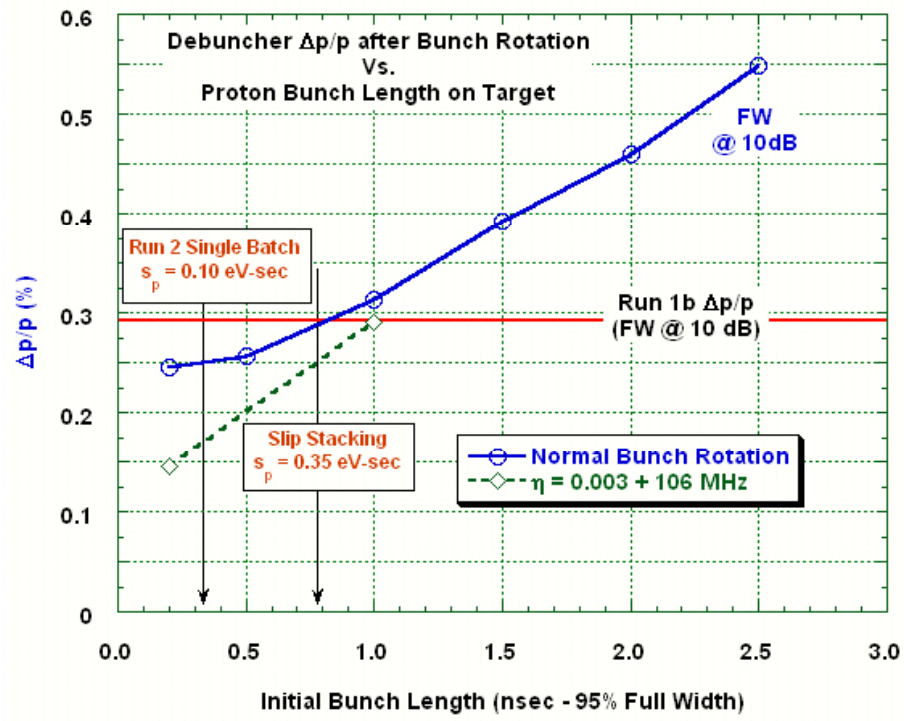
Bunch Length and the Debuncher

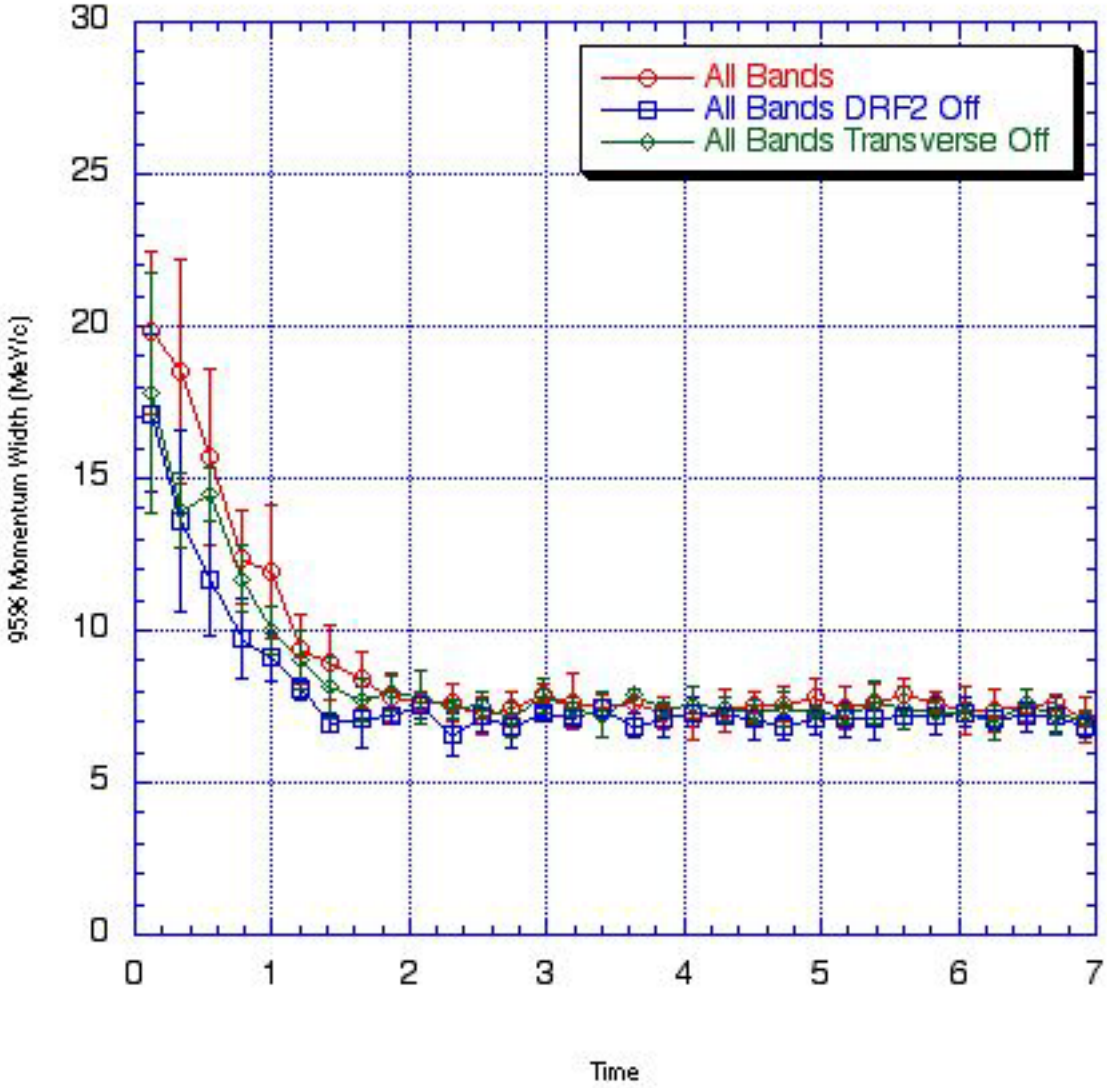
- Momentum Spread in the Debuncher after bunch rotation is proportional to the proton bunch length on target.



