# A CubeSat Microgravity Experiment on Collisions in the Protoplanetary Disk

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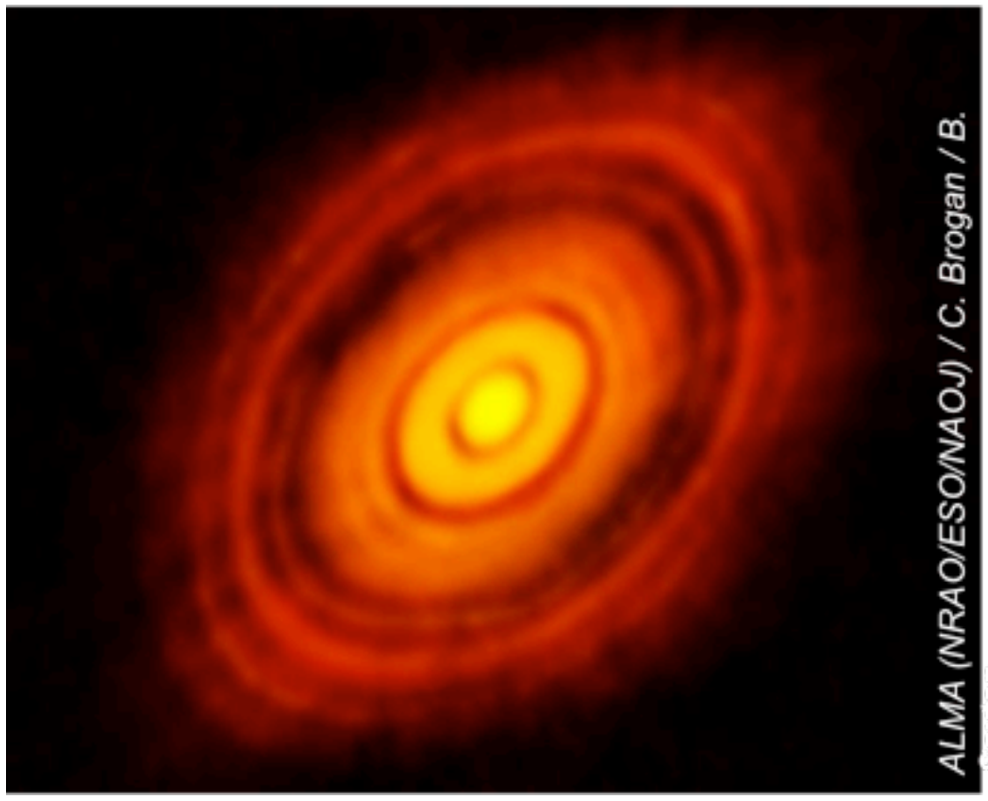
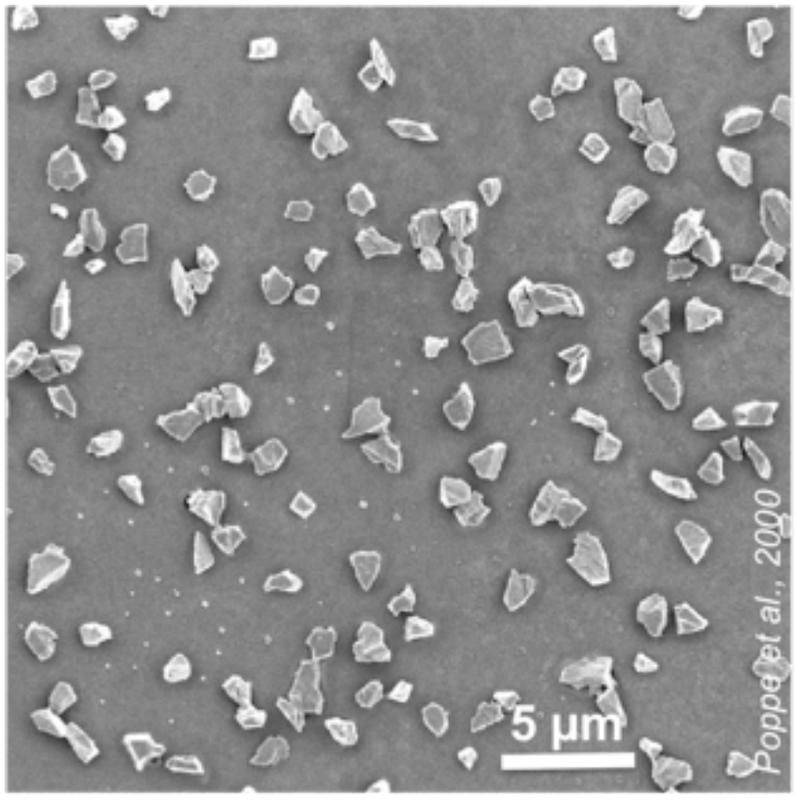
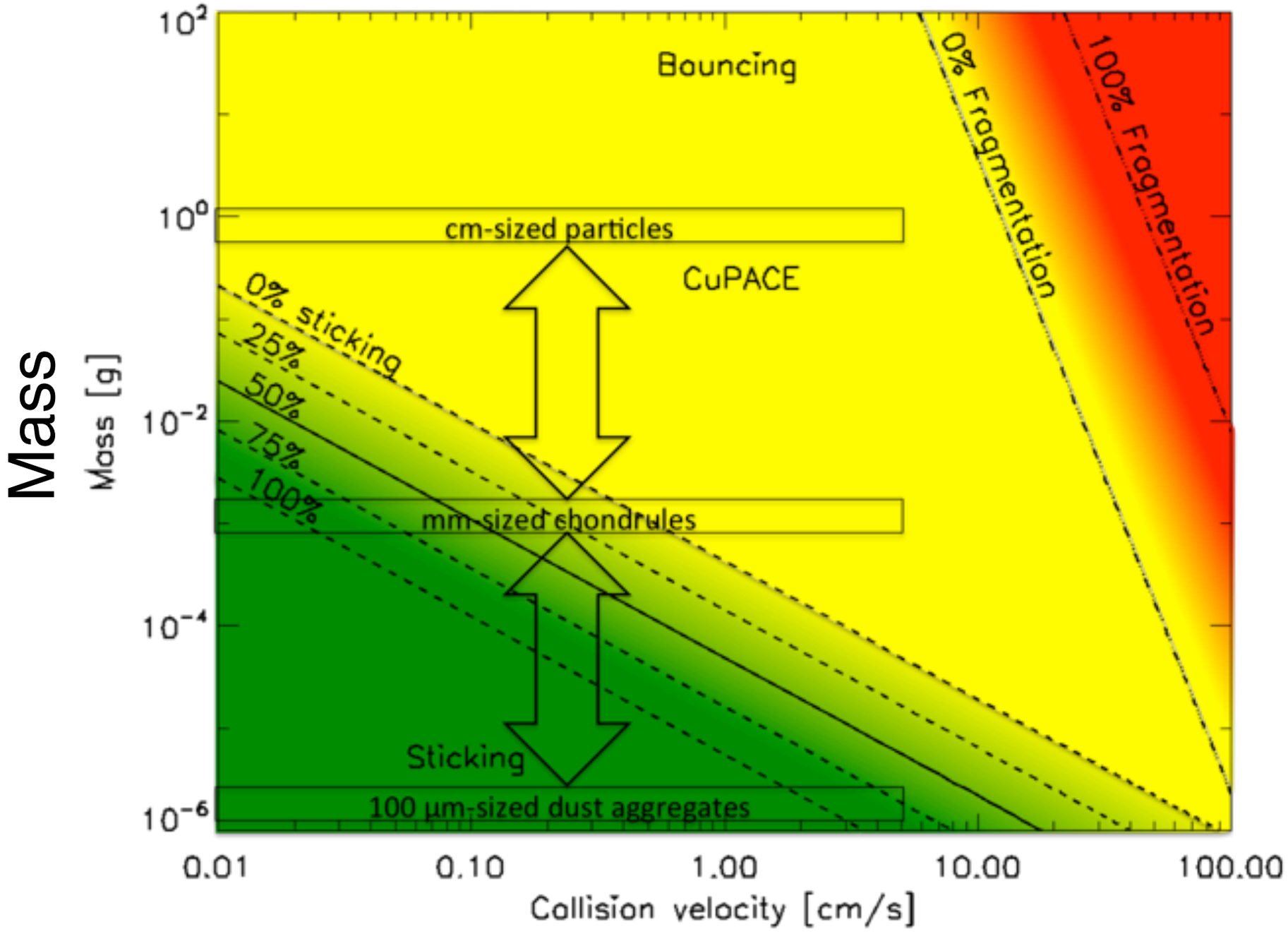
# Q-PACE Science Question

