

Matching Between LTB and Booster

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AGS Complex Machine Studies (AGS STUDIES REPORT Number <u>277</u>) 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	<i>To attempt to match the LtB beam optically to the booster</i>

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
$\epsilon_{rms_h} [\pi \mu m]$	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
$\epsilon_{rms_v} [\pi \mu m]$	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)
$x_{m_h}^m$ [mm]	- 10.25	0.76	- 5.29
$x_{m_v}^m$ [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 Corbit = 201.78 m, we have

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

or

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

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

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

(xxx) : expected values.

Fig. 2b and 2c show $x[\text{mm}]$ and $x' [\text{mrad}]$ 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 $t=31.60 \text{ ms}$ (5 ms after injection) before and after matching. Missteering at injection was corrected to about $\pm 3 \text{ mm}$ 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
$\epsilon_{rms_h} [\pi \mu\text{m}]^\dagger$	≤ 4.9	≤ 4.4
$\epsilon_{rms_v} [\pi \mu\text{m}]$	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 $t=31.60 \text{ ms}$ 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.

BETA-X (m)

a)

BETA-Y (m)

INITIAL QV07 H18 V18 QV017 QV039 BEM1 QH012 BEM2 QV064 BEM3 QH000 QV005 Z005 XF011 QH016 QH017 BP0018 QV02 D005 BP0027 QV4 QH5 AY035 DH2 DH3 CH5 QH6 QH7 BP0028 DH5 Z074 DH078 BP0078 QH6 QH5 QH3 QH2 QH000 QH010 QV11 XF100 XF002 BP0002 BP0007 BP0008 BP0009 BP0010 BP0011 BP0012 BP0013 BP0014 BP0015 BP0016 BP0017 BP0018 BP0019 BP0020 BP0021 BP0022 BP0023 BP0024 BP0025 BP0026 BP0027 BP0028 BP0029 BP0030 BP0031 BP0032 BP0033 BP0034 BP0035 BP0036 BP0037 BP0038 BP0039 BP0040 BP0041 BP0042 BP0043 BP0044 BP0045 BP0046 BP0047 BP0048 BP0049 BP0050 BP0051 BP0052 BP0053 BP0054 BP0055 BP0056 BP0057 BP0058 BP0059 BP0060 BP0061 BP0062 BP0063 BP0064 BP0065 BP0066 BP0067 BP0068 BP0069 BP0070 BP0071 BP0072 BP0073 BP0074 BP0075 BP0076 BP0077 BP0078 BP0079 BP0080 BP0081 BP0082 BP0083 BP0084 BP0085 BP0086 BP0087 BP0088 BP0089 BP0090 BP0091 BP0092 BP0093 BP0094 BP0095 BP0096 BP0097 BP0098 BP0099 BP0100 BP0101 BP0102 BP0103 BP0104 BP0105 BP0106 BP0107 BP0108 BP0109 BP0110 BP0111 BP0112 BP0113 BP0114 BP0115 BP0116 BP0117 BP0118 BP0119 BP0120 BP0121 BP0122 BP0123 BP0124 BP0125 BP0126 BP0127 BP0128 BP0129 BP0130 BP0131 BP0132 BP0133 BP0134 BP0135 BP0136 BP0137 BP0138 BP0139 BP0140 BP0141 BP0142 BP0143 BP0144 BP0145 BP0146 BP0147 BP0148 BP0149 BP0150 BP0151 BP0152 BP0153 BP0154 BP0155 BP0156 BP0157 BP0158 BP0159 BP0160 BP0161 BP0162 BP0163 BP0164 BP0165 BP0166 BP0167 BP0168 BP0169 BP0170 BP0171 BP0172 BP0173 BP0174 BP0175 BP0176 BP0177 BP0178 BP0179 BP0180 BP0181 BP0182 BP0183 BP0184 BP0185 BP0186 BP0187 BP0188 BP0189 BP0190 BP0191 BP0192 BP0193 BP0194 BP0195 BP0196 BP0197 BP0198 BP0199 BP0200 BP0201 BP0202 BP0203 BP0204 BP0205 BP0206 BP0207 BP0208 BP0209 BP0210 BP0211 BP0212 BP0213 BP0214 BP0215 BP0216 BP0217 BP0218 BP0219 BP0220 BP0221 BP0222 BP0223 BP0224 BP0225 BP0226 BP0227 BP0228 BP0229 BP0230 BP0231 BP0232 BP0233 BP0234 BP0235 BP0236 BP0237 BP0238 BP0239 BP0240 BP0241 BP0242 BP0243 BP0244 BP0245 BP0246 BP0247 BP0248 BP0249 BP0250 BP0251 BP0252 BP0253 BP0254 BP0255 BP0256 BP0257 BP0258 BP0259 BP0260 BP0261 BP0262 BP0263 BP0264 BP0265 BP0266 BP0267 BP0268 BP0269 BP0270 BP0271 BP0272 BP0273 BP0274 BP0275 BP0276 BP0277 BP0278 BP0279 BP0280 BP0281 BP0282 BP0283 BP0284 BP0285 BP0286 BP0287 BP0288 BP0289 BP0290 BP0291 BP0292 BP0293 BP0294 BP0295 BP0296 BP0297 BP0298 BP0299 BP0300 BP0301 BP0302 BP0303 BP0304 BP0305 BP0306 BP0307 BP0308 BP0309 BP0310 BP0311 BP0312 BP0313 BP0314 BP0315 BP0316 BP0317 BP0318 BP0319 BP0320 BP0321 BP0322 BP0323 BP0324 BP0325 BP0326 BP0327 BP0328 BP0329 BP0330 BP0331 BP0332 BP0333 BP0334 BP0335 BP0336 BP0337 BP0338 BP0339 BP0340 BP0341 BP0342 BP0343 BP0344 BP0345 BP0346 BP0347 BP0348 BP0349 BP0350 BP0351 BP0352 BP0353 BP0354 BP0355 BP0356 BP0357 BP0358 BP0359 BP0360 BP0361 BP0362 BP0363 BP0364 BP0365 BP0366 BP0367 BP0368 BP0369 BP0370 BP0371 BP0372 BP0373 BP0374 BP0375 BP0376 BP0377 BP0378 BP0379 BP0380 BP0381 BP0382 BP0383 BP0384 BP0385 BP0386 BP0387 BP0388 BP0389 BP0390 BP0391 BP0392 BP0393 BP0394 BP0395 BP0396 BP0397 BP0398 BP0399 BP0400 BP0401 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AFTER

