Current Developments in Future Planetary Probe Sensors: Heatshield Ablation Detector Adaptation to Mid Density Ablators

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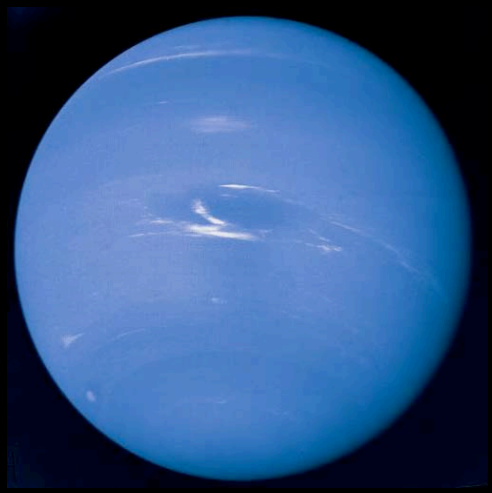
3rd International Planetary Probe Workshop
Anavyssos, Attica, Greece



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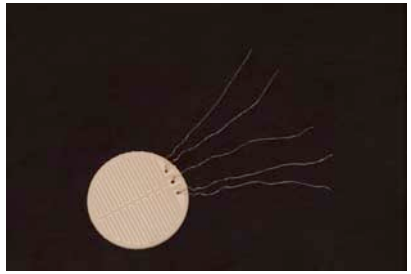
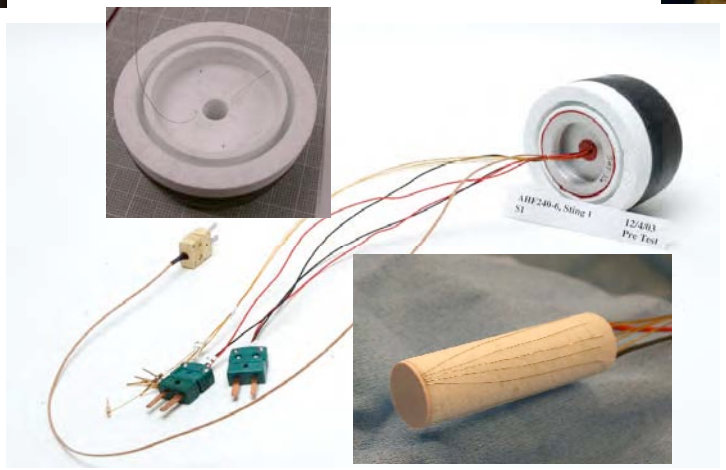
Outline

- Background
- Sensor System Development
- Sensor Testing
- Future Developments
- Summary

