Preliminary Tevatron Transverse Emittance Study using the Flying Wire

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Abstract

A preliminary analysis of the Tevatron Flying Wires (FW) at 150 GeV and at 980 GeV is presented. For protons, the transverse emittance decreases during the ramping and squeeze, to about 25. π mm mRad then slowly increases again during the store, to about 32 π mm mRad. For antiprotons, the trend is rather different: the transverse emittance barely changes, as both scraping and small emittance dilution takes place. Calibration of the FW and cross-checks with SBD is briefly discussed, and some correlation plots between losses, intensities and transverse emittances are presented. Data presented here have been obtained from recent stores (1285-1309)

1 Remarks on Flying Wires Calibration and Availability.

The Tevatron FW have been restored and checked, and are now giving us good emittances. As a cross-check, the 95 %, normalized, transverse emittance has been re-computed based on the "σ" written in SDA and the MAD files machines paramters found in the Tevatron Web pages, for the case "Remove Halo". The comparison is shown in figure 1. The disagreement, of the order of 5%, can be attributed to:

- Different machine parameters: In this calculation, the vertical beta function (β) at E11, where the vertical wire is located is 80.804 m. The horizontal beta function at E11 and E17 are 80.16 and 68.16 m, while the dispersion D is 2.030 and 5.278 m. This has to be checked against the values loaded in the LabView front-end program.

- Different formulas could have been used. For istance, the correlation between x' and x (or y' and y) (related to the α Courand parameter) have been ignored. For the vertical plane the emittance is simply

$$6\,\sigma^2\,/(\beta\,\gamma)$$

  where γ is the Lorentz factor, E/M. For the vertical plane, we first estimate the $\delta P/P$ by comparing the two observed σ at E11 and E17:

$$\delta P/P = (\sigma_{11} 1^2/\beta_{11}\ -\sigma_{17} 1^2/\beta_{17})/(D_{11}^2/\beta_{11}\ -\ D_{17}^2/\beta_{17}$$

  then, subtract the apparent increase in $sigma$ from the measured sigma in quadrature and use the same formulas as for the vertical plane, at E11 or E17 (by assumptoin, the are equal to each other).

- Round-off errors..

The re-calculate momentum spread $\delta P/P$ agrees with the front-end, within a few percent. The $\delta P/P$ obtained from the FW can be directly compared to the SBD measurement. The SBD systematicaly over-estimates the momentum spread with respect to the FW, at 980 and 150 GeV, by roughly 10 to 15 %, as shown on figure 2. All FW transverse emittance reported in the next section are coming from the FW front-ends, except the for the last case, "Pause HEP", occuring at the end of the store, for which the ACNET Emittance variables are not loaded in SDA, while the new ACNET variables reporting the σ, amplitudes and centroids are.

Finally, as Stephen Pordes reported a few days ago, the FW Front-End recently started to develop a problem, not reporting data for some bunches. See next plots..

