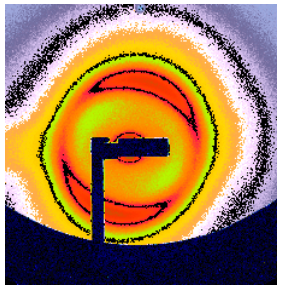
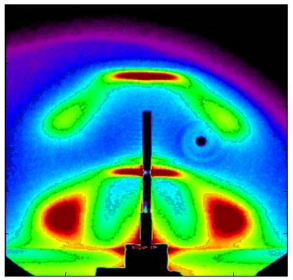
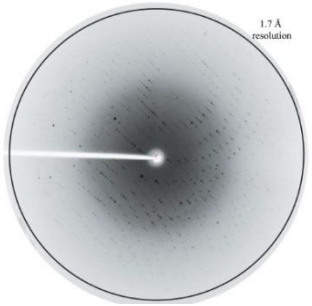
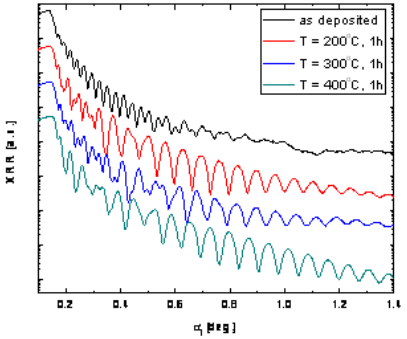
Synchrotron radiation work at RBI









Maja Buljan

Department of Material Physics

Ruđer Bošković Institute, Zagreb, Croatia

Outline

- Synchrotron users from RBI
- Structure determination by GISAXS technique

  -quantum dot lattices

  -ion beam modified surfaces

  -*GisaxStudio*: sofware for GISAXS analysis

Synchrotron users in Croatia

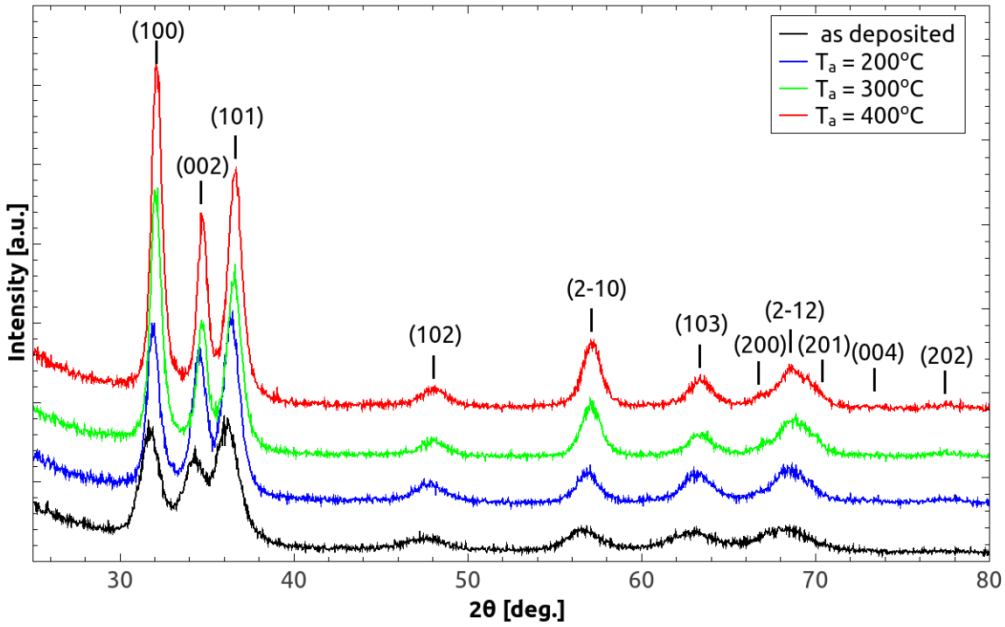
- There are about 50 active users from five research organizations in Croatia.
- They use most of the EU synchrotrons, but synchrotron *Elettra* Trieste is the most attended one.
- More than half of them is from Ruđer Bošković Institute - RBI
- About one third of them are from the Department of Material Physics, RBI
- Department of Material Physics produce about 10 publications per year based on synchrotron measurements.

Main techniques

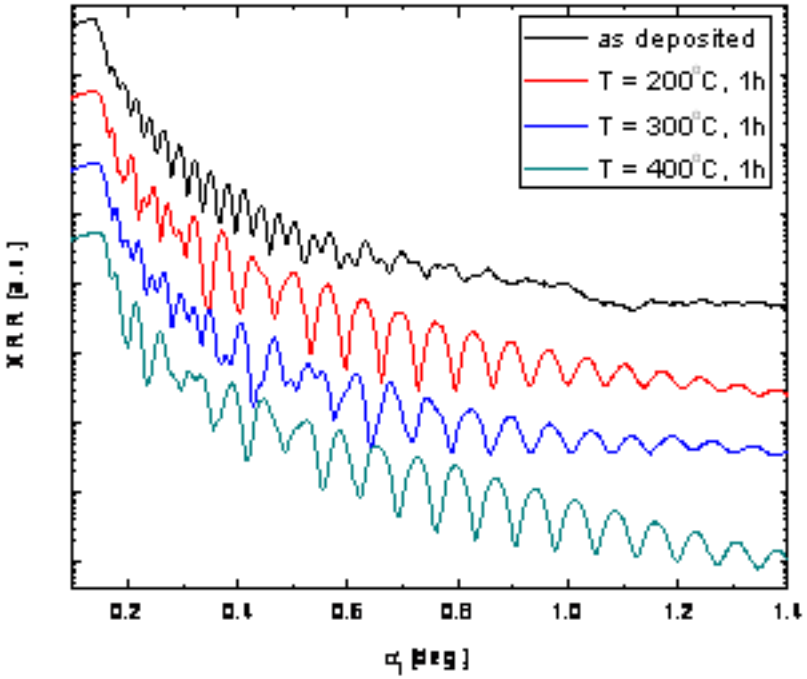
- MCX beamline: GIXRD, XRR
- XRD1 beamline: XRD
- EXAFS beamline: XANES
- SAXS beamline: SAXS, GISAXS, WAXS

MCX beamline: GIXRD, XRR

Crytsalline structure (ZnO)

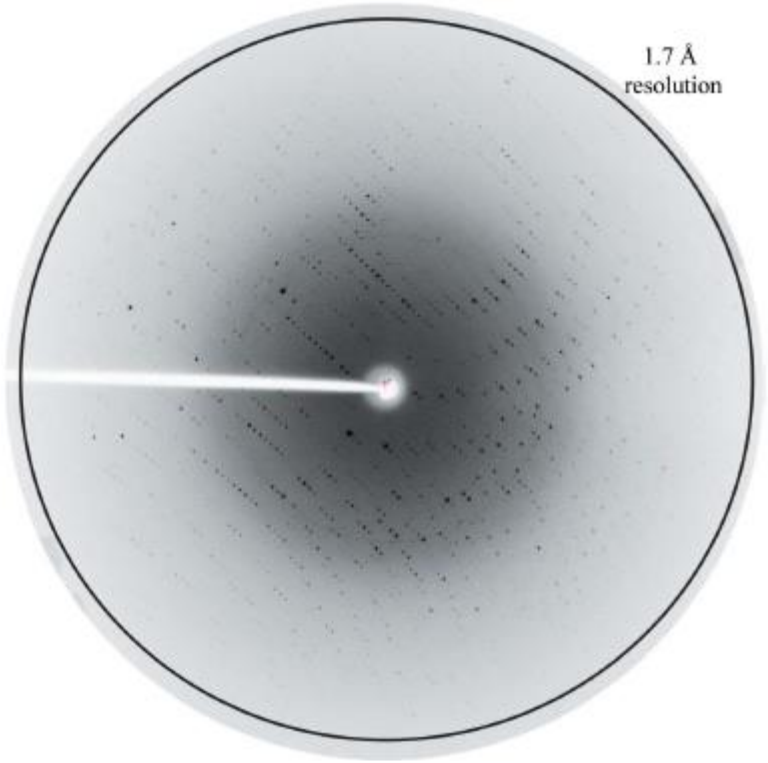


Film thickness and roughness (a-Si)



