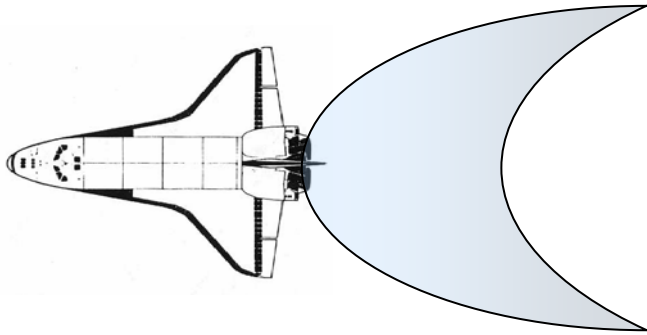




INFRARED SPECTRAL MEASUREMENTS OF SHUTTLE ENGINE FIRINGS

**AMOS 2005 TECHNICAL
CONFERENCE WORKSHOP**

**5 September, 2005
Maui, Hawaii**



**M. Venner
AFRL, Edwards AFB, CA**

**M. Braunstein, L. Bernstein
Spectral Sciences, Inc., Burlington, MA**

**R. Dressler
AFRL, Hanscom AFB, MA**

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE AUG 2005	2. REPORT TYPE	3. DATES COVERED -	
4. TITLE AND SUBTITLE Infrared Spectral Measurements of Space Shuttle Engine Firings - Briefing Charts		5a. CONTRACT NUMBER F04611-03-C-0015	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Marty Venner; Matt Braunstein; Larry Bernstein; Reiner Dressler		5d. PROJECT NUMBER BMSB	
		5e. TASK NUMBER R2FT	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Research Laboratory (AFMC), AFRL/PRSA, 10 E. Saturn Blvd., Edwards AFB, CA, 93524-7680		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited			
13. SUPPLEMENTARY NOTES			
14. ABSTRACT N/A			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	
			18. NUMBER OF PAGES 9
			19a. NAME OF RESPONSIBLE PERSON

Space Shuttle Exhaust Plume Infrared Measurement Analysis

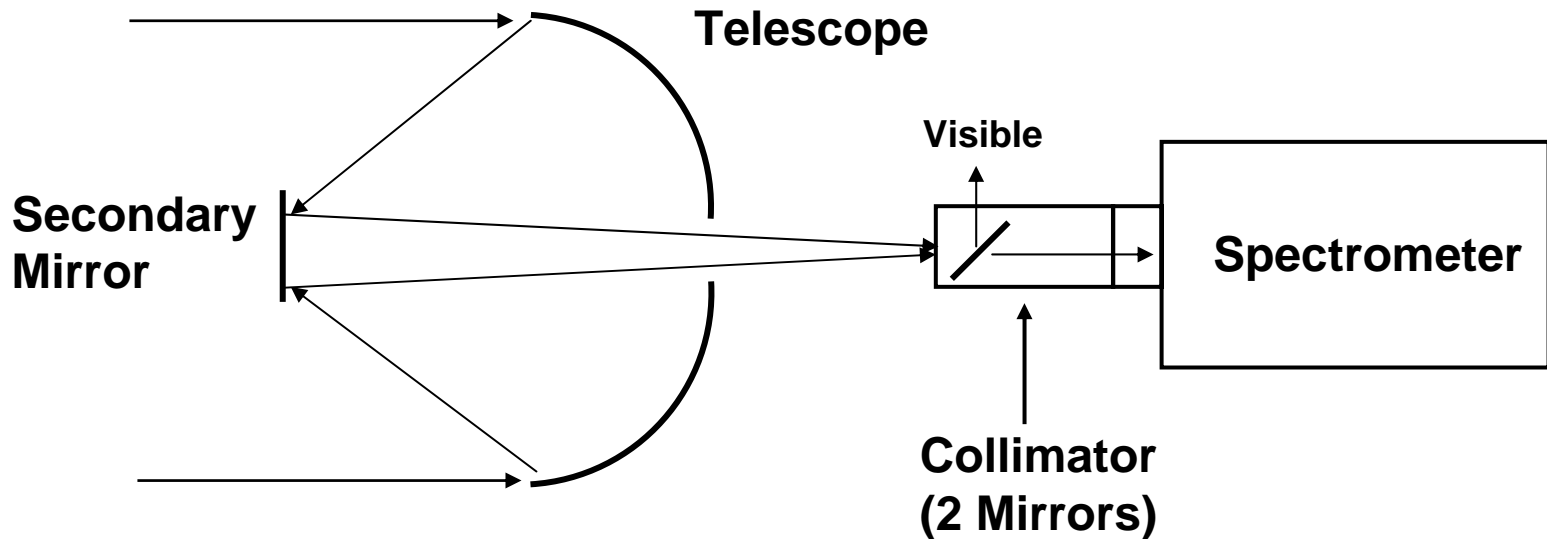
- Utilize Total Signal Calculation to Estimate a Signal-to-Noise for Two Available Spectrometers – $3.76e04$ W (11 km/s Case)
- Assume Both Integrable onto AMOS Telescope (Most Likely B37)
- 5 km Diameter Plume at 390 km Altitude and 60 Degree View From Zenith
- Expect Plume Radiance to Fill the FOV (B37 is Only 3 mrad Total)
- Calculate Average Radiance by Dividing by 4π Steradians and Estimated Plume Area

