



# Power input measurements in Lorentz force-driven turbulent flow

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# Goals

- measure local velocity in a flow driven by known Lorentz forces

$$\vec{F}_L = \rho \vec{J} \times \vec{B}$$

- use velocity measurements to yield local power input

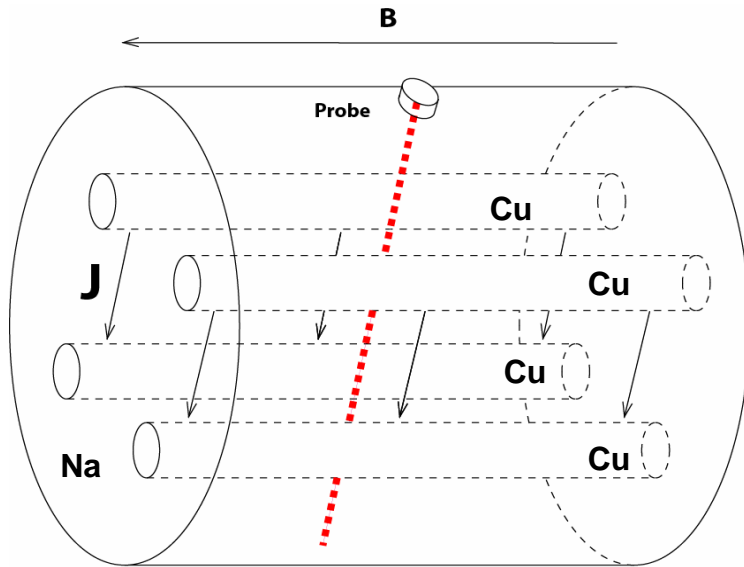
$$P = \vec{u} \cdot \vec{F}$$

- correspondence to steady-state Fluctuation Theorem?

$$\lim_{\tau \rightarrow \infty} \frac{1}{\tau} \ln \frac{\Pr(P)}{\Pr(-P)} = P$$

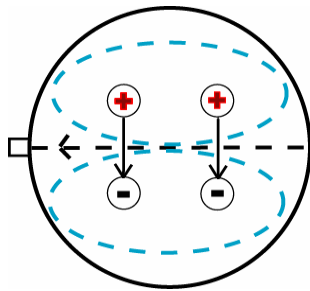


# Experimental Set Up

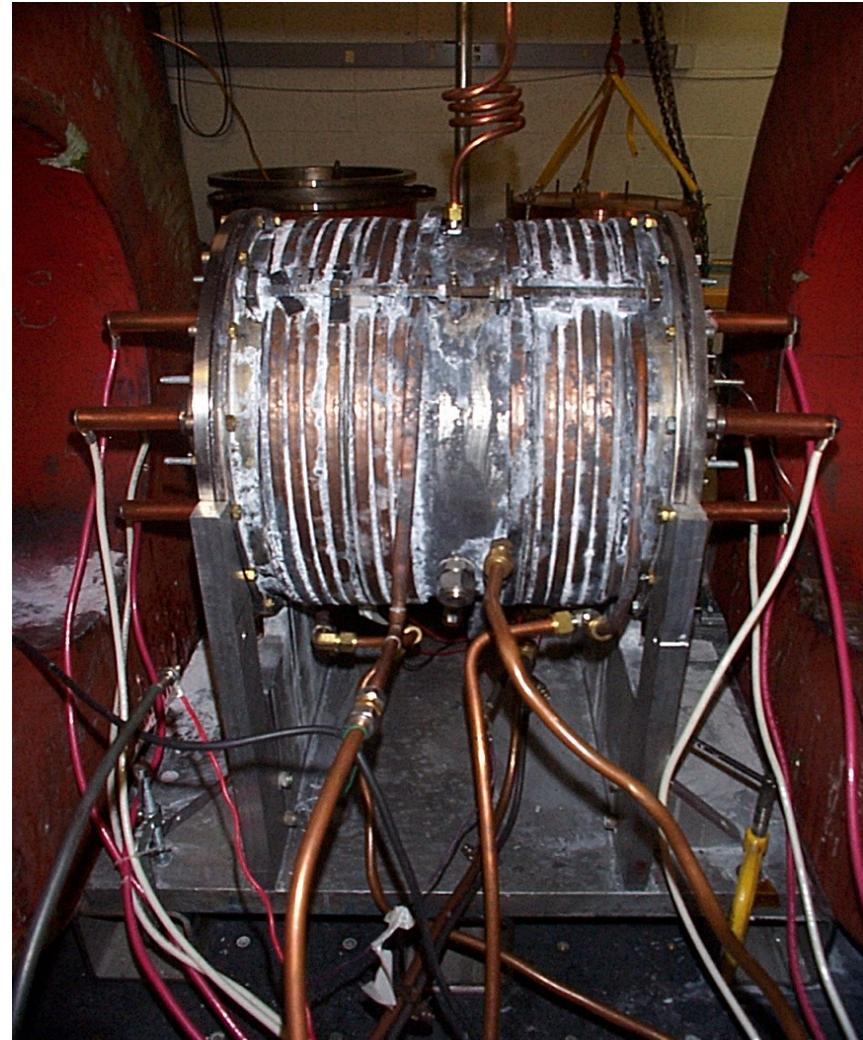
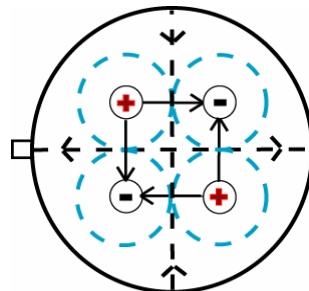


