4m Undulator Design Concepts

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On behalf of the HeLiCal Collaboration

Specification for 4m Undulator Magnet

On axis field	0.9 T
Peak to peak variation	<1%
Pitch	11.5 mm
Nominal Current	<300 A
Nom current as % of Short Sample	80%
S/C wire	Nb Tn 0.4mm dia. SC:Cu ratio 0.9:1
Winding Cross Section	7 wires wide x 8 high
Number of magnets per module	2 (powered separately)
Length of magnetic field	2 x 1.74 m

Specification for 4m Undulator Module

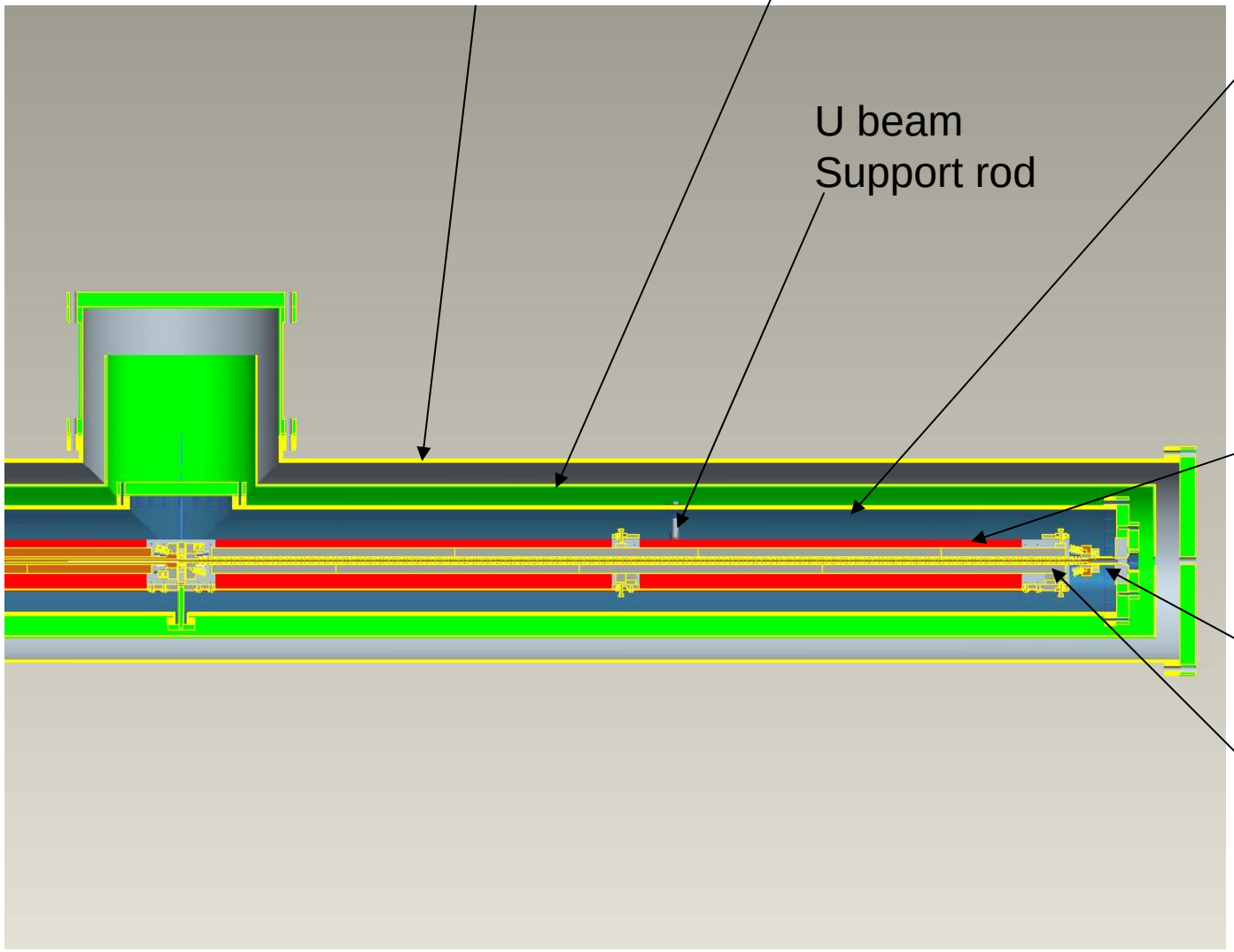
Pole	Iron (BS080A15) with a square section groove
Beam/winding tube	Copper (6.35od x 0.56wall) with a non polished bore.
Beam Stay Clear	4mm Diameter
Central Beam pipe connection	Plain butt joint
Beam pipe connection at ends	Tapered 1:10 out to 10mm dia

No Beam Collimators or Beam Pipe Vacuum pumping ports in the beam pipe

4m Module Overview

Stainless steel vacuum vessel with Central turret

50K Al Alloy Thermal shield. Supported from He bath



U beam Support rod

Stainless Steel He bath contains100L liq He. Supported by 4 rods attached to the vacuum vessel

