

Spectral Measurements of HCl and AlO from the burning of Aluminized Ammonium Perchlorate Solid Propellant

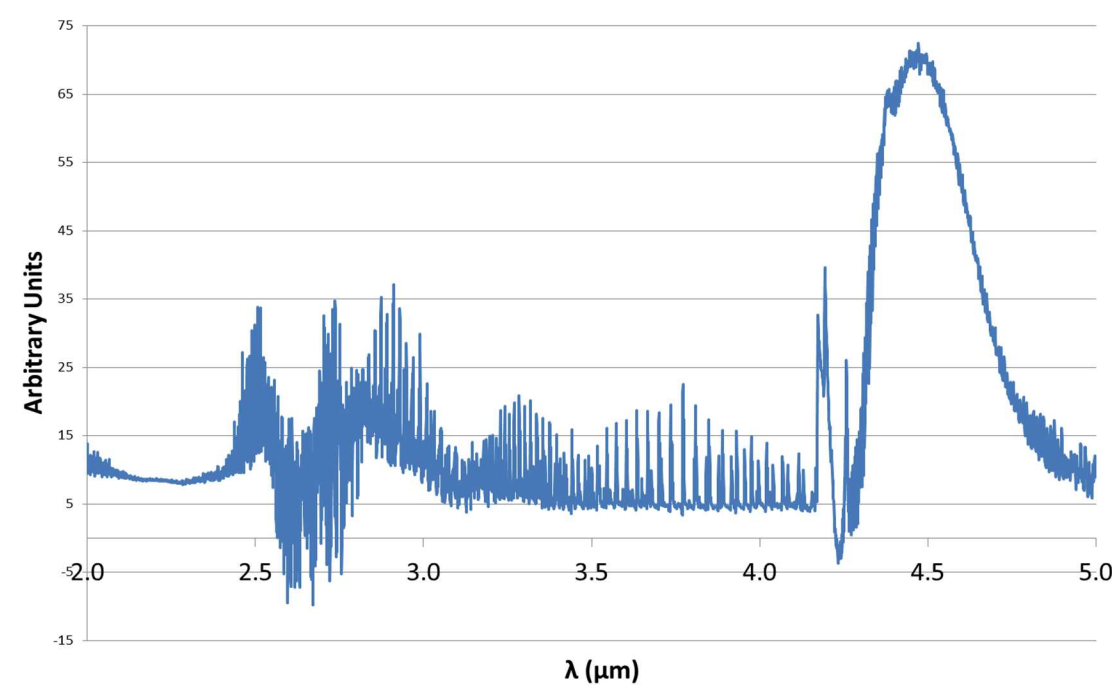
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Abstract

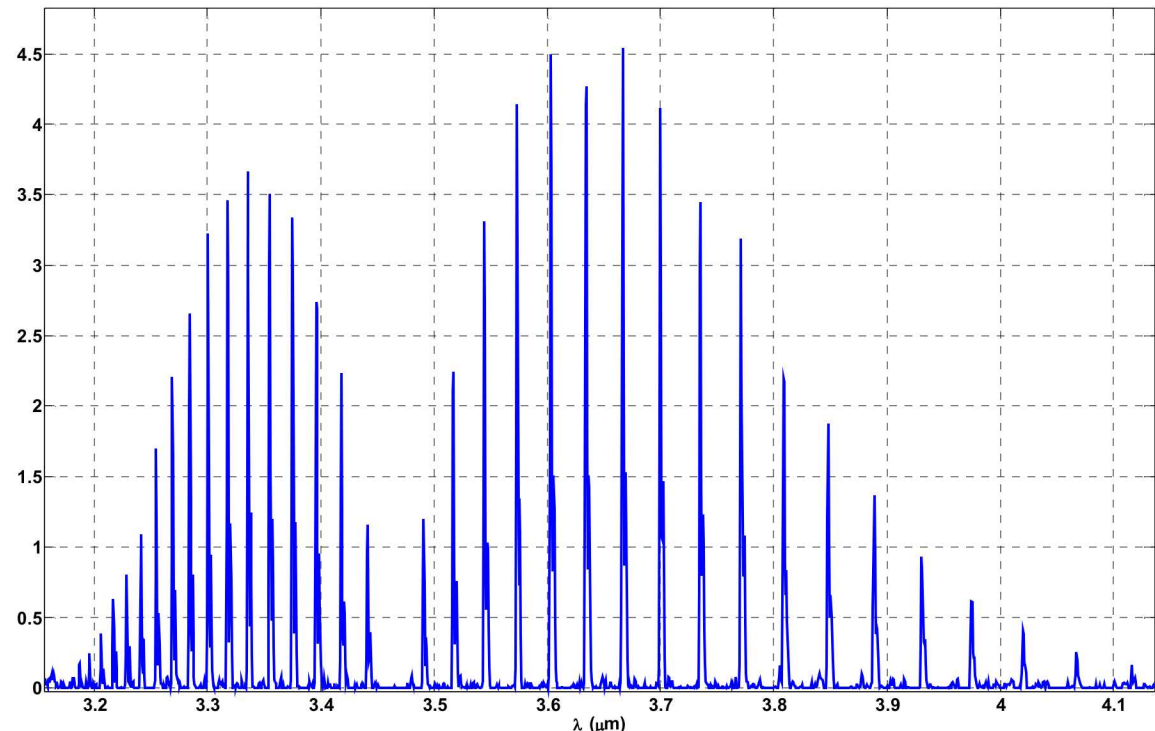
Spectral measurement of HCl gas and AlO particles emissions were performed in the plume burning of aluminized solid rocket propellant samples at atmospheric pressure. The aluminized ammonium perchlorate propellant plume contained burning liquid aluminum droplets due to the off design burning behavior at low pressure. This produced a non-thermal equilibrium plume containing high temperature burning droplets suspend in a lower temperature combusting gas envelope. The obtained spectra were used to estimate the temperature of the combustion gases and the temperature from the burning aluminum droplets. These experiments with burning propellant were intended to understand the hazards of an anomalous burn of the propellant during an accident or launch abort scenario.

