OPTICS BEAMLINE AND SYNCHROTRON RADIATION OPTICS AND INSTRUMENTATION AT CESLAB

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One of the beamlines for the proposed CESLAB (Central European Synchrotron LABoratory) is an Optics beamline (OB). This beamline will represent a unique feature of this facility because similar beamlines are missing in other European facilities except of ESRF. The main feature of the OB will be *flexibility*. Its purpose will be testing X-ray optics and instrumentation, heat load studies and experiments whose specific and unique arrangements limit their feasibility at other specialized beamlines. The need for such a beamline is obvious, because beside the BM05 at the ESRF, there is no OB, which could allow the testing and development of X-ray optics and instrumentation. With the development of the next generation synchrotron sources (X-FELs) and the upgrade program of the ESRF we see higher demands on the quality and accuracy of X-ray optics.

The energy source of the OB will be either a wiggler or a superconducting bending magnet. These sources allow a cover of a broad range of wavelengths, from the soft X-rays of about 4 keV to hard X-rays of about 30 keV. As a good example, we can choose the super bending magnet at PSI (X02DA – TOMCAT), with a critical energy of 12 keV and a magnetic field of 3 T. Figure 1 shows the energy-flux plot of the X02DA.

The beamline will be equipped with two monochromators, one Si(111) with a resolution of E/E 10^{-4} and a photon flux of $1\ 10^{14}$ and a multilayer monochromator with a resolution of E/E 10^{-2} and a photon flux of $1\ 10^{14}$. To allow heat load studies, we need a white beam. This may be reached with a telescopic monochromator mechanism, which can be moved out of the beam. The beam size at 20m from the source will be 40 mm (H) 4–7 mm (V). Further focusing devices like mirrors are not planned. The optics hutch will be equipped with various types of filters (Al, Be, Cu) from tens to hundreds of m thick and shutters. To reach a small focus spot size the length of the OB will be about 60 m. The high flexibility should be provided by four independent goniometer heads, which are mounted on one reflectometer and one optical table (Figure 2).

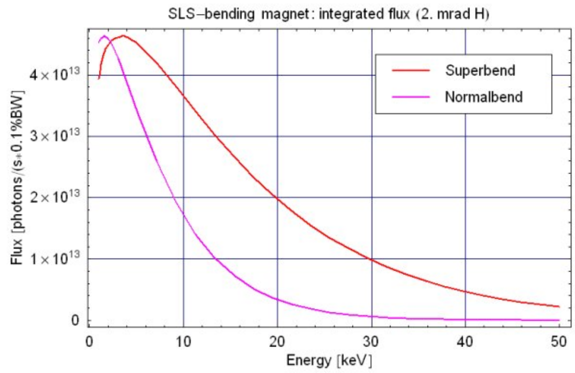

Figure 1. Energy-flux plot of the X02DA.

There is a large synchrotron user community in the Czech Republic and in the surrounding countries. Within this community there are potential users of the OB. They are not only in the academic community; several groups are also in the industry.

Academics

1) X-ray optics group at the Institute of Physics at the ASCR.
2) X-ray holography group at the Institute of Physics at the ASCR.
3) X-ray group at the MU.
4) X-ray optics group and detectors at ČVUT.
5) X-ray astronomical group at the ASCR.

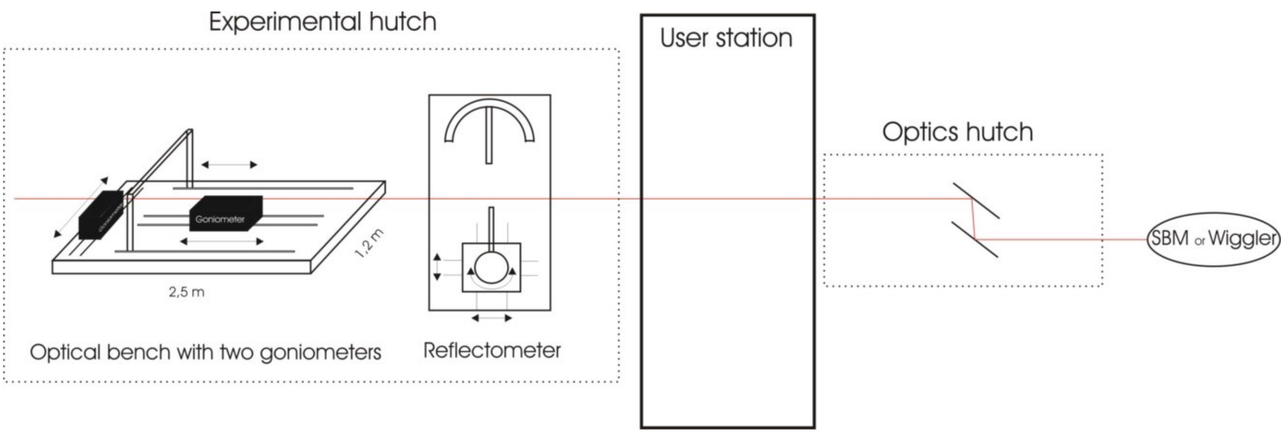

Figure 2.

