Analysis and Control of Coherent Structures in Jet Noise and Shock/Boundary Layer Interactions
COMPUTATIONS

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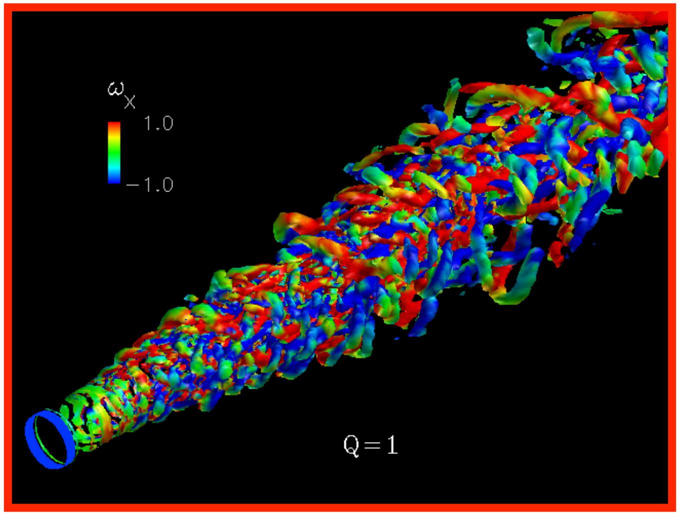
Support

AFOSR (Dr. J. Schmisseur)
DoD HPCMP: AFRL, ERDC, NAVO
Ohio Supercomputer Center

Overall Objectives

- Use high-fidelity simulations anchored in experiment to...
- ...examine physics of small perturbation control

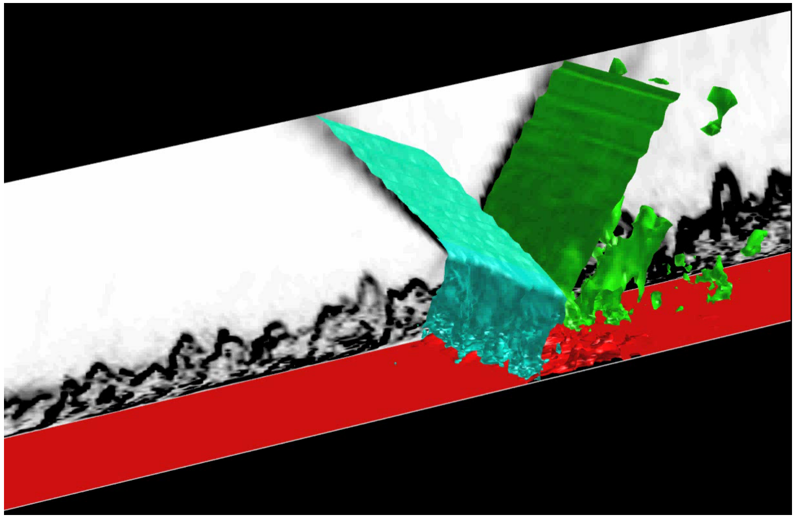
Jet Flow



Current Goal: Near Field Dynamics

Rachelle Speth, MS

SBLI



Current Goal: Unsteadiness analysis

Nathan Mullenix*, Post doc

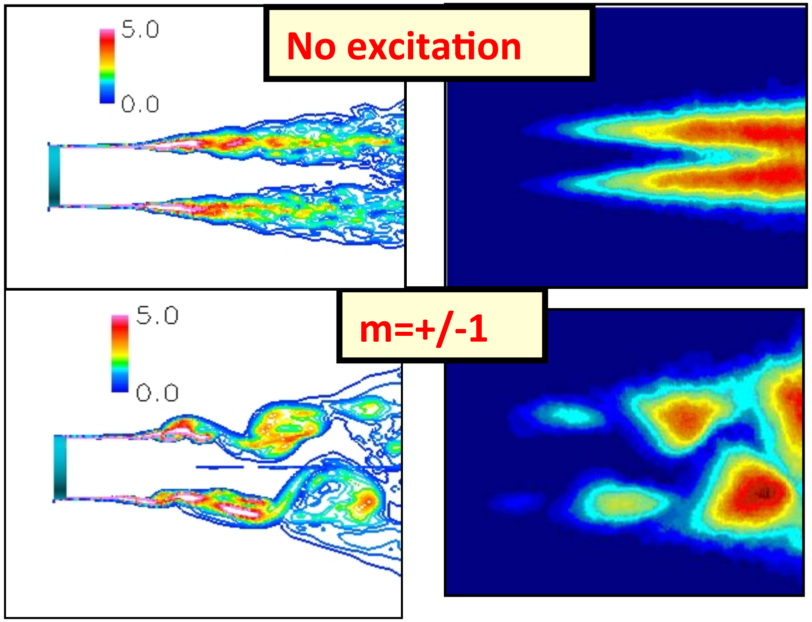
✓Support: AFOSR (J. Schmisseur)

