

# 20mK Space

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Jessica Fry

DMRadio Collaboration Meeting

August 5, 2024

# Outline

- Goals & Considerations
- Components
- Constraints
- Present Design
- Assembly
- Open Questions
- Timeline

# Design Goals

1. Mechanically support detector components.
2. Thermalize detector components.
3. Thermally & electromagnetically shield sensitive components.
4. Maximize capacitor space.
5. Accommodate future upgrades.

# Design Considerations

- Minimize light leaks to hutches.
- Keep sensitive electronics and wires inside shielded hutches.
- Minimize assembly procedures in between plates (i.e. keep necessary wiring along the perimeter).

# Components

Baseline package: *components for commissioning and initial needle search*

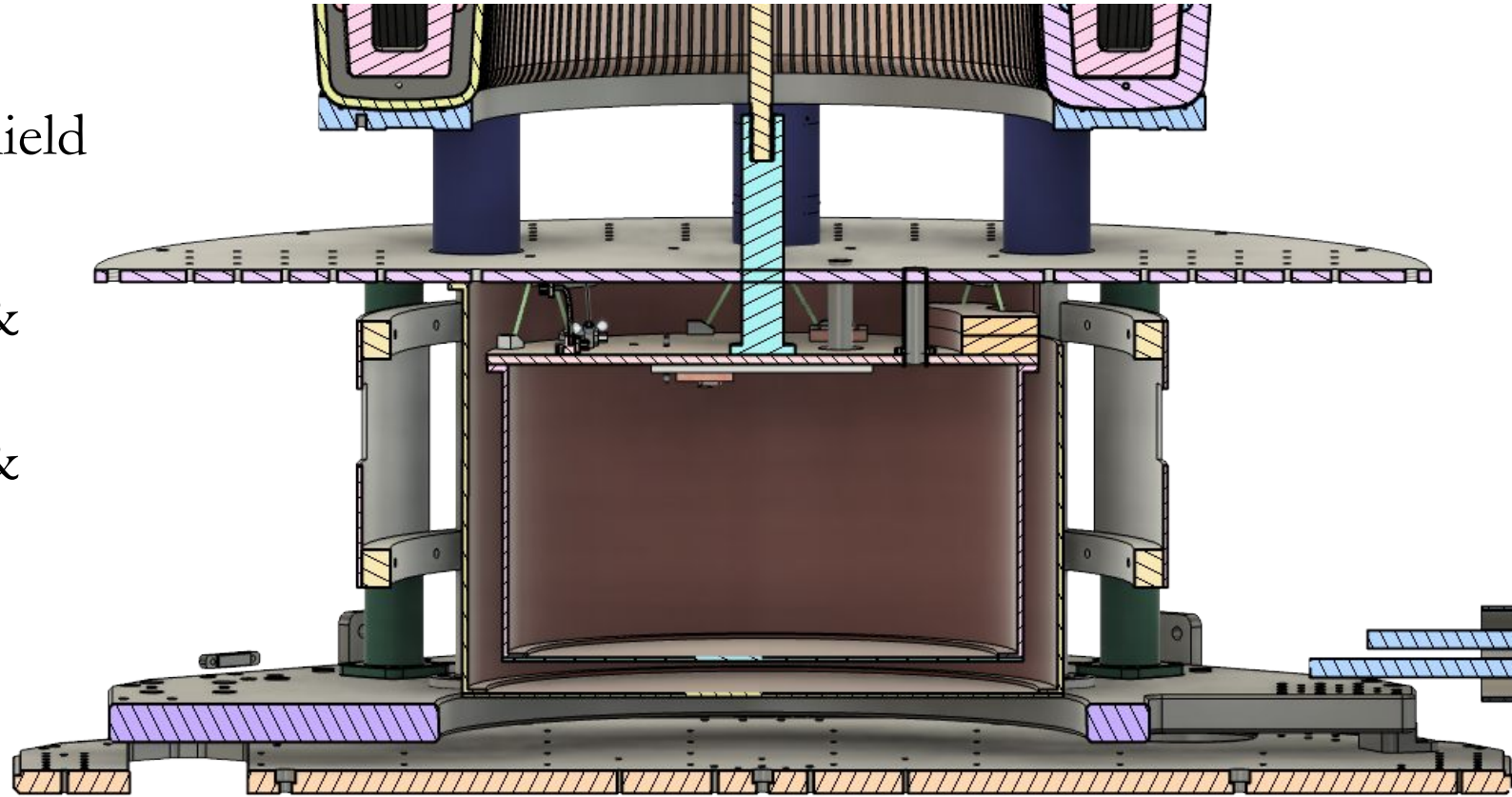
- Detector components
  - Fixed capacitor
  - SQUID
  - Inductor
  - Transformer
- Shields
  - Capacitor hutch
  - SQUID hutch
  - Inductor shield
  - 20mK shield
- Aux devices
  - Actuator feed throughs

Jessica Fry

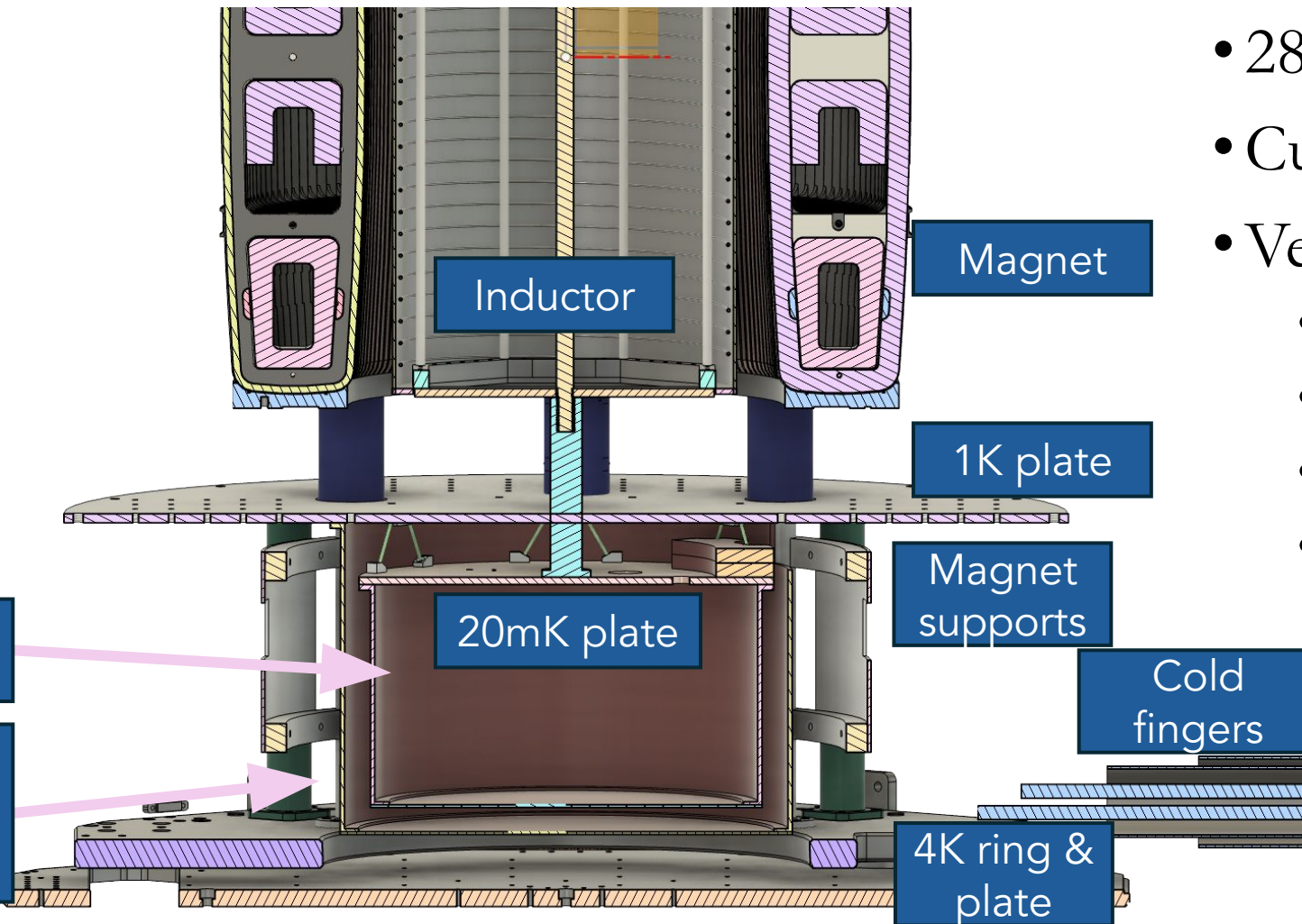
Maria Salatino

# Constraints

- Mechanical
  - Fit within 1K bottom shield
- Thermal
  - Minimize 1K radiation & conduction
  - Minimize 4K radiation & conduction
- Assembly
  - Added after 1K plate

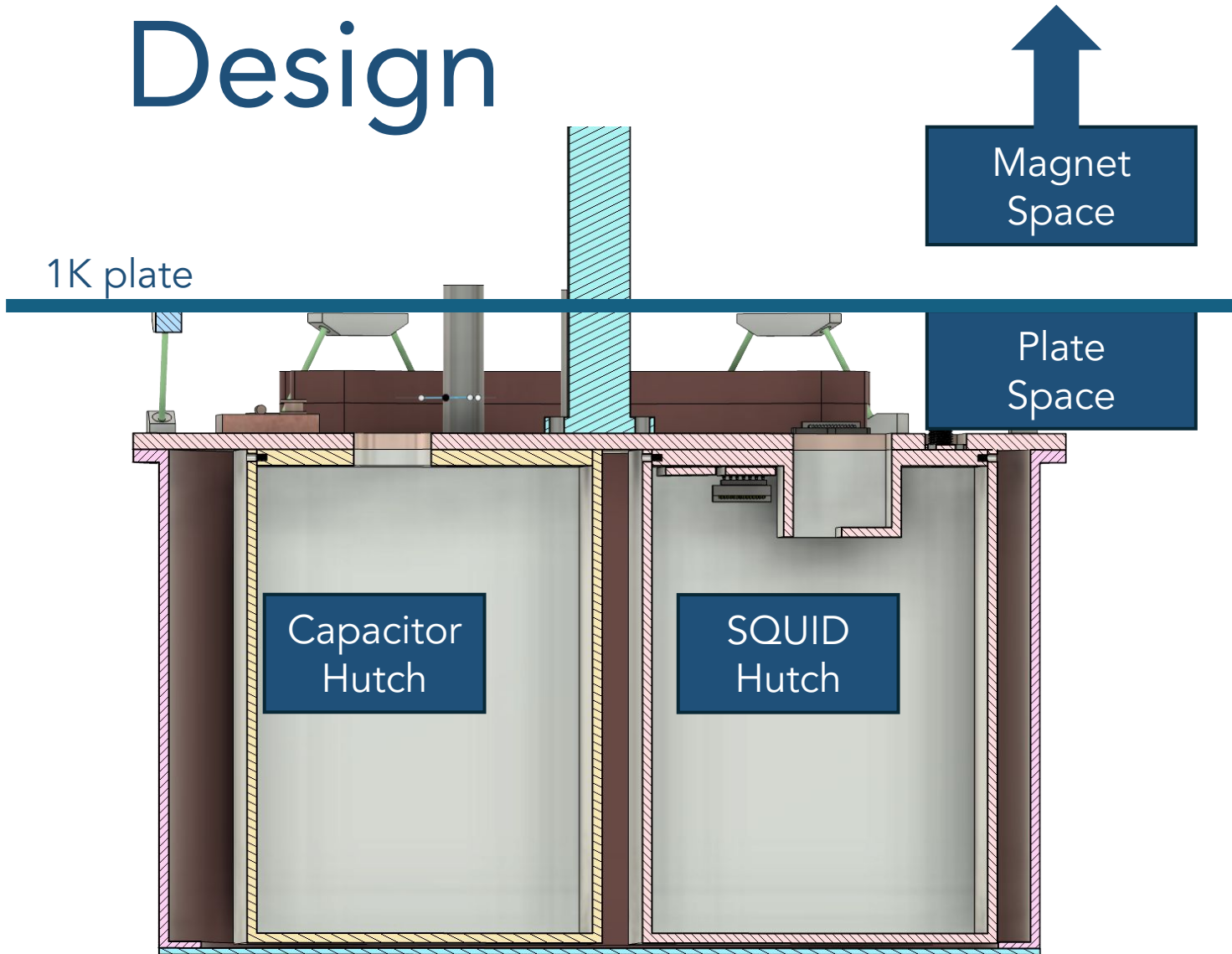


# Plate & Shield



- 28.9 cm diameter plate
- Cu plate
- Vertically
  - Magnet 1K [8cm]
  - 1K 20mK [4 cm]
  - 20mK shield [18cm]
  - 1K Magnet supports [2cm]

