Beamline Instrumentation: From Insertion Devices to Experimental Stations

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Primary authors : Dr. VOGEL, Hanspeter (RI Research Instruments GmbH)

Co-authors :

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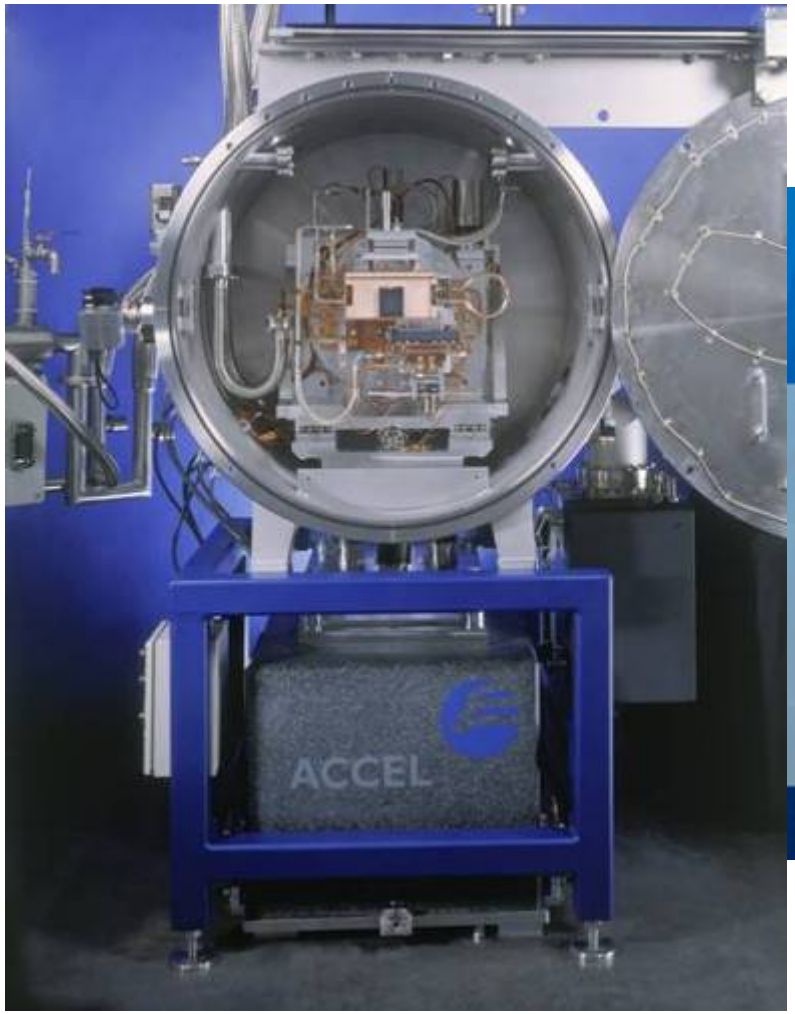


Bruker ASC

Beamline Instrumentation: From Insertion Devices to Experimental Stations

Hanspeter Vogel (RI), Wolfgang Diete

- General Introduction
- Insertion Devices
- Complete Beamlines and Beamline Components
- Experimental Stations

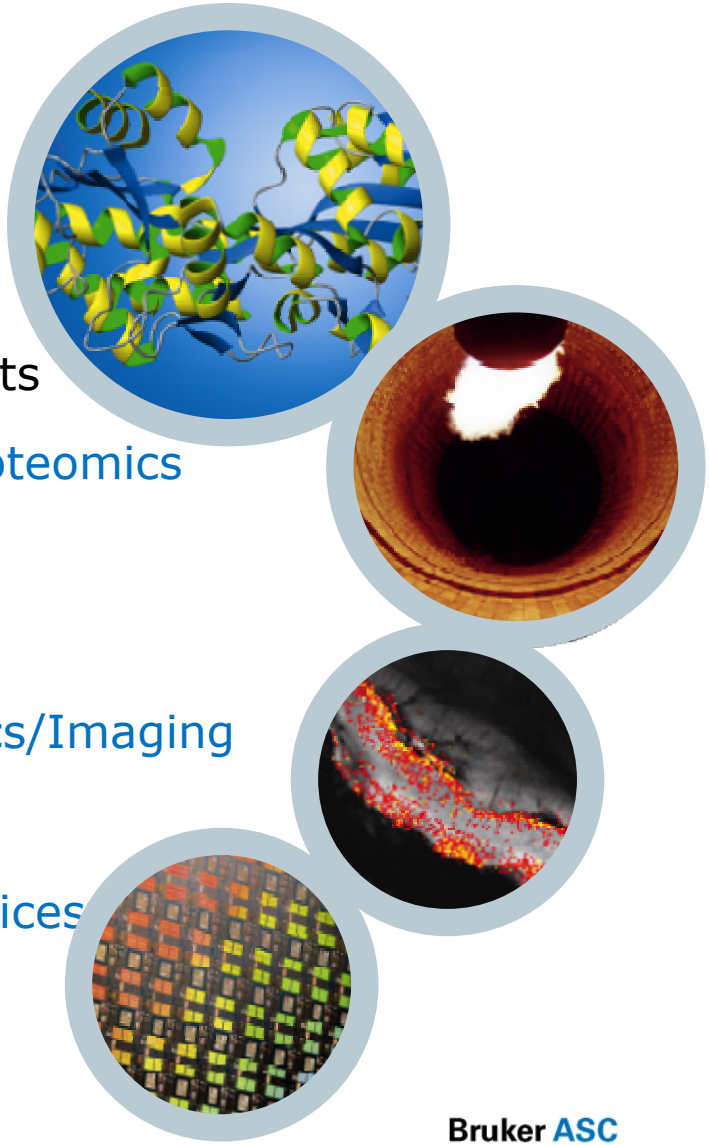
From Insertion Devices to Experimental Stations (on behalf of Wolfgang Diete, Bruker ASC)

Content:

- **Overview Bruker ASC**
- **Insertion Devices**
- **Complete Beamlines and Beamline Components**
- **Experimental Stations**

Performance Leader in Life Science and Analytical Systems

- Commitment to innovation, R&D and quality
- Leading market position in key segments
- Synergies in attractive and diversified markets
  - Molecular Research in Chemistry and Proteomics
  - Materials Research and Nanotechnology
  - Applied and Industrial Analysis
  - Clinical Research to Molecular Diagnostics/Imaging
  - CBRNE Detection for Homeland Security
  - HTS Superconductors and Supercon Devices
- Strong Bruker brand recognition



Bruker Corporation

Bruker Corporation operates in synergistic businesses

- **Bruker AXS** – X-ray Analysis and Elemental Analysis Systems
- **Bruker BioSpin** – Magnetic Resonance Spectroscopy and Imaging
- **Bruker Daltonics** - Mass Spectrometry and CBRN Detection
- **Bruker Optics** – Molecular Spectroscopy (FT-IR & Raman)

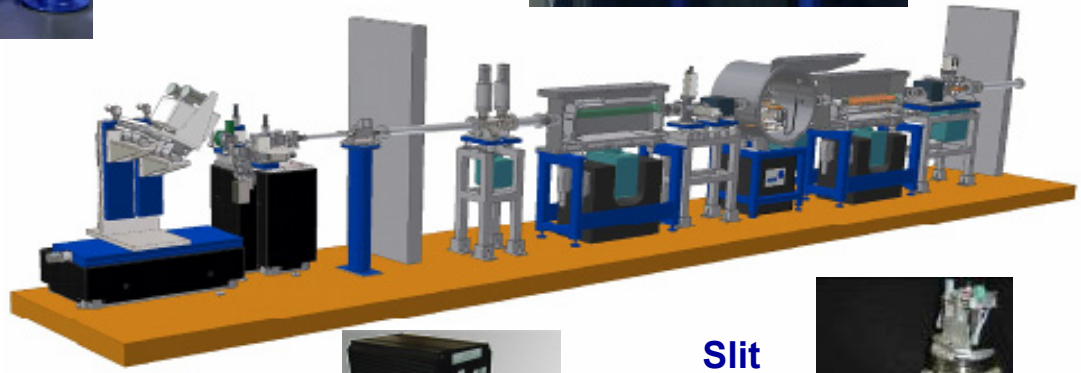
- **Bruker EST -** High and low temperature superconducting wires, magnets and devices, accelerator instrumentation and within **Bruker ASC** synchrotron instrumentation and laboratory XUV/EUV equipment

- **Bruker Analytical Services** – Professional Analytical Services

Synchrotron Beamlines
Complete Systems and Components

Endstation

Double Crystal Monochromator



Shutter

Slit System

Mirror Systems

From Insertion Devices to Experimental Stations (on behalf of Wolfgang Diete, Bruker ASC)

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Superconducting Insertion Devices

Superconducting Wave Length Shifters

- delivered to BESSY
- delivered to ESRF
- zero boil off cryogenic system
- cryogen free system available

SC Wigglers

- delivered to DELTA (Germany)
- anti- / symetric magnetic design
- zero boil off system available
- cryogen free system available

SC Undulators

- delivered to NUS (Singapore)
- delivered to ANKA (Germany)
- design for ESRF (France)
- cryogen free cooling
- phase error of 3° r.m.s.

possible (theoretically approved)

- existing concept for high heat loads
- proven synchrotron use at ANKA

Permanent Magnet Insertion Devices and Measurement Benches

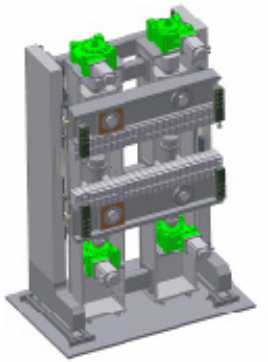
Cooperation with **Kyma Srl**

Conventional Wigglers
- delivered to FZK (Germany)

Conventional Undulators
- 6 identical PPM structures delivered to ENEA (Italy) for FEL experiment
- 1 hybrid undulator delivered to DELTA
- phase errors down to 2°r.m.s.
- Beckhoff / LabView control system

