Magnet Overview

Chelsea Bartram

06/26/2023

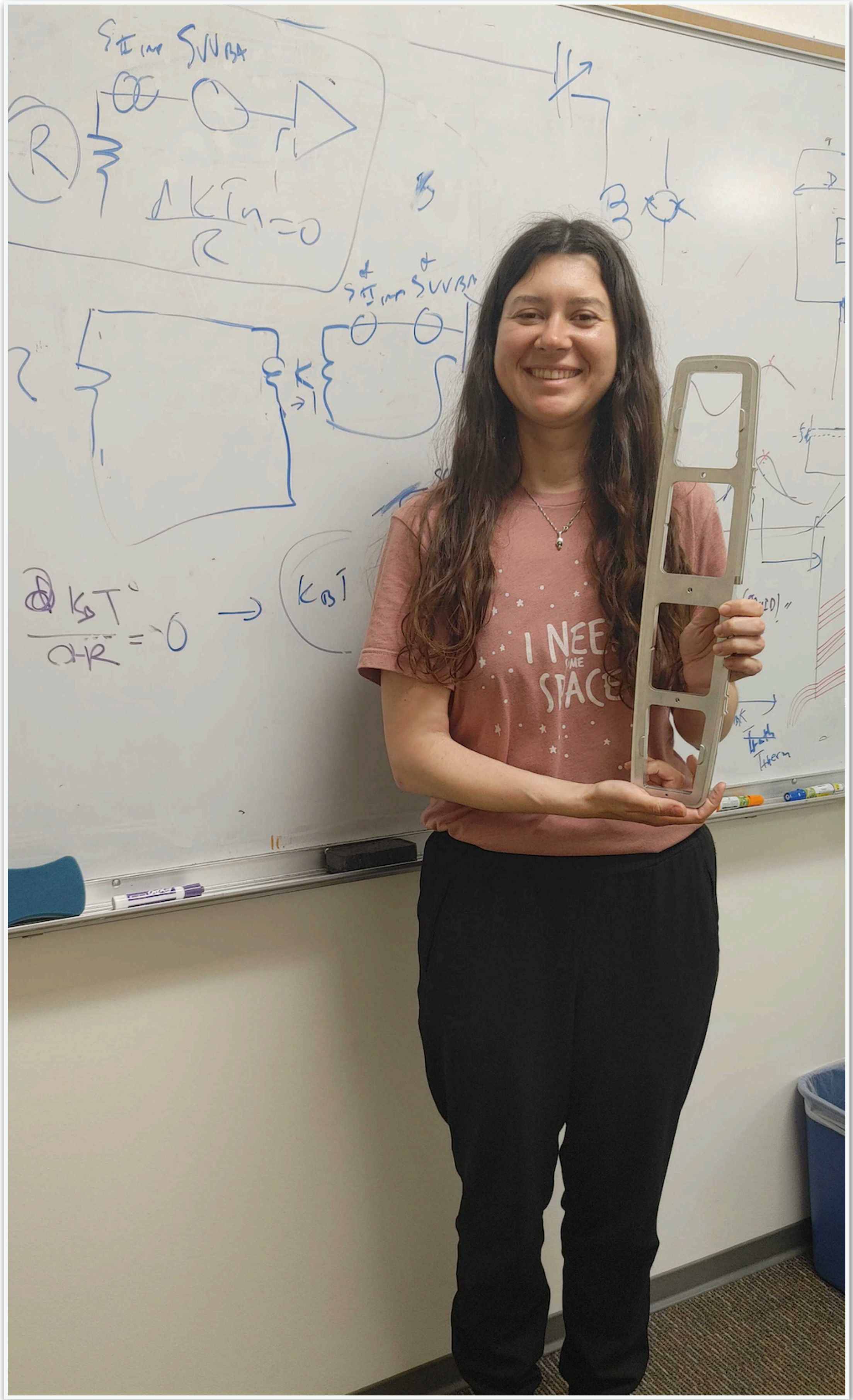
Notable milestones

- 12-21-2023: Al 3003 shipped to Marty for wedge machining
- 01-18-2023: Practice winding happens at SSI
- 02-14-2023:
  - Discussion of where to put HTS leads and diode tower initiated
  - Discussion about heat leak to 1K plate via HTS leads: risk is not yet clear

Notable milestones

Wedge Machining

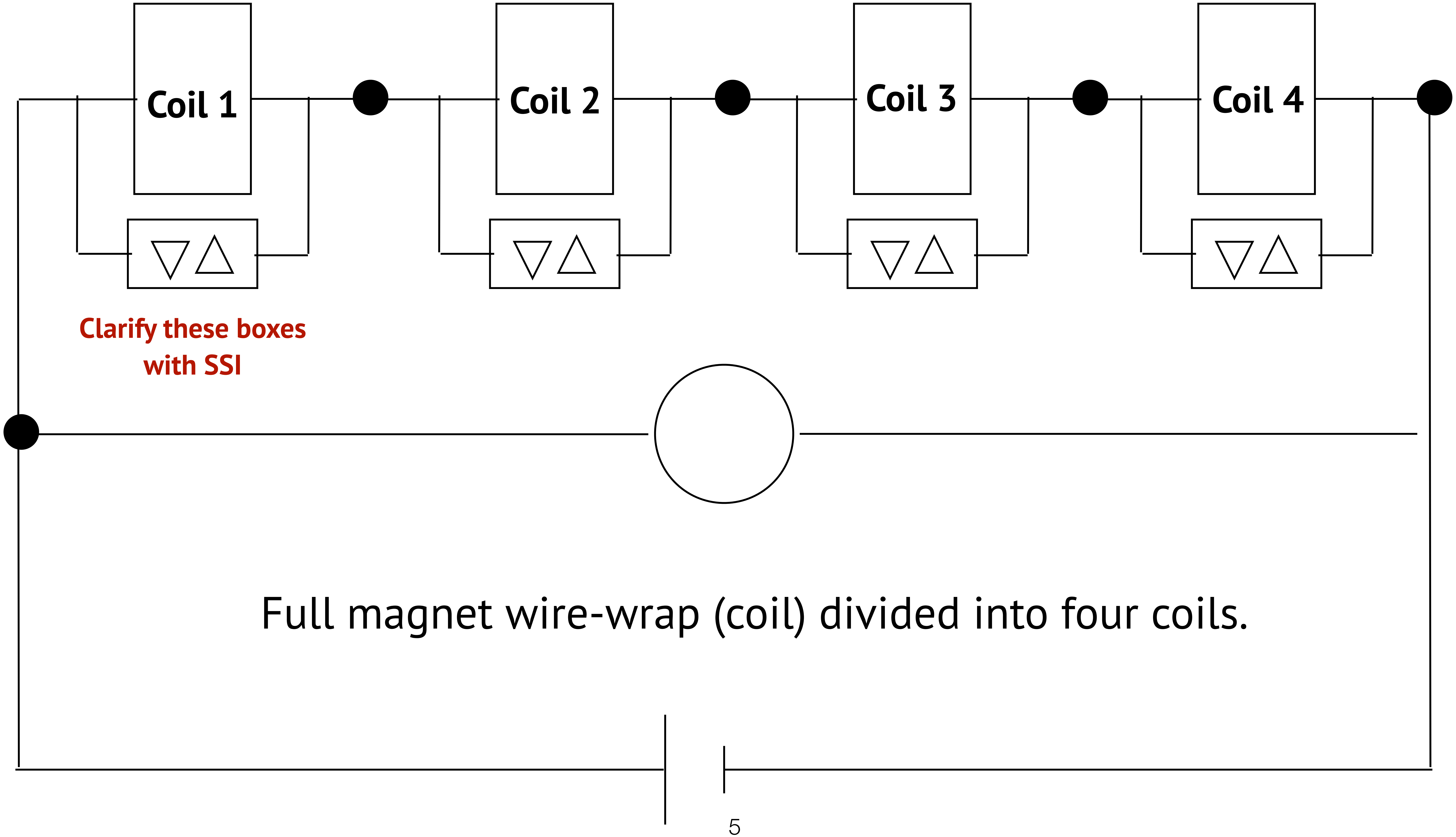
- 05-26-2023: Test wedges arrive at Stanford!
- 06-07-2023: SSI receives 134 wedges, including previous 9 pieces for a total of 143 pieces
- 06-08-2023: SSI receives endcaps
- SSI will commence wire-wrap week after July 4th.



