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Sandia National Laboratories

Fire Science & Technology

EIVR 61 EMP and Fire Meeting

October 5-8, 2015, AWE Aldermaston, UK

Solar Furnace NW Fire Tests at Sandia National Labs

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Fire Science and Technology Department

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Background

- Fire ignition by high heat flux from a NW event is difficult to assess
  - Pyrolysis kinetics are normally measured at low heating rates
  - Modeling is not necessarily mechanistic, extrapolates poorly
- Historical ignition data is dated
  - Construction and typical building materials have changed with time
  - Data are predominantly from the Pacific islands, NTS
- We are considering the Solar Furnace as an experimental facility to produce relevant conditions
  - Can focus thousands of suns on a spot
  - Rapid shutter movement helps match temporal profiles
  - Provides data that can be used to characterize model accuracy
- Initiated some scoping tests on FY15 PD funding from DTRA

Solar Furnace Facility

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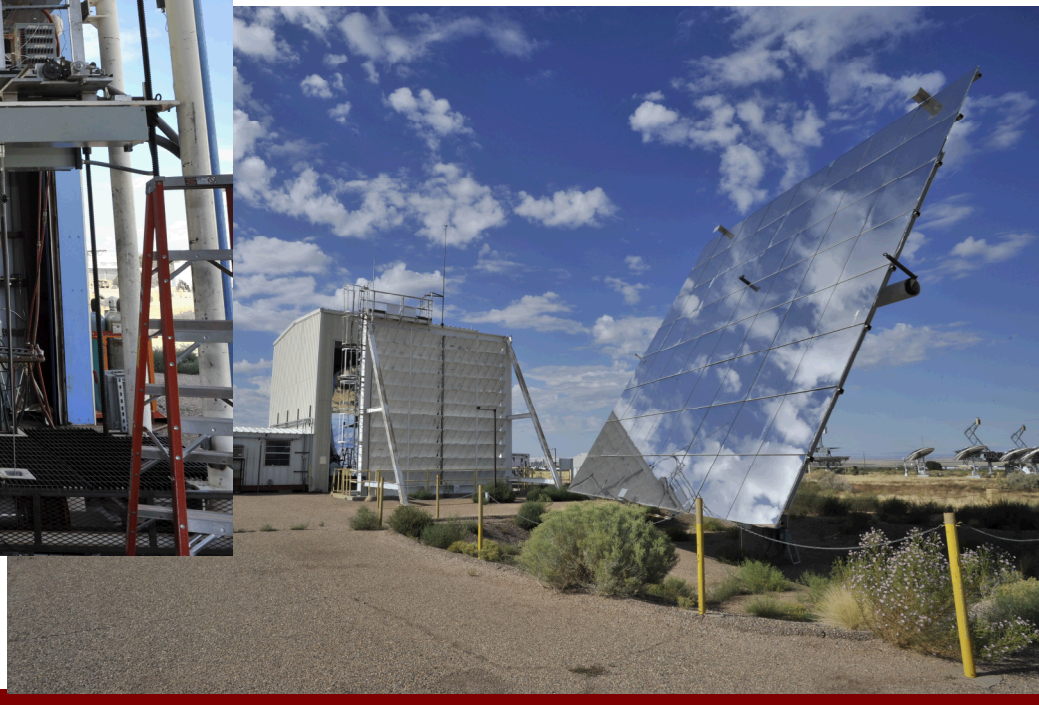
- Reflects sun using a heliostat through a louvered panel
- Shaped mirror focuses sunlight onto a test article

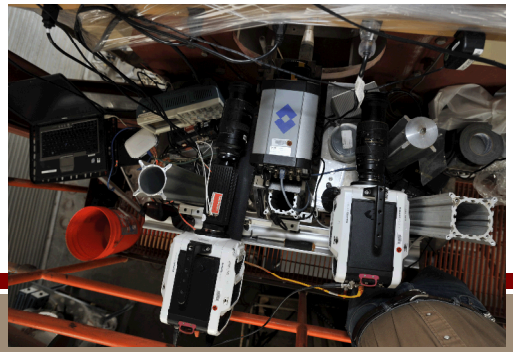


Test Conditions

- Total fluence of around 500 J/cm^2 (representative of a 100 kT 10 psi condition based on ARA estimates)
- Flux applied for about 2 seconds, ramp up, short hold, ramp down (similar to ARA estimate conditions).
- Spot size around 1 inch diameter.
- Ambient weather conditions typical of Albuquerque at 11:00 am in September.
  - Dry
  - Room temperature (~25-30 ºC)
  - Sunny

