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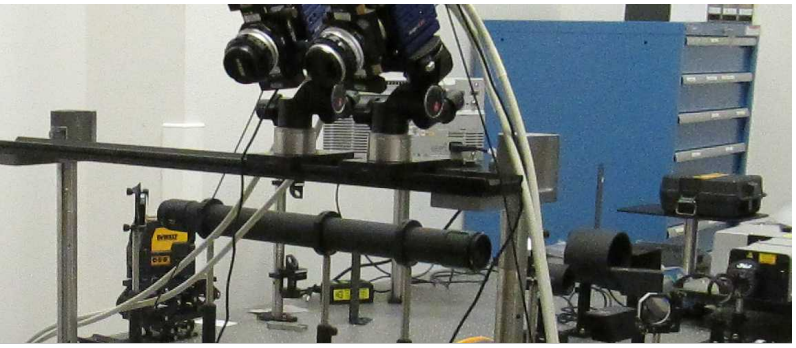
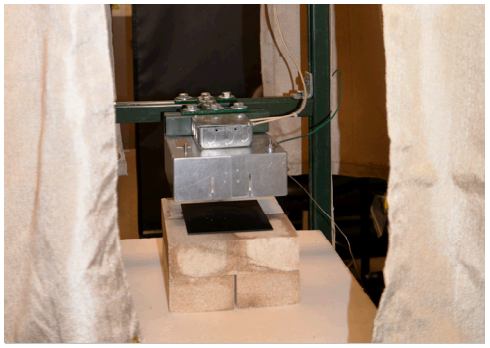
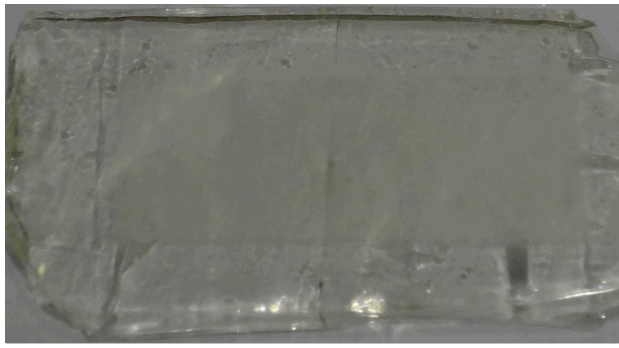

Thermal Phosphor Thermometry for Solid Reacting Materials

Aditya Chandramohan

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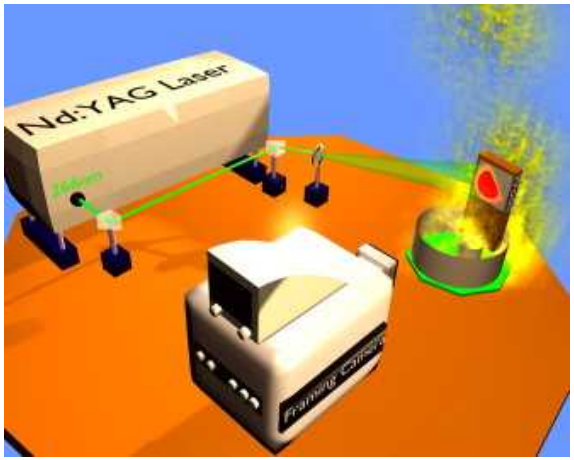
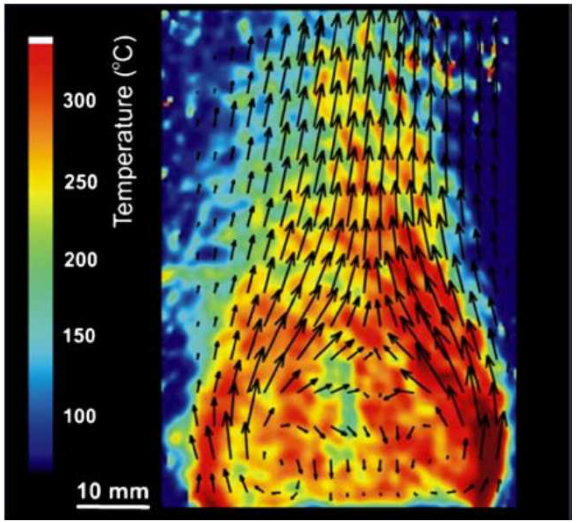
Motivation

- An effective means for surface thermographic measurements is needed for high temperatures, particularly under burning environments.