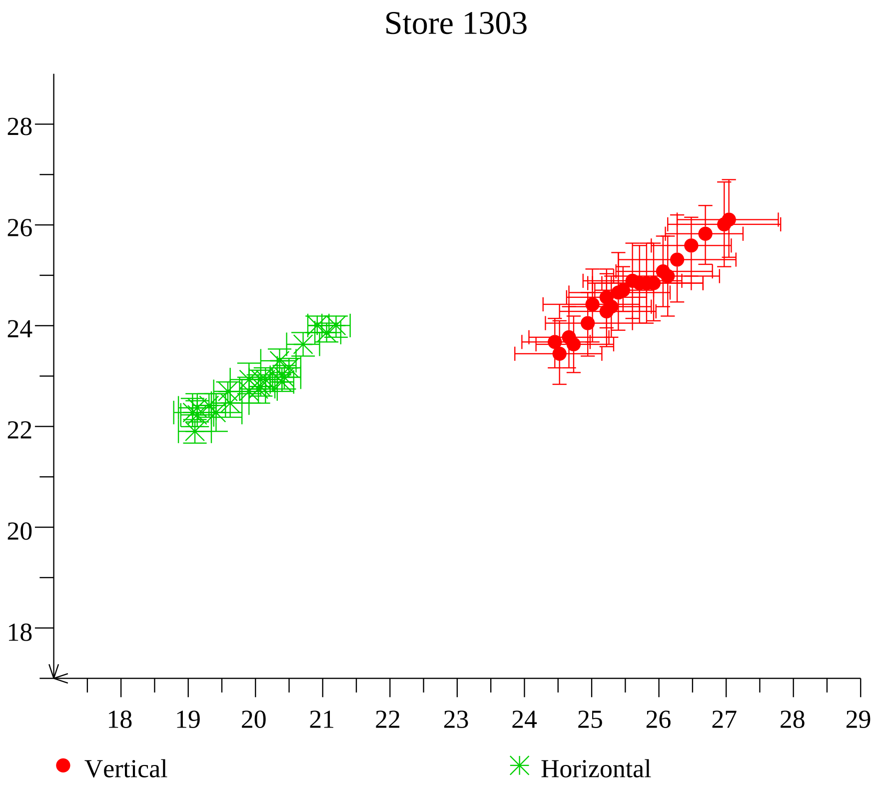


Figure 1: Scatter plot SDA-Front-End emittances (horizontal axis) versus the re-calculate emittances (vertical axis), for the proton beam. The SDA case is "Remove Halo" (after scraping, at 980 GeV). The error bars have been computed based on the difference of the measured σ first vs second pass within the same fly, using a simple variance fomula based on this two measurements.

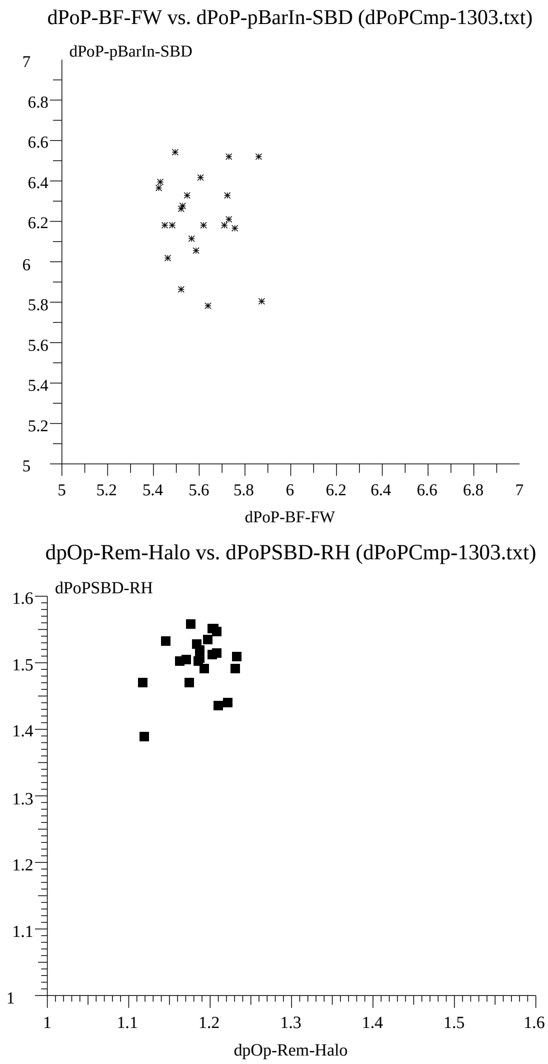


Figure 2: Scatter plot of SDA-Front-End $\delta P/P$ reported by the Flying Wire (horizontal axis versus the $\delta P/P$ obtained from the SBD (vertical axis), at 150 GeV (Before Ramp), shown on top and at 980, after scraping, shown below. Data is from store 1303.

2 Direct Comparison of FW emittances at 4 Tevatron stages, store 1303

The Transverse emittances going from 150 to collisions at 980 are shown on figure 3 and 4 for the proton and antiproton beams respectively, for store 1303. In addition, we also fly the wires at the end of the store, case "Pause Hep", allowing us to measure the emittance increase during the store. See figure 5 and 6

3 More stores, Histograms and correlations.

Data for stores 1243, 1253, 1258, 1260, 1280, 1285, 1287, 1288, 1289, 1291, 1303, 1305, 1307, 1309 have been collected, allowing us to start seeing expected correlations between horizontal and vertical emittances, emittance reduction and loss going up the ramp, and so forth.

The correlation between the transverse and horizontal - presumably due to coupling, is shown before ramp (150 GeV/c) on figure 7. The vertical emittance before and after the ramp are also correlated (figure 8), "diffuse bunches" remains relatively diffused on ramp. However, for pBar, at small emittance, instead of a reduction of the emittance due to scraping, we in fact observe a small, anticipated, emittance dilution across the ramp.

