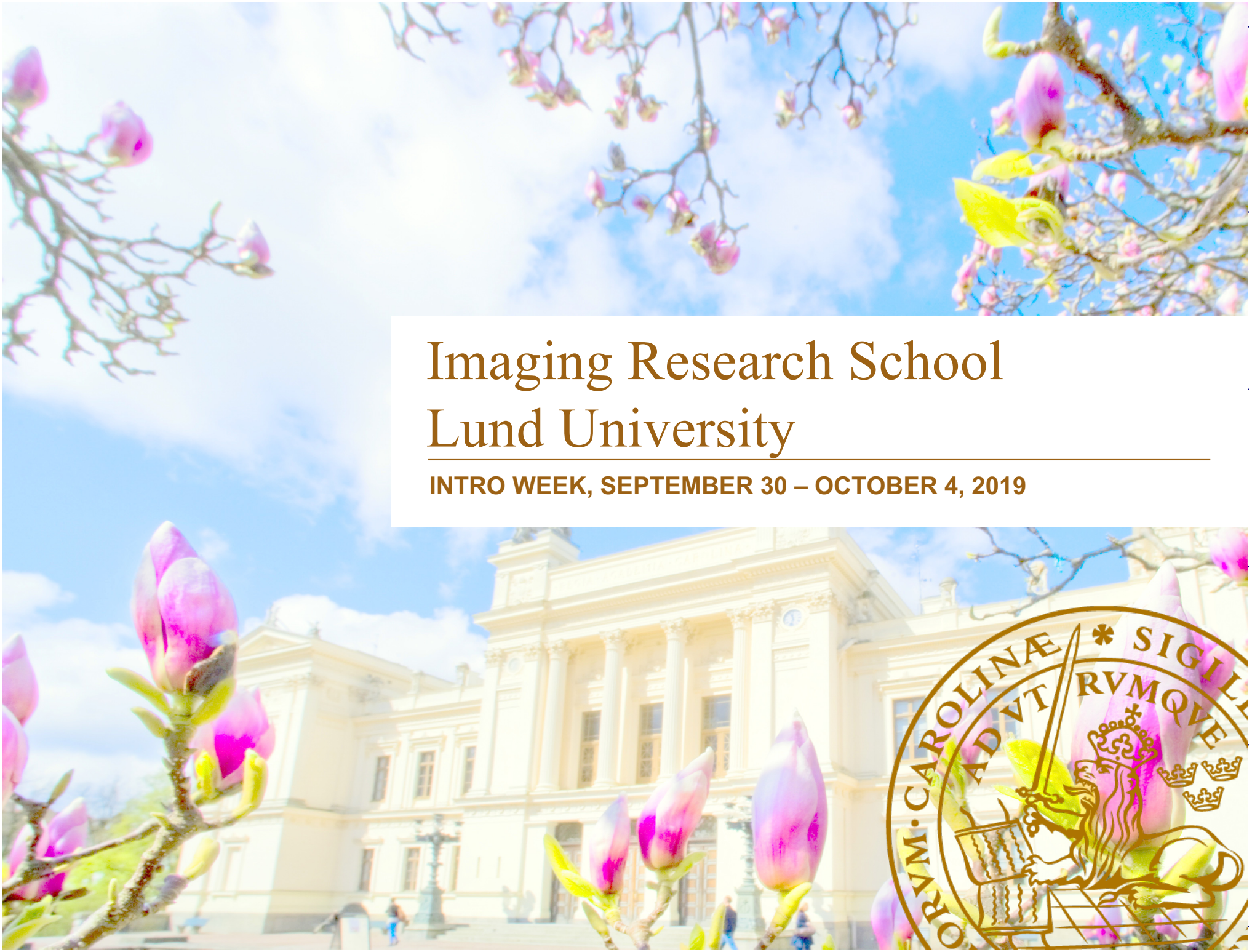

Imaging Research School
Lund University

INTRO WEEK, SEPTEMBER 30 – OCTOBER 4, 2019

Imaging Research School

- School coordinator
  - Martin Bech, Faculty of Science
- Concept developers
  - Steve Hall, Faculty of Engineering (LTH)
  - Jens Lagerstedt, Faculty of Medicine
  - Kajsa Paulsson, Faculty of Medicine
- First time to be hosted at LINXS

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Martin Bech

- Universitets lektor (associate professor) Department for Medical Radiation Physics
- Spokesperson for MedMAX beamline
- Coordinator of Imaging Research School

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Martin Bech

- Danish
- Studied **Physics** at the Niels Bohr Institute in Copenhagen.
- Field of research:
  - Dark-field and Phase-contrast x-ray imaging
  - Bio-medical applications

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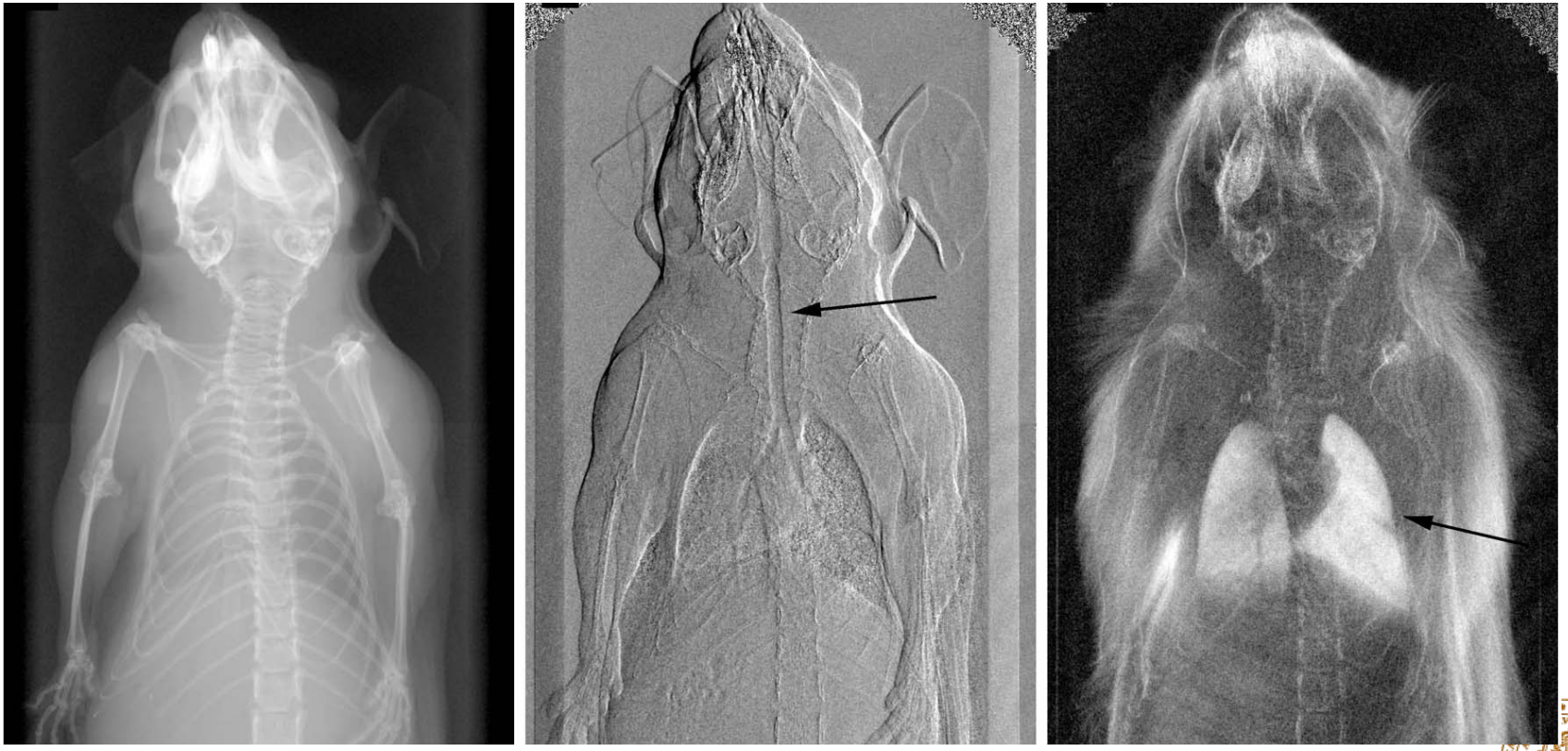
Martin Bech
Mouse x-ray scanner

