5 Hz Catalytic Emissions FT-IR Monitoring during Lean-Rich Engine Cycles: Comparison to Reference Methods

Technology for Productivity

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Background Issues

- Run FT-IR fast enough at high resolution
  - Increase mirror speed
  - Measure interferogram in both direction
- High enough SNR to provide sub 1 ppm detection limits
  - Improve detector sensitivity
- High enough flow rate to turn sample over in gas cell
  - Modify plumbing to handle flow
  - Prevent “whistling” and back pressure in gas cell
- Run analysis fast enough to keep up with data collection
  - Need really fast computer
- Watch Lean-Rich cycles from Low NOx trap
  - Provide quality analysis in real-time (with correct timing)
  - Observe standard and non standard emission gases

High Flow Gas Cell

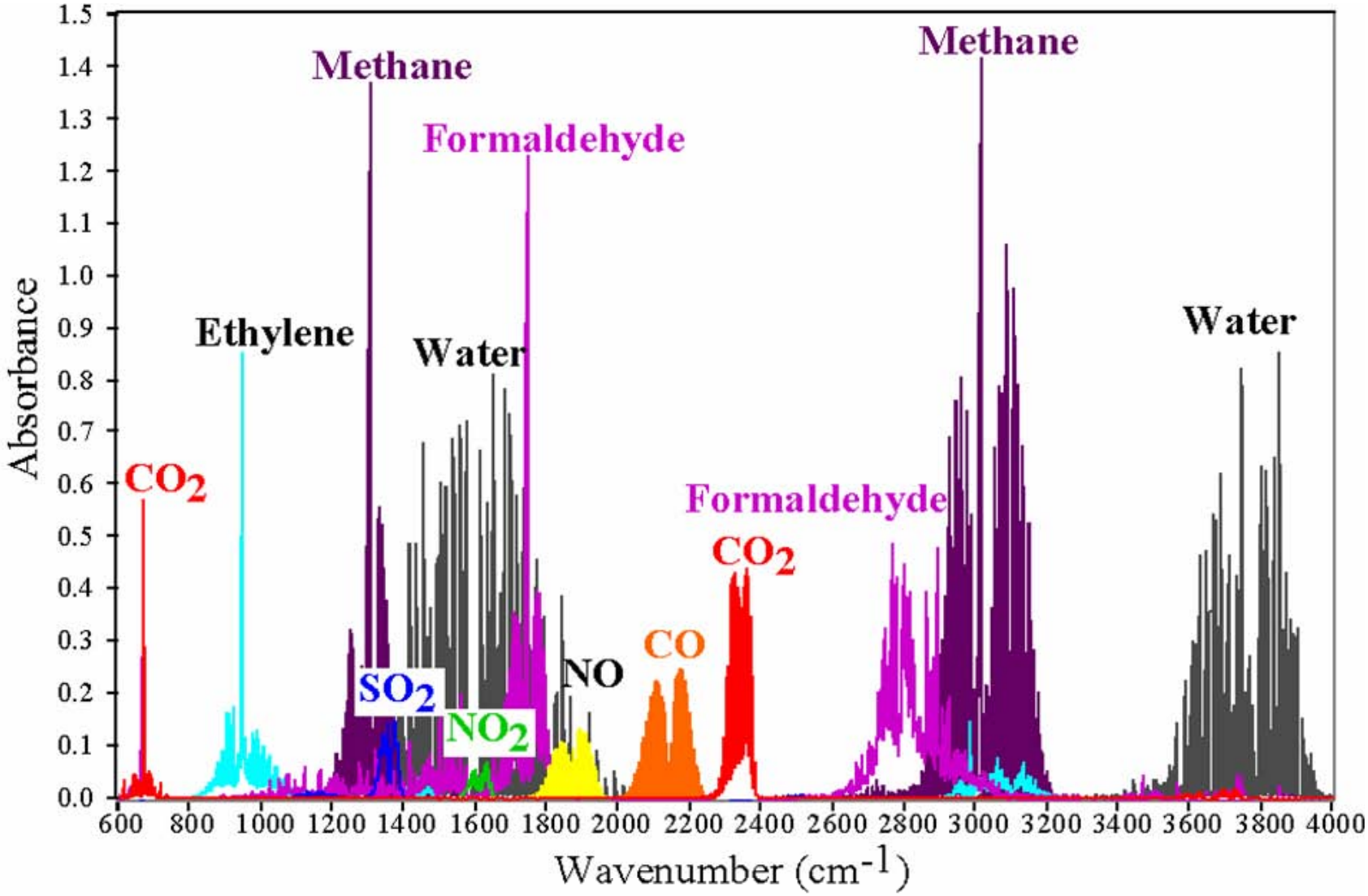
- White Cell Design
  - High throughput
  - Better signal to noise
- Ease of maintenance