- Not every bunch has the same bunch length
- Because of beam loading and instabilities in MI, not every bunch is at the correct 53 MHz phase. Mis-phased bunches will be rotated to the wrong energy in the Debuncher giving a larger overall momentum spread

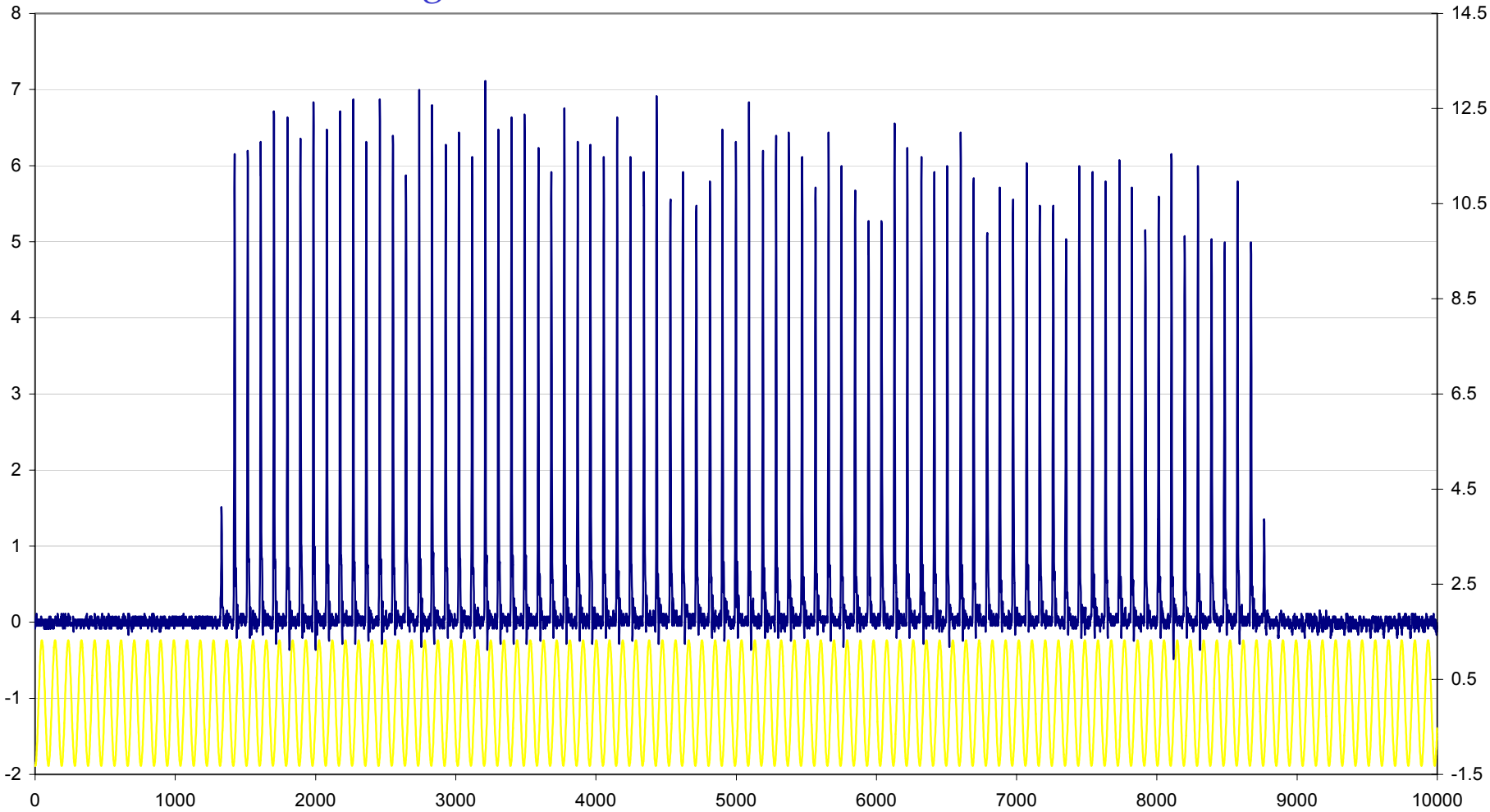
Debuncher Momentum Cooling Problems

- Bunch length on target is not important now because the momentum width reaches an asymptotic value.
- Once this problem is fixed, smaller bunch length on target will result in smaller momentum spread which will allow faster cycle time.



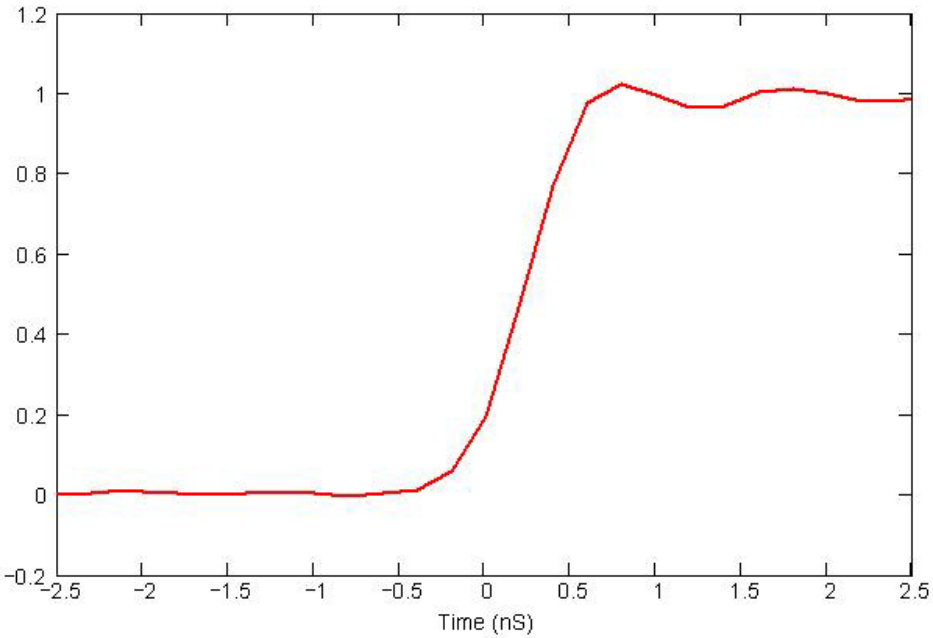
APO Resistive Wall Monitor and Scope

- Digitize 10,000 pts at 5 GSample/Sec with a TEK 3054
  - AP0 Resistive Wall monitor
  - MI 53 MHz signal.

