wissen schafft nutzen

GKSS FORSCHUNGSZENTRUM

# Standardization of SRμCT for high throughput maintaining the dynamic range and contrast

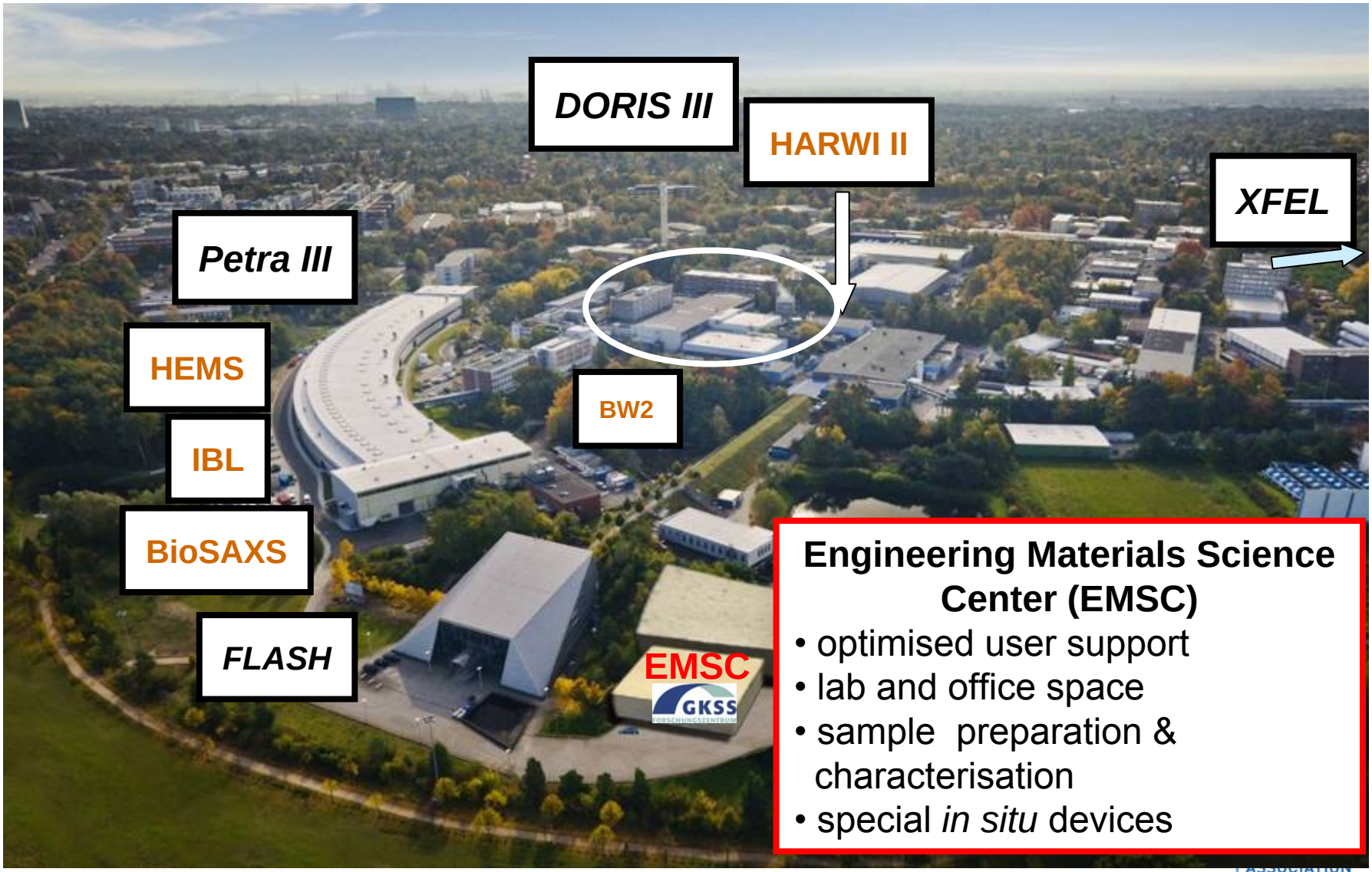
**F. Beckmann: GKSS-Research Centre Geesthacht**

HDRI-Workshop: Standard Data Formats, 27th November 2010

HELMHOLTZ ASSOCIATION

# GKSS Outstation at DESY






**Engineering Materials Science Center (EMSC)**

- optimised user support
- lab and office space
- sample preparation & characterisation
- special *in situ* devices

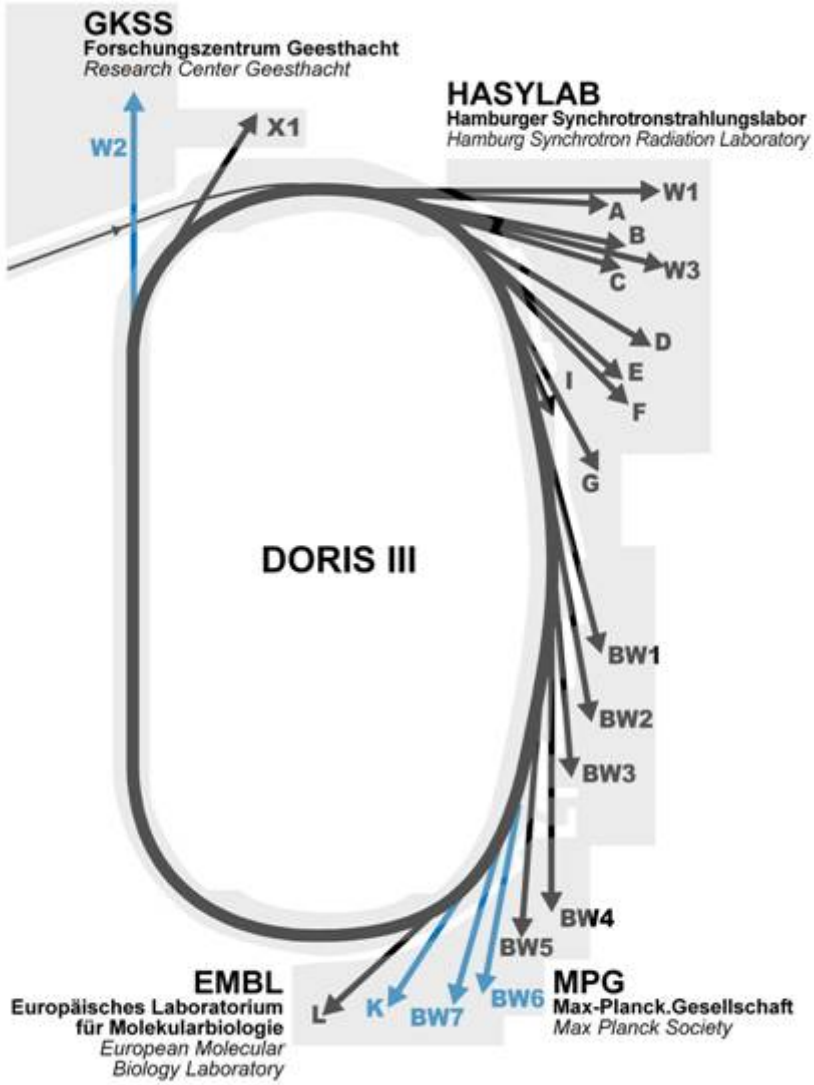
# Complementarity of the GKSS Beamlines @ DESY for SR-CT



| Tomography | DORIS III | | PETRA III | |
|---|---|---|---|---|
| | BW2 | HARWI | Micro and Nano Tomography | High Energy Materials Science |
| X-ray energies | 7 - 24 keV | 20 - 250 keV | 5 - 50 keV | 50 - 300 keV |
| field of view | up to 20×4mm | up to 70×8mm | up to 5 × 0.9 mm @ 87.5 m, low-β | up to 6 × 1.2 mm @ 100 m, low-β |
| coherence | no | no | yes | yes |
| spatial resolution | 2 µm | 3 µm | 0.7µm / < 100nm | 0.7 µm |
| phase contrast | yes (interferometer) | yes (DPC) | yes | yes |