FEL Undulators
- Prototype for European X-FEL as PETRAIII upgrade hybrid undulator
- delivered with specified Beckhoff C.S.
- sub 1 µm positioning of magnet arrays
- sub 1 µm parallelism of magnet arrays also during movement
- achieved with dual encoder system

APPLE II Devices
- supression of roll of magnetic girders due to dual frame concept (support and guiding frame)
- 4 or 2 motor drive system
- 2 or 4 array drive system

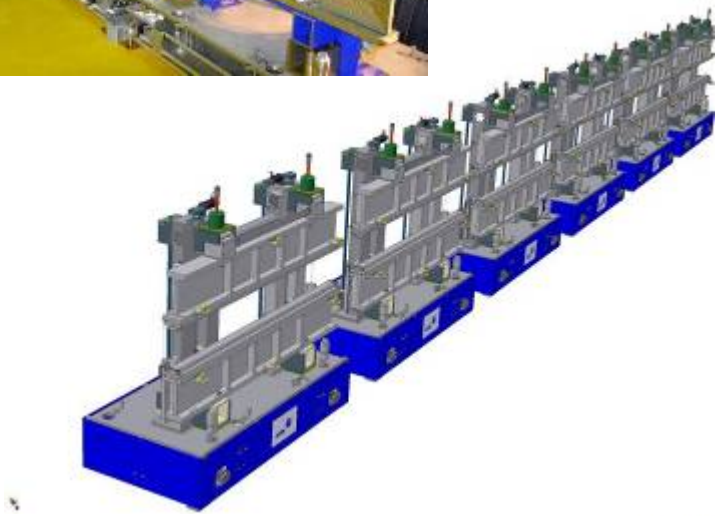


Measurement Systems
- newest ESRF standard granite bench
- up to 6.5m length
- laser tracker alignment
- motion error correction

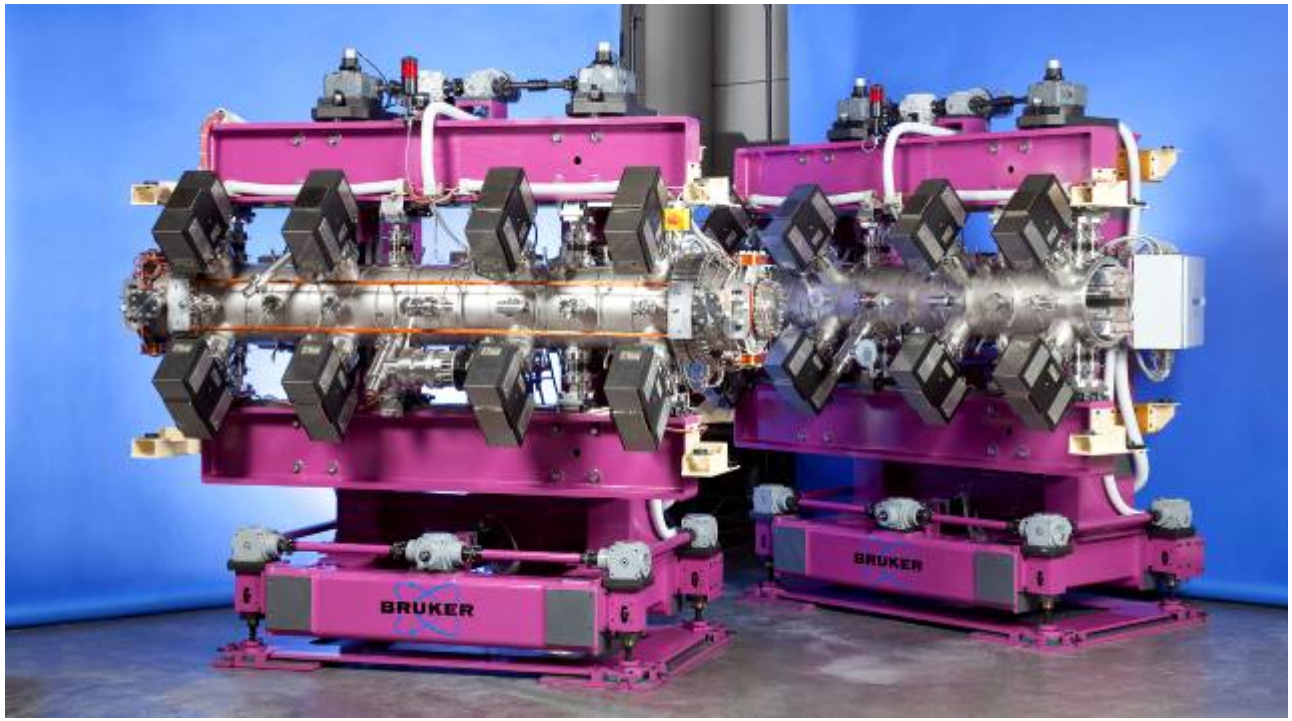
SASE FEL Undulators for ENEA (Italy)

- Halbach type design
- Production of 6 identical Undulators completed in Jan. 2007
- Including turn key control system

No. of periods:	75
Period length:	28 mm
$Gap_{magnetic}$:	6 mm – 25 mm
k-Value:	2.16 @ 9.2mm gap



Two IVUs for ALBA

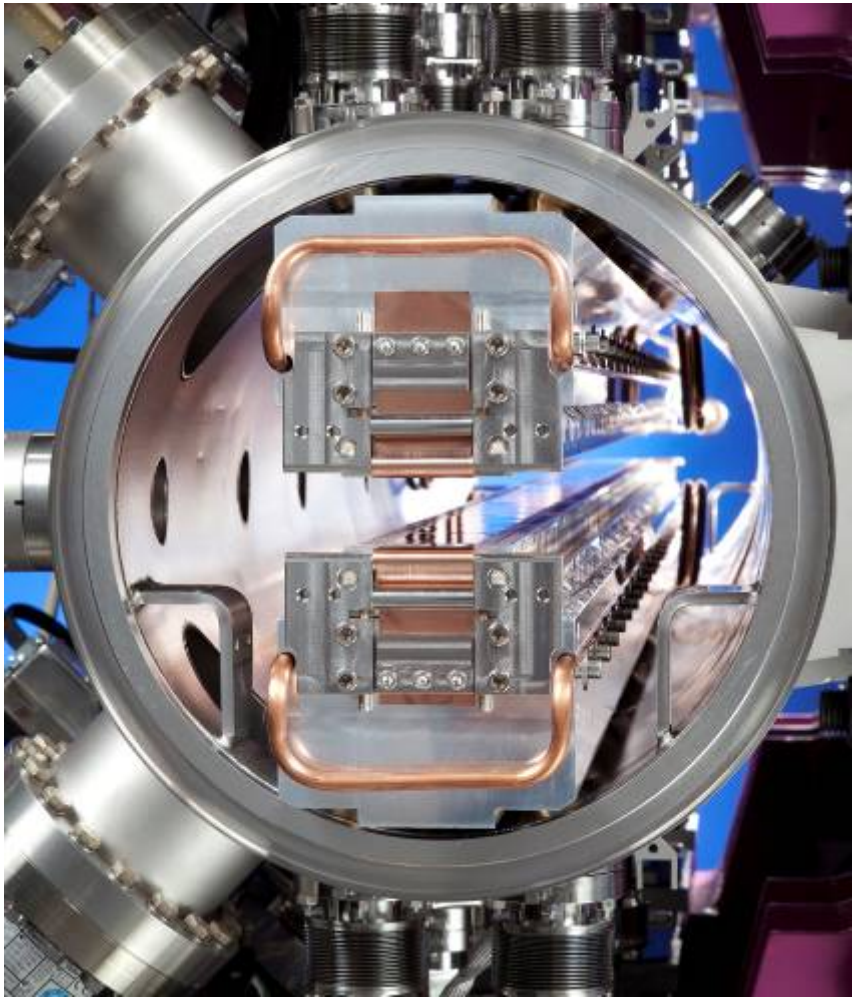


Magnetic Characteristics

- SmCo PPM Undulators; 92 periods, λ = 21.6 mm
- Magnetic length: 2017 mm
- K value: 1.6 at 5.7 mm gap
- Horizontal and vertical correction and kicking coils
- Gap between 5.7 and 30 mm

