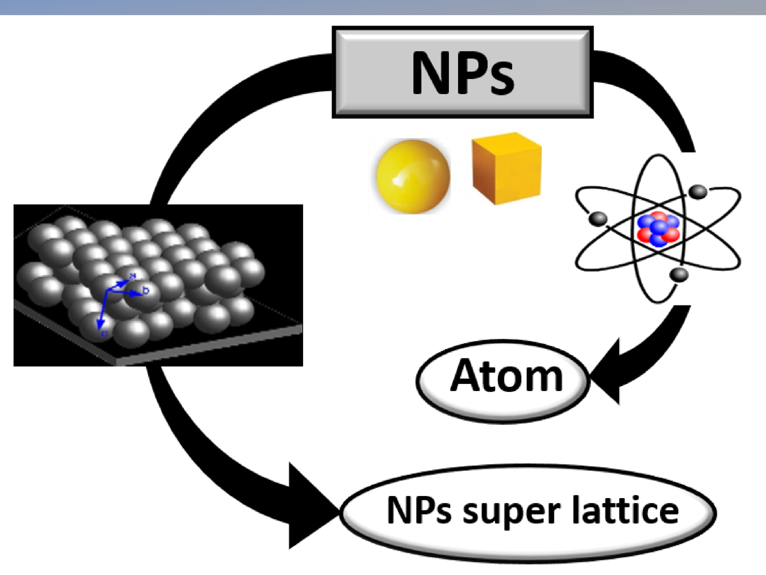
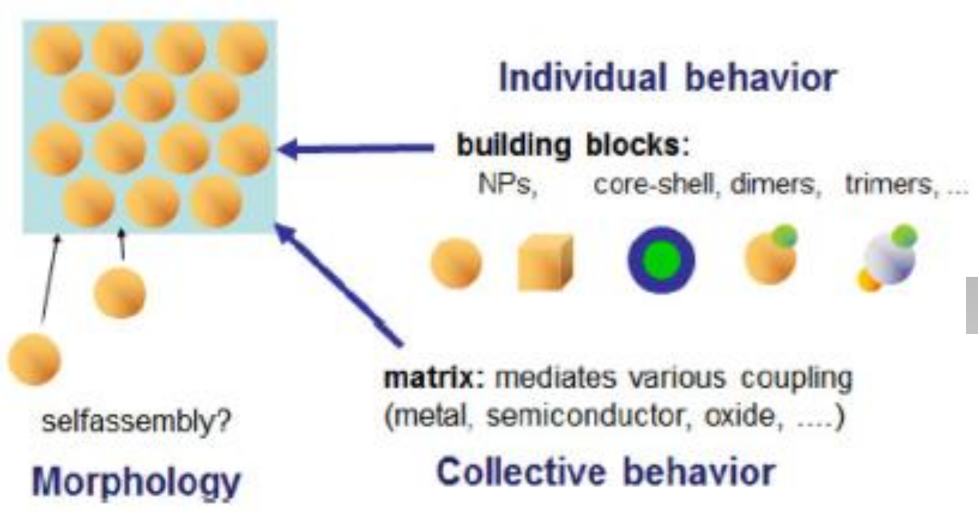
Nanoparticle assemblies: Order by self-organization and collective magnetism

A.Qdemat, E. Kentzinger, G. Portale, M. Ganeva, S. Mattauch, J. Buitenhuis, S. Disch, U. Rücker, and T. Brückel

