

ELETTRA PERFORMANCE AND UPGRADES

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Abstract

The present status of the ELETTRA synchrotron radiation light source is given. Of importance to the User community is the brightness and the stability of the source. Recent improvements to the machine, completed or in progress, allow a further increase of the performance values. These upgrades include modifications to increase the current and/or beam energy, improved compensation of insertion device effects, orbit feedback and the control of multibunch instabilities.

1 PRESENT STATUS

The present organisation of machine operation periods follows that of last year [1], namely, three to four week round the clock operation followed by a one to two week shutdown period. The facility during 1997 will operate for a total of 6168 hours of which 5064 will be dedicated to User experiments. The uptime of the machine for the past calendar year was 93.6%, an improvement compared to the previous year which was 91.5%. The major source of downtime still remains external disturbances on the electrical line from thunderstorms or otherwise and accounted for 24% of all downtime.

At present the facility is providing photons from five insertion devices and one bending magnet. The total number of beamlines active at the time of this conference is ten with additionally four under construction. This autumn will see the installation of an electromagnetic elliptical wiggler, a collaboration between BESSY and MAX-lab [2]. The device is an open sided structure and utilises electromagnets for the generation of both horizontal and vertical fields allowing both wiggler and undulator modes of operation. It can switch its fields in a trapezoidal manner between 0.1 to 1.0 Hz and sinusoidally from 10 to 100 Hz. Four new insertion devices, up to 2.2m in length, have been approved for construction, see [3] for further details. These devices, for which installation is foreseen in 1998, are elliptical undulators (APPLE-II types) providing photons which cover the range 10 to 2000 eV.

A new low gap insertion device vacuum chamber is under construction and will be installed in August this year. The chamber made of stainless steel has an internal aperture of 15 mm and externally 17 mm. The novel feature of this chamber is the absence of pumping along its length, thereby simplifying its fabrication. A cross-section is shown in figure 1. In addition a new bending magnet chamber is being studied, made of aluminium, for the new helical insertion devices. These will have larger

vertical radiation slots to accommodate the increased vertical divergence of the radiation from the new devices.

This year saw the full implementation of the operations task manager program "One Button Machine" [4]. It is a UNIX based tool that spawns, communicates and controls the logical flow of the pre-defined operations required for a machine refill. The program reduces to the theoretical minimum the preparation time for a refill. Modules are presently being included to perform the ramping and final insertion device settings before consignment of control to the Users.

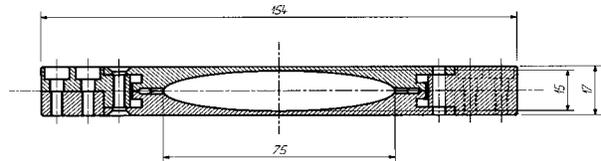


Figure 1: Cross-section of vacuum pump free insertion device chamber.

2 INCREASING THE CURRENT/ENERGY

The routine 250 mA current already exceeds the design current of 200 mA at 2.0 GeV. The main limitation at the facility to fully exploit the flexibility of ELETTRA and operate at even higher currents is the thermal load on the vacuum chamber due to synchrotron radiation. The main obstacle for an increase of current and/or energy is the thermally induced mechanical stress on the vacuum gaskets of the beam position monitors (BPM's) downstream of the bending magnets. Already in 1994-95 additional cooling was installed which gave noticeable improvement in vacuum and thermal stability. The BPM monitor, however, still suffers from thermal stress because of the difficulty in providing additional cooling to the body of the monitor. In view of this, composite gaskets of steel/copper have been designed and are being installed. The installation takes one week per achromat and all gaskets will be upgraded by summer 1997. This will permit an increase of current to 300 and it is expected to 350 mA. Alternatively the machine energy may then be increased to 2.35 GeV with a current of 200 mA which would generate the same heat load as 350 mA at 2.0 GeV. The higher energy is beneficial in improving the Touschek lifetime and helps in combating multi-bunch instabilities. The radio frequency system would limit the current at this higher energy at about 250 mA.

