



Searching for an Alternative Operating Point of the CEBAF Injector

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I. INTRODUCTION

Currently, the CEBAF injector is being operated at(or at least very close to this)[1,2,3]:

Buncher phase = 19.5 deg ahead of zero crossing phase
Buncher amplitude = 0.0605 MV/m

Capture phase = 16.5 deg ahead of the crest phase when the buncher is off
Capture amplitude = 1.245 MV/m

In the quarter cryomodule,
Cavity 1 phase = 7.5 deg ahead of the crest phase
Cavity 1 amplitude = 4.8 MV/m

Cavity 2 phase = on crest
Cavity 2 amplitude = 5.0 MV/m.

We will refer this setting of the injector as the nominal. The nominal set up provides a very short beam bunch which meets all the performance requirements for the CEBAF accelerator. However, the bunch length is extremely sensitive to a phase error in rf fields at the buncher and the capture section cavities. For the ease of operating the injector, it would be desirable to find a less sensitive operating point, if it exists at all.

II. A PARMELA STUDY

A numerical modeling study with PARMELA has been carried out to search for a possible alternative operating set point of the injector. Under the belief that the machine will be more tolerant if one sends the beam to the buncher at zero crossing, on crest at the capture, and on crest at two superconducting cavities in the quarter cryomodule, we have searched a set point exhaustibly by varying the amplitudes of the buncher and the capture. However, this search ended unsuccessfully because the minimum bunch length we could achieve under those restrictions was about 1.7 degree which is too long for the CEBAF.

During the sensitivity study of the bunch length to the variation of the capture amplitude in the nominal set up, we noticed that the bunch length is fairly insensitive to an increase of the capture amplitude while it is very sensitive to a decrease of the amplitude. This suggested a possible operating point with a higher capture amplitude still providing a reasonably short bunch length. Indeed, this turns out to be true and the new set point we found is the complementary one to the nominal setting in regard to the bunch behavior in the longitudinal phase space. The bunch length is now far less sensitive to phase errors in the buncher and/or in the capture. However, the sensitivity of the energy spread to the phase errors has increased significantly.

Figures 1 to 4 summarize the sensitivity study. In the Figures dot-dashed ones are for the nominal setting and the solid lines are for the new setting. The unit of the bunch length is in degree at the fundamental rf frequency of 1497 MHz. Energy spread is in percent at the beam energy after the quarter cryomodule which is about 5 MeV. Buncher and capture amplitudes are in MV/m, and buncher and capture phases are in degree at 1497 MHz. The bunch length and the energy spread numbers are full(4 sigma) values.

One notable difference between two operating points is that the beam is diverging coming out of the quarter cryomodule in the new set up while the beam is converging in the nominal set up. Therefore, 4 quadrupoles (between the quarter cryomodule and the first cryomodule of the injector) must be used to control the transverse phase spaces.

Amplitude and phase set point of new solution are:

Buncher phase = 19.5 deg ahead of zero crossing phase
Buncher amplitude = 0.0605 MV/m

Capture phase = 0.8 deg ahead of the crest phase
Capture amplitude = 1.285 MV/m

In the quarter cryomodule,
Cavity 1 phase = 20.0 deg ahead of the crest phase
Cavity 1 amplitude = 4.8 MV/m

Cavity 2 phase = 10.0 deg ahead of the crest phase
Cavity 2 amplitude = 5.0 MV/m.

III. CONCLUSION

We suggest this new solution to be tested in the CEBAF injector.

