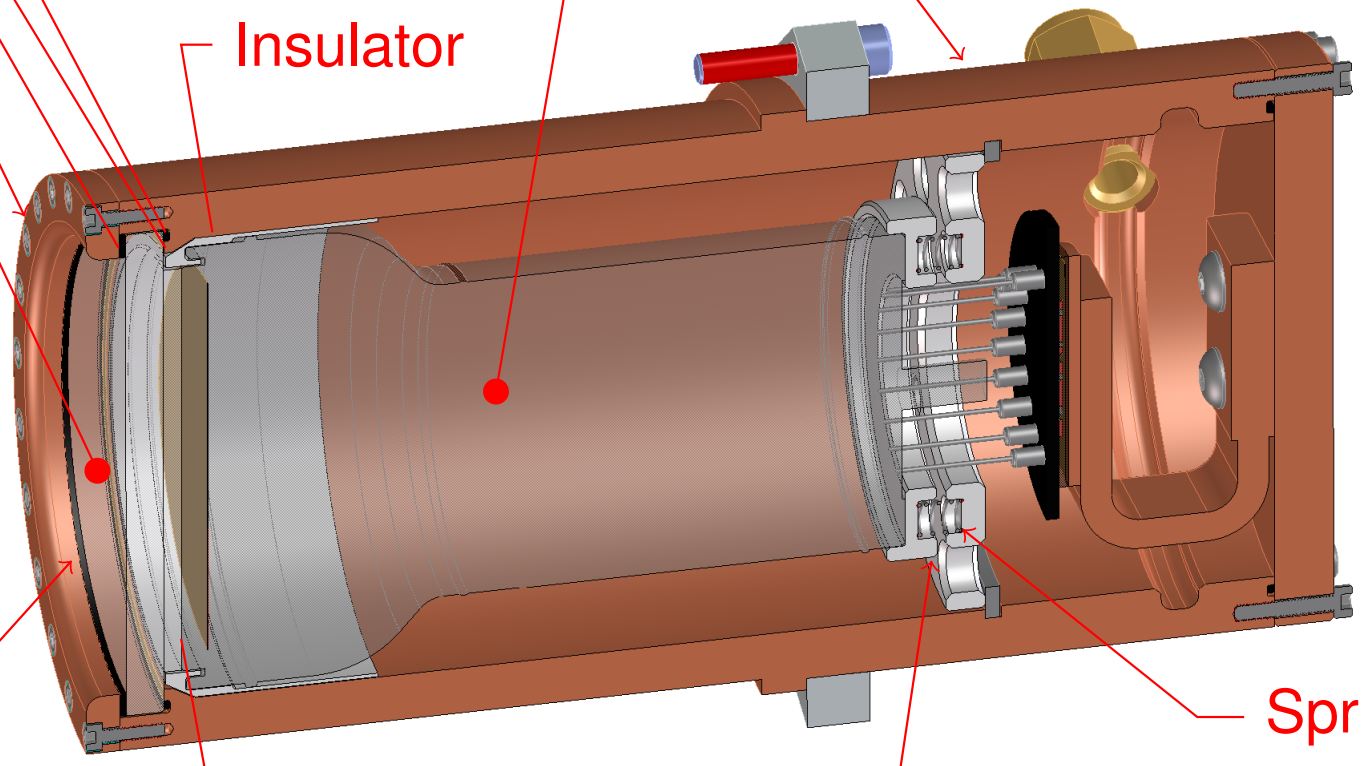

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
O-Ring
PMT
Optical Coupling Pad, 3mm
Mesh, grounded

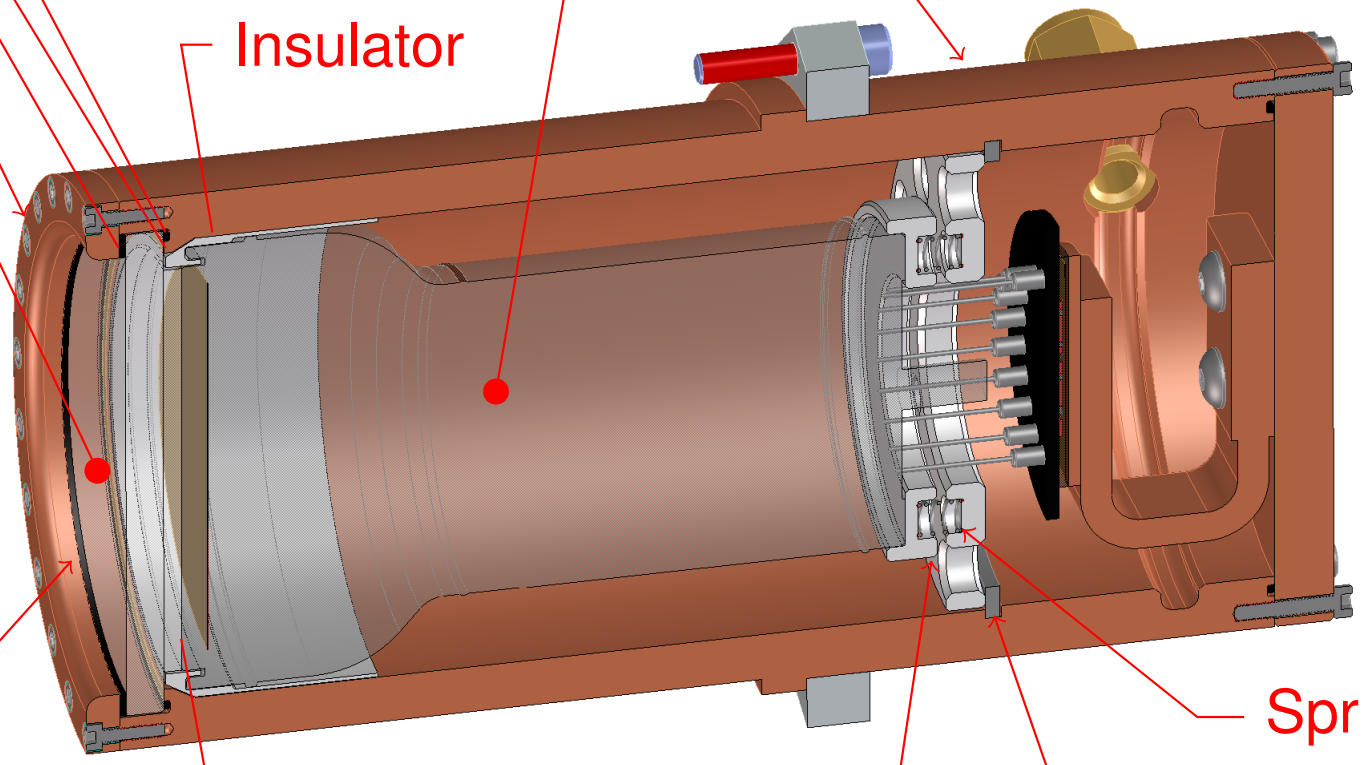

Sapphire window, 6mm,TPB coated
Clamp Ring
Pressure ring
Enclosure
O-Ring
PMT
Optical Coupling Pad, 3mm
Mesh, grounded

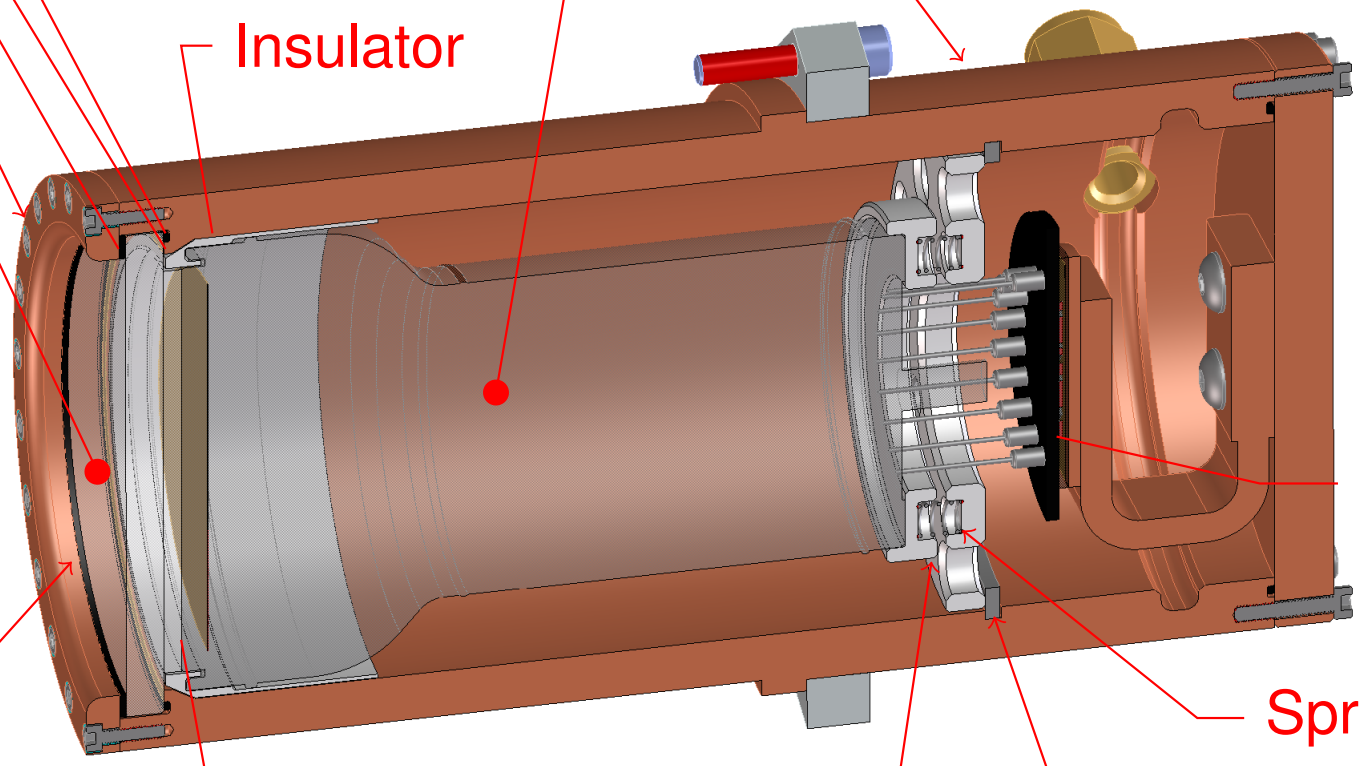

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Optical Coupling Pad, 3mm
Mesh, grounded

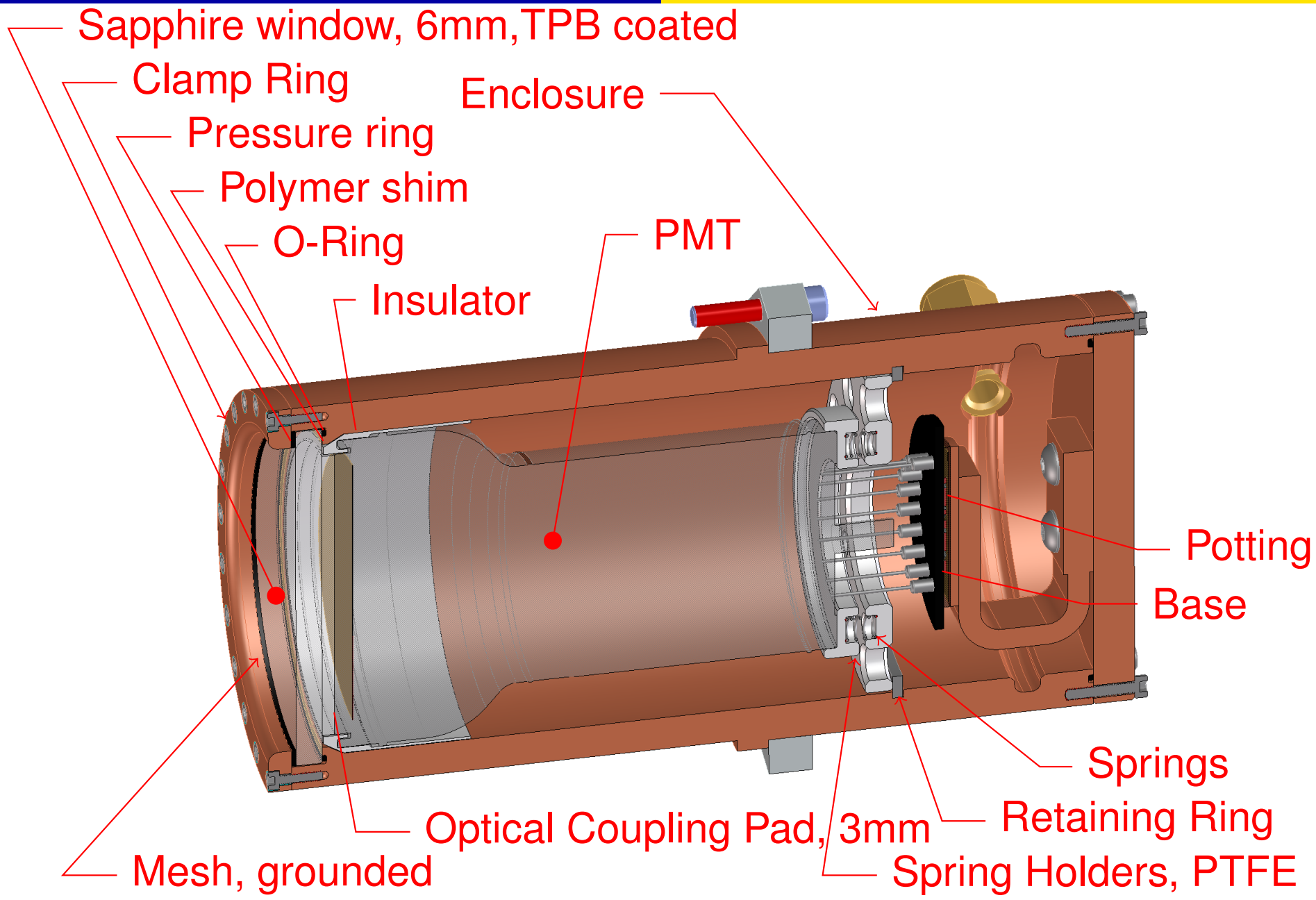

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Insulator
Optical Coupling Pad, 3mm
Mesh, grounded

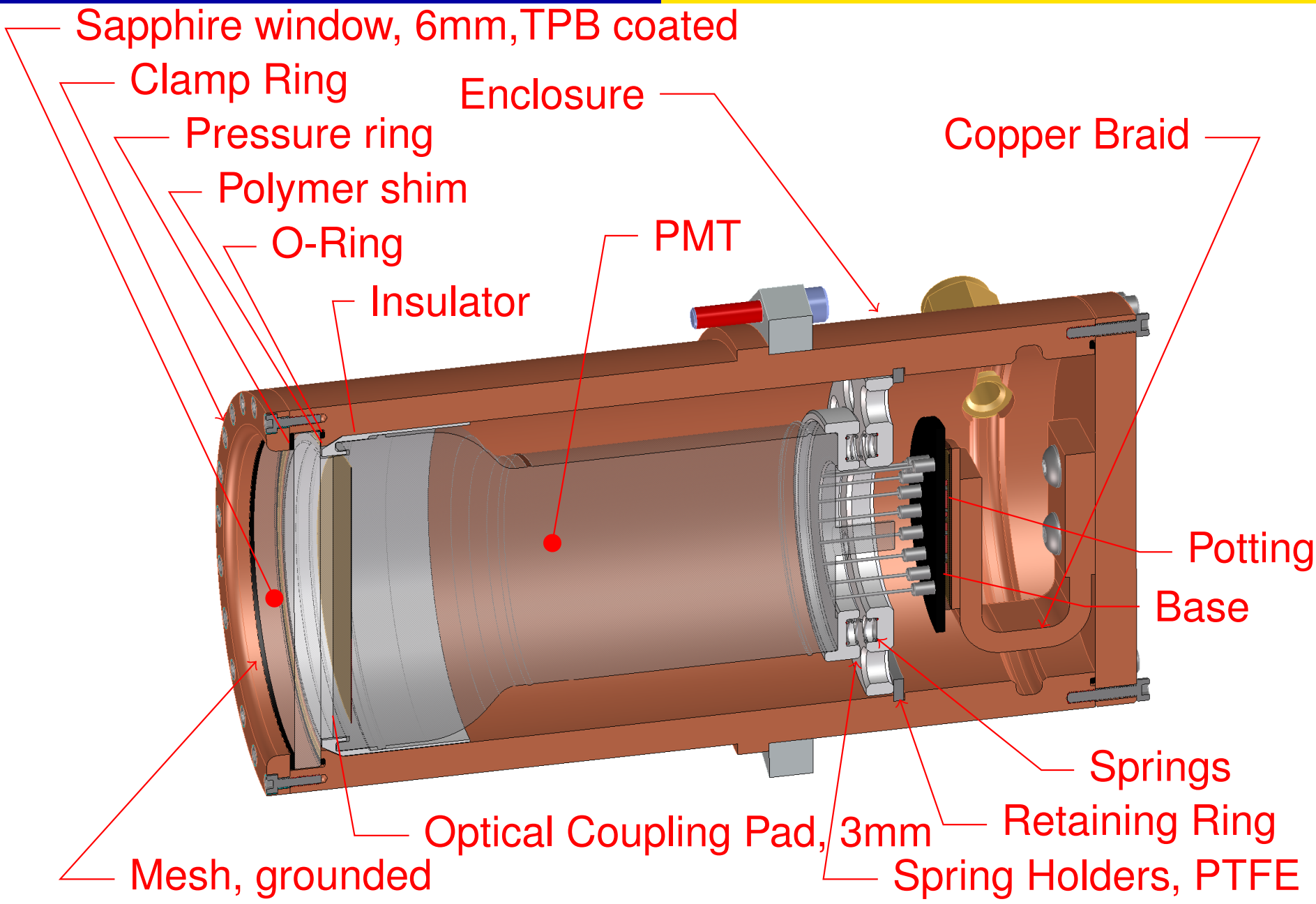

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Insulator
Springs
Optical Coupling Pad, 3mm
Mesh, grounded

