Overview of the Data Collected on the 1AT1 Protect Monitor During Fall 2000

Date: January 23, 2001

1 Introduction

The new T1 protect monitor which has a 5mm separation between the top and bottom plates, with a 4mm separation between the left and right plates was mounted onto one target ladder in September and installed into the beam line on October 18th. This monitor is similar to the previous T1 protect monitor design except for the left and right plates now being 1mm closer. The purpose of the new monitor was to decrease the horizontal region between the left/right plates and thus reduce the distance in which the horizontal beam spread can exist without intercepting the plates.

2 Measurements

Data was logged on the T1 protect monitor on a second by second basis for the period beginning October 18 and continuing until early December. Some time intervals are missing due to maintenance days as well as computer malfunction, etc. If time allowed, during maintenance days beam calibration scans of the T1 protect monitor were performed.

2.1 Beam Scan Calibrations

To calibrate the protect monitor, a low intensity beam ($\sim 1\mu$A) was scanned across each plate and the signal from the plates recorded. To minimize the length of this procedure, Mike Mouat has written and implemented a dac control program which steps the horizontal and vertical steering thumbwheels to steer the proton beam across the plates and logs the pertinent data. Consequently, scans can now be performed in about 15 minutes.

Two such scans are shown in Fig. 1 and Fig. 2, with the beam line configured to $\pi+$ and $\pi-$ polarity respectively. It was not expected that the calibration (dac/mm) would be different for the two beam line polarities (as these are secondary channel changes) however, it should be noted that scans performed for the same beam line polarity do show the same calibration with respect to a given dac/mm conversion. Perhaps the difference in calibration between $\pi+$ and $\pi-$ running can be

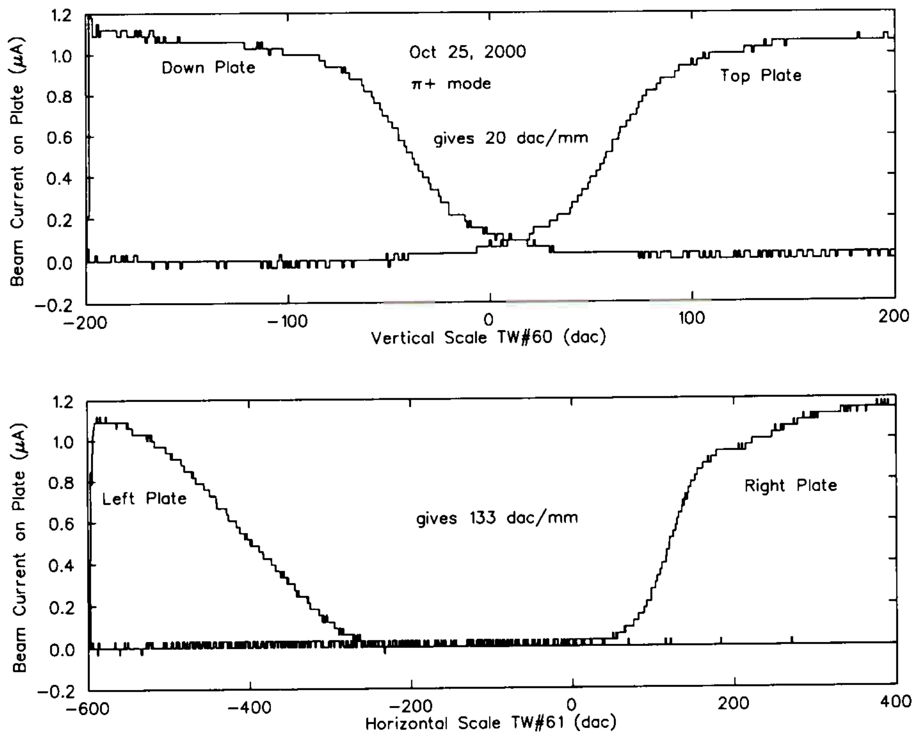

Figure 1: Beam scan performed Oct. 25, 2000, with the beam line in $\pi+$ mode.

attributed to the slight changes made to elements upstream of T1 (such as steering magnets and quadrupole settings) to optimize the proton beam on the production target in $\pi+$ vs. $\pi-$ running modes.

