ONE AND A HALF YEARS OF EXPERIENCE WITH THE OPERATION OF THE SYNCHROTRON LIGHT SOURCE ELETTRA

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Commissioning of ELETTRA started in October 1993. By the end of 1994 the beam time dedicated to experiments was gradually increased to a level of 80%. The performance is presented and developments on the machine are discussed.

I. INTRODUCTION

The commissioning of ELETTRA started on October 4 and has progressed without major problems [1]. On the third day, beam was stored for the first time and in the following days the current level was increased up to 216 mA on October 16. A proof of principle experiment using bending magnet synchrotron radiation could already be carried out on October 25. Table 1 summarises the major commissioning steps. A more comprehensive summary of the achievements and the measurements performed during the first phase of commissioning is given in reference [2].

Date	Achievement
Oct. 4 /1993	Start of commissioning
Oct. 25	Bending magnet experiment
Nov. 7	Radiation seen from U5.6
Dec. 11	410 mA, design current passed
Jan. 24 /1994	2.3 GeV, design energy passed
Feb. 4	Experiment at 1.5 GeV
Mar	Light from U5.6 with low gap and U12.5
Apr	Light from W14.0
May	Light from ID's at 2.0 GeV with low gap

Table 1: Milestones of ELETTRA Commissioning

II. OPERATION AND PERFORMANCE

Injection is performed by a high energy linac [3] at 1.0 GeV. A ramping procedure was installed which allows the selection of any operating energy from injection up to the maximum energy [4]. Currently, the experimental runs are performed at 2 GeV, with three insertion devices closed to a minimum gap of 26 to 28 mm [5]. At the beginning of May this year a fourth insertion device U8 will be installed and operated with a low gap vacuum chamber. The filling time for the storage ring is determined by the cycling, loading of the injection file and final ramp to the operating energy. At present these operations are limited by the configuration of the power supplies. The average time for beam ready of a little more than one hour will be reduced to some tens of minutes at the end of the year with the implementation of hardware and control software changes to the current system. In the multibunch mode a maximum current of 530 mA has been reached, whereas >50 mA has been stored in a single bunch, both at an energy of 1.1 GeV. After improvement of the gas pressure in the vacuum chamber, the lifetime becomes dominated by Touschek scattering and depends therefore strongly on the optical beam conditions. Running the machine with a relaxed vertical optics, i.e., larger vertical beam size, the lifetime is 30 hours at 200 mA and 2.0 GeV. An optics giving the minimum vertical beam size has a lifetime of 14 hours at the same current and energy. Under normal conditions the machine is loaded with a partial filling, leaving a 20% gap.

Machine reliability has increased significantly after one and a half years of operation and already reached a level of 90% at the end of 1994. Major interruptions due to linac unavailability have been reduced by injecting at predefined times. All systems have in general performed well. Downtime due to failures are mostly associated with rf and power supplies.

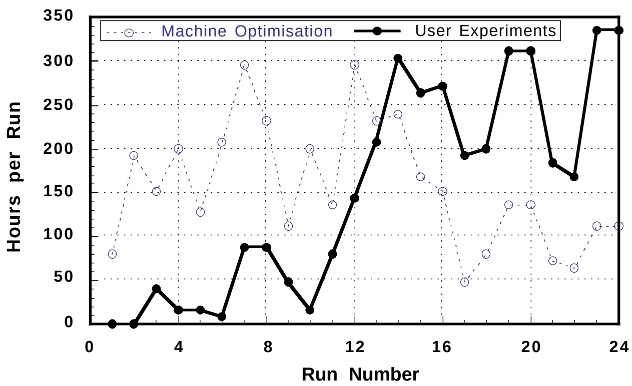

Figure 1: Hours per run for machine and user experiments since the start of commissioning. Run 24 ends June 1995.

Five beamlines are at present installed in the experimental hall. Two of them, the SuperESCA and VUV-Photoemission lines are fully operational and open to external users. Two other lines, X-Ray Diffraction and ESCA-microscopy are close to completion of commissioning and already provide beam for external users. The Spectromicroscopy beamline is still in the commissioning phase. In addition there are two more lines in construction, the Surface Diffraction line (ALOISA) and the Small Angle Scattering line (SAXS). Construction activities have been started for the Spin Polarisation and Spiral Spectroscopy line (using a cross-field undulator [6]) and the Mammography line (using a bending magnet). Go-ahead has been given to an industrial initiative at ELETTRA, the installation of a Lithography line for micromechanics by the private company Micromore. Excellent results have been achieved with all operating lines. Figure 2 for instance shows recent results of the SuperESCA beam line [7].

