Inspection of the CERES FM-6 Shortwave Filter at Satellite Integration Level with Portable Raman Spectroscopy

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Contamination: What? Where? When?

- **During a routine visual inspection of Clouds and the Earth's Radiant Energy System (CERES) Flight Model-6 (FM6), potential contamination was identified in July 2015 on the surface of the shortwave (SW) telescope filter**
  - Smudges and scratches observed on the central metallized disk portion of the filter and residue observed on the clear aperture
- **Risks:**
  - Risk of contamination changing over time and impacting science data
  - Risk of damage to optic from contact sampling or cleaning creating greater performance degradation than contamination alone
- **Issue was found late in the systems integration and test phase at satellite integration level**
  - More difficult to diagnose and correct than earlier hardware lifecycle phases

CERES FM6

Novel approach was needed to probe the suspected molecular film and possibly chemically identify the feature without contacting the optical surface

New Method: Portable Raman Spectroscopy

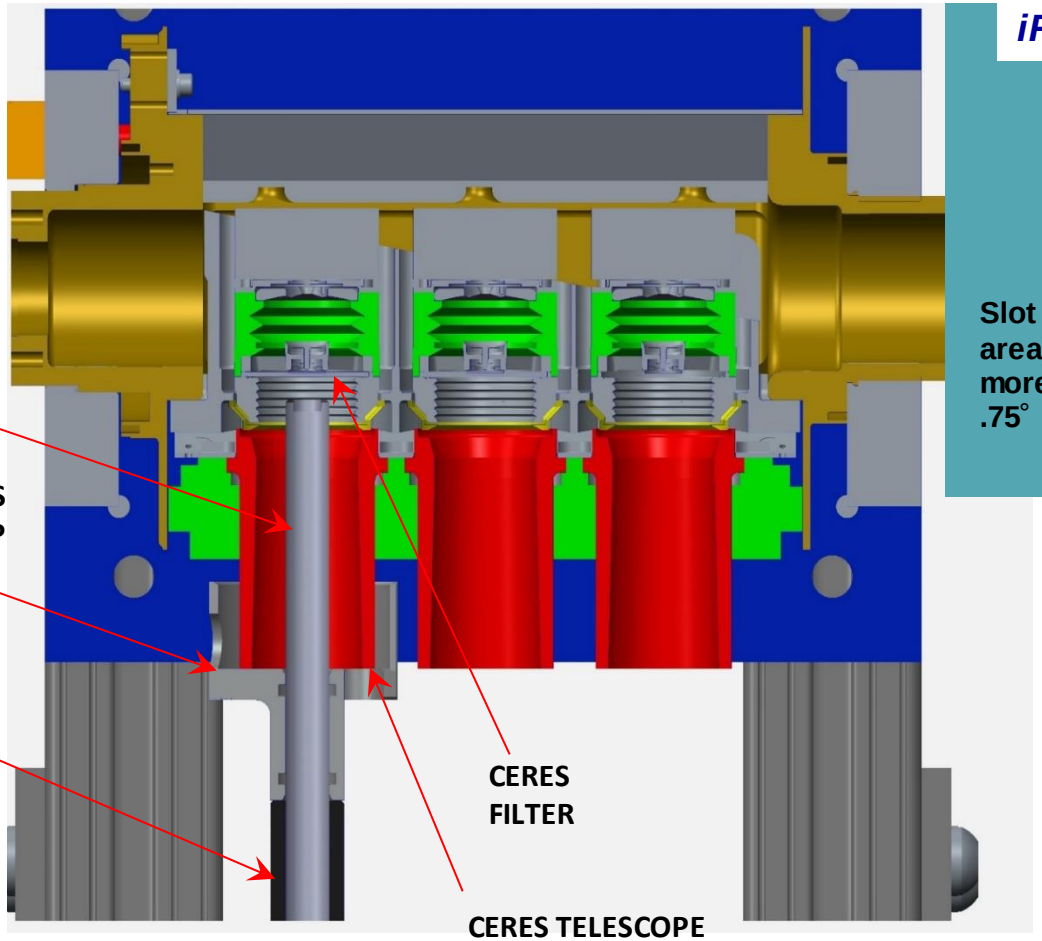
- **Portable Raman Spectroscopy chosen as the analysis method**
  - Sample irradiated with excitation laser and the resulting scatter from the material generates a Raman spectrum which can be used in material identification
- **Benefits:**
  - Non-contact
  - Instantaneous results
  - Repeatable measurements
  - Portable equipment
- **Challenges:**
  - Sample fluorescence can overwhelm the Raman signal
    - 1064 nm laser chosen to help reduce fluorescence
  - Potential laser damage of substrate
    - Hundreds of material trials performed to determine test settings
    - Laser power limited to 7%

