

Applications of Tribo-electric Probes in Fluidized Beds

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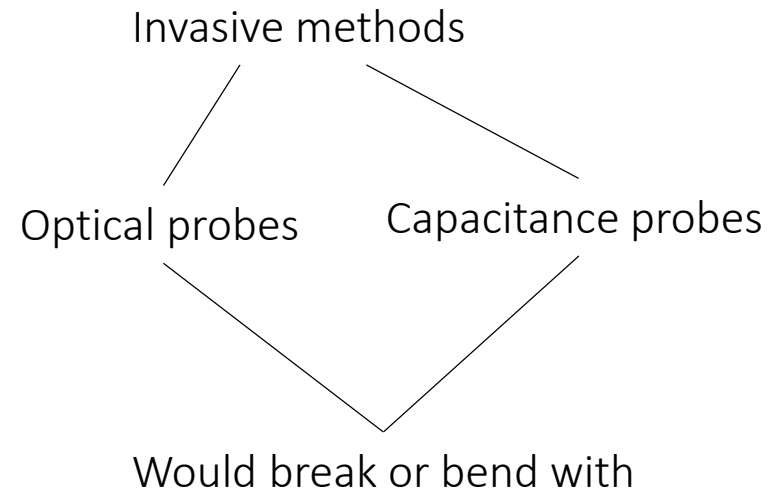
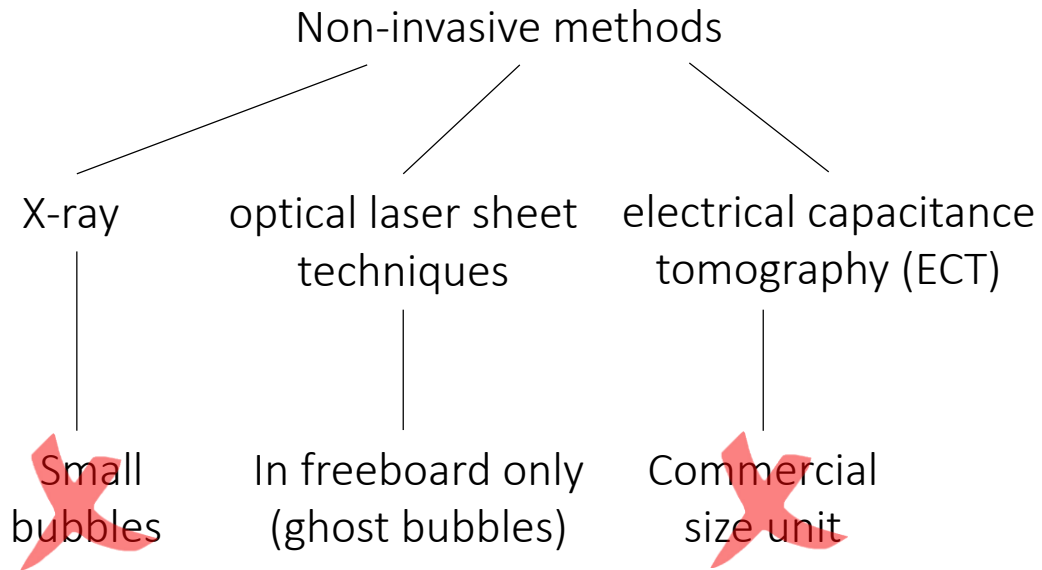
Jennifer McMillan **Syn**crude

May 26th, 2019

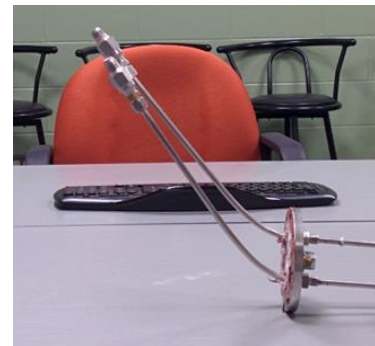
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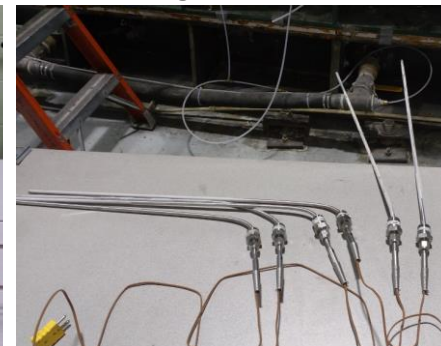
Bubble Characterization Methods in Gas-Solid Fluidized Bed