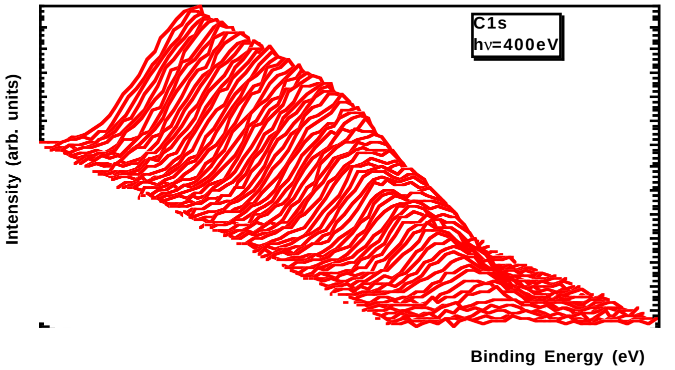

Figure 2: Time resolved X-ray photoelectron spectroscopy (C1s) of CO adsorption on Rh(110). Individual spectra took less than 5 seconds to produce [8].

For the moment three insertion devices are installed in ELETTRA, each of them providing light for two beamlines. Table 2 reports the status of the insertion device installation during the year 1995.

ID - type	N	Gap[mm]	Bo[T]	K	Status
U12.5	36	28	0.506	5.91	operat.
U5.6	81	27	0.444	2.34	operat.
W14.0	30	26 (20)	1.3 (1.6)	17	operat. +)
U8.0	19	20	0.866	6.5	inst. May
U12.5	36	28	0.506	5.91	inst. Dec.
EEW	12	25	0.6 (v) 0.047 (h)	13 1	prototype

+) in parenthesis the numbers for the new 20 mm chamber.

Table 3: ELETTRA Insertion Devices

III. MACHINE DEVELOPMENTS

A series of improvements have been performed during the last one and a half years (the achievements before this time have already been reported in reference [1]).

III.1 Improvement of vacuum chamber cooling

In ELETTRA the beam position monitors are rigidly attached to the adjacent quadrupoles, allowing only a longitudinal motion for thermal expansion of the chamber. It was observed that at 2 GeV and currents beyond the design current (200 mA at 2 GeV, 400 mA at 1.5 GeV) the thermal load creates a transverse movement of the vacuum chamber of which approximately one third is transferred to the quadrupoles via the BPM support system. This occurs only for those BPM's immediately after the bending magnet and in spite of an already existing cooling tube brazed on the outer side of the vacuum chamber. An enhancement of cooling power in this area considerably reduced the transverse movements. Furthermore the thermal desorption was strongly diminished, as shown in figure 3, which increased the lifetime at 2.0 GeV by about a factor of 2 for 200 mA.

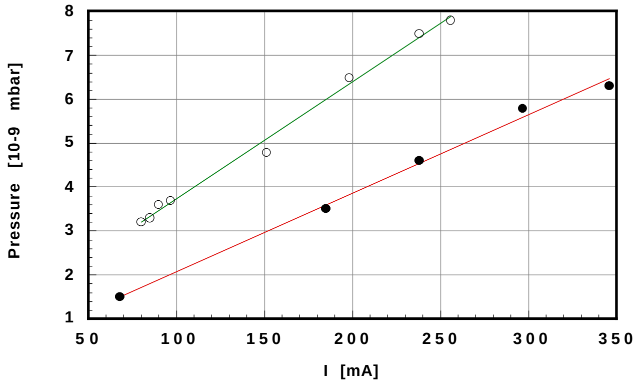

Figure 3: Pressure versus beam current at 2.0 GeV before and after the enhancement of the vacuum chamber cooling.

III.2 Continuous (slow) orbit correction

Residual thermal beam movements have been effectively corrected by a continuous slow orbit correction (once every three minutes) which has been implemented. The orbit displacements in the straight sections are in this way maintained to within a few microns over a 24 hours period.

III.3 Fast local orbit feedback system

The commissioning of the fast local orbit feedback system with synchrotron light monitors has started. Several closed loop tests have been performed which bring encouraging results. The system is expected to be fully active in the second half of 1995.

III.4 Dispersion correction

In ELETTRA the emittance coupling is dominated by spurious vertical dispersion [9]. A scheme has been implemented in association with closed orbit correction which can reduce this dispersion to a level below 0.4 cm rms,

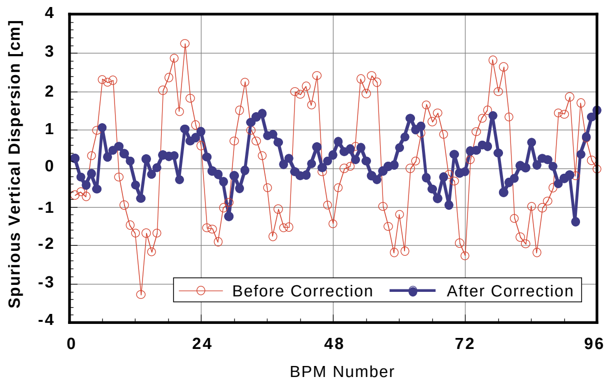

Figure 4. Dispersion correction

corresponding to less than 0.3% effective emittance coupling. Figure 4 shows the vertical dispersion before and after correction.

