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## **KiOR UPDATE:**

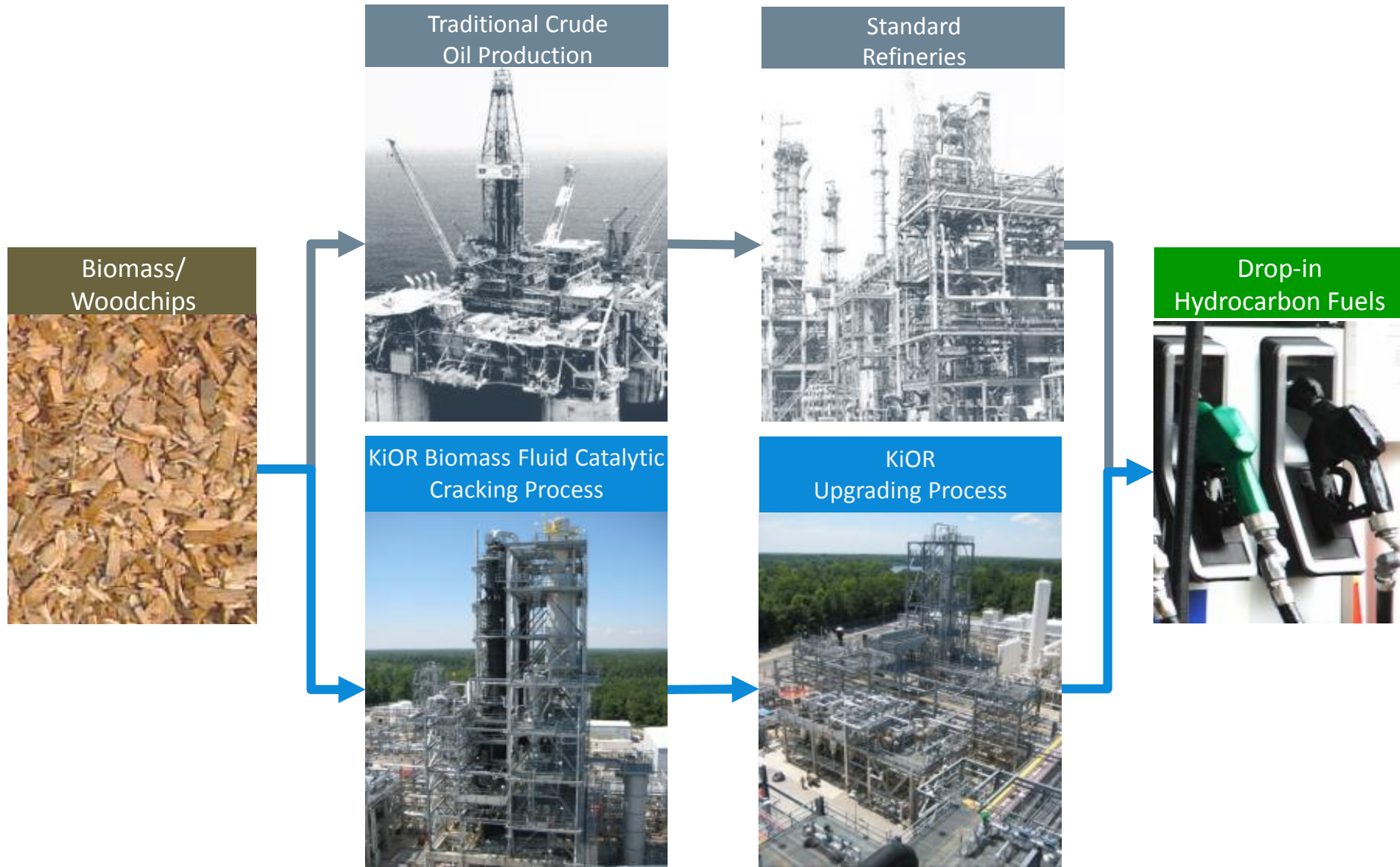
**INCORPORATING BARRACUDA® IN OUR BFCC DEVELOPMENT PROCESS**

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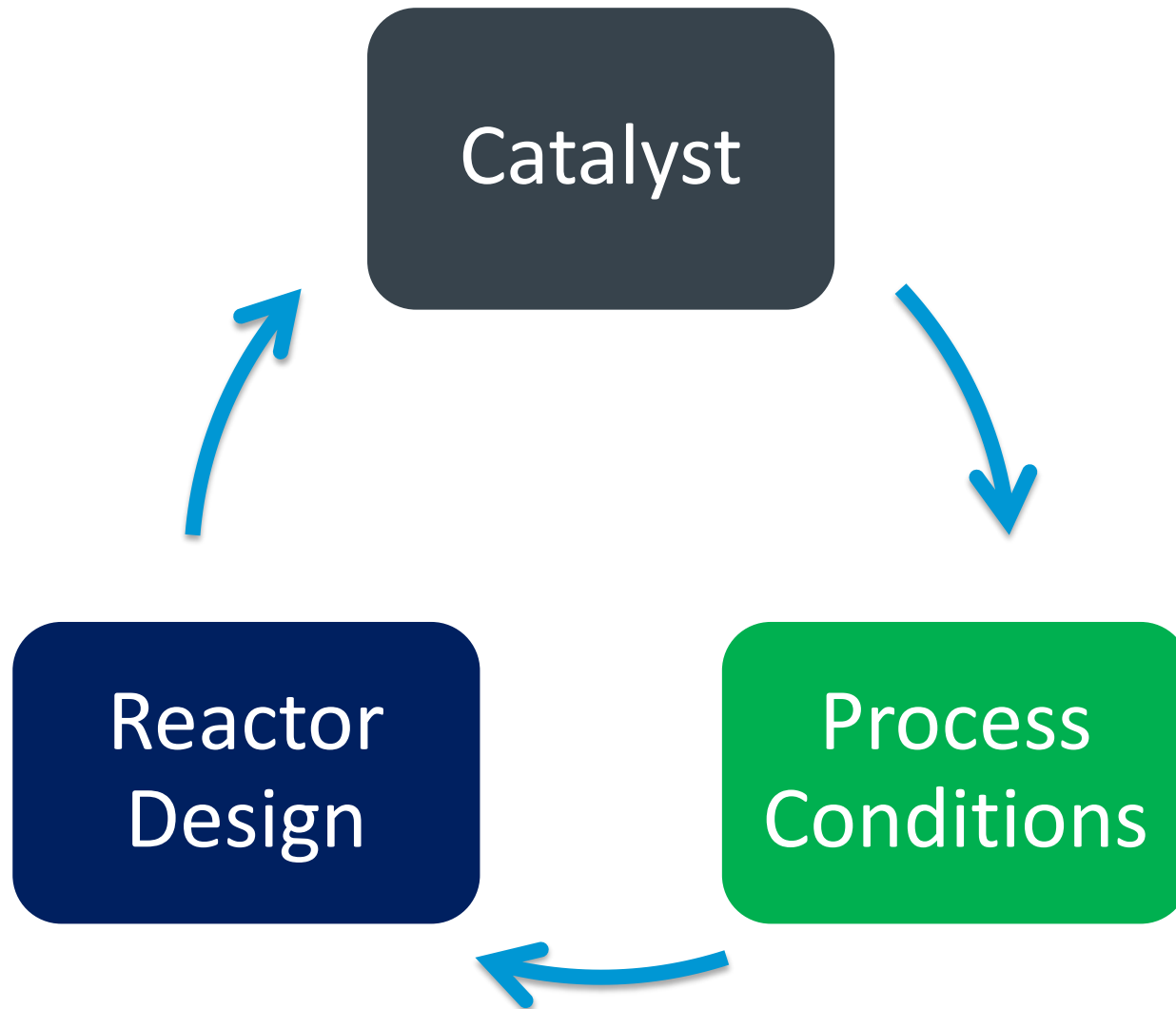
Bruce Adkins and Neeti Kapur, KiOR