The intensity loss on ramp, squeeze and scraping is simply defined as the relative difference between the fast bunch integrator counts, at case "Remove Halo" and at case "before Ramp". Correlation plots between this loss and the vertical and horizontal emittances are shown on figure 9 and 10. Finally, the correlation between the small vertical emittance dilution/reduction ("Remove Halo" - "Before Ramp") and the loss is shown on figure 11.

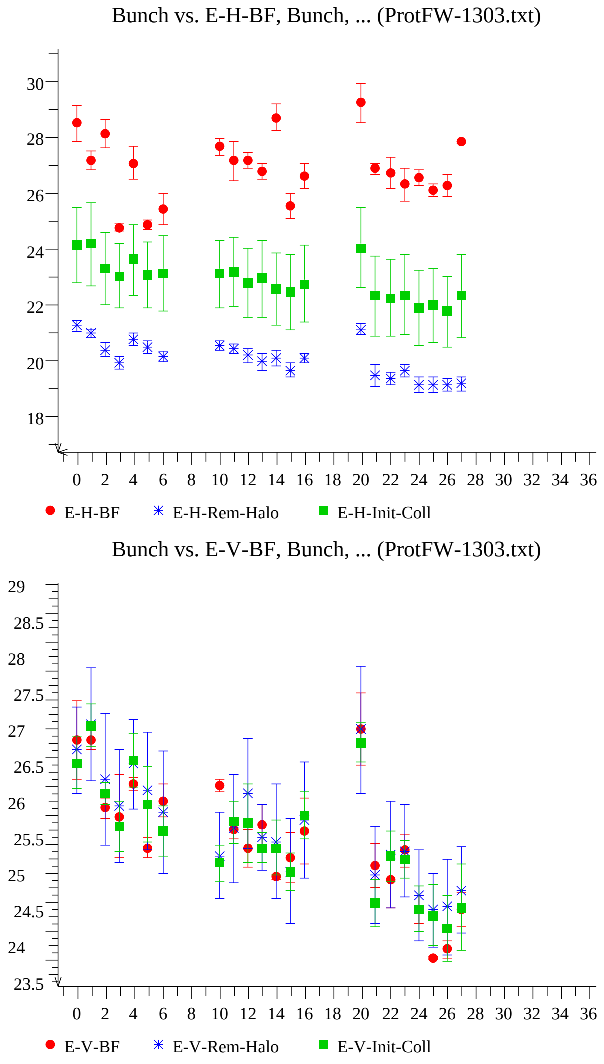


Figure 3: Tranverse emittance at 150 GeV, Before Ramp (red filled circles), at 980, at "Initiate Collision", before scraping (green squares) and after scraping, just before the HEP stores begins. Top is the horizontal emittance, bottom is the vertical emittance. This is for the proton beam.

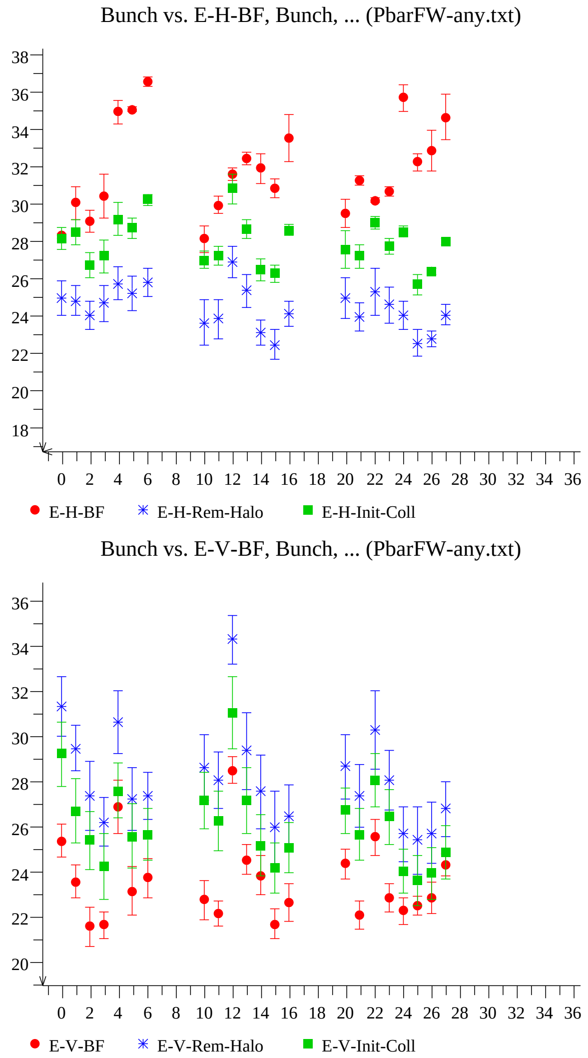


Figure 4: Tranverse emittance at 150 GeV, Before Ramp (red filled circles), at 980, at "Initiate Collision", before scraping (green squares) and after scraping, just before the HEP stores begins. Top is the horizontal emittance, bottom is the vertical emittance. This is for the antiproton beam.