## Electrode Configurations

Dipole

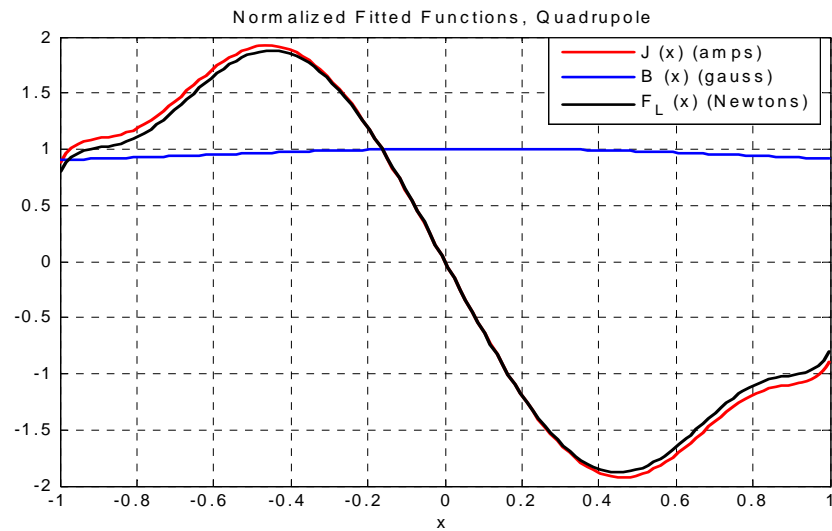
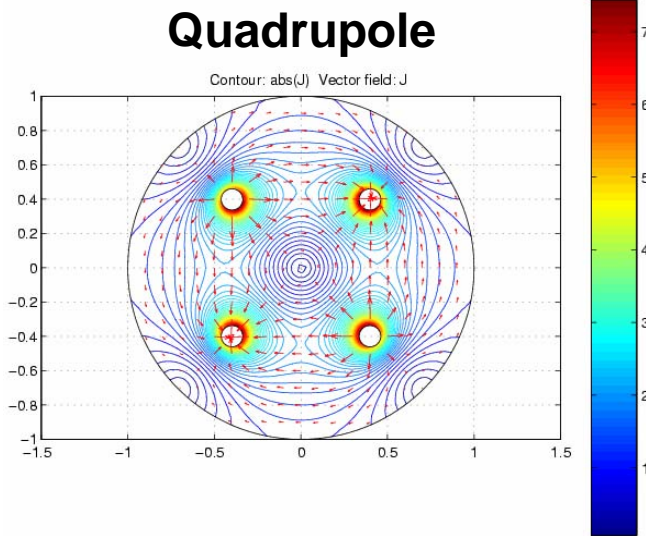
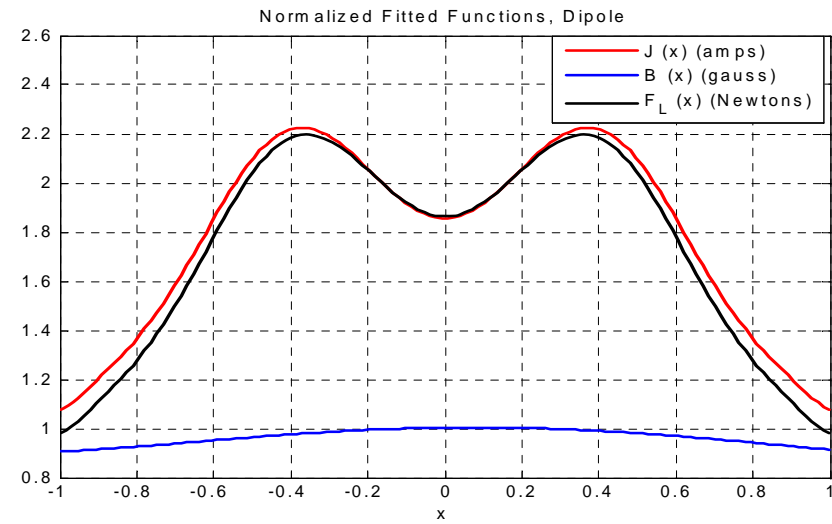
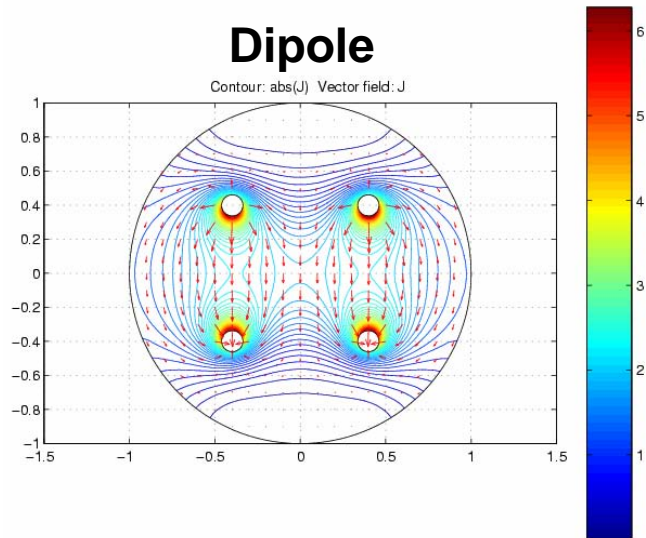


