



Engineered Solutions & Service in a complex environment of Gas Sampling & Analysis.

Engineered Technical Solution to Meet Every Need.

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TDLS & DOAS Insitu Cross Stack Solutions

*By
Gary Cacciatore
TDL Product Specialist*

***Engineered technical solution to
meet every need...***

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Agenda

1. Introductions
2. What is a CEMS
3. Traditional CEMS Designs
4. TDL theory of operation, capabilities and EPA Calibration
5. DOAS theory of operation, capabilities and EPA Calibration
6. Cost Saving Charts (Potential > \$1,000,000 Cost Savings)



What is a “CEMS”

- Required by a permit issued by an EPA regulatory agency before installation/operation of a combustion source.
- CEMS measures emissions to demonstrate compliance with permit emissions limits utilizing probe, sample lines, sample handling, analyzers, electronics, PLC, DAS, and House: O₂, CO, CO₂, NO_x, SO₂, NH₃, VOC, H₂S, HCl,
- DAS Reports emissions data to regulatory agency
- CEMS must meet regulatory approvals before (RATA) & after installation (important to use qualified CEMS vendor)





Traditional CEMS Design

- Sample extraction (sample probe)
- Sample transport (sample line)
- Sample conditioning, pumps, eductors, filters, scrubbers
- Gas Analyzers
- Calibration Equipment (Daily & CGA QA/QC)
- System control (PLC) or Datalogger
- Data acquisition, storage and reporting (DAHS)
- Shelter or Enclosure
- Peripheral: Flow Monitor, Opacity, PM, Mercury





CEMS Monitoring on CT

HRSG Bypass Exhaust
CEMS

NO_x
CO
O₂

Turbine Exhaust CEMS

NO_x
CO
O₂
CO₂
NH₃
VOC

SCR Inlet CEMS

NO_x
O₂

CO Catalyst
Inlet CEMS

CO
VOC

Compliance CEMS

40CFR Part 75

40CFR Part 60

South Coast AQMD

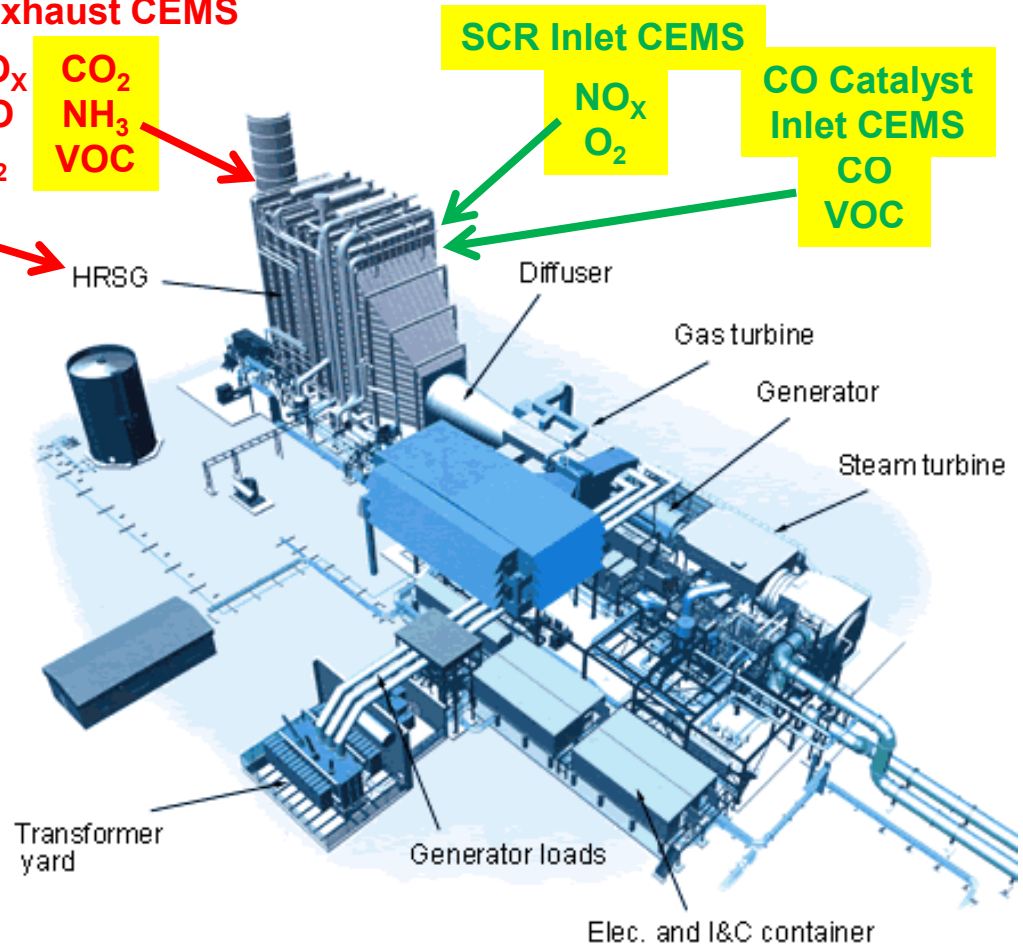
RECLAIM

Process CEMS

SCR inlet NO_x, CO, O₂

Regulatory Compliance CEMS

Process CEMS





Two Fully Extractive CEMS in a Shelter on natural gas fired turbines with an ESC DAHS measuring NO_x, CO and O₂



Typical Site CEMS Location



Monitoring O₂, CO, CO₂, NH₃/H₂O & Nox on Gas Turbines/Coal Fired Plants using TDL Cross Stack Technology

TDL Tunable Diode Laser Spectroscopy

NH₃, HCl, H₂S, H₂O,
HF, CH₄, HCN, CO₂,
CO, O₂, NO, HDO,
D₂O



**DOAS
Differential
Optical Absorption
Spectrometer, NO,
NO₂, (NO_x), SO₂,
NH₃, C₆H₆, C₈H₁₀,
C₈H₈, O₃, C₁₀, H₈,
CS₂, CL₂, HCHO**





Monitoring O₂, CO, CO₂, NH₃/H₂O on Gas Turbines/Coal Fired Plants using TDL Cross Stack Technology

TDL Tunable Diode Laser Spectroscopy

NH₃, HCl, H₂S, H₂O,
HF, CH₄, HCN, CO₂,
CO, O₂, NO, HDO,
D₂O





Why Cross Stack TDL

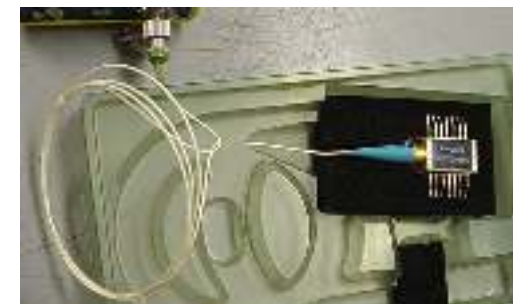
- Ultra High Accuracy & Sensitivity
- No Interference from other background gases
- Eliminates all components in contact with gas sample
 - Probe, Sample Line, chiller, filters, pump, converters
- Immediate Response Time
- Simple to Maintain
- Locate analyzer in Shelter off of stack (CO exception)
- Measure multiple Stacks with one Analyzer
- Compact & Easy to Install and Operate
- Meets & exceed EPA Performance Specifications, Calibration and Certification/RATA Requirements Part 60 & 75
- TDL technology typical life > 10 years
- Low operating Costs



TDLs: How they work

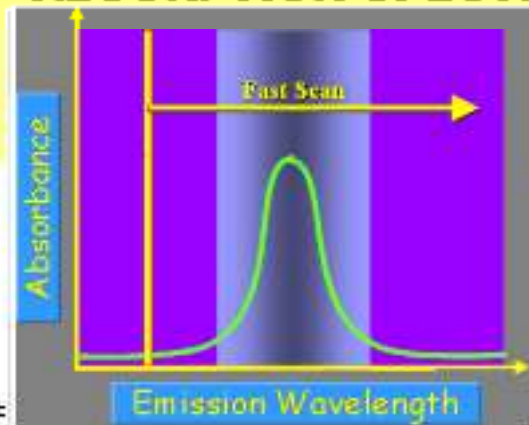
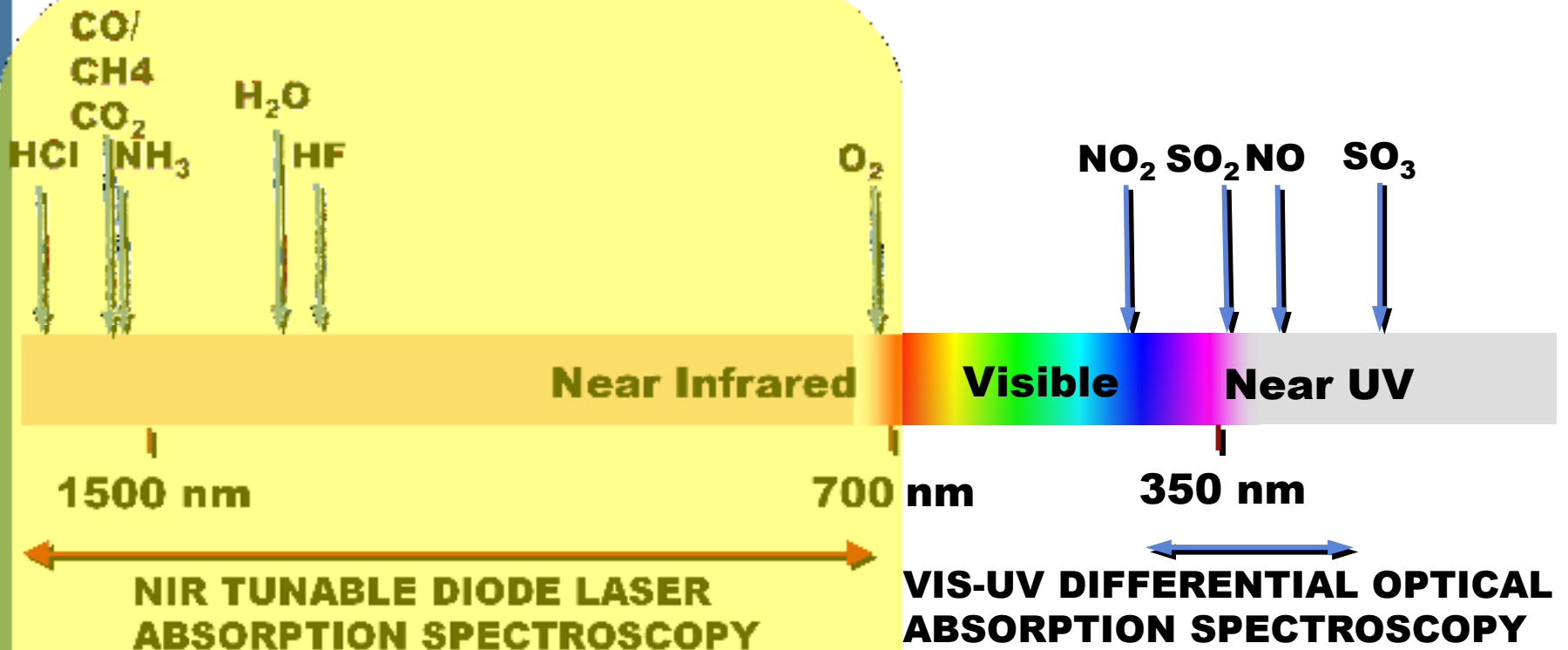
■ Tunable diode lasers



