PROFILING POLLUTION FROM THE SURFACE TO THE TROPOPAUSE

Reinhard Beer & Stanley P. Sander (PI)

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA

Co-Investigators:

Jean-Francois Blavier, Kevin W. Bowman, Annmarie Eldering,
David M. Rider, Geoffrey C. Toon, Wesley A. Traub, John R. Worden

From the NRC Decadal Survey:

"Air quality measurements are urgently needed to understand the complex consequences of increasing anthropogenic pollutant emissions both regionally and globally. The current observation system for air quality is inadequate."

The report recommends the Geostationary Coastal and Air Pollution Events (Geo-CAPE) mission to address this problem.

From the Community Workshop on Air Quality Remote Sensing from Space (Boulder, CO 2006):

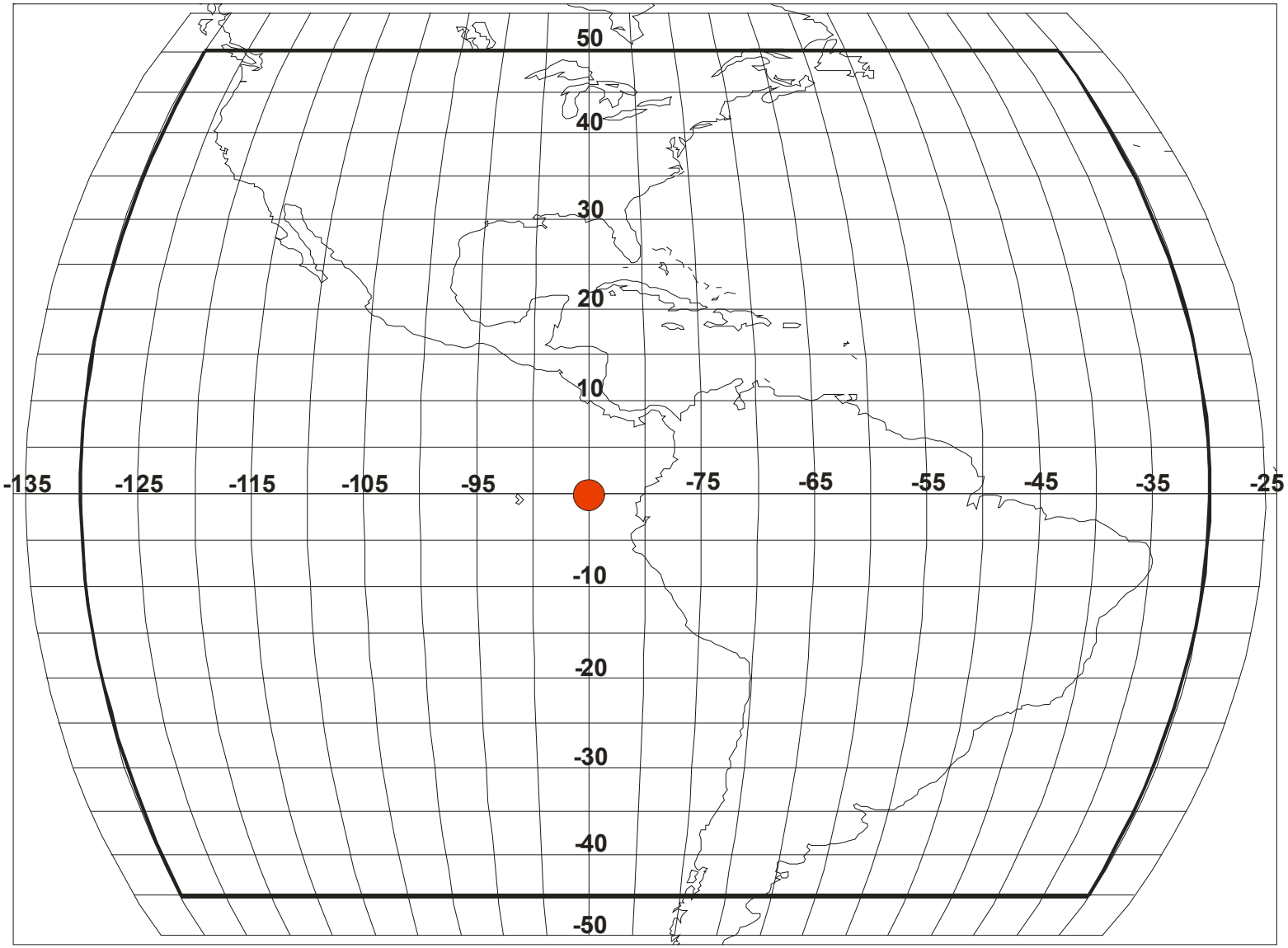
"The ability to observe the boundary layer from space is a major priority for air quality applications".

