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Matching Between LTB and Booster

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AGS Complex Machine Studies

(AGS STUDIES REPORT Number 277)

Matching between LtB and Booster

Study Period:	09 -12 March 1993
Participants:	K. Reece, T. Roser, R. Thern, M. Tanaka, V. Garczynski,
	J.Wei, D-P Deng+MCR
Reported by :	T. Roser at the 10.Mar.93 System Coordinators Meeting
Edited by :	M. Tanaka
Machines:	LINAC + LtB+ AB_Inj
Beam:	User3, 200 MeV low intensity H^- injection with the fast chopper and 1/2 turn beam, RF off
Instruments:	HARPS @LtB, PIP and IPM@AB_Inj
Aim	***To attempt to match the LtB beam optically to the booster***

I. Transport quadrupole settings:

The following quadrupole setting of the HEBT and LtB Lines are used before and after matching the Twiss parameters and dispersion at the C5 foil:

	Before	After	
QV07I :=	630	630	[A] @HEBT
QH017 :=	650	650	
QV029 :=	640	640	
QH042 :=	750	750	
QV054 :=	490	490	
QH1I :=	160	160	[A] @LtB
QV2I :=	213	213	
QH3I :=	112	112	
QV4I :=	156	156	
QH5I :=	203	203	
QH6I :=	184	110	
QH7I :=	166	175	
QH8I :=	122	55	
QV9I :=	131	45	
QH10I :=	111	0	
QV11I :=	72	67	
QH12I :=	207	237	
QV13I :=	208	201	

Fig.1a and 1b show β_h (S) and β_v (S) at HEBT and LtB before and after matching.

II. Summary of LtB3 emittance measurements:

Measurements of the transverse beam emittance in the LtB3 were made by varying quadrupoles and observing the change in the HARP beam profile (MW107). The profile were analyzed by a new method described in ref.[1], which fits the initial beam parameters to all measured beam profiles simultaneously, rather than to the beam sizes since the emittance obtained by the standard method depends strongly on the way to calculate the beam size from the measured profiles.

The following table summarized the results together with the previous measurements(26.Feb.93) for comparison. As seen, the present results are in agreement with the previous one.

Twiss parameters... at Tank 9	(26.Feb.93) (9 meas.)	09-10.Mar.93 **before** (5)	12.Mar.93 **after** (6)
α_h	2.0 ± 0.1	2.0 ± 0.3	1.4 ± 0.2
β_h [m]	9.1 ± 0.6	7.3 ± 0.7	7.6 ± 1.0
$\varepsilon^{rms}{}_h$ [π μm]	1.7 ± 0.2	1.6 ± 0.2	**0.9 ± 0.2**
$\sigma p/p$ [10^{-3}]	2.5 ± 0.1	2.1 ± 0.1	1.0 ± 0.2
α_v	-0.1 ± 0.1	0.4 ± 0.1	0.1 ± 0.1
β_v [m]	3.6 ± 0.2	4.2 ± 0.2	7.9 ± 0.6
$\varepsilon^{rms}{}_v$ [π μm]	1.2 ± 0.1	1.3 ± 0.1	**0.6 ± 0.1**

[1] T. Roser, AGS Studies Report No. 275

III. Beam profiles at MW107 before and after matching (HARP):

The beam profiles before and after matching were measured at MW107 as follows:

	MW035 (before)	**MW107 (before)**	**MW107 (after)**
$x^m{}_h$ [mm[	- 10.25	0.76	- 5.29
$x^m{}_v$ [mm]	- 0.69	- 4.50	- 0.39
FWHM$_h$ [mm]	20.50 (21.2)	4.06 (5.6)	**10.32 (9.7)**
FWHM$_v$ [mm]	5.56 (9.1)	14.81 (14.9)	**6.88 (13.1)**

	before	**after**
DH115/Width	43.3 A/4.9 mm (5.1 mm)	46.7 A/5.3 mm (7.0 mm)