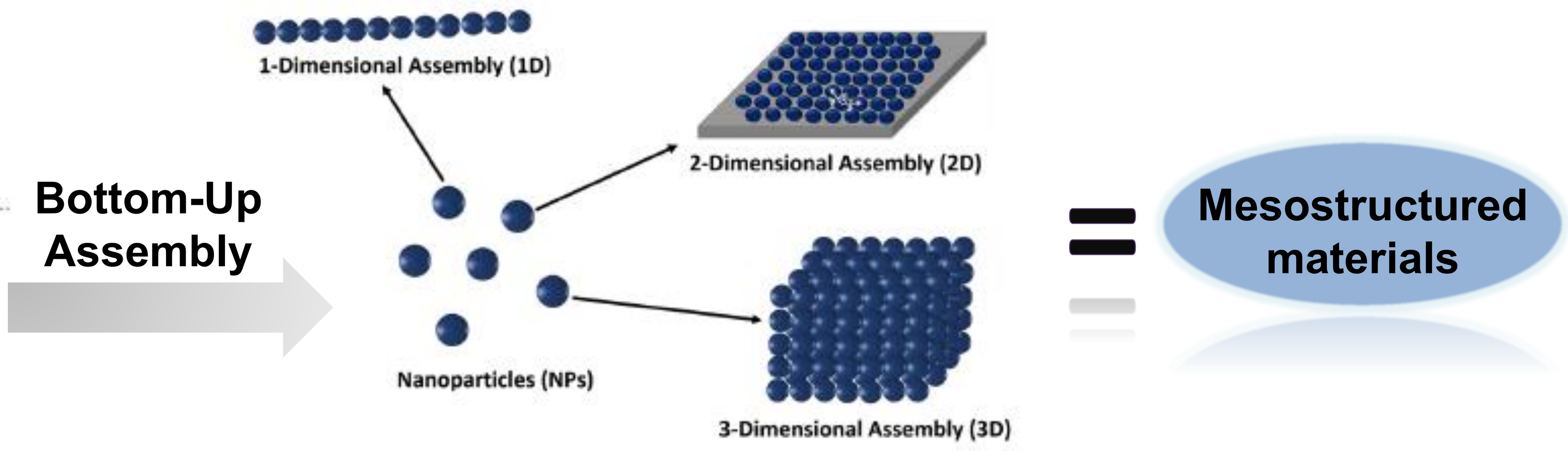
Introduction & Motivation



- Nanoparticles → 1-100 nm – building blocks



- Discovery of fundamental properties → pathways to manipulate matter at the nanoscale

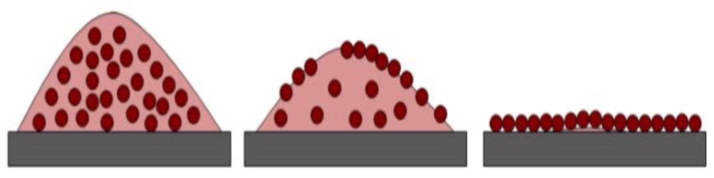


- Appealing properties arise from the interplay of individual and collective behavior of the nanoparticles

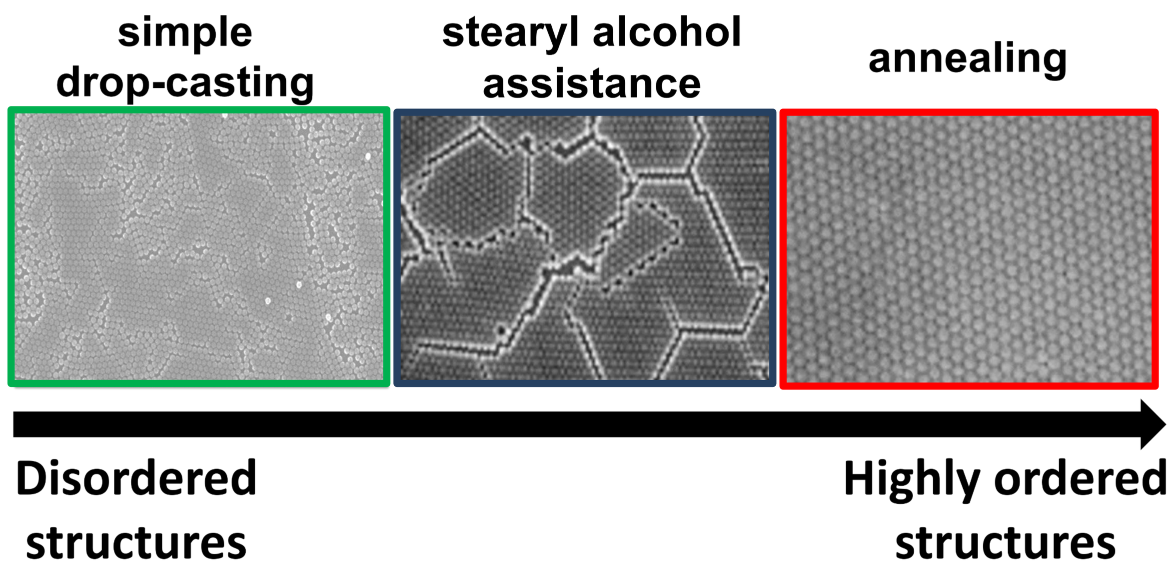
2d: Towards ordered monolayer of nanoparticles