Bonding Tests

Jamie reported no issues after bonding 10 ‘test’ wedges.

Circuit Diagram

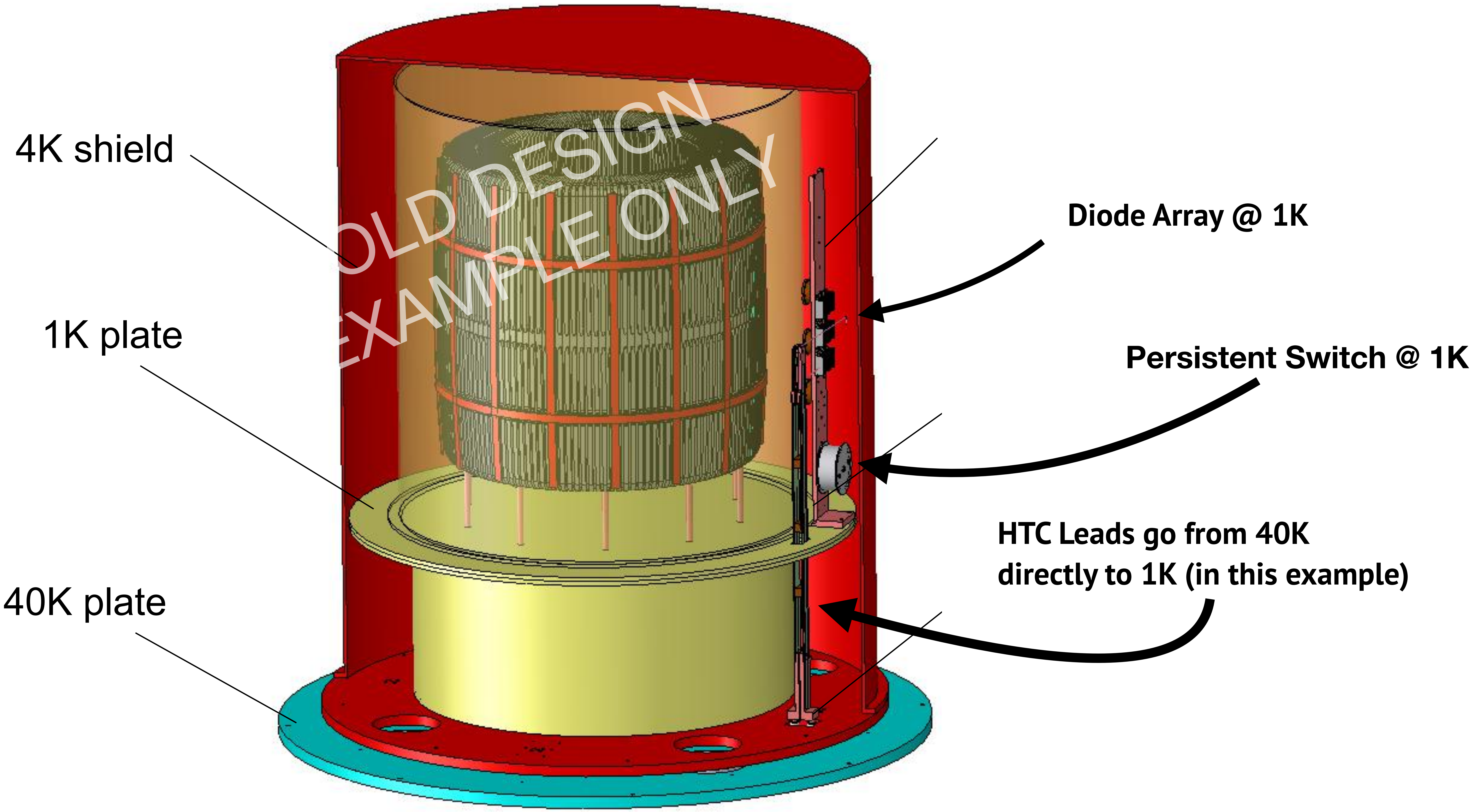


Full magnet wire-wrap (coil) divided into four coils.

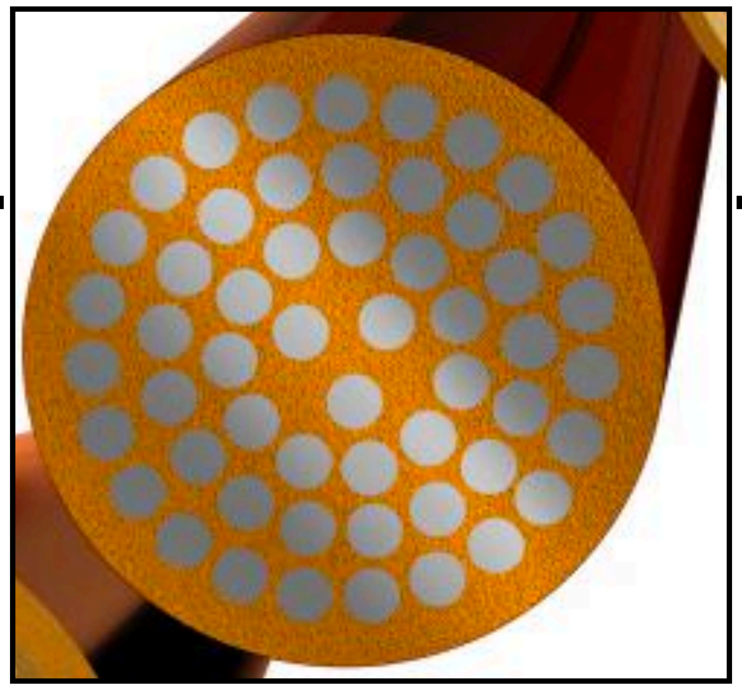
EXAMPLE ONLY!

