

# **Q(t) and Q'(t) during the Ramp – revisited –**

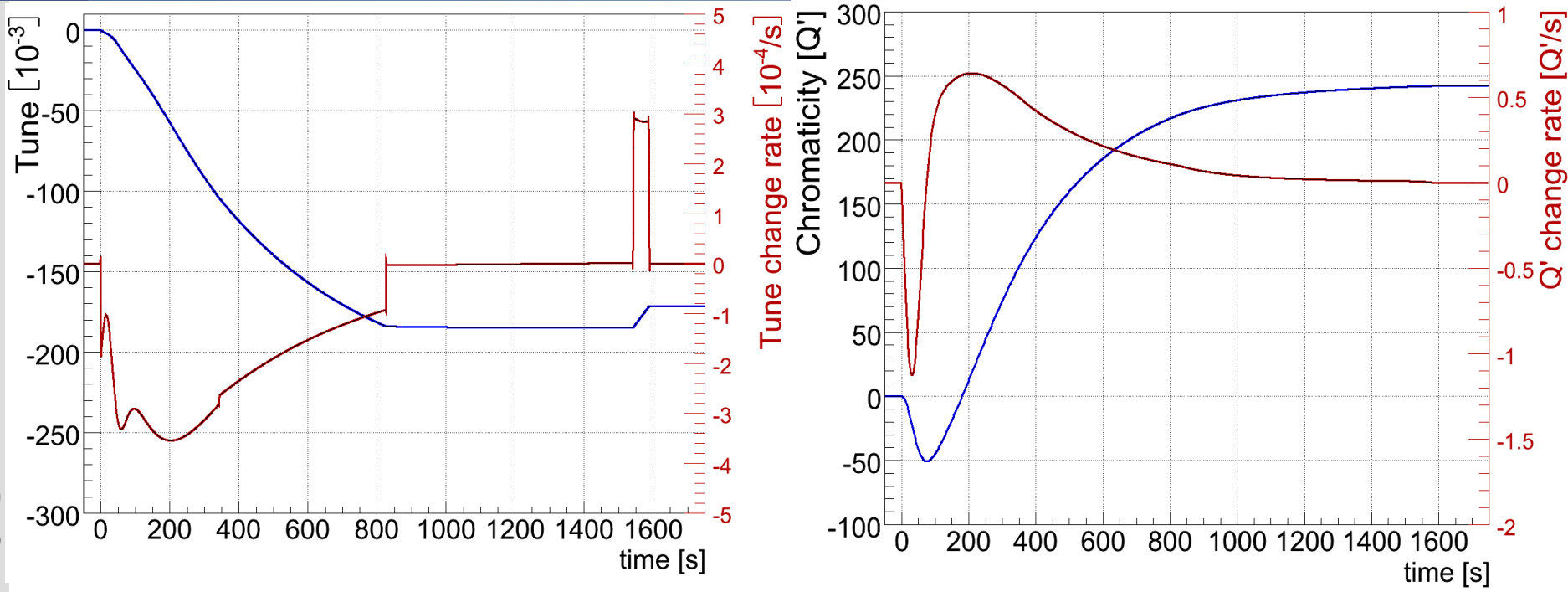
**Ralph J. Steinhagen, BE-BI**

**Special thanks to: G. Arduini, M. Gasior,  
M. Lamont, M. Pereira and M. Strzelczyk**



# (Very) Early Estimates prior to First Beam Tune and Chromaticity Drifts during LHC Ramp to 7 TeV

FIDEL, Q(t) & Q'(t) during the ramp, Ralph.Steinhausen@CERN.ch, 2010-04-13



[...] maximum drift rates are expected to be slow in the LHC

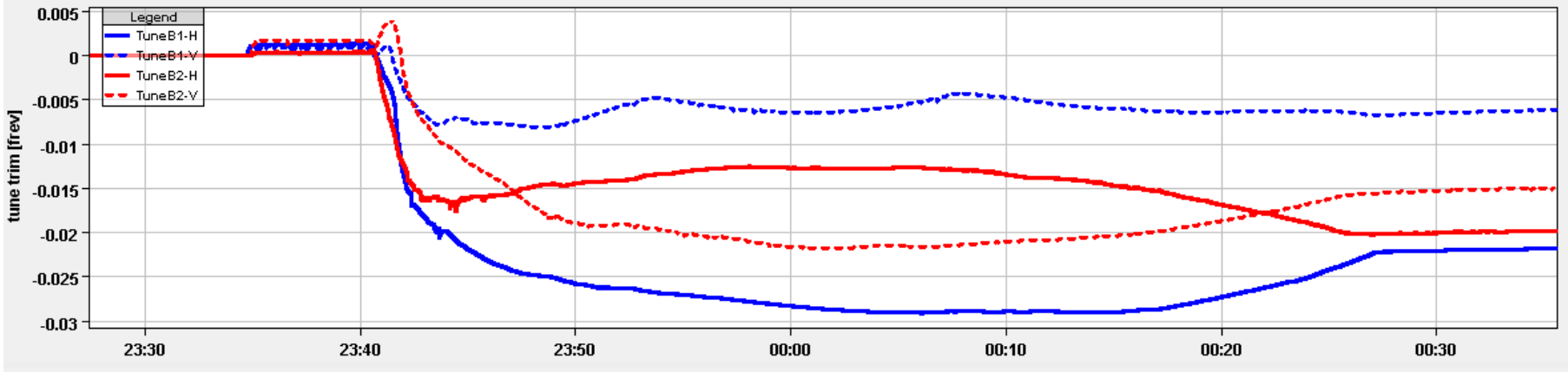
- Tune:  $\Delta Q/\Delta t|_{\max} < 10^{-3} \text{ s}^{-1}$
- Chromaticity:  $\Delta Q'/\Delta t|_{\max} < 2 \text{ s}^{-1}$  ← the critical/difficult parameter

■ Requires active control relying on beam-based measurements

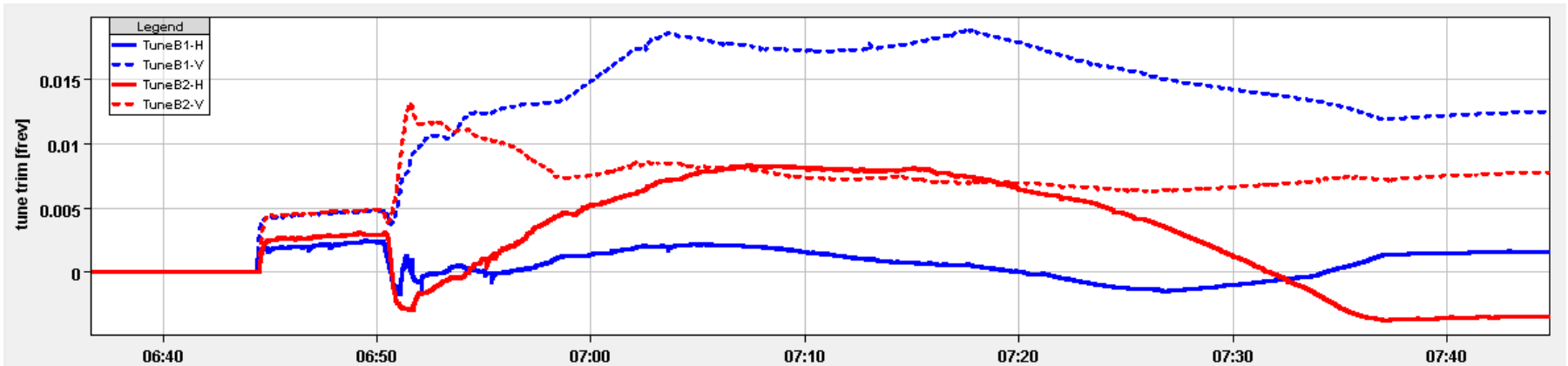
■ Initial estimate assumed no feed-forward correction!

