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Strategy for background-free measurements of high-speed OH in turbulent flames using SLIPI

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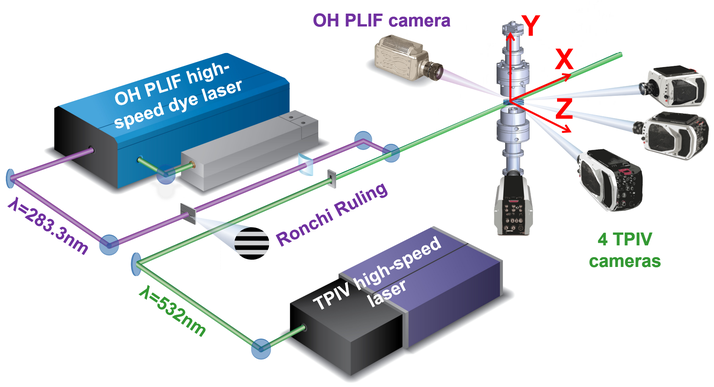
High-speed OH measurements combined with tomographic PIV (TPIV) measurements at 10 kHz is demonstrated. This allows turbulent combustion phenomena, such as, quenching and re-ignition, to be studied from temporal/Lagrangian perspective. However, it may not be trivial to unambiguously identify a quenching event for high speed scalar measurements because of the finite exposure gate width available and comparably weak signal levels which often result in the detected image being a mixture of signals and significant background from flame chemiluminescence and stray lights. Structured Laser Illumination Planar Imaging (SLIPI) is employed to high-speed OH measurements, and its potentials to effectively extract the desirable signals from significant background are discussed.

Combined High Speed OH and Tomographic PIV



Tomographic PIV

Two Nd:YAG laser heads
Power: 50W/head @ 10kHz
Wavelength: 532 nm

4 High-speed CMOS cameras
Resolution: 1024x768 px^2 @20 kHz

Probe volume: 18x14x2 mm^3

OH PLIF

10kHz Nd:YAG-pumped dye laser
Energy: 60 μJ/pulse
Wavelength: 283.3 nm

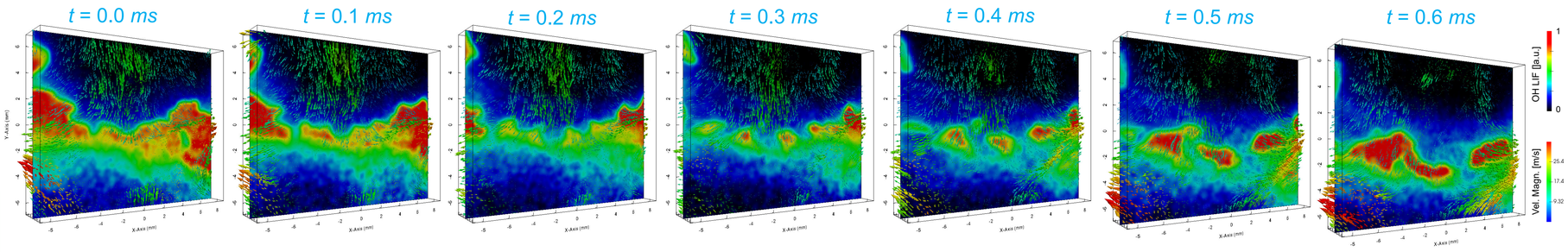
Intensified high-speed CMOS camera
Resolution: 704x432 px^2 @10kHz
Imaging Size: 18x14 mm^2
Exposure time: 1 μs

