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Workshop on a Project
for a FZR-Beam Line at ESRF
Workshop on a Project for a FZR-Beam Line at ESRF
Rossendorf, 28. / 29. September 1993

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Introduction

The Research Center Rossendorf (FZR) investigates the possibilities to install its own beam line as a Cooperative Research Group-project (CRG) at the European Synchrotron Radiation Facility (ESRF) in Grenoble. The main interests for the FZR to use high brilliant synchrotron radiation are in the Institute of Radiochemistry and the Institute of Ion Beam Physics and Materials Research. This workshop was organized by these two institutes together with the FZR Study group Synchrotron. The purpose of the workshop was to achieve a better understanding for the technical needs of the projected beam line for the planned research projects. Experts with experience in beam line design met with the Rossendorf groups to discuss the best layout for such a beam line.

The summary of this workshop and the copies of transparencies of the lectures that were given are published in this booklet. Additionally, there was a short presentation of the capabilities of the Department for Research and Information Techniques of the FZR which will be strongly involved in the construction of such a beam line.

The organizer would like to thank Dr. Kevin D'Amico (X-ray Analytics, Upton, USA), Dr. Michael Hagelstein (ESRF, Grenoble), Dr. Ulrich Hahn (HASYLAB at DESY, Hamburg) and Dr. Philip Pattison (University of Lausanne) for coming to Rossendorf / Dresden and helping with their experience in the process of defining the technical project of an ESRF beam line.

The meeting was made possible in part by the financial support of the Saxonian Ministery for Science and Art.

Rossendorf, 1. October 1993
Summary of the Workshop

The following questions were discussed during the workshop:

1. Can the different demands be achieved in one beam line?
   - change of monochromator / mirror
   - different experimental stations (sequence)
   - option for additional surface sensitive techniques (e.g. XSW)

2. Which components can be ordered commercially?
   - Which solutions / construction blueprints / can be adapted from existing
   - beam line or beam lines under construction?
   - delivery time?

3. Which parts of the whole equipment should be designed and built in Rossendorf?
   - (vacuum system; sample chambers; detector electronics; remote control of
   - optics and experimental stage; data handling)

4. Time schedule
   - Cost estimation / cost distribution over the period of the project realization

5. Consequences of investigating radioactive samples

The following conclusions were made:

1. The demands of the different institutes can be achieved in one beam line by tuning the optics through remote control, according to the need of the different end-stations. Goals are to have available i) a focused beam with dimensions of about 0.5x0.5 mm² (full width) and ii) an unfocused beam (1:1 optics)
   - The optical component design for such a beam line is well established. Therefore, there is no need for further development work. The equipment needed is similar to that used at wiggler beam lines at low energy synchrotron radiation sources (e.g. SRS, NSLS,...). Furthermore, there are already four other bending magnet beam lines at the ESRF, from which technical solutions can be adapted.

2. The different experimental stations should be located in different hutches with independent radiation shielding. This demand is mainly due to the different scientific goals of the FZR institutes.
   - The demands for the different end stations (ion beam chamber, glove box)
   - should be specified before making the decision about the optics layout.
   - The radiochemical hutch should be the first in the beam, to allow access to the ion beam equipment for preparation of the experiment (longer time needed).
3. It may desirable to split the beam into two beam lines (in analogy to the Swiss-Norwegian BL) to have the option for an additional end station for work with non-radioactive samples. The instrumentation of this end station can be build later. The technical complications due to the splitting should be considered.

The reduction of the acceptance angle of the incident radiation to 2.5 mrad is no serious intensity limitation. Other beam lines use at maximum 4 of the 6 mrad, where part of the 4 mrad has no proper optical performance.

4. Key components of the optical system can be ordered commercially. Further components can be produced in FZR or contract shops on the base of supplied drawings.

Lists of potential suppliers can be obtained from the different groups (HASYLAB, ESRF, SRS, ...). The experience of different institutions should be used on the base of the concept demands.

Drawing may have to be adapted in Rossendorf, but the principal layout can be used from existing solutions.

5. The main development effort for the FZR will be the construction of the experimental end-stations. Components of the vacuum system and other mechanical parts can also be build there.

Members of the construction team can be trained at existing SR-laboratories.

It is recommended to develop the electronics (data handling, control system) in Rossendorf on the base of experience of existing instruments at ESRF, HASYLAB and others. The ESRF standard should be used wherever possible.

The special technical demands may result in electronics that differs from existing standard beam lines.

