

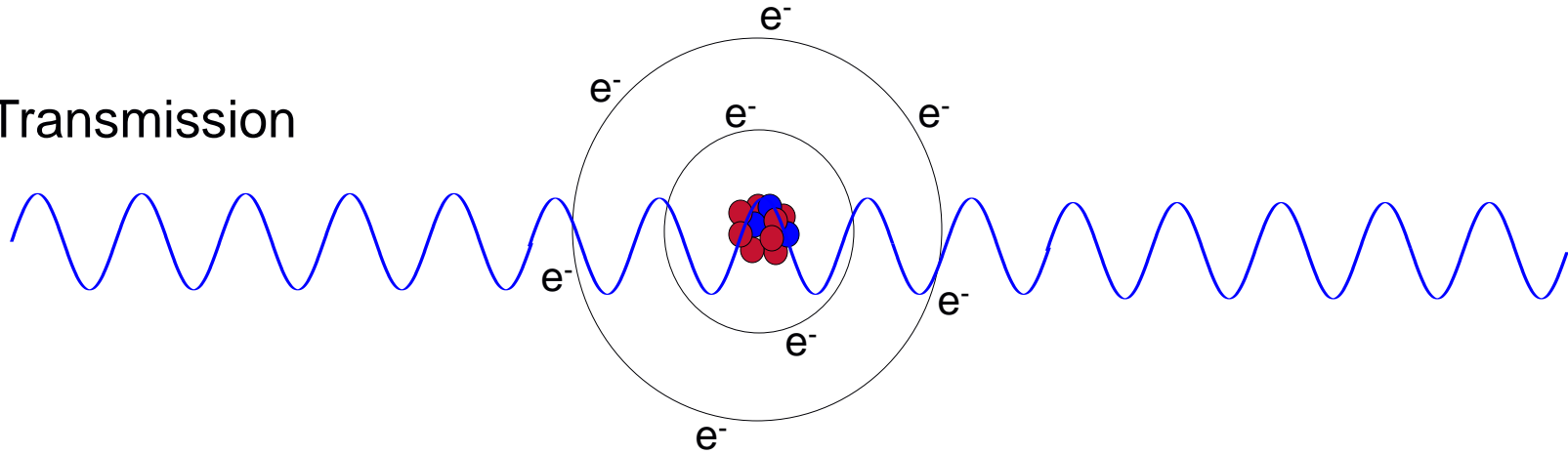


The Power of SAXS: Exploration of the Magic World of Bio- and Nanomaterials

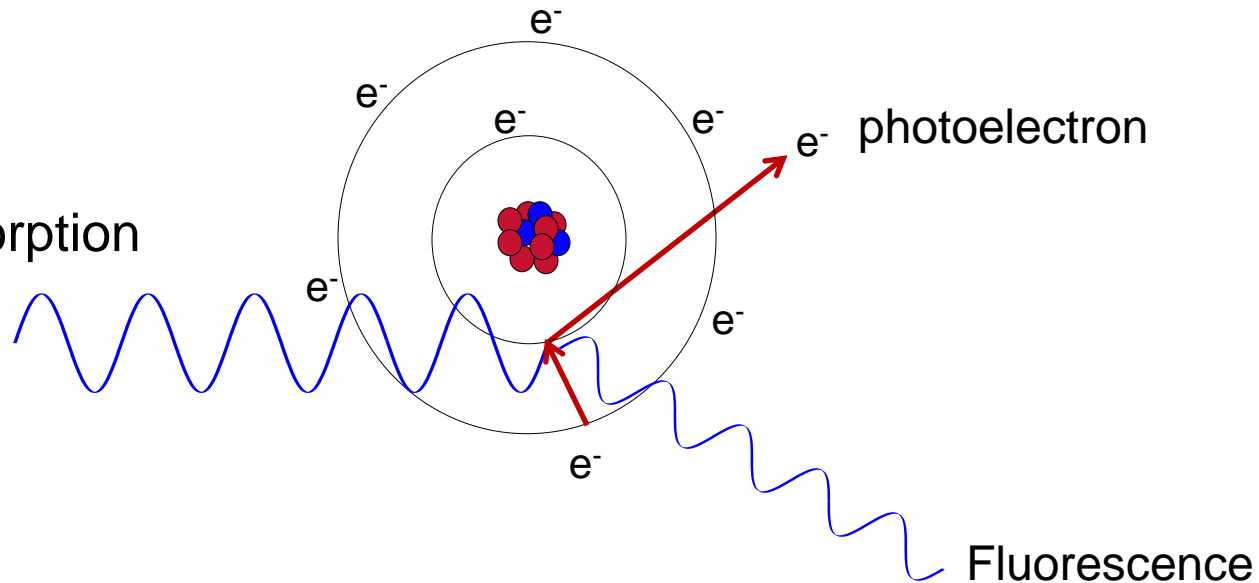
Michael Rappolt

Interaction of X-rays with Matter

Transmission

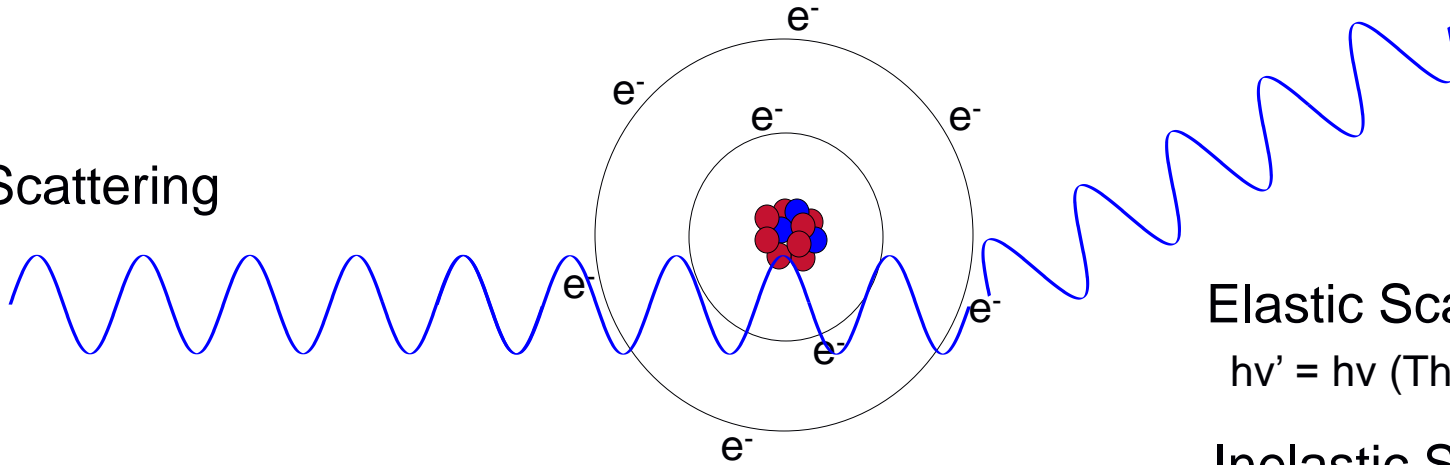


Absorption



Interaction of X-rays with Matter (cont.)

