# Advanced Infrared Gas Sensors: Development and Real-World Applications

F.K. Tittel
Rice University
Houston, TX

fkt@rice.edu
http://www.ruf.rice.edu/~lasersci/

OUTLINE

CA Meeting
Rice
Oct 3 2001

- Motivation and Technology Issues
- Infrared Diode and QC Laser-based Gas Sensors
- Selected Applications of Trace gas detection
- Summary and Outlook

# Acknowledgements


L. Goldberg (Keopsys)
M.M. Fejer (Stanford)
L. Hollberg (NIST)
J.C. Graf (NASA)
K.P. Petrov (Gemfire)
F.Capasso (Lucent )
C.Gmachl (Lucent )

R.F. Curl
A.A. Kosterev
M. Erdelyi
R.Claps
D.Rehle
D.Richter (NCAR)
D.Lancaster (DSTO)

- National Aeronautics and Space Administration (NASA)
- National Science Foundation
- Texas Advanced Technology Program
- Welch Foundation

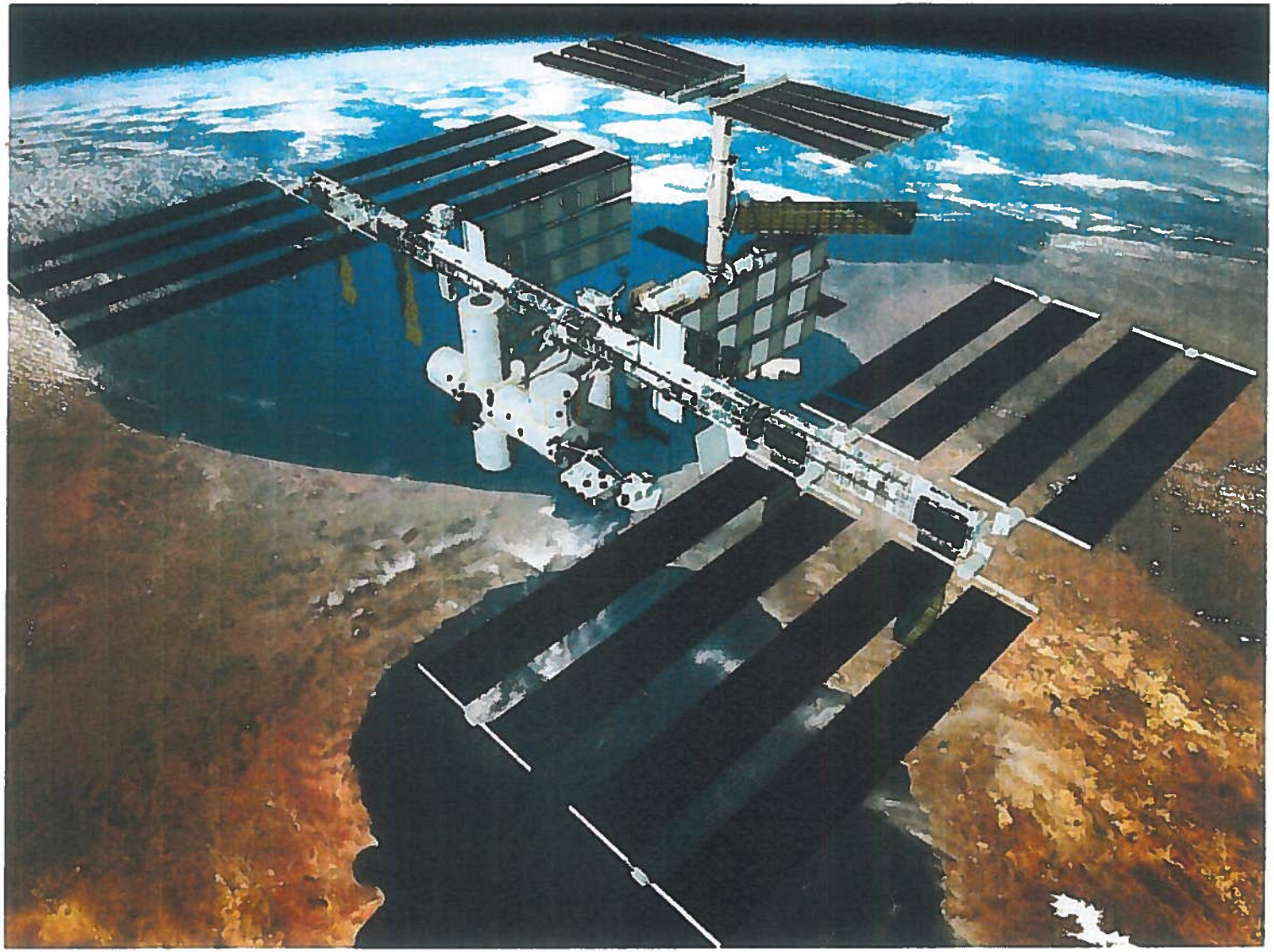

RICE

# Wide Range of Gas Sensor Applications

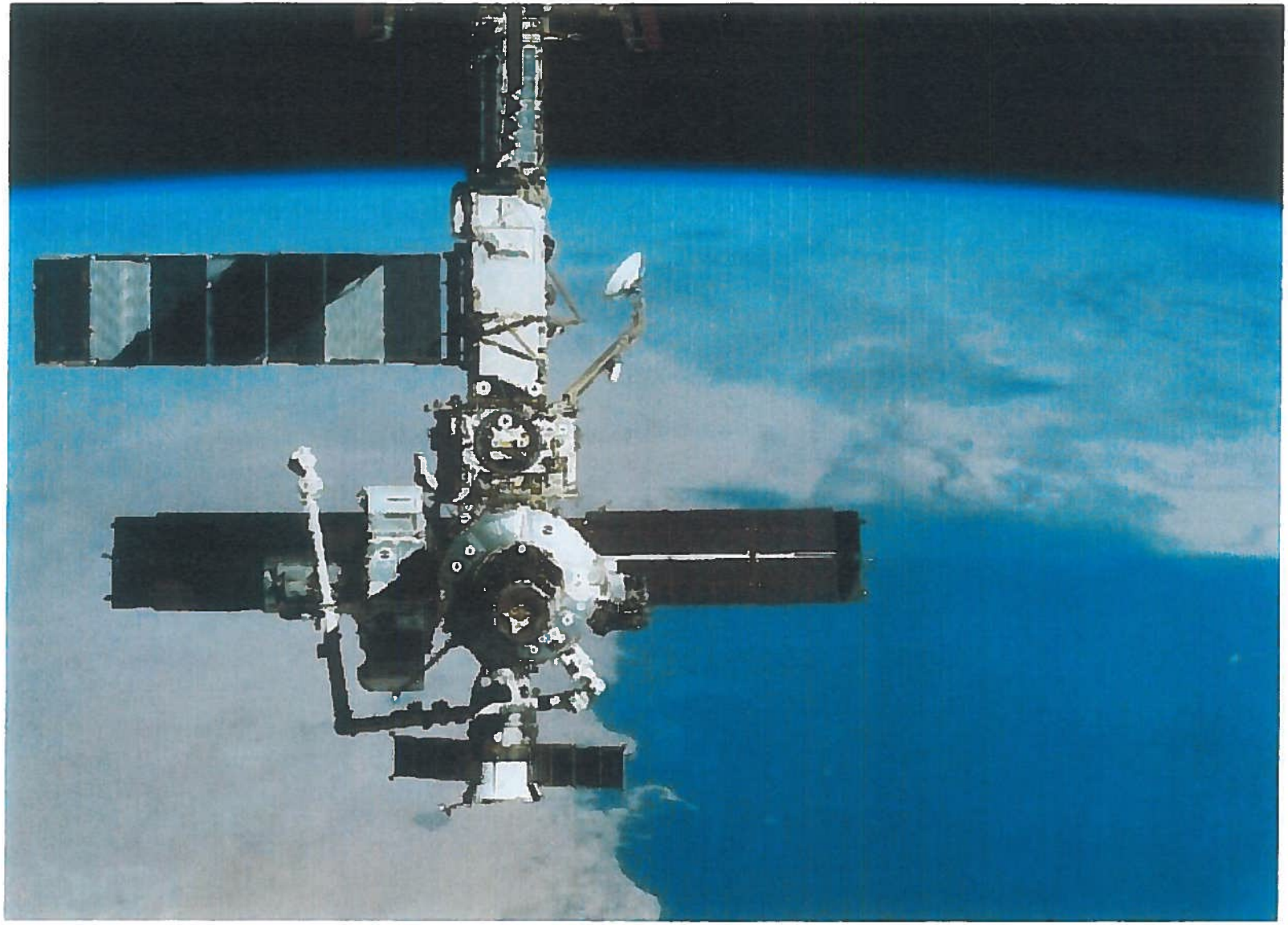
- Urban and Industrial Emission Measurements
  - Industrial Plants - Fenceline perimeter monitoring
  - Combustion Sources
  - Automobile
- Rural Emission Measurements
  - Agriculture
- Environmental Monitoring
  - Atmospheric Chemistry
  - Volcanic Emissions
- Spacecraft and Planetary Surface Monitoring
  - Crew Health Maintenance & Life Support
- Chemical Analysis and Industrial Process Control
  - Petrochemical and Semiconductor Industry
- Medical Diagnostics

