National Aeronautics and Space Administration

FY24 R&TD Innovative Spontaneous Concepts (ISC)

High Temperature Superconductors for Space Quantum Applications

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Strategic Focus Area: Innovative Spontaneous Concepts

Objectives: This proposal aims to investigate the feasibility of using HTS coils for Space and/or Moon applications, specifically for quantum applications. As part of the feasibility, we will develop a thermal model and derive a passive-cooling mechanism down to the superconductor critical temperature to use REbCO, GdBaCuO and YBCO-based coils in Space or on the Moon. Furthermore, we will derive requirements for the next generation of current driver assemblies for HTS-based magnetic field circuits.

Experiment setup using LN2, GdBaCuO coils and a magnetometer

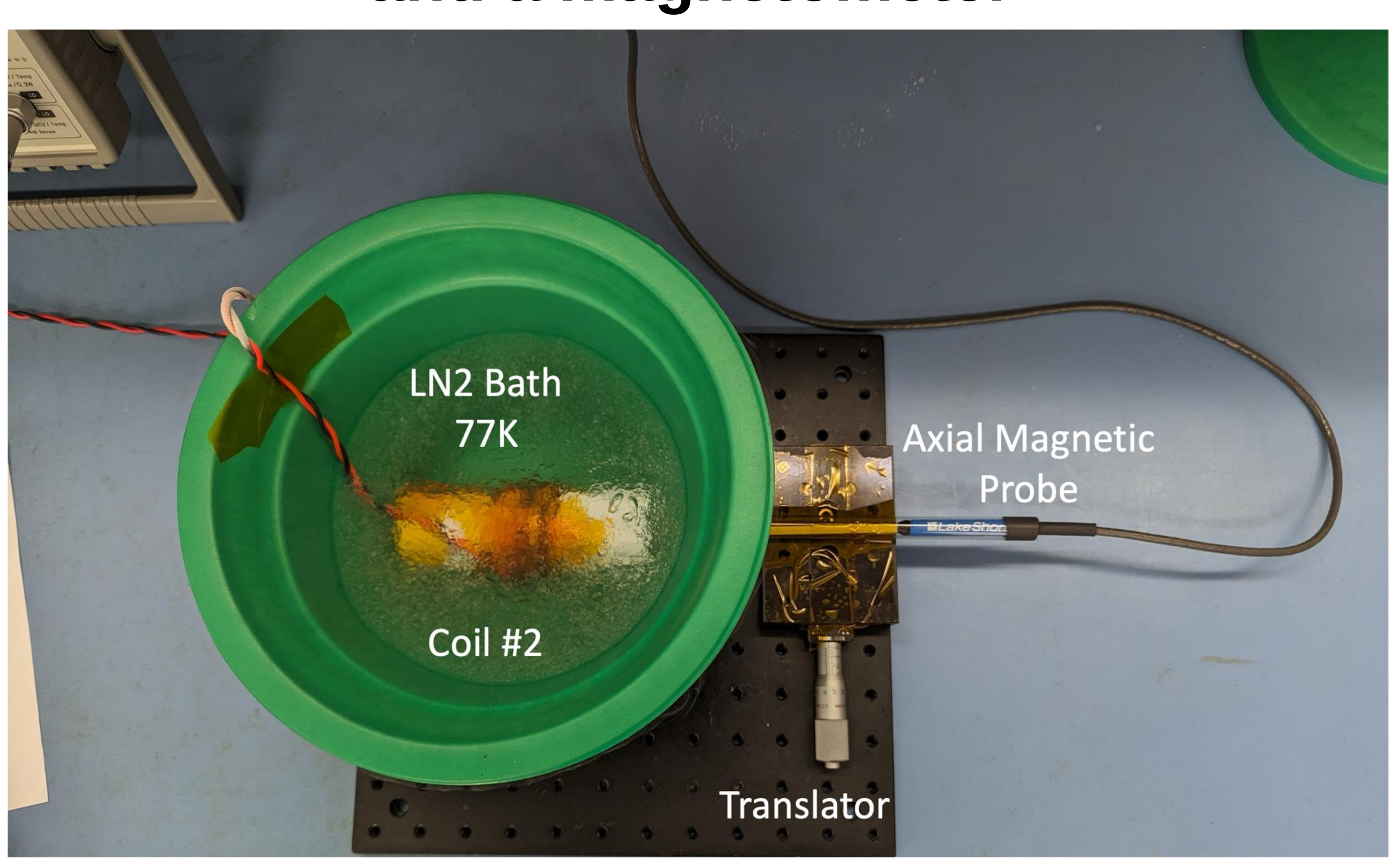
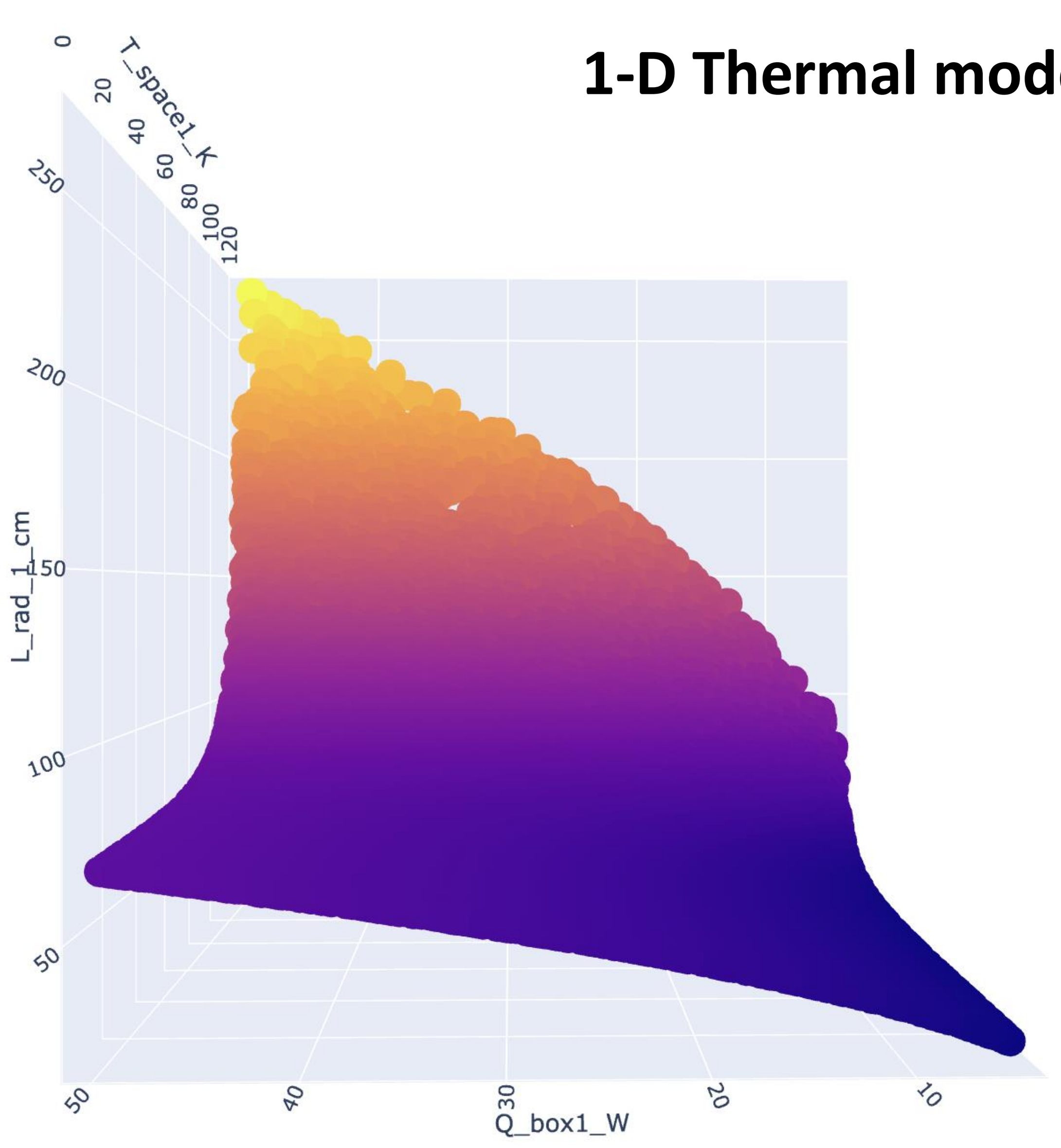


