PanFTS IIP Instrument for GEO-CAPE: Year 1 Progress

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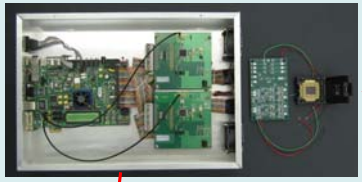
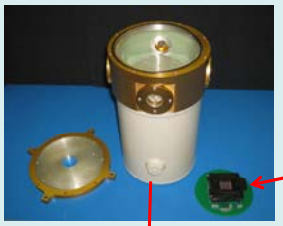
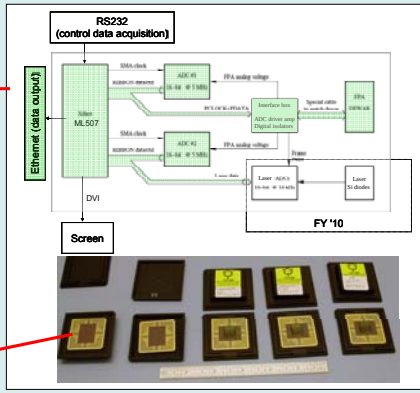
The PanFTS Instrument Concept

The Panchromatic Fourier Transform Spectrometer (PanFTS) is an Instrument Incubator Program (IIP) funded development to build and demonstrate a single instrument capable of meeting or exceeding all GEO-CAPE requirements. The PanFTS design combines measurement capabilities for IR (e.g. TES) and UV-Vis (e.g., OMI) in a single package (including full spatial coverage), plus the ability to measure ocean color .



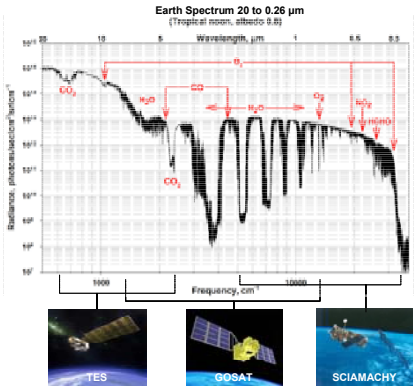


Infrared Focal Plane Array



- JPL-designed digitizer employs dual16-bit, 5 MHz ADC's interfaced to a Xilinx FPGA with ethernet connection to host processor (storage/display)
- FPGA board controls the operation of the FPA via digital isolators in the interface box
- FPGA board captures data (from ADCs) in internal HW FIFOs
- DMA engine transfers data packets from HW FIFOs to main memory
- Raytheon 256x256 InSb array bump-bonded to a CMOS readout IC (ROIC) with twin outputs / references and windowing capability
  - 1-5 µm spectral response, LN_2 cooled in custom dewar
  - 8x8 pixel window can be read at 10 kHz frame rates with a 5 MHz clock

PanFTS Spectral and Temporal Coverage



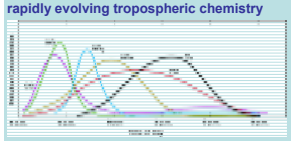
High spectral resolution (0.05 cm^{-1}) and wide spectral sensitivity (from 15 µm to 0.26 µm) allows simultaneous observations of reflected sunlight and thermal emission (day/night) enabling retrieval of several important species such as

Pollutants: O_3, CO, NO_2, HCHO, SO_2, NH_3, CH_3OH

Greenhouse Gases: CO_2, CH_4, N_2O, O_3, H_2O

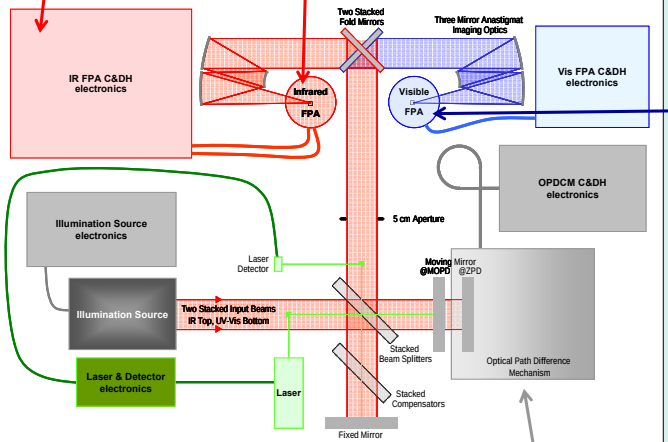
Dynamical Tracers: HDO, N_2O, O_2, O_4

Need to measure several species with high temporal and vertical resolution to capture rapidly evolving tropospheric chemistry



