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SCIENCE RESEARCH COUNCIL

DARESBURY LABORATORY

The SRS Flight Path (2)

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1. Introduction

The beam optics of the SRS flight path described in SRS/NS/75/72 have been reassessed in view of the inefficiencies involved in the capture of off momentum electrons using the proposed momentum matching system. This note describes the changes made and shows the beam profile along the new beam line.

2. Beam capture in the booster synchrotron

On injection into the booster the electrons follow a closed orbit which is moved close to the injection septum by a pair of kicker magnets placed approximately one-half of a betatron wavelength apart about the injection straight section. After one turn of the booster the beam is shifted towards the centre of the vacuum chamber due to a coherent betatron oscillation about the closed orbit and so avoids collision with the septum magnet. Similarly the beam circulates without obstruction during the second turn. On the third turn however the beam finds itself on a collision trajectory with the septum magnet and so the kicker magnets are switched off to bring the closed orbit - and the circulating beam - back to the centre of the vacuum vessel.

The radial phase space occupied by the beam during this process is shown in figures 1 a-c.

In the original flight path design (F.P.(1)), electrons with energy different from nominal were injected into the booster along trajectories corresponding to their off-momentum closed orbits to reduce their betatron oscillation amplitude to a minimum. However this leads to collimation by the septum of electrons with less than average momentum since the closed orbit for these electrons lies within the on momentum orbit.

For this reason it has been decided to inject a beam with zero dispersion at the septum magnet. This results in a larger beam size with higher captured currents (due to the capture of lower momentum electrons) at the expense of collimation of high momentum electrons on the second orbit, as indicated in figures 2a-c. Such a beam is best achieved by eliminating the momentum matching section of the flight path (see SRS/NS/75/72) and injecting directly from the achromatic bend.

3. The new flight path layout

The linac flight path has been redesigned with the constraints imposed by the radiation shielding and by the necessity to keep the injection straight geometry unchanged. This can be achieved by rotating the booster clockwise by $\sim 10^{\circ}$ (in relation to the F.P.(I) layout) and by reducing the angles in the achromatic bend from 45° to 30°.

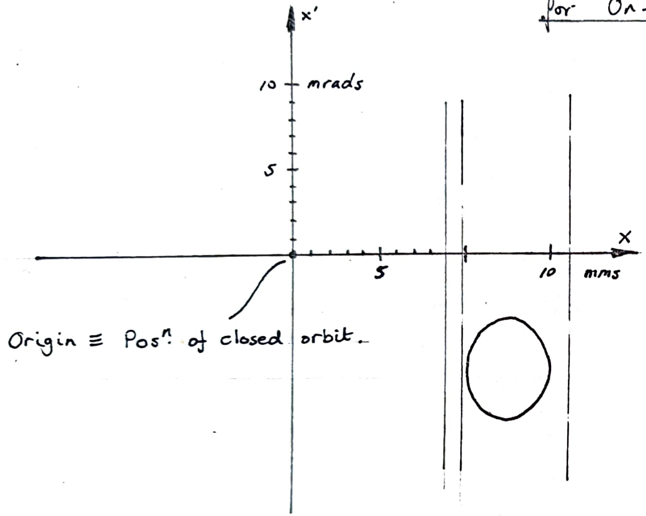
The new flight path and the beam profile along its length are shown in figures 3 and 4 respectively. By comparing these profiles with those of F.P.(I) it is immediately apparent that the new line gives a much superior emittance match for single bunch operation. This is because with the elimination of the momentum quadrupole, it has been possible to push the quadrupole triplet back towards the radial focus of the single bunch beam chopping section so containing the beam before it grows too large in the vertical plane.

Finally it should be noted that the rotation of the booster affects the transfer path layout between the booster and storage ring (since the extraction point is changed). The repercussions of this change have been assessed and found to give an acceptable layout together with improved beam characteristics.