6. The time needed to construct a beam-line is at minimum two year after the decision on the base of a conceptual design report.

The cost estimation can be oriented on other CRG projects. The overall costs for the beam line including 2 experimental end-stations range between 4 and 6 Mio DM.

7. The aspects of radiological safety when investigating radioactive samples (including transport and storage of samples) should be investigated as early as possible. Requirements to the experimental end-station and their technical implications should be discussed with the ESRF management.

8. Because of the specialized end stations (radioactive glove box, ion beam chamber), it should be discussed what the beam line can offer to the ESRF for the general use (1/3 of beam time).

9. Personnel who will be located at the ESRF to operate the beam line should be identified as soon as possible and they should also be involved in the construction process in Rossendorf.
Requirements for a Radiochemistry/Environmental Research Beam Line at ESRF

H. Nitsche

Research Center Rossendorf Inc.
Institut of Radiochemistry
Dresden

September 1993

FZR
Research of Metal Contaminant Transport in the Environment

* Fundamental knowledge required of aqueous, surface and solid state chemistry
  - liquids
  - solids
  - interfacial reactions

* Environmental Restoration
  - metals and radionuclides

* Nuclear Waste Repository Performance Assessment
  - radionuclides
  - actinides and fission products
  - lanthanide model systems
Research of Metal Contaminant Transport in the Environment (continued)

* Molecular-level mechanistic understanding
  - transported species in solution
    . oxidation state
    . complex formation (mono or multinuclear)
    . low concentrations

  - sorption processes on liquid-solid interphase
    . minerals, soils, solids
    . biological materials
    . varying concentration range (high to low)
XANES and EXAFS are Our Methods of Choice

* Solutions and solids
  - XANES
    . oxidation state specificity
    - comparison with models systems
    - speciation at low concentration levels
    - development of new detection systems
  - EXAFS
    . chemical environment of metal atoms
    - complexation reactions
      . ligand coordination

* Solids on surfaces / interfaces
  - XANES
    . change in oxidation state
      - comparison with model systems
  - EXAFS
    . binding mechanism
      - inner sphere vs. outer sphere
    . variations of chemical environment

* Bioinorganic systems
  - XANES
    . change in oxidation state
Experiments at Stanford Synchrotron Radiation Laboratory (SSRL)

* Collaboration with
  D. Shuh, J. Bucher, N. Edelstein, LBL

* Wiggler Beam Line 4-1
  - double crystal monochromator
    . Si (220) or (400) crystals
  - transmission data collected using ion chambers
  - Stern-Heald or solid-state Si detector for fluorescence
  - standard detection geometry and set-up with energy calibration reference
  - motorized detector and sample stages
  - samples prepared at LBL and transported to SSRL
    . Se, Tc, U

FZR
Bioremediation of Se by \textit{B. Subtilis}

* Environmental Selenium contamination of several sites in California and the Carson River Sink in Nevada
  - bioremediation is an attractive possibility for clean-up

* \textit{Bacillus Subtilis} are common aerobic soil bacteria

* Large uptake of Se and incorporation in the vegetative bacteria
  - biological research program to explore uptake mechanism
  - takes up Se(IV), but not Se (VI)

* XANES to determine oxidation state of Se after microbial uptake
  - comparison with Se model systems \( \text{Na}_2\text{SeO}_4, \text{Na}_2\text{SeO}_3, \text{Se} \)

\textit{FZR}
Selenium K-edge X-ray Absorption Spectra of Model Compounds and Bacillus Samples Containing Selenium

\[ \text{Na}_2\text{SeO}_4 \text{(VI)} \]
\[ \text{Na}_2\text{SeO}_3 \text{(IV)} \]
\[ \text{Se metal} \]
\[ \text{Bacillus B} \]
\[ \text{Bacillus K} \]

Photon Energy (eV)

Technetium Reduction by FeS (slag) in Cement

* TcO$_4^-$ present in processing waste
  - very mobile
  - nearly no adsorption onto geologic material

* Proposed waste treatment to less mobile and insoluble Tc compound by adding FeS to the cement wasteform matrix

* XANES and EXAFS for technetium model systems and comparison with untreated and treated waste form
  - TcO$_4^-$, TcO$_2$, Tc metal
99TcO₄⁻ K-edge EXAFS Spectrum

Energy (eV)

Absorbance

21000 21200 21400 21600 21800
TcO₂ raw data

Absorption (arbitrary units)

