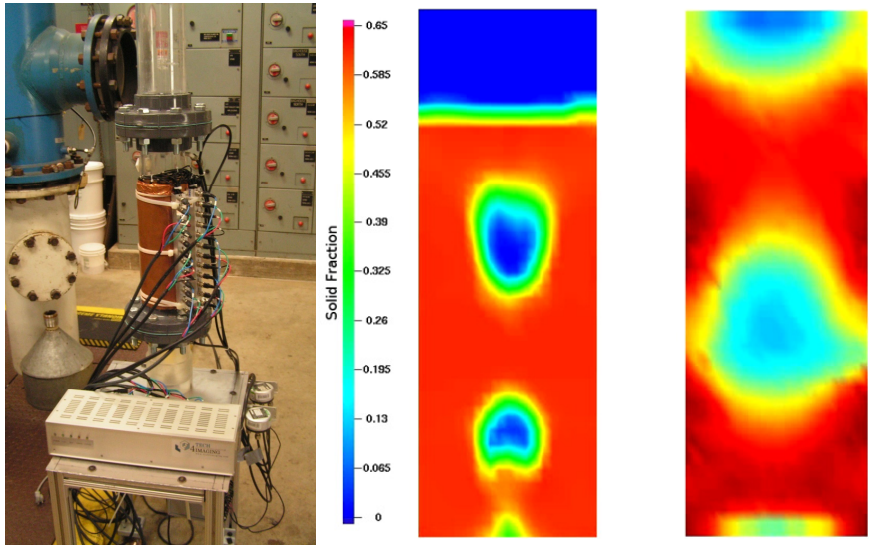
NATIONAL ENERGY TECHNOLOGY LABORATORY

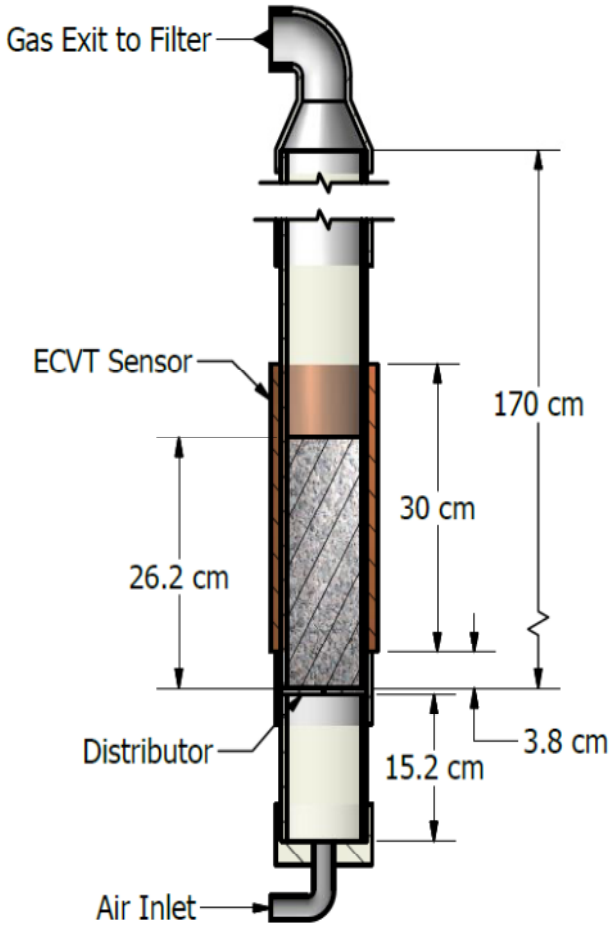


Electrical Capacitance Volume Tomography (ECVT) Applied to Bubbling Fluid Beds

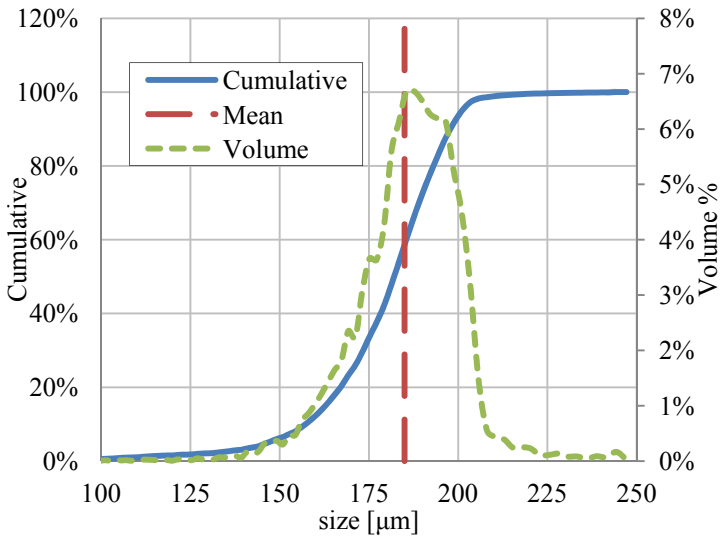
J. Weber, J. Mei, Tech4Imaging

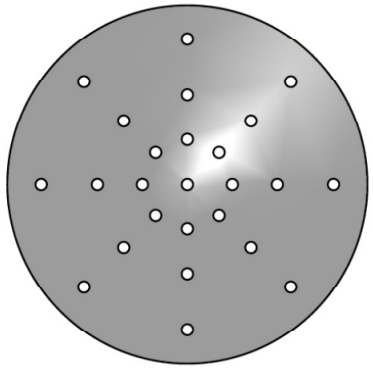
U.S. DEPARTMENT OF ENERGY

Experimental Apparatus



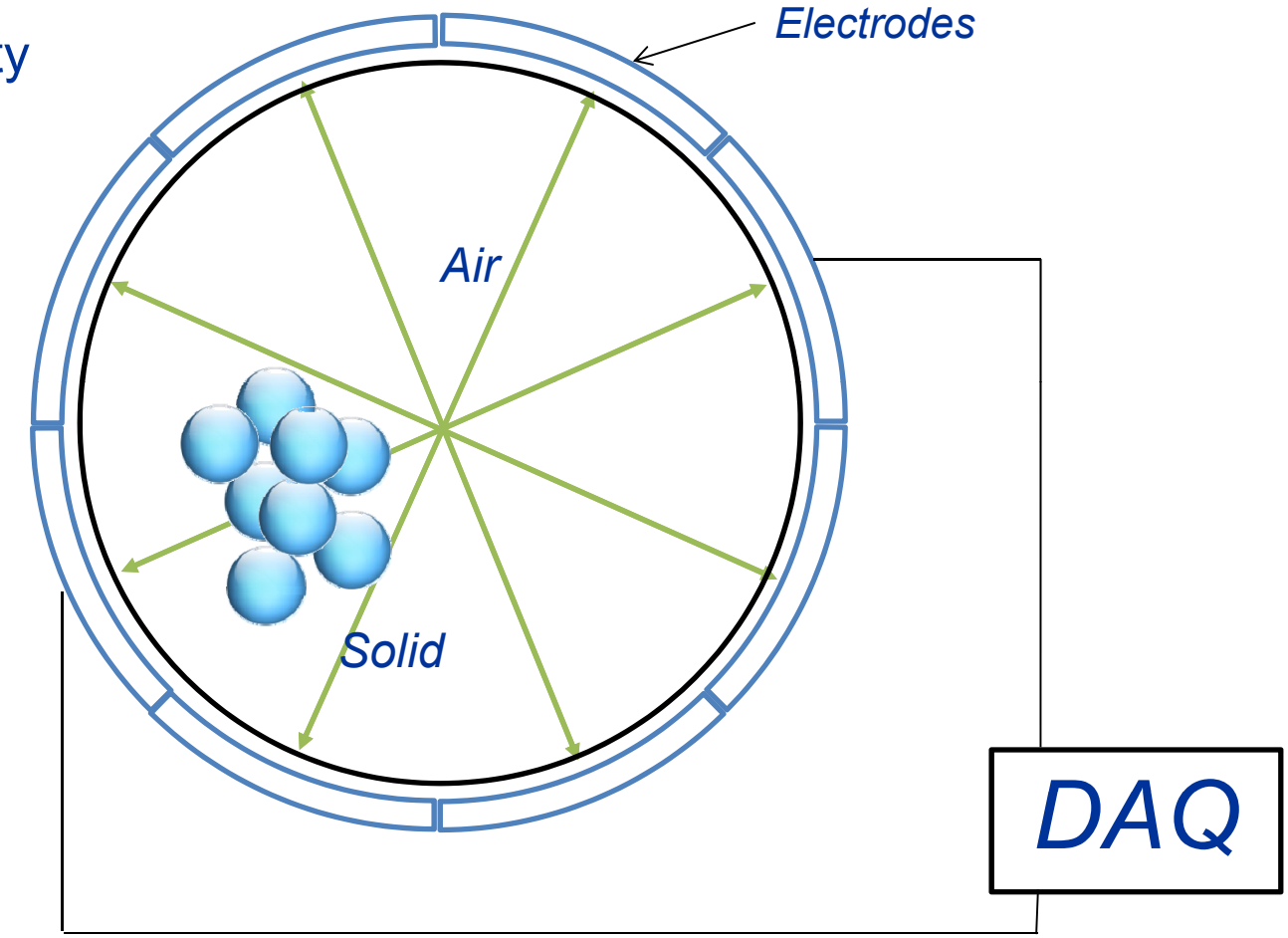
- 10cm Diameter Fluid Bed
- Bed Height: 26.2 cm, mass: 3303.8g
- 185 μm glass beads
- Particle density: 2.483 g/cm^3
- Close pack Solid Fraction: 0.63
- Minimum Fluid, U_{mf} : 3.17 cm/s
- Operated at 1,2, 4, and 6x U_{mf}





