

# Laser manipulation for combined shear and heating of two-dimensional dusty plasmas

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## 2D Dusty Plasmas

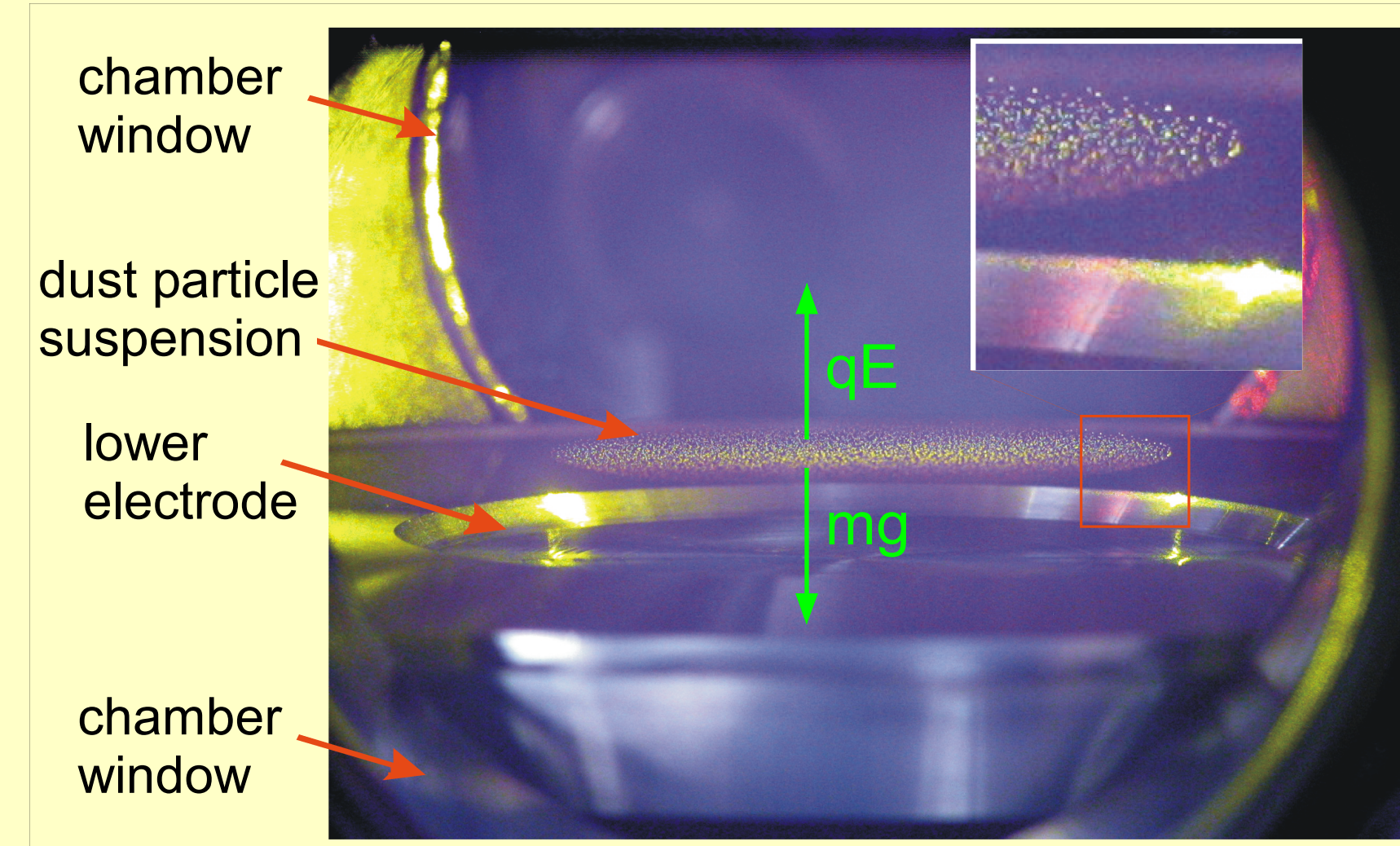


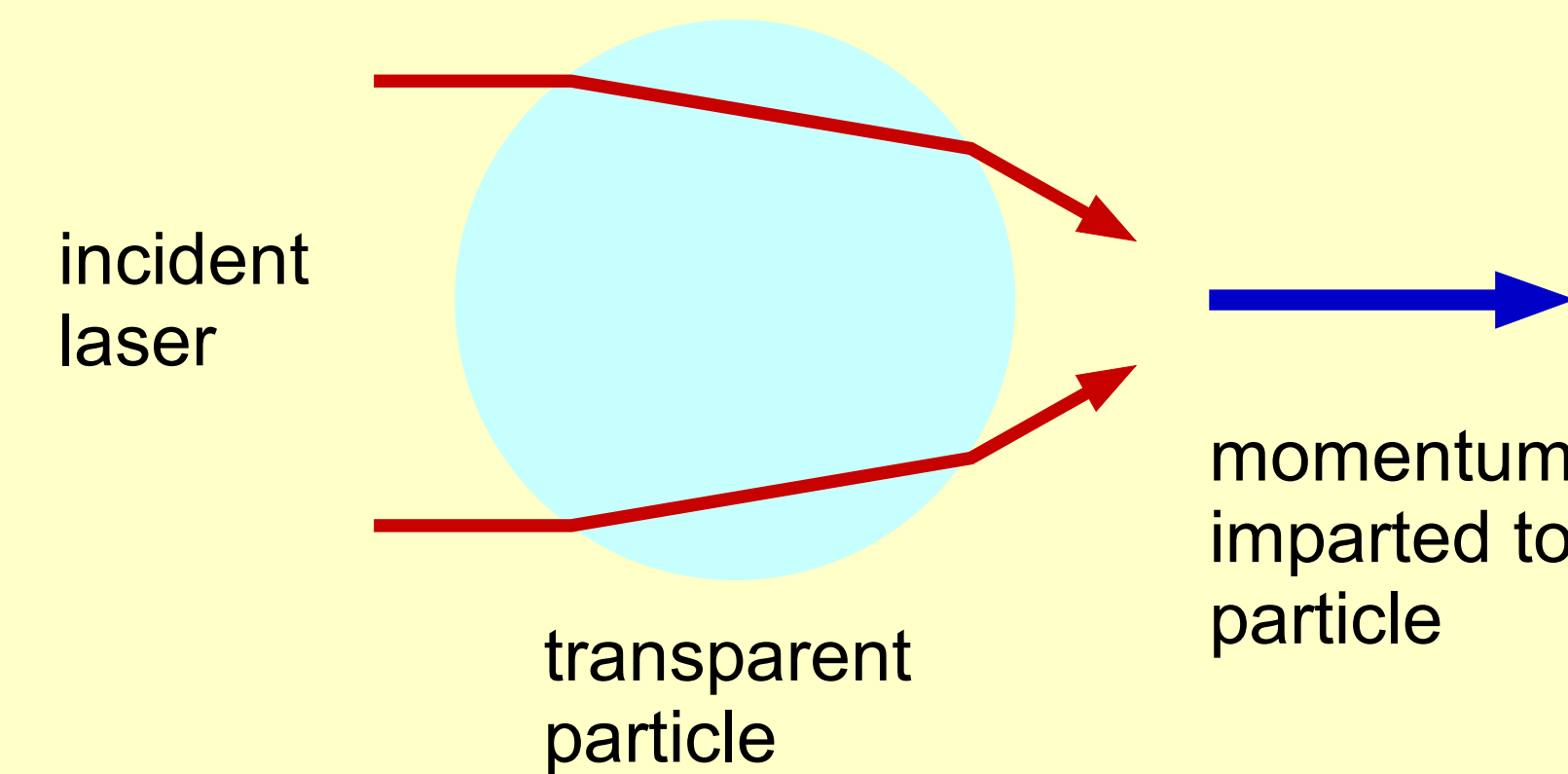
