STUDY FOR A SUPERCONDUCTING MULTI-GEV PROTON LINAC

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A study group has been established which will investigate the problems connected with a high energy superconducting linac. This type of accelerator has been selected for various reasons, the three most important of which are:

1. The experience with synchrocyclotrons has shown that for many experiments high currents are useful only if combined with a high duty cycle.

2. The technology of a superconducting accelerator is interesting in itself.

3. If a proton accelerator is built in Germany, it should be of an advanced type and it should permit the production of strange particles.

The advantages offered by a superconducting linac seem to be so attractive that we think it worthwhile to make an effort to overcome the great difficulties and to take into account the unavoidable delay in the construction.

The study group will investigate the physical and technological problems of superconducting cavities at 1200 Mc. In addition, various accelerating structures will be studied at room temperature and 400 Mc.

Since experimental data for the production cross sections of secondary particle beams are very scarce between 1 and 10 GeV, calculations based on the statistical model are being performed in order to provide a basis for the final choice of the energy of the accelerator. It is hoped that a definite proposal can be worked out within 1 or 2 years.

In order to give an impression of the implications of such a project, a few very tentative figures may be quoted. A major advantage of a superconducting linac lies in the fact that, because of the small rf losses and the good vacuum high gradients can be used, resulting in a large energy gain/m. Values of about 5 MeV/m seem possible. For a disc-loaded structure this implies maximum magnetic fields of about 200 gauss compared to the critical field of 500 gauss for Pb and 1400 gauss for Nb.

Adopting an energy of 3 GeV, the accelerator length would then be only about 600 m. For a frequency of 400 Mc, and scaling the improvement factors q obtained at Stanford for Pb at 2800 Mc to this frequency, one expects q $\simeq$ 40,000 or perhaps even more if other superconductors are used. With an average shunt impedance of 20 M Ω/m (which seems conservative, considering the new structures discussed at this conference), one calculates a power loss for lead of P = 40 kW which has to be cooled away at liquid He-temperature.

The refrigeration system able to achieve this will require an input power of about 20 MW and is estimated to cost approximately 6 M$. Since the saving on the rf system is much higher, it is to be expected that a superconducting linac will not be more expensive than an ordinary linac with the same energy but a much lower duty cycle.

NAGLE: What current do you expect to get?

SCHOPPER: The current will be limited mainly by the shielding and the power the target can stand. Most of the rf power will go into the beam, of course. Assuming a current of 100 μA, the beam power would be 300 kW compared to the power loss of 40 kW.

MARTIN, J. H.: Do these figures push you uncomfortably high in rf magnetic field strengths?

SCHOPPER: No, it depends on the structure of course. If we assume the ordinary iris-loaded structure, then the maximum field that you get is 260 G compared to the critical field for lead of 500 G, and 1400 G for Miobium. I forgot to mention that in calculating the power, I assumed an average shunt impedance of 20 MΩ/m, which I think is on the safe side.

WORSHAM: Have you looked at the problem of how you would build the cryostat?

SCHOPPER: We haven't made any detailed studies. This will be one of the tasks of the study group.

DICKSON: Have you done any rf measurements yet on superconducting surfaces?

SCHOPPER: Not yet, but we hope to start in about two months.

GUILBAUD: The rf magnetic field you mentioned is related to the 40 kW energy loss?

SCHOPPER: Yes, the field is proportional to the energy gain per meter which in turn is related to the energy loss.