Parmela Simulations of the Wilson Laboratory Injector

Cheng-Yang Tan

Cornell University

ABSTRACT: We discuss the results of our *parmela* simulations of the Wilson Laboratory Injector. These simulations were done prior to the installation of the new SLAC section. The main objective of our simulation was to identify any possible problems that would be encountered when the old CEA section is replaced by the new SLAC† section.

To verify that the *parmela* simulation corresponded to reality, we simulated the old CEA section which has empirical data to which our results could be compared.

The efficiency of the injector at SLAC was also used as the basis of comparison with our present injector.

A possible future model based on the SLAC injector model was also simulated.

As of 18 Aug 95, the injector with the new SLAC section has operated successfully for low beam currents.

† More commonly known as the Chinese section here at Wilson Laboratory.

INTRODUCTION

parmela (phase and radial motion in electron linacs) is a simulation programme written by L. Young[1] of Los Alamos. We have used this programme to simulate the injector with the CEA section and compared its results to that of observation. We then replaced the linac section with the new SLAC section and observed the capture efficiency. After which, we inserted a harmonic buncher before the linac section to see whether we can effect a better capture. For the sake of comparison, we have used the SLAC injector as a yardstick for capture efficiency.

Our *parmela* simulation starts with 1000 particles emitted from the gun. Space charge is taken into consideration. The source parameters are obtained from SLAC[2] and are shown in Table 1.

Table 1. Gun parameters used in all simulations

source type : gaussian	*no. of particles* : 1000
total current : 4.6 A	
$\sigma_r = 0.4$ cm	$r_{max} = 0.6$ cm
$\sigma_z = 1000° \equiv 0.97$ ns	$z_{max} = 1600° \equiv 1.56$ ns

The choice of gun current 4.6 A† comes from what is observed at the gun BPM. See the photograph in Figure 1.

Note: The base width of the pulse is $2 z_{max} \approx 3$ ns.

INJECTOR WITH THE CEA SECTION

To simulate the present injector which has a CEA linac section, we have used the SLAC cell parameters but have mimiced a CEA section by changing the phase of the first twelve cells. We had to do this because of the dearth of information with respect to this section. These first twelve cells are operated at 45°C, while the rest of the section operates at 30°C. This corresponds to a 25° phase change between the first twelve cells and the rest of the section because a 6°C temperature change produces a 10° phase change in this design.[3] These twelve cells were designed to capture low energy ~ 125 keV electrons.

† 4.6 A comes from the fact that we have 8.6×10^{10} particles at the gun for 3 ns. This implies a current of 4.6 A.

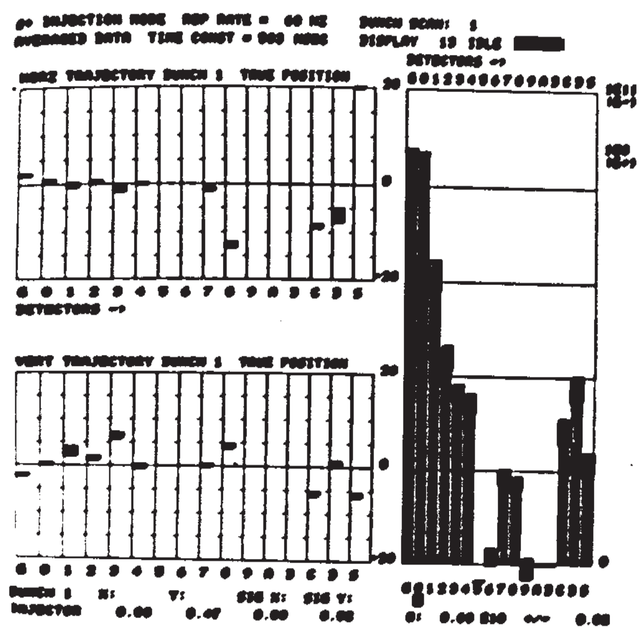

Figure 1 This photograph shows the charge as recorded by the linac BPMs in $e+$ conditions (photograph taken on 15 June 94). We see a beam loss of 30% from 8.6×10^{10} particles at the gun to 6×10^{10} particles at the end of section 1.

