Dynamic Shear Band Dependence on Particle Size

Katherine Newhall

TREND program, 2004

Masahiro Toiya, Wolfgang Losert

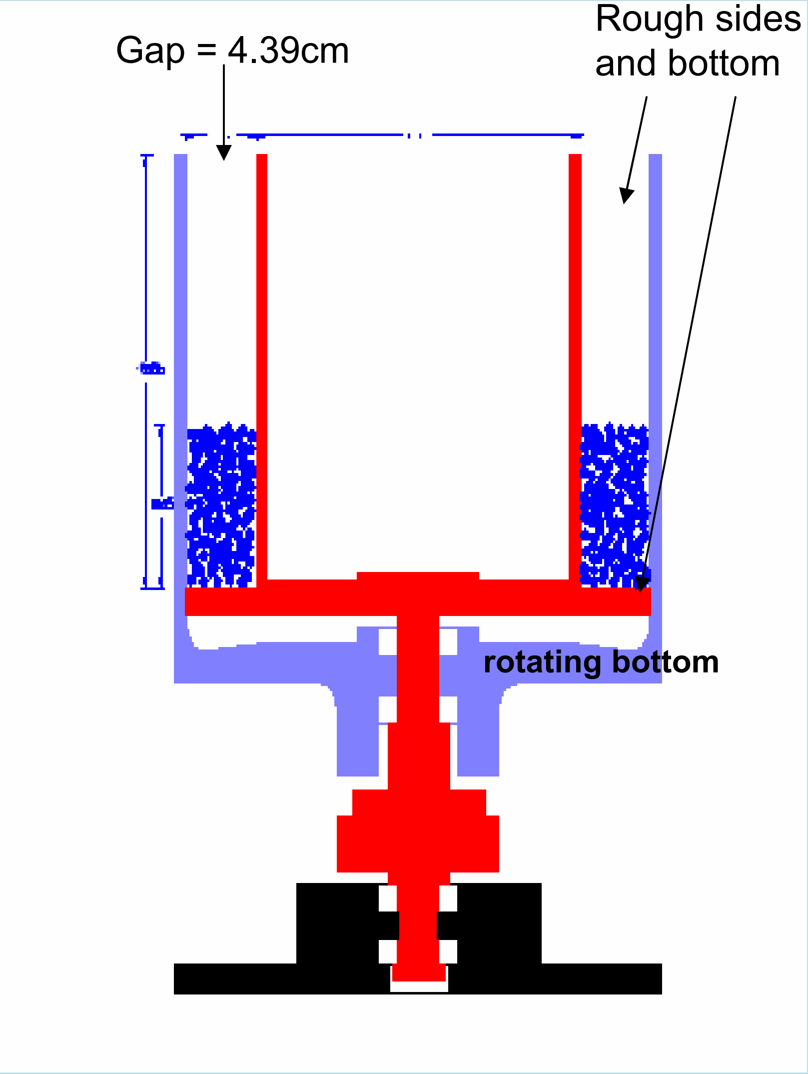
Dept. of Phys, IREAP, University of Maryland

Background

- Understanding granular flows will aid industrial preparation and transportation of granular materials
- Granular materials do not flow as a whole, flow is usually confined to a localized shear band
- Shear bands of different sizes are created to study the universal effects of reversing shear direction

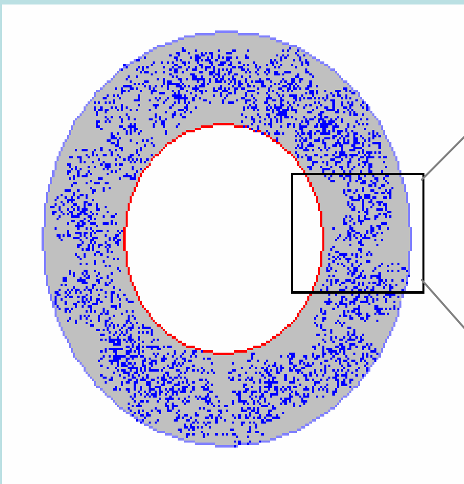
Experimental Procedure

- Rotating rough inner cylinder and bottom
- Various filling heights of 1mm, 2mm and mixtures
- “stop start” shearing and “reversal”

