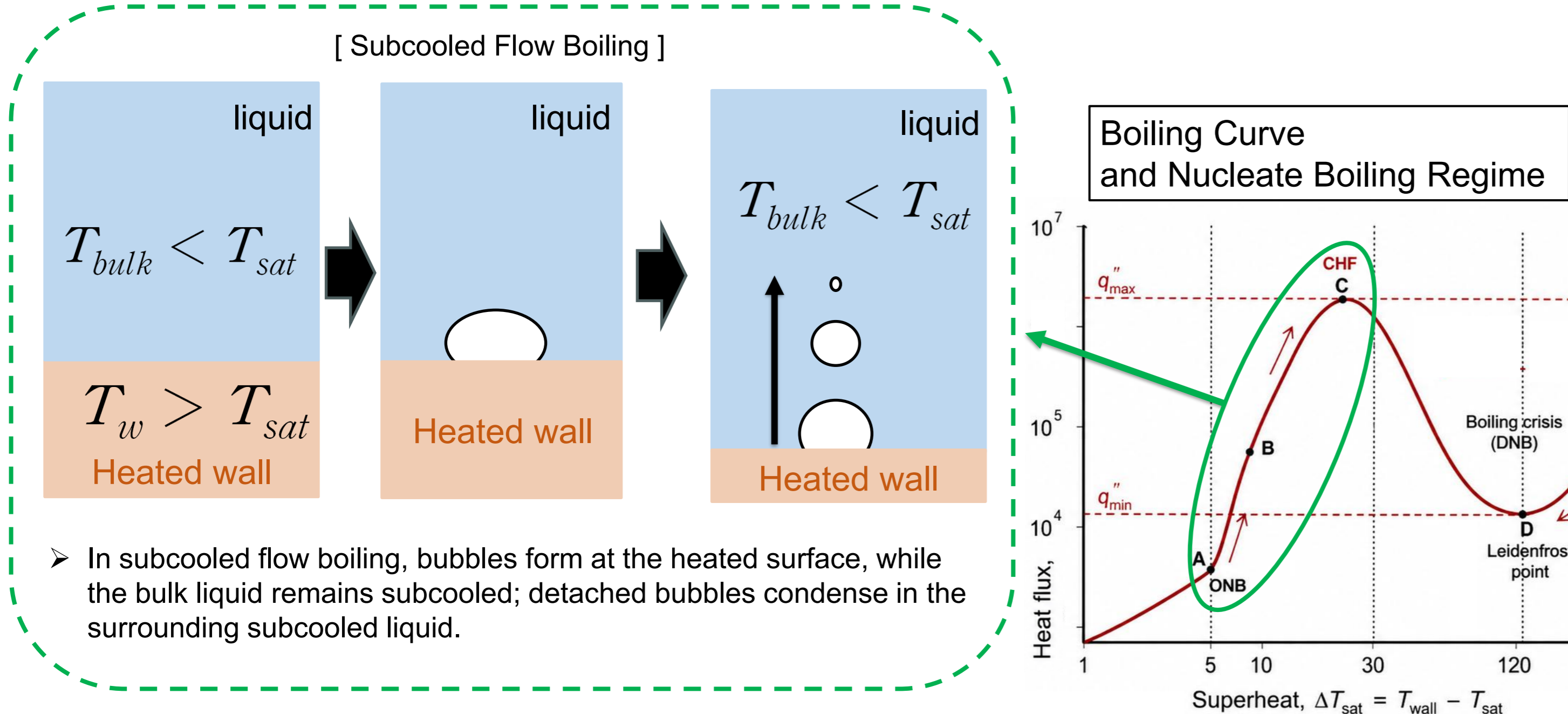


Introduction

- Bubble behavior in subcooled flow boiling was analyzed, and the effects of heat flux and mass flux were investigated.
- The relationship between bubble departure diameter and velocity was examined.
- Based on these findings, a new correlation was proposed to predict the bubble departure diameter.