INJECTOR WITH A SLAC SECTION

The main concern of the laboratory is whether the new SLAC section would be abl energy ~ 125 keV beam. The difference between the SLAC section and CEA section is section does not have any bunching cells.

We assume that the present linac section will be replaced with a SLAC section. T at various points of the injector are shown in Figure 3. Notice that the mean energy at the gun.

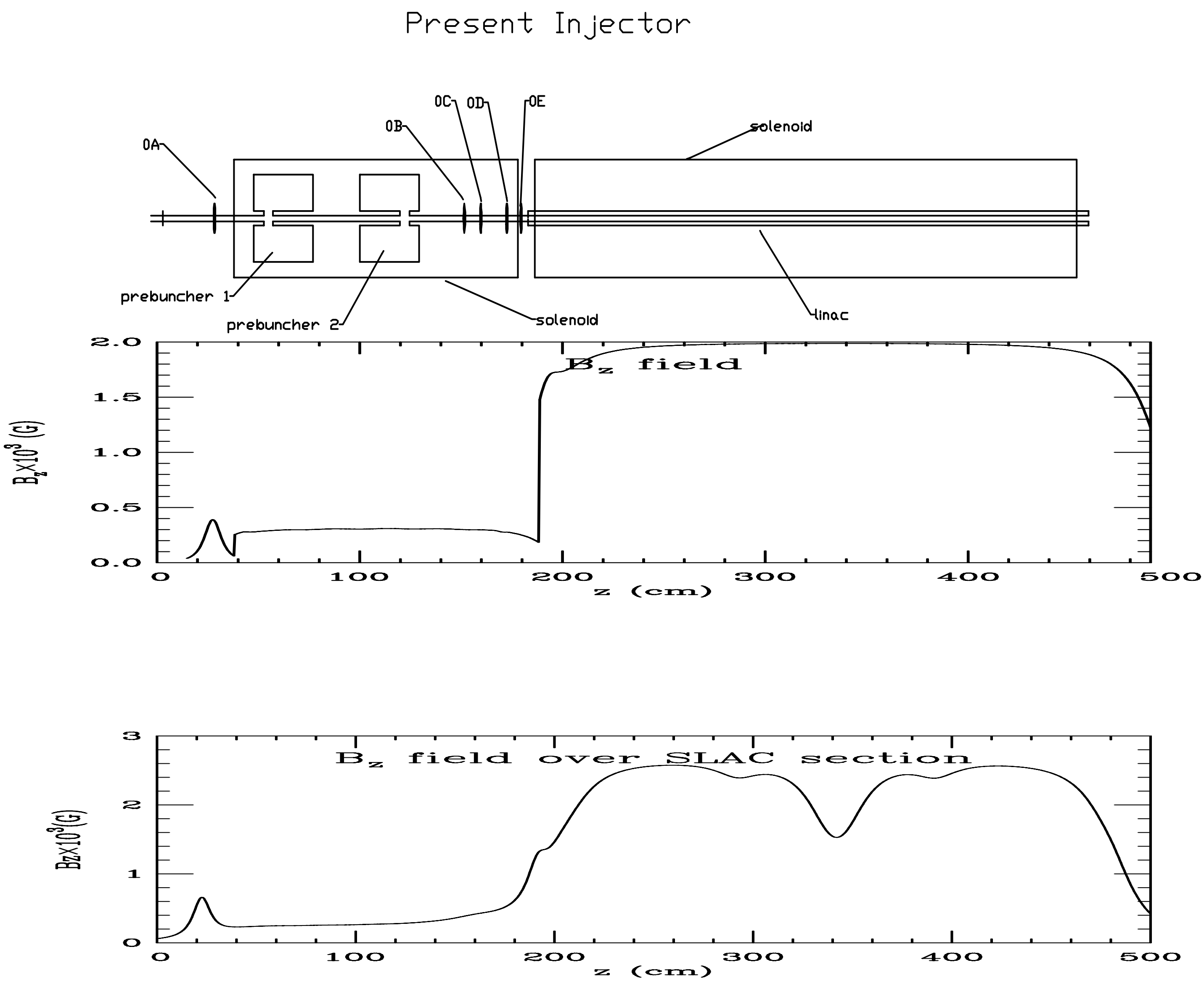

Figure 2 This figure shows the differences in axial B-field as used by the old injector with the CEA section and the new SLAC section. Notice that the field higher over the new SLAC section and the dip around 350 cm. This dip comes from the gap for the water pipes.