The 2007 NASA Science Plan reached similar conclusions.

Geo-CAPE Mission Requirements

- **Measure air pollutants such as ozone and aerosols**
- **Improve air quality forecasts "through assimilation of chemical data, monitoring pollutant emissions and accidental releases, and understanding pollution transport on regional to intercontinental scales."**
- **Cover North & South America from -45° to +50° latitude with 7 km resolution "at about hourly intervals"**
- **Longitude range is therefore 30° W to 140° W with the spacecraft positioned on the Equator at about 85° W**

The Geo-CAPE Region of Interest



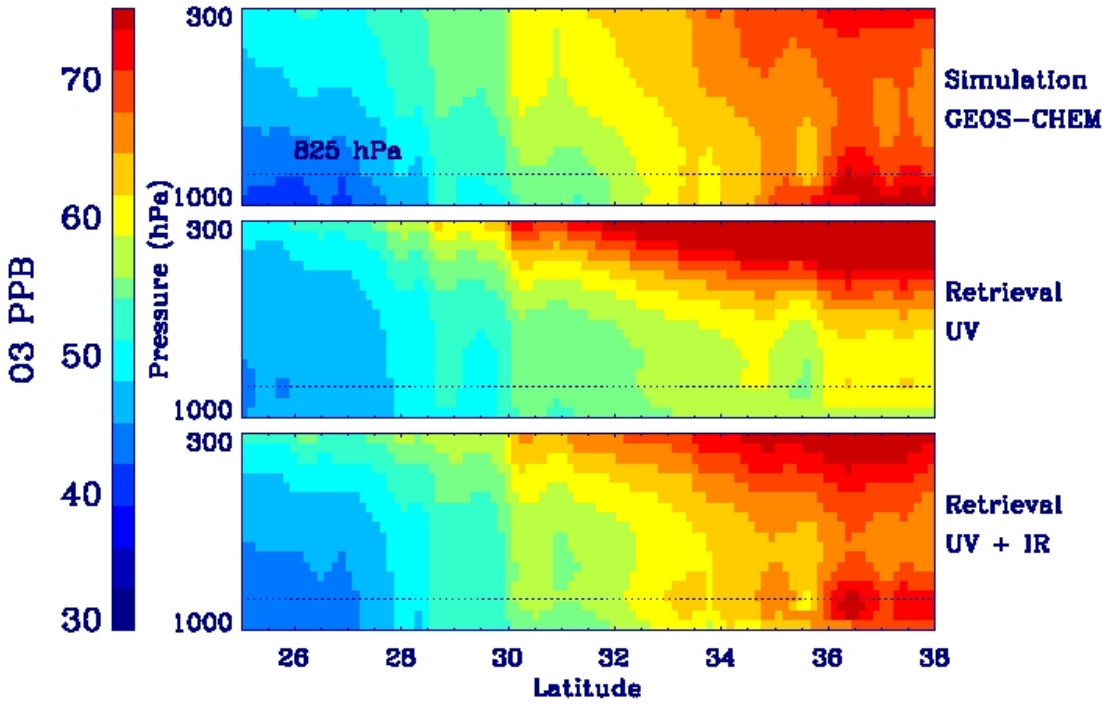
The PanFTS Approach

An Instrument Incubator Program (IIP) proposal has been accepted by NASA to begin the development of a system that will meet or exceed all Geo-CAPE and GACM requirements.

We call this concept "PanFTS", a Fourier Transform Spectrometer that combines the strengths of the IR (e.g., TES) and the UV-Vis (e.g., OMI) into a single package (including full spatial coverage).