# DORIS III at DESY






## Microtomography using SR

**Beamline W2 (HARWI-II)**

Photon energy: 20 – 250 keV

Beam size: 70 mm x 7 mm

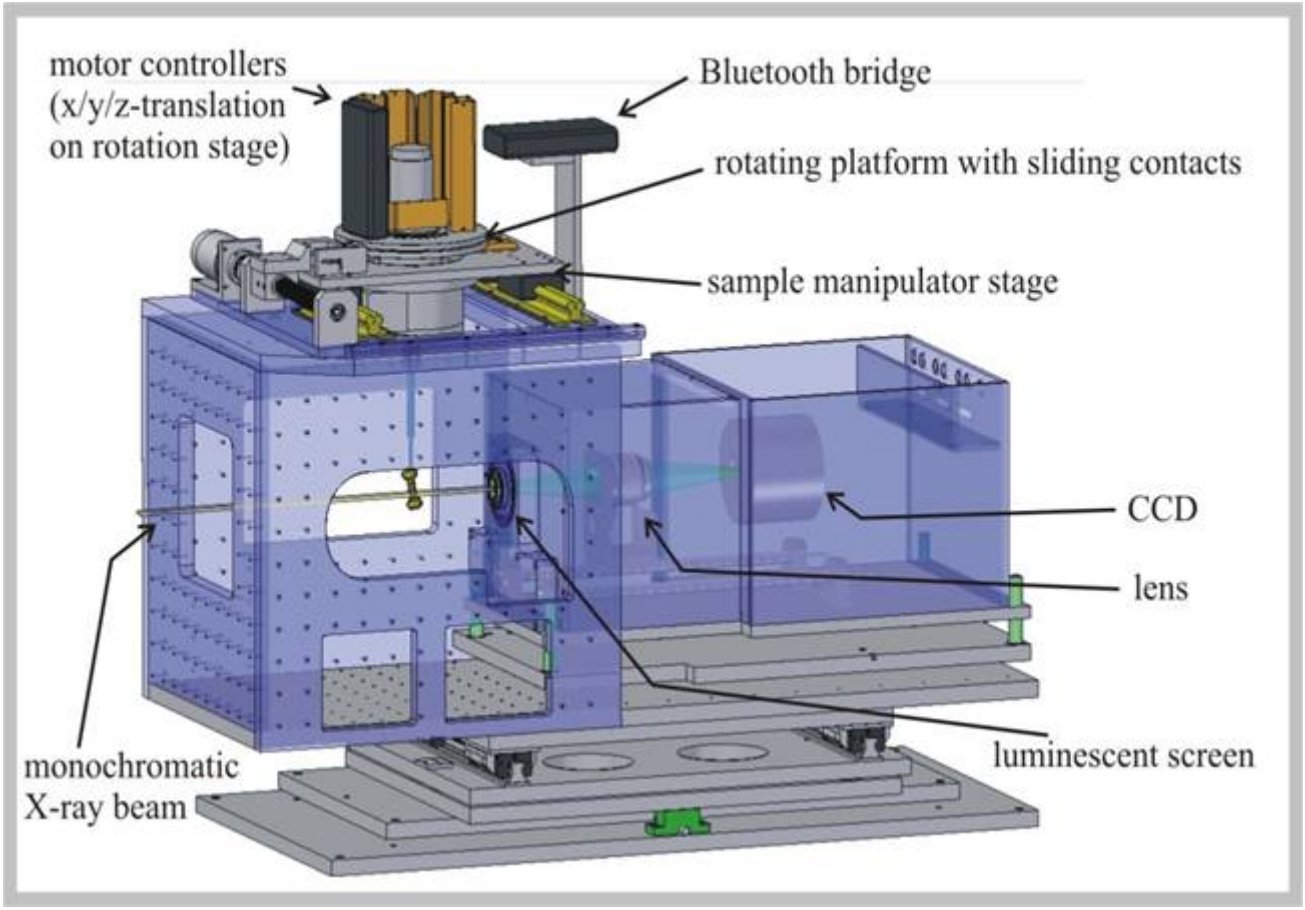
**Beamline BW2**

Photon energy: 7 – 24 keV

Beam size: 20 mm x 4 mm

# Microtomography at BW2






Photon energy:
7 – 24 keV

Field of view:
20 x 4 mm²

Spatial resolution:
Up to 2 µm

# SRμCT at BW2



42 million-year-old fossil †*Mengea tertiara* (Insecta, Strepsiptera)

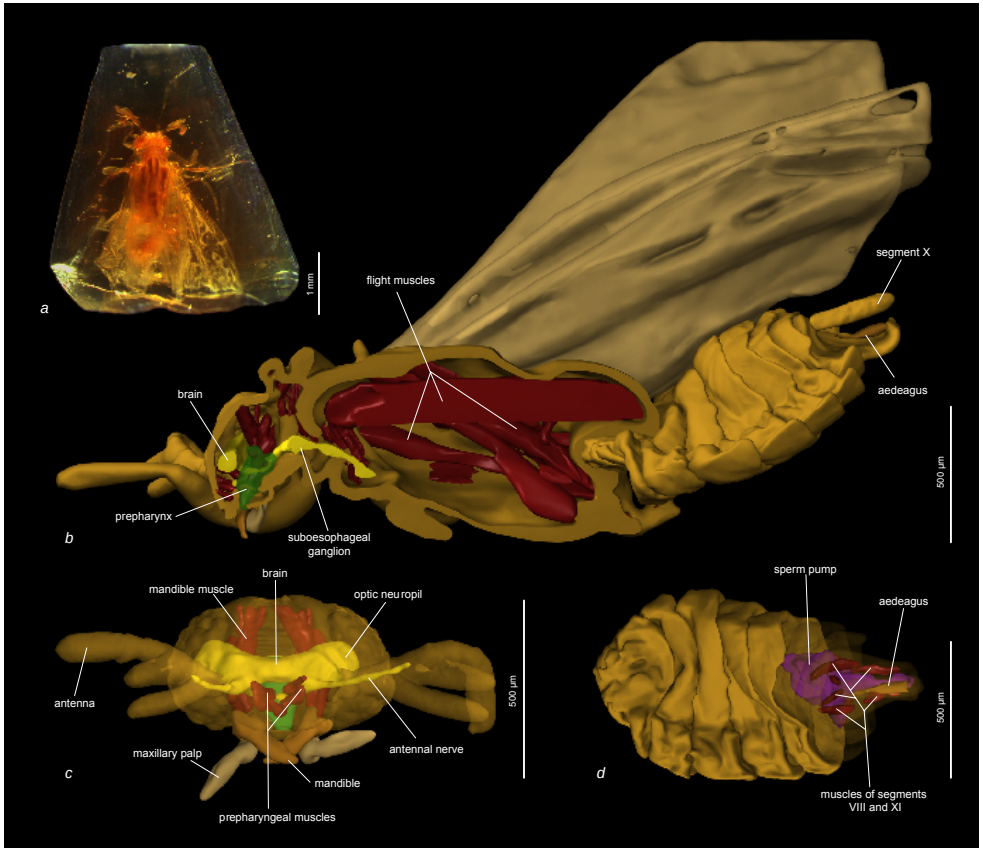
In cooperation with H. Pohl: Entomology Group, FSU Jena

Institut für Spezielle Zoologie und Evolutionsbiologie mit Phyletischem Museum

# SRμCT at BW2



## 42 million-year-old fossil †*Mengea tertiara* (Insecta, Strepsiptera)

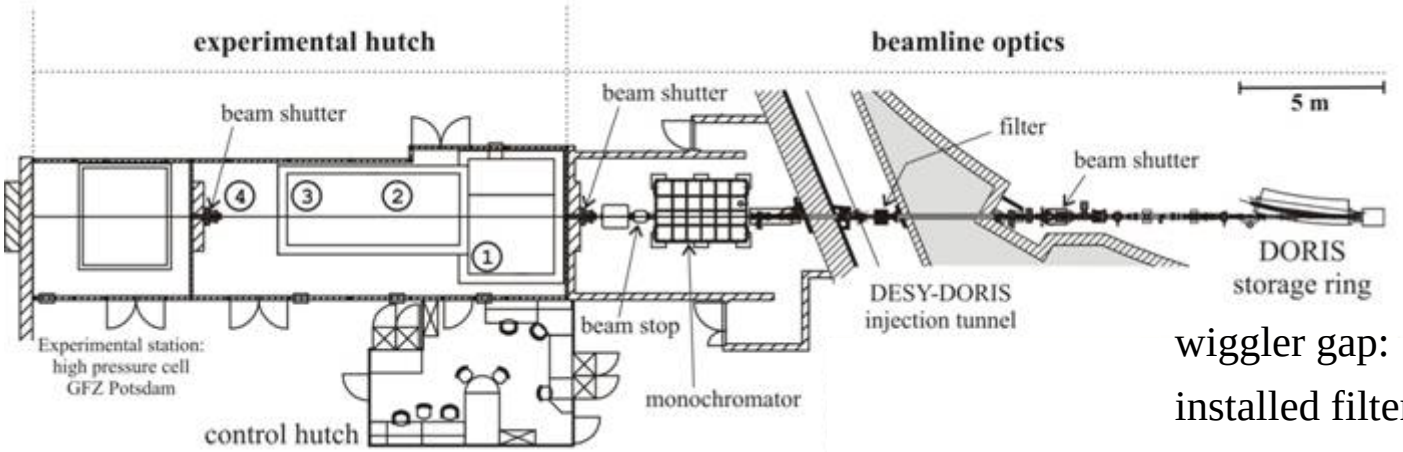



Photon energy: 11.5 keV
Sample volume: 5 x 4 x 2 mm³

Increase in density resolution by: rotation axis at the side, 360° scan, resulting in 720 projections (step 0.25°)