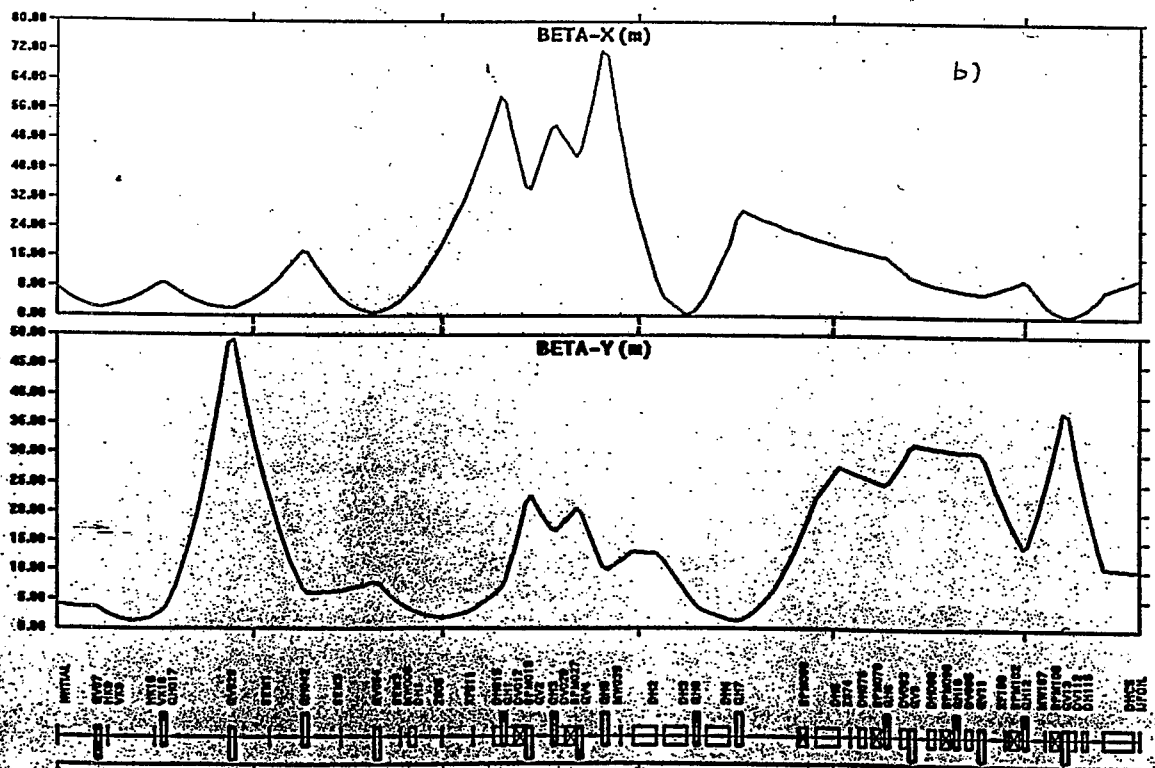


Fig. 1b

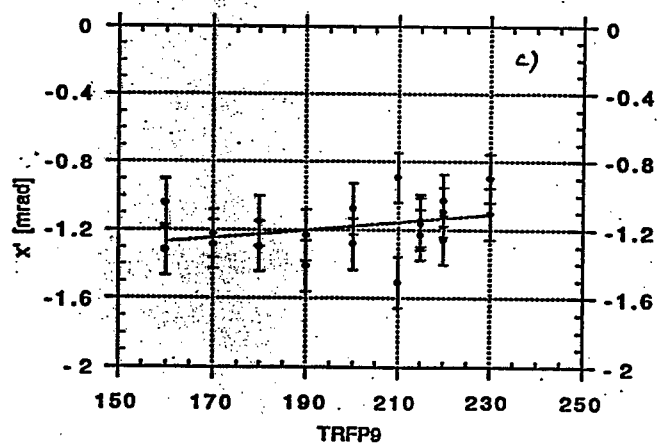