Bubble Behavior and Wall Heat Flux in Subcooled Flow Boiling

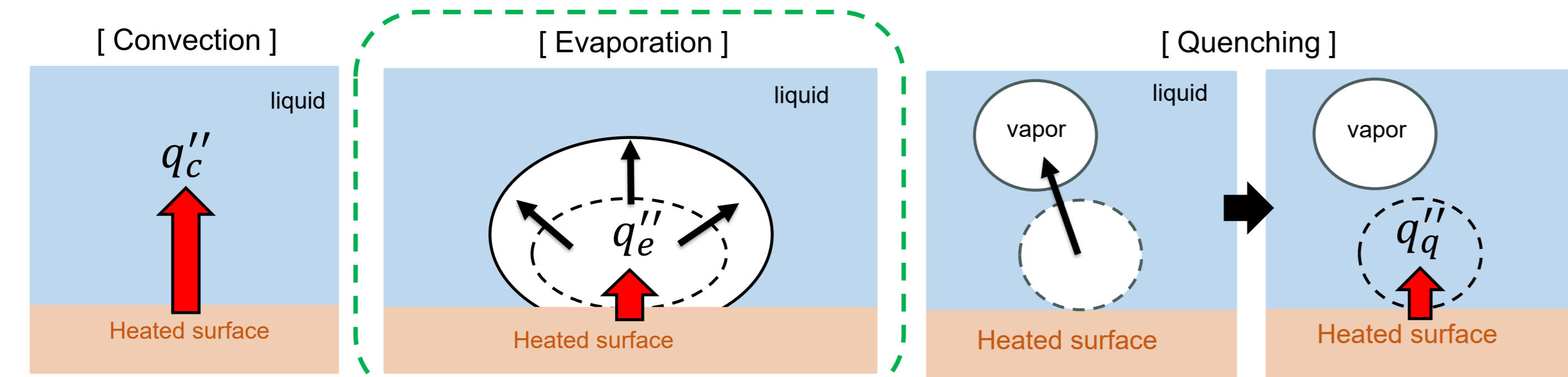
Bubble Behavior



Wall Heat Flux Partitioning

- Kurul-Podowski Wall boiling model

$$q''_w = q''_c + q''_e + q''_q$$

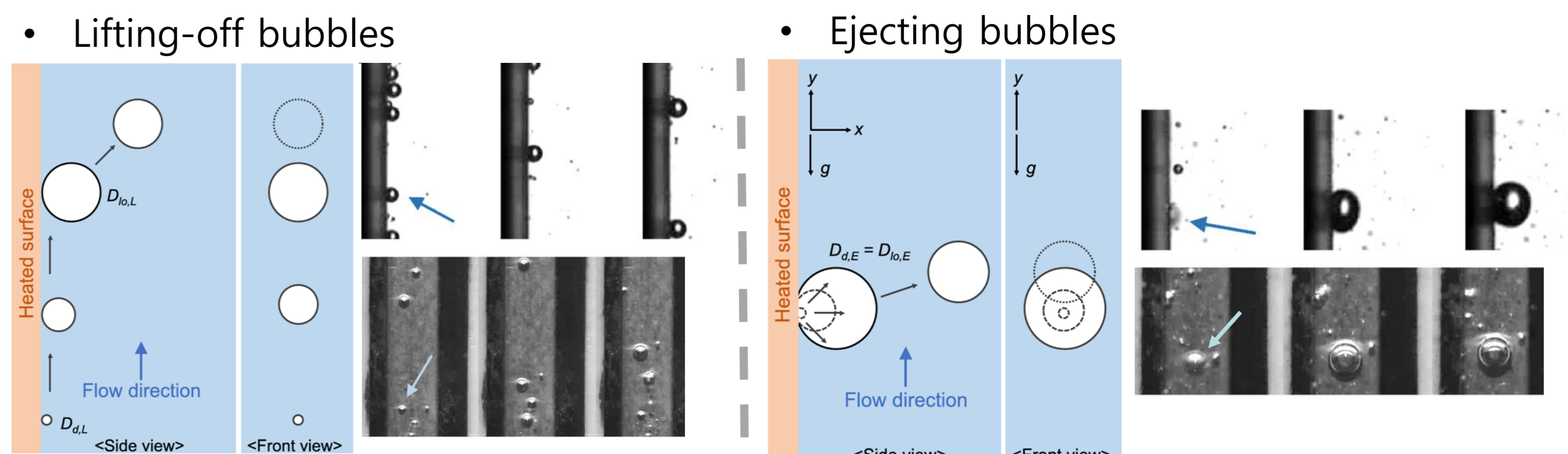


$$q''_e = \frac{\pi}{6} D_{lo}^3 \rho_v h_{fg} f_d N_a$$

Evaporative heat flux is proportional to the cube of the bubble diameter, making it a critical parameter.

