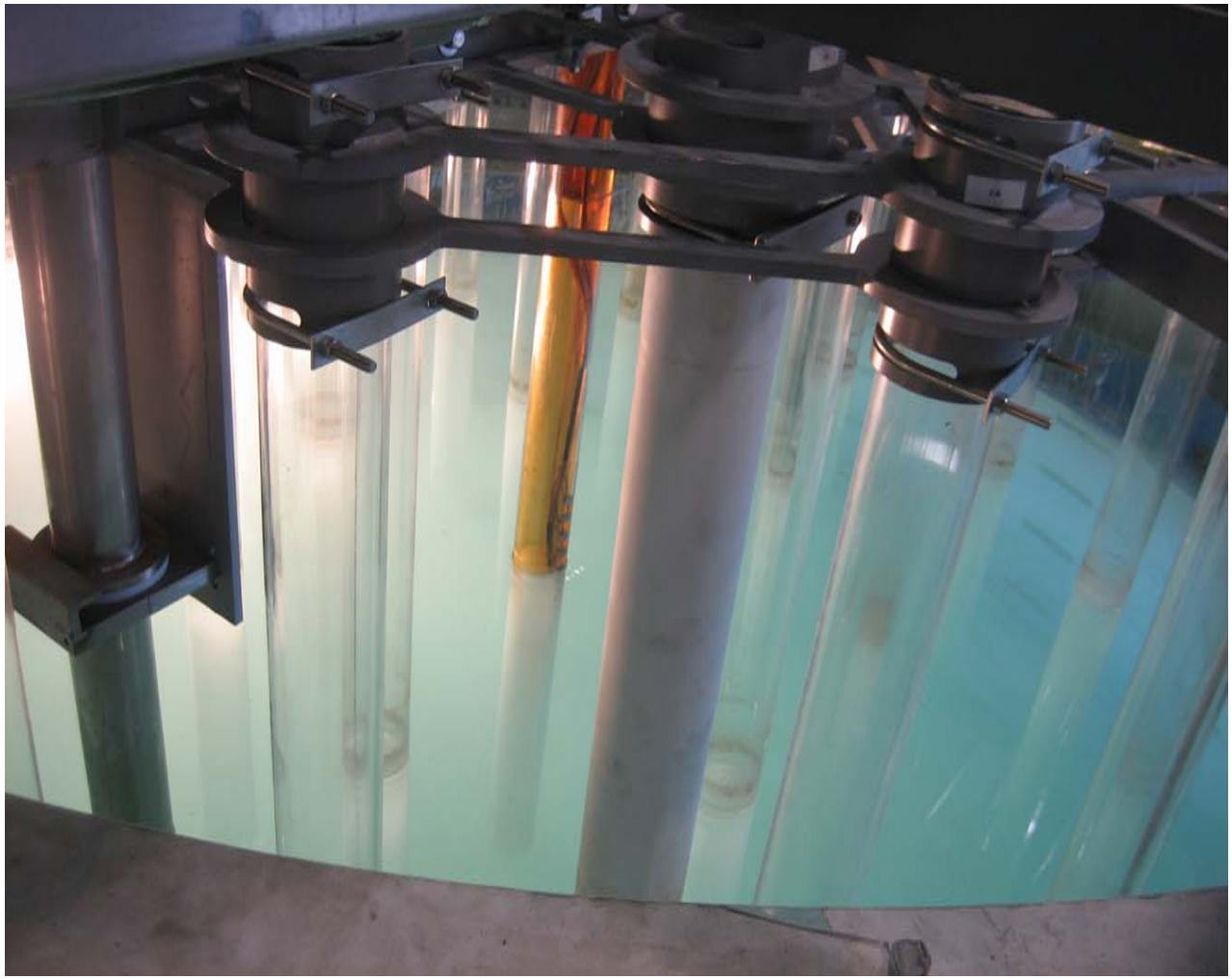
Hanford Small Scale Mixing Demonstration Program

EM Waste Processing Technical Exchange

November 17, 2010

Mike Thien



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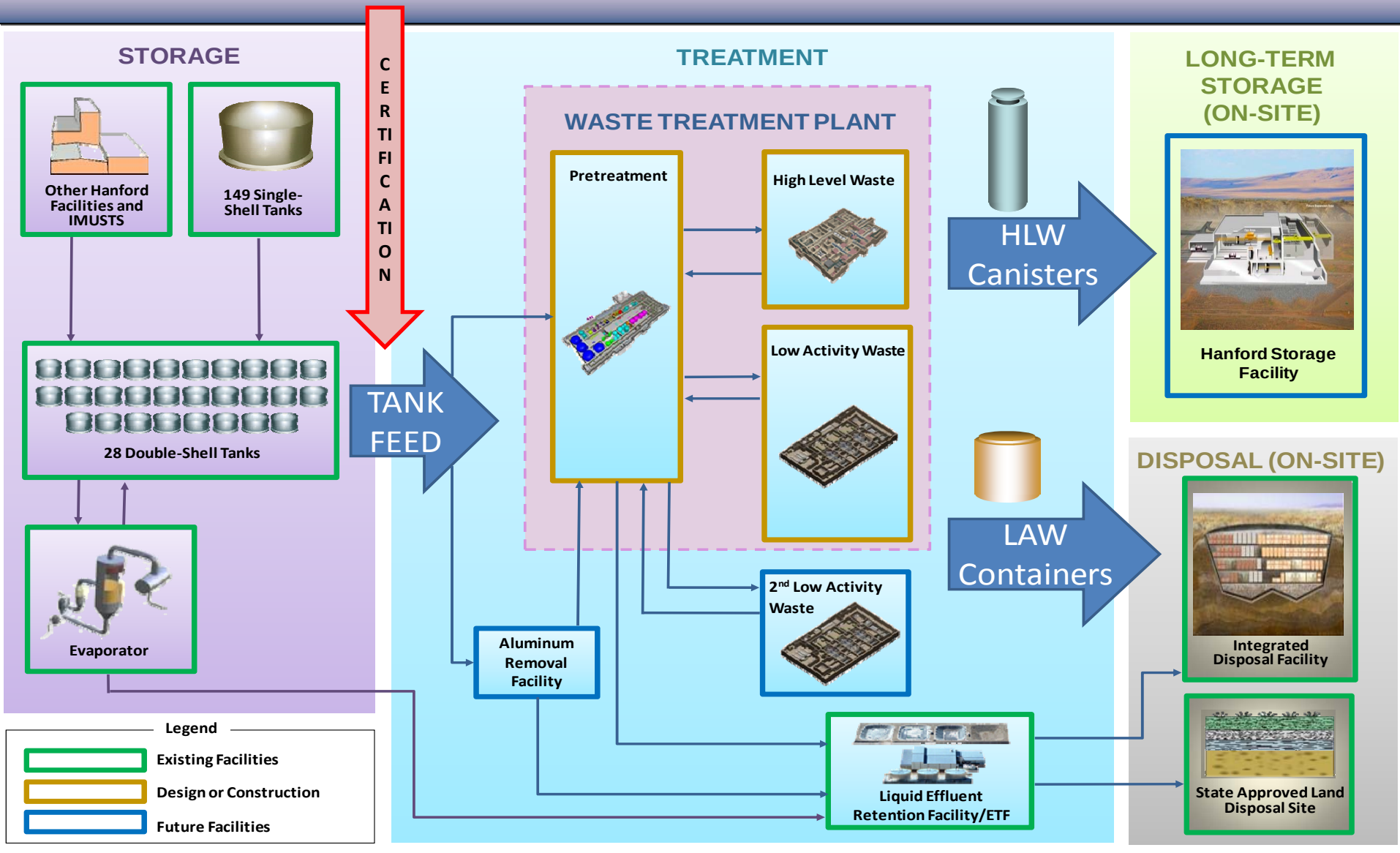
Agenda

- Hanford Tank Waste Mission
- Feed Challenge and Solution
- Program Description
- Program Component Discussion
- Deployed Technology Discussion
- Program Path Forward
- Questions

Simplified Tank Waste Mission



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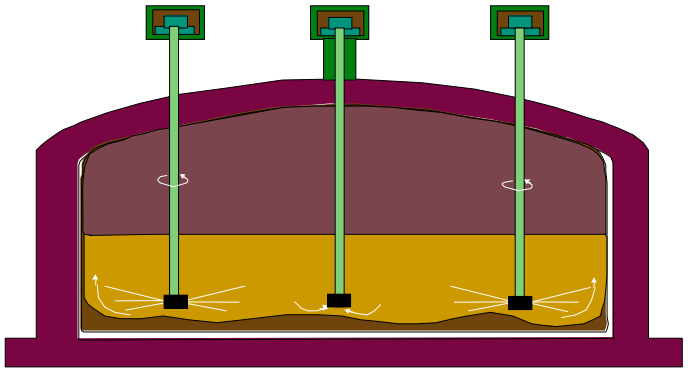
Feed Challenge – Solution

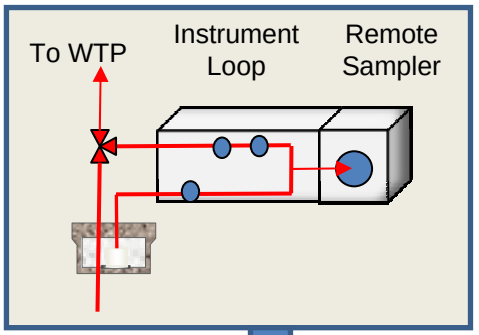
Sufficiently mix and sample double shell tank HLW sludge batches to provide accurate characterization allowing WTP feed certification and consistent HLW batch delivery

1,000,000 gallon double shell feed staging tank



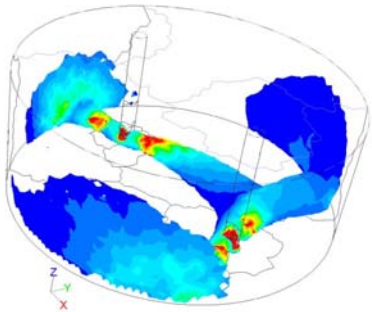
Critical Velocity Instrument Evaluation

Certification Loop Demonstration



Scouting Studies

Small Scale Demonstration



Computer Modeling

Full Scale (AY-102) Demonstration

Mixing Demonstration Program

2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017

Small Scale Mixing Demonstrations

RA Funded

Optimization and Scaled Demonstrations

Full Scale Installation and Demonstration

Mission Application Demonstration

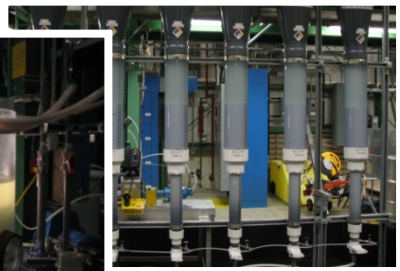
First Feed Delivery to WTP (May 2018)

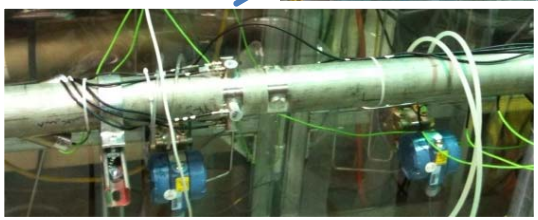
Decision Point:

Need for Separate Feed Blending and Certification Facility

Small Scale Demonstration

- ✓ Batch Transfer Demo (SRNL)
- ✓ Computer Modeling (Vista)
- ✓ Multi-Scale Demo (Energy Solutions & Monarch)
- ✓ Critical Velocity Instrument Selection (PNNL)
- • Certification Loop Demo (TBD)





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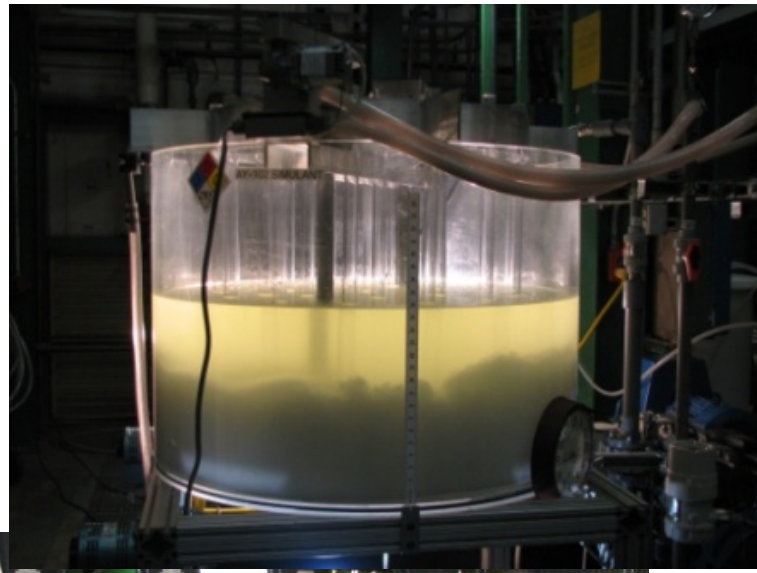
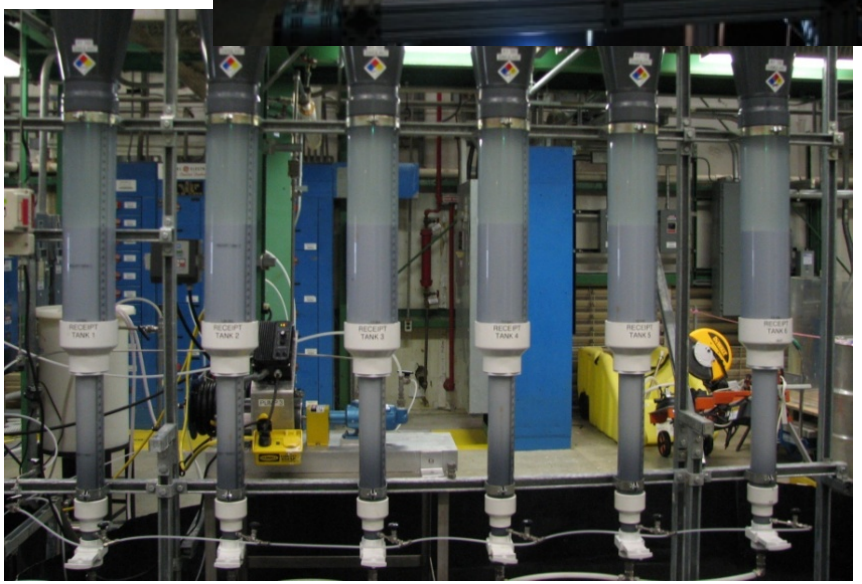
SRNL Platform