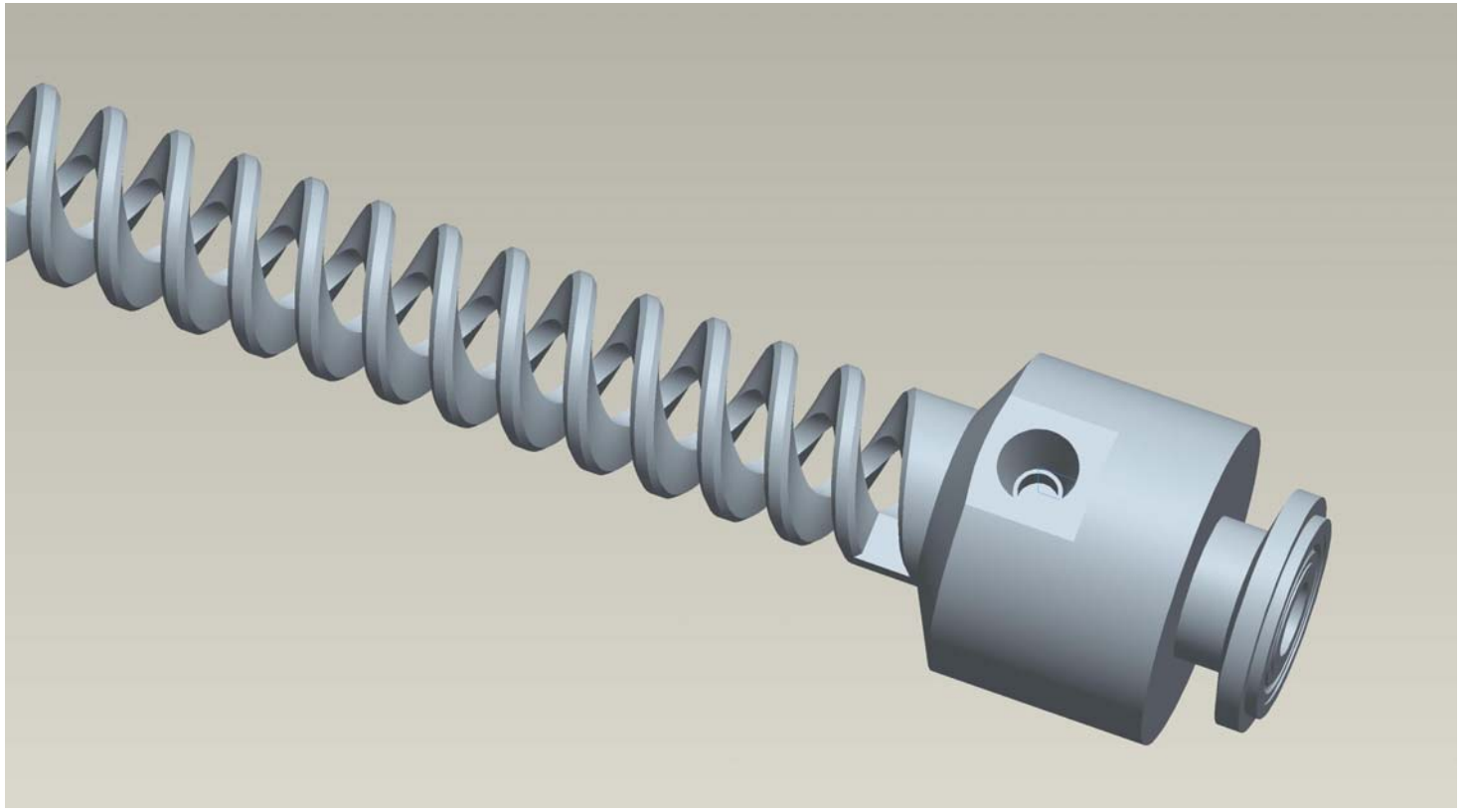
U Beam used to support/align the magnet.

Beam Tube

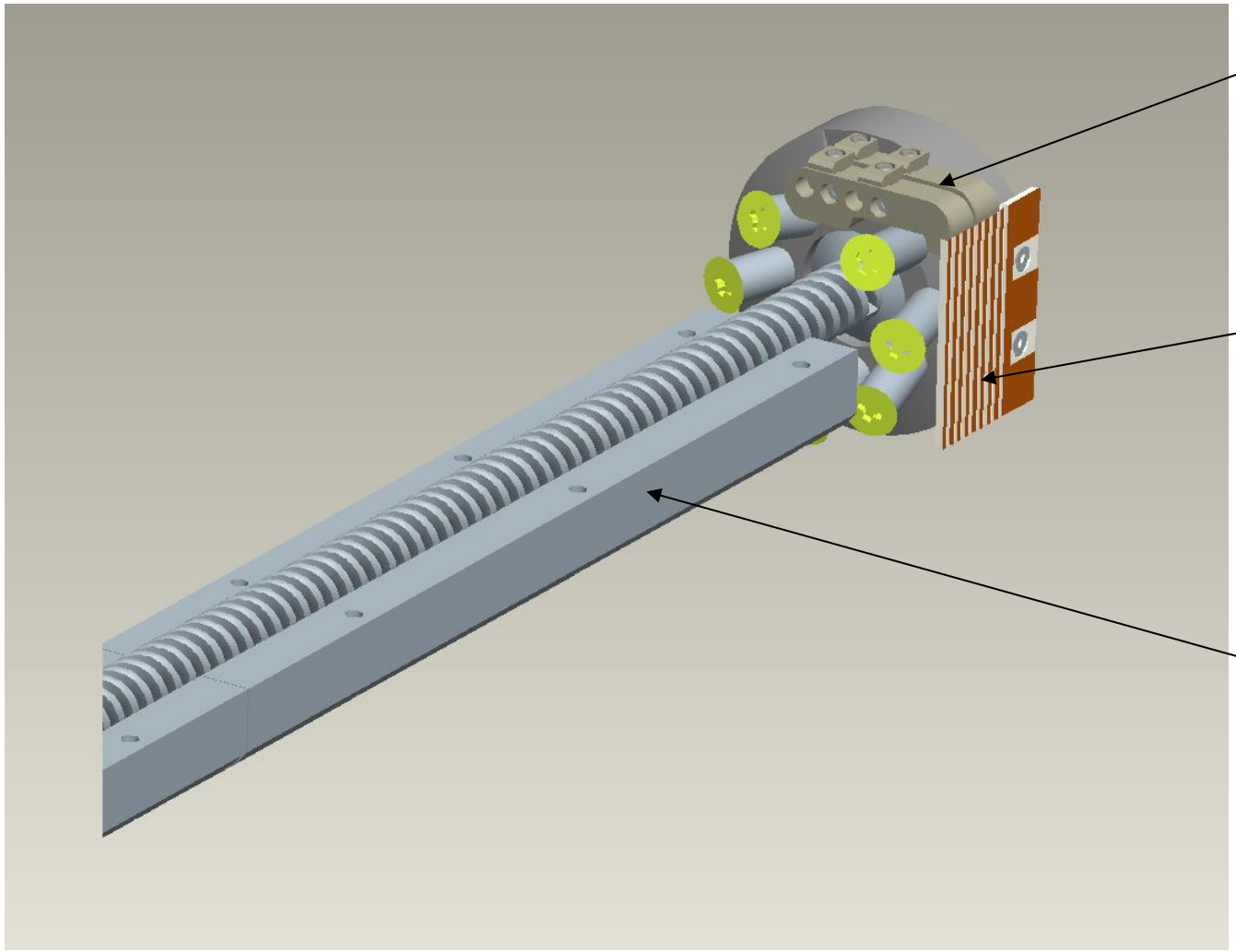
Magnet cooled to 4.5K by liq He in bath.

