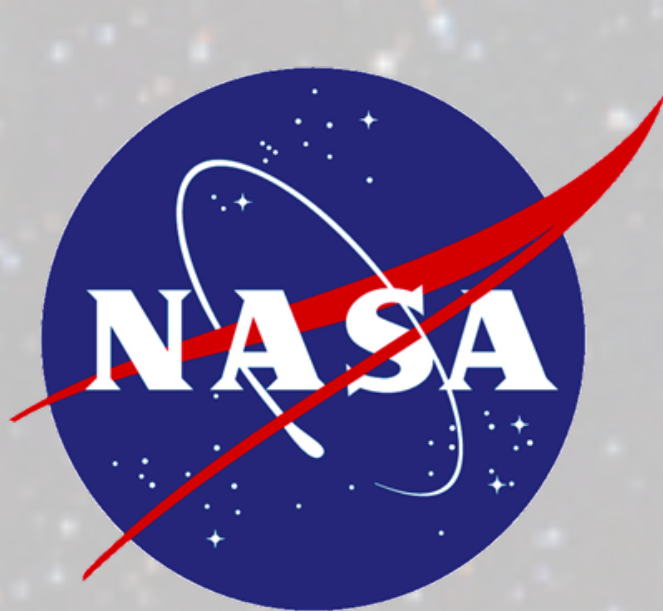
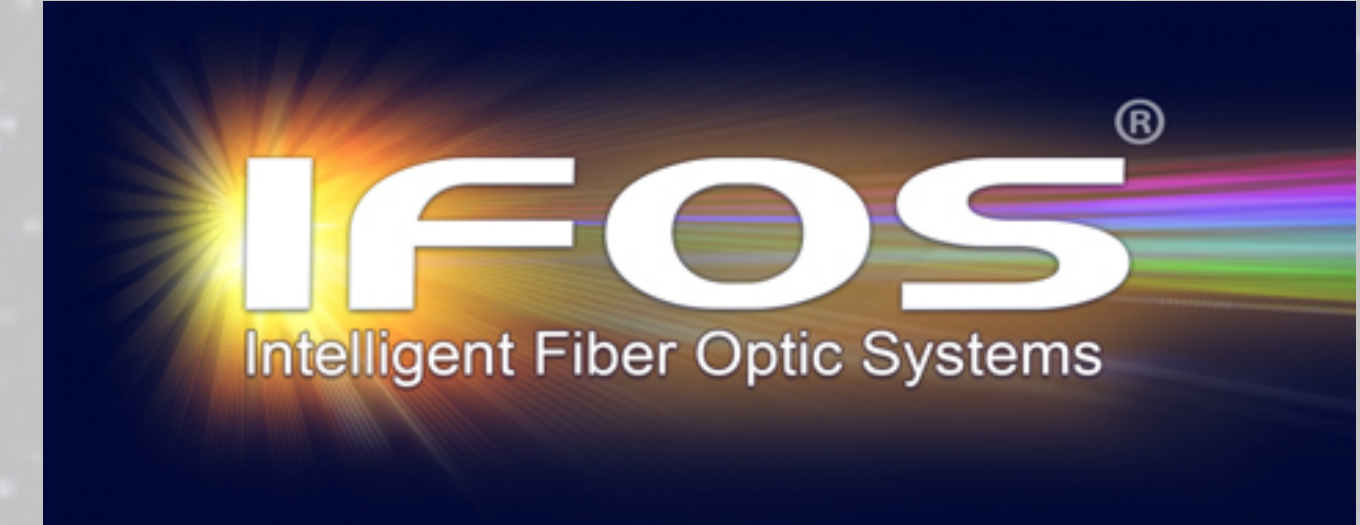