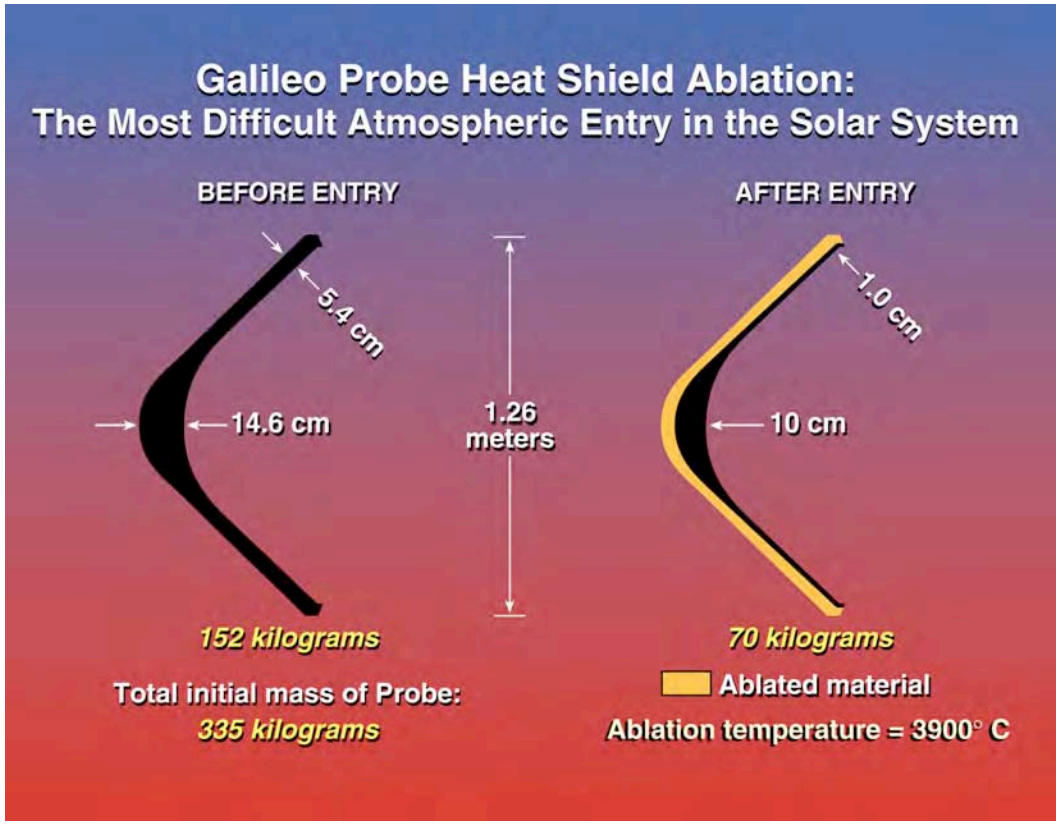
Background

- **Risk *reduction* requires risk *quantification***
- Risk quantification requires ***entry physics sensors***
  - Flight Data + Math models + Ground test data
  - Aerothermal CFD, materials response models,
- **Sensors support engineering and science**





NASA Galileo Jupiter Probe
Recession Sensor for Atmospheric Reconstruction



Analysis of Galileo Probe Heatshield Ablation and Temperature Data, Milos, et. al, Journal of Spacecraft & Rockets 1999

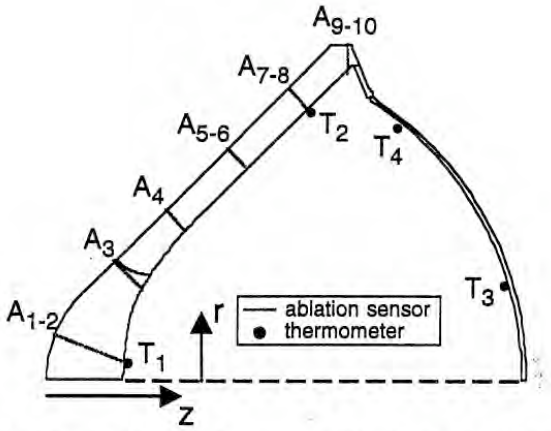


Fig. 2 Locations of 10 ablation sensors (A_1–A_{10}) in heatshield and four resistance thermometers (T_1–T_4) inside structure; sensors are not coplanar.

