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OVERVIEW OF CW ELECTRON ACCELERATOR PROPOSALS

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Electron beams in the MeV to GeV energy range have been used for nuclear studies for the last thirty years. The advances in our fundamental understanding of nuclear properties made using this probe are impressive. They range from the first determinations of nuclear sizes and shapes to the discovery of the quark constituents of nuclear matter. The precision of measurements made using electrons is sufficiently high that they also are now used as starting points for the analysis of data obtained using strongly interacting probes such as pions and protons. In this way, electro nuclear physics is having a great effect on all branches of the discipline.

Virtually all measurements made to date have been of the inclusive variety. That is, only a single reaction product is detected and the physics of the reaction must be inferred from this one observation. Often several types of reaction involving different distributions of reaction products can lead to the observation of one particular particle with a particular momentum. In order to accurately differentiate between such competing processes it is necessary to detect two or more reaction products in coincidence. Undesirable background in these measurements results when two or more reaction products from different reaction events are observed within the resolving time of the detectors. The probability of such events can be minimized by making the period of time during which events can occur as large as possible relative to the resolving time of the detectors. Experimentally, this means making the duty factor of the beam as high as possible.

This argument for high duty factor is not new. The need for high duty factor electron beams has long been recognized. In the late 1960's a Stanford University proposal for the construction of a high duty factor electron superconducting accelerator (SCA) was approved. The SCA achieved an electron energy of about 250 MeV and a duty factor in excess of 90%. Unfortunately, operation of this machine for nuclear physics research was recently terminated.

Several other laboratories have also pursued high duty factor electron accelerators. For instance, the Universities of Mainz and Illinois both have operating high duty factor machines. Descriptions of these facilities and their plans for future upgrades will be discussed in subsequent presentations.

The widespread interest in high duty factor electron accelerators is indicated in Fig. 1. Shown on this map of the world are the locations of laboratories or institutes in the process of a) increasing the duty factor of an existing accelerator, b) proposing to do so, or c) proposing to construct a high duty factor electron accelerator. The universality of the interest is clear. The only existing electron accelerator laboratory that I know of for which no plans are being made to obtain high duty factor is the Lawrence Livermore Laboratory. The plans for their accelerator involve shortening the pulse lengths (lowering the duty factor) to increase the resolution of neutron time-of-flight measurements!

The range of electron energies contemplated for these high duty factor accelerators range from a few tens of MeV to a few GeV. Existing high duty factor accelerators have energies in the tens of MeV range (Illinois - 60 MeV) to the few hundred MeV range (Mainz - 190 MeV). The energies of the proposed machines range from the 100 MeV Lund machine to 4^+ GeV designs of the Argonne National Laboratory (ANL), the Massachusetts Institute of Technology (MIT), and the Southeastern Universities Research Association (SURA).

Existing and proposed high duty factor electron accelerators can be grouped into three categories. First, there are those involving a pulsed accelerator plus a pulse stretcher ring. In these machines short (on the order of 1 μsec), high current pulses are injected into pseudo-storage rings at repetition rates of 100 to 1000 Hz. During the interval between injections the stored electrons are extracted from the ring in an almost continuous stream. Clearly, the addition of such a ring to an existing pulsed accelerator is a straightforward avenue of upgrade.

The second category contains machines based on the microtron concept. The basic microtron consists of a short CW linac located between two 180° dipole magnets. The beam is passed through the linac several times each time returning to the head of the linac by a trajectory of steadily increasing diameter. When the desired energy is attained the beam trajectory falls outside a septum and the beam is extracted. As the energy of such devices is increased, the sizes and costs of the magnets grow dramatically. Increasingly clever variations of this basic concept have been devised to control the costs of such machines. The proposal to be presented here by the ANL group is such a variation.

The third category (recirculated linac) could be considered as another variation of the microtron. It consists of machines wherein the beam is recirculated several times through a longer CW linac than is used in the microtron. That is, in the microtron the electrons pass many times through a short linac whereas in a recirculated linac the electrons pass fewer times through a longer linac. The Stanford University High Energy Physics Laboratory (HEPL) super conducting accelerator was such a device.

The current proposals can be divided into two groups, those involving the upgrade of an existing pulsed accelerator and those involving the construction of a new accelerator. The group of laboratories proposing upgrades includes the Universities of Saskatchewan (SAL), Bonn, and Lund, as well as MIT, NIKHEF (Amsterdam), Saclay, and Kharkov. In each case the upgrade would proceed (or is proceeding) by the addition of a pulse stretcher ring. The details of the proposed pulse stretcher rings differ widely, the design of each being strongly influenced by local considerations such as available space.