B&W Tek i-Raman® EX portable Raman system with 1064 nm excitation laser

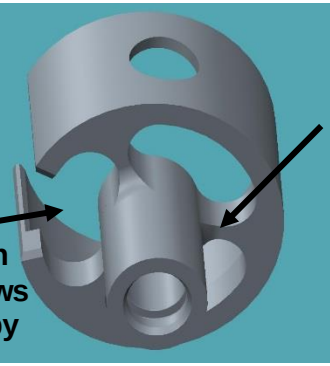
Modifications made and custom tooling created for reducing risk to instrument and spacecraft

Custom Probe and Probe Guide

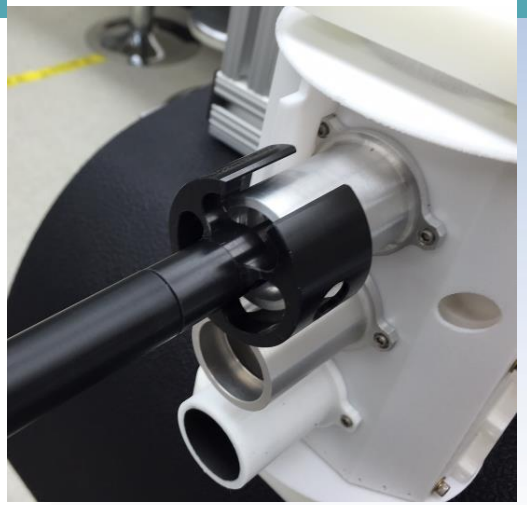
- Custom 9 inch probe purchased from B&W Tek
- Custom Probe Guide designed to prevent probe contact with optical surface and also maintain 5.4 mm working distance



