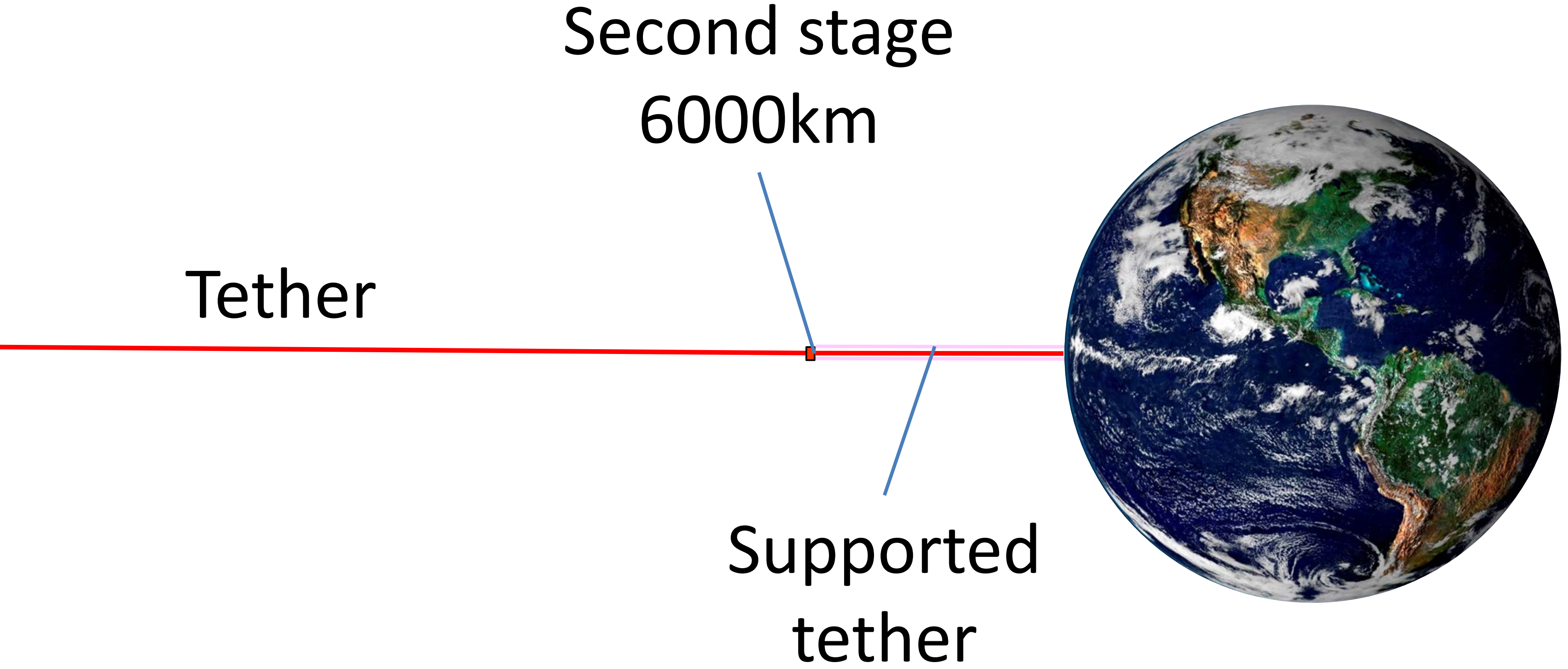
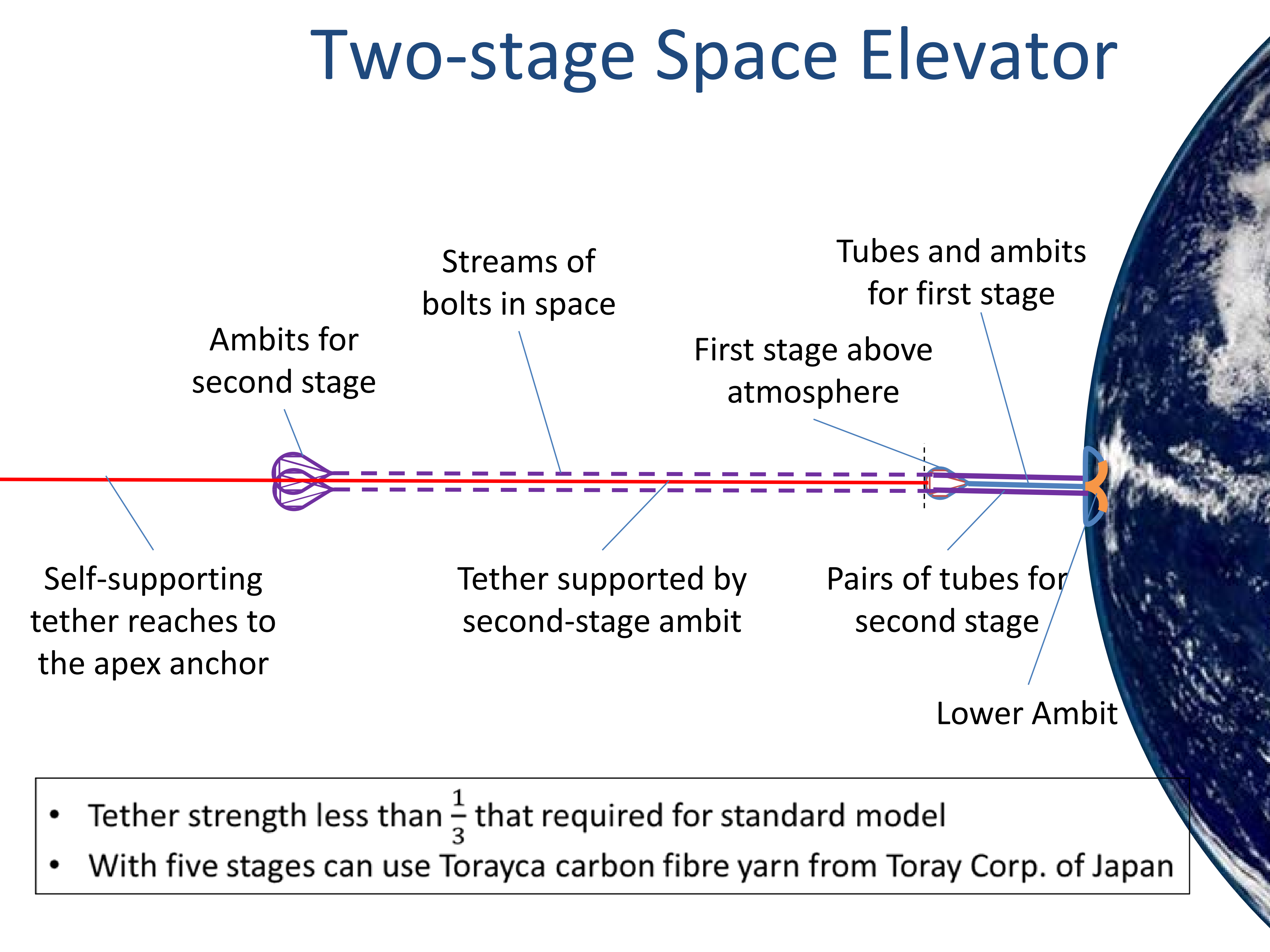
# Progress Report on the Multi-stage Space Elevator

