Addressing challenging issues of CO2 flow assurance in transport and injection system

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Introduction

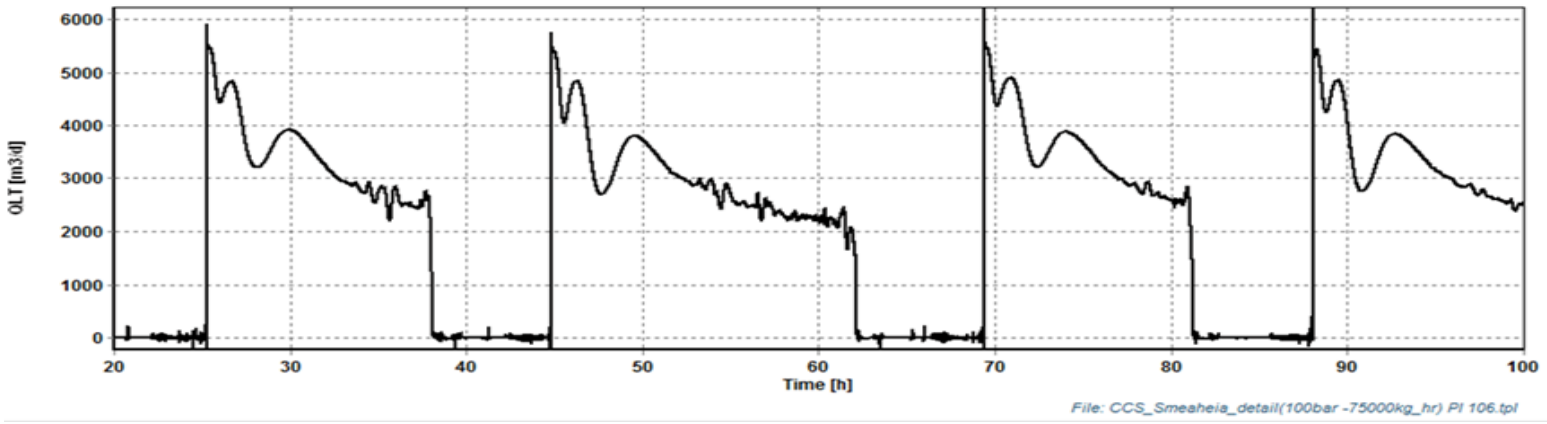
Extensive operational experience in Snøhvit CO2 and Northern Lights project development

Existing flow assurance tools developed from O&G industry → proven technology for CO2 transport and injection with single-phase flow

CO2 storage in low pressure or depleted reservoirs (28 Gt in UK and 8 Gt in Norway identified)

Two-phase CO2 flow can be observed in transport and injection system

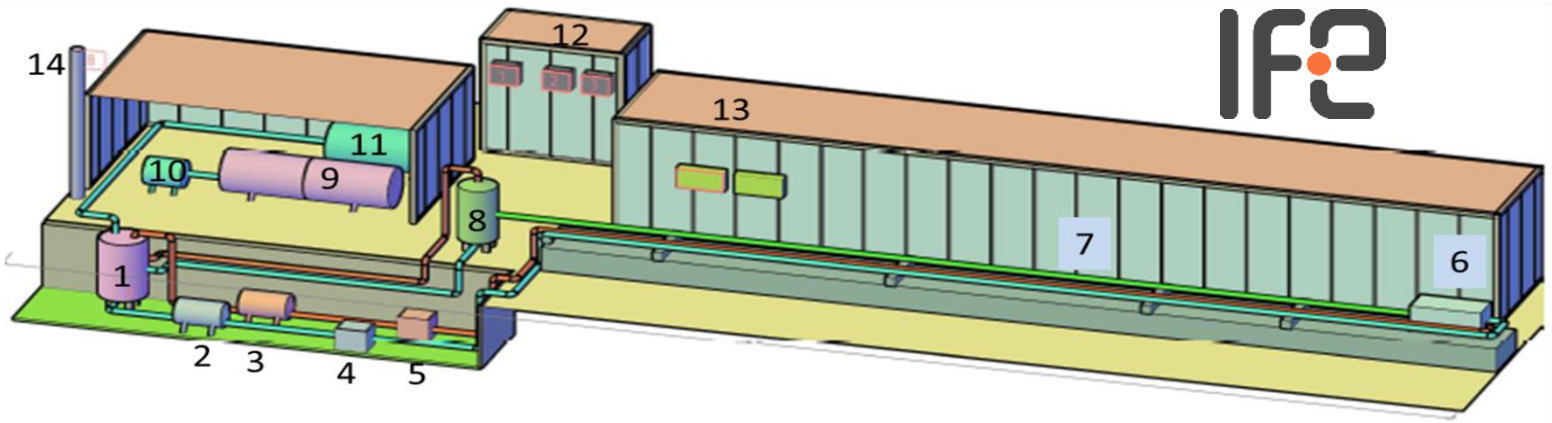
Limited knowledge of many physical phenomena of two-phase CO2 flow, and the existing flow assurance tools not verified