- Made of small crystals of Ga, As, Sb, P
- **Similar to lasers used in telecommunications applications**
 - Rugged
 - Long life
- **Commercially available**
- Emits light emissions in the **near-infrared region** when an electric current is applied
- Laser center wavelength depends on composition of crystal
- **Laser wavelength can be tuned over narrow range by changing current (fine) or by adjusting laser operating temperature (coarse)**
- **Output can be fiber coupled allowing easier installation and multi-channel capability**





Tunable Diode Laser Measurement Technique



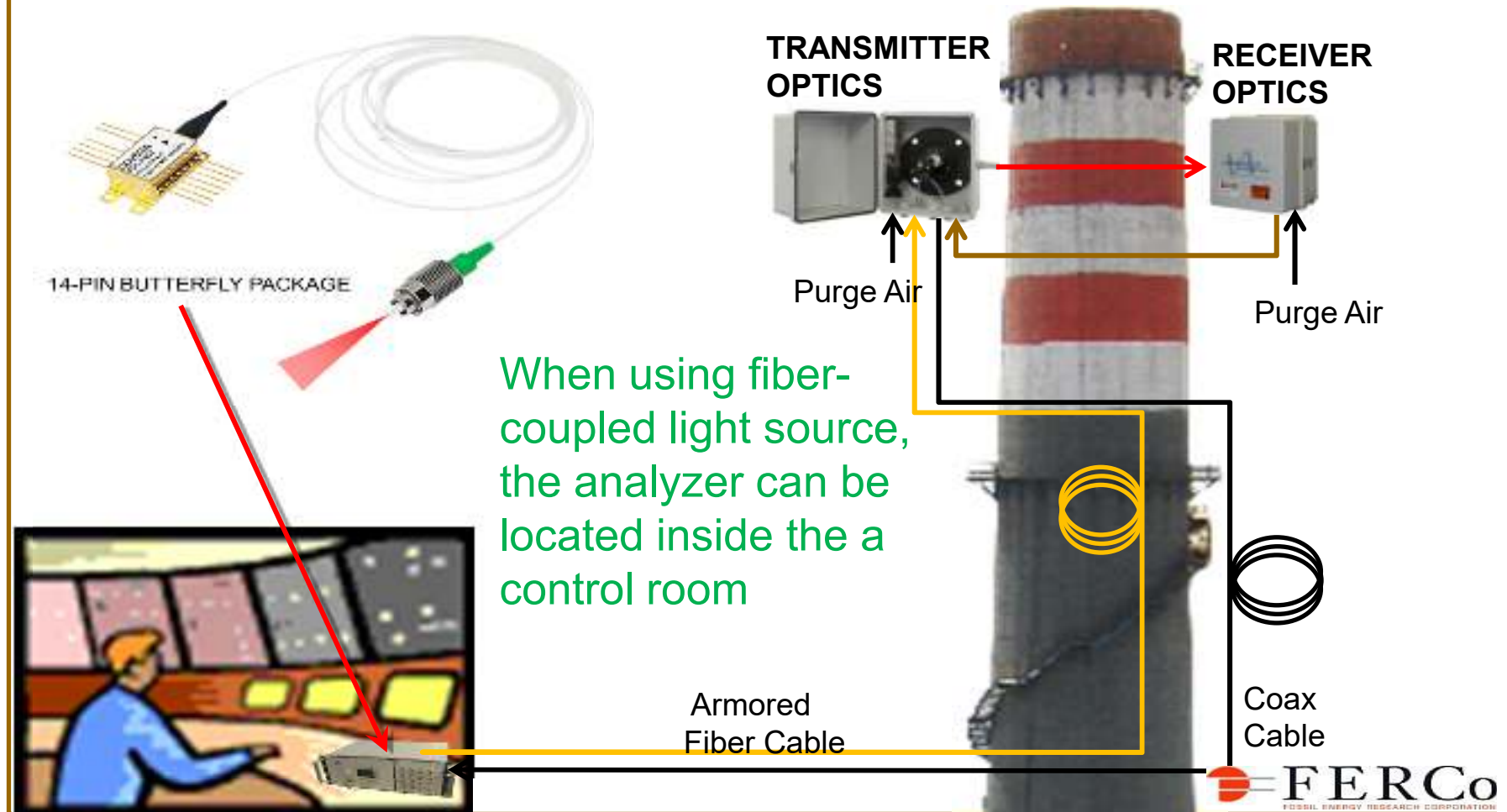
-  **Absorption region**
-  **Side wavelengths, without absorption**



Fiber Coupling



Fiber-Coupled Light Source



Gas Reference Cell

- Internal Reference Cell
- Module spiked with known amount of target gas
- Isolated cell measurement