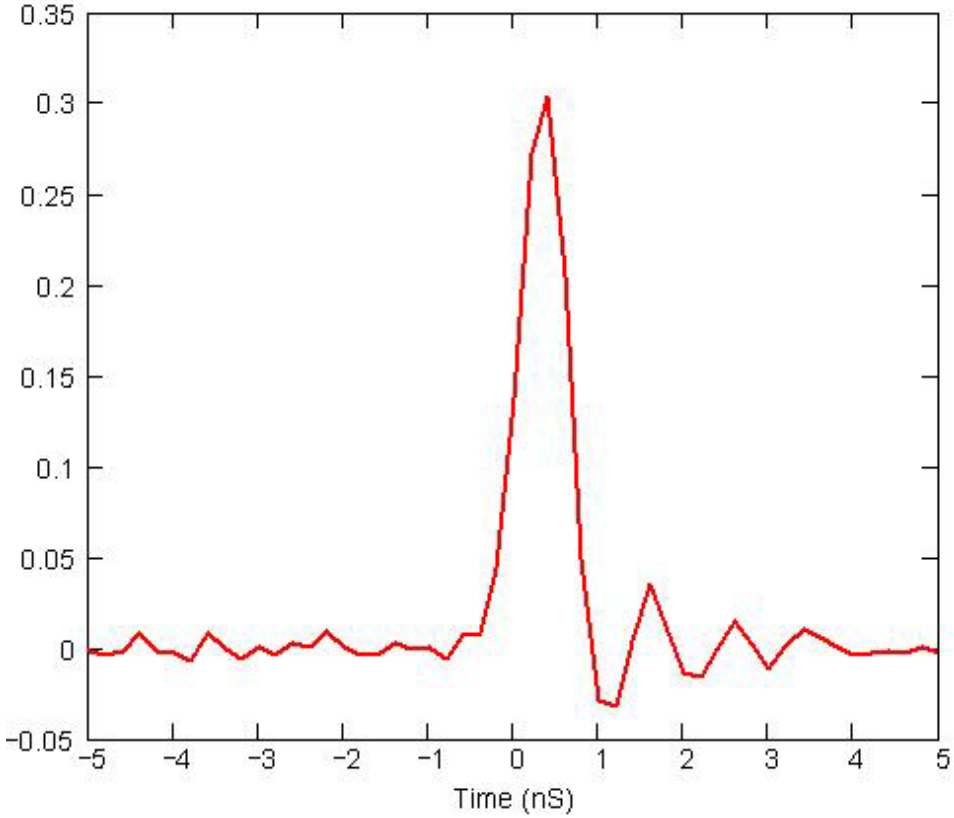


Scope Bandwidth

- Measure the step response of the TEK 3054 with a fast 25 pS step (from a TEK TDR)

