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Dependence of BPM Resolution on Time During a Store

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Abstract

This note follows up on a question raised in BTeV-doc-1124. It watches the proton and Pbar resolution over a period of about 12 hours, starting from the start of a store. The proton resolution is stable over this time but the Pbar resolution grows by about 50% and then appears to plateau.

1 Introduction

The data presented here were acquired using the data logger between 1 AM and noon on April 20, 2004. A shot started at about midnight and by 1 AM collisions had started. During this time the Tevatron BPM VA15 was read out using the modified recycler Echotek card, in short gate mode (also known as Plan B mode). This mode is described in BTeV-doc-1124. The Pbar cables had the low pass filters in place. The data were data logged at 15 Hz.

2 Data Collection

I extracted 1 minute of data from the logger starting 1:00 AM, 2:00 AM and so on. For each dataset I looked a time series of the proton and Pbar positions to make sure that no glitches were present. Then I plotted a histogram of the proton position and fitted it to determine the resolution and the error on the resolution. I repeated this for the Pbar position. I also computed the mean of A+B for each of these datasets.

3 Results

The blue data points in the top part of Figure 1 show the proton resolutions, measured as described above, as a function of time. The error bars are the errors reported by the fitting the position histogram. The red line is the result of fitting the 12 data points to a first order polynomial. The slope, reported on the figure, is not statistically significant. The purple histogram shows proton A+B. There is no measurable change in the resolution for about a 15% change in A+B. The step size in the purple histogram decreases with time, showing the increase of beam lifetime as the store progresses.

The blue data points and purple line in the bottom part of the figure show the same information but for Pbars. In this case, however, the resolution grows significantly as the store progresses. The green histogram shows a crude attempt at modeling the change in resolution. It is obtained by taking the purple histogram and, on a bin by bin basis, computing,

$$3170 - (\text{purple}) \tag{1}$$

The constant 3170 was chosen so that the green histogram goes through the data point taken at 6:00 AM. This exercise shows that for about 8 hours or so the Pbar resolution rises linearly with the drop in A+B. After that, the resolution appears to plateau.[1]

The reasons for this behavior are not yet understood. Several candidates explanations have been identified but none have been pursued quantitatively. It is possible that the final answer will be an interplay of several effects. The effects considered are:

1. For a constant variation in $A - B$, a decrease in $A + B$ will lead to an increase in the variation of $(A-B)/(A+B)$. This will not cause a plateau and should affect both P and Pbar equally.

2. The digitization process produces quantization errors. These are less important for large values of A and B and so should affect protons less than Pbars.

3. As the store progresses, longitudinal emittance growth increases the time width of each beam pulse, reducing the power at high frequencies. If aliasing from high frequencies contributes to the resolution, that component might decrease with time. I can imagine that this might effect protons and Pbars differently.

4 Summary and Conclusions

The proton resolution remains stable over a period of 12 hours from the start of a store. The Pbar resolution increases by about 50% over the first 8 hours, or so, and then appears to plateau. While this effect is not yet understood, it is small enough that it can be ignored for the time being. Unless someone has a good idea that can be looked into quickly, this work is done for now.

[1] To be fair, the time period of 12 hours is too short to see significant deviation from linearity. If we want to take this seriously we need data from a full store.

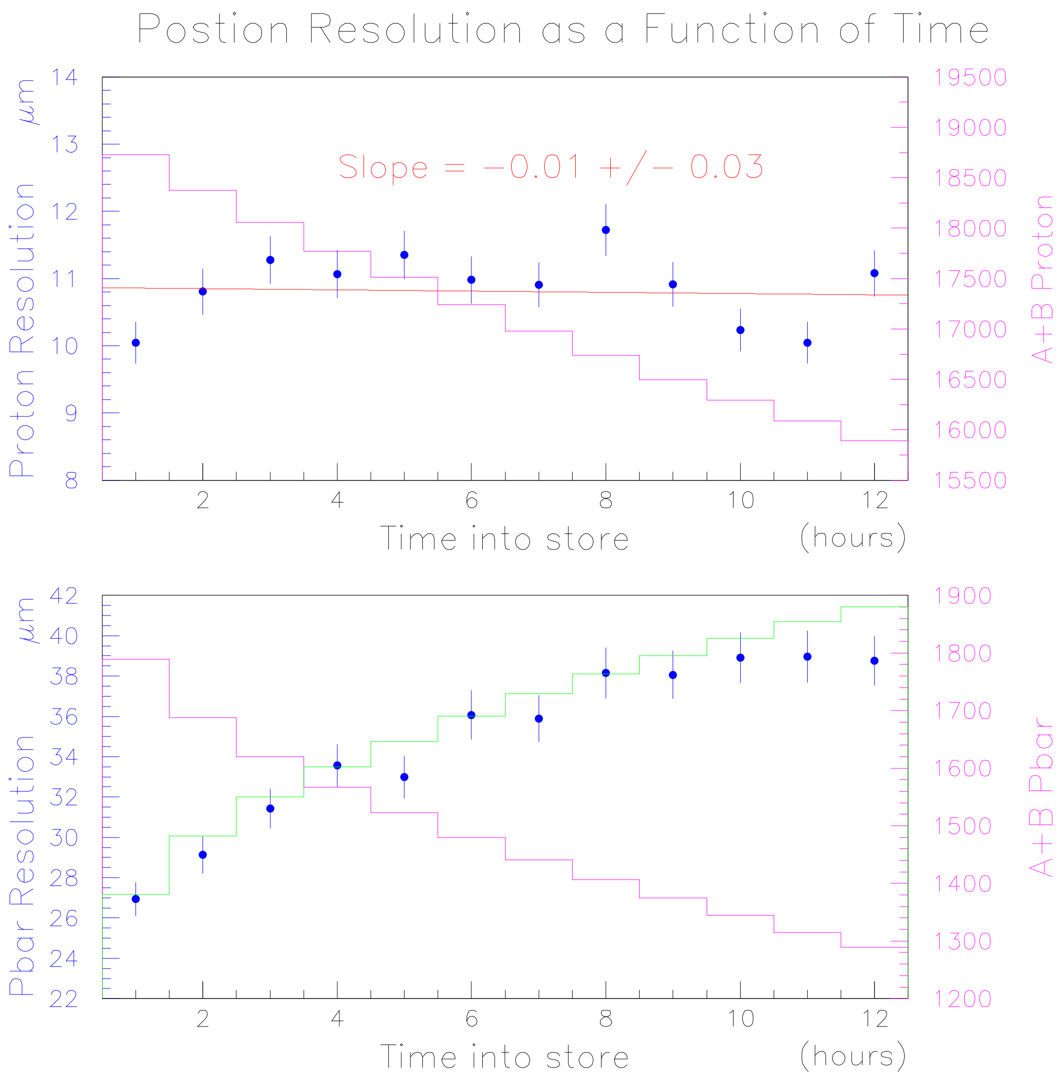

Figure 1: The data points show the measured proton and Pbar positions as a function of time. The horizontal axis is time of day, which closely corresponds to time since the start of proton injection. The purple histograms show the proton and Pbar A+B signals. The units of A+B are raw Echotek output units. The green curve on the bottom plot is a very crude attempt to model the growth in the resolution and is described in the text.