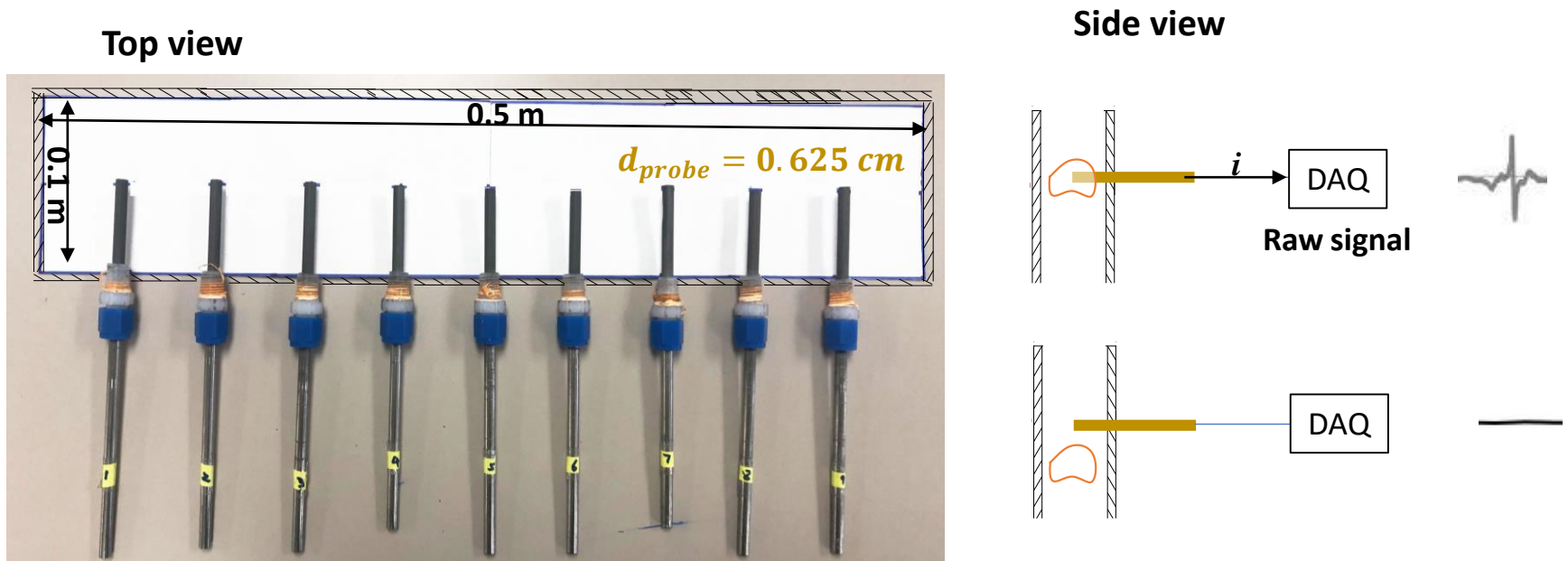
High local bubble flows



Big bubbles



Solution: Tribo-probes



- ✓ High V_g (up to 2 m/s), High temperature (limited by metal)
- ✓ High bed density (1500 kg/m^3), Large equipment

Applications of Tribo-probes

- Slugging check
- Bubble flow profile
- Bubble velocity

With Gas-Liquid Injection:

- Jet penetration

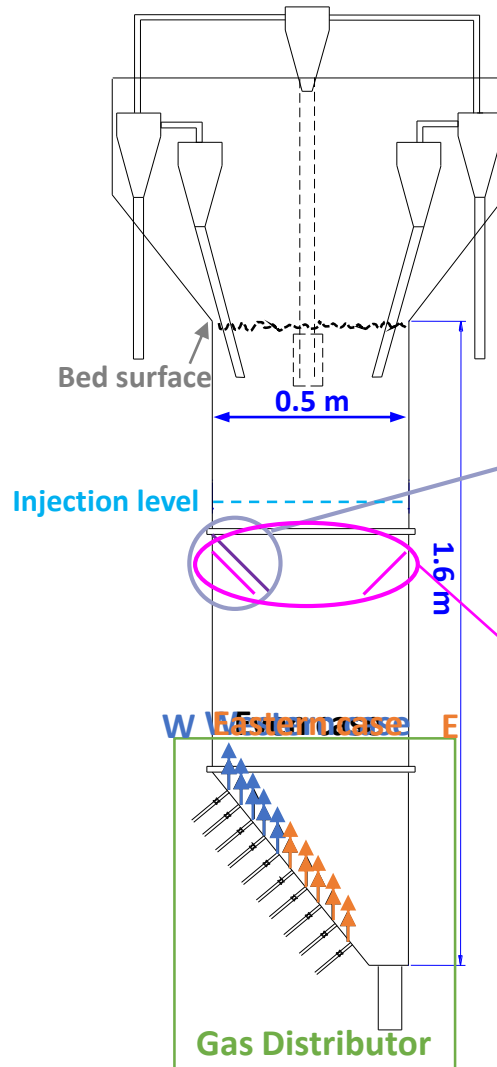
Due to confidential check from Syncrude:

- Liquid distribution (see full paper)
- Local bogging (see full paper)

Experimental set-up

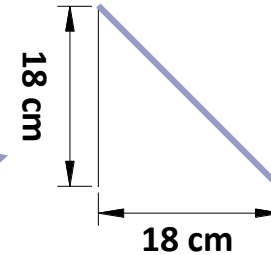
To modify gas bubble distribution

Approach 1:
Change the initial inlet gas distribution configuration

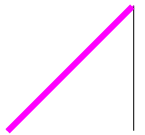
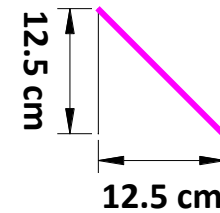