- Long path length – 5.11 m
- Low volume 200 mL
  - Faster sampling

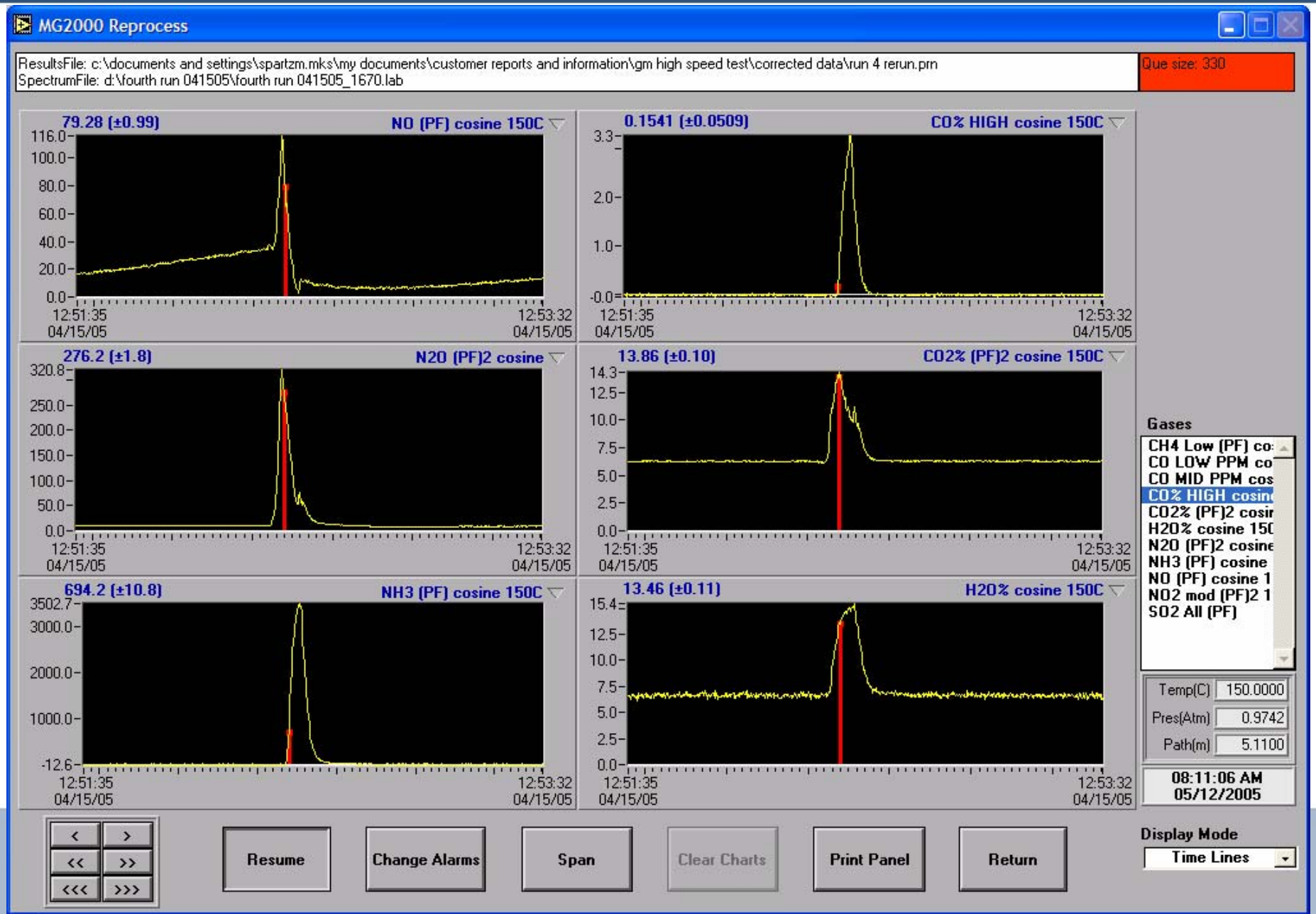
Instrumental Configuration

- FTIR Analyzer
  - 0.5 cm^{-1} Resolution
  - 7.4 um LN_2 cooled MCT 0.5 mm
  - 5.11 m Gas Cell Modified to ½ inch plumbing
  - 0.2 sec / measurement (single scan)
  - 100 L/min Flow Rate (1 inch heated sampling line)
  - 150 C Gas Temperature
  - 1.0 atm Gas Pressure
  - Dual Xeon Server for data collection & processing
- MEXA 7000 Series Emissions Bench