Scattering



Elastic Scattering:

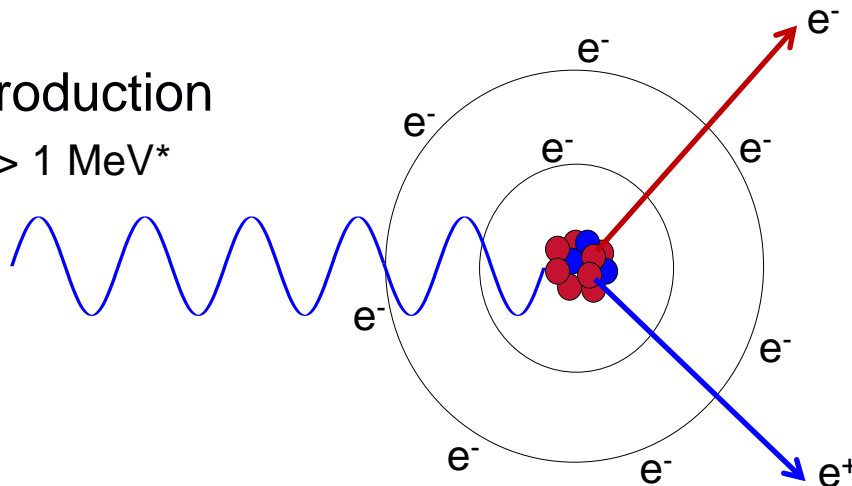
$$h\nu' = h\nu \text{ (Thomson)}$$

Inelastic Scattering:

$$h\nu' < h\nu \text{ (Compton)}$$

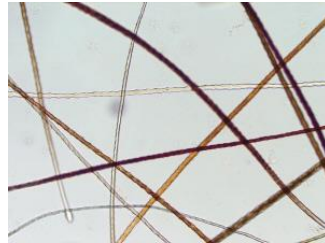
Pair Production

$$E = h\nu > 1 \text{ MeV}^*$$

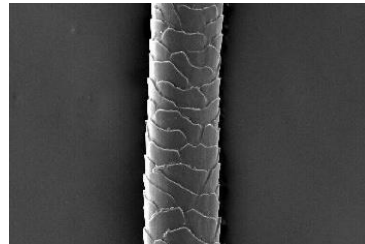
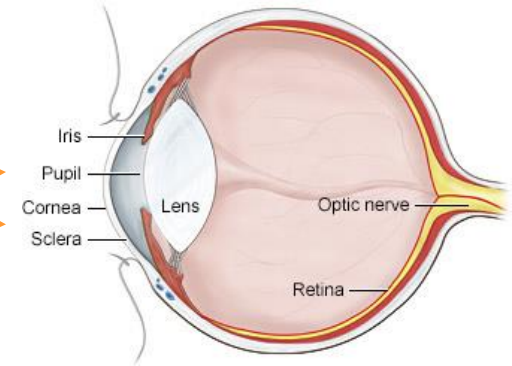
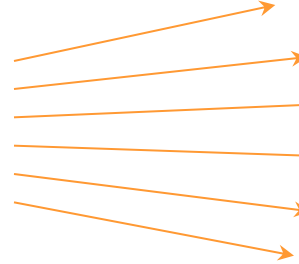


*1 eV = 1.602×10^{-19} J

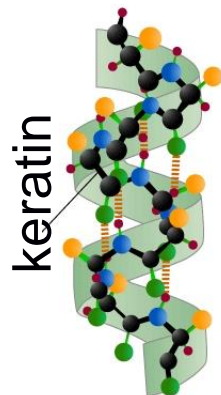
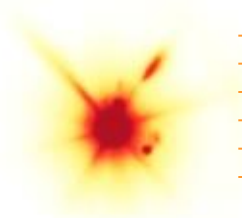
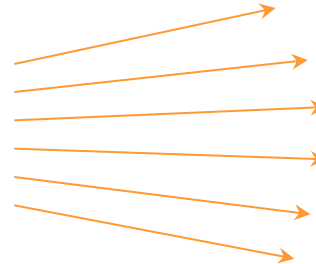
What can we see?



millimeter

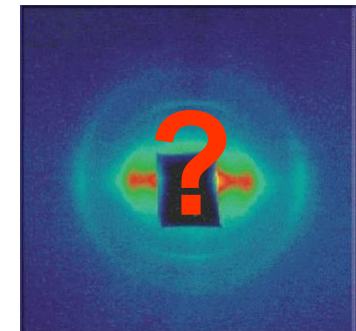
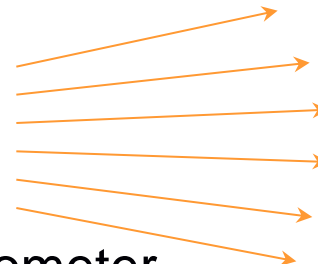