Assembly of nanoparticle monolayers

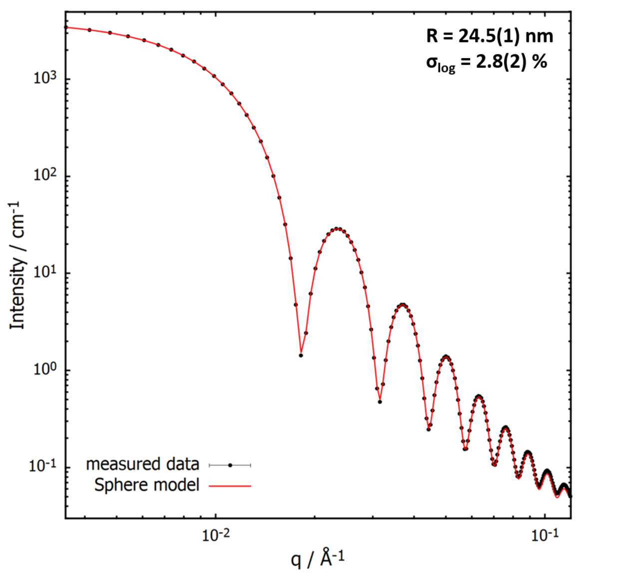
Fabrication **(Drop casting)**



Local characterization by **SEM**

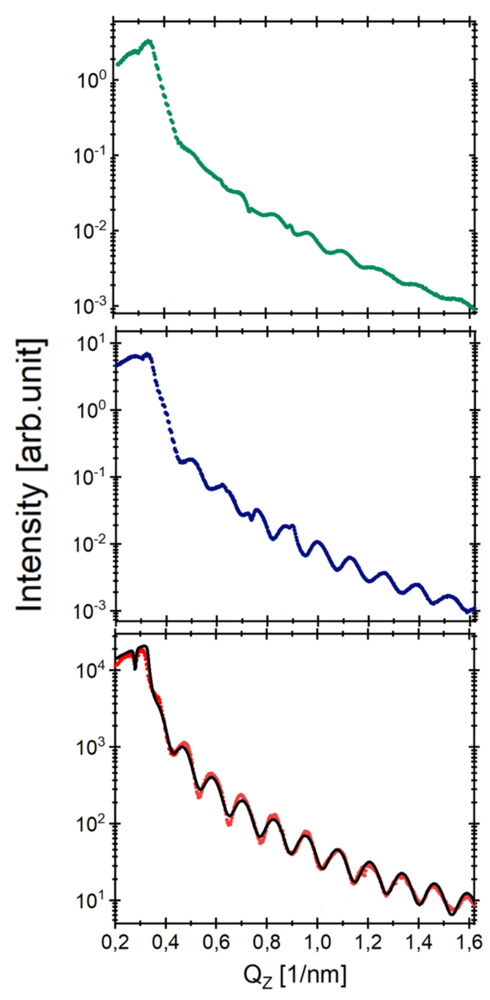


