Chromaticity, Tune, and Coupling Drift and Snapback Correction Algorithms in the Tevatron

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Updates

The first version of this memo documented the chromaticity drift and snapback correction algorithms used at the start of Collider Run II.

The second version of the memo was updated to include the tune and coupling drift and snapback correction algorithms. The tune and coupling drift compensation was commissioned on 9/23/02 during Collider Run II.

This version (Version 3.0) of the memo documents the TCHROM program and the correction algorithms that were implemented in November 2004. Previously, the drift and snapback corrections were limited to Tevatron operations preceded by a 30 minute long "dry squeeze" with a 90 second long back porch. With the updates to TCHROM the drift and snapback can also be compensated correctly for Tevatron operations preceded by a flattop of greater than 1 hour long with a 5 minute long back porch. This is used to reduce the shot setup time by eliminating the need for an intervening 30 minute "dry squeeze" between stores. This mode of operation was successfully tested during shot setup for store 3745 on 8/22/04.

There are three main differences in the updated TCHROM and correction algorithms:
- The quartic polynomial snapback function at the start of acceleration is replaced by a Gaussian function of time.
- There are two (or more) sets of parameters used in the correction algorithms. The first set is used whenever the Tevatron performs a dry squeeze between stores. The second set is used when a shot setup is performed directly after a store without an intermediate dry squeeze pre-cycle. Other sets of parameters can be used for studies.
- To be compatible with all expected Tevatron operations, the functional forms of the algorithms have been modified.

Introduction

Drifts in the chromaticity, tunes, and coupling are observed in the Tevatron at 150 GeV. A snapback effect of these parameters is also observed at the start of the Tevatron energy ramp. Without compensation the chromaticity changes by ~50 units, the tunes by ~0.01 units, and the coupling by ~0.02 minimum tune split over about 2 hours while the Tevatron is at 150 GeV. By applying a time varying corrections to the Tevatron trim magnets we are able to compensate for the drifts and reduce their magnitude to ~2 units in the chromaticity, ~0.002 units in the tune, and ~0.003 units in the minimum tune split.

The known cause of the chromaticity drift and snapback is the time varying sextupole fields from persistent currents in the Tevatron dipole magnets. The magnitude of this drift and snapback has been measured and an algorithm was developed to compensate for these drifts by applying a time varying current to the sextupole corrector magnets. The algorithm is implemented in hardware via an applications program called TCHROM that calculates time varying functions and loads the Tevatron hardware with the appropriate settings.

In Collider Run II tune and coupling drifts at 150 GeV and the corresponding snapback at the start of the Tevatron energy ramp are also observed. After making measurements to quantify the magnitude of these drifts, additional hardware was installed to compensate for the tune and coupling drifts and the applications program TCHROM was expanded to include these algorithms. The tune and coupling drift and snapback compensation was commissioned on 9/23/02 .[1]

Later in Collider Run II, algorithms were developed for the chromaticity, tune, and coupling drift on the 150 GeV front porch and the snapback at the start of the ramp after a long flattop and a 5 minute back porch after a store without an intermediate "dry squeeze" pre-cycle. The changes to the algorithms are based on MTF measurements of the b2 drift behavior of Tevatron magnets after long flattops (> 1 hour) with a 5 minute long back porch time and recent measurements with beam in the Tevatron.[2]

When updating the algorithms several assumptions were made based on the MTF measurements and the beam based studies. First, a more accurate description of the observed drift on the front porch is given by the form in Equation 1.

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[1]J. Annala, P. Bauer, M. Martens*, "Commissioning of the Tune Drift Compensations System in the Tevatron",* Fermilab Beams Division Internal Document, Beams-doc-475, March 2003. Available online at beamdocs.fnal.gov/cgi-bin/public/DocDB/ShowDocument?docid=475

[2] G. Annala, P. Bauer, M. Martens, D. Still, G. Velev, *"Tevatron Chromaticity and Tune Drift and Snapback Studies Report,"* Fermilab Beams Division Internal Document, Beams-doc-1236, November 2004. Available online at beamdocs.fnal.gov/cgi-bin/public/DocDB/ShowDocument?docid=1236

Equation 1

$$b_2(t) = m \times \ln\left(\frac{t+c}{c}\right)$$

This form is based on MTF measurements of the b2 drift showing that the drift was not a pure logarithm. In this form the amount of b2 drift at the start of the front porch is zero at time t = 0. The form of the algorithm used by TCHROM is given in Equation 2

Equation 2

$$b_2(t) = b_{2i} + m \times \ln(t+c)$$

We note that the new form of the b2 drift in Equation 1 can be expressed terms of the previous form in Equation 2 by making the substitution $b_{2i} = -m \times \ln(c)$. Therefore we can continue to use the form given in Equation 2 for the TCHROM algorithms.

