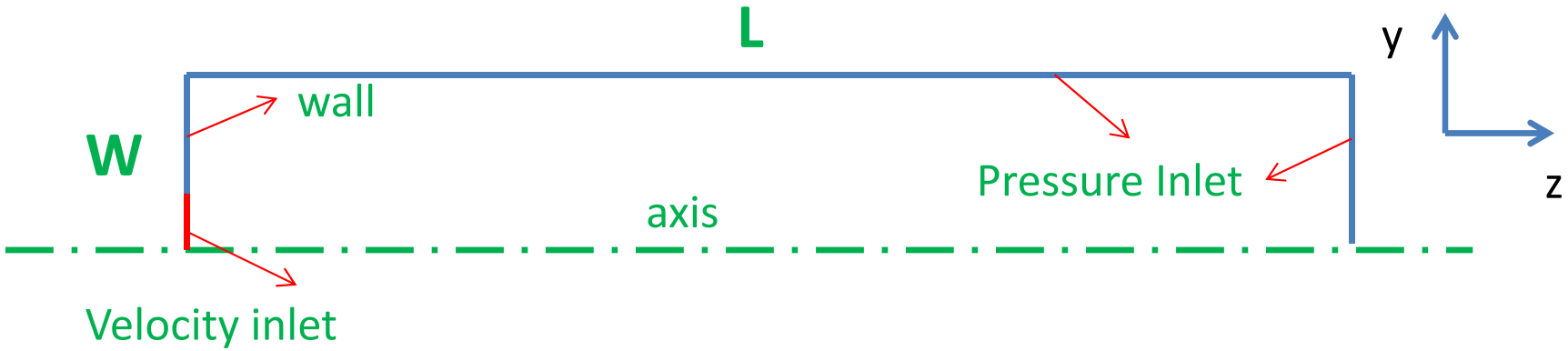
Implicit LES Simulation of Two-phase Turbulent Jet Flow

Feb. 27th 2014

Yan

Studied Problems

- Implicit LES simulation on 2D mesh with radius = N-jet-diameters, for N = 3,5,7
  - VOF Multiphase Model
  - CLSVOF Multiphase Model

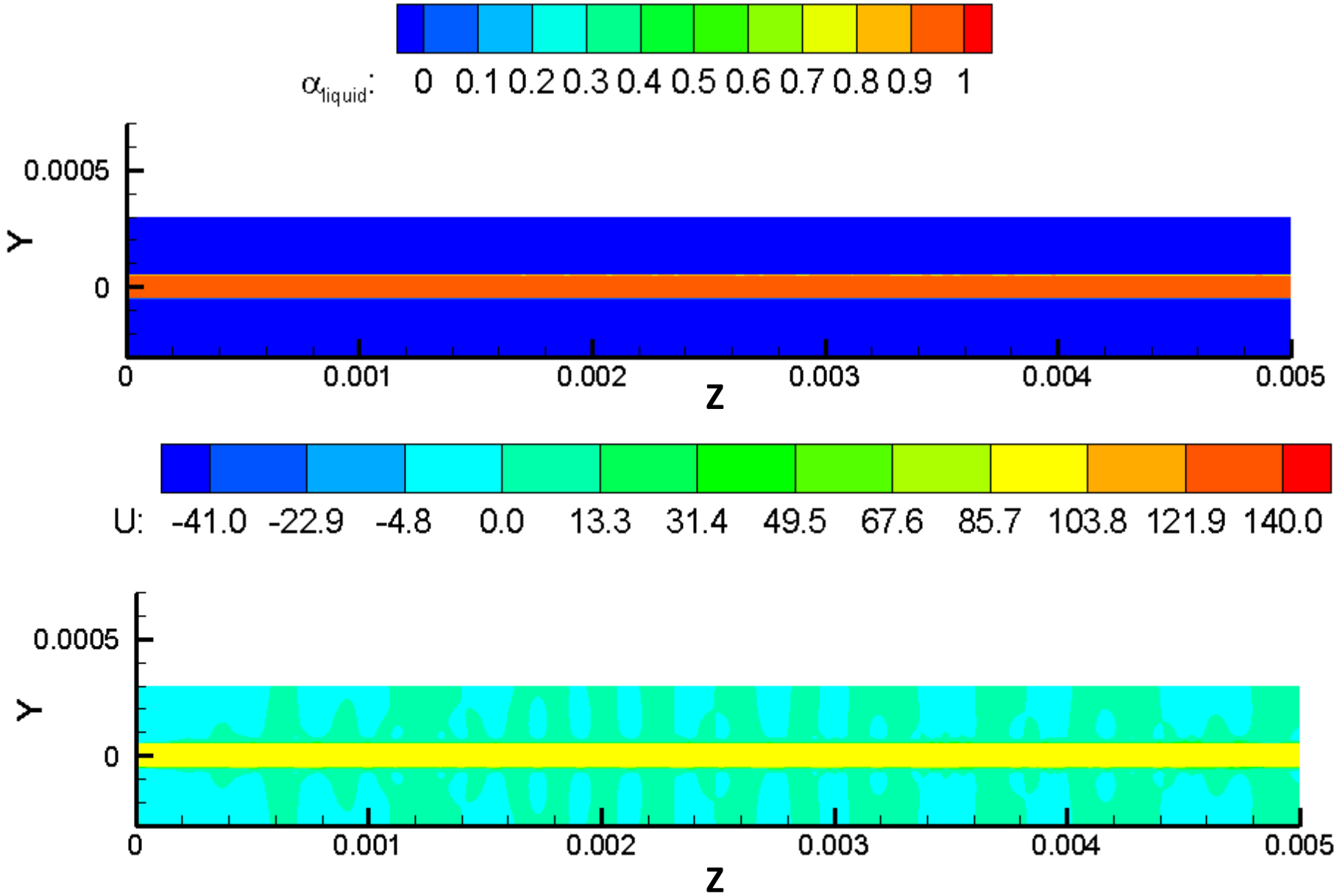


Width (W)	Length (L)	Grid # in z (Nz)	Grid # in y (Ny)	Total Grid # (Nt)
3D	50D	2120	127	269,240
5D	50D	2120	212	449,440
7D	50D	2120	297	629,640

Results ---- 3-Jet-Diameter Case

- VOF

Initialization (t = 0 s)

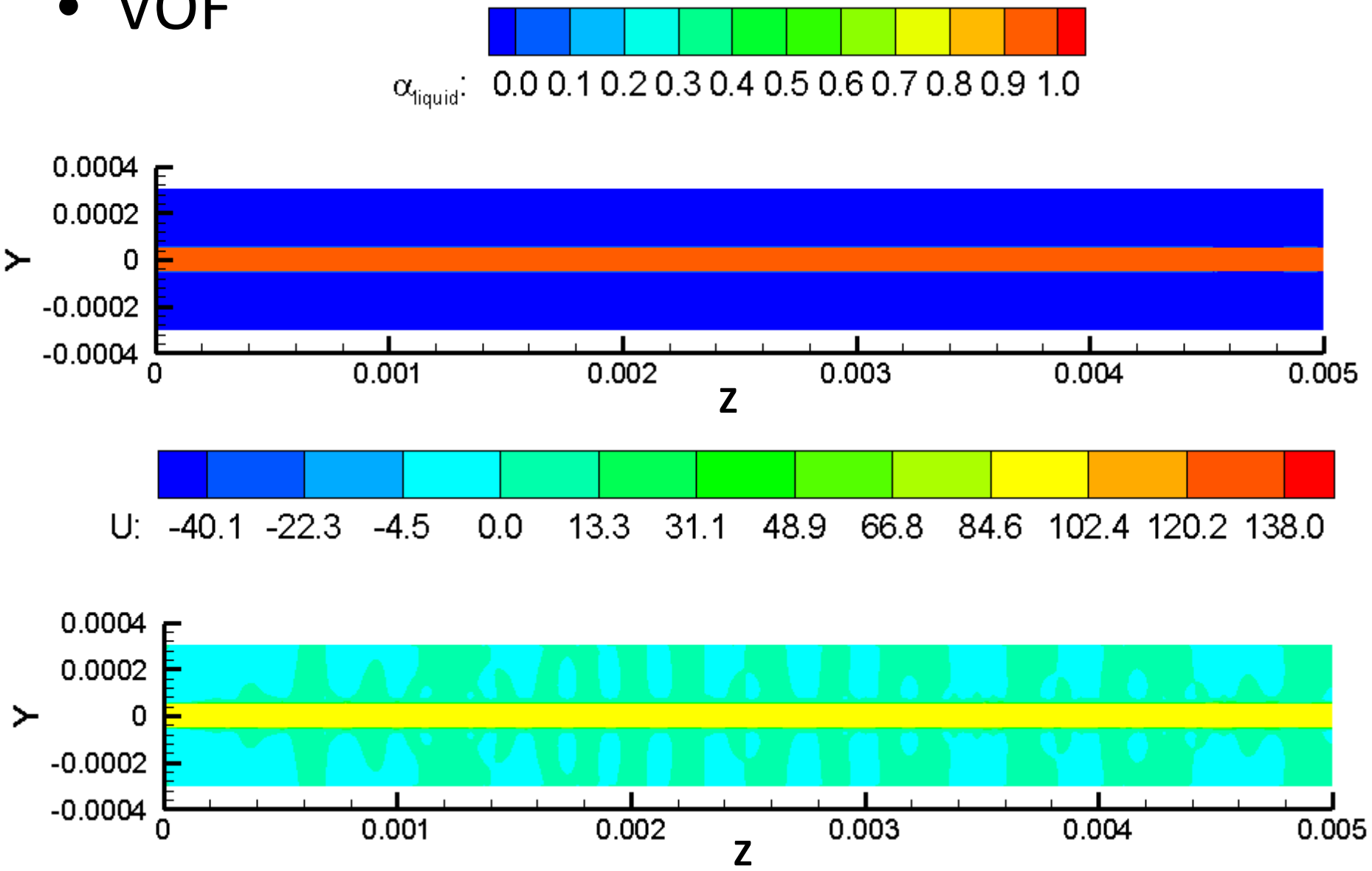


Results ---- 3-Jet-Diameter Case

(click to watch the movie)

