

Electrical and Grounding Review for Temperature Profiler

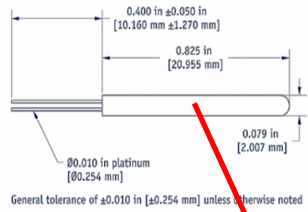
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University of Hawaii & Fermilab

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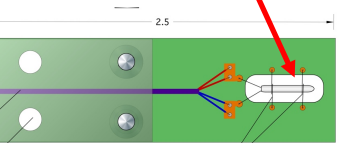
Hawaii Temperature Profiler

PT-102



Lakeshore RTD temperature sensor PT-102

Fragile sensor carefully fastened to PCB



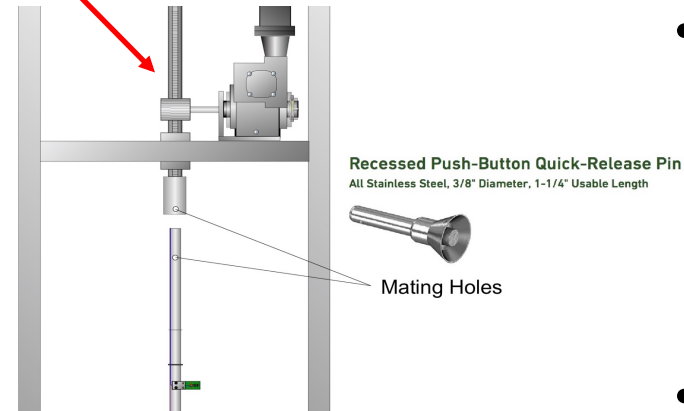
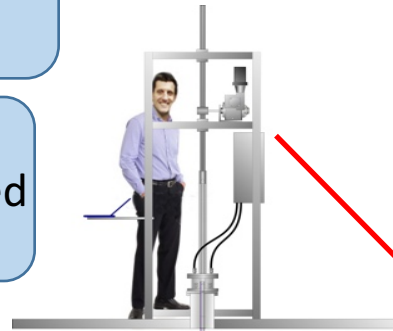
Tied and Soldered Stainless Suspension Wires

C.Kenziora 3.14.17

Weight per Segment 8 lbs
Total Weight 65 lbs

- **High precision relative temp. measurement** achieved by movable array, allowing cross-referencing of temperature sensors **in-situ**.

- Immune to changes from lab testing to installation.
- Measurement taken in two easy steps with entire array moved up to compare readings from two sensors at each location for cross-referencing.
- Expect to achieve required temp. measurement precision of few mK.



Temperature profiler moves using stepper motor that moves the rack and pinion gear system connected to rod assembly up to 1 m.