Secondly, MTF measurements of Tevatron magnets suggest that the constant c is equal to 328 seconds, but beam measurements in the Tevatron show that c = 170 seconds gives a better fit to the observed drift. The choice of 170 seconds which is determined from fits of the b2 measurements in the Tevatron is assumed to apply to the tune and coupling drift as well. For the tune drift the measured data in the Tevatron suggests this assumption is correct.

Finally, we choose to set the offset in the drift compensations equal to zero. Again this is based on MTF data and the belief that the drift compensation should start a zero at time t = 0. Without this choice an arbitrary offset could be applied to the algorithm which would be compensated by changes in the 150 GeV values of the chromaticity, tune, and coupling parameters for the Tevatron ramp.

In the next sections we document the specifics of the correction system which has three major parts:

- Hardware, including CAMAC 465 modules and voltage summing modules, to drive the trim corrector magnet power supplies.
- The TCHROM Open Access Client (OAC) program. THCROM responds to Tevatron states variables and TCLK events and then loads the CAMAC 465 cards with waveforms to compensate for the drifts in the Tevatron.
- A database of parameters which is used by the TCHROM to determine the type and amount of correction to be applied.

Hardware for the Drift and Snapback Correction

The current supplied to the trim sextupole magnets is the sum of two terms: 1) a term to set the desired chromaticity (this includes compensation for the geometric and hysteretic b_2 in the dipoles, and the natural chromaticity of the Tevatron) and 2) a term to compensate for the time dependence and snapback of the b_2 component of the Tevatron dipoles. The current for the first term is controlled with the CAMAC 467 cards labeled T:SF and T:SD. The current for the second term, the time dependent portion, is controlled with the CAMAC 465 cards labeled C:SFB2 and C:SDB2. The voltage outputs of these cards are summed together to provide a reference voltage for the SF and SD power supplies. A sketch of the hardware hookup is shown in Figure 1.
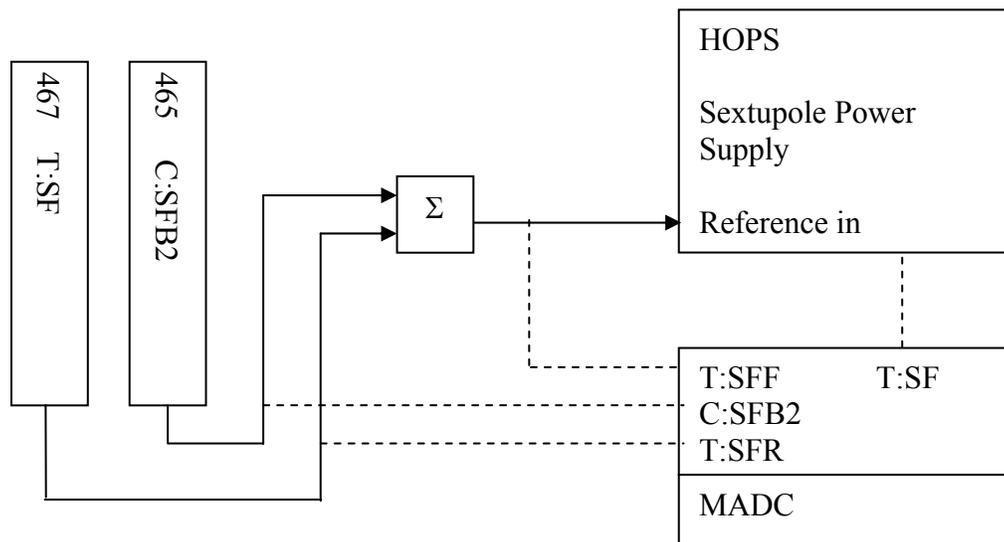

Figure 1 Sketch of the installation at the C3 house for controlling the SF chromaticity sextupole correction power supply. The reference voltage from the T:SF card and the C:SFB2 card are added together with a summing module. The output of the summing module is input to the power supply controller for the SF circuit. A similar hookup exists at the C4 house for the SD magnets.