- 40” tank w/15 wt% solids
  - 90 % Gibbsite
  - 10 % Silica Carbide
  - DST similar supernatant
- Batch Transfer Demonstrations
  - Mixer pump rotation/flow
  - Transfer pump location/elevation
  - Mixer pump synchronization
  - Simulant variations
- Conclusions
  - Variable changes had no noticeable impact on batch consistency
  - As tank is emptied, slower MJP rotation improves solids transfer



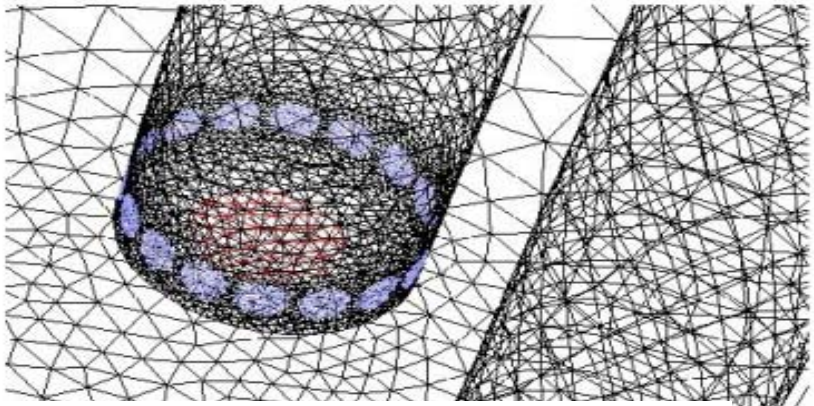


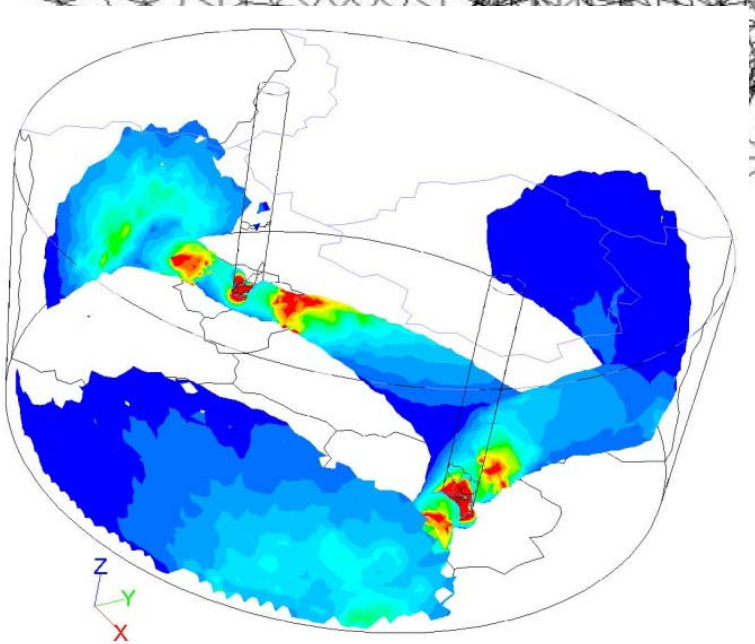
SSMD Platform

- 43” and 120” tanks
  - Single to complex simulants
  - Water supernatant
- Mixing Test Objectives
  - Demonstrate equivalent performance between tanks
  - Collect velocity data
  - Learning for batch transfer phase
- Takeaways
  - Lots of data – focus on objectives
  - Tank performance boundaries more important that full scale equivalence
  - Simulant attributes important
    - Equipment, Instrumentation

Computational Fluid Dynamics Model

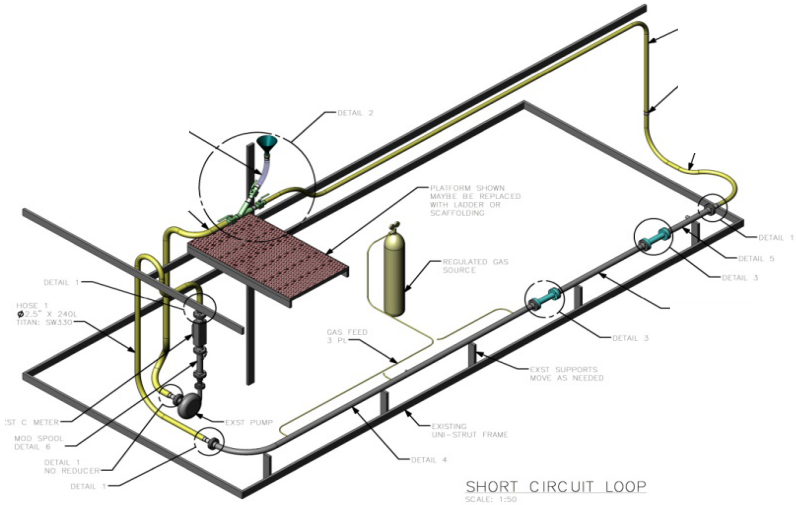
- 43”, 120” and 75’ tank
  - Supplements SSMD platform data
  - Single phase velocity model
  - Simulated mixer pump rotation
  - Internal obstructions included
- Model Output
  - Velocity vectors
  - Velocity surfaces
  - Particle traces
- Future Uses
  - Parameter sensitivity evaluations
  - Two phase model to simulate solids

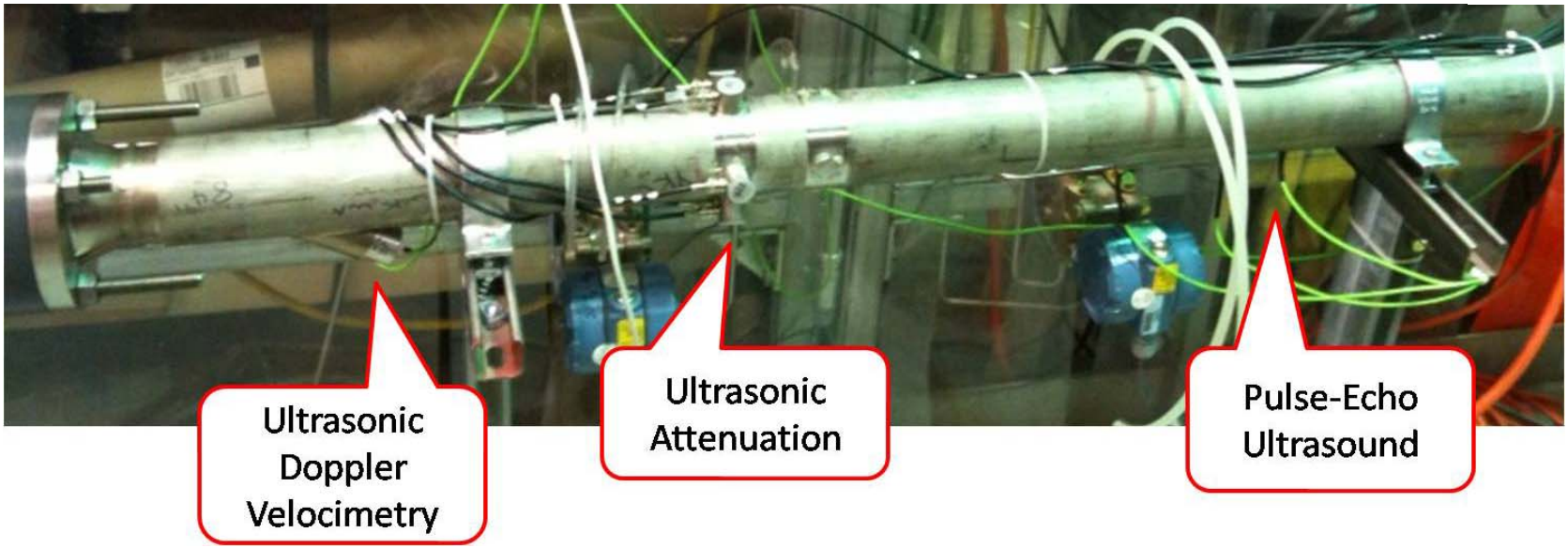




Critical Velocity Measurement

- Flow Loop Evaluation
  - 3 ultrasonic based instruments
  - Solids deposition with wide range of simulants
- Results
  - Pulse-Echo Ultrasound preferred
    - UDV alternate option

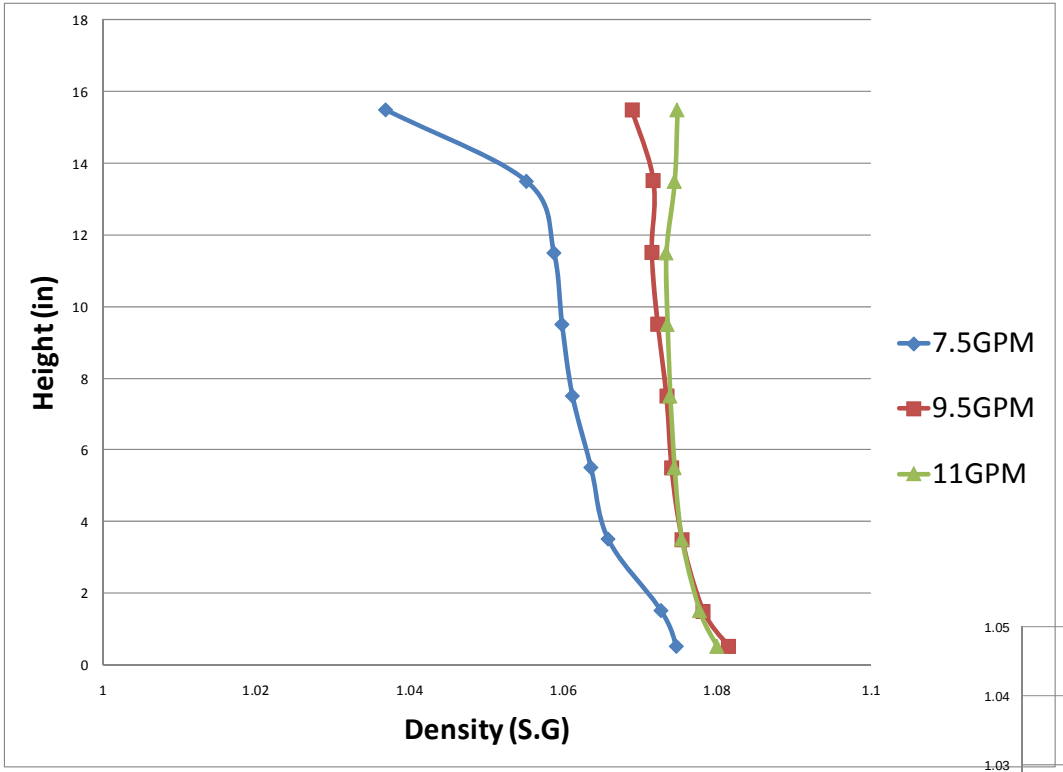


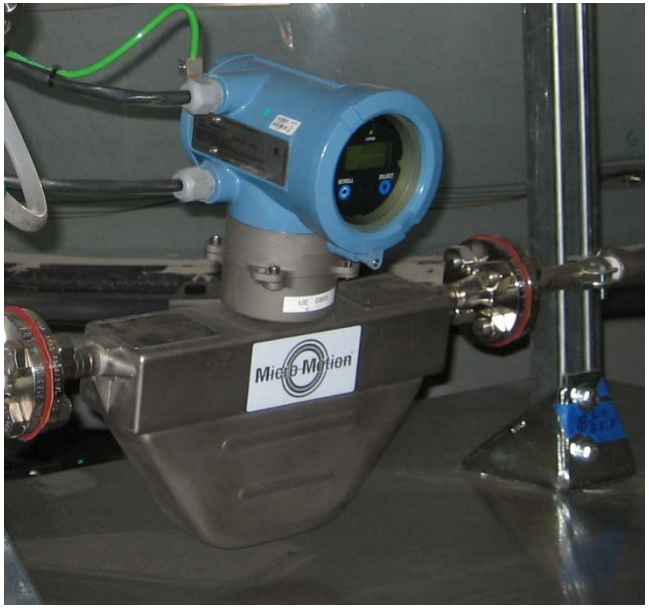


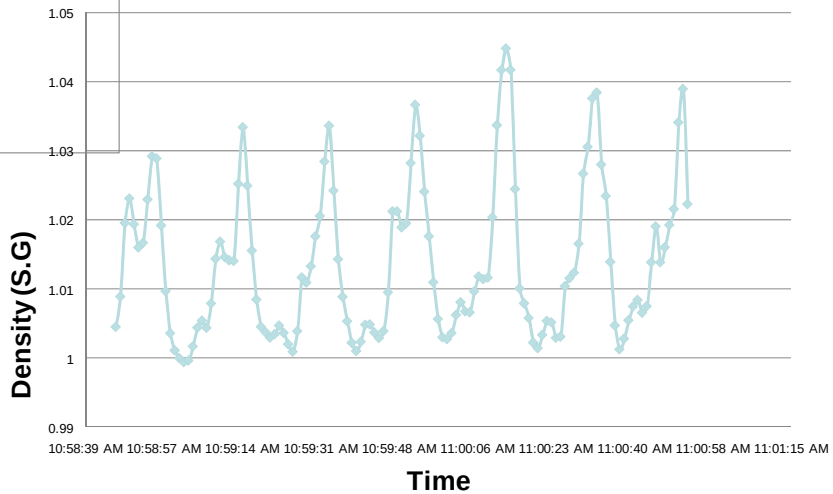
SSMD Technology

- **Density**
  - Coriolis Meter
- **Particle Size**
  - Focused Beam Reflectance Measurement (FBRM)
- **Particle Distribution**
  - Electro Resistive Tomography (ERT)
- **Dynamic Fluid Modeling**
  - Computational Fluid Dynamics Model
- **Critical Velocity**
  - Pulse Echo Ultrasound

