AUTOMATIC BEAM TUNING AT GANIL

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Abstract
The GANIL facility consists of 3 successive cyclotrons : C01 or C02, CSS1, CSS2. A fourth one : CIME, is to be added in 1999 (SPIRAL project). The tuning of these cyclotrons, including the transfer beam lines, may be achieved in approximately 24 hours. Efforts must be made to reduce the time necessary to set up the machine, and to improve beam intensity and quality.

Thus, the tuning is progressively made automatic. As regards the beam lines, our programs have been written these two last years. Automatic transverse matching and beam centering are now operational.

The GANIL beam lines are composed of sections with separated functions. The matching section includes 4 magnetic quadrupoles and 3 beam profile monitors. By construction, the beam is matched if the beam presents a cross-over on the central profiler, and if the beam size on the middle profile monitor is half of the value of the other ones. This disposition made the matching easy to check visually.

The quadrupoles are initially set to theoretical values. The manual tuning consisted in varying one quadrupole, visualizing the effect on the beam sizes, then trying another quadrupole, and so on.

The automatic matching program uses now an on-line beam optics calculation.

It first translates the beam sizes on the 3 profile monitors in terms of emittance and betatron functions. The second step is to calculate the betatron functions at the entrance of the first quadrupole, using the transfer matrix from one point to another. The third step is to optimize this transfer matrix, so that the betatron functions correspond to a matched beam.

Automatic matching is operationnal since the beginning of 1997, and really makes the tuning easier.

Similarly, an automatic beam centering program is now used.

The first step of the method is to measure the beam center of gravity as seen by the wire profile monitors.

The second is to calculate the matrix M related to the effect of each steerer on each monitor. Let P be the vector of the beam centers of gravity and S be the vector of the steerers intensities. It is desired that : $P = -MS$. Thus, the solution may be determined as : $S = -(M^T M)^{-1} M^T P$ with M^T the transposition of the matrix M. This coresponds to a least-squares fit. In addition, the corrector values are simultaneously minimized.

The results of the beam centering program are very convenient. The beam centers of gravity in both planes after automatic beam centering are bellow 1 mm, and the tuning is really faster and more reproducible.

In writing these programs, the main work was to add all the data needed in the beam optics calculation in the data base used for operation. This addition has

required some modification of the structure of this data base, and, thus, some modification of other programs.