ESRF	**Experiment title:** Dynamical Heterogeneities in a macroscopic glass model system	**Experiment number:** MA-1253
Beamline: ID15A	**Date of experiment:** from: June 29, 2011 to: July 5, 2011	**Date of report:** September 18, 2012 *Received at ESRF:*
Shifts: 18	**Local contact(s):** Mario Scheel	

Names and affiliations of applicants (* indicates experimentalists):
*Matthias Schröter, *Jean-François Métayer, *Zeina Khan,
MPI for Dynamics and Self-Organization, Bunsenstrasse 10, 37073 Göttingen

*Mario Scheel
ESRF, rue Jules Horowitz, 38043 Grenoble

Report:
The aim of this experiment is to study the formation and evolution of dynamical heterogeneities (DH) in a water-driven granular suspension using high speed tomography. DH are a hallmark of the glass transition [1,2], they describe a state where the particles in neighboring areas have very different timescales of relaxation and particle motion. Several competing microscopic theories of the glassy state can be distinguished by their predictions for the length and time-scales characterizing the DH [3]. While a direct observation of the dynamics of individual molecules in a supercooled melt is still beyond the reach of current experimental techniques; recent experiments in driven dense granular systems have demonstrated them to be good model systems for the glass transition [4-6]. However, all previous experiments have either been performed in two dimensional systems [4,6] or at the boundaries of three dimensional systems [5]. The measurements reported here are the first three dimensional observations of DH.

The experimental setup consists of a water-fluidized bed with an 8 mm inner diameter filled with 250 μm diameter soda-lime glass beads. As the measurements have to be performed while the bed is fluidized, the in- and out-flow of water has been achieved through a rotational two-way coupling mounted on top of the fluidized bed. Flow rates between 33 and 46.5 μl/s were provided by a custom syringe pump with a injection volume of 200 ml.

Figure 1 a) shows a crossection through a fluidized bed where the particles are driven with a flow rate of 38 μl/s. The motion blur visible in the center bottom part indicates, that the exposure time of 1.75 s was not short enough to freeze the motion of the fastest beads. Panel b shows the difference image between two subsequent tomograms of the same experiment. There exist three clearly separated regions where the particles are moving, while the rest of the bed is virtually at rest, thus demonstrating for the first time the existence of DH in three dimensions.

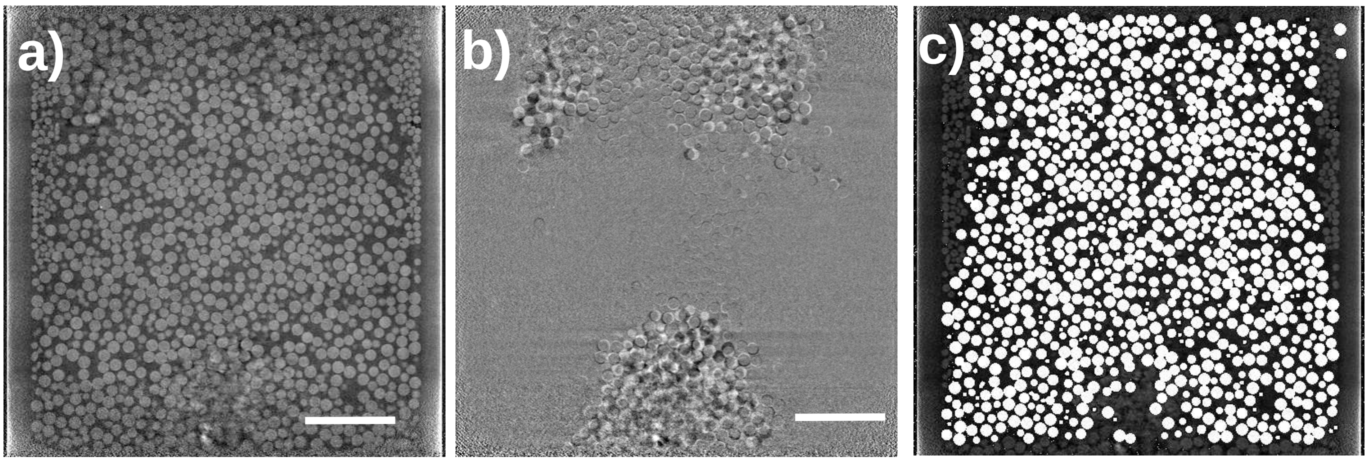

Fig1 : a) Tomographic reconstruction of a crossection through the fluidized bed filled with 250 μm glass beads (smaller beads are glued to the wall to create rough boundaries). The white bar corresponds to 2 mm. b) Difference image between to tomography slices taking with a $\Delta t = 3.5$ s. Moving particles appear in black and white. c) Corresponds to panel a) after all particles found by the image processing have been removed.

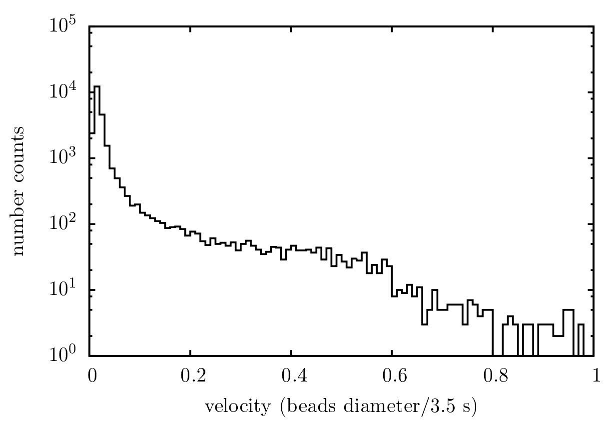

Fig 2: Histogram of particle velocities found in the tomography depicted in Fig. 1.

Our first step in the analysis was the development of code for identifying and tracking the individual particles in the tomographies. Figure 1 c) demonstrates that the particle identification works well except for the regions where the particles move too fast. Figure 2 shows the histogram of particle velocities. The highly overpopulated tail clearly demonstrates that a wide range of particle velocities are present in the experiment. The analysis of the spatial distribution of the velocities is still ongoing work.

[1] Ediger, *Ann. Rev. Phys. Chem.* **51**, 99 (2000)
[2] Berthier et al., *Science* **310**, 1797 (2005)
[3] Cavagna *Phys. Rep.* **476**, 51, (2009)
[4] Dauchot, Marty, and Biroli *Phys. Rev. Lett.* **95**, 265701 (2005)
[5] Goldman and Swinney, *Phys. Rev. Lett.* **96**, 145702, (2006)
[6] Keys, Abate, Glotzer, and Durian *Nature Physics* **3**, 260, (2007)