image: Yan Feng

Experiment reported here:

- 13.6 MHz plasma
- 6.0 mtorr Argon
- 8.7  $\mu\text{m}$  diameter particles

## Laser Manipulation

Radiation Pressure Force:



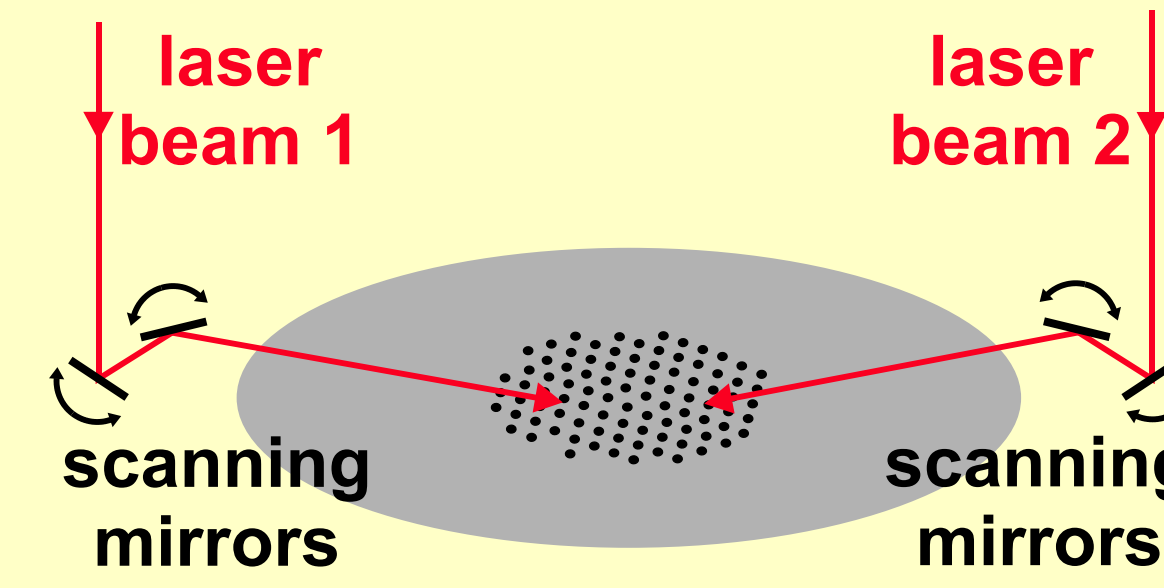
Force is proportional to laser intensity.