micrometer

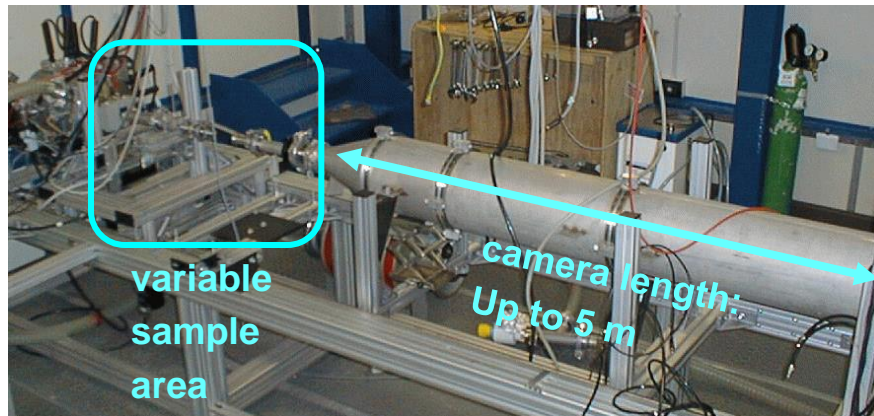


keratin

nanometer

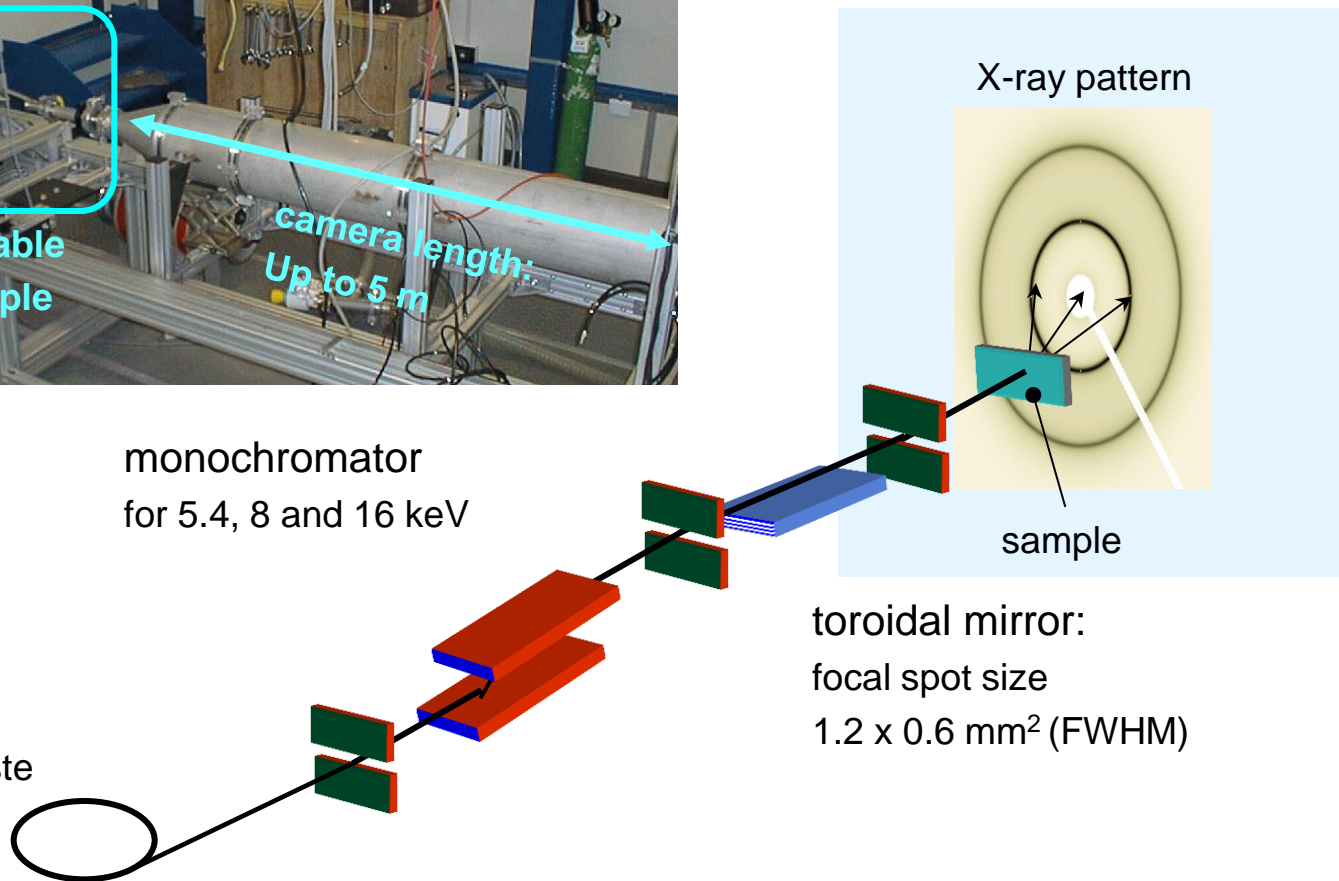


The Austrian SAXS Beamline



monochromator
for 5.4, 8 and 16 keV

light-source:
Sincrotrone Trieste



SAXS Methods

➤ *Solution Scattering:*

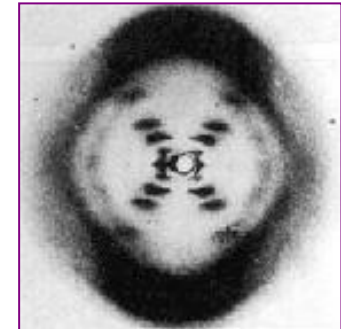
Formation of CaCO_3 ; Proteins



Diffuse scattering
of water

➤ *Fiber-Diffraction:*

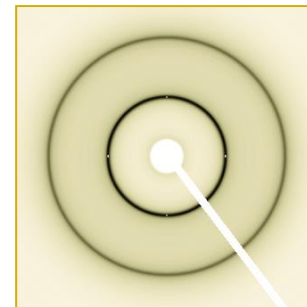
Discovery of DNA; Collagen



Rosalind Franklin's X-ray
diffraction photograph
of DNA, 1953

➤ *Small Angle X-ray Diffraction:*

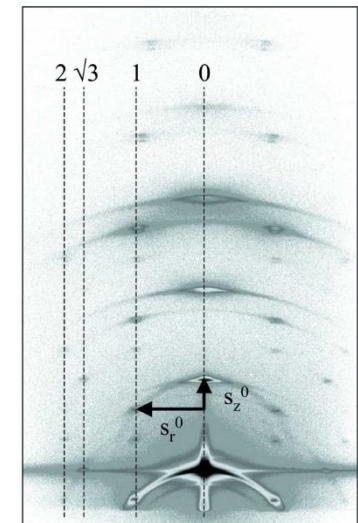
Liquid Crystal Membranes



Powder diffraction on
lipid/water systems

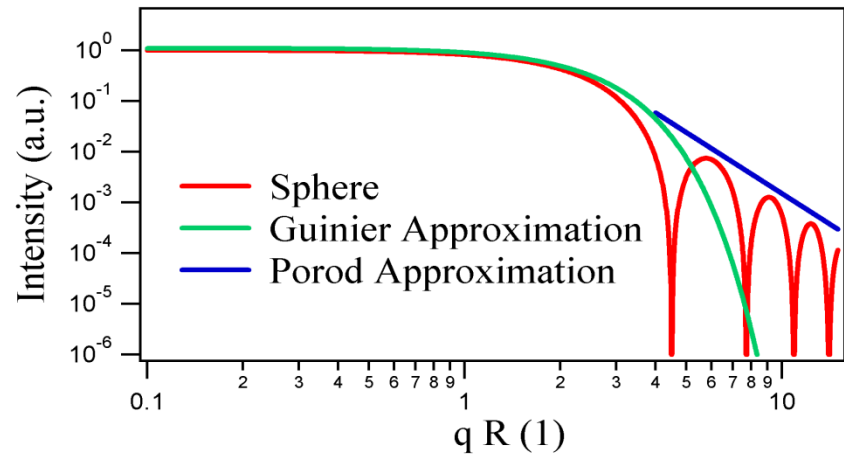
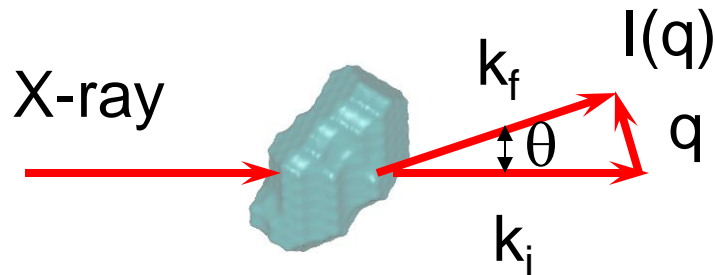
➤ *Grazing Incidence X-ray Scattering:*

Membrane Fusion; Quantum Dots



Surface Diffraction

Solution Scattering: Diluted Systems



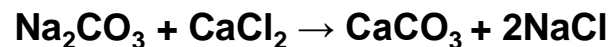
Scattering function of monodisperse spheres

Guinier Approximation ($qR \ll 1$):
$$I(q) = p \cdot \Delta\rho^2 \cdot V_p \cdot \exp\left(-\frac{q^2 \cdot R_g^2}{3}\right)$$

