BEAM OPTICS PROGRESS FOR THE ALPI PROJECT

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Abstract

During the last two years the general layout of the ALPI linac has been further analyzed and some refinements were introduced in order to optimize the beam transport.

A considerable effort has been put in minimizing the length of the ALPI module (two cryostats with a focusing triplet in between) in order to avoid an excessive growth of the beam envelopes. The beam optics of the machine has been studied by means of the LYRAN code with different ions and charge to mass ratios, adopting a 3 MV/m mean accelerating field for the Quarter Wave Resonators.

1. Introduction

The ALPI post-accelerator project [1,2] is now entering into its construction phase and the design parameters and the general layout have been fixed, after the last adjustments for the transport optimization.

The foremost change to the general layout of the ALPI post-accelerator during the past two years is the underground location of the machine. In the new design the post-accelerator beam-axis lies 4 meters below the XTU Tandem axis in order to achieve a more efficient shielding of the linac. The plane of the transfer line between the two machines is accordingly tilted by 6.34° with respect to the horizontal plane.

The transfer line contains two -90° dipole magnets, with a 2 meters radius of curvature, which can transport beams with a maximum rigidity of 3.3 Tm. The first one will be located downstream the existing +90° energy analyzer with the new object point 3 meters from the existing slits.

The U-bend as a whole is completely isochronous with three crossovers between the two -90° dipoles. The first crossover is located in the optical image of the first -90° dipole; the second one is defined in the symmetric midpoint of the U-bend (where an isochronizing quadrupole is placed) and the last one will be in the optical object of the second -90° dipole.

We chose three different stripper locations placed respectively in both the object slits of the two -90° dipoles and at the post-accelerator entrance, where the high energy buncher time focus is produced.

The longitudinal matching is achieved by means of two superconducting resonators working at 80 and 160 MHz respectively, which allow the injection of the beam into the linac with the proper energy-time ratio.

The basic element of the ALPI post-accelerator is a module with two cryostats and a room temperature triplet in between which provides the radial focusing force. Two subsequent modules are connected by a diagnostics box. The post-accelerator is subdivided into three different sections according to the ion velocity: a low-β section with 24 cavities ($\beta_{opt} \simeq 0.055$), a medium-β section with 48 cavities ($\beta_{opt} \simeq 0.11$), and a high-β section with 21 cavities ($\beta_{opt} \simeq 0.15$). Each cryostat accommodates four Quarter Wave Resonators (QWR)[3] in the low- and medium-β sections and three QWR's in the high-β one.

In the last two years many refinements on the optical transport have been made to overcome some new problems which has been put in evidence by the numerical simulations during the optimization . One of them was due to the mid U-bend where simulations done with the LYRAN code [4,5] showed that the beam sizes were too close to the bore diameter of the rebunchers beam ports.

The new layout of the machine, shown in fig.1, includes now only one cryostat at the center of the mid U-bend, housing four resonators acting as rebunchers; we definitely discarded the possibility of using those resonators in accelerating mode and, in order to preserve the designed final specific energy, we added a new module in the medium-β section.

In order to avoid an excessive growth of the transverse and longitudinal beam envelope we reduced the length of the ALPI module to 4.30 m in the medium- and high -β sections and to 4.06 m in the low -β section, where the lower electrical rigidity of the beam makes the transport more demanding.

Following the recent results obtained within the research and development programmes of the LNL on the bulk and sputtered niobium resonators [6,7] we also performed simulations assuming 5 MV/m accelerating field.

Effects coming from misalignment or field and phase instabilities were not taken into account in the present simulations.

2. Numerical results

A great number of numerical simulations with different masses and effective charge states have shown a critical beam transport in the low-β section at the post-accelerator entrance where the beam envelope (longitudinal and transverse) grows because of the low ion velocity and the related high radial defocusing effect of the accelerating gaps.This effect is of course stronger with very heavy ions which have low electrical rigidity.

