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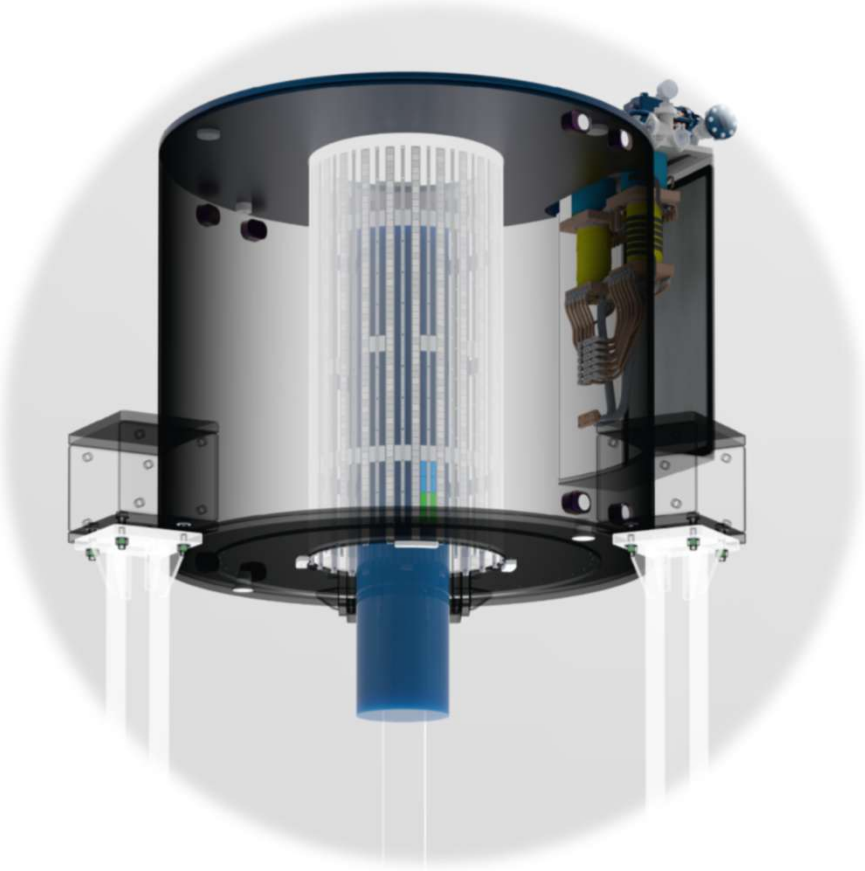
A novel view into aerated stirred tanks:

Magnetic resonance imaging
(L25)



Till Lenczyk[1], Noah v. Schnitzler[2], Stefan Benders[1], Michael Schlüter[2], Alexander Penn[1]

1 Institute of Process Imaging, Hamburg University of Technology (TUHH), Hamburg, Germany
2 Institute of Multiphase Flows, Hamburg University of Technology (TUHH), Hamburg, Germany

MRI introduction

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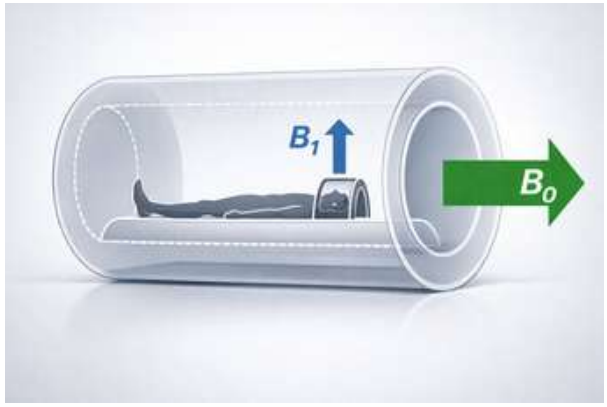
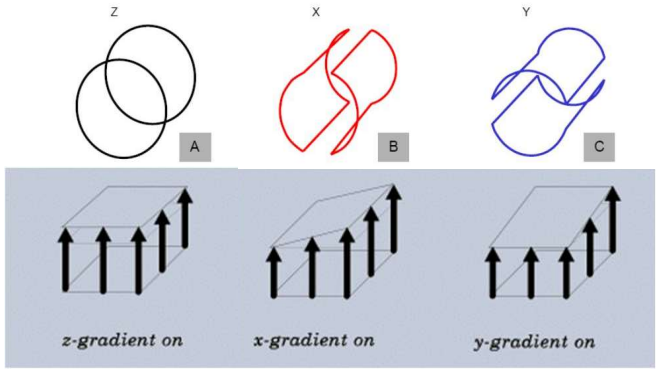
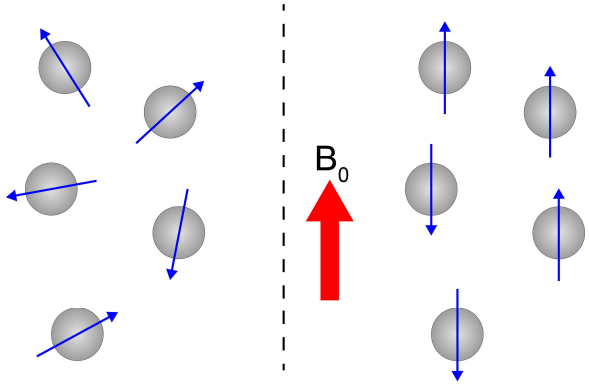
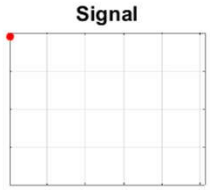
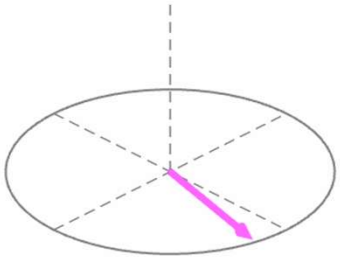