CAD Mock-up

EXAMPLE ONLY!



Magnet Thermal Considerations



Cartoon rendering of standard SSI magnet leads

- Magnet wires (there are 4):
  - 75% Cu, 25% NbTi
  - Diameter. 0.7 mm, Length = 1m
- Need to solve this!

→ **10 mW!**

- Replace wire with NbTi —> dangerous in quench
- Wire with HTc wires with no copper —> joints are hard
- Lengthen wires
- Change switch thermal sinking and/or magnet thermal sinking

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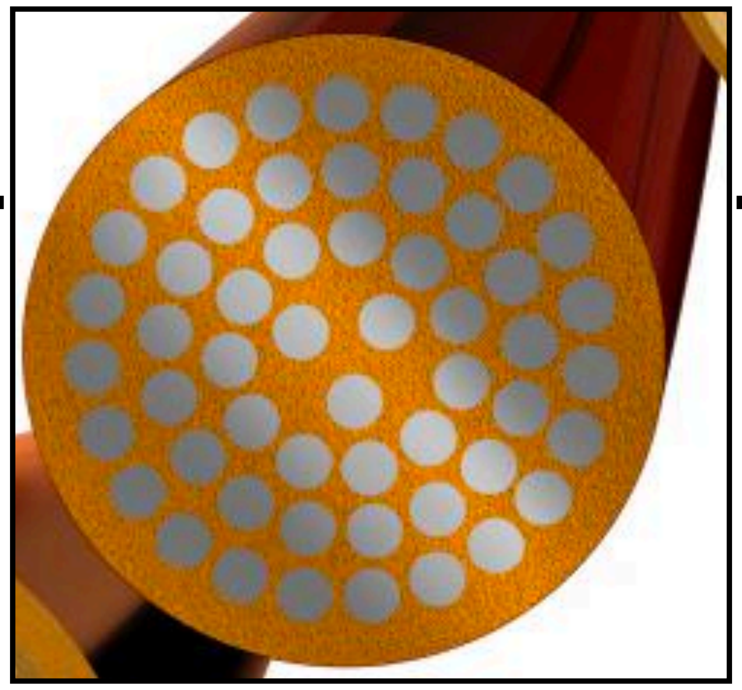

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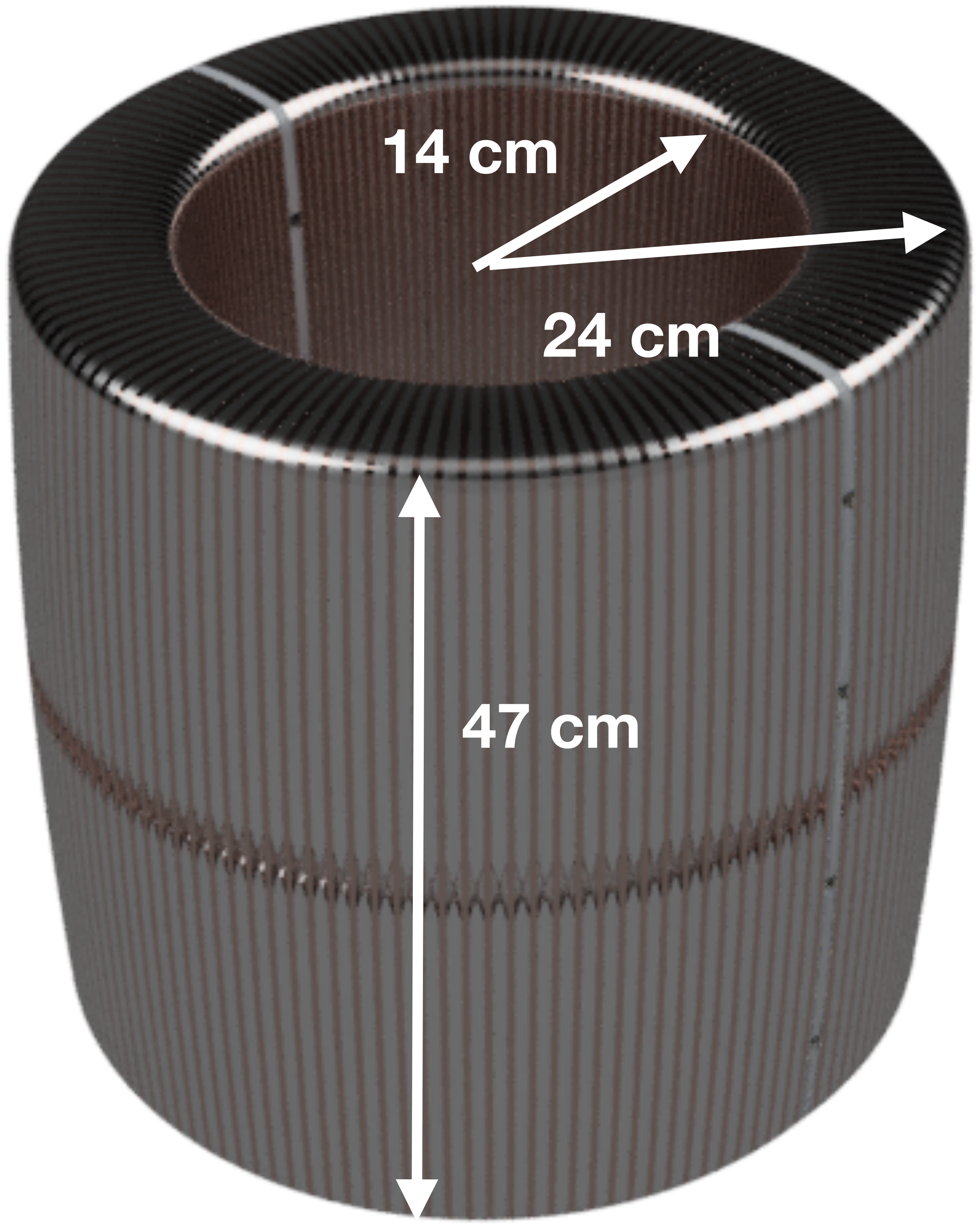
Magnet Quench Considerations

$$U = \frac{1}{2\mu_0}\int B^2 dV \approx \pi r_1^2 h \ln\left(\frac{r_2}{r_1}\right) B_{max}^2 \approx 5\,\mathrm{kJ}$$

