Probability description of single droplet event at high pressure: droplet-wall collision case.

1st Trondheim Gas Technology Conference 2009

Pablo M. Dupuy, Nils Kleinohl, Hugo A. Jakobsen,
Hallvard F. Svendsen.

Department of Chemical Engineering,
Norwegian University of Science and Technology.

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Outline

- Motivation
- Stochastic vs. Deterministic
- Three approaches
- Conclusion

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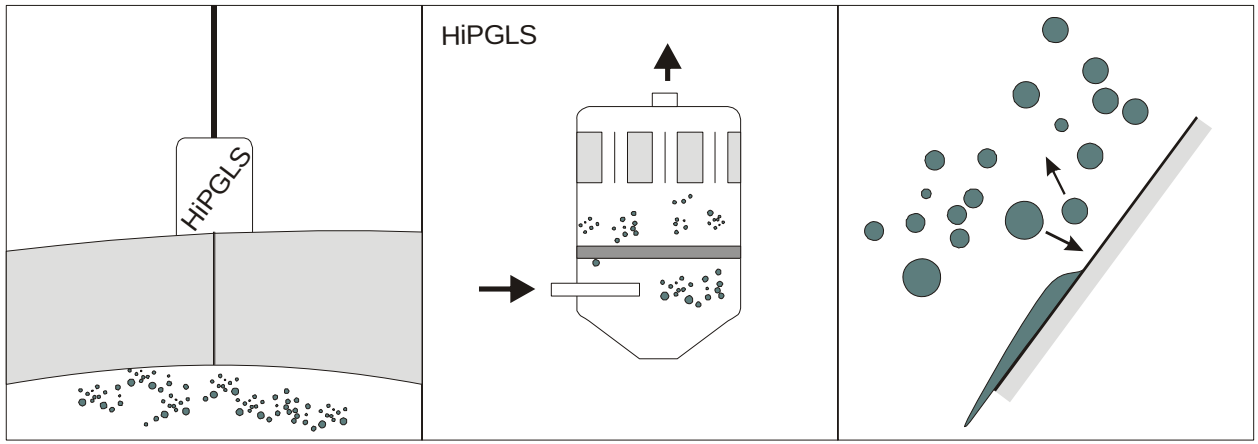
In Focus:
High Pressure Gas Liquid Separation



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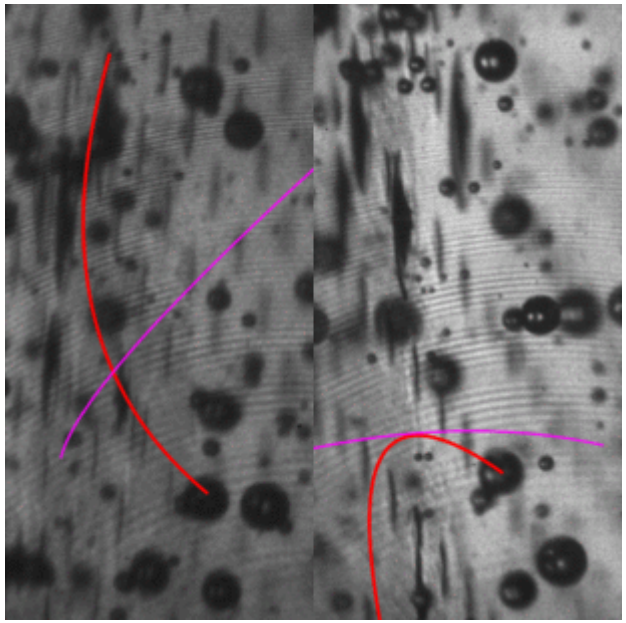
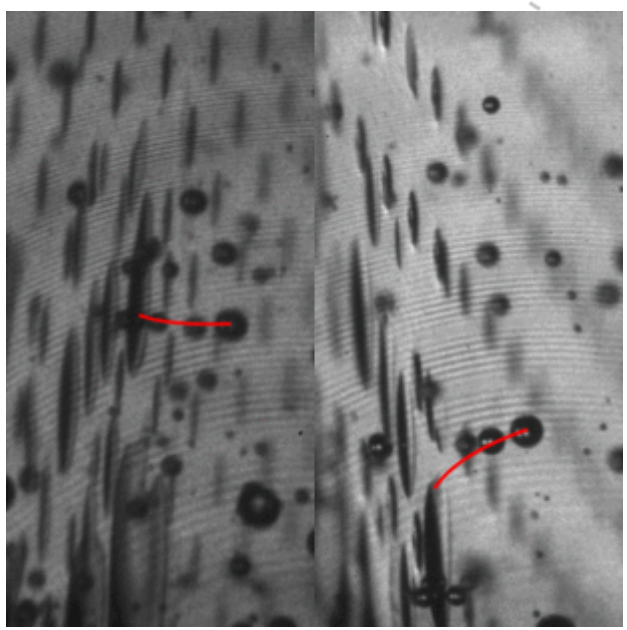
Bouncing / Coalescence