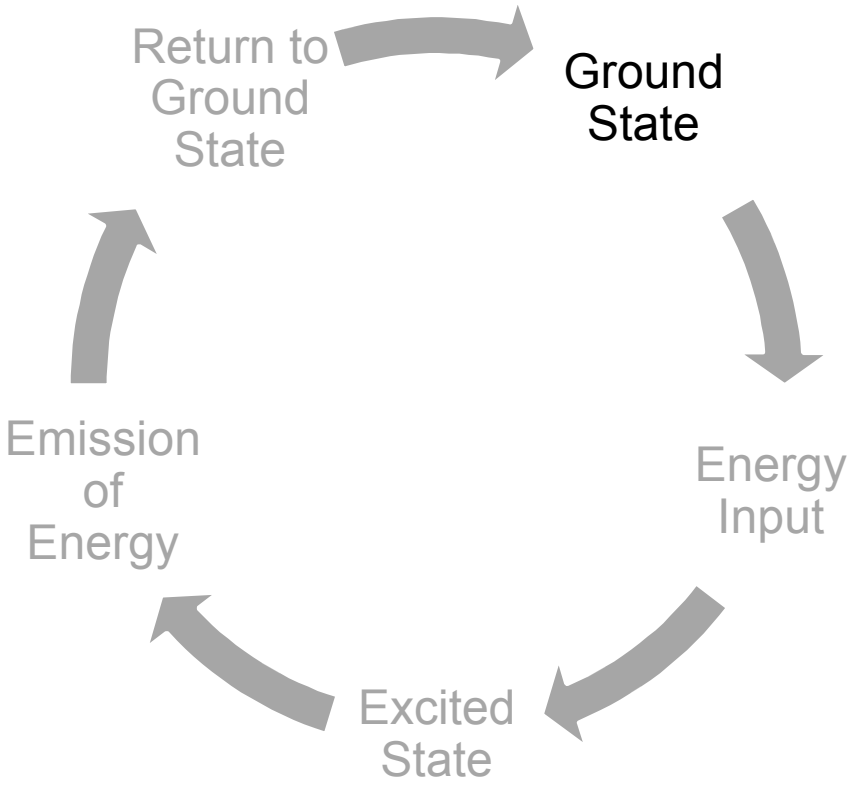
Aldén, Marcus, et al. "Thermographic phosphors for thermometry: a survey of combustion applications." Progress in energy and combustion science 37.4 (2011): 422-461.

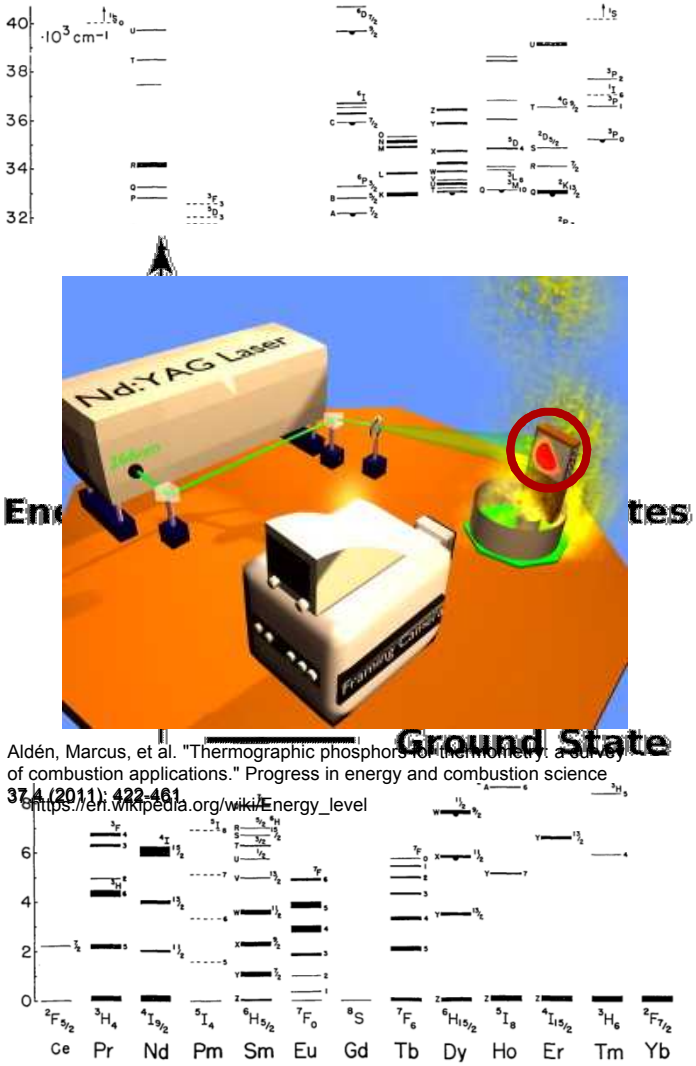


Omrane, Alaa, et al. "Simultaneous 2D flow velocity and gas temperature measurements using thermographic phosphors." *Applied Physics B: Lasers and Optics* 92.1 (2008): 99-102.

- A simultaneous velocity measurement technique using the same phosphor particles seeded in the air.

