Near-MHz LAS Measurements of Temperature and Species Concentration in Post-Detonation Fireballs

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Measurements of Temperature, Pressure, and CO in RP-80 Fireballs

Goals

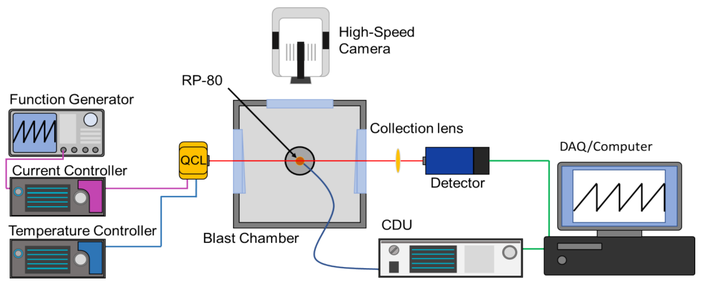
- Measure temperature, pressure, and CO in post-detonation fireballs of RP-80 detonators
- Compare these measurements to synthetic measurements produced using reactive CFD for validation

Challenges

- Need for μs time resolution due to highly transient fireball
- Non-uniform line-of-sight (LOS)

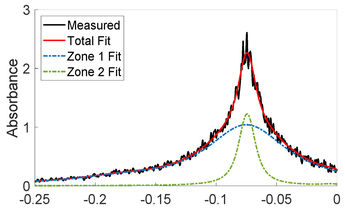
Experimental Setup

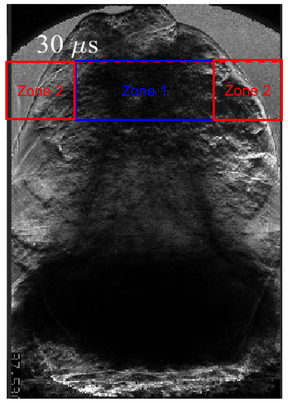
- The setup consisted of a quantum-cascade laser (QCL) emitting near 2008.5 cm^{-1} being directed into a blast chamber containing an RP-80 detonator. The transmitted light through the chamber was then focused with a collimating lens on to a detector and the resulting signal was routed to a high-speed data acquisition system



Dual-Zone Model

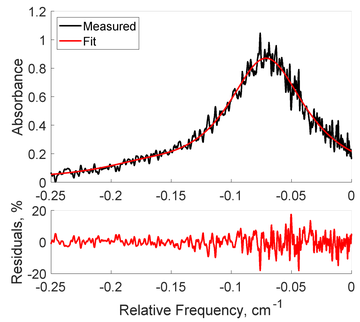
- To address moments when the LOS was extremely non-uniform, a model was developed that consisted of two homogeneous zones





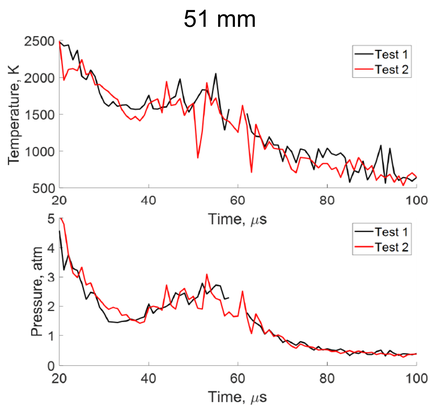
Measured Spectra

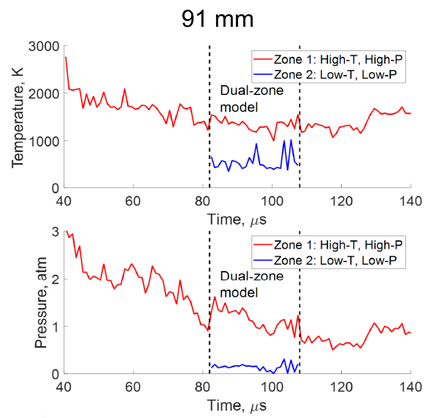
- Beer's law was used to calculate the absorbance spectra for each scan
- A least-squares fitting routine was then employed to infer the values of temperature, pressure, and CO partial pressure from this spectra