K. Juraić, et al. (unpublised)

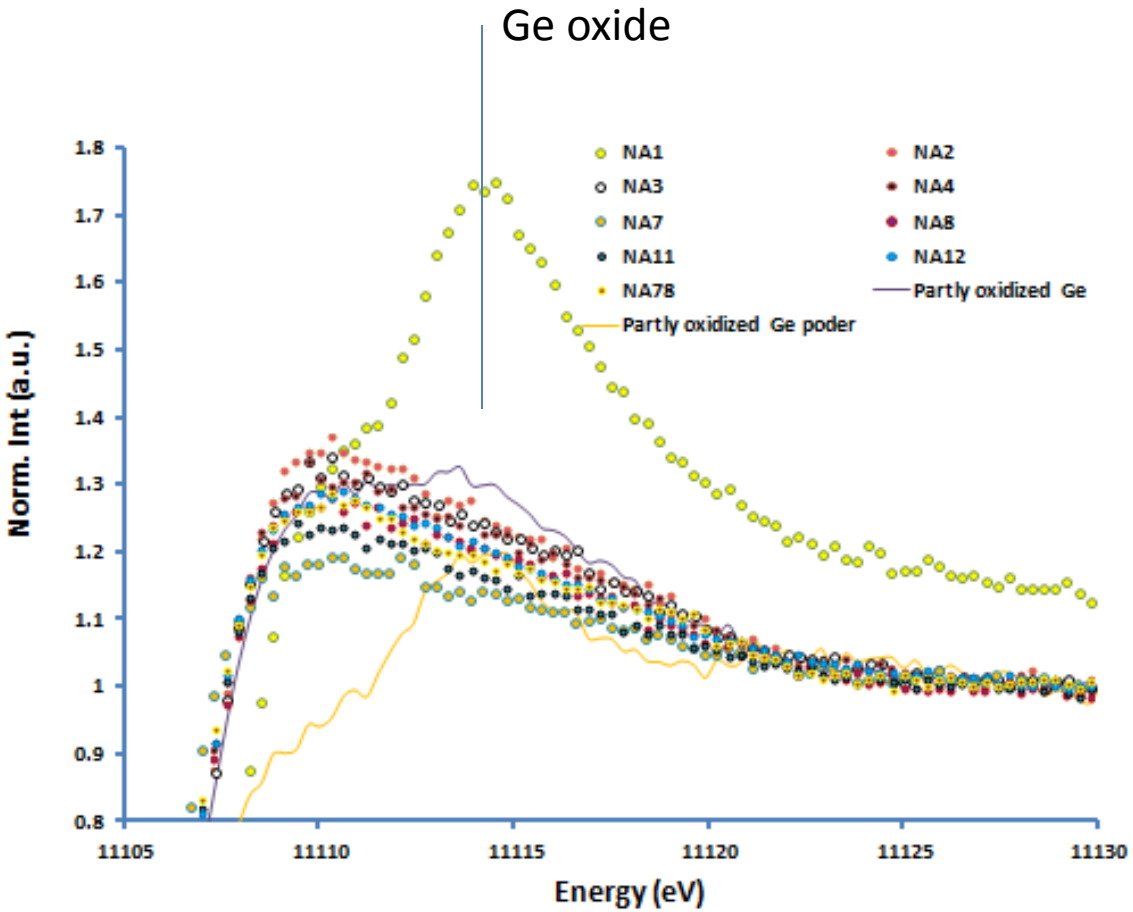
Protein structure determination



I. Leščić Ašler et al., Acta Cryst F 67 , 1378 (2011)

EXAFS beamline: XANES

Ge/Si quantum dots



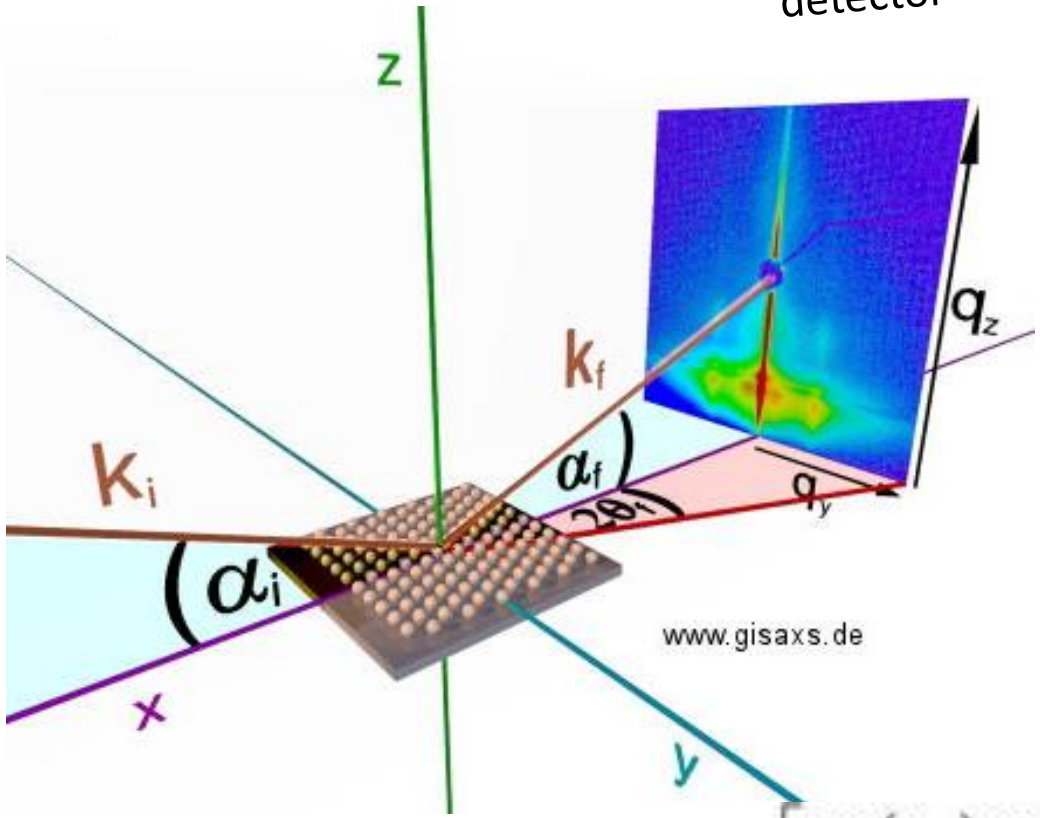
Ge K edge XANES spectra of Ge/Si/Al_2O_3 samples

M. Buljan, S. Fazinić et al, (unpublised)

Started with measurements in 1997 (Pavo Dubček, A. Turković)

detector

source



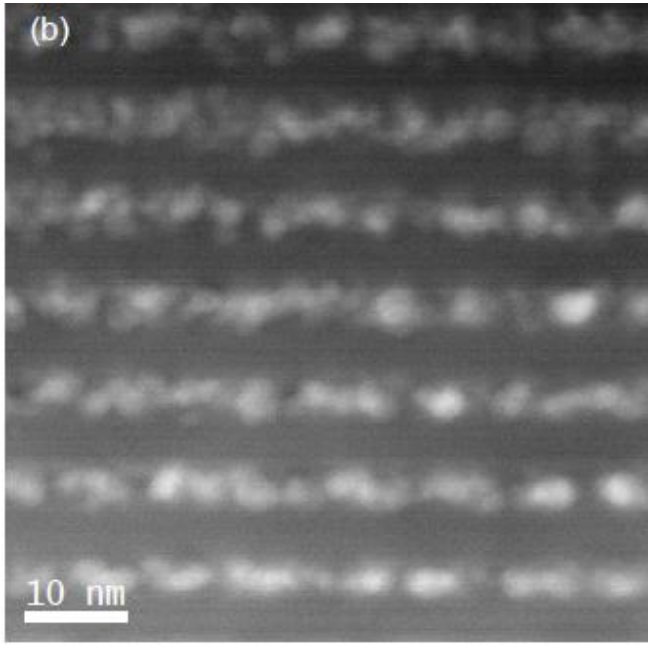
Scatteing vector: $\mathbf{q}=\mathbf{k}_f - \mathbf{k}_i$

$$q_{x,y,z} = \frac{2\pi}{\lambda}\begin{bmatrix}\cos(\alpha_f)\cos(2\theta_f)-\cos(\alpha_i)\\ \cos(\alpha_f)\sin(2\theta_f)\\ \sin(\alpha_f)+\sin(\alpha_i)\end{bmatrix}$$

