Muon Collider Workshop -BNL
Front End Studies
International Design Study &
Muon Collider

David Neuffer
FNAL

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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
New Results

- Insulated rf lattice
  - Recent results show similar insulated/uninsulated simulation results

- Shielded rf cooling channel

- Front End with reduced rf/B requirements

- Front End Cooling
  - "snake"
  - Match into HCC
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
    - $V'_{\text{rf}} < 12 \text{ MV/m}$

- Will see if we can get “better” optimum

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![Diagram showing FE Target, Solenoid, Drift, Buncher, Rotator, and Cooler.](image)

- FE Target: ~18.9 m
- Drift: ~60.7 m
- Buncher: ~33 m
- Rotator: 42 m
- Cooler: up to ~100 m
High-frequency Buncher and ϕ-E Rotator

- Drift ($\pi \rightarrow \mu$)
- “Adiabatically” bunch beam first (weak 320 to 232 MHz rf)
- $\varphi$-E rotate bunches - align bunches to ~equal P (233MeV/c)
  - 232 to 202 MHz, 12MV/m
- Cool beam 201.25MHz
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, $P_0 = 232$ MeV/c,
  - Baseline has 15MV/m, 2 1.1 cm LiH absorbers /cell
progression through system

\[ z = 1\text{m} \]

112m

156m

215m

80m
How Long a Bunch Train for IDS?

ISS study allotted space for 80 bunches (120m long train)

- 80m or 54 bunches is probably plenty

NFFAG sequential ejection delays:
\((p + m/n) T_d\) for \(m = 1\) to \(n (= 3 \text{ or } 5)\)

Final, 80 \(\mu^-\) or 80 \(\mu^+\), bunch trains 3 and 4

Pulse < 40 \(\mu\)s for a liquid-Hg target
Pulse < 70 \(\mu\)s for a solid metal target
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

<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>
<th>10/13</th>
<th>11/14</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>
<td>.821</td>
<td>.839</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
Move toward “realistic” configuration
- More realistic B-field
  - $B = 1.5T \rightarrow$ coil-based fields
- add Be windows
- smaller number of rf frequencies

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 ...
- Fermilab meeting (July)
- ~Biweekly phone Conference
- Meeting at RAL
  - December 14-18
- April at Fermilab (IDS meeting)