Meeting on ELENA Transfer Lines

24-July-2012, 865-1-D17, 10:30 - 12:15

Present: G. Vanbavinckhove, F. Butin, J. Baillie, D. Nisbet, D. Barna, R. Kersevan, W. Bartmann

Agenda:

- TL optics and geometry (G. Vanbavinckhove)
- Bending element feasibility (D. Barna)
- Input for vacuum calculation (All)
- Input for power converter dimensioning (All)
- Effects from electrostatic elements on optics and vice versa (All)

Regarding the planning the aim is to install parts of the Gbar TL and the TL to the existing experiments together with the ring. This should allow for AD physics transparent commissioning of the extraction systems but also the matching sections at the beginning of the transfer lines.

- ➔ ring installation from spring 2015 until end 2015
- ➔ ring and extraction commissioning start summer 2016

In the last BPPC it was brought up that the experiments will have periods without beam request. Despite the low intensity, a clean way of beam dumping needs to be considered (Wolfgang).

ELENA transfer line studies (Glenn Vanbavinckhove):

Glenn is showing the TL geometries of the existing experiments' side (excluding a possible experiment next to ASACUSA) which amount to a total length of about 62 m. The same bending angles are assumed for the lines directing to ASACUSA, ATRAP and AEGIS. For the possible experiment next to ASACUSA space for another fast switch has to be considered.

Critical points are the final 90 deg bends at ALPHA and ATRAP, the bend and focal position of ASACUSA1 and the additional experiment.

A layout of the focussing and bending elements from extraction until the first FODO cell and from extraction to ATRAP is shown. The drift length in the FODO cell is about 1.4 m. In total ~66 quadrupoles are needed, of which 30 are in the regular FODO cells with voltages of 1.7 kV. 18 quadrupoles are needed for the matching sections with a voltage range from 0.4 to 5 kV and 6 triplet assemblies with voltages from 0.8 to 7 kV.

The bending angles are distributed over several dipoles of 40 cm length which leads to a required voltage range of 9 to 20 kV. The total number of dipoles is ~30.

About 60 orbit correctors of 10 cm length are assumed.

Conclusion:
The basic geometry is defined and the critical points, in particular at the 90 deg bendings for ALPHA and ATRAP are identified. The ALPHA line geometry can be finalised after magnetic measurements and error studies. A dense population of elements in the matching sections and at the triplet regions is expected. A preliminary count of electrostatic devices is given.

Discussion:

Moving the focal point of ALPHA due to the large bending radius seems very difficult. The large bending radius shall alleviate the requirements on the voltage but also allow for an achromatic design of the bends to reduce the created dispersion and thus the beam size. The dispersion is more critical at the beginning of the lines; close to the experiments we can probably afford a small bending radius with a strong focussing triplet downstream.

The same geometric concerns due to large bending radii apply to ATRAP, the transfer line is at 1.2 m, the remaining vertical space for bending and focussing is tight; a compact 90 deg bend design for the focal points of ATRAP and ALPHA is needed (Glenn, Daniel, Wolfgang).

ALPHA might not need a 90 deg bend, depending on which line geometry is chosen. Magnetic measurements in the AD hall are supposed to take place this week and should give input for error studies to decide on the final geometry.

According the bend PC limits, for higher voltages the cost for cables and connectors increase but the suggested range is fairly modest. Beyond 30 kV one needs to check which cables can be used. The same limits apply to quadrupole PCs as long as they are DC; ISOLDE uses up to 6 kV.

According the switching time of power converters: switching times of 1 us change significantly the PC design; this has to be requested soon (Wolfgang).

It is suggested to study if combined horizontal/vertical steerers can be used.

The PCs might be separated in 3 families of maximum voltages of 2, 7 and 20 kV, always with a margin of 10%, taking care of the sensitivity.

Further inputs for the PC design are the capacitances of the electrodes (Daniel).

Electrostatic deflector simulation studies (Daniel Barna):

Daniel is explaining the dynamics of cylindrical and spherical deflectors. Acceleration/deceleration in the fringe fields causes focussing in the bending plane for the cylindrical, and focussing in both planes with coinciding focal points for the spherical shape. There is coupling of transverse and longitudinal motions.

