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Soot and temperature measurements and predictions in highly sooting turbulent flames

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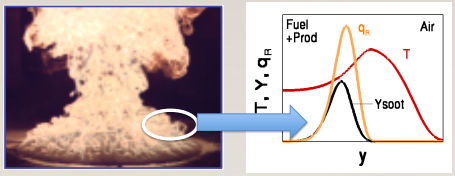
Motivation

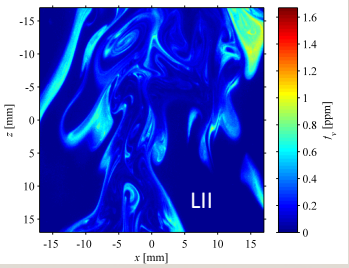
- **Soot radiation emission is dictated by the interplay between concentration and temperature fields**

$$\frac{\overline{dI_\lambda}}{ds} = \overline{\mu_\lambda I_{\lambda,b}(T)} - \overline{\mu_\lambda}\,\overline{I_\lambda}$$

- **Temporally and spatially correlated temperature/soot statistics are needed for model development and validation**

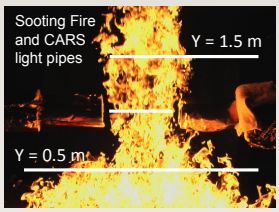


Piloted Turbulent Jet Flame

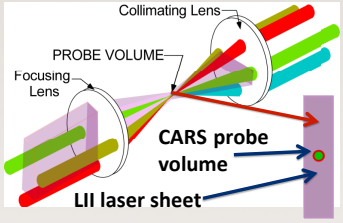


- **C_2H_4 jet flame based on Zhang and Shaddix design[1]**
- **Pilot-stabilized canonical flame is well-suited for model development**

CARS/LII Measurements in 2-m Sooting Pool Fire[3,4]



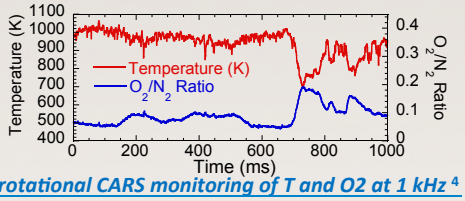
2-m-diamter toluene/ methanol fire



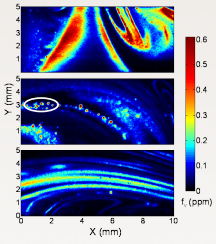
CARS/LII beam arrangement

High-Speed Diagnostics for Enhanced Data Rates

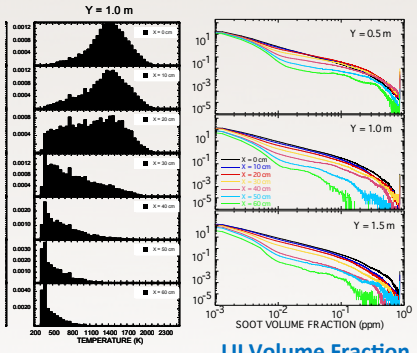
- **kHz rate femtosecond, DPSS, and pulse-burst lasers**
- **Converged T/fv joint statistics**
- **3-4x improvement in measurement precision**



fs rotational CARS monitoring of T and O2 at 1 kHz [4]



LII images at center of the fire plume



CARS Temperature pdfs at height Z =1 m

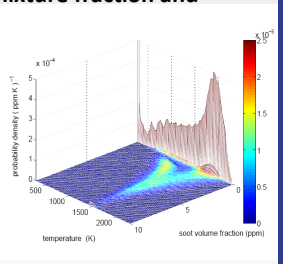
LII Volume Fraction pdfs at 3 heights

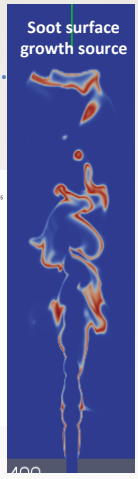
Modeling Work

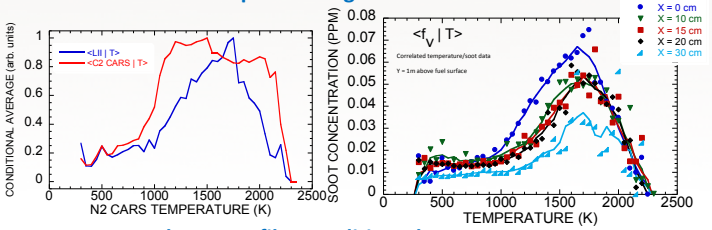
LES to capture fluctuations in mixing histories.

- **Evolve soot moments and enthalpy.**
- **Main flame chemistry, soot sources: quasi-steady-state in mixture fraction and enthalpy.**

Supporting stochastic simulations with ODT and OU models to understand role of fluctuations.







Averaged soot profiles conditioned on temperature

Expected Results

- New data with *better converged* temperature/ soot statistics.
- Joint f_v/T pdf for radiation modeling.
- Canonical pilot-stabilized jet flame geometry.

References

[1]J. Y. Zhang, C. R. Shaddix, and R. W. Schefer, *Review of Scientific Instruments*, vol. 82, Jul 2011.
[2] Kearney, S.P. and D.J. Scoglietti, *Opt. Lett.* **38**, 833 (2013)
[3] Kearney, S.P., K. Frederickson, and T.W. Grasser, *Proc. Combustion Inst.* **32**, 871 (2009)
[4]Frederickson, K., S.P. Kearney, and T.W. Grasser, *Appl. Opt.* **50**, A49 (2011)

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