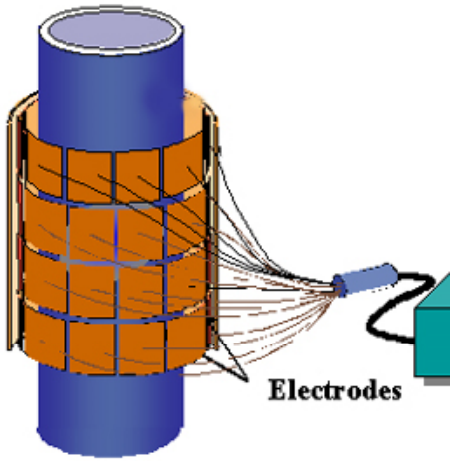
Electrical Capacitance Tomography [ECT]

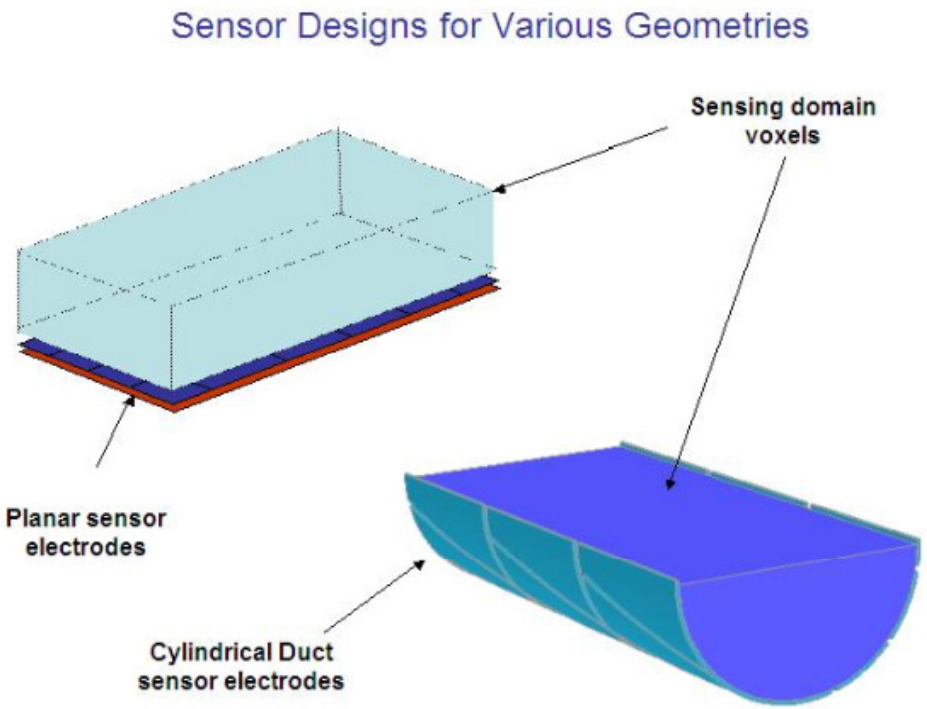
Relative permittivity
Air ≈1
Polyethylene ≈ 2.25
Glass ≈ 4.7



Electrical Capacitance Volume Tomography [ECVT] Sensor Overview

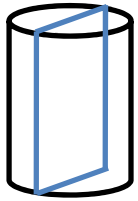
TECH 4IMAGING





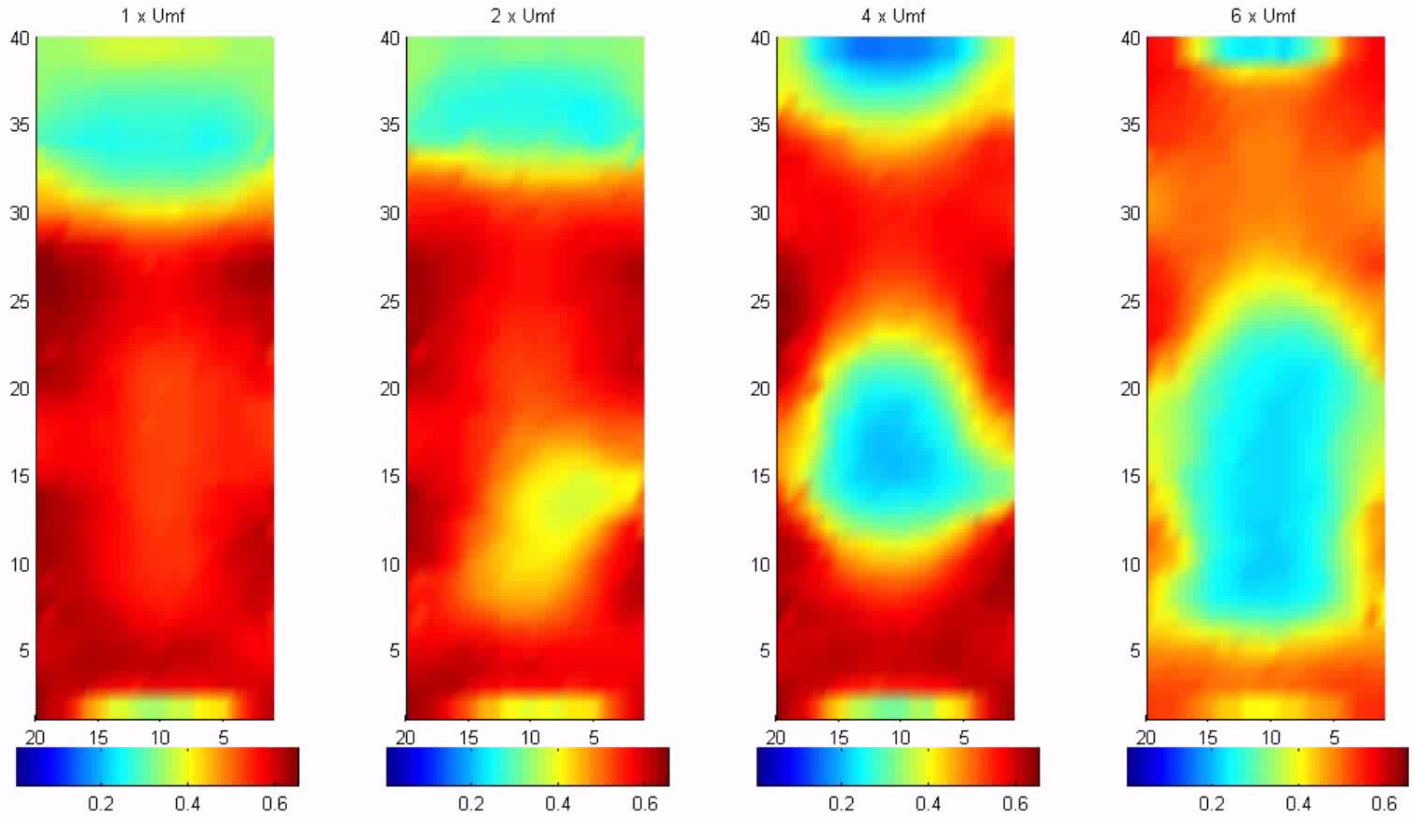
Data Collection	Reconstruction	Post Processing
24 channels, 52Hz	*3D-NN-MOIRT*	*Custom Program*

