Absorber Modeling of Pilot Plant Results with Aqueous Piperazine

PCCC4

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Outline

- **Introduction**
- **Modeling Activities**
- **Preliminary Data Reconciliation Results**
- **Conclusions**

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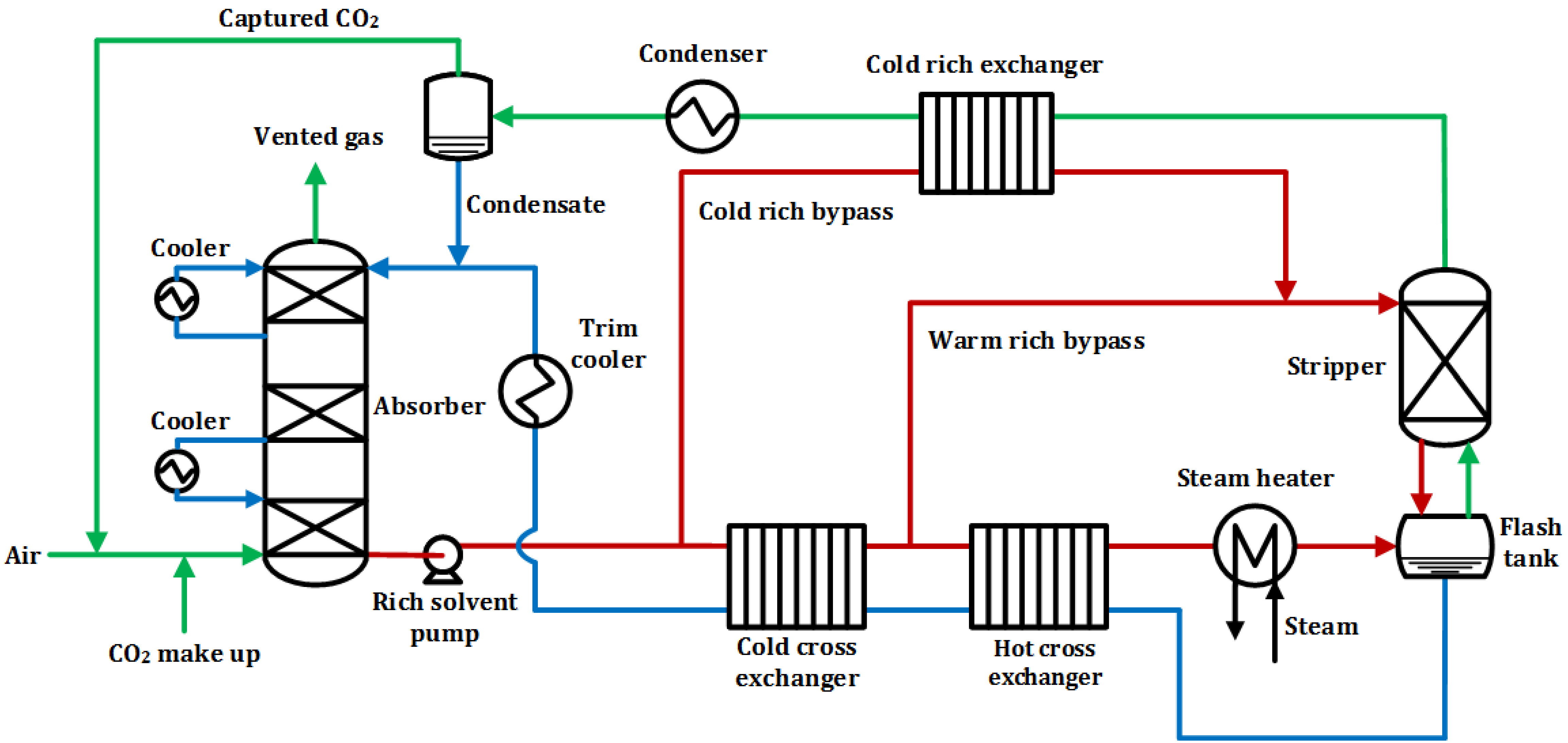
5 m Piperazine with the Advanced Flash Stripper (AFS)