Experimental Results and Correlation Development

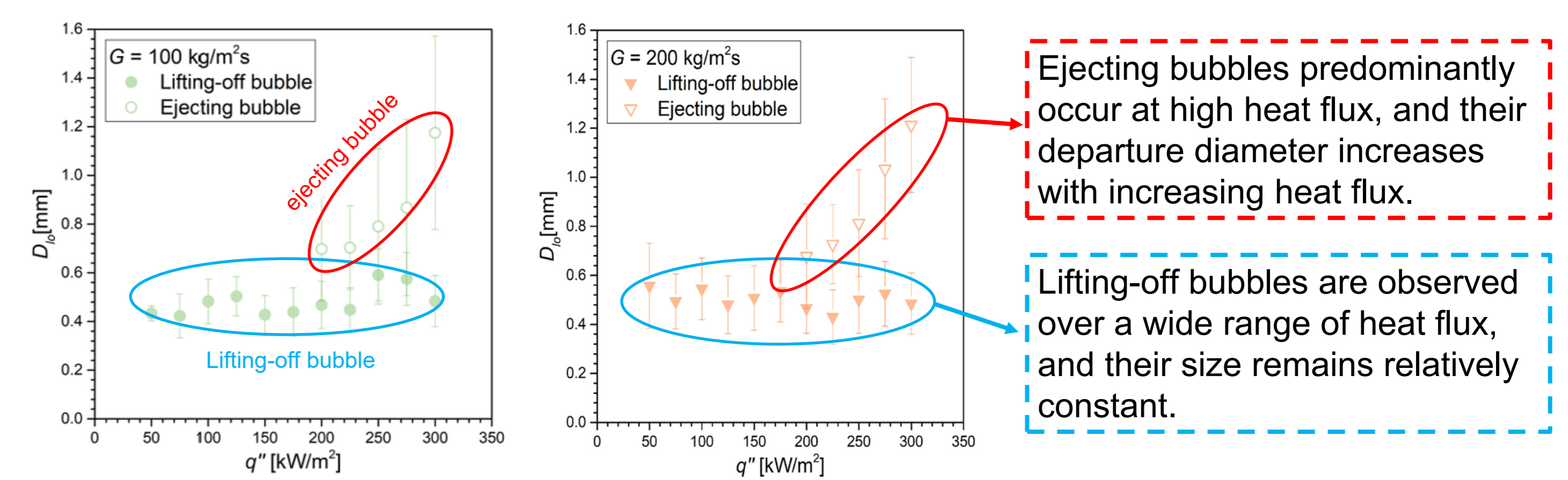
Bubble Detachment Types



- Slide along the surface before departure and grow gradually
- Depart immediately normal to the surface, typically at high heat flux

