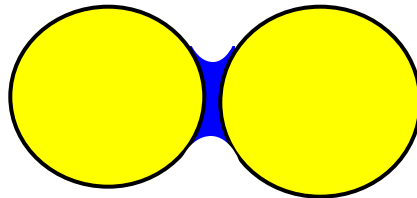


# Wet Granular Media

Add small quantities of liquid uniformly to grains

Ⓜ **liquid at every grain-grain contact**



Adds new dimensions to granular physics

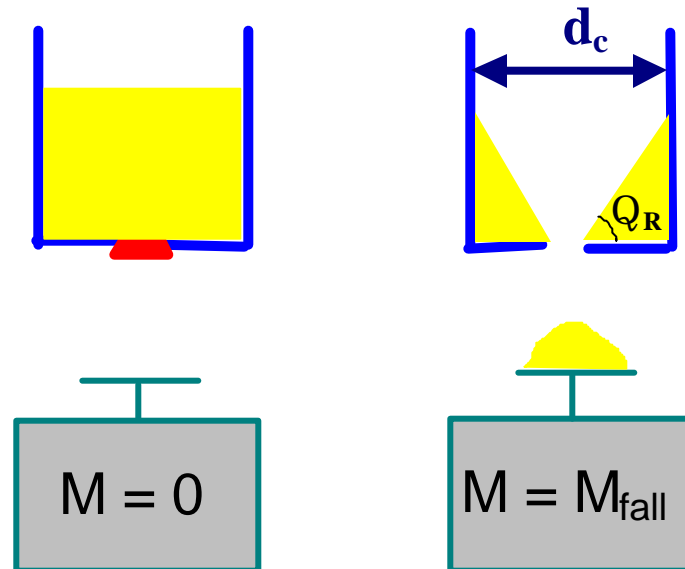
- Capillary forces – attractive force, cohesion
- Lubrication – decrease of static friction
- Viscous forces

In ambient atmosphere always  
interstitial liquid from humidity

- Impact on Physics
- Big Impact in Applications



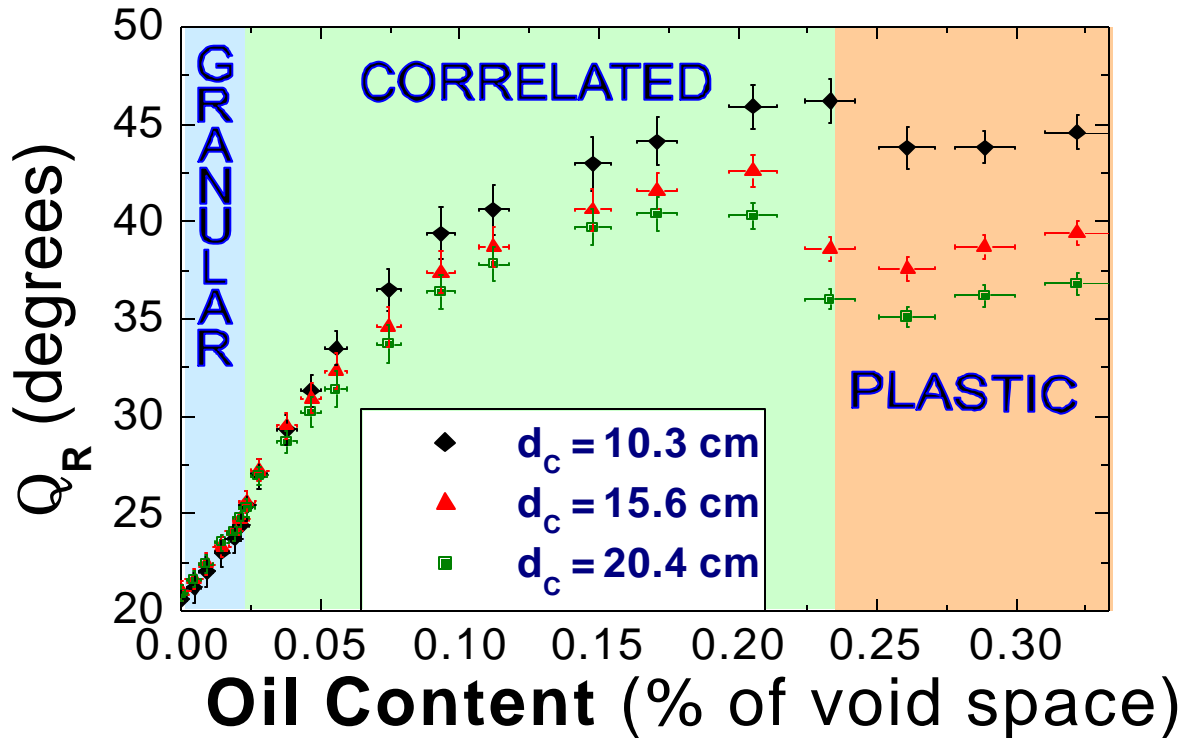
# Draining crater method to measure repose angle ( $Q_R$ ) as a function of wetting