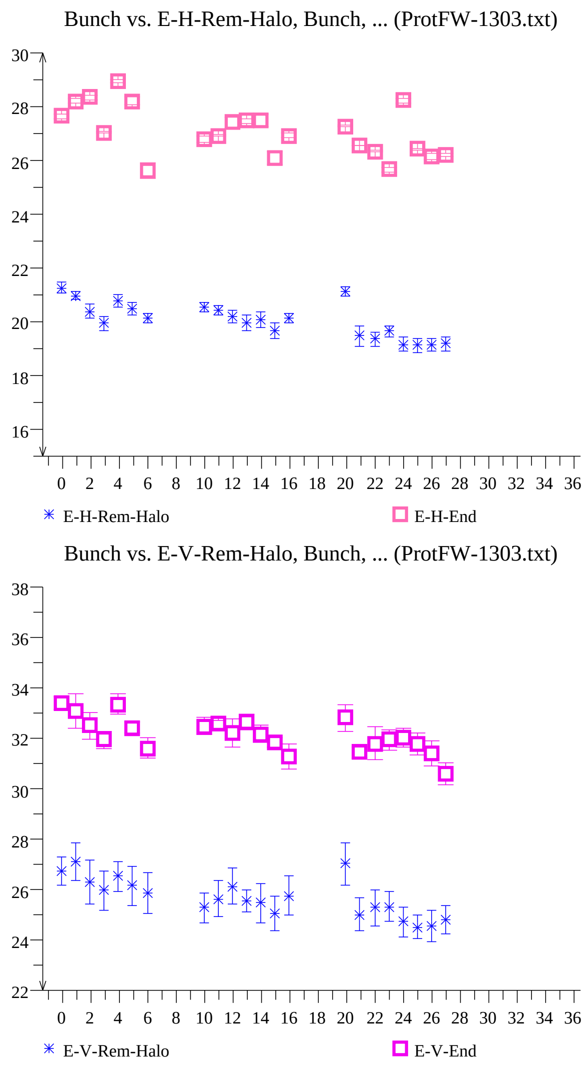


Figure 5: Tranverse emittance at the beginning and at the end of the store. Top is the horizontal emittance, bottom is the vertical emittance. This is for the proton beam.

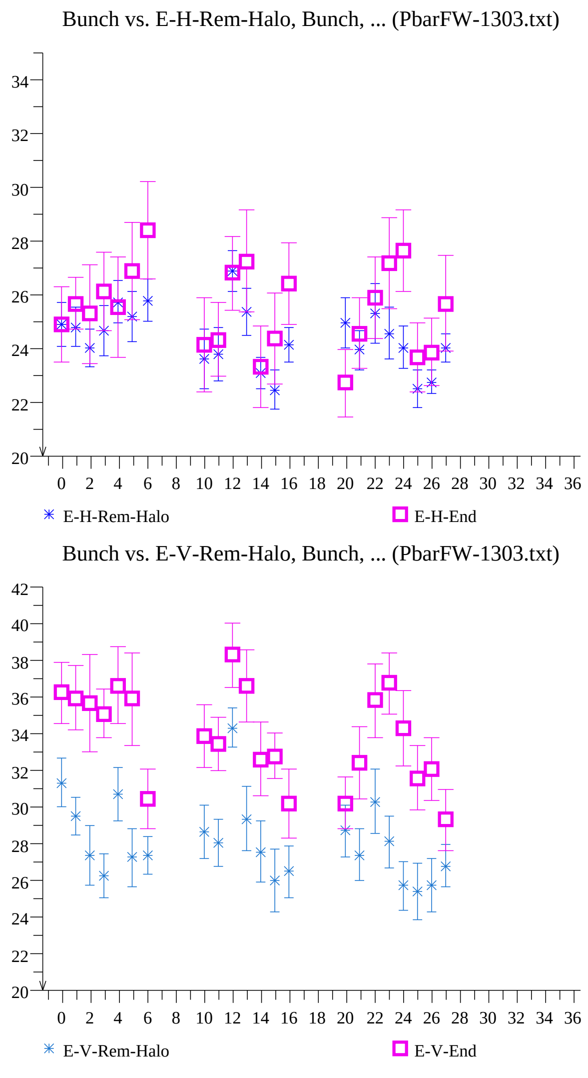


Figure 6: Tranverse emittance at the beginning and at the end of the store. Top is the horizontal emittance, bottom is the vertical emittance. This is for the antiproton beam.

