

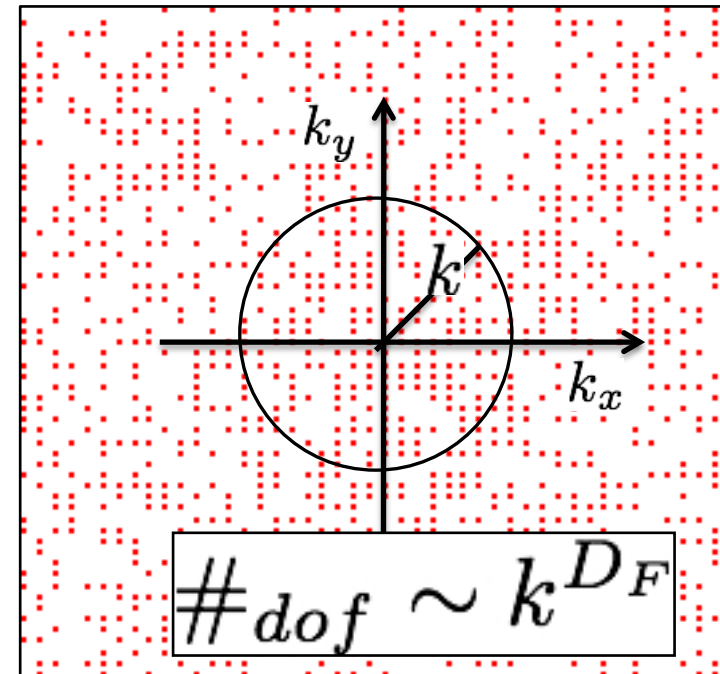
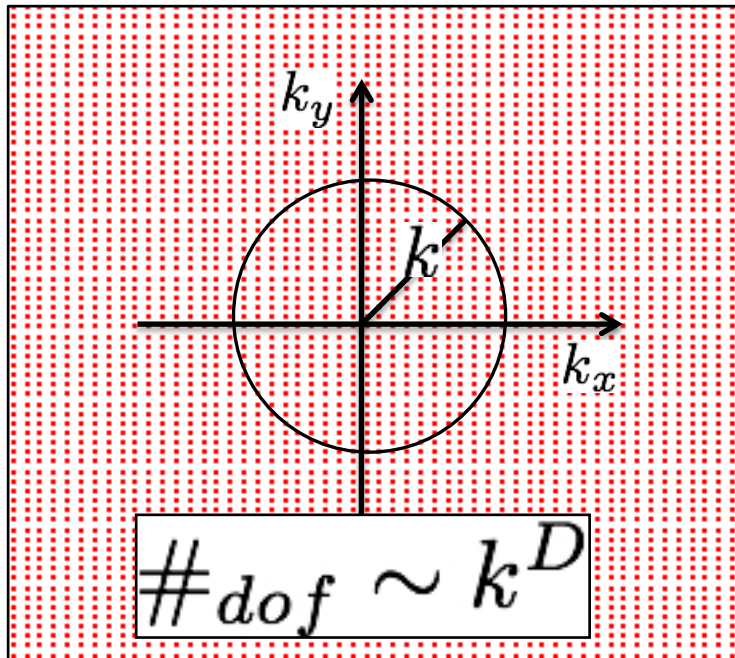
TURBULENCE ON FRACTAL FOURIER SPACES



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APS - SAN FRANCISCO - NOV 2014



A.S. Lanotte (CNR, Italy)