# Design

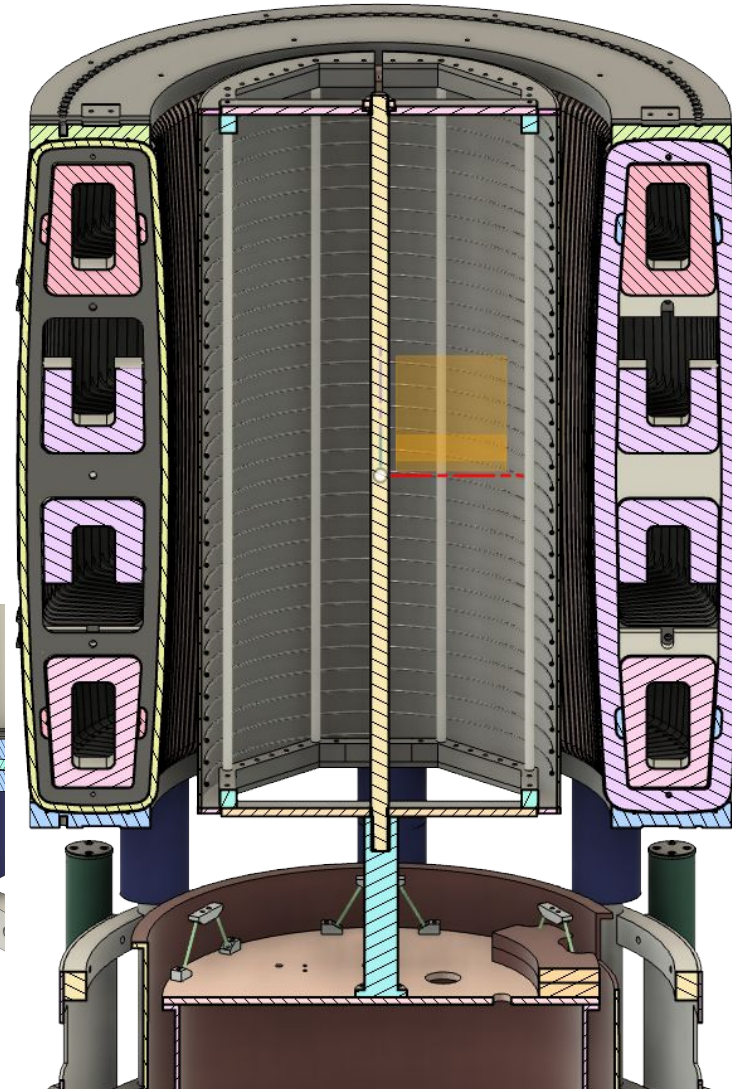
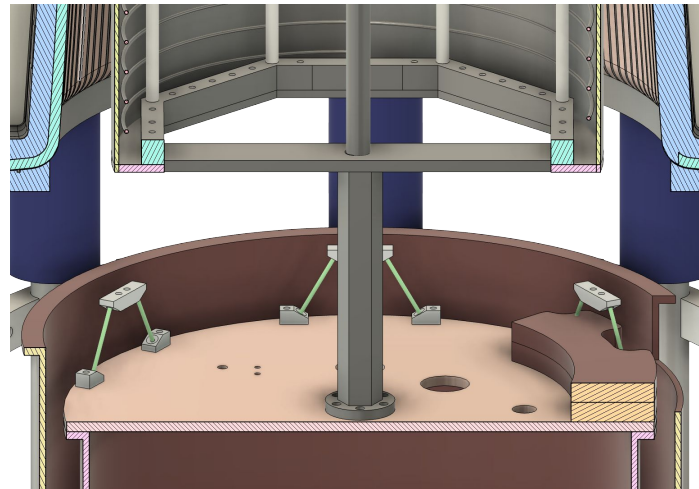
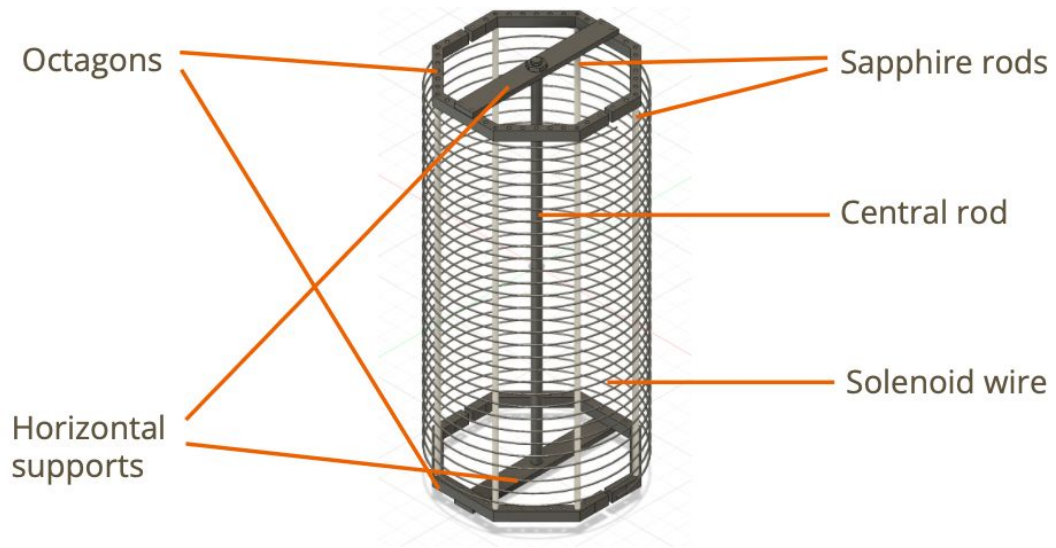


- Break 20mK space into four subspaces
  1. Magnet space (i.e. inside the donut)
  2. SQUID hutch
  3. Capacitor hutch
  4. Plate space



# Magnet Space

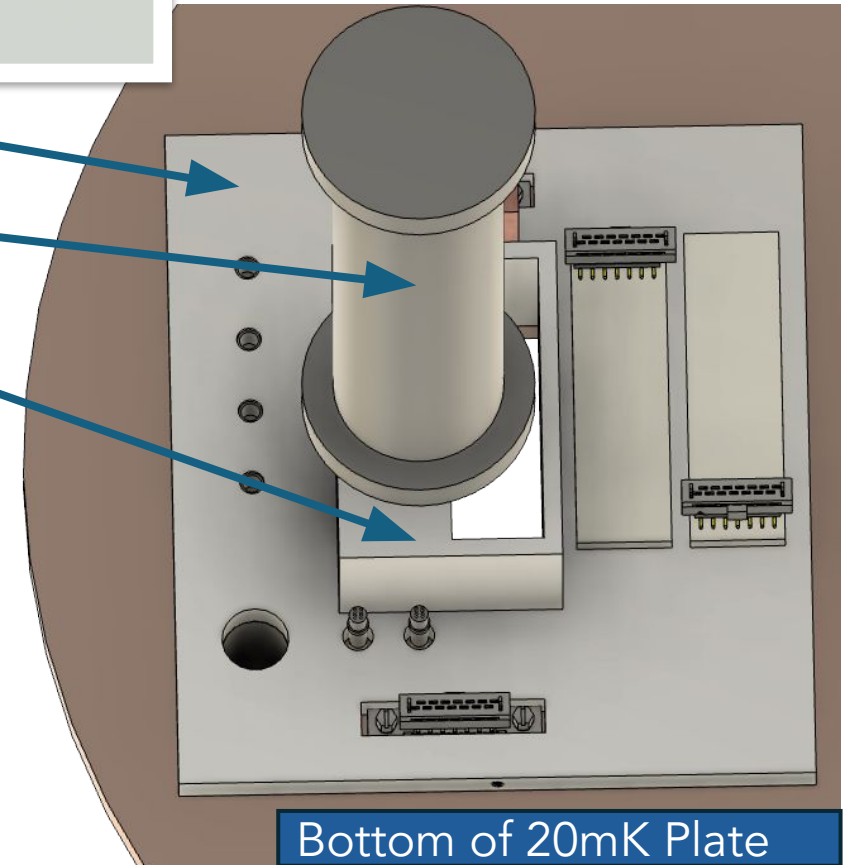
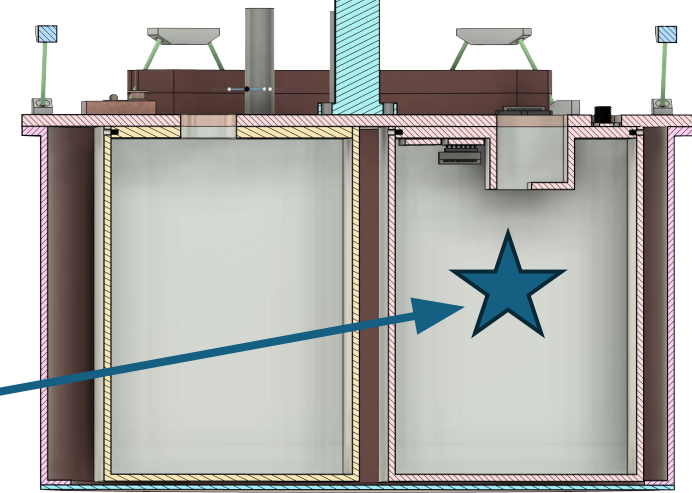
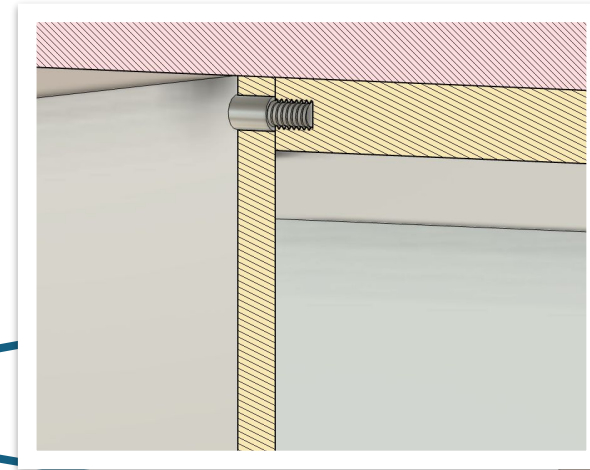
- Parts
  - Inductor
  - Inductor shielding (i.e. corset)
  - Hexagonal, tapped mounting rod.



# SQUID hutch

- Parts:

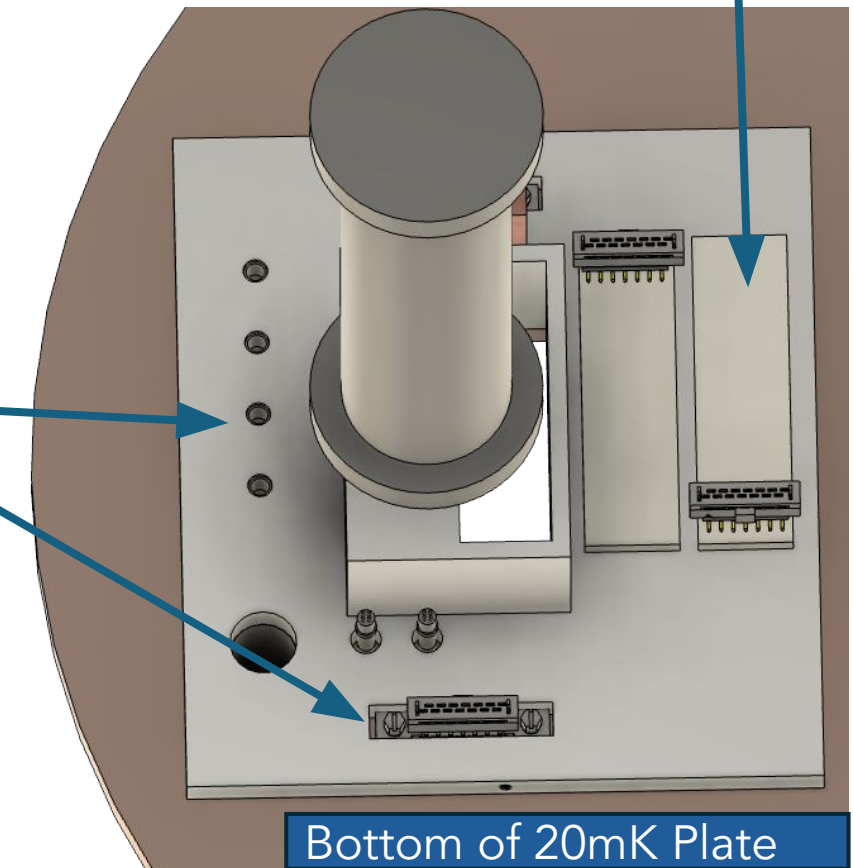
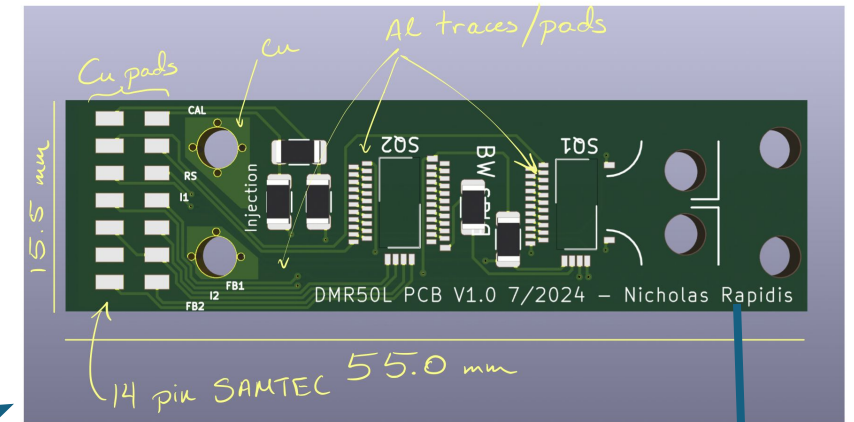
- Hutch plate
- Hutch body
- Tunable transformer
- Linear Attocube cutout & shielding
- 2x SQUID PCBs
- SQUID out wiring (SMA & Samtec options)
- Standardize thermometry (copper plate, bobbin, RuOx, heater)
- 8x DC wiring connectors
- Al thru tube (for sensitive wiring)