Standard Phase-Contrast Dark-field



Nature Scientific Reports, November 2013

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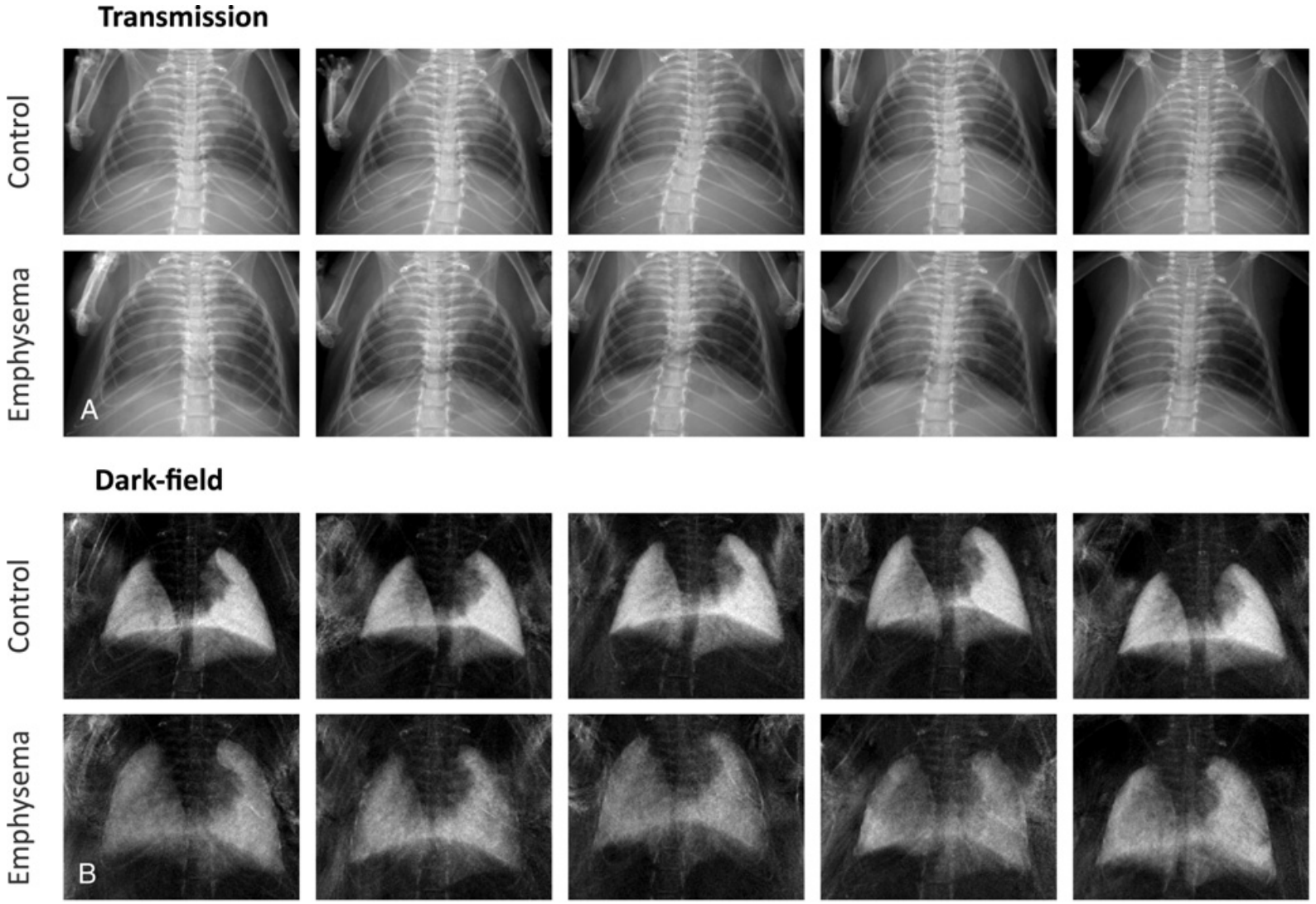
Martin Bech
Mouse lung in-vivo emphysema study



Investigative Radiology, 2014

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Imaging Research School

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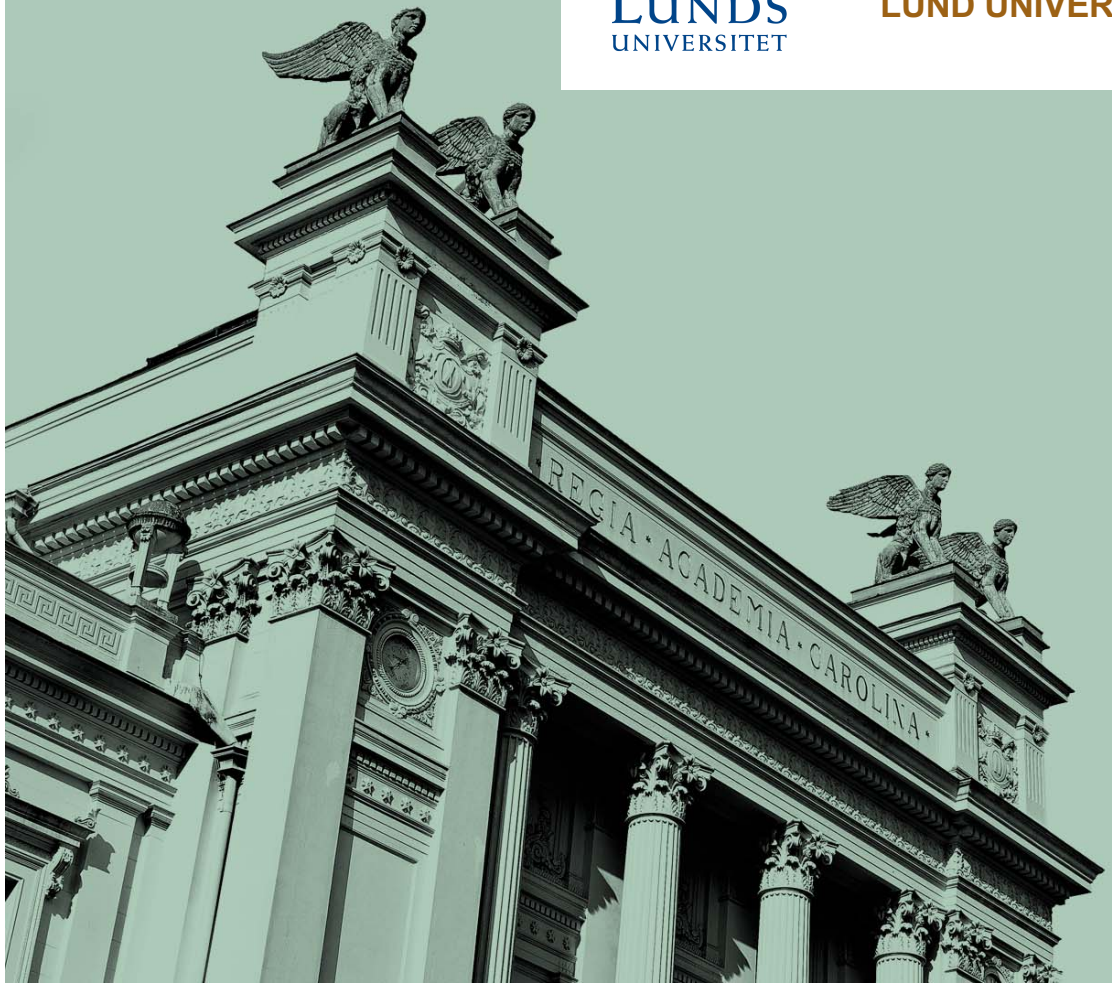
LUNDS UNIVERSITET



Imaging Research School

» Intention of School

– To create a **network** of researchers (young and senior) working with x-ray/neutron imaging

– To **educate** researchers in the field of x-ray/neutron applications in particular at Max-IV and ESS

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Programme for the Imaging Research School

- The school will involve a **“summer school”** with presentation and poster session (3 ECTS)
- Individual project and report, with oral presentation (4.5 ECTS)
- Students may **choose** to collect all credit points during one year, or during 2-3 years
- Furthermore, each student has the opportunity to specialise in a particular imaging area by following **specialised courses**.