425 (60%) Bounced



273 (40%) Coalesced



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Droplet-Droplet

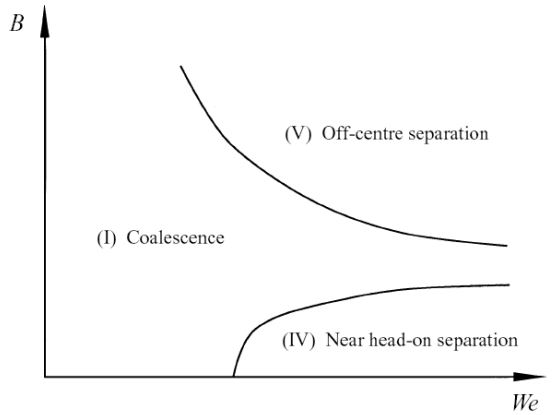

FIGURE 1. Schematic of various collision regimes of water droplets in 1 atm. air.

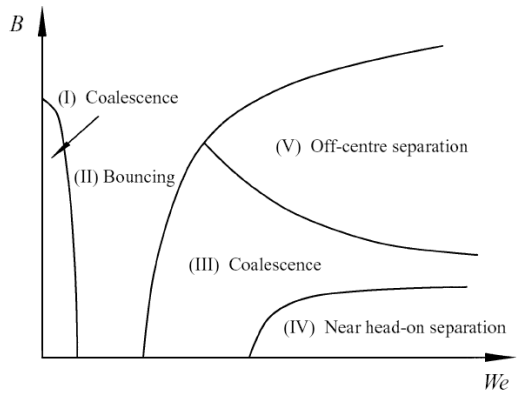

FIGURE 2. Schematic of various collision regimes of hydrocarbon droplets in 1 atm. air.

Qian, J. & Law, C.K. (1997). **Regimes of coalescence and separation in droplet collision**. Journal of Fluid Mechanics, Vol. 331, 59-80.

