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Verification of the BTA Model

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Title: Verification of the BTA Model

Study Period: February 3, 1996

Participants: P. Sampson

Reported by: P. Sampson

Machine: Booster (BTA)

Tools: BTA Multiwires

Aim: Predict BTA behavior using the application "Bmline Emit".

P. W. Sampson

Verification of the BTA model using measured dispersion effects:

[1] Introduction:

A measure of dispersion effects in the Booster to AGS line (BTA) can be made by varying energy at extraction and observing beam profile motion on the multiwires in the BTA line.

Data for profile movement as a function of measured energy changes was taken by varying the extraction radius in the Booster and recording profiles on all of the BTA multiwires[1], as well as the extraction frequency of the Booster.

A MAD projection, using the present BTA model, was then used to generate expected values for the dispersion function at any location in the BTA line[2].

Measured changes in position and values for $\Delta p/p$ calculated from measured $\Delta f/f$ define D_x[3]. The MAD output for the above mentioned projection predicts values for D_x at each multiwire. The measured values for D_x can then be compared to modeled ones and the validity of the model then checked.

[2] Method:

A measure of the beam width at MW006 in BTA was used with parameters generated by a MAD model for the Booster to calculate initial TWISS parameters for the $Au32^+$ beam entering the BTA line. See table I.

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[1]Done with the assistance of the FORTRAN code LOGMW which takes simultaneous data for all four harps in the BTA line. It was written by M. Blaskiewicz

[2]The projections are done using the Booster applications code 'Bmline_emit'.

[3]D_x is measured in meters is the magnitude of motion a particle beam will experience as a result of a momentum change $\Delta p/p = 1$.

Table I.

Values TWISS parameters at F6 as generated by MAD.

α_x	β_x (m)	D_x (m)	DP_x	α_y	β_y (m)
1.85	13.26	2.9	-.41	-.61	4.19

Measured 1 σ widths at multiwire 006 of 2.91mm and 3.48mm for the horizontal and vertical respectively give emittances as: ϵ_x = 3.2mm/mrad and ϵ_y = 3.21mm/mrad (geometric).

Table II.

TWISS parameters projected to the foil.

α_x	β_x (m)	D_x (m)	DP_x	α_y	β_y
-1.78	.711	-.359	.268	-1.06	4.156

Equations 1-5 below were used to transform the TWISS parameters through the foil[4]. These transformed TWISS parameters were then projected to A5 in the AGS ring.

The transformation formulae are listed below:

1) *let;* $$f=(1+\frac{\delta^2}{2\varepsilon})^{1/2}.$$

2) *where;* $$\delta^2=\frac{AVG(\Delta\vec{p}_\perp^{\,2})}{p^2}$$
$$=2(\sigma^2(\dot{x}))$$
$$=2(\sigma^2(\dot{y}))$$

and:

3) $$\varepsilon_1=f\varepsilon\geq\varepsilon$$

4) $$\beta_1=\frac{\beta}{f}\leq\beta$$

5) $$\alpha_1=\frac{\alpha}{f}\leq\alpha$$

Where α,β,γ are just upstream and $\alpha_1,\beta_1,\gamma_1$ are just downstream of the foil.

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[4]Transformations provided by M. Blaskiewicz.

Transforming the projection gives table III.

Table III
TWISS parameters at the downstream end of the foil.

α_x	β_x (m)	D_x (m)	DP_x	α_y	β_y
-.9	.54	-.41	.132	-.27	1.04

The extraction radius was changed to several different values. At each value, the R.F. frequency and beam centroid positions were measured over 10 consecutive pulses. Average values for these are in table IV.

Table IV

Measured frequency vs. Profile centroid position (average).

#	Frequency (Mhz)	MW006 (mm)	MW060 (mm)	MW125 (mm)	MW166 (mm)
0	5.0279	-4.956	-2.576	8.532	8.036
1	5.0292	-5.017	-0.852	6.990	7.090
2	5.0305	-4.993	0.740	5.480	6.070
3	5.0316	-4.886	2.522	3.670	4.628
4	5.0341	-4.620	6.198	0.168	2.128

From these values the relative change in energy was calculated using the transformation in equation 6[5]. Table V shows the results.