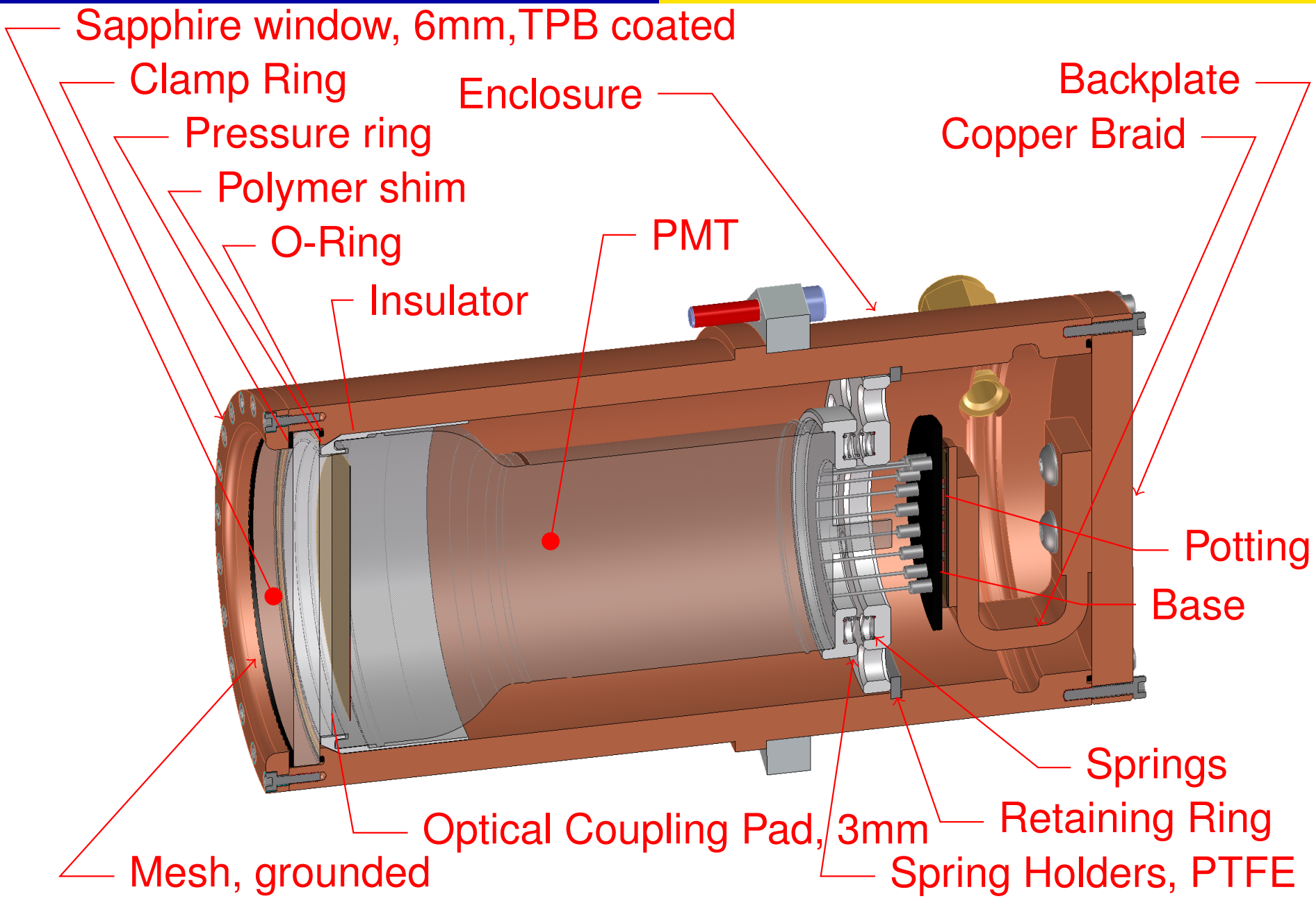

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Insulator
Springs
Optical Coupling Pad, 3mm
Mesh, grounded
Spring Holders, PTFE

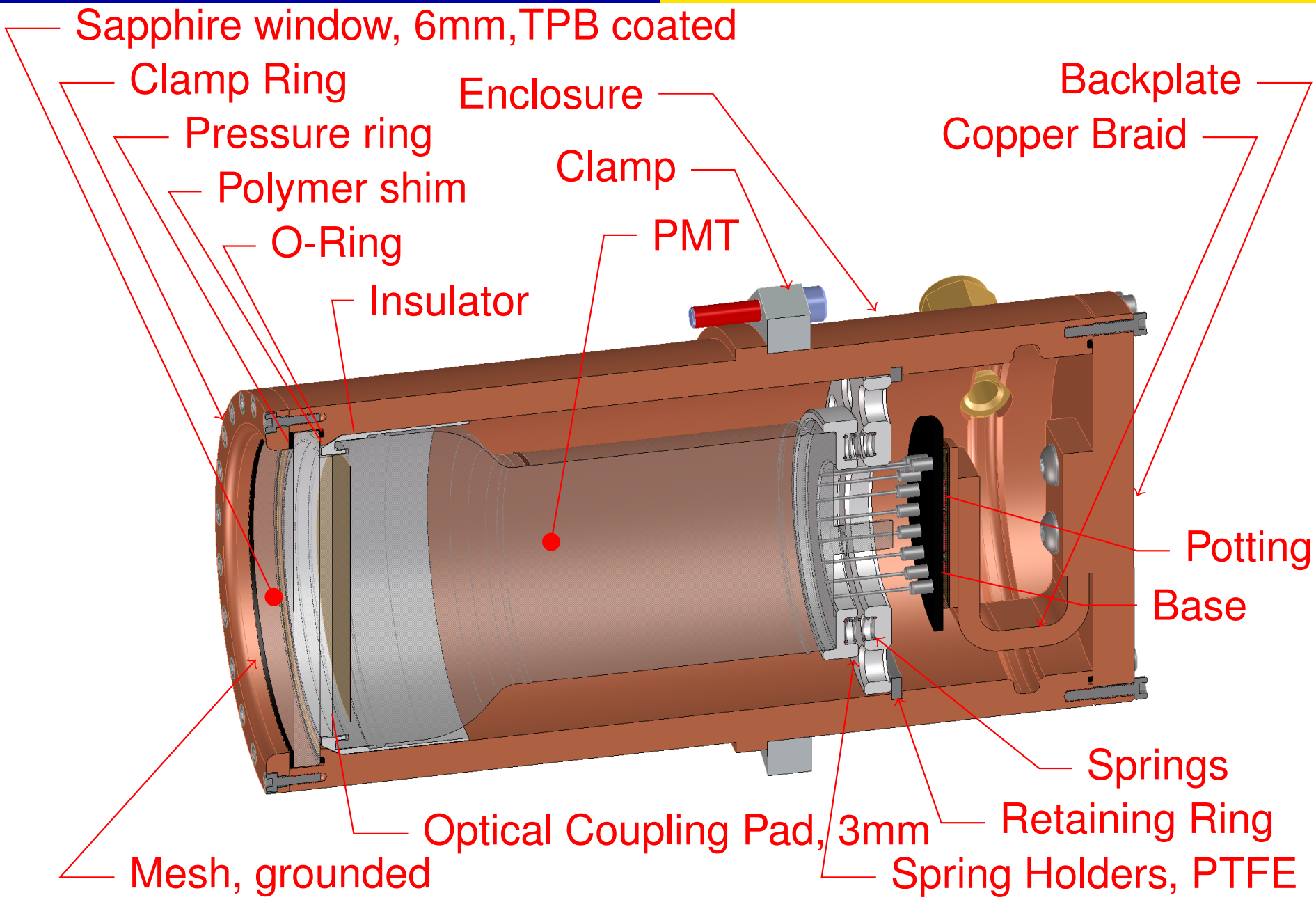

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Insulator
Springs
Retaining Ring
Optical Coupling Pad, 3mm
Mesh, grounded
Spring Holders, PTFE

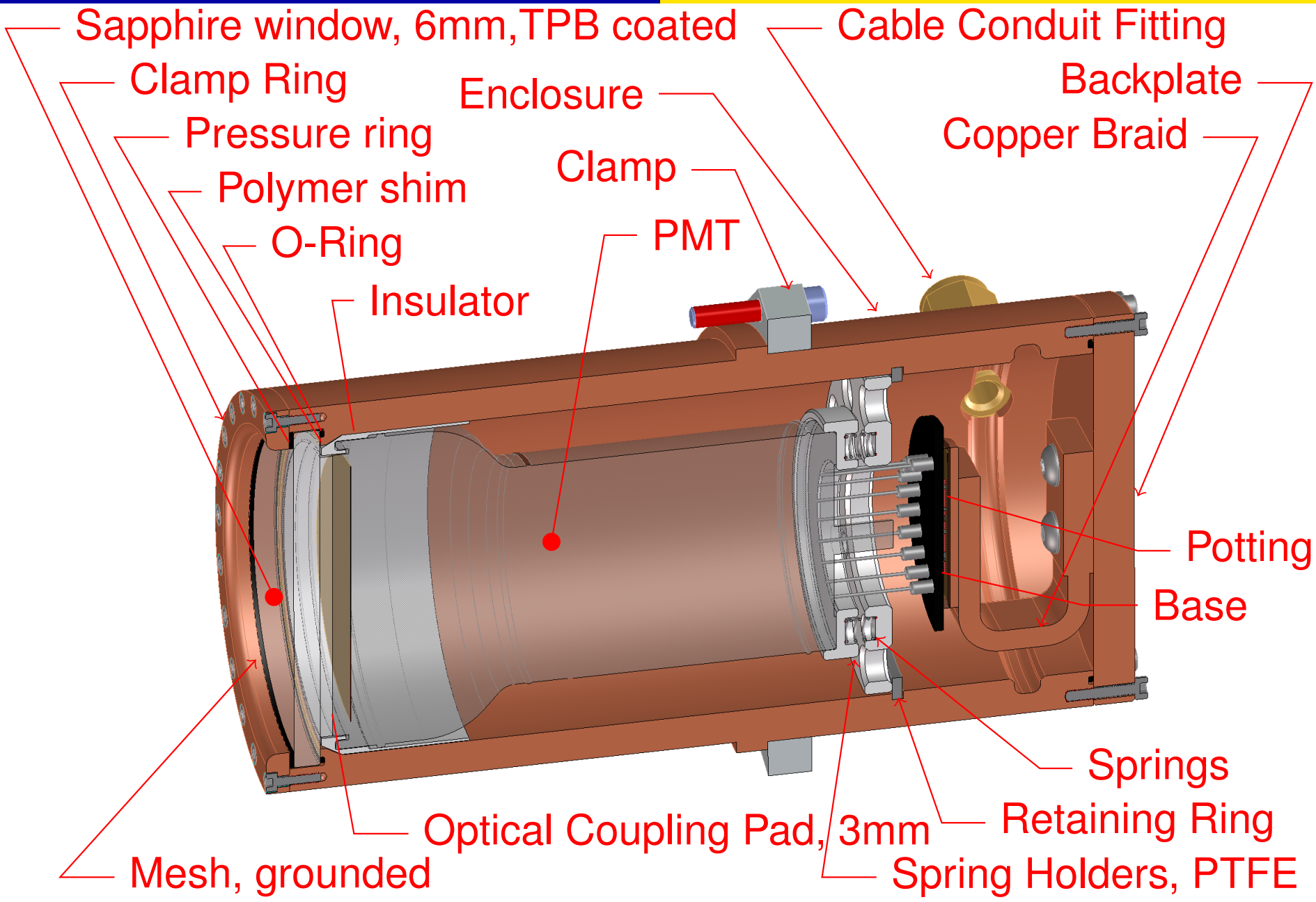

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Insulator
Base
Springs
Retaining Ring
Optical Coupling Pad, 3mm
Spring Holders, PTFE
Mesh, grounded

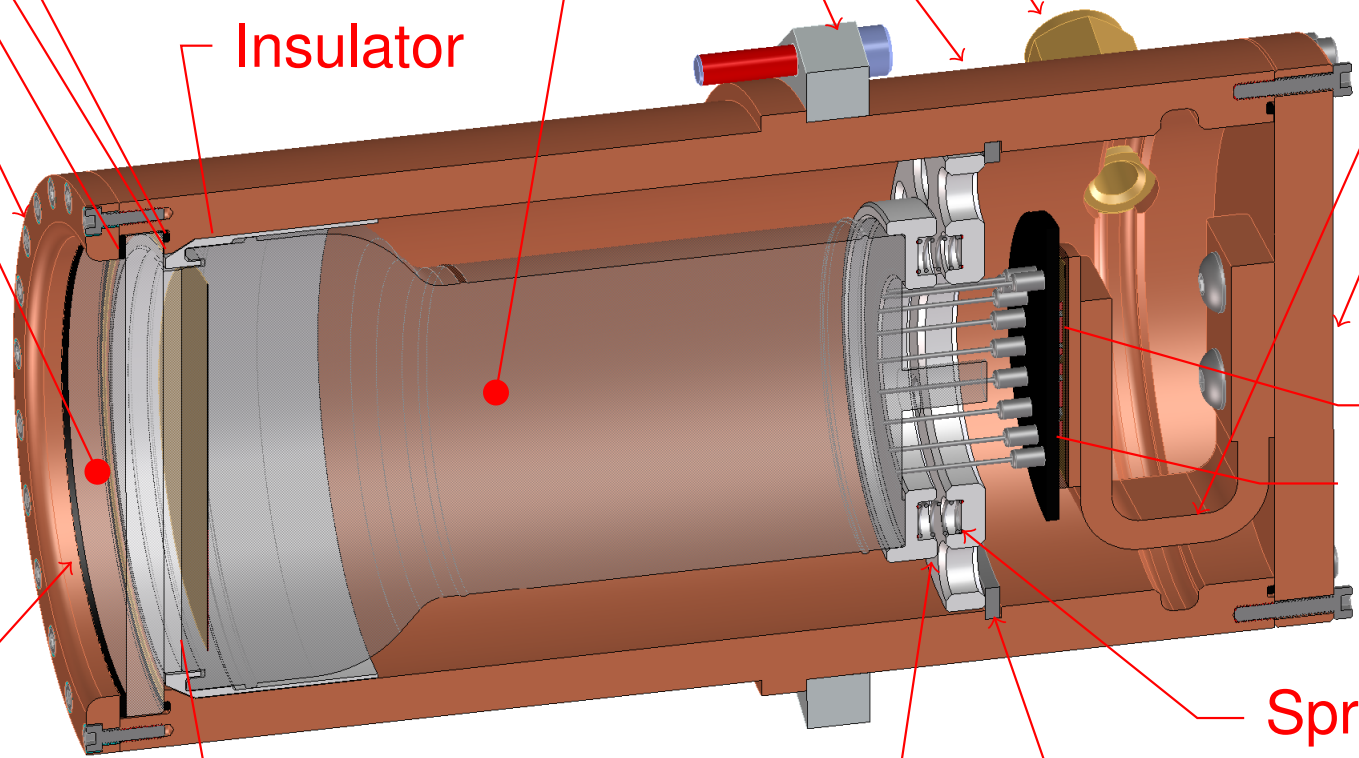

Sapphire window, 6mm,TPB coated
Clamp Ring
Enclosure
Pressure ring
Polymer shim
O-Ring
PMT
Insulator
Potting
Base
Springs
Retaining Ring
Optical Coupling Pad, 3mm
Spring Holders, PTFE
Mesh, grounded


Sapphire window, 6mm,TPB coated
Clamp Ring
Pressure ring
Polymer shim
O-Ring
Insulator
Enclosure
PMT
Copper Braid
Potting
Base
Springs
Retaining Ring
Spring Holders, PTFE
Optical Coupling Pad, 3mm
Mesh, grounded

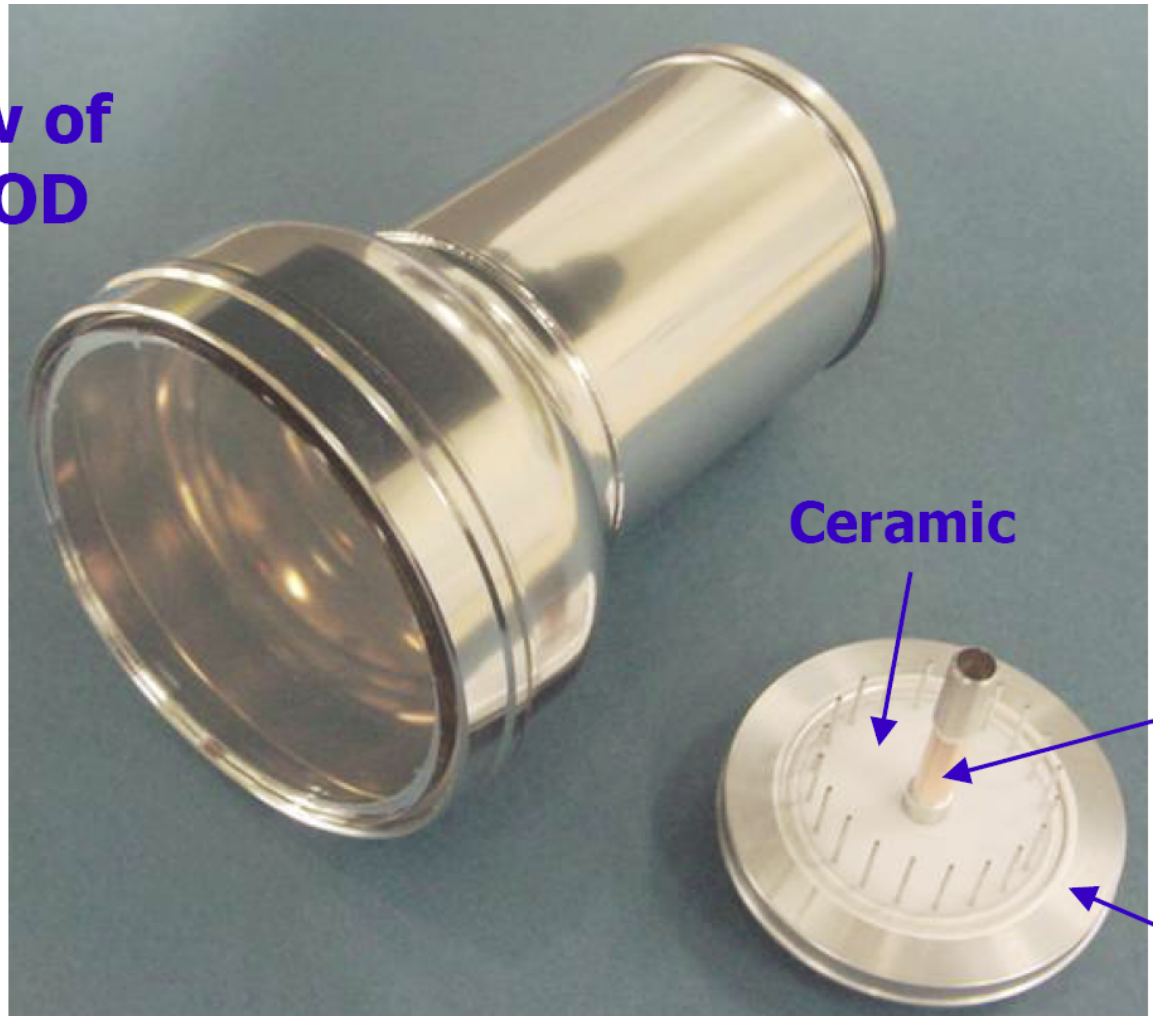

Sapphire window, 6mm,TPB coated
Clamp Ring
Pressure ring
Polymer shim
O-Ring
Insulator
Enclosure
PMT
Backplate
Copper Braid
Potting
Base
Springs
Retaining Ring
Spring Holders, PTFE
Optical Coupling Pad, 3mm
Mesh, grounded