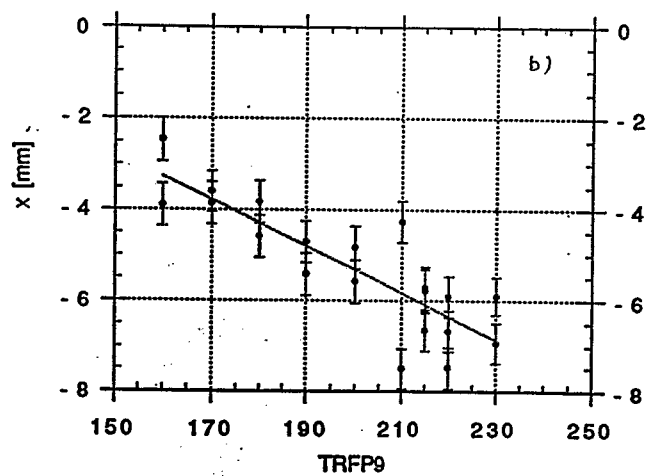
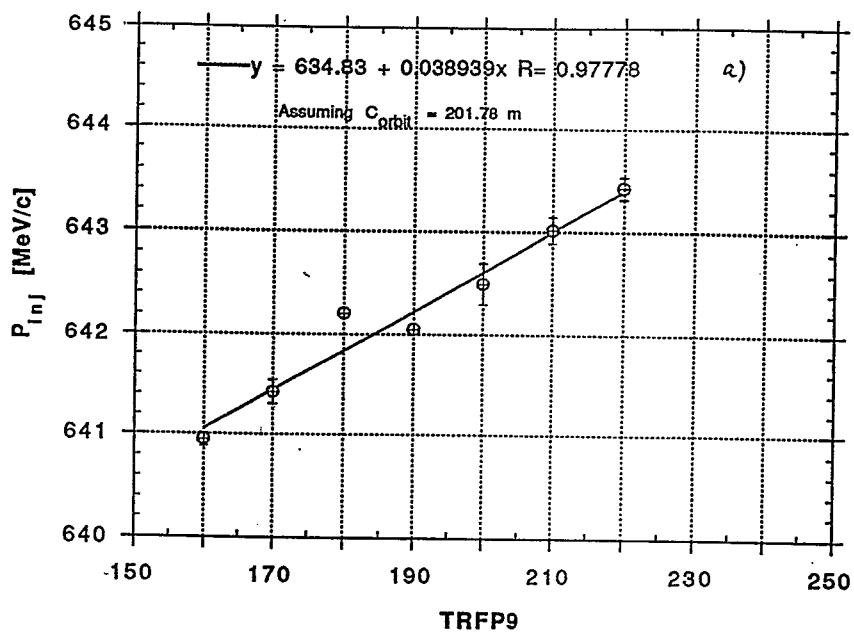
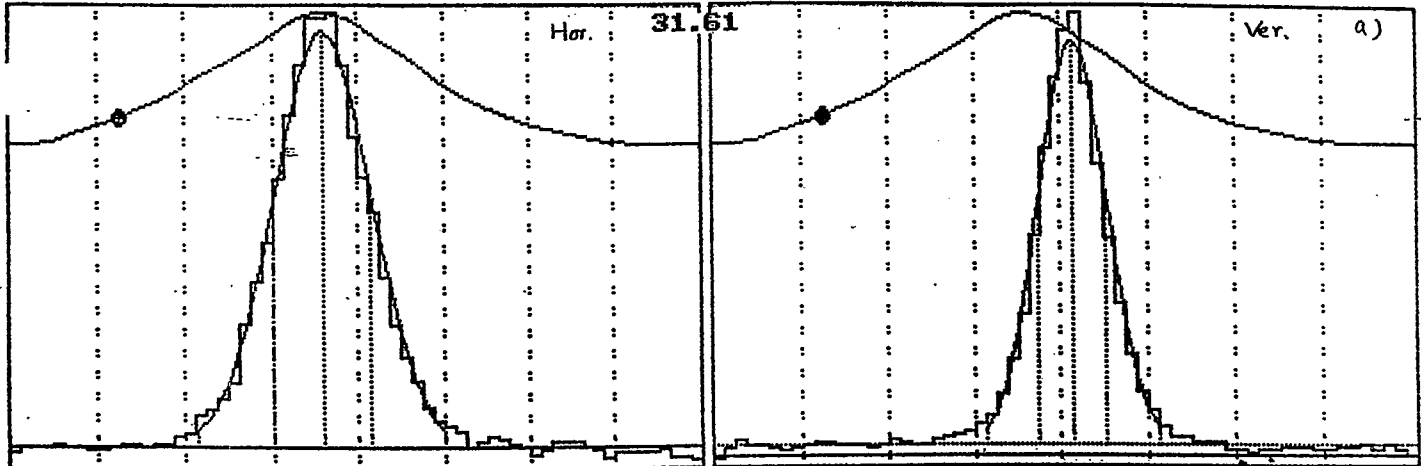


