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PLANS FOR A SUPERCONDUCTING C.W. ELECTRON LINAC AT THE UNIVERSITY OF ILLINOIS

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In Illinois we have a tradition in physics with electron accelerators which began with Kerst's invention of the betatron in 1940. At the present time two betatrons are still operating, the original 180 c/sec 22 MeV betatron completed in 1941 and the 340 MeV pulsed betatron completed in 1950. The first is operated so as to produce an external electron beam of 3 x 10^{-9} amperes with a resolution up to 3 keV and a duty factor up to 4%. At the present the electrons are used in a coincidence arrangement for selecting photons of known energies for the study of two reactions, (1) the elastic scattering of photons and (2) the time of flight spectrum of fast photoneutrons associated with the absorption of a photon of known energy. The time to collect significant data in such experiments with our present duty factor is about a month and does not allow one to vary the experimental conditions or to make checks on the results. This work serves to emphasize the fact that for some experiments a duty factor of 100 percent is worth 10 times as much as one of 10 percent. The currents required are not large. 1 to 10 microamperes are sufficient for most experiments being considered.

The program with the 340 MeV betatron emphasizes photon interactions with simple nuclei rather than those with nucleons. Since these allow a number of possible reactions, coincidence arrangements which help define the reactions being observed are often necessary. At the present time experiments are in progress on the coherent production of π^0 mesons from He^3 and He^4. The duty factor of 0.2 percent is the principal limitation. In this energy range also a current of 10 microamperes would be sufficient.

Choice of Accelerator

In examining possible proposals for replacing our present accelerators, we can consider the AGS synchrotron and the FFAG betatron, but these cannot reach a full 100% duty factor. The machines which can effectively reach unit duty factor and which are most attractive to us are the C.W. linac and the microtron using superconducting cavities such as are under development at Stanford. We would require only small currents but want the ultimate in energy resolution, hopefully 0.1 percent or better.

A program which is being considered by our group is to build an L band section, 15 feet long, which might be operated at 30 MeV. Such a section could serve as an electron source for the photon monochromator. Our goal, however, is a C.W. accelerator of 400 MeV which might be achieved by a straight linac or by a microtron. If the development of reliable superconducting sections proceeds slowly, we could start by building a microtron using a conventional linac with as high a duty factor as is practical. The conventional section could then be replaced by a superconducting section if and when a reliable section is developed. A summary of the characteristics of these accelerators is given in Table I. The numbers are based on those given by Wilson and Schwettman last year except that the higher shunt impedance of the Los Alamos cavities are used.

TABLE I

	Superconducting Section	Room Temp. Section for Microtron
Energy gain	30 MeV	30 MeV
Length	15 feet	15 feet
Frequency	1300 MHz	1300 MHz
Shunt Impedance (Cu, 300°K) (Pb, 1.8°K)	$1.7 \times 10^{13}\,\Omega/m$	$6.3 \times 10^{7}\,\Omega/m$
Wall power	12 watts	3.2 Mw
Duty factor	1.00	1.00
Power input	27 kw	10 Mw

Work in Progress

Since we believe that the use of superconducting cavities has been shown to be useful we think it may be worthwhile to operate a short section of waveguide in order to gain some experience with the problems involved. So far we have constructed and assembled a nitrogen shielded cryostat about 4 feet long, into which can be mounted an L band section 3 wavelengths long, surrounded by liquid helium at temperatures down to 1.8°K, as shown in Figure 1. This cryostat is placed near a Collins machine and can be connected directly to the liquifier so as to make a closed cycle refrigerating unit

A one-wavelength section has been electroplated with lead and has been held at liquid nitrogen temperature for some time, but difficulties with the liquifier have so far prevented us from operating at helium temperatures. We hope that we can make sustained tests on the one-wave-length section and extend them to other sections soon. The accelerator sections constructed so far are based on the M.I.T. design. The effective shunt impedance of this system, however, is only around 10 megohms per meter and is considerably lower than can be obtained from cavities having the shapes calculated at Los Alamos. We are in the process of assembling and plating a single half-wave cavity of this shape and hope to use such shapes in future designs. The coupling of many cavities into a single unit seems desirable but the production of such cavity assemblies with acceptable lead coatings seems formidable and as yet has not been attempted.

Developments in the production of surfaces may strongly affect the design of coupled structures. It isn't clear that the more complicated shapes can be electroplated. There are, however, a number of processes for coating surfaces with lead which may be better adapted to complex shapes. We plan to try the method of electrodeless plating from a solution which was recently reported by Slay and Carbajal of Texas Instruments.