John M. Knapman, Ph.D., FBIS
Director of Research
ISEC

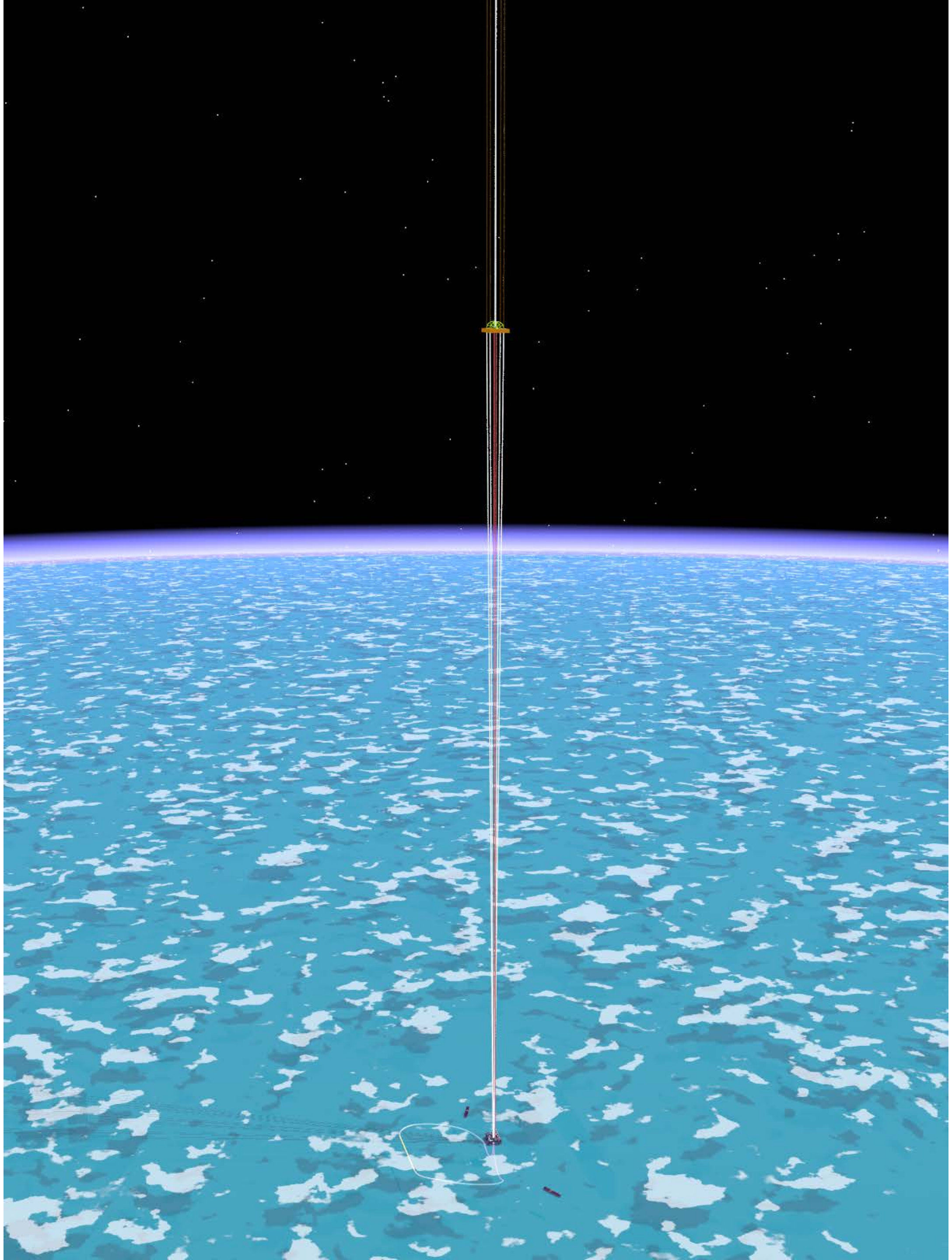
# Two-stage Space Elevator

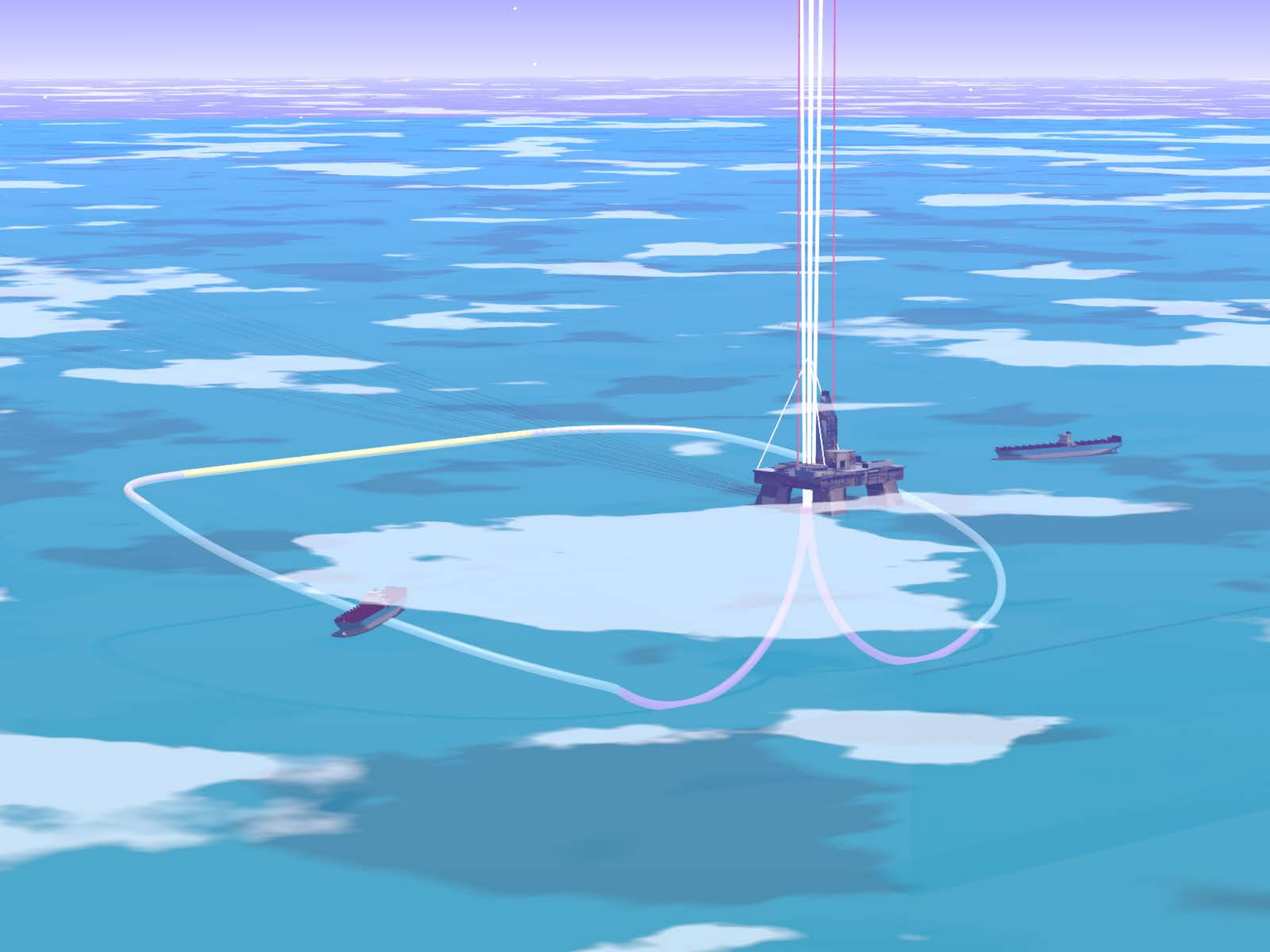


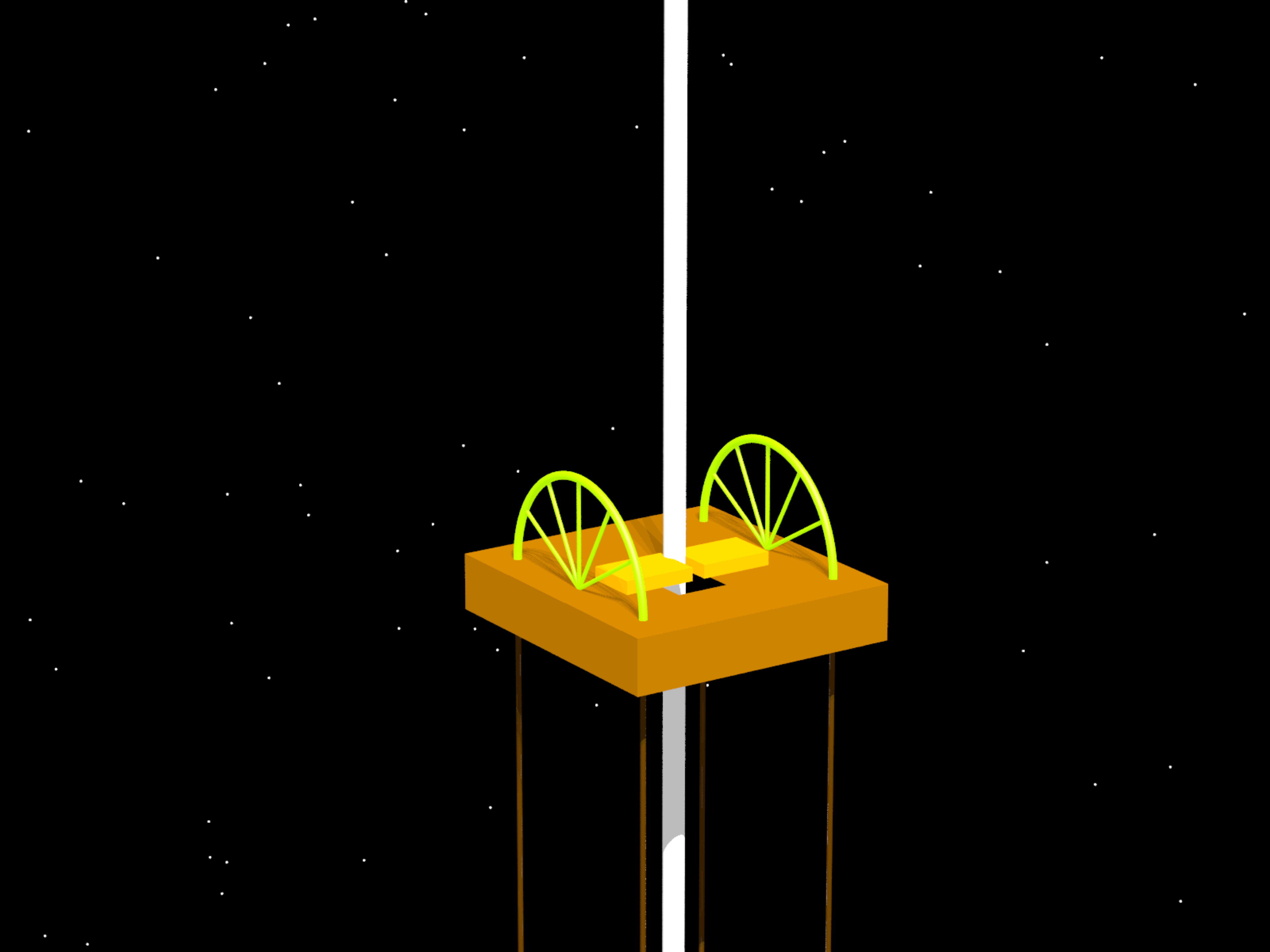
# Two-stage Space Elevator




- Tether strength less than $\frac{1}{3}$ that required for standard model
- With five stages can use Torayca carbon fibre yarn from Toray Corp. of Japan







# Resilience

- Power failure
  - Use the stored energy until power is restored
  - Ensure standby power is always available
- Multiple tubes provide backup if one tube needs repairs
- Space debris
  - Structures in space need shielding
  - Bolts travel in vacuum of space without tubes

