# The High Level Software Programs : TUNE and ID-COMP

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*Abstract:*

In order to aid the commissioning of the ELETTRA Storage Ring, several high level software programs have been developed. In this paper, a description of the programs TUNE and ID-COMP are given. The first is a program which allows the user both to set desired tune values to the machine and to perform resonance scans througout the tune diagram. ID-COMP, instead, has been developed in order to compensate the linear distorsion introduced by the presence of insertion devices using several techniques.

## 1. INTRODUCTION

Many high level software programs [1] have been developed at Sincrotrone Trieste for the commissioning of ELETTRA, the third generation light source constructed in Trieste, Italy. The existence of such codes has proven to be extremely useful during the commissioning period, giving an excellant control of the machine and at the same time facilitating measurements and operations, which otherwise might have been tedious and time consuming. One of the advantages of having such codes also lays in the fact that, once the specific measurement procedure has been implemented, any sufficiently trained machine operator, even with little accelerator physics background, may perform the measurement. A further big advantage is that the code may already process the measurement data on line and display the results immediately.

In this paper, the details of two high level software programs are presented. The first, TUNE, has been written in order to permit the operator to vary the betatron tunes to any desired values, using quadrupoles in the non-dispersive straights. Associated with the produced tunes variations, the program can record the lifetime and the beam current and correlate these parameters to the actual tunes currently being set on the machine by the software, giving thus information on the stopbands of eventually encountered resonances.

Since the storage ring ELETTRA has eleven straight sections to accomodate insertion devices, the second program, ID-COMP, has been written to compensate the linear distorsions introduced by the devices. Different compensation techniques have been implemented, which go from local optics compensations [2], [3] with the additional possibility of setting the horizontal or vertical beta function to a desired value at the center of an insertion device to global optics compensations minimizing the beta beats around the ring. All techniques give the possibility of tune re-adjustments. The program may also allow the operator to compensate the linear distorsions dynamically while an insertion device gap is changing.

Both programs have been implemented in C language and run on UNIX workstations. As all the other high level programs developed at ELETTRA, the software is built on top of a complex and complete data structure [4] and it may be essentially divided into three parts : an interactive graphical user interface, the interfaces to the hardware and the modules for the accelerator physics computations. The graphical user interfaces are based on the use of panels and widgets and have been implemented using the Xt-Toolkit libraries and OSM-Motif. An extremely useful aid in the layout of the panels was given by the use of CPE [5]. The main philosophy of the design was based on creating panels which would be the most user friendly as possible and which in the meantime would prevent users from performing any harmful or useless action on the machine, through a strong error handling. Regarding the interfaces to the machine, all the details of accessing the hardware are completely transparent to the programmer with the aid of a library. Any changes made at lower levels are updated just in the library and all programmers have only to relink. This feature minimizes eventual bugs and increases both the flexibility and the portability of the programs.

As for the accelerator physics algorithms, a description of the ones used by TUNE and ID-COMP are given in the following sections, together with a brief explanation of the graphical interfaces. Both programs have been extensively tested with a simulated machine before installation. However, while TUNE is currently operational on the real machine, only tests regarding the connections with the hardware on the real machine have been achieved for ID-COMP.

## 2. TUNE

As stated in the previous section, TUNE has been developed mainly for applying desired betatron tunes to the Storage Ring and to perform resonance scans. The graphical user interface for the program consists in three panels. The main one appears on the terminal screen after the program has read the power supplies' currents from the machine. The user, just by selecting with a mouse the options required for the measurement, may change the default values and create all the necessary initial conditions to perform betatron tune variations on the machine. Among the required inputs for the measurement are the initial tune values and the final ones to which the user wishes to arrive. Since these sets of values define a line in the tune diagram and unfortunately the settings of the currents on the power supplies of the quadrupoles used are not simultaneous, the program allows the user to define in how many steps the final values should be approached. The line defined by the initial and final tune values appears in a plot of the tune diagram, where the user may change scale and also visualize all resonance lines up to fifth order included. This feature gives a clear view to the operator of where the tunes will be moved and if on the way there may be the risk of a partial or total beam loss.

The graphical interface permits the user to choose between several combinations of the quadrupoles in the non-dispersive straights, taking care that the total number of quadrupoles is correct. Automatically it computes all the necessary current increments to set on the power supplies, by solving the linear bidimensional system:

$$\Delta Q = \partial Q/\partial I \ \Delta I \qquad (1)$$

where $\partial Q/\partial I$ is the tune sensitivity matrix expressed in $Amp^{-1}$ and $\Delta Q$, $\Delta I$ are bidimensional vectors containing respectively the tune and quadrupoles' current increments in one step.

With the option of applying the desired tune values, the operator can visualize with a plot both the horizontal and vertical fractional parts of the tunes the program is currently setting on the machine. The resonance scan option, instead, displays on a graph the lifetime associated to each step. The recorded lifetimes normalized to the maximum lifetime value and the corresponding fractional parts of the tunes set by the procedure may also be displayed, giving, together with the above described tune diagram, immediately a view to the user of the resonances and of their widths.

In the near future, as soon as new low level processes for controlling the spectrum analyzer will be ready, the program will contain options for changing remotely measurement parameters on the spectrum analyzer.

## 3. ID-COMP

The program ID-COMP has been written in order to compensate the linear distorsions produced by the introduction of insertion devices in the Storage Ring. Since the actual gap setting of the device and the compensation method applied may strongly affect the machine performance, an important feature of the code is the possibility of visualizing beforehand, through graphs and numbers, all the important parameters, such as tunes and beta-beats, generated by the compensation and by the device itself. This gives the user a strong inner-view on how he or she is going to change the machine and in the same time allows on-line comparison between the effectiveness of different schemes according to the current machine optics.

Once the user has selected the insertion device whose linear effects have to be compensated and the final gap settings, a choice between several techniques is available. The operator has also the possibility of choosing the reference optics which has to be restored. The latter may be the nominal optics with no insertion device in or the current optics without the selected device. All methods use the quadrupoles in the non-dispersive straights and they may be essentially divided into two classes: local compensation and global compensation.

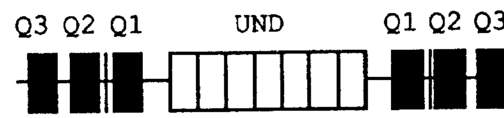


Figure 1. Structure of the Lattice near an Insertion Device

### 3.1. *Local Compensation*

Under this class go all the schemes which use only the quadrupoles allocated in the straight of the selected insertion device (Figure 1). The basis of the compensations is on taking the horizontal and vertical beta values at the beginning of the straight to be equal to the reference ones and forcing the beta slopes to be equal to zero at the center of the straight. In this way the beta-beats should remain localized in the insertion device region and not leak out to the rest of the ring. In order to achieve this, one needs only two of the three quadrupole power supply families available in the straight. The software allows the user both to select directly which two families to use or to visualize with graphs and numbers the results coming from all the three possible combinations, permitting thus the best choice for the current situation before any action is taken on the machine.

A second local compensation scheme consists in using all three quadrupole families and forcing also one of the two beta values at the center of the straight to a desired value. Even in this case the user may visualize the results.

### 3.2. *Global Compensation*

Under this class go the methods which make use of quadrupole families in any non-dispersive straight. The algorithm consists in minimizing the function :

$$\Sigma_i \, [\, (\beta_{h_i} - \beta_{href_i})/\beta_{href_i}]^2 + [\, (\beta_{v_i} - \beta_{vref_i})/\beta_{vref_i}]^2 \qquad (2)$$

where $\beta_{h_i}$ and $\beta_{v_i}$ are the current horizontal and vertical beta functions at location i in the ring and the subscript 'ref' stands for reference. The minimization is searched for in the multidimensional space of the possible quadrupole settings, using the most effective correction method. In alternative, also a harmonic correction is available. All results are immediately displayed on graphs which have clear references to the various elements in the ring and which permit visualization also of the details.

The user may restrict the maximum number of quadrupoles to be used and he or she may also reduce the dimension of the space, by excluding desired quadrupole families, which might be wanted available for the local compensation of a particular device.

Whatever the method, there is always the possibility of re-adjusting the betatron tunes to their initial values. Among the quadrupole families which have not been used by the program for the compensation, the program will automatically compute which are the most suitable for this purpose and the relative power supplies' currents to set.

A further important feature about the possibility of visualizing beforehand the optics resulting from a compensation lays in that the program allows the user to update in the model used the settings found. This leads to the possibility of making multiple compensations, turning the software in an interactive optics design tool.

## 4. CONCLUSIONS

In this paper, two high level software programs developed in home for the commissioning of ELETTRA have been described. While TUNE is currently operational on the Storage Ring, the effectiveness of the compensation schemes in ID-COMP still has to be verified with measurements.

## 5. REFERENCES


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## ACKNOWLEDGEMENTS


The author is grateful to A. Wrulich for intensive discussions on the linear optics distorsion compensation methods and to G. Surace for explanations and help in the process of learning the usage of Xt-Libraries. The author also thanks all colleagues whose suggestions have improved the programs.