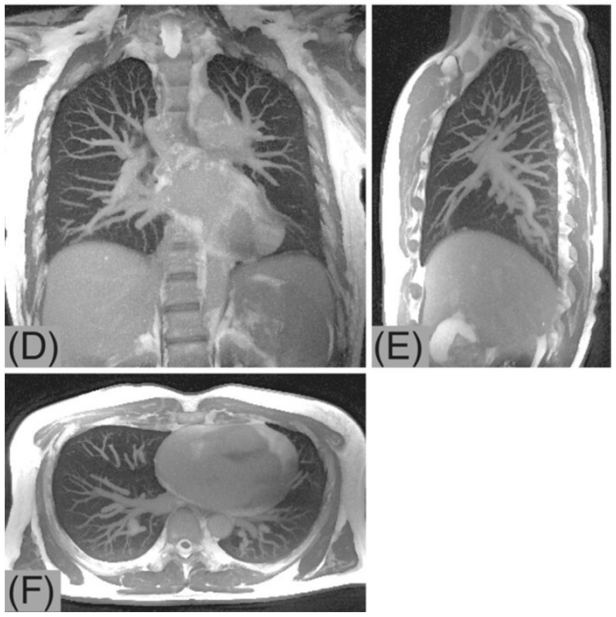
https://maxfacts.uk/



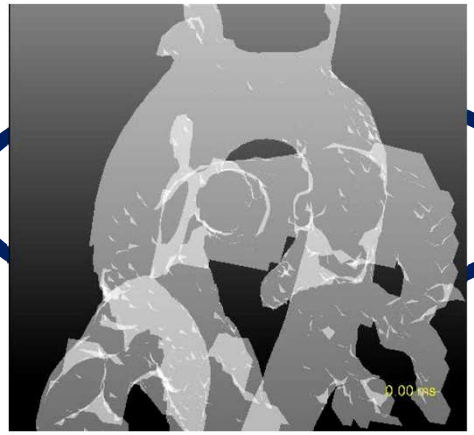


https://mriquestions.com/

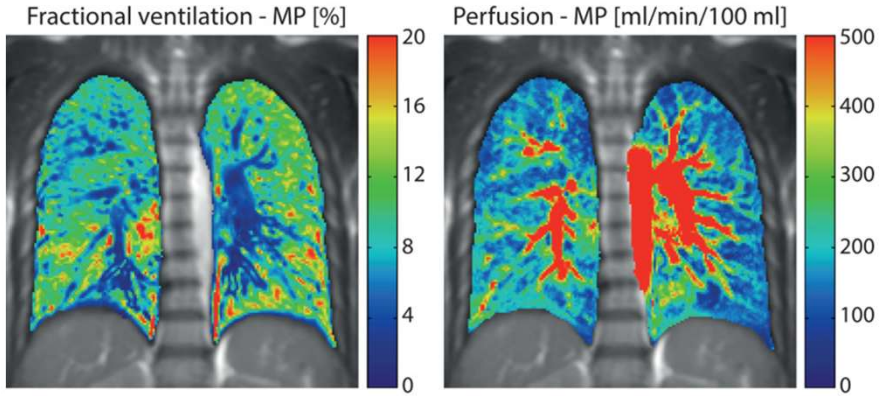
MRI introduction



G. Baumann, University Basel



G. Crelier, ETH Zürich



G. Baumann, University Basel

