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Study of Sensitivity vs. Excitation Time of LED Excited Thermographic Phosphor

PRESENTED BY

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Outline

Background on Thermal Test Complex at SNL

Motivation

LED Pulse Characterization

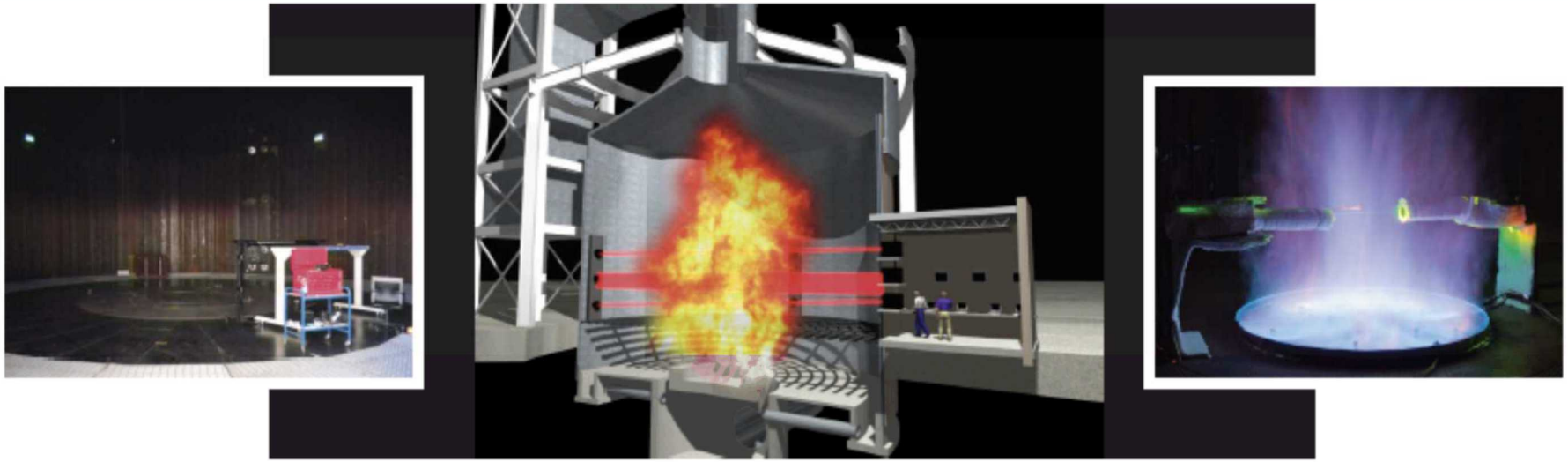
Oven Calibrations

Application to Silicon Carbide Heater

Conclusions

FIRE SCIENCE AND TECHNOLOGY

FIRE LABORATORY FOR ACCREDITATION OF MODELS AND EXPERIMENTS (FLAME)



State-of-the-Art facilities and diagnostics for fire environment characterization

Primary Purpose

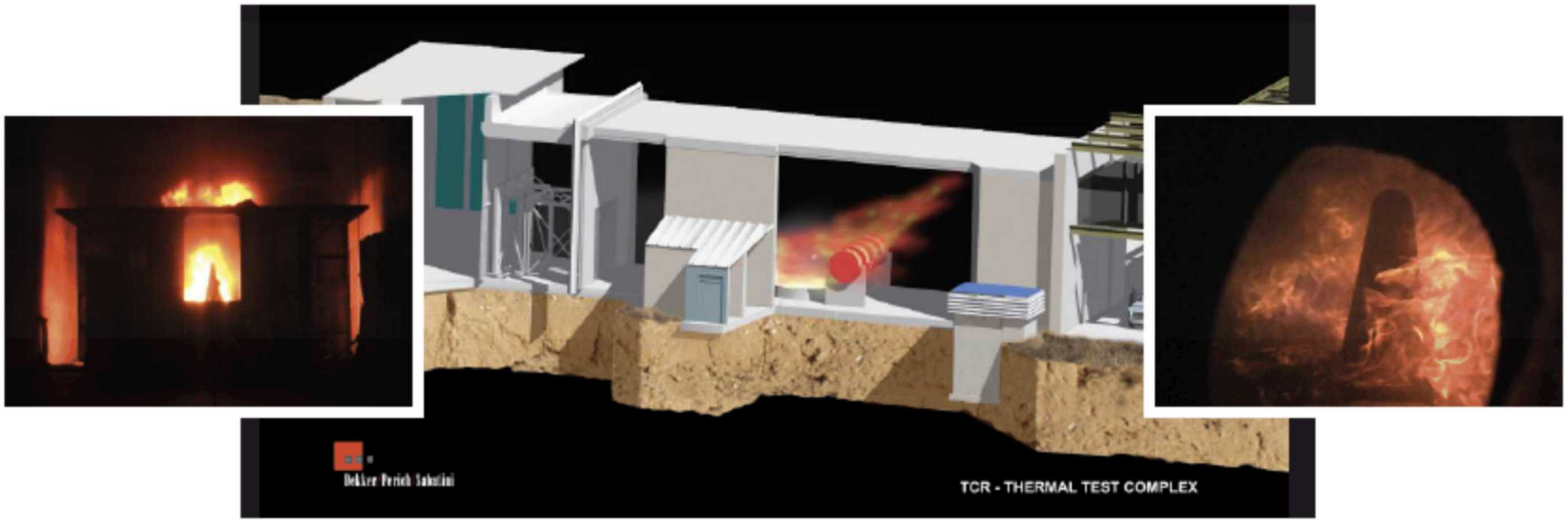
Testing of Component, Subsystem, and Systems to support Thermal Qualification and Model Development and Validation
Controlled Fires in Quiescent Conditions, Controlled Radiative and Convective Heating

Test Facility Size (approx.)	50 ft. high x 60 ft. diameter
Maximum Fuel Fire	20.0 MW
Maximum Fire Test Duration	1 hour
Airflow	150,000 scfm inlet
Maximum Radiant Test	5.2 MW

Quiescent (calm) wind fire experiments are performed in the 60-foot diameter FLAME test cell that has water-cooled walls and well controlled/characterized airflow equipment. Laser diagnostic equipment is used in the cell to help understand the burning process. Systems to allow jet fuel, methanol, and other liquid fuels as well as hydrogen, methane, and other gas fuels are part of the design.