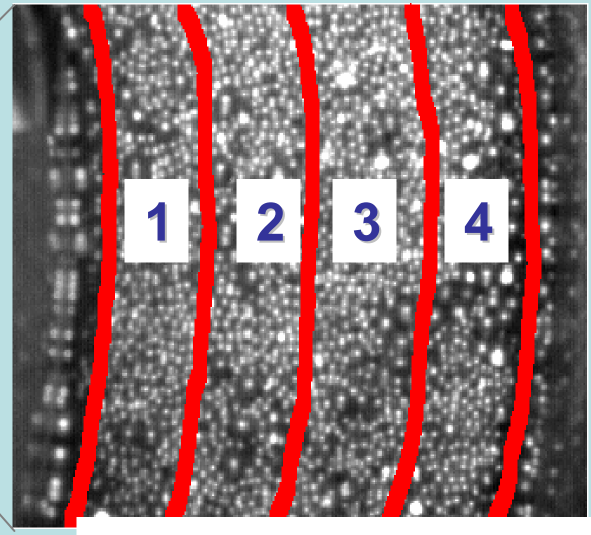


Data Analysis

Top View



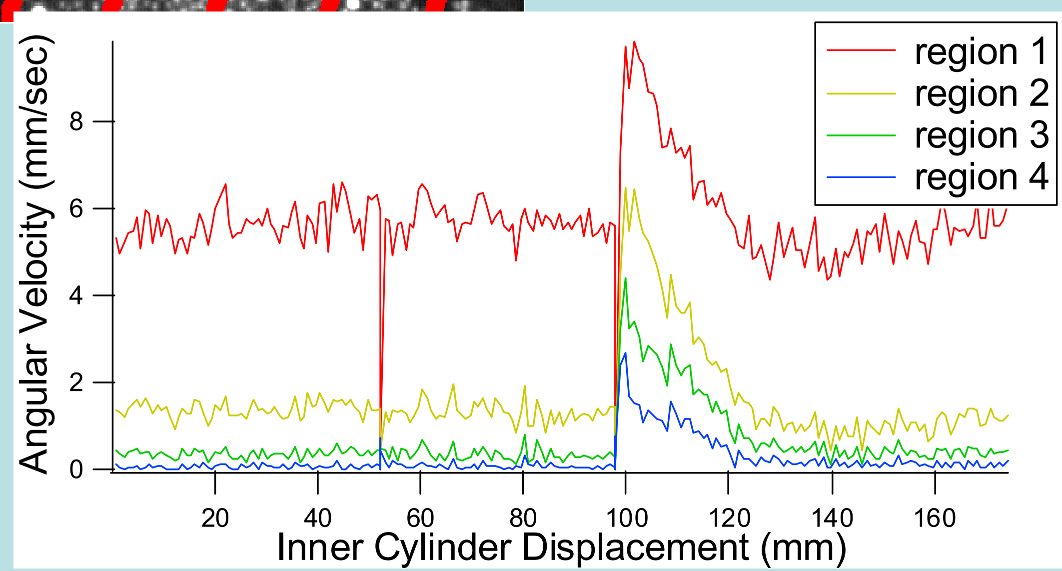
Inner cylinder



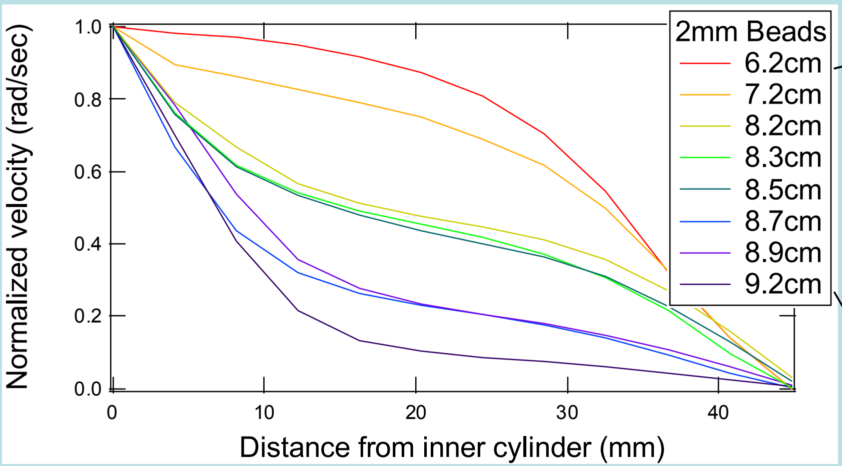
Outer cylinder

1mm Beads
8.8 cm Depth

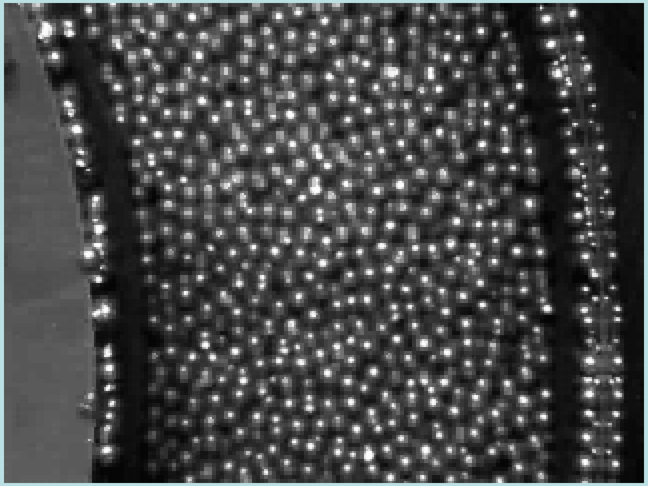
- Average over each region and time
- Angular velocities are displayed