Pohl, H., Wipfler, B., Grimaldi, D., Beckmann F. & Beutel, R.G., "Reconstructing the anatomy of the 42 million-year-old fossil †*Mengea tertiara* (Insecta, Strepsiptera)". Naturwissenschaften, (in press):

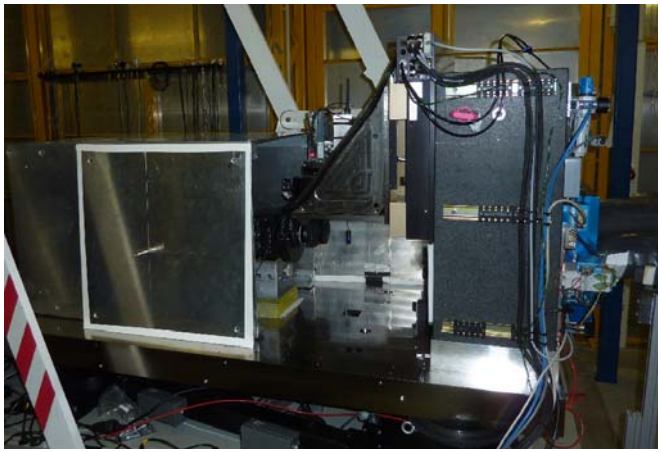
# High-Energy SRμCT at HARWI II

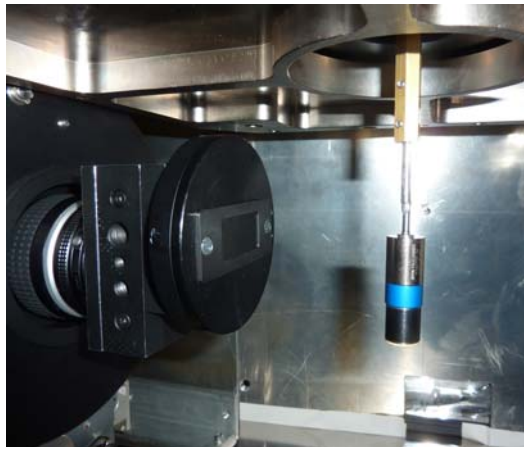



wiggler gap: 16 mm

installed filter: 10 mm C, 2 mm Cu

crystal: bent Laue, thickness 1.5 mm





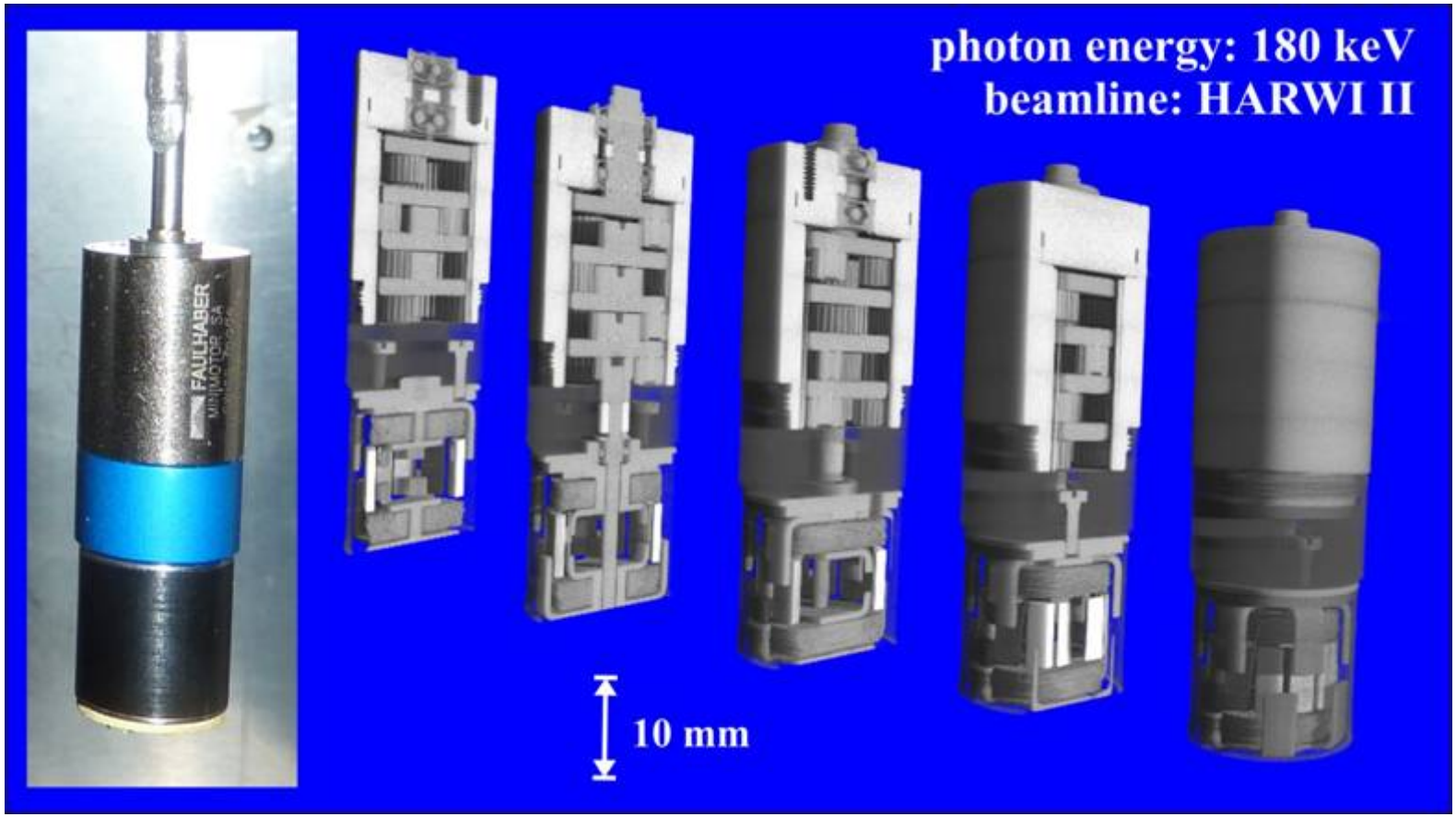
photon energy: 180 keV

field of view:
28.8 x 5.0 mm²

measured spatial resolution:
20 μm

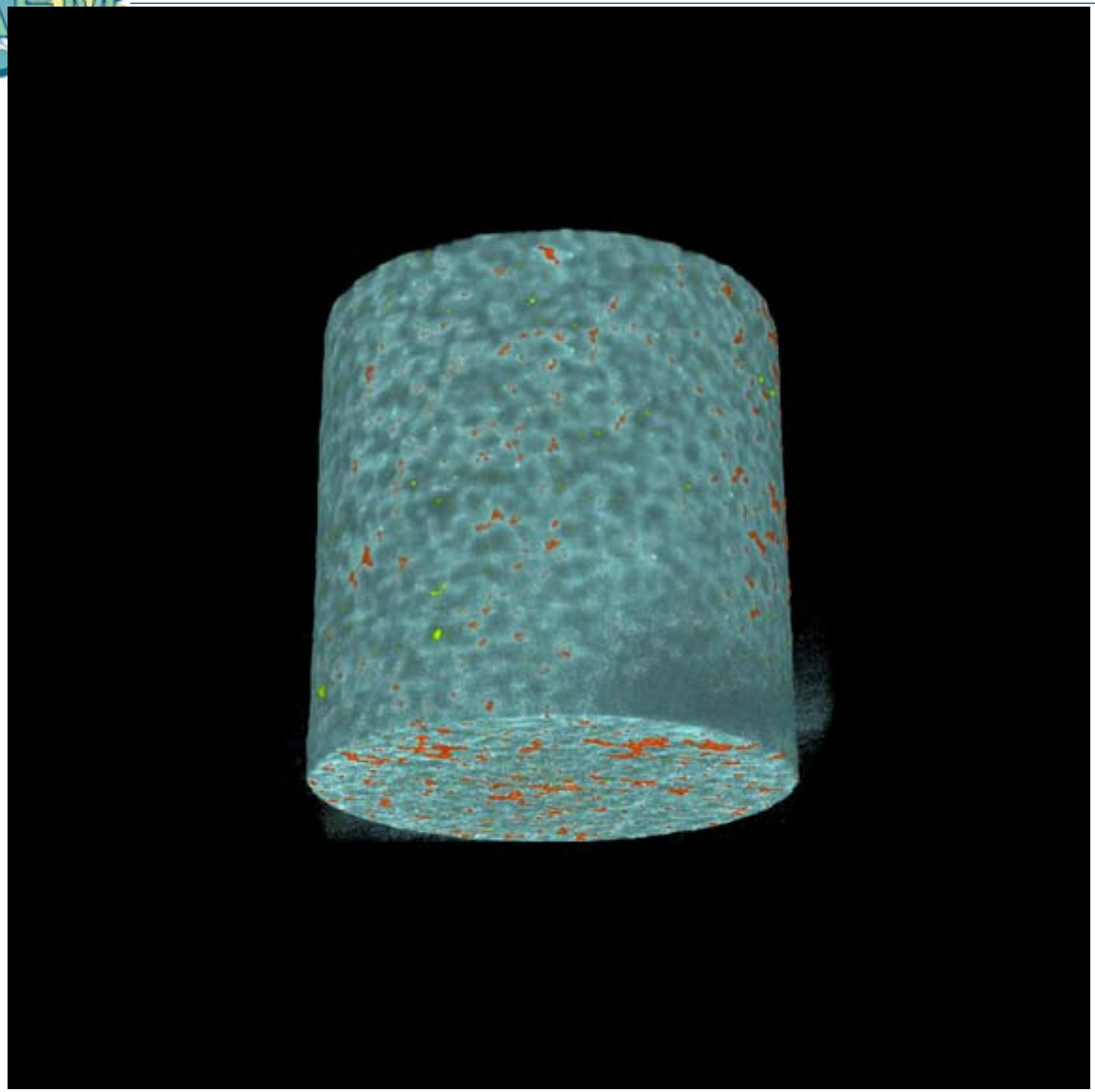