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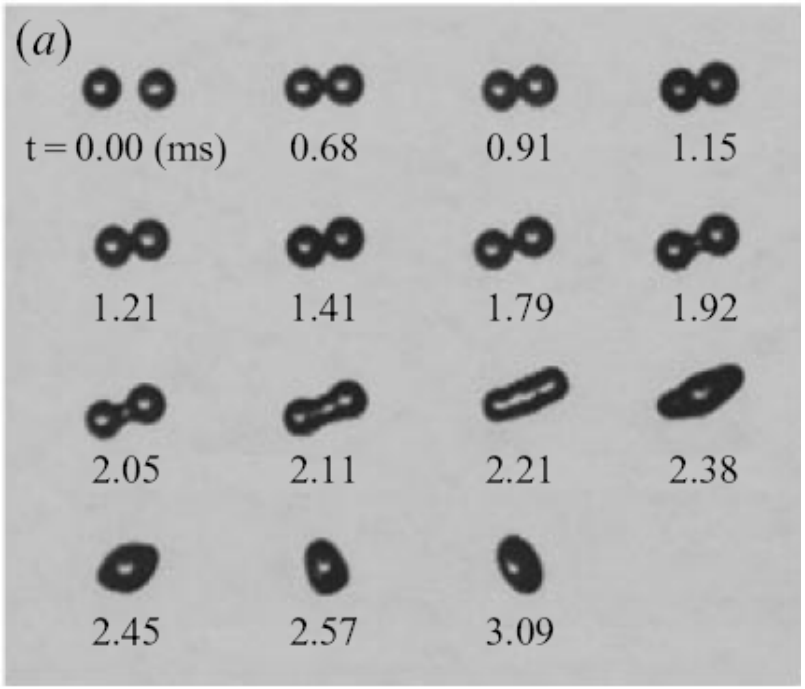
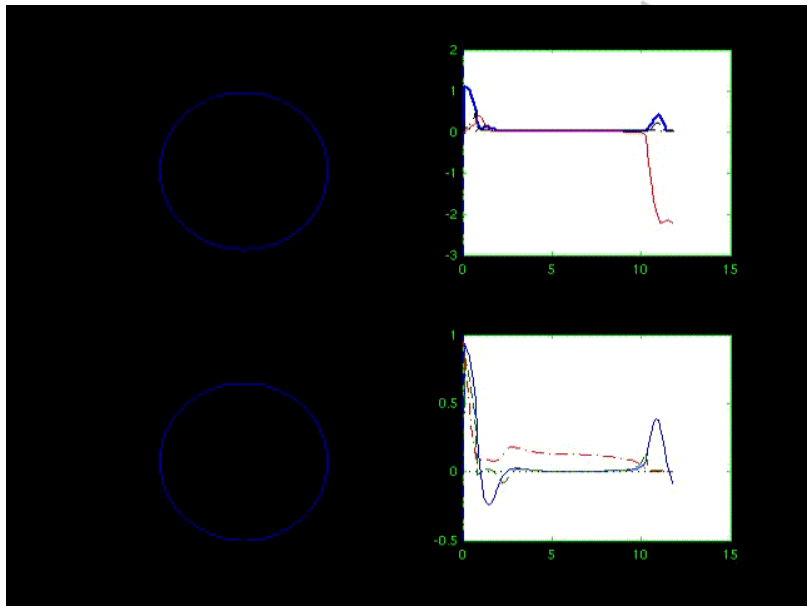
Droplet-Droplet





Qian, J. & Law, C.K. (1997). **Regimes of coalescence and separation in droplet collision**. Journal of Fluid Mechanics, Vol. 331, 59-80.

Dupuy et al. **Modeling of high–pressure binary droplet collisions.** Submitted to Computers and Mathematics with Applications.

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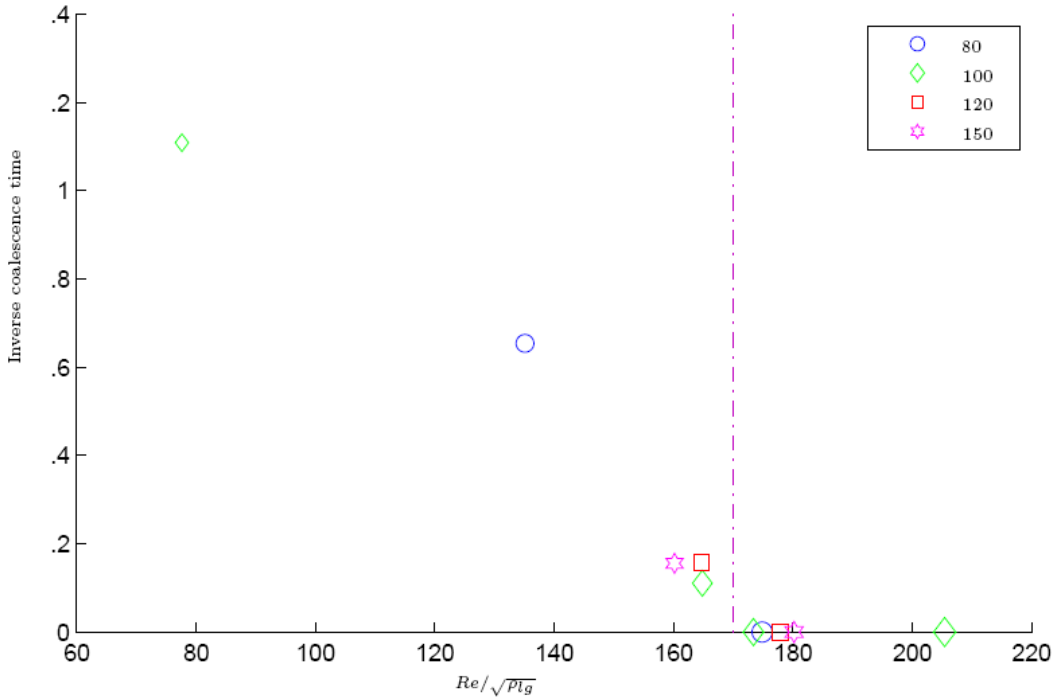
Time for disturbances to take place