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Programme for the Imaging Research School, core courses

- A week of **introductory lectures** covering the different areas of imaging at large-scale facilities. This will followed up by course assignments (total 3 ECTS)
- Course assignment: beamtime application

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Programme for the Imaging Research School, core courses

- An individual project/report *(presentations in May 2020). Projects will involve **hands-on** experience using tomography facilities (data acquisition, image analysis and visualisation)* (total 4.5 ECTS)
- Presentation to group on specific subject at the end-of-year **wrap-up meeting** *(May 2020)*

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Programme for the Imaging Research School, specialised courses

- Suggested courses:
  - PhD course in X-ray microscopy
    - the course will be held as a one-week course, full time, Jesper Wallentin (ADMIRE + IMAGING) http://www.admire.lu.se/courses/x-ray-microscopy/
  - Admire – image analysis (7,5 credits)

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Programme for the Imaging Research School, summer schools

» Summer/winter schools:

- MAXIV summer school https://www.maxiv.lu.se
- Helmholz Berlinwww.helmholtz-berlin.de/events/neutronschool/
- ESRF (Grenoble) X-rays / neutrons www.hercules-school.eu

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Intro week Programme

» Programme.pdf

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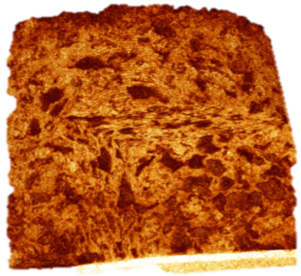
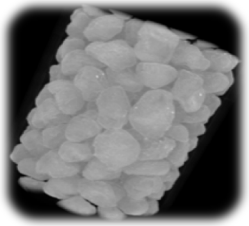
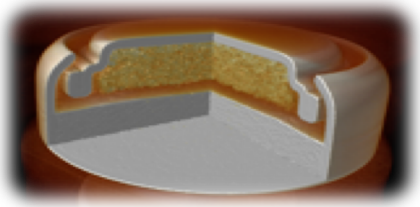
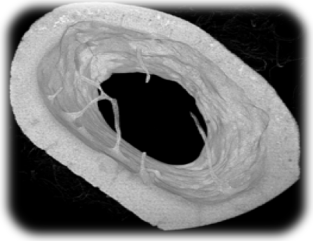
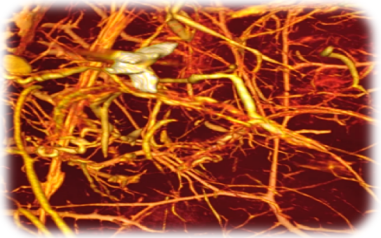
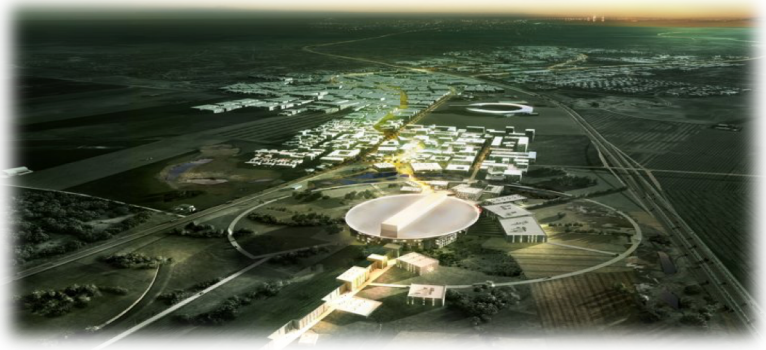
Welcome to the Imaging Research School





» www.imagingresearch.lu.se

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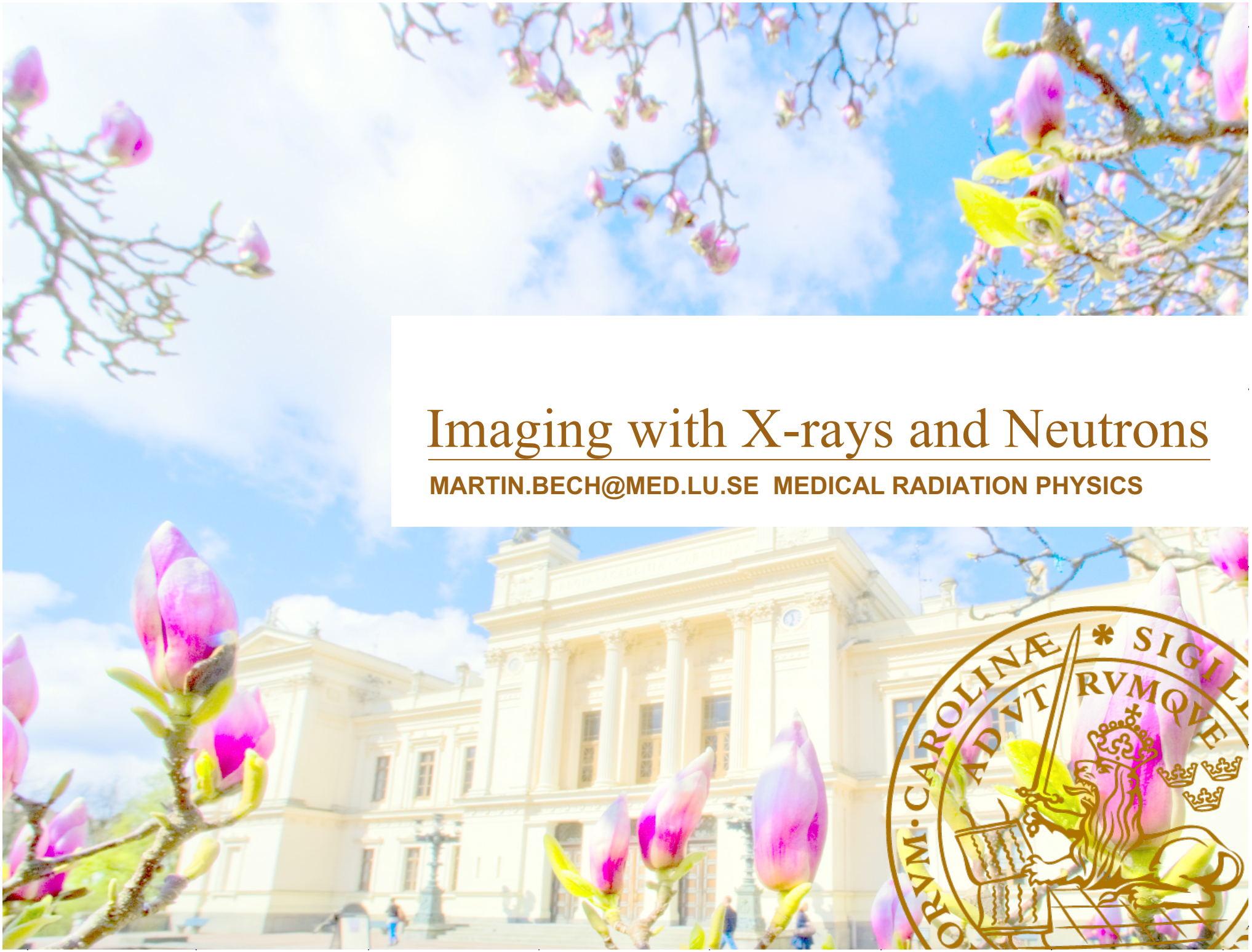

Imaging with X-rays and Neutrons

MARTIN.BECH@MED.LU.SE MEDICAL RADIATION PHYSICS

X-rays and Neutrons

» Are “the same” in many respects:

- Particle wave duality
- Diffraction
- Scattering
- Interference

X-rays and Neutrons

» Have very different properties:
  – Cross section, mass, spin, velocity, …

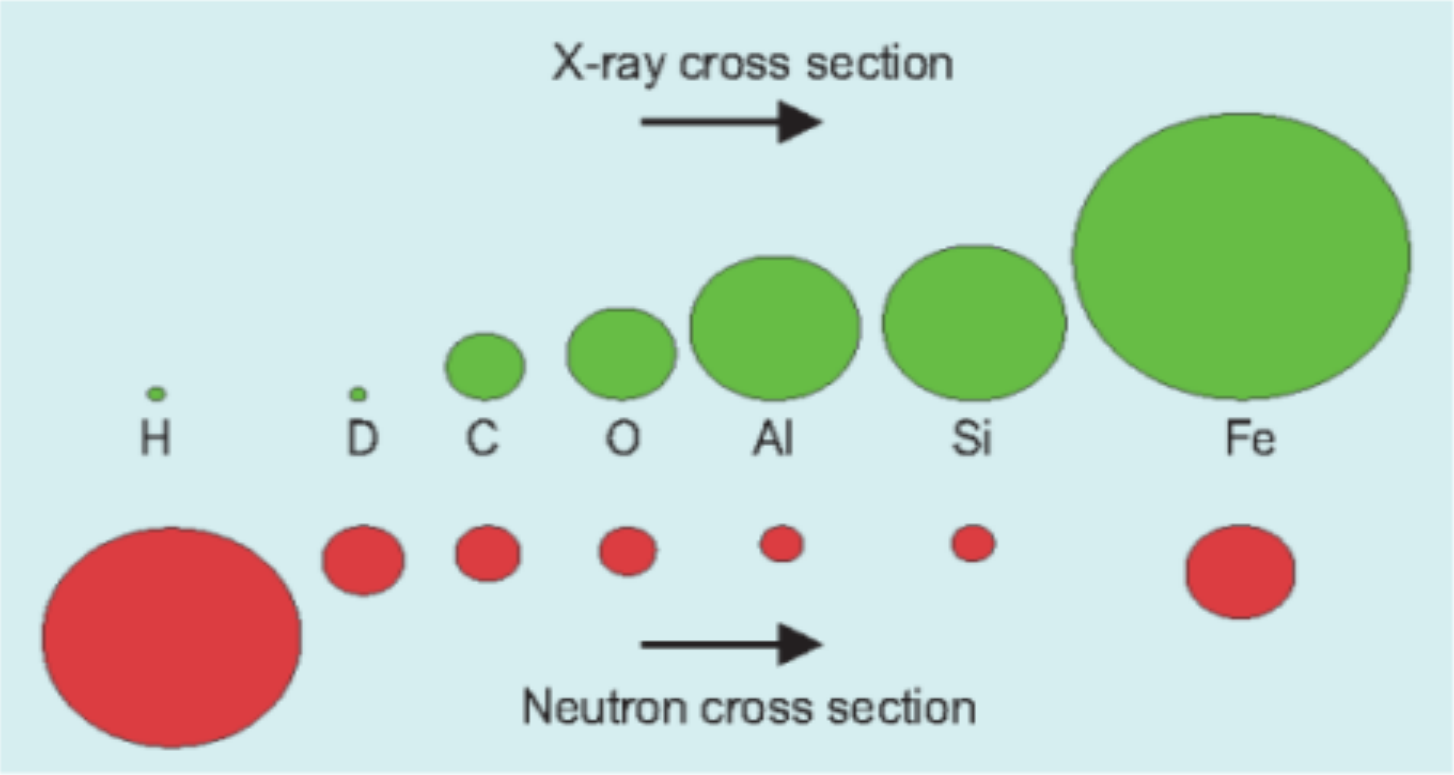

Fig. 2. Neutron and x-ray scattering cross-sections compared. Note that neutrons penetrate through Al much better than x rays do, yet are strongly scattered by hydrogen.

Source: www.ncnr.nist.gov

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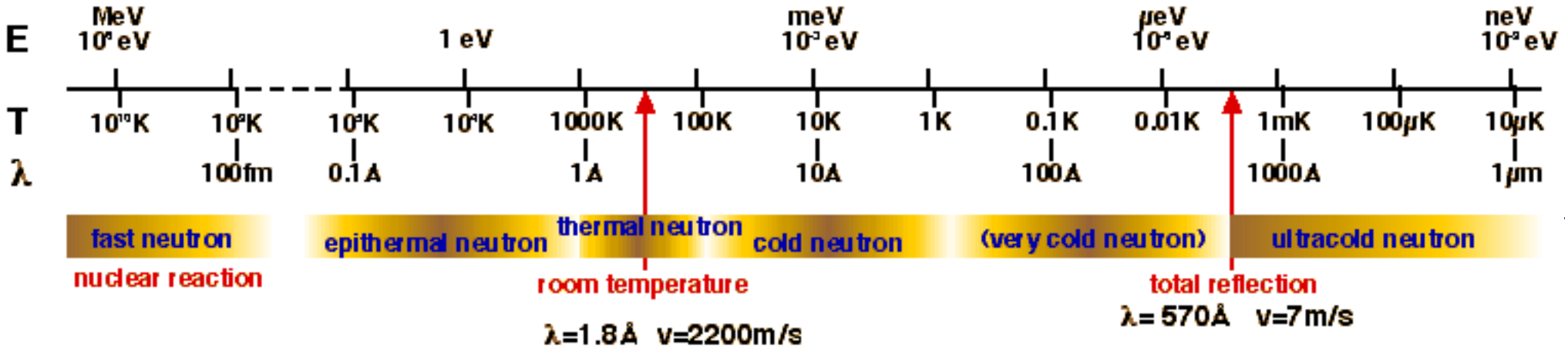
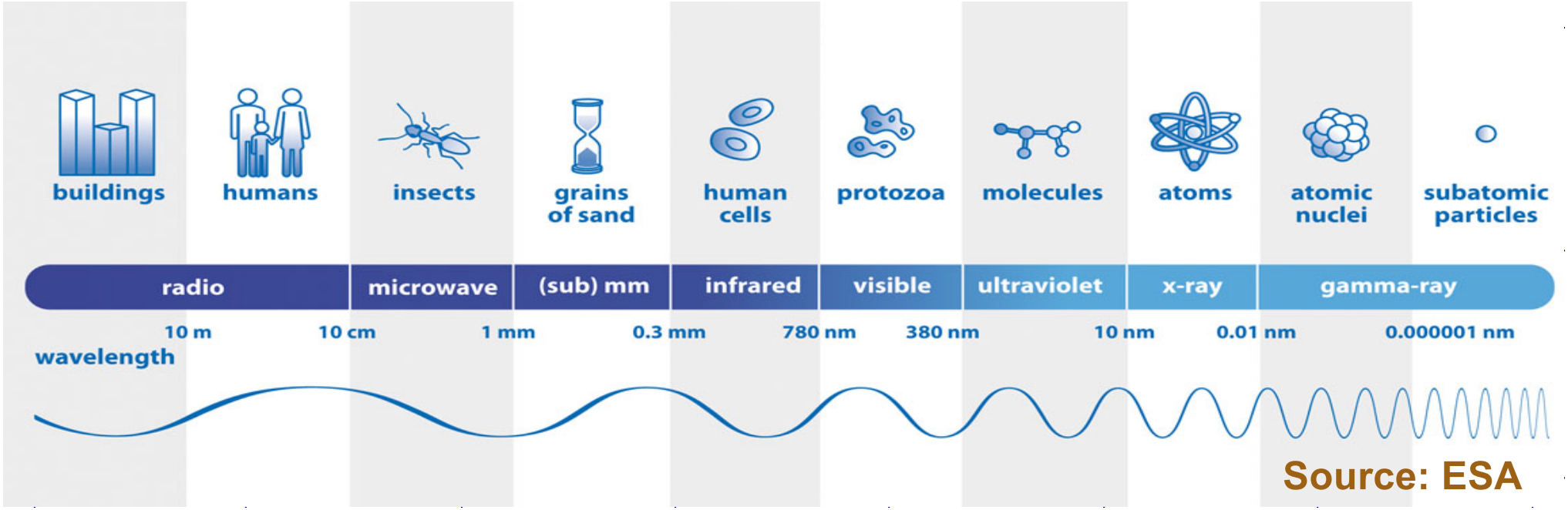
Wavelength of X-rays and Neutrons