3 COMPENSATION OF INSERTION DEVICE EFFECTS

Insertion devices are the principle sources of bright photon beams in ELETTRA. To minimise the effect of gap changes the devices are fabricated to the highest standards. Notwithstanding the fact, however, that the magnetic field integrals are measured and minimised to the lowest possible levels given by present day methods and even utilising the most sophisticated techniques in pole shimming, residual field errors persist which disturb the closed orbit. To compensate this effect correction coils or rotating blocks (for the wiggler) are used. A lookup table is utilised for the compensation. Recently the correction method has been improved and also takes into account the simultaneous compensation of horizontal and vertical effects which arise through the non orthogonal magnetic fields used in the compensation of some devices. The technique has been automated to provide the fastest characterisation allowing rapid confirmation, and if needed adjustment, for new machine files. The method gives a factor of five improvement over the previous correction scheme. The maximum closed orbit displacement relative to the beam size at the source point is 1.1% horizontally and 6.7% vertically for an effective emittance coupling of 1%. This is sufficient to allow User control of the insertion devices. Work is terminating for the complete implementation on all insertion devices which will permit experimental Users to control their devices in May 1997. The present level of correction is at the limit of the BPM resolution and method will be upgraded to incorporate information from the photon BPM's. This in combination with the local orbit feedback system will provide substantial beam stability for the Users.

4 LOCAL ORBIT FEEDBACK

Transverse orbit stability is essential to guarantee the maximum exploitation of the brightness of a light source. The amount of beam degradation observed by an experimental User depends on the frequency of the disturbance compared to the speed of the measurement. With increasing data acquisition rates from beamline experiments it is essential that a fast orbit stabilisation system be employed. At ELETTRA the sources of disturbance are primarily due to thermally induced mechanical movement of the chamber, to insertion device manipulation (both slow effects) and fast spurious signals at 50 Hz and multiples thereof due to the mains. Extensive tests have so far failed to pinpoint the source of the latter disturbance. In view of this the fast local orbit feedback utilising digital controllers and signal processors has been implemented to locally combat all the above mentioned effects at the insertion device source points [5]. The high frequency component has been successfully eliminated using a dedicated harmonic suppressor. Figure 2 shows the reduction in noise level for the lower frequencies. The system will be implemented on all insertion device beam lines by the end of summer 1997. The foreseeable use of the system will be to isolate beamlines from external disturbances. The known effects, however, of insertion de-

vice gap changes producing fictitious orbit displacements (due to the presence of bending magnet radiation) may limit the use to fixed gaps and rely on insertion device compensation as described in section 3 for gap/monochromator scans. Studies are presently being completed to evaluate this effect as a function of gap. A foreseeable development would be the use of electron BPM's as the monitors for the system [6].

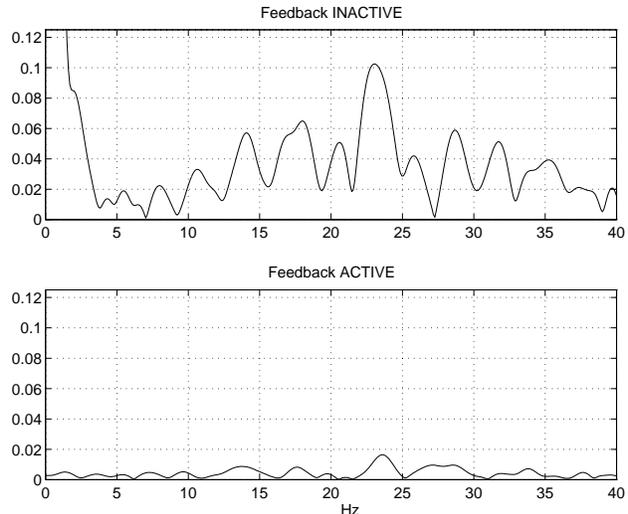


Figure 2. Results of local orbit feedback at ID_6 in compensating low frequency disturbances.

