

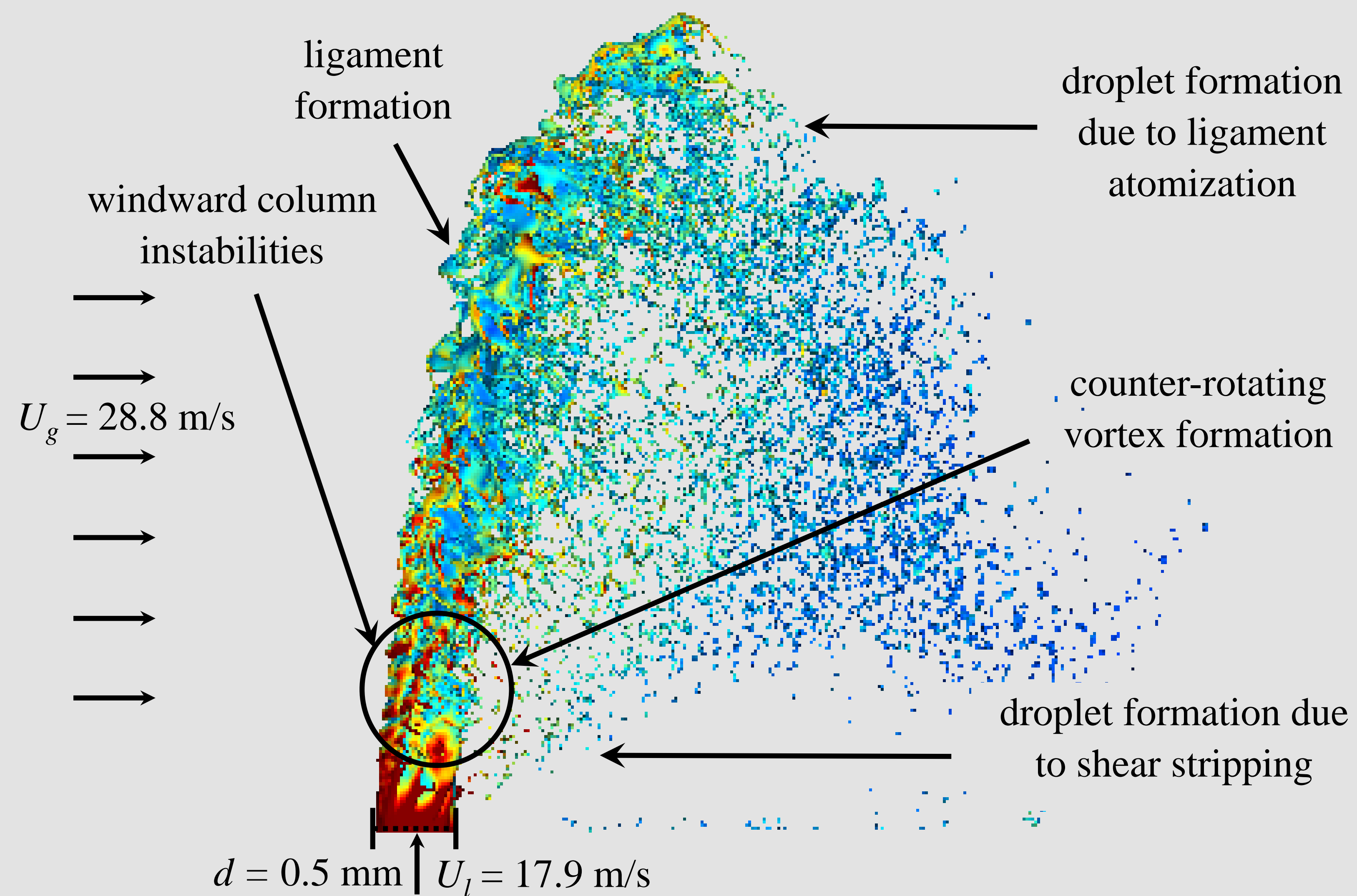
# High-Fidelity Simulations of Water Jet in Air Crossflow

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This work was supported by the College of Engineering and Applied Science at the University of Cincinnati

## Phenomenon Investigated



### Objectives

- Investigate detailed physics underlying liquid jets in crossflow configurations applicable to various applications such as, gas-turbine, scramjet, and afterburner fuel injection.
- Develop models to predict the statistical behaviors of resulting droplets.

