# MONITORING PILOT SCALE COAL GASIFIER FLAMES WITH UV-VIS SPECTROSCOPIC SENSOR

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Presented by Serguei Zelepouga (GTI)

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# Project Team

> National Energy Technology Laboratory

> Gas Technology Institute

> North Carolina State University

> ConocoPhillips

# Project Goal

> Development of reliable optical, non-intrusive monitoring of gasifier injector performance in order to detect:
  - unfavorable gasification flame conditions which cause injector wear and process inefficiency
  - injector malfunction and deterioration

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# Sensor Development Stages

- Sensor development and testing with natural gas flames (GTI , Des Plaines, IL) (completed)
- Testing on a vertical atmospheric pressure coal combustor (CETC, Ottawa, Canada) (completed)
- Testing on entrained flow coal gasifier (CETC, Ottawa, Canada) (completed)
- Testing at Wabash River Coal Gasification Plant (Terre Haute, IN)

  (planned for next year)

## Demonstrated Capabilities

- UV/VIS/NIR spectroscopy is a feasible method to monitor:
  - temperature
  - oxidizer to fuel ratio
  - moisture to fuel ratio
- Potentially, this information can lead to:
  - Assessment of gasifier performance
  - Detect/Predict injector wear
  - Allow better gasifier controllability

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# Technical Approach

- Design and testing of an optical sensor to monitor spectral characteristics of gasifier flame
- Correlation of flame spectral characteristics with gasification process conditions
- Interpretation of flame spectra to obtain information relevant to the gasifier injector performance (temperature, oxidizer to fuel ratio, etc)

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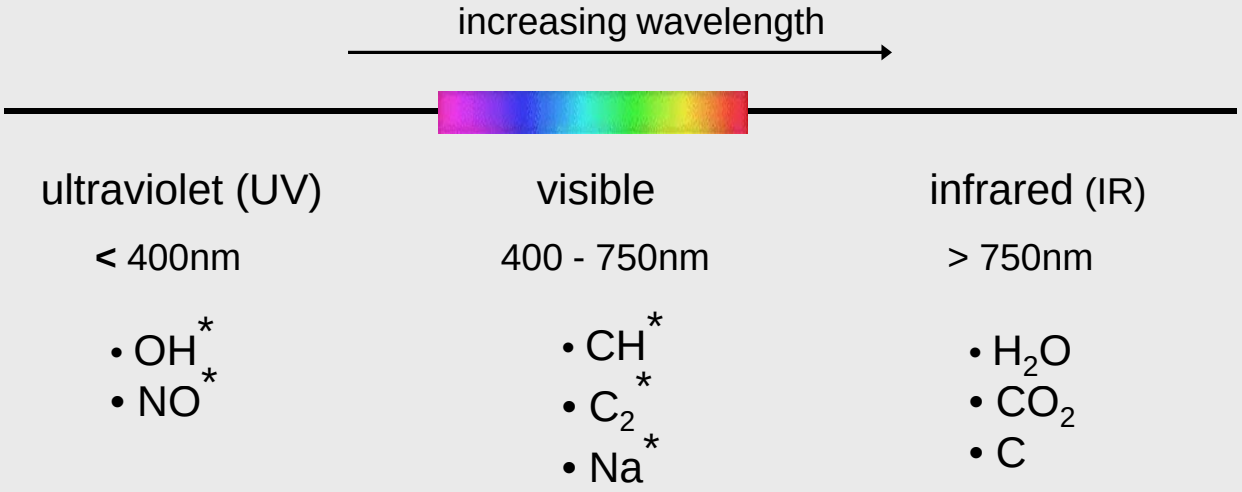
# Flame Light Emissions




- Intermediate radicals—$OH^*$, $CH^*$, $C_2^*$, $NO^*$, $Na^*$—present in flames emit light due to chemical and thermal excitation
- Water and carbon dioxide emit mostly in mid infrared region
- Soot and carbon particulates emit continuous “black body” spectrum