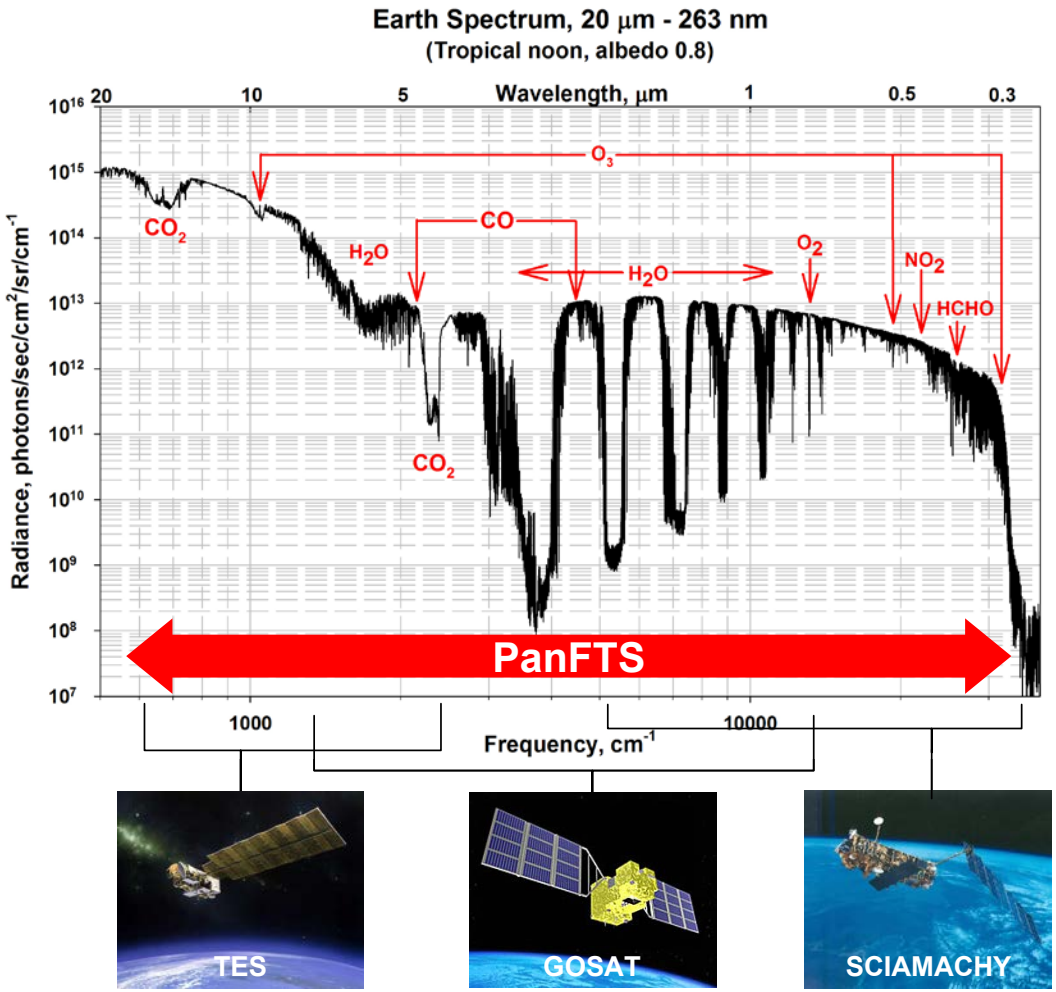
In addition, the ability to measure ocean color is readily incorporated.