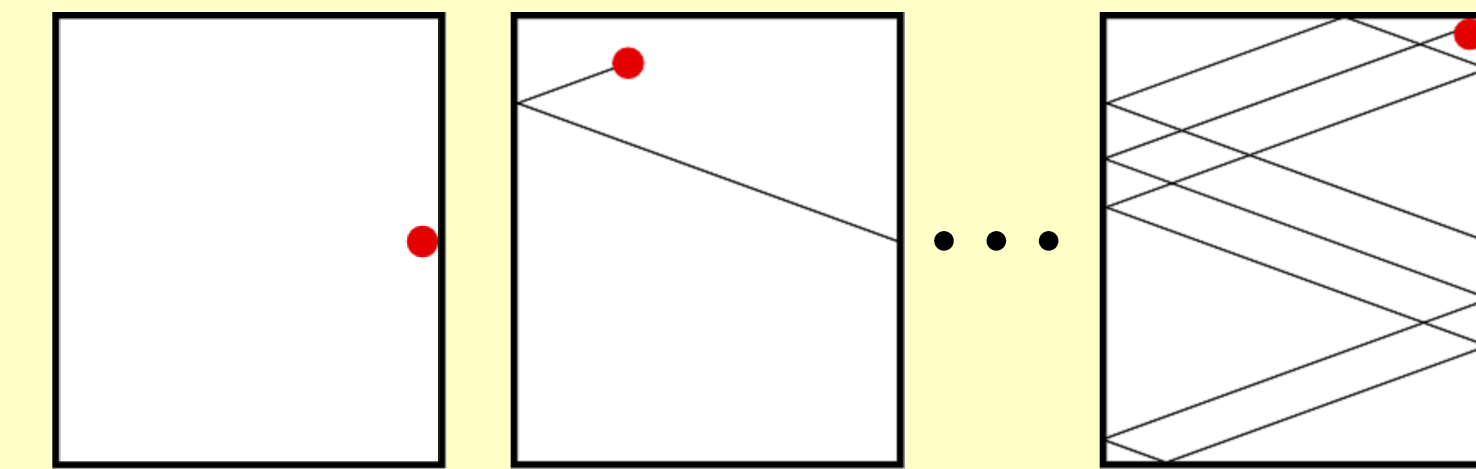
## Heating

Scheme:

- beams:
  - incident at  $\sim 6^\circ$  from horizontal
  - scanned across entire suspension
  - random kicks increase kinetic energy



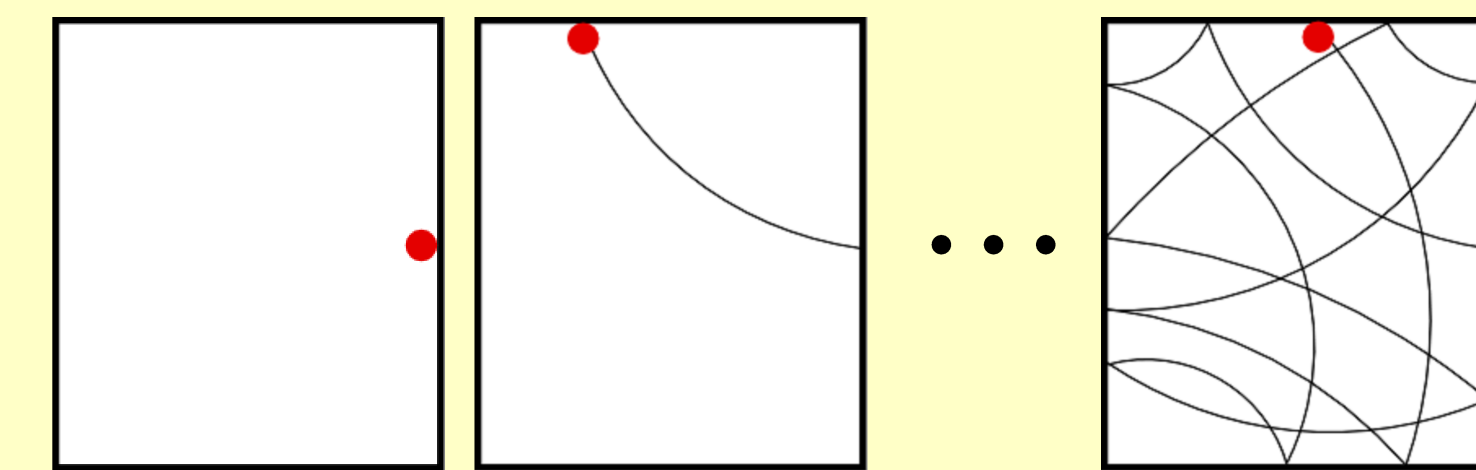
Previous methods:



- Nosenko *et al.*, PoP (2006)
- two beams
  - triangular waveforms
  - fixed frequencies

- Schablinski *et al.*, PoP (2012)
- four beams
  - random frequencies

Arc method:

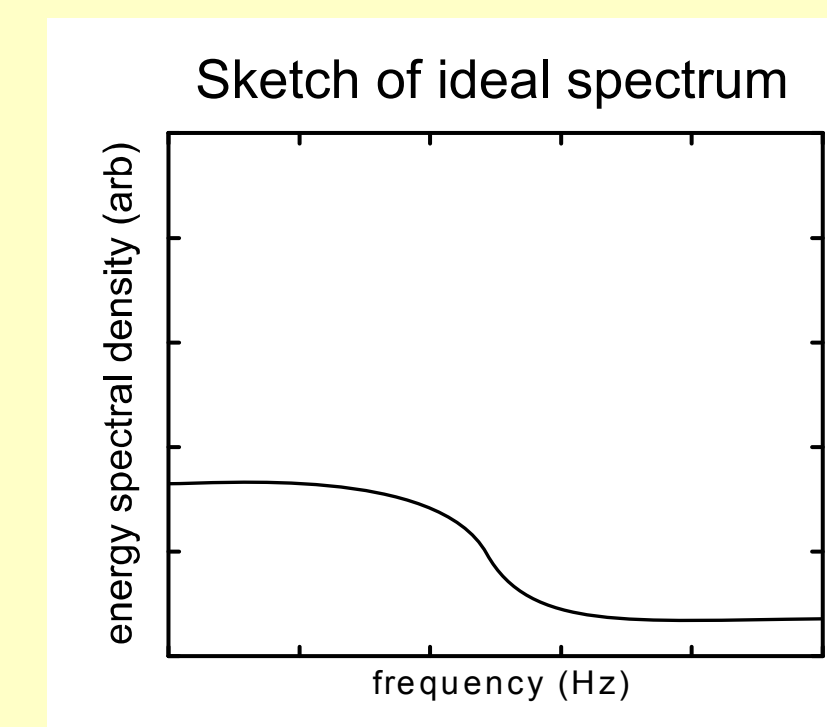


- two beams
- circular arcs
- varying curvatures
- avoids retracing similar paths

