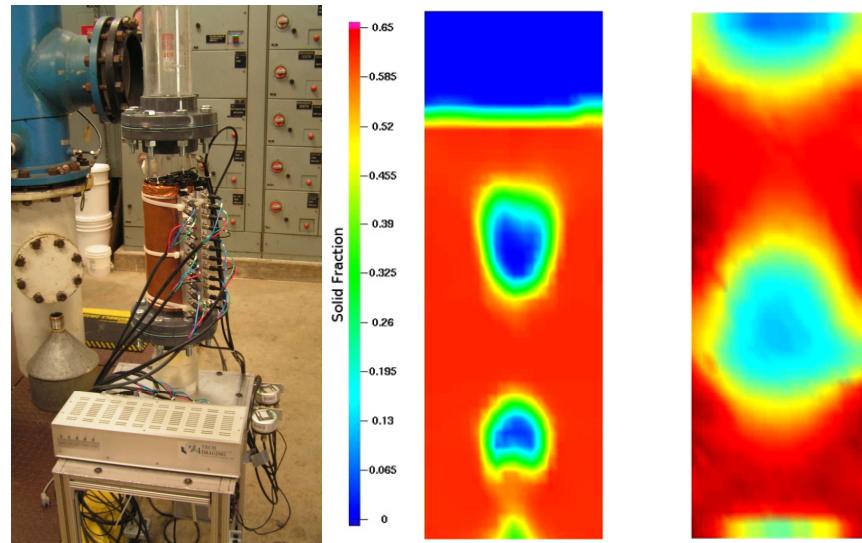




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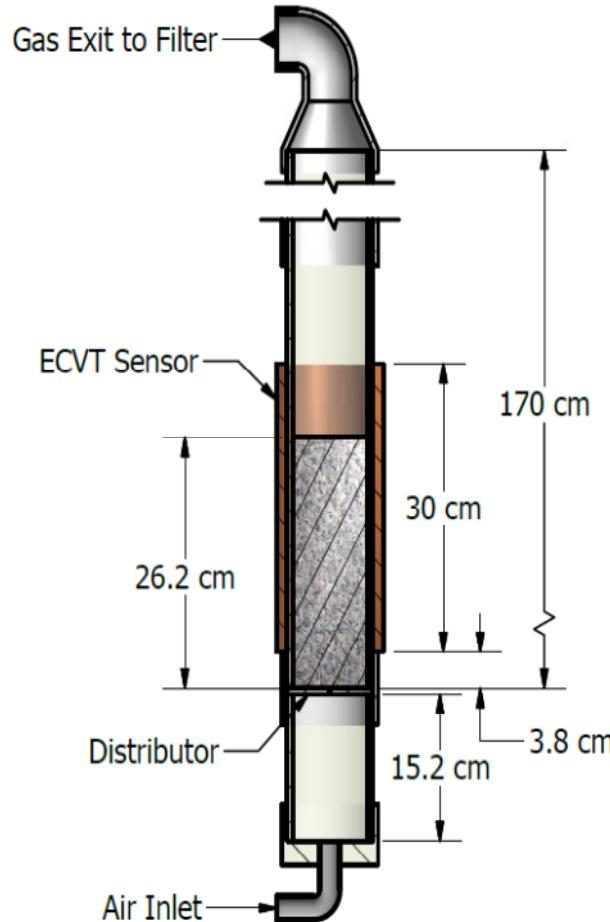


Electrical Capacitance Volume Tomography (ECVT) Applied to Bubbling Fluid Beds

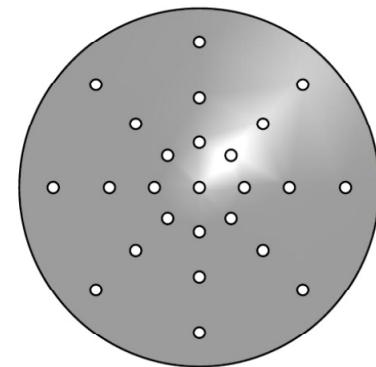
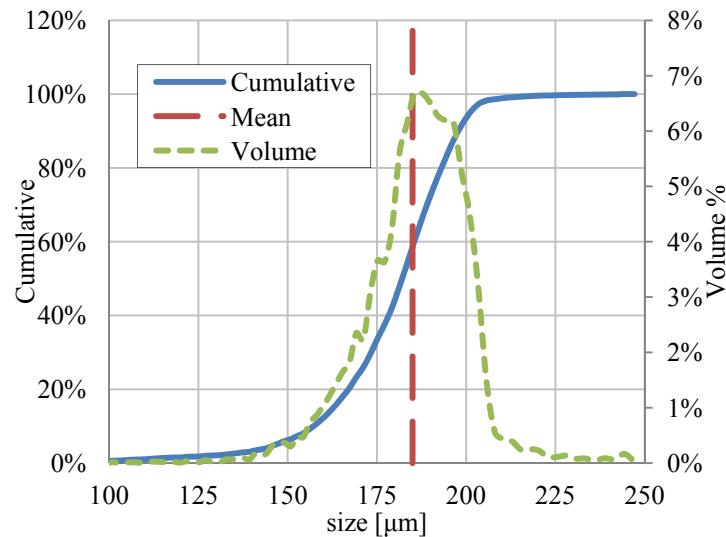
J. Weber, J. Mei, Tech4Imaging



Experimental Apparatus



- 10cm Diameter Fluid Bed
- Bed Height: 26.2 cm, mass: 3303.8g
- 185 μm glass beads
- Particle density: 2.483 g/cm³
- Close pack Solid Fraction: 0.63
- Minimum Fluid, U_{mf} : 3.17 cm/s
- Operated at 1, 2, 4, and 6x U_{mf}



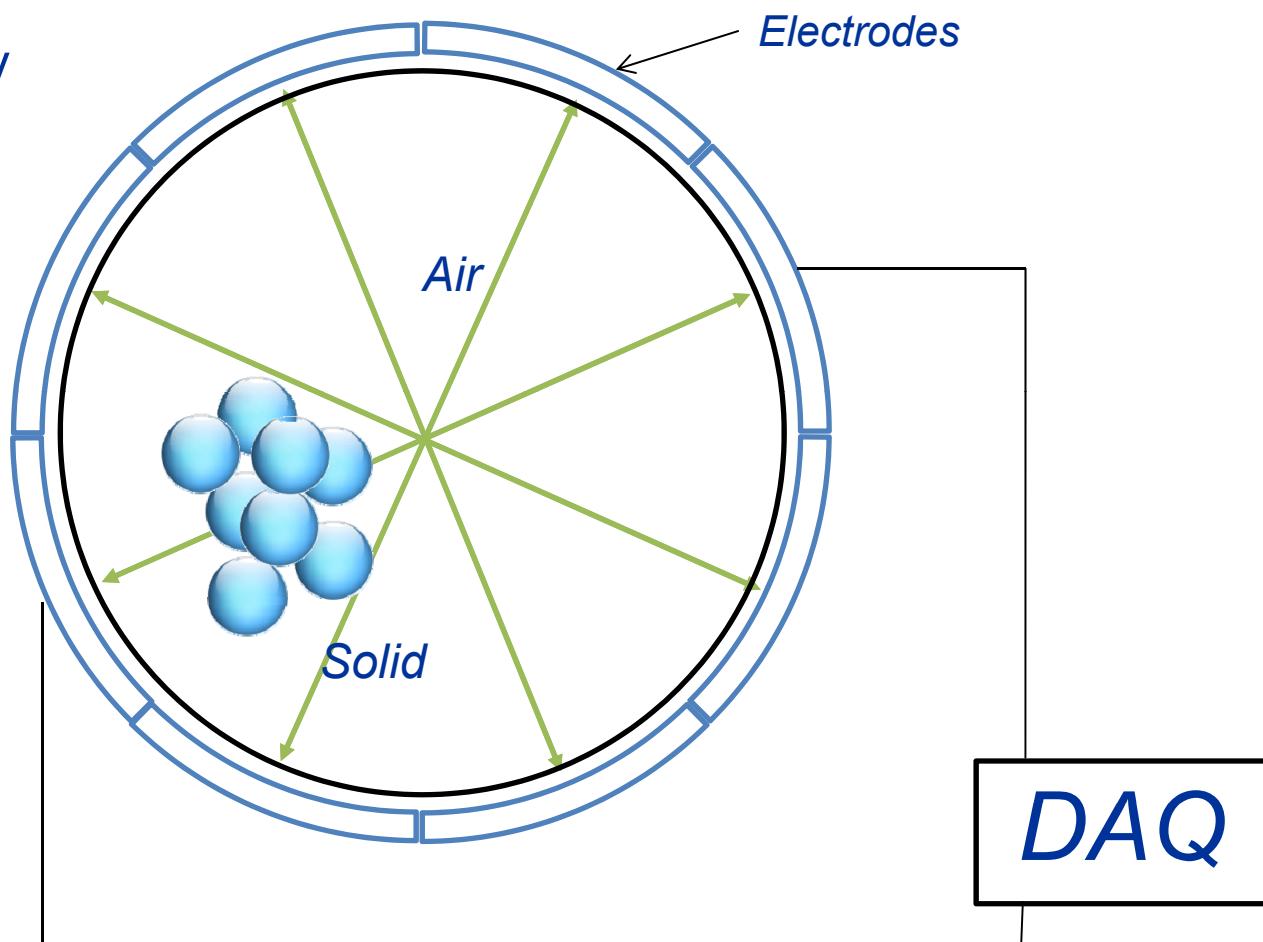
Electrical Capacitance Tomography [ECT]