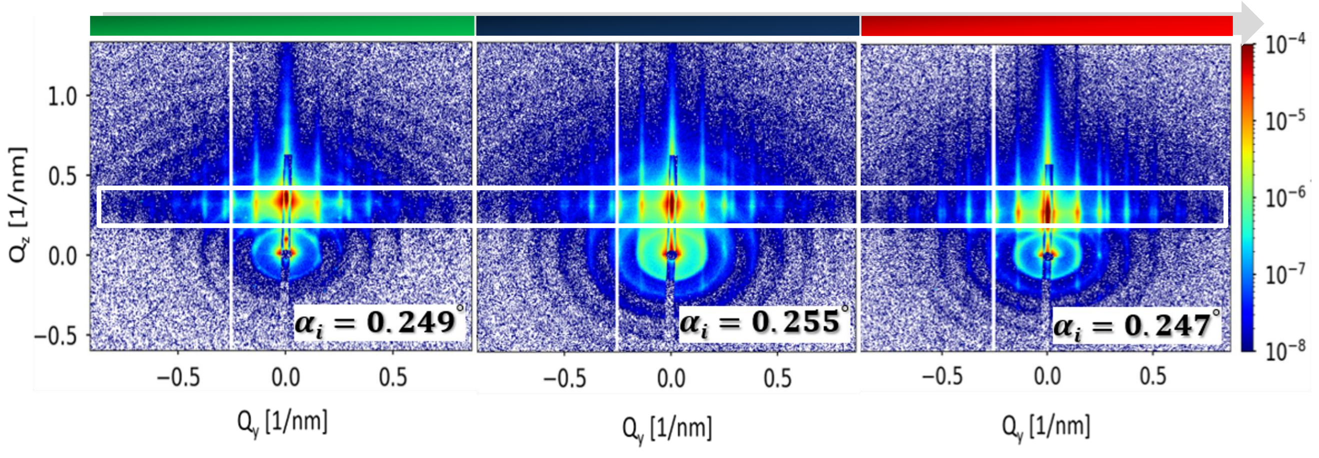
SAXS → Statistically average information



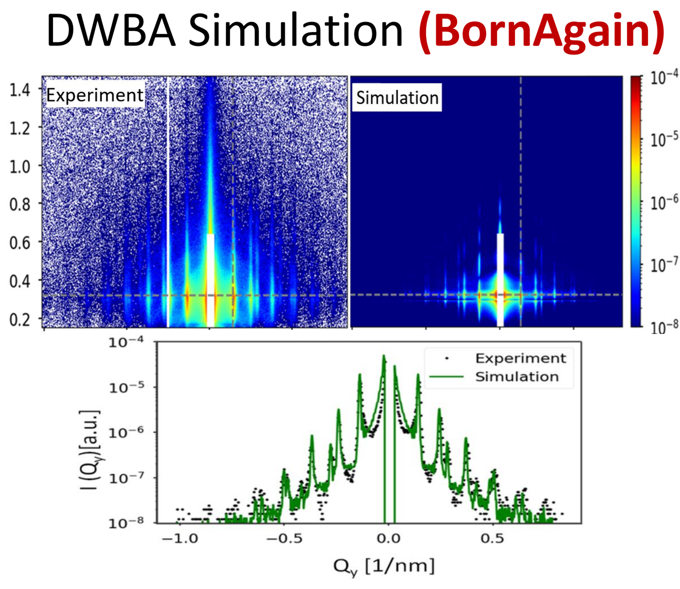
- SiO_2 NP
- Grafted with $C_{18}H_{38}O$
- Dispersed in toluene

