BBAT: bunch and bucket analysis tool*

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Abstract

BBAT [‘bat] is a graphical package, written in C, tcl/tk and BLT, to analyze bunch and bucket properties in the longitudinal phase space for a single and double rf system (Dr. BBAT) interactively. Its usage is detailed fully.

I. Introduction

BBAT is written to meet the need of an interactive graphical tool to explore the longitudinal phase space. It is driven for testing new ideas or new tricks quickly. It is especially suitable for machine physicists or operation staff as well both in the control room during machine studies or off-line to analyze the data. The heart of the package contains a set of c-routines to do the number crunching. The graphics part is wired with scripting language tcl/tk and BLT. The c-routines are general enough that one can write new applications such as animation of the bucket as a machine parameter varies via a sliding scale.

BBAT deals with single rf system. For double rf system, one can use Dr. BBAT, which stands for **D**ouble **r**f **B**unch and **B**ucket **A**nalysis **T**ool. One usage of Dr. BBAT is to visualize the process of bunch coalacing and flat bunch creation.

II. Layout of BBAT

The layout of BBAT has basically four parts, see Figure 1, parameter editing, basic derived parameters, plotting and phase space position. In the parameter editing part, Naturally, this part has two sections, one for the machine parameters and one for the beam parameters. In the machine parameters section, one needs to input the machine, the change rate of main dipole magnets, the energy, the rf gap volts and the rf harmonic numbers. In the beam parameter section, one needs to input the ion species, the charge state and the bunch size either the bunch length or the bunch area. Some parameters have multiple choices. In such cases, the multiple choices are arranged in buttons. In the **Machine** button, one can choose to work with different machines, where *AGS* , *Booster* and *RHIC* are built in machines, for other machines, one is prompted to enter some basic machine parameters. In the **Energy** button, one has a choice of the dipole magnet strength, the gamma value or the momentum or the kinetic energy of the beam. Then in the **Species** button, one can choose from a set of ions or inputing new ones.

Some basic derived parameters are displayed in the second part. These are the synchronous phase angle, stationary bucket area the moving bucket area, the small amplitude synchrotron frequency, bunch area and bunch length. The calculation on bunches is based on the calculation on the buckets, one is expected to redo the calculations on the buckets if the machine parameters are to be changed. The button **More Results** will pop up a window displaying more related parameter values.

In the third part: plotting, a bucket and a bunch is shown. By pointing the cursor in the plotting region, the position of the cursor in the phase space is displayed in the fourth part. The cursor itself has a horizontal hair which measures the vertical axis and a vertical hair which measures the horizontal axis. The phase space parameters displayed are the phase, bunch length, energy dE and momentum dP and fractional energy and momentum $\frac{dE}{E}$, $\frac{dP}{P}$, and the fractional radius or frequency changes $\frac{dR}{R}$, $\frac{df}{f}$, synchrotron frequency at any amplitudes and the difference with respect to that of small amplitudes. The last parameter displayed is the rf gap volts, which is the matching voltage for a bunch whose energy and phase are determined by the cross hairs of the cursor.

III. Layout of Dr. BBAT

The layout of Dr. BBAT, see Figure 2 is closely followed to BBAT. The first part is parameter editing. The parameters are the gap volts for the fundamental and high harmonic rf system, and the harmonic number which is not restricted to integer, the phase shift between the two rf systems, synchronous phase angle. The second part is basically the same as in the first part, slide scales are used instead of text entry. The third part is a plotting area, where the buckets, bunch, synchrotron potential, the combined rf waveform are displayed. The phase space parameters are displayed in the fourth part, which are the phase, bunch length, energy dE and momentum dP and fractional energy and momentum $\frac{dE}{E}$, $\frac{dP}{P}$, and the fractional radius or frequency changes $\frac{dR}{R}$, $\frac{df}{f}$, synchrotron frequency at any amplitudes. The bucket and bunch areas are also displayed, notice there could be multiple buckets.

IV. Usages

The main usages of BBAT are, not exclusive, follows:

- Bucket sizes, such as the bucket height, width, are easily calculated and graphically displayed. The relationship between the bucket and bunch can be visualized.
- Bunch area can be calculated by knowing the bunch length, and visa versa. The bunch height and synchrotron frequency spread is also easily shown just by moving the cursor to any where of the user’s interests. In the plotting area, you can create new bunches by simply click of the cursor, new bunch length is automatically chosen and the bunch is updated.
- Matching a bunch in two machines, such as matching bunch from *Booster* to *AGS* , is easily accomplished by placing the cursor at the right height and length of the injected bunch in the *AGS* , the required matching voltage is automatically shown. The user can explore different matching scheme. If

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mismatch, the user can easily find out how much dilution has incurred.