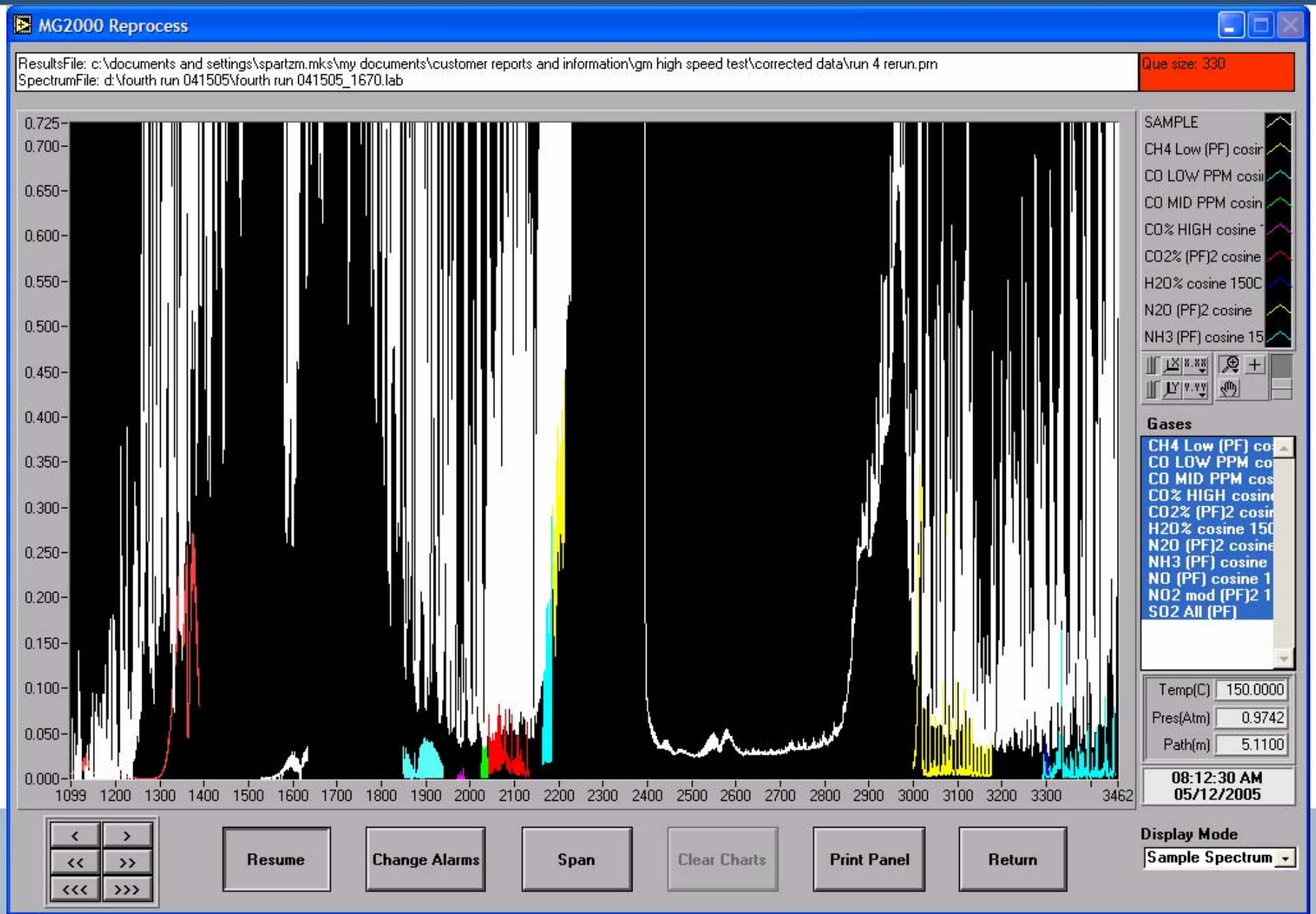
Infrared Spectral Analysis



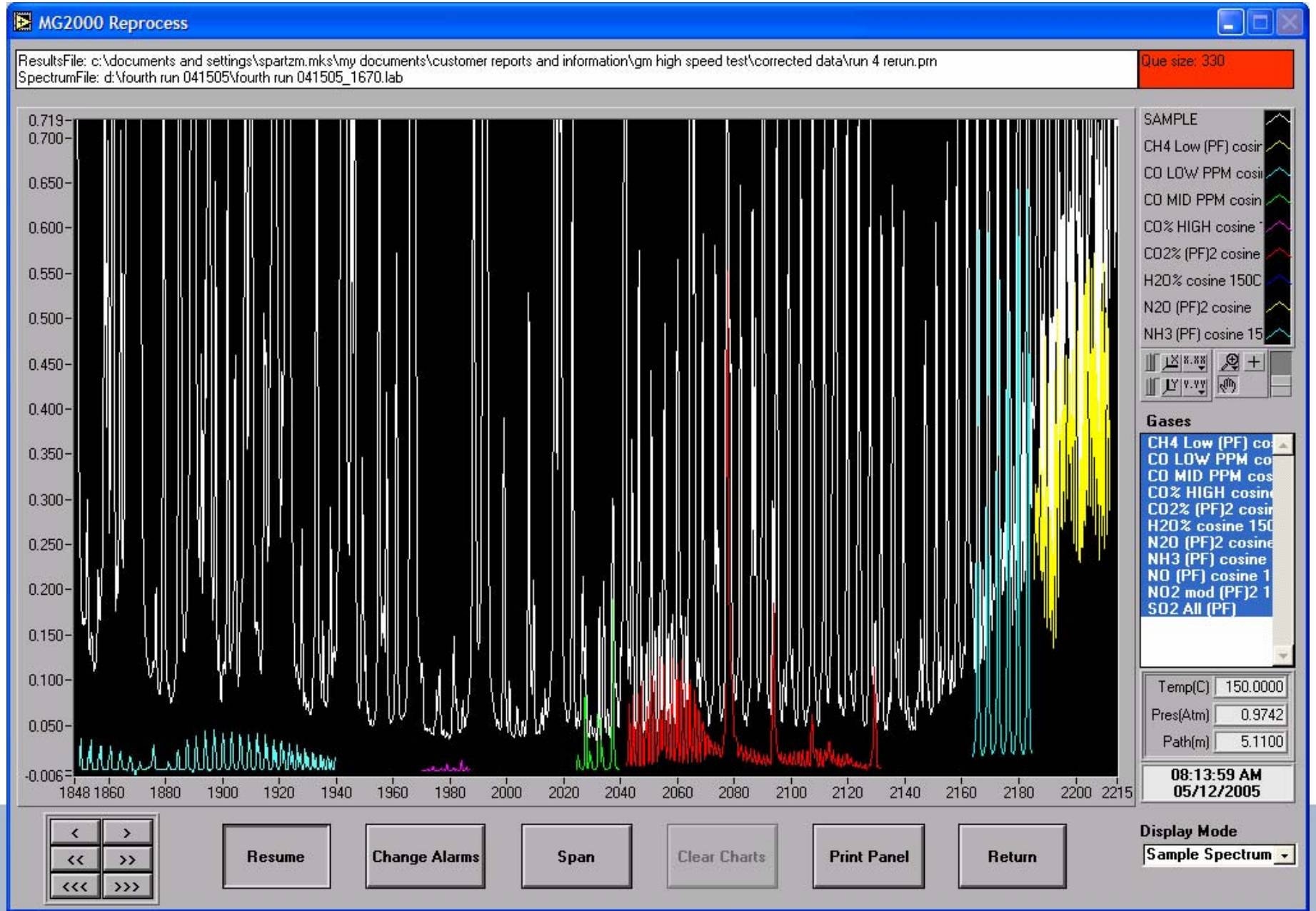
