A New NIST FT-IR Spectral Detector Comparator

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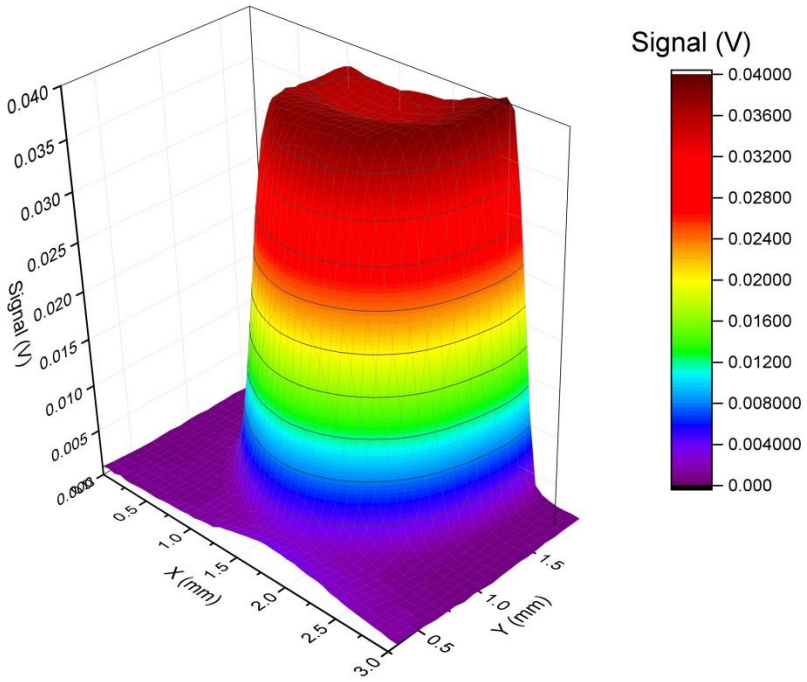

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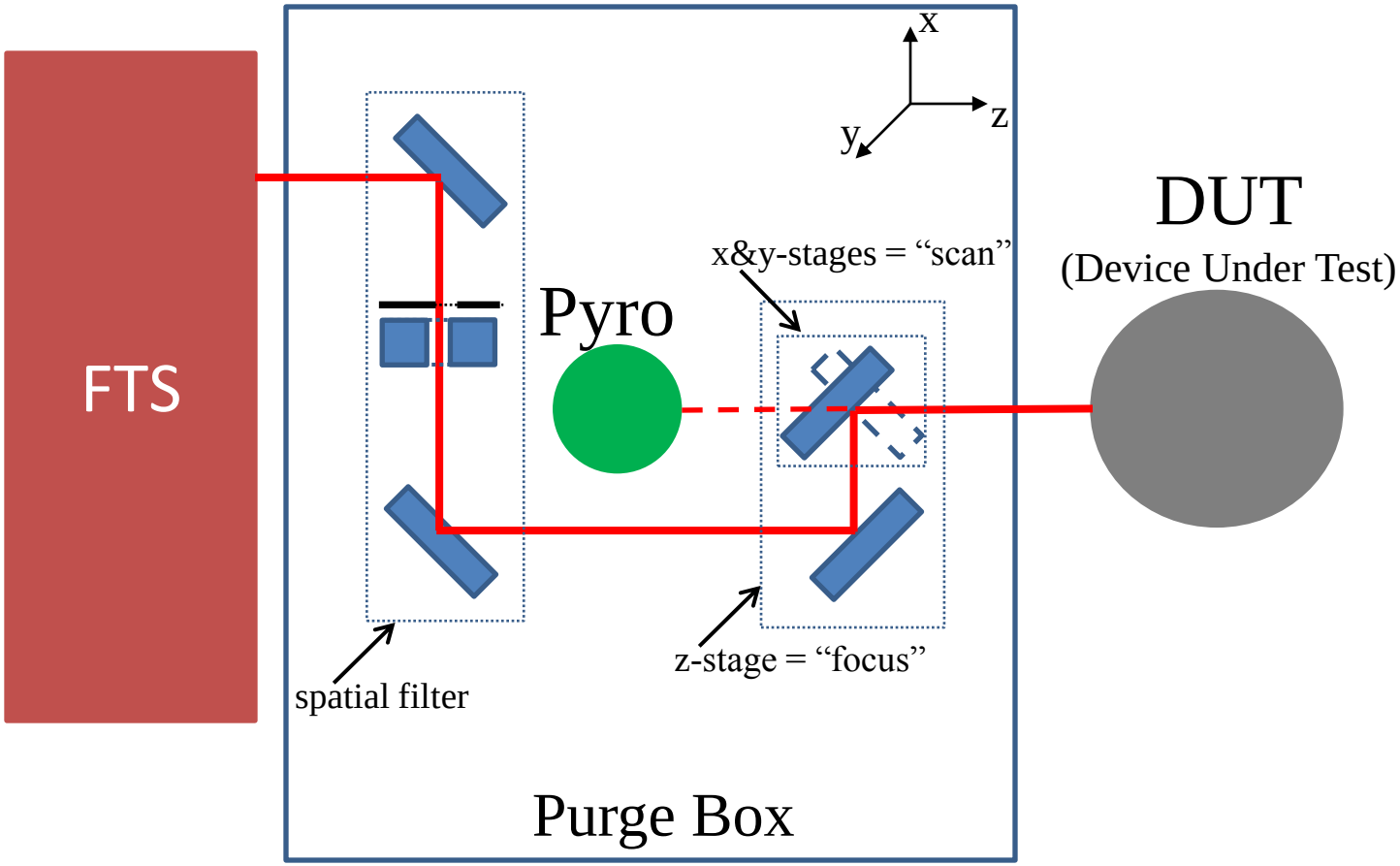
Talk Outline

- Overview of the FT-IR Spectral Detector Comparator
- Details of the Comparator Components
- Modes of operation, types of measurements
  - Spectral Comparator
  - Spatial Scanning
  - Chopper Measurements
  - Electrical Substitution Measurements
- Results of detector characterization and calibration
- Future tests and and plans for design improvements

FT-IR Spectral Calibration Schematic



FT Spectrometer Characteristics

Resolution: 0.125 cm^{-1} to 128 cm^{-1}; 32 cm^{-1} (typical), 128 cm^{-1} (centering)

