ELETTRA STATUS AND DEVELOPMENT PLANS

C. J. Bocchetta#, S. Tazzari and R. P. Walker, on behalf of the ELETTRA team
Sincrotrone Trieste, Trieste, Italy

Abstract

The present performance and upgrade projects of the ELETTRA light source are presented.

1 INTRODUCTION

The 2 GeV third generation light source ELETTRA has now completed more than 5 years of operation since the start of commissioning (October '93). ELETTRA currently operates for a relatively large number of hours per year, and with good efficiency. Far from being in a static operations phase however, a great deal of investment is being placed in the future growth and improvement of the facility including the construction of a number of new beamlines and insertion devices and a number of important machine development projects [1]. A major upgrade of the injection system is also under consideration.

2 STATUS AND ONGOING DEVELOPMENTS

2.1 Operations

At the end of 1998 ELETTRA completed five years of operation for Users. Over this period the facility operated for more than 27,000 hours of which more than 20,000 were dedicated to User experiments. 1998 concluded with a User uptime of 92.6% (93.6% excluding storms) bringing the overall five year up time to 93%. Last year the facility operated for the greatest number of hours, a total of 6528 of which 5256 were dedicated to User operation. The scheduled operations calendar for 1999 is less dense (6192 hours) and reflects the large number of installations to be performed on the machine. The more frequent shutdowns will be used for the installation of new front ends, vacuum chambers and insertion devices for new beamlines and for strategic upgrades to improve the performance of the accelerator. By the end of 1999 there will be 18 operational insertion device sections occupying eight of the eleven available straight sections. To date ELETTRA has eight beamlines fully operational, three are being commissioned of which one is fed by a bending magnet source. Eight additional beamlines are under construction of which four are bending magnet sources.
The accelerator which is normally run at 2.0 GeV is scheduled to operate at 2.4 GeV for 23% of its time during the first semester of 1999. At this higher energy the current is limited to 120 mA to contain the thermal load on the vacuum chamber at acceptable values. The lifetime, strongly limited by the Touschek effect at the lower energies, is 52 hours at 100 mA compared to 32 at the same current at 2.0 GeV. ELETTRA is able to provide a maximum beam energy of 2.5 GeV.

2.2 Insertion Devices

The increased demand of the User community to have polarised radiation from insertion devices is being satisfied by the construction of new APPLE type undulators having four arrays of permanent magnets (NdFeB) [2].By the end of November this year four of six planned undulators will be installed in the storage ring. Two of these with periods of 60 and 125 mm will be installed in one straight section separated by a chicane magnet, which enables two experimental stations to be operated simultaneously. The undulators of length about 2.2m are separated by a small dipole magnet that will provide a 2 mrad separation of the two photon beams.
One device has already been assembled and shows good agreement between measured field distributions and model calculations [3]. Traditional shimming techniques are not applicable in the elliptical undulator configuration and so new methods have had to be developed. Vertical block displacements were used to correct a phase independent quadrupole error. The optical phase error is a function of the field polarisation, but has been able to be compensated by groups of shims on two consecutive horizontally magnetized blocks. End coils will compensate residual gap and phase dependent first and second field integrals.
In addition to the above mentioned undulators a wiggler has been approved and is under study for a second crystallography beamline. The main characteristics that are currently being studied are the length of the sections and end terminations that allow a better correction of field integrals.
Progress is being made with the compensation of residual closed orbit distortions of the electromagnetic elliptical wiggler (EEW) [4]. A dedicated digital feed-forward system compensates for the residual magnetic field errors by correcting the beam orbit with four coils (two per plane) powered by four independent power supplies. It is based on a DSP (Digital Signal Processor) system with A/D and D/A converters. The system samples the

email: carlo.bocchetta@elettra.trieste.it

horizontal and vertical currents provided by the EEW power supplies and computes the four correction currents. At present the computation is based on a pre-calibrated look-up table which minimizes the residual beam orbit distortion. The programmability of the DSP allows, however, to implement more sophisticated correction techniques.