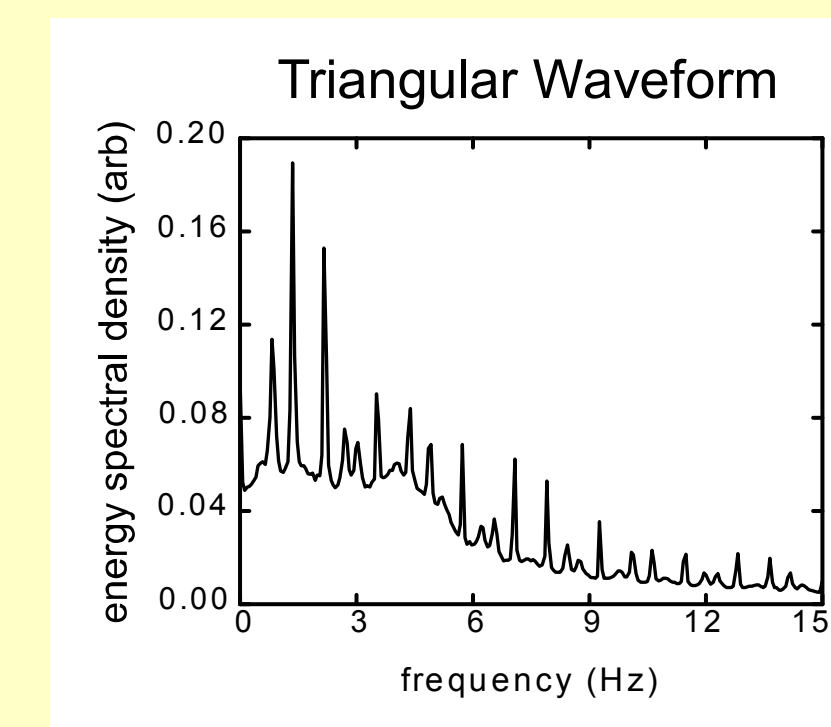
Coherent particle motion:

- revealed by peaks in power spectra of particle velocities
- undesired; coherent motion is unlike thermal equilibrium

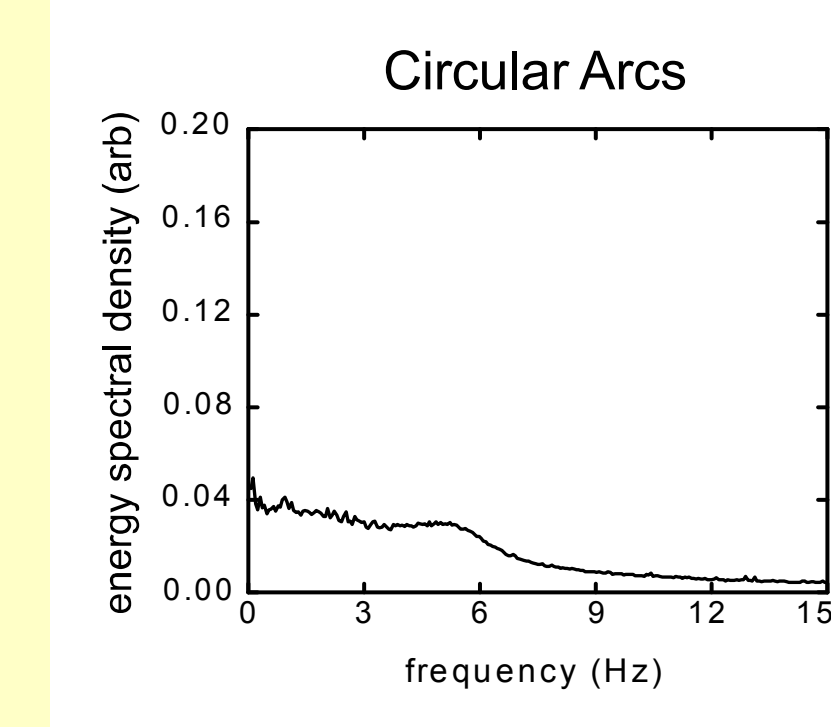
Ideal spectrum:



Measured spectra:

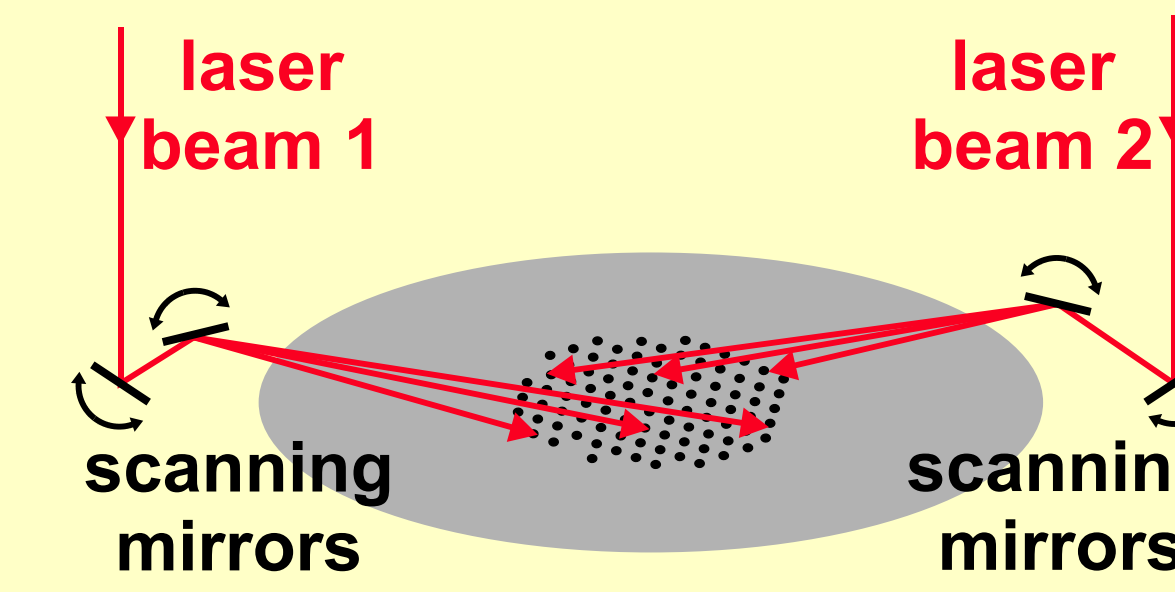


energy in peaks:  
reduced ten-fold  
with Arc method



## Shear

Previous methods:

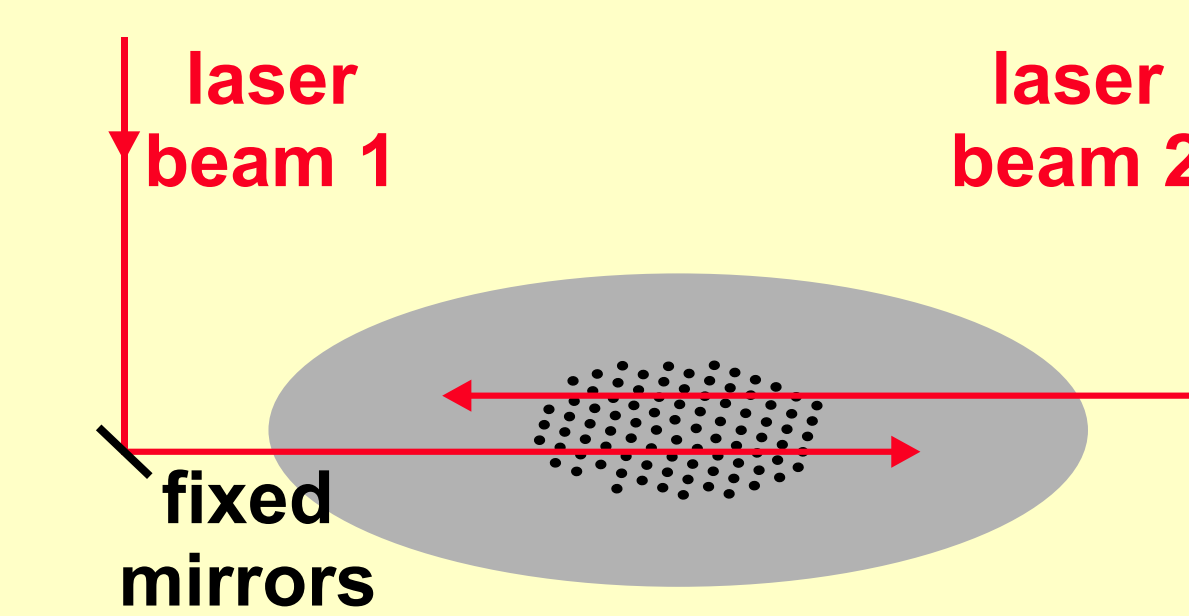


- Beam:
- scanned over narrow strips

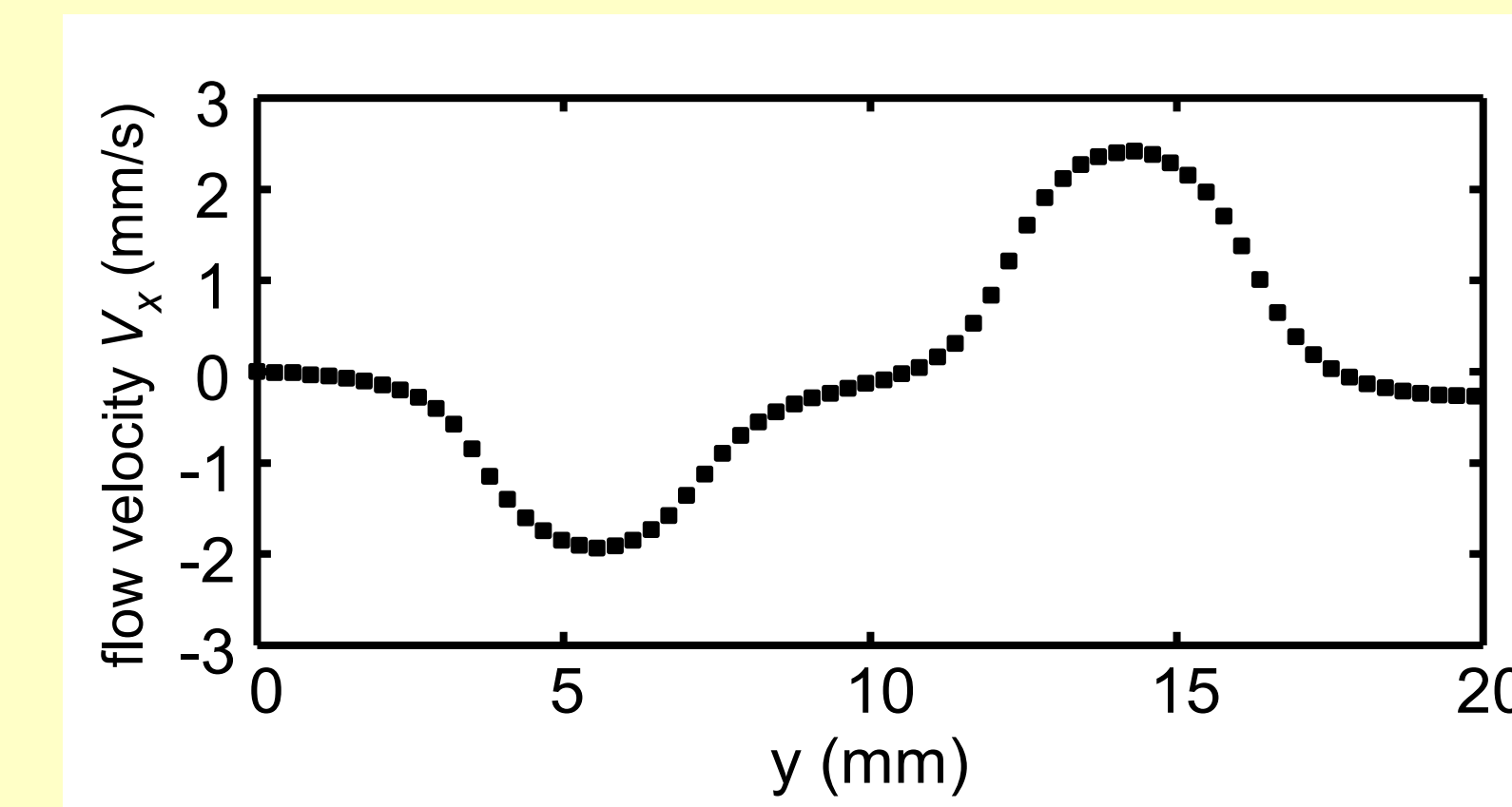
Nosenko & Goree, PRL (2004)  
Feng, Goree, & Liu, PRL (2012)

