

# 3D Imaging Of Wet Granular Matter

With Application to Penetrometer Insertion

Leonard Goff

Advisor: Dr. Wolfgang Losert



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## Background

### •Granular matter:



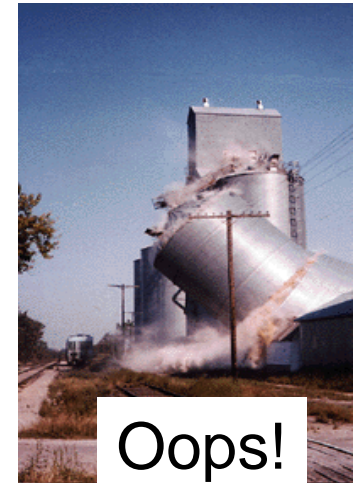
Sand



Gravel



Coffee



Oops!

- **Interesting Question: How does a stable configuration of granular matter fail under stresses?**
- **Knowledge of internal particle dynamics are important for answering this question**

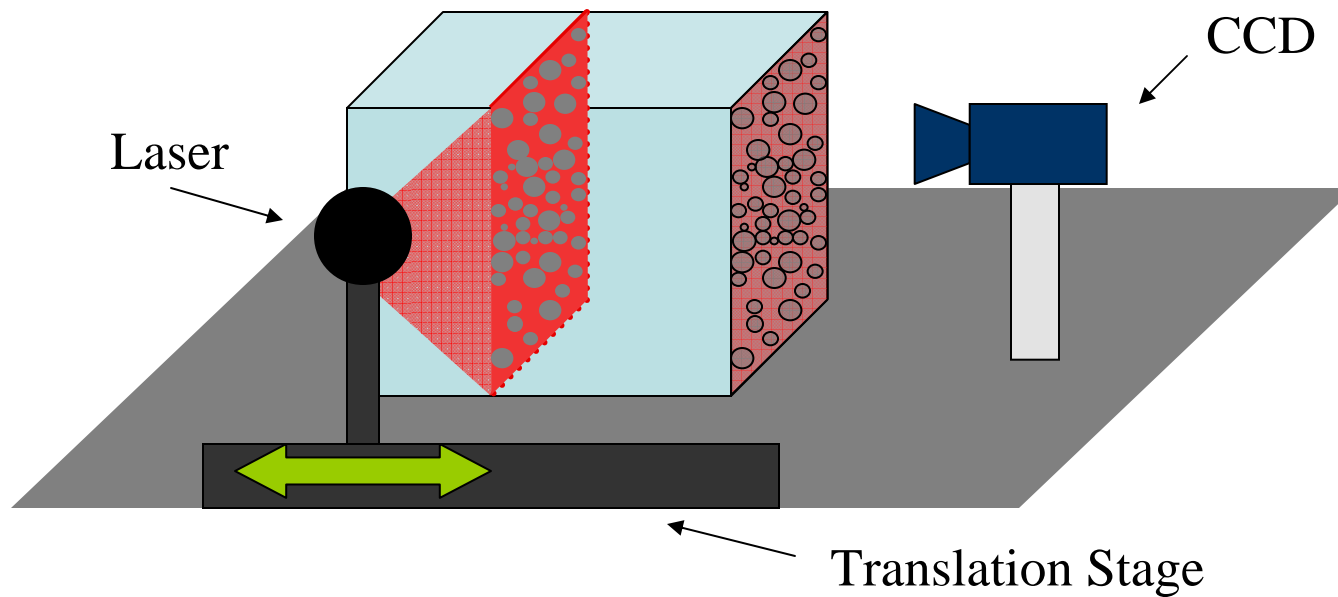


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## Laser Sheet Scanning



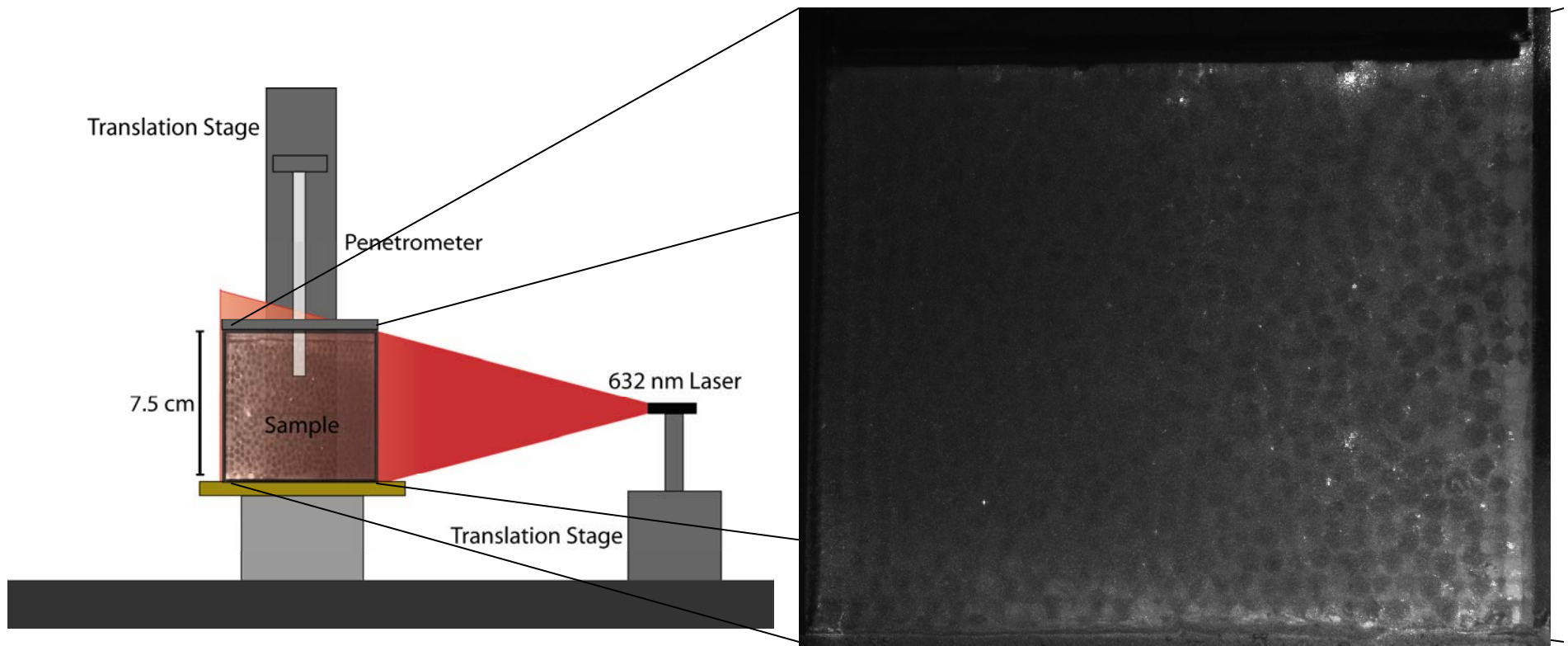


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## Penetrometer Experiment



