

# A METHOD OF INTERCHANGING HORIZONTAL AND VERTICAL PHASE SPACE AREA

A. W. Maschke

March 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. 16

A.W. Maschke

March 25, 1966

A METHOD OF INTERCHANGING HORIZONTAL AND VERTICAL PHASE SPACE AREA

The following is a brief description of a method for decreasing the horizontal phase space area occupied by a beam at the expense of the vertical phase space. The problem is of interest for accelerators because the usual multiturn injection techniques employ only horizontal stacking. Therefore, the number of protons injectable into a machine by this method depends only on the horizontal phase space density. Therefore, if the horizontal phase space density can be increased, the number of injectable protons can also be increased.

Consider a linac beam impinging on an electrostatic\* inflector as shown in Fig. 1. The left side is bent to the left, the right to the right. The result is that one now has two beams, each with the same vertical phase space area, but half the horizontal phase space area. One then recombines the two beams in the vertical phase, one above the other. The result is a beam of half the horizontal phase space area but twice the vertical phase space area. Fig. 2 shows the arrangement of the various bending magnets, and Fig. 3 shows the relevant phase space ellipse.

In principal the beam could be split into an arbitrary number of segments, and stacked up on each other. The mechanical arrangement of the elements becomes somewhat more difficult. However, the case for triple stacking appears quite simple, since one merely lets the central portion drift through the system and uses essentially identical techniques as with the method described above.

\* A pulse ferrite magnet with a septum may be simpler, and according to E. Forsyth, seems to be a quite reasonable approach.

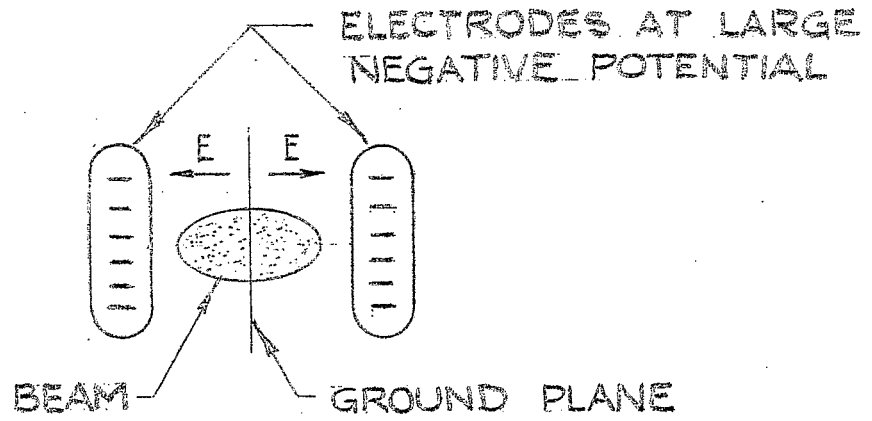
The septums can be made thin enough that a negligible amount of beam is lost in this way ( $\sim 1\%$ ). Ninety percent of the beam can be put into half the phase space area of the original beam, with a vertical dilution factor of about 1.5 (3 times the original emittance). With a linac beam of emittance  $1.2 \pi$  cm-mr, and a machine acceptance of  $4.1 \pi$  cm-mr, the vertical dilution should not present any problems.

