Developing methods to study multi-phase phenomena in Stirred Tanks using Magnetic Resonance Imaging

Institute of Process Imaging

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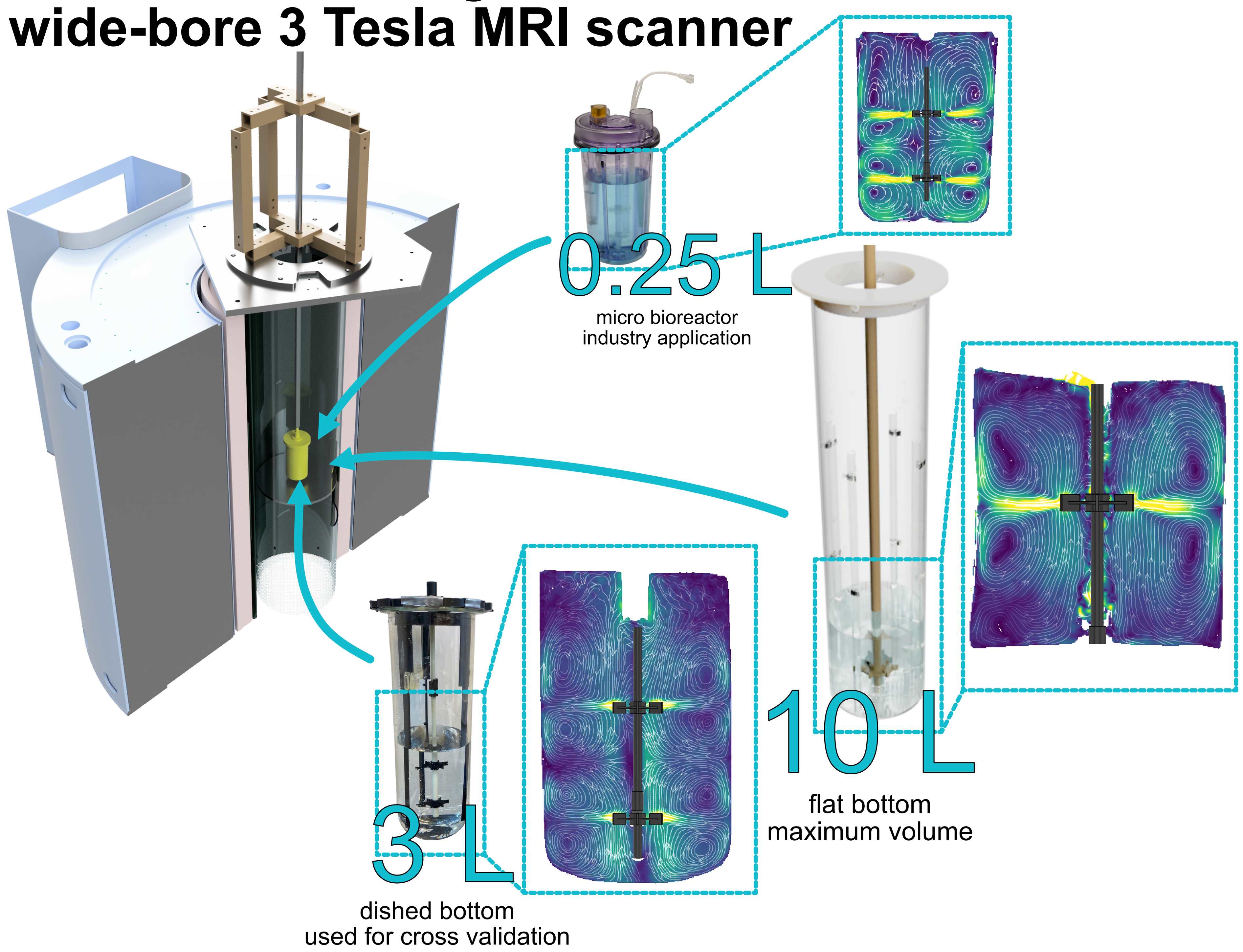
Velocimetry of a variety of stirred tanks using a vertical wide-bore 3 Tesla MRI scanner



