# High Speed Shadowgraphy of a Combusting Air Blast Atomizer Spray at Elevated Pressure

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**Abstract**

This contribution demonstrates the use of a compact high repetition rate pulsed high power LED light source in conjunction with a high speed camera to obtain high speed shadowgraphs of an airblasted spray in a fired research combustor at medium pressures.

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## Introduction

In gas turbine combustion of liquid fuels, the fuel placement is of primary importance for the ensuing combustion characteristics. Current knowledge shows, that the time dependent behaviour of the flow as well as that of the atomization process of the liquid fuel itself exhibit coherent structures, which can have an influence on macroscopic features of combustion. Therefore, high speed visualisation of the emerging spray and its mixing into the burner air flow is a useful tool to gain a quick overview on the unsteady phenomena which might be of importance throughout the operation range of the combustor. High speed imaging has seen a very rapid development in recent years with increasing camera performance at decreasing prices. Yet simple to use, high speed light sources remained scarce until the recent introduction of high power LED. In this contribution, an application of a pulsed LED light source is exemplified. The temporally resolved structures of the spray are compared with time series of drop-sizing measurements made by a Phase Doppler instrument.

## Materials and Methods

The facility, an optically accessible, single sector combustor, is described in detail in [1]. The general arrangement of the high speed shadowgraphy imaging setup was already described in [2] to study the atomization of a single kerosene jet issuing into an isothermal cross-flow. For the present application however a new high power LED source enabled the illumination of a significantly larger field of view allowing the full spray field downstream of the burner to be imaged at frame rates of 20 kHz. Details of the pulsed LED light source and experimental procedures will be presented in the paper. Fig. 1 shows a photograph of the combustor facility in operation with the pulsed LED light source and high speed camera positioned on opposite sides. Frequency spectra of high framing rate videos were obtained by image processing. These are compared in the paper to time series of Phase Doppler measurements.

## Results and Discussion

The compact, pulsed LED light source enabled the visualization of the global characteristics of the unsteady spray. Fig. 2 shows an example of the spray structure. A helical structure can be seen, which is present right from the atomizer edge and persists long enough to enter the combustion zone in which the spray is eventually completely evaporated. Spectra of type shown in Fig. 3 can be obtained from the high speed films by sampling the temporally evolving image intensity at a fixed position. For the present investigation a dominant frequency near 2 kHz is present and is representative of the periodic detachment of the helical spray structure from the burner exit into the combustion chamber. Future work will concentrate on the coupling of unsteady atomization with the unsteady characteristics of the gas flow.

## References

[1] S. Freitag, U. Meier, J. Heinze, T. Behrendt and C. Hassa, Measurement of initial conditions of a kerosene spray from a generic aeroengine injector at elevated pressure., *Accepted: 23rd ILASS Europe 2010*

[2] C. Willert, S. Freitag, and C. Hassa, High speed imaging of fuel sprays using a low-cost illumination source, *22nd ILASS Europe 2008*, Como, Italy, Sept. 2008, Poster No. 15

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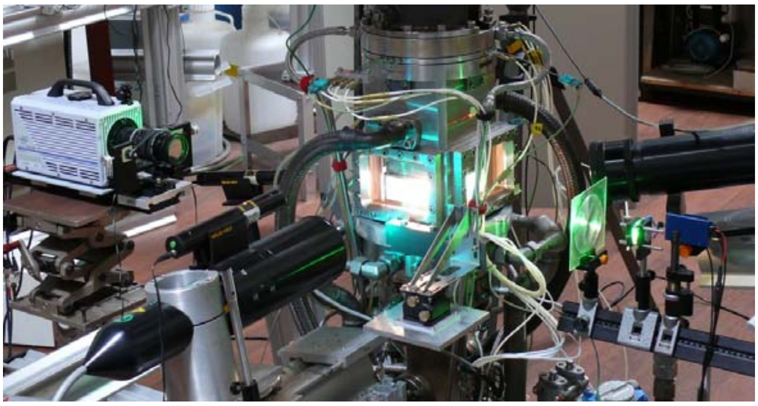

**Figure 1.** High speed shadowgraphy set up on the optically accessible single sector combustor facility during operation at 4 bar. The LED light source and collimating optics can be seen on the right while the camera is located on the opposite side to the left of the facility. PDA delivery and receiving optics are also visible.

