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# **Challenges with modern materials studied with new neutron facilities**

Adrian Rennie  
Materials Physics



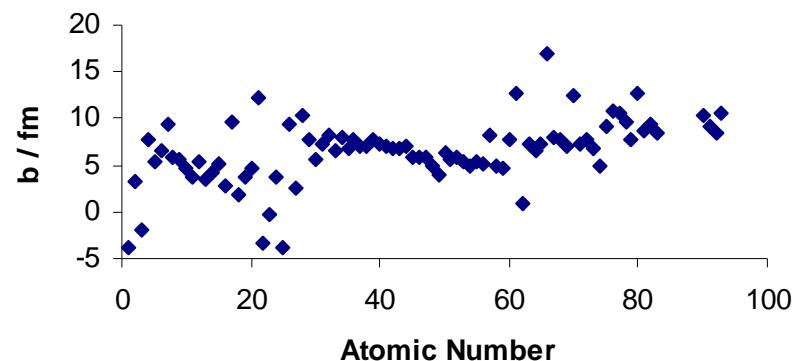


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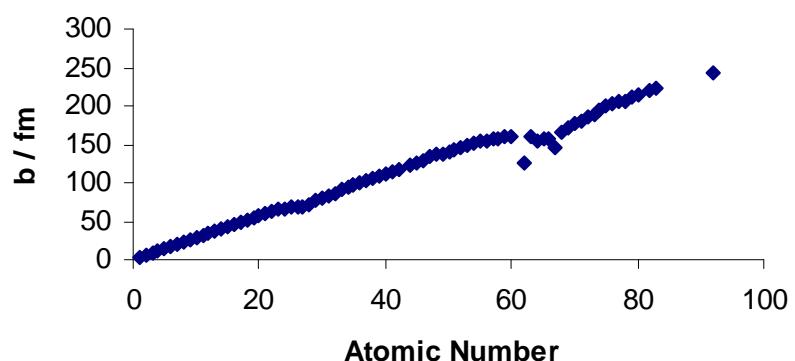
# Optimist or Pessimist?



**Neutron Scattering Length  
(natural abundance)**



**X-ray Scattering Length**



Opportunity and challenge?

Contrast, magnetism, dynamics



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# Use of Neutrons – some numbers

Sweden participates at:

Institut Laue Langevin, Grenoble France	1.8% + $\frac{1}{2}$ CRG
ISIS, RAL, Oxford, UK	2.6%

ESS – 30% of construction costs

Swedish Neutron Scattering Society – more than 180 members



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# Trends in Science

Respond to challenges of society

Health, Energy, Environment, Food

Combinations of different technologies and materials

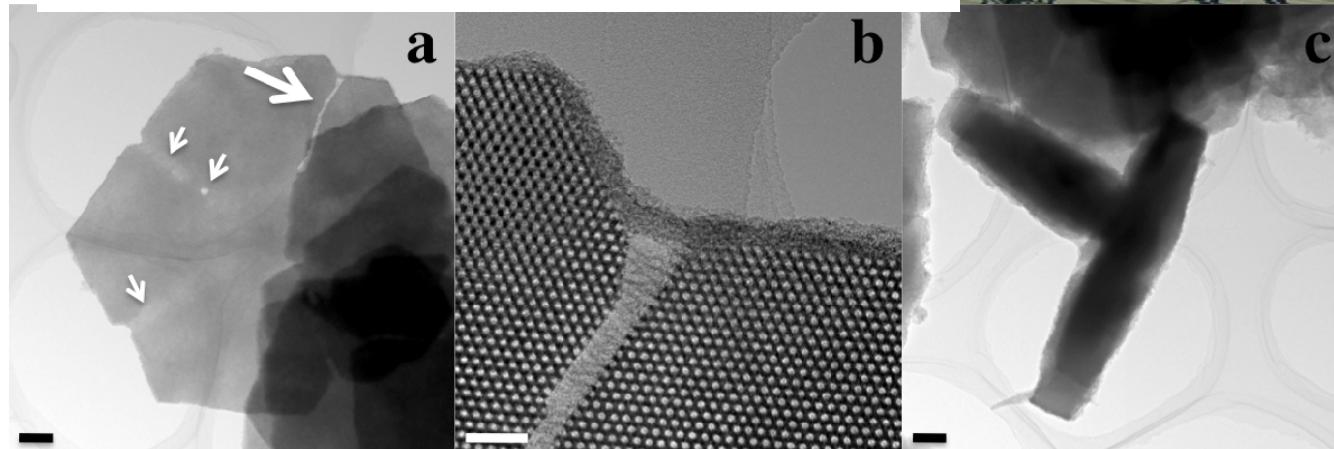
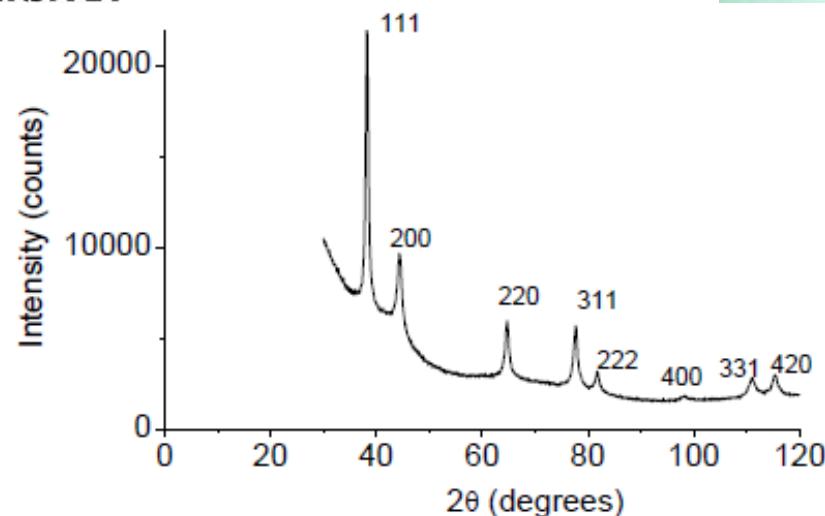
Interfaces, amorphous and complex structures, interior of big samples

Understand properties in terms of dynamic behaviour and not just structure



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# Trends in Science





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# Use of Neutrons - themes

Problem driven research:

Soft Matter

Interfaces & Thin Films

Solid state chemistry

Magnetic structures

Ion dynamics

**Techniques:** primarily powder diffraction, SANS, reflection  
but also other experiments



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# Water Purification with MO protein

- Protein extracted from seeds of *Moringa oleifera* tree (Miracle tree)
- 92 to 99% reduction in turbidity
- Efficiency as good as  $\text{Al}^{3+}$  salts
- Binds minerals and bacteria