- Understand protoplanetary growth from pebbles to boulders with *Q-PACE: CubeSat Particle Aggregation and Collision Experiment* by performing long-duration microgravity collision experiments.



# Collision Parameter Space



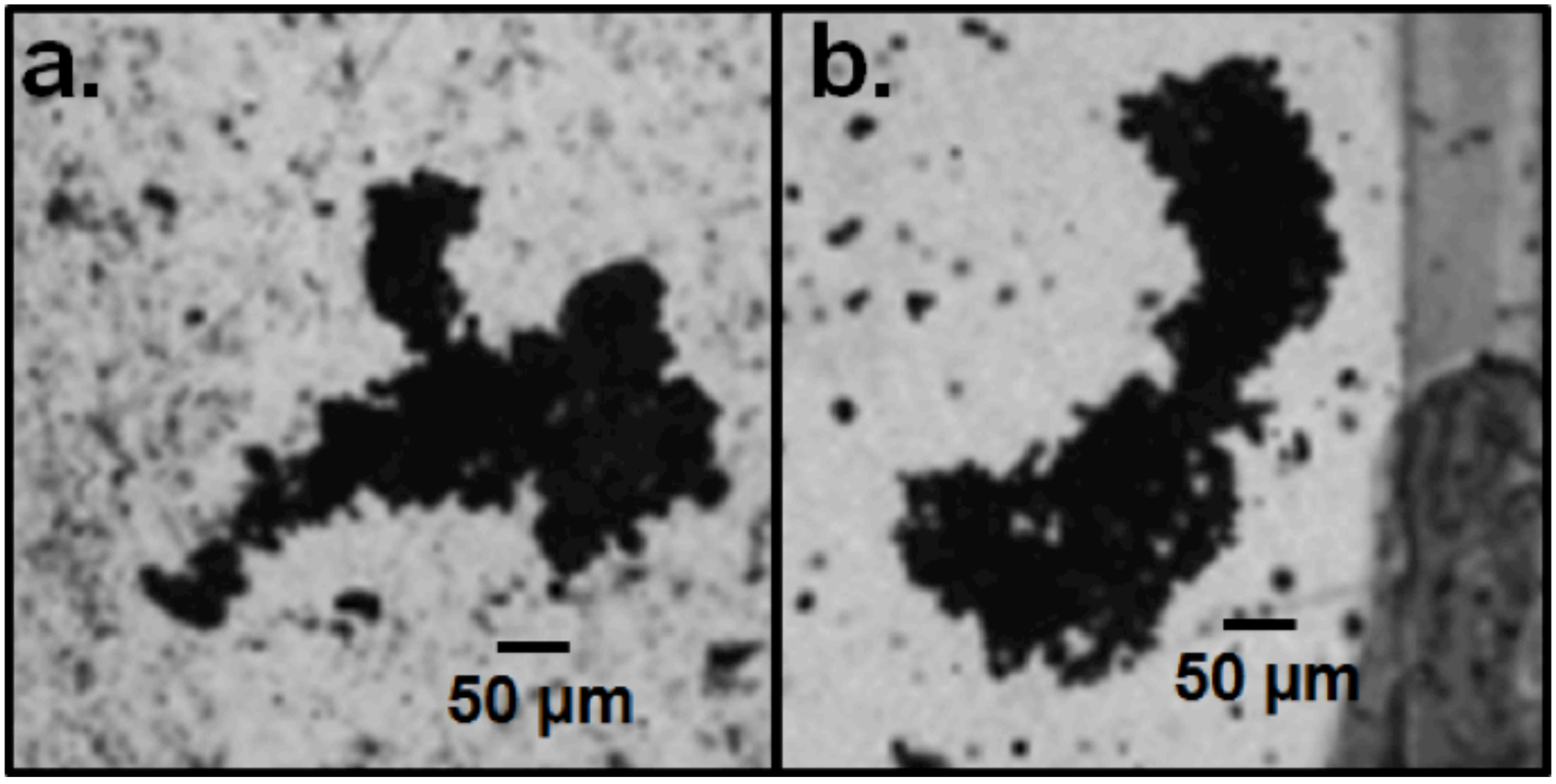

Mass

Velocity

# Q-PACE Objectives

1. Quantify the energy damping in multi-particle systems at low collision speeds (< 1 mm/s to 10 cm/s)
2. Identify the influence of a size distribution on the collision outcome.
3. Observe the influence of dust on a multi-particle system.
4. Quantify statistically rare events.

# SPACE: Suborbital Precursor to Q-PACE




Clusters of 0.1 mm dust aggregates formed in the microgravity SPACE payload.