S. Malapaka (Tor Vergata Univ. Italy)

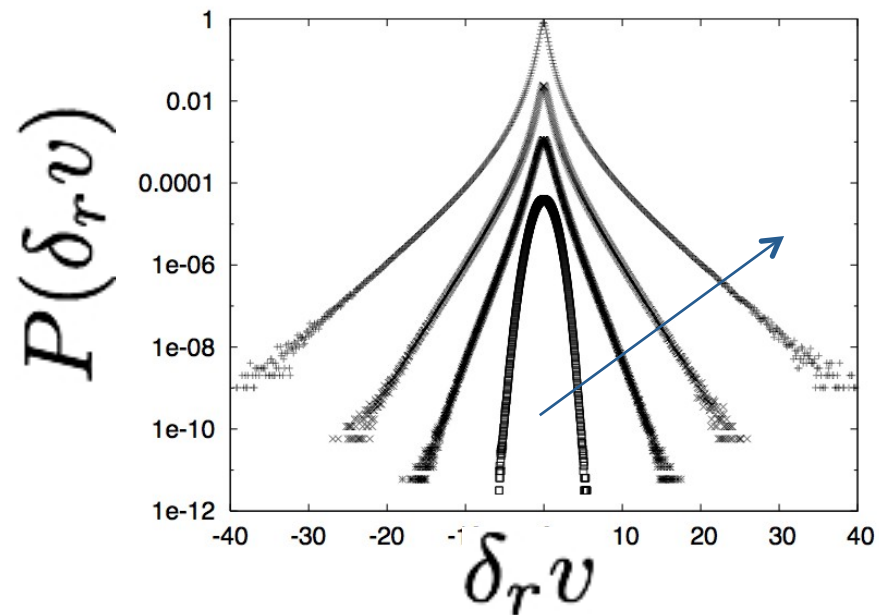
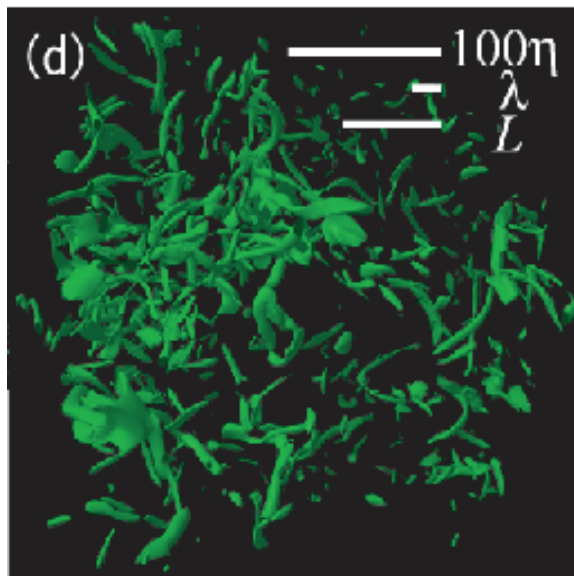
F. Toschi (TuE, The Netherlands)

