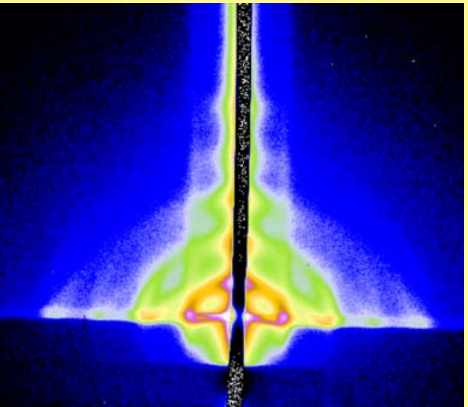
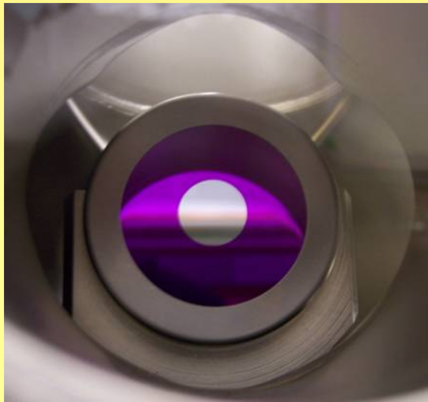
Ordering Kinetics in Nanoscale Systems