The calibration is calculated by knowing the separation between the plates (4mm between right and left and 5mm between top and down) and assuming that the distance between the half-height points of the curves corresponds to this separation. By looking at the valley region in which no signal above zero is seen between the plates, we can estimate the width of the proton beam profile from tail to tail (or width of the beam at the base). Notice that in the scan of the top/down plates there is no appreciable valley and hence the beam when centered deposits some halo on both plates, implying its base must be 5mm wide or slightly larger. However, for the left/right plates Fig. 1 shows a valley corresponding to 1.8mm while Fig. 2 shows a valley which corresponds to 1.6mm, implying the beam width at its base was $\sim$ 2.3mm (ie: since the beam is scanned across the plates from left to right, the 4mm gap between plates - 1.7mm = beam width at base).

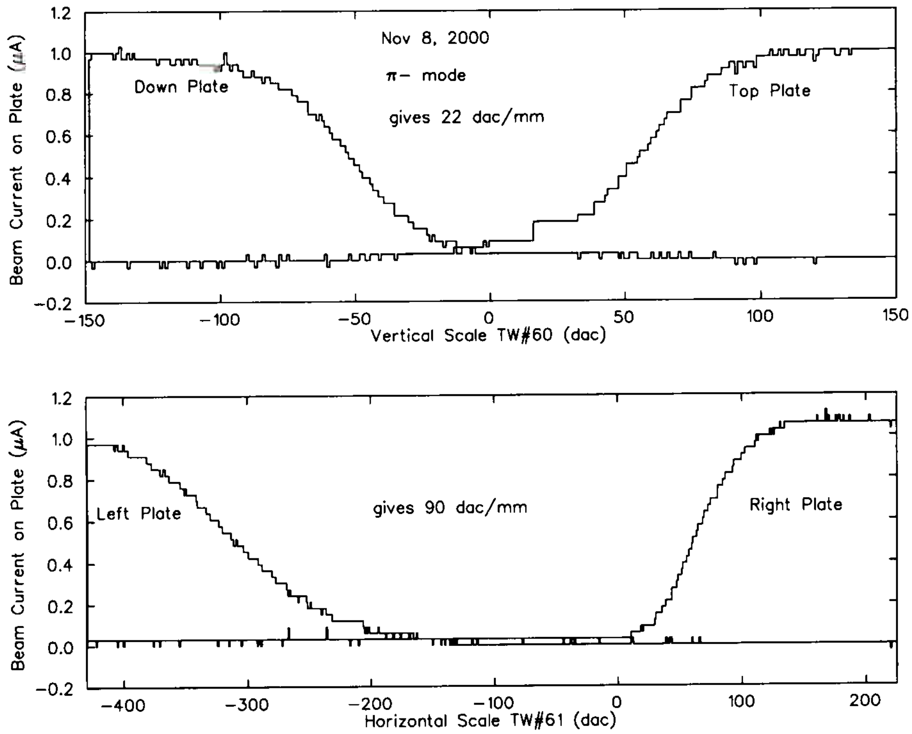

Figure 2: Beam scan performed Nov. 8, 2000, with the beam line in π- mode.

2.2 Proton Beam Properties

To determine the profile of the proton beam at the T1 target, we had intended to use the profile monitor mounted on the target ladder. However, during the run period the monitor was not working. A beam line monitor 1AM6.6, which resides upstream of the T1 target and protect monitor, as well as upstream of Q7(vertical) and Q8(horizontal), was used to give a general idea of the beam width. However because of the monitor's location, the proton beam is not focussed at this position in the beam line and this profile can only be used as a rough estimate. Typically it showed a beam of FWHM(vertical)=3.9mm and FWHM(horizontal)=2.7mm. From the signals detected on the protect monitor in comparison to studies conducted in the summer of 2000, we believe the horizontal width of the beam was narrower than this. The above calculation in which the base width was found to be 2.3mm, also confirms this premise.

