

BNL-104463-2014-TECH

AGS/AD/Tech Note No. 22;BNL-104463-2014-IR

BEAM MEASUREMENT WITH THE FAST KICKER

A. R. Watts

June 1966

Collider Accelerator Department Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.AT-30-2-GEN-16 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Accelerator Department BROOKHAVEN NATIONAL LABORATORY Associated Universities, Inc. Upton, L.I., N.Y.

AGS DIVISION TECHNICAL NOTE

No. 22

A.R. Watts

June 16, 1966

BEAM MEASUREMENT WITH THE FAST KICKER

To use the fast kicker as a beam measuring tool it is necessary to know the beam transport characteristics of the magnets and vacuum piping located downstream from this magnet. Knowledge of the beam trajectories and oscillations, both when "Kicked" and undisturbed, is also needed so that partial beam stoppers and detection devices may be positioned to advantage. This report describes how the information was obtained using the "Beam" computer program.

The Undisturbed Beam

The undisturbed beam was considered to be limited in horizontal phase space by the 5 3/4-in. straight sections following the number 5 magnets in each of the superperiods. Vertical phase space was taken to be limited by the 2 1/2-in. vertical opening of the fast kicker scheduled for installation at L10. Using the "Beam" program (EDC-36), as modified by M. Barton and H. Reich (Memorandum November 24, 1965), an injected particle momentum of .4040 x 10^6 gauss inches was found to have its equilibrium orbit passing very near the center of the No. 5 straight sections. Horizontal betatron oscillations are then allowed to have their greatest amplitudes at this momentum, and this was the momentum used for computations.

The transformation matrices calculated and printed out by "Beam" when searching for equilibrium orbits were used to obtain values for α and β at the straight section locations. These values were in turn used to construct beam ellipses about the equilibrium orbit positions at each of the straight sections. When the results in the horizontal plane were tested with four test particles in the "Beam" program there was close agreement in the results. This indicates, along with computational consistency, that the machine may be considered linear for the dimensions involved.

The Deflected Beam

The kicked beam was taken as at present where we have the old injection system piping fitted in at L10 to L12. The centerline of the deflected beam pipe is approximately 8 in. from the undisturbed beam pipe at L12. The deflected beam pipe is not quite 4 in. in diameter and extends from the center of the L12 magnet to the straight section after L13.

As the beam size is a maximum right at injection before betatron oscillation amplitudes are reduced with increasing energy, this is the condition for which to plan. Using "Beam" an angular deflection of .02496 radians when added to the equilibrium orbit at L10 was found to trace a suitable path down the pipe. Making use of the transformation matrices produced by the program α and β were transformed to L11, L12, and to L13. Again ellipses were constructed about the midpoint path. This time, when test particles were launched through the program to check results, the agreement was good through L12 straight section. At L13 the non-linearity of the fringe field is evident but there is still good agreement for particles with small radial deviation from the central path.

-2-

v Value

For these calculations the "Beam" program was used without quadrupole or sextupole fields. This yields a mathematically "Natural" machine with a vH of 8.65 and vv of 8.73. Actual machine operation is generally with quadrupole fields such that vH is about 8.3 and vv about 8.7.

The effect of this reduction in horizontal v value is to decrease the machine acceptance by an amount approximately equal to the decrease in v value.

From EDC-28

 $\beta \cong \beta n \ \frac{\nu n}{\nu}$ then $W = \frac{\alpha^2}{\beta} \cong \frac{\alpha^2}{\beta n} \ \frac{\nu}{\nu n} = Wn \ \frac{\nu}{\nu n}$

The actual beam envelope is then somewhat smaller than described. All beam clearances should certainly still be valid and transformation matrices from L10 to L13 are unchanged.

Observations

Referring to the beam ellipses:

The horizontal beam envelope at L12-L13 is greater than the 4 in. allowed by the vacuum pipe. To obtain complete transmission at injection energy through to L13 the pipe would have to be widened to 7 in.

The L11 straight section is a good location for a beam collimating device. The undisturbed beam has a maximum horizontal betatron oscillation amplitude of but 1.8 in. As the deflected beam is displaced 4 in. from the undisturbed beam, there is more than 1/4 in. free for a support. A support so positioned would not interfere with the beam before, or after, the "Kick".

Detection equipment can be located anywhere up to the L12 straight section before beam is lost on the vacuum chamber walls.

-3-

Linear transformation of beam characteristics should certainly be adequate for measurements made up to L12. To so transform measurements made at L13 would introduce an error depending on the particles' radial position.