FIRE SCIENCE AND TECHNOLOGY

CROSS-WIND TEST FACILITY



Primary Purpose

Testing of Component, Subsystem, and Systems to support Thermal Qualification and Model Development and Validation Fires in Crosswind conditions

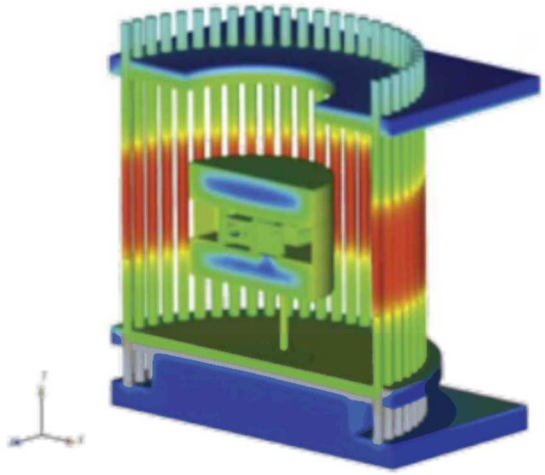
Maximum Fuel Fire	20.0 MW
Maximum Radiant Test	2.8 MW
Maximum Explosive Load	106 lb equivalent TNT
Airflow Inlet	8500-170,000 scfm

The Cross Flow Fire Test Facility, or XTF, is a 25-ft-high by 25-ft-wide by 84-feet long facility that is an indoor "fire wind tunnel" for testing objects with hazardous components (including explosives) at wind speeds up to 20 mph. Built with 30-inch reinforced concrete walls and special refractory concrete, the XTF also has radiant heat test capabilities.

FIRE SCIENCE AND TECHNOLOGY

RADIANT HEAT TEST CELL

A KEY CAPABILITY FOR NUCLEAR WEAPON ASSURED SAFETY



Use of highly controlled heaters and precision diagnostics to measure thermal response of nuclear weapon safety systems
Goal is to assess the performance of safety critical components and evaluate system design in abnormal thermal environments
Energy storage device must fail irreversibly before either safety component is compromised

Primary Purpose

Testing of Component, Subsystem, and Systems to support Thermal Qualification and Model Development and Validation
Controlled Radiative and Convective Heating
Testing Facilities include Radiant Heat, FLAME, and XTF test cells