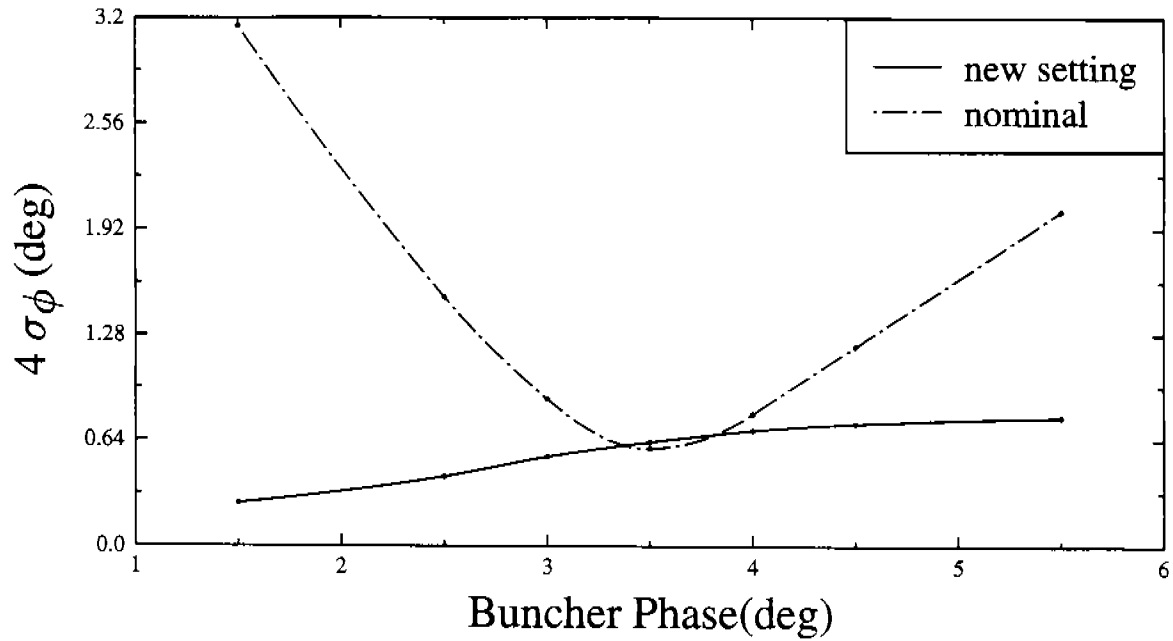
IV. ACKNOWLEDGEMENT

We thank Hongxiu Liu and Geoffrey Krafft for help.

V. REFERENCES

- [1] J. A. Jackson, G. A. Krafft, and R. Abbott, A Method for Achieving Minimum Bunch Length in the CEBAF Injector, CEBAF-TN-92-047 (1992)
- [2] H. Liu, Optimization of Bunch Length using Sensitivity Matrix, CEBAF-TN-94-011 (1994)
- [3] G. A. Krafft, On Optimizing the Bunch Length, CEBAF-TN-94-013 (1994)