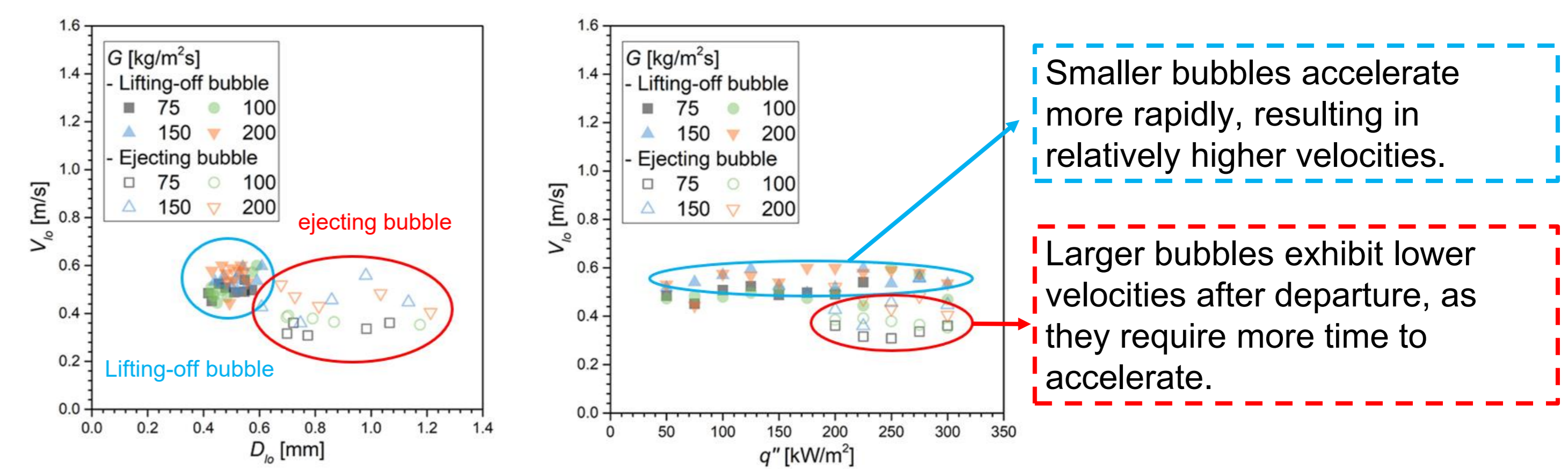
Bubble Behavior Analysis

- Bubble size variation with heat flux and mass flux



- Mass flux has a limited effect on bubble growth, while bubble behavior is primarily governed by heat flux.

- Bubble velocity after departure



- Bubble velocity is strongly dependent on bubble size, while the effects of heat flux and mass flux are relatively limited.

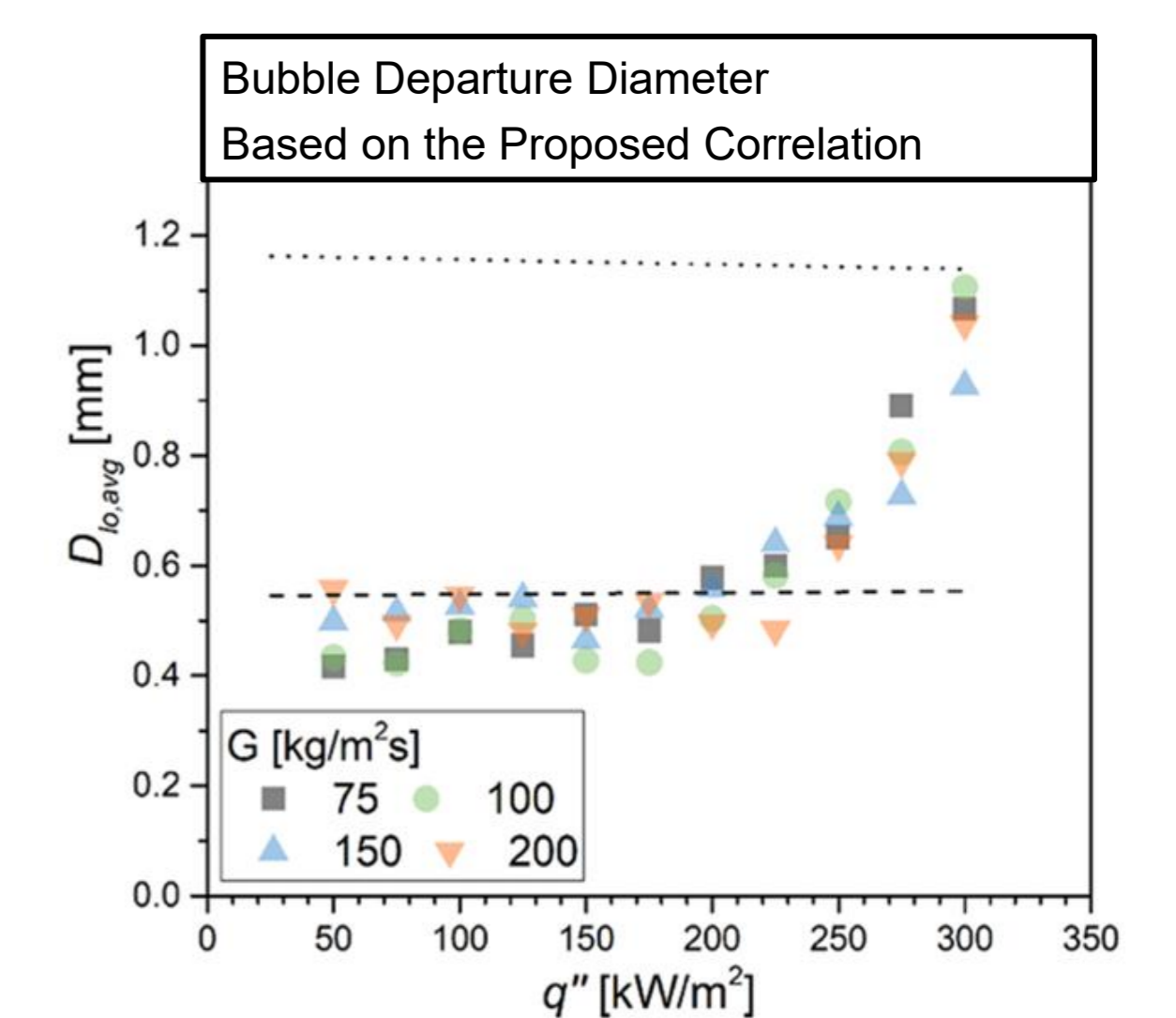
Proposed Correlation for Bubble Departure Diameter Based on Experiments