5 COMBATING MULTIBUNCH INSTABILITIES

Longitudinal and in particular transverse multibunch instabilities degrade machine brightness. The effects vary from a blow-up of the longitudinal bunch dimensions to transverse jitter and partial to total beam loss. As has been described elsewhere ELETTRA utilises temperature tuning of the cavities for mode shifting [7]. This method, however, becomes more laborious and possibly impossible to use as the stored beam current increases. In view of the planned increase in current adjustable higher order mode frequency shifters (HOMFS's) are being installed in all four cavities [8]. The work started in late summer 1996 will terminate by the end of 1997. The first results performed last year are very promising and showed an improvement in shifting both the longitudinal and transverse modes. Figure 3 illustrates the behaviour of transverse coupled bunch modes in cavity S9 as a function of cavity temperature at a beam energy of 2.0 GeV and 250 mA stored current. The first diagram shows the distribution of the most prominent modes before installation of the adjustable HOMFS. The broad transverse mode complicated matters during ramping of the beam from the injection energy to the final operating value of 2.0 GeV. The instability led to partial or total beam loss during the ramp. The second figure shows the distribution after installation of the adjustable HOMFS in this cavity which allowed a careful tuning and shifted the dangerous mode out of the temperature working window. A complete characterisation of the machine with all cavities having the HOMFS's will take place in the later part of this year. The characterisation will be performed with the higher

stored current and based on these results a decision will be made as to whether or not a longitudinal multibunch feedback system will be implemented.

To allow rapid evaluation of the best position for the HOMFS's a system of mode measurement with beam has been implemented. The system operated from a UNIX environment can perform a complete scan of the 432 modes in 10 minutes.

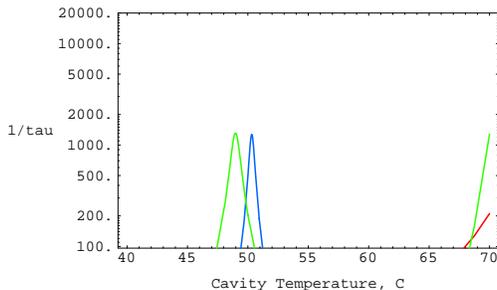
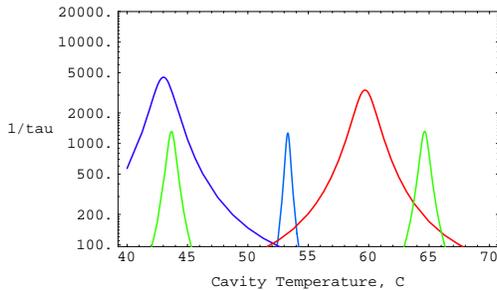


Figure 3: The shifting of horizontal transverse coupled bunch modes with a adjustable HOMFS on cavity S9. 2.0 GeV, 250 mA. Before installing the adjustable frequency shifter (upper graph) and after (lower graph).

6 FUTURE OUTLOOK

With the operation of the facility at higher currents the control of dangerous transverse coupled bunch modes becomes more difficult. Therefore to guarantee the best possible conditions for experiments a transverse multibunch (bunch by bunch) feedback system is being actively studied and developed. The installation date is foreseen for 1998. For what regards orbit stability and in view of the increasing number of future bending magnet beam lines a global feedback system will be studied to enhance the already existing slow feedback which currently operates at a high control level to compensate the slow thermal drifts of the orbit.

Apart from the newly approved devices the possibility of building a short period (22 mm) in vacuum device is being evaluated [3]. This device will have a tentative operational gap of 7mm.

To compensate the increased effect of Touschek scattering associated with the higher currents and/or denser bunches a study programme has been launched with the task of evaluating the impact of installing a super conducting radio frequency cavity for compensating the energy loss of the Touschek scattered particles. The study will also examine the feasibility of installing additional sextupole magnets into the ring which would be required to improve the transverse off-momentum energy acceptance. In addition a re-optimisation of the existing harmonic sextupoles will be performed to see the impact of lessening the compensation of the geometric aberrations in favour of an increased off-momentum aperture. Associated with this study will be the examination of an alternative method to improve the beam lifetime through the use of a super conducting higher harmonic cavity. This would provide a longer Touschek lifetime by lengthening the bunch. In this case the time structure of the beam would be altered and special machine periods would then be dedicated to Users requiring short bunches for experiments.

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