6) $$\frac{\Delta p}{p}=\frac{\Delta f}{f}\left(\frac{\gamma_{tr}^2\gamma^2}{\gamma_{tr}^2-\gamma^2}\right)$$

The ratio of Δx to $\Delta p/p$ is D_x.

[3] Results:

In table V below, the measurement b-a reflects the frequency

[5]Constants used, such as m_0 for gold, Booster radius and γ_{tr} are listed in the FORTRAN code 'deltapp' by P. Sampson

difference between measurements b and a listed in table IV. For example, 1-0 lists data $\Delta f=f_1-f_0$.
Table V.

Δ measurement	Δf (kHz)	Δp/p (10^{-4})
1-0	1.3	3.318
2-0	2.6	6.636
3-0	3.7	9.442
4-0	6.2	15.820
2-1	1.3	3.318
3-1	2.4	6.125
4-1	4.9	12.500
3-2	1.1	2.807
4-2	3.6	9.184
4-3	2.5	6.387

Tables VI-IX show Δx (measured), Δp/p (calculated from measurement) and pΔx/Δp. The value pΔx/Δp is a constant equal to D_x.

Table X gives the projected values of D_x vs. values calculated from the data.

Figure 1. Is a plot of the unfitted Δp/p vs. Δx.

Figure 2. Shows linear regressions of there plots. The errors in table IX are from this fit.

Figure 3. Is a plot of the MAD projection for the dispersion function. Measured values are superimposed.

Table VI: Multiwire 006

Δmnt	Δx (mm)	$\Delta p/p*10^{-4}$	pΔx/Δp
1 - 0	-.061	3.318	-.1838
2 - 0	-.037	6.636	-.0558
3 - 0	.070	9.442	.0741
4 - 0	.336	15.820	.2139
2 - 1	.024	3.318	.0723
3 - 1	.131	6.125	.2138
4 - 1	.397	12.500	.3176
3 - 2	.107	2.807	.3812
4 - 2	.373	9.184	.4061
4 - 3	.266	6.387	.4164

Table VII Multiwire 060:

Δmnt	Δx (mm)	$\Delta p/p*10^{-4}$	pΔx/Δp
1 - 0	1.724	3.318	5.1959
2 - 0	3.316	6.636	4.9970
3 - 0	5.098	9.442	5.3993
4 - 0	8.774	15.820	5.5461
2 - 1	1.592	3.318	4.7981
3 - 1	3.374	6.125	5.5086
4 - 1	6.750	12.500	5.4000
3 - 2	1.782	2.807	6.3484
4 - 2	5.458	9.184	5.9430
4 - 3	3.676	6.387	5.7554

Table VIII Multiwire 125.

Δmnt	Δx (mm)	$\Delta p/p*10^{-4}$	pΔx/Δp
1 - 0	-1.542	3.318	-4.6474
2 - 0	-3.052	6.636	-4.5992
3 - 0	-4.862	9.442	-5.1493
4 - 0	-8.364	15.820	-5.2870
2 - 1	-1.510	3.318	-4.5509
3 - 1	-3.320	6.125	-5.4204
4 - 1	-6.822	12.500	-5.4576
3 - 2	-1.810	2.807	-6.4482
4 - 2	-5.312	9.184	-5.7840
4 - 3	-3.502	6.387	-5.4830

Table IX Multiwire 166.

