RAL +
Front End Studies
International Design Study

David Neuffer
FNAL

(January 5, 2009)
Outline

- Front End for the Neutrino Factory/MC
  - Concepts developed during study 2A

- Concern on $V_{\text{rf}}'$ as function of $B_{\text{sol}}$

- Need baseline design for IDS
  - need baseline for engineering study
    - lower fields; medium bunch length
Front End ReOptimization

- Change reference B-field to 1.5T
  - constant B to end of rotator

- changing to \( n_B = 12 \) example
  - A bit longer than \( n_B = 10 \)
  - optimize with lower fields
    - \( \nu'_{\text{rf}} < 12 \text{ MV/m} \)

- Will see if we can get "better" optimum

---

**Diagram:**

- FE Target
- Drift: \( \sim 18.9 \text{ m} \), \( \sim 60.7 \text{ m} \)
- Buncher: \( \sim 33 \text{ m} \)
- Rotator: 42 m
- Cooler: up to \( \sim 100 \text{ m} \)

**Diagram Details:**

- Solenoidal coils
  - \( r=0.5 \text{ m} \)
  - \( r=0 \text{ m} \)
  - \( 2.25 \text{ m} \)
- Cooling lattice
  - SC coil: 106 A/mm²
  - rf cavity: 201.25 MHz
  - 15.25 MV/m
  - L/H 1 cm

**Equation:**

\[ \pi \rightarrow \mu \]
Parameters of candidate release

- **Initial drift from target to buncher is 79.6m**
  - 18.9m (adiabatic ~20T to ~1.5T solenoid)
  - 60.7m (1.5T solenoid)

- **Buncher rf - 33m**
  - 320 → 232 MHz
  - 0 → 9 MV/m (2/3 occupancy)
  - B=1.5T

- **Rotator rf -42m**
  - 232 → 202 MHz
  - 12 MV/m (2/3 occupancy)
  - B=1.5T

- **Cooler (50 to 90m)**
  - ASOL lattice, $P_0 = 232\text{MeV/c}$,
  - Baseline has 15MV/m, 2 1.1 cm LiH absorbers /cell
Some differences

- Used ICOOL to set parameters
  - ACCEL model 10,
  - Phase Model 0 -
  - zero crossing set by $t_{\text{REFP}1}$
    - refp 1 @ 233MeV/c,
    - 2 at 154MeV/c, 10 $\lambda$

- Cool at 232 MeV/c
  - ~10% higher momentum
  - absorbers ~10% longer
  - Cools transverse emittance from 0.017 to 0.006m
Beam Through System

z=0

z=80m

z=111m

z=156m

z=236m
Vary buncher/rotator gradients from baseline to explore sensitivity to gradient limits.

- same baseline cooling channel (16MV/m, 1.15cm LiH)
  - 15 MV/m -> 1.1cm Li H

Somewhat less sensitive than previous cases

<table>
<thead>
<tr>
<th>Buncher / Rotator</th>
<th>0/0</th>
<th>3/6</th>
<th>4/7</th>
<th>5/8</th>
<th>6/9</th>
<th>7/10</th>
<th>8/11</th>
<th>9/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>µ/8GeVp at 240m (×10)</td>
<td>.136</td>
<td>.508</td>
<td>.686</td>
<td>.753</td>
<td>.797</td>
<td>.800</td>
<td>.831</td>
<td>.857</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10/13</th>
<th>11/14</th>
</tr>
</thead>
<tbody>
<tr>
<td>.821</td>
<td>.839</td>
</tr>
</tbody>
</table>
More realistic model

- For buncher & rotator replace $B=1.5T$ with “realistic” solenoid coils
  - $(B \sim 1.5T)$
  - 0.5 m long, 0.25m spacing
  - OK for rf feed in between

- ICOOL simulation shows no change in performance
  - ($\sim 1\%$)
Recent Studies

- **From Juan G.'s studies**
  - 8GeV 20T beam from H. Kirk
  - Also 8GeV 30T beam

- **New H. Kirk initial beam**
  - 20 T, 8 GeV beam, Hg target
  - from more recent MARS (?)-
  - (subtract 2.9ns to get mean of 0)
  - more π/8GeV p (~10%)