Scoping Tests

- First test round Sept. 9, 2015
  - Verified instrumentation
  - Worked on replicating ARA provided flux profiles
  - Developed production operational methods
  - High clouds, flux levels not particularly reproducible
  - Tested three materials, wood, HIPS, PMMA
- Second test round Sept. 15, 2015
  - Conducted with ARA and LANL participation
  - Good test conditions, partially clear skies
  - Tested four material, wood, HIPS, cotton, paper
- Additional instrumentation and videography provided by the SNL photometrics group
  - Narrow-band IR
  - Post-test production video creation



First Test Round Results

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- Flaming only occurred in HIPS, a few frames
- PMMA was transparent, barely distorted, lightly smoked
- Wood decomposes heavily, does not ignite

Lessons Learned:

- To achieve flaming (a main objective):
  - Use paper and/or cotton
- Look for a better test day for reproducible fluxes
- Some operational issues were noted
  - Some video files were large, data transfer took too long
  - Some video was missed, requires consistent coordination
  - Flux measurements had low temporal resolution

Second Test Round Results

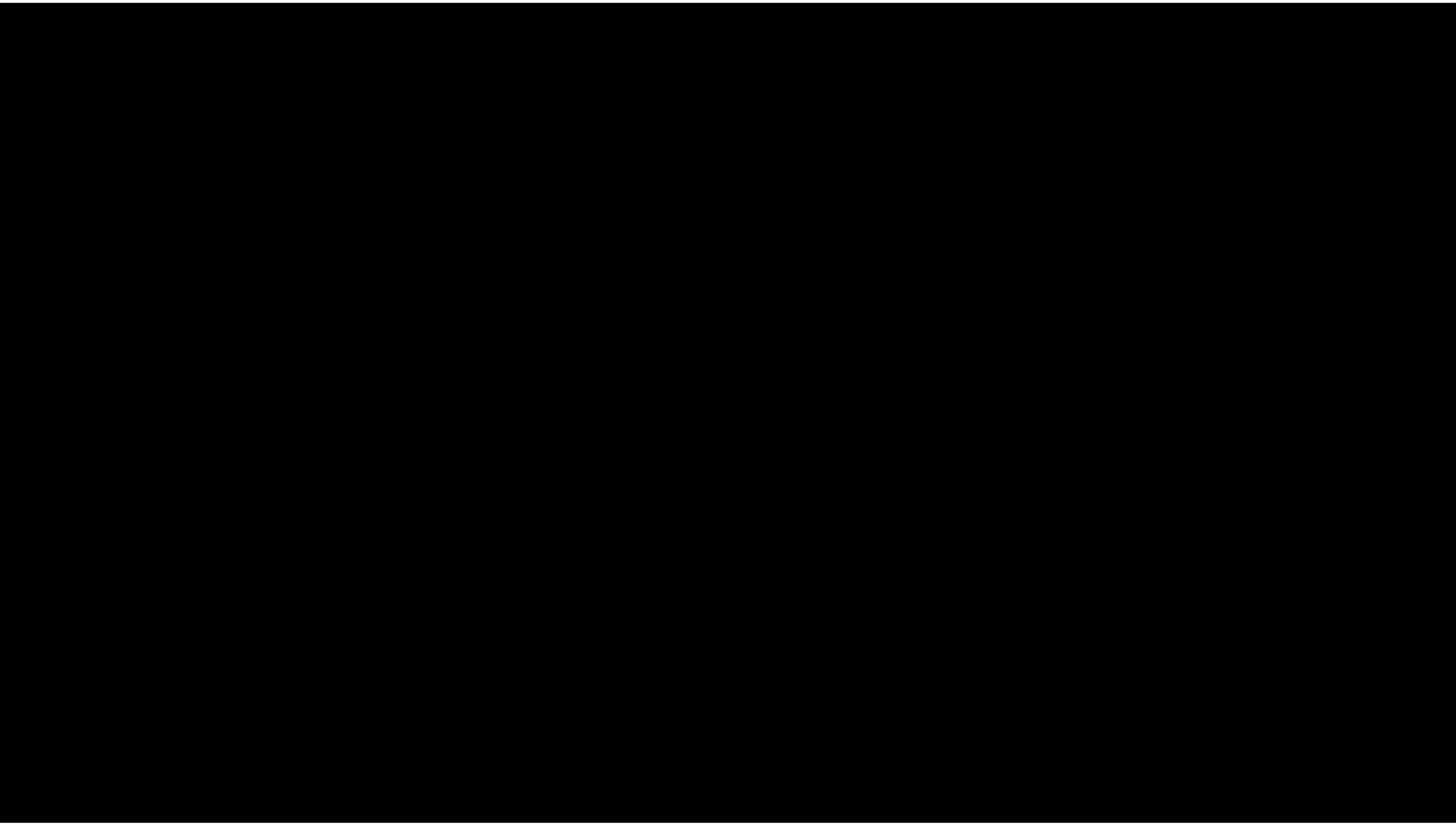
- Significant flaming for paper, cotton, and paper/wood mix scenarios
- HIPS did not ignite
- Some materials (cotton and paper) continued to smolder for 10+ minutes after the initial pulse