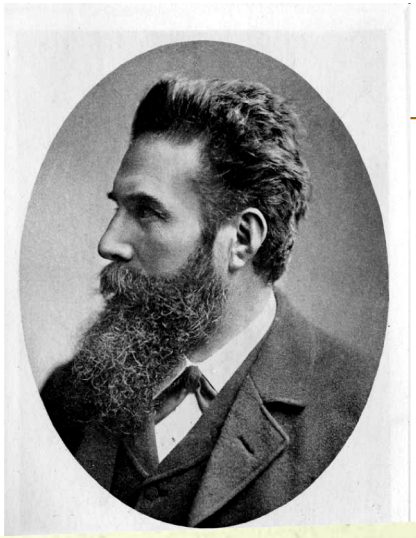


Source: http://nop.kek.jp



Source: ESA

Röntgen was also looking for refraction…



W. C. RÖNTGEN

ÜBER EINE NEUE ART VON STRAHLEN

SITZUNGSBERICHTE
IZINISCHEN GESELLSCHAFT ZU WÜRZBURG
, S. 132 UND JAHRGANG 1896, S. 10

W. C. RÖNTGEN
ER GESELLSCHAFT DIE ERSTE MITTEILUNG
IM ENTDECKTEN STRAHLEN VOR

NEUDRUCK
ES 100JÄHRIGEN BESTEHENS
ALISCH-MEDIZINISCHEN
HAFT ZU WÜRZBURG

RÜNDET 1849 VON
ECKER · J. SCHERER · R. VIRCHOW
UND ANDEREN

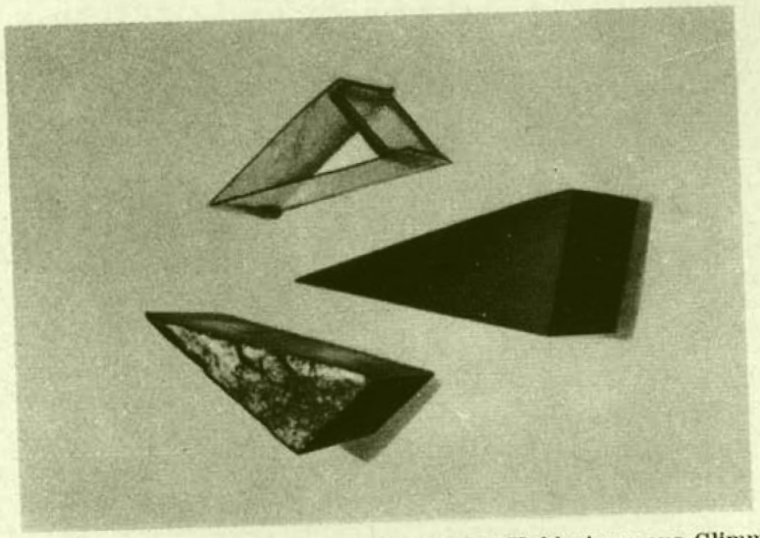
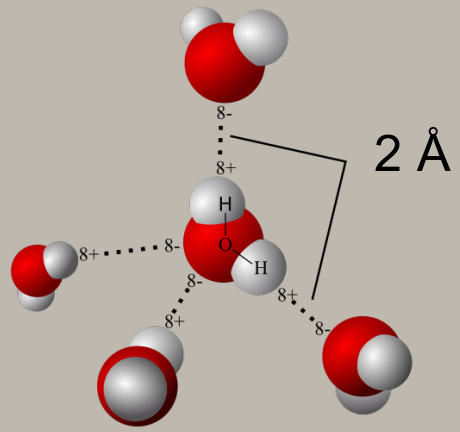


Bild 5. Prismen aus Hartgummi und Aluminium und Hohlprisma aus Glimmerplättchen wurden auf die horizontale Bleiplatte von Bild 4 gesetzt; etwaige Ablenkung der Strahlen hätte auf diese Weise erkennbar werden müssen (vgl. Abschnitt 7).

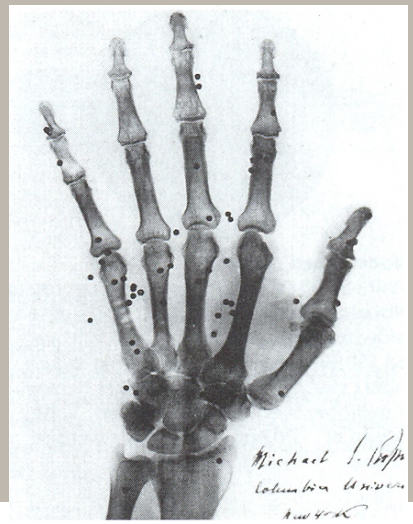
Imaging at different length scales

- Atomic



- Microscopic

- Macroscopic



Neutron and Synchrotron Radiation

» What is a neutron/synchrotron radiation facility?

  – Monday

» How do we use it for better imaging?

  – Tuesday through Thursday

  – what is coherence and what is phase contrast imaging?

ESRF and ILL, Grenoble France

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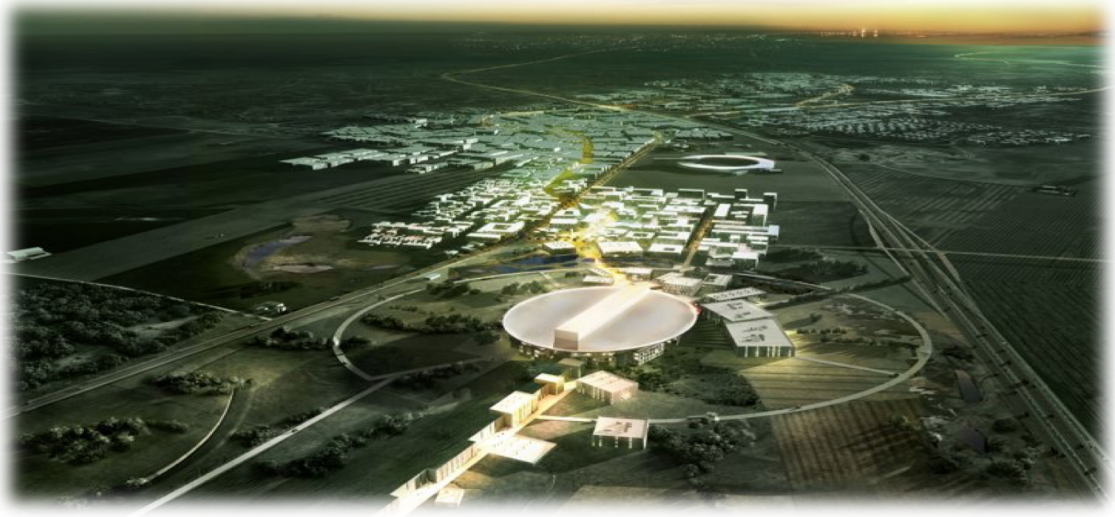
Swiss Light Source and Neutron Spallation source, Villigen Switzerland