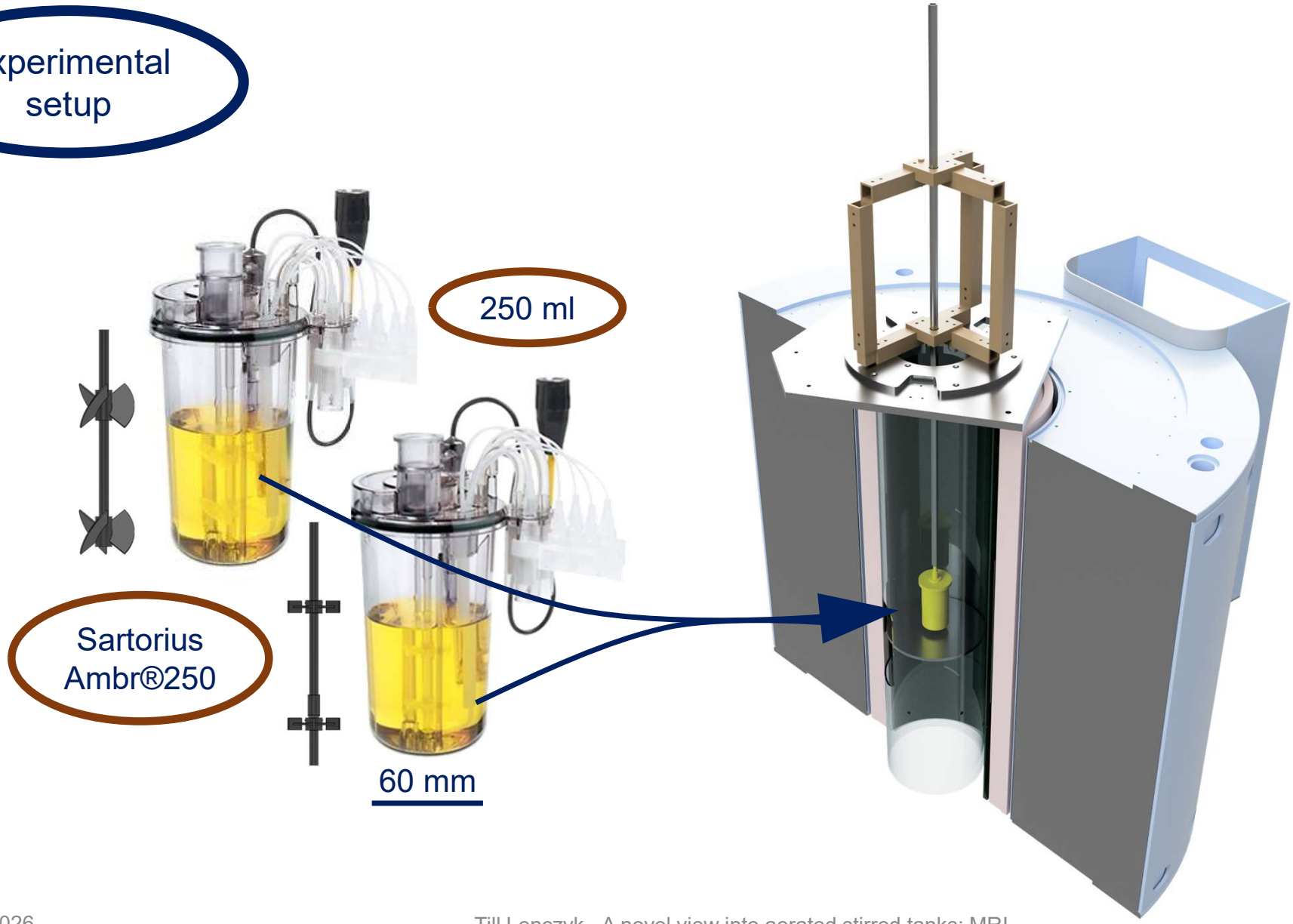
TUHH MRI setup

Flow

Material contrast

Gas content

Experimental setup



Material contrast

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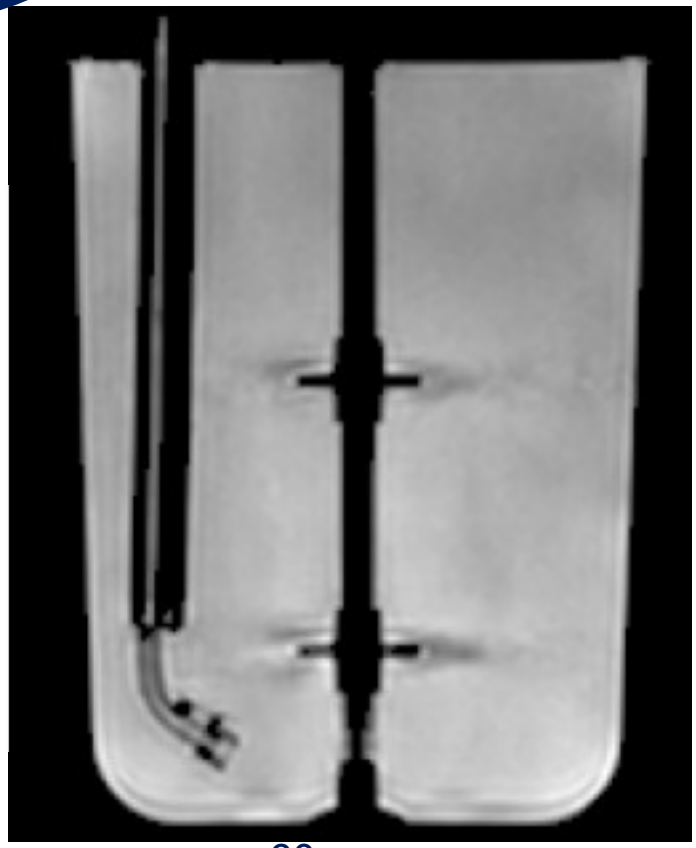
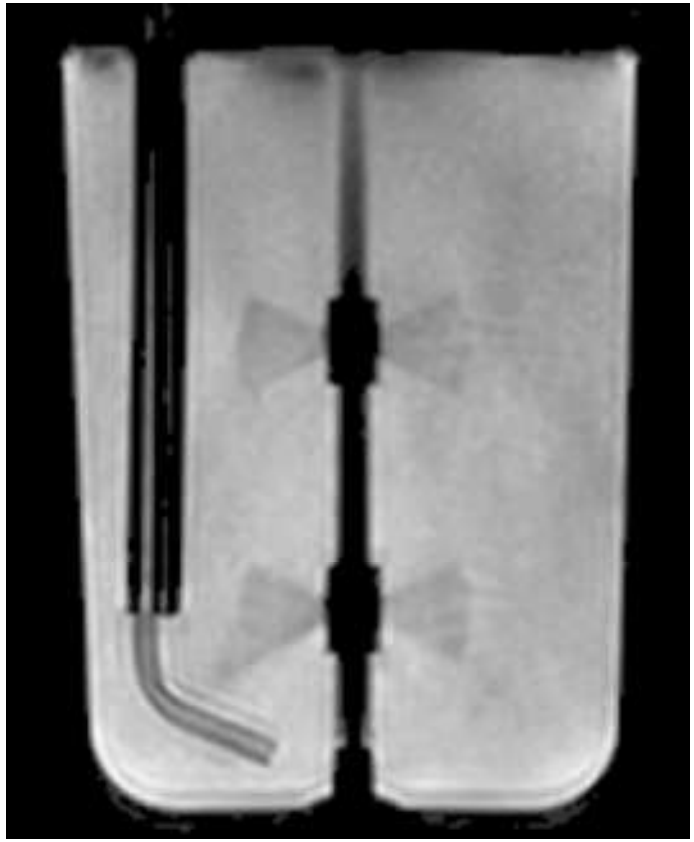
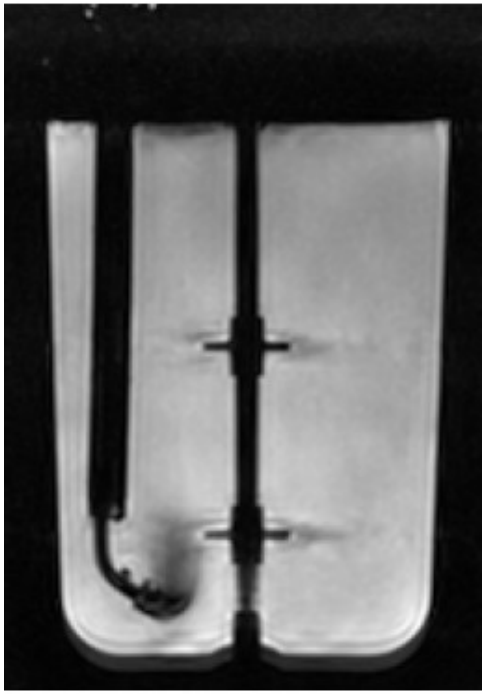
350 rpm