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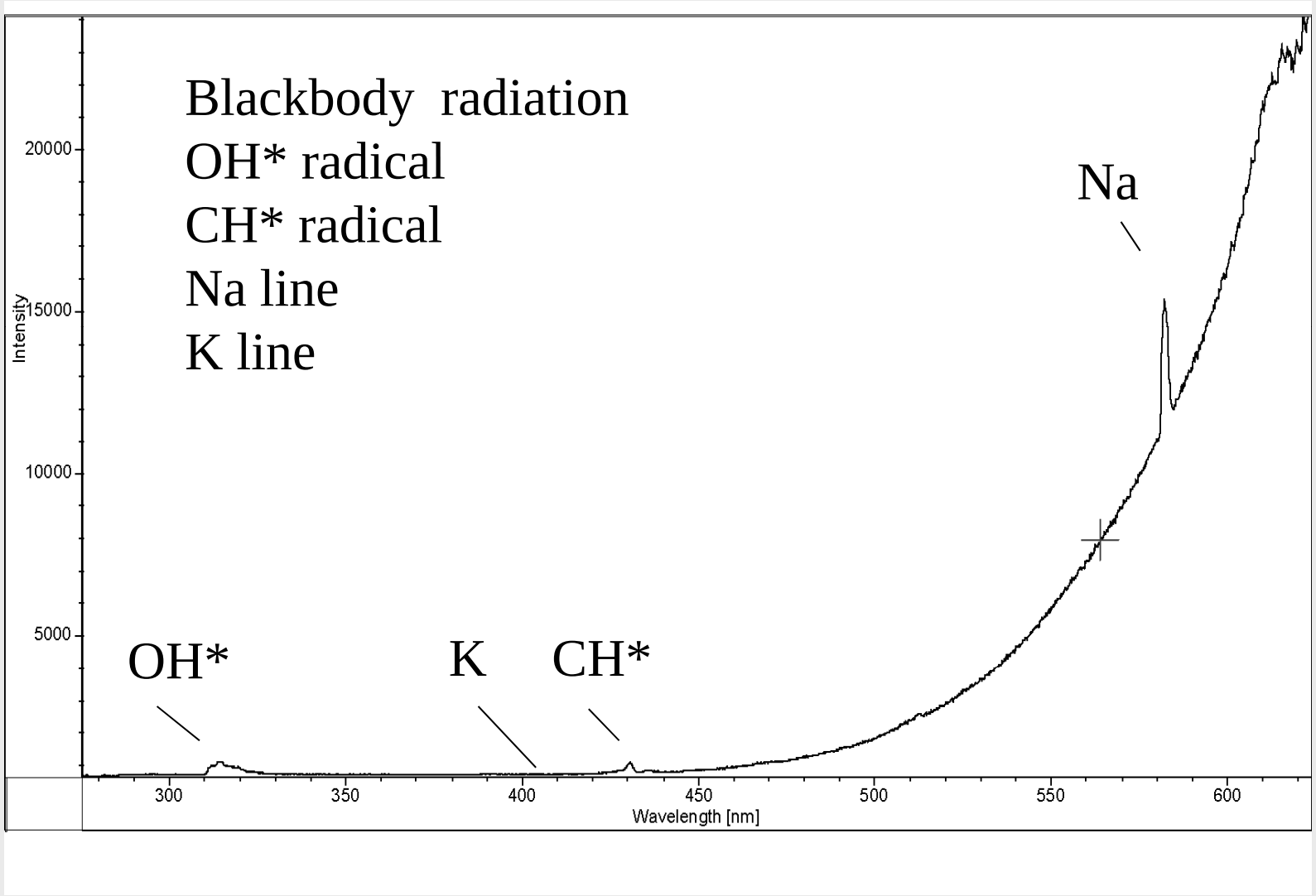
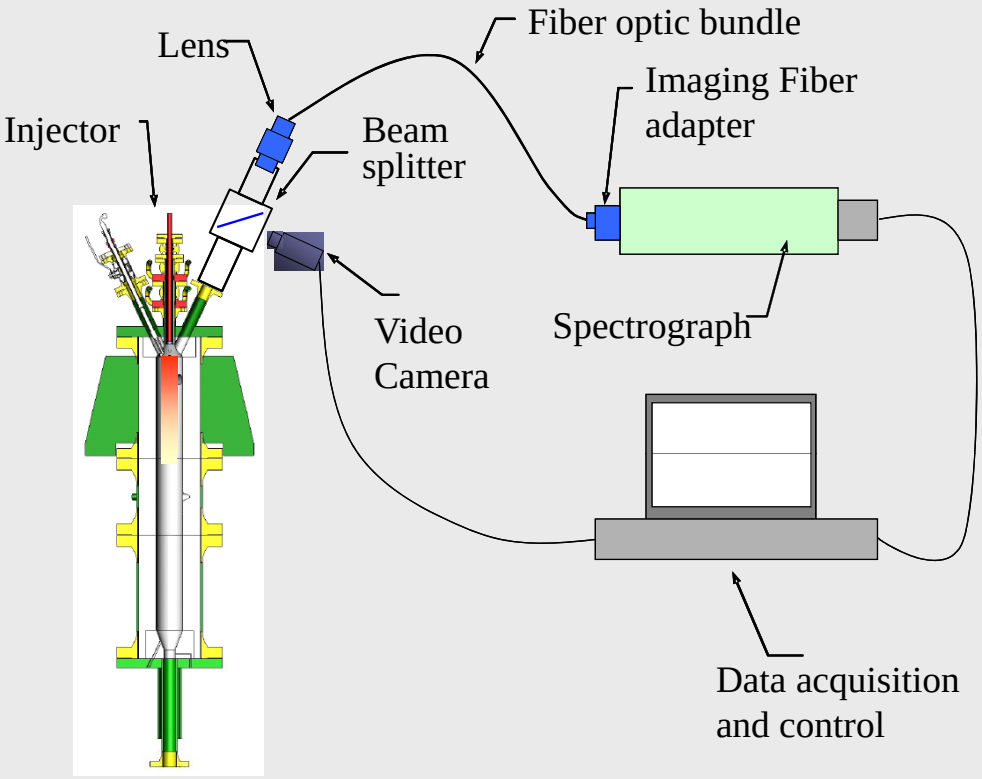
# Key Diagnostic Features