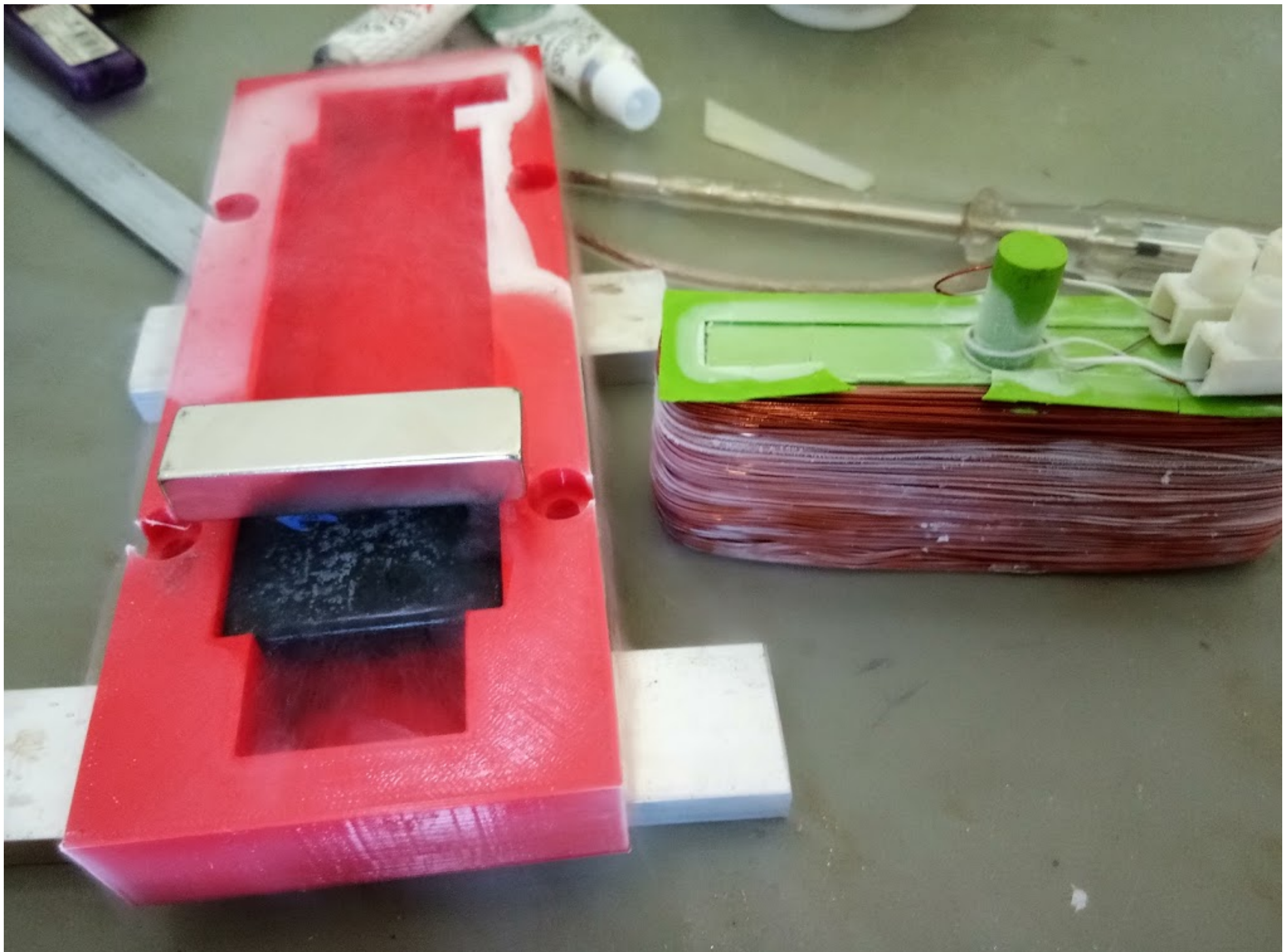
# Stability

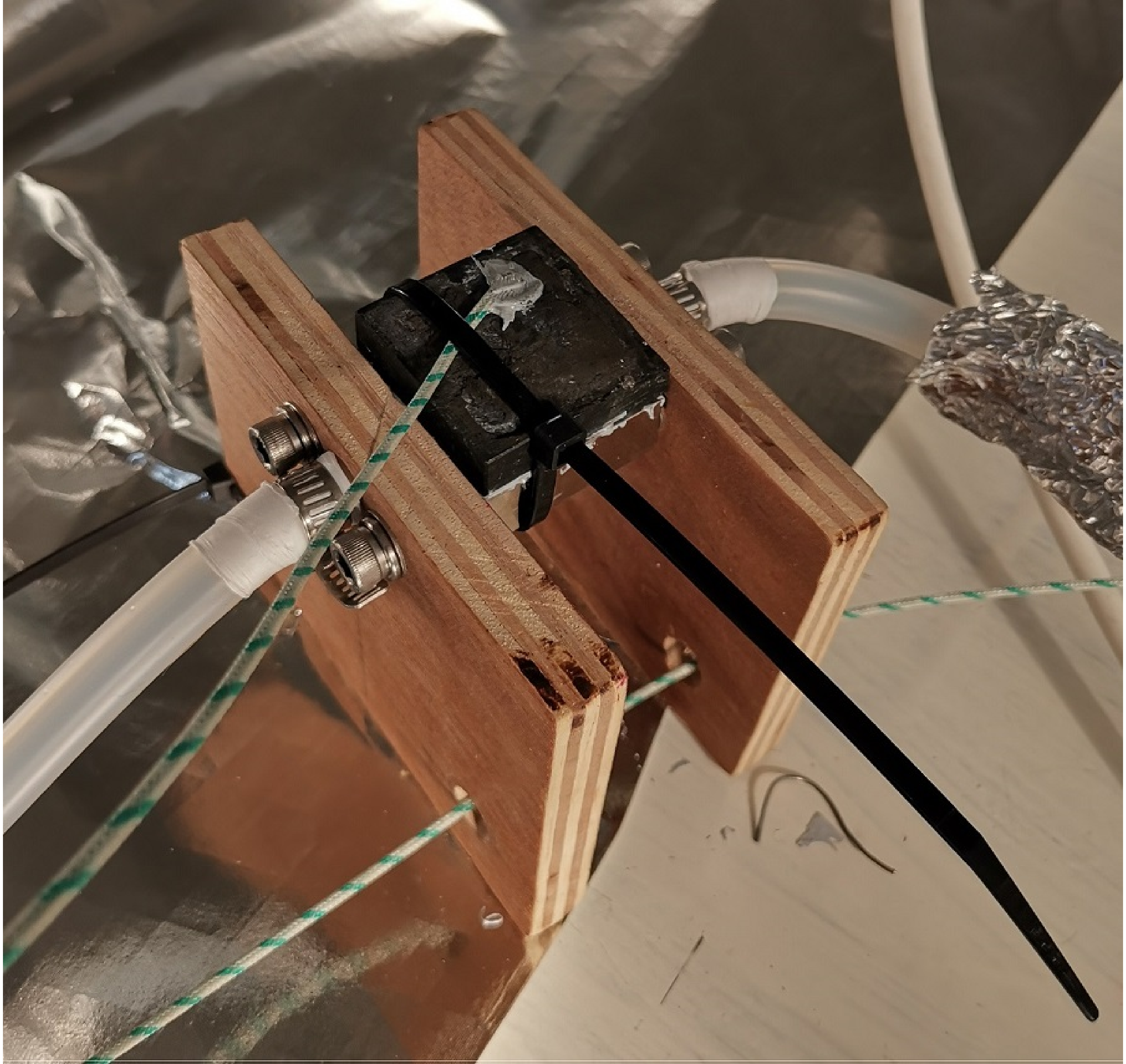
- In the atmosphere, measure the wind force near each control point along the tube
  - Algorithm called “active curvature control”
  - The tubes bend so that the centrifugal force as the bolts pass the bend equals the wind force
- In space, measure the gap between ascending and descending bolts
  - Controls in the bolts ensure that they arrive at the ambits in the right positions