Spectral Coverage: 1 μm to 50 μm

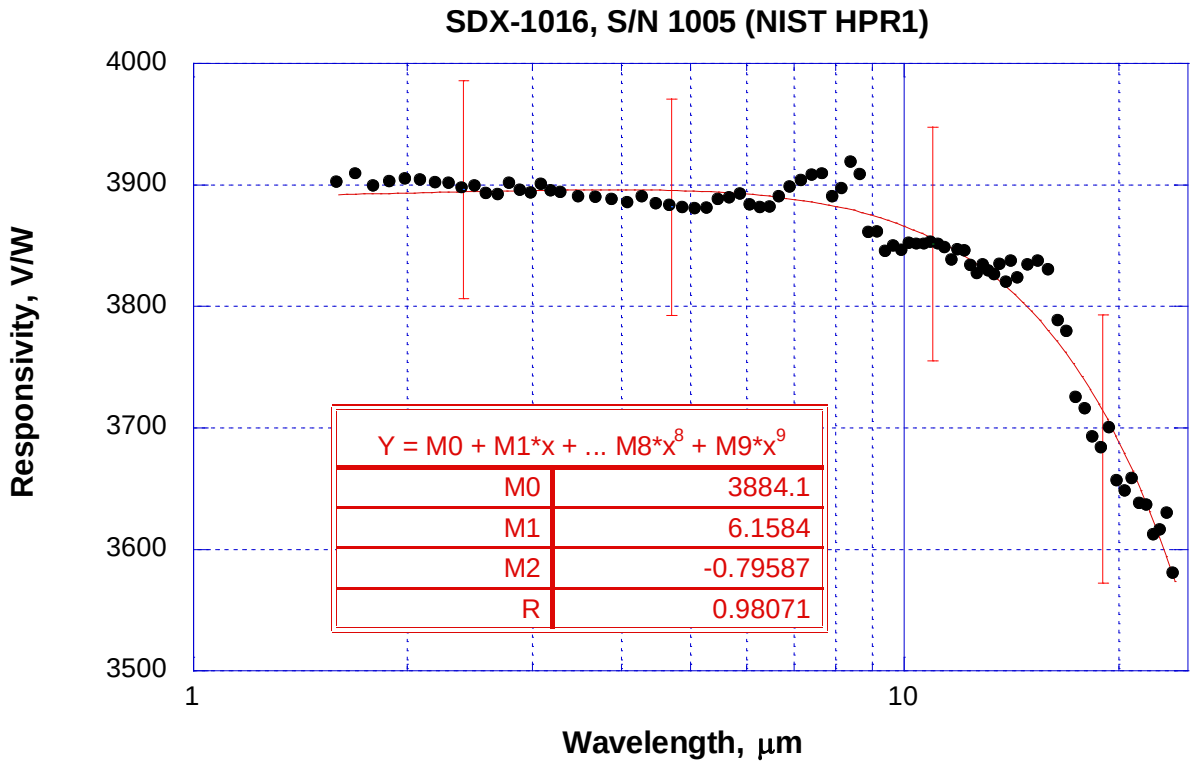
Sources: tungsten-halogen, globar, mercury vapor

Beamsplitters: quartz, KBr, CsI

Scan Speeds: 50 Hz to 20000 Hz (HeNe laser modulation frequency)