Laser-Induced Phosphorescence





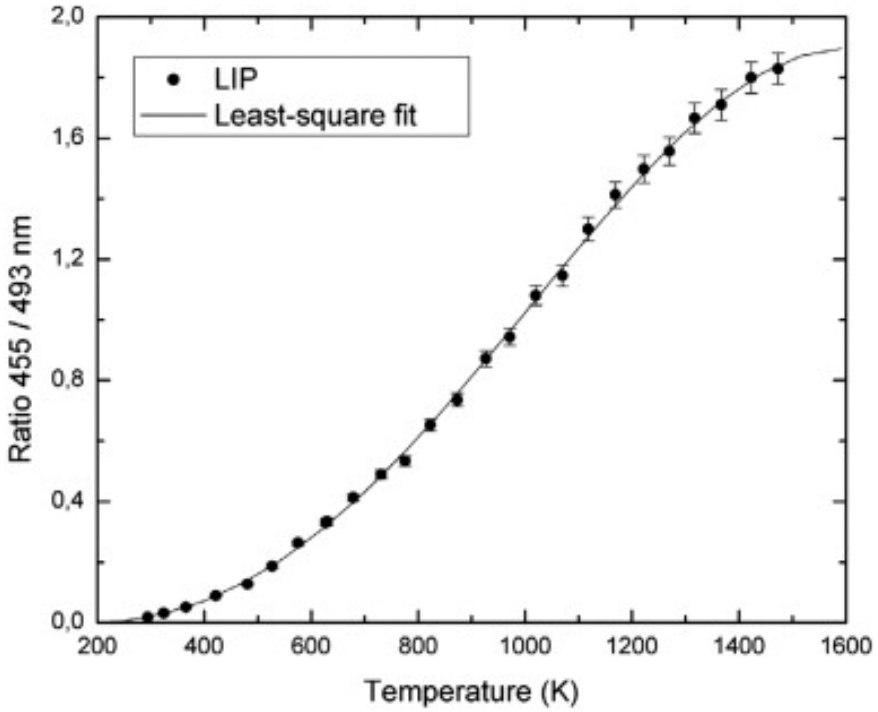
Aldén, Marcus, et al. "Thermographic phosphors for thermometry: a survey of combustion applications." Progress in energy and combustion science 37.4 (2011): 422-461.

https://en.wikipedia.org/wiki/Energy_level

Dieke, Go Ho, and H. M. Crosswhite. "The spectra of the doubly and triply ionized rare earths." Applied optics 2.7 (1963): 675-686.

Thermal Phosphors

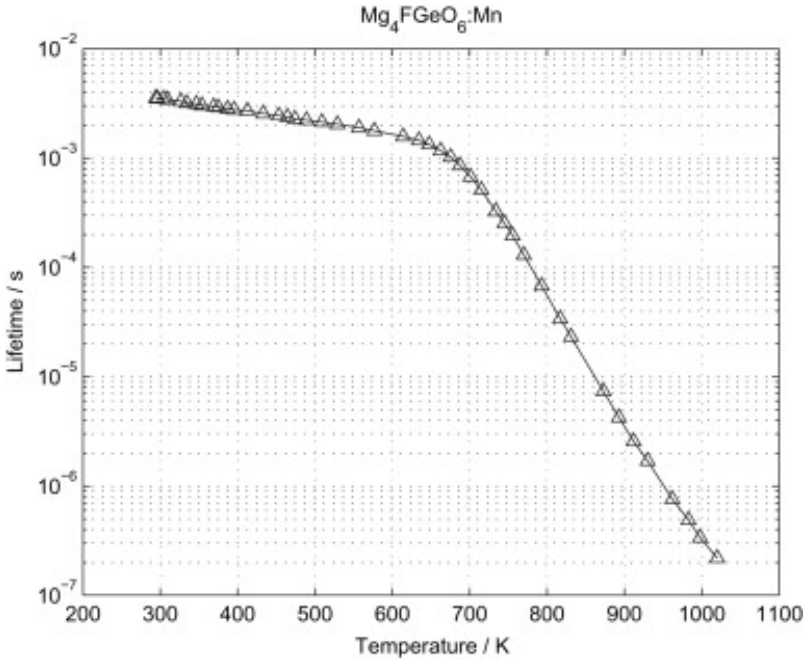
- Ceramics doped with an activator material (rare earth metal).
  - Spectral response to excitation varies with temperature in a well-characterized manner.
- Two methods:
  - Lifetime
    - Pulse laser and record lifetime of phosphorescence
  - Ratio
    - Ratio of the phosphorescence at two wavelengths



Aldén, Marcus, et al. "Thermographic phosphors for thermometry: a survey of combustion applications." Progress in energy and combustion science 37.4 (2011): 422-461.

$Mg_3F_2GeO_4$:Mn

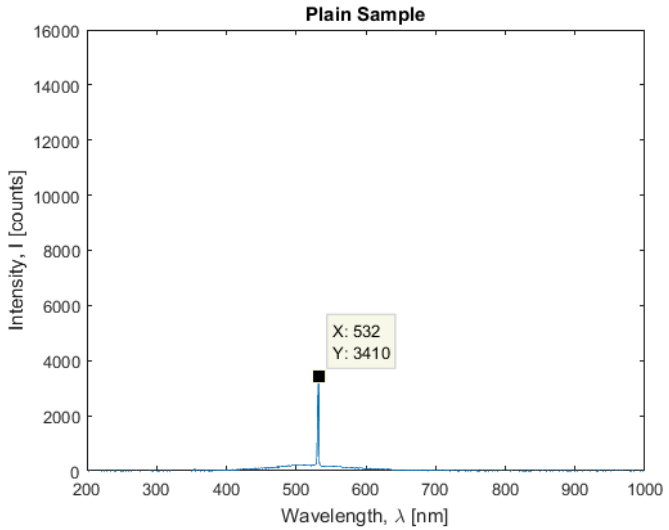
- The peaks are expected to be 631 nm and 657 nm, the latter having a strong relationship with temperature.
- Usually used in a lifetime approach.