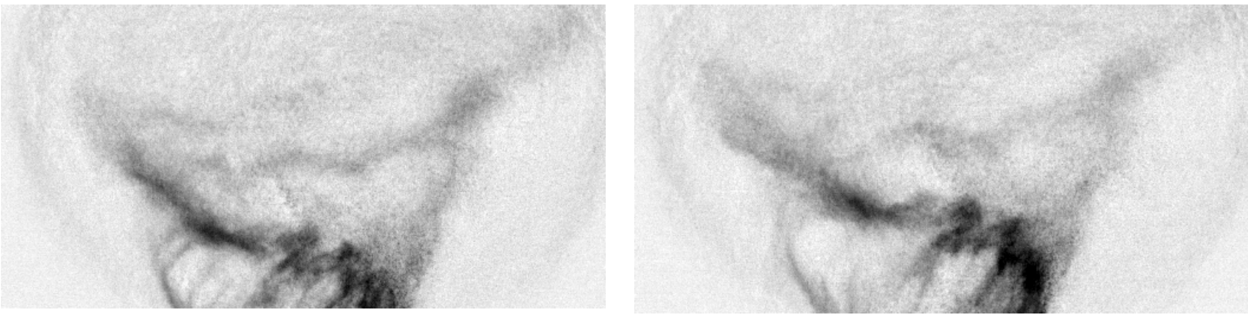

**Figure 2.** Two successive shadowgraph images of the airblast spray at 4 bar pressure obtained at 50µs time separation (20 kHz). LED illumination was limited to 2µs to freeze the motion of the structures

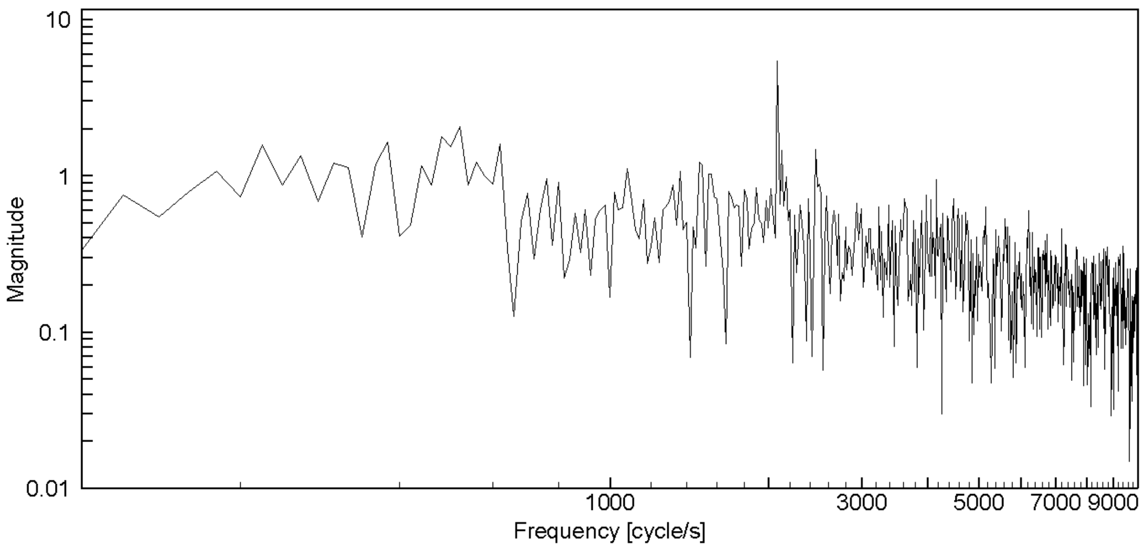


**Figure 3.** Frequency spectrum calculated from high speed shadowgraphy image data of the type shown in Fig. 2