# What neutrons tell us about meat analogues

Bei Tian, Atze Jan van der Goot, Wim Bouwman *et al.*

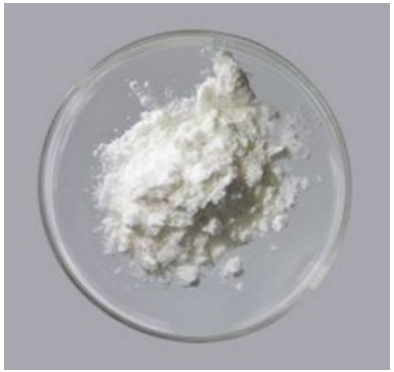
TU Delft

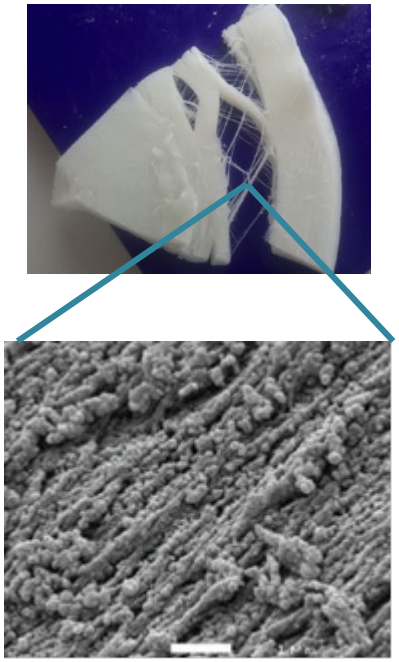
# Food production
# 20% $CO_2$ emission

- Sustainable ingredients
  Plant based proteins
- New ingredients need new processes
- Rational redesign requires quantitative structural information

TU Delft

# Calcium caseinate forms sometimes good fibres

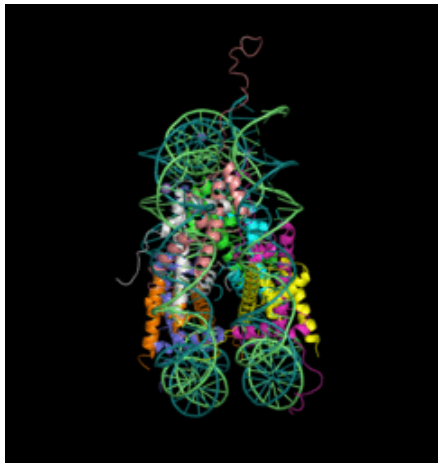




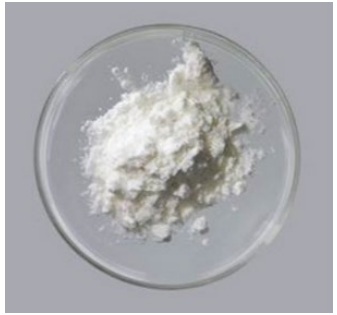
- Zhaojun Wang Wageningen University
- Manski J M, van der Goot A J, Boom R M. Biomacromolecules, 2007, 8(4): 1271-1279.

# Questions to be answered

1. **Effect mobility proteins?**
2. Length scale orientation starts?
3. Number of fibres and air bubbles?