- If it's desired to move the orbit by certain amounts, the amount of changes in the rf frequency can be read off from the screen directly.

The main usages of Dr. BBAT are, not exclusive, follows:

- Dr. BBAT makes the very complicated bucket size calculations in a double rf system easy.
- The user can animate the process of bunch coalacing by changing the relative gap volts of the two system via a sliding scale.
- The user can also visualize the creation of a flat bunch.

V. Acknowledgement

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References

[1] Hofmann, A., Myers, S., Beam Dynamics in a Double RF System, Proc. XIth International Conference on High Energy Accelerators, CERN (1980).

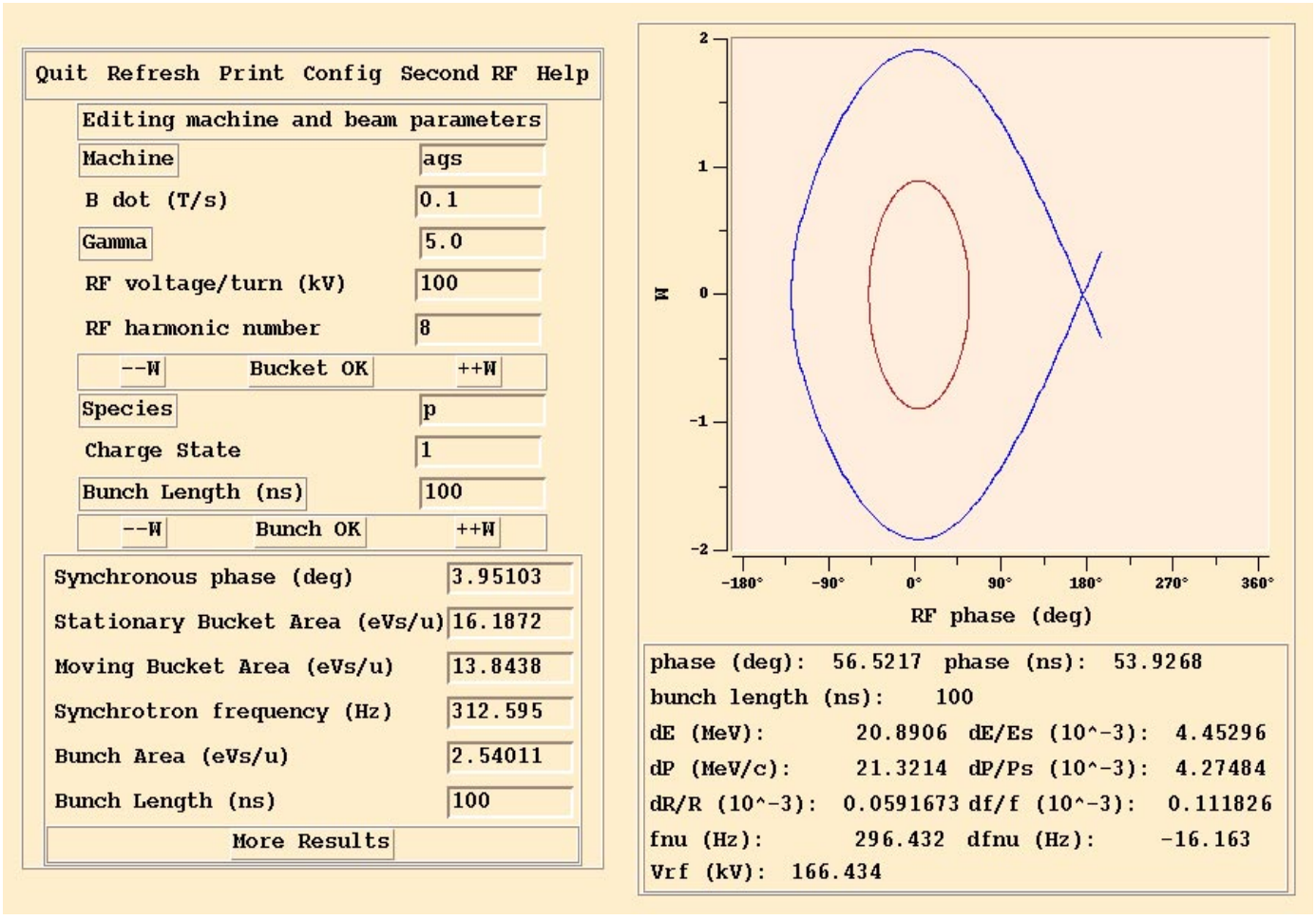

Figure. 1. A snapshot of BBAT.

