Tevatron Extraction Modeling

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Abstract

A comparison is made between measured and predicted transverse beam profiles in the Fermilab Switchyard. In the vertical plane a prosaic but operationally important issue is examined; for the case of consecutive splits using electrostatic septa, how does multiple scattering from the first septa affect the distribution from a highly asymmetric downstream split. In the horizontal plane the input distribution for the Switchyard is determined by the extraction process; and the particular case of increasing the step size across the extraction septa is examined.

1. INTRODUCTION

In preparation for the increase in intensity from the forthcoming upgrades at Fermilab and for the expected changes in momentum (both higher and lower) for the fixed target program, a series of modelings of the extraction from the Tevatron through the Fermilab Switchyard has been undertaken. The Switchyard is a set of splitting stations with attendant bending and focusing elements which delivers beams of varying intensity to different external experimental areas. The splitting stations consist of thin wire electrostatic septa followed by magnetic septa (Lambertsons).

At the present stage of development the Tevatron Extraction Modeling Program ,TEVEXT [1], and Transport/Turtle [2] have been compared at A0, the beginning of the extraction channel leading into the Switchyard. In the future a TEVEXT file will be used as input for Turtle now that this consistency checking has been performed.

To determine the input beam parameters for Transport the conceptually simple method of sending all the beam to one area (i.e. not splitting any of the beam with an electrostatic septa) has been used. With these parameters determined for one beam line the same input parameters have been used for the other beam lines, i.e. one may consider two of the beam lines to be a zero parameter fit. Figures 1, 2, and 3 show the results of the Transport runs compared to the data from our SWIC[3] data and the agreement is quite excellent. As a side product of preparing this paper, a long standing mystery [4] in the Switchyard has been cleared up concerning the comparison of the Proton line to the Meson/Neutrino lines.

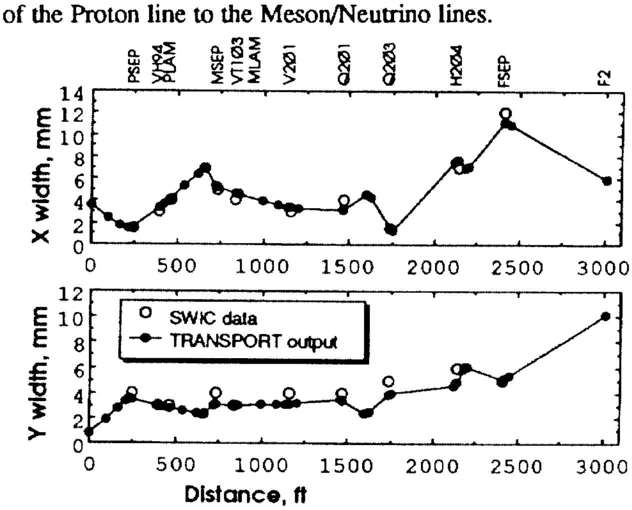

Figure 2: Comparison of SWIC data to TRANSPORT output for the MESON area.

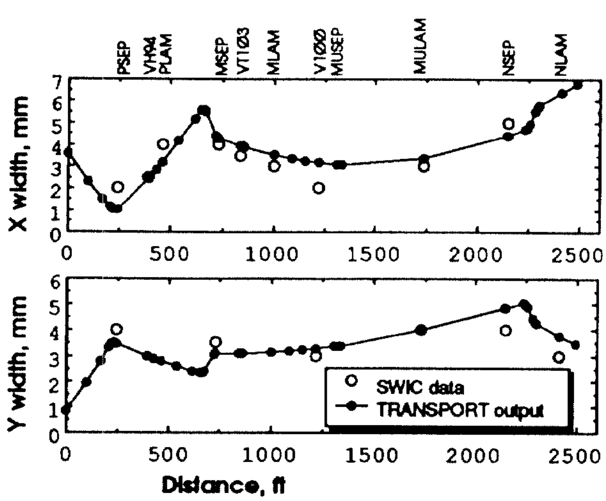

Figure 1: Comparison of SWIC data to TRANSPORT output for the NEUTRINO area.