# NanoRocks ISS Microgravity Collision Experiment

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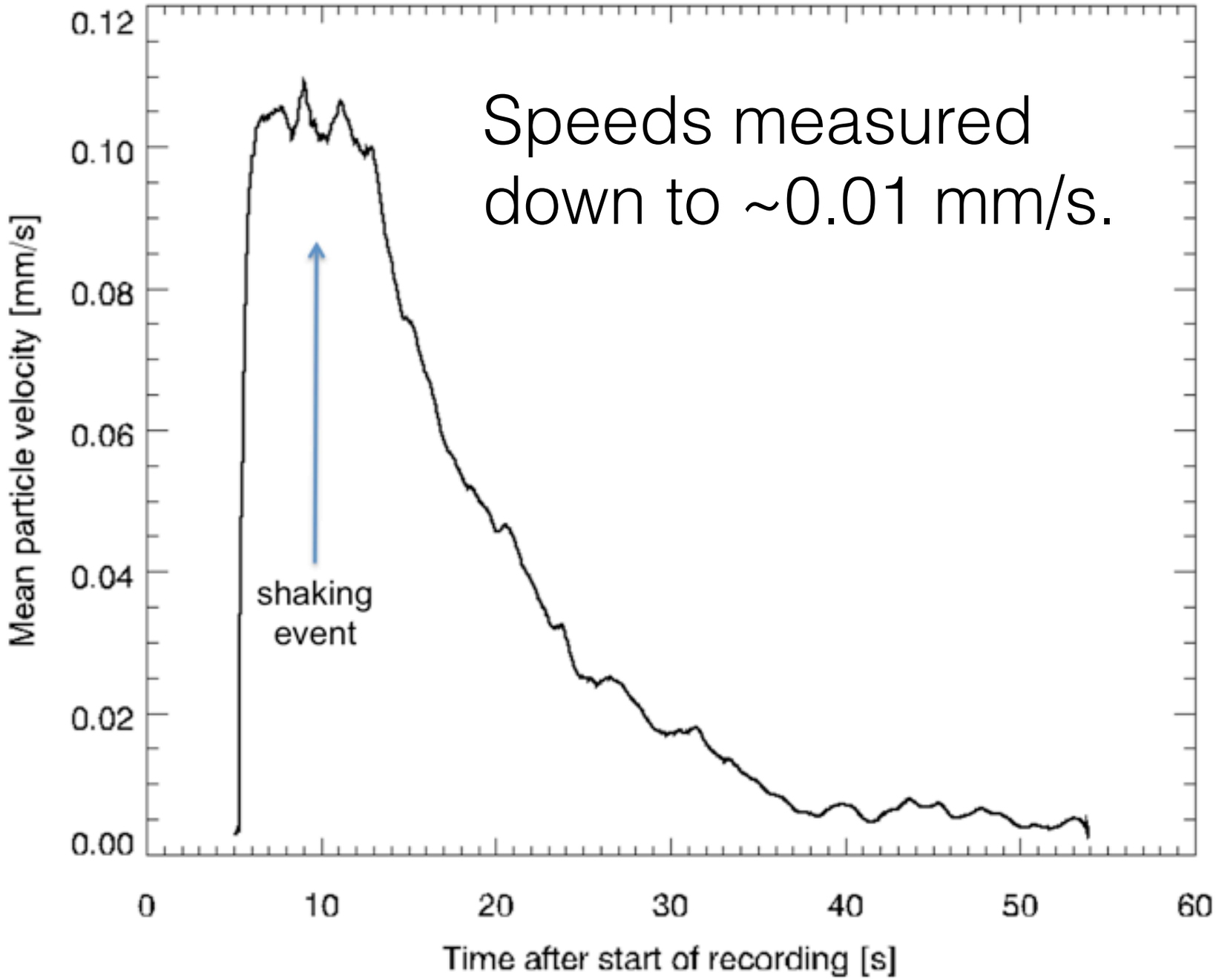
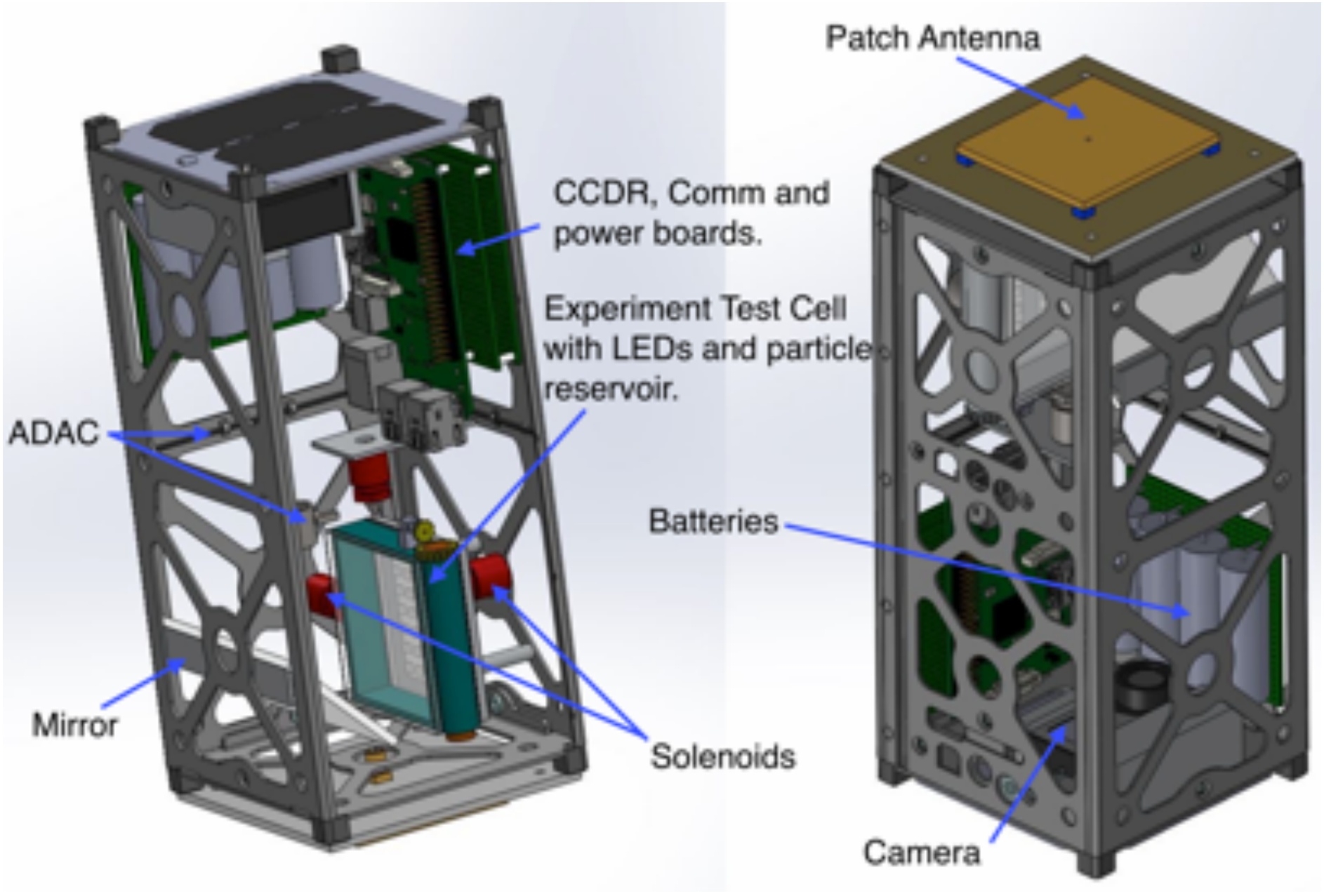
Distortion removed

