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Interface
LINAC
ID 51 – Electromagnetic fields

DRAFT

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1. ELECTROMAGNETIC FIELDS

Both acceleration and steering of the ion beam is done with electromagnetic fields and the accelerator contains several sources of such fields. This is, however, entirely a working environment issue, no fields are strong enough to be a concern outside their surrounding buildings. Magnetic fields decrease very rapidly with distance from the source. Possible sources are the RF system: klystrons, waveguides, cavities, the ion beam itself, and magnets. Conceivable frequencies of the fields would be the RF resonance frequencies, 352 MHz and 704 MHZ, the pulse frequency of 14 Hz and static fields from magnets.

1.1 RF systems

The electromagnetic fields that are used for acceleration of the ion beam are created in the klystrons, transported via the waveguides to be deposited in the cavities. The fields are very well contained in these structures which are made of highly conducting metals (copper and superconducting niobium). In principle no magnetic fields are expected to be detectable outside the equipment. If there should be a leak anywhere, the fields would drop below detectable levels within half a metre from the point of the leak [1].

Both klystrons and cavities will be sources of x-rays, which are a matter for radiation protection. Klystrons are shielded in a layer of lead, and cavities are located in the accelerator tunnel. The accelerator is heavily shielded against beam loss compared to which the RF-induced x-rays are negligible.

1.2 Ion beam

The ion beam is a current moving in a straight line in the linear accelerator and gives rise to a magnetic field

$$B = \frac{\mu_0 I}{2\pi r}$$

at a distance r from the beam of current I. Considering a current of I = 50 mA, the induced field is B = 10 nT at one meter's distance. This is well below the limits set by SSM. The ion beam travels in a vacuum tube of conducting material, which effectively shields the outside world from the fields created by the current, so that there will be no detectable magnetic fields generated by the ion beam in locations where people might be present.

1.3 Magnets

There are several strong electromagnets positioned along the accelerator, but they are not expected to induce problems outside the accelerator building. They use direct current and static magnetic fields, which are not considered a problem. Even though some of the magnets are strong, they are designed to concentrate their fields in the gaps and reduce their fringe fields. Magnetic fields decrease rapidly with distance, and outside the shielding walls not much remains. Figure 1 shows the simulated magnetic field from a typical dipole magnet with a partially saturated iron core at 1.5 T [2]. From the simulation a relation for the magnetic field strength can be estimated as $B(x) = 0.0001/x^2$ T and it can be concluded that the magnetic field outside the shielding berm (roughly 20m) is in the order of 0.2 μT. This is a low field strength, even in comparison to the earth's magnetic field of about 50 μT.

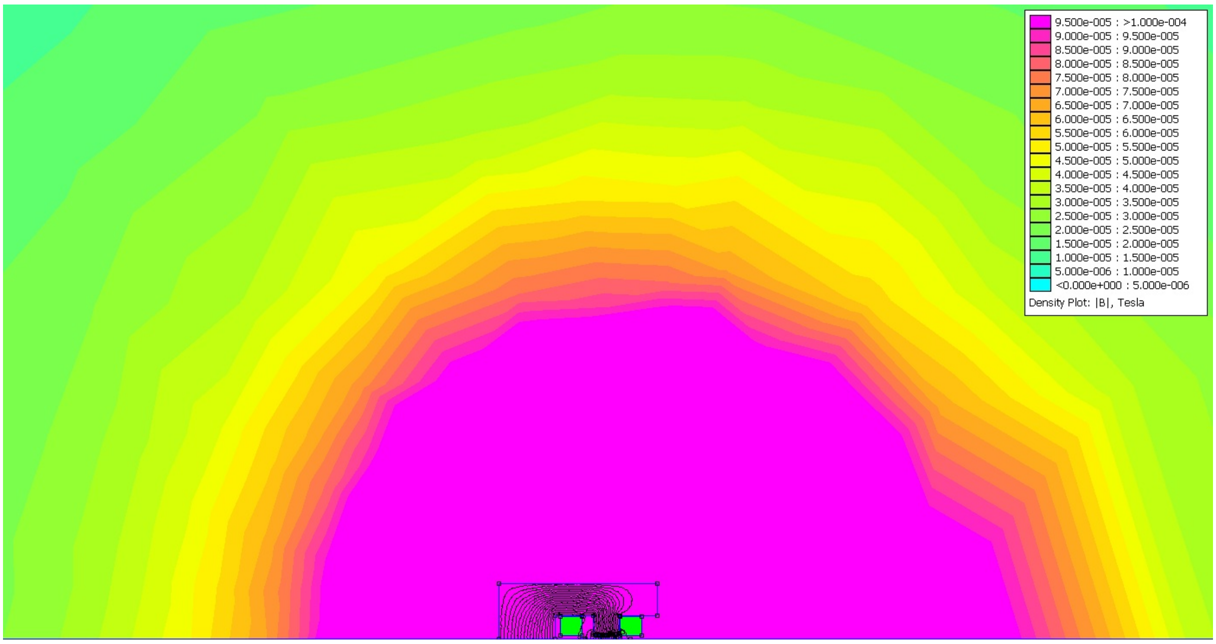

Figure 1: simulated magnetic field around dipole

2. CONCLUSIONS

There are many magnets and electromagnetic devices in use for the accelerator operation, but there is no need for concern about magnetic fields outside the accelerator tunnel or klystron gallery. These areas will be buildings with limited access and warnings about magnetic fields (among others) posted clearly.

3. REFERENCES

[1] A. Stenvall, A. Edvardsson, J. Ståhl Kornerup, *Mätningar av elektriska och magnetiska fält MAX-lab,* 2010

[2] M. Johansson, *Private communications,* e-mail correspondence, 2010