- Basically, all ramps until now rely on the Tune-FB, with varying reproducibility:

– Example 1:



– Example 2 (a few hours later):

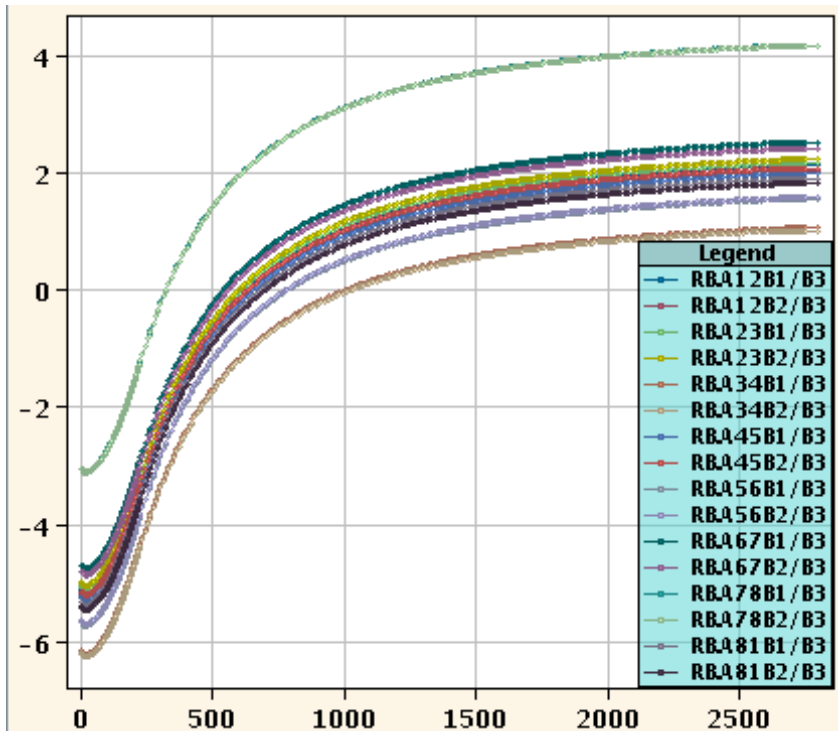


... similar features but not the same. More than a trivial incorporation issue ???