Distribution: AGS Staff M. Barton J. Herrera

ARW/pam

Transform	mation Matrices	Srow "BEAN	<u>M"</u> May 66
Injection Sield $\begin{pmatrix} X_2 \\ X_2' \end{pmatrix} =$	P=.4040 XII (an anz) (X (azi azz) (X	06 gaussincles di 212 212 221	UNITIESS W = 8.657 UNITIESS Killoinch Millirad /inch UNITIESS

From	10 Carbon		Houiso	ints/	•		Vertica	X	
St Section	- St Section	all	212	221	222	211	212	221	an
 L5	L9	.66982	.72033	49654	.95894	.60641	.32139	-2,55147	. 24676
L9	L10	.76415	.14004	-2.3481	.87750	1.24646	.162308	2.49773	1.12706
LIO	LII	1.12795	.16237	2.51574	1.24870	.87671	.13446	-2.3632	.76328
L 11	L12	1.12796	10823	2.51585	1.12795	.87670	.097903	-2.3633	.87671
L12	L13	.77458	,12475	-2.8850	.82635	1.24013	.147.728	3.1646	1.18334

WITH Kick at LIO

10	LII	1.13170 .16280	2.58421	1.25538	.847339	.13978	-2.4205	75755
LII	L12	1.11635 .10773	2 .16387	1.10460	.88748	.098754	-2.0481.3	.64867
L12	L13	1.17244.143303	5 1946101	.09078	.834046	.124964	-1,83973	.4122d

	Undisturbed Beam (equilibrium orbit)	Kickled Beam (beamcenter path)				
St Section	X X prime	X X prime				
L5	.002230 .000007					
L9	.093995 .000177	· · ·				
LIO	.066890 - 00 0 362	.066890 .024599				
LII	.033001 .000039	4.092789 .031290				
L12	.028325001667	7.998246 .043691				
L13	.023858000017	15.864964 .068029				

-5-

(

(





$$-9-$$

$$Computations$$
From EDC-10
$$T((s+c)/s) = \begin{pmatrix} \cos\mu + \alpha \sin\mu & \beta \sin\mu \\ -\gamma \sin\mu & \cos\mu - \alpha \sin\mu \end{pmatrix} = \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix}$$

$$W_{1}+h(\beta \tau = 1 + \alpha^{2})$$

$$\mu = \cos^{-1} \frac{1}{2} (\alpha_{11} + \alpha_{22})$$

$$\alpha = (\alpha_{11} - \alpha_{22})/2 \sin\mu$$

$$\beta = \alpha_{12}/\sin\mu$$

$$\gamma = -\alpha_{21}/\sin\mu$$

$$\begin{aligned} & (Again EDC-10) \\ & T'(S_2/S_1) = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \\ & (S_2/S_1) = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \\ & (S_2 = (b_{11} b_{22} + b_{12} b_{21}) & (A_1 - b_{21} b_{11} (B_1 - b_{12} b_{22})) \\ & (B_2 = -2 b_{11} b_{12} (A_1 + b_{11}^2 (B_1 + b_{12}^2 (A_1 + b_{12}^2 (B_1 + b_{22}^2 (A_1 + b_{22}^2 +$$

$$W = admittance/_{TT} = \frac{2^2}{\beta mox}$$

$$W_{H} = (2.86)^2 = .0074848 \text{ index radians}$$

$$W_{V} = (1.25)^2 = .002505 \text{ index radians}$$

-. • ·

: .

(



5,5000	000071	S HONI	HUIJH 9995 - 2999	0003*3-	0009'C000010'-	000	HELTHI INCHES	4	9285'E-	0995"Z	SBHONI IHO	194 St- 000211 20071	(
													쫕쁖끹쁖슻닅칰큟귿근 긻뭱슸뚖룘앍끰땹캾솒
									nno I				
							"我们就是我们的问题,我们不是我们的。" "我们我们就是你们的你?"	0278,083 6	nm.				
		\uparrow			· "我们的问题。" "你们的问题。"			SH68941 7					
			92809	201								202100	
			8	81 21 2 7	n nortere							84.2122 90	
							XX						
					ODDOCT-				6070				
		<u> </u>			1.0.9					hơ 비닐 거부는 문제한 동안 또 한 비행 문제한			
											渡城드용성인 :: 동네하고 등관대		
					P0-5								
		清点(1994) 日本(1994)	\mathbf{N}										
						il)					슻슻슻슻슻 깱뚶걒멾쑫슻		
		21212						sim		1600			
		Isar	ITH WHEEL	ABA			ZII 10 98411191	VERT BER			LH BSAITT	WHEE TREV	
18,500	208141	ACHEE 1970	I SPICES	er solo		<u></u>	ne <u>ne ara an american ana ana an</u> Bail 18 1904ES	<u>ti litila para dala</u>	ali de servera		<u>ere Perenana</u> Sanki sh	<u>de lette ja de lette ja</u> Ged	
						30. 00S	01 06376 0.0576 802°2	063-4 003-3	000 1 200		15 (65) h 60		* 000°* 000020*
					XY								
					/								
調整部門													
			2									33450455	
				Z									
			Z = Z		Ne di Jiana Ne di Jiana Ne di Jiana Ne di Jiana	<u>a - 17</u>							ren en e
		\mp	• /			10							
			/		0055	10-11-11 20-11-11							
						n				: 2017년 왕 대학원 11 1월 21일 왕 대학원 11일 왕 11일 11일 11일 11일 11일 11일 11일 11일 1	0		
				·다양,									
	<u>/ </u>												
+X													
	\boldsymbol{X}		102609 1006075	107 5									
12								4774					
सिंह विविधि			TTH KICK	X					002				
	CI II	Isa		HO			2 LU Sa L	HE HOH			10 ISAL 11	HOLE BEEM	
1 1 1 1 1 1	111楼。村时中中位	和同時期	<u>ar han di k</u>	到自由自由		8							