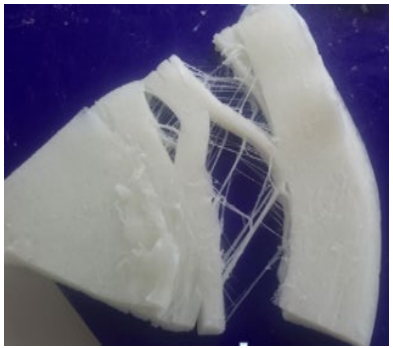


# Drying method affects texture
# Protein mobility?



Spray dried Calcium caseinate

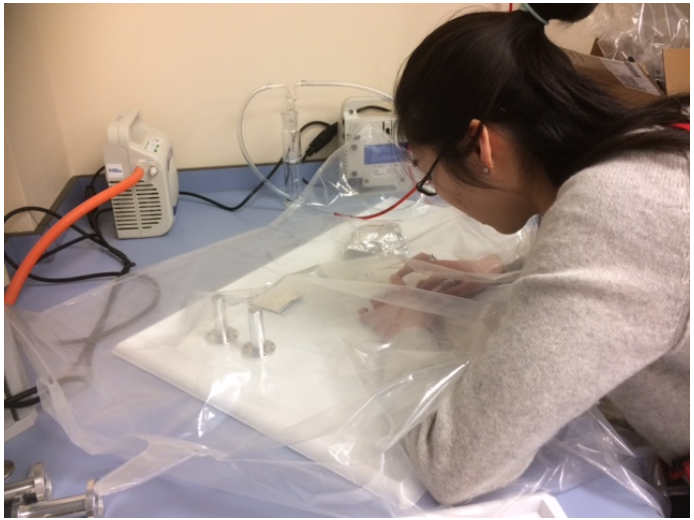
$H_2O$



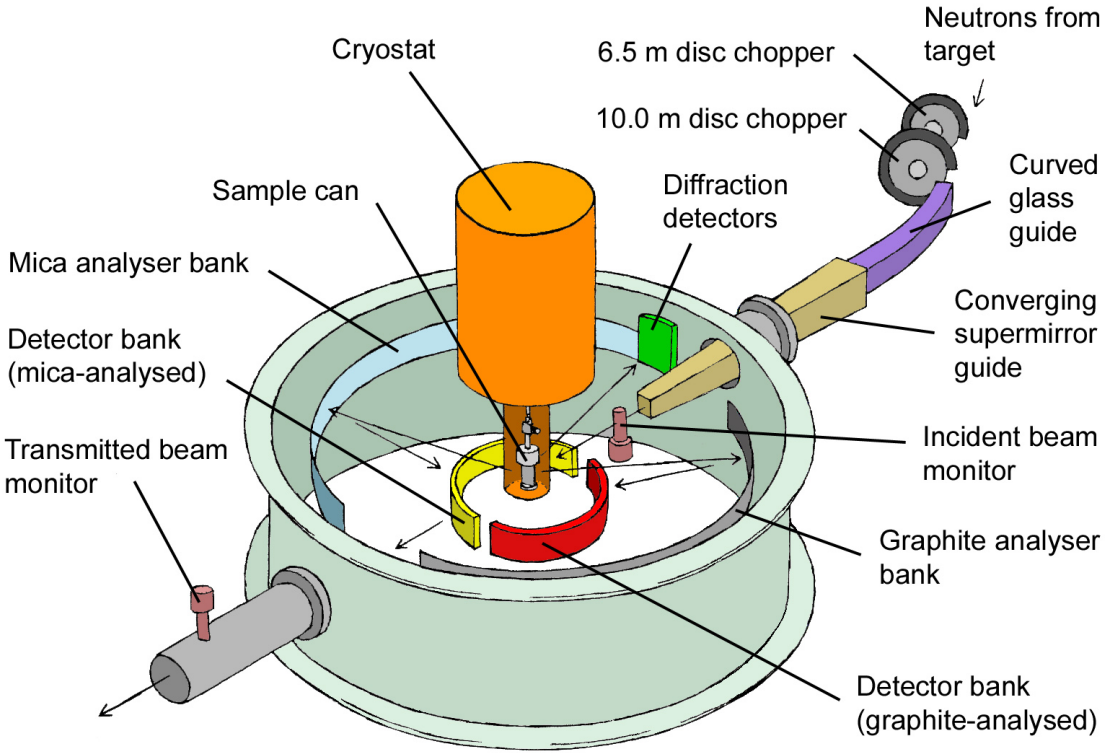
Roller dried Calcium caseinate

