Turbulence through Vortex Ring Collisions

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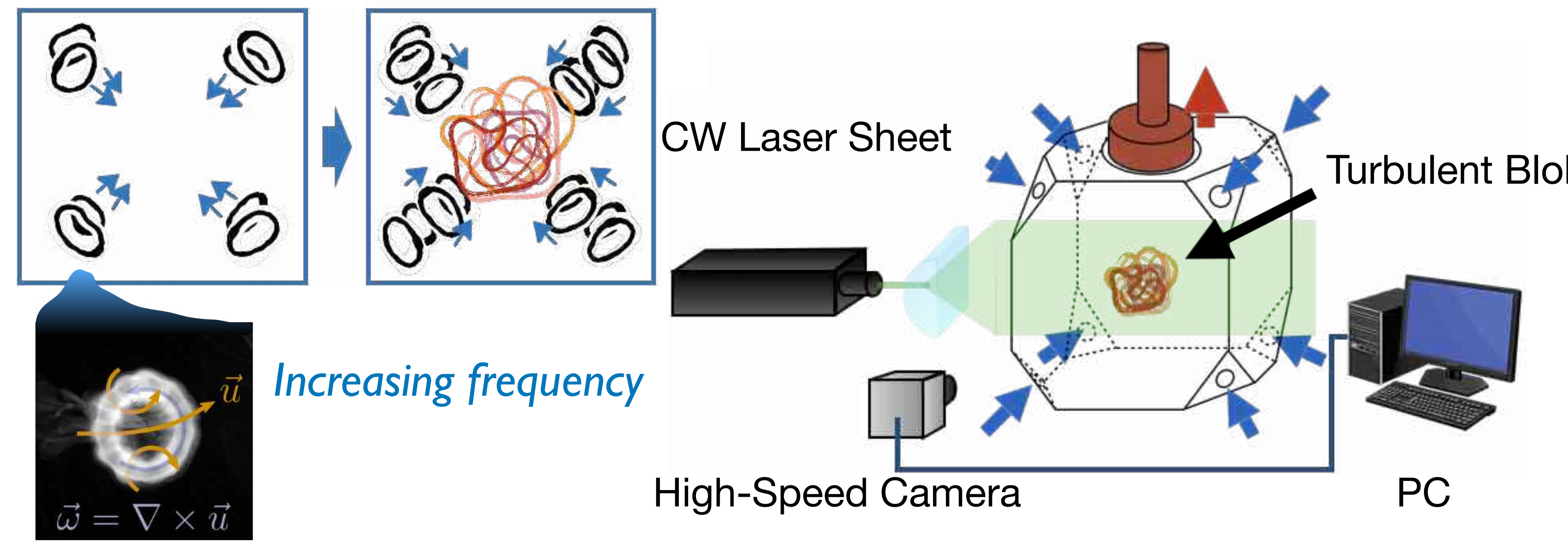
Bottom-up Approach to Turbulence

