

# Preliminary computer experiments for supersonic turbulent flows in high- energy density plasmas

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# Multiply shocked astrophysics

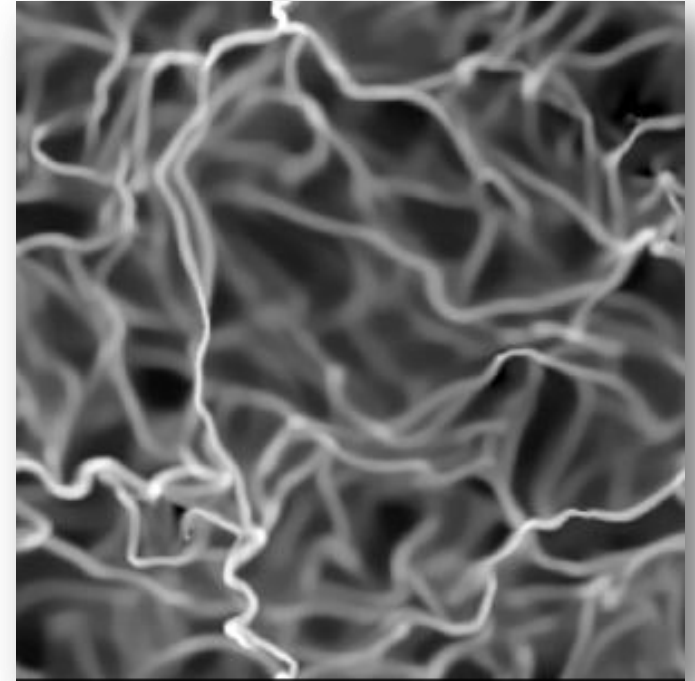
- ▶ Star forming regions
- ▶ Multiply shocked regions
  - Driven by supernovae
- ▶ Density distribution affects star distribution and creation rate



N-90 Star-forming region. Credit: NASA, ESA and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration

# Complications

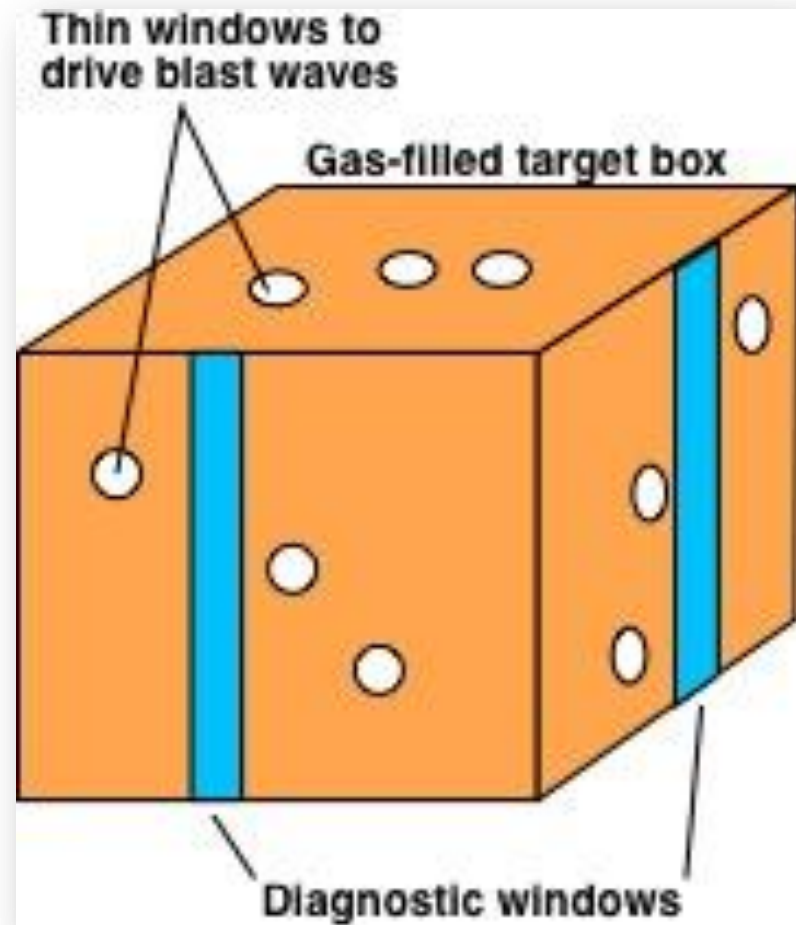
- ▶ Self-gravity, heating, radiation, rotation, magnetic fields
- ▶ Indications that it is hydrodynamically dominated
  - Scalo et al. (APJ 1998)
    - Isothermal
  - Localized magnetic effects? (Biermann battery + other terms)