Sapphire window, 6mm,TPB coated
Clamp Ring
Pressure ring
Polymer shim
O-Ring
Insulator
Enclosure
Clamp
PMT
Backplate
Copper Braid
Potting
Base
Springs
Retaining Ring
Spring Holders, PTFE
Optical Coupling Pad, 3mm
Mesh, grounded

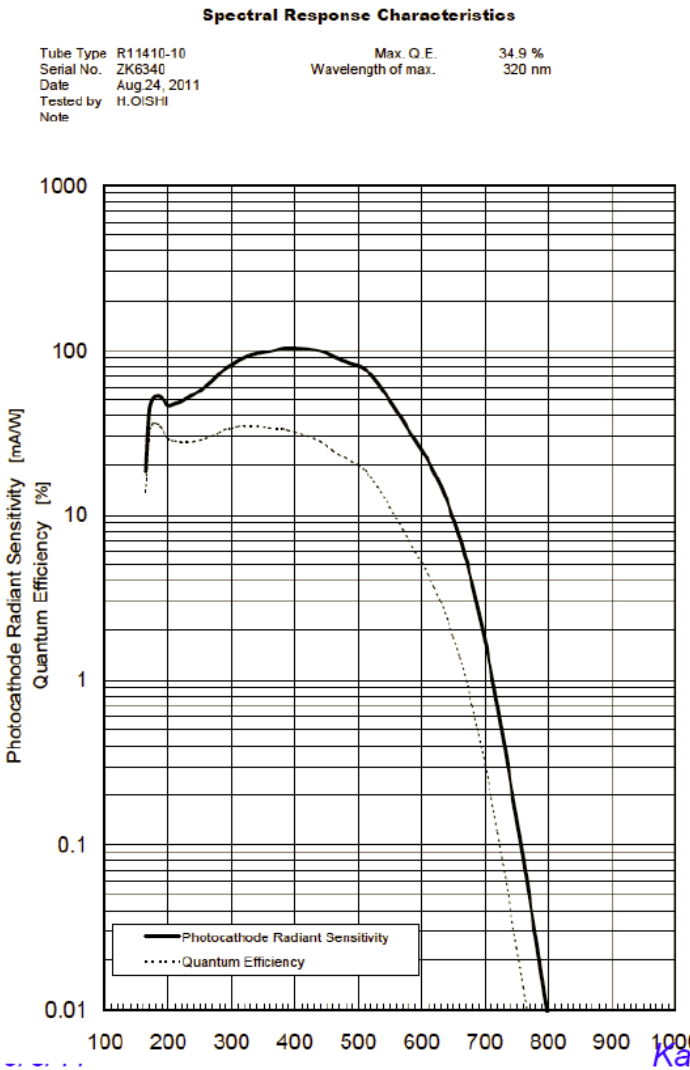

Sapphire window, 6mm,TPB coated
Cable Conduit Fitting
Clamp Ring
Enclosure
Backplate
Pressure ring
Copper Braid
Clamp
Polymer shim
PMT
O-Ring
Insulator
Potting
Base
Springs
Optical Coupling Pad, 3mm
Retaining Ring
Mesh, grounded
Spring Holders, PTFE

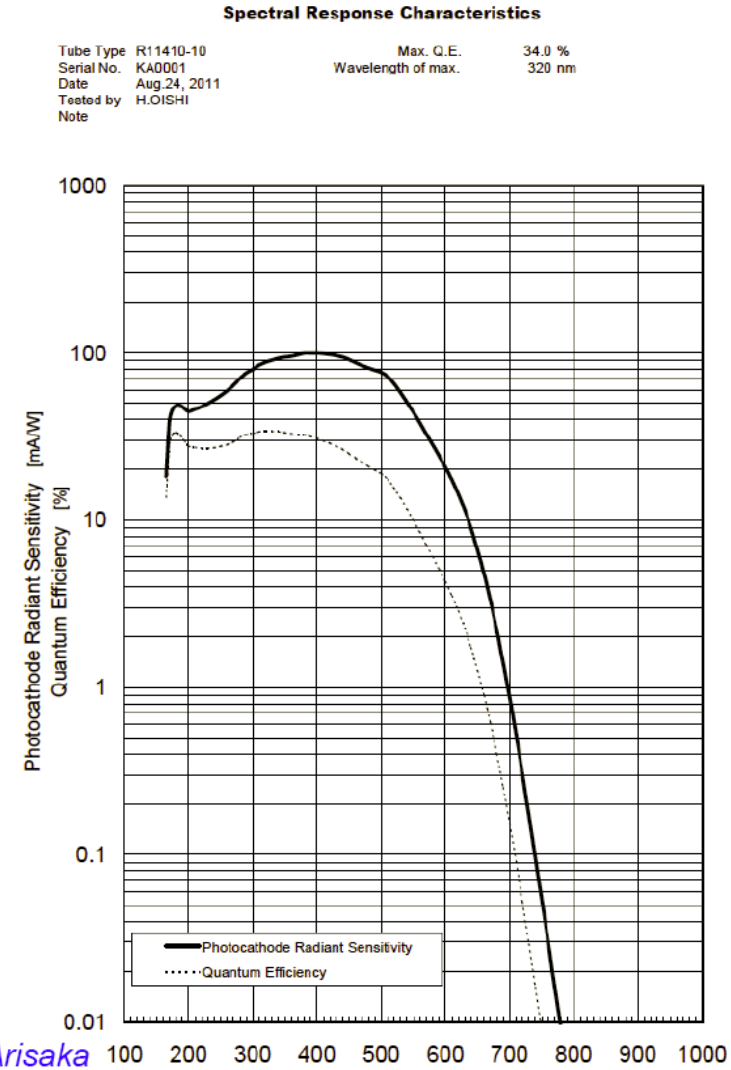

Sapphire window, 6mm,TPB coated
Clamp Ring
Pressure ring
Polymer shim
O-Ring
Insulator
Enclosure
Clamp
PMT
Cable Conduit Fitting
Backplate
Copper Braid
Potting
Base
Springs
Retaining Ring
Spring Holders, PTFE
Optical Coupling Pad, 3mm
Mesh, grounded

Hamamatsu R11410-10



Typical quantum efficiencies, as measured, from [arisaka]

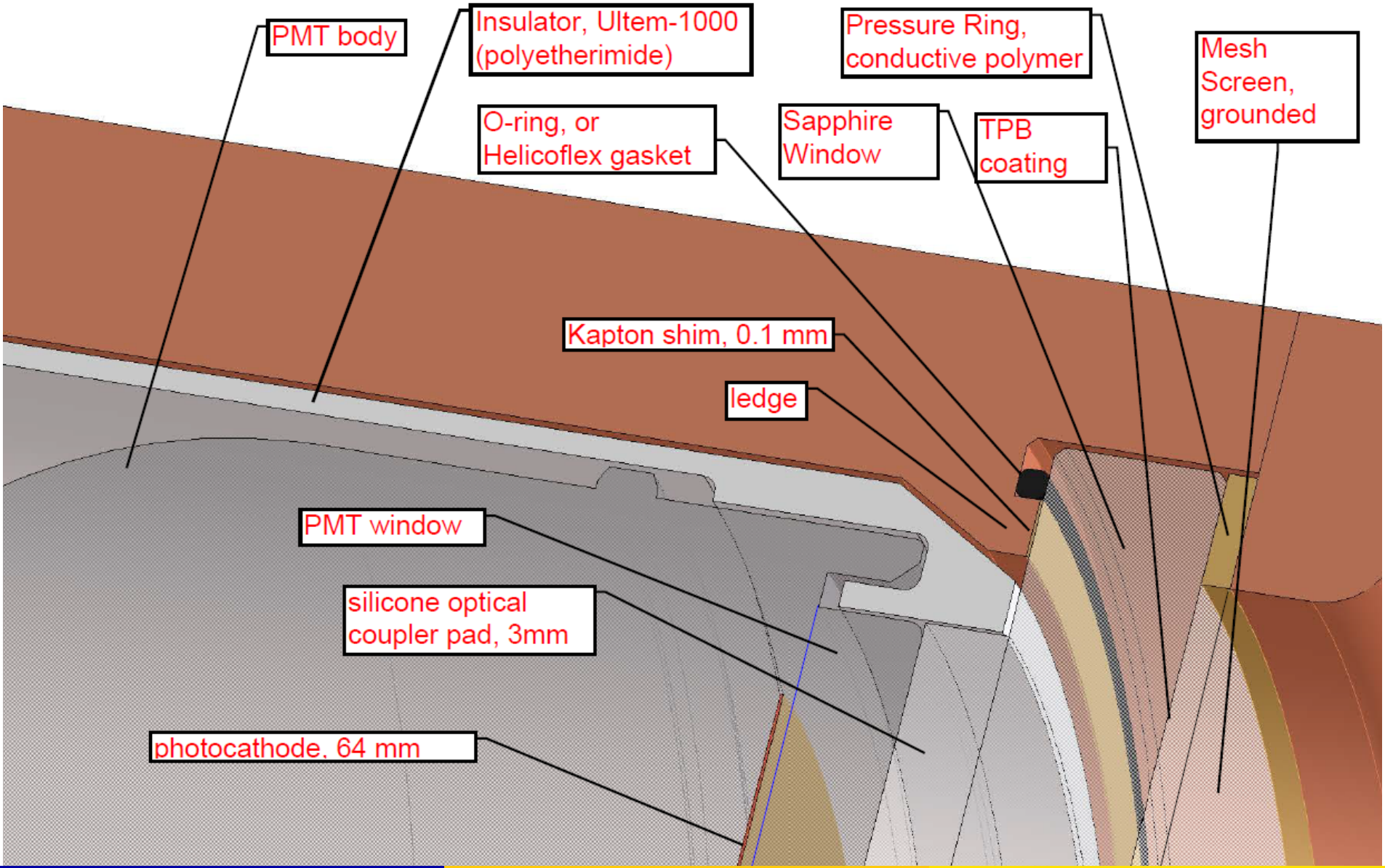




Katsushi Arisaka

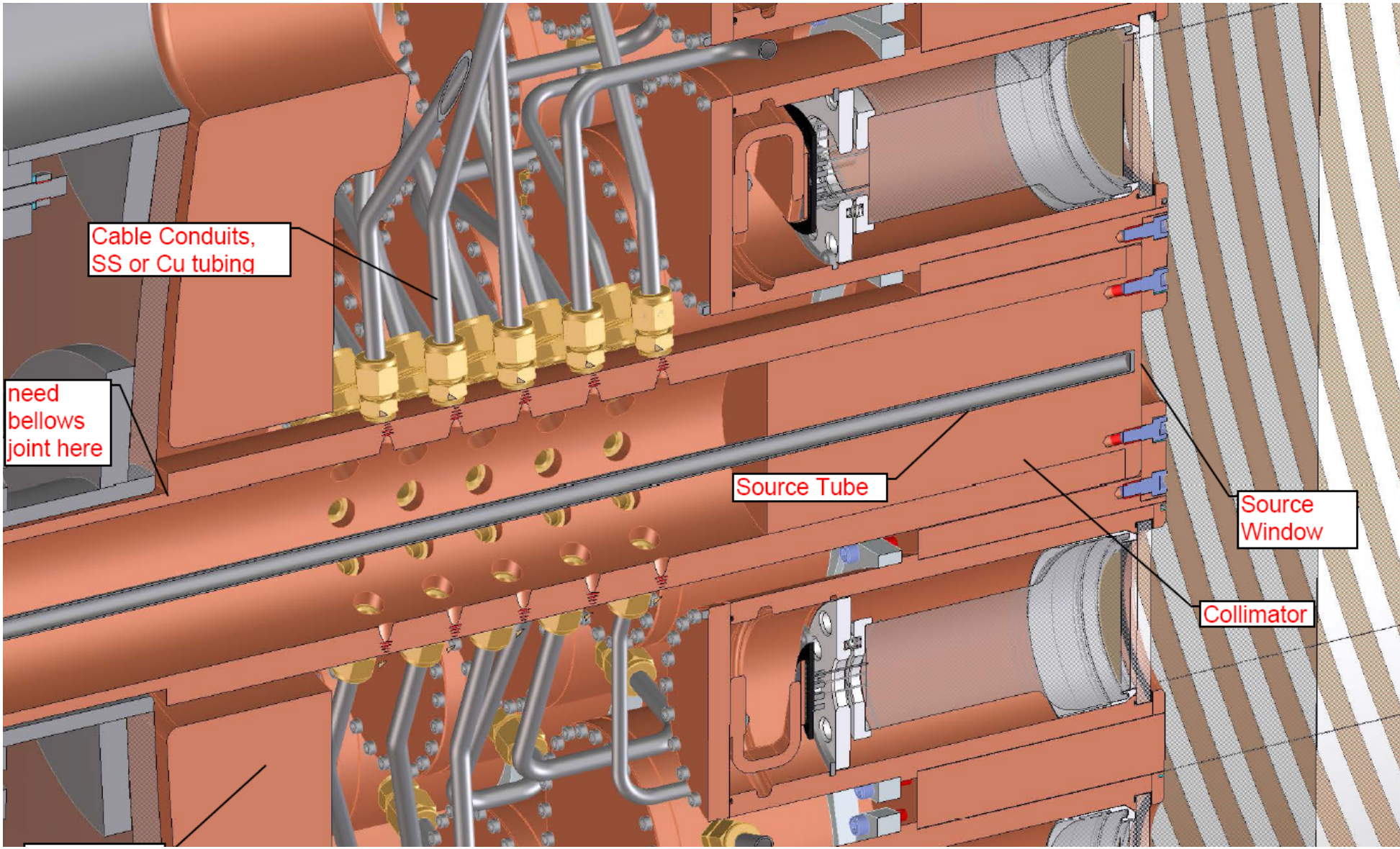
Window strength assurance

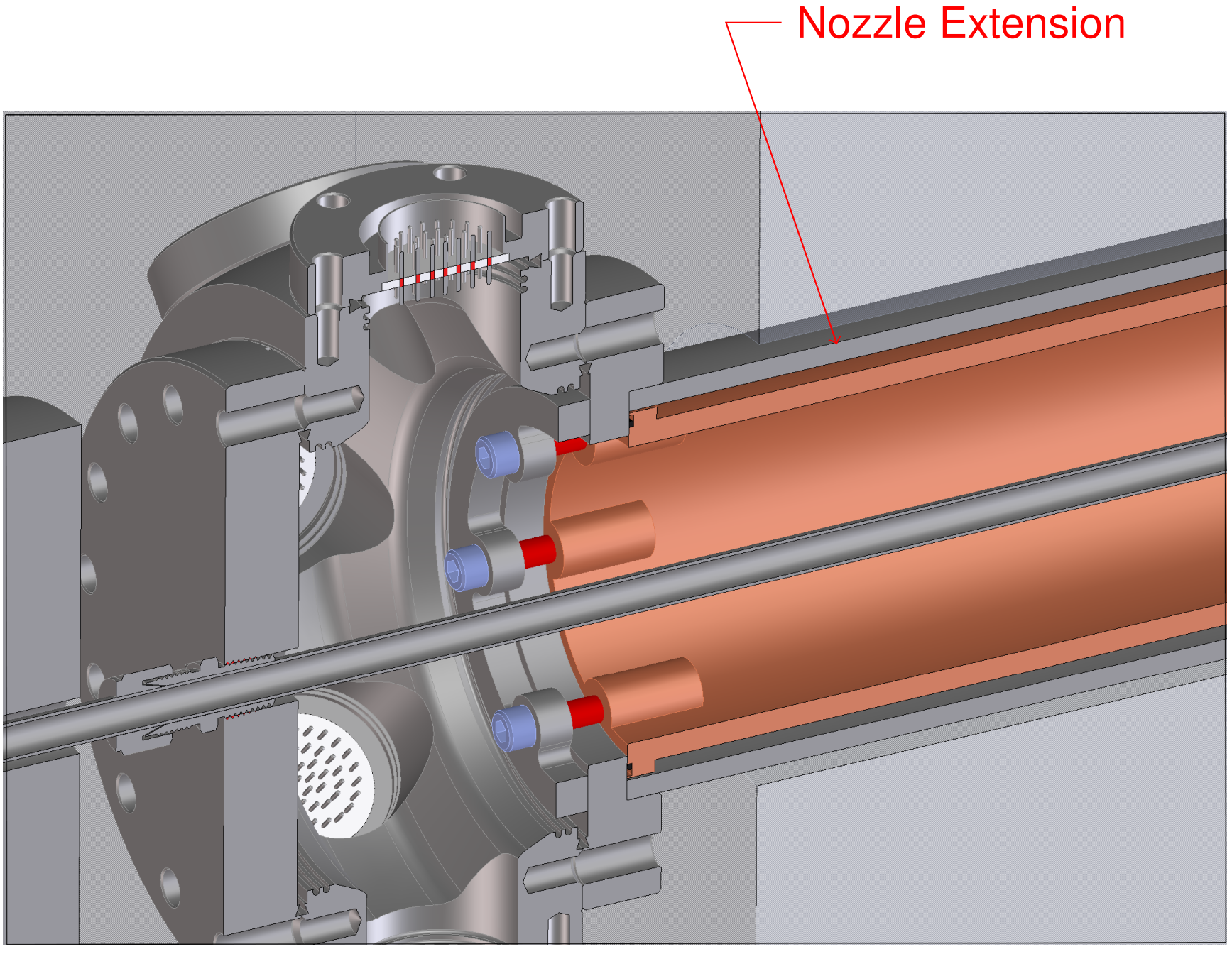
- Strength is a strong function of area and finish (as well as intrinsic strength)
- Weibull distribution: failure probability vs. stress-area function
- Sapphire and quartz have well characterized Weibull parameters (moduli and characteristic strength)
- Choose thickness, finish to give low failure probability (5% or less) at a TEST pressure
- Test pressure set to assure: if no failure under test then no failure under fatigue (cyclic or static)
- Pressure Test all windows