View from camera

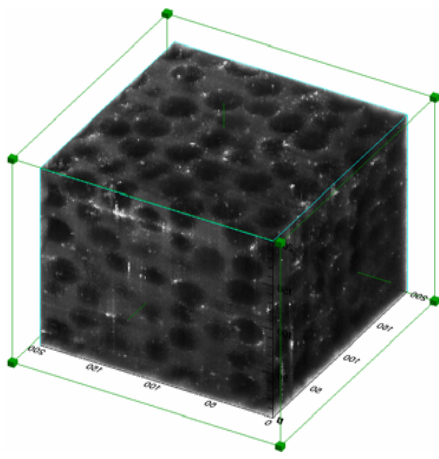


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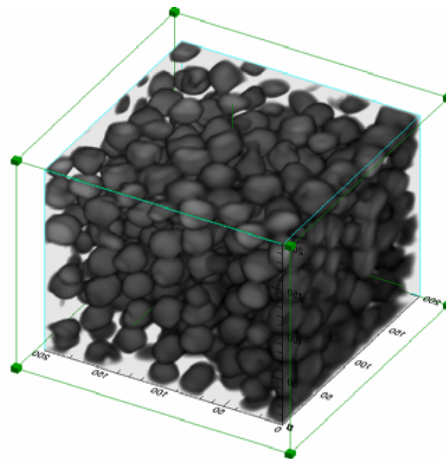
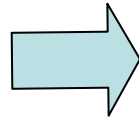
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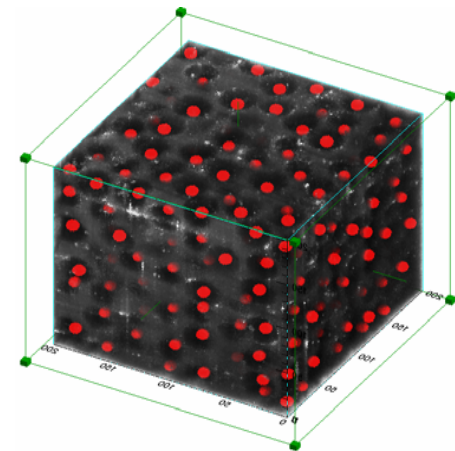
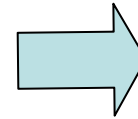
## Feature Location Process



Section of original data.  
10 pixels = 1mm



After inversion and  
bandpass filter



Extracted particle centers over  
original. (Roughly 300 particles)

- This can be done on several sets of data, each taken after a small change in penetrometer depth. If the displacements are small enough, the individual particle trajectories can be tracked across multiple scans.