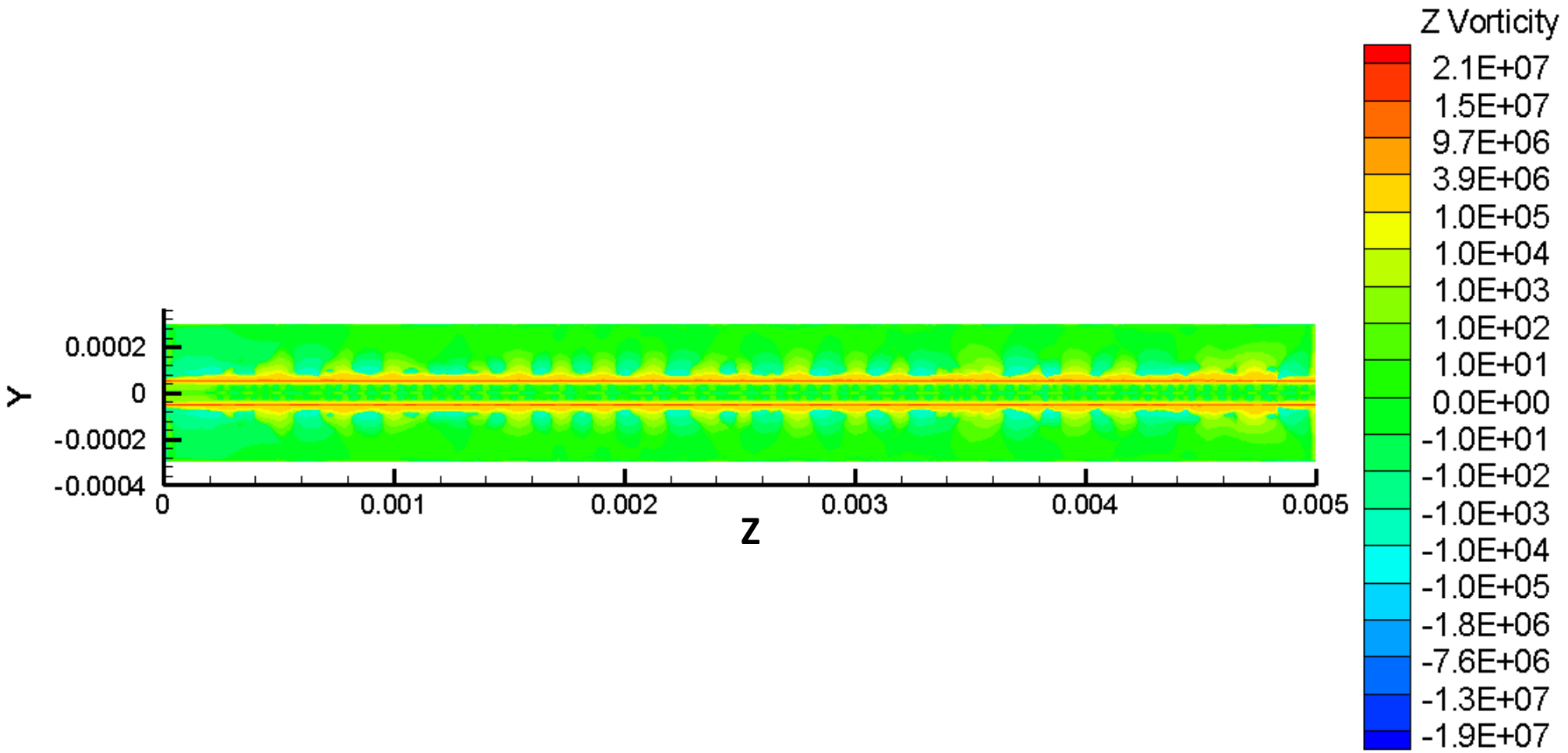
- VOF

0 < t < 5.3 ms



Results ---- 3-Jet-Diameter Case

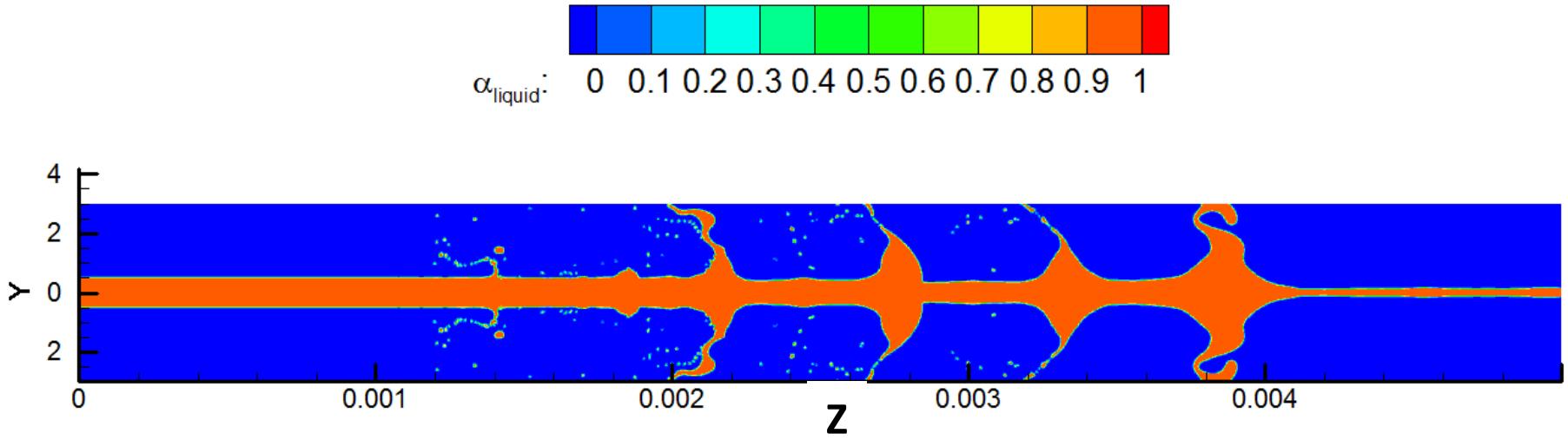
(click to watch the movie)



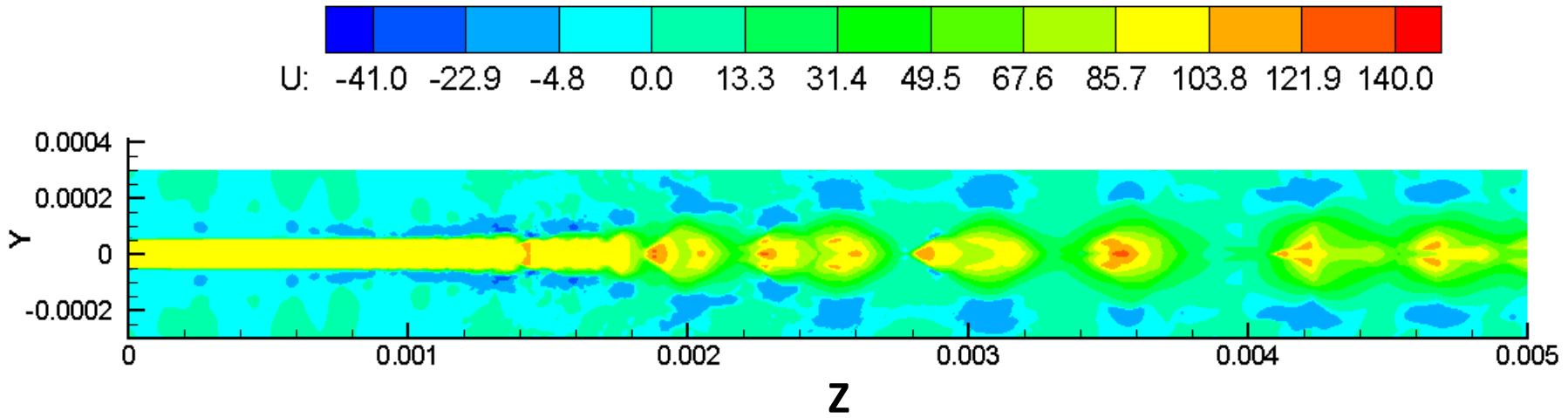
Results ---- 3-Jet-Diameter Case

- VOF

t = 5.3 ms



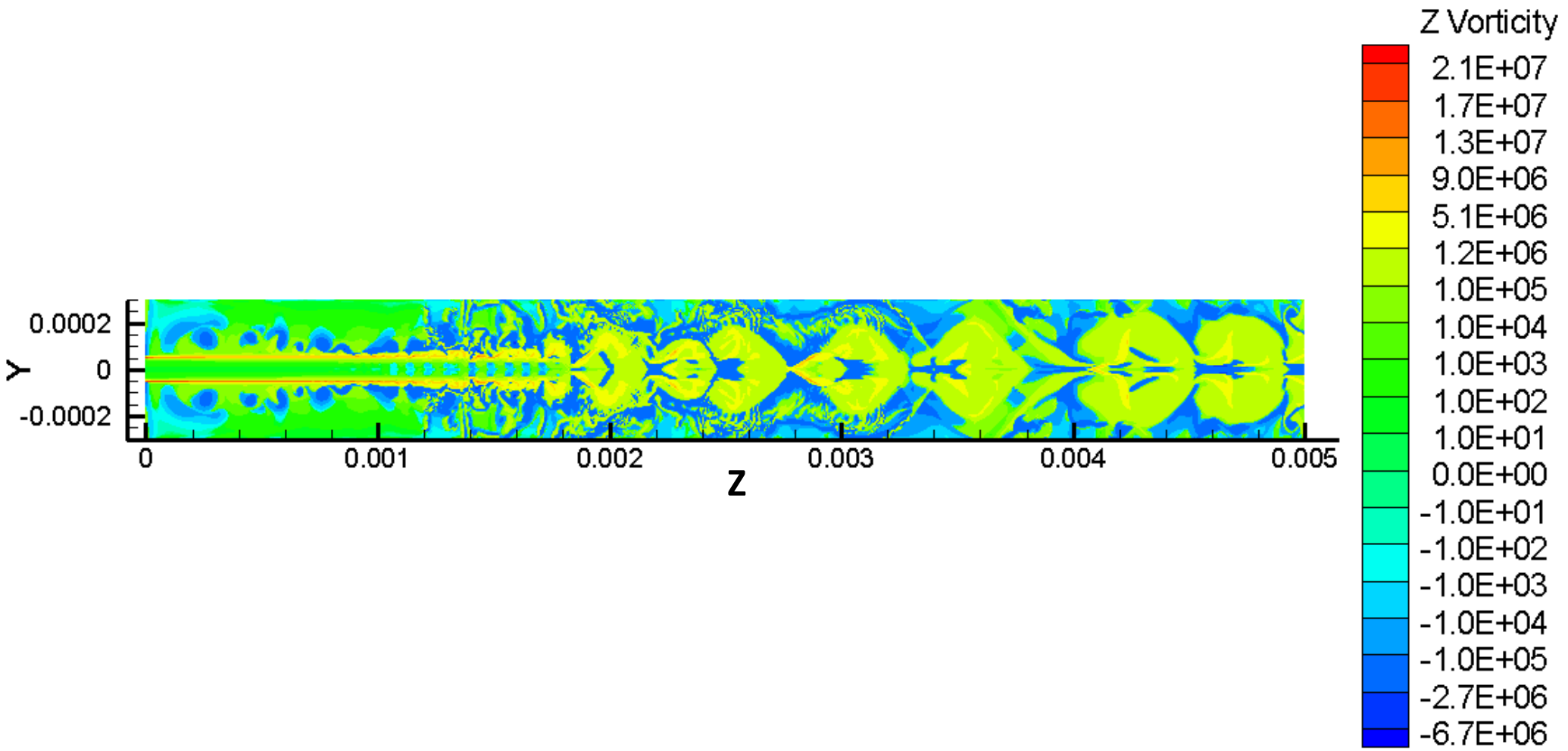
location of onset of turbulent breakup ≈ 14 jet diameters