Entire array is 7.5 m high, spanning the full height of protoDUNE LAr volume

2 PCBs with sensors attached to 1 m long segments with 0.5 m spacing between them

3

3

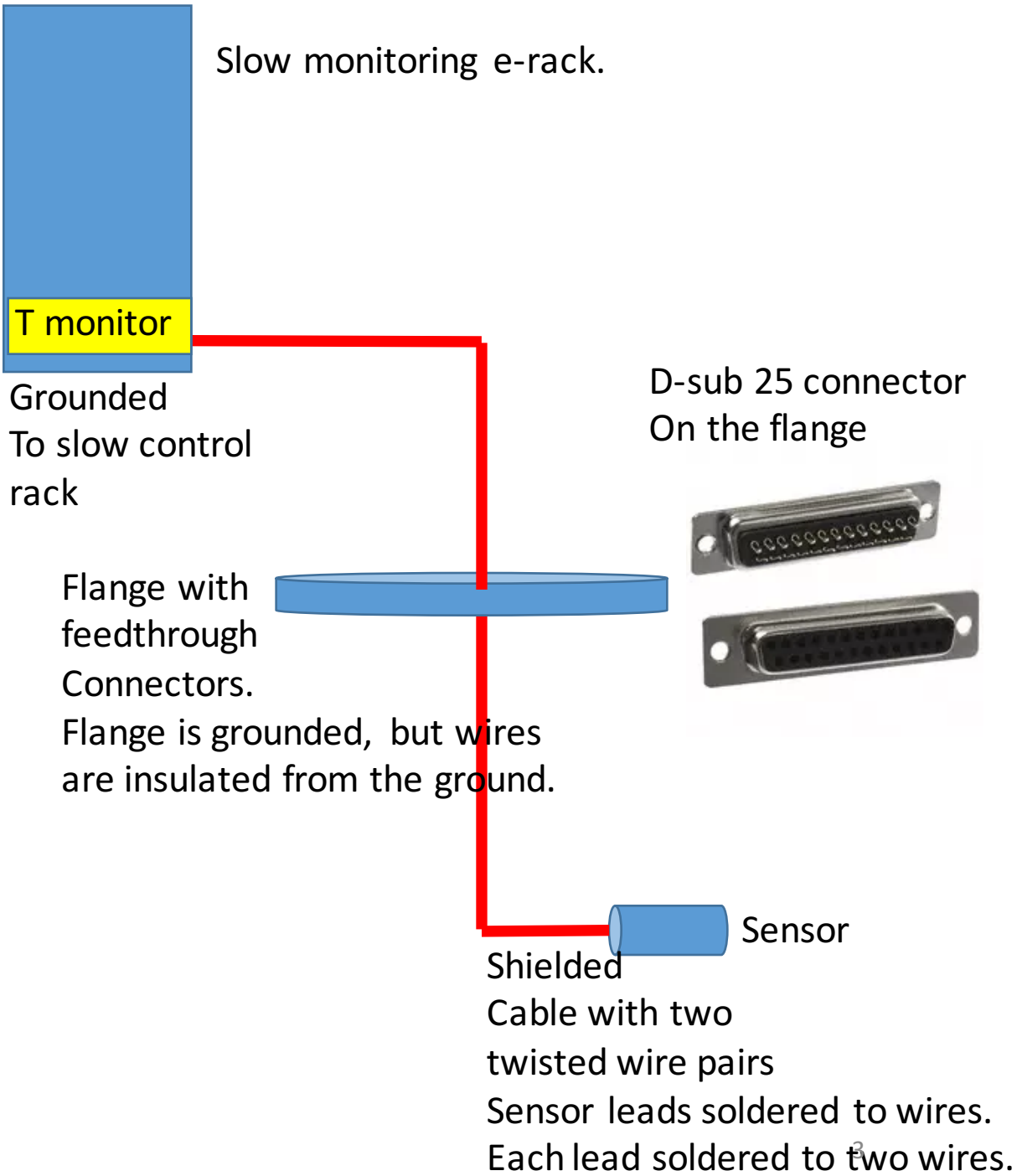
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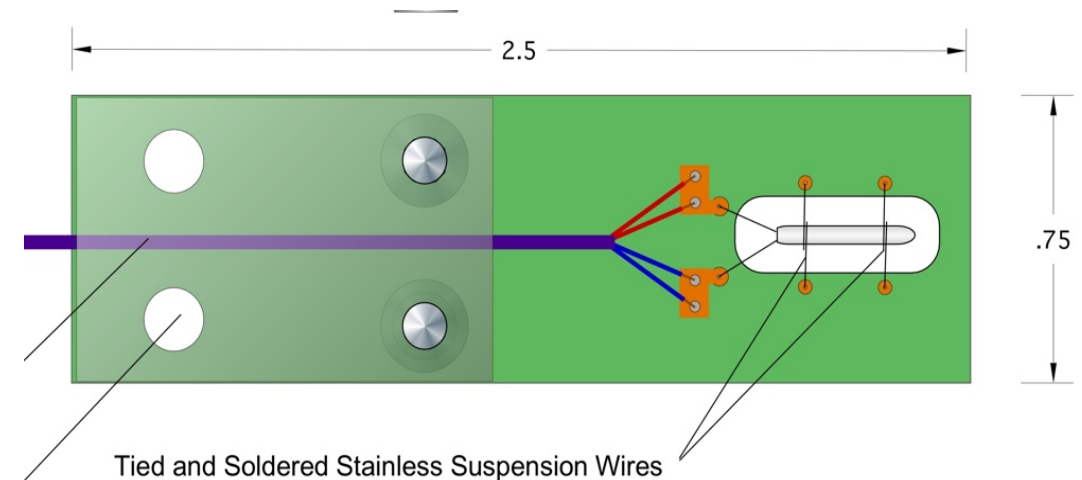
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Electric scheme overview for sensor connections

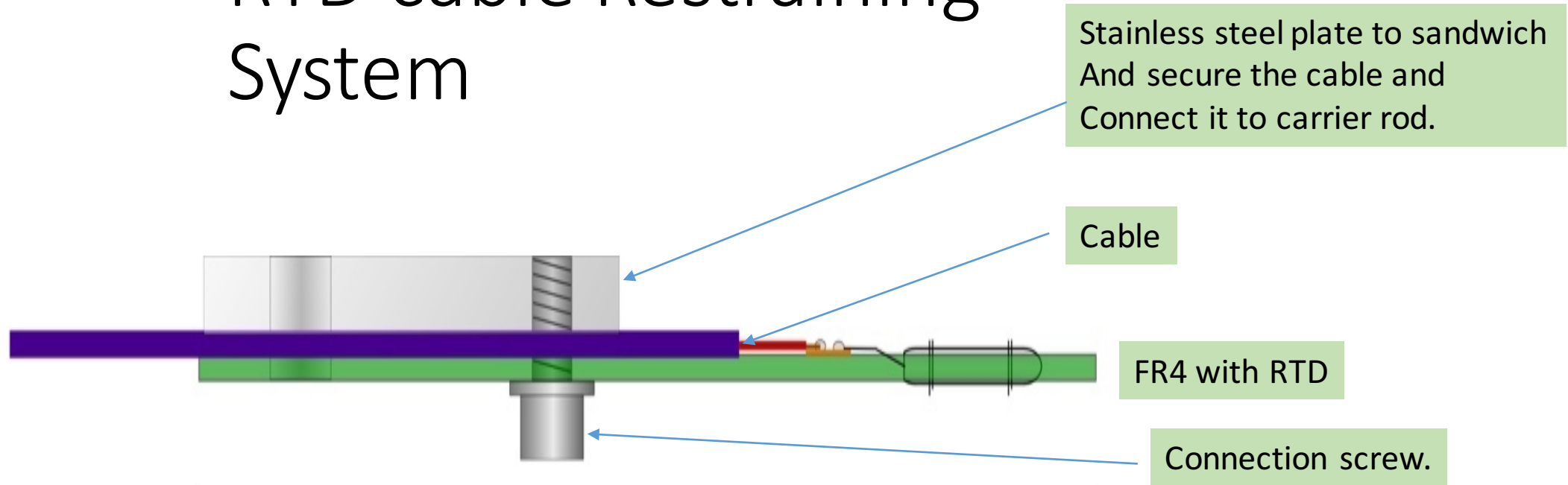


RTD sensor connection

- System is located behind the anode plane
- Four wire connection for each sensor to eliminate the influence of leads and contacts
- Two twisted pairs shielded on the outside by a braided cable.
- Sensor pins and wires will be soldered on common pads for connection.
- Sensor is held in place by two wrap-around stainless steel loops to protect it from vibrations.
- The FR4 cutout around the sensor allows free flow of argon.