Combining UV-Vis-IR Improves Vertical Resolution



From Worden *et al*, GRL 2007

PanFTS Spectral Coverage

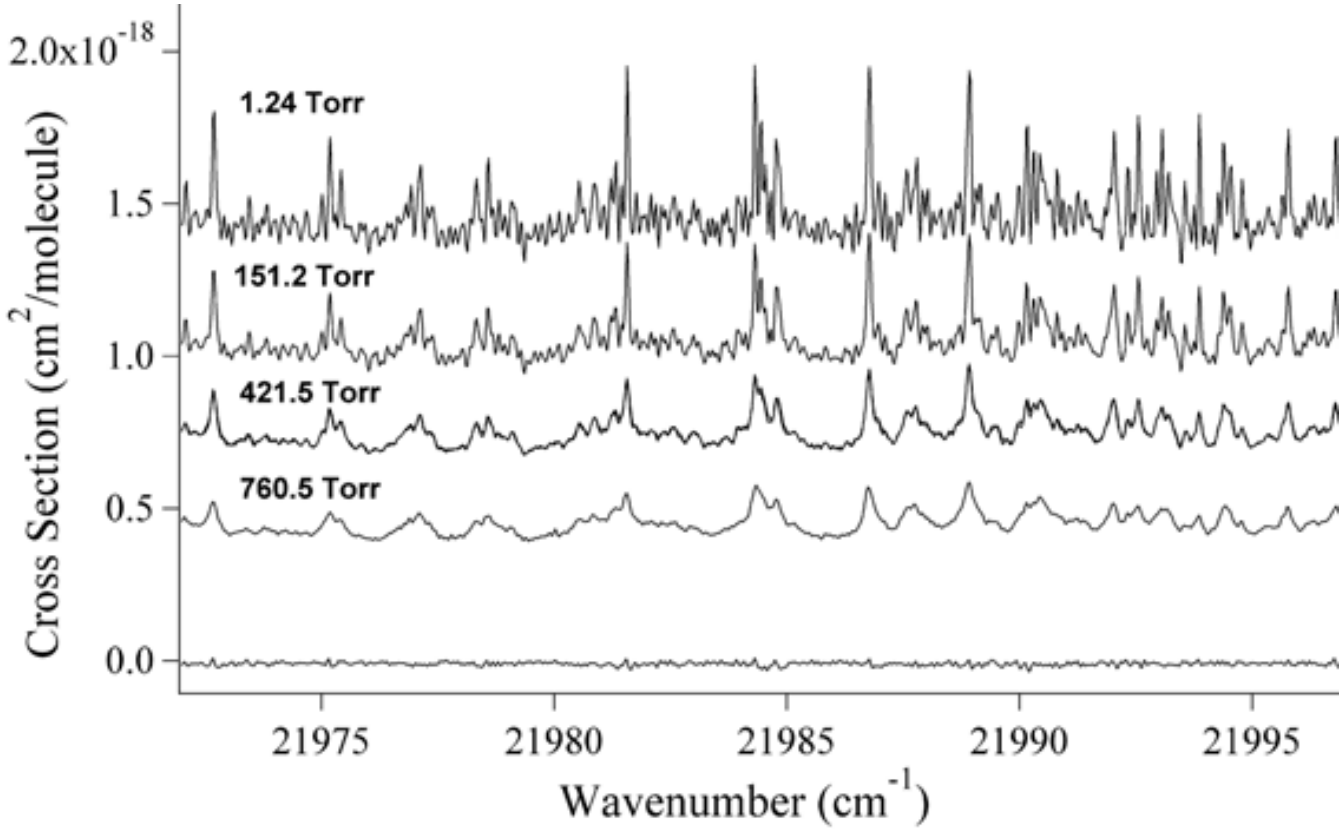


PanFTS will greatly advance atmospheric chemistry

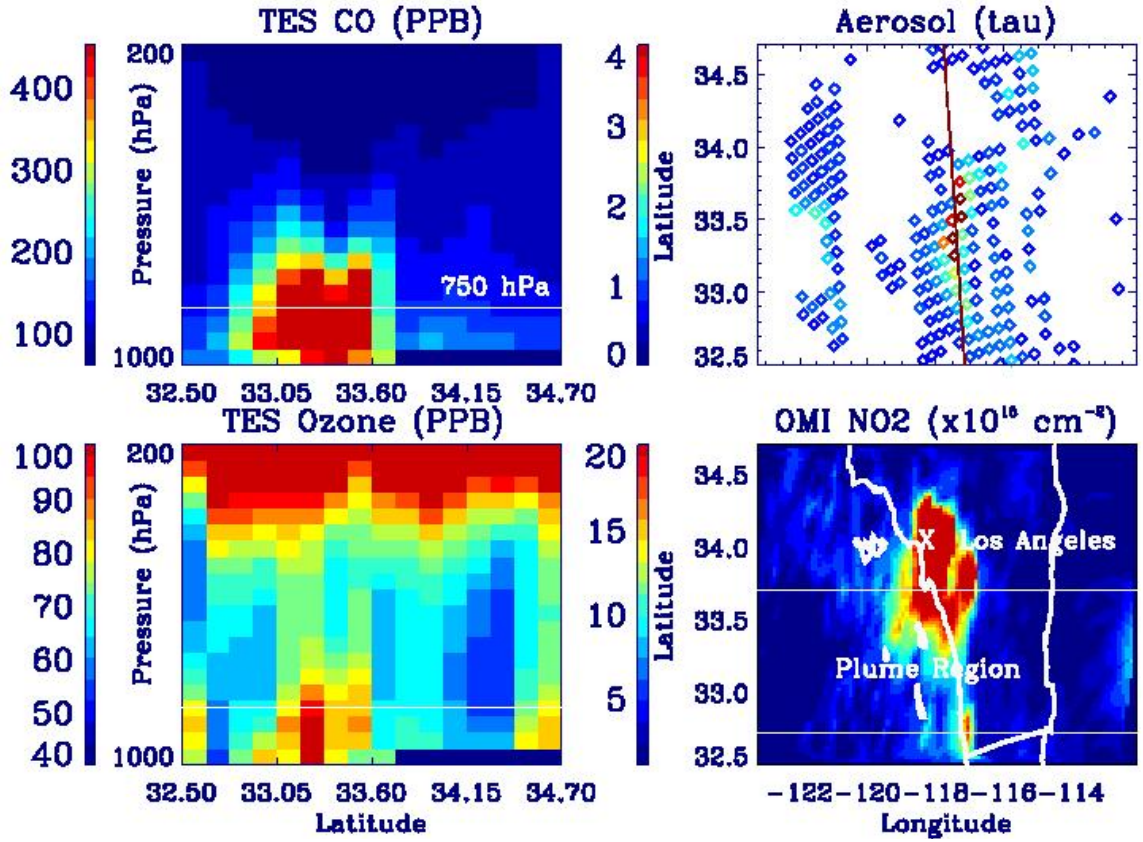
Measurement	PanFTS	Geo-CAPE	GACM	TES	OMI	GOME-2	Scia-machy
O_3 (boundary layer)	✓						
Tropospheric O_3 profile	✓		✓	✓			
Tropospheric O_3 column	✓	✓	✓		✓	✓	✓
Stratospheric O_3	✓	✓	✓		✓	✓	✓
Tropospheric NO_2 profile	✓						
Tropospheric NO_2 column	✓	✓	✓		✓	✓	✓
Tropospheric CO profile	✓	✓	✓	✓			
Aerosol Optical Depth	✓	✓	✓		✓	✓	✓
CO_2 profile	✓						**column**
CH_4 profile	✓			✓			**column**
HCHO column	✓	✓	**?**		✓	✓	✓
Temperature	✓		**UT + ? strat**	✓			✓
Tropospheric H_2O profile	✓			✓			✓
Tropospheric HDO profile	✓			✓			
NH_3 column	✓			✓			
CH_3OH column	✓			✓			
SO_2 column	✓	✓	✓	✓	✓	✓	
BrO column (?)	✓	✓	✓		✓	✓	✓

Profiling NO_2 near 455 nm

Note how the lines "wash out" with increasing pressure – this is the secret of tropospheric profiling



The IR is sensitive to the boundary layer when concentrations and air-surface contrast are high



Southern California wildfire emissions

PanFTS Measurement Capabilities

(Shaded Green)

Program Linkage			Measurement	Scientific Issues from the Decadal Survey		
				AQ Forecasting/ Human Health	O_3 precursor and Aerosol Sources	Pollution Transport/ Chemical Weather
NASA SCIENCE PLAN	GACM	Geo-CAPE	O_3 (column)			■