# Collisional Damping in NanoRocks

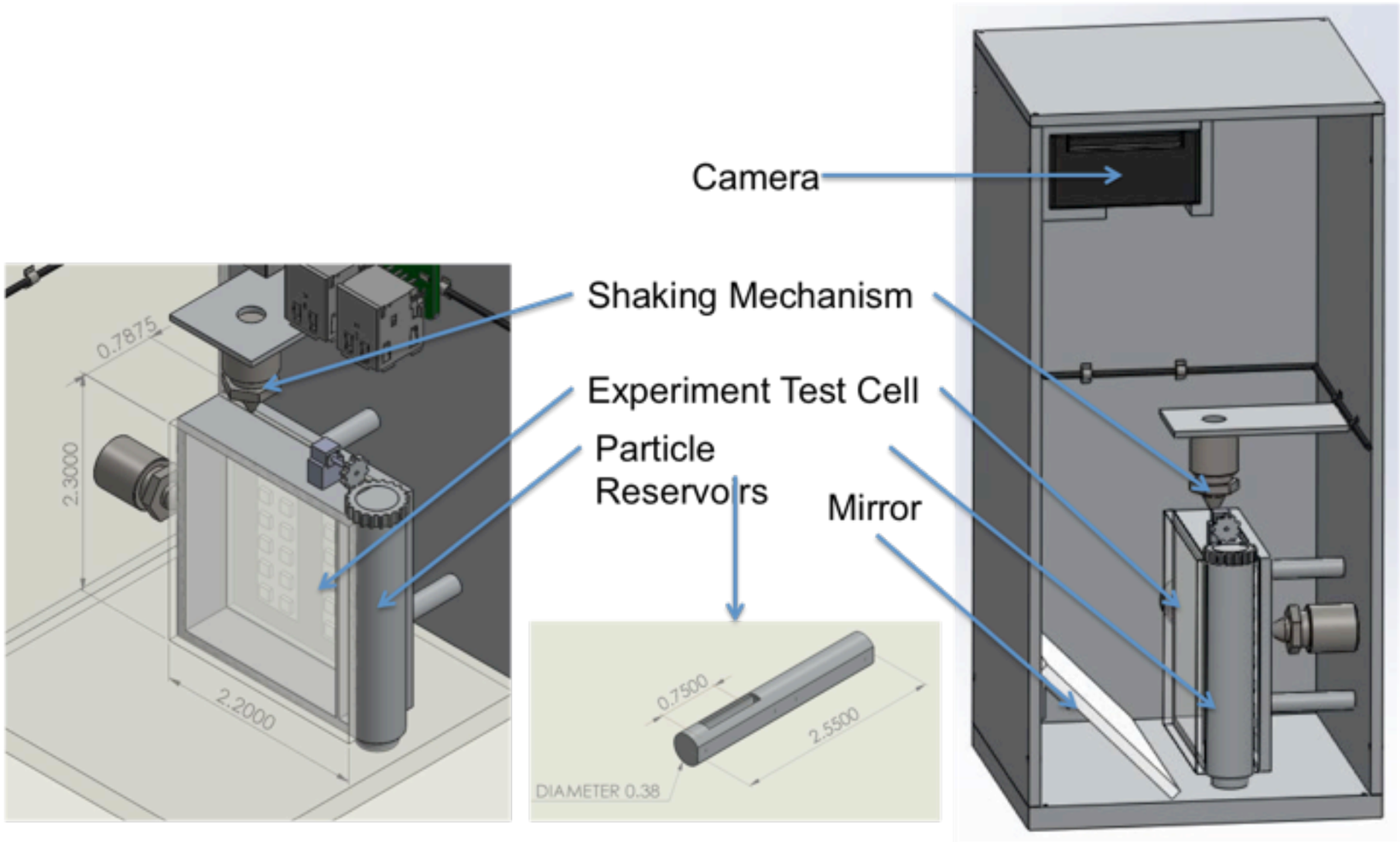


# PRIME Parabolic Microgravity Impact Experiments

# Q-PACE 2U Microgravity Experiment



# Q-PACE Measurements

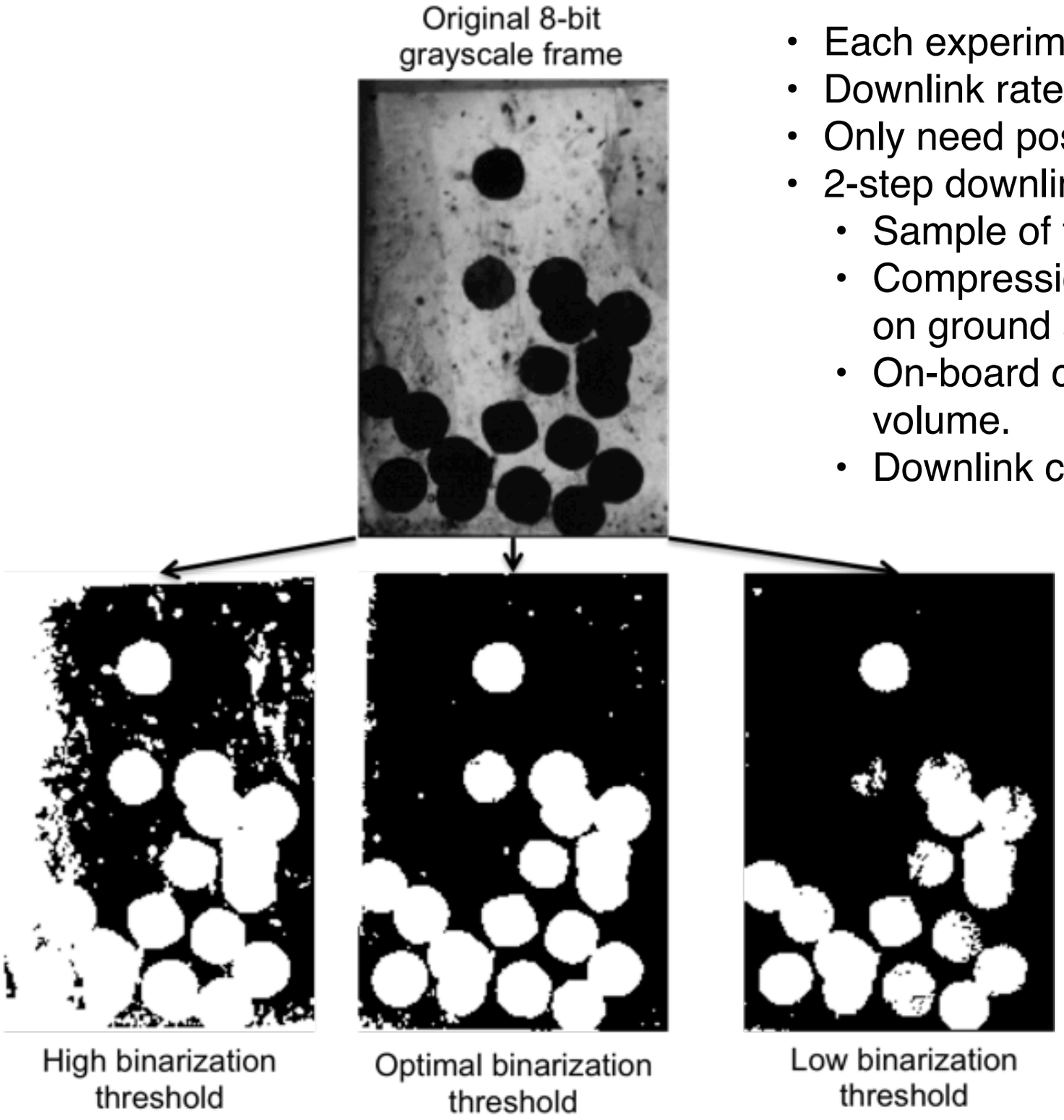


# Experiment Test Plan

| | Properties of marbles | Properties of marbles | Properties of beads | Properties of beads | Properties of dust aggregates |
|---|---|---|---|---|---|
| Diameter | 1 cm | 1 mm | 100 µm | 100 µm | 1 mm |
| Porosity | 0 | 0 | 0.5-0.7 | | |
| Mass | 1 g | 5 g | $10^{-3}$ g | $5x10^{-3}$ g | $10^{-5}$ g |