RTD cable Restraining System

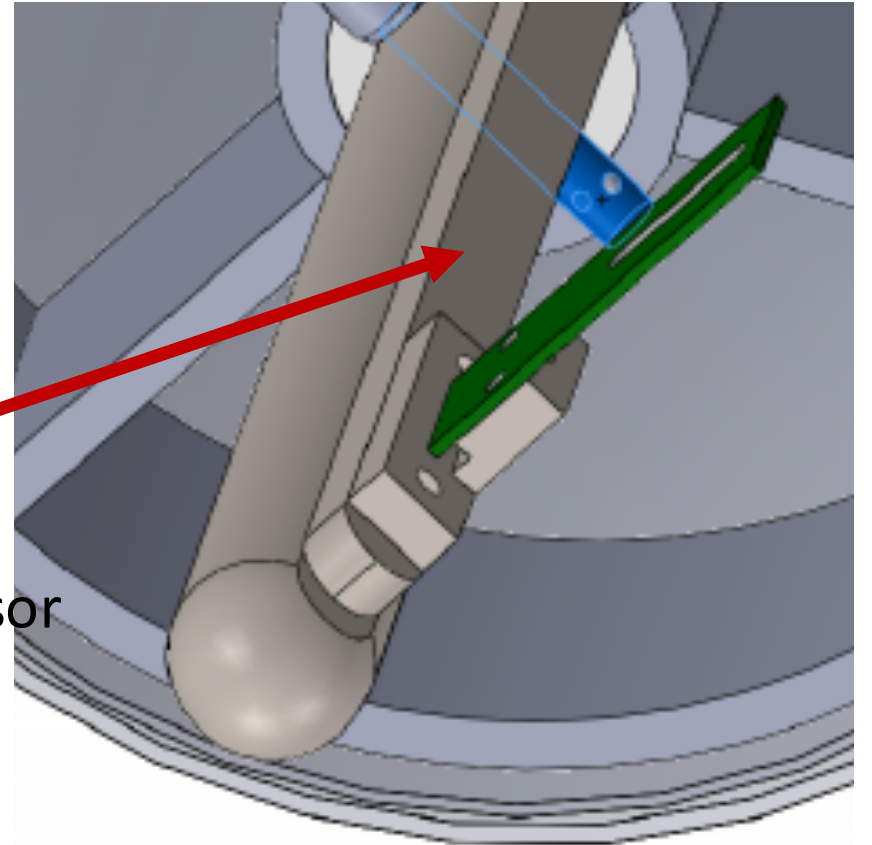


- Cable is sandwiched between the PCB and stainless steel rod mount.
- Sensor soldering joints are tension free during construction and installation.
- Four screws hold together two boards and cable in between, to make a sandwich.

Mounting the RTD Sensor FR4 Board to Carrier Rod

- RTD sensor FR4 board and top stainless steel board are attached to the carrier rod via stainless key that runs along the entire rod length.
- It is attached with two stainless steel screws.

Stainless key to attach sensor
Assemblies.



Cable composition

CABLE COMPOSITION

1- PTFE fillers for roundness

2- 2x twisted pairs ref. 2x PT3007

Description of one wire PT3007:

Conductor

Material: Nickel plated annealed copper

Composition: AWG30 or 7x0.102mm nom

Diameter: 0.303 mm nom

Section: 0.057mm² nom

Resistance: 34.63 Ω/100m nom @ 20°C

Insulation

Material: Extruded PFA

Diameter: 0.62mm nom

Colors: Red/Black and Brown/Orange

3- Braided shield

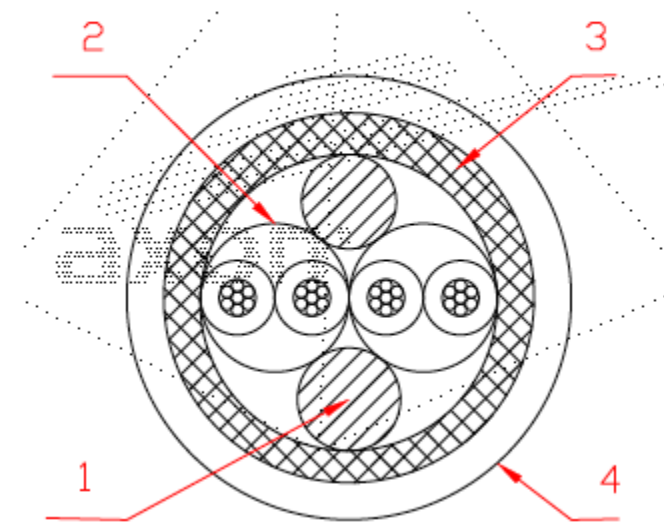
Material: Nickel plated annealed copper

Strand diameter: 0.127mm nom

4- Outer jacket

Material: Extruded PFA

Color: White

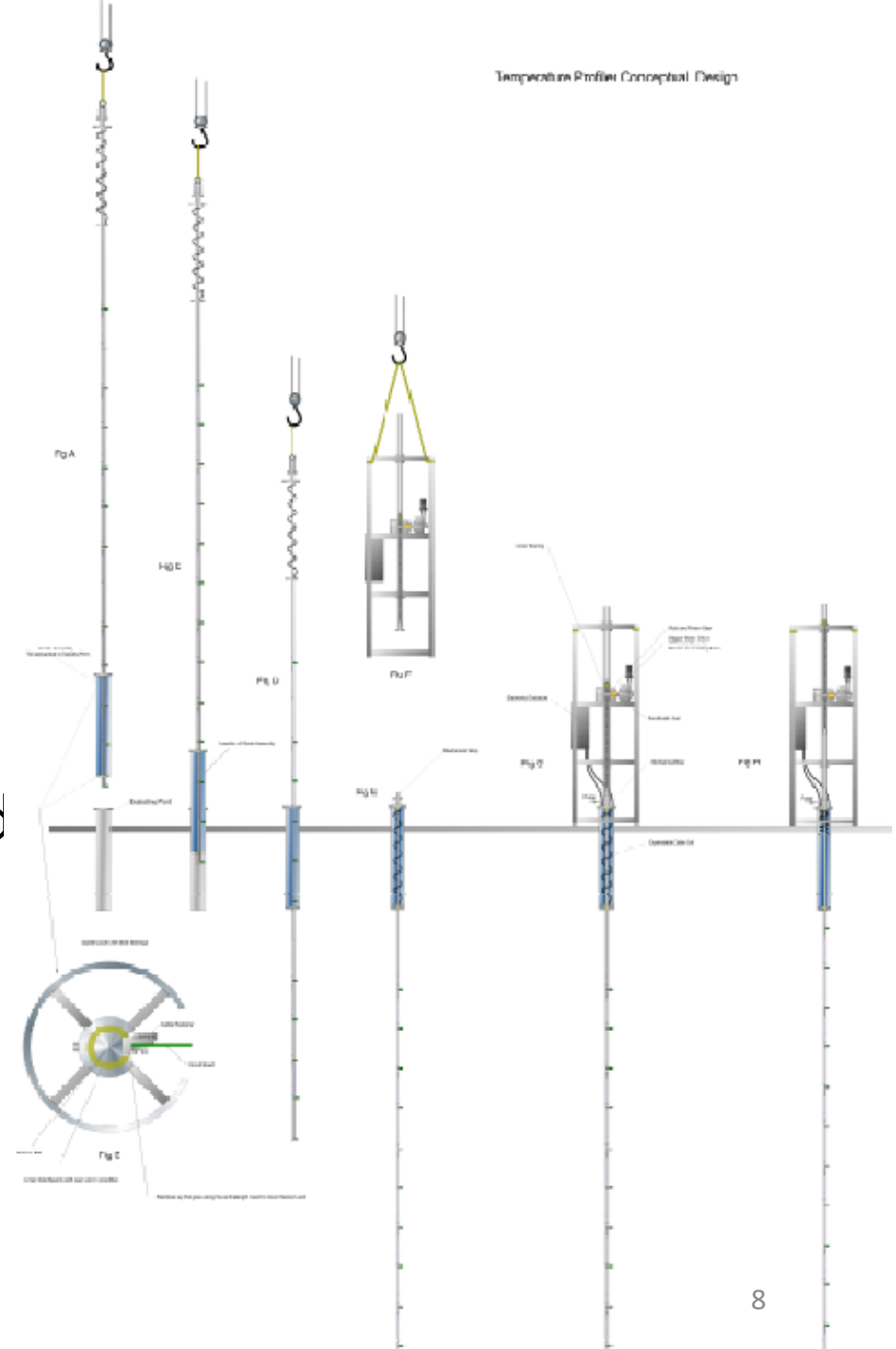


Braided shield is not connected to the flange
But freely floats.