Magnet Design Concept

- Mild steel former 1.8 m long machined with 2 start helical groove.
- Beam pipe (Cu tube) soldered into bore of the former
- Superconducting ribbon wound on to the copper tube



Magnet Design Concept



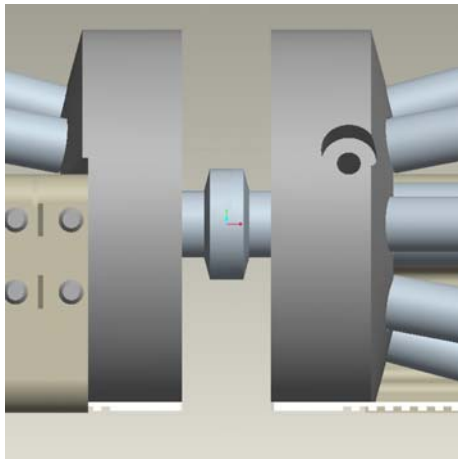
Revised Ribbon in/out guides

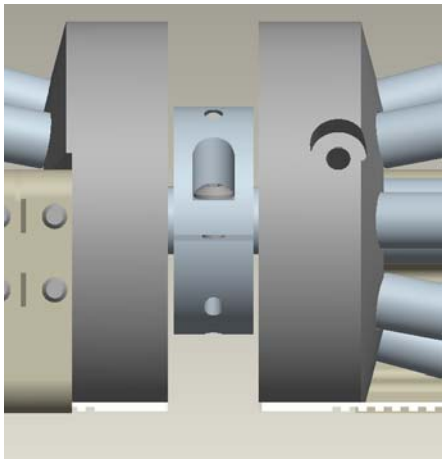
PC board for S/C ribbon connections

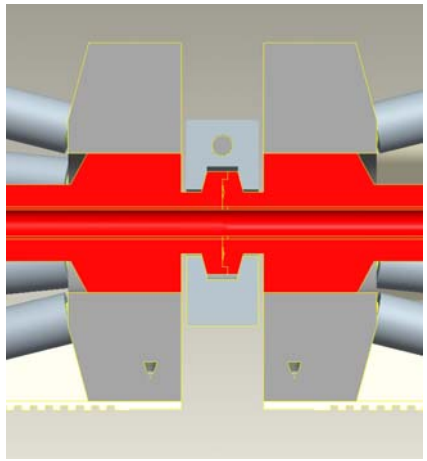
8 Piece iron yoke. Provides support for the former and increases the magnetic field

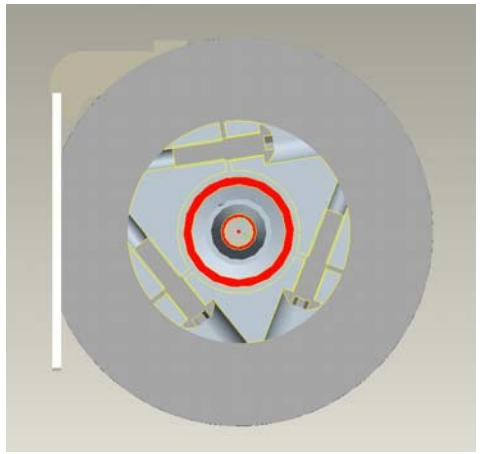
Central Clamp

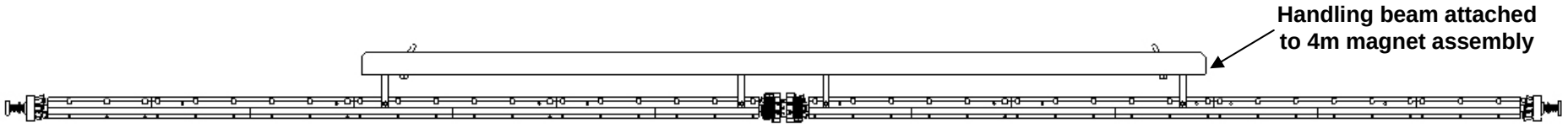
The two magnet assemblies are joined via an Indium seal. This is held together using a 3-way clamp which is assembled before the magnets are installed into the U-beam. To prevent movement of the joint, the 4m magnet assembly is bolted to a handling beam which also ensures correct orientation of the two magnets.





