# More Debuncher Momentum Cooling Characterization Measurements
# Pbar Note 685

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**Abstract**

Improvements to the analysis of the Debuncher momentum cooling systems, first presented in Pbar Note 673[**?**], are documented. Results for data taken in November 2002, February 2003, and April 2003 are presented.

## 1 Measurement method

All measurements use the 8813th harmonic of the debuncher central revolution frequency, which is nominally 590035 Hz, corresponding to a frequency of 5.199976 GHz. This frequency is in the center of band 2. The HP 89410A Vector Signal Analyzer (VSA) operates in the range 0-200 MHz. I use the spectrum analyzer(SA) IF output signal, which down converts from the central value sampled to a central frequency of 21.4 MHz. The SA is centered at 5.199976 GHz, operated in 0 span mode, with a resolution bandwidth of 1 MHz. The input signal to the SA is the band 2 momentum Schottky signal. The full setup of the SA can be found in reference [**?**].

The 21.4 MHz IF output signal is taken across the aisle in spigot FILLMEIN, where it is then connected to the input of the AD8116 Multiplexer at spigot 5. Channel 11 of the multiplexer output, which connects to the VSA RF input, is set to that input channel (currently known as Horizontal Damper Loop In on P189).

The VSA is centered at 21.4 MHz with a span of 350 kHz. I use rms averaging over 7 traces, with updates every 7 traces. In this way, each average trace is independent of the previous and following trace. The VSA is operated in armed trigger mode, with the arm on event (D:MOUNTT) at \$80 + 1.03 seconds (as bunch rotation concludes) and arm off (D:BEEPT) at \$80+8.03 seconds. A 10 second cycle time for \$29 events is used. Waterfall mode is turned on, with buffer depth of 100. The trace buffer is saved and then cleared before the next measurement. The full setup of the VSA can be found in reference [**?**]. The setup for both the SA and the VSA is the same as in previous measurements.

## 2 Data Analysis

The trace buffer is converted from SDF file format (native to the VSA) to ASCII using the DOS program SDFPRINT. The resulting file is read and analyzed, computing the mean of the distribution, the RMS of the distribution, the power within $\pm 2\times$ the RMS, and the 95% width.

| Date | Cooling Time (seconds) | Asymptotic Width (MeV/c) |
|---|---|---|
| 12 Nov 02 | 0.79 ± 0.04 | 7.18 ± 0.14 |
| 17 Feb 03 | 0.58 ± 0.04 | 6.44 ± 0.11 |
| 23 Apr 03 | 0.51 ± 0.03 | 6.20 ± 0.08 |

Table 1: Fit results for different data periods. Note the improvement in both cooling time and asymptotic width.

All calculations subtract out a noise floor. The noise floor is found dynamically for each trace. I fit the last trace in the cycle to a Gaussian plus a constant, where the constant is the power at the noise floor. The 95% width is defined symmetrically, by looking for the points where the integral power (above the noise floor) goes past 2.5% and 97.5%. Figure 1 shows a sample trace near the end of the cycle. All frequencies are down converted to the fundamental (with nominal center of 590035 Hz).

In Figure 2, I show the data for a single 7 second time period. All 4 momentum bands are on. On the left are the individual traces in the buffer, with the horizontal axis the frequency in GHz and vertical power in dBm. The plots on the right show the mean (with respect to 590035 Hz), the power (within $\pm 2\times$ the RMS), the RMS of the distribution, and the 95% width. In these plots, the horizontal axis is time (in seconds). For the characterization measurements, I take 5 pulses for each setting and calculate the average and standard deviation for each statistic (mean, power, RMS, 95% width). The 95% width is converted from frequency to momentum with the following equation:

$$\delta \mathrm{p} = \frac{\delta \mathrm{f}}{f_0} \times \frac{\mathrm{p}}{\eta} \tag{1}$$

where $\mathrm{f}_0$ is the measured 95% width, $f_0$ is the Debuncher central frequency (590035 Hz), p is the Debuncher central momentum (equal to Accumulator extraction orbit energy of 8886 MeV/c), and $\eta$ is the Debuncher phase slip factor (0.006). For the Debuncher, a frequency width of 1 Hz corresponds to a momentum width of 2.51 MeV/c.