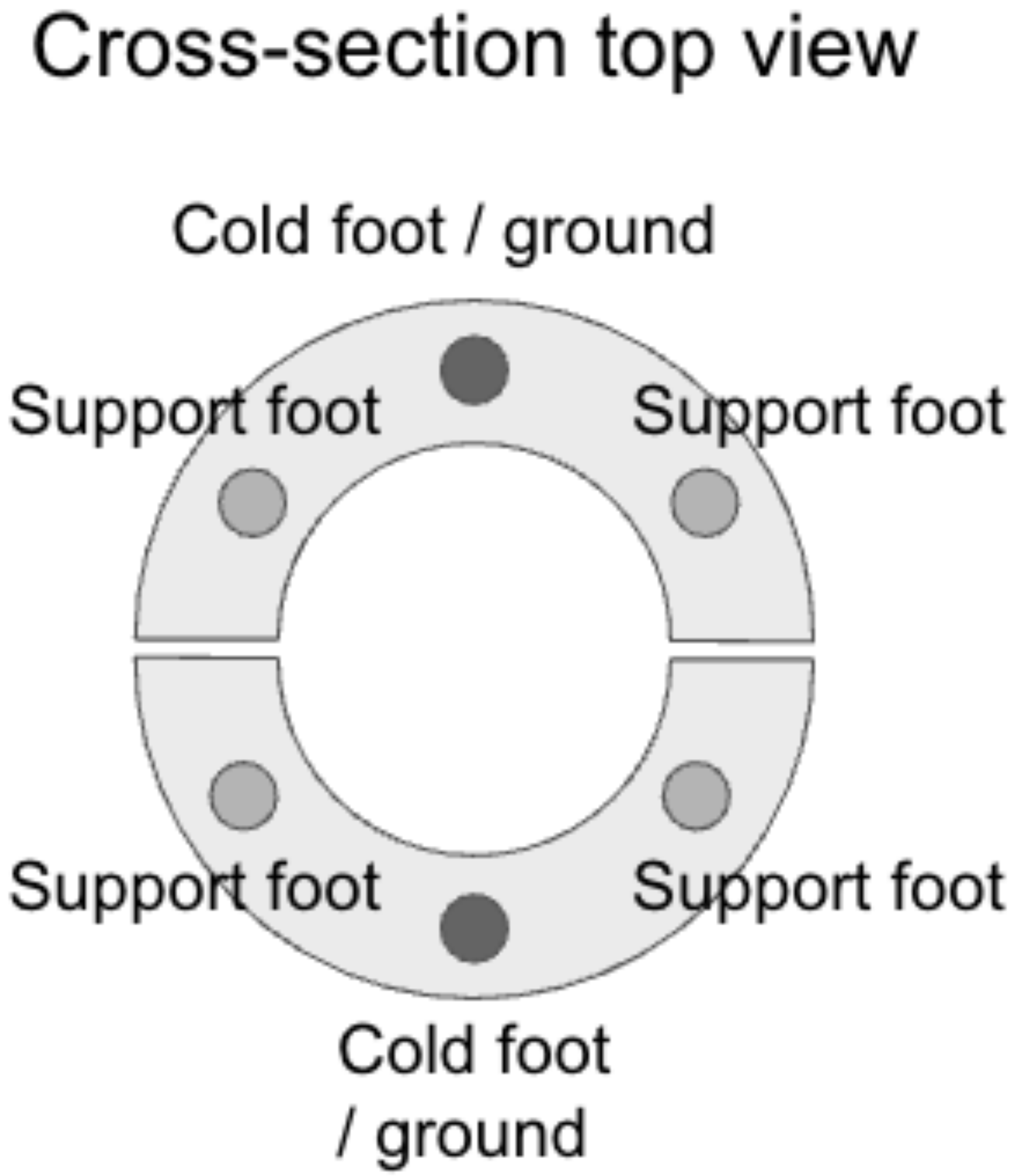
- Claim (ignoring heat capacity of Cu wires): all energy dissipated in few seconds and $T_{mandrel}$ = 24K

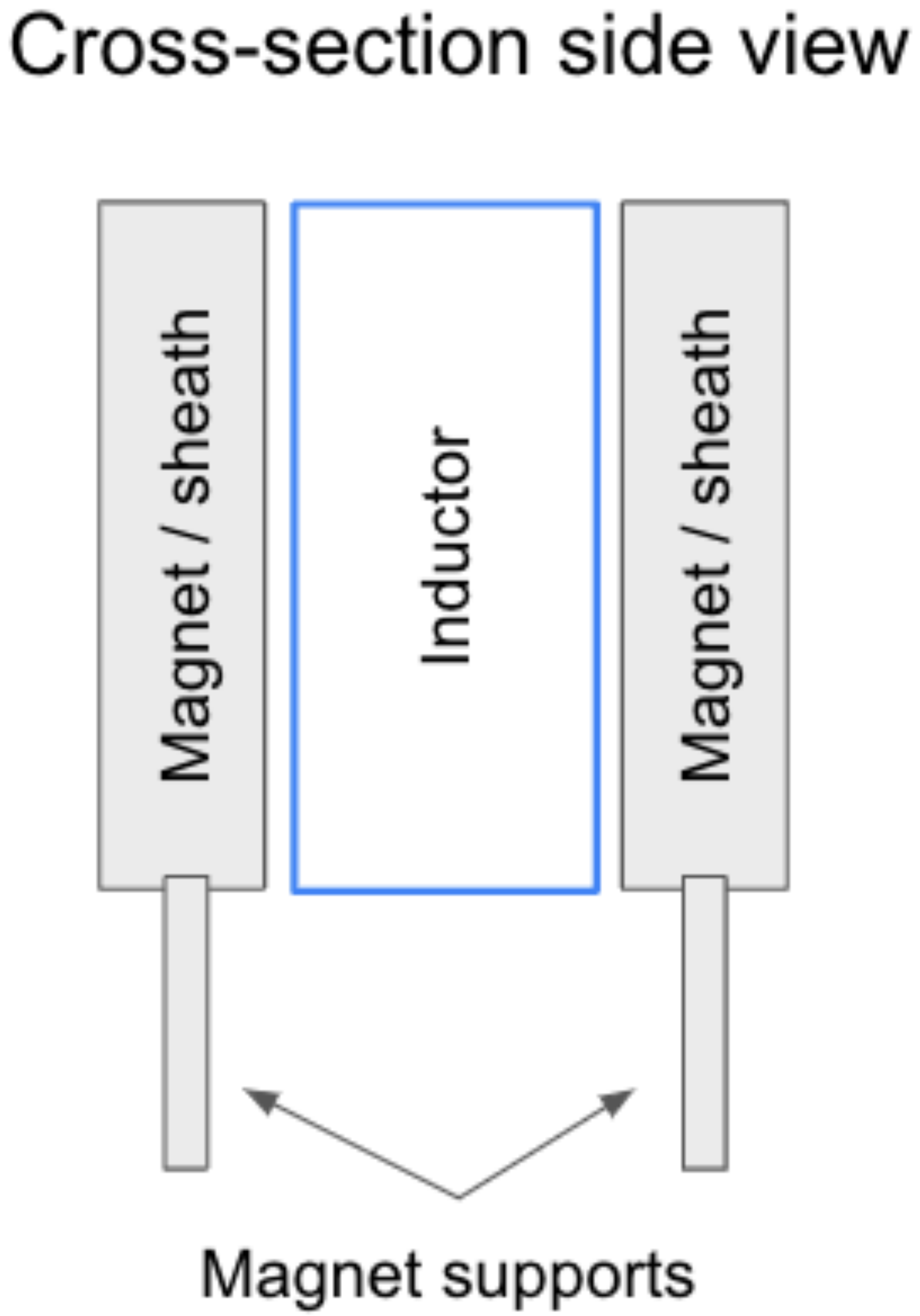
Other people besides Jon should verify this calculation!
Put in Jupyter notebook!
Chelsea has new student: Molly Hammond?

