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Scalar dissipation statistics in turbulent swirling flows

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1. INTRODUCTION

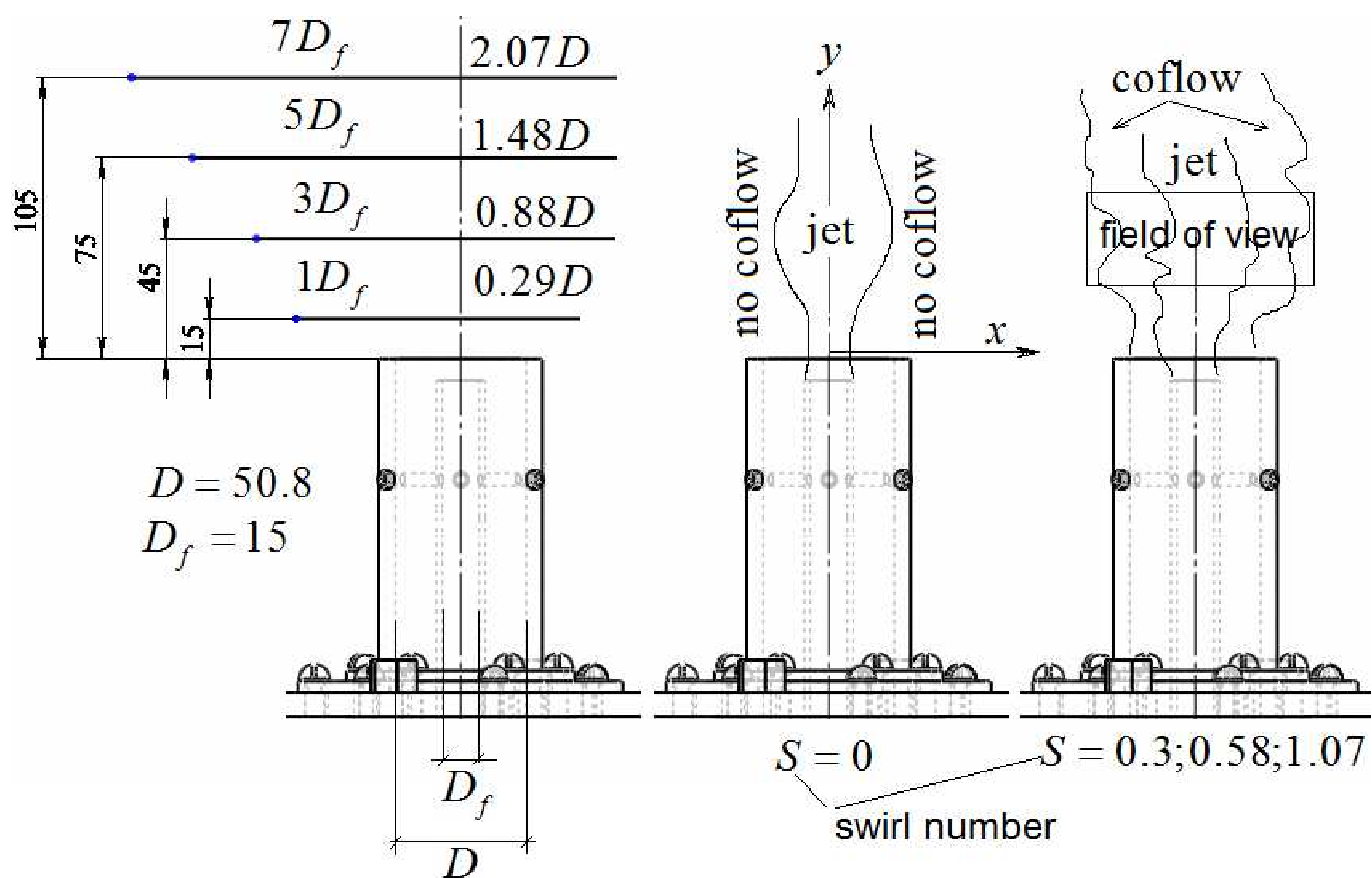
The dissipation rate $\chi \equiv D \nabla z \nabla z$ (z denotes mixture fraction, D is diffusivity) requires modeling in essentially all models for non-premixed combustion. The scalar dissipation rate can be used for instance in a pdf-flamelet approach in which species mass fraction and mean reaction rate are pre-calculated as a function of two variables namely mixture fraction and the scalar dissipation rate. Peters (1983) identified the scalar dissipation rate as a characteristic diffusion time scale, imposed by the mixing field.