HCl Temperature Measurements

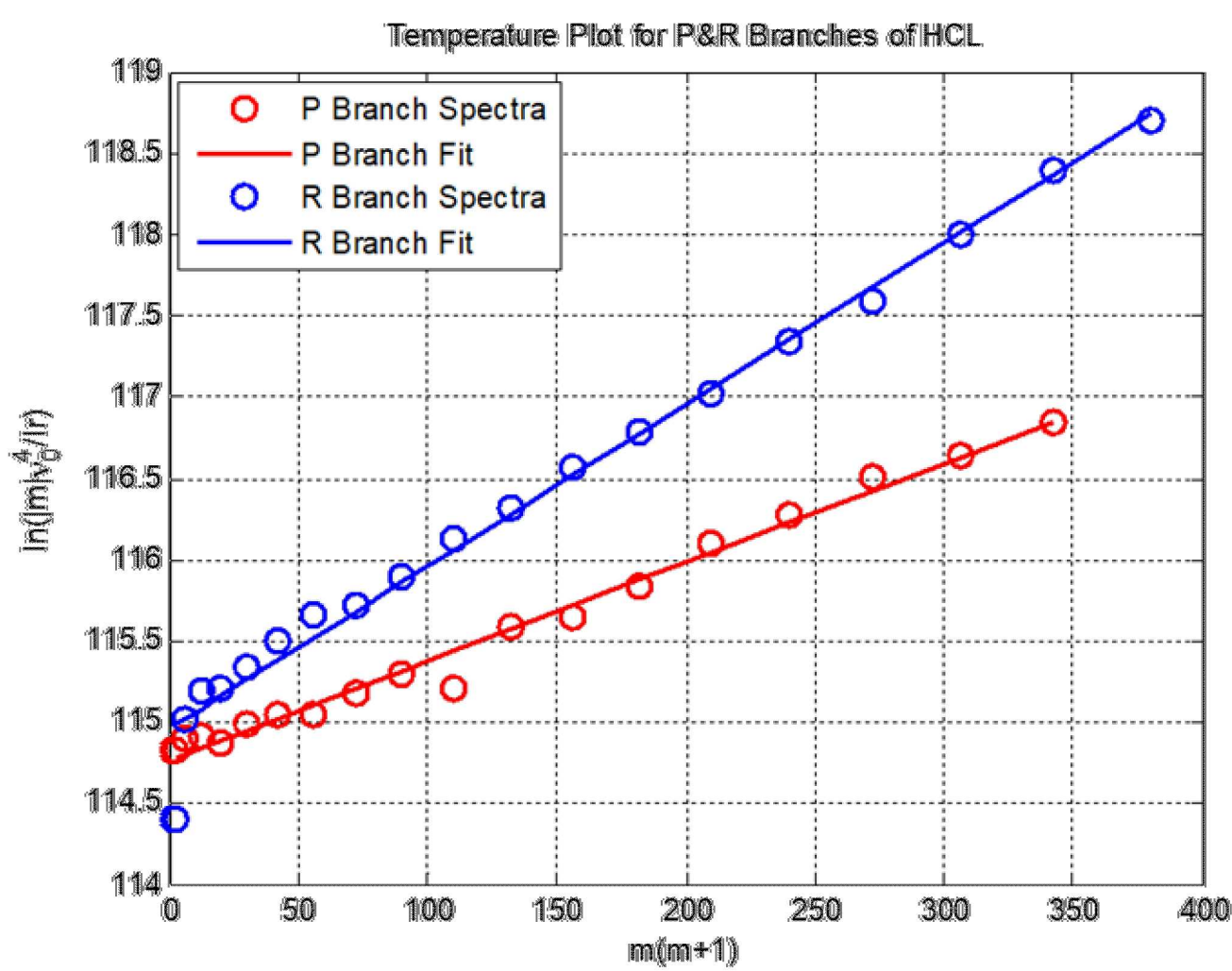
Collected Uncorrected Spectrum



Corrected HCl Spectrum

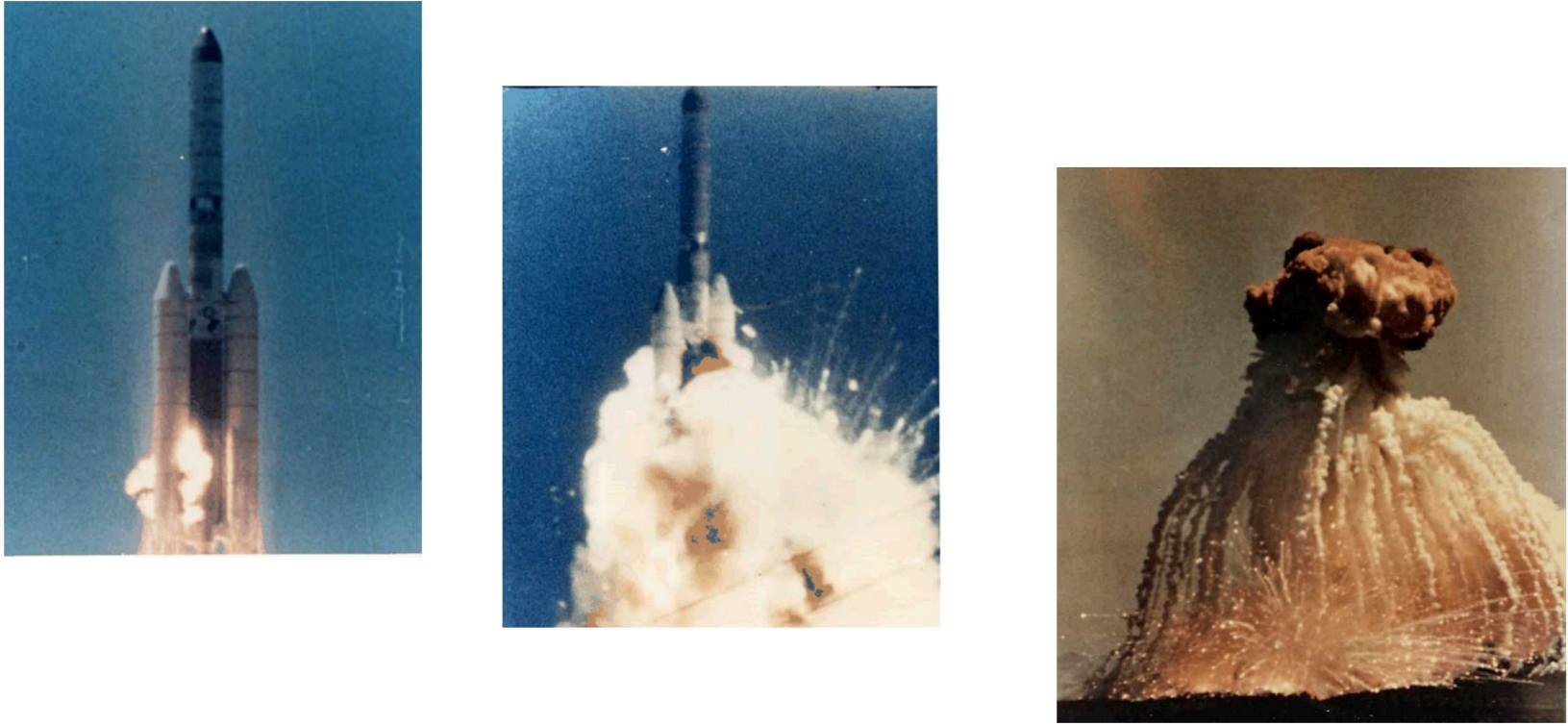


Fit For Linearized P & R Branches



Motivation