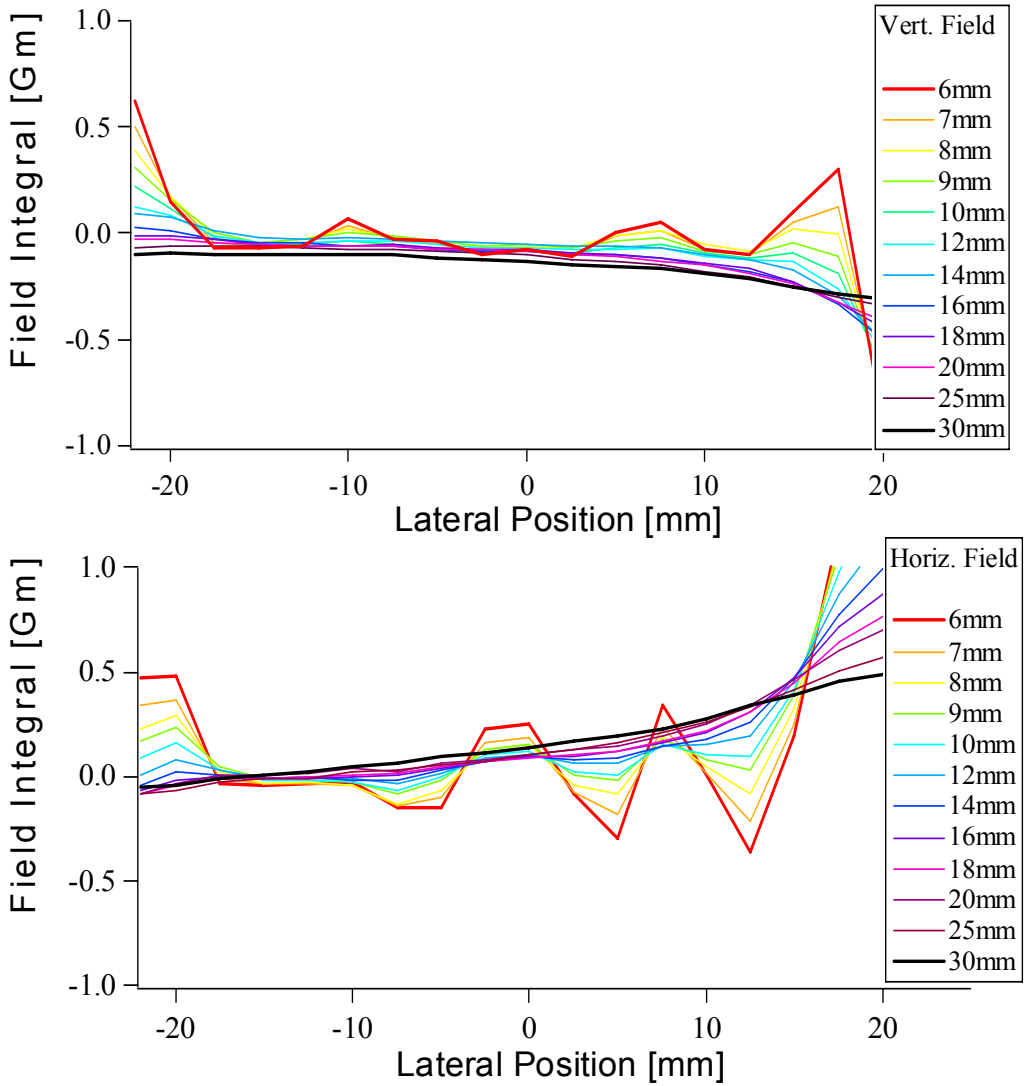
Two IVUs for ALBA

- Based on ESRF design close co-operation based on license agreement
- Optimized flexible taper design
- One motor magnetic tapering of the undulator
- Direct linear encoders for magnetic gap and tapering
- Magic finger field shimming



First Field Integral Data

ALBA IVU-2



- FI Abs. Value @ X=0

  Gap = 6 mm: ~ 1 Gcm

  For all gaps: < 14 Gcm

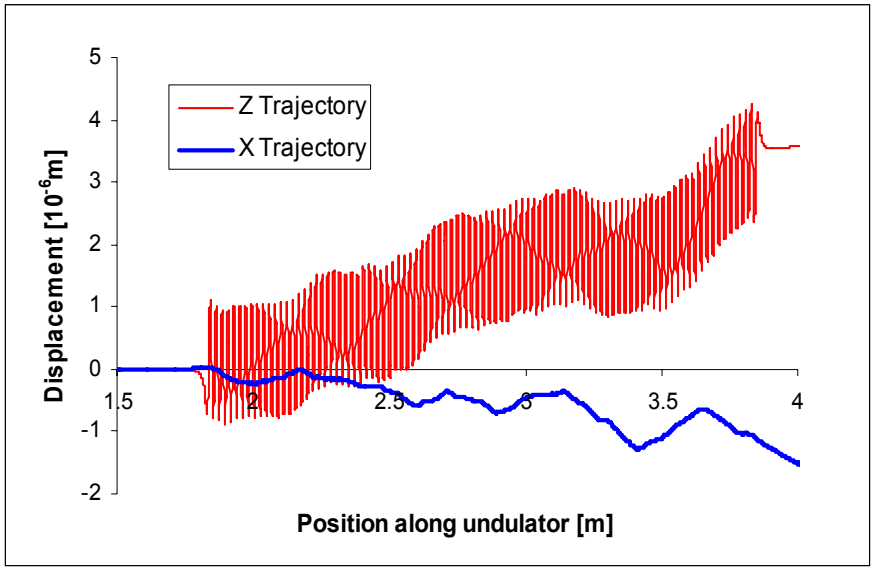
- 3rd order polynomial fit coefficents better than the specified values within -15 mm ≤ X ≤ 15 mm

	Ix	Iz
Dip.	< 14 Gcm	< 13 Gcm
Quad.	< 11 G	< 5 G
Sext.	< 7 Gcm^{-1}	< 3 Gcm^{-1}

- Measuring error of flip coil around ±2 Gcm

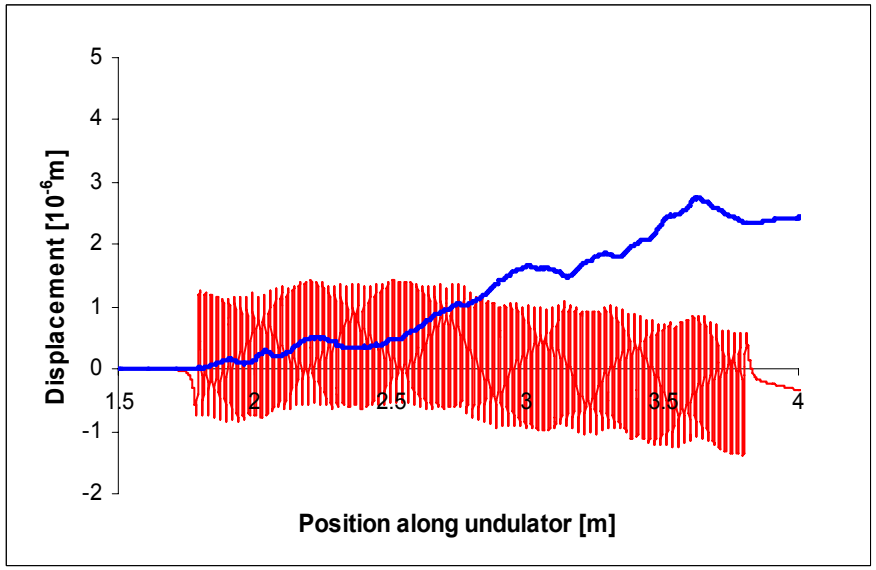
Second Field Integral Data

ALBA IVU-1



Jx = 2137 Gcm^2
Jz = 3817 Gcm^2

ALBA IVU-2

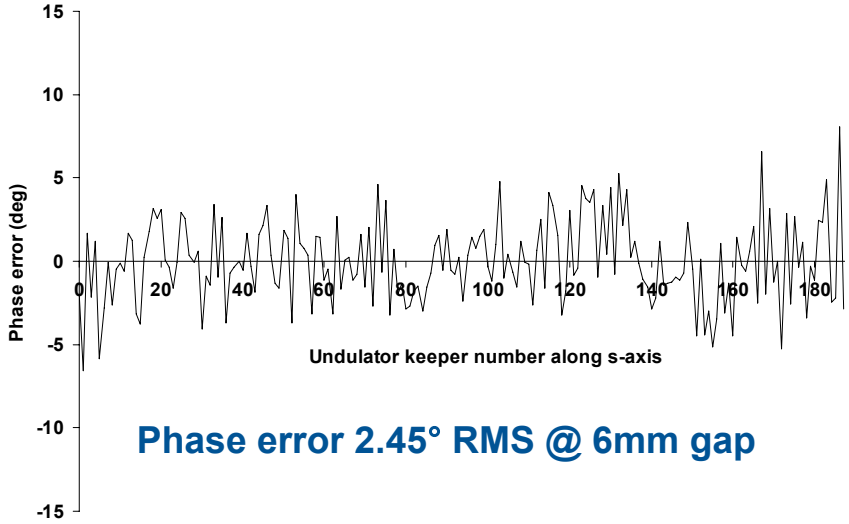


Jx = -2300 Gcm^2
Jz = -644 Gcm^2

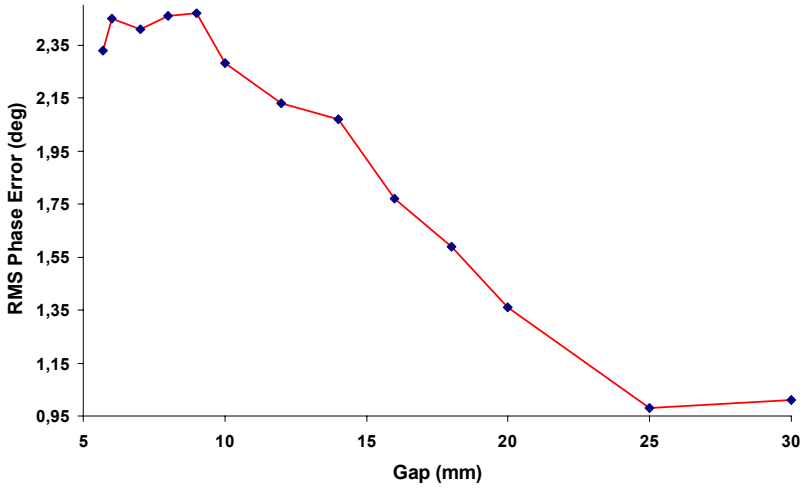
- Trajectories at 6mm gap, not corrected by correction coils
- Second field integral is well below specification (< 7000 Gcm^2)
- weak gap dependency

Phase Error Data

ALBA IVU-1



Phase error 2.45° RMS @ 6mm gap



- Phase error within specification (< 2.5° for all gap settings)
- Phase error has maximum at 6 - 8 mm gap
- Taper was not optimised at each gap
- Phase error versus gap shows behaviour as known from other publications

From Insertion Devices to Experimental Stations (on behalf of Wolfgang Diete, Bruker ASC)