Present Experiments and Future Applications at an ERL Light Source

Detlef-M. Smilgies





cell membranes

MEDICINE **BIOLOGY**

medical implants

supramolecular assemblies

Organic Thin Films

ENGINEERING **CHEMISTRY**

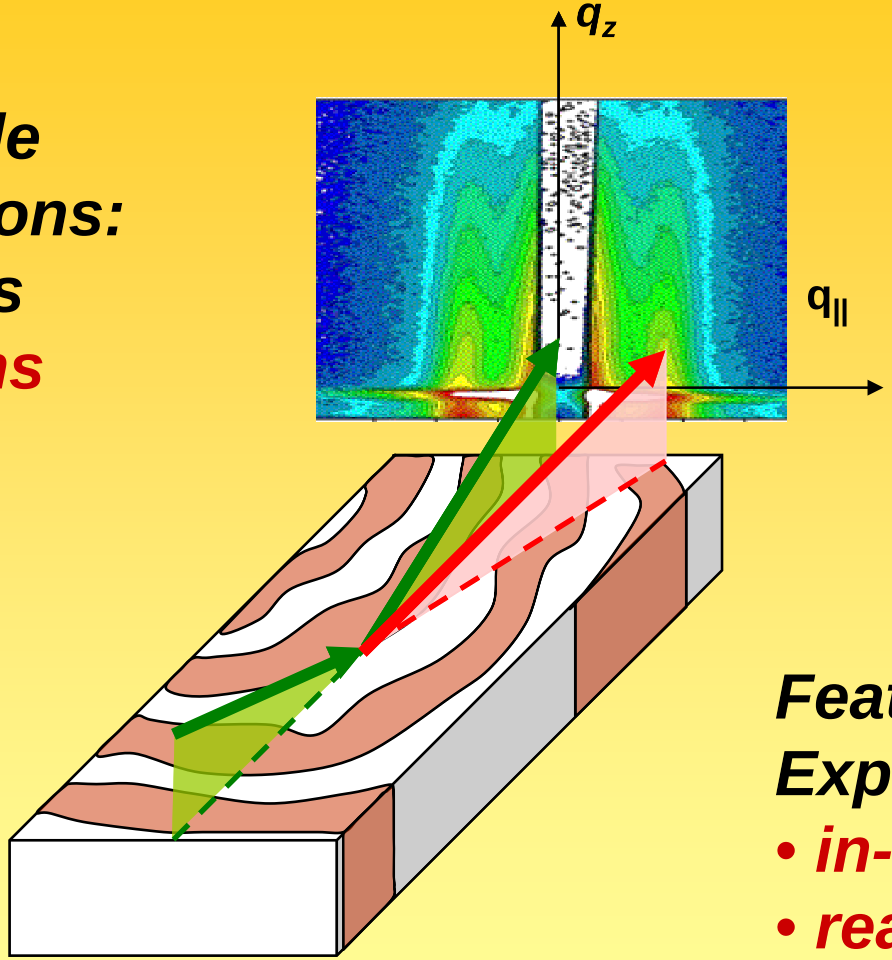
molecular electronics

self-organized nanostructures

PHYSICS

Grazing-Incidence SAXS

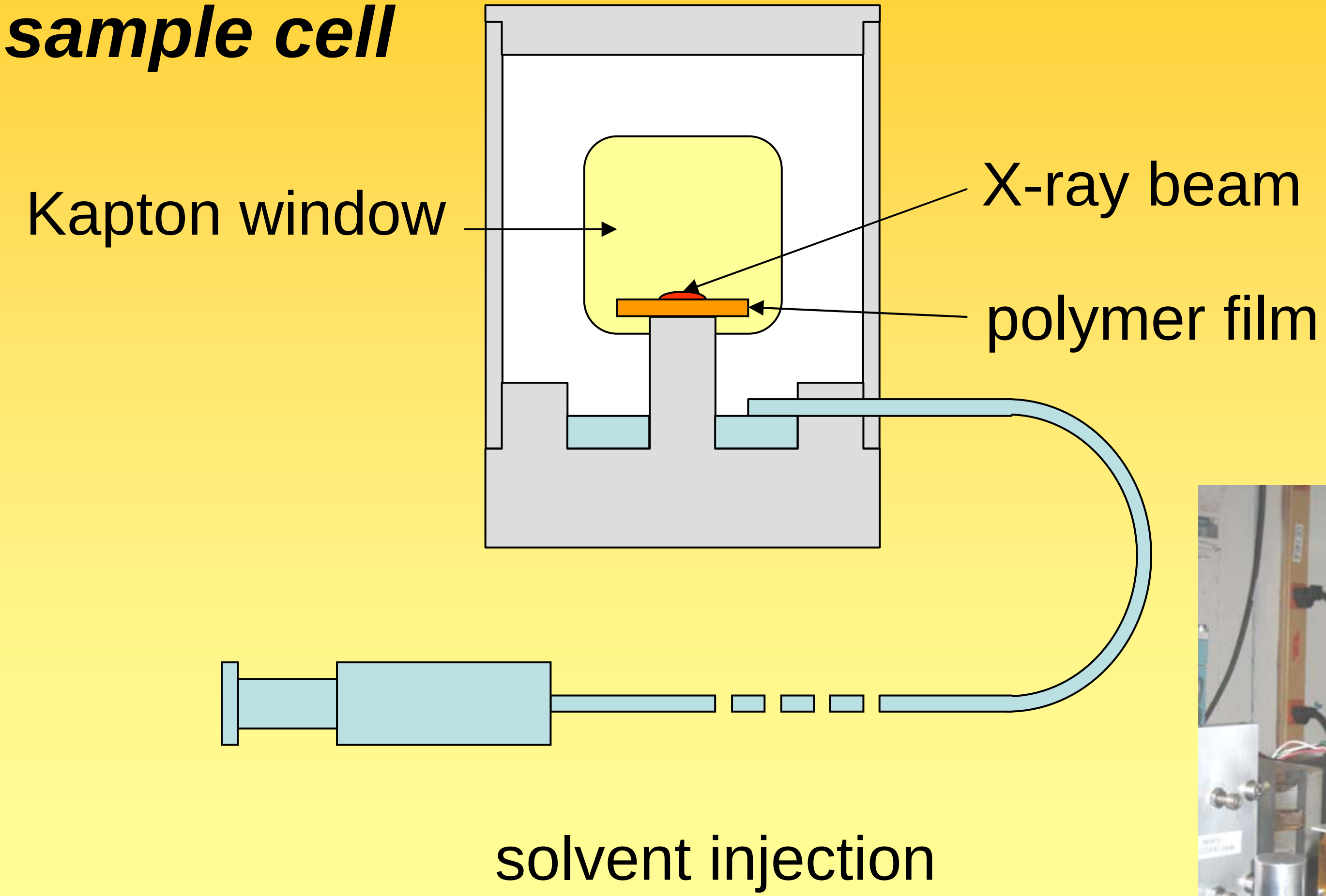
Nanoscale Applications:
- ***surfaces***
- ***thin films***

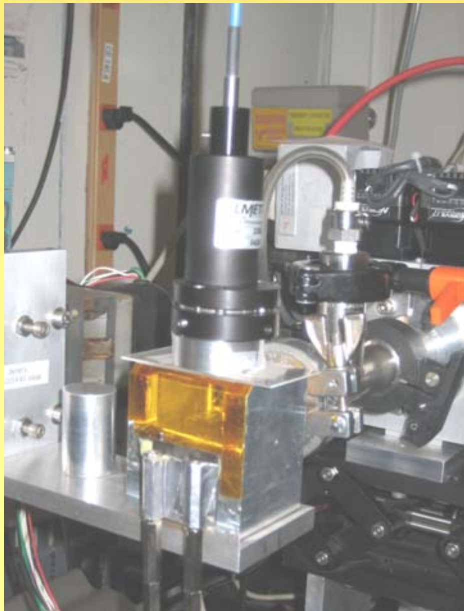


Featured Experiments:
- ***in-situ***
- ***real time***

Smilgies et al., Synchrotron Radiation News 15(5), pp. 35-41 (2002).
http://staff.chess.cornell.edu/~smilgies/gisaxs/GISAXS.php

Stability of a lamellar BCP film

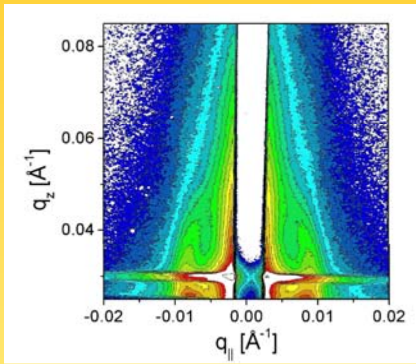




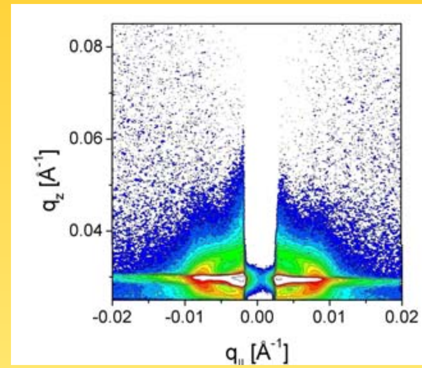
In-situ & real time:
PS-PB film exposed to solvent vapor

Smilgies, Busch, Posselt & Papadakis, SRN 15(5), pp. 35-41 (2002).