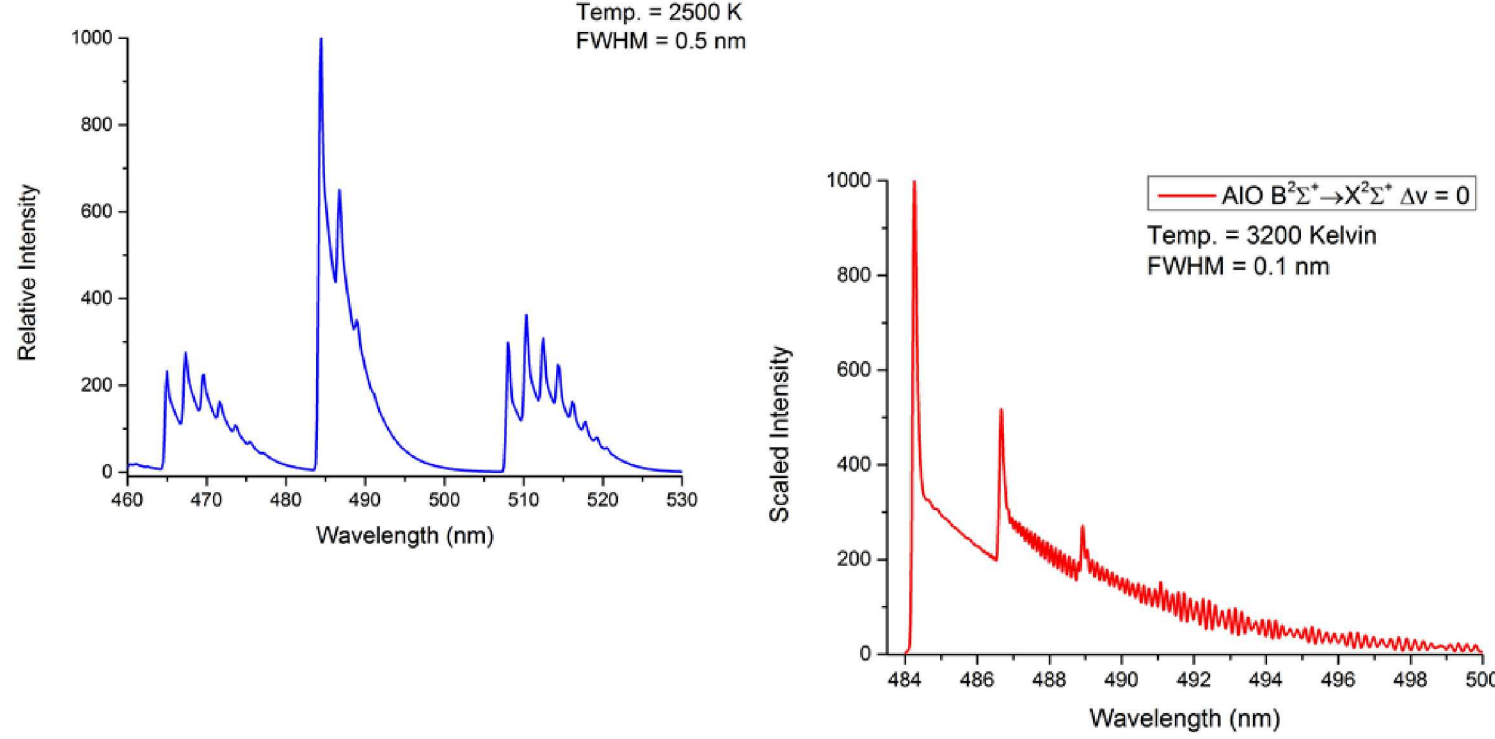
Our objective is to define the **thermal-chemical-physical** environment **in and around a plume** formed from a burning **fragment of solid rocket fuel** at atmospheric pressure in a launch accident.