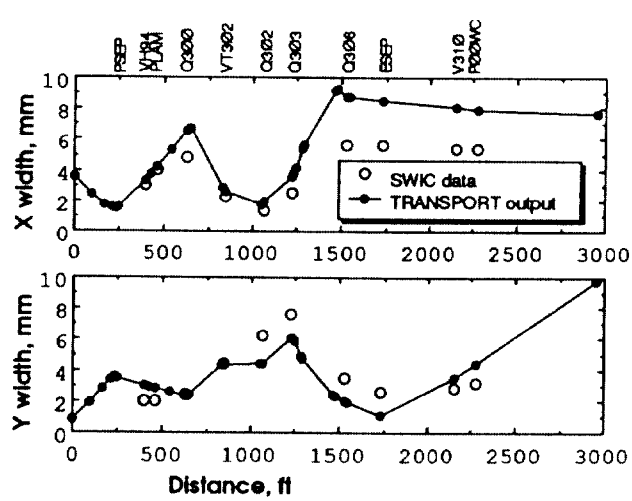

Figure 3: Comparison of SWIC data to TRANSPORT output for the PROTON area.

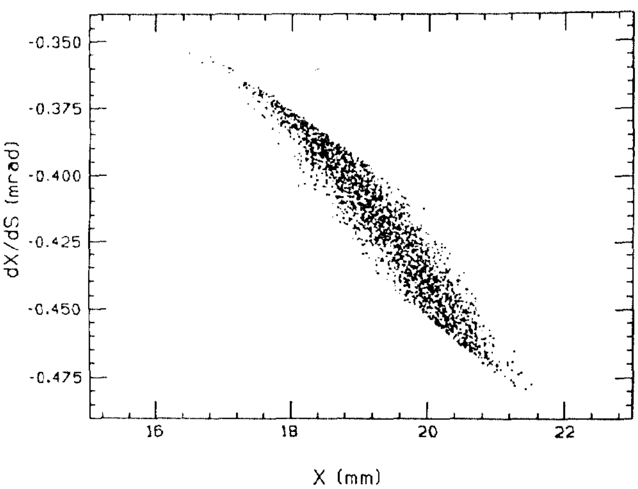

Figure 4: Extracted beam phase space at AØ.

Figure 4 shows TEVEXT output at the start of the extraction Lambertsons which is the start of the Transport. Using several reasonable assumptions for approximating the extracted beam phase space distribution with an ellipse a range of values for the parameters alpha , beta, and emittance have been extracted. It is assumed that the vertical phase space will be the same as given by normal Synch output along with a conventional assumption for the emittance. Table I compares these values with the values found in the SWIC fitting procedure. It will be noted that the emittances are predicted to be smaller than that deduced from the measured data. However, there are two independent pieces of information that indicate that the SWICs may systematically overestimate the widths of the beam. One piece of information is from measuring how far one has to move septa to produce a certain split ratio, and the other piece of information is from a wire scan. Figure 5 shows the result of a wire scan downstream of PSEP, which is the electrostatic septa which splits beam off to the Proton area, the relevant SWIC data, and a Turtle output which represents the same situation. For this paper we will use the raw SWIC data (which is consistent with earlier investigations), however we are investigating this situation.

Table I

	TEVEXT	TRANSPORT	unit
Alpha X	2.7 to 3.4	2.2	
Beta X	100 to 140	197	meter
Emittance	24 to 46	56	π•mm•mr

	SYNCH	TRANSPORT	unit
Alpha Y	- .6	- .8	
Beta Y	29	24	meter
Emittance	11	23	π•mm•mr

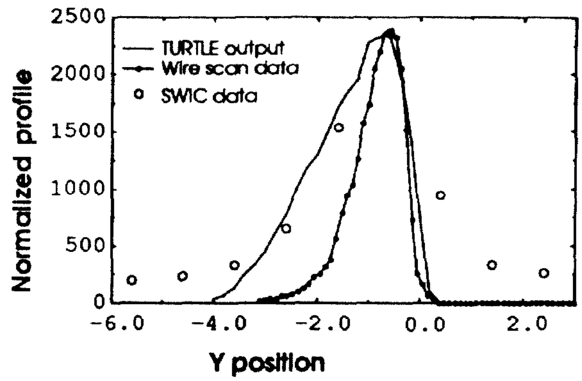

Figure 5: SWIC data, wire scan data, and TURTLE result for split beam profile downstream of PSEP

