# ION OPTICAL LAYOUT AND FOCUSING ELEMENTS FOR THE HIGH ENERGY PART OF THE SNQ-LINAC

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## Summary

The ionoptical layout and the design of the focusing elements for the high energy part (HELA) of the SNQ-LINAC is discussed. A simple FODO-structure for the single cell LINAC part has been optimized. Tolerances are discussed. Optical, electrical and magnetic date of a fast Kicker system is given.

## Ionoptical layout of the HELA

From the economical point of view a focusing structure using identical quadrupoles seems favorable. General properties of such a design are described by H. Lustfeld at this conference.

For calculation of the beam properties the program TRANSPORT[1] has been used.

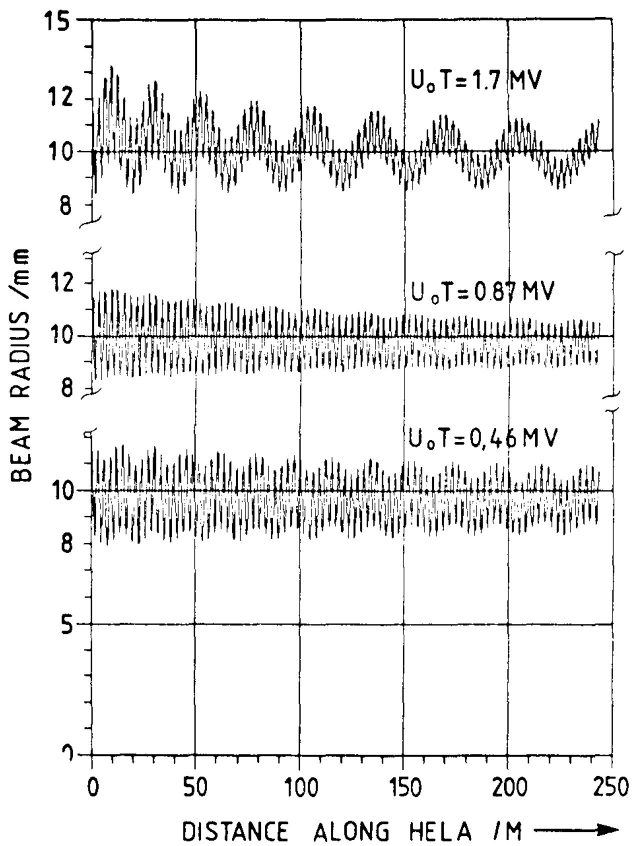


Fig. 1. Radius of the beam envelope for acceleration voltages of $U_0T$ = 0.46, 0.87, and 1.7 MeV, corresponding to final energies of 230, 350 and 590 MeV. The magnetic field gradient is 3.3 T/m and held constant through the HELA. For the upper and lower graphs the transverse ellipses are not matched at the beginning. The unit cell length is 3 m.

In Fig. 2 it is shown that the tune decreases from about 30 degrees at 100 MeV to 17 degrees at 350 MeV.

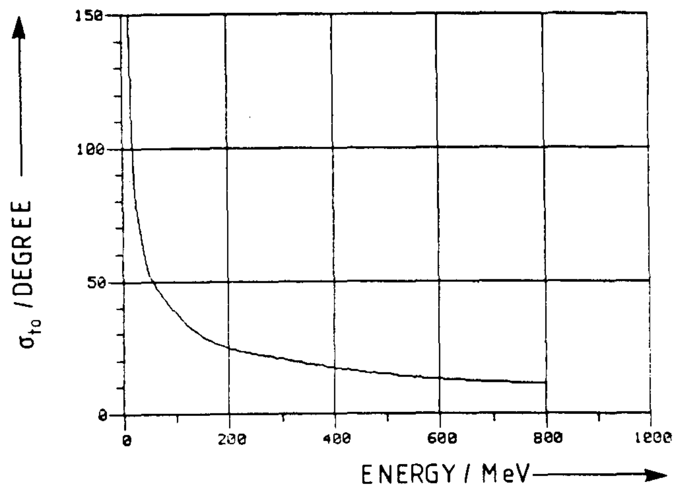


Fig. 2. Energy dependence of the transverse tune $\sigma_{to}$ for a constant magnetic field gradient of 3.3 T/m.

In Fig. 1 the radius of the beam envelope is plotted along the HELA. The corresponding transverse tune shown in Fig. 2 decreases along the HELA because the strengths of the quadrupoles are held constant. The initial transverse ellipses are matched for $E_0T \cdot L_{gap} = U_0T$ = 0.87 MV, corresponding to $E_0T$ = 1.9 MeV/m and $L_{gap}$ is the gap length. The same starting ellipses are used for lower and higher energy gains.

Fig. 1 shows a relatively small mismatch for $U_0T$ = 0.46 MV and for $U_0T$ = 1.7 MV. This demonstrates that
- the matching at the beginning is not very sensitive to the energy gain,
- the beam line with the same constant quadrupole stetting can transport beams of different final energies,
- to demonstrate the transverse space charge effects[2] in fig. 3 the acceptance of the FODO-structure with an aperture radius of 12 mm versus the quadrupole strengths is shown. The acceptance decrease caused by transverse space charge effects is at 100 MeV expected to be about 10 %.