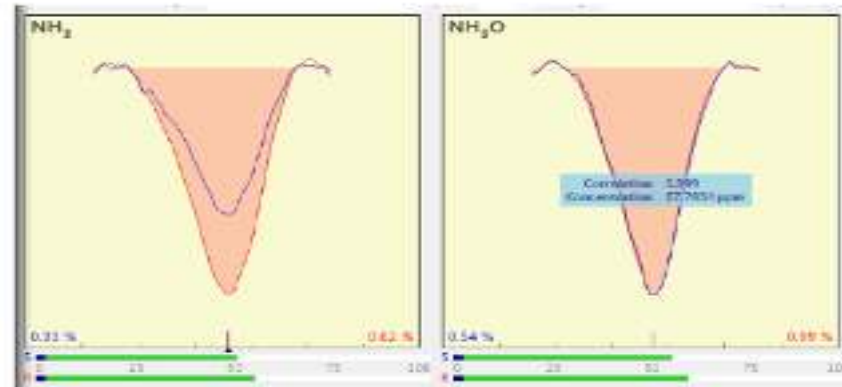
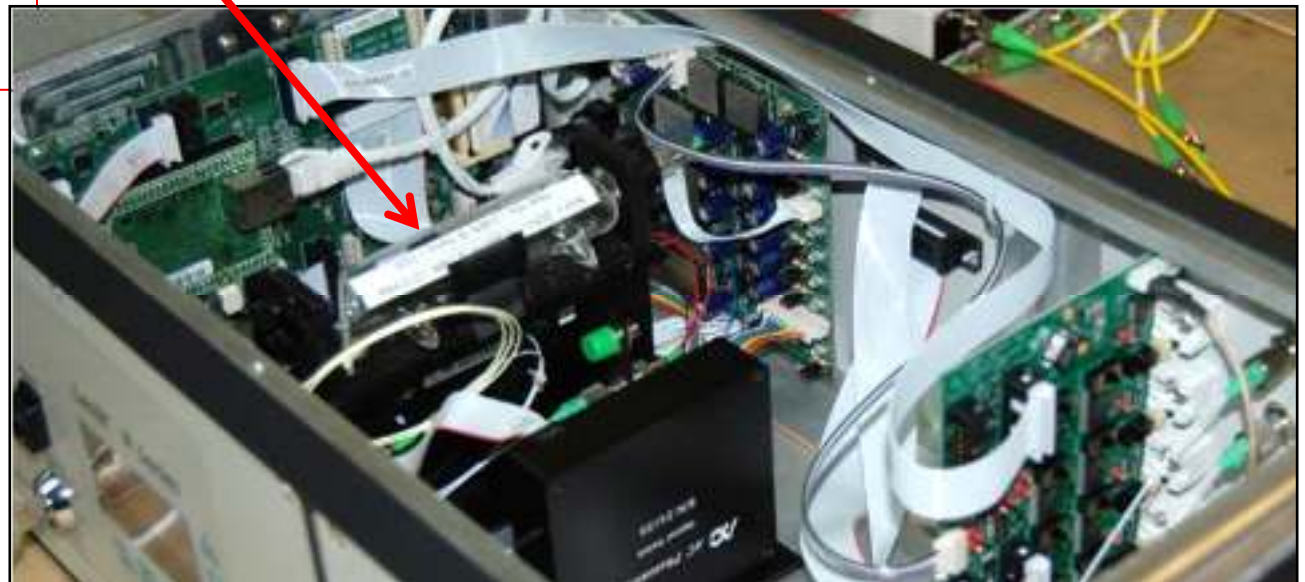
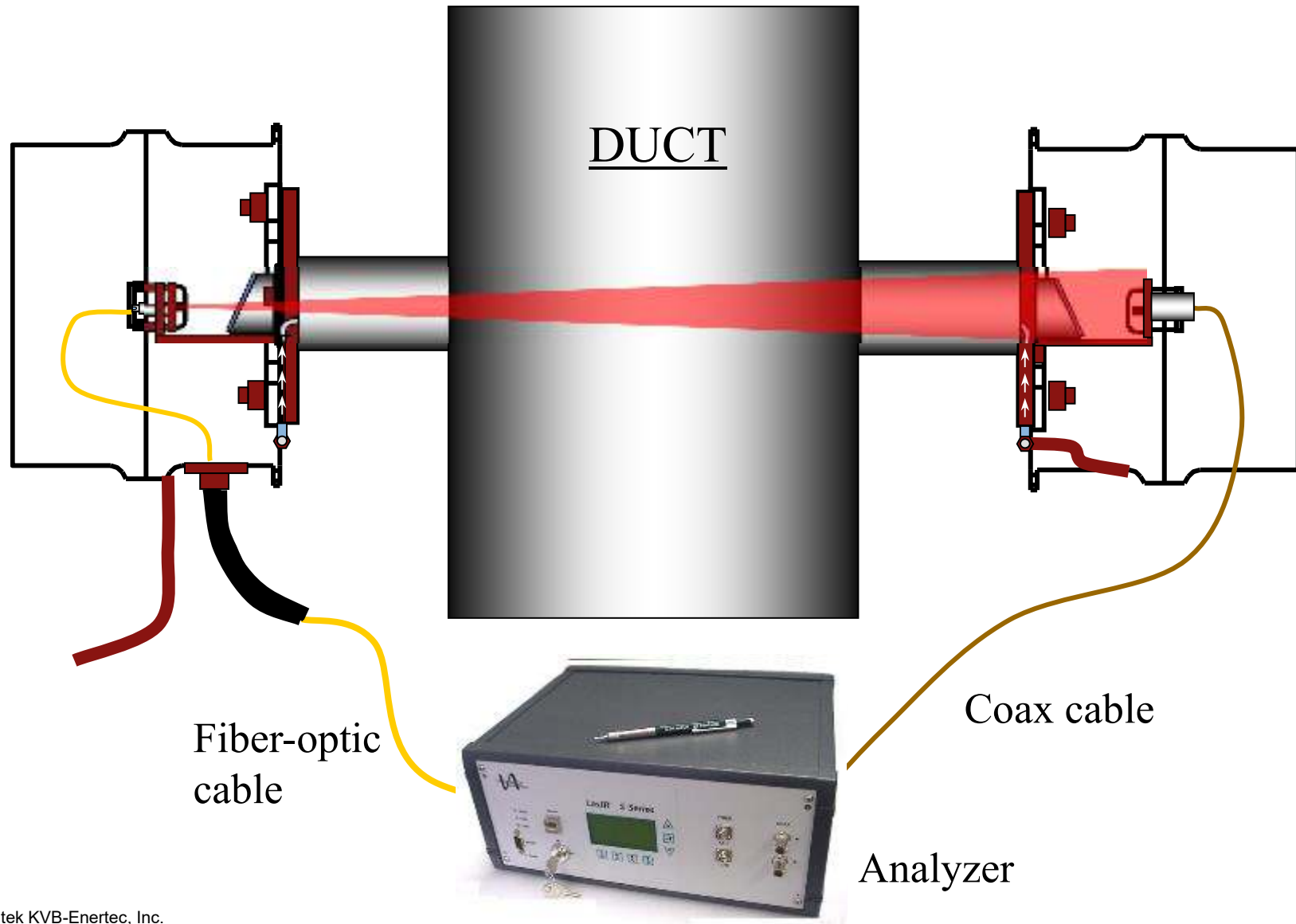


Figure 4-10
Reference Cell (Red) Response which has 5% of the Laser Light, and the Measured Paths (Blue) which has 95% of the Laser Light



