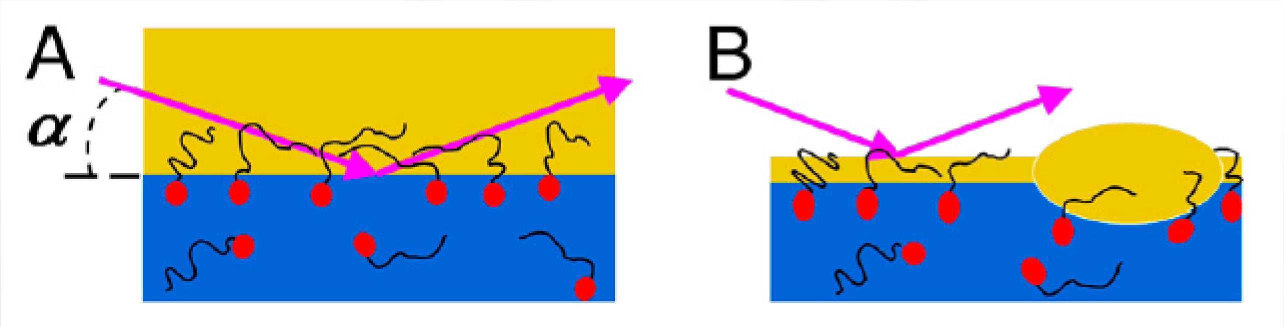
European Synchrotron Radiation Facility

High-Energy Scattering with Micro- and Nanobeams

H. Reichert

taylored hydrophobicity at the oil-water interface



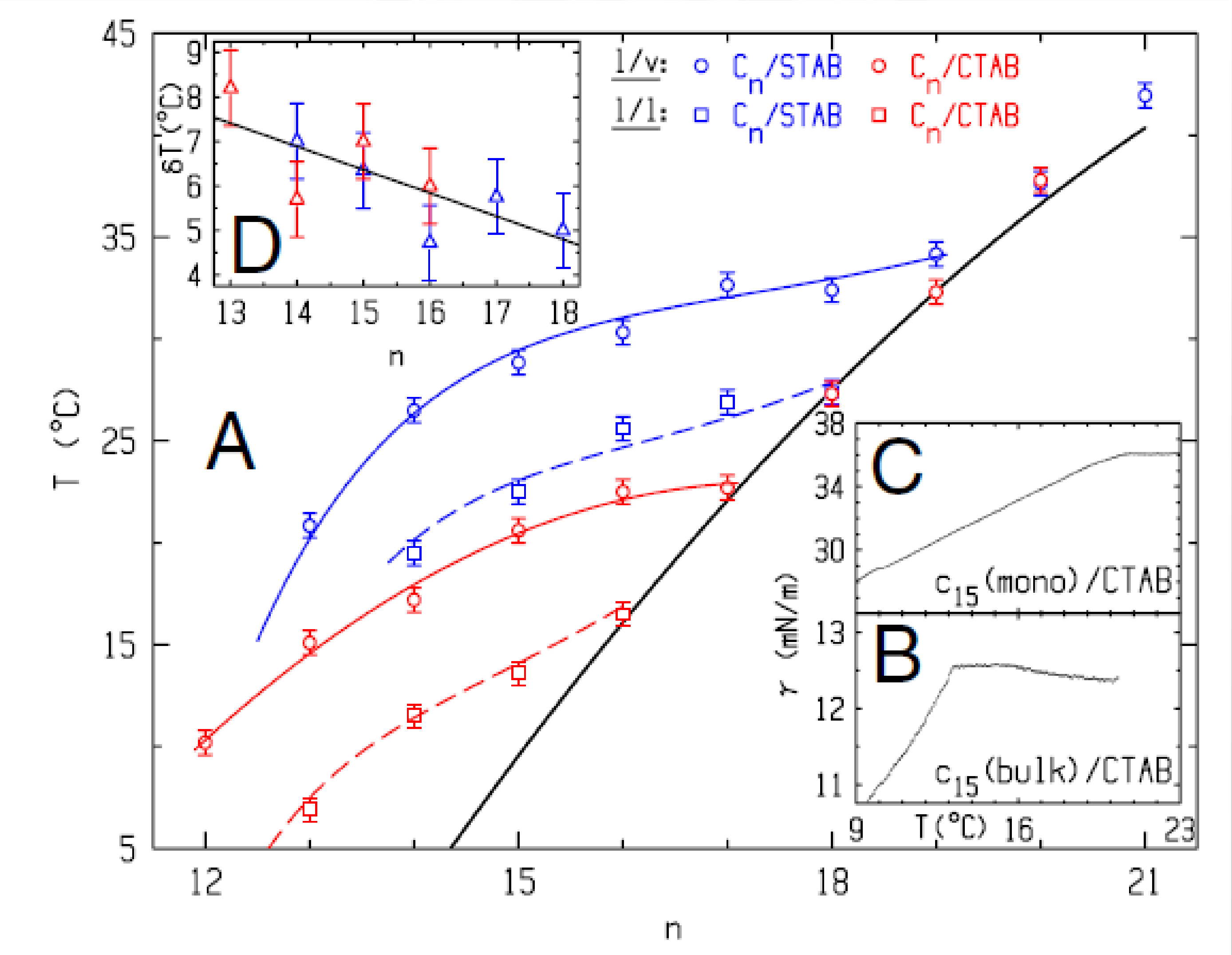
$$[H(CH_2)_m N(CH_3)_3 Br]$$

Surfactants: m=16 CTAB cetyltrimethylammonium bromide
m=18 STAB