Bunch Length vs. Buncher Phase



Energy Spread vs. Buncher Phase

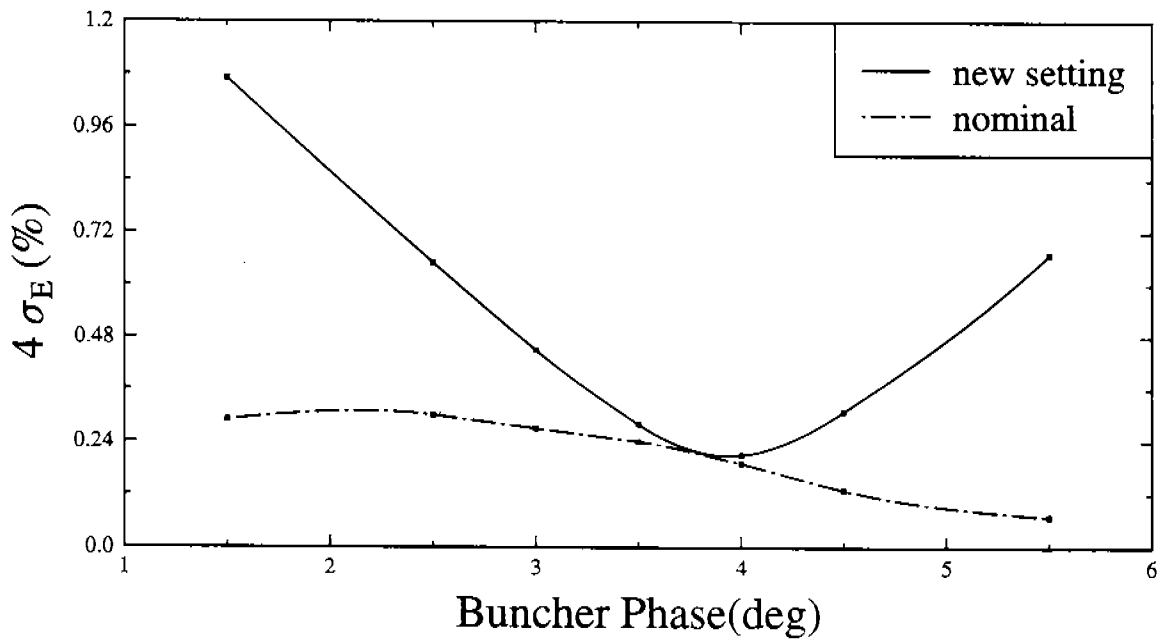
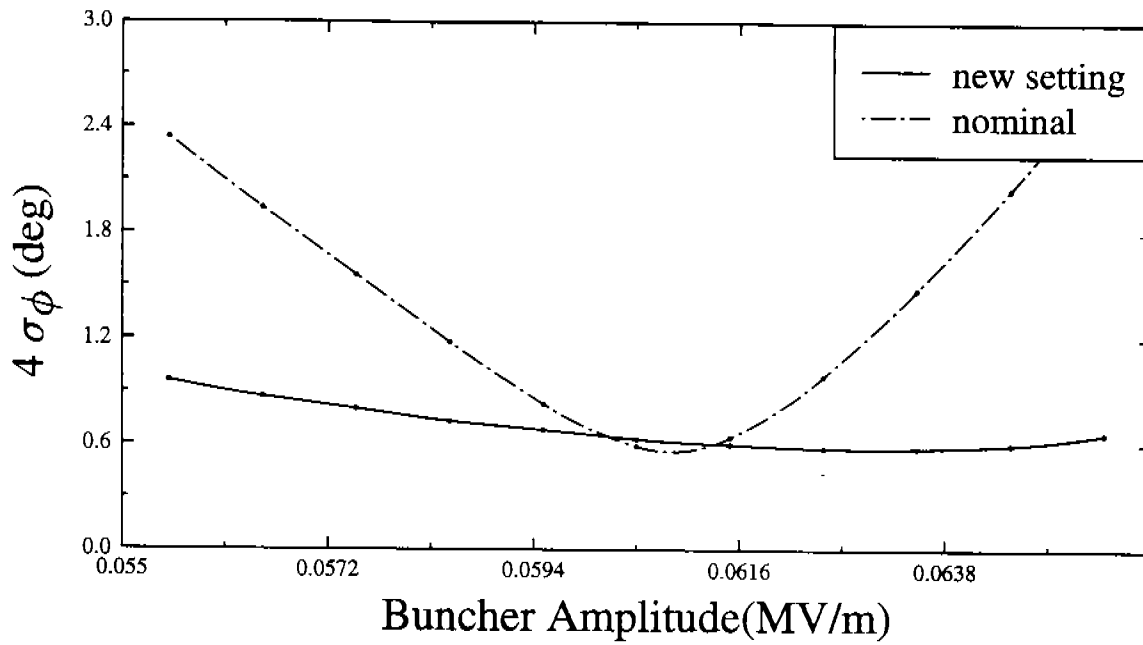


Fig. 1 Sensitivity to Buncher Phase.