Coriolis Sample Loop







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Focused Beam Reflectance Measurement (FBRM)

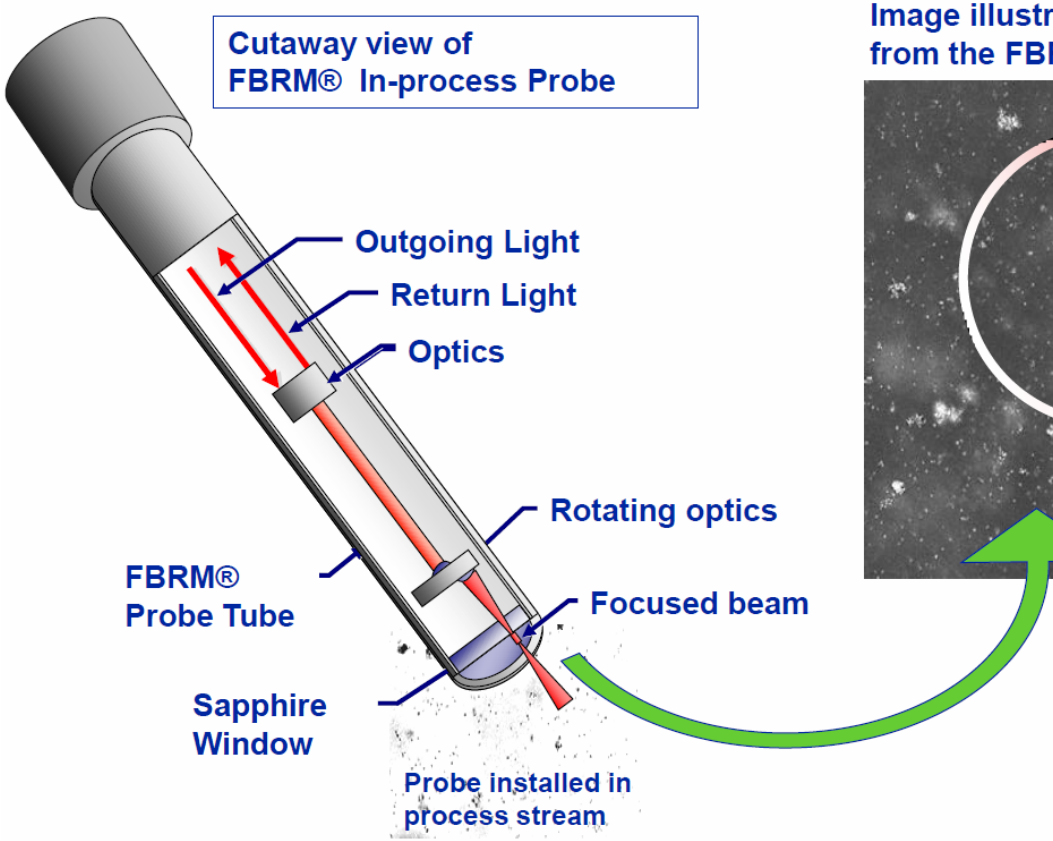
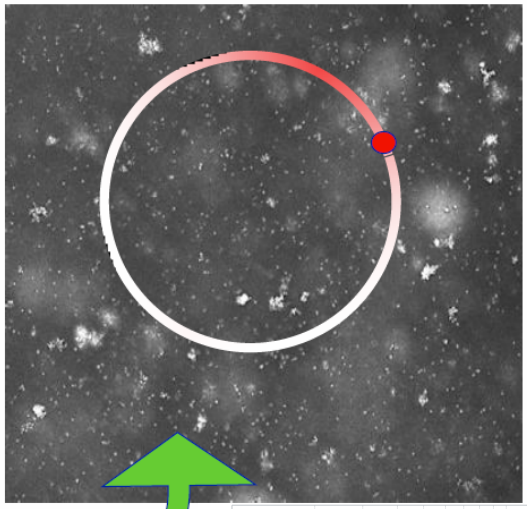
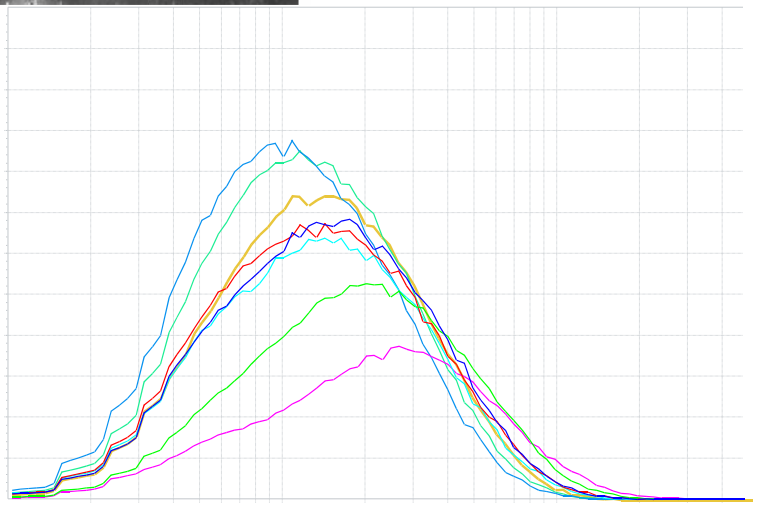


Image illustrating the view from the FBRM® Probe Window





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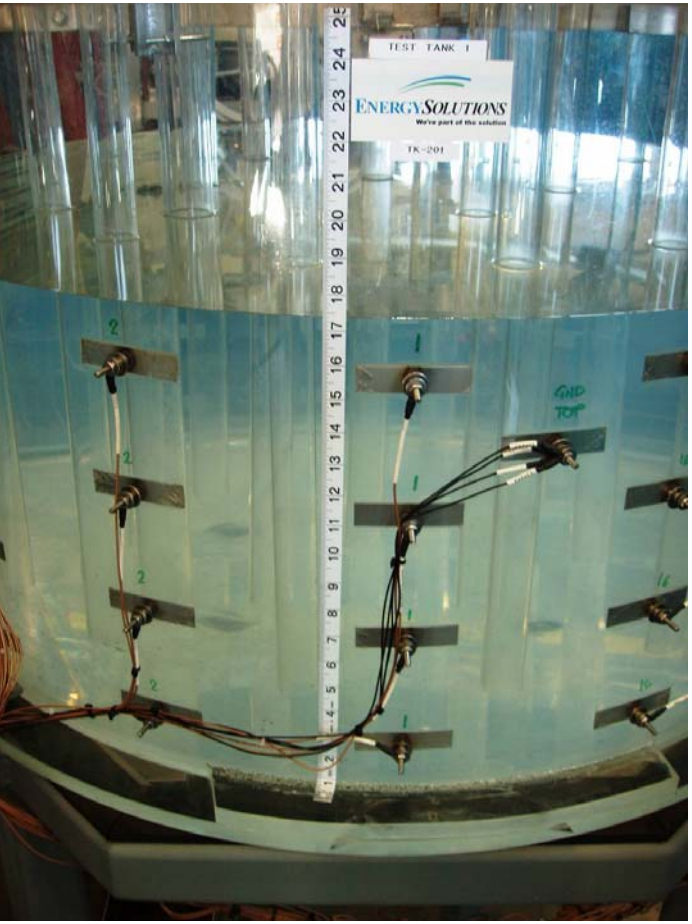
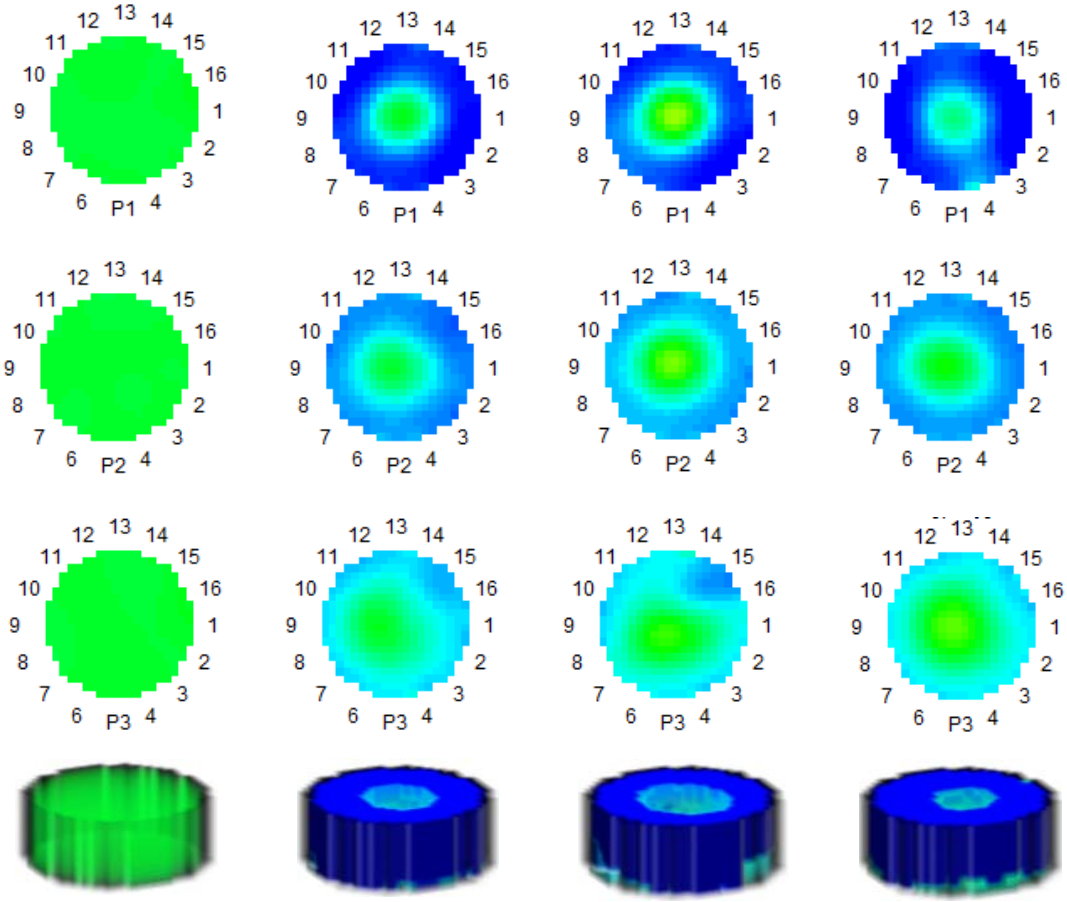
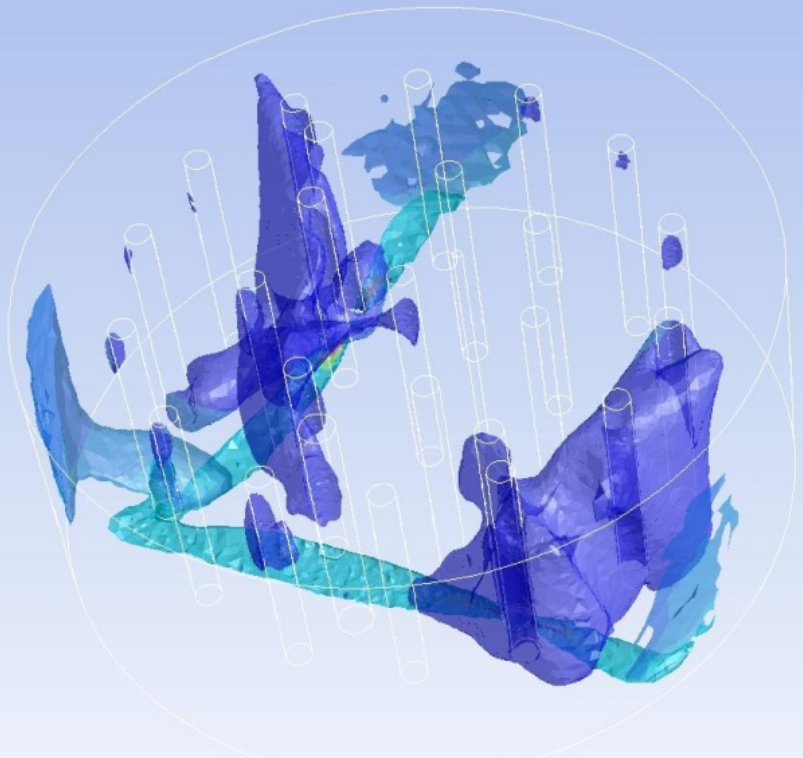
Electro Resistive Tomography