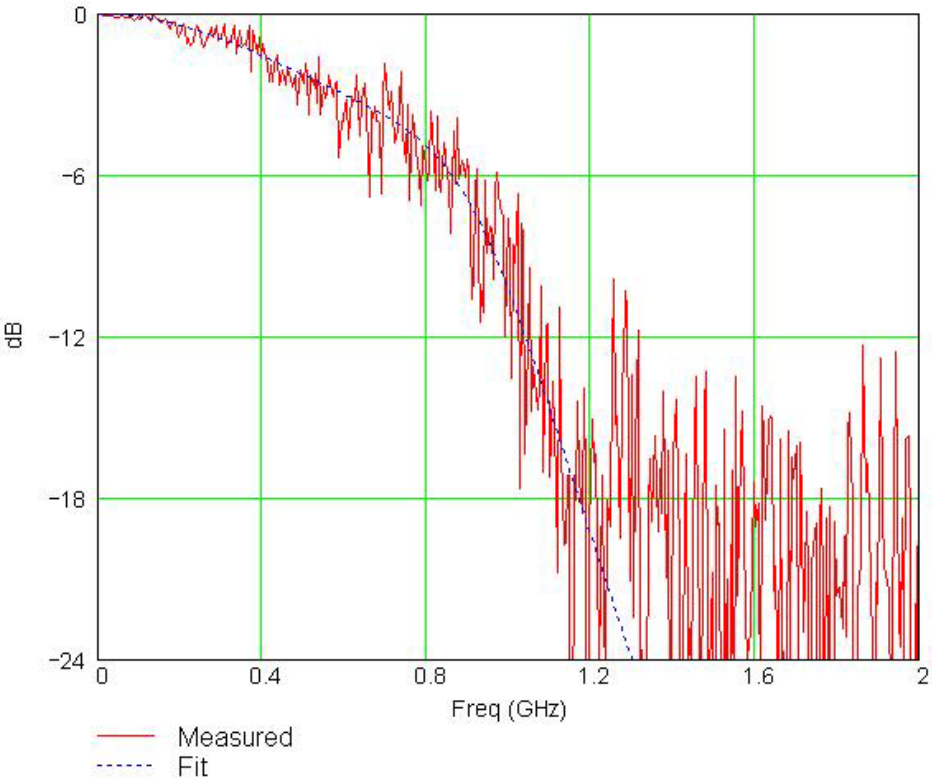


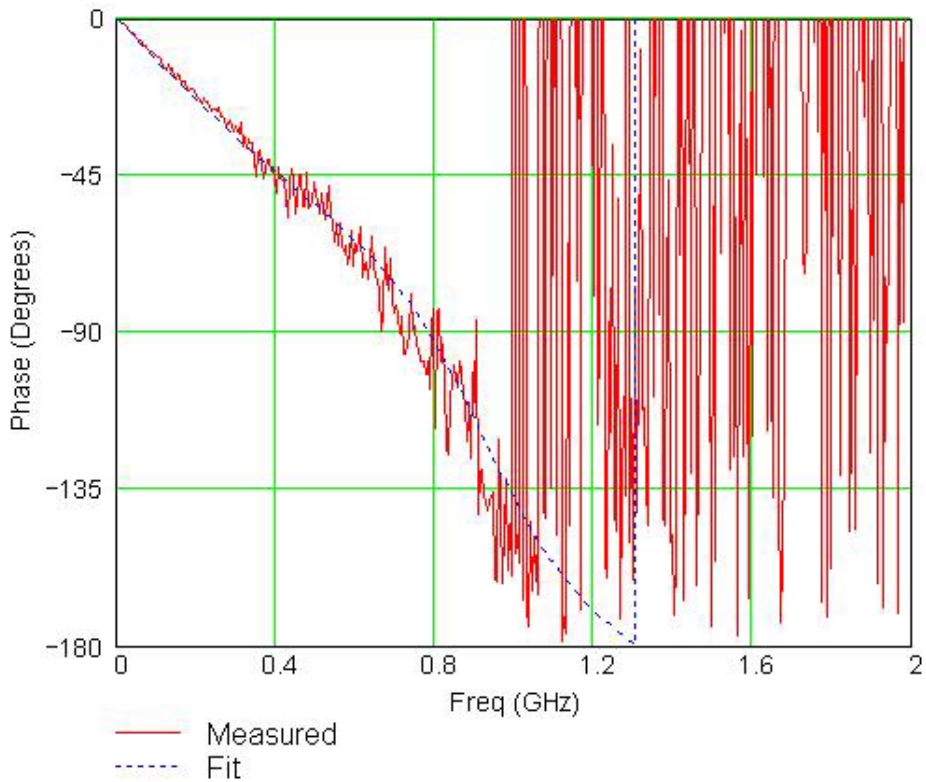
Step Response



Impulse Response

Frequency Response of Scope





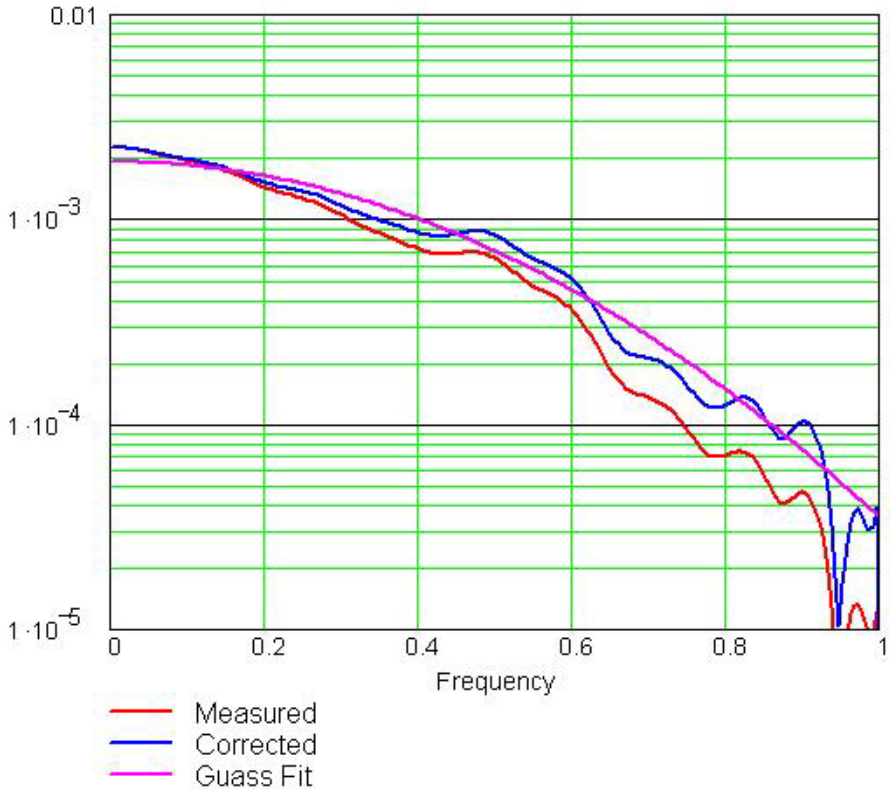
$$f_{c1} = 0.6 \text{ GHz}$$
$$f_{c2} = 0.95 \text{ GHz}$$

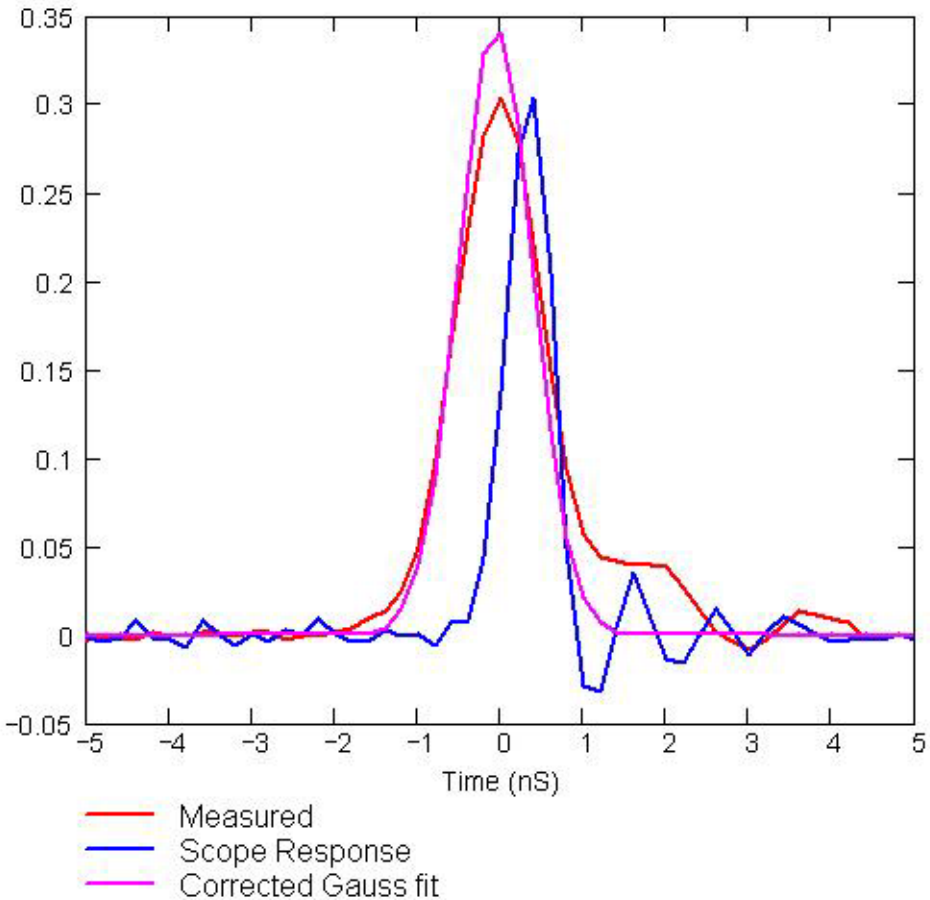
$$F(\omega) = \frac{1}{1 + j\dfrac{\omega}{\omega_{c1}}} \frac{1}{1 + j\left(\dfrac{\omega}{\omega_{c2}}\right)^6}$$

Algorithm for Determining Bunch Length

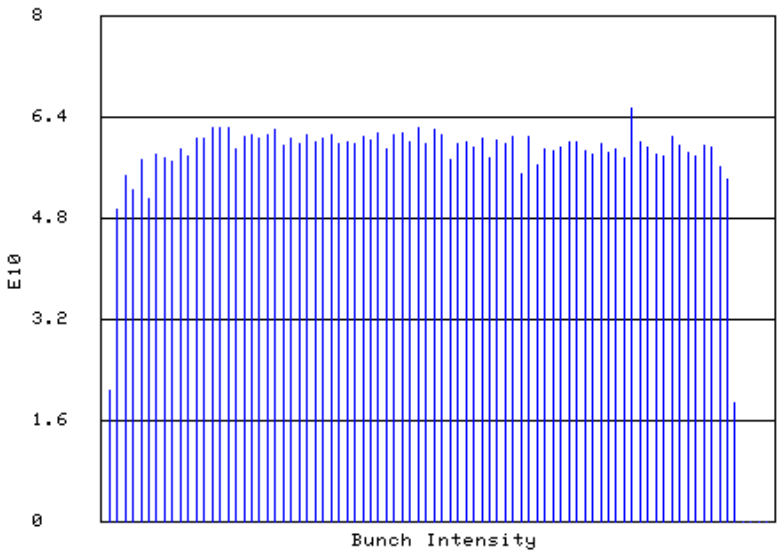
- Digitize Resistive Wall and 53 MHz waveform
- Fit 53 MHz phase with respect to scope trigger
- Locate the rough position of each bunch in trace data
- Segment trace data around each bunch
- FFT each bunch
- Divide bunch FFT by complex frequency response of the scope
- Fit the corrected bunch frequency data to a delayed GAUSSIAN
  - We are assuming that the "raw" bunch shape is gaussian
  - The fit can determine the sigma, the mean, and the area.
- Effective Bunch length
  - Sum over all bunches with respect to the 53 MHz zero crossing of each bunch.