Flame condition for Counter Flow Turbulent Flame

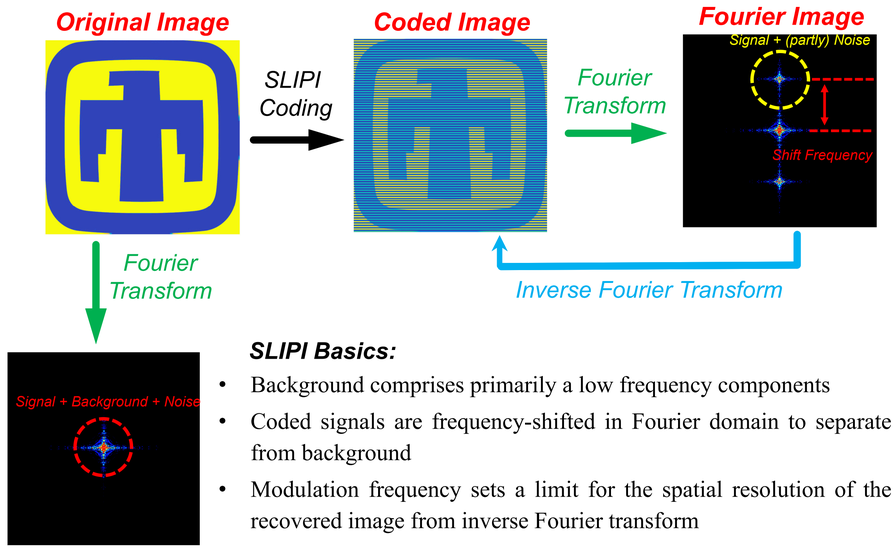
The lower nozzle supplies hot product of Phi=1.0
The upper nozzle supplies unburn mixtures given below:

Mixture	N_2/O_2 Ratio	Phi	S_L (cm/s)	Re_l	u' (m/s)	l_F (mm)
$CH_4/N_2/O_2$	70/30	1.0	79.1	1050	3.9	0.25

Background issue in identifying a quench event visualized by OH/TPIV



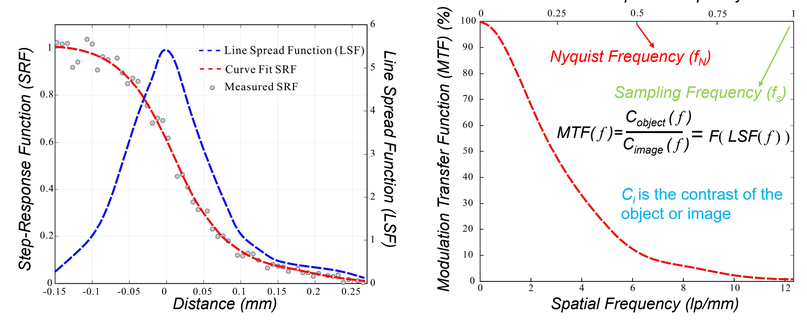
Concept of SLIPI



SLIPI Basics:

- Background comprises primarily a low frequency components
- Coded signals are frequency-shifted in Fourier domain to separate from background
- Modulation frequency sets a limit for the spatial resolution of the recovered image from inverse Fourier transform

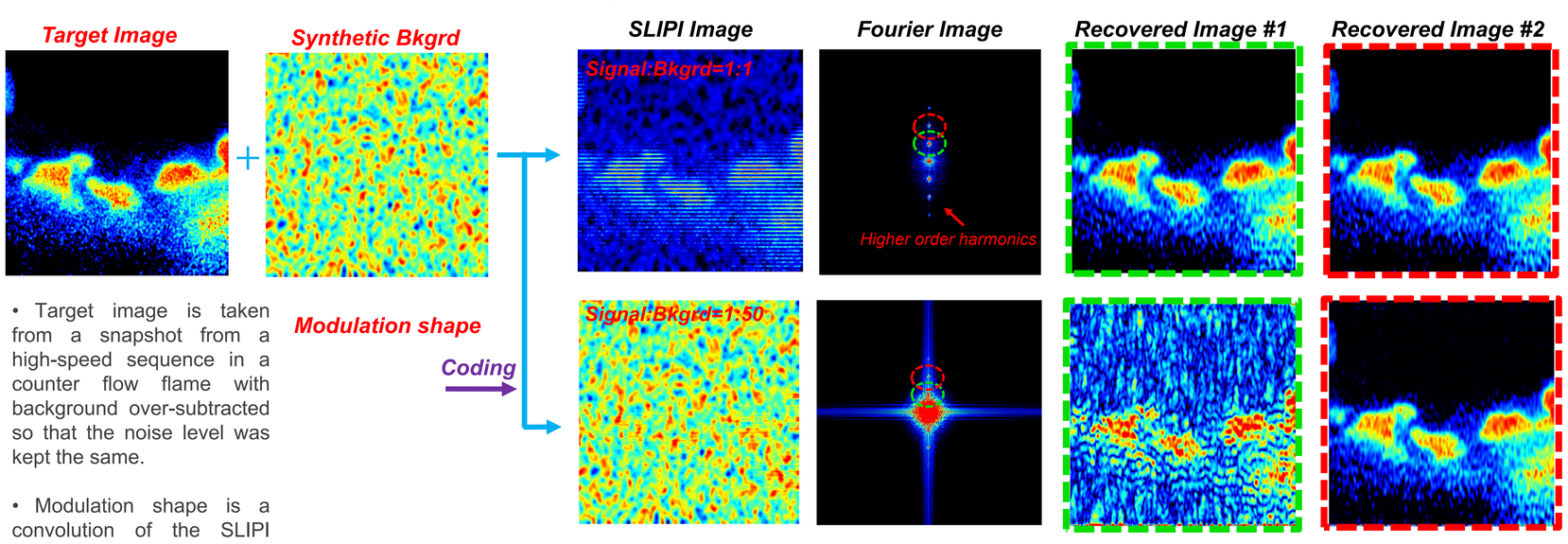
Characterization of high-speed OH detection system