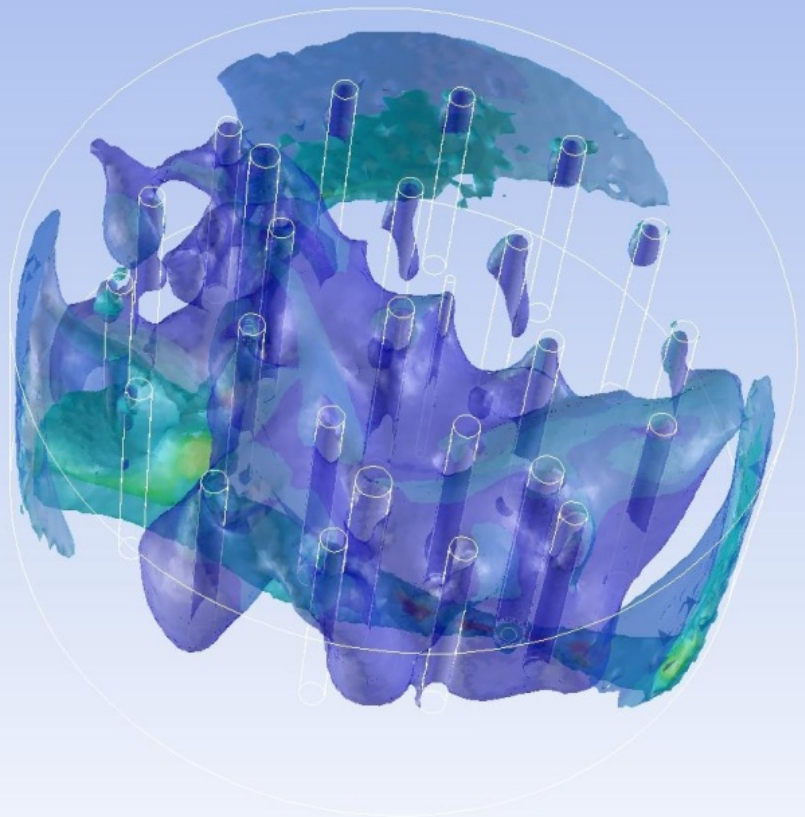


CFD Model Movie Example

120” Tank Model



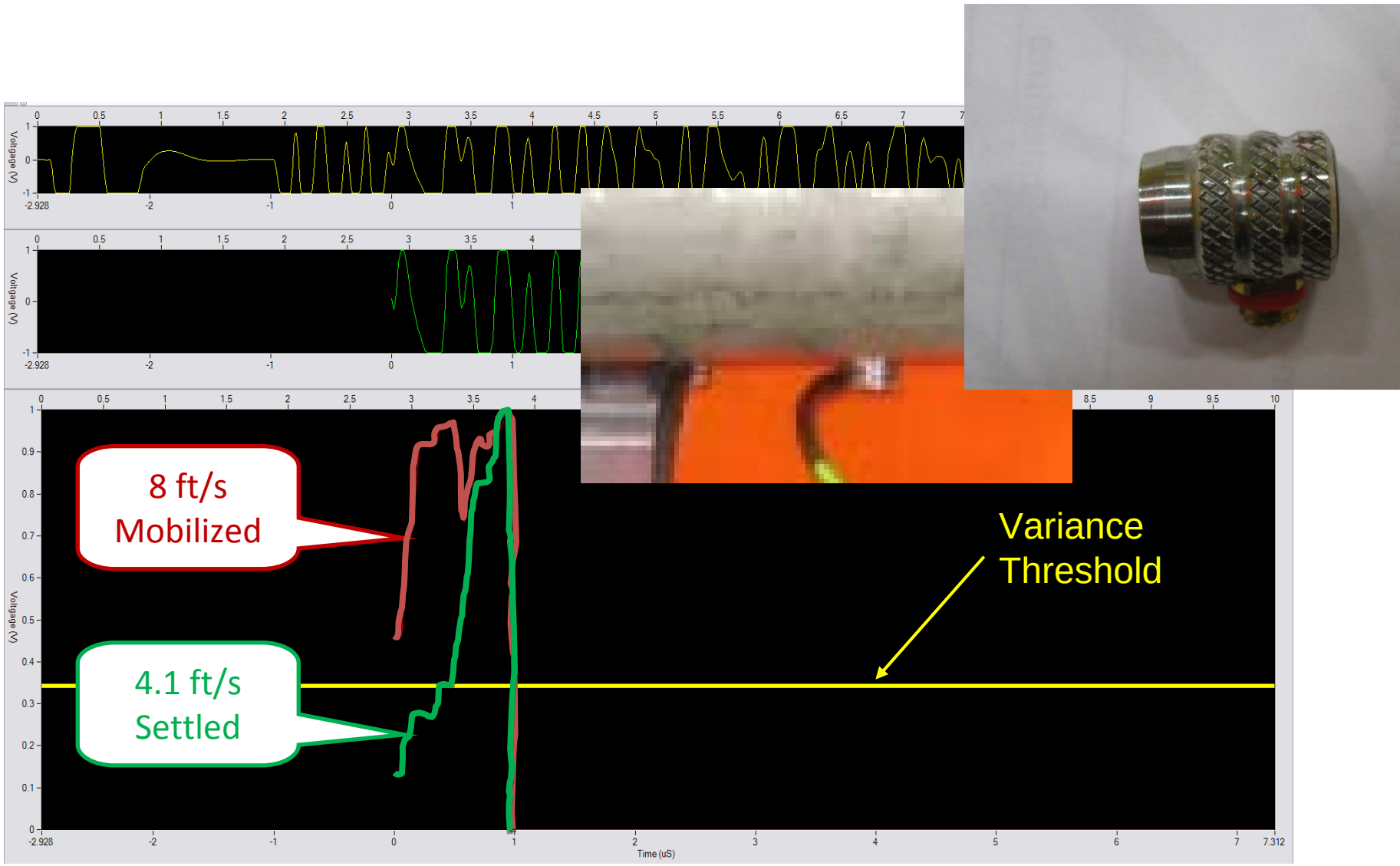
Full Scale Tank Model



Three Iso-value Surfaces

- 0.7 m/s velocity magnitude
- 0.3 m/s +z velocity (up)
- 0.1 m/s –z velocity (down)

Pulse Echo Ultrasound

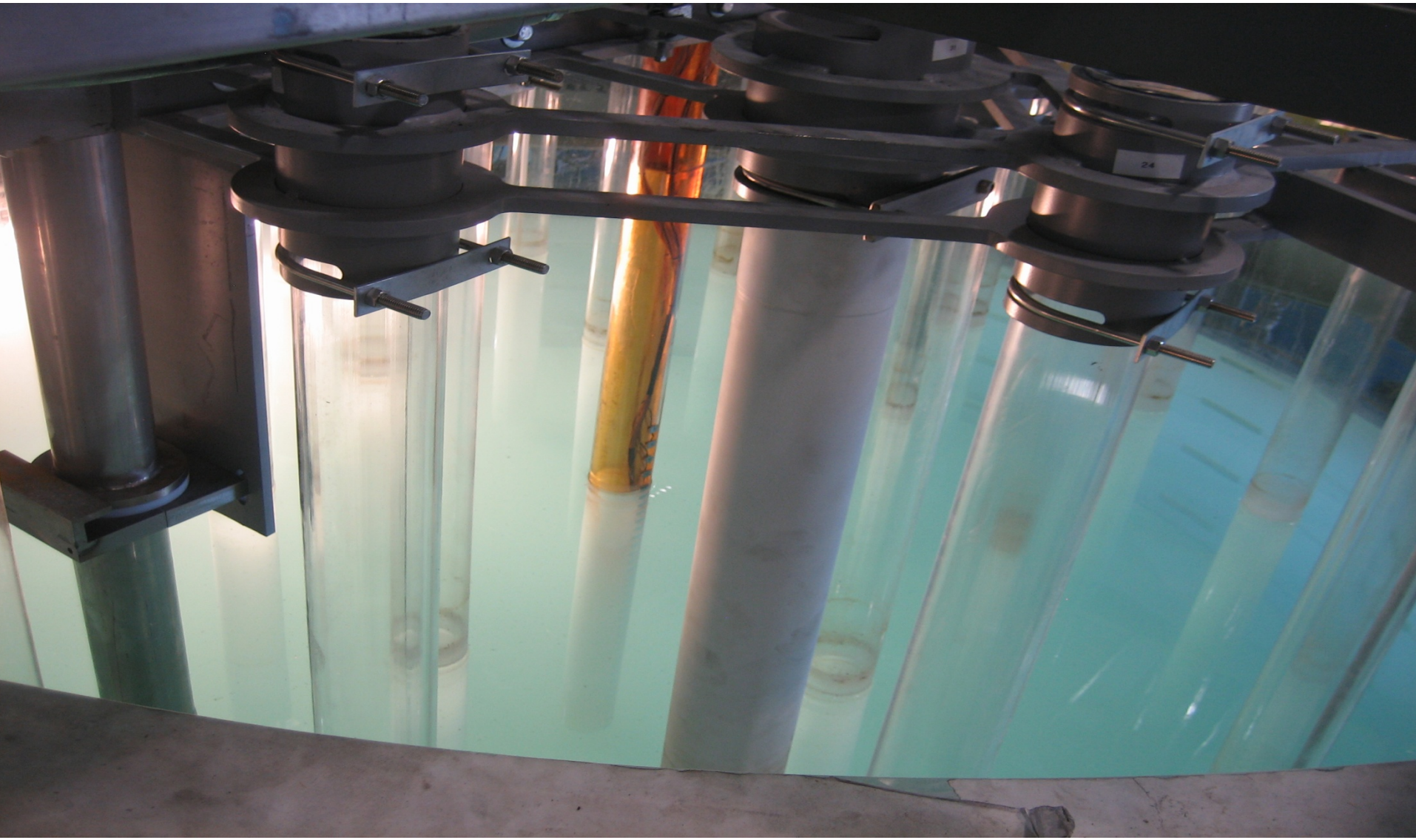


Path Forward

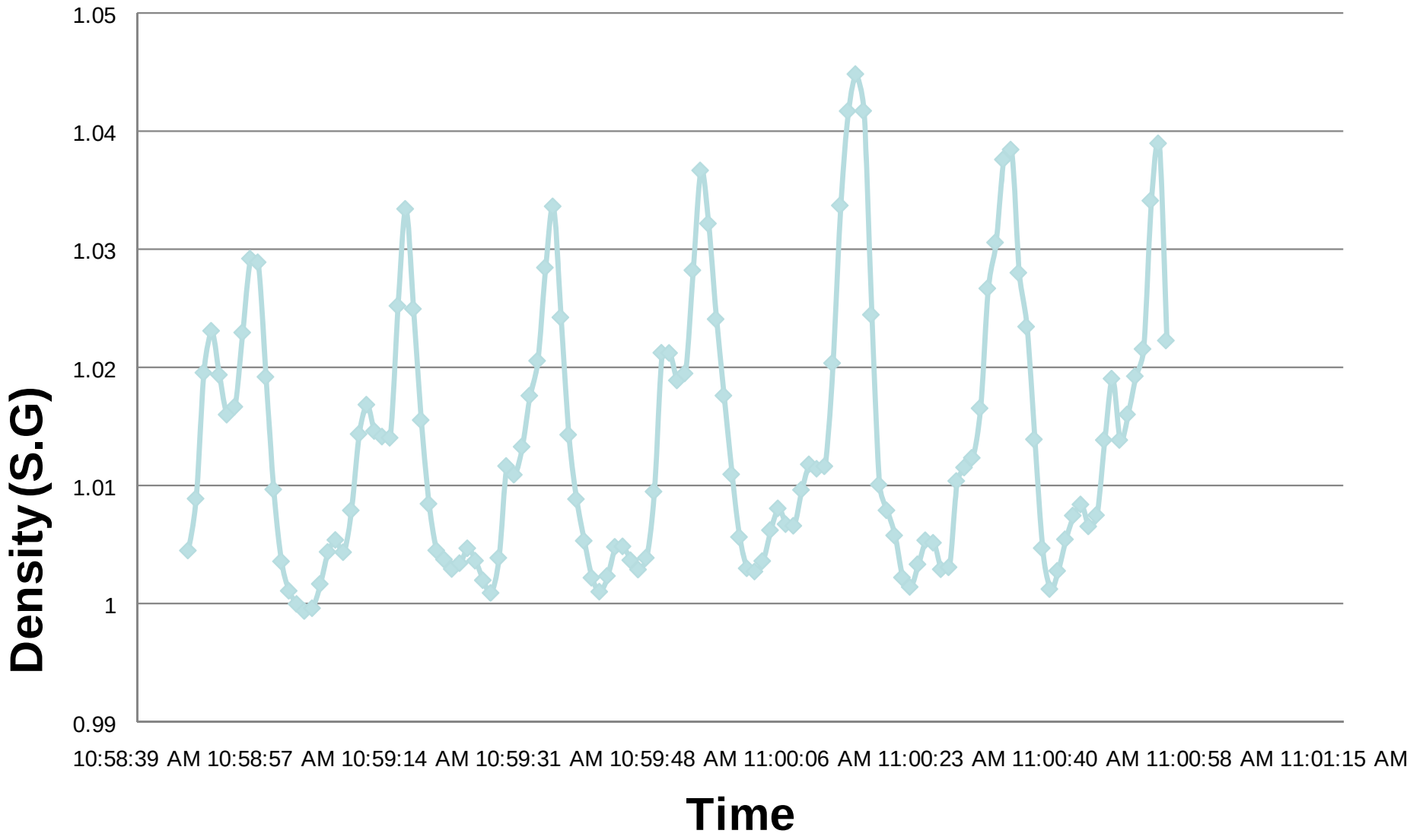
- Sample and Batch Transfer Demonstration
  - Tank sample representativeness
  - Batch transfer consistency
- Define Performance Plateaus
  - CFD model sensitivity analysis
  - Statistical results analysis
- Certification Loop Demonstration
  - Demonstrate remote sampler concept
  - Integrate critical velocity measurement
- Cohesive Simulant Scouting Studies
  - Estimate cohesive particle impact on batch transfer consistency

Questions?