James Parker, Peter Blaser and John Pendergrass, CPFD Software

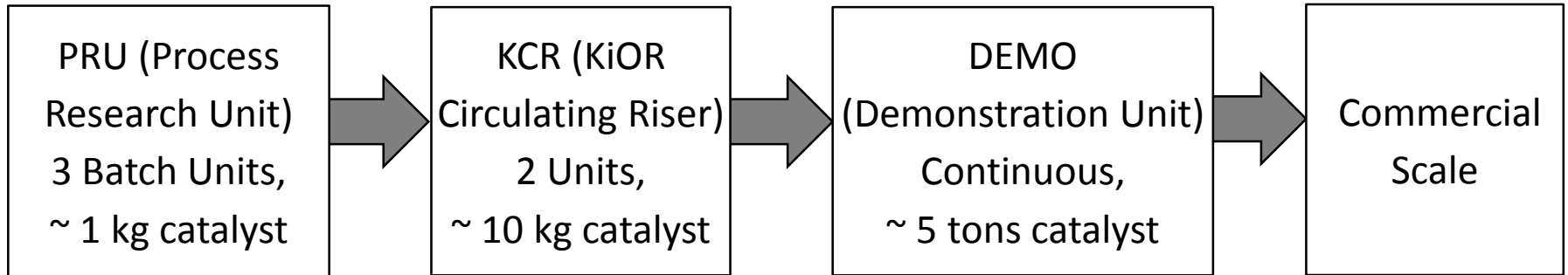
# KiOR Two Step Biomass-to-Fuels Process



# Elements of BFCC Development Process



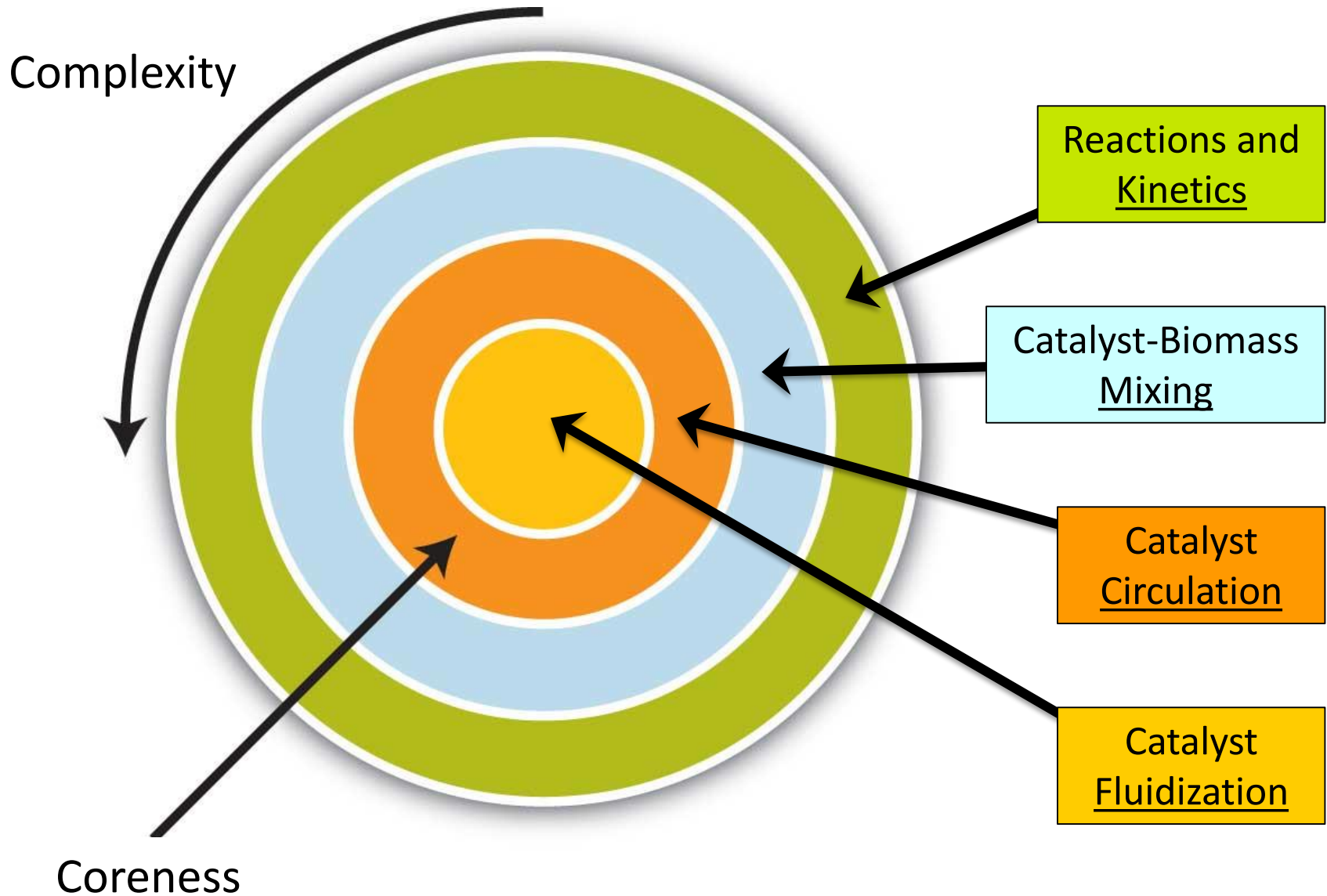
# Objectives of CFD – Development and Scale-up