# High Temperature Superconductors (HTS)

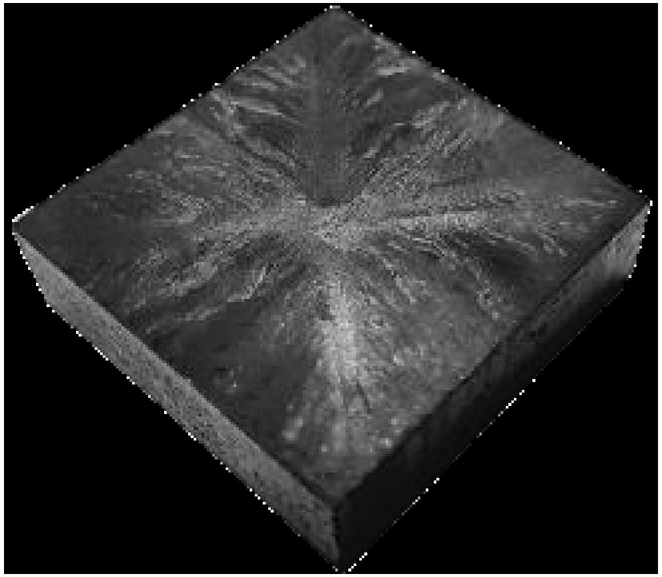
- YBCO
  - Yttrium Barium Copper Oxide
  - $YBa_2Cu_3O_{7-x}$ with $Y_2BaCuO_5$ excess + additives
  - Liquid nitrogen coolant
- Flux pinning
  - Provides stable magnetic levitation
  - Works with type 2 superconductors
  - No need for electronic controls to stabilize bolts
    - Still needed to deal with winds – Active Curvature Control