Fig. 2

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 00 00
 ADC08-15: -1339 -1417 -1307 -1661 -1554 -1428 -1167 -1310 [NL] []

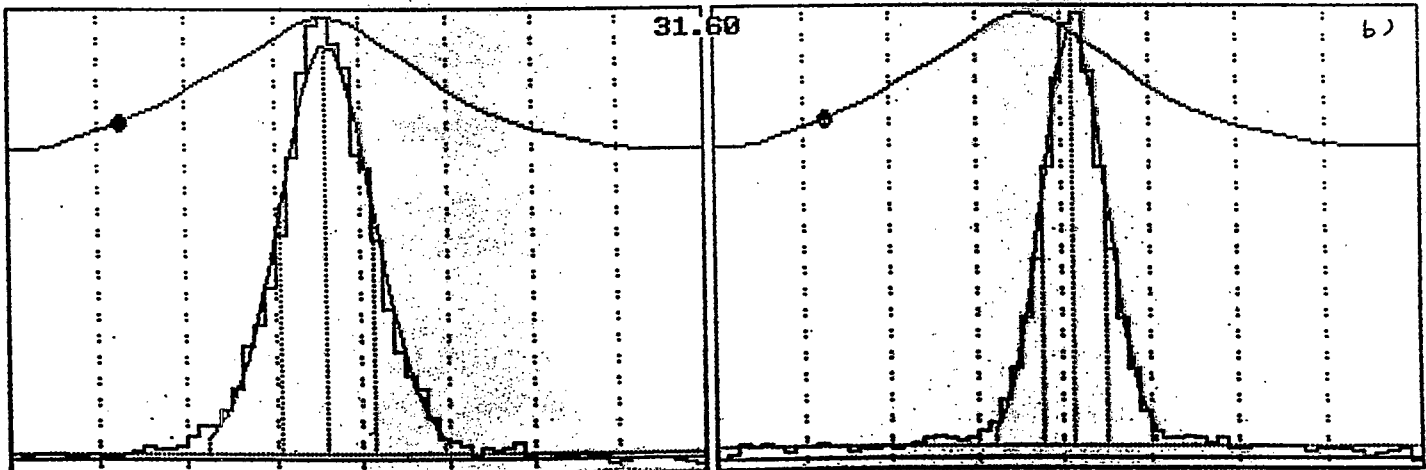
beam aligned using PIP
 $\epsilon = 4.9\pi$

Fig. 3a

$\epsilon = 3.1\pi$ (EXPECT 3.8)

AFTER

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



H min= -14 max= 815 tot= 8686 V min= -3 max= 1312 tot= 11649
 M0-1-2: 8172 -4.802 6.320 X: 0.05 M0-1-2: 8191 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 1600 0 1600 0 out: 22 01 02
 ADC00-07: -328 -166 -157 -1754 -648 -328 -1941 -1206 in: 00 00 00
 ADC08-15: -1341 -1418 -1308 -1668 -1555 -1429 -1170 -1310 [NL] []

After matching

$\epsilon = 4.4\pi$

$\epsilon = 2.5\pi$ (EXPECT 1.3 π)

Fig. 3b

Fig. 3