MECHANICAL ASPECTS OF THE LNS SUPERCONDUCTING CYCLOTRON UPGRADE

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Abstract

The Superconducting Cyclotron (CS) is a three sectors compact accelerator with a wide operating diagram, capable of accelerating heavy ions with q/A from 0.1 to 0.5 up to energies from 2 to 100 MeV/u. The proposed upgrade to increase the light ion beam intensity by means of extraction by stripping implies many modifications of the median plane. The main activities of the mechanical upgrade are: the actuation of the new magnetic channels for the extraction by stripping and the realization of the two extraction modes, by stripping and by electrostatic deflection. For the magnetic channels and compensating iron bars, we are studying the problems of mechanical handling. To obtain the two extraction modes, we are trying to design a new set that allows for the exchange of two devices: electrostatic deflectors and stripper with its magnetic channels for stripping extraction.

INTRODUCTION

The Superconducting Cyclotron (CS) is an accelerator which was designed for low intensity beams, whose main limitations to extract high beam power are the two electrostatic deflectors. The goal of the upgrade is to make extraction by stripping possible, interchanging the stripper with one of the two electrostatic deflectors, to achieve high power beams for the set of beams of interest and, at the same time, to maintain the versatility of the CS [1]. The detailed study of the beam dynamics along the stripping trajectory, for various ions at different energies, has led to the need for a new extraction channel. The interference of this channel with the electrostatic deflector handling, is the start of our study of the technical implications on the CS median plane.

RESULTS ON THE STRIPPING EXTRACTION

A study about beam dynamics of the stripping extraction, was necessary to compute stripping extraction for every ion and energy whatever the charge state of the accelerating particle is [2]. The results of this study are reported in another paper presented at this conference and are summarized in (Fig. 1).

The optimization of the different particles and energy trajectories allow us to have a common extraction point, for the purpose of making easier the design of the new extraction channel.

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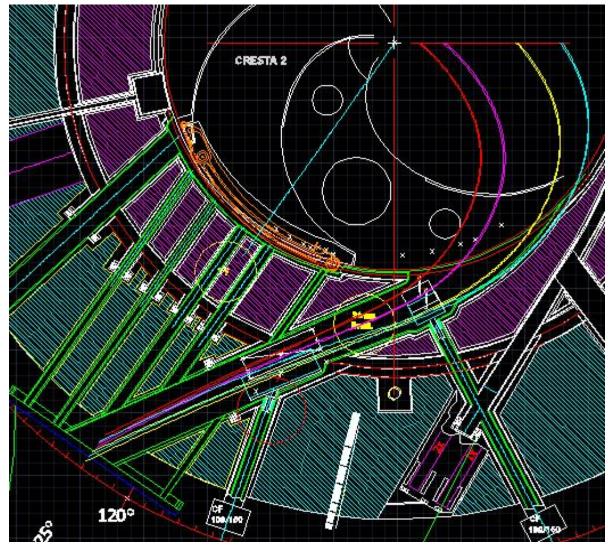

Figure 1: The different particle trajectories after the stripper crossing.

MECHANICAL ASPECTS

The fundamental mechanical aspects of the extraction by stripping, concern the modifications of the median plane of the CS (Fig. 2). Due to the design of the new extraction channel, there is the necessity of moving one of the lifting points of the vacuum chamber (from 107° to 90°). This forced us to rotate the position of the three horizontal suspensions (from 96°, 216°, 336° to 41°, 161°, 281°) because in the 90°-110° area, there is not enough space to allocate both the lifting point and the horizontal suspension. The new lifting points positions are 90°, 210°, 330°. The 41° and 281° horizontal suspensions caused respectively the suppression of the M7 and M2 magnetic channels, which were designed as part of the electrostatic extraction equipment but have never been used in the real life. Moreover the radial penetration for the beam injection was removed. Furthermore for the new extraction by stripping, a study has been done for the design of the magnetic channels. Able to reduce locally the magnetic field and to focus the beam in the radial direction, as a result of this study, two magnetic channels, M1S and M2S, are necessary: they are made up of three iron bars that we have to block inside a steel housing to avoid their movements. Through the simulations, we obtained the force values in the three directions and their range on the median plane for every ions. About the channel M1S, the resultant force is of about 9 KN, towards the CS centre. There is no need to remove it except in emergency case from the inner side of the CS. Its mechanical handling, for the necessary movement, had an interference with the old extraction channel (Fig. 3).