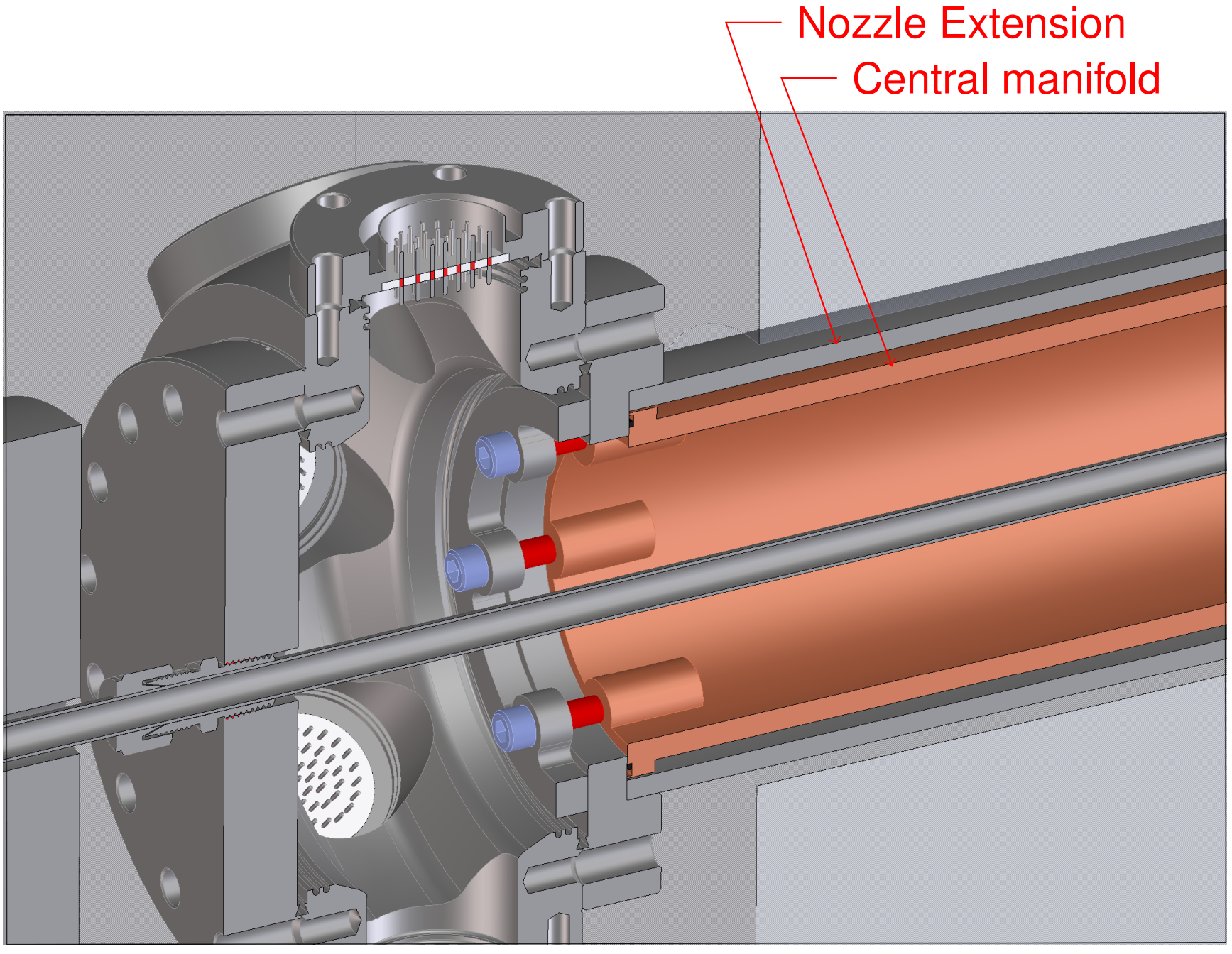

PMT body
Insulator, Ultem-1000 (polyetherimide)
Pressure Ring, conductive polymer
Mesh Screen, grounded
O-ring, or Helicoflex gasket
Sapphire Window
TPB coating
Kapton shim, 0.1 mm
ledge
PMT window
silicone optical coupler pad, 3mm
photocathode, 64 mm

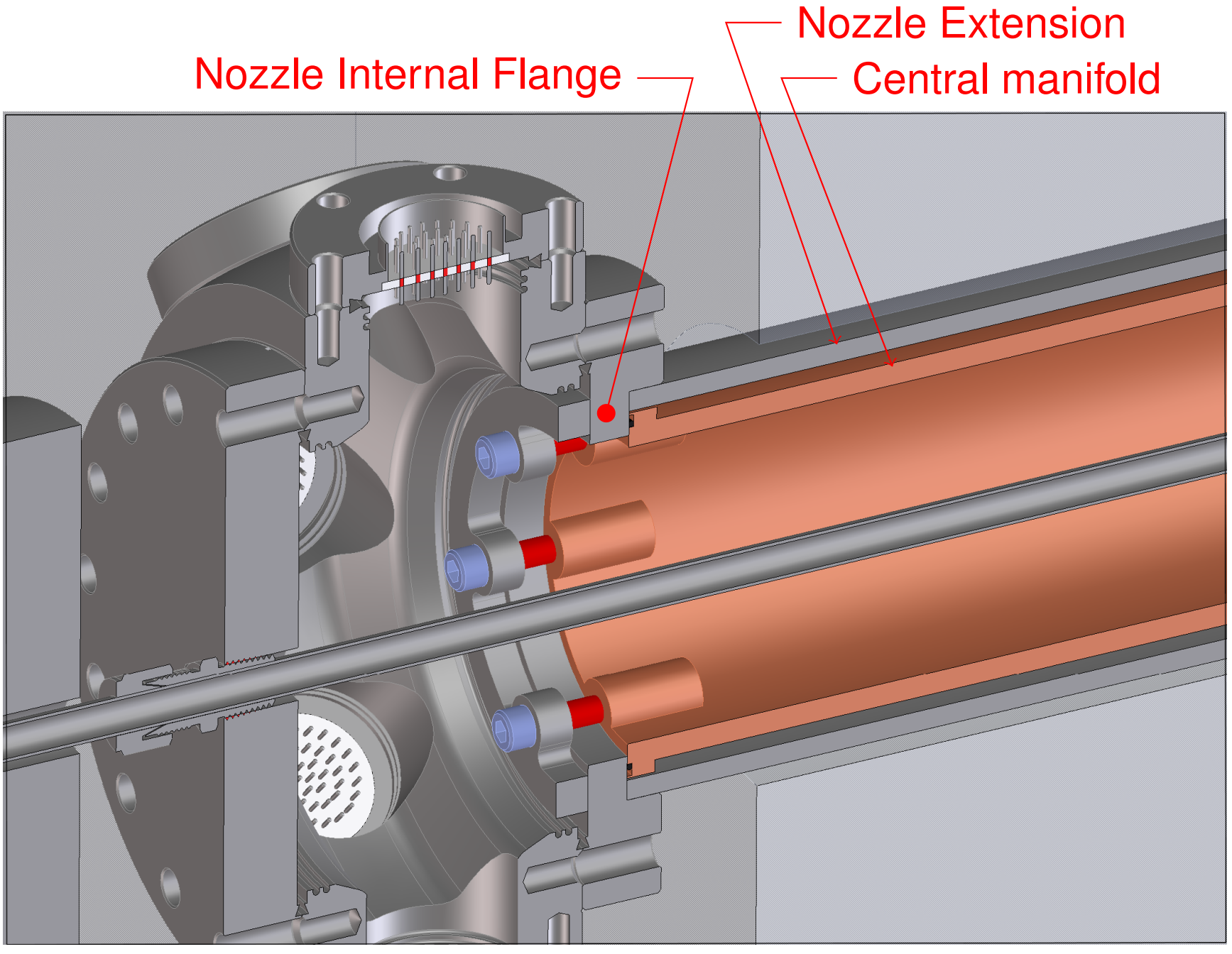
(Temperature Drop, Base to ambient @1750V, 3.5MOhm)

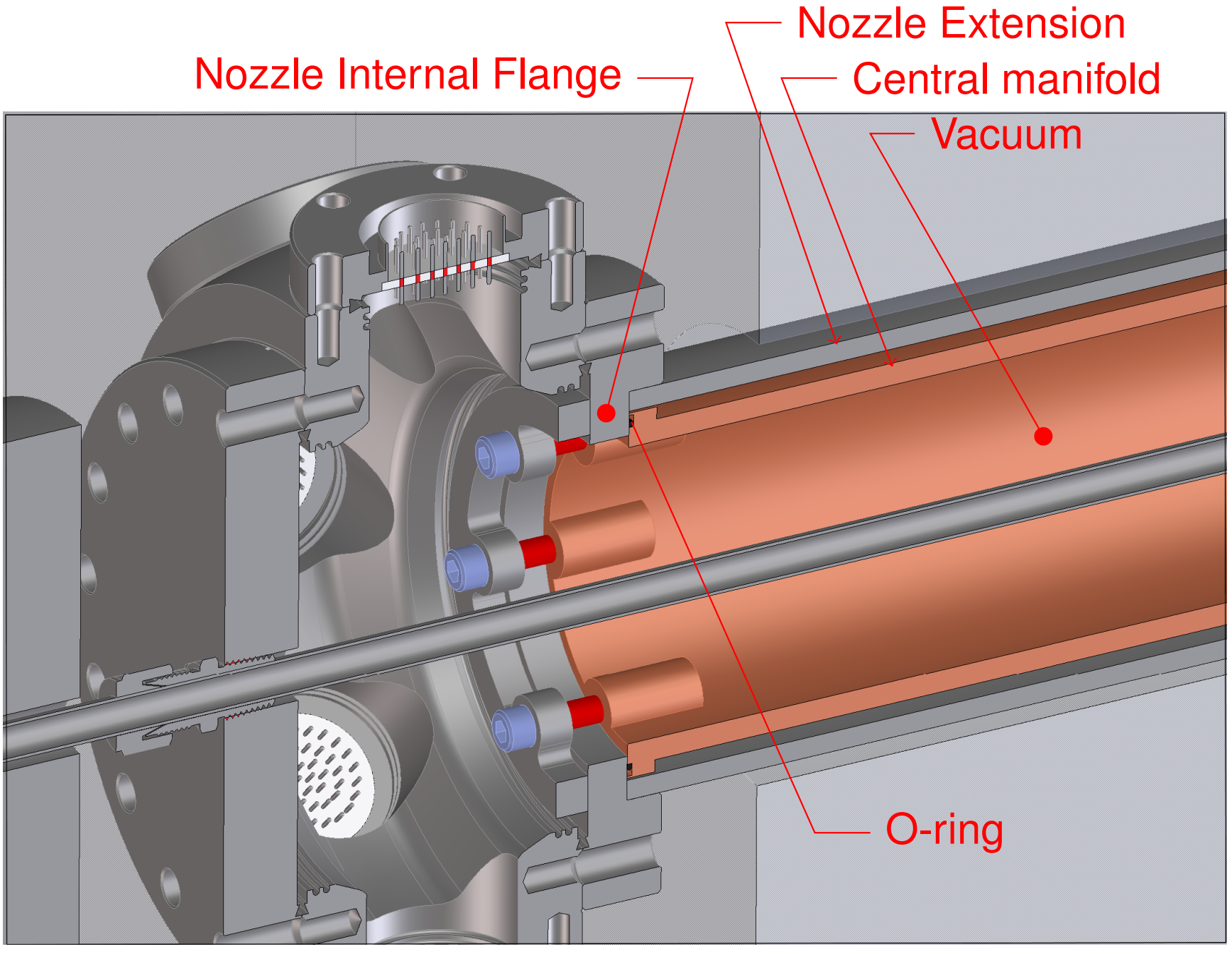
Section	**deg. C**
Potting Compound, 1mm (1W/(m*K))	2.38
Kapton MT insulation, .05mm	0.33
Cu braid, 259 kcmil x 7.5cm	1.34
Contact, into backplate	0.04
Contact, into enclosure	0.02
Enclosure to Clamp	0.17
Contact into Carrier Plate	0.02
Carrier plate to convolution	0.22
Convolution to Vessel flange	0.48
Vessel flange	1.32
Total Temp Drop	6.3

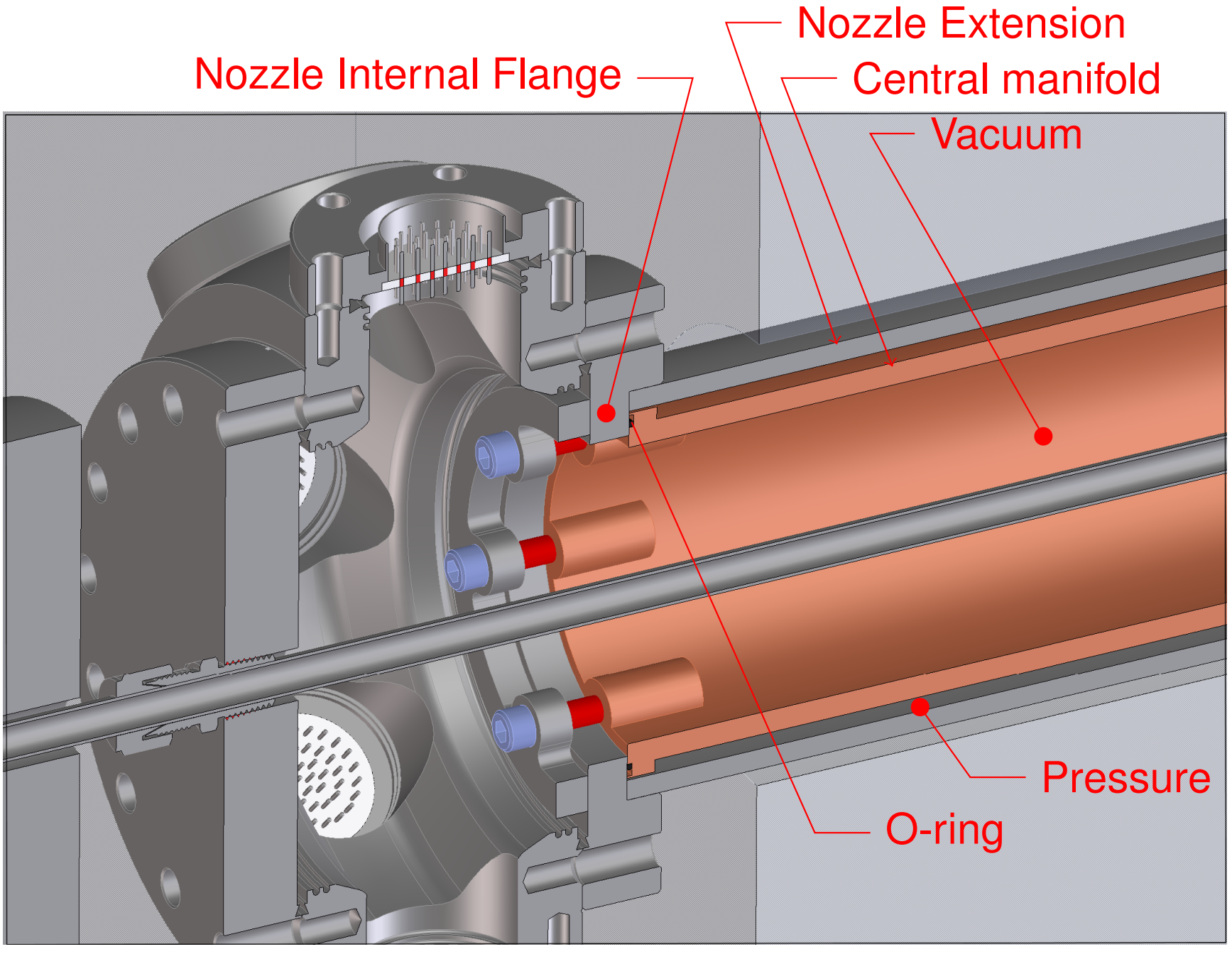

Cable Conduits,
SS or Cu tubing
need
bellows
joint here
Source Tube
Source
Window
Collimator