**How does it work?**





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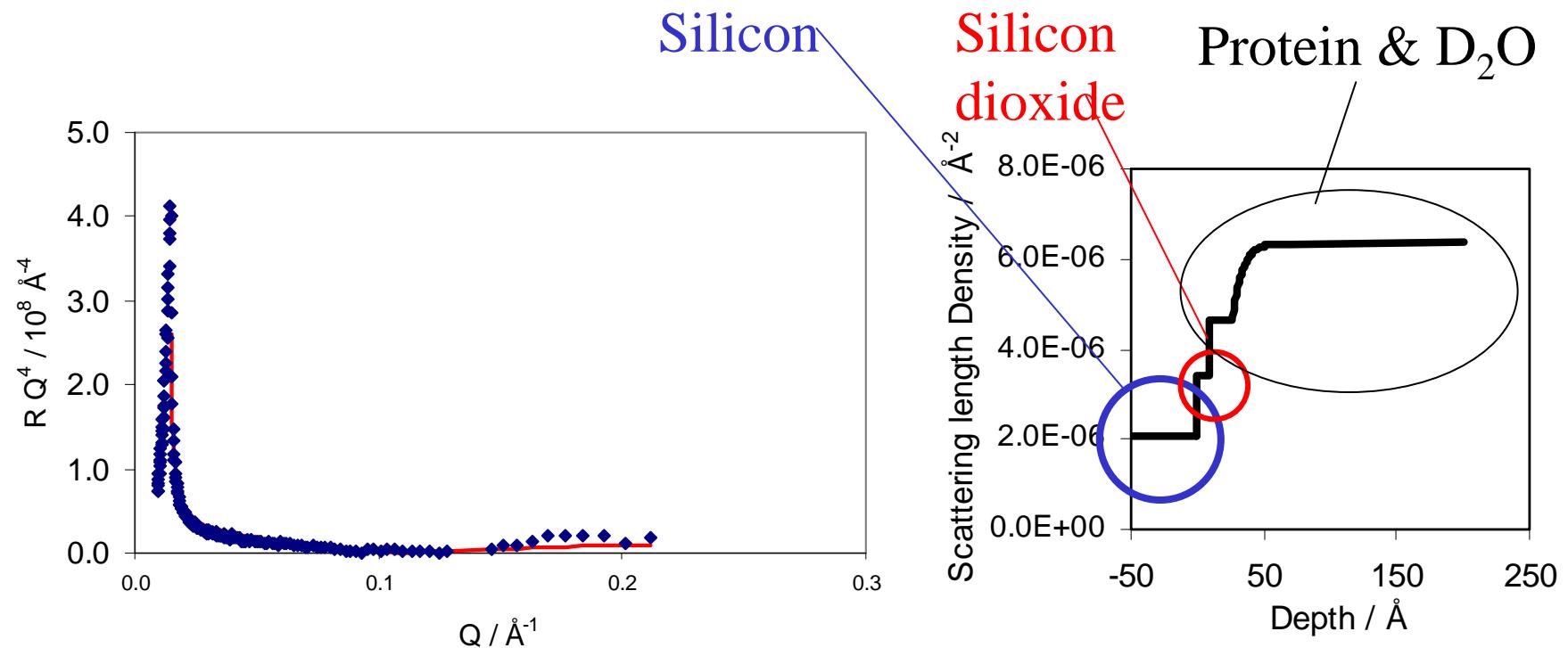
# From use to understanding





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# Profile of layer on $\text{SiO}_2$



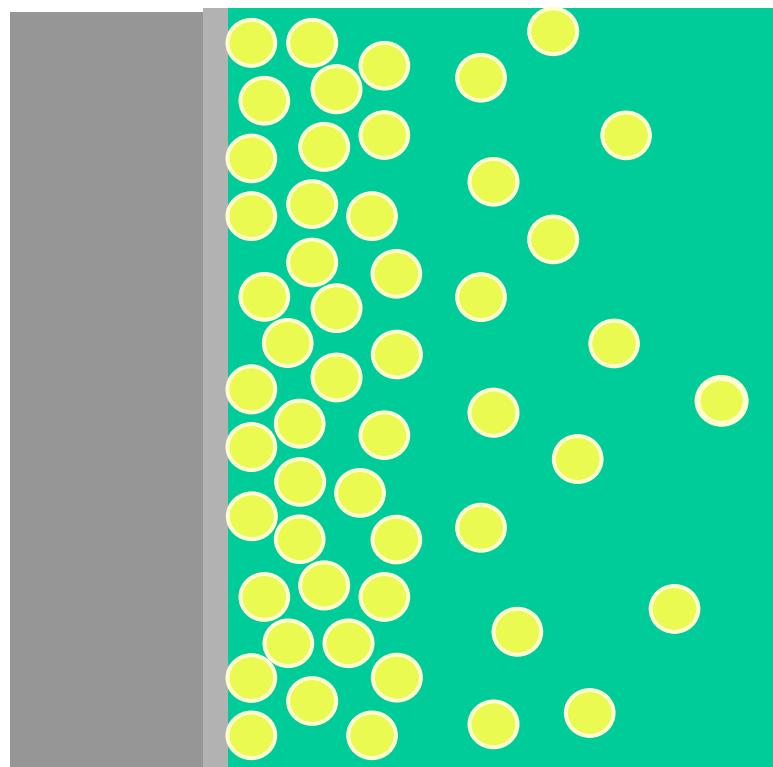
0.005% wt MO protein solution in D<sub>2</sub>O



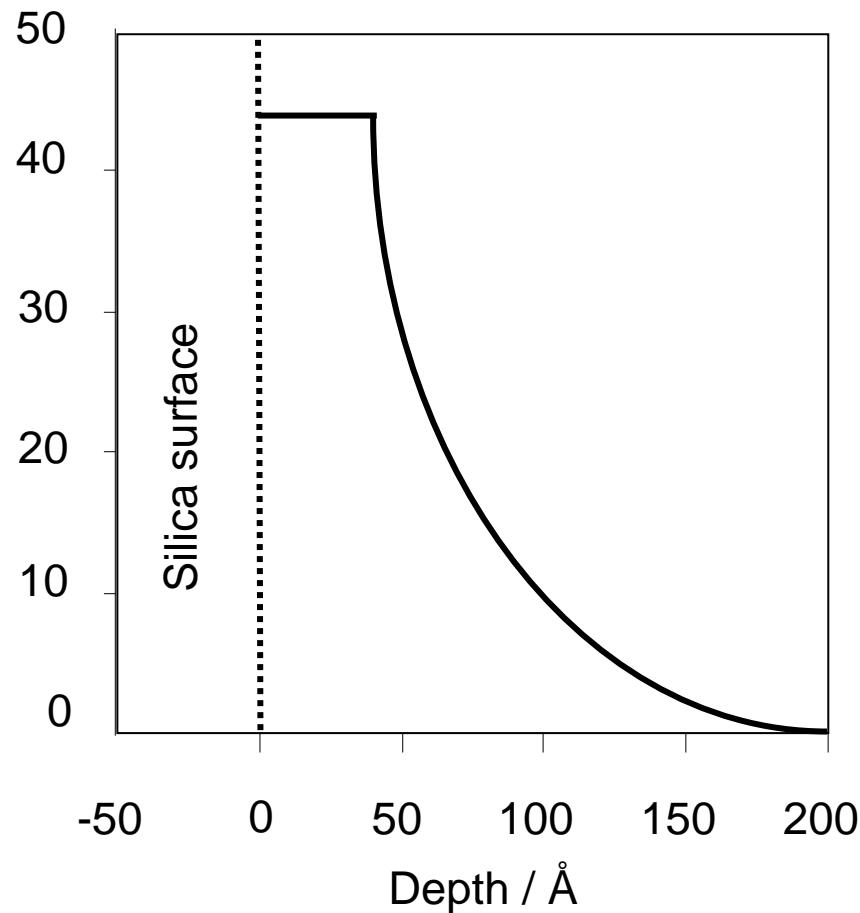
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# MO Protein Adsorbed Layer on SiO<sub>2</sub>