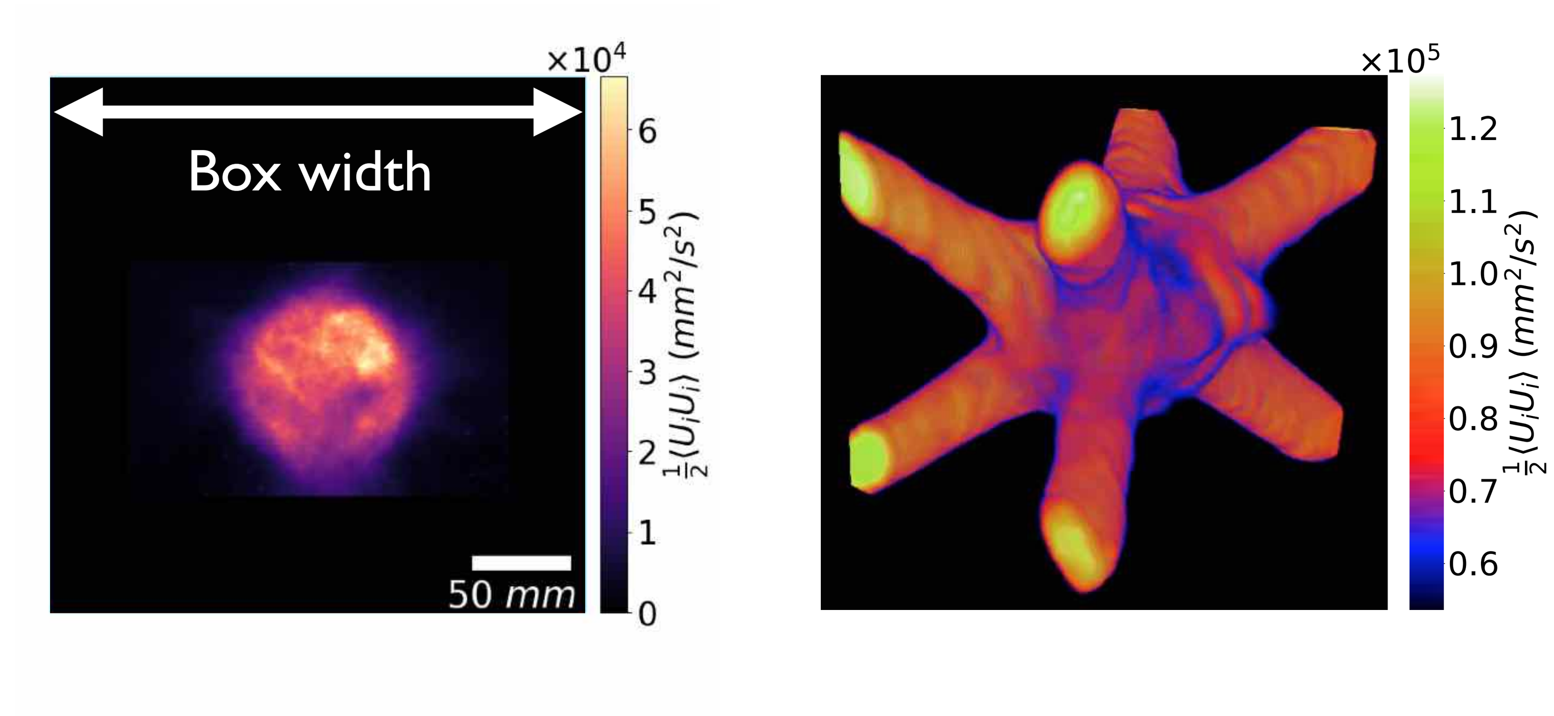
Vorticity is a fundamental building block of turbulence. We seek to generate turbulence by bringing eddies together one at a time.

We fire a collection of vortex rings, generated at the 8 corners of an approximately cubic flow chamber. They collide at the center of the chamber. Successive collisions result in a steady blob of turbulence.

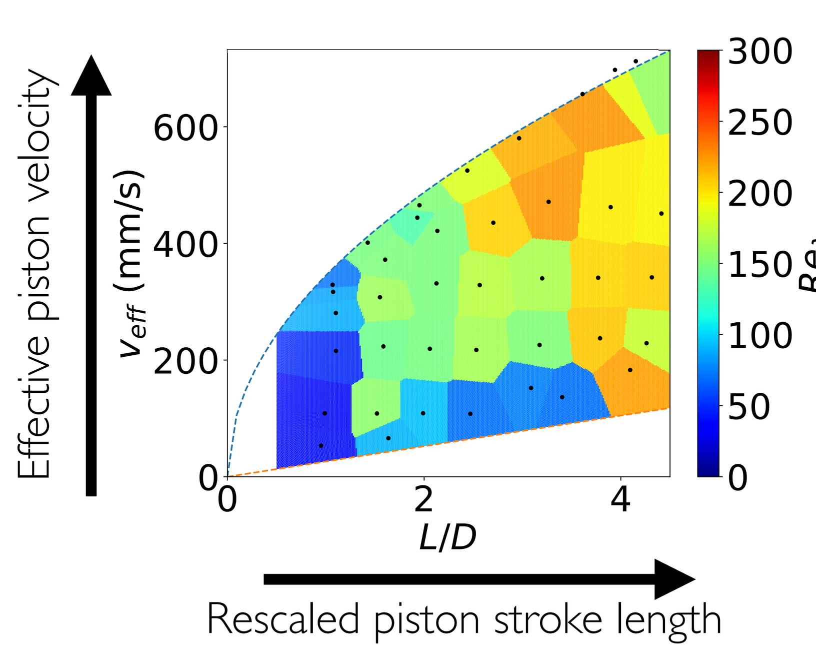


Flow Confinement

Our 2D PIV analysis reveals an isolated blob of energy and enstrophy at the center of the chamber. With a PIV tomography technique we developed, we reconstructed the energy distribution in 3D to study the structure of the blob.