# SQUID hutch

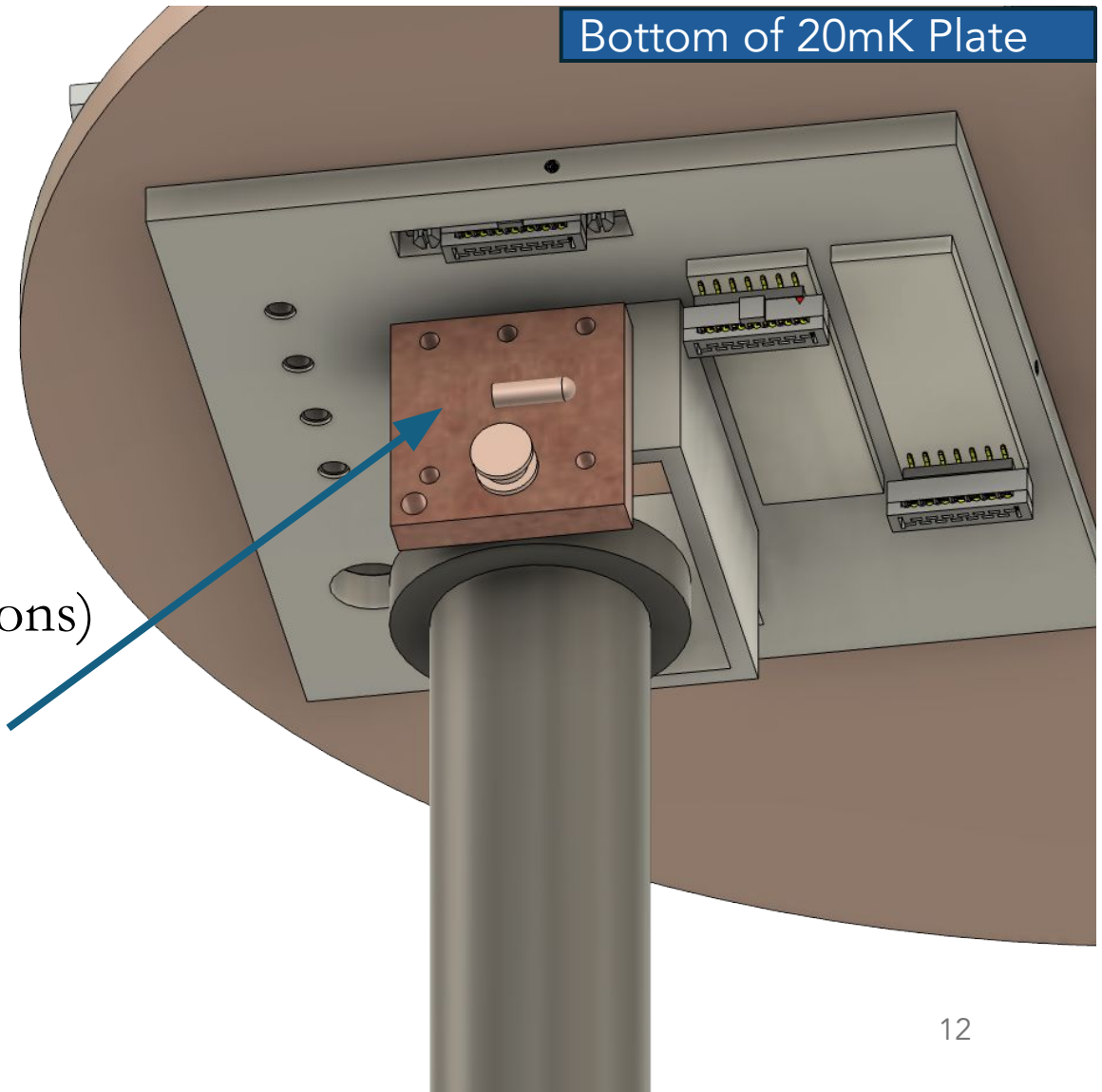
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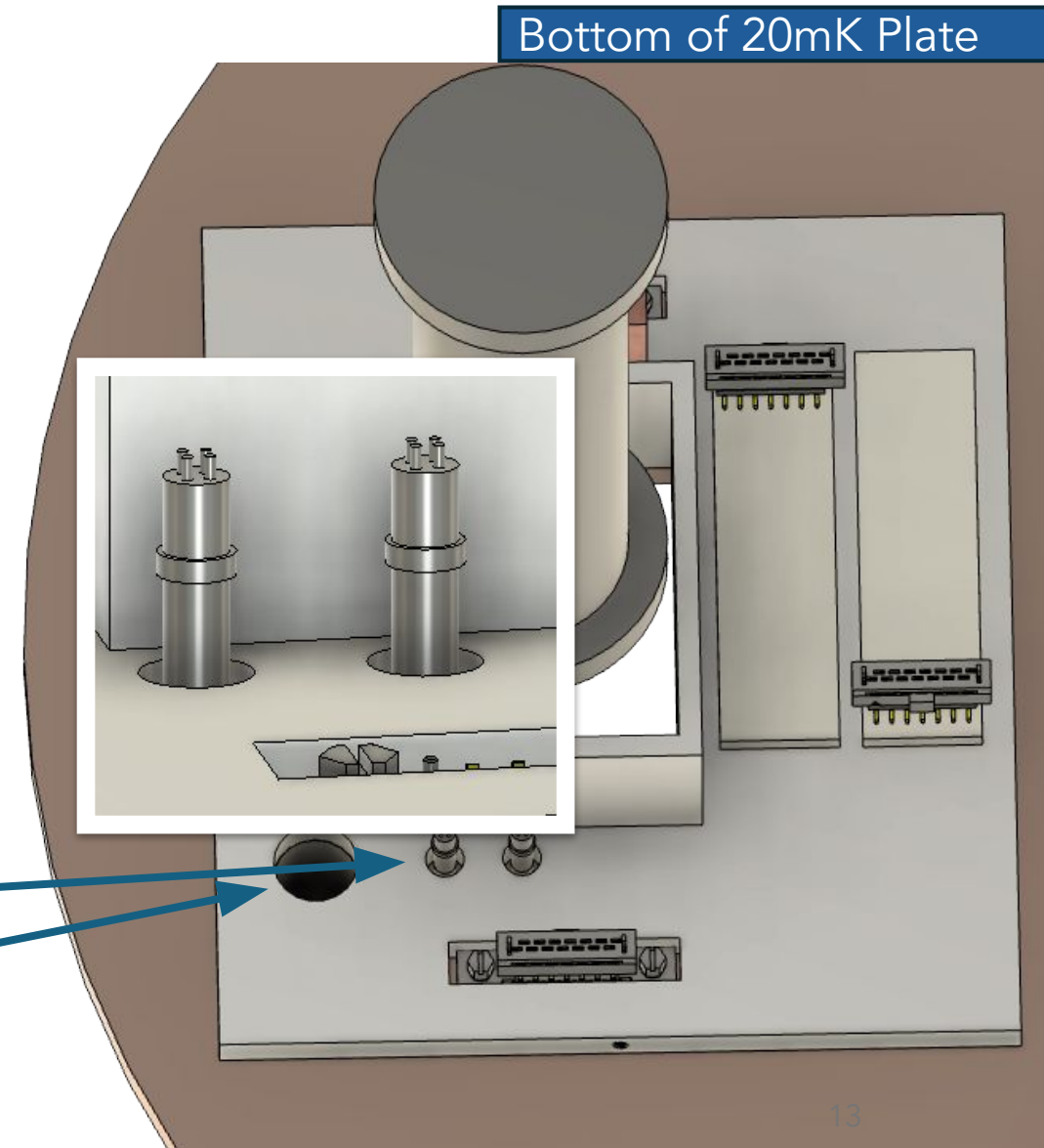
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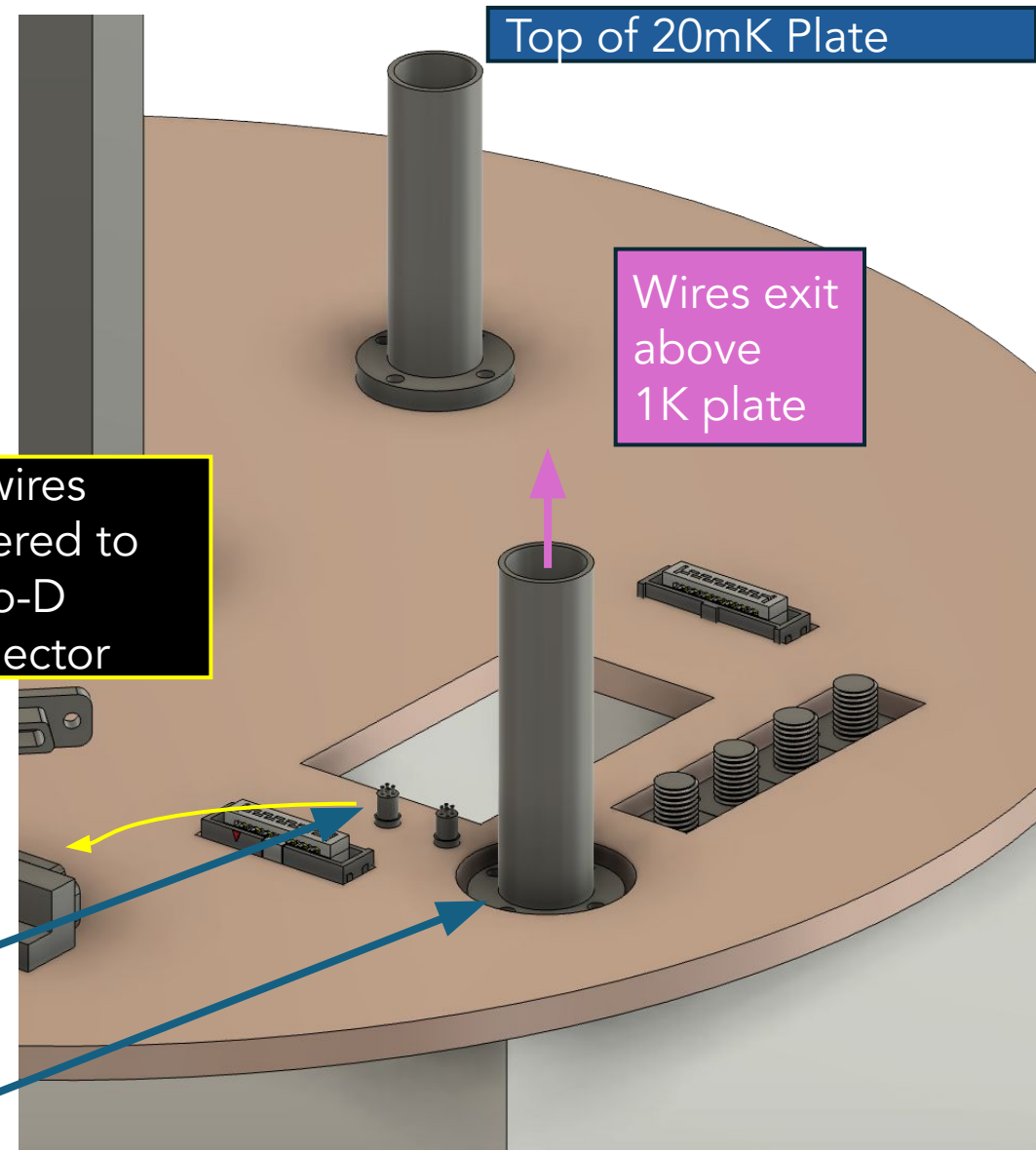
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DC wires soldered to micro-D connector

Top of 20mK Plate

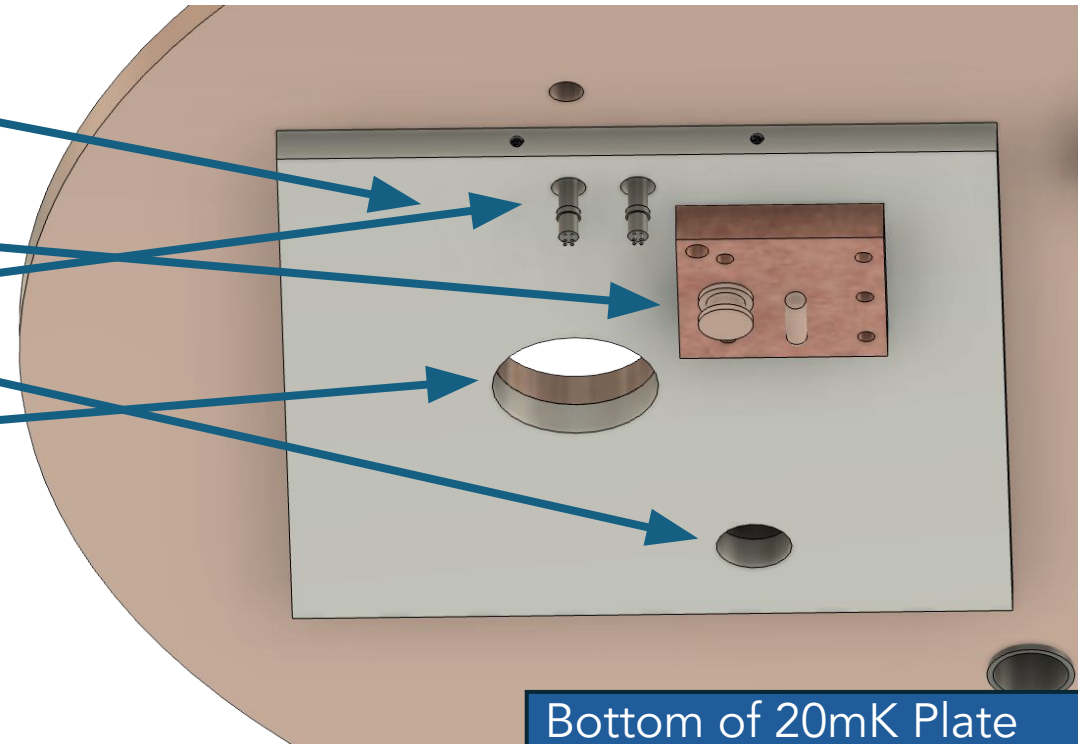
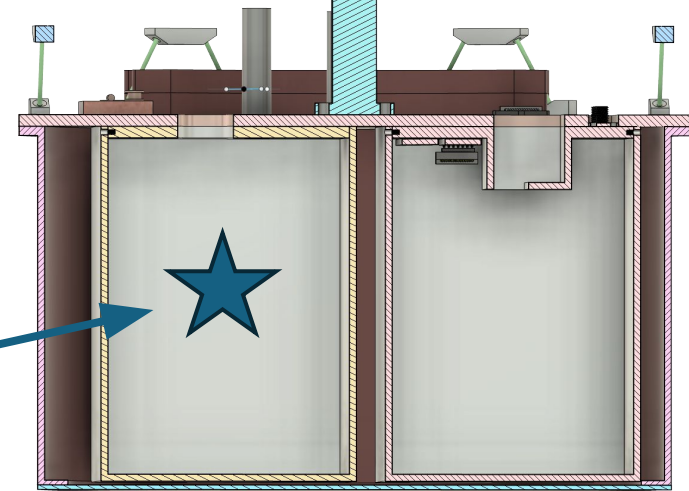
Wires exit above 1K plate



# Capacitor hutch

- Parts:

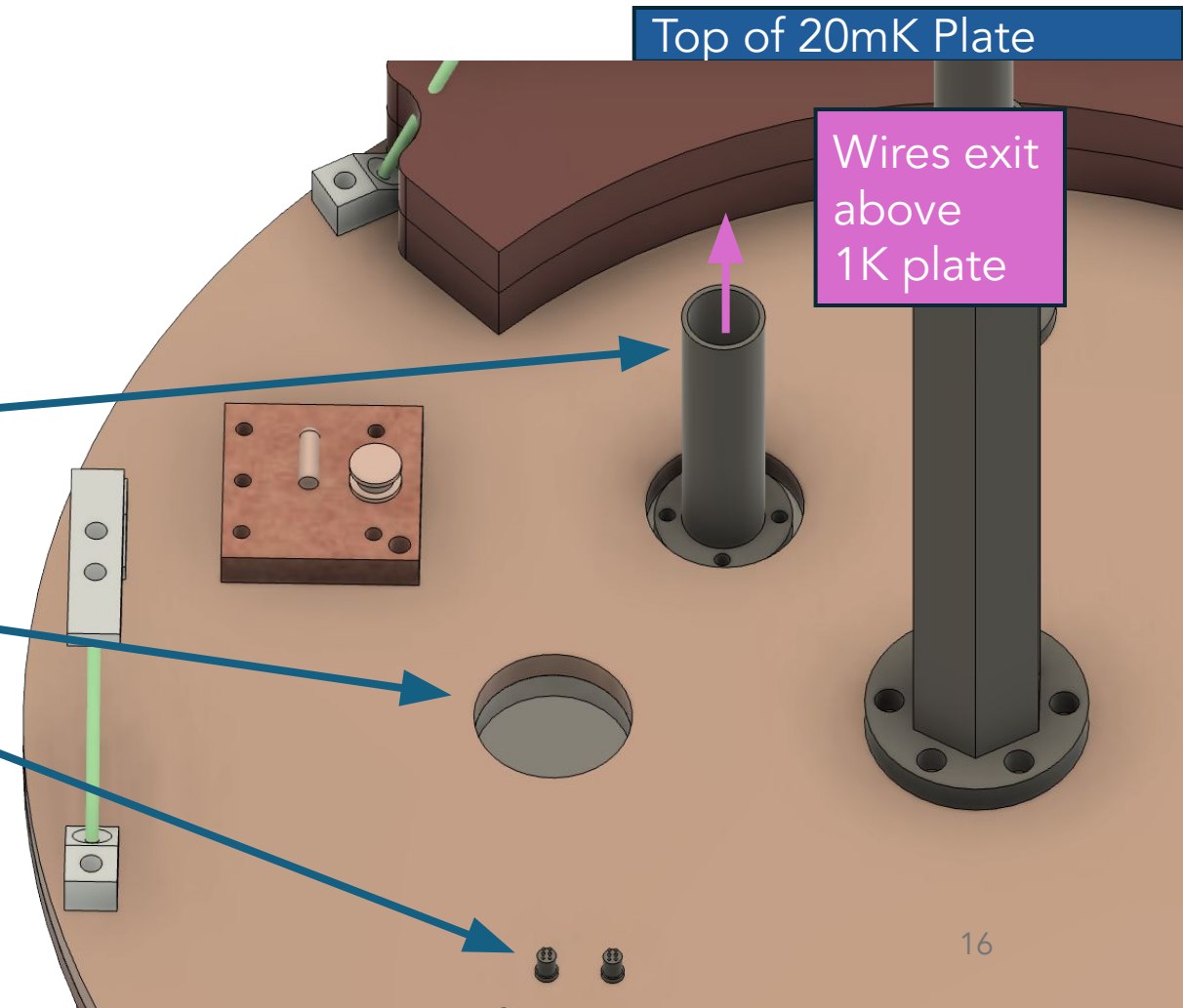
- Hutch plate
- Hutch body
- Standardize thermometry (copper plate, bobbin, RuOx, heater)
- Thru tube (for sensitive wiring)
- 8x DC wires
- Rotational Attocube cutout
- 1nF fixed parallel plate capacitor
- Screw terminal



# Capacitor hutch

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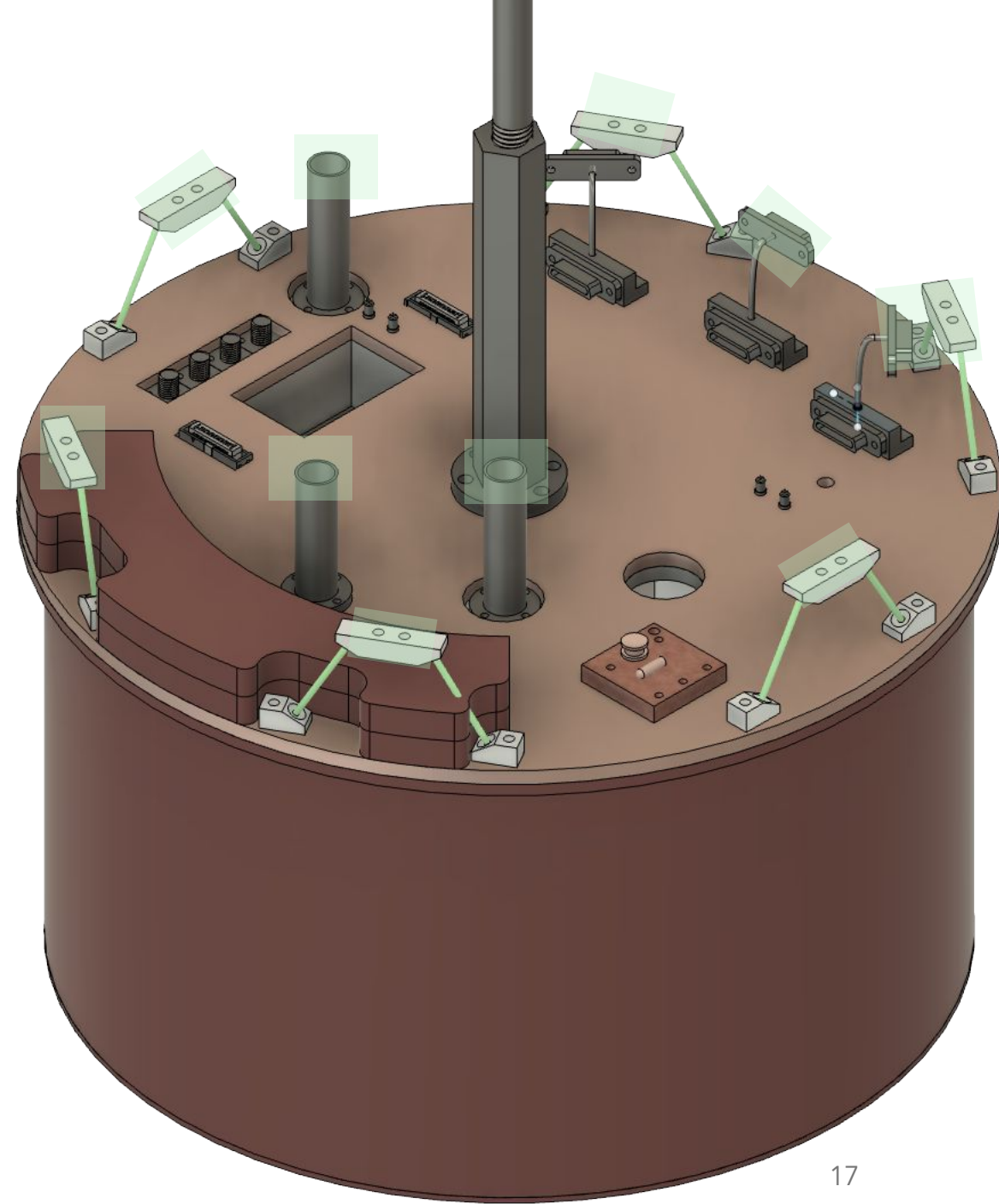
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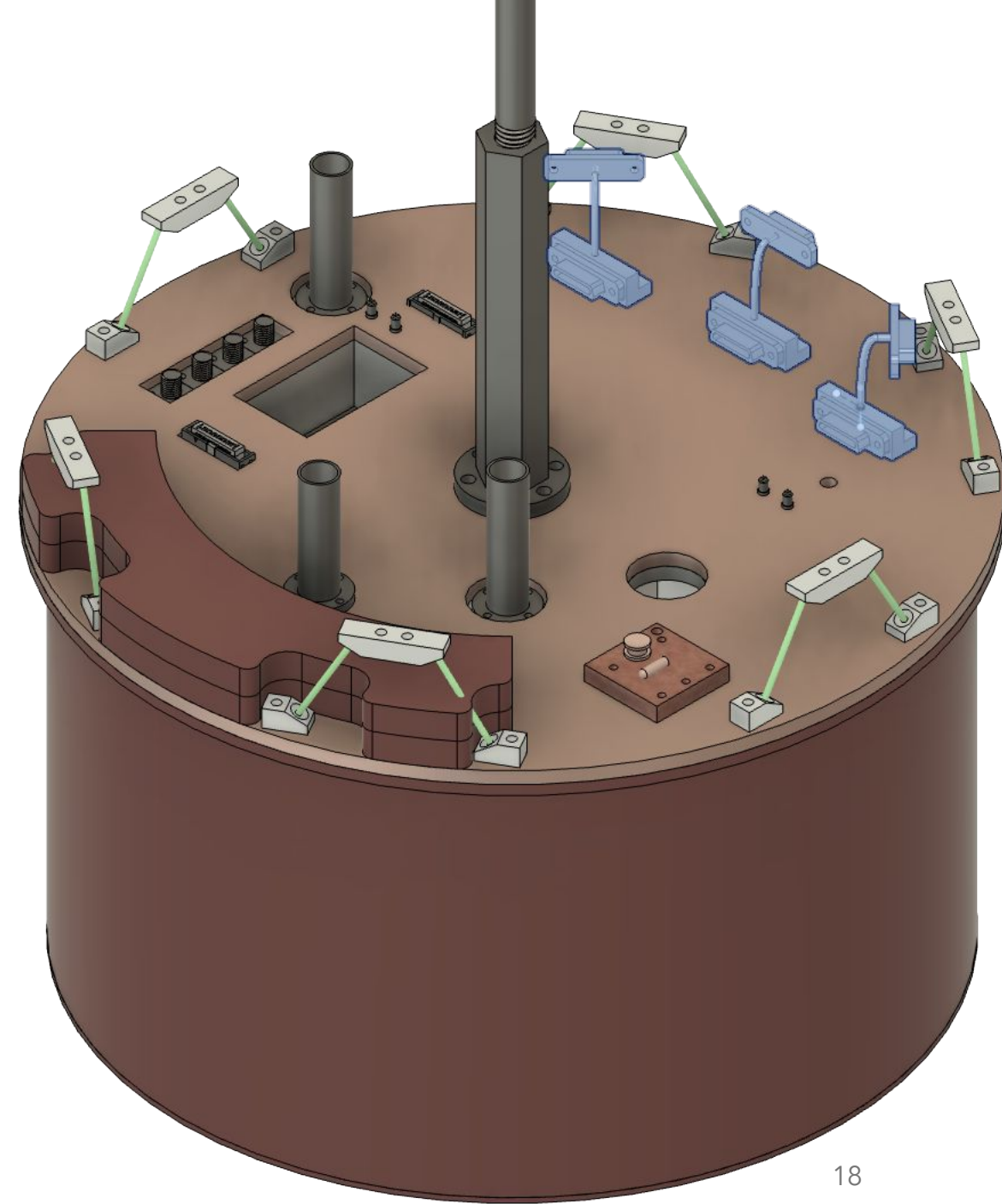
# Plate components

- Parts:
  - 3x DC 25 pin micro-D connectors
  - Thru tube
  - Thermal braid
  - 6x Vespel struts
  - Standardize thermometry (copper plate, bobbin, RuOx, heater)
  - DC wiring hole into general 20mK space