## 3 Results

Data has been taken on 12 Nov 2002, 17 February 2003, and 23 April 2003. All measurements were made with DRF2 off. Improvements to the cooling systems (mainly new equalizers in the notch filters) have taken place in between measurements [2]. I average the width vs time for the 5 individual pulses, plotting the mean and RMS width. The data is fit to an exponential plus a constant, as it is expected that the width should reach an equilibrium value based on the system noise and notch filter alignment. Figures 3, 4, and 5 show the data and fit for the 3 different time periods. Table 1 contains the fit results listed together.

## References


[1] P. F. Derwent, "Debuncher Momentum Cooling Characterization", Pbar Note 673 (unpublished), 2002. Available at http://www-bdnew.fnal.gov/pbar/documents/pbarnotes/pdf_files/PbarNote673.pdf

[2] Ralph Pasquinelli, "Performance of Debuncher Momentum Cooling Notch Filters", Pbar Note 672 (unpublished), 2002 (updated April 2003). Available at http://www-bdnew.fnal.gov/pbar/documents/pbarnotes/pdf_files/PbarNote672.pdf

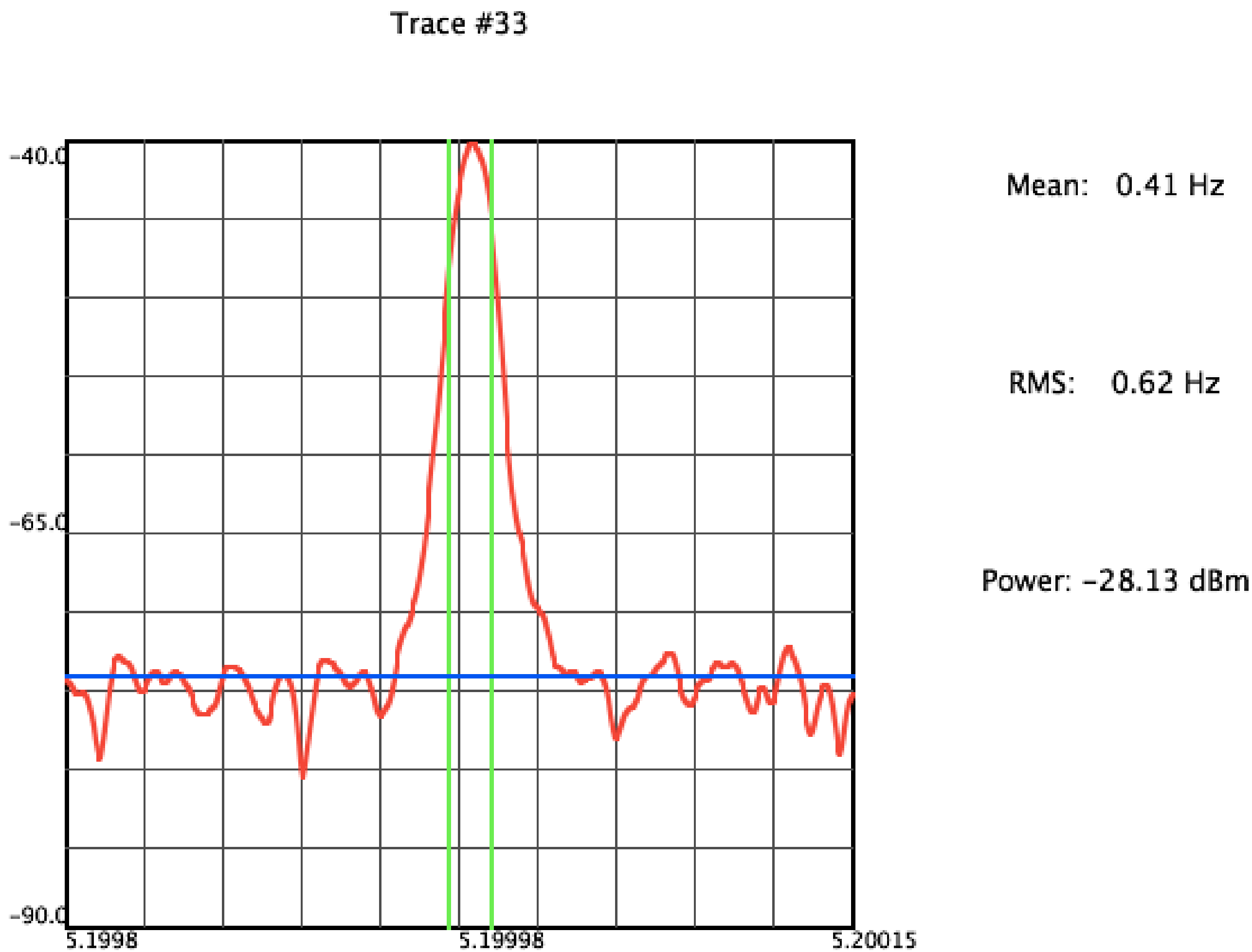


Figure 1: A sample trace near the end of the cooling cycle, with debuncher momentum cooling bands turned on. The horizontal axis is frequency in GHz, the vertical axis is power in dBm. The blue line is the fitted value of the noise floor, the green lines represent the 2.5% and 97.5% points.