$H_2O$

# Sample mounting
# Protein in $D_2O$ atmosphere

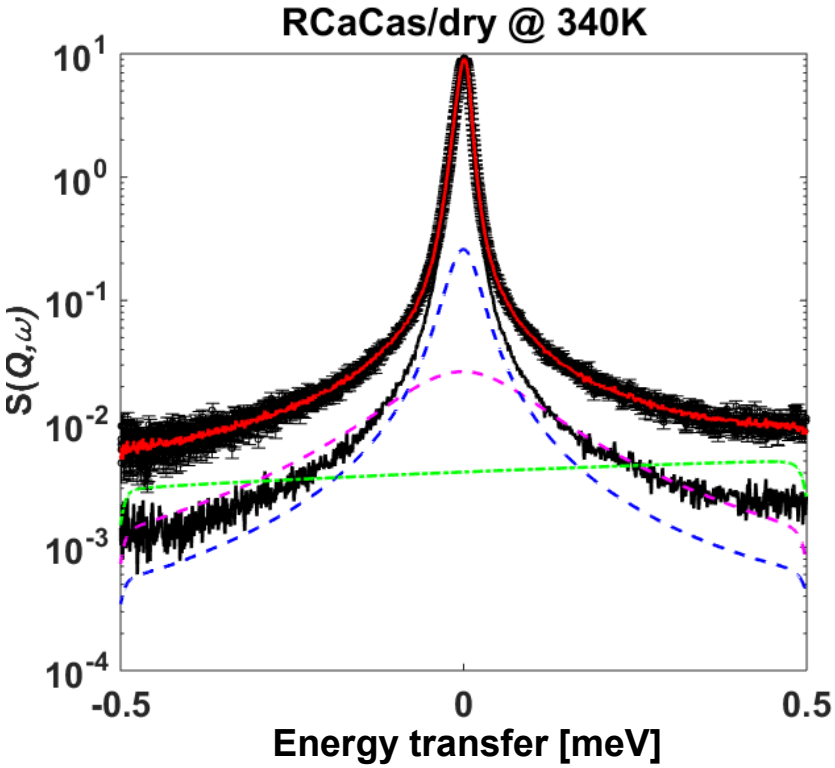


# Inelastic neutron spectrometer IRIS




TU Delft

# Quasi Elastic Neutron Scattering




– Elastic

- - Fast movement

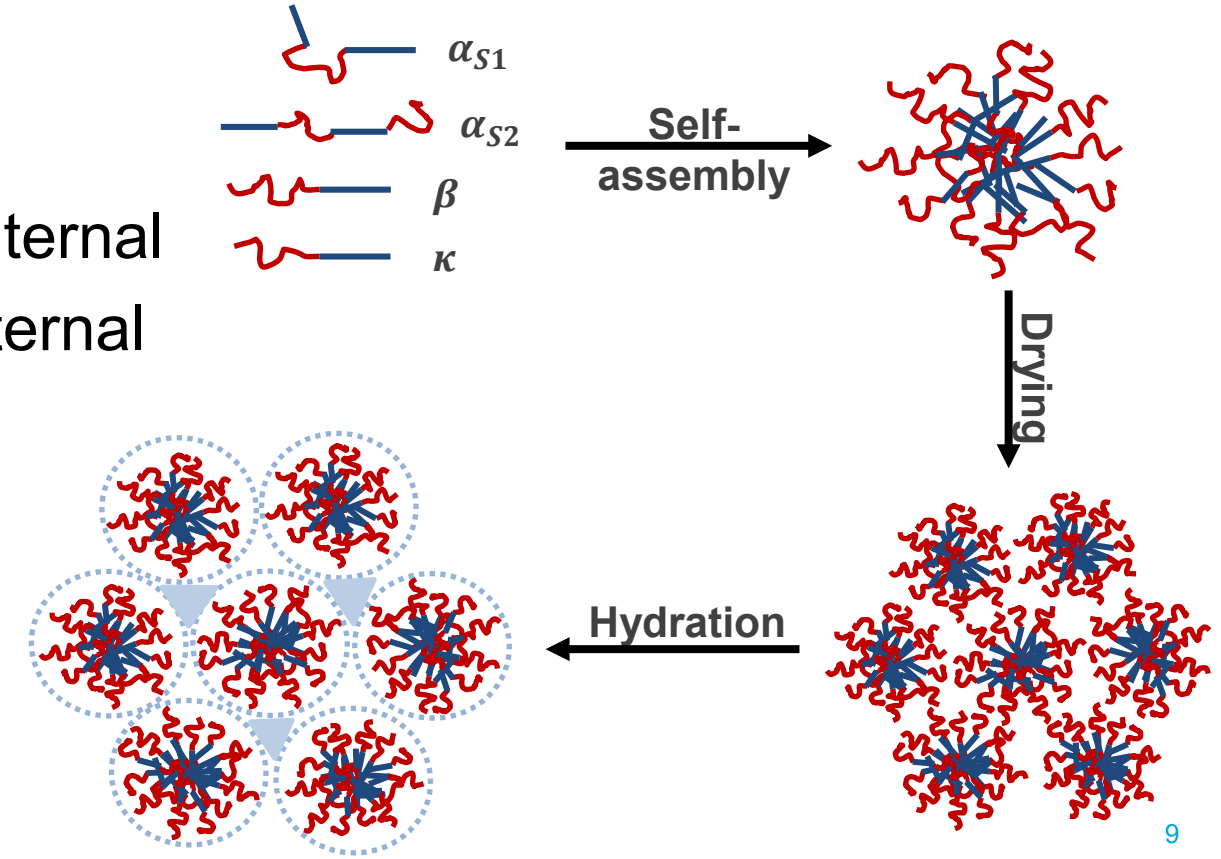