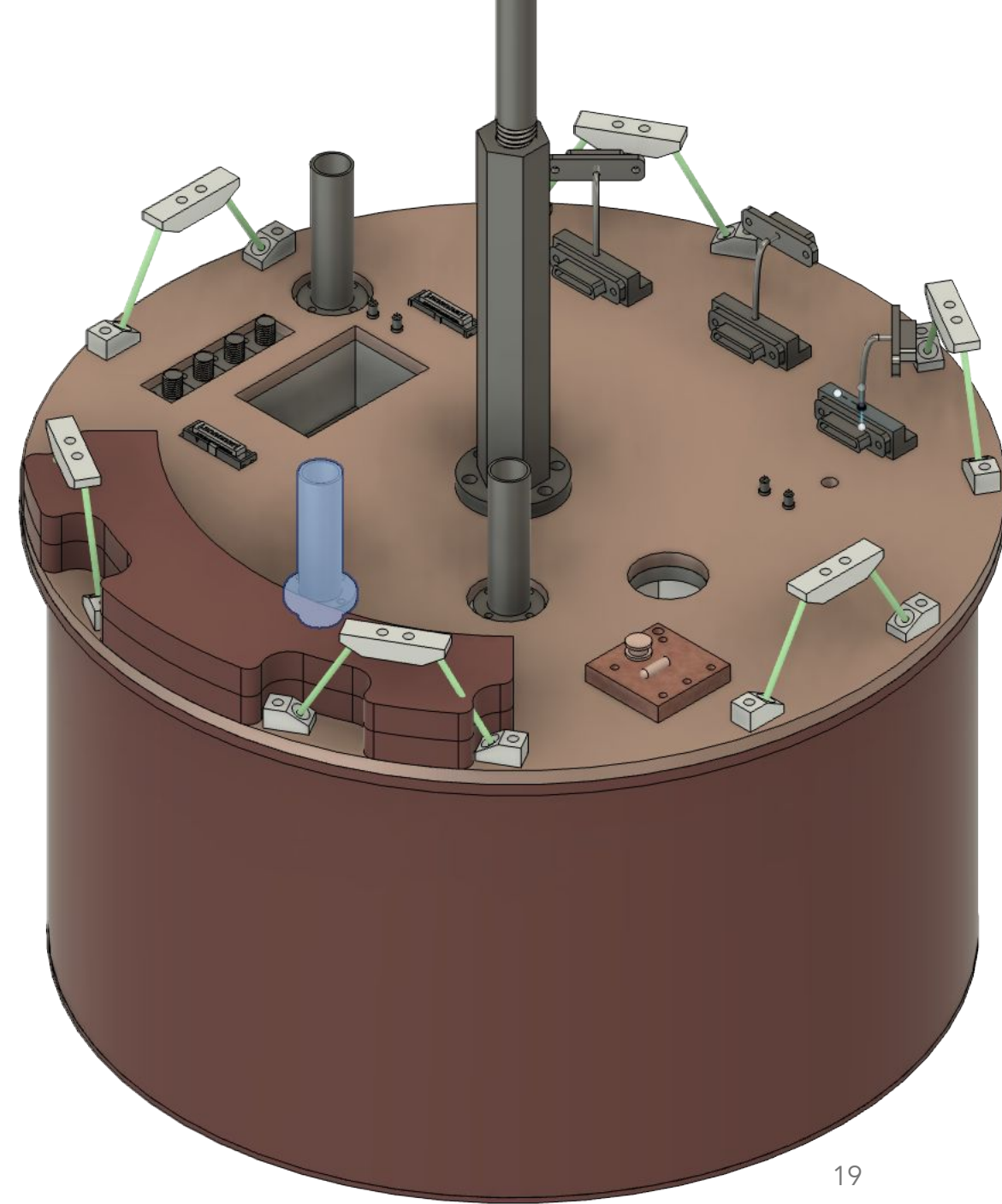
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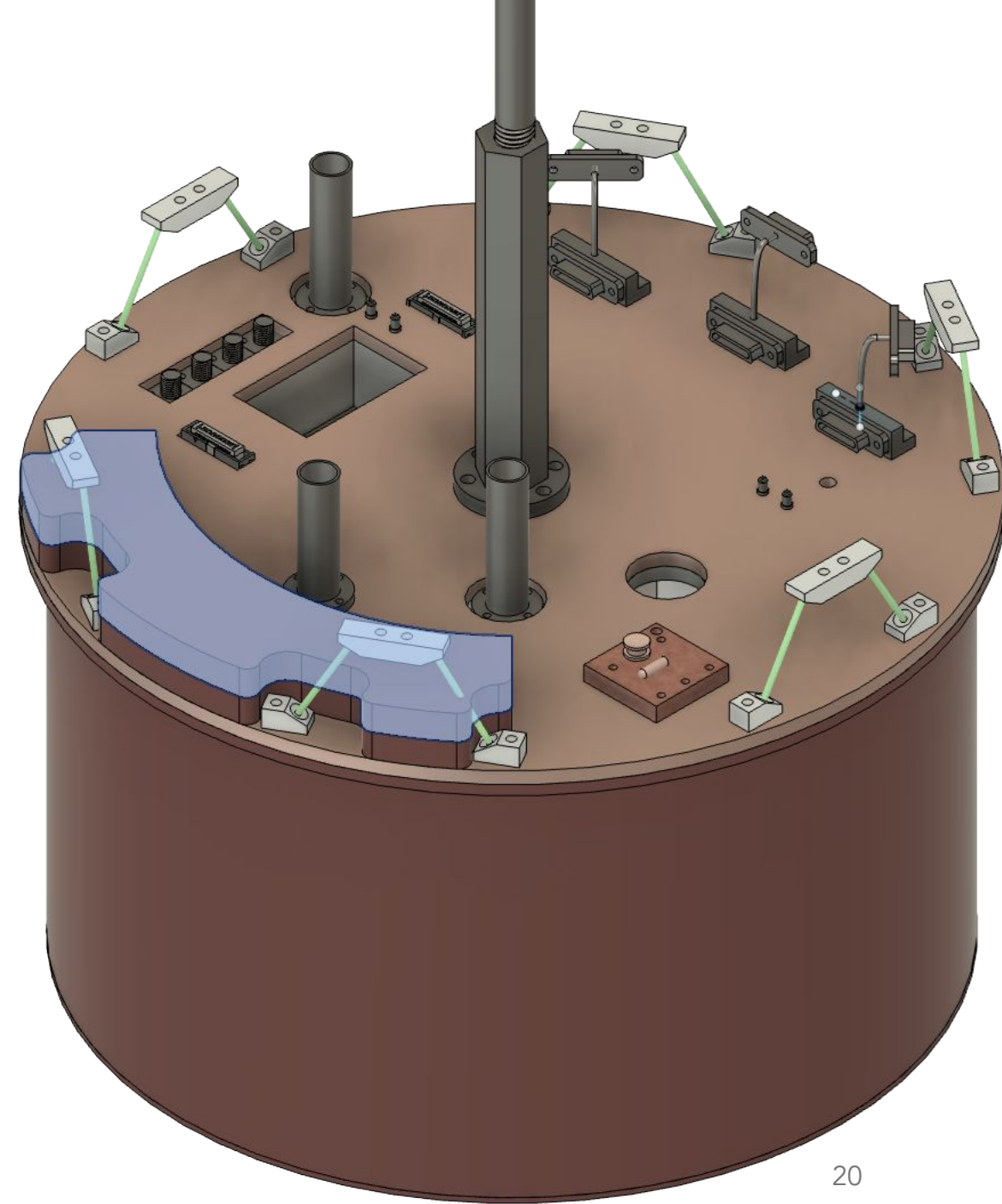
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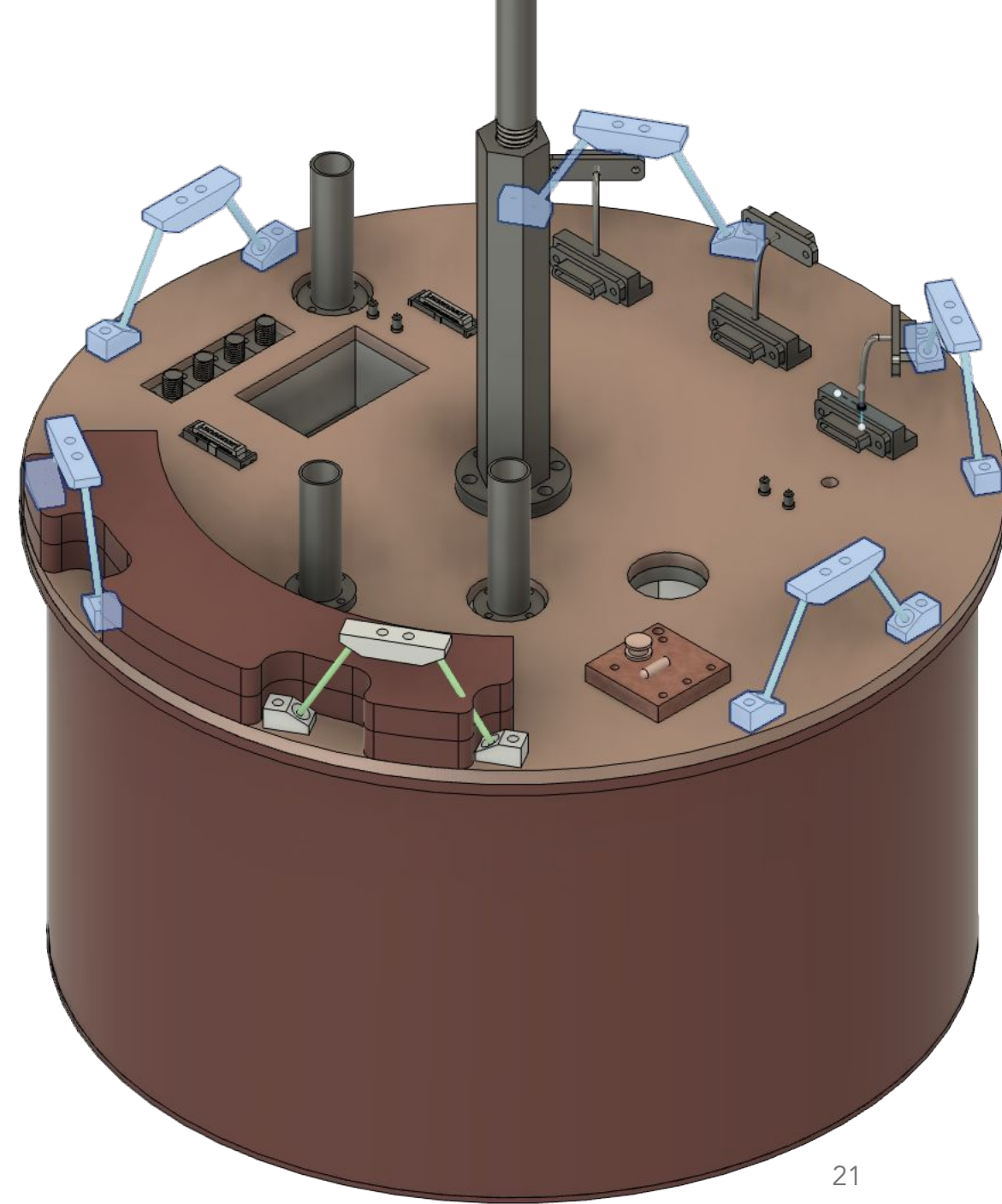
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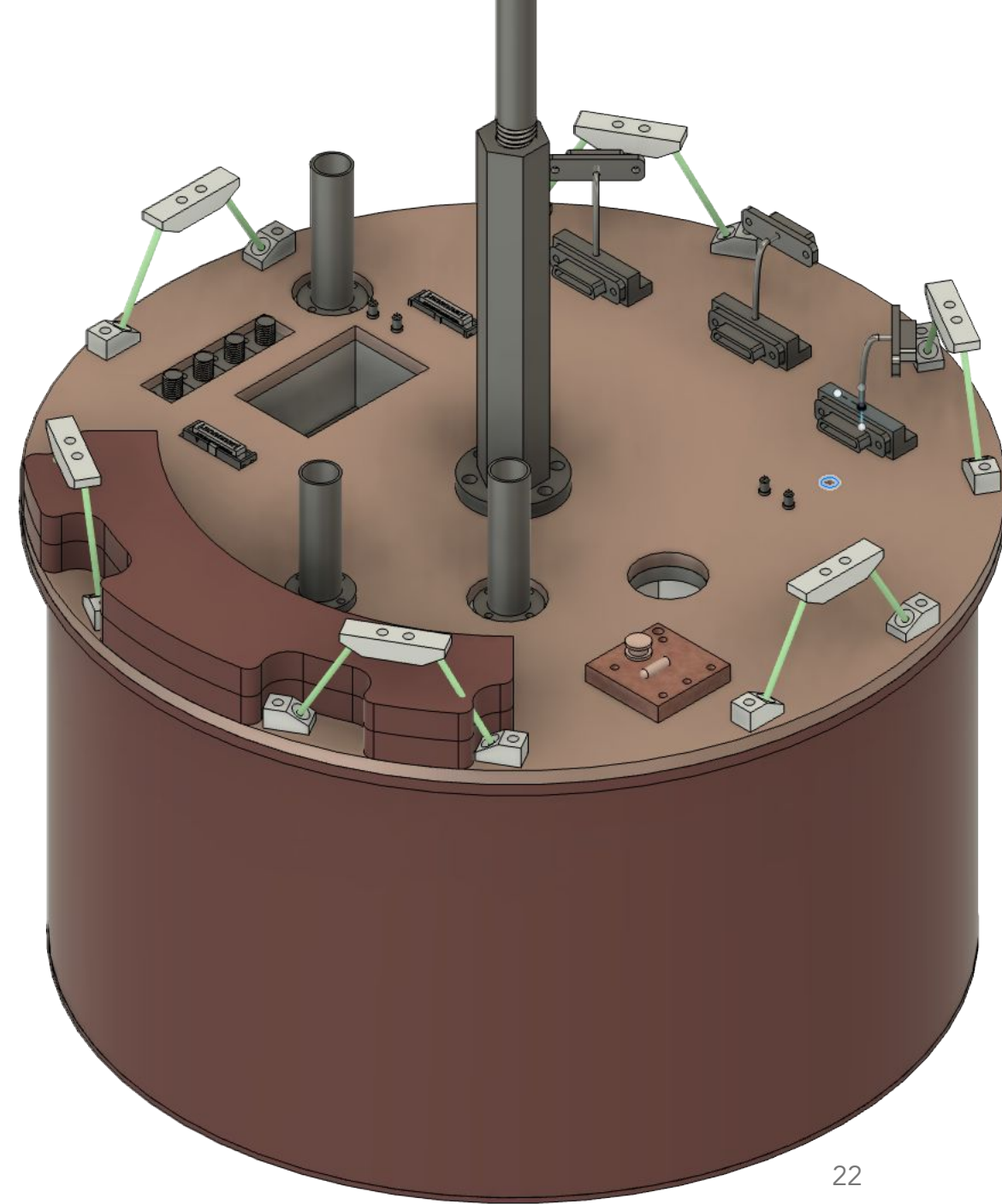
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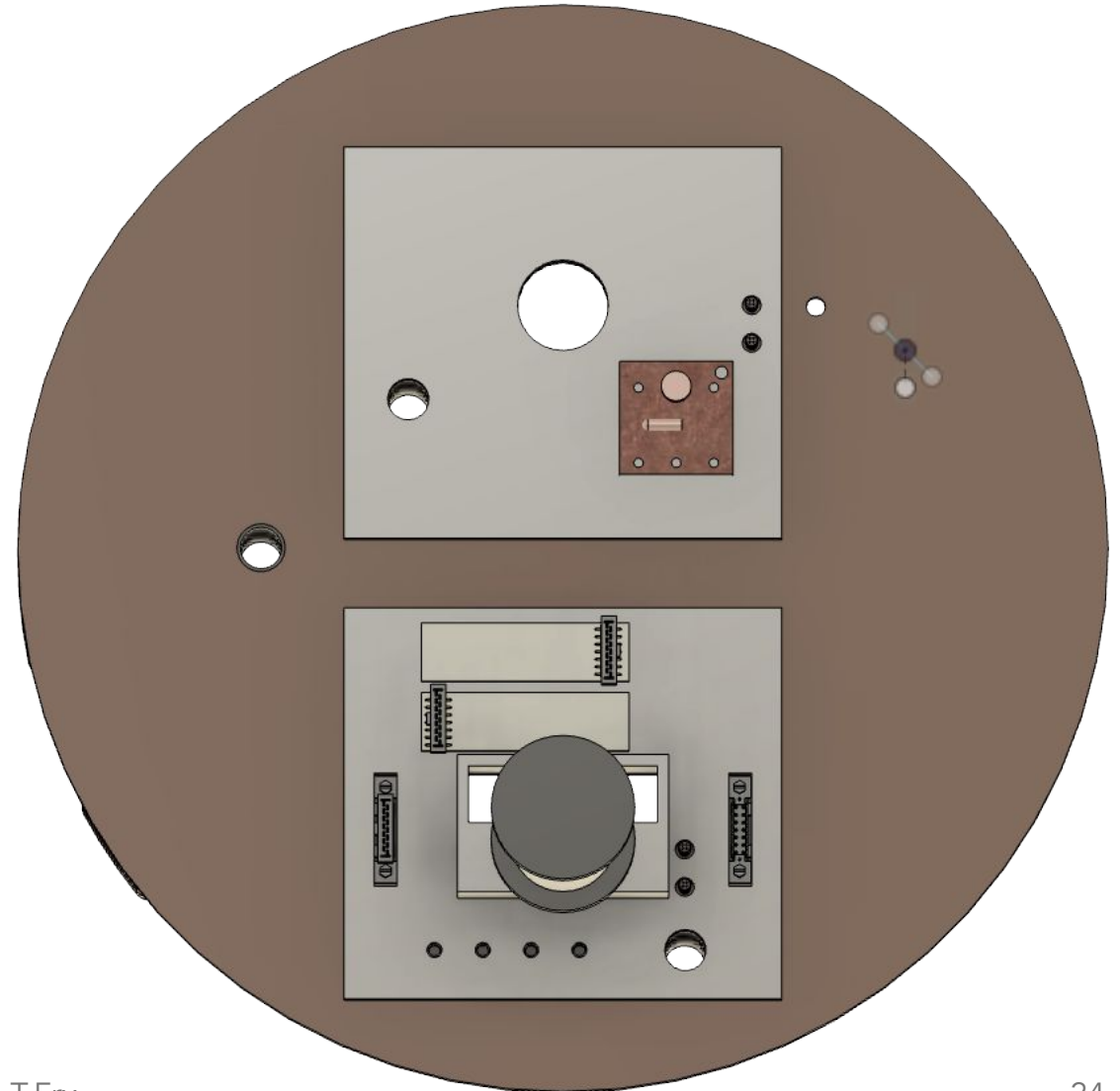
# Assembly