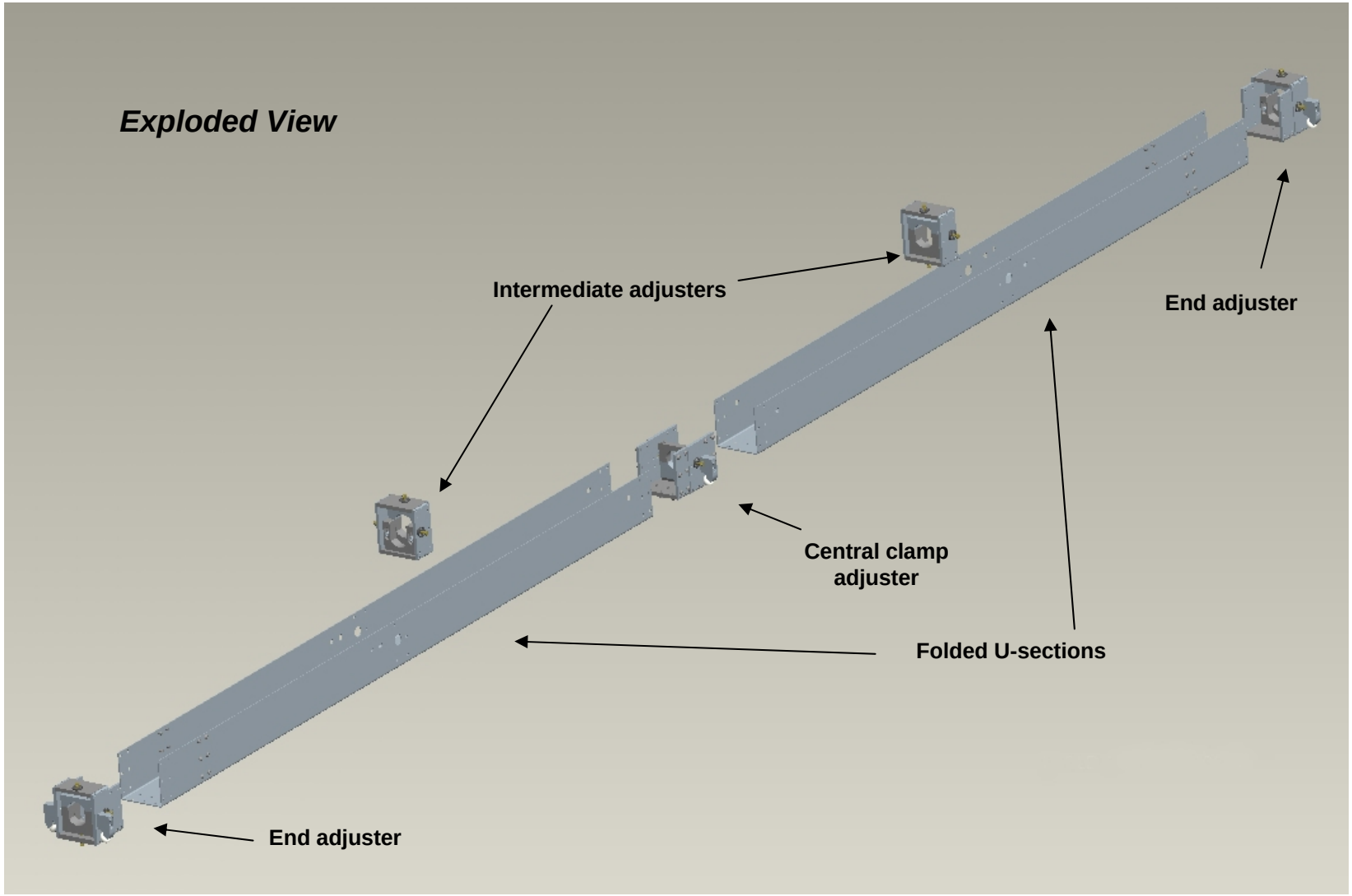






U-beam layout

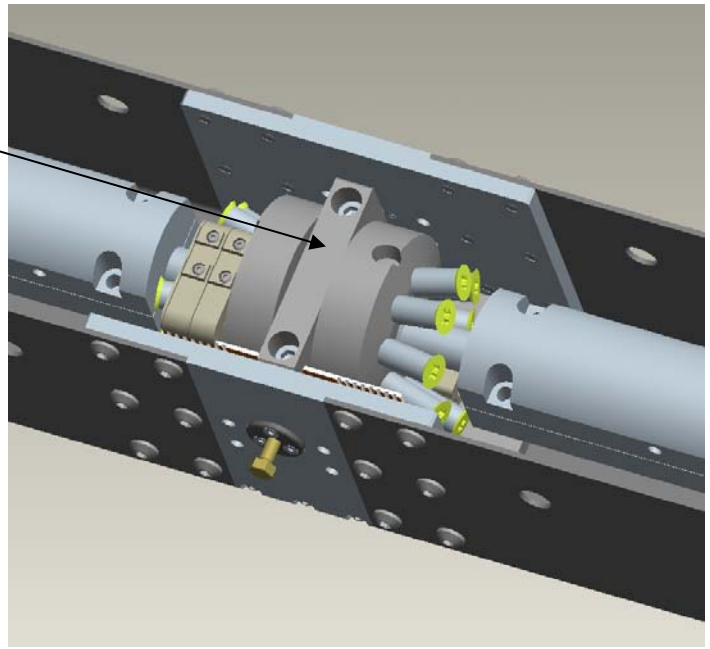
The completed magnet is supported and aligned within a stiff U beam

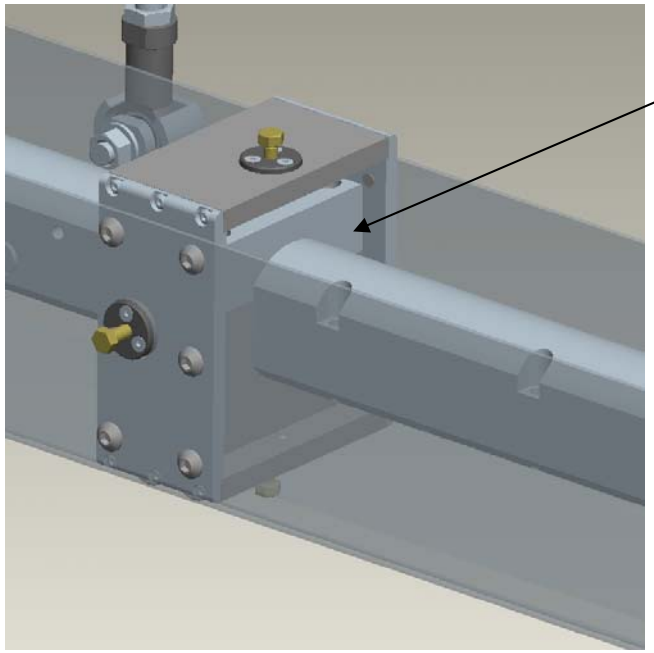


Alignment

Once installed into the U-beam the magnet itself can be aligned using the U-beam adjusters. An alignment telescope will be used to look down the bore of the magnet and ensure that it remains coaxial between the two ends within the tolerances set out in the specification.