0.05 % Protein



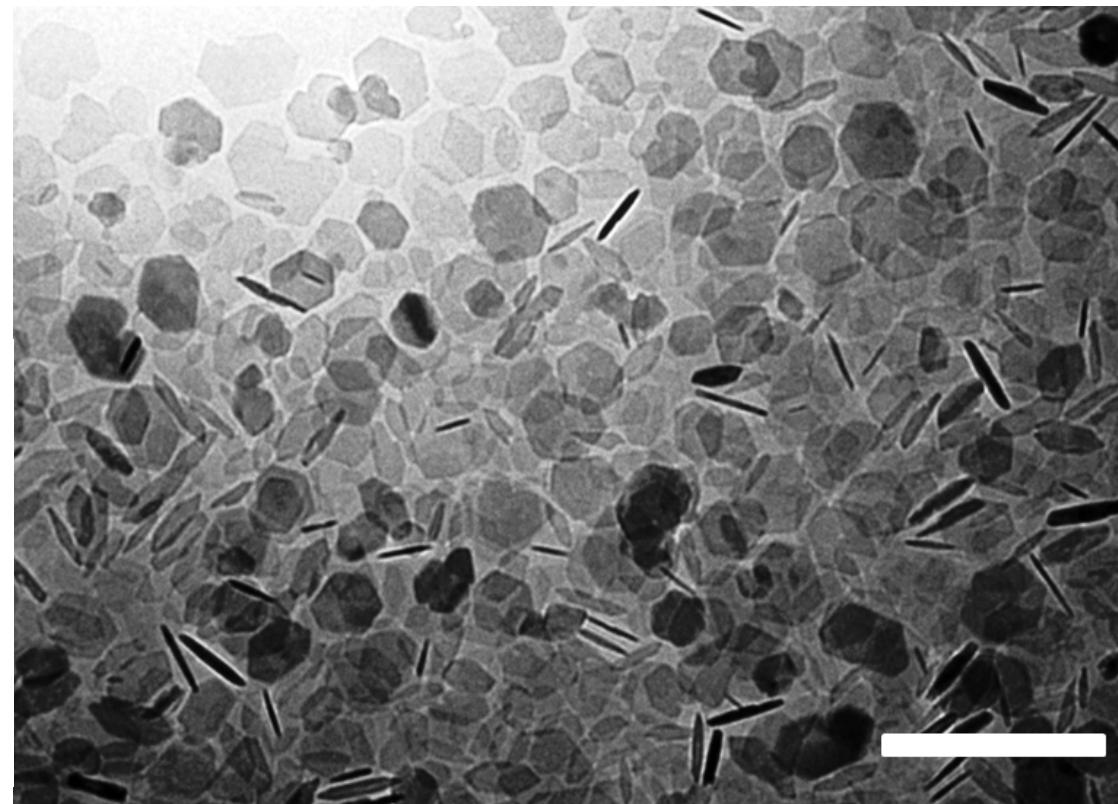
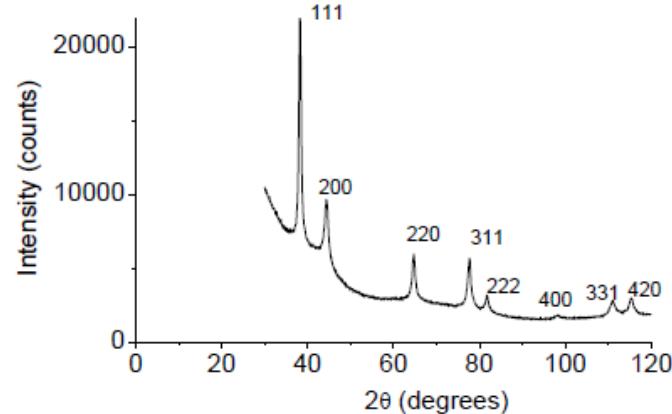
Protein %





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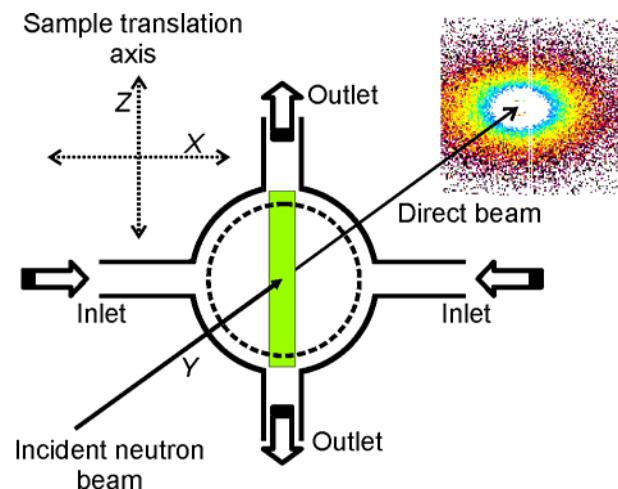
$\text{Ni(OH)}_2$  90 nm  
diameter



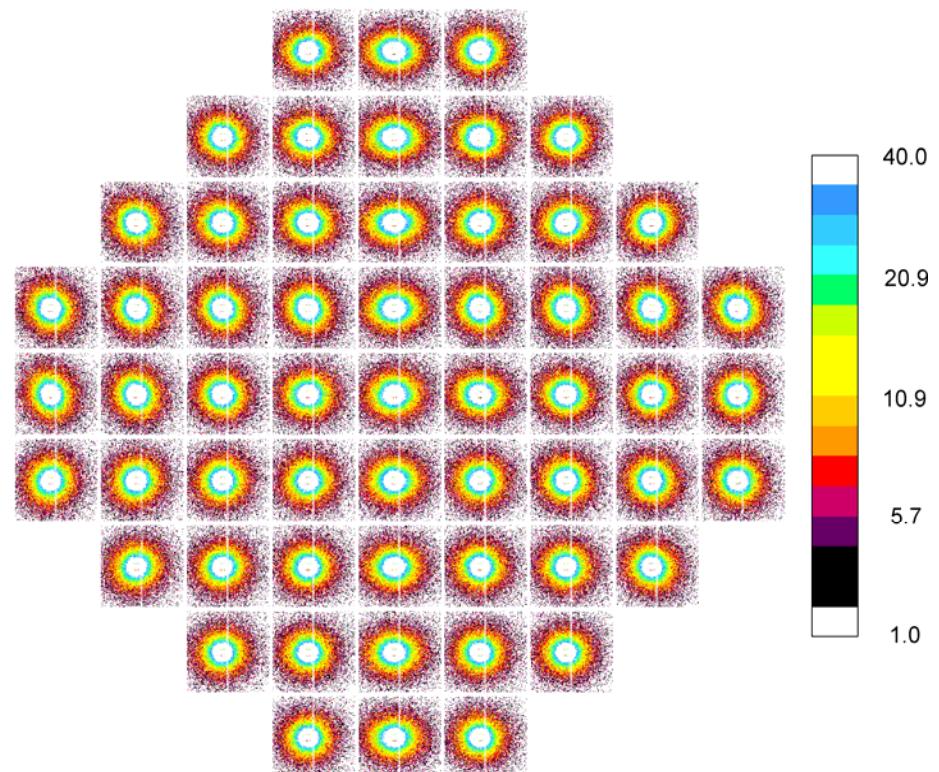
S. J. S. Qazi, A. R. Rennie, J. K. Cockcroft, M. Vickers (2009)  
*Journal of Colloid & Interface Science* **338**, 105-110.



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22% wt





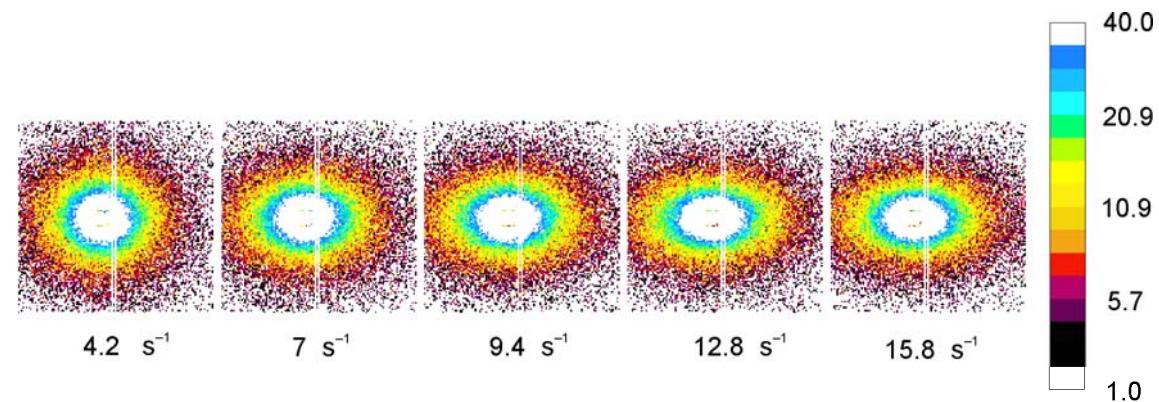
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$\text{Ni(OH)}_2$  22% wt