Speciation of Gas Stream during Cycle



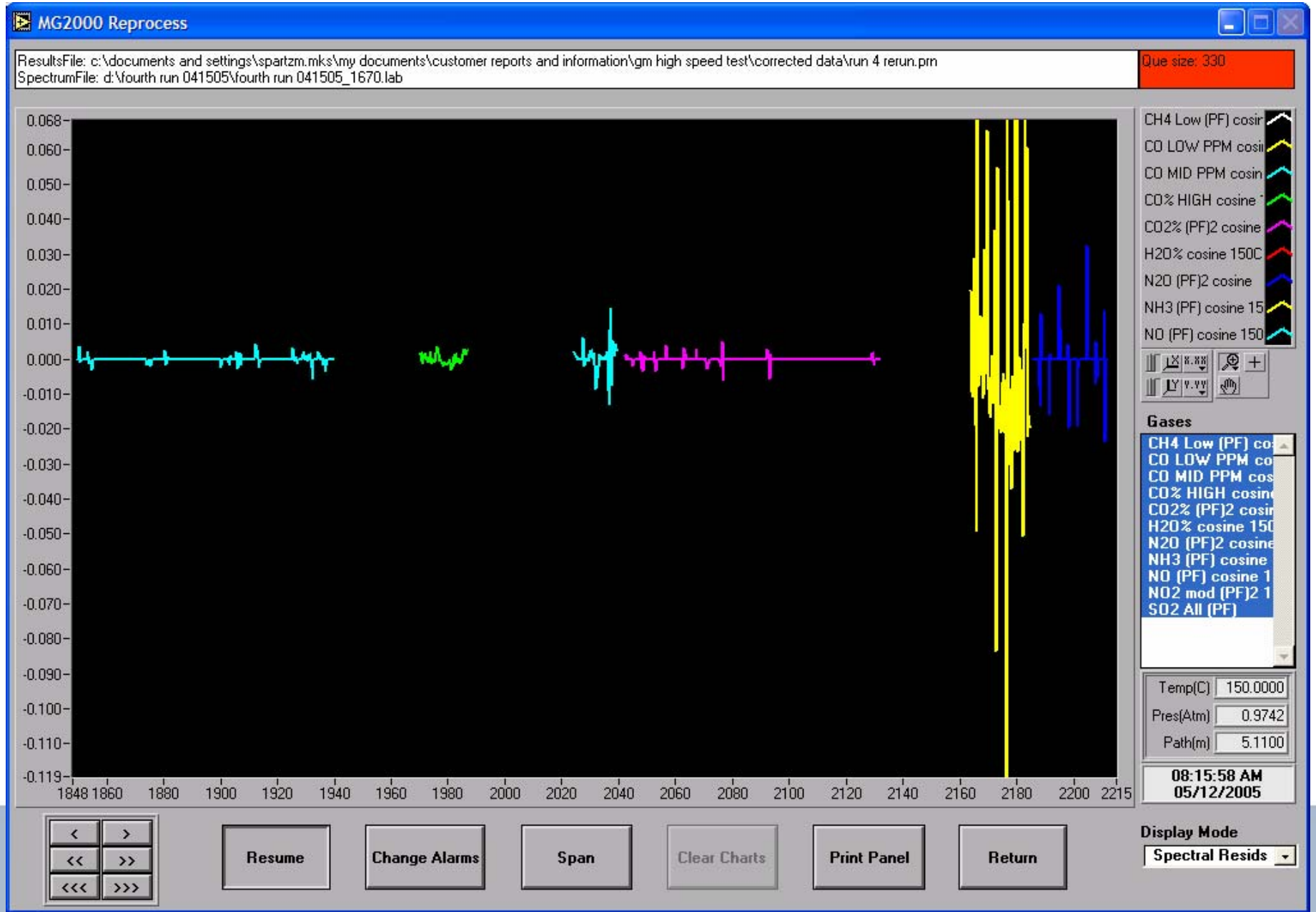
Combustion Spectra



