Capillary μRheoSANS for High Shear Rate, Low Volume Studies

Zach Riedel, Clemson University, NCNR

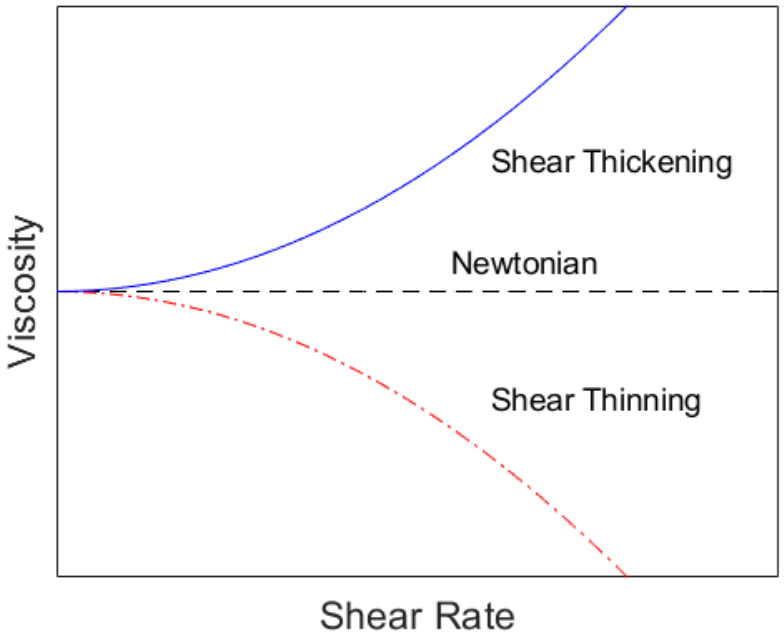
Advisors: Katie Weigandt & Ryan Murphy, NCNR