CO2 FACT JIP

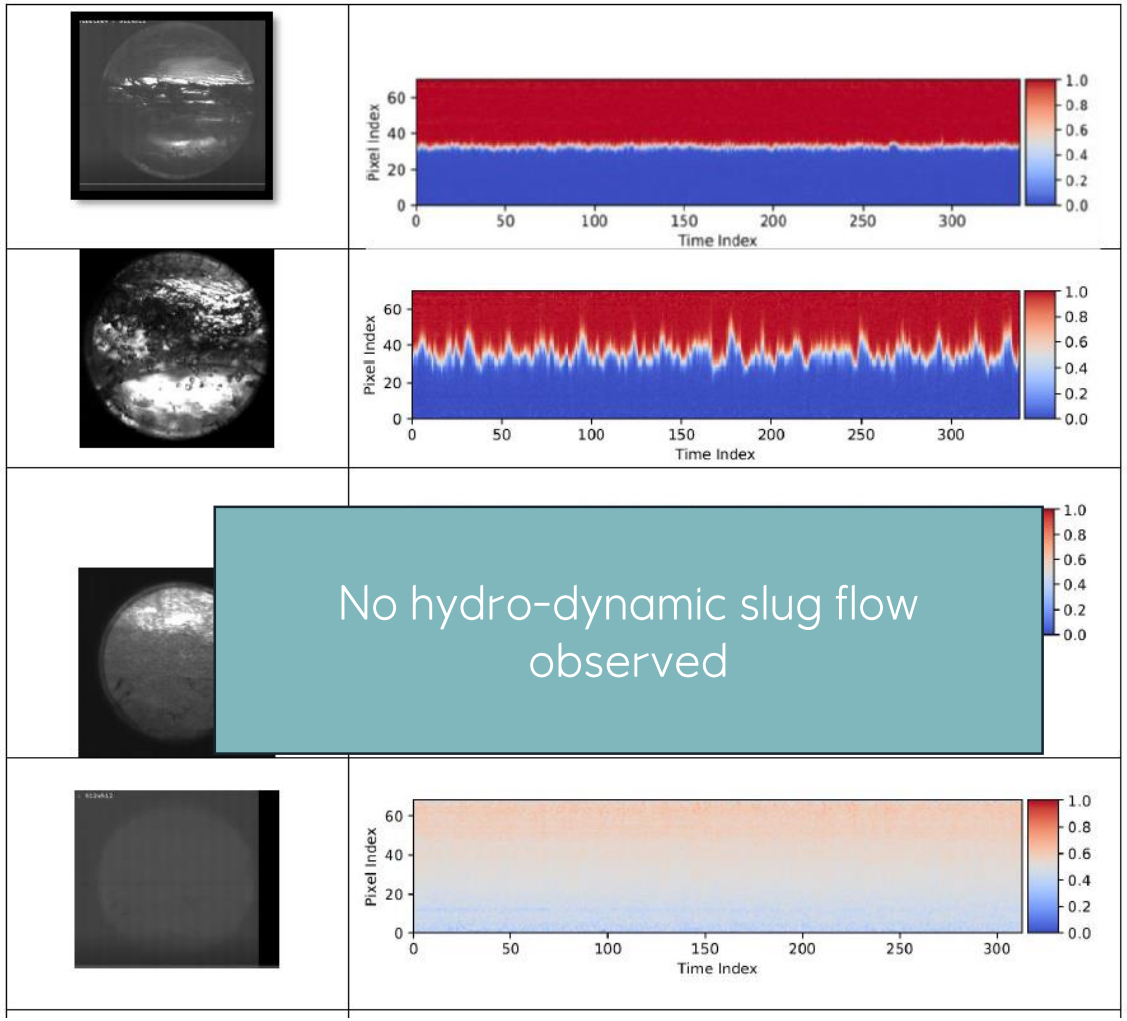
Co-funded by Gassnova CLIMIT-Demo Program