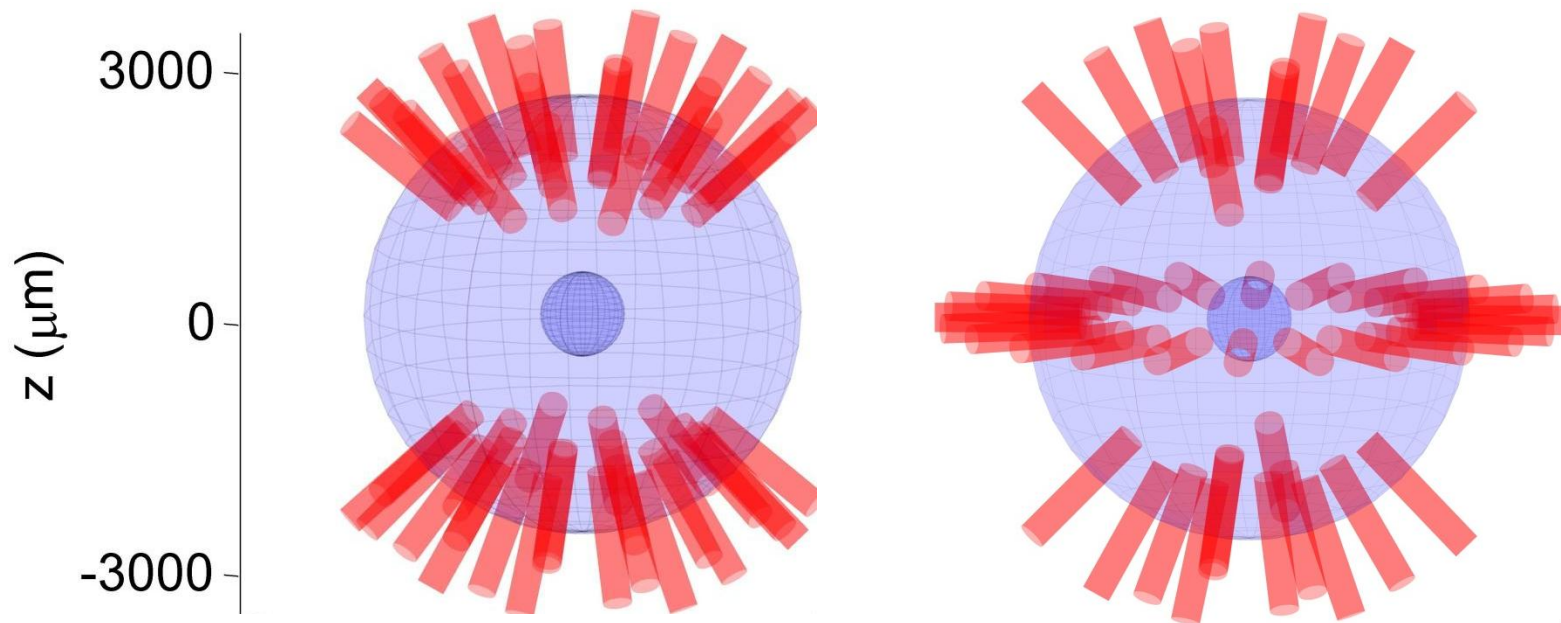
Log density (Scalo et al.)

# Revival of previous work

- ▶ Replicate a section of the star forming region inside a target box
- ▶ Proposed by Paul Drake et al.
- ▶ Drive blasts through windows of target box



# New Configuration



NIF Indirect Drive

Equatorial Drive

Inner radius	500 $\mu\text{m}$
Outer radius	$\sim 2800$ $\mu\text{m}$
Inner density $\leq$ Outer density	