Approach 2: Baffle

a. Asymmetrical baffle

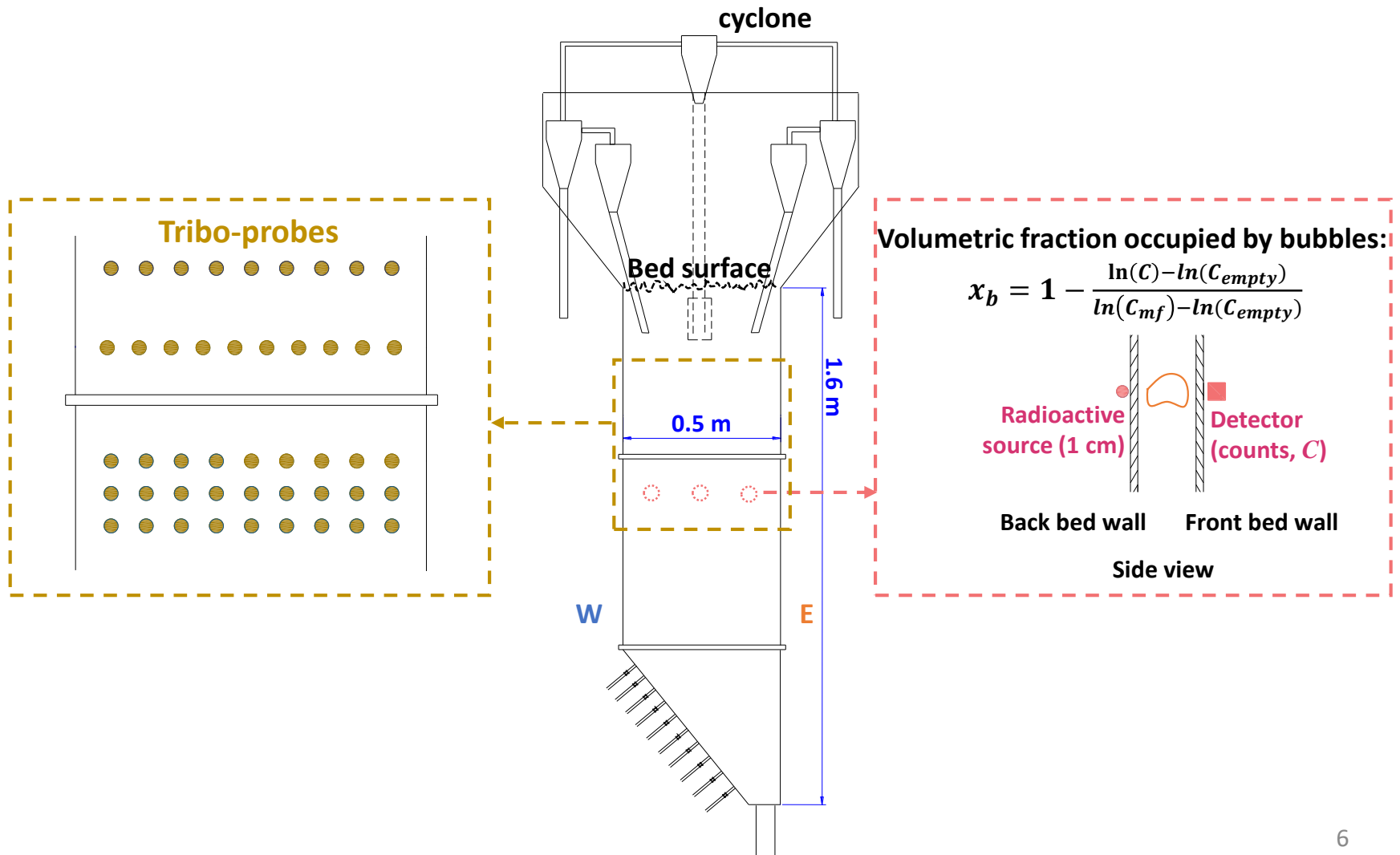


b. Symmetrical baffle



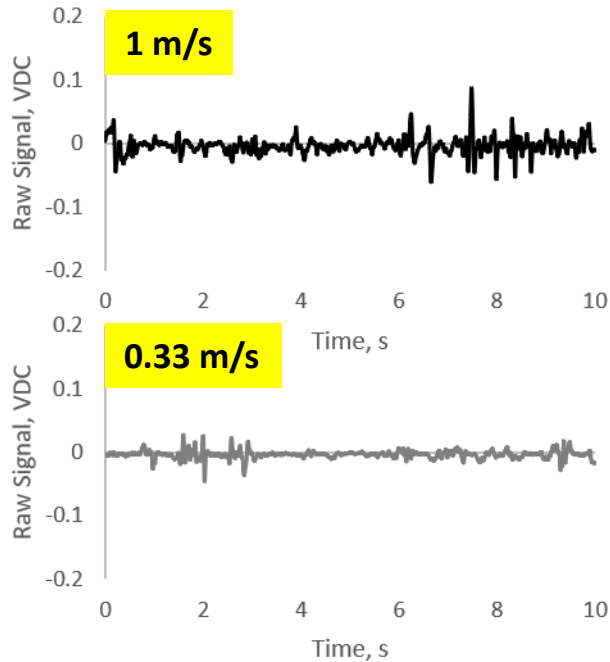
Solids: silica sand, 108 kg
Fluidization gas: Air