Operational improvements:

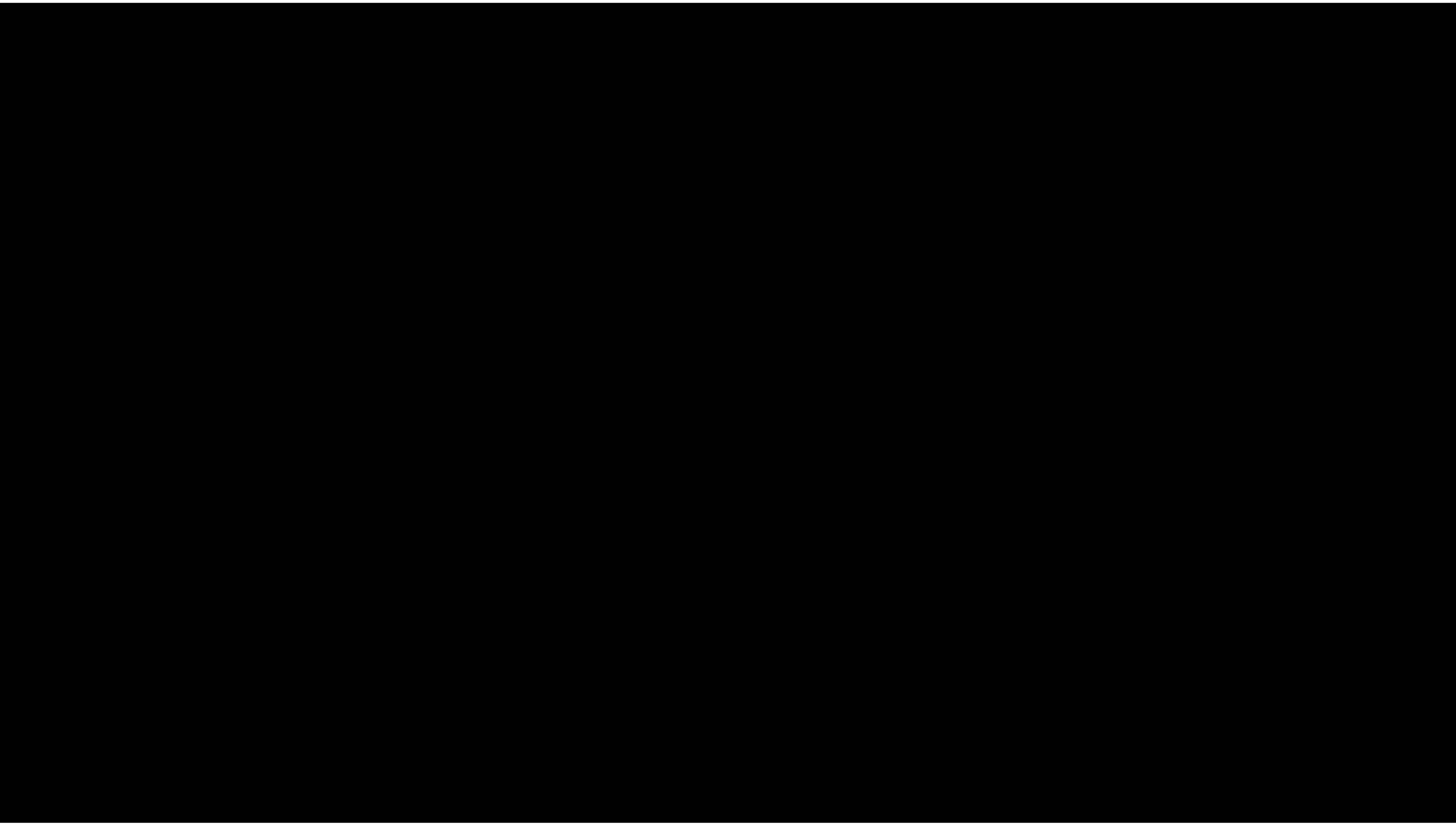
- Slightly improved flux recorded from heat flux gauges
- Fewer issues with videography

