CRF Website- Reacting Flows- Advanced Imaging

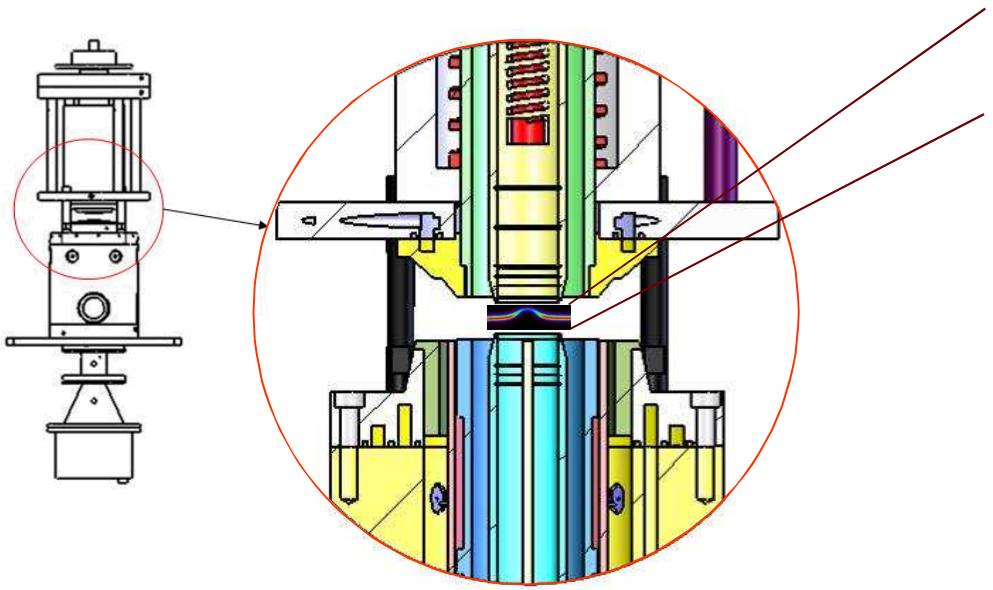
SAND2011-6397P

Development and application of imaging diagnostics for reacting flows are focused on improving fundamental understanding of flow-flame interactions. In turbulent combustion, complex interactions between turbulent flows and flames span a wide range of length scales. Imaging techniques provide spatially and temporally resolved measurements of these interactions. Multi-dimensional measurements are necessary to determine spatial correlations, gradients, flame orientation, curvature, and connectivity.

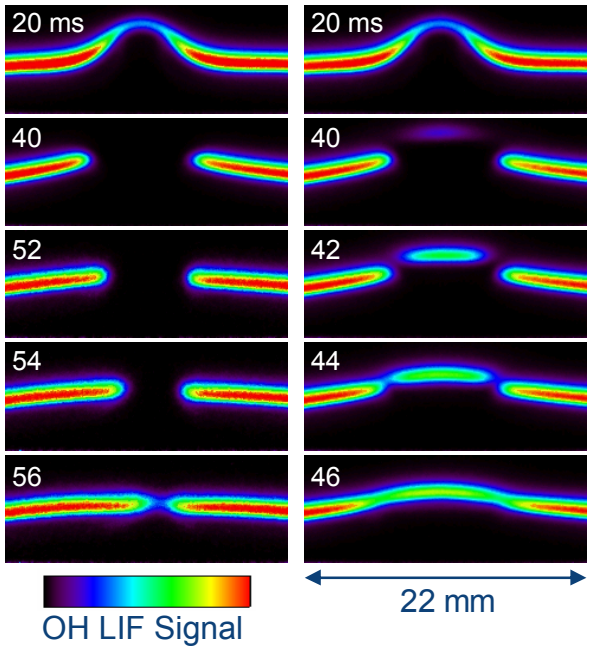
Combinations of laser Rayleigh scattering and laser-induced fluorescence are used to measure spatial distributions of key quantities such as temperature, species concentrations, reaction rates, mixture fraction, and scalar dissipation. The velocity fields are probed using particle imaging velocimetry. A set of complementary approaches are used for studying flow-flame interactions. In one approach, a suite of diagnostic techniques is applied to isolated repeatable flow-flame interactions to investigate the effects of flow transients on detailed flame structure. By performing measurements at different phase delays in a highly reproducible forced flow, we can eliminate constraints of temporal resolution and obtain detailed phase-resolved measurements. A complementary line of research uses instantaneous measurements in turbulent flames to elucidate turbulence-chemistry interactions using ensemble statistics of single-shot imaging measurements. The third component of our research focuses on directly probing the time-history of transient events in turbulent flames, such as localized flame extinction or ignition. Advances in diagnostic capabilities enable us to probe the temporal evolution of turbulent flames using high repetition rate laser and camera technology.

