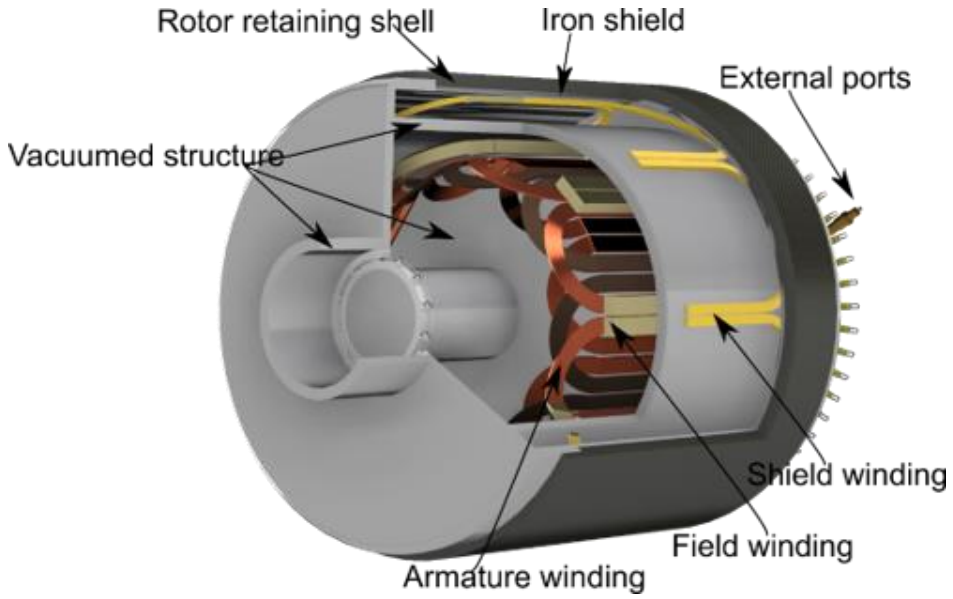
Fully Superconducting, Hydrogen-Cooled Motors for Electric Aircraft Propulsion