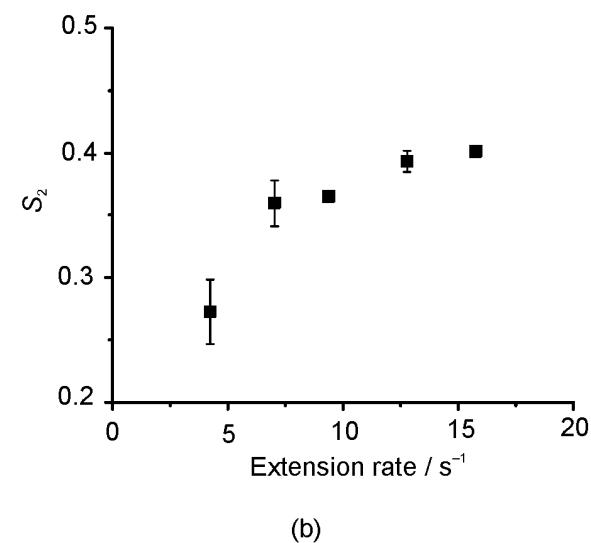
Order parameter  
changes with  
elongational strain  
rate

Relate to rotational  
dynamics studied by  
XPCS

# Anisotropic Particles Flow



(a)



(b)



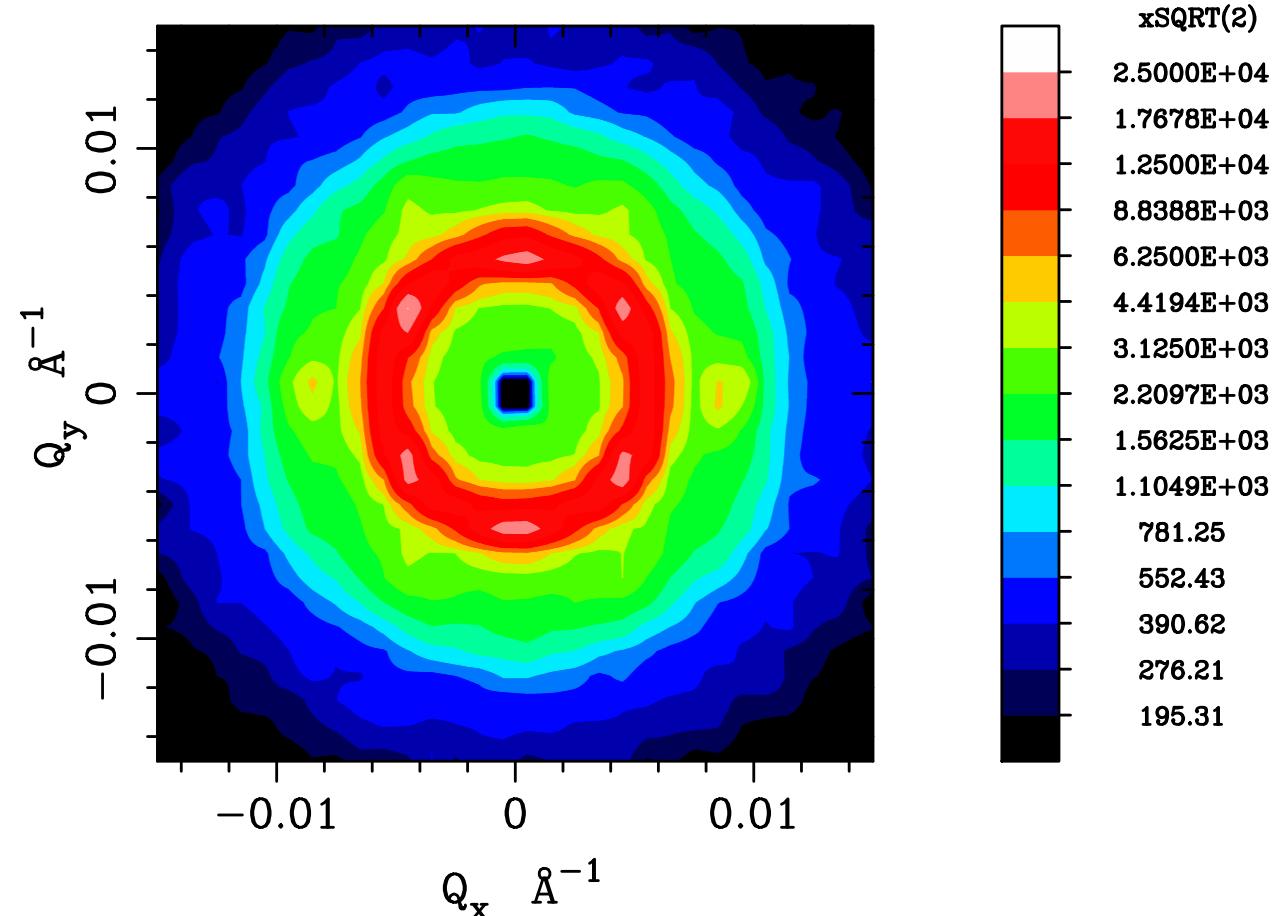
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15% Polystyrene  
latex in deionised  
water ( $D_2O$ )

'Single Crystal'  
diffraction with  
neutrons

PS11

# Colloidal Particles - Structure



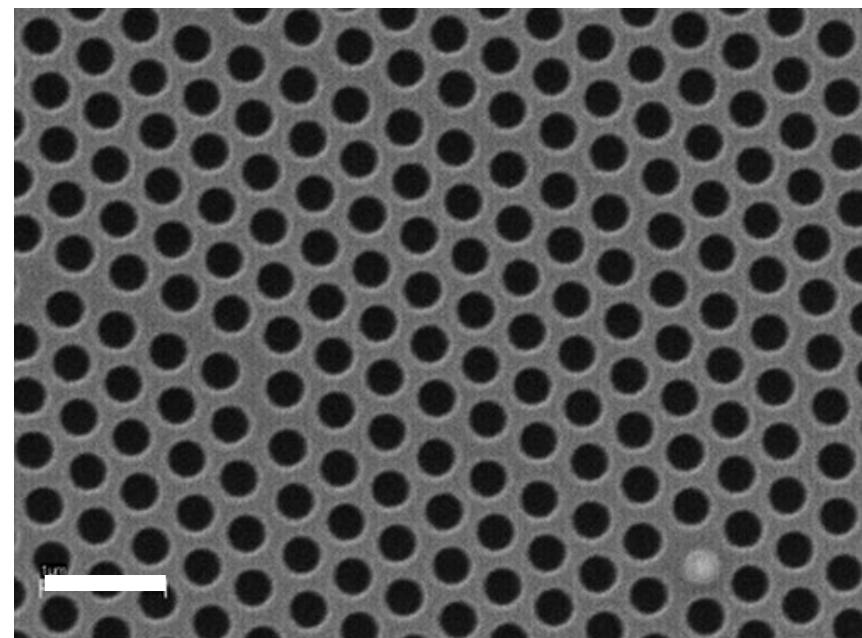
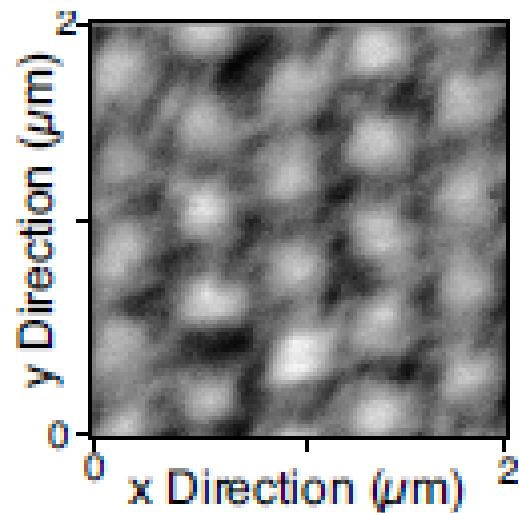