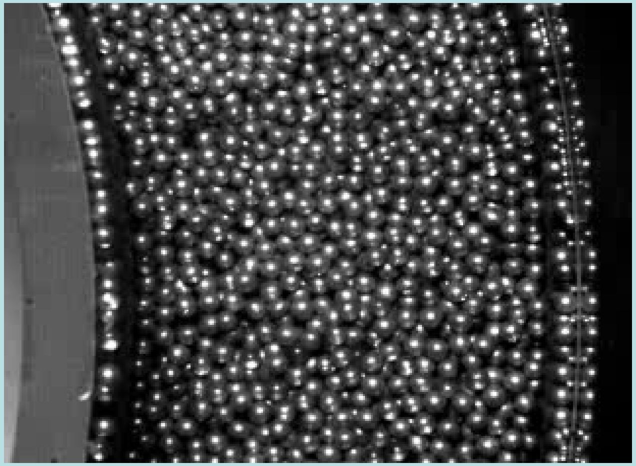
Shear Bands at Various Heights

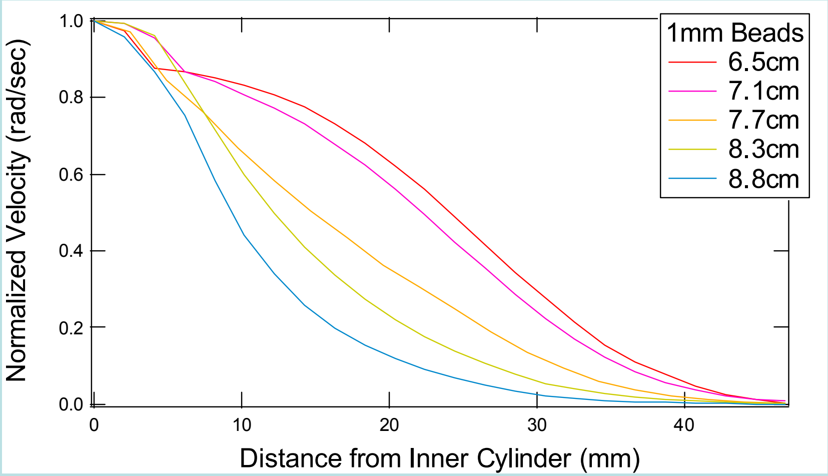


6.2cm Depth



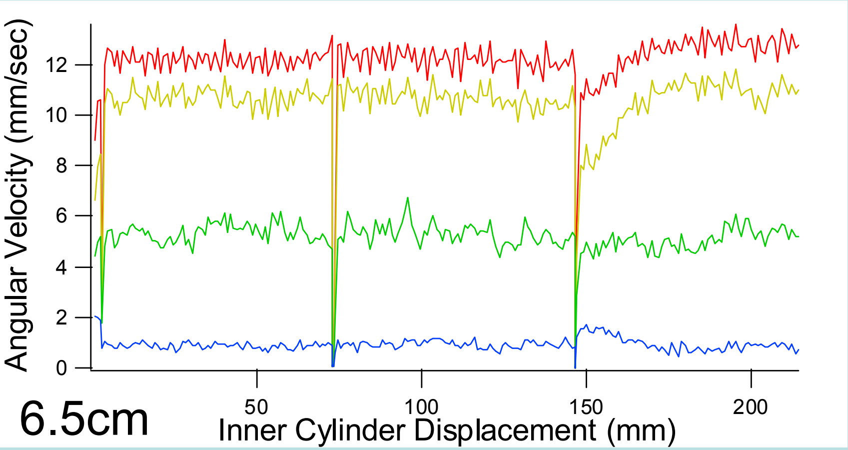
9.2cm Depth



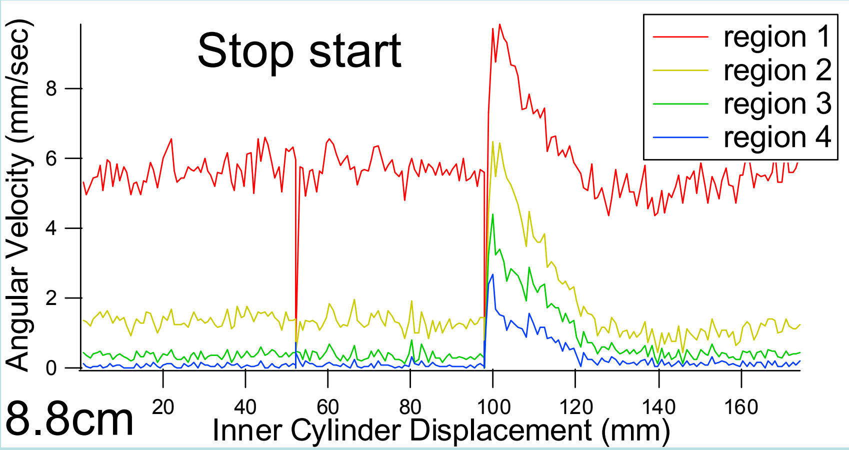


Angular Velocity vs. Time