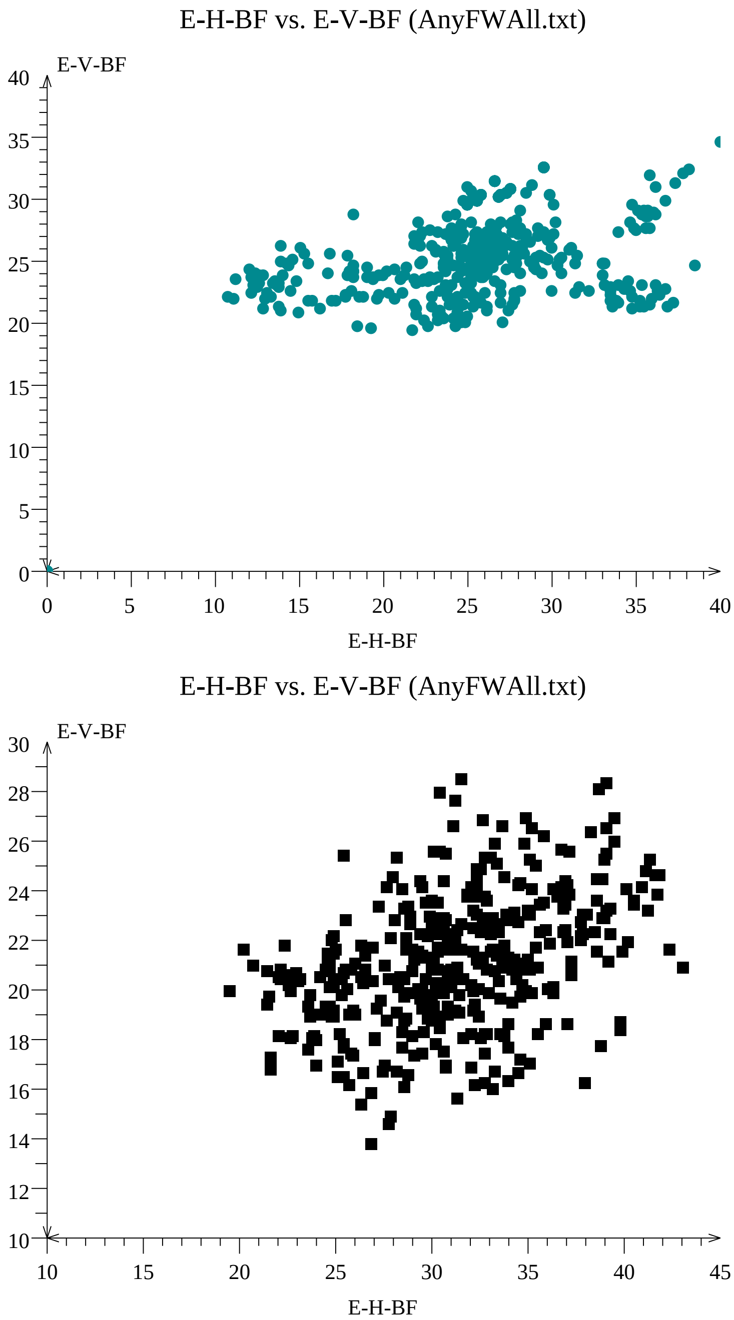


Figure 7: Scatter plot of the vertical (E-V-BF) and horizontal (E-H-BF) emittance at 150 GeV, before ramp. Top is protons, bottom is antiprotons.