Wood (test 1)

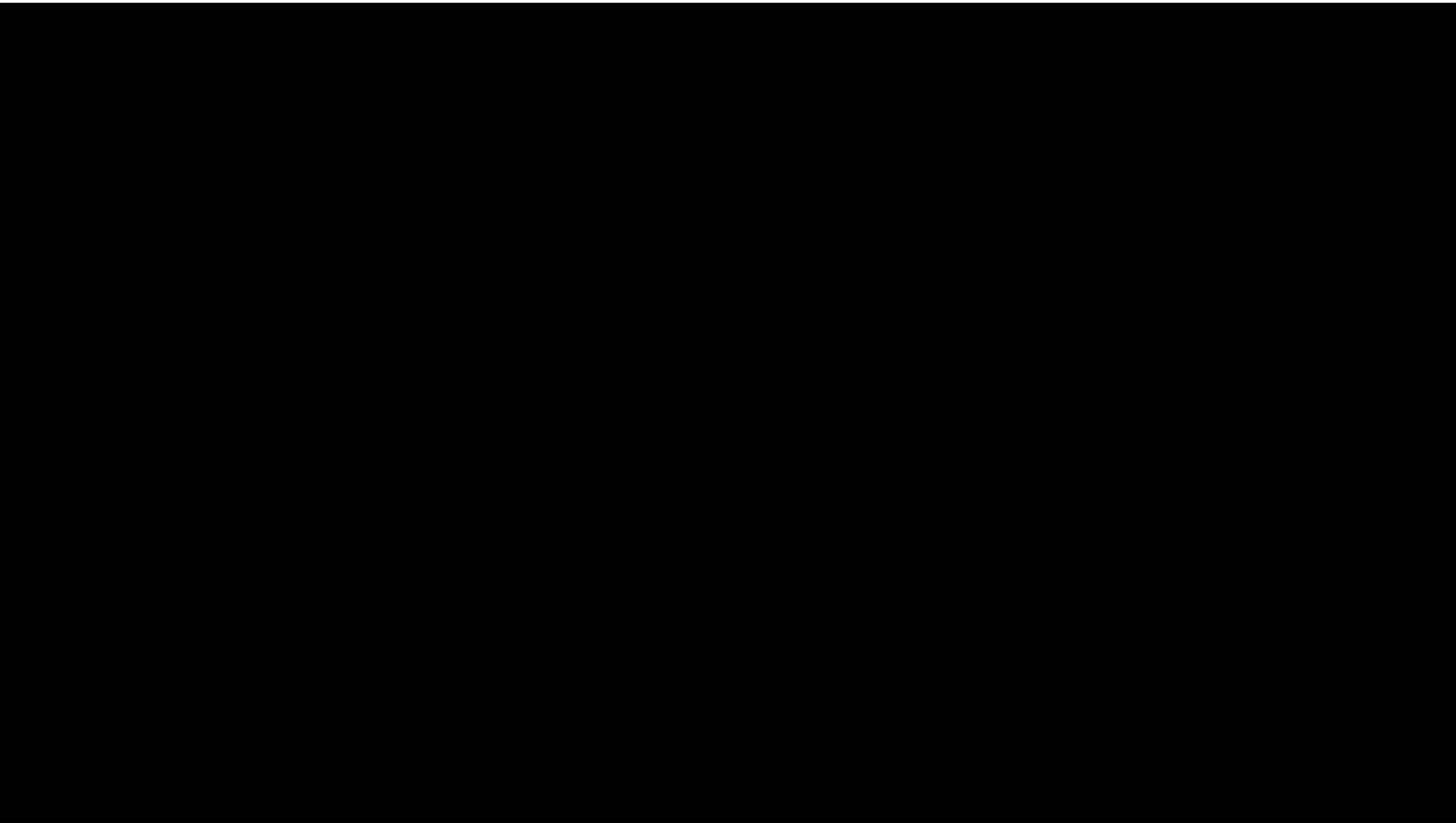
High Impact Polystyrene HIPS (test 2)