RICE

# International Space Station



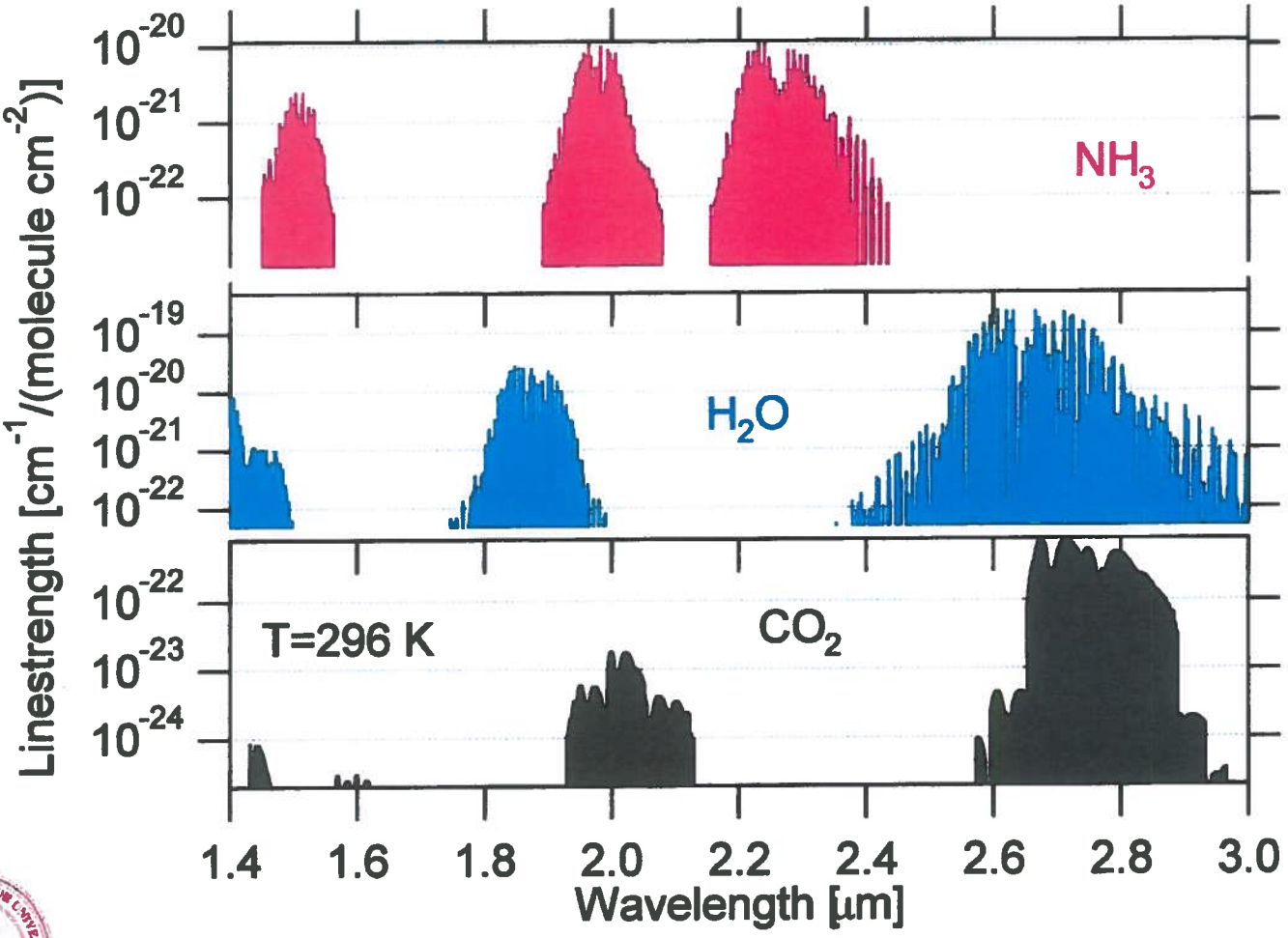
# ISS Passing over Persian Gulf July 27, 2001