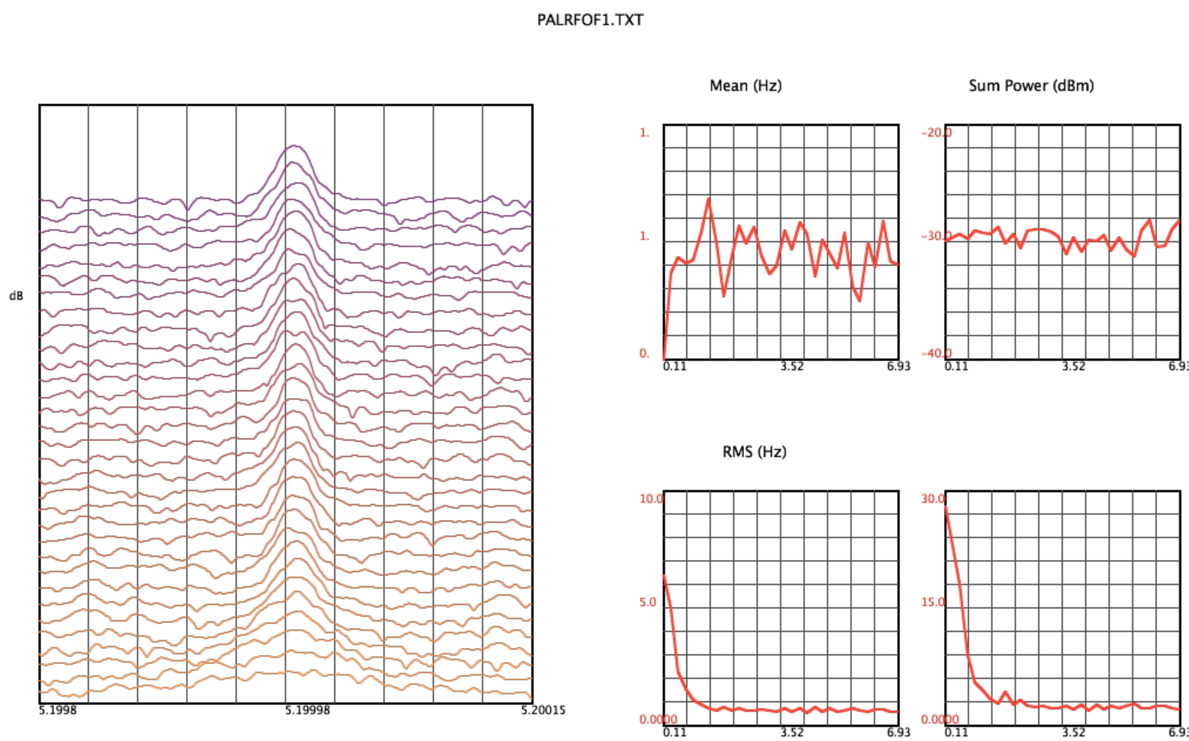


Figure 2: Summary data for an example trace. All four cooling bands are on for this data. The left plot shows the individual traces in the buffer, the right plots the statistics calculated for each trace.