Stop start Reversal



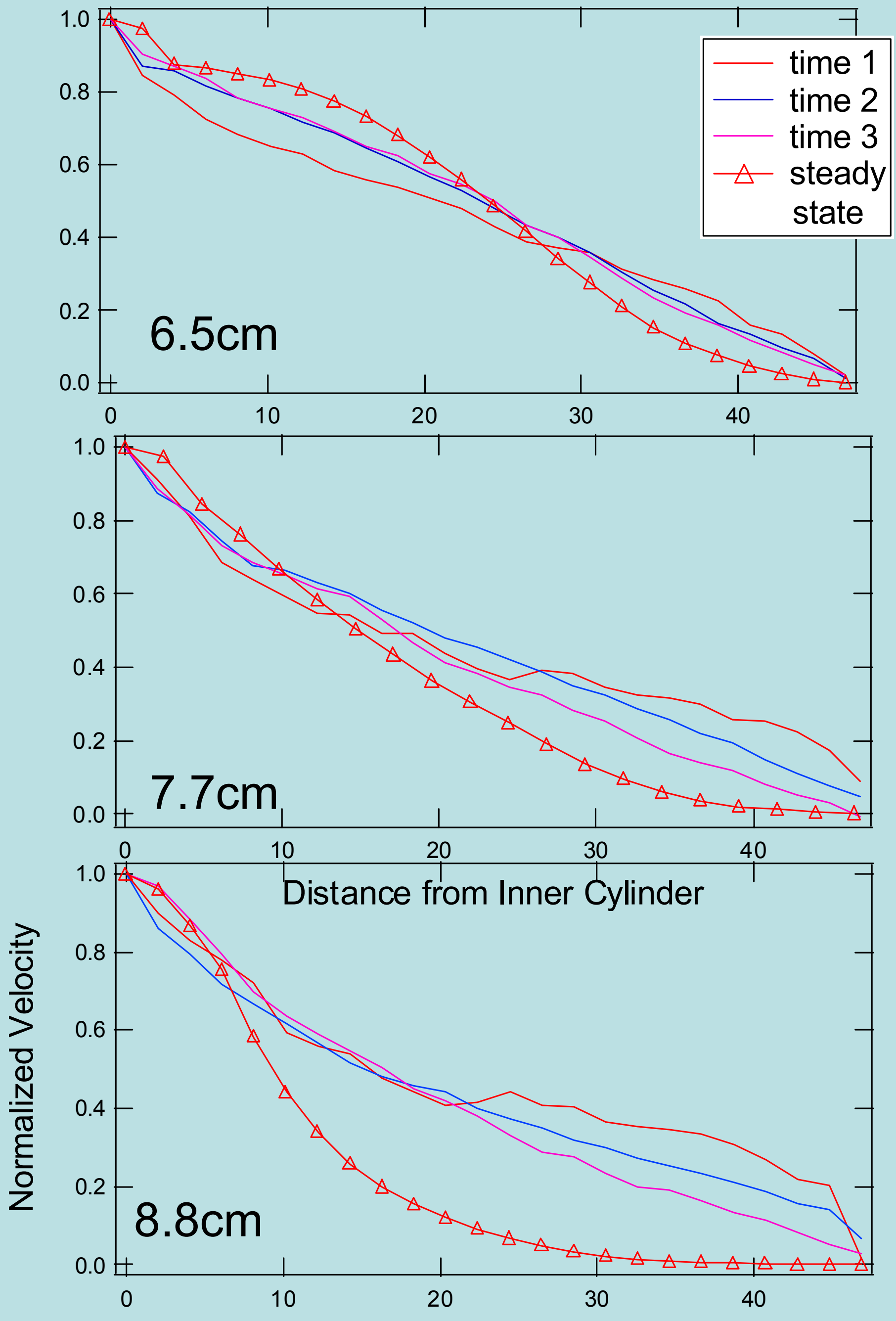
Reversal



- No change observed when shearing started in same direction
- Widening of shear band seen in previous results when direction is reversed, for large height
- Very different behavior for small height