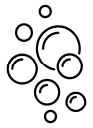


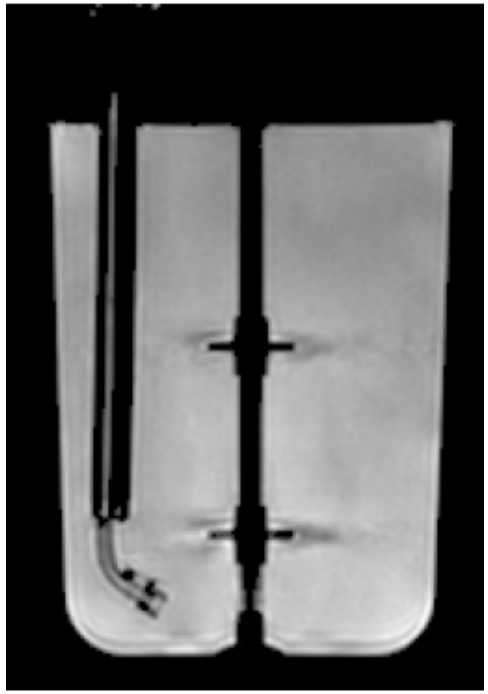


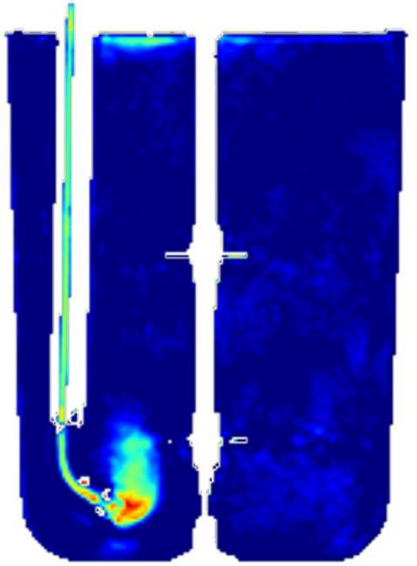
60 mm

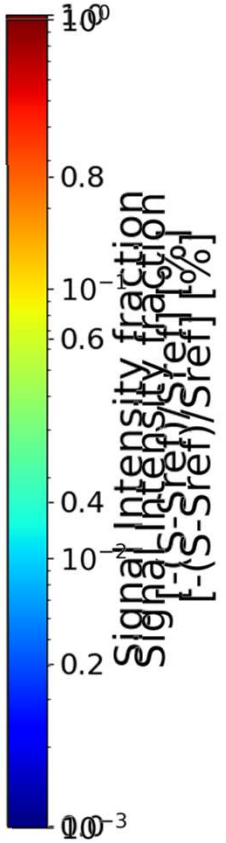
Gas content











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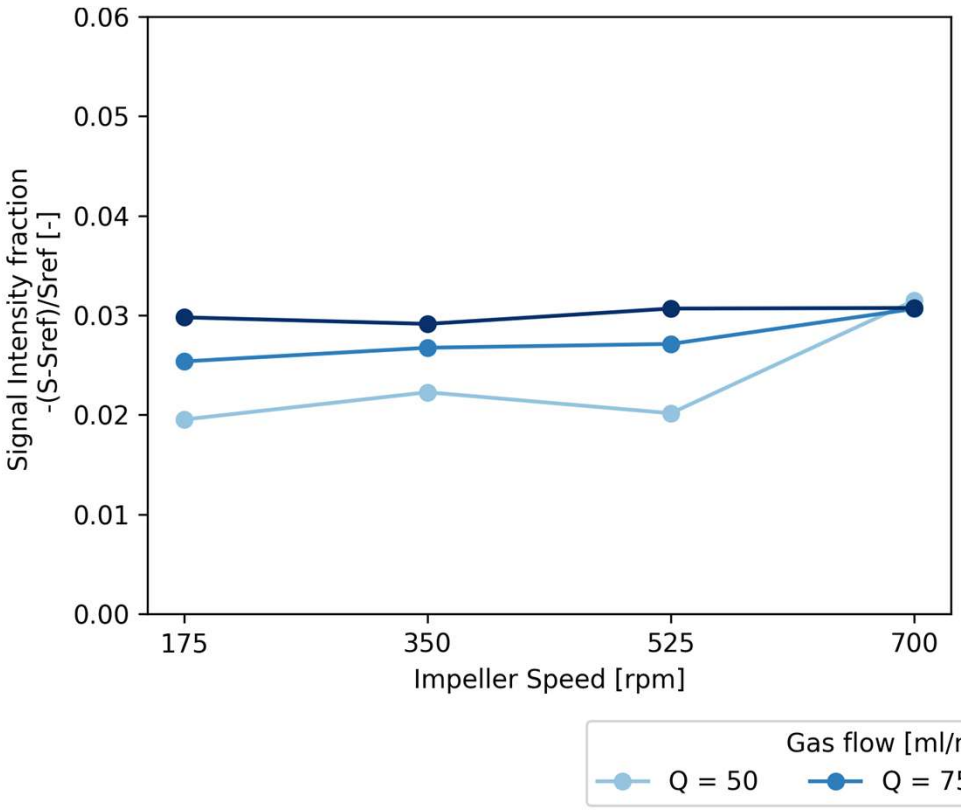
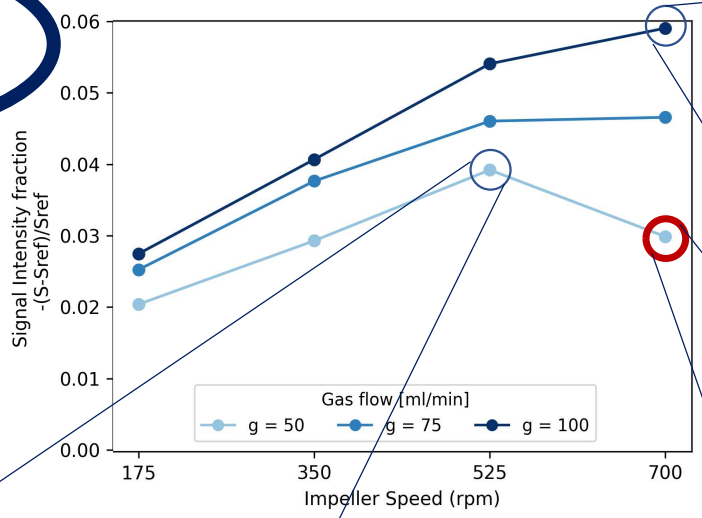
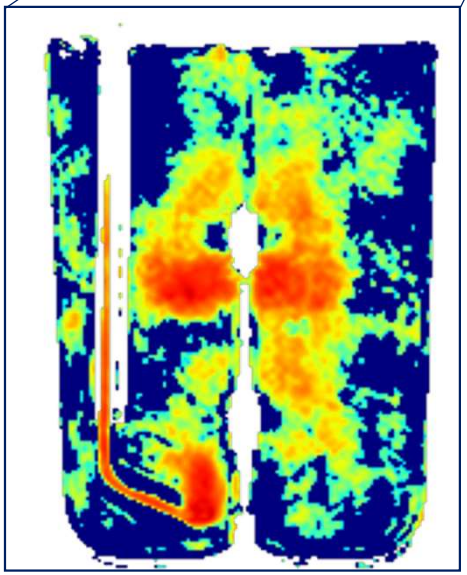
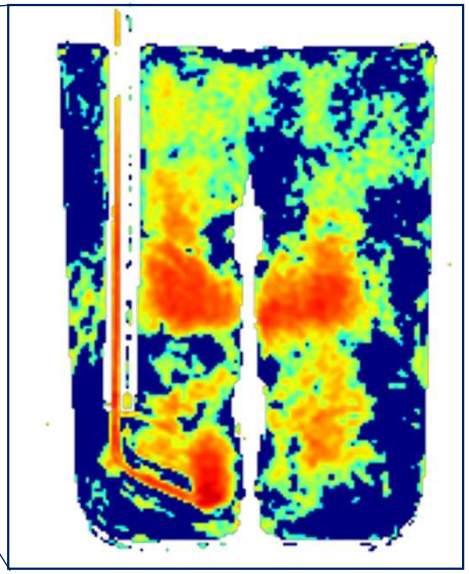
Gas content

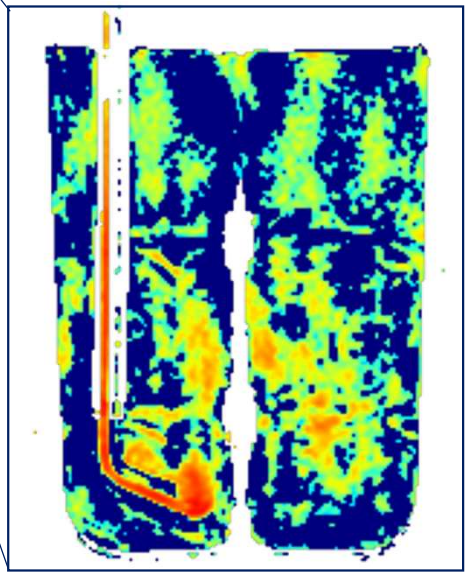

Rushton
Pitched-blade
Signal Intensity fraction
-(S-Sref)/Sref [-]
0.06
0.05
0.04
0.03
0.02
0.01
0.00
175
350
525
700
Impeller Speed [rpm]
Gas flow [ml/min]
Q = 50
Q = 75
Q = 100

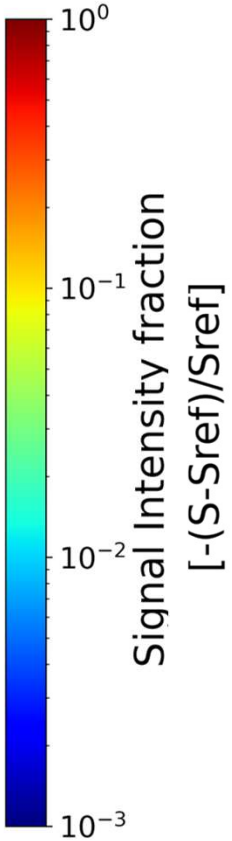
Gas content


Signal Intensity fraction
-(S-Sref)/Sref
0.06
0.05
0.04
0.03
0.02
0.01
0.00
175
350
525
700
Impeller Speed (rpm)
Gas flow [ml/min]
g = 50
g = 75
g = 100