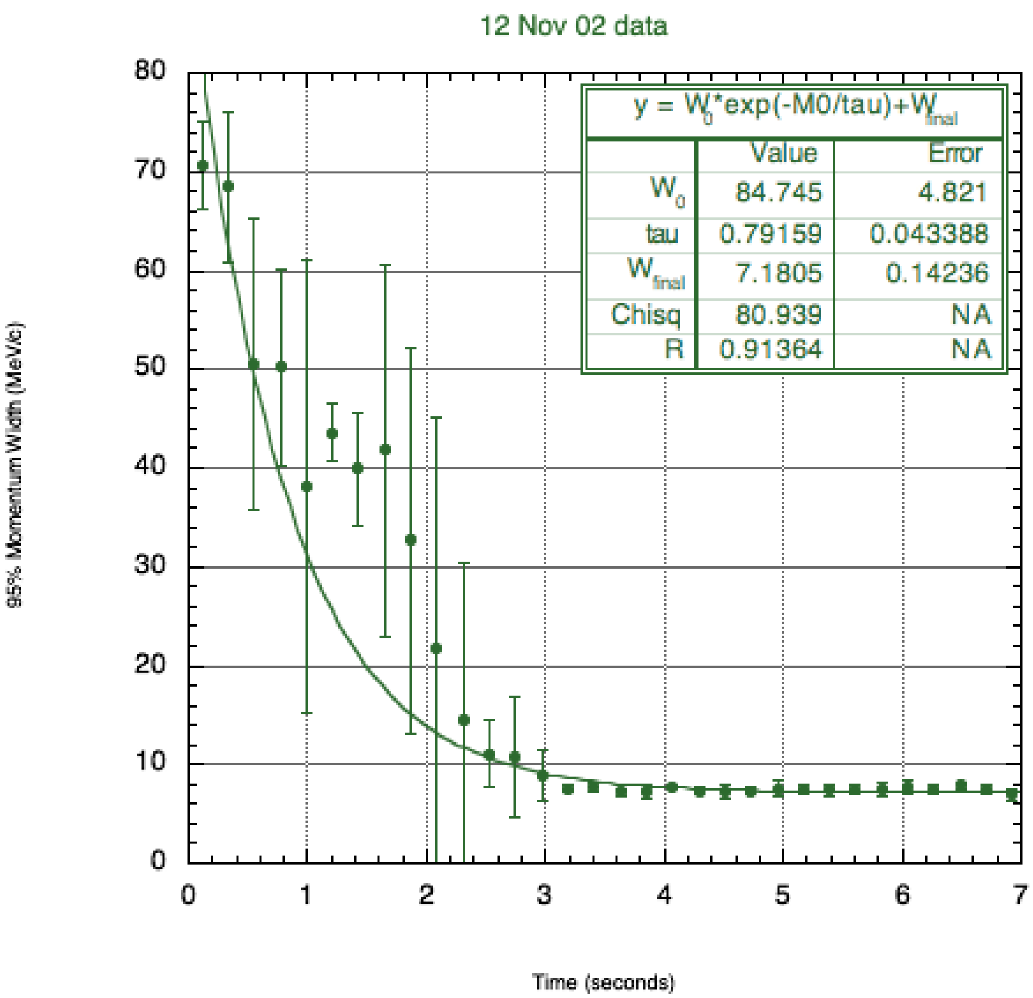


Figure 3: 95% momentum width measurements for data taken on 12 Nov 02. The asymptotic value for all bands is $7.18 \pm 0.14$ MeV/c with a fitted cooling time of $0.79 \pm 0.04$ seconds.