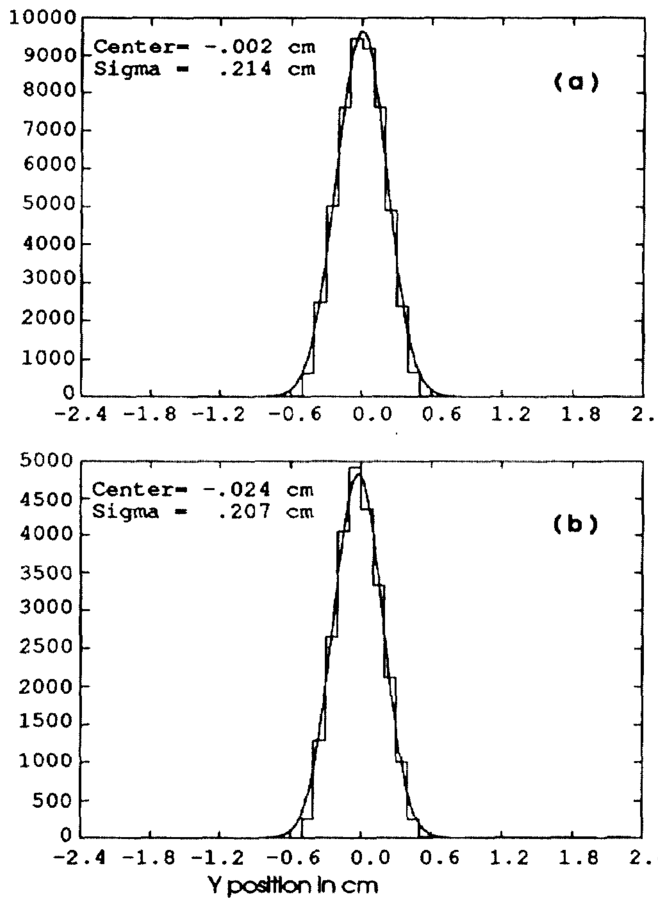

Figure 6: Simulated Y profile of the beam to MESON area at Q203. (a) Single beam; (b) a 50/50 split at PSEP

2. SEPTA SPLITTING

The data in figure three was in fact not taken with a single beam to Proton. The highly successful operation of the fixed target program made it difficult to justify beam study time and the only single beam data to proton that we have, was taken before we did extraction tuning to reduce losses which is discussed in section 4. However a Turtle study was undertaken to study how the phase space distribution evolves downstream from a split. Figure 6 compares the distributions at a downstream location with and without a split at PSEP (c.f. figure 5). As we can see the shapes of the distributions are almost indistinguishable. Hence the distributions in figure 3 are reasonable representations of the beam from the accelerator.

3. MULTIPLE COULOMB SCATTERING

In the Switchyard there are many sources for multiple scattering, vacuum windows for the septa and cryogenic regions, SWIC windows, SWIC wires, and septa wires. In general the effect is not large, however we have investigated one situation. This is the case when we have a very asymmetric downstream split, i.e. we have a user who is requesting a small amount of beam after we have split the beam several times. Figure 7 shows Turtle distributions for the specific example of the Meson East beam line with and without multiple scattering at the PSEPs and FSEPs (assuming a 50/50 split at PSEP and a 90/10 split at FSEP). Figure 8 shows the corresponding experimental SWIC profile and the qualitative effect of multiple scattering is evident although clearly quantitatively our assumptions need to be improved.