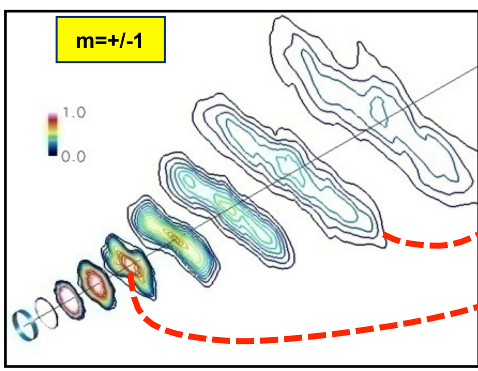
✓DOD HPC Modernization Program and Ohio Supercomputer Center (CPU hours)

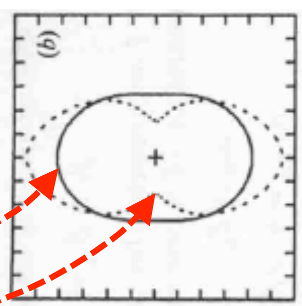
* Partly supported by Ohio Research Scholar Program

Validation: Coherent Structures

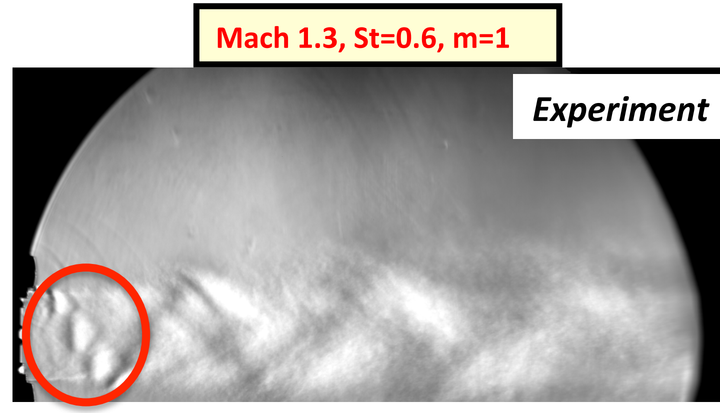
Computation *Experiment*



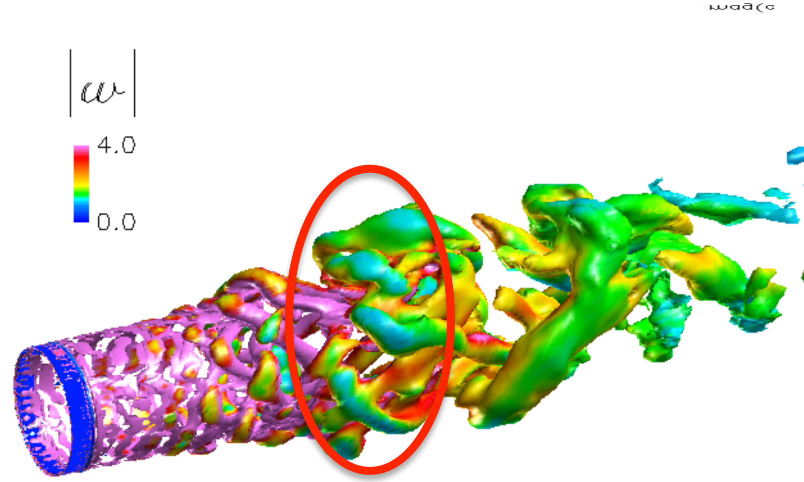




Theoretical iso-velocity contour plots (Cohen and Wygnanski)