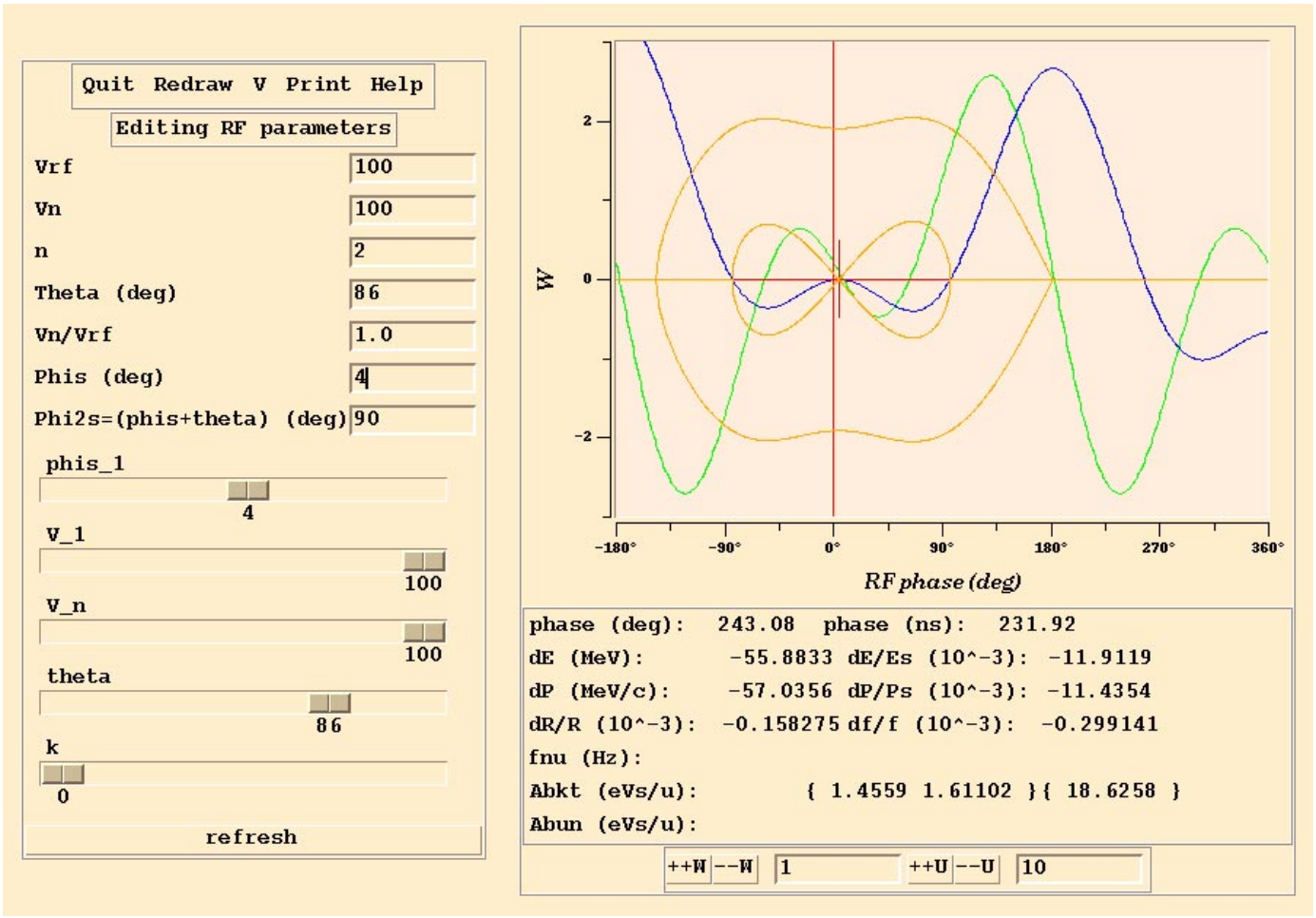

Figure. 2. A snapshot of Dr.BBAT