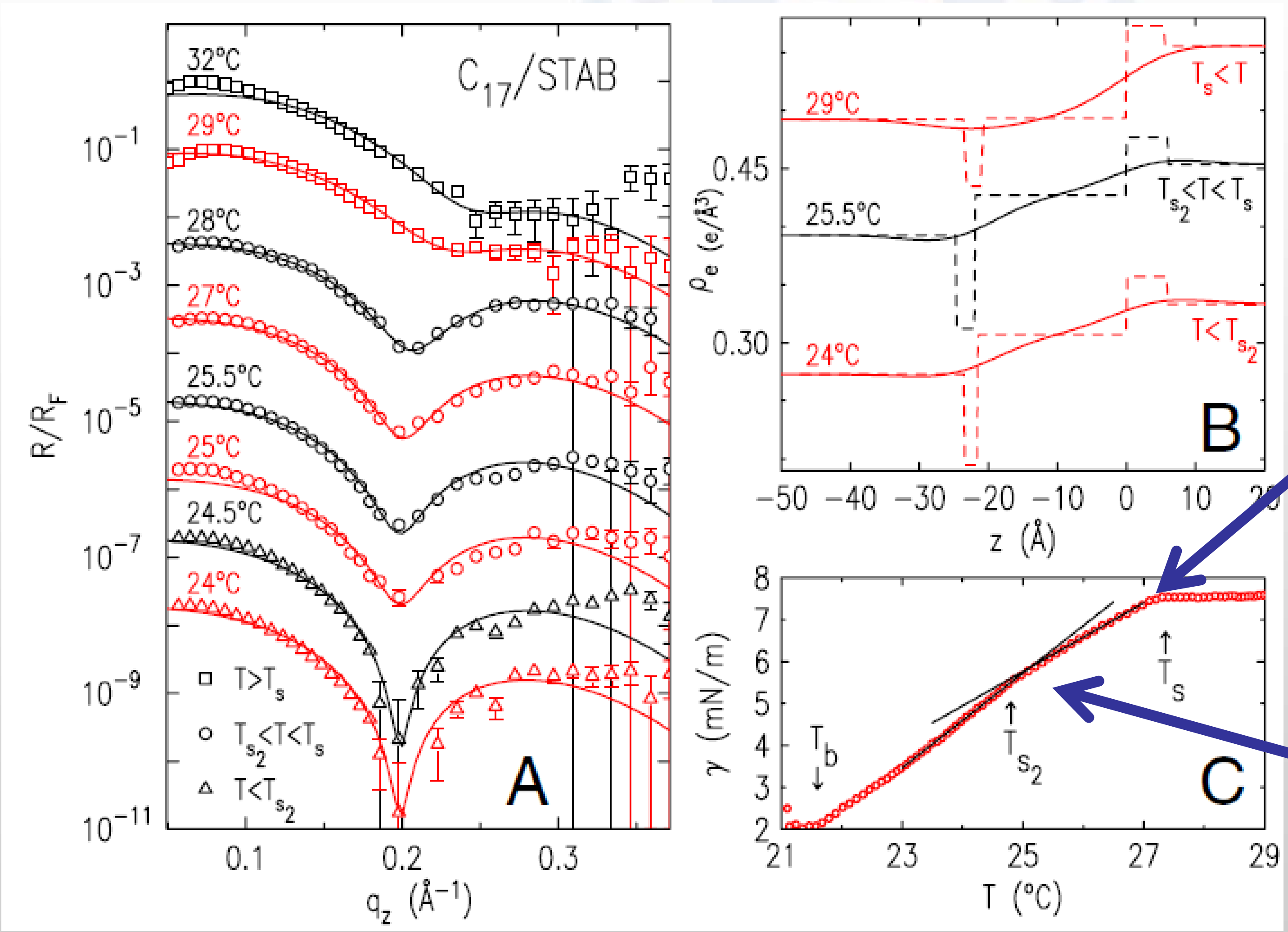
ϕ_{cmc} = 0.92 mM (CTAB)

L. Tamam et al., PNAS 2011

Complete phase diagram from interface tension measurements



Interfacial structure determined by XRR: C_{17}/STAB

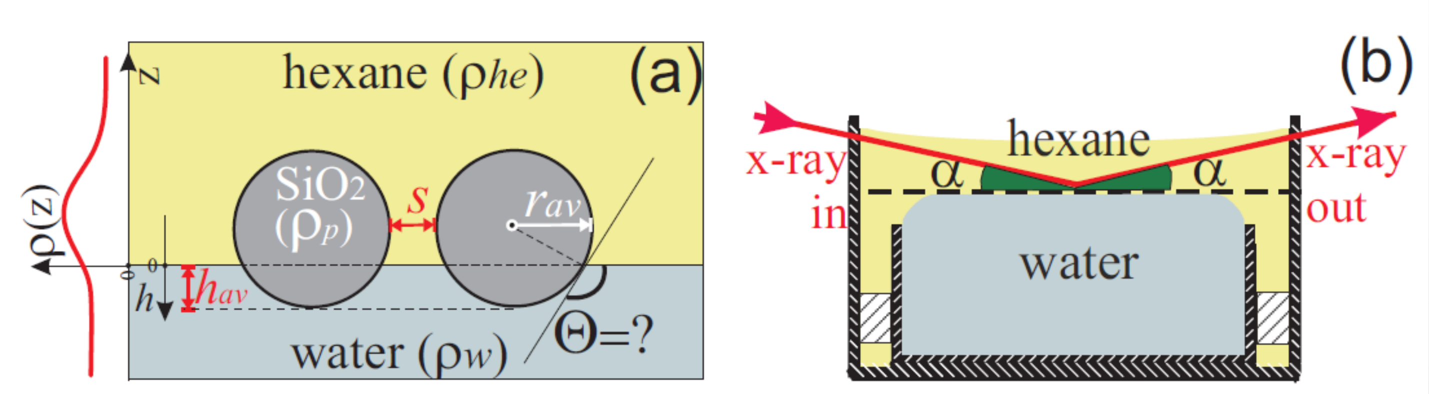


freezing

rotator-to-crystal transition ?

In-plane structure unknown !!