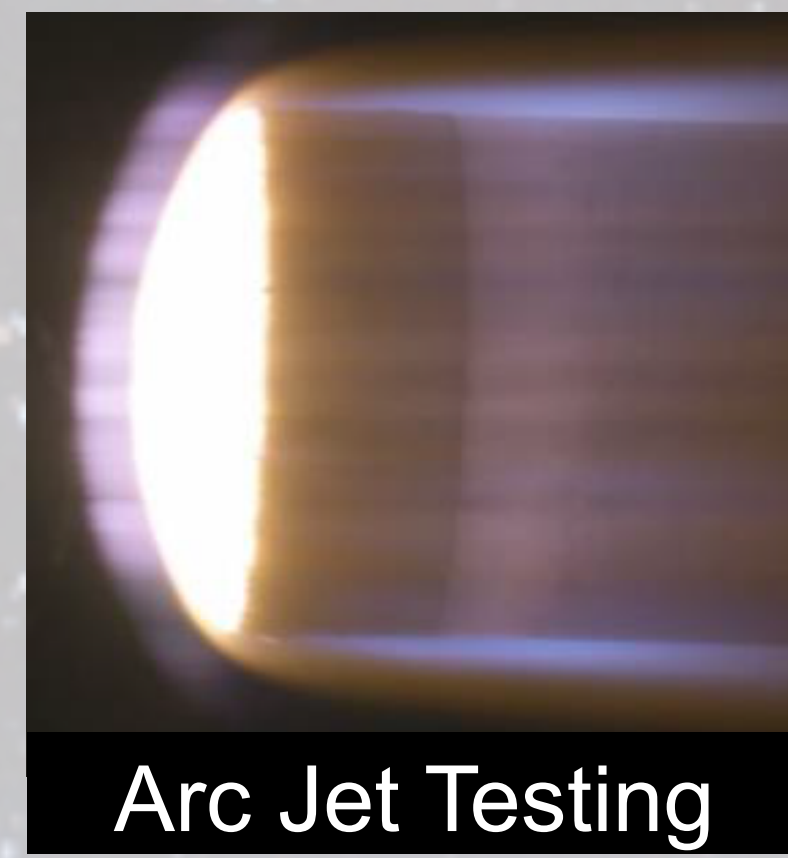


Fiber Optic Temperature Sensors in TPS: Arc Jet Model Design & Testing



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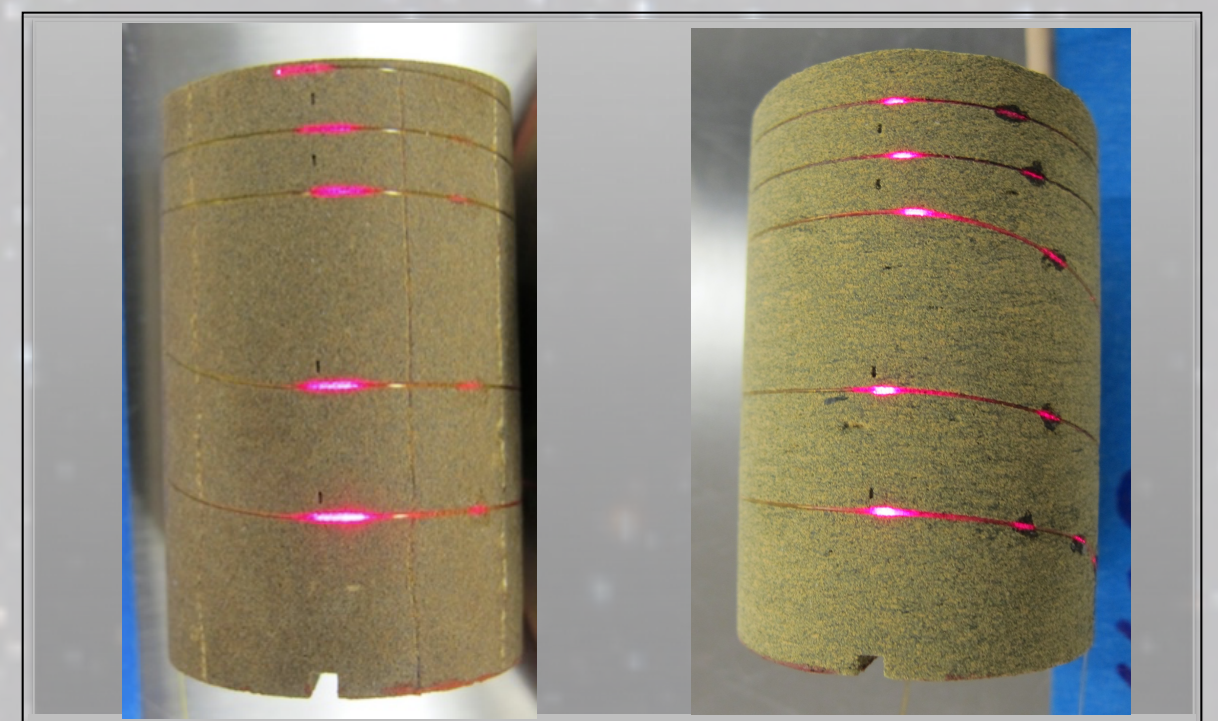
Arc Jet Testing

Introduction

This poster describes an IFOS-NASA collaboration resulting in the first-ever arc jet testing of fiber optic temperature sensors