# High-Energy SRμCT of stepper motor






reconstructed volume: 18.1 x 17.0 x 46.8 mm³
measured spatial resolution: 20 μm
tomographical scans at 10 different sample heights

# Magnesium based Biodegradable Implants



## WE 43

Zirconium
Yttrium
Neodymium

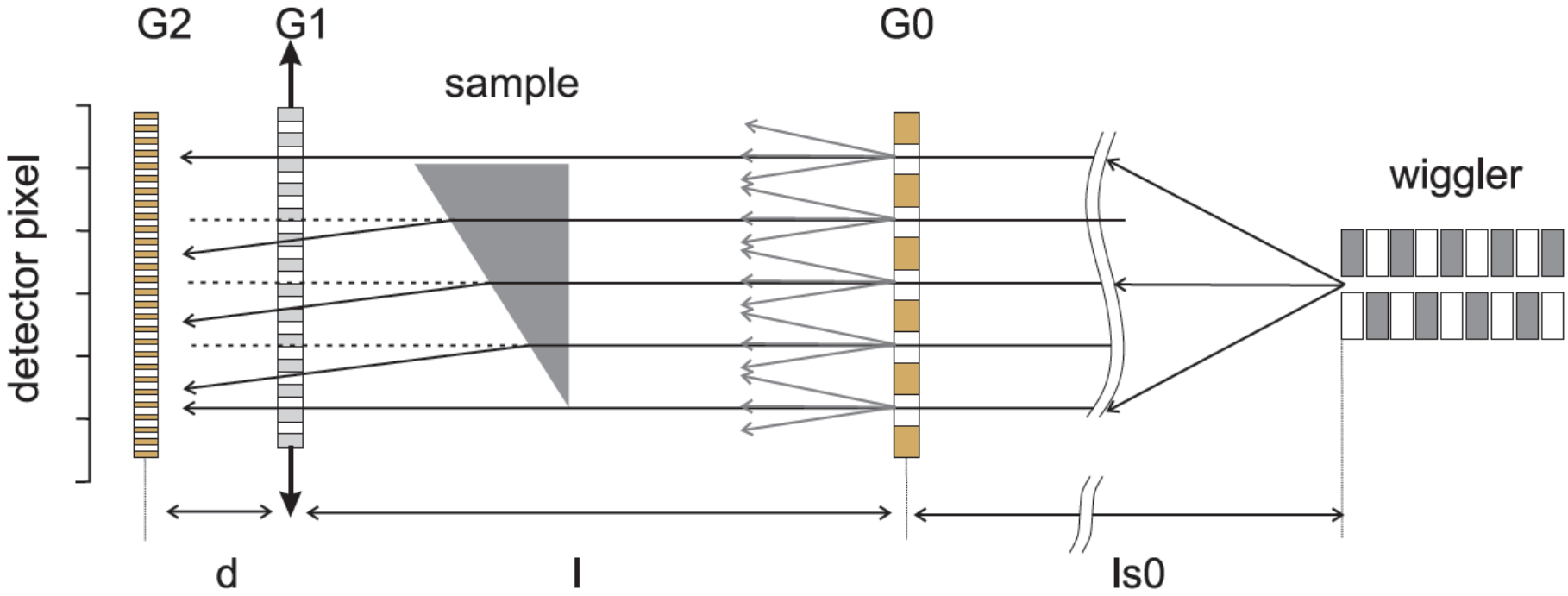
**Mg not visualized**

**HARWI II**

In cooperation with
F. Witte: MHH Hannover

# Grating Interferometer @ HARWI II



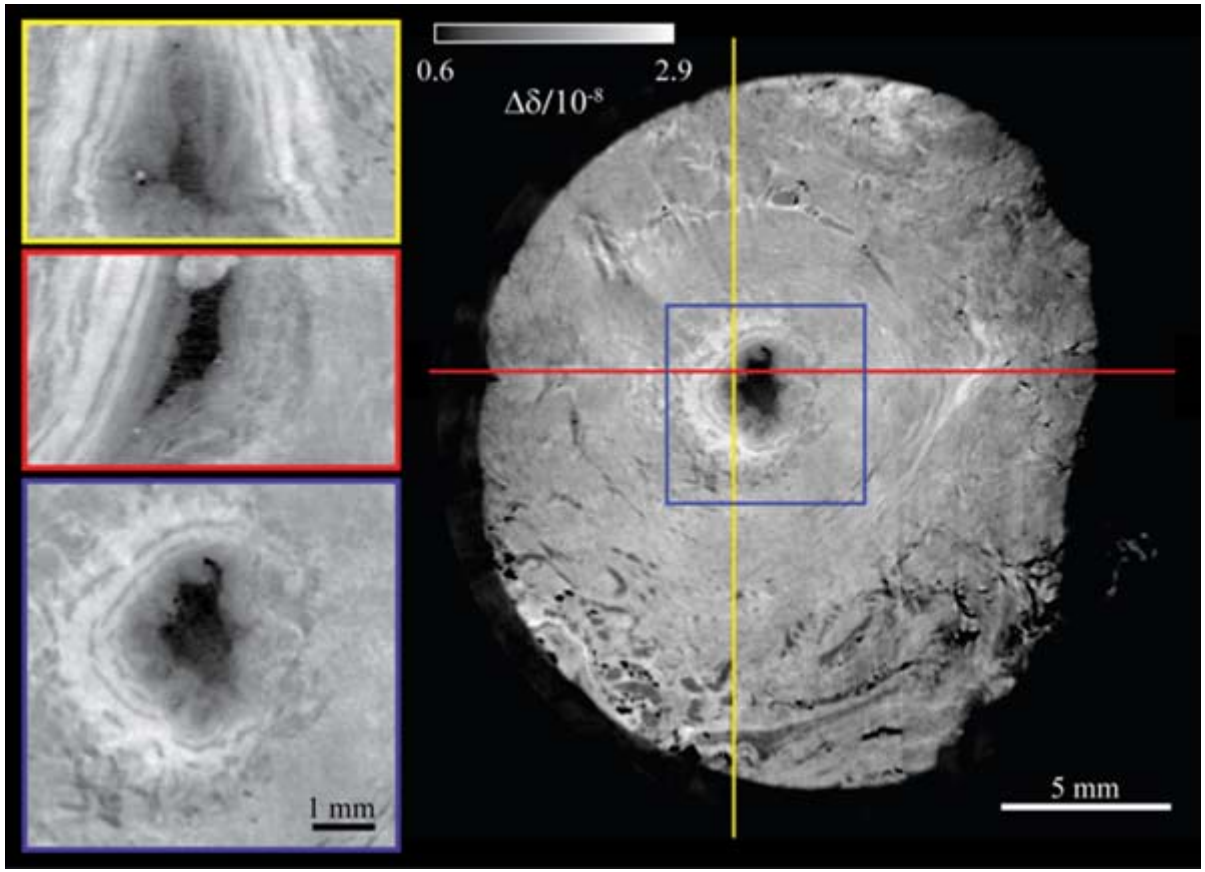



**X-ray grating interferometer for imaging at a second-generation synchrotron radiation source:** Julia Herzen, et al., SPIE 7804-6, 2010.