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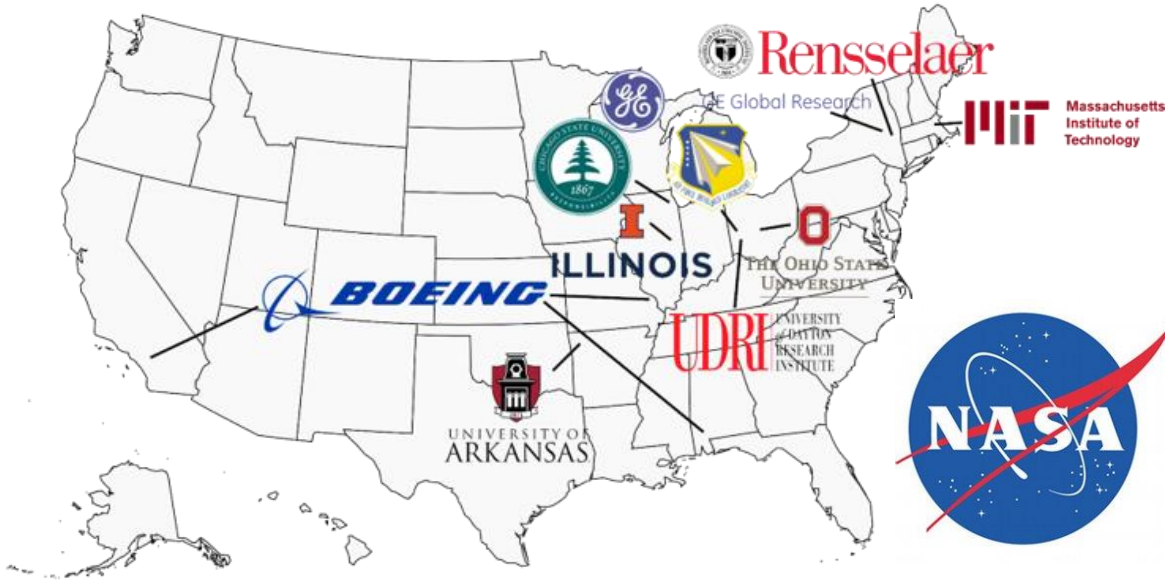
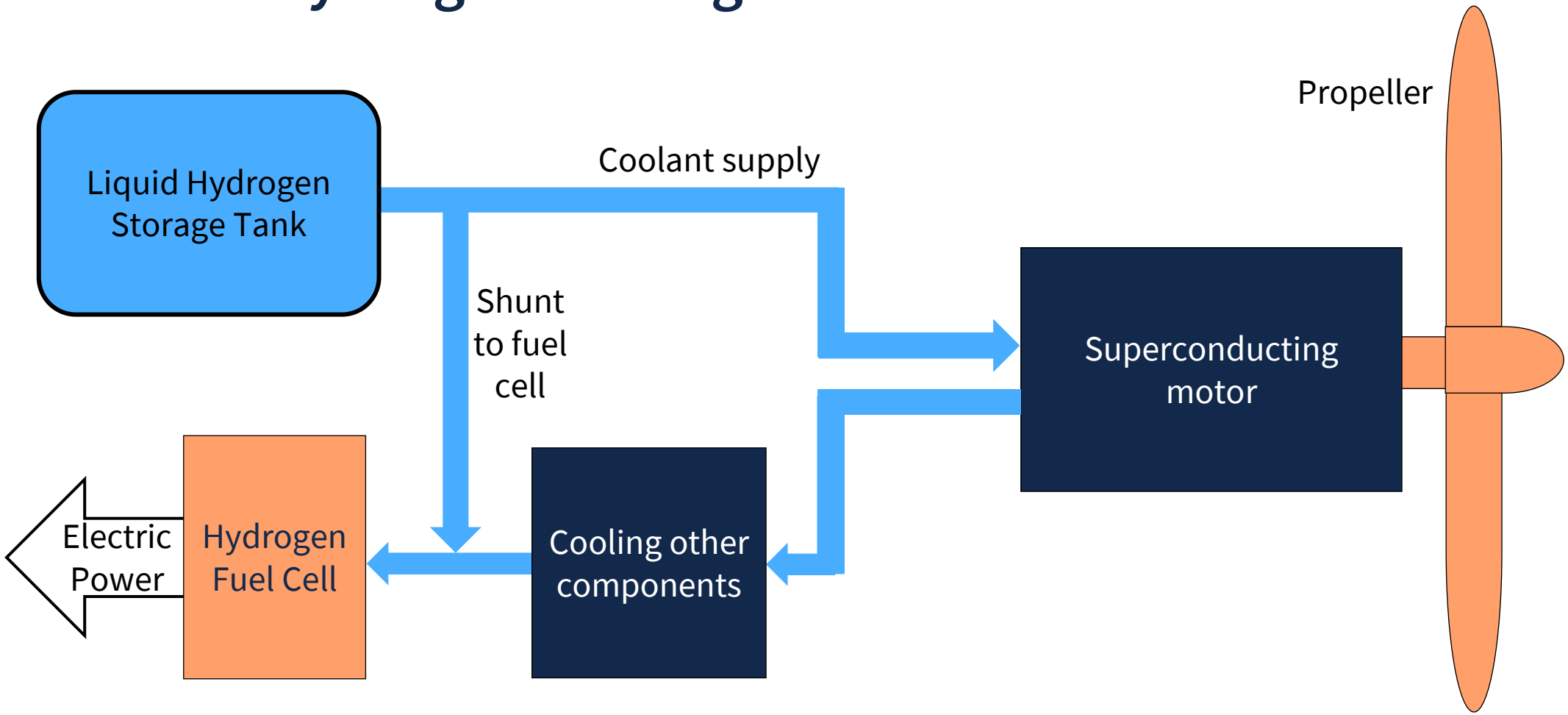
CHEETA is a collaboration to research all-electric, hydrogen-powered commercial aircraft

