achieving good detection sensitivity in the conventional EDXRF. The critical angle for x-rays, below which total reflection occurs, is typically in milliradian range and such small angles are quite difficult to adjust and maintain properly. In addition to the precise control of the grazing angles, all optical components of the spectrometer require good mechanical stability.

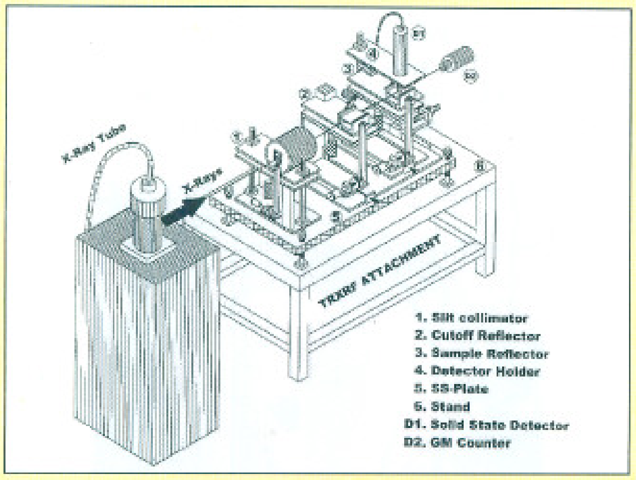

Fig. A.6.1 An isometric view of the TXRF attachment

A simple and fairly inexpensive TRXF spectrometer has been designed, constructed and realized in CAT. The TXRF setup comprises of an x-ray generator, a slit collimator arrangement, a monochromator / cutoff-stage, a sample reflector stage and an x-ray detection system.

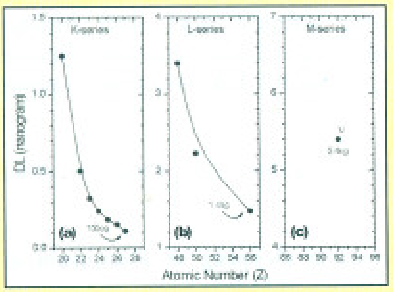

Fig. A.6.2 Detection limits of the TXRF spectrometer

The glancing angle of incidence on the two reflectors is implemented using a sine-bar mechanism that enables precise angle adjustments. An energy dispersive detector and a GM counter are employed for measuring the fluorescence intensities and the direct x-ray beam intensity respectively. A Cu-target x-ray generator with its line focus window is used as an excitation source. The spectrometer is quite compact in design and employs a peltier cooled solid-state detector for energy dispersive detection. Alignment and characterization of the TXRF system has been performed and the detection limits for various elements have been determined to be in the range of 100pg to 5ng even at low x-ray generator powers of 150 W. The capability of the TXRF system for thin film characterization is also demonstrated. Isometric view of the TRXF spectrometer and the detection limits achieved are shown in figs. A.6.1 and A.6.2. The spectrometer is being adopted for use with 4kW x-ray generator that will further improve the detection sensitivities of the spectrometer.

(Reported by: K.J.S. Sawhney; sawhney@cat.ernet.in)

A.7 Linac and Undulator Development

For a terahertz free-electron laser (FEL), lasing between 50–100μm, a 5cm period, 2.5μm long undulator has been designed in two equal sections each of length 1.25m. At present one of these sections has already been assembled (fig. A.7.1) and field-mapped. The quality of the undulator is within specification. For example, we had calculated a requirement of a field quality of better than 1% in $\Delta B/B$ – we obtained 0.7%. This can be improved further by using magnetic shims. The second section has been assembled, and field mapping is presently on. This undulator has established our ability to master undulator technology for IR/FEL applications.

Another major challenge has been the development of the linear accelerator structure. Rather than buy the structure outright, we chose to build it ourselves, motivated by the desire to develop linac technology in the country. With this view, we also chose to build a rather unconventional structure – the Plane Wave Transformer (PWT) linac. This is a much more open structure, with strong coupling between the cells – and consequently with relaxed fabrication tolerances. The only PWT linac working in the world is at UCLA, and once operational ours would be the second in the world. After building a number of prototypes and ascending a steep technology curve, we now have a structure (fig. A.7.2) that has been fabricated to the required tolerances (30μm) and surface finish (0.2μm CLA), which can hold UHV ($1x10^{-8}$ Torr), resonates at the desired frequency of 2856MHz, and has a loaded Q of 8,000. High power conditioning will commence shortly.