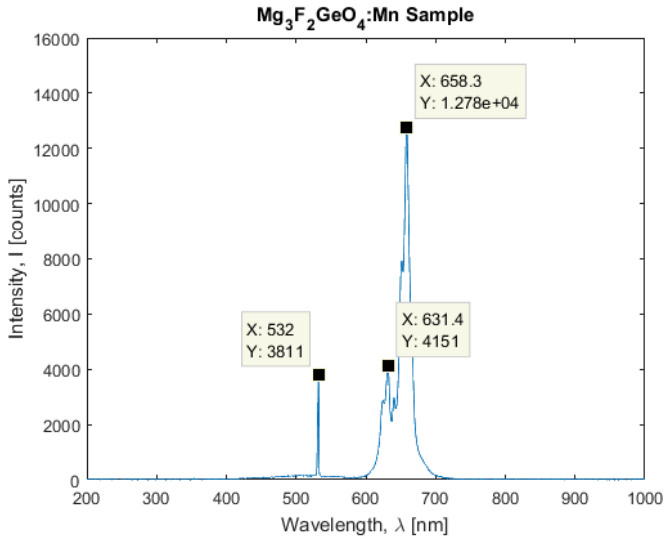


Aldén, Marcus, et al. "Thermographic phosphors for thermometry: a survey of combustion applications." Progress in energy and combustion science 37.4 (2011): 422-461.

$Mg_3F_2GeO_4$:Mn Sample 3

- Integration time of 400 ms.
- 532 nm peak is significantly less important.

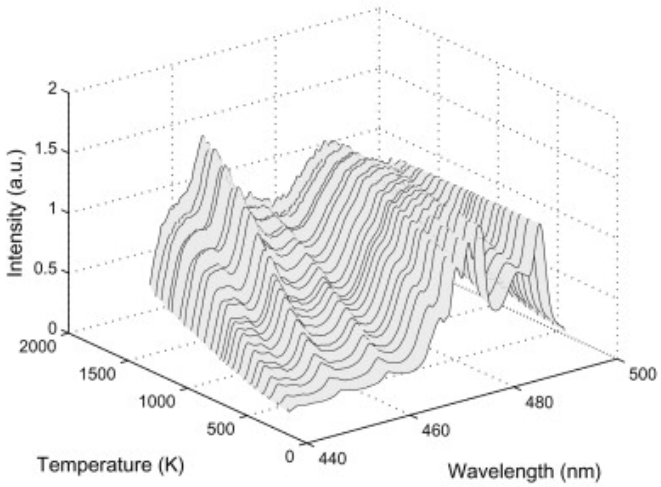


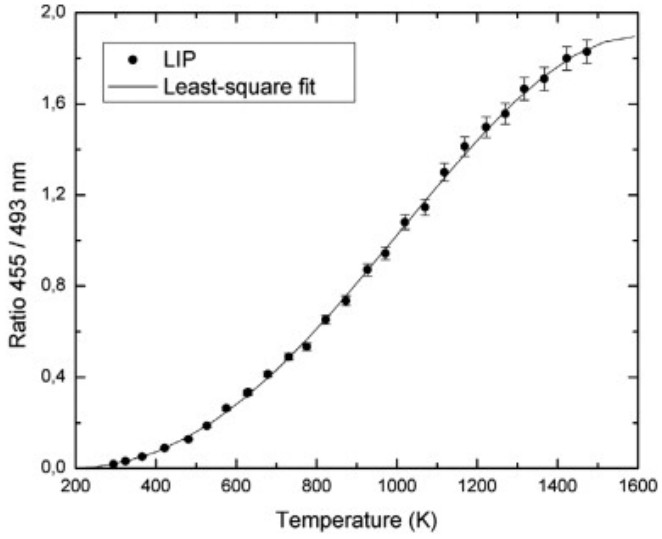


YAG:Dy

- The peaks are expected to be groups at 480, 580, and 680 nm.

- For temperature measurements the ratio of the intensities at 458 and 497 nm is used from 400 K and 1700 K.



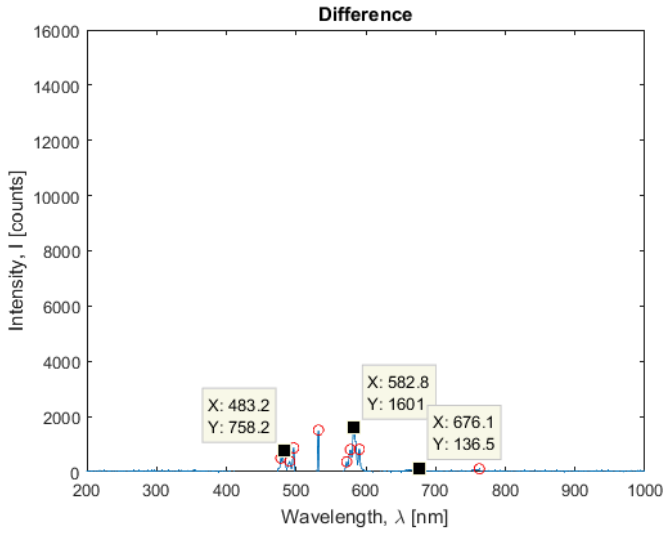


Aldén, Marcus, et al. "Thermographic phosphors for thermometry: a survey of combustion applications." Progress in energy and combustion science 37.4 (2011): 422-461.