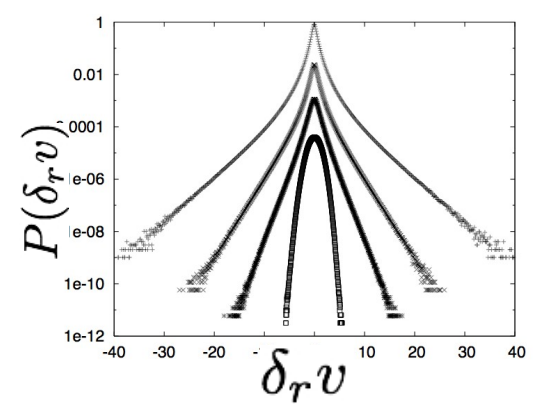
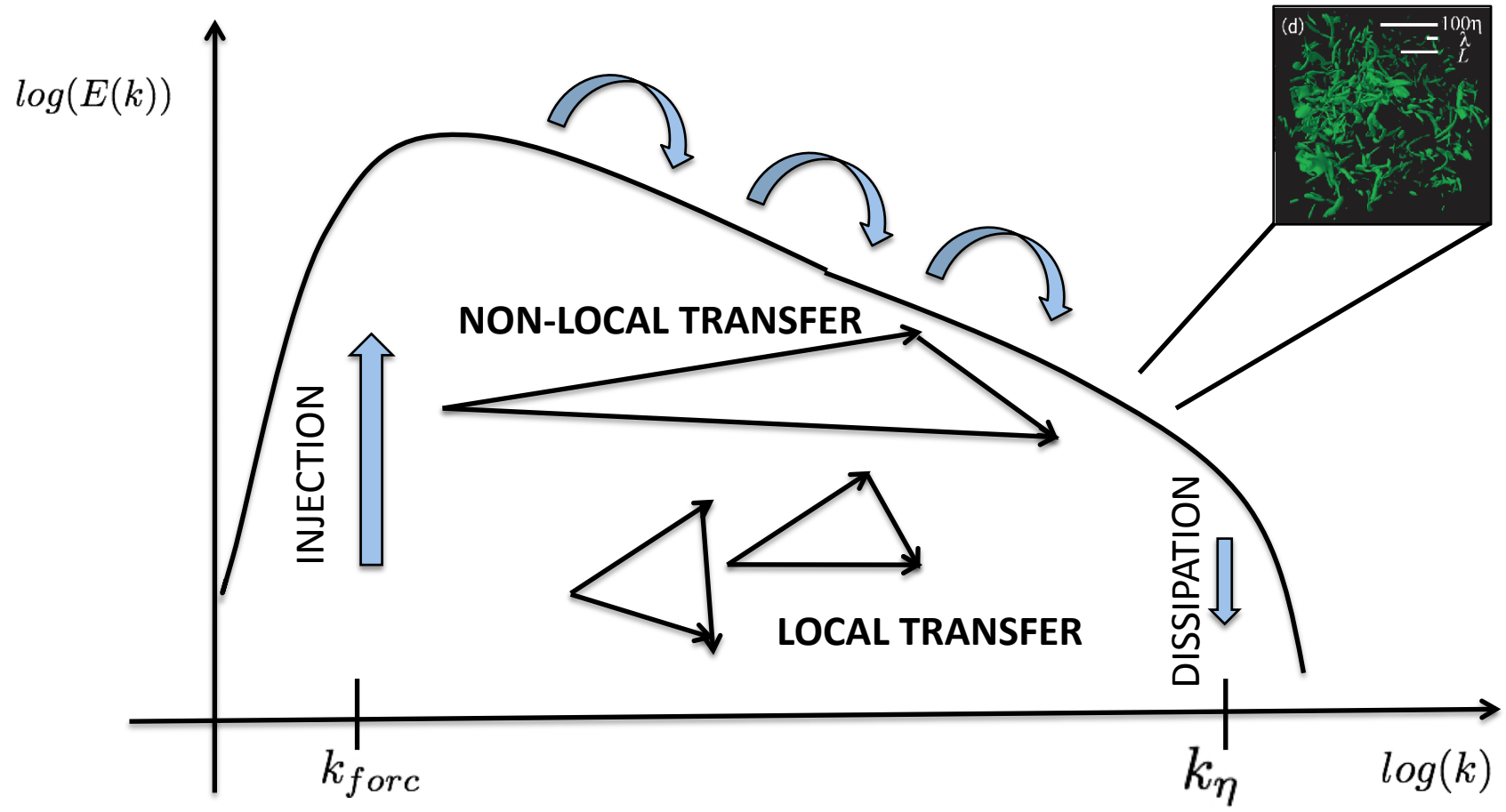