Δmnt	Δx (mm)	$\Delta p/p*10^{-4}$	pΔx/Δp
1 - 0	-0.946	3.318	-2.8511
2 - 0	-1.966	6.636	-2.9626
3 - 0	-3.408	9.442	-3.6094
4 - 0	-5.908	15.820	-3.7345
2 - 1	-1.020	3.318	-3.0741
3 - 1	-2.462	6.125	-4.0196
4 - 1	-4.962	12.500	-3.9696
3 - 2	-1.442	2.807	-5.1372
4 - 2	-3.942	9.184	-4.2922
4 - 3	-2.500	6.387	-3.9142

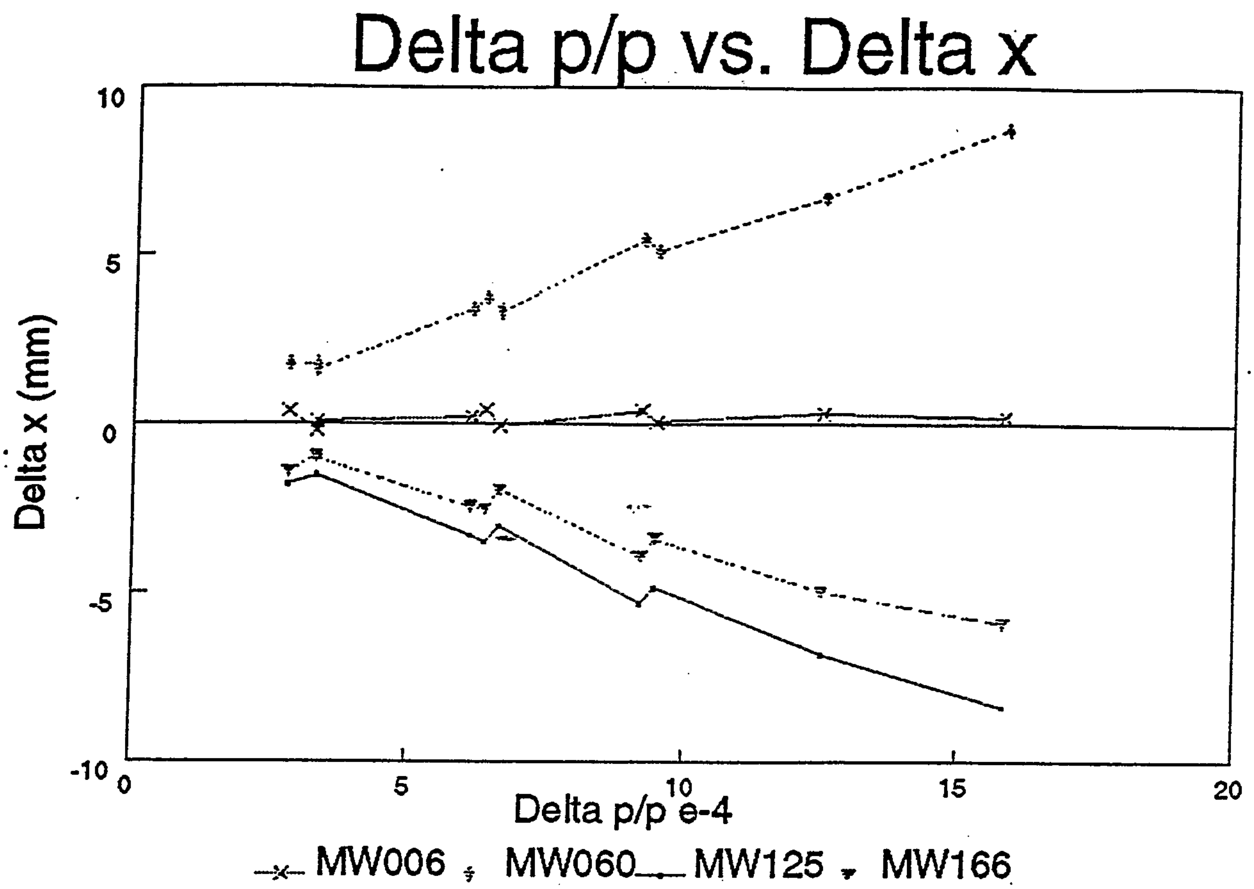

Figure 1.
Plots of Δp/p vs. Δx.