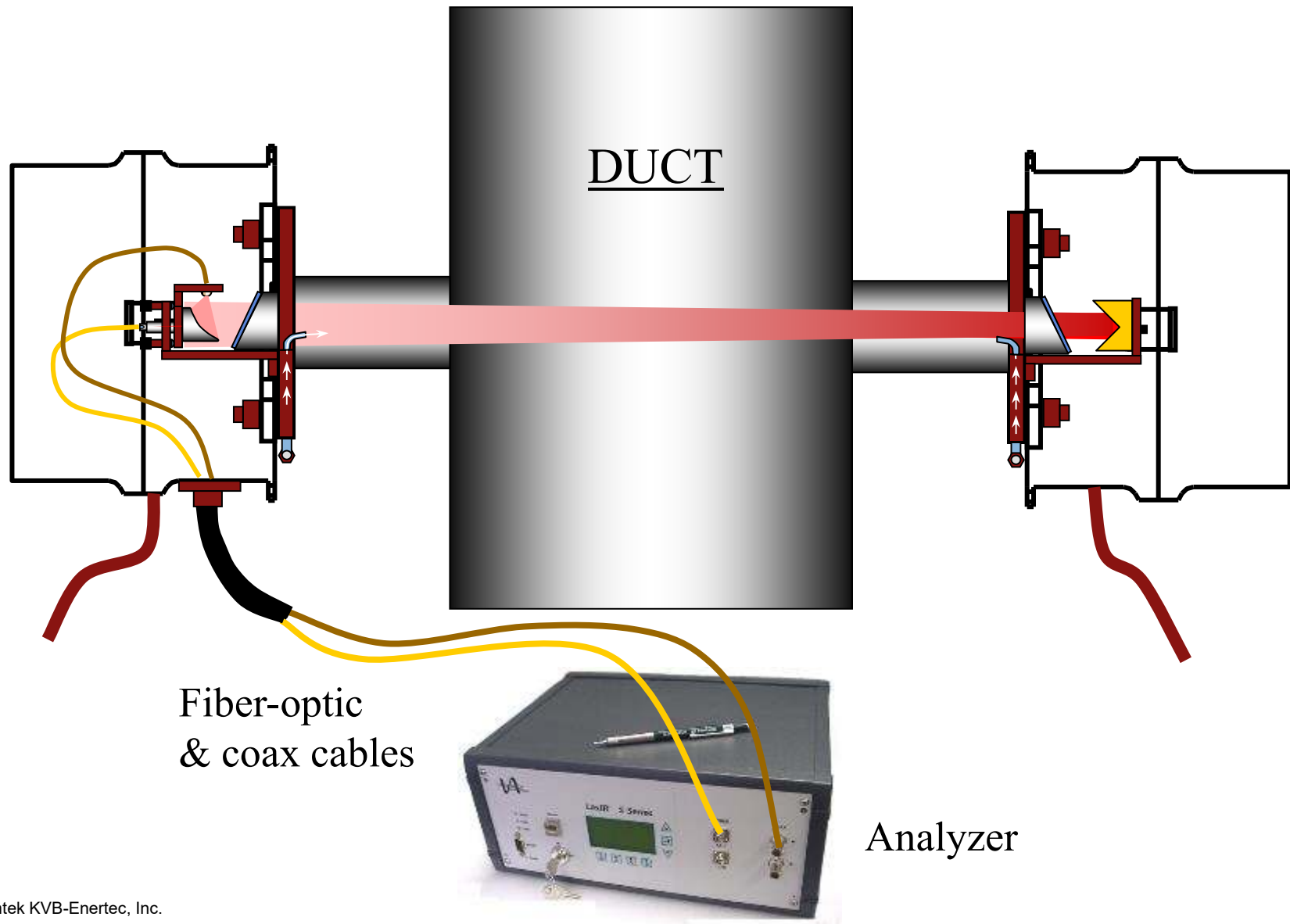


Single Pass Stack Configuration



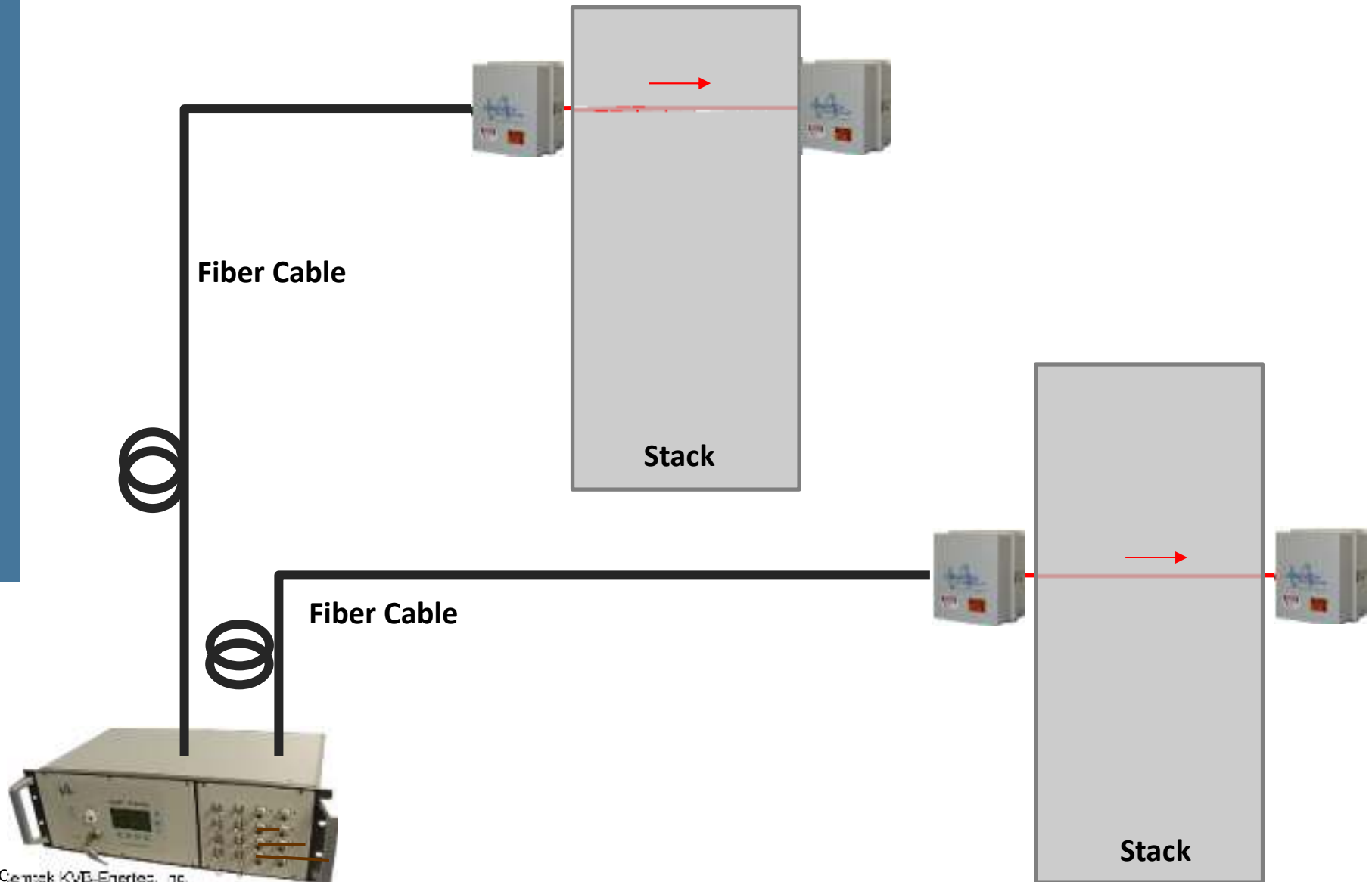


Dual Pass Stack Configuration – Ultra low sensitivity/accuracy



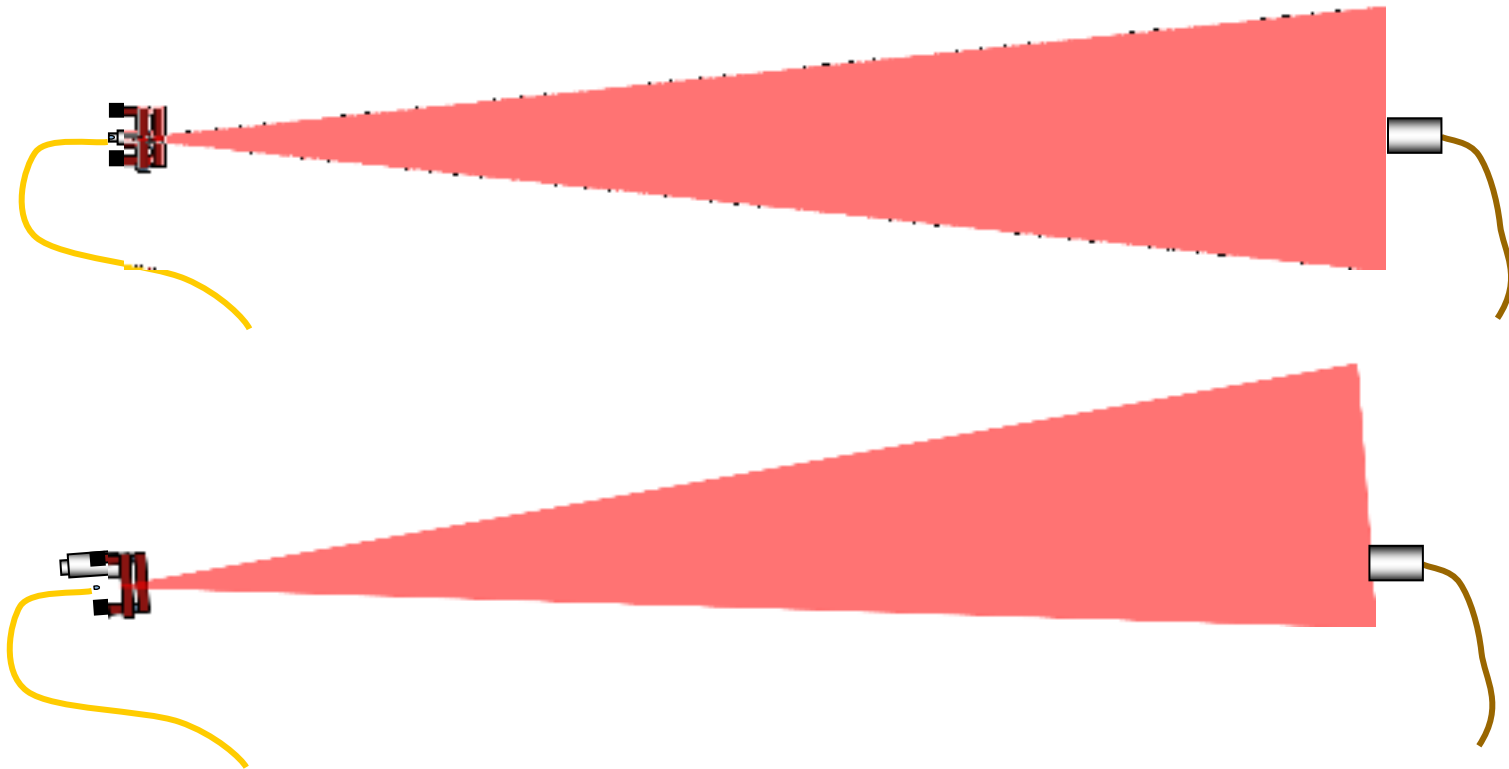


Multiple Sample Points – Up to 8





Tunable Diode Laser Alignment Beam



- Higher laser powers allow beam expansion to attain alignment stability
- By de-focusing the beam, overfill of the detector optics allows for alignment changes



Tunable Diode Laser Maintenance & Adjustment

Maintenance



Lens Removal for Cleaning

Alignment



Micro Adjustment Screws



Tunable Diode Laser Internal Calibration

- **Three Options to Calibrate**
 - **Internal Sealed Gas Cell – Automatic**
 - **Meets PPS-001 Compliance Calibration Regulations. Currently used as there is no Performance Specification for NH₃**
 - **NIST Traceable Calibration Gas – Semi Automatic**
 - **Meets EPA 40 CFR Part 60 & 75 Requirements, along with PS18 specific for HCl compliance**
 - **External Audit Module – Manual**
 - **Maintenance Tool**



Tunable Diode Laser Calibration - Internal Sealed Gas Cell

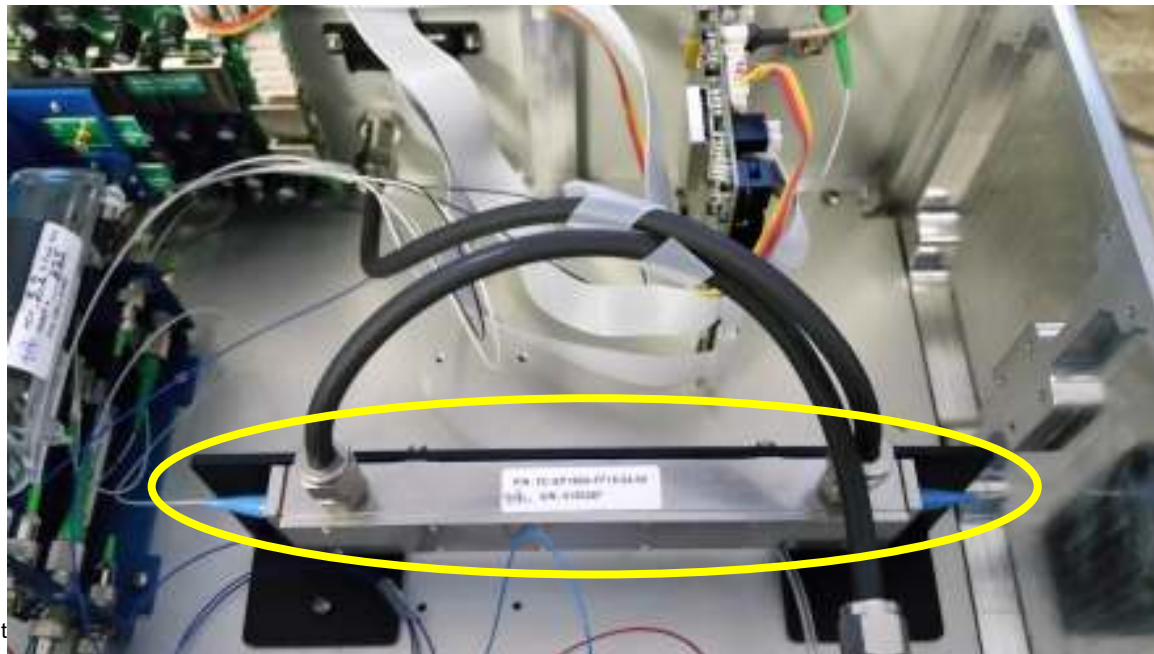
- Sealed Calibration Cell – Daily Calibration Gas not required
- Auto Daily Calibration - Instantaneous Response
- Utilizes NIST Traceable Protocol Gas