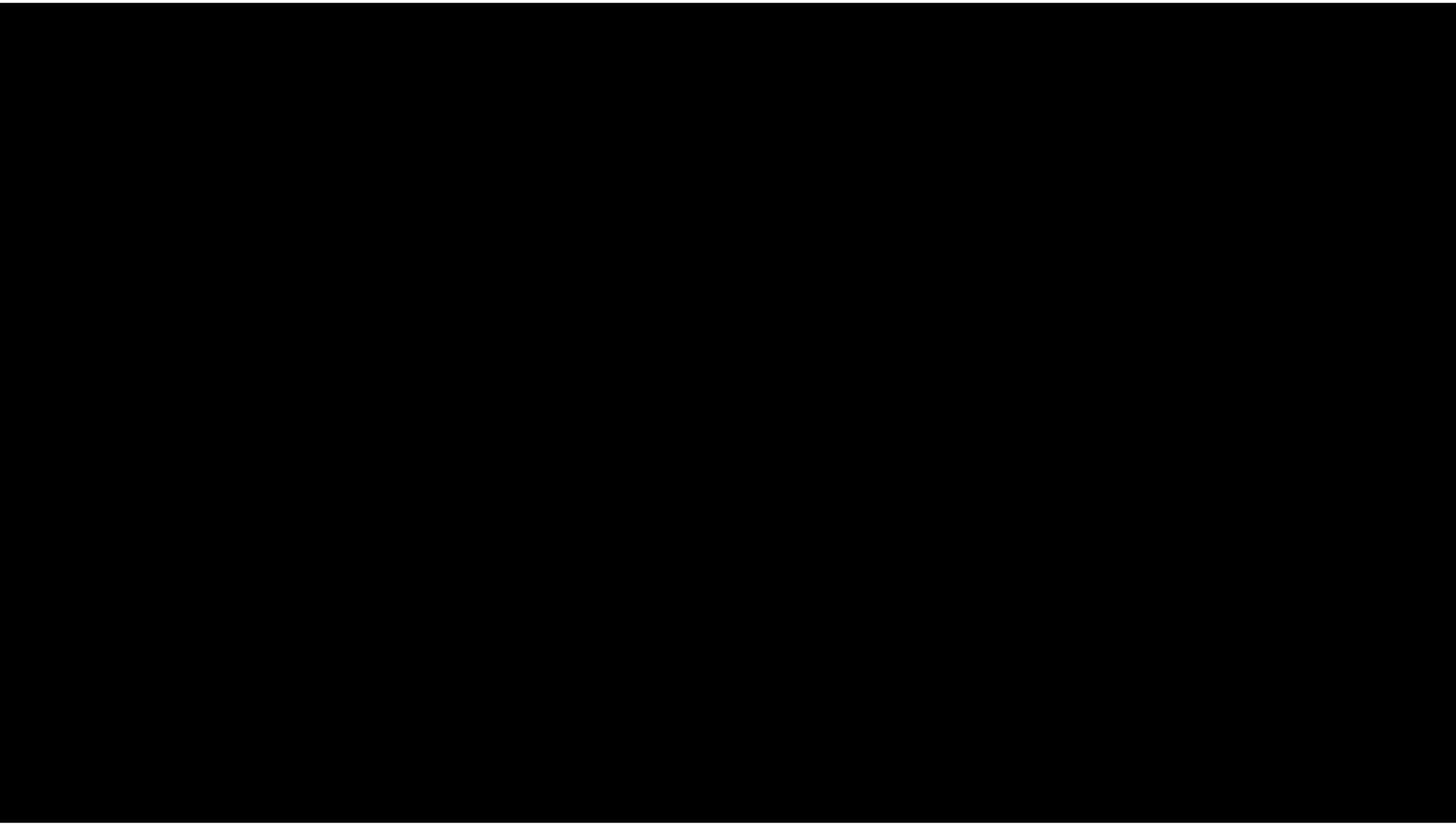
Paper notebook (test 3)



Paper and Wood (paper on a desk; test 4)



Cotton Fabric, 8 layers (test 5)



Scoping Test Results (Round 2)