2.3 Proton Beam Stability

From the beam halo intercepting the T1 protect monitor plates and the calibration data taken during the protect monitor scans, a position in units of mm was calculated. Shown in Fig. 3 and Fig. 4 are the determined beam halo stability on the protect monitor plates versus time for $\pi+$ and $\pi-$ running modes of the secondary channel. Note that because the beam centroid position could not be determined without the profile monitor, these positions are given in terms of how much halo was intercepted on each plate, top, down, left and right.

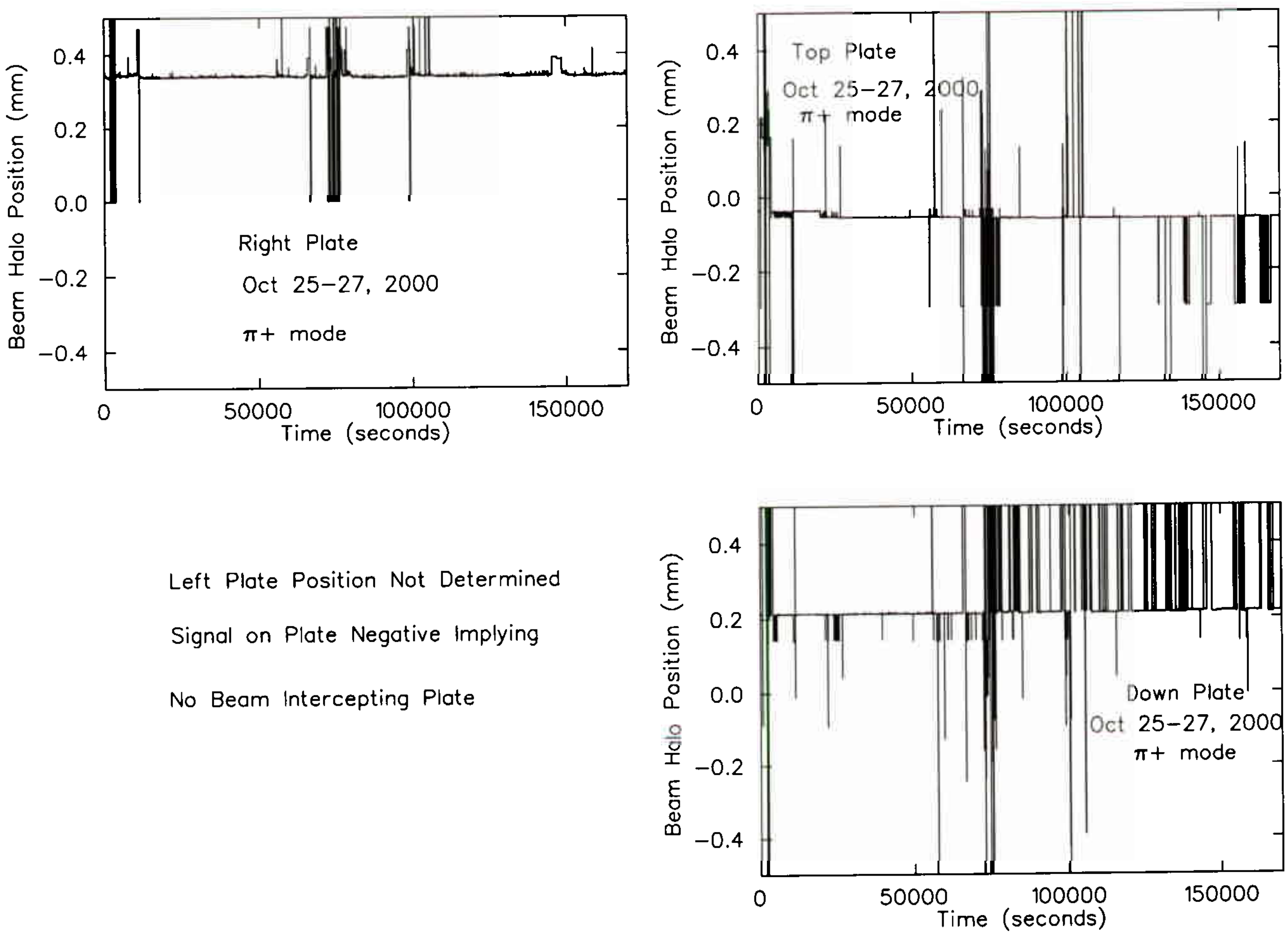

Figure 3: Calculated positions from the beam halo intercepting the T1 protect monitor plate for Oct. 25-27, 2000. Note the beam line was configured for $\pi+$.