## Physical Parameters and Operating Conditions

Operating Conditions	P (bar)	T (K)	We	Momentum ratio, q
	20	300	54.9	15.5
Water Properties		$\sigma$ (N/m)	$\rho_l$ (kg/m <sup>3</sup> )	$\mu_l$ (kg/m-s)
		0.0729	1000	0.001

## Methodology

Incompressible, variable-density, Navier-Stokes equations:

$$\rho(\partial_t \mathbf{u} + \mathbf{u} \cdot \nabla \mathbf{u}) = -\nabla p + \nabla \cdot (2\mu \mathbf{D}) + \sigma \kappa \delta_s \mathbf{n}$$

$$\partial_t \rho + \nabla \cdot (\rho \mathbf{u}) = 0$$

$$\nabla \cdot \mathbf{u} = 0$$

Volume fraction, two-phase fluid density and viscosity:

$$\rho(c) \equiv c\rho_1 + (1-c)\rho_2$$

$$\mu(c) \equiv c\mu_1 + (1-c)\mu_2$$

- Second-order piecewise-linear geometrical VOF scheme

Advection for volume fraction:

$$\partial_t c + \nabla \cdot (c\mathbf{u}) = 0$$

Relevant  
Non-Dimensional  
Numbers

$$We = \frac{\rho_g U_g^2 d}{\sigma}$$

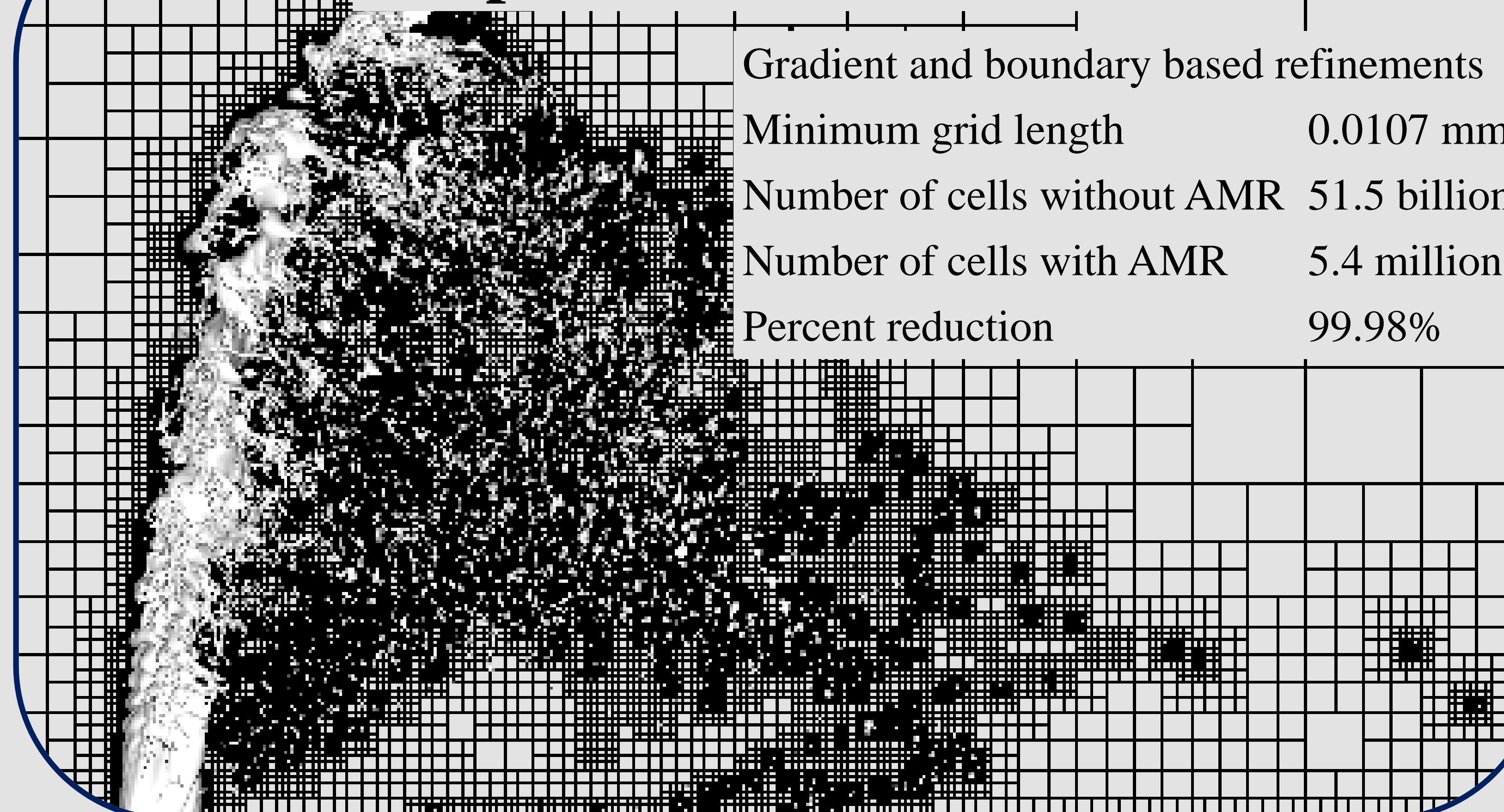
$$q = \frac{\rho_l U_j^2}{\rho_g U_g^2}$$

