Preliminary Conceptual Design for a 510 MeV Electron/Positron Injector for a UCLA ϕ Factory

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Abstract

UCLA is proposing a compact superconducting high luminosity ($10^{32\text{-}33}$ cm^{-2}sec^{-1}) e^+e^- collider for a ϕ factory [1]. To achieve the required e^+e^- currents, full energy injection from a linac with intermediate storage in a Positron Accumulator Ring (PAR) is used. The elements of the linac are outlined with cost and future flexibility in mind. The preliminary conceptual design starts with a high current gun similar in design to those developed at SLAC and at ANL (for the APS). Four 4-section linac modules follow, each driven by a 60 MW klystron with a 1 µsec macropulse and an average current of 8.6 A. The first 4-section module is used to create positrons in a tungsten target at 186 MeV. The three remaining three modules are used to accelerate the e^+e^- beam to 558 MeV (no load limit) for injection into the PAR.

I. Discussion

Based on experience with linacs at SLAC, each 3-meter contoured S-band 3 GHz section can be expected to produce accelerations of approximately

$$\varepsilon = 12\sqrt{P_{MW}},$$

where ε is the particle energy in MeV and P is the klystron power in MW.

This relationship immediately leads to a cost/benefit tradeoff in the number of sections vs. the klystron power delivered to each section.

The minimum cost for the linac occurred with one 60 MW klystron driving four 3-meter sections with a 1 µsec macropulse; this configuration is shown in figure 1. At 3 GHz, a total cluster

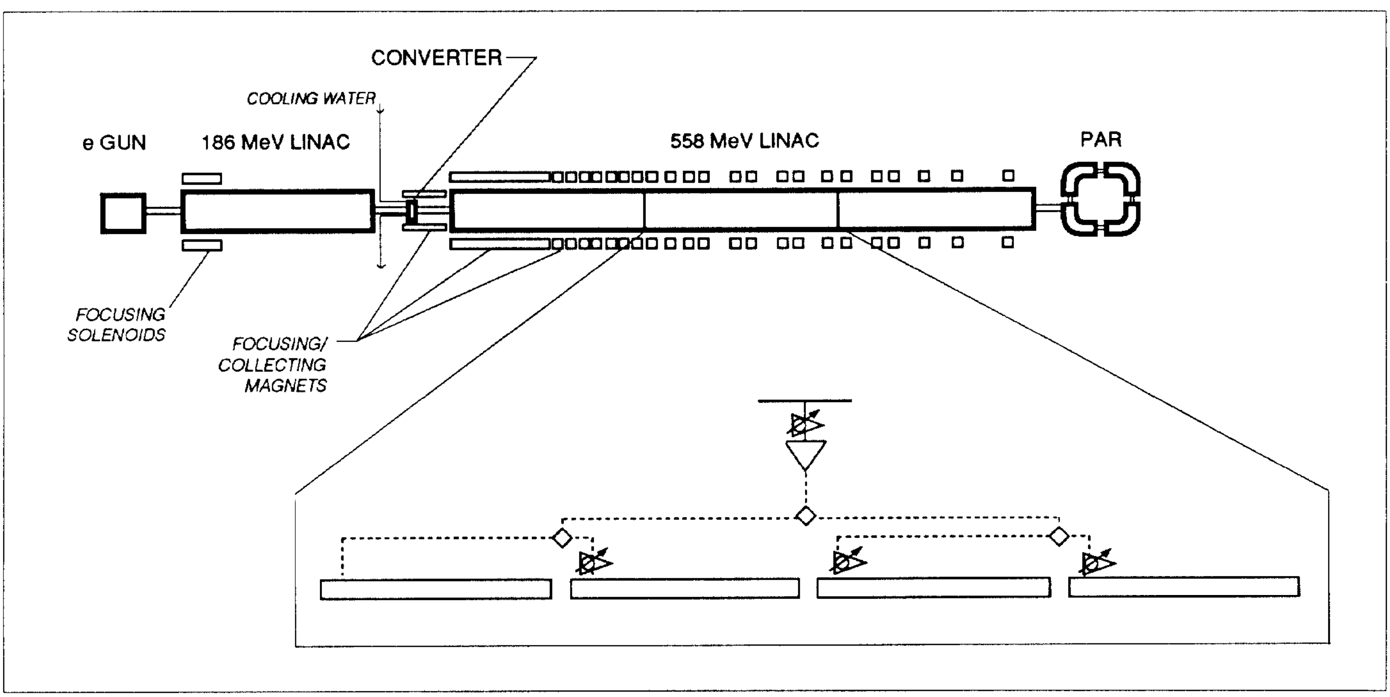

Figure 1. Components of proposed injector.