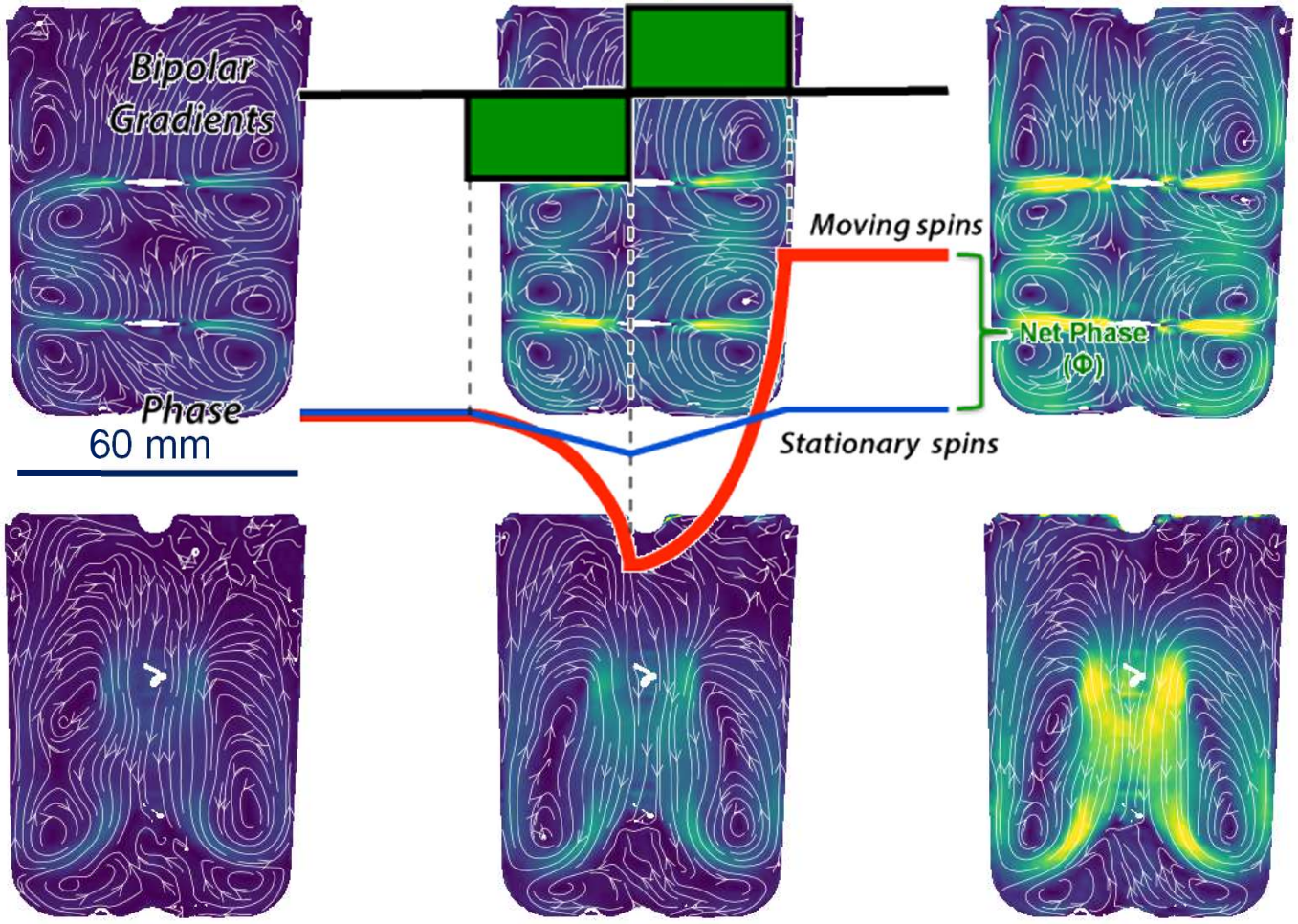


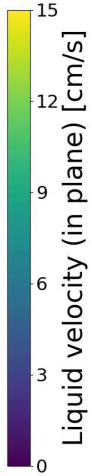


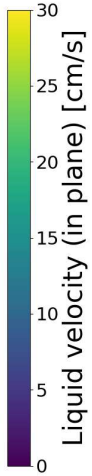



10^{0}
10^{-1}
10^{-2}
10^{-3}
Signal Intensity fraction
[-(S-Sref)/Sref]

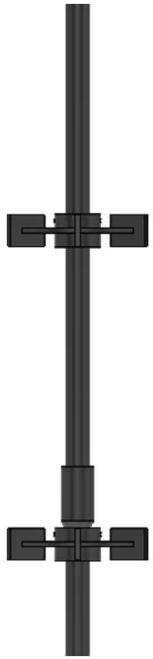
Flow


175 rpm
350 rpm
700 rpm
Bipolar Gradients
Phase
60 mm
Moving spins
Net Phase (Φ)
Stationary spins


