High Energy Materials Science at PETRA III

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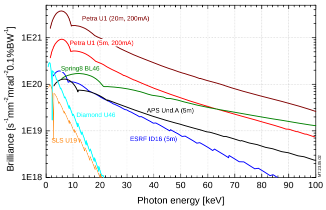
High Energy Experiments at PETRA III

Currently refurbished for operation with 6 GeV @ 100 mA, the storage ring PETRA III on the DESY site in Hamburg will be one of the most brilliant 3rd generation x-ray sources with planned user operation in 2009. [*PETRA III: A Low Emittance Synchrotron Radiation Source, Technical Design Report*, ed. K. Balewski *et al.*, Hamburg, DESY, 2004]

Artist's view of the new 280 m long experimental hall with 14 beamlines and up to 30 experimental stations.



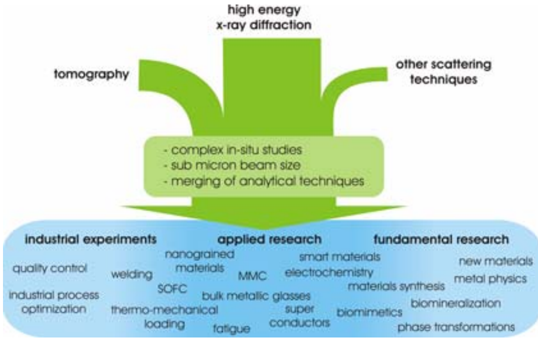
Comparison of PETRA III with current 3rd generation synchrotron radiation sources.

The future **H**igh **E**nergy **M**aterials **S**cience Beamline **HEMS** will be ***fully tunable in the range of 30-300 keV***, and optimized for ***sub-micrometer focusing*** with Compound Refractive Lenses and Kirkpatrick-Baez Multilayer mirrors. Design, construction, operation and main funding (4.7 Mio €) is the responsibility of GKSS. 2/3 of the beamtime will be dedicated to Materials Research, 1/3 to "general physics" experiments covered by DESY.

▪ **Fundamental research** will encompass metallurgy, physics, chemistry, biology. First experiments are planned for the investigation of the *relation between macroscopic and micro-structural properties of polycrystalline materials*, *grain-grain-interactions*, *re-crystallisation processes*, and the *development of new & smart materials or processes.*

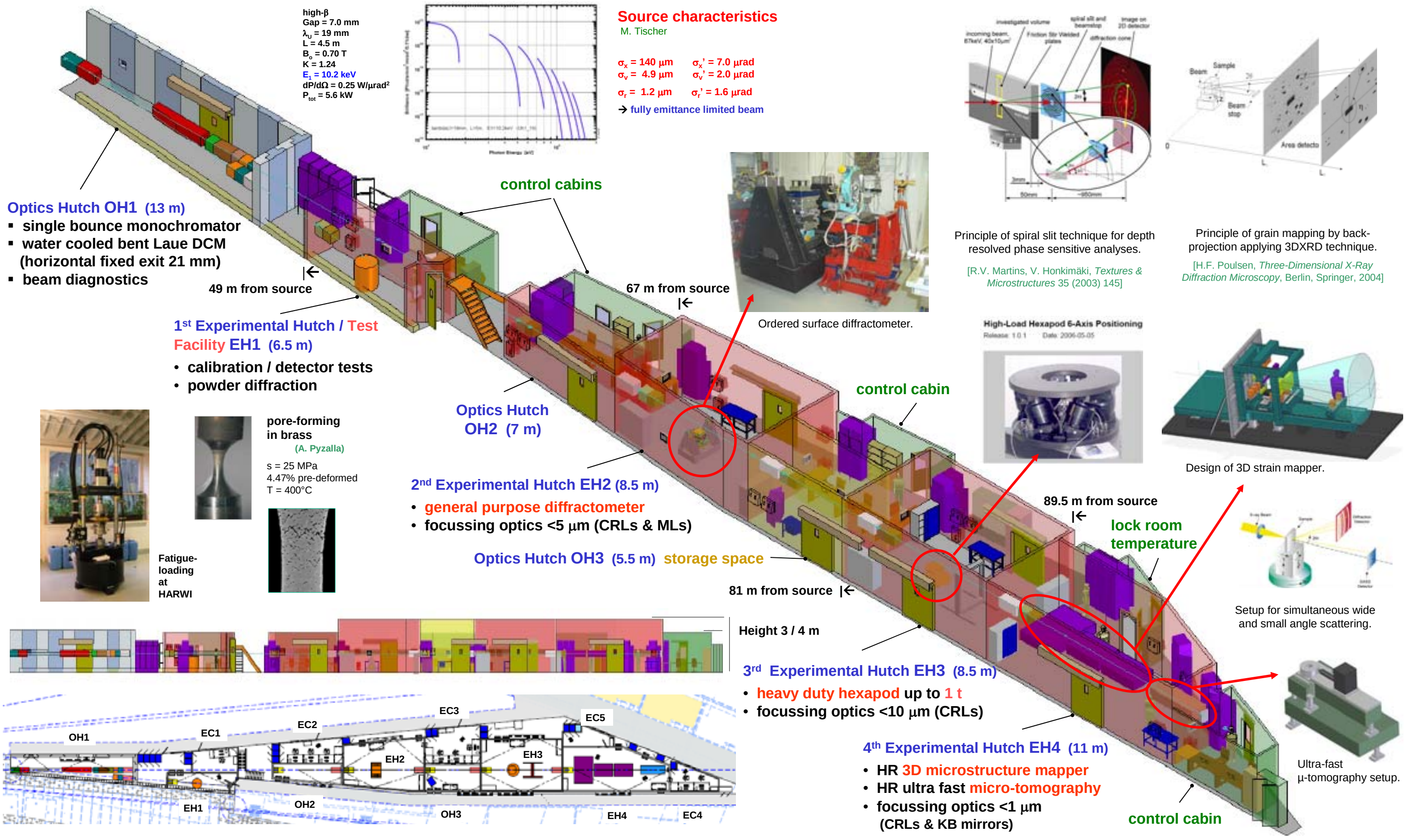
▪ **Applied research** for manufacturing process optimization will benefit from high flux in combination with ultra-fast detector systems allowing *complex and highly dynamic in-situ studies of micro-structural transformations,* e.g. during friction stir welding. The beamline infrastructure will allow easy accommodation of large and heavy user provided equipment up to 1 t.

▪ Experiments targeting the **industrial user community** will be based on well established techniques with standardised evaluation, allowing "*full service" measurements*. Environments for strain mapping will be provided as well as automated investigations of large sample numbers, e.g. for texture determination and tomography.



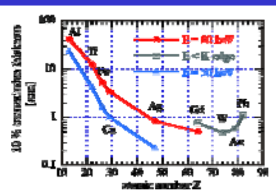
Main analytical techniques and capabilities available at the beamline and research topics addressed.

Beamline Layout and Instrumentation



Key Properties of High Energy X-Rays

- **High penetration depth**
  - → non-destructively bulk properties measurable
  - → deeply buried structures accessible
- **Large Ewald Sphere**
  - → lines and planes in reciprocal space can be imaged
  - → small Bragg angles (typically 5° to 15°), monitoring of complete diffraction rings with area detectors possible
- **Extinction and multiple Bragg scattering negligible**
- **Focussing to spot sizes in nm range possible**
  - → combination of high penetration depth and high flux
  - → very short data acquisition times possible (< 1 s)
  - → non-destructive observation of highly dynamic processes
  - → high spatial resolution narrowing the gap to electron microscopy



10% transmission thicknesses of technologically relevant metals for different x-ray energies.

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