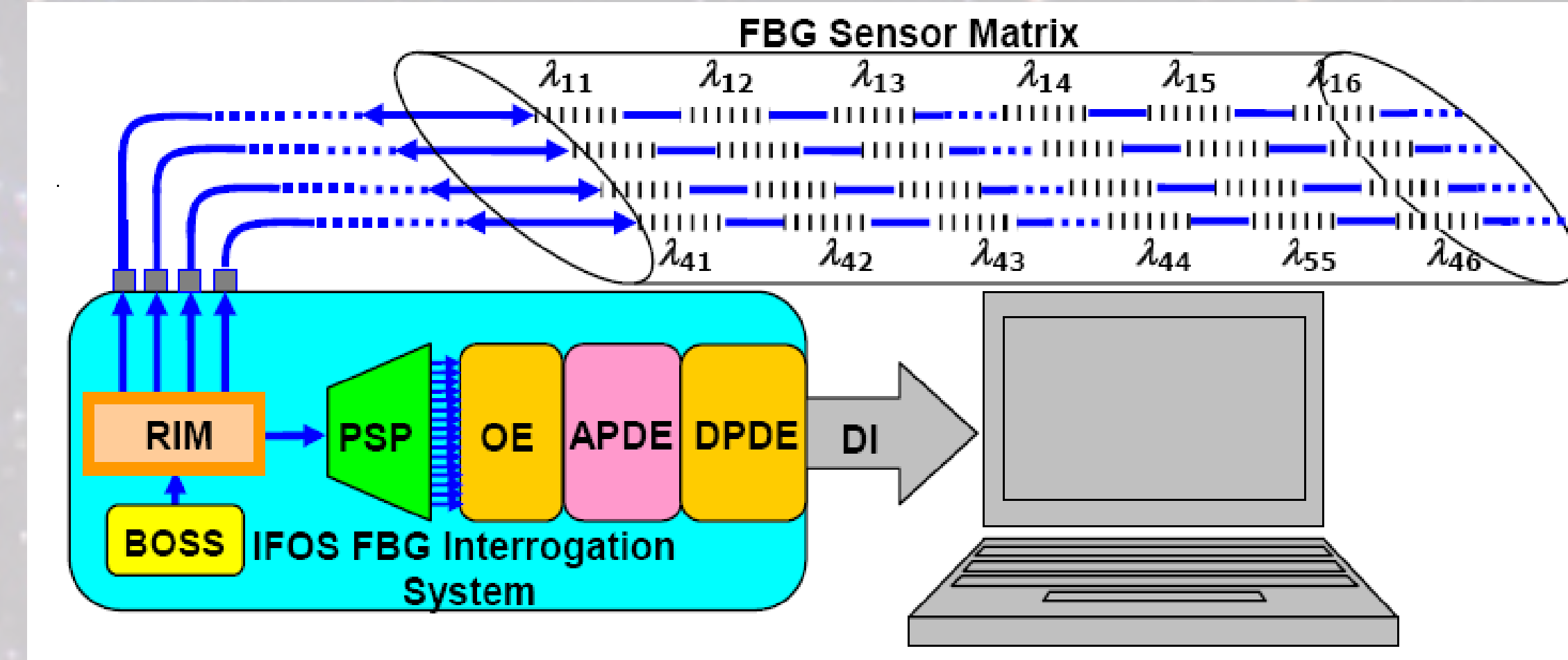
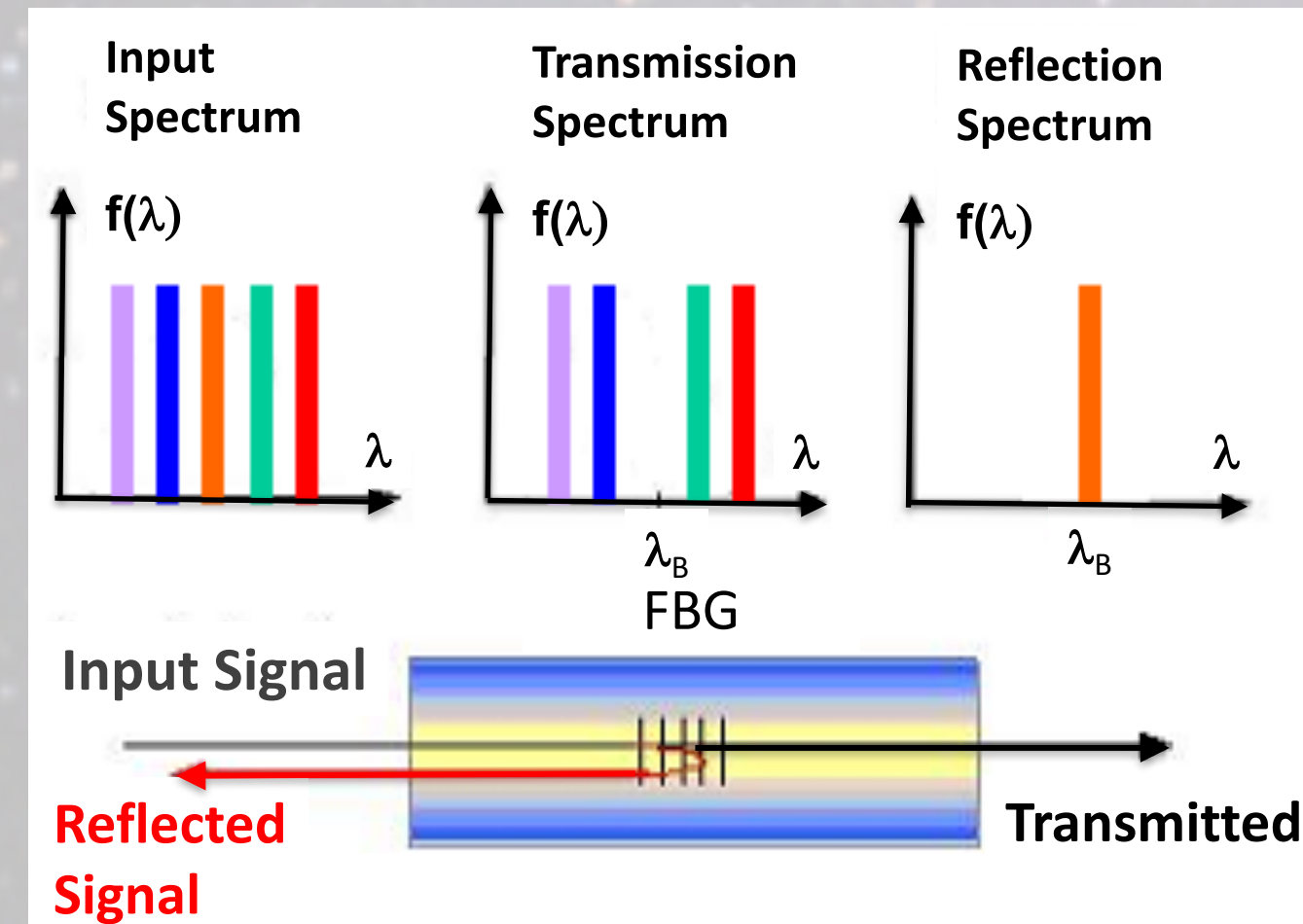
IFOS Corp. has developed fiber optic temperature sensing technology for Thermal Protection System (TPS) materials