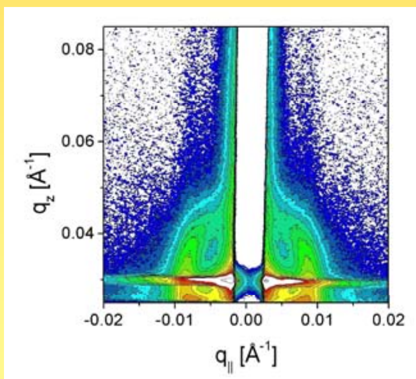
1 min swelling



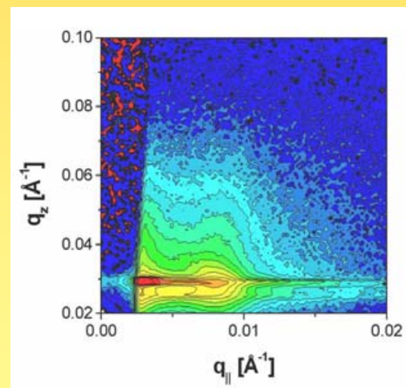
17 min swelling



→ 1 image per 40 sec



4 min swelling



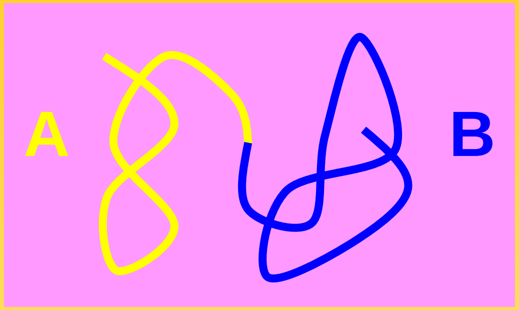
dried film

PS-*b*-PB
183 kg/mol,
D_{lam}= 836 Å,
D_{film} = 2340 Å

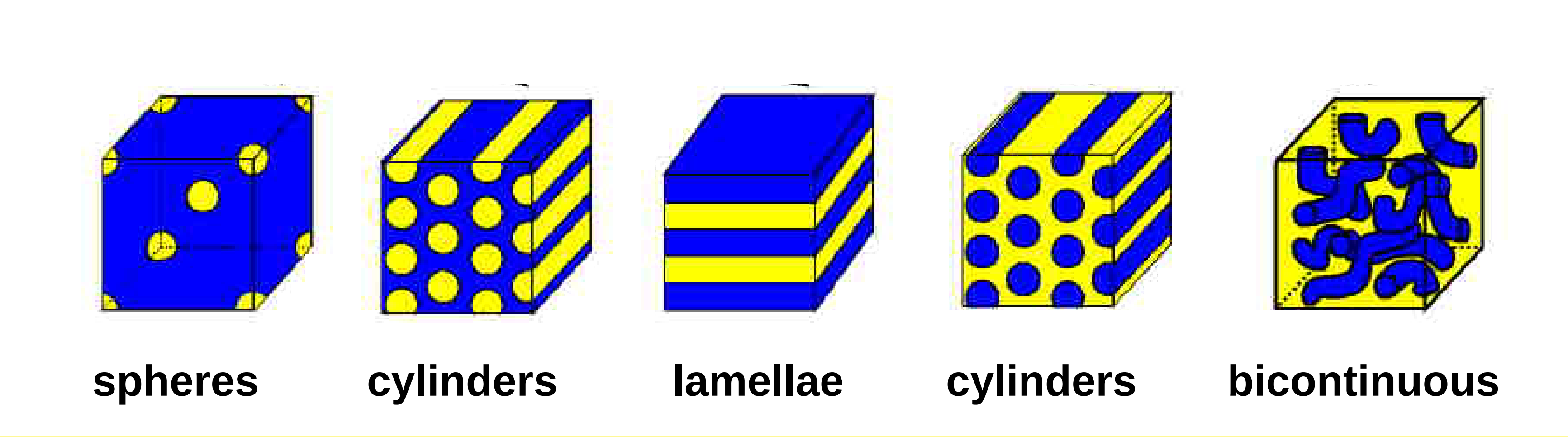
Bragg rods shorten and bend:

- increase of lamellar thickness
- change of lamellar orientation during vapor treatment

Block copolymer architectures



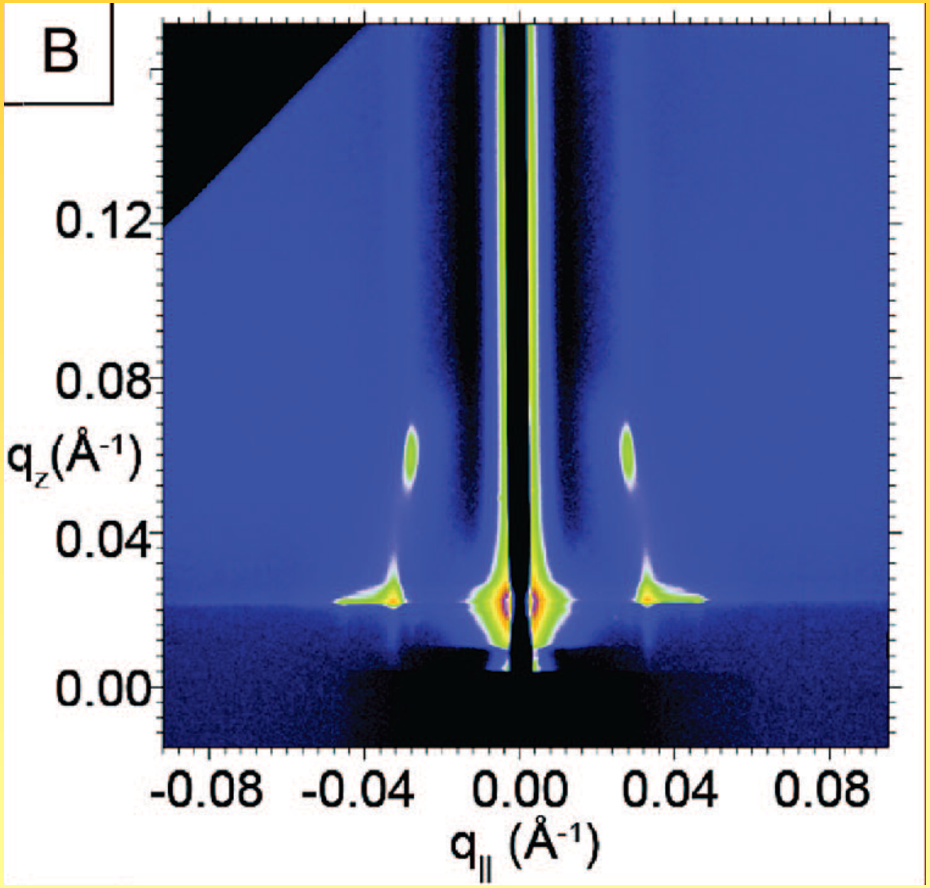
block copolymers (BCP):
two inmiscible polymer chains connected by a chemical bond