Calculations in Google doc link:
https://docs.google.com/document/d/1LVQSg5x6R8rjwDcVc8dMjzAs86HNoMqc-eIg_KzZAAM/edit?usp=sharing



Cartoon model



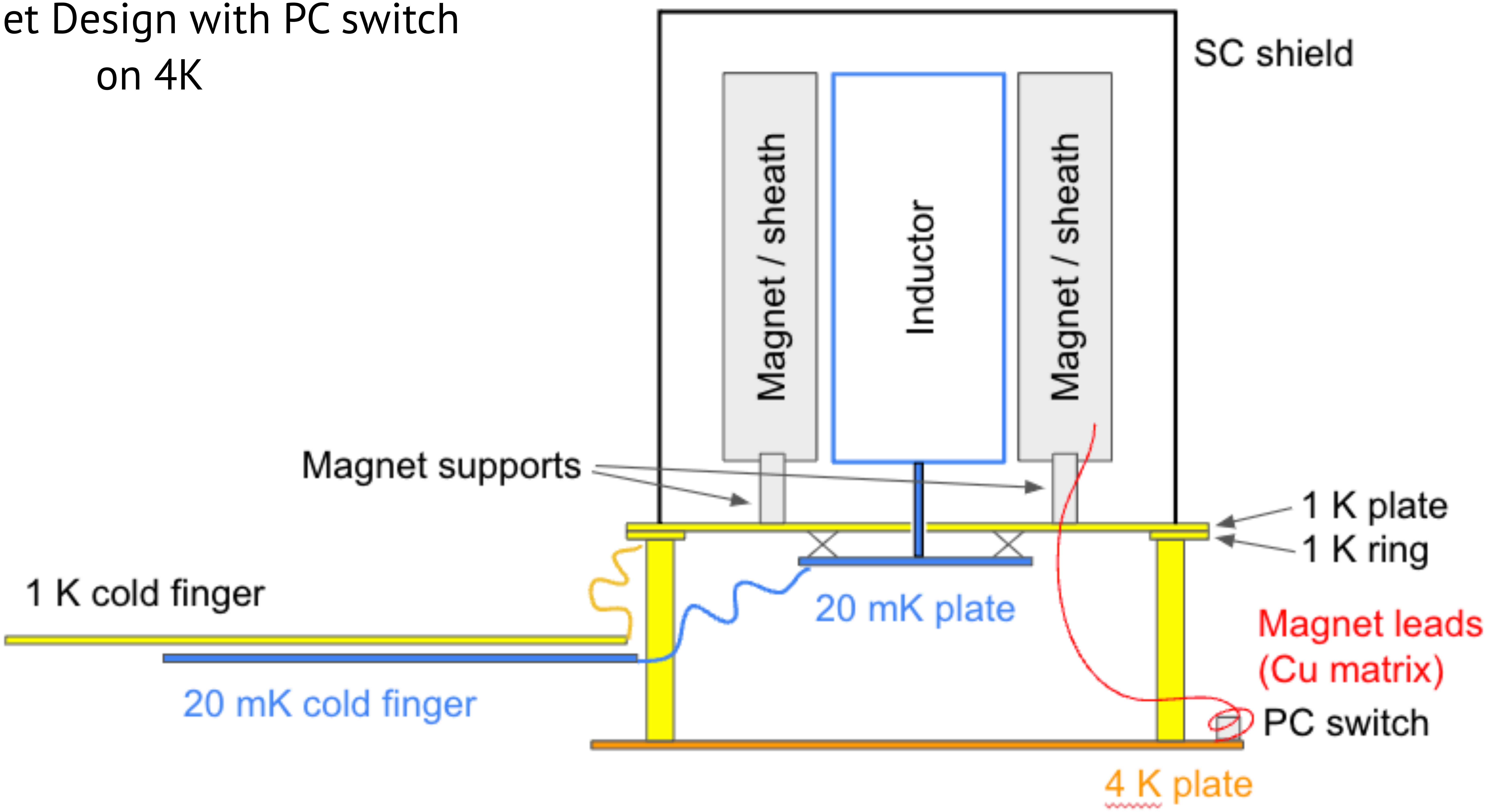


Magnet weight: ~200 lbs

***Credit to Maria Simanovskaia**

Cartoon model

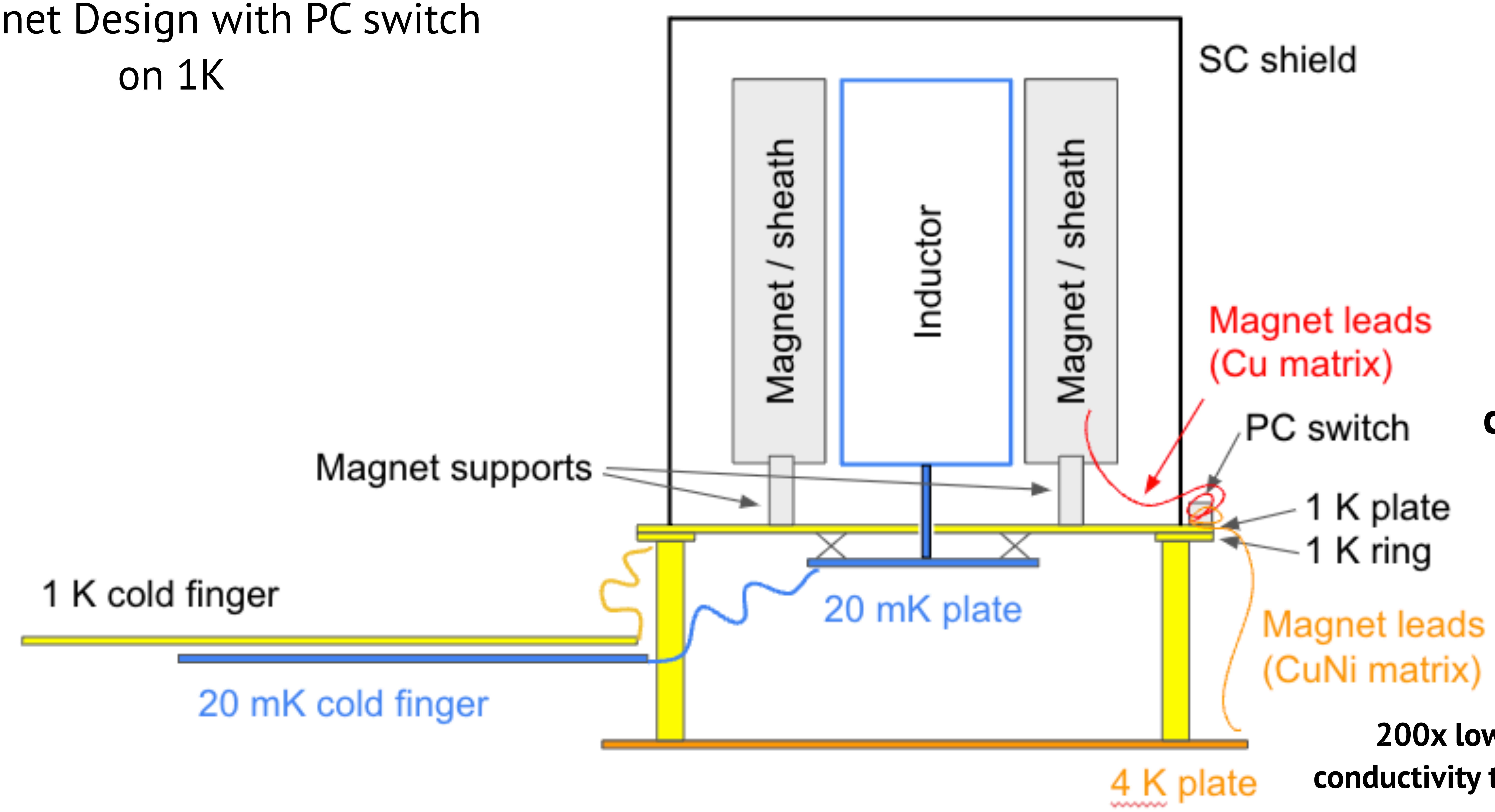
1K Magnet Design with PC switch on 4K



*Credit to Maria Simanovskaia

Cartoon model

1K Magnet Design with PC switch on 1K



200 mW of heat when charging. Must charge at 4K.