- Beam:
- not scanned
  - in plane of suspension

Chan, Woon, & I, PRL (2004)  
Hartmann *et al.*, PRE (2011)



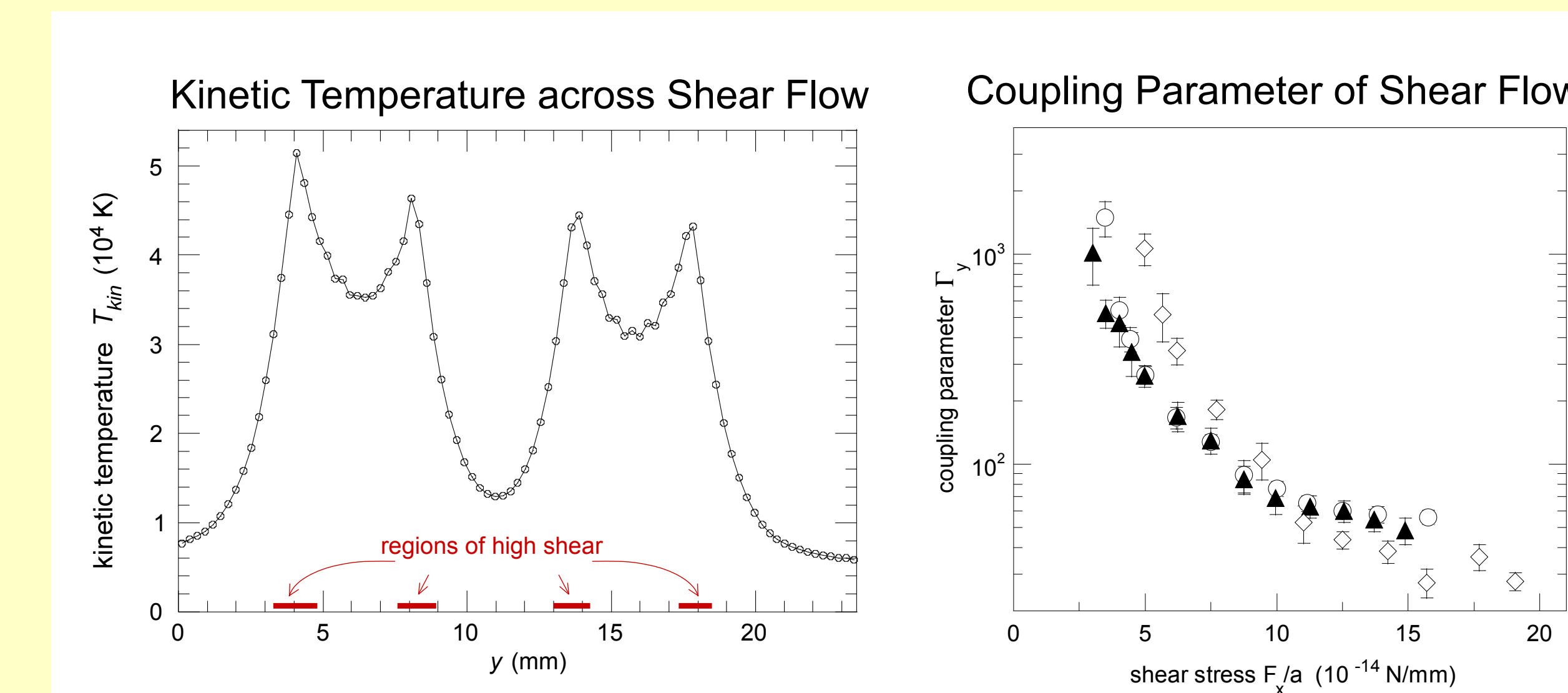
Shear flow profile:



- Previous methods:
- melt crystal in high shear regions
  - drive smooth flow

Limitations of shear without heating:

- Temperature of suspension is:
- highly nonuniform due to localized energy input
  - determined by strength of shear manipulation

