Construction and utilization of beam lines for INDUS-2*

A discussion meeting was organized to deliberate upon the participation by universities in the construction and utilization of beam lines for INDUS-2. About 30 scientists from different universities, IITs, IISc and national research laboratories participated in the meeting. The prime purpose of this discussion meeting was to inform and sensitize the university community about the various potentialities and possibilities for frontline research with this major research facility of the Department of Atomic Energy (DAE).

Centre for Advanced Technology (CAT), Indore has recently commissioned INDUS-1 which is a 450 MeV electron storage ring. It gives useful radiation in the vacuum ultra violet and soft X-ray region, up to about 600 eV.

INDUS-2, which is in an advanced stage of construction, will be a 2.5 GeV–300 mAmp electron storage ring when completed. It will be useful in the hard X-ray regime. In the softer energy region also it will be much superior compared to INDUS-1 ring. It is expected that this machine would be ready for commissioning in two and a half years. Time is therefore ripe for users to start planning beam lines and experiments. DAE has already appointed a coordination committee to examine the suite of instruments/beam lines which may be installed at INDUS-2.

The discussion meeting started with a status report on INDUS-2 by A. S. Raja Rao, Project Manger, INDUS-2. He said that the tunnel to house the electron beam of 179 m circumference is ready and the experimental hall outside this tunnel is in an advanced stage of construction. He also described in some detail the state of readiness of the 17 dipole-, 80 quadrupole- and 48 sextupole-magnets, a large number (~ 100) of power supplies for the magnets, vacuum systems, including specialized vacuum vessels (circumference ~ 180 m; pressure $< 10^{-9}$ torr) and electronic controls. A project implementation approach involving in-house as well as private and public enterprises has been adopted to minimize the construction time consistent with the project cost. One of the results of this decision is to procure ~ 500 MHz RF system from Italy and order the construction of dipoles with a private Indian firm after prototyping and testing the first magnet at CAT. Overall he conveyed a sense of confidence to the audience that INDUS-2 would be ready for commissioning in 2002–2003. Phase I would be operational at 2 GeV–100 mAmp, which will go in three steps to 2.5 GeV–300 mAmp.

This talk was followed by a presentation about the beam characteristics by Gurnam Singh of CAT, who went into some of the intricacies of electron trajectories through the various bending, focusing and defocusing magnets. He said that in addition to the sixteen bending magnets giving two photon beams each, there will be several straight sections where insertions devices like wavelength shifters and wigglers can be introduced. A couple of insertion devices are planned for phase I. The insertion devices mentioned above will give harder and more intense spectra compared to those from bending magnets. In all, nearly twenty-five beam lines can be installed on INDUS-2. A visit to the INDUS tunnel, magnet laboratory and machining workshop to see the large vacuum chambers completed the first leg of the meeting.

Following this, R. V. Nandedkar from CAT and Vinay Kumar, D. Bhattacharyya and Jagannath from BARC gave brief descriptions of the eight beam lines with their experimental stations, on which preparations have already started. The eight beam lines approved by the coordination committee for detailed consideration are given in Table 1.

During the presentations, a number of questions were posed by the participants, with satisfactory clarifications provided by the speakers. A general feel for the sophisticated nature of work in relation to both the beam lines and experimental stations at the end of the beam lines was provided by the speakers. Preliminary project reports for all these beam lines have been submitted to the coordination committee along with cost estimates. Various laboratories of DAE have earmarked some funds for development and more is proposed under the tenth 5-year plan starting in 2002. Concluding this session, B. A. Dasannacharya of IUC whose mandate is to coordinate DAE–university collaboration for INDUS-2 invited university scientists to join in this effort.

The afternoon session started with an introductory description of some of the relevant parameters that one deals with while working with synchrotron sources. It was noted that there are a number of areas of interest to Indian scientists which were not included or inadequately covered by the eight experimental stations described above. Some of them are: imaging and very high resolution diffraction, circular magnetic dichroism in the energy range of 200 to 1500 eV (this covers many absorption edges of transition metals), electron spectroscopies and imaging, white beam (pink beam) diffraction for real time experiments, magnetic scattering, high momentum transfer experiments (for study of amorphous materials), etc. Some of these were covered in the following talks. Krishan Lal of NPL, and Satyam of IOP (Bhubaneswar) talked about ultra-high resolution diffraction and intensity correlation spectroscopy, respectively. Krishan Lal also referred to imaging and topography with white radiation. The first day ended with a brief

Table 1. Proposed beam lines at INDUS-2

Beam line	Participating laboratories
Materials science	CAT, IGCAR, BARC, IUC
Micro XRF	CAT
Macromolecular crystallography	BARC
High pressure EDXRD	BARC
SAXS	BARC, IGCAR, IUC
EXAFS, MCD, Triple axis spectrometry	BARC, IUC
PES	BARC, IUC, IGCAR
Reflectivity, Surface diffraction, etc.	SINP, CAT