# Motivation for $NH_3$ Detection

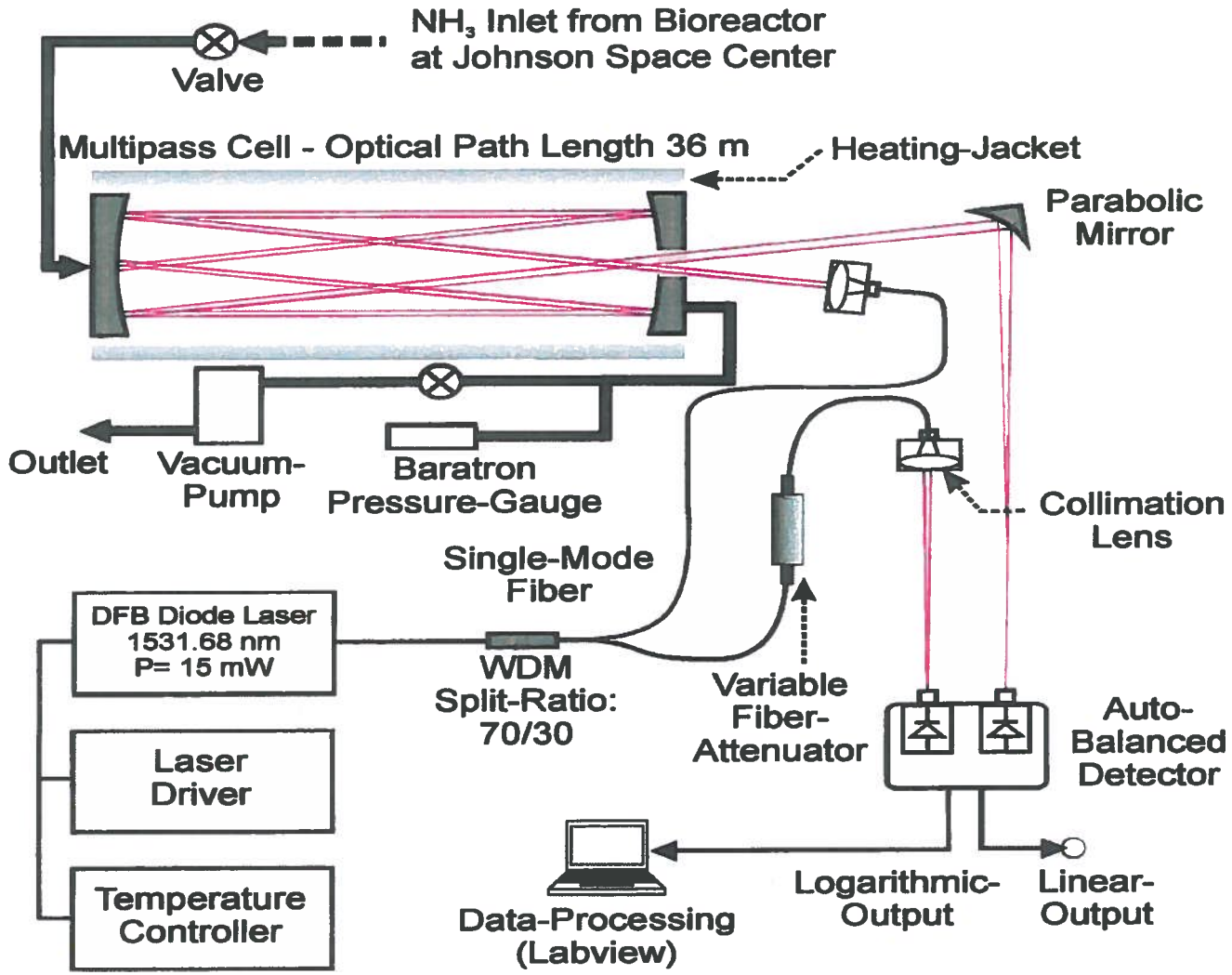
- Monitoring $NH_3$ concentration after De-$NO_x$ process in exhaust pipes in electric power stations
- Pollutant gas monitoring
- Atmospheric chemistry
- Semiconductor Processing
- Medical diagnostics (kidney)
- **Space craft related gas monitoring**