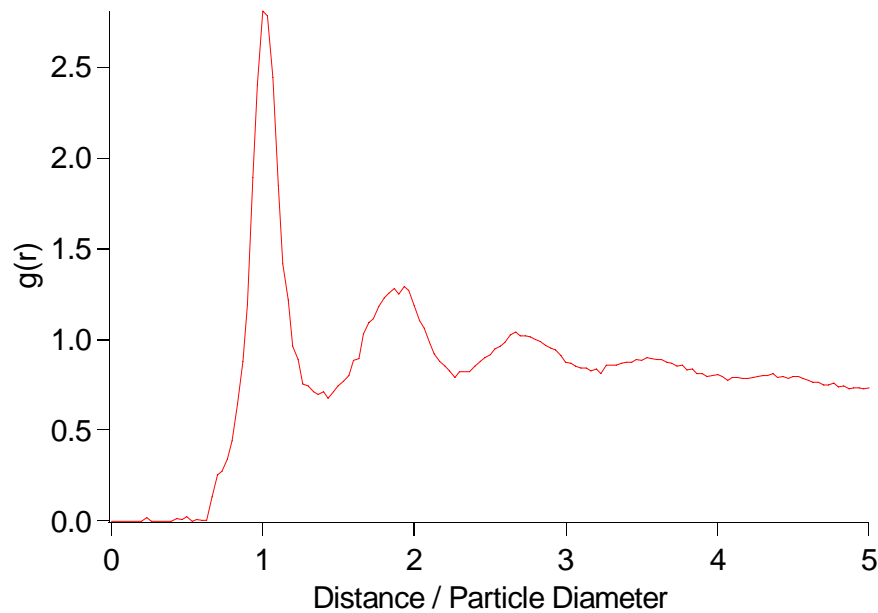
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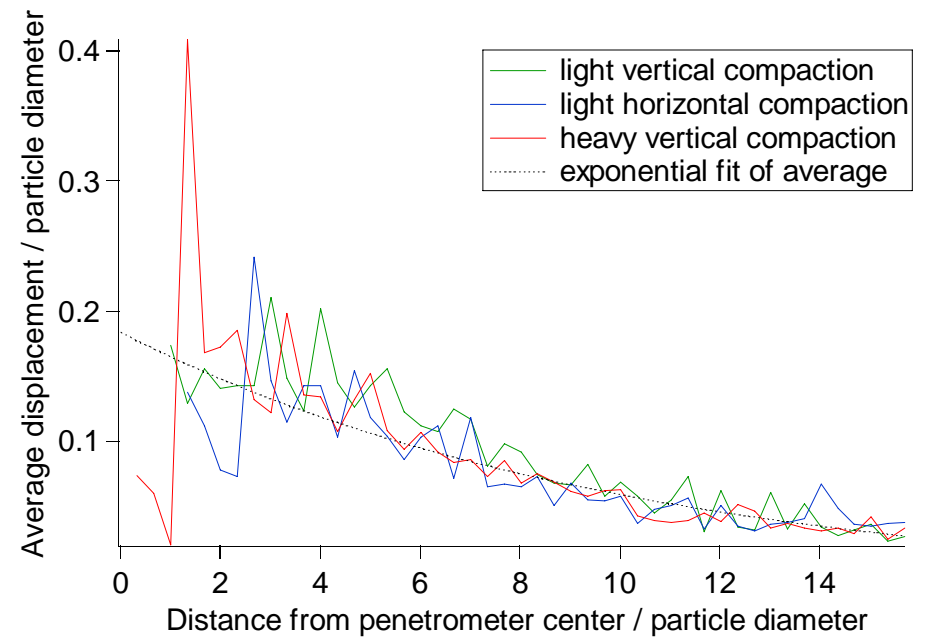


## Analysis

### Pair Correlation Function



### Particle Displacement





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## Summary/Directions

- For a section of image with high contrast, feature extraction appears to find centers to within 3-4 pixels (on the order of 100 microns in this case).
- No clear signs of the effects of asymmetry detected, but more analysis might prove otherwise.

### Future Work:

- Further analysis/visualization of data
- Further experimentation: e.g. How might results depend on grain size?