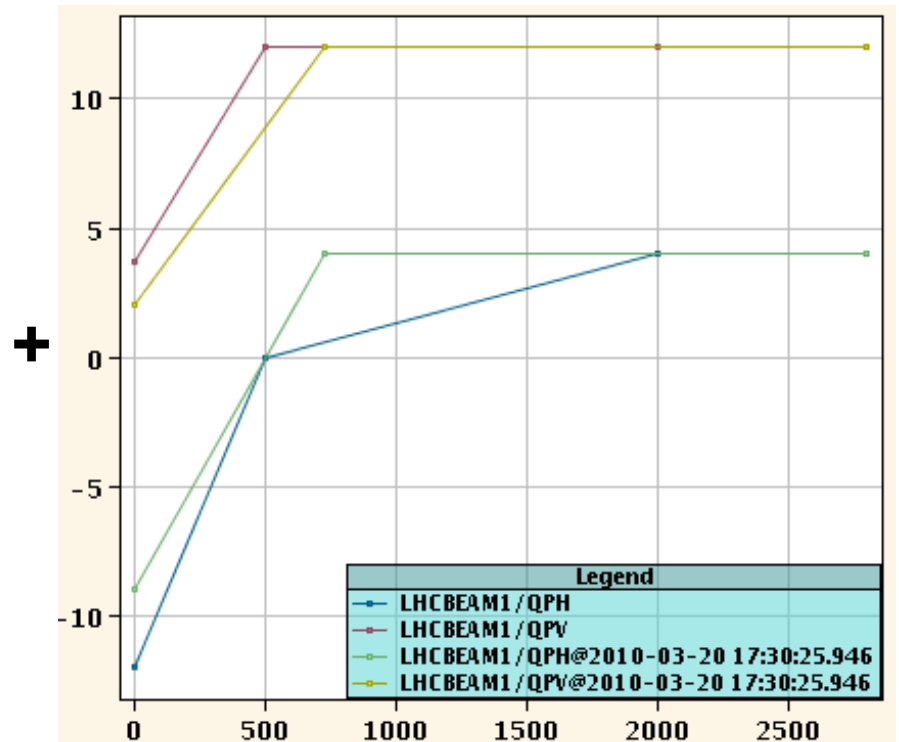
# Initial Q' Feed-Forward Correction

- $b_3$  based on FIDEL prediction, initial MCS correction of about  $\Delta b_3 \approx 7$  units
  - Initial model assumption (2 kA & 2 A/s, now: 6 kA & 2 A/s)