tayloring hydrophobicity at the oil-water interface with N'Ps

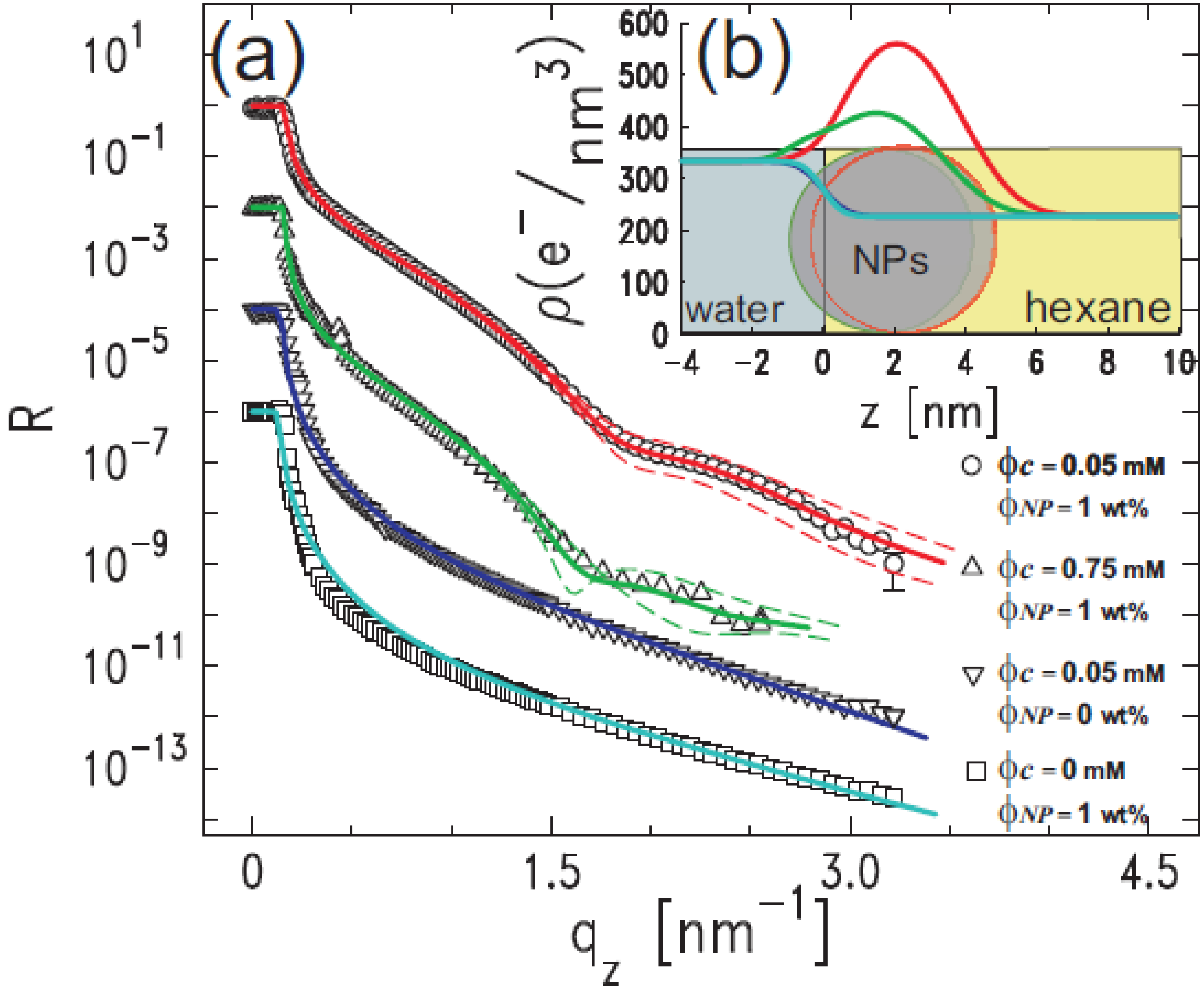


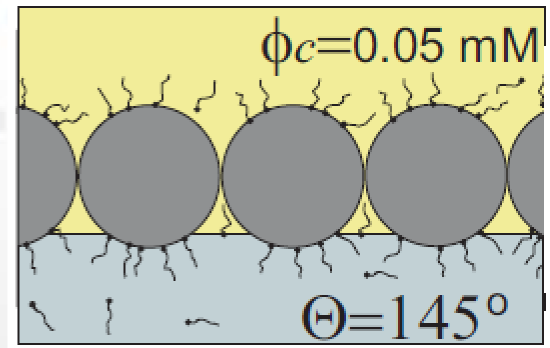
Surfactant: CTAB cetyltrimethylammonium bromide

ϕ_{cmc} = 0.92 mM (CTAB)