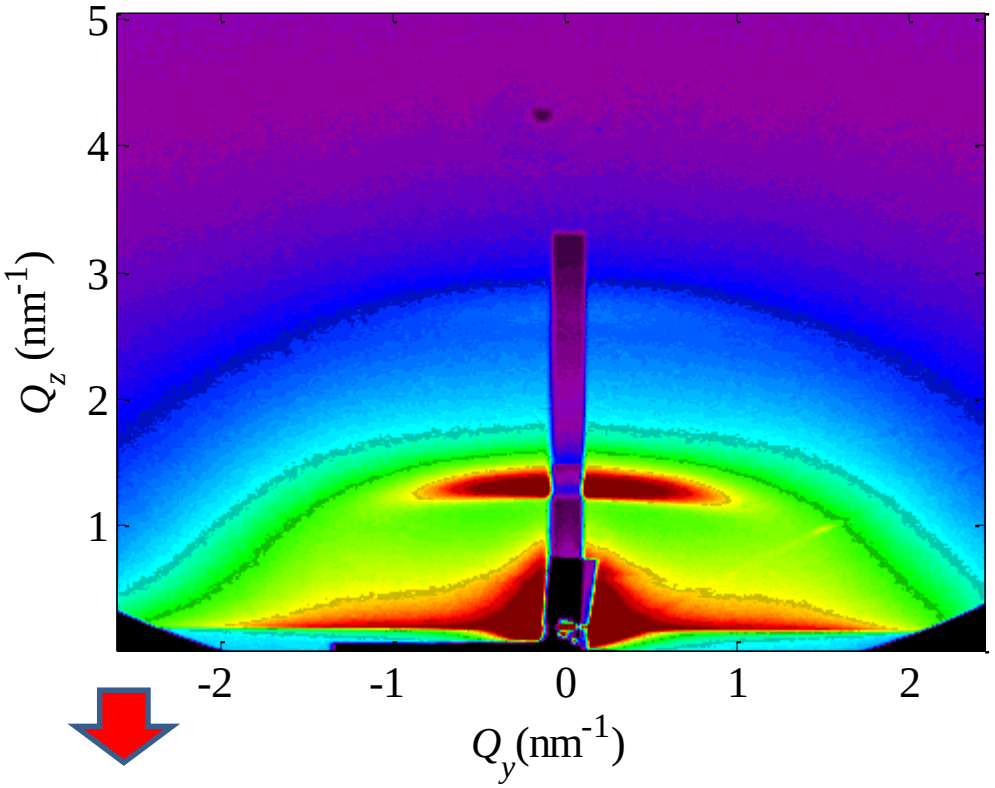
Ge QDs in SiO_2

Deposition at RT

TEM



GISAXS

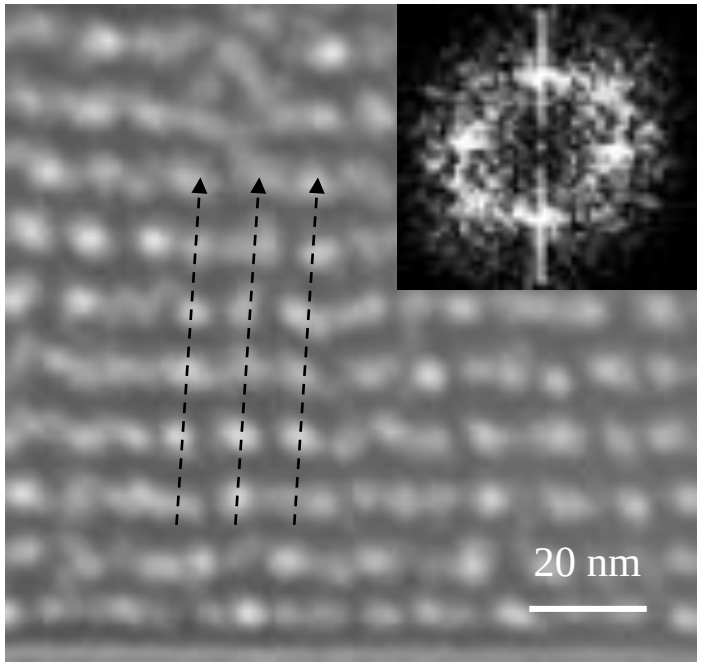


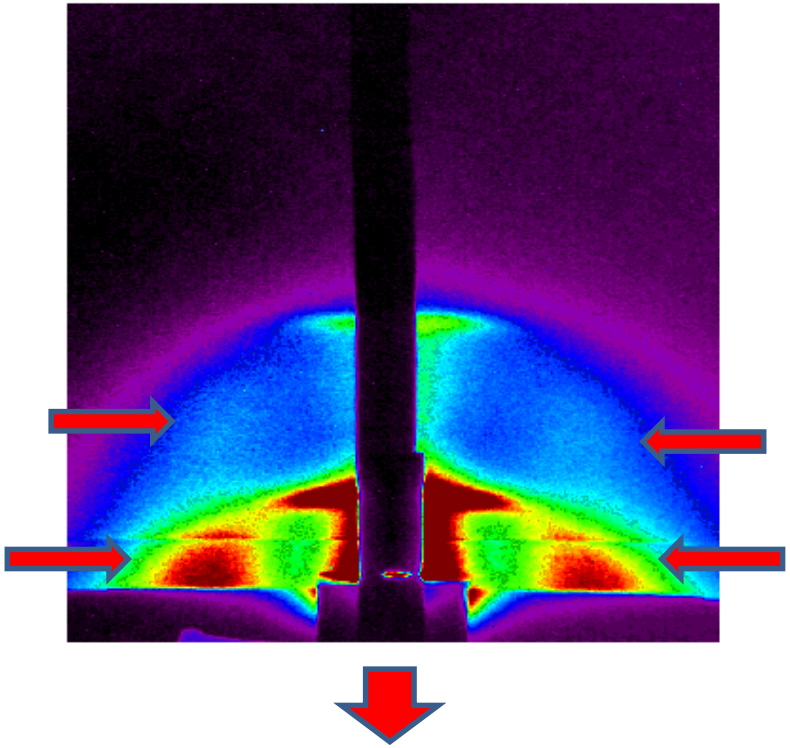
- Nanoparticles within layers

GISAXS: self-assembled quantum dots

Ge QDs in SiO_2

Deposition at 500°C:
ABCABC stacking



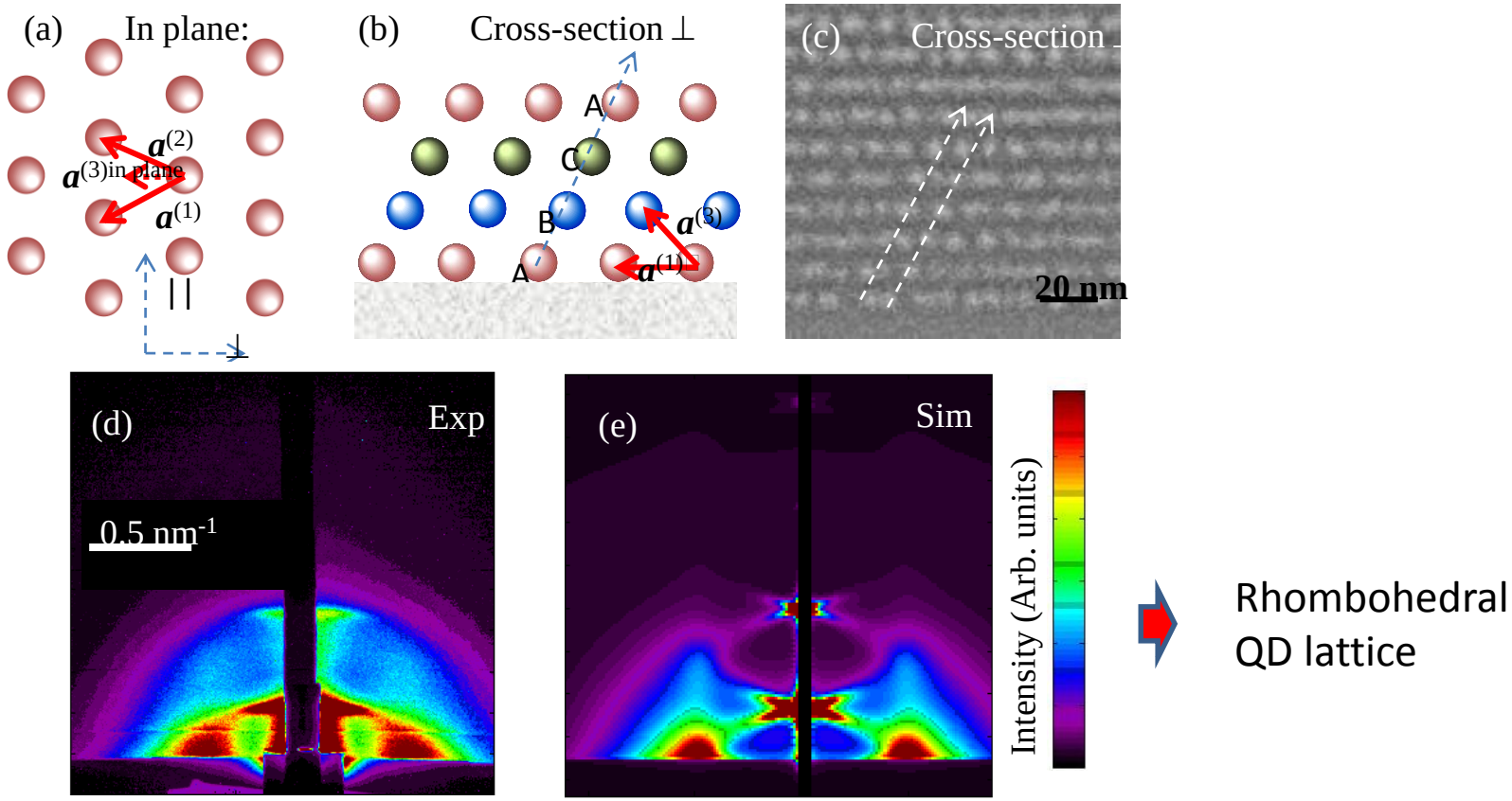


Regular 3D ordering

M. Buljan, U.V. Desnica, G. Dražić, M. Ivanda, N. Radić, P. Dubček, K. Salamon, S. Bernstorff, V. Holý; **Phys. Rev. B 79, 035310 (2009).**