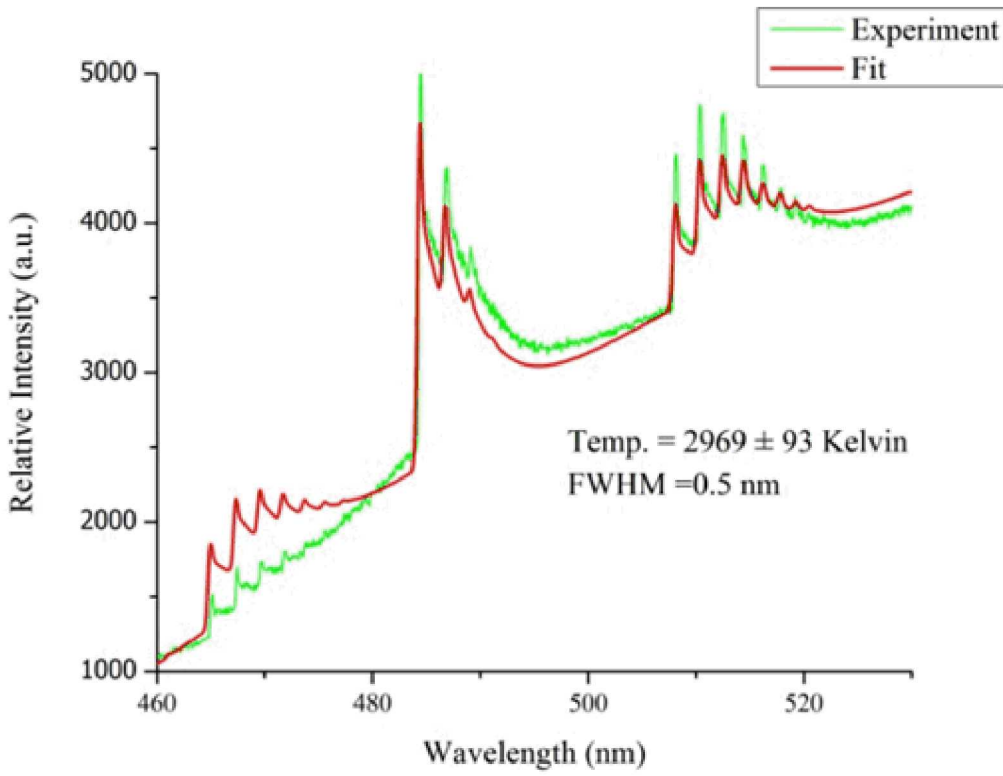
The **environment specification** will be used to **quantify the risk associated** with a **launch pad abort** involving solid fueled rocket motor debris and **high hazard payloads**.