Tunable Diode Laser Calibration – Flow Thru

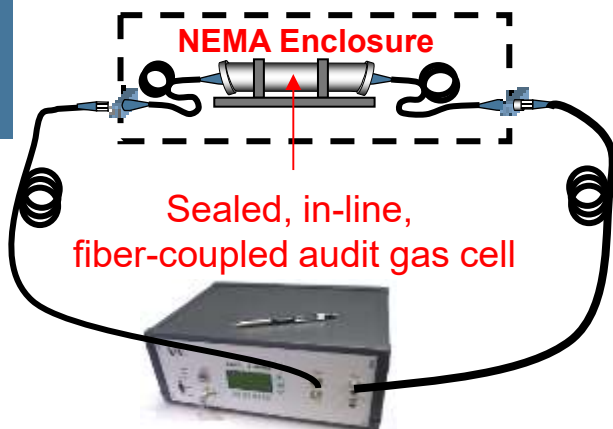
- Calibration Gas Flow Thru Cell
- Daily Calibrations, CGA's, 7 Day Drift Test
- Requires NIST Traceable Protocol Calibration Gas bottles
- Quick Response Time
- Temperature Corrected to Stack Gas Temp



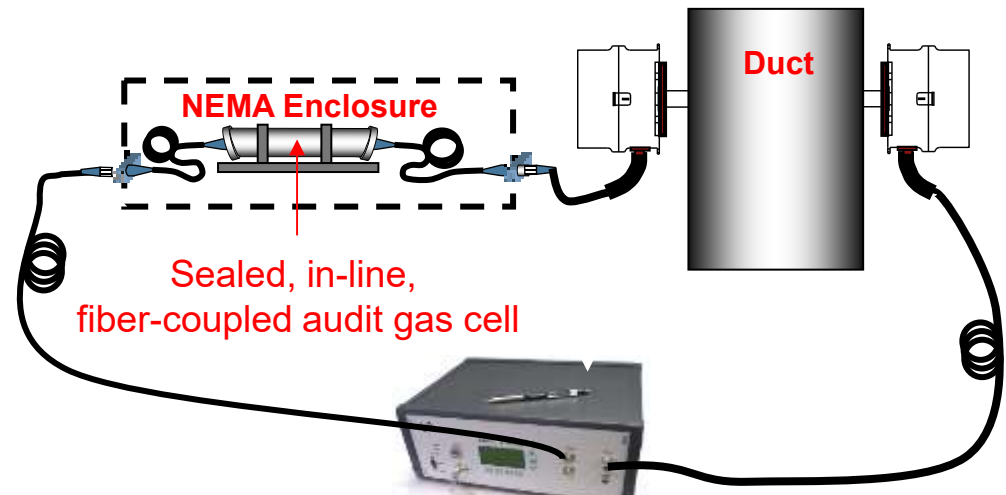


Tunable Diode Laser Manual External Audit Method

- Diagnostic Tool
- Dynamic Spiking
- Analyzer Isolation



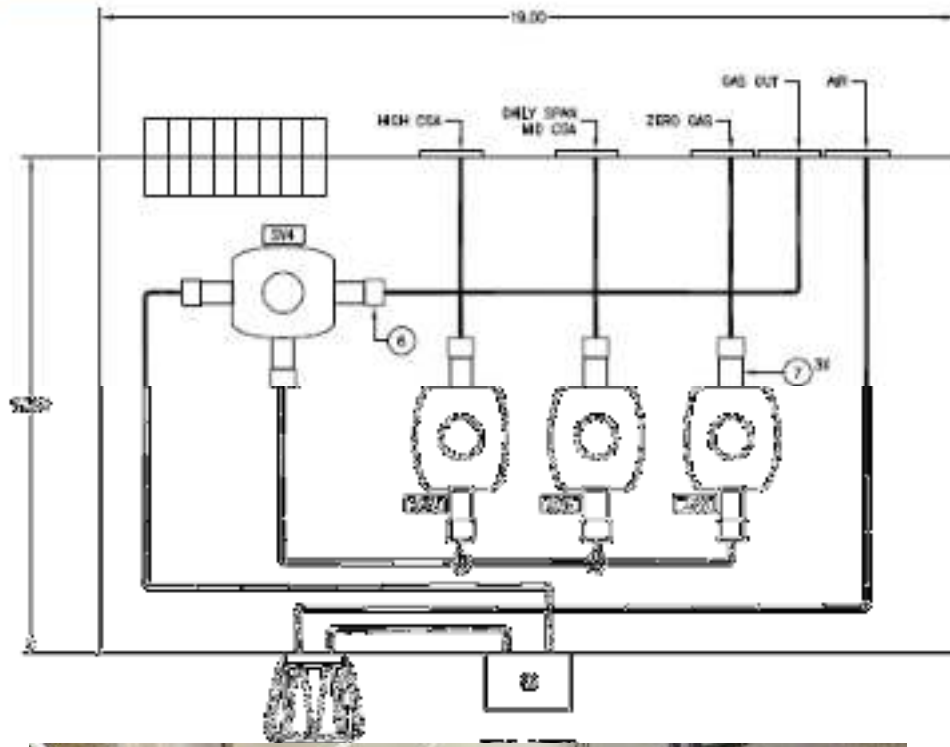
Analyzer Isolation Configuration



Dynamic Spiking Configuration

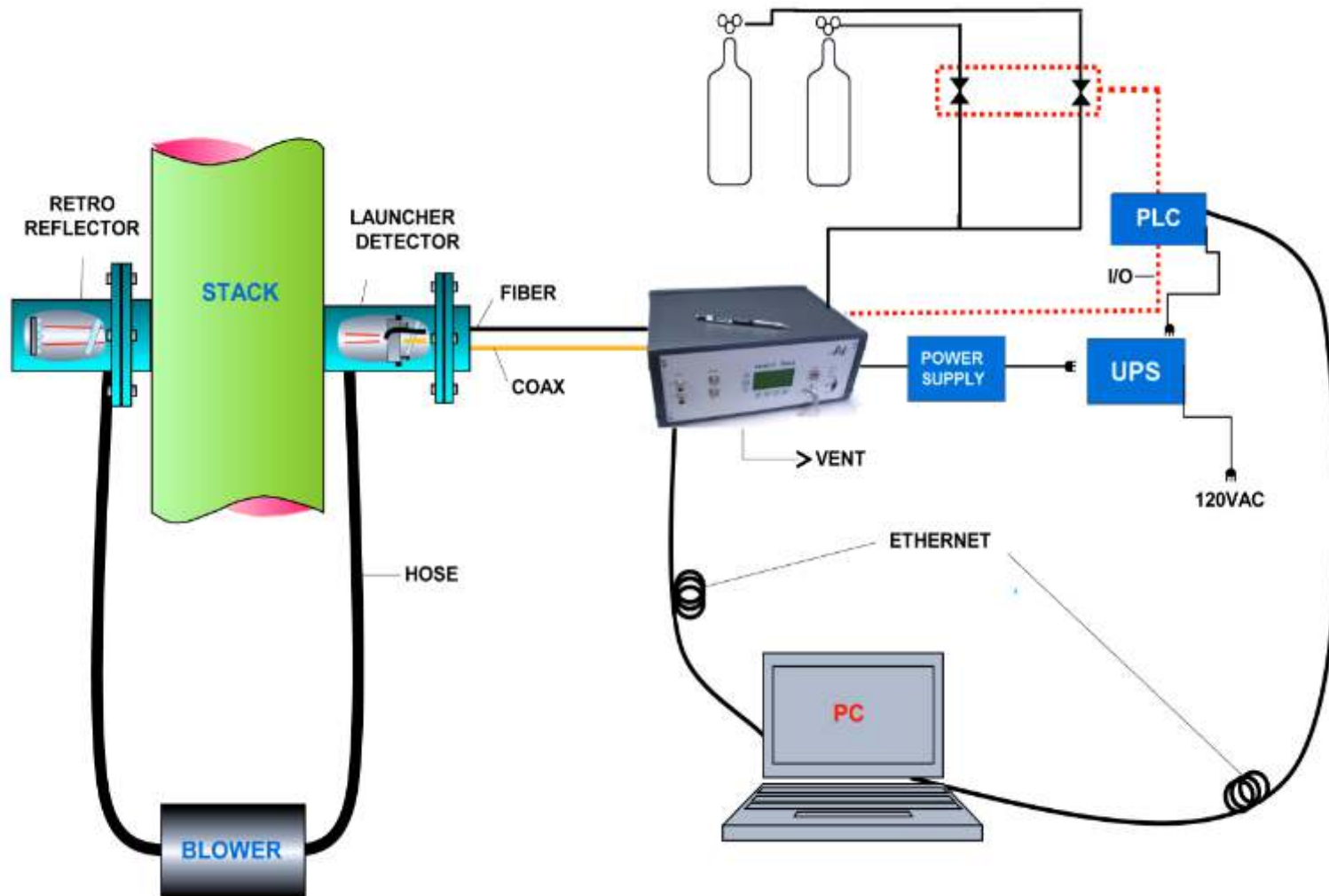


Auto Calibration Box Option





TDL Test Configuration