The sextupole current for the first term is loaded into the T:SF and T:SD CAMAC cards through the applications program C49 that controls most of the major circuits in the Tevatron. The sextupole current for the time dependent term is loaded into the C:SFB2 and C:SDB2 CAMAC cards via the open access client (OAC) program called TCHROM. The choice of algorithms is based on magnet and beam based measurements and is not discussed here. Instead we limit ourselves to documenting the algorithms that are used.

Similarly, the current supplied to the tune and coupling trim circuits is the sum of two terms: 1) a term to set the desired tunes and coupling, and 2) a term to compensate for the time dependence and snapback of the tune and coupling. The current for the first term is controlled with the CAMAC 467 cards labeled T:QFA4, T:QDD1, T:SQ, and T:SQA0. The current for the second term, the time dependent portion, is controlled with the CAMAC 465 cards labeled C:QFB2, C:QDB2, C:SQB2, and C:SQ0B2. The outputs of these cards are summed together to provide a reference voltage for the QFA4, QDD1, SQ, and SQA0 power supplies. A sketch of the hardware hookup is shown in Figure 2

The new summing modules have a long term drift of not more than 100 ppm ($\pm$0.01%), and the absolute accuracy of the output no worse than $\pm$0.1%). The modules in C3 and C4 take TWINAX as one of the inputs signals, and the summed output. The other input, and the output to the MADC are limo. Staying with this configuration is not necessary, as long as we make up the correct jumper cables so the new modules can plug right in at C3 or C4.
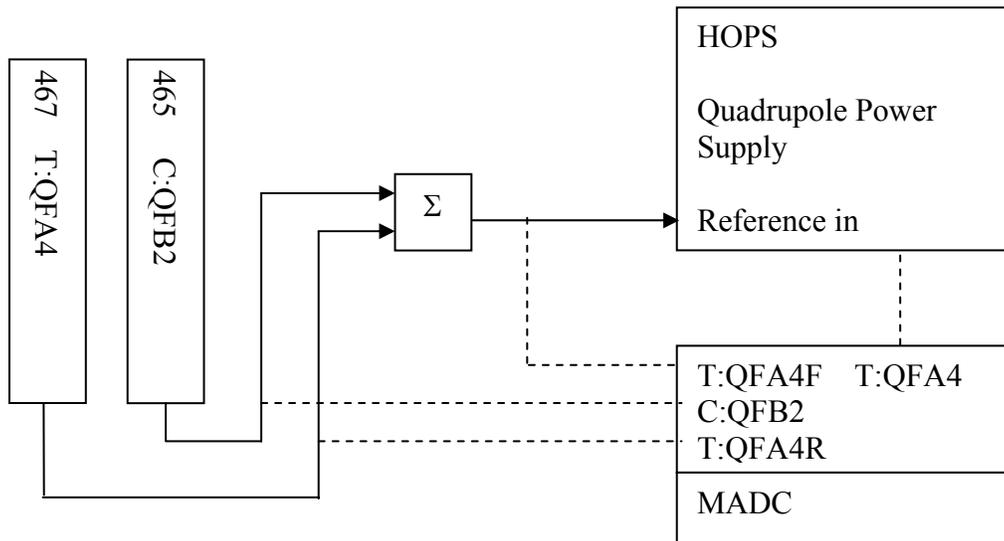

Figure 2 Sketch of the installation at A4 house for controlling the QFA4 trim quadrupole power supply. The reference voltage from the T:QFA4 card and the C:QFB2 card are added together with a summing module. The output of the summing module is input to the power supply controller for the QFA4 circuit. A similar hookup exists for the QDD1 (at the D1 house), the SQ (at the B2 house), and the SQA0 (at the A4 house) magnets.

The quadrupole current for the first term is loaded into the T:QFA4, T:QDD1, T:SQ, and T:SQA0 CAMAC cards through the applications program C49 that controls most of the major circuits in the Tevatron. The quadrupole current for the time dependence term is loaded into the C:QFB2, C:QDB2, C:SQB2, and C:SQ0B2 CAMAC cards via the open access client (OAC) program called TCHROM. The choice of algorithms is based on beam measurements and is not discussed here. Instead we limit ourselves to documenting the algorithm that is used.

Parameters for Algorithms in TCHROM.