ABB (Bomem) FTIR Spectrometer Spec's

- **Two Simultaneous Non-Imaging Detectors**
 - 1- 6 μm InSb, 1.37e-09 RMS NESR at 1 cm^{-1} Resolution
 - 2 - 15 μm MCT, 1.4e-08 NESR at 1 cm^{-1}
 - **Currently Use LN2 for Detector Cooling**
- **5, 28, 75 mrad Telescopes Available as Attachments**
- **LN2 Cooled Cold Source**
- **Weight – 45 kg Nominal**
- **Scan Rate and Spectral Resolution Specifications:**

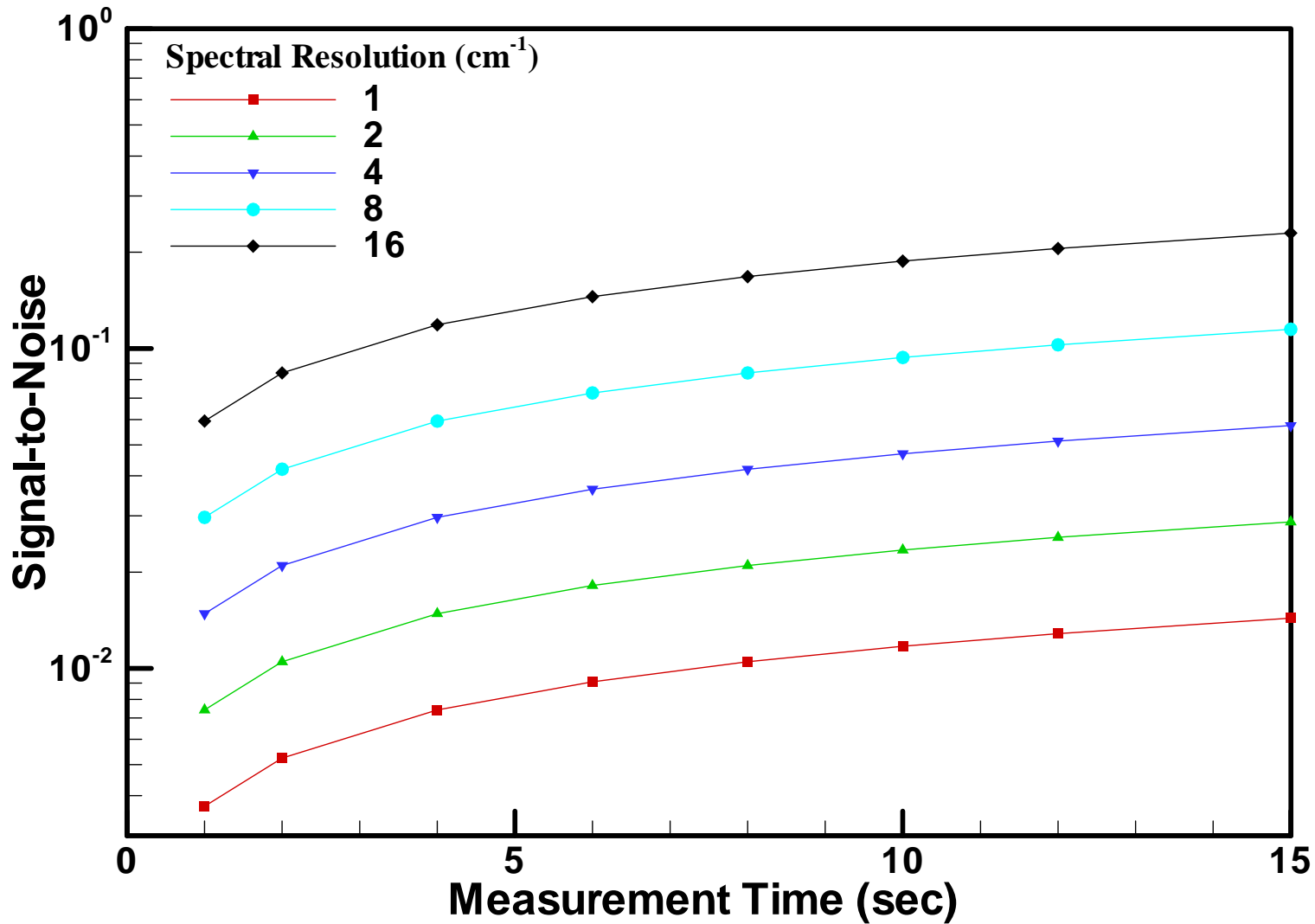
Resolution (cm^{-1})	16	8	4	2	1
Frame Rate (scans/sec)	64.6	47.8	31.4	18.6	10.3
Maximum Acq Time (sec)	242	163	125	104	95

