

# Testing Cassini Heritage and Next Gen RTG Mod 1 RTG Silicon-Germanium Thermoelectric Couples

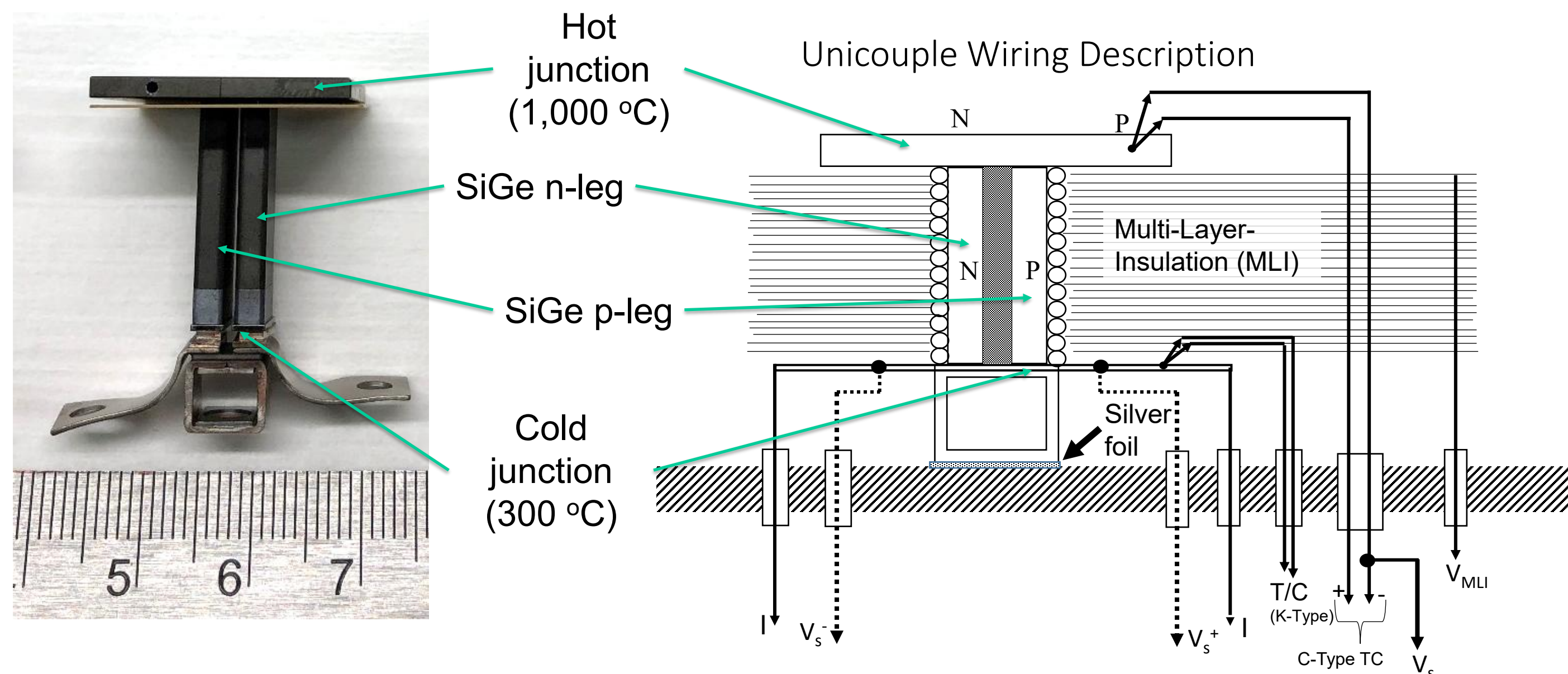
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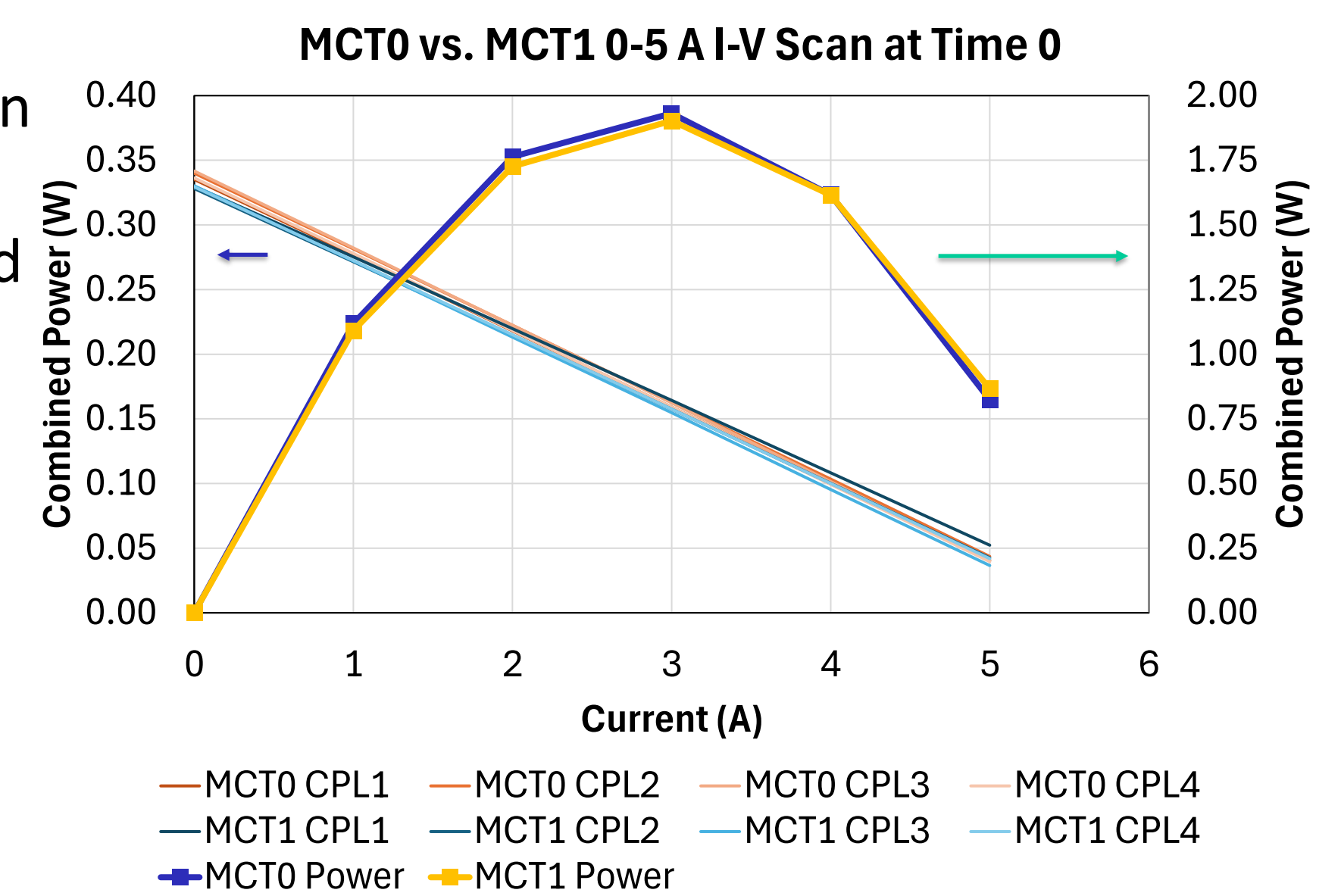