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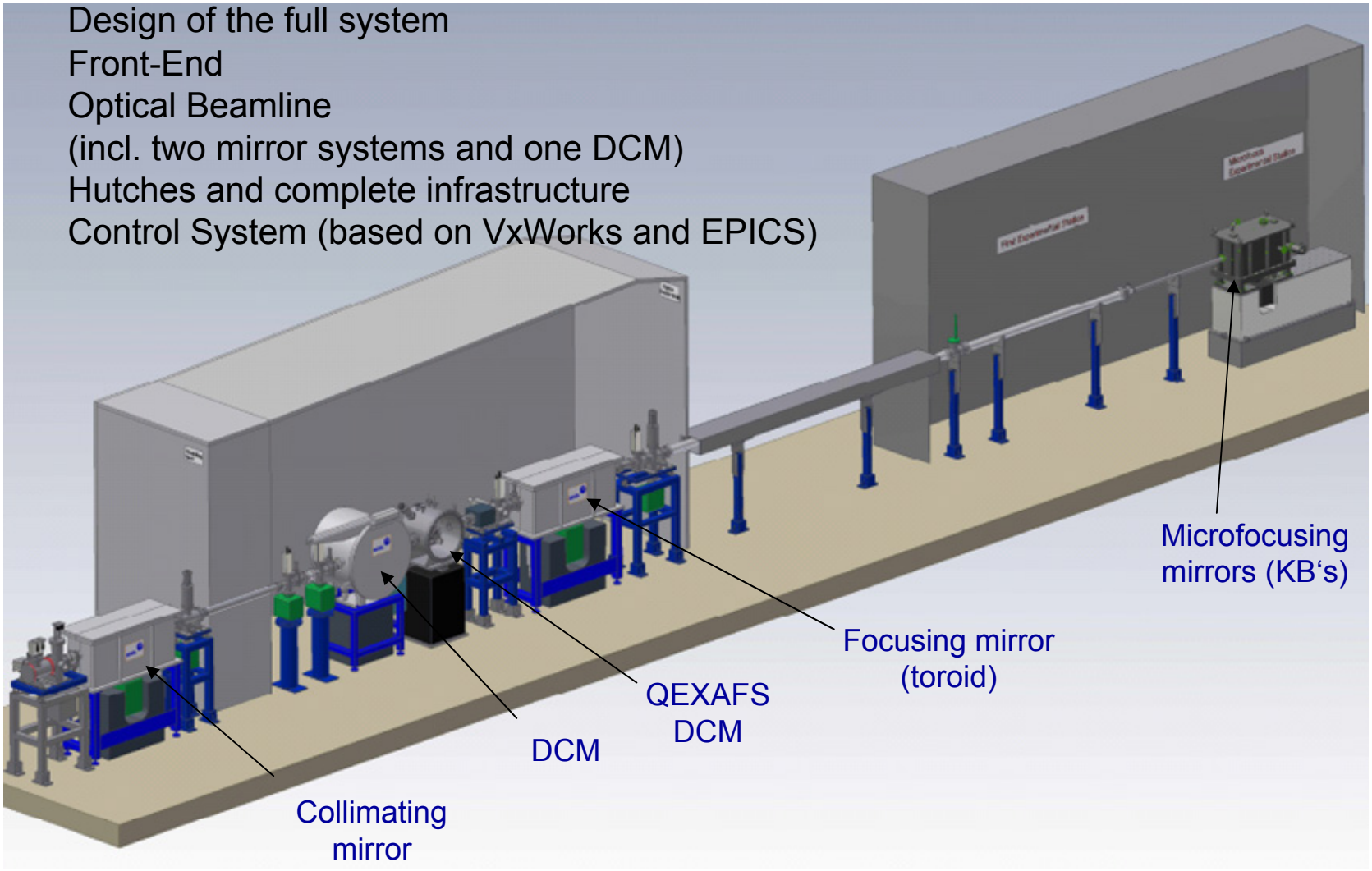
Super XAS Beamline at the SLS

Scope of Supply:

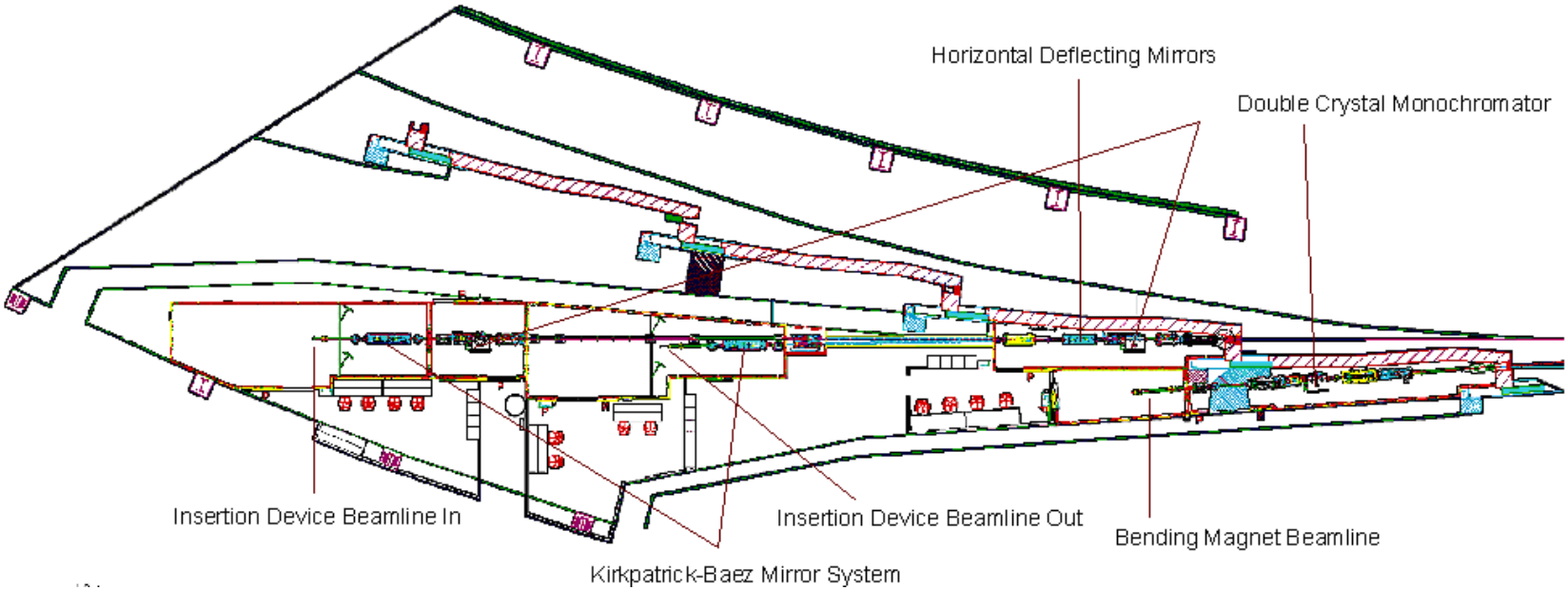
Design of the full system
Front-End
Optical Beamline
(incl. two mirror systems and one DCM)
Hutches and complete infrastructure
Control System (based on VxWorks and EPICS)



GM/CA - CAT Sector at the APS

Sector for Crystallographic Structure Determination of Proteins and other Macromolecules at the APS (funded by NIH)

Two Insertion Device Beamlines and One Bending Magnet Beamline

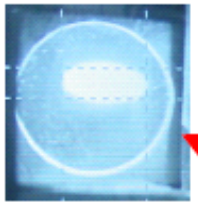


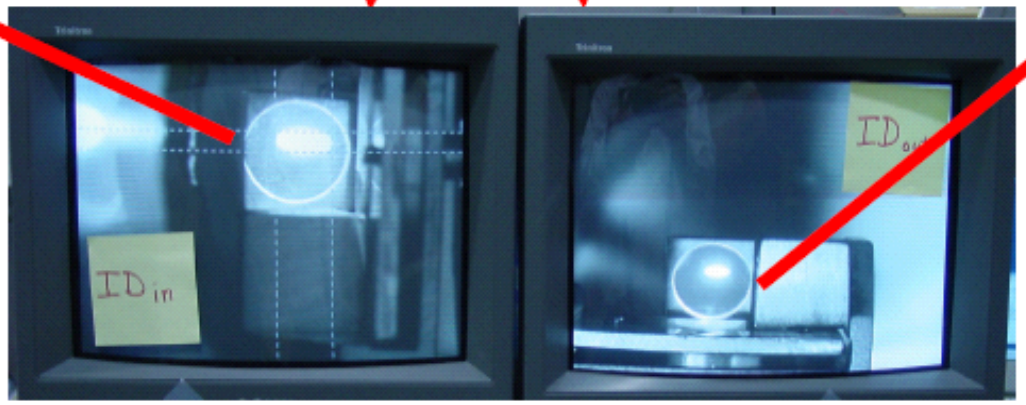
GM/CA CAT and ACCEL Instruments, GmbH Demonstrate Monochromatic X-rays from the First "Hard" Dual Canted Undulators in the World.

February 16, 2005

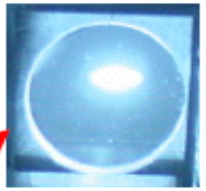
Advanced Photon Source
Argonne National Laboratory

Monochromatic X-Ray Beam form the Downstream Undulator Source





Monochromatic X-Ray Beam form the Upstream Undulator Source



NIGMS National Institute of General Medical Sciences 40 years of discovery
National Institutes of Health

National Cancer Institute
U.S. National Institutes of Health | www.cancer.gov

GM/CA CAT and ACCEL Instruments, GmbH Demonstrate Monochromatic X-rays from the First "Hard" Dual Canted Undulators in the World.

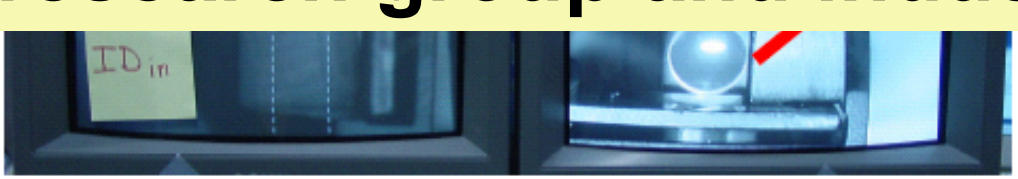
February 16, 2005

Monochromatic X-Ra for Down Unc Sc

Monochromatic am e m or

Today GM/CA-CAT is one of the most renowned centre for state-of-the-art Protein Crystallography !

A good example for a very successful co-operation between the research group and industry !