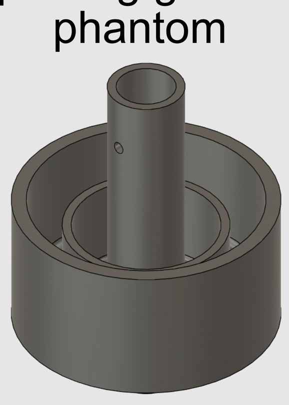
Motivation

Non-invasive	Opaque systems	High resolution
no probes or tracers needed	sees through reactor walls, dense gas flows, opaque liquids	capturing detailed structure and flow
no flow disturbance	no optical access needed	< 1 mm voxel size < 200 ms per scan

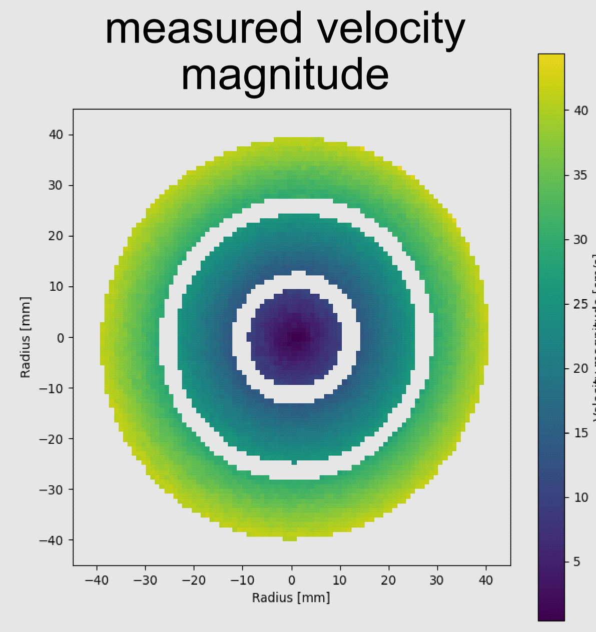
Validated quantitative velocimetry

Validated by a spinning gel disc at controlled stirring speeds and over the whole measurement space.