TcO₂ EXAFS

χ(k)*k³

k (Å⁻¹)
Background-Subtracted Frequency Component of $^{99}$TcO$_4^-$ K-edge EXAFS Spectrum

\[ \chi(k) \times k^3 \]

$R+\Delta (\text{Å})$

$k (\text{Å}^{-1})$

\[ N = 4.000 \quad R = 1.7156 \quad \sigma_2 = 0.00110 \quad E_0 = -7.280 \]
Collaborators for SSRL Experiments

* LBL/Chemical Science Division
  D. Shuh, J. Bucher, N. Kaltsoyannis
  W. Lukens, N. Edelstein

* LBL/Earth Sciences Division
  I. Al Mahamid, K. Roberts, P. Torretto,
  H. Nitsche

* University of California Berkeley, UCB
  T. Leighton, Dep. Molecular and Cell Biology
  B. Buchanan, Dep. of Plant Biology

* Savannah River Ecology Laboratory
  S. Clark

FZR
ESRF is the Ideal Synchrotron Source for Our Experimental Work

* Allows to conduct cutting edge science

* Hard x-ray energy range required
  - ~ 5 - 20 keV
  - L and K edges

* High flux
  - for homogenous solutions

* High brilliance and excellent spatial resolution
  - for inhomogenous solids

* Great international / national interest in proposed beam line
  - Lawrence Berkely Laboratory
  - Lawrence Livermore Laboratory
  - Freie Universität Berlin
  - possible interest of other users

FZR
Radiological Aspects

* List of possible radioelements
  - Th, U, Np, Pu, Am and Tc
    - less than 37 MBq to 37kBq (1mCi - 1μCi)
    - many non-radioactive samples

* Radioactive Samples are not directly connected to beam line
  - conventional beam line with Be window

* Only experimental station must be equipped to handle radioactive samples
  - samples are double contained
  - possibility of installing radioactive glove box with additional Be window in beam
    * negative pressure guarantees integrity

* Samples can be prepared at FZR or elsewhere

* Need for shipping and storage facility
Technical and Financial Project Participation

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<th>TOPIC</th>
<th>FZR</th>
<th>ESRF</th>
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<td>* Beam line construction</td>
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<tr>
<td>- monochromator design</td>
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<tr>
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<td>electronics</td>
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<tr>
<td>* Experimental Station/Hutch</td>
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<td>- Table</td>
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<td>* synchronized with monochromator</td>
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<td>- sample positioning system</td>
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<td>* video system</td>
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<tr>
<td>- detection systems</td>
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</table>

FZR
Some Technical Specifications

* Conventional XAS beam line
* Double Crystal Monochromator
  - e.g., Si (400)
  - $\Delta E/E = 10^{-4}$
  - $S_x = 160 \mu m$ \hspace{0.5cm} $S_x' = 140 \mu \text{rad}$
  - $S_z = 130 \mu m$ \hspace{0.5cm} $S_z' = 5 \mu \text{rad}$
* Macro beam
  - flux $= 10 \text{ keV}: 1.10 \frac{13 \text{ Ph}}{\text{sec} \text{ mrad} 0.1 \% 3W (\text{Band. M.})}$
* Micro beam
  - brilliance =

---

FZR
Proposal

for an Experimental Station at the ESRF for the Institute of Ion Beam Physics and Materials Research

W. Matz, W. Möller
Institute of Ion Beam Physics and Materials Research at FZR

1. Surface modification by ion beams
2. Methods of investigation with synchrotron radiation
3. Demands for beam line parameters
4. Compatibility with the experimental setup of Radiochemistry
1. Surface modification by ion beams

Influence of ion bombardment to surfaces

- Surface Topography
- Surface Composition
- Surface Properties
- Thin Film Deposition
- Buried Layers

Elementary Processes

Implantation  Sputtering  Defect Formation  Relocation
IBAD (ion beam assisted deposition)

(energy range of ions 100 eV - 1 keV)
--> plain layers / minimum roughness
--> different ion beams - compound formation
     (hard covers)
--> adhesion
** Investigation of the process of the beginning of film growth (in-situ)

planar growth / island formation / surface mixing

optional also investigation of buried layers after implantation (ex-situ)

Material systems:
- IBAD
- substrate: iron (steel), titanium
- layer: C-B-N
- buried layers: Co, Fe, in Si, SiC
2. Methods of investigation with synchrotron radiation

in general for surface sensitive experiments:

- grazing incidence technique

IBAD in situ

* beginning of growth change of neighborhood of substrate atoms

EXAFS with fluorescence radiation
Quick EXAFS for the study of growth process in-situ
Figure 1. XANES spectra of $5 \times 10^{16}$ cm$^{-2}$ As implanted specimens; (a) as-implanted, (b) after 800°C annealed for 30 minutes and (c) after 1000°C annealed for 30 minutes.