Measuring Systems

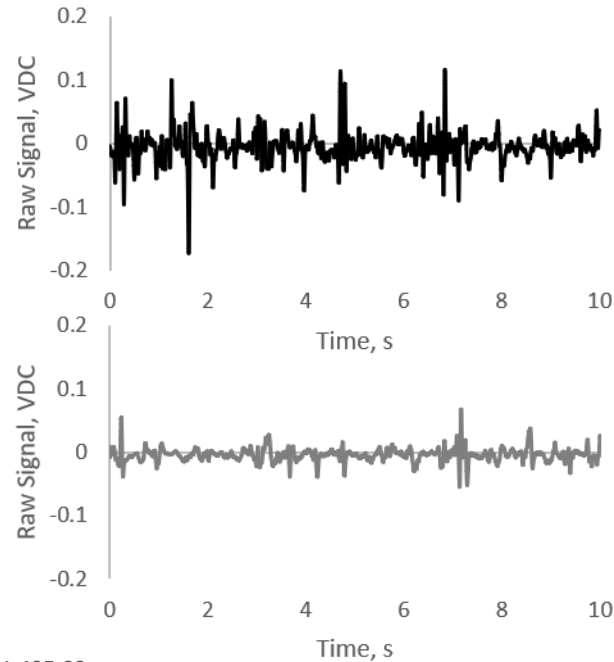


Raw Signal Comparison (for Even Case)