YAG:Dy Sample 5

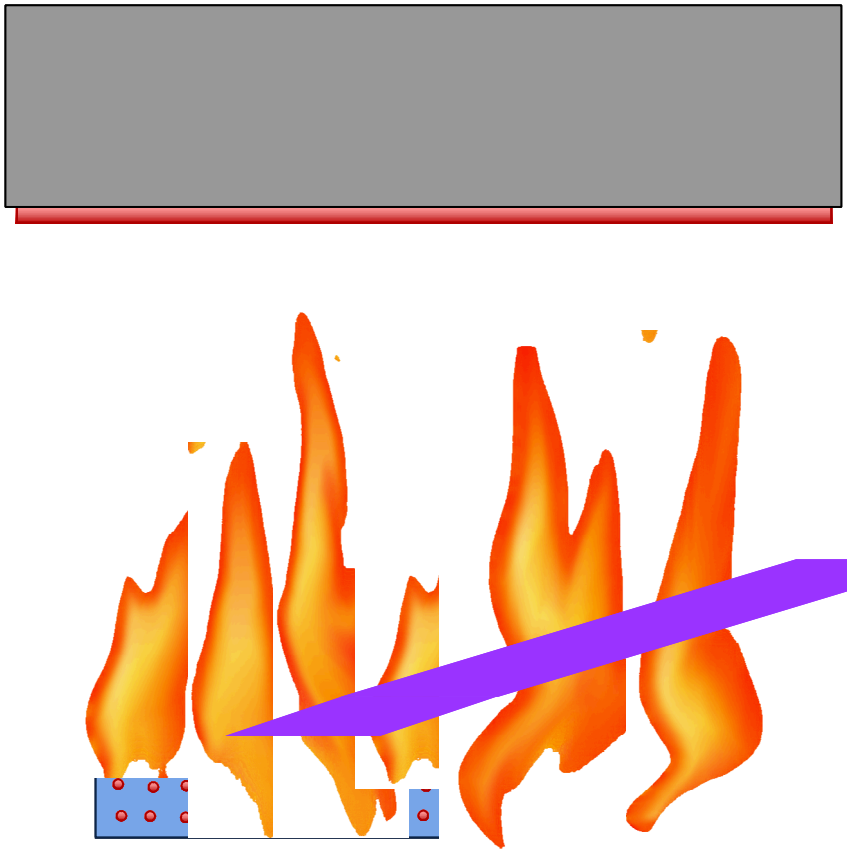
- The peaks are expected to be groups at 480, 580, and 680 nm.

- For temperature measurements the ratio of the intensities at 458 and 497 nm is used from 400 K and 1700 K.

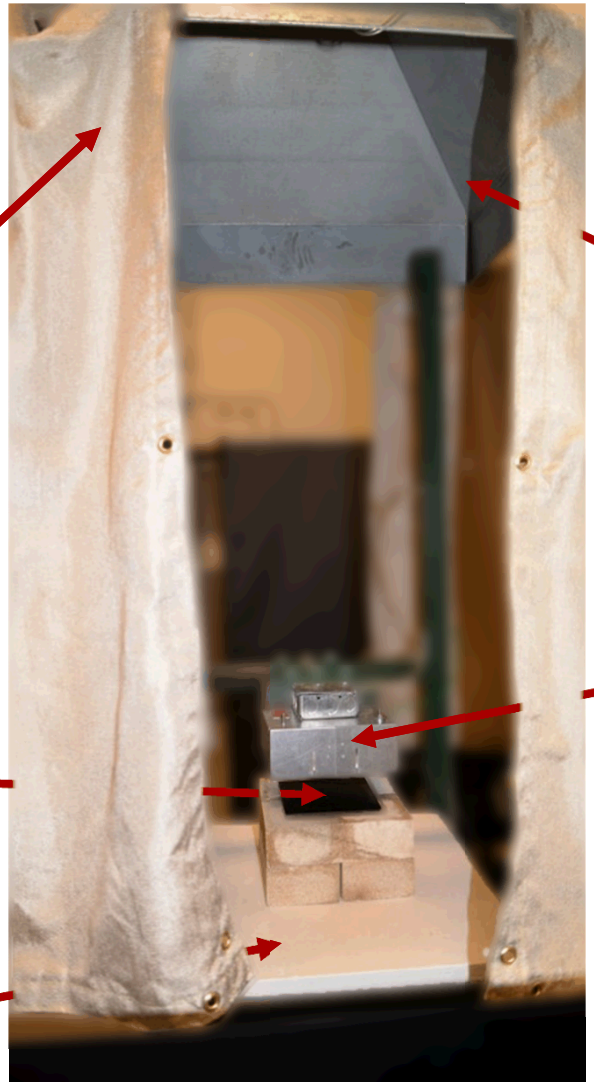


Premise

- Fabricate materials doped with thermal phosphor particles.
- Heat and burn the sample.
- Excite the phosphors to get the temperature of the surface.
- If particles are ejected from surface, make velocity measurements using PIV.