CFD

1. Add a Parallel Path to our Development Process
2. Speed Scale-up and Commercialization

# Modeling: The Validation Onion



# Model Validation: Layers

1. FFB = Fixed Fluid Bed
2. CFB = Circulating Fluid Bed

Layer	Validation			Primary Model Parameters						N <sub>SIM</sub>
	Cold Flow Unit	Test Unit	Measured Variables	Drag	BAM	Avg Grid Cell Size		U cm/s	Other	
Catalyst Fluidization	FFB <sup>1</sup>	N/A	<ul style="list-style-type: none"> <li>• <math>\Delta P</math> profile</li> <li>• Bed Expansion</li> <li>• Visualization</li> </ul>	<ul style="list-style-type: none"> <li>• Parker</li> <li>• WenYu</li> </ul>	<ul style="list-style-type: none"> <li>• NO</li> <li>• YES</li> </ul>	2D	<ul style="list-style-type: none"> <li>• 4 mm<sup>2</sup></li> <li>• 1 mm<sup>2</sup></li> </ul>	0.5 – 6.0	<ul style="list-style-type: none"> <li>• Catalyst PSD Grade</li> </ul>	46
						3D	<ul style="list-style-type: none"> <li>• 29 mm<sup>3</sup></li> <li>• 3.7 mm<sup>3</sup></li> </ul>	0.5 – 7.0		
Catalyst Circulation	CFB <sup>2</sup>	KCR	<ul style="list-style-type: none"> <li>• <math>\Delta P</math> Profile</li> <li>• Catalyst Holdup</li> <li>• Visualization</li> </ul>			3D	<ul style="list-style-type: none"> <li>• 0.7 mm<sup>3</sup></li> <li>• 0.3 mm<sup>3</sup></li> </ul>	> 1 m/s	14	
							<ul style="list-style-type: none"> <li>• 9.5 mm<sup>3</sup></li> <li>• 3.2 mm<sup>3</sup></li> </ul>			
Catalyst-Biomass Mixing	FFB <sup>1</sup>	N/A	<ul style="list-style-type: none"> <li>• Biomass “Erosion Time”</li> <li>• Mixing Quality: CTF Dist. v Time</li> </ul>	2D	<ul style="list-style-type: none"> <li>• 4 mm<sup>2</sup></li> <li>• 1 mm<sup>2</sup></li> </ul>	1.8 – 3.0	<ul style="list-style-type: none"> <li>• Biomass PSD</li> </ul>	36		
	CFB <sup>2</sup>		TBD	TBD						
Reactions and Kinetics	N/A	PRU	<ul style="list-style-type: none"> <li>• Yields of Oil, Coke, Char, CO, CO<sub>2</sub>, H<sub>2</sub>O, etc.</li> </ul>	TBD						
KCR										