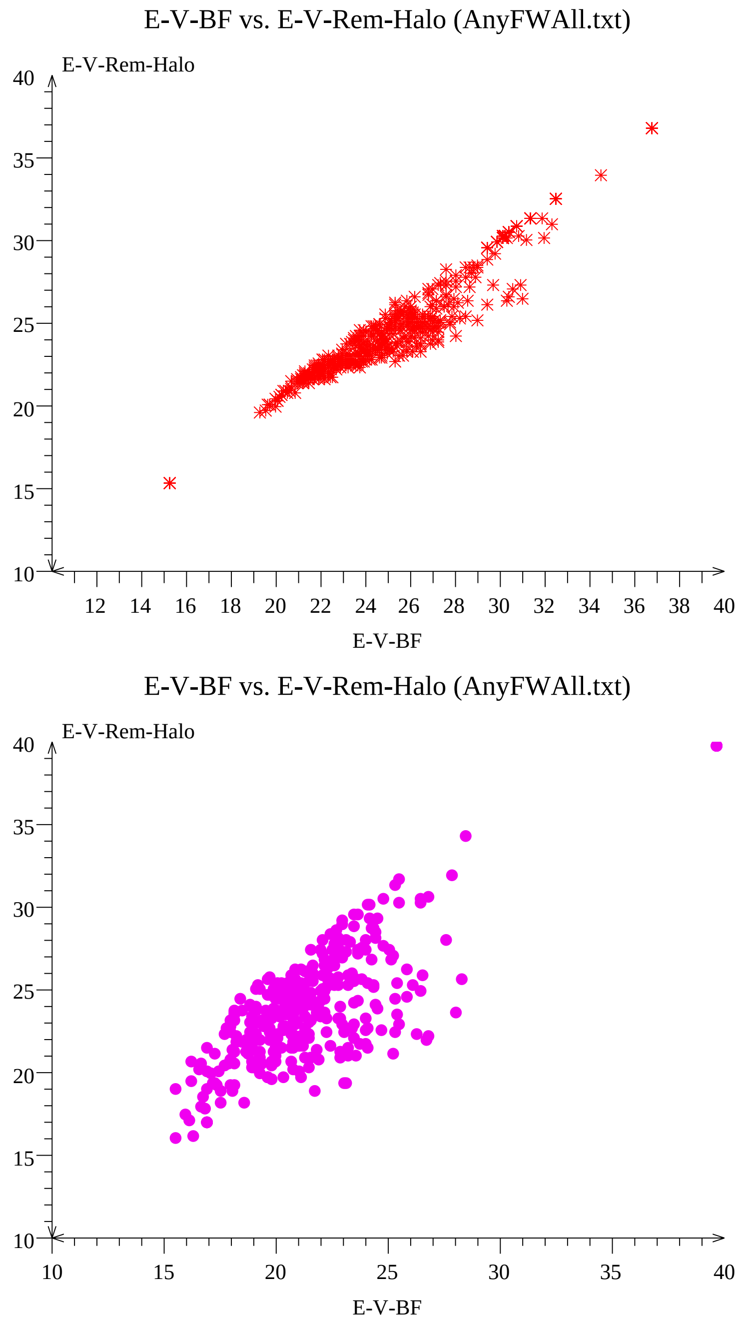
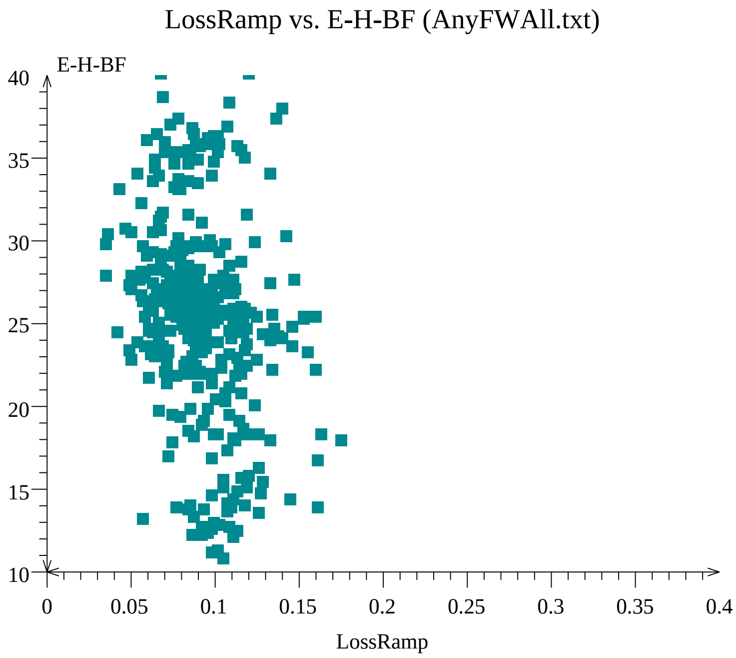


Figure 8: Scatter plot of the vertical (E-V-Rem-Halo) emittance at 980 GeV, measured after the ramp, squeeze and scraping and the same emittance at 150 GeV before ramping (E-V-BF). Top is protons, bottom is antiprotons.