Global and depth-resolved characterization by **XRR** and **GISAXS** @ GALAXI

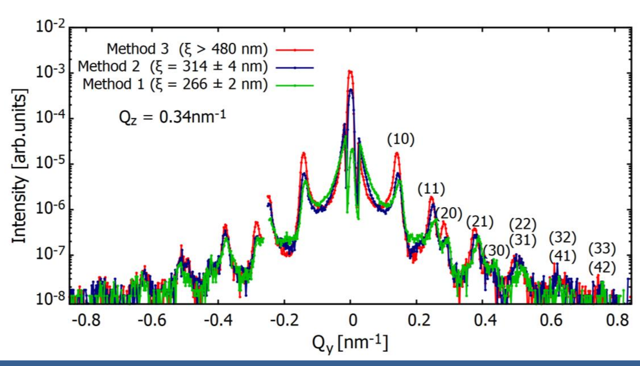




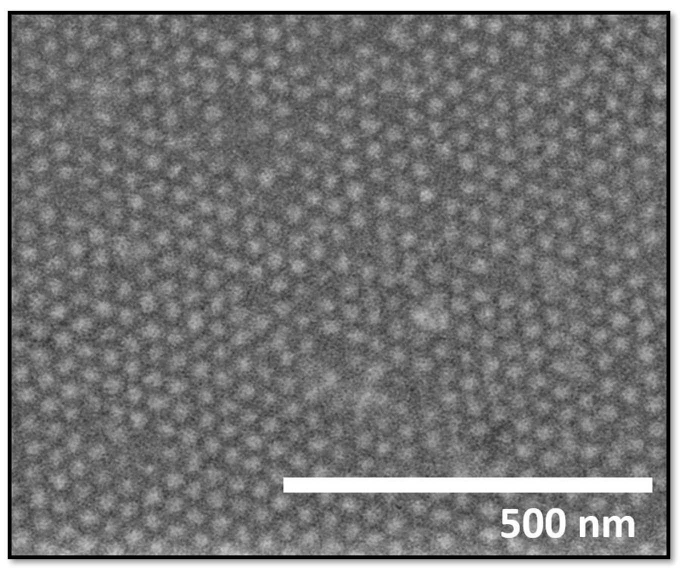
DWBA Simulation **(BornAgain)**



- Full sphere
- 2D hexagonal lattice
- Lattice constant = 52 nm
- 120 lattice rotation angles