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# Colloidal Particles – as template

Fe antidots prepared by  
lithography with assembled  
particles

Electron Microscope 1  $\mu\text{m}$  scale bar



Magnetic Force Microscope

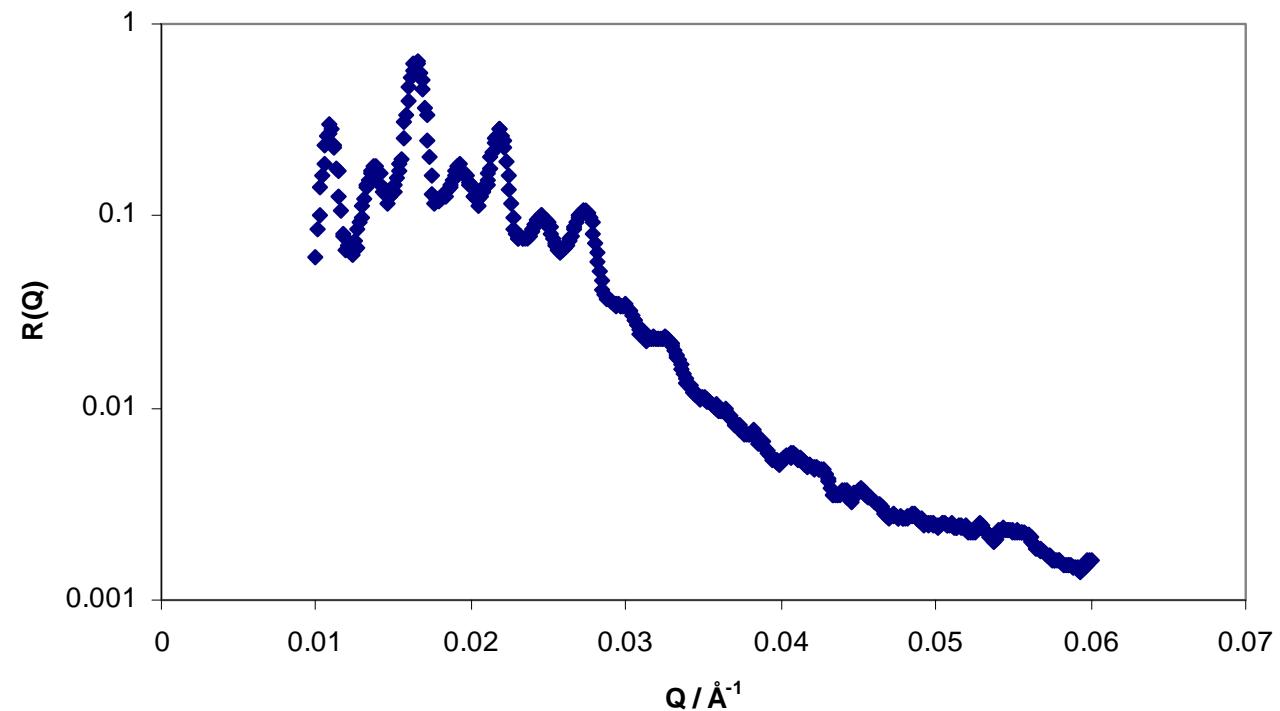
Papaioannou E. Th., Kapaklis V., et al Phys. Rev. B 81, 054424 (2010).



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# PS latex in D<sub>2</sub>O – sapphire surface

Sum along Q<sub>x</sub>



10% vol dispersion, 0.35



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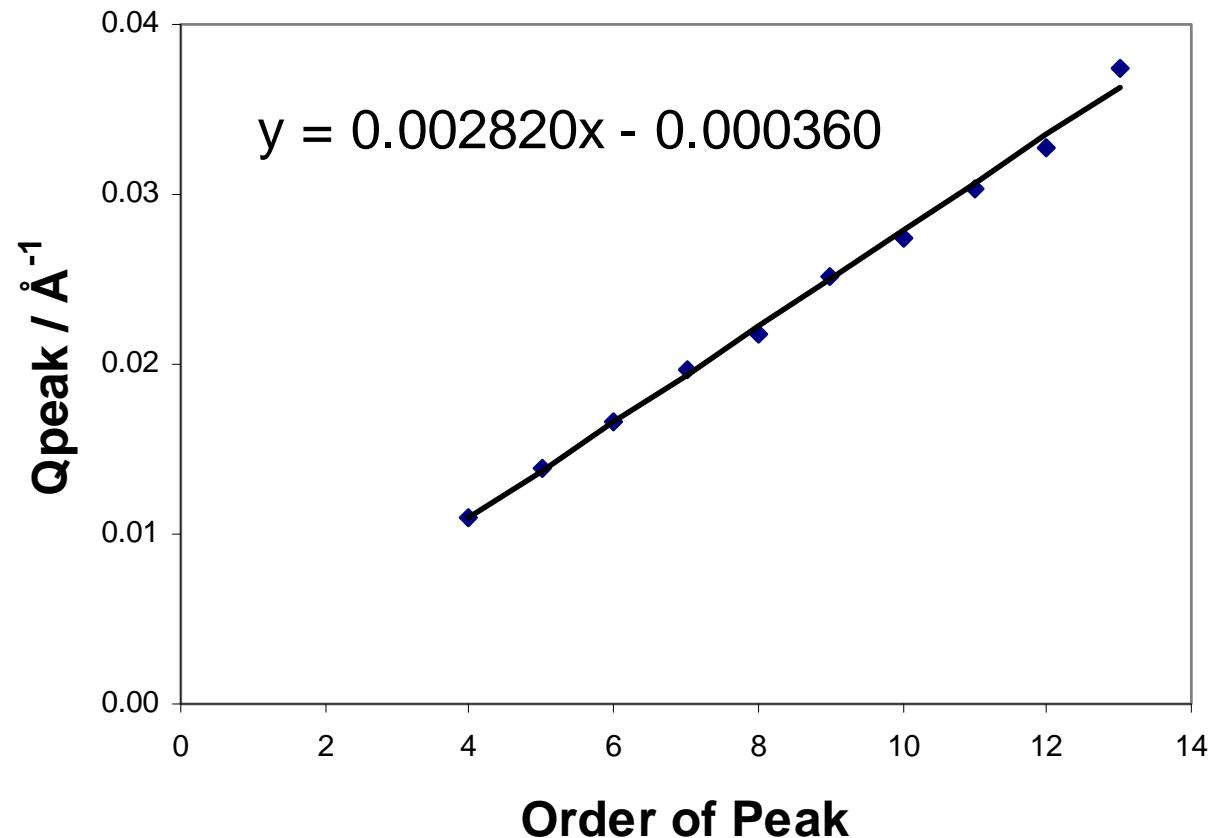
# PS latex in D<sub>2</sub>O – sapphire surface