**PhD thesis J. Herzen, in cooperation with C. David, PSI, and F. Pfeiffer, TUM**

# DPC @ HARWI II: urethra (male)

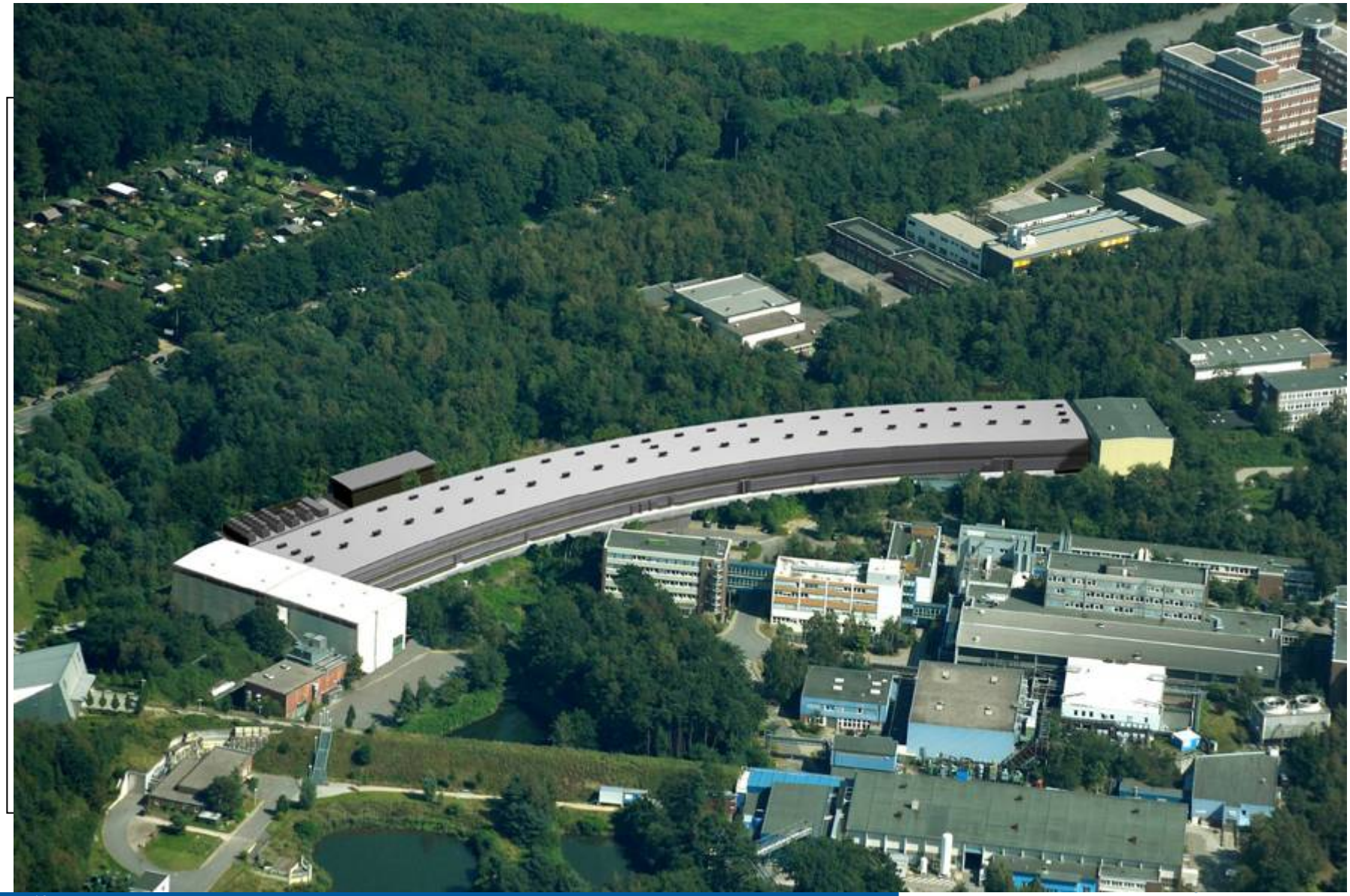





**Micro-morphology of biological tissue**
Bert Müller, et al., SPIE 7804-12, 2010.

# IBL/HEMS @ PETRA III





# The Imaging Beamline IBL @ PETRA III
## Layout

### Optics Hutch
- double crystal monochromator
- double multilayer monochromator
- energy range 5-50 keV

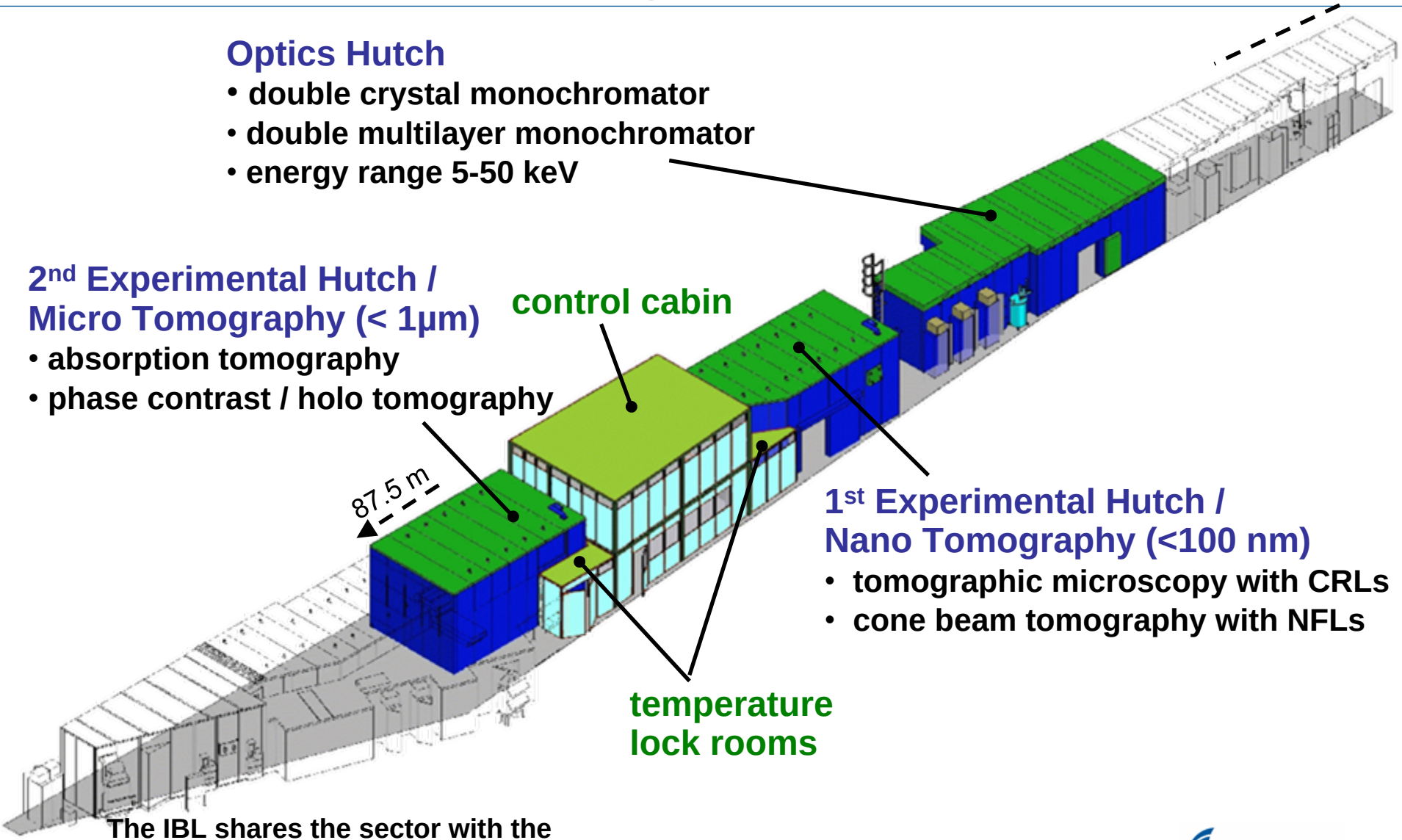
### 2nd Experimental Hutch / Micro Tomography (< 1µm)
- absorption tomography
- phase contrast / holo tomography

control cabin

87.5 m

### 1st Experimental Hutch / Nano Tomography (<100 nm)
- tomographic microscopy with CRLs
- cone beam tomography with NFLs