Acquisition Mode: A/D card collected at 200 kHz

Calibrated Pyroelectric Reference Detector



** Thanks to George Eppeldauer for providing the reference detector

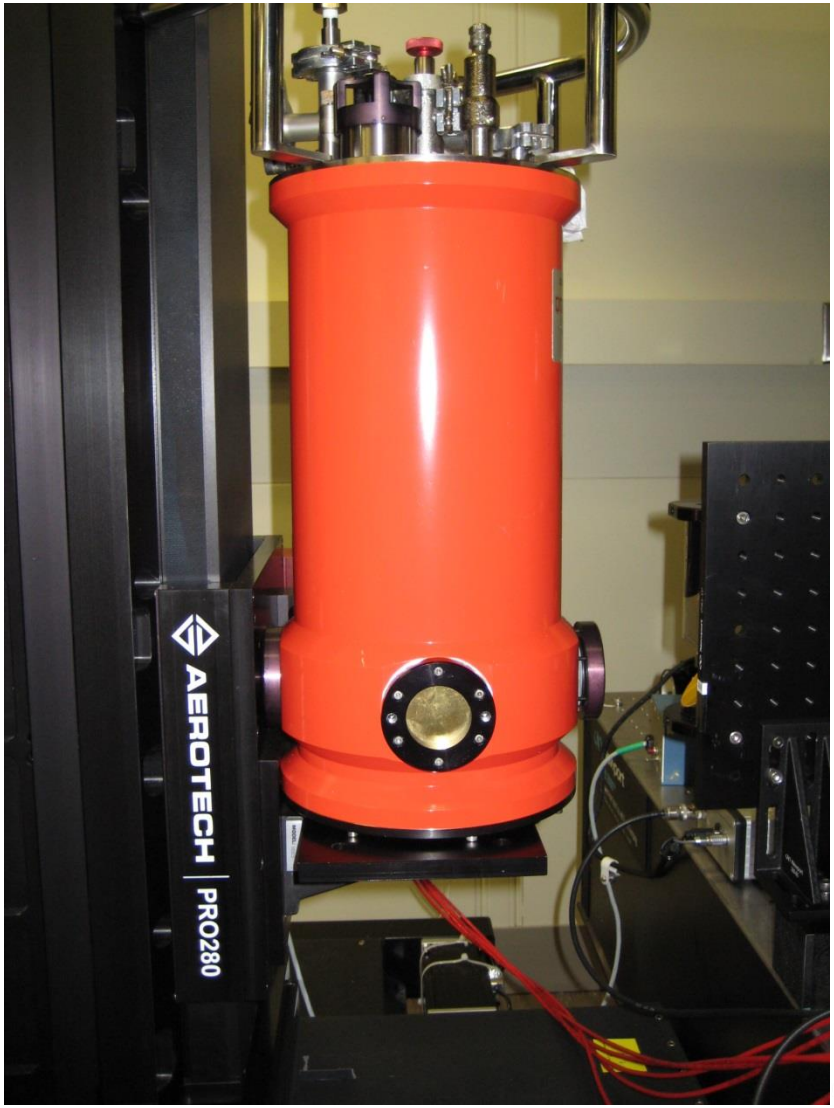
Helium Cryostat for Cryogenic Detectors

Base Temperature: 4.2 K at cold plate
~ 5 K at sample

Hold Time: 26 hours

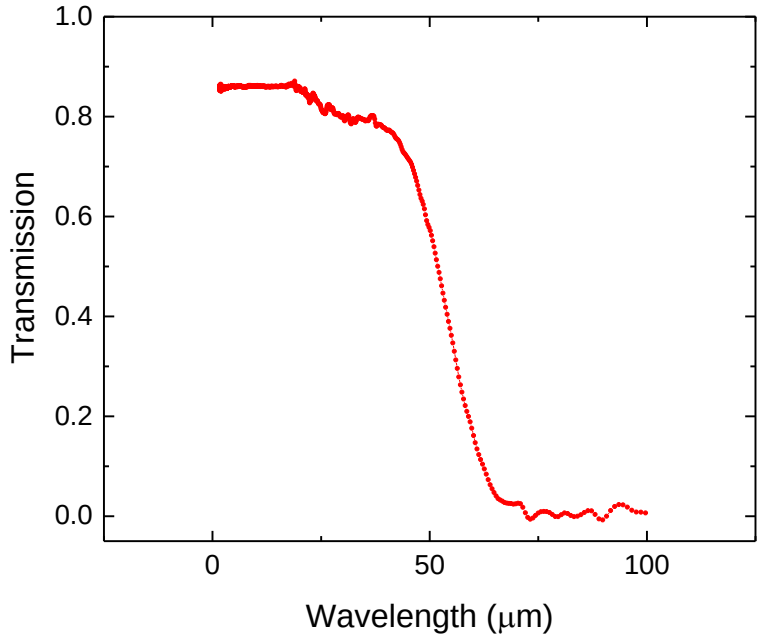
Mounting Area: 140 mm diameter

Detectors: BIB, BIB-trap, CNTR

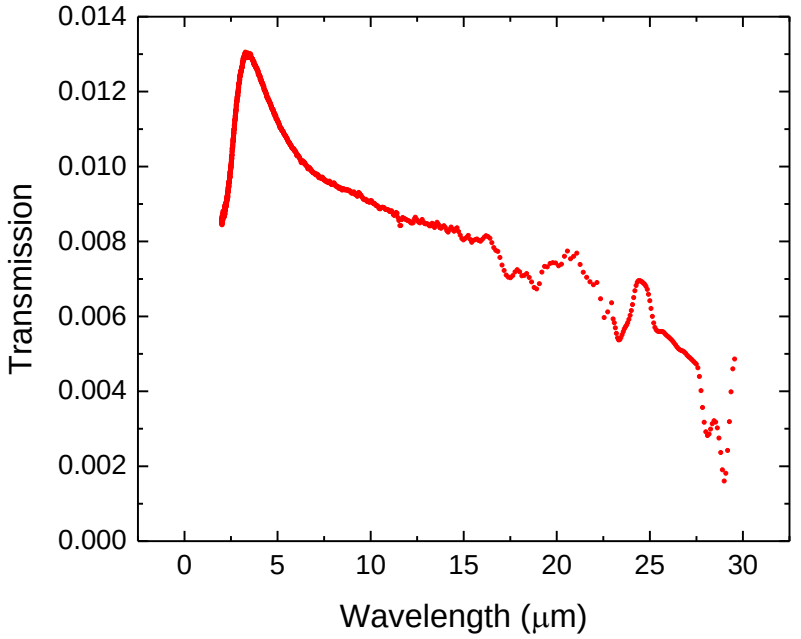


Cryostat Window and Filter Transmittances

Room-Temperature CsI Window (295 K)



Cold ND2 Filter (20 K)