GISAXS: self-assembled quantum dots

- 3D paracrystal model: size, shape and ordering parameters

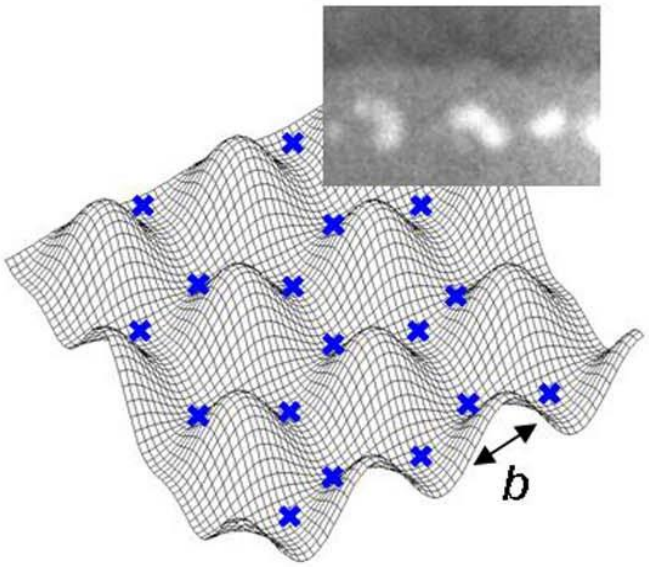


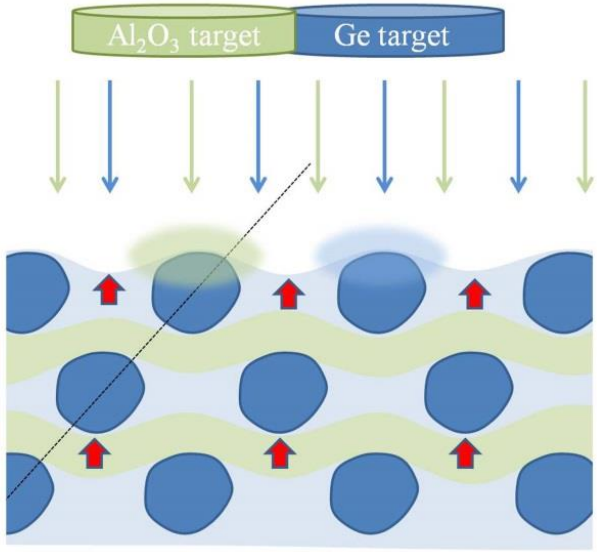
Rhombohedral QD lattice

M. Buljan, et al. *Grazing incidence small angle x-ray scattering: application in study of quantum dot lattices*, **Acta Cryst. A 68 124 (2012)**

Nucleation in walleys:

Main mechanism of self assembly



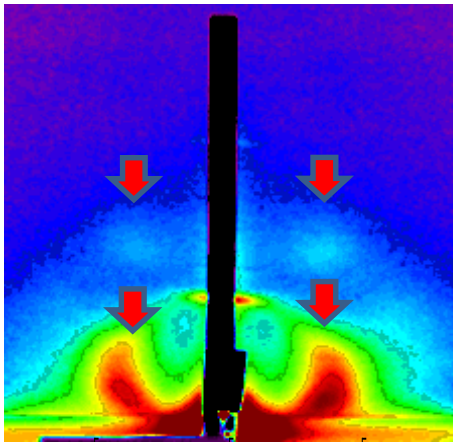


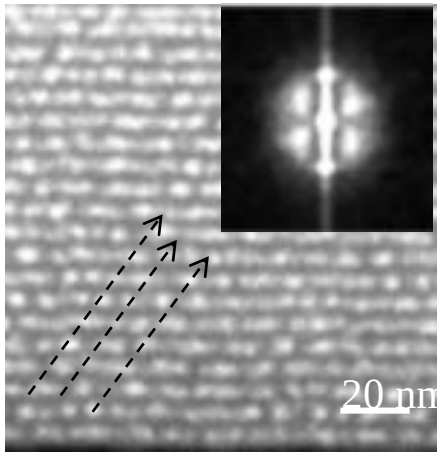
M. Buljan, U.V. Desnica, G. Dražić, M. Ivanda, N. Radić, P. Dubček, K. Salamon, S. Bernstorff, V. Holý; **Phys. Rev. B 79, 035310 (2009).**

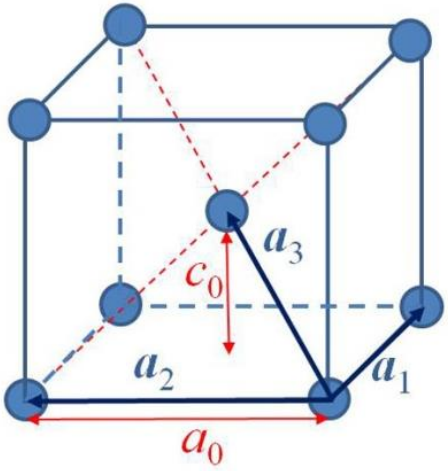
Ge QDs in Al_2O_3

Deposition at 300°C:
ABAB stacking

BCT ORDERING!

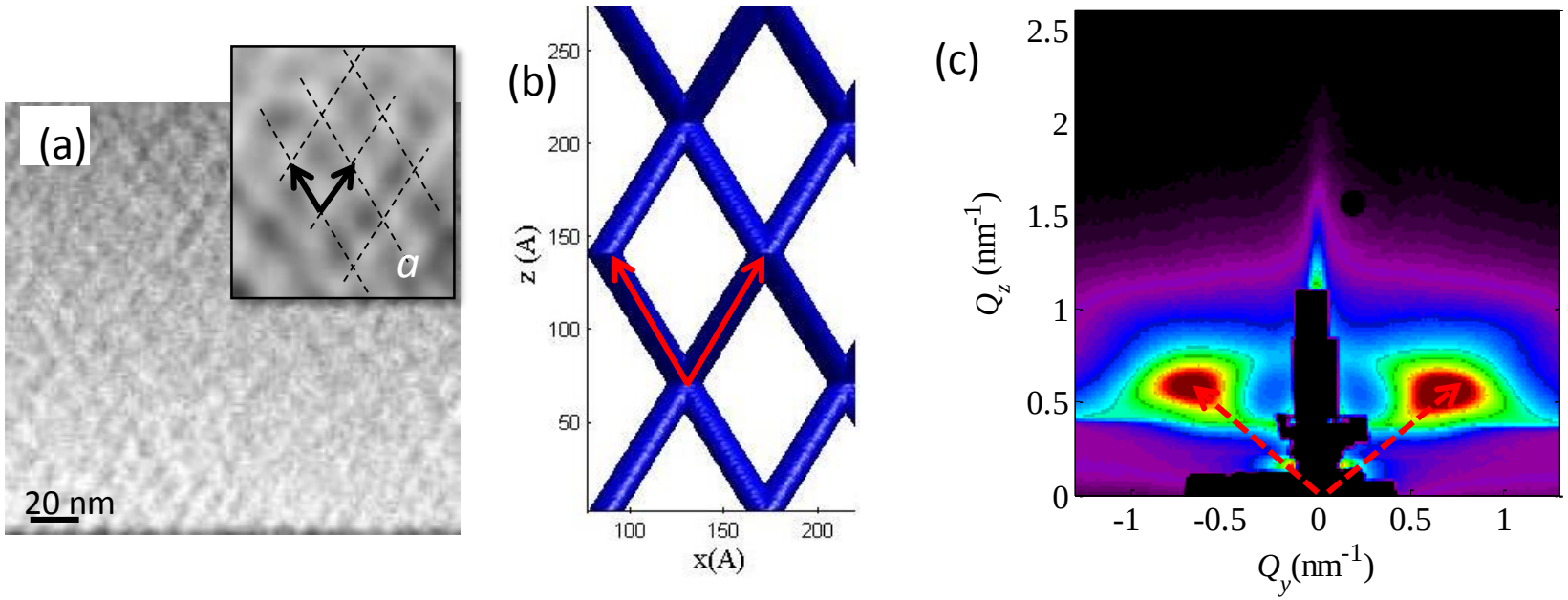






M. Buljan, N. Radić, et al. *Ge quantum dot lattices in Al_2O_3 multilayers*
J. Nanoparticle Res. 15, 1485 (2013)

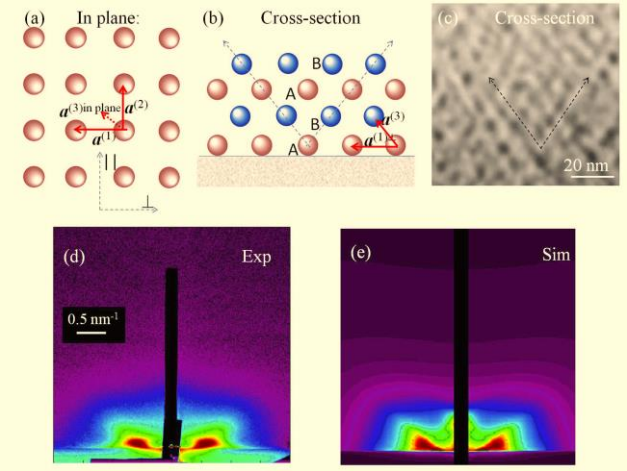
Ge nanowire networks:



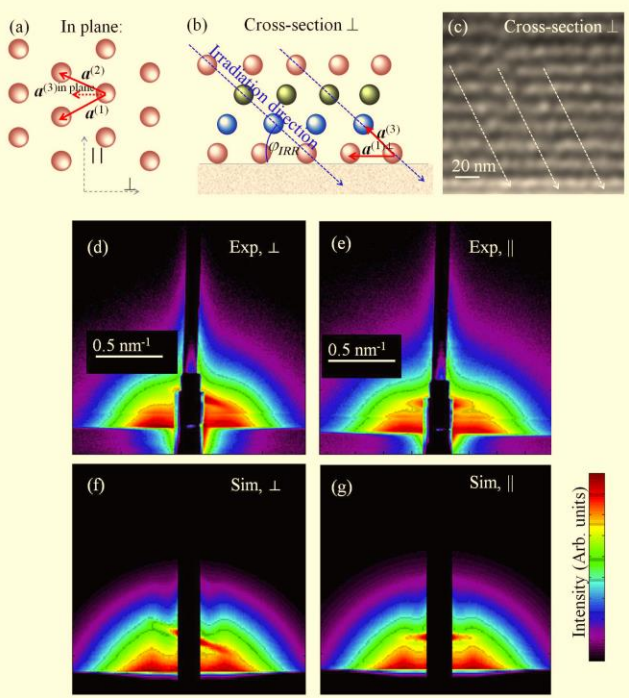
M. Buljan, et al; "*Self-assembling of Ge quantum dots in an alumina matrix*", **Phys. Rev. B 82 235407 (2010).**

Modelling of GISAXS from QD lattices

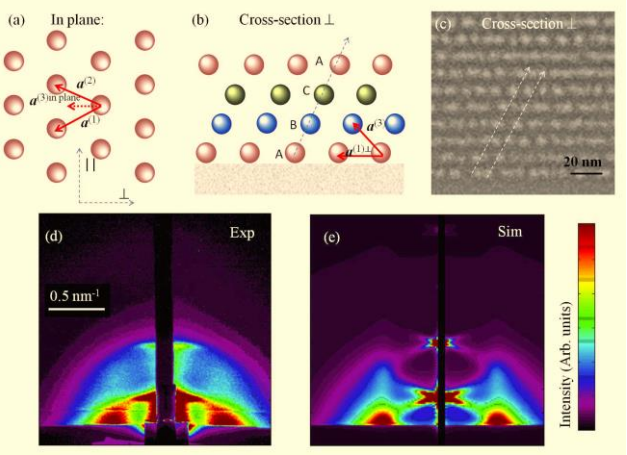
Model 1



Model 2

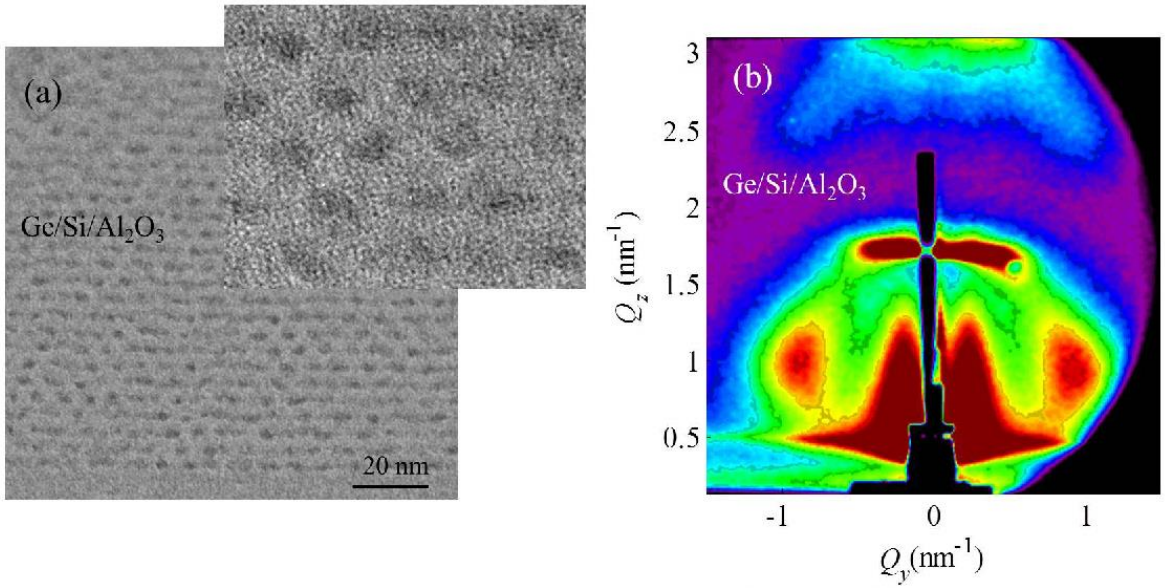


Model 3



M. Buljan, et al.
Grazing incidence small angle x-ray scattering: application in study of quantum dot lattices,
Acta Cryst. A 68 124 (2012)

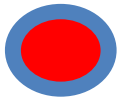
Ge/Si core/shell QDs in Al_2O_3



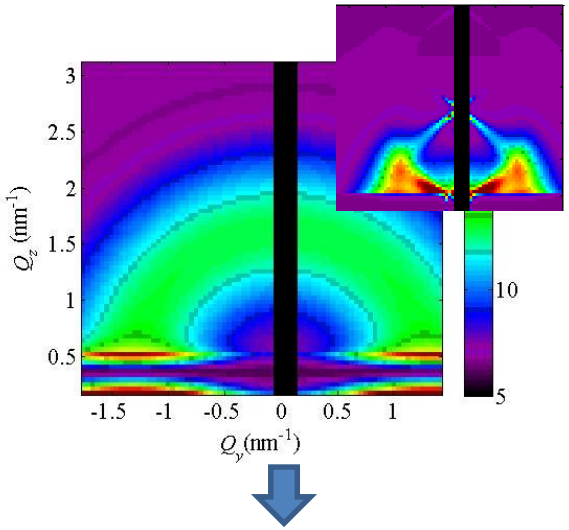
M. Buljan et al., Nanotechnology 26, 065602, (2015).

GISAXS analysis:

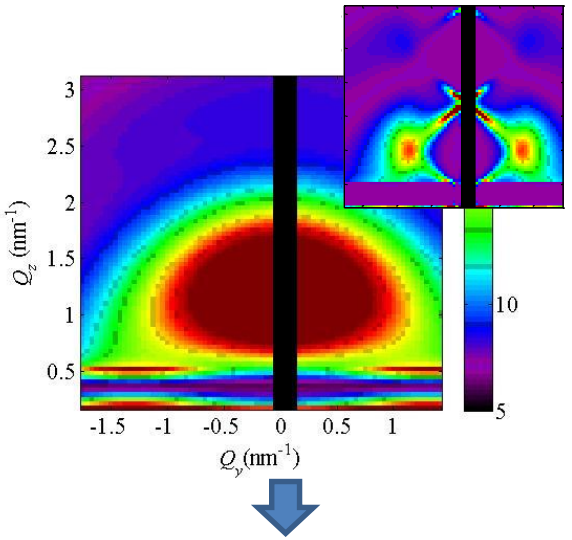
ellipsoid Core/shell –no shift



Core/shell – shifted origin



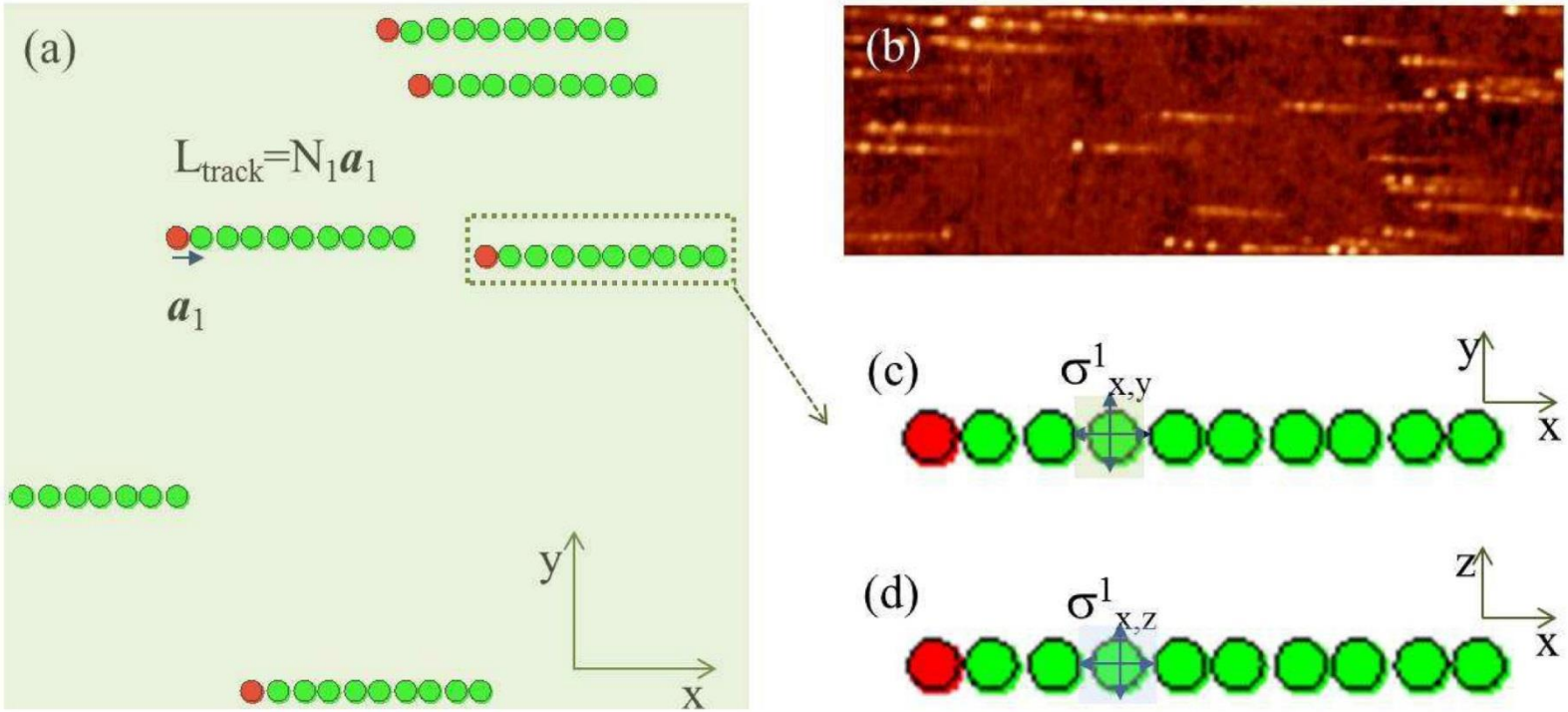
Bad fit, incorrect sizes



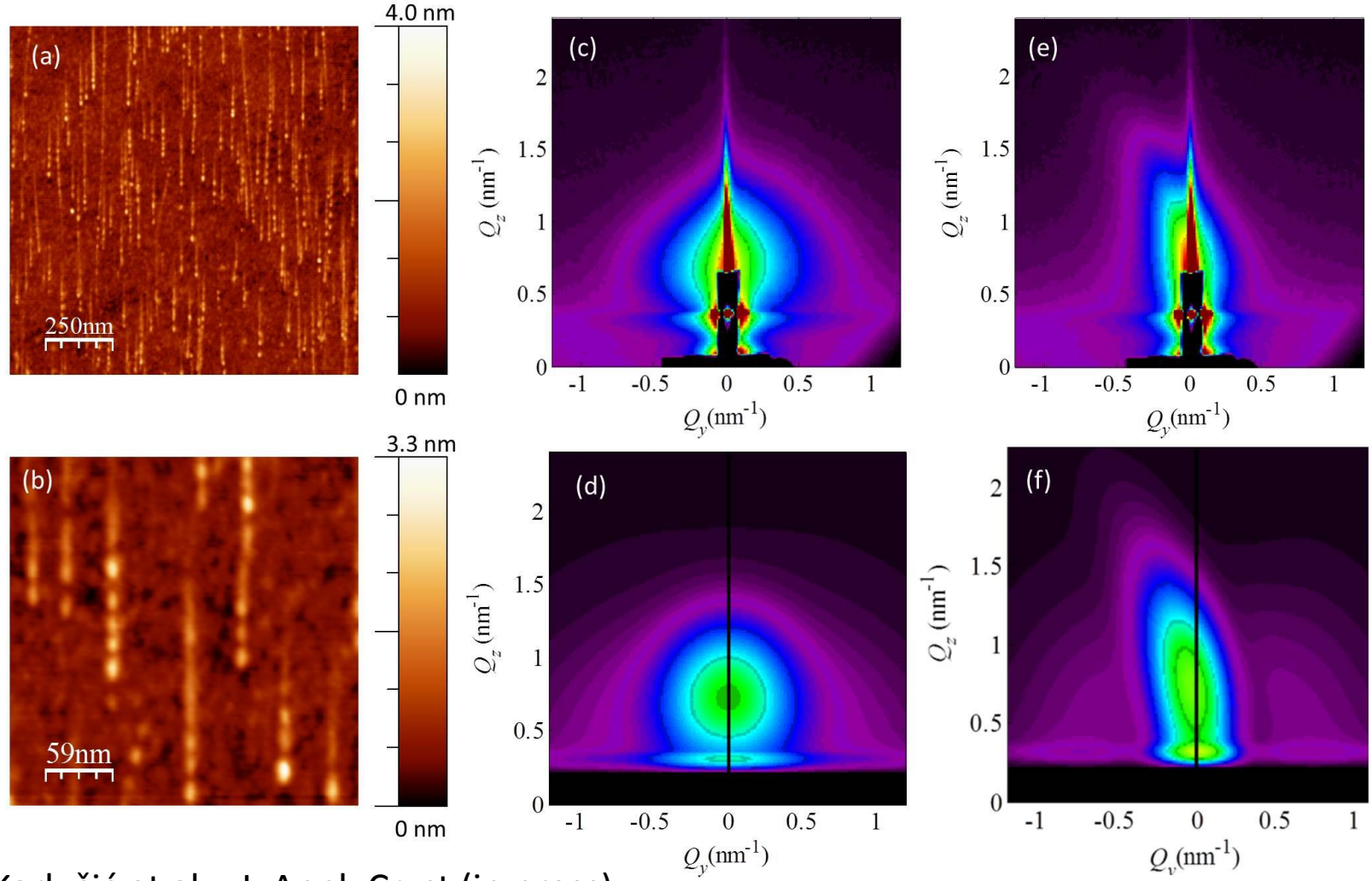
Correct values of radii

M. Buljan et al., Nanotechnology 26, 065602, (2015).

Single ion traces

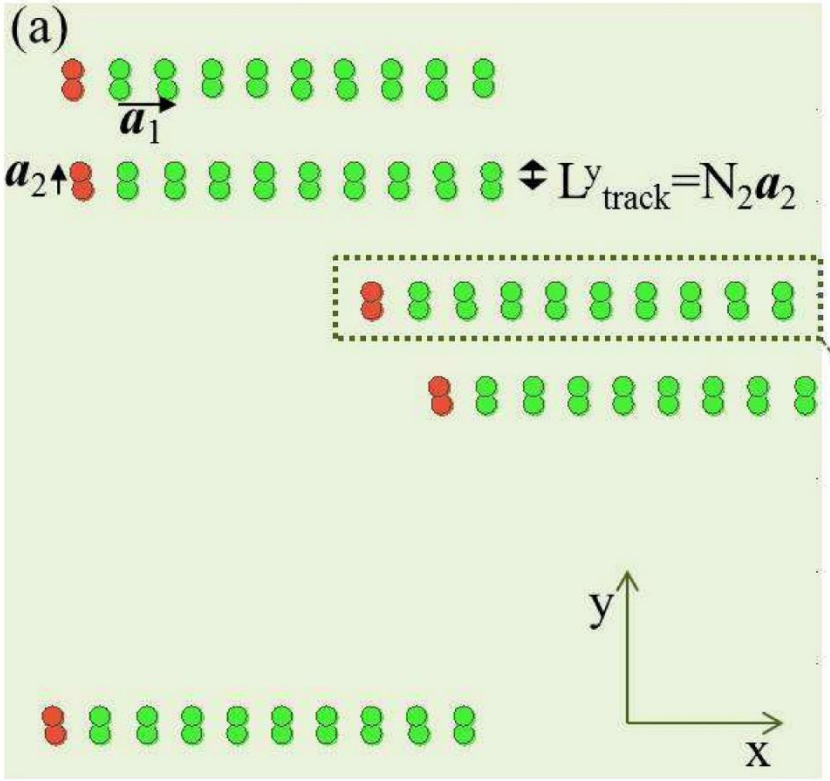


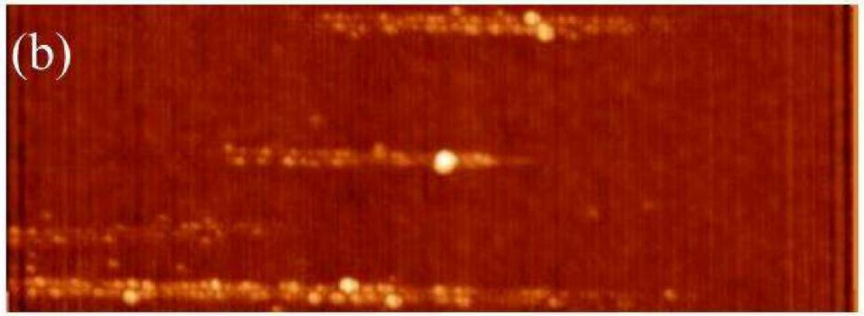