Lund facilities (Friday) for X-ray and Neutron Science

» MAX-IV

» European Spallation Source, ESS



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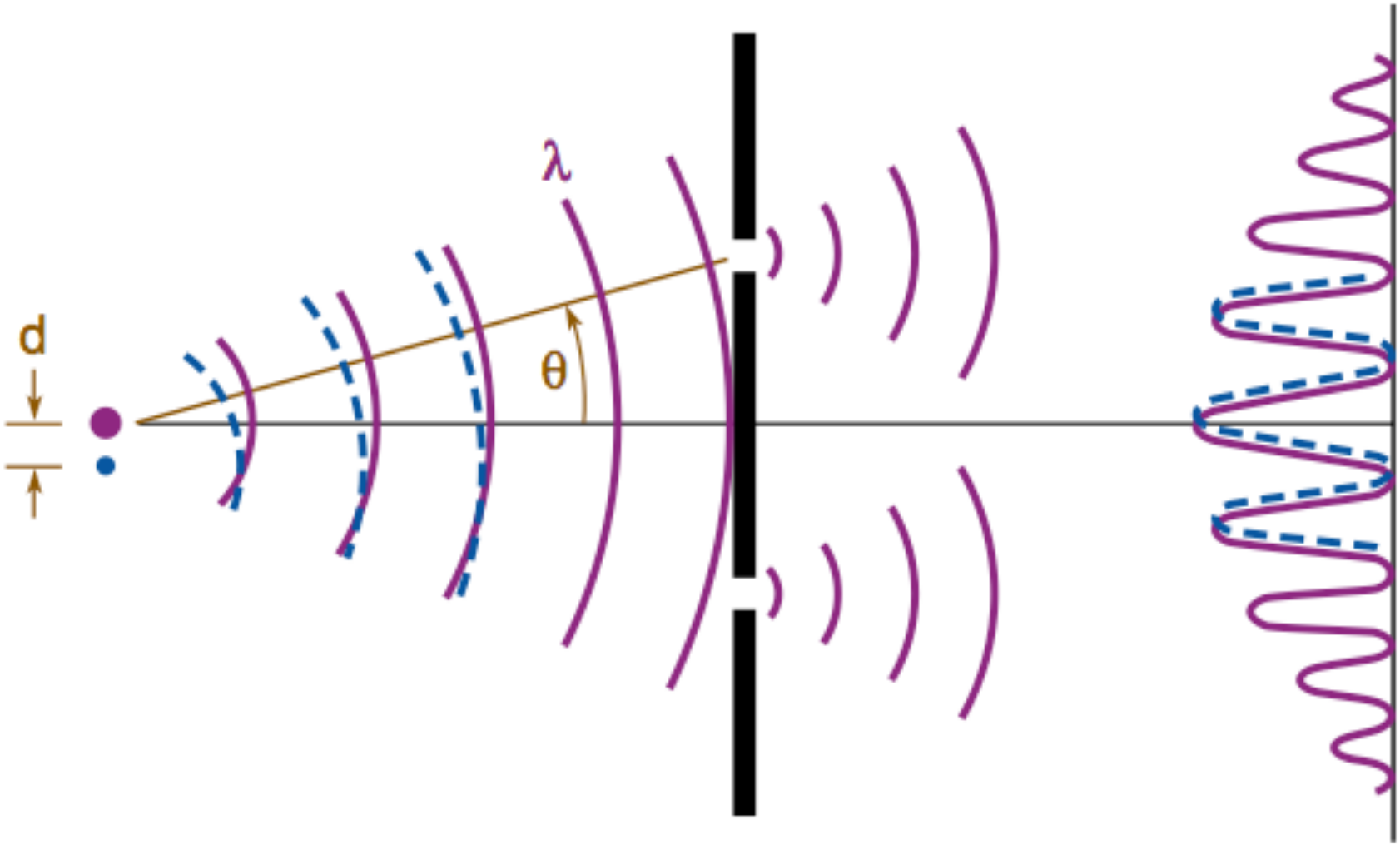
Synchrotron Radiation

- what is coherence?
- what is phase contrast imaging?

Coherence

» Ability to interfere due to particle/wave duality



Imaging regimes

Wave propagation:

Fresnel number: $F = \frac{a^2}{\lambda Z}$

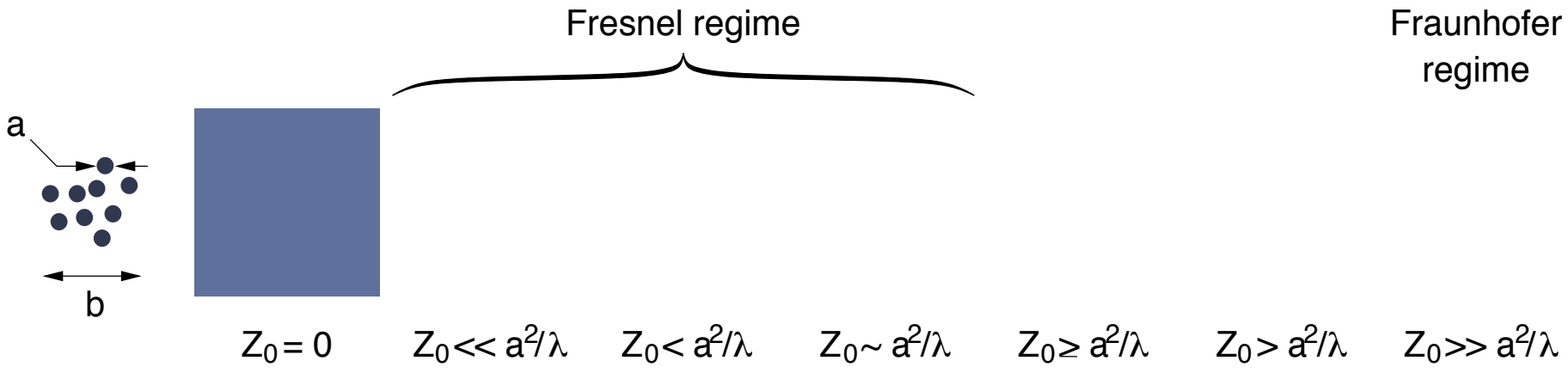
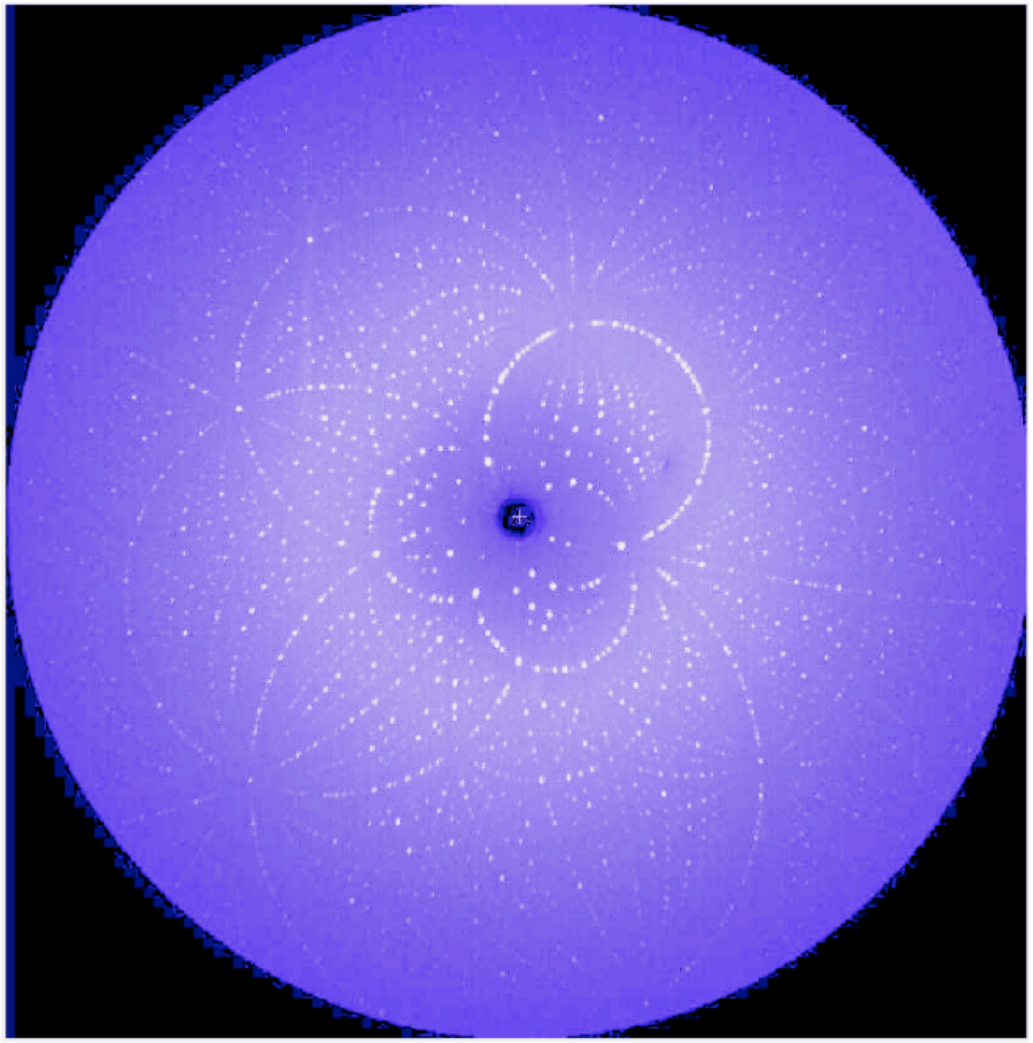


Figure courtesy: Timm Weitkamp; Phil Willmott

X-ray Diffraction (Wednesday)
Crystallography and Structural biology



Far-field imaging

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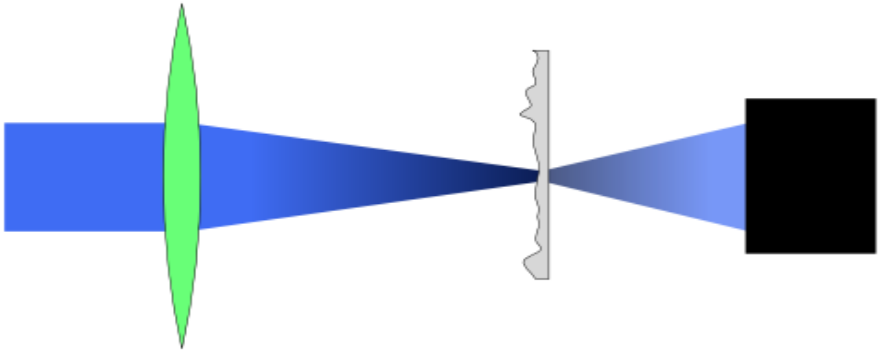
Refraction based imaging (Thursday)
Coherent Diffractive Imaging CDI