When determining the amount of correction to apply to the Tevatron, TCHROM will access a database table to determine the parameters of the correction algorithms.[3] The functional form of the correction applied by TCHROM is the same, but which set of parameters is used depends on the mode of Tevatron operations.

A list of the parameters used by TCHROM is given in Table 1. Those values in the column with **parameter_version = 1** are for Tevatron operations following a 30-minute dry squeeze. Those values in the column with **parameter_version = 2** are for Tevatron operations following a flattop longer than 1 hour, a 5 minute back porch, and without an intervening dry squeeze.

In addition to the parameters listed in Table 1, there are several parameters relevant to the history of the Tevatron ramp that are monitored and recorded by THCROM. These are:

- The flattop time, T_{FT}, is the time (in seconds) spent on the previous flattop
- The back porch time, T_{BP}, is the time (in seconds) spent on the previous back porch
- The front porch time, T_{FP}, is the time spent on the 150 GeV front porch just before accelerating.

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[3] The database table is annala.tchrom_constants in the appdb database on the ADBS databse server.

Table 1: Parameter names and values for TCHROM. Those values in the column with **parameter_version = 1** are for Tevatron operations following a 30-minute dry squeeze. Those values in the column with **parameter_version = 2** are for Tevatron operations following a flattop longer than 1 hour without an intervening squeeze.

parameter_version	1	2
b2_to_sf_current	-0.4965	-0.4965
b2_to_sd_current	-0.765	-0.765
bp_b2i_slope	0.082	0.082
bp_b2m_intercept	-0.196	0.196
bp_b2m_slope	0.024	0.024
bp_b2c_const	20.0	20.0
fp_b2i_intercept	0.0	-2.383
fp_b2i_bpslope	0.04	0.0
fp_b2i_ftslope_1	0.161	0.0
fp_b2i_ftslope_2	0.0277	0.0
fp_b2m_intercept	0.342	0.4586
fp_b2m_slope	0.0208	0.0
fp_b2m_constant	0.0	170.0
sb_b2_time_constant_1	0.0606	0.0606
sb_b2_time_constant_2	0.0682	0.0682
sb_b2_time	0.0	0.0
decel_b2_time	5.0	5.0
htune_to_qf_current	10.747	10.747
vtune_to_qf_current	2.9797	2.9797
htune_to_qd_current	-2.746	-2.746
vtune_to_qd_current	-10.28	-10.28
fp_htune_intercept	-0.00778	-0.0208
fp_htune_slope	0.0019	0.00405
fp_htune_const	0.0	170.0
fp_vtune_intercept	0.0127	0.0256
fp_vtune_slope	-0.0031	-0.00498
fp_vtune_const	0.0	170.0
sb_tune_time_constant_1	0.0606	0.0606
sb_tune_time_constant_2	0.0682	0.0682
sb_tune_time	0.0	0.00
ksq_to_sq_current	9.47	9.47
ksq0_to_sq_current	0.0	0.0
ksq_to_sq0_current	0.0	0.0
ksq0_to_sq0_current	122.0	122.0
fp_ksq_intercept	0.025	0.03419
fp_ksq_slope	-0.0061	-0.00665
fp_ksq_const	0.0	170.0
fp_ksq0_intercept	0.0	0.0
fp_ksq0_slope	0.0	0.0
fp_ksq0_const	0.0	170.0
sb_coupling_time_constant_1	0.0606	0.0606
sb_coupling_time_constant_2	0.0682	0.0682
sb_coupling_time	0.0	0.0

THCROM Correction Algorithms

TCHROM uses algorithms to calculate the chromaticity, tune and coupling corrections for the Tevatron when the Tevatron is in the following states:
- Front porch
- Acceleration
- Deceleration
- Back Porch.

Presently, only the algorithms for the Front Porch drift and the Acceleration snapback are tuned up for Tevatron operations. The Deceleration and Back Porch algorithms are not needed but were included in anticipation of pbar recycling operations.

For each Tevatron state, the amount of chromaticity correction, $b_2(t)$, the amount of tune correction, $\Delta\nu_x(t)$ and $\Delta\nu_y(t)$, and the amount of coupling correction, $\Delta\kappa_{SQ}(t)$ and $\Delta\kappa_{SQ0}(t)$, are all functions of time. The functions used for each Tevatron state are given in the following subsections.