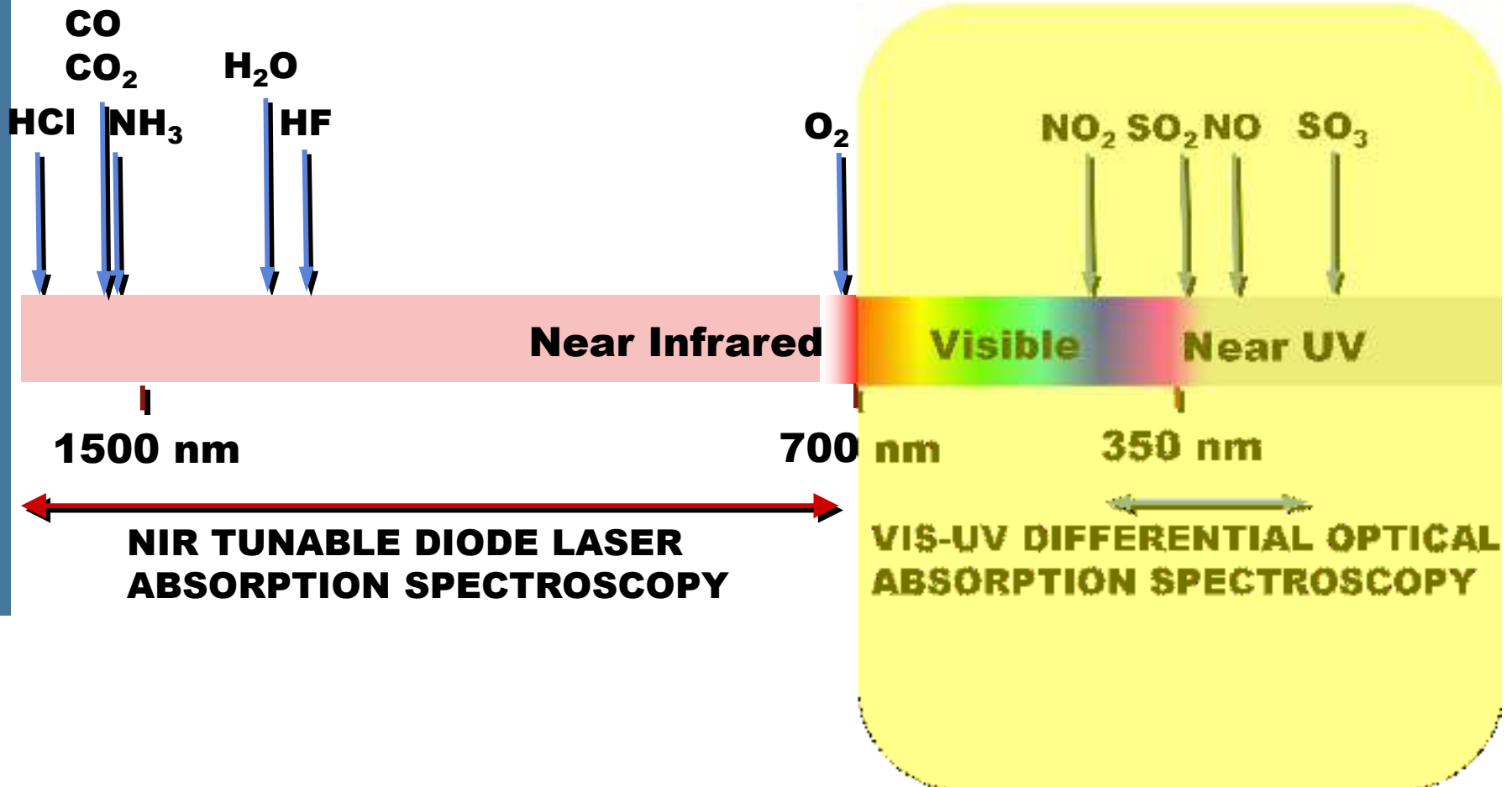
Monitoring NO_x & SO₂ Gas Turbines/Coal Fired Plants using TDL Cross Stack Technology



DOAS
Differential
Optical Absorption
Spectrometer, NO,
NO₂, (NO_x), SO₂,
HCHO, NH₃, C₆H₆,
C₈H₁₀, C₈H₈, O₃,
C₁₀, H₈, CS₂, CL₂



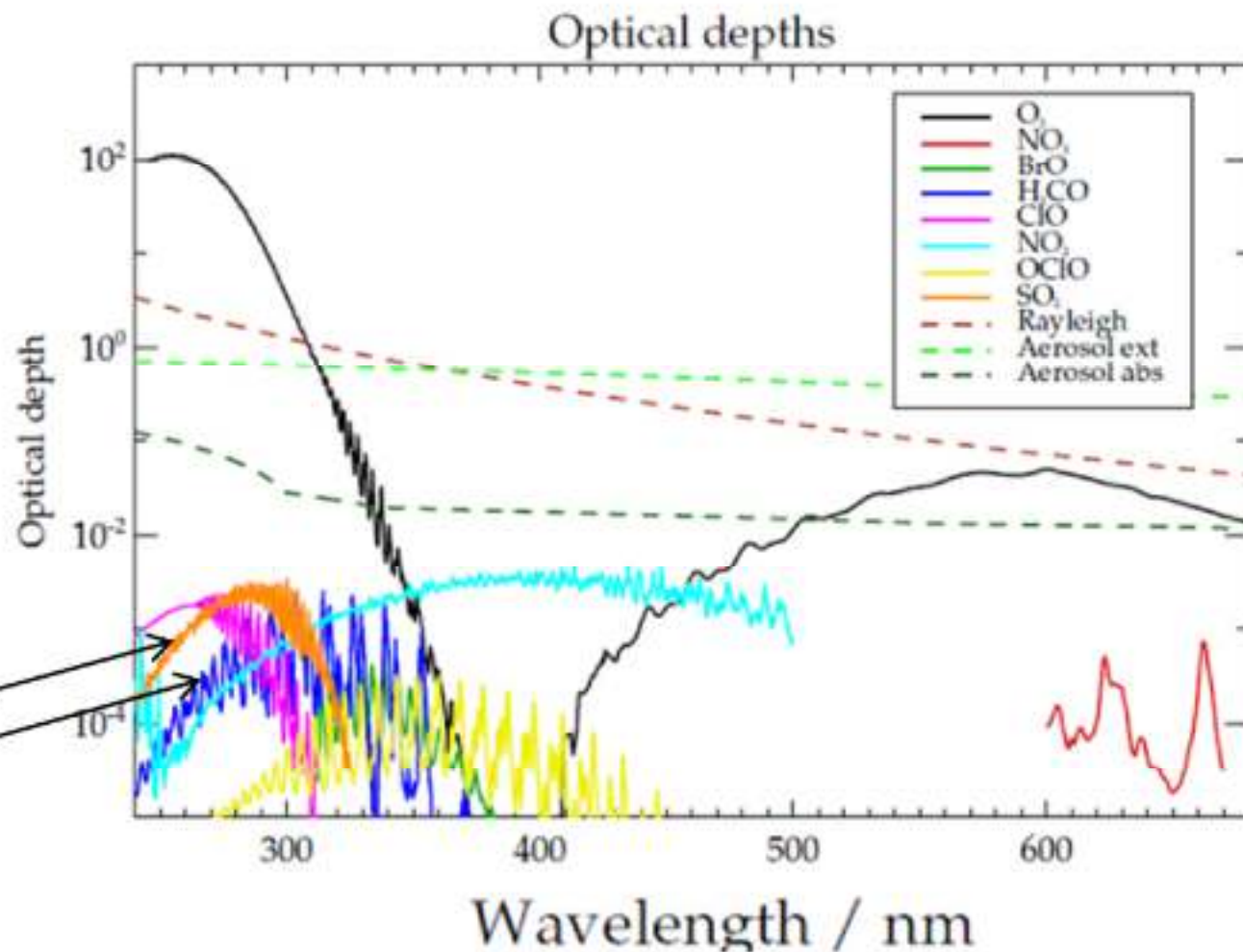
DOAS Measurement Technique





DOAS Spectral Response

Region for enhanced grating response 210 to 230 nm. Far more sensitive to SO_2 than HCHO



Nitric Oxide (NO)
Nitrogen Dioxide (NO₂)
Sulfur Dioxide (SO₂)
Ammonia (NH₃)
Benzene (C₆H₆)
Toluene (C₇H₈)
Xylene (C₈H₁₀)
Styrene (C₈H₈)
Ozone (O₃)
Naphthalene (C₁₀H₈)
Carbon Disulfide (CS₂)
Chlorine (Cl₂)