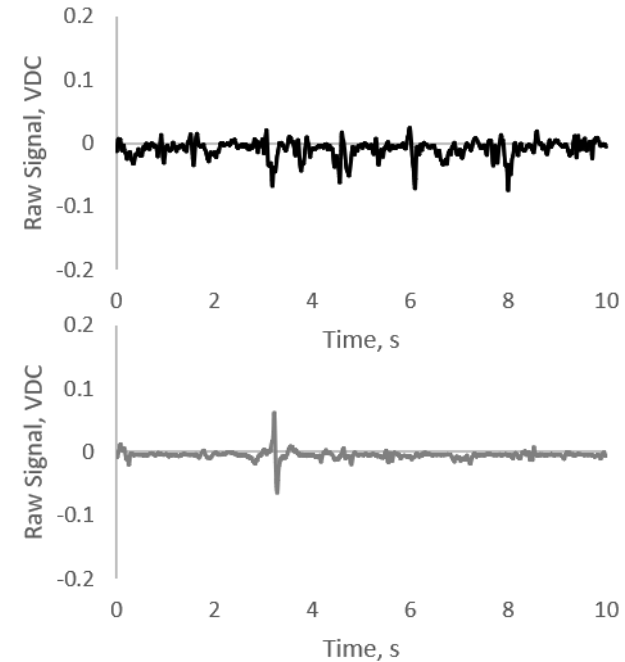
Western side bed wall



Bed centre



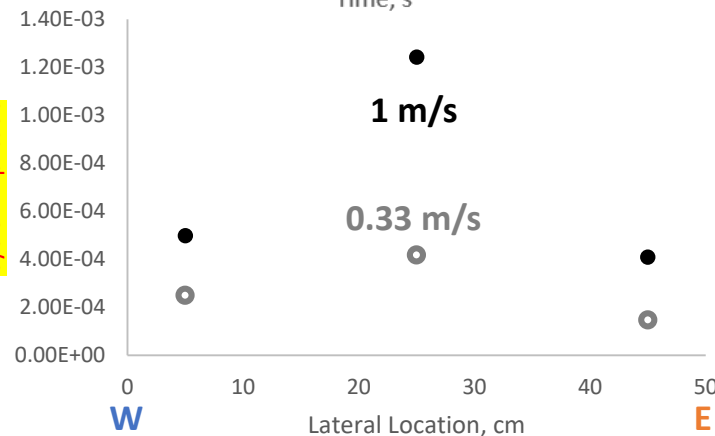
Eastern side bed wall



Algorithm from:
Briens et al., 2002



Cycle Amplitude



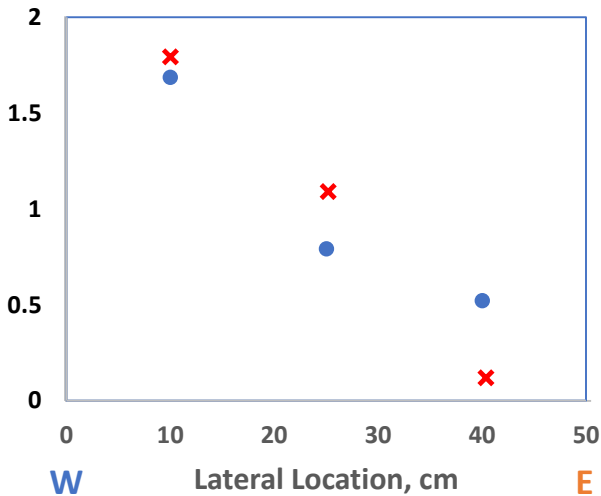
Bubble Flow Profile

Comparison Tribo-probes and Radioactive Transmission

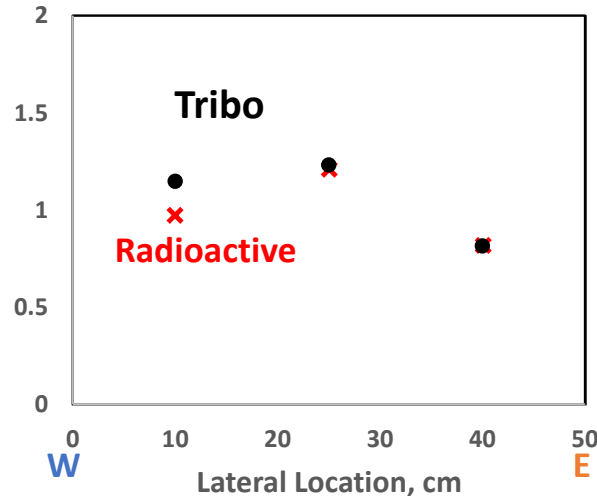
Tribo. $\frac{q_{bi}}{q_b} = \frac{\text{Local bubble volumetric flux}}{\text{cross-section average}}$: bubble flowrate profile