iRaman Probe Guide Features



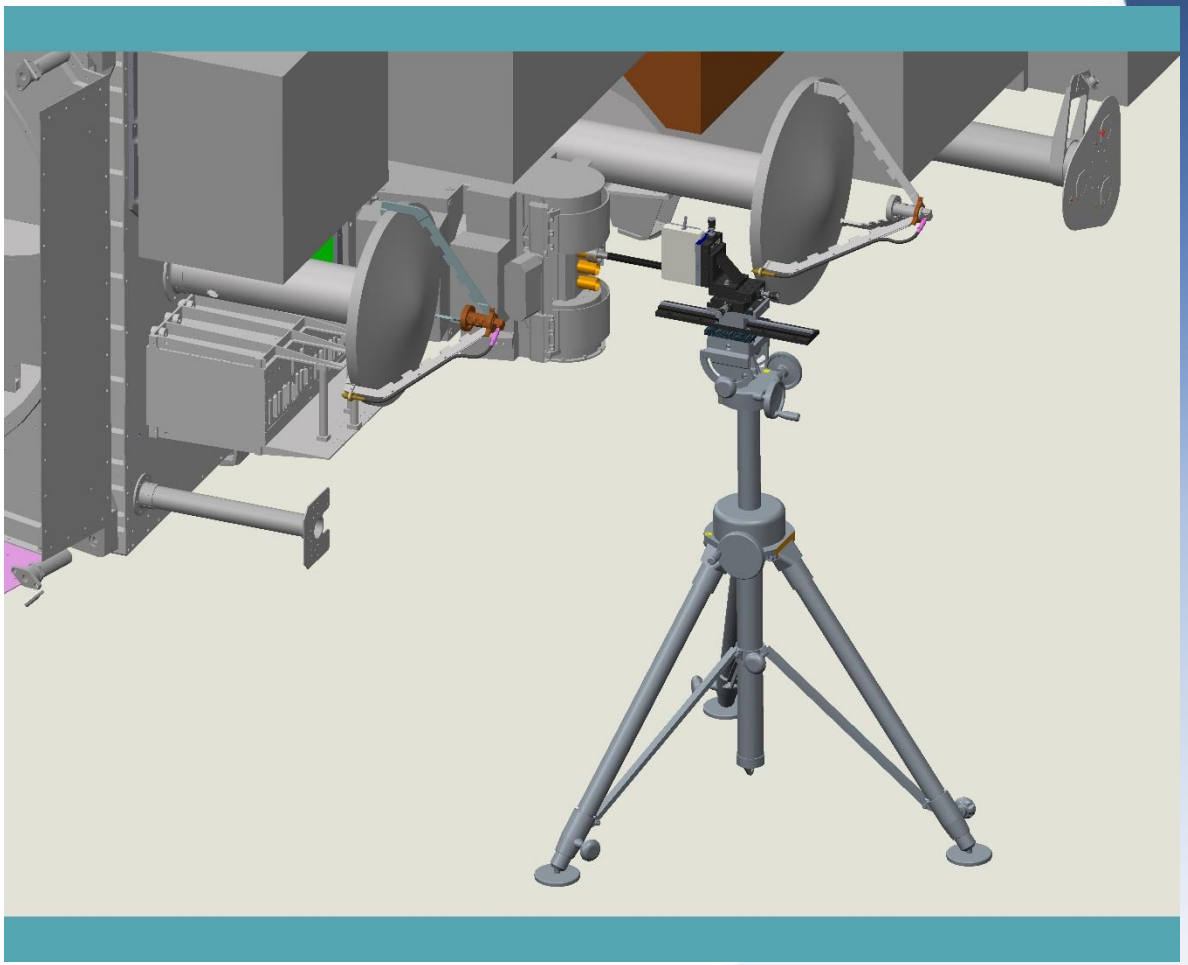
Probe Guide and Mock-up



Probe Mounting, Precision Translation Stage, and Tripod

- Delrin fixture captured probe handle and mounted to translational stage
- XYZ stage mounted to tripod for stability and precision adjustment