Using these correction functions and parameters from the database, TCHROM scales the currents needed in the 465 CAMAC cards C:SFB2 and C:SDB2 for the chromaticity correction, C:QFB2 and C:QDB2 for the tune correction, and C:SQB2 and C:SQ0B2 for the coupling correction according Equation 3 through Equation 5.

Equation 3

$$I_{SFB2}(Amps) = (b2\_to\_sf\_current) \times b_2(t)$$
$$I_{SDB2}(Amps) = (b2\_to\_sd\_current) \times b_2(t)$$

Equation 4

$$I_{QFB2}(Amps) = (htune\_to\_qf\_current) \times \Delta\nu_x(t) + (vtune\_to\_qf\_current) \times \Delta\nu_y(t)$$
$$I_{QDB2}(Amps) = (htune\_to\_qd\_current) \times \Delta\nu_x(t) + (vtune\_to\_qd\_current) \times \Delta\nu_y(t)$$

Equation 5

$$I_{SQB2}(Amps) = (ksq\_to\_sq\_current) \times \Delta\kappa_{SQ}(t) + (ksq0\_to\_sq\_current) \times \Delta\kappa_{SQ0}(t)$$
$$I_{SQ0B2}(Amps) = (ksq\_to\_sq0\_current) \times \Delta\kappa_{SQ}(t) + (ksq0\_to\_sq0\_current) \times \Delta\kappa_{SQ0}(t)$$

For example, in Equation 3 the amount of sextupole drift, $b_2(t)$, is a function of time with a functional form that depends on the state of the Tevatron. The parameters **b2_to_sf_current** and **b2_to_sd_current** are coefficients used to convert $b_2(t)$ into currents in the trim sextupole correctors. The values of the parameters **b2_to_sf_current** and **b2_to_sd_current** are defined in a database table along with other parameters. See Table 1 for a complete list of parameters and their values. Note that the values of the parameters will change depending on which row of the database table is used.

The functional form of the compensations $b_2(t)$, $\Delta\nu_x(t)$, $\Delta\nu_y(t)$, $\Delta\kappa_{SQ}(t)$ and $\Delta\kappa_{SQ0}(t)$ depend on the history of the Tevatron ramp and the state of the Tevatron. In the next sections the functional forms are defined for each of the Tevatron states.

On the Front Porch

On the Front Porch $b_2(t)$ has the form

Equation 6

$$b_2(t) = b_{2i} + m \times \ln(t + c)$$

where t is the time (in seconds) since the start of the 150 GeV front porch. The individual terms in Equation 6 are calculated as shown in Equation 7 through Equation 9.

Equation 7

$$
\begin{aligned}
b_{2i} \;=\; & (\text{fp\_b2i\_bpslope}) \times \ln(T_{BP} / 60) \\
& - \left[(\text{fp\_b2i\_ftslope\_1}) - (\text{fp\_b2i\_ftslope\_2}) \times \ln(T_{BP} / 60)\right] \times \ln(T_{FT}) \\
& + (\text{fp\_b2i\_intercept})
\end{aligned}
$$

Equation 8

$$m = (\text{fp\_b2m\_intercept}) - (\text{fp\_b2m\_intercept}) \times \left[2 \times \ln(T_{BP}) - \ln(T_{FT})\right]$$

Equation 9

$$c = (\text{fp\_b2m\_constant}).$$

In these equations, T_{FT} is the number of seconds spent on the previous flattop, and T_{BP} is the number of seconds spent on the previous back porch. The values of the parameters in these equations are determined from Table 1.

On the Front Porch the tune and coupling corrections have the form

Equation 10

$$\Delta v_x(t) = n_{xi} + m_x \times \ln(t + c_x)$$

$$\Delta v_y(t) = n_{yi} + m_y \times \ln(t + c_y)$$

$$\Delta\kappa_{SQ}(t) = n_{SQi} + m_{SQ} \times \ln(t + c_{SQ})$$

$$\Delta\kappa_{SQ0}(t) = n_{SQ0i} + m_{SQ0} \times \ln(t + c_{SQ0})$$

where t is the time (in seconds) since the start of the 150 GeV front porch. The terms in Equation 10 are calculated as in Equation 11.