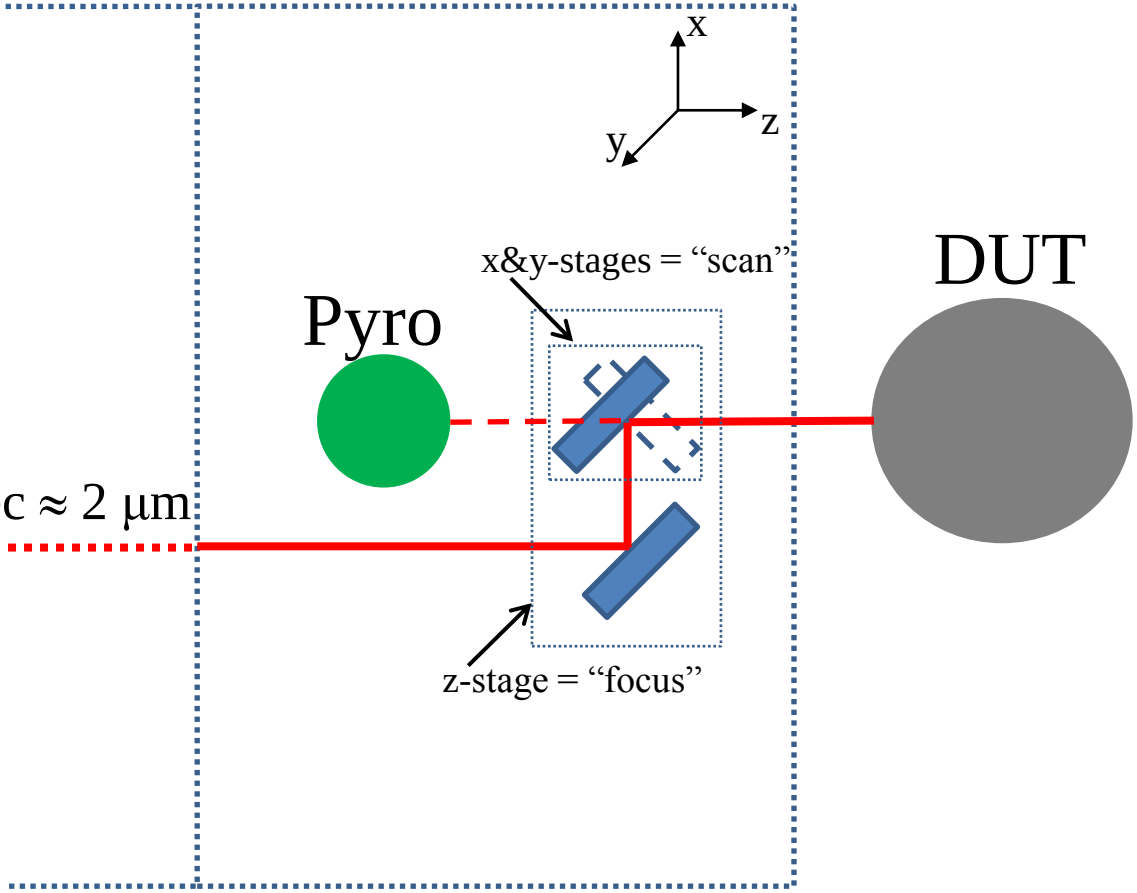


Stage and Actuator Specifications

x-stage:
repeatability = 2 μm

y-stage:
1° = 3.325 mm at detector
minimum step = 2.19 arcsec ≈ 2 μm

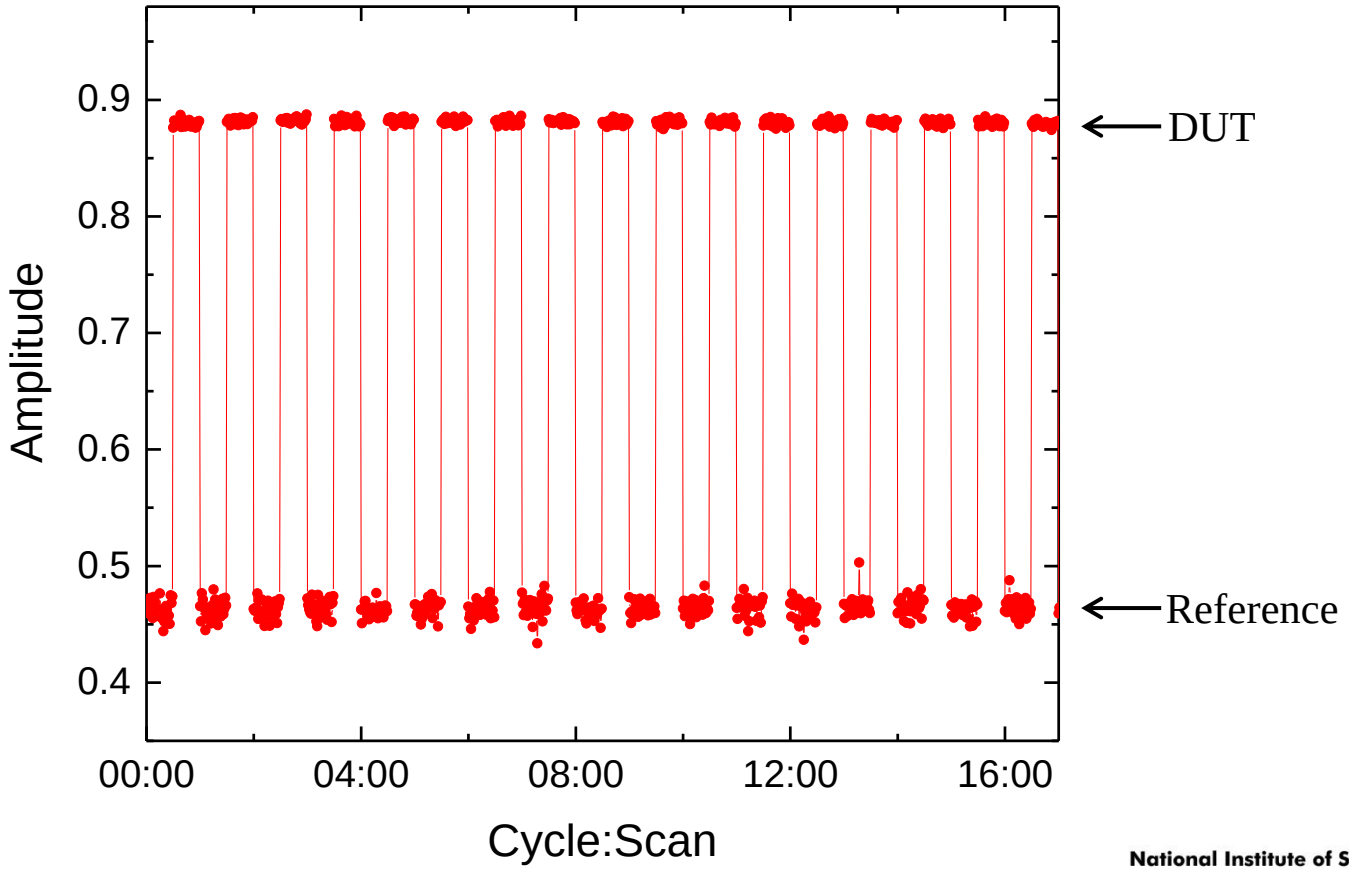
z-stage:
repeatability = 2 μm



Mode 1: Spectral Comparator

FTS: scanning
Paraboloid: cycled (comparator), fixed ("stare")

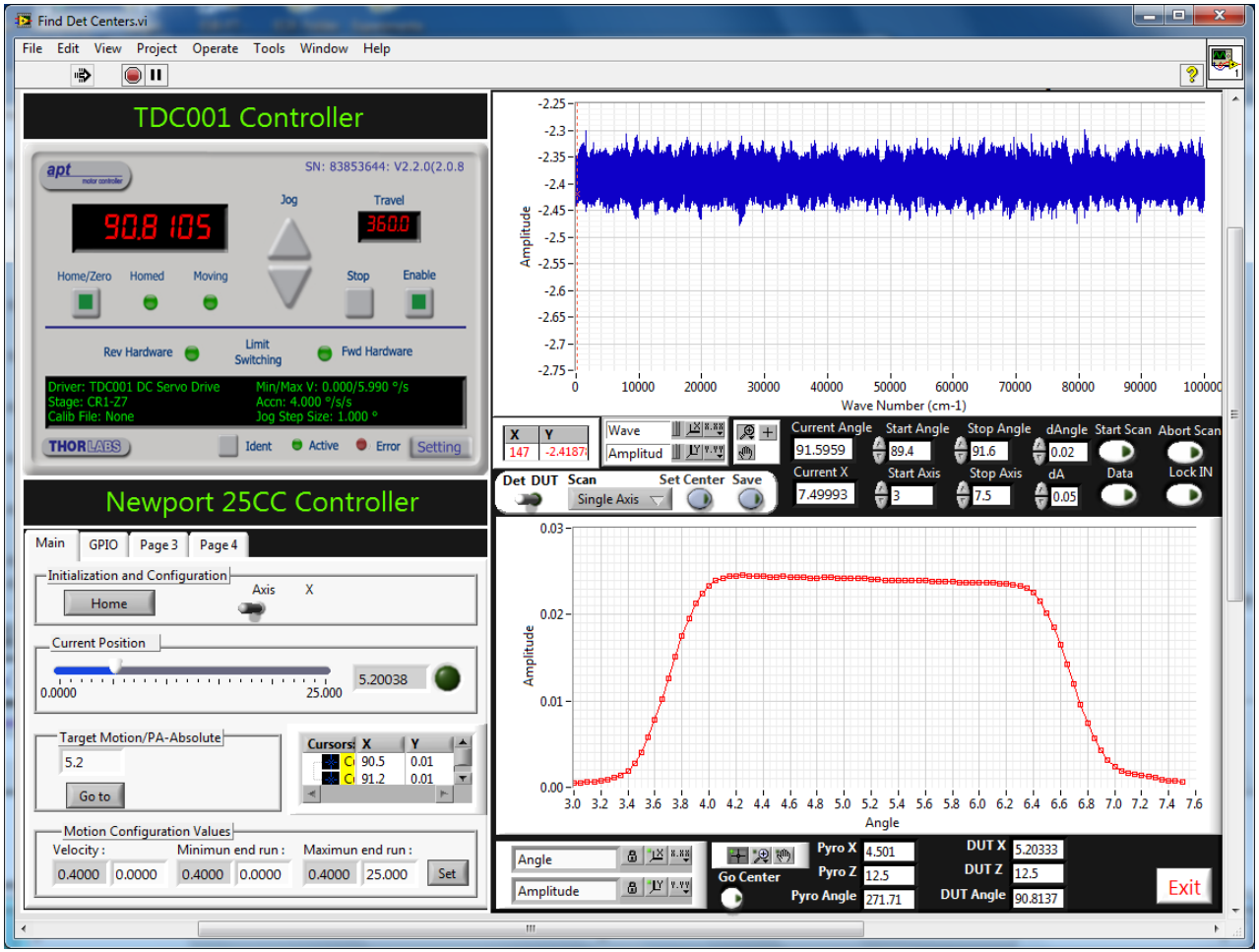
Trace of signal near 2000 cm^{-1}



Mode 2: Chopped Measurements with FTS Source

FTS: fixed for use as DC source

Paraboloid: cycled (comparator), fixed (spatial uniformity scan, centering)



Mode 3 & Mode 4: Under Development

Mode 3: Chopper measurements with narrowband sources

Sources: LEDs and lasers from 3 μm to 8 μm
Paraboloid: cycled (comparator), fixed (spatial uniformity scan, centering)