Single ion traces -example

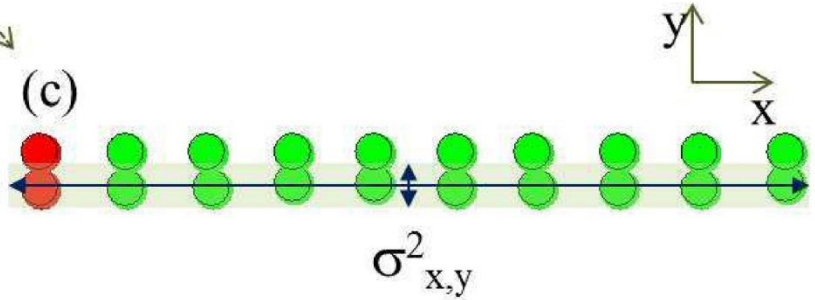


M. Karlušić et al., J. Appl. Cryst (in press)

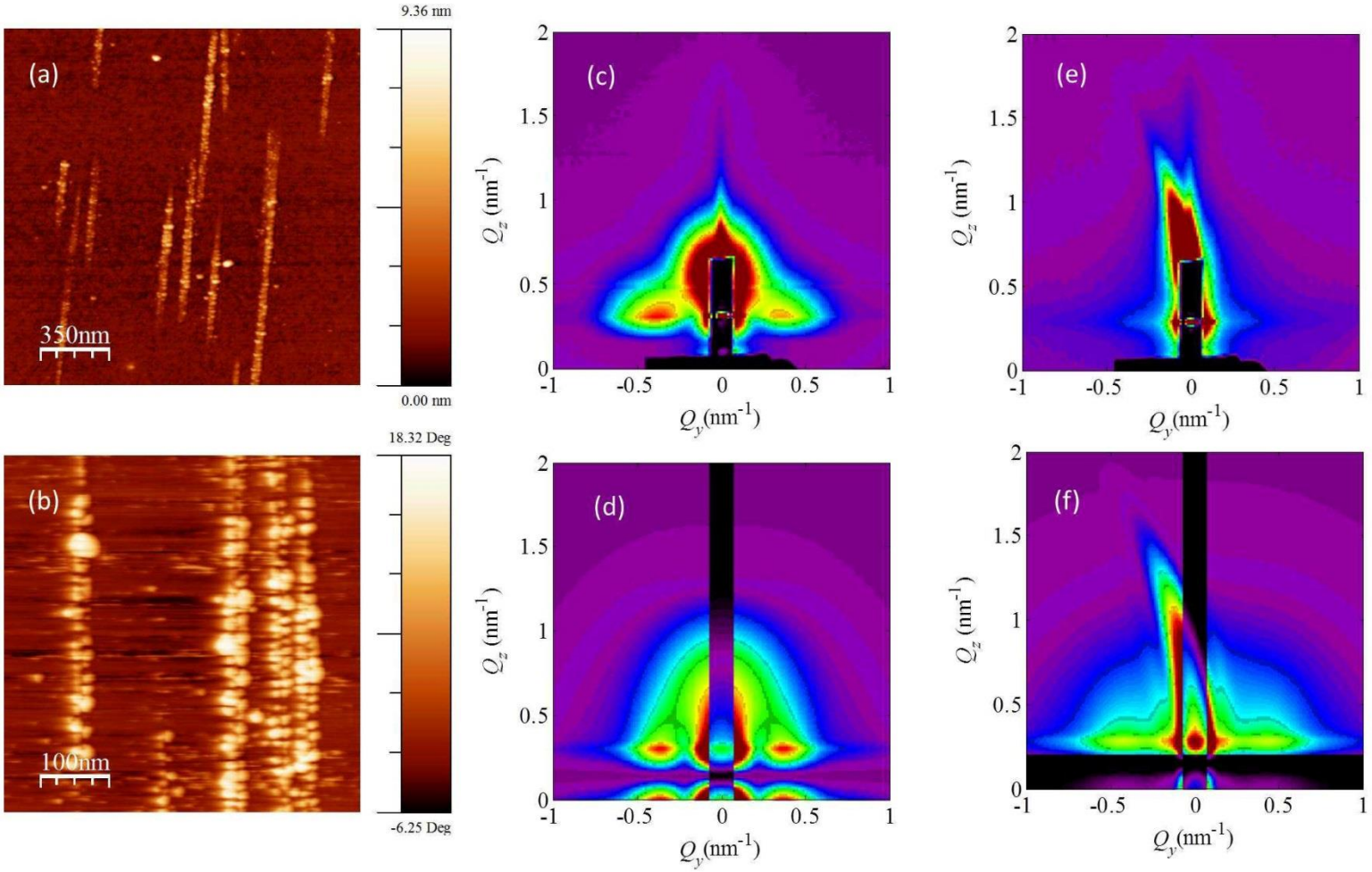
Double ion tracks



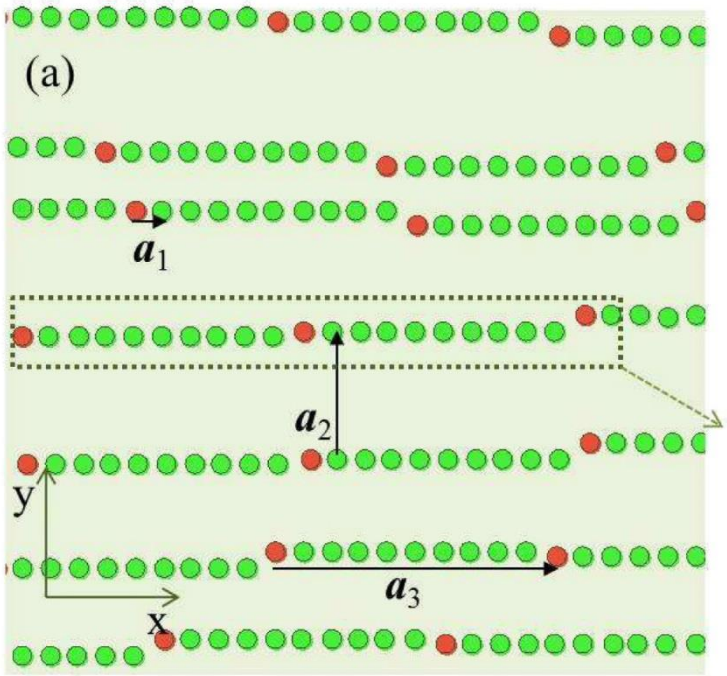


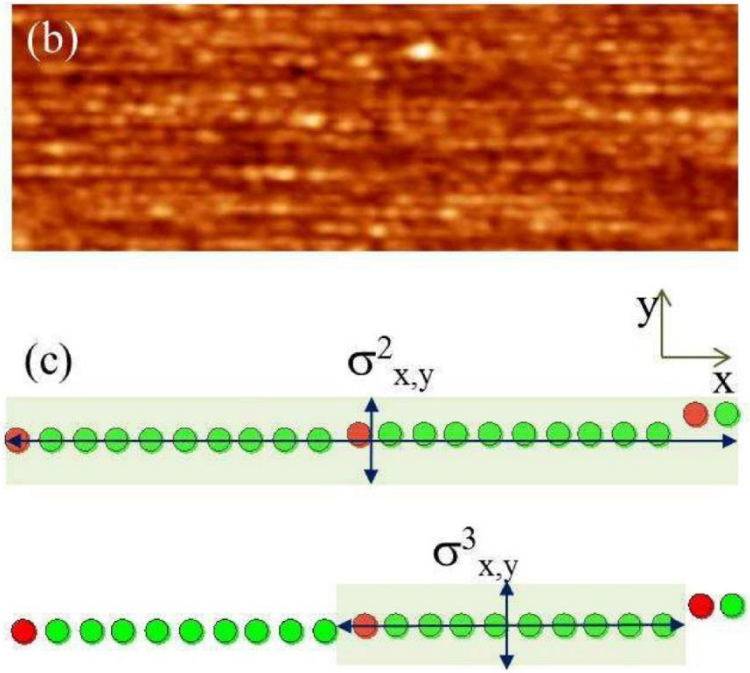


Double ion tracks - example

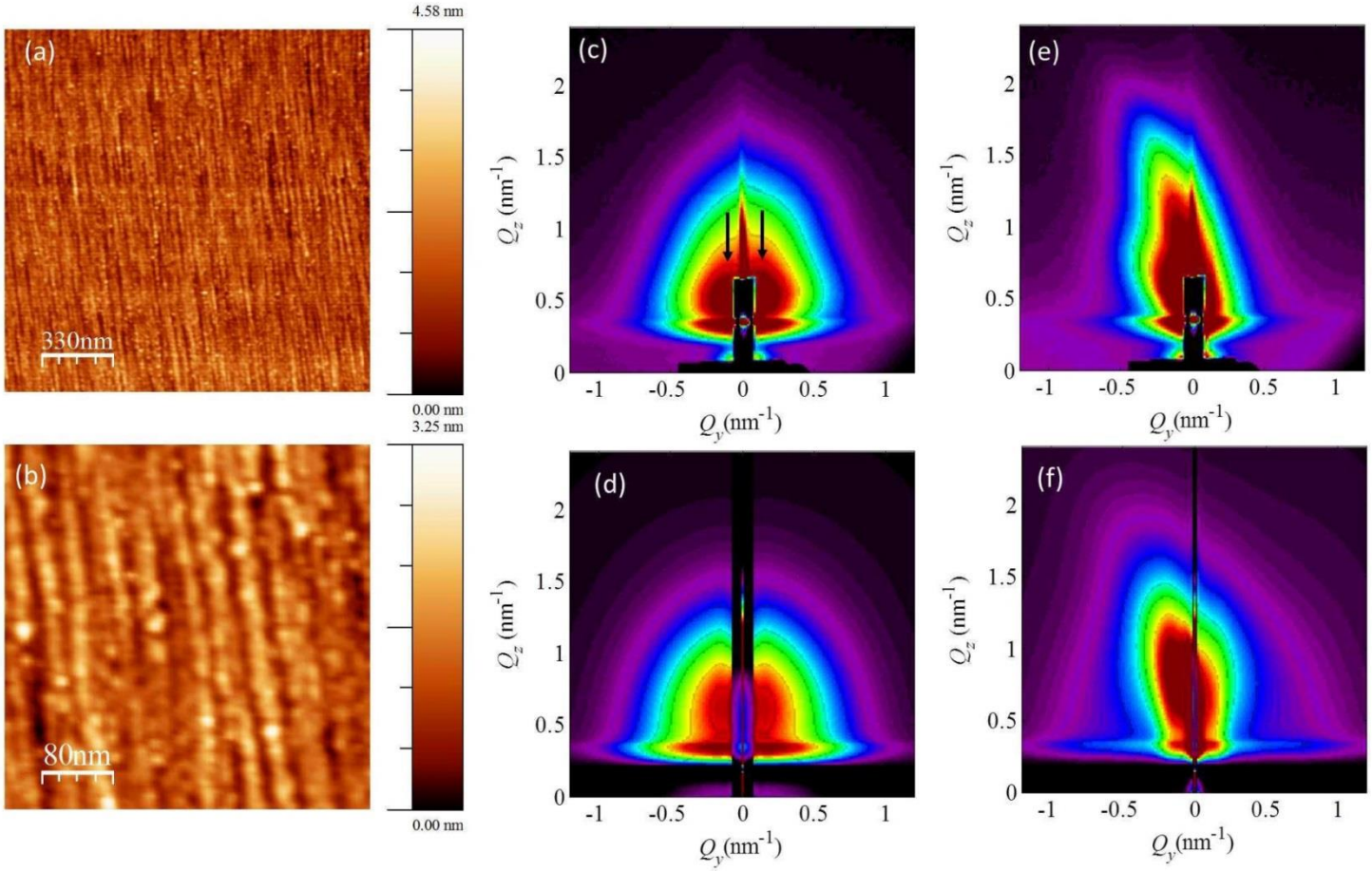


Correlated ion tracks





Correlated ion tracks - example