2. AIMS AND OBJECTIVES

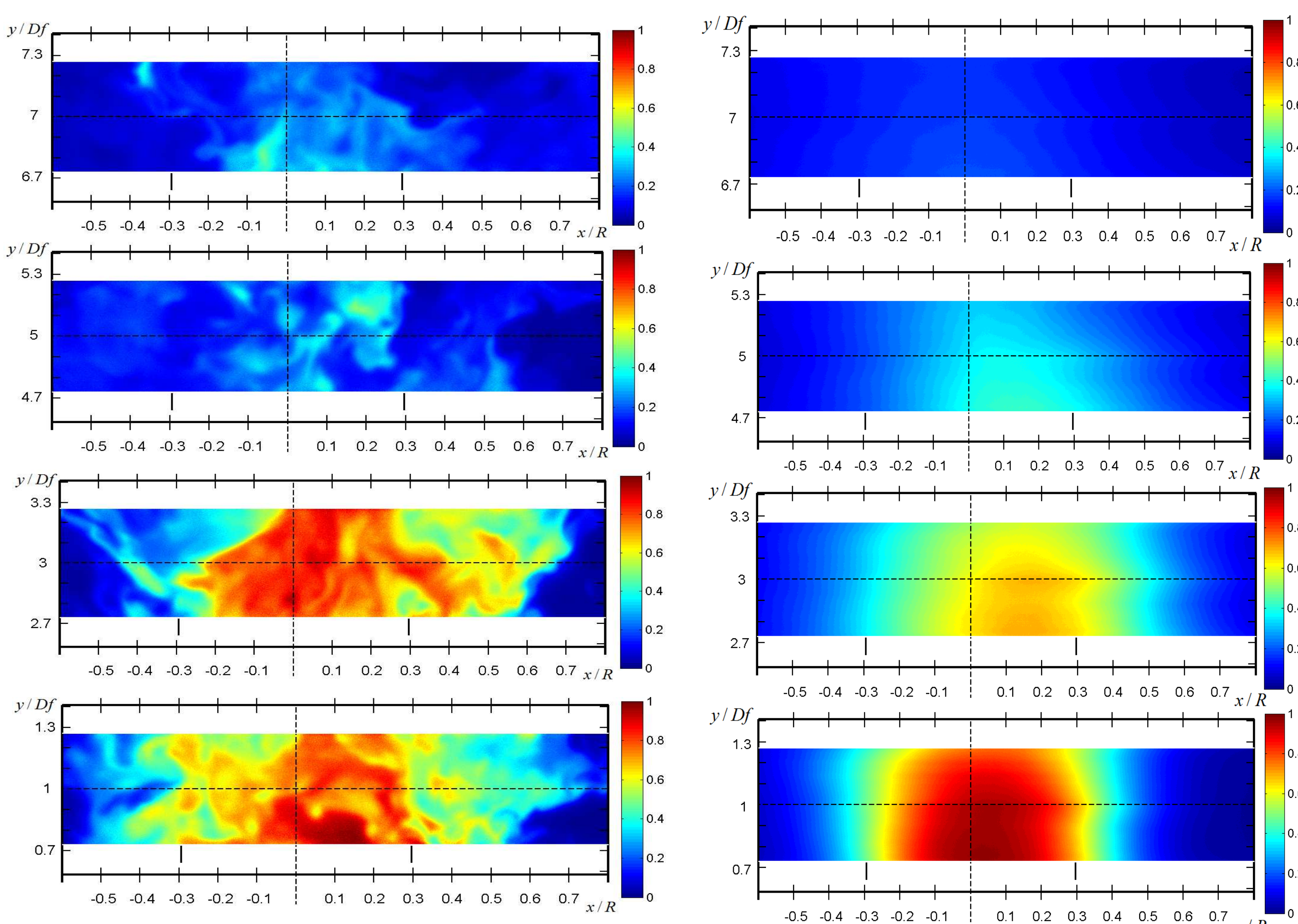
- measurements of scalar dissipation in turbulent non-premixed, non-reacting swirling jets in order to provide unconditional and conditional statistics for combustion modeling