The proposals for new machines can be further subdivided into two categories, those involving linac pulse stretcher combinations and those involving microtrons. The only operational linac pulse stretcher system is the 150 MeV pulse stretcher attached to the Tohoku University 300 MeV linac. This device was built as a prototype for a subsequent 1.5 GeV accelerator. Other groups contemplating new linac pulse stretcher combinations include those at Frascati and SURA.

Proponents of the microtron concept are planning

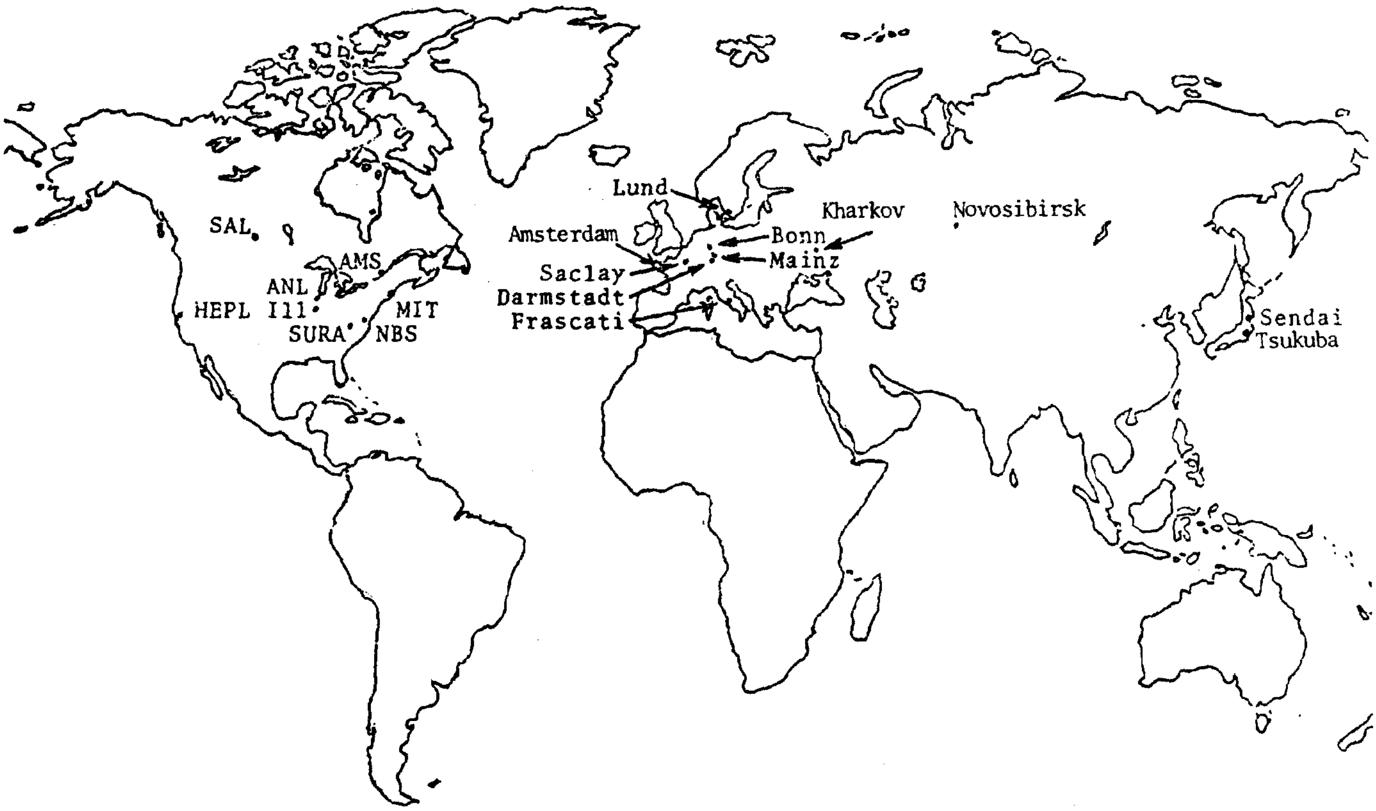

Fig. 1. Institutions constructing or planning to construct high duty factor electron accelerators for nuclear physics.

The interest in high duty factor electron beams for nuclear physics that has been steadily building throughout the world is culminating in the construction and proposed construction of several machines. While several distinct technological approaches will be described this afternoon, there is unity in the interest in the physics which will be made accessible by these machines. Uncertainties inherent in the interpretation of many previously observed processes will be resolved and a much clearer picture of the elementary phenomena obtained.

a variety of machine designs. The Illinois and Mainz designs involve sequences of three basic microtrons of increasing energy to obtain a final electron energy approaching 1 GeV. The Montreal (AMS) proposal also involves a basic microtron. The ANL design consists of a basic microtron injecting into a three linac, six faceted machine, aptly named the hexatron. All of these proposed machines incorporate normal conducting rf systems. The Darmstadt recirculated Linac is unique in that it employs superconducting rf technology.

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