p colored by ω

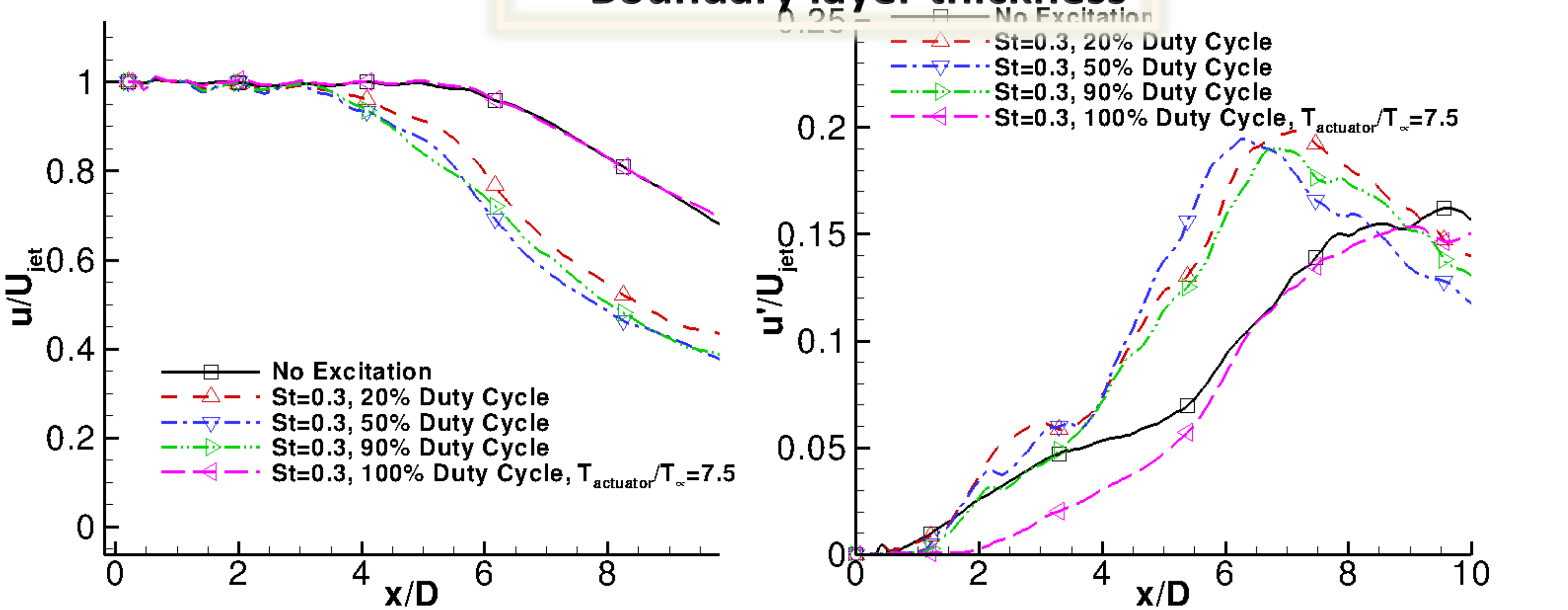


✓**Pervasive, on-going effort to compare computations with experiment**

✓**Compelling evidence that simulations capture coherent structures**

Recent Parametric Studies

- Duty cycle
- Frequency
- Disturbance amplitude
- Boundary layer thickness



✓Relatively insensitive to duty cycle (except 100%)

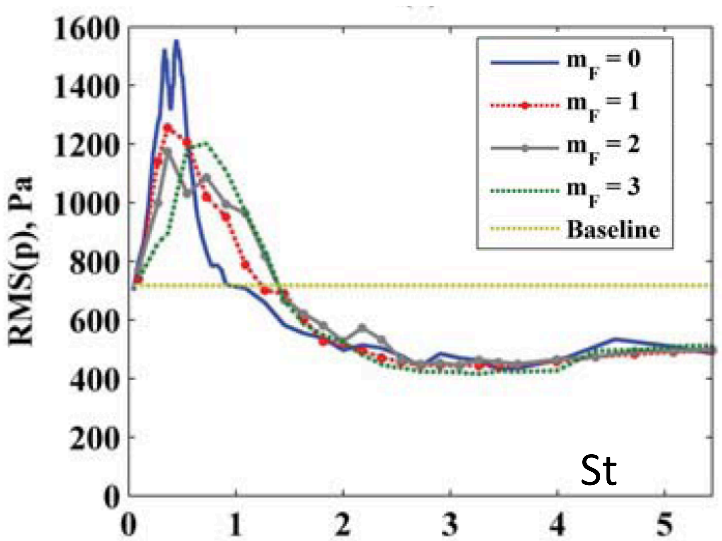
✓Relatively insensitive to amplitude

✓Frequency and mode determine response, not total energy input

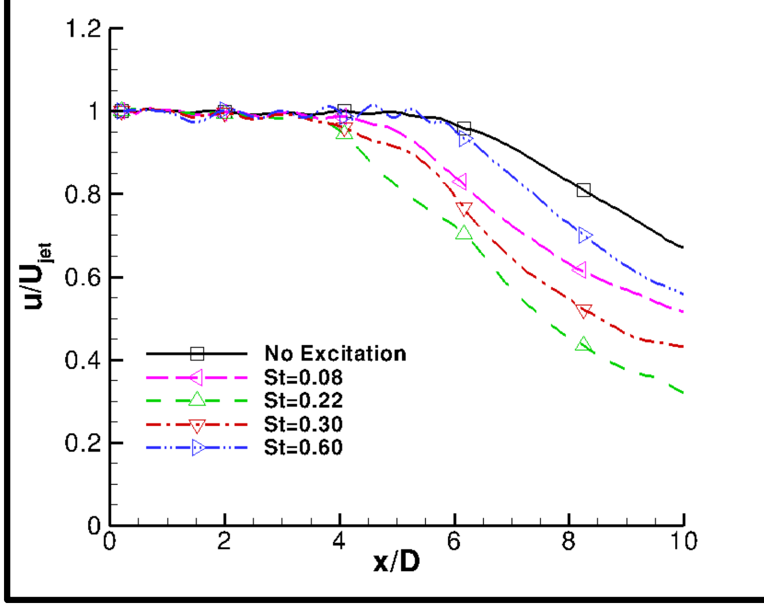
Detailed analysis of lip-line analyses, Reynolds stresses, correlations in papers