Applications in industry

~1,000,000 s^{-1}

Shear rate and traditional RheoSANS

Shear Rate: $\dot{\gamma} = v/h$

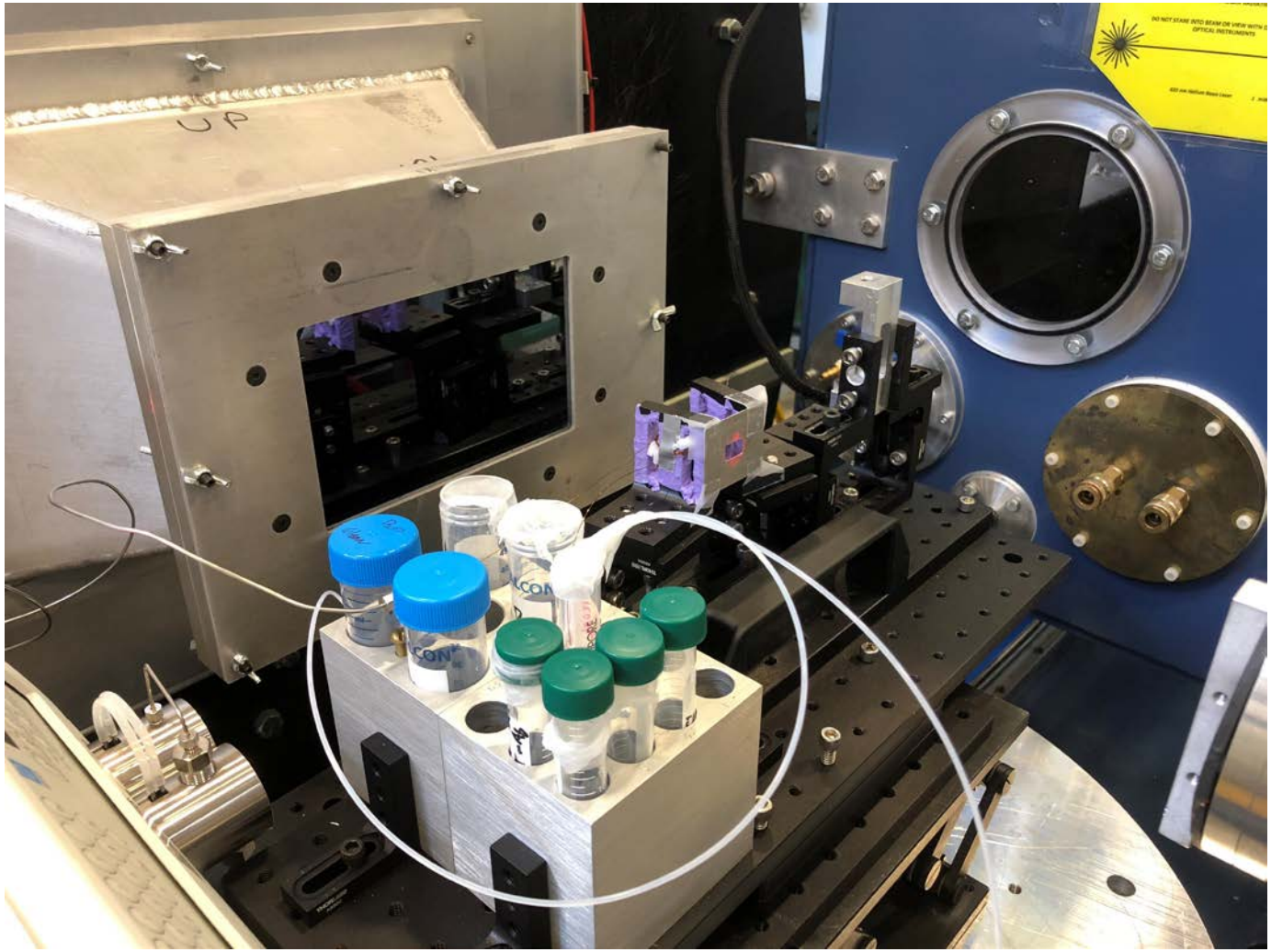


~5000 s^{-1}
7-20 mL Sample

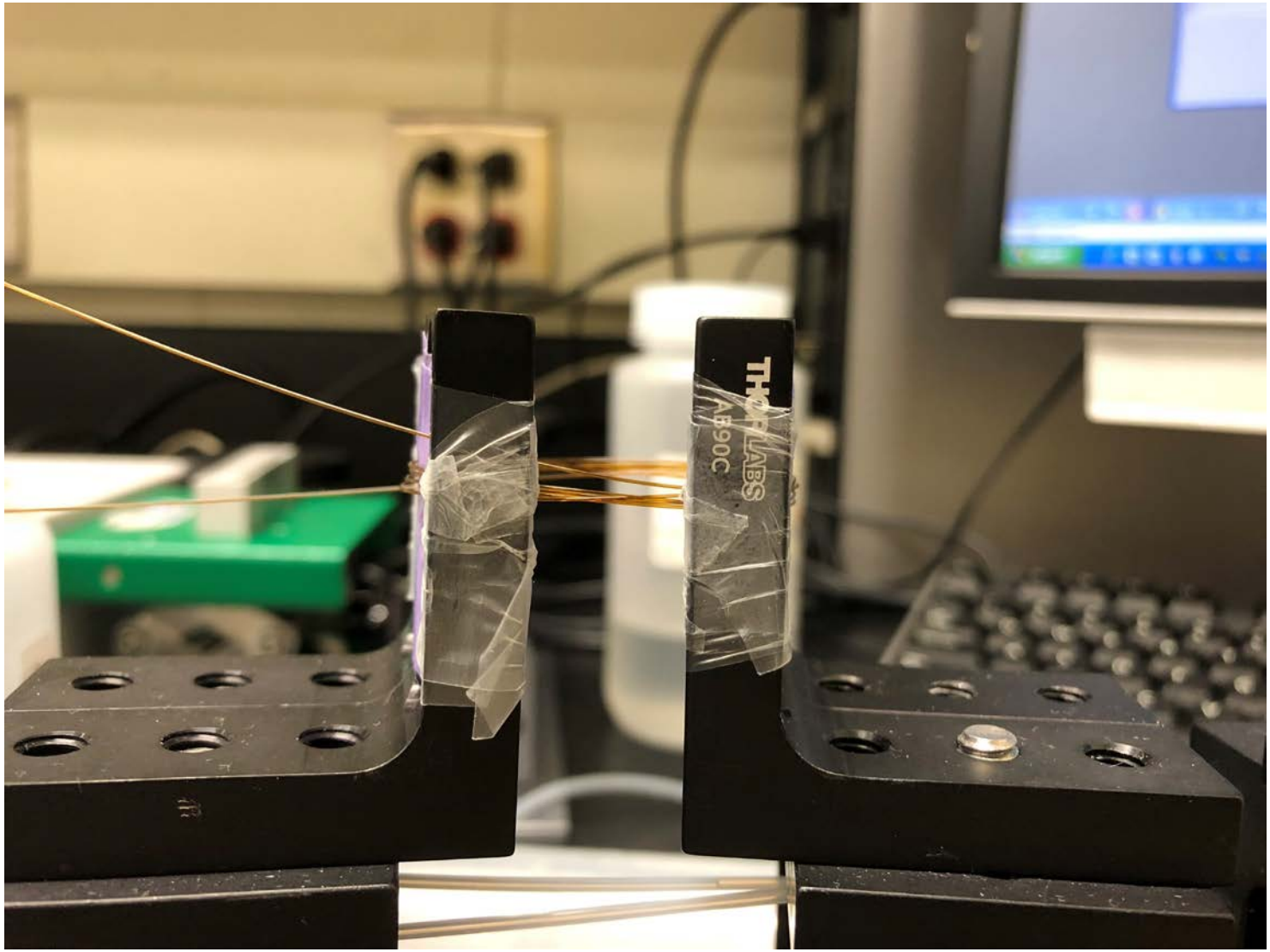
Applications in industry

~1,000,000 s^{-1}

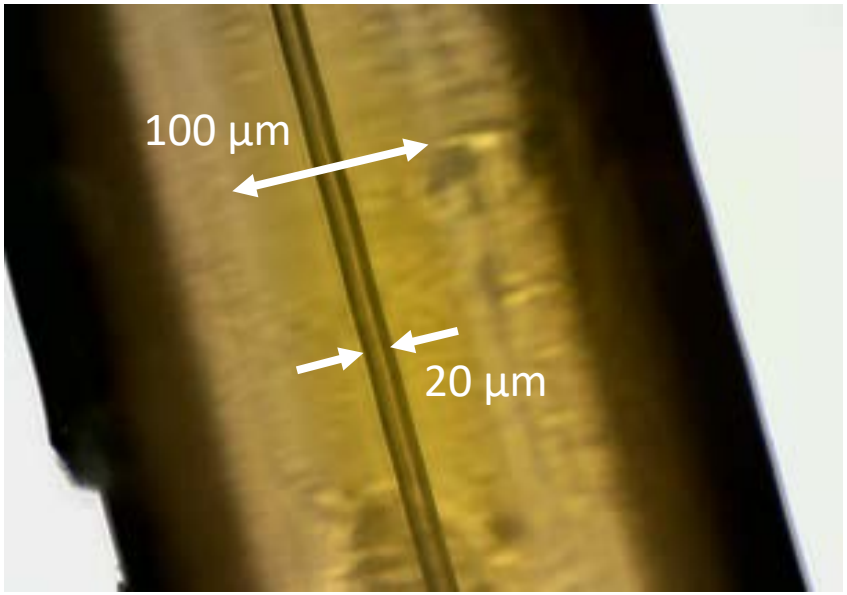
Capillary µRheoSANS



Capillary µRheoSANS



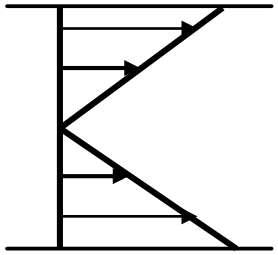
Capillary size and velocity



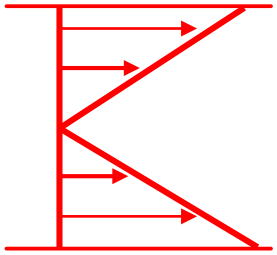
Capillary fluid flow

Laminar Poiseuille Flow (Newtonian)

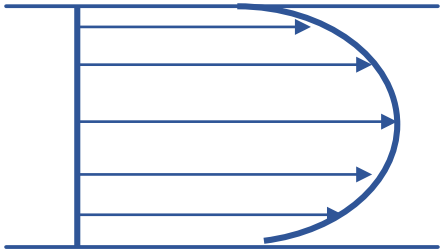
$$\tau = \mu\dot{\gamma}$$



Shear Stress (τ)



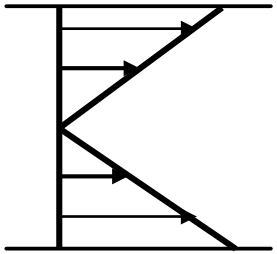
Shear Rate ($\dot{\gamma}$)