* layer characterisation after growth: reflectivity or diffraction
3. Demands for beam line parameters

typical data of sample: linear dimension up to 20 mm
growth rate 1 monolayer ≤ 100 sec
pressure during process 10^{-5} mbar

*synchrotron radiation beam*

energy range: 5-15 keV
resolution in energy: ΔE/E ∼ 10^{-4}
scanning time (QEXAFS): 100 sec.

beam characteristics: parallel beam for grazing incidence
(at sample) fixed beam position (IBAD chamber)
width up to 20 mm (?)
high < 700 μm
Technical

* IBAD-chamber + window system for incident beam and detection (contamination problem from ion beam)
  + adjustable sample holder
  + sample holder with heating up to 600°C
  + vacuum system

  alternatively
  goniometer for reflectivity and diffraction experiments (?)

* Detector system

* Data accumulation
  + high data rate
  + synchronization with monochromator drive
  + correlation to deposition process
4. Compatibility with experimental set up of Radiochemistry

* same demands
  + energy range
  + energy resolution
  ==> double monochromator system
      Si (400)
      Si (311)

* additional demand
  + continuous change of incident energy for QEXAFS
  ==> precision drive of crystals with
      synchronization to detection unit

* different demands
  + beam size
  + parallel beam
  ==> change in optics design
      (? only influence to mirrors or also to
       monochromator crystals ?)
ESRF EXAFS Group

ID 12  BEAMLINE 6
Circular Polarization

José Goulon, Nicolas Brookes, Jeroen Goedkoop

ID 24  BEAMLINE 8
DEXAFS for time resolved studies

Michael Hagelstein

D 27  BEAMLINE 18
EXAFS

José Goulon, Nicolas Brookes

BEAMLINE 23
XAUS, XAS on ultradilute samples
## ESRF-Funded Beamlines

<table>
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<tr>
<th>BL No.</th>
<th>Source No.</th>
<th>Short Title</th>
<th>Scientist-in-charge</th>
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<td>BL 1</td>
<td>ID13 (U)</td>
<td>Microfocus</td>
<td>C. Riekel</td>
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<tr>
<td>BL 2</td>
<td>ID11 (W)</td>
<td>Materials Science</td>
<td>Å. Kvick</td>
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<td>BL 3</td>
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<td>BL 5</td>
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<td>High Energy</td>
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<td>BL 6</td>
<td>ID12 (W)</td>
<td>Circular Polarization</td>
<td>J. Goulon</td>
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<td>BL 7</td>
<td>ID3 (U)</td>
<td>Surface Diffraction</td>
<td>S. Ferrer</td>
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<tr>
<td>BL 8</td>
<td>ID24 (U)</td>
<td>Dispersive EXAFS</td>
<td>M. Hagelstein</td>
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<td>BL 9</td>
<td>ID10 (U)</td>
<td>Troika or &quot;Open&quot; Beamline</td>
<td>G. Grübel</td>
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<td>BL 10</td>
<td>(BM)</td>
<td>Bending Magnet &quot;Open&quot; Beamline</td>
<td>G. Grübel</td>
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<td>ID18 (long) (U)</td>
<td>Mössbauer</td>
<td>R. Rüffer</td>
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<td>BL 12</td>
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<td>ID32 (U)</td>
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<td>F. Comin</td>
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<td>BL 14</td>
<td>ID17 (long) (W)</td>
<td>Medical Beamline</td>
<td>H. Moulin-Elleaume</td>
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<tr>
<td>BL 15</td>
<td>D16 (BM=U)</td>
<td>Powder Diffraction</td>
<td>A. Fitch</td>
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<td>BL 16</td>
<td>ID19 (long) (W)</td>
<td>Topography</td>
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<td>XAUS</td>
<td>J. Goulon</td>
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<td>D5</td>
<td>Optics Test Beamline</td>
<td>A. Freund</td>
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<tr>
<td></td>
<td>ID6</td>
<td>Machine Test Beamline</td>
<td>P. Elleaume</td>
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The energy-dispersive X-ray absorption spectroscopy beamline for time resolved studies

40 mm undulator ($K_{\text{max}} = 1.38$)

Coupling optics (Kirkpatrick-Baez)