Back-up Data



Coriolis Meter, Density vs. Time



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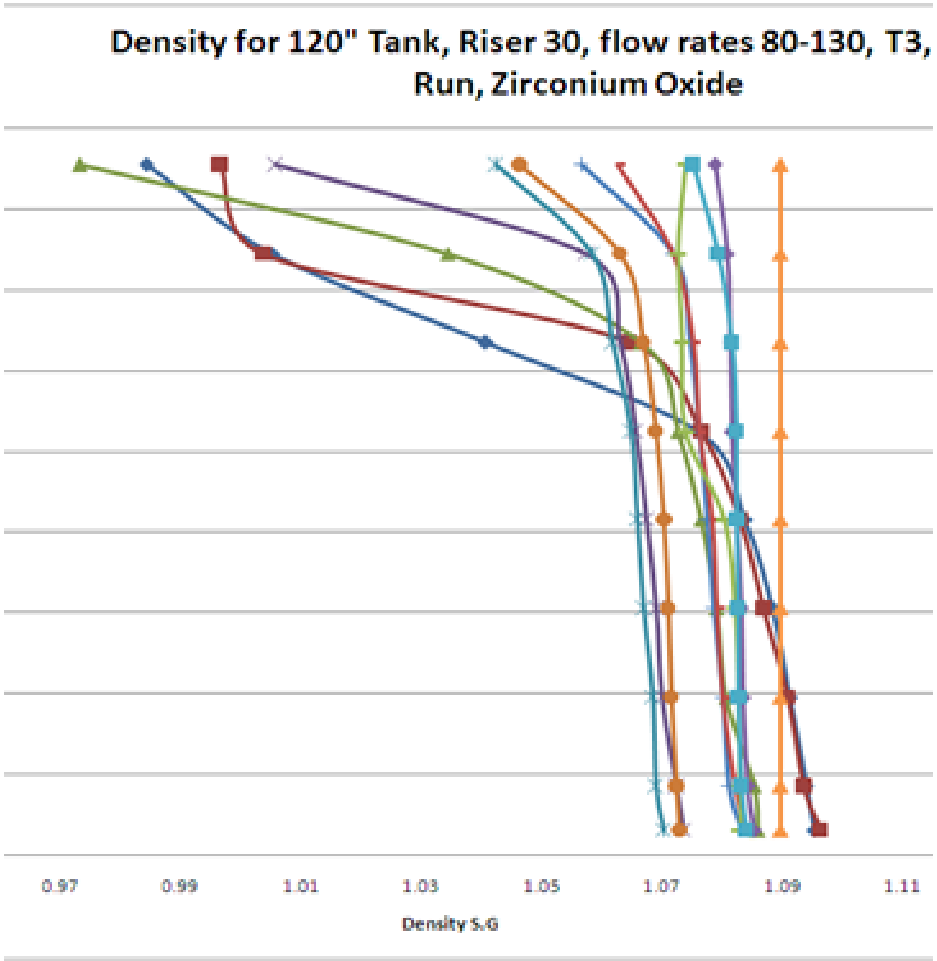
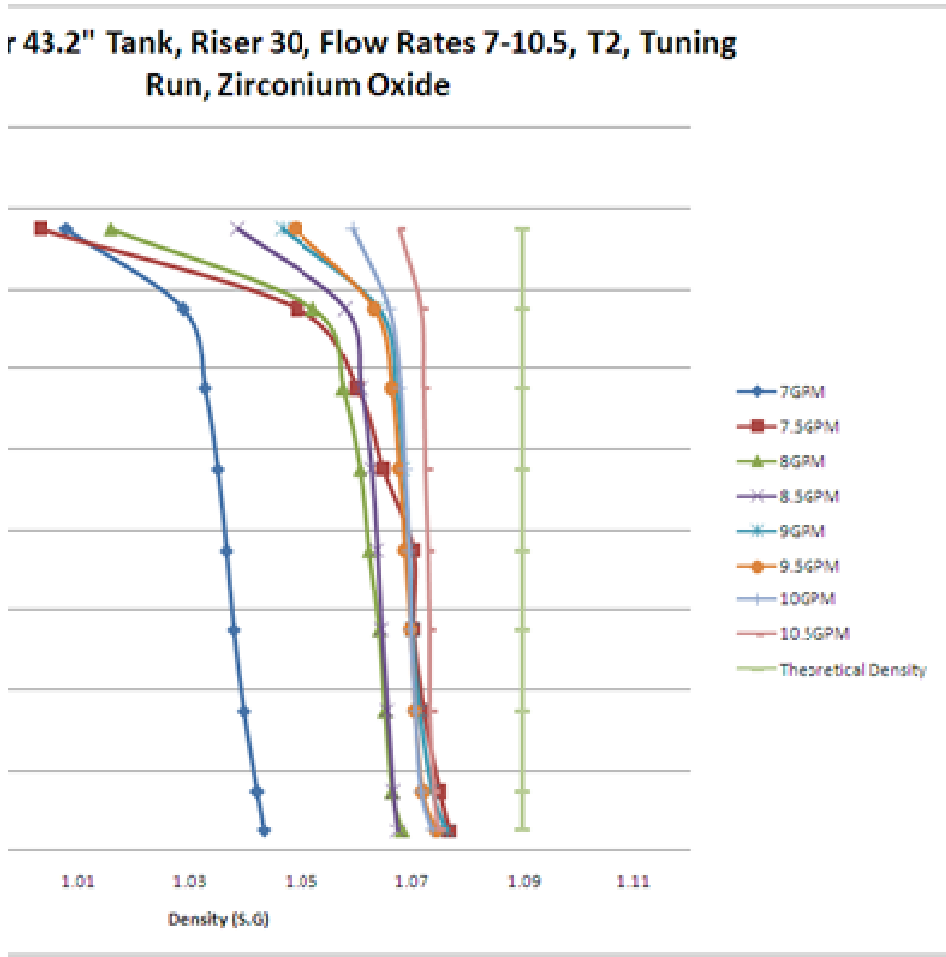
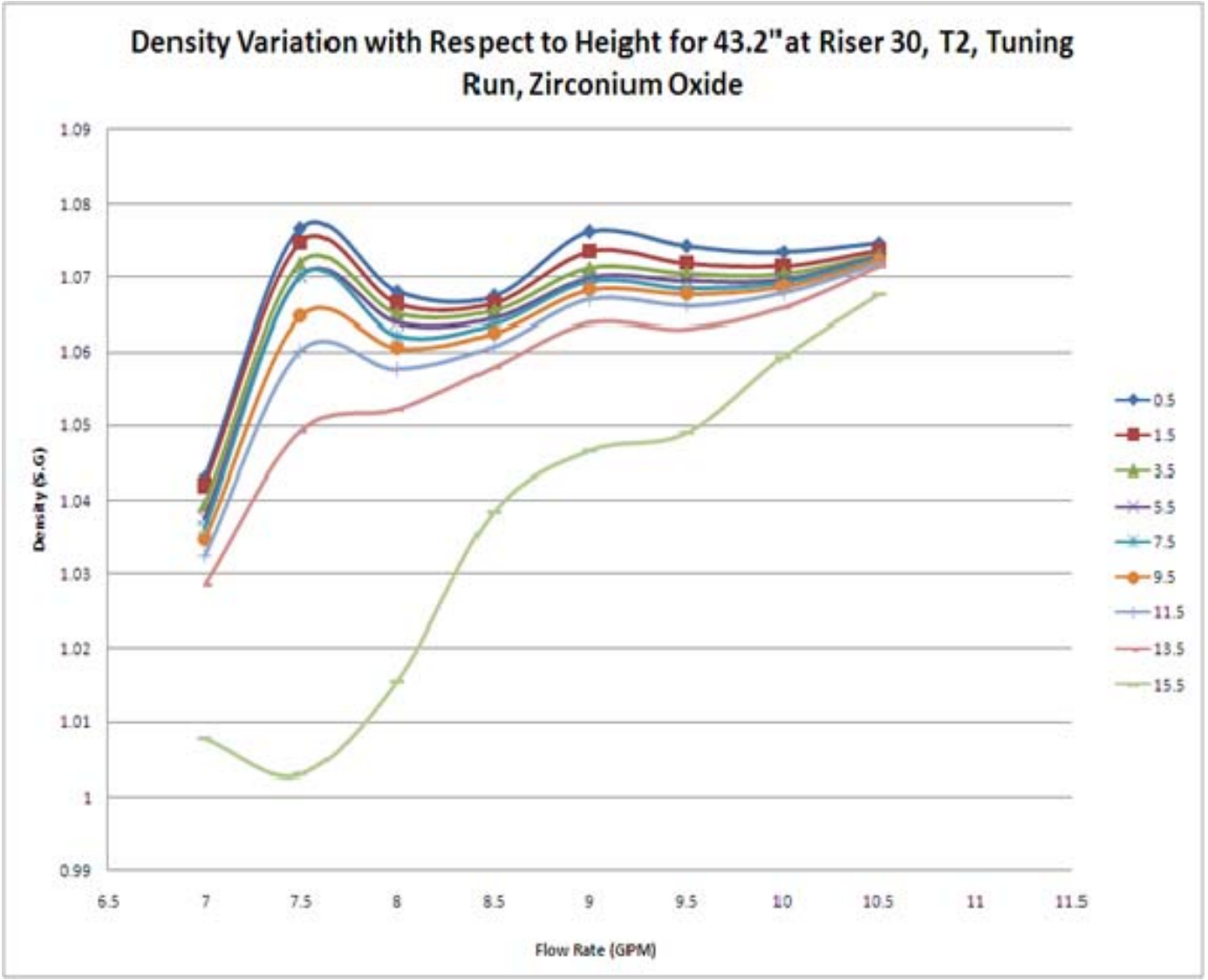
Tuning Data – One Look