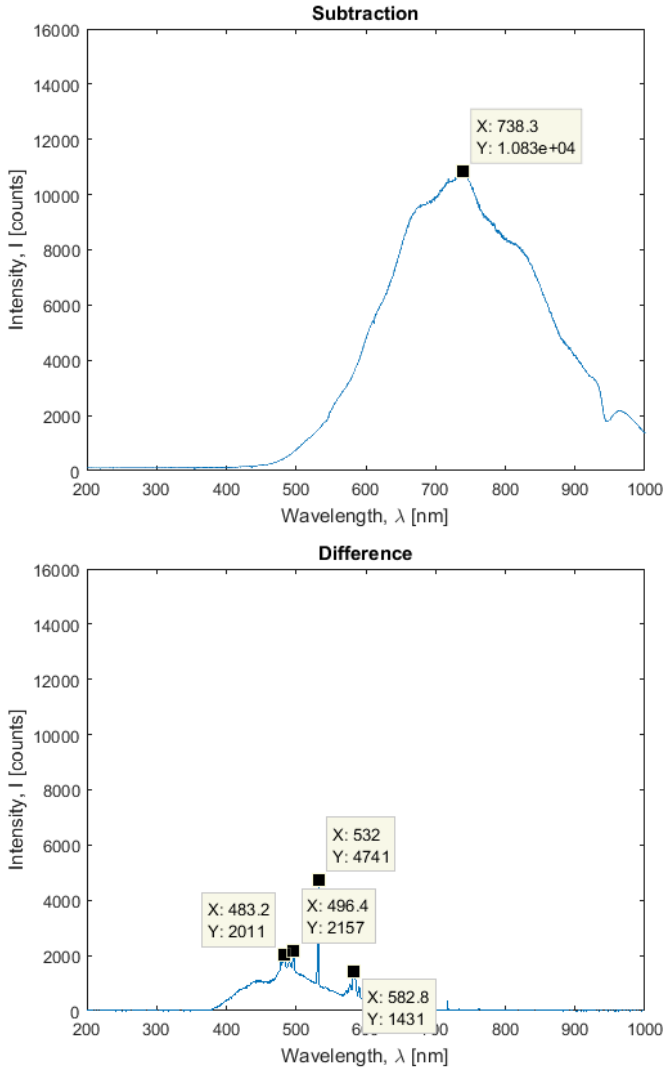


Heat/Burn Facility



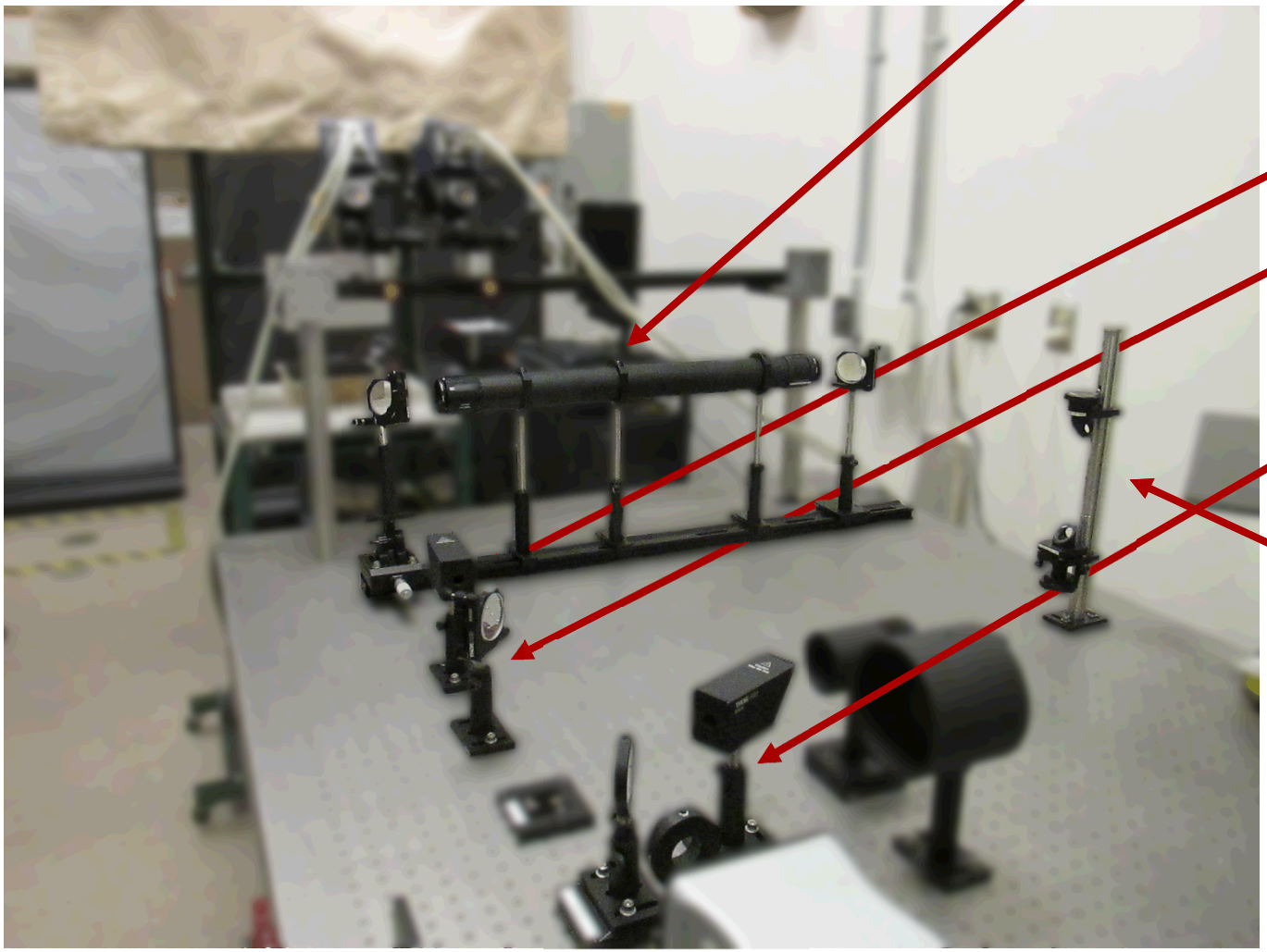
Burn Test Results (Polyester Resin)