$$D_{lo} = 13 \times 10^5 \rho_f \alpha_f^2 \sigma^{-1} \left(\frac{\rho_f c_{p,f} (T_w - T_{sat})}{\rho_g h_{fg}} \right)^{-1.75} \left(\frac{T_w - T_b}{T_w - T_{sat}} \right)^{-0.12} \left(\frac{\rho_f}{\rho_g} \right)^{1.36} \left(\frac{q''}{h_{fg}} \right)^{2.25}$$

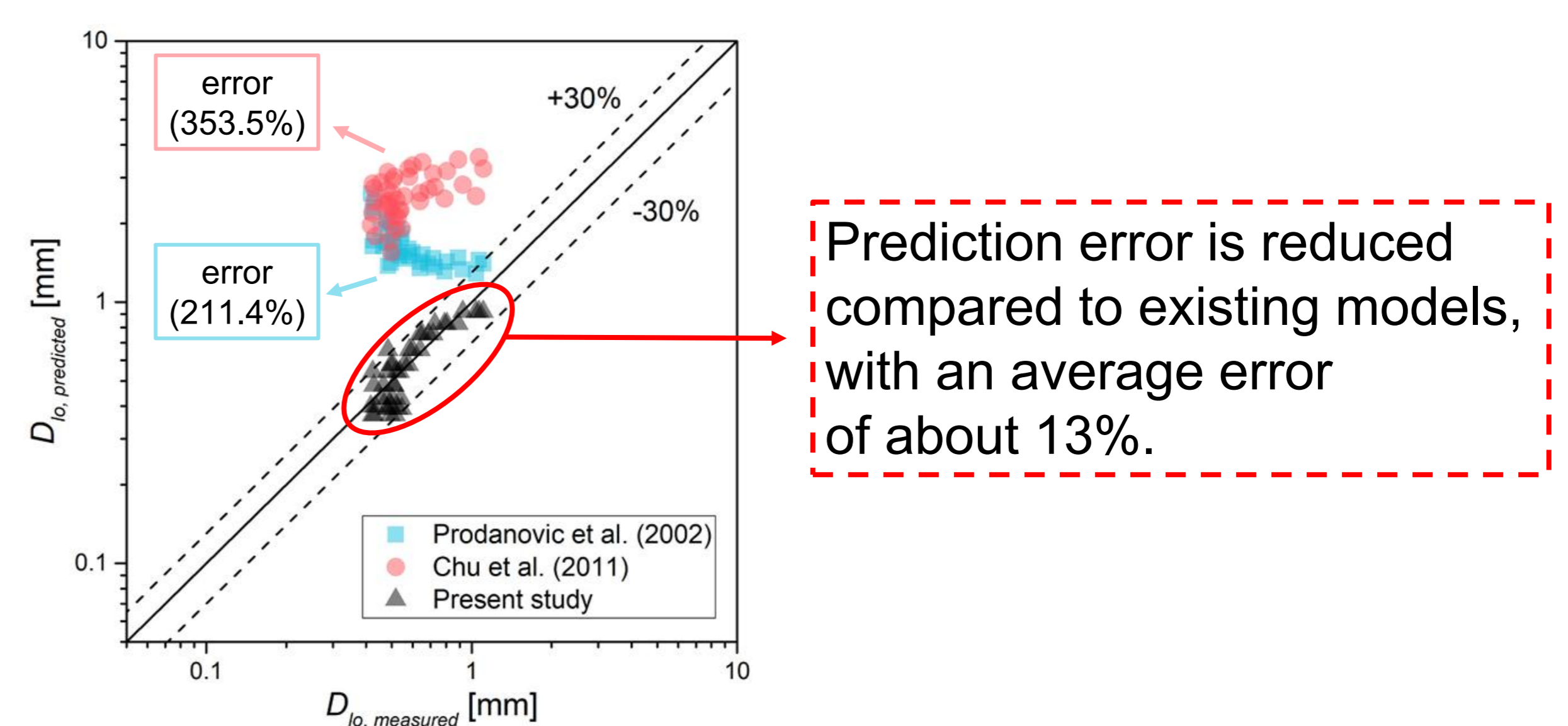
- ✓ The proposed correlation incorporates heat flux and wall superheat to predict bubble departure diameter.