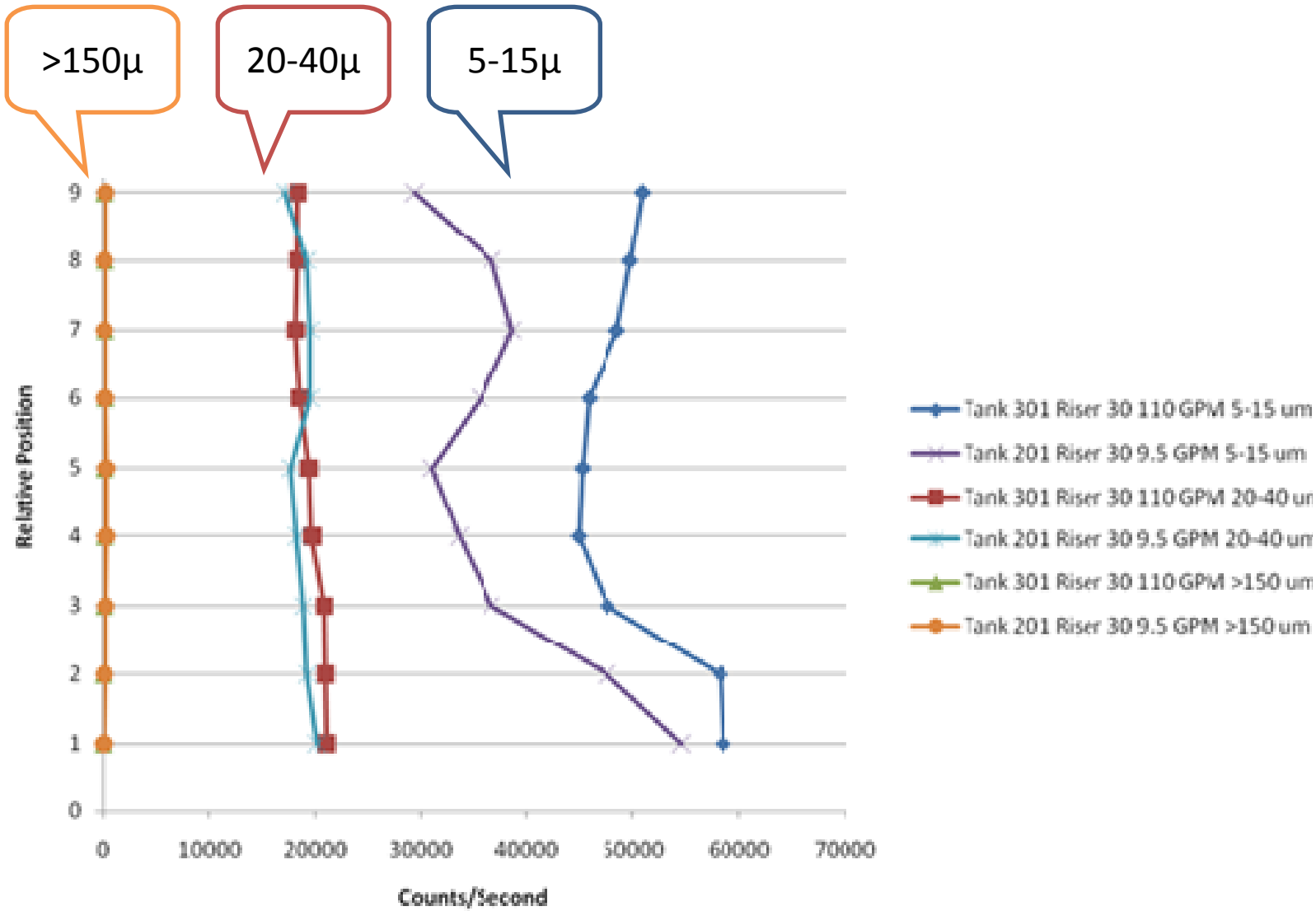




Tuning Data – Another Look



FBRM Data Evaluation Options



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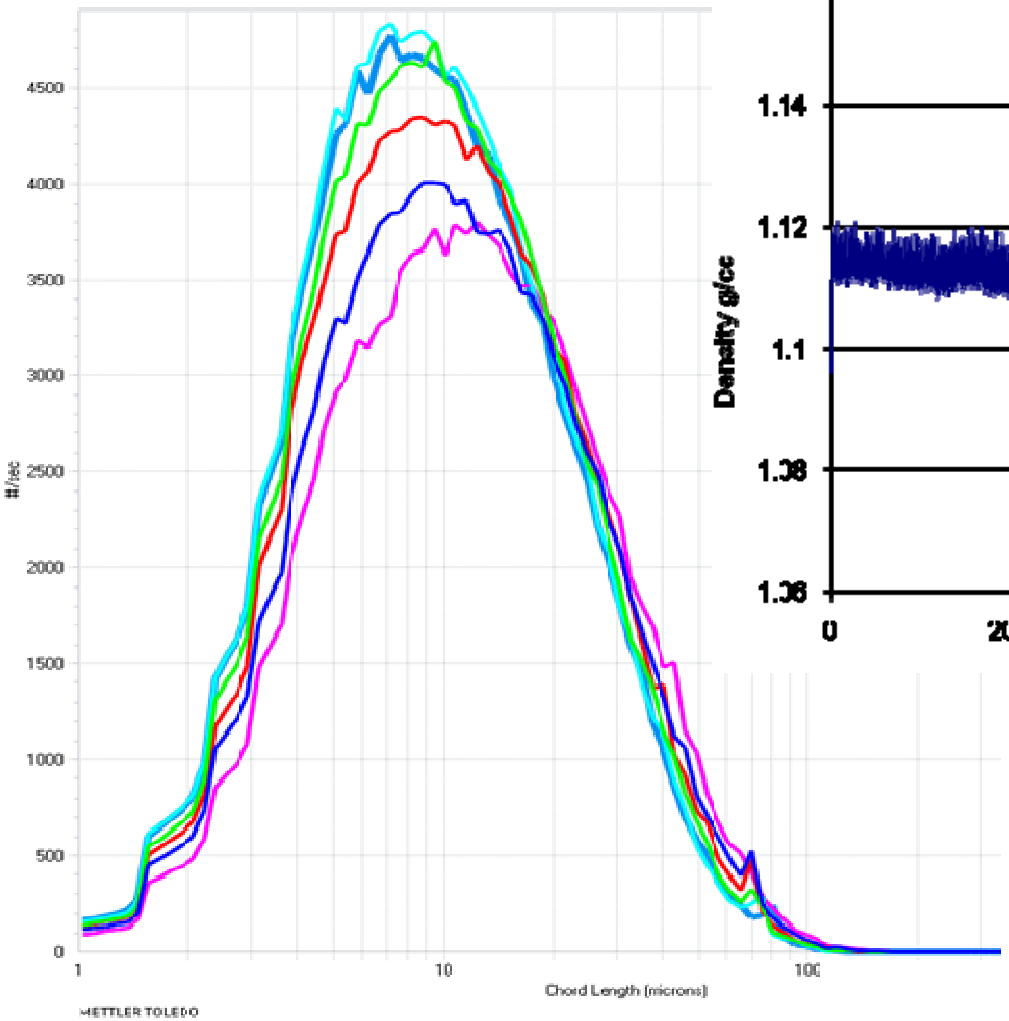
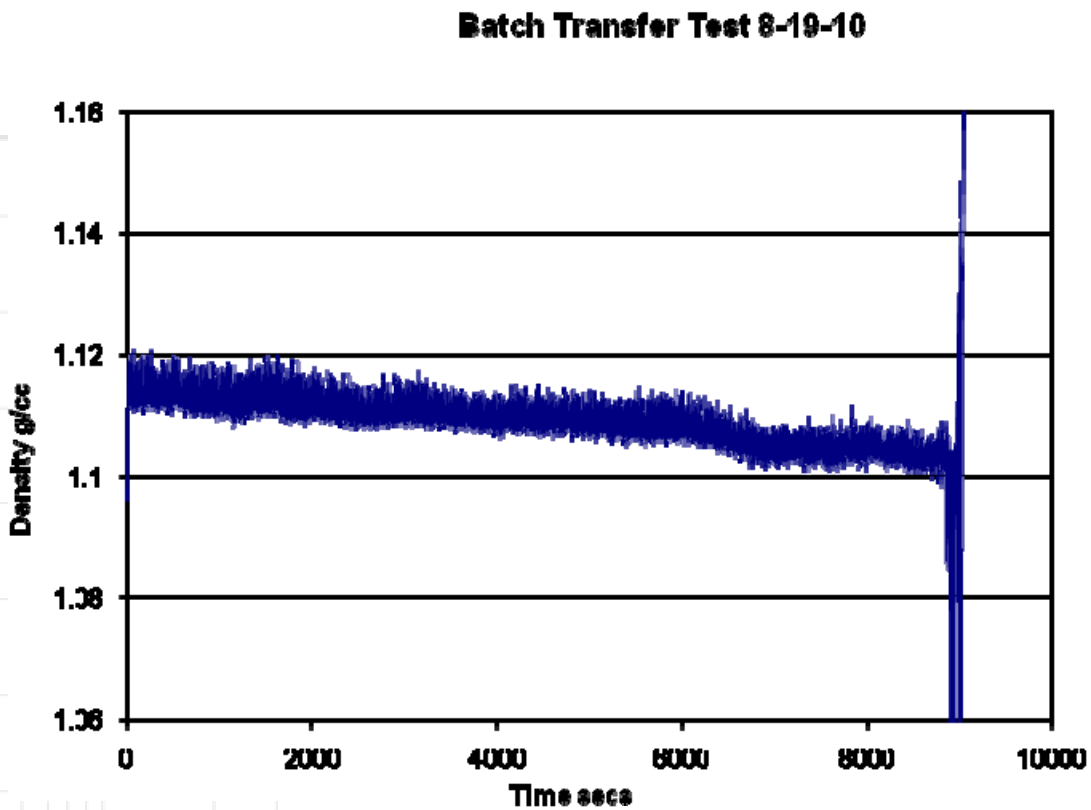
Batch Transfer Performance





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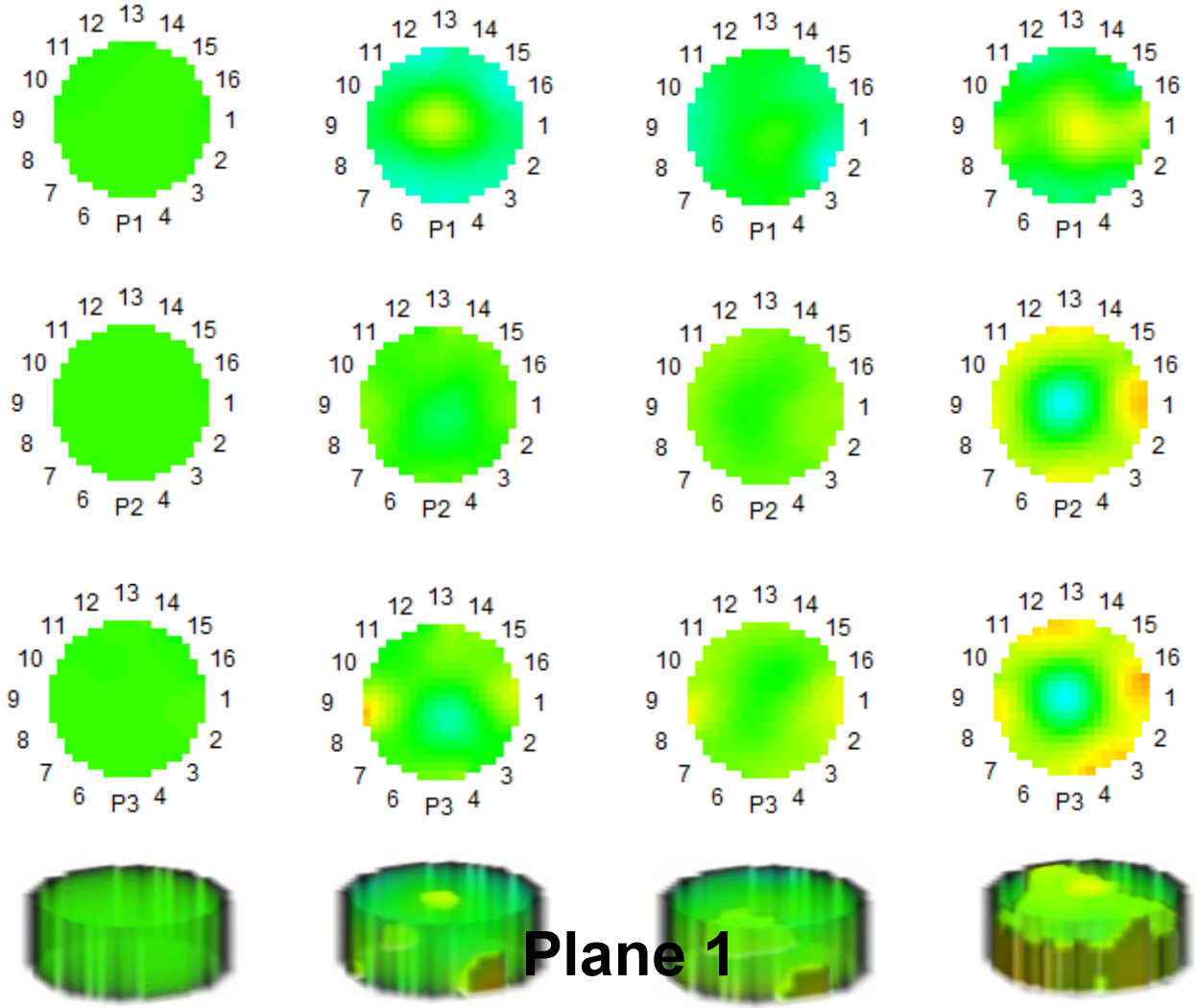
ERT Snapshot



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Biologic Optical Receptors

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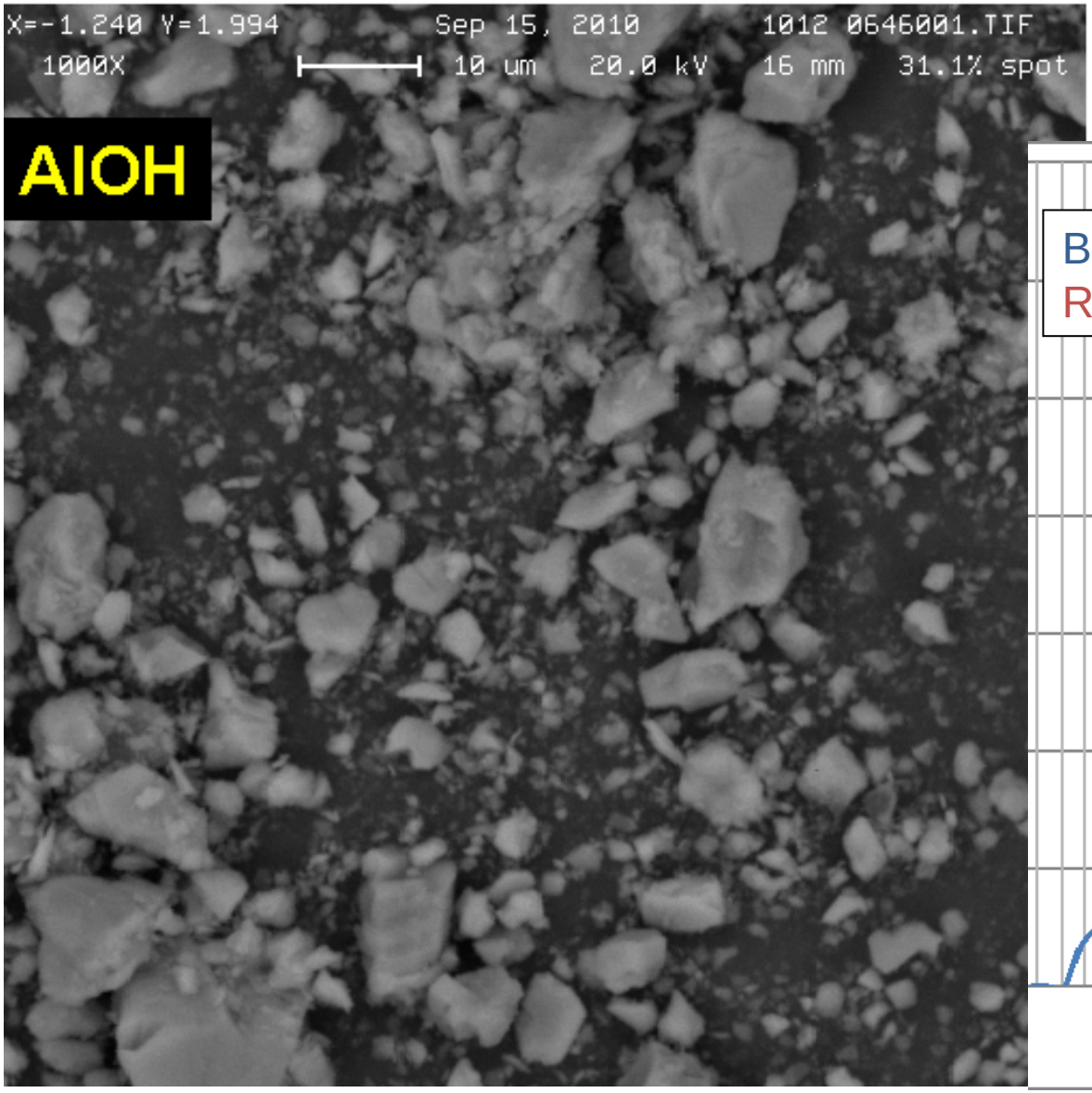
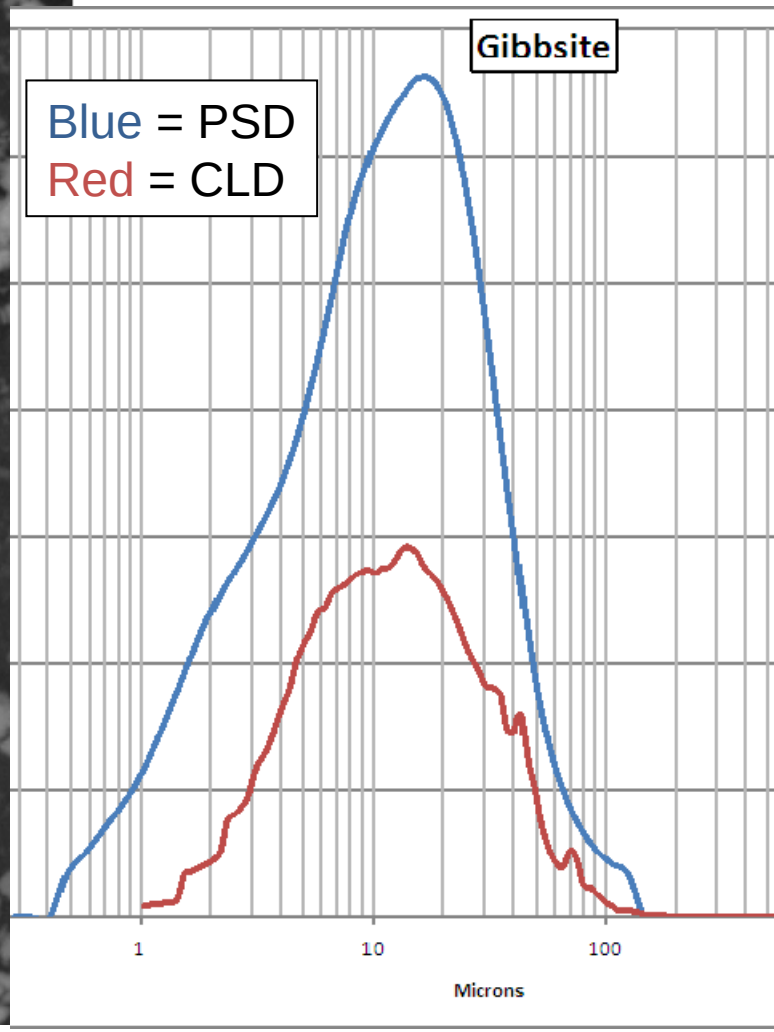
Simulant – Aluminum Hydroxide (gibbsite)