Assign Bragg  
peaks (index)

$$Q_1 = 0.00282 \text{ \AA}^{-1}$$

$$d = 2230 \text{ \AA}$$

3 first peaks  
outside range



10% vol dispersion, 0.35, 0.8 and 1.5 deg

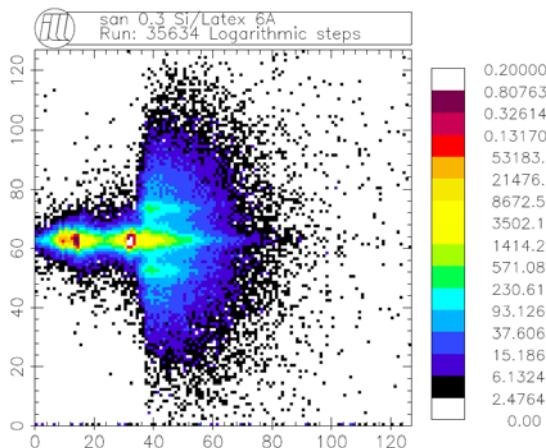


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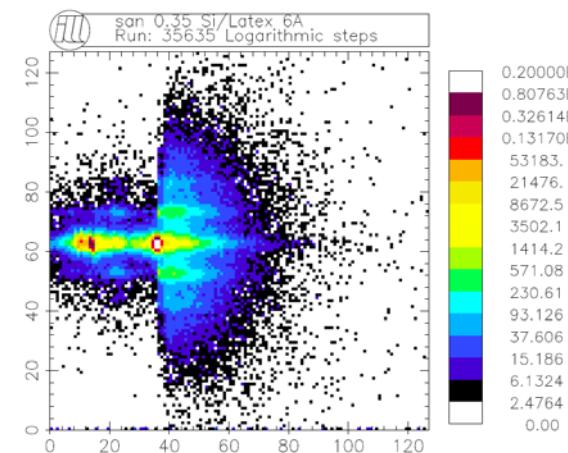
# GiSANS – Polystyrene Latex / Si

10% vol. 6 Å

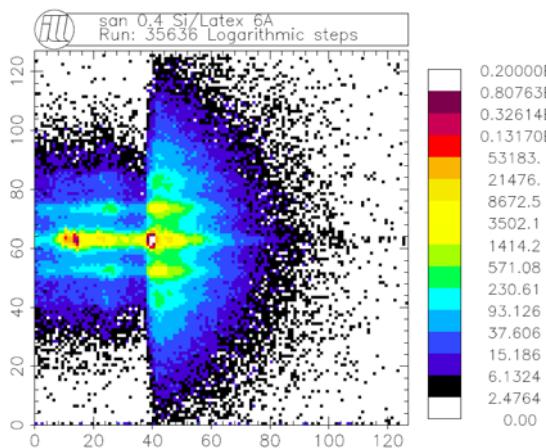
0.3°



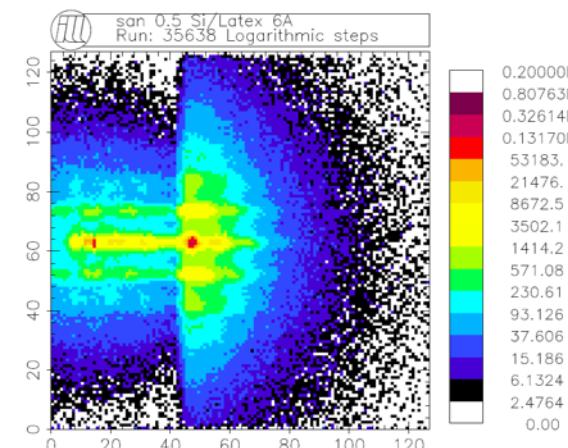
0.35°



0.4°



0.5°

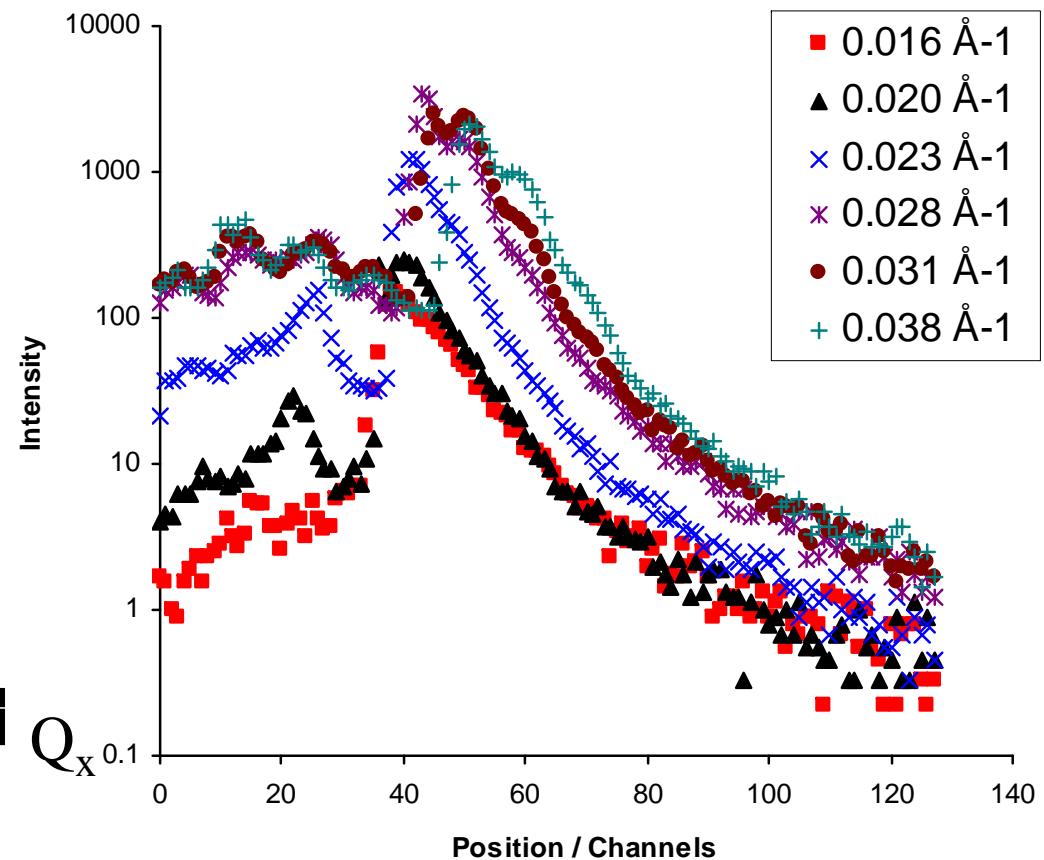
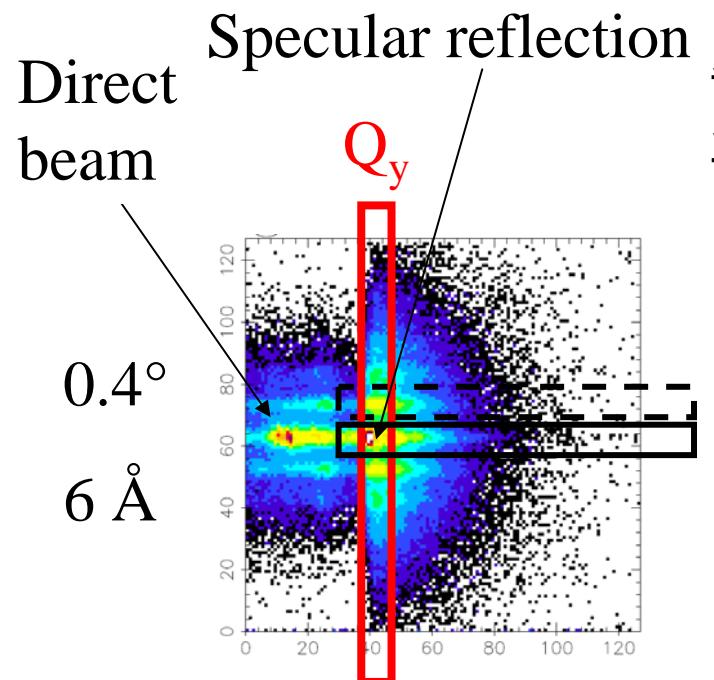