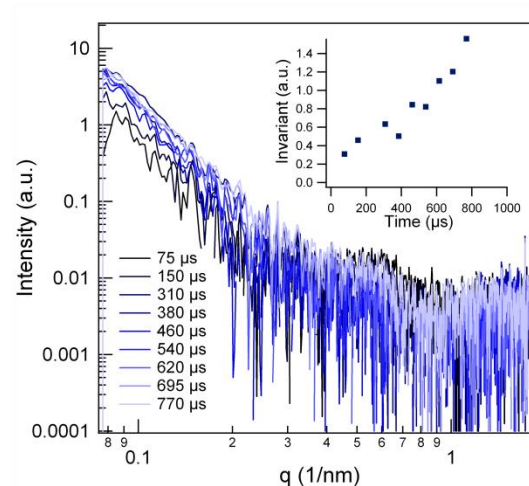
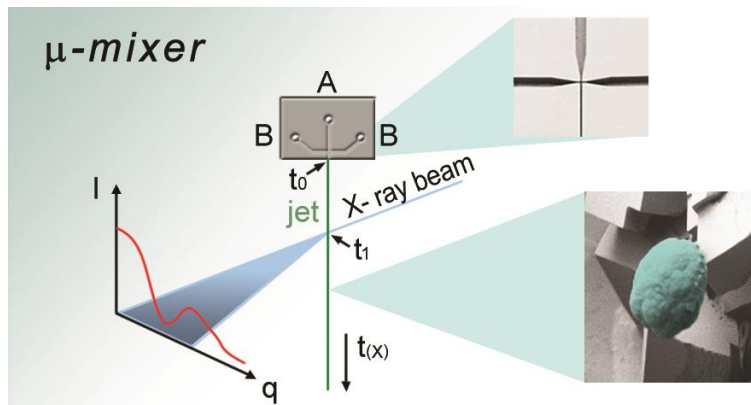
Porod Approximation ($qR \gg 1$):
$$I(q) = \text{const.} + \frac{P}{q^4} \quad P \propto p \cdot \Delta\rho^2 \frac{S}{V}$$

Fast Chemical Reactions in a Free Standing Jet

Free jet micromixer to study sub 100 μs chemical and biological reactions



Concentration of reagents: 50 mM



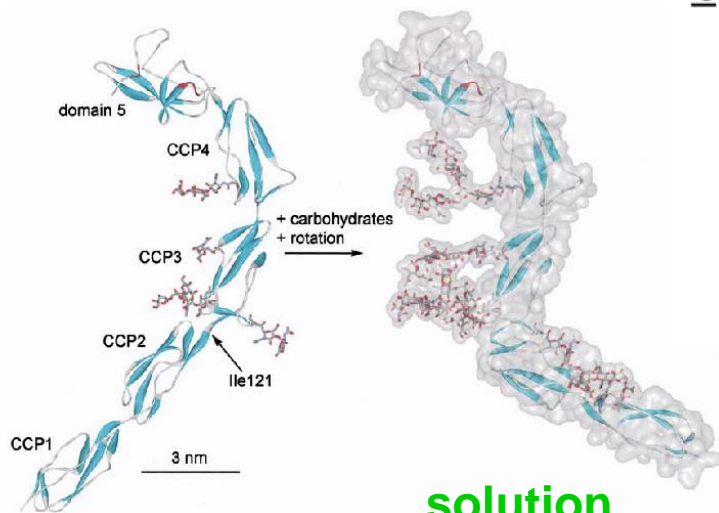
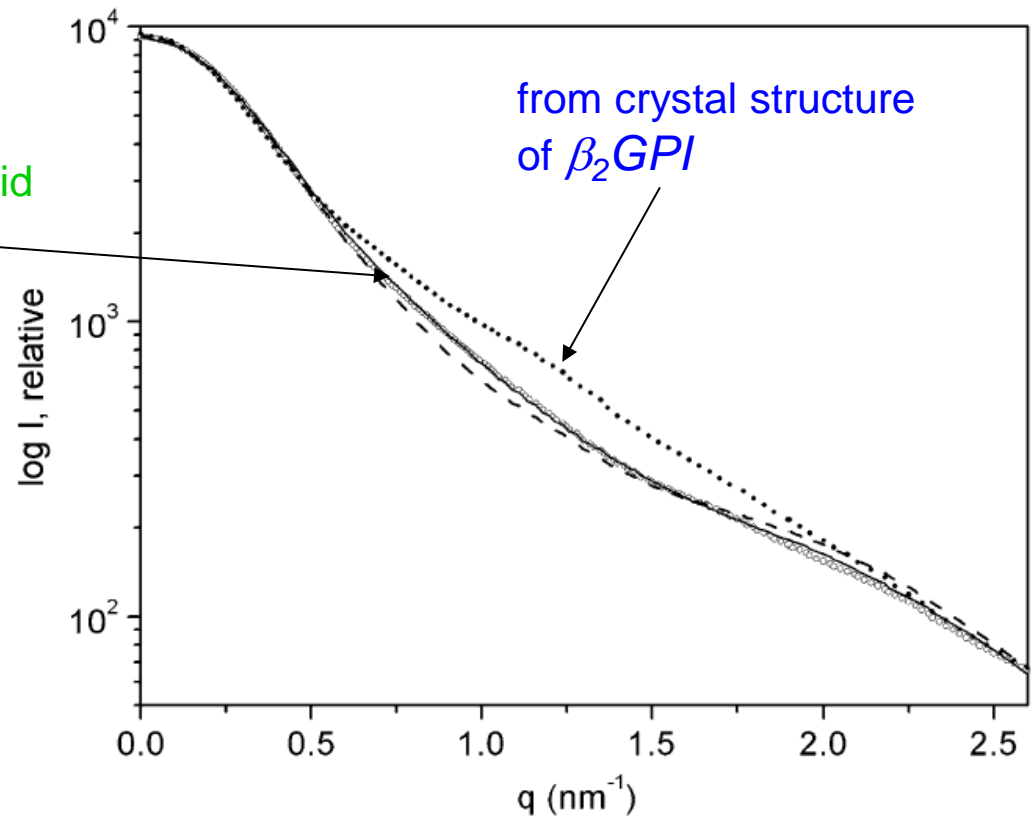
- Time of first accessible measurement 75 μs
- The evolution of the chemical reaction is detected: volume fraction increasing

Marmioli, B., G. Greci, F. Cacho-Nerin, B. Sartori, E. Ferrari, P. Laggner, L. Businaro and H. Amenitsch, Lab Chip, 9, 2063-2069 (2009)

Shape Analysis of Proteins

shape reconstruction and rigid
body refinement

from crystal structure
of β_2 GPI



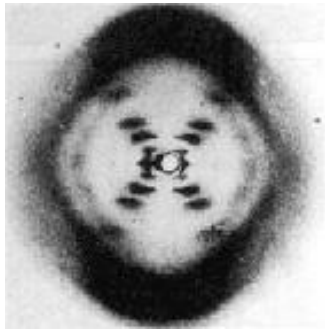
crystal

solution

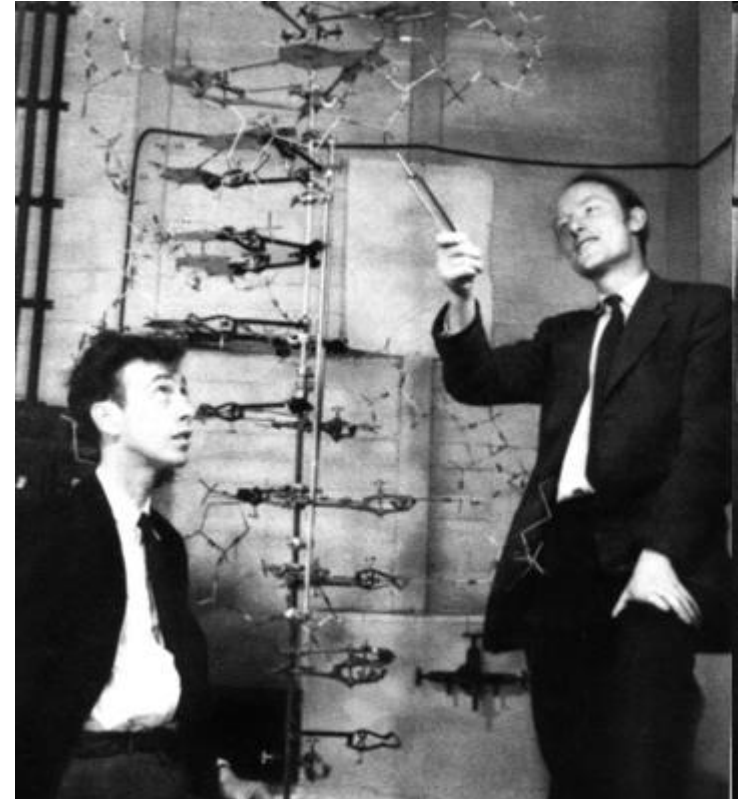
M. Hammel, M. Kriechbaum, A. Gries, G.H. Kostner, P. Laggner & R. Prassl **2002** JMB 321, 85.