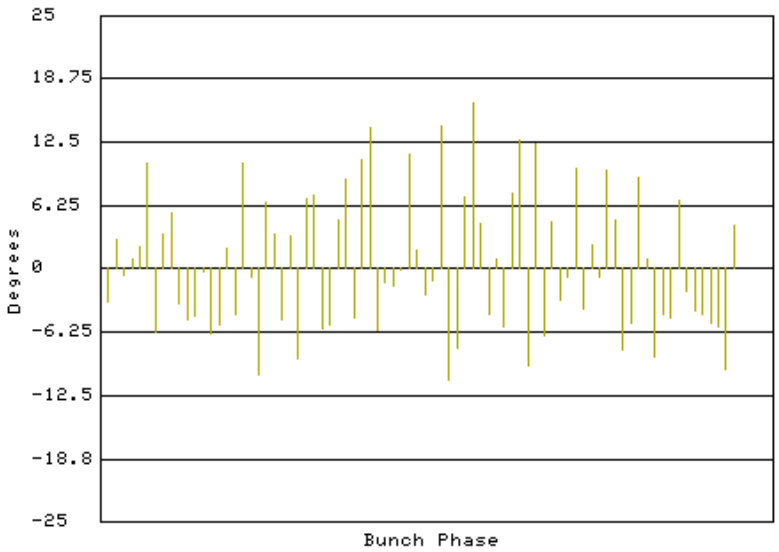
Gaussian Fit in the Frequency Domain

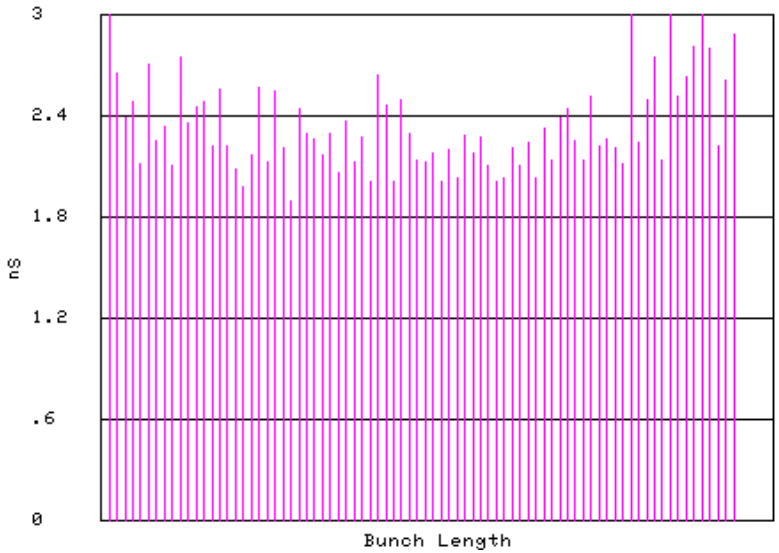


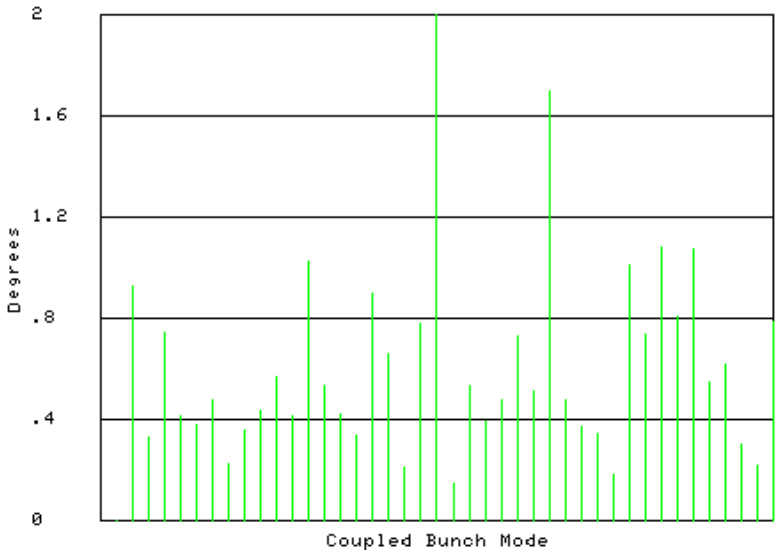


MI Bunch Rotation Off

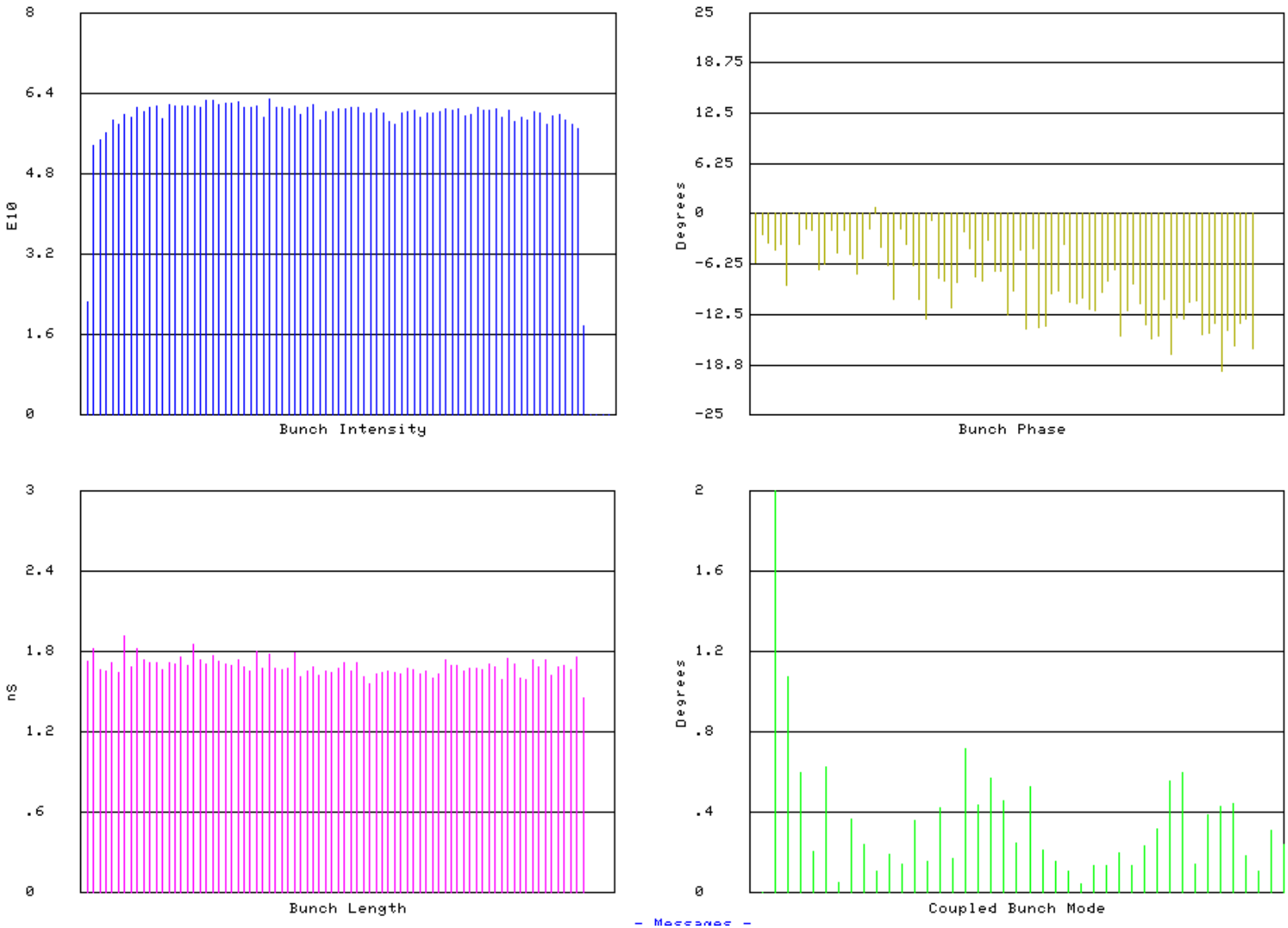








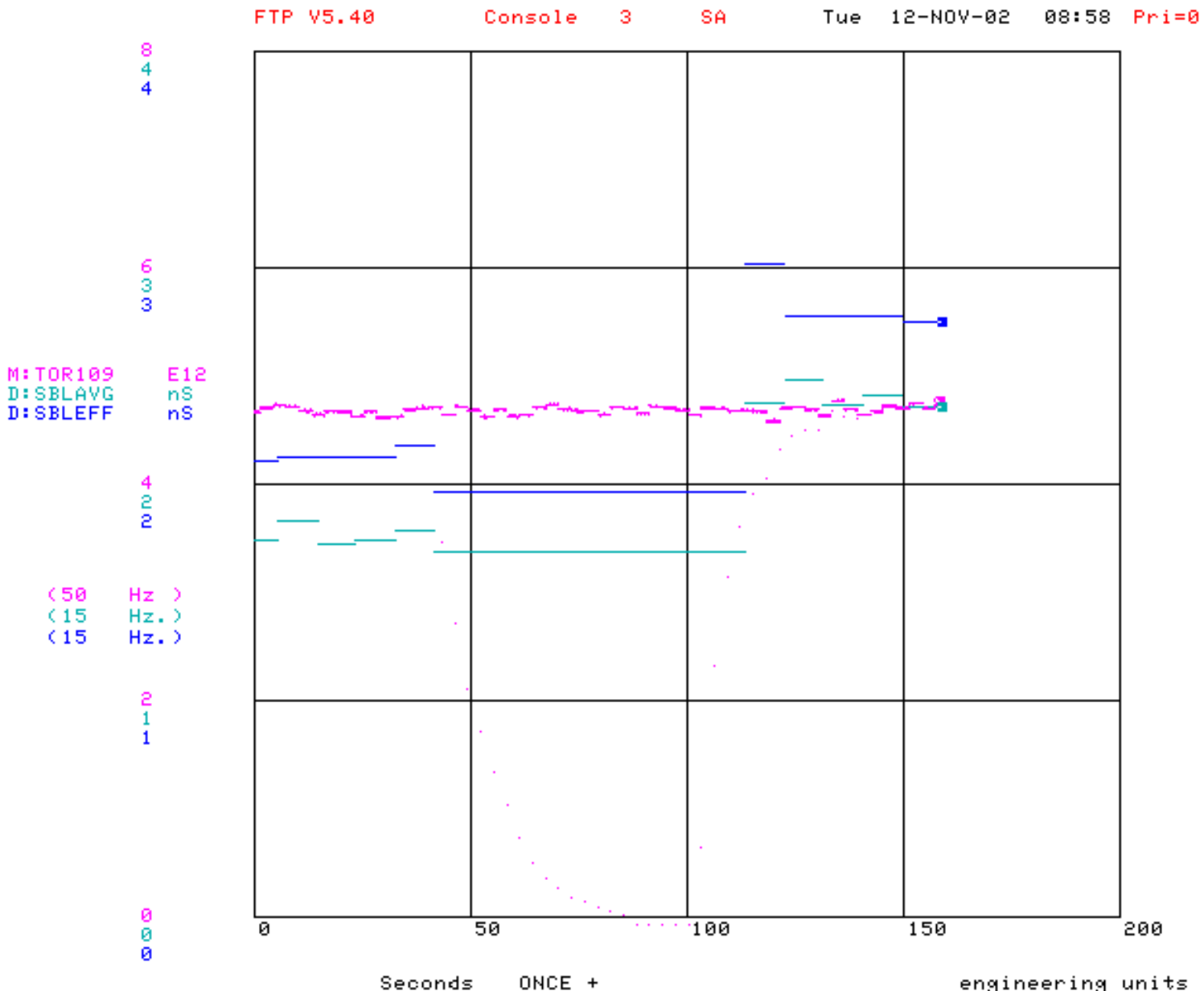
MI Bunch Rotation On



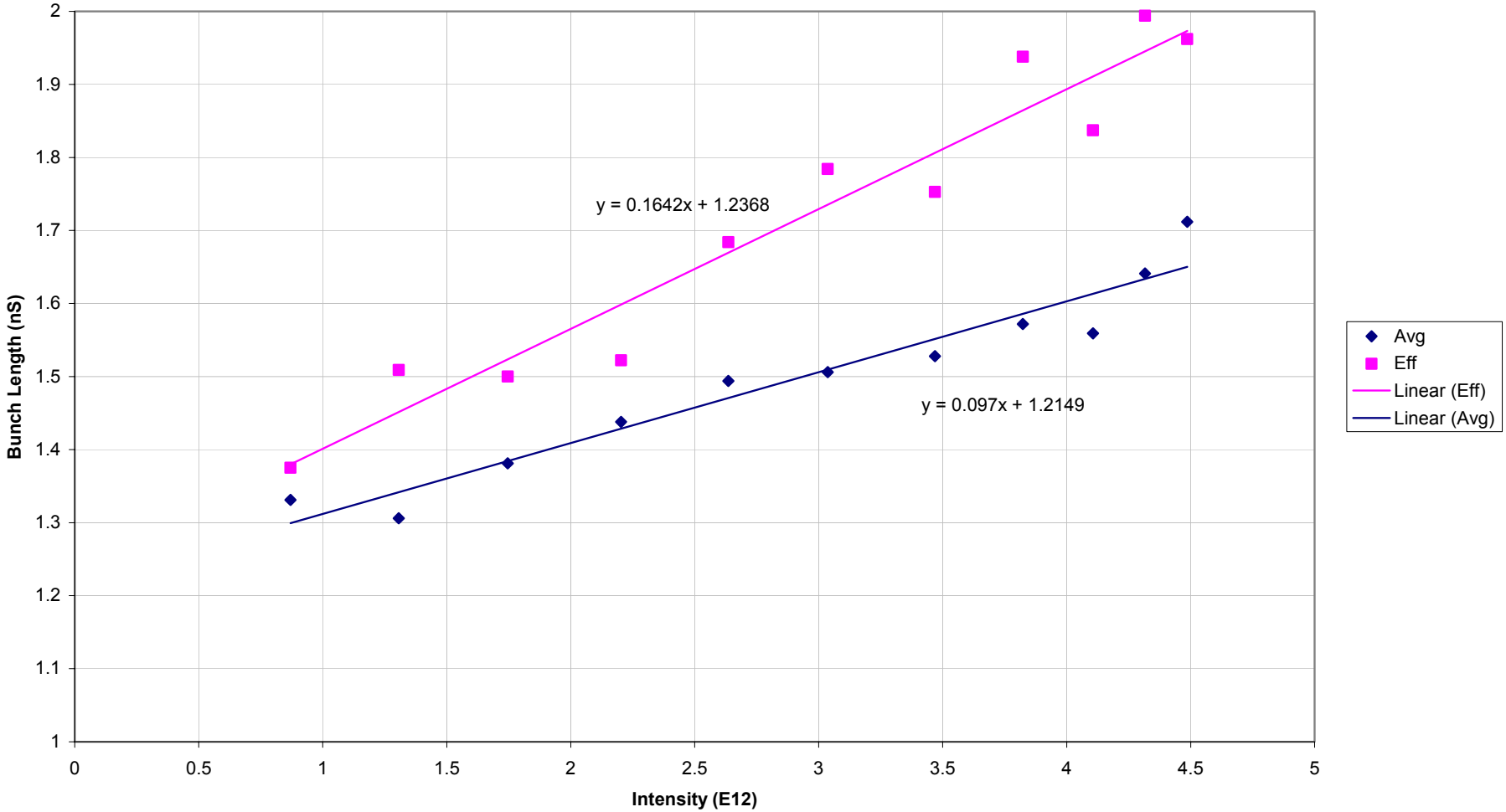
ACNET Parameters

```
P38   PROTON TORPEDO PARAMATERS    SET     D/A   A/D  Com-U ◆COPIES◆
-<FTP>+ *SA◆ X-A/D  X=TIME     Y=D SINAVG,M:TOR109,D:SBLAVG,D:SBLEFF
COMMAND .... Eng-U  I= 0       I= 0      , 0      , 0      , 0
-< 7>+  One+ AUTO   F= 200     F= 8      , 8      , 4      , 4
dampers emitmon mux_sw  plcs    java    ibeam   xxxxxxx MCGINNI
-D:SBLAVG      Avg. Stack. Bnch. Lngth.     2.35     2.35   nS
-D:SBLRMS      RMS. Stack. Bnch. Lngth.      .309     .309  nS
-D:SBLEFF      Eff. Stack. Bnch. Lngth.     2.744    2.744  nS

-D:SPHAVG      Avg. Stack. Bnch Phase        .434     .434  deg
-D:SPHRMS      RMS. Stack. Bnch Phase       6.722    6.722  deg

-D:SINAVG      Avg. Stack. Bnch Intense     5.822    5.822  e10
-D:SINRMS      RMS. Stack. Bnch Intens       .659     .659  e10

-D:PTRST       Proton Torp Reset             0        0     Flag
-D:PTINTS      Prot Torp Int. Scaling       8        8      E10
-D:PTPHSS      Prot Torp Phase Scaling      25       25     Degs
-D:PTBLS       Prot Torp Bnch Lgn Scale     3        3      nSec
-D:PTCBMS      Prot Torp Coup.Bnch Scal     2        2      Degs



-D:PT109S      Prot Torp Tor109 Scale        .55      .55
-D:PTRWTH      Prot Torp Res Wall Thres      .5       .5    Volt
-D:PTBRTH      Prot Torp Bnch Rat Thres      .1       .1    Volt

 M:TOR109      AP1 PQ9B Beam Toroid              -.053125   E12
-D:PTTOTI      Prot Torp Total Intense      4.66     4.66   E12
-D:PTBNFD      Prot Torp Bunches Found      80       80     Bnch
```