April 2017 Pilot plant campaigns

UT-SRP pilot plant in Austin, TX

- **20% CO_2 for parallel membrane-amine process**
- **3.5% CO_2 for NGCC conditions**
- **12% CO_2 for coal conditions**
- **April 2017, 4 weeks**
- **0.2 MW**

Packing Characterization

Packing Measurements conducted independently in pilot columns: a_e, k_g, k_l

Pilot plant runs reflect real packing performance with all underlying factors

Objective

Improve the existing packing model by pilot plant absorber data reconciliation

Absorber Modeling Activities

- **Test plan development to maximize value of data**
- **Accurate simulation of test conditions before the campaign**
- **Design of experiments using simulation results**
- **Data reconciliation and model validation**

Data Modeled by Independence

- **Rate-based Absorber model developed in Aspen Plus**
  - **PZ Thermodynamics by e-NRTL**
  - **PZ Kinetics regressed from WWC**
- **Solvent 5 m PZ: fast absorption rate, low viscosity, good energy performance**
- **Packing parameters from Song and Wang**
- **Absorber Rating model: interfacial area factor = 0.6**

Absorber Test Plan

- **4 weeks (4.5 day/wk),**
  - **29 factorial runs**
  - **(including 18 of 20 recommended by preliminary DoE)**
- **30 ft absorber packing or 20 ft + 10 ft water wash**
- **350, 600 cfm**
- **3.5, 12, 20% CO_2**
- **0.18 - 0.27 lean ldg, 0.32 - 0.40 rich ldg**

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Data Reconciliation: Loading & CO_2 balance

Redundant measures of rich and lean loading do not agree

- **Immediate titration of manual samples at the pilot plant**
  - **Alkalinity & total CO_2**
- **Laboratory analysis by TIC after the campaign**
- **On-line Density (total CO_2)**
  - **Regression provided by bench-scale, ldg by TIC**
  - **Calibrated to match pilot plant titration**

Material balance for total CO_2 removed

- **L * Δloading, by all measures of loading**
- **Stripper Overhead CO_2**
- **$G * (y_{in} - y_{out})$**

On-line, precise, Density to predict loadings

$$\rho_{PZ} = \rho_{H2O} \cdot (0.0407 \cdot C_{CO2} + 0.008 \cdot C_{PZ} + 0.991)$$

$$\frac{\rho_{Pilot}}{\rho_{PZ}} = \frac{\rho_{InhA}}{\rho_{H_2O}} = 0.00741 * Inhibitor(wt\%) + 1.0018$$

Where:

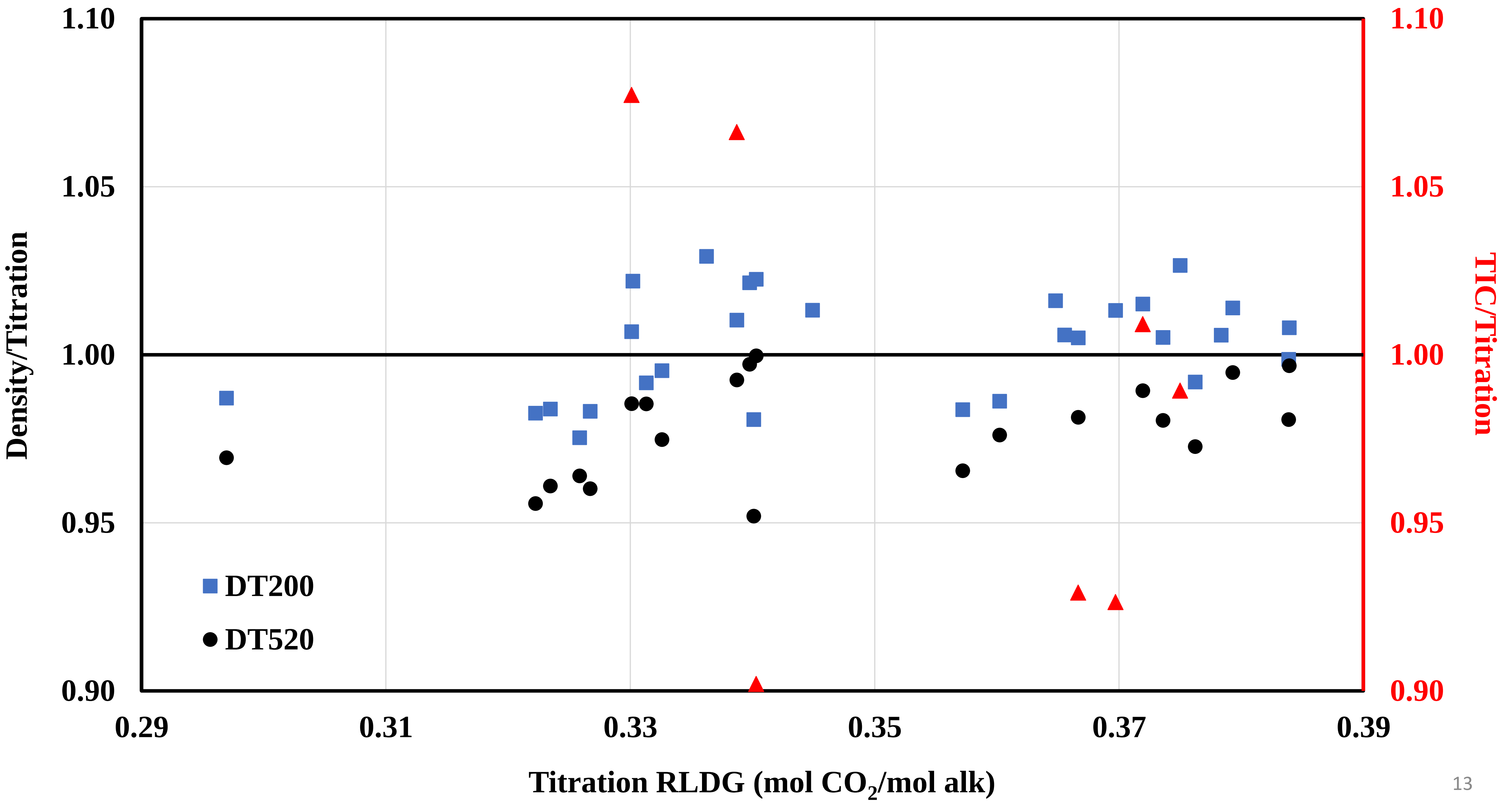
ρ = liquid density (kg/m^3), measured online

C_{CO2} = CO_2 concentration in the solution (mol/kg)

