UMER: Machine Description and Magnets
FNAL-UMD, S. Bernal, Jan. 29th, 2013

Source: Thermionic, Pierce-type E. Gun
Injection Line: 1 Solenoid, 6 Quads
Y-Sect.: 1 Fast-pulsed Dipole, 2 Quads
Ring: 70 DC Magnetic Quads
35 DC Bending dipoles
Other: H, V Steering Dipoles, H. Coils

0.6–100 mA, at 10 keV

36,18, OR 9 FODO PERIODS
**BEAM PARAMETERS**

10 keV e⁻ → \( \beta = 0.20, \gamma = 1.02 \)

Lap time = 197 ns, (5.08 MHz)

Pulse Length = 15 to 145 ns,

Full-Lattice Period = 0.32 m (std. lattice)

Vacuum Pipe radius = 25.4 mm

\[
\frac{v_i}{v_0} = \sqrt{1 - \chi}, \quad \chi = \frac{K}{k_0^2 a^2}
\]

Tune \( v_{ox} = v_{oy} = 6.6 = k_0 R \)

<table>
<thead>
<tr>
<th>( I )</th>
<th>( \varepsilon_{n,rms} )</th>
<th>( a_{ave} )</th>
<th>( \chi )</th>
<th>( v_i/v_0 )</th>
<th>( \Delta v_{coh} )</th>
<th>( \Delta v_{inc} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>[mA]</td>
<td>[\mu m]</td>
<td>[mm]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>0.4</td>
<td>1.6</td>
<td>0.28</td>
<td>0.85</td>
<td>-0.005</td>
<td>0.94</td>
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<tr>
<td>6.0</td>
<td>1.3</td>
<td>3.4</td>
<td>0.61</td>
<td>0.62</td>
<td>-0.05</td>
<td>2.4</td>
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<tr>
<td>21</td>
<td>1.5</td>
<td>5.2</td>
<td>0.90</td>
<td>0.31</td>
<td>-0.17</td>
<td>4.5</td>
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<tr>
<td>78</td>
<td>3.0</td>
<td>9.6</td>
<td>0.97</td>
<td>0.18</td>
<td>-0.67</td>
<td>5.4</td>
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<tr>
<td>104</td>
<td>3.2</td>
<td>11.1</td>
<td>0.98</td>
<td>0.14</td>
<td>-0.91</td>
<td>5.6</td>
</tr>
</tbody>
</table>

*M. Reiser, Theory and Design of Charged Particle Beams, 2\textsuperscript{nd}. Ed., 2008*
UMER PRINTED-CIRCUIT MAGNETS*

\[ \int K_z dz \propto \cos n\theta, \quad n=\text{order of multipole}. \]

- High-tolerance design
- Design of any multipole or combination possible
- Low cost
- Variable strength and no hysteresis
- Almost any size or aspect ratio possible
- DC or pulsed operation
- Light but mechanically sound
- Stackable

UMER PRINTED-CIRCUIT MAGNETS

Rotating Coil

Axially-Int. $B_y$ vs. Radial Dist.

FFT of Rotating Coil Signal

PC QUADRUPOLE

Integrated $B_y$ (G cm/A)

Radial distance (% Quad Radius)

On-Axis Gradient Profile

Gauss/cmA

z(cm)
BETATRON RESONANCES AND BEAM CURRENT

Transmitted beam peak current at 10\textsuperscript{th} Turn vs. Bare Tunes:

- 0.6 mA
- 6.0 mA

2010 results, Bernal et al*

2012 results, Beaudoin et al, after detailed survey and alignment

6.0 mA beam more stable than 0.6 mA

*S. Bernal, et al, Proc. 14\textsuperscript{th} AAC Workshop, AIP 1299, June 2010
Backup Slides
IDEAL TUNE DEPRESSION VS. FOCUSING:
3 BEAMS AND TWO LATTICES

Tune Depression, \( \frac{\sigma}{\sigma_0} \)

Nominal \( \sigma_{0X} = \sigma_{0Y} \) (deg./period)

0.6 mA, S=32cm
6 mA, S=32cm
21 mA, S=32cm

0.6 mA, S=64cm
6 mA, S=64cm
21 mA, S=64cm

EMITTANCE DOMINATED
SP. CHARGE DOMINATED