Magnet central clamp





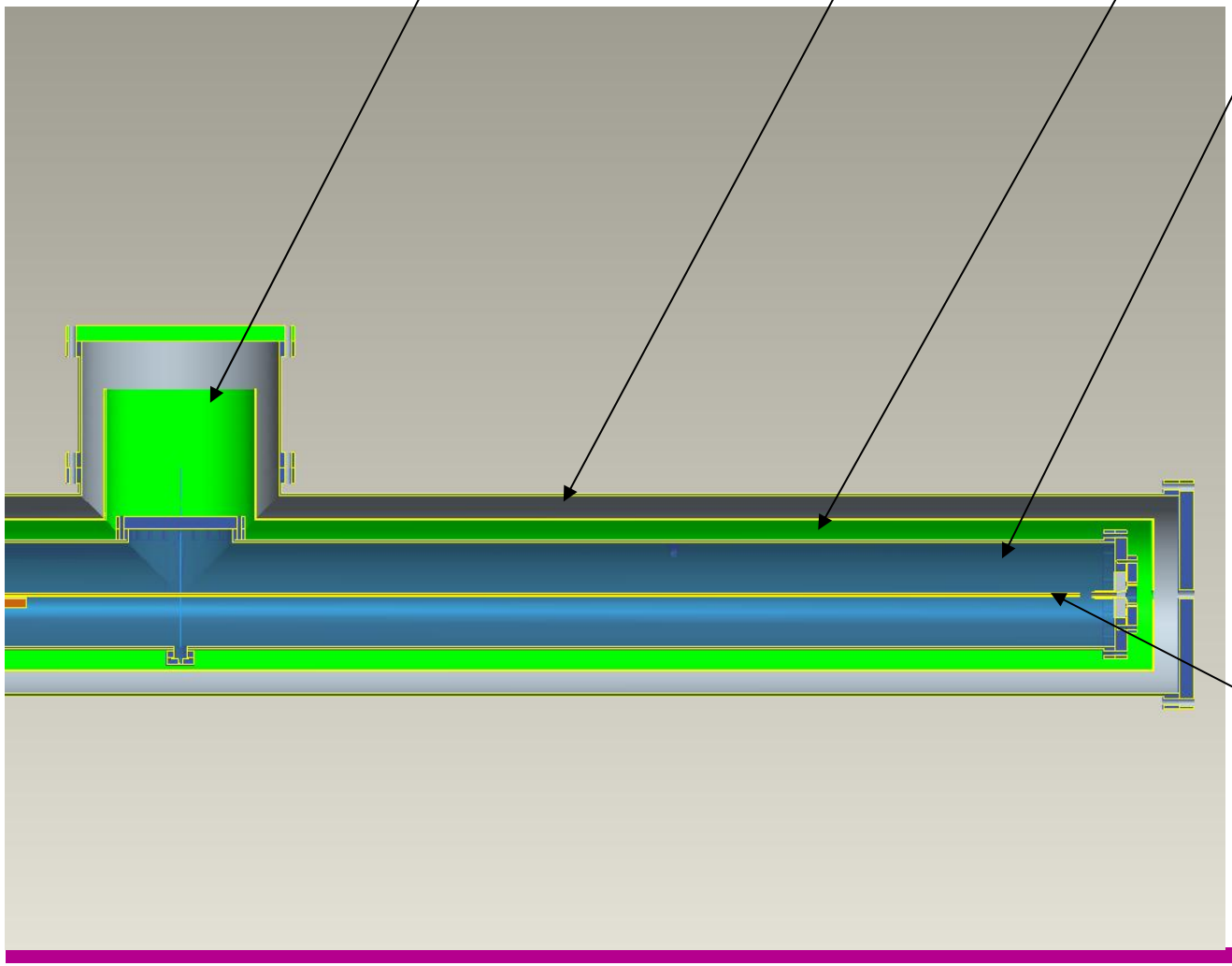
Intermediate adjuster with magnet in position. Sliding joint between the yoke and adjuster block to allow for contraction in Z-axis.

Cryostat Cross Section

Services turret contains cryogenic cooler, 4 HTC current leads, He / N_2 pipes and Instrumentation