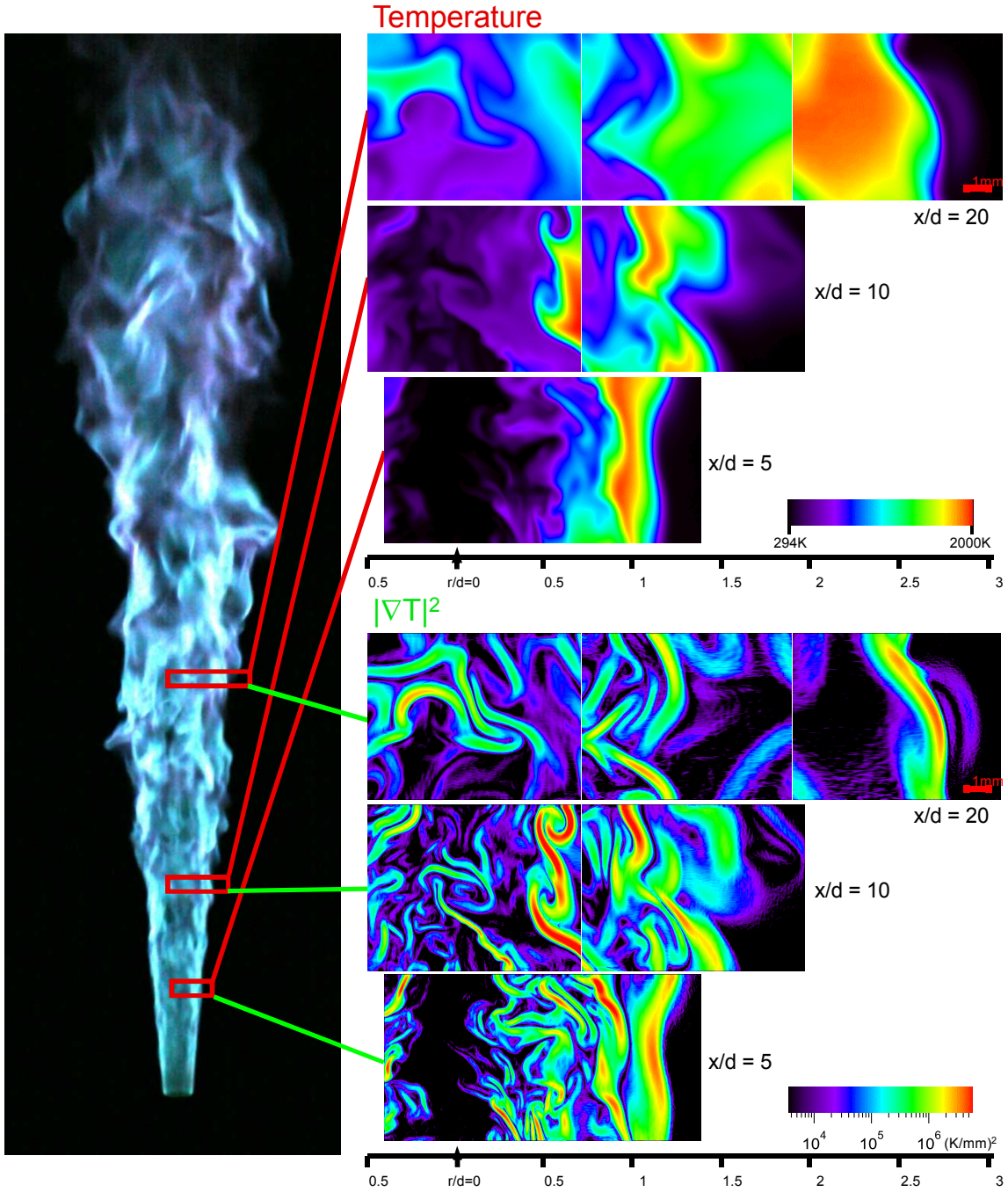
Recent experiments have contributed to the knowledge base of turbulent partially premixed jet flames, premixed and non-premixed counterflow flames, and stratified premixed flames. Experimental results are frequently coupled with numerical simulations of flow-flame interactions in order to further the development of combustion modeling.

Hydrogen-air Counterflow Flame



160 ppm NO in air flow




Temperature
1mm
x/d = 20
x/d = 10
x/d = 5
294K
2000K
0.5
r/d=0
0.5
1
1.5
2
2.5
3
|∇T|2
1mm
x/d = 20
x/d = 10
x/d = 5
10^4
10^5
10^6 (K/mm)^2
0.5
r/d=0
0.5
1
1.5
2
2.5
3

Stratified Combustion Studies