volume fraction of block A

- ***tunable morpholgies as templates for nanostructured films***

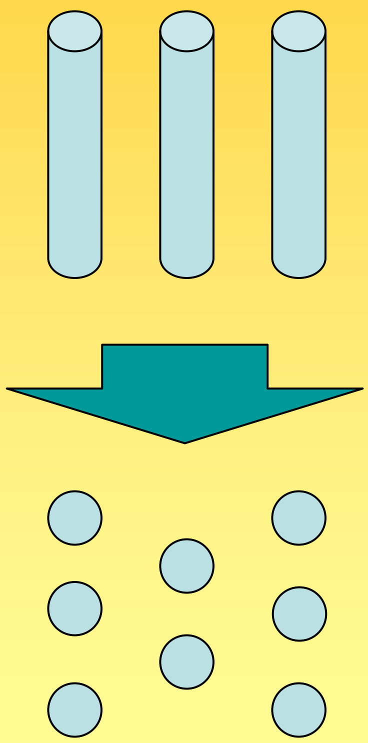
Selective Solvents: Solvent induced phase transition



Katy Bosworth, Marvin Paik et al. ACS Nano 2, 1396 (2008)

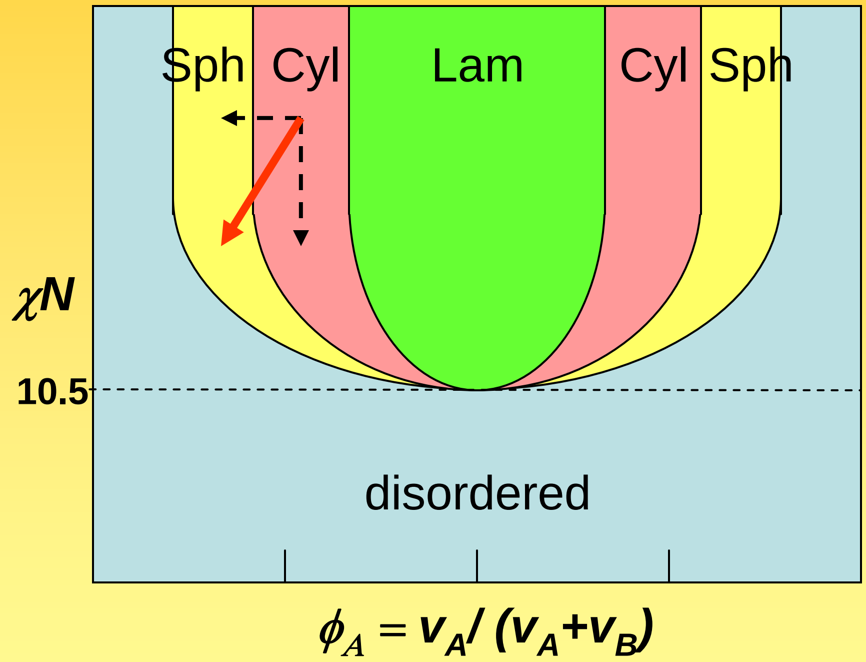
Selective solvents: Solvent induced phase transition