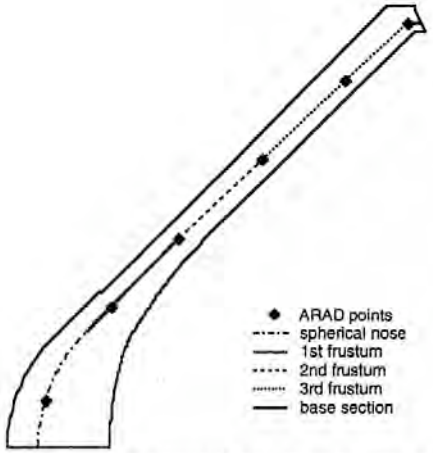
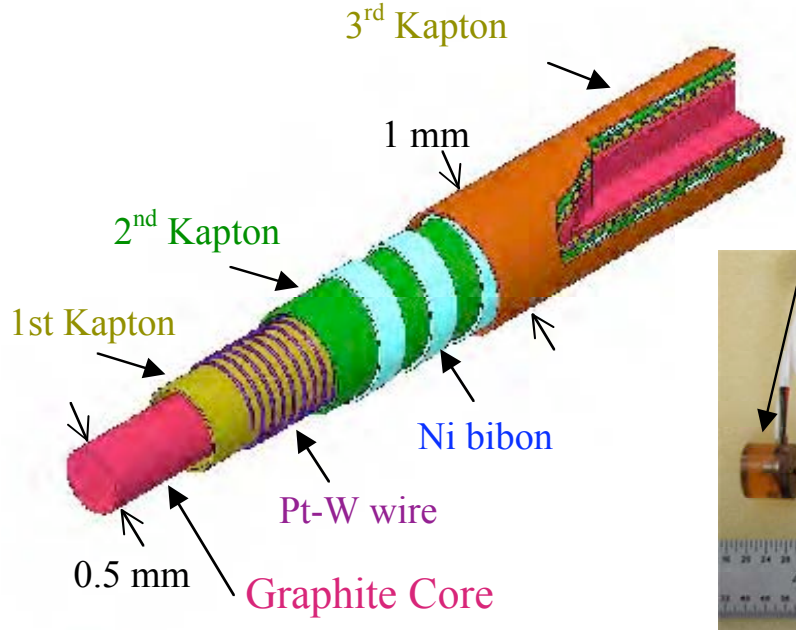
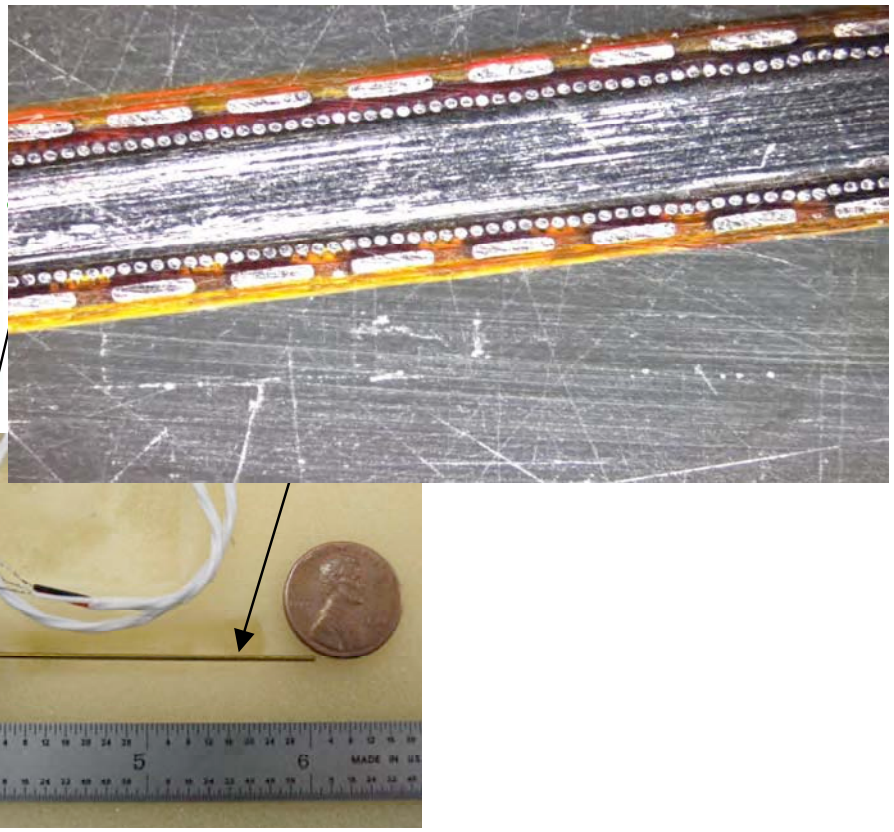


Fig. 5 Reconstruction of heatshield final shape (to scale with initial centerline thickness of 14.6 cm).