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Three approaches for scrubber modeling

- Using directly experimental results.
- Population Balance Estimation – Sharp boundaries
- Population Balance Estimation – Probability Description

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Using directly experimental results

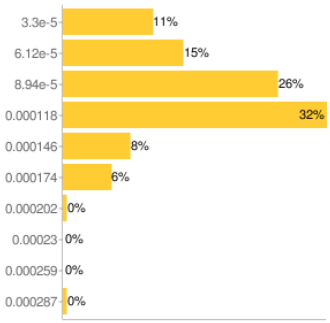
60% Bounced

40% Coalesced

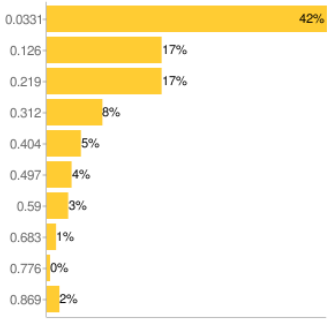
Limitations…

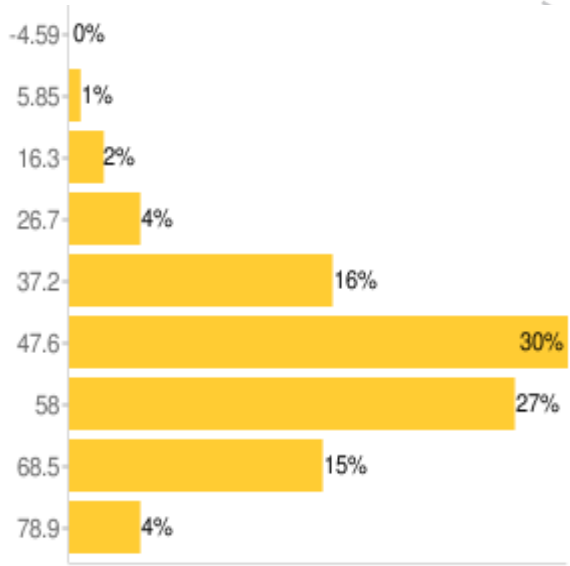
Experiment Distribution

Size



Velocity





Angle

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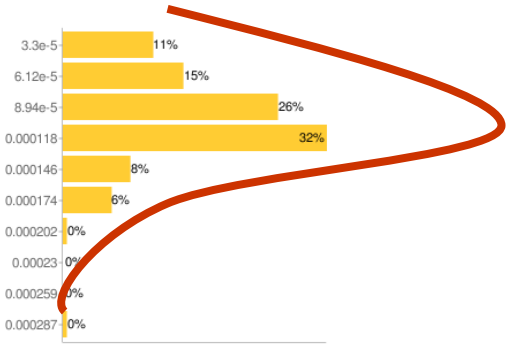
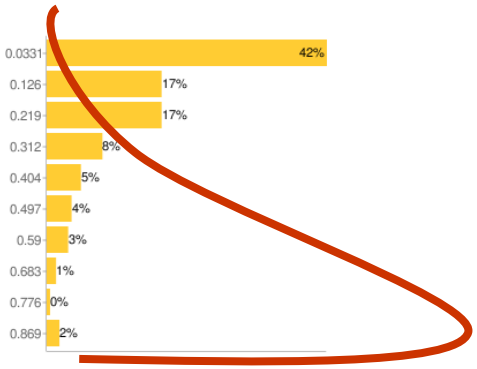
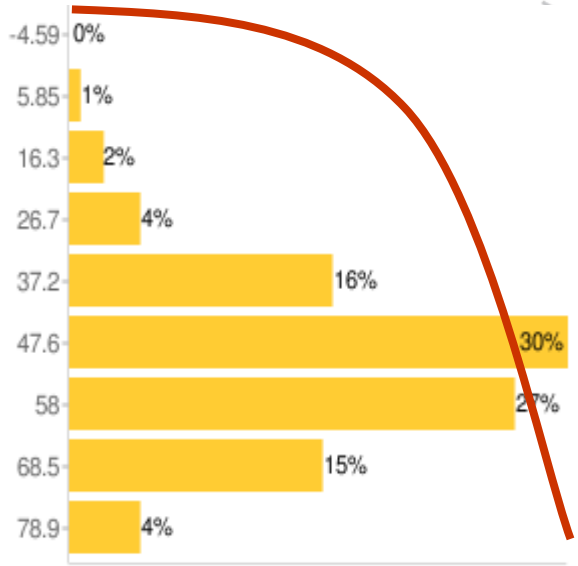
Distribution in the Scrubber