- - Slow movement

-·- Background

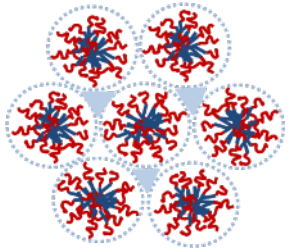
TU Delft

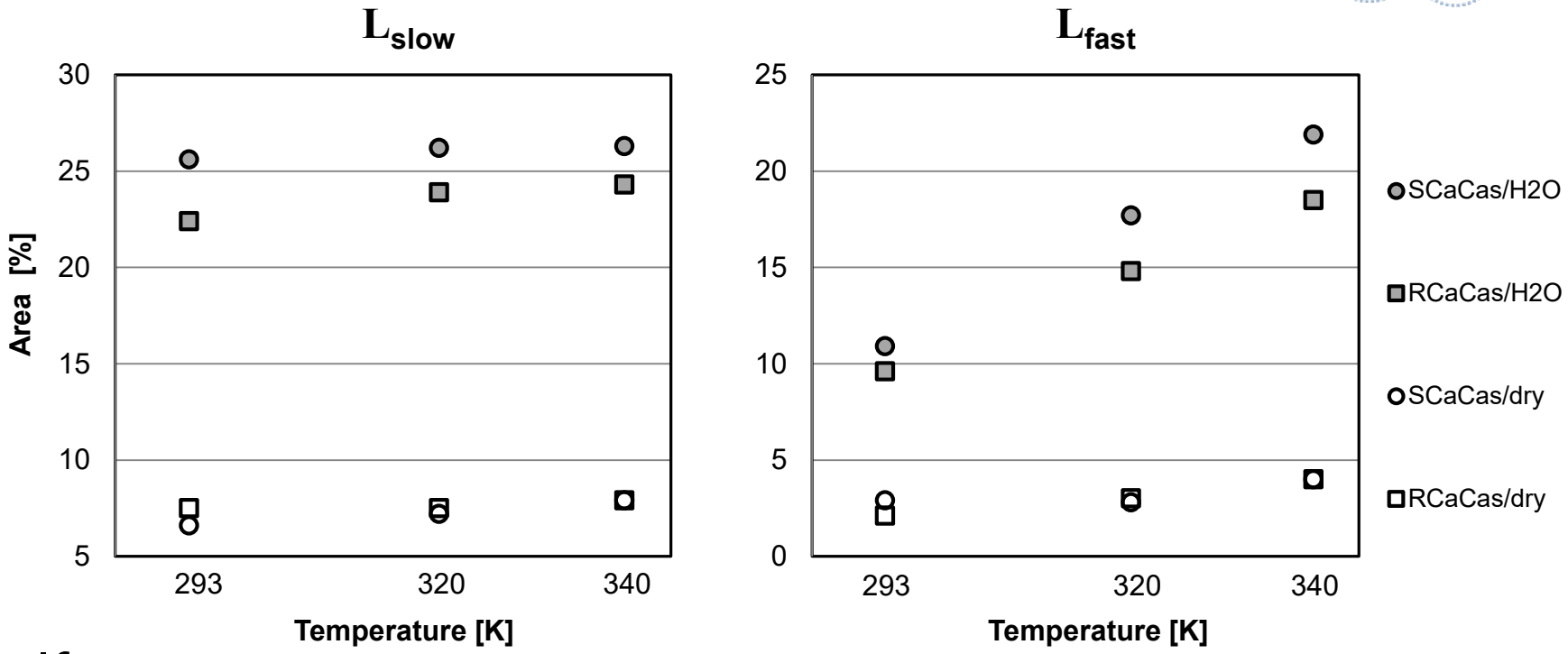
# slow and flow movements protein

- 20 ps internal
- 3 ps external



# Spray dried higher mobility

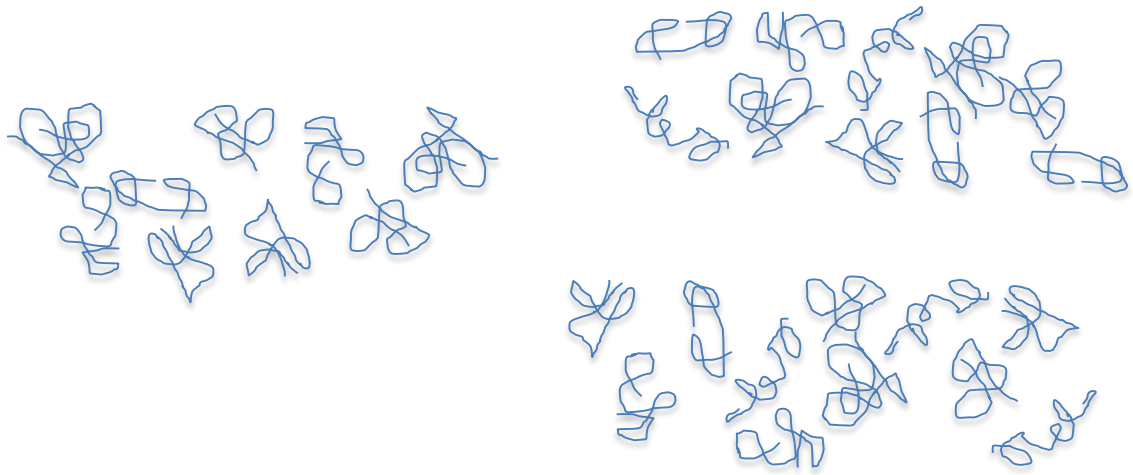




