Soft-edge Modeling in Dipole cooling Rings

Muon Simulations Workshop
Miami Beach, Fl.
December 13, 2004
The Weak-focusing Rings

4–Sector Ring
\( \lambda = \frac{R_c}{\rho} = 1 \)
\( \theta = \pi/4 \)
\( \varepsilon = \pi/8 \)

Lattices examined:
4 sector ring, \( \lambda = 1 \)
4 sector ring, \( \lambda = 3/4 \)
6 sector ring, \( \lambda = 1 \)
Introduce Skew Quadrupoles

- Bracket dipoles with thin (3cm) skew quadroles
- Skew quadrupoles real estate at 9% circumference
- Test various gradients.
- X/Y Coupling achieved
Performance for 6 sector ring: 100 atmos

Skew Quadrupoles: \( p_0 = 250 \text{ MEV} \)

Horizontal Focusing
Performance for 6 sector ring (cont)

Skew Quadrupoles: $p_0=172$ MEV

Horizontal Focusing

Merit Factor vs. Skew Norm Factor
Soft Edge Dipoles

The Tune Parameters

<table>
<thead>
<tr>
<th>Design</th>
<th>$\beta_x$</th>
<th>$\nu_x$</th>
<th>$\beta_y$</th>
<th>$\nu_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synch-Hardedge</td>
<td>0.379</td>
<td>0.277</td>
<td>0.570</td>
<td>0.257</td>
</tr>
<tr>
<td>ICOOL-Hardedge</td>
<td>0.380</td>
<td>0.278</td>
<td>0.571</td>
<td>0.257</td>
</tr>
<tr>
<td>Kahn-Softedge</td>
<td>0.443</td>
<td>0.257</td>
<td>0.734</td>
<td>0.215</td>
</tr>
<tr>
<td>Palmer-Softedge</td>
<td>0.404</td>
<td>0.272</td>
<td>0.723</td>
<td>0.208</td>
</tr>
</tbody>
</table>

Harold G. Kirk
Closed orbit for 250 MeV/c muons at r = 55.03 cm
Performance of the Kahn Model

Kahn’s 4 Sector Dipole Lattice: 172 MeV/c

Admittance

\[ \varepsilon_x = 1.7 \text{ mm} \]
\[ \varepsilon_y = 1.9 \text{ mm} \]
\[ \varepsilon_z = 2.0 \text{ mm} \]

Note: No MC or Straggling
Performance of the Palmer Model

4 Sector Lattice: 172 MeV/c

Admittance

\[ \varepsilon_x = 17 \text{ mm} \]
\[ \varepsilon_y = 11 \text{ mm} \]
\[ \varepsilon_z = 36 \text{ mm} \]

Pressure at 40 atmos
Total 6D Merit 9
Introduce Skew Quad to the Palmer Ring

Palmer 4 Sector Dipole Ring

Field at x=y=-1mm

Bx
By

Skew Quadrupoles : p0=172 MEV

Merit Factor
Skew Norm Factor

X
Y
Z

Merit Factor
Skew Norm Factor

Harold G. Kirk
Palmer 4 Sector Dipole Ring

Field at x=y=-1mm

Bx  
By

Skew Quadrupoles : p0=172 MEV

Merit Factor

Skew Norm Factor

Skew Norm Factor

Merit Factor

Skew Norm Factor

Merit Factor

Harold G. Kirk
Palmer Ring: Skew configuration 3

Palmer 4 Sector Dipole Ring

Field at x=y=-1mm

Skew Quadrupoles: p0=172 MEV

Merit Factor

Skew Norm Factor

Harold G. Kirk
Insert the skew component by introducing the skew transport term:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & k & 0 \\
0 & 0 & 1 & 0 \\
k & 0 & 0 & 1 \\
\end{bmatrix}
\]
Revisit the Hard Edge Model

Use Synch solution in ICOOL
- 4 sector dipoles
- 1.8 peak field
- 20 atmos pressure
- $p_0 = 172$ MeV
Summary

- Weak focusing dipole rings with soft edges continue to show 6D cooling
- The Kahn TOSCA dipole models to date yield field profiles that result in admittances which are a factor \( \sim 10 \) too small.