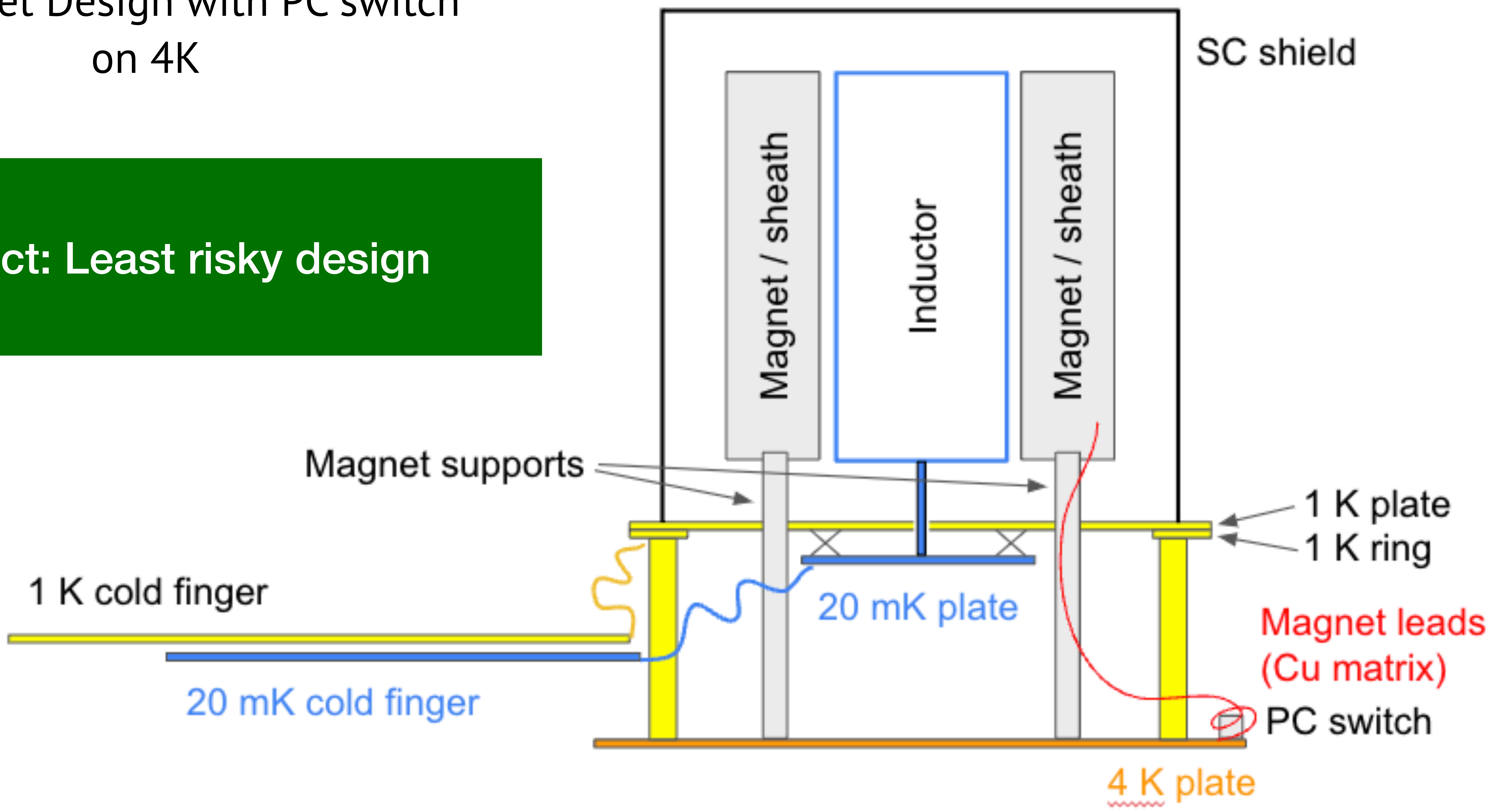
200x lower conductivity than Cu

***Credit to Maria Simanovskaia**

Cartoon model

4K Magnet Design with PC switch
on 4K

Verdict: Least risky design



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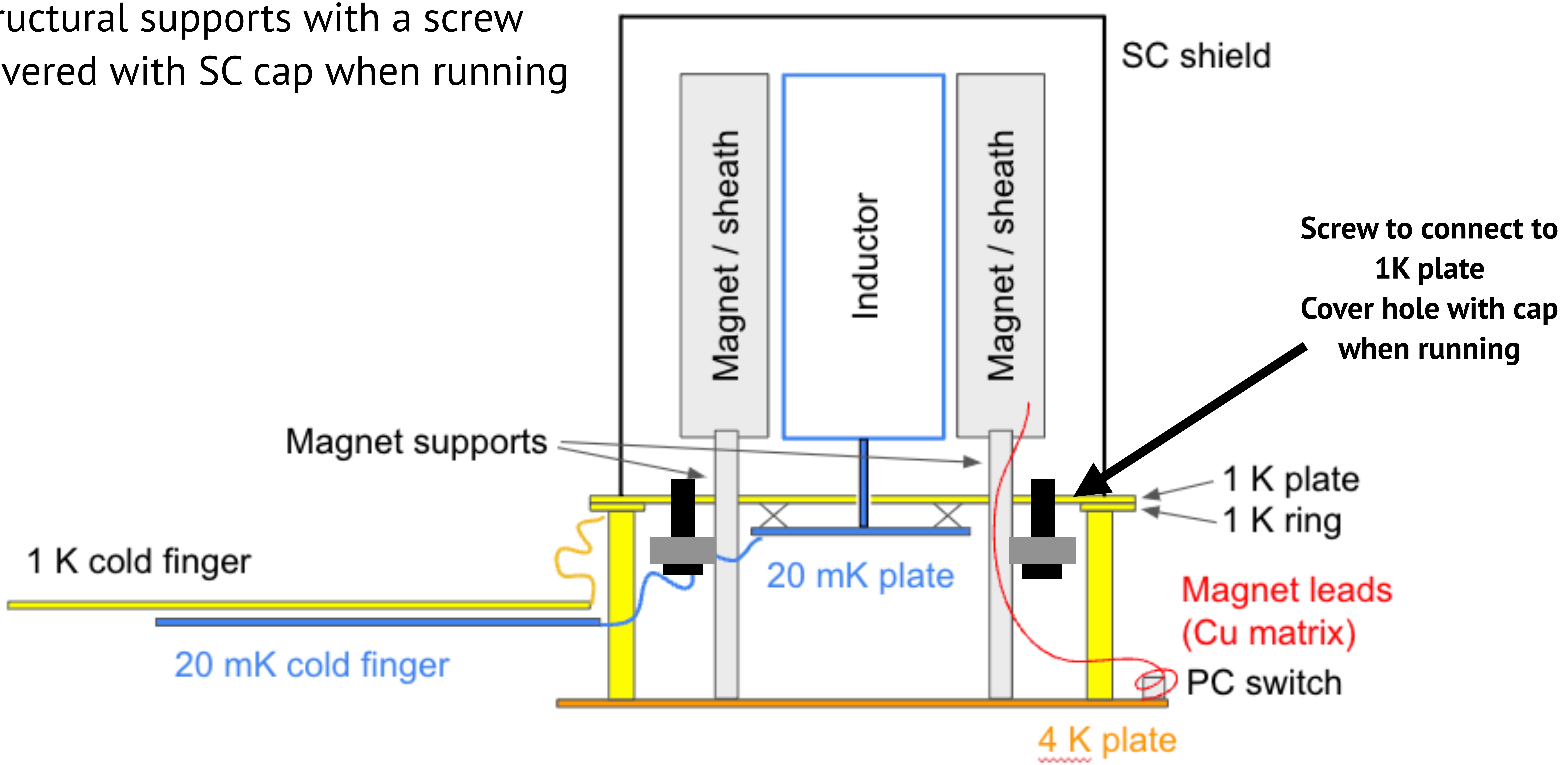
Magnet Disassembly Considerations

Need to connect:

- 4K magnet structural supports with a screw
- Screw hole covered with SC cap when running



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Need to connect:

- 4K magnet structural supports with a screw