- ✓ It captures the transition from lifting-off to ejecting bubbles under high heat flux conditions.

- ✓ The effect of mass flux is negligible within the tested range.

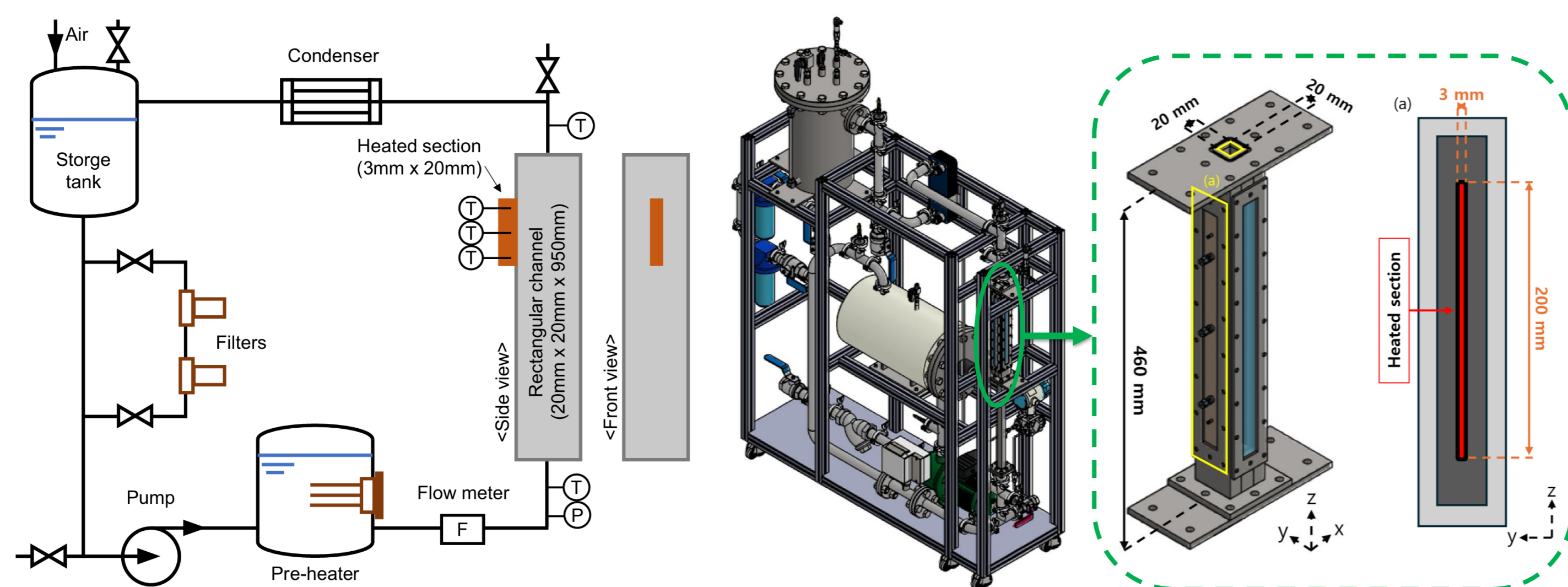


- Prediction Error Comparison



Experiments

- Schematic illustration of test facility
- 3D images of test facility and square channel



Conditions

Working fluid	Pressure	Mass flux(G)	Heat flux(q'')	Subcooling (ΔT _{sub})
DI water	Atmospheric	75–200 [kg/m ² ·s]	25–300 [kW/m ²]	4.5 [K]

Experimental Parameters

- Heat flux
- Mass flux

Observable Bubble Behavior in This Study

- ✓ Bubble detachment behavior
- ✓ Bubble lift-off diameter
- ✓ Bubble velocity after departure

Conclusion

- ✓ Bubbles in subcooled flow boiling are classified as lifting-off and ejecting.
- ✓ Lifting-off dominates at low heat flux, while ejecting increases with heat flux.
- ✓ Bubble behavior affects departure diameter and velocity.
- ✓ The proposed correlation improves prediction accuracy over existing models.