A.1: Indus-2 operates in round the clock mode at 2 GeV & 100 mA

Since February 8, 2010, Indus-2 is being operated in round the clock mode. This source is operated continuously for three weeks followed by one-week break for carrying out maintenance work. This has greatly enhanced the availability of photon beam to the synchrotron radiation users.

Operation trials to store 100 mA beam current at 2 GeV were started on January 20, 2010. To achieve this, various experiments were conducted. Initially different RF bucket filling patterns were tried to accumulate and sustain more beam current at beam injection energy of 550 MeV. In a typical operation, with 200 buckets filled out of 291, the maximum stored current was 135 mA with good injection rate. In partial bucket filling mode, a high beam loss was observed during beam energy ramp. Later in full buckets filling mode with further optimization of RF phases, injection parameters, auto-ramping of RF voltages facilated by round the clock operation, a set target of 100 mA at 2 GeV was realized on March 06, 2010. In this run, 111.6 mA beam current accumulated at injection, its energy was ramped and 102.7 mA survived at 2 GeV. A typical operation for 100 mA at 2 GeV is shown in Fig. A.1. 1, The beam lifetime at 2 GeV and 100 mA is around 10 hours and at 50 mA is around 12 hours. In a trial to store more beam current at injection energy, 175mA current was stored.

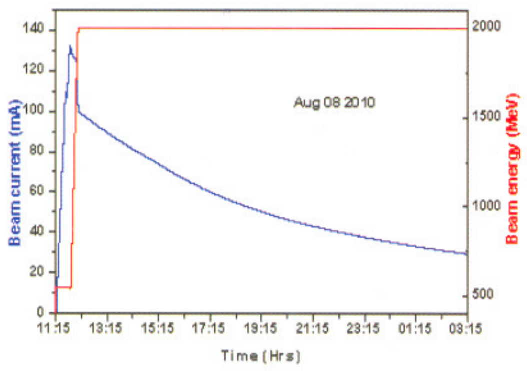

Fig. A.1.1: A typical operation chart of Indus-2

For smooth, efficient & reliable operation of Indus facility, a dedicated operation team with an integrated approach and knowledge of all the sub-systems has been developed. For this purpose elaborated training and licensing programme was initiated, which includes lectures, literature study, on job training, clearing of check lists, written examinations, walkthrough examinations and interview by licensing committee. Training of first batch of 31 staff members has been completed and they are deployed in the routine operation. Training for another batch of 34 staff members is presently going on.

The photon beam was provided to the beam line users to carry out an alignment of beam line components under the strict supervision of the Health physicists. In order to provide photon beam at the desired locations in the beam lines namely BL-8 & BL-12, electron orbit was adjusted by generating localized orbit bump using 8 vertical steering magnets (LS2-CV4C, SS2-CV5I,....) in the dipole magnets DP-4 & DP-5 from which these beamlines have been tapped.

As more and more beamlines are becoming operational, there is a need for the global orbit correction. Groundwork for this correction has already been done. First exercise to reduce the closed orbit distortion (COD) has been performed with the available beam position indicators (BPIs) using algorithm based on MICADO and singular value decomposition. In an experiment at 2 GeV with 32 BPIs and 6 steering magnets each in horizontal and vertical plane, horizontal rms COD was brought down to ~2.7mm from ~4.8mm and in the vertical plane reduction was from ~3.2mm to ~1.3mm. The uncorrected and corrected vertical COD is shown in Fig. A.1.2. Further reduction in rms COD to less than a mm will be carried out in both the planes using all the 56 BPIs and more number of steering magnets.

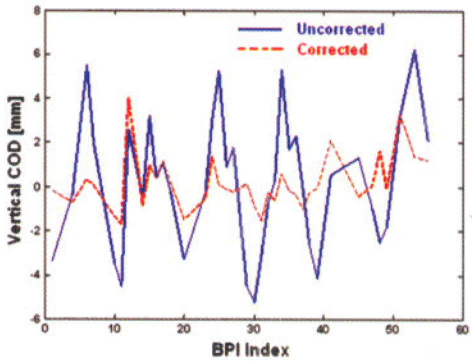

Fig. A.1.2: Uncorrected and corrected vertical COD at 2 GeV

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A.2: Terahertz Spontaneous Emission Observed in CUTE-FEL

The Compact Ultrafast Terahertz free electron laser (CUTE-FEL) being built at RRCAT is designed to lase in the 80 - 150 μm wavelength band using a 10 - 7 MeV electron beam and a 2.5 m long, pure-permanent magnet undulator. Very recently, first measurements of terahertz undulator radiation from the CUTE-FEL have been made using a liquid helium cooled bolometer.