# Experimental Setup at CANMET Gasifier




- Pressurized, entrained flow, down-fired, dry coal-oxygen
- Coal flow: 10-14 kg/hour
- Pressure: 750 kPa

# Test Parameters Selection

- Injector damage leading to improper fuel and oxidant mixing
  - simulated by changing the oxygen to fuel ratio (oxygen/coal ~ 0.8-0.95)
- Injector damage leading to wrong amount of $H_2O$ fed into the gasifier
  - simulated by changing the amount of steam injected into the gasifier (steam/coal ~ 0.2- 0.3)
- Flame temperature deviation from optimum
  - flame temperature was varied by changing the oxygen to fuel ratio

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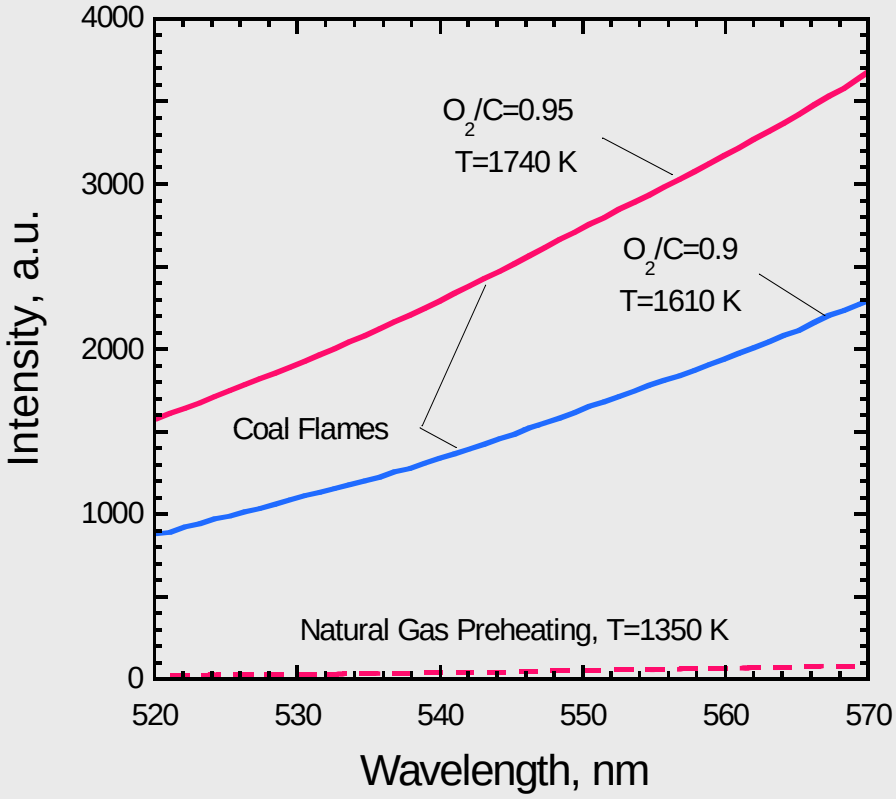
# Flame Temperature