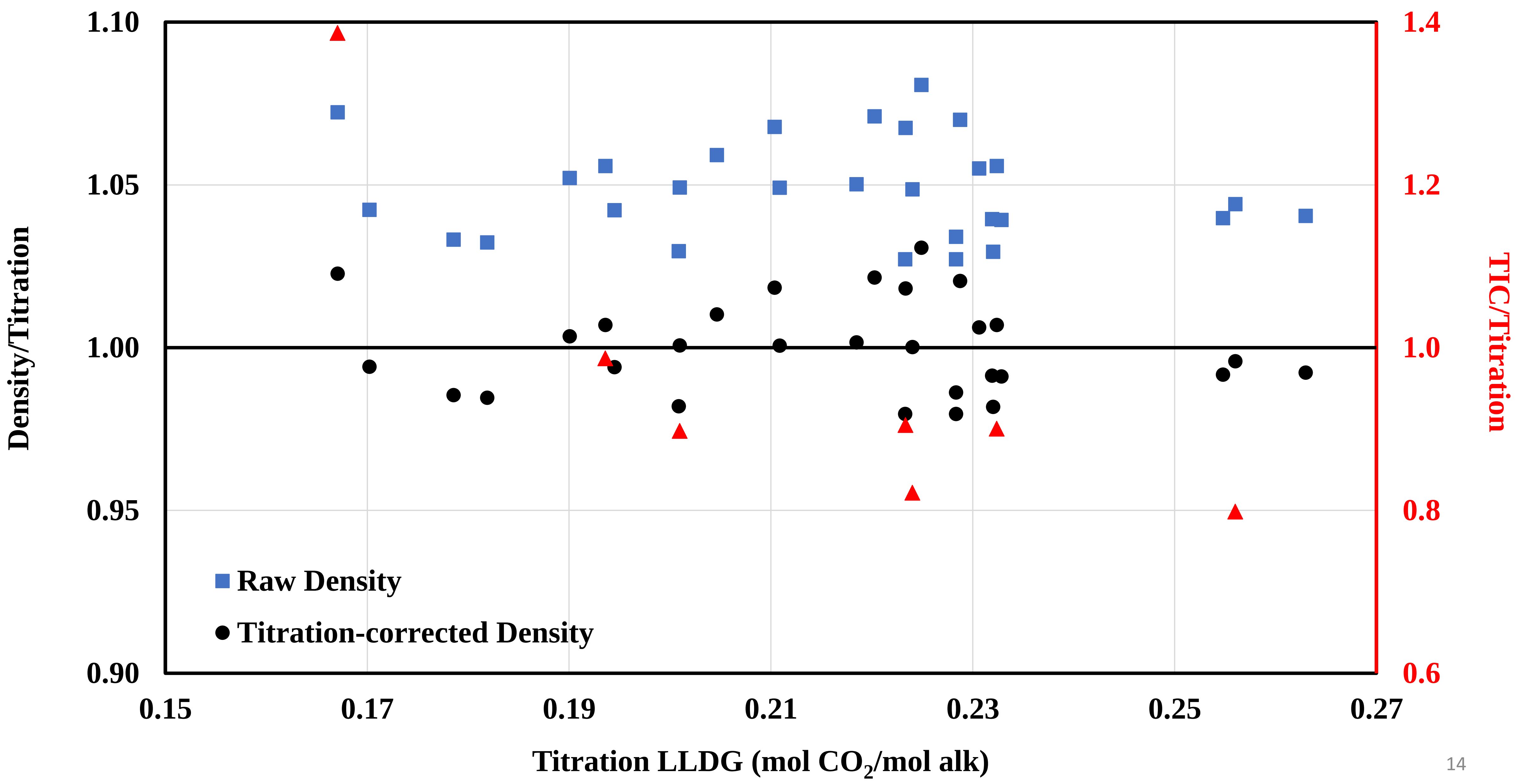
C_{PZ} = PZ concentration (mol/kg)