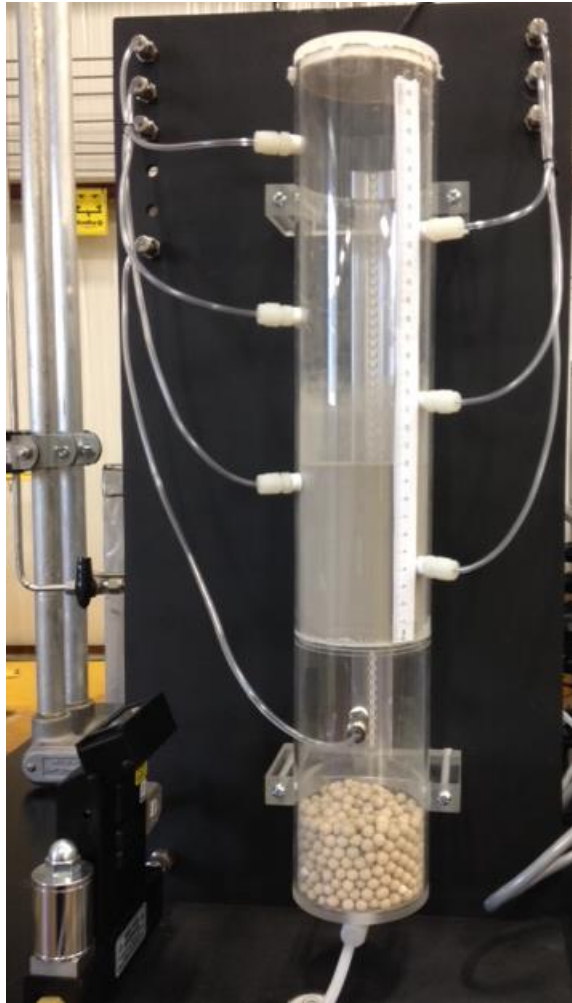
# Cold Flow Units: Fixed Fluid Beds

## 3D FFB

- 32 cm tall
- 7.5 cm id

Main Use:  
Fluidization

Typical:  
350 g Catalyst  
10 cm Bed

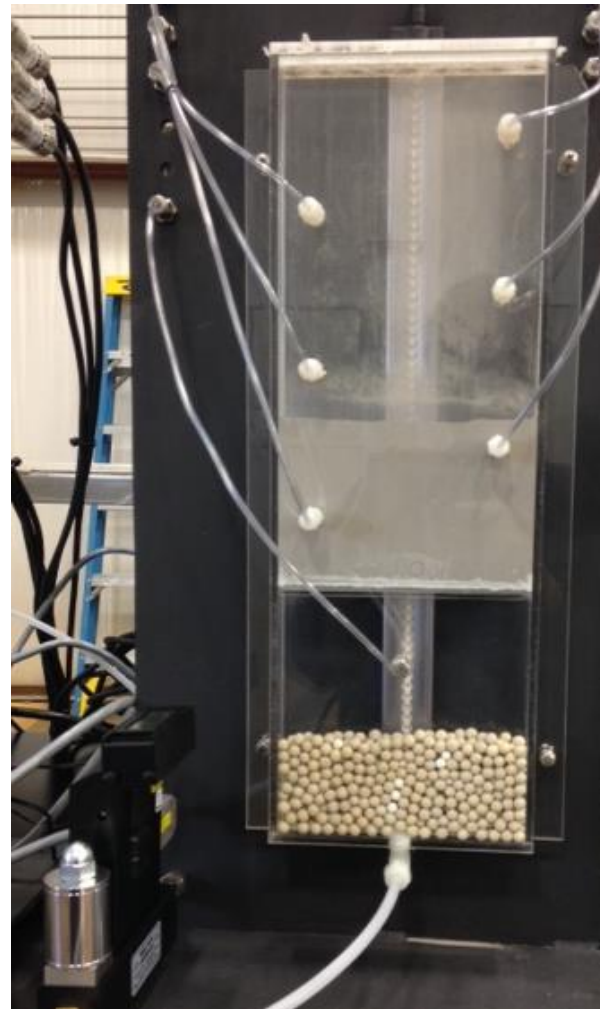


## 2D FFB

- 30 cm tall