Quadrupole





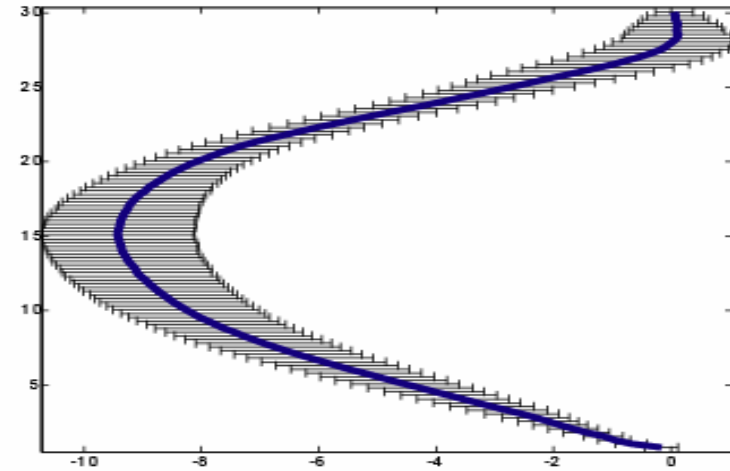
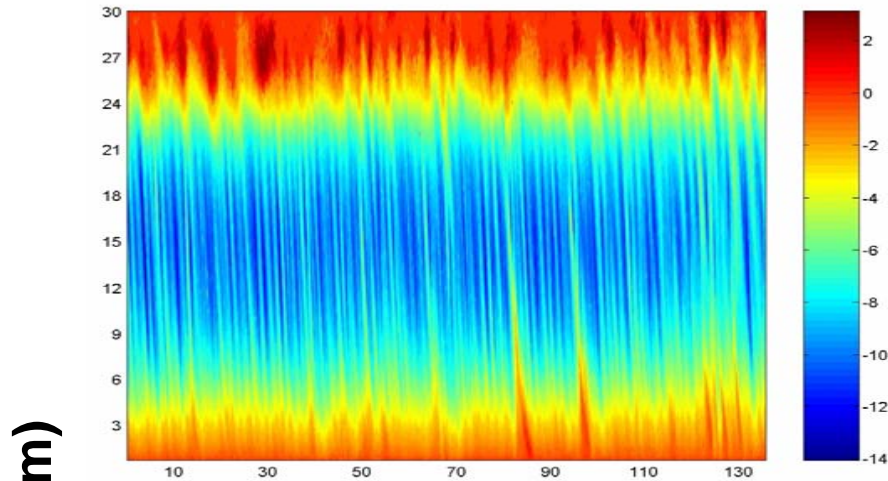