Such a correction reduces the lifetime due to Touschek scattering. Under normal operating conditions the users would therefore prefer a larger coupling with improved lifetime, since the vertical photon beam size is dominated by diffraction for most of the experiments.

III.5 Cure of multibunch instabilities

Intensive studies were performed to analyse multibunch instabilities and to cure them. The high precision temperature tuning of the cavity is an excellent method to shift dangerous parasitic cavity resonance's away from coupled bunch modes. In this way satisfactory conditions for operation could be achieved for currents up to 230 mA at 2.0 GeV, see these proceedings [10]. For even higher currents and enhanced instabilities the method starts to become critical, therefore the development of a longitudinal multibunch feedback system is envisaged, or alternatively the development of new cavities with higher order mode suppressors.

III.6 Accelerator physics issues

Great progress has been made in the understanding of the machine. A long standing puzzle was the interpretation of low frequency oscillations in the beam from fractions of Hertz up to 50 Hz depending on the machine parameters, i.e., current, energy, cavity temperature, rf-voltage, filling mode, etc. The oscillations were interpreted as an increase of the longitudinal oscillation amplitude due to multibunch instabilities up to a loss of coherence through the action of Landau damping. This fast blow up is then followed by a reduction of the beam size due to radiation damping. Figure 5 shows the beam as seen by a button electrode. The fast blow-up followed by the slower damping is clearly depicted.

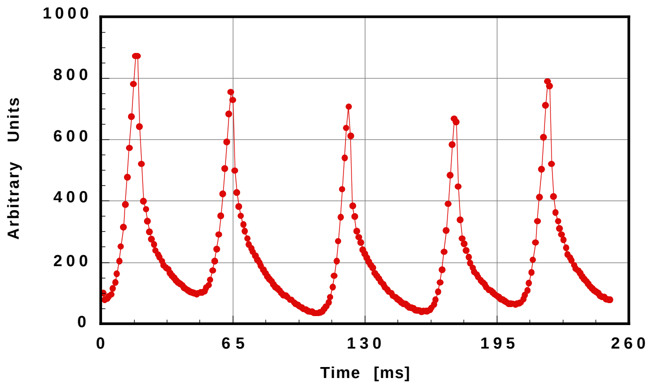

Figure 5: Beam signal on a button electrode which accompanies low frequency beam oscillations.

II.7 Re-alignment

The storage ring magnet positions have been surveyed and realigned after one year of operation. The results confirm the excellent geological conditions and the well constructed storage ring foundation. Figure 6 shows the vertical position of the bending magnet sockets after one year of operation. Eighty percent of the positions were within ±100µm. Maximum deviations only occurred at positions where the transfer line and the service tunnel cross the storage ring.

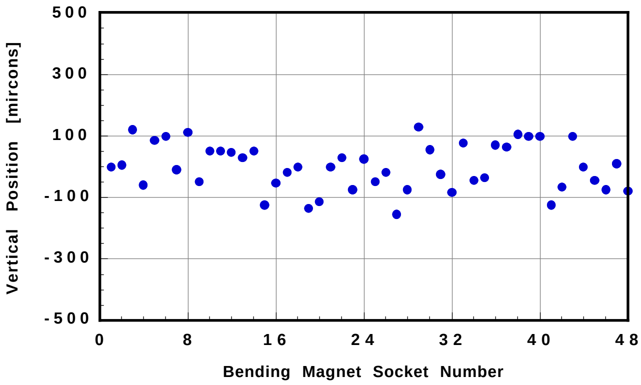

Figure 6. Relative position of bending magnet sockets after one year of operation.

IV. OUTLOOK

Future work will comprise the exploration of higher energies for ELETTRA (2.4 GeV) and the testing of a new optics, that leaves a residual dispersion in the straight sections but considerably reduces the emittance. The development of fast automatic machine preparation and ramping for user experiments. The development of an elliptical insertion device, micro-undulators and the implementation of a new generation of insertion device vacuum chambers with even lower gaps will be continued. Furthermore work is going on for the development of a cavity gun for the linac, the infrared FEL project FERMI [11] and the development of new cavities with waveguide mode suppressors or alternatively a longitudinal multibunch feedback system.

V. REFERENCES

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