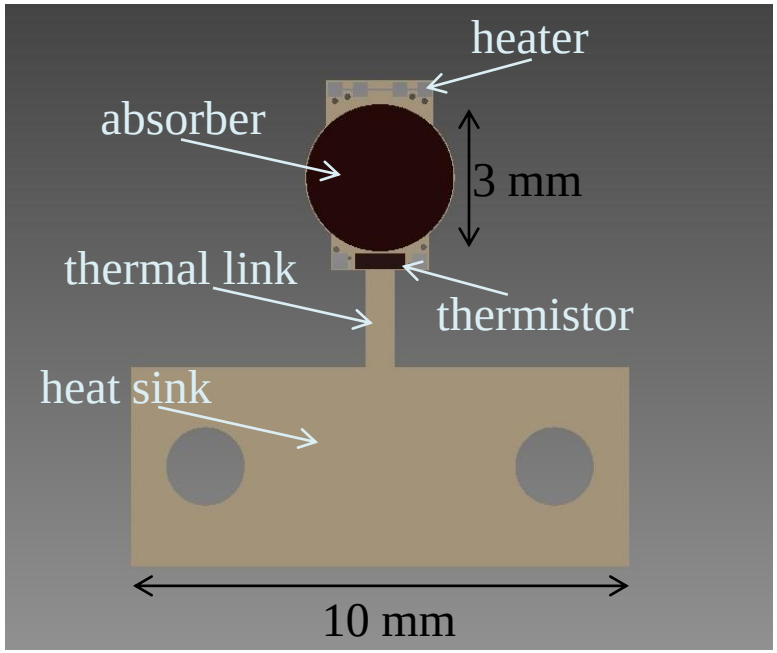
Mode 4: Electrical substitution measurements

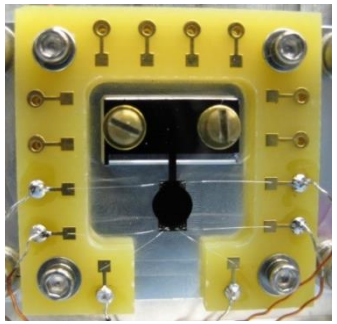
DC Measurement: Shutter modulation
Feedback = DC heating

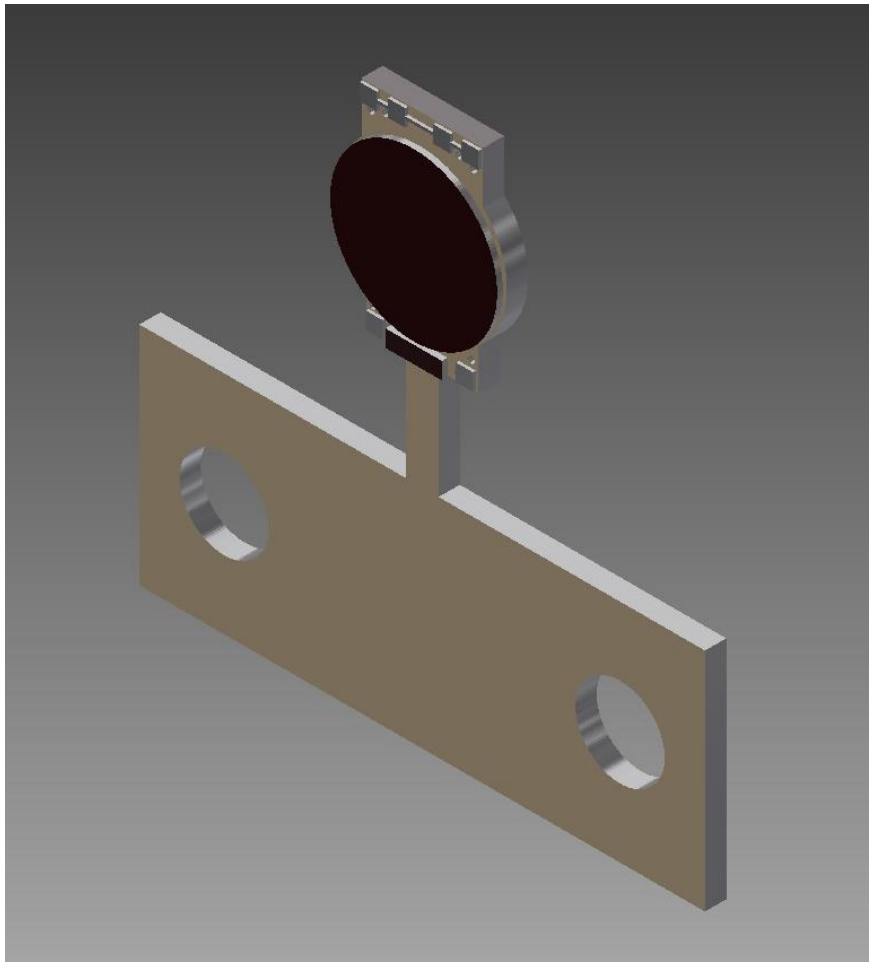
AC Measurement: Chopper modulation
Feedback = AC heating

Spectral Measurement: FTS modulation
Feedback = heat pulse from D/A card to null A/D card signal

Detectors Tested: Carbon Nanotube Radiometer (CNTR)

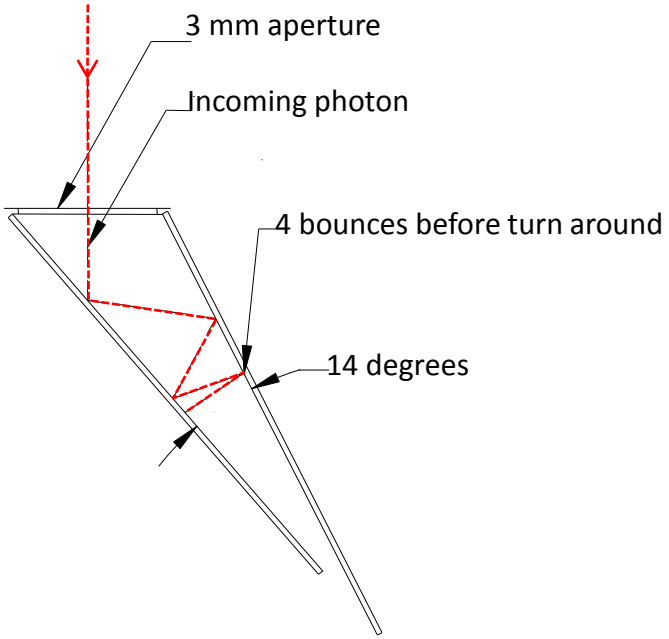


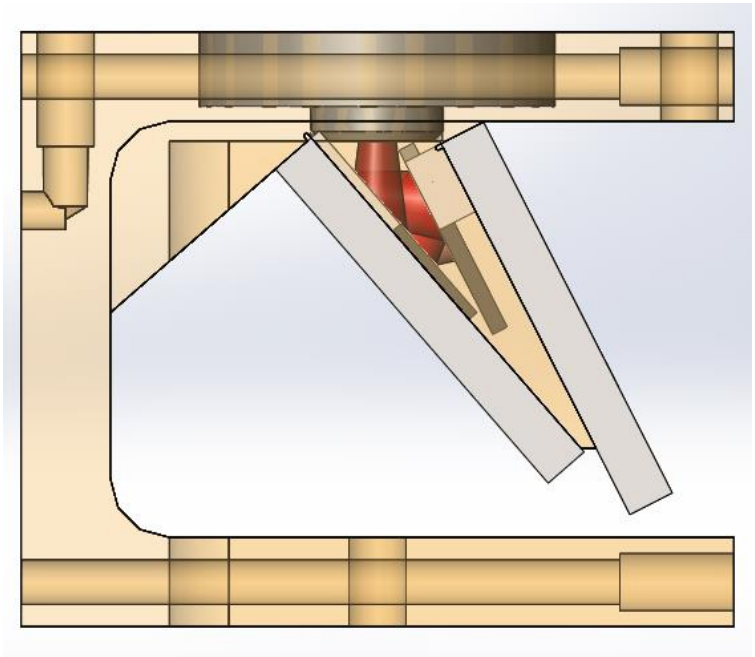


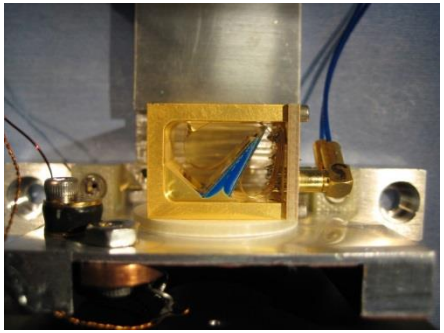


Planar ACR with Vertically-Aligned Carbon NanoTubes (VACNT) for the absorber. The VACNT material has reflectivity less than 0.2 % out to 18 μm, and less than 1 % out to 50 μm.