# Computational Components

## Computational Model

Drive Model

Drive-Target  
Interaction

CRASH

Proteus

Carbon  
foam

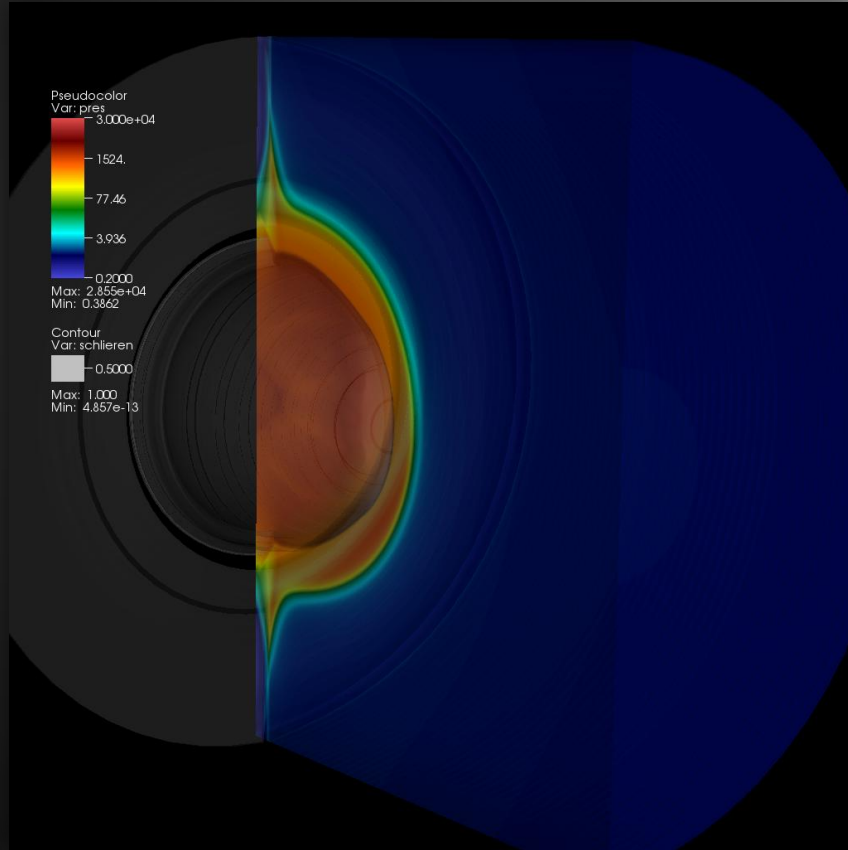
Rad-Hydro

Cylindrical  
drive  
profile

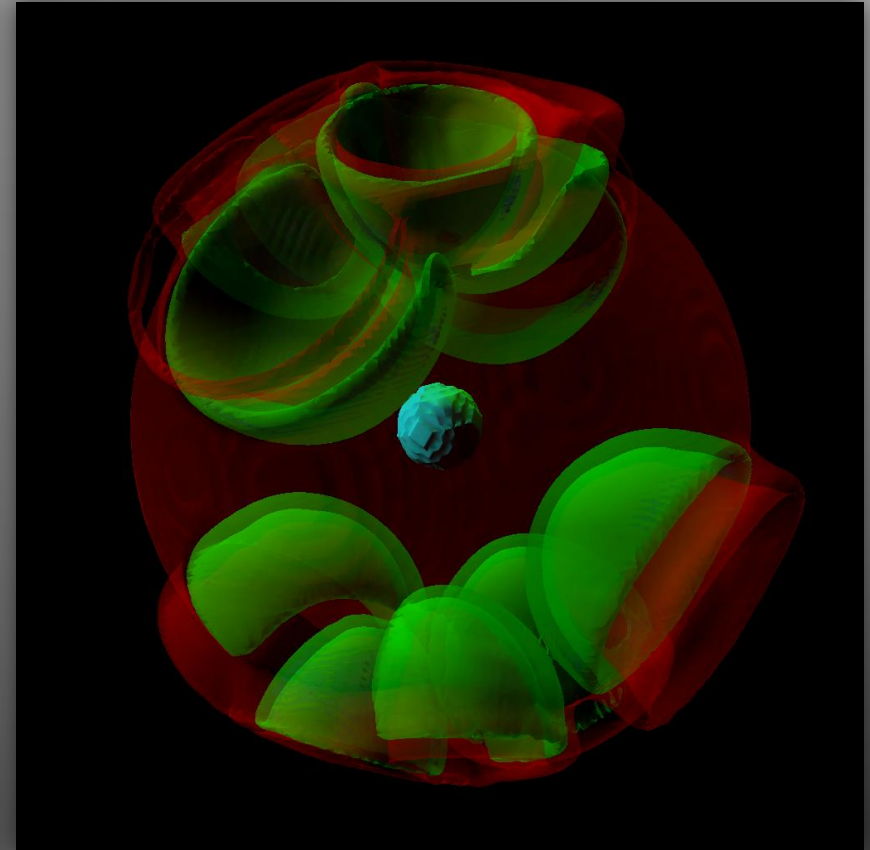
Hydro  
(+MHD)