Size



Velocity





Angle

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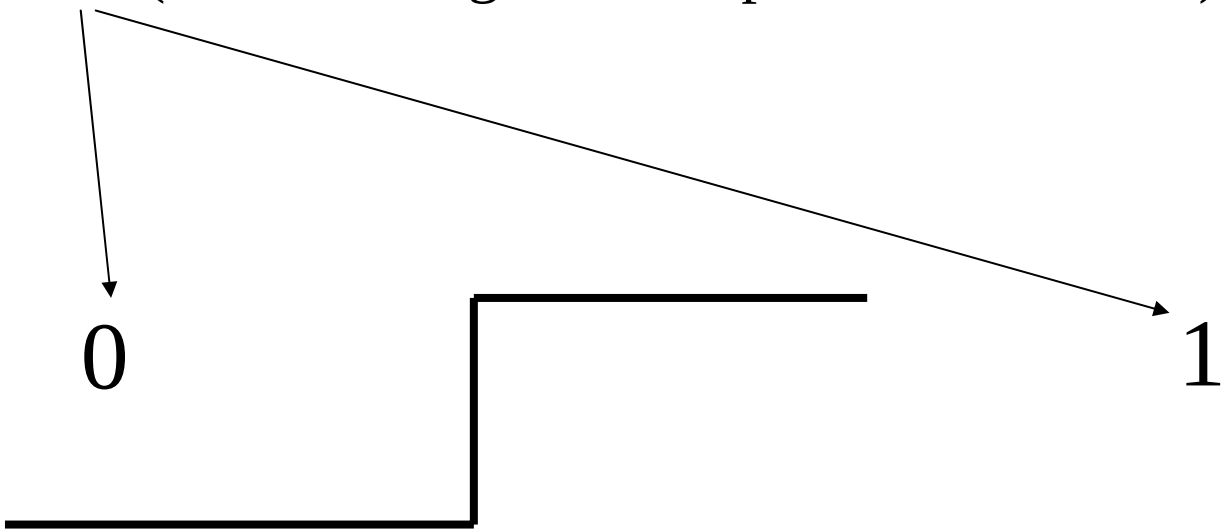
Population Balance Estimation – Sharp boundaries

- Lim(Re, We, Ang, FilmProp, ….→ Outcome)



Heaviside step function

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Droplet-Wall Results

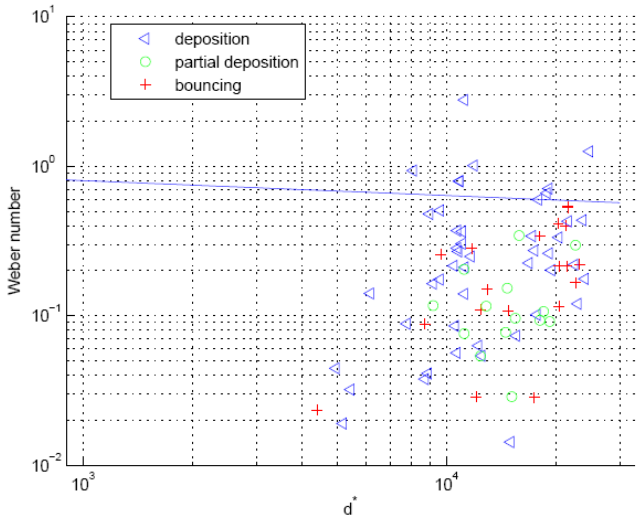

Figure 5.3: We over d^* diagram for Decane-Carbon dioxide regime with solid surface