# NIR Spectra of $NH_3$, $CO_2$ and $H_20$

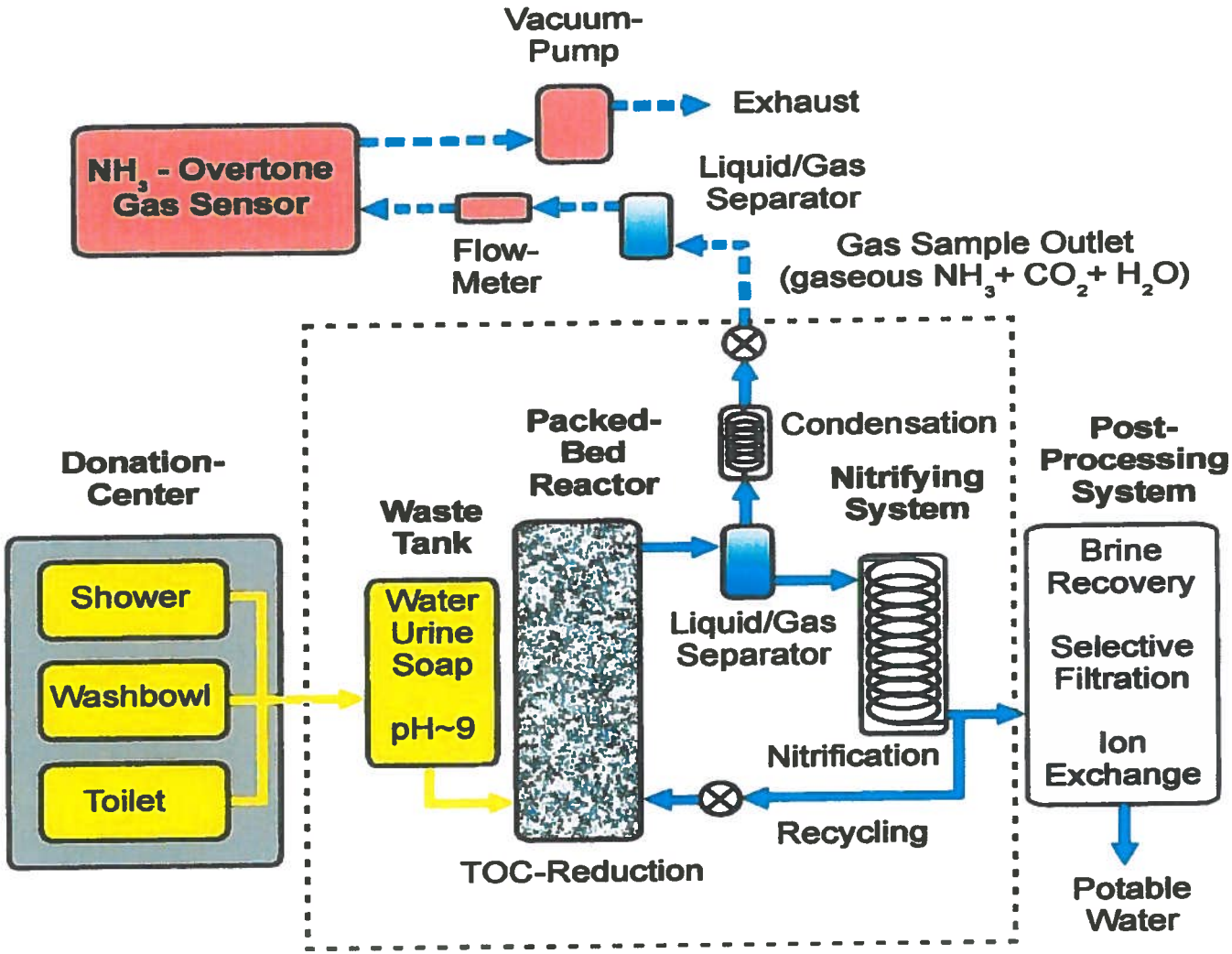



M.E. Webber, et al.
Submitted to Applied Optics Jan. 2001

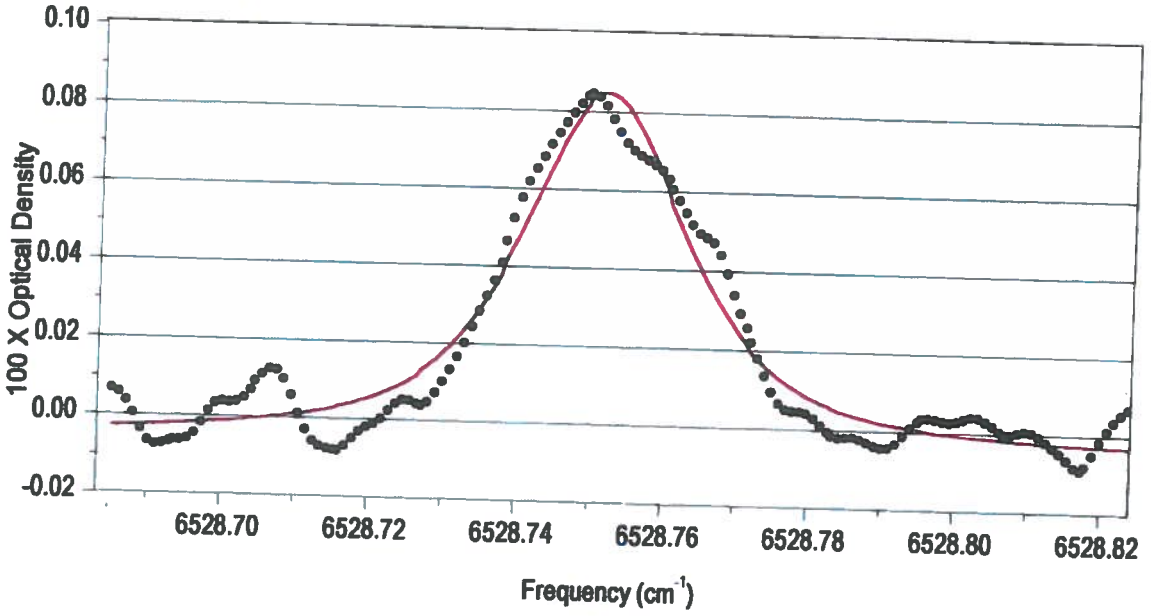