AlO Temperature Measurements

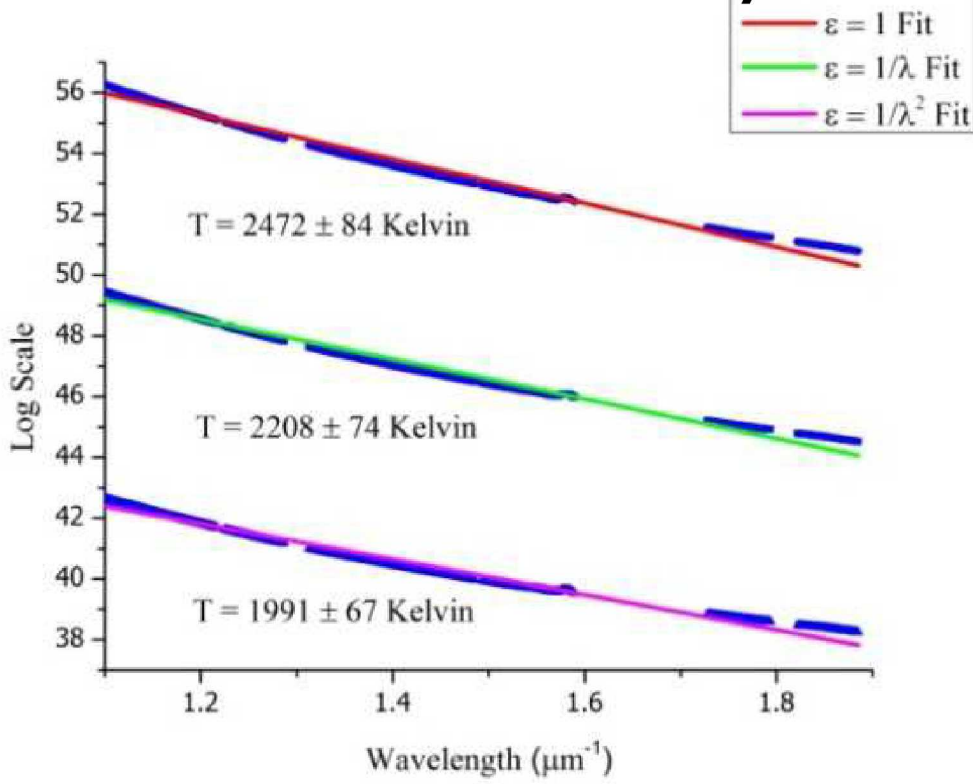
Theoretical Calculation of the AlO B²Σ⁺ → X²Σ⁺ Transition