Double Crystal Monochromator

Cryogenically cooled for Insertion Device Beamlines

System for PAL, Korea

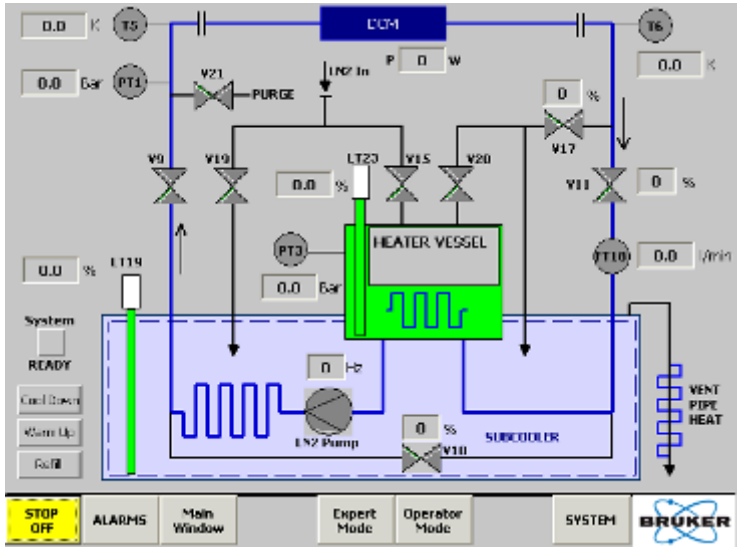
- **More than 20 ACCEL DCMs in routine operation worldwide**
- First crystal indirectly cryo-cooled (total power load up to 700 W)
- Options for the second crystal, e.g.:
  - Long crystal indirectly cryo-cooled
  - Sagittal bender (SLS design)
- Water-cooled Compton shielding for 1st and 2nd crystal
- Thermal stabilisation of goniometer base-plate and crystal holder
- Main movements equipped with optical encoders

Closed-Loop Cryo Cooler

Cooperation with Cryotherm

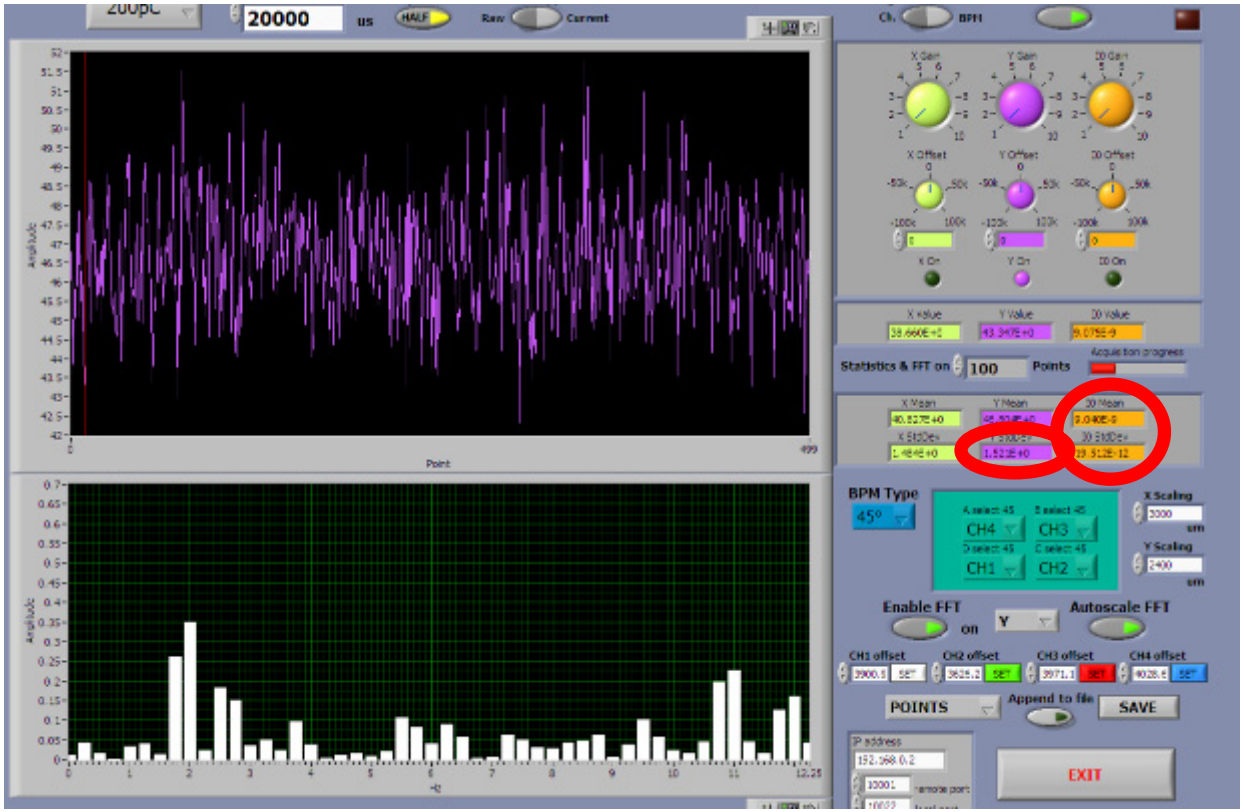
About 100 systems in routine operation worldwide

- Optimized pressure stability
- Fully remote controlled
- PLC with touchscreen
- Different interfaces, e.g. EPICS, TANGO
- Automated processes



Measurements – Combination of Cryo Cooler and DCM

- **Vertical beam position and intensity stability**
  - measured vert. beam stability 0.2 µrad RMS at 25 Hz sampling
  - intensity stability of < 0.2% at 25 Hz sampling

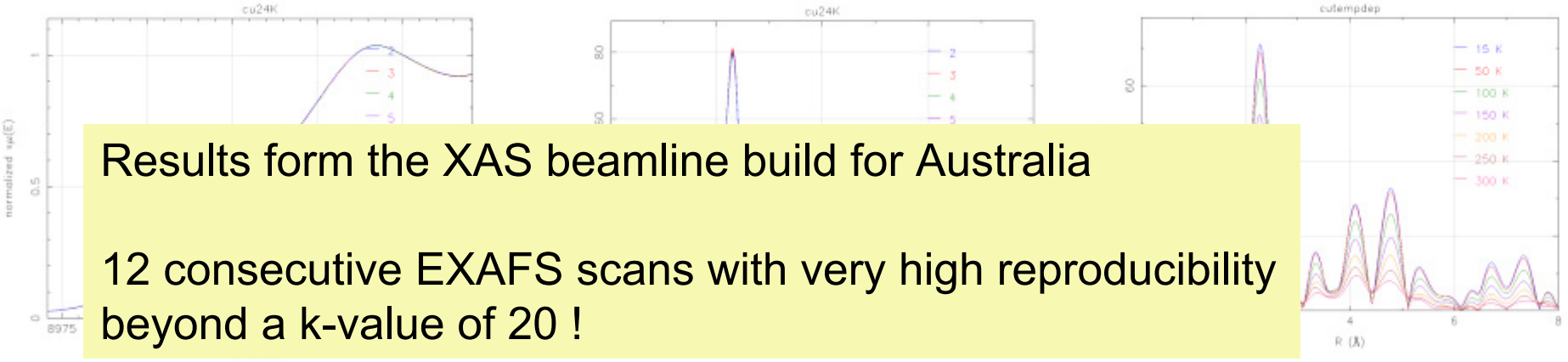


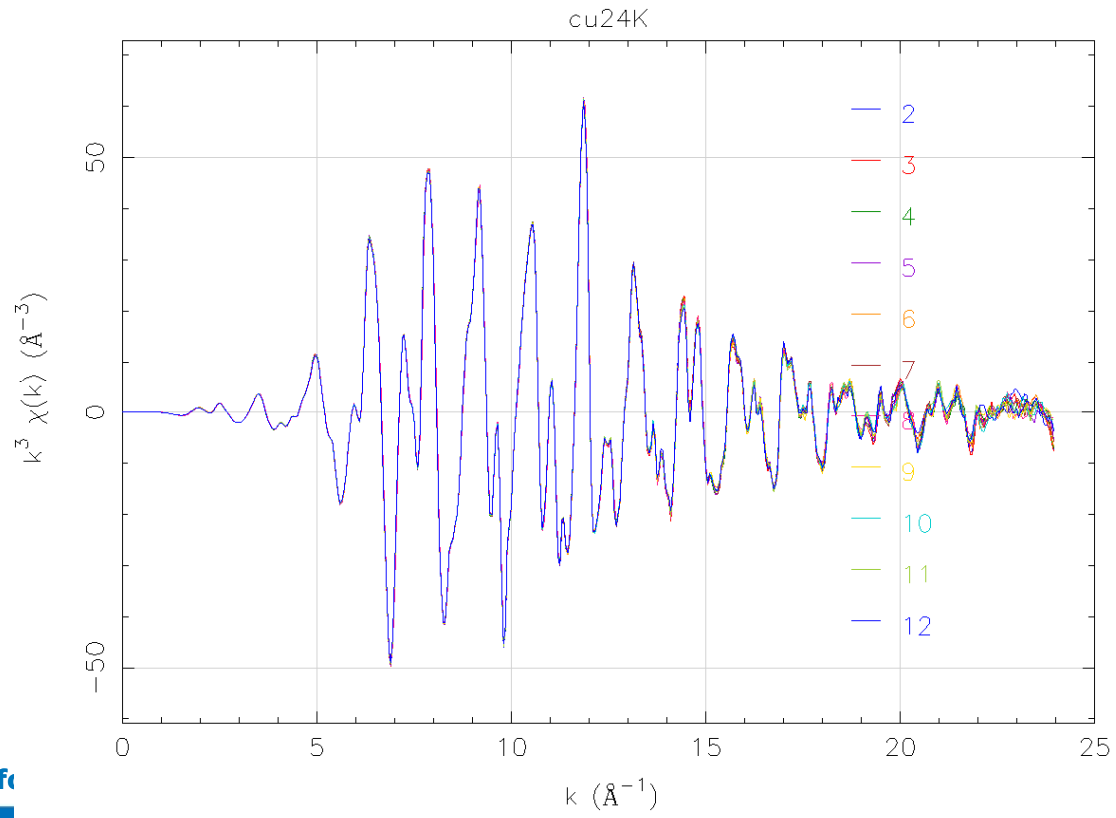
Standard DCM for DLS, UK:

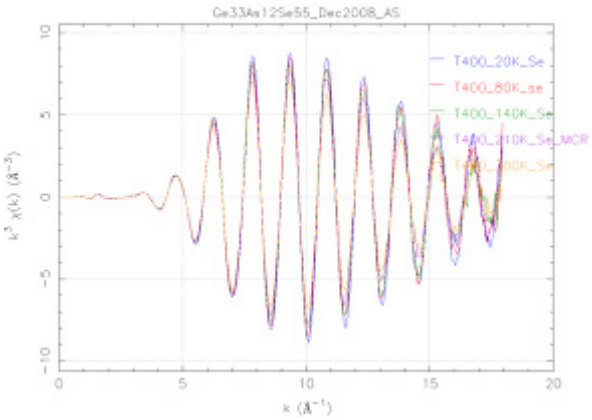
- Measurements performed with our XBPM 11 m downstream the DCM
- with running Cryo Cooler at standard operation (pump at 41 Hz)
- Si(111), no mirrors, direct beam from the DCM

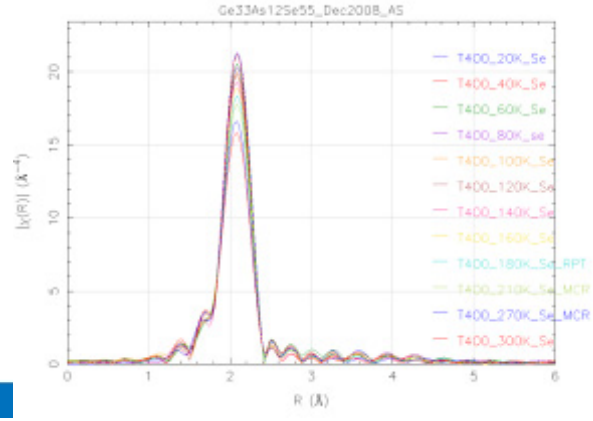
Results form the XAS beamline build for Australia

12 consecutive EXAFS scans with very high reproducibility beyond a k-value of 20 !



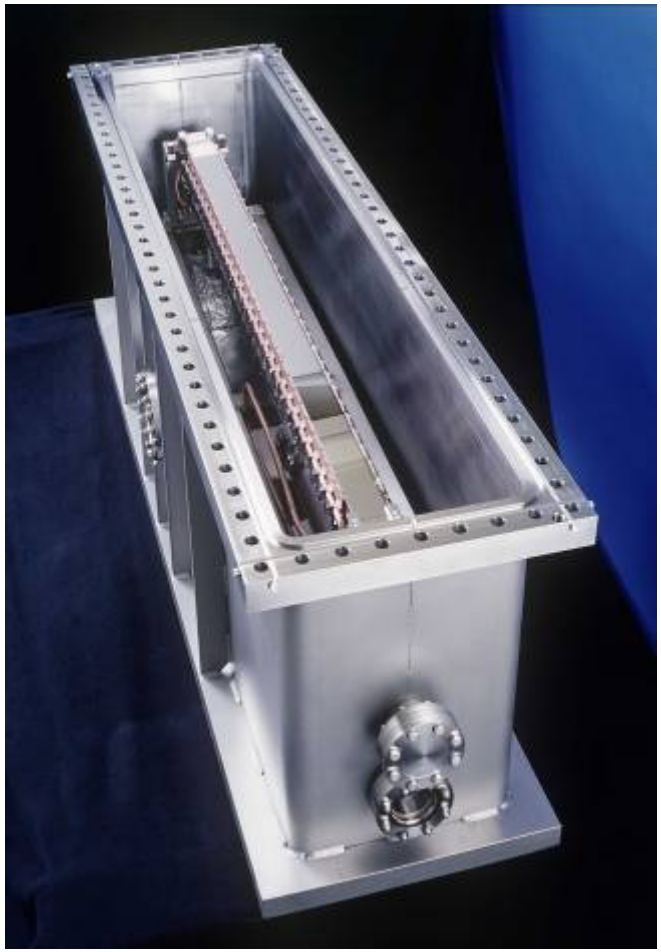






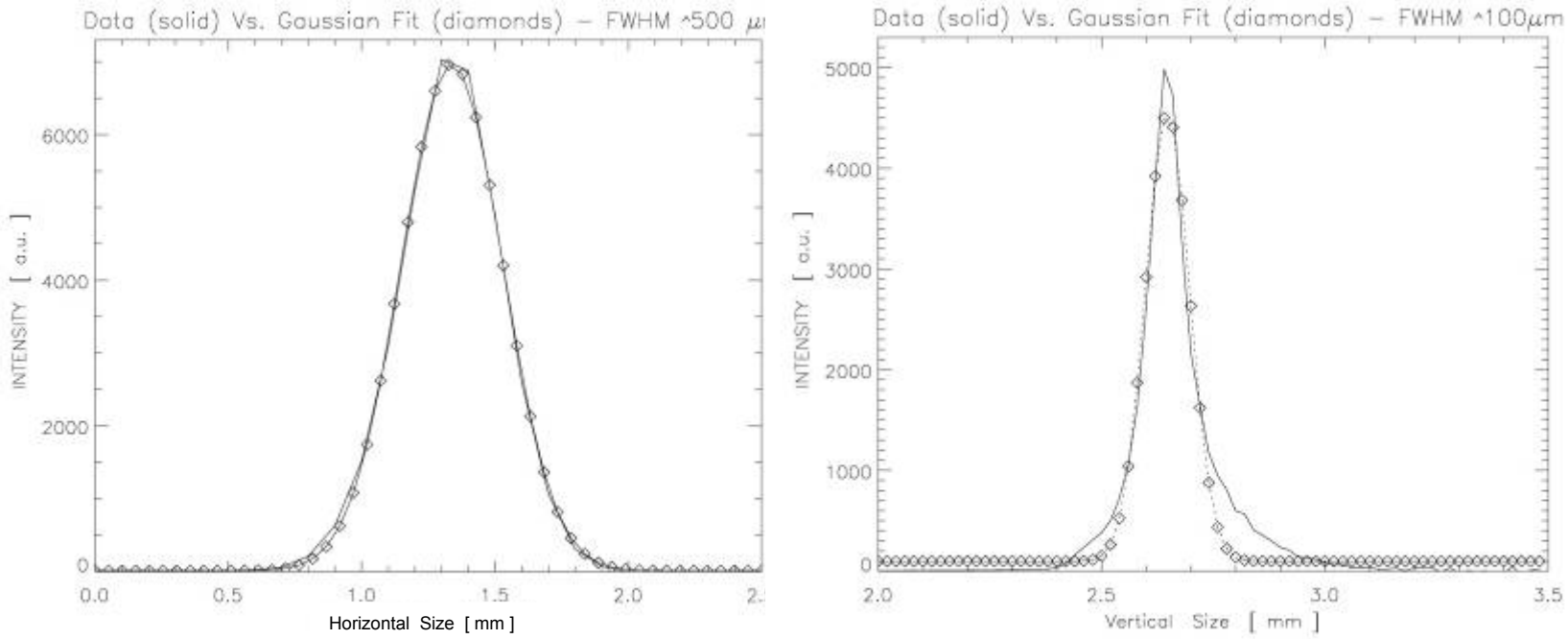
X-Ray Mirror System

More than 30 ACCEL Mirror Systems in routine operation worldwide



- Vacuum < 10^{-9} mbar
- Mirror cooling
  up to 2 kW and even beyond
- Different bending mechanisms
- Vertical or horizontal reflection
- Mirror mechanically isolated from vacuum chamber
- Fully adjustable in pitch, roll, yaw, and height
- Horizontal movement for different mirror coatings

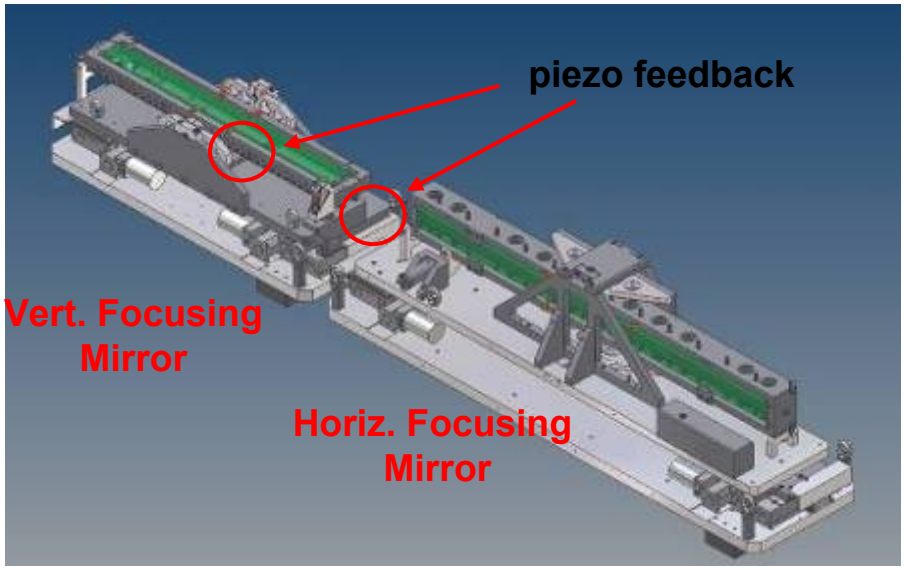
High Power Wiggler XAS beamline at the Australian Synchrotron



2:1 imaging of wiggler source, with 2 mrad of horizontal acceptance using:
a double-toroid mechanically bendable focusing mirror
&
a high-heatload (up to 2 kWatt) mechanically bendable collimating mirror

Compact System for large KB Mirrors

- Horizontal and vertical focusing mirrors in one chamber
- Very compact design
- Each mirror adjustable in pitch, roll, yaw, height and horizontal position
- Piezo driven fine pitch control for positional feedback
- Adaptive bimorph mirrors