Velocity

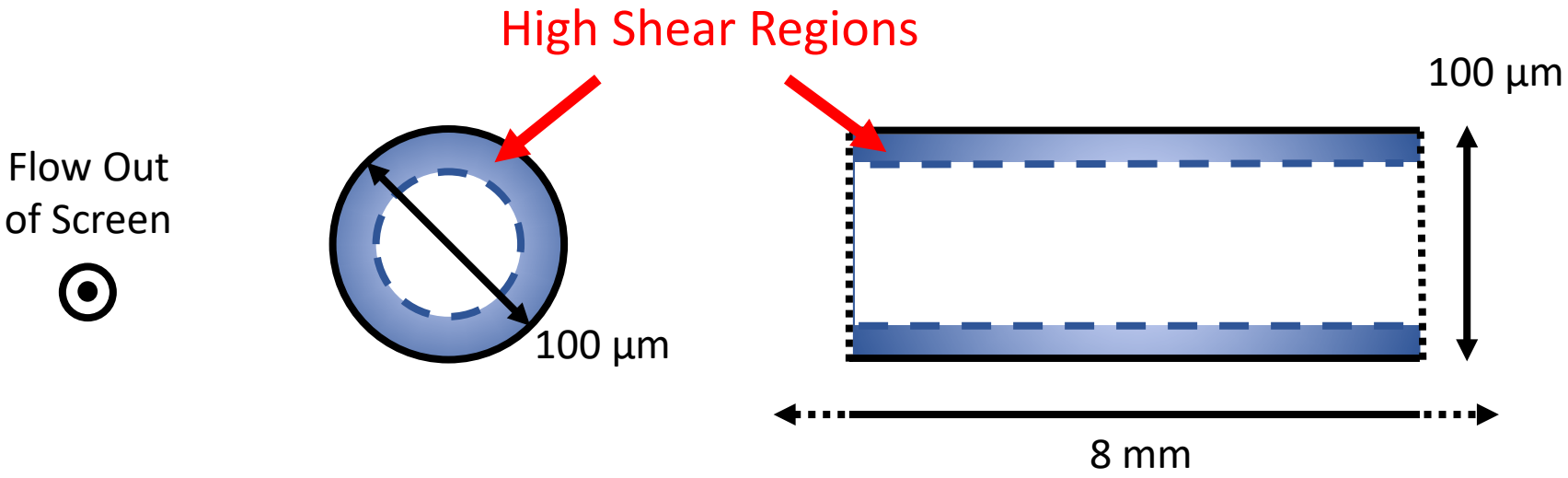
Non-Newtonian

$$\tau = \mu(\dot{\gamma}) \cdot \dot{\gamma}$$



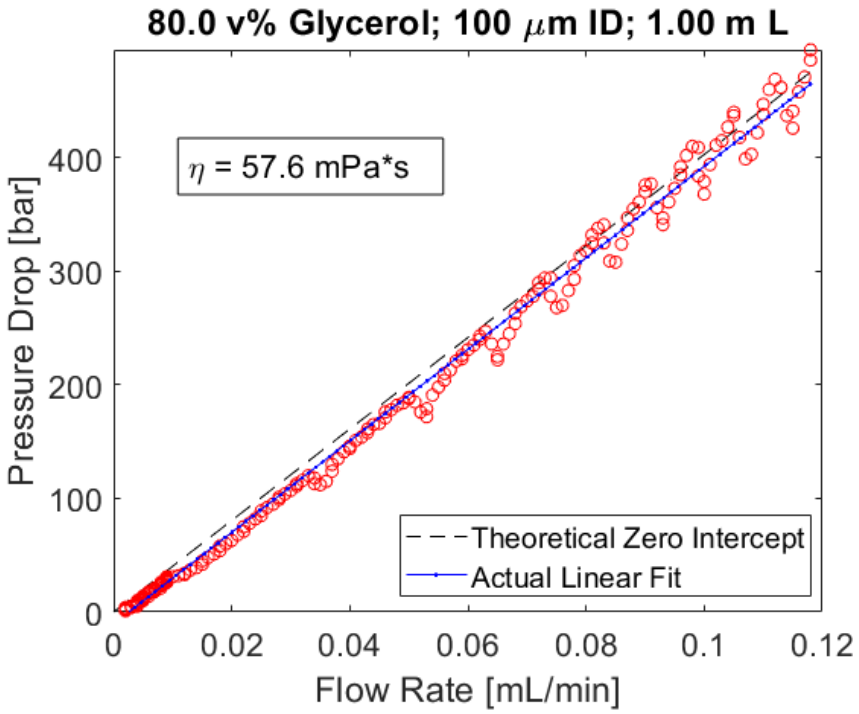
Shear Stress

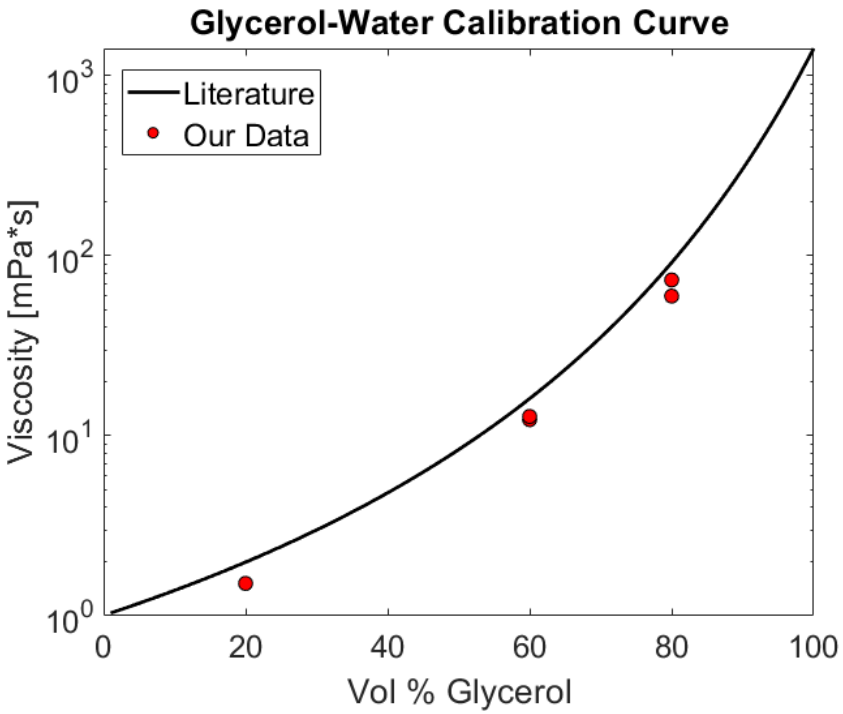
Comparison to Slit µRheoSANS



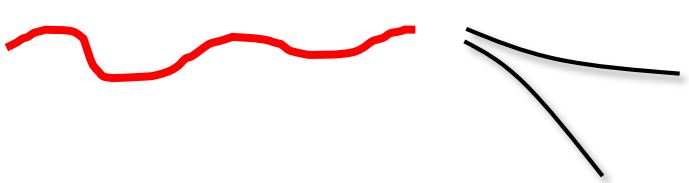
Approximate Scattering Volume [µL]	
SANS	100
Slit Cell	10
Capillary	1