INJECTOR AT SLAC

As a comparison with SLAC, we ran a simulation of the SLAC injector. The main ele injector are shown in Figure 4. The main differences between our injector and the SL

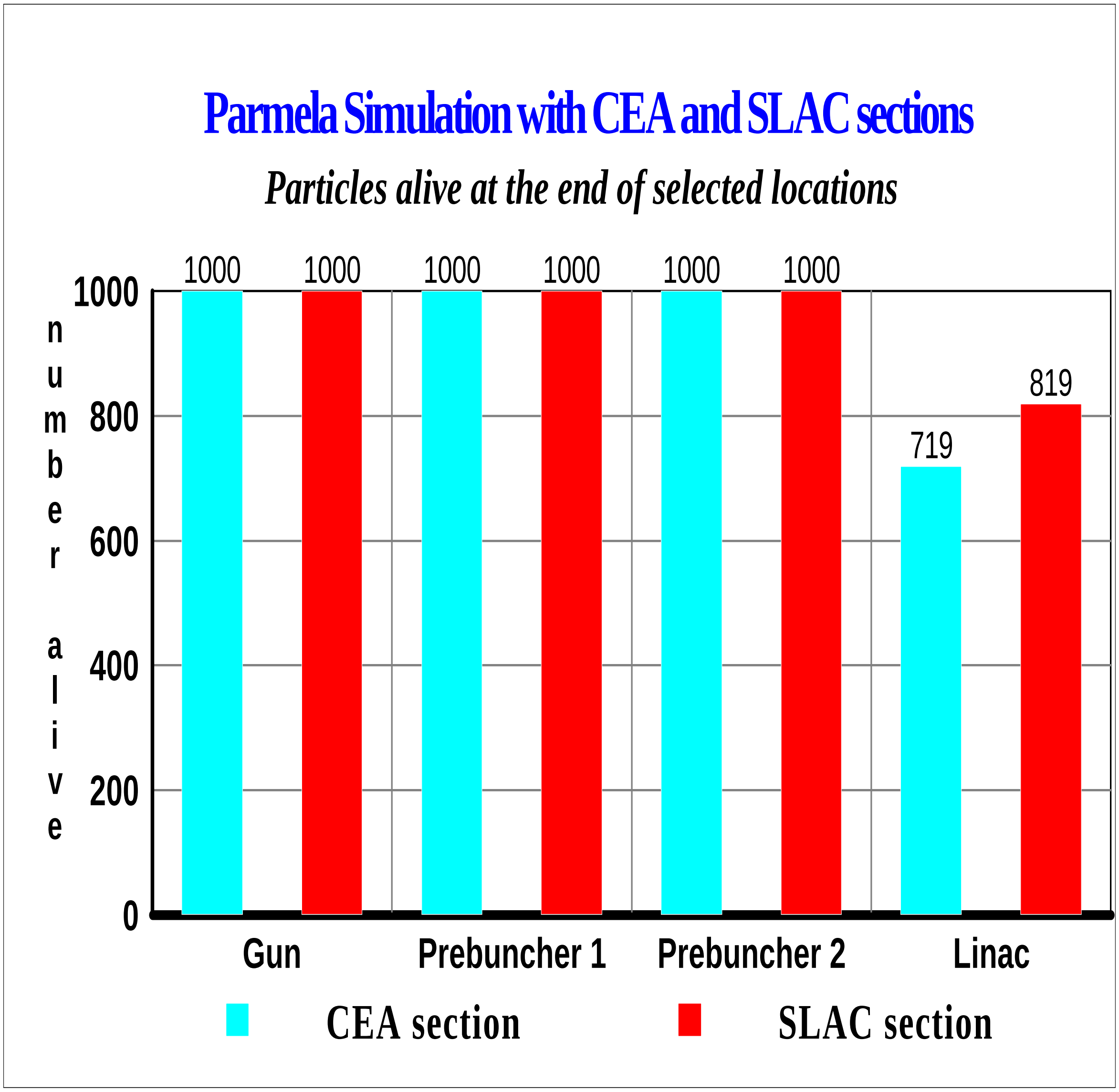

Figure 3 The histogram shows the losses after selected elements for the old C
section and the new SLAC section. The gun current is set to 4.6 A. The results
the simulation for the CEA section agrees with observation.