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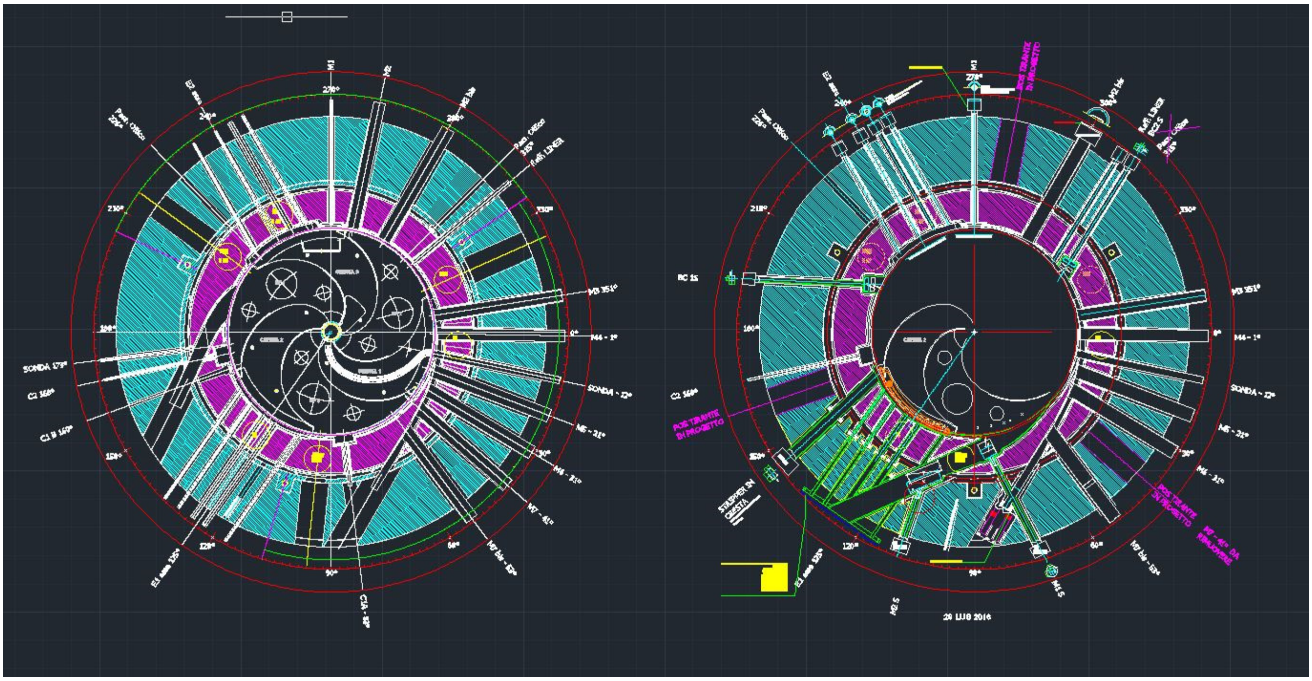

Figure 2: The current median plane (left) and the new median plane (right).

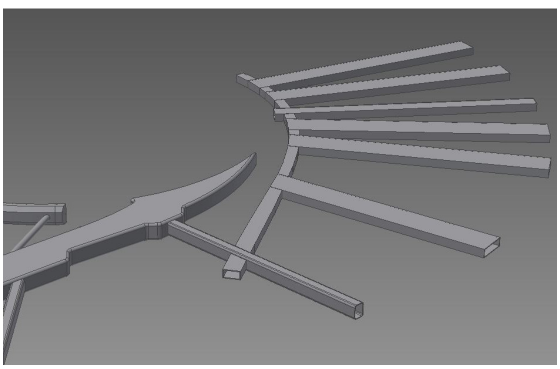

Figure 3: Interference between M1S mechanical handling and the old extraction channel.