3D HOMOGENEOUS AND ISOTROPIC TURBULENCE

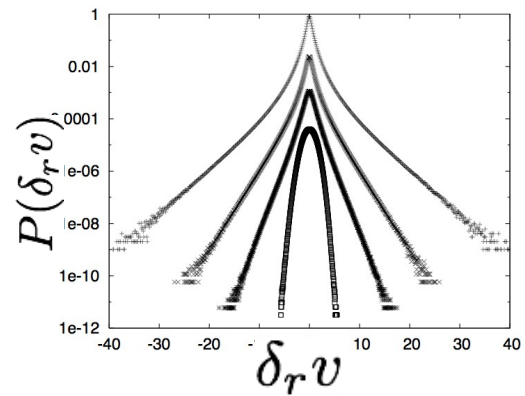
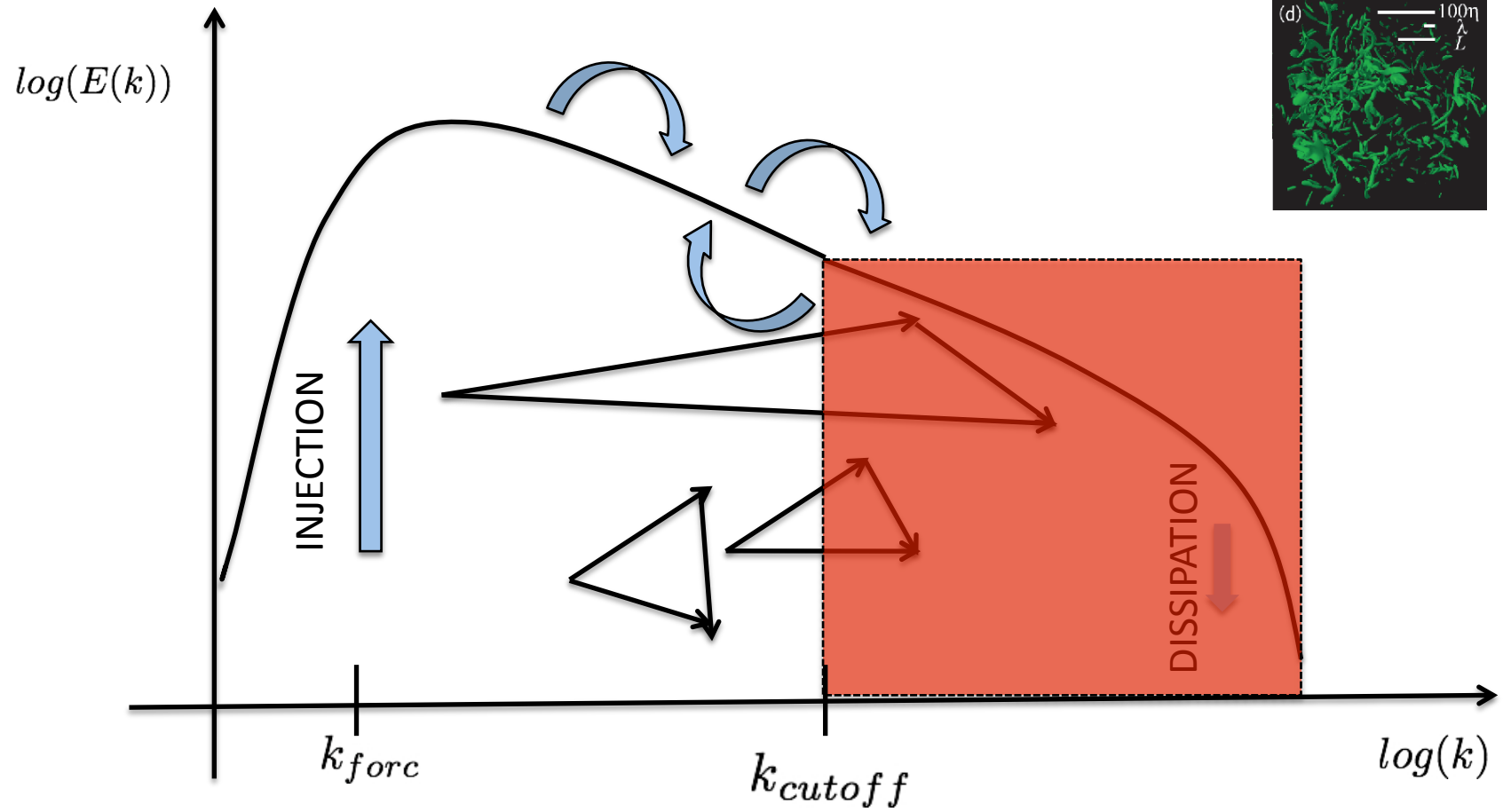
$$\begin{cases} \partial_t \mathbf{v} + (\mathbf{v} \cdot \partial) \mathbf{v} = -\partial P + \nu \Delta \mathbf{v} + \mathbf{F} \\ \partial \cdot \mathbf{v} = 0 \\ + \textit{Boundary Conditions} \end{cases}$$