S.G. = 2.4
50 percentile = 10µ



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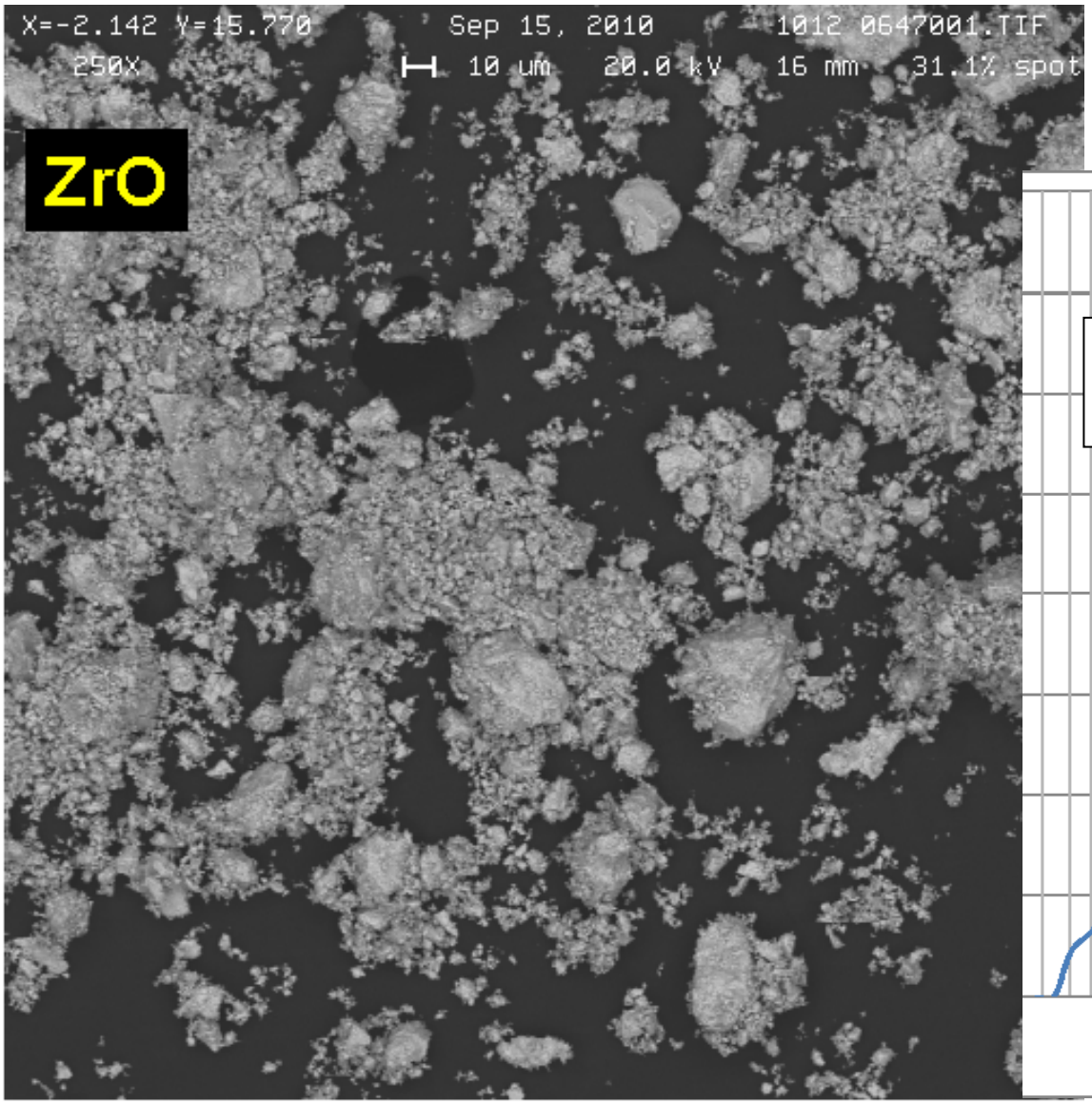
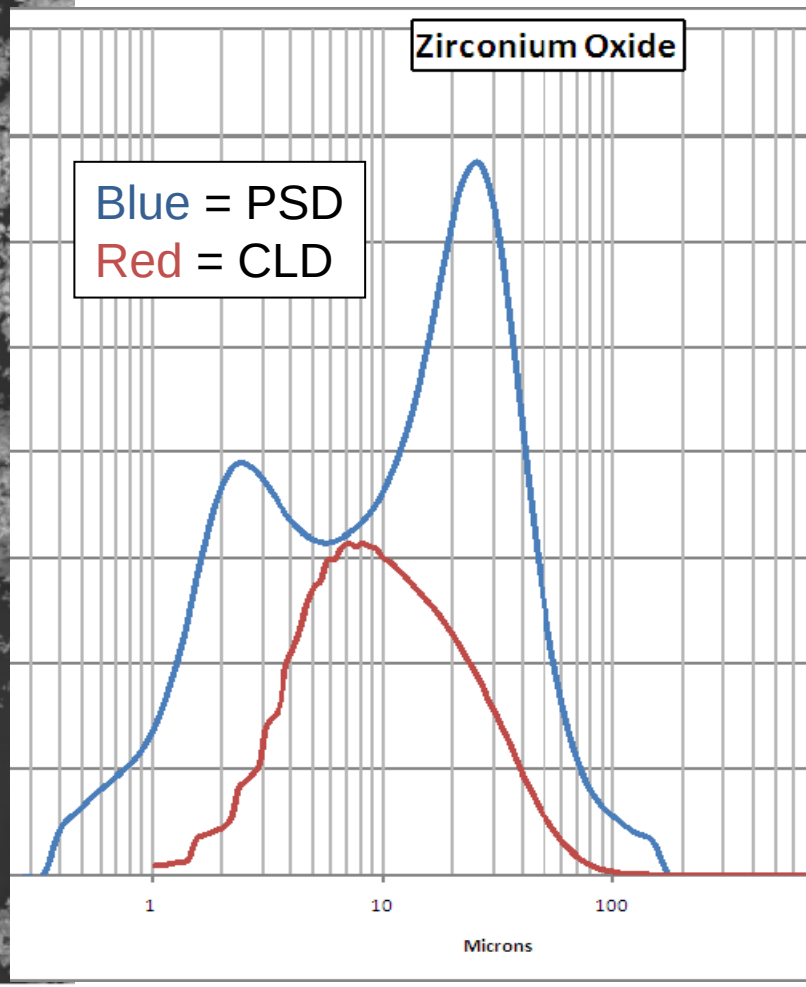
Simulant – Zirconium Oxide



S.G. = 5.5
50 percentile = 11µ



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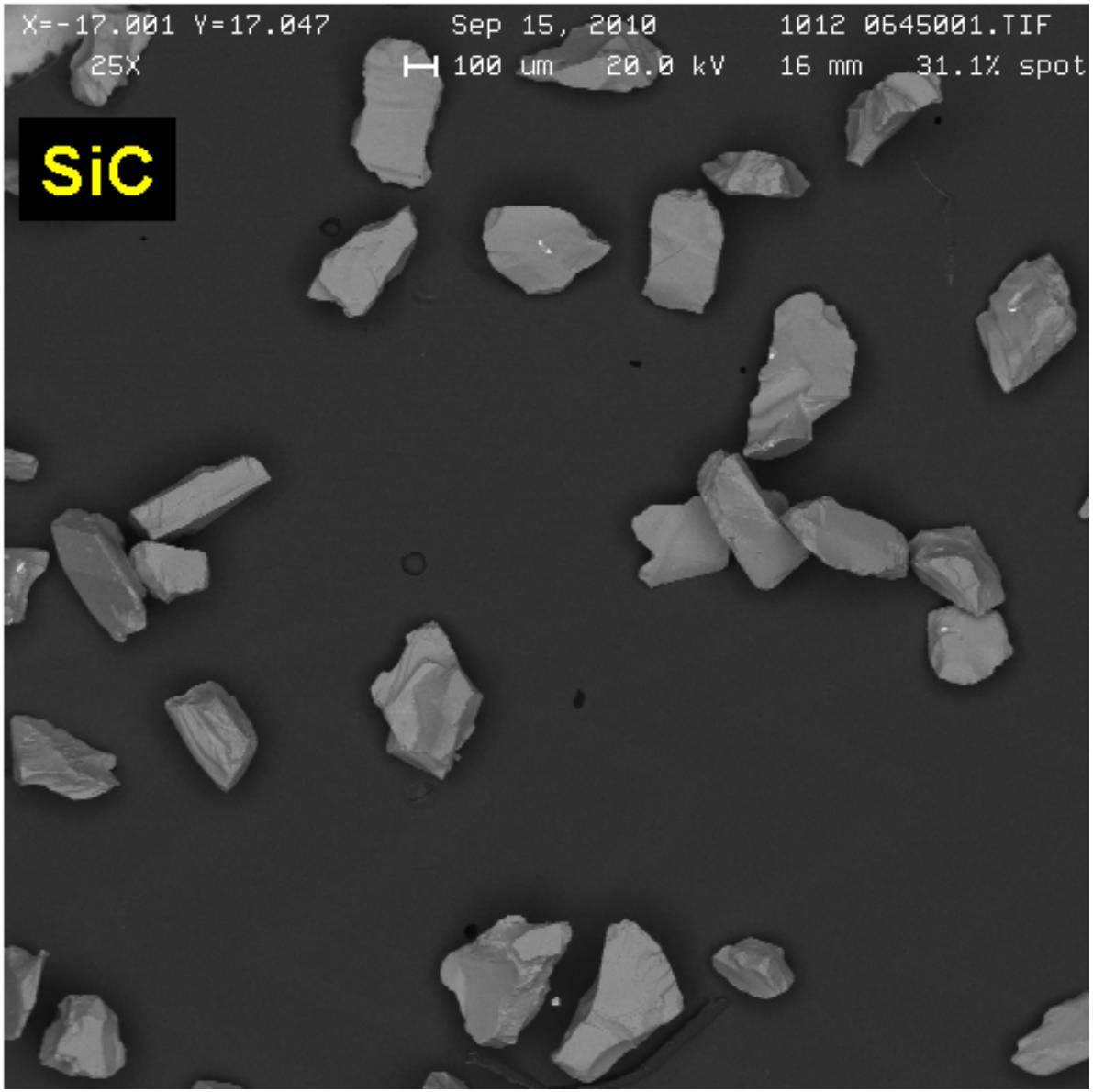
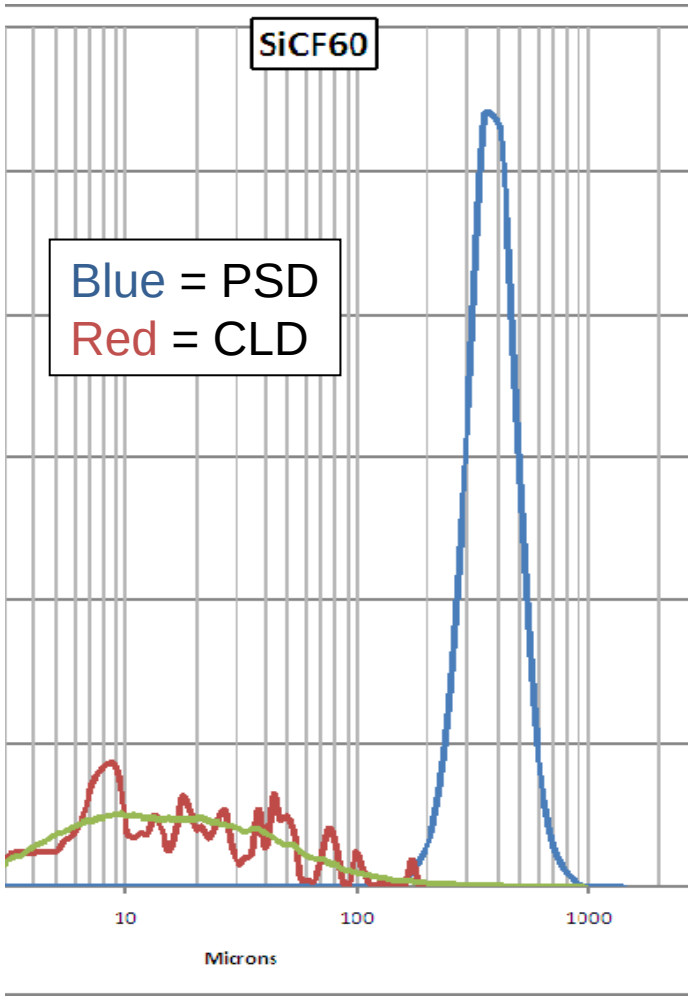
Simulant – Silica Carbide