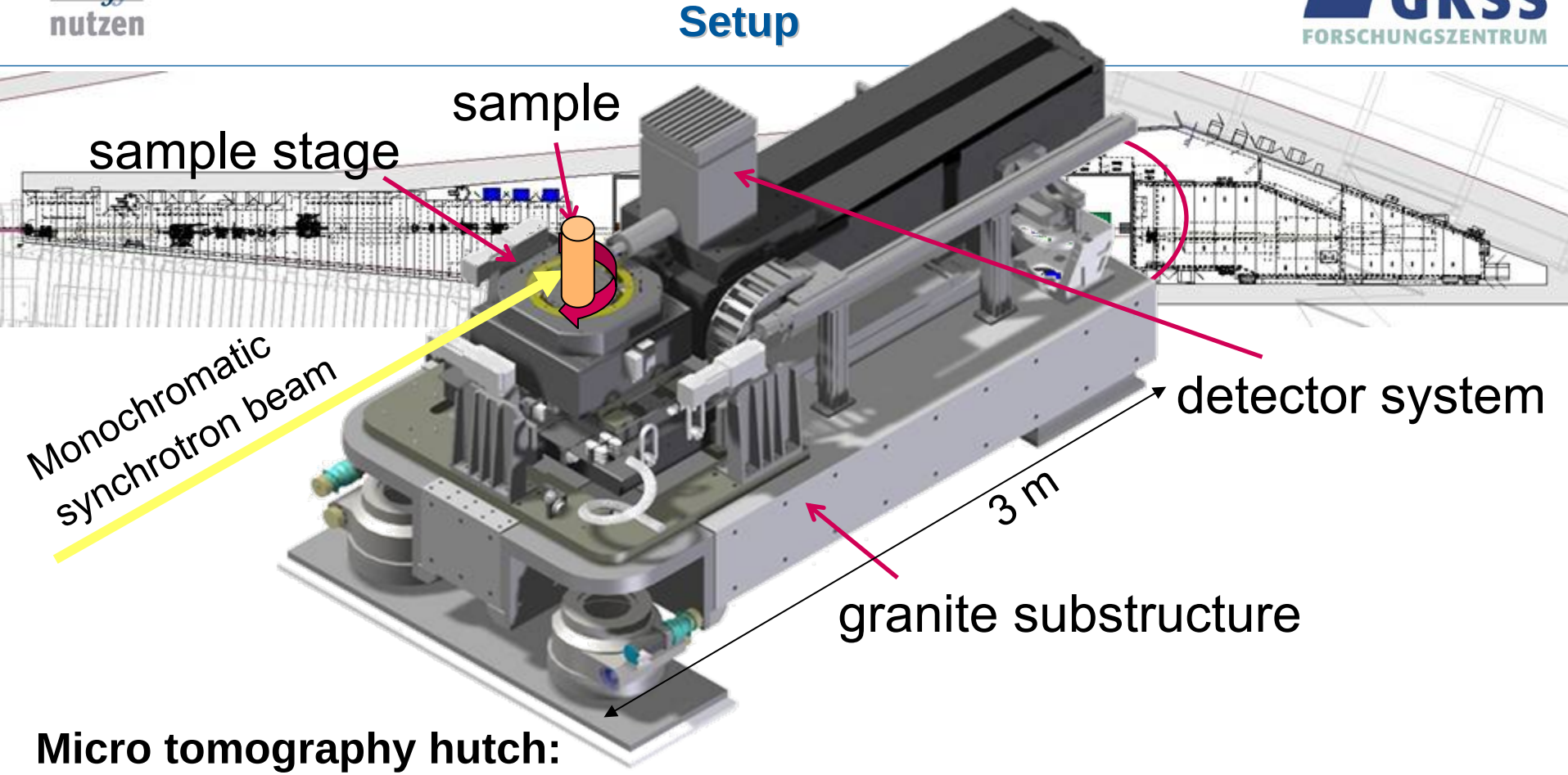
temperature lock rooms



The IBL shares the sector with the hard X-ray micro and nanoprobe beamline.

# Micro Tomography @ IBL
## Setup






**Micro tomography hutch:**

- field of view: 1.2×5.6 mm (FWHM) @ 87m
- absorption, phase enhanced and phase contrast tomography
- spatial resolution < 1 µm
- in situ experiments
- complementary experiments (e.g. diffraction, fluorescence)