Motor and carrier rod Installation and Overview

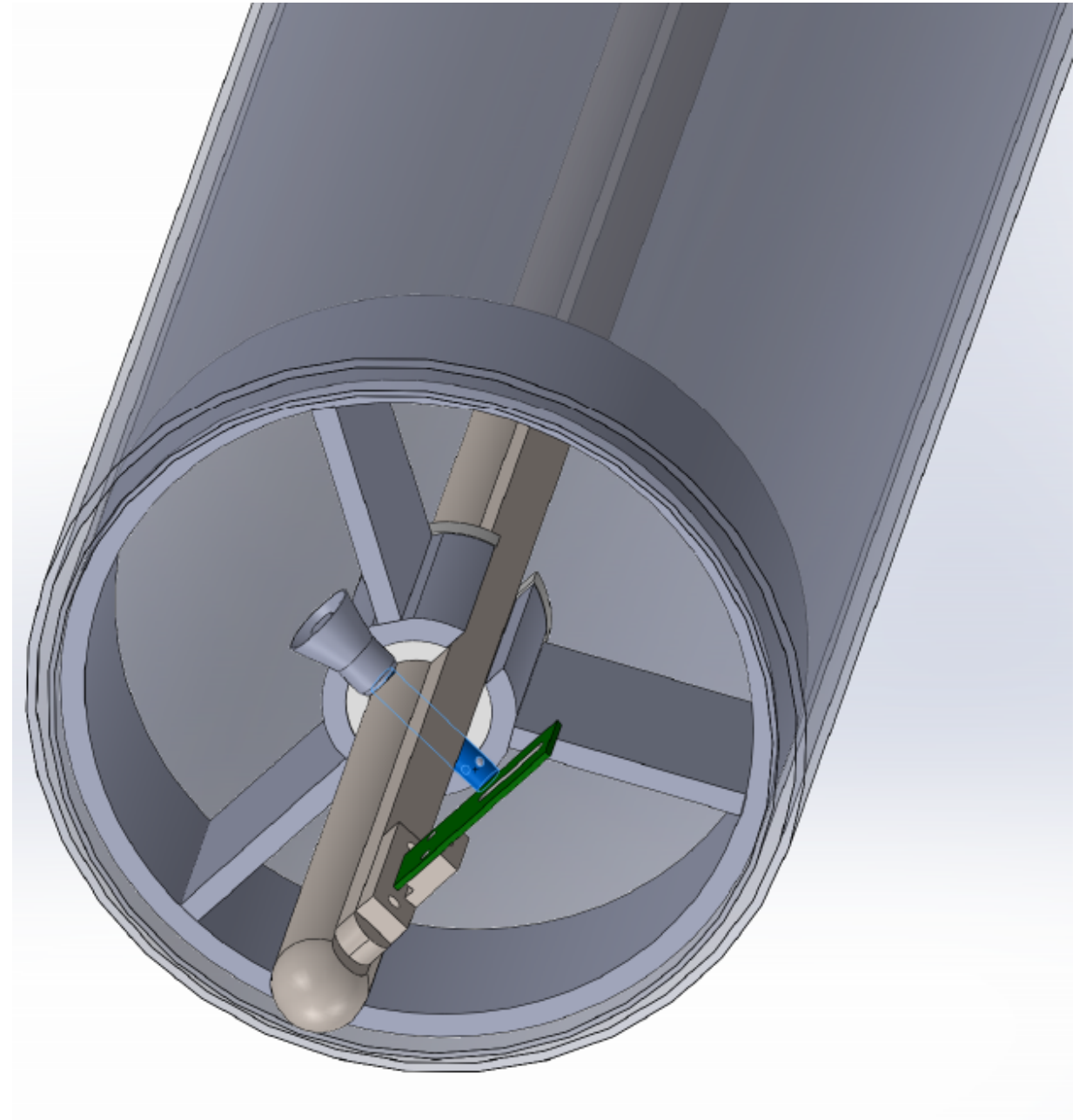
- Carrier rod has a mechanical stop at the top that prevents the carrier rod from slipping inside the cryostat.

Once the carrier rod is in place, it is connected being lowered on the top of it.

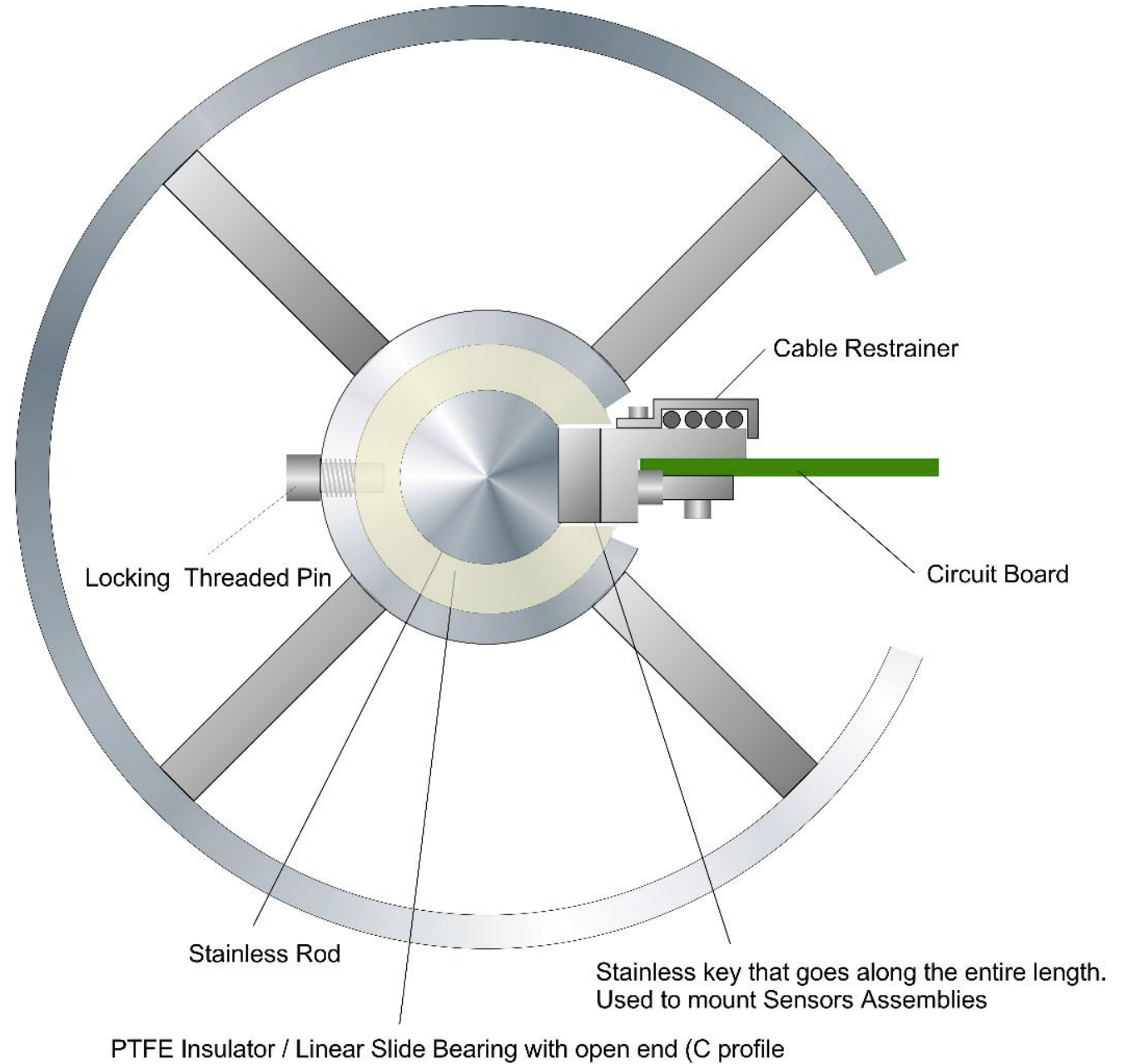


View up the sleeve

- The sleeve has a double sided CF flange.
- Spider guide is located at the bottom of the sleeve.
- Spider guide holding firmly the carrier rod to avoid any lateral motion.
- Distance between APA and temperature monitor flange 20 cm.