- This test checks for the wavelengths seen from simply burning the material.
- The flame has visible emission with the peak at 738 nm.
- For comparison, the $Mg_3F_2GeO_4$:Mn sample's peaks are approximately 630 and 660 nm.
  - (Note that the integration time shown for the flame is 100 ms while it is 400 ms for the phosphor)
- For YAG:Dy, the peaks are at 483, 496, and 583 (the integration time was 1000 ms).



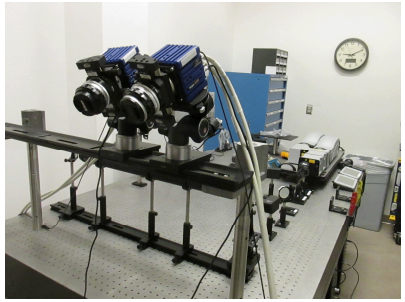
Experimental Setup

Sandia National Laboratories



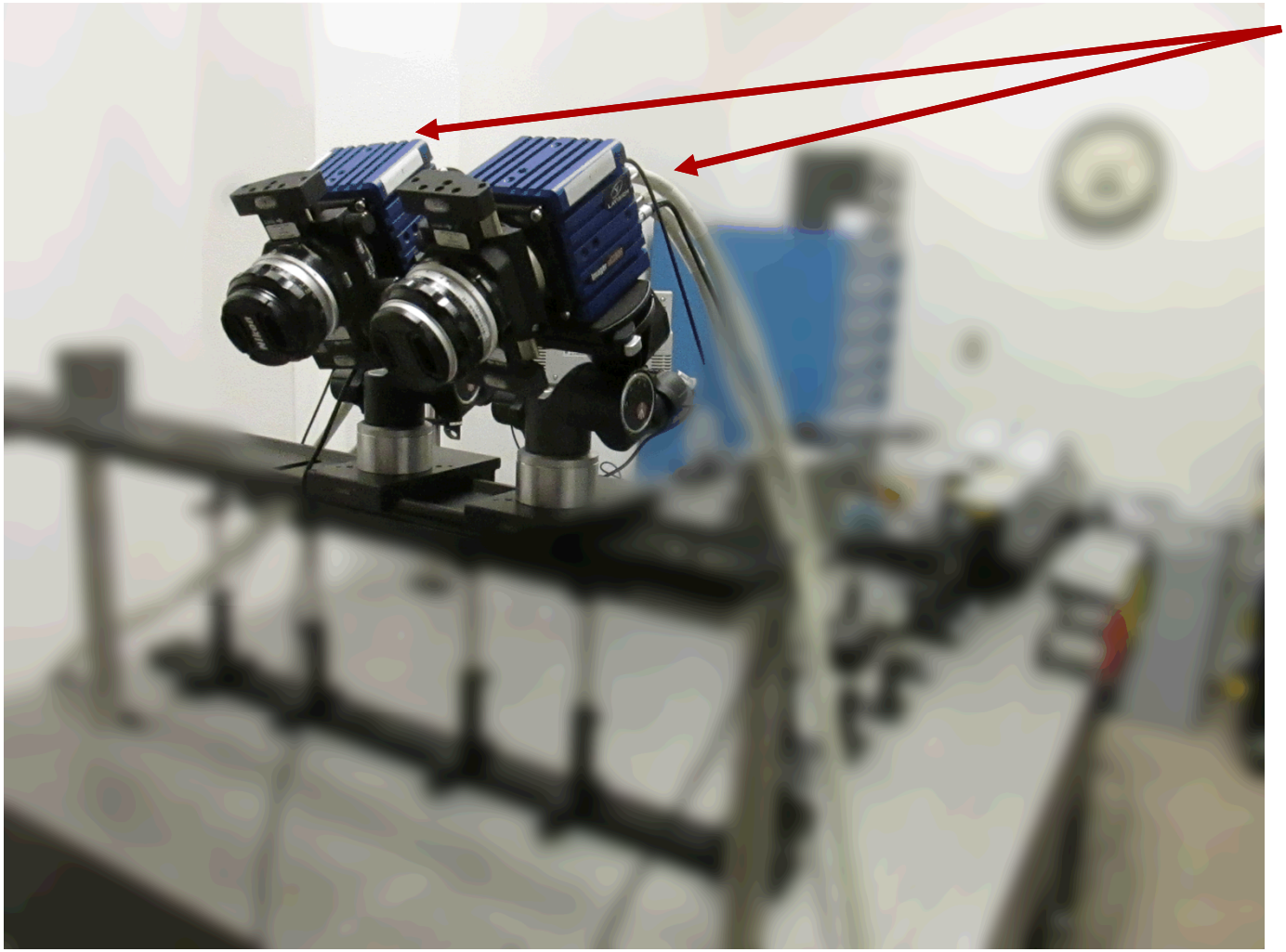
Back

Front



Experimental Setup (cont.)

Sandia National Laboratories



Front

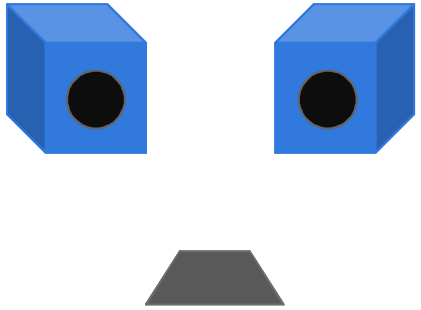