Voltage	up to 12 Conductor 480VAC
Amperage	1000/leg
Phase	3

5.2 MW Radiant Heat Test Cell for performing high heat flux experiments

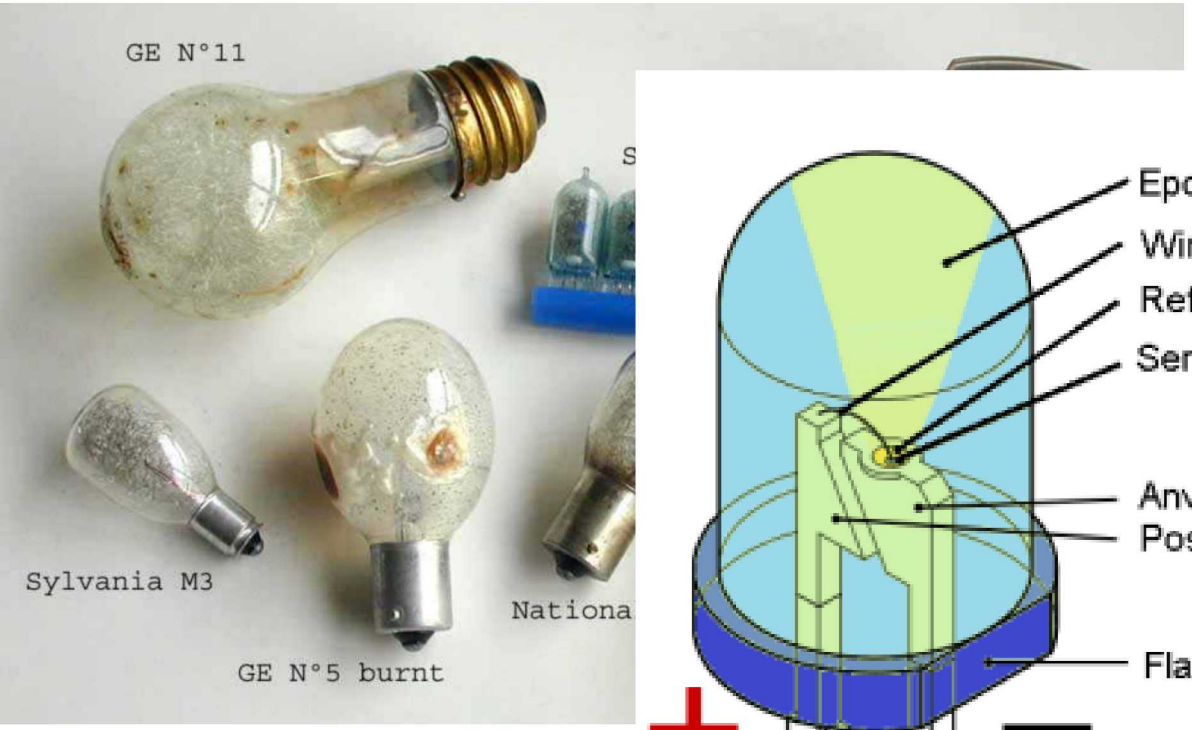
Motivation

Lasers are powerful tools

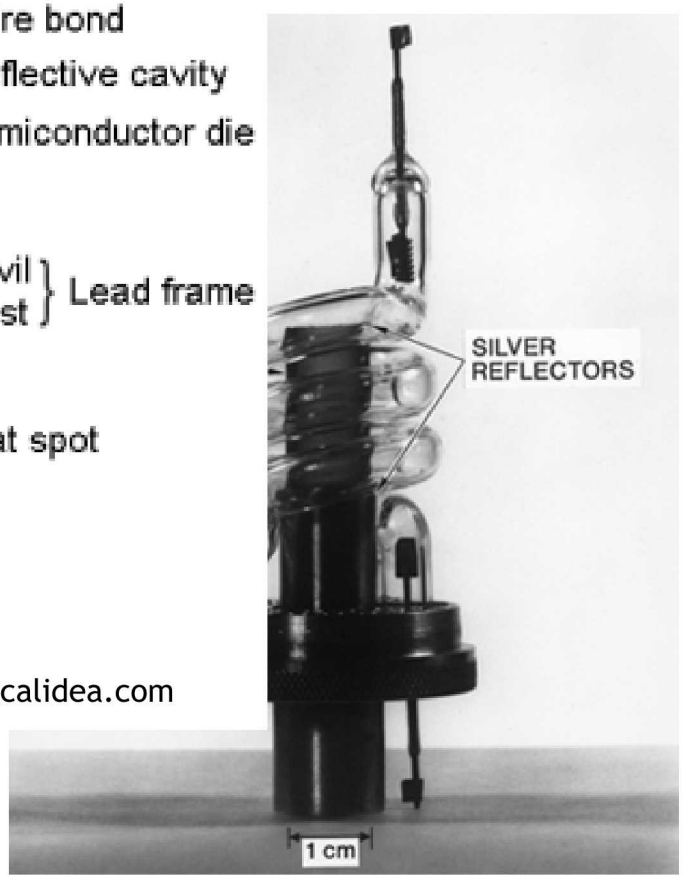
But not always the right tool

- Expensive
- Complex
- Extensive training required
- Safety hazards

Excitation of Thermographic Phosphors

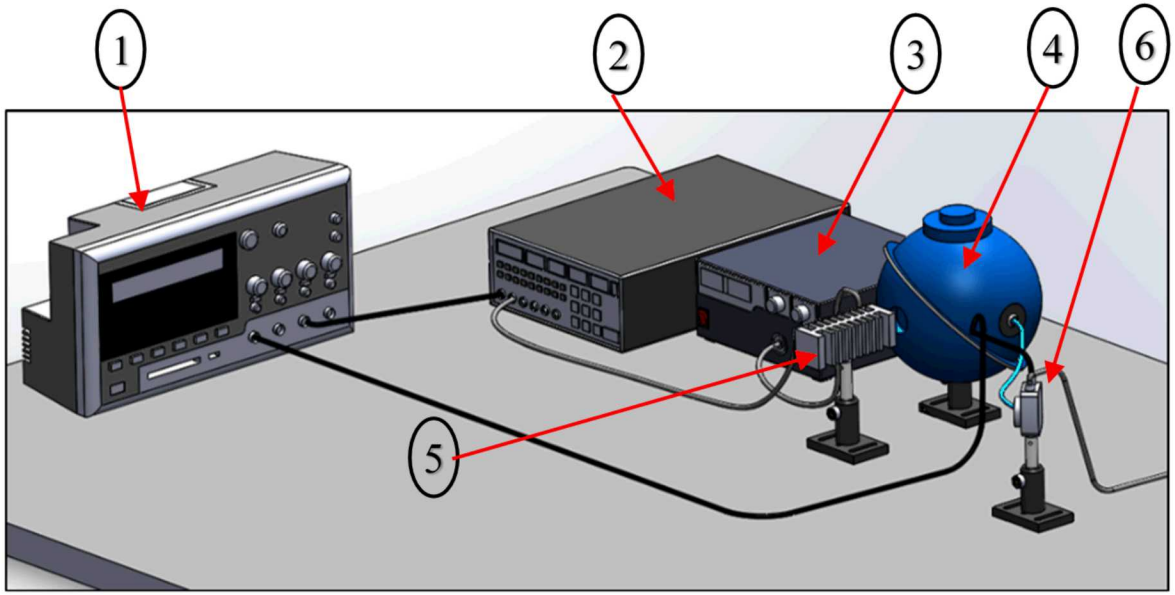


electricalidea.com



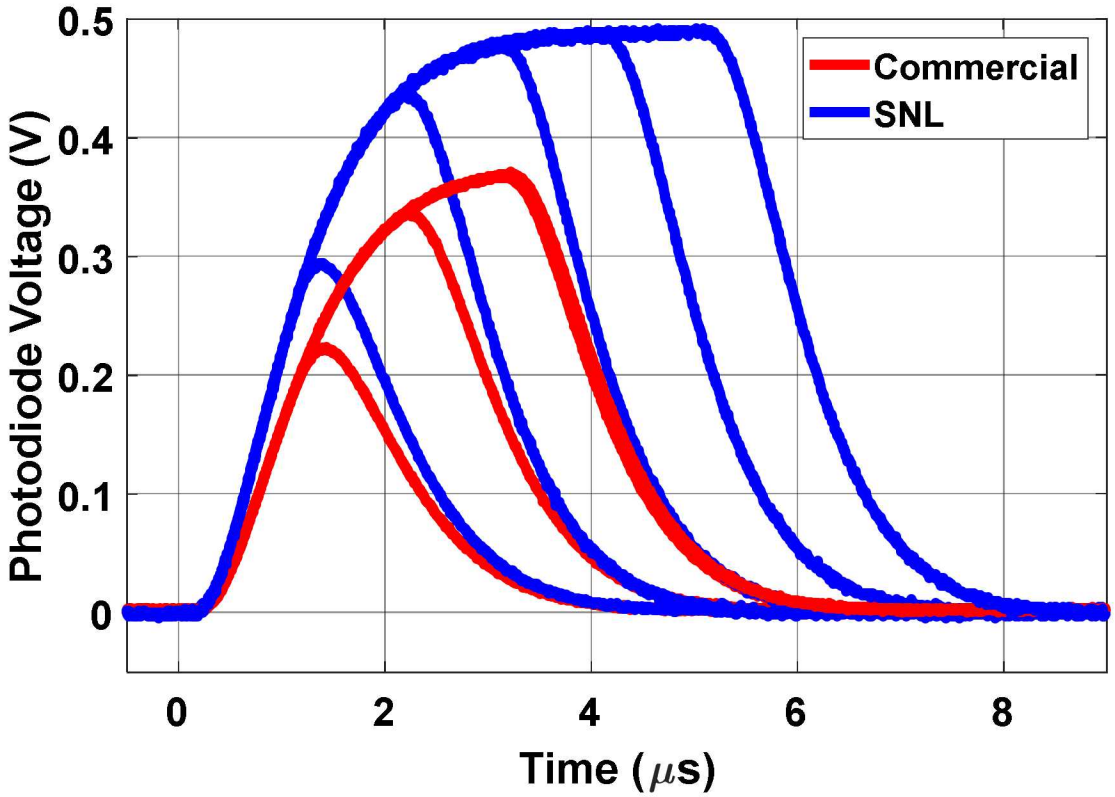
LED Pulse Characterization/Comparison

- Custom-built SNL vs commercially-available Lightspeed LED driver
- Flat-lens LED star array centered @365nm