Distribution: AGS Division Staff

AM/ah

Fig. 1

HORIZONTAL  
BEAM SPLITTER



VERTICAL  
BEAM SPLITTER

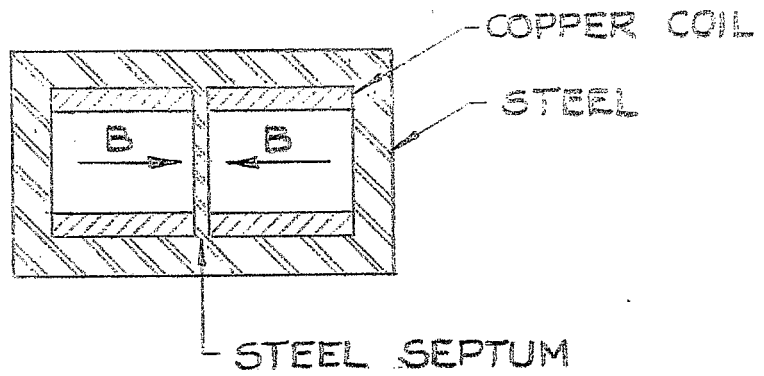
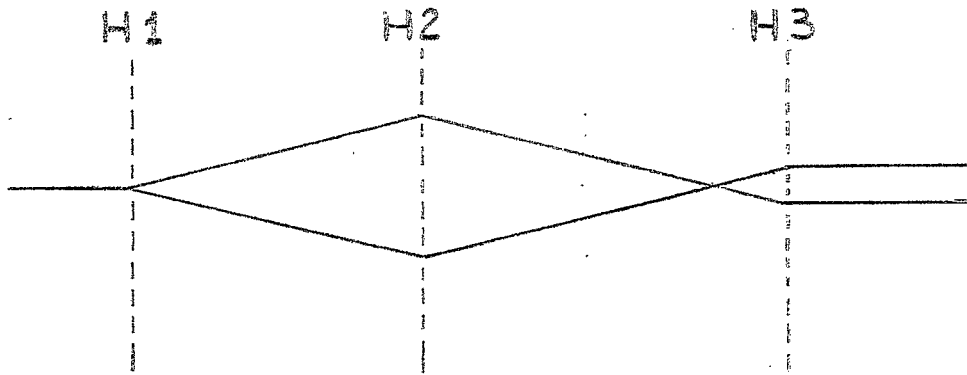
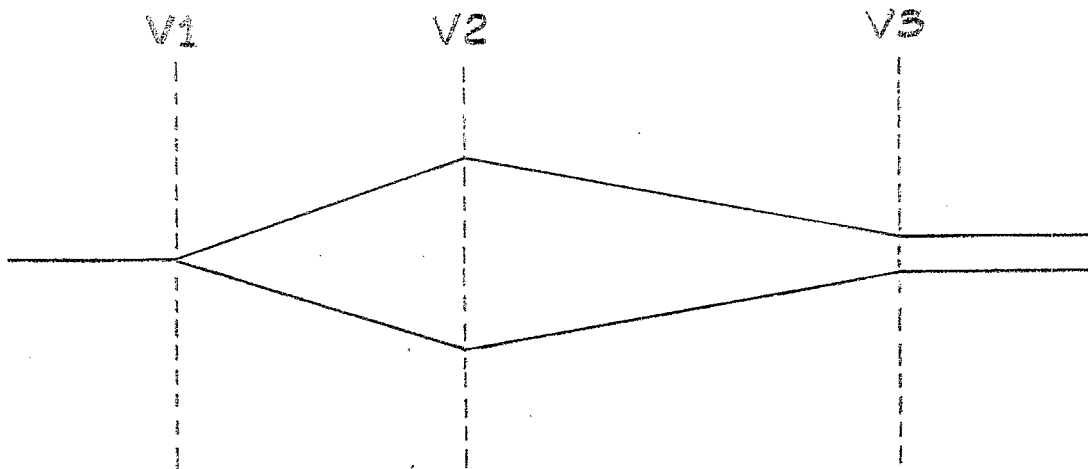


Fig. 2

HORIZONTAL RAY TRACE :



VERTICAL RAY TRACE :



H1 = HORIZONTAL BEAM SPLITTER

V1 = VERTICAL BEAM SPLITTER

H2 = HORIZONTAL BEAM SPLITTER

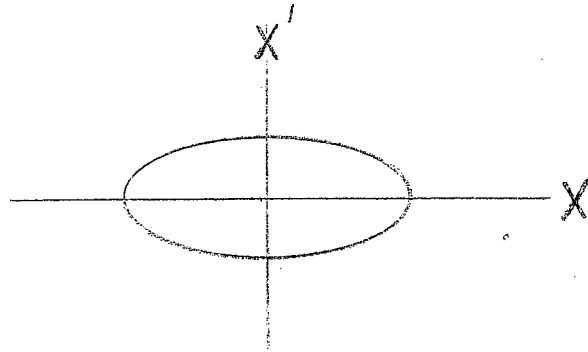
V2 = VERTICAL BEAM SPLITTER

H3 = VERTICAL BEAM SPLITTER ROTATED 90°

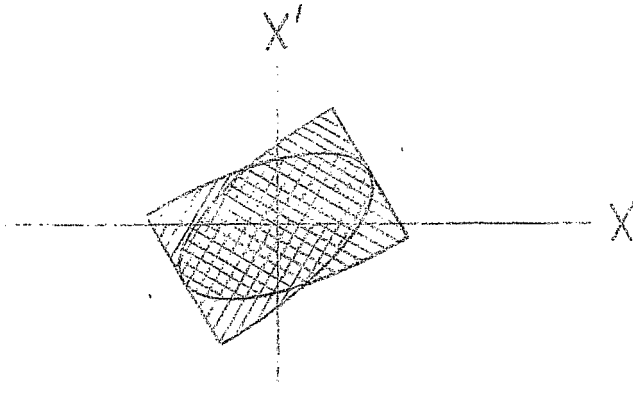
V3 = HORIZONTAL BEAM SPLITTER ROTATED 90°

Fig. 3

HORIZONTAL PHASE SPACE AT H1



HORIZONTAL PHASE SPACE AT H3



VERTICAL PHASE SPACE AT V3