Discovery of the DNA-Structure



Rosalind Franklin's
X-ray diffraction photograph
of DNA



Watson and Crick in front of
their DNA model, 1953

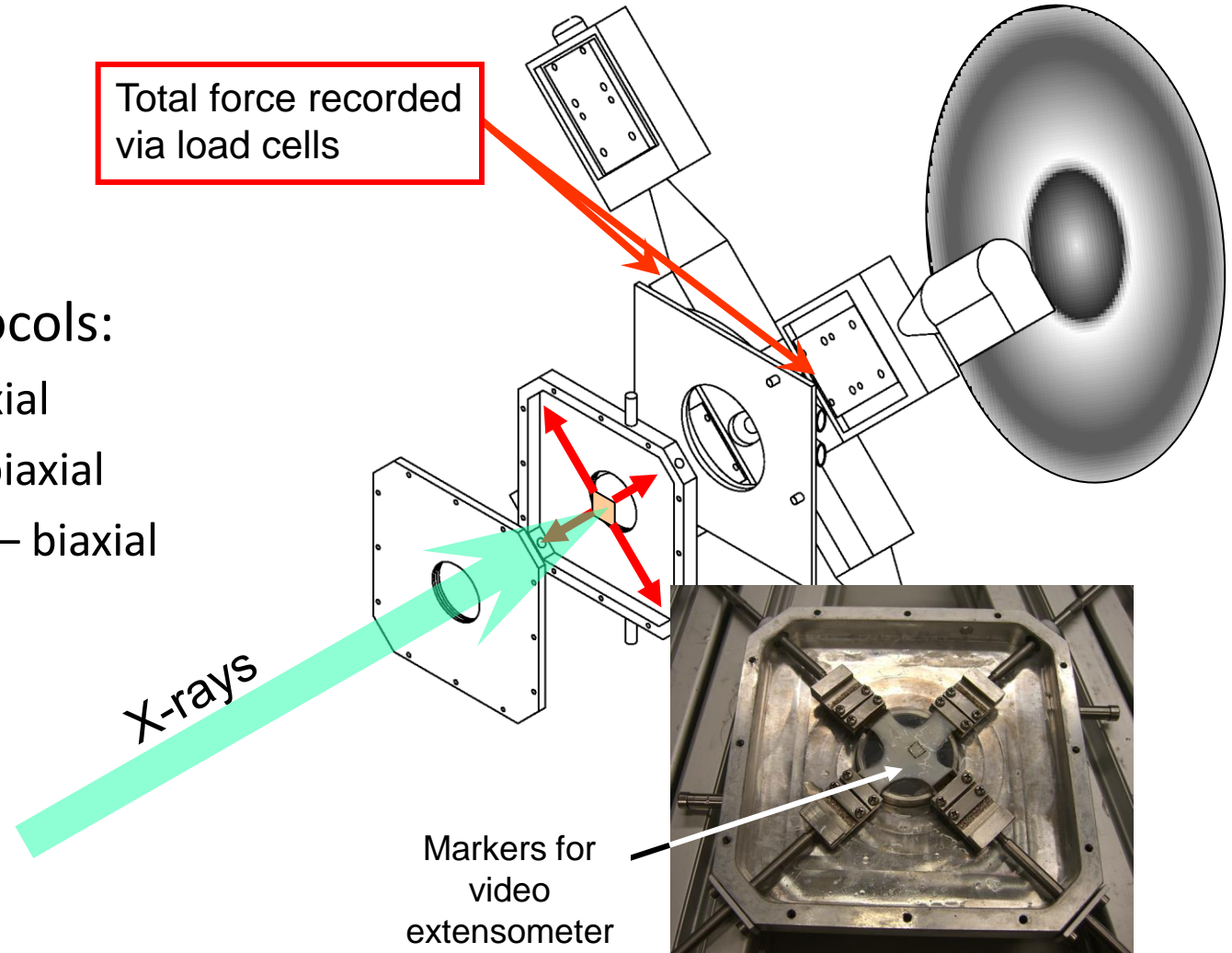


The Nobel Prize in Physiology or Medicine 1962
Francis Crick, James Watson, Maurice Wilkins

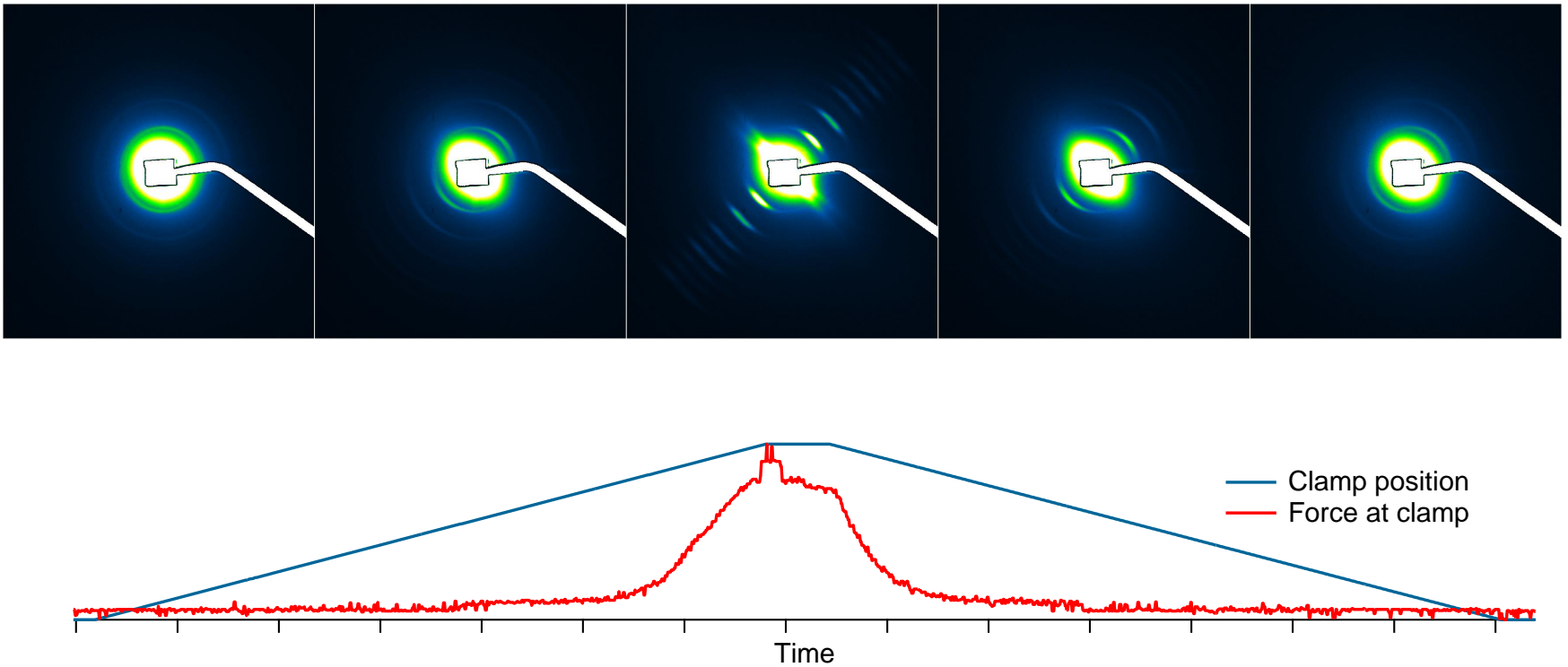
In-Situ Testing of Human Aortas: the Set-up