We are building a special cooling arrangement based on heat transfer through a grease film. If tests are satisfactory this could simplify the assembly and maintenance of the cavity system.

Because of the high Q of the cavities we will have to provide for automatic tuning and amplitude control of each section. The tests planned on the Los Alamos-shaped cavity include a test of ideas for pneumatic tuning by using phase signals to control the pressure of helium in a closed section of the cavity wall.

We are uncertain about beam stability due to the excitation of transverse fields in cavities of very high Q but we hope that present studies with ordinary linacs might point to a solution which would allow the modest currents we plan to use.

Calculations for particular microtron arrangements are in progress. These support previous studies which have made such arrangements appear to be feasible.

In conclusion, our brief examination of the problems associated with the development of a low current superconducting accelerator indicates that the largest uncertainty involved is that of obtaining and maintaining good lead surfaces. By building and operating small test sections at Illinois, we hope to learn how to cope with some of the practical problems involved.

DISCUSSION

A. O. HANSON, Illinois

SMITH, Stanford: Are all your measurements at 1300 Mc that is, your one-cavity structure there?

HANSON: That is also at 1300 Mc. On the other hand, as I was going to say, we did make some plating tests at 3 cm using the standard solutions. We didn't match your best results by about a factor of 4 if we extrapolate to your frequencies. I think Dr. Hietschold will say more about this problem. We're attempting to learn from him how to improve our plating techniques. As I said earlier, I don't think our measurements on the superconducting films are good, but we are set up to measure these by the simple decay methods. Our refrigerator hasn't operated yet, so we don't have any measurements at 1300 Mc.

COCHRAN, LASL: In the superconducting linac system has any attention been given to the problem of radiation damage at low temperatures?

HANSON: I don't think I am the one to answer that question. I don't know if anyone here has any knowledge about that. We certainly worry about this point, and I guess that's one of the reasons we would like to operate this cavity for a certain length of time. Probably the Stanford people could answer in part.

FAIRBANK, Stanford: We haven't been able to find out any reason why we should get radiation damage. The real answer has to come experimentally.

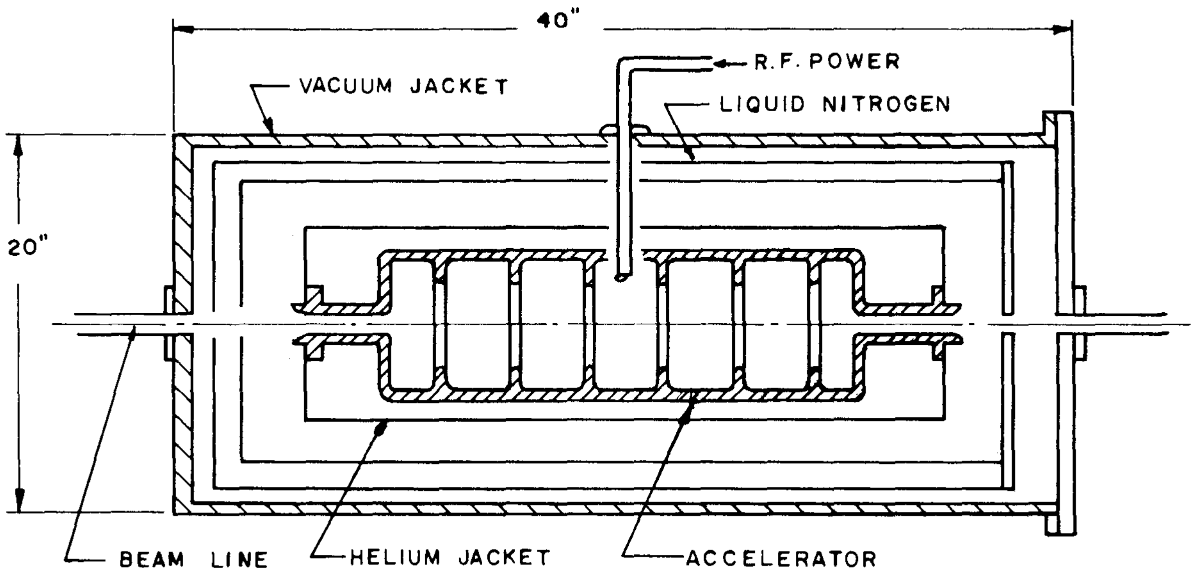

Fig. 1. Superconducting Linear Accelerator.