# $NH_3$ Diode Laser Based Sensor

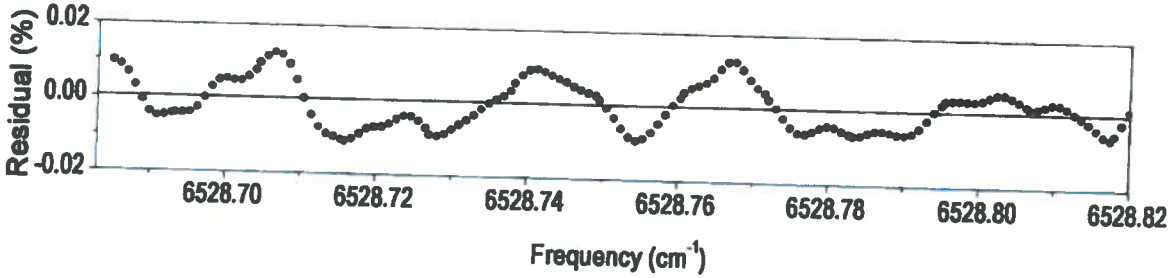


# NASA Water Recovery System



# Typical Ammonia Spectrum @ 6528.76 $cm^{-1}$

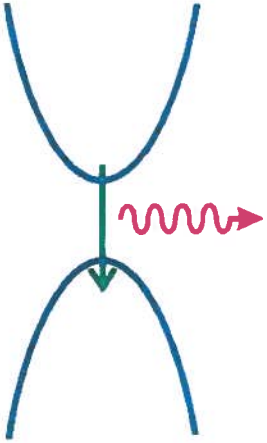