Bunch Length vs. Buncher Amplitude



Energy Spread vs. Buncher Amplitude

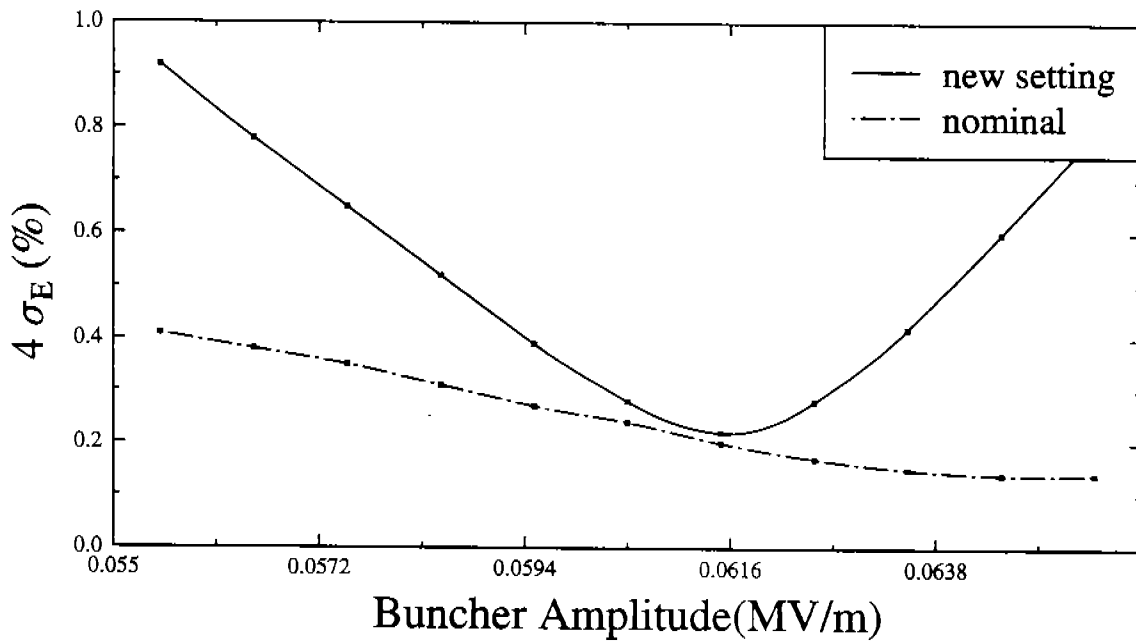
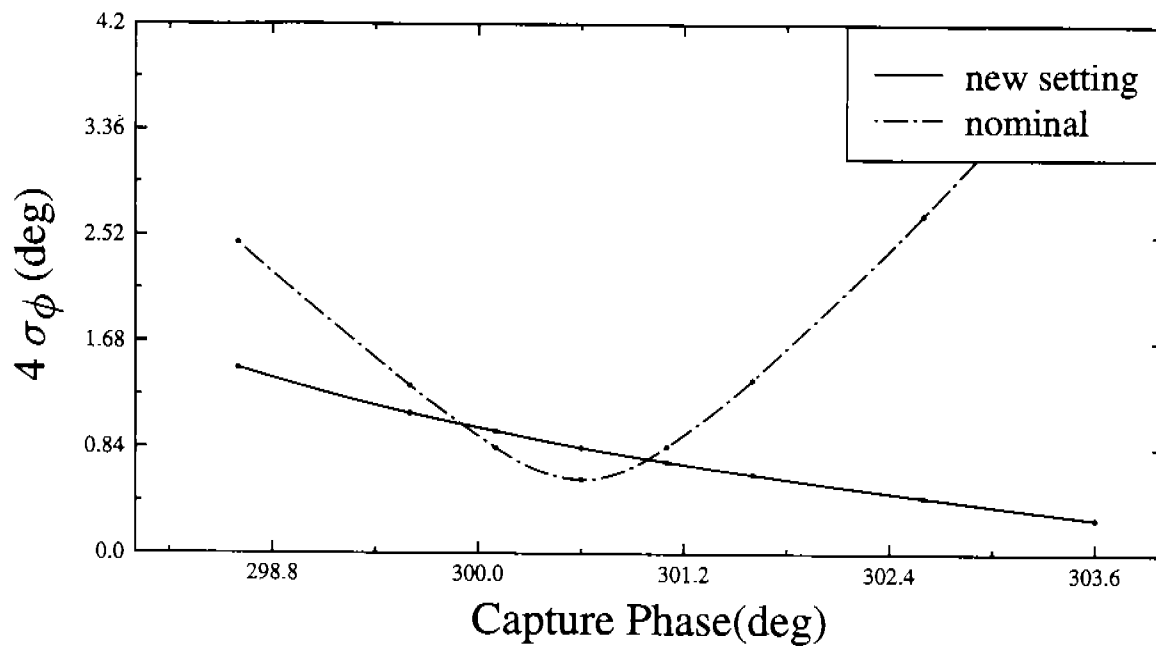


Fig. 2 Sensitivity to Buncher Amplitude.