Two options have been considered in order to overcome the blow up of the beam envelope in the low-β section;the first

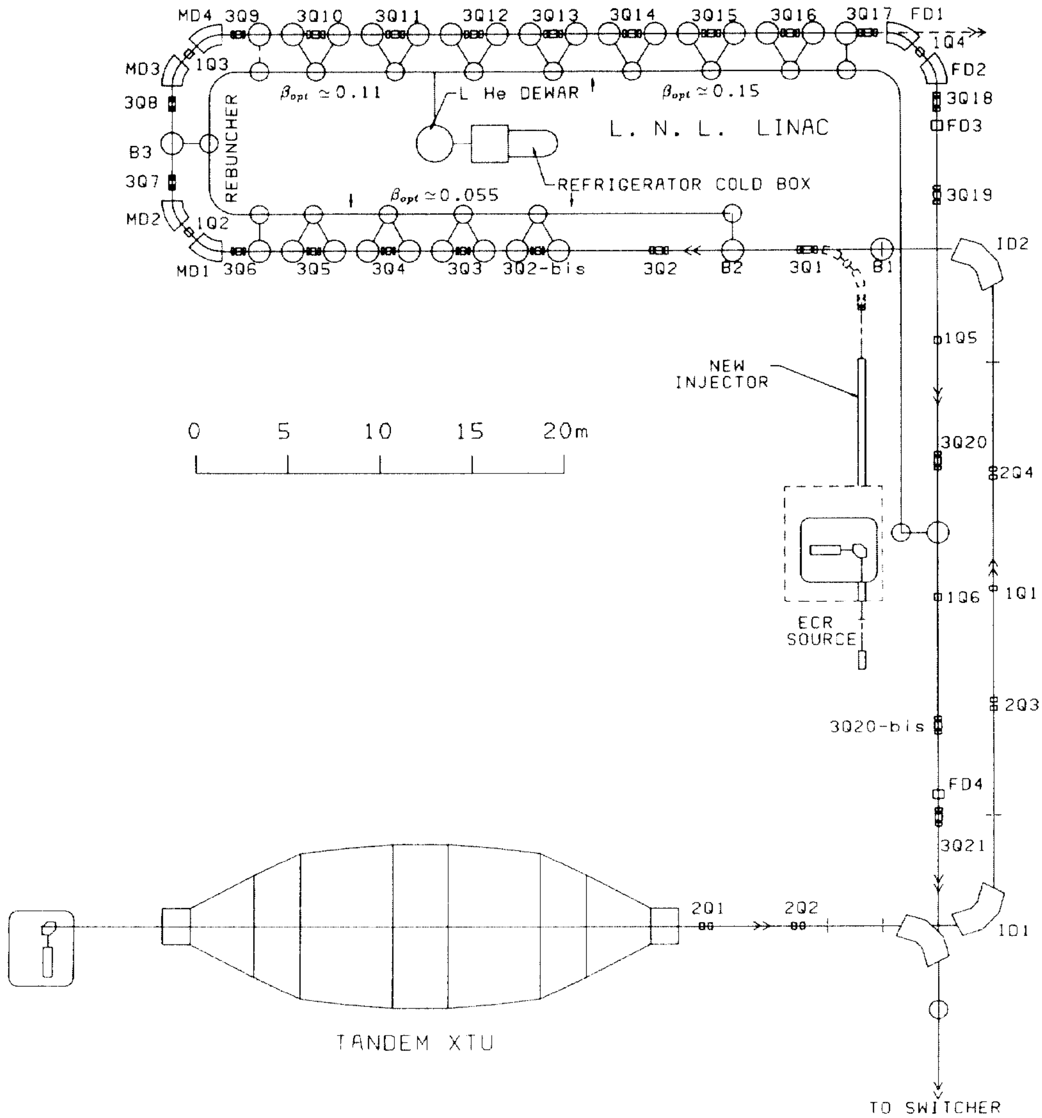

Fig.1 : Layout of the ALPI complex project .

one is the contraction of the module length by means of triplets with an overall length of 86 cm versus the 110 cm of those used in the higher β sections. With this choice the beam can be transported through the low-β section without loss of particles if the accelerating field does not exceed 3 MV/m.

The second option is a more classical approach in which the radial focusing is performed with a short doublet every one cryostat and the diagnostics stations are totally removed until the entrance of the mid U-bend. Further studies are now in progress in order to define the best solution for the low-β section which will be adopted for the final phase of the post-accelerator.

A second critical region for the beam transport is localized in the mid U-bend where the long drift causes an excessive growth in phase.The adopted solution is a rebunching section in the middle part of the U-bend where, to preserve the symmetry,the requested rebunching action can be obtained by means of two cavities.

