NEW OPERATIONAL ASPECTS AT ELETTRA

C. J. Bocchetta, F. Iazzourene, E. Karantzoulis, C. Scafuri, M. Svandrlik, L. Tosi, R. P. Walker
Sincrotrone Trieste, 34012 Trieste, Italy

Abstract

In order to maintain ELETTRA as one of the most brilliant sources of VUV and soft X-ray radiation, continued efforts are being made to further improve and optimise the performance of the storage ring. The main activities pursued are operation with a higher current, increase of beam energy, the introduction of new bunch filling modes and the further increase of the level of automation.

1 INTRODUCTION

The facility is providing photons from six insertion devices and one bending magnet. There are eleven active beam lines and four under construction. Six new insertion devices (elliptical undulators providing photons which cover the range from 10 to 2000 eV), up to 2.2m in length, have been approved and installation is foreseen starting in 1998, see [1] for further details. This increased demand in insertion devices has naturally had its impact on machine operations. Already the operation periods are following a new pattern, namely, six to eight weeks continuous operation followed by one to four weeks shutdown period. The facility during 1998 will operate for a total of 6528 hours of which 5256 (81%) are dedicated to the users.

The efficiency of ELETTRA expressed in user uptime is high, being above 91% of the total user time since 1995 (official start for users); but it can surely improve. A large amount of the downtime stems from external disturbances of the electrical line and thunderstorms (~20% of the downtime on the average). However if we discard down time due to the component failure there is still 10-15% due to operators mishandling and machine set-up that can improve. This particular aspect comes from the mismatch between ELETTRA's nominal operational energy (2 GeV) and its injection energy (1 GeV). Thus a series of complicated operations has to take place between injection and light delivery with an increase in the probability of hardware failures and/or operational mishandling. A series of automatic procedures have been devised to minimise this conflict.

A parallel way to increase the demand on the machine is by providing attractive options for the users. Those include flexibility in energy (ELETTRA can potentially reach up to 2.5 GeV) and new filling configurations. Both aspects were tested and well received by our user community. Spectra have been taken by various beamlines in multibunch 90% filling at 2.4 GeV and in two few bunch modes at 2 GeV, namely six and twelve equidistant bunch filling, with satisfying results. Nowadays the users of ELETTRA ask for beam quality and high intensity while in the past long lifetime was preferred. This means higher beam currents and stability with a "longish" lifetime! (as users phrase it). As it will be seen many improvements can be made before feed back systems are installed in ELETTRA [1] for higher beam stability and a higher harmonic cavity for lifetime[2].

2 INCREASING THE OPERATIONAL EFFICIENCY

Due to mismatch between the injection and operational energy, a 2-3% average efficiency loss directly connected to up-time is estimated. To that one additionally has a 10-15% downtime due to the mishandling of the procedures and to power supply fatigue since it has been noticed that many power supply failures occur during cycling. Thus our investigations were based on:

- increasing automation in order to minimise human intervention
- abandoning cycling

Ring refilling operations are controlled by a new extended version of the "One Button Machine" [3] task manager program. 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 definition of an operation is given by means of a configuration file. The program reduces to the theoretical minimum the preparation time for a refill. There are two configuration files in use. The first configuration file (full version) performs the injection -under the supervision of the operator- the ramping and final insertion device settings before consignment of control to the Users.

The second configuration file performs the above tasks without cycling of the storage ring magnets prior injecting. This has been achieved by energy ramping the 2 GeV machine to 1 GeV. After correcting the tunes this file was saved as the 1 GeV injection without prior cycling. Practically one could either directly load the file which would however kill the beam or ramp to this file (down-ramping) without loss of the remaining current (usually 100 mA), refill and ramp up to 2 GeV again. Both ways function very well however we are reluctant to inject with insertion devices at small gaps and thus the down-ramping method is not for the moment advantageous. On the other hand the direct loading of the file takes only 30 seconds and the injection itself with an average speed of 2.5 mA/s refills to the full current of 320 mA in 130 sec. We have performed a series of measurements to verify the repeatability of the machine for the non-cycling procedure. For this we have repeated the 1 to 2 GeV injection and ramping cycle many times observing the orbit, the tunes, the chromaticity and dispersion of the machine at 2 GeV. No effect on tunes, chromaticity and dispersion was observed. Results on the uncorrected difference orbit rms are shown in figure 1.