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# GiSANS – Inspecting data

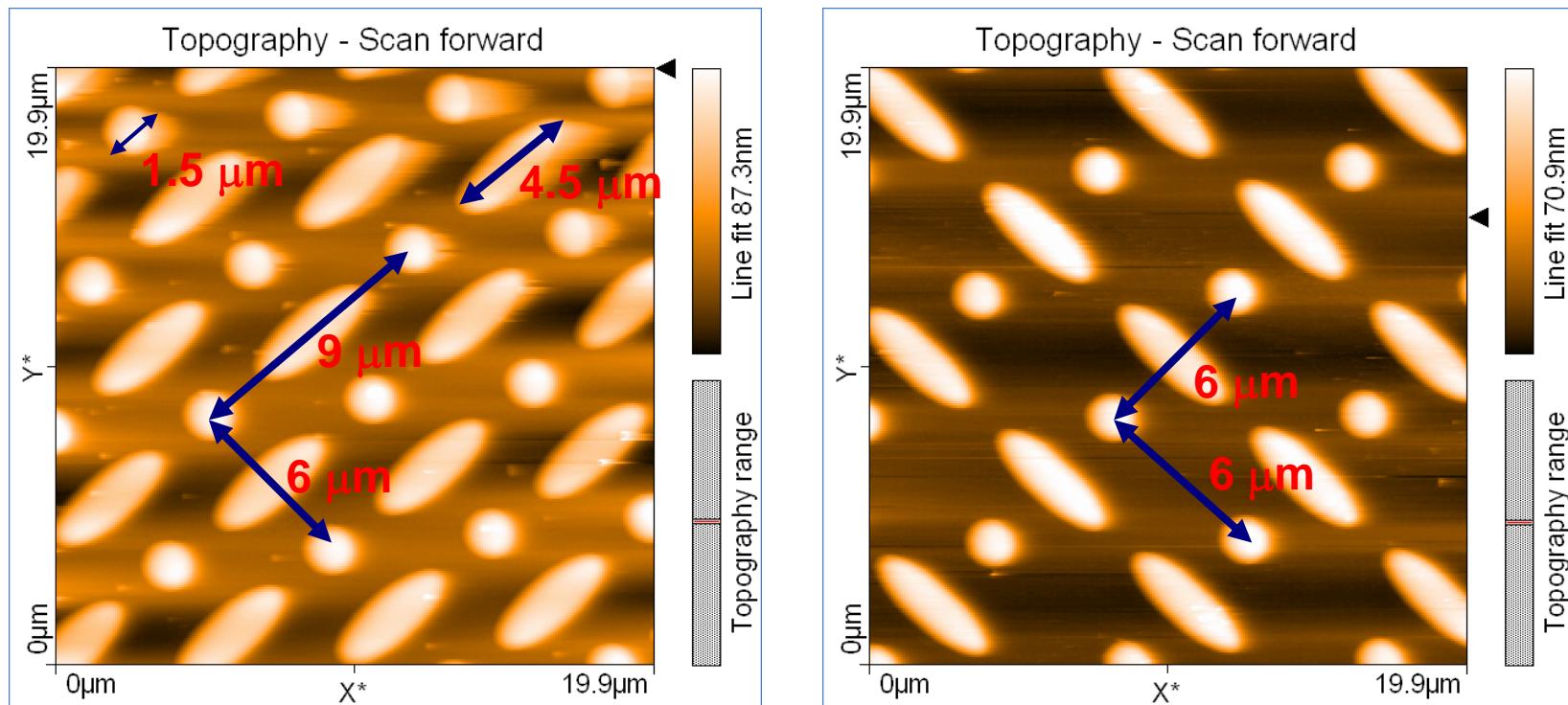
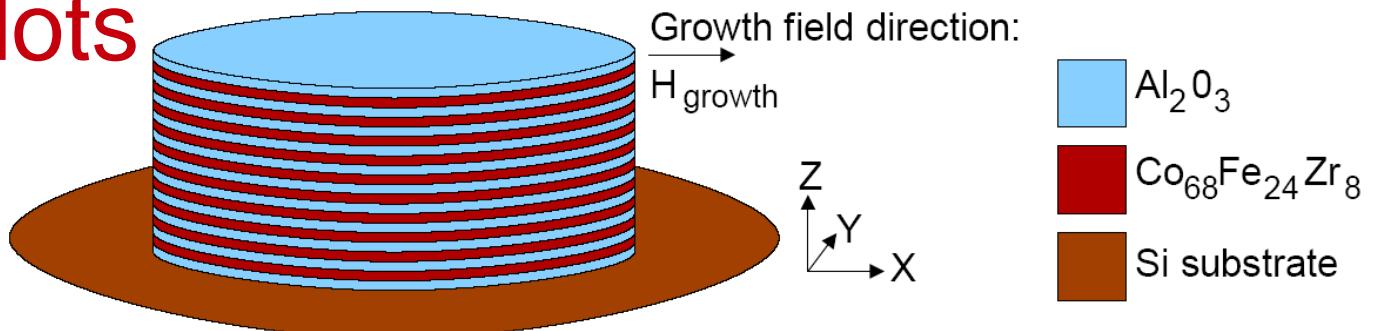
Cuts in data give  
simple ideas





# Nanodots

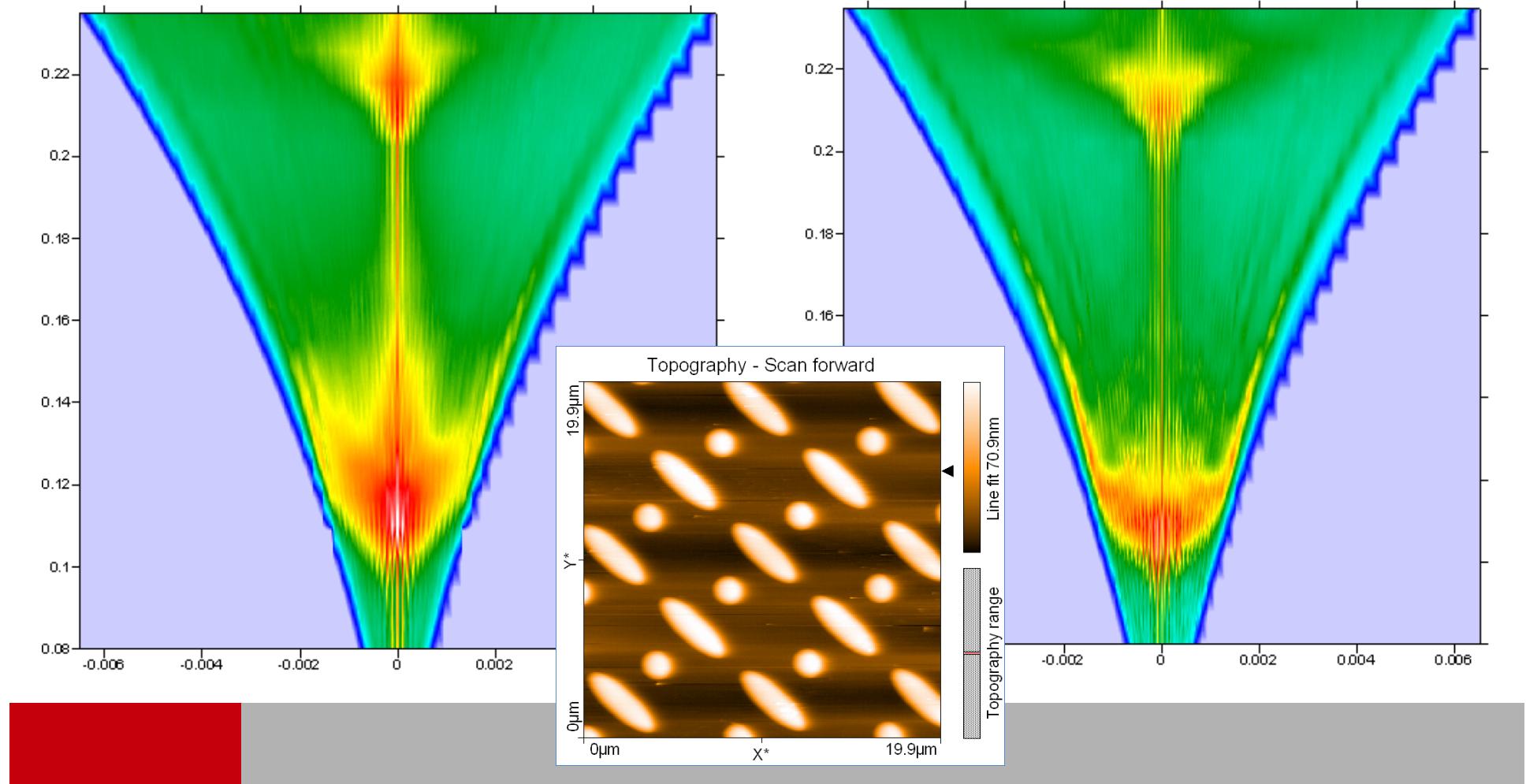
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Anisotropy set along ellipse direction by growth in a field (easy axis)

Hase, Hjörvarsson, Arnalds, et al.