3. EXPERIMENTAL SETUP

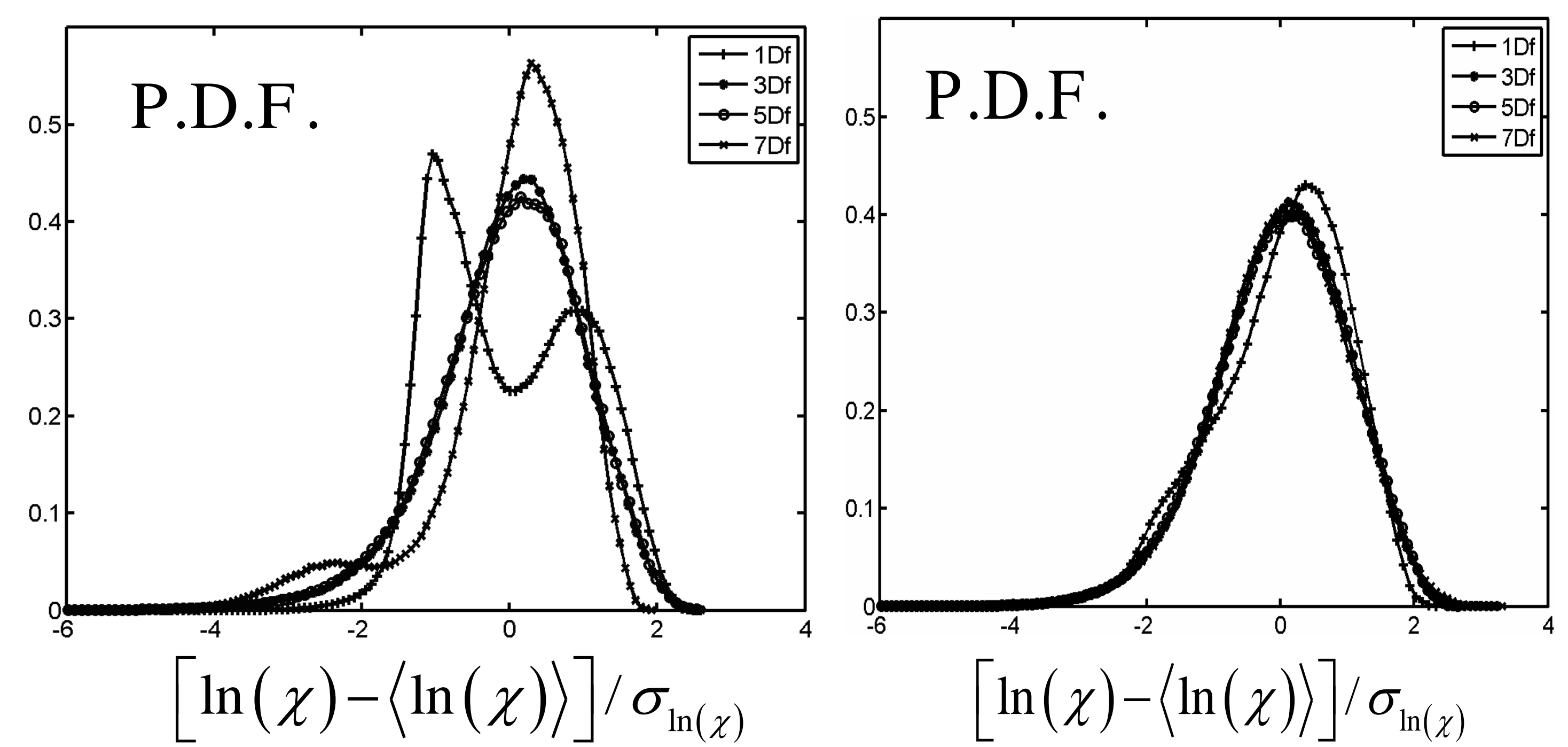
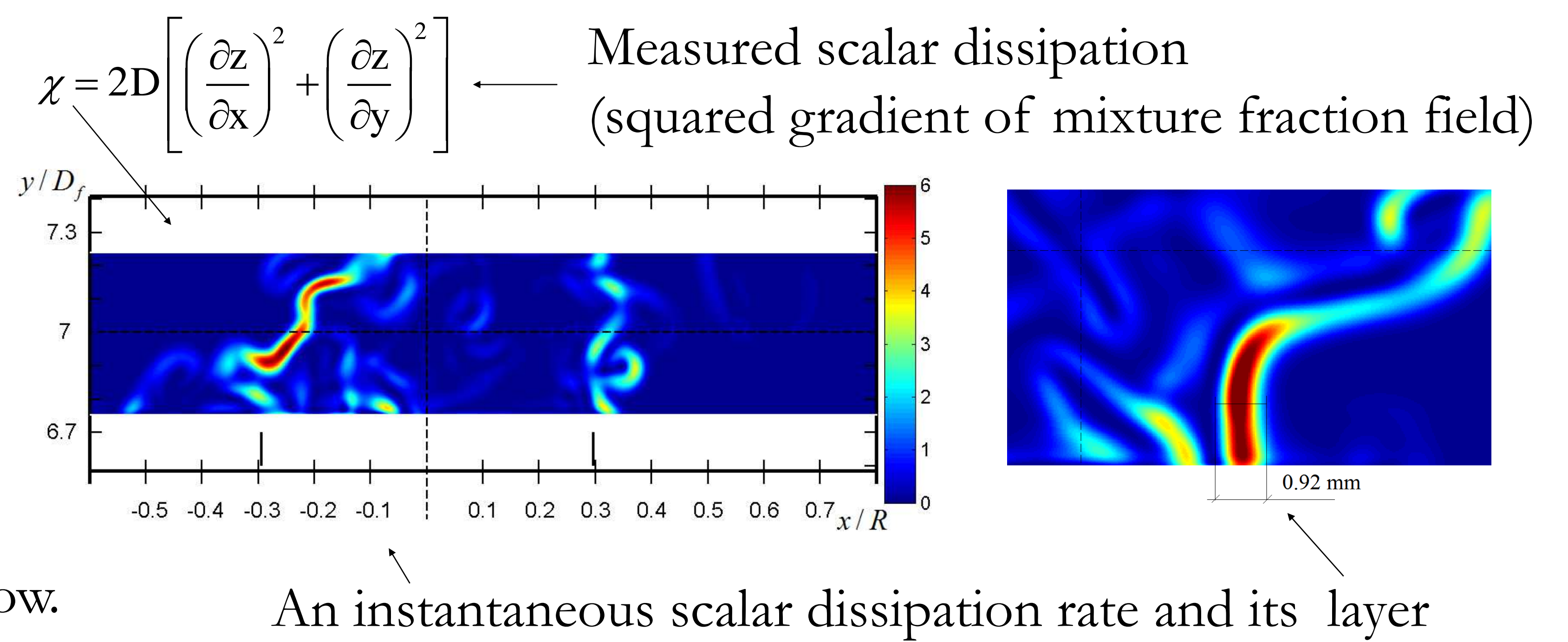
A central fuel nozzle is surrounded by a concentric swirling air flow. The “fuel” used was air seeded with acetone and planar laser-induced fluorescence (PLIF) of acetone is used to obtain the concentration field in the swirling, isothermal flow, with swirl numbers $S = 0.3, 0.58$ and 1.07 . The spatial resolution is 0.0263 mm/pixel and the Kolmogorov scale is circa 0.15 mm . The Reynolds number of swirling and jet fuel flow are 28662 and 3770 respectively.