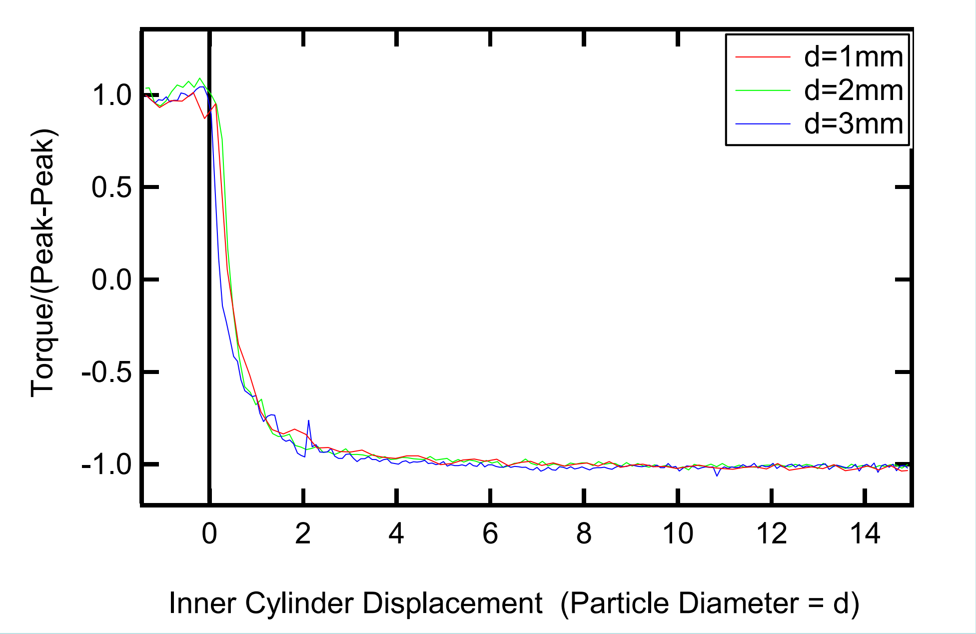
Velocity Profile during Reversal

- Can see a general trend throughout all
- Shear band widens beyond some radius
- Passes through near linear to return to steady state
- Same trend seen in 2D system

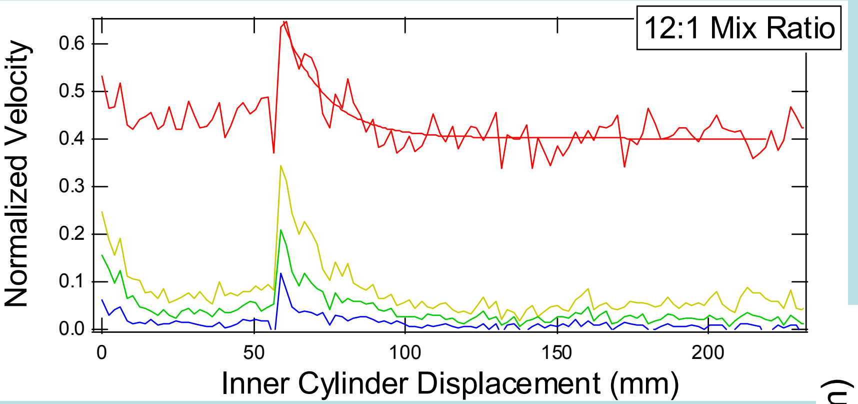


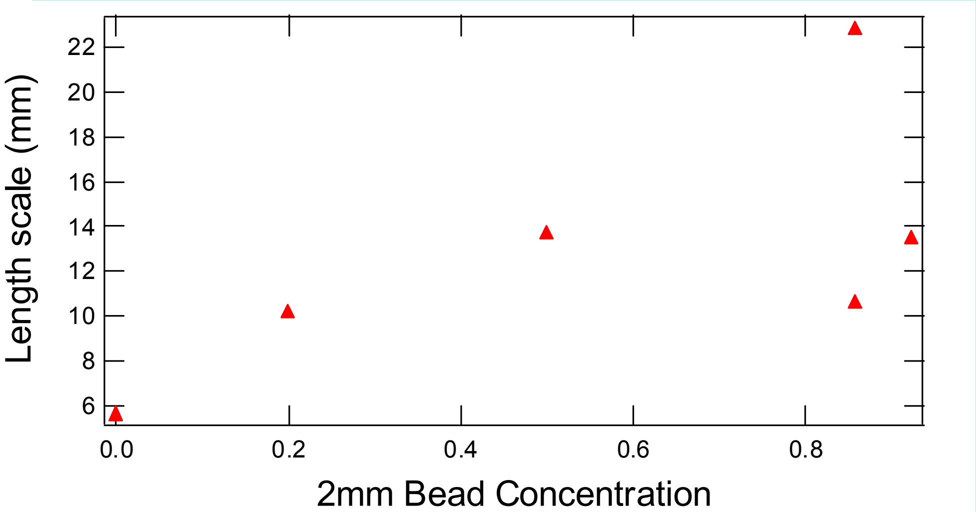
Torque Required to Shear

- Takes time for force network to reform
- Shear displacement is proportional to particle diameter
- 1mm beads (blue line) take less force to shear than 3mm beads (red line)