Uses CRASH  
drive  
profile

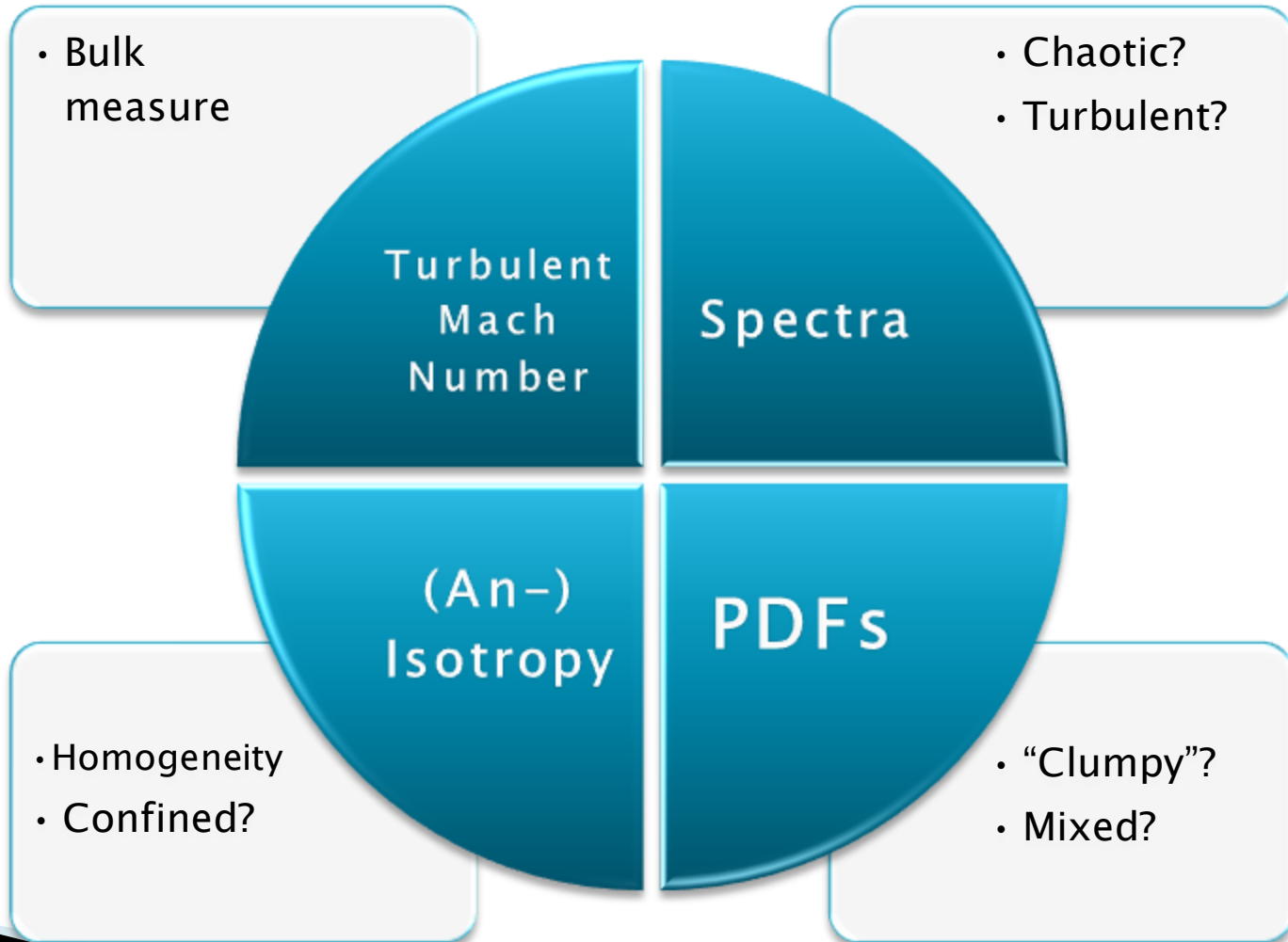
# CRASH – Laser Drive



# Proteus – Mapped 3D



# Quantities of Interest



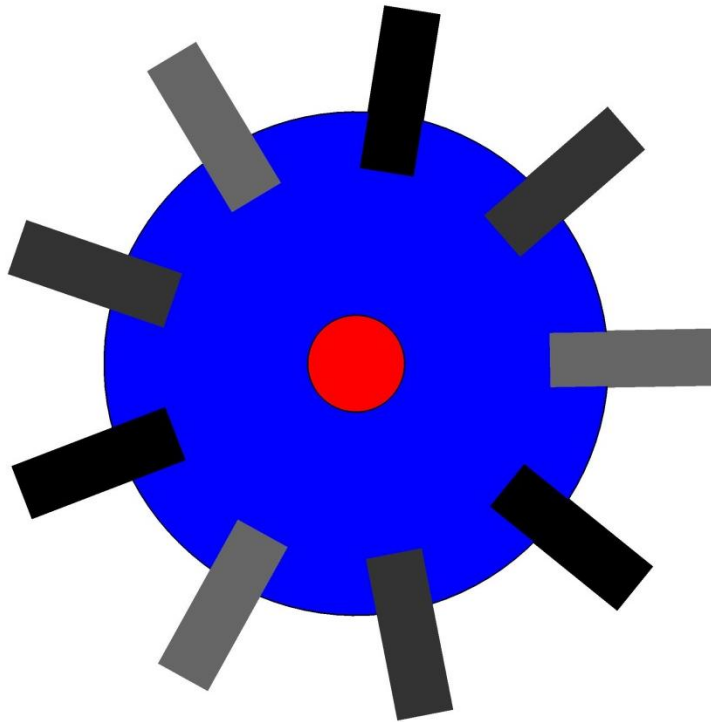


# Quantities of Interest

Diagnostics

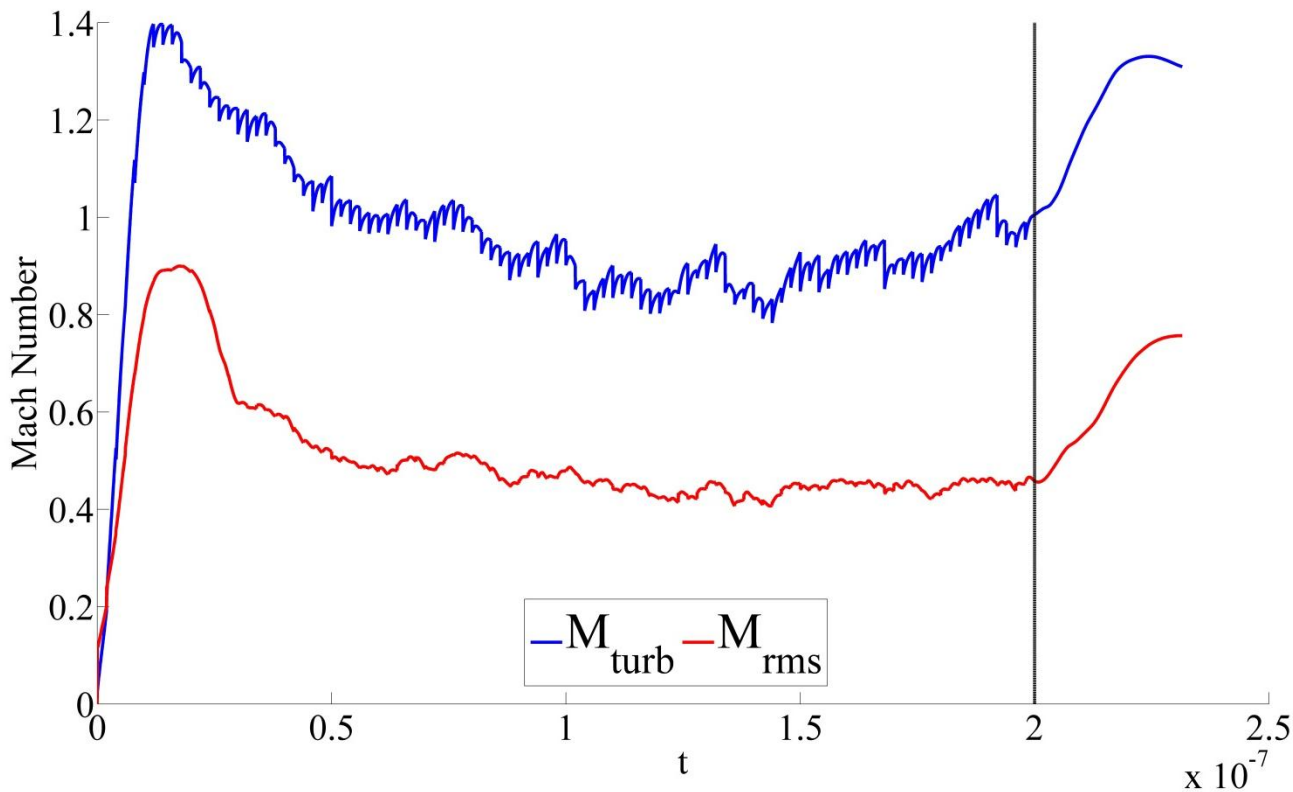
- PDFs
- Thompson scattering
- Column Density
- Radiography