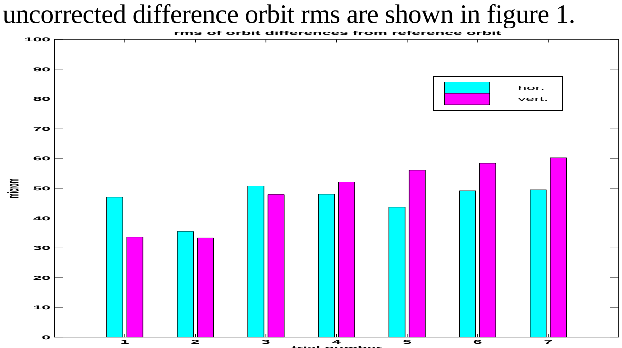

Figure 1: Orbit repeatability without magnet cycling.

3 INCREASING THE CURRENT

The routine 320 mA current already exceeds by more than 50% 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 was the thermally induced mechanical stress on the vacuum gaskets of the beam position monitors (BPMs) downstream of the bending magnets. Already in 1994-95 additional cooling was installed which gave noticeable improvement in vacuum and thermal stability. The BPMs, however, still suffered from thermal stress because of the difficulty in providing additional cooling to the body of the monitor.

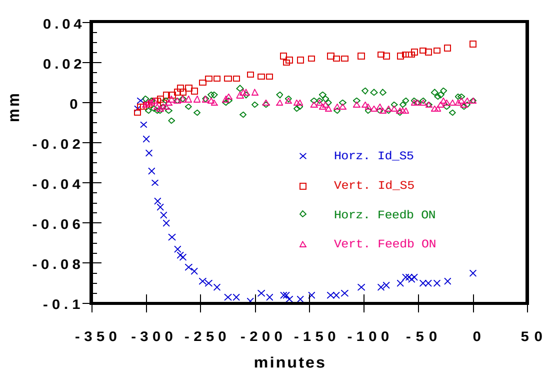

Figure 2: Worst case local orbit drift for a period of five hours without any feed back at 2 GeV with an initial current 320 mA.

In view of this, composite gaskets of steel/copper have been installed that permit an increase of current to 350 mA. In fact 340 mA have been ramped to 2 GeV without any problem. The chamber however still heats up reaching even 90^0 C in some BPMs downstream of the bending magnets inducing an orbit drift since the BPMs are fixed to the quadrupoles of the machine. This drift has its maximum in the horizontal plane (Figure 2) and is continuously corrected at the users source points by means of a slow orbit feedback system. In Figure 2 the worst case orbit drift is shown for an initial current of 320 mA. The horizontal maximum occurs 1.5 hours after the end of ramping. After 5 hours the current was 210 mA. For comparison the beam position is shown (7 μ horizontal and 5 μ vertical peak to peak) when slow feed back is active.

4 INCREASING THE ENERGY

The machine energy may be increased up to 2.4 GeV with a current of 170 mA which generates the same total heat load ($\sim E^4$) as 350 mA at 2.0 GeV. However due to power density considerations ($\sim E^5$) the current at this energy is not allowed to exceed 140 mA. 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 200 mA.

At 2.3 GeV with 130 mA and 2.4 GeV with 100 mA, photon beam spectra have been taken by various beam lines. At higher energies the beam is more stable giving a better signal to noise ratio and the lifetime can be as much as 60% higher (for 100 mA: 32 hours 2 GeV, 52 hours 2.4 GeV) giving a better integrated flux over 24 hours. From those preliminary data it seems that the measured flux for the same current between 2.0 and 2.4 GeV is comparable or slightly better although there is an up to 50% emittance increase.

In the next figure comparative spectra at a resolving power of 5000-10000 are shown while the undulator is at two different gaps in order to match the photon energy.

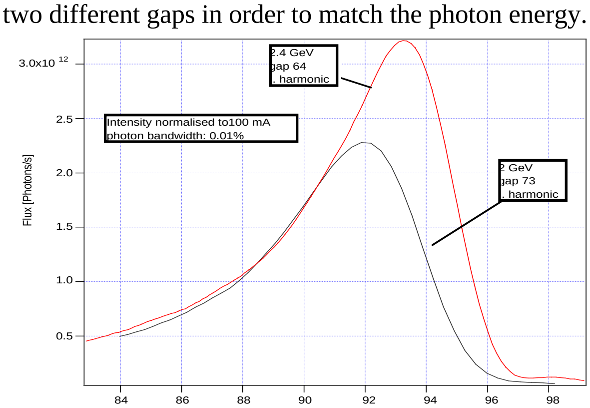

Figure 3: First harmonic intensity preliminary spectra taken at 2.0 GeV 250 mA and 2.4 GeV 100 mA.