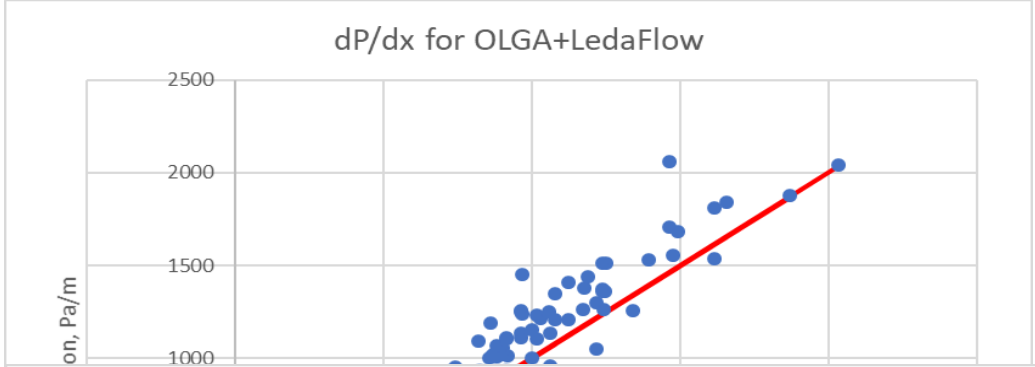
- **Scope of work**
  - Extensive experimental laboratory study various CO2 flow phenomena in a pipe
    - Steady-state two-phase flow
    - Phase change, flow via valve (Cv, cavitation, critical flow), fluid hammering
    - Shut-in and restart, depressurization, effect of impurities etc.
  - Systematic testing of OLGA and LedaFlow
    - All available laboratory CO2 flow data
    - Operational data from Snøhvit CO2 injection system and other field data
- **Schedule:** 2018.12 – 2021.12