Effect of Frequency

Expt M=0.9

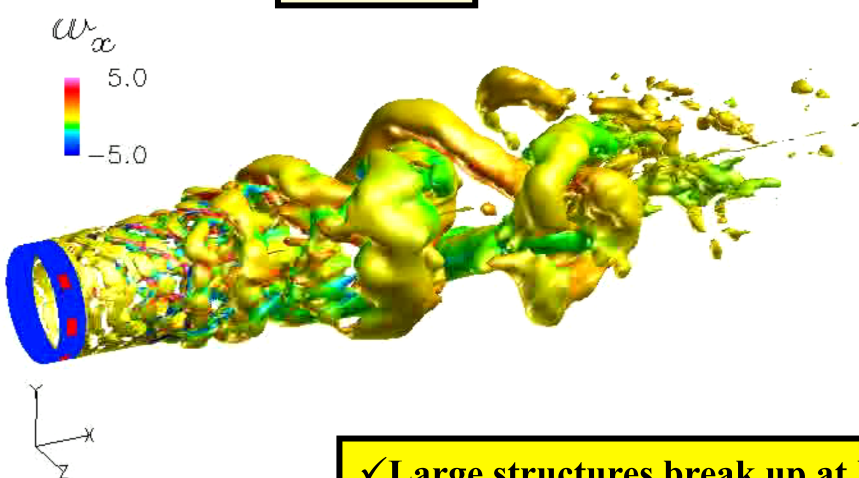


CL streamwise m=+/-1

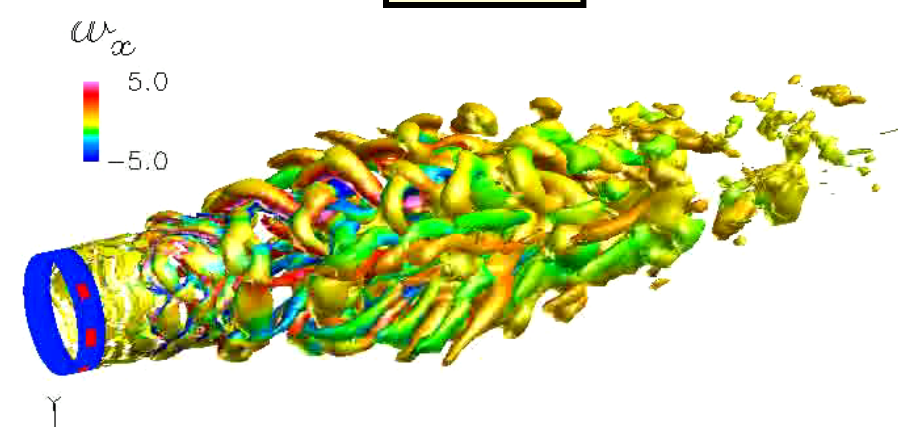


✓**Higher frequencies reduce near-field acoustic pressure**

St=0.3



St=0.6

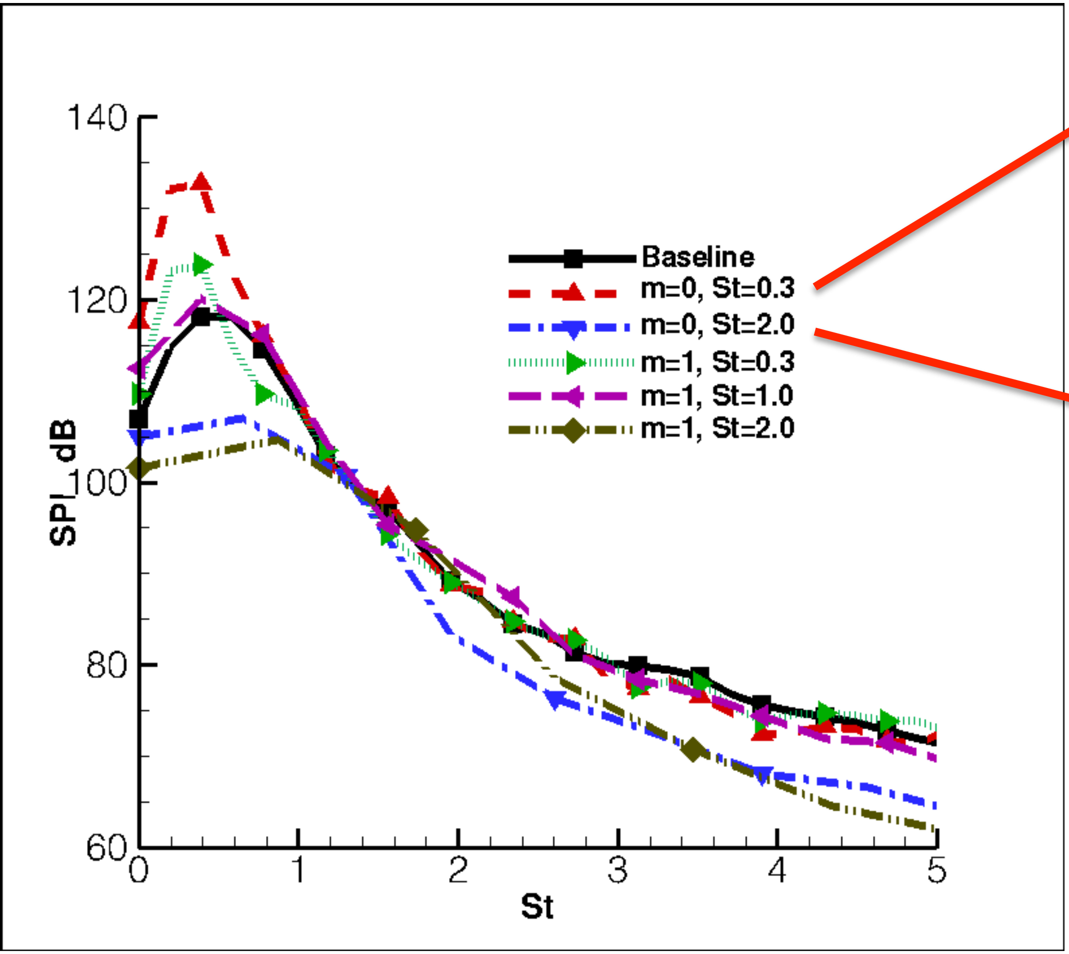