- After initial Q' measurement at 450 GeV and 3.5 TeV
  - added linear compensation of  $\Delta Q' \approx 12$ 
    - fixes start and end point to the same Q'

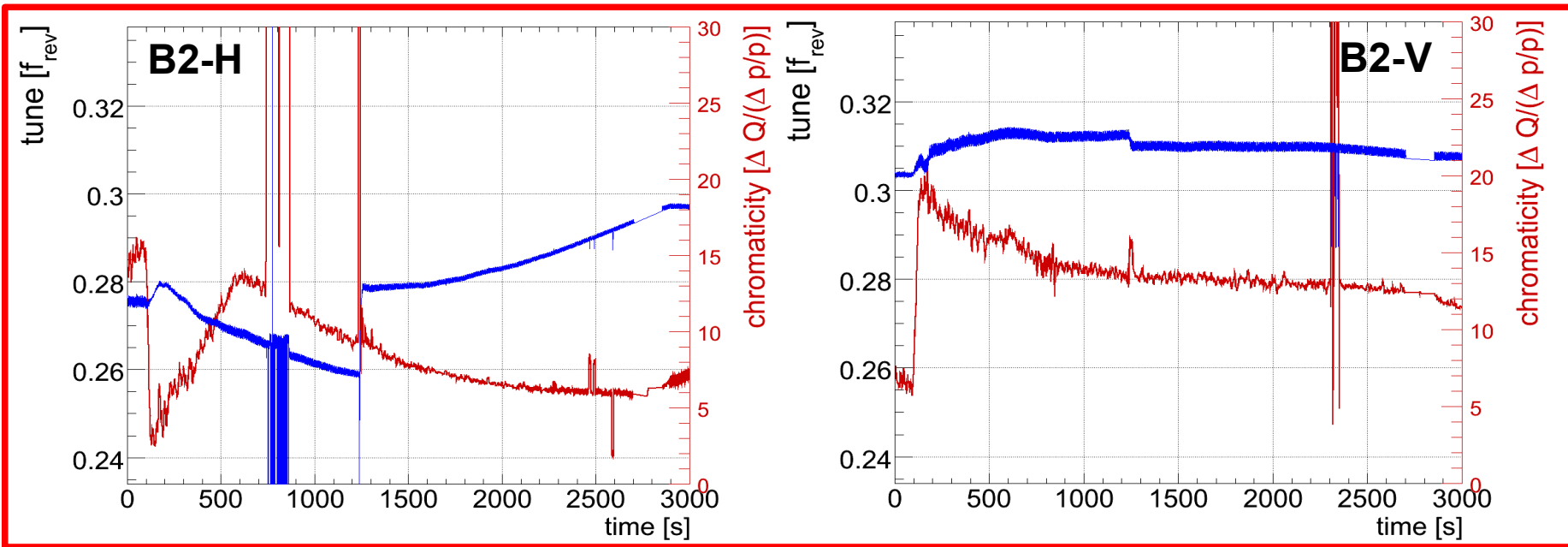
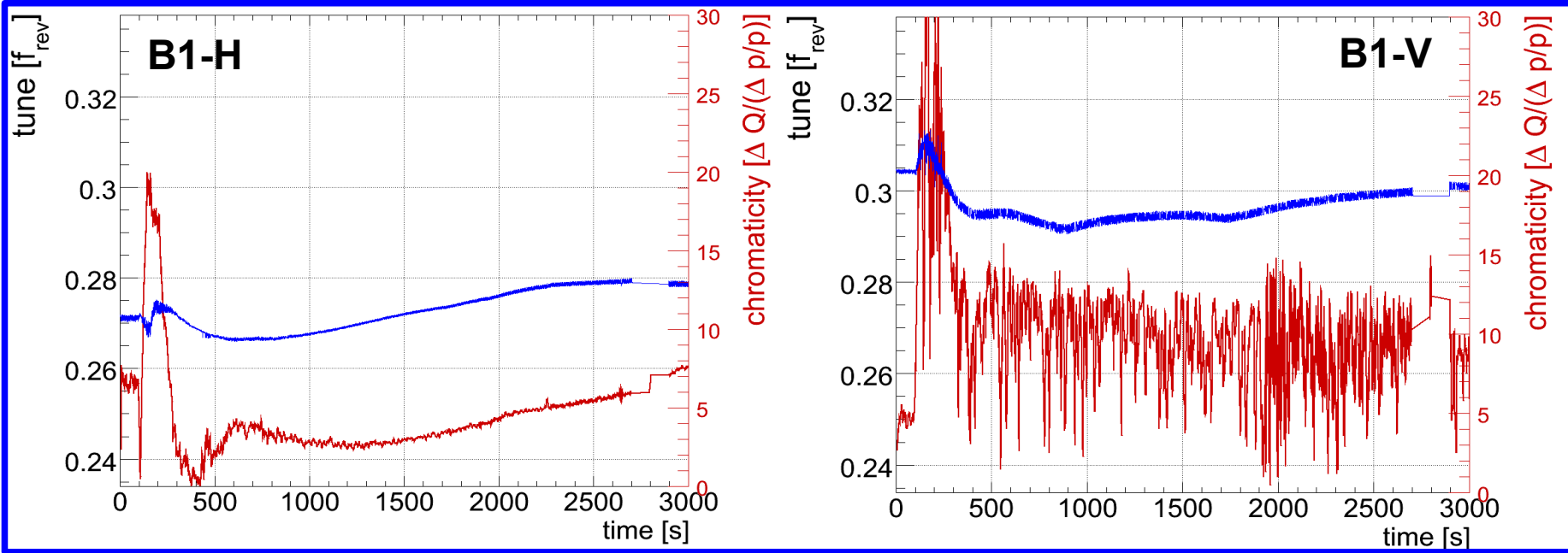
FIDEL  $b_3$  trims