Relative permittivity

Air ≈ 1

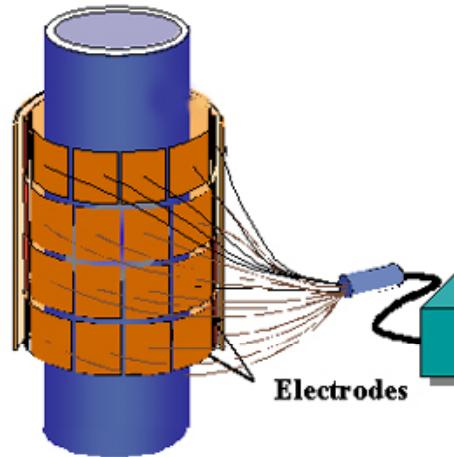
Polyethylene ≈ 2.25

Glass ≈ 4.7

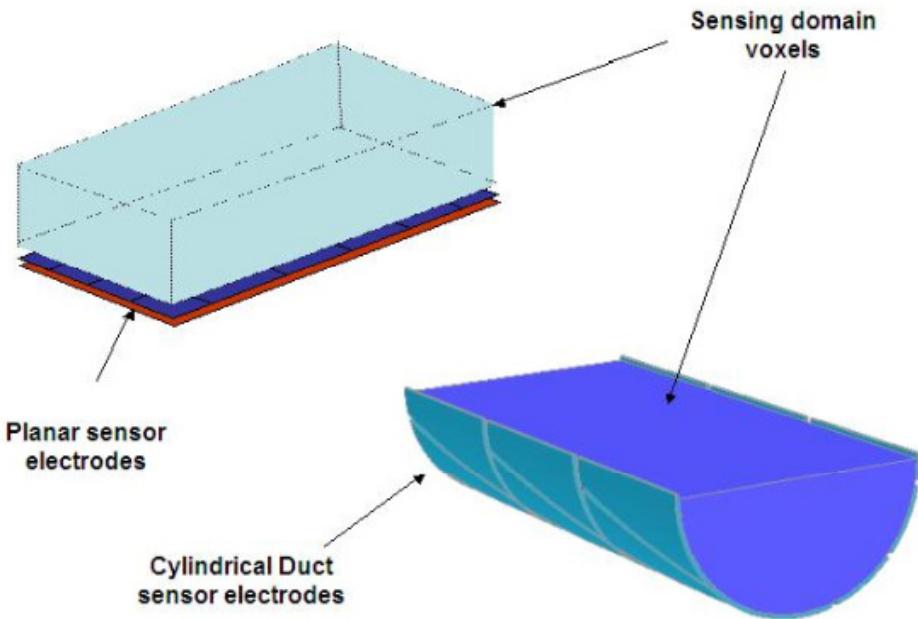


Electrical Capacitance Volume Tomography [ECVT] Sensor Overview

TECH
4IMAGING



Sensor Designs for Various Geometries



Data
Collection

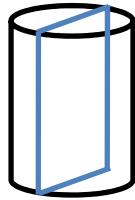
24 channels, 52Hz

Reconstruction

3D-NN-MOIRT

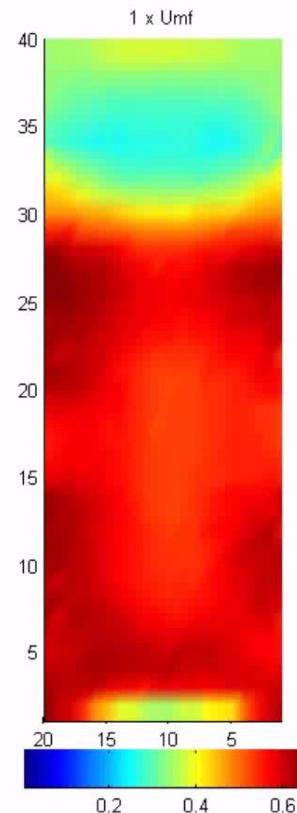