			NO_2 (column)	■	■	■
			HCHO (column)		■	
			SO_2 (column)		■	
			BrO (column)		■	
			CO (profile)	■		■
			Aerosol Opt. Depth	■	■	■
			O_3 Profile	■	■	■
			H_2O (profile)			■
			O_3 (boundary layer)	■	■	■
			NO_2 (boundary layer)	■	■	■
			NO_2 (profile)	■	■	■
			HDO (profile)			■
			NH_3 (column)		■	
			CH_3OH (column)		■	
			Temperature			■
			Nocturnal Capability	■		■

PanFTS has superior measurement capabilities

Instrument	Spectral Range (microns)	Spectral Resolution (nm)	Horizontal Resolution (km)	Vertical Resolution (km)
SCIAMACHY	0.25 – 2.0	0.25 – 0.4	30 x 60	-
GOME-2	0.24 - 0.79	0.24 – 0.53	40 x 40	-
OMI	0.27 – 0.5	0.45 – 1.0	13 x 24	-
TES	3.2 – 15.4	0.06 cm^{-1}	5.3 x 8.5	3 - 5
MOPITT	2.3, 4.67	(0.1 cm^{-1})	22 x 22	3 - 5
PanFTS	0.26 – 15.0	0.05 cm^{-1}	7 x 7	2 - 3

Technology Readiness

An avowed aim of the IIP program is to advance technologies to a level where they can plausibly be proposed for spaceflight.

For PanFTS the primary issues are:

A long-life, high precision scan mechanism (flexures, actuators, >5 years continuous low temperature operation)

2-D detector arrays with fast readout electronics + many analog-digital converters (ADCs)

The Next Step

PanFTS has been accepted for the NASA Instrument Incubator Program (IIP) to undertake a 3 year development culminating in a down-looking field test based either at Table Mountain or Mt. Wilson, CA.