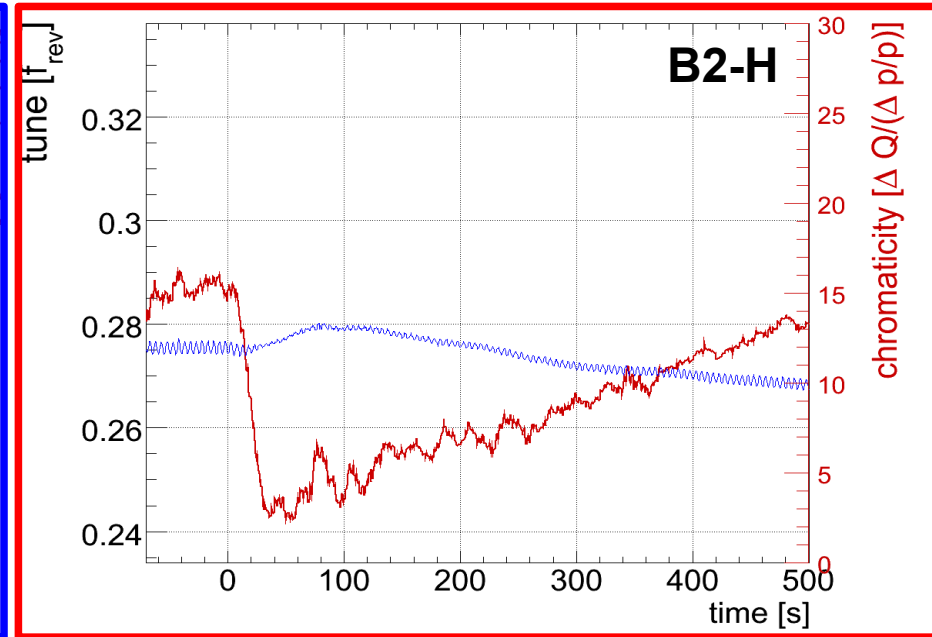
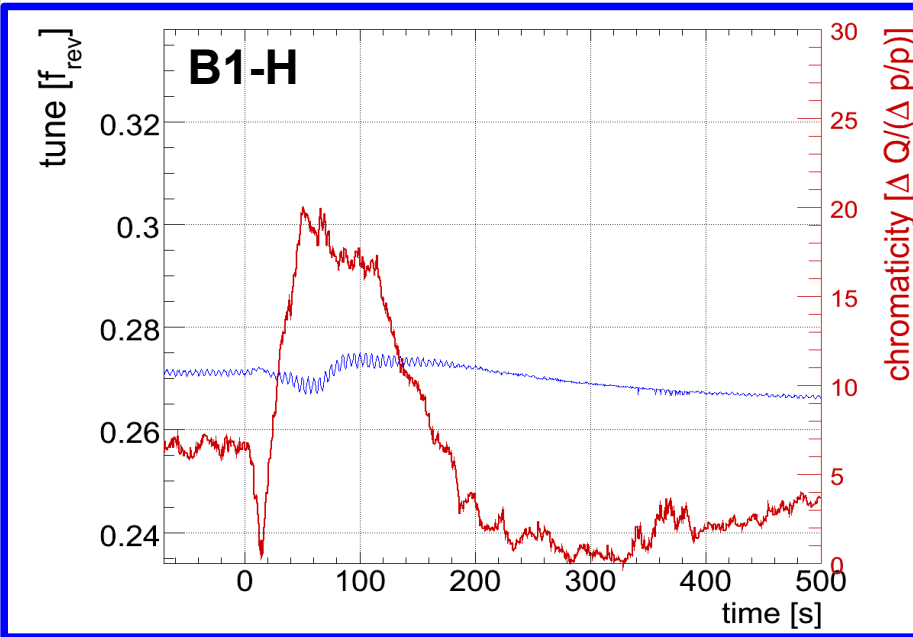
Q' measurement "inspired" trims