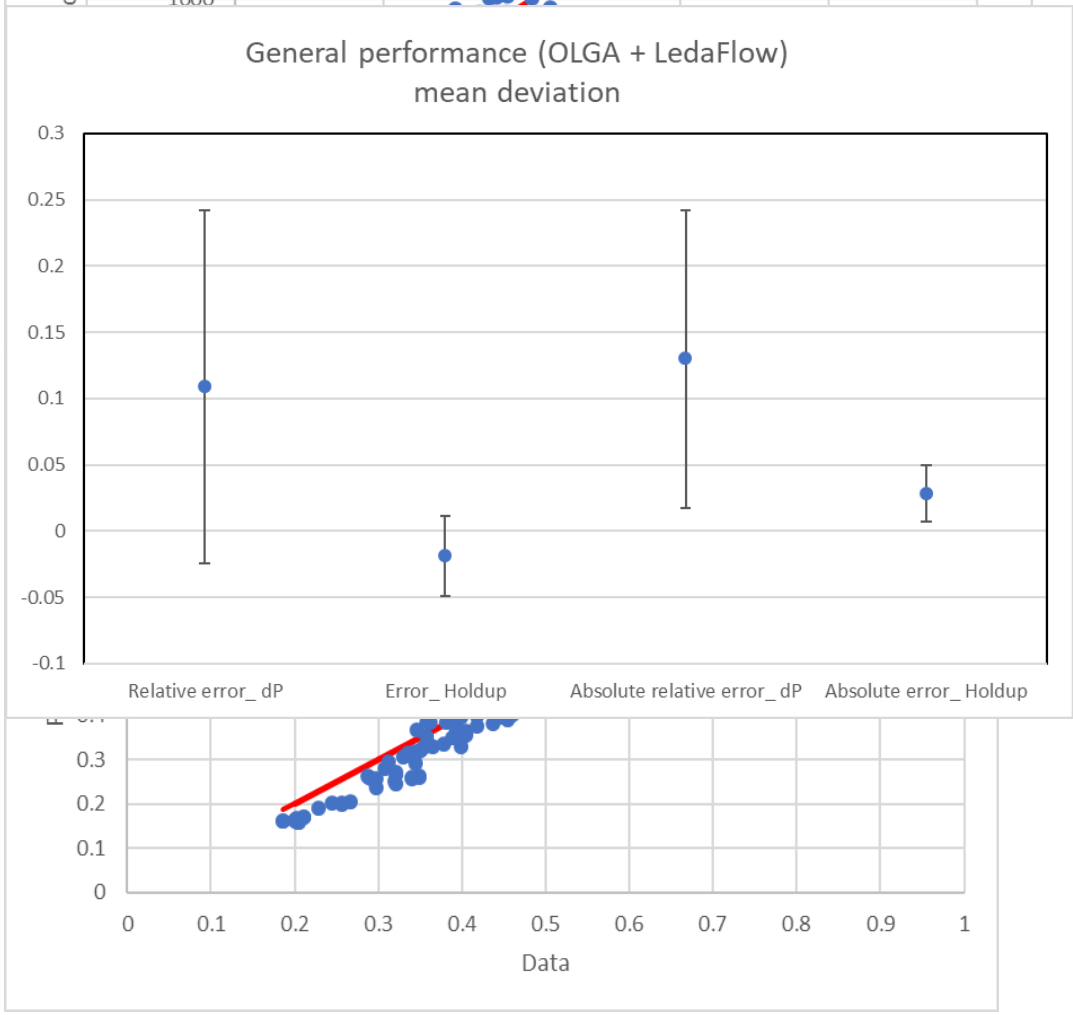


Key parameters
- P: 5-140 bar
- T: -30 – 40 oC
- ID = 44 mm
- L = 13 (23) m
- Angle: -90 to 90o
- Usg < 8m/s
- Usl < 2 m/s

Selected results from CO2 FACT JIP - CO2 two-phase flow in a close horizontal pipe (steady-state, pure CO2)