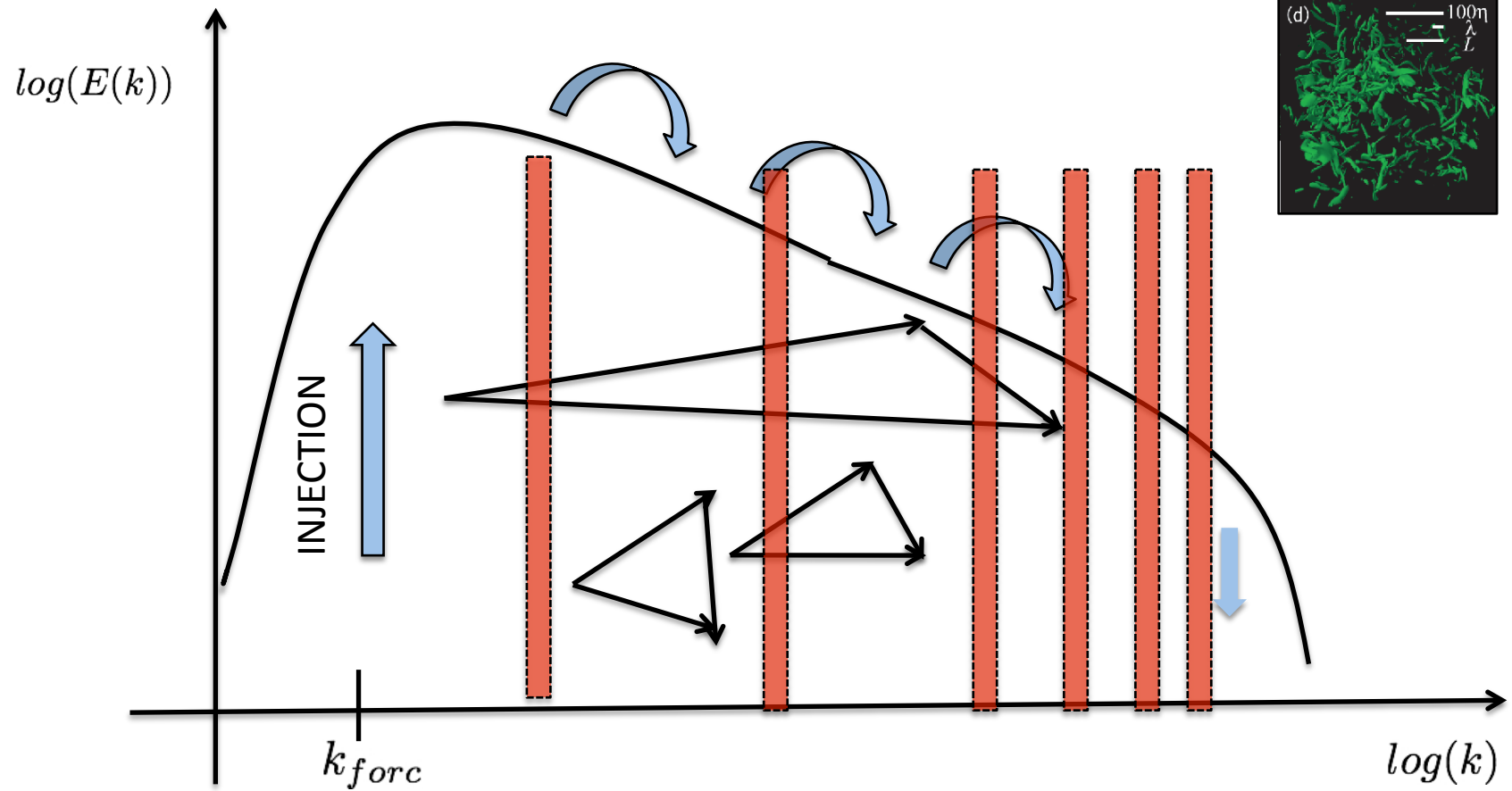
**EXPERIMENTS IN-SILICO:
CAN WE ASK QUESTIONS ABOUT THE ENERGY TRANSFER
BY DECIMATING INTERACTIONS IN THE NON LINEAR TERM?**