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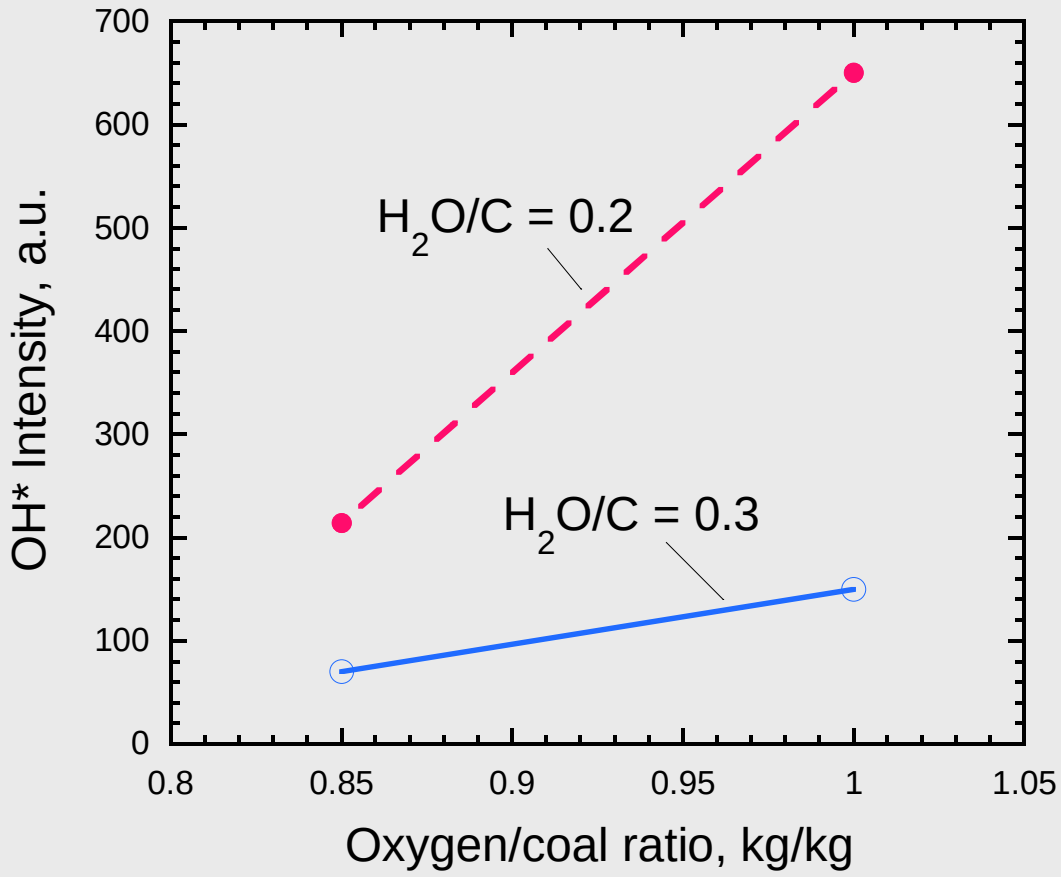
> Flame temperature is measured by fitting the obtained spectra to blackbody distributions given by Planck's equation