Liquid velocity (in plane) [cm/s]
0
3
6
9
12
15


Liquid velocity (in plane) [cm/s]
0
5
10
15
20
25
30

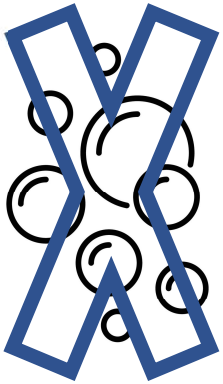
Flow



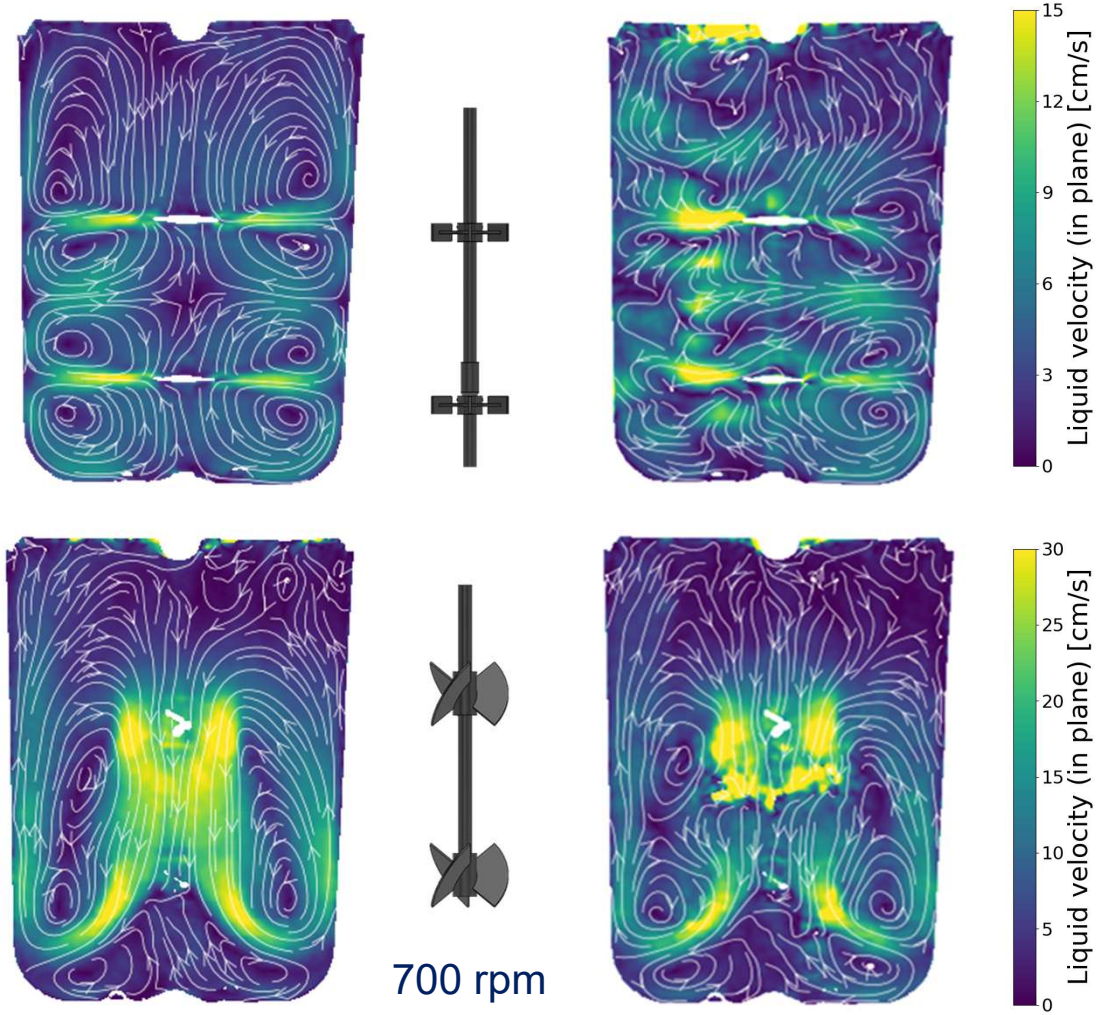
350 rpm

60 mm

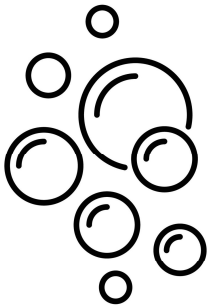
Flow



0 ml/min



700 rpm

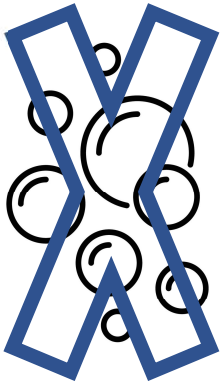


100 ml/min

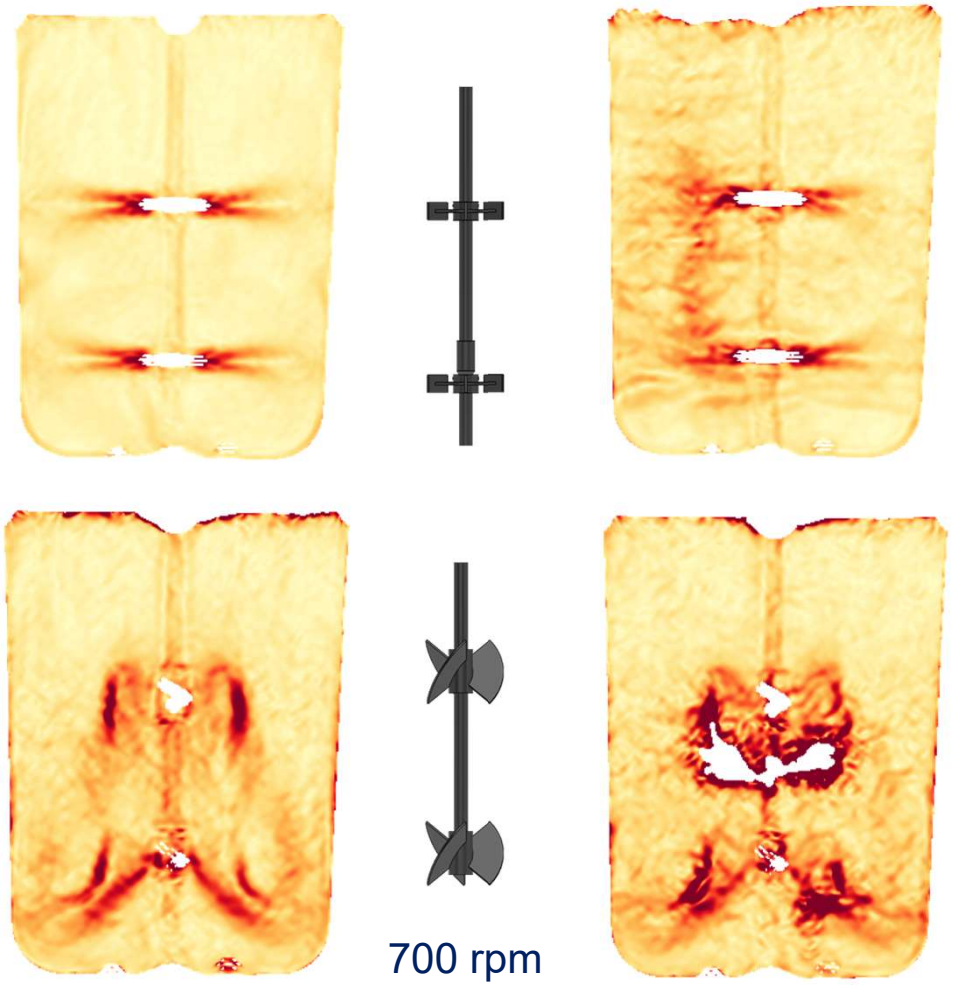
Flow
Shear rate

$$\dot{y} = \sqrt{2\left(\left(\frac{du_x}{dx}\right)^2 + \left(\frac{du_y}{dy}\right)^2 + \left(\frac{du_z}{dz}\right)^2\right) + \left(\frac{du_x}{dy} + \frac{du_y}{dx}\right)^2 + \left(\frac{du_x}{dz} + \frac{du_z}{dx}\right)^2 + \left(\frac{du_y}{dz} + \frac{du_z}{dy}\right)^2}$$

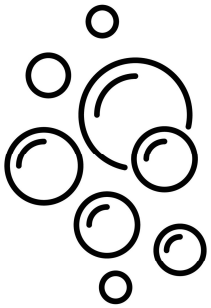
Bird et al. (1960)