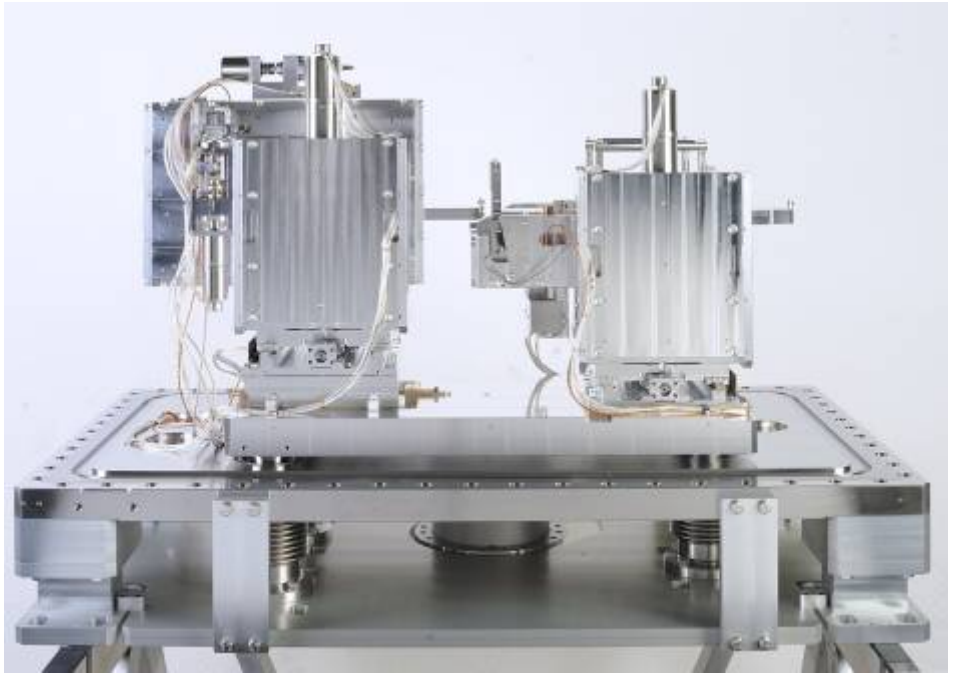
More than 10 systems in routine operation

XFEL Kirkpatrick-Baez Mirror System for the CXI Instrument @LCLS (Stanford)

- World-Class Optical and Mechanical Specifications
  - Shape error < 1 nm rms
  - Slope error < 0.25 µrad rms
  - µroughness < 0.25 nm rms
  - Pointing stability < 0.5 µrad

SPECS ACHIEVED

Overall system design, manufacturing, testing, integration and installation by Bruker-ASC



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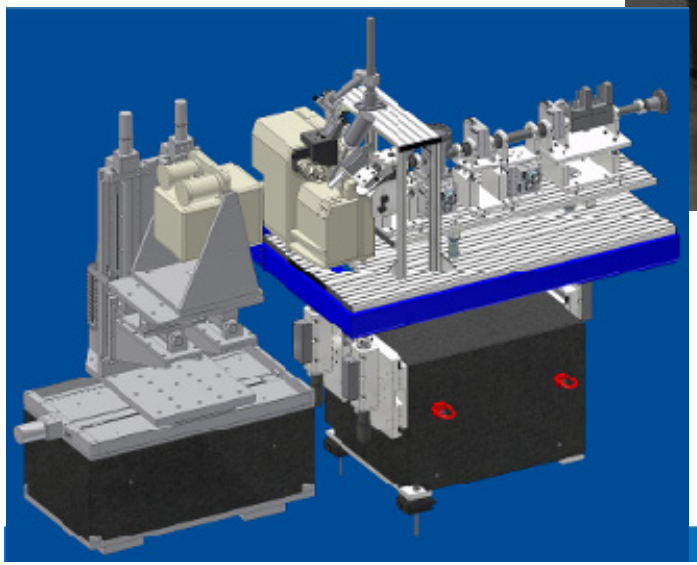
Protein Crystallography Endstation

Modular Endstation Systems

- Microdiffractometer MD2
- Alignment Table
- Beam Conditioning Elements
- Detector Support
- Control System



Installed at LS-CAT at the APS, BESSY, CLS and MaxLab

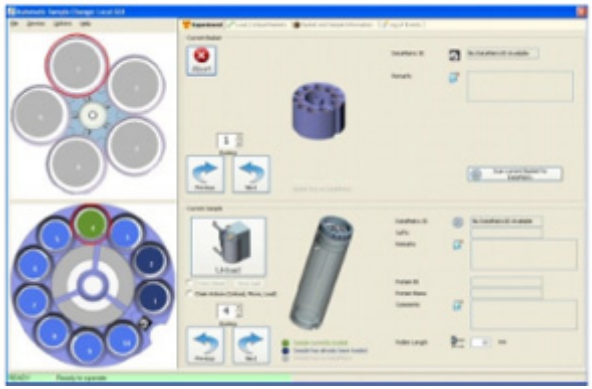
Protein Crystallography Endstation

EMBL Microdiffractometer and Sample Changer

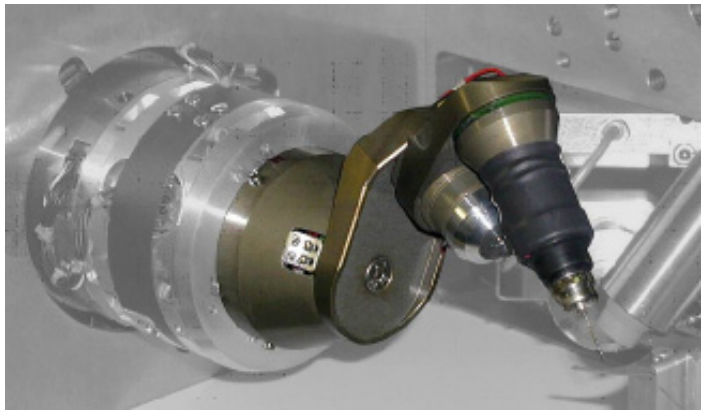
Co-operation with EMBL Grenoble and Maatel on this Patented Technology

EMBL MAATEL

- Microdiffractometer MD2
- Minidiffractometer
- Sample changer
- Visualisation system
- Goniometer
- Mini Kappa



MD2's in operation at ESRF, SLS, APS, ALS, BESSY, CLS, MaxLab, DLS, Hasylab, ALBA



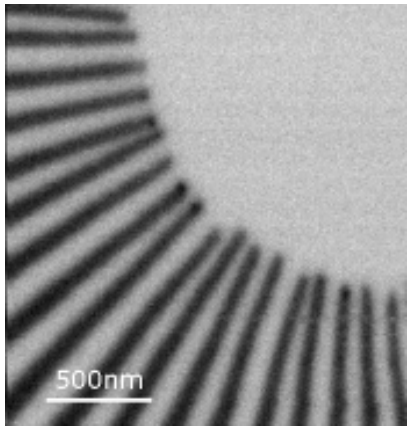
Robotic sample changer in the final stage of development and industrialization

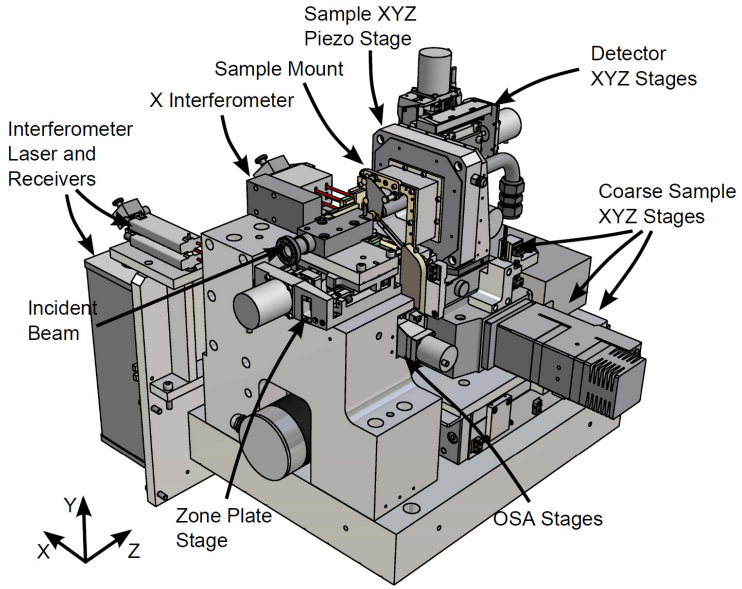
Scanning Transmission X-Ray Microscope

- **Endstation at bending magnets or undulators**
- **Cooperation with NCSU and ALS**
- **STXM at POLLUX Beamline at SLS in routine operation since two years**
- **UHV Version under realization for MPI to be installed at BESSY in Berlin**
- **SLS developed new technique for high resolution zone plates**

=> record resolution of about 15 nm

[PRL 99, 264801 (2007)]