Bunch Length vs. Capture Phase



Energy Spread vs. Capture Phase

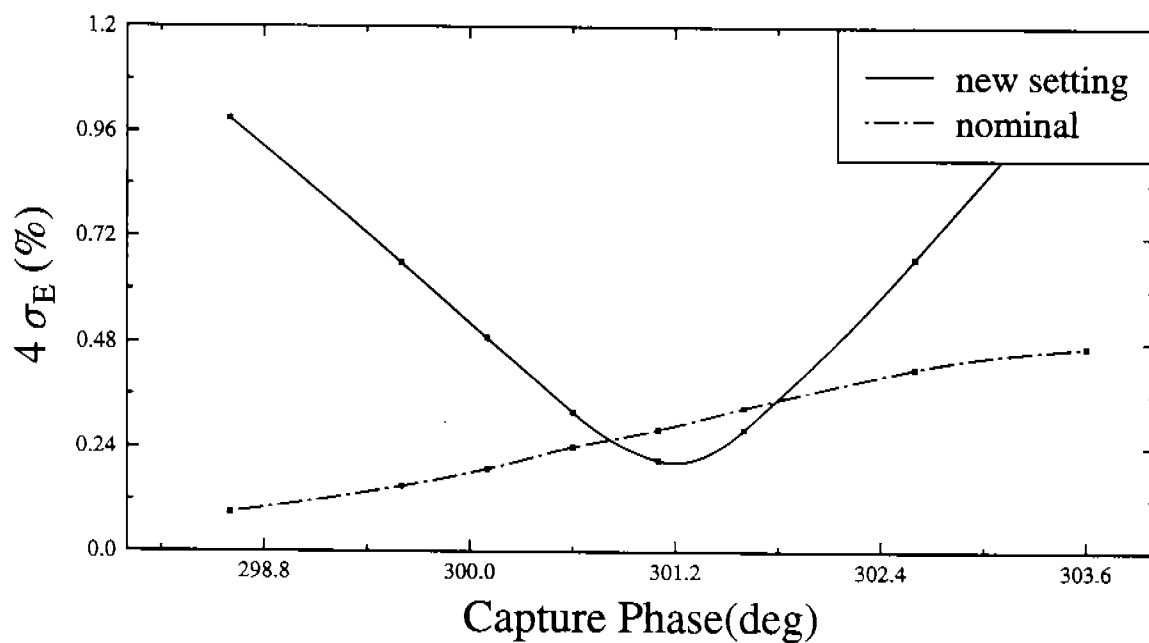
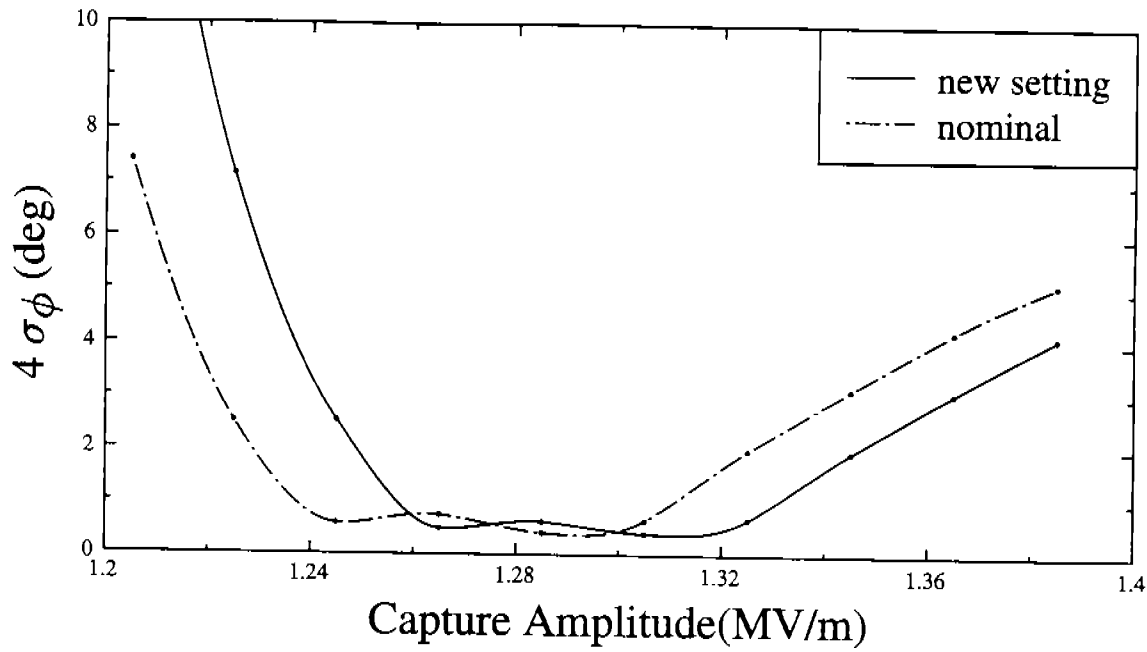