Results ---- 3-Jet-Diameter Case

- VOF

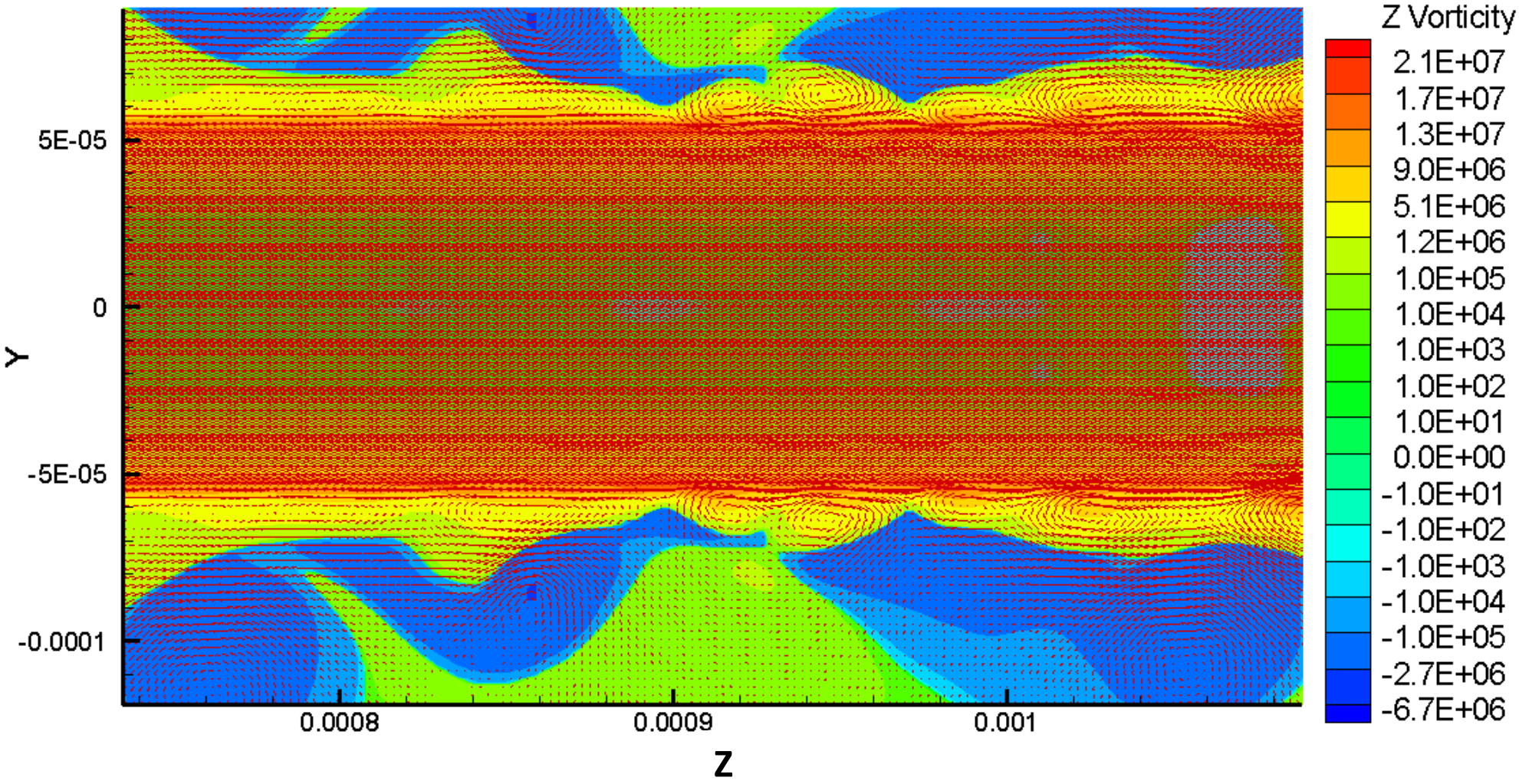
t = 5.3 ms



Results ---- 3-Jet-Diameter Case

- VOF

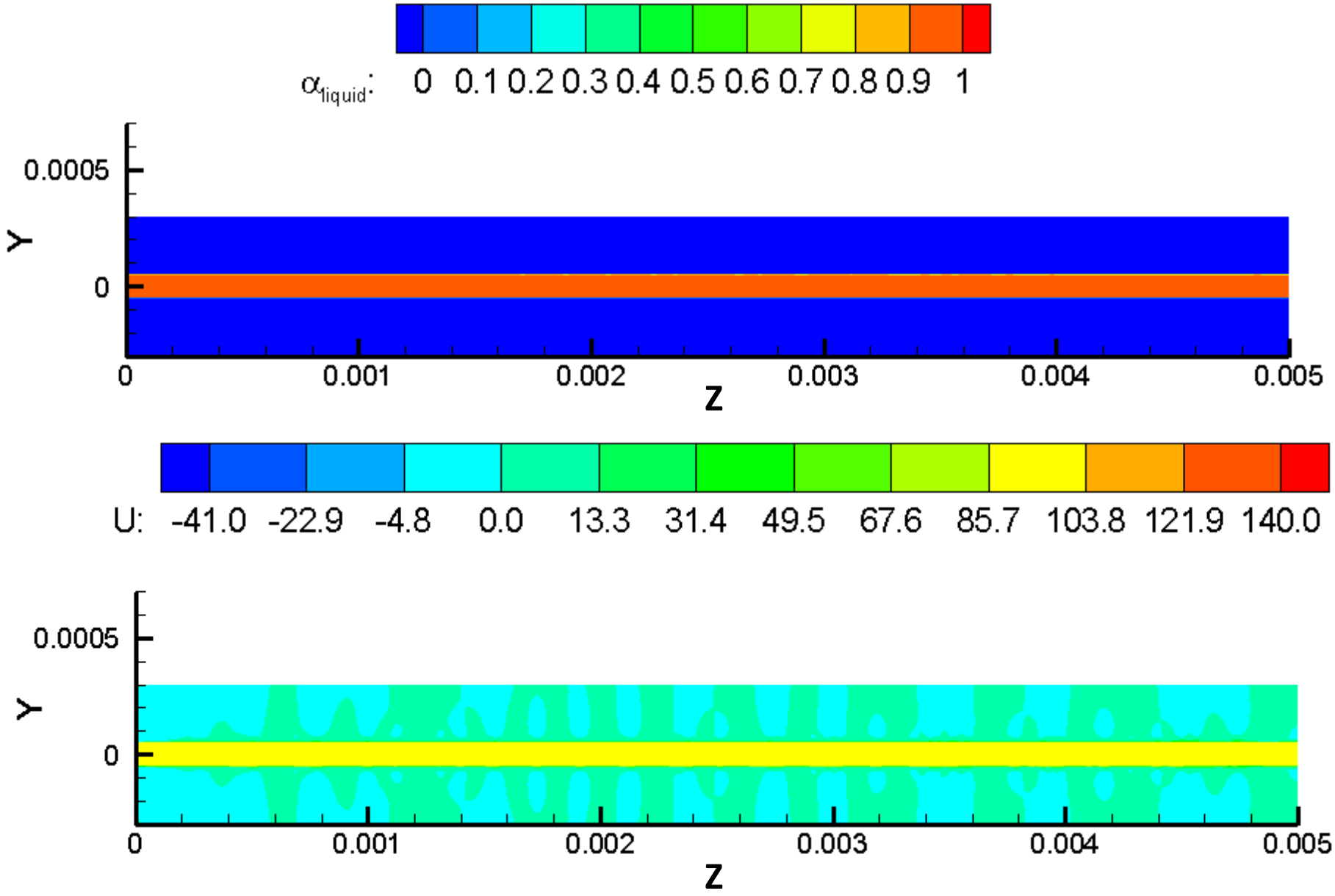
t = 5.3 ms



Results ---- 3-Jet-Diameter Case

- CLSVOF

Initialization (t = 0 s)

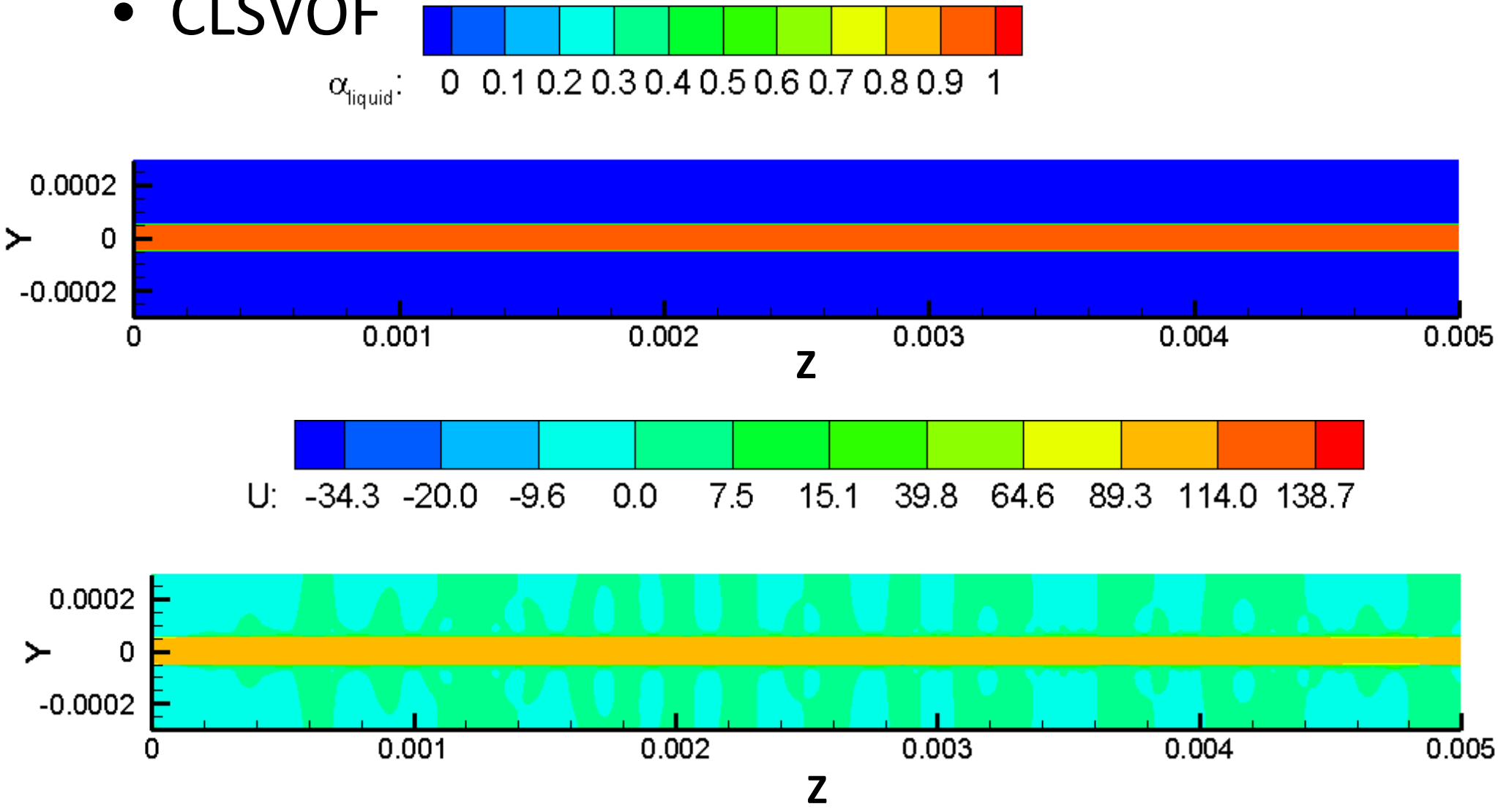


Results ---- 3-Jet-Diameter Case

(click to watch the movie)

0 < t < 3.75 ms

- CLSVOF

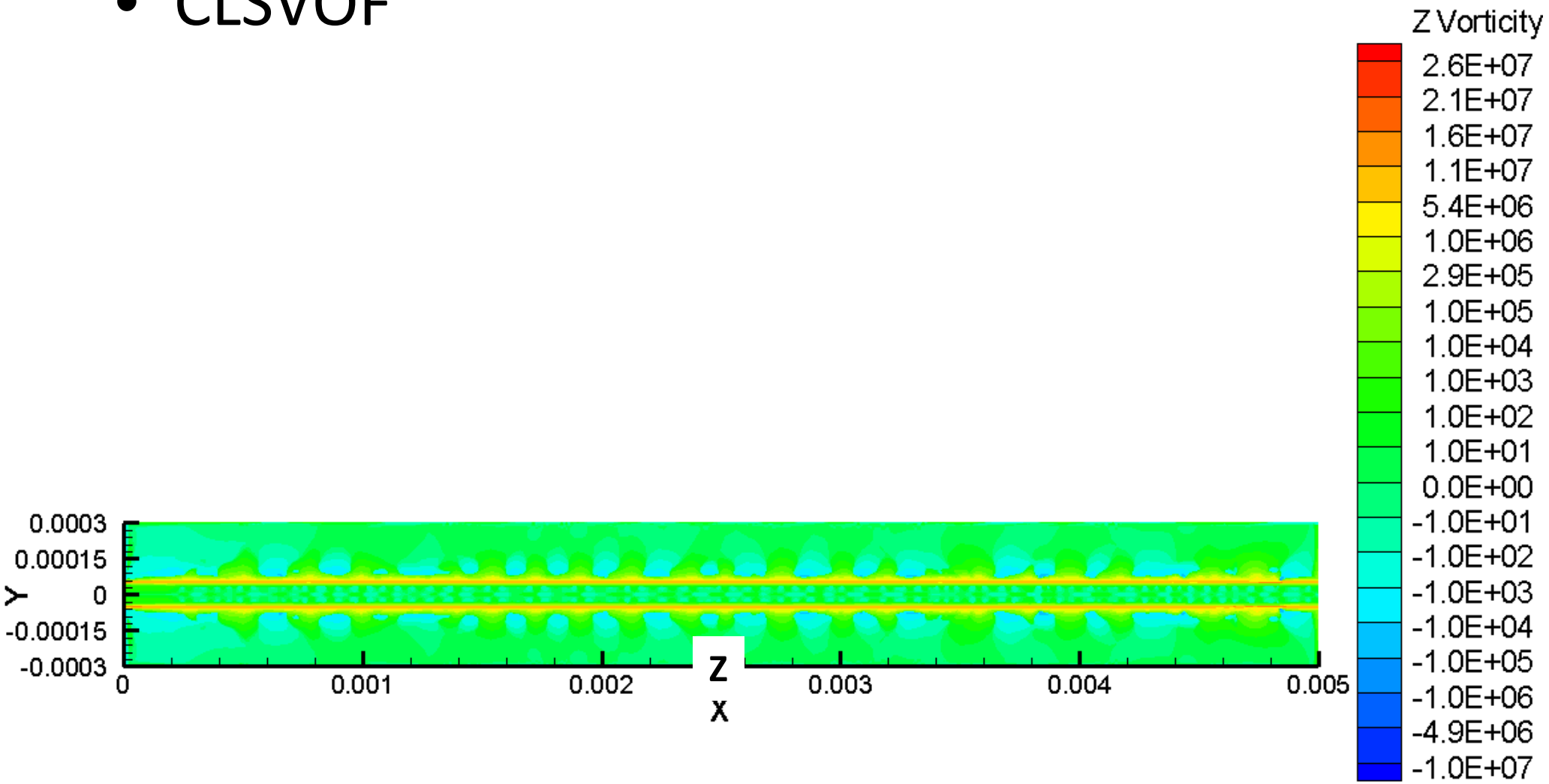


Results ---- 3-Jet-Diameter Case

(click to watch the movie)