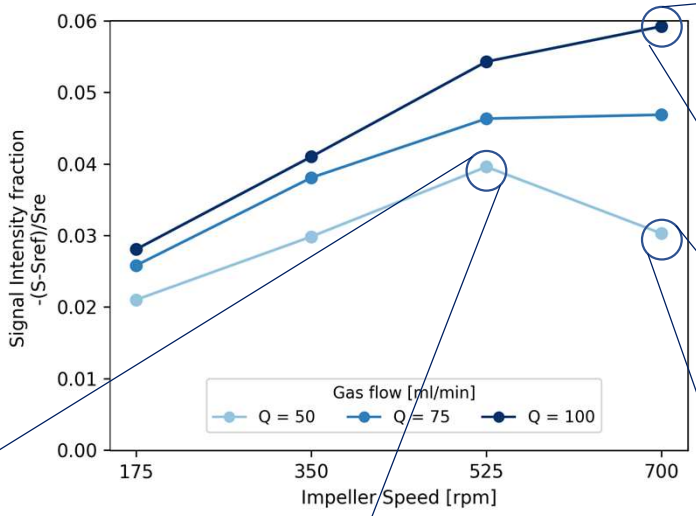
0 ml/min

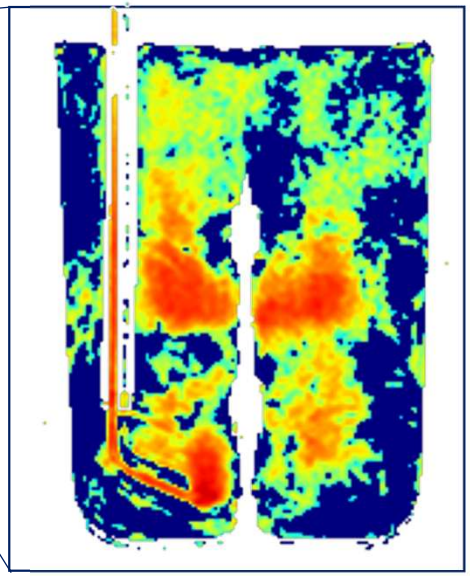


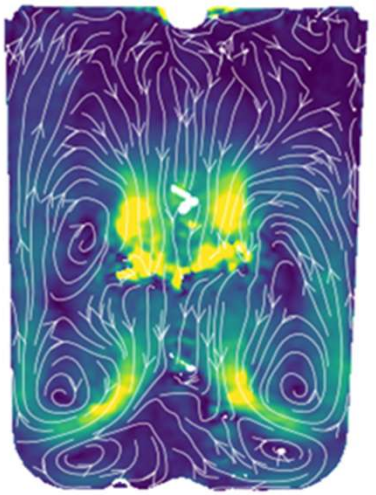
700 rpm

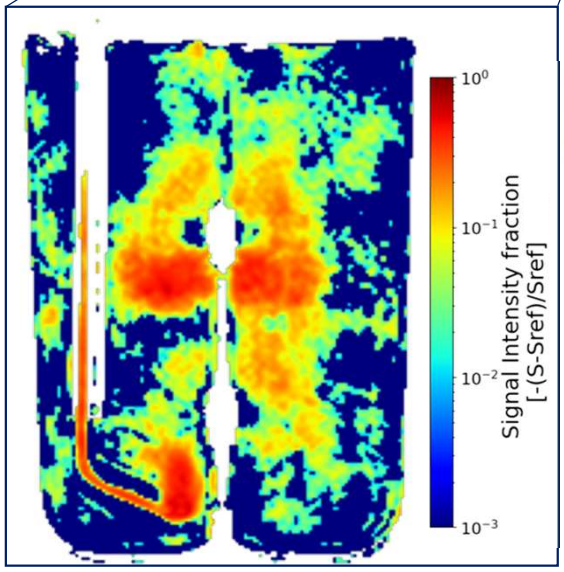


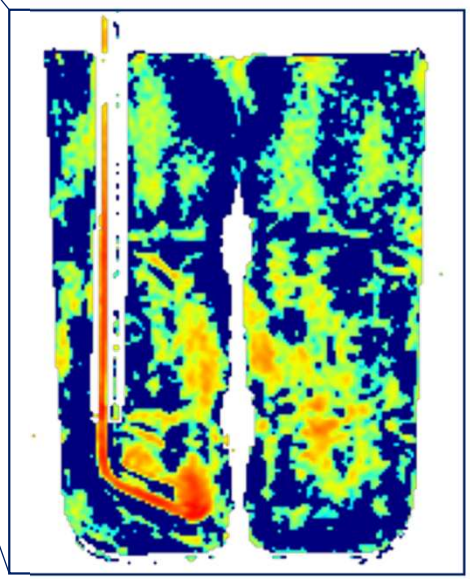
100 ml/min

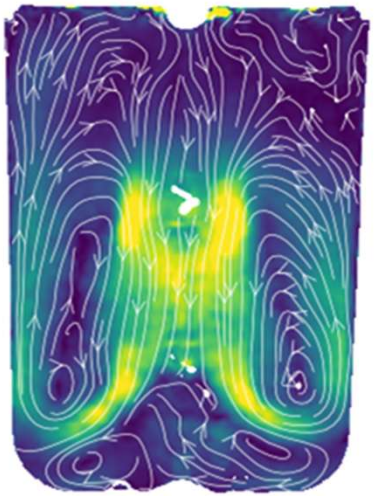

Signal Intensity fraction
-(S-Sref)/Sre
0.06
0.05
0.04
0.03
0.02
0.01
0.00
175
350
525
700
Impeller Speed [rpm]
Gas flow [ml/min]
Q = 50
Q = 75
Q = 100

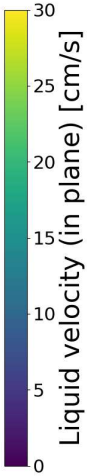





10^{0}
10^{-1}
10^{-2}
10^{-3}
Signal Intensity fraction
[-(S-Sref)/Sref]






30
25
20
15
10
5
0
Liquid velocity (in plane) [cm/s]

Summary

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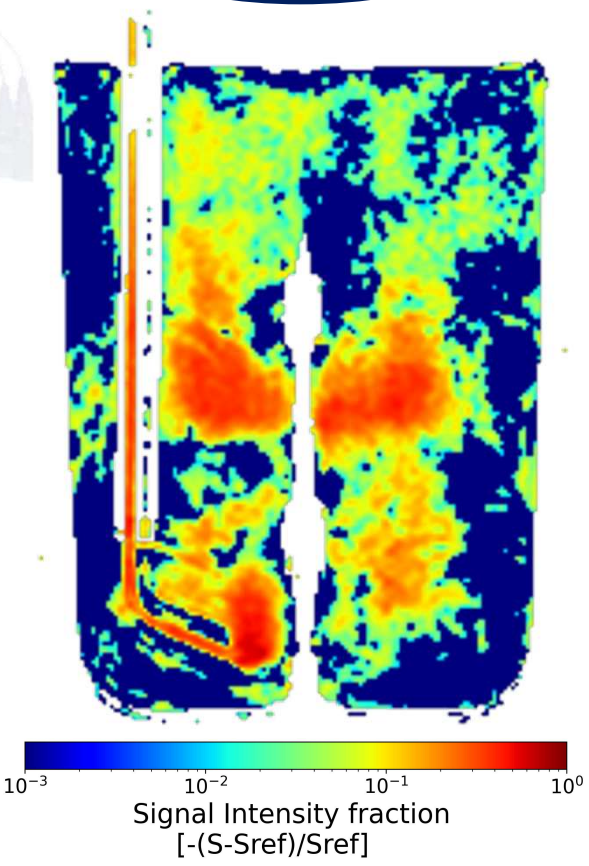
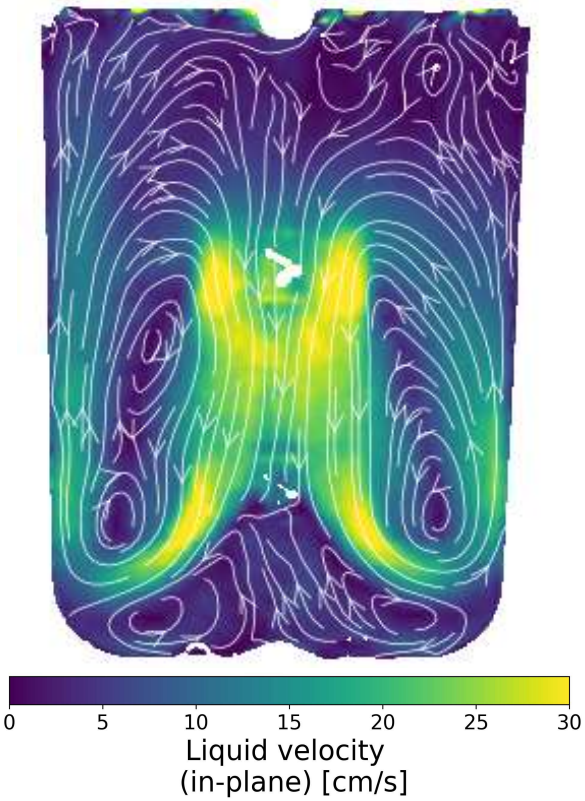
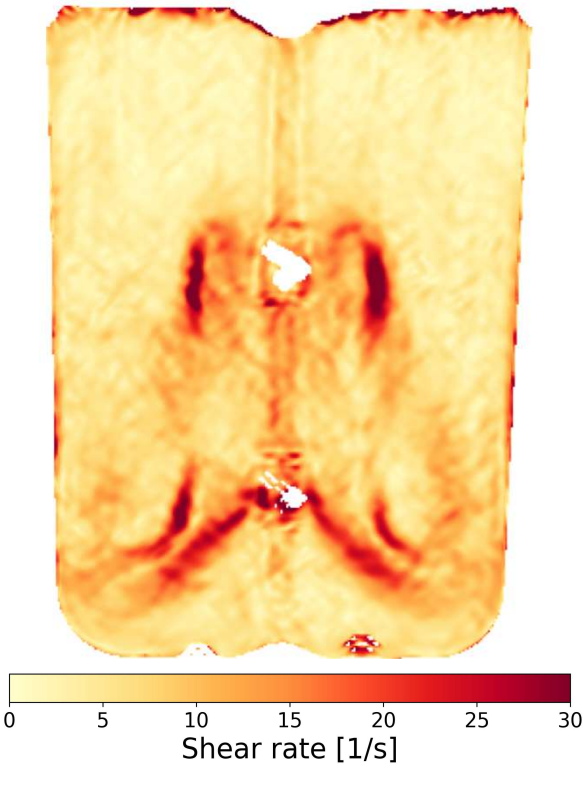
Gas hold-up



Velocity distribution

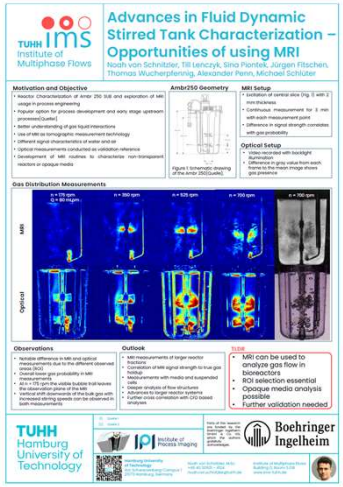


Shear-rate distribution



Outlook

Verification & Quantification of gas-liquid data



Noah v. Schnitzler

P42: Advances in Fluid Dynamic Stirred Tank Characterization – Opportunities of using MRI