# Coal to Oxygen ratio

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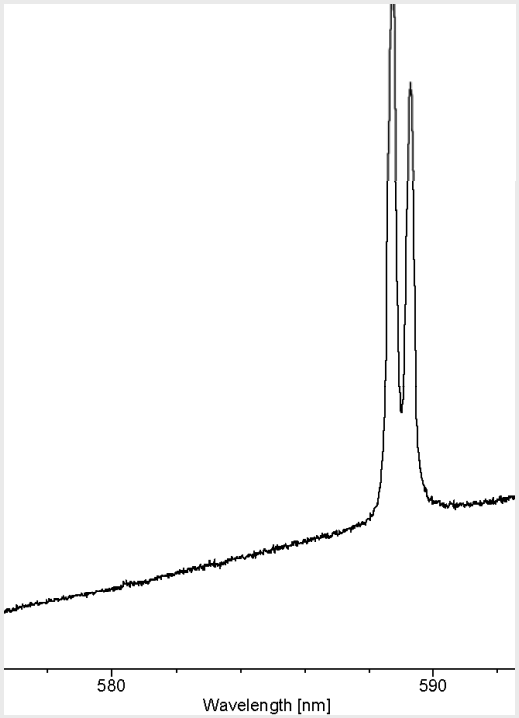
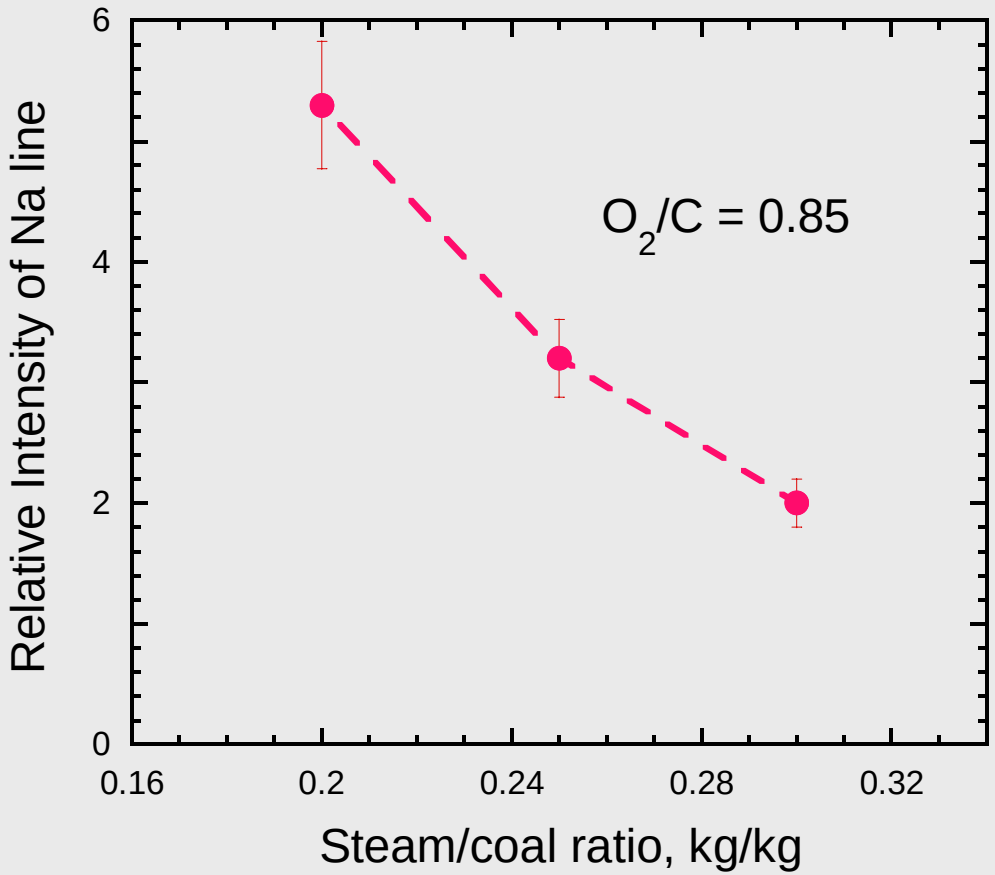
> The intensity of OH* emission is a sensitive indicator of oxygen/coal and steam/coal ratios

# Moisture Content Assessment




> The relative intensity of Na line exhibits strong dependence on steam to coal ratio

# Testing of the sensor at industrial gasifier

- Reliable optical access port is key to successful monitoring
- Main technical problem is to maintain the sight path free of obstruction
- Design issues:
  - solid and liquid particles entrained in the swirling gases inside the gasifier
  - molten slag running down the gasifier walls
  - high temperature, chemically aggressive environment