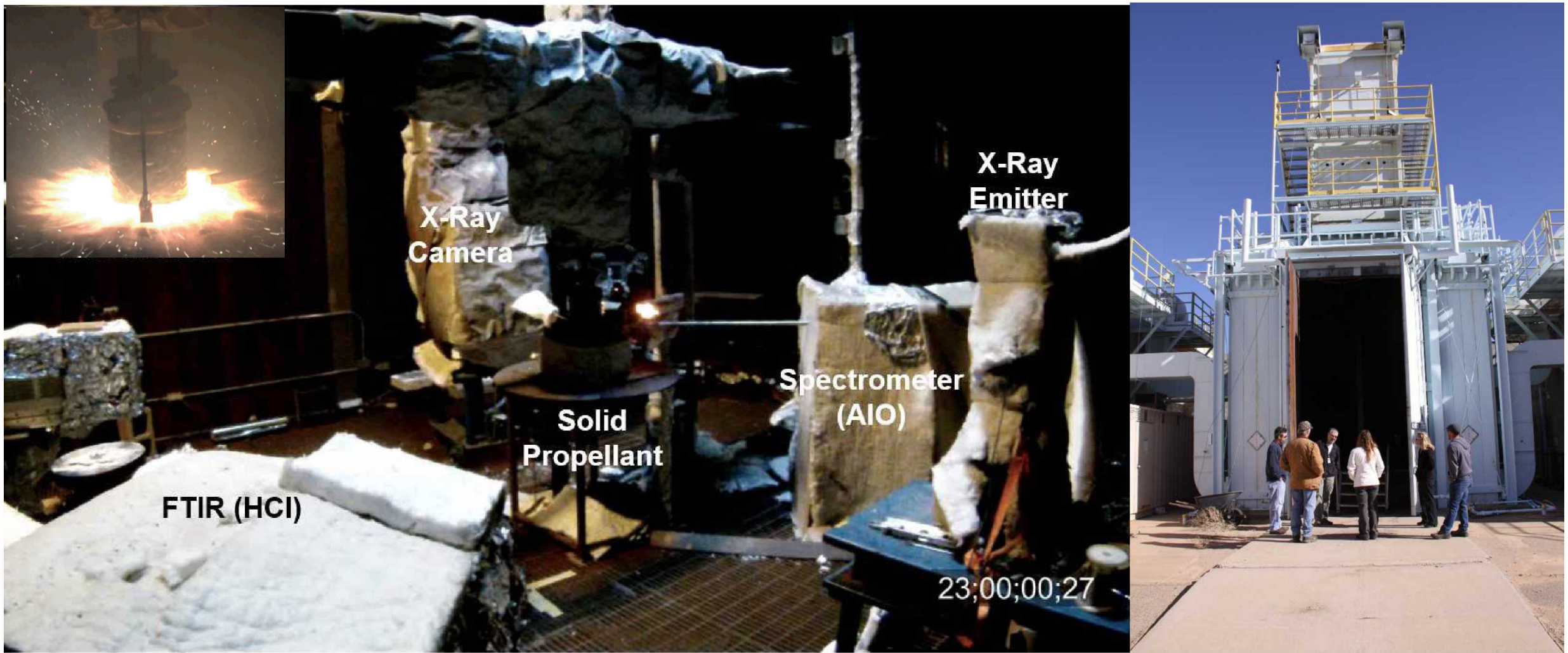
Nelder-Mead Nonlinear Fitting Algorithm



Planck Fitting Results For Three Emissivity Models

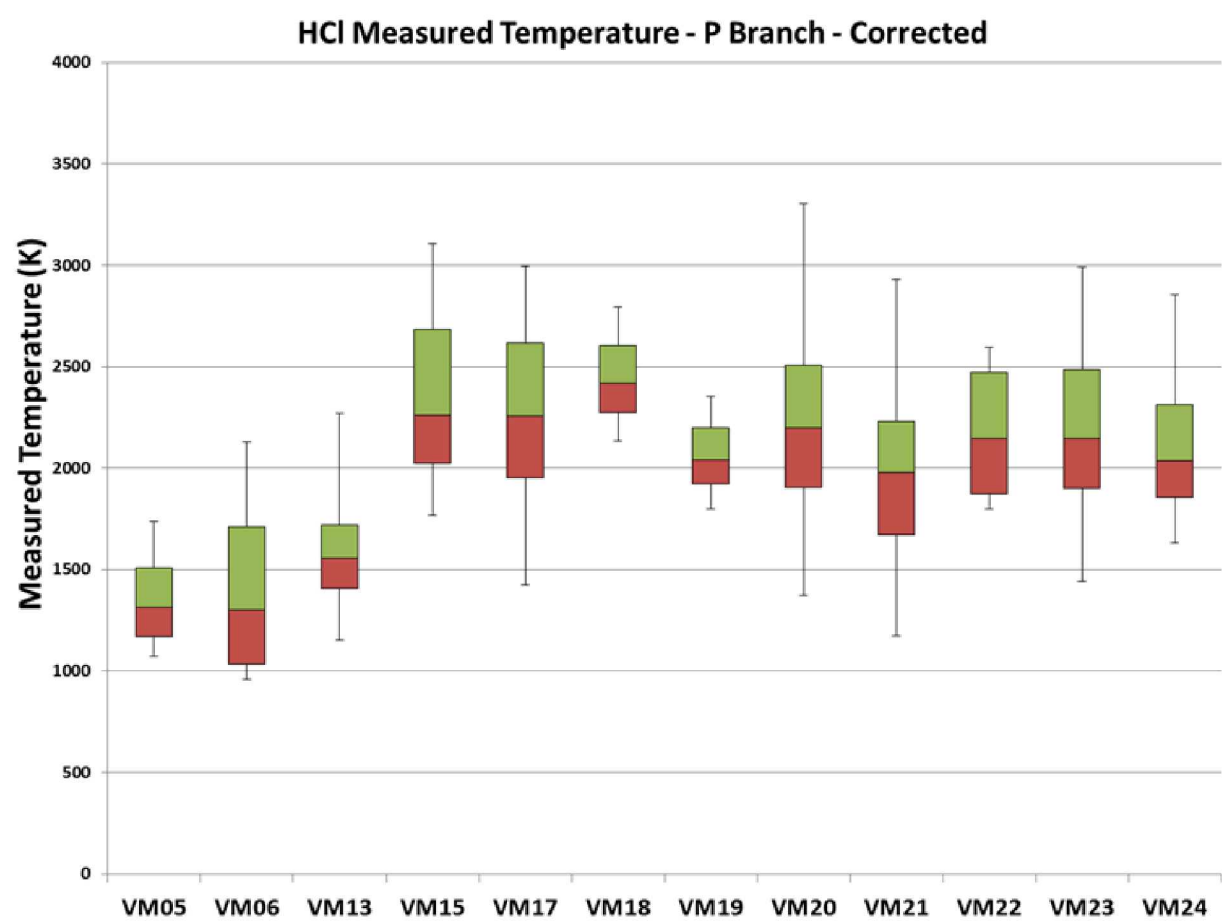