Detectors Tested: BIB trapping detector (BIB-trap)



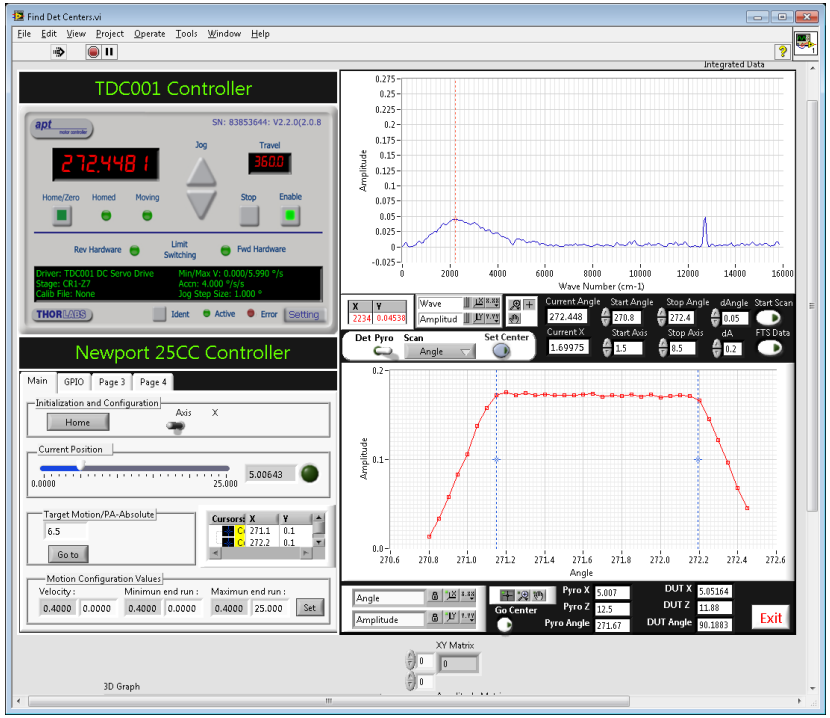




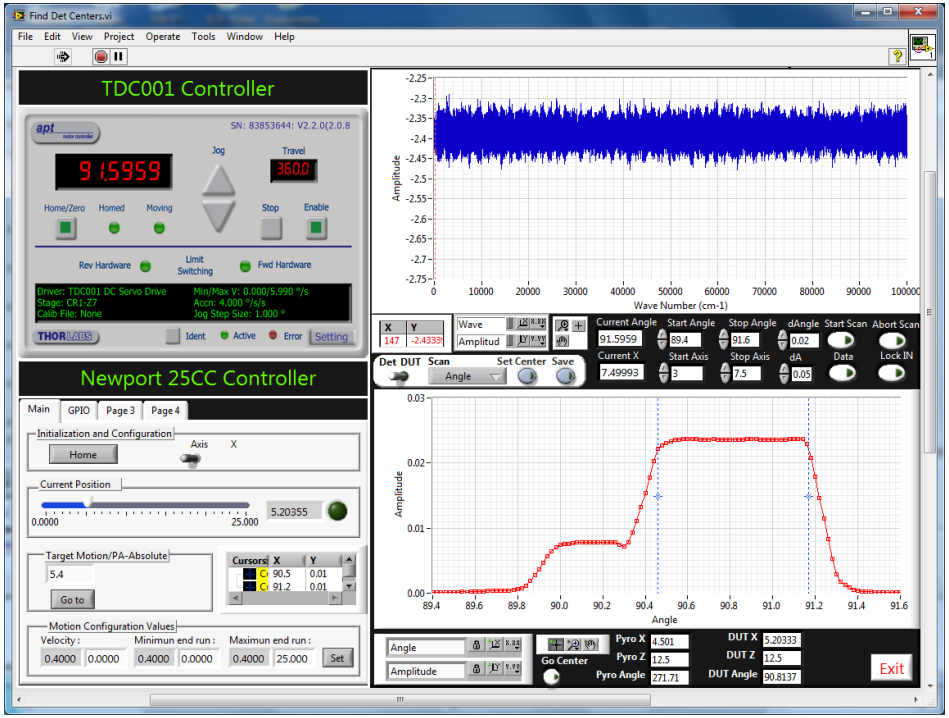
Trapping detector composed of two BIB (blocked impurity band) detectors, which exhibit significant responsivity from 2 μm to 28 μm.