# B1 & B2 Tune and Chromaticity Evolution

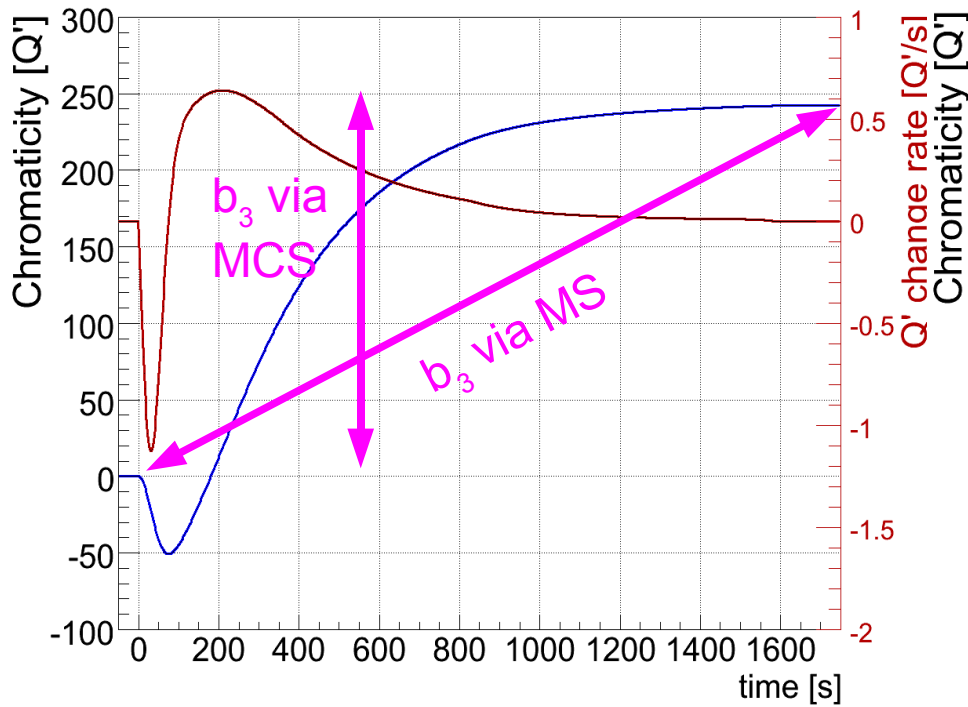


- Snap-back at the start of the ramp visible:
  - time-constant about 50-70 seconds (gaussian decay) depending on fitting