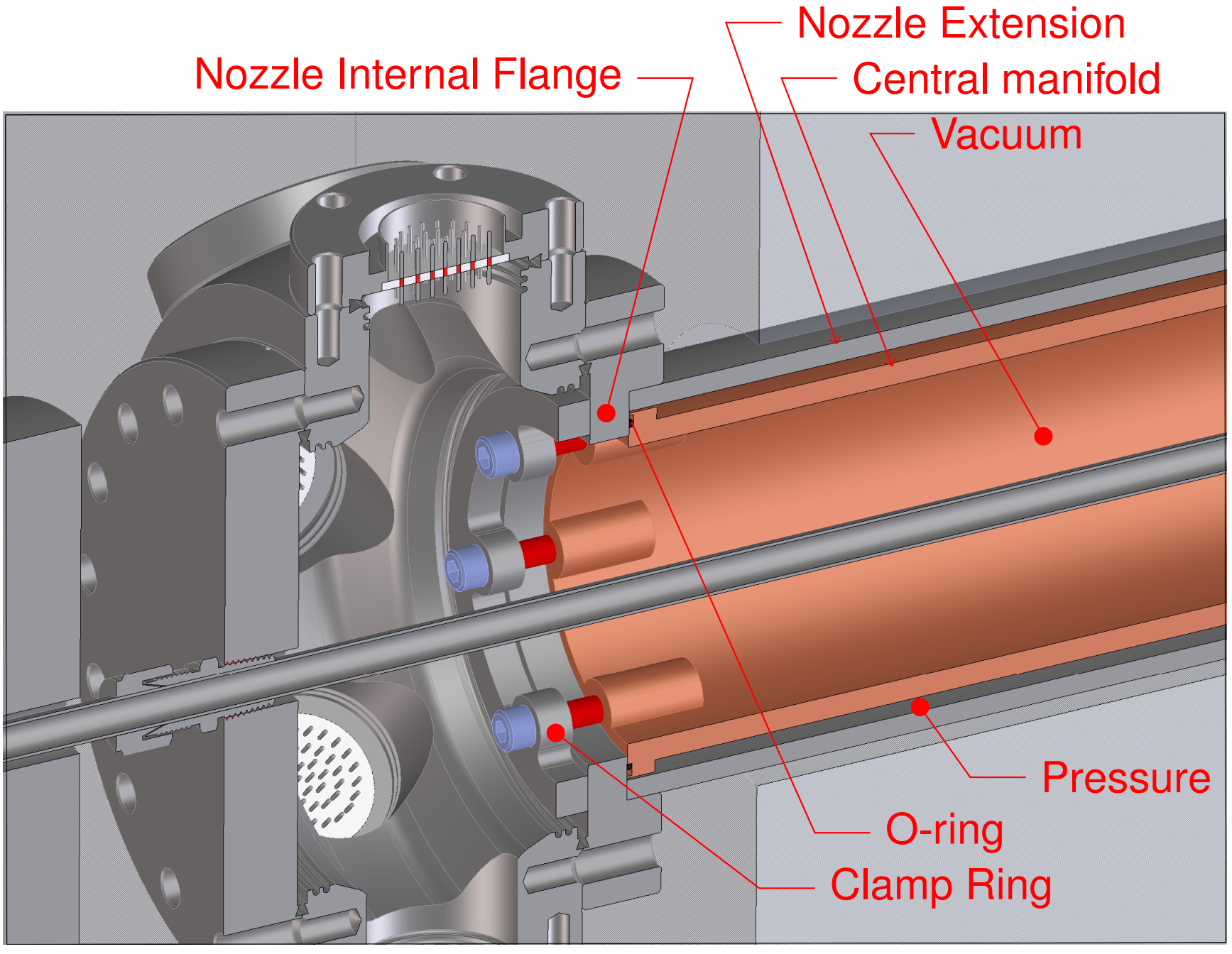

Nozzle Extension

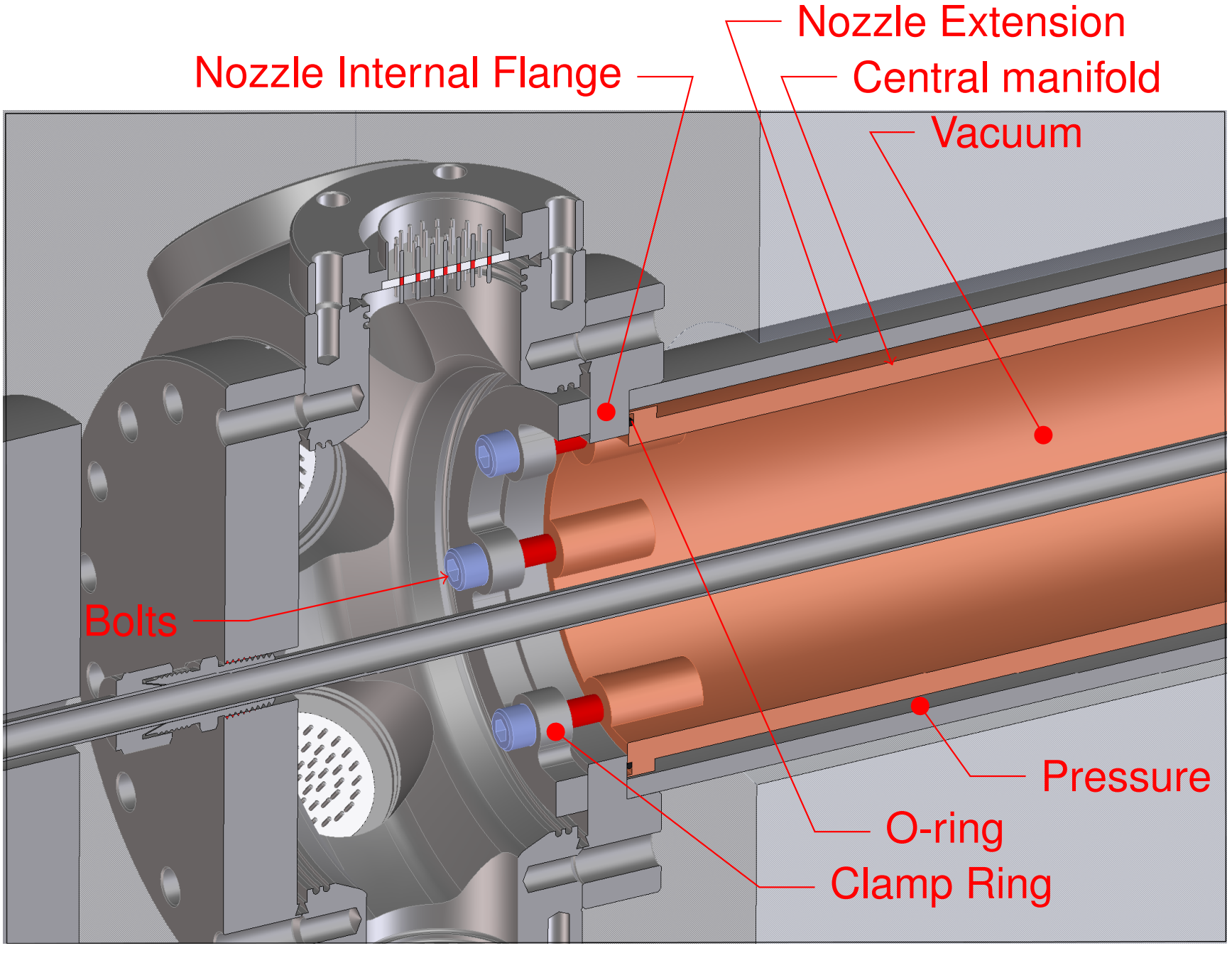

Nozzle Extension
Central manifold

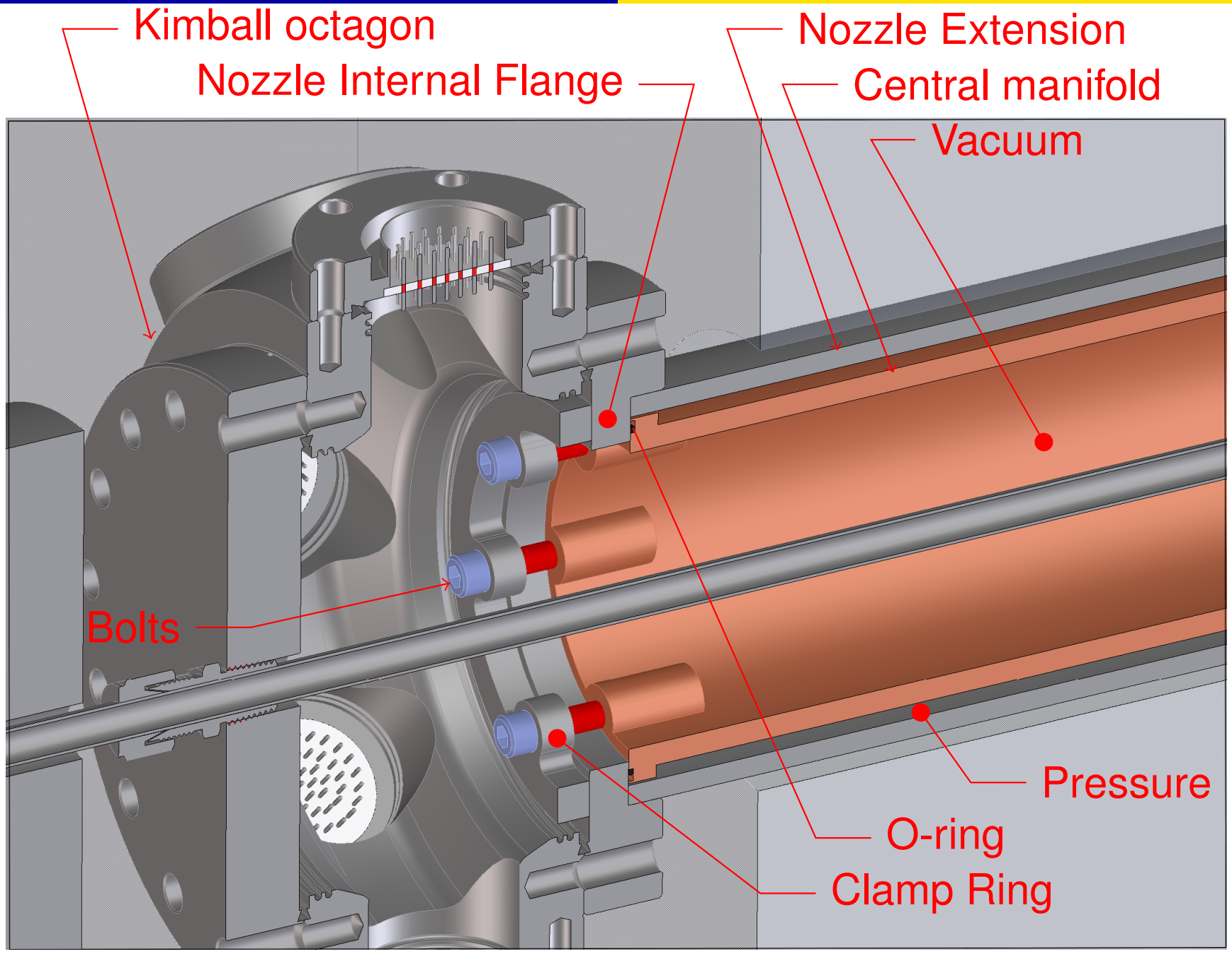

Nozzle Extension
Nozzle Internal Flange
Central manifold

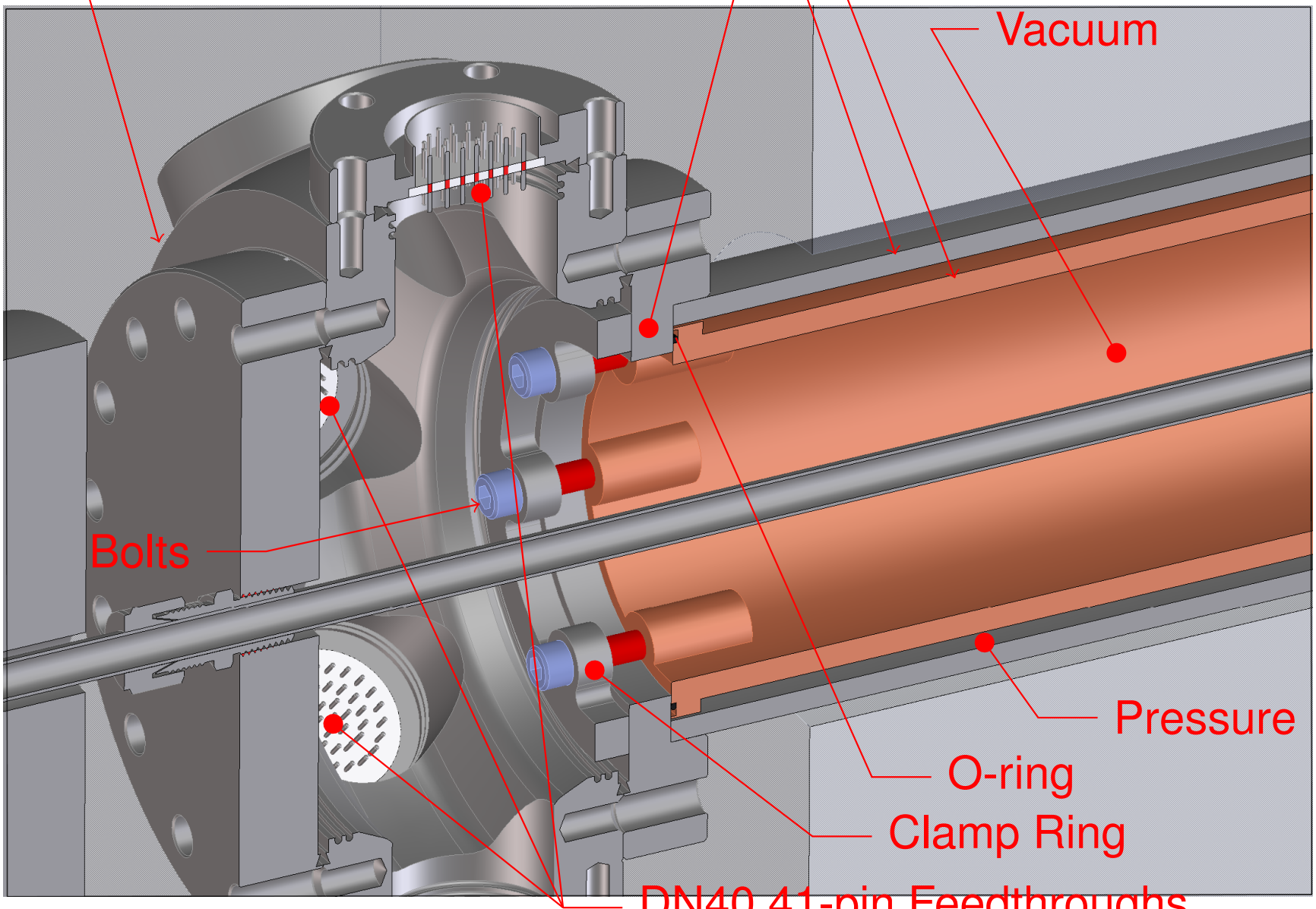

Nozzle Extension
Nozzle Internal Flange
Central manifold
Vacuum
O-ring

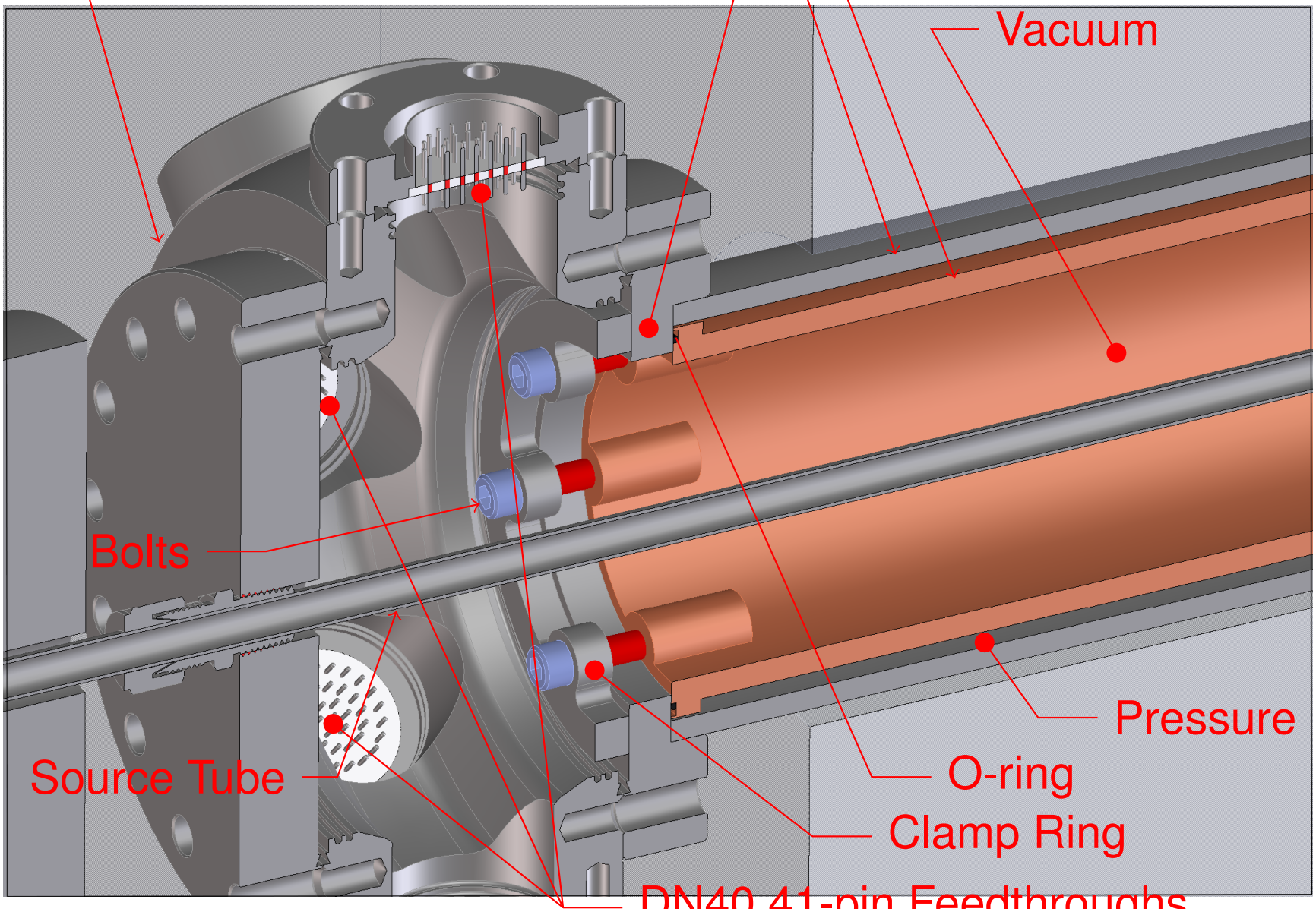

Nozzle Extension
Nozzle Internal Flange
Central manifold
Vacuum
Pressure
O-ring

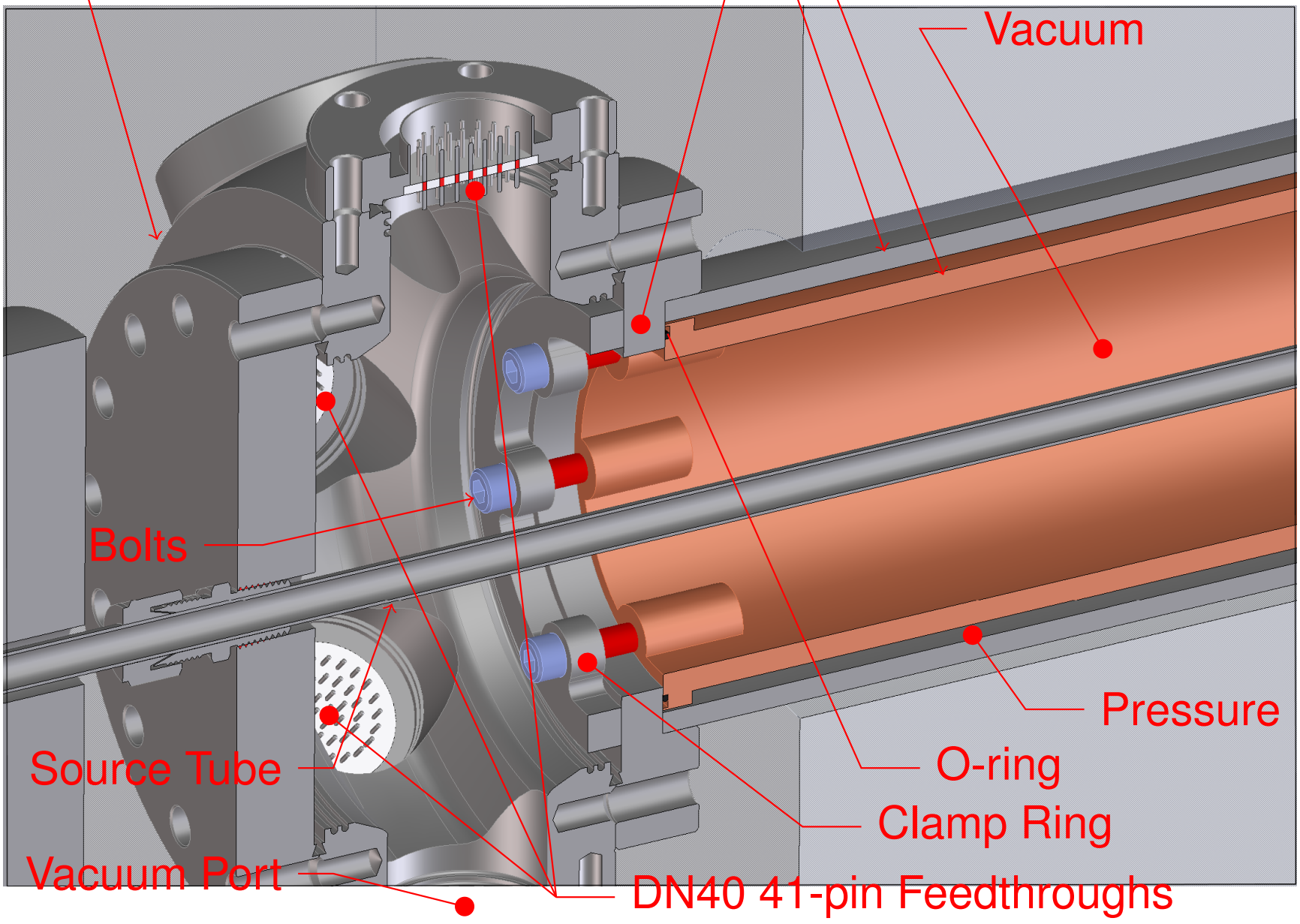

Nozzle Extension
Nozzle Internal Flange
Central manifold
Vacuum
Pressure
O-ring
Clamp Ring

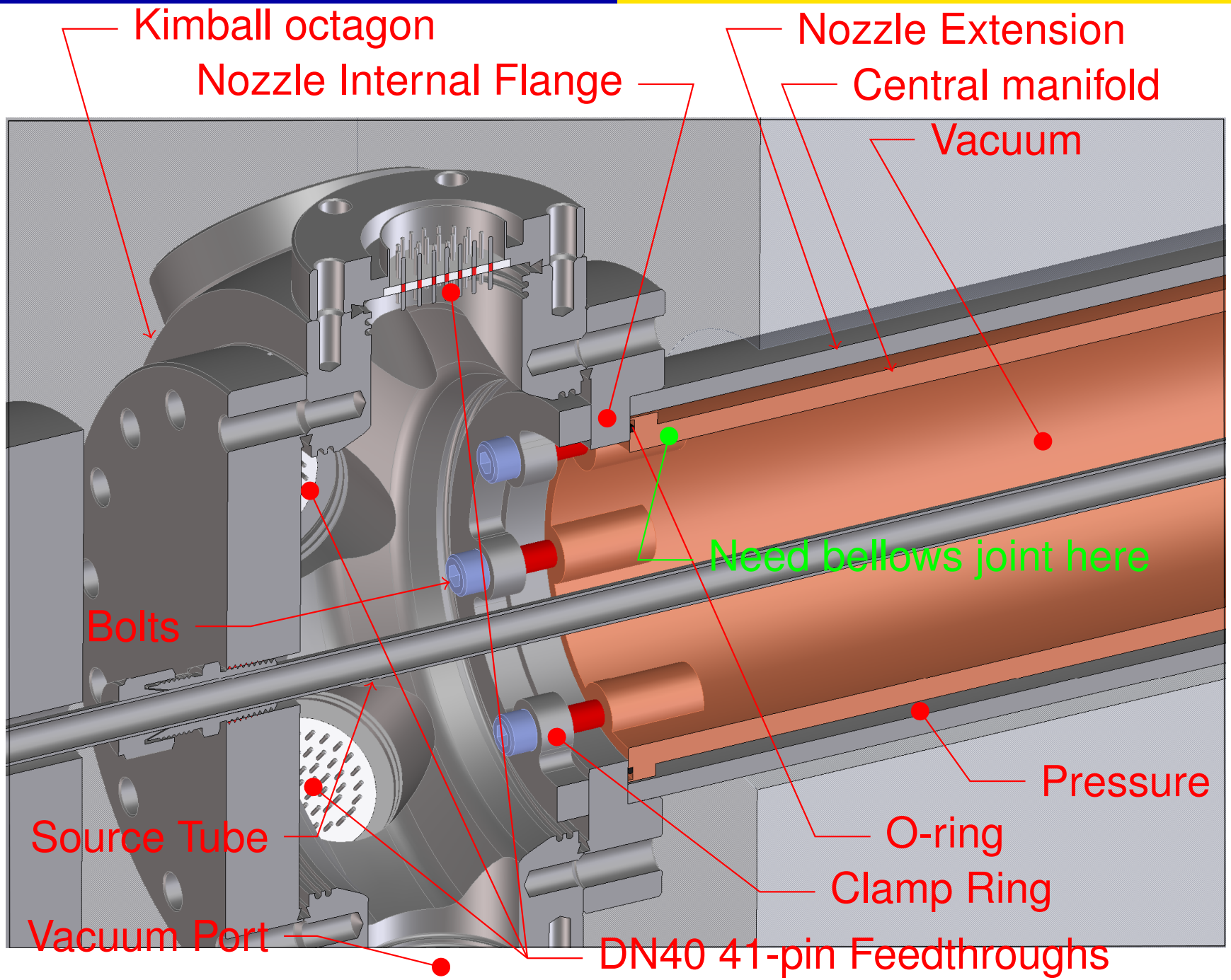

Nozzle Extension
Nozzle Internal Flange
Central manifold
Vacuum
Bolts
Pressure
O-ring
Clamp Ring

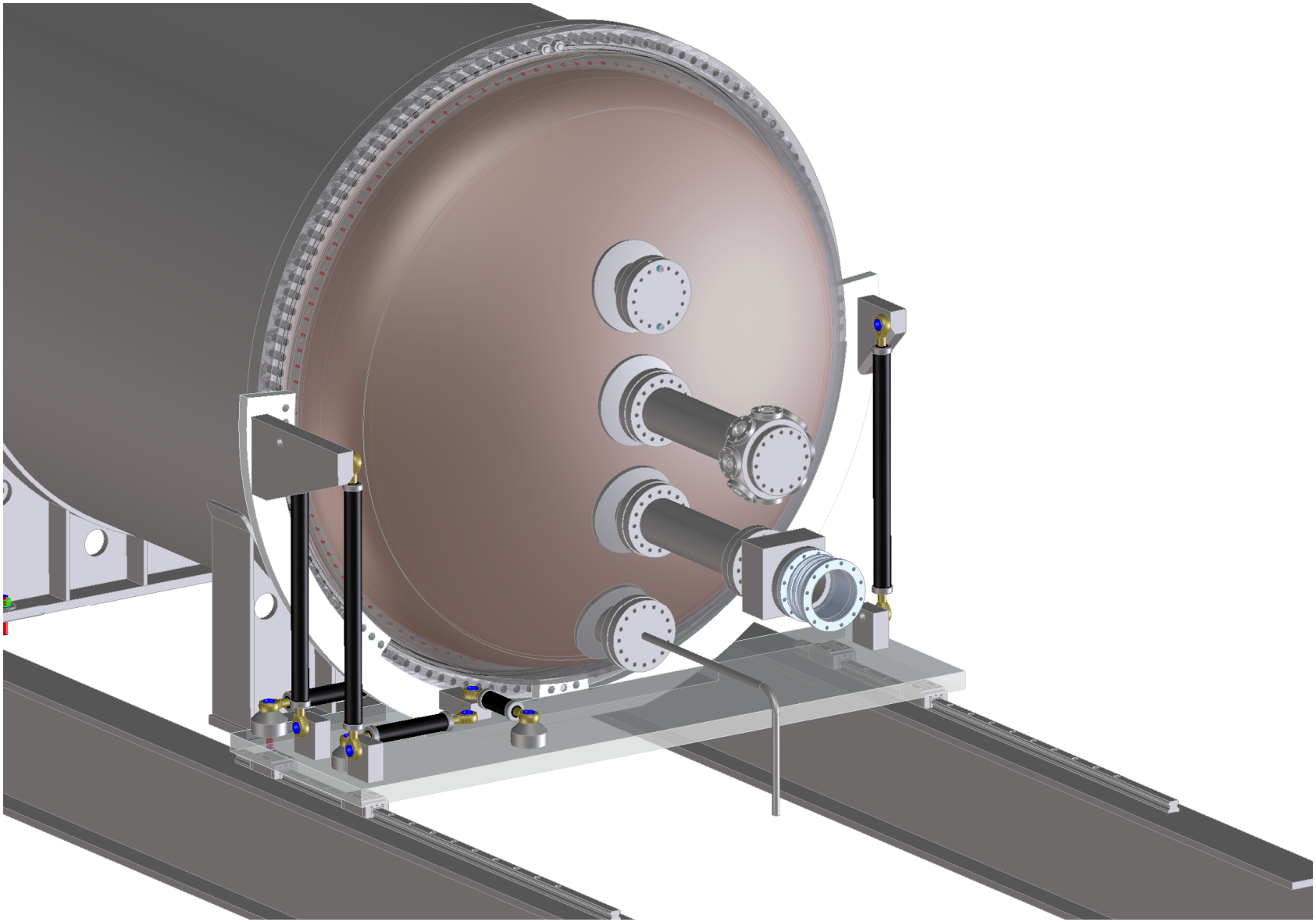

Kimball octagon
Nozzle Internal Flange
Nozzle Extension
Central manifold
Vacuum
Bolts
Pressure
O-ring
Clamp Ring


Kimball octagon
Nozzle Internal Flange
Nozzle Extension
Central manifold
Vacuum
Bolts
Pressure
O-ring
Clamp Ring
DN40 41-pin Feedthroughs


Kimball octagon
Nozzle Internal Flange
Nozzle Extension
Central manifold
Vacuum
Bolts
Pressure
Source Tube
O-ring
Clamp Ring
DN40 41-pin Feedthroughs