Control Parameters



$Re_\lambda : 50 - 250$

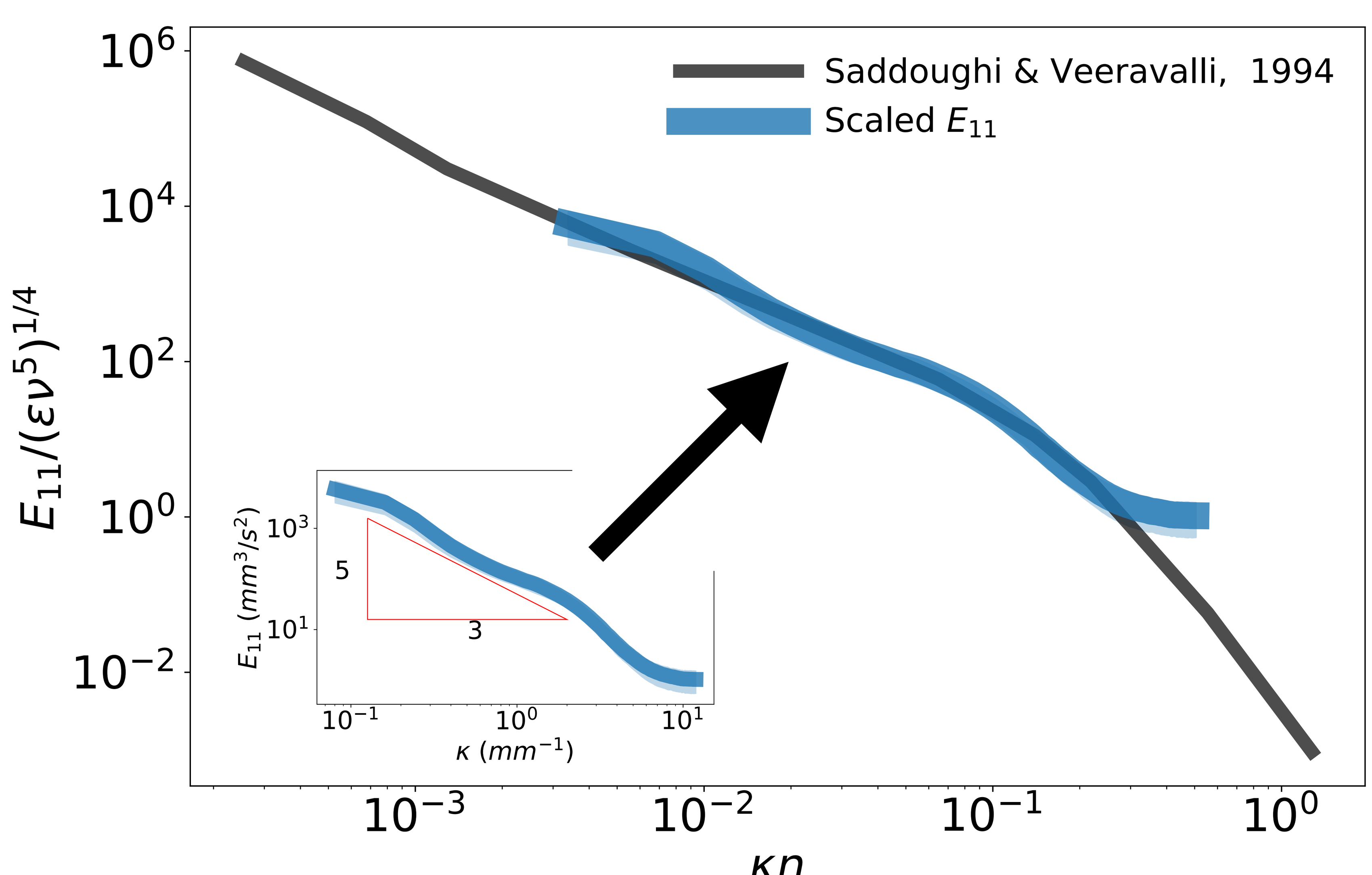
$\epsilon : 0.5 - 5 \ (\times 10^5 mm^2/s^3)$

$\eta : 40 - 70 \ \mu m$

$\lambda : \sim 1 \ mm$

Turbulent Blob

One-dimensional energy spectrum can be measured inside the blob, obeys the Kolmogorov's -5/3 law, and can be rescaled to the universal curve with an appropriate value of dissipation rate.



