Bunched beam Phase Rotation Optimization

R.B. Palmer

ISS KEK Workshop

1/23/06

- Study 2a
- Initial Concept
- 1D optimizing Model
- Problem with delta
  - eg 1 unoptimized
  - eg 2 optimized
  - eg 3 Short
- problem with delta
  - eg 4 Adiabatic
- Conclusion
Study 2a Rotation with ICOOL

110.7 m End of drift

161.7 m End of bunch

215.63 m End of rotate

265.9 m 50 m of cooling

Momentum (GeV/c)

ct (m)
Study 2a diagnostics

![Graph showing frequency (MHz) vs. length (m)]

- Frequency (MHz) values: 200, 225, 250, 275, 300, 325, 350
- Length (m) values: 100, 200, 300
- Lines are mean energies of time slices
- **Note delta was not set as theory suggested**
• Green line joins bunch centers
• It is not constant
• though deviations less than spread
Projections of previous plot

![Graph showing projections of initial and final KE (GeV)]
Method as Conceived

- Two reference particles, that see no RF, with p1 and p2,
- Drift 100 m

- Start RF with $\lambda = c(t_1 - t_2)/n$ with n=18
  where $t_1$ and $t_2$ (of reference particles)
- Increase the average RF gradient over next 50 m to bunch

- Lower the upper reference energy $dE/dz=$slope 1
- Increase the lower reference energy $dE/dz=$slope 2
- RF wavelength $\lambda = c(t_1 - t_2 + \delta)/n$ with n=18 and $\delta=.03$

- When reference 1 = reference 2 (56 m)
  go to the fixed wavelength $\lambda = c(t_1 - t_2)/n$
Effect of Delta

- Black line is before rotation
- Black dot are bunch centers
- Red line is after delta lambda
- Red dots are delta E at centers
- The effect is sinusoidal
Computer Optimized Design

- 1D Model (but with some transverse effect)
- Start with generated tracks or tracks from ICOOL at end of drift
- Propagation can include an amplitude dependent effect
- Pure sin RF acceleration (no amplitude effect)
- Energy Loss in windows ($t \propto \mathcal{E}^2$)
- Embedded in optimizer
Try original concept
(without window E loss, or amplitudes)
Parameters bucket centers

Length (m) 100

ref2 E and p: 187.8929 273.425
ref1 E and p: 83.29317 156.2988
ref2 E and p: 187.8929 273.425
ref1 E and p: 83.29317 156.2988
Length (m) 206 and 215

ref2 E and p: 135.6425 216.5267
ref1 E and p: 135.543 216.4161
Centers of selected energies vs x

\[ \text{rms E (MeV)} = 18.88114 \quad \text{eff} = 0.6059026 \]

<table>
<thead>
<tr>
<th>E1 (MeV)</th>
<th>E2 (MeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>83.29317</td>
<td>187.8929</td>
</tr>
<tr>
<td>51.2988</td>
<td>168.425</td>
</tr>
</tbody>
</table>

drift 0-100 bunch 100-150 rot 150=206 (m)
grad bunch= 0-5 rotate 5 (MV/m)
• similar to S2a
• Some gain from optimizing
• But no better for high E
Try shorter Rotation: 30 m (vs 56 m)

Loses higher energy tracks
Problem with use of delta

Length (m) 151

desired DE and dE x Lrot (MeV)

dct (m)

-200 0 200

-25 0 25 50 75 100
• Slow onset and removal of ref dE/dz
• No delta
• Significant apparent improvement
Compare Bunch Center E2’s vs E1’s

Gain may not be large because fewer high energy tracks
Conclusion

• Neuffer scheme does not work as I imagined
  – Use of ”delta f” does not work well
  – Adiabatic bunch dragging seems better

• Reducing Rotation length looses higher energy tracks
• Have not tried increasing it

• Overall performance not clearly better (not shown)
  – Need Ecalc9 like criterion
  – Bunching not yet optimized

• Must transfer design to ICOOL
• Try optimizing in ICOOL (Marco)