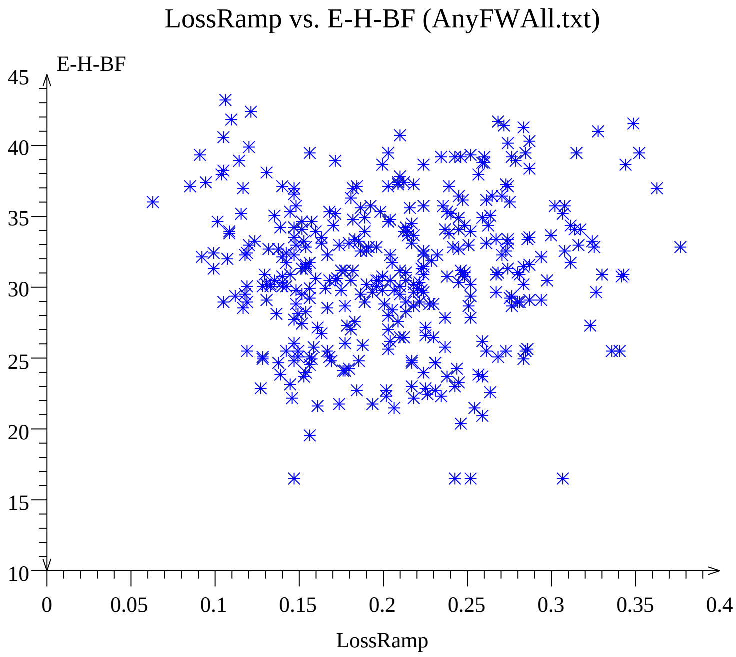
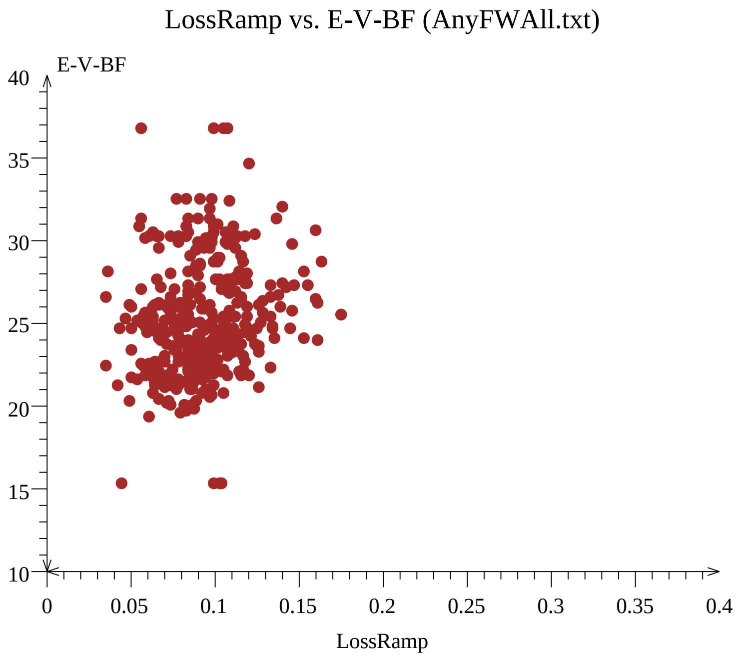


Figure 9: Scatter plot of the horizontal (E-H-BF) emittance at 150 GeV, measured before the ramp and the intensity loss. Top is protons, bottom is antiprotons.