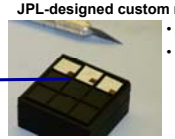
Retrieval of important atmospheric composition species and chemistry requires hourly sampling with broad spectral sensitivity and high spectral resolution

PanFTS IIP Instrument Block Diagram

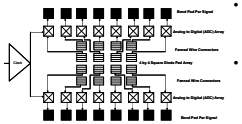


UV/Visible Focal Plane Array

- UV/Vis Hybrid CMOS FPA's consist of silicon photosensitive layer bump-bonded to a JPL-designed custom readout integrated circuit (ROIC)
  - 206 photosensitive layers have been manufactured by Teledyne
  - Measured quantum efficiency is 80-90% (>50% from 400-1000 nm)



- JPL-designed ROIC is a PanFTS IIP key technology development
  - Demonstration of on-chip sigma-delta digitizer
    - One ADC per pixel
    - 4x4 array
  - Driving requirements are
    - Read out frame rate (16 kHz)
    - ADC precision (14-16 bits)
    - Operating mode (snapshot)



- Development Status (Sept, 2009):
  - 2nd-order sigma-delta ADC has been designed and performance verified by modeling
  - Tape-out and mask fabrication are done
  - Fabrication by foundry (Avago) will commence in coming weeks after mask verification
- Bump bonding of photosensitive layer and ROIC will take place at JPL early next year
- UV-Visible FPA testing in mid 2010

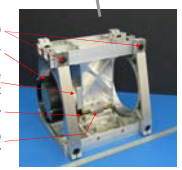
GEO-CAPE Flight Instrument Design Drivers

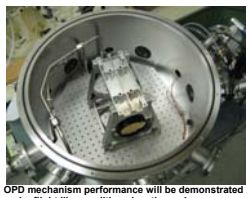
Capability	Wide-Field	Narrow-Field	Comments
Field of regard	50° N to 45° S latitude -35° to -125° longitude	50° N to 45° S latitude -35° to -125° longitude	Approximately 11,000 km by 11,000 km
Spatial sampling	7 km ground sampling distance at nadir	250 m ground sampling distance at nadir	Drives fore optics (telescope) design, and focal plane pixel count
Spectral range	0.26 µm to 15 µm	0.35 µm to 2.1 µm	Drives camera design, and interferometer materials and coatings
Spectral resolution	0.05 cm^{-1}	50 cm^{-1}	Drives interferometer design
Spectral SNR	1000	1000	Drives instrument design & observing scenario
Interferogram dynamic range	2^{16}	2^{15}	Drives ADC design
Sampling interval	Approximately hourly	Approximately hourly	Drives data management design
Lifetime	5 years	5 years	Drives reliability

- PanFTS IIP instrument addresses the most important flight instrument requirements to increase TRL in key areas (focal plane arrays, optical design, mechanical design)
- IIP instrument has wide field only, no foreoptics, spectral range 0.4-5 µm, room temperature operation
- Companion ACT proposal (D. Rider, PI) addresses full 128x128 FPA with in-pixel ADC

Optical Path Difference Mechanism

- OPDM is a flexure-based parallelogram mechanism that controls the optical path difference between the fixed and moving arms in the Michelson interferometer
- OPDM driving requirements:
  - Maximum optical path difference: 10 cm (physical travel 5 cm)
  - Maximum mirror tip/tilt error: < 1 microradian
  - Full translation duration: 1 minute
  - Velocity stability: better than 1% over the full range of travel
  - Operating temperature: 180-320 K
  - Operational lifetime: 5 years (more than 2.6 million cycles)
- Heritage: JPL FTUVS instrument at Table Mountain Facility which has 12 years of continuous operation





OPD mechanism performance will be demonstrated under flight like conditions in a thermal-vacuum chamber starting in 2010

Summary

PanFTS Capabilities and Development Status

- OSSE results (see Bowman poster) confirm panspectral retrieval benefits (vertical profiling, boundary layer visibility)
- IIP optical design has continuous sensitivity over 0.4 – 5 µm spectral range
- IR FPA testing is ready to begin
- Visible FPA ROIC design incorporating parallel sigma-delta ADC's is complete
- Sigma-delta ROIC performance has been verified by simulations
- ROIC masks are made – semiconductor fabrication begins in 4-6 weeks
- OPD mechanism is designed and built – characterization testing underway
- IIP instrument fabrication and assembly has begun
- Field testing will be done at JPL's Mt. Wilson and Table Mountain facilities

Acknowledgements

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