Fiber optic-based temperature sensors offer potential improvements over state-of-the-art thermocouples (TCs), as described below



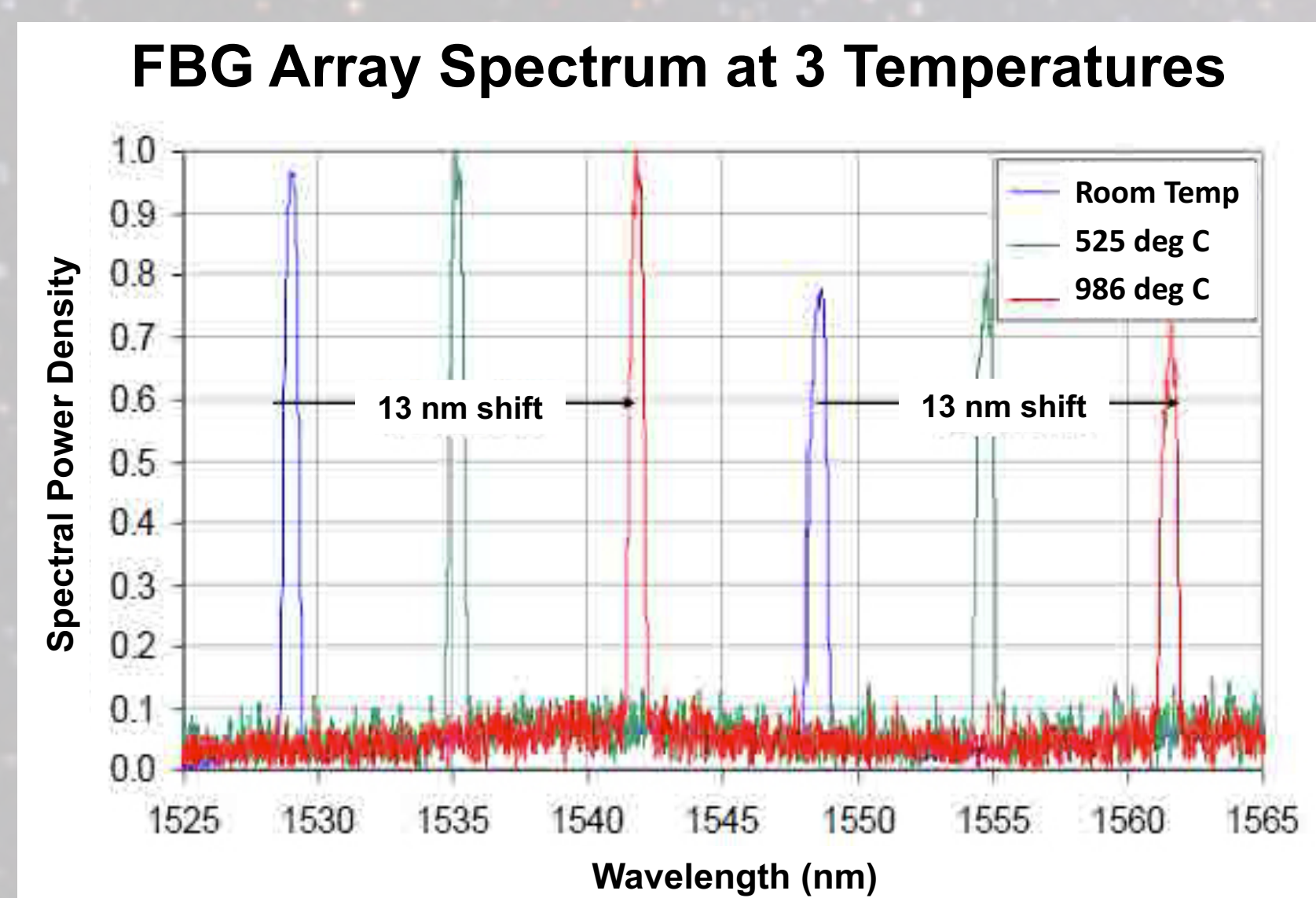
Fiber Optic Sensor Plugs

Background: Fiber Bragg Grating Based Sensing