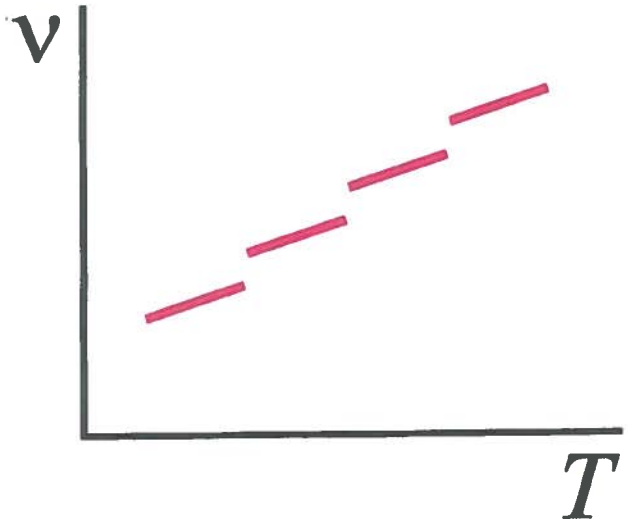



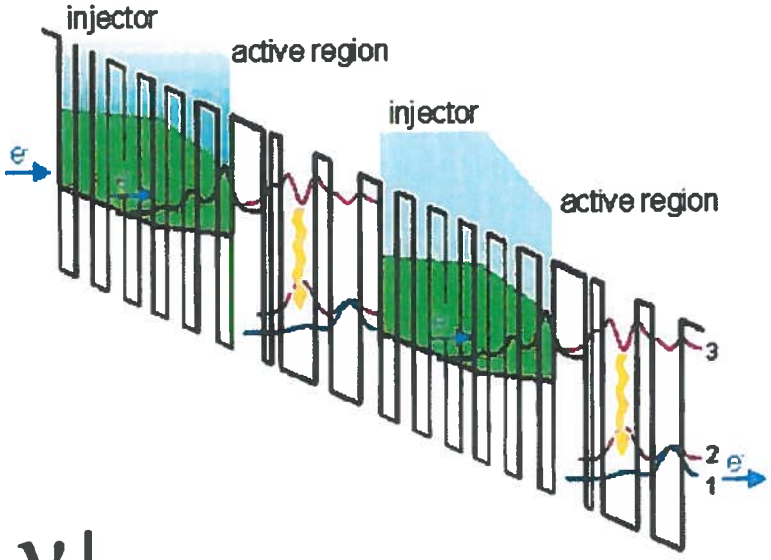

- Voigt lineshape fit @ 100 Torr.
- $NH_3$ concentration of 1.4 ppm.
- Minimum absorbance Sensitivity: $10^{-4}$