(xxx) : expected values

IV. Dispersion at injection before and after matching (PIP):

The position and angle of the injected beam at the foil were measured by PIP as a function of the tank 9 phase (TRFP9) which changes the momentum of the LINAC beam. The revolution frequency of the spiral beam was also measured to calibrate the TRFP9 command. Assuming the $C_{orbit} = 201.78$ m, we have

$$\Delta p/\Delta TRFP9 = 0.039 \text{ MeV/c/count}$$

or

$$(\Delta p/p)/\Delta TRFP9 = 6.1\text{x}10^{-5}/\text{count}$$

and $p_{inj} = 642.5$ MeV/c (T = 198.90 MeV) at TRFP9 = 200 as seen in Fig. 2.a.

	before	after
$\Delta x/\Delta TRFP9$ [mm]	-0.17	**-0.05**
$\Delta x'/\Delta TRFP9$ [mrad]	-0.035	**0.003**
$Dx=\Delta x/(\Delta p/p)$ [m]	-2.8 (-1.3)	**-0.81** (0.0)
$Dx' =\Delta x'/(\Delta p/p)$ [rad]	-0.6 (-0.4)	**0.05**

(xxx) : expected values.

Fig. 2b and 2c show x[mm] and x' [mrad] at D2 vs. TRFP9 command after matching, respectively

The measured dispersion mismatch is about a factor 2. This could be due to an error in the calibration of Tank9 phase or D2 PUE.

V. Beam emittance at injection before and after matching (IPM):

IPM data were taken at t=31.60 ms (5 ms after injection) before and after matching. Missteering at injection was corrected to about ± 3 mm in both planes before taking IPM profiles. After matching, there is an improvement in both vertical and horizontal emittance though the values are still a factor of two higher than expected one. The horizontal emittance is not corrected for dispersion effects.

	before	after
$\varepsilon^{rms}{}_h$ [π μm]†	≤ 4.9	≤ 4.4
$\varepsilon^{rms}{}_v$ [π μm]	3.1 (3.8)	2.5 (1.3)

† values are obtained neglecting dp/p.
(xxx) : expected values

Fig.3a and 3b shows the IPM beam profiles at t =31.60 ms before and after matching, respectively.

VI. Conclusions:

✍ The matching procedure did not introduce any additional losses in the LtB line. It successfully reduced the dispersion mismatch to negligible levels. The horizontal beam width in LtB is well controlled, however, the is not true for the vertical width. Some improvement in the emittance of the circulating beam was achieved, but there is still a factor of 2 emittance blow-up.