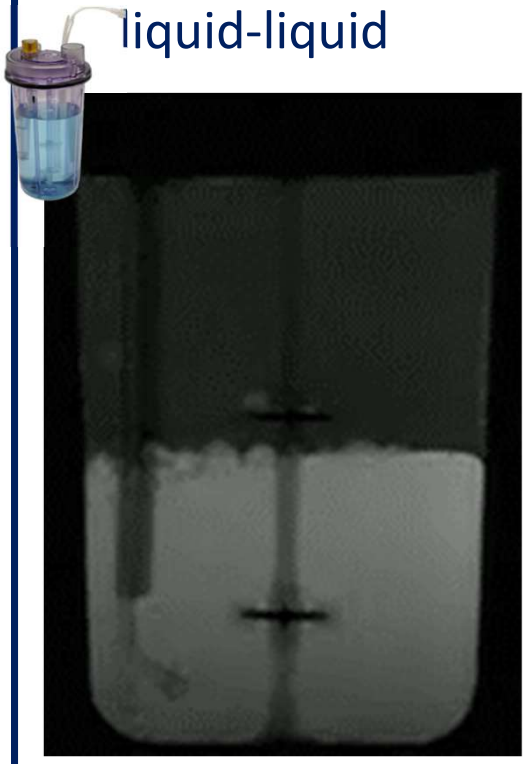
TUHH Hamburg University of Technology

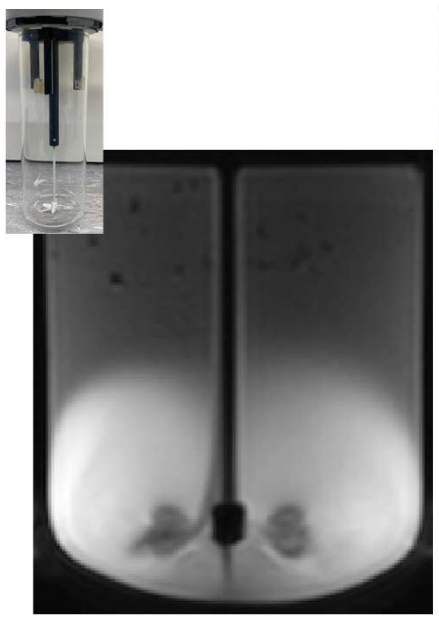
Investigation of other complex fluid dynamic systems

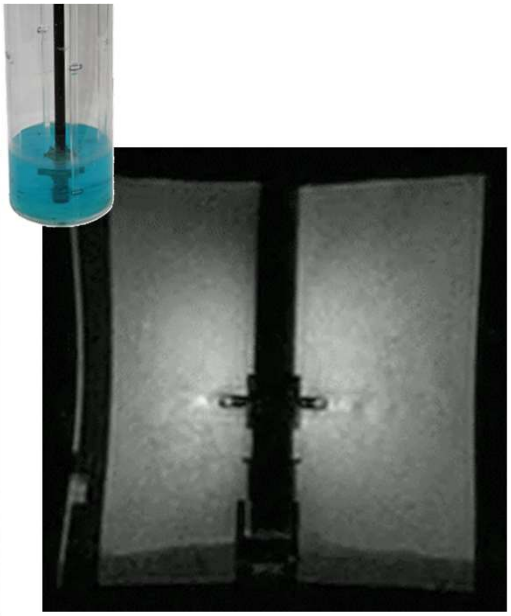
liquid-liquid

Non-Newtonian liquids

liquid-solid







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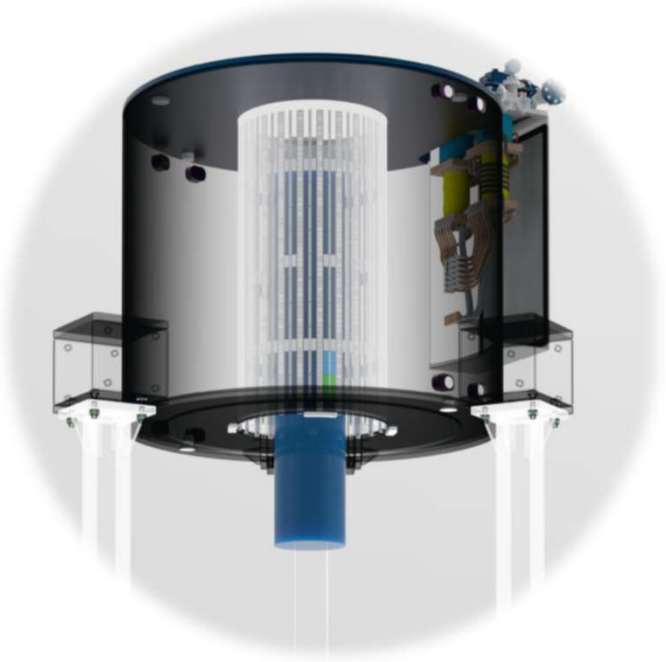
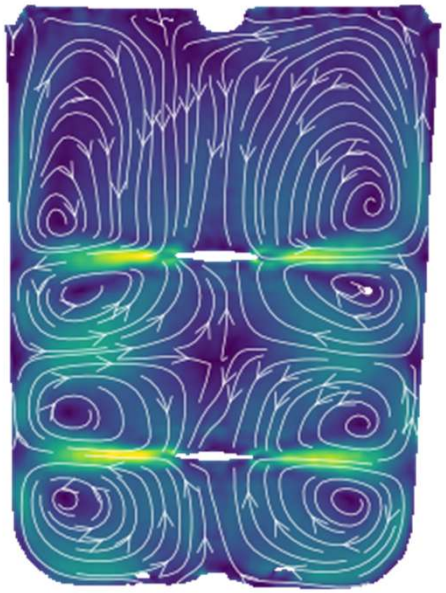


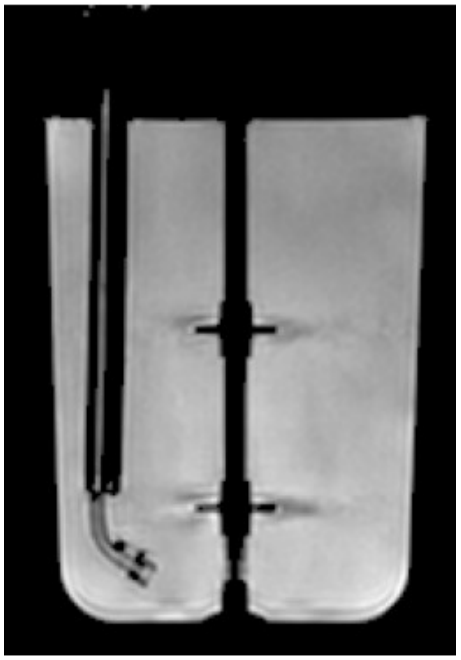
Institute of
Process Imaging

Contact:
Till Lenczyk
Institute of Process Imaging - V10
Hamburg University of Technology
till.Lenczyk@tuhh.de



Field-of-view	82 x 110 x 10 mm^3
Slice thickness	10 mm
Pixel size	1 x 1 mm^2
Number of averages	20
Total scan duration	100 sec
Field-of-flow	50 cm/s (in all directions)
Echo time	5.8 ms
Repetition time	15 ms
Flip angle	30°

Field-of-view	70 x 70 x 84 mm³
Slice thickness	4 mm
Pixel size	1 x 1 mm²
Number of averages	8
Total scan duration	710 sec
Field-of-flow	50 cm/s (in all directions)
Echo time	3.2 ms
Repetition time	15 ms
Flip angle	30°



Field-of-view	82 x 110 x 2 mm^3
Slice thickness	2 mm
Pixel size	0.8 x 0.8 mm^2
Number of averages	16
Total scan duration	166 sec
Field-of-flow	-
Echo time	2.4 ms
Repetition time	100 ms
Flip angle	90°