5 FEW BUNCH MODE

Although we have not had up to now any official request for single bunch operation lately users became interested in the few bunch filling mode. The machine can be filled to any combination of bunch number including strange fillings such as half ring continuous filled accompanied with a single or few bunch in the empty other half. Users performed measurements with 6 and 12 equidistant bunches with 10 mA/bunch and took spectra as well as performed time of flight experiments. Figure 4 shows a spectrum taken with 6 and 12 bunches. A small number of bunches increases the chance of mode self-cancellation. In fact, it has been proven that partial mode self-cancellation can be achieved with up to 18 bunches thus rendering a very stable beam, see [4] for further details.

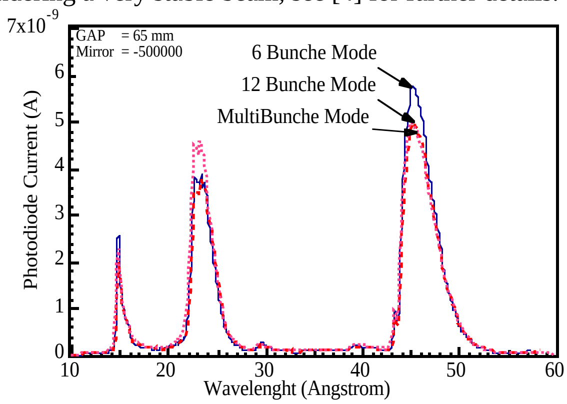

Figure 4: Beam spectra from ALOISA showing the first 3 harmonics. The first harmonic (first from right) corresponds to 275 eV.

6 CONTROLLING MULTIBUNCH INSTABILITIES

Longitudinal and transverse multibunch instabilities degrade ELETTRAs 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 [5]. To render this method more flexible adjustable higher order mode frequency shifters (HOMFS's) have been installed in two out of four cavities [6] with very good results showing an improvement in shifting both the longitudinal and transverse modes as well as having more flexibility in the tuning range.

The control of the beam quality and hence lifetime is by means of the longitudinal cavity HOM corresponding to the coupled bunch mode n=86. Tuning the temperature of a cavity in order to have a low excitation of the mode we obtain the so called high brightness operating condition which is the current operating mode for users. In this the lifetime is very close to the Touschek limit of approximately 9 hours at 300 mA. Suppressing this HOM all longitudinal coupled bunch instabilities are eliminated but at the same time the induced Landau damping is lost and transverse coupled bunch instabilities manifest themselves deteriorating the beam quality. To this end a transverse multibunch feeback [1] is under construction to be installed next year.

At present the machine operates with an adequate longitudinal excitation of the n=86 mode at 19° (Fig. 5); this excitation is well accepted by the users giving a noise to signal ratio of less than 0.5% but is enough to give the much needed transverse stability and longer lifetime.

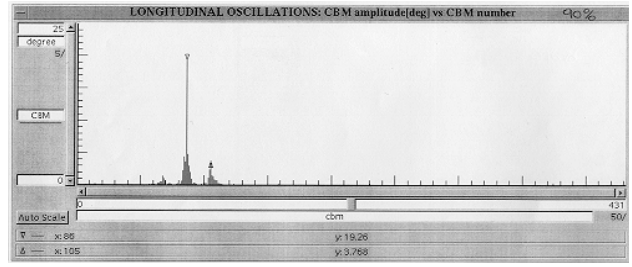

Figure 5: Longitudinally excited modes during users run.

7 CONCLUSIONS

Continuous effort is made to improve ELETTRA. Increasing the automation and reducing its downtime we render the machine more efficient. Knowing that the machine can perform very well at energies up to 2.4 GeV and at the same time providing a wide choice of filling modes we enhance the versatility of the machine that certainly can now satisfy a higher diversity of user demands.

Software programs have been upgraded to adapt to the changes and to further simplify their operational effectiveness based on our accumulated experience with the machine. This includes also programs that have been replaced by simpler and user friendly ones that can also be easily used by the operators [7].

The future trend at ELETTRA is towards higher currents that can be achieved and the instability control is very satisfactory. However for an efficient control of coupled bunch instabilities at a wide current range (100-400 mA) with acceptable lifetime additional systems will be used to make this possible [1].

8 ACKNOWLEDGEMENTS

The authors thank the GPH and ALOISA personnel, especially M. Coreno and R. Gotter for their assistance in the measurements.

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