

# **Attenuation of Gas Turbulence by a Nearly Stationary Dispersion of Fine Particles**

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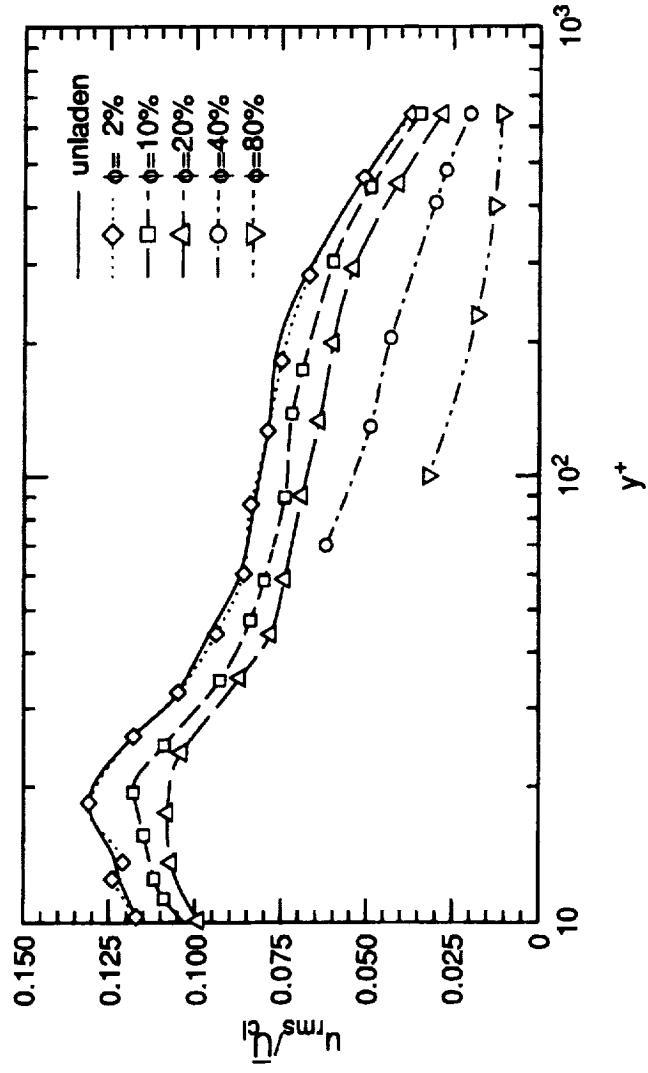
Stanford University

Sponsor: NASA; Microgravity Fluid

Physics Program

# Background

- Fine particles with a mass loading ratio as low as 5% can attenuate turbulence
- Existing models do not correctly explain the attenuation, which is a function of  $St_{\text{particle}}$ ,  $Re_{\text{particle}}$ ,  $Re_{\text{flow}}$ , mass loading ratio, and flow structure



Streamwise turbulence intensity  
with various loadings of 70  $\mu\text{m}$   
copper particles.

From Kulick et al. (1994)

# Transport Equation for TKE in Homogeneous Flow

$$\frac{Dk}{Dt} = \underbrace{-\overline{u_i' u_k'} \partial_k U_i - \nu \partial_k \overline{u_i' \partial_k u_i'}}_{\text{production from mean gradient}} - \underbrace{\frac{1}{\rho_f \tau_p} \left[ C(\overline{u_i' u_i'} - \overline{u_i' v_i'}) + (\overline{c' u_i' u_i'} - \overline{c' u_i' v_i'}) + (\overline{U_i - V_i}) \overline{c' u_i'} \right]}_{\text{dissipation by viscosity}}$$

production from  
mean gradient

dissipation  
by viscosity



Represents the drag on turbulent eddies by particles. Incorporated in current models, but does not capture full turbulence modification.

## Possible Cause

The gravitational potential energy of particles is converted to turbulent velocity fluctuations which distort the turbulent eddies, leading to higher dissipation rate.