- CLSVOF

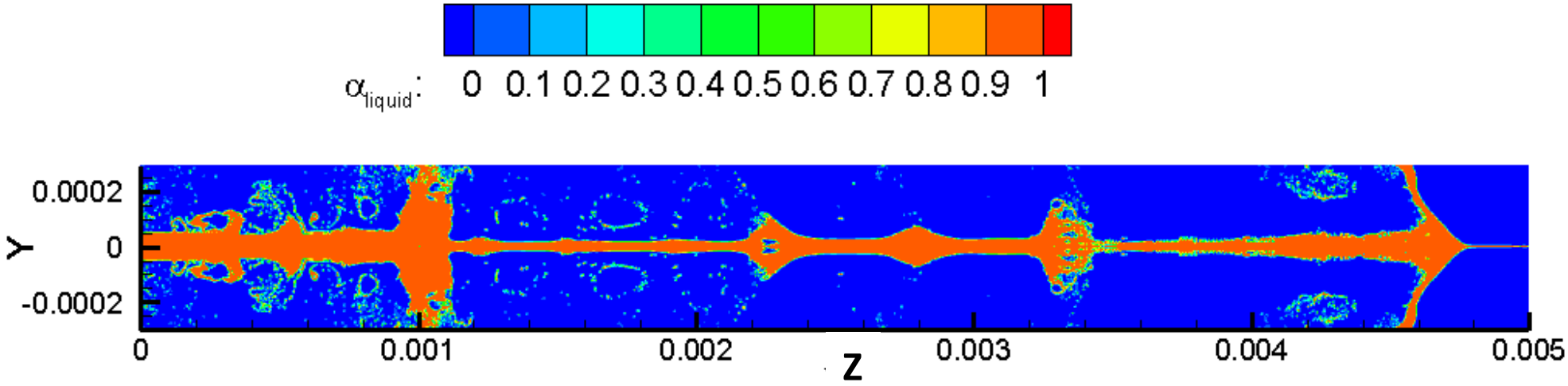
0 < t < 3.75 ms



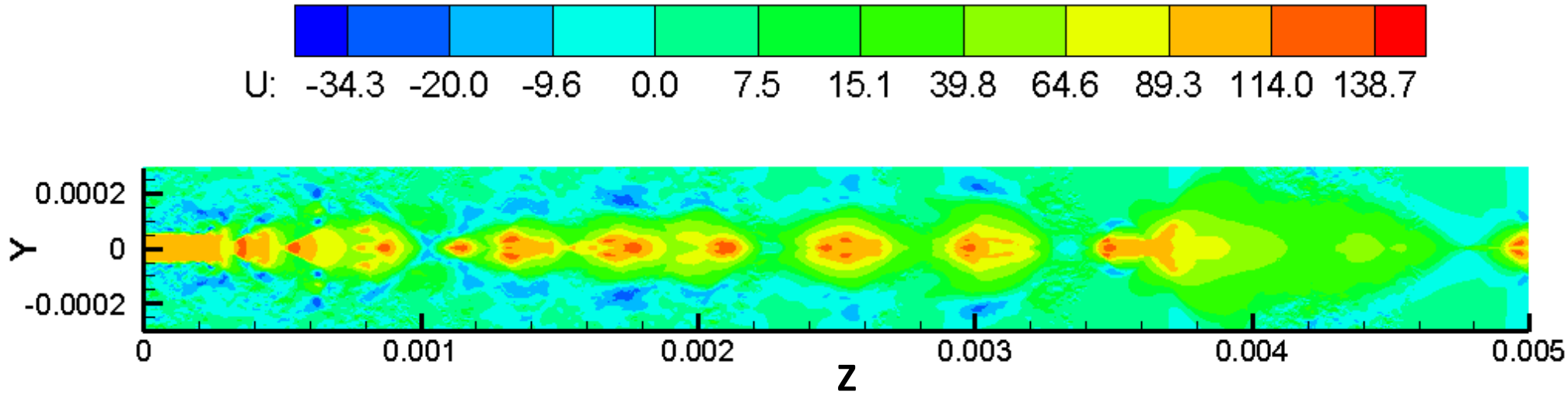
Results ---- 3-Jet-Diameter Case

- CLSVOF

t = 3.75 ms



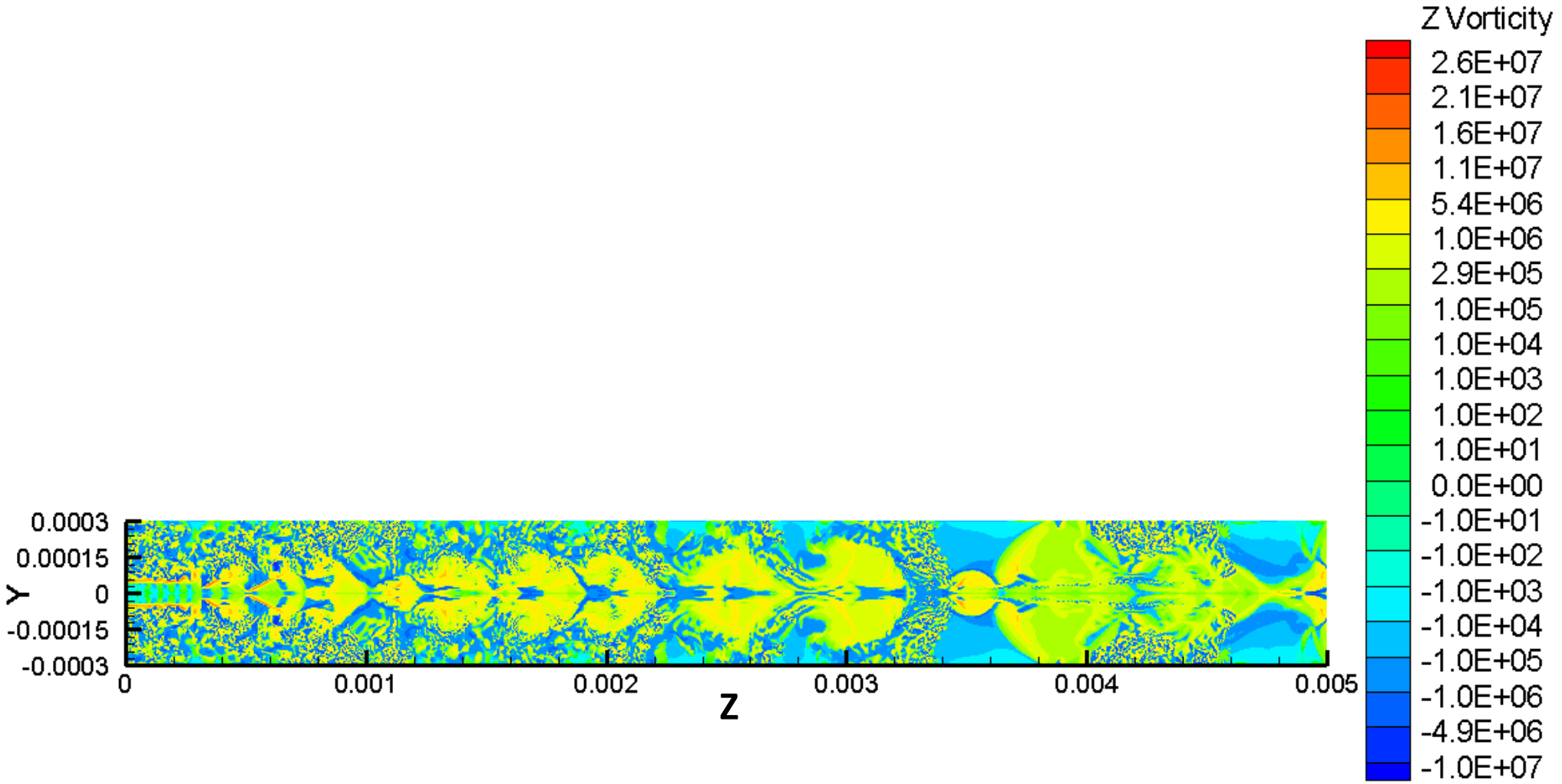
location of onset of turbulent breakup ≈ 1.6 jet diameters



Results ---- 3-Jet-Diameter Case

- CLSVOF

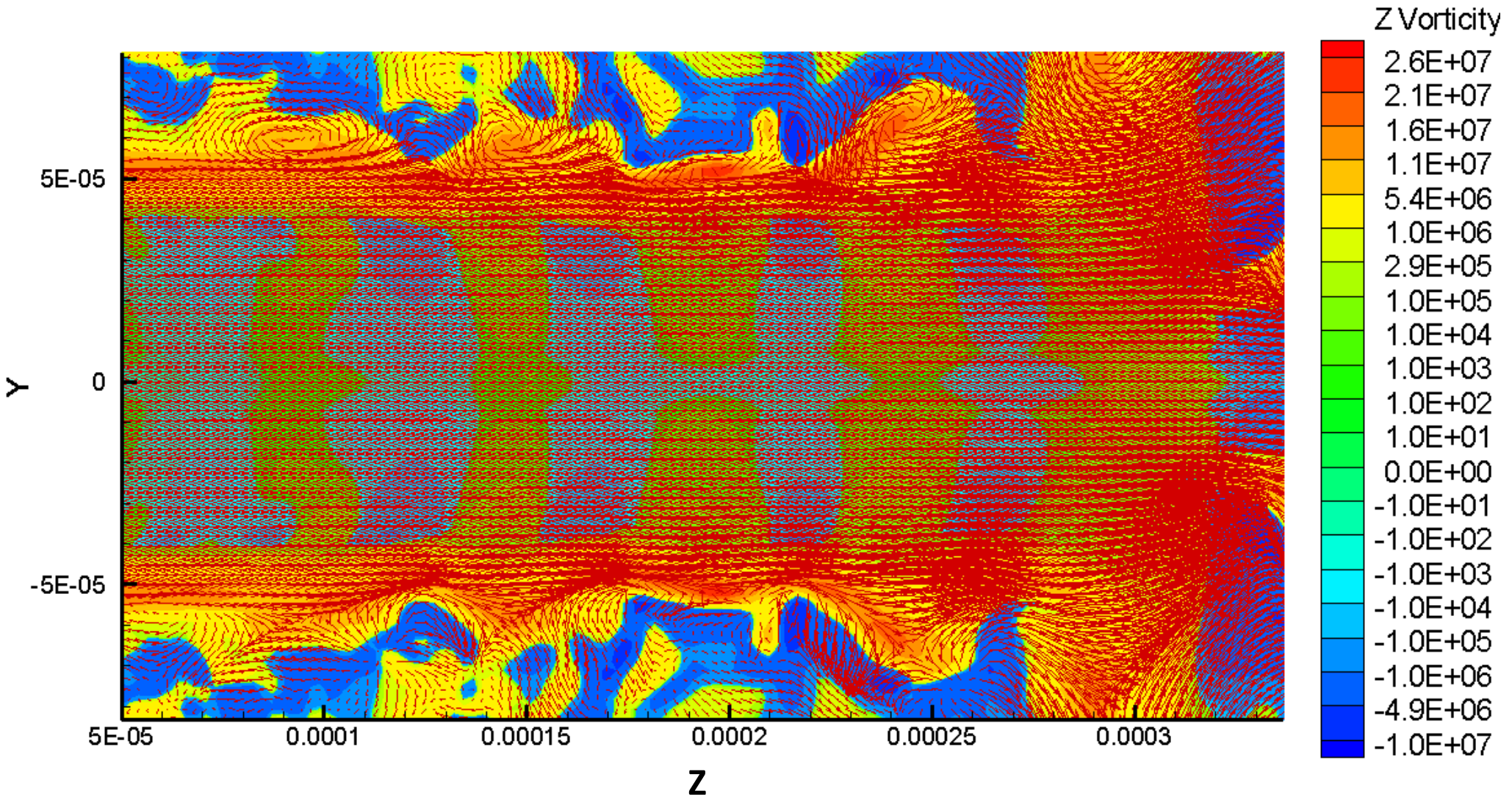
t = 3.75 ms



Results ---- 3-Jet-Diameter Case

- CLSVOF

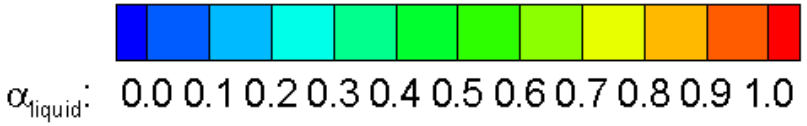
t = 3.75 ms



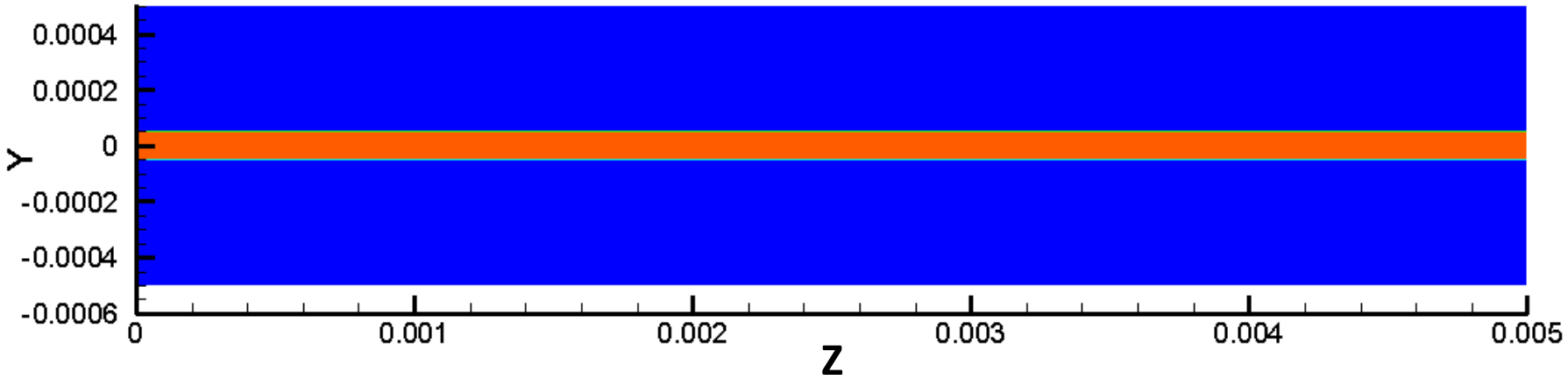
Results ---- 5-Jet-Diameter Case

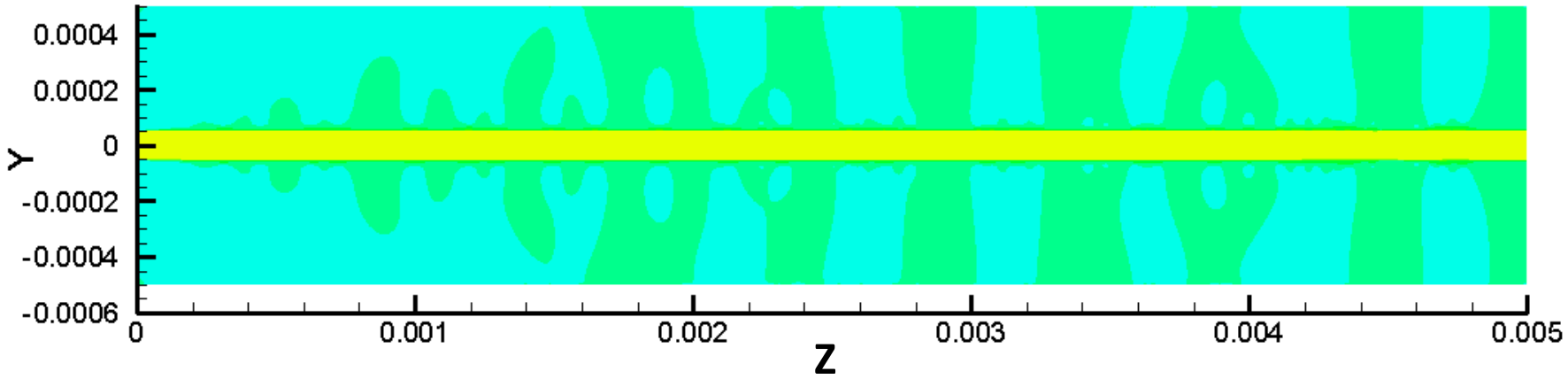
(click to watch the movie)