LSF characterizes how an infinitely thin line is broadened when imaged by the detection system

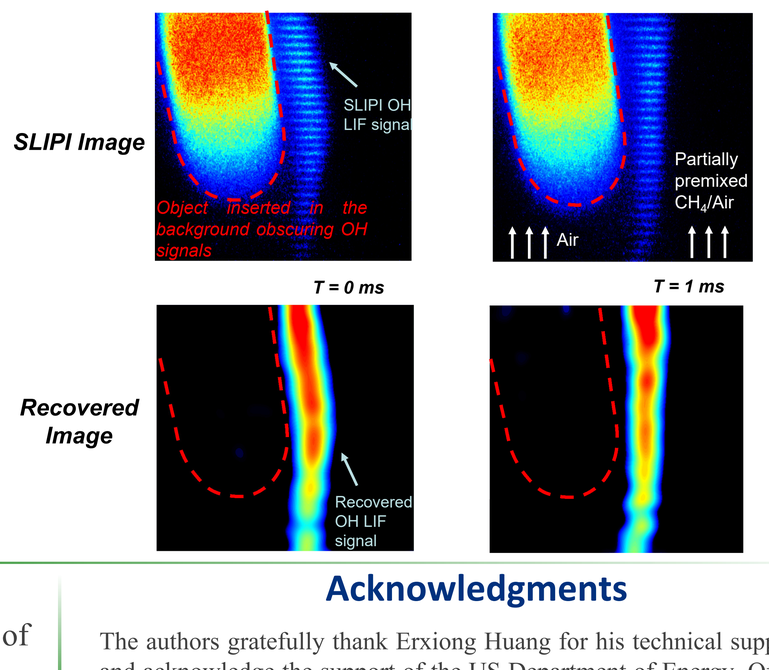
MTF describes the change of imaging contrast of an object imaged by the detection system, and is obtained through Fourier Transfer of the **LSF**.

Effect of background levels and modulations



- Target image is taken from a snapshot from a high-speed sequence in a counter flow flame with background over-subtracted so that the noise level was kept the same.
- Modulation shape is a convolution of the SLIPI modulation profile and the LSF.

Experimental realization of high-speed SLIPI OH in a lifted jet flame



Summary

- Combine high-speed OH/TPIV provides the potential to unveil new information from studying the temporal dynamics of turbulent flames. High fidelity of the high speed data can be critical for this purpose.
- SLIPI technique shows potentials to provide high fidelity of high speed scalar measurements even under the presence of significant background interference. Characterizations of detection system as well as modulated laser sheet are recommended to ensure a successful SLIPI measurement.
- The demonstrated high tolerance of SLIPI signal to background suggests high speed SLIPI could be applicable to even harsher environment than the situation presented in this work.

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