HEX cylinders



BCC spheres

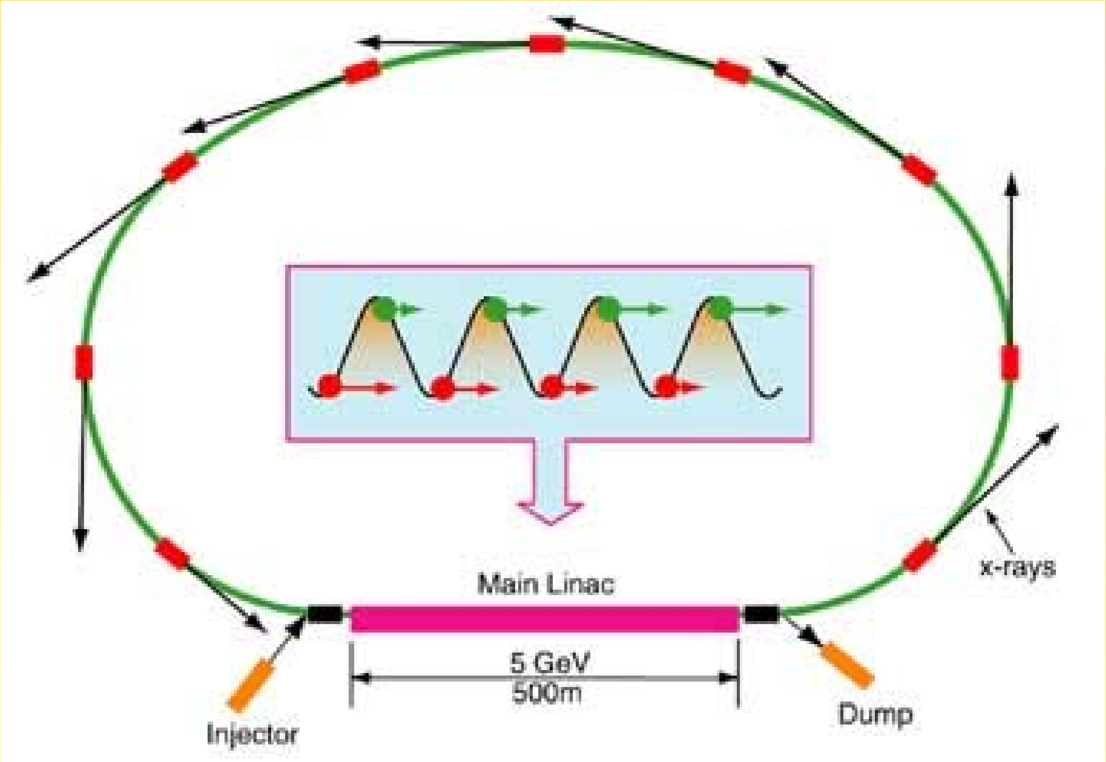
BCP phase diagram



uptake of selective solvent

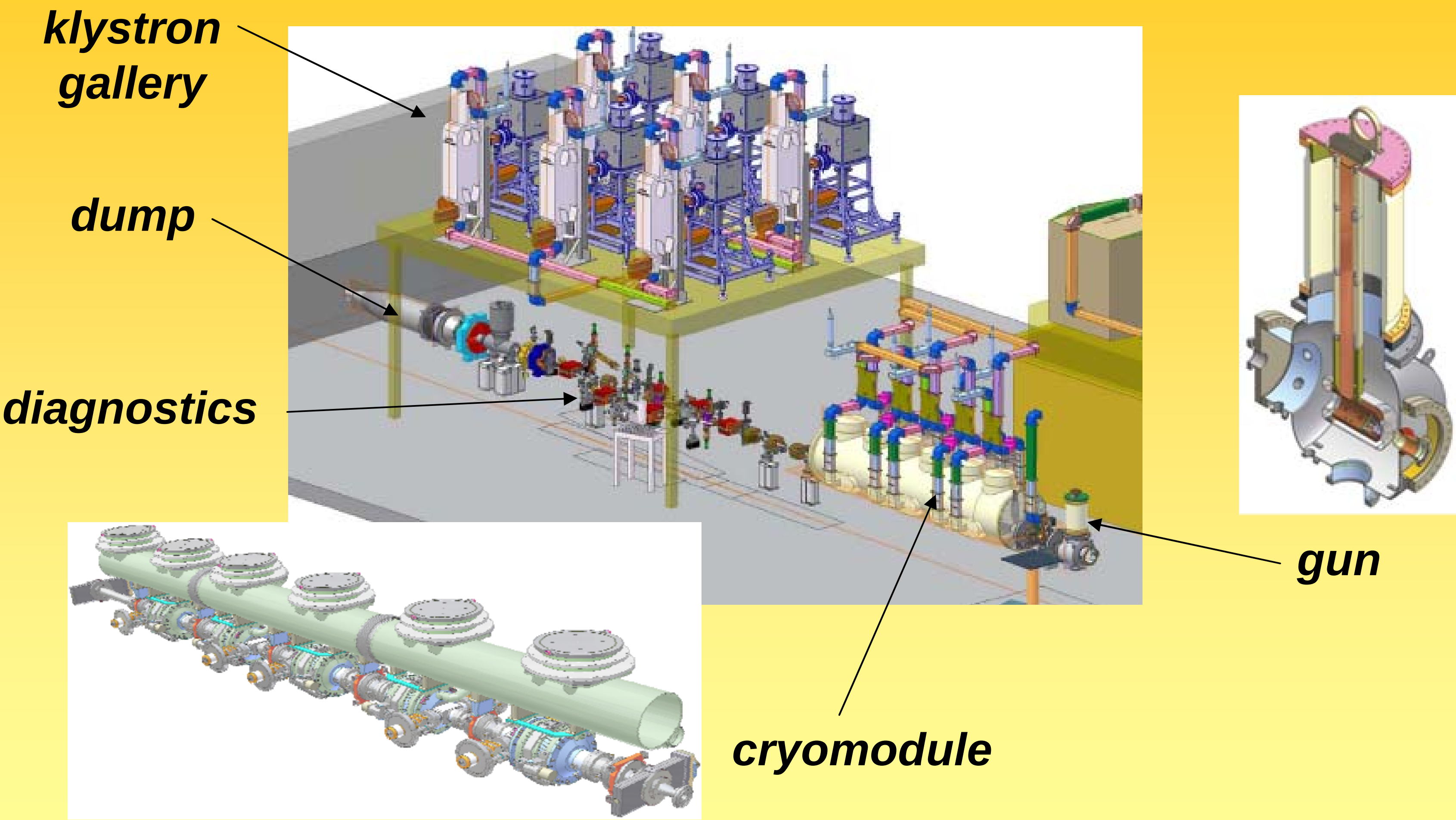
- swelling of solvable block > v_A
- rescaling of A-B interaction > χN