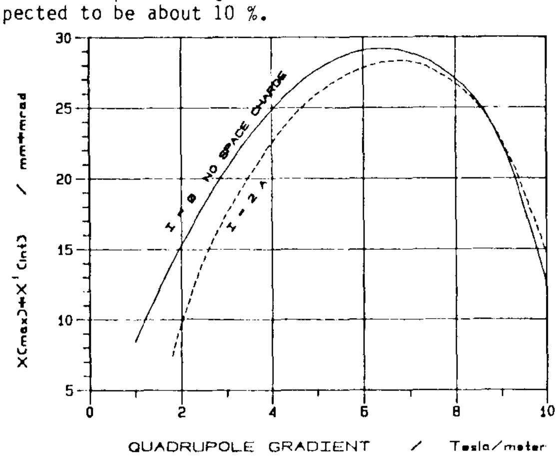


Fig. 3. Acceptance of a FODO-structure vs. Quadrupole strengths. The dotted line takes into acount a 2A current in bunches of .15 m length at a momentum spread of 0.1 %.

The alignment tolerances were estimated using the misalignment options of the TRANSPORT program. In Fig.4 it is shown that a misalignment of +- 0.05 mm, +- 0.1 mrad in transverse position and angle produces an uncertainty of the beam position of 1.5 mm after 360 accelerating cells. Scaling this result with $(N)^{1/2}$, where is the number of the misaligned quadrupole, we expect a beam deviation of about 2 mm at the end of the LINAC in stage II.

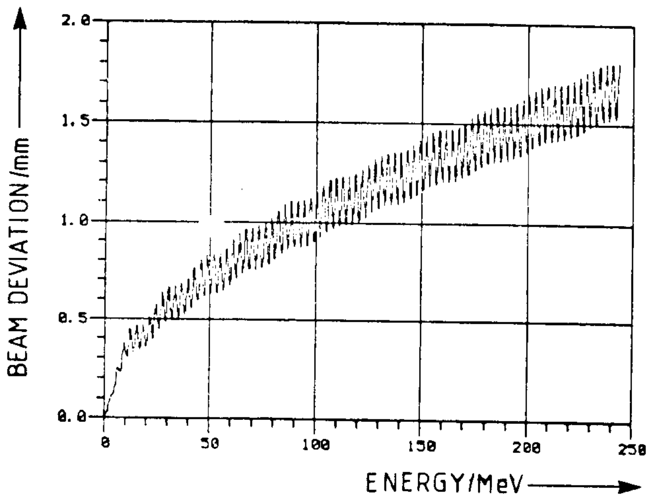


Fig. 4. Effect of statistical misalignment (+- 0.05 mm, +- 0.1 mrad) in the radial direction of the first 160 quadrupoles.

Allowing for a maximum beam deviation of less than 1.5 mm after 320 accelerating cells, the long-time tolerances (delta (t) about 8 hours) given in the table are required. These tolerances are technically feasible.

TABLE 1

LONG-TIME TOLERANCES FOR THE HELA QUADRUPOLES

| | | |
|---|---|---|
| longtudinal position | +- 0.1 | mm |
| transversal position | +- 0.05 | mm |
| angular | +- 0.2 | m |
| magnetic field gradient | +- 0.1 | % |

According to the ionoptical layout, 16 cm long quadrupoles (effective length 20 cm) with 6 T/m gradient and an aperture of 8 cm are needed. Different designs are under study to meet the restricted space requirement in the single cell section. For economic reasons all quadrupoles are identical. Only a few high current low voltage power supplies are needed to supply the magnets. Correction is done by separate magnetic elements. Fig. 5 shows a drawing of a quadrupole with outer dimensions of 40 x 30 cm and an aperture of 8 cm. This magnet uses a minimum of 25 cm in beam direction for iron, coils, supply connections and mounting. Table 2 gives the parameters of the magnet. Table 3 gives the field coefficients of this design. Due to the radiation exposure, organic materials may not meet the reliability requirements, so a design of a coil without insulation (insulation by distance) is also under study (see fig. 5).

