COMPUTER SUPPORTED TUNING METHOD FOR MCR

J. F. Ryan

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Collider Accelerator Department

Brookhaven National Laboratory

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Introduction

This paper describes a method of tuning parts of the AGS that can, in some instances, be very useful. The author used it when tuning the downstream part of the C line for the experimenters. Hopefully, other users will find this technique useful for improving AGS operation. Essentially when one is tuning and finds that different devices are each controlling a few different measurements, this procedure will allow one to isolate the control of each measurement. For example, the two power supplies CP3 and CP466 both controlled the C1 and C3 telescope counts. This procedure allows one to vary CP3 and CP466 so that only one variable, either C1TEL or C3TEL, would be changed. One direct result of this procedure is to experimentally find the constants for an ORTHO file and to determine if these constants are "constant". A small computer or calculator program is needed to do the calculations.

Different Tuning Examples

This method assumes that each power supply or device controls some effect in a linear manner. The range over which this cause and effect is linear may be wide or narrow depending on the physics of the tuning being done.
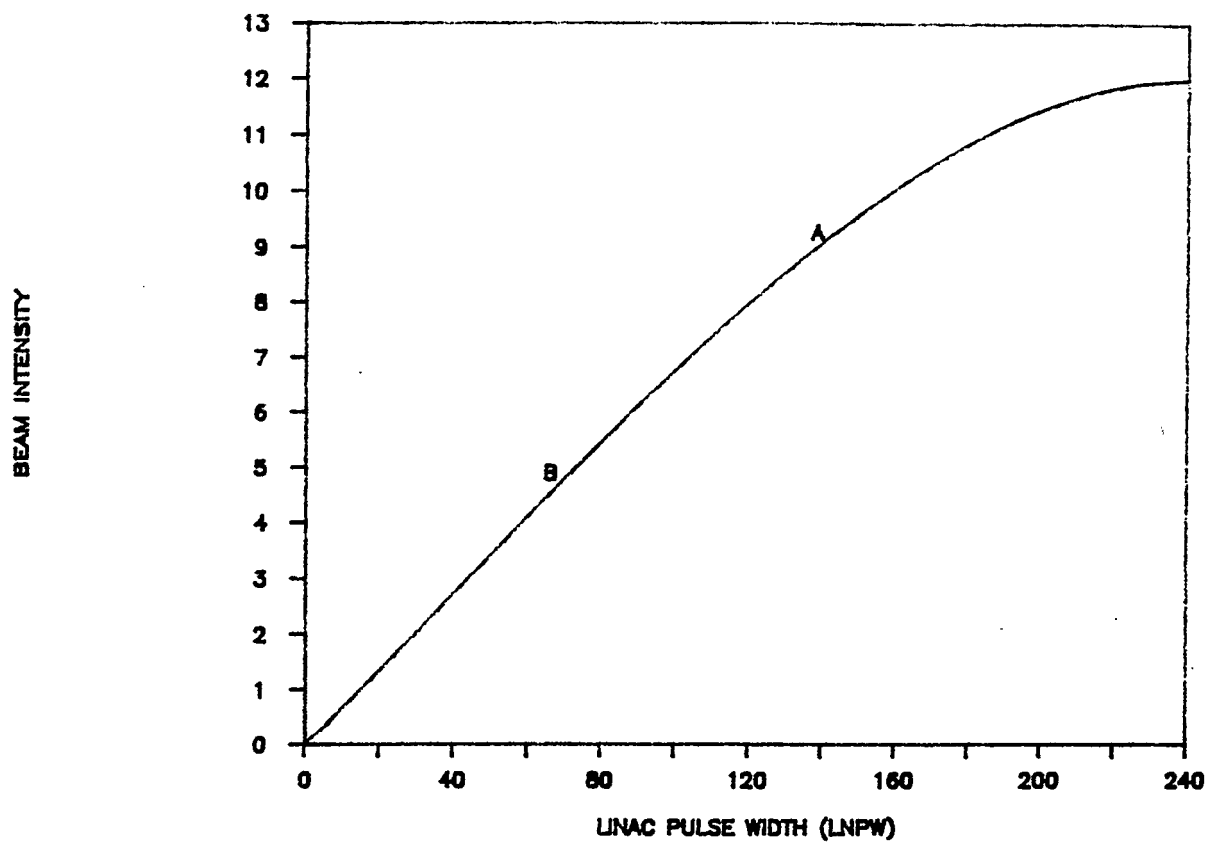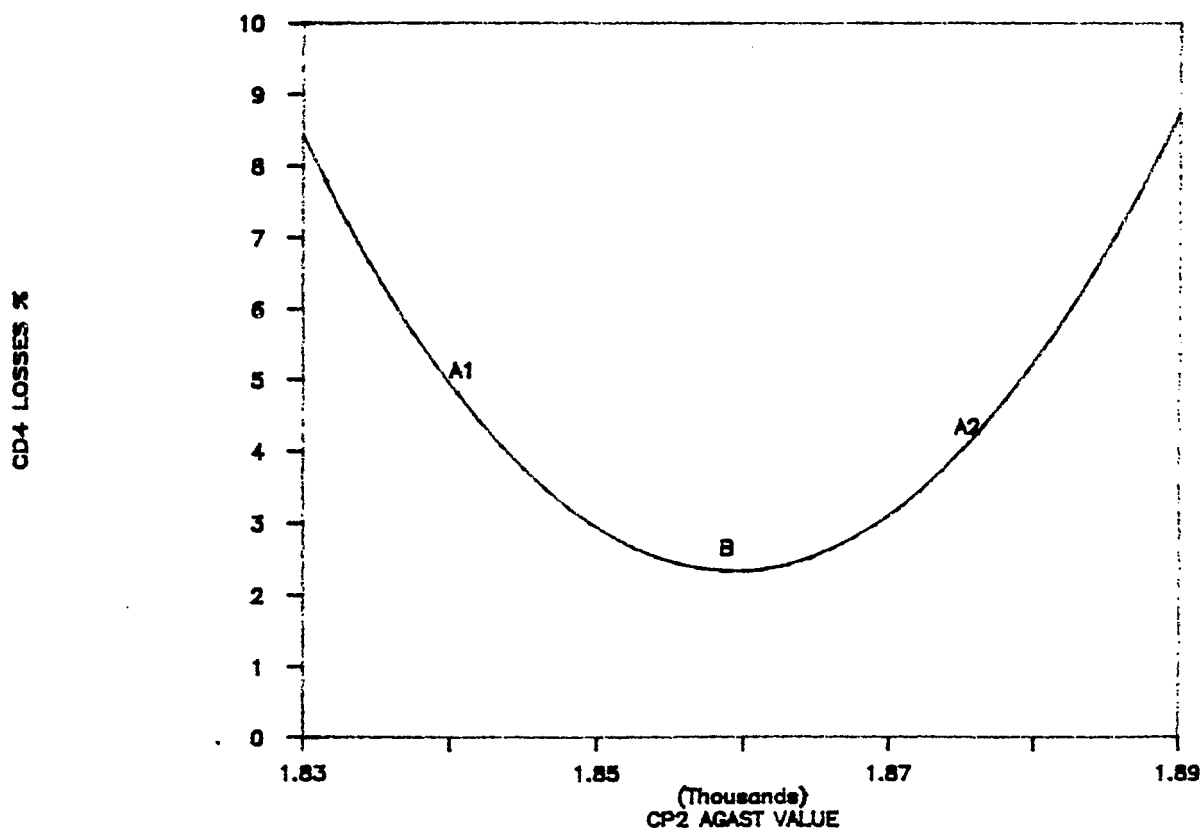
FIGURE 1