# Lorentz Force



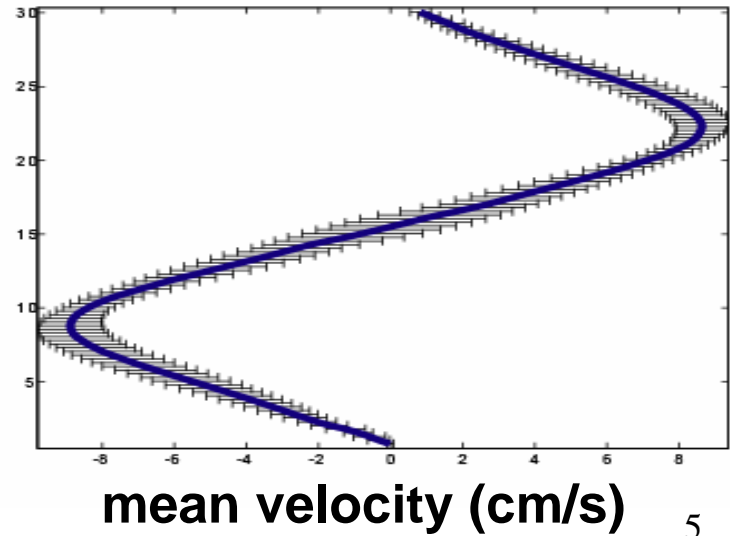
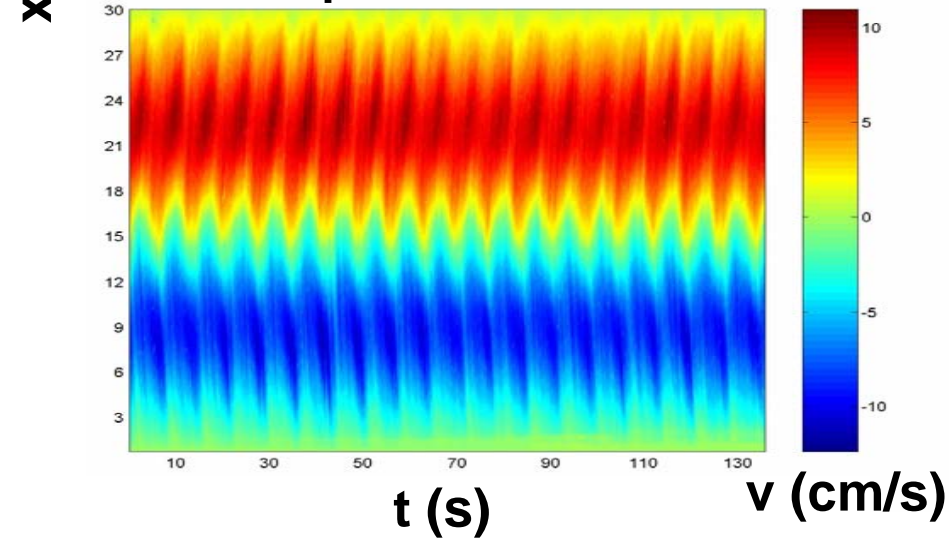