Length Scale for Mixtures

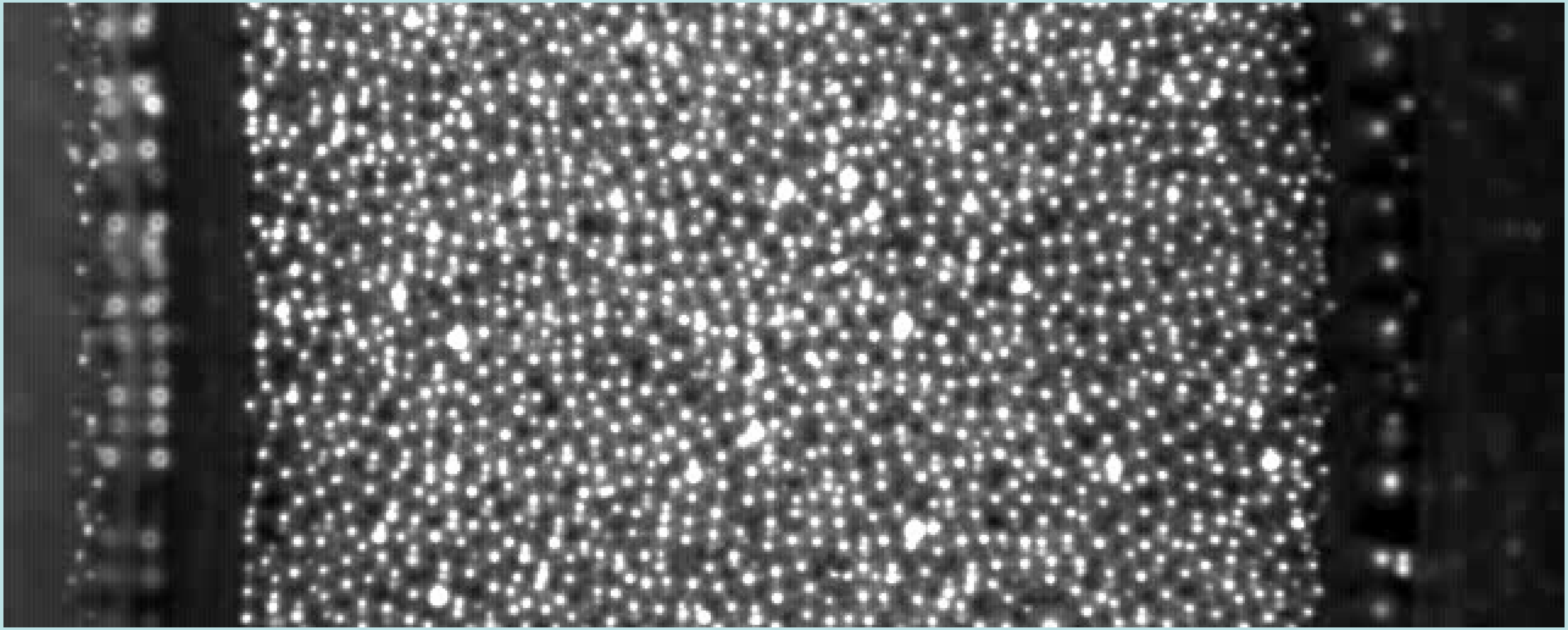




- Exponential fit, $y \sim e^{-x/\tau}$, to region 1 of the velocity graph
- Time to return to steady state depends on particle size

Mixtures

- Segregation was not studies, but occurs when a mixture is sheared
- Larger particles come to the surface in one region, then spread across the surface



Conclusion

- Shear band width and location can be adjusted with filling height
- Different steady state shear bands pass through the same near linear velocity profile upon reversal of shear direction
- Shear strain to return to steady state after reversal scales linearly with particle diameter