Images courtesy of Tech4Imaging [http://www.tech4imaging.com/]



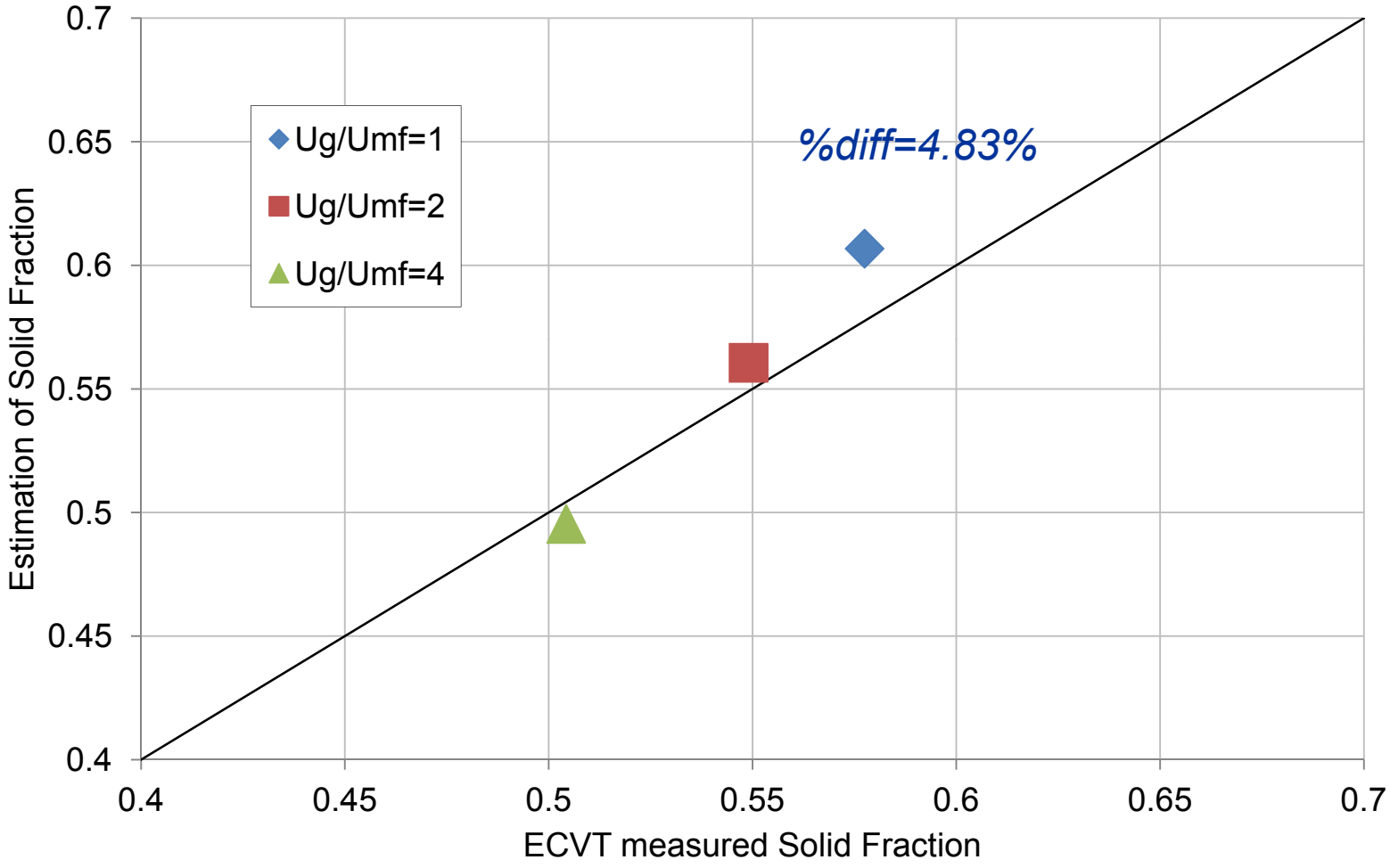
Cross-Section at Center

1x Umf 2x Umf 4x Umf 6x Umf

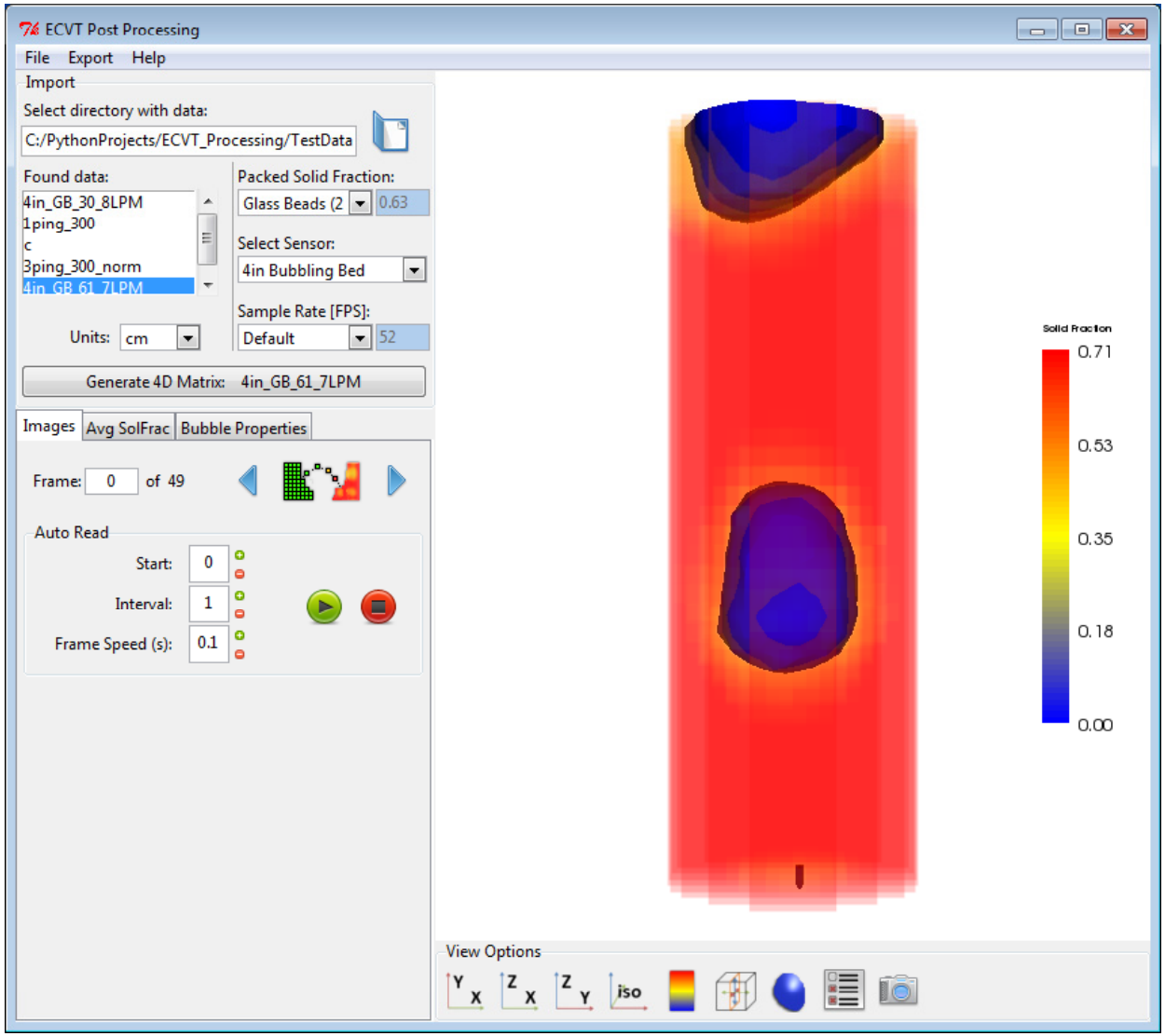


Frame:1 Time:0.00s 50 FPS

ECVT Verification