LARGE EDDY SIMULATION





DECIMATED WITH PROBABILITY $\sim 1 - k^{D_F - 3}$

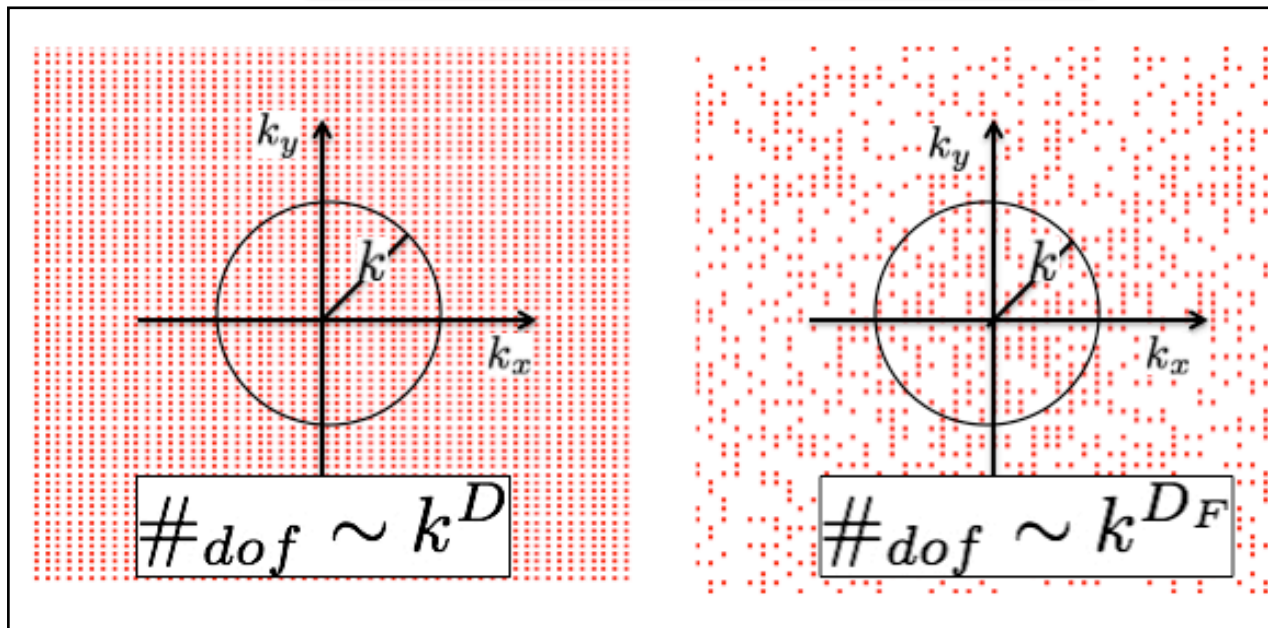
HOMOGENEOUS & ISOTROPIC & SELF-SIMILAR (NO EXTERNAL SCALES)

SELF- SIMILAR SURGERY OF NAVIER-STOKES INTERACTIONS

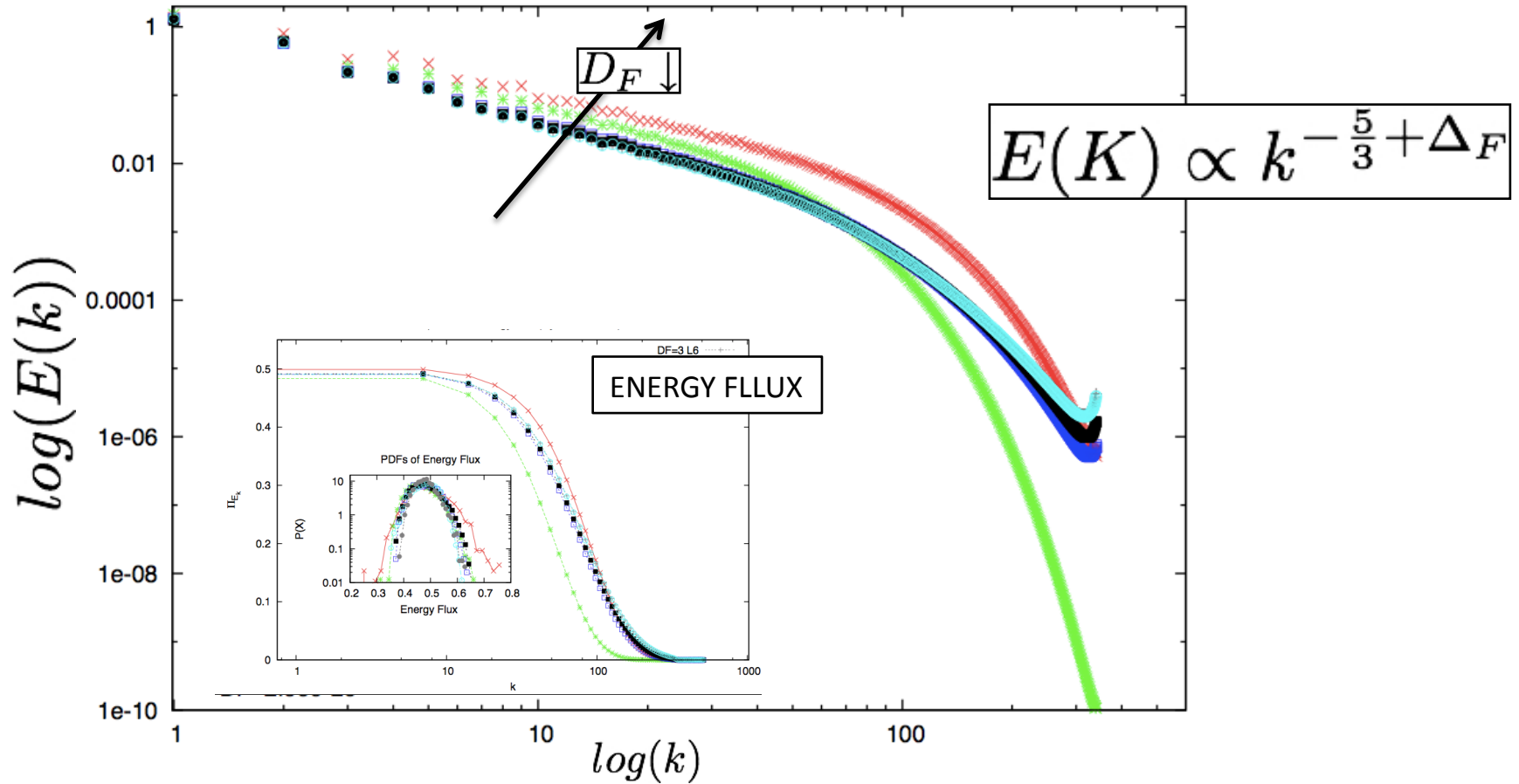
U. Frisch, A. Pomyalov, I. Procaccia and S. Ray PRL 2012
S. Grossmann, D. Lohse and A. Reeh, PRL 1996