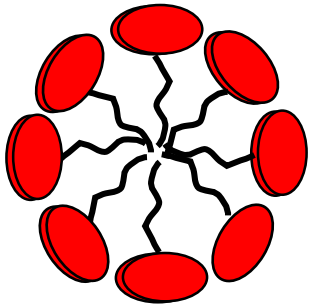
Determining physical limits



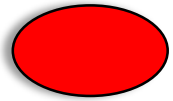


Wormlike micelles



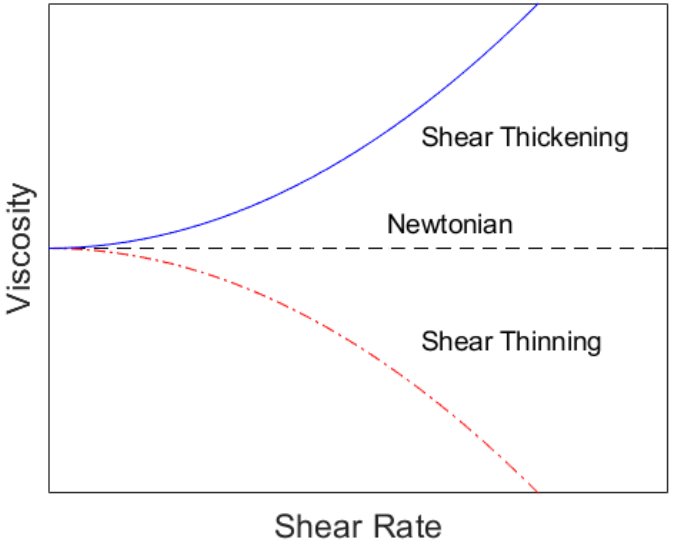


Cross-section

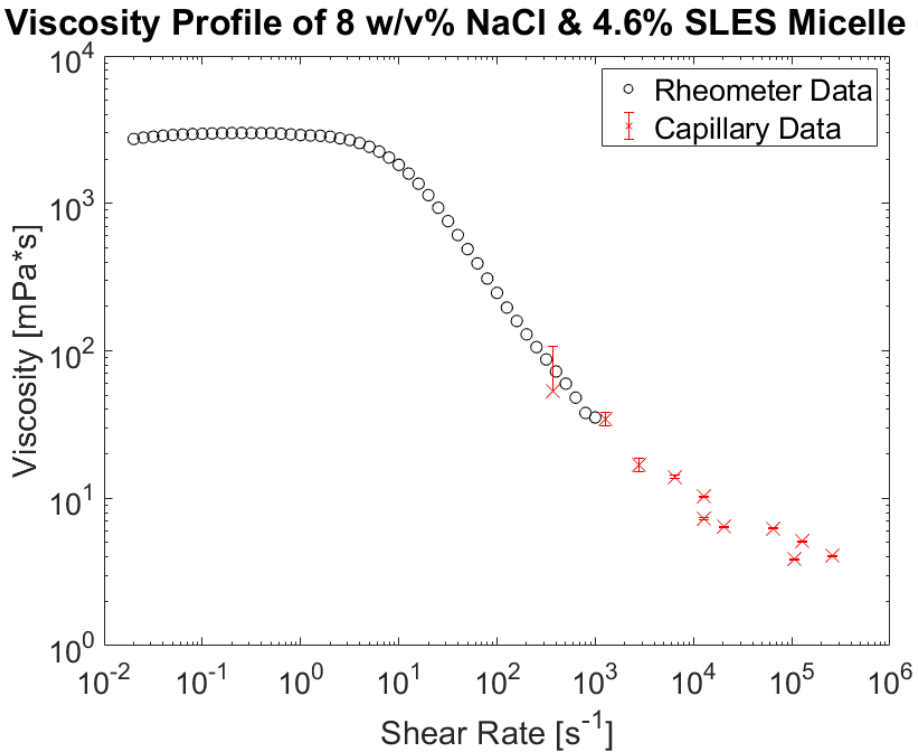


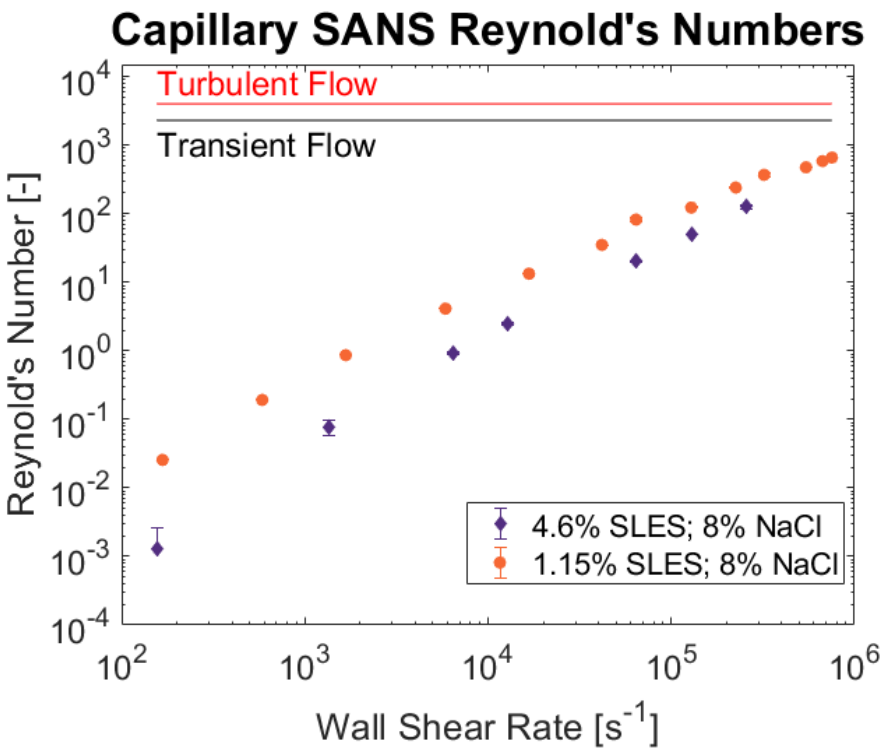
Hydrophilic head

Hydrophobic tail

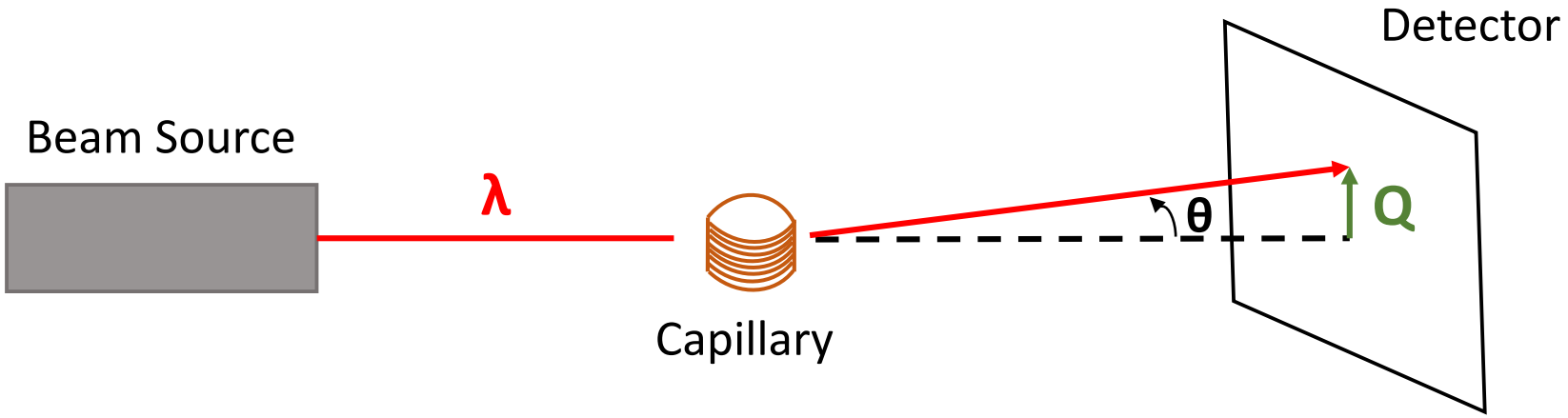


Micelles under high shear





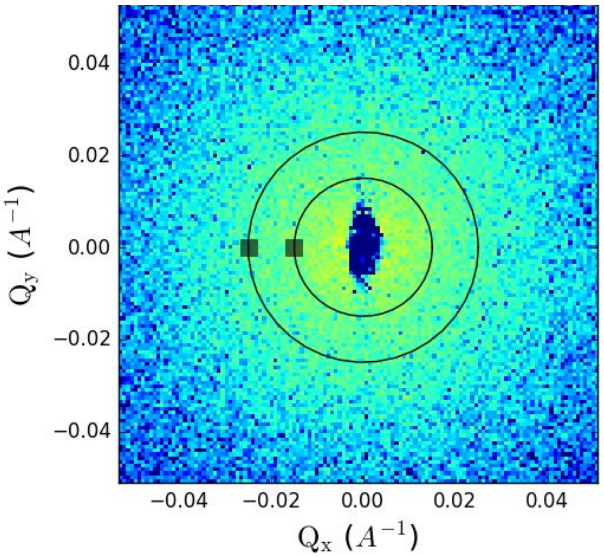
Small Angle Neutron Scattering (SANS)