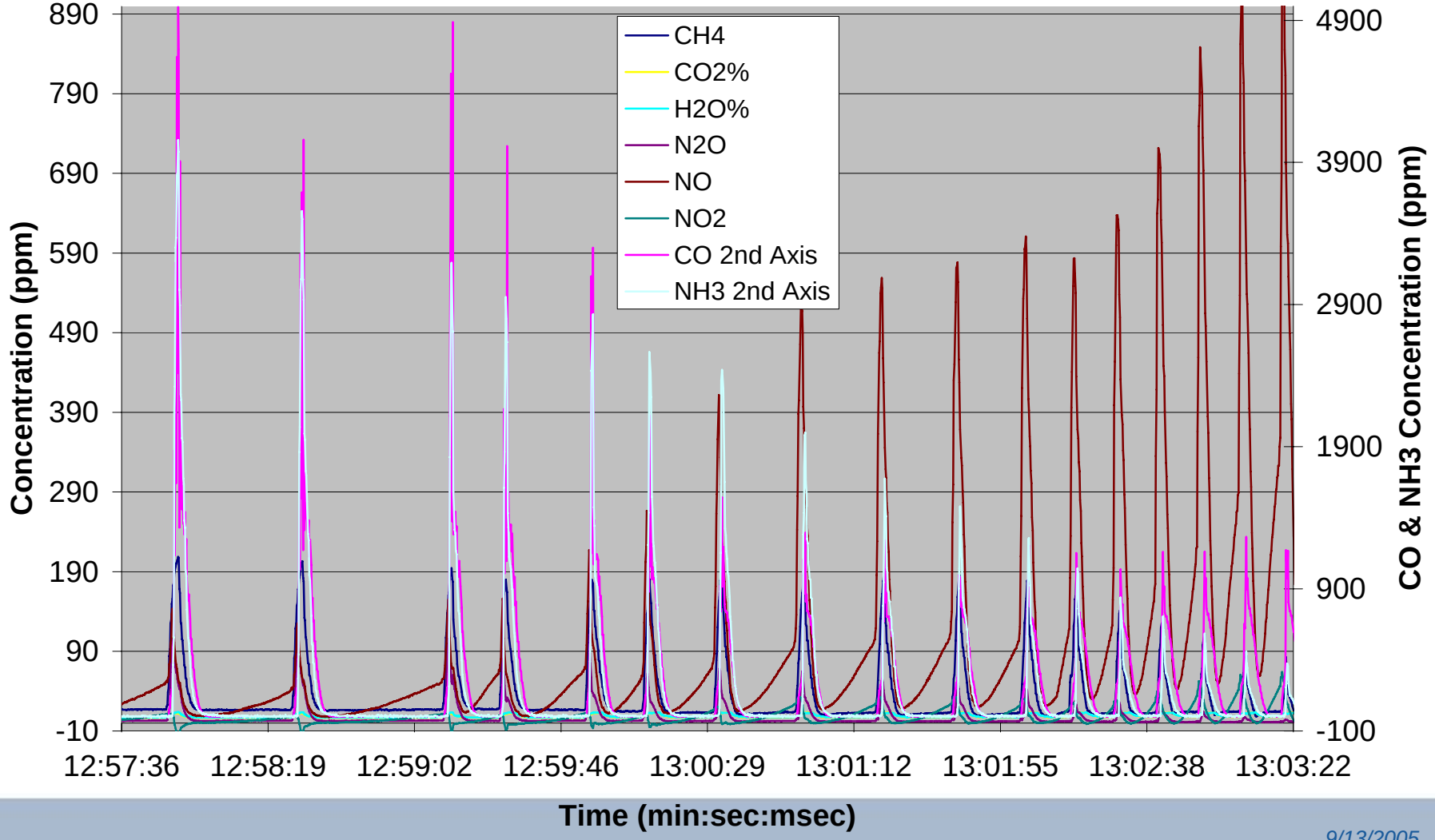
Key Spectral Region



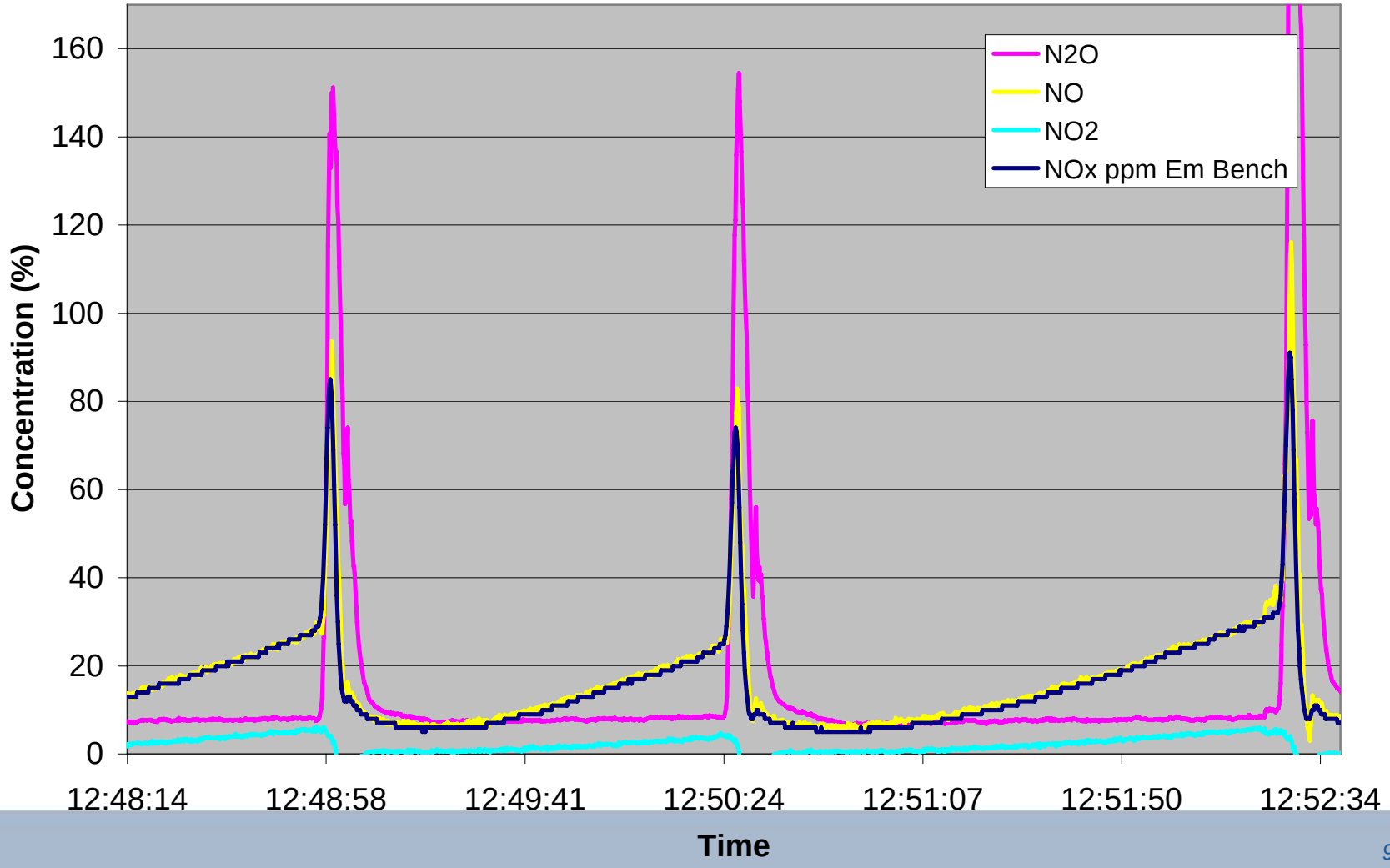
Residual Spectra