Radioactive. $\frac{x_{bi}}{x_b}$: bubble concentration profile

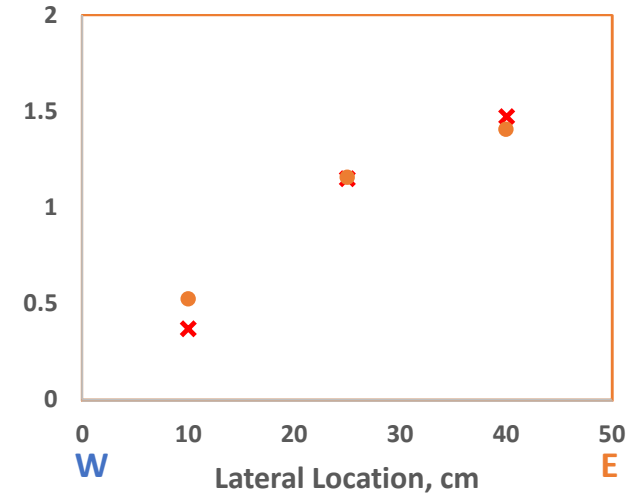
Western case



Even case



Eastern case



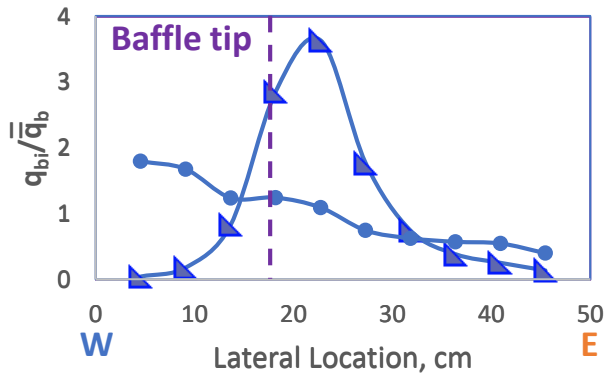
Consistent results

Superficial gas velocity for all results: 1 m/s

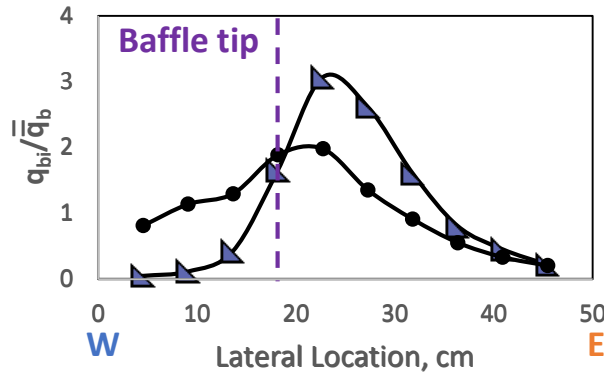
Bubble Flow Profile – spray level

3 Gas Distributions with (\blacktriangle , \blacktriangleleft , \blacktriangleright) and without (\bullet) Baffle

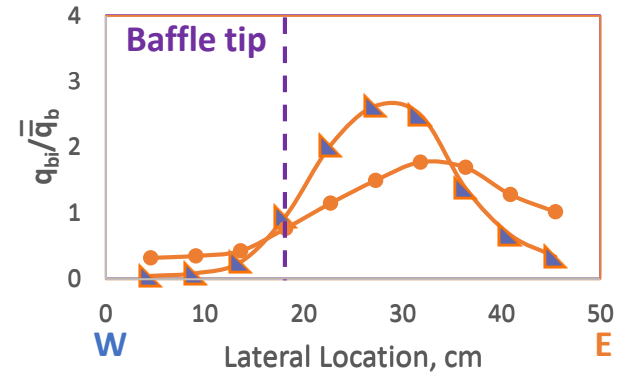
Western case