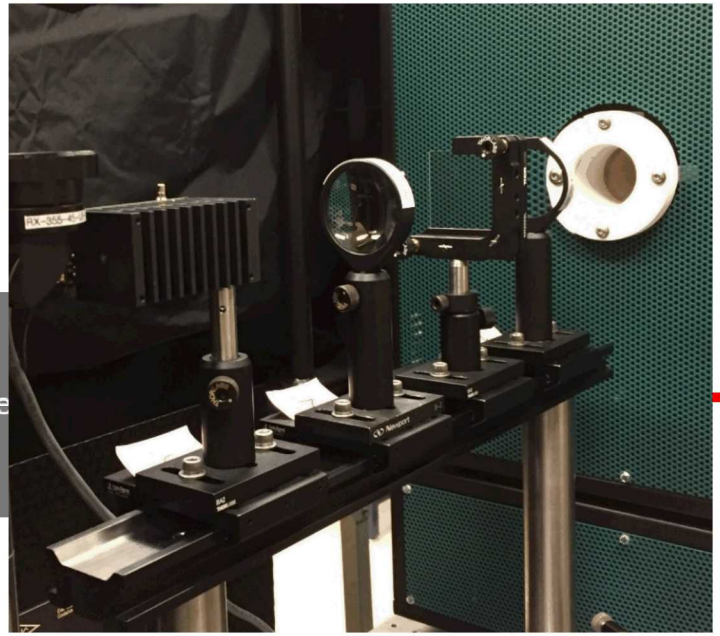
ID Number	Description
1	Oscilloscope
2	Delay Generator
3	DC Power Supply
4	Integrating Sphere
5	LED Driver
6	Photodiode

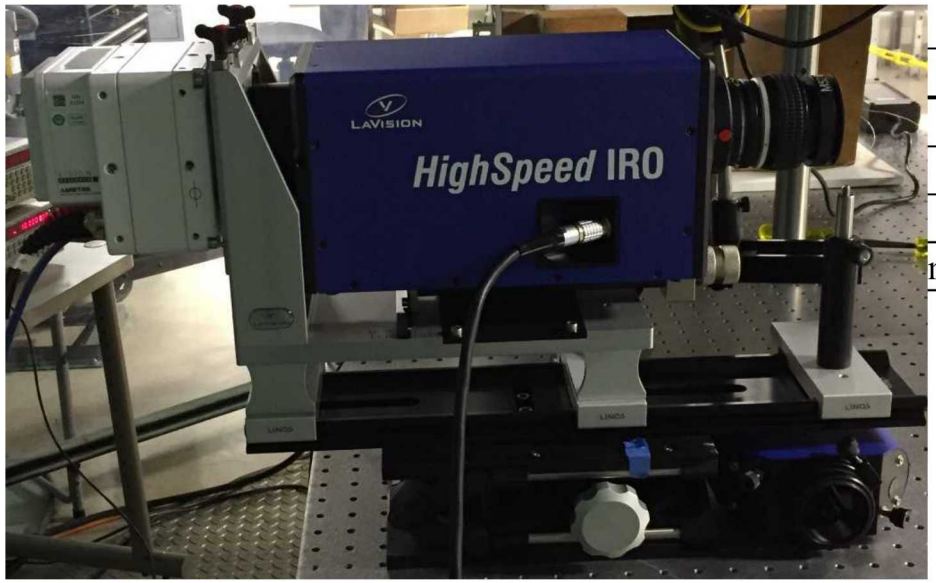
Voltage vs Time



- ~30% more power out SNL-driven LED
- No built-in power limiter to protect circuitry