A 69kV, 330A, 25MW, 10μs, line-type pulse modulator, has been developed for powering the 10MW, 10μs, 2856MHz klystron that we have bought from TOIRY, Russia. We have successfully extracted up to 6MW of power from the klystron, and are only limited from going to higher power by the fact that our wave guides are presently pressurized with N_2. We plan to switch later to SF_6, which has a higher breakdown threshold, after which we expect to be able to extract the full 10MW from the klystron.

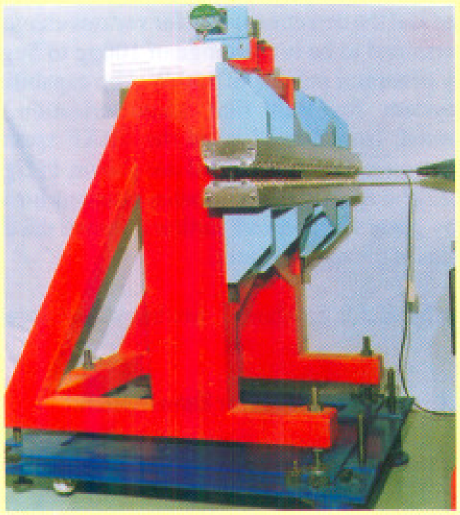

Fig. A.7.1 1.25m undulator structure

Fig. A.7.2 4-cell PWT linac structure

(Reported by: S. Krishnagopal; skrishna@cat.ernet.in)

A.8 Restoration of RF cavity for synchrotron storage ring Indus-1

RF cavity for synchrotron storage ring, Indus-1, is made of stainless steel and it is internally electroplated with copper. The cavity is having an internal diameter of 840mm and length of 600mm. The cavity structure is re-entrant type and there are big "capacitor disks" at 10mm from the median plane which are attached to the end plates through 250mm long "drift tubes". Vacuum in the RF cavity of storage ring, Indus-1, started deteriorating in the month of June 2001 and within few weeks time the vacuum level deteriorated by 3 orders. The leak check, which became quite complicated due to the location and internal electroplated surfaces, showed a leak in the drift tube. Work was done to analyze the problem that involved, design of alternate structure and the cooling circuit, FEM analysis of temperatures and thermal deformations, tuning, manufacturing, electroplating, assembly, vacuum testing, RF testing and integration into the ring for operation. All the work of design and manufacturing was completed in two months time. The cavity is now working in the ring with a vacuum level of 1×10^{-8}mbar. The total thermal detuning is now less than 50kHz at 22kV, which is well within the on-line tuner range (80kHz), and start-up time is about 10 minutes.

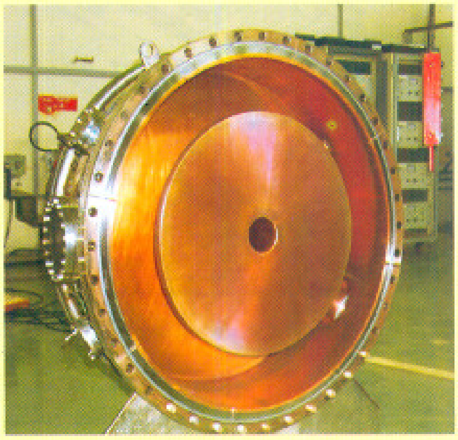

Fig. A.8.1 View of one half of the RF cavity

Figure A.8.1 shows the view of one half of the RF cavity showing stainless steel outer structure, internal copper plated surfaces, large flange for helicoflex seal (with seal in place), capacitor disk, beam port, vacuum and tuner ports.

(Reported by: Jishnu Dwivedi; jishnu@cat.ernet.in)

A.9 Chemical cleaning of aluminum alloy dipole chambers of Indus-2

Indus-2 storage ring vacuum envelope consists of 16 dipole chambers each of length 3.6m, with a bending angle of 22.5°. Aluminum alloy 5083 H321 plates were machined in two halves and welded on mid plane for making dipole chambers. Aluminum being highly electropositive is converted to aluminum oxide upon exposure to air. The thickness of the oxide layer will depend on the treatment it has undergone during fabrication and storage conditions. At temperatures above 340°C, magnesium is incorporated into the oxide film by diffusion, forming a duplex film of aluminum and magnesium oxides. Lubricants used during