(*i*) The harmonic buncher between the second prebuncher and the first acceleratin

(*ii*) The SLAC gun operates at 10 A and 145 keV as compared to 4.6 A and 125 keV here.

The losses at selected elements are shown in Figure 6. For comparison purposes,
and optimized for the condition of a 10 A beam at 125 keV with our new injector with t

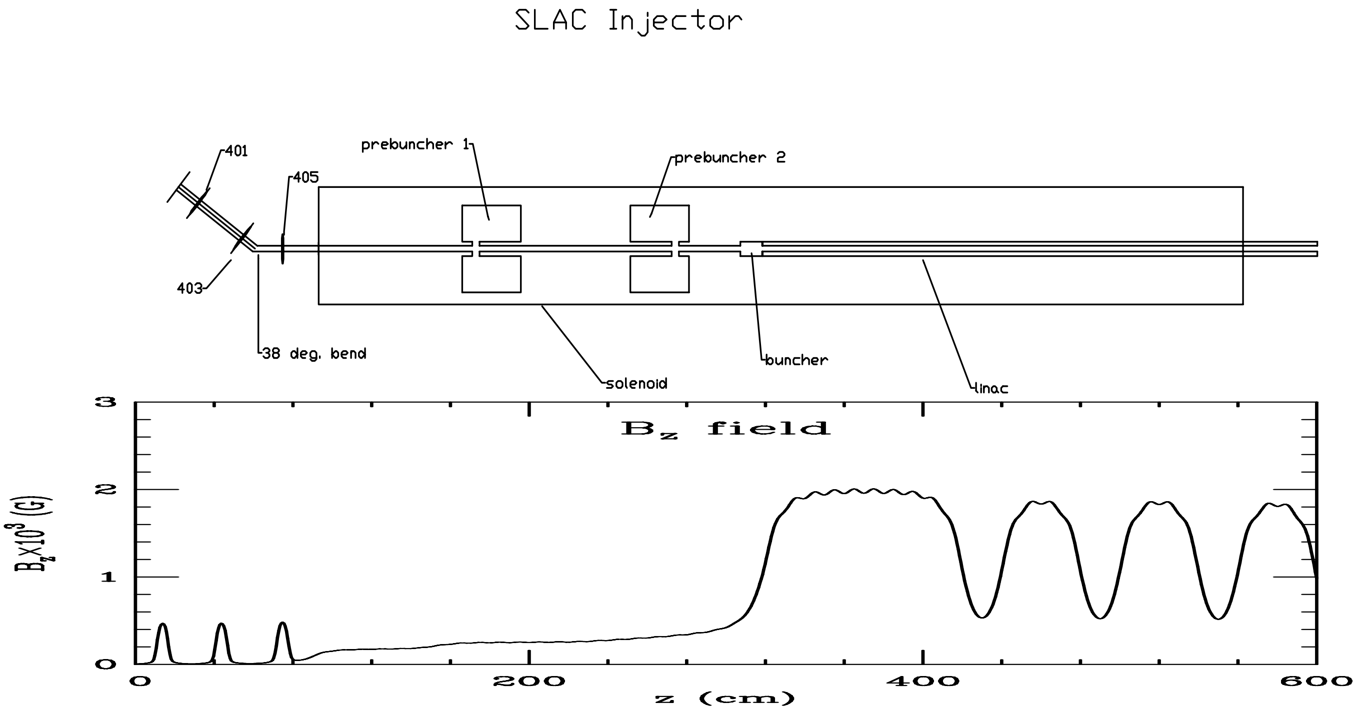

Figure 4 This figure shows the SLAC injector. The main difference between our injector and the above is the harmonic buncher between the second prebuncher a the first accelerating section. Operationally, the SLAC gun runs at 145 keV.

OTHER PREDICTIONS WITH CAVEATS

parmela has made the prediction that by turning *off* the lenses 0B to 0E, there will The histogram for the various capture efficiencies as each lens is turned off is sho however, is contrary to empirical evidence. Turning off lens 0E causes significant recoverable by steering of the beam.