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charge of 9 nC (three 3 nC bunches) and an average current of 8.6 A was necessary to achieve 100 nC e^+ fill at 30 Hz in less than 6000 cycles. The sections each store 54 joules during the 1 μsec fill time. At the highest current loading, the particles extract 1.7 joules from the field. This corresponds to a 3.15% loading.

The first 4-section module is used to drive the positron convertor target, shown schematically in figure 2. It consists of a 2 m radius × 7 mm tungsten rod. The converter efficiency is estimated to be ≥ 0.04 e^+/e^-/GeV, so the extracted positron charge will be 0.06 nC/cluster (or 0.02 nC/bunch). The target will dissipate 300 W and will need to be conductively cooled by copper supports and water cooling. Details of the support structure will be computed with standard thermal analysis software, using the ANL design for the APS as guidance.

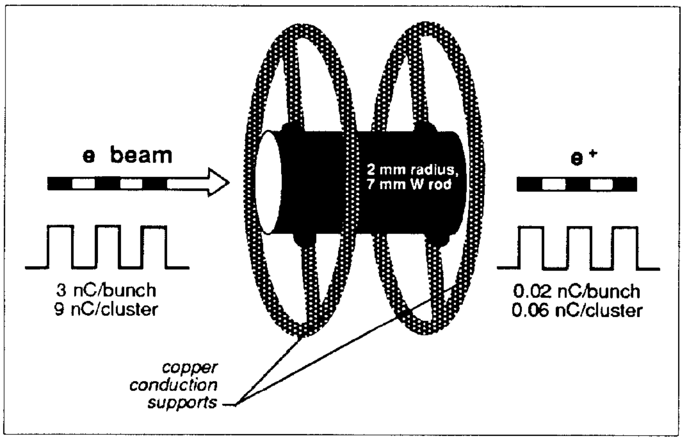

Figure 2. Tungsten converter.

After the conversion, the positrons will be collected by solenoid magnets of up to 2 meters in length. The subsequent linac in principle can accelerate particles to 558 MeV (no load), but because the additional capability will be degraded by rf window losses and loading, routine operation at 510 MeV is anticipated.

The positrons will then be injected in a damping ring, shown schematically in figure 3. A 30 kV, 60 kW rf system can drive a four dipole, 3.8 m ring with room temperature magnets of 1.3 T. The system would accept 1.4×10^{10} e^+ at 30 Hz and switch out 2×10^{12} e^+ in about 55 pulses.

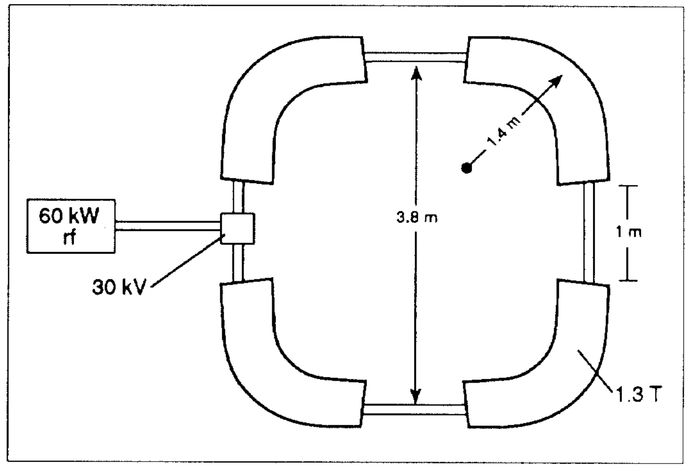

Figure 3. Positron Accumulator Ring (PAR).

II. CONCLUSION

In summary, the injection and positron production system for a UCLA ϕ factory has been considered. The system requires a high current gun that is at the state of the art. The linac and PAR are well within proven capabilities.