MAP Acceleration Simulation and Design

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MAP Acceleration Primary Tasks

- Neutrino Factory: IDS-NF
  - Linac and RLA design (next talk)
  - FFAG design
- Muon Collider
  - Choose high energy acceleration scenarios
    - RLAs
    - Fast ramping synchrotrons
  - Collective effects, especially RF cavities

IDS-NF FFAG Base Lattice Design

- Three updated designs
- FODO: high average gradient
- Triplet, one cavity: 15% cost savings
- Triplet, two cavities: better average gradient ($<$ FODO), easier injection
- Must choose one soon
- Minor tweaks still needed, will not change significantly

IDS-NF FFAG Injection and Extraction

- Scenarios designed for three lattices (Kelliher, Pasternak)
- 0.1 T kickers, shared for two signs
- Triplet with two cavities easier
  - Fewer kickers (5 or 6 vs. 8 each)
  - Septum field lower
- Larger aperture in injection/extraction regions
  - Closed orbit distortion manageable

IDS-NF FFAG
Chromaticity Correction

- Designed chromaticity correction (Machida): improves longitudinal dynamics
- Permits insertions to ease injection/extraction
- Poorer dynamic aperture, but maybe sufficient
- More costly (TODO: quantify)
- Evaluate level of partial correction to use
- Look at correcting with higher tune (less costly?)

IDS-NF FFAG MAP Contributions

- Up to now
  - Design and beam dynamics of FFAG
  - Similar, related work for the EMMA experiment
- Priority needs
  1. Serious look at kickers
  2. Cost comparison with RLA
  3. More beam dynamics studies

Muon Collider
Acceleration Scenario Choice

- Two scenarios discussed in any detail
  - RLA(s)
  - Fast ramping synchrotrons
- Choose based on
  - Cost
    - Strongly related to efficiency, mostly correlated with number of passes
  - Technical feasibility

Muon Collider Acceleration RLA Scenario (Bogacz, others)

- Increase RLA passes to 12 by
  - Ramping linac magnets
  - FFAG-like arcs (Trbojevic), two passes each
- Areas for study
  - Requirements for ramping magnets
  - Arc-linac matching
  - Collective effects with limited synchrotron oscillations
  - Still few passes: cost

Muon Collider Acceleration
Fast Ramping Synchrotrons

- Original idea by Summers
- Magnet fields increase with beam momentum
  - Much faster than usual
  - Fixed-ramping combination at high energies for high average field
- Potentially many turns: efficient
- Lose RF synchronization: design lattice to fix
- Many challenging pulsed magnet systems

Fast Ramping Synchrotrons Lattice Design

- Lattice design goals
  - Keep RF synchronized
  - Minimized beam excursion
  - Avoid resonances
- Optimization problem (like FFAGs!)
  - Vary two quads and dipoles (3 knobs)
  - Fix time of flight and tunes
  - Minimize horizontal position variation

Muon Collider Acceleration Collective Effects

- Huge collective effects
  - 1.3 GHz: 8.3% energy extraction/bunch pass
  - Additional higher order/propagating modes
  - Good: beam loading gives efficiency
  - Massive localized collective effect
- Few passes
- Will synchrotron oscillations stabilize?
  - Fast ramping: strong synchrotron oscillations

Muon Collider Acceleration MAP R&D Priorities

- RLA Scenario
  1. Lattice design and simulation
  2. Specification of ramped magnet hardware
- Fast ramping scenario
  1. Detailed lattice design (try different possibilities)
  2. Specification of all pulsed magnet systems
- Objective costing for comparison

Muon Collider Acceleration MAP R&D Priorities

- Collective effects
  1. Study dynamics in above scenarios
  2. Understand impedance sources
     - Cavities
     - Pulsed magnets