$$\partial_t \mathbf{v}^{D_F} = P^{D_F} B(\mathbf{v}^{D_F}, \mathbf{v}^{D_F}) + \Delta \mathbf{v}^{D_F} + \mathbf{f}^{D_F}$$

SELF-SIMILAR GALERKIN TRUNCATION



$$D_F = 2.5, 2.8, 2.98, 2.99, 2.999, 3.0$$

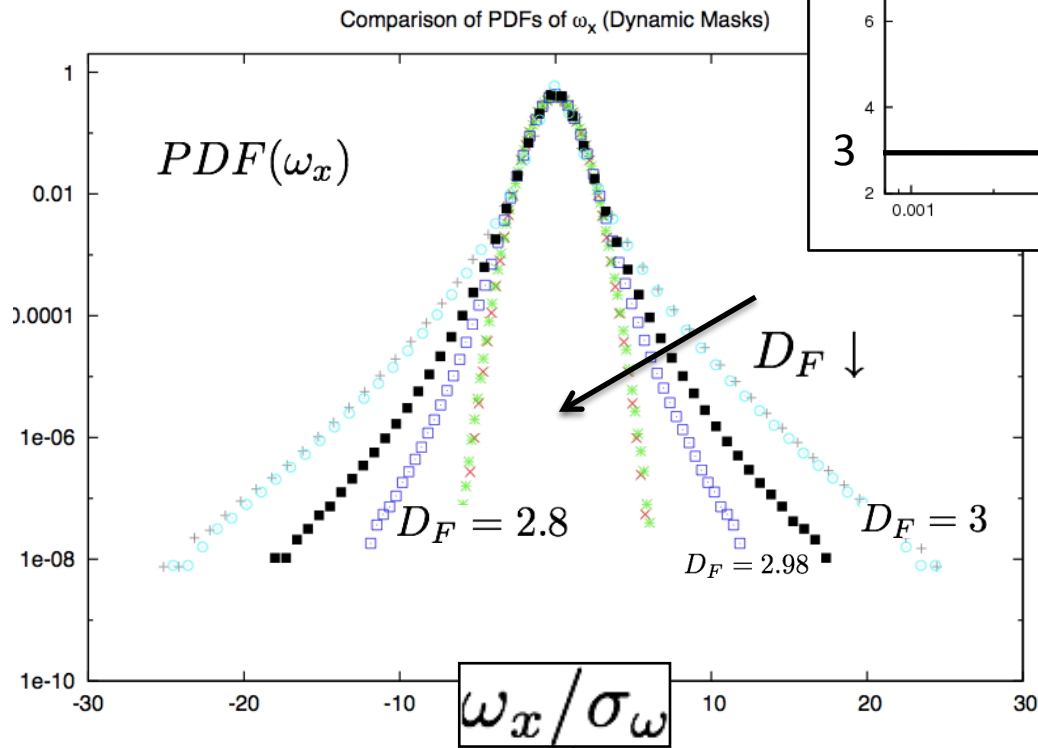
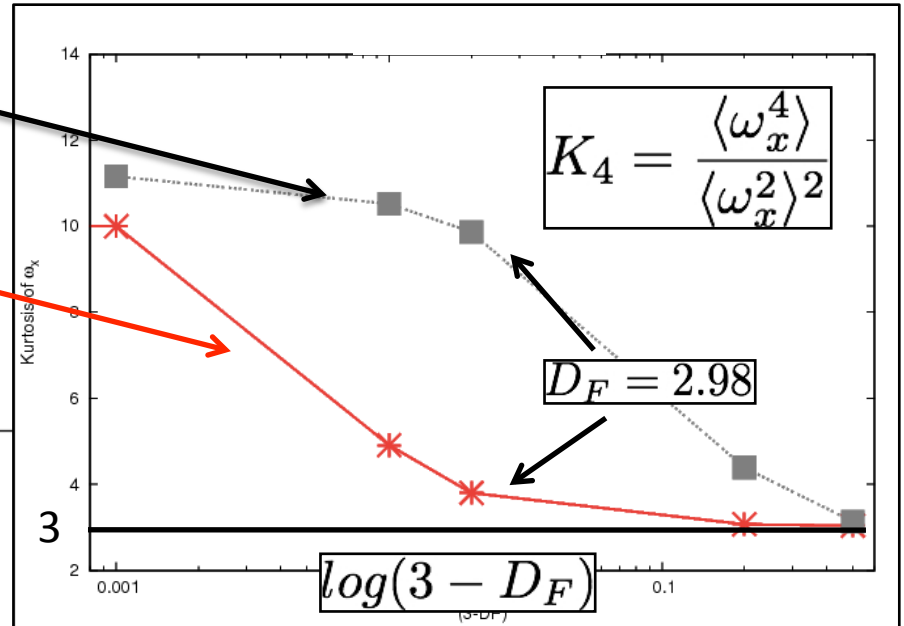