Load protocols:

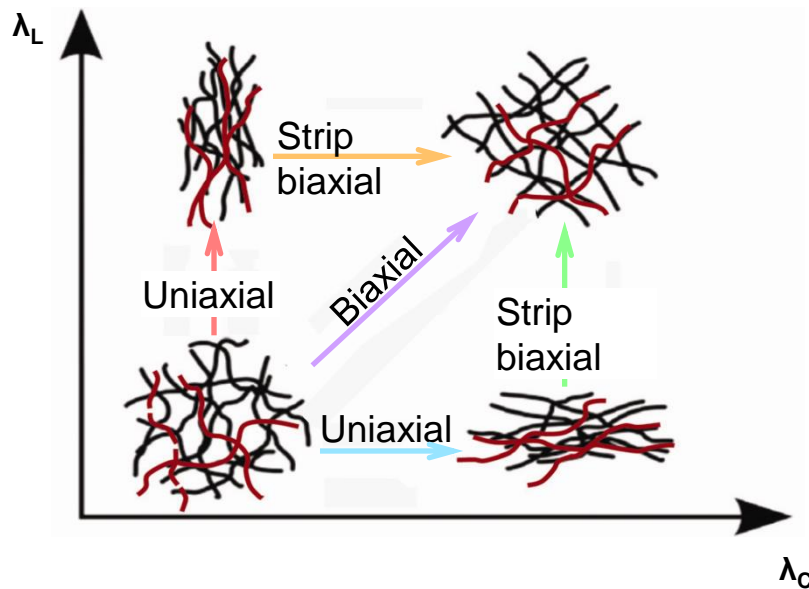
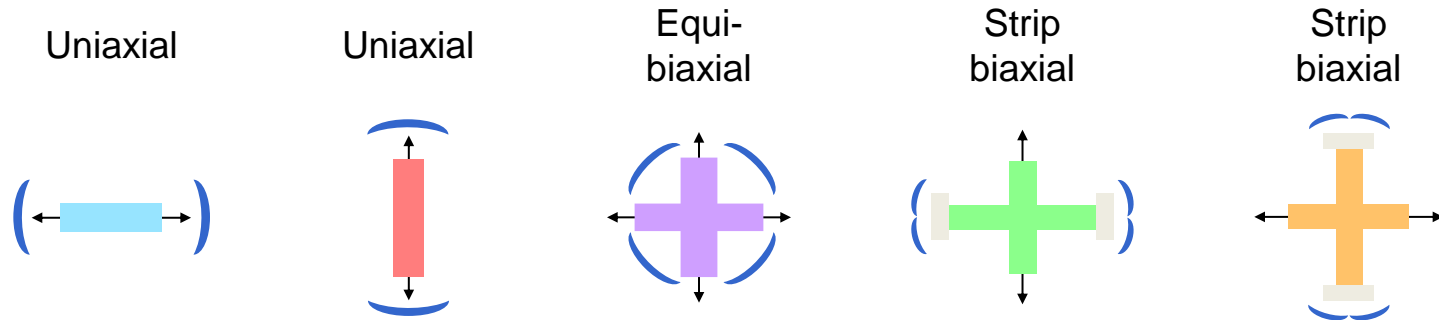
- Uniaxial
- Equibiaxial
- Strip – biaxial



In-Situ Testing of Human Aortas: one Example



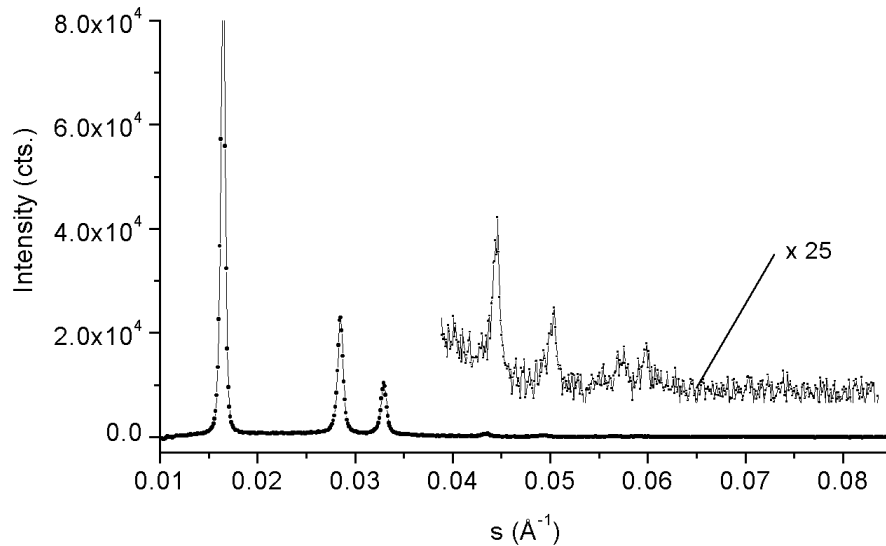
In-Situ Testing of Human Aortas: Conclusion



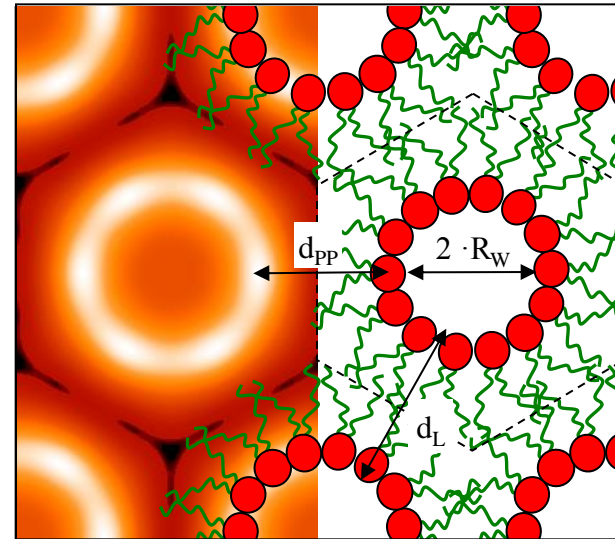
Schmid, F., Sommer, G., Rappolt, M., Schulze-Bauer, C.A.J., Regitnig, P., Holzapfel, G.A., Laggner, P., and Amenitsch, H. (2005) J. Synchrotron Rad. 12: 727-733.