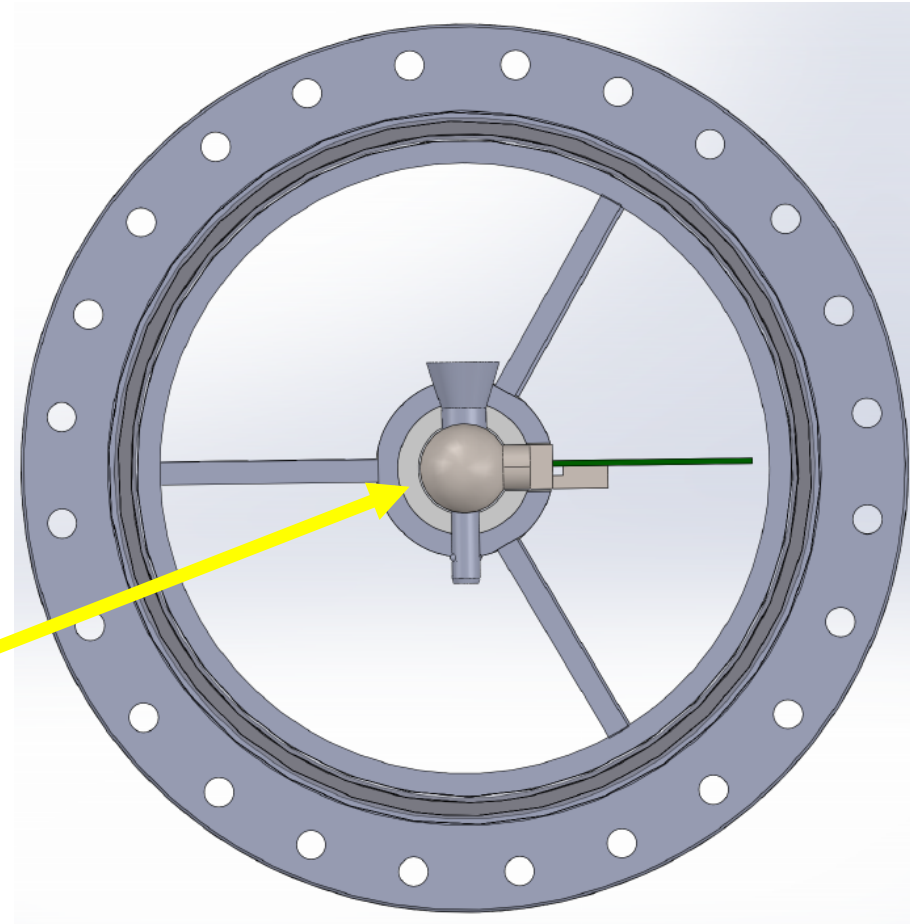


Details of the spider guide



Contact between the spider guide and sleeve

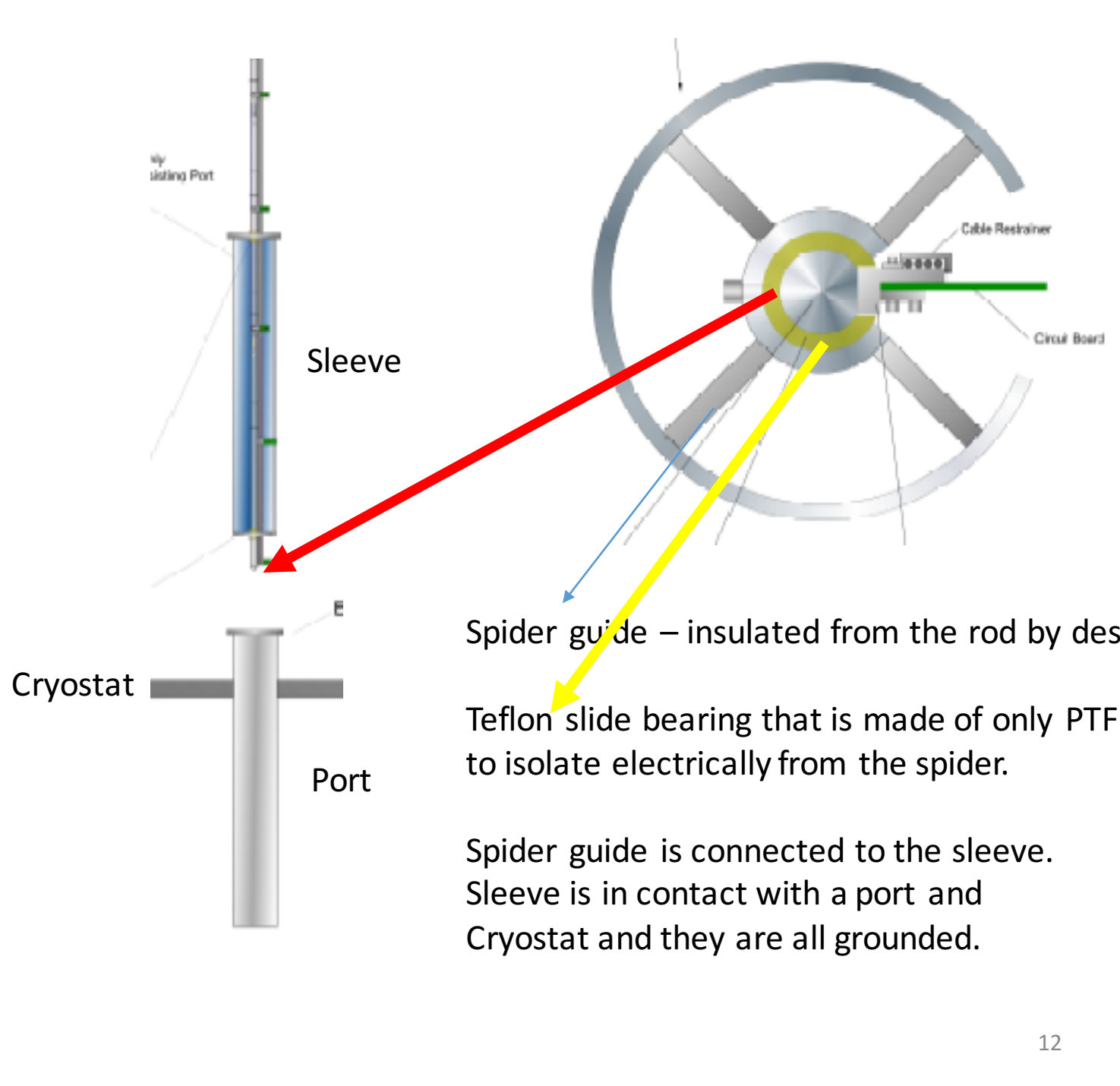
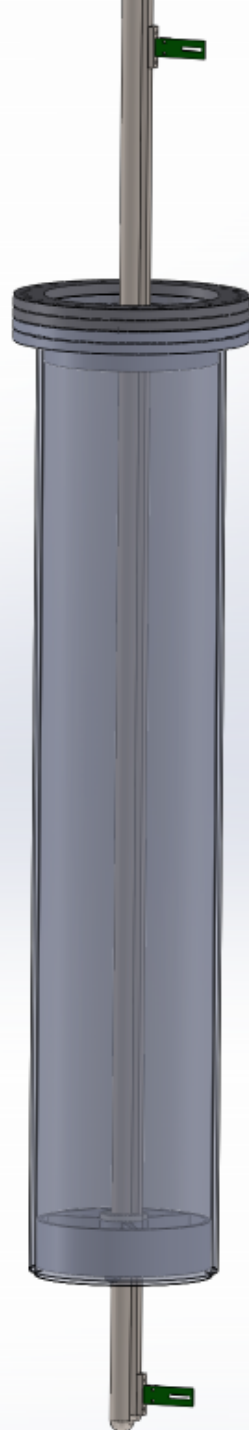
- Port and sleeve are fully in contact and connected to ground.
- Spider guide is welded to the sleeve.



Teflon slide bearing

The guiding sleeve