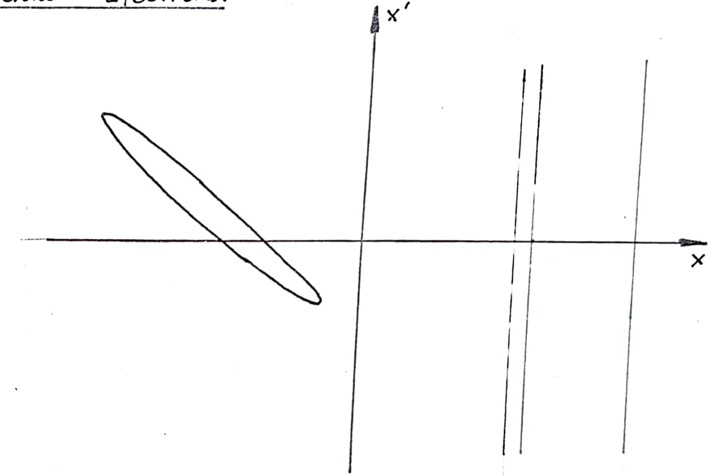
4. Summary

The linac flight path has been redesigned to give a zero dispersion at the injection point into the booster synchrotron in order to enhance the injection efficiency. The resulting beam line gives a good emittance match into the booster for both normal operation and signle bunch operation when extra quadrupoles are used to focus the beam onto narrow collimator slits. A rotation of the booster by 10° is necessary to keep the line within the limits imposed by the allocated radiation shielding. The resulting changes to the transfer path have been assessed and found to be acceptable.

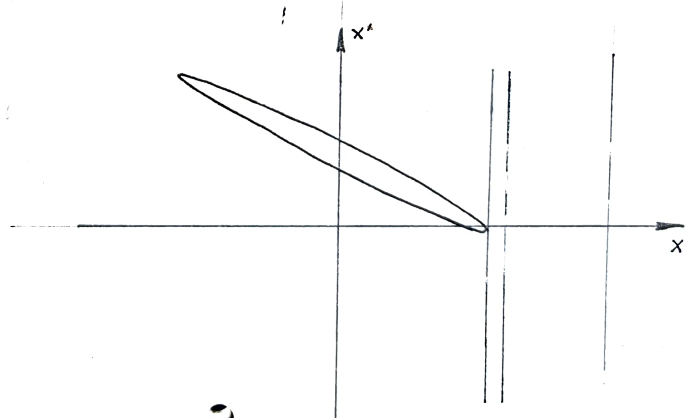
Figure 1 Radial Phase Space at the Injection Septum for On-momentum Electrons.



1(a) Phase space occupied by the injected beam at the output from the septum magnet.