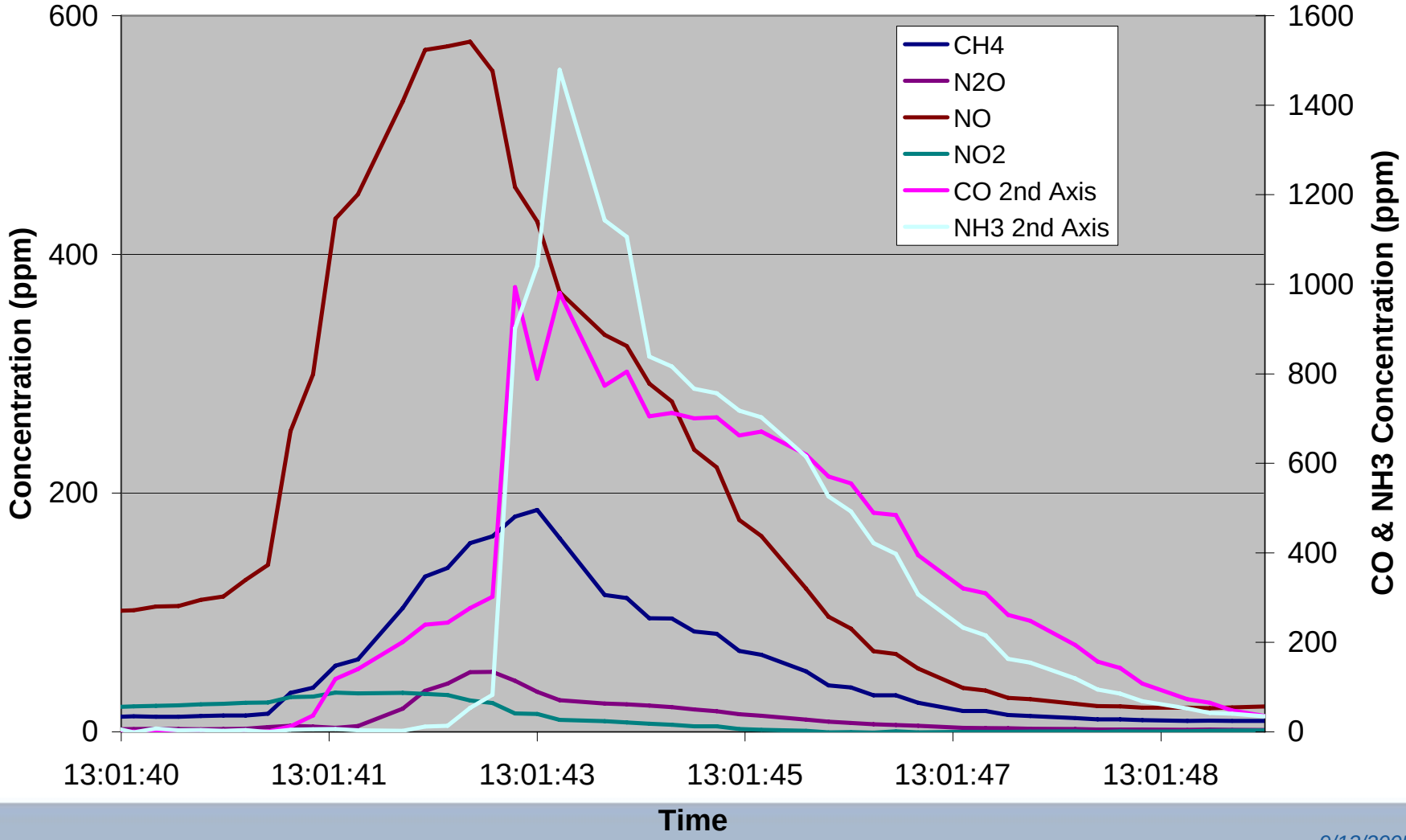
Series of Lean-Rich Cycles on Lean Nox Trap
Transient Detection with 5 Hz FT-IR