sCMOS Cameras with Scheimpflug Adapters

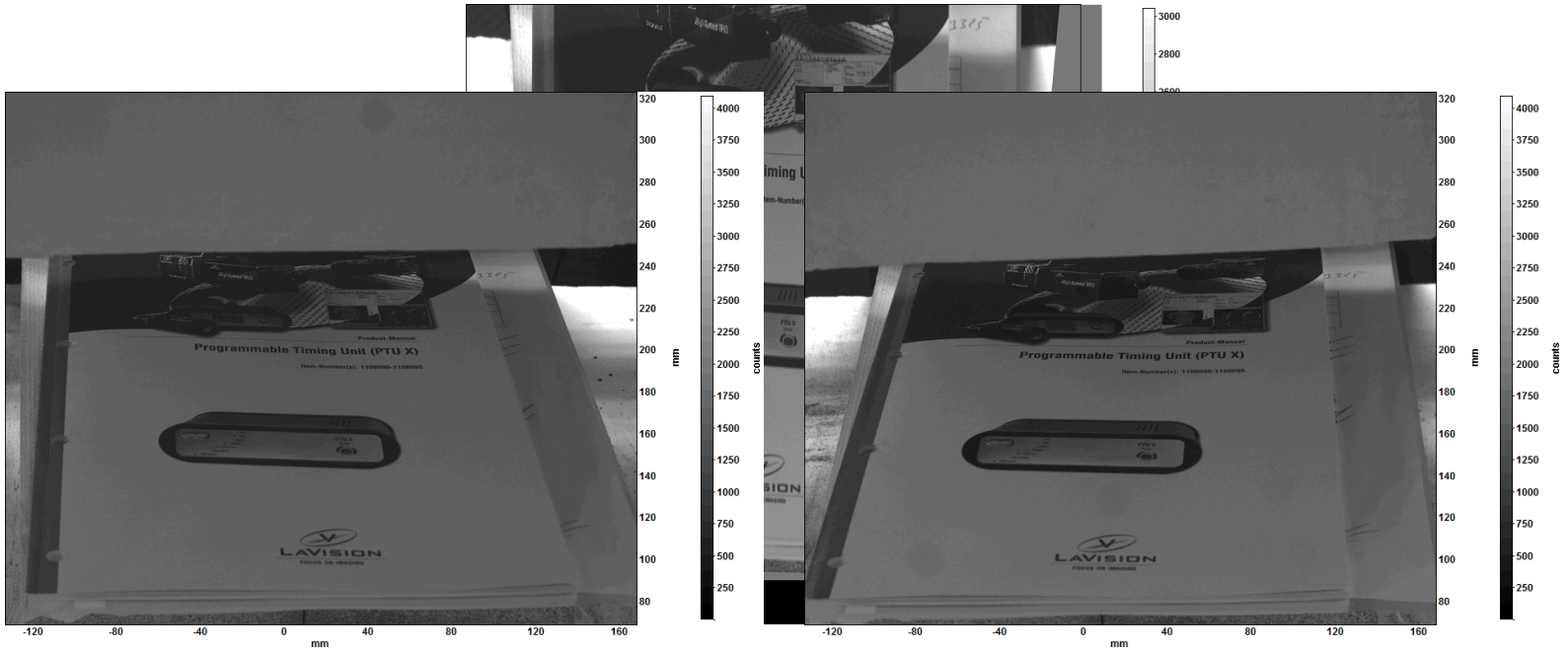
The cameras have a 460 nm and 500 nm filter respectively to capture the two YAG:Dy peaks for the ratio test.

Back

Camera Calibration

- Calibration plate points manually selected of points and known dimensions of the plate.
- By mapping both images properly, it will be possible to make ratio-based phosphor measurements





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- Dieke, Go Ho, and H. M. Crosswhite. "The spectra of the doubly and triply ionized rare earths." Applied optics 2.7 (1963): 675-686.
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Questions?