- **Tried 30T initial beam**
  - scaled 20 to 1.5T to 30 to 2.25 to 1.5T
  - ~20 to 25% more than with 20T

<table>
<thead>
<tr>
<th>Case</th>
<th>μ/p @ z=245m</th>
</tr>
</thead>
<tbody>
<tr>
<td>old CY init beam</td>
<td>0.083</td>
</tr>
<tr>
<td>new 20T HK beam</td>
<td>0.090</td>
</tr>
<tr>
<td>new 30T HK (25cm)</td>
<td>0.107</td>
</tr>
<tr>
<td>new 30T HK (30cm)</td>
<td>0.113</td>
</tr>
</tbody>
</table>
rf requirements

- **Buncher**
  - 319.63, 305.56, 293.93, 285.46, 278.59, 272.05, 265.80, 259.83, 254.13, 248.67, 243.44, 238.42, 233.61 (13 f)
  - ~100MV total

- **Rotator**
  - 336MV total

- **Cooler**
  - 201.25MHz - up to 75m ~ 750MV
# Buncher rf cavity requirements

<table>
<thead>
<tr>
<th>RF frequency</th>
<th>Total voltage</th>
<th>cavities</th>
<th>Gradient</th>
<th>Peak rf power</th>
</tr>
</thead>
<tbody>
<tr>
<td>319.63</td>
<td>1.368</td>
<td>1 (0.4m)</td>
<td>4 MV/m</td>
<td></td>
</tr>
<tr>
<td>305.56</td>
<td>3.915</td>
<td>2 (0.4m)</td>
<td>5MV/m</td>
<td></td>
</tr>
<tr>
<td>293.93</td>
<td>3.336</td>
<td>2 (0.45m)</td>
<td>4 MV/m</td>
<td></td>
</tr>
<tr>
<td>285.46</td>
<td>4.803</td>
<td>2 (0.45m)</td>
<td>5.5MV/m</td>
<td></td>
</tr>
<tr>
<td>278.59</td>
<td>5.724</td>
<td>2 (0.45m)</td>
<td>6.4 MV/m</td>
<td></td>
</tr>
<tr>
<td>272.05</td>
<td>6.664</td>
<td>3 (0.45m)</td>
<td>5MV/m</td>
<td></td>
</tr>
<tr>
<td>265.80</td>
<td>7.565</td>
<td>3 (0.45m)</td>
<td>5.7MV/m</td>
<td></td>
</tr>
<tr>
<td>259.83</td>
<td>8.484</td>
<td>3 (0.45m)</td>
<td>6.5MV/m</td>
<td></td>
</tr>
<tr>
<td>254.13</td>
<td>9.405</td>
<td>3 (0.45m)</td>
<td>7MV/m</td>
<td></td>
</tr>
<tr>
<td>248.67</td>
<td>10.326</td>
<td>4 (0.45m)</td>
<td>6MV/m</td>
<td></td>
</tr>
<tr>
<td>243.44</td>
<td>11.225</td>
<td>4(0.45m)</td>
<td>6.5MV/m</td>
<td></td>
</tr>
<tr>
<td>238.42</td>
<td>12.16</td>
<td>4 (0.45m)</td>
<td>7MV/m</td>
<td></td>
</tr>
<tr>
<td>233.61</td>
<td>13.11</td>
<td>4 (0.45m)</td>
<td>7.5MV/m</td>
<td></td>
</tr>
<tr>
<td><strong>98.085</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plans etc.

- Move toward “realistic” configuration
  - add Be windows

- Set up design for cost algorithm
  - rf cavity design (pillbox, dielectric)
  - rf power requirements
  - Magnet design

- Continuing front end IDS design study
  - C. Rogers, G. Prior, D. Neuffer, C. Yoshikawa, K. Yonehara, Y. Alexahin, M. Popovic, Y. Torun, S. Brooks, S. Berg, J. Gallardo ...
    - ~Biweekly phone Conference
    - Cost meeting at CERN March
    - April at Fermilab (IDS meeting)