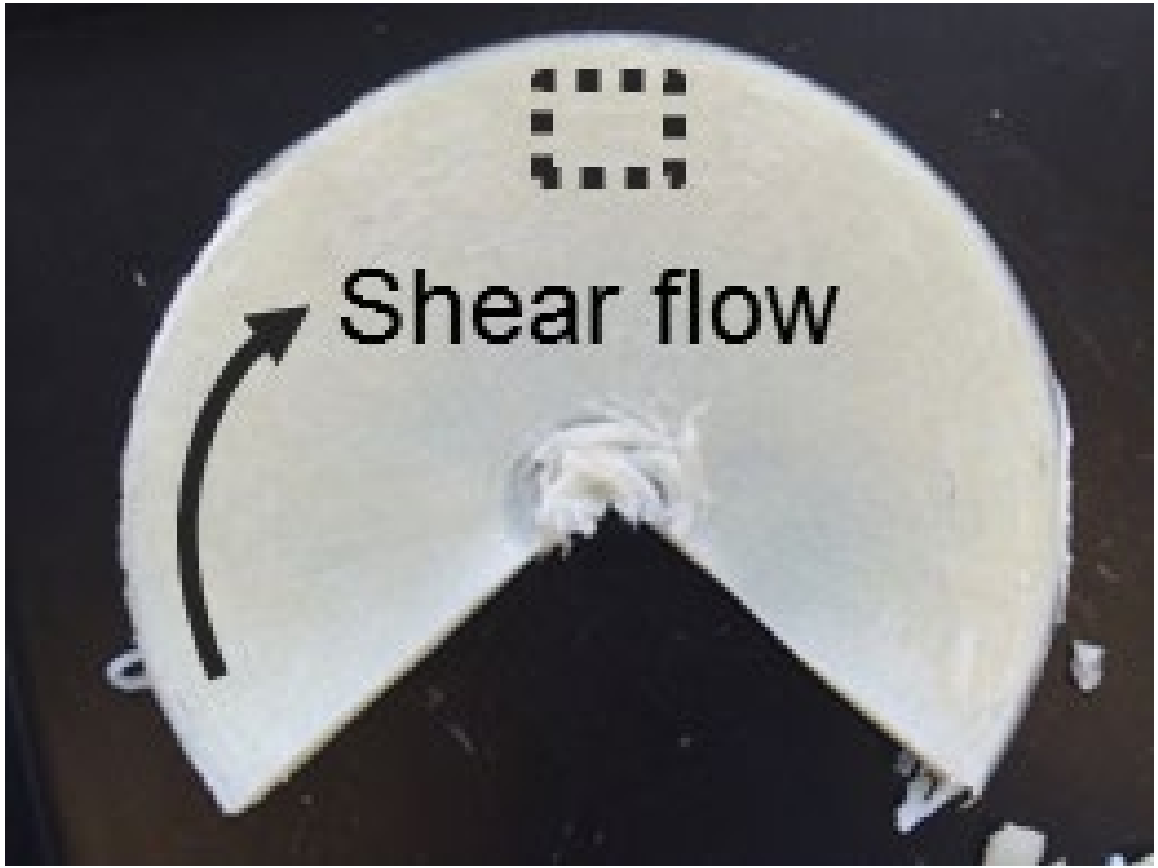

TU Delft

# Questions to be answered

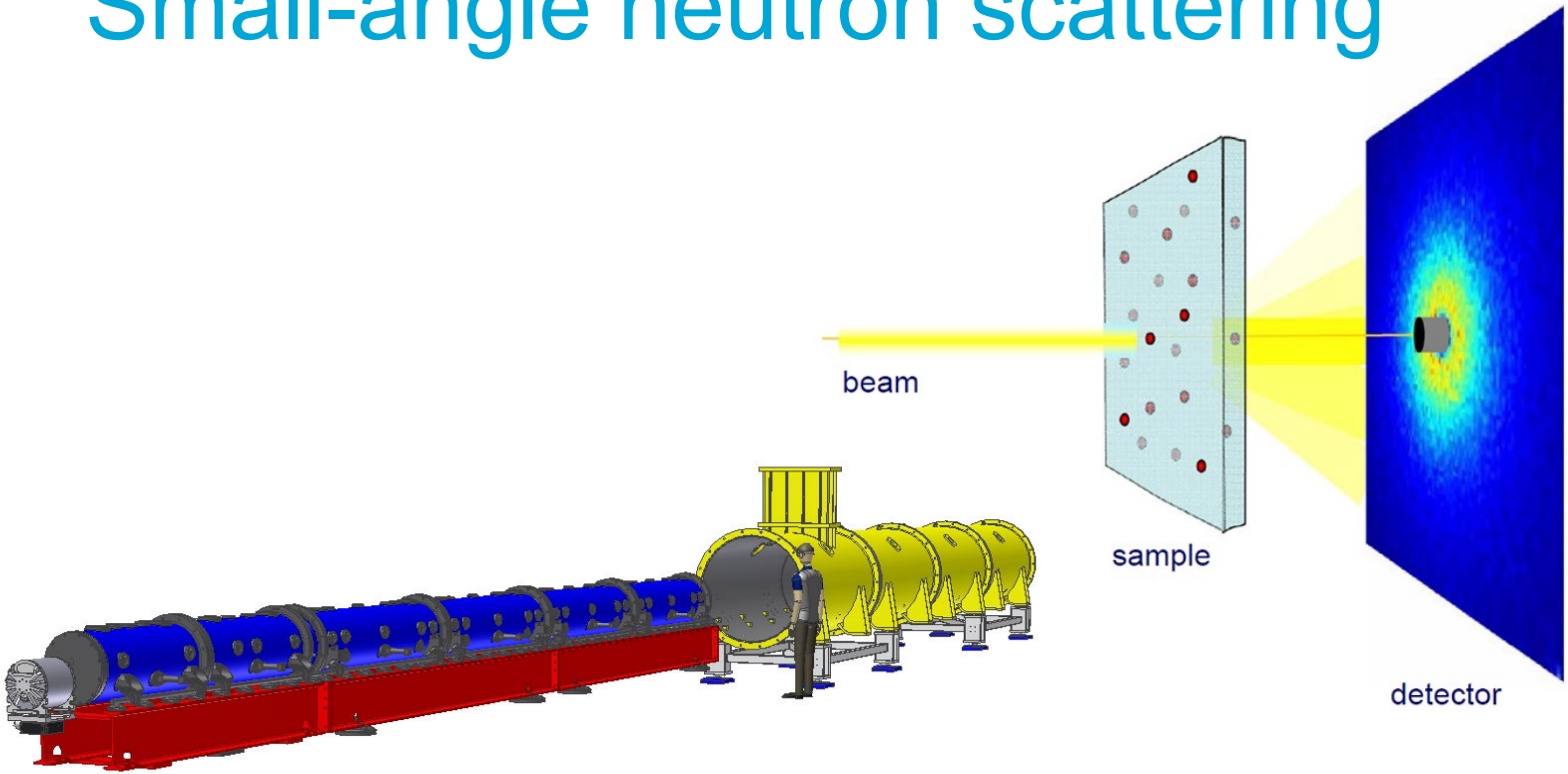
1. Effect mobility proteins?
2. **Length scale orientation starts?**
3. Number of fibres and air bubbles?