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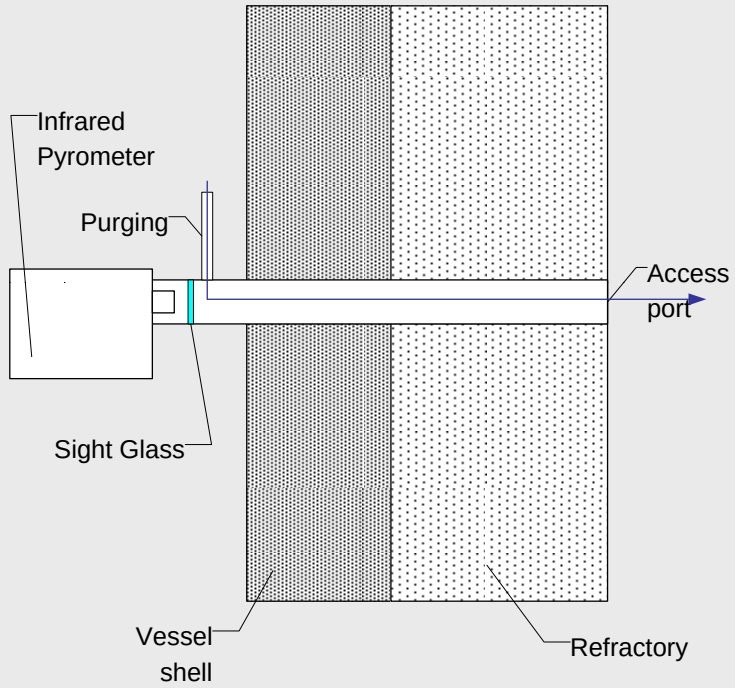
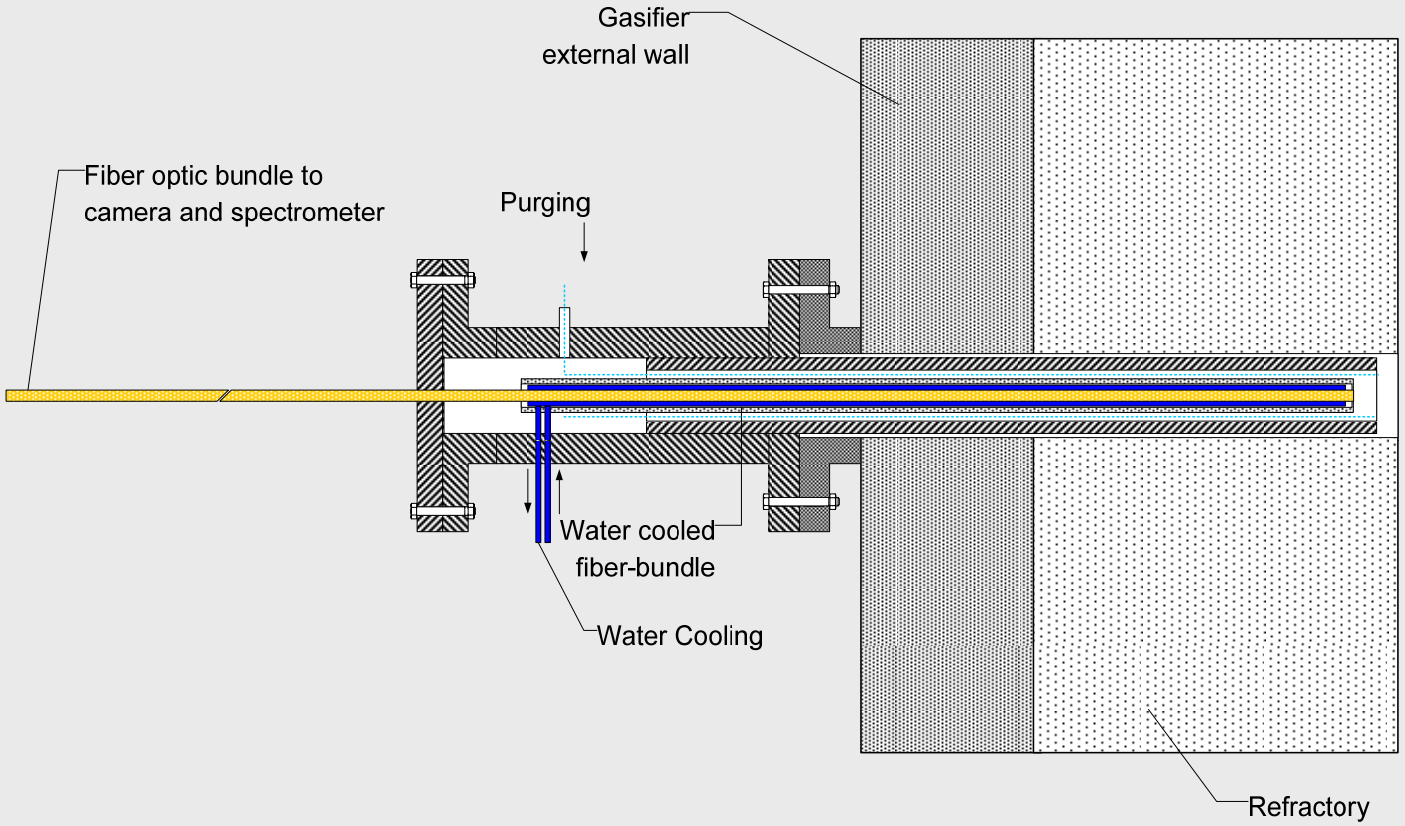
# Conventional Optical Access