- Sleeve fits inside the port and they are in contact along the entire length and connected to the ground of the cryostat.
- Spider guide also stainless steel and welded to the bottom of the sleeve.



The Carrier Rod

Location where
Where carrier rod is
connected to ground.



Motor connection to ground

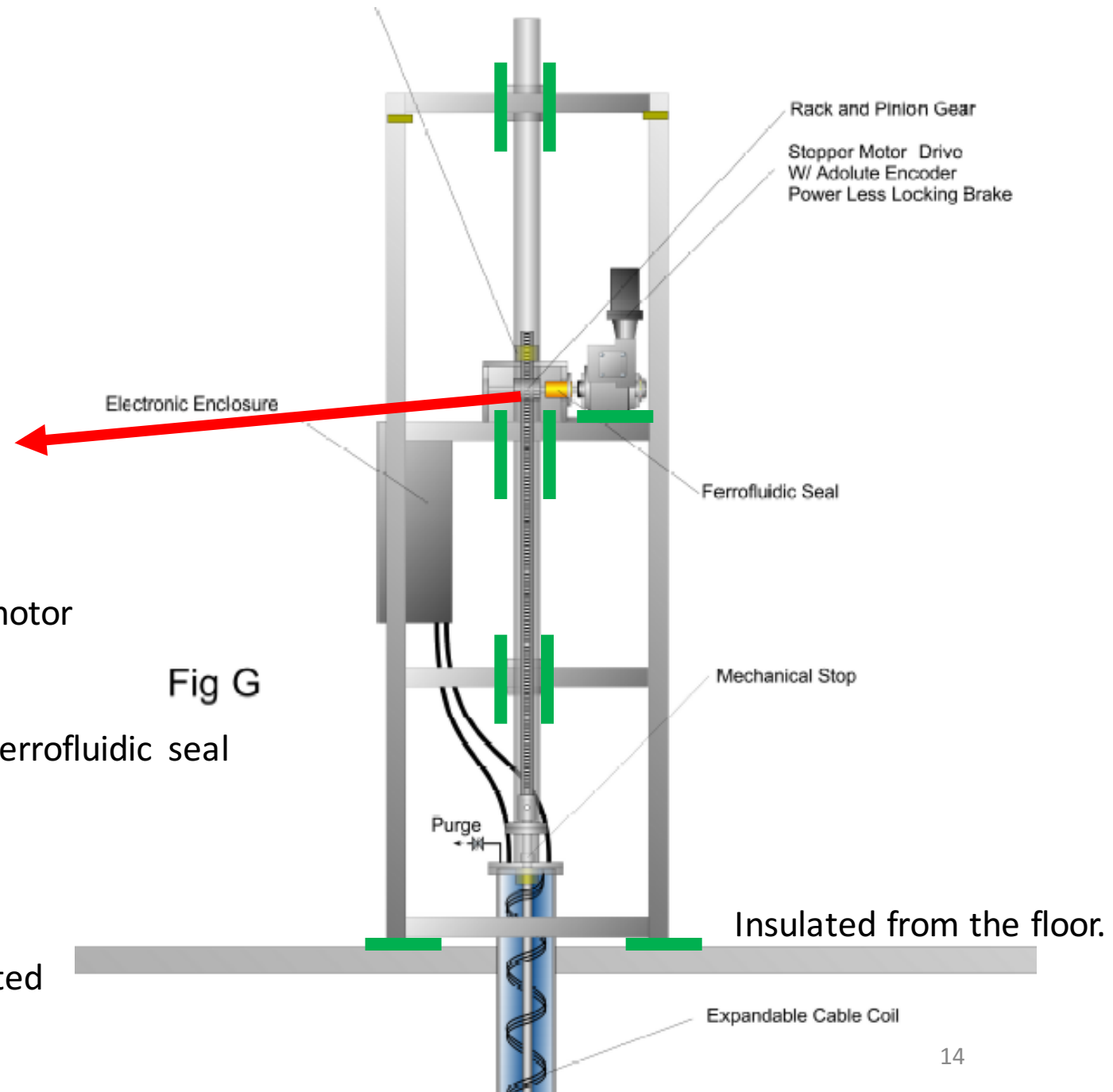
Motor is connected to the ground through a rod at Rack and pinion gear point connection.