Extracting bubble properties



python™

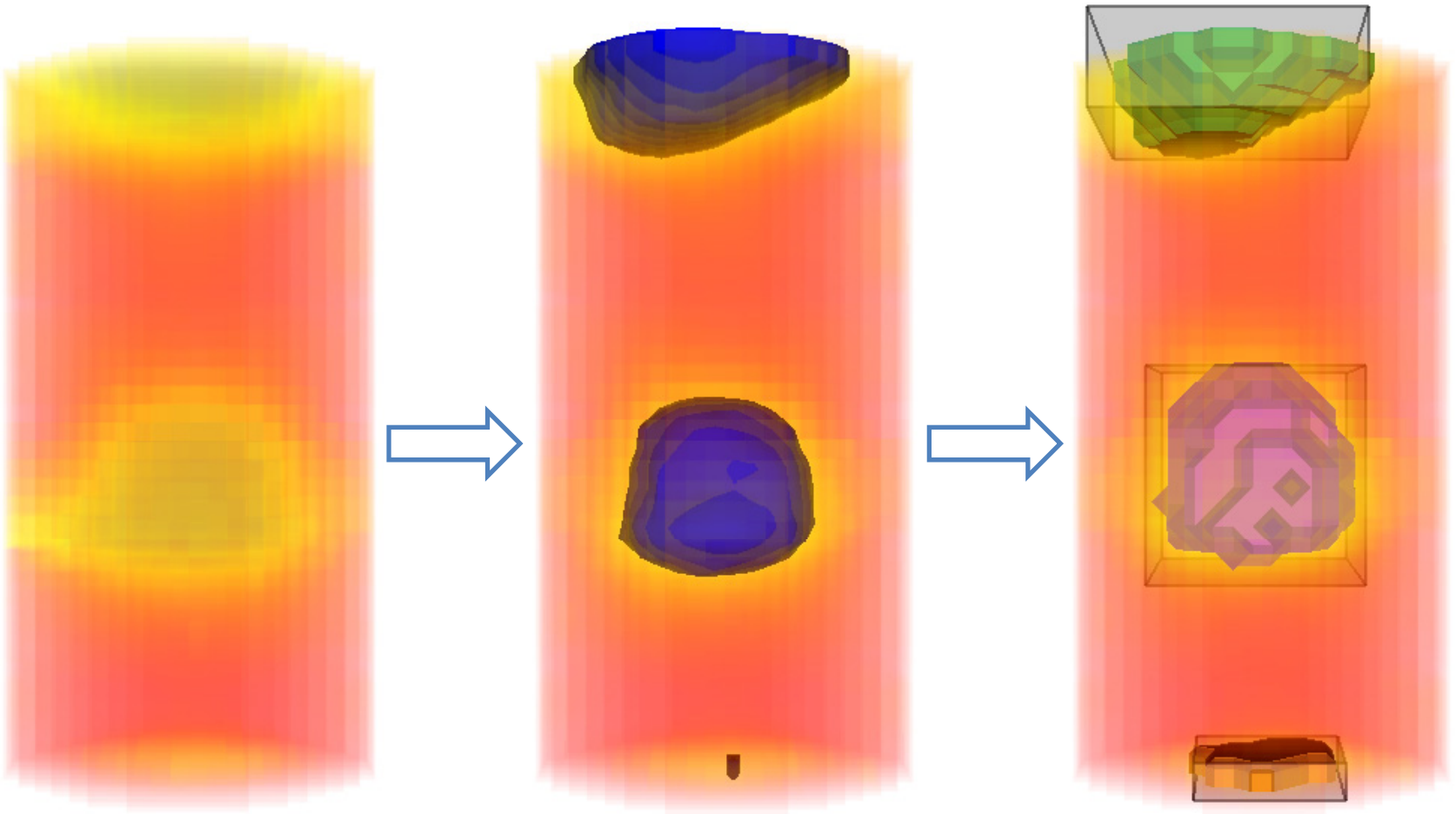
Numpy/
Scipy

Tkinter

vtk

matplotlib

Extracting bubble properties

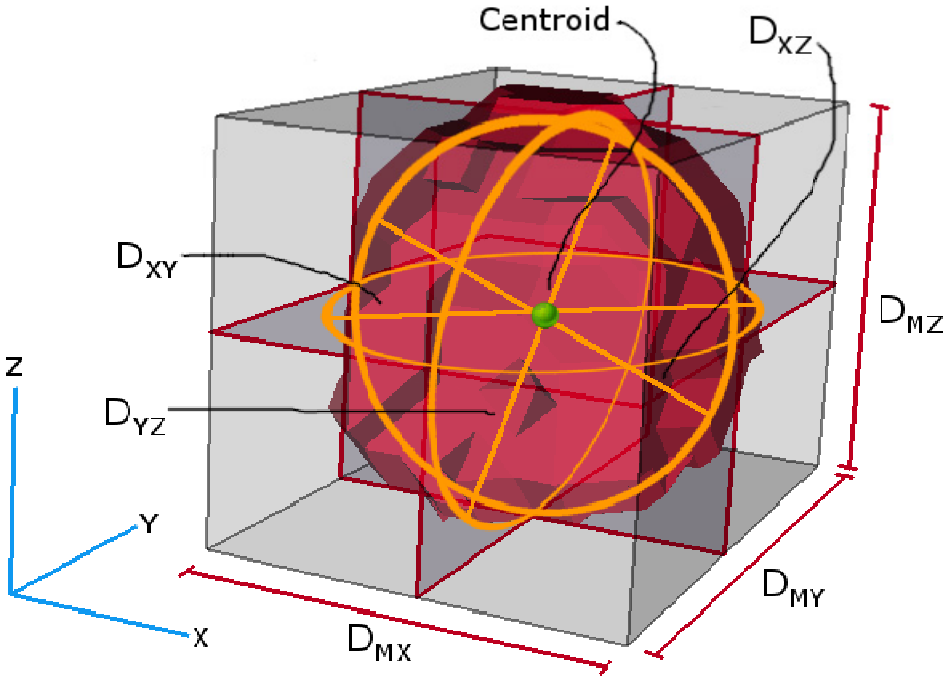


Data

Thresholding
Problem: What is a bubble?