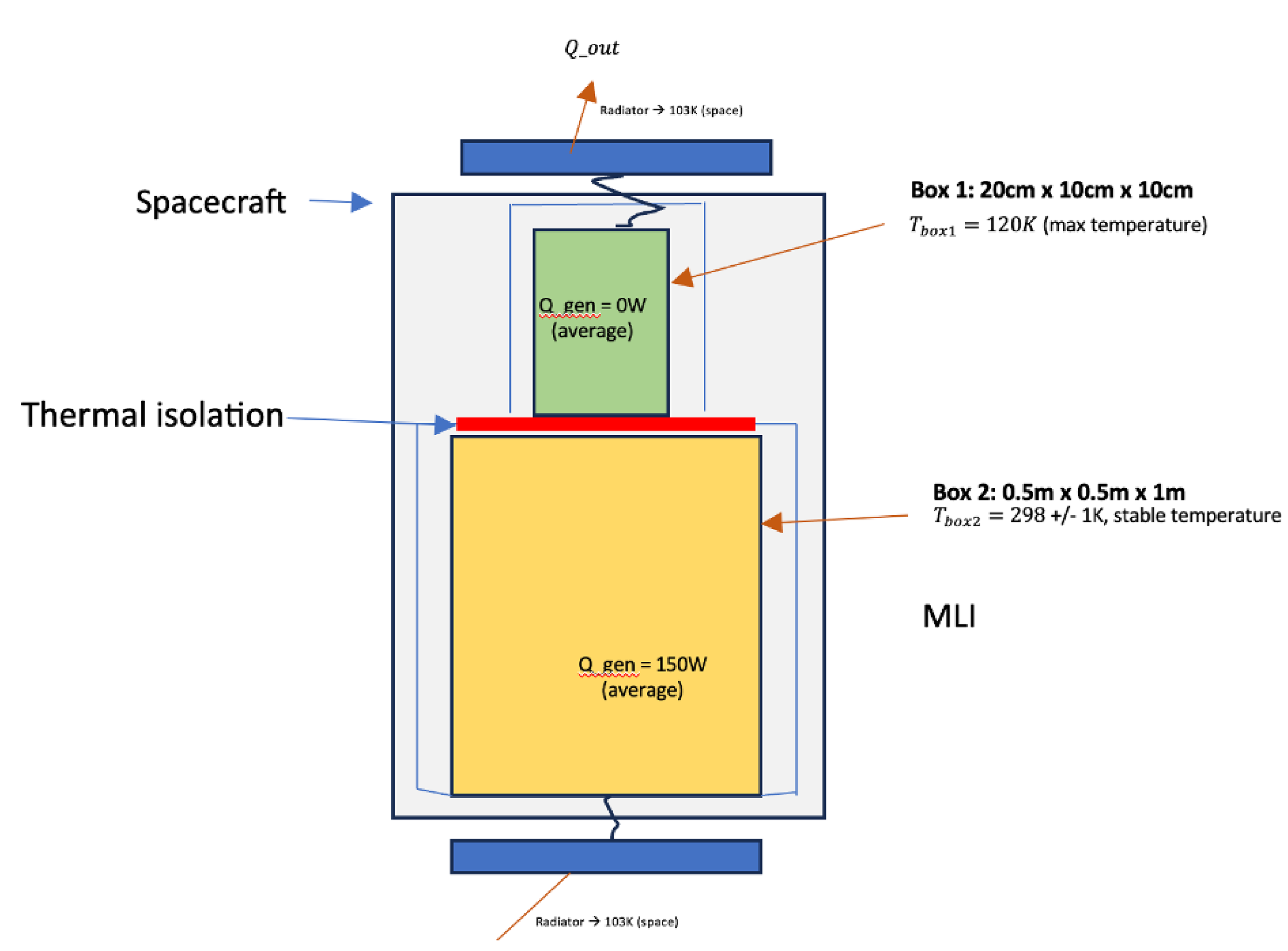
Table summary of the 7 coils what we build and tested