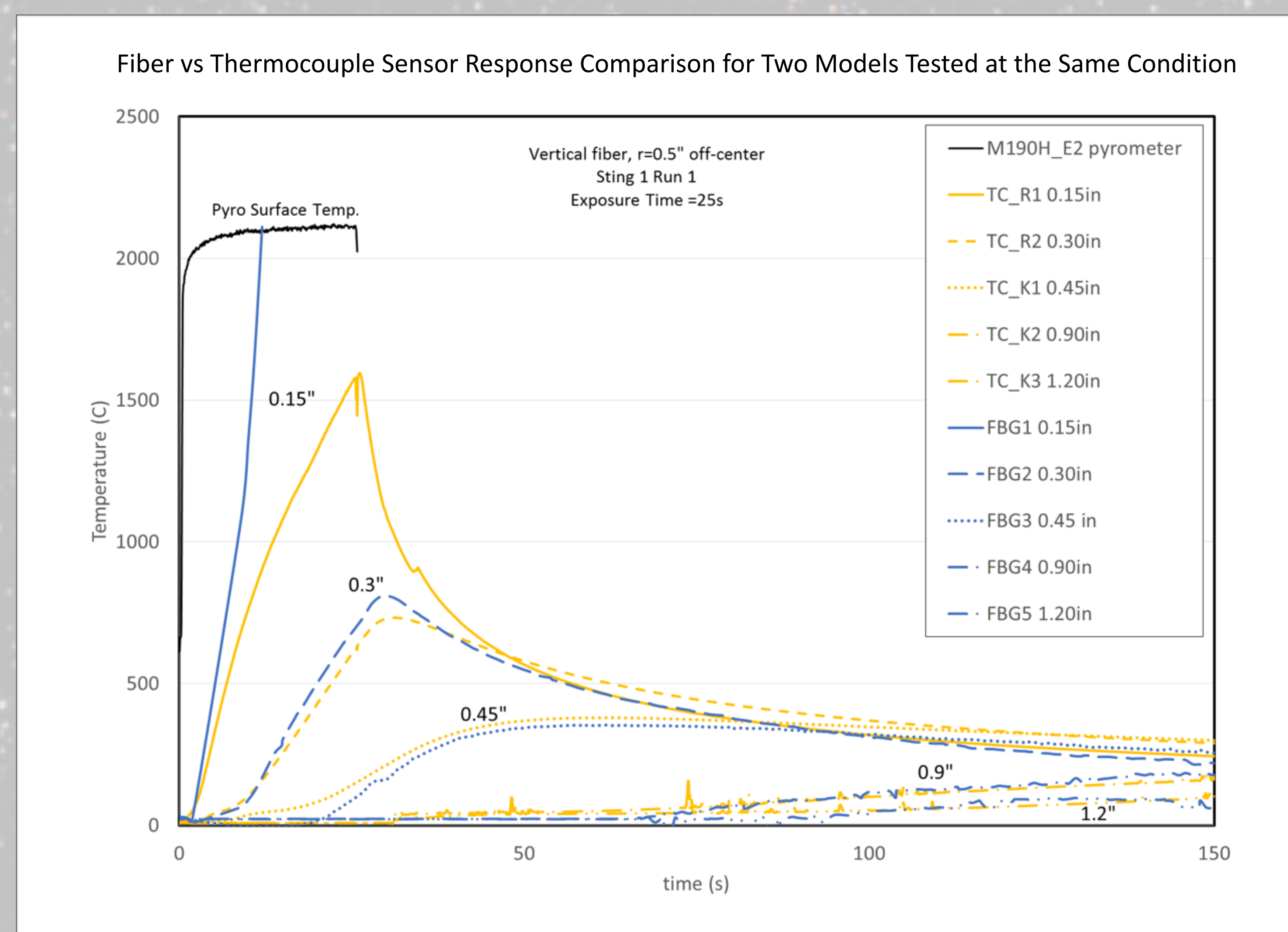
- Fiber Bragg Gratings (FBGs) are designed to reflect precise wavelengths of light
- Many FBGs, each of a unique wavelength, can be produced on a single fiber