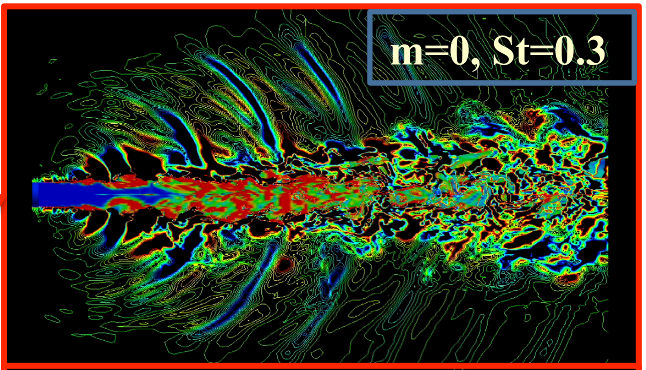
✓**Large structures break up at higher frequencies**

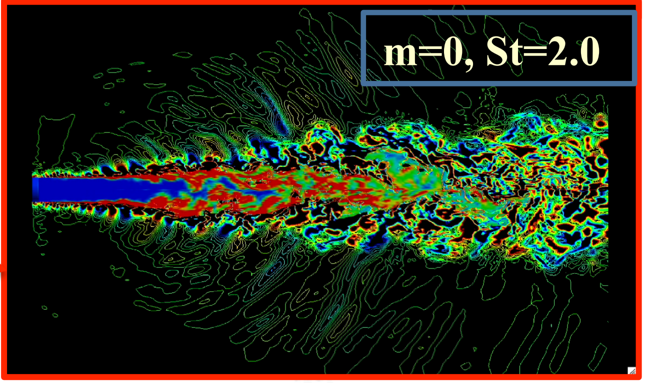
✓ **Hairpin vortices with streamwise legs (ribs)**

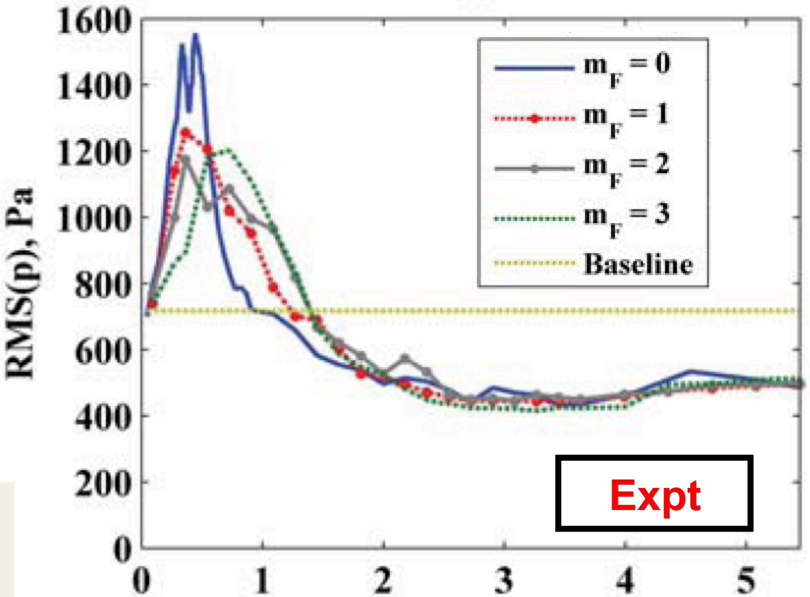
Effect of control on near field pressure