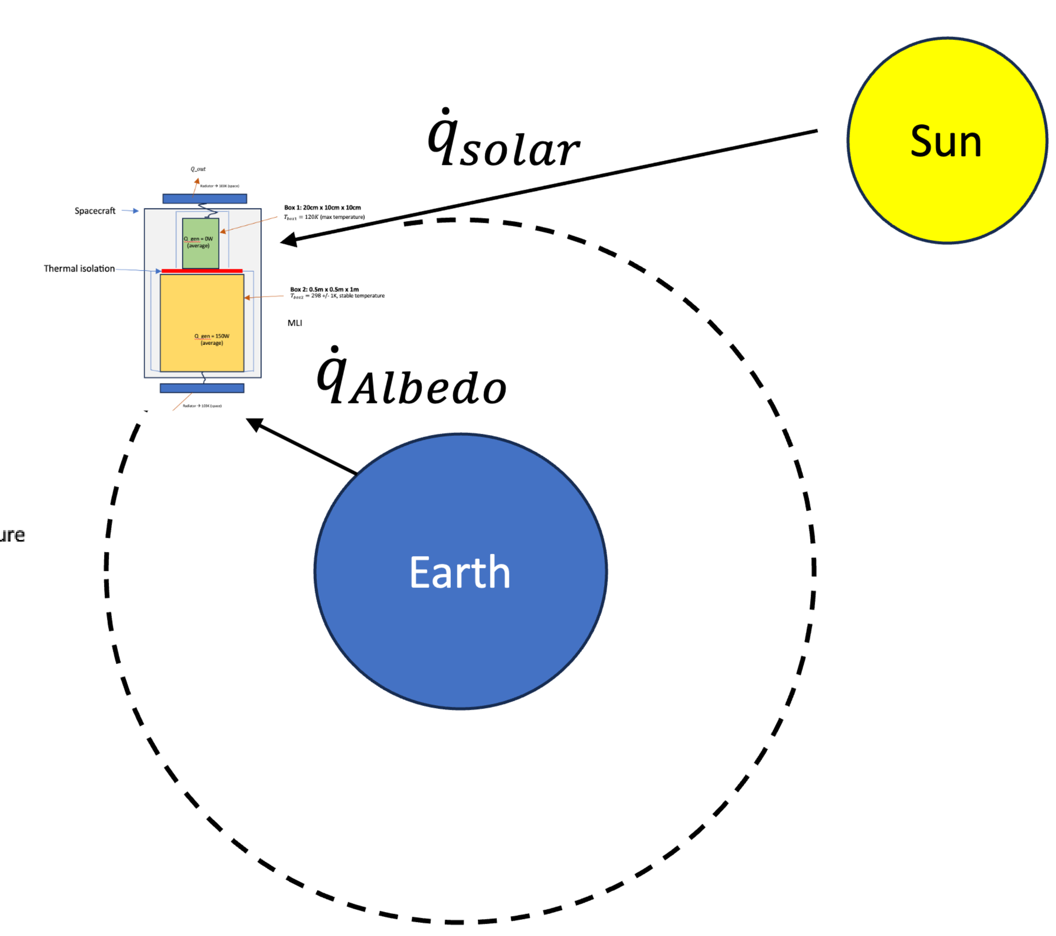
	Coil #1	Coil #2	Coil #3	Coil #4	Coil #5	Coil #6
N	50	20	75	20	98	50
Length	8.4 m	3.2 m	12.8 m	3.2 m	26.2 m	13.4 m
Starting marker	183.2 m	174.8 m	171.2 m	NA	61.8 m	36.2 m
End marker	174.8 m	171.6 m	158.4m	NA	35.6 m	49.6 m
coil isolator	cooper	Kapton tape	cooper	PVC	Kapton tape (@10 turns)	
Material	QS220020 (130 A) GdBaCuO			cooper	QS220027 (130 A) GdBaCuO	
Meas. Resistivity (300K)	0.108 Ω	0.563 Ω	0.108 Ω	0.332 Ω	0.201 Ω	0.0989 Ω
Meas. Resistivity (77K)	0.014 Ω	0.075 Ω	0.01 Ω	0.014 Ω	0.03 Ω	0.049 Ω
Power ratio 300/77K	7.6	6.8	2.5	3.2	6.4	2.5
Cable type	AWG14	AWG14	AWG14	AWG14	AWG14	AWG14
Solder type	In97Ag3	In97Ag3	In97Ag3	In97Ag3	In97Ag3	In97Ag3
Measured Diameter	4.445 cm	4.445 cm	4.445 cm	4.445 cm	7.62 cm	7.62 cm

1-D Thermal model created to evaluate the feasibility of achieving T>120 K in LEO



Solution space for achieving 120 K: required size of the radiator for a given space temperature and instrument dissipator.





Results/Conclusion: We conducted experiments on High Temperature Superconductors (HTS) made from GdBaCuO to evaluate their power efficiency, resistance levels, and applicability in space. Multiple coil configurations were tested under liquid nitrogen, achieving significant power reductions and micro-Ohm resistances. Alongside this, we performed thermal analysis, demonstrating the feasibility of cooling the HTS to 120K in space using passive cooling through radiators, without the need for a cryocooler. These findings suggest HTS can drastically reduce the Size, Weight, and Power (SWaP) requirements for spacecraft, making them ideal for generating magnetic fields with minimal power consumption. Future work will focus on further optimizing the integration of HTS into spaceborne quantum sensing systems.

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