Figure A.2.1 below shows the CUTE-FEL setup used to generate terahertz radiation. A 0.5 µs, 90 keV beam of electrons from a pulsed thermionic electron gun was transported through an un-energized 476 MHz (1/6 harmonic) pre-buncher cavity into the 8-cell, S-band PWT linac structure for acceleration to rated beam energy of 7 - 10 MeV. The pre-buncher was not energized since the RF power source for the same is still awaited. A low energy beam transport line comprising solenoids and rotatable saddle dipole coils was used to optimize transmission of the 90 keV beam from the gun to the 8-cell PWT linac structure. Accelerated beam from the linac was transported to the optical cavity of the CUTE-FEL using a beam transport line comprising a quadrupole triplet and an achromatic double bend. The beamline has provision for steering the electron beam, if needed. Diagnostic elements are provided in the beamline for measurement of beam current and beam profile at different points for optimizing beam transport

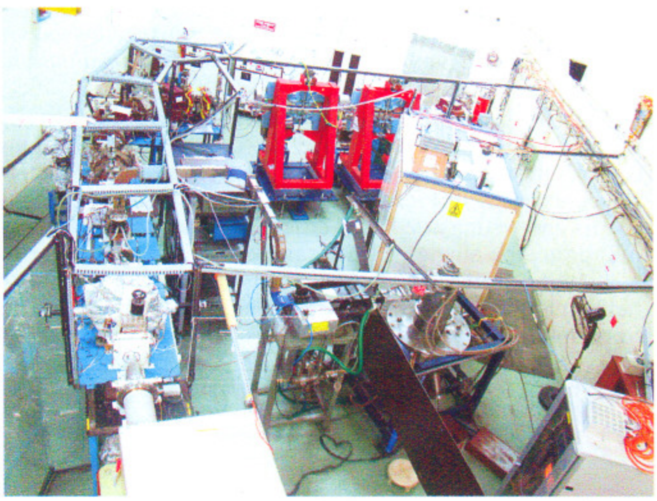

Fig. A.2.1: CUTE-FEL setup

The optical cavity for the CUTE-FEL is 4.1 m long with out-coupling of radiation through a hole in the downstream mirror. The first set of experiments were aimed at optimization of transmission of beam through the undulator for generation of spontaneous terahertz radiation. Hence, the downstream mirror was not installed, as it would have severely curtailed the out-coupled power, making measurements with the bolometer difficult due to low expected power levels.

Figure A.2.2 shows traces of the beam current, measured using fast current transformers, at the entrance and exit points of the linac and the undulator. Figure A.2.3 shows the bolometer trace corresponding to the beam current shown in Fig. A.2.2. The measured signal of 11.2 V corresponds to a CW average power of 6.5 nW and a macropulse power of ~ 15 mW in the 0.2 µ s pulses.

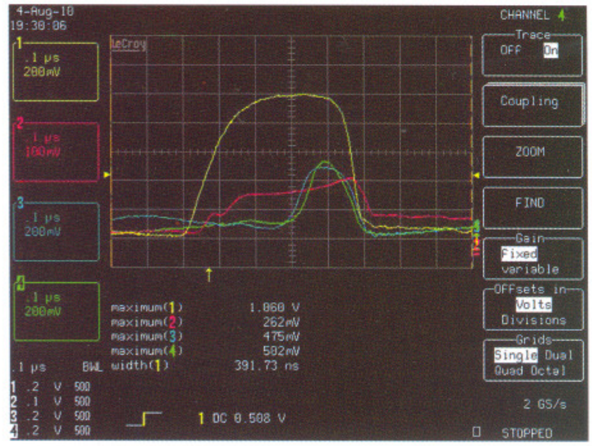

Fig. A.2.2: CRO traces of FCT signals before linac (yellow, 1A), after linac (red, 262 mA), before undulator (blue, 31.7 mA) and after undulator (green, 25.1 mA)

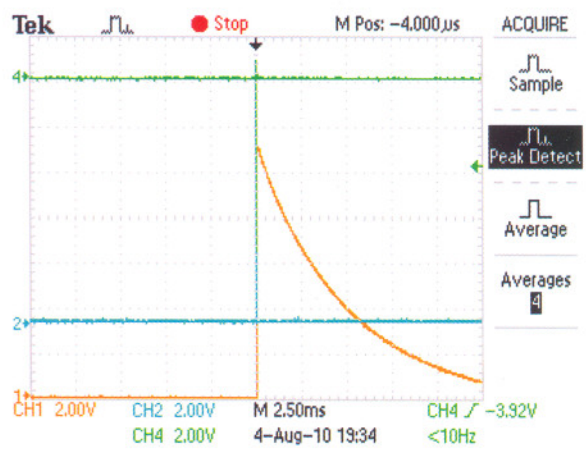

Fig. A.2.3: CRO trace of signal from Bolometer

In near future, it is proposed to use fast pulsing of the electron beam with pulse spacing matching the round trip time of optical radiation in the optical cavity of the CUTE-FEL. This will give the micro-pulse peak current required for amplification of spontaneous emission with small beam loading in the linac.

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A.3: Development of 1.3 GHz Single cell SCRF cavities

Two numbers of 1.3 GHz prototype Single cell Superconducting Radio frequency (SCRF) cavities have been successfully developed by a team of members from Power Supply and Industrial Accelerator Division (PSIAD), Accelerator Components Design and Fabrication Section