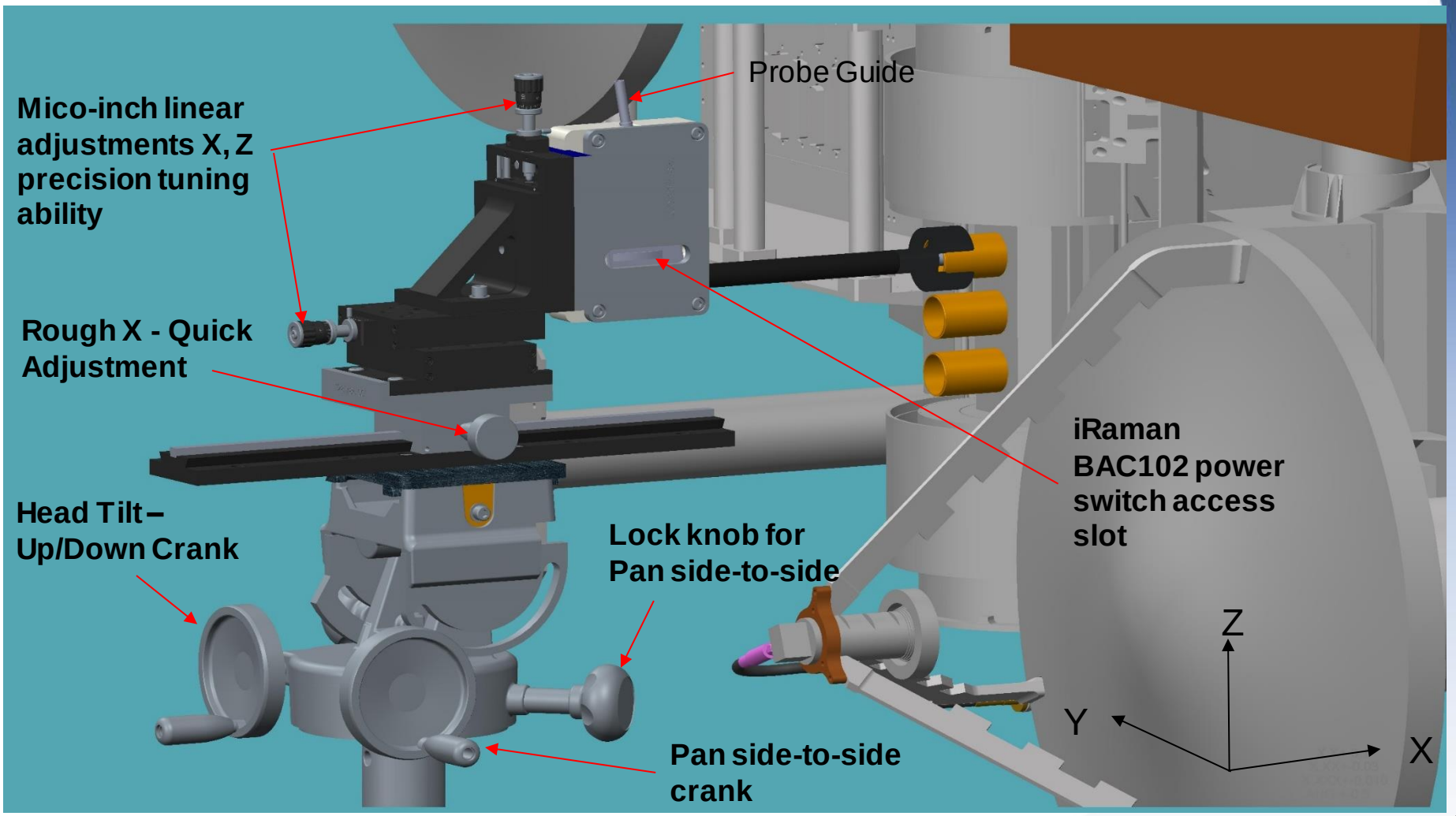
Probe Handle Mounting on Tripod



Modeled Test Configuration with Spacecraft

Test Procedure Development

- Test procedure developed to precisely position the probe and analyze 4 areas of the SW filter within the 4 hour instrument off-purge limit

