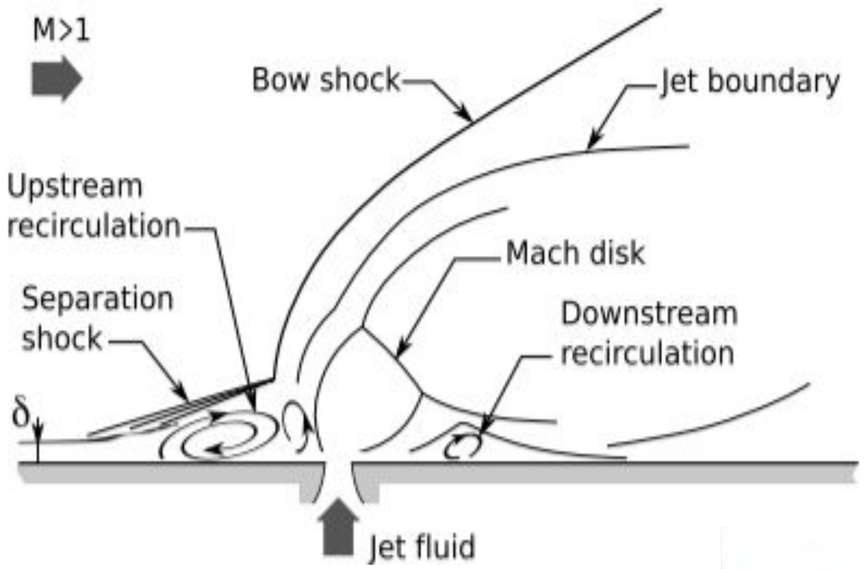
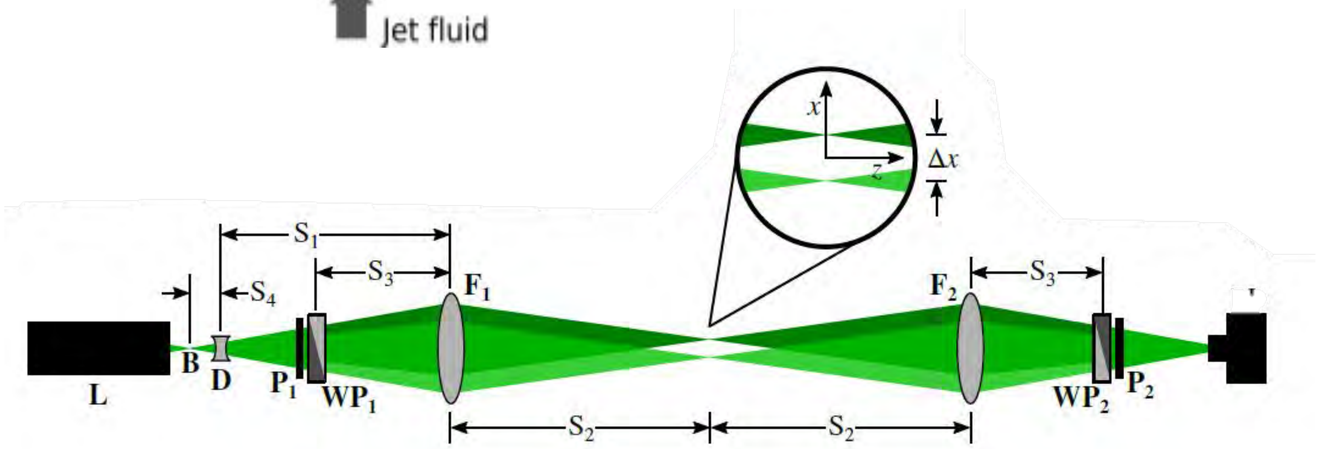
By: Paul Medina (Presenter) & Jack Ninos (Collaborator)

How Can Focused Laser Differential Interferometry (FLDI) Assist in Analyzing Jets in Hypersonic Crossflow?

