Analysis of Garren's 27-Jul-2011 Hybrid Synchrotron Lattice

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Review of Garren's Hybrid Lattice

- Accelerate from 375 GeV/*c* to 750 GeV/*c*
- 8 superperiods, 13 cells per superperiod
  - FODO, 90° in both planes
  - 6 arc cells, 3 straight cells
  - 2 dispersion suppression cells on either side
    - Shorter than other cells to get high packing factor
- 8 T cold dipoles
- Warm dipole ramped −1.8 T to +1.8 T