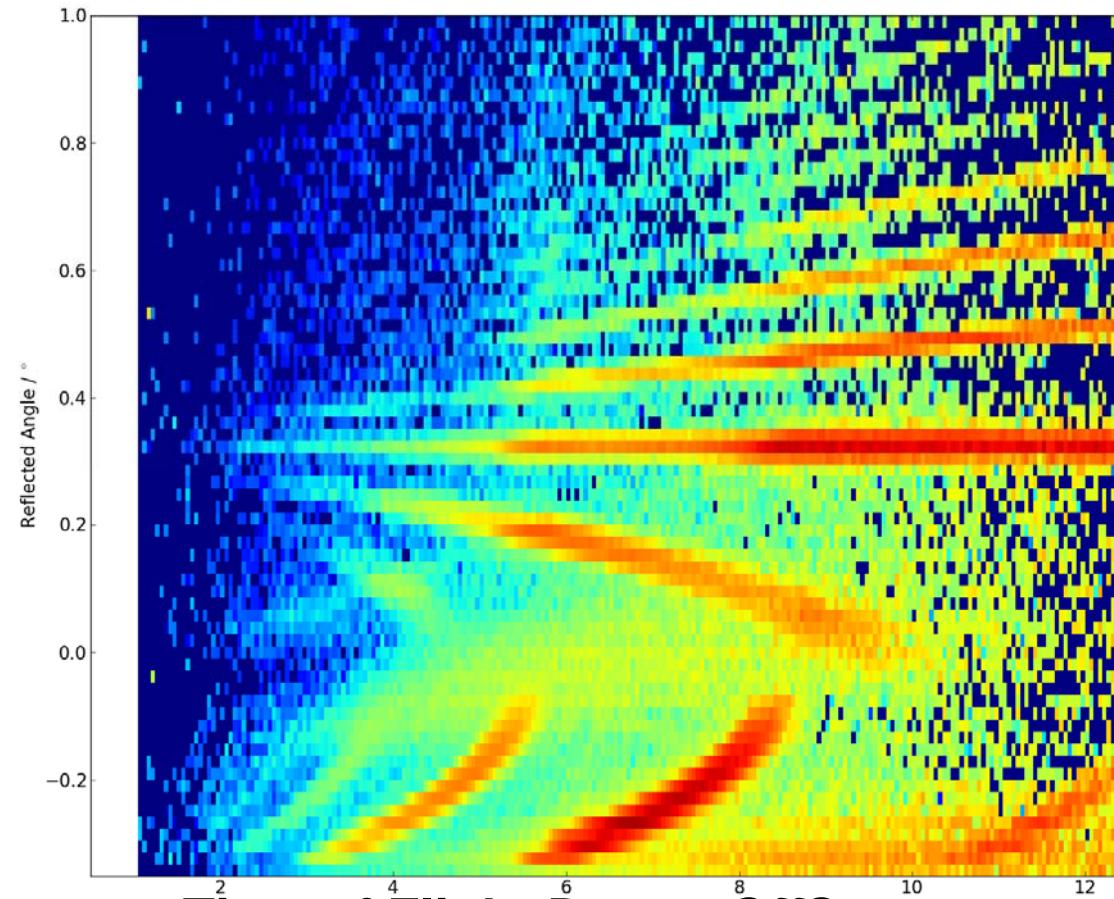
# Nanodots Sample D, 2 azimuth angles



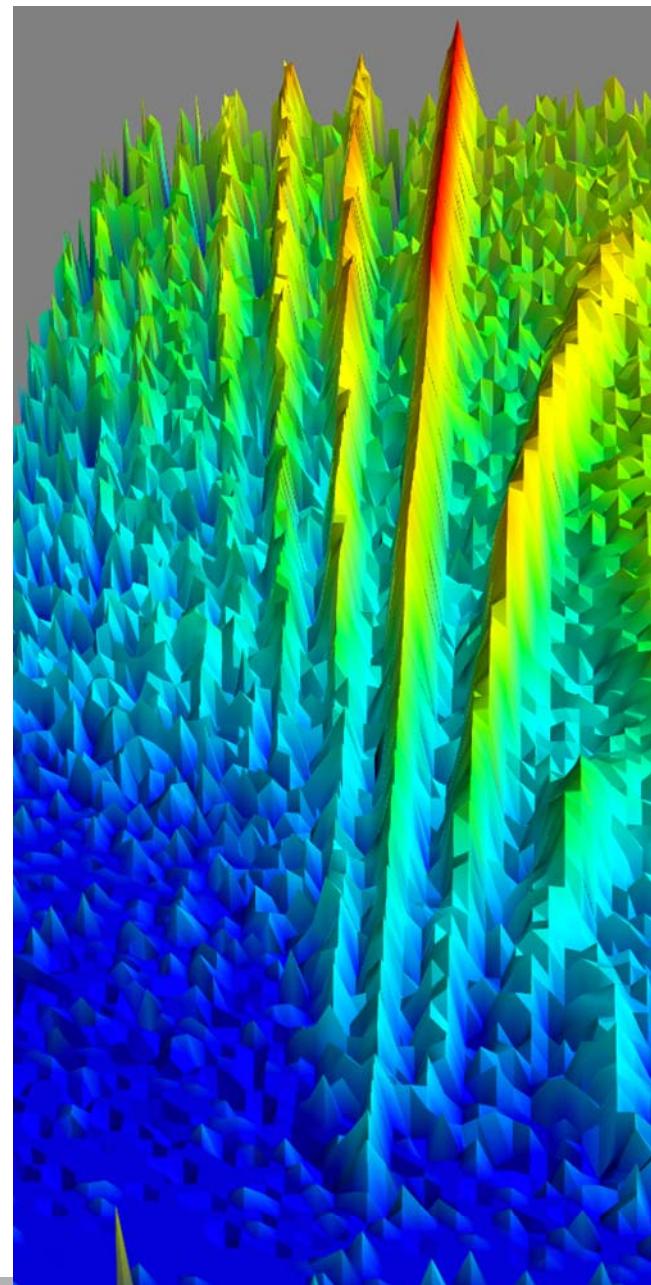


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# Neutron Scattering



Time of Flight Data—OffSpec  
TS2 ISIS





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# Opportunities - examples

## Environment

Atmospheric chemistry  
Pollutants – ozone  
Water purification  
Soil remediation

## Energy

Novel conductors  
Lubrication  
Storage

## Health

Tissue replacement  
Biocompatibility  
Drug delivery

etc. etc.



# Challenges

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## Instrumentation

Optical devices – thin film,  
prisms

Detectors – high resolution

Optimisation for science not just  
flux

## Sample Environment

Dynamic – beyond B, T

Beyond shear – elongation,  
strain history, combined E, B,  $\gamma$

## Analysis & Software



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# Thank You