Post
Processing

Custom Program

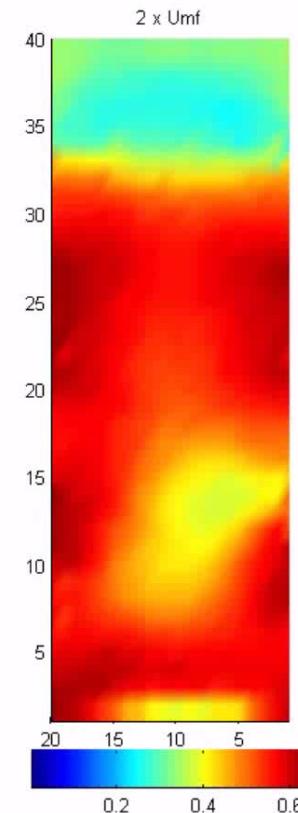


Cross-Section at Center

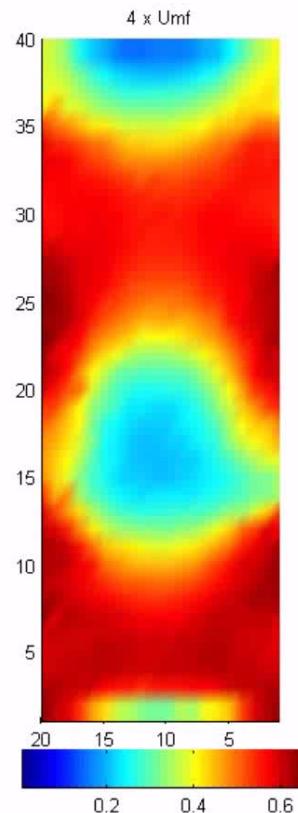
1x Umf



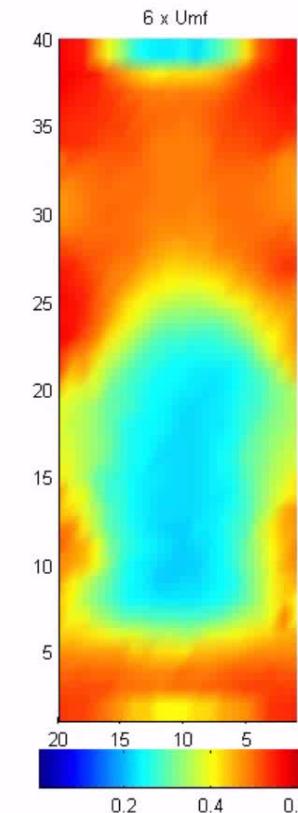
2x Umf



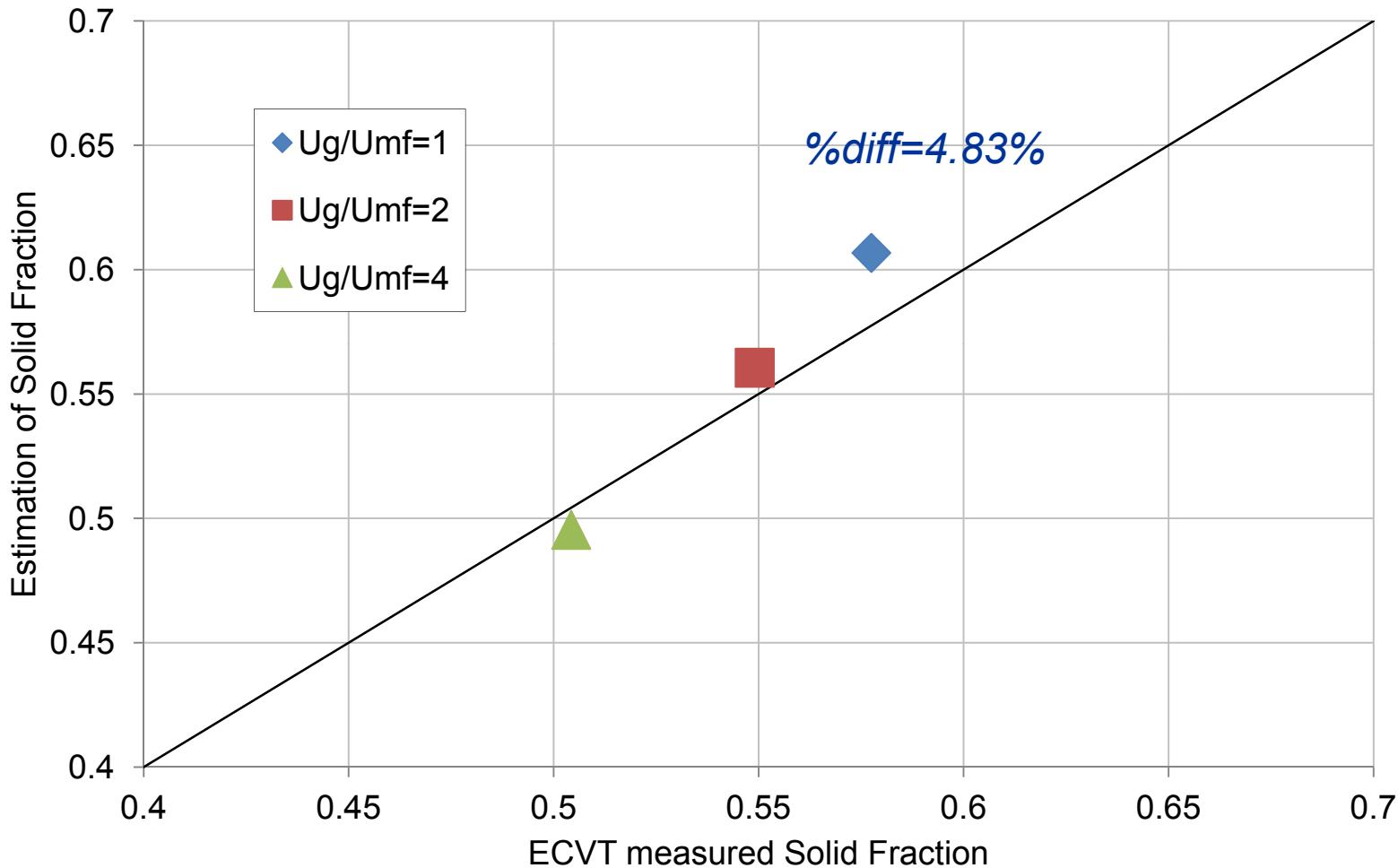
4x Umf



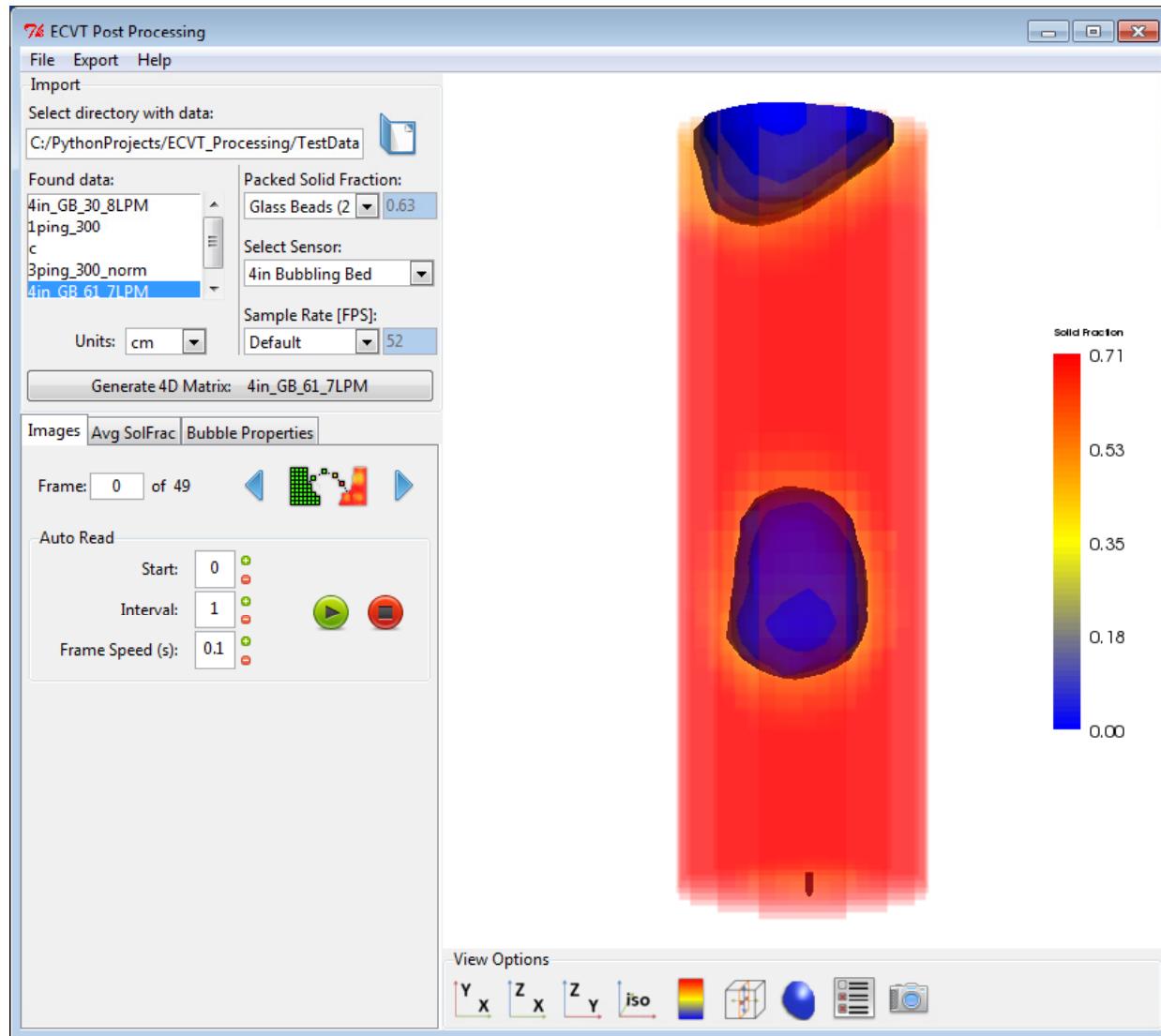
6x Umf



ECVT Verification



Extracting bubble properties

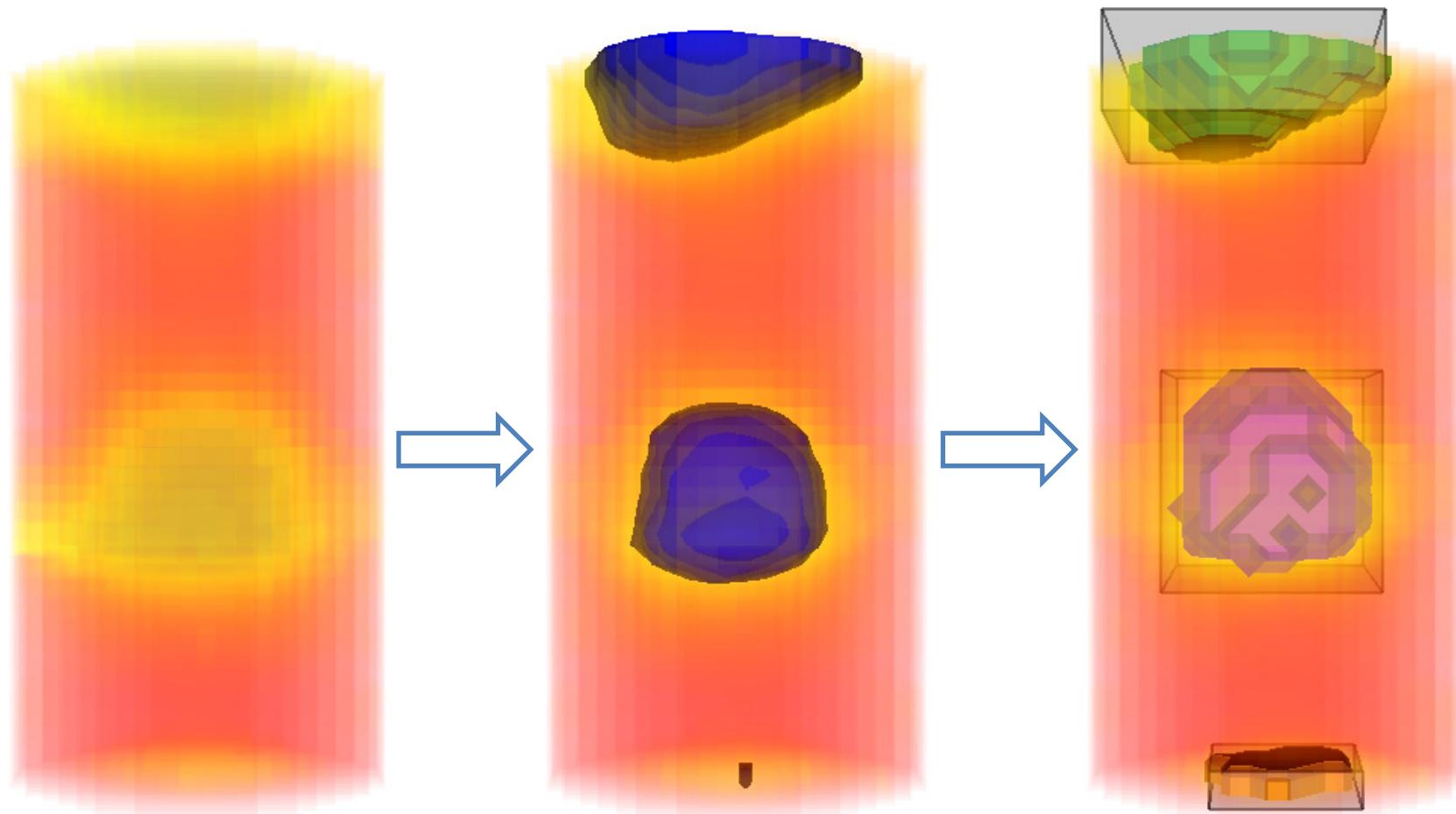


Tkinter