# 2D Configuration



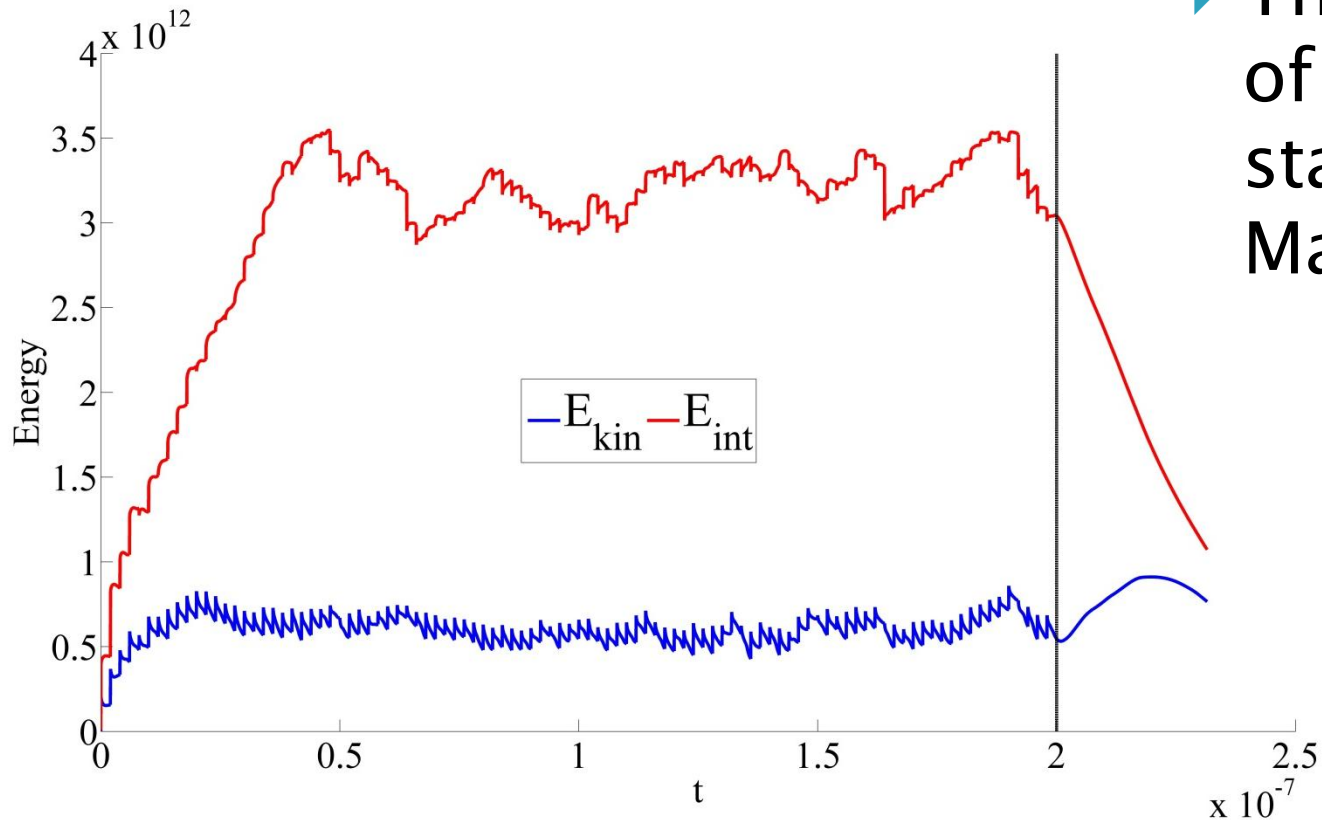
- 3 Quads per shot
  - Triangle configuration
- Shot fired every  $2n_s$
- Total driving time is  $200n_s$ 
  - 100 shots
  - 300 quads