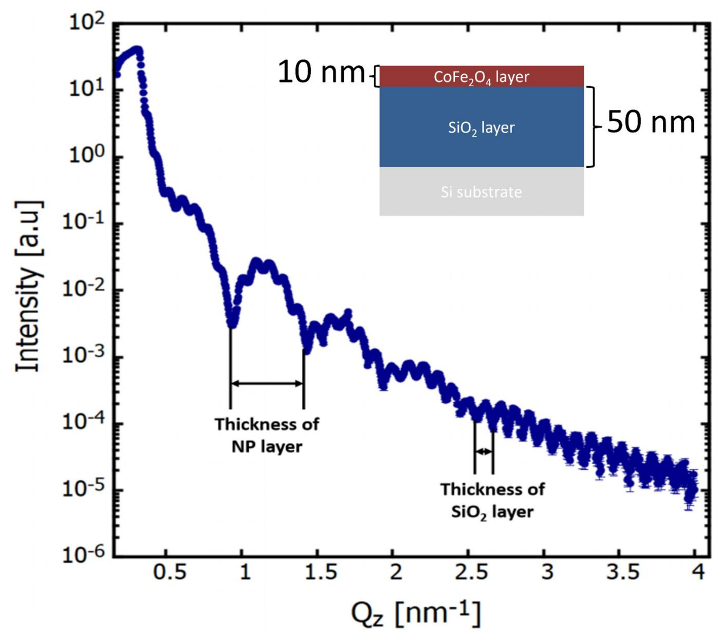


2D arrays of $CoFe_2O_4$ nanoparticles

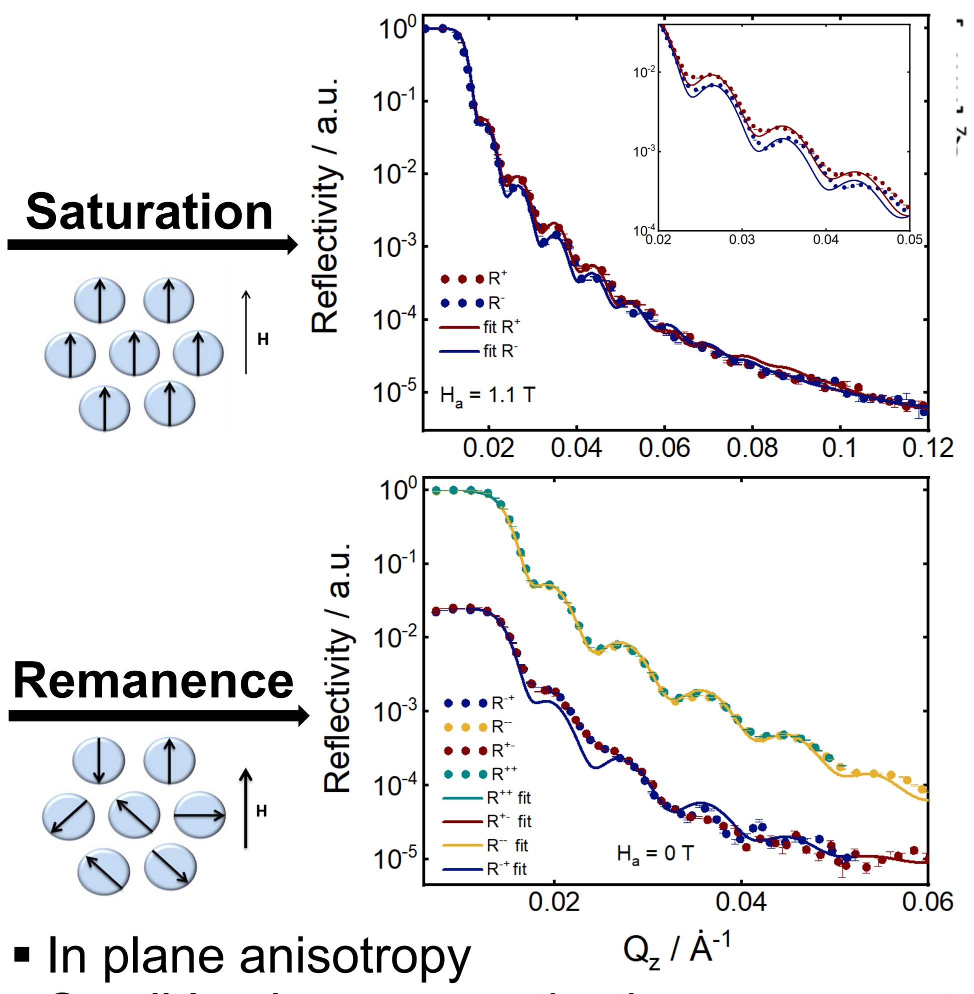


- Ferrimagnetic
- Inverse spinel structure
- 2D hexagonal lattice

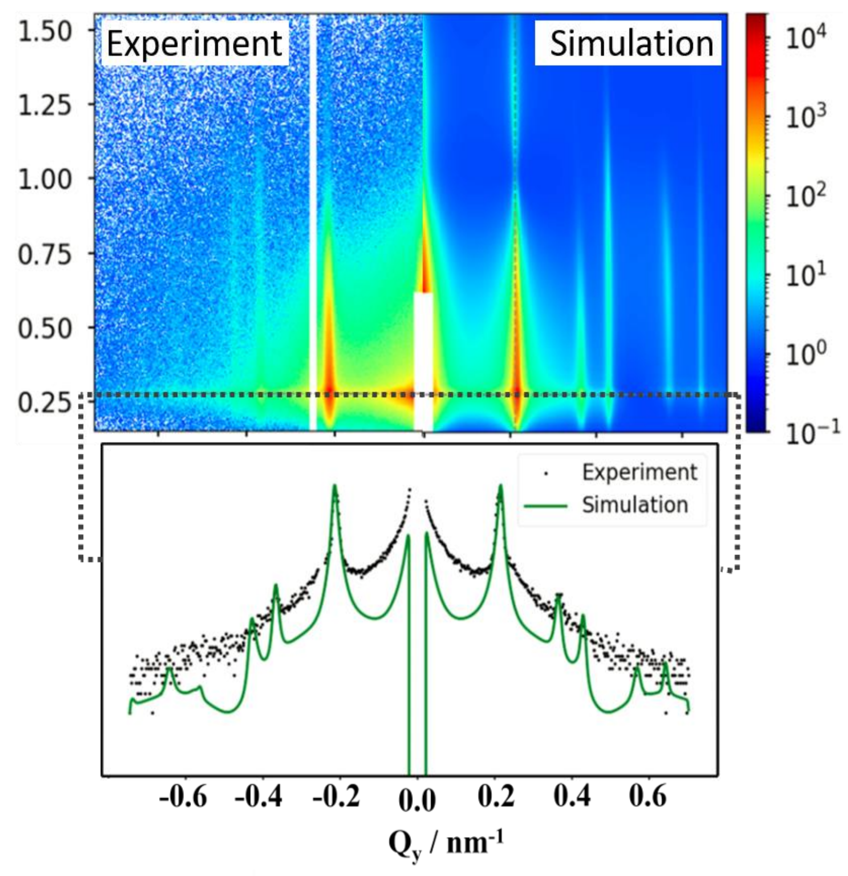
XRR → Out-of-plane ordering



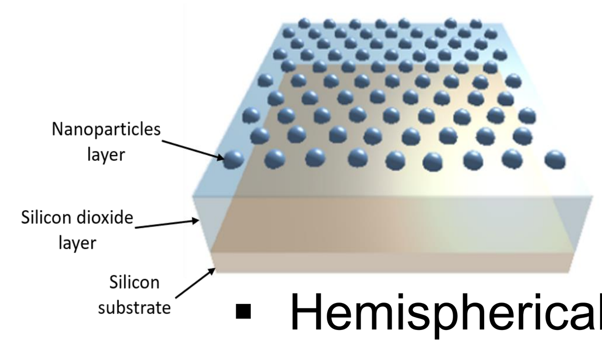
PNR @ MARIA