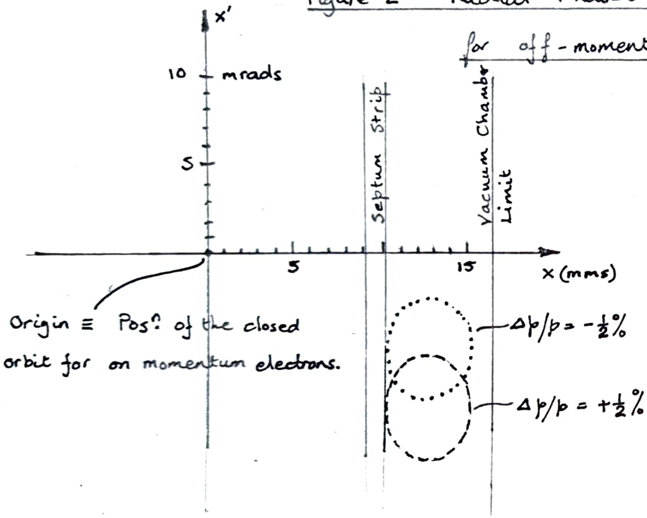


1(b) After one turn

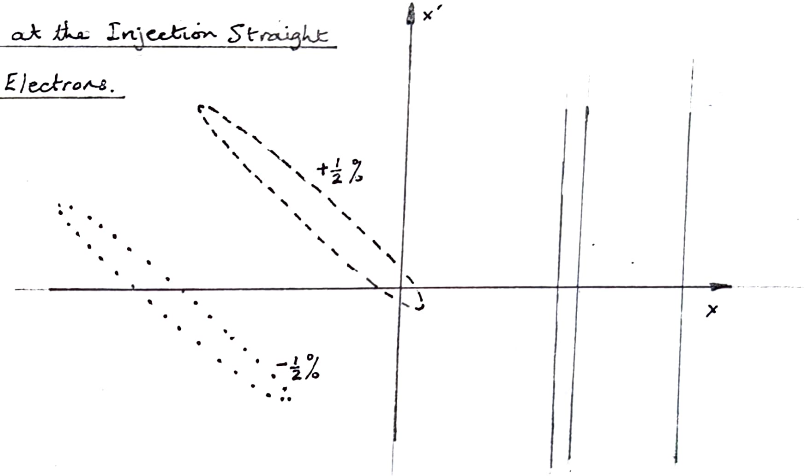


1(c) After two turns

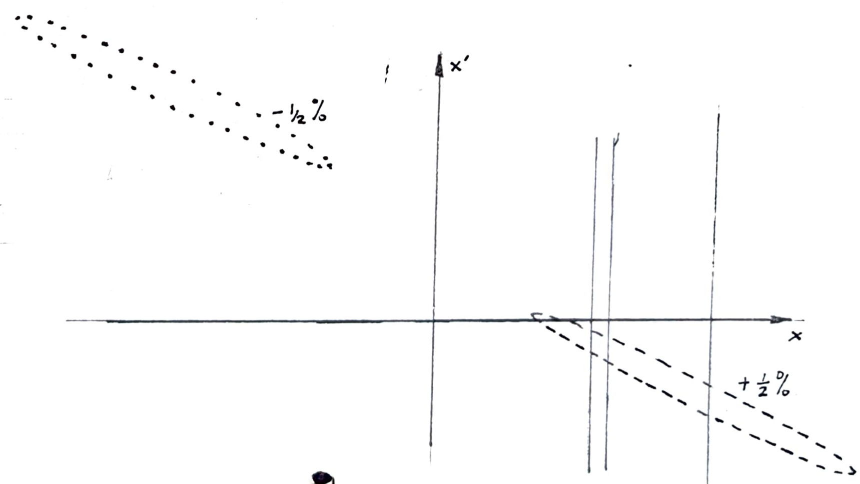
Figure 2 Radial Phase Space at the Injection Straight for off-momentum Electrons.