- VOF



0 < t < 3 ms

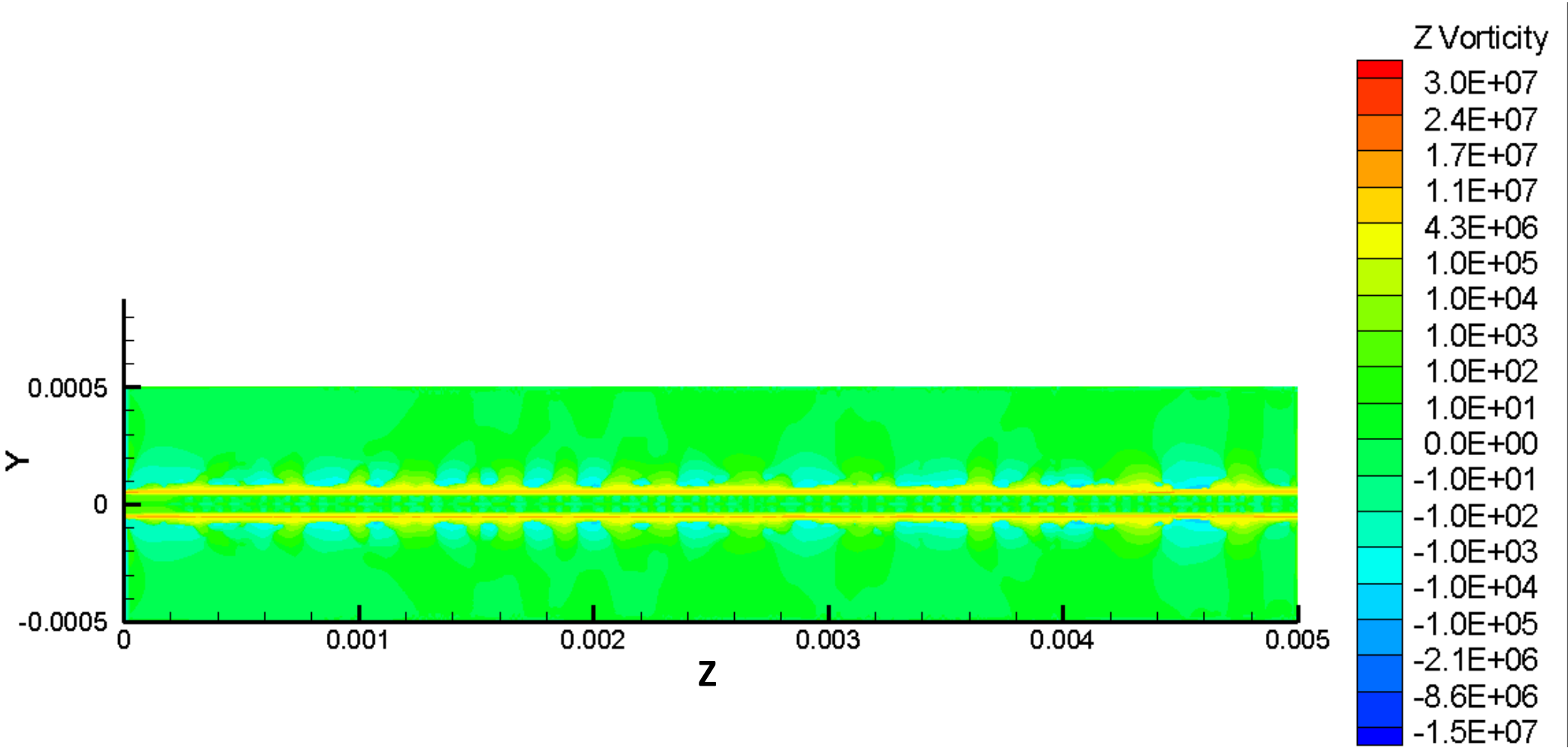




Results ---- 5-Jet-Diameter Case

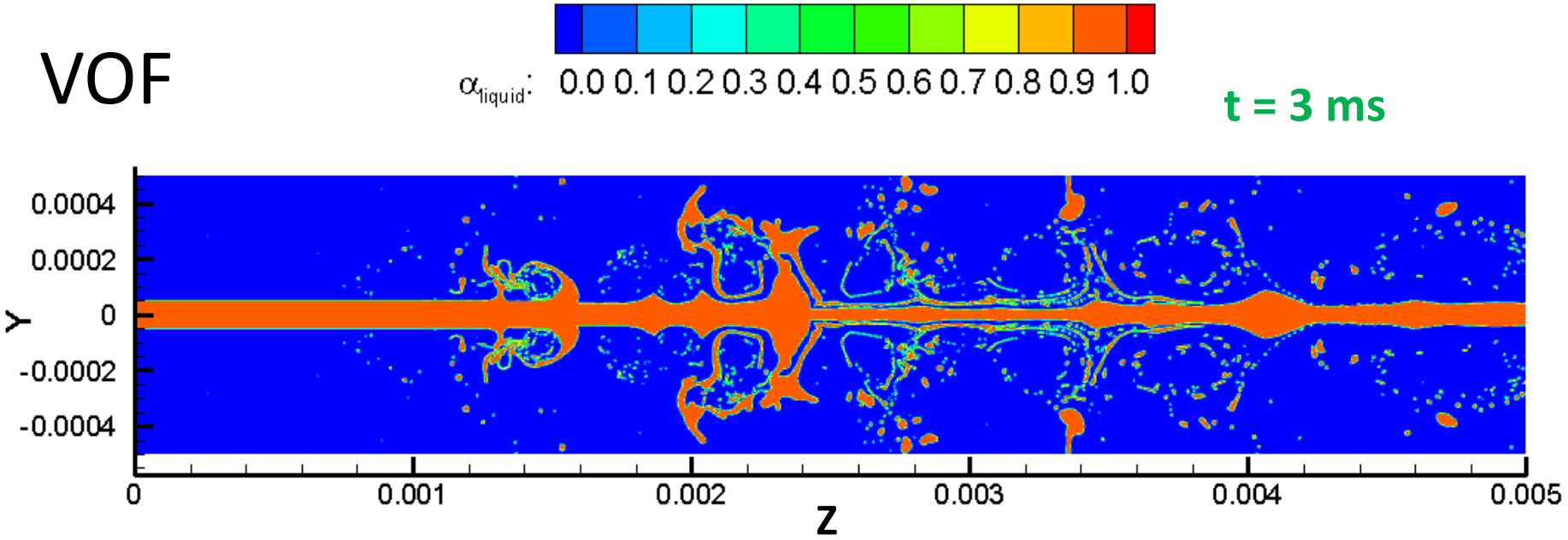
(click to watch the movie)

0 < t < 3 ms

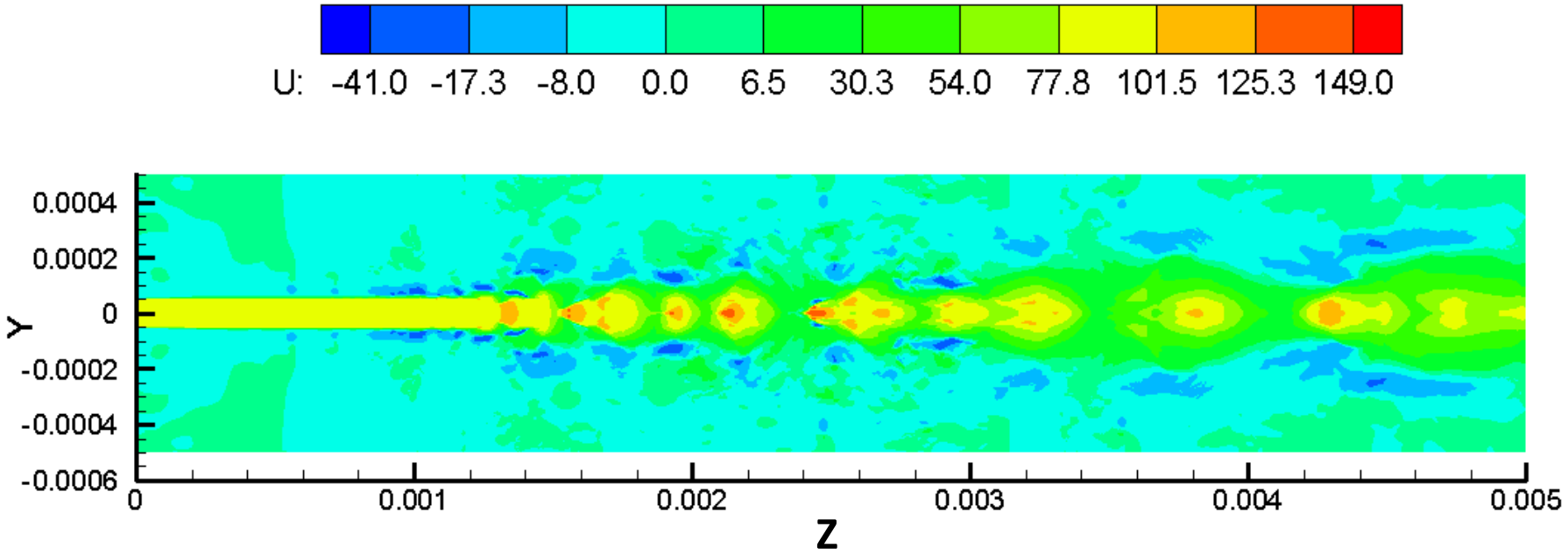


Results ---- 5-Jet-Diameter Case

- VOF



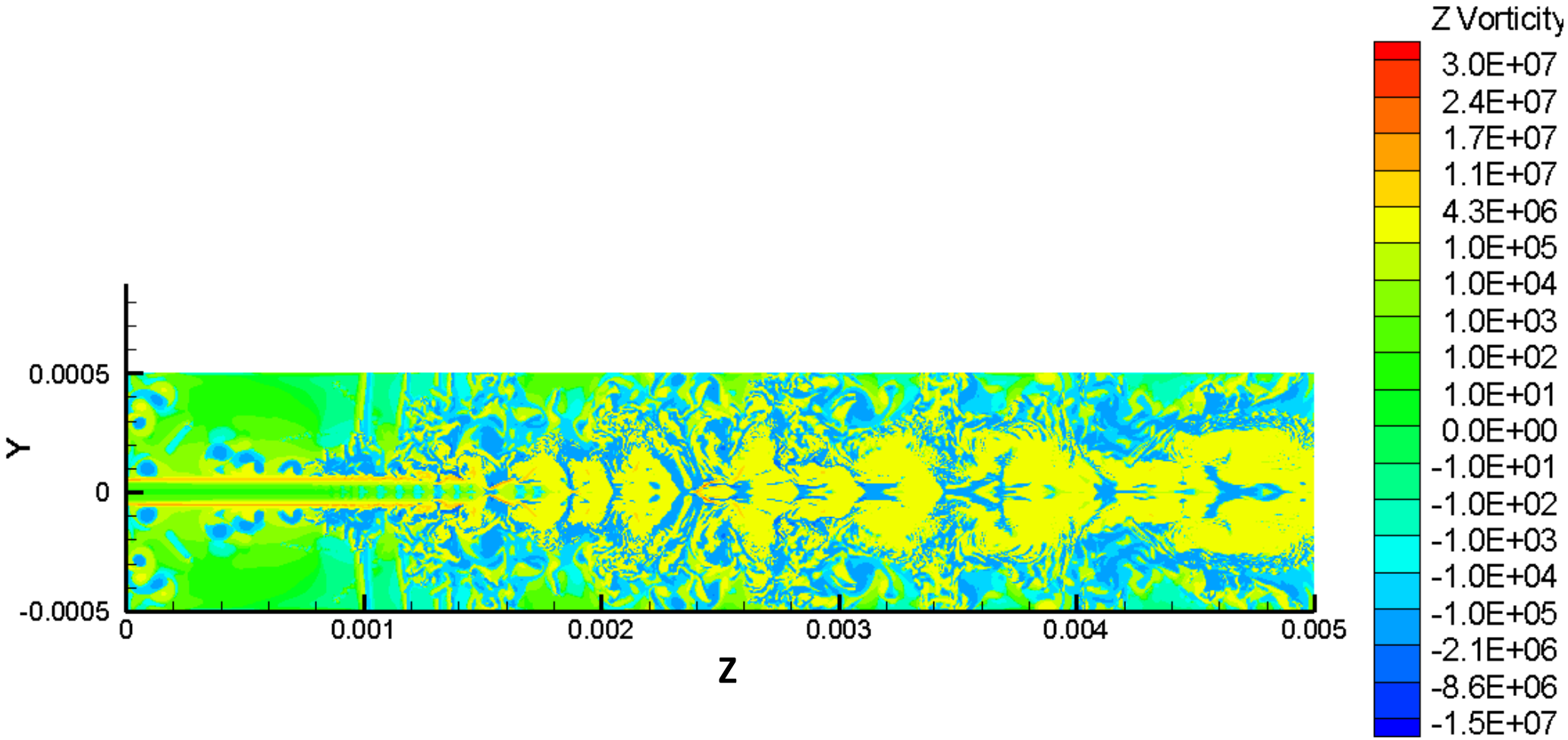
location of onset of turbulent breakup ≈ 11.6 jet diameters