$$\frac{\partial \vec{v}}{\partial t} + \vec{v} \cdot \nabla \vec{v} = -\nabla p + \mu \nabla^2 \vec{v} + \rho \vec{g}$$
$$W = \frac{m_1 m}{\delta_1 \rho_1 \sigma_2} = \frac{U_{\phi_1}^2}{\delta_1 \rho_1 + 8\pi^2} \left| \frac{U_{\phi_1}^2}{U_{\phi_2}^2} \alpha_2 \right|^{\frac{m_1 m}{U_{\phi_2}^2}}$$

Extracting bubble properties

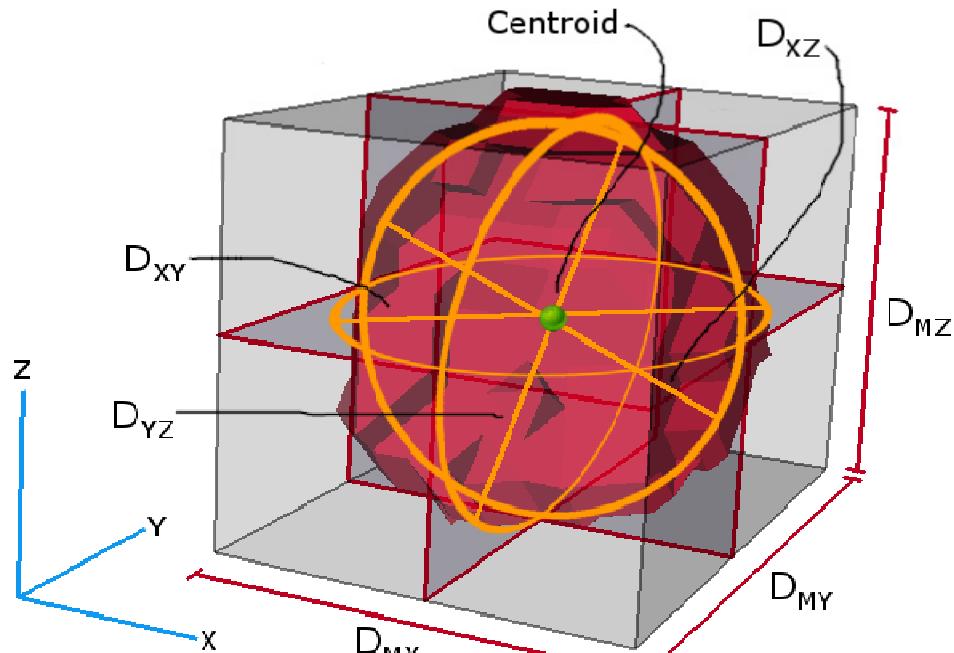


Data

Thresholding
Problem: What is a bubble?