$\rho_{H2O} = f(T)$

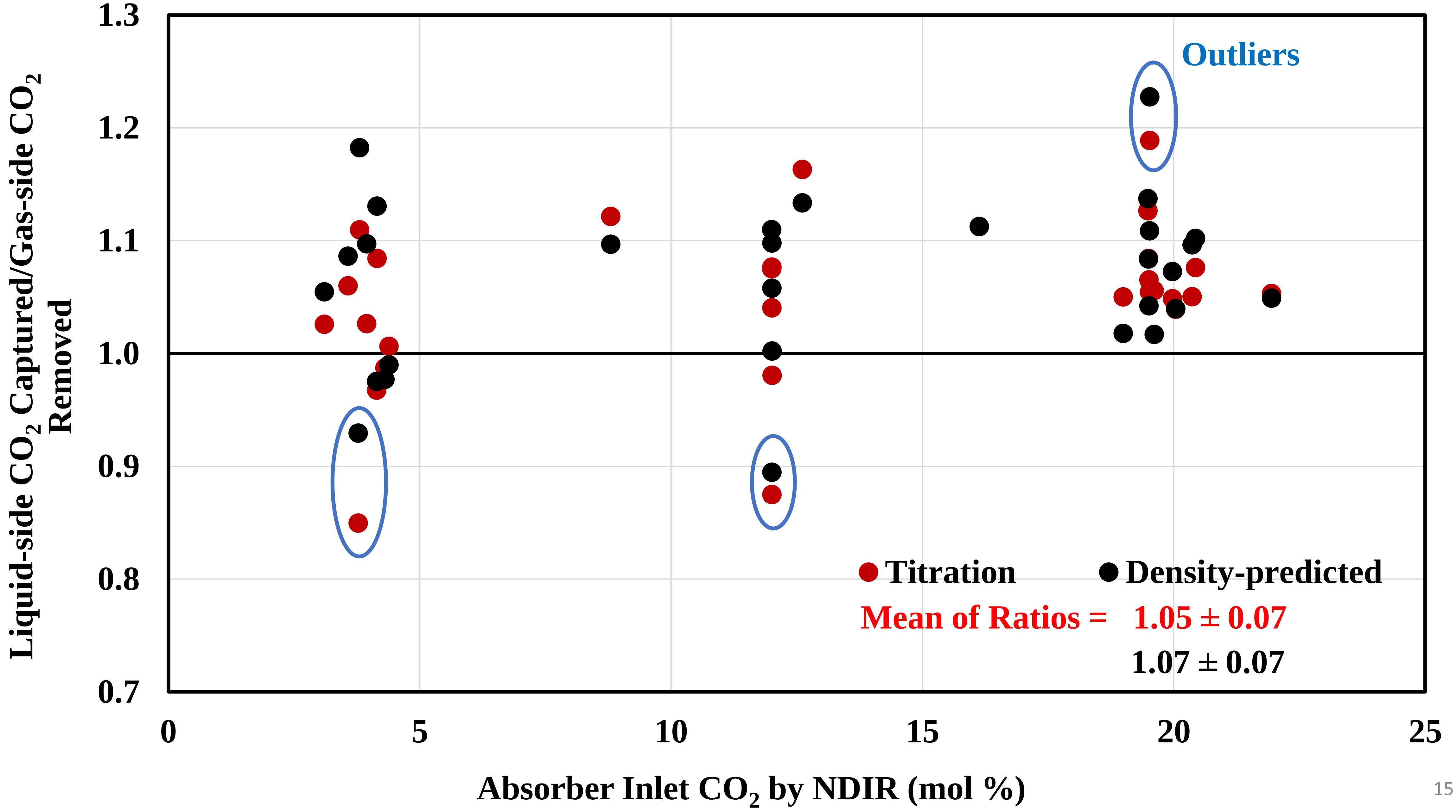
Density works reasonably well for Rich Loading