A typical result of the simulations with the LYRAN code is shown in Fig. 2 which represents the beam envelopes for the silicon ion with a charge state 13^+ (after the second stripper) for the first phase of the project where only the medium-β cavities are foreseen. The accelerating field is 3 MV/m in the accelerating cavities. The injected beam transverse rms emittance is 2 π mm mrad and the longitudinal one is 50 keV nsec. The small longitudinal emittance values which are possible with the light ions put clearly in evidence the isochronous behaviour of each L-bend separately.

3. Conclusions

The systematic numerical study of the ALPI complex has shown the overall reliability of the project and has put in evidence some critical points where a deeper analysis is required. In particular the low-β section for the second phase at the post accelerator entrance requires, expecially with the low electri-

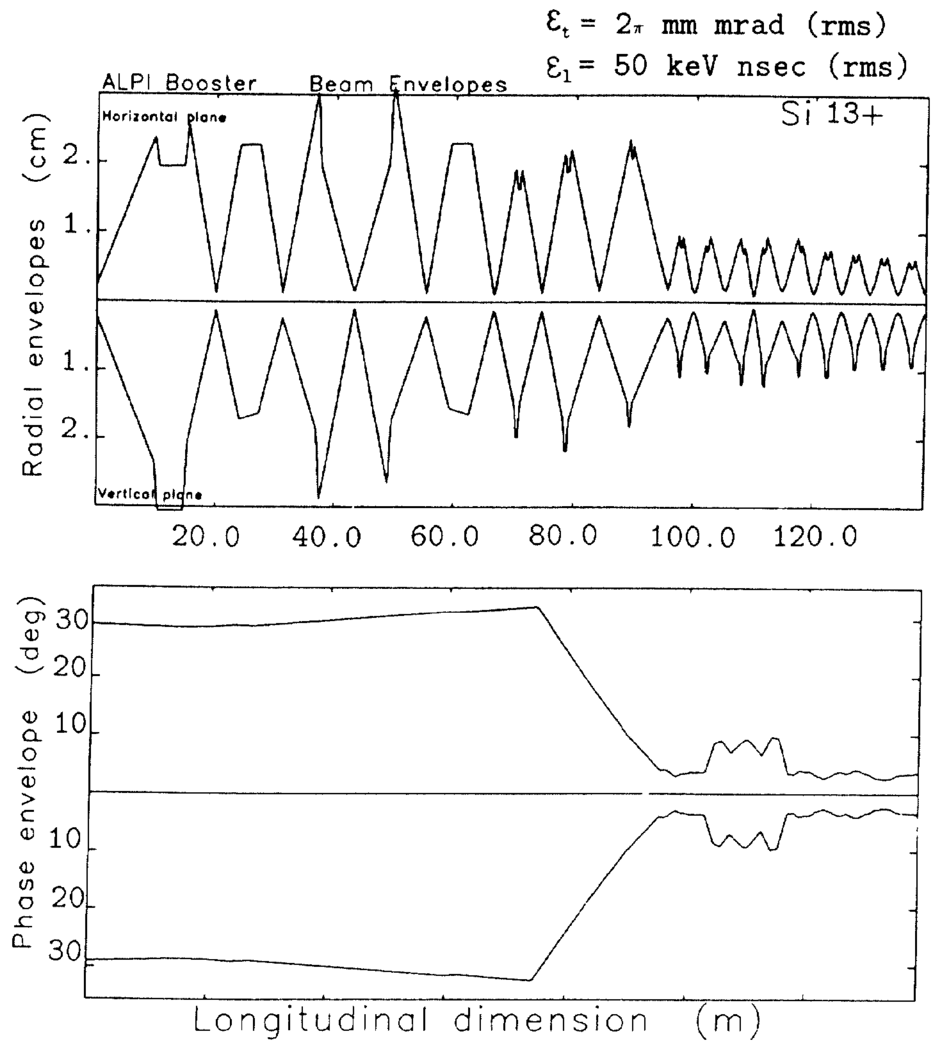

Fig. 2 : Expected beam envelopes and phase spread for a matched Si (13^+) beam.

cal rigidity of heaviest ions, a very compact structure. Two solutions are now under study in order to define the low-β section which will be adopted. In the first solution we preserve the same topology which has been adopted for the medium- & high-β section with a smaller triplets; in the second one a more classical approach is assumed with a doublet every one cryostat.

References

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