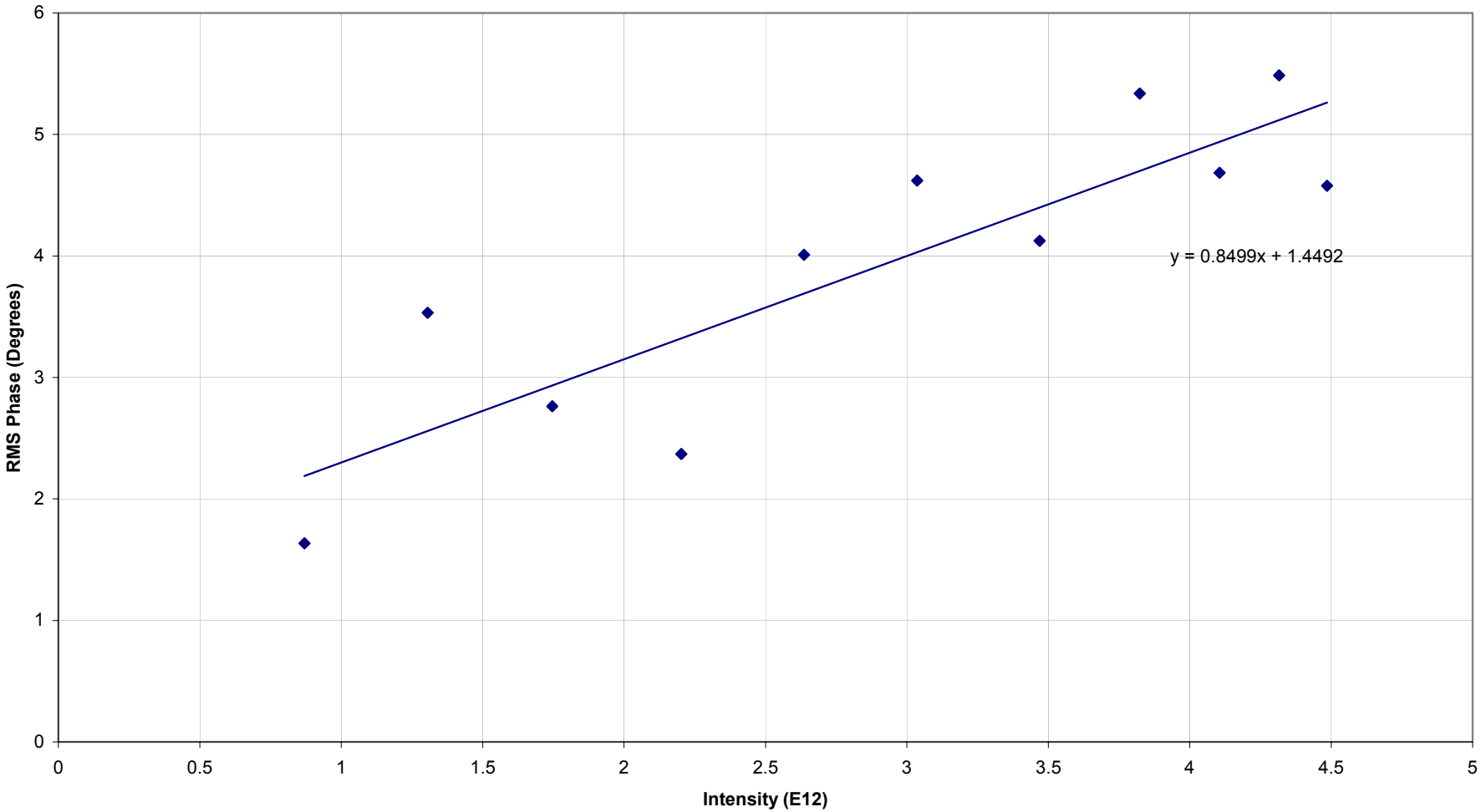
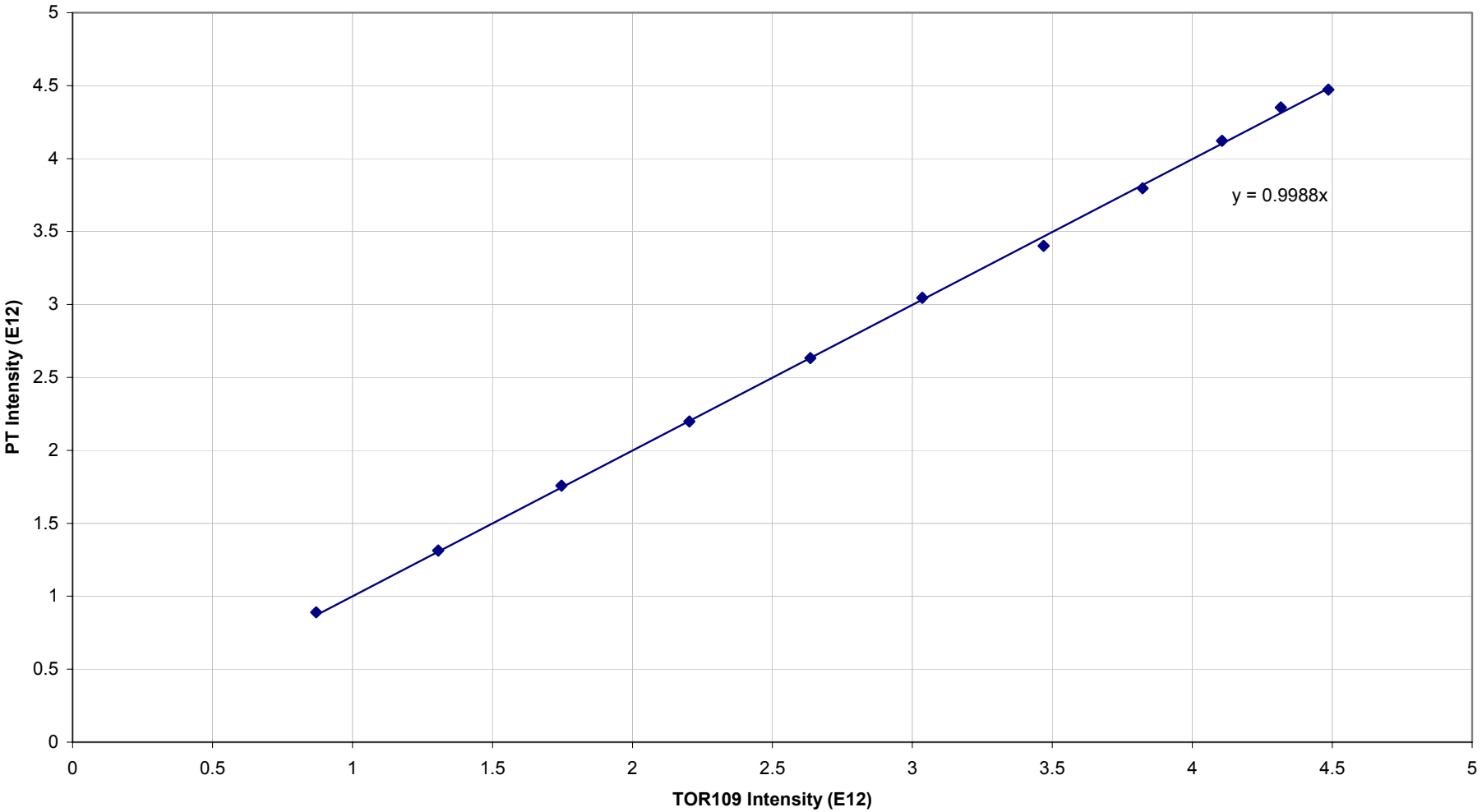
ACNET Parameters



Bunch Length vs MI Intensity



RMS Phase Variation vs Intensity



Intensity Calibration