# 2D: Mach Number Evolution



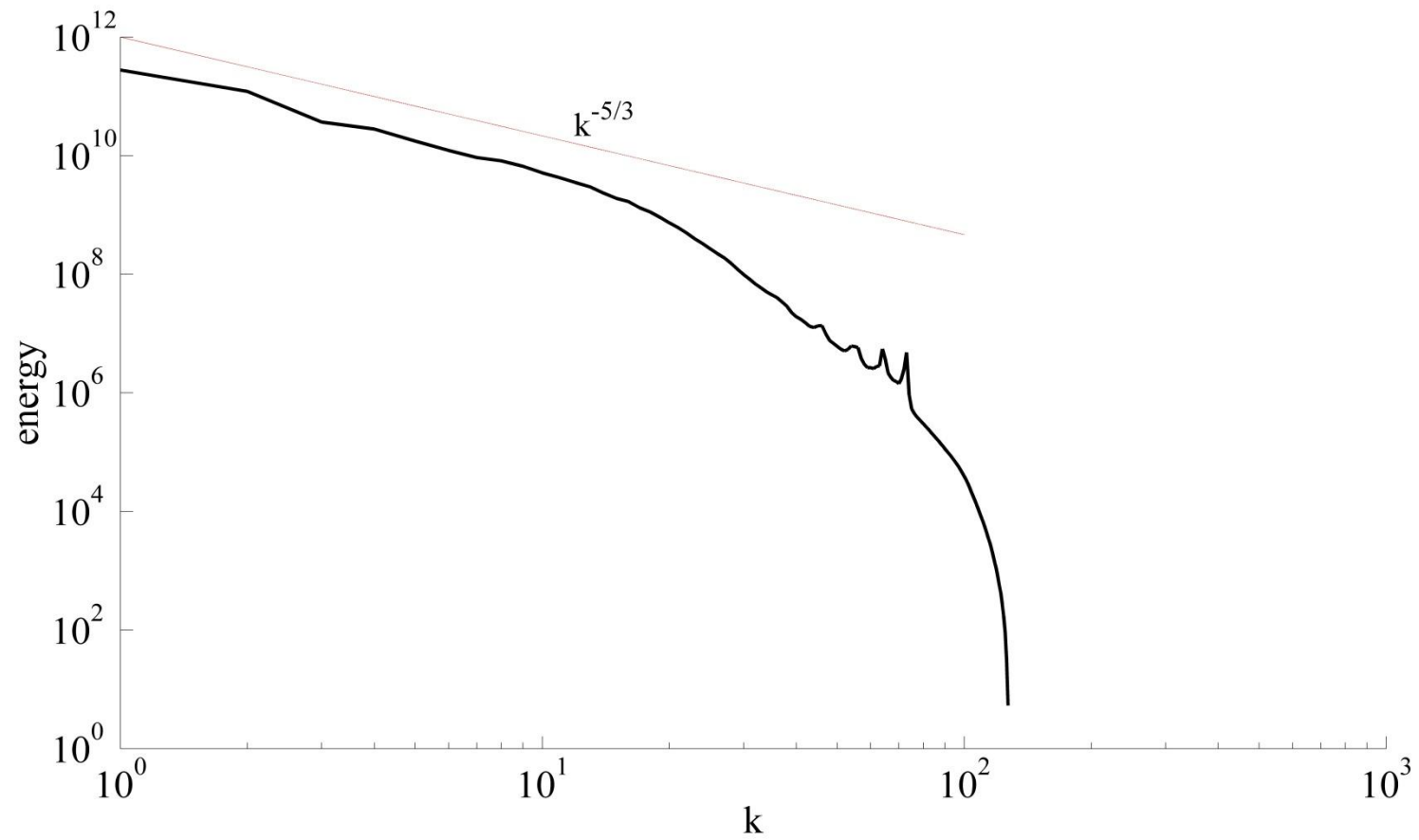
- ▶  $M_{\text{turb}}$ 
  - Density weighted sum of Mach numbers
- ▶  $M_{\text{rms}}$ 
  - Statistical RMS Mach number

# 2D: Energy evolution

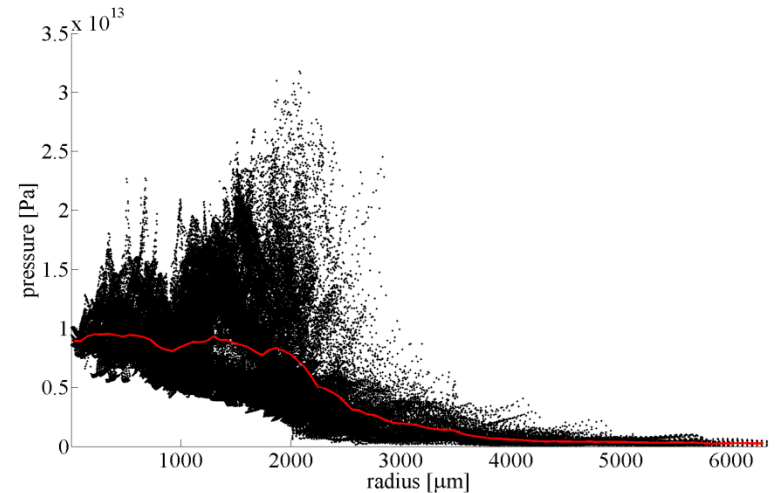
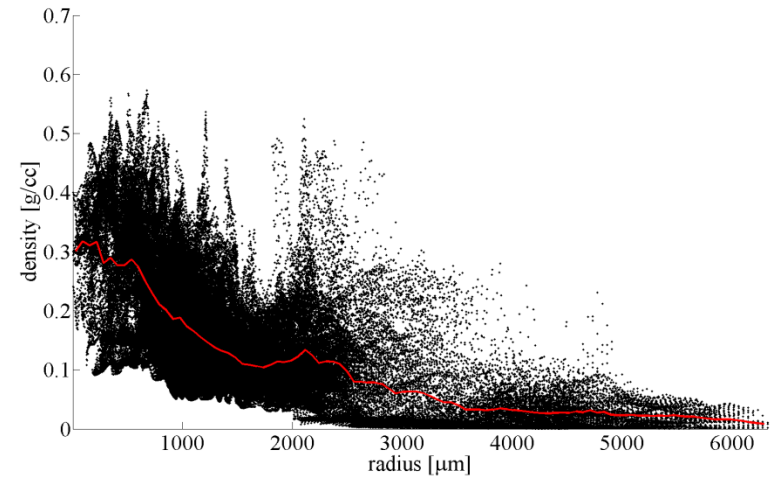
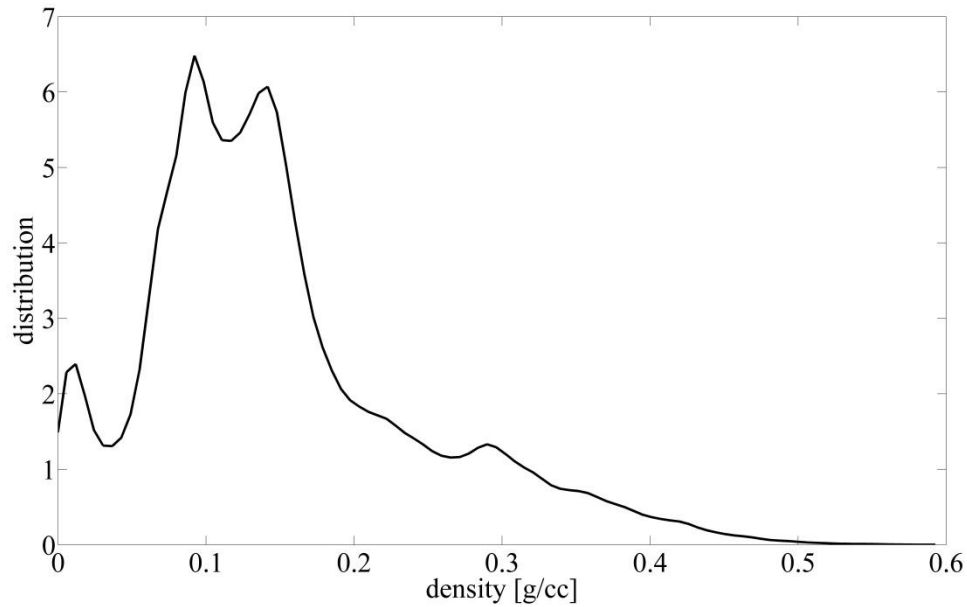