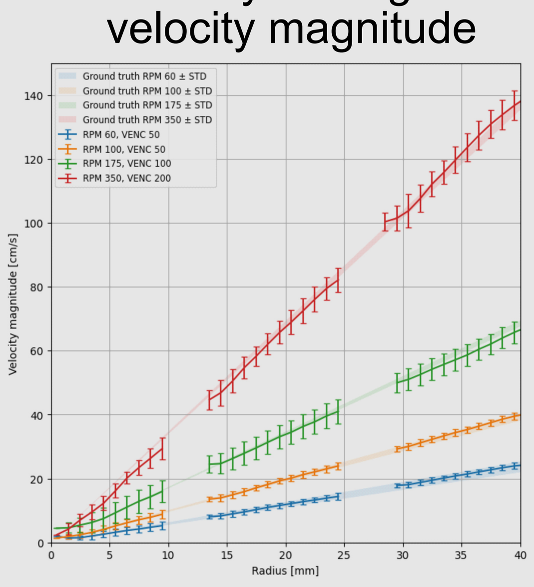
spinning gel disc phantom



measured velocity magnitude

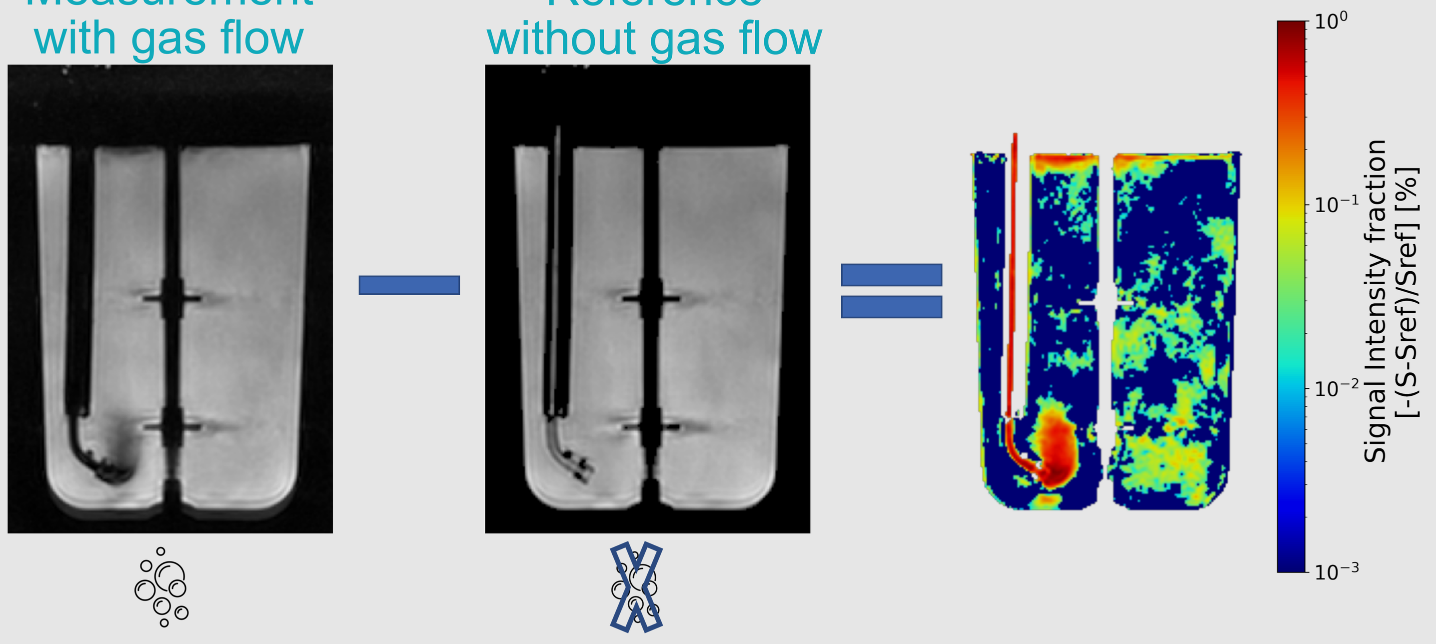


radially averaged velocity magnitude

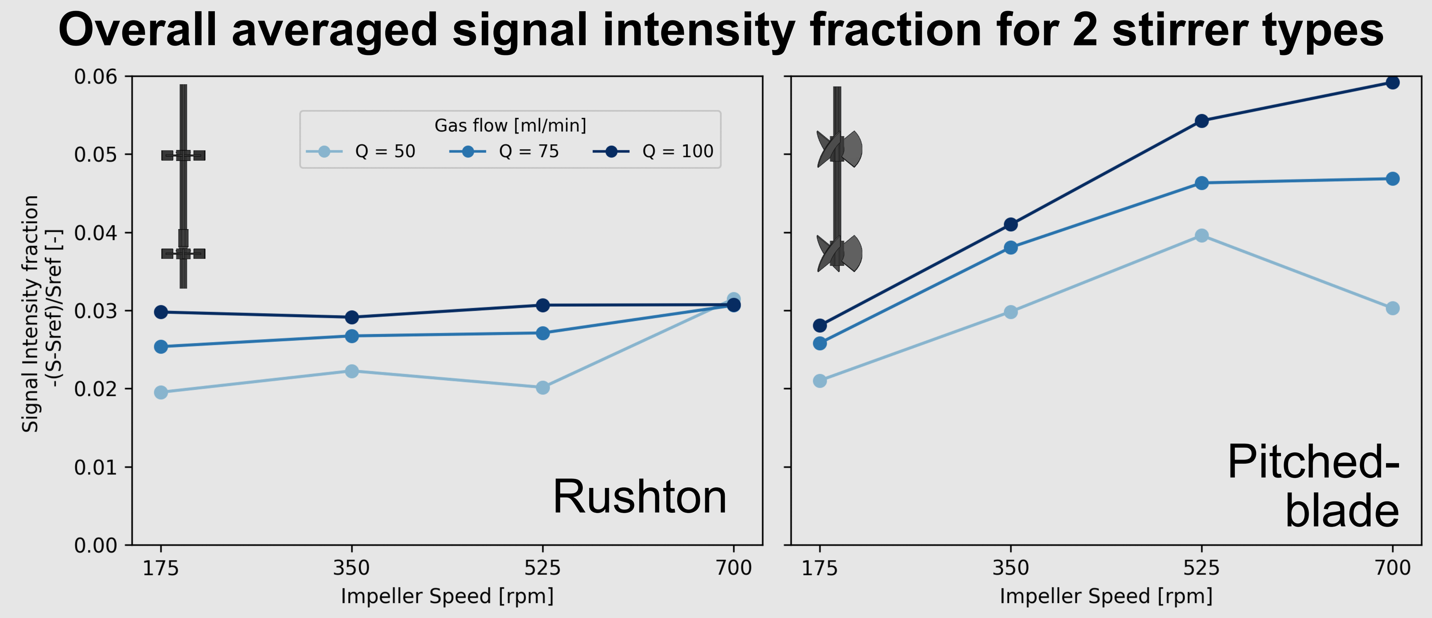


Gas hold-up
by using
MRI signal intensity

MRI signal is generated by resonant 1H-nuclei. These are abundent in liquid (here water) and not present in air. This creates contrast between the two phases. The signal intensity fraction will correspond proportionally to the gas hold-up after calibration.