Near UV-VIS DOAS Gas Analyzer

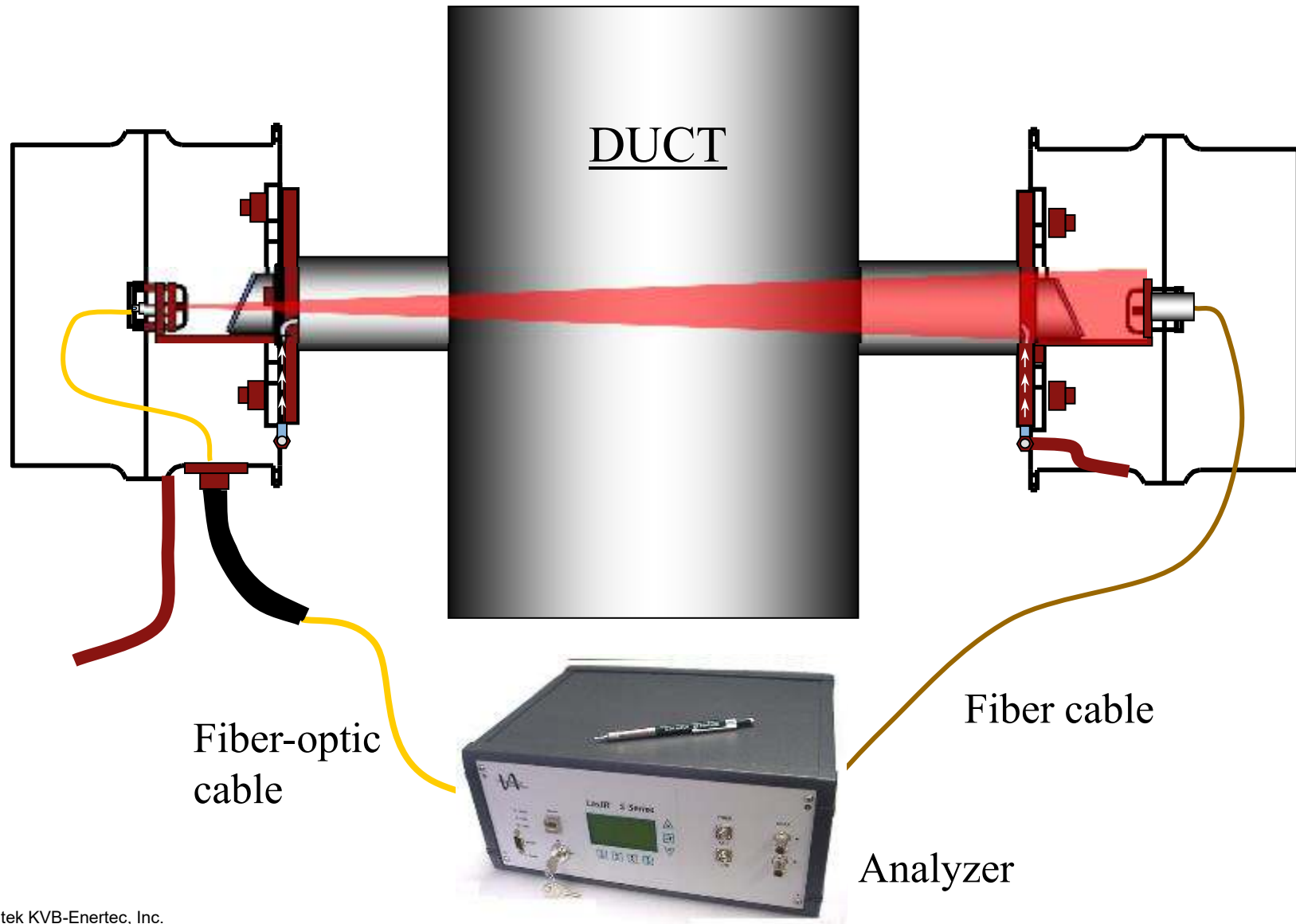
- Uses broadband UV light source instead of a laser light source
- Multiple gases can be measured with a single analyzer
(in general, different from TDL)
- Principle of measurement is similar to TDL

Most have ppb to ppm level of detection, depending on path length





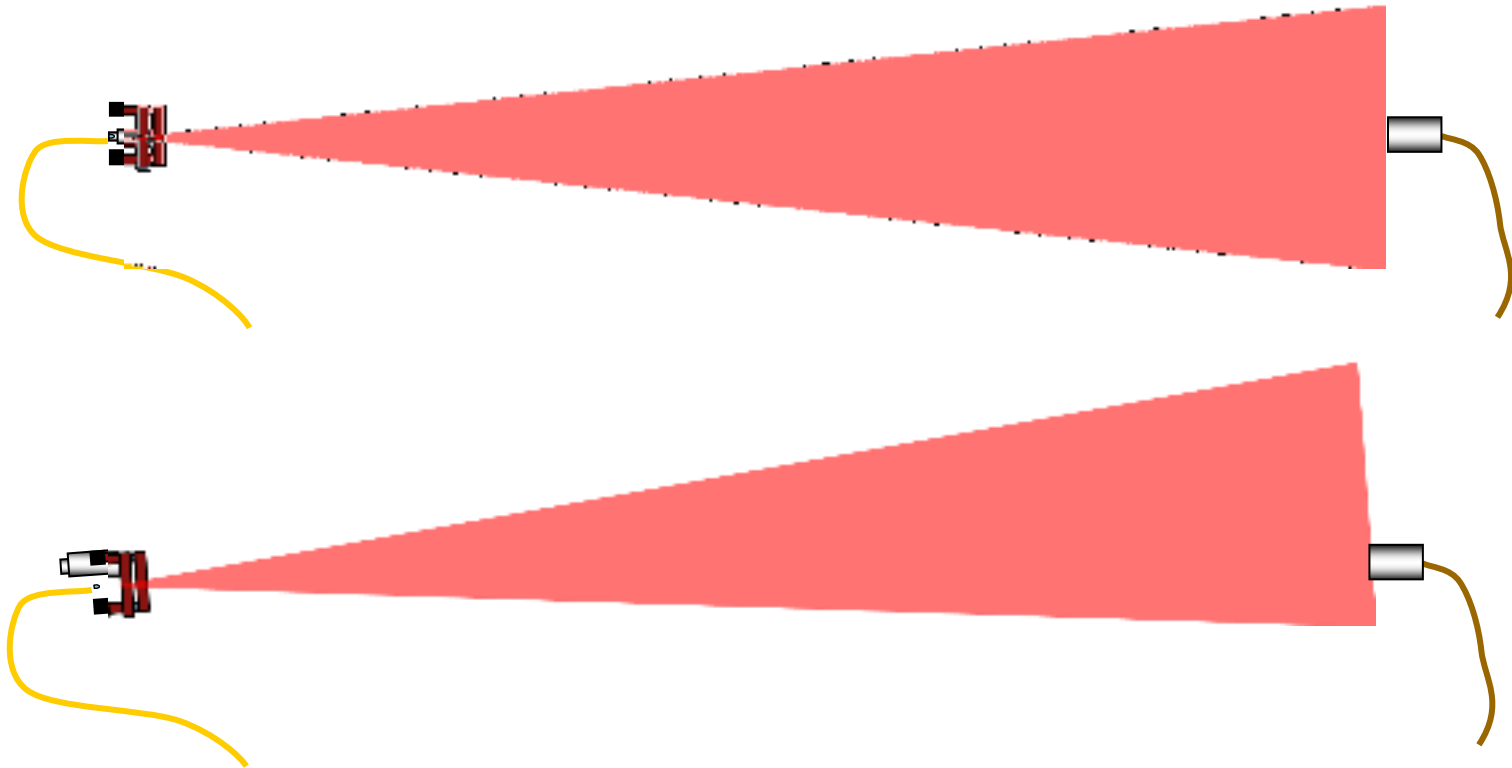
Single Pass Stack Configuration







Alignment Beam



- beam expansion to attain alignment stability
- By de-focusing the beam, overfill of the detector optics allows for alignment changes



DOAS Calibration – Flow Thru

- Calibration Gas Flow Thru Cell
- Daily Calibrations, CGA's, 7 Day Drift Test
- Requires NIST Traceable Protocol Calibration Gas bottles
- Quick Response Time
- Temperature Corrected to Stack Gas Temp





DOAS Optics



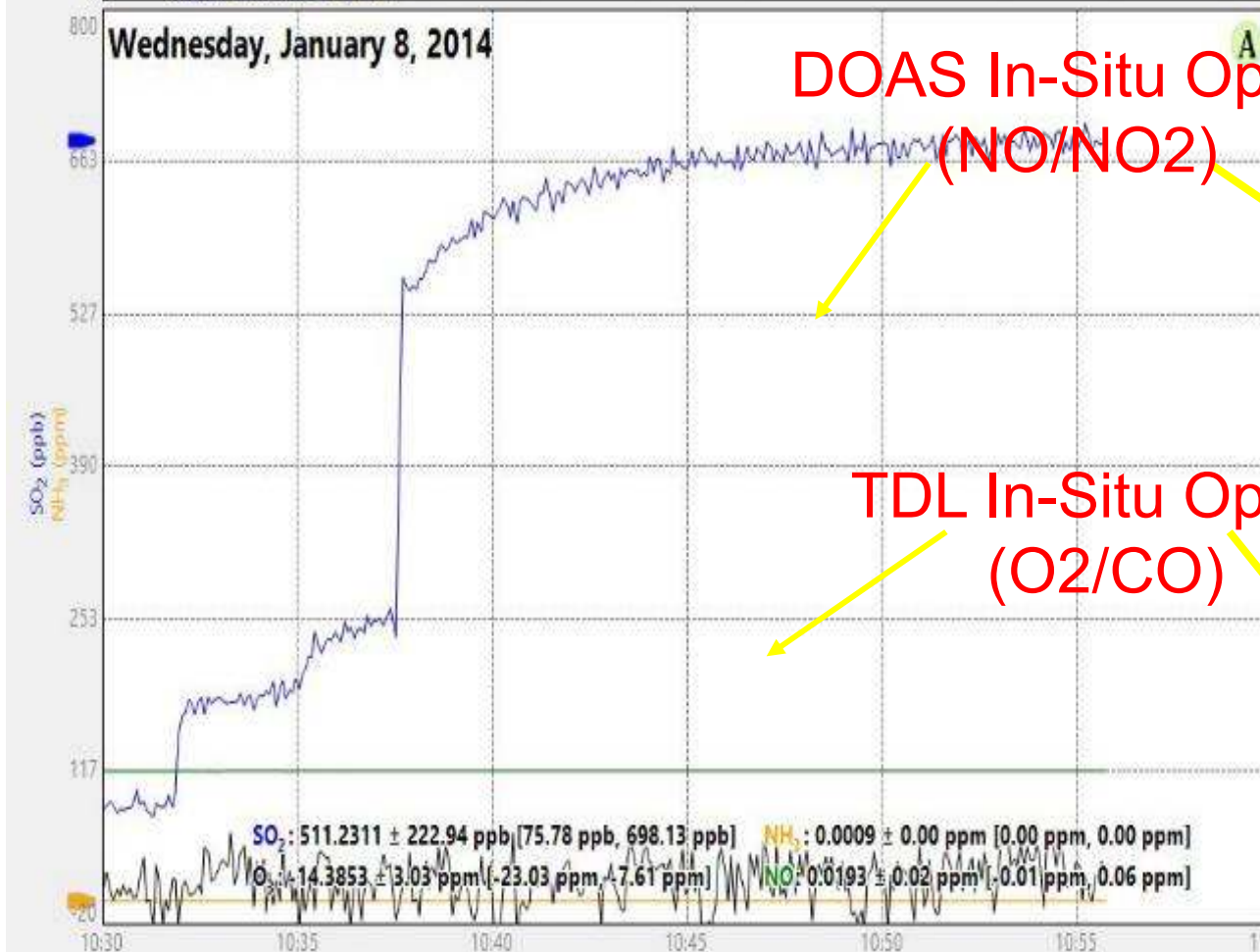
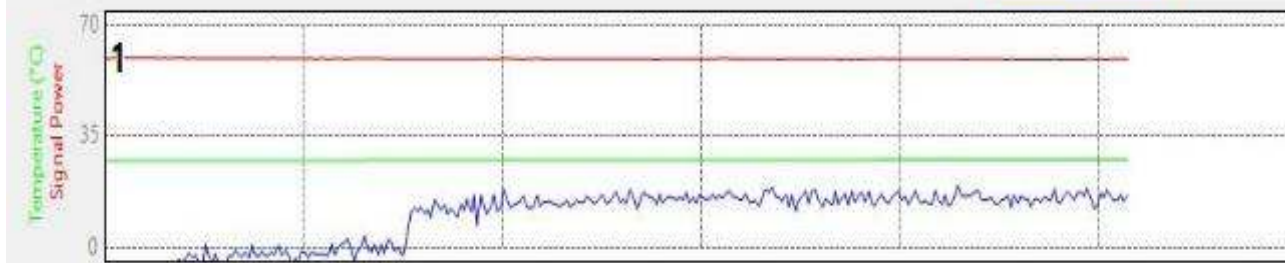