Energy dispersive X-ray absorption spectrometer

Michael Hagelstein
Optical Design
Powder Diffraction BL15

Horizontal Plane

Bending Magnet

$S_x' = 4 \text{ mrad}$

collimating mirror

focussing mirror (optional)

Si 311 Sagittally-Focussing Monochromator

2-circle diffractometer
Optical Design
MAD (PX) BL19

Horizontal Plane

Bending Magnet

$S_x = 4 \text{ mrad}$

optics hutch

collimating mirror

focusing mirror

Si 111 Channel - Cut Monochromator

3-circle crystal orienter

experimental hutch
Beam Line 18 - a general purpose beam line for EXAFS

Initial phase

Source

double crystal (sagittal focusing)
multi-layers
chopper BPM
4 - 40 KeV

Second phase

Source

vertically collimating band pass filter

expt. 1 expt. 2

optics hutch experimental hutch

28.5 m ~ 38 m ~ 45 m
Fig. 1. A mechanism to keep the exit-beam height constant. The $x$ and $y$ axes are taken on the reflected beam from the second crystal and perpendicular to it, respectively, by choosing the position of the rotation axis as the origin. For more details, refer to the text.


*Matsushita et al.*

(Lemonnier et al. (1978))

(Goulon et al. (1983))
Fig. 10 An adaptive second crystal placed on a bender equipped with two inchworm motors.
An international collaboration between Norway and Switzerland to construct and operate a general purpose synchrotron radiation beamline at the European Synchrotron Radiation Facility (ESRF).

The beamline will be used for experiments in:

* Single crystal diffraction
* Powder diffraction
* X-ray absorption spectroscopy (EXAFS)
* White beam diffraction (Topography)
**Spectral flux**

**ESRF bending magnet**

photons/sec/horizontal mrad/0.1% bandwidth

---

![Graph showing spectral flux for ESRF bending magnet](image)

Photon Energy [keV]
ARRANGEMENT OF BEAMLINES

- CRG IF (B 32)
- CRG SNBL (B 1)
- BL 4 (ID 2) High Brilliance (Install.: 10/5-30/8)
- CRG D2AM (B 2)
- BL 7 (ID 3) Surface Diffraction (Install.: 8/3-21/6)
- Optics (B 5) (Install.: 5/7-25/10)
- Machine (ID 6) (in operation)
- GRAAL (B 7)
- CRG GILDA (B 8)
- BL 3 (ID 9) White Beam (Install.: 7/6-27/9)
- BL 9 (ID 10) Troika (in operation)
- BL 2 (ID 11) Materials Diffraction (in operation)
- BL 6 (ID 12) Circular Polarization (Install.: 5/4-12/7)
- BL 1 (ID 13) Microfocus (in operation)
- BL 5 (ID 15) High Energy (Install.: 16/8-22/11)

January 1993
Swiss-Norwegian Beam Line

General Layout
Splitter vessel

Beam Position Monitor
Cooled aperture plate
Slit system
Slit system
Cooled absorber
Cooled Absorber
Vacuum valve

6 mrad

0 250 500

2.5 mrad

1.0 mrad
Beamline Optics

(A)

(B)

(C)
X-ray optics

Source

Monochromator

Focussing Optics

Focus

Shield Wall

Shield Wall

Collimating Optics

Focus

Focussing Optics
Progress Report

1992

Beamline design work completed
Orders placed for all major beamline components
Delivery of all vacuum pumping and controllers completed
Many components (slits/absorbers/Be windows etc) delivered

1993

April/May
Delivery of all vacuum vessels
Assembly, alignment and testing of vacuum components

June
Monochromator delivered and testing begins

July
Installation of radiation enclosures begins in Grenoble
Electrical and fluid services installed

Oct
Beamline moved to Grenoble and installed

Dec/Jan
Beamline takes first beam

1994

Jan-March
All beamline components tested with beam

March-June
Test experiments start

July -
Scheduled beam ...