Kimball octagon
Nozzle Internal Flange
Nozzle Extension
Central manifold
Vacuum
Bolts
Pressure
Source Tube
O-ring
Clamp Ring
Vacuum Port
DN40 41-pin Feedthroughs


Kimball octagon
Nozzle Internal Flange
Nozzle Extension
Central manifold
Vacuum
Need bellows joint here
Bolts
Pressure
Source Tube
O-ring
Clamp Ring
Vacuum Port
DN40 41-pin Feedthroughs



- Design by James White, Clement Sofka, TAMU

- Design by James White, Clement Sofka, TAMU
- 3cm polyethylene rotomolded and machined

- Design by James White, Clement Sofka, TAMU
- 3cm polyethylene rotomolded and machined
- 130 cm drift length, 25 cm cathode buffer region grade-down

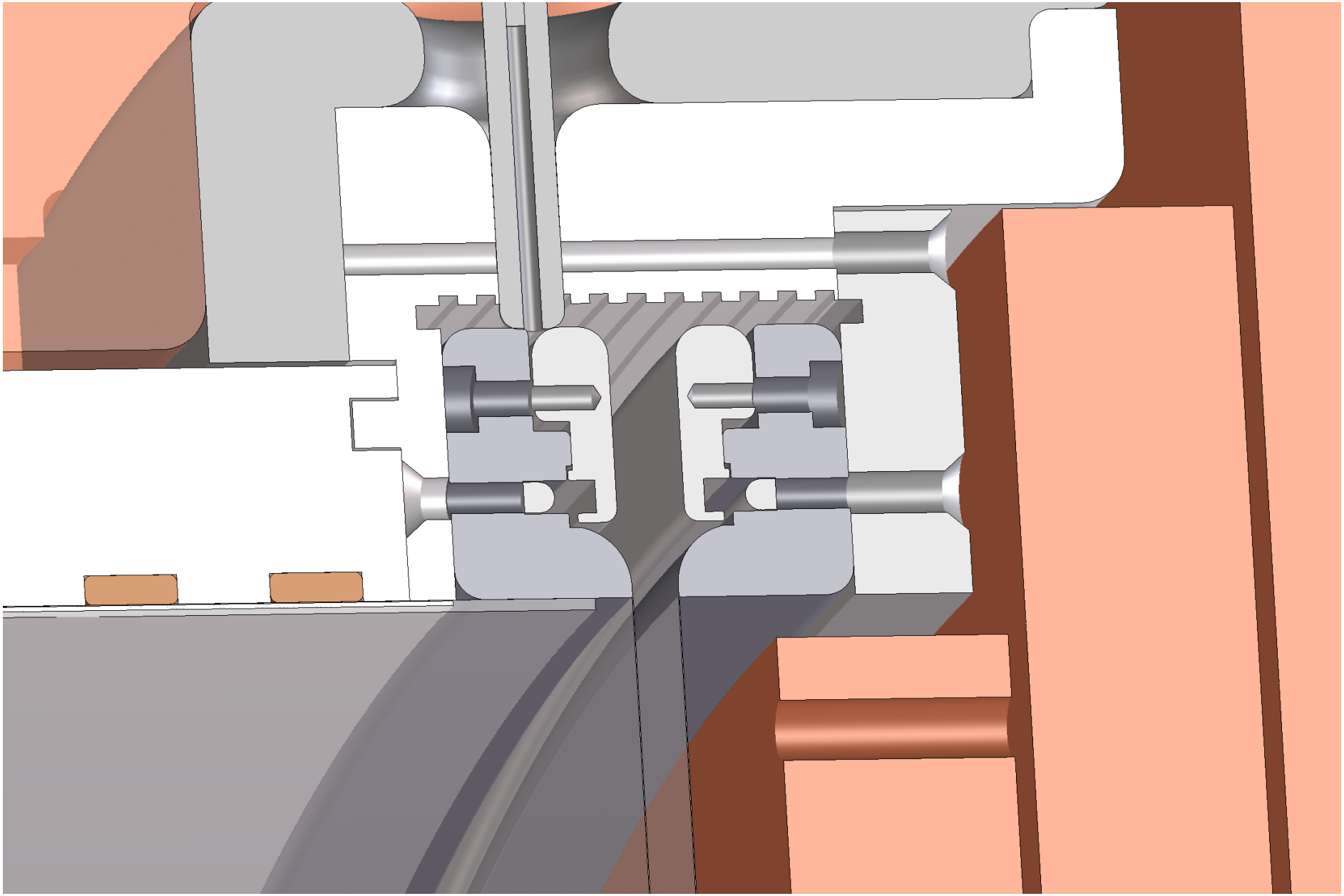
- Design by James White, Clement Sofka, TAMU
- 3cm polyethylene rotomolded and machined
- 130 cm drift length, 25 cm cathode buffer region grade-down
- "C-clamp" EL mesh connection avoids sparking or tracking

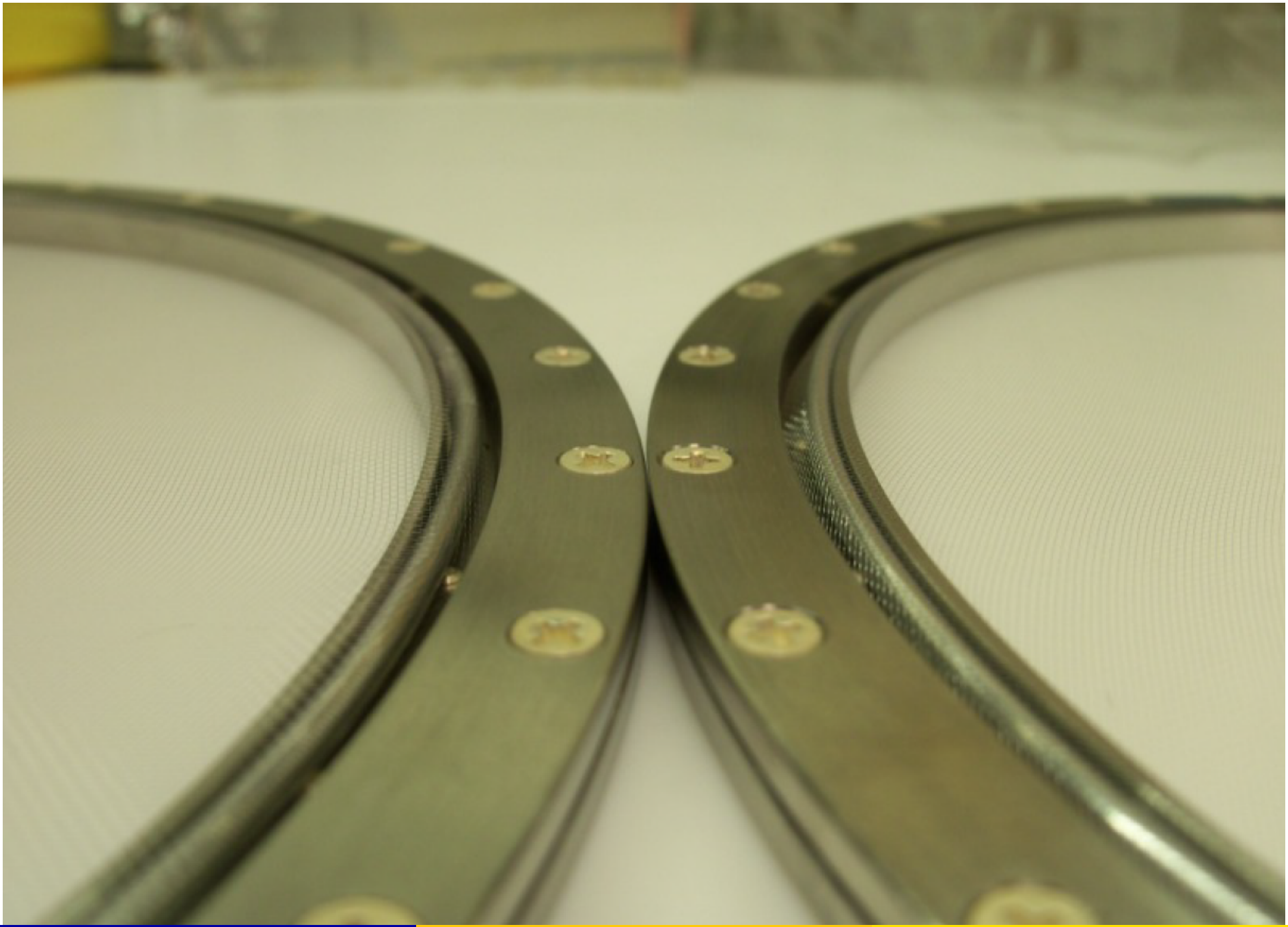
- Design by James White, Clement Sofka, TAMU
- 3cm polyethylene rotomolded and machined
- 130 cm drift length, 25 cm cathode buffer region grade-down
- "C-clamp" EL mesh connection avoids sparking or tracking
- EL meshes and frame based on proven designs up to 50 cm dia.