- Reflected FBG spectrum is temp. dependent
- Compared to thermocouples (TCs), fiber optics have lower thermal conductivity (therefore perturb local thermal gradient less) and are non-electrically conductive (which is problematic for some TPS materials with TCs)
- Fibers with many FBG sensors offer higher spatial resolution of temperature sensing compared to TCs



Arc Jet Testing & Preliminary Results

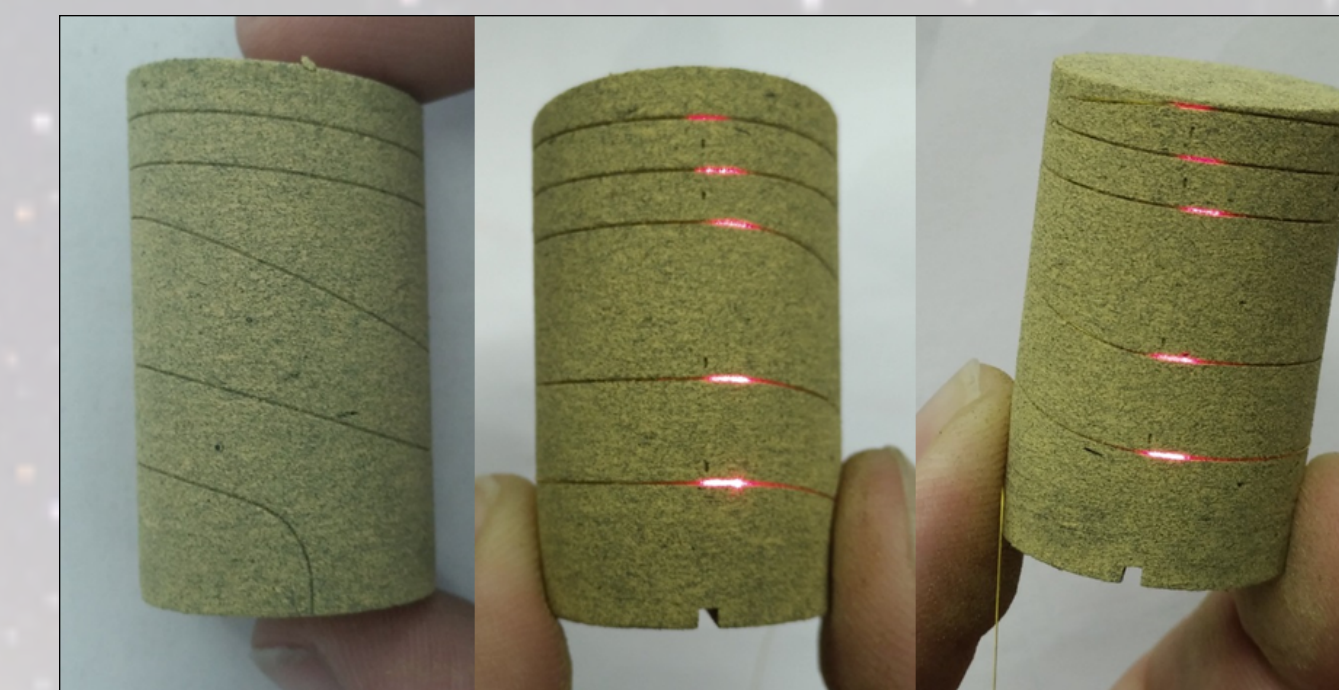
- A total of 18 PICA and BPA models were arc jet tested at a cold wall heat flux of 240 W/cm², at a pressure of 9 kPa, and for durations of 15 to 60 seconds
- In each arc jet run, one TC model and four fiber models were tested
- Testing was recently completed, data analysis is ongoing