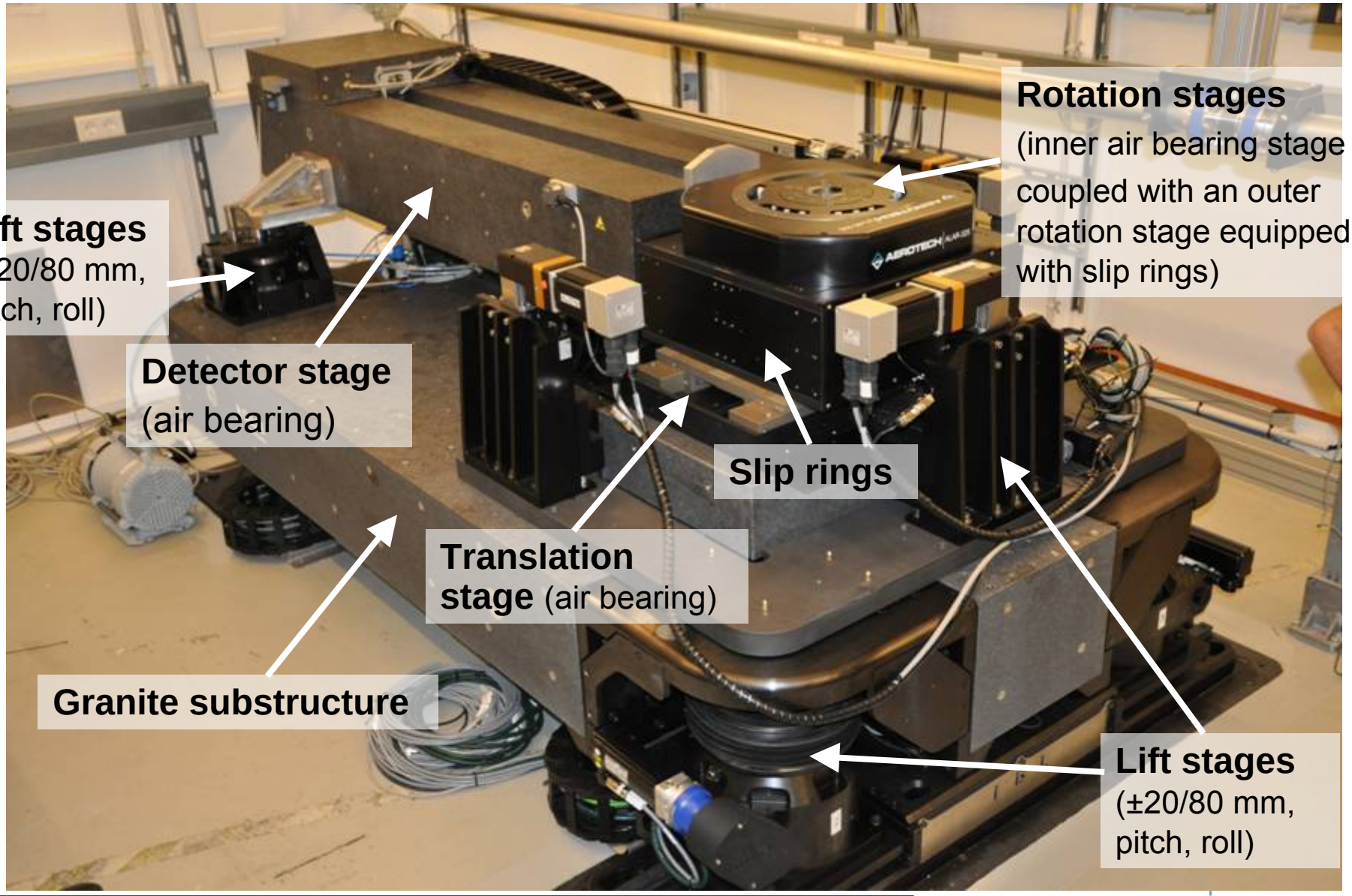
# Micro Tomography

## @ IBL

## @ HEMS

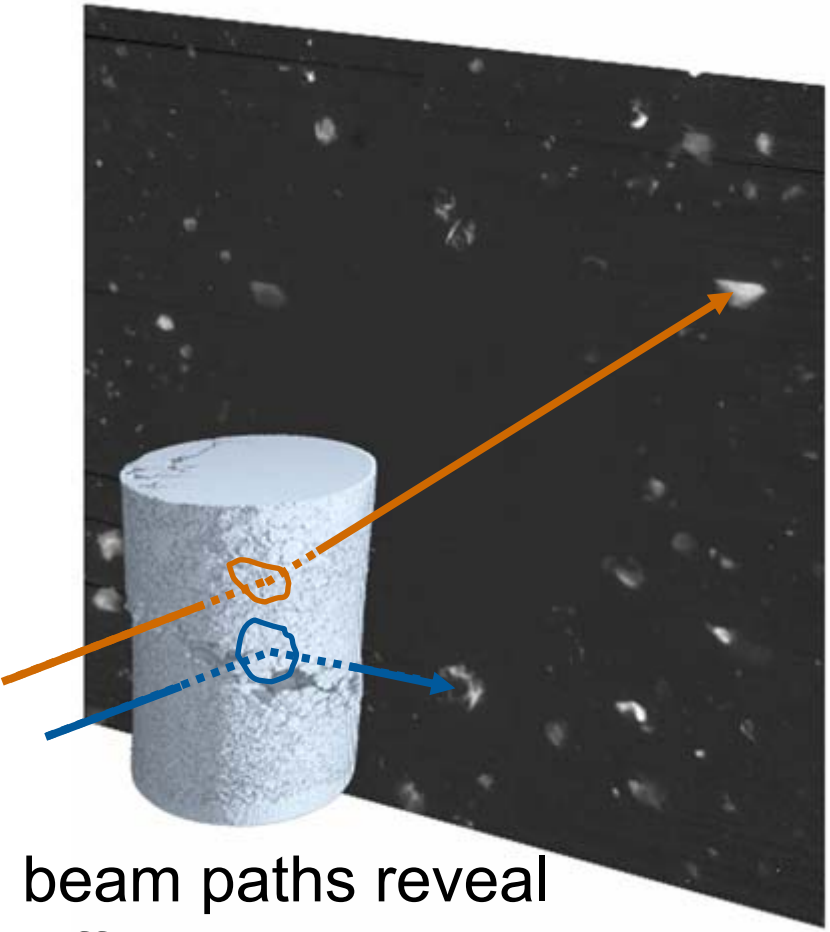
# Micro Tomography Setup



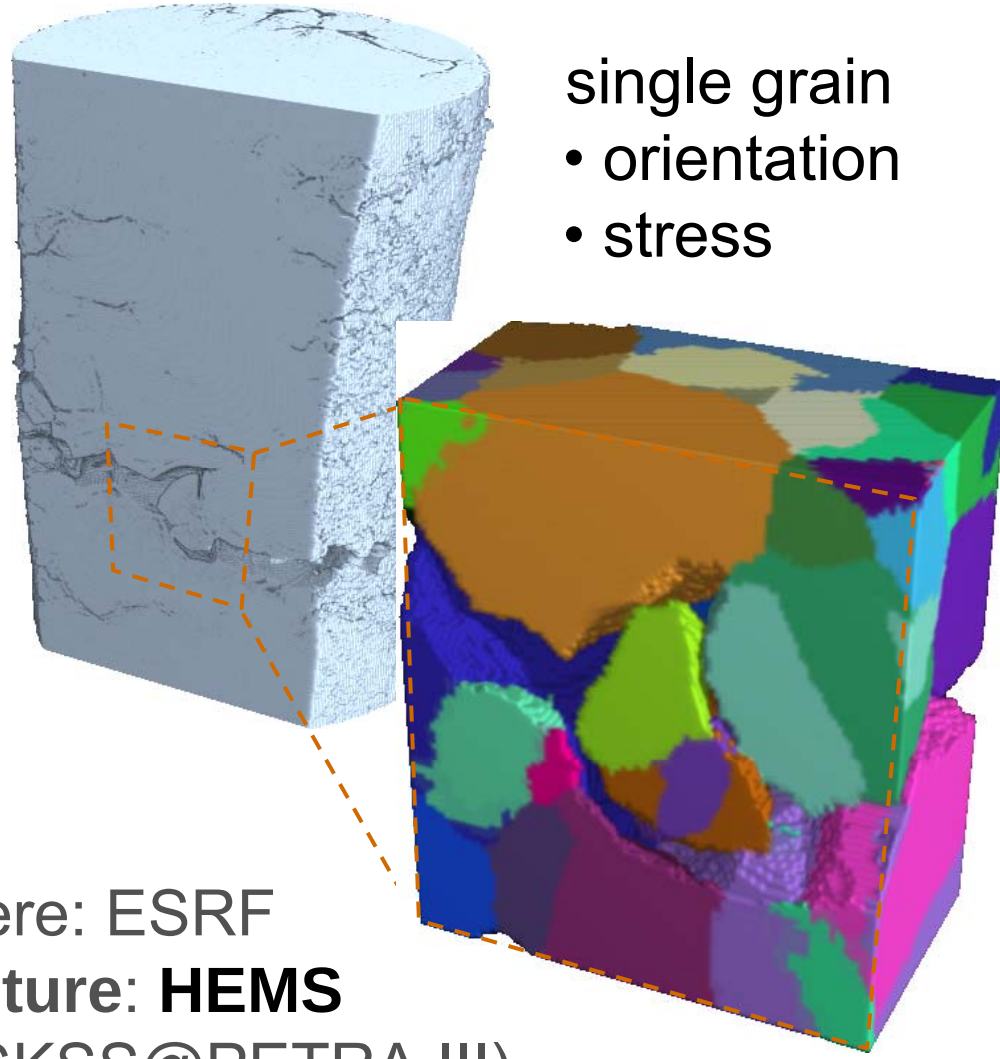


# Tomography and diffraction: grain mapping





beam paths reveal diffraction angles and grain position



single grain
- orientation
- stress

here: ESRF
**future**: **HEMS**
(GKSS@PETRA III)

A. King et al., *Science* **321**, 382 (2008)

# Experimental goals and requirements



- Establish self describing investigation method
- High sample throughput maintaining high quality tomograms
- Sample changer for pre-characterization and measurement
- Single software solution for different experimental methods

**New software environment has to be build**

High Data Rate Processing and Analysis Initiative (HDRI)

- Helmholtz initiative
- more efficient use of the SR source
- new common concept to deal with high data rates

# Sample Preparation



## Light microscope

- preparation of µm sized samples for nano tomography
- FIB tomography by milling the samples
- 3D-EBSD

- precharacterisation the samples before synchrotron µ-CT


## FIB/SEM


## nanotom CT (phoenix|x-ray)

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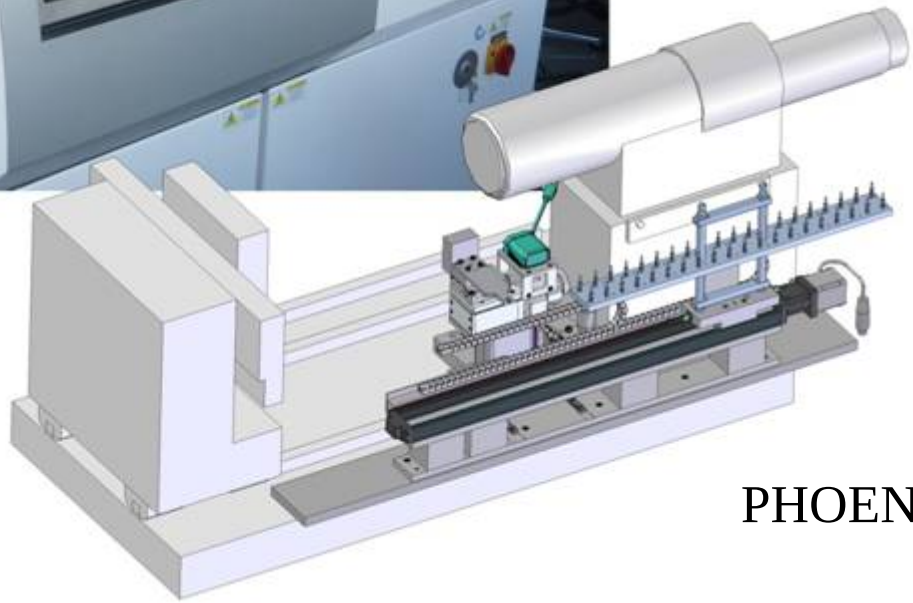
# Sample pre-characterization




- X-ray inspection
- automatic sample changer
- automatic scanning of 18 samples
- information used for defining region of interest, scan parameter, and area for reconstruction



Scripting-Software
for the NANOTOM
in cooperation with
PHOENIX X-ray, Germany

# Data Format Structure suggested for tomography



Measurement

1st: Description of user and any meta data available before experiment (e.g. sample pre characterisation, ..)