Experiment Setup

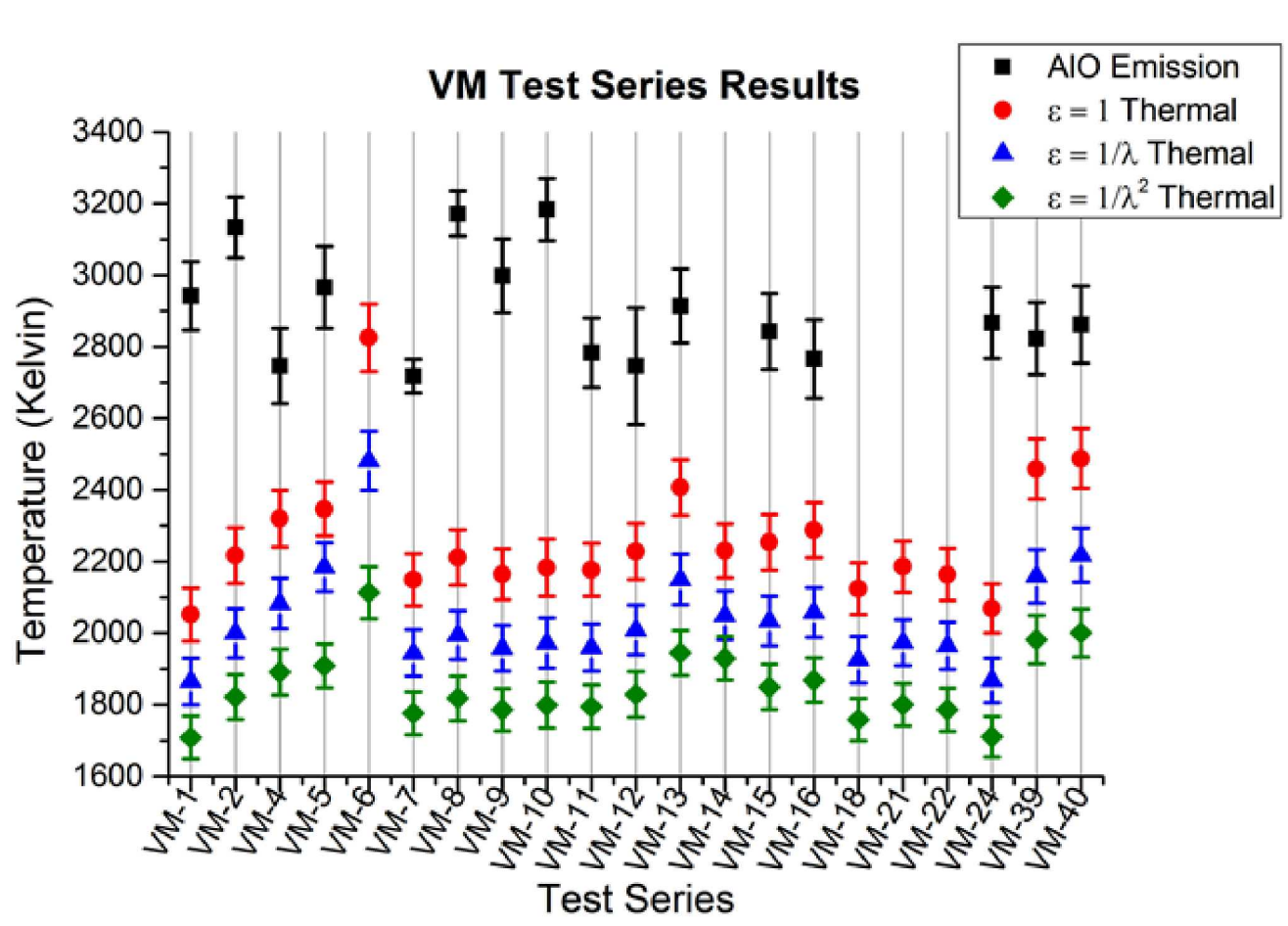


Aluminized ammonium perchlorate solid propellants, up to 16 inches (40 cm) in diameter, were tested at this facility