Results ---- 5-Jet-Diameter Case

- VOF

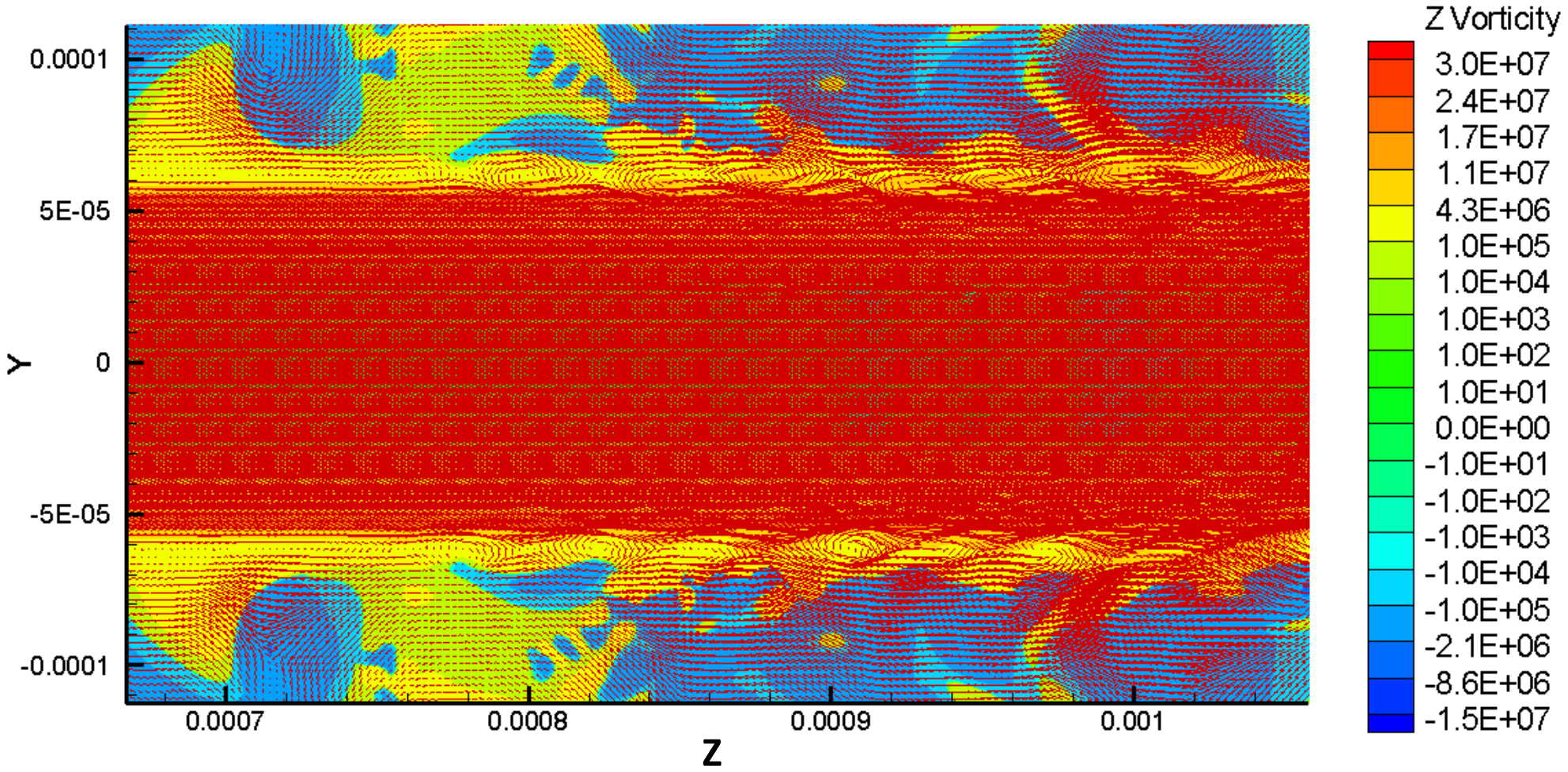
t = 3 ms



Results ---- 5-Jet-Diameter Case

- VOF

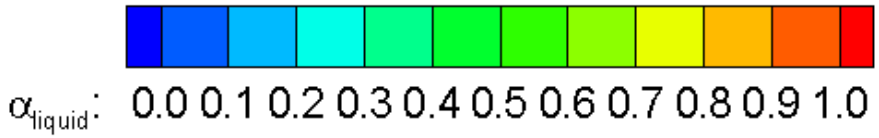
t = 3 ms



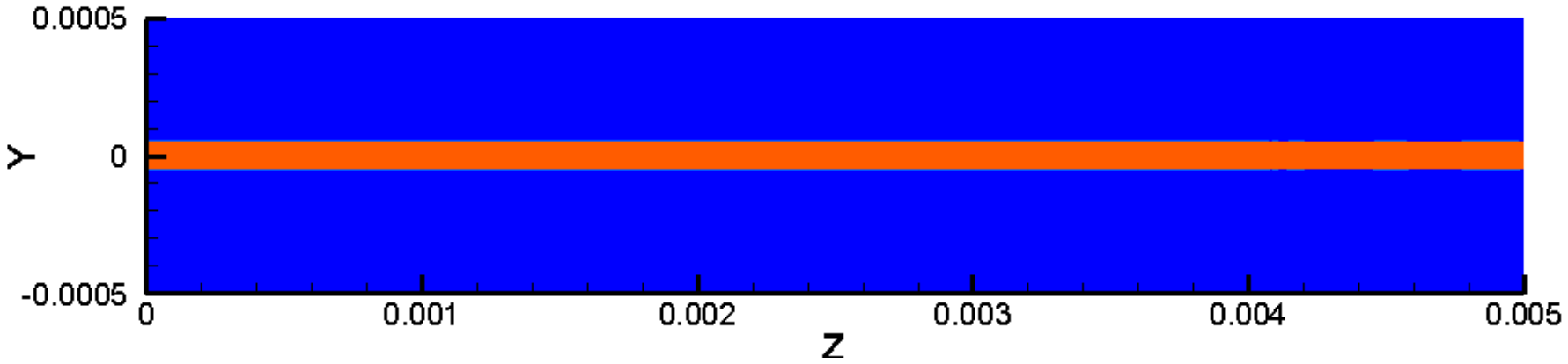
Results ---- 5-Jet-Diameter Case

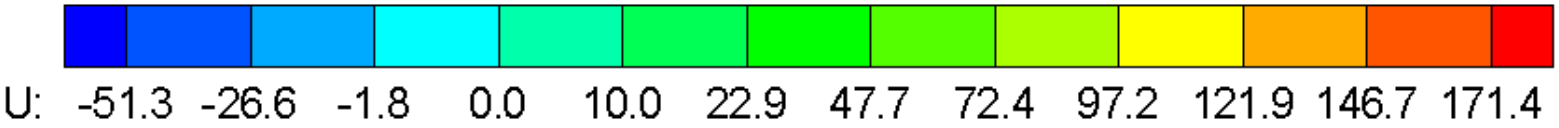
(click to watch the movie)