SAXD: Electron-Density of Lipid Liquid Crystals

SAXD

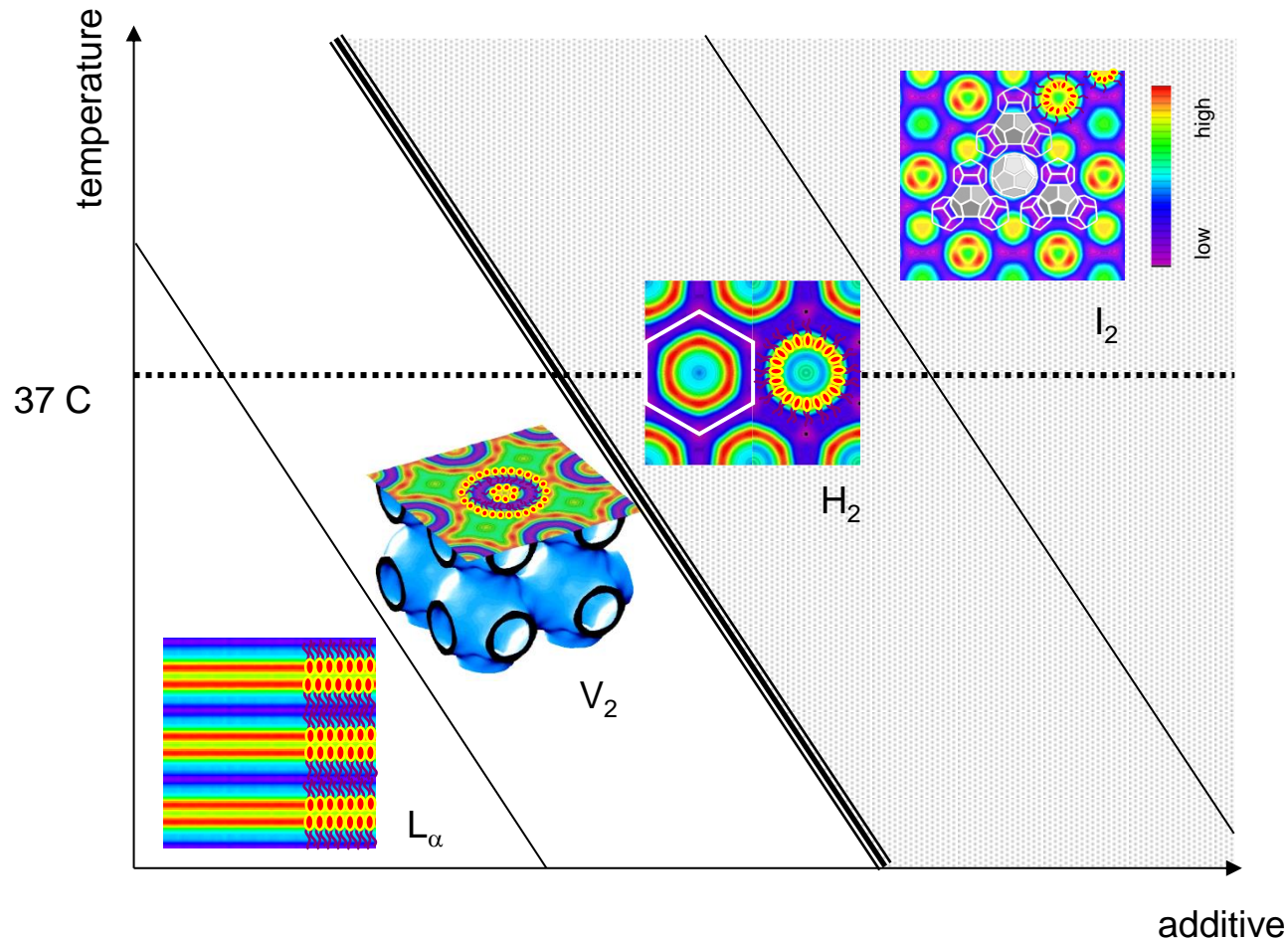


electron density map



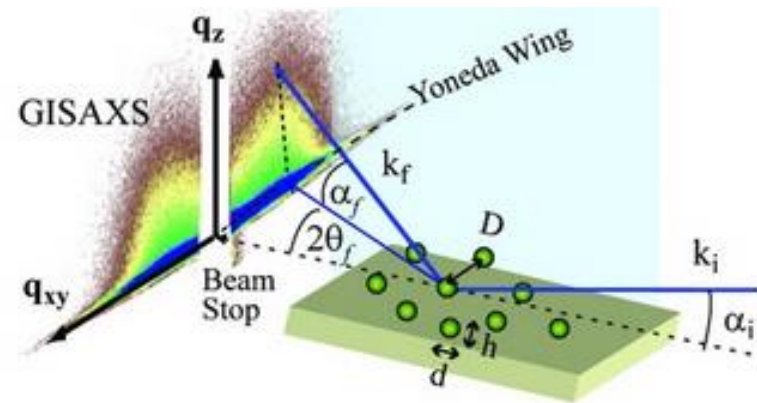
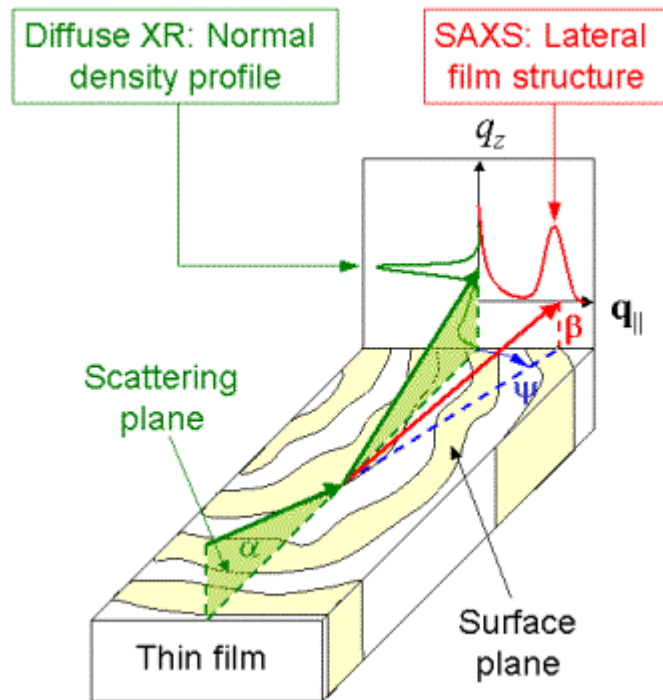
$$\tilde{\rho}(\vec{r}) = \sum_{hkl}^{max} \alpha_{hkl} |F_{hkl}| \cos(\vec{q}_{hkl} \cdot \vec{r})$$

SAXD: Polymorphism of Lipid Liquid Crystals



Yaghmur, A., and Rappolt, M. (2011): Recent advances in the characterization of lipid-based nanocarriers. In: Nanotechnologies for Solubilization and Delivery in Foods, Cosmetics and Pharmaceuticals, Nissim Garti and Ididt Yuli-Amar (eds.), DEStech Publication Inc., Lancaster, pp. 187-208.