Drawing of proposed CHEETA airplane

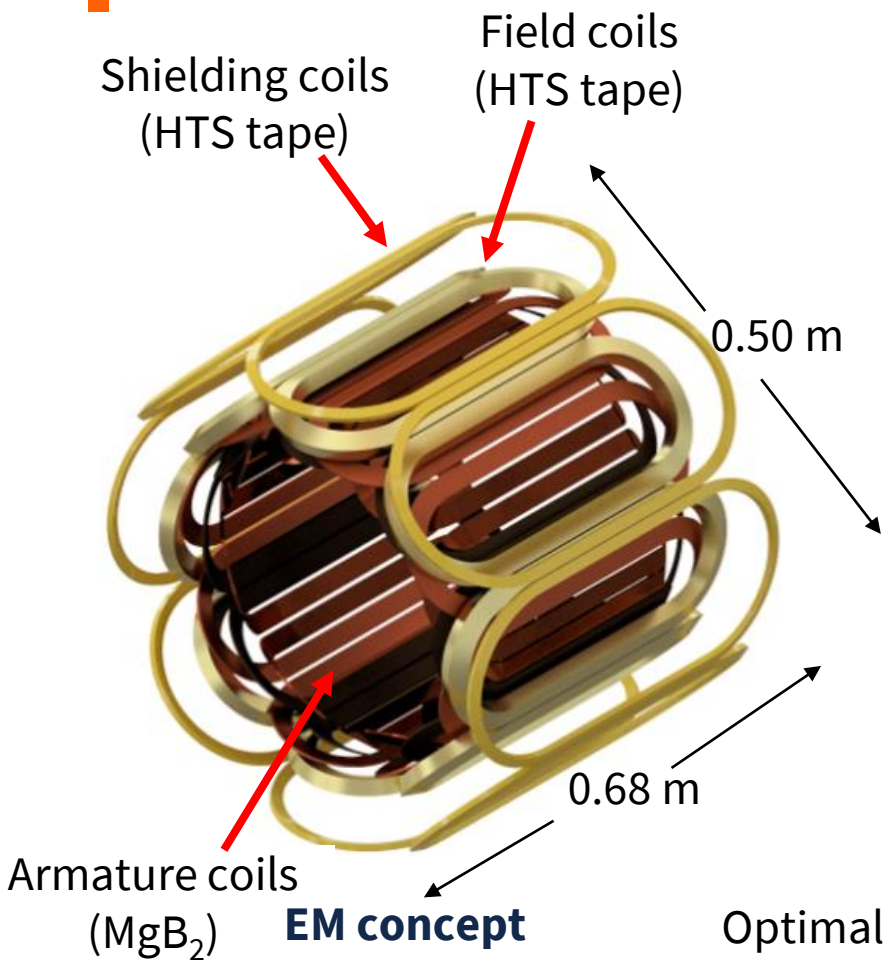


CHEETA members

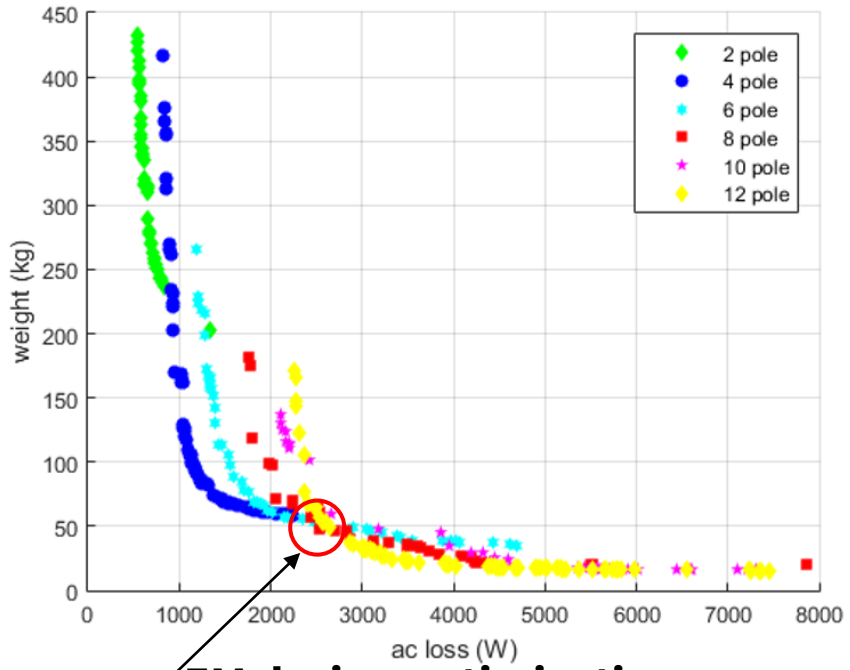
Illinois is designing a power-dense superconducting motor with hydrogen cooling



