Incorporating MTF Data into Tevatron Operations

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Summary of b2 correction before Fall shutdown

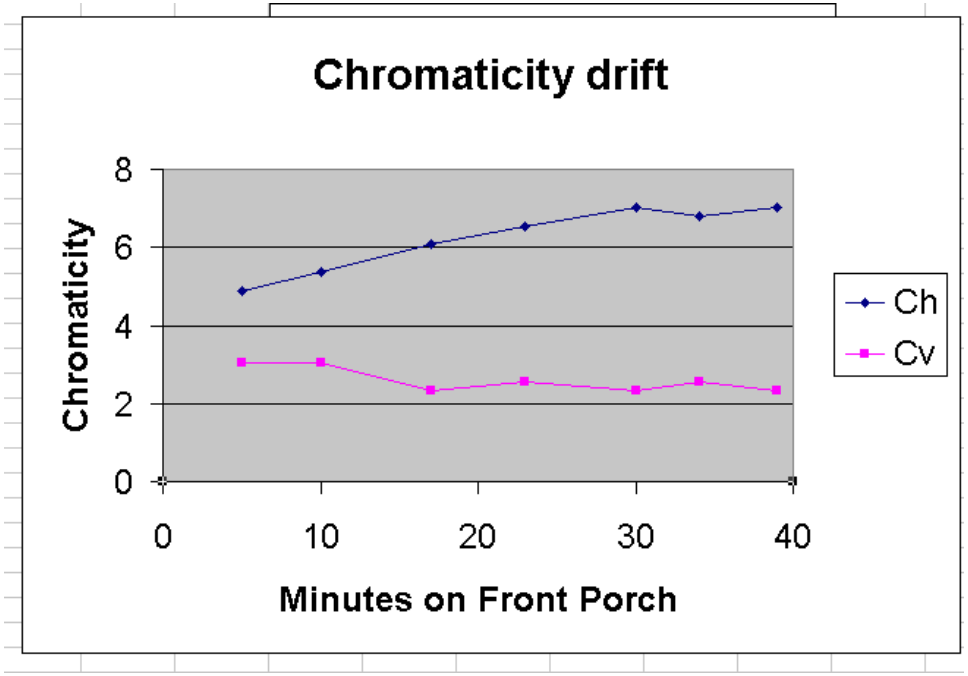
- Standard Shot Setup:
  - 20-minute dry squeeze between stores
  - ~90 sec back porch time, but not precisely controlled
  - Six ramps + 20 minute dry squeeze after quench.
- Front Porch:
  - b2 correction keeps $\Delta\xi$ < ~2 units.
  - b2 algorithm is f(Flattop Time, Back Porch Time)
  - Tune correction keeps $\Delta\nu < 0.001$, $\Delta\nu_{min} < 0.003$
  - Tune correction algorithm fixed for standard ramp
- b2 and tune drift snapback:
  - Uses $b2_0*[1-(T/T_0)^2]^2$, T_0 = 6 secs

Major Changes to Tevatron during shutdown

These changes may have affected the b2 and tune drift compensation:

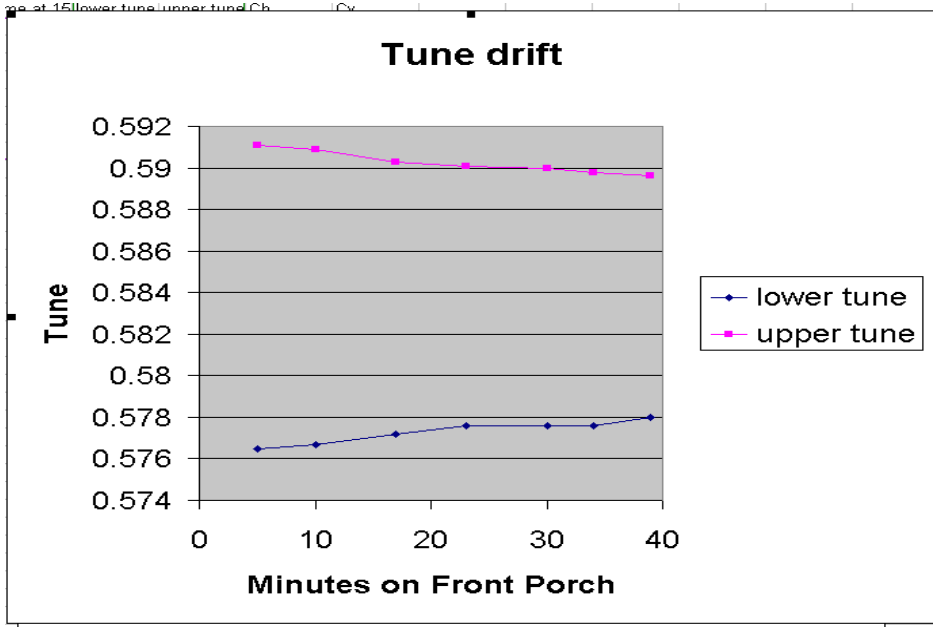
- o Re-shimming of ~106 dipoles to reduce a1.
- o Unroll ~30? Dipoles.
- o Changed RF frequency by -15 Hz, (and horz orbit)
- o Moved B0 Low beta quadrupoles ~2 mm, and orbits at B0 IR by ~3.5 mm.