Results 1: Detector Centering

FTS Mode y-Centering

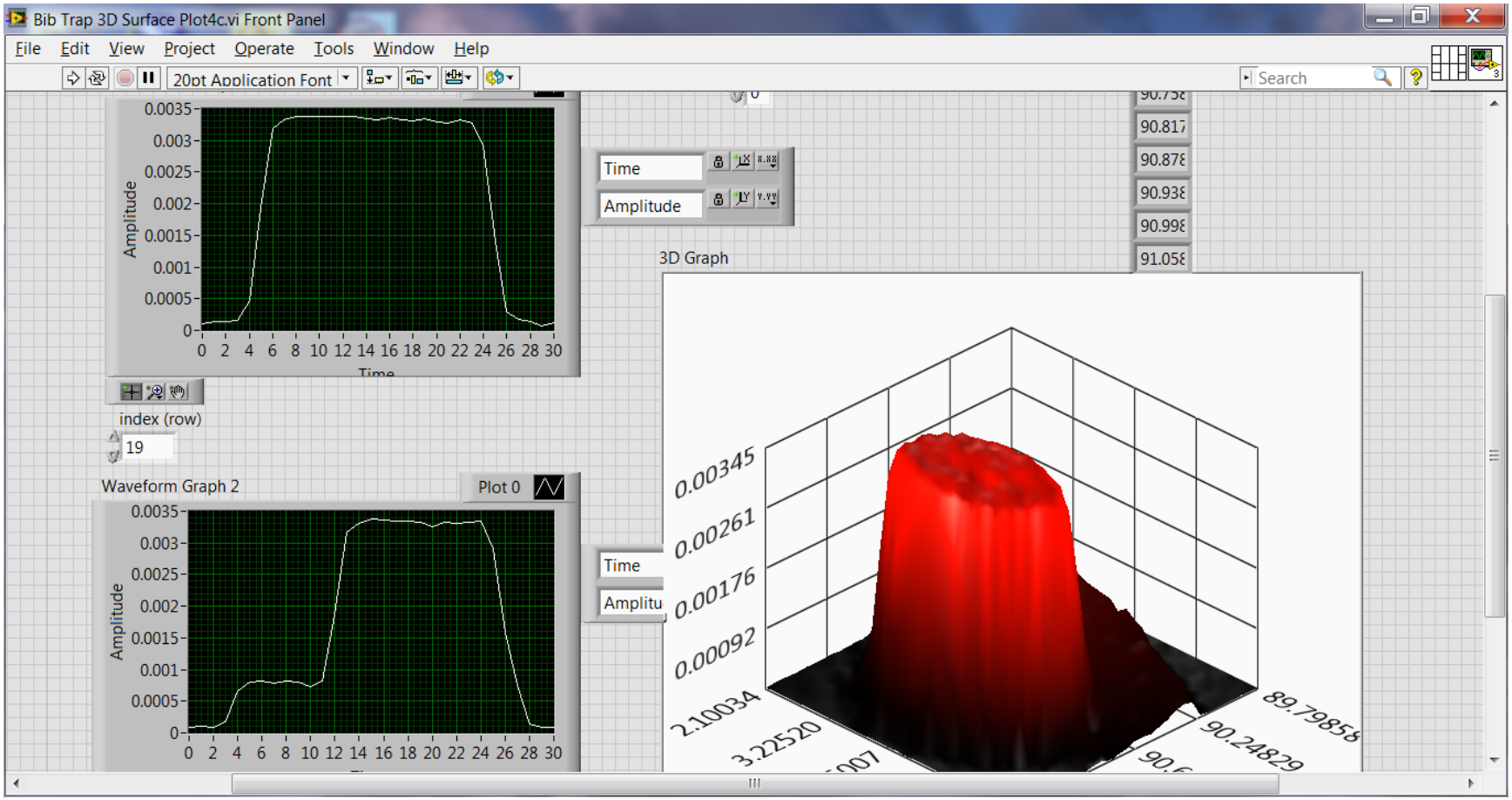


Chopper Mode x-Centering



Center determined from midpoint of selected cursor positions.

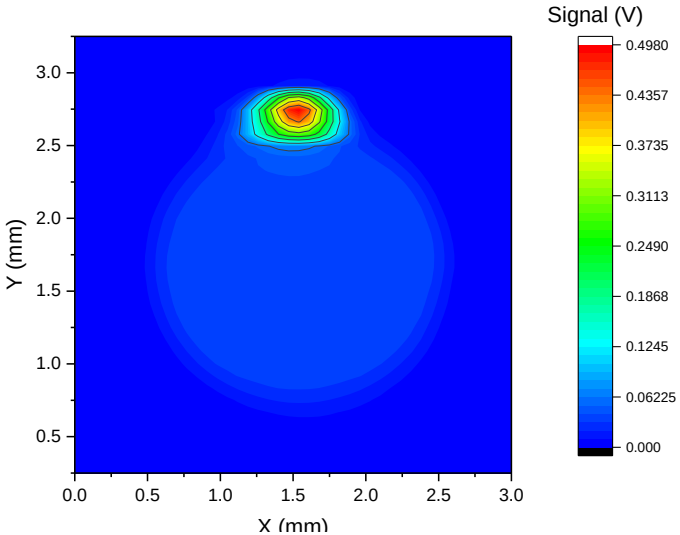
Results 2a: Detector Spatial Uniformity

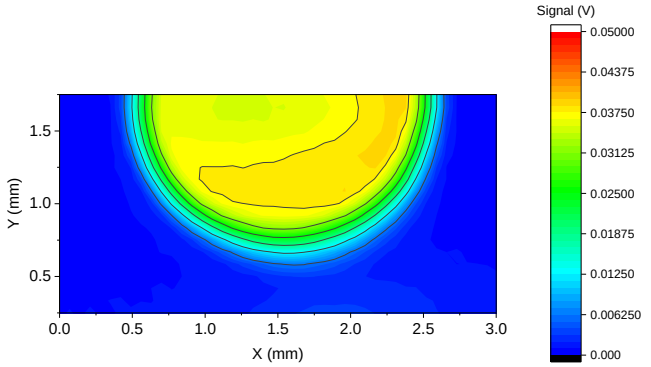


Cuts taken along x and y directions, showing extra plateau along y-scan.

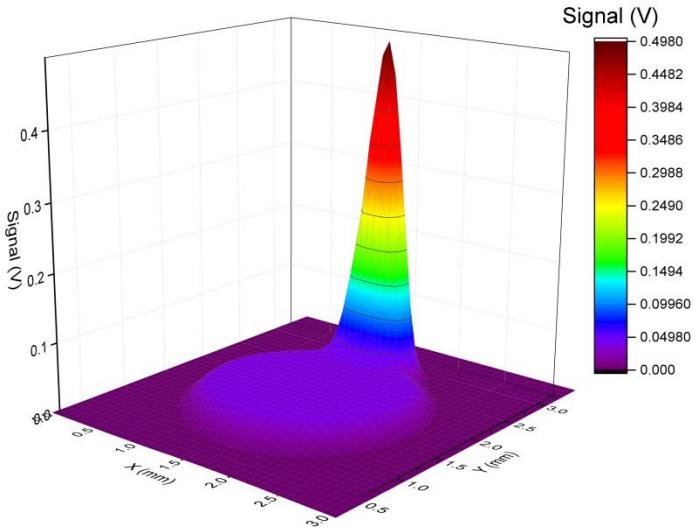
Results 2b: Detector Spatial Uniformity

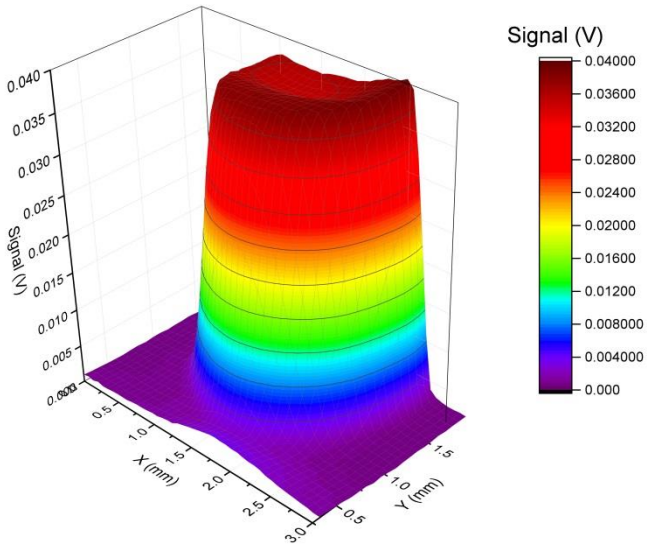
Contour Plots





Surface Plots





Spatial scan of a detector showing a “hot-spot.”