BEFORE

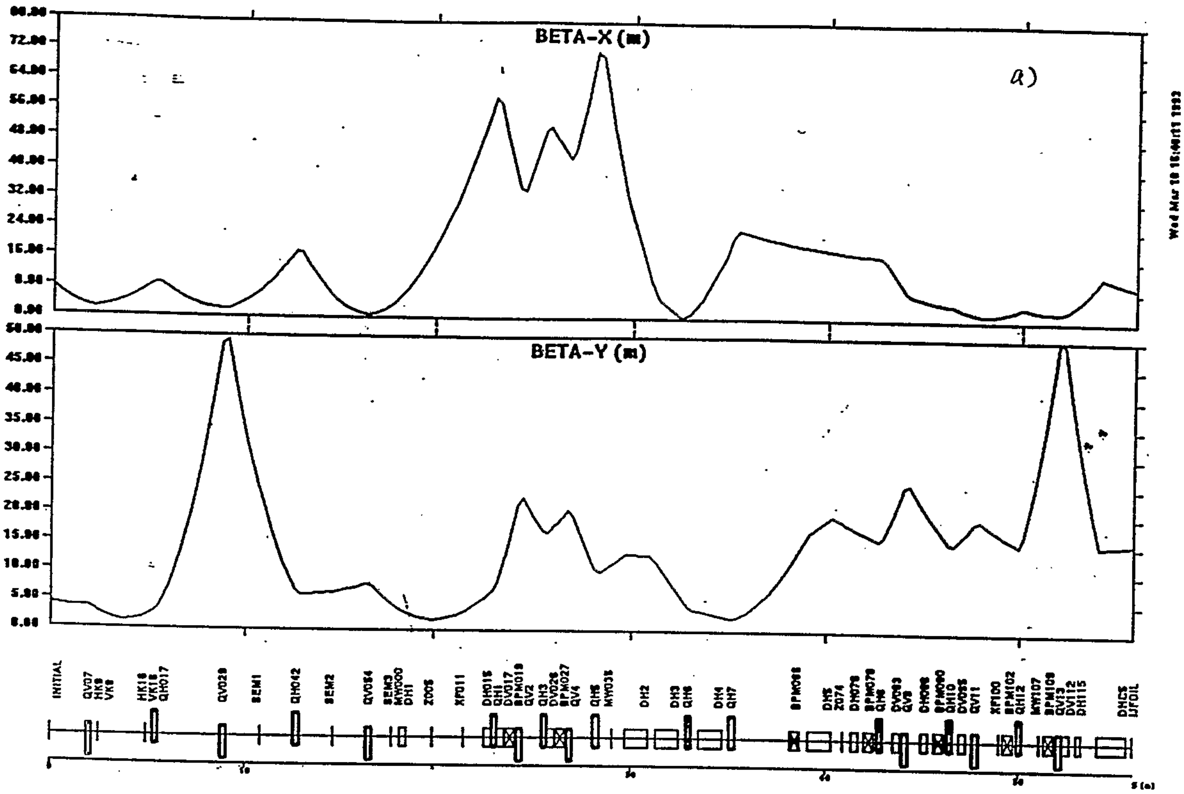


Fig. 1a

AFTER