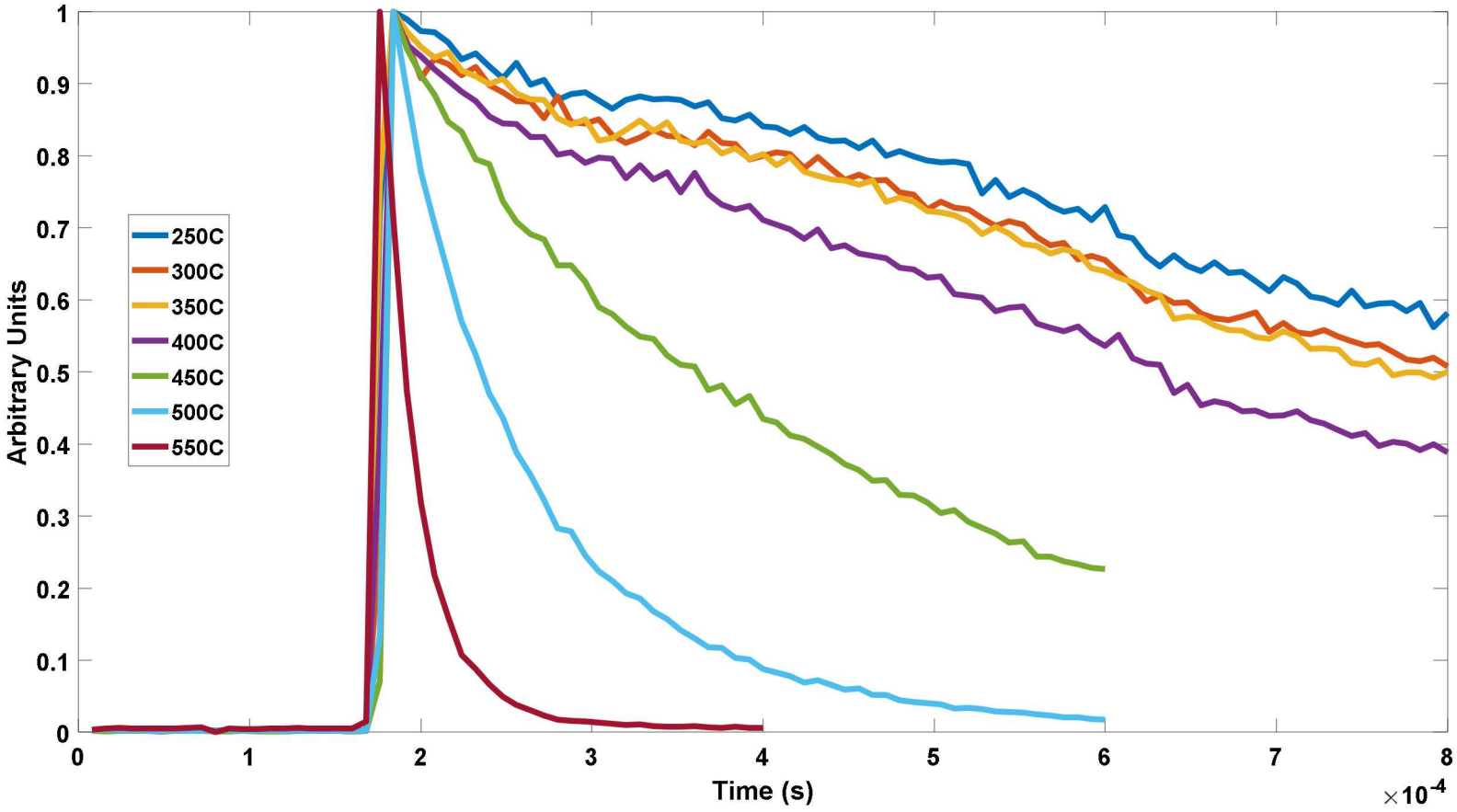
Oven Calibrations





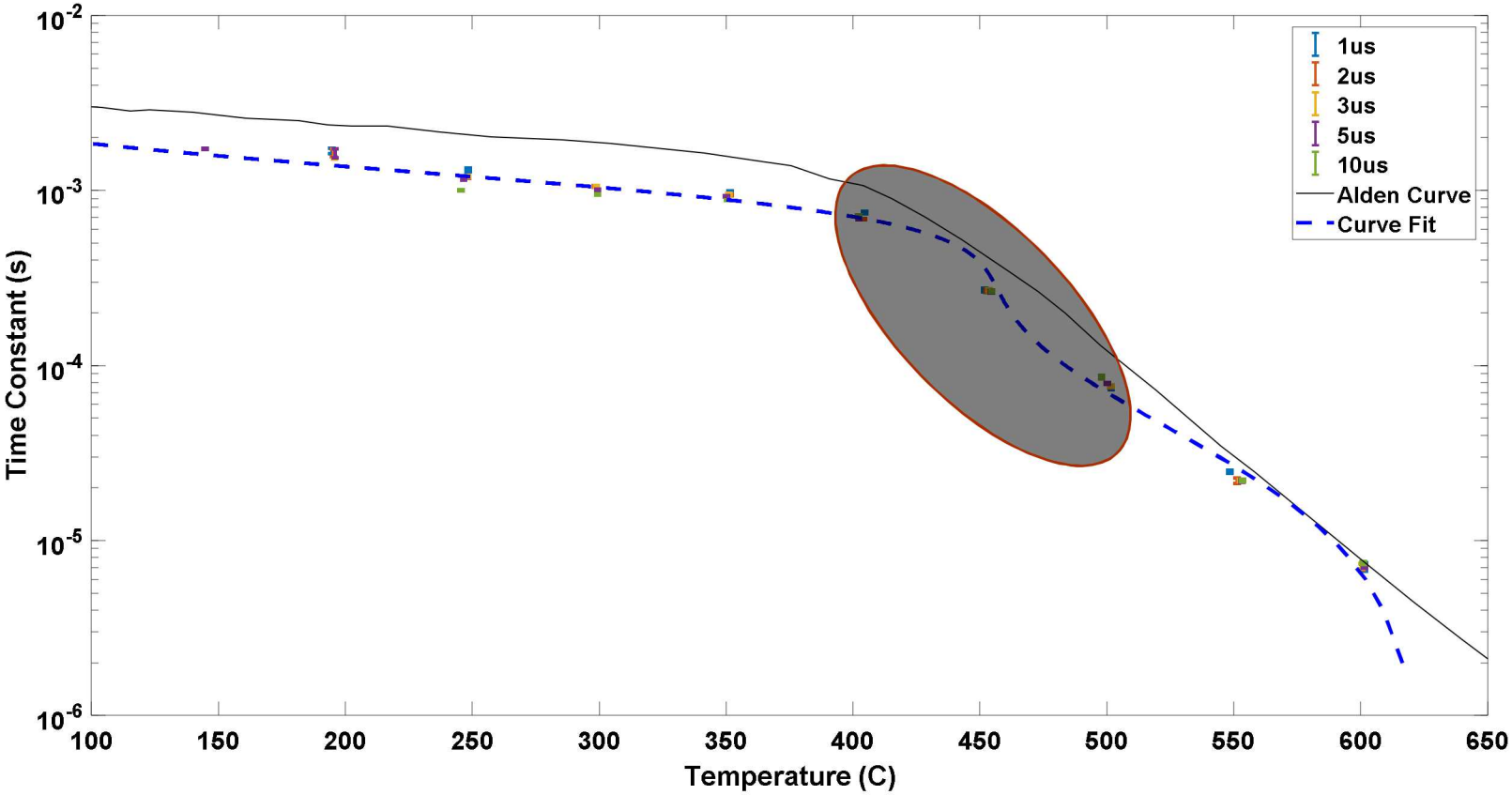
Description
SNL LED Driver
Plano Convex Lens
Neutral Density Filter
mera with IRO and 660nm bandpass filter