Energy Recovery Linac Light Source

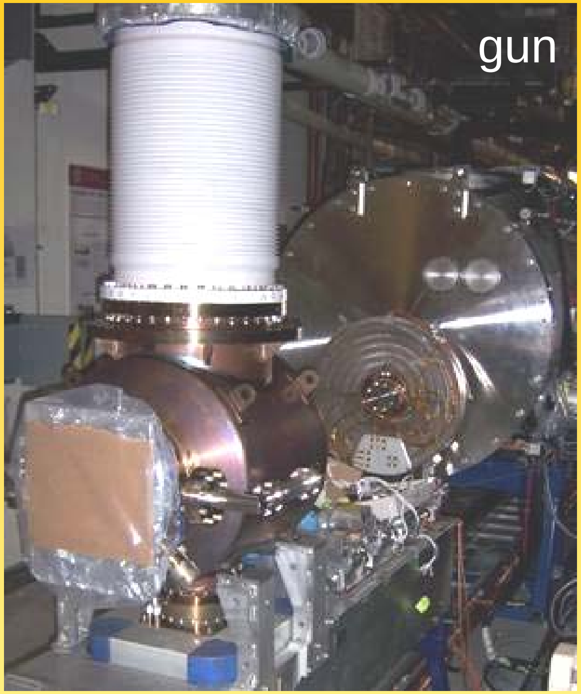


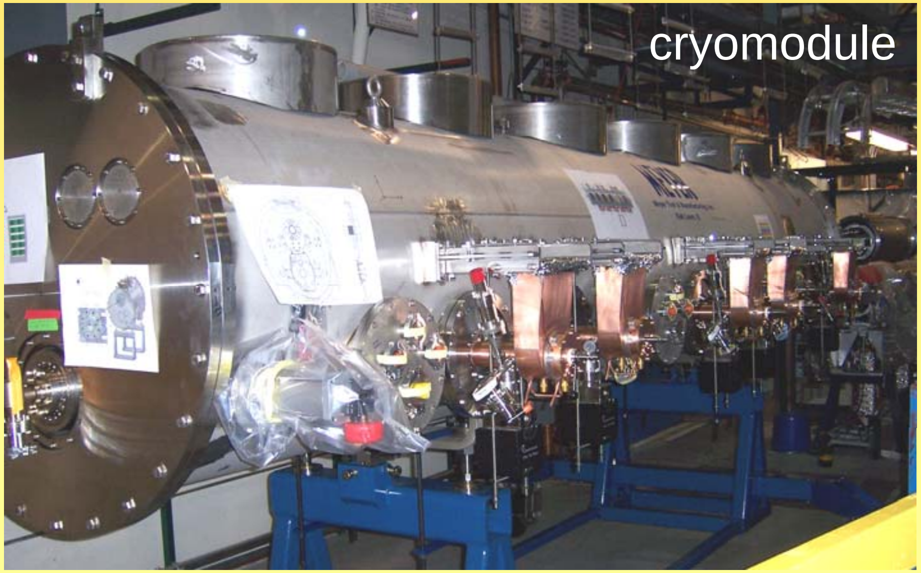
>> extending current 3rd generation sources <<

Cornell ERL: Phase 1A

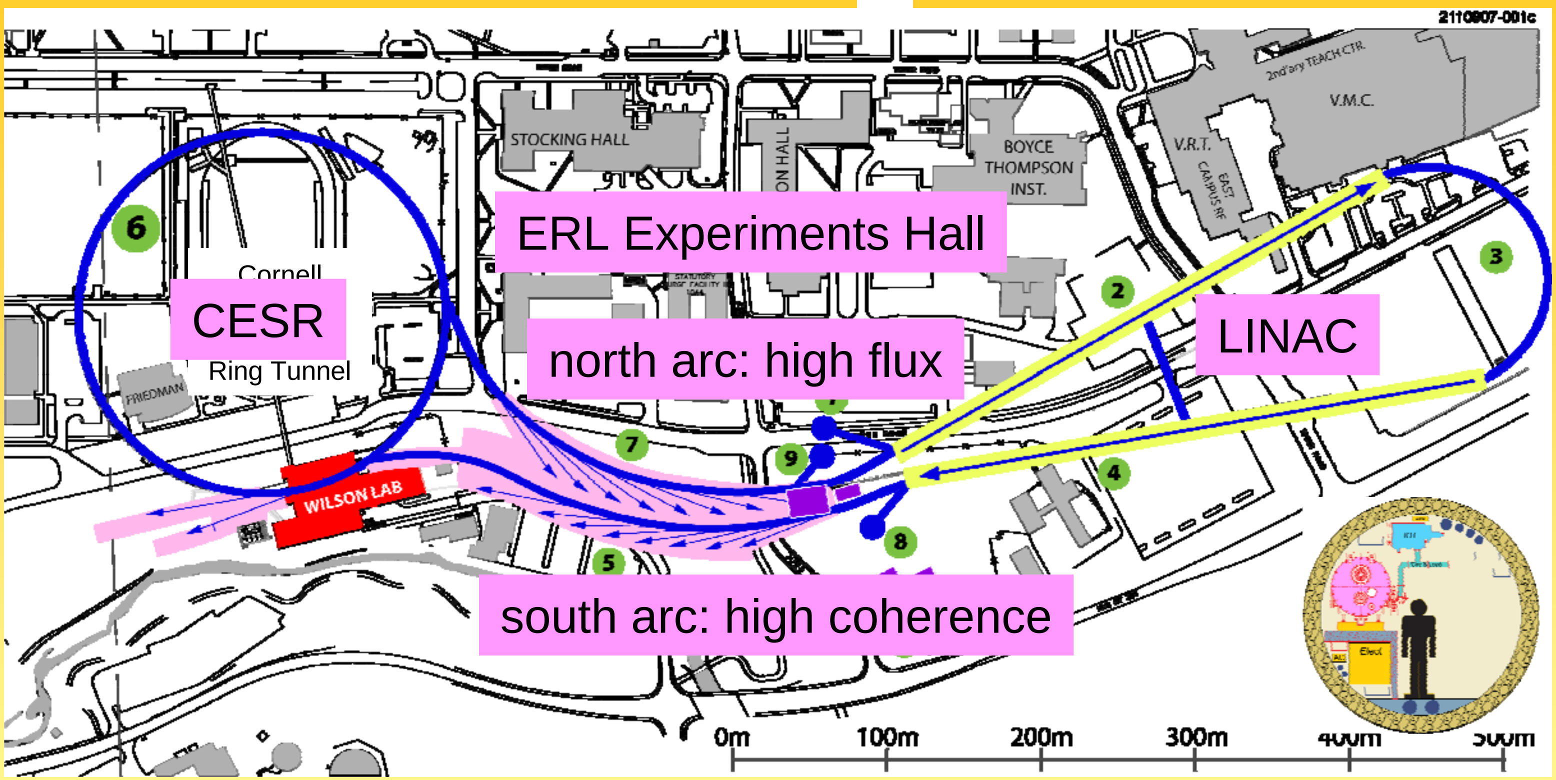


ERL Phase 1A Photographs





Cornell ERL Project



- funding for phase 1A: development of photo injector
- proposal for phase 1B: further development
- science proposal for **phase 2**: full facility