After shutdown



Initial measurements show somewhat larger drift in chromaticity

After shutdown



Measured tune drift with compensation active.

Need a more complete study including measurement of coupling.

Initial measurements show larger tune drift than before the shutdown.

Suggested Changes

- Better control of back porch time. (Change in the Sequencer)
- Lengthen Back Porch time. From ~90 seconds to 300 secs?
- Eliminate dry squeeze sequence
- Update b2 algorithm for front porch compensation.
- Switch snapback from polynominal to gaussian form.

Time on Back Porch

One of the largest impacts on the b2 drift and snapback is the time spent on the back porch preceding the 90 Gev reset ramp. The amount of b2 drift on the front porch changes significantly as a function of the backporch time, especially when the backporch time is shorter than 5 minutes. Presently, the back porch time for the Tevatron is about 90 seconds, but it is not controlled precisely. The actual time depends on manual interupts in the sequencer during shot setup.

It makes sense to change the Tevatron sequencer to control the backporch time so that it is repeatable from shot setup to shot setup. The time spent on the back porch should also be increased from ~90 seconds to ~5 minutes since this reduces the amount of b2 drift on the front porch. With a more consistent back porch time we may be able to eliminate the chromaticity measurement and adjustment during shot setup. (An error in the calculation of the back porch time by the TCHROM OAC has also been noted and should be fixed. There is also a small error in the snapback algorithm which could be corrected.)

Time on Back Porch

Steps for Modifying the Back Porch Time

o Change to Tevatron operating sequence.
(Change almost compete and ready for testing.)

o Switch from ~90 sec BP time to ~5 min BP time

o Study to measure b2 drift with new BP time.
(Approximately 1 shift of beam time.)

Is b2 drift algorithm valid for different BP time?

Can algorithm be improved with new MTF info?

How is tune drift affected by change in BP Time?

B2 snapback

Careful measurements of the b2 snapback in the Tevatron magnets shows that the snapback follows a gaussian function exp[(-t/t0)2] with a time constant t0 of about 10 seconds. Presently, in the Tevatron we calculate a snapback correction using the function [1-(t/t0)2]^2 with a time constant t0 of 6 seconds. (Data on the tune drift snapback also suggests that the time constant is closer to 10 seconds than 6 seconds.) Thus an improvement in the snapback correction can be made by changing the function used to calculate the snapback and increasing the time constant from 6 to 10 seconds.

B2 snapback

Steps for Modifying b2 snapback

o Update the TCHROM program which calculates the b2 snapback correction. (Relatively simple change to use $b2(t)=b20*\exp[(t/Tau(b2drift)^2]$ instead of $b20*[1-(T/T0)^2]^2$

o Should be OK to "just use", but verify with test beam.
Tev and MTF data both suggest this change is OK.

o Separate study to carefully measure b2 snapback with longer BP time, new snapback function, no dry squeeze. Requires several (~3 shifts of beam measurements.)

For present operations the present algorithm is fine. This will become more important as we run with lower chromaticity.

Assumes tune/coupling snapback follows the same function?

Eliminate Dry Squeeze

It appears from magnet measurements that the flattop time is not a large effect whenever the flattop time is greater than 60 minutes. This means it should be possible to implement a b2 correction scheme which allows us to eliminate the 30 minute dry squeeze sequence between stores that are ended intentionally and without a quench. The magnet measurement data suggests that the variation of b2 drift on the front porch depends less on the flattop time than the currently implemented algorithm. Therefore it may be possible to modify the b2 correction algorithm for flattop times greater than 60 minutes. Eliminating the needed for the 30 minute dry squeeze can reduce the shot setup time and improve the integrated luminosity.

Eliminate Dry Squeeze

Steps for Eliminating the Dry Squeeze

- Recommend the we implement the BP Time and new snapback first?
- Update the b2 drift algorithm based on MTF data.
- Test with proton only stores.

Requires us to give up the comfort of the old ways.

Assumes that the tune and coupling drift behave as do the b2 drifts?

Eliminate Ramps after quench

The magnet measurements suggest that the number of ramps after a quench may not be important. This disagrees with Tevatron experience from years ago, but may be worth investigating. If the currently used six ramps after a quench could be reduced to one it would reduce startup time after a quench.

Required Work

- o Modify Sequencer Aggregate to lengthen and control back porch time.
- o Change ramp procedure after quench.
- o Re-measure tune and coupling drift. (Requires beam study)
- o Eliminate dry squeeze. (Requires beam study)
- o Update TCHROM OAC to use new snapback function.
- o Update b2 algorithm for front porch compensation.
- o Careful re-measurement of b2 and tune drift and snapback. (Requires beam study.)

Conclusion

o Recent MTF measurements have provided useful insight and suggest changes for improvement in the Tevatron.

o Outline of plan for implementing the changes exists

o More work needed to make a detailed plan and to implement the changes.

o Beam studies are a necessary part of the changes.