We designed an outer-rotor machine with 2.3 kW losses in the stator



EM concept



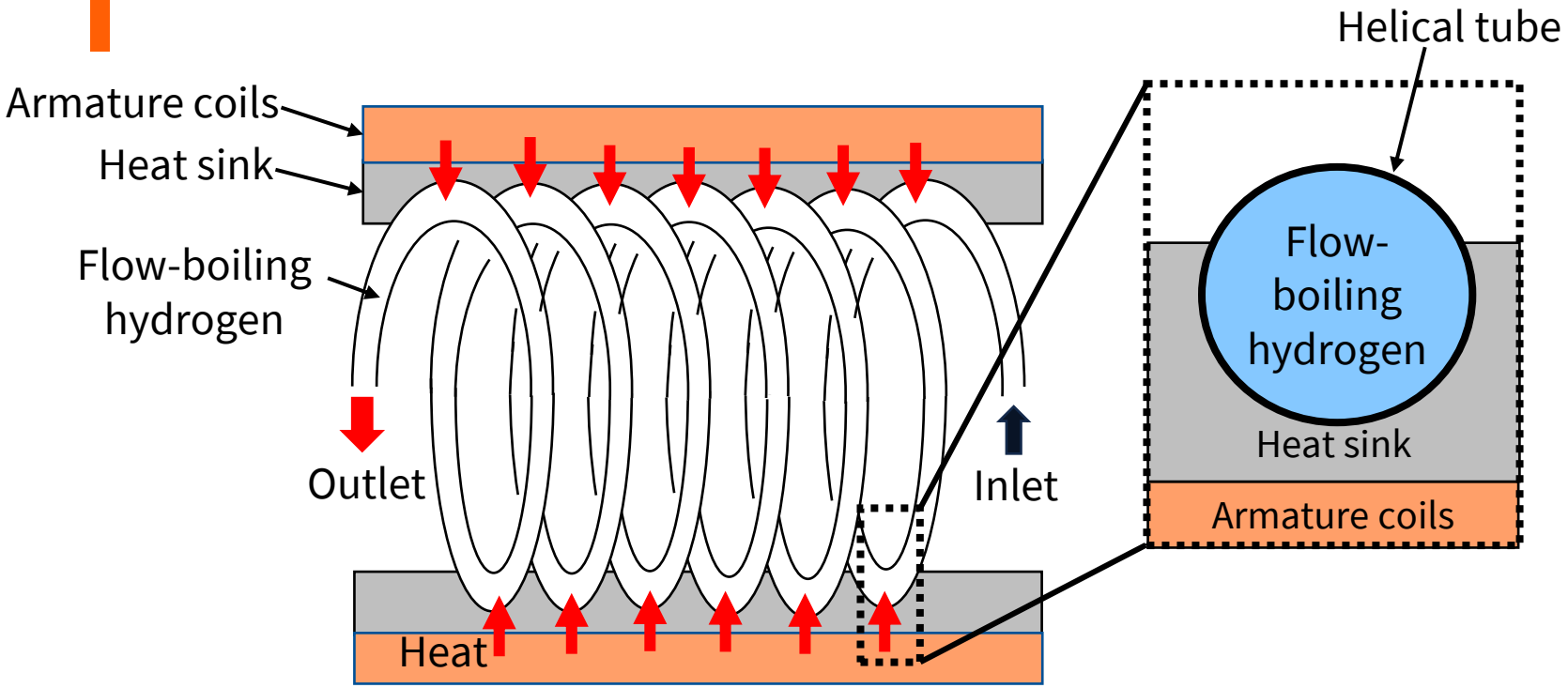
EM design optimization

Optimal design

Optimal design

Parameter	Value
Pole count	8
Power	2.5 MW
Rotor losses	< 10 W
Stator losses	2.3 kW

A helical-tube heat exchanger cools the stator



Side View

Optimal Design

Parameter	Value
Heat removed	2.3 kW
Max. coolant flow	20.2 LPM
Tube diameter	3/4”
Mass	21.1 kg
Hotspot Temperature	23.5 K
Specific Power	47.9 kW/kg