2.3 New Vacuum Chambers

The installation of new insertion devices (ID's) providing horizontal, circular and vertical polarised synchrotron radiation has called for the development of new bending magnet vacuum chambers to account for the increased thermal load on the radiation slot. The chambers made of aluminium alloy AlMg-Mn (Peraluman) have high thermal conductivity and are greatly simplified compared to the original stainless steel types. The main differences being the absence of an internal NEG strip, and the removal of the photon beam stopper away from the chamber body. This has allowed a more compact form and minimised chamber deformation in addition to easing upgrades of the photon beam shutter whenever higher power densities are encountered from new insertion devices. The body has been constructed from two welded machined halves with an internal surface roughness of 0.2 µm. Both Conflat and the rhomboidal VAT anticorodal flanges use diamond edged gaskets for aluminium to stainless steel connections.

In addition to the bending magnet chambers, extruded aluminium vacuum vessels are now being adopted for all future and some existing insertion devices. These ID chambers are pump-free with an elliptical cross-section that has a minimum internal aperture of 14 mm and an external dimension of 17 mm. These economical chambers are easy to manufacture and have cooling channels on either side. The same technique is also being adopted for those parts of the machine having a rhomboidal cross-section. In this case the extrusion is machined to the final exterior cross-section including cooling channels. Tapers to small aperture cross-sections, placed beneath lumped corrector magnets, are still made of stainless steel to reduce eddy current effects during operation of fast orbit feedbacks.

The first set of chambers (for bending magnet and insertion device) was installed in October last year.

2.4 SR-FEL Project

A storage ring FEL project was initiated in May 1998 under partial EC funding together with other European partners (CEA/LURE, CLRC-Daresbury, Univ. Dortmund, ENEA-Frascati and MAX-lab) [5]. All major equipment items are now under construction and are due for installation between August and October. First lasing attempts will be made towards the end of this year at 350 nm before proceeding towards shorter wavelengths (• 200 nm). Recent tests of ELETTRA performance in FEL mode (1 GeV, 4-bunches) have given encouraging results that stable operation with 100 mA total current can be achieved with of the order 200 A peak current.

2.5 New Diagnostics

A new electron Beam Position Monitor (BPM) is presently under advanced design for the storage ring. The purpose of this system is to provide ultra-stable, at the µm level, position signals for a Local Feedback processor. The BPM has been designed for the low gap aluminium chambers mentioned above. In order to achieve the expected performance, two main developments have been undertaken: a mechanical design of a low gap BPM fitted with 14mm diameter buttons along with the relative support system and vacuum chamber interface and an electronic design that includes a new analogue front-end and a digital amplitude demodulator.

For maximum sensitivity in the vertical plane the buttons have been located close together with only 12mm center-to-center distance in the horizontal plane. Two bellows, either side of the BPM body, will isolate mechanical movement transmitted by the vacuum chamber. The support system will provide state-of-the-art short-term (vibrations) and long-term (thermal) stability to the monitor. Furthermore a monitoring of BPM motion at the sub-µm level will be installed. Two such systems are presently under evaluation, one based on an opto-electronic micrometer, the second based on capacitive sensors.

The electronics of the BPM system is composed of the following blocks: an analog front-end, a digital receiver (AM demodulator) and a DSP processor. The main function of the front-end is to provide high-stability and resolution for the button signals with sufficient bandwidth for the Local Feedback to operate properly. Two front-end solutions are presently being designed: a 4-channel front-end, developed in collaboration with the Swiss Light Source, and a 4-to-1 multiplexed front-end, being developed in-house. In order to keep the gains matched on the four channels, a pilot frequency signal will be injected at the front-end inputs and the amplitudes of the four outputs will be kept equal by tuning each channel gain. The digital receiver block will provide x & y position signals by means of a state-of-the-art Digital Demodulator (Digital Down-Converter). Finally a DSP module will manage the data stream and provide filtered values to the central processor of the Local Feedback.

The BPM's will be installed in an ID straight of an existing beamline this summer. First tests with the new electronics are expected towards the end of the year.

In addition to new electron BPM's a new type of photon BPM is under development. This diagnostic is based on the energy analysis of emitted photo-electrons when an undulator photon beam strikes a blade. A prototype system based on two blades and hemispherical energy analysers will be installed on a beamline at the end of this year [6].

A recently installed dual-sweep streak camera manufactured by Photonetics has been added to the arsenal of beam diagnostics. The device can operate in a syncroscan mode at 250 MHz, thereby allowing the observation of consecutive bunches spaced 2ns apart.