Note:
Beamline will begin operation without mirrors
Mirrors installation planned for winter shutdown 1994
Beamline Equipment at HASYLAB
by Ulrich Hahn - HASYLAB

Outline
Introduction
Layout of SR Beamlines
Front End Components
Beamline Components
Running a Beamline
# Major Components of a X-Ray Beam Line

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<th>Function or Purpose</th>
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<td>Storage Ring</td>
<td>SR - Source</td>
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<tr>
<td>Absorber</td>
<td>Protects the valves from BM radiation (50 W/mrad at DORIS with 4.5 GeV and 0.1 A)</td>
</tr>
<tr>
<td>Ring Valve</td>
<td>Vacuum separation of Storage Ring and beamline</td>
</tr>
<tr>
<td>Fast Acting Valve</td>
<td>Protection against accidental venting</td>
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<tr>
<td>Beam Position Monitor 1</td>
<td>Beam alignment for the experiment (position)</td>
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<tr>
<td>Beam defining Apertures</td>
<td>Protection of the beam pipe</td>
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<tr>
<td>Beam Position Monitor 2</td>
<td>Beam alignment for the experiment (angle)</td>
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<tr>
<td>Beamshutter</td>
<td>Radiation safety</td>
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<td>Front End Valve</td>
<td>Vacuum separation front End - beamline</td>
</tr>
<tr>
<td>Slits (horizontal – vertical)</td>
<td>Beam definition for the experiment</td>
</tr>
<tr>
<td>Mirror</td>
<td>Focussing of the beam</td>
</tr>
<tr>
<td>(Window or differential pump)</td>
<td>UHV $\rightarrow$ HV</td>
</tr>
<tr>
<td>Monochromator</td>
<td>$\rightarrow$ Monochromatic beam</td>
</tr>
<tr>
<td>(Window or differential pump)</td>
<td>UHV $\leftarrow$ HV</td>
</tr>
<tr>
<td>Monitor</td>
<td>Definition of the monochromatic beam</td>
</tr>
<tr>
<td>Experiment</td>
<td></td>
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</tbody>
</table>
Strahllagemonitor NW 150

Vorderansicht
Strahllagemonitor NW 150

Seitenansicht
X-ray mirror chamber for high power beamlines at HASYLAB

Design criteria:
- mirror alignment by moving the whole mirror chamber
- linear and rotational movements mechanically decoupled
- rigid central chamber frame as mirror support
- friction-free rotation of the deflection angle (resolution < 1 μrad)
- chamber movement decoupled from the beamline by formed bellows
  range of linear movement ± 25 mm

1. toroidal mirror (1000 x 130 x 130)
2. water cooling
3. water-cooled absorber (protection of the mirror face)
4. linear encoder
5. mirror support and aligning system
6. ion pump
7. bellows
Vakuumkammer
mit Spiegellagerung
Montagezeichnung

ZUSAMMEN. 2.
M400 - Messung:
Datensatz: FSCD0702
RMS - Tangentenfehler:
X-Richtung: 1.63 arcsec
Y-Richtung: 3.01 arcsec
BM WHITE BEAM WINDOW
Carbon foil window

Contamination barrier window for high power x-ray beamlines

1 Carbon foil (50 x 80 mm, 130 μm thick)
2 Water-cooled Cu - Block
3 Vacuum bypass with valve
Guiding Philosophy for running a beamline

Electron beam dump of the Storage Ring only when
- there is danger of irradiating a person
- there is danger to damage equipment

Personnel protection:
The personnel protection always requires a device which is controlled by at least two redundant circuits to stop the beam. In the white beam an additional power absorber is required. The white beam has to be terminated by a beam stop.

Storage Ring and front end protection:
The beamline has to fulfill the vacuum requirements downstream the front end valve.

Fast valve action: (Triggered by an accidental vacuum break down)
- beam dump at ID beamlines when the ID gap is closed
- no beam dump at bending magnet lines and at ID beamlines when the ID gap is open

Before venting a beamline section, two upstream valves must be closed.

Beamline equipment protection
Before closing a beamline valve or moving an insufficient cooled device into the beam a power absorber must be in the beam.
Kevin D' Amico

Experience in EXAFS Beam - Line Design

General Issues Associated with Beamline Planning

Phases of Project

I. Define Technical Boundaries
II. Produce a Workable Concept
III. Design and Engineering
IV. Fabrication / Construction / Testing
V. Assembly / Installation
VI. Commissioning
VII. Operation
Details of Phases I. and II.

I. Define Technical Boundaries:

- scientific justification
- information from ESRF
- (particular issues, e.g. safety)
- determine technical requirements

II. Produce Workable Concept "Conceptual Design Report":

- assess existing technology
- understand necessary infrastructure:
  - financial
  - technical
  - logistical
- equipment needed "Work Breakdown Structure"
- cost estimate
- manpower estimate and timetable:
  - design
  - engineering
  - scientific
- final document for external and internal purposes

CDR becomes roadmap or blueprint for carrying out project