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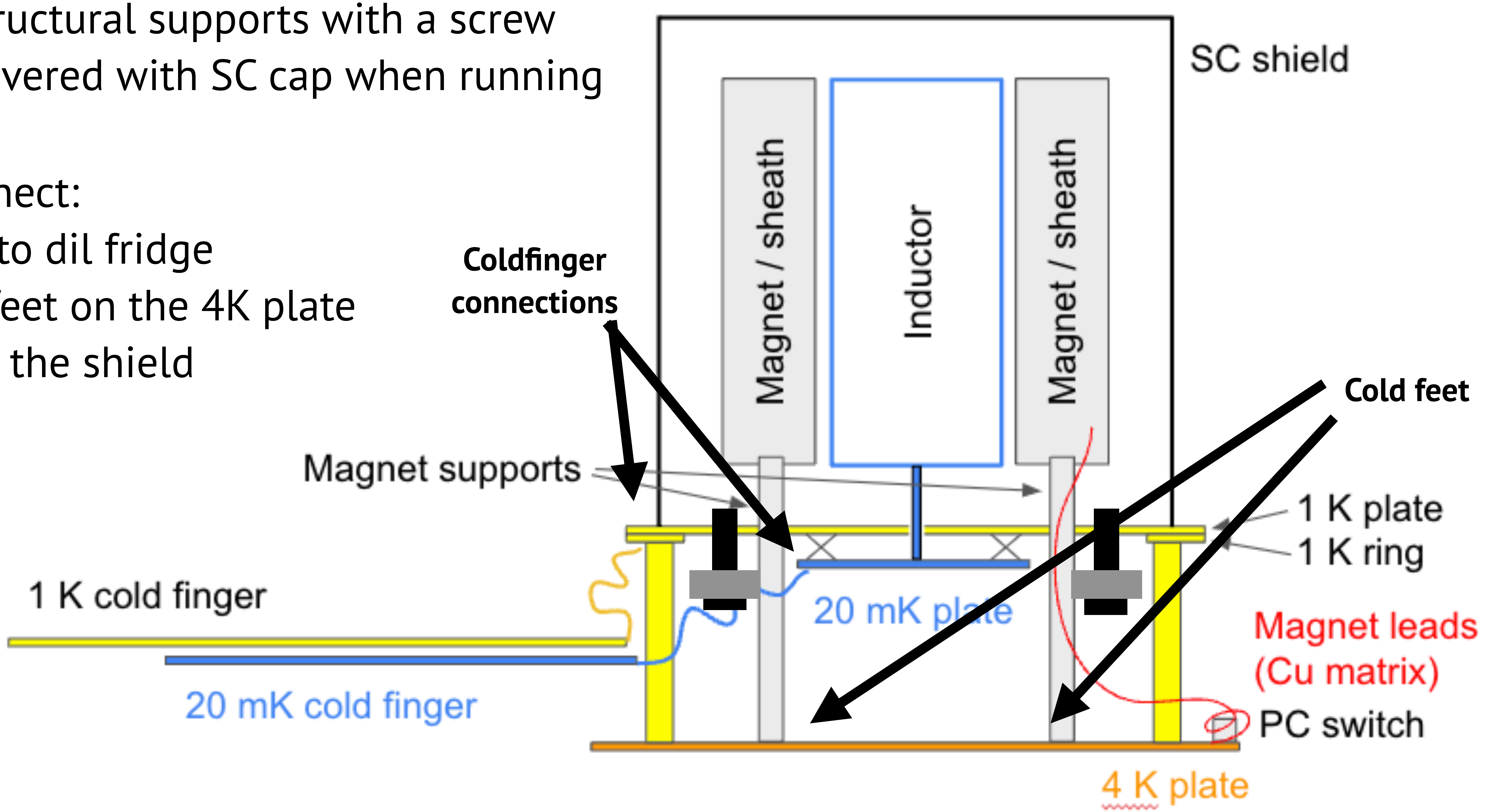
Need to disconnect:

- 2 coldfingers to dil fridge
- Magnet cold feet on the 4K plate
- 1K plate from the shield
- 4K shield



Magnet sensors

- SSI magnet temperature sensors:
  1. RuOx (RO600) on switch
  2. RuOx (RO600) on coil
  3. Silicon diode (Si410 or SI415) on coil
  4. Silicon diode (Si410 or SI415) on the HTS
  5. One “undecided”: usually between coldfingers and magnet

There are 4 coils. Should we request one sensor per coil?