1. Bottom mounted assembly
2. Top mounted assembly
3. Mount 20mK plate
4. 20mK to 1K connections
5. 20mK Shield mounting

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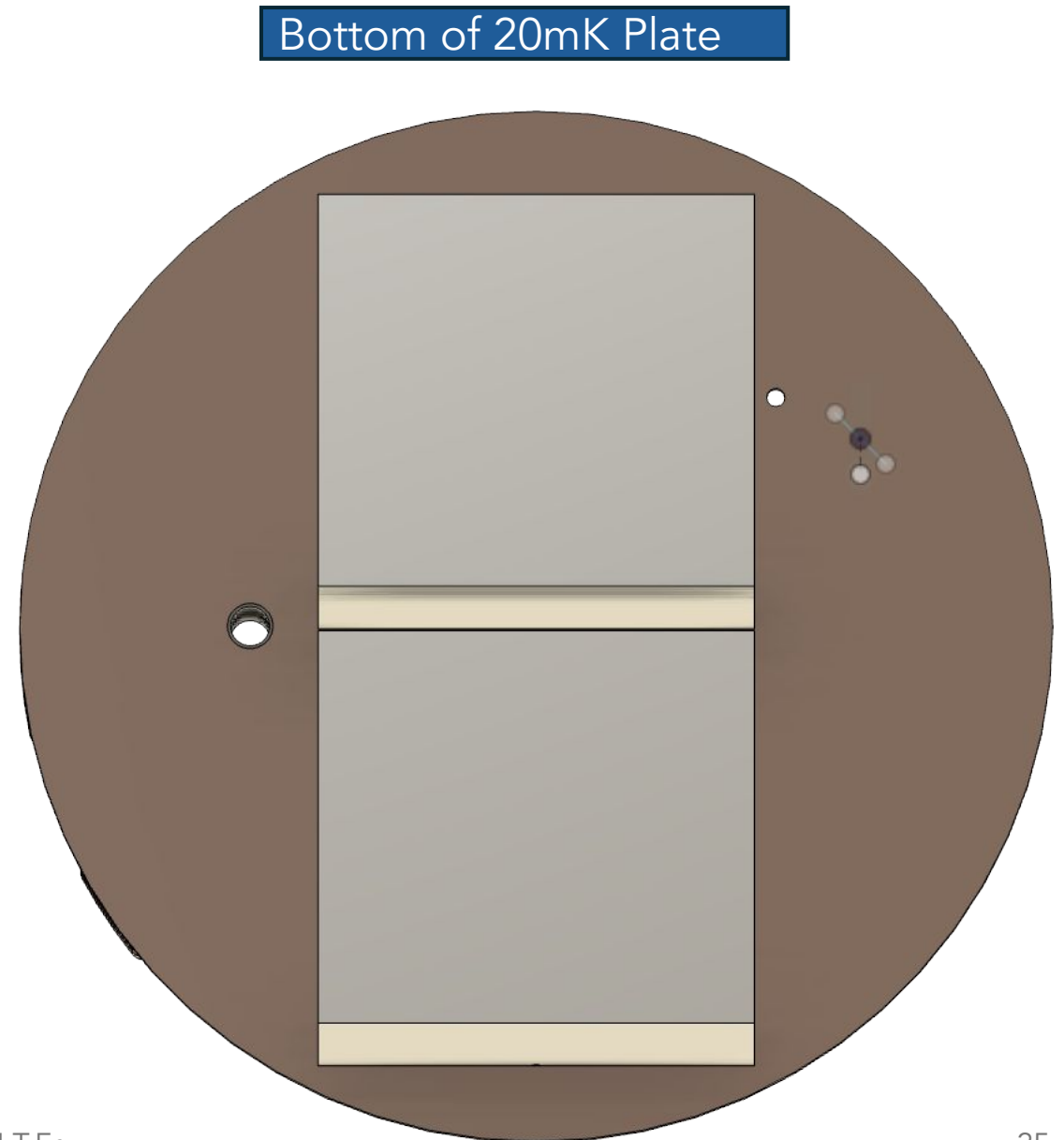
Bottom of 20mK Plate





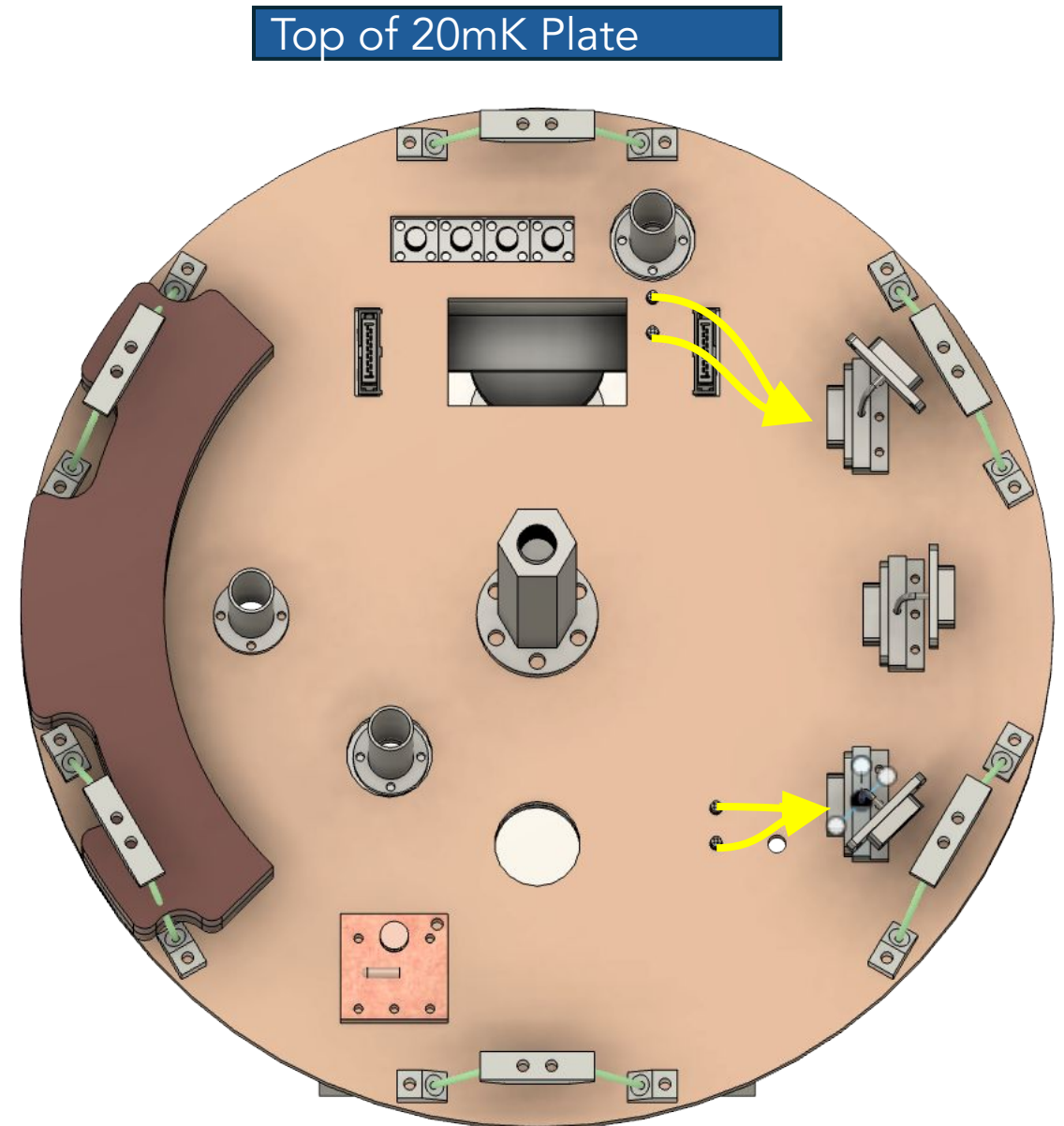
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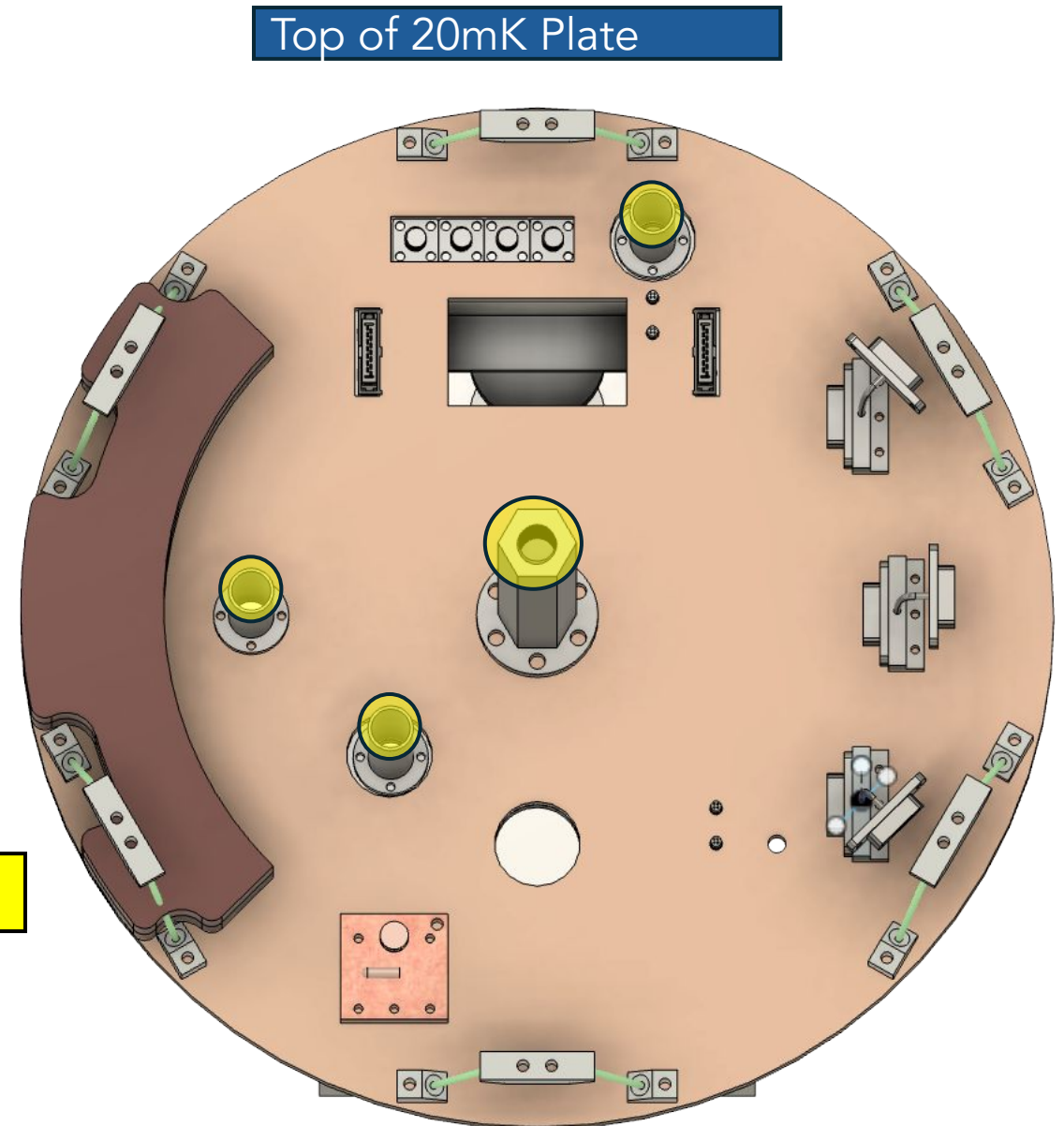
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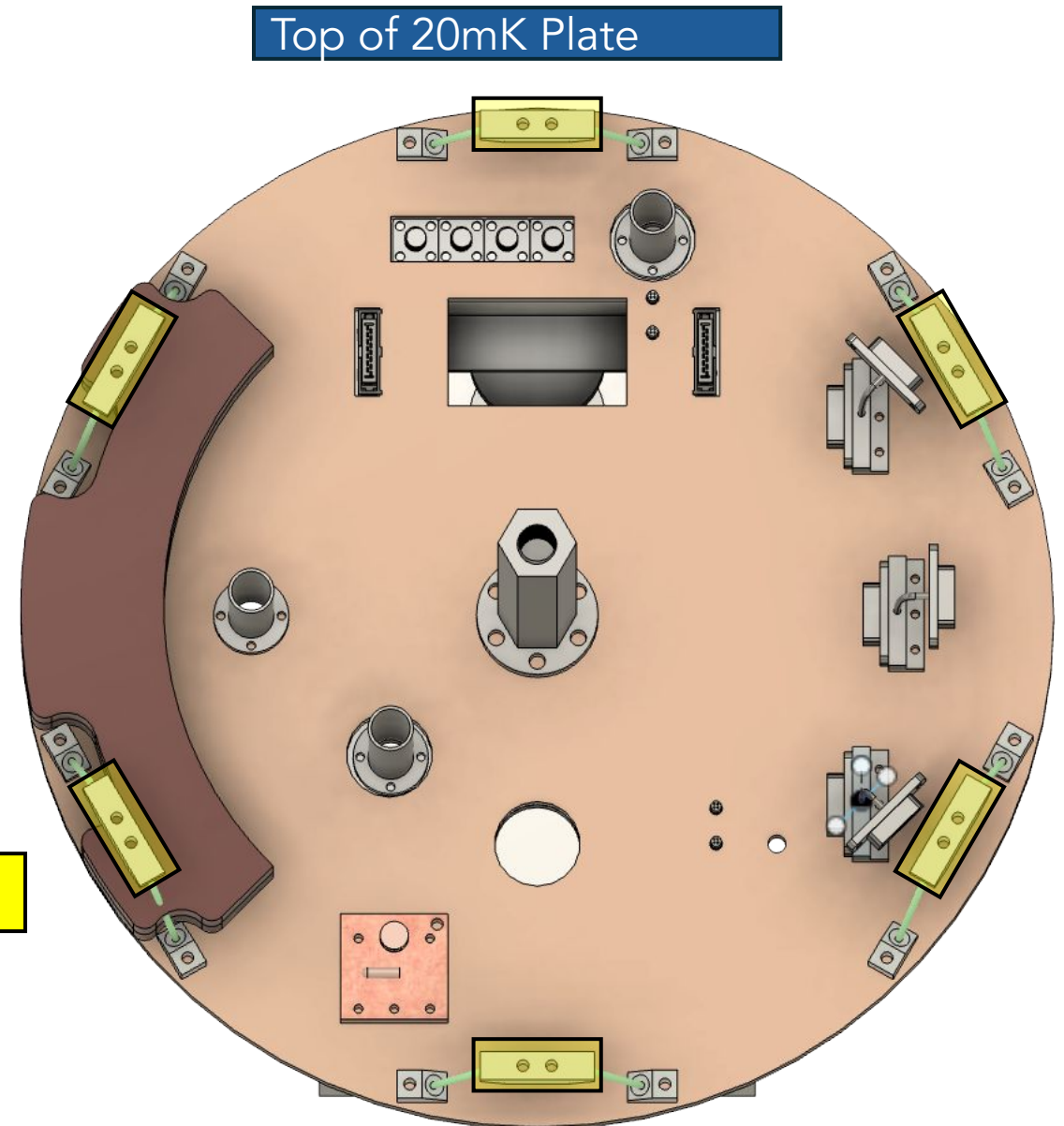
1K cut outs