S.G. = 3.2
50 percentile = 347µ



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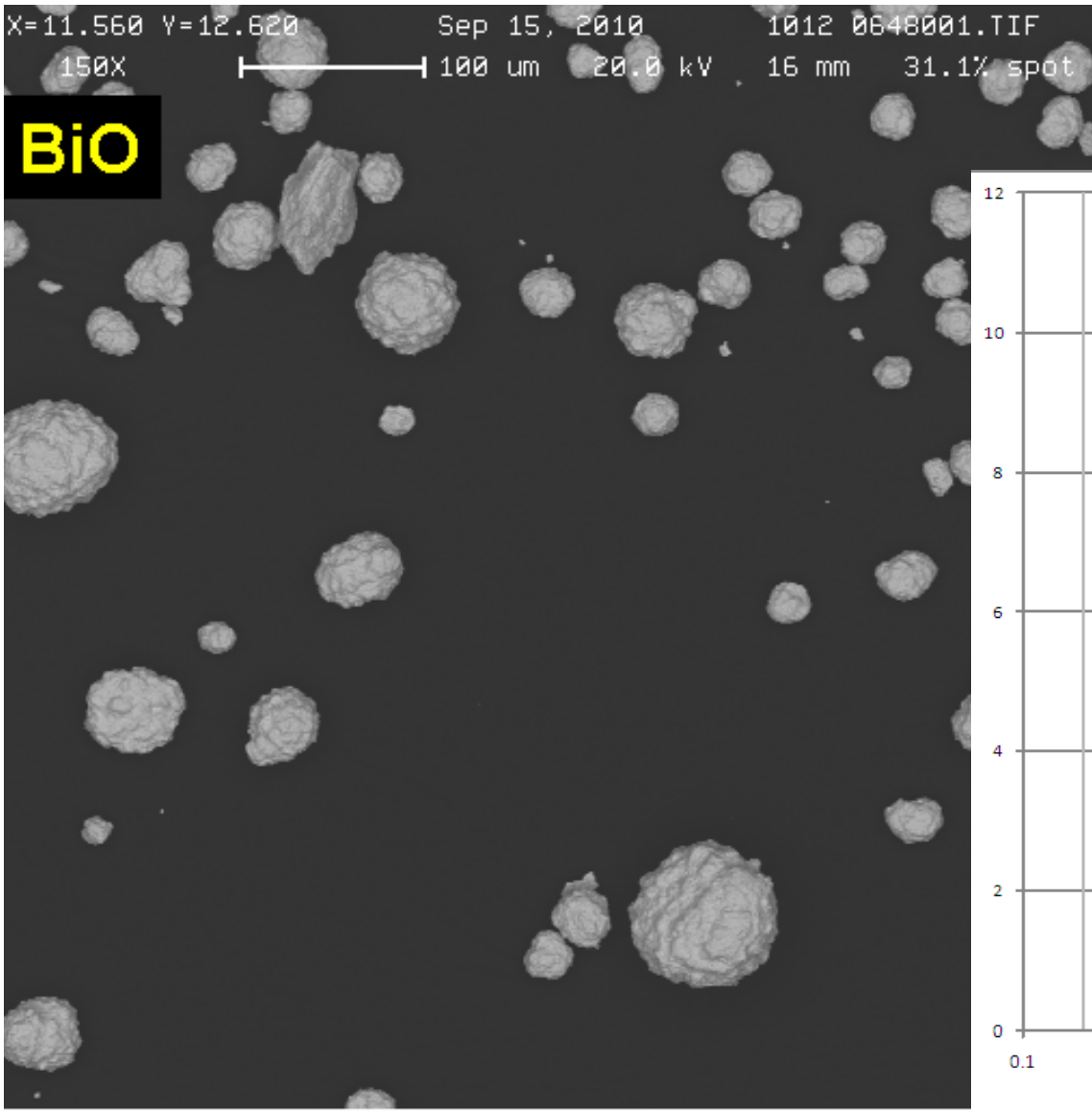
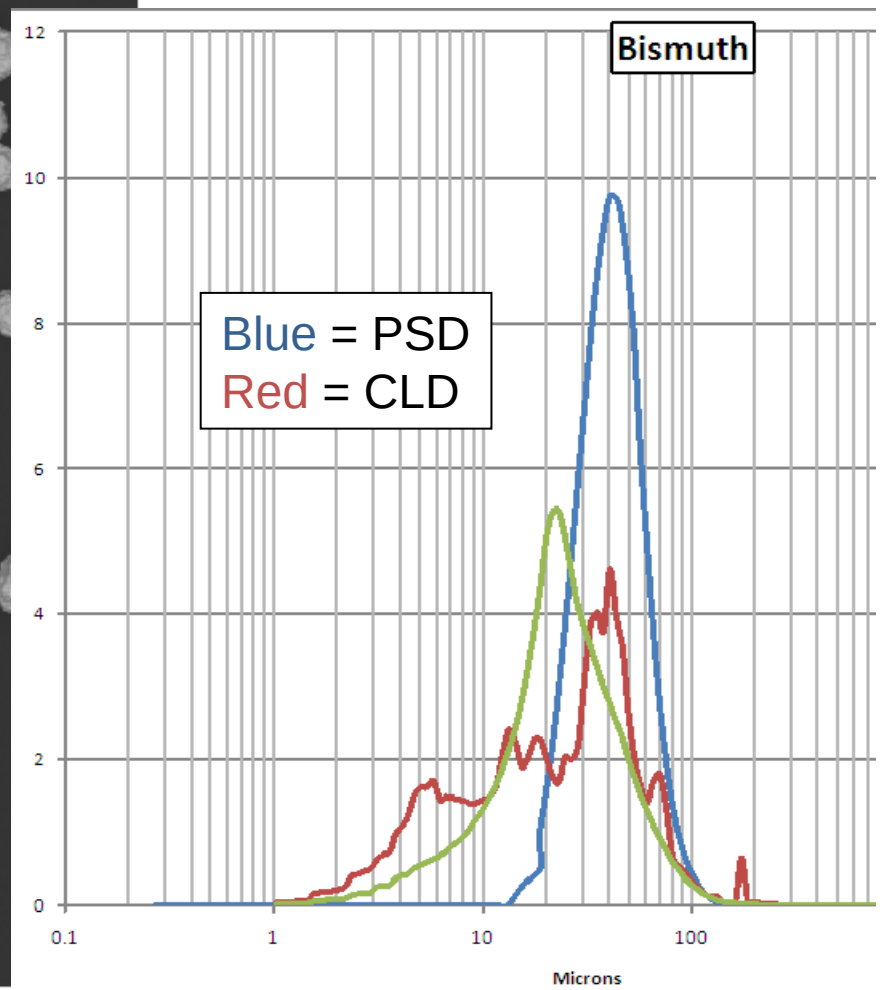
Simulant – Bismuth Oxide



SG = 8.9
50 percentile = 39µ



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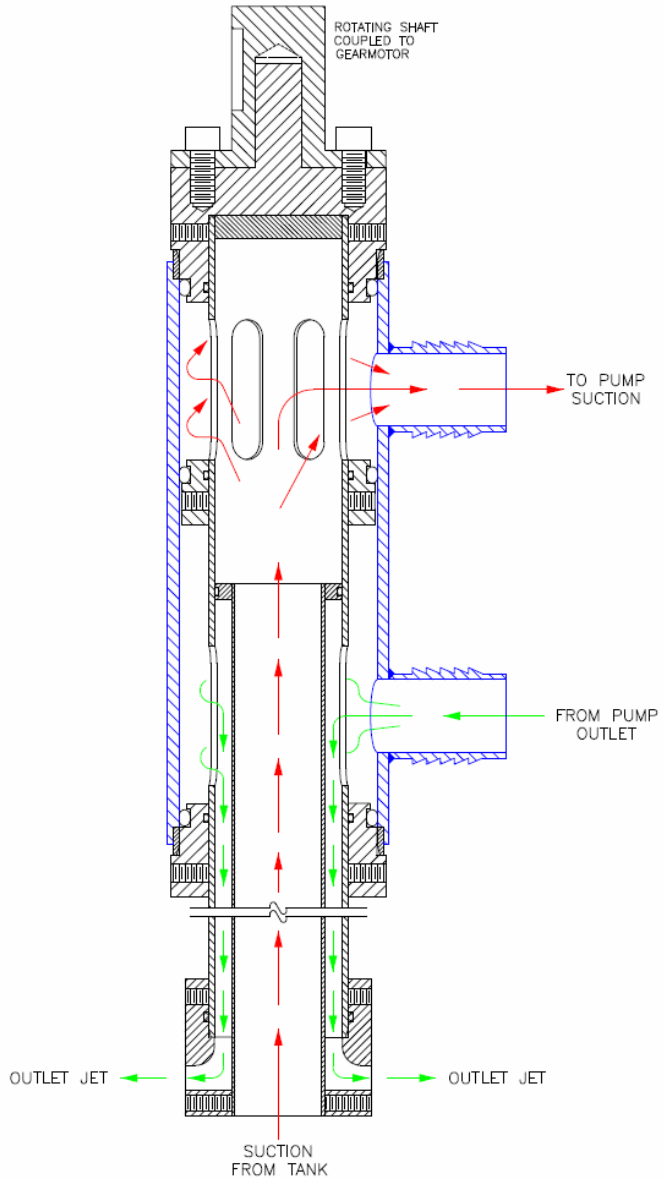
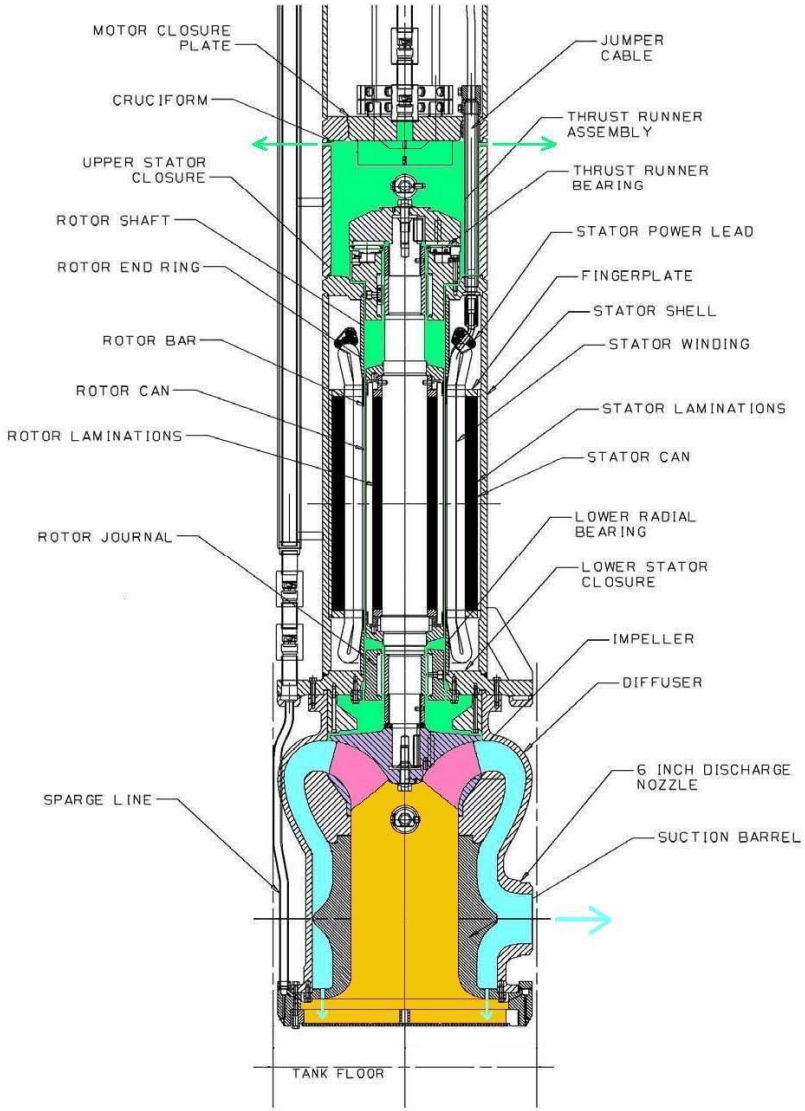
Scaled and Full Size Mixer Pumps





Critical Velocity

Critical velocity is one of the most significant WTP acceptance parameters identified in ICD-19

Currently only theoretically estimated and not measured

$$v_{cr} = \sqrt{g\, d_p \left(\frac{\rho_s}{\rho_L} - 1\right)}\; 1.85 C_s^{0.1536} C_L^{0.3564} \left(\frac{d_p}{D}\right)^{-0.378} \left(\frac{D \rho_L \sqrt{g\, d_p \left(\frac{\rho_s}{\rho_L} - 1\right)}}{\mu_L}\right)^{0.09} \chi^{0.30}$$

Analytical Measurement

d_p = median particle diameter, d_{50}

ρ_L = liquid density

ρ_s = solids density

C = solids volume fraction

C_L = liquid volume fraction $(1 - C_s)$

μ_L = liquid viscosity

v_s = particle settling velocity

Theoretical Estimate

v_{cr} = critical velocity

χ = eddy velocity factor

Constant

g = gravitational acceleration

D = pipe inside diameter

From RPP-5346