NP size: r = 2.7 ± 0.9 nm

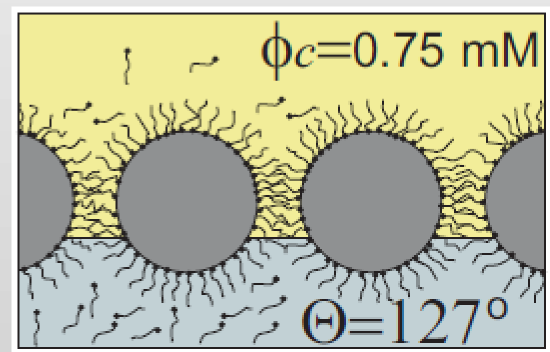
D. Calzolari et al., submitted, 2011





dense NP monolayer

ΔE = 5 kT



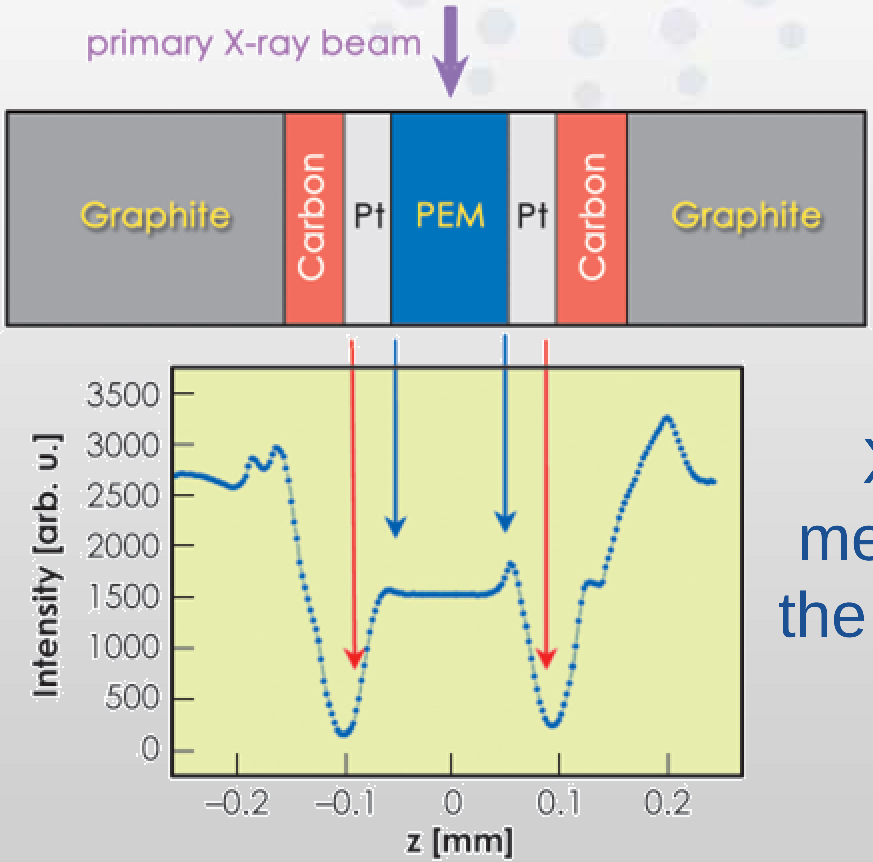
dilute NP monolayer

ΔE = 25 kT

In-plane structure unknown

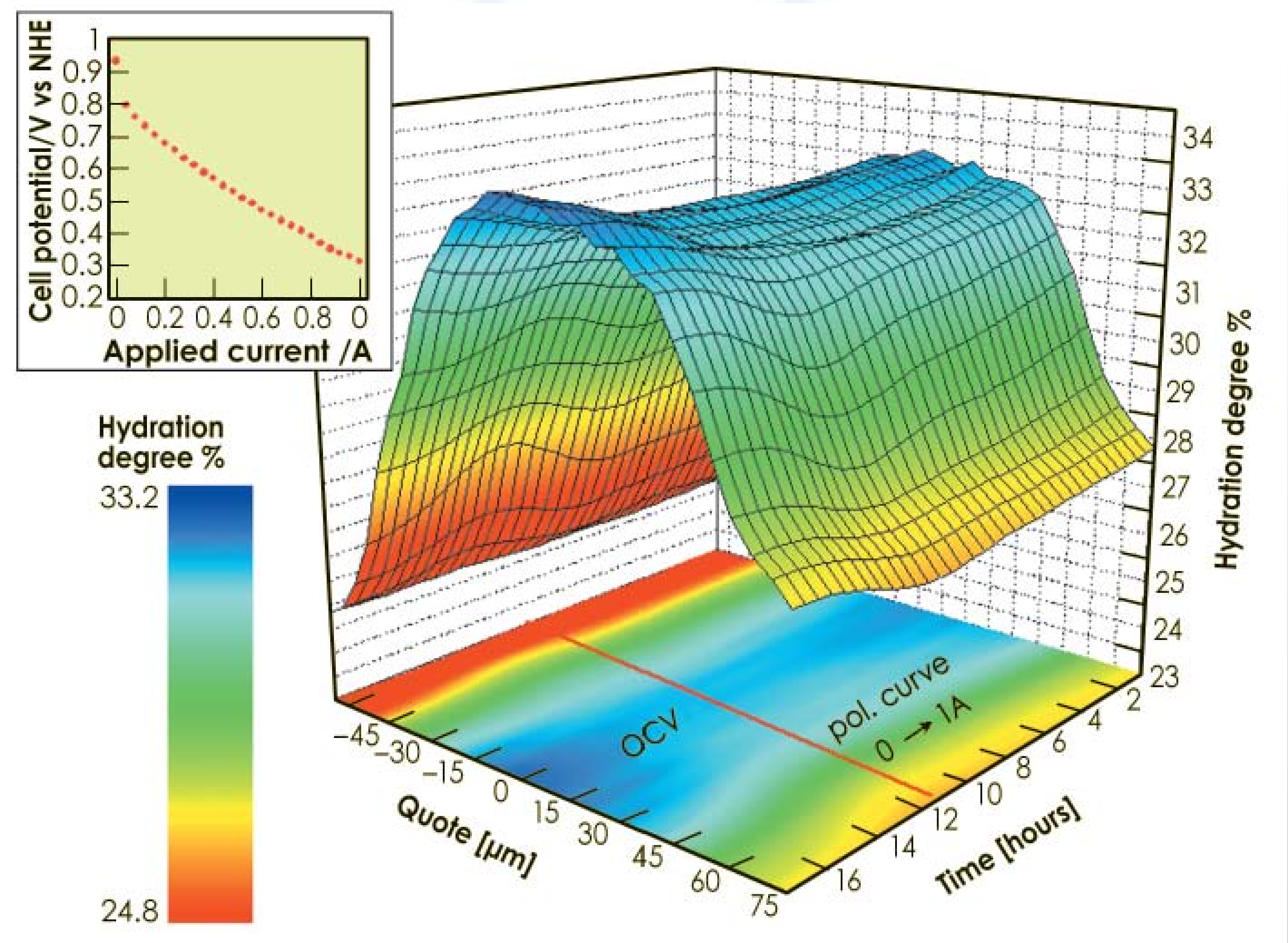
Fuell cells: Hydration of a Nafion membrane

Degree of hydration of the proton exchange membrane (**PEM**) determines fuel cell performance



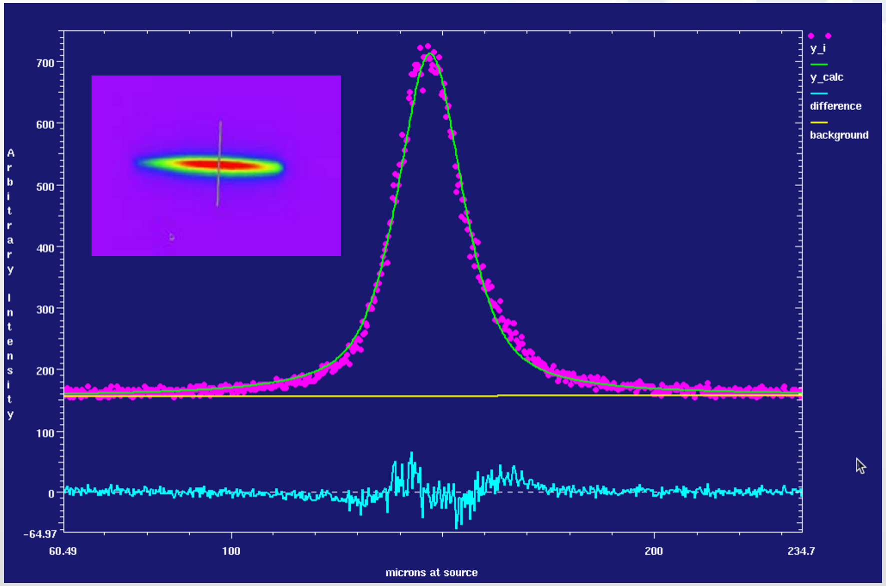
X-ray transmission measurements through the membrane-electrode assembly in a **working fuel cell**

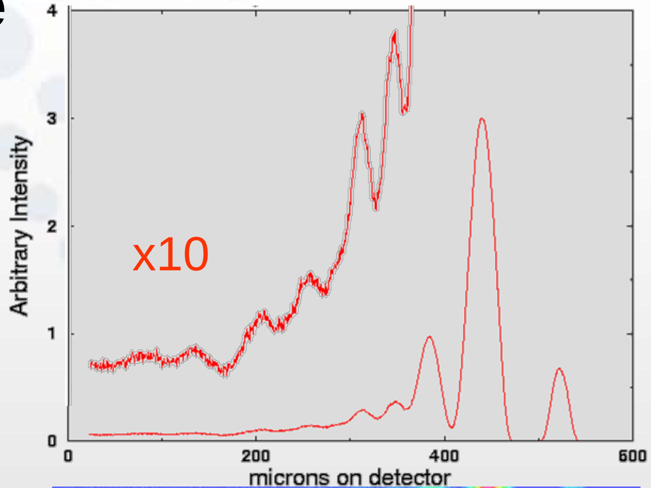
V. Rossi Albertini et al. , *Advanced Materials* **21** (2009)

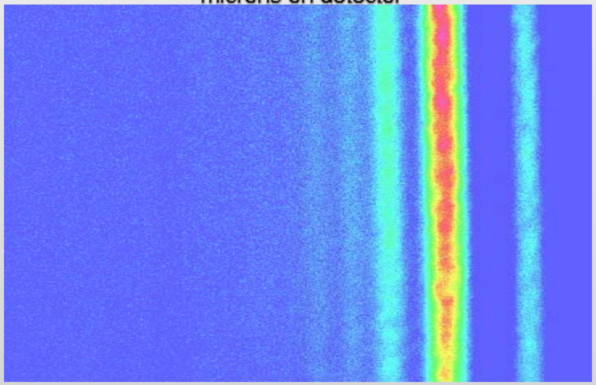


Space/time-resolved water distribution in the PEM under working conditions. Beam 100 x 5 μm^2. Diffraction patterns were collected during a polarisation curve (inset: 40 mA steps of 30 mins duration) from 0 to 1 A.