| Material | Glass | Brass | Chondritic Material | Brass | SiO2 |
| Material density | 2.6 g/cm$^3$ | 8.7 g/cm$^3$ | 3.2 g/cm$^3$ | 8.7 g/cm$^3$ | 2.6 g/cm$^3$ |
| Monomer diameter | N/A | N/A | N/A | N/A | 1-10 µm monomers |
| Shape | spherical | spherical | irregular | spherical | irregular |

**Phase 1: marble-marble collisions**
**Phase 2: introduce beads into ETC**
**Phase 3: introduce dust aggregates into ETC**
**Phase 4: disaggregate dust and reform**

# Downlink and Data Analysis Plan




- Each experiment run makes 18 GB of data.
- Downlink rate is 10 kBps.
- Only need positions and velocities.
- 2-step downlink:
  - Sample of full 8-bit frames downlinked.
  - Compression scheme for raw data optimized on ground and uplinked to Q-PACE.
  - On-board compression reduces data volume.
  - Downlink compressed data.

# Q-PACE Schedule

- Selected for flight by NASA CubeSat Launch Initiative competition (Feb. 2015)
- Ground station partnerships with University of Arkansas, NASA-KSC and University of Puerto Rico
- Fabrication and component testing 6/2015-3/2016
- Integration and systems testing 3/2016-8/2016
- Ready for flight Sep. 2016.