- glass beads -- ~1 mm diam.
- add oil -- low vapor pressure
- vary oil content -- limit of small oil (0.001%–1%)
- vary container size -- expect size dependence

Experimental checks to be sure grains are well-mixed and no time-dependent effects

# Draining crater data: three regimes of behavior with increasing liquid content



## Granular Regime

Individual grains flow down surface

## Correlated Regime

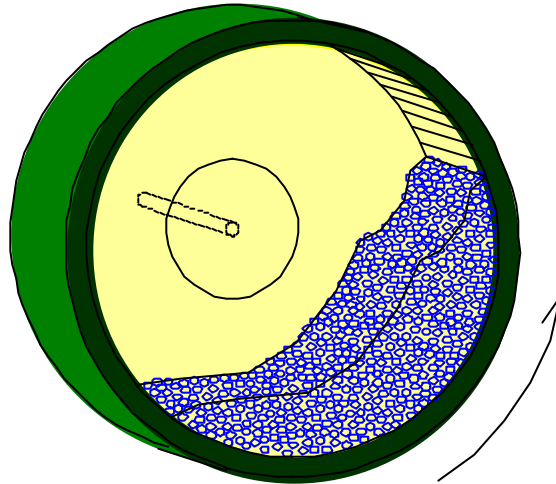
Correlated clumps flow down surface

## Plastic Regime

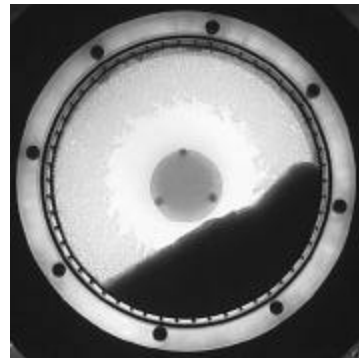
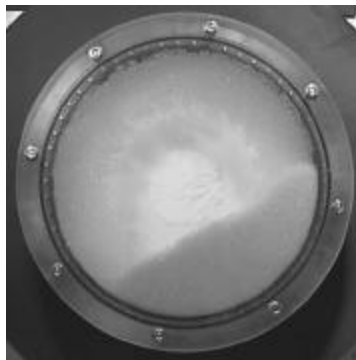
Coherent surface flow (like viscous liquid)  
 $Q_R$  drops with increasing liquid content

# Wet materials in the rotating drum

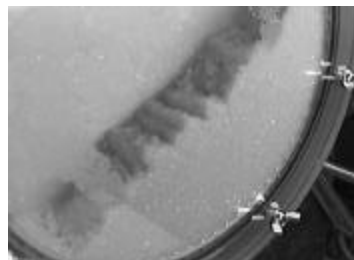
glass beads ( 0.9mm & 0.5mm) + oil ( 0.001%-1%)



Use background illumination to overcome problems with grains sticking



- **Observe new features in statics:**  
**Surface Roughness**



- **Observe new features in dynamics: Deep Avalanches**