- 15 cm wide
- 2 cm deep

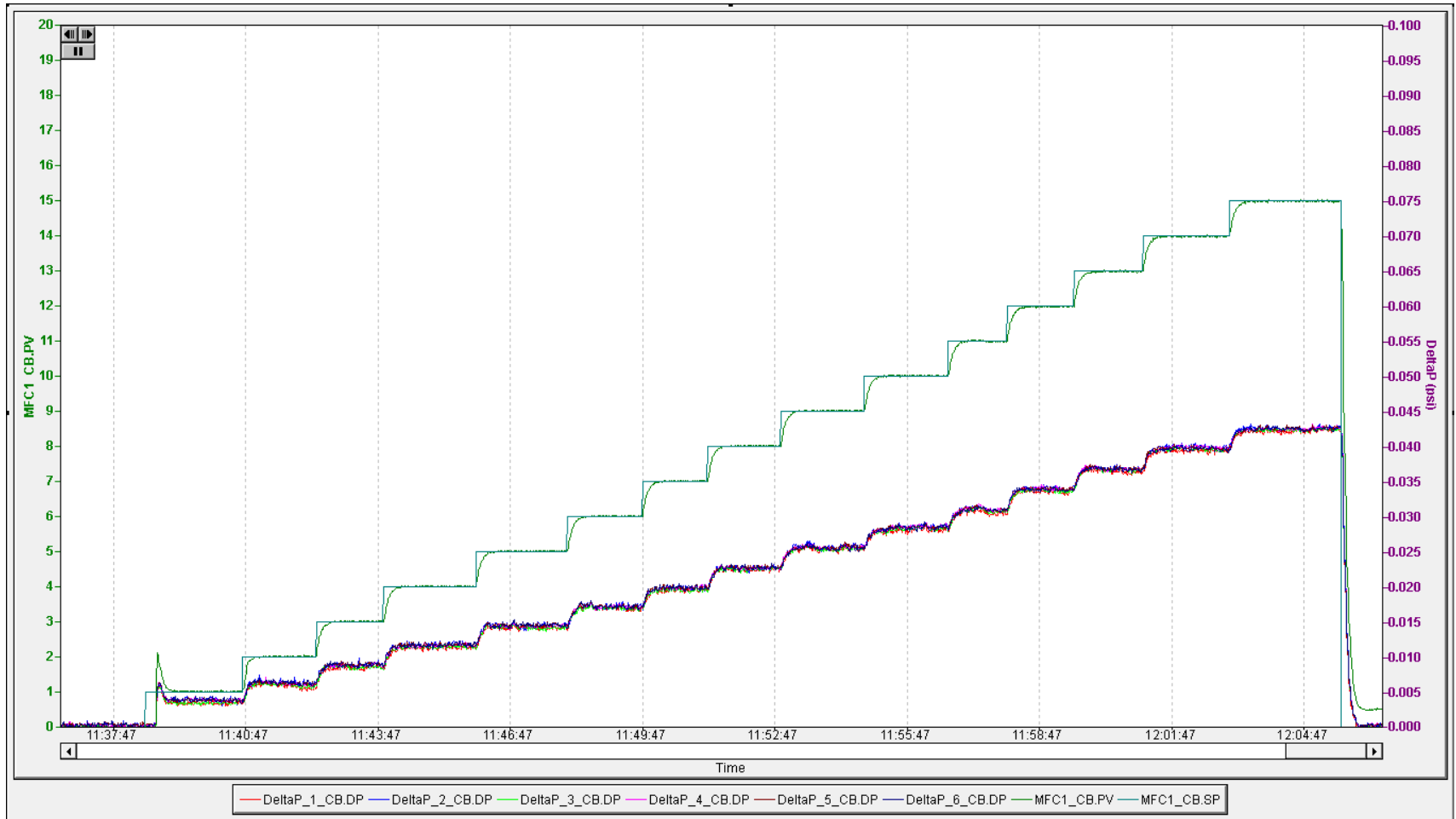
Main Use:  
Mixing

Typical:  
190 g Catalyst  
19 g Biomass  
(CTF = 10)



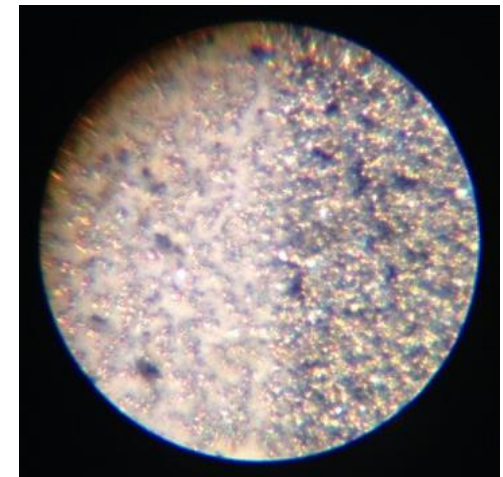
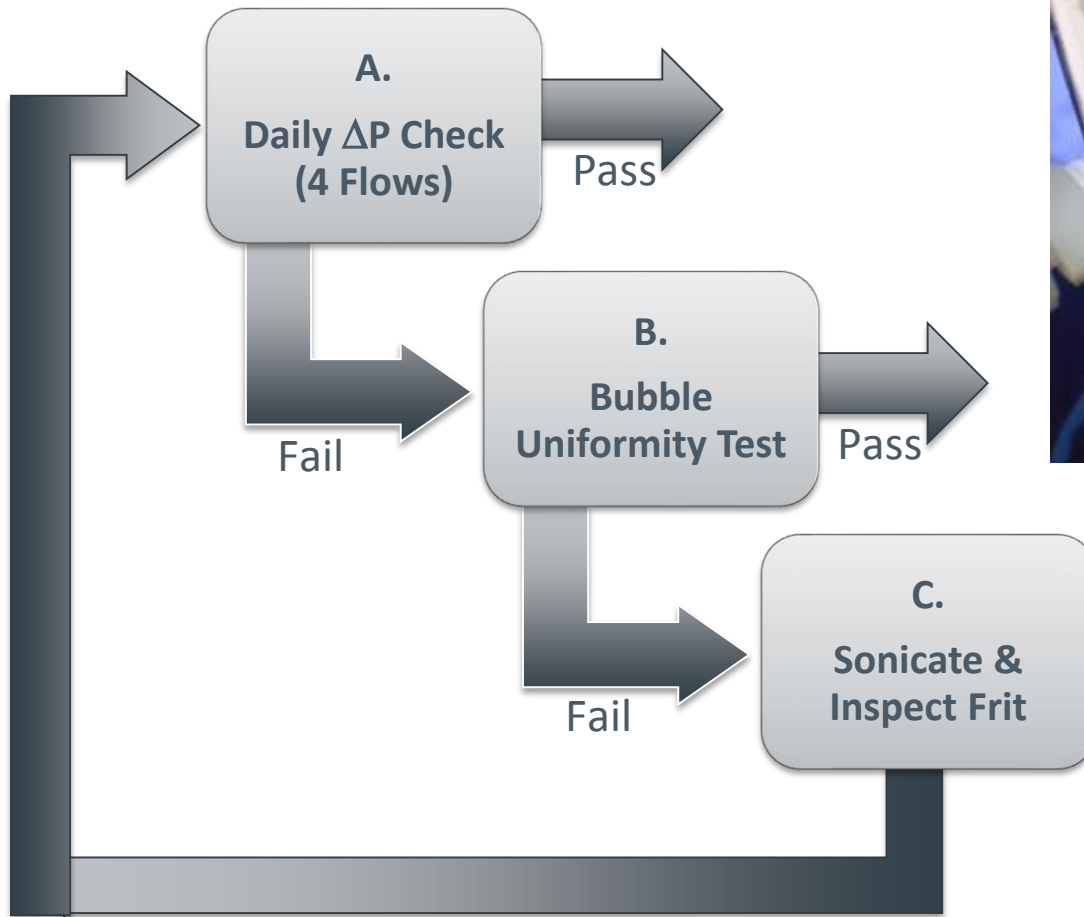
# Experimental Best Practices