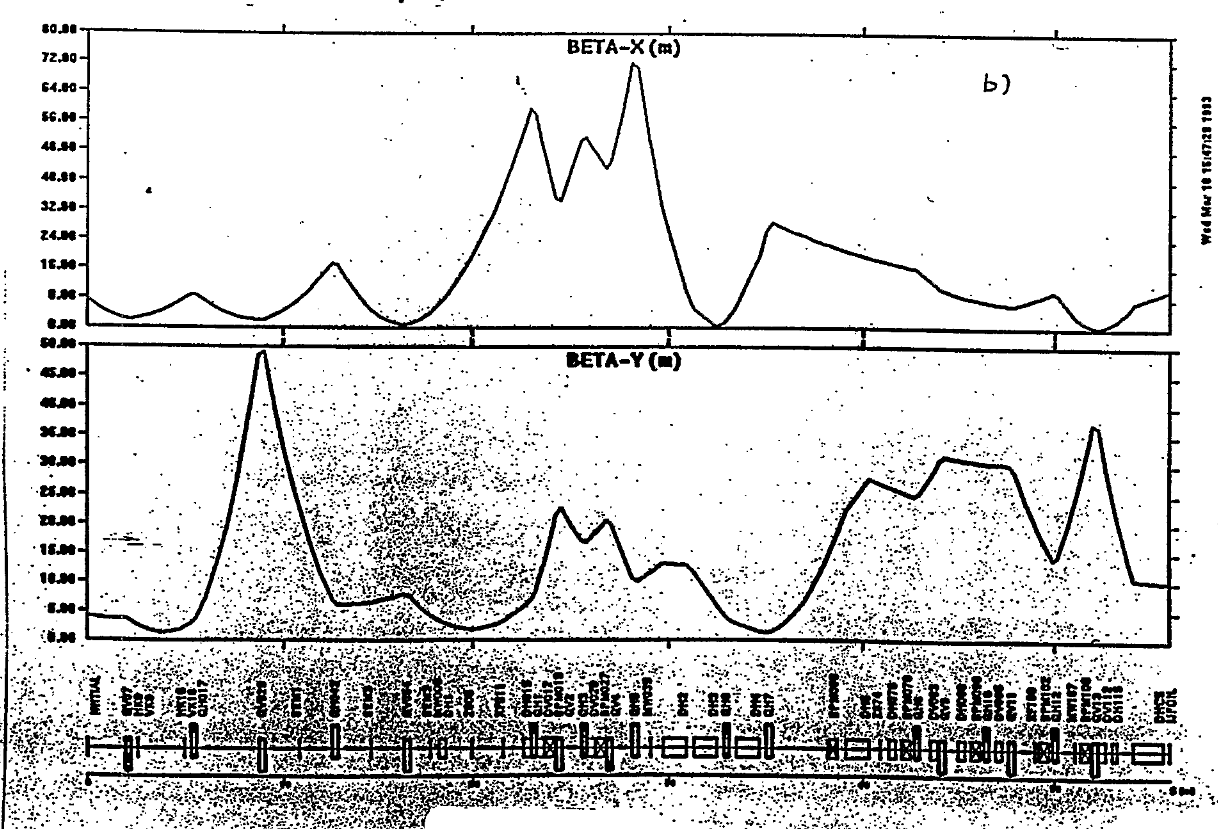
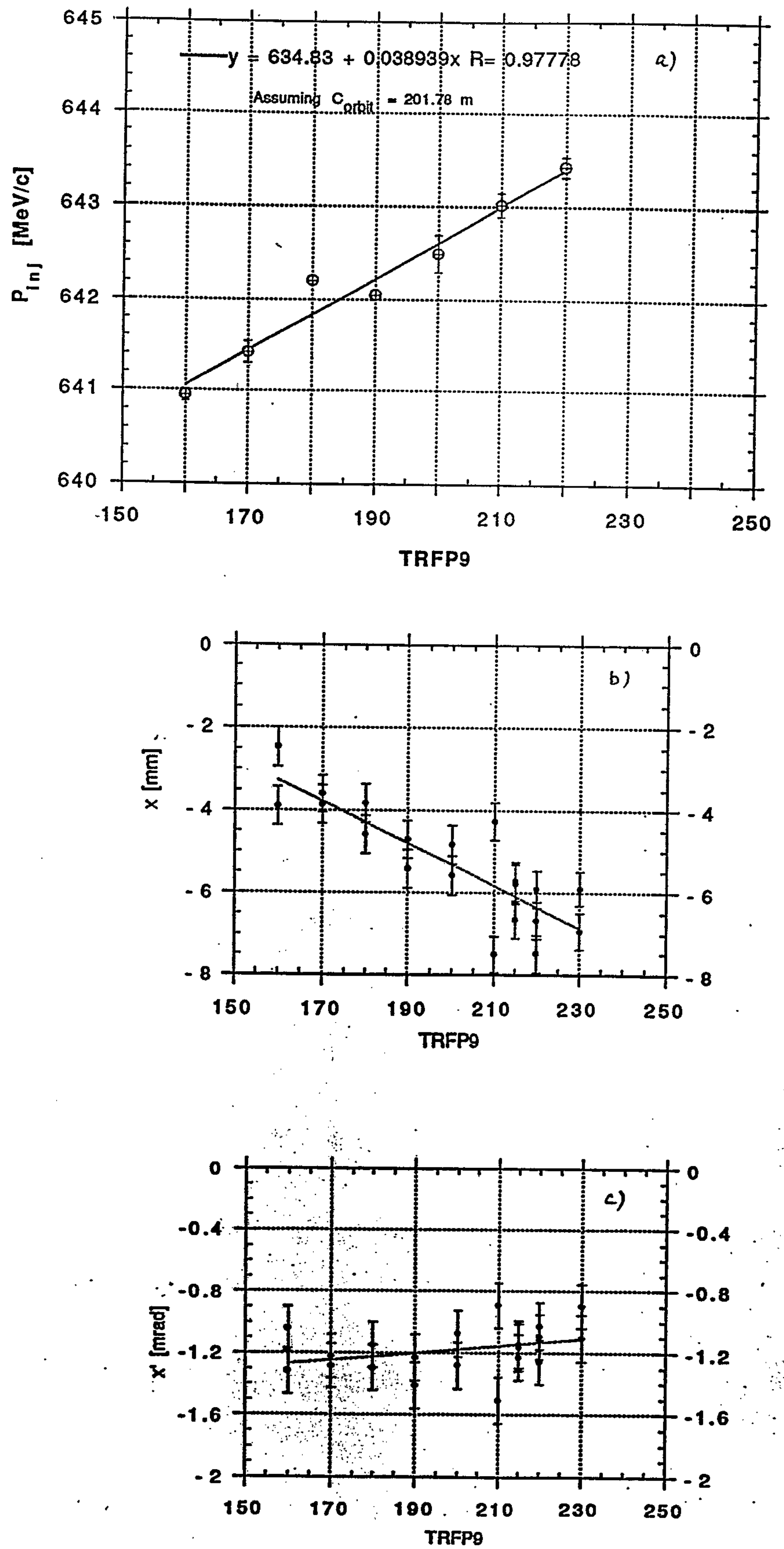