Vacuum vessel

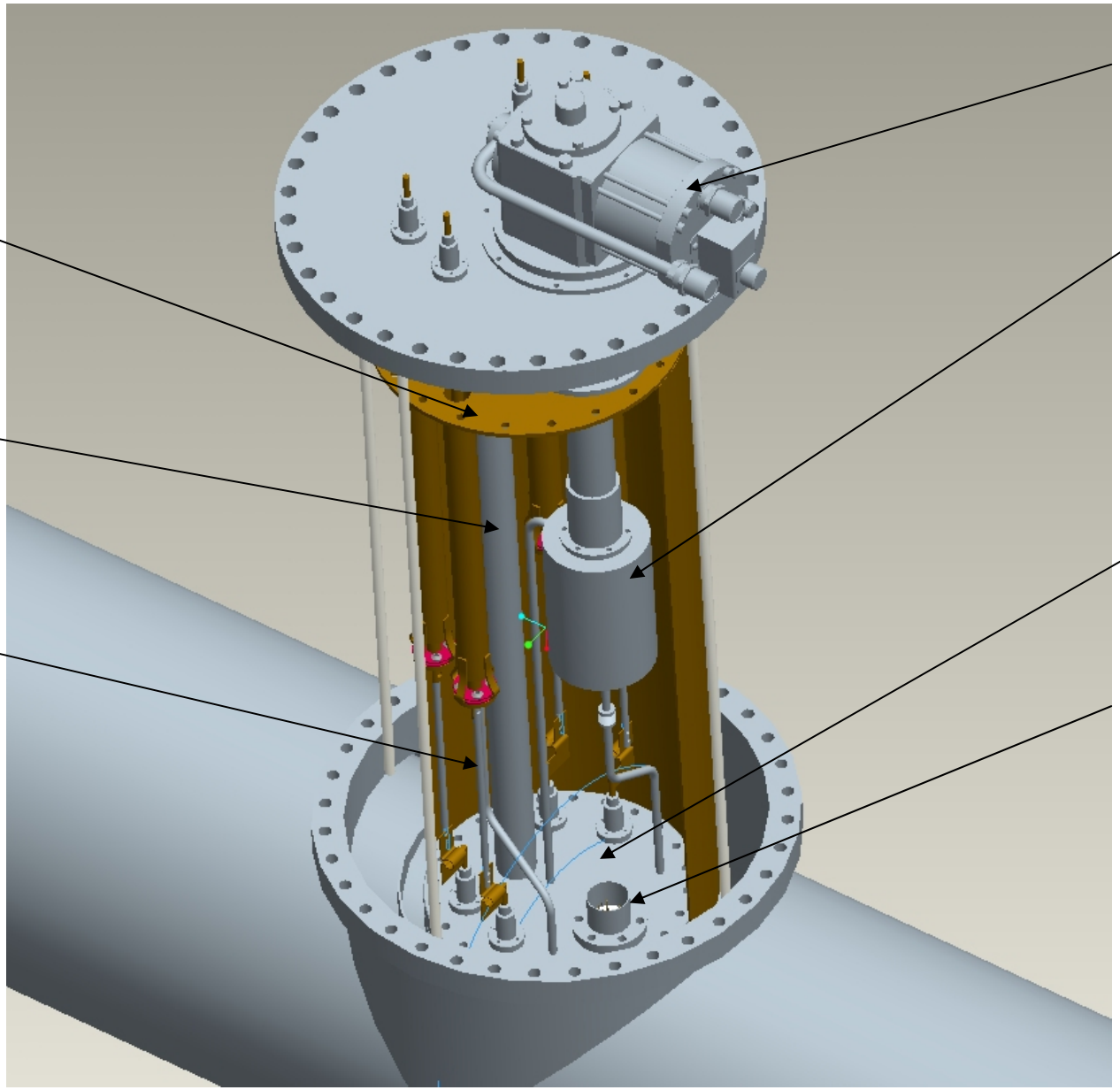
50K Thermal Shield cooled by conduction from cryogenic cooler 1st stage



He bath. Precooled to 77K via N_2 cooling pipes on OD. Filled with 100L liq He from dewar.
Liq He level topped up during operation from He condensing pot in turret.
No external cryogens required during operation.

Cold bore (Beam tube)

Cryostat Turret



50K Thermal shield

36mm dia He vent pipe

4 off HTC current leads. Cooled to 50K from cooler 1st stage

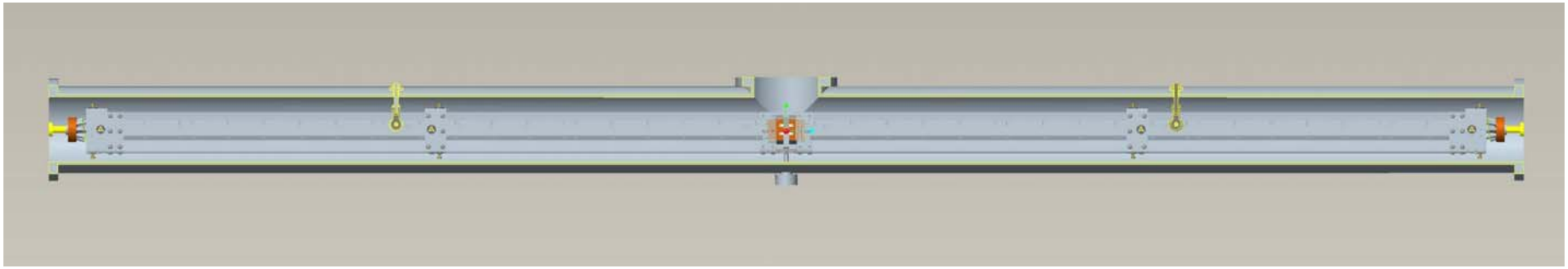
Cryogenic Cooler

Liq He Condensing pot. Cooled to 4.5K from cooler second stage

He bath Top plate

Instrumentation Lead thro'

Support systems



Two support System required –

1. U Beam within He bath (Shown)
2. He Bath within vacuum vessel

Conceptually the two systems are identical –

Adjustable in X and Y to allow the beam pipe to be centred within the vacuum vessel. Fixed at the magnet mid position to allow for thermal contractions of ~6mm at each end.