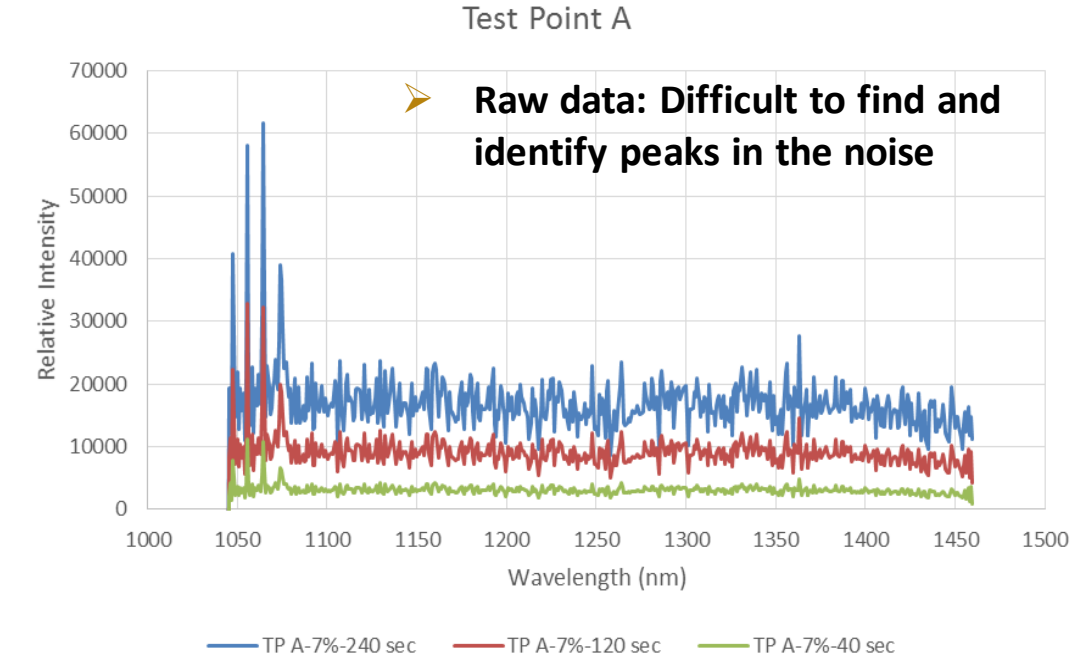


Data Collection and Analysis

- **4 test points identified based on visible features**

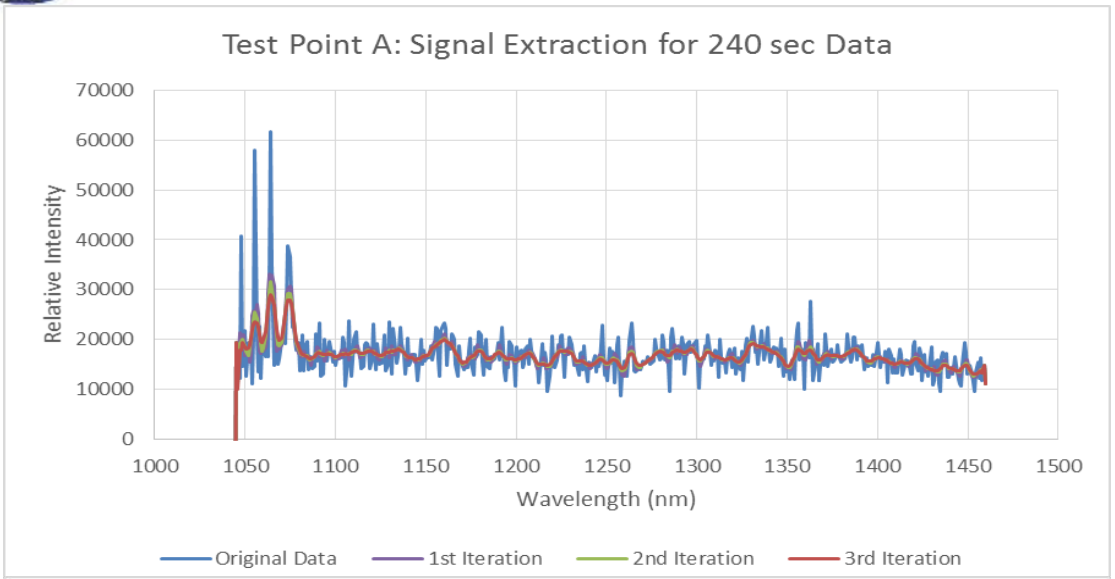
Test Point on Filter	Description
A	Most smudging visibly detected
B	Limited smudging and scratching
C	Scratch marks and limited smudging
D	Scratch marks and limited smudging

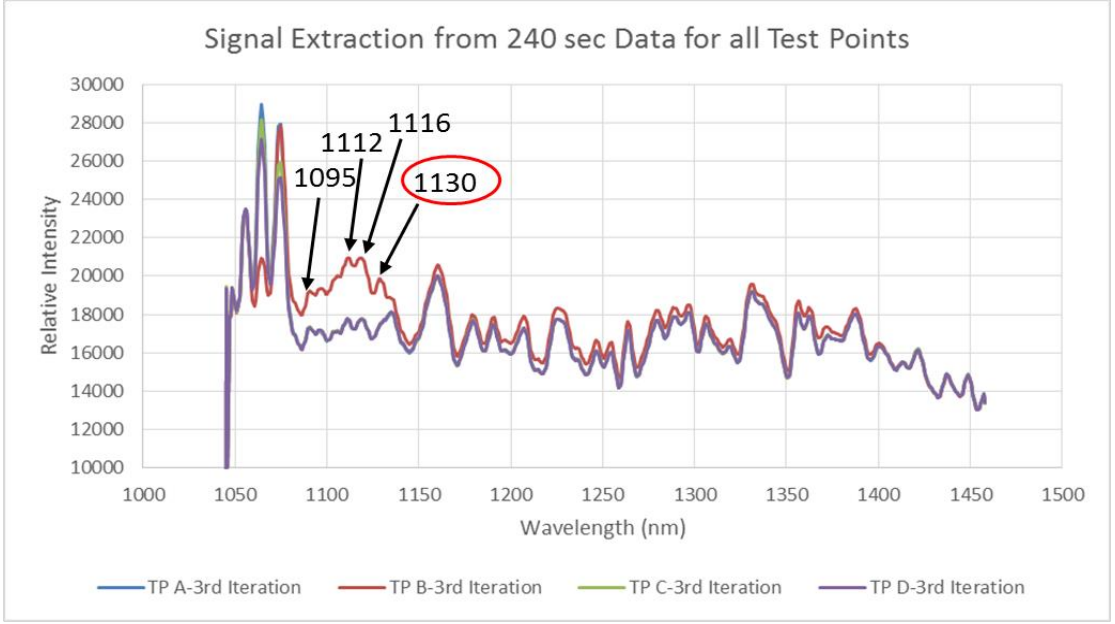
- **Each area was scanned for 40, 120, and 240 seconds**
- **Laser power limited to 7%**
- **IPA blank scanned to verify proper iRaman operation**



Raw data from Test Point A

Signal Extraction





- **Signal extraction algorithm applied to data**
- **After 3 iterations, key peaks can be identified**

Conclusions and Future Work

Conclusion

- Data from portable Raman spectroscopy aided project decision makers
  - Determined contact cleaning would not be performed on SW filter

Additional Development

- Development continues on contaminant detection with portable Raman spectroscopy
  - Film thickness detection trials performed to compare to visual inspection method
    - Results currently under journal peer review
  - Trials underway on surface enhancement of Raman signal for better witness surfaces

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