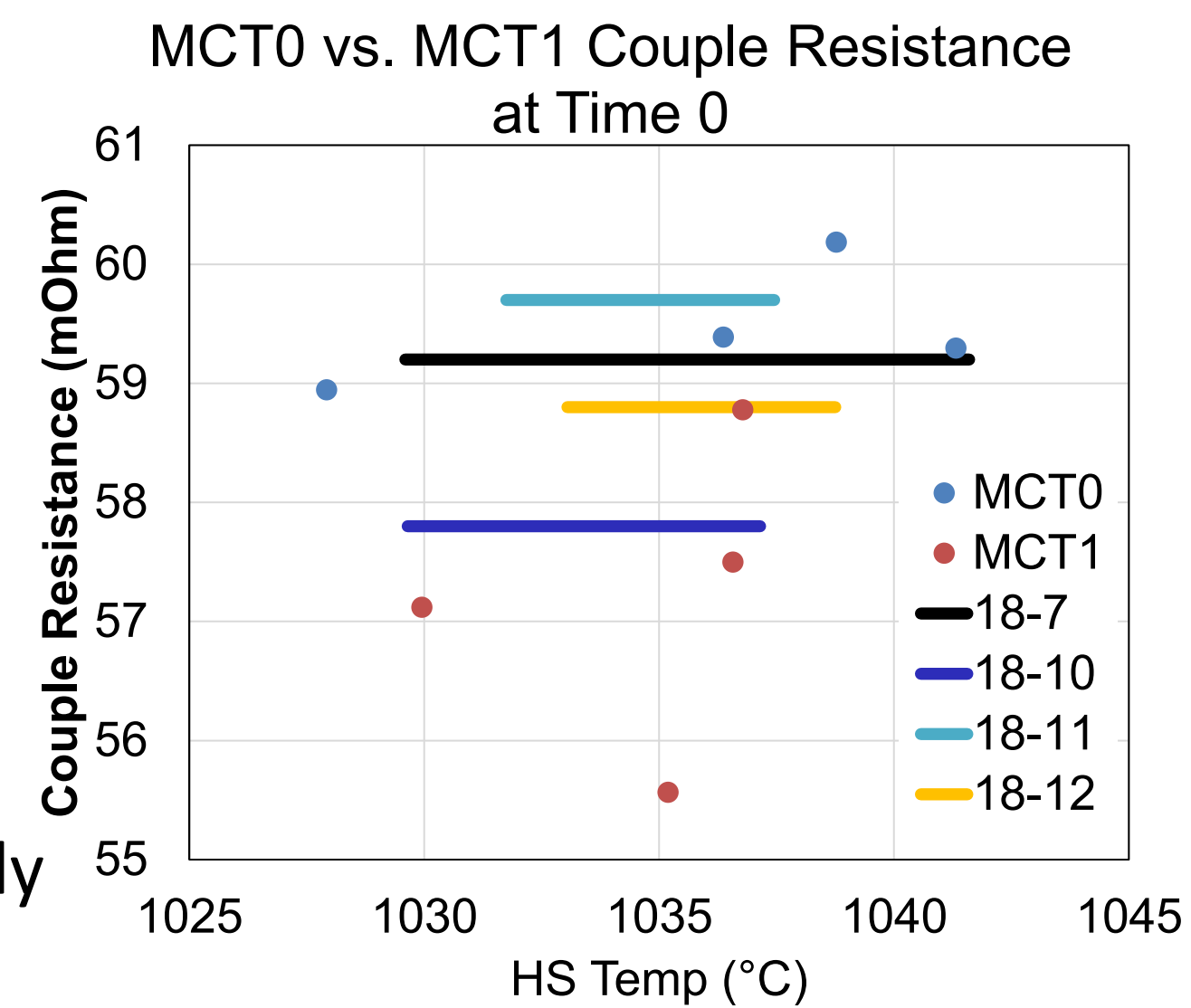
## SiGe Thermoelectric Couples for Next Gen RTG Mod 1