Source Size and coherence





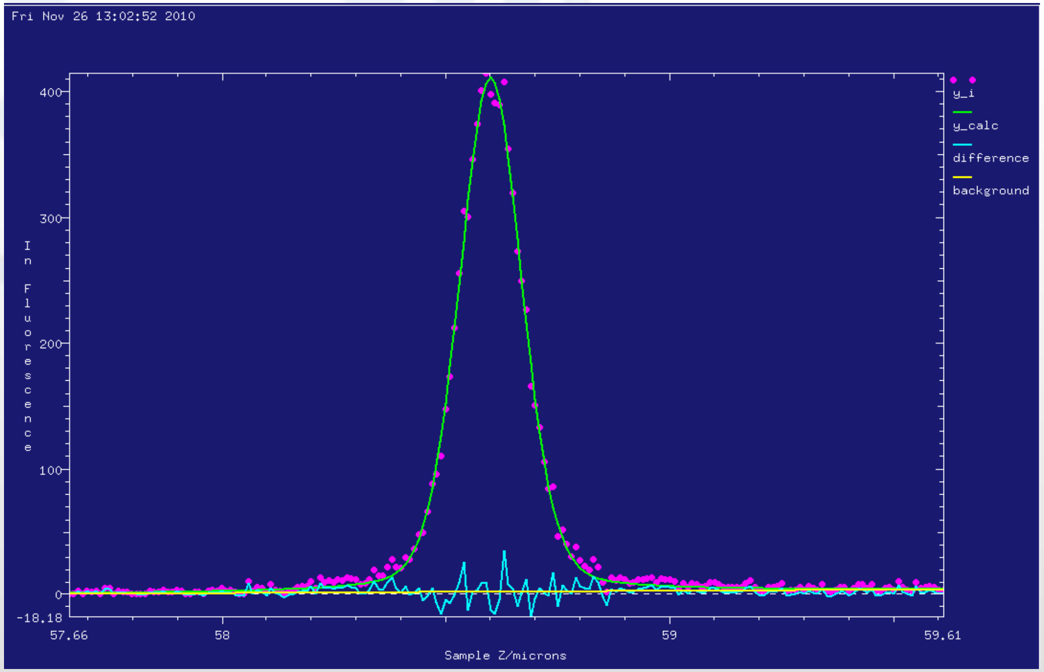


Vertical source < 20 μm – almost theoretical value. After the double Laue monochromator, the source has an aspect ratio of about 8

Measured vertical transverse Coherence ~ 220 μm at 29.2 keV

Vaughan et al., Proc. Risoe Symp 2010

Nano-diffraction

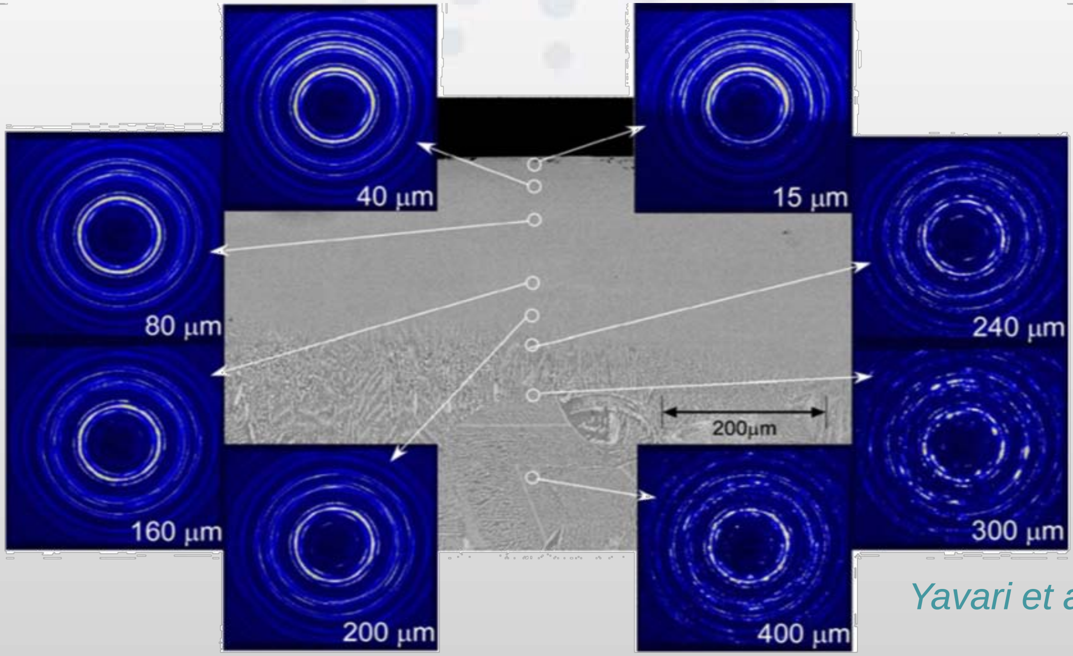


Nano-diffraction using Si nano-lenses gives a vertical spot of 80nm at 35 keV

- A scan of a 140 nm thick In Film gives ~160 nm wide peak.
  Deconvolution indicates 80 nm beam height.
- In this configuration:
  - Diffraction limit ~ 40 nm
  - Geometrical limit < 20 nm (considering 17 micron source size as measured)
  - Vertical vibrations in prototype assembly ~50 nm (measured)
  - Band-pass broadening ~ 80 nm begins to dominate

Diffraction Mapping – Direct Mapping in 2d

Samples with rotational symmetry (many surfaces, films) can be mapped rapidly with line beams