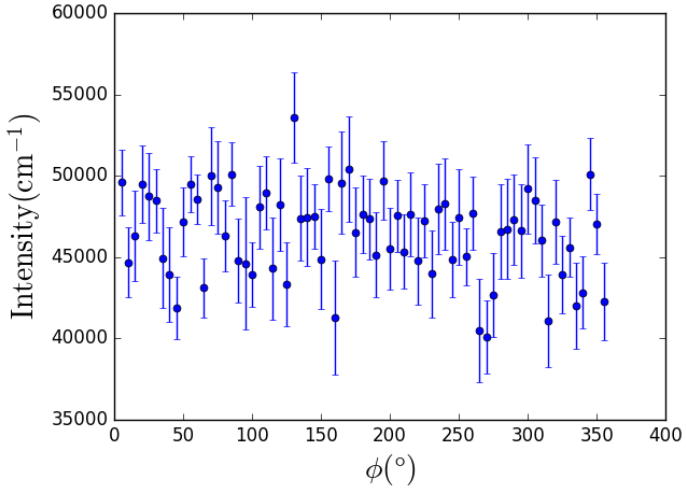


$$Q = \frac{4\pi \cdot \sin(\theta)}{\lambda}$$

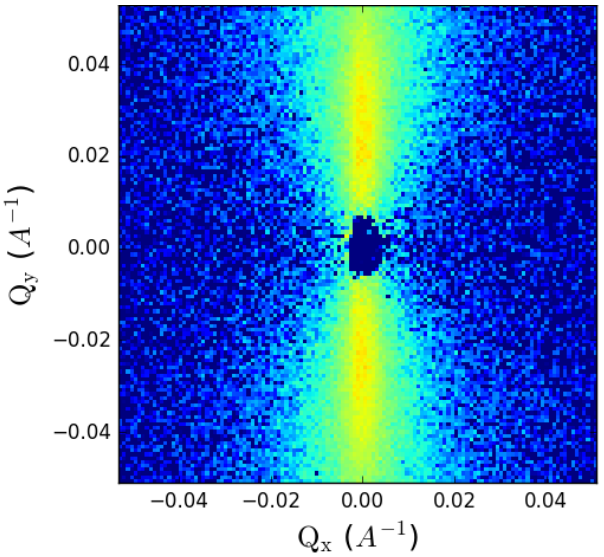
2D SANS profiles

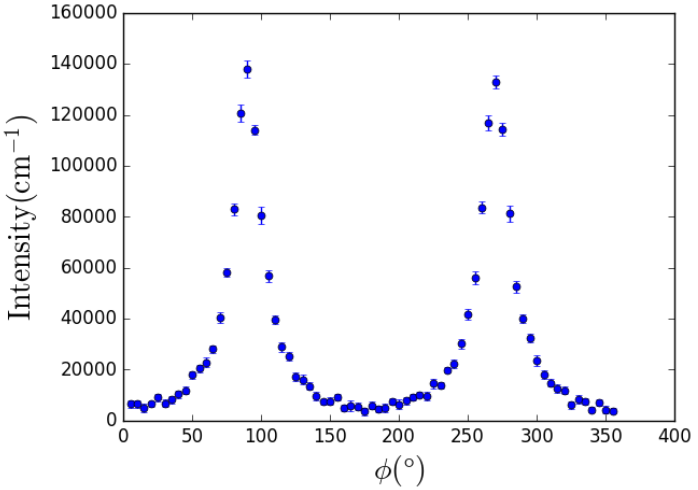
Wall $\dot{\gamma}$ = 0 s^{-1}
WLM (SLES 4.6% NaCl 8%)



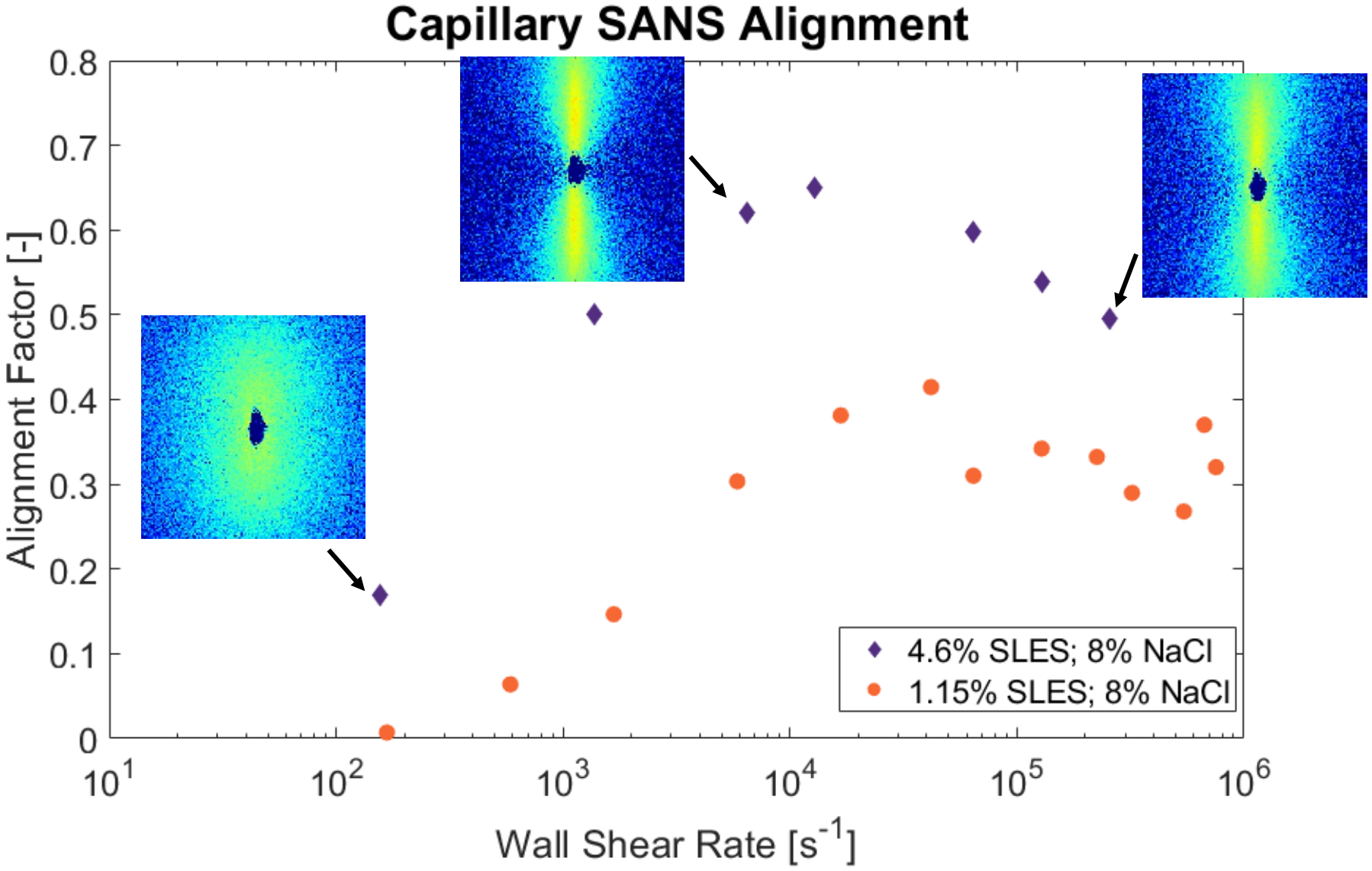


Wall $\dot{\gamma}$ = 1.3·10^4 s^{-1}
WLM (SLES 4.6% NaCl 8%)