- RTGs powered by <sup>238</sup>Pu use thermoelectric couples to convert heat into electricity
- SiGe couples are ideal for higher temperature RTGs (can only be used in vacuum)
- ~2x higher specific power relative to MMRTGs (used on Mars)
- Higher operating temperature (~1,000 °C) and higher delta T (~700 °C)
- Objective is to characterize new couples being produced by the Next Gen RTG Mod 1 contractor by comparing them to heritage Cassini couples



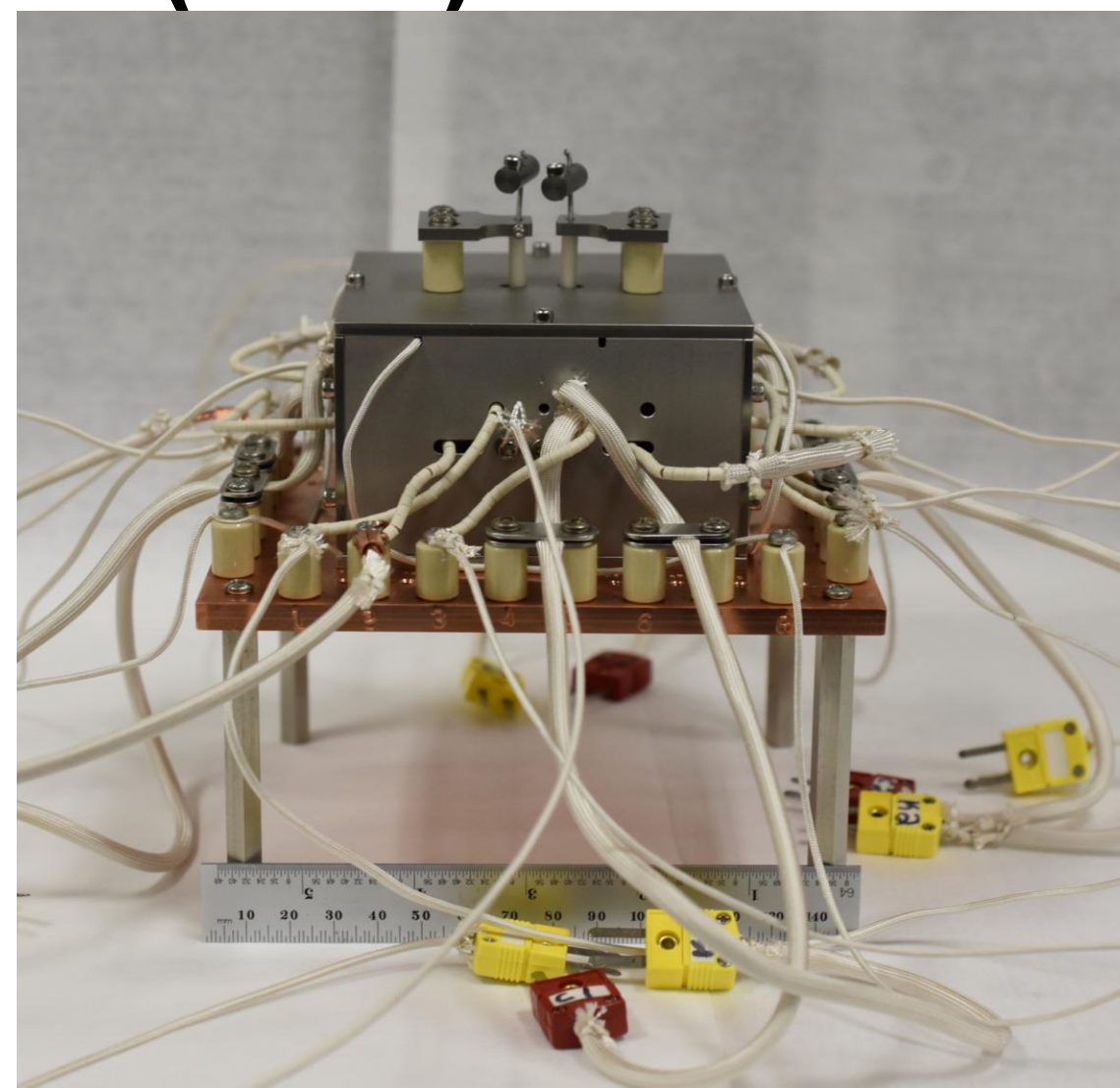
## Beginning of Life (BOL) Measurements

- 2x 4CM are under test so far
- MCT0 uses spare Cassini heritage couples
- MCT1 uses new pathfinder couples produced by the contractor
- 4CM ramped to 1035 °C over three weeks
- Critical for ramp rate to match with GPHS-RTG fueling
- Heritage measurements were mostly performed on 18-couple modules (Cassini 18-7 through 18-12)
- Comparing both heritage couples in 4CM and Cassini data from 18-couple modules to new couples
- Current sweep from 0 to 5 A allows us to extract resistance and maximum power
- Agreement between heritage and new couples is very good at BOL