Equation 11

$$n_{xi} = (fp\_htune\_int ercept) \quad m_x = (fp\_htune\_slope) \quad c_x = (fp\_htune\_cons\tan t)$$
$$n_{yi} = (fp\_vtune\_int ercept) \quad m_y = (fp\_vtune\_slope) \quad c_y = (fp\_vtune\_cons\tan t)$$
$$n_{SQi} = (fp\_ksq\_int ercept) \quad m_{SQ} = (fp\_ksq\_slope) \quad c_{SQ} = (fp\_ksq\_cons\tan t)$$
$$n_{SQ0i} = (fp\_ksq0\_int ercept) \quad m_{SQ0} = (fp\_ksq0\_slope) \quad c_{SQ0} = (fp\_ksq0\_cons\tan t)$$

(Note: Even though some of the constants in Equation 10 and Equation 11 are zero they may change to some non-zero value in the future which explains why they are included.

The Acceleration Ramp (snapback or unwind)

The b_2 snapback that occurs at start of the Tevatron energy ramp (event $42) has a Gaussian form

Equation 12

$$b_2(t) = b_{2,start} \times e^{-(t/T_{CHROM})^2}$$

where the value of $b_{2,start}$ is the value of $b_2(t)$ at the end of the front porch as given in Equation 13

Equation 13

$$b_{2,start} = b_2(T_{FP}) = b_{2i} + m \times \ln(T_{FP} + c)$$

where T_{FP} is the time (in seconds) spent on the front porch before accelerating. The value of T_{FP} is calculated just before the start of the Tevatron ramp and then TCHROM recalculates Equation 12 and loads the values into the CAMAC 465 time table. The value of $b_{2,start}$ can also be calculated by using the current in the C:SDB2 corrector at the time of the end of the front porch

Equation 14

$$b_{2,start} = \frac{I_{SD}(t = T_{FP})}{(b2\_to\_sd\_current)}$$

The time constant, T_{CHROM}, for the Gaussian snapback in Equation 12 is a function of $b_{2,start}$ (and therefore indirectly a function of the time spent on the front porch.) The value of T_{CHROM} is calculated as in Equation 15 just before the start of acceleration.

Equation 15

$$T_{chrom} = \sqrt{\frac{b_{2,start} - (sb\_b2\_time\_const\_1)}{(sb\_b2\_time\_const\_2)}} + (sb\_b2\_time)$$

For the tune and coupling snapbacks, each of the four drifts, $\Delta\nu_x(t)$, $\Delta\nu_y(t)$, $\Delta\kappa_{SQ}(t)$ and $\Delta\kappa_{SQ0}(t)$ has its own snapback time table which also follow a Gaussian function of time as shown in Equation 16.

Equation 16

$$\Delta\nu_x(t) = \Delta\nu_{x,start} \times e^{-(t/T_{TUNE})^2}$$

$$\Delta\nu_y(t) = \Delta\nu_{y,start} \times e^{-(t/T_{TUNE})^2}$$

$$\Delta\kappa_{SQ}(t) = \kappa_{SQ,start} \times e^{-(t/T_{COUP})^2}$$

$$\Delta\kappa_{SQ0}(t) = \kappa_{SQ0,start} \times e^{-(t/T_{COUP})^2}$$

The only parameters that are input to these time table calculations are the starting values and the time constant for the Gaussian snapback which are shown in Equation 17 and Equation 18.

Equation 17

$$\Delta\nu_{x,start} = \Delta\nu_x(T_{FP}) = n_{xi} + m_x \times \ln(T_{FP} + c_x)$$

$$\Delta\nu_{y,start} = \Delta\nu_y(T_{FP}) = n_{yi} + m_y \times \ln(T_{FP} + c_y)$$

$$\Delta\kappa_{SQ,start} = \Delta\kappa_{SQ}(T_{FP}) = n_{SQi} + m_{SQ} \times \ln(T_{FP} + c_{SQ})$$

$$\Delta\kappa_{SQ0,start} = \Delta\kappa_{SQ0}(T_{FP}) = n_{SQ0i} + m_{SQ0} \times \ln(T_{FP} + c_{SQ0})$$

Equation 18

$$T_{tune} = \sqrt{\frac{\Delta\nu_{x,start} - (sb\_tune\_time\_const\_1)}{(sb\_tune\_time\_const\_2)}} + (sb\_tune\_time)$$

$$T_{coup} = \sqrt{\frac{\Delta\kappa_{SQ,start} - (sb\_coup\_time\_const\_1)}{(sb\_coup\_time\_const\_2)}} + (sb\_coupling\_time)$$

NOTE: The algorithms for the Back Porch and the Deceleration are not yet documented in this memo.