The enclosure is insulated from the floor, from the motor body and pipe enclosing the carrier rod.

The enclosure connection to the ground is through ferrofluidic seal and the housing of the rack and pinion gear.

Green rectangles show insulation using G10 or FR4.

If necessary, the enclosure can be completely insulated from the ground.



Drive assembly selection

- Cary has selected a stepper motor from Tecmatic and is in the process of checking all the specs to fit our needs.
- It is a DC motor using < 48 V.
- Large number of steps for fine positioning.
- Uses double worm gear for excellent speed control (~0.3 cm/s)
- It can be completely powered off when not in use
- It uses absolute encoder – remembers absolute position after being turned off and on again.
- Utilizes a mechanical break that stays on when the power is off.
- Can slide the system up and down manually in case of motor failure
- Mechanical stop at the top of the assembly rod, prevents the rod from slipping down inside the cryostat
- Manual control in case of motor failure.

Qty	Item/Part Number	Description	Price
1	E20CDS502X0UB	4000:1 Winsmith Reducer Input Speed: 2500 RPM Output Speed: 0.6 RPM Rated Output: 595 in-lbs Efficiency: 39% Duty Cycle: <25% (intermittent) Motor Adapter for Elmo L80	\$2,490
1	G-DCWHI20/100EES	G-DC Whistle 20A/100 VDC Drive	\$1,158
1	CBL-GDCWHIKIT02	Cable Kit Gold DC-Whistle	\$169
1	L80-7530A6ABC	Motor-2.39 Nm, 3000 RPM, 20 Bit Enc	\$968
1	CBL-PML80WBR48V	CBL-Power+Brake 25 A	\$205
1	CBL-MABSENCL80	CBL-Feedback	\$132
		Total:	\$5,122

Fabrication and Testing Plan

- The temperature profiler will be fabricated, assembled and tested in Hawaii and at Fermilab.
 - ✓ Electric connections for all sensors will be tested after soldering pins and wires to the FR4 board by taking temperature readings directly with a temperature monitor.
 - ✓ Sensors will be lowered in LN2 along with a calibrated sensor. Temperature reading will be taken for both sensors to test whether they are in a good working condition and for crude comparison.
 - ✓ Twisted pairs of wires are color coded and labels will be placed on the outside of the cables on both ends, once the sensor is attached to certain location on the carrier rod.
 - ✓ Labels will look like RTD-1-750 (the middle number is the sensor number based on lab testing of the sensor, while the last number is the position of the sensor on the carrier rod)
 - ✓ Carrier rod pieces will be assembled and disassembled.
 - ✓ Drive assembly will be tested, including the motor break, the encoder, manual drive and overall operation. The system will be driven a large number of times to check for slippage or other effects.
 - ✓ The entire system will be assembled and tested in a high bay facility.
- The profiler will be shipped to ProtoDUNE site partially assembled (rod disassembled in several pieces with sensors and cables in place, motor and electronic enclosure detached)

Installation and Commissioning

- Wires will be soldered to the D-sub connectors on the flange.
- Cable shielding will not be connected to the flange ground.
- Cables with twisted wires will be soldered on the upper side of the flange and cables will be labeled at that point, after each soldering of four wires.
- Sensor reading will be checked with the temp. monitor at the rack afterwards, one at the time.
- Multimeter will be used to check that the cable shielding is properly insulated from the flange and the ground.
- Motor assembly will be tested – first independently of the temperature profiler (motor operation, encoder, break). Then, it will be connected to the carrier rod and the entire assembly will be driven up and down through allowed 1 m range.
- Sensors will be retested after motor installation and connection to carrier rod.