- Jets in hypersonic crossflow are difficult to characterize.
- FLDI provides advantages over typical measurement techniques.
- Non-invasive with high spatial and temporal resolution.
- Innovations include multi-point and integration with other measurement techniques.



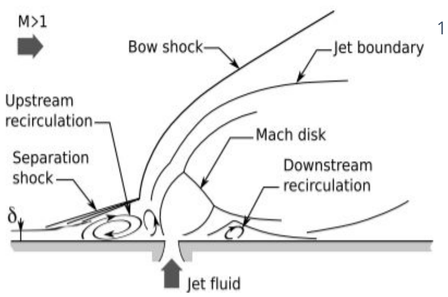


Analysis of Jets in Hypersonic Crossflow using Focused Laser Differential Interferometry (FLDI)

By: Paul Medina (Presenter) & Jack Ninos (Collaborator)

What are Jets in Hypersonic Crossflow?

- Hypersonic Flow (Mach > 5).
- Canonical Transverse Jet.
- Shock Induced B.L. Separation.
- Unsteadiness.
- Flow Distortion.
- Total Pressure Loss.
- High Temperature & Pressure.
- Induce Streamwise Vortices to Control Flow Separation.



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Difficulties Measuring Turbulence Statistics

- Typical measurement techniques lack temporal resolution in the MHz range.
- Techniques such as Hotwire Anemometry are limited to the kHz range and are invasive.
- Other techniques such as PIV are difficult to implement in short duration shock tubes like our Mach 2 Ludwieg tube.
- Similarly, Schlieren is useful, but limited to mainly qualitive results.
- Useful statistics such as mean flow velocity and fluctuations are difficult to measure without encompassing techniques examining all parts of the flow.
- Typically, comparison with low Re DNS data is needed to qualify experiments.

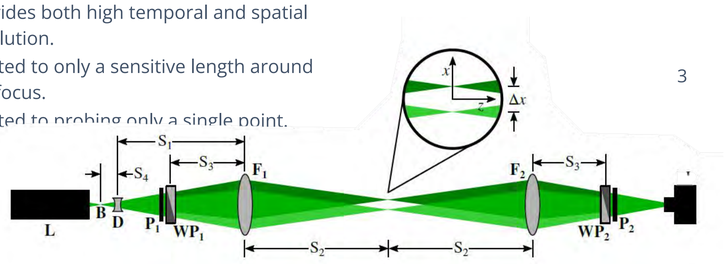
What is Focused Laser Differential Interferometry?

- FLDI leverages Laser Differential Interferometry.
- Interference fringes from common path laser beams are correlated to density gradients.
- Focusing allows the rejection of density fluctuations away from point of interest.
- Helps avoid unwanted interactions from tunnel boundaries.
- Provides both high temporal and spatial resolution.
- Limited to only a sensitive length around the focus.
- Limited to probing only a single point.

$$\Delta\phi = \frac{2\pi K}{\lambda}\left(\int_{s_1}\rho_1\,ds - \int_{s_2}\phi_2\,ds\right)$$

2

$$\frac{\Delta\phi}{\Delta x}\frac{\lambda}{2\pi K L} = \frac{\int_{s_1}\rho_1\,ds - \int_{s_2}\rho_2\,ds}{\Delta x} \approx \frac{\partial\bar{\rho}}{\partial x}$$



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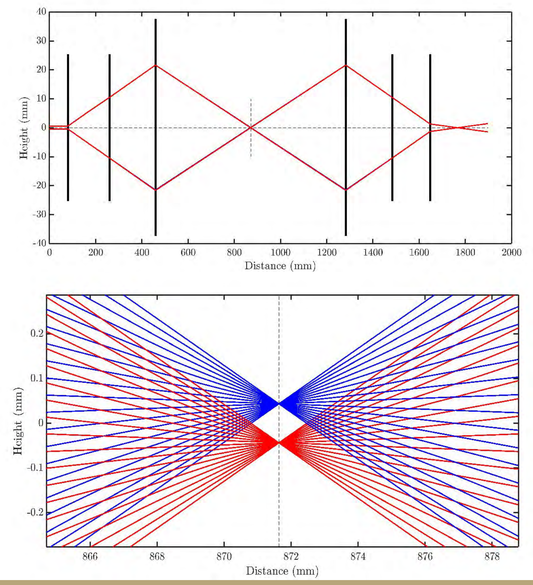
Our Design