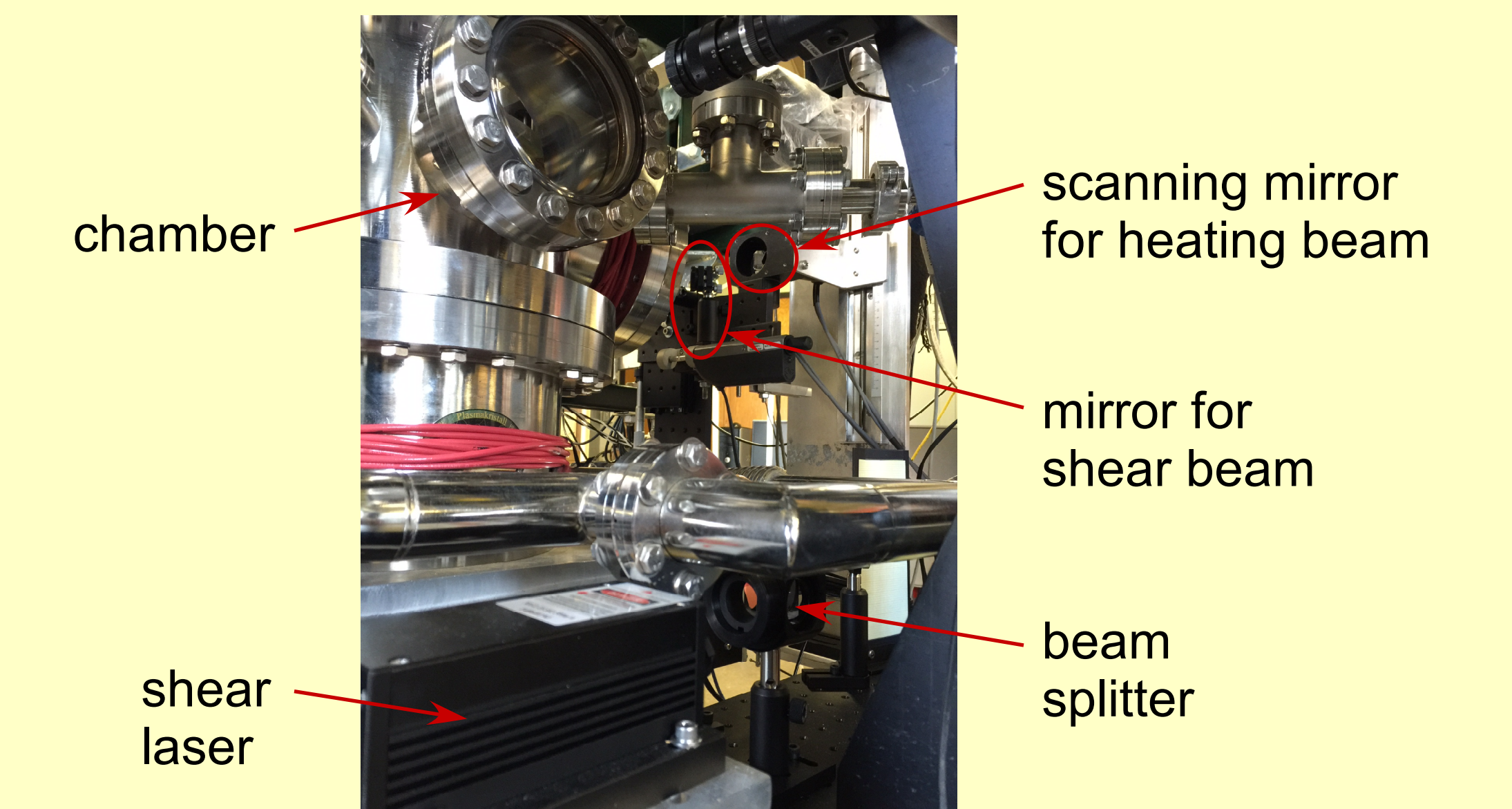
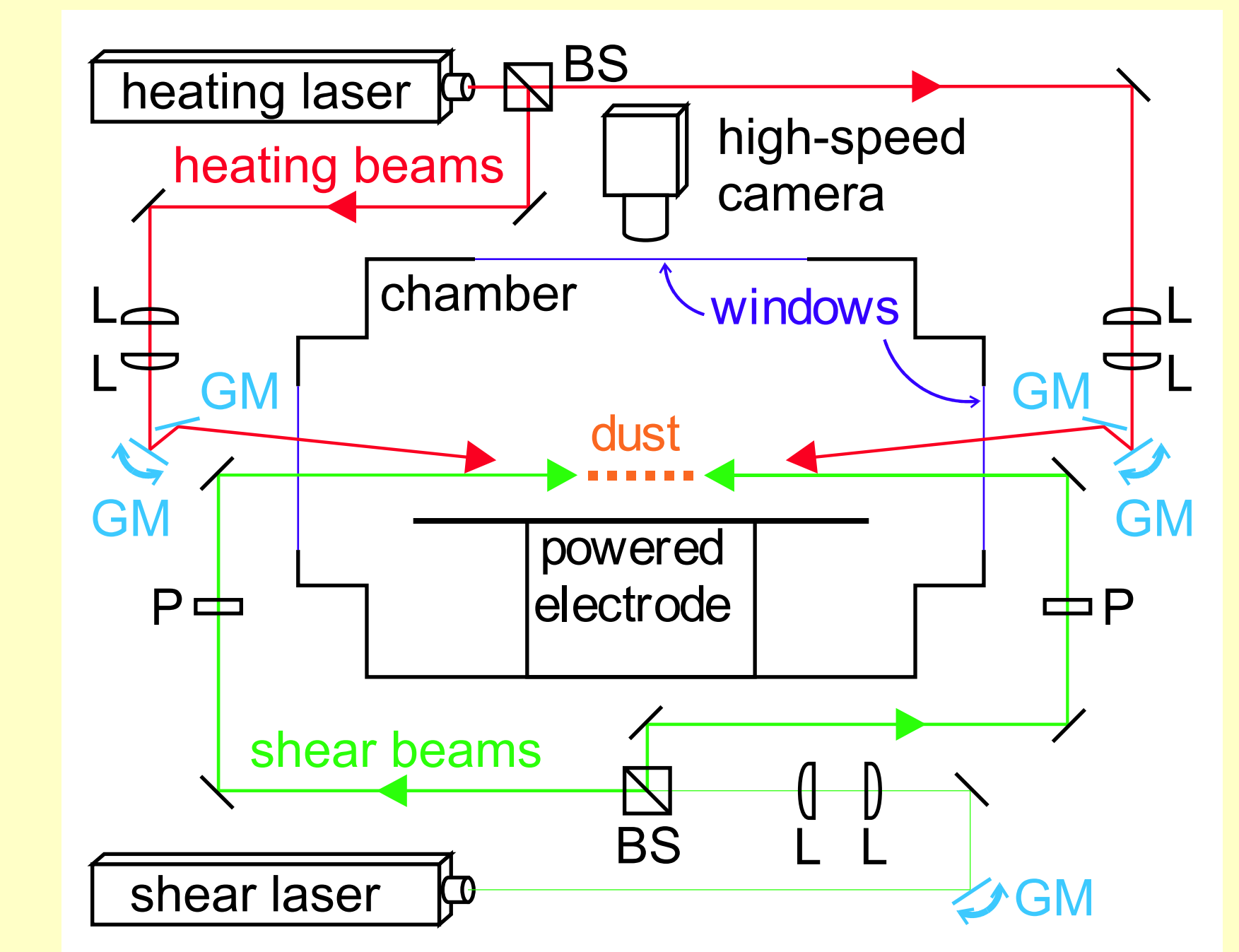