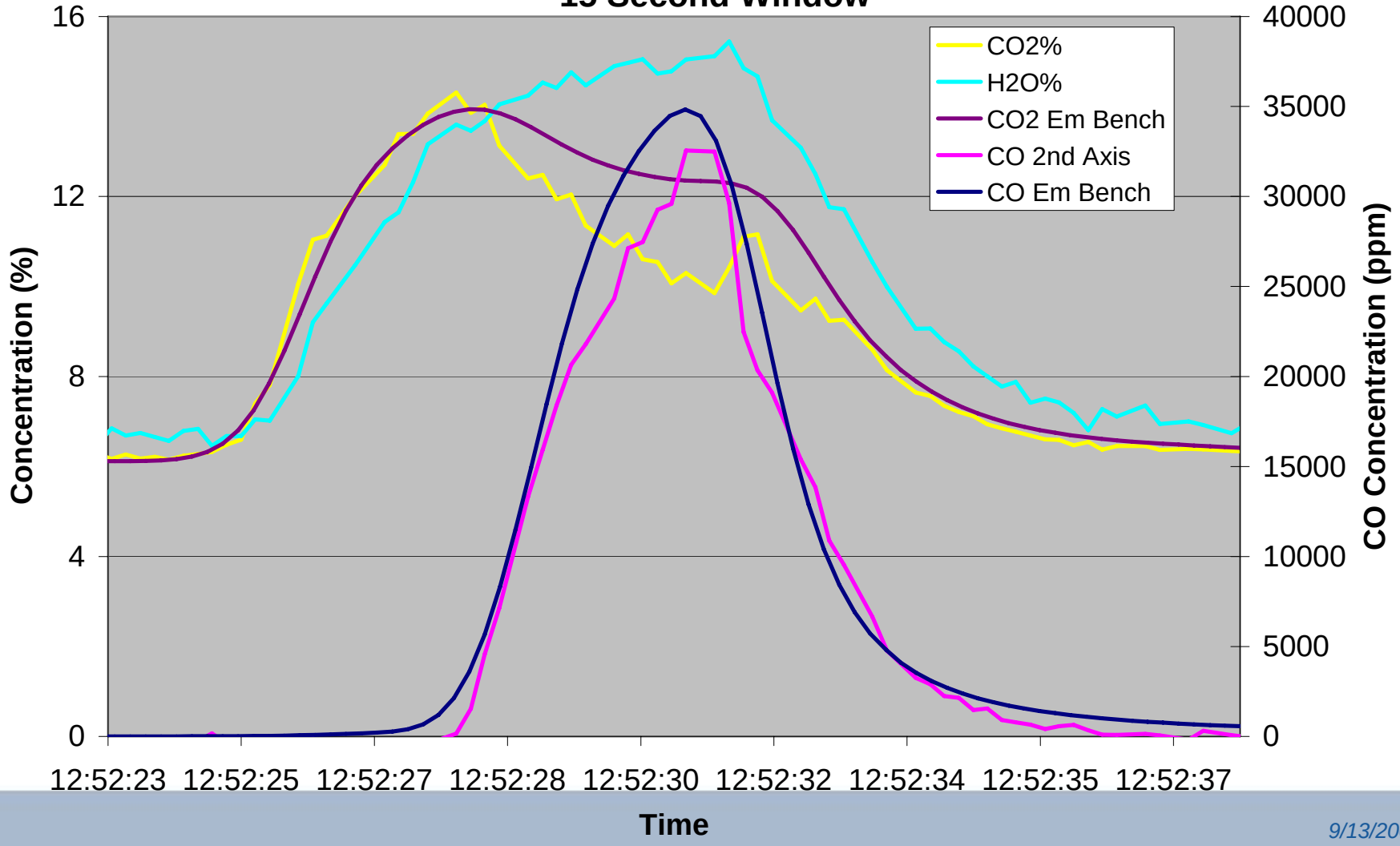
Transient Detection with 5 Hz FT-IR
4 Min Window