- The purpose of our project is two-fold:

1. Measure turbulent statistics of a jet in hypersonic crossflow utilizing FLDI and compare to traditional measurement techniques.
2. Analyze FLDI by varying optical components to gauge spatial sensitivity of FLDI. Determine a method to accurately determine the sensitive region along the optical axis.

- Our design aims to vary the dimensions of the diffractive Wollaston prisms an



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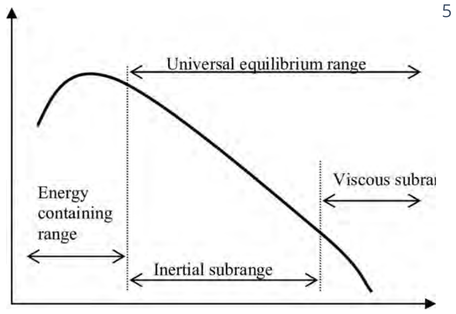
How does FLDI Enable Analysis?

- Provides density gradients at a point with high spatial resolution.
- Provides insight into turbulent energy cascade via power spectral density (PSD).
- Helps identify dominate frequencies in turbulence.
- Mutli-point FLDI provides velocity correlations which identifies turbulent transport processes.



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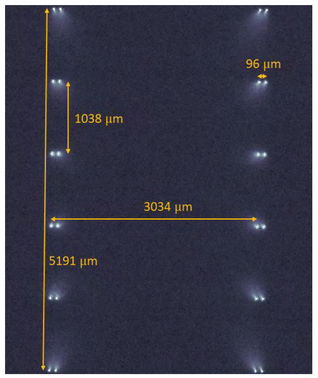
Goals & Next Steps

- Our next steps are to build single-point FLDI system in GUG 114 on our Mach 2 Ludwieg tube.
- Test on simple cone geometry using a canonical transverse jet.
- Implement a linear array FLDI system to measure density gradients at multiple points.
- Asses spatial sensitivity of system at multiple points.



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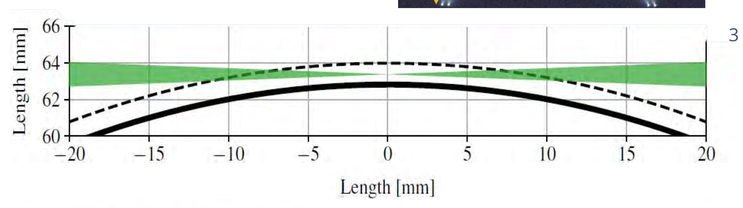

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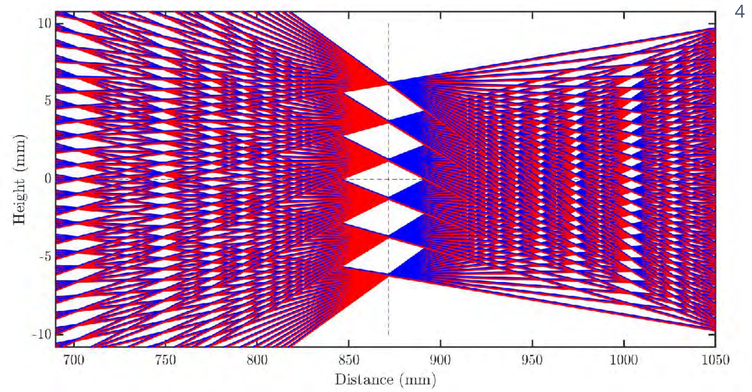

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