## 1. Standardized, Automated Tests with Data Collection

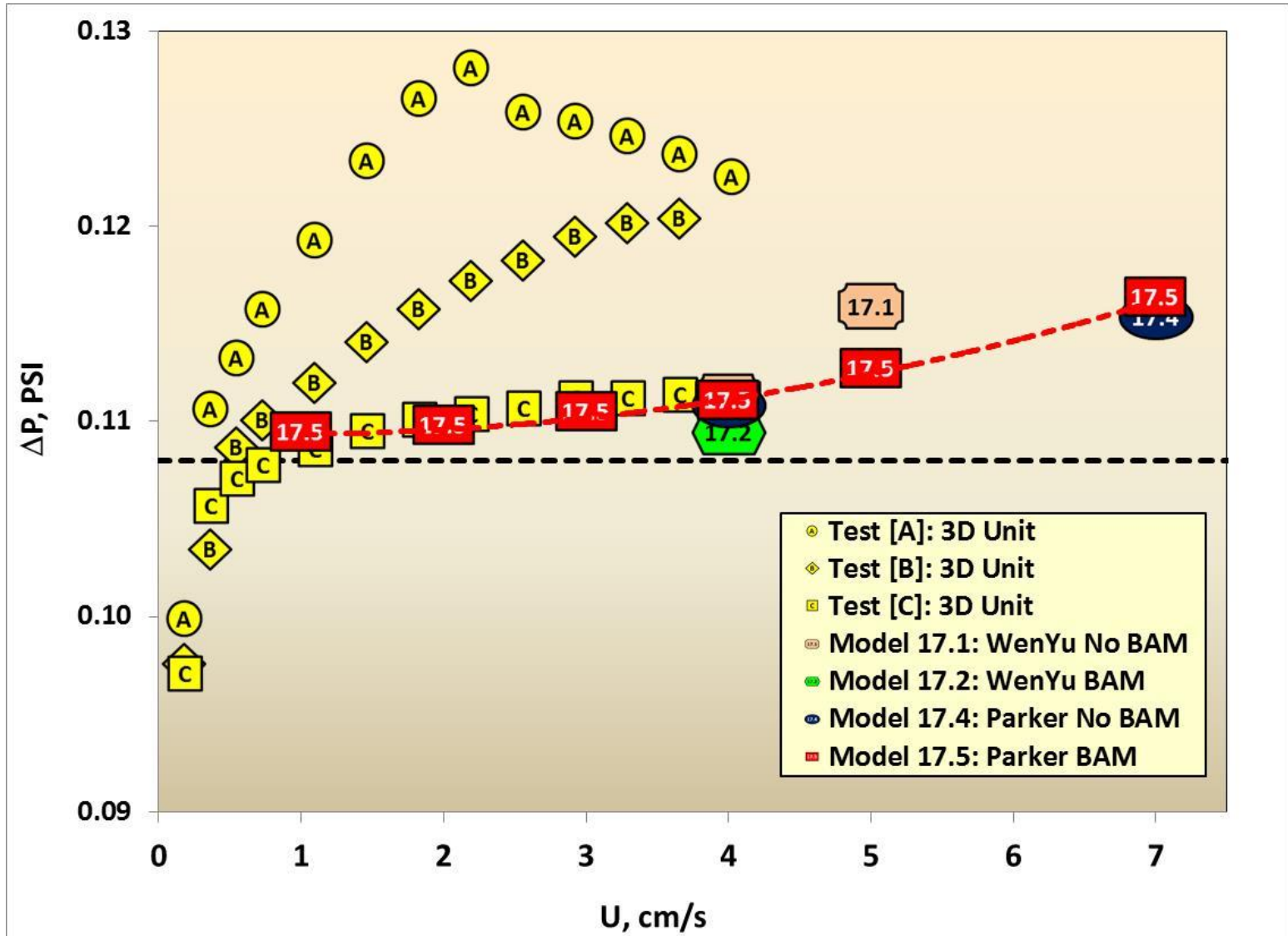


# Experimental Best Practices

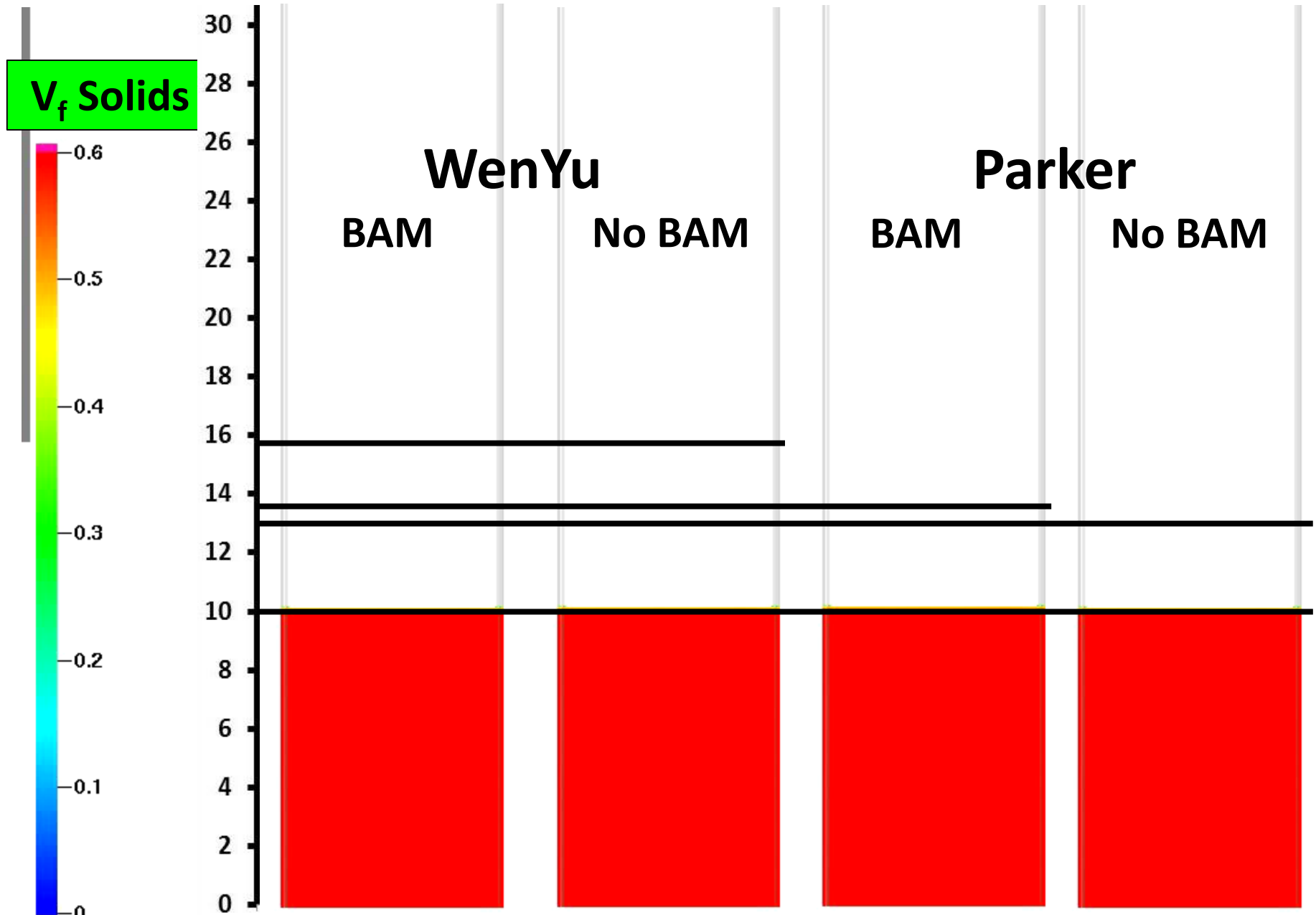
## 2. Frit Maintenance



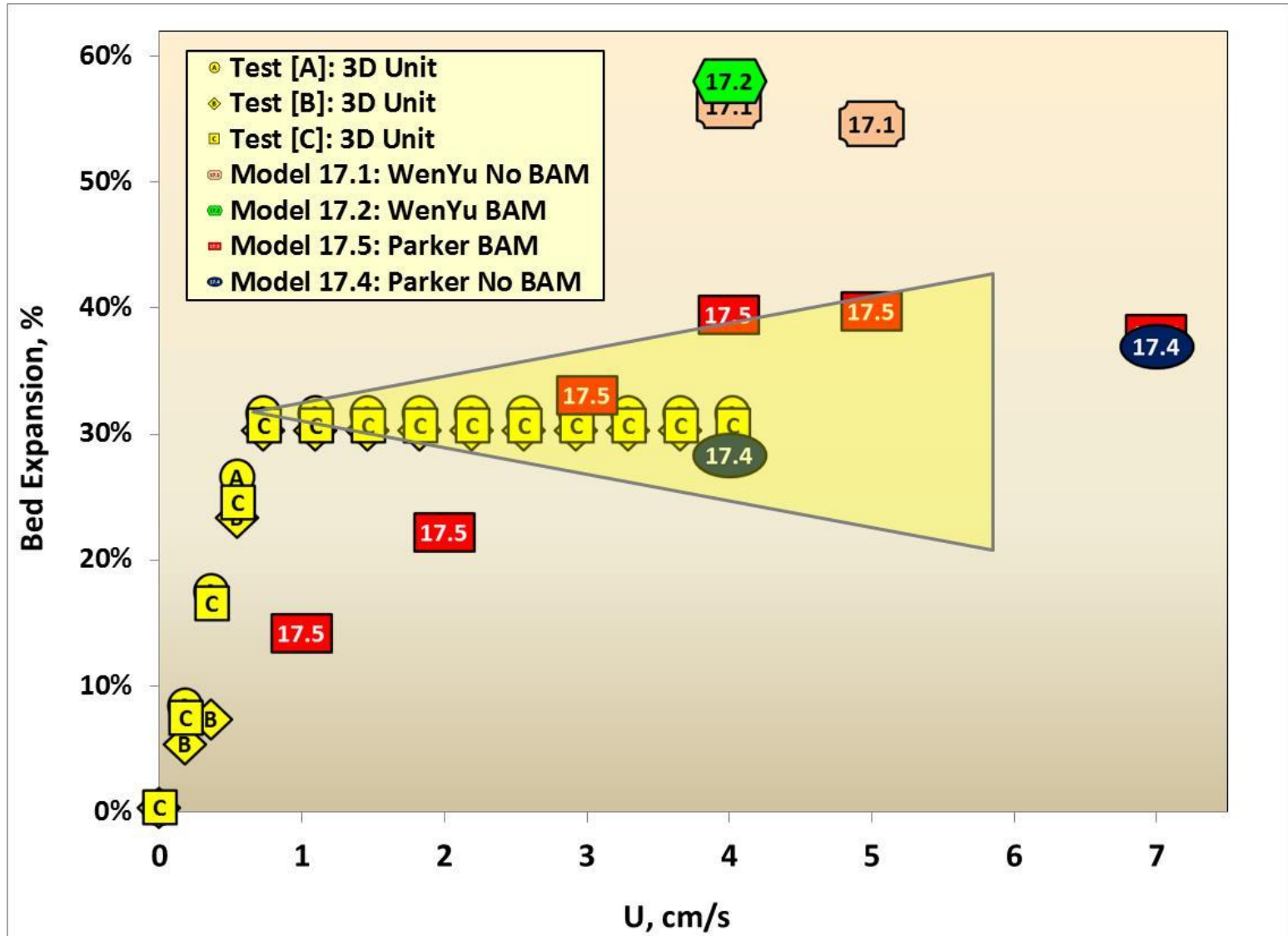
# Bed $\Delta P$ : Measurements v. Simulations