## Validation

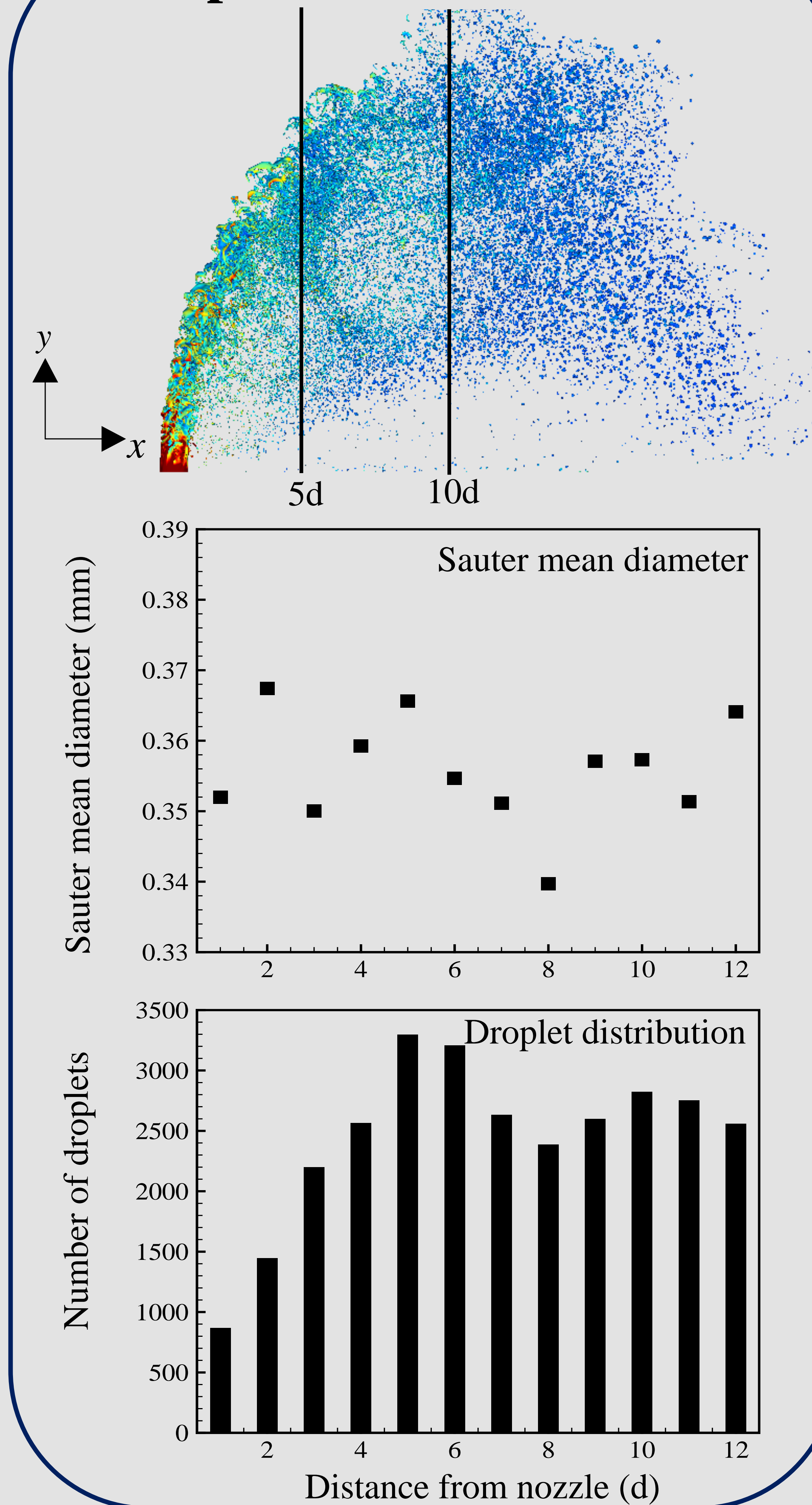
Penetration at  $x/d = 14.16$

y/d	Experiment (Ragucci et al., 2007)	Present	% Error
	19.88	18.14	8.72

## Adaptive Mesh Refinement



## Droplet Size Distributions



## Detailed Physics of Liquid Jet in Crossflow

### Liquid Iso-Surface Colored by Vorticity Magnitude

non-dimensional time,  $t = t^*/(d/U_j)$