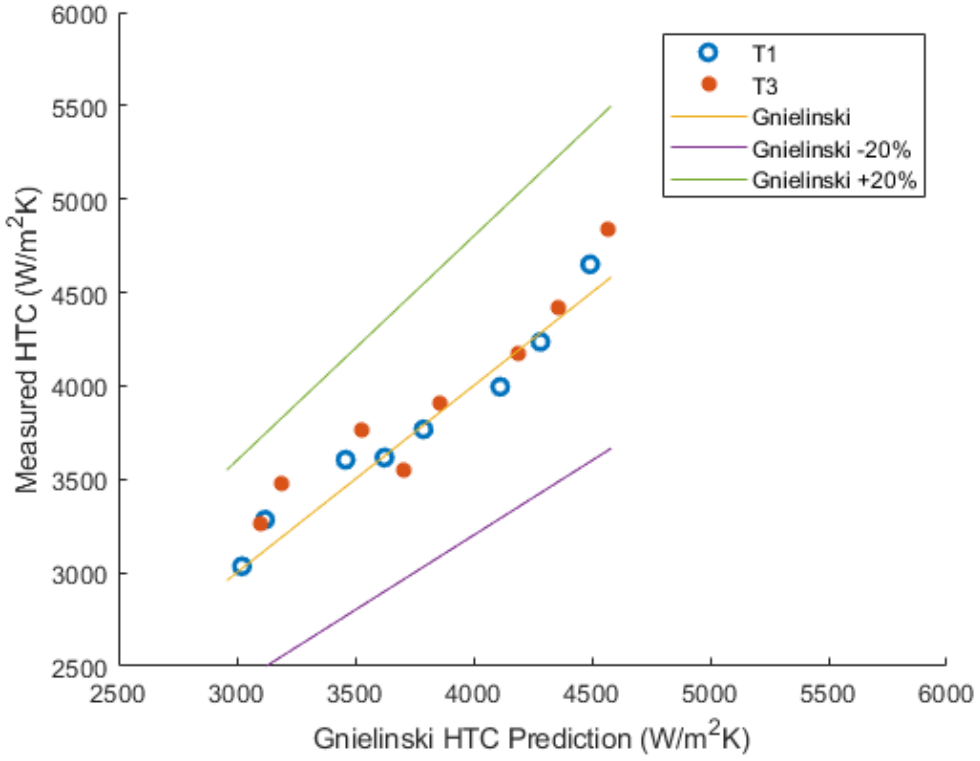
1D thermal analysis used straight-tube flow-boiling models

Experiment needed to determine tube curvature effect in flow-boiling cryogenic fluids