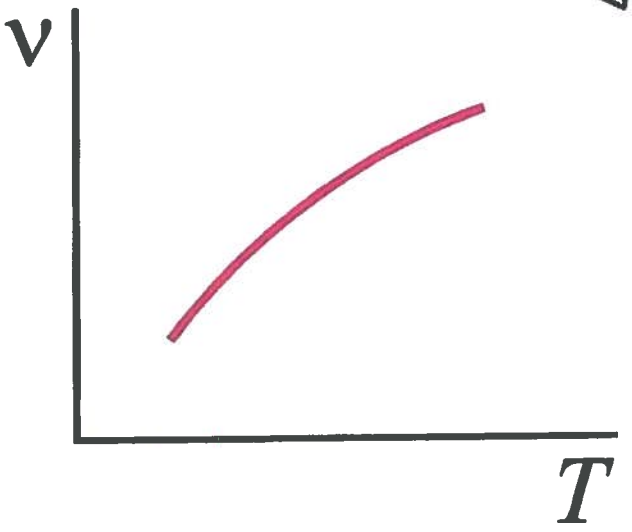
# Megacity Air Pollution: Houston, TX

# Diode Lasers compared to QC-DFB Lasers



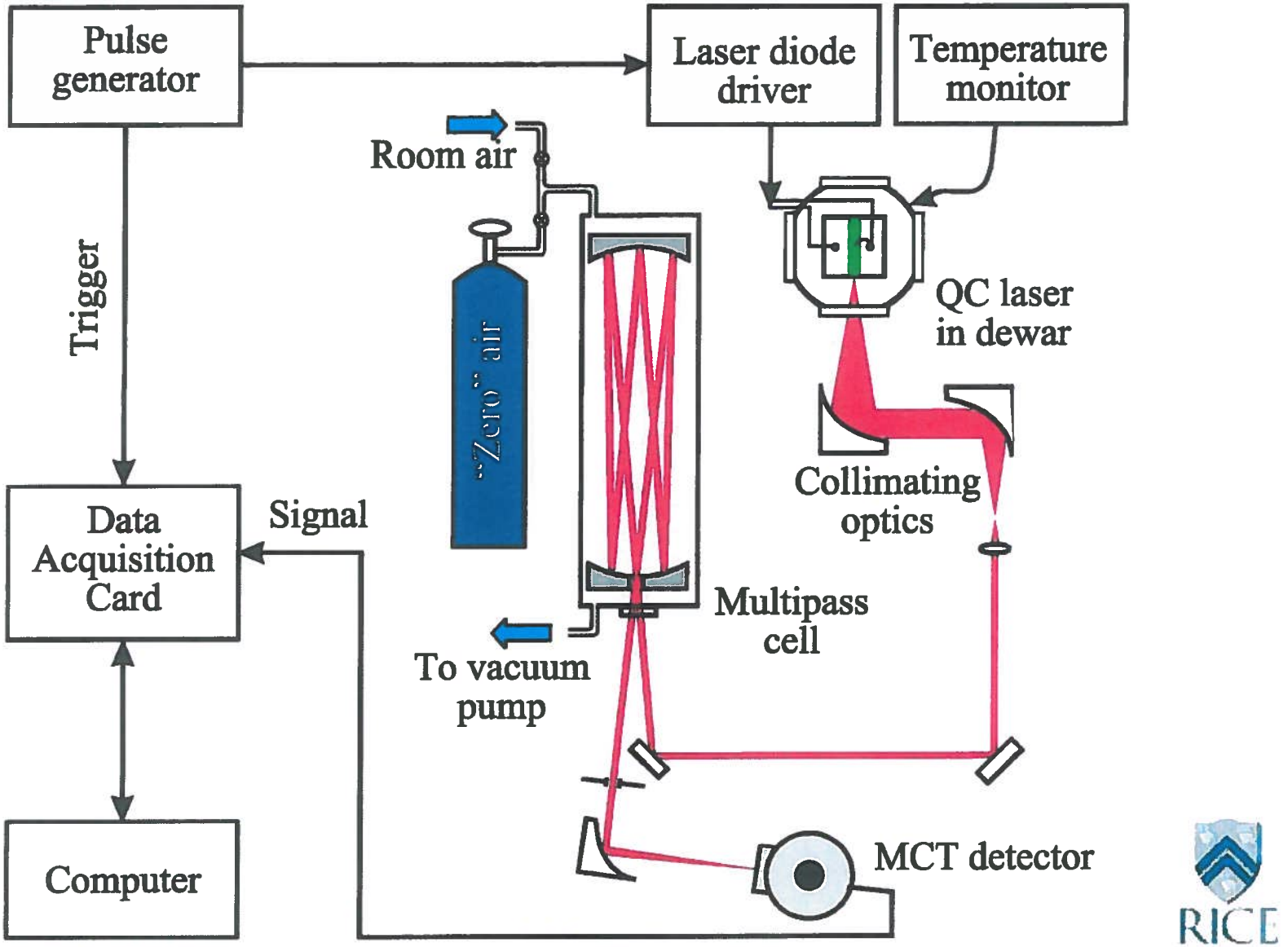



RICE

# Trace Gas Detection with a Multipass Cell




RICE

# Mars NASA Pathfinder Climate Monitoring