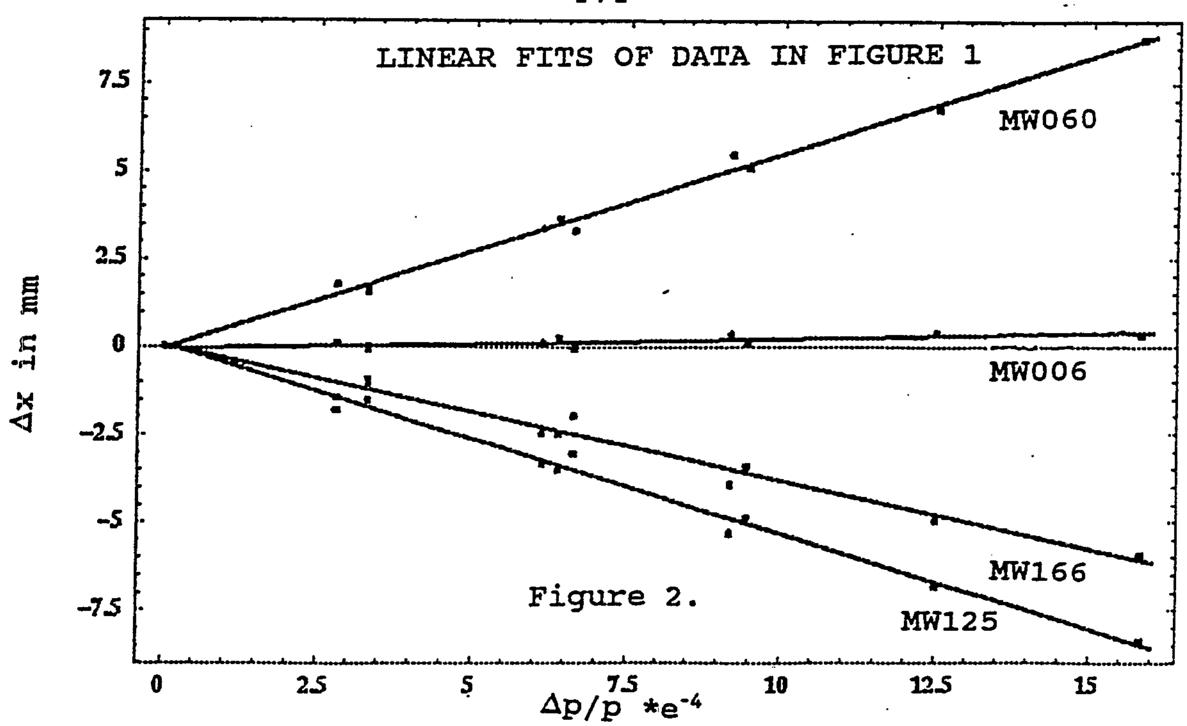

Figure 2.