# Assembly

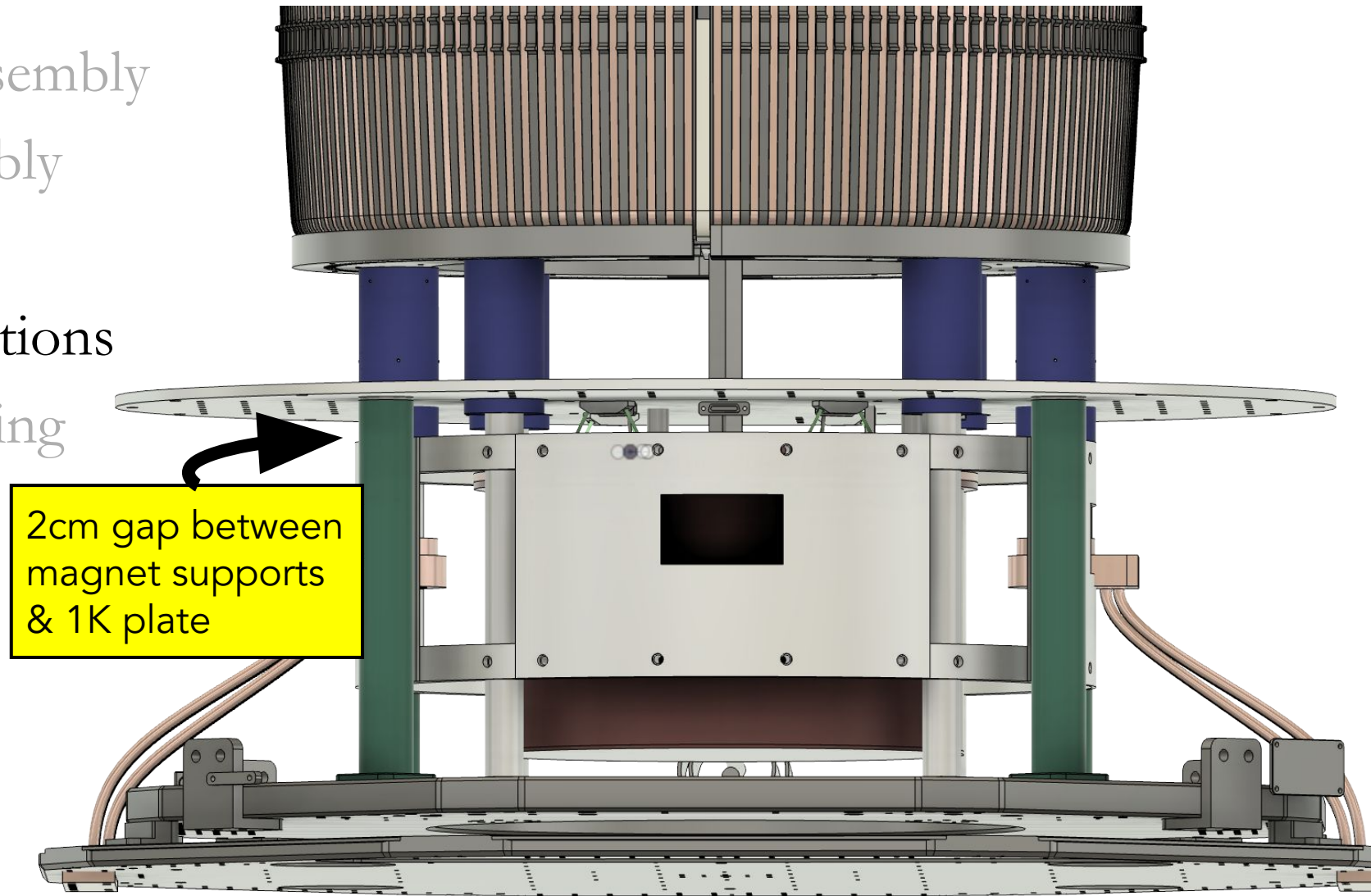
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Mounting Points



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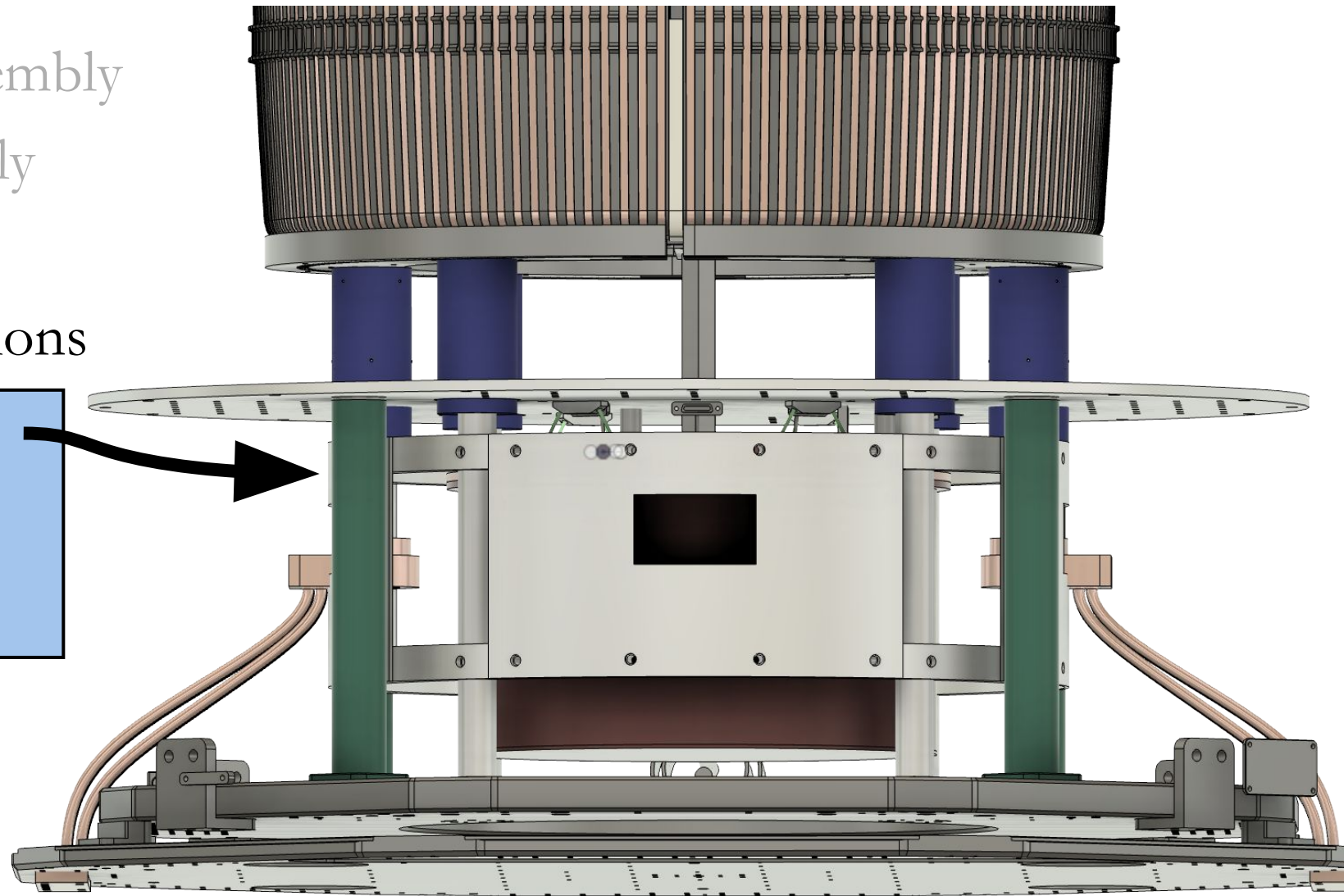
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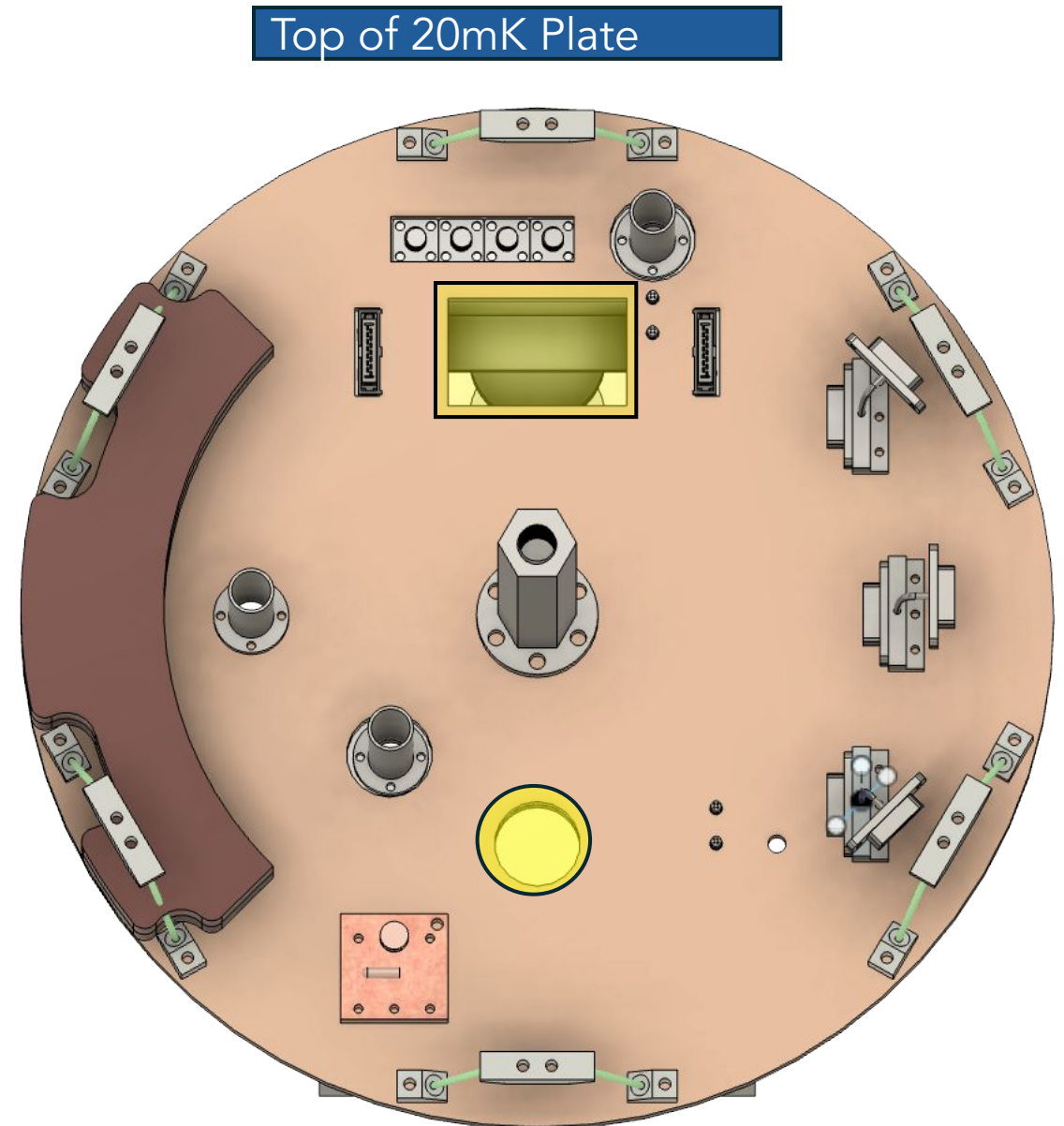
- 4.0. Lower support ring
- 4.I. Attocube connection
- 4.II. DC & RF wiring
- 4.III. Inductor Install
- 4.IV Inductor wiring