# In a Bath of Liquid Nitrogen at 77$^{o}$K



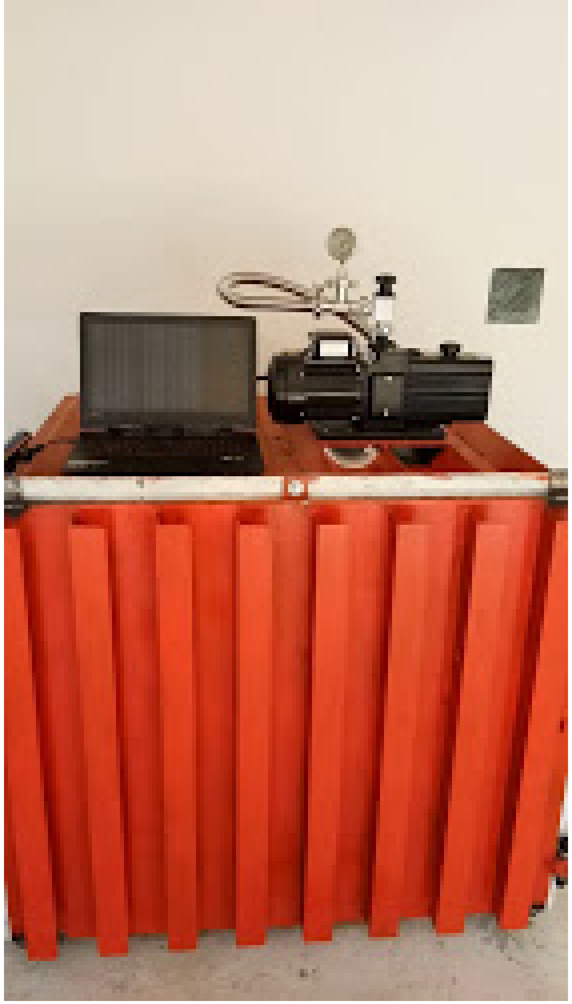


HTS bulk



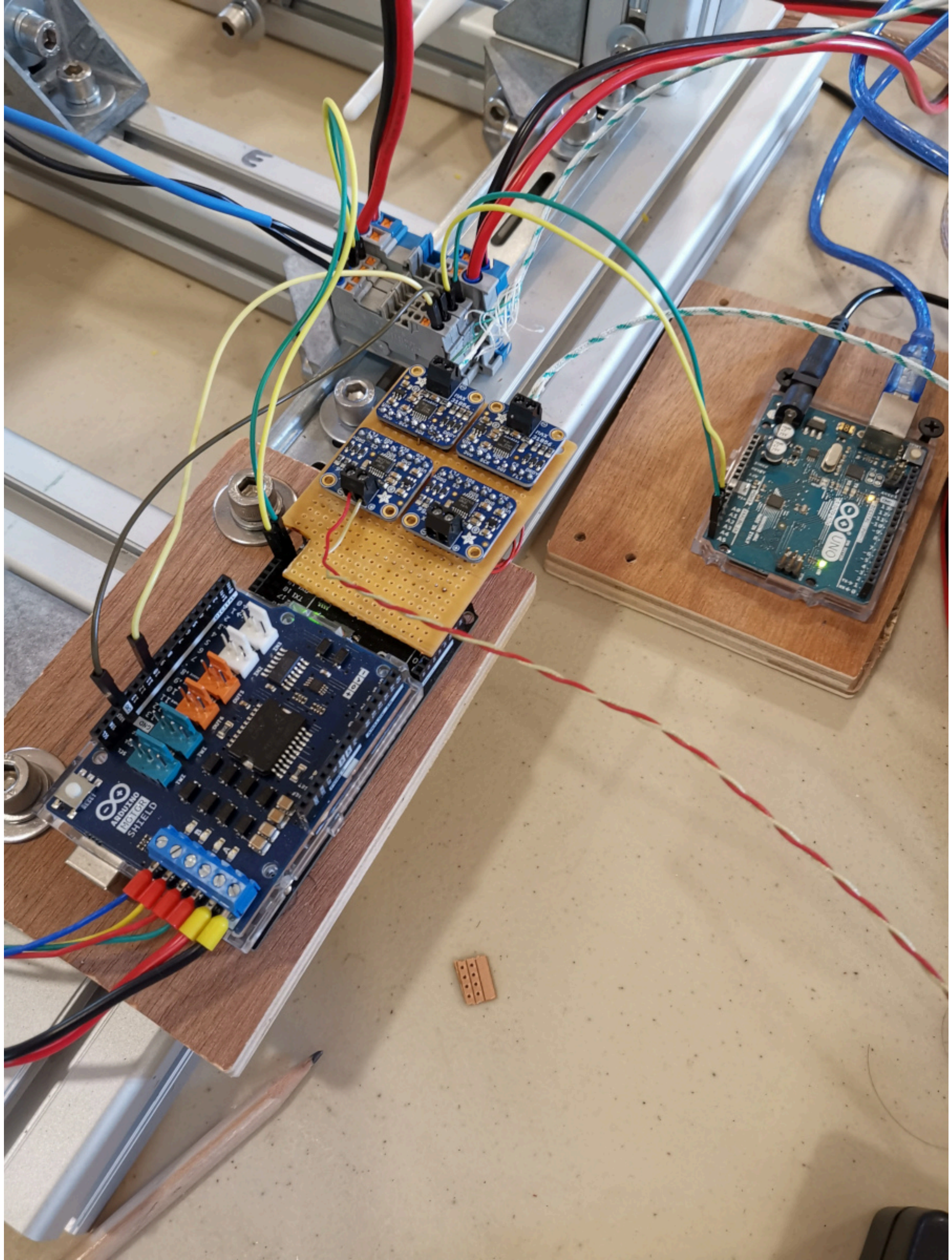