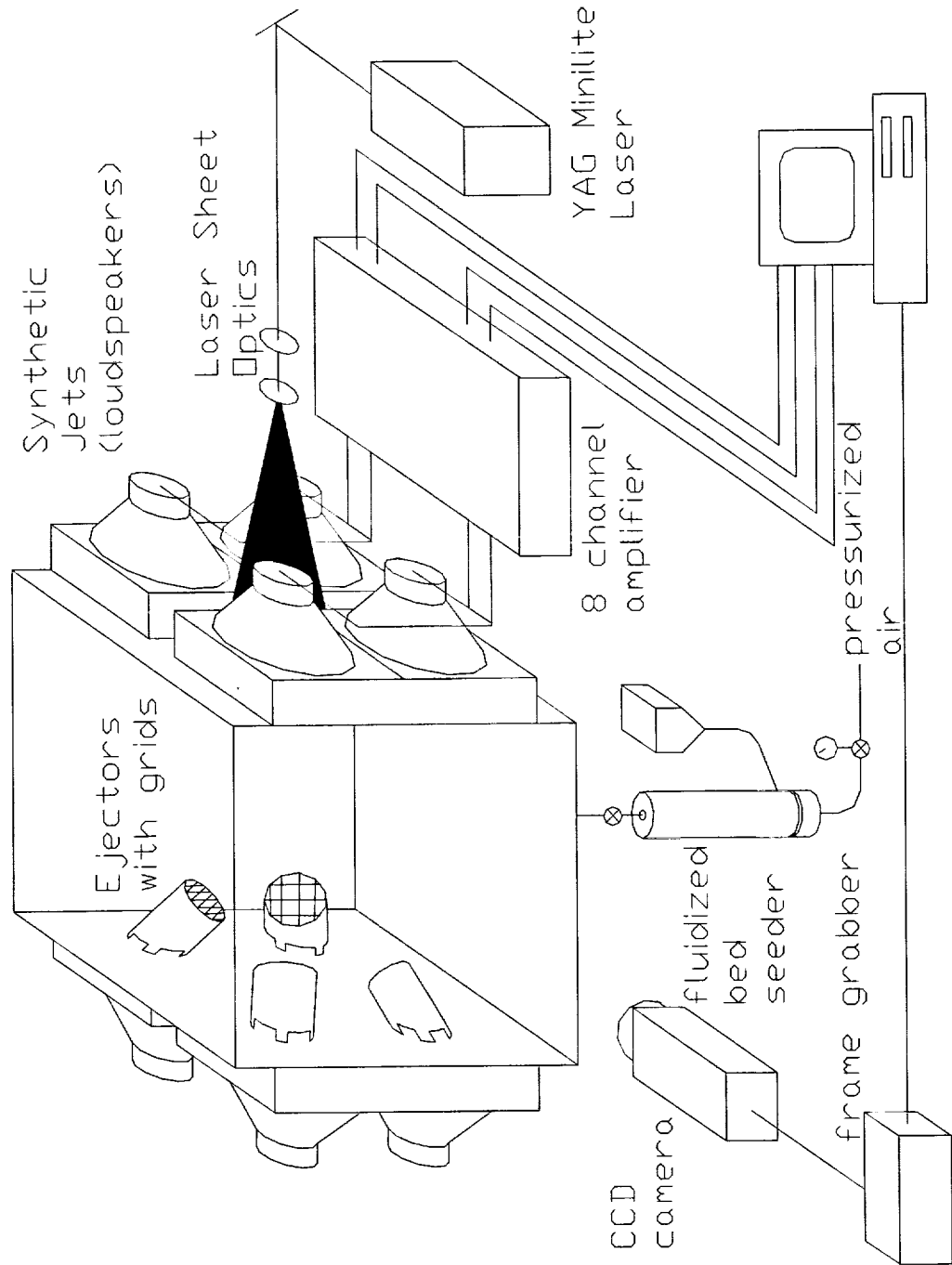
## **Objectives**

- Investigate the direct effects of particles on homogeneous turbulence by using a microgravity environment to eliminate the mean velocity of the particles
- Observe distortion of individual eddies by particles and also examine the details of the flow around single particles