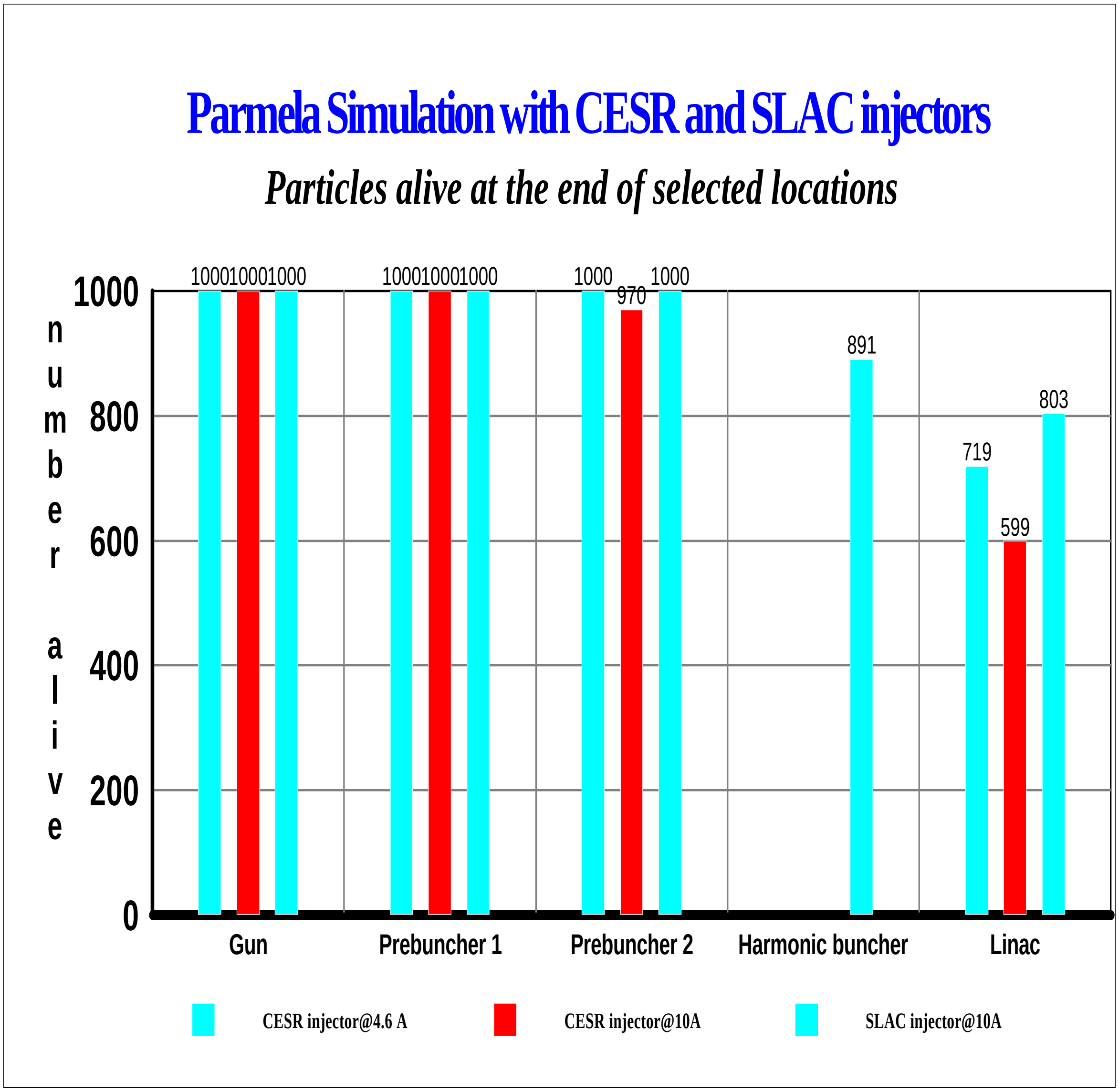

Figure 5 The histogram shows the losses after selected elements for the ne
injector with a SLAC section and the injector at SLAC. The CESR injector wit
the SLAC section does not contain a harmonic buncher and operates at a lowe
gun voltage of 125 keV. The SLAC gun is operated at 145 keV. For comparison
purposes, we also did a simulation and optimization of the new CESR injector
10 A, 125 keV.

