A major purpose of the Technical Information Center is to provide the broadest dissemination possible of information contained in DOE's Research and Development Reports to business, industry, the academic community, and federal, state and local governments.

Although a small portion of this report is not reproducible, it is being made available to expedite the availability of information on the research discussed herein.
A LATTICE WITH NO TRANSITION AND LARGE DYNAMIC APERTURE

G. Guignard, Collaborator for MP-14

1989 Particle Accelerator Conference
March 20-23, 1989
Chicago, IL

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, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness 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. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Los Alamos National Laboratory
Los Alamos, New Mexico 87545
LATTICE WITH NO TRANSITION AND LARGE DYNAMIC APERTURE

G. Guignard
Collaborator for MP-14, Los Alamos National Laboratory, Los Alamos, U.S.A.
LEP Division, CERN, Geneva, Switzerland

1. Summary

In the case of a one-ring high-energy scheme for an advanced hadron facility, beam losses can be reduced if the ring lattice accommodates the beam from injection to maximum energy without crossing the transition. Since there is no synchrotron booster in such a scheme and the injection energy is relatively low, this requirement implies a negative compaction factor and an imaginary transition energy. This can be achieved by making the horizontal dispersion negative in some regions of the arcs so that the average value taken in the dipoles is globally also negative. Such a modification of the dispersion may result in an increasing difficulty to obtain a large enough dynamic aperture in the presence of sextupoles. A careful optimization is therefore necessary and the possibility of modifying the linear lattice in order to reduce the requirements associated with chromaticity adjustments has to be studied. This paper summarizes the work done along this line and based on previous searches [1] for a race track lattice that can be used in a hadron facility main ring. It describes an alternative lattice design, which tends to minimize the effect of the nonlinear corrections introduced by sextupoles and to achieve a large dynamic aperture, keeping the bendstram amplitudes as low as possible.

2. Concepts for the arc lattice

As in the existing proposals for main ring lattices [1], a race track integration is obtained with two long dispersion-free straight sections and two 360-degree arcs. The acceptance design described below is intended to optimize the phase planes between sextupoles, minimize their strengths and reduce geometric aberrations, while keeping the transition energy negative. The dynamic aperture consistent with the proposed design has to be based on the presence of sextupoles. The main ingredients of this optimization are given in detail in appendix A. In order to reduce the main ring dispersion, it seems appropriate to refer to the design of a ring lattice without the injection in the straight sections, having an integer number of oscillations, in which the phase advance per cell is chosen to be in agreement with published stable beam experiments. If, however, necessary, the injection dispersion will be increased. The requirements that minimize sextupole nonlinear aberrations. It is known from previous work [4] that two nonlinear kicks of same strength, due to two sextupoles, may cancel each other if the injection amplitudes are the same, the phase separation is an odd multiple of \( \pi \) and there are no other nonlinear perturbations in between. Since in practice only the last condition cannot be satisfied, it is important to find positions where horizontally and vertically correcting sextupoles are not strongly coupled and to ensure cancellation over a distance so close that it is possible, i.e., over a phase separation corresponding to a small number of groups of cells. These requirements are somewhat in conflict with the negative compaction factor concept and this makes the lattice optimization more challenging.

All the conditions described above can be expressed mathematically. Each arc is supposed to be made of \( N \) groups of \( k \) cells. The \( k \) cells are organized such as to achieve an imaginary transition energy in a negative integral of the dispersion. The nonlinear kicks due to sextupoles are then supposed to cancel over a phase separation corresponding to \( N \) groups of \( k \) cells. The average phase advance per cell in each group is denoted \( \phi_i \) and \( \phi_j \), while the maximum and minimum values, which appear in the lattice and are likely to be of similar magnitude, are denoted \( \phi_i^+ \) and \( \phi_i^- \). The conditions for nonlinear kick cancellation and sextupole de-coupling imply that the tangent of much smaller than the maximum and that of \( \phi_i^+ \) can be approximately the same with these conditions. The requirements mentioned can be written as follows.
<table>
<thead>
<tr>
<th>k</th>
<th>n</th>
<th>m</th>
<th>N</th>
<th>p</th>
<th>( \theta_{xy} ) (degree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>105</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>135</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>57.5</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>5</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Possible combinations satisfying equations

![Graph 1](image1)

Fig. 1: Light's function for group 1.

![Graph 2](image2)

Fig. 2: Another possible graph for group 1.