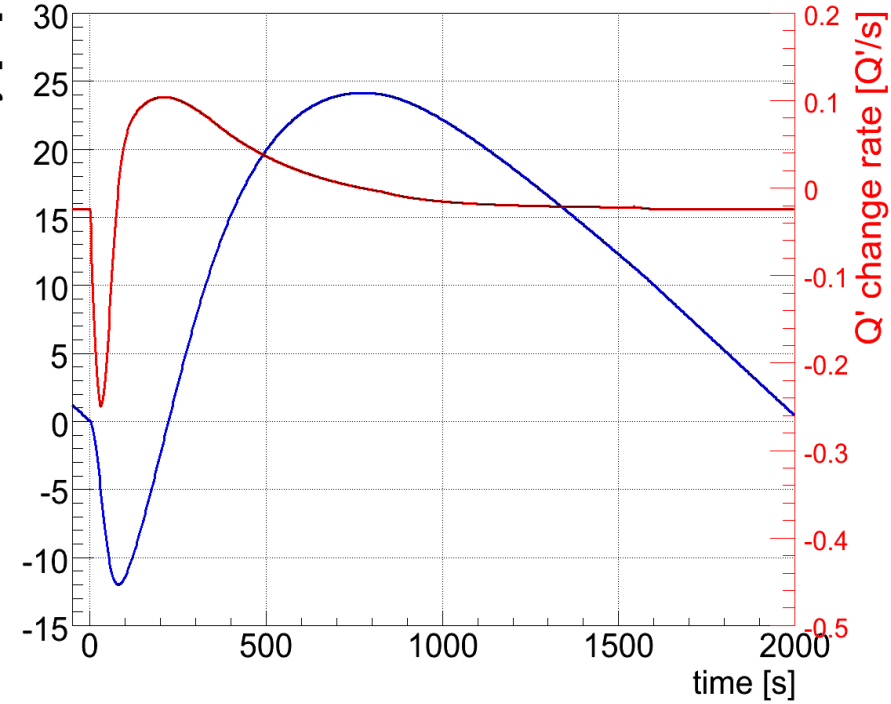


- $Q'(t)$  evolution compatible with applied FIDEL and linear feed-forward correction, (example is for nominal 7 TeV & 10 A/s operation):

before correction:



with partial FIDEL/feed-forward:

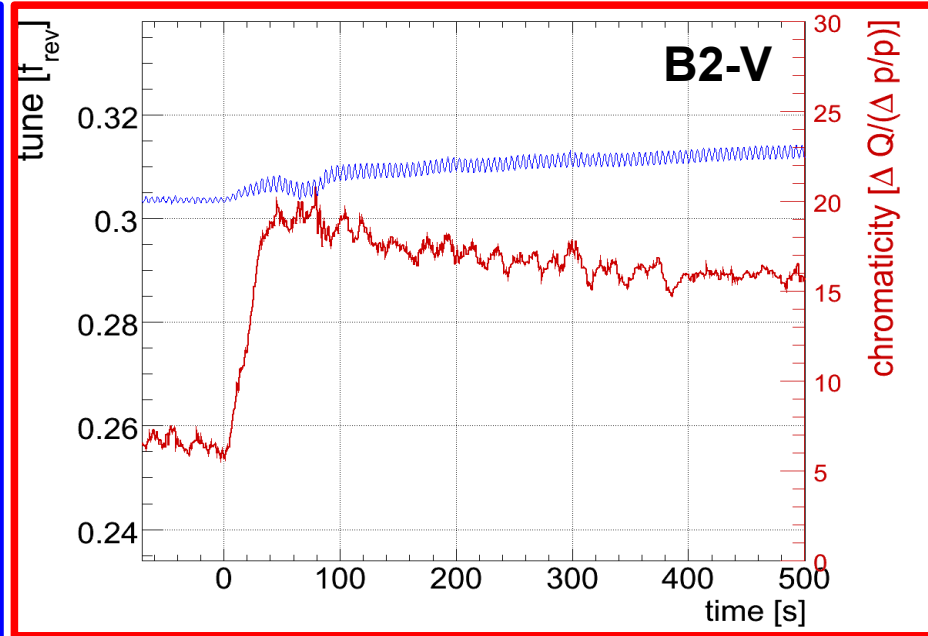
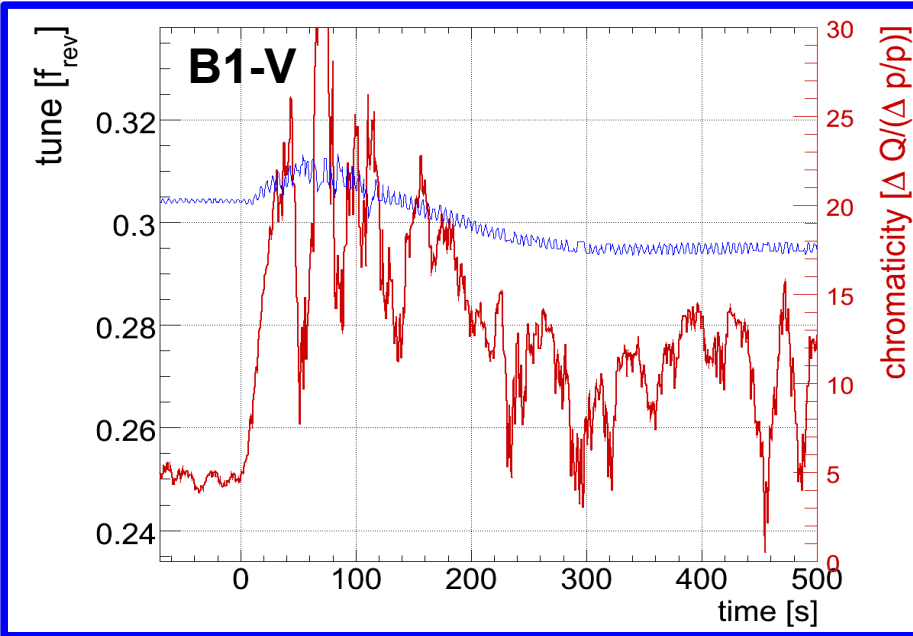


- Explains part of the qualitative  $Q'(t)$  evolution
- However, reconstruction is not as trivial as one may think...

- Reconstruction is convoluted and depends on many parameters:
    - interdependence between snap-back amplitude  $\Delta b_3$  and time constant
      - A matter of finding the right snap-back, persistent current errors but also **time constant** (N.B.  $\Delta t$  Increases with increasing  $\Delta b_3$ )!
        - 6 FIDEL parameter for the actual perturbation:
          - » 2 governing the snap-back
          - » 3 the persistent current decay
          - » 1 for the eddy-current component
        - 6 FIDEL parameter for the correction attempt
- } Need to de-convolute these 12 parameter
- **Situation confused with de-facto two/"three" pre-cycles at the moment:**
    - 'Rampdown Combo': MB/MQ down from 6 kA at 2 A/s
    - 'Precycle' (following access etc.): MB/MQ to 2 kA at 2 A/s, and
    - (unfortunately) a mixture of the two (many fills do not end with a 'programmed dump' but some QPS, cryo or other failure)
  - Hope to get these errors down to about  $\Delta Q' = \pm 5$  and mop-up the rest (non-reproducibilities, errors due to partial pre-cycles) with beam-based feedbacks.



- Much noisier due to spurious/noisy peak detection
  - Partially due to large  $Q'$  (synchrotron side-bands)



- attempted to fixed this on the  $b_3$  level (FIDEL on MCS)
  - hasn't been re-qualified with beam yet...