Reconciliation of 4 Redundant Lean Loading Measurements

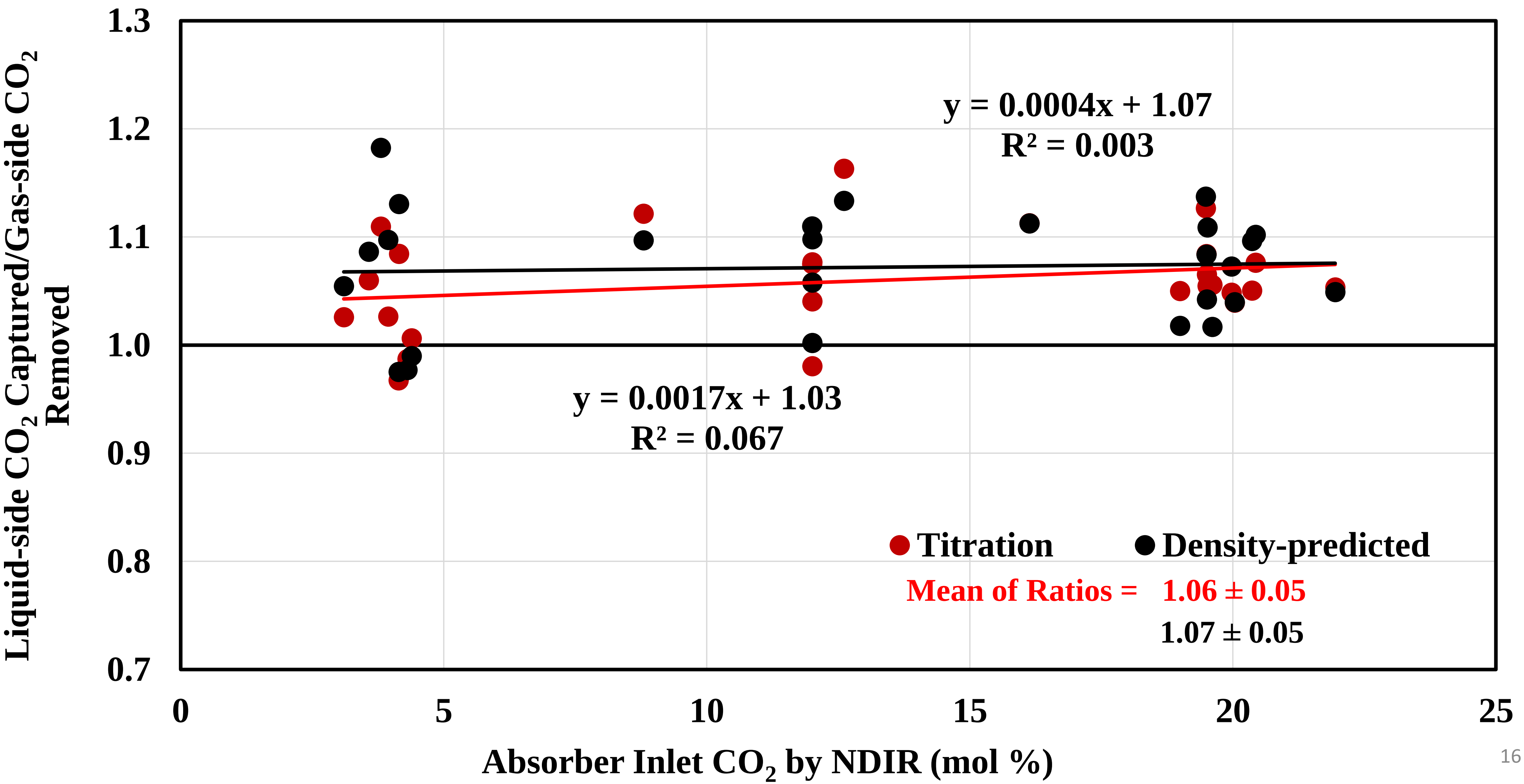


Outliers identified by CO_2 material balance

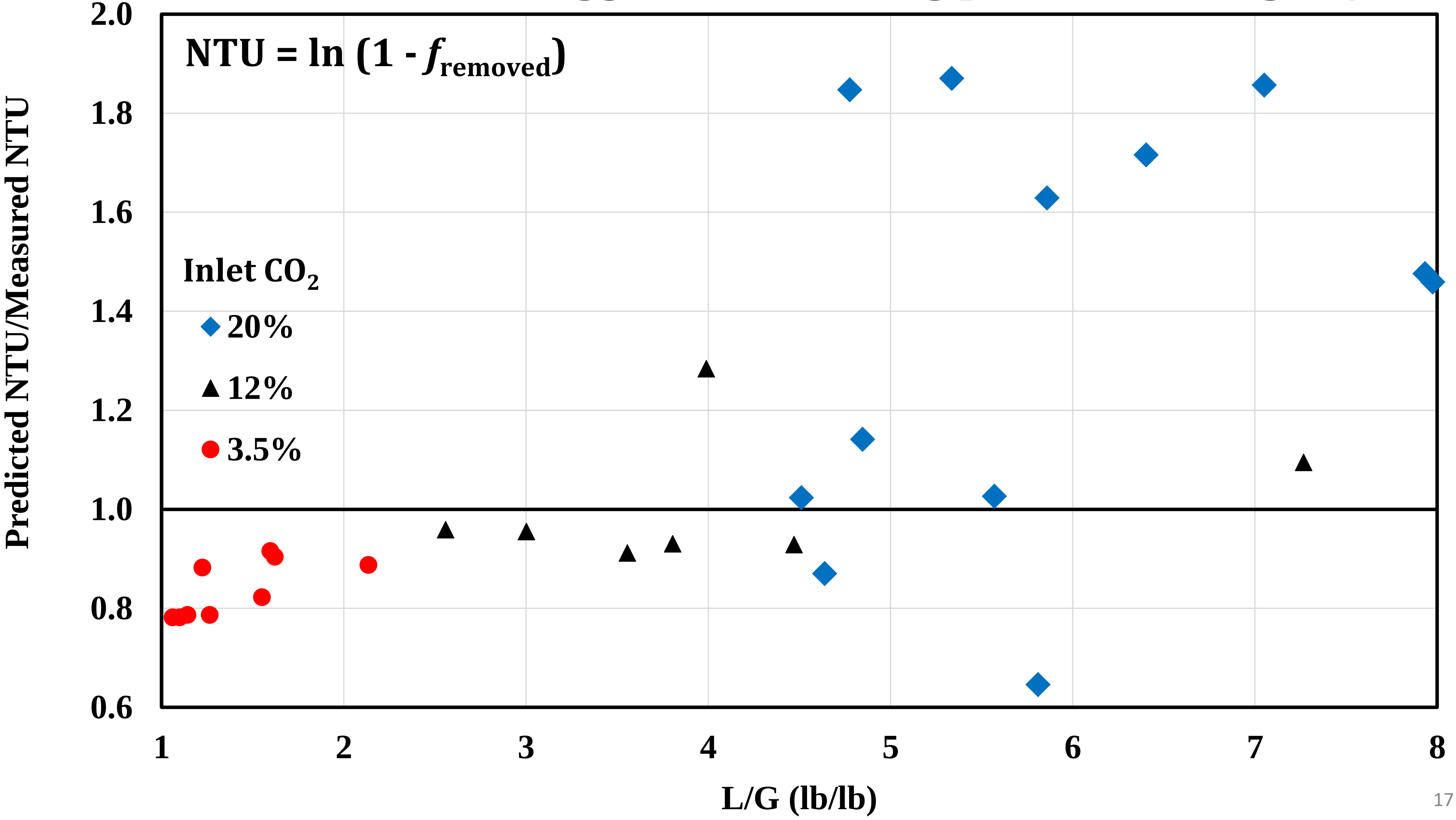


Systematic bias is not dependent on inlet CO_2

Basis to correct inlet CO_2 or select correct lean loading



Predicted NTU suggests contacting problem at High L/G