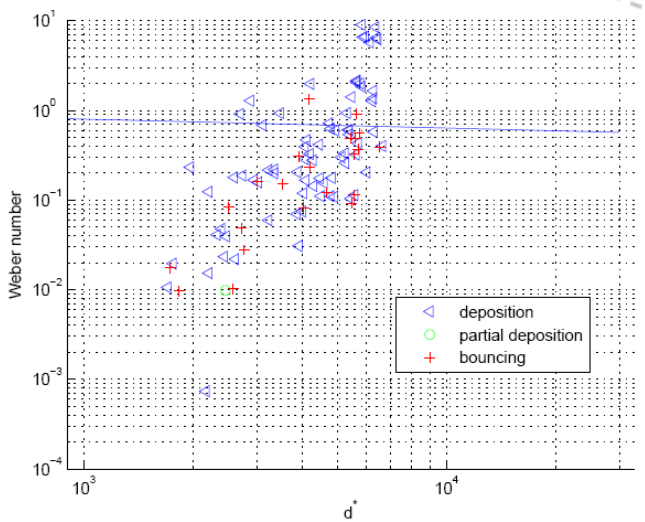

Figure 5.2: We over d^* diagram for Decane-Nitrogen regime with solid surface

Nils. Kleinohl (2009). **Experimental analysis of droplet-surface interactions at low impact velocities**. Master Thesis. ITLR

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Internal Coordinate Integration

- Population Balance
  - (Droplet relative velocities)
- Experiments
  - Surfactants distribution
  - Turbulence in the gas phase
  - Non-equilibrium effects

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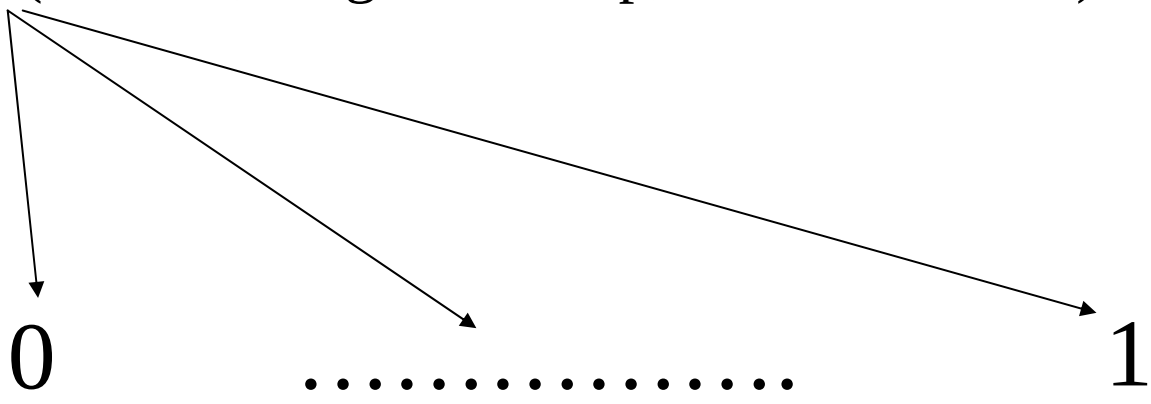
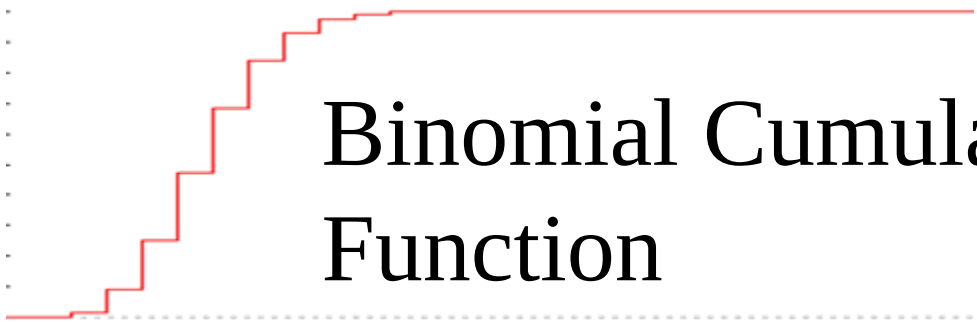
Population Balance Estimation – Probability Description