Helical tube cooling experiment underway

Nitrogen flow setup

Helical tube with heaters attached



Water validation test

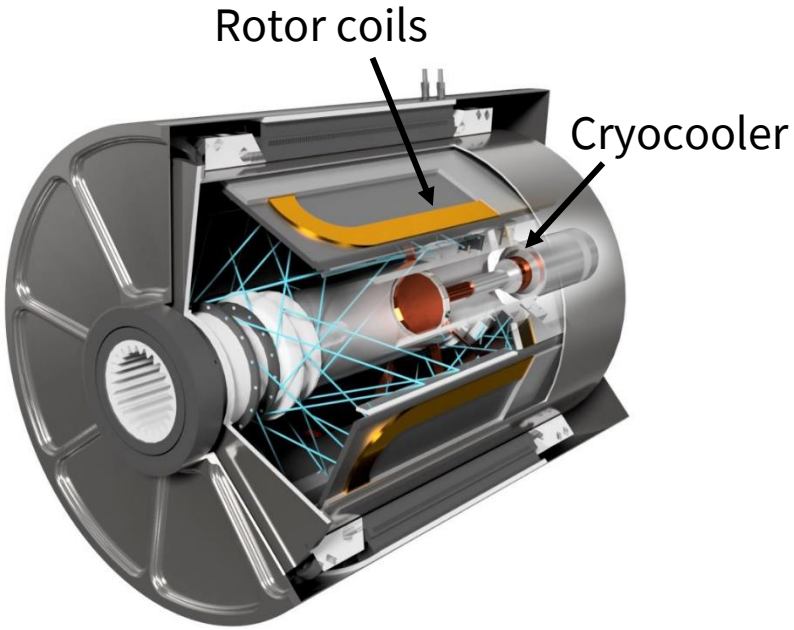
Setup validated with water tests

Troubleshooting issues with nitrogen setup

The rotor is cooled using a rotating cryocooler

Heat is transferred by conduction to cryocooler

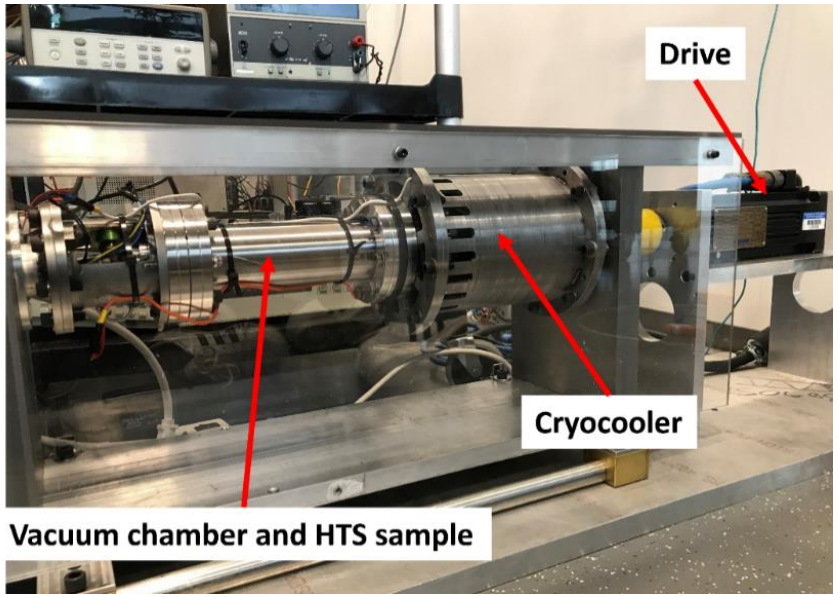
Approach avoids use of rotary transfer coupling with liquid hydrogen



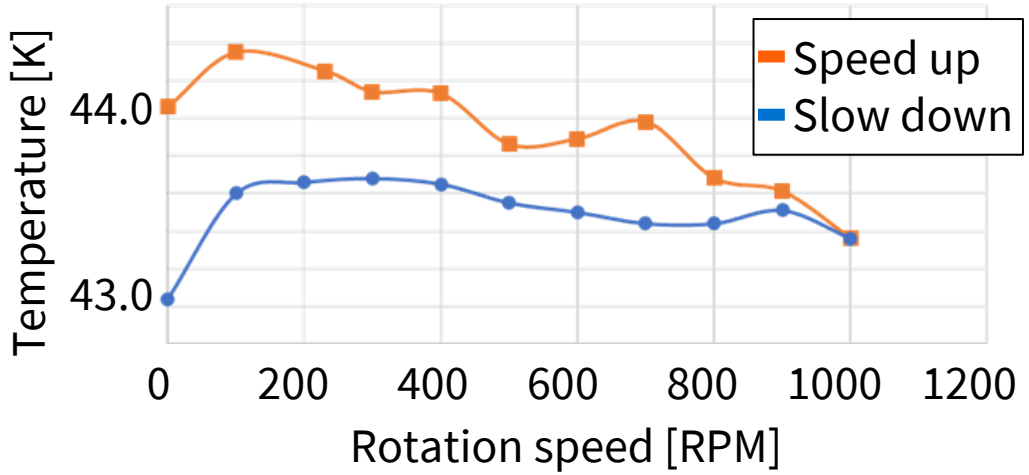
Rotor cooling concept

Rotating cryocooler test shows satisfactory operation up to 1000 rpm

Cryocooler being tested



Experiment setup



Low-speed test results

High-speed test (up to 4000 rpm) planned for future

Summary

The CHEETA partnership is researching all-electric, hydrogen-powered aircraft

Illinois is designing a superconducting motor for CHEETA

A helical-tube heat exchanger cools the stator
- Experiment underway to assess tube curvature effect

A rotating cryocooler is used to cool the rotor
- Experiment validates approach up to 1000 rpm

Questions?
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