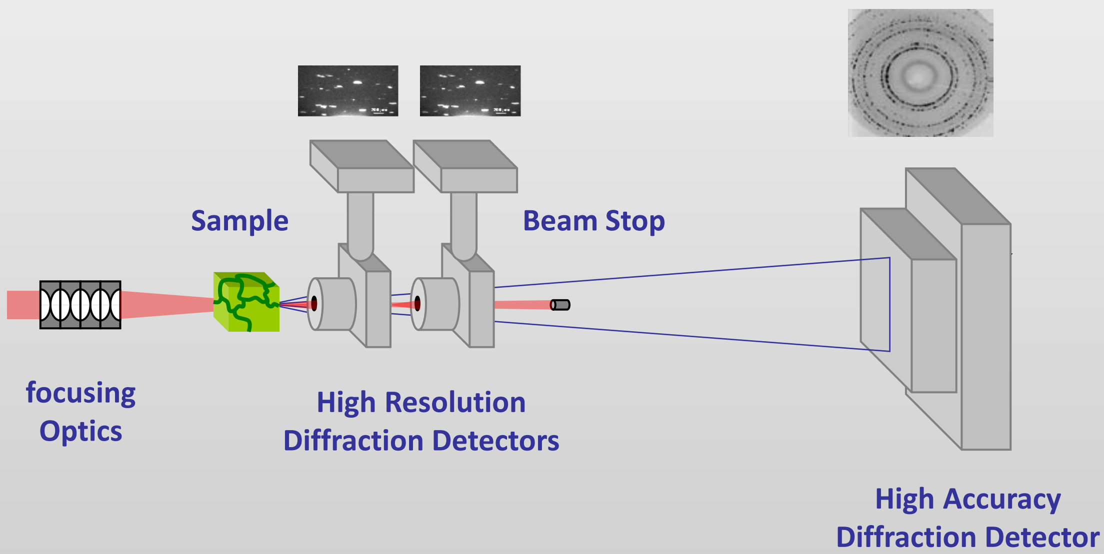


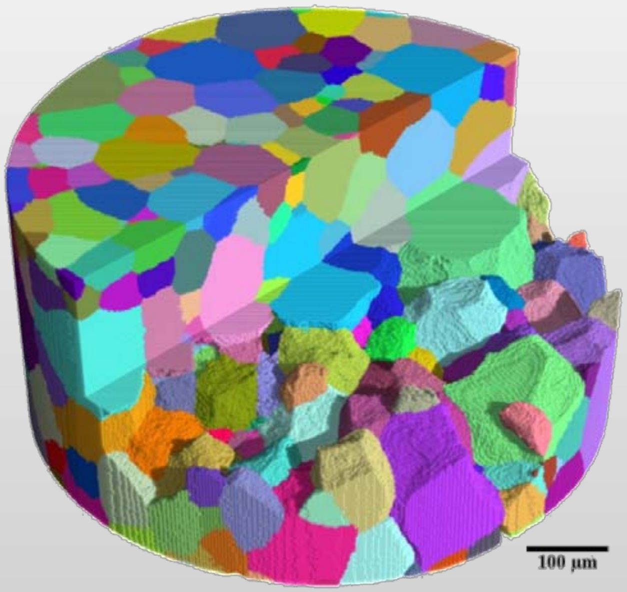
Yavari et al., Scripta Metal. 2008

Beams as small as **85x40000** nm^2 have been used in user experiments (*Paci et al., in progress*)

Diffraction Mapping – 3d Reconstruction

- Many samples for 3d reconstruction contain too many crystals to be mapped with a large beam
- In this case single layers are measured and combined to create a 3d grain map

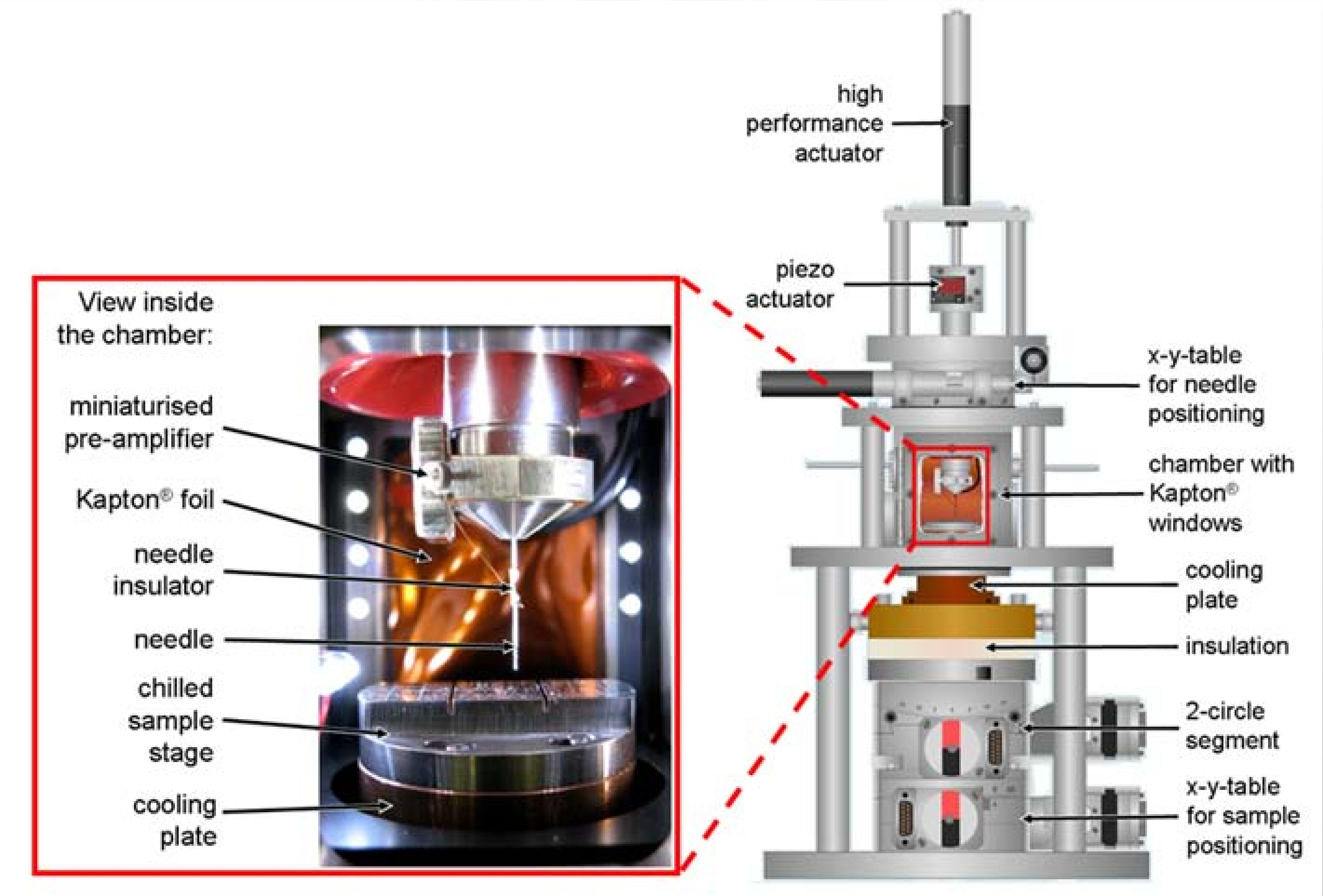




e.g.,
Poulsen et al., Riso Symposium (2010)
Ludwig et al., *Rev. Sci. Instrum.* (2009)