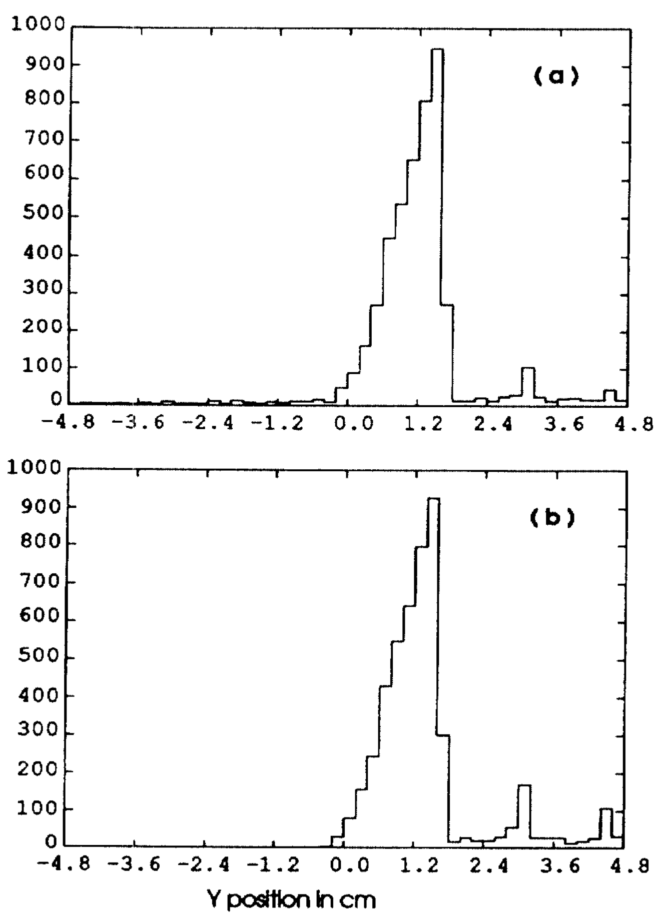

Figure 7: Simulation of Y profile of beam to MESON area at ME2WC, (a) with Coulomb scattering from the PSEP septa wires; (b) without Coulomb scattering.

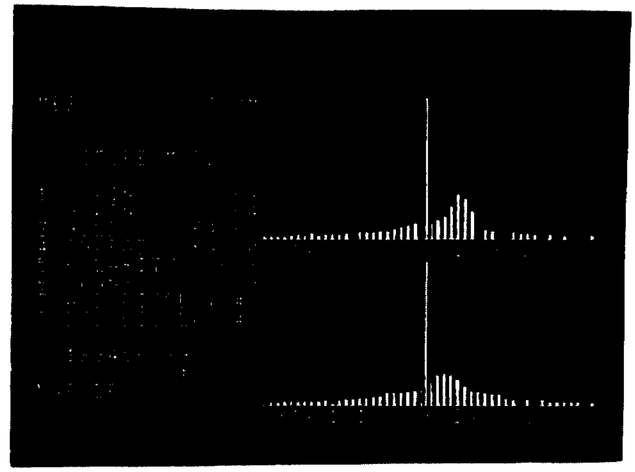

Figure 8: SWIC data at ME2WC, MESON area.

4. EXTRACTION LOSSES

During the hiatus in the 1990-1991 fixed target program new quadrupoles were installed at D0. These new quadrupoles changed the lattice of the Tevatron and consequently the extraction process. One of the symptoms was larger losses at D0 and this had an impact on the people working on the installation of the D0 detector. Hence a study period to investigate the problem was scheduled, and the losses were reduced by a factor of two. In attempting to model the tuning with TEVEXT, it appears , with the magnitude of the change in the parameters used, that the angle of the beam across the D0 septa was changed more than the step size in normalized phase space. All fitting and modeling in this paper was done after this tuning was performed.

5. CONCLUSION

TEVEXT needs more development work before it can be used to predict the effect of proposed tuning, and before we use it to study the Switchyard. Also the SWIC resolution question is currently under study. These efforts along with the improvement of the inclusion of the effects of multiple scattering in the splitting of beams in Transport/Turtle will be aided by the continuation of these studies which use the present extraction from the Tevatron to calibrate our predictions for the Main Injector era.

6. REFERENCES

[1] G. Goderre TEVCONFIG to be published as a Fermilab Technical memo.

[2] K. L. Brown et al., TRANSPORT, A Computer Program for Designing Charged Particle Beam Transport System, CERN 80-04.

[3] F. Hornstra, Jr. and J. R. Simanton; A Multichannel Integrator and Scanner for Wire Plane Beam Profile Displays, NIM, 77 (1970) 303-305

[4] S. Childress et al.,Fermilab Fixed Target Beams from the Main Injector, Fermilab TM 1599, 1989.