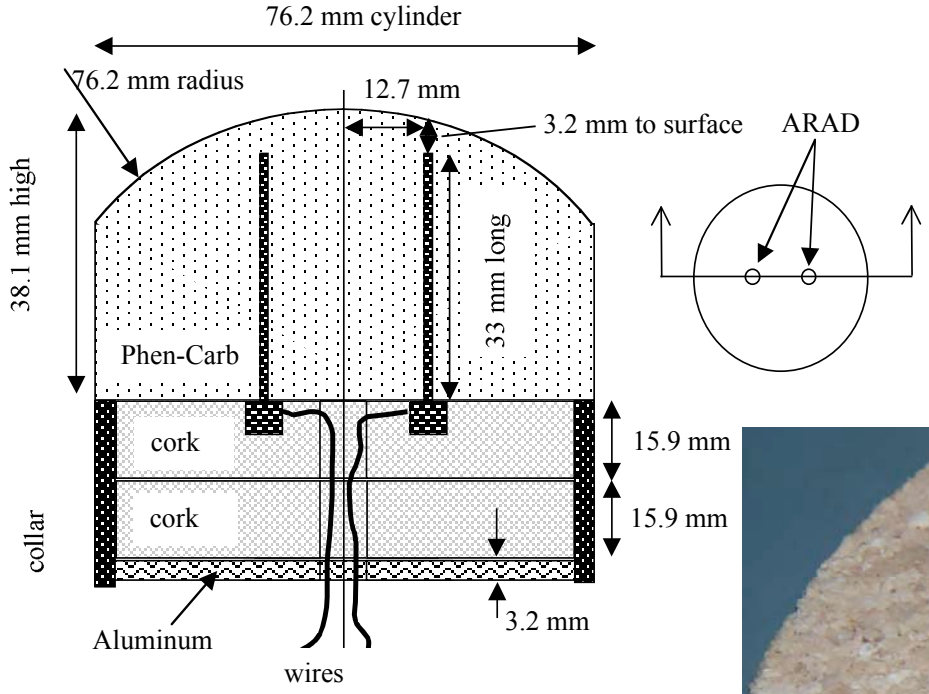
Heat Shield Recession Sensor
ARAD Construction

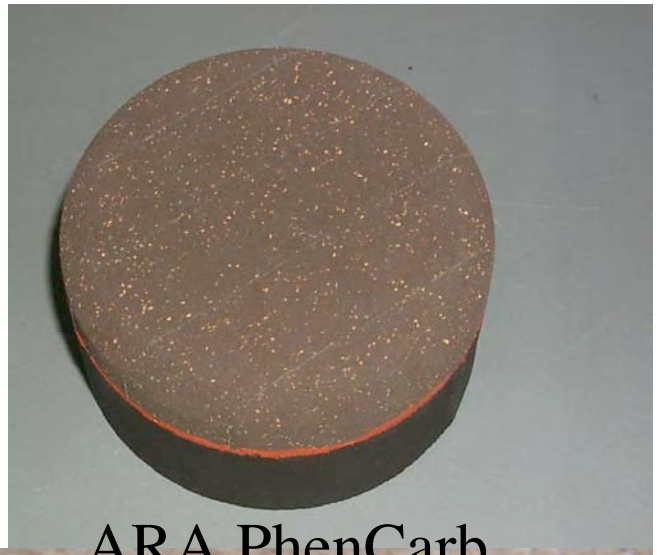
- Three coaxial conductive elements: Pt-W winding; Nickel ribbon; graphite core
- Kapton/epoxy provides a tenacious, electrically conductive char
- Measures a char zone - following a ~700 C isotherm
- Uncertainty of ~ +/- 0.2 mm - based on current source uncertainty of ~10 mV (0.91mm for Galileo)