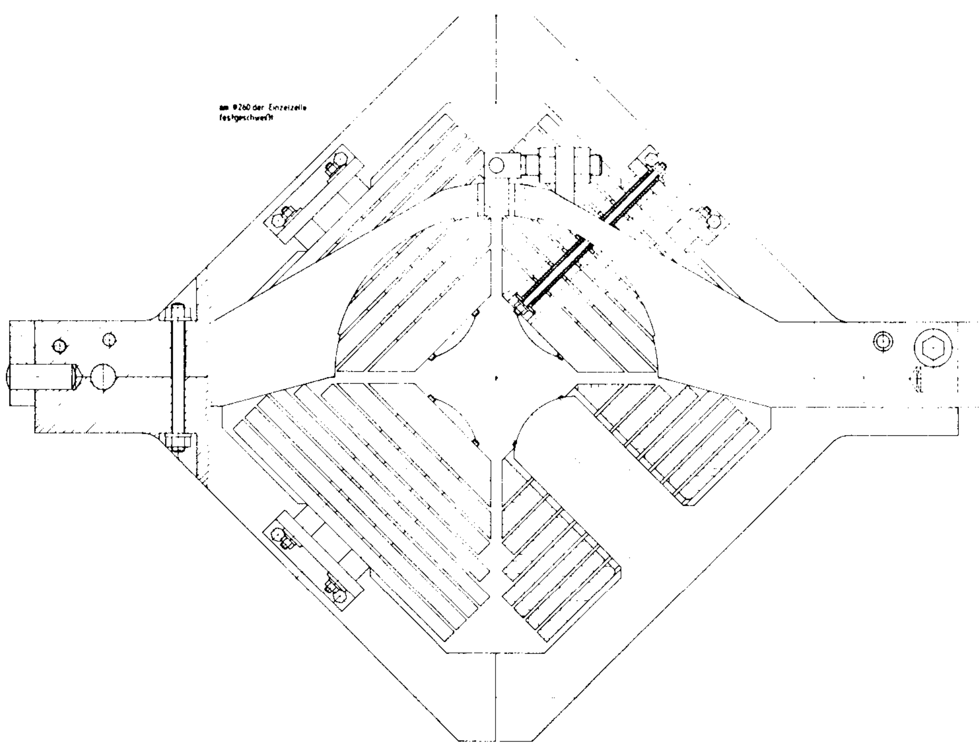

Fig. 5. Drawing of HELA-quadrupol.

TABLE 2

PARAMETERS FOR HELA QUADRUPOLES

| | | |
|---|---|---|
| Effective length | 20.0 | cm |
| Pole aperture | 8 | cm |
| Max. flux at pole tip | 0.26 | T |
| Max. flux inside yoke | 0.8 | T |
| Max. field gradient | 6 | T/m |
| Outer dimension | 40 x 30 | cm |
| Overal iron length | 16 | cm |
| Total mass | app. 220 | kg |
| Ampere turns per pole | 3800 | Ampere turns |
| Power consumption/Quad. | app. 220 | W |

TABLE 3

RELATIVE MULTIPOLE COMPONENTS OF HELA QUADRUPOLES (3) (NORMALIZATION RADIUS R = 1.0 CM). THE HARMONIC FIELD COMPONENTS ARE NORMALIZED TO THE QUADRUPOLE COMPONENT. A MATERIAL INHOMOGENEITY OF 10 % IS ASSUMED.

| field component | relative potential |
|---|---|
| quadrupole | 1.0 |
| sextupole | 7.025 E-05 |
| octupole | 2.49 E-05 |
| decapole | 5.842 E-06 |
| dodecapole | 1.84 E-05 |

Kicker magnet

For several experimental areas (e.g. medical application, high energy physics) which share the LINAC beam, only a short (variable) fraction of one pulse is required. Kicker magnets are needed to switch this beam fraction to the experiments in order to keep the intensity at the spallation target as high as possible.

Rise times including control time are of the order of 90nsec. A structure of 12 magnets is planned, consisting of 10 kickers and 2 antikickers to correct malfunction of the switch circuit. With an expected field of .01 to .03 Tesla a total kick of 18 mrad can be achieved. This needs a power supply of about 100 KV with 75-100 A/nsec switched by thyratrons.

A prototype magnet will be built in order to make frequency and time analysis measurements. These measurements will act as a check on the transient response analysis models of the magnet which are investigated using the SPICE computer code (4). The measurements on the prototype magnet can be made without the added complications of high vacuum systems.

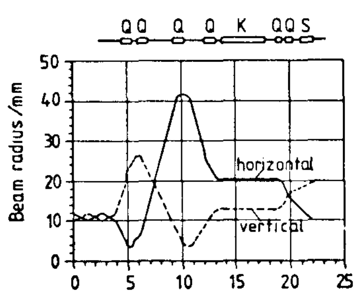


Fig. 6. Beam envelope of kicker section in horizontal (___) and vertical (...) plane (Q - Quadrupole, K - Kicker magnet, S - Septum).

Electrical and mechanical data are given in table 4.

TABLE 4

KICKER SEGMENT DATA

| | | |
|---|---|---|
| gap height | | 8 cm |
| gap width | | 11 cm |
| rise time of segment | | 24 ns |
| fillup time 1 % - 99 % | about | 88 ns |
| segment length | | 35 cm |
| number of segments | | 10 |
| magnetic field strength | | 30 mT |
| kick at 1100 MeV | | 18 mrad |
| average power per kick | | 19 kW |
| loading voltage | | 96 KV |

References

1. K.L. Brown, D.C. Carey, Ch. Iselin, and F. Rothacker, TRANSPORT, CERN 80-04 (1980)

2. F. Sacherer, CERN /SI-BR/72-5

3. K. Halbach, Nucl. Instr. Meth. 74, (1969)

4. SPICE Vers.2G USERS GUIDE 1981, Univ. Berkeley