On the Back Porch

On the Back Porch $\langle b_2 \rangle$ has the form

Equation 19

$$b_2(t) = b_{2i} + m \times \ln(t + c)$$

where t is the time (in seconds) since the start of the 150 GeV back porch. The terms in Equation 19 are calculated as

Equation 20

$$b_{2i} = (bp\_b2i\_slope) \times \ln(T_{FT})$$

Equation 21

$$m = (bp\_b2m\_intercept) - (bp\_b2m\_slope) \times \ln(T_{FT})$$

Equation 22

$$c = (bp\_b2c\_constant)$$

where T_{FT} is the number of seconds spent on the previous flattop.
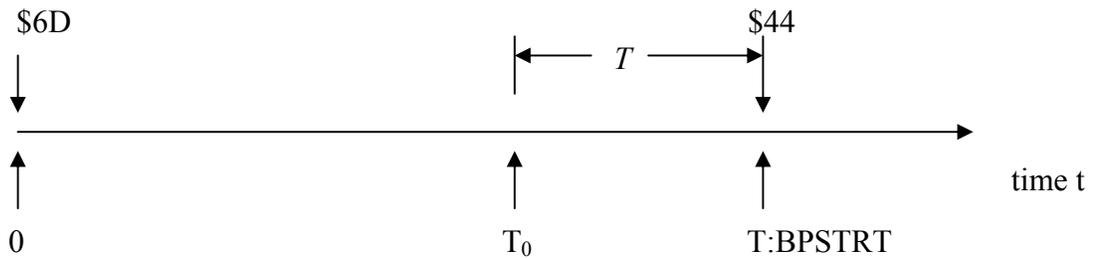
The Deceleration Ramp

The deceleration ramp has a time table that starts at zero and ends up at b_2 at the start of the back porch. The reason for this ramp is to smoothly connect the back porch table with the deceleration ramp. This ramp is triggered by event \$6D and the final value for the ramp is b_2 (t=0) for the back porch H-table (this is not b_{2i} on the back porch - we will call this value b_{2f}). The only parameter that will be an input to the time table calculation will be the ramp length (*T*).

In order to calculate the table, the OAC needs to know the length of the deceleration ramp (T:BPSTRT). The time ramp should be all zeros until time = (T:BPSTRT - *T*) (we will call this time T_0). From time t = T_0 until t = T:BPSTRT the time table will be calculated as

Equation 23

$$b_2 = b_{2f} \times (t - T_0)^2 / T^2$$

This diagram describes the times involved in this calculation. $6D is defined to occur at time 0.

Test mode loading of the sextupoles can be done by setting a value to T:CHRCOM. Setting this device will force a download of the B2 devices as if the proper state change had taken place. The values to load specific ramps are:
1 ->load front porch curve, 2 -> load unwind (snap back) curve, 3 -> load back porch match curve, 4 -> load back porch curve, 5 -> clear load status

TCHROM Commands

Here are the values that can be passed to the command device (T:CHRCOM)

COMMAND_LOAD_FP	1	/* load front porch B2 min table */
COMMAND_LOAD_UNWIND	2	/* load unwind table */
COMMAND_LOAD_BP_MATCH	3	/* load back porch match table */
COMMAND_LOAD_BP	4	/* load back porch B2 min table */
COMMAND_CLEAR_LOAD_STATUS	5	/* clear load status */
COMMAND_LOAD_TUNE_FP	6	/* load tune front porch table */
COMMAND_LOAD_TUNE_UNWIND	7	/* load tune unwind table */
COMMAND_LOAD_TUNE_BP_MATCH	8	/* load tune back porch match table */
COMMAND_LOAD_TUNE_BP	9	/* load back porch tune table */
COMMAND_CLEAR_TUNE_LOAD_STATUS	10	/* clear coupling load status */
COMMAND_LOAD_COUPLING_FP	11	/* load coupling front porch table */
COMMAND_LOAD_COUPLING_UNWIND	12	/* load coupling unwind table */
COMMAND_LOAD_COUPLING_BP_MATCH	13	/* load coupling back porch match table */
COMMAND_LOAD_COUPLING_BP	14	/* load back porch coupling table */
COMMAND_CLEAR_COUPLING_LOAD_STATUS	15	/* clear coupling load status */
COMMAND_READ_CALC_CONSTANTS	16	/* read constants from the database */
COMMAND_USE_ALT_UNWIND	17	/* use alternate unwind calculation */
COMMAND_NORMAL_ALT_UNWIND	18	/* use normal unwind calculation algorithm */