Copper block for cooling

# Vacuum Chamber with Pump

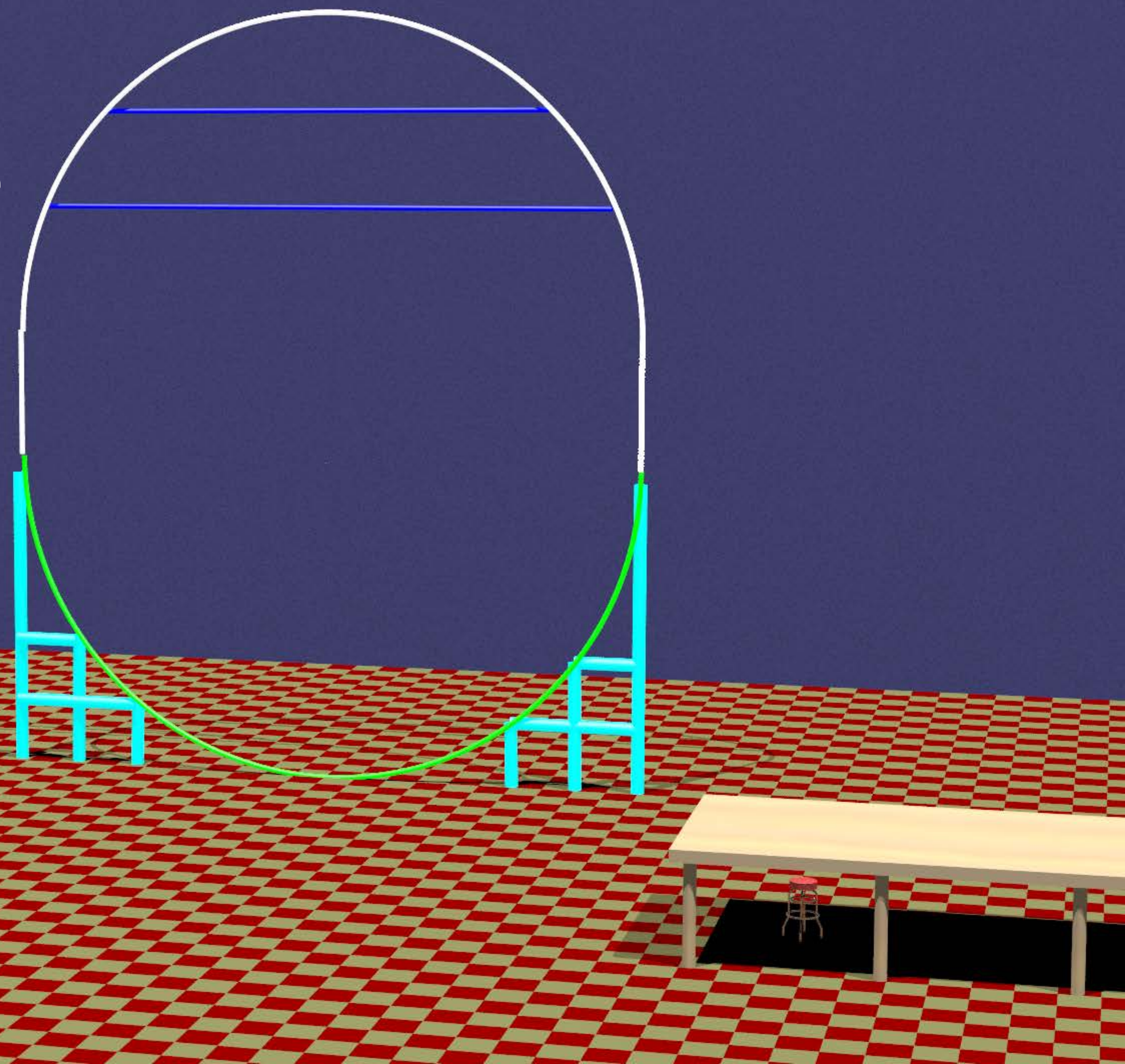


# Test Rig in Vacuum Chamber