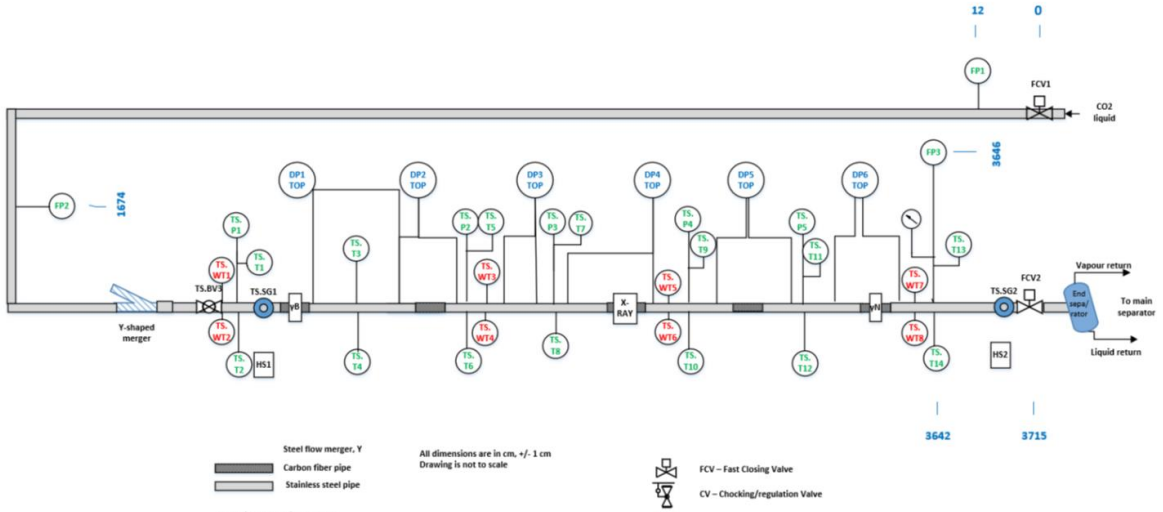


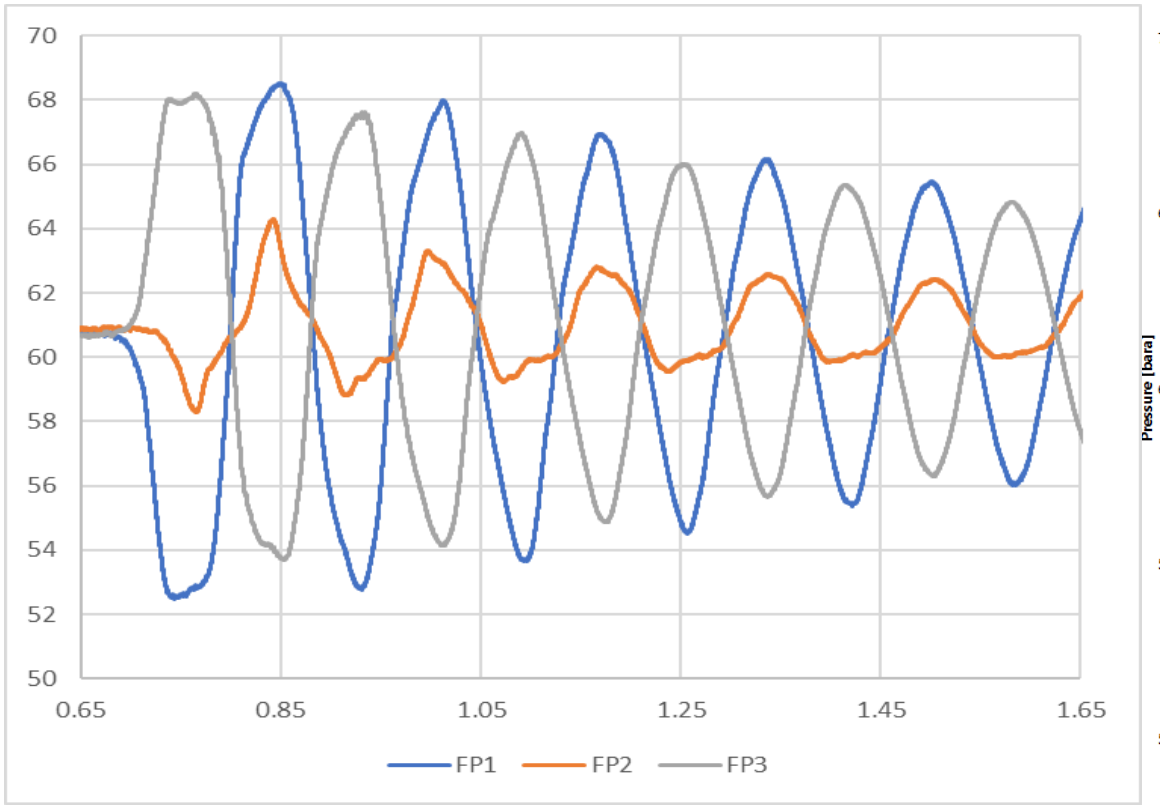


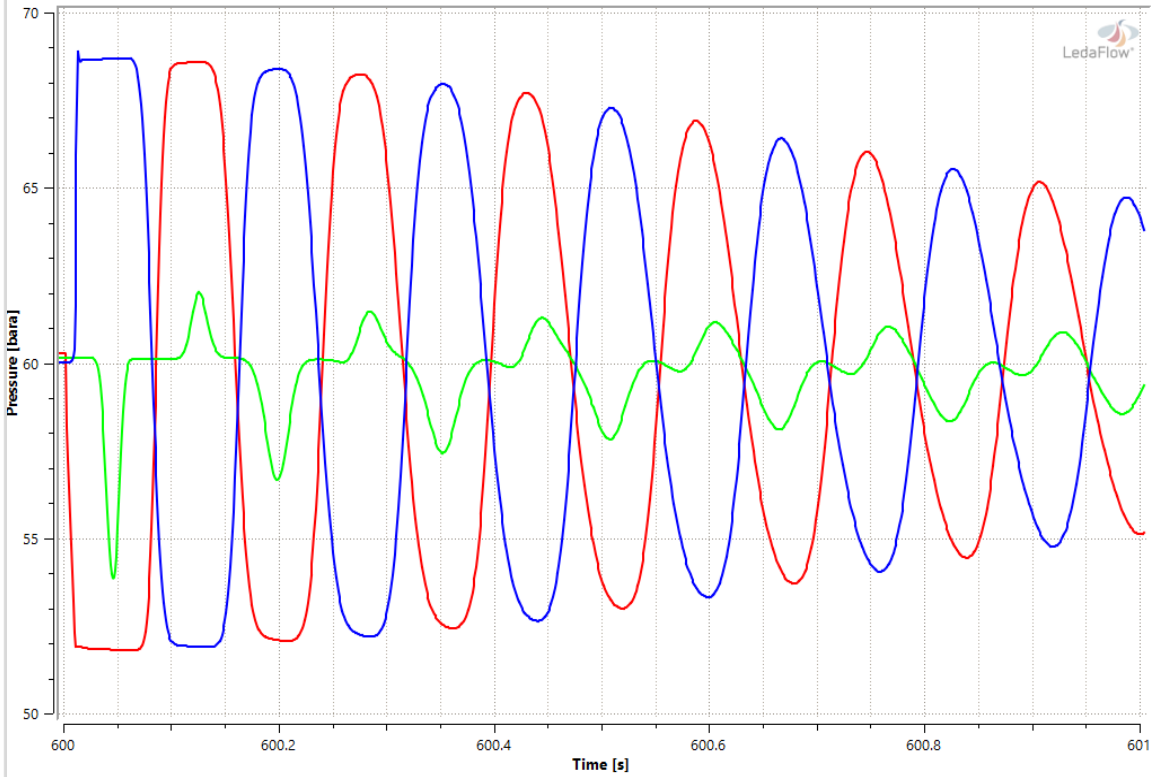


Selected results from CO2 FACT JIP - Fluid hammering with LedaFlow

- Test with two valves closed at the same time





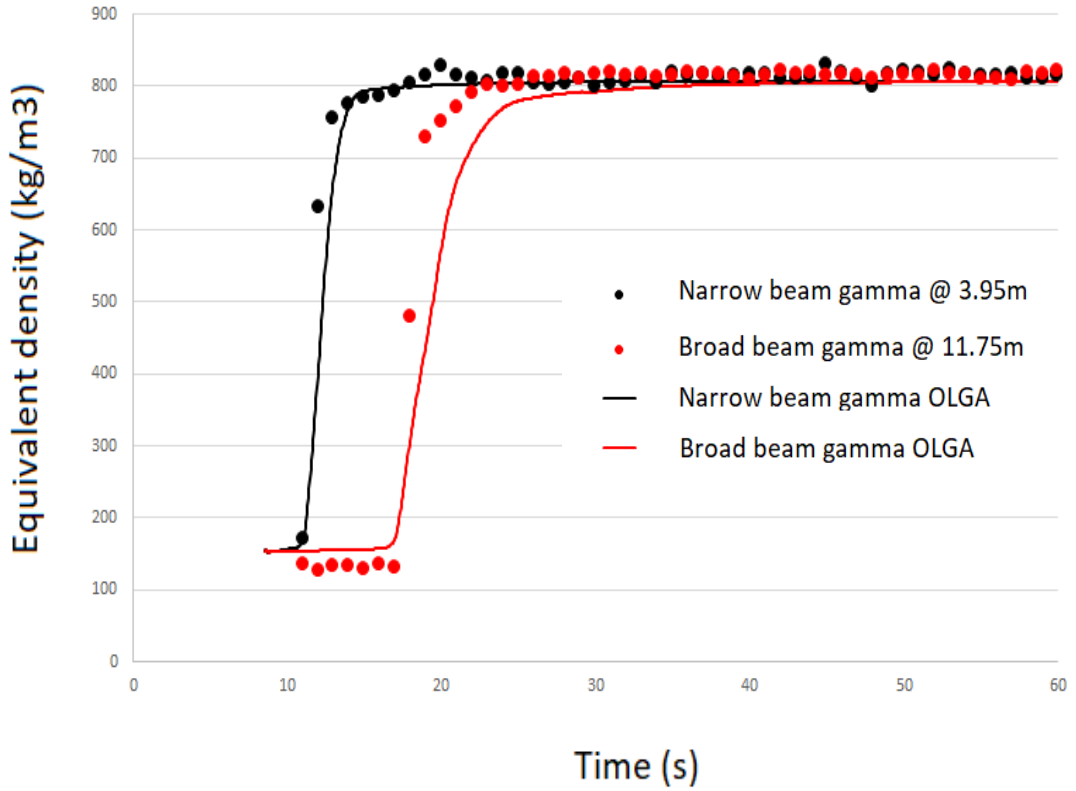


Selected results from CO2 FACT JIP - Horizontal restart & OLGA

CO2 flow assurance with OLGA

- Verified two-phase pressure drop and hold-up
  - Same performance as for oil and gas
- Verified depressurization computations over valves for CO2 applications
- Handling of impurities with Compositional Tracking
  - Phase II of CO2 FACT

Exp: 1606. Horizontal restart at 50 bar on saturation line CO2(l) displaces CO2(g)



Summary

- Extensive experimental study on various two-phase CO2 flow phenomena (impurity effect) within CO2 FACT JIP is the first step for qualification of existing flow assurance tools for CO2 transport and injection applications
  - Flow assurance tools for single phase flow application verified by JIP lab data and Snøhvit field data
  - Some differences in flow behavior between CO2 and O&G fluid systems observed
  - Phase II tests on-going and with focus on the impact of impurities (<5%Mol)

- Extensive testing of the commercial flow assurance tools OLGA and LedaFlow is still on-going
  - Satisfactory performance obtained for some data
  - Large deviations for two-phase flow applications expected

- Future work
  - Establish best practices of current commercial flow assurance tools for CO2 applications
  - Establish further improvement and development plan for qualification of commercial flow assurance tools
  - Perform further experimental studies for CO2 data collection
    - Large scale facility testing to address scaling issues of flow models
    - Fundamental understanding of slugging mechanism