Results

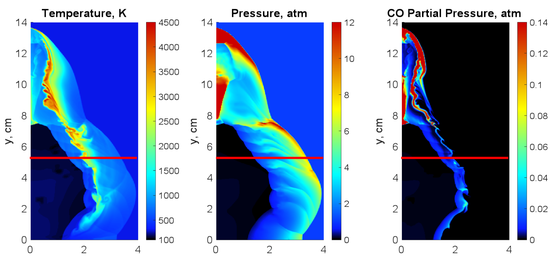
- Measurements of temperature, pressure, and CO column pressure were taken at a height of 51 mm and 91 mm from the surface of the RP-80
- At a height of 91 mm from the output pellet of the RP-80, measurements at certain times were fit using the dual zone model described above to decrease the sum-squared error of the fitting routine



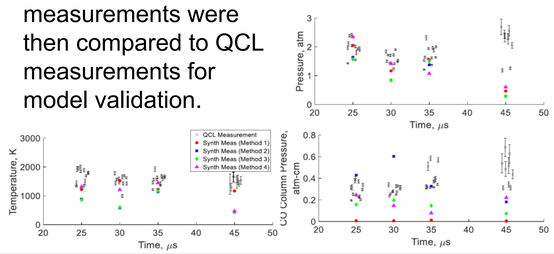


Model Validation

- Synthetic measurements of temperature, pressure, and $P_{CO}L$ were calculated from synthetic absorbance spectra produced using CFD results



- These synthetic measurements were then compared to QCL measurements for model validation.



Measurements of Temperature and H_2O in Post-Detonation Fireballs of 25 g Hemispherical Explosives

Goals

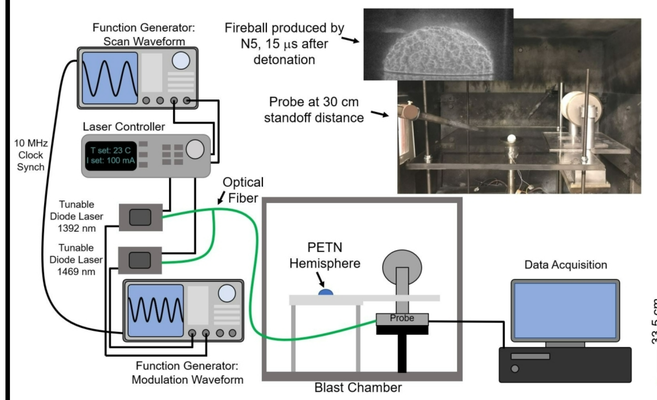
- Measure temperature and H_2O at 500 kHz in post-detonation fireballs of large-scale explosives

Challenges

- Need for near-μs time resolution due to highly transient fireball
- The larger scale and harsh environment created by these explosives necessitates the use of a hardened optical probe in order to protect the optical equipment used in this experiment

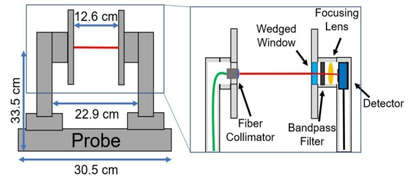
Experimental Setup

- Two tunable-diode lasers (TDL) emitting near 1392 and 1469 nm were fiber coupled into the optical probe which was placed in a blast chamber. The optical probe pitched this laser light across the measurement line-of-sight and focused it onto a detector. The resulting detector signal was then routed out of the blast chamber to a high-speed data acquisition system



Left: Schematic of setup used to measure T, and H_2O in large-scale post-detonation fireballs

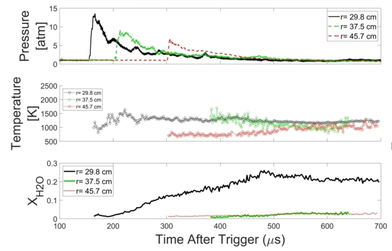
Below: The optical probe used to pitch laser light across fireball and collect it on a detector



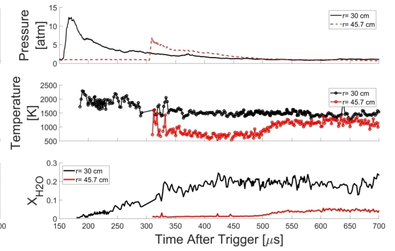
Results

- Measurements of temperature and X_{H2O} were taken at multiple standoff distances for both PETN and N5 explosives

PETN Results



N5 Results



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