2.6 Third Harmonic Cavity

Progress has been made with the design of a third harmonic cavity to enhance beam lifetime. The decision to adopt a single super-conducting cavity has been taken, but the decision to go ahead awaits a final budgetary quotation and its approval. The structure of the cavity is a scaled version of the Soleil double cell system. It will operate at 1.5 GHz and the flange to flange length of the cryostat is approximately 1.1m. The cavity is idle and will provide a maximum voltage of 600 kV. Beam energy losses of a few Watts are easily replaced by the 500 MHz rf system. Taking into account static losses plus a safety margin a refrigerator of 40 W will be sufficient. The construction will be outsourced and a possible installation date is mid 2001. The improvement to the Touschek lifetime is of the order of a factor 3 to 3.5 at 2.0 GeV and 2 to 2.5 at 2.5 GeV.

2.7 Transverse Multibunch Feedback

A transverse multi-bunch feedback (one BPM and one kicker/plane) consisting of a wide-band bunch-by-bunch system is nearing completion [7]. The positions of the 432 bunches, separated by 2 ns, will be individually sampled and corrected. A prototype RF front-end module has been installed. The data is processed by digital electronics. Extensive filter simulations have been performed in a Matlab environment. Installation and first commissioning of the system is foreseen for the end of this year.

3 DEVELOPMENT PLANS

3.1 Short Insertion Devices

The beamline construction plan has already allocated ten insertion devices to the eleven possible long straight sections and the last remaining section will be allocated within the year. Attention is now turning therefore to the two short (1.2-1.5 m) sections in each achromat of the expanded Chasman-Green structure. Much of this space has already been put to good use by placing diagnostics and the rf cavities there, however even without moving existing diagnostics nine locations are available.

Machine operation with such devices has been studied and appears to be possible, with certain restrictions. Beam sizes and divergences are larger than for standard IDs and there is a greater sensitivity to energy spread variations. Linear optics effects on tunes, beta functions and dispersion are acceptable provided many high field devices are not installed. No further deterioration in dynamic aperture is expected above that introduced by the existing devices. Effects on emittance are not great, but may limit the field of any high field tuneable devices to prevent intensity fluctuations on other beamlines. Flux and brightness calculations for representative devices indicate 20 times better flux from a wiggler and 200 to 300 times more brightness from an undulator compared to the bending magnet sources

In view of the strong interest in such sources a first bending magnet chamber is being constructed to allow the extraction of radiation at both 0° (ID) and 3.45° (bending magnet). This chamber will be in aluminium and is planned for installation in September. The ID itself is under study. With minor modifications a standard bending magnet front end will be adopted.

3.2 A New Injector

A decision has been taken to concentrate on a booster synchrotron as a possible new full-energy injector for ELETTRA. A design study is being carried out to be completed by the end of the year. The new injector would use a 100 MeV linac as a pre-injector. The 2.5 GeV booster placed on the inner side of the storage ring building can be constructed without major interference to the operation of the light source, up to the moment of connection. Studies are being performed to find the optimum lattice in terms of construction costs bearing in mind the requirement for top-up injection. An upgrade will also be performed of the storage ring injection elements. Use will be made as much as possible of existing equipment, for example the transfer line and parts of the existing linac.

4 REFERENCES

[1] C. .J. Bocchetta and R.P. Walker, “Present Performance and Future Objectives at ELETTRA”, Proc. EPAC 1998, p. 568.

[2] B. Diviacco, et al., “Construction of elliptical undulators for ELETTRA”, Proc. EPAC 1998, p. 2216.

[3] B. Diviacco, et al., “Development of elliptical undulators for ELETTRA”, this Conference.

[4] R. P. Walker et al., “Construction and testing of an electromagnetic elliptical wiggler for ELETTRA”, Proc. EPAC 1998, p. 2255.

[5] R. P. Walker et al., Proc. 1998 Int. FEL Conf., to be published.

[6] A. Galimberti, et al., “A new approach to photon beam position monitoring at ELETTRA”, This Conference.

[7] R. Bressanutti, et al., “Design considerations for the Elettra Transverse multi-bunch feedback”, This Conference.