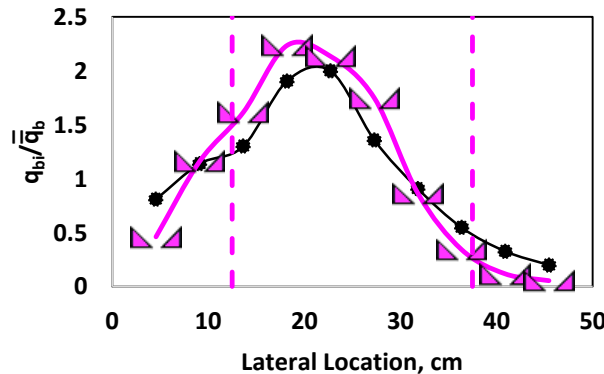
Even case



Eastern case

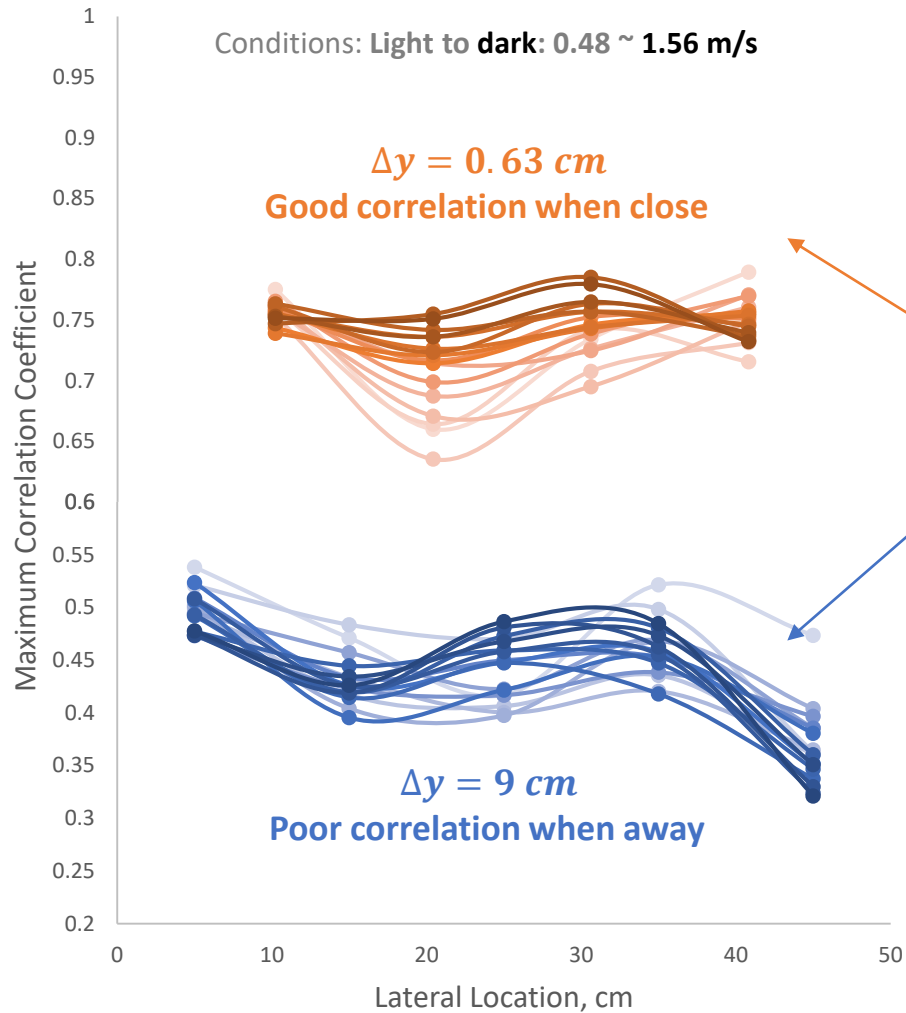


Asymmetrical baffle successfully concentrates gas bubbles

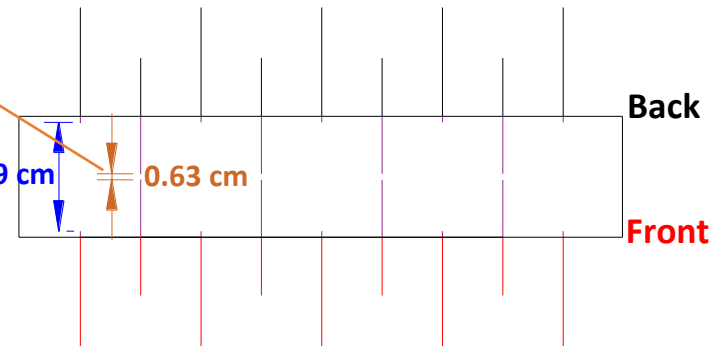


Symmetrical baffle doesn't help a lot

Slugging Check



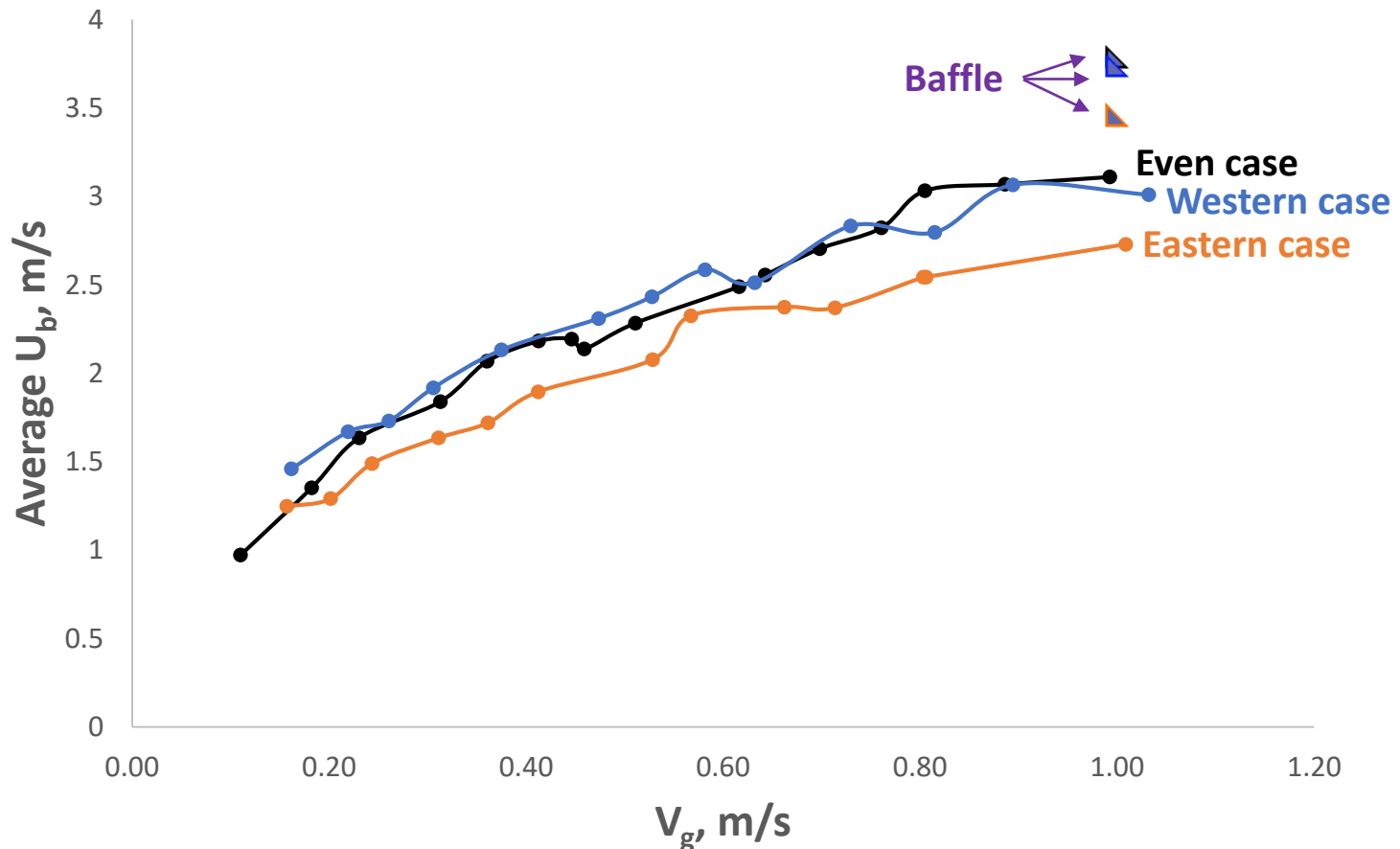
Row above spray level, top view



No slugging between front & back bed walls at any gas velocity

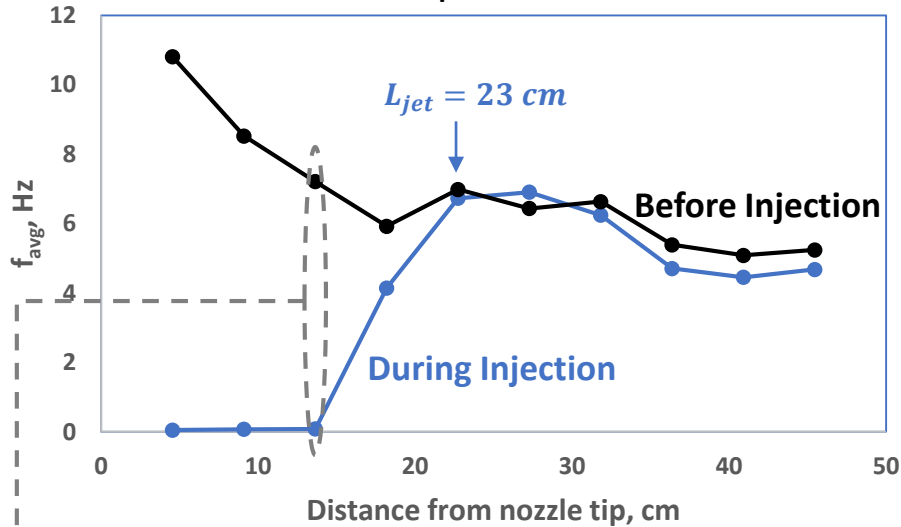
Bubble Velocity: $U_b = \frac{\Delta z_{probes}}{\Delta t_{lag}}$