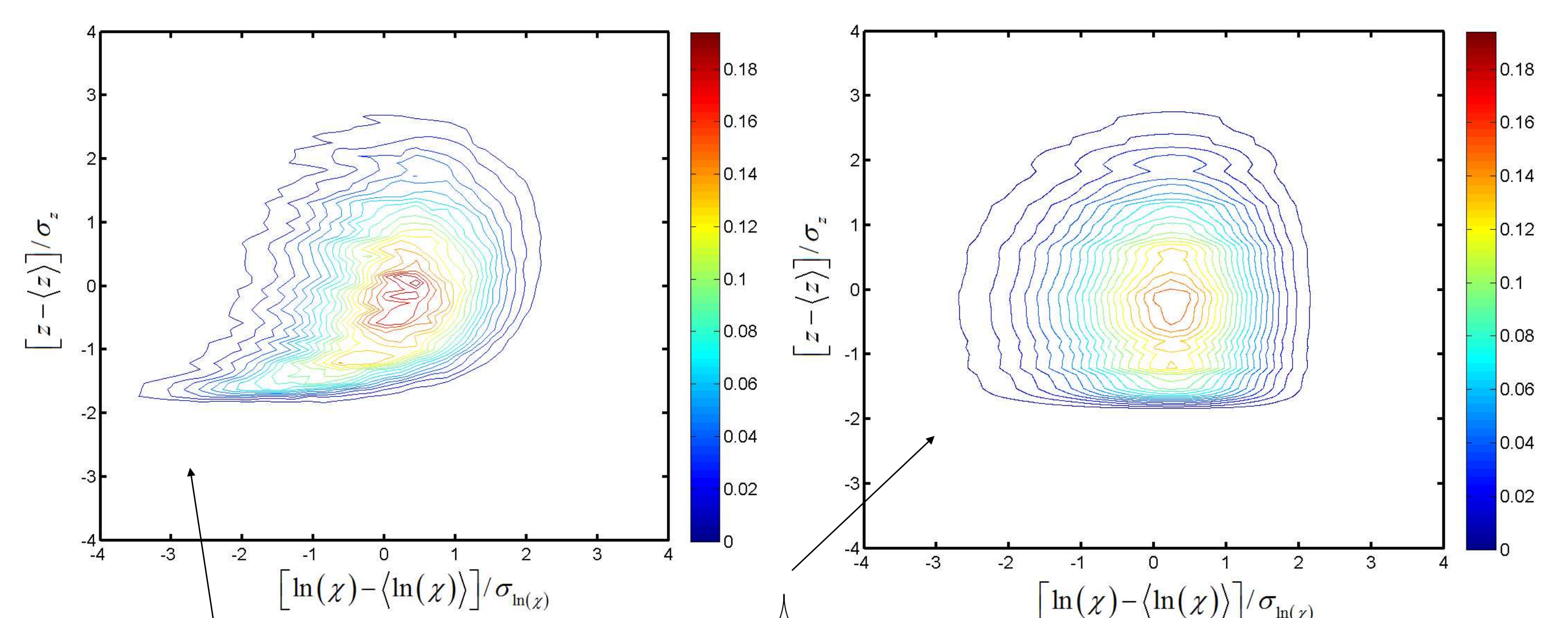
4. RESULTS



Instantaneous and Mean mixture fraction fields for $S=0.58$



P.D.F. of scalar dissipation fluctuation



$$\text{pdf}(z, \chi) = \text{pdf}(z) \text{pdf}(\chi) \rightarrow \text{Usually assumed}$$

Joint P.D.F. of the scalar and its dissipation

5. CONCLUSIONS

- The maximum of instantaneous scalar dissipation rate was found to be up to 35 s^{-1} while mean values were circa 3 s^{-1} .
- The dissipation layer was defined as 1% of maximum scalar dissipation value across the layer and was computed to be approximately 0.92 mm thick.
- The P.D.F. of the scalar dissipation was found to be slightly negatively skewed at low swirl number (0.3) and almost symmetrical when swirl number increased to $0.58-1.07$.
- Statistical independence between scalar and its dissipation was validated and did hold for high swirl numbers.
- P.D.F. of the scalar dissipation was log-normal.