GISAXS → In plane ordering



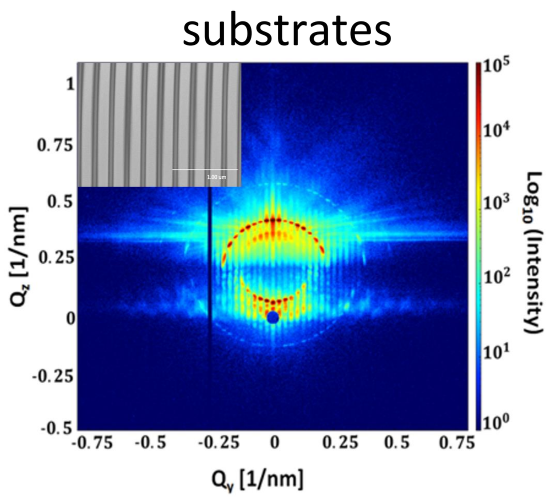
- In plane anisotropy
- Small In plane magnetization component parallel to the magnetic field
- Demagnetized state with zero net magnetization



- Hemispherical
  - D~24 nm
  - h~10 nm

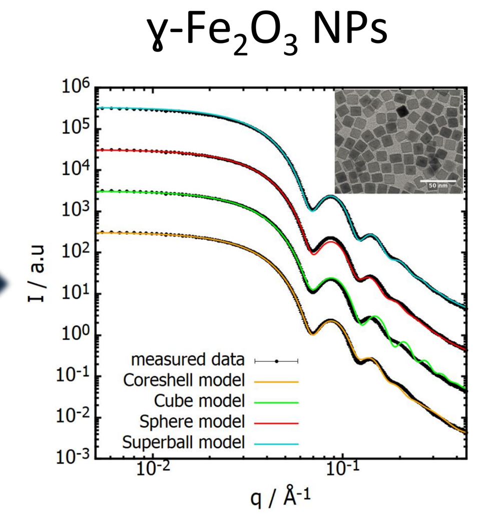
3d: Towards single crystal of nanoparticles