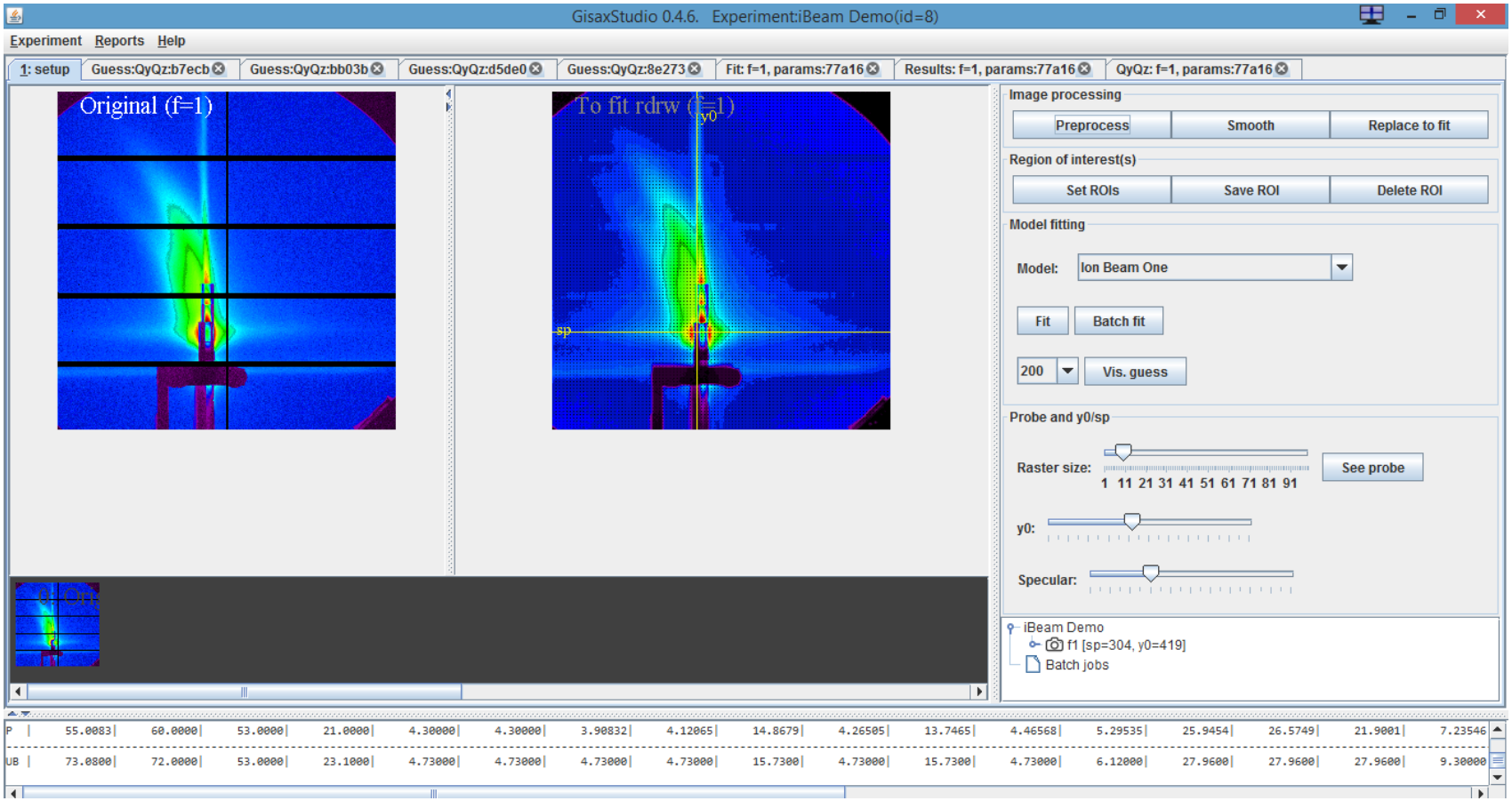
M. Karlušić et al., J. Appl. Cryst (in press)

Software for GISAXS analysis

- ✓ **IMAGE PROCESSING**
- ✓ **DIFFERENT MODELS**
- ✓ **SIMULATION**
- ✓ **FITTING**
- ✓ **BATCH FIT**
- ✓ **SAVING TO DATABASE**

M. Buljan et al. Computer Physics Communications (2016)

Software for GISAXS analysis



http://homer.zpr.fer.hr/gisaxstudio/

Thank you very much for your attention!