During the fall running period, optimization of the BL1A tune meant that the majority of time (all the time when running $\pi-$ and sometimes when running $\pi+$) was spent running with the proton

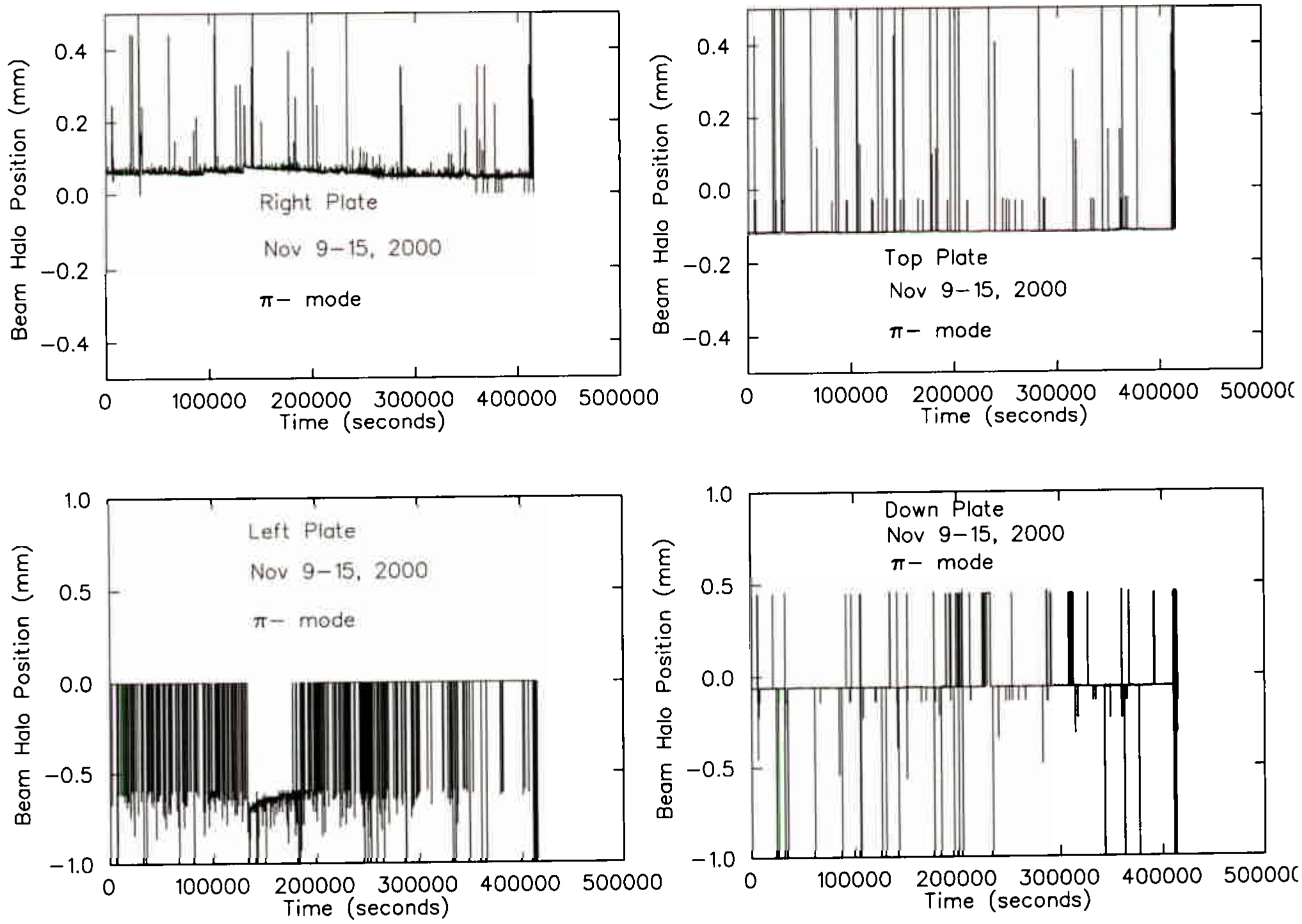

Figure 4: Calculated positions from the beam halo intercepting the T1 protect monitor plate for Nov. 9-15, 2000. Note the beam line was configured for π-.

beam slightly off center in the horizontal plane. Thus, more halo intercepts the right T1 protect monitor plate than the left plate. This same trend was seen during the summer 2000 studies as well. Since the T1 protect plate zeros are set by adjusting offset potentiometers on each amplifier card with the beam off, a zero signal on the plate confirms the absence of intercepted beam halo. As well, a negative signal is read on the plates when the beam halo approaches the plate but does not intercept it (a known property of the monitor, not well understood but thought to be due to inductance effects). Thus, we see that in both Fig. 3 and Fig. 4 a reliable position of the beam halo on the left plate is not measured. The other plates show stability over 2 to 7 days with fluctuations occurring only on small time scales.

3 Considerations, Discussion and Conclusions

The new T1 protect monitor with narrower 4mm separation between the left/right plates was installed and tested during the Fall 2000 running period. We have seen that the proton beam position can remain stable within ~0.1mm on the timescale of about one week (this is of course from data in which there existed enough halo on the plates to determine a position–see scenario below in which no halo can intercept plates and thus no position can be determined). The calibration of the monitor depends on the secondary channel beam line polarity. During the running period the proton beam horizontal spread was found to be narrower than during previous summer 2000 running which showed (from target scans in August) a FWHM(horizontal)=2mm and FWHM(vertical)=7mm. The reason for this difference is not clear, however, it is known that the stripper foil used in summer running was older, hence could be one source of a wider beam; the observation by ops was also made the the cyclotron was using a tighter tune than usual running due to inflector problems which occurred at the beginning of November along with RF booster and injector problems occurring in late October. To determine the profile of the beam a working profile monitor mounted on the T1 target ladder is needed.