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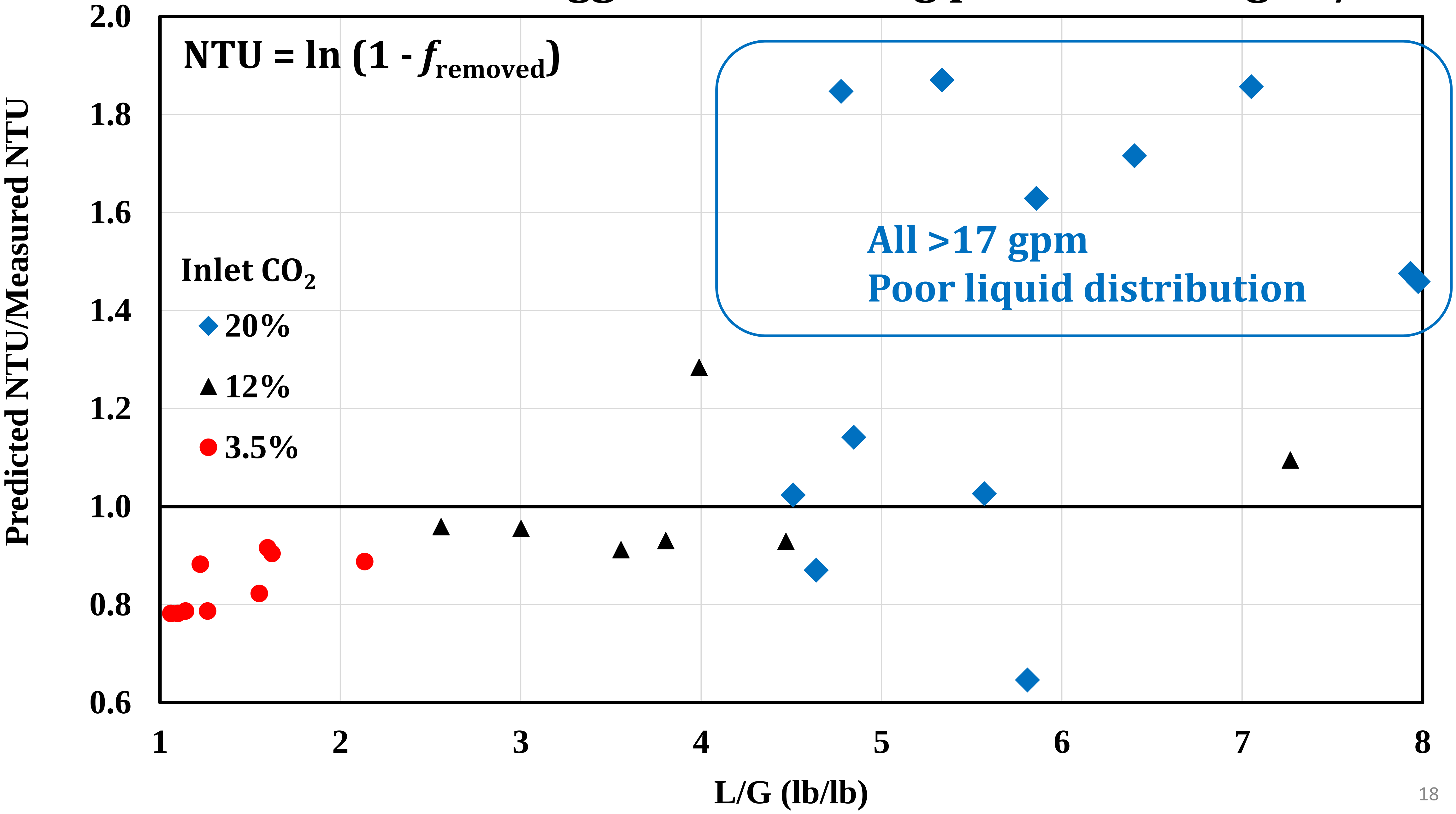

Conclusions

- **Perform careful data reconciliation to**
  - **Select inlet CO_2 analyzer**
  - **Or correct inlet CO_2**
  - **Select loadings**
- **Rely more on on-line density to provide loadings**

Future Data Reconciliation Approach

1. **A data consistency check: material balance check**
2. **Gross error detection: identify the variables that require statistically larger changes**
3. **Data reconciliation with parameter adjustment: if the model cannot be reconciled within the measured uncertainty, adjustable parameters will be added**

For more information

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