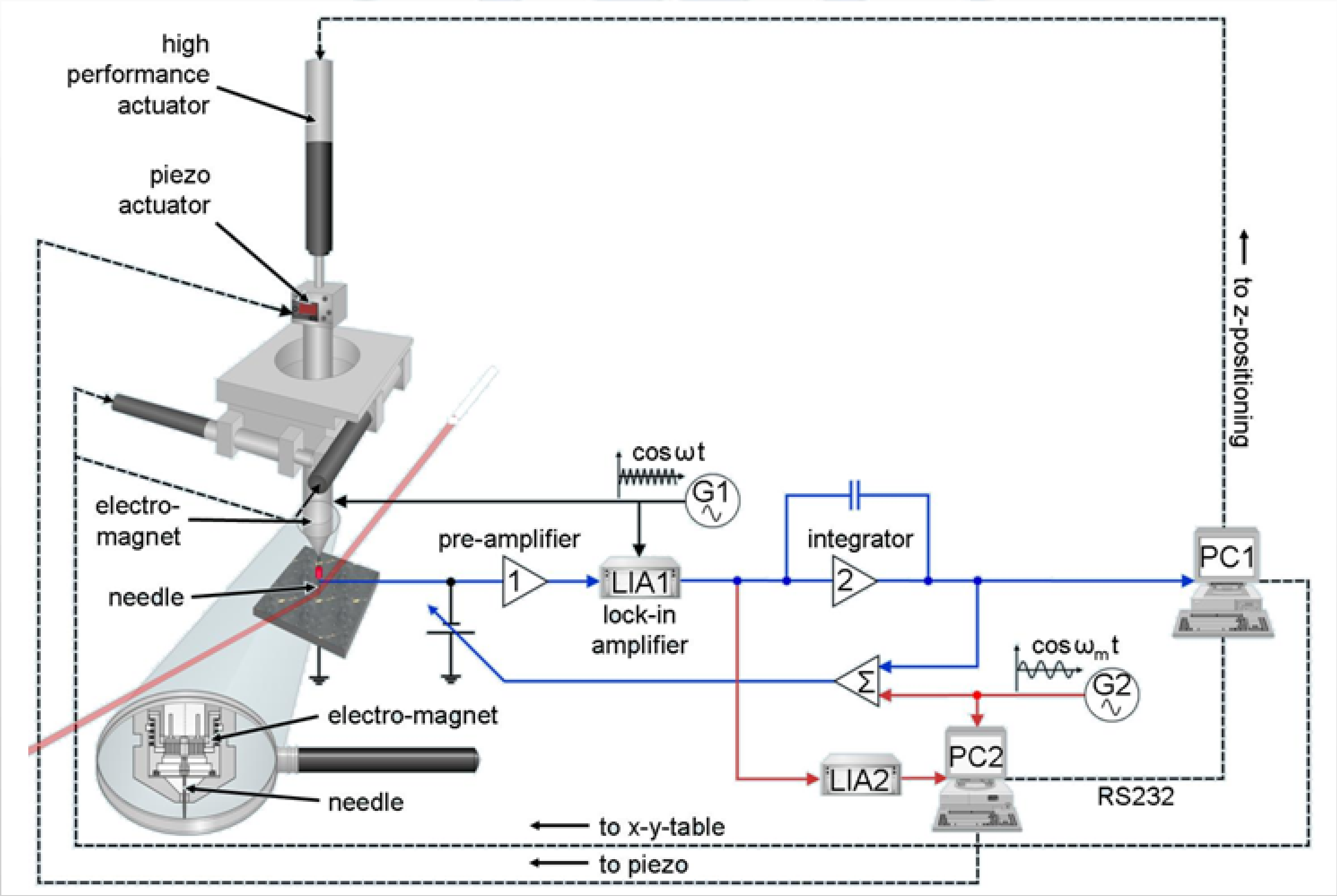
Beam-induced effects at high photon densities