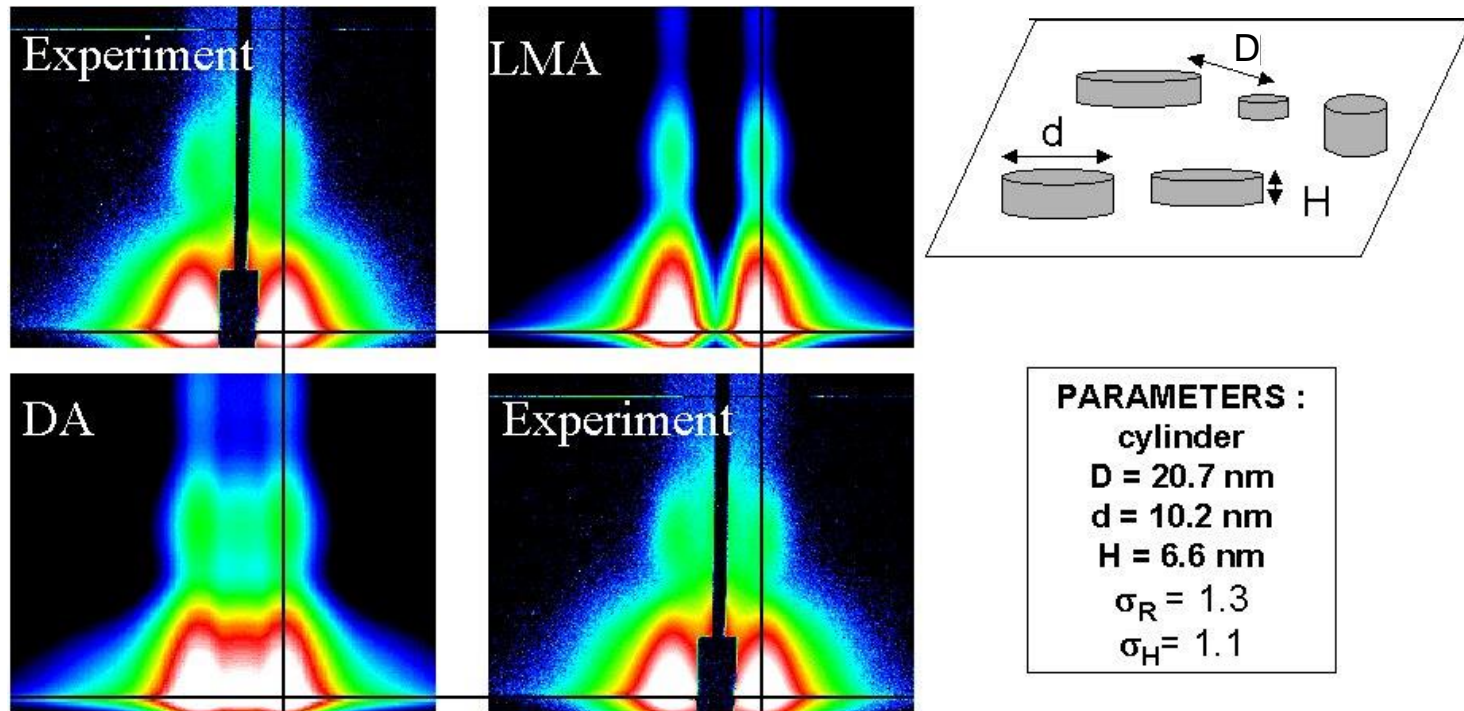
The GISAXS Set-Up



Characterizing Quantum Dots with GISAXS

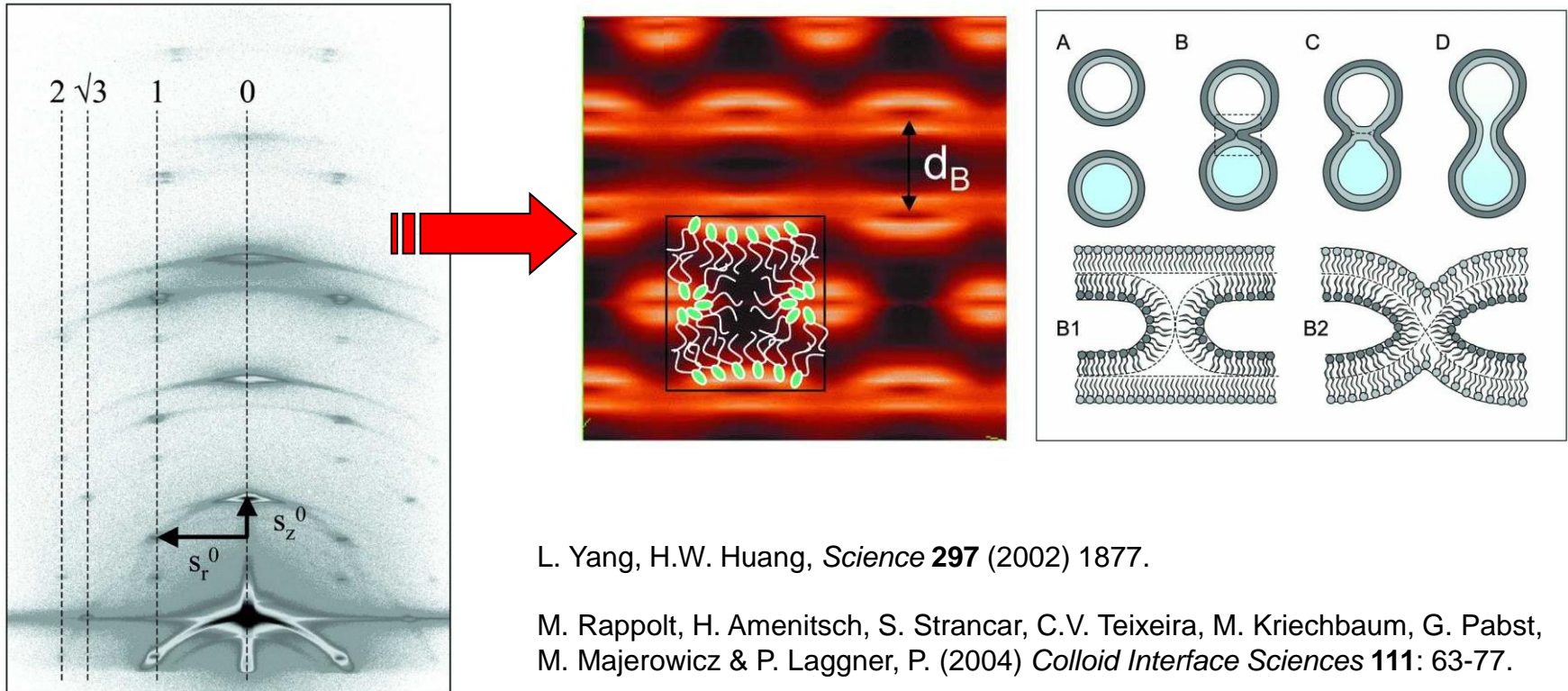
Out of plane and in plane information

Characterizing Quantum Dots with GISAXS



Simulation of a GISAXS pattern obtained for a 3nm thick deposit of Pd on MgO(100)@700K.

GISAXD: Membrane Fusion Caught in the Act



L. Yang, H.W. Huang, *Science* **297** (2002) 1877.

M. Rappolt, H. Amenitsch, S. Strancar, C.V. Teixeira, M. Kriechbaum, G. Pabst, M. Majerowicz & P. Laggner, P. (2004) *Colloid Interface Sciences* **111**: 63-77.

Thank You!

My special thanks go to:



Heinz Amenitsch, Barbara Sartori, Fernando Cacho-Nerin & Benedetta Marmioli, *Austrian SAXS Beamline Trieste, TU Graz*

Sigrid Bernstorff
ELETTRA, Sincrotrone Trieste, Italy