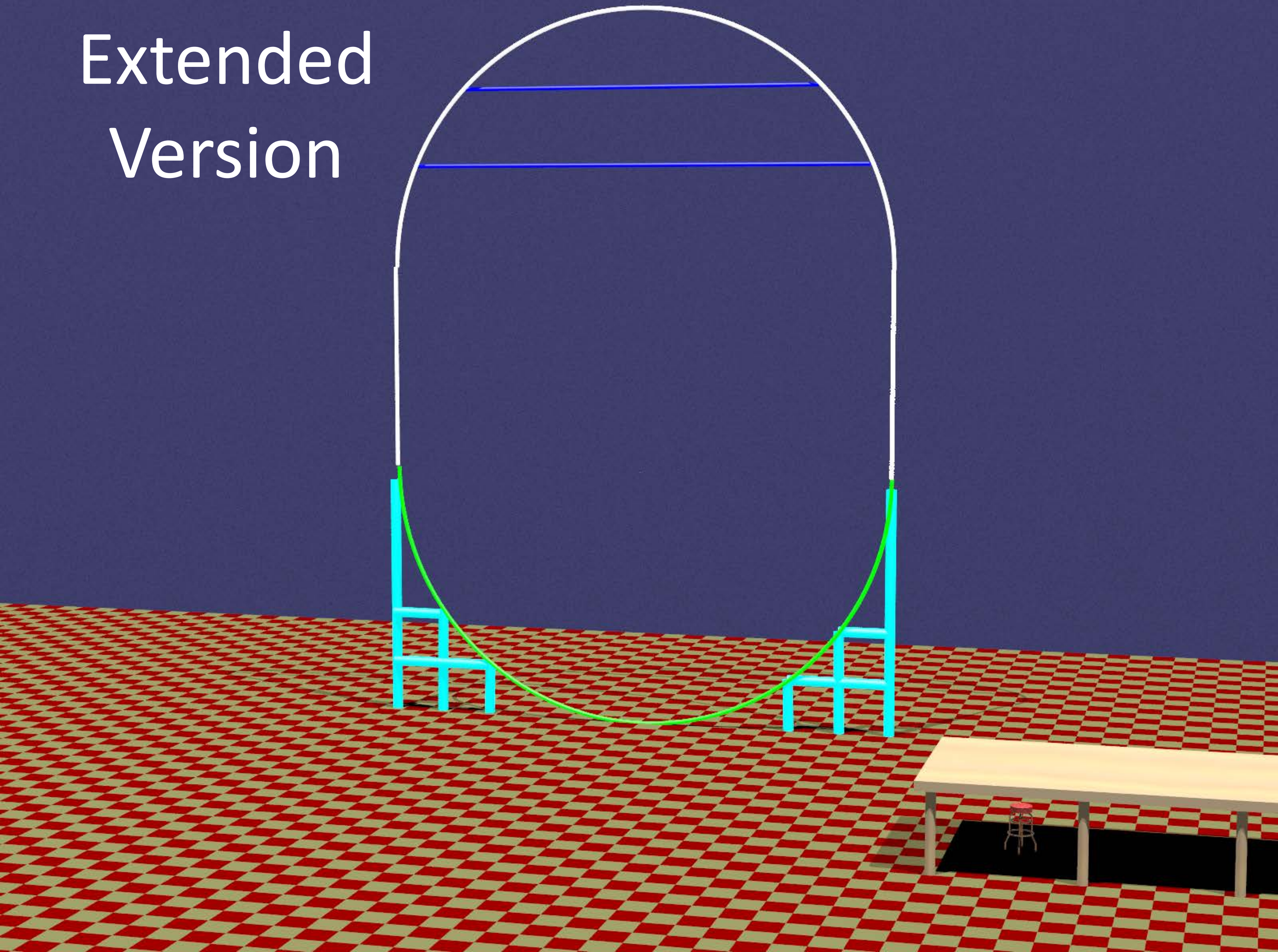
# Liquid Nitrogen Connections



# First Planned Prototype



# Extended Version



# Second Planned Prototype