ERL Beamline Projects
- Joel Brock -

- *Don Bilderback: nanofocus (1nm)*
- *Joel Brock: ultrafast scattering (100 fs)*
- *Darren Dale: coherent scattering (CDI, XPCS)*
- *Ken Finkelstein: inelastic scattering (meV, eV)*
- *Detlef Smilgies: microbeam scattering*
  - *Christian Riekel, ESRF*
  - *Lois Pollack, Cornell*
  - *Ron Pindak, NSLS, Brookhaven Nat'l Lab*

A Microbeam Scattering Beamline for the ERL

ERL key features:		
❖ small source size	>>>	focus size – ***r***-resolution
❖ small divergence	>>>	flux & ***q***-resolution
❖ round beam	>>>	***r*** & ***q*** resolution in 2D
❖ high coherence	>>>	high performance optics – flux
❖ high brilliance	>>>	time-resolved studies (μsec, msec)

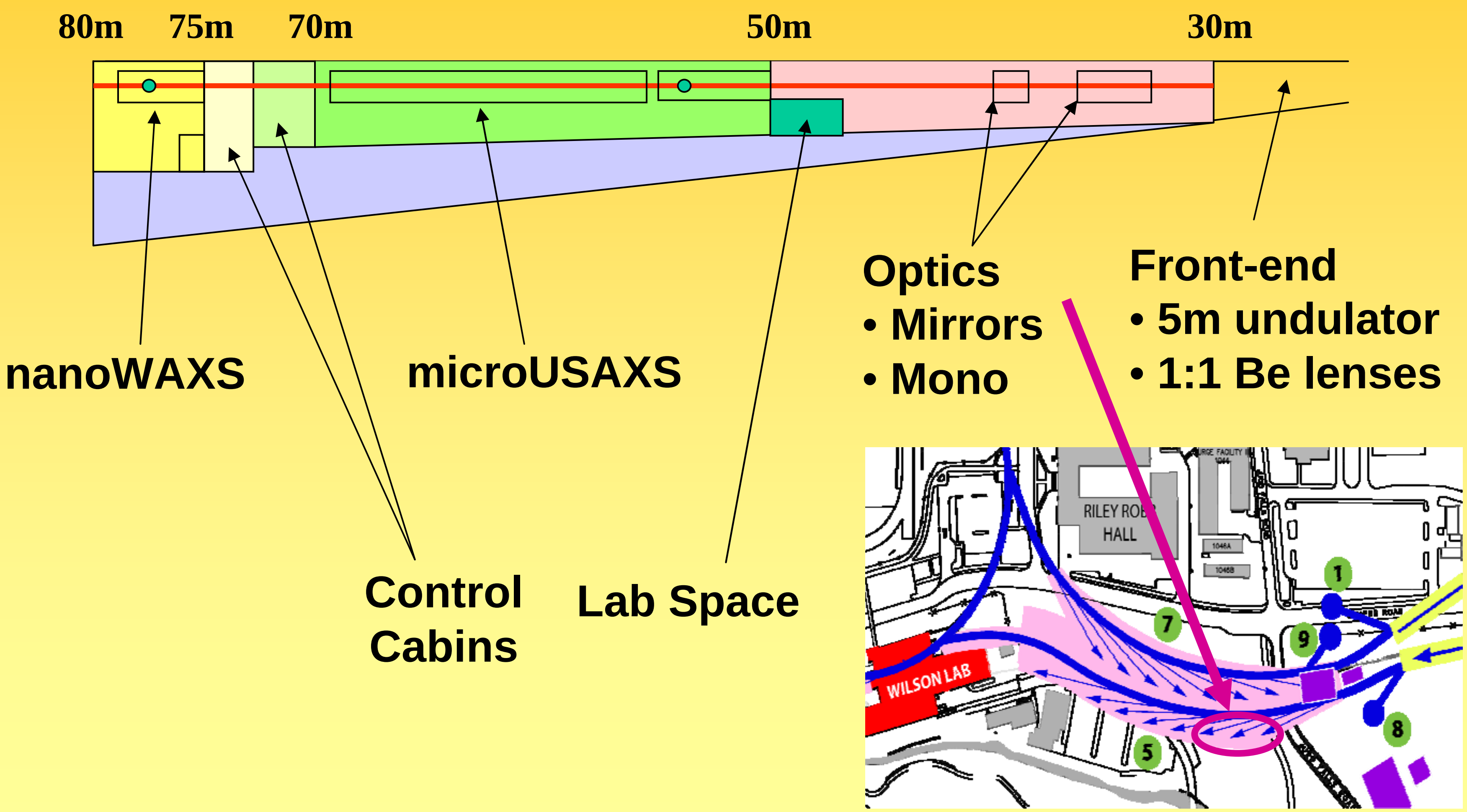
>> An ERL is the ideal source for microbeam scattering. <<