Saddoughi SG, Veeravalli SV. 1994. Local isotropy in turbulent boundary layers at high Reynolds number. *J. Fluid Mech.* 268:333–72

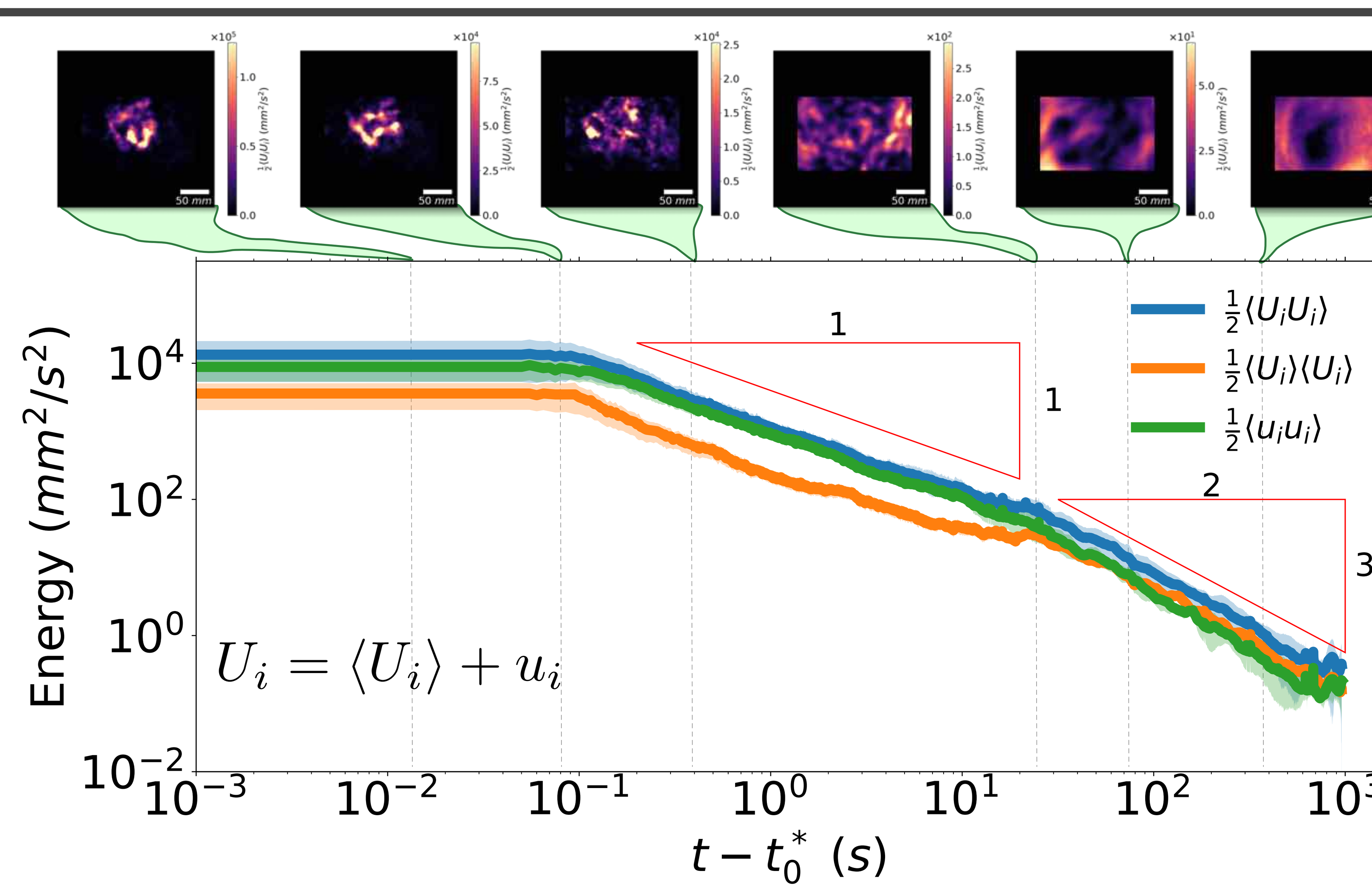
The dissipation rate can be well estimated solely via energy balance because the majority of dissipation takes place inside the blob.

$$\underbrace{\rho \epsilon V_{blob}}_{\text{Dissipated power}} \approx \underbrace{8 E_{ring} f}_{\text{Injected power}}$$

Decay of Turbulence

The isolated nature of the turbulent blob makes it well suited to study the classical problem of turbulence decay because the turbulent region is stationary and not advected out of the measurement volume by mean flow.

Our preliminary data appears to indicate the presence two decay regimes.



Successive collisions of multiple vortex rings generate **an isolated region of turbulence**.
The method provides a unique playground explore the effect of geometry on turbulence formation and decay.

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