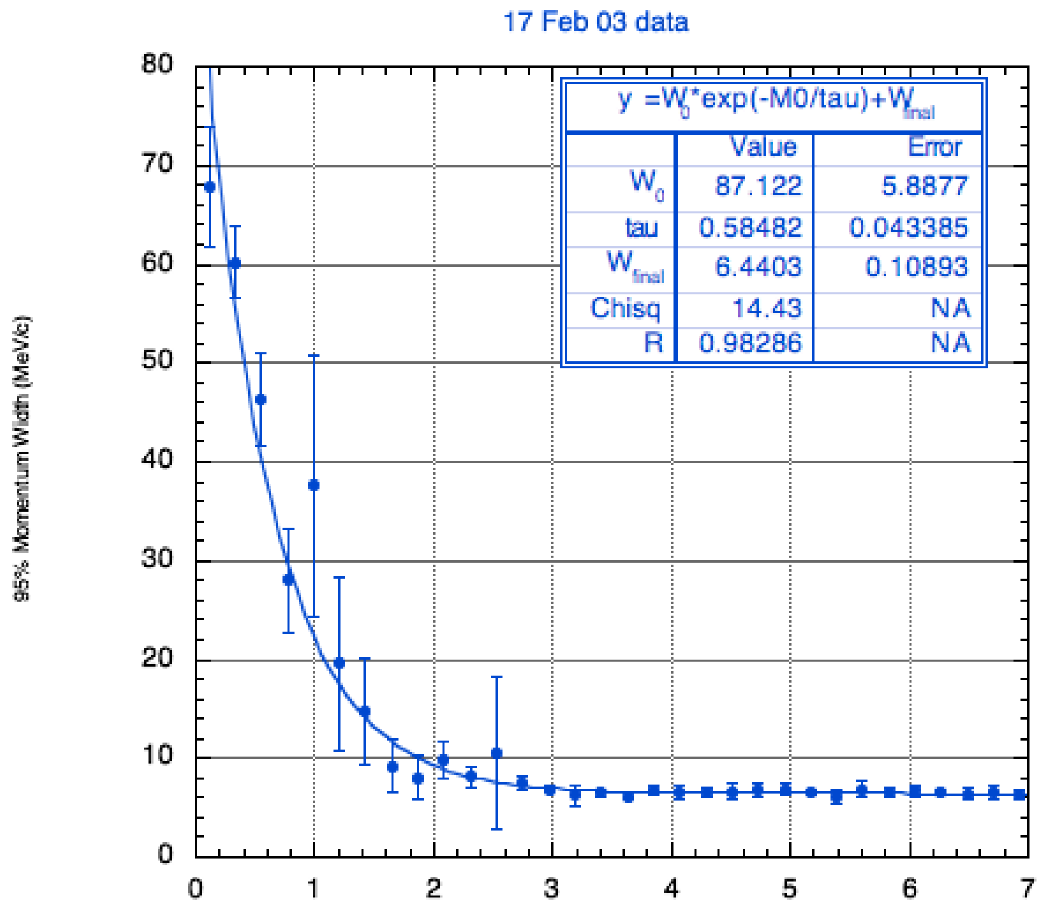


Figure 4: 95% momentum width measurements for data taken on 17 Feb 03. The asymptotic value for all bands is $6.44 \pm 0.11$ MeV/c with a fitted cooling time of $0.58 \pm 0.04$ seconds.