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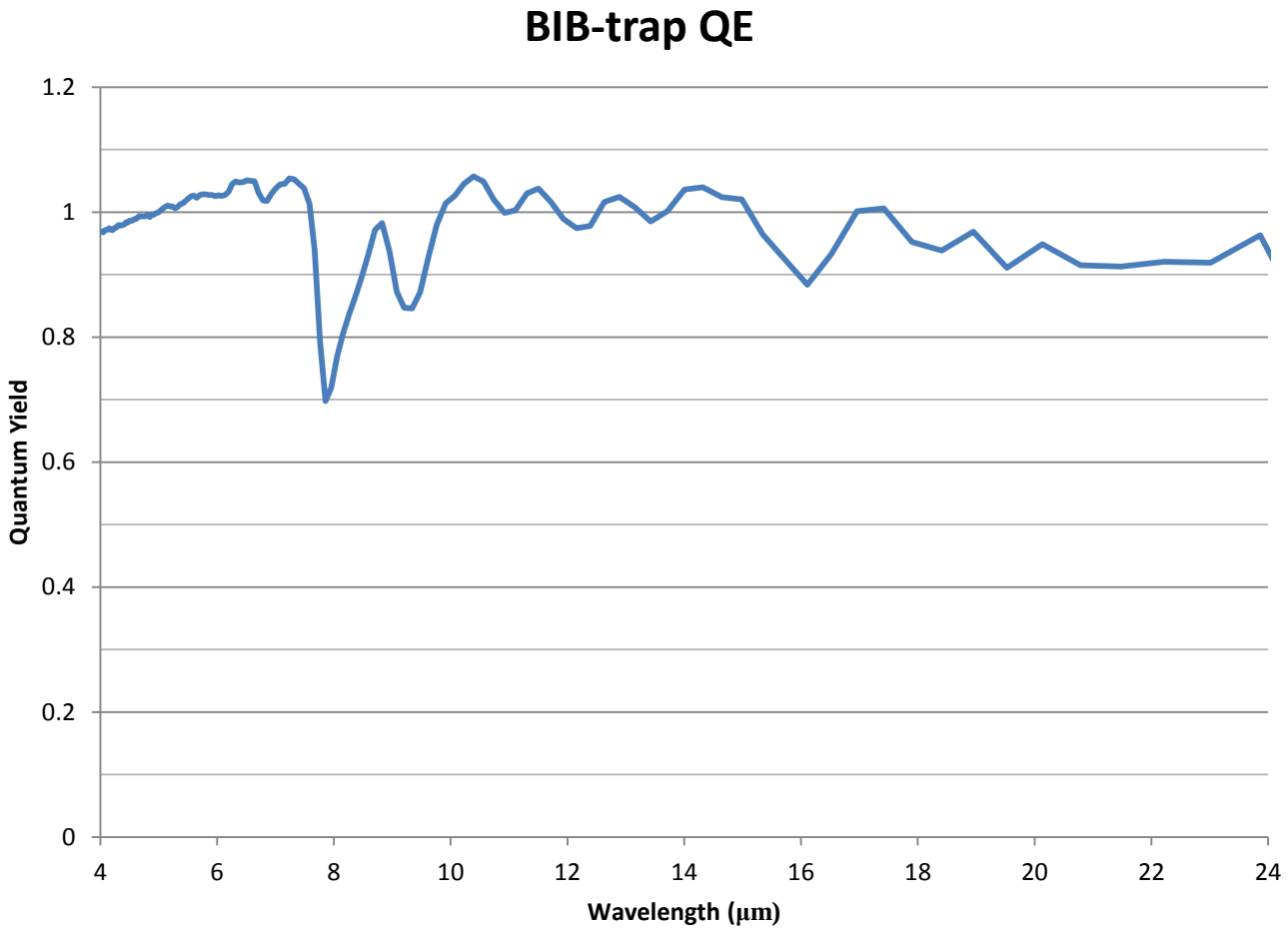
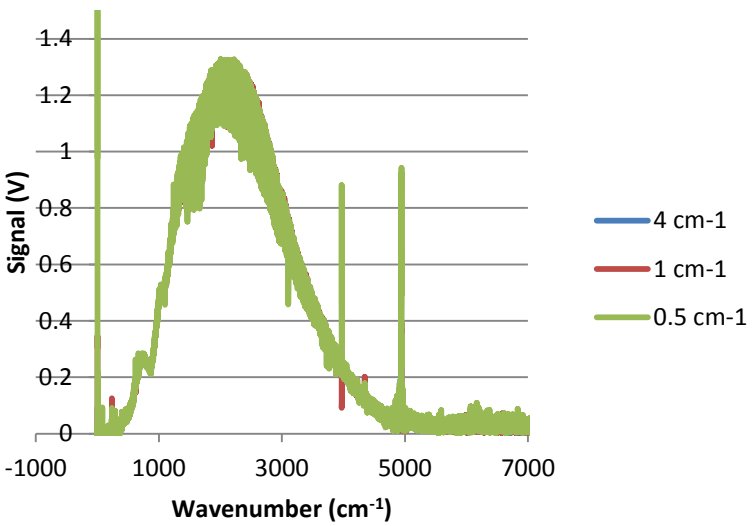
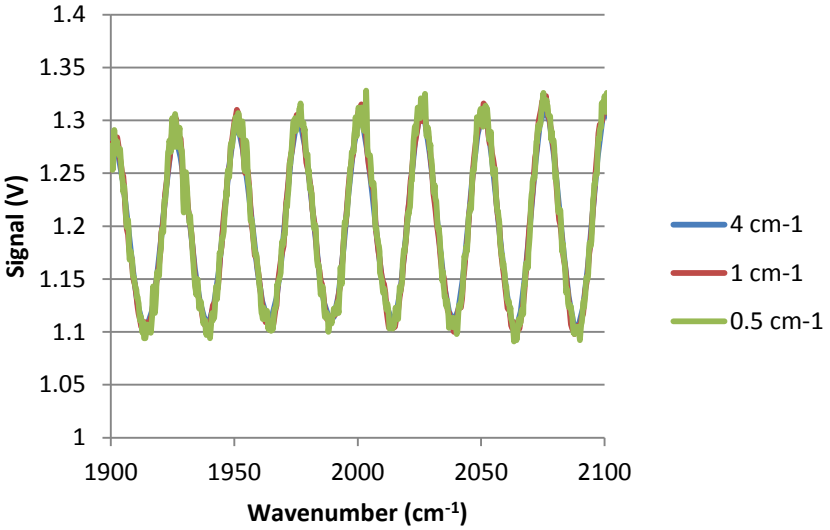
Results 3: Spectral Comparator



Spectral dependence of the quantum efficiency of a BIB-trap detector from calibration against the pyroelectric reference detector.

Results 4: High Resolution Scans





Spectral dependence of the response of a BIB detector taken with resolution of 0.5 cm^{-1}, 1 cm^{-1} and 2 cm^{-1}. Shows etalon associated with interference effects from parallel planes of the detector.

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Future Plans and Design Developments

- FT-IR detector comparator will be upgraded with narrowband sources (lasers and LEDs from 3 μm to 8 μm) as tie-points for spectral calibrations.
- Developing spectral electrical substitution technique for spectral calibrations against ACR-type detectors.
- Will develop cryostat system with ACR reference detector for the comparator.
- Analyze component uncertainties and develop uncertainty budget for FT-IR spectral comparator system; perform inter-comparisons with monochromator-based system
- Make cryogenic detector spectral calibrations for customers with spectral coverage initially from 1.6 μm to 24 μm.