Far-field imaging



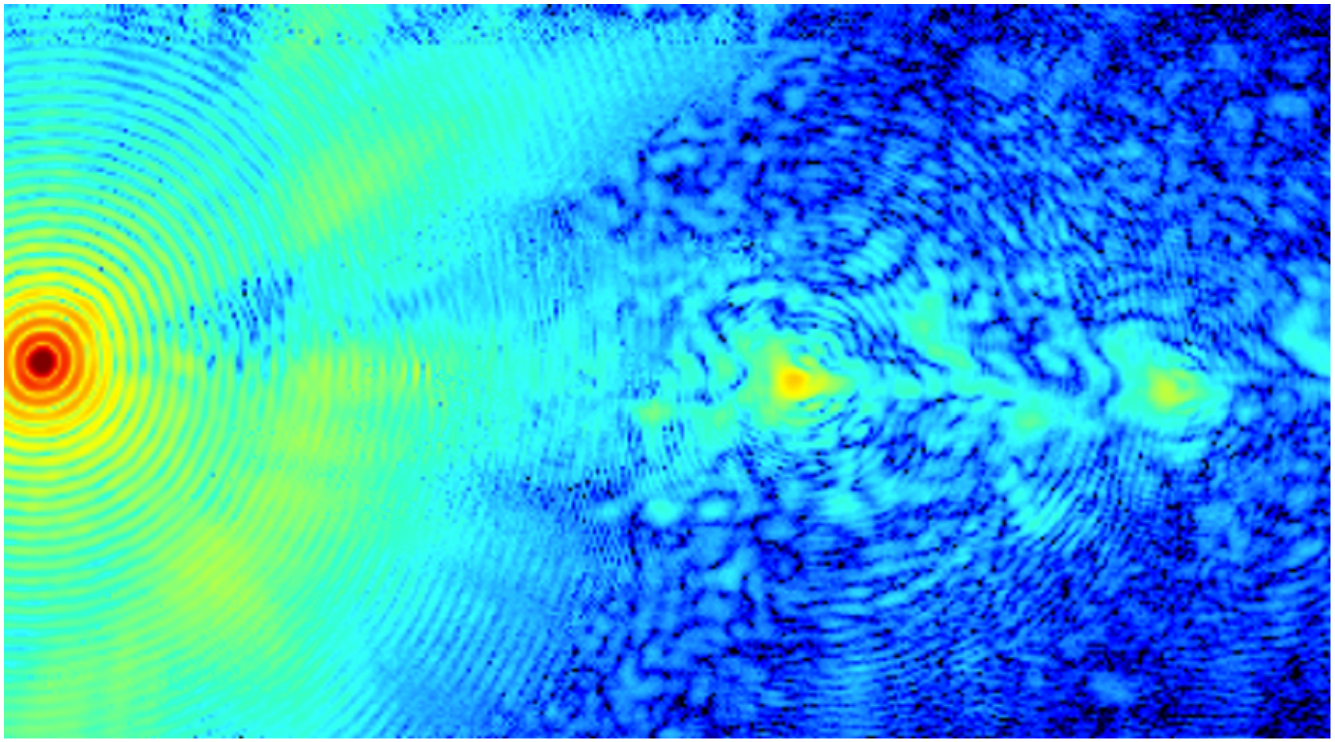


Figure courtesy: Pierre Thibault

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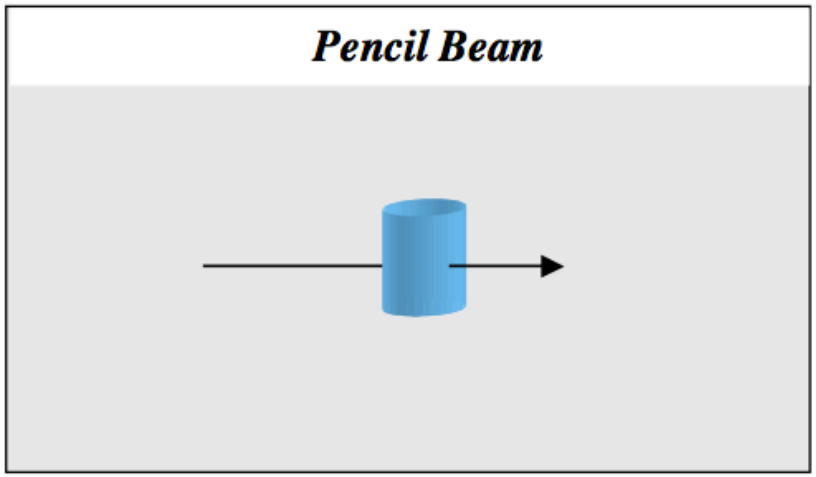
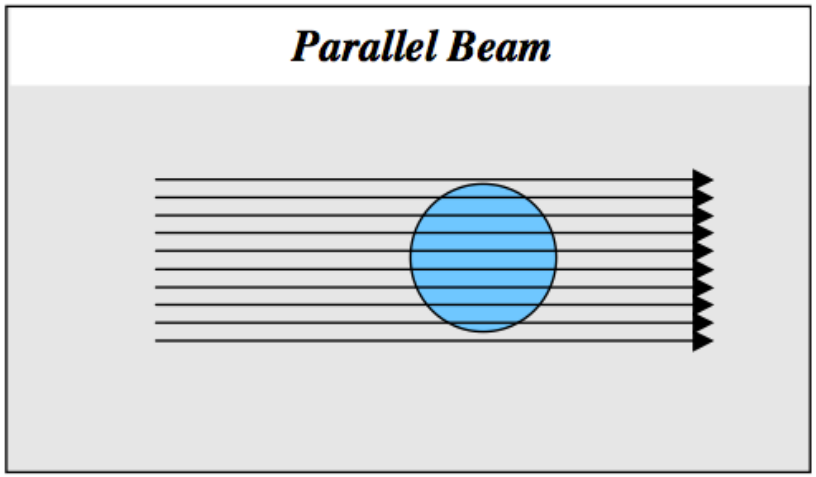
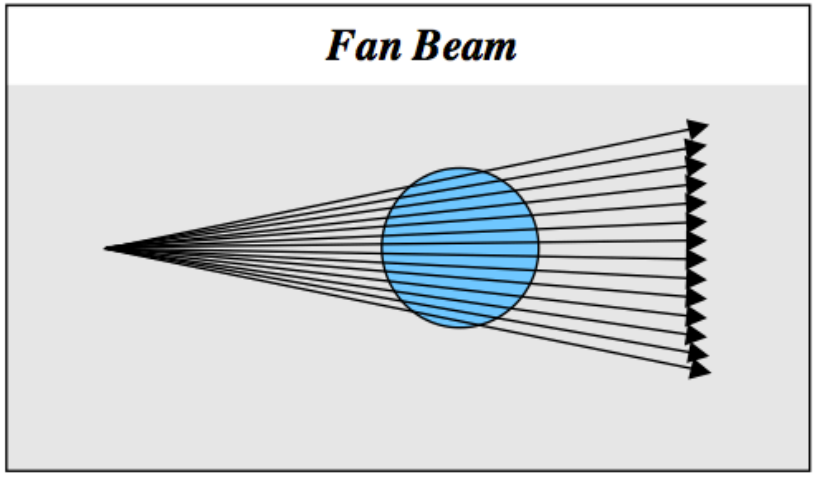
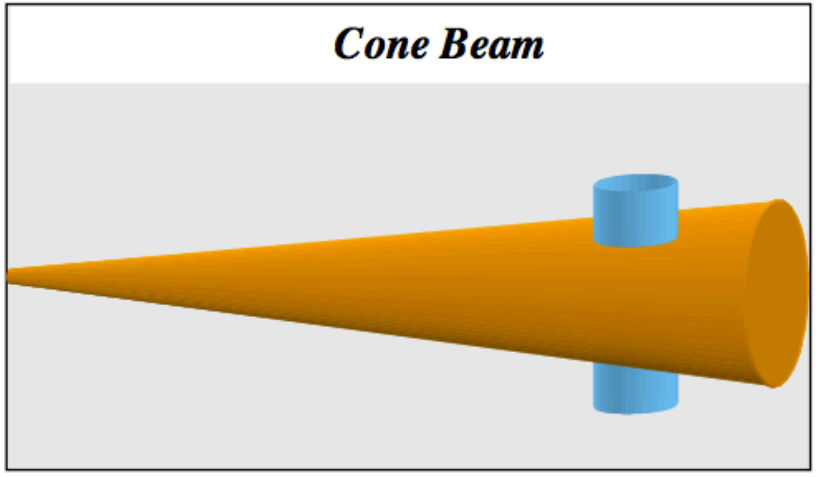
Full field vs pencil beam