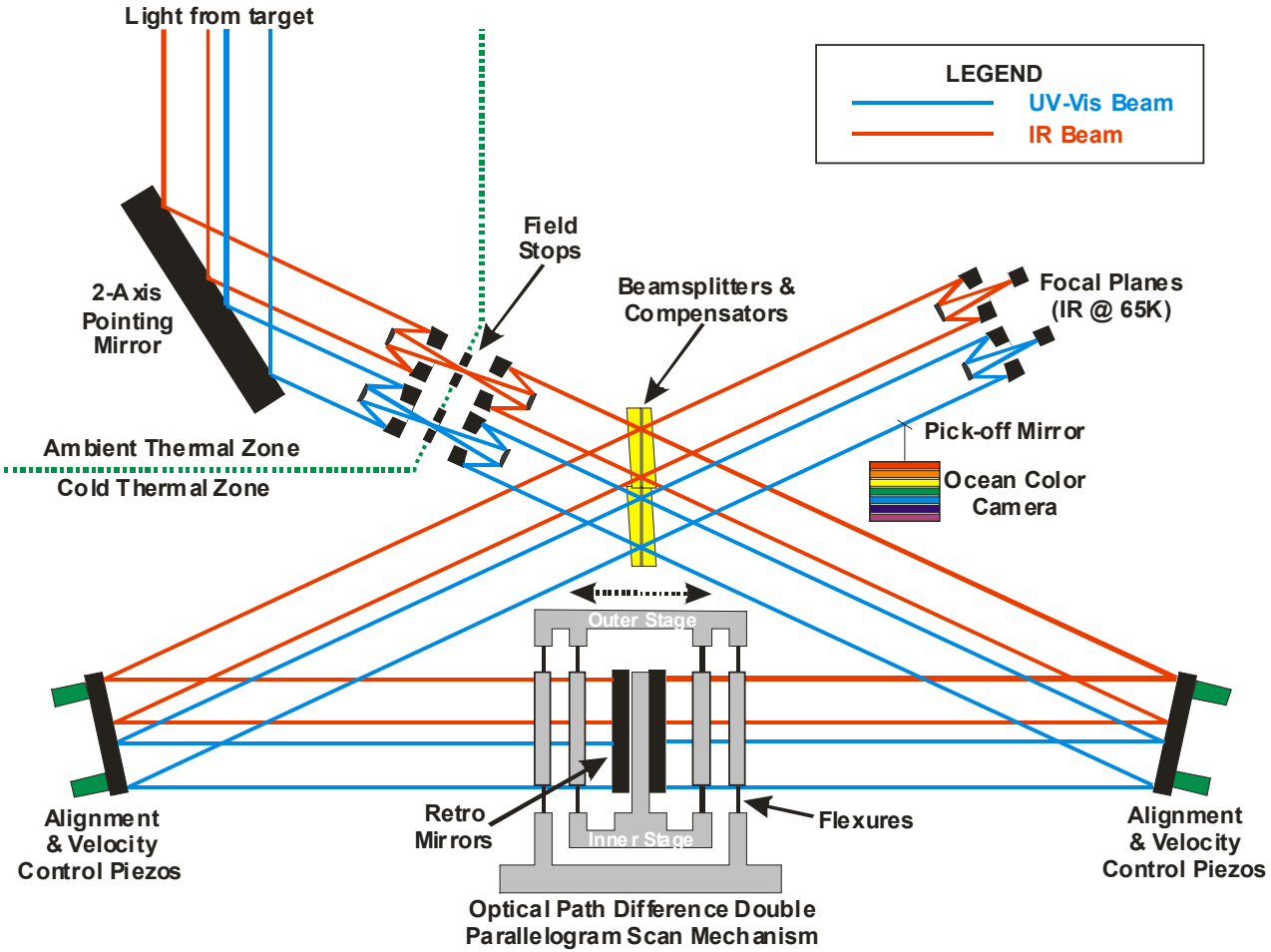
CONCLUSIONS

PanFTS will enable greatly improved spaceborne observations of atmospheric pollution and tropospheric chemistry and do so in real time.

We invite all members of the community to participate in this endeavor.

For further information, please contact:

Stanley.P.Sander@jpl.nasa.gov

BACKUP

The PanFTS concept