- Window based design
- Optical sensor with focusing lenses is positioned outside of the gasifier
- High intensity purging with pulsed purging for slag removal
- Provides line-of-sight measurements
- Incorporates high pressure enclosure or safety chamber



# Alternative Optical Access Approach




- Fiber optic design of sensor allows positioning of miniature sensor head in close proximity of internal gasifier wall
- Wide field of view (up to 110˚) allows optical access to larger area of flame

# Optical Access

- Advantages
  - multiple sensing points
  - lower flow rate of purging gases
  - stable operation in dusty and slagging environments (higher purging gas velocity, purging gas temperature flexibility)
- Implementation plan
  - probe design and prototype fabrication
  - lab testing
  - design modification based on the test results
  - fabrication of high temperature, high pressure probe
  - field testing

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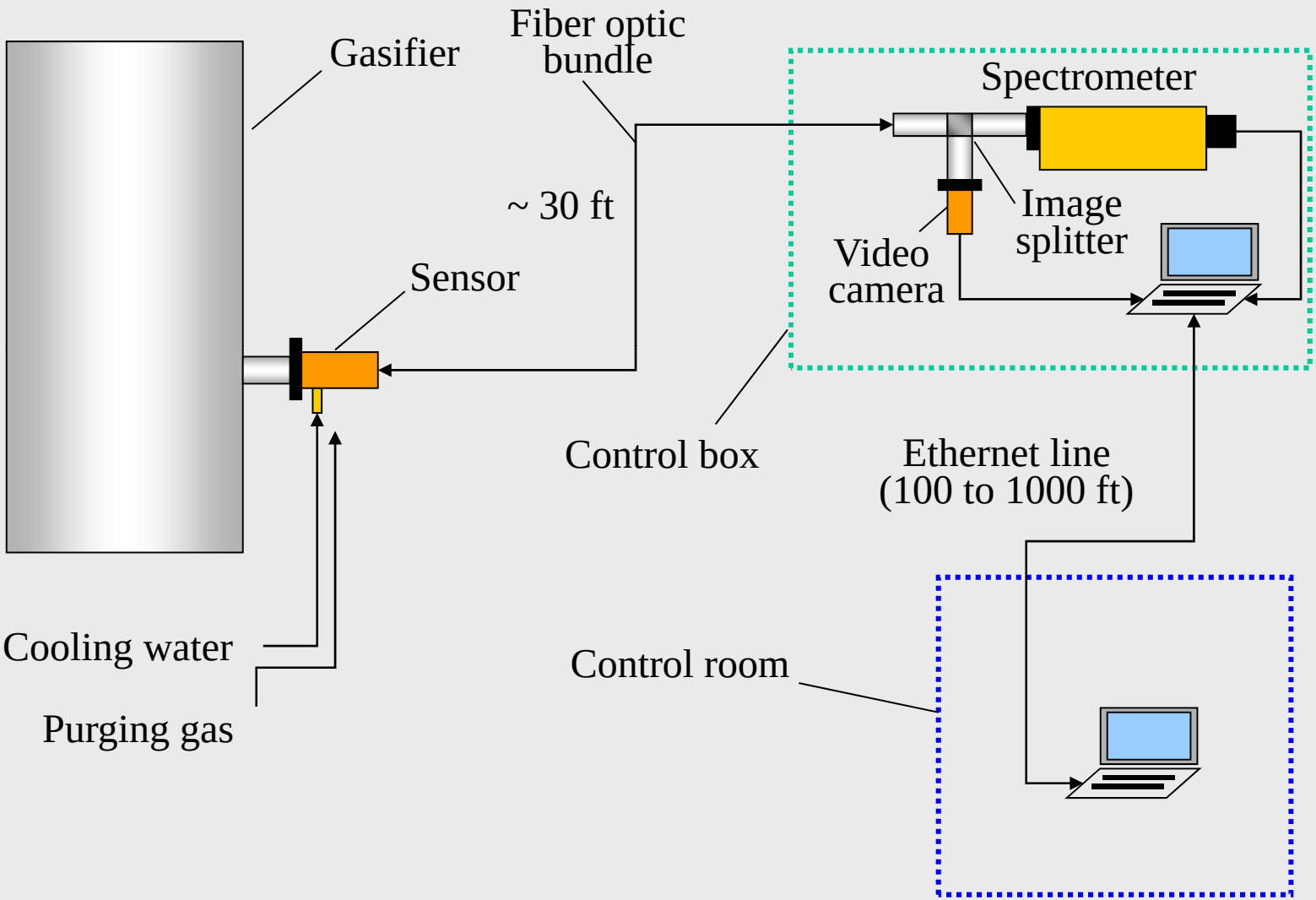
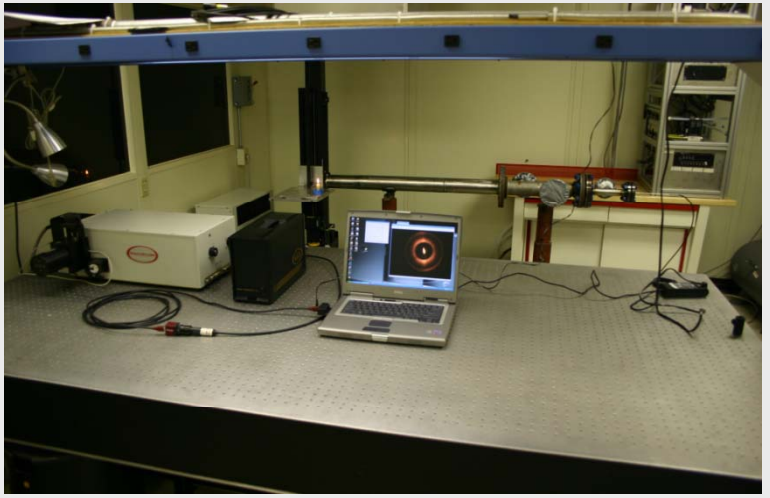
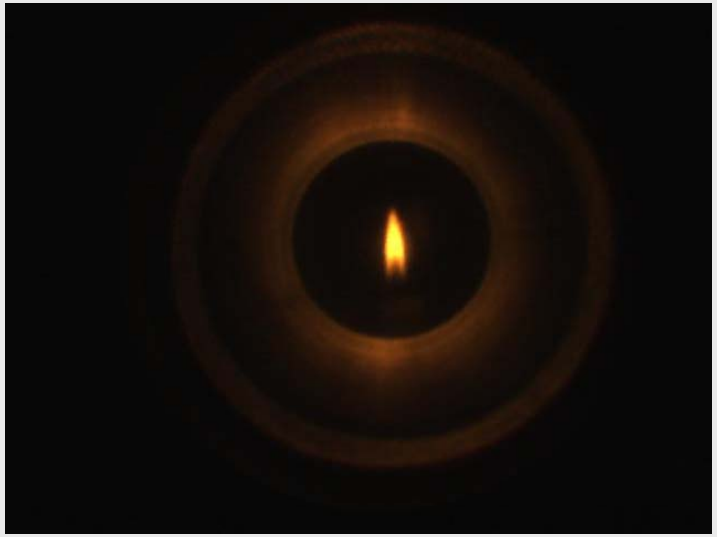
# Sensor Installation Schematic



# Status

- GTI jointly with North Carolina State, ConocoPhillips and the NETL have completed the sensor preparation for testing in harsh operating environment of working gasifiers.
- A water-cooled fiber-optic probe designed to interface the sensor hardware with the gasifier interior was built and tested at GTI lab.
- The sensor is ready for installation.





# Next Steps

- Sensor testing at the Wabash River Gasification Plant is expected to be performed next year.

# Acknowledgements

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