Example Time Series of Calibration Images



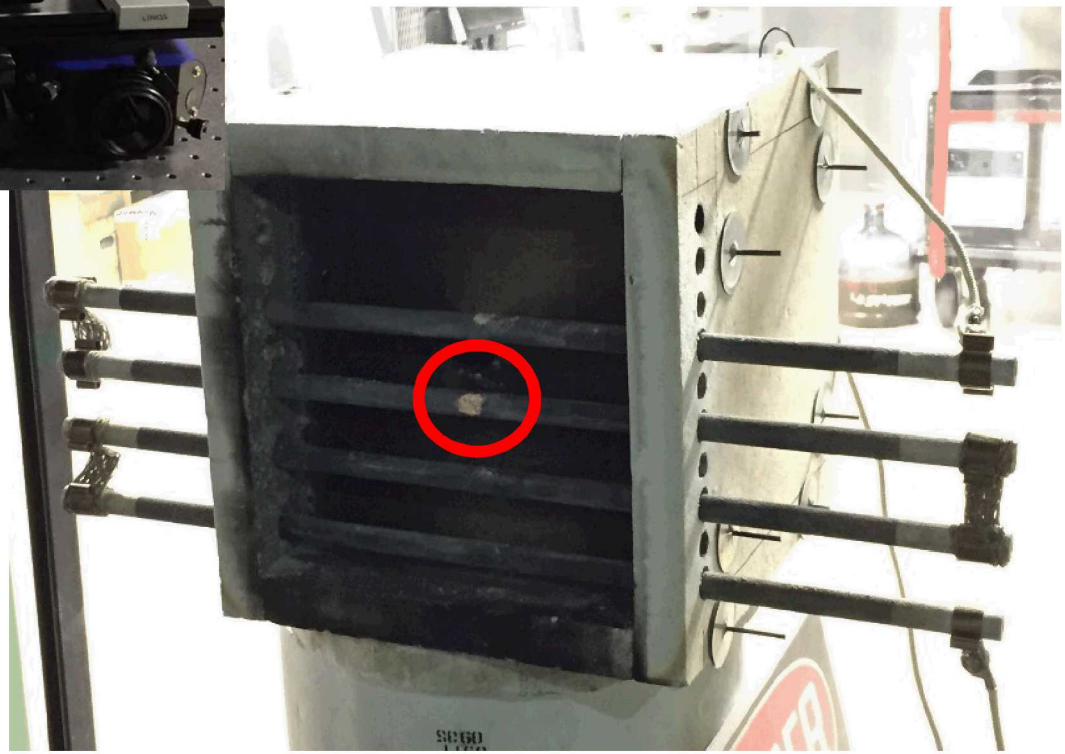
- $Mg_3F_2GeO_4$:Mn phosphor

$Mg_3F_2GeO_4$:Mn Curve Fit to Calibration Data

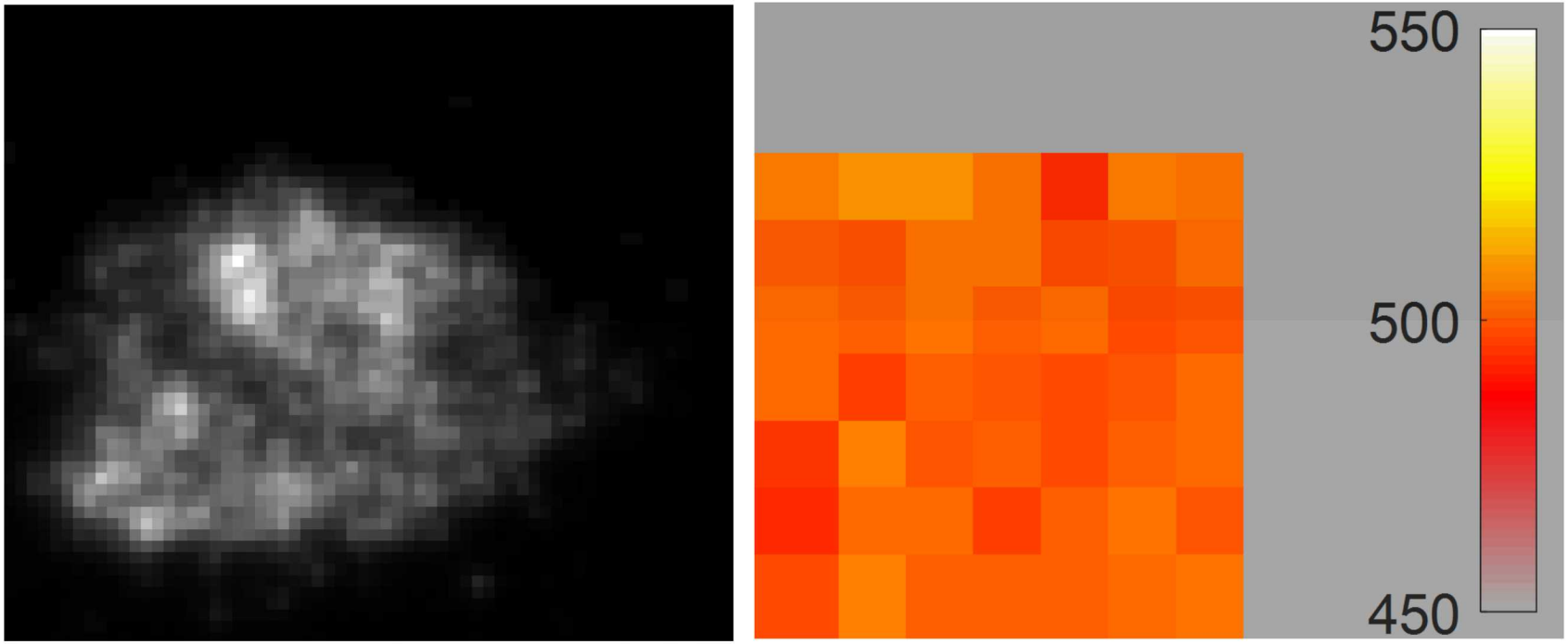


Need more data in this region for better fit!