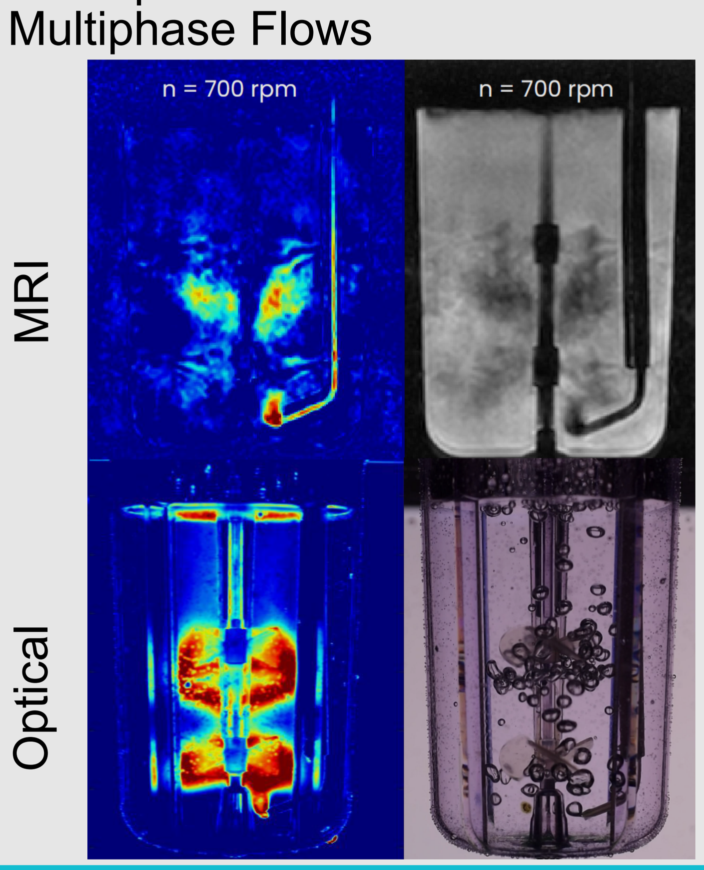


Overall averaged signal intensity fraction for 2 stirrer types



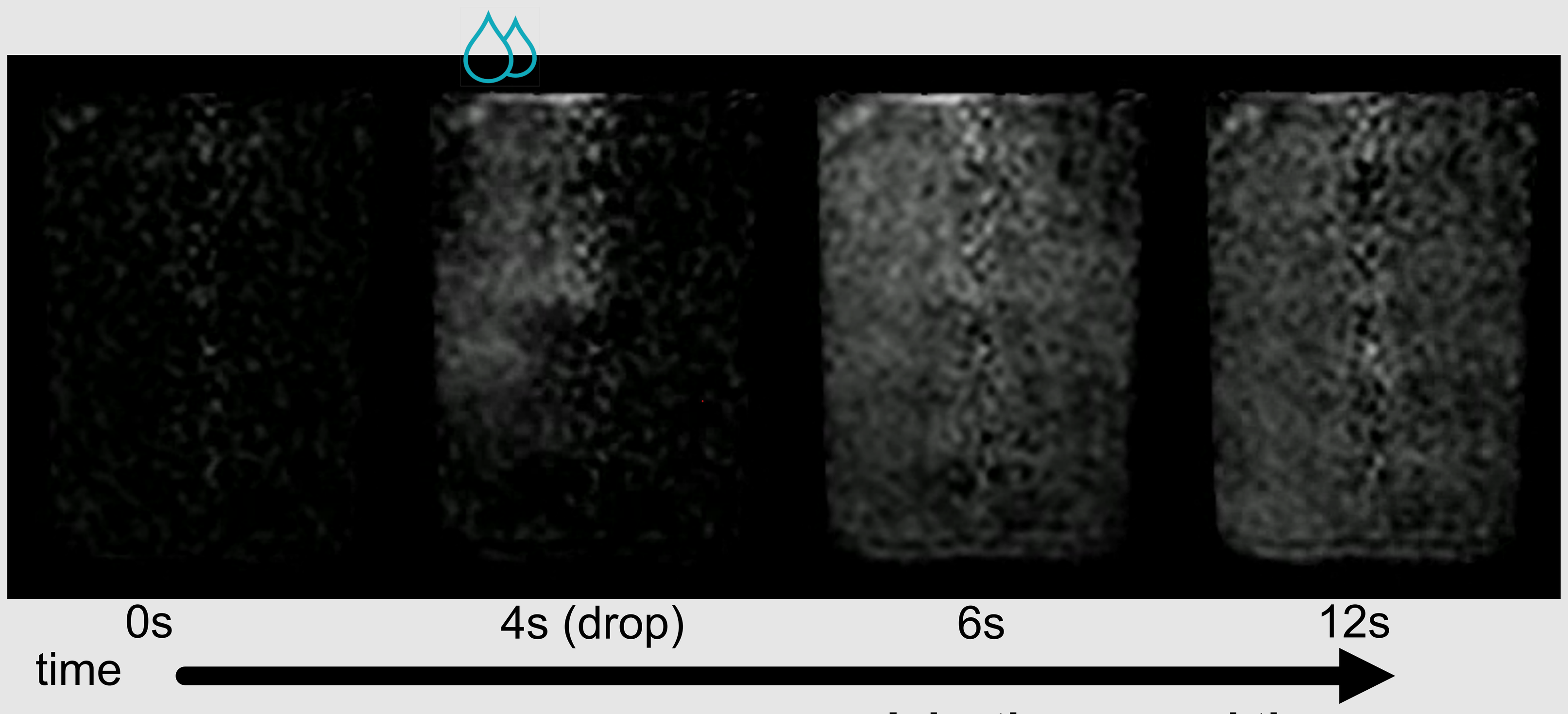
Validation by executing
optical experiments
in cooperation with Institute of Multiphase Flows