2(a) Phase space occupied by injected beam at the output from the septum magnet



2(b) After one turn

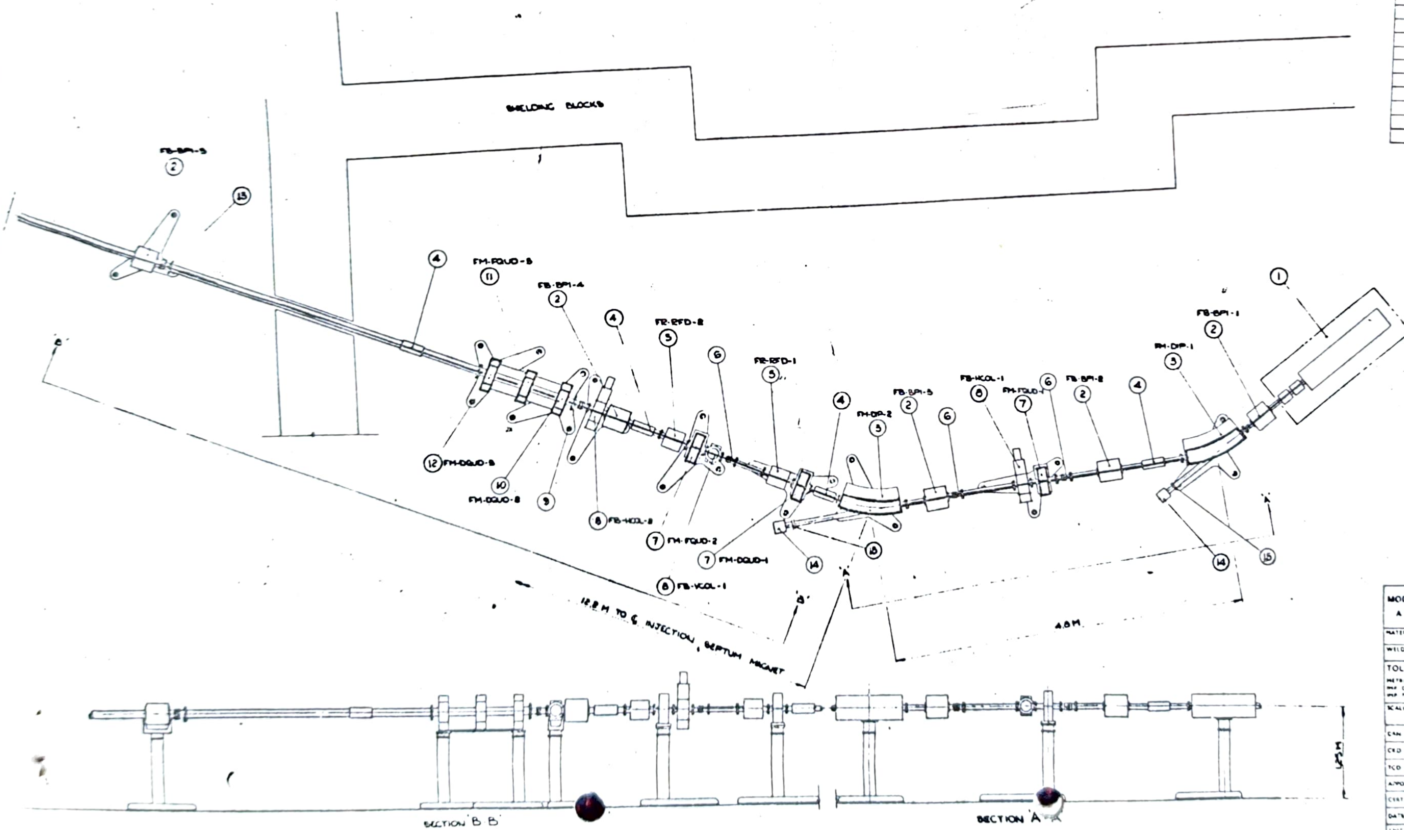


2(c) After two turns.

Note. After two orbits a large proportion of the beam with $\Delta p/p = +\frac{1}{2}\%$ is lost to the vacuum chamber and septum magnets.

Figure 3 LAYOUT OF THE LINAC FLIGHT PATH

ITEM	DRG No	DESCRIPTION	QTY
1		RDL EQUIPMENT	1
2		B.P.I.	5
3	3/41/090	BENDING MAGNET	2
4		VERTICAL STEERING COIL	3
5		RF DEFLECTOR PLATE	2
6		BELLOWS	3
7	3/42/106	SINGLE QUADRAPOLE MAG	3
8	99/266	COLLIMATOR	3
9		BELLOWS	1
10		QUADRAPOLE MAGNET	1
11		QUADRAPOLE MAGNET	1
12		QUADRAPOLE MAGNET	1
13		BELLOWS	1
14		FARADAY CUP	2
15		BeCu WINDOW	2



MOD A	9.5.76	FB-HCOL-2, FB-BPI-4 BELLOW & STEERING COIL RE-POSITIONED	MOD B	
MATERIAL		MATERIAL SPEC		
WELDING SPEC		FINISH		

TOLERANCES UNLESS OTHERWISE STATED
METRIC DIMENSIONS ±
IMP DECIMAL ±
IMP FRACTIONAL ±

SCALE 1:20 0 500 1m 2m

DRN		SCIENCE RESEARCH COUNCIL DARESBURY LABORATORY CHESHIRE
CKD		
TCD		TITLE LAYOUT OF FLIGHT PATH
APPD		
CERT		ORIGINAL SIZE AO — DRG No 42/050 — MOD A
DATE	11-5-76	

USED ON DRWG. No.

FIGURE 4. BEAM PROFILES ALONG THE LINAC FLIGHT PATH