Trench-patterned substrates

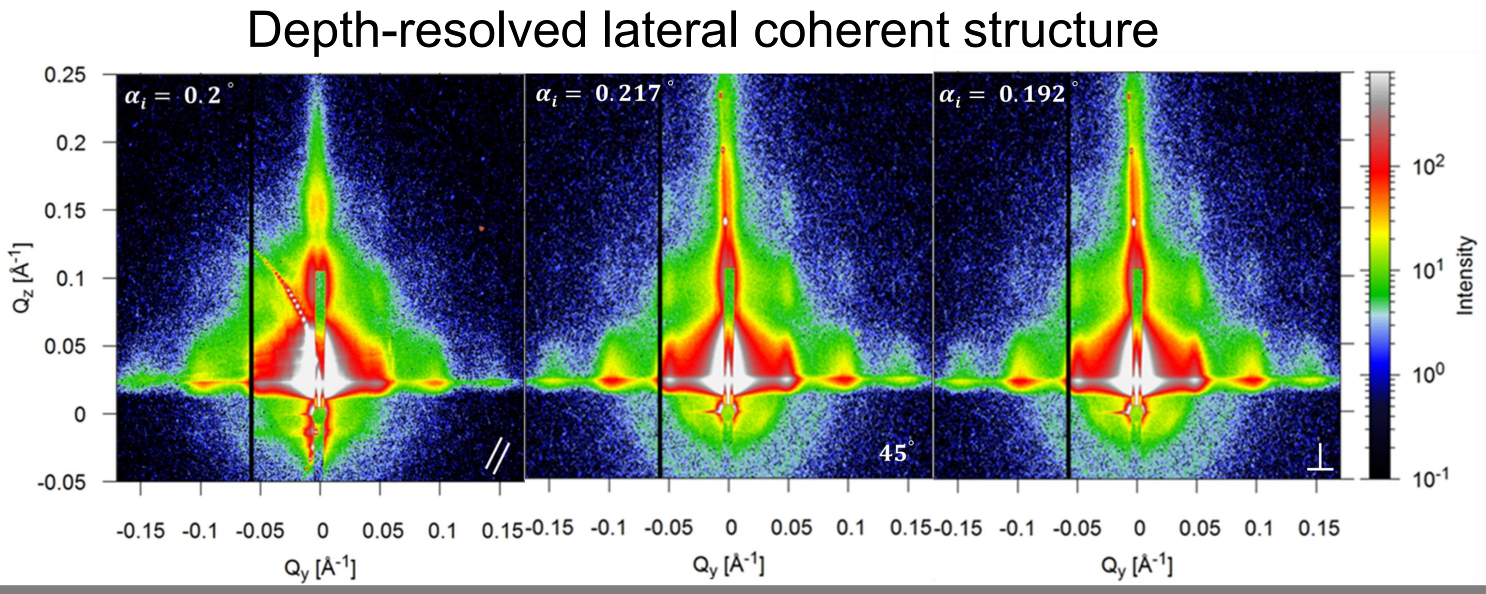


DSA

γ-Fe_2O_3 NPs



Depth-resolved lateral coherent structure

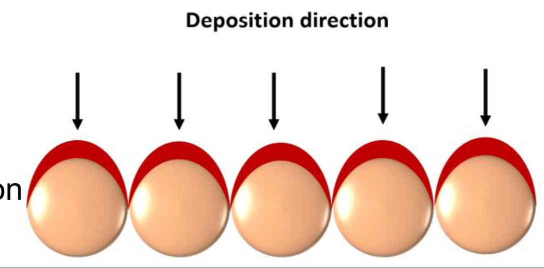


No correlation between the structural arrangement of nanoparticles and the geometry of the trench-patterned substrates

Ongoing work

magnetic multilayers on self-organized nanospheres

- Investigate the influence of curved surfaces on the magnetic thin film properties
- Tuning shape-imposed anisotropy
- Study the NP size dependence in the magnetization reversal of the magnetic multilayers



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Acknowledgment

We thank **Jochen Friedrich** from **PGI-7** for providing SEM.

Contact: a.qdemat@fz-juelich.de