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DESIGN OBJECTIVES FOR A GeV C.W. ELECTRON ACCELERATOR*

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Design objectives are proposed for a continuous beam 2 GeV electron accelerator. Various accelerator concepts are examined in light of these requirements. A double-sided microtron shows promise for yielding major savings in capital cost and excellent beam characteristics.

A strong concensus has developed recently among the nuclear physics community that research with electromagnetic probes in the 1-2 GeV range generated by a high current 100% duty factor electron accelerator represents an exciting frontier. In order to assess possible accelerator concepts for an accelerator facility we have reviewed recent discussions of future needs. The design objectives listed in Table I result from the consideration of perspective experiments which place the most stringent requirements on the pertinent beam properties. They are design goals which should serve as standards against which to measure the various alternatives. After examining the various possibilities we have developed detailed conceptual designs for a 2 GeV linac-stretcher ring accelerator and a double-sided microtron. The linac-ring system consists of a 2 GeV SLAC type linac which injects into a storage ring consisting of a lattice of computer-controlled-separated functions. The storage ring includes an r.f. cavity system whose purpose is to compensate for synchrotron radiation losses, control the beam orbit and the rate of extraction from the ring. Single turn injection into the ring is used, and extraction is accomplished by inducing a third-integer resonance in the horizontal phase space which permits extraction at suitably located septum magnets. The features of the ANL microtron design are shown in Table II and figure 1.

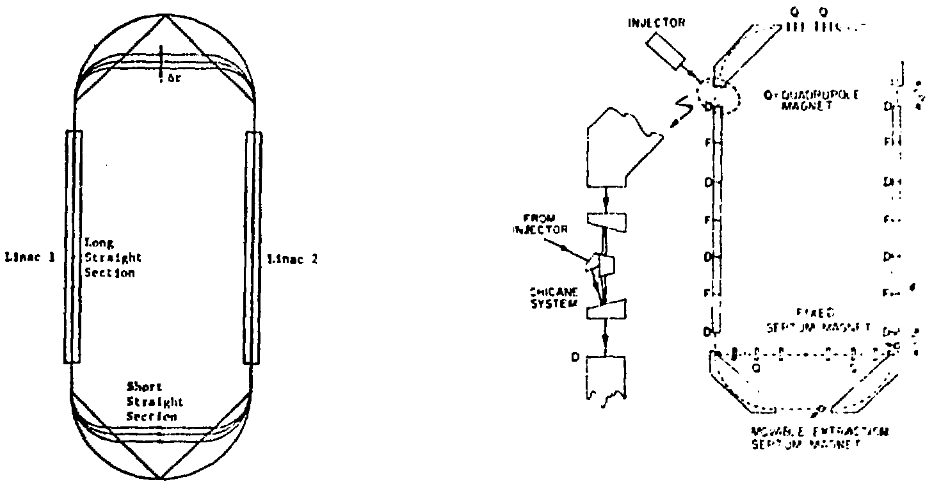
Table I. Accelerator system design objectives

E_{max}	$\geq$2 GeV
Variability	in steps of ∿100 MeV from ∿500 MeV
I_{av} (per beam)	$\geq$100 μA
Number of beams	>1
Duty factor	70 - 100%
ΔE	$\leq$ ±200 keV
Emittance	0.2 π mmmr
E reproducibility	∿100 keV
E stability	∿300 keV
I_{av} stability	1 - 5%

*Work performed under the auspices of the United States Department of Energy.

Table II. ANL Microtron Parameters

Maximum energy	2 Gev
Injection energy	5 MeV
Linac peak voltage	25.3 MV
Synchronous phase	9°
Energy gain per turn	50 MeV
Length of linac	18.75 m
Number of linac	2
Accelerating field	1.4 MV/m
Frequency rf field	2.4 GHz
Bending magnet field	1.523 T
Maximum orbit radius	4.38 m
Orbit separation	0.1095 m
Maximum number of recirculation	40
First turn harmonic number	530
Increase of harmonic number per turn	2
Length of long straight sections	21.72 m
Maximum length of short straight section	11.17 m
Design intensity	300 μA
Energy spread	±100 keV
Beam emittance	0.2 mm-mrad



Schematic Diagram Plan View

Fig. 1. ANL Double-Sided Microtron

Table III. Comparison of Accelerator Designs

Characteristic	Linac-Ring	Microtron
Beam Quality, $\Delta E/E$	$\gtrsim 10^{-3}$	$\gtrsim 10^{-4}$
Emittance	$\gtrsim$0.2mm-mr	$\gtrsim$0.1mm-mr
Capital Cost	$28.6M	$17.4M
Power Req.	5.0 MW	3.6MW
Scaling Law, Capital Cost	$\sim E$	$\sim E^3$

The characteristics of the two approaches are compared in Table III. A major attraction of the linac-stretcher ring system lies in its use of state-of-the-art technology developed in the design of storage ring systems for research in elementary particle physics. It is evident from the conceptual design data that no research and development is needed to prepare a proposal for a system capable of furnishing 100 μA external beams. Such a system can be built with designs taken from existing high-energy physics facilities. With a limited development effort directed at refining the extraction technique this design can be exploited to give stretcher ring currents suitable for multiple beam operation. The stretcher ring has the added appeal of great flexibility for extension to operation at higher beam energies. No change in ring design would be required and a simple linear increase in linac-accelerator structure is all that is required.

However, the linac-ring system does not meet our design objective for beam quality. In this respect the microtron design is a much better option. This may be a very important factor in the design selection because of the implications of beam quality for the design of the high-resolution spectrometers used in electron scattering measurements. At the present time we estimate that the capital cost of experimental facilities will be approximately $20 million. Spectrometer design could be considerably simplified if a high quality electron beam ($\Delta E/E \lesssim 10^{-4}$) is available, with attendant savings in capital costs.

From the discussion presented we have reached the following conclusions:

- A GeV continuous beam accelerator consisting of a SLAC type linac and a conventional stretcher-ring can be built using existing technology.

- The energy spread for the stretcher ring in the extracted beam is expected to be an order of magnitude larger than the design objective.

- The double-sided microtron is a promising option which may meet all the design objectives.

- The savings in capital cost which could be realized by development of a microtron accelerator could be as large as $11M.

- Operating costs for the microtron systems would be substantially less than those expected for a linac-stretcher ring system.