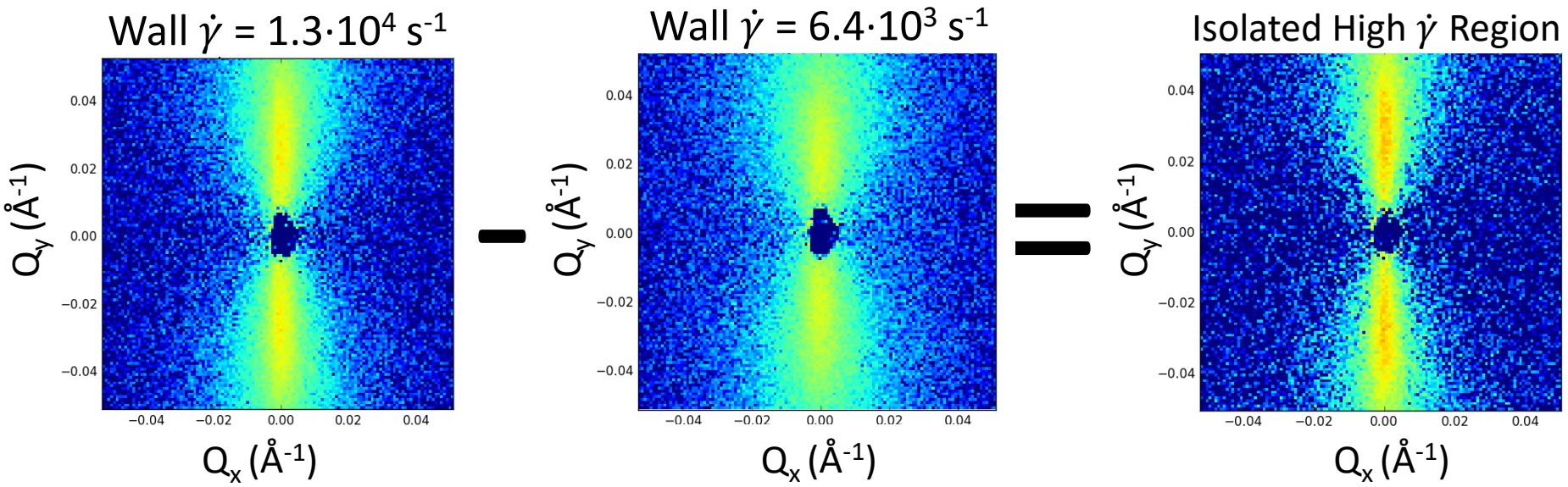


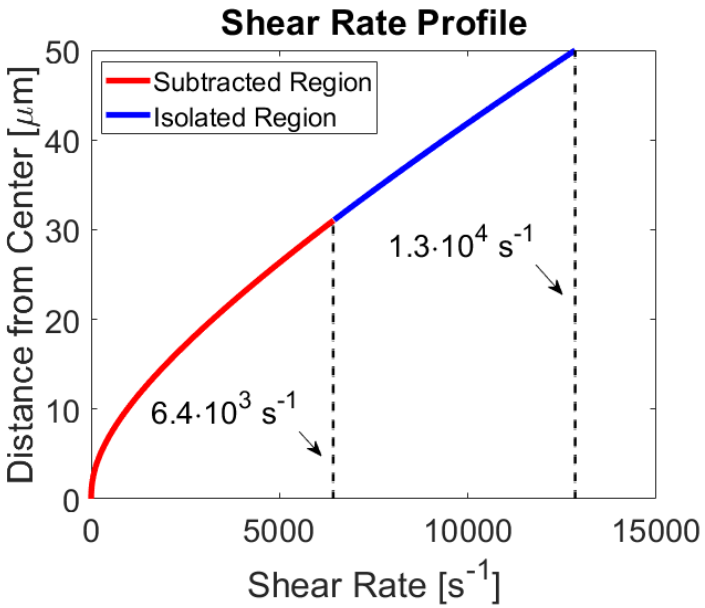


Micelle alignment factors

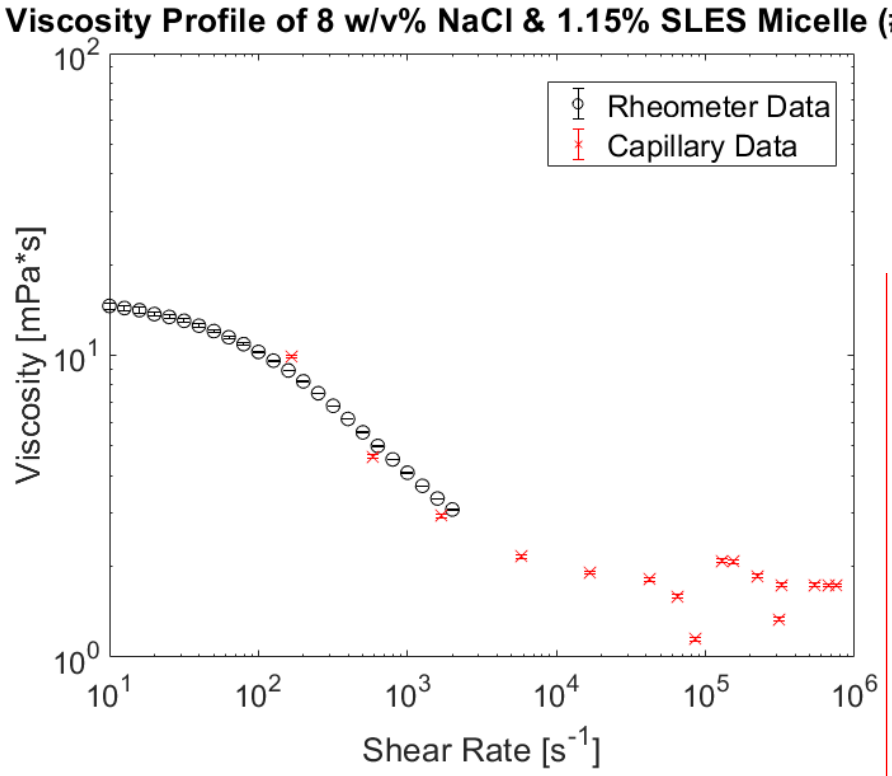


Wall shear rate scattering isolation



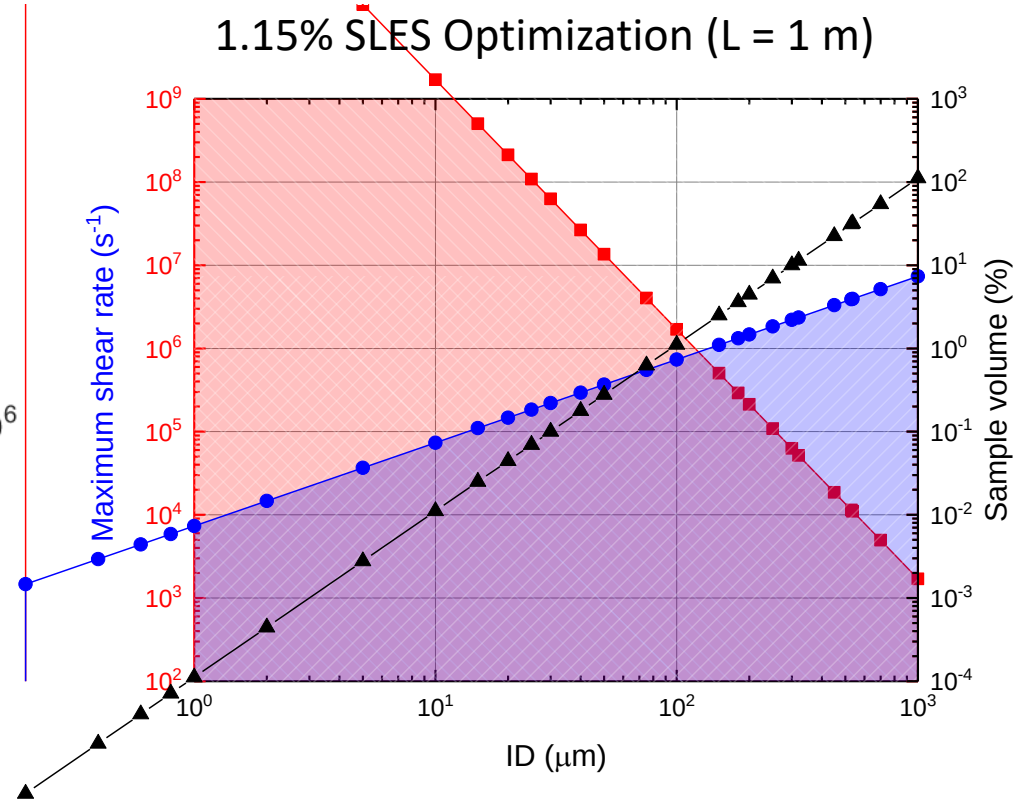


Validating results



$\dot{\gamma}_{max} = 7.5 \cdot 10^5\ s^{-1}$

$V_{sample} = 2\ mL$



Acknowledgements