DF	2.5	2.8	2.98	2.99	2.999	3.0
1024 ³	X	X	X	X	X	X
2048 ³			X	X		

PDF OF VORTICITY AT CHANGING FRACTAL DIMENSION

$$\begin{cases} \partial_t \mathbf{v} = B(\mathbf{v}, \mathbf{v}) + \Delta \mathbf{v} + \mathbf{f} \\ \mathbf{v} \rightarrow P^{D_F} \mathbf{v} \end{cases}$$

$$\partial_t \mathbf{v}^{D_F} = P^{D_F} B(\mathbf{v}^{D_F}, \mathbf{v}^{D_F}) + \Delta \mathbf{v}^{D_F} + \mathbf{f}^{D_F}$$



DF	2.5	2.8	2.98	2.99	2.999	3.0
1024^3	3%	25%	87%	93%	99%	100%

CONCLUSIONS

FRACTAL DECIMATION: MILDEST REMOVAL OF DEGREE OF FREEDOM HOMOGENEOUS & ISOTROPIC & SELF SIMILAR

- + QUANTIFY IMPORTANCE OF LOCAL VS NON-LOCAL TRIADIC INTERACTIONS
- +/- QUANTIFY IMPORTANCE OF $\#_{\text{DOF}}$ FOR VORTEX STRETCHING
- + CORRECTION IN THE MEAN RESPONSE (SPECTRUM) PROPORTIONAL TO $3-D_F$: YOU CAN HAVE A LITTLE CHANGE IN THE SPECTRAL PROPERTIES AND STILL GAINING IN THE $\#_{\text{DOF}}$
- + CORRECTION IN FLUCTUATIONS: HUGE. SMALL SCALE VORTICITY IS STRONGLY SENSITIVE TO DECIMATION. COHERENT SMALL-SCALE STRUCTURES FEELS NON-LOCAL CORRELATIONS ACROSS SCALES IN FOURIER (ADV: SEE ALSO TALK M32.1 BUZZICOTTI TUESDAY)
- > SELF SIMILAR EDDY SIMULATIONS WITHOUT LOSING RESOLUTION ? WHAT IS A GOOD STOCHASTIC/DETERMINISTIC MODELING FOR THE MISSING MODES?