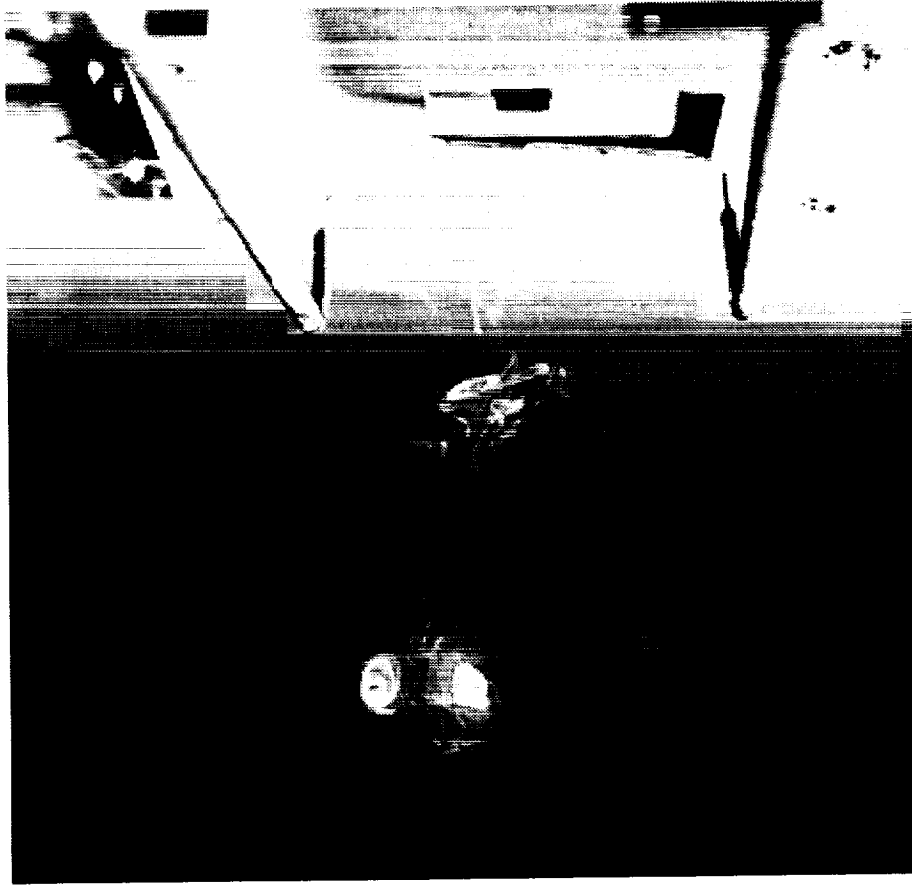
## **Current Status**

- The current emphasis is to create isotropic homogeneous turbulence in the chamber. Testing several different methods including ejectors, grids, various configurations of the synthetic jets.
- Two-phase PIV system development nearly complete

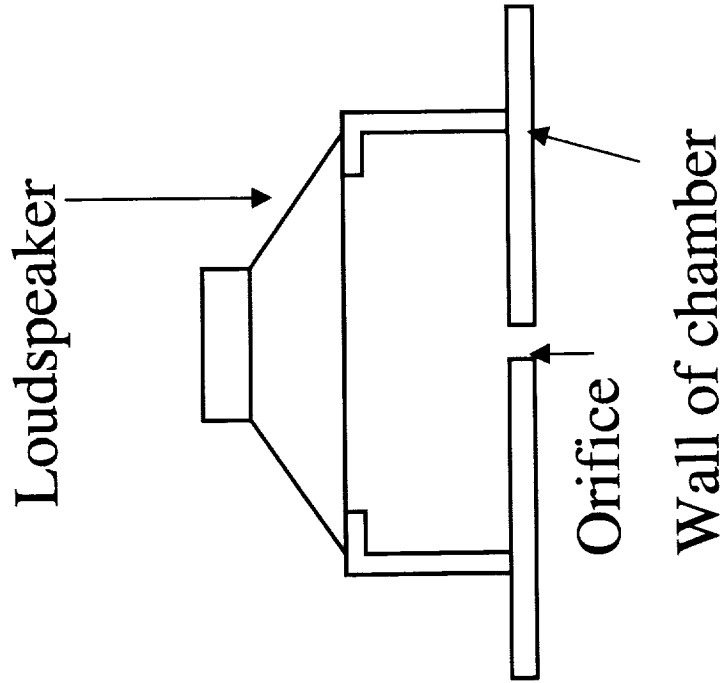
# Facility



# Synthetic Jet



Vortex ring ejected from a square orifice



# Digitized PIV photograph (single laser pulse)

150 micron glass

1 micron TiO<sub>2</sub>