Feng, Goree, & Liu, PRL, **109**, 185002 (2012) Nosenko & Goree, PRL, **93**, 15 (2004)

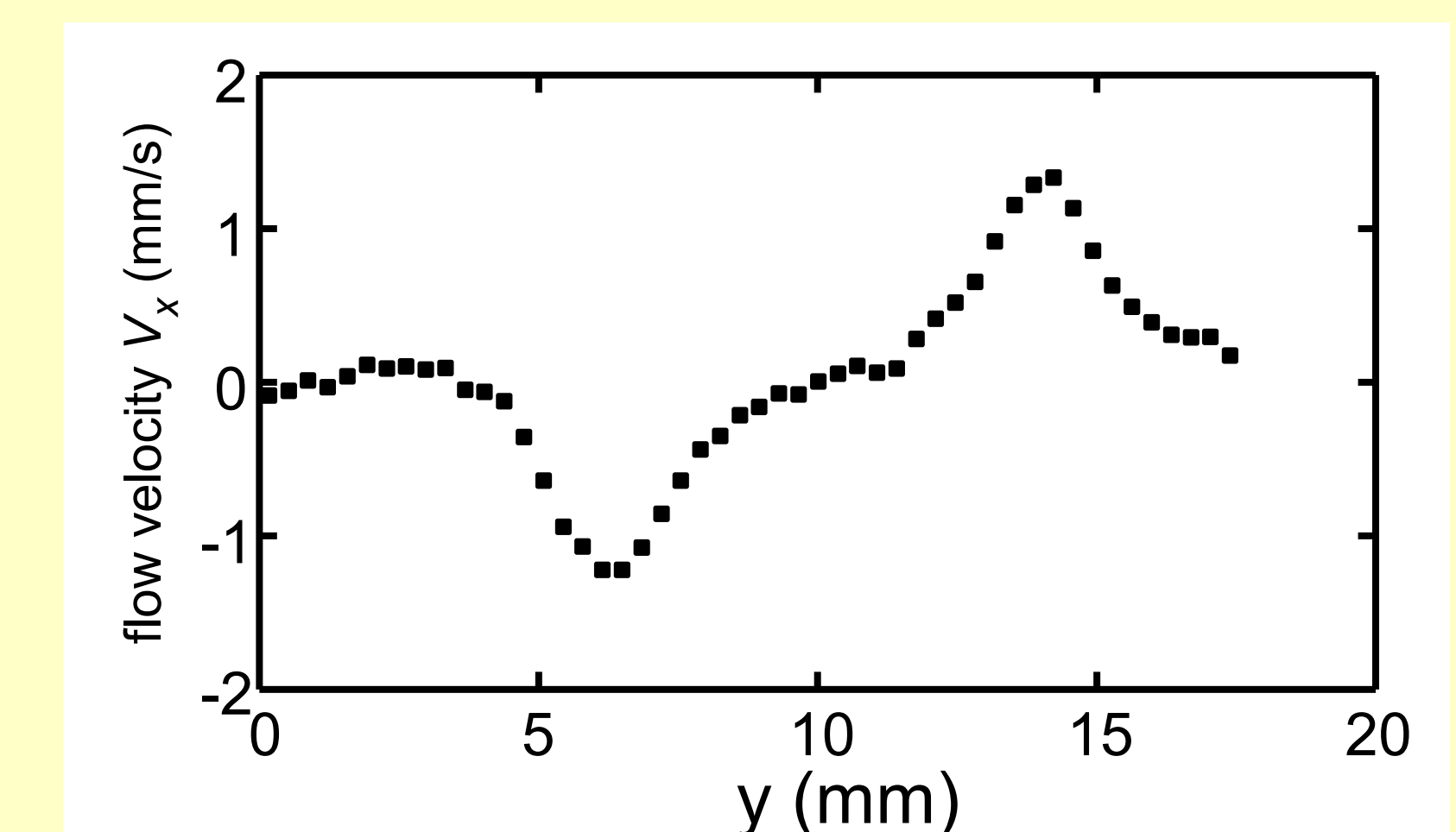
## Combined Heating & Shear

Additional beamlines:

- apply shear and heating separately
- maintain uniform temperature to within 10% across shear flow



Heated shear flow profile:



- profile less smooth than for shear without heating

Work supported by NSF