# Velocity Profiles

## Dipole



## Quadrupole

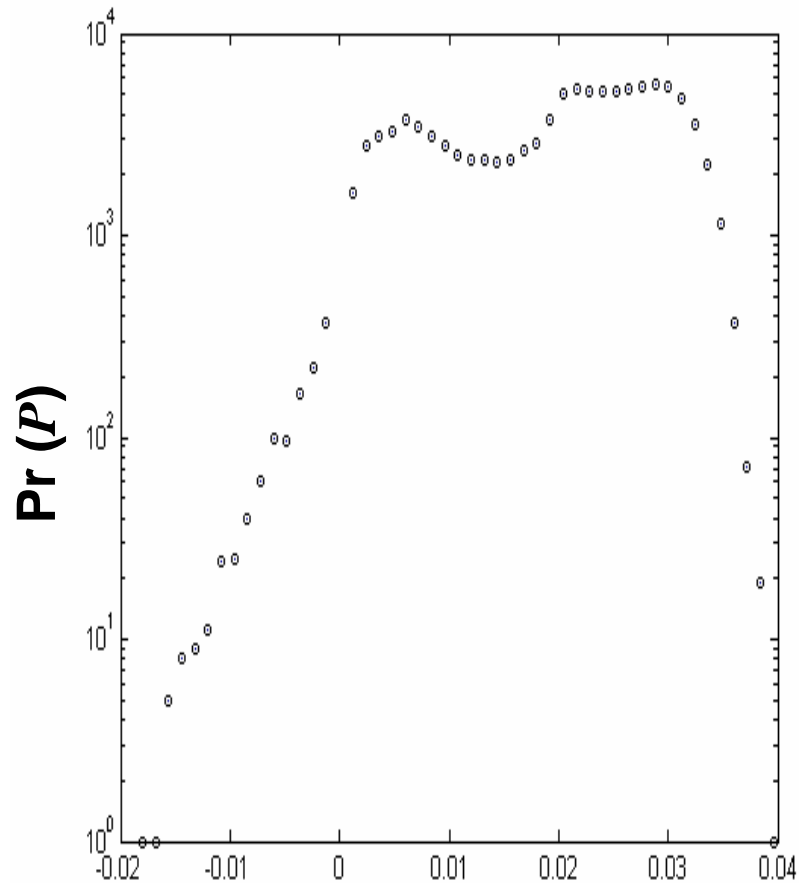




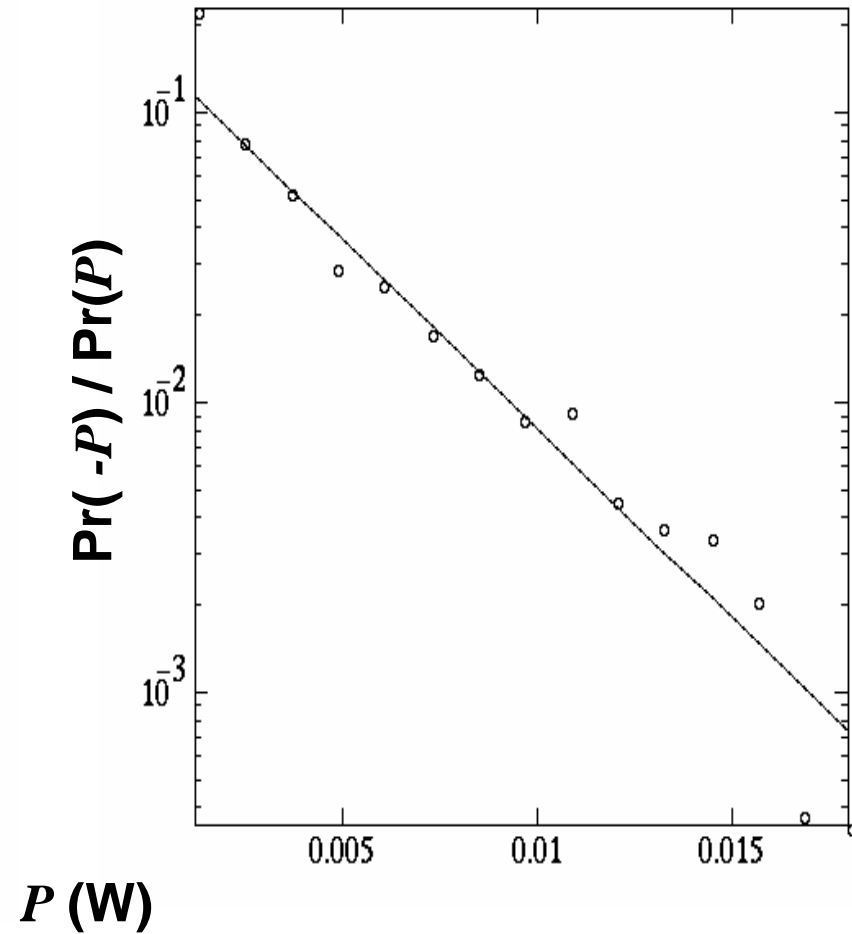
# Power

Dipole  
10 A  
300 G

### Power vs. Pr ( $P$ )

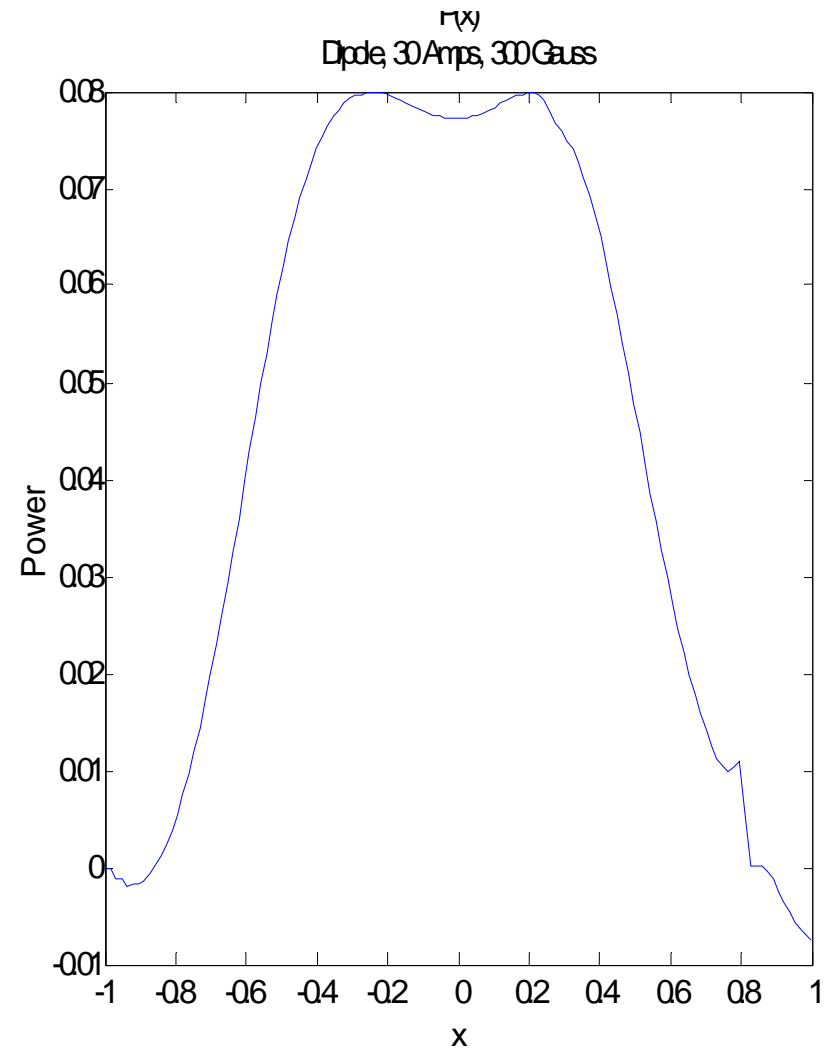