3D Connected Components

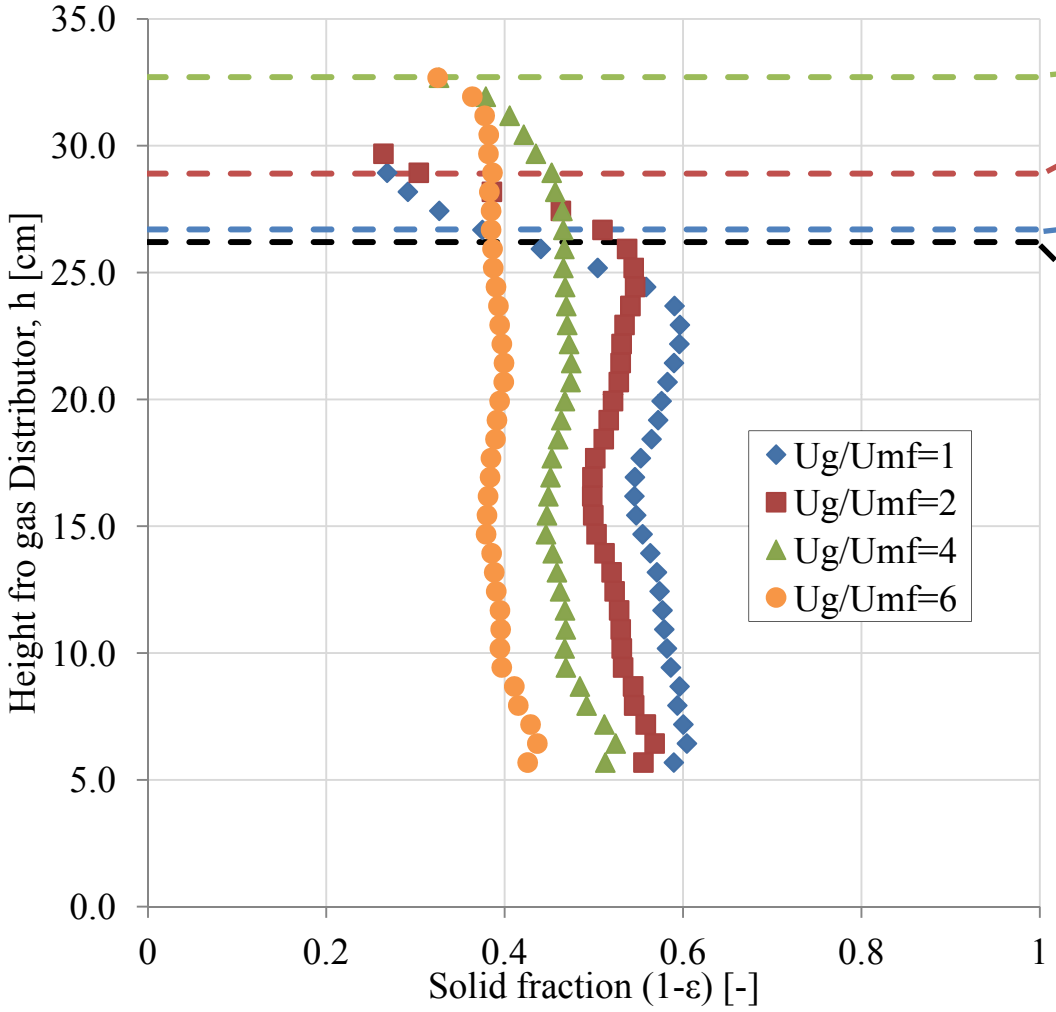
Bubble Parameter Definitions



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

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

Solid Fraction



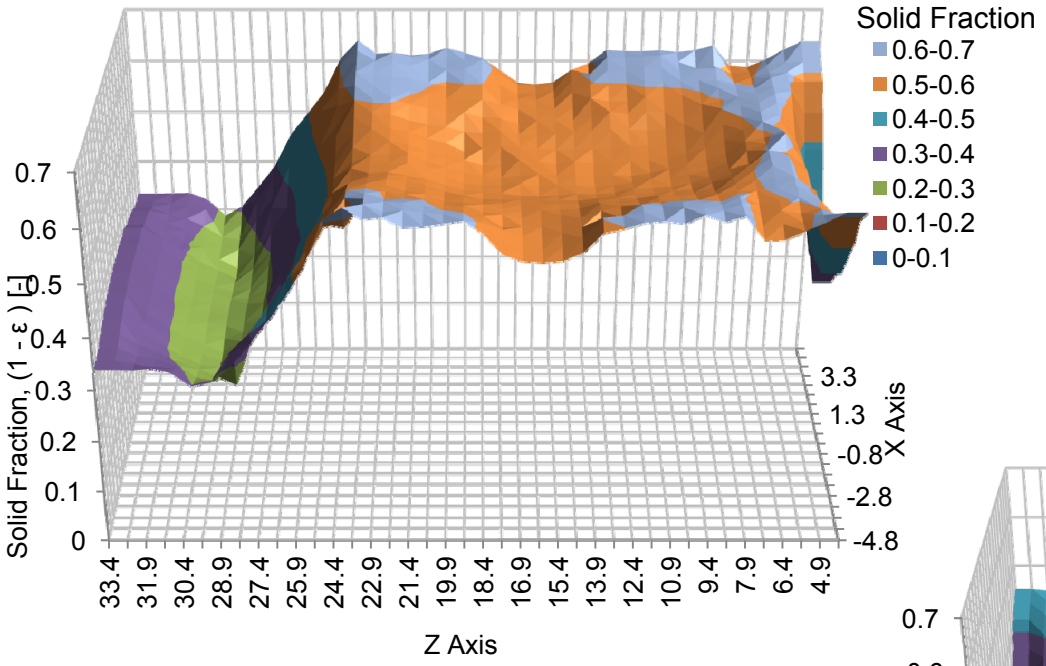