- Pr(Re, We, Ang, FilmProp, ….→ Outcome)





Binomial Cumulative Function

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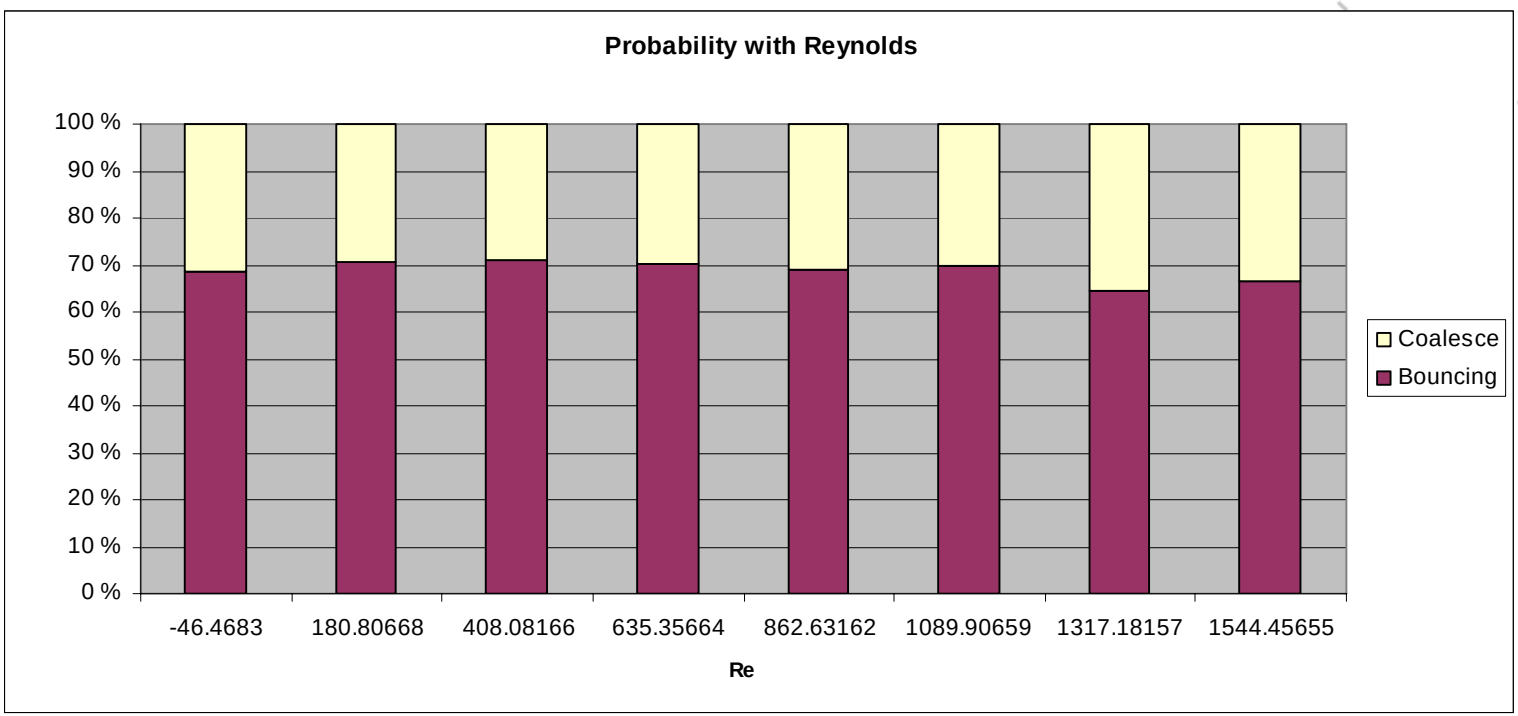
Results. Probability with Reynolds