From our results, if we consider a proton beam centered on the beam line axis with a beam base width of 2.3mm, it is possible for the beam to wander by 0.85mm left or right before interception of any beam halo on the plates separated by 4mm. We have seen however that ops may run with the beam spot closer to the right plate, however this does depend on target scans as well as the relative alignment between the T1 target and the T1 protect monitor (see below). If we were to go back to the old T1 protect monitor with 5mm spacing between the left/right plates, under the above conditions the beam could in principle wander 1.3mm in either direction before we could detect any change in position.

Of course we have so far not considered muon production and optimizing the secondary muon beam down the channel which will indeed have consequences for steering the primary proton beam. It was noticed during the beam studies in the fall that an optimal tune of muons down the channel resulted in the proton beam being steered too close to one of the protect monitor plates. The old T1 protect monitor on the spare ladder was then put into place and a better optimization of muons down the channel achieved. It seems that the alignment of the protect monitor with respect to the

T1 carbon target was not optimal on the target ladder. Cyclotron ops also stated that the protect monitor with the smaller left/right separation made tuning the proton beam more difficult.

It seems to be a tradeoff between how much we are going to allow the proton beam to wander in the horizontal direction versus how well we need to optimize the muon beam down the channel. Of course it should be noted that remote handling can only guarantee alignment between the T1 protect monitor and T1 carbon target to between 1 and 3mm. This is due to these devices being mounted on separate rods of the target ladder which can twist slightly when put into position in the beam line, along with the remote handling nature of the mounting procedure.

The Monte Carlo studies conducted in the summer indicate that it if the proton beam was impinging on an optimal position on the carbon production target, then the beam could wander $\sim$2mm before a significant change in the muon depolarization was seen. See the beams groups posting of Aug 2, 2000 for reference.