Risks

- Thermal load is too big and we do not have sufficient cooling power to reach 1 K
  - Risk level: **HIGH**
  - Mitigation: Development of 3 alternative designs. Requiring new thermal calculations and exploring ways to improve radiative loads and increase cooling power available.
- Quench forces are too strong and crush the dielectrics
  - Risk level: **MEDIUM**
  - Mitigation: Testing dielectric pieces with a press. Requesting quench force estimate from SSI. Development of tensioning strap to maintain magnet alignment.
- Magnet cannot be easily removed and disassembled from the cryostat.
  - Risk level: **LOW**
  - Development of 3 alternative designs. Continued simulation of structural supports.

Magnet Timeline

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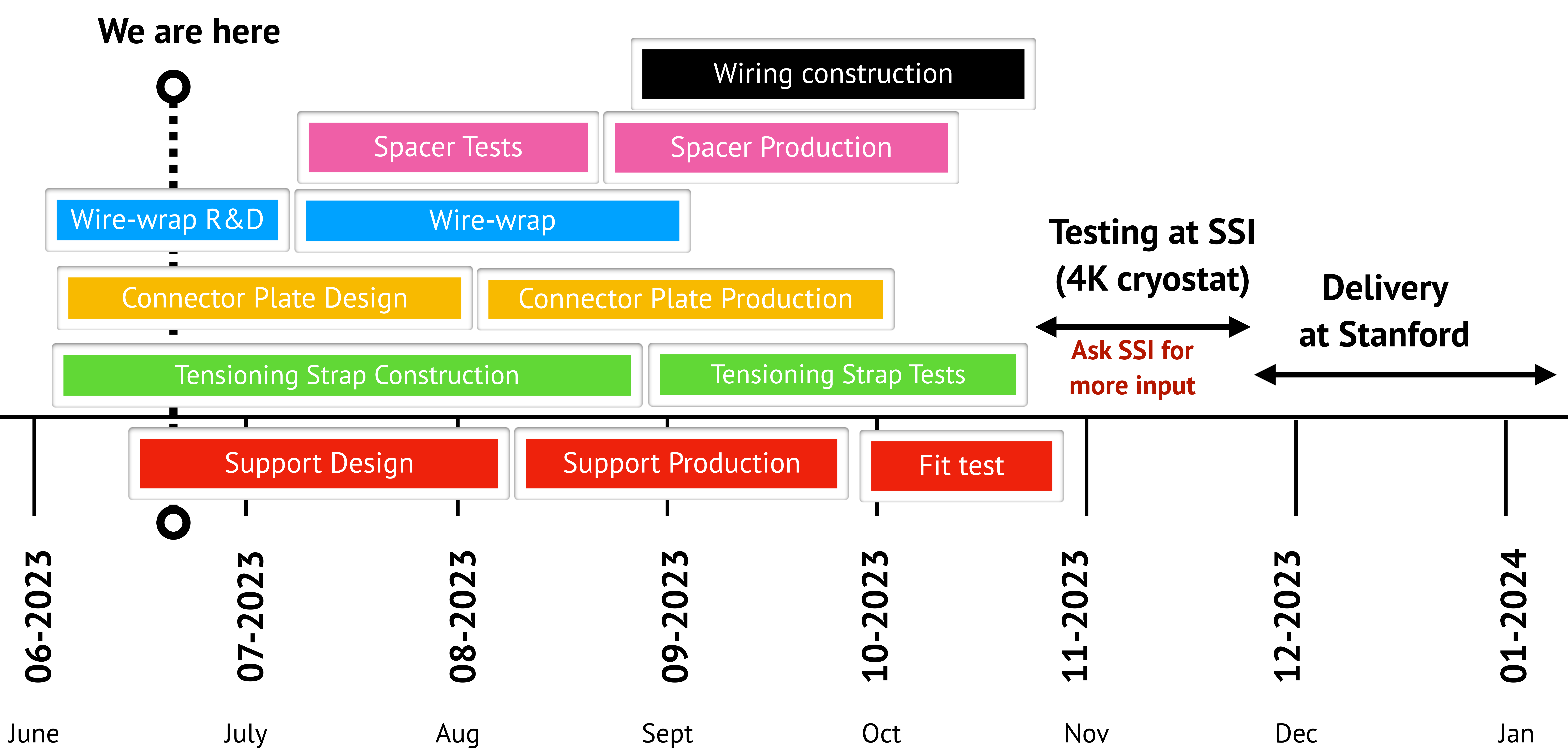


Magnet Timeline

Near-term Task List

- SSI wants a template for cutting teflon sheet according to the contour of the wedge —> submit quote to Fictiv or other company quickly (need by July)
- Ensure Jamie has clarity on the 4 K magnet plan: some confusion over physics location of magnet vs thermal sinking
- Improved thermal simulations of all magnet components: Alex D. —> supports, but need more. Thermal notebook on GitHub*.
- Full CAD workup (requested by Karl) —> Who is responsible?
- Other?

***Credit to Jon Ouellet**

Thanks!

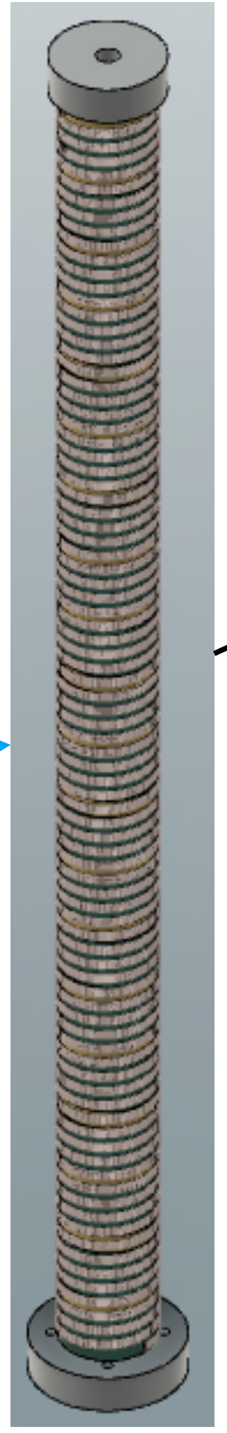
Look under "**Miscellaneous Meeting Notes**" on DMRadio confluence for 4K magnet documentation by Maria

- https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=383927015
- https://confluence.slac.stanford.edu/display/DMRadio/2023-06-08+Magnet+Leads+Meeting+notes
- https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=383933070
- https://confluence.slac.stanford.edu/display/DMRadio/2023-06-14+conceptual+4+K+magnet+design+brainstorm+Meeting+notes
- https://confluence.slac.stanford.edu/display/DMRadio/2023-06-20+SSI+Meeting+notes

Backup

Barber's pole

- Combination of G10 for thermal insulation and brass to provide heat sinks for wires in a quench
- 40 cm total height
- Extends the wires to 7m, but heat also passes through G10 pole
- Naive thermal calculation gives 900 uW heat load from 4K to 1K
- Alex D ran COMSOL simulation gives 1.1 mW heat load from 4K to 1K



Broken Barber's pole

- Can extend the concept in height, but bring the wires back to the 1K plate
- 82 cm total height
- Extends wires to 21m
- Extrapolation gives 400 uW, but perhaps other things come into play → this design probably needs better structural support, which might short the heat path
- How do you wind this?

Wire schematic