- Katie Weigandt
- Ryan Murphy
- Javen Weston

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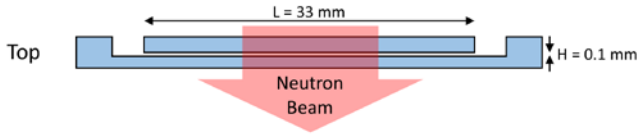
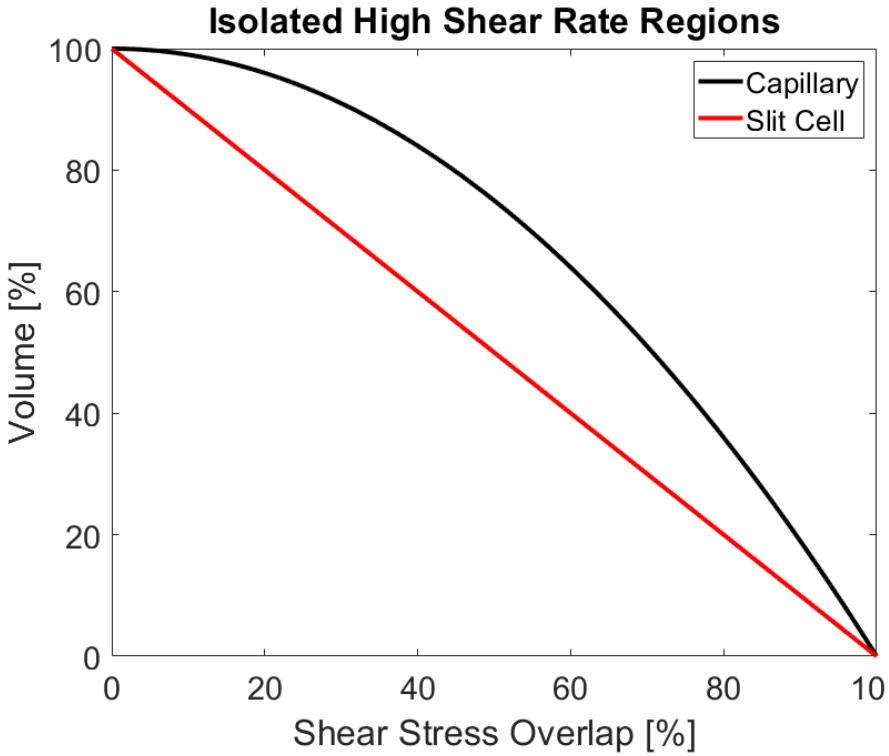
Questions

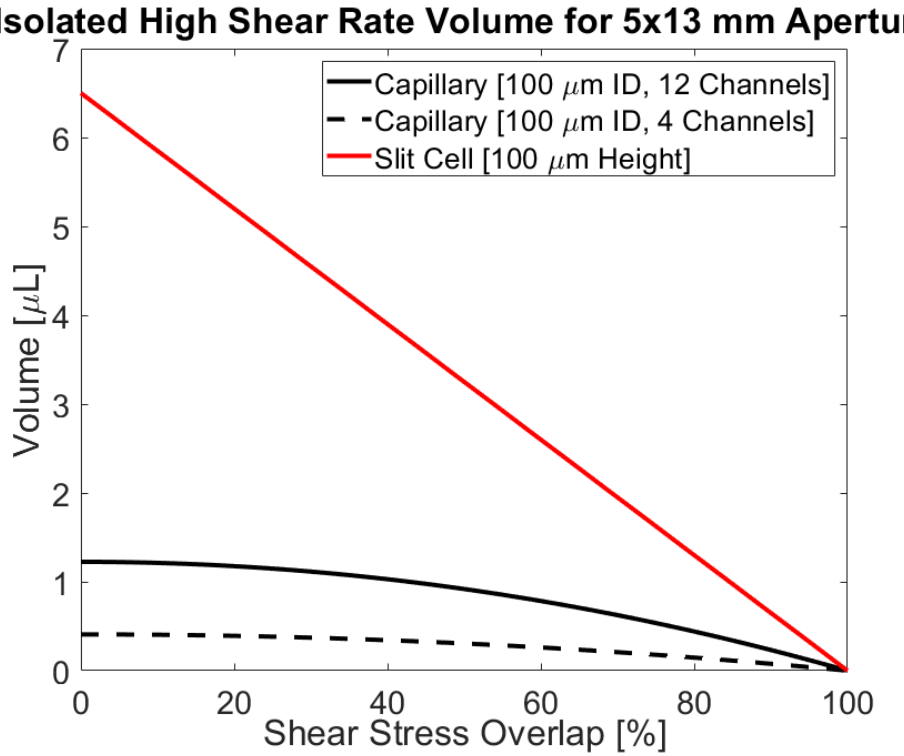
Extra Slides

Comparison to Slit µRheoSANS

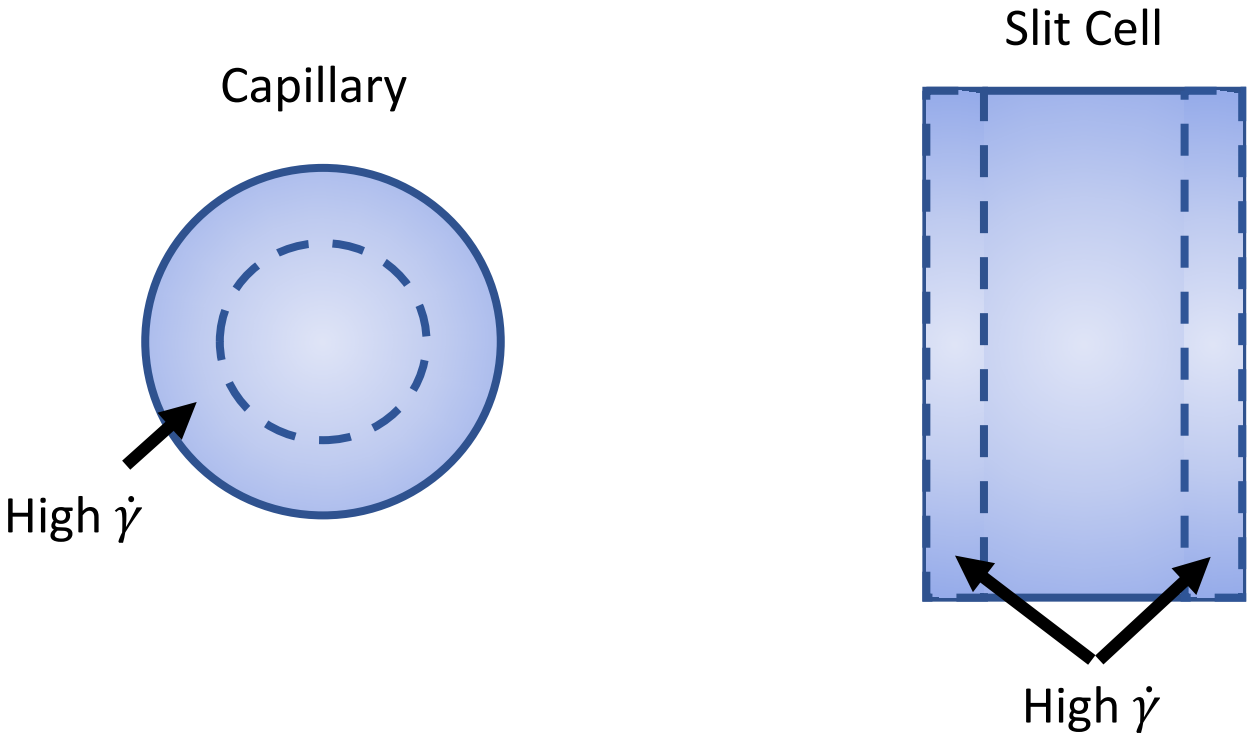
Slit Cell[1]