- Design by James White, Clement Sofka, TAMU
- 3cm polyethylene rotomolded and machined
- 130 cm drift length, 25 cm cathode buffer region grade-down
- "C-clamp" EL mesh connection avoids sparking or tracking
- EL meshes and frame based on proven designs up to 50 cm dia.
- EL mesh of fine wire (30μm) and pitch (0.5mm), 88% transparent

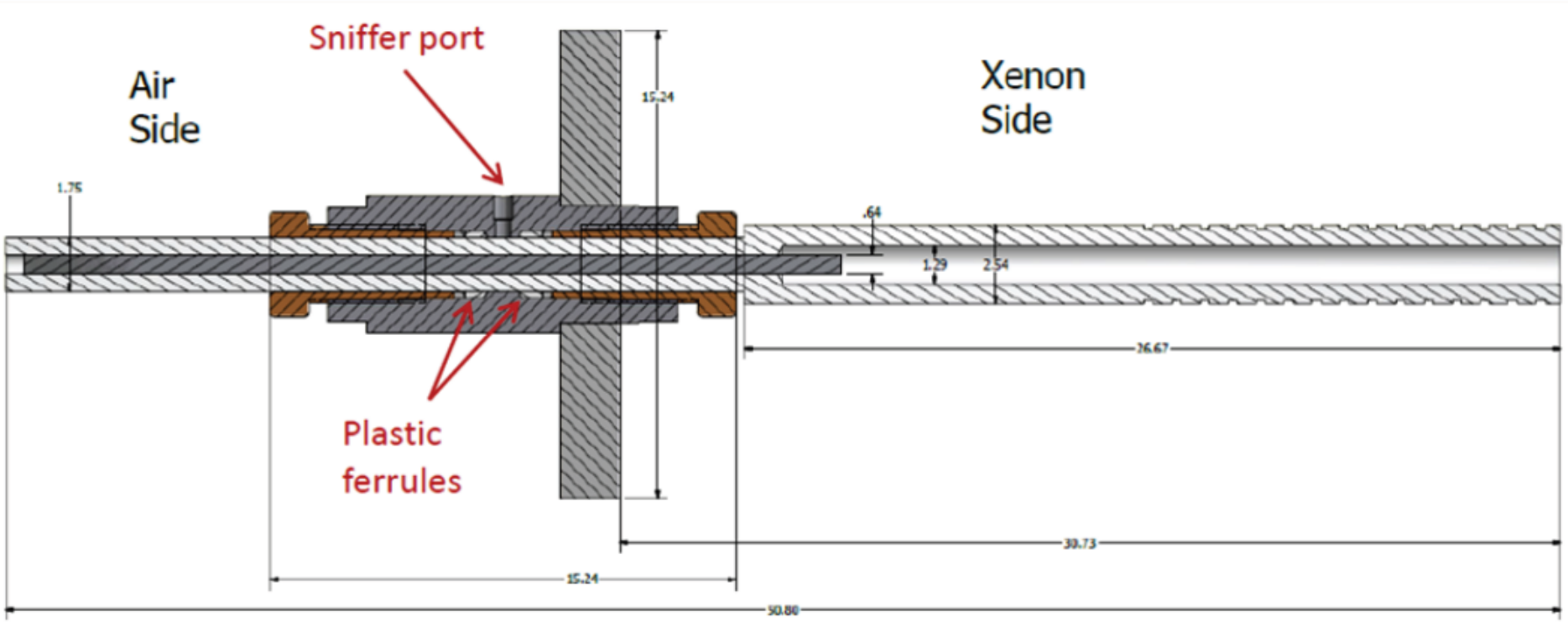
- Design by James White, Clement Sofka, TAMU
- 3cm polyethylene rotomolded and machined
- 130 cm drift length, 25 cm cathode buffer region grade-down
- "C-clamp" EL mesh connection avoids sparking or tracking
- EL meshes and frame based on proven designs up to 50 cm dia.
- EL mesh of fine wire (30μm) and pitch (0.5mm), 88% transparent
- Coarse, stiff wire mesh on cathode for simplicity (88% transparent)

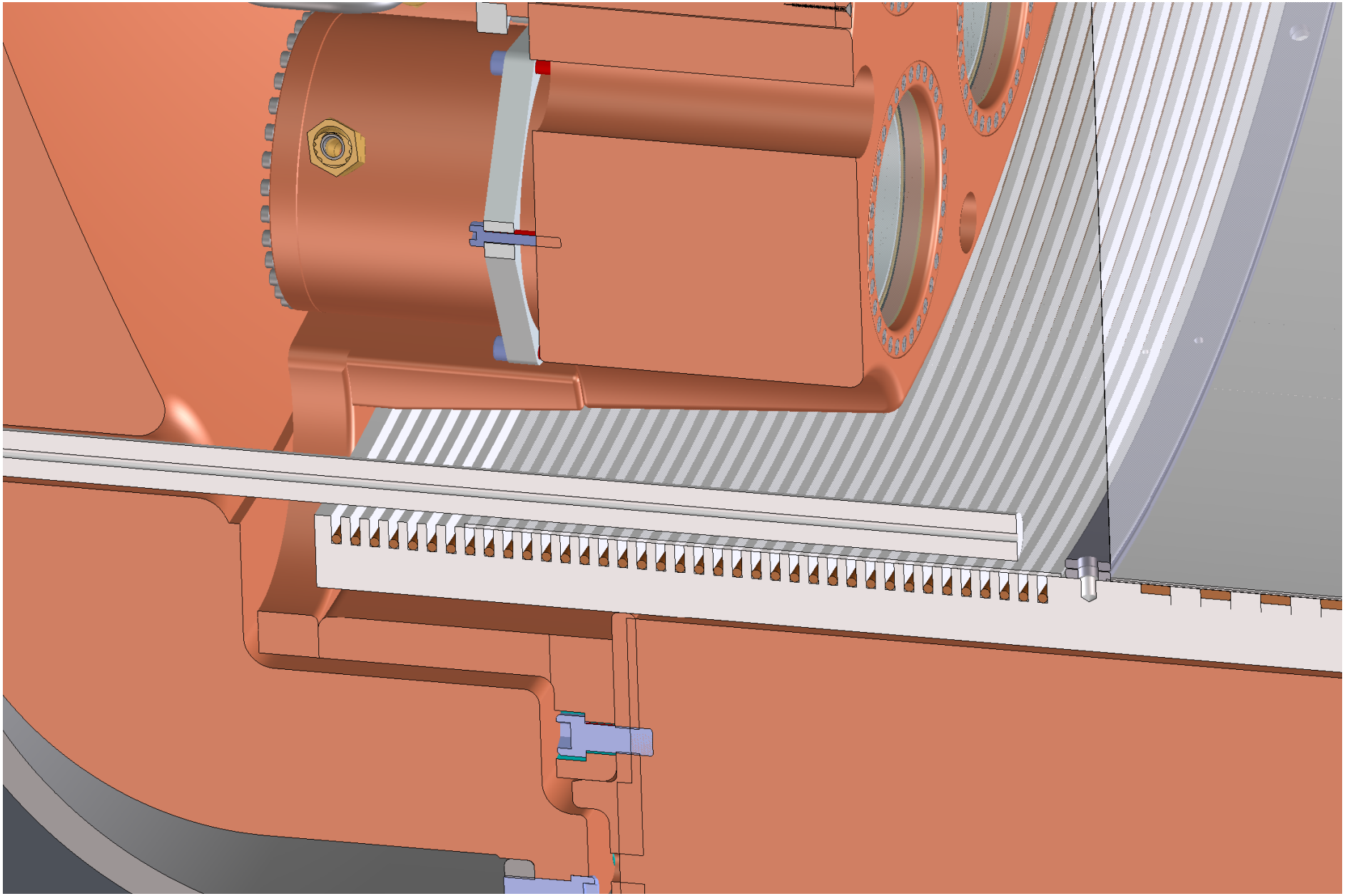
Drift field strength	$0.3\ \mathrm{kV\ cm^{-1}}$
EL field strength (E/p)	$3.0\ \mathrm{kV\ cm^{-1}\ bar^{-1}}$
Optical gain	$2500\ \mathrm{photons/e^{-}}$
Drift length	130 cm
EL gap	0.5 cm
Cathode voltage	-61.5 kV @15 bar (a)
Gate grid voltage	-22.5 kV @15 bar (a)
Anode grid voltage	0

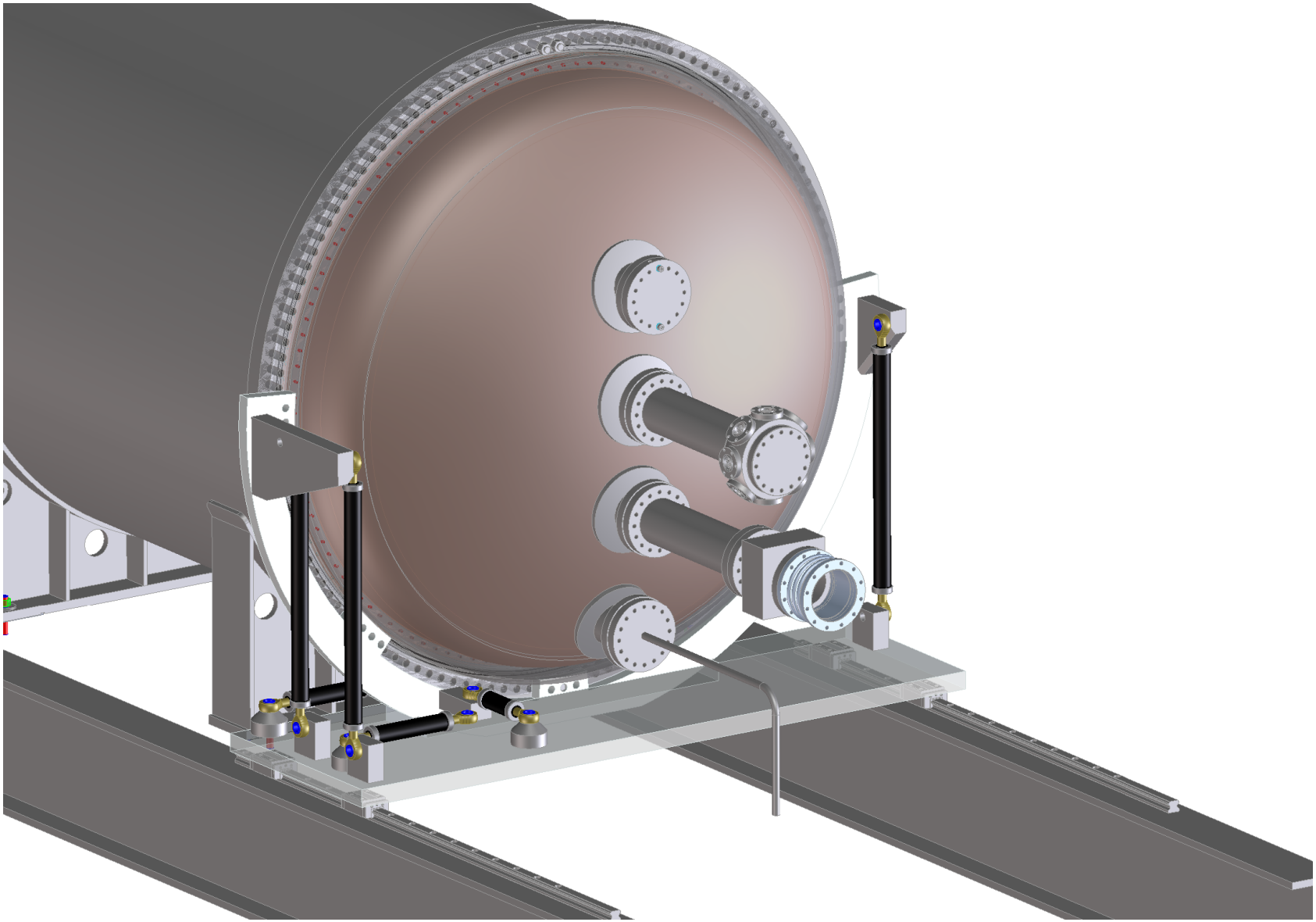




Tefzel insulator, will be graded on OD (contacts FC buffer grade down rings)







- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB

- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout

- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)

- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)

- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield

- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield
- Cables (FPC) are stripline, 50Ω for reduced capacitance to ground

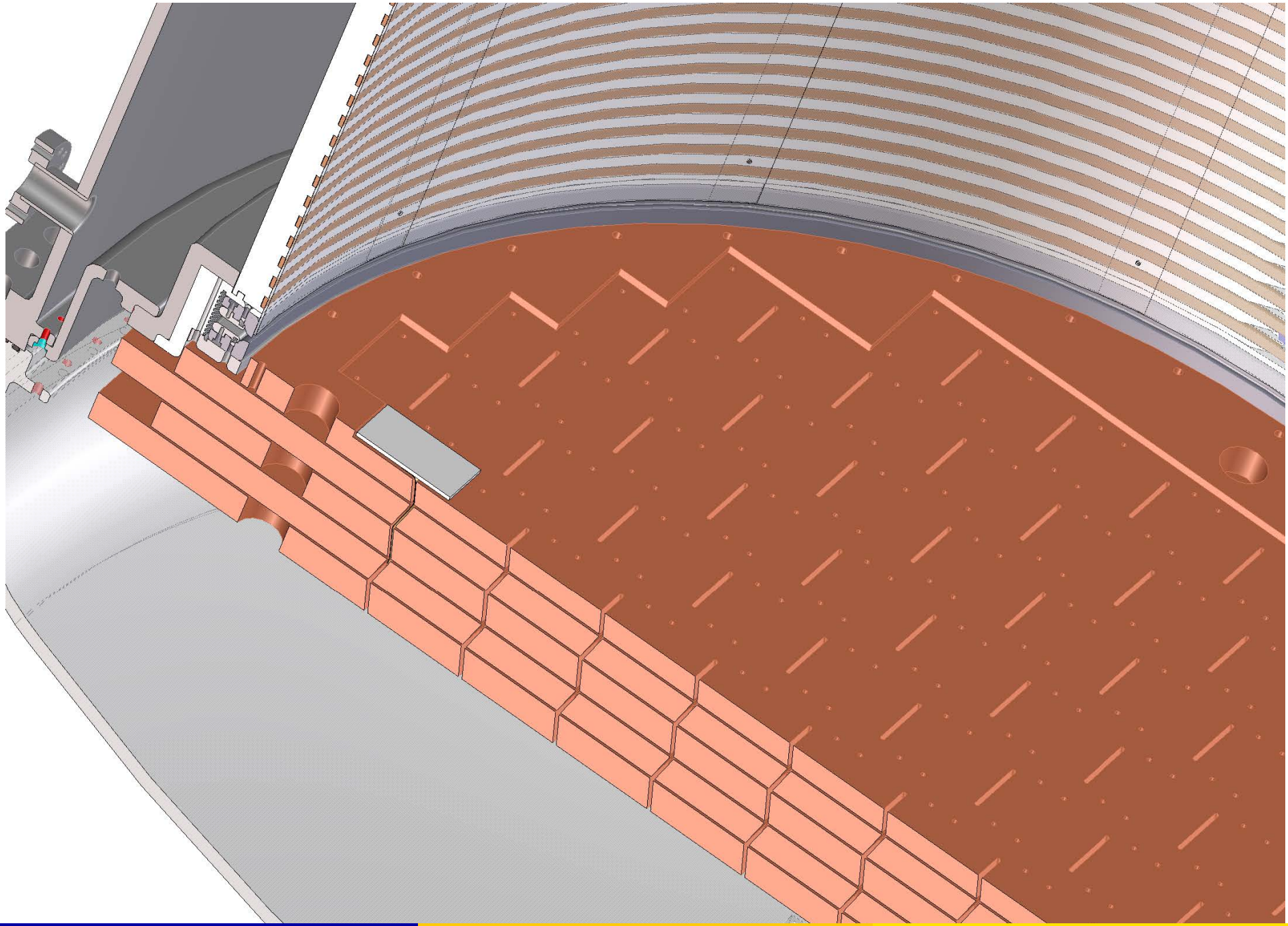
- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield
- Cables (FPC) are stripline, 50Ω for reduced capacitance to ground
- Cables bundled into 3 sets, rest on shelves cantilevered from shield