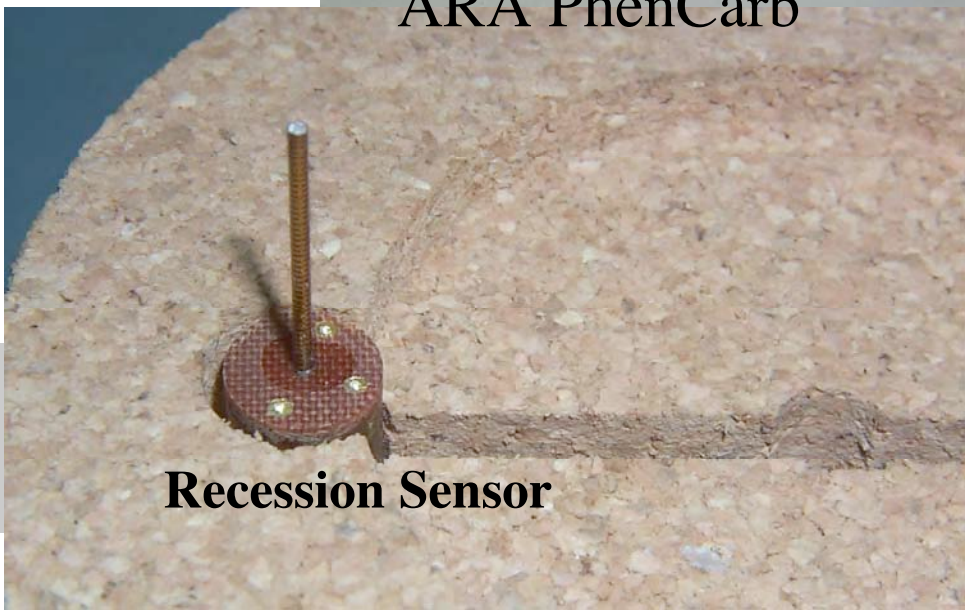


Integration of Models & Recession Sensors





ARA PhenCarb

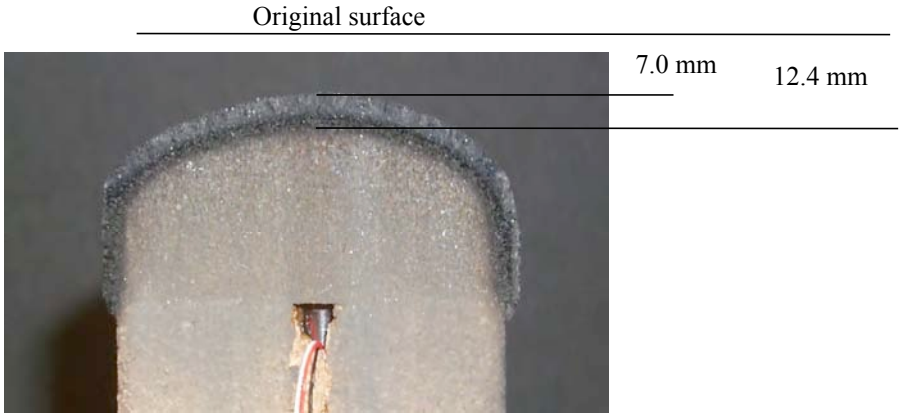


Recession Sensor

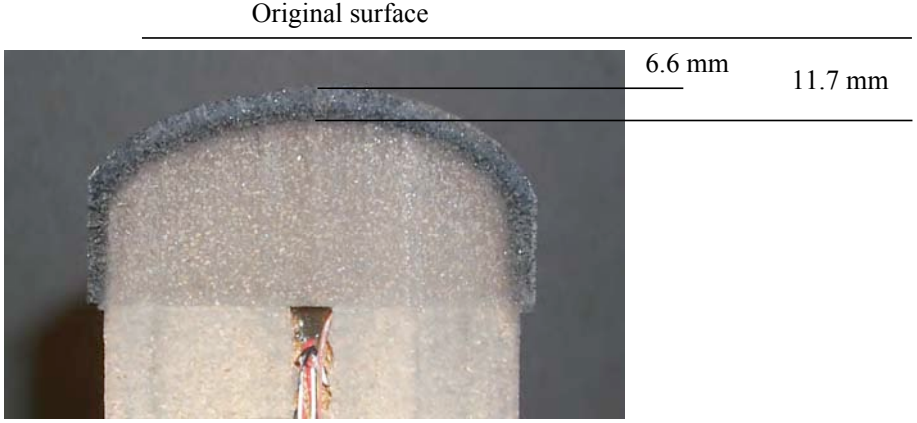
Model#	Density (lb/ft^3)	Density (g/cm^3)	Heat Flux (W/cm^2)	Duration (sec)
P24	24	0.385	610	145
P28	28	0.449	835	145
P32	32	0.513	1003	145