Comparison to Slit μRheoSANS



Important equations

$$\tau = \mu\dot{\gamma}$$

Shear Stress

$$\tau = \frac{\Delta P R}{2L}$$

Capillary Shear Stress

$$v = \frac{\Delta P R^2}{4\mu L}[1 - (r/R)^2]$$

Capillary Velocity

$$\mu = \frac{\Delta P \pi R^4}{8LQ}$$

Capillary Viscosity (Hagen-Poiseuille)

$$\dot{\gamma} = \frac{4Q}{\pi R^3}$$

Apparent Wall Shear Rate

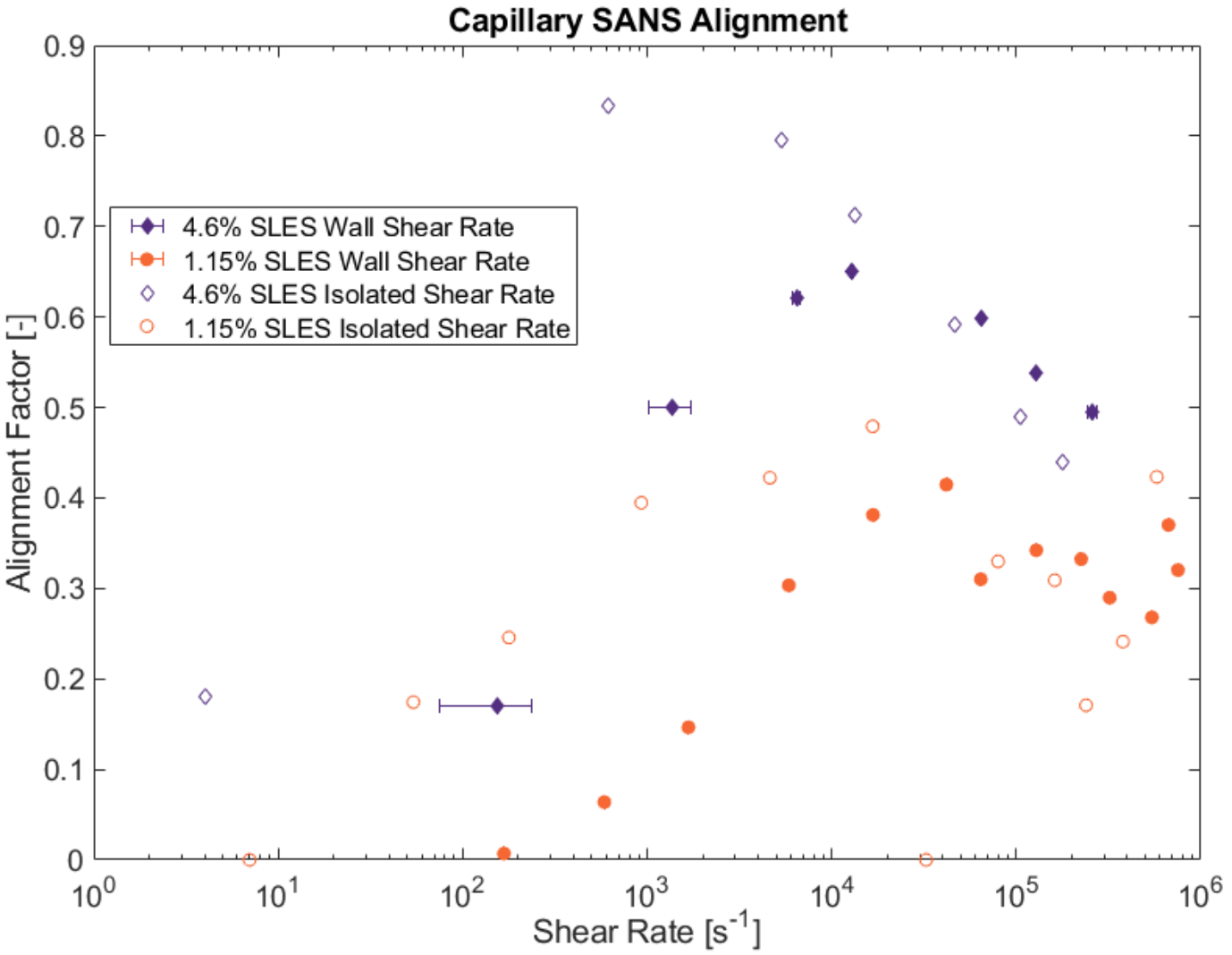
$$\dot{\gamma}_{WR} = \dot{\gamma}_a \left[\frac{1}{4}\left(3 + \frac{d \ln \dot{\gamma}_a}{d \ln \tau}\right)\right]$$

Corrected Wall Shear Rate (Weissenberg-Rabinowitsch)

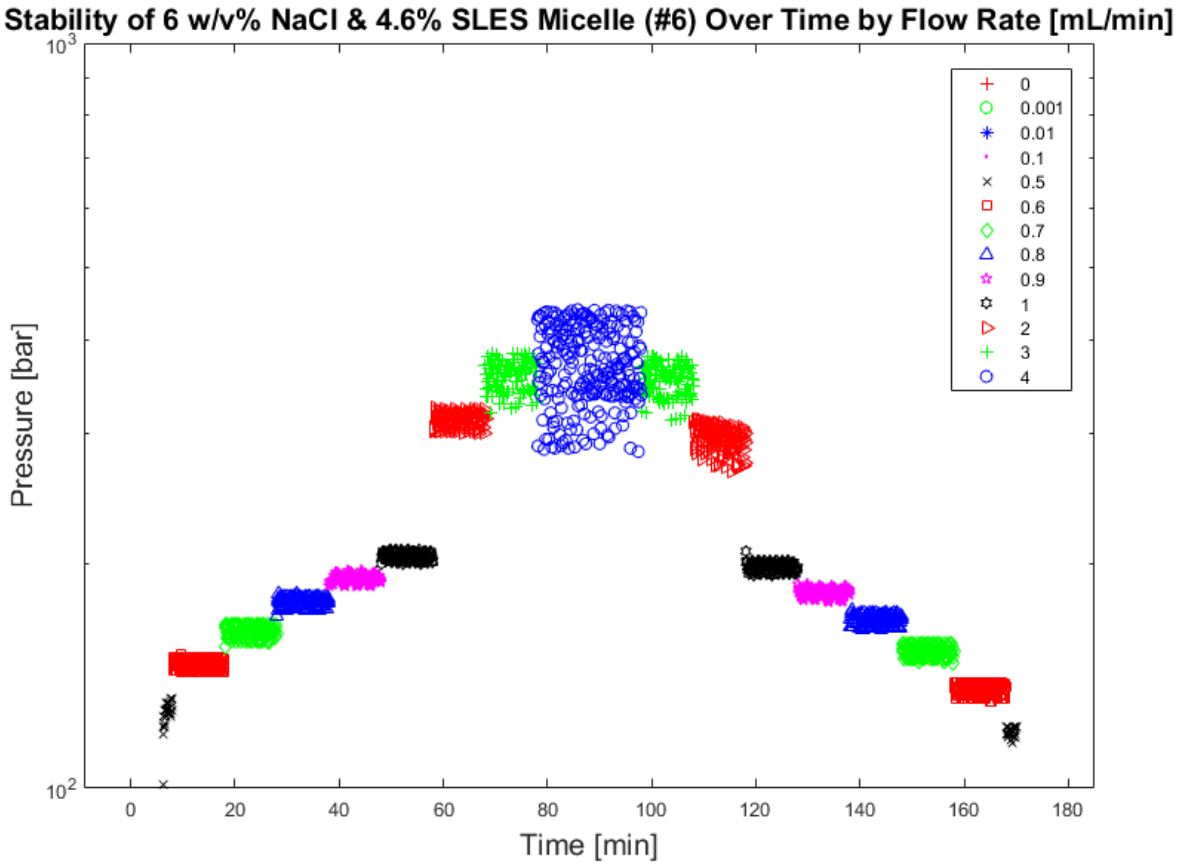
$$Re = \frac{\rho D Q}{A\mu}$$

Reynold's Number

Micelle alignment factors



Stability of micelle pressure drops



Other capillary jet video