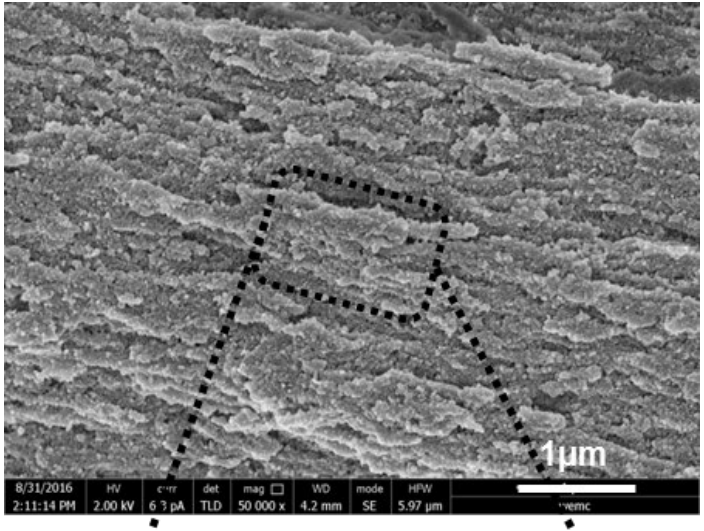
# Shear rate, shear time sufficient?