FUTURE INJECTOR WITH HARMONIC BUNCHER

A future improvement of the CESR injector is the insertion of a harmonic buncher
prebuncher and the first section *à la* SLAC so that a higher current beam can be efficie
the end of the first section. For this particular simulation, we have assumed that
this future injector will be the same as SLAC. Figure future.ps shows the results of
to the SLAC injector. Our simulation shows that we can, in fact, do better than SLA

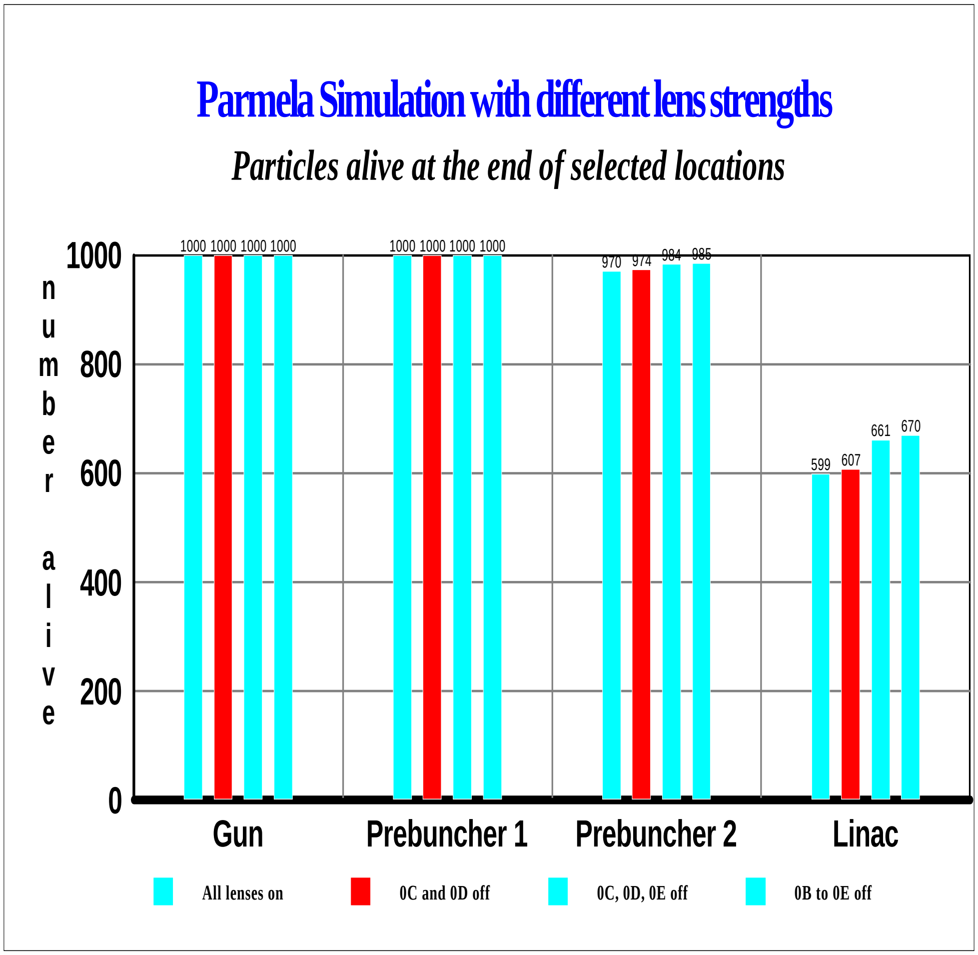

Figure 7 The beam current is @10 A. *parmela* predicts a much better capture as the lenses in the solenoidal field are turned off. This simulation was done the old injector with the CEA section.

CONCLUSION

parmela has proven itself to be a very useful tool in simulating the CESR injector. evidence that it is accurate in the larger context of capture efficiency. However, ce out in the text still remain.