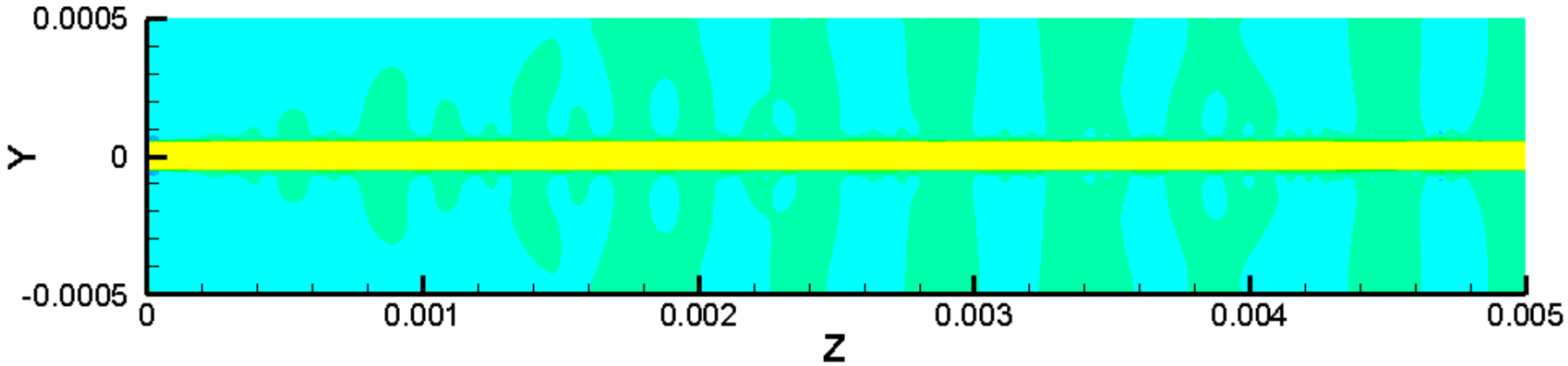
- CLSVOF



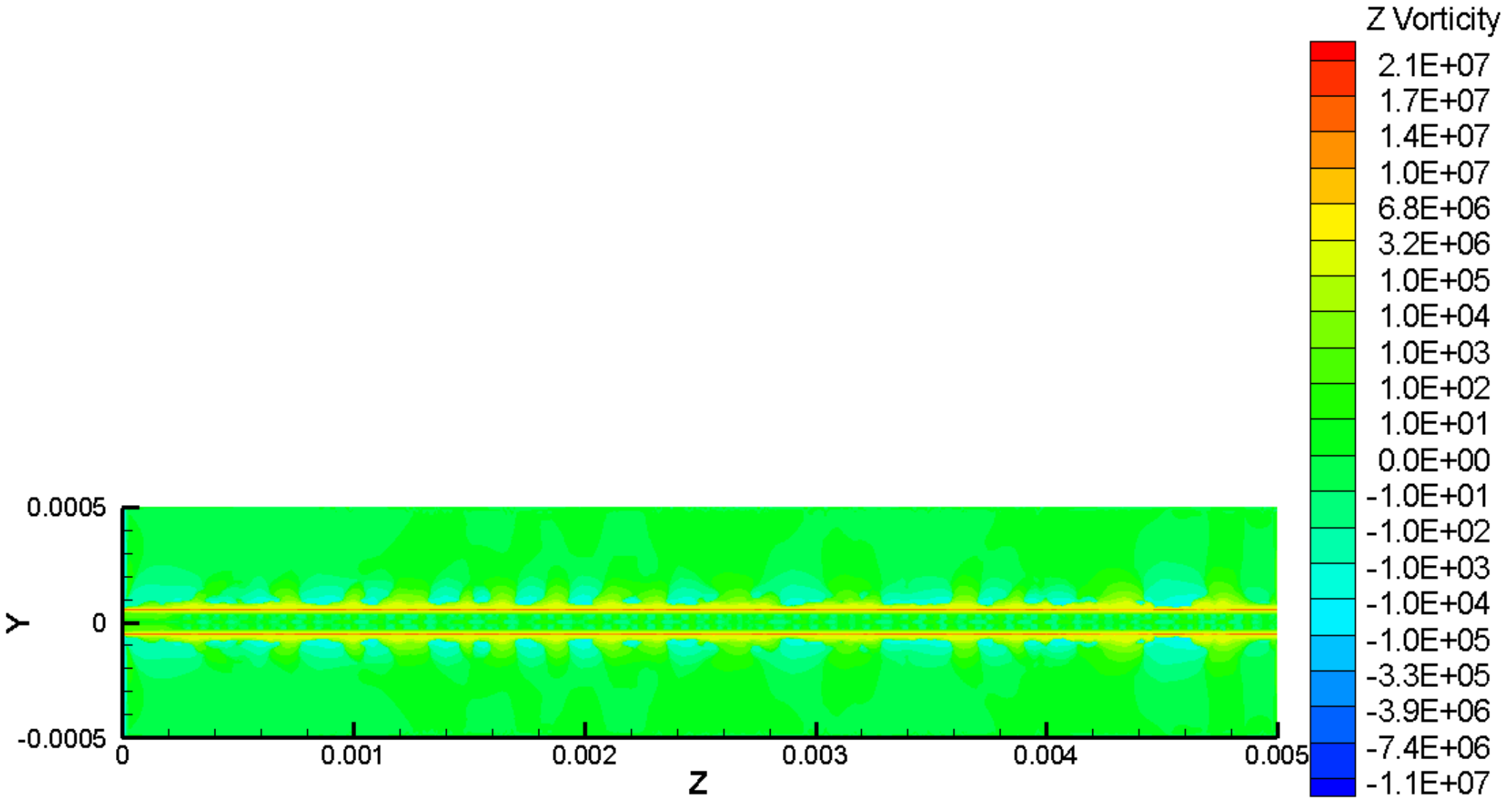
0 < t < 3 ms





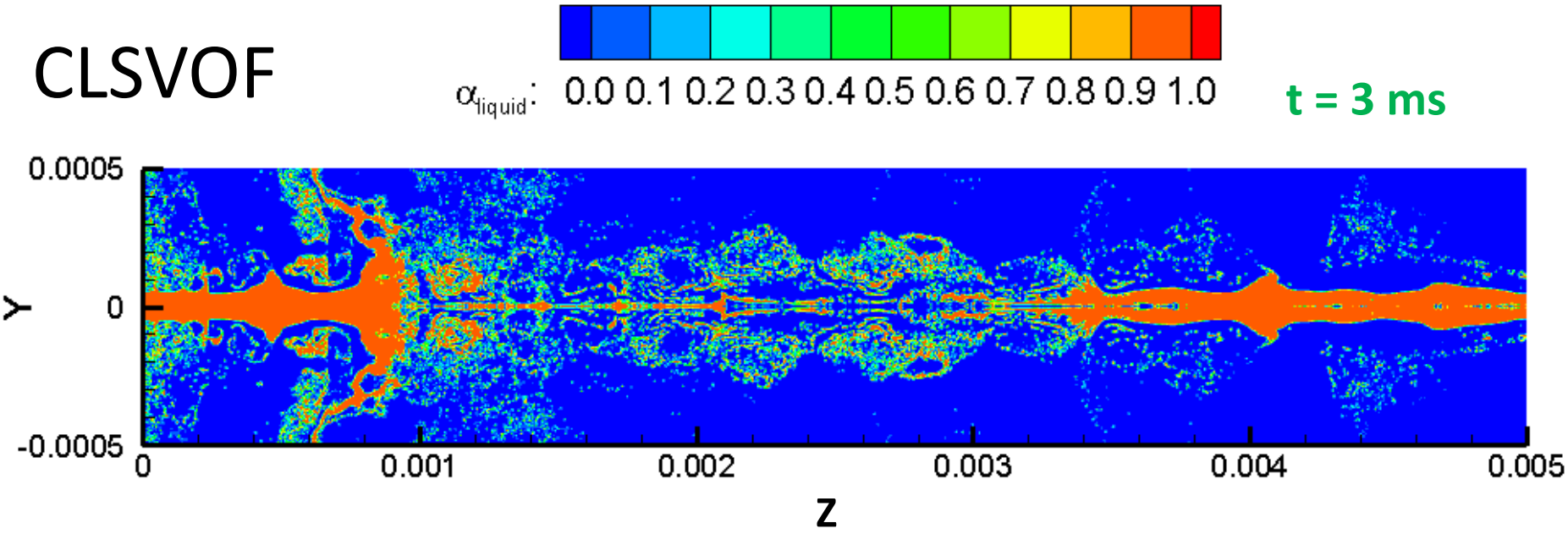


Results ---- 5-Jet-Diameter Case

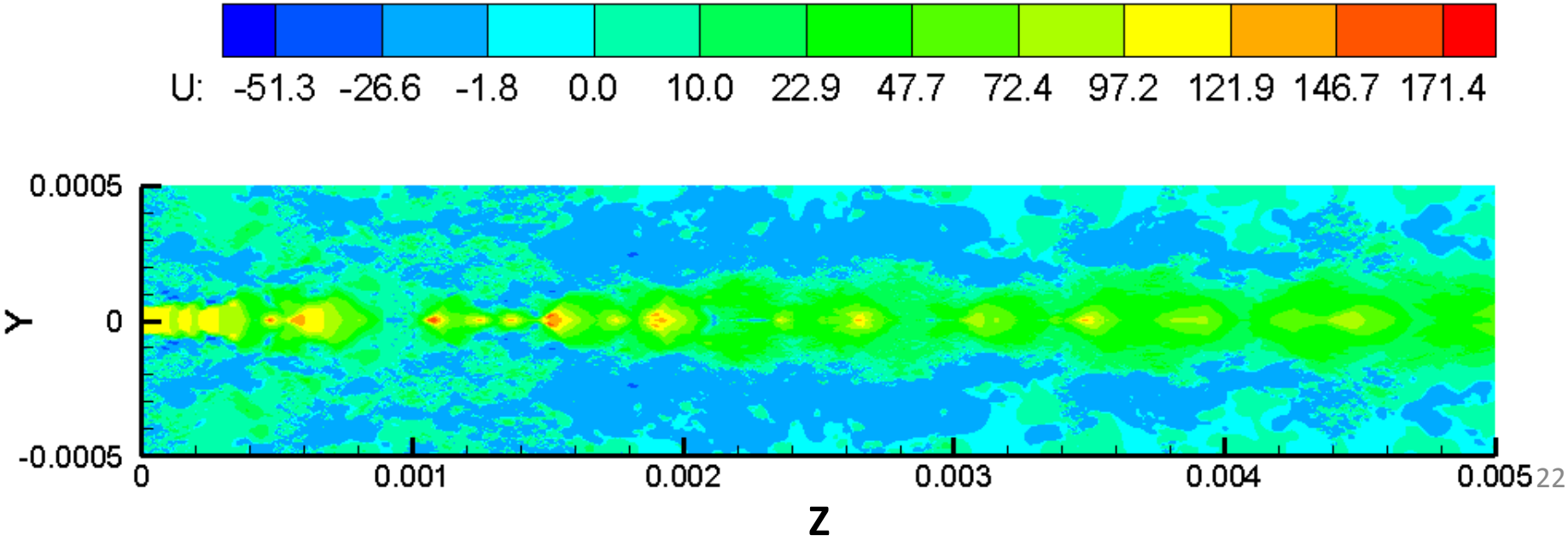


Results ---- 5-Jet-Diameter Case

- CLSVOF



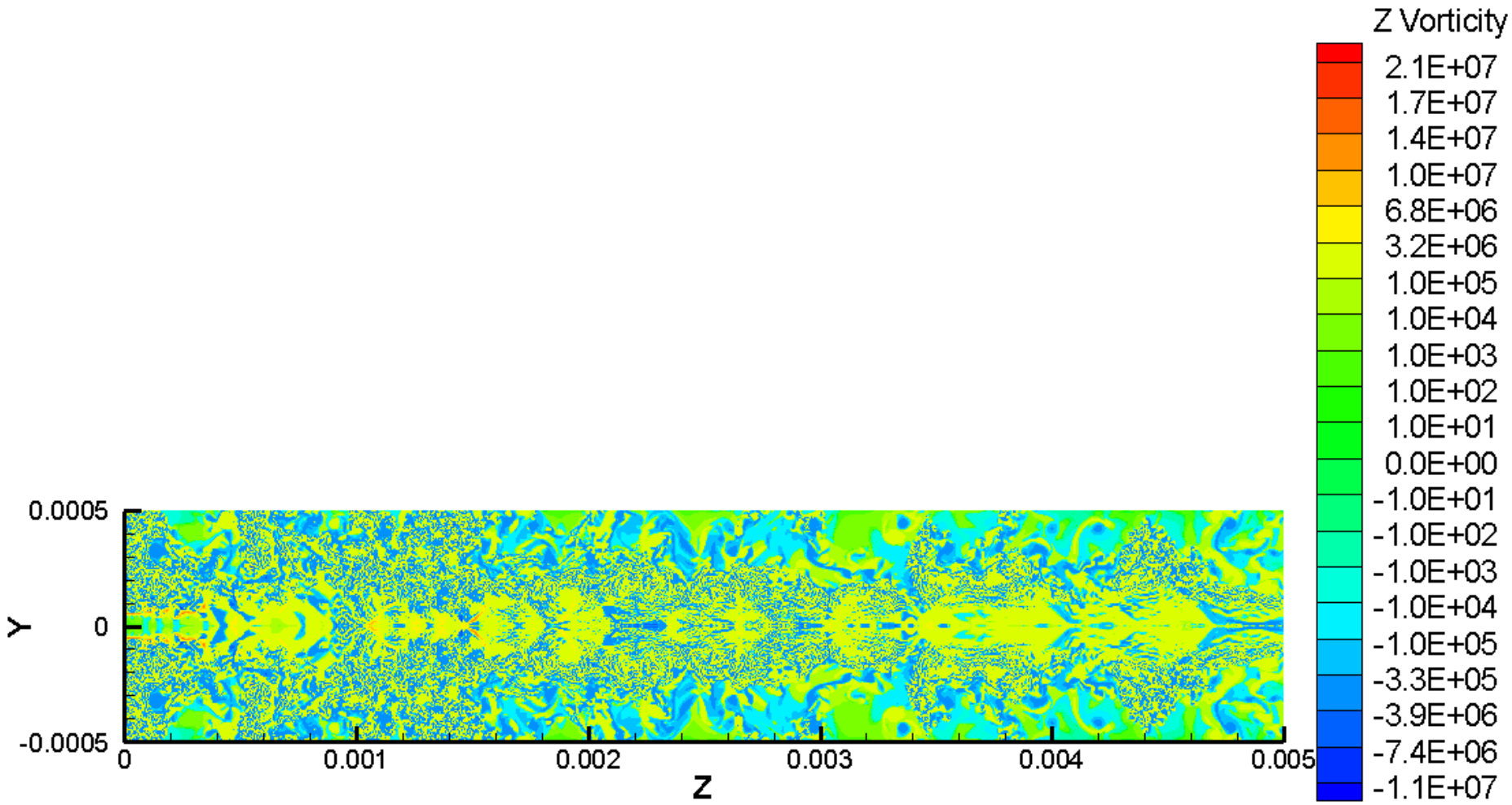
location of onset of turbulent breakup ≈ 0.4 jet diameters



Results ---- 5-Jet-Diameter Case

- CLSVOF

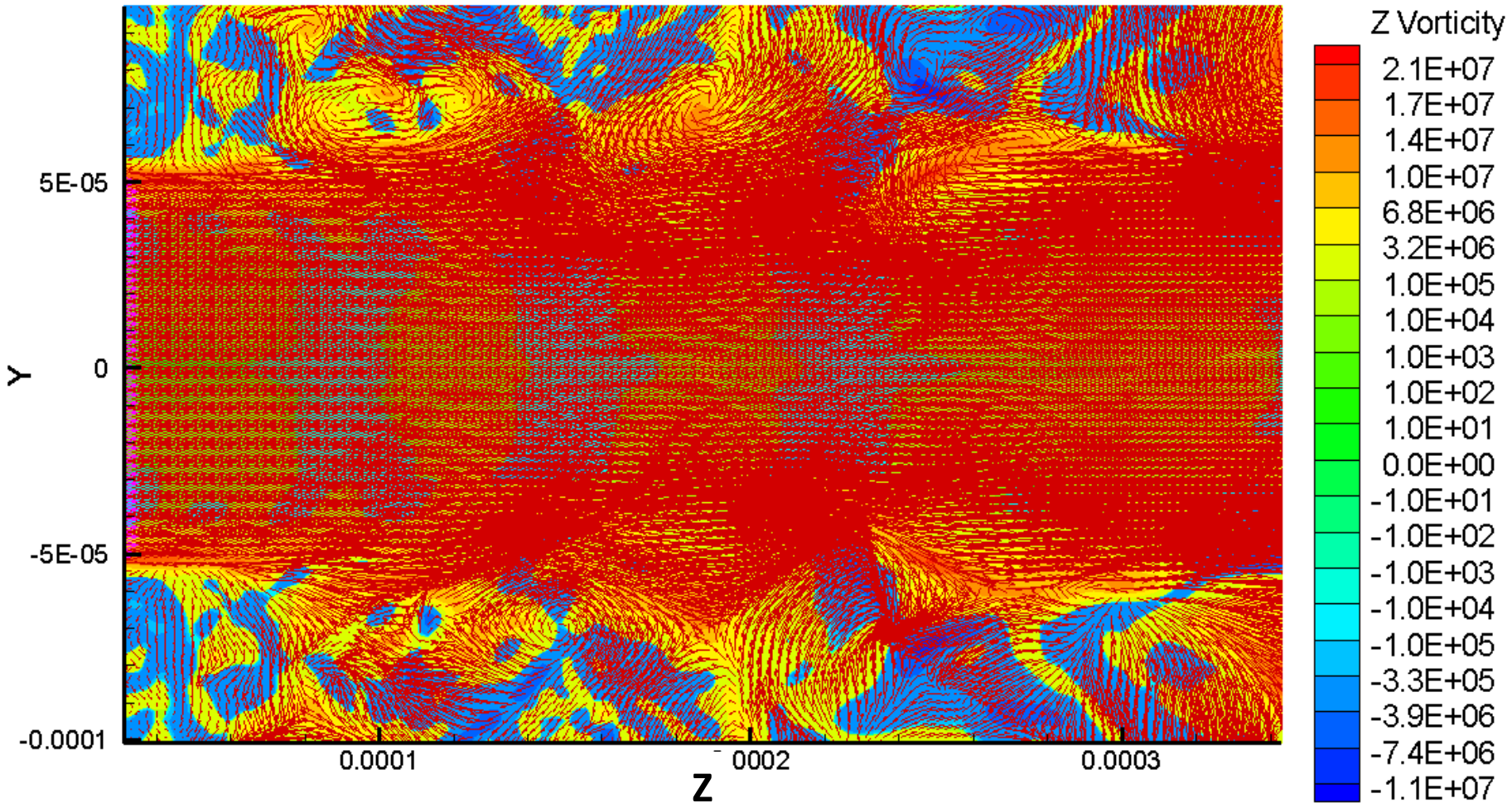
t = 3 ms



Results ---- 5-Jet-Diameter Case

- CLSVOF

t = 3 ms

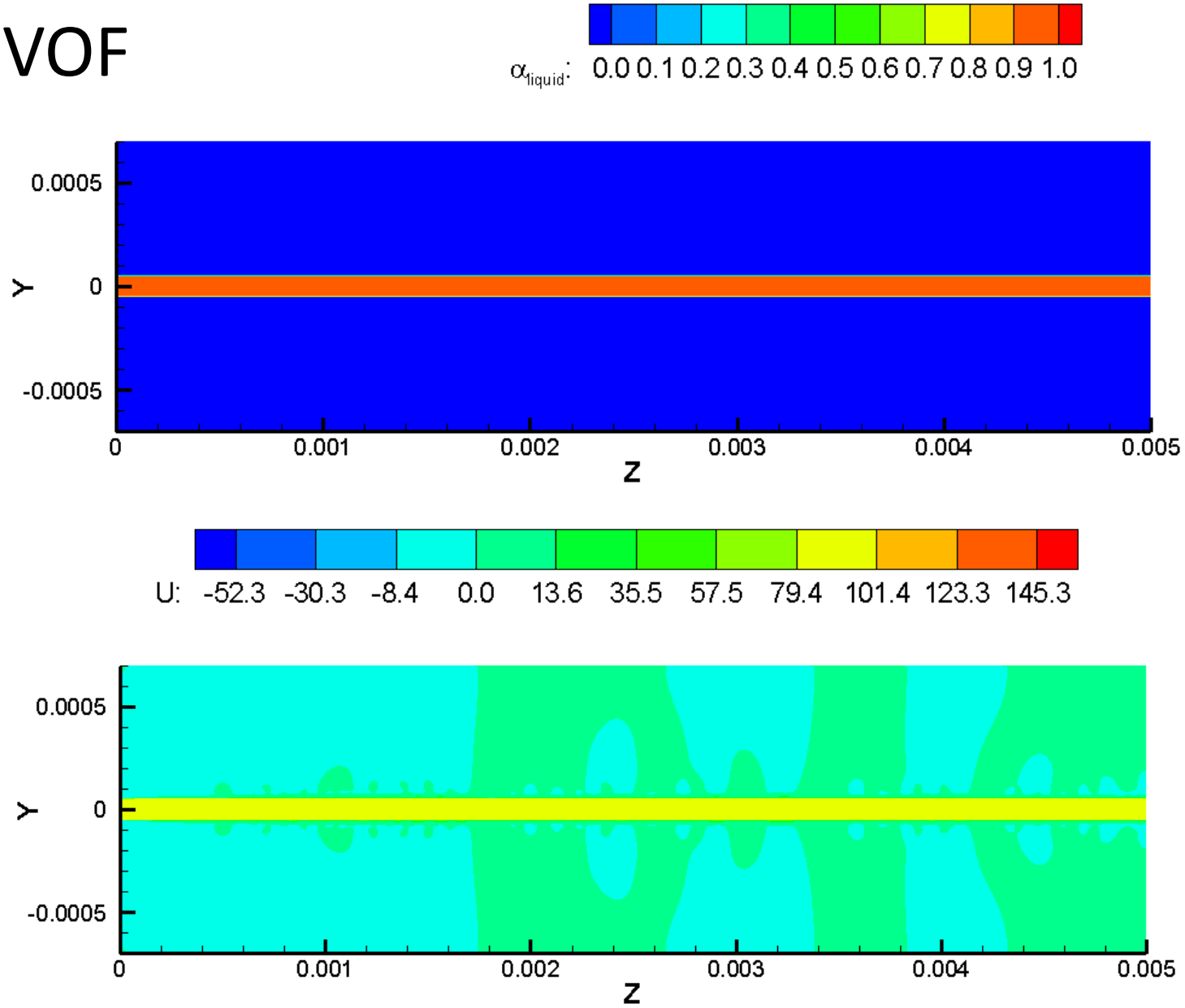


Results ---- 7-Jet-Diameter Case

(click to watch the movie)

0 < t < 1.75 ms

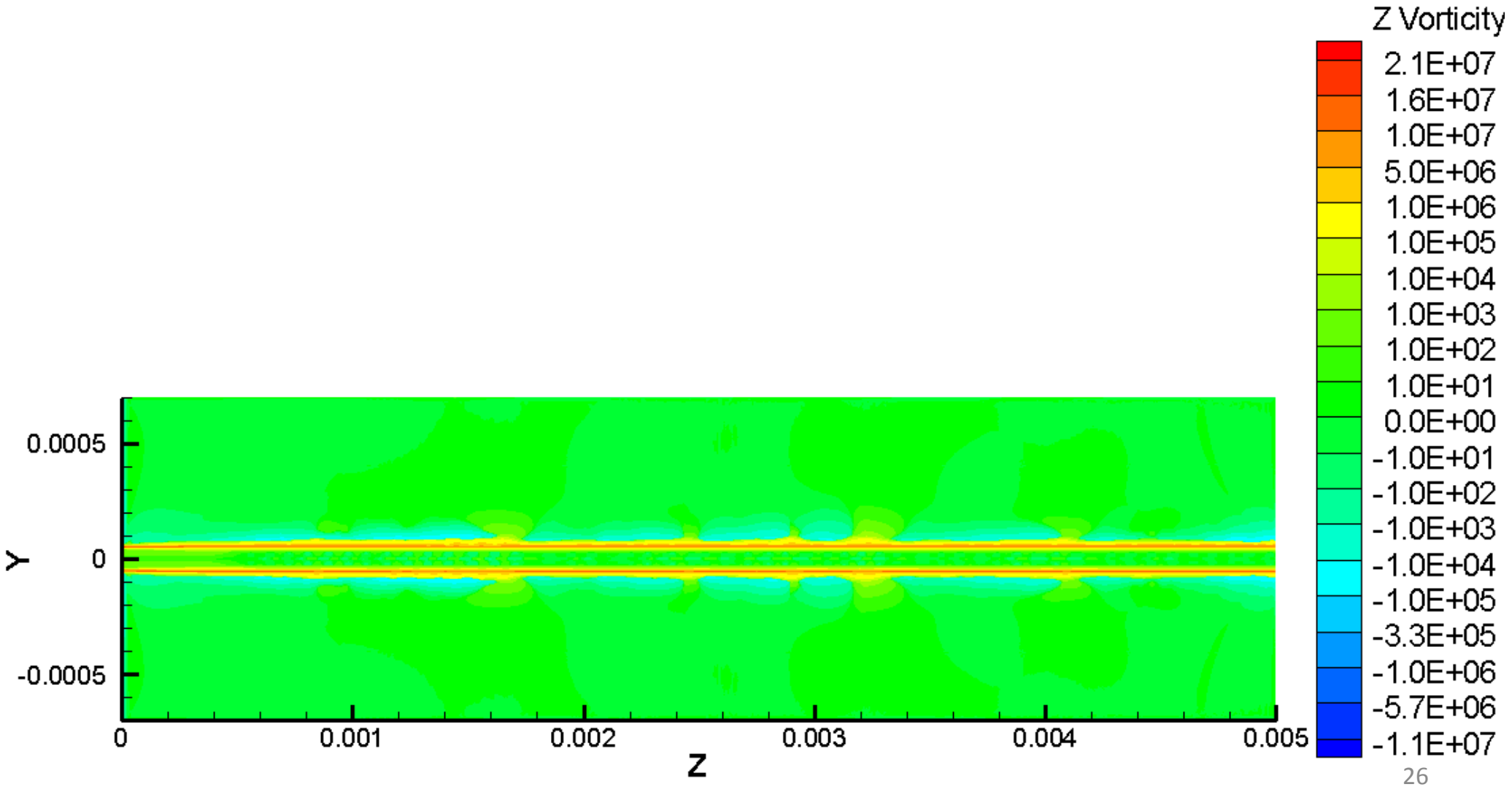
- VOF



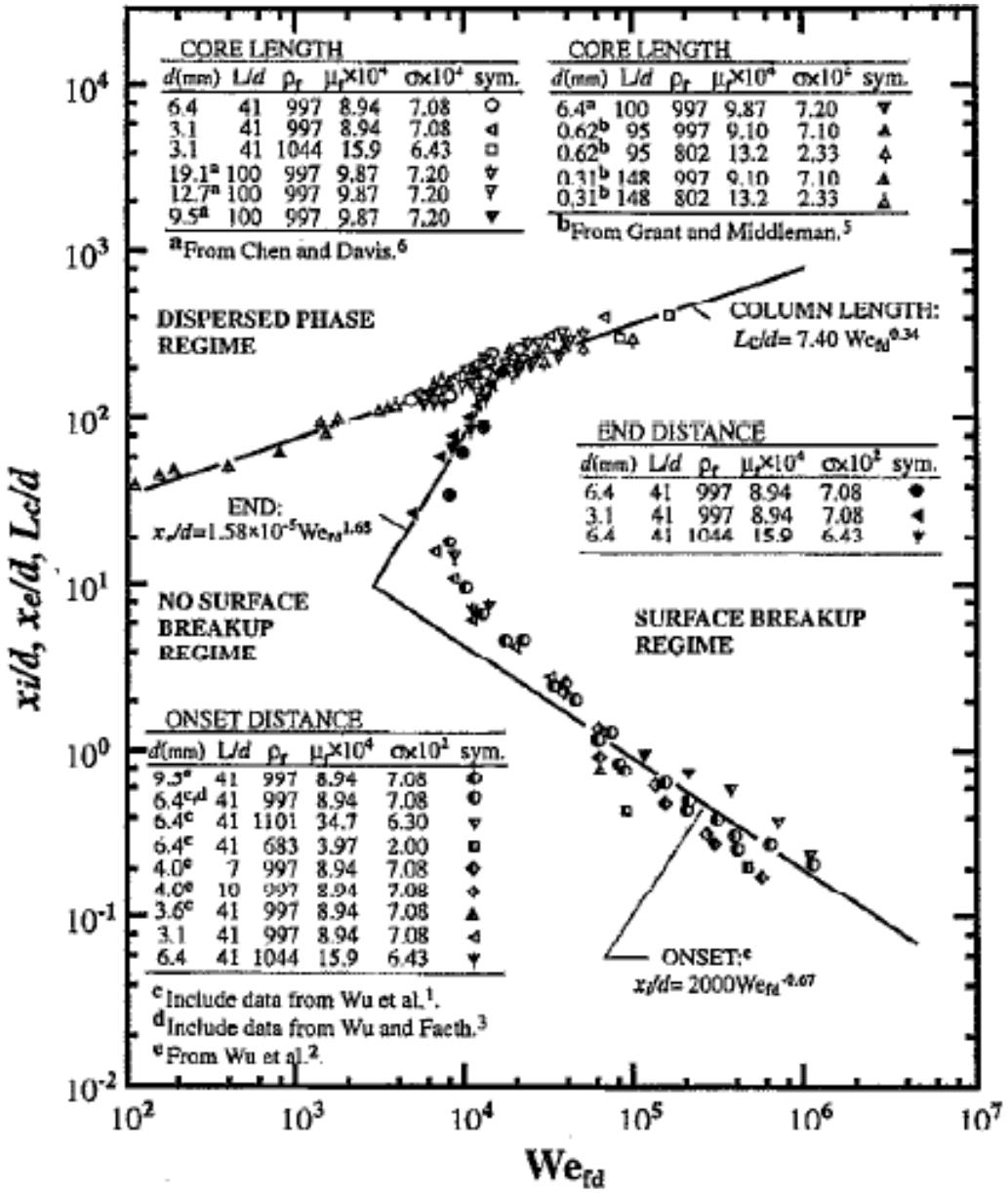
Results ---- 7-Jet-Diameter Case

(click to watch the movie)

0 < t < 1.75 ms



Hand Calculation



Considered Range:

Weber numbers ($We_{fd} = \rho d u_0{}^2 / \sigma$) : 1.0X 10^2- 1.1X1 0^6;

Reynolds numbers ($Re_{fd} = \rho_f d u_0{}^2 / \mu_f$) : 3.4X$10^3$-8.5X 10^5 ;

Ohnesorge numbers ($OH_d = \mu_f / \rho_f d\sigma$) : 0.001-0.017.

[2] P-K Wu and G M Faeth, Onset and end of drop formation along the surface of turbulent liquid jets in still gases, Phys. Fluids, Vol. 7, No. 11, November 1995

Surface breakup regime map for turbulent liquid jets in still gases when aerodynamic effects are small (liquid/gas density ratios are larger than 500)[2]

Hand Calculation

We_{fd}	Re_{fd}	OH_d	$x_i = 2000We_{fd}{}^{-0.67}d$	$x_e = 1.58\times10^{-5}We_{fd}{}^{1.68}d$
11,600	5,800	0.01857	3.783d	106.4d

x_i: location of onset of turbulent breakup;
x_e: location of end of turbulent breakup,
d: jet diameter.

Case	x_i
3-Jet-Diameter VOF	14d
3-Jet-Diameter CLSVOF	1.6d
5-Jet-Diameter VOF	11.6d
5-Jet-Diameter CLSVOF	0.4d
7-Jet-Diameter VOF	Not Completed