Ug/Umf=4, Bed Height

Ug/Umf=2, Bed Height

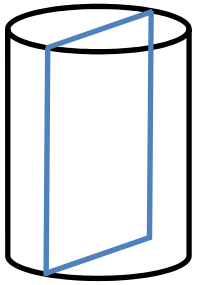
Ug/Umf=1, Bed Height

Static Bed Height

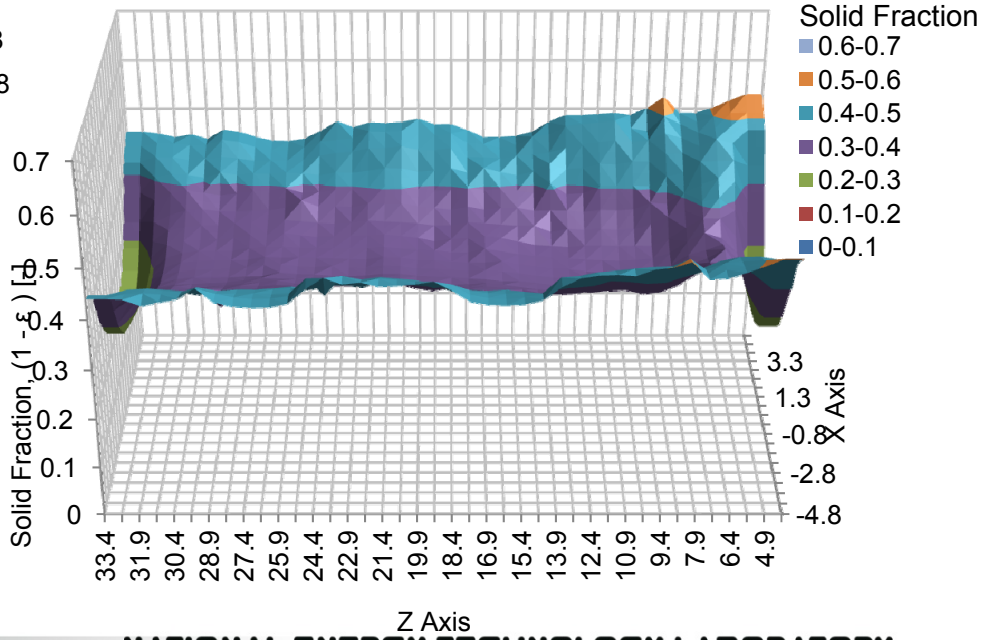
Time Averaged Solid Fraction



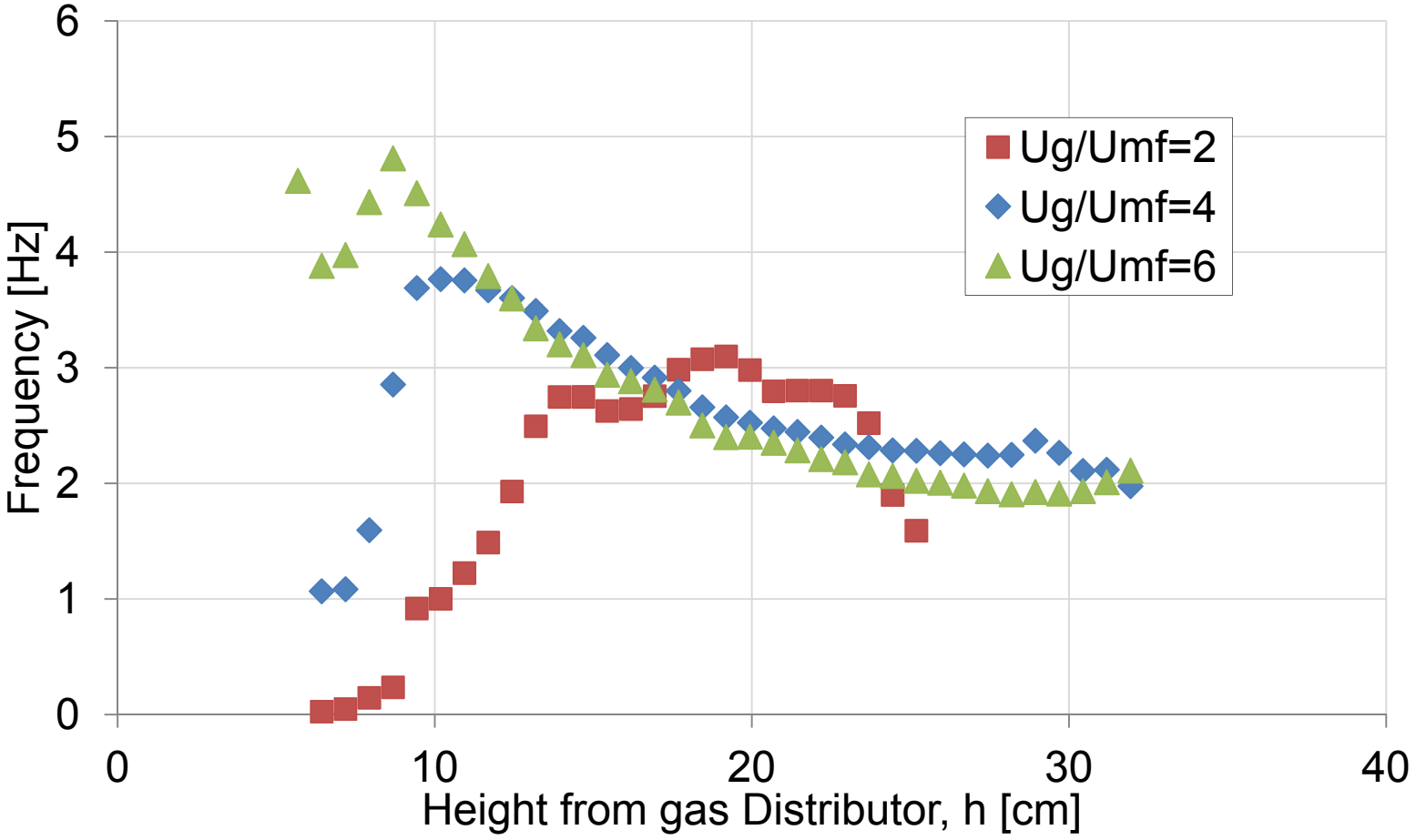
Umf



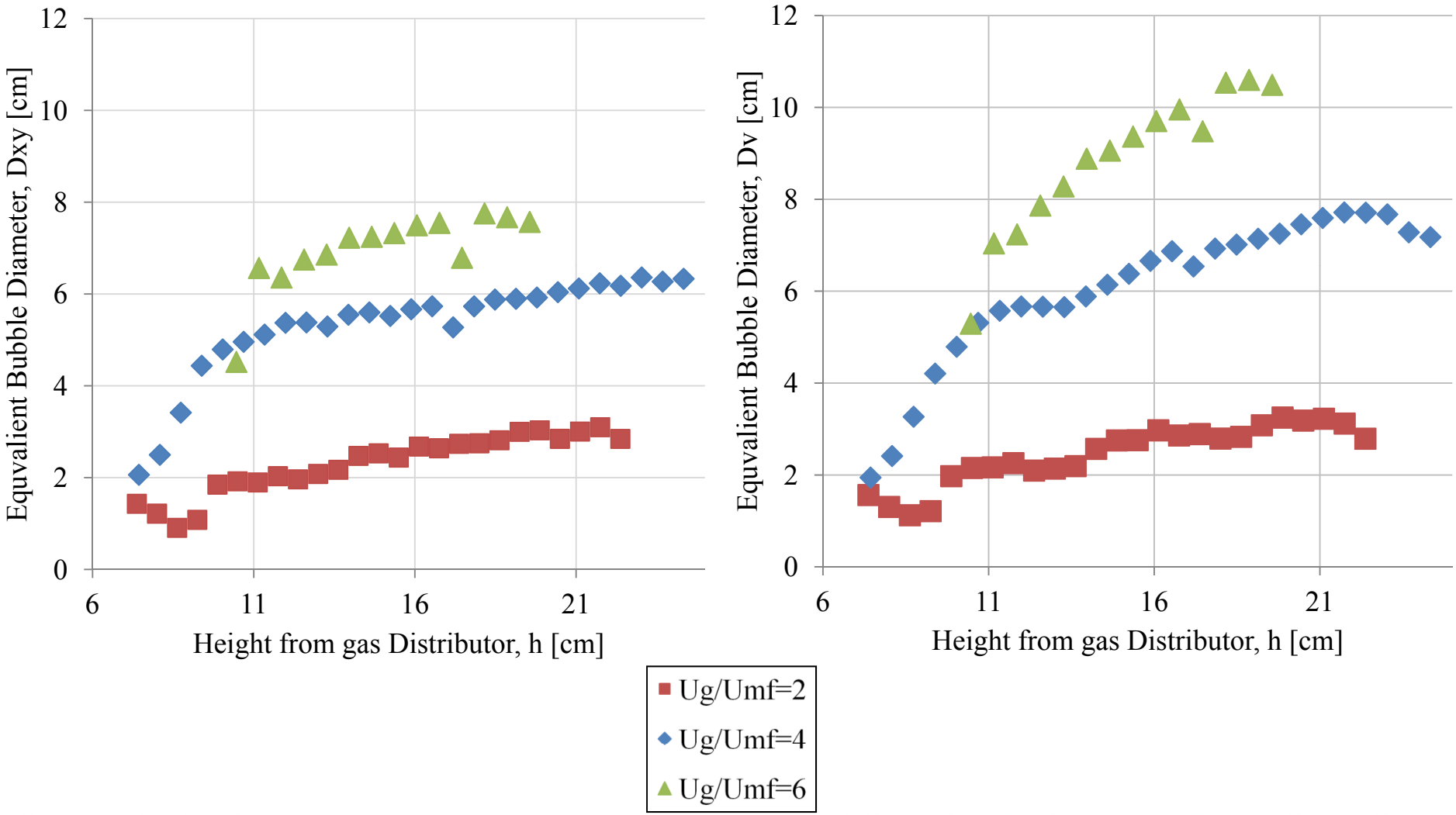