Fig. 1b



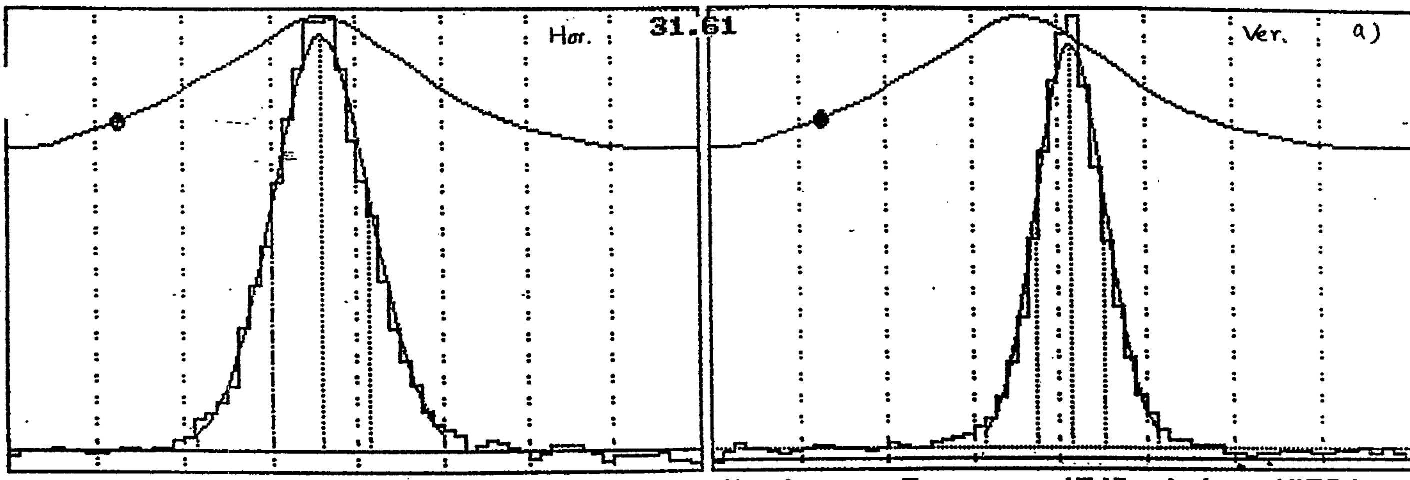
y = 634.83 + 0.038939x R= 0.97778
Assuming C orbit = 201.78 m
a)
P inj [MeV/c]
645
644
643
642
641
640
-150
170
190
210
230
250
TRFP9
b)
x [mm]
0
- 2
- 4
- 6
- 8
150
170
190
210
230
250
TRFP9
c)
x' [mrad]
0
-0.4
-0.8
-1.2
-1.6
- 2
150
170
190
210
230
250
TRFP9