x/D=3, r/D=1



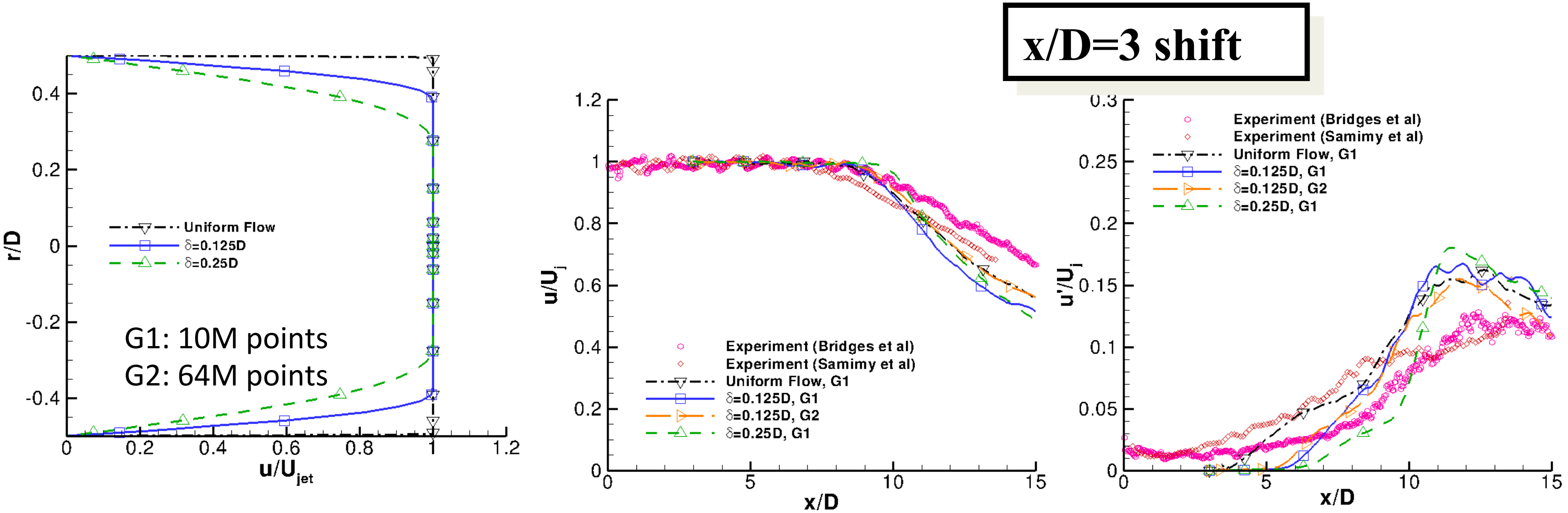


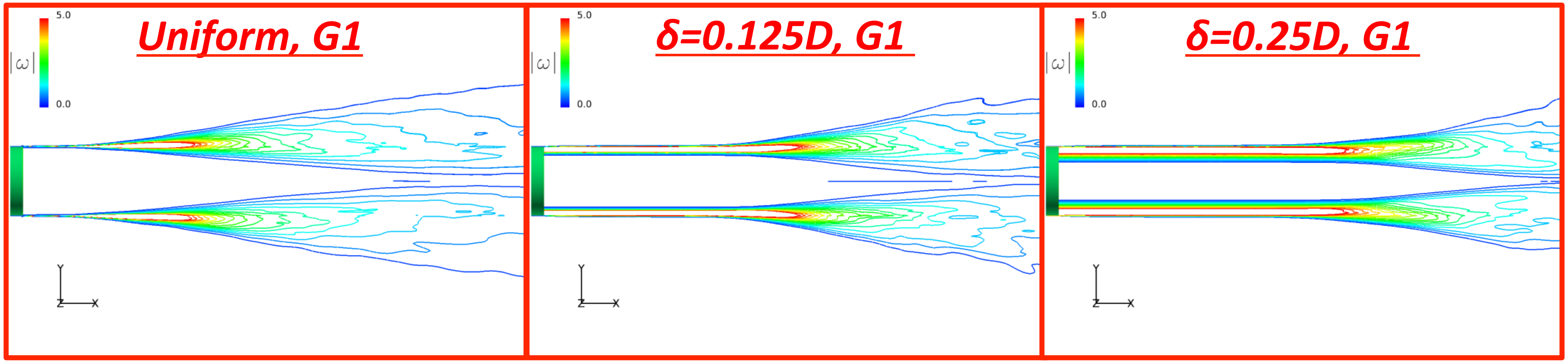




- ✓Simulations reproduce observed trends
- ✓Near field correlates with generation of coherent structures