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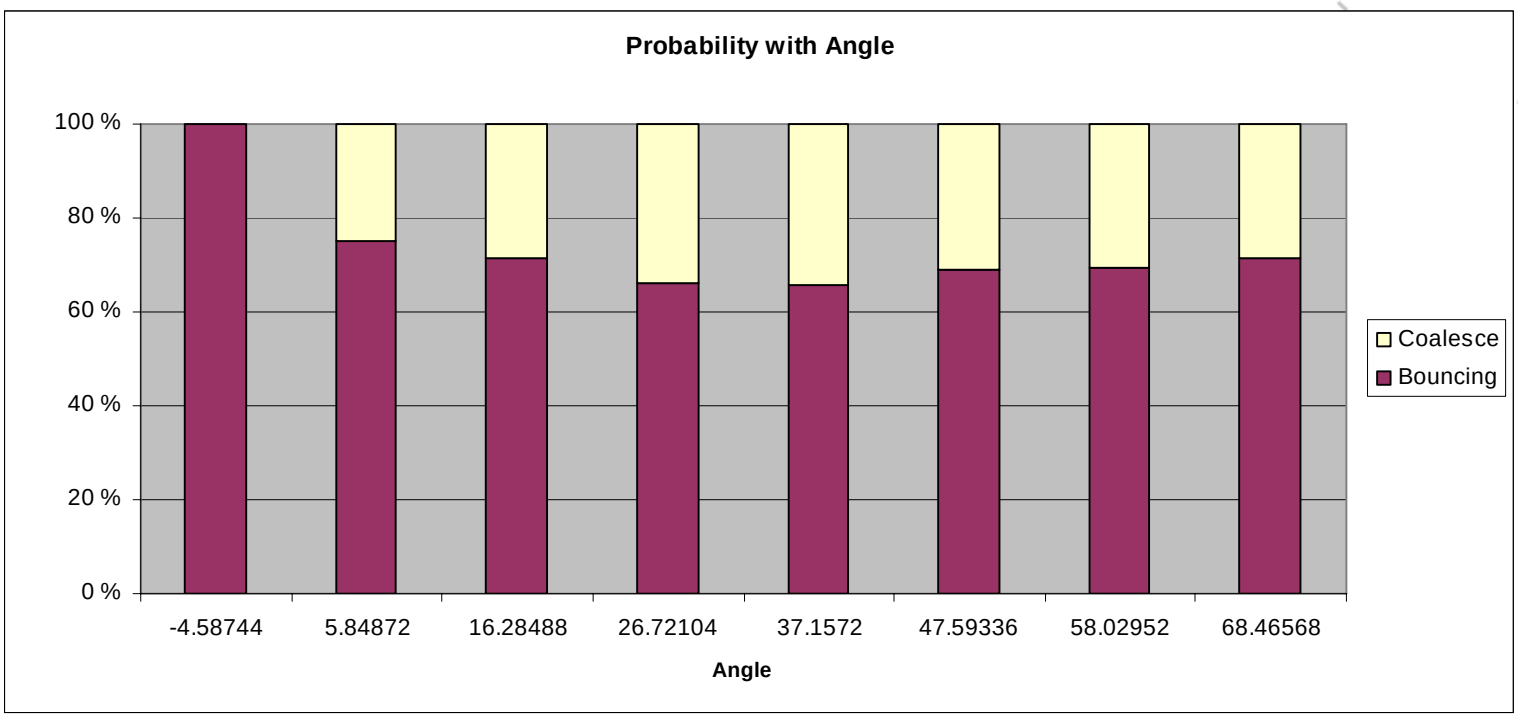
Results. Probability with Angle



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Conclusion

- Using a cumulative distribution function when defining population balance kernels is a general approach to Heaviside functions.
- This approach is more suitable when more variables are already integrated in the experiments.

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Acknowledgment

The PhD fellowship financed by the Research Council of Norway through the PETROMAKS program is gratefully apreciated.

Thanks for your attention

Time for questions?

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