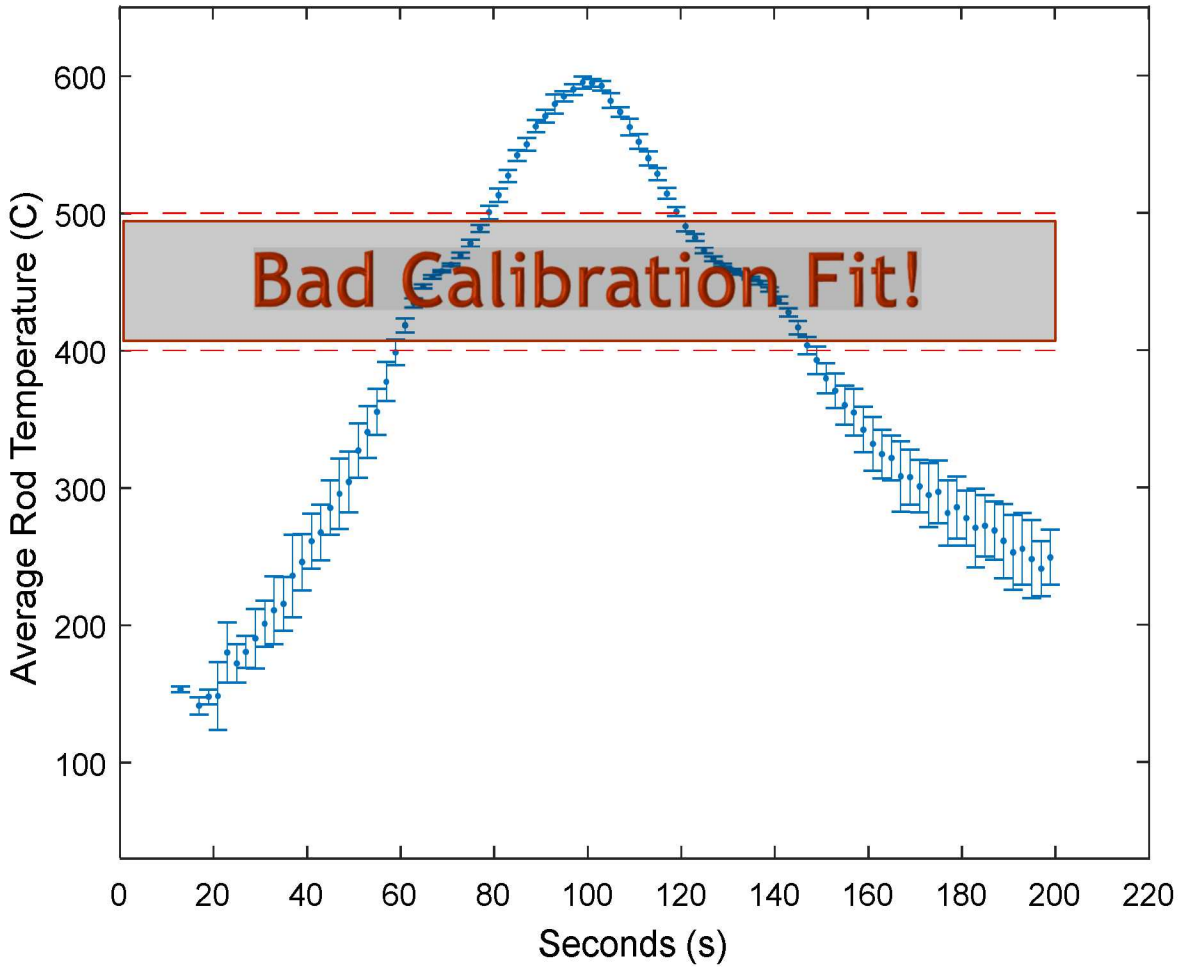
Test in Silicon Carbide Heater



Silicon Carbide Rod Temperature Imaging

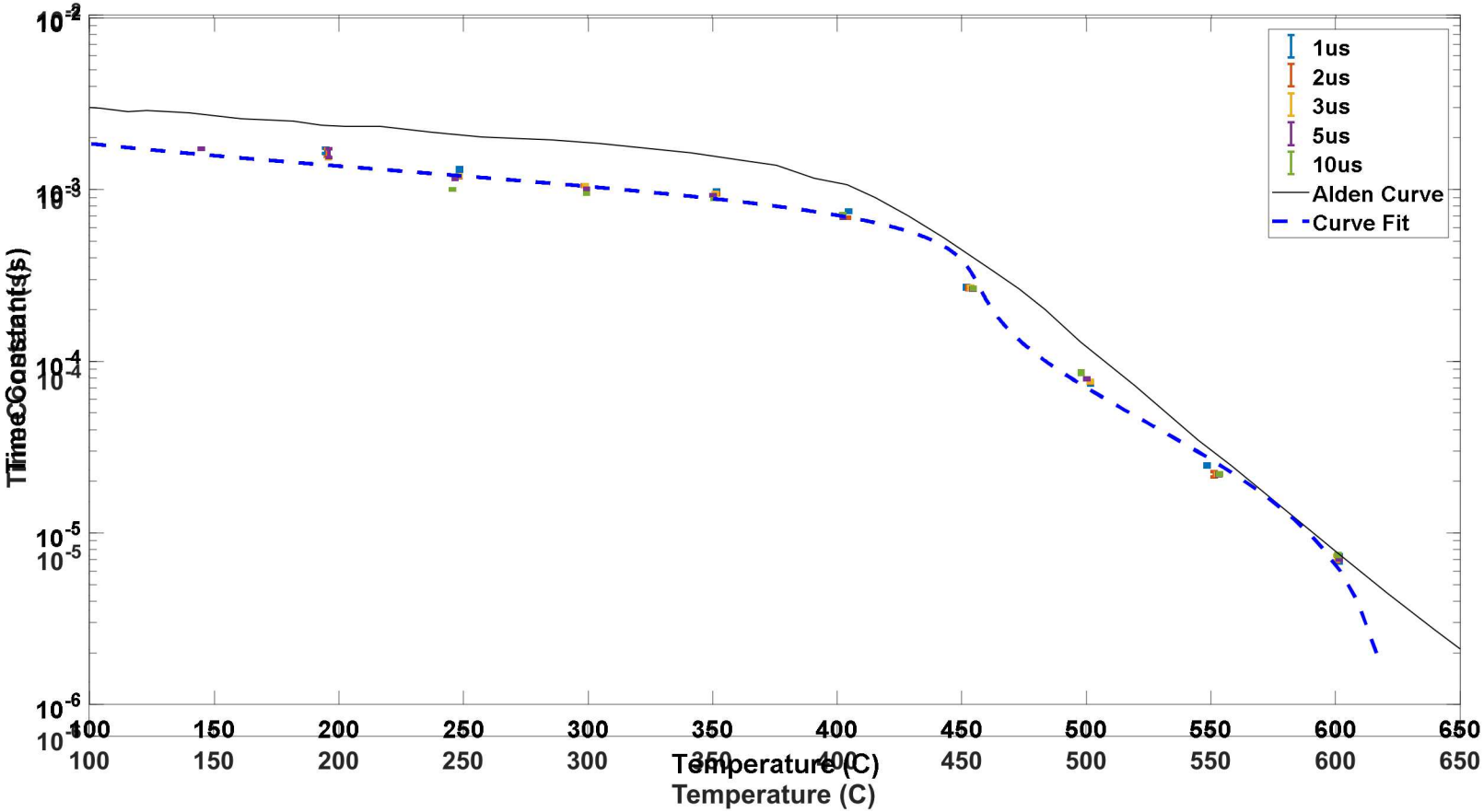


Temperature vs Time During Heating Cycle

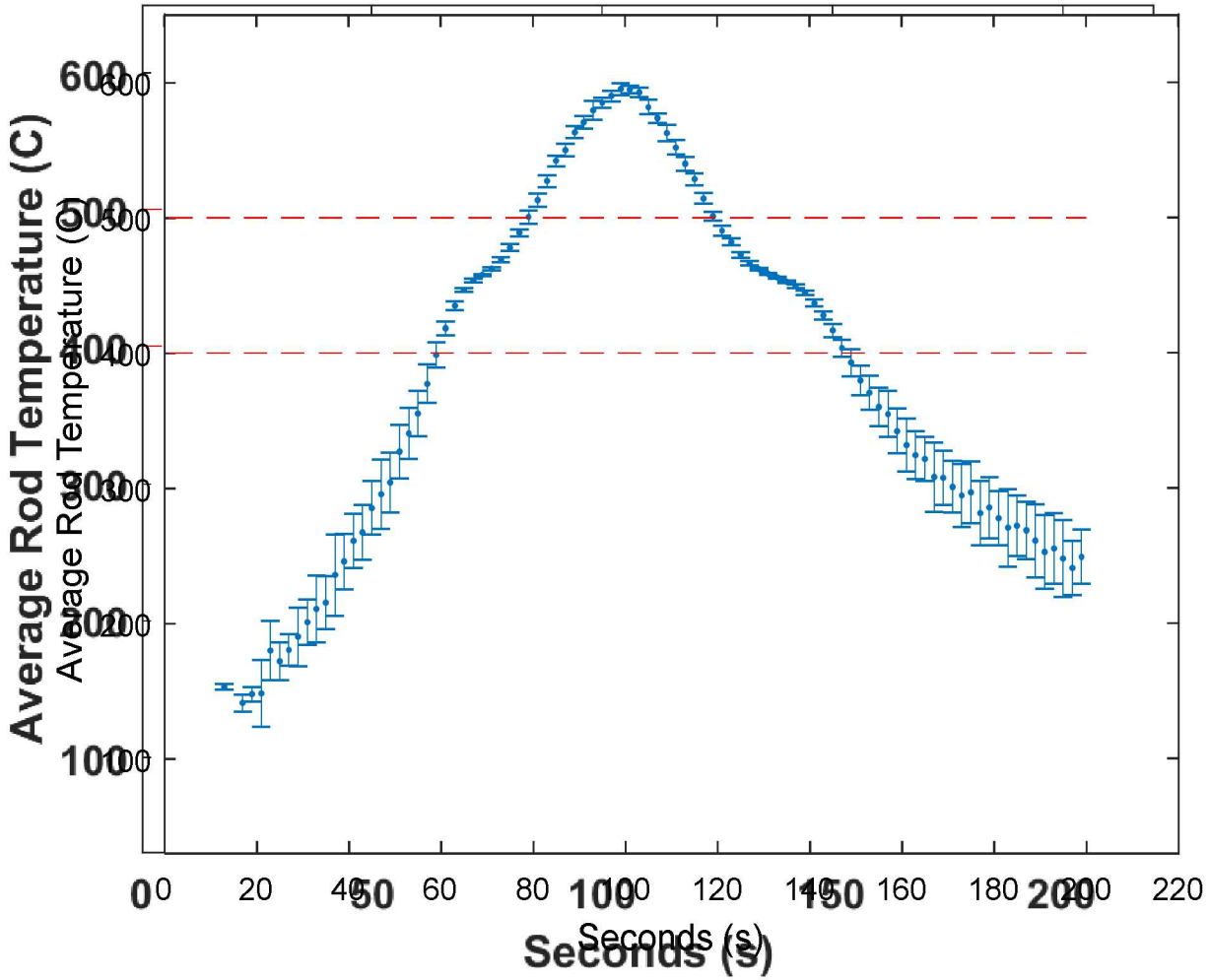


- Low temperature error limited by recording length on camera

$Mg_3F_2GeO_4$:Mn Curve Fit to Calibration Data



Temperature vs Time During Heating Cycle



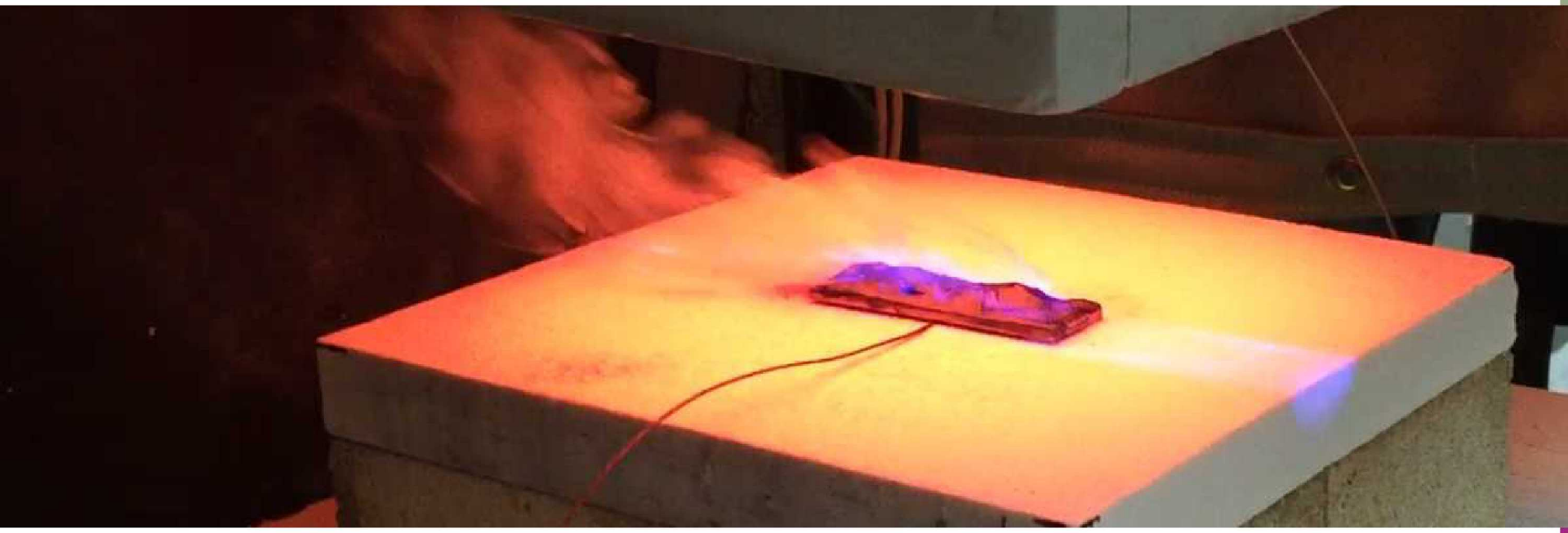
- Low temperature error limited by recording length on camera

Summary & Conclusions

- SNL LED driver allows for more control over LED pulse shape and power
- For radiant heat applications, long LED pulses (>2 μs) can be used
- Error limited by record length on intensified camera
  - Future work look into removing intensifier
    - Focus LED to increase power at phosphor
    - Multiple LED arrays
    - Wider filters

Next Up

Burning epoxy at ~300℃



Acknowledgements

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