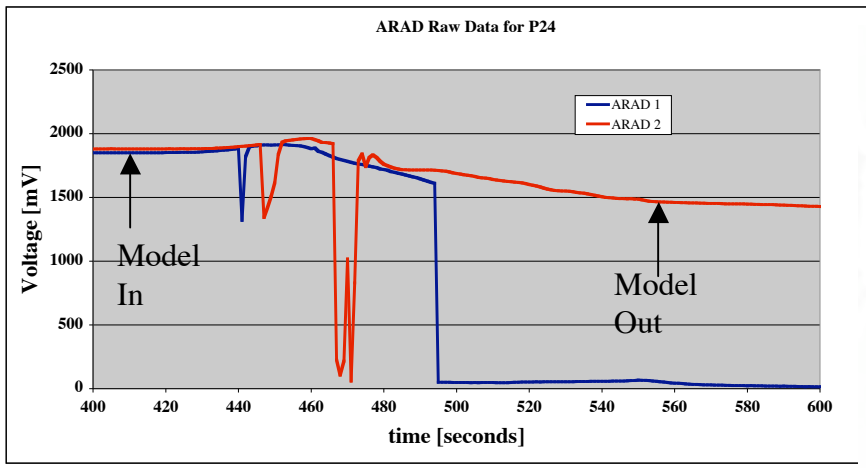
NASA Ames ArcJet Test Results

PhenCarb-28 Tested at 835 W/cm^2

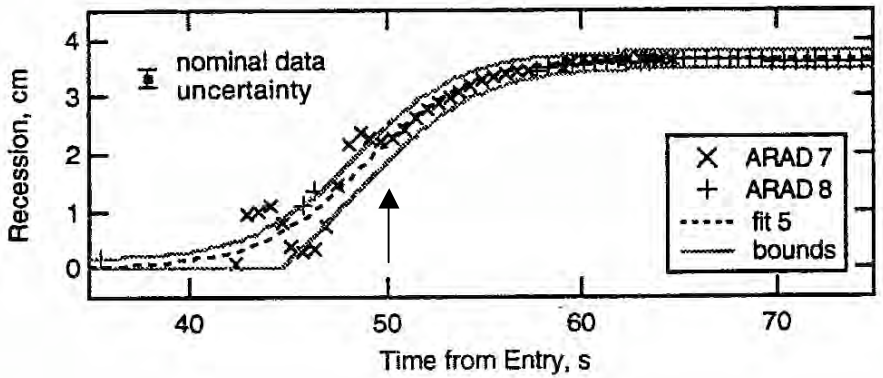


PhenCarb-24 Tested at 610 W/cm^2





Resistance of ARAD for PhenCarb-24



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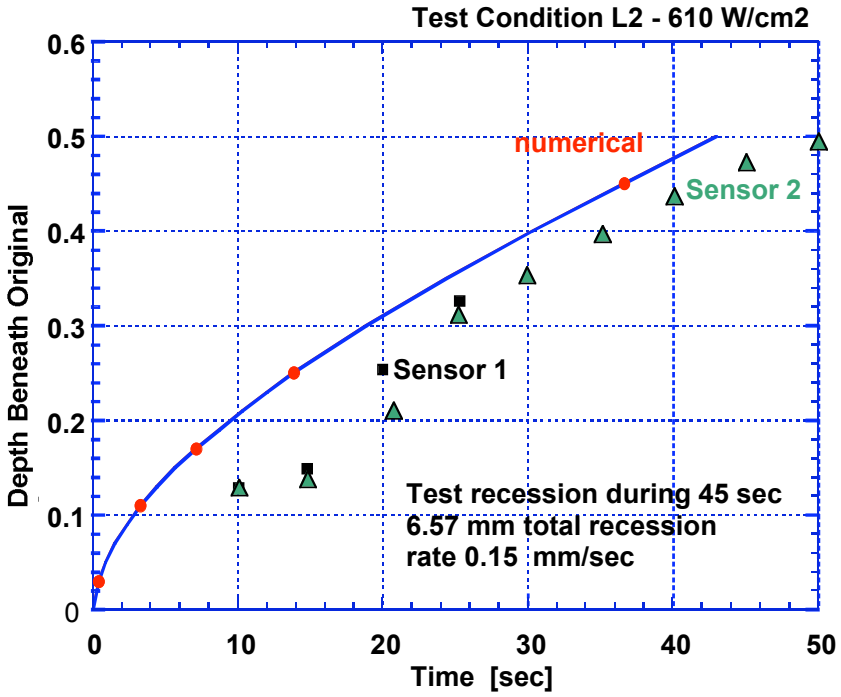
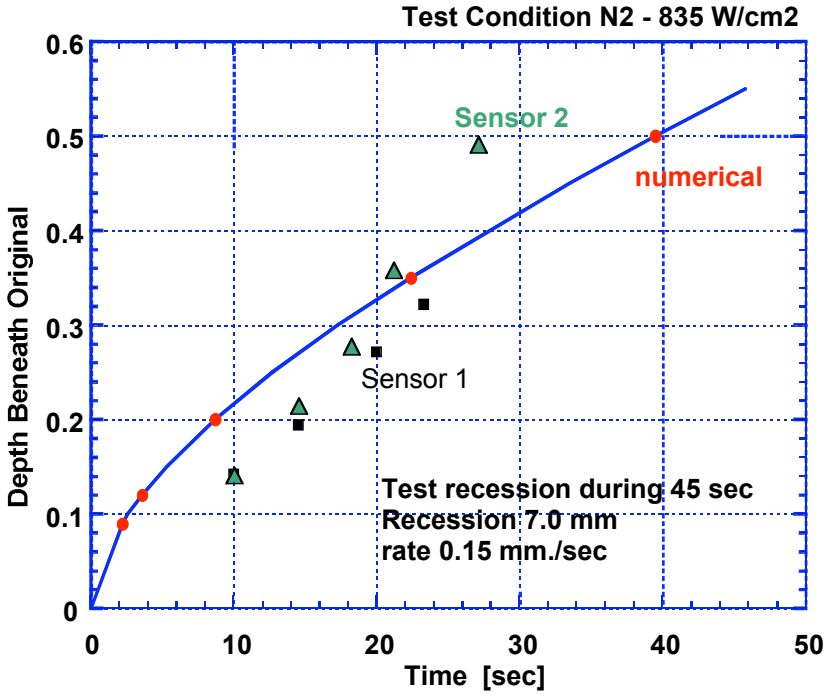
Sensor Response versus Material Model

PhenCarb-24 Tested at 610 W/cm²



Movement of 700 Deg-C Isotherm for PhenCarb-24

PhenCarb-28 Tested at 835 W/cm²



Movement of 700 Deg-C Isotherm for PhenCarb-28

Summary & Future Developments

- NASA has developed the basis for a **plug-and-play sensor system** for aeroshell traceability and science: Thermal, pressure, and **recession**.

- NASA has produced an updated recession sensor (**Ames ARAD**) for mid density ablators. They have been tested with two TPS materials for **traceability (leading to risk reduction)** of TPS and Aeroshell engineering performance suitable for Mars and outer planet missions.

- Potential application of thermal microsensors for extreme environments science, and **recession sensors for atmospheric reconstruction.**