Fig. 3 Sensitivity to Capture Phase.

Bunch Length vs. Capture Amplitude



Energy Spread vs. Capture Amplitude

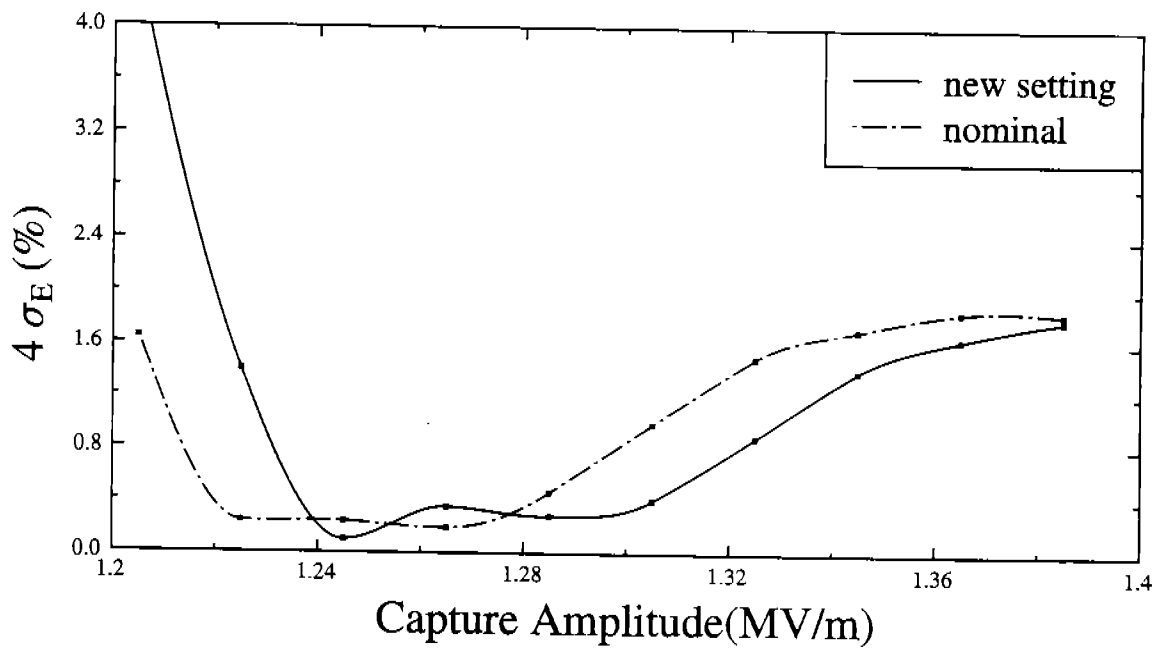


Fig. 4 Sensitivity to Capture Amplitude.