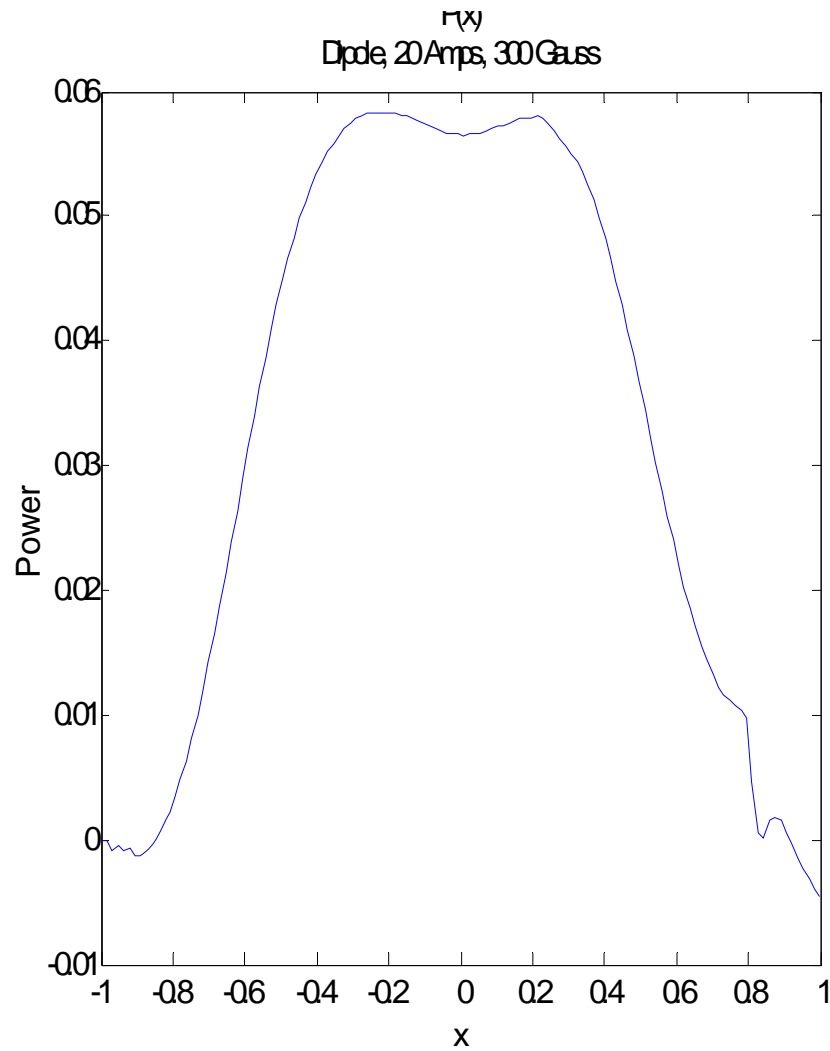


### Probability Distribution





# Continuing Power Analysis





# Summary

- Turbulent flow from body force

Reynolds number  $Re=1.5 \times 10^4$ , where  $Re=(v_{\max}D)/\nu$   
( $\nu$  kinematic viscosity  $\nu = 0.008 \text{ cm}^2/\text{s}$ )

Schumacher and Eckhardt, PHYSICA D-NONLINEAR  
PHENOMENA 187 (1-4): 370-376 JAN 1 2004

- Fluctuation Theorem holds outside standard context  
(local vs. global power)

Mazonka and Jarzynski, ARXIV:COND-MAT/9912121 V1:  
7 DEC 1999