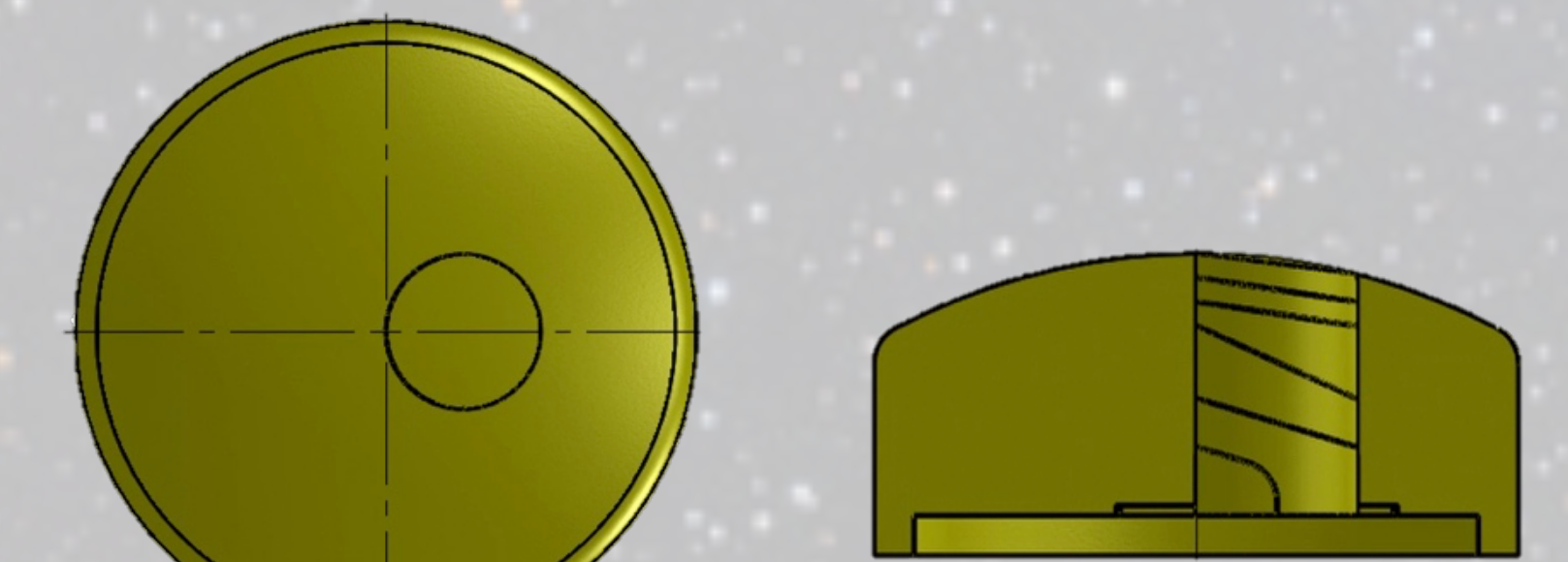
- In-depth sensors responded similarly (0.3" below surface and lower)
- The 0.15" FBG response shows much higher temperatures than expected, but is also well beyond the ~1000 °C max calibration range

Arc Jet Model & Fiber Optic Plug design

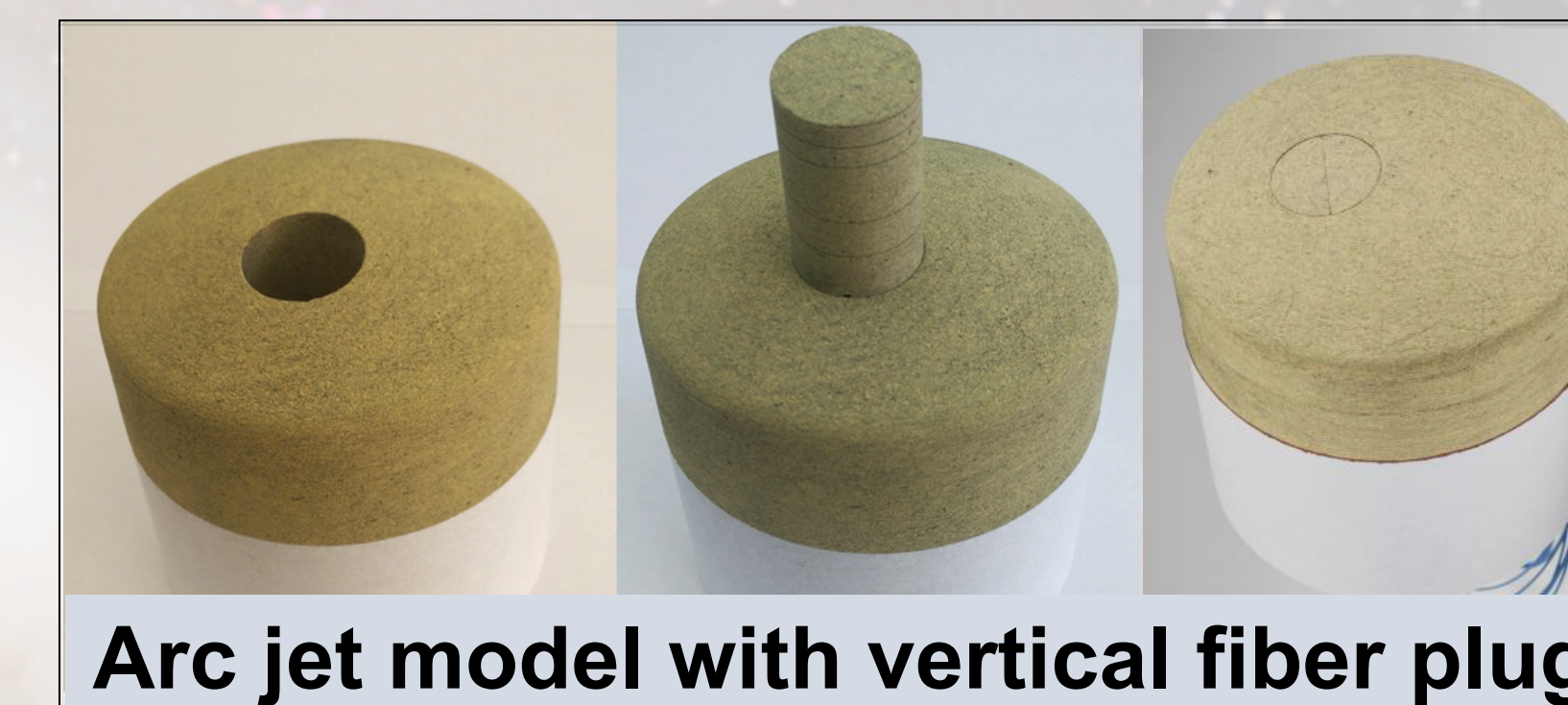
- The primary design consists of 1" diameter plug with fiber optic wound around the circumference in a precisely-machined groove to align FBGs along two axes
- Five FBGs along centerline axis and 5 offset to detect sidewall heating
- 4 mm long FBGs parallel to the outer surface to limit in-depth thermal conduction
- Thermocouple and fiber optic models were instrumented with the same sensor locations to facilitate comparison of the two techniques