2nd: Description of experiment independent of method, using a common way of description (including all experimental data)

3rd: Method description for the experimental scan, including quality parameters and all parameters need for further data evaluation

Reconstruction

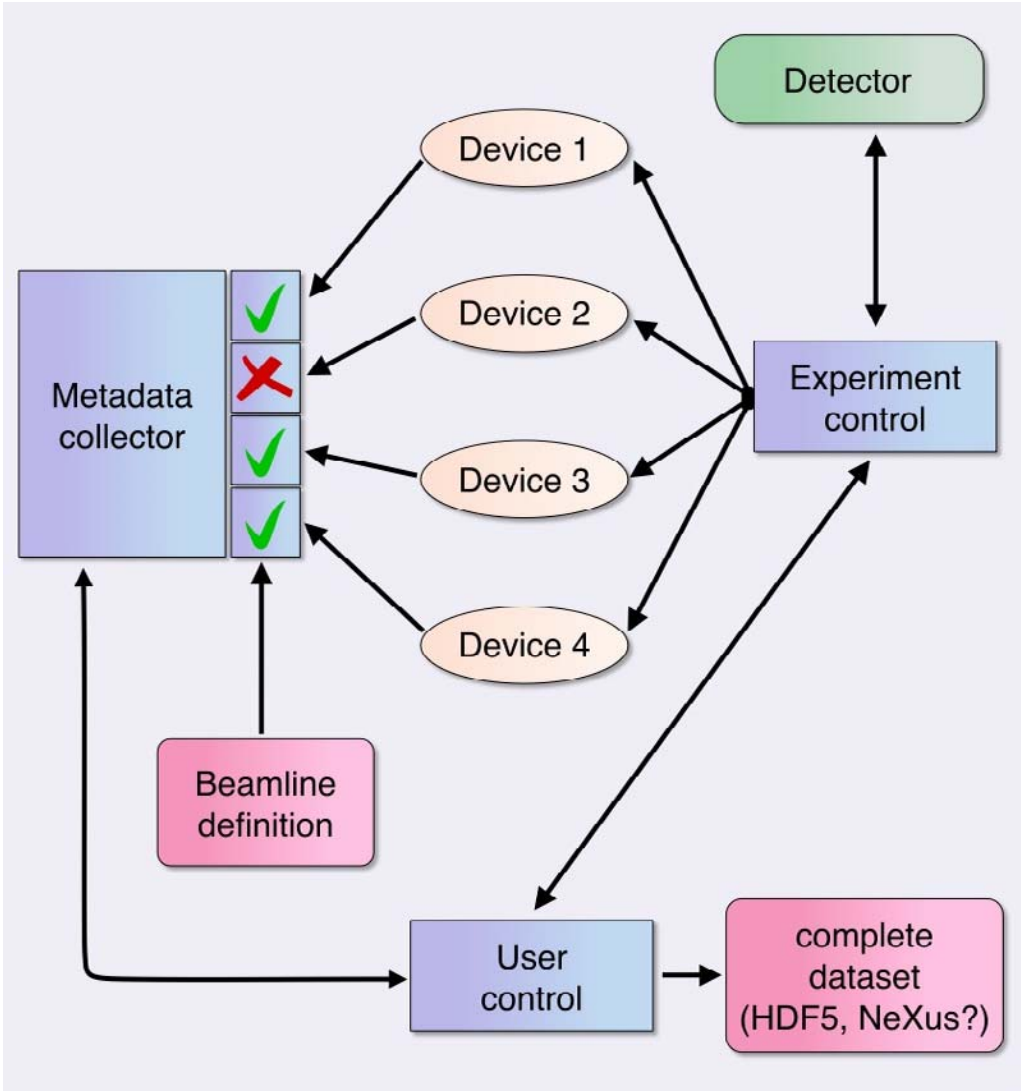
1st: Subset of the measurement

2nd: Parameter used for reconstruction

3rd: Reconstruction data

# Concept for data collection



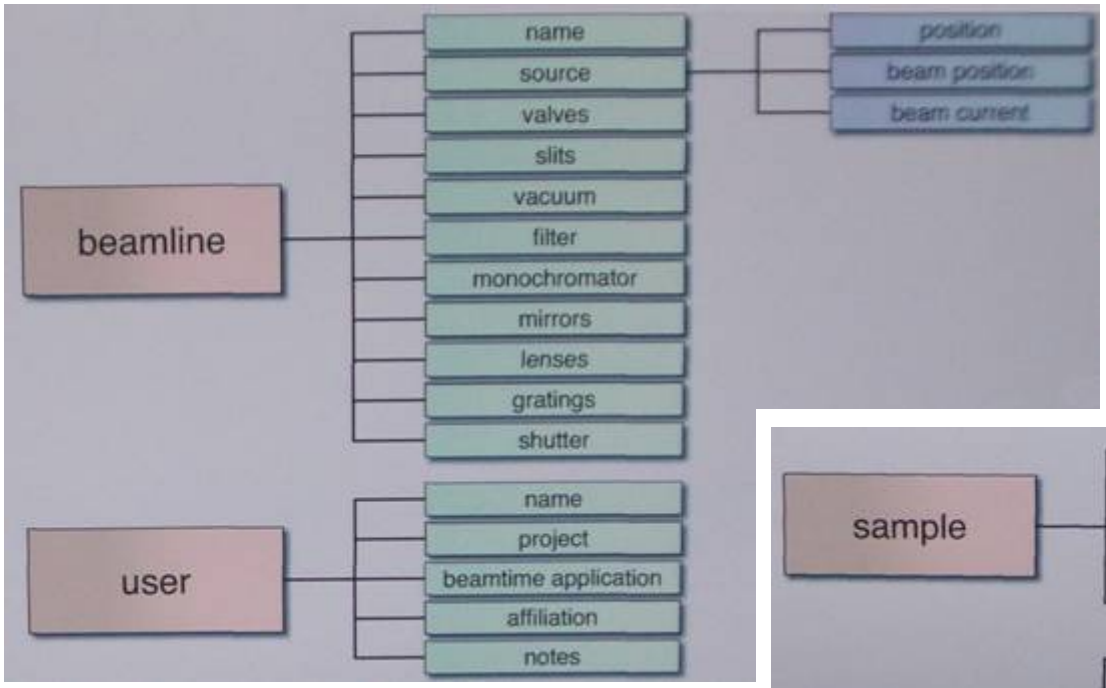



- unified organization for experiment control
- metadata collection centralized
- collection control via beamline description file
- valid for all different techniques

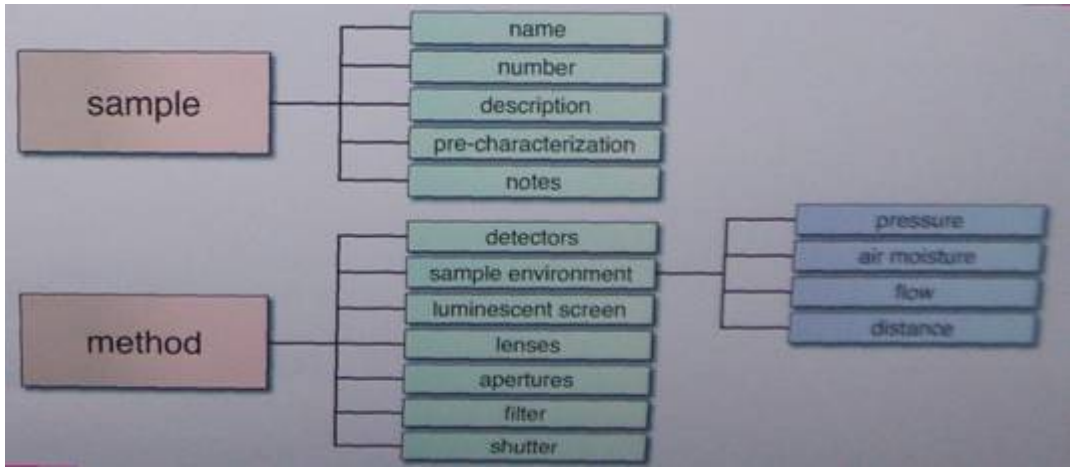
# Data structure



- hierarchical data structure
- tomographic data, meta data and reconstruction data joined together




- subsets of immutable datasets combined with variable datasets
- to be defined by HDRI



# Time schedule

| | |
|---|---|
| - sample changer at NANOTOM | 12 / 2010 |
| - visible light inspection | 04 / 2011 |
| - sample changer at HARWI-II, BW2 | 04 / 2011 |
| - sample changer at IBL/HEMS | 10 / 2011 |
| - definition of data format (DESY) | 12 / 2010 |
| - first implementation for SRCT | 2011 … |
| - effective use of hardware by sophisticated software as an user experiment | to be defined |

# Acknowledgements

**GKSS-Outstation at DESY**

- A. Schreyer, M. Müller

Tomo-Team at HARWI-II, BW2, IBL, HEMS:
- A. Haibel, F. Wilde, M. Ogurreck, T. Dose, [J. Herzen (Tu Munich)]

HARWI-II:
- T. Lippmann, L. Lottermoser, H. Burmester

HEMS:
- N. Schell, R. Kirchhof , [A. King (ESRF)]

**Beamline BW2**

- W. Drube, H. Schulte-Schrepping: HASYLAB / DESY

**Examples:**

- B. Müller: University of Basel, Switzerland
- F. Witte: Medizinische Hochschule Hannover, Germany
- R. Willumeit, F. Feyerabend: GKSS, Geesthacht, Germany

# Thank you for your attention !