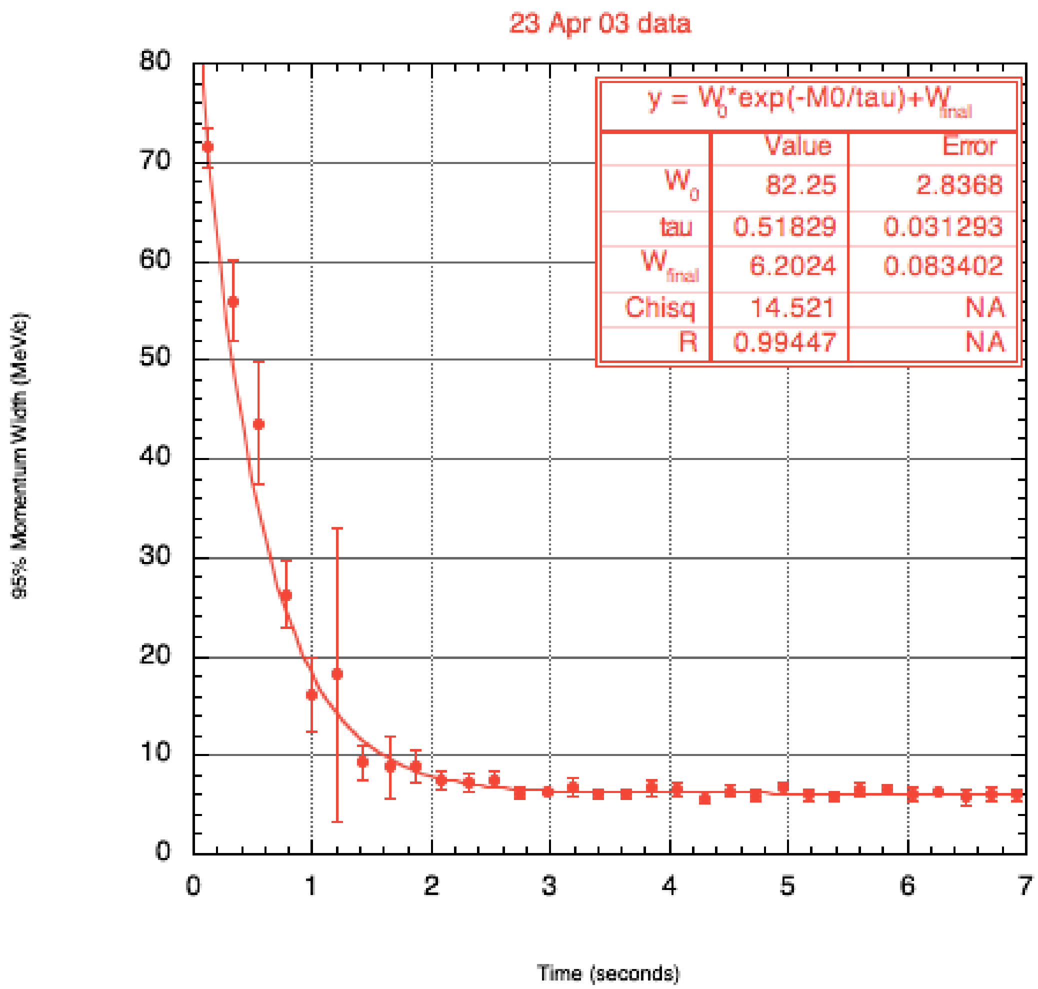


Figure 5: 95% momentum width measurements for data taken on 23 Apr 03. The asymptotic value for all bands is $6.20 \pm 0.08$ MeV/c with a fitted cooling time of $0.51 \pm 0.03$ seconds.