Reported Temperatures from HCl Measurements



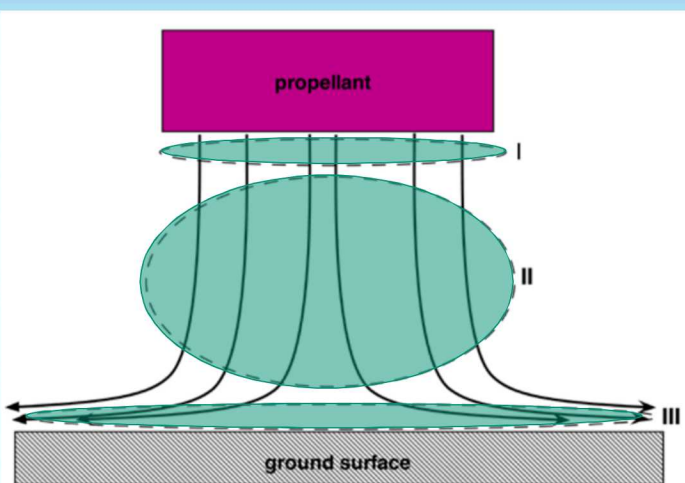
Reported Temperatures from AlO Measurements



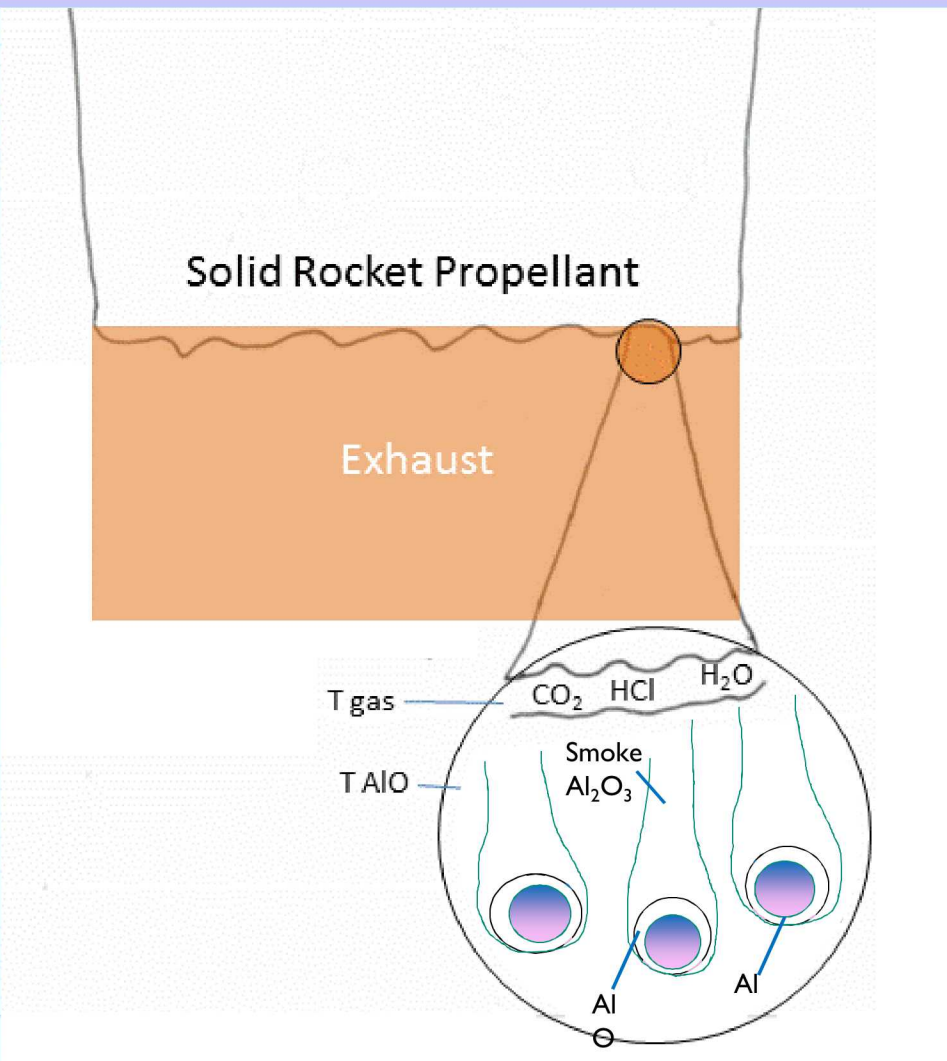
Background

Regions of Analysis

- Region I is where the aluminum and the ammonium perchlorate burn
- Region II is populated by hot emitting gases (HCl, CO₂, H₂O) and particles (AlO/Al₂O₃, etc.)
- Region III is where the flame will most likely interact with the hazardous material in the payload → This could lead to more complicated interactions in Region II



Region I & II Dynamics



- Region I shows the burning aluminum and ammonium perchlorate
- Multiple temperatures are present in Region II, complicating measurement and models
- AlO is believed to have some of the highest temperatures in this region
- Other oxides maybe present but we are not measuring them
- The smoke and soot (non aluminum related) has the lowest temperature in Region II, probably conforming to a grey body profile
- The gases (CO₂, H₂O, and HCl) fall in the middle of temperature ranges

References

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