6x Umf



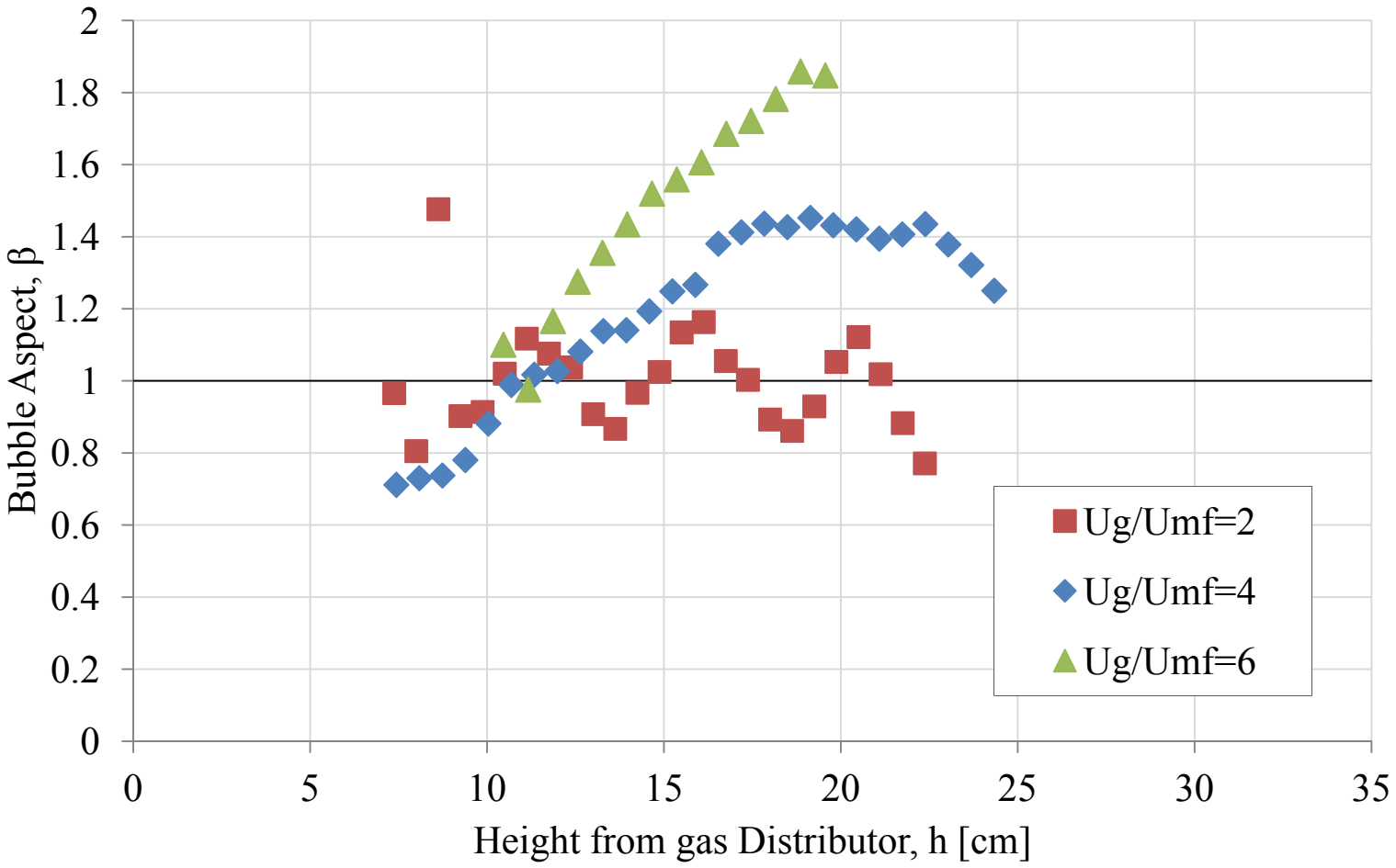
Bubble Frequency



Bubble Diameter

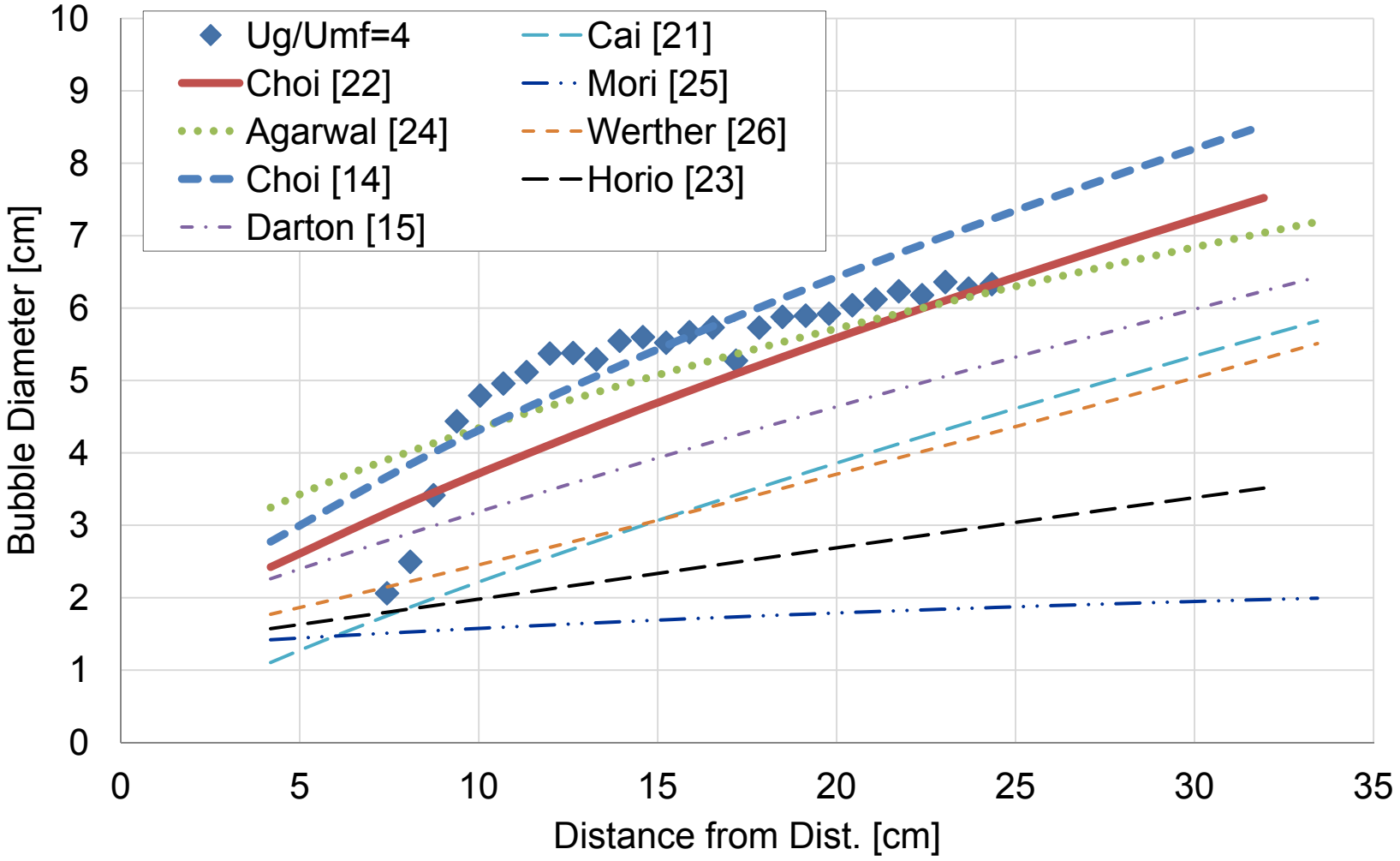


Bubble Aspect

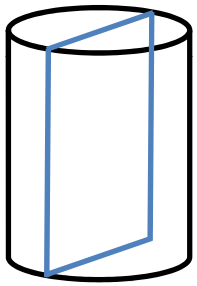


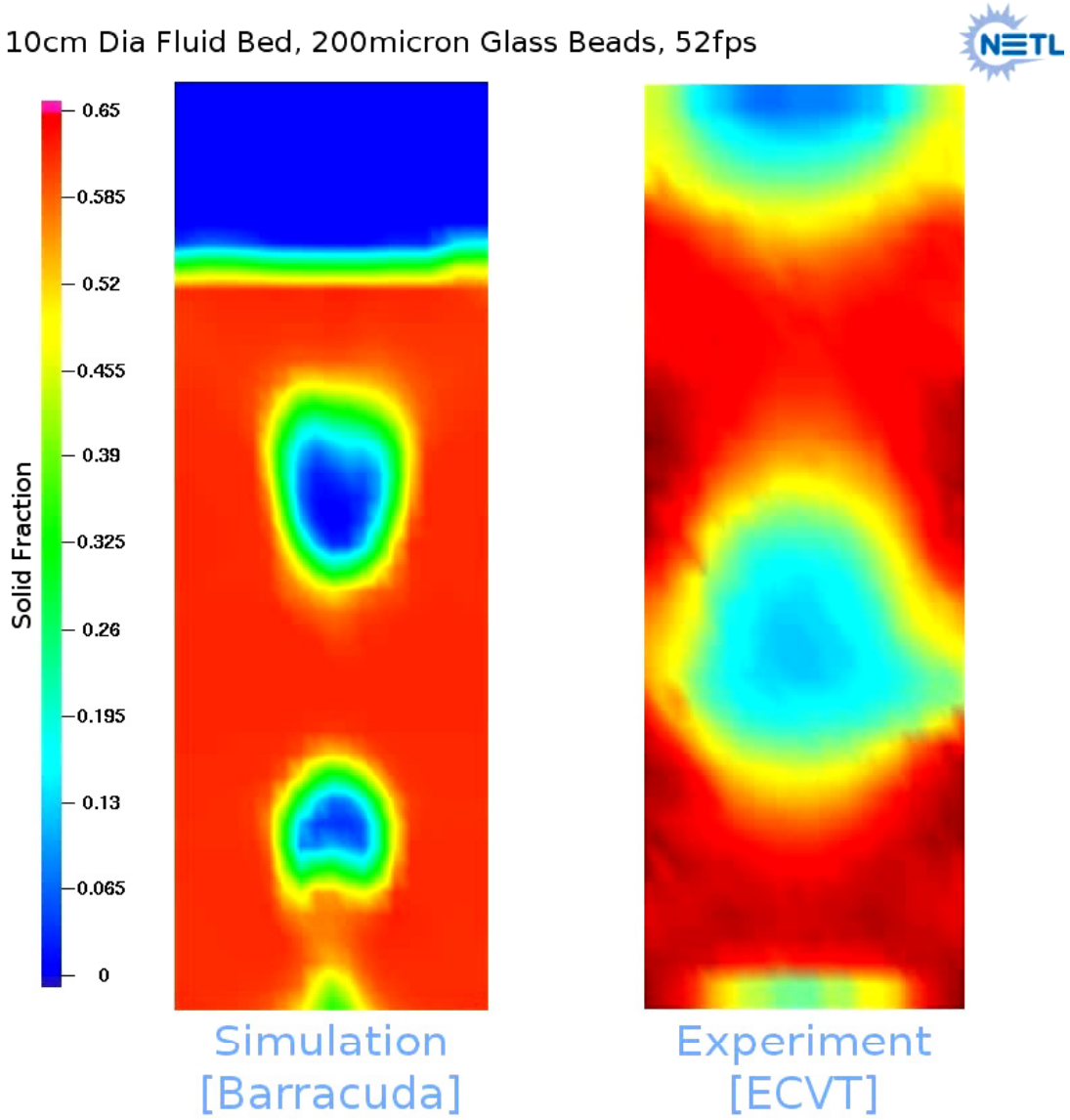
$$\beta = \frac{2D_{MZ}}{D_{MX} + D_{MY}}$$