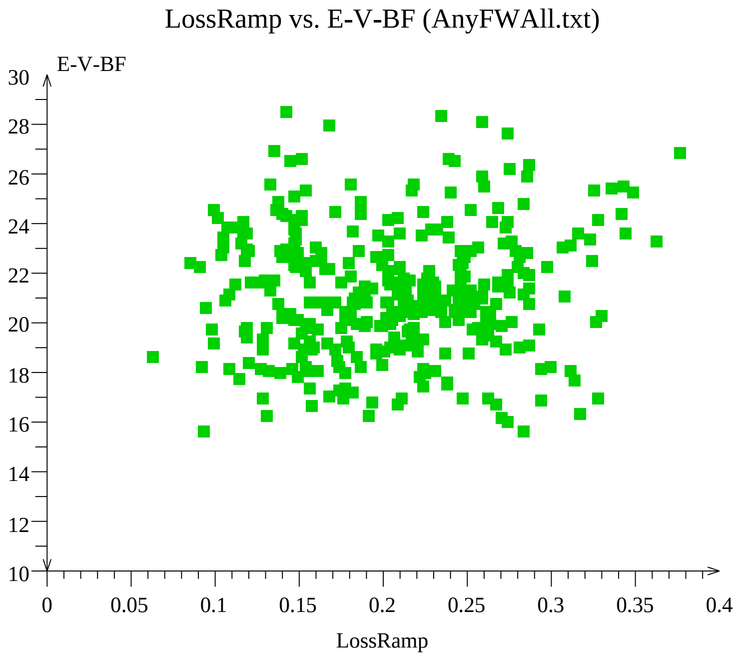
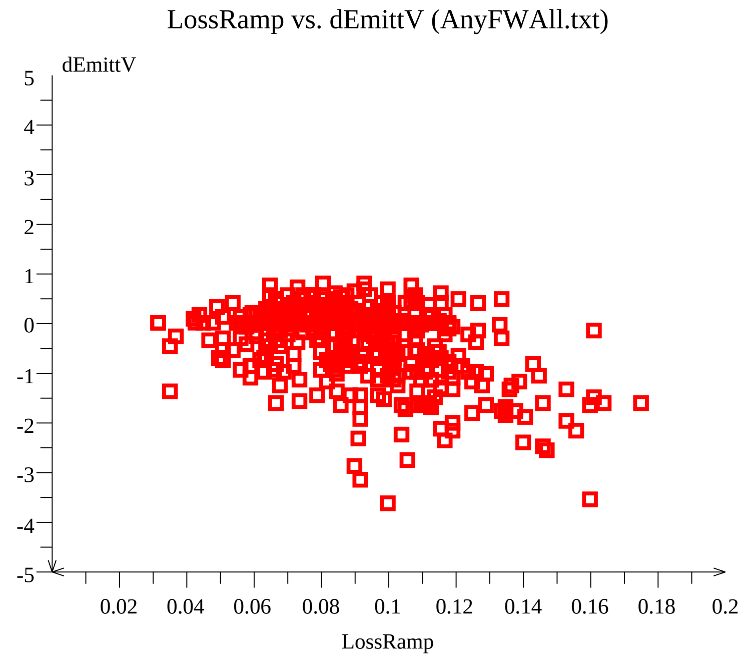


Figure 10: Scatter plot of the vertical (E-V-BF) emittance at 150 GeV, measured before the ramp and the intensity loss. Top is protons, bottom is antiprotons.



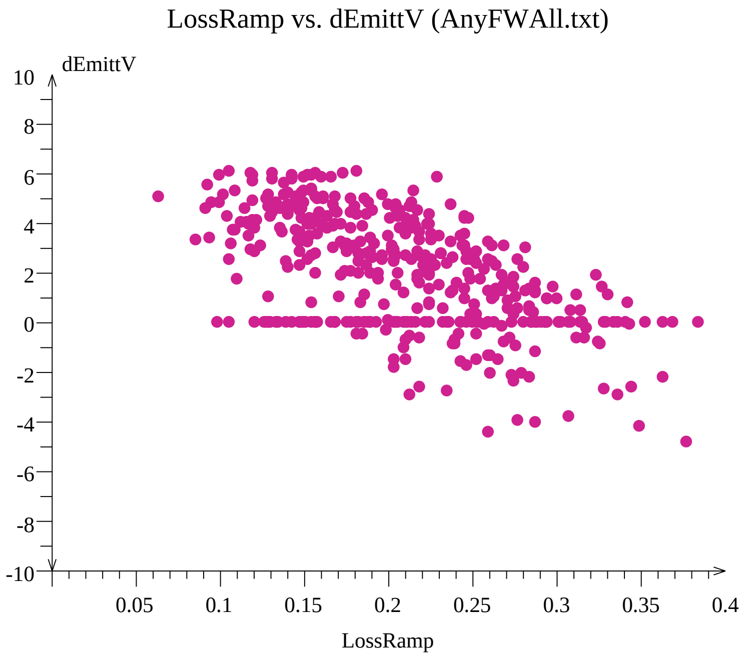


Figure 11: Scatter plot of the vertical emittance change ("980" - "150") the intensity loss. Top is protons, bottom is antiprotons.