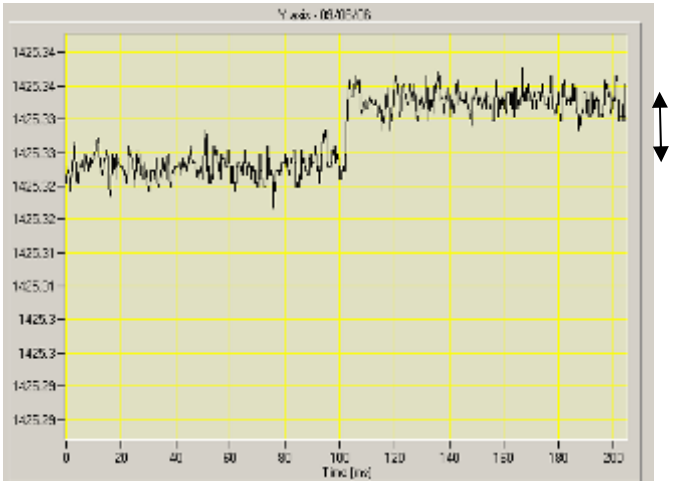


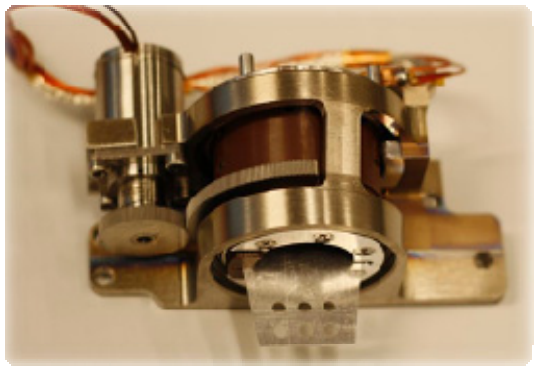


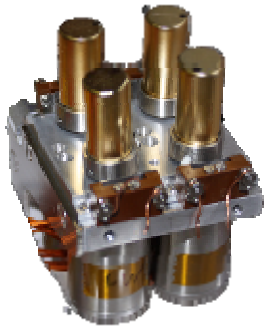
Installation at SLS POLLUX Beamline

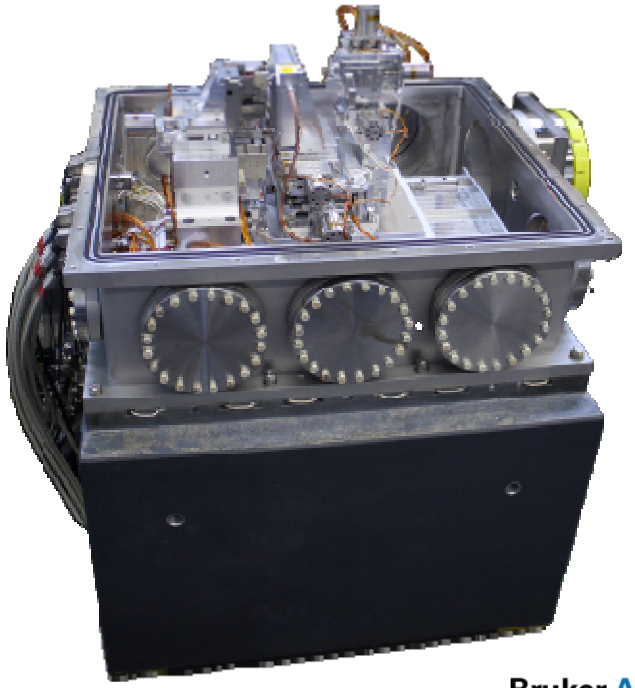
BESSY/MPI SXM: New Features

- ZP scan
  - Low vibrations (<2nm RMS)
  - Fast scan
- Modular chamber design
  - HV cover for easy access
  - UHV cover (<1x10^{-8}mbar) with bakeout, sample transfer system
- Goniometric sample mount
- Magnet system



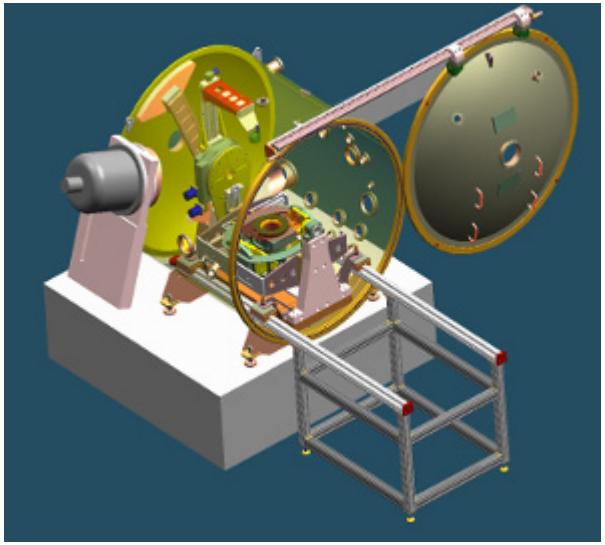






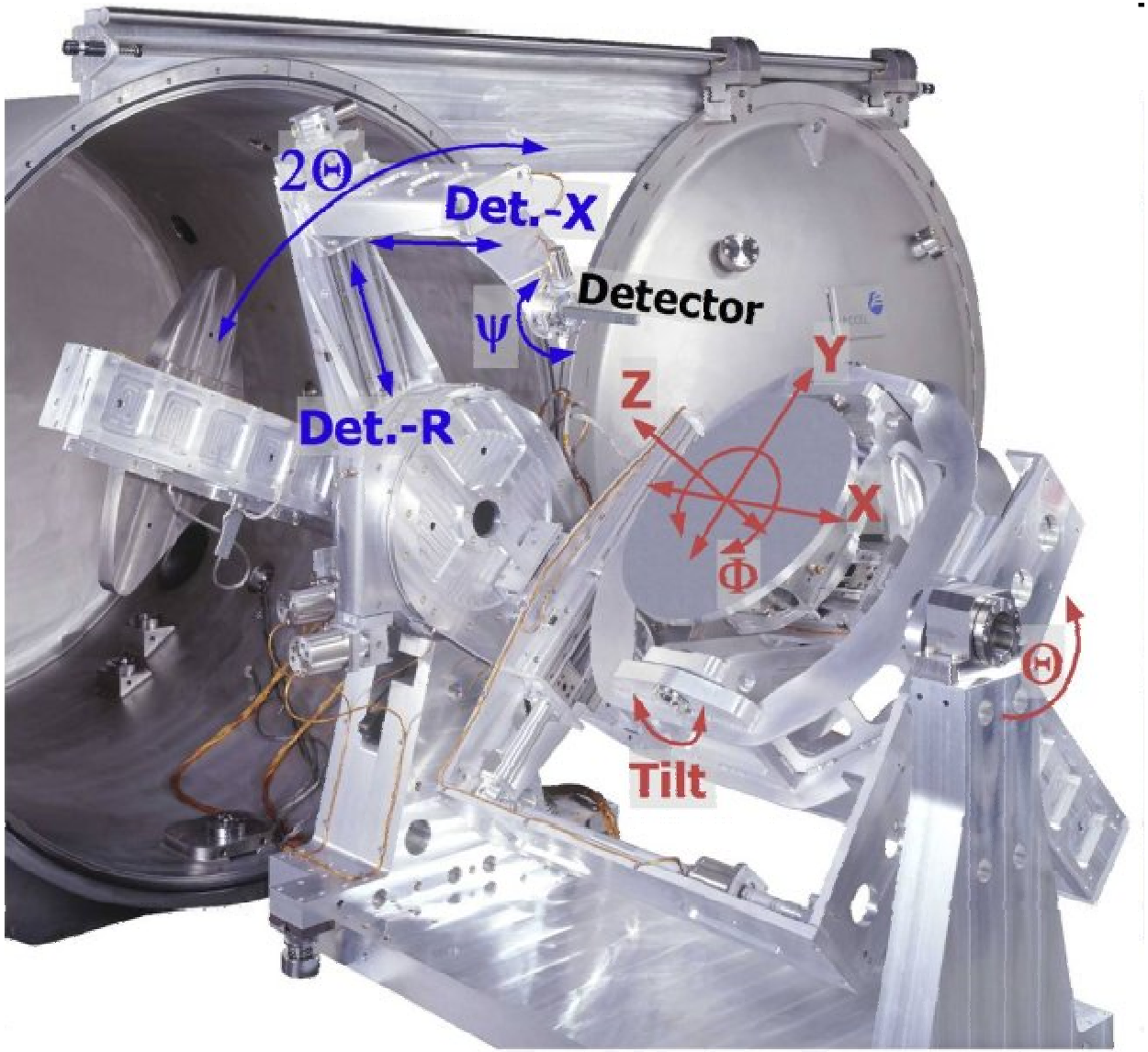
In-Vacuum EXAFS Station installed at ANKA

EUV-Reflectometer for PTB at BESSY



Most measurements on EUV-Components at synchrotrons in Europe are performed with this tool.

Full in vacuum reflectometer for the characterisation of EUV multilayer mirrors ($p < 2 \times 10^{-7}$ mbar)

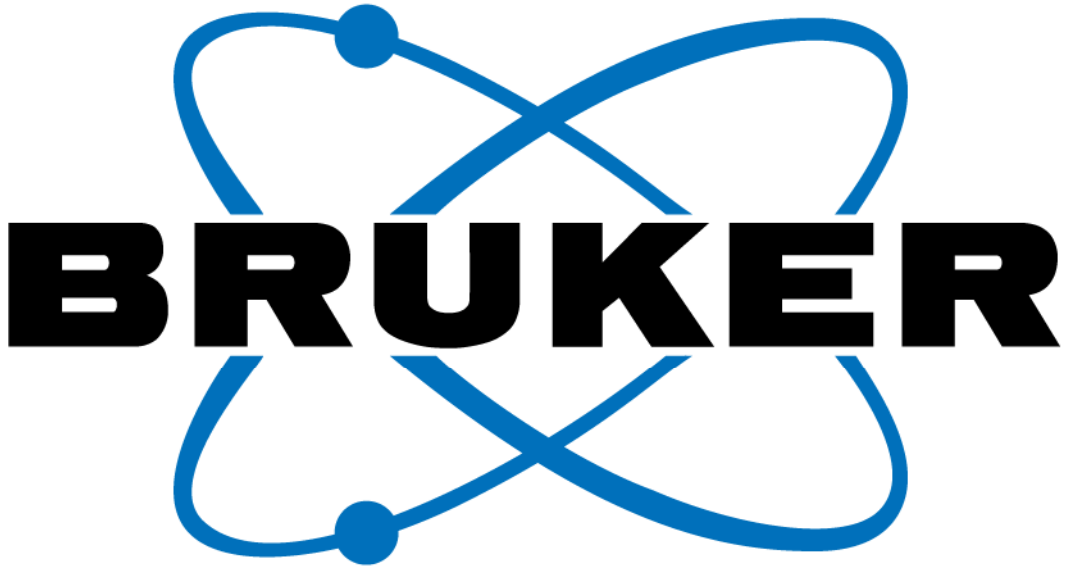


Summary

- We have shown a number of examples on what has been realized by Bruker ASC on:
    - Insertion Devices
    - Beamline Components and Complete Beamlines
    - Experimental Stations
- There are other companies around with partly similar activities

State-of-the-art technology exist in industry to build those devices

Thank you very much for your attention !



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