Fig. 2

Fig. 2

BEFORE

BOOSTER IPM [030493] 03-11-1993 14:38:47 file:30310215.725 no: 2 of 31



H min= -18 max= 666 tot= 7268 V min= -7 max= 1546 tot= 13534
M0-1-2: 7283 -4.948 6.694 X: 0.04 M0-1-2: 11342 1.509 4.706 X: 0.04
ags: 1466 bstr: 1 #: 1 trig: 31.61 int req: 3.000 actual: 3.008
DAC00-07: 0 -200 -200 0 1600 0 1600 0 out: 22 01 02
ADC00-07: -325 -164 -154 -1753 -632 -328 -1938 -1204 in: 00 0D 00
ADC08-15: -1339 -1417 -1307 -1661 -1554 -1428 -1167 -1310 [NL] [ ]

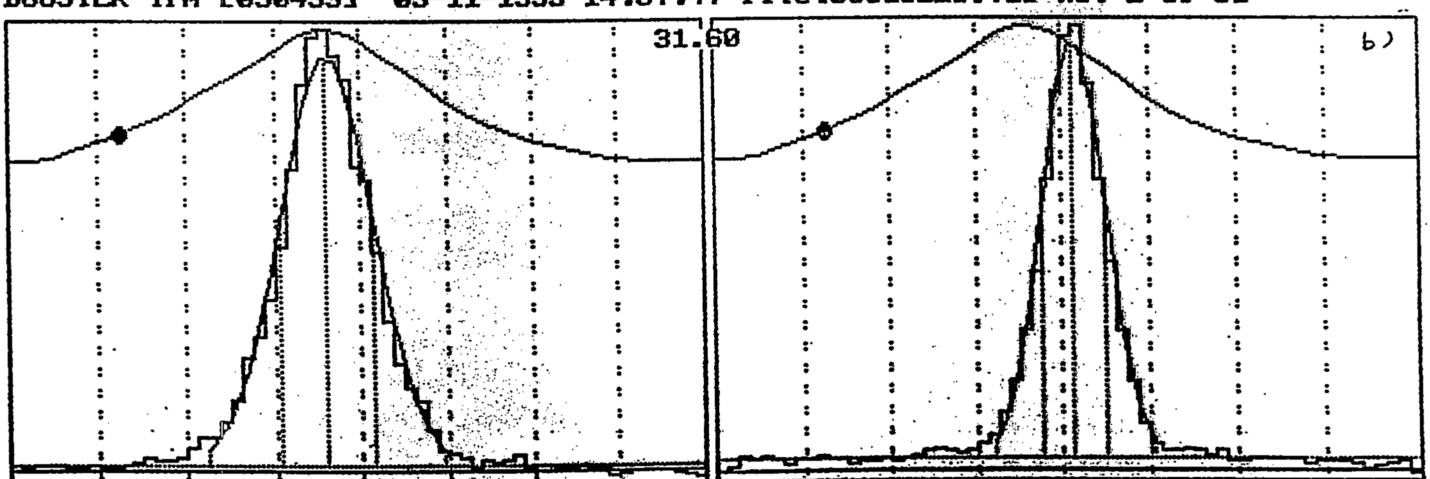
beam aligned using PIP

$\varepsilon = 4.9\pi$ $\varepsilon = 3.1\pi$ (EXPECT 3.8

Fig. 3a

AFTER

BOOSTER IPM [030493] 03-11-1993 14:37:47 file:30310223.710 no: 2 of 31



H min= -14 max= 815 tot= 8600 V min= -3 max= 1312 tot= 11649
M0-1-2: 8172 -4.802 6.320 X: 0.05 M0-1-2: 9131 1.454 4.371 X: 0.04
ags: 2101 bstr: 1 #: 1 trig: 31.60 int req: 3.000 actual: 3.008
DAC00-07: 0 -200 -200 0 1650 0 1650 0 out: 22 01 02
ADC00-07: -328 -166 -157 -1754 -648 -328 -1941 -1206 in: 00 0D 00
ADC08-15: -1341 -1418 -1308 -1660 -1555 -1429 -1170 -1310 [NL] [ ]

After matching

$\varepsilon = 4.4\pi$ $\varepsilon = 2.5\pi$ (EXPECT 1.3π

Fig. 3b

Fig. 3