ims

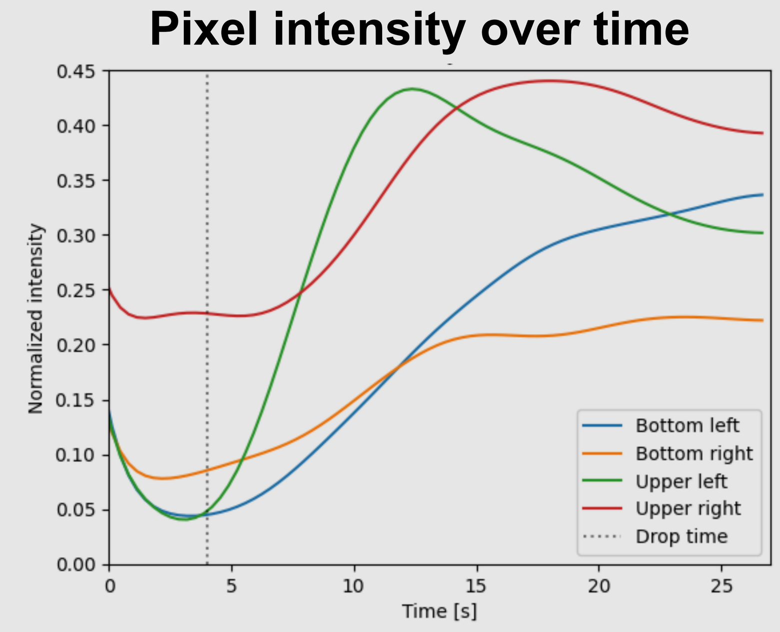


Mixing time
by using
T1 Relaxation time contrast

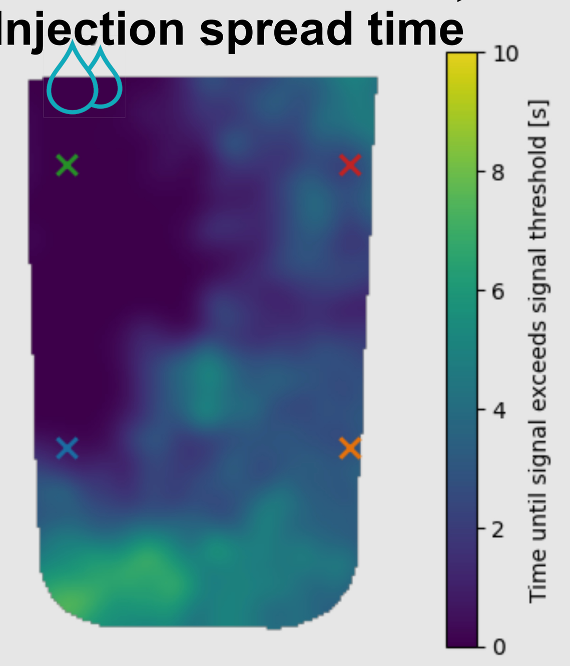
By using T1 weighted contrast, MRI creates contrast between the bulk and the injected fluid. The signal intensity of the injected fluid is higher, and so indicating the spread of it after injection.



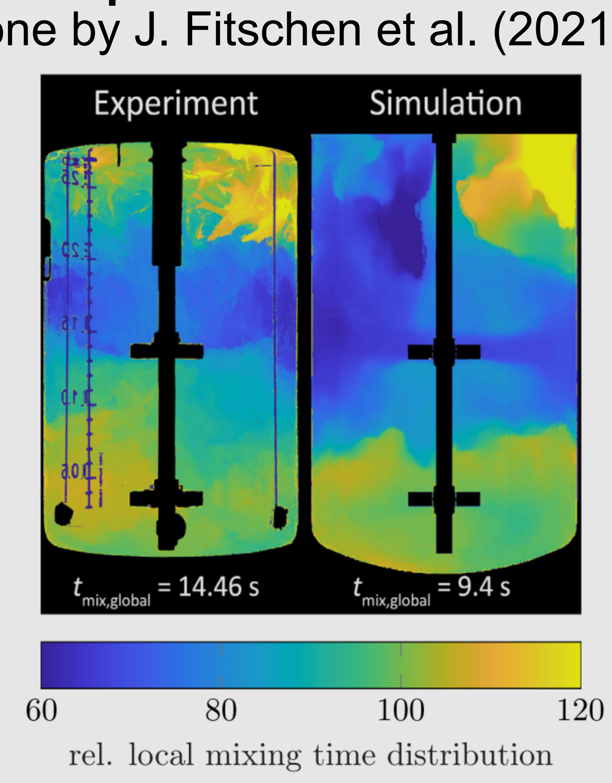
Pixel intensity over time



Injection spread time



Validation
by recreating **optical experiments in 3L reactor**
done by J. Fitschen et al. (2021)



Outlook

Solid/liquid suspension	Non-Newtonian liquids	Liquid/liquid mixing/ emulsions
Particle distribution, settling and clustering behavior	Shear-rate and shear-rate dependent flow measurements	Bulk mixing dynamics

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