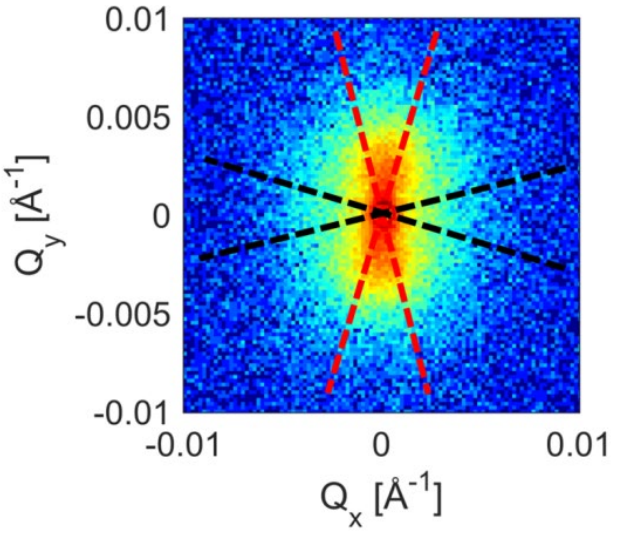


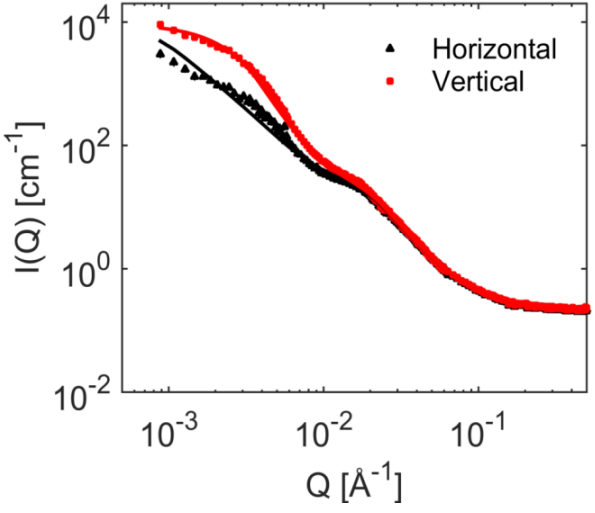
# Small-angle neutron scattering



# Isotropic to fibre

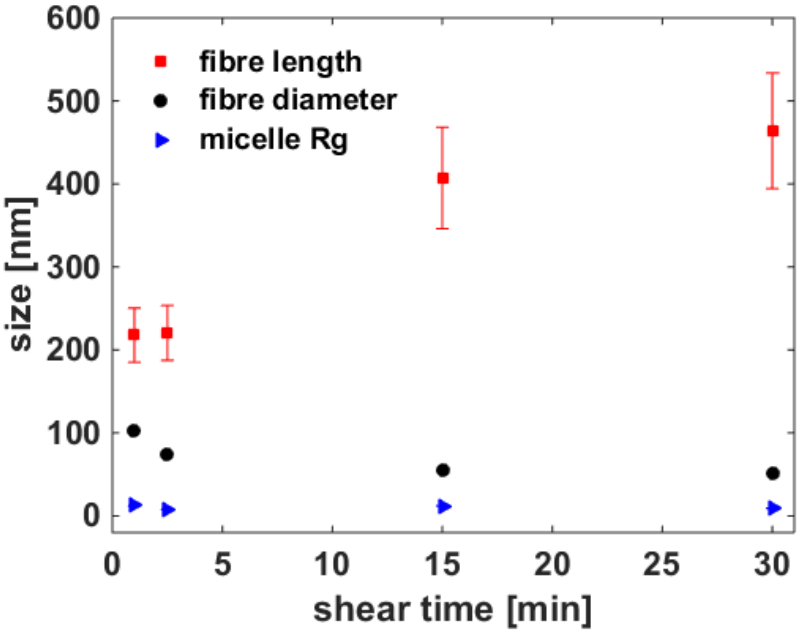


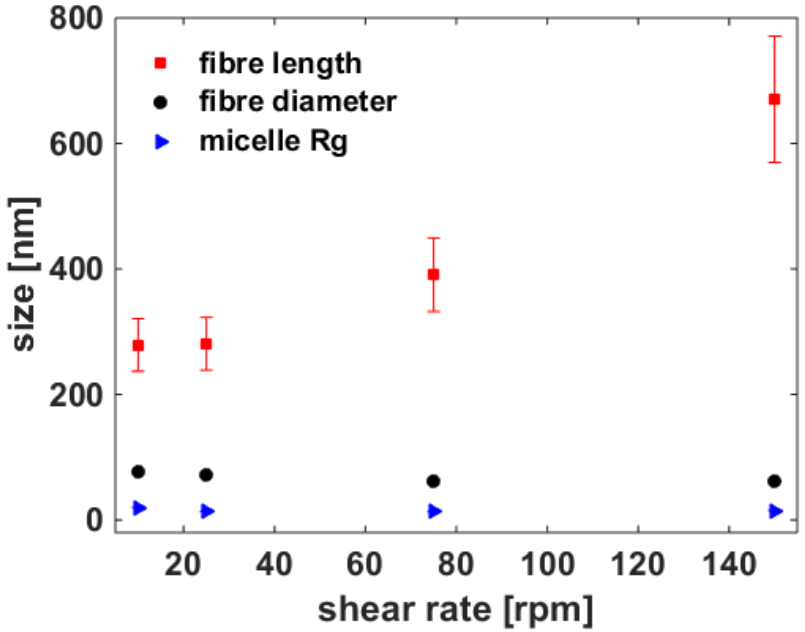




TU Delft

# Quantification fibrousness

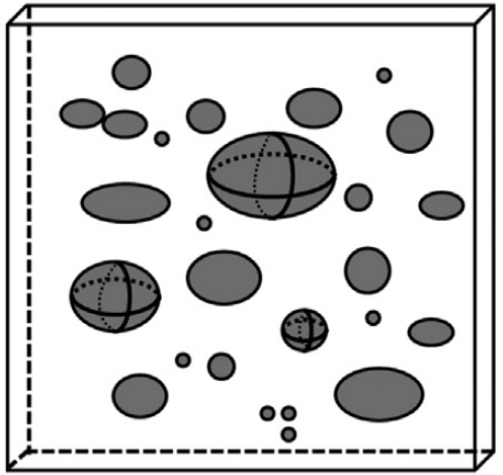



TU Delft

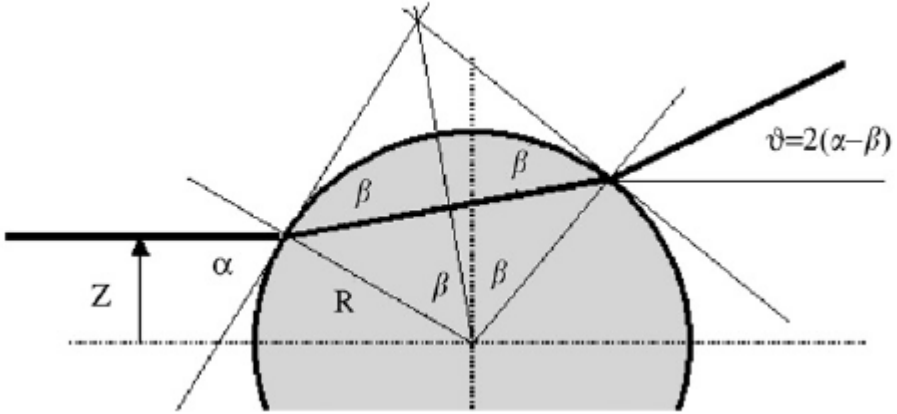
# Questions to be answered

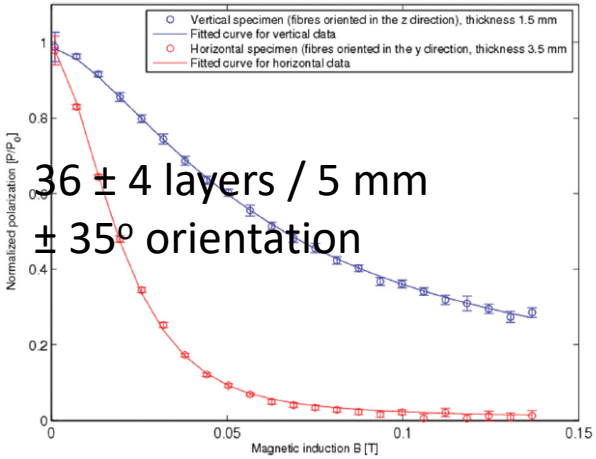
1. Effect mobility proteins?
2. Length scale orientation starts?
3. **Number of fibres and air bubbles?**



# Refraction very small angles

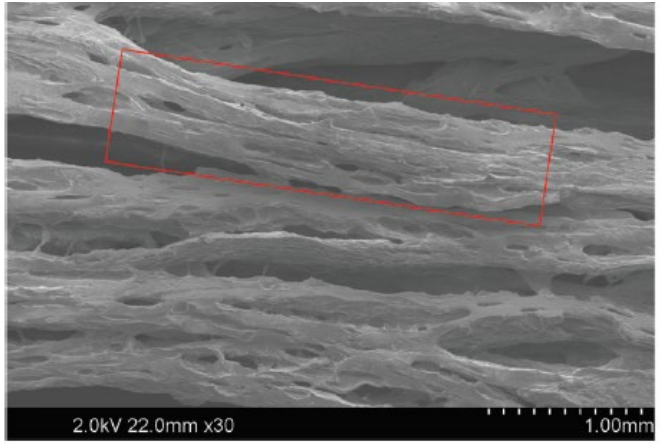
# Refraction: # layers + orientation

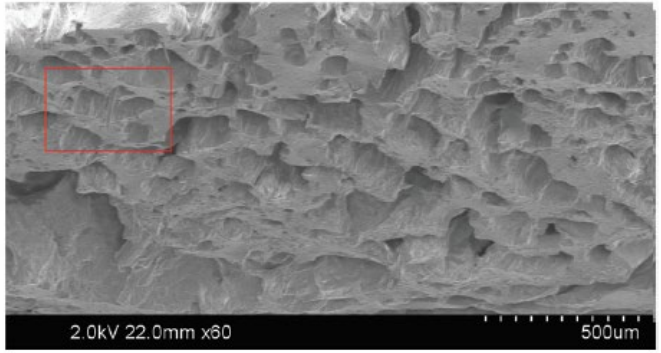



36 ± 4 layers / 5 mm

± 35º orientation



# Conclusions

- Protein mobility yield better texture
- Fibre structure above 40 nm
- Quantification fibres and air bubbles

# Plans

- In situ
- Combined with modelling

TU Delft

# Literature

*Betere textuur vleesvervangers met neutronenverstrooiing*
B. Tian, A.J. van der Goot, W.G. Bouwman
Nederlands Tijdschrift voor Natuurkunde **86** 8-11 (2020)

*Small angle neutron scattering quantifies the hierarchical structure in fibrous calcium caseinate*
B.Tian, Z. Wang, L. de Campo, E.P. Gilbert, R.M. Dalgliesh, E. Velichko, A.J. van der Goot, W.G. Bouwman
Food Hydrocolloids **106** 105912 (2020)

*Fibre formation in calcium caseinate influenced by solvent isotope effect and drying method – A neutron spectroscopy study*
B.Tian, V. Garcia Sakai, C.P. Pappas, A.J. van der Goot, W.G. Bouwman
Chemical Engineering Science **207** 1270-1277 (2019)

*Air bubbles in fibrous caseinate gels investigated by neutron refraction, X-ray tomography and refractive microscope*
B.Tian, Z. Wang, A.J. van der Goot, W.G. Bouwman
Food Hydrocolloids **83** 287-295 (2018)

*On characterization of anisotropic plant protein structures*
G.A. Krintiras, J. Göbel, W.G. Bouwman, A.J. van der Goot and G.D. Stefanidis
Food & Function **5** 3233-3240 (2014)