3D Connected Components

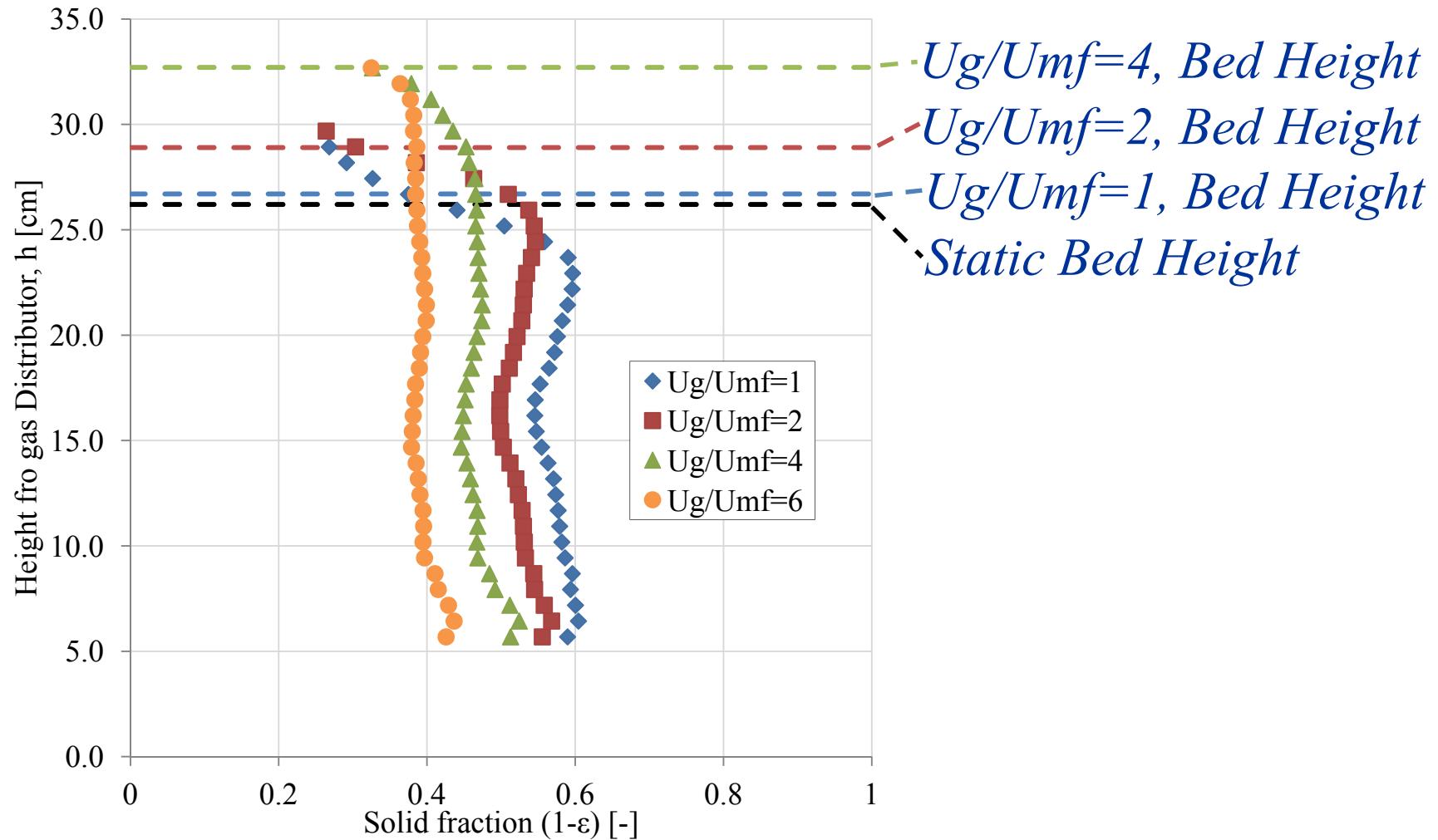
Bubble Parameter Definitions



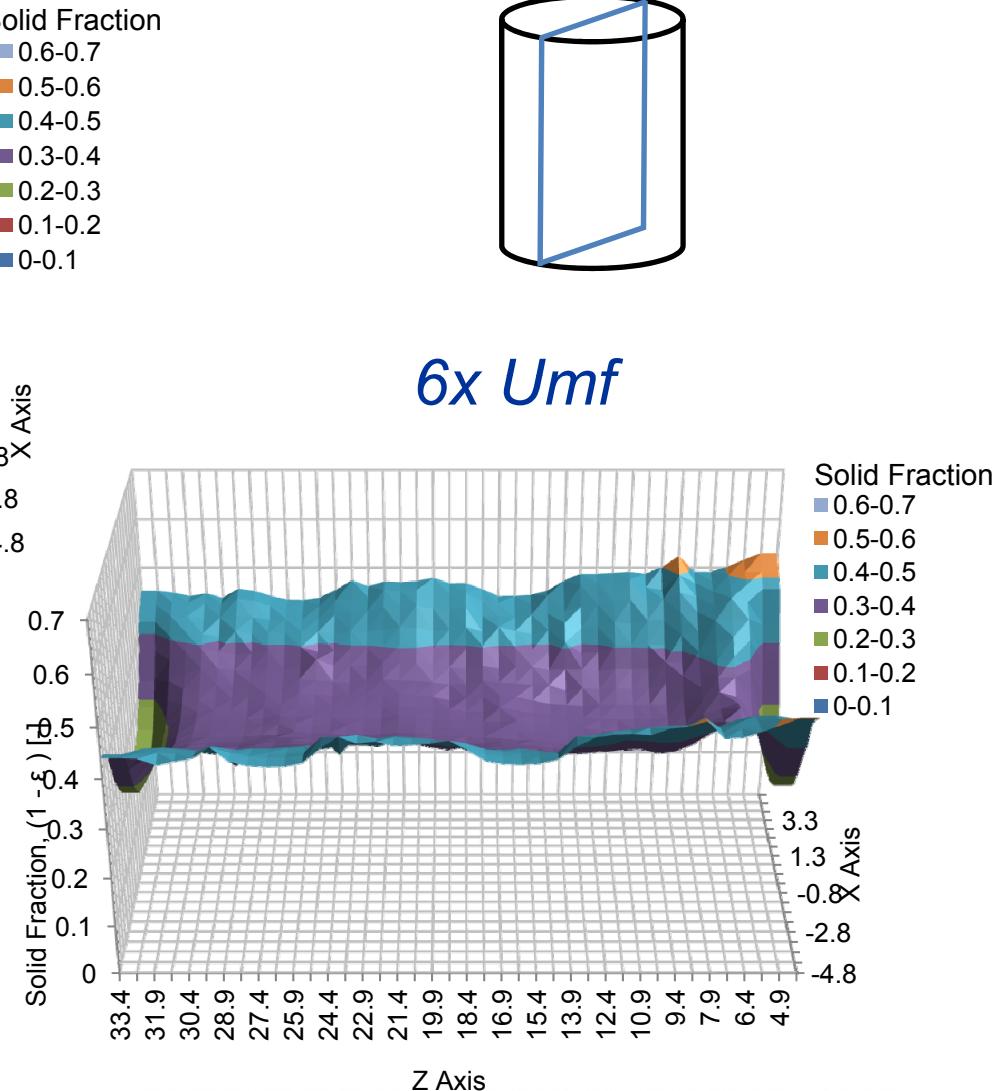
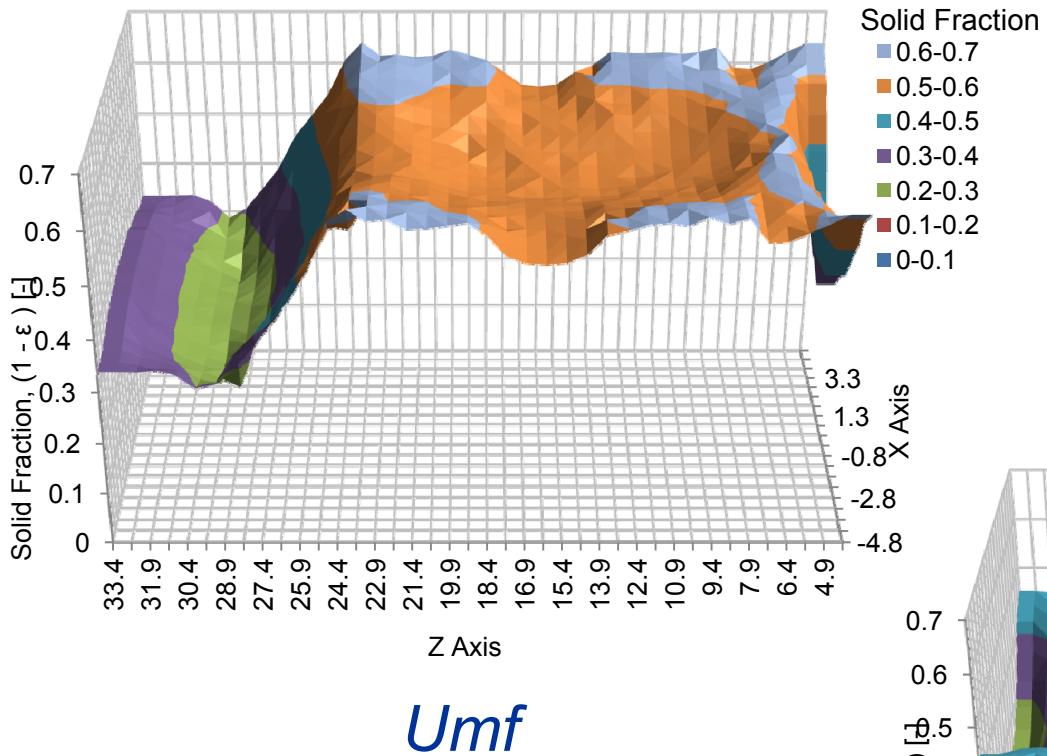
$$\beta = \frac{2D_{MZ}}{D_{MX} + D_{MY}}$$