Construction of a dedicated synchrotron scanning SKP

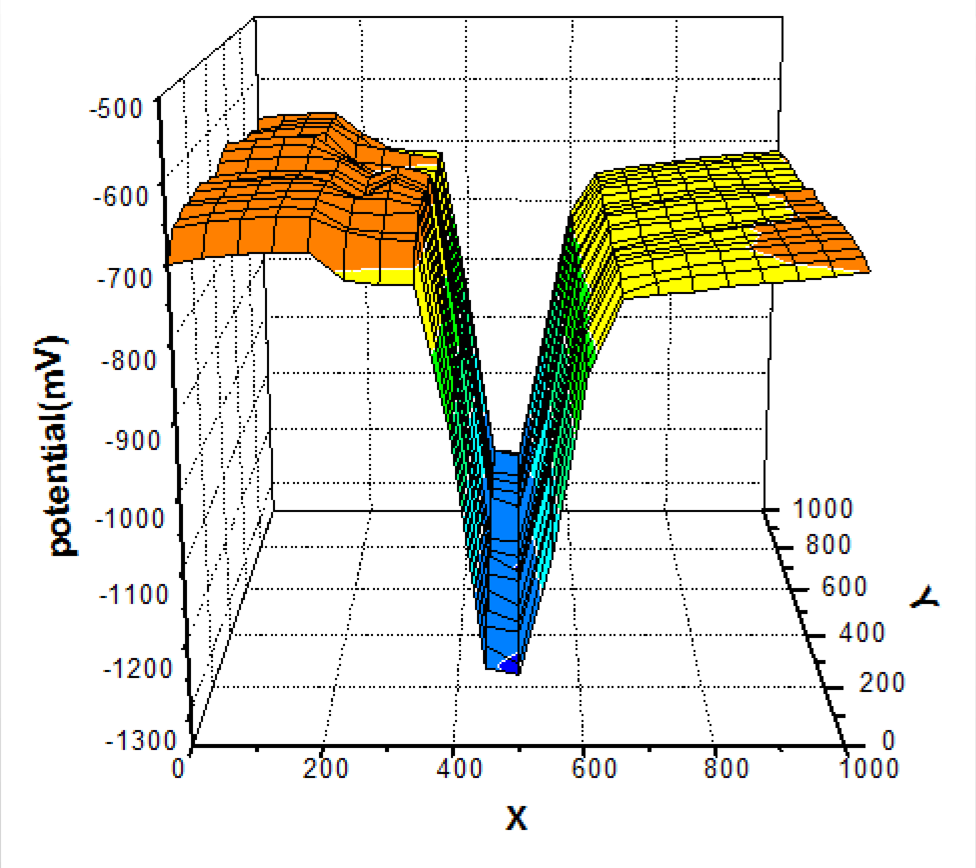


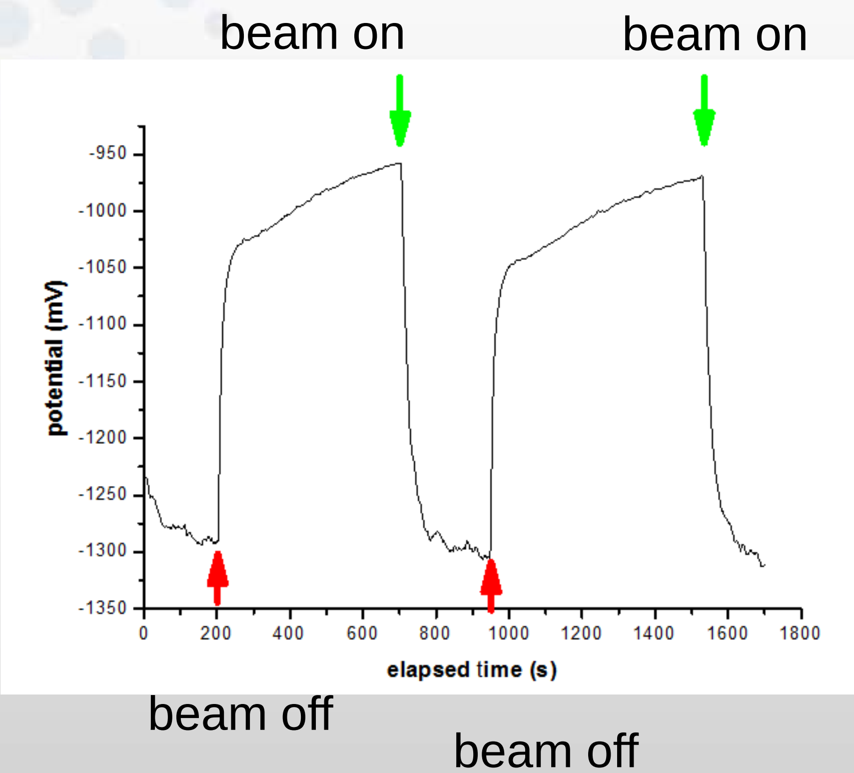
Assess beam-induced modifications in the electronic properties

Complex device for measuring the surface/interface potential with mV accuracy



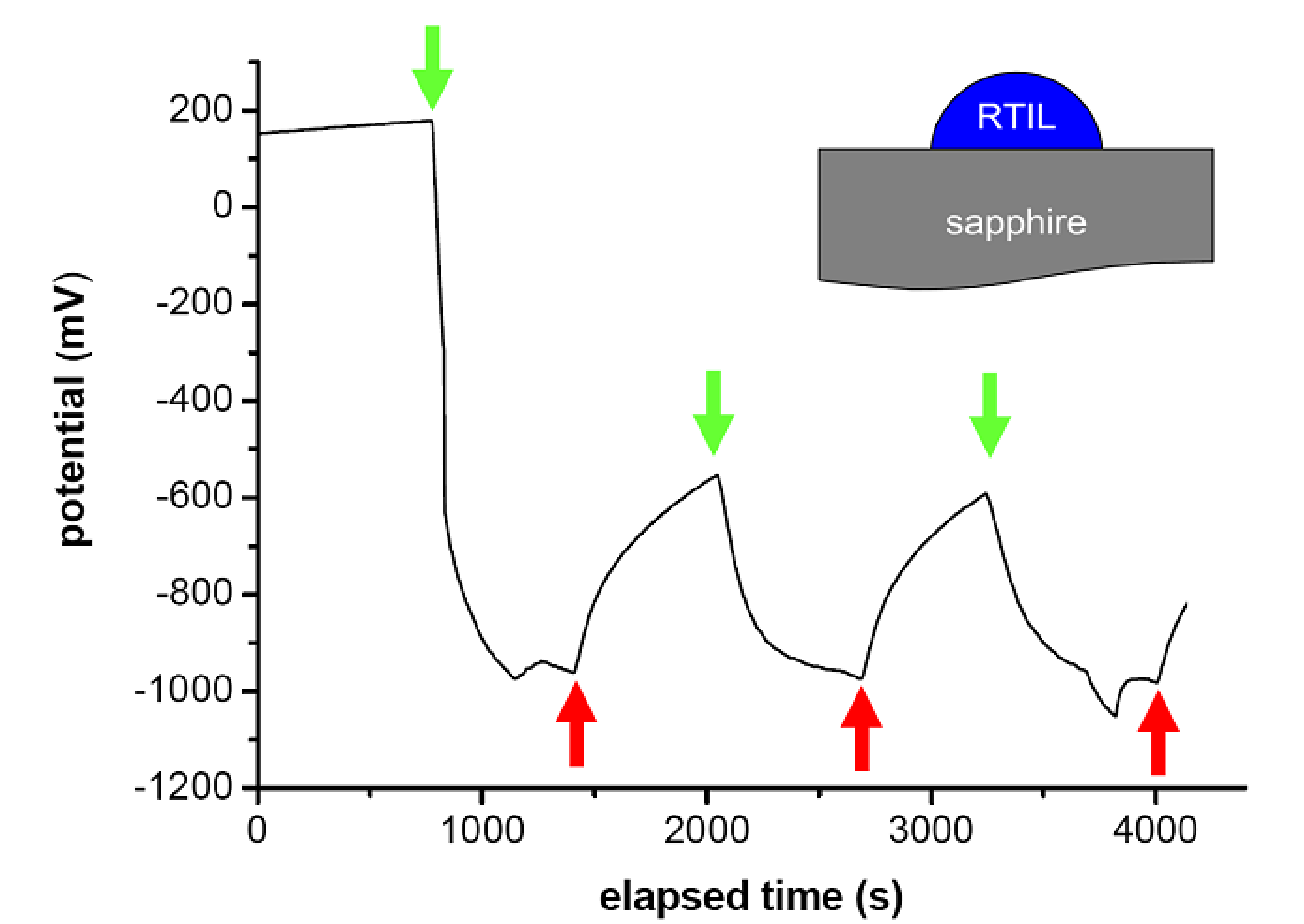
High-energy beam on sapphire (0001)





Buried interface RTIL/sapphire (0001)

Cation [bmpy]$^+$: 1-butyl-1-methylpyrrolidinium;
Anion [FAP]$^-$: tris(pentafluoroethyl)trifluorophosphate



What would we like to have

- Nanobeam 50-100 nm (pencil or line shape)
- Low divergence
- Large focal depth
- Efficient high energy x-ray detectors

Collaborators

- V. Honkimaki, D. Pontoni, D. Calzolari (ESRF)
- M. Rohwerder, M. Vogel, B. Salgin (MPI Duesseldorf)
- M. Mezger, H. Schroeder, H. Dosch (MPI Stuttgart)
- T. Salditt, S.K. Ghosh (Goettingen University)
- M. Deutsch (Bar-Ilan University)
- B.M. Ocko (BNL)