*A report on the discussion meeting on INDUS-2 organized during 28–29 September 2000 by the Inter University Consortium for Department of Atomic Energy Facilities in Indore.

discussion on the need for a ultra-high resolution/topography/imaging beam line. Though there was some difference in the perception about an instrument being a medium resolution, a high resolution or an ultra-high resolution instrument, there was a general consensus that a topography/imaging beam line would be an important addition to the existing set of proposals. It was particularly noted by M. A. Vishwamitra of IISc, P. S. Goyal of IUC and many others that imaging of biological systems by various X-ray based techniques has made phenomenal progress in recent years with the advent of third generation synchrotron sources and some work must be started along these lines. Participants were informed that IUC will be holding a meeting on biological applications of radiations in January 2001 in Mumbai (Contact: P. S. Goyal, Centre-Director, IUC-DAEF Mumbai Centre, BARC, Mumbai 400 085, India).

The session on the second day started with a talk on high temperature EDXRD for study of structure of glasses by Khanna from Patiala. Joarder from Jadavpur, who could not attend the meeting had sent a suggestion for an EDXRD beam line for liquids and liquid crystals. This was followed by two talks (M. A. Vishwamitra and M. R. N. Murthy both from IISc) on macromolecular crystallography. It was pointed out that other than the standard technique of Bragg crystallography, Laue diffraction is breaking new ground in studying dynamic/time dependent phenomena in biological systems, in what may be called as equivalent of pump-probe experiments. Murthy strongly supported Vinay Kumar's effort for the macromolecular beam line. He was, however, of the view that in order to stay on the frontline of research in this field, one should not try to develop all components but get the best available equipment. This was a question which has troubled many workers in the field and different approaches have been advocated by different scientists. However the discussion had to be curtailed somewhat after a spirited reiteration of his own approach by Vinay Kumar, which supported a judicious combination of development and outright purchase.

The next session continued with three talks (D. D. Sarma, IISc; K. J. S. Sawhney, CAT; S. M. Chaudhari, IUC) on magnetic circular dichroism, undulator based beam line for circularly polarized light, and non-undulator based methods of producing circularly polarized light, both at low (< 1500 eV) and high energies (~ 10 KeV). There was a strong support for such a facility, details of which should be decided after a thorough discussion of the entire beam line, which should cater to conventional photoelectron spectroscopy also in this energy range.

There were a number of individual presentations and remarks after this by Nandedkar, CAT; Major and Vitta, IIT (Mumbai); Sarode, Goa; H. L. Bhat, IISc; N. P. Lalla, Barman and Pimpale, IUC; B. K. Sharma, Jaipur and others. Nandedkar said that CAT has been interested in developing a beam line for circularly polarized light with a helical undulator and invited IUC and university groups to join in this effort.

He also mentioned that modifications in the proposed materials science beam line are possible if required/suggested by users. Major and Vitta were interested in studies on LB films and metallic multilayers. S. Chadrasekharan and M. S. Hegde (both of IISc) noted the need for grazing incidence X-ray diffraction and high resolution instruments for thin film studies. Sarode emphasized the need for NEXAFS. Bhat gave a brief description about topography beam line and noted that in an earlier meeting on INDUS-2 such a beam line was indeed envisaged. Lalla argued for a general purpose 'white' beam line and showed that a white beam line makes the most economic use of photons and is very well suited for a variety of experiments which included high-Q diffraction, reflectivity, SAXS, magnetic scattering, Laue diffraction, topography and real time experiments.

There were several remarks on various aspects of organizing work on and utilization of such beam lines – user groups, time-discipline, information-dissemination, monitoring were some of the aspects mentioned in this connection.

Rajiv Sharma from DST and Kailas from BRNS were present to feel the pulse of the audience. Kailas briefly described the activities of BRNS which was beginning to concentrate on giving larger meaningful projects in preference to subcritical ones.

R. Srinivasan gave the concluding remarks. At the outset he remarked that IUC and university scientists must get together and build at least one beam line if the mandate of IUC-Indore Centre has to be properly fulfilled, as it was done with INDUS-1. The need for participation from universities in such high-tech activity was particularly emphasized. The involvement should be both in hardware and software development. Three beam lines were particularly mentioned. They are: (i) Topography/microscopy/imaging beam line, (ii) low energy (< 1.5 keV) beam line for MCD and electron-spectroscopies and (iii) white beam line with multiple stations for different experiments as mentioned earlier.

IUC solicits response from scientists of different universities to form groups and produce preliminary project reports for these beam lines for submission to beam line committee and funding agencies. Those interested in participating in these activities in any fashion are requested to write to the Director, IUC-DAEF, Khandwa Road, Indore 452 017; Fax: 0731-462294, e-mail: badas@iucindore.ernet.in.

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