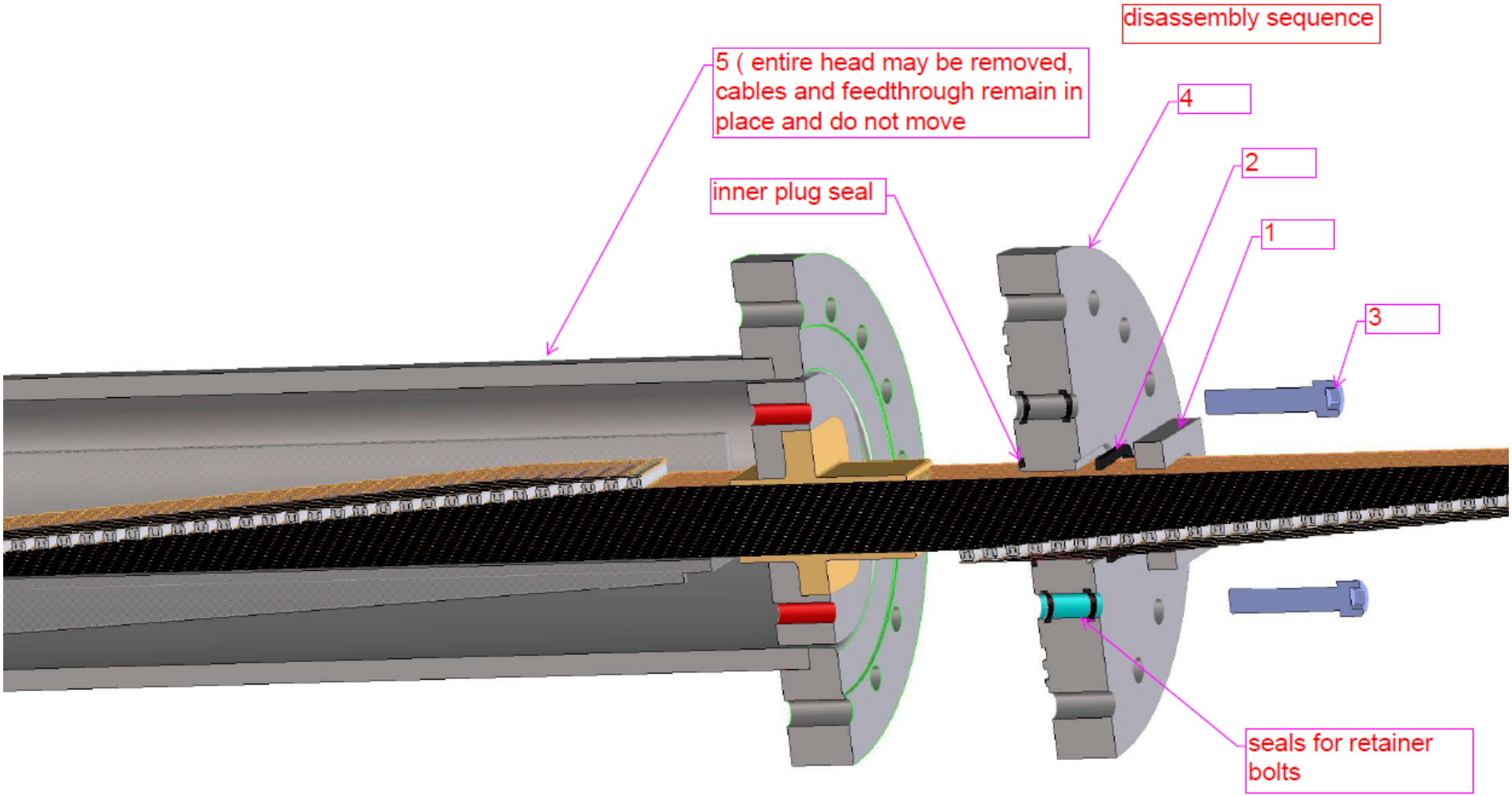
- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield
- Cables (FPC) are stripline, 50Ω for reduced capacitance to ground
- Cables bundled into 3 sets, rest on shelves cantilevered from shield
- Feedthrough is all-polyimide (Cirlex) multilayer rigid-flex circuit (42 FPCs/FT)

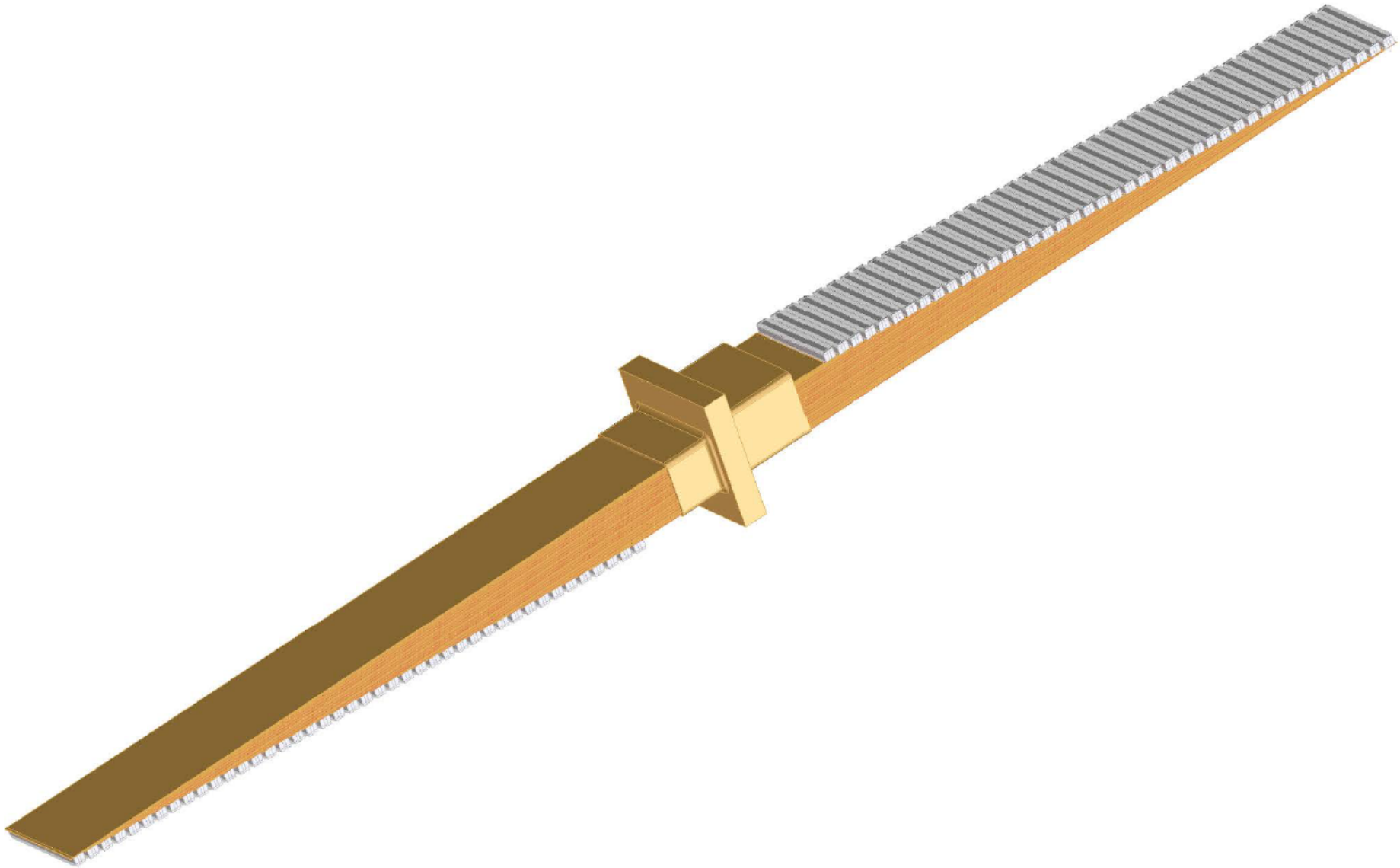
- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield
- Cables (FPC) are stripline, 50Ω for reduced capacitance to ground
- Cables bundled into 3 sets, rest on shelves cantilevered from shield
- Feedthrough is all-polyimide (Cirlex) multilayer rigid-flex circuit (42 FPCs/FT)
- Feedthrough made with a machined flange for internal sealing

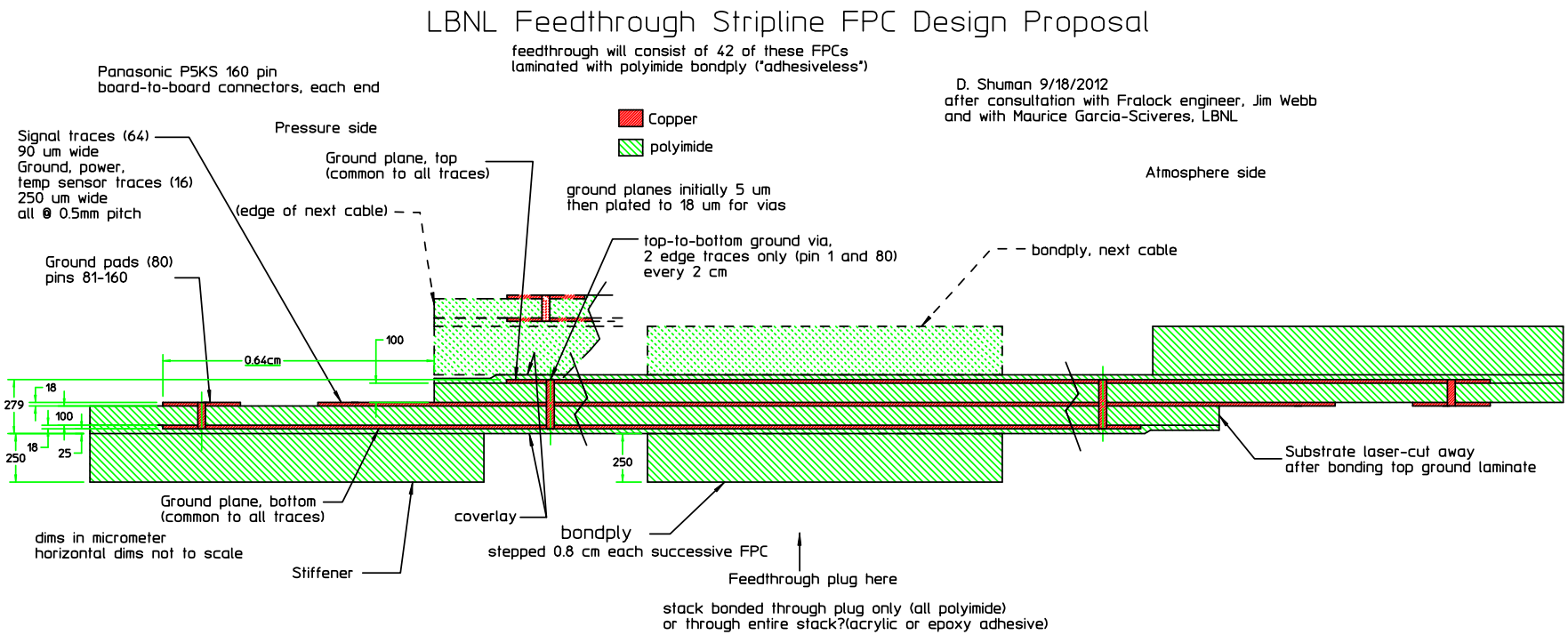
- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield
- Cables (FPC) are stripline, 50Ω for reduced capacitance to ground
- Cables bundled into 3 sets, rest on shelves cantilevered from shield
- Feedthrough is all-polyimide (Cirlex) multilayer rigid-flex circuit (42 FPCs/FT)
- Feedthrough made with a machined flange for internal sealing
- Metal flange and PV head removable from outside without disturbing cables

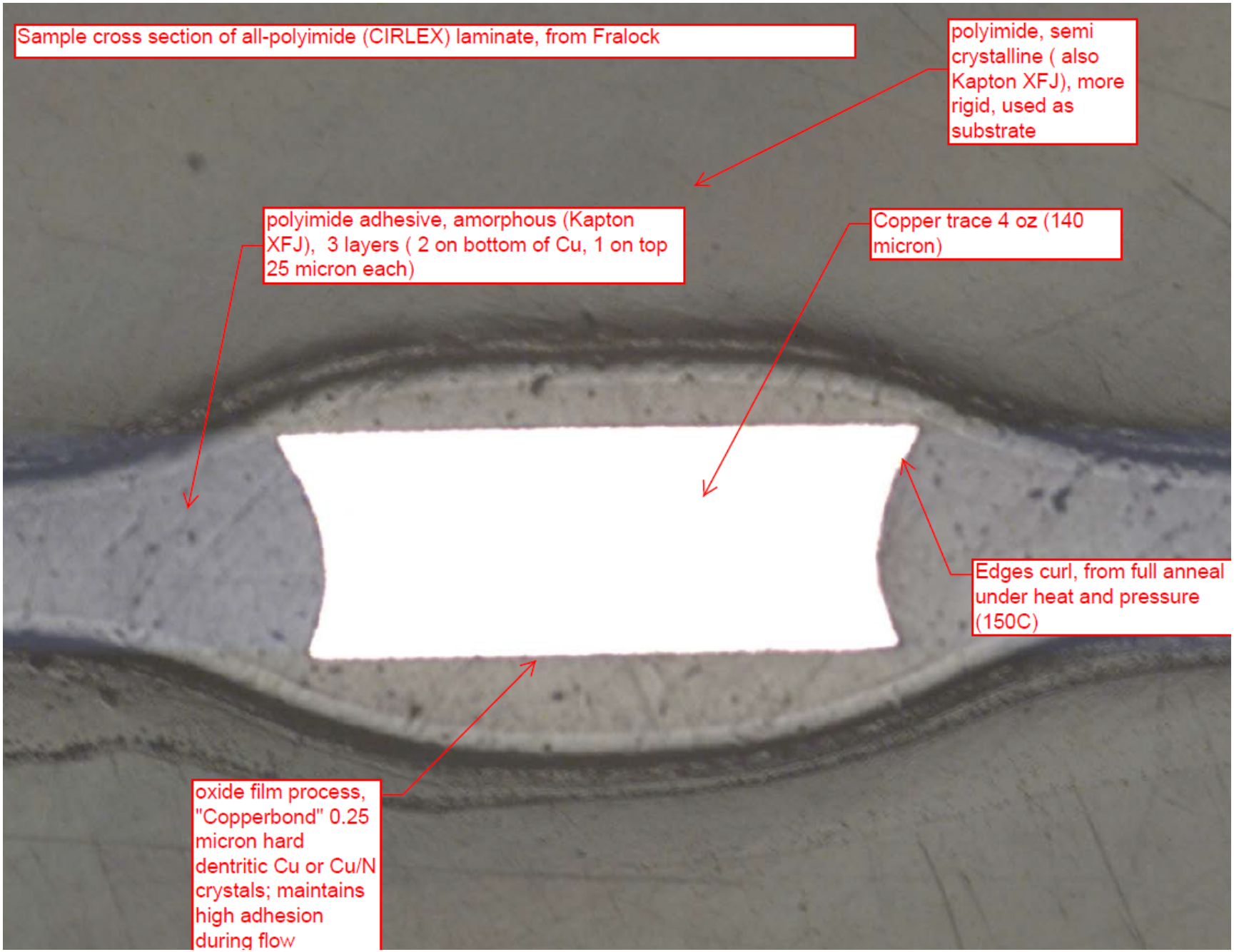
- 111 Dice Boards (DBs) 80mm square pitch, 64 SiPMs/DB
- DB is 4 layer Cuflon multilam PCB, 80 pinout
- Xe flows around edges of each DB and behind them (no flow allowed elsewhere)
- DB carrier plate doubles as ICS shield (allows connectors inside vessel)
- ZIF connector (0.5mm pitch) on FPC cable attaches to DB pigtail, behind Cu shield
- Cables (FPC) are stripline, 50Ω for reduced capacitance to ground
- Cables bundled into 3 sets, rest on shelves cantilevered from shield
- Feedthrough is all-polyimide (Cirlex) multilayer rigid-flex circuit (42 FPCs/FT)
- Feedthrough made with a machined flange for internal sealing
- Metal flange and PV head removable from outside without disturbing cables




disassembly sequence
5 (entire head may be removed, cables and feedthrough remain in place and do not move
4
2
inner plug seal
1
3
seals for retainer bolts




LBNL Feedthrough Stripline FPC Design Proposal
feedthrough will consist of 42 of these FPCs
laminated with polyimide bondply ("adhesiveless")
Panasonic P5KS 160 pin
board-to-board connectors, each end
D. Shuman 9/18/2012
after consultation with Fralock engineer, Jim Webb
and with Maurice Garcia-Sciveres, LBNL
Copper
polyimide
Pressure side
Atmosphere side
Signal traces (64)
90 um wide
Ground, power,
temp sensor traces (16)
250 um wide
all @ 0.5mm pitch
Ground plane, top
(common to all traces)
ground planes initially 5 um
then plated to 18 um for vias
(edge of next cable)
top-to-bottom ground via,
2 edge traces only (pin 1 and 80)
every 2 cm
bondply, next cable
Ground pads (80)
pins 81-160
0.64cm
100
279
18
100
18
25
250
250
Substrate laser-cut away
after bonding top ground laminate
Ground plane, bottom
(common to all traces)
coverlay
bondply
stepped 0.8 cm each successive FPC
dims in micrometer
horizontal dims not to scale
Stiffener
Feedthrough plug here
stack bonded through plug only (all polyimide)
or through entire stack?(acrylic or epoxy adhesive)


Sample cross section of all-polyimide (CIRLEX) laminate, from Fralock
polyimide, semi crystalline (also Kapton XFJ), more rigid, used as substrate
polyimide adhesive, amorphous (Kapton XFJ), 3 layers (2 on bottom of Cu, 1 on top 25 micron each)
Copper trace 4 oz (140 micron)
Edges curl, from full anneal under heat and pressure (150C)
oxide film process, "Copperbond" 0.25 micron hard dentritic Cu or Cu/N crystals; maintains high adhesion during flow