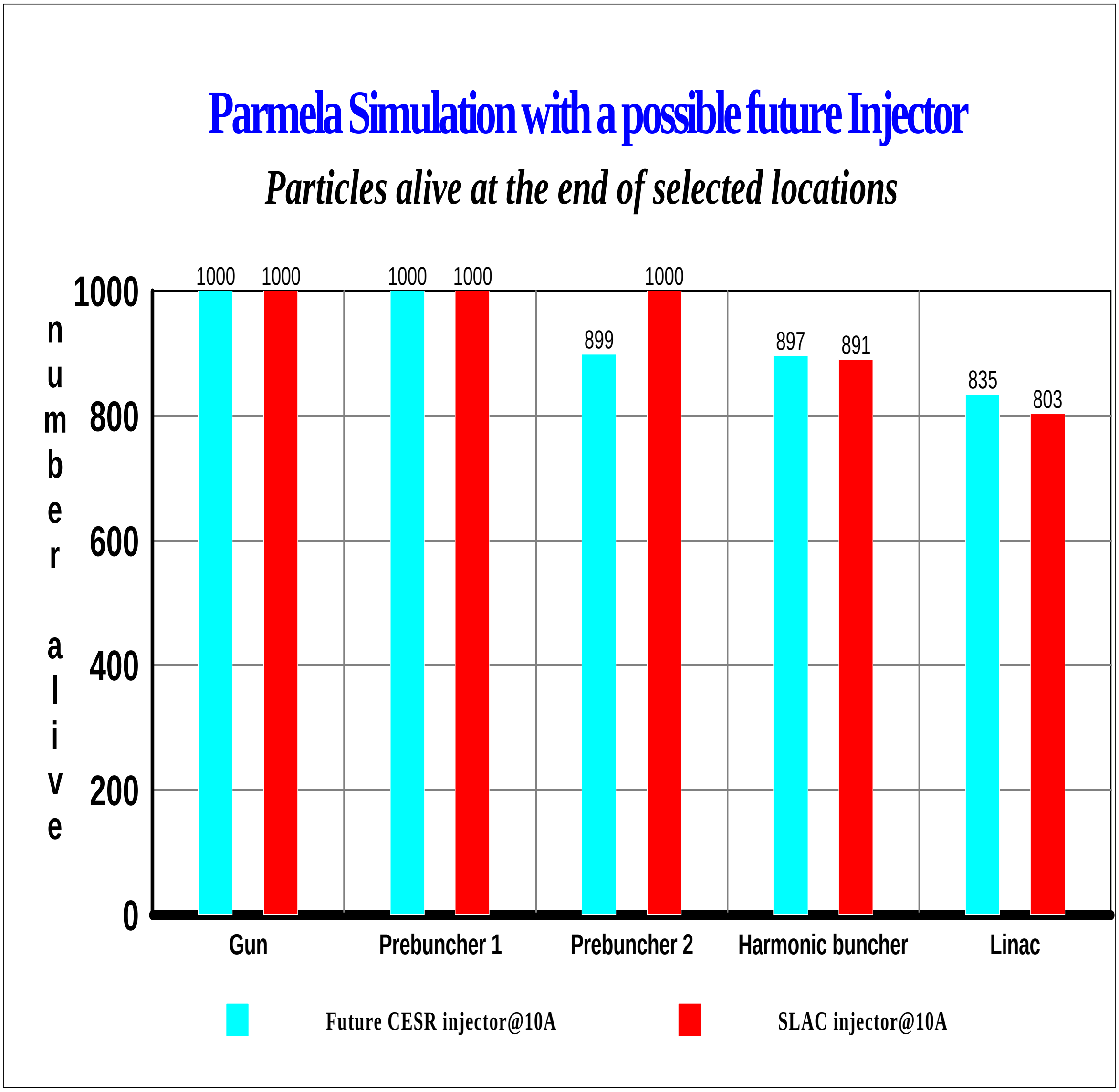

Figure 9 A possible future improvement to the CESR injector is the insertion a harmonic buncher *à la* SLAC. We have assumed that we will be using a similar field like that of SLAC in this simulation. Our simulation shows that we can, fact, do better than SLAC.

ACKNOWLEDGEMENTS

R. Cutler for hunting down the parameters of the present CEA section and the SLA

V. Kazacha for helping me do the simulations on a workstation.

REFERENCES

[1] *parmela*, L. Young, Los Alamos National Laboratory, 1994.

[2] Private Communication, R. Miller, SLAC, 1994.

[3] Varian inter-office memo, N. Pering to F. Weber and V. Valencia, 21 July 1965.