Compared to Correlations



CFD comparison

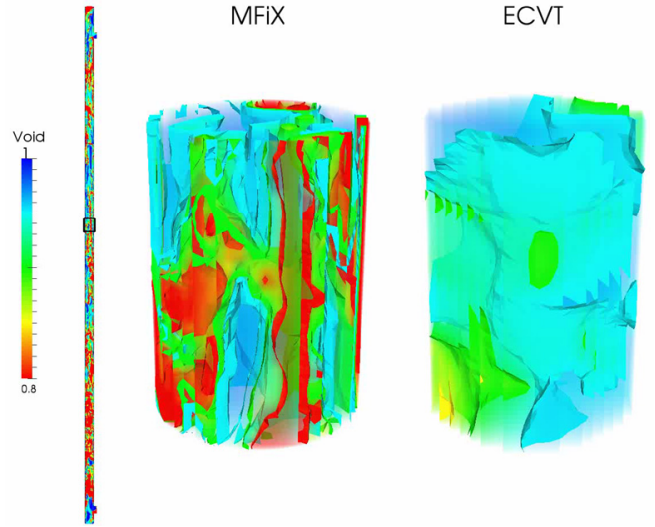


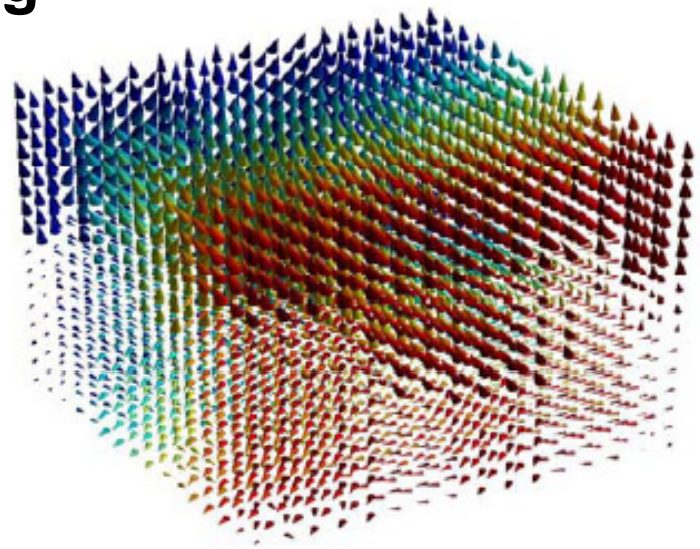


Simulation performed with CPFD's Barracuda

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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