MAGNET SYSTEM OF THE S.I.N. RING INJECTOR CYCLOTRON

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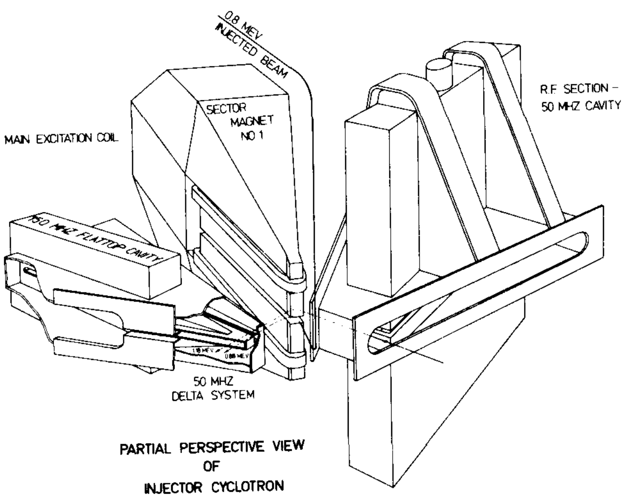
Summary

As beam guiding elements for the proposed new S.I.N. Injector Cyclotron four sector magnets will be used[1]. They are of the conventional C-type with a constant air-gap; the poles have a zero spiral angle (see figure).

The main characteristic of the magnet system is the simplicity of its overall design as well as those of the field correcting elements, for which some unusual solutions can be applied.



PARTIAL PERSPECTIVE VIEW OF INJECTOR CYCLOTRON

Sector Magnets

Four 26° sector magnets of the conventional C-type, approx. 120 t in weight ea., will serve as the main part of the Ring Injector magnet system. Simple magnet cost optimizing calculations[2,3] have shown that at the induction level of 10 kG in the 35 mm constant air-gap, a flux density of roughly 12 ÷ 14 kG in the steel would minimize the manufacturing cost. Using this value, no special precautions must be made concerning the yoke steel quality. However, for the magnet poles, cyclotron steel forgings will be used in order to provide the most possible field homogeneity and to eliminate possible three-dimensional saturation effects. The latter ones may especially occur in the very narrow pole region ("nose") at the beam injection area.

The upper and the lower magnet yoke will be subdivided - mainly for reasons of the cyclotron crane capacity - leading to a maximum weight of approx. 22 t for a single piece. Since no spiral angle is required, all steel parts can be machined on a planer.

Each sector magnet will be excited with max. 35 000 At by a pair of pole coils. Due to the lack of space and the bustle in the injection area, the main coils will be partially mounted in a pole groove located close to the pole-yoke boundary. The coils placed so far away from the air-gap are advantageous, leaving free space on the pole sides for the field correction elements (see below) and the vacuum chambers.

On top of each main coil, few turns of an equalizing coil (for compensation of the gap-tolerances and different yoke steel characteristics) will be placed and energized individually whilst the main coils of all four magnets will be connected in series.

Field Corrections

Due to beam optics calculations, a 35 mm air-gap seemed to be advantageous. Naturally that such a small gap led to a very modest overall magnet power consumption of only 20 kW.

However, the small gap did not allow enough space for any kind of correcting elements. Besides that, for reason of simplicity, one has tried to find a solution for those elements (trimm-coils or shims) to be located outside the vacuum chamber.

Presently, two-stage corrections will be used:

1) For the compensation of the relativistic mass increase, correspondingly machined steel blocks will be used. They are fixed on one pole side - facing the gap - within the vacuum chamber.

2) Either movable pole-side shims[4] or pole-side trimm-coils[5,6] will serve to correct the magnetic field for machining and assembly errors as well as for local permeability perturbancies in the steel.

Extensive calculations and model tests on both versions of the second stage correction were performed some time ago. The results were very satisfactory and encouraging as well as the efficiency is concerned as from realization standpoint of view.

In case of trimm-coils, they would be placed directly on the pole side between the

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vacuum chamber and the main coil. Because of almost no space restrictions in this region, the power consumption of the coils can be kept very low[5]. The length (radial extension) of the trimm-coils would be something like 30 ÷ 50 cm.

Pole-side shims would consist of steel prisms with a cross-section of approx. 2 x 4 cm (W x H) and a length of 20 ÷ 30 cm. They would be placed on mechanical devices, few centimeters apart from the pole. By moving the shims toward or from the magnet midplane, field corrections of different strengths can be introduced.

Because no preference exists for either one or the other correcting system, final decision will be made on basis of cost calculations.

Injection and Extraction

The elements for beam injection and extraction were already briefly described elsewhere[1].

Here, of a major interest might be to mention, that the injection through the first sector magnet (SM1) will be accomplished by a magnetic cone sector. This cone shows focussing properties, necessary for the proper beam matching between the injection beam line and the accelerator. A model of this device is under construction and preliminary magnetic field measurements will start in the next future.

Extensive calculations[7] and field measurements on stray-field screening elements for the 0,8 MeV beam transport elements have been made. This was necessary because of the small rigidity of the low energy injection beam and correspondingly high influence of the sector magnet stray-fields on the beam behaviour.

A large turn separation enables to perform the extraction with only one low field septum magnet, followed by an extraction bending magnet. Both elements are located within the vacuum chamber.

References

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[7]) D. Brombach
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