## Four Couple Modules (4CM)

- Testing must be performed in a relevant environment (high vacuum <1x10<sup>-7</sup> Torr)
- 4CM testbed uses a cartridge heater surrounded by four TE couples electrically connected in series
- Extensive MLI insulation surrounding the couples allows us to achieve close to 700 °C delta T
- Heat is lost almost exclusively radiatively, just like a GPHS-RTG
- 4CMs have extensive measurement capabilities:
- P and n-leg potentials, resistance, temperature
- Current and voltage is controlled to mimic the mission profile/generator thermal conditioning profile
- 28 V (excluding interconnect voltage drop) equivalent held at the 4CM module by adjusting current to match voltage
- Hot side controlled to achieve temperature targets during ramp up, then by power afterwards to avoid perturbations due to changing TE properties

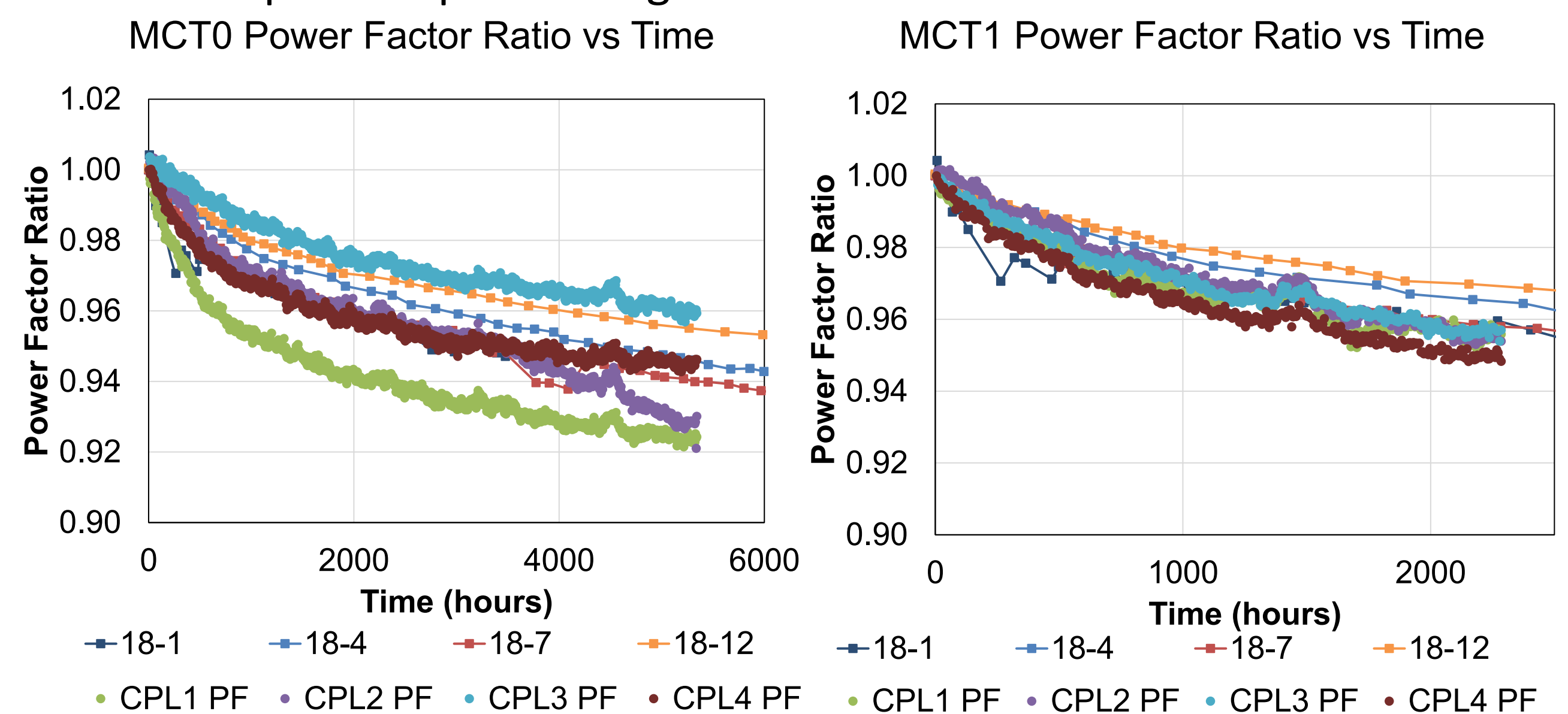


## Power Factor Ratio

- I-V scans are automatically performed every six hours on the 4CM
- Many factors affect performance, so power factor (PF) is a calculated metric to help quickly determine how rapidly the couples are degrading by factoring in Voc, ΔT and resistance:

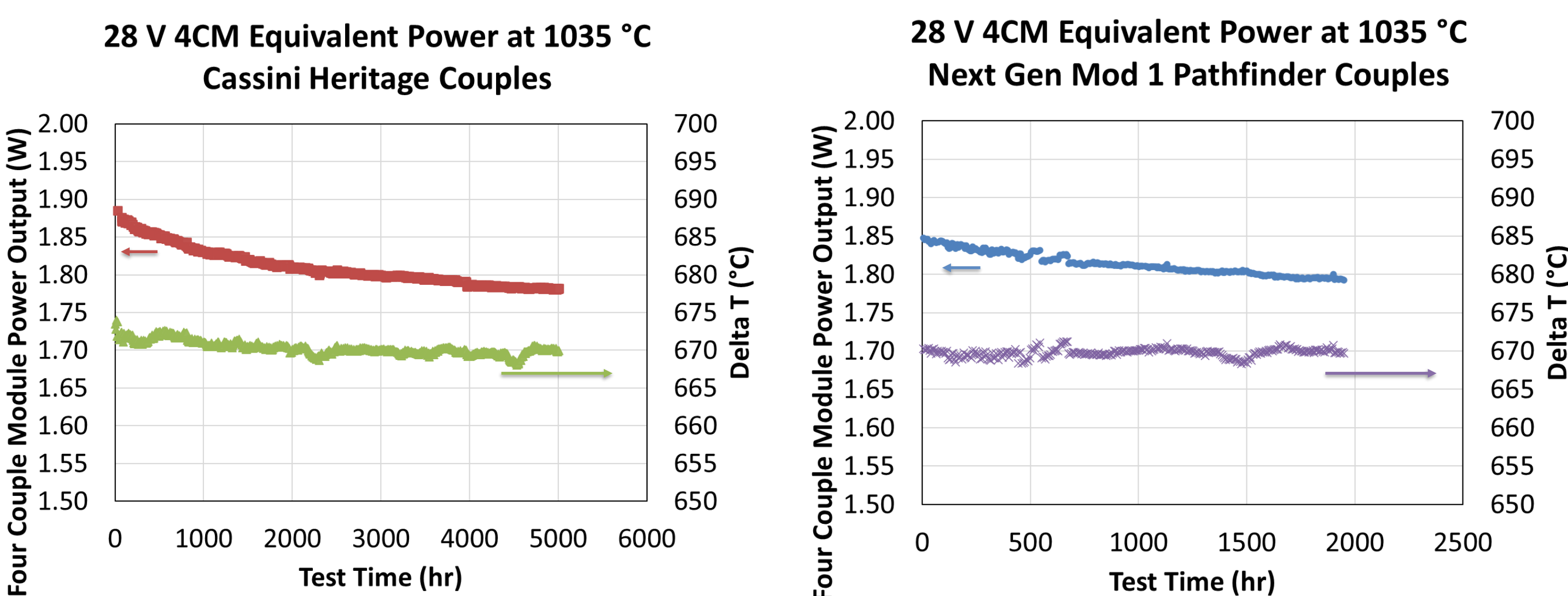
$$PF = (V_{oc} / \Delta T)^2 / R_{int}$$

- PF eliminates minor differences in test setup to help determine how the couples are performing relative to BOL



## Lifetime Predictions

- A key performance parameter is how much power the GPHS-RTG will produce over long missions (≥ 10 years)
- Life testing is key to understand and quantify degradation
- Degradation mainly occurs because TE materials or insulation properties change over time
- It's critical to maintain a stable and repeatable thermal environment to reproduce heritage data
- Current life test goal is 10,000 hours (almost 14 months)
- So far, 5,000 hours on heritage couples compares well with 2,000 hours on new pathfinder couples produced by the contractor



## Acknowledgements

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