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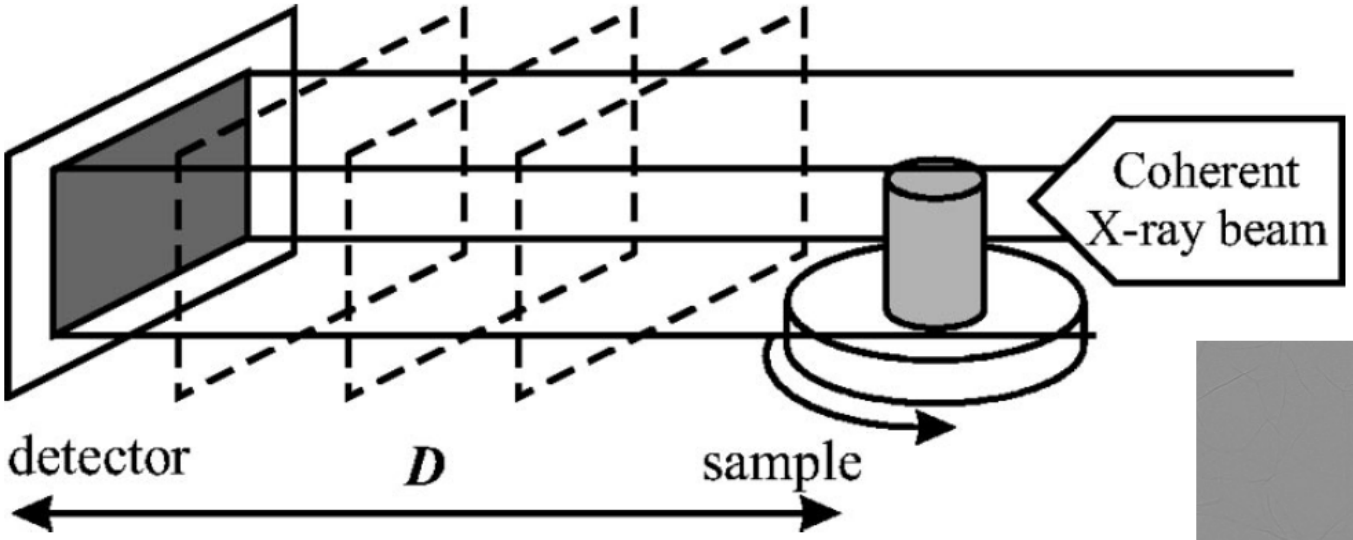
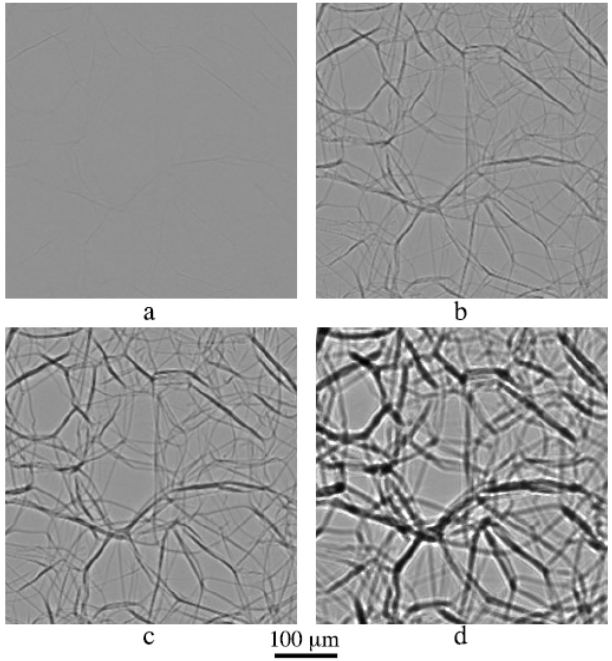
Refraction based imaging (Tuesday/Thursday)

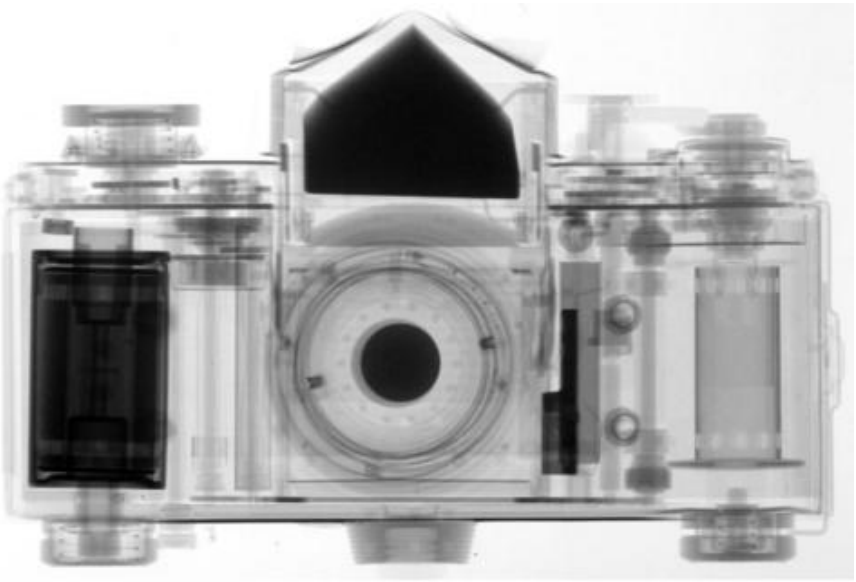
X-ray Phase Contrast Imaging



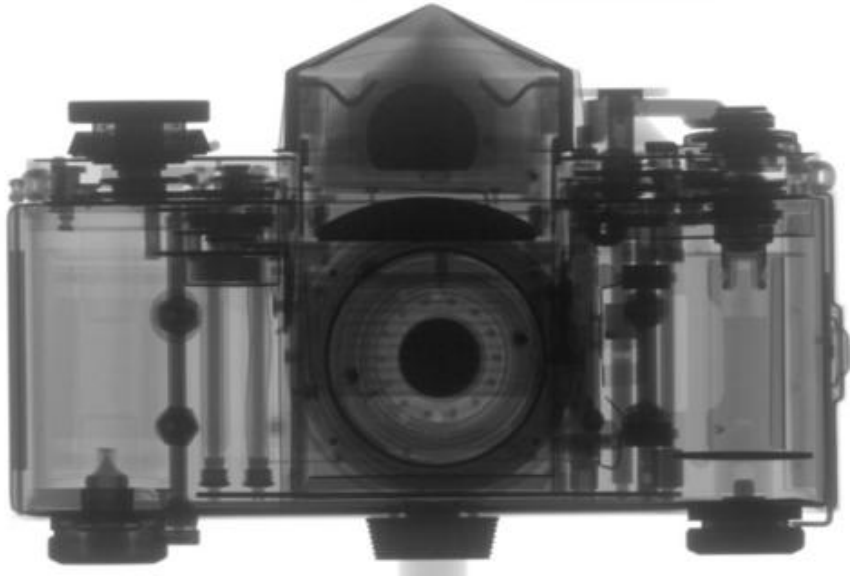


Polystyrene foam.
P. Cloetens 1999

Absorption based imaging (Tuesday/Wednesday)



Neutron Image



X-ray Image

Source: PSI
www.psi.ch/niag/what-is-neutron-imaging

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