TCHROM database table

```
use appdb
go

drop table martens.tchrom_constants
go

create table martens.tchrom_constants
(
 parameter_version              int                not null  unique,
 b2_to_sf_current               double precision   not null,
 b2_to_sd_current               double precision   not null,
 bp_b2i_slope                   double precision   not null,
 bp_b2m_intercept               double precision   not null,
 bp_b2m_slope                   double precision   not null,
 bp_b2c_const                   double precision   not null,
 fp_b2i_intercept               double precision   not null,
 fp_b2i_bpslope                 double precision   not null,
 fp_b2i_ftslope_1               double precision   not null,
 fp_b2i_ftslope_2               double precision   not null,
 fp_b2m_intercept               double precision   not null,
 fp_b2m_slope                   double precision   not null,
 fp_b2m_constant                double precision   not null,
 sb_b2_time_constant_1          double precision   not null,
 sb_b2_time_constant_2          double precision   not null,
 sb_b2_time                     double precision   not null,
 decel_b2_time                  double precision   not null,
 htune_to_qf_current            double precision   not null,
 vtune_to_qf_current            double precision   not null,
 htune_to_qd_current            double precision   not null,
 vtune_to_qd_current            double precision   not null,
 fp_htune_intercept             double precision   not null,
 fp_htune_slope                 double precision   not null,
 fp_htune_const                 double precision   not null,
 fp_vtune_intercept             double precision   not null,
 fp_vtune_slope                 double precision   not null,
 fp_vtune_const                 double precision   not null,
 sb_tune_time_constant_1        double precision   not null,
 sb_tune_time_constant_2        double precision   not null,
 sb_tune_time                   double precision   not null,
 ksq_to_sq_current              double precision   not null,
 ksq0_to_sq_current             double precision   not null,
 ksq_to_sq0_current             double precision   not null,
 ksq0_to_sq0_current            double precision   not null,
 fp_ksq_intercept               double precision   not null,
 fp_ksq_slope                   double precision   not null,
 fp_ksq_const                   double precision   not null,
 fp_ksq0_intercept              double precision   not null,
 fp_ksq0_slope                  double precision   not null,
 fp_ksq0_const                  double precision   not null,
 sb_coupling_time_constant_1    double precision   not null,
 sb_coupling_time_constant_2    double precision   not null,
 sb_coupling_time               double precision   not null
)
go

grant select on martens.tchrom_constants to appdb_isql, appdb_readonly
go

grant select, update, insert, delete on martens.tchrom_constants to annala
go

grant select, update, insert, delete on martens.tchrom_constants to hendricks
go
```

```
insert into martens.tchrom_constants values (
   1,
 -0.4965,
 -0.765,
  0.082,
 -0.196,
  0.024,
 20.0,
  0.0,
  0.04,
  0.161,
  0.0277,
  0.342,
  0.0208,
  0.0,
  0.0606,
  0.0682,
  0.0,
  5.0,
 10.747,
  2.9797,
 -2.746,
-10.28,
 -0.00778,
  0.0019,
  0.0,
  0.0127,
 -0.0031,
  0.0,
  0.0606,
  0.0682,
  0.0,
  9.47,
  0.0,
  0.0,
 122.0,
  0.025,
 -0.0061,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0606,
  0.0682,
  0.0
)
go
```

```
insert into martens.tchrom_constants values (
  2,
 -0.4965,
 -0.765,
  0.082,
  0.196,
  0.024,
 20.0,
 -2.383,
  0.0,
  0.0,
  0.0,
  0.4586,
  0.0,
170.0,
  0.0606,
  0.0682,
  0.0,
  5.0,
 10.747,
  2.9797,
 -2.746,
-10.28,
 -0.0208,
  0.00405,
170.0,
  0.0256,
 -0.00498,
170.0,
  0.0606,
  0.0682,
  0.00,
  9.47,
  0.0,
  0.0,
122.0,
  0.03419,
 -0.00665,
170.0,
  0.0,
  0.0,
170.0,
  0.0606,
  0.0682,
  0.0
)
go
```