Current Measurement Method



- **Collimator Input Aperture – 6.4 mm (Field Stop)**
- **45 mrad FOV**
- **Must Form Image at Collimator Entrance**
- **Can Use Visible Light to Characterize FOV**

ABB FTIR InSb Detector S/N Calculations



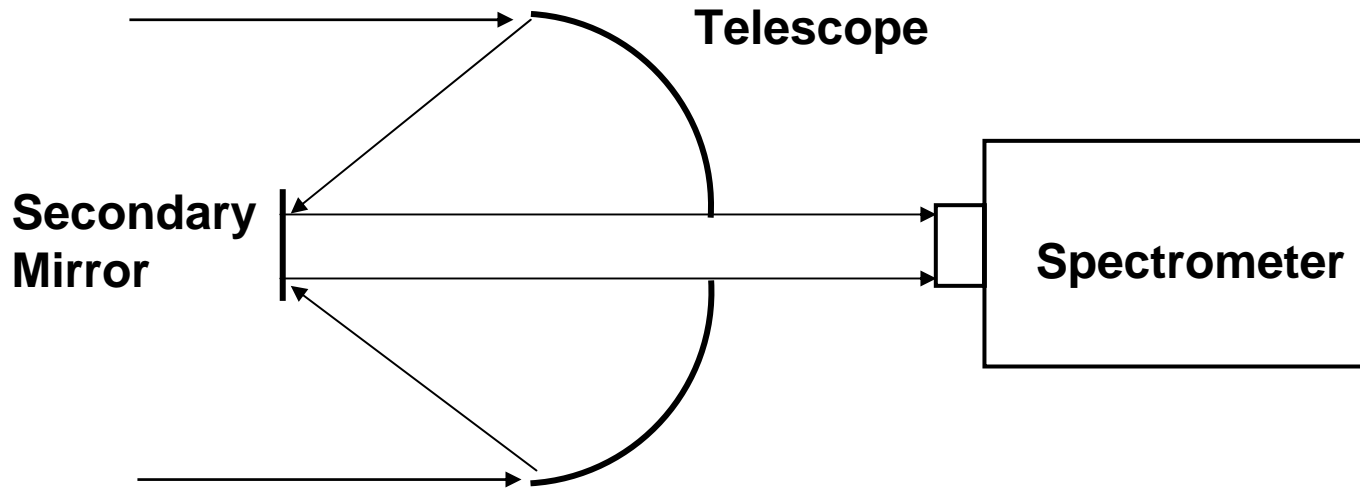
Broadband Array Spectrograph System (BASS)

- **Aerospace Corporation Sensor (Dave Lynch)**
- **Wavelength Dispersive System – 2 Prisms**
- **116 Total Detectors**
- **3 – 13.5 μm Waveband**
- **Approximately 0.1 μm Resolution (Much Lower Than Desired)**
- **Noise Equivalent Power: 4.0e-14 W/Sqrt(Hz) (1 Sec Integration)**
- **Frame Rate: 0.1 – 200 Hz**
- **Estimate S/N = 1448 Over the 3 – 4.2 μm Region**
 - **Calculations Not Reviewed by Aerospace Corp. Personnel**

Potential Solutions/Improvements

- **Large Telescope With a Short Focal Length (i.e. Fast Optics)**
- **OHMS Burn at 250 km Altitude – De-Orbit?**
- **Simultaneous Firing of Two PRCS Engines**
- **Install More Sensitive Detectors – Significant Cost**
- **Upgrade to New 300 Series System – X2 Improved Sensitivity**
- **Estimate Additional Signal From Other Species - O + CO, O + H₂, etc.**
- **Afocal Telescope System**

Afocal Telescope System



- **Spectrometer Input Aperture – 1.5 in. (3.8 cm)**
- **Must Be Well Collimated Beam**
- **May Allow a Larger FOV**
- **Reduce Reflection Loss Due to Two Less Mirror Reflections**
- **No Dichroic Mirror to Divert the Visible Light for FOV check**

Conclusions

- **ABB FTIR Spectrometer Not Sensitive Enough With Present Configuration**
- **BASS Sensor Appears to Have Sensitivity But Very Low Spectral Resolution**
- **Additional Analysis Required**