Effect of Jet Exit Profile: No Control

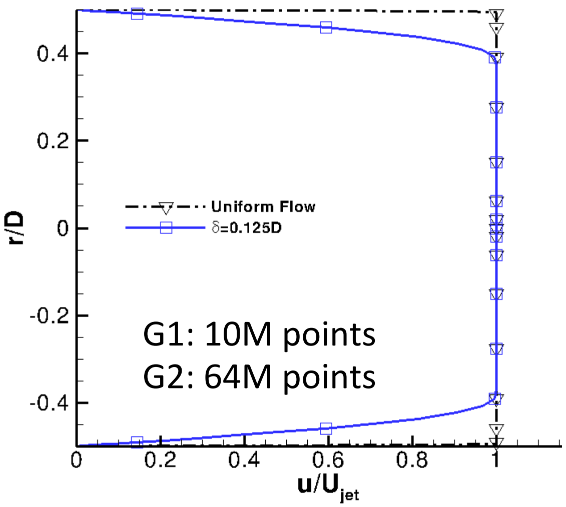


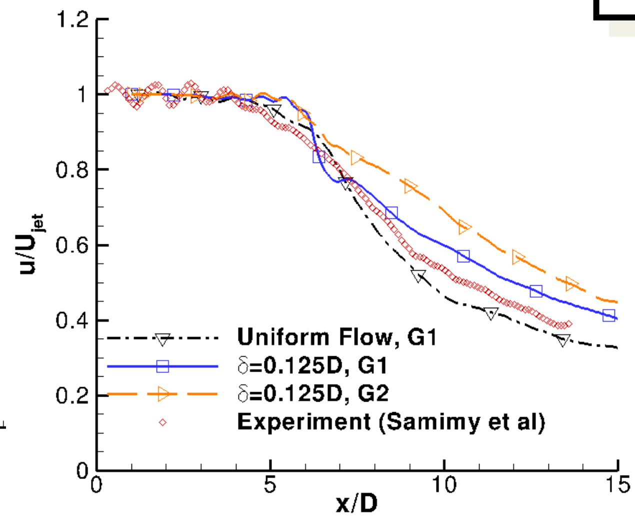


✓Thicker b.l delays growth, but core length remains roughly same

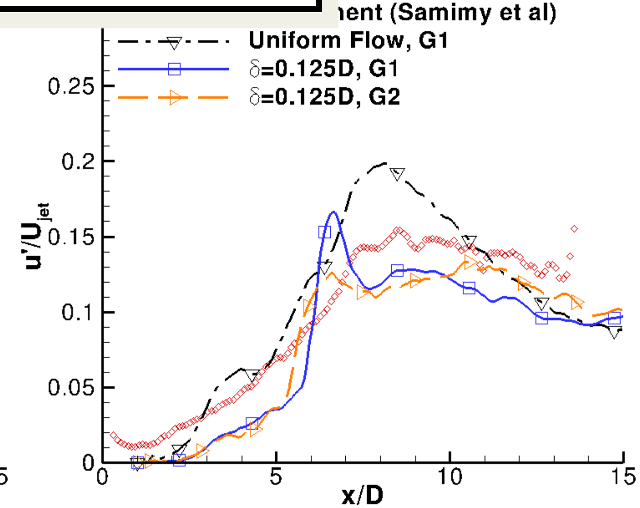
✓Similar trends observed by with Bogey and Bailly at Mach 0.9

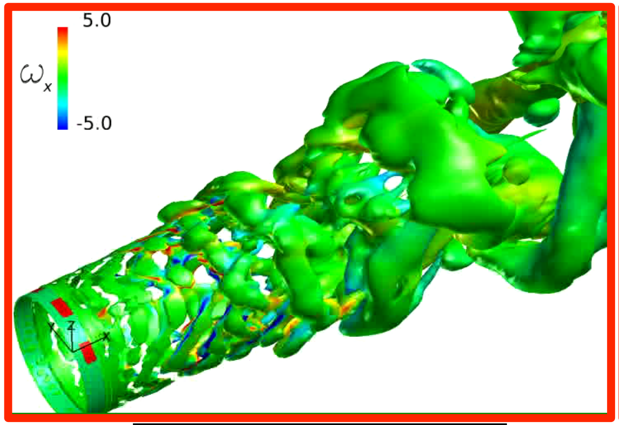
Effect of Jet Exit Profile: Control cases

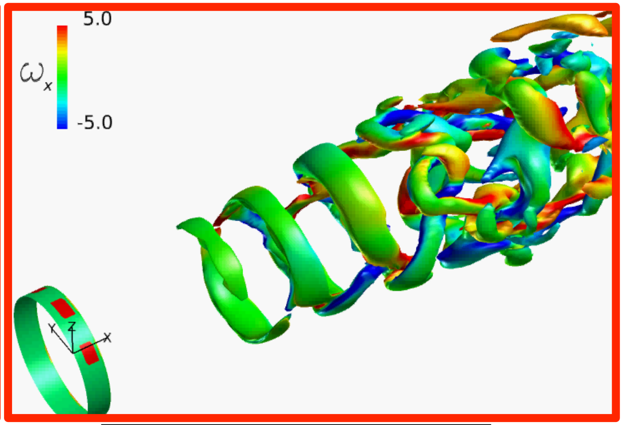


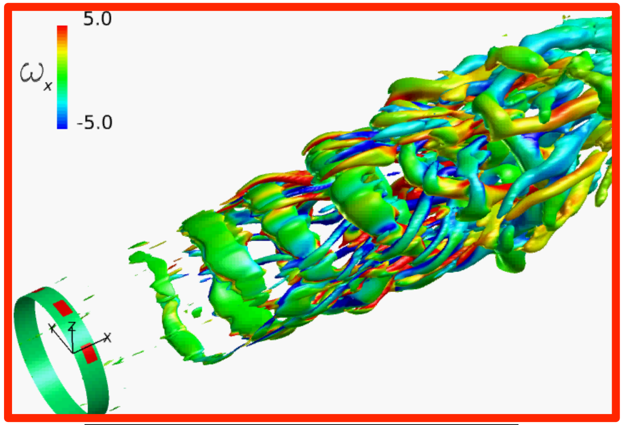


x/D=1 shift









Uniform, G1 | **δ=0.125D, G1** | **δ=0.125D, G2**

- ✓**Rings are thinner and more frequent in the thicker boundary layer**
- ✓**Intensity of effect diminishes**