BEAM INTENSITY

LINAC PULSE WIDTH (LNPW)

FIGURE 2

CD4 LOSSES %

(Thousands)
CP2 AGAST VALUE

The trim pitching magnets CP3 and CP466 were to be used. Since either power supply effected both counts this tune space was a three-dimensional space. However, it was known from the QTUNE model that for steering elements the tune space is linear. Using brute force, this problem was solved but the problem always reoccurred as the experimental requirements changed. This tuning was made easy using a tuning process described in this note.

Computer Supported Tuning Process

It should be pointed out that this computer supported procedure is not new but is commonly used by many computer fitting programs. A. Ruggiero described this procedure when he discussed how computer programs find a closed orbit in particle accelerators. This tuning procedure simply instructs the operator to follow a proven procedure in his tuning. It is commonly known as the Newton-Raphson method of iteration. It has limitations which are determined by the noise that is on the available data. If an operator knows that he has low noise input data, this procedure will help his tuning. The matrix equations shown below are solved with computer or calculator help.

One-Dimensional Graphic Description

This procedure can be illustrated best with a graphical description and example. Consider the first example of varying the beam intensity with the linac pulse width as shown in Figure 3. As discussed earlier, one way of moving from point A to point B is to assume a linear response between the beam intensity and the linac pulse width as shown. The problem, experimentally, is to measure the slope and to find the necessary change in the LNPW to give the required change in beam intensity. If one starts at point A and reduces the LNPW by 5%, the change in beam intensity can be recorded. Let the linac pulse width be x and the beam intensity be y, then:

$$dx = C * dy \qquad \text{where dx means the change in x}$$

or

$$C = dx/dy = [LNPW (A1) - LNPW (A2)] /[(Beam (A1) - Beam (A2)]$$

Thus, if you decrease the LNPW by 20 counts and observe that the beam intensity drops by 2 TP, then:

C = 20 / 2 = 10 counts per TP.

If one desires a change of 5 TP, then:

DELTA (LNPW) = DELTA x = 10 * 5 = 50 counts.

The linac pulse width must be decreased by 50 counts to drop the beam intensity by 5 TP assuming a linear response. The ORTHO constant for this simple example is 10 counts per TP.

Multidimensional Example

Now assume that one wants to vary CP3 and CP466 to control the CTEL and C3TEL counts independently. A linear tune space diagram is assumed between CTEL & C3TEL and CP3 & CP466. It is also assumed that the C3 experimenter does no tuning since he also can effect the C3TEL counts. The linear equations describing this system are as follows. The range of the power supplies · over which the linear equations are valid depends on the physics of the scheme.

D * d(CP3) + E * d(CP466) = d(CTEL)

F * d(CP3) + G * d(CP466) = d(C3TEL)

In other words, for a linear system, a constant D times the change in CP3 plus another constant E times the change in CP466 will give the change in CTEL counts. It was known from the physics of the system that the CTEL counts depend strongly on the vertical beam position at the target and the C3TEL counts on the vertical angle. Since both the position and angle are linear functions of the magnet bend angles, it was known that these equations would be valid over a wide range. These equations make a set of non-homogeneous linear equations of the following type:

D * x + E * y = P

F * x + G * y = Q

This matrix equation can be used to find the necessary changes to CP3 and CP466 to obtain any change in CTEL and C3TEL counts. In particular, to find the ORTHO constants, one wants to change one variable CTEL and hold the other variables (C3TEL) constant. Then, for a 100 count change in CTEL,

$$\begin{bmatrix} d(CP3) \\ d(CP466) \end{bmatrix} = \frac{\begin{bmatrix} 100 \\ 0 \end{bmatrix}}{\begin{bmatrix} D & E \\ F & G \end{bmatrix}}$$

These two values, d(CP3) and d(CP466), give the CP3 and CP466 ORTHO constants for a constant C3TEL counts or these are the ORTHO constants if one wants to vary the CTEL counts while holding the C3TEL counts constant. Experimentally, d(CP3) and d(CP466) were found to be 100 and -390 for one setup in the C3 line.

In a similar manner the ORTHO constants for varying the C3TEL counts only are obtained by solving:

$$\begin{bmatrix} d(CP3) \\ d(CP466) \end{bmatrix} = \frac{\begin{bmatrix} 0 \\ 100 \end{bmatrix}}{\begin{bmatrix} D & E \\ F & G \end{bmatrix}}$$

Experimentally to keep CTEL constant, it was found that d(CP3) and d(CP466) were 100 and -414. These are the ORTHO constants at this operating point. One can use these constants and make a large change in CTEL expecting to keep C3TEL constant. If C3TEL does not stay constant, then this process could be repeated at this new point and the new ORTHO constants found.

This is the procedure one uses to find how "constant" the ORTHO constants are or to find the range over which the system has a linear response.

Each of the six constants D, E, F, G, H, & J must be found as before:

If CP466 and CP3 are constant; D = d(CTEL) / d(CP349)

The other constants are calculated in a similar manner.

The operator does not need to calculate these constants since the computer program TUNER will do the bookkeeping and calculations. The D, E, F ... constants can be calculated from a model of the system or from measurements on the accelerator.

The ORTHO constants are found as before. If one wants to vary these three power supplies to keep CTEL constant and only vary C3TEL, the following equation should be solved.

$$\begin{bmatrix} d(CP349) \\ d(CP466) \\ d(CP466) \end{bmatrix} = \frac{[M]^T * \begin{bmatrix} 0 \\ 100 \end{bmatrix}}{[M]^T * [M]}$$

These values of d(CP349), d(CP3), and d(CP466) are the ORTHO constants or give the values that each power supply must be changed to vary only C3TEL. To keep C3TEL constant while varying only CTEL, the following equation will be solved by the TUNER program.

$$\begin{bmatrix} d(CP349) \\ d(CP3) \\ d(CP466) \end{bmatrix} = \frac{[M]^T * \begin{bmatrix} 100 \\ 0 \end{bmatrix}}{[M]^T * [M]}$$