# Bed Expansion: Simulations, $U = 4 \text{ cm/s}$



# Bed Expansion: Measurements v. Simulations

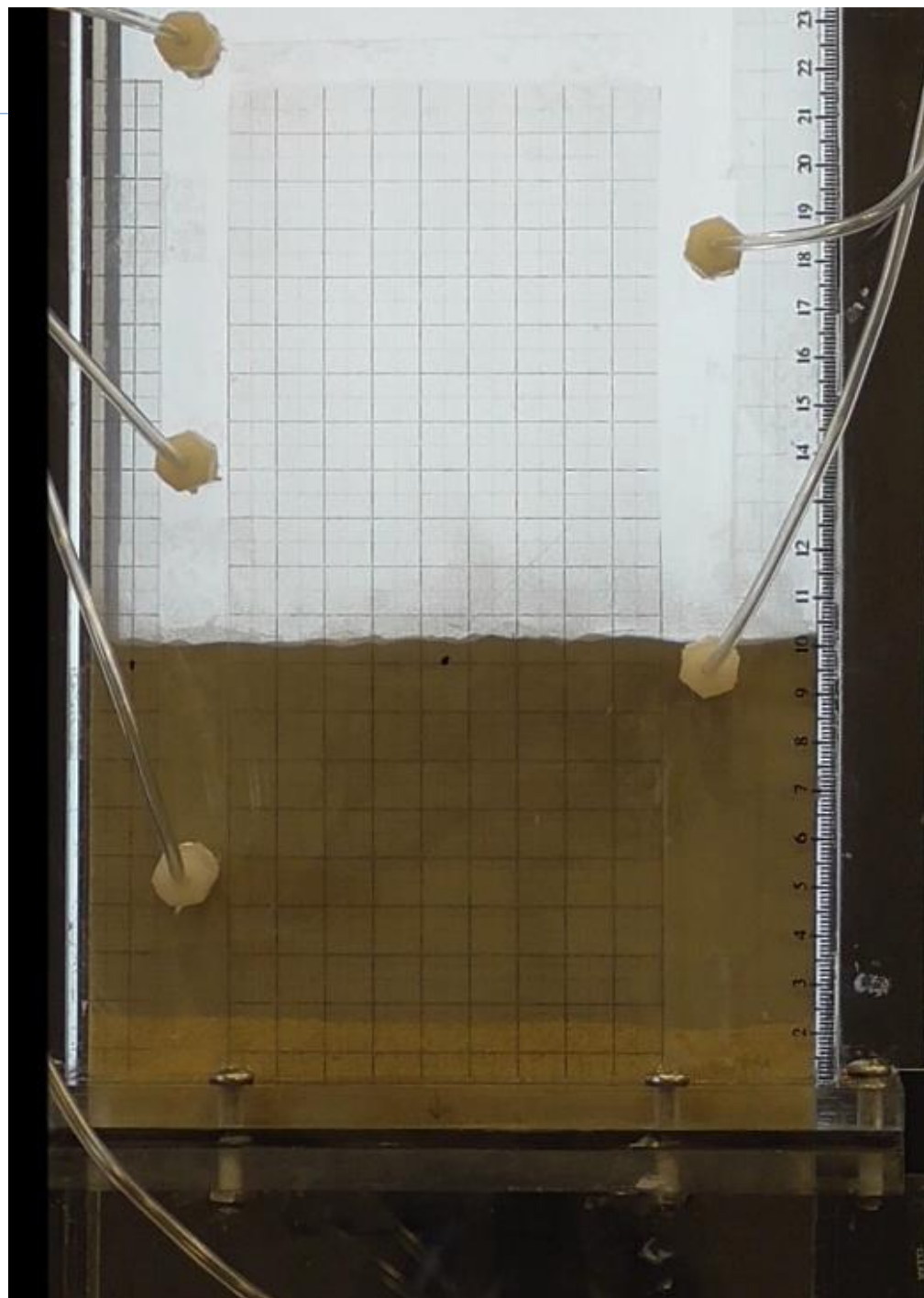


# Catalyst-Biomass Mixing

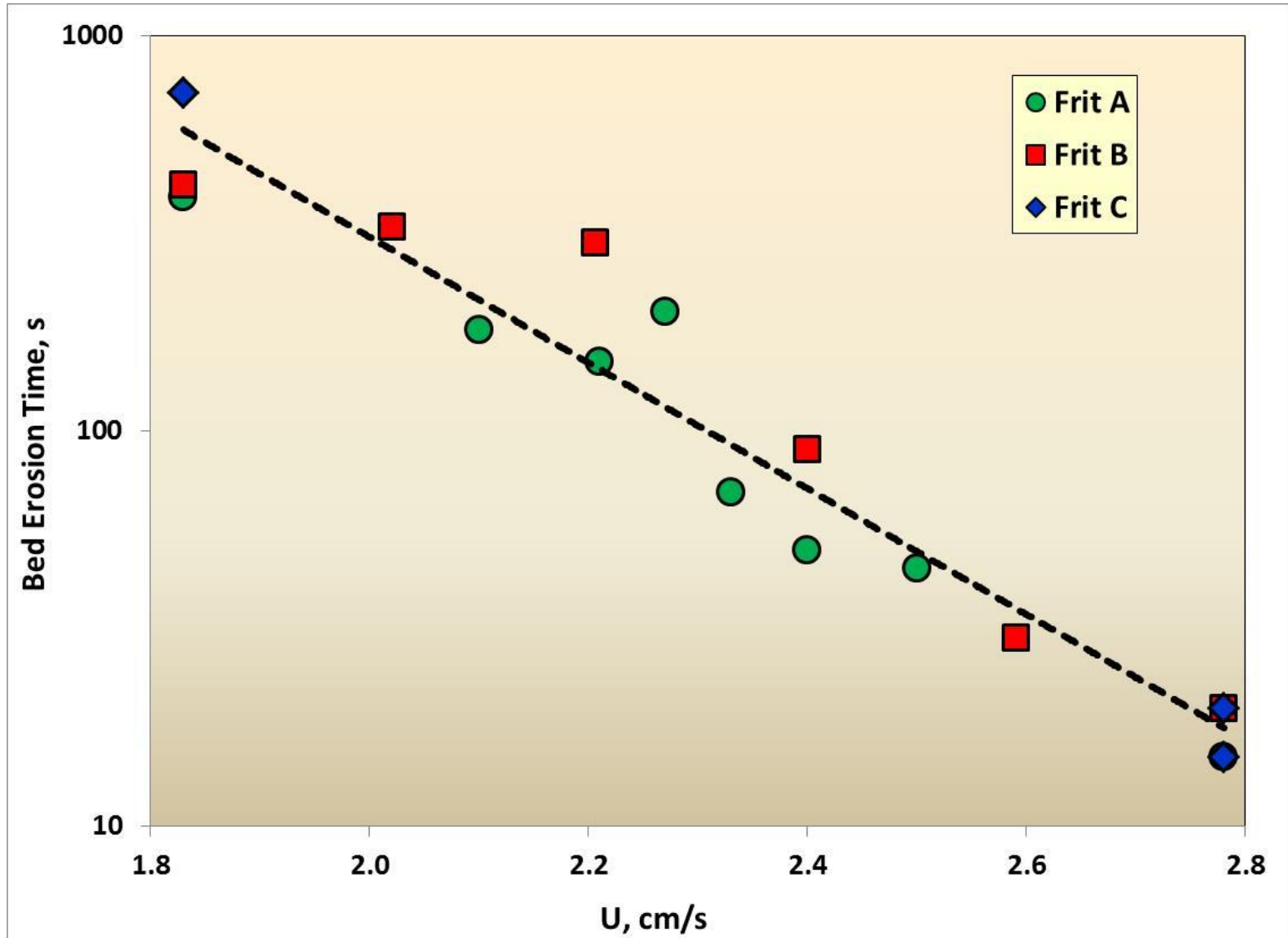
$U = 2.78 \text{ cm/s}$

Bed Erosion Time  $\approx 14 \text{ s}$

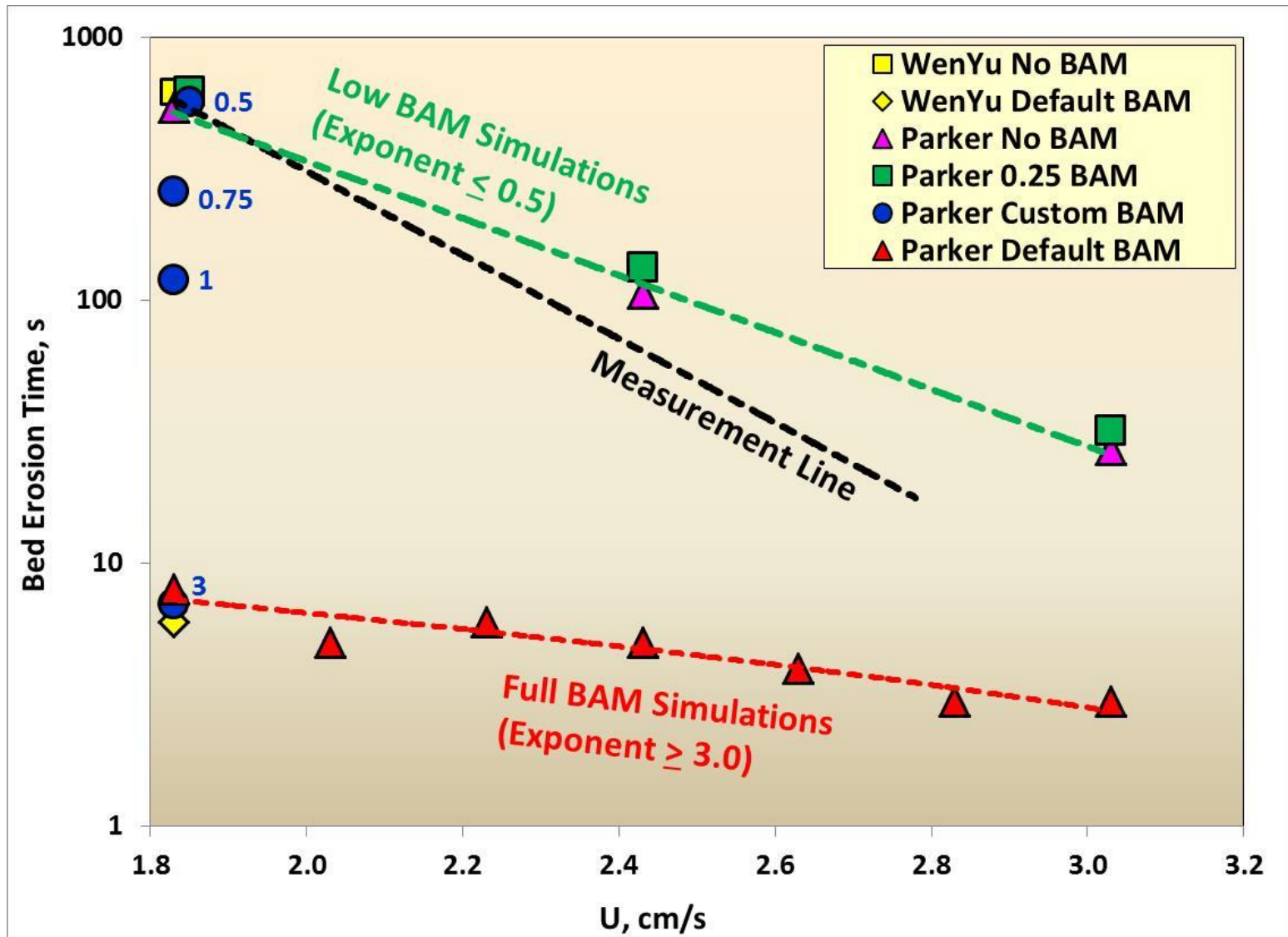
GO



# Bed Erosion Time: Measurements

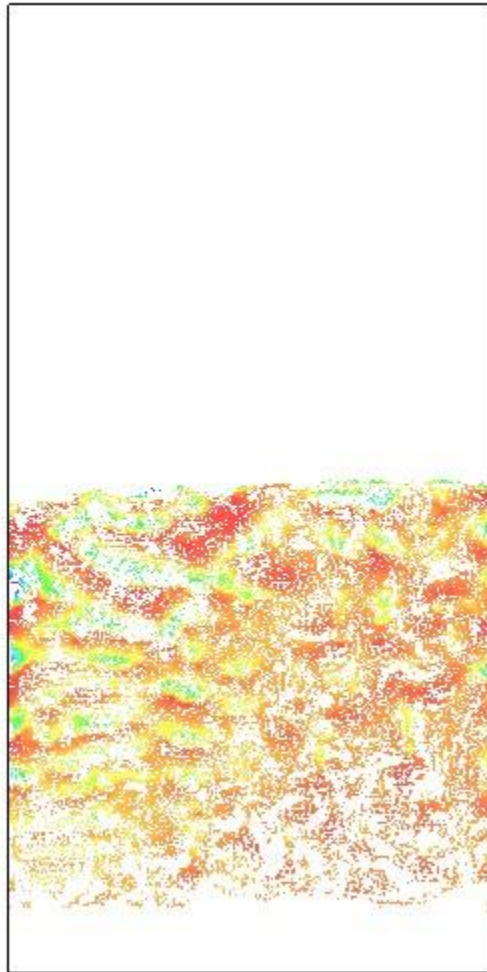
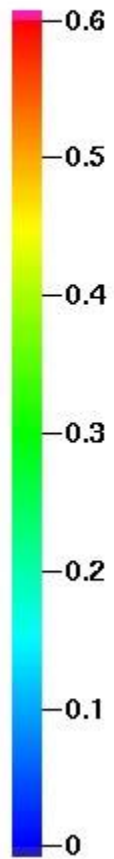


# Bed Erosion Time: Simulations

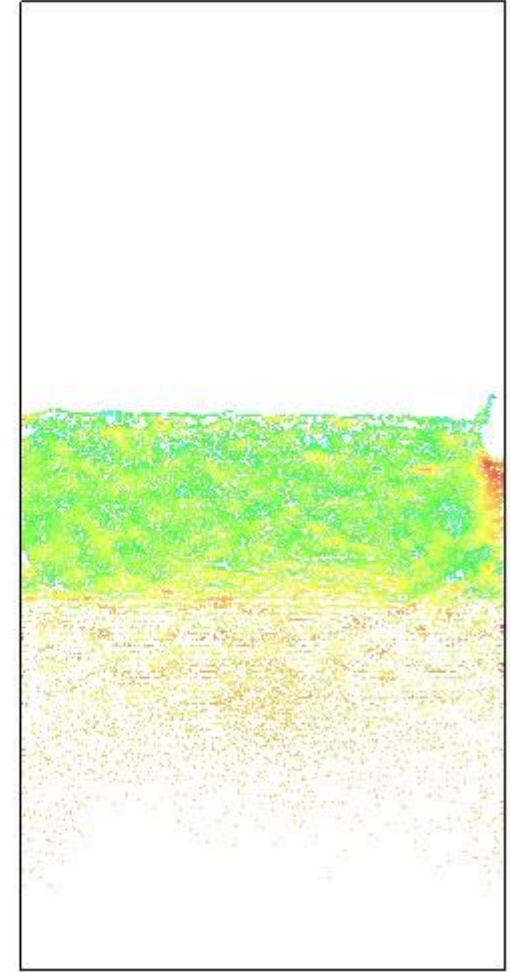
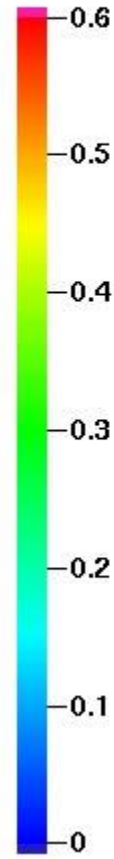


# Biomass Distribution

Particles VolFrac



Particles VolFrac



# Conclusions

1. First and foremost: accurate lab data, obtained meticulously, is essential to model validation
2. In the KiOR BFCC system:
  - a. Fluidization: drag model is most important, followed by BAM and grid resolution
  - b. Catalyst-biomass mixing: use (or not) of BAM is most important, followed by drag model and grid resolution
  - c. Best overall fit between data and model are with Parker drag model and low but non-zero values of BAM exponent
3. Work is continuing, with current focus on mixing and catalyst circulation