Microbeam Scattering Beamline Suite

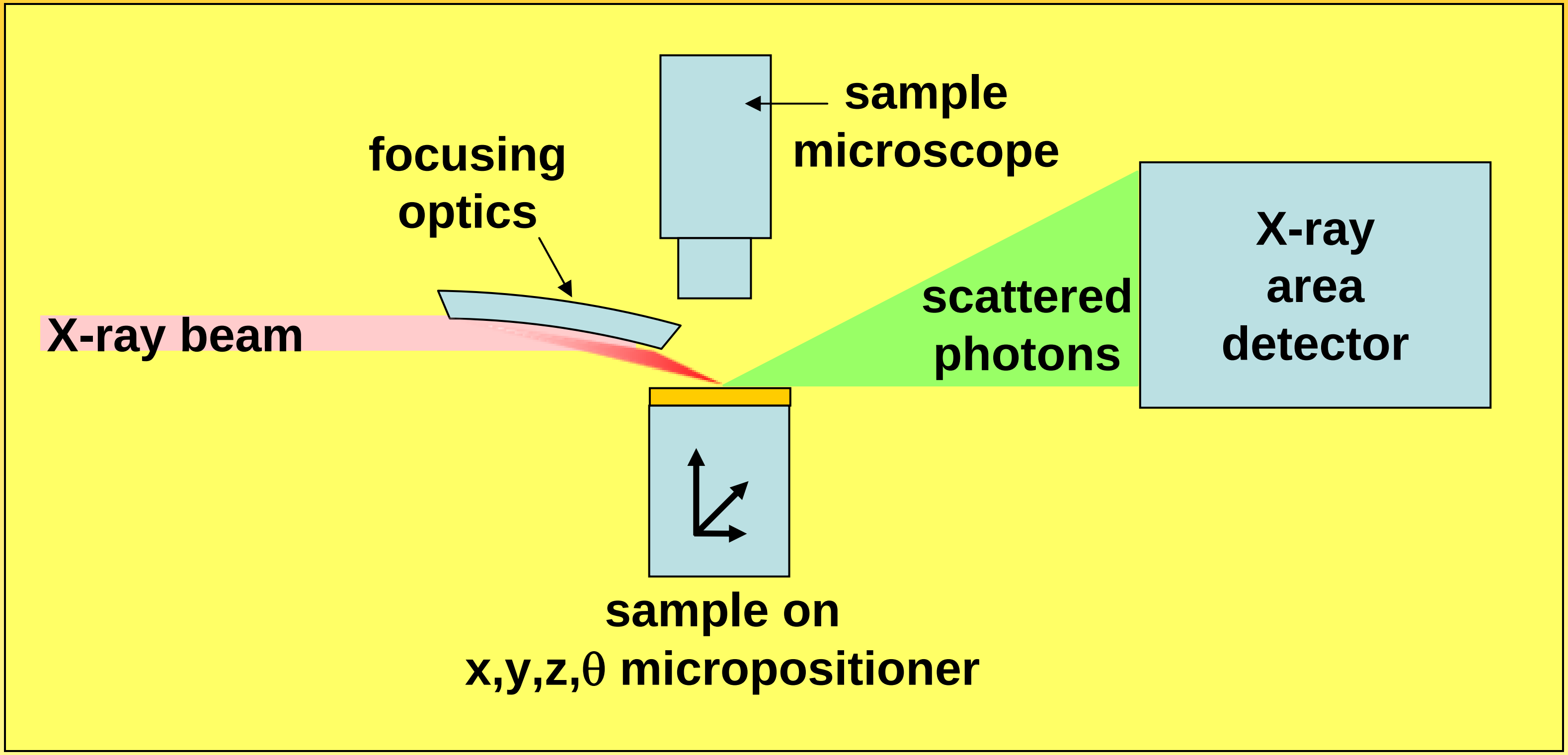
Microbeam Scattering – Applications

- Hard Materials – grain structure, local structure, interfaces
- High Pressure – ultrahigh pressure, laser heating
- Protein Crystallography – protein microcrystals
- Soft & Biologic Materials – complex materials
    - hierarchic materials (bone, muscle, wood, tissue)
    - biomimetic materials
    - microfluidics: fast mixing & combinatorics
    - devices: organic electronics & biosensors

A Microbeam Scattering Beamline for Soft Materials at the ERL

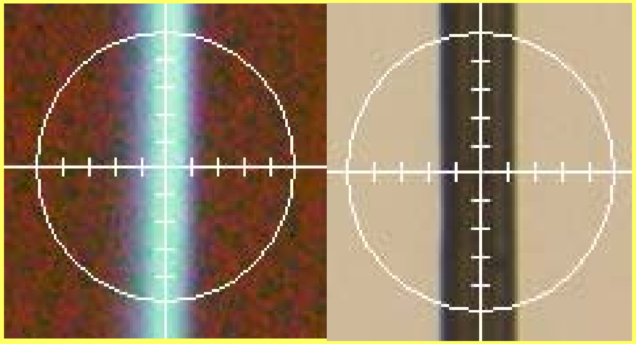


A microGIWAXS setup at CHESS D1

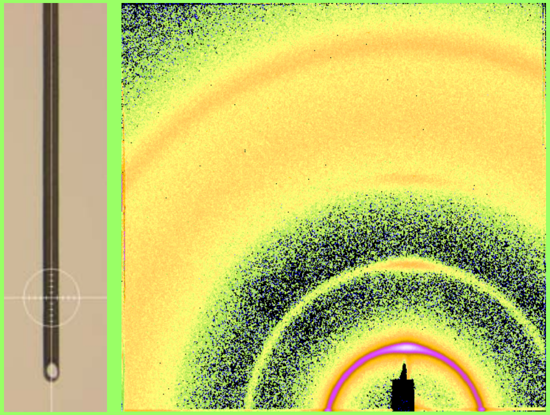


>> gaining experience for a future ERL beamline

Example: Polythiophene Microstrips



How to put a 20 μm sample into a 20 μm beam: sample microscope!



grazing-incidence μWAXS

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Sterling Cornaby, Cornell A&EP + CHESS

T. Miyajima, KEK & Cornell ERL groups

Samples: ***CMU Chemistry, Cornell MS&E***