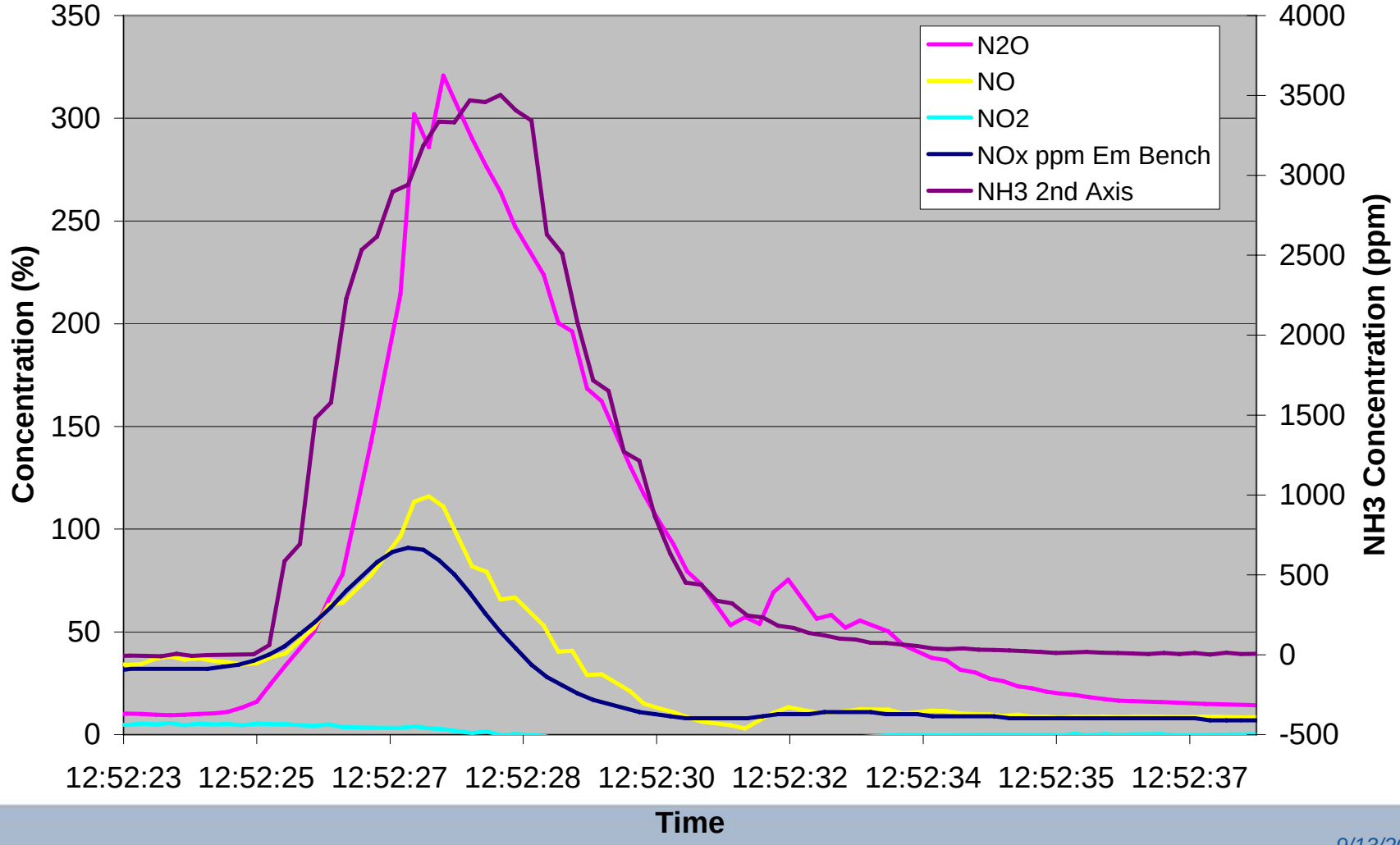
Lean - Rich LNT Transient Detection with 5 Hz FT-IR
10 Second Window



Comparison of CO & CO_2
IR and Traditional Emissions Bench
15 Second Window



NOx Comparison + NH_3 and N_2O
15 Second Window



Concluding Remarks

- Demonstrated true 5 Hz Monitoring with FT-IR
  - No pressure or temperature issues
  - No timing issues
- Data compared well with Horiba MEXA system
- Able to monitor standard gases (CO, CO_2, NOx, SOx)
  - Lean to rich with single method
- Able to monitor additional gases (N_2O, NH_3, CH_4)
  - Provide additional information for development LNT
- Expandable to additional gases
  - Speciate hydrocarbons (C_2H_2, C_2H_4, C_2H_6, C_3H_8, etc)