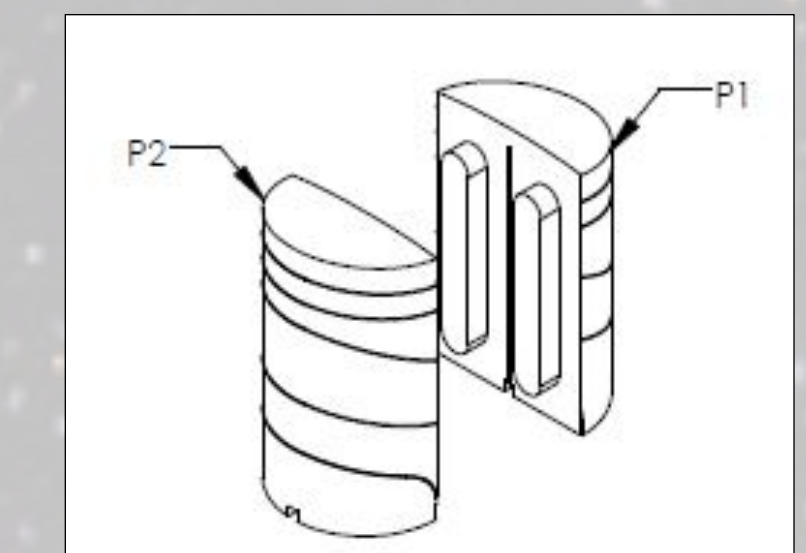
Wound plug with FBGs 180° apart to measure centerline & sidewall heating



4" diameter Iso-q arc jet model with plug



Arc jet model with vertical fiber plug



A few models were produced with vertical fiber FBG plugs

Conclusions & Future Direction

- Fiber optic temperature sensing of TPS materials in a planetary entry-relevant heating environment has been demonstrated based on IFOS interrogation of FBG-reflected spectra in PICA and BPA arc jet coupons
- Fiber plug design allows for many sensors per plug, high data rates (kHz)
- In-plane distribution of sensors enables assessment of 2D/3D heating effects (still under evaluation for this test series)
- Fiberglass-based FBG sensing is reliable to at least 1000 °C
- High temperature fiber optic sensing limits could be increased using sapphire fibers, which is currently under development by IFOS
- Other parameters tested during this series include the effect of FBG size (trading signal for location precision with decreasing size) and a vertical fiber orientation are still under evaluation



BPA before & after arc jet testing



PICA before & after arc jet testing

Acknowledgements: Thanks to Raj Venkatapathy of ARC for guidance, NASA's Game Changing Development Program for funding, Robert Frampton of Boeing for providing BPA material, Mark Lippold of FMI for providing PICA material, Jose Chavez-Garcia for CAD work, ARC AHF Arc Jet Facility personnel for their help in preparing & executing this test series, especially Enrique Carballo & Imelda Terrazas-Salinas, Ames STAR labs for machining & assembly of arc jet models