$$\overline{f_{eq}(z)} = \frac{B_{count}(z)}{\Delta t}$$

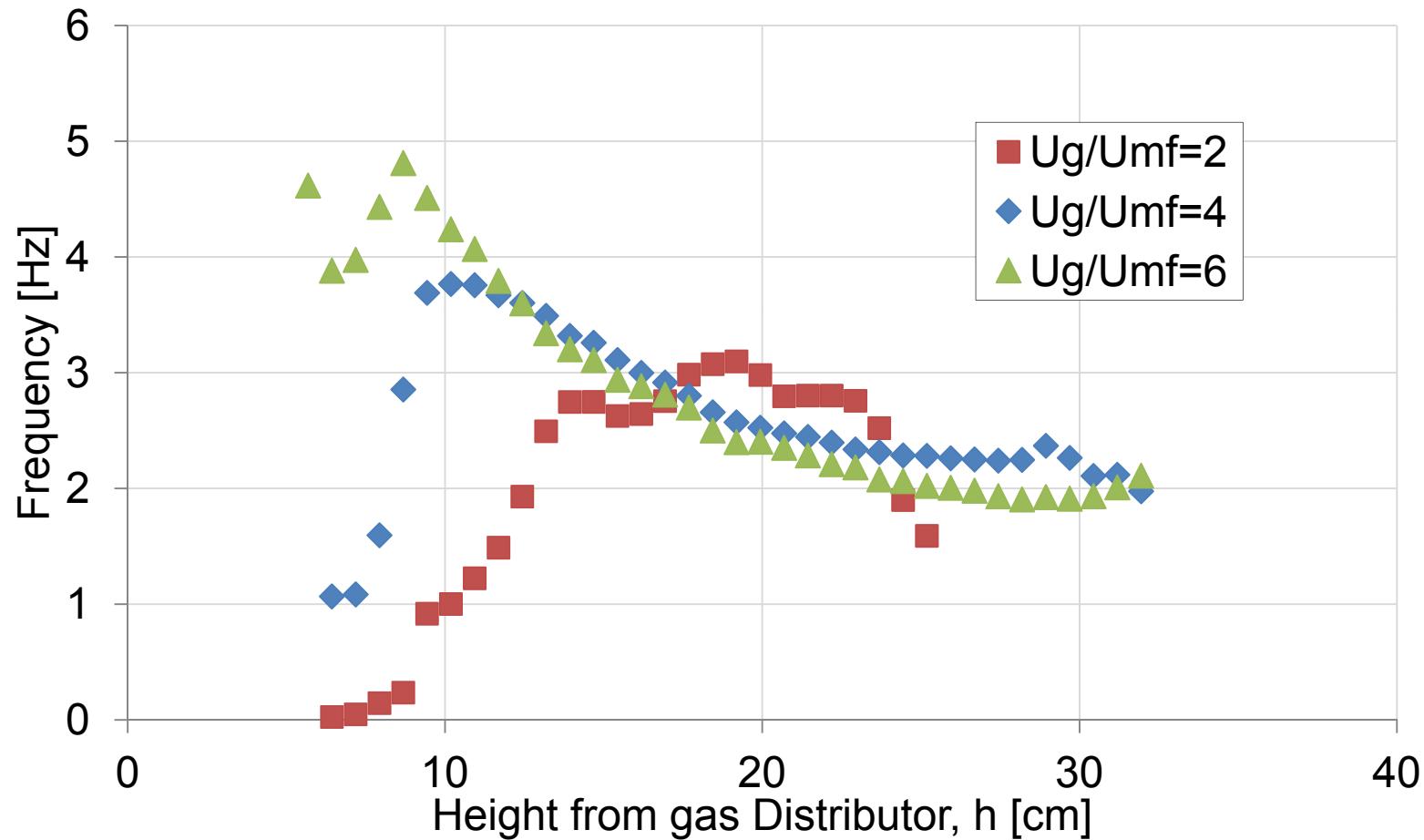
Solid Fraction



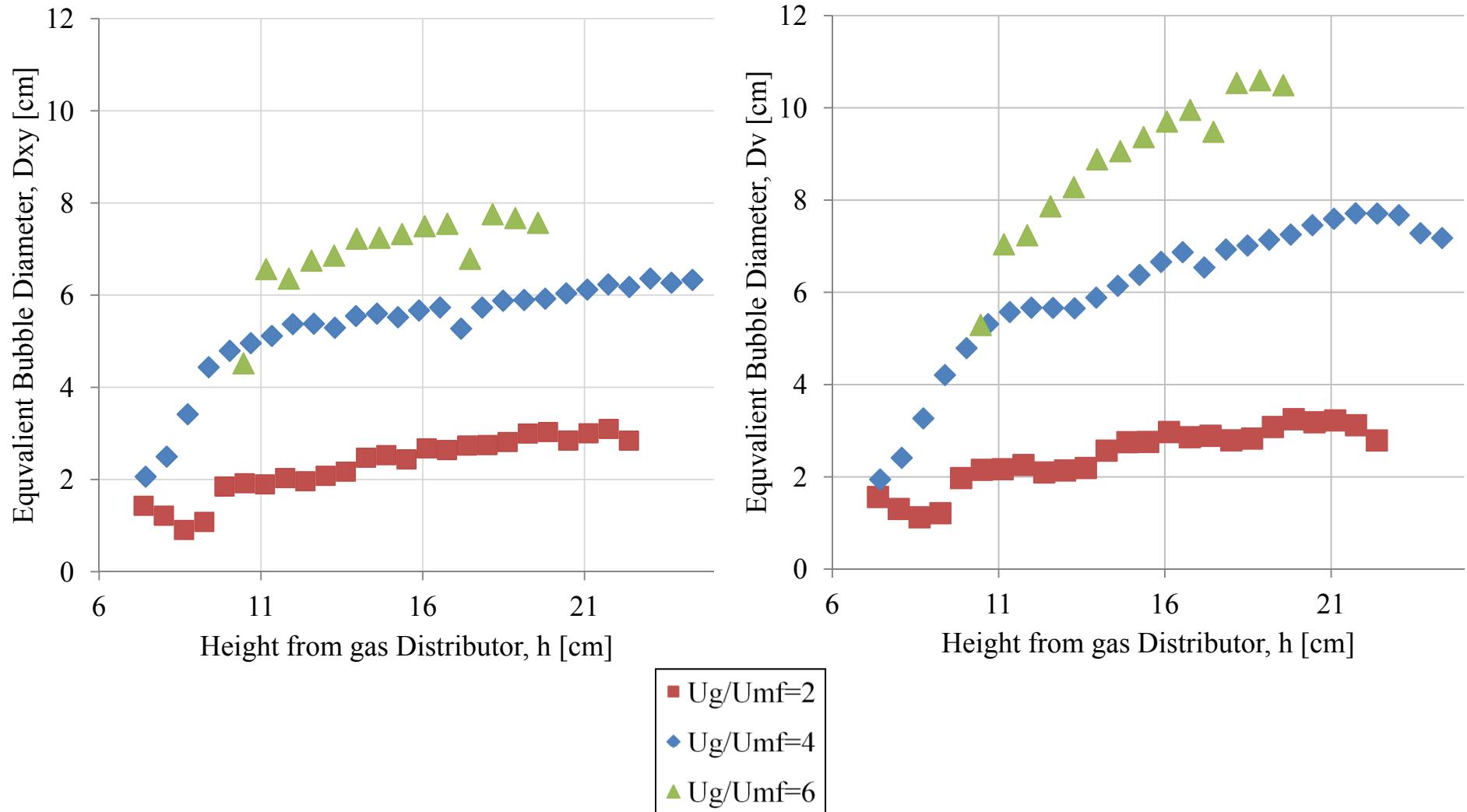
Time Averaged Solid Fraction



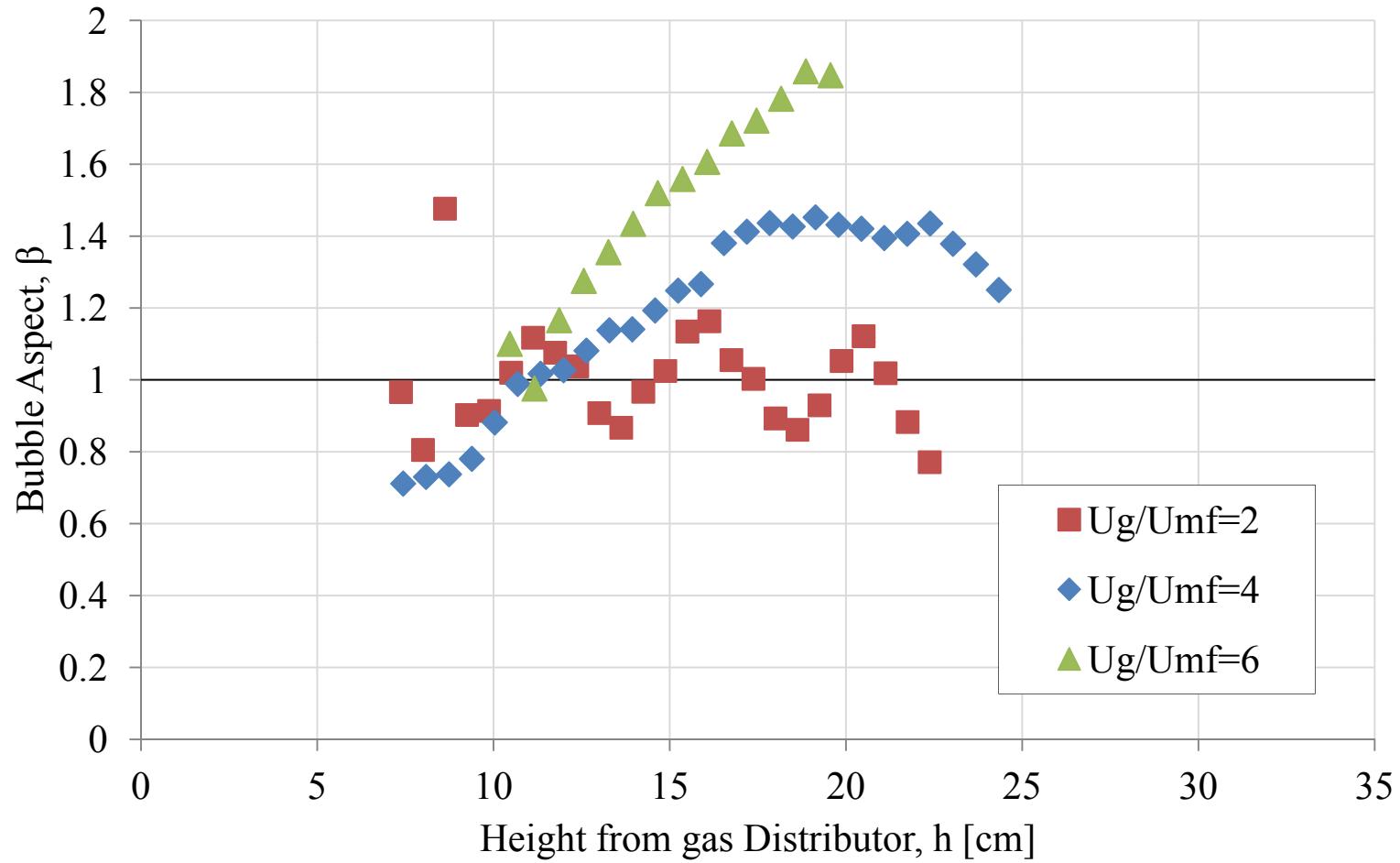
Bubble Frequency



Bubble Diameter

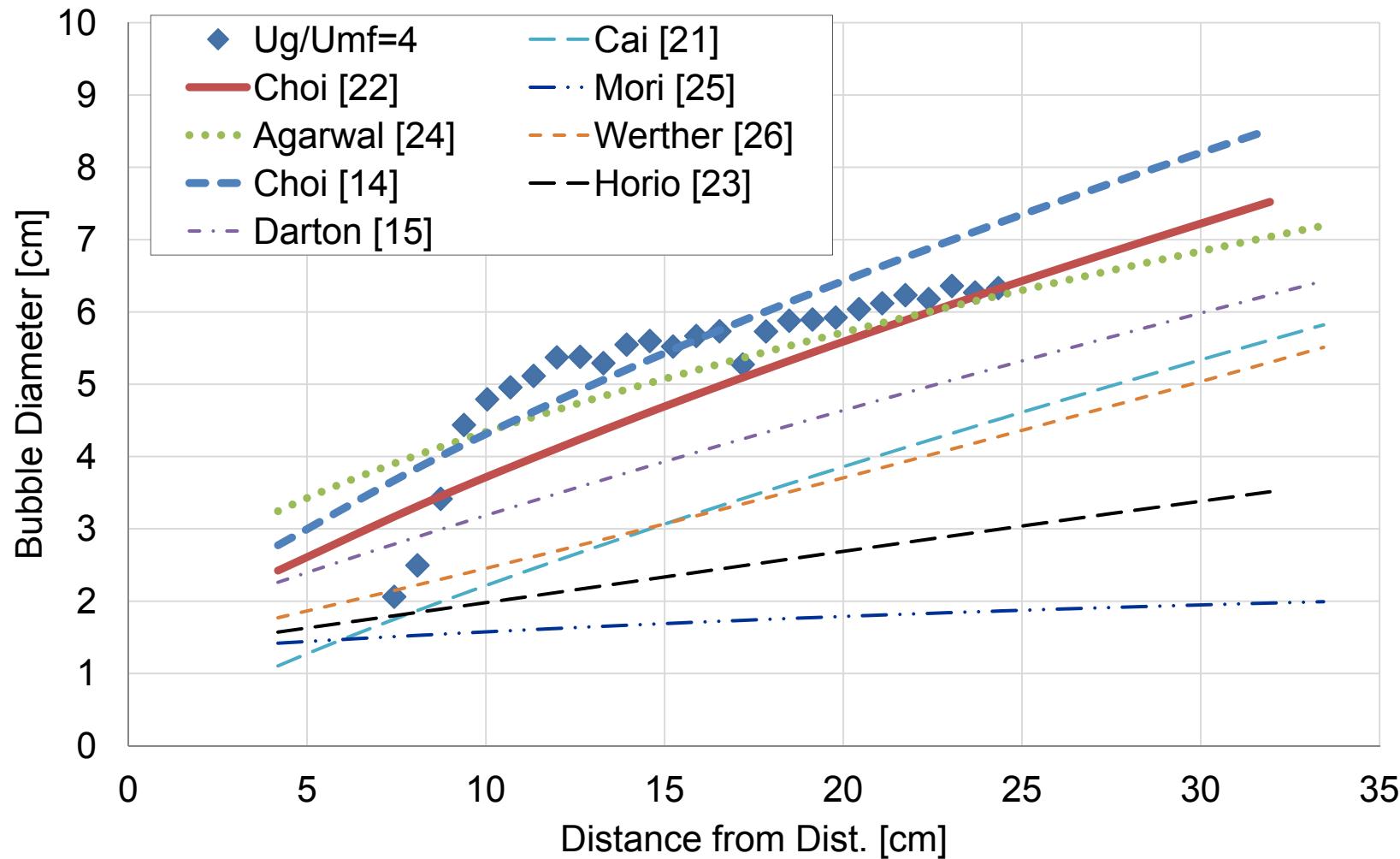


Bubble Aspect



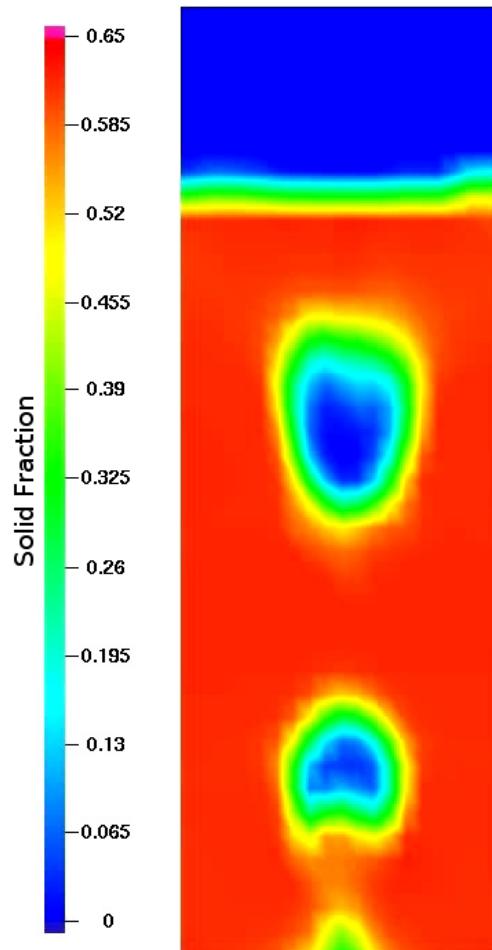