For electrode distances between 4 and 8 cm and bending radii from 0.2 to 1.5 m the required voltages amount from 5 to 80 kV (potential difference).
Due to availability on the market bending radii of less than ~~1 m~~ (*corrected after the meeting to 0.5 m*) for a pipe diameter of 200 mm are preferable.

The following Ansoft MAXWELL simulations are done for a selected deflector of bending radius 1 m, aperture 6 cm and cylindrical electrodes. The full 3D field map from this simulation is interpolated in C++ between the grid points and scaled to the desired voltage. Particles are tracked (4^{th} order Runge-Kutta) and from fitting the output and input for x, x' etc. the transfer matrix elements are obtained.

The assumed electrode height is 120 mm (twice the aperture) which gives sensible fields at the centre of deflection. The field homogeneity was checked for the height/aperture ratio of 2. There is a 1.5 % change in the transverse fields Ex,y [kV/cm], the vertical field showing a dependency on the voltage distribution.

To crosscheck the tracking and algorithm a hard edge field was simulated and the simulated particles follow the theoretical trajectory.

X-X' isolines between inner and outer voltage on the electrodes are calculated; for the isoline X,X'=0 (particles entering on the centre of the deflector also leave on the centre) three trajectories with different voltage combinations have been plotted. While the trajectories remain the same, the kinetic energy of the particles inside the field is varying which leads to different focussing properties depending on the distribution of voltage between inner and outer electrode:

- -5/+4.98 kV: Focussing only in bending plane with focal length of 4 m
- -8/+2.2 kV: Modest focussing in both planes with focal lengths of 4 and 2.5 m in the horizontal and vertical plane, respectively
- -2/+7.7 kV: Strong focussing in the horizontal plane (1.3 m) and modest focussing in the vertical plane (2.5 m)
- -6/+4 kV: Very little focussing of about 10 m in both planes

First ideas how to mount such a bend in the chamber with the spring loaded feedthroughs and Macor supports is shown. This assembly allows for simple and cheap manufacturing. The field shaping is suggested to be reached rather by shaping the electrodes than adding extra electrodes.
According magnetic shielding, for small angle bends (10 deg) straight boxes are suggested which facilitate permanently installed heating jackets inside.

Conclusion:
Field simulations have been performed for a deflector of 1m radius, 6 cm aperture and voltages below 6 kV. The inner and outer electrode voltages shall be separately adjustable.

The focussing properties of the device can be shaped by tuning the voltage distribution. For small bending angles (10 deg) simple and cheap manufacturing is possible.

Discussion:

The vacuum chamber is taken into account in the field simulation.

The bending angles needed along the lines have to be checked (Glenn, Daniel, Wolfgang).

According the effect of machining inaccuracies of the electrodes on the field, the effect is expected to be small for short length electrode, to be checked for long devices (Daniel).

The focussing effect of the bends needs to be included in the optics model and investigated if it is beneficial to have focussing in one or both planes (Glenn).

Additional electrodes for field shaping would considerably complicate the assembly and are not preferable.

It is suggested to study if holes in the mu metal shielding allow for a better heat transport.

Priority on the source lines is recommended.

General discussion on TL vacuum:

Since vacuum windows have to be avoided, the vacuum level of the lines will be close to the machine vacuum level of 1e-12 mbar instead of 1e-9 mbar as originally assumed. Differential pumping at the source and close to the experiments will be necessary.

To reach this level, a bakeable system with NEG coating is envisaged. The coating process shall be considered in the assembly strategy of the electrostatic devices. In-house coating is preferable; 200 mm pipe diameter coating is feasible.

Permanent heating jackets are advantageous to cover better any irregularities of the chamber, insulate more efficiently and avoid air convection.

There is a negligible cost impact whether the full line is baked and coated or only parts of it.

For fast valves a reduced diameter (100 mm) can be assumed.

The layout of the lines with element positions, length and apertures will be sent to Roberto (Glenn).

AOB:

The presentations and minutes of these meetings are saved on EDMS.

An INDICO entry for file upload and minutes will be setup.

Next meeting: 2nd half of August, to be announced.