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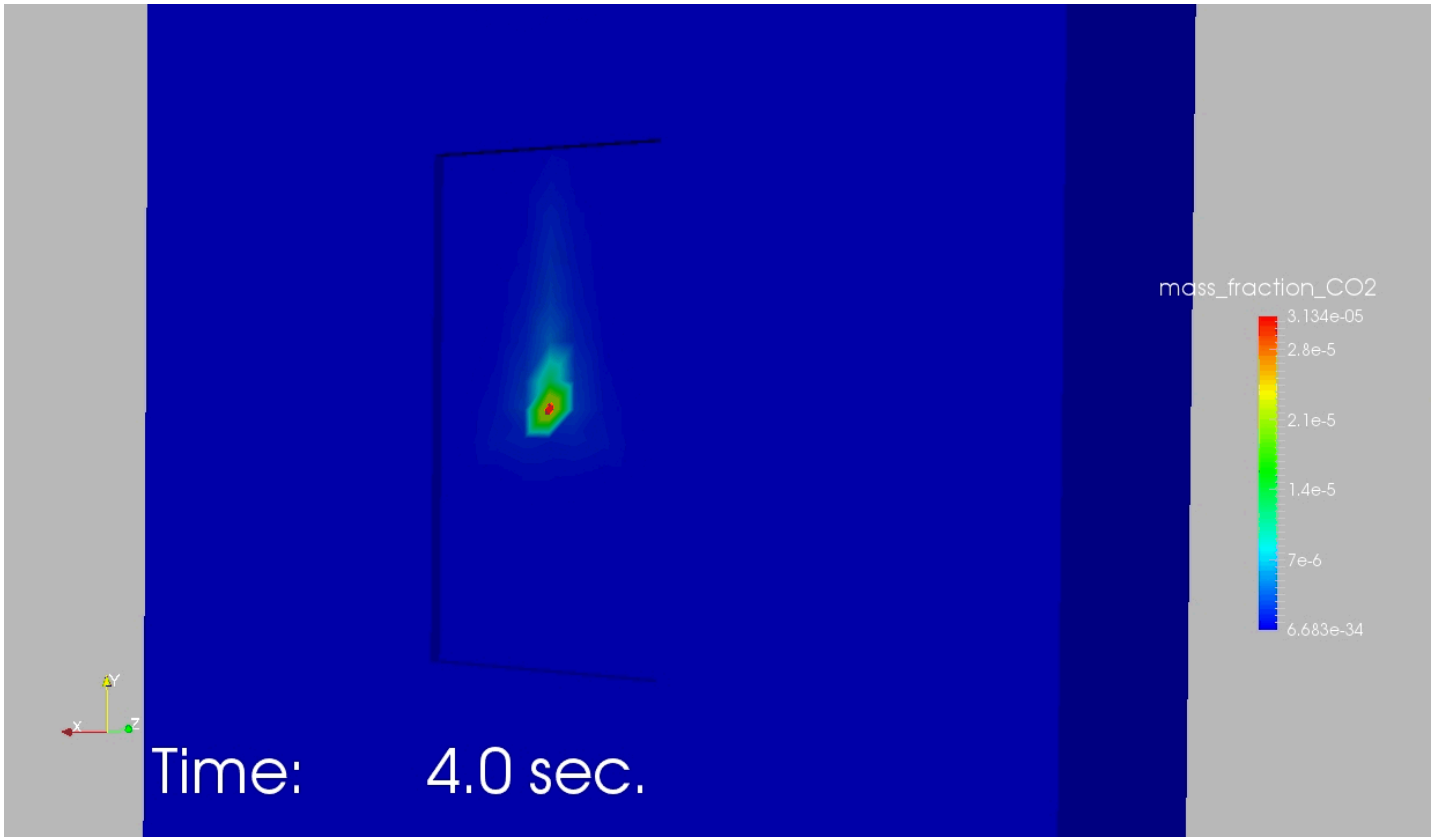
Next Step

- Consider the materials we wish to test
  - Select ones we know little about but are relevant
  - Select ones we should be able to do well (know a lot about)
  - Select ones that are of highest relevancy
- Design test conditions to optimize utility of data
  - Do we impose a wind pulse?
  - Defocus the shot for a bigger spot?
- Determine/prescribe instrumentation
  - What will we measure? Temperatures, species, velocities, weights?
  - What instrumentation will we field?
  - What is most valuable to the modeling team?

Working on a Model in Fuego

- Using the 1-D boundary condition
- Replicating the directionality of the flux is a challenge



Summary

- We brought together the SNL/LLNL/ARA team to conduct some initial fire tests at high heat flux
- Flaming was easily achieved for paper and cotton
- HIPS exhibited minor flaming (not sustained)
- Wood did not ignite, off-gassed heavily
- SNL photometrics department exhibited some post-processing capabilities

Acknowledgements

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