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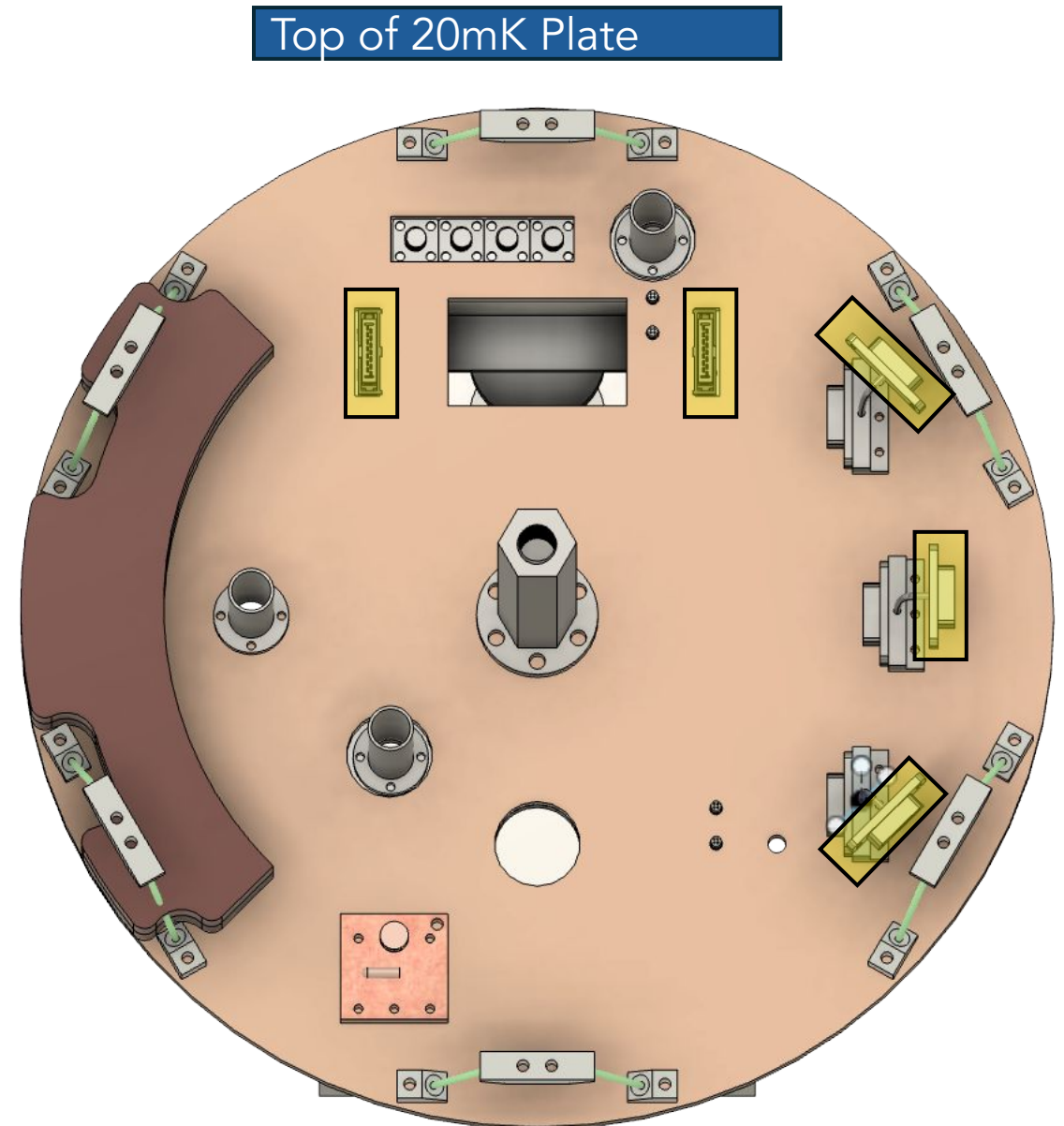
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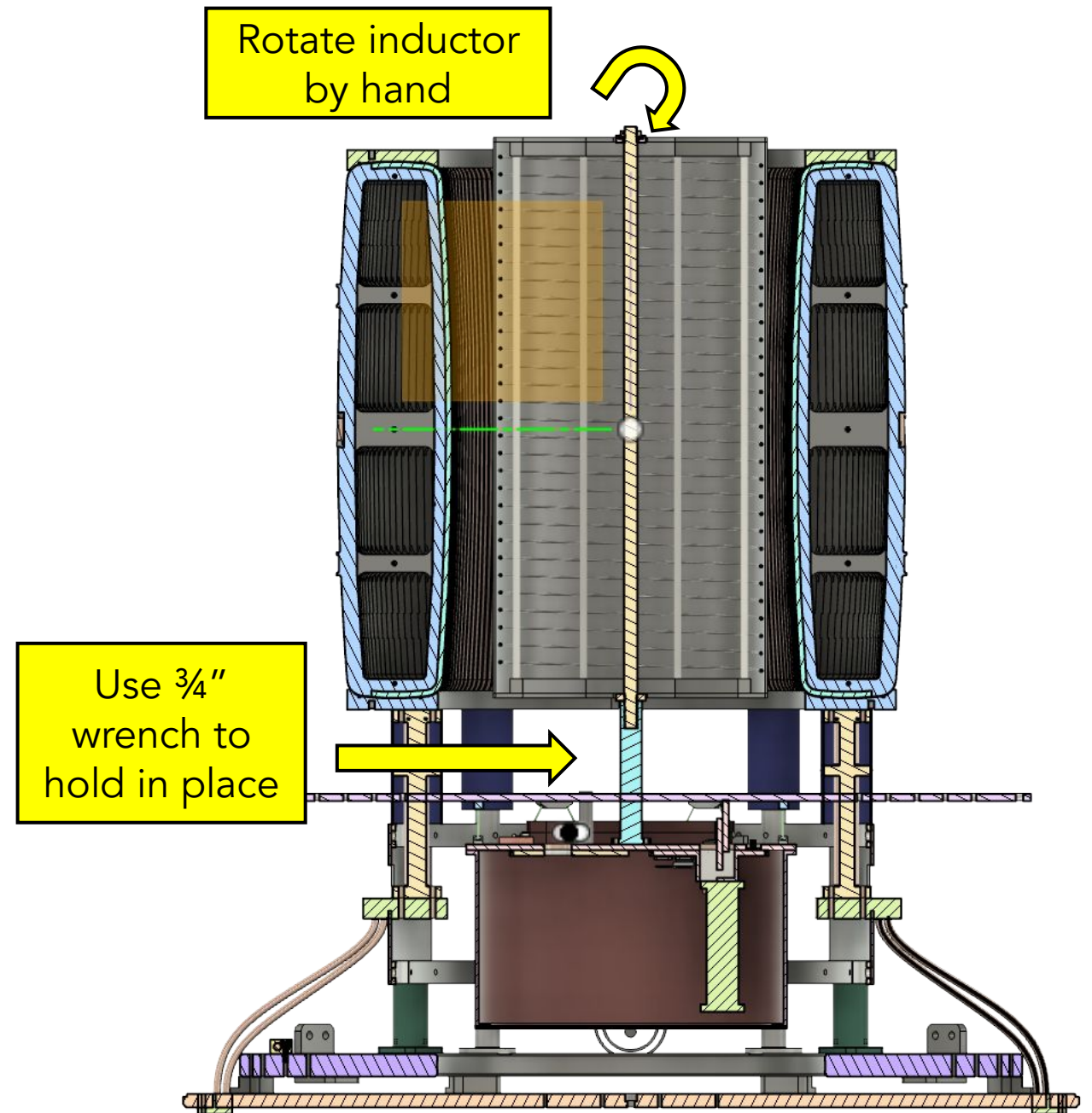




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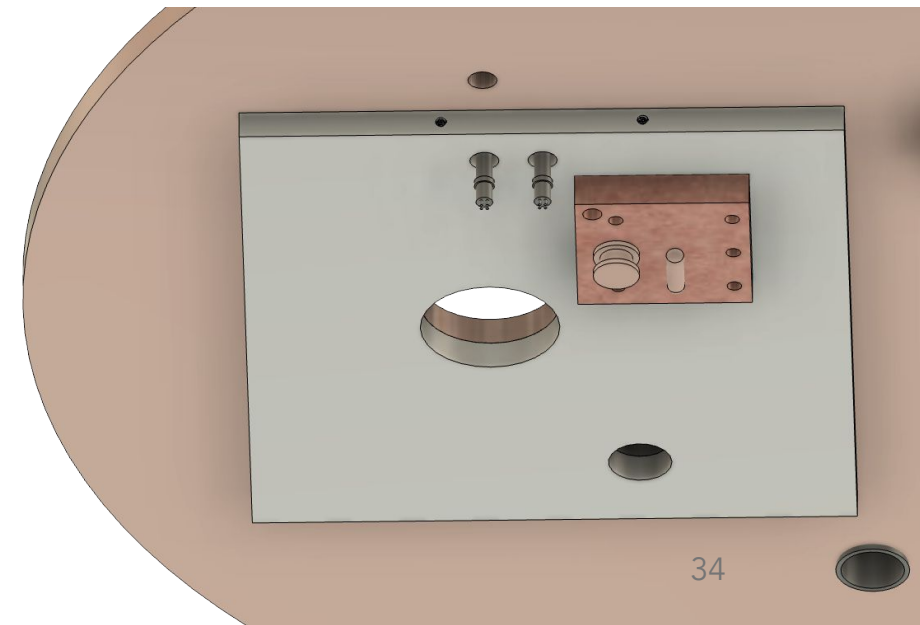
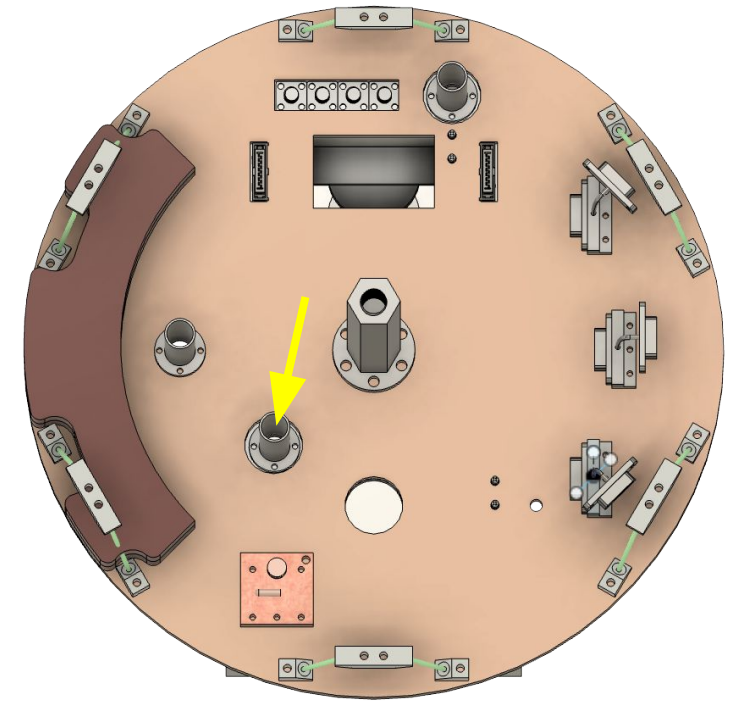


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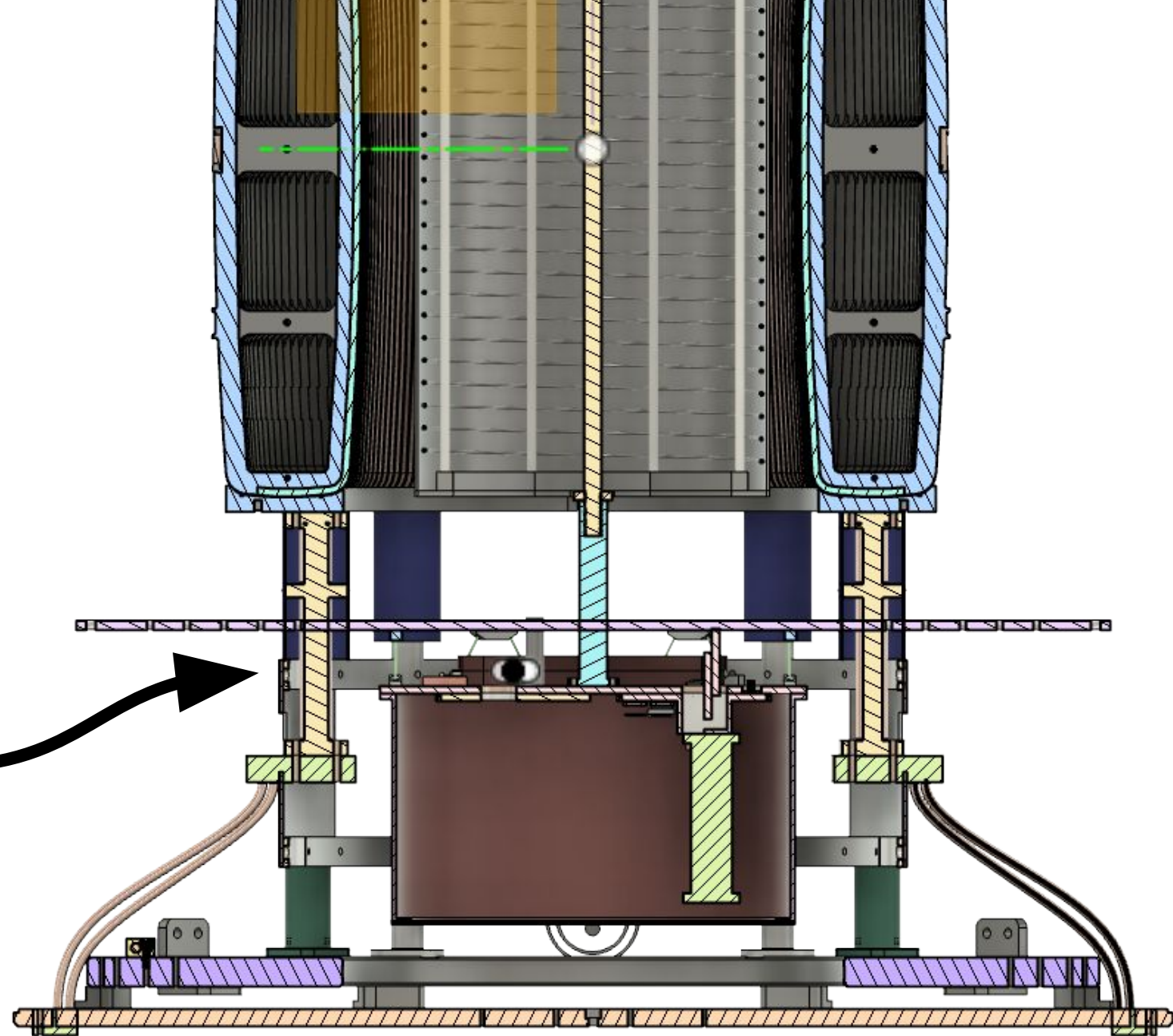
4.IV.a Remove C hutch body  
4.IV.b Bring L wiring through thru hole  
4.IV.c Complete screw terminal connection  
4.IV.d Mount C hutch body



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5.1. Remount support ring



# Open Questions

- Are there other 20mK parts or requests?
- How/where do we inductively couple the resonator to the readout?
- Does the inductor vertical mounting rod sufficiently constrain the xy motion of the inductor?
- How do we assemble the Attocube mounted on 1K with the transformer?
- Do we have enough flexibility in the wiring?
- Is a  $\sim 100$  kHz needle search an acceptable first campaign for the collaboration? (1nF, 24mH)

# Timeline

## 20mK Timeline

PROJECT TITLE	20mK Stage	COMPANY NAME	DMRadio
PROJECT MANAGER	Jessica Fry	DATE	7/5/24

PHASE	DETAILS	July 2024																October																										
		Week 1				Week 2				Week 3				Week 4				Week 11			Week 12			Week 13			Week 14			Week 15														
PROJECT WEEK:		8	9	10	11	12	15	16	17	18	19	22	23	24	25	26	29	30	31	1	2	18	19	20	23	24	25	26	27	30	1	2	3	4	7	8	9	10	11	14	15	16	17	18
1	<b>Project Conception and Initiation</b> - Rough CAD of all parts - Assembly sketch - Rough CAD review	Rough CAD				Assembly sketch																																						
2	<b>Shielding Design</b> - Detailed SQUID hutch design - Detailed Capacitor hutch design - Detailed through hole design - Shielding design review					SQUID hutch				Capacitor hutch				Through hole																														
3	<b>Capacitor Design</b> - Define design specifications - Design fixed capacitor - Fixed capacitor design review					Capacitor Design																																						
4	<b>Inductor Supports Design</b> - Simulate current inductor supports - Edit current inductor support design - Edit current inductor shielding - Inductor design review																	Simulate induc																										
5	<b>Wiring &amp; Aux Detectors</b> - Define list of aux detectors - Create thermalization plan - Define connector types & loc. - Design wiring shielding - Wiring review																																											
6	<b>Finalize Project</b> - Finalize necessary hole patterns - Design review - Order parts - Commission 20mK space																	Finalize hole pattern			Order parts																							

Sept 25. 20mK plate hole pattern finalized & parts ordered  
Oct 9. Parts delivered