Industry
1) Polovodiče a.s., Prague.
2) Reflex s.r.o., Prague.
3) Vakuum Praha, Prague.
4) Delong Instruments, Prague.
5) Crytur s.r.o., Turnov.

Slovakia, Hungary and Poland (selected as an example)
1) Crystal optics group at the Electrotechnical institute at the SAS in Pieš any.
2) Multilayers for SR at the Institute of Physics of the SAS in Bratislava.
3) X-ray holography at the Institute for Solid State Physics in Budapest.
4) X-ray waveguides at the Institute of Physics at the PAS in Warsava.

During and after the realization of the synchrotron source, formation of many new groups is expected.

OPPORTUNITIES FOR PROTEIN CRYSTALLOGRAPHY AT THE CENTRAL EUROPEAN SYNCHROTRON LABORATORY

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We were witnesses of a huge increase of knowledge about life sciences in the last three decades. We already understand many processes taking place in organisms on a molecular level. We understand many intermolecular interactions governing the immune reactions of organism against diseases or parasites and are beginning to understand differences between proteins from different organisms and therefore we have tools to design new generation drugs highly efficient against bacteria and viruses, without causing any harm to human or animal health. We understand better the processes of aging, the deceases causations and new positive habits are gradually introduced into the daily life of people. The life expectancy increased by 10–15 years during this period of understanding the principles of life on the molecular level.

Diffraction analysis of the structure of biological macromolecules utilizing synchrotron radiation is behind these changes positively influencing the quality and length of our lives. The structure and function of most of biological molecular systems known today was elucidated using this particular method. Structures determined by protein crystallography comprise more than 90 % of all structures deposited in the Protein Structure Database and almost 6 000 new records accumulates each year, most of them originating from synchrotron radiation sources.

Structure biology and diffraction methods

The necessity of synchrotron radiation for the development of our knowledge on the life nature (from biology, agriculture up to medicine and health care) follows namely from the fact that there is no other method allowing an efficient direct observation of such a large molecular complexes with sufficient accuracy. Thanks to synchrotron radiation we can observe the spatial structure of molecular systems composed of millions of atoms and observe the interplay and cooperation of many tenths of macromolecules. This knowledge is principal for understanding a function of living organisms (e.g. elucidation of structure and function of ribosomes). Moreover, using the synchrotron radiation one can achieve such high accuracy of measurement that a transfer of a single electron can be detected even in large proteins explaining thus an immense increase of catalytic efficiency seen in enzymes, etc.

Special experiments also allow an imaging of the structure changes taking place during the biochemical reaction with a speed higher than it is necessary for direct observation of most of the biochemical reactions (~ 100 ps). In addition to quick, reliable and accurate imaging of the structure, a special configuration of beamline allows observation of the dynamics of the molecular systems.

The scientific use of synchrotron radiation and applications resulting from protein structure analysis in industry, medicine and health care were the reasons why 17 sources of synchrotron radiation have been build in the western region of the European Union, thus providing more than 40 diffraction beamlines for advanced measurements in this part of Europe.

Contrary to the rapidly growing number of synchrotrons in the western part of EU, the eastern region of Europe (Czech Republic, Poland, Slovakia, Slovenia, Hungary, Austria, Bulgaria, Romania, Latvia, Estonia, Lithuania) have no experimental arrangement of this type to date.

Diffraction beamlines at the synchrotron sources around the world

There are more than 70 sources of synchrotron radiation build in 23 countries all over the world, most of them in Japan, EU and USA (see Table 1).

Synchrotrons have usually several beamlines dedicated to the macromolecular crystallography (Table 2). A priority has the Advanced Photon Source (APS) in Chicago with 18 beamlines specialized on protein crystallography. The number of dedicated beamlines is roughly proportional to the number of newly produced structures of macromolecular complexes per year. For example, 45 beamlines in the EU correspond to 1700 solved structures and 75 macromolecular beamllines in United States correspond roughly to 2800 protein structures solved in the USA in 2007.