Maintenance

Maintenance

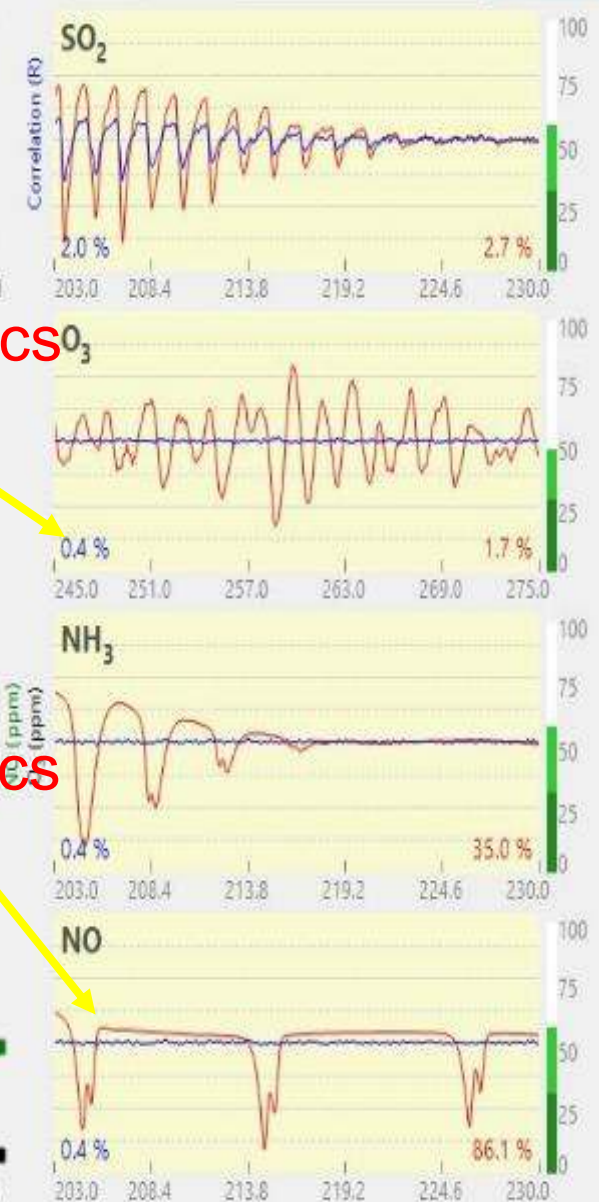


Lens Removal for Cleaning



DOAS In-Situ Optics
(NO/NO₂)

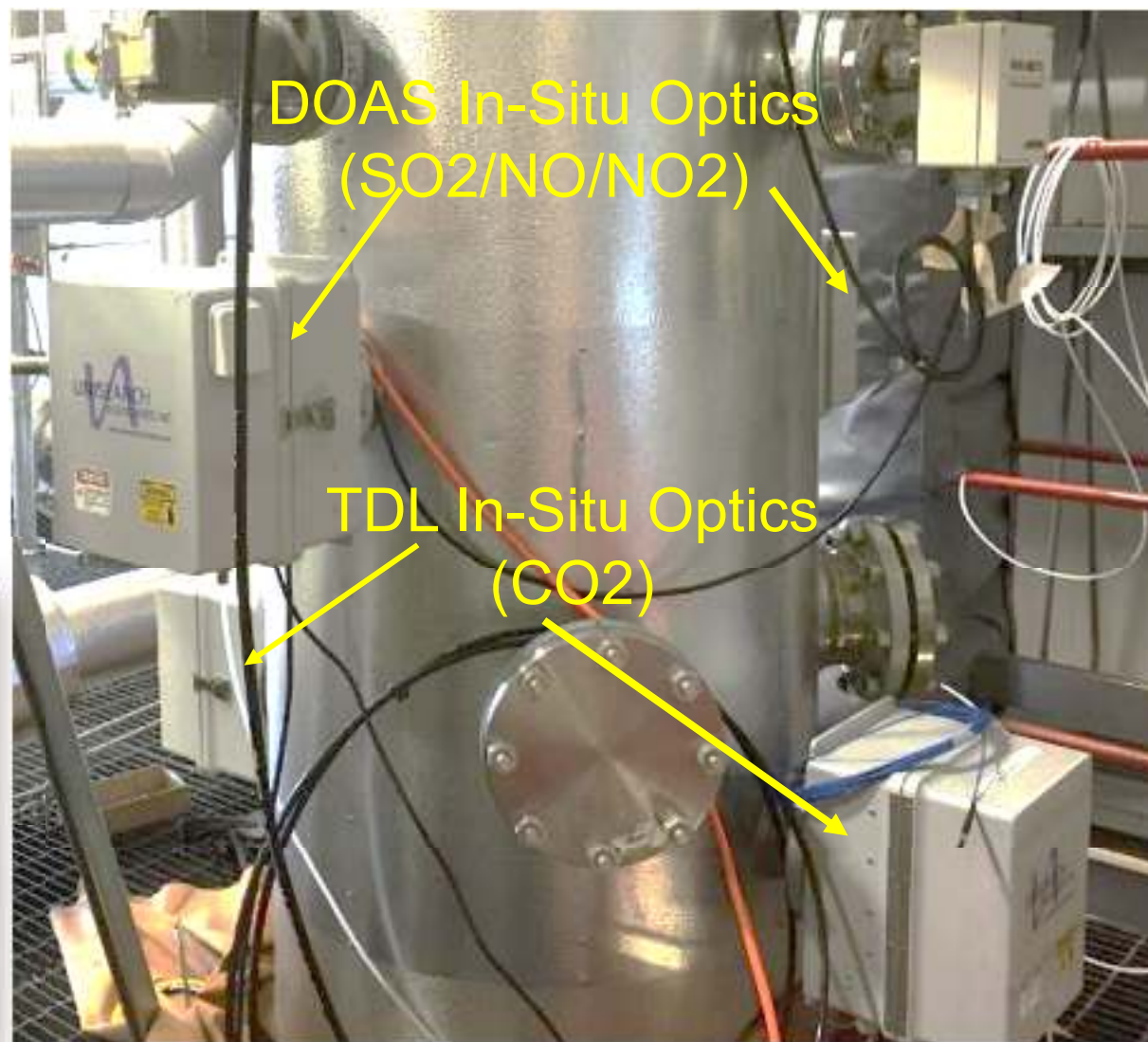
TDL In-Situ Optics
(O₂/CO)



Telescope 1 SO₂ 682.4541 ppb $r^2 = 0.985$ NH₃ 0.0001 ppm $r^2 = 0.056$ 2014-01-08 10:55:42.678
 O₃ -13.7677 ppm $r^2 = -0.393$ NO 0.0357 ppm $r^2 = 0.233$ Next Value O2



TDL/DOAS Installation





DGas Turbine Installation Product Requirements

- Qty TDLs/DOAS Required
 - Stack
 - Qty 1 TDL O2 & CO
 - Qty 1 DOAS NOx
 - Qty 1 TDL NH3/H2O or CO2
 - Inlet
 - Qty 1 TDL O2 & CO
 - Qty 1 DOAS NOx





TDL/DOAS Cost Savings Charts



Major Component Comparison

Component	DE CEMS	Cross StackTDL /DOAS
Sample Probe		Optic Enclosure
NH3 Converter		
Sample Line		Fiber Optic/ Air Cable
Sample Handling System		
Filters		
Chiller		
Peristaltic Pump		
Flow Control Panel		
O2 Analyzer		
CO Analyzer		
NOx Analyzer		
NOx or NH3 Analyzer		
PLC		
DAS		
Shelter		Optional
Cabinet		

DE CEMS





Questions?

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