Δt_{lag} from cross-correlation between Rows

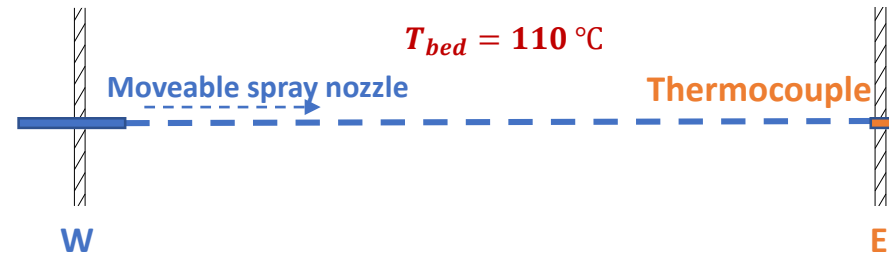
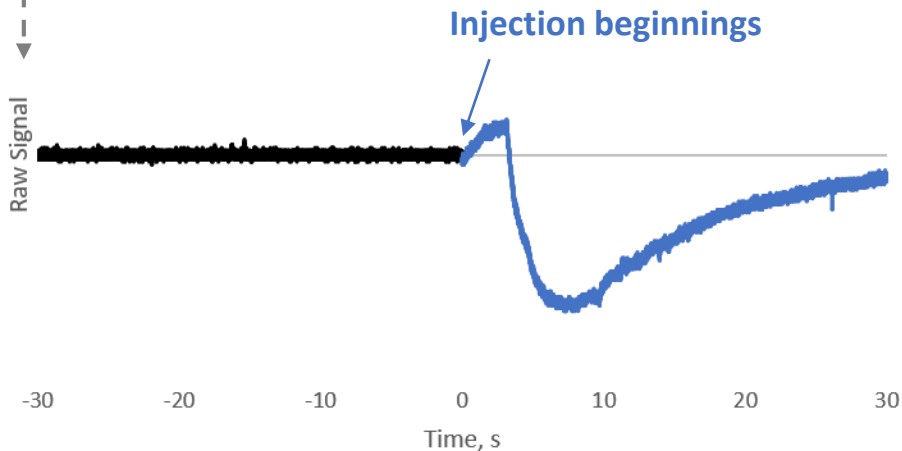
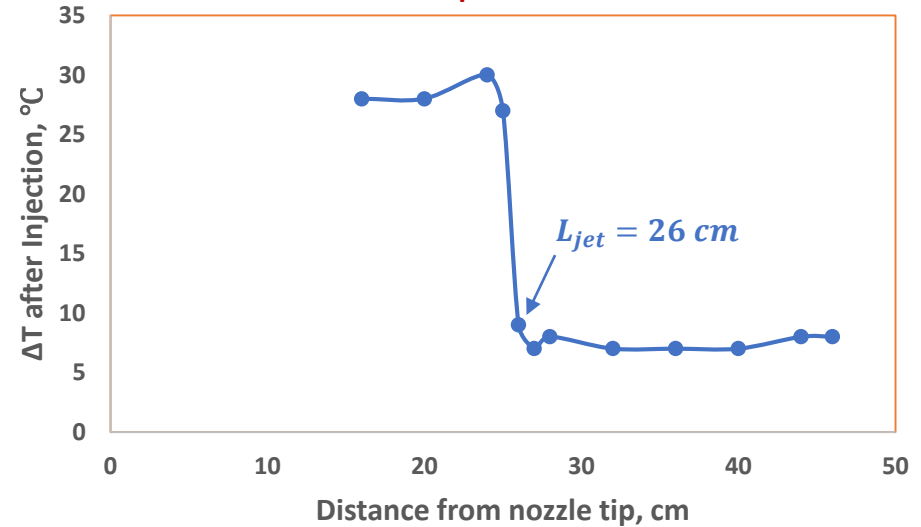


Gas-Liquid Jet Penetration

Tribo-probes, 30 °C



Thermocouple method, 110 °C



Result from (Ariyapadi et al., 2004) Correlation:

$$L_{jet} = 28 \text{ cm}$$

Superficial gas velocity for all results: 1 m/s

Conclusion

Tribo-electric probe measurements provide:

- Bubble flow profile
- Jet penetration
- Liquid distribution (see full paper)
- Local bogging (see full paper)

Cross-correlation between probes provides:

- Slugging detection
- Bubble velocity

Acknowledgments

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in Fluid Coking Technologies*



**NSERC
CRSNG**

ExxonMobil

Syncrude



References

Briens, L. A., & Briens, C. L. (2002). Cycle detection and characterization in chemical engineering. *AIChE journal*, 48(5), 970-980.

Li, Lingchao, "Effect of Local Bed Hydrodynamics on the Distribution of Liquid in a Fluidized Bed" (2016). *Electronic Thesis and Dissertation Repository*. 4120.

Jahanmiri, Majid, "Effect of a baffle on gas bubbles flow patterns and the distribution of liquid injected into gas-solid fluidized beds" (in press).

Ariyapadi, S., Berruti, F., Briens, C., McMillan, J., & Zhou, D. (2004). Horizontal penetration of gas-liquid spray jets in gas-solid fluidized beds. *International Journal of Chemical Reactor Engineering*, 2(1).