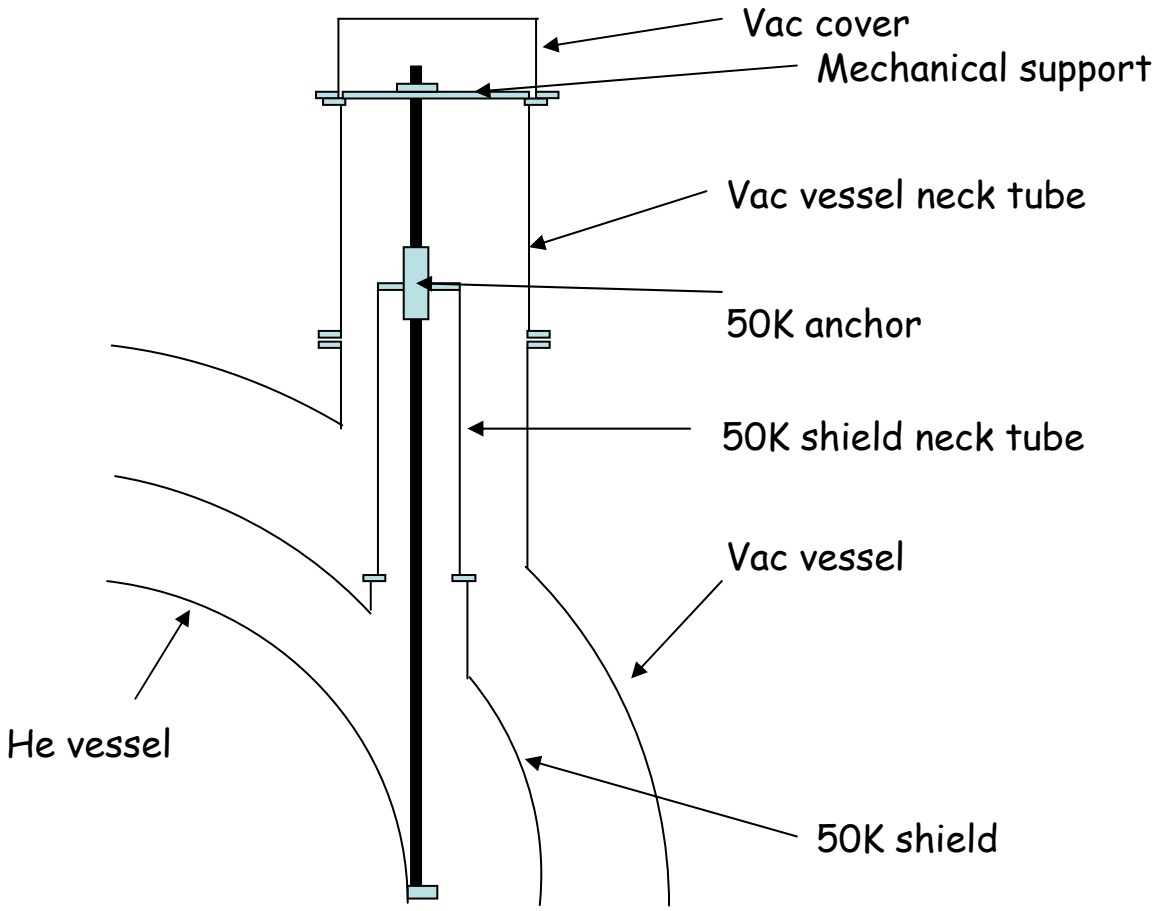
Y Support rods

He bath supports shown. U beam supports similar but without thermal intercept.

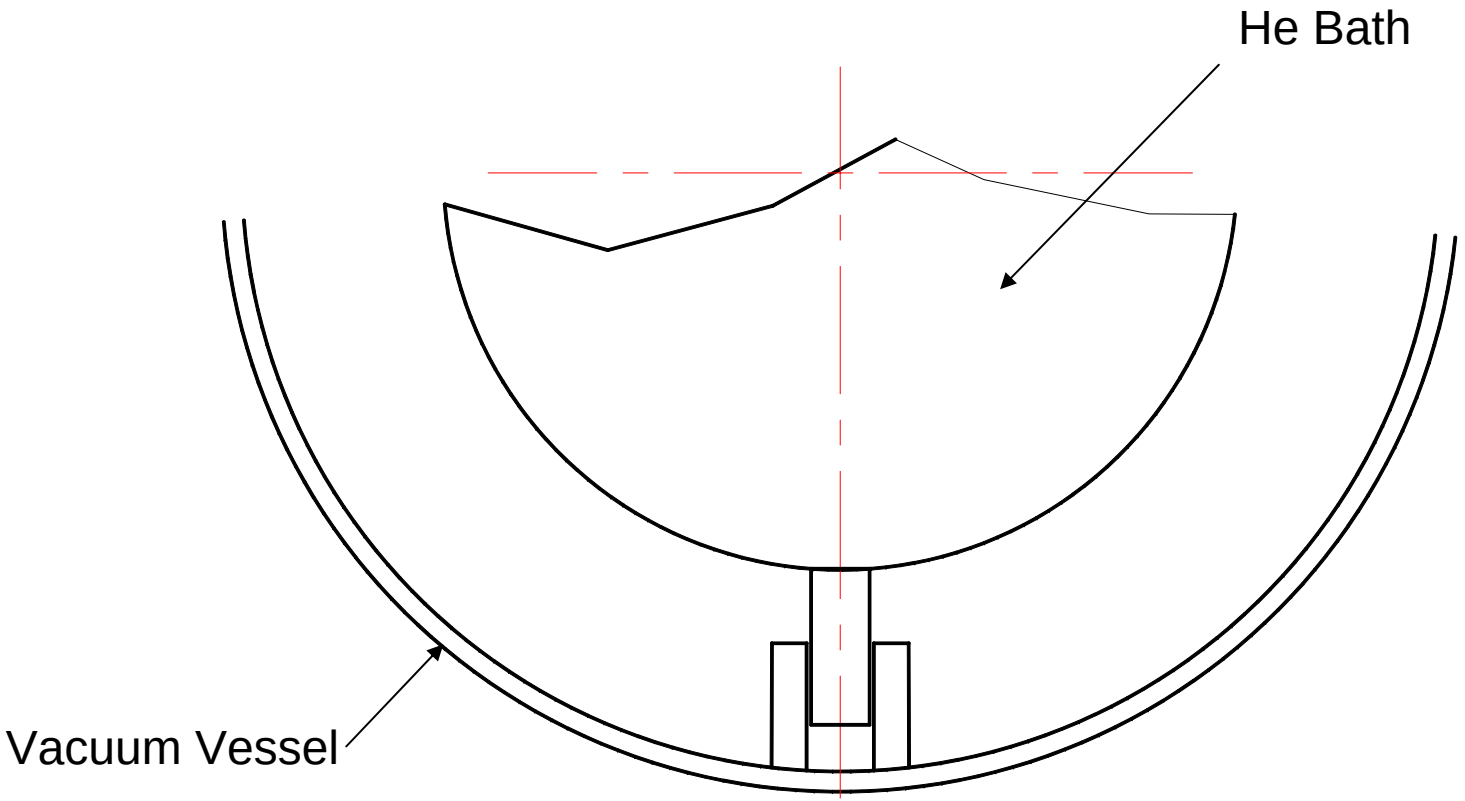
Support rod material will be determined by heat leak and thermal contraction.