- ▶ Thermalization of the flow stabilizes the Mach number

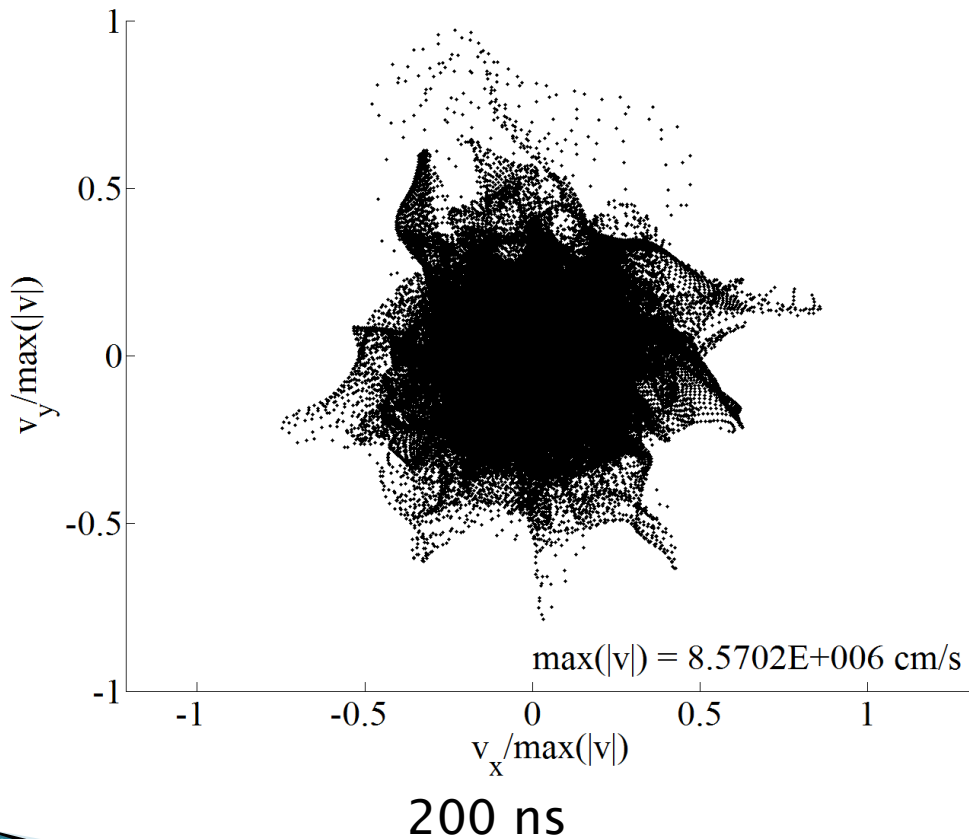
# 2D: Power Spectra



# 2D: Distributions (200ns)

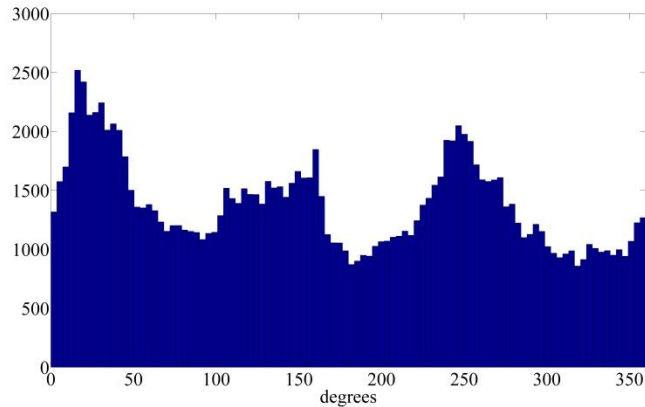


# 2D: Isotropy

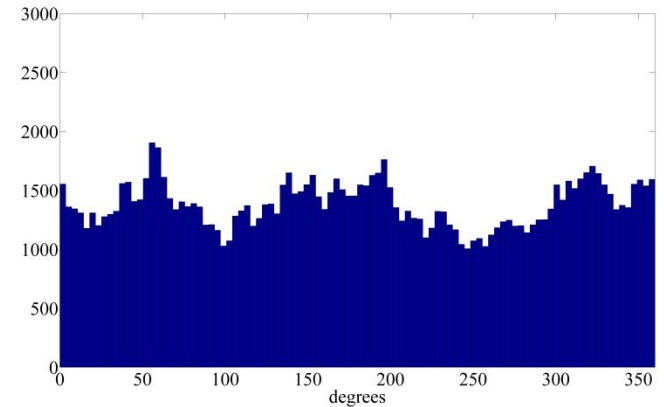


- ▶ Distribution roughly radial
  - Little angular dependence
- ▶ Outbursts are remnants from the most recent firings

# 2D: Isotropy



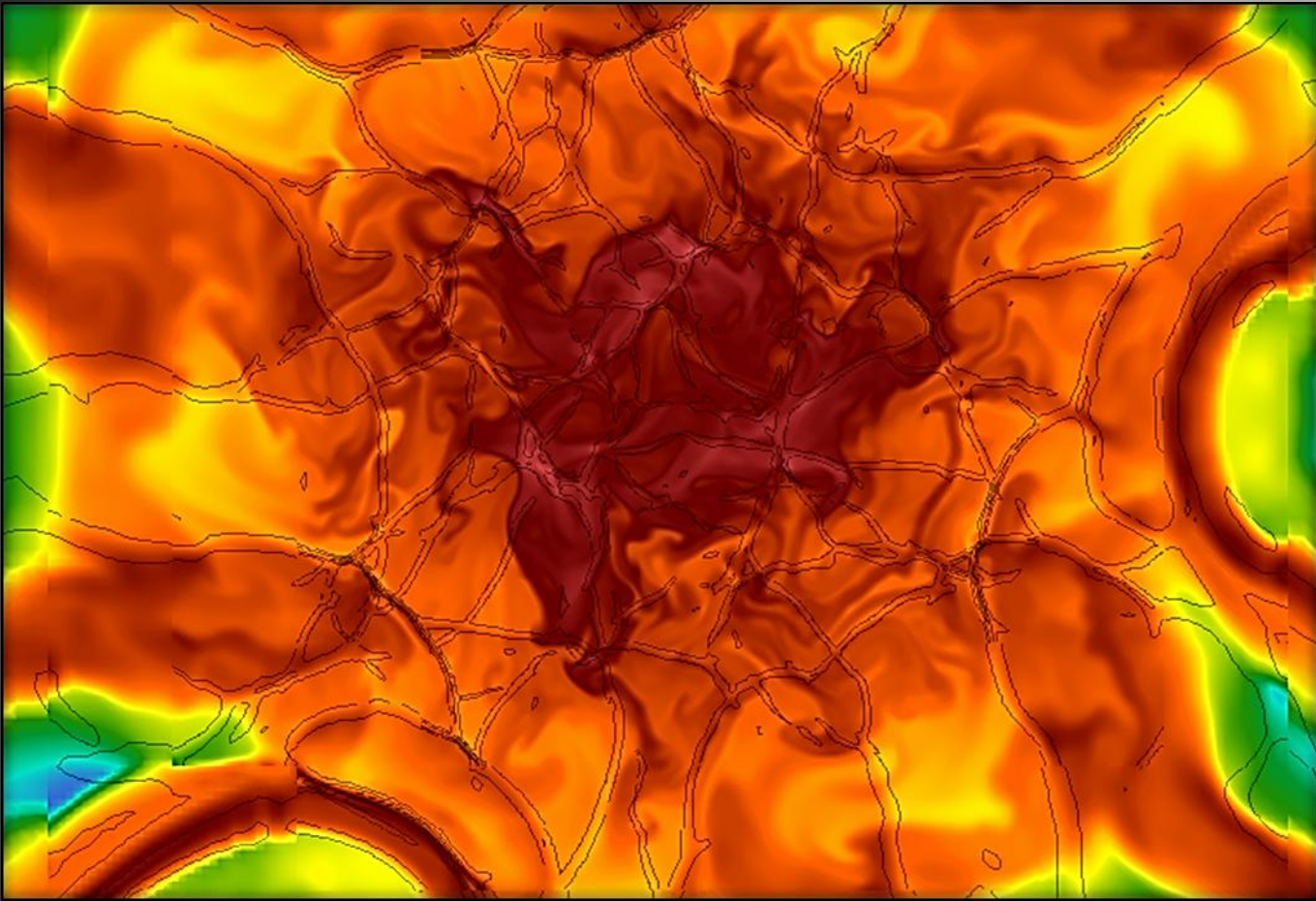
50 ns



200 ns

- ▶ Imprint of initial firing (at  $t=0s$ ) persists for a long time
  - Anisotropic
- ▶ At the end of firing, distribution is “flatter”
  - Isotropic





## 2D: Density >>

Density pseudocolor. Compressive regions ( $\text{div } \mathbf{V} < 0$ ) contoured in black.

# Conclusions & ongoing work

- ▶ Summary:
    - Usage of laser facilities to study supersonic turbulence seems feasible
    - Containable
    - Isotropic
    - Filament structure
    - Chaotic (maybe turbulent)
  
  - ▶ Currently investigating
    - 3D
    - Pre-existing magnetic fields
    - Self-generated magnetic fields
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