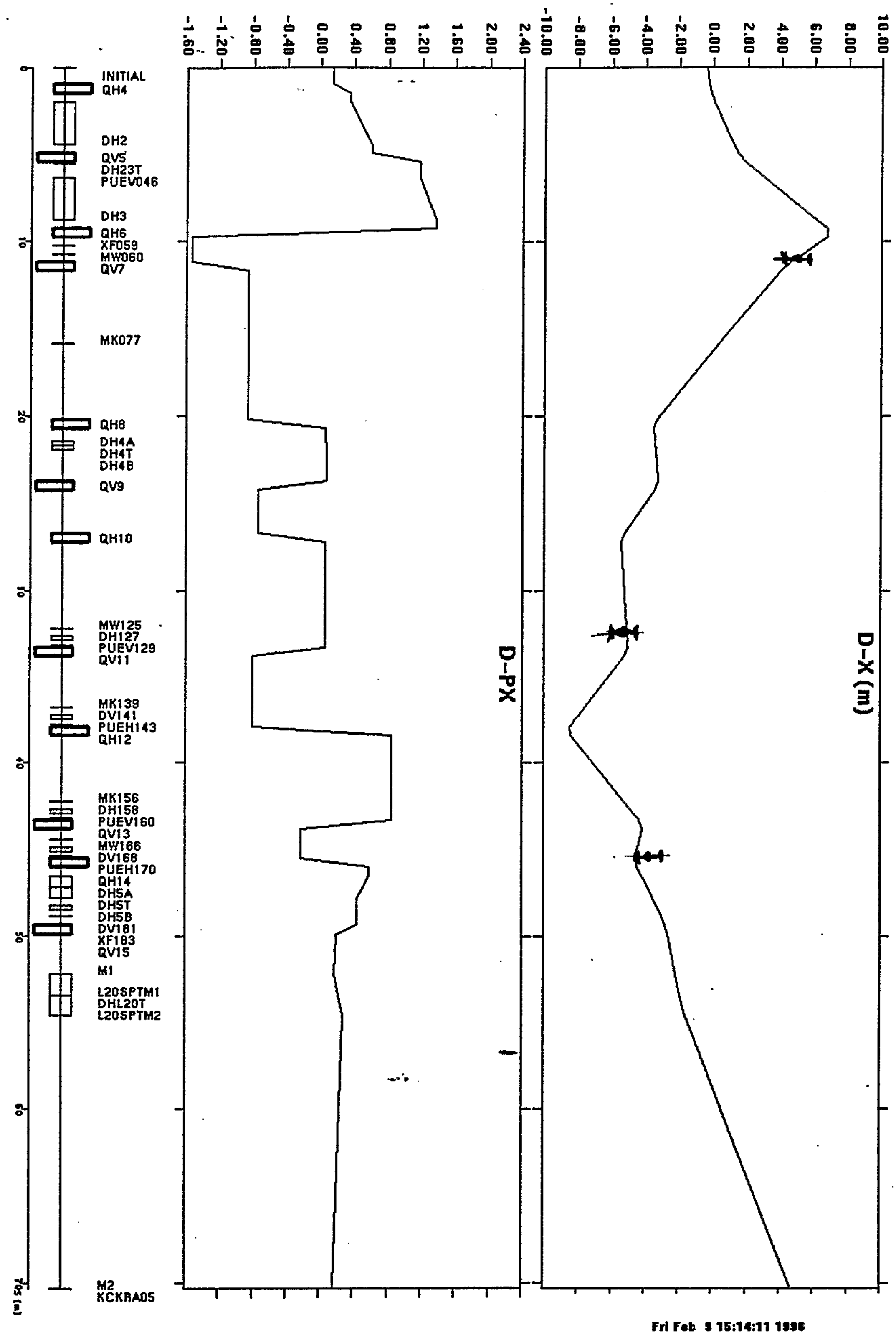
D-X (m)
D-PX
INITIAL
QH4
DH2
QV5
DH23T
PUEV046
DH3
QH6
XF059
MW060
QV7
MK077
QH8
DH4A
DH4T
DH4B
QV9
QH10
MW125
DH127
PUEV129
QV11
MK139
DV141
PUEH143
QH12
MK156
DH158
PUEV160
QV13
MW166
DV168
PUEH170
QH14
DH5A
DH5T
DH5B
DV181
XF183
QV15
M1
L20SPTM1
DHL20T
L20SPTM2
M2
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Table X.

Projected vs. measured values of D_x.

Measured D_xs are the slopes from figure 2.

Multiwire	D_x Projected	D_x Measured
MW006	0.608	0.185±0.195
MW060	5.281	5.489±.429
MW125	-5.065	-5.203±.559
MW166	-4.264	-3.757±.653

Note: Errors in the measured D_x are slope errors in the linear fits from figure 2.

[4] Conclusions:

Values measured with beam for D_x were predicted by a projection of the MAD model within reasonable errors. This suggests that the present MAD model of the BTA model is useful in predicting beam behavior in the line.

The next task is to generate optics using the MAD model that match the AGS acceptance and implement them. Further studies would then determine how well the matched optics work.