Carbon fibre Thermal contraction <0.1mm

Stain Steel Thermal contraction ~0.6mm

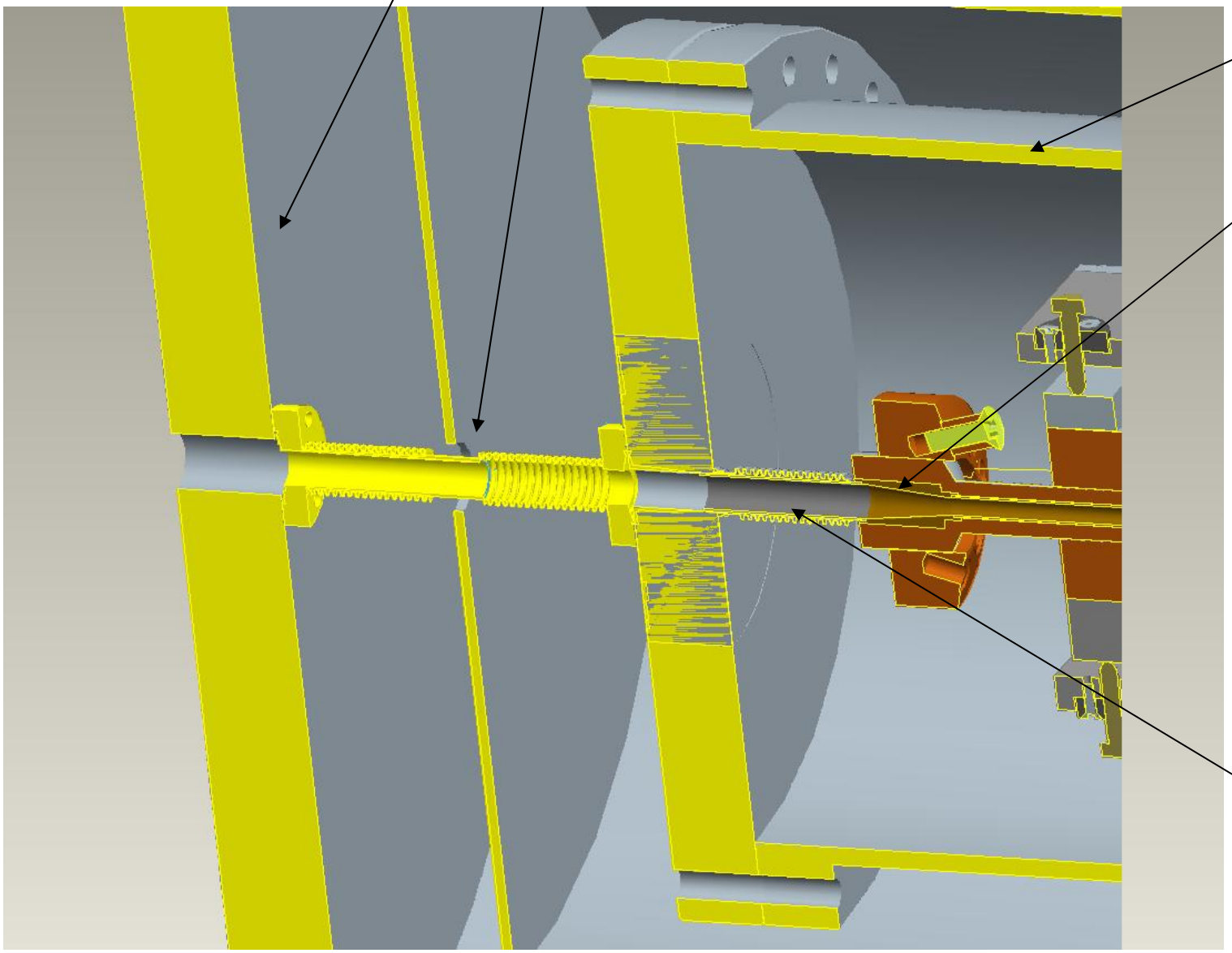


X constraint



Tongue and groove system constrains in X but allows thermal contraction in Z.
(Similar system for U beam)

Beam Tube


Vacuum Vessel
Thermal shield with 50 K Thermal Intercept
He Bath
Copper insert with tapered bore soldered into iron former as part of the beam tube assembly
10mm bore shielded bellows

Bellows

Bellows design still being worked on, parameters are to –

- Accommodate thermal contractions of 6mm in Z and up to 0.6mm in Y.
- Minimise any steps/cavities in the beam pipe.
- 10mm ID for bellows between magnet former and He bath.
- Maximise the ID of the bellows between He bath and vacuum vessel

Envelopes and Interfaces

- Overall length of cryostat – 4m
- Beam pipe vacuum interface - TBD
- Alignment system – TBD
- Turret Services interfaces – TBD
- Beam Height - TBD
- Vacuum vessel – Girder Interface - TBD