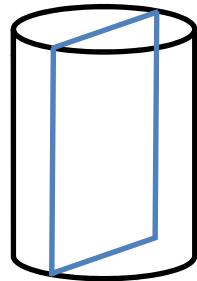
$$\beta = \frac{2D_{Mz}}{D_{Mx} + D_{My}}$$

Compared to Correlations

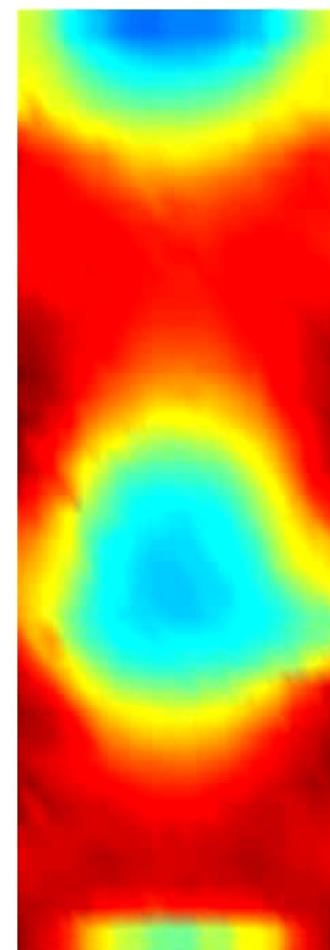


CFD comparison

10cm Dia Fluid Bed, 200micron Glass Beads, 52fps



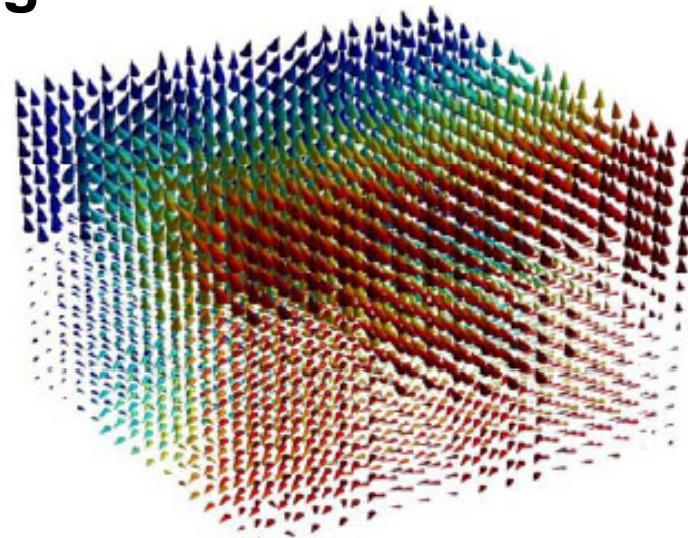
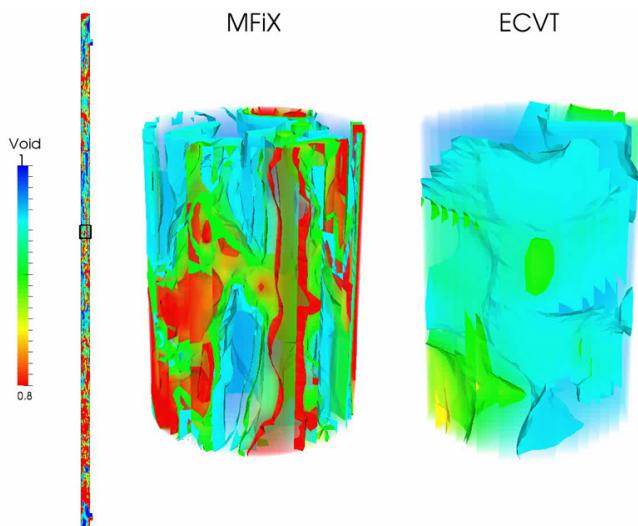
Simulation
[Barracuda]



Experiment
[ECVT]

Future Work

- Quantitative comparison to CFD
- Improvement in bubble tracking
- Solids velocity and Fluxes



Marashdeh et al. "3D Velocity Profiles of Multi-Phase Flow Systems Using Electrical Capacitance Volume Tomography," IWPT-3

References

ECVT sensors design and constructed by Tech4Imaging [<http://www.tech4imaging.com/>]

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