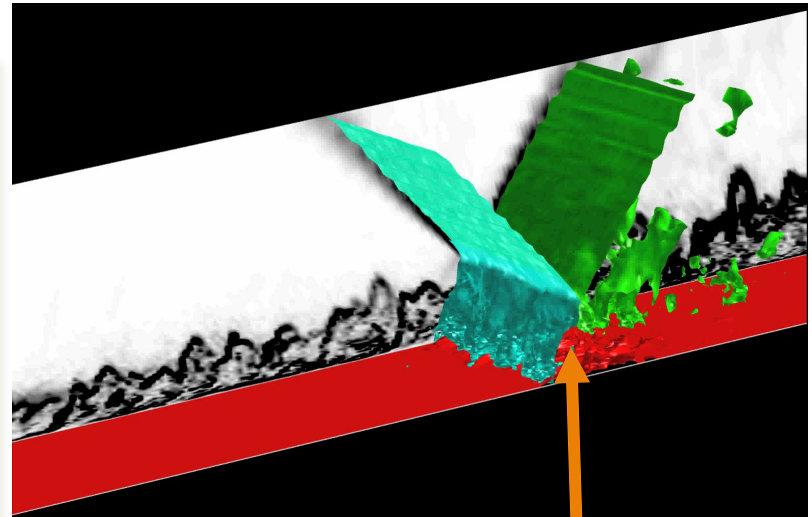
Future Activities

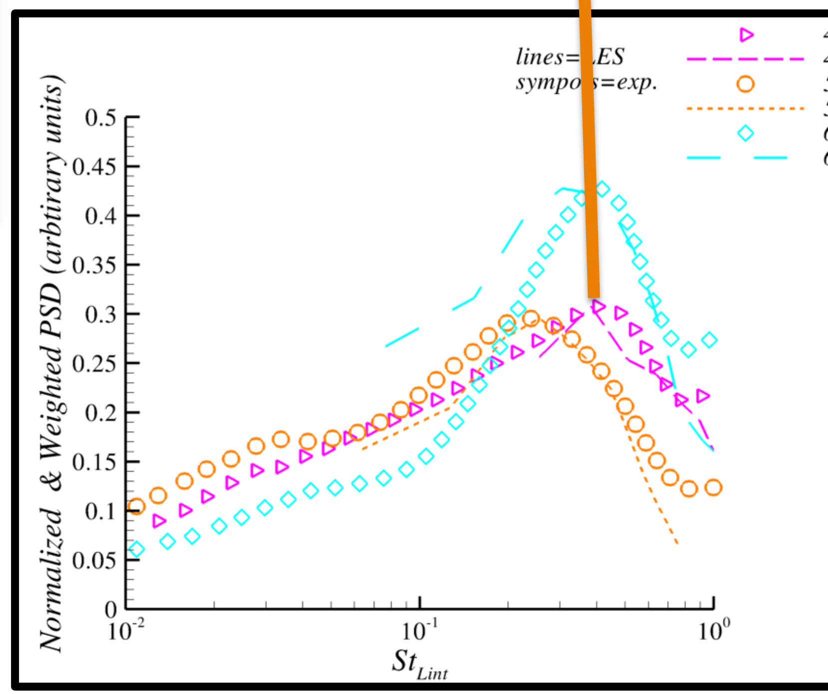
JET FLOW

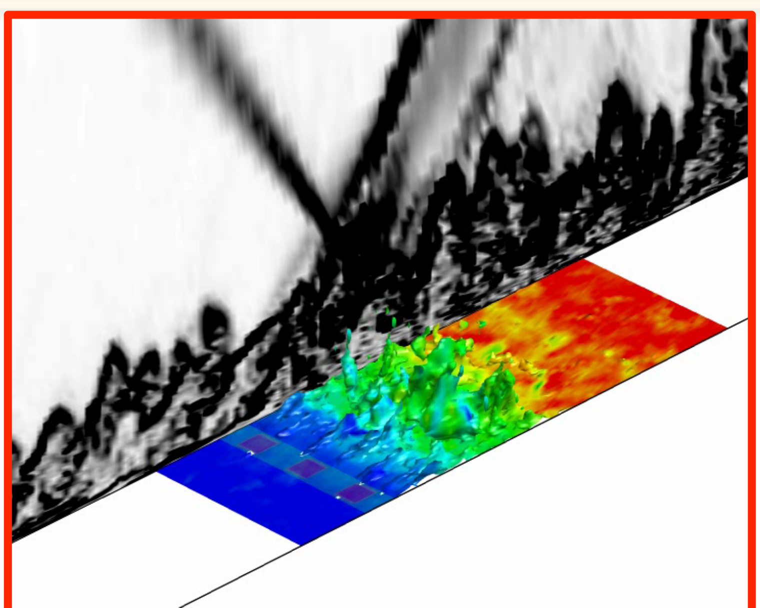
- **Near field SPL analysis**
  - Further comparison with experiment
  - Correlation to coherent structures
- **Impulse response of jet**
- **Non-thermal perturbations**
- **Far field SPL correlation with near field**

SBLI

- **Analysis of low frequency unsteadiness**
  - POD and DMD analyses
- **Control**







Outstanding Scientific Research Issues

- Jet noise
  - *Dynamics of large scale structures and their relation to jet noise*
  - *Effective control of jet noise*
- Shock/boundary layer interaction
  - *Control of separation and spectral content*
  - *Mechanism and structure of low frequency oscillations in the interaction region*