Therefore we will design a fork system in that critical zone, that allows for the beam clearance, in the electrostatic extraction mode. We will simulate mechanical stresses on the link between the fork and the handling shaft, because the load is very high. About the channel M2S, the resultant force is of 3 KN, towards the direction opposite to the CS centre and it must be possible to remove it through the new extraction channel which is necessary for beams to be extracted by electrostatic deflection, because M2S interferes with one of the electrostatic deflector shaft. To compensate the imperfection field generated by M1S and M2S, we designed two iron bars, B1S and B2S; through the simulations, we obtained the force values in the two directions and their ranges on the median plane. In both cases, the resultant force is of about 4 KN, towards the CS centre and we are studying their mechanical issues. The mechanical handling, near to the B2S, is for the Liner cooling. To implement the two extraction modes, by stripping and by electrostatic deflection, we had to solve the critical interference between the new extraction channel and the electrostatic deflector handling. Our project is to weld the extraction channel with the three deflector penetrations and with a flange: this would not have critical consequences because all the components are of steel (Fig. 4).

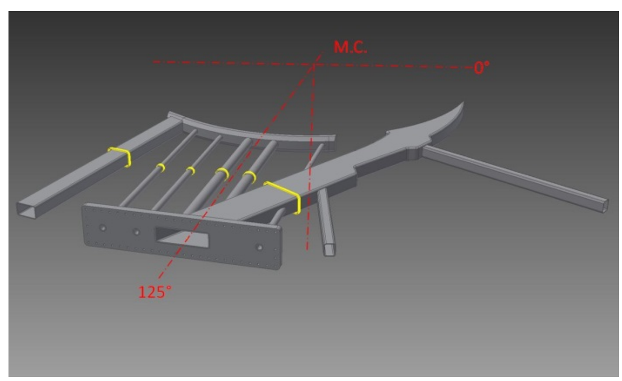

Figure 4: Assembly of the extraction channel with deflector penetrations.

We are studying two interchangeable chambers, to be coupled with the terminal flange of the assembly, to take into account the two extraction modes. Every chamber has the necessary features: for the extraction by stripping, the extraction channel continuation, for the extraction by deflector, the holes for the mechanical handling. We are considering the use of bellows for the penetration, useful during the cryostat construction. We are studying how to compensate the possible misalignments of the two tubes of each penetration: they are necessary to conjugate the requirement of the acceleration chamber (internal tube) with the cryostat (external tube). The bellow should allow us the last butt fusion between the two tubes.

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STRIPPING SYSTEM

To extract the beam we need to use a moveable stripper foils (Fig. 5). The positions of the stripper foil stay in the area of the electrostatic deflector. To adjust the radial and azimuthal position of the stripper foil, a preliminary solution consist of an arm rotating around a fixed point and a belt, placed inside the arm, moved by a endless screw system, through two pulley. On the arm a minimum of 8 stripper foils will be mounted; they roll along the belt and only one of them will be hitted by the beam.

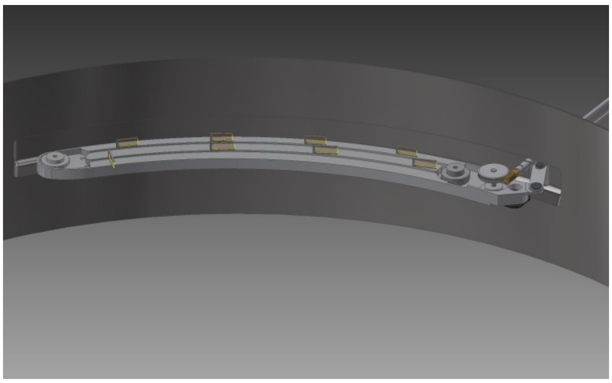

Figure 5: Stripping system.

CONCLUSION

The CS upgrade, required a starting phase, whose objective was to verify the feasibility of the extraction by stripping by a wide number of simulations that proved the design of a new extraction channel. Then we modified the median plane: the change of lifting points and horizontal suspensions position and the suppression of magnetic channels. For the new magnetic channels, we are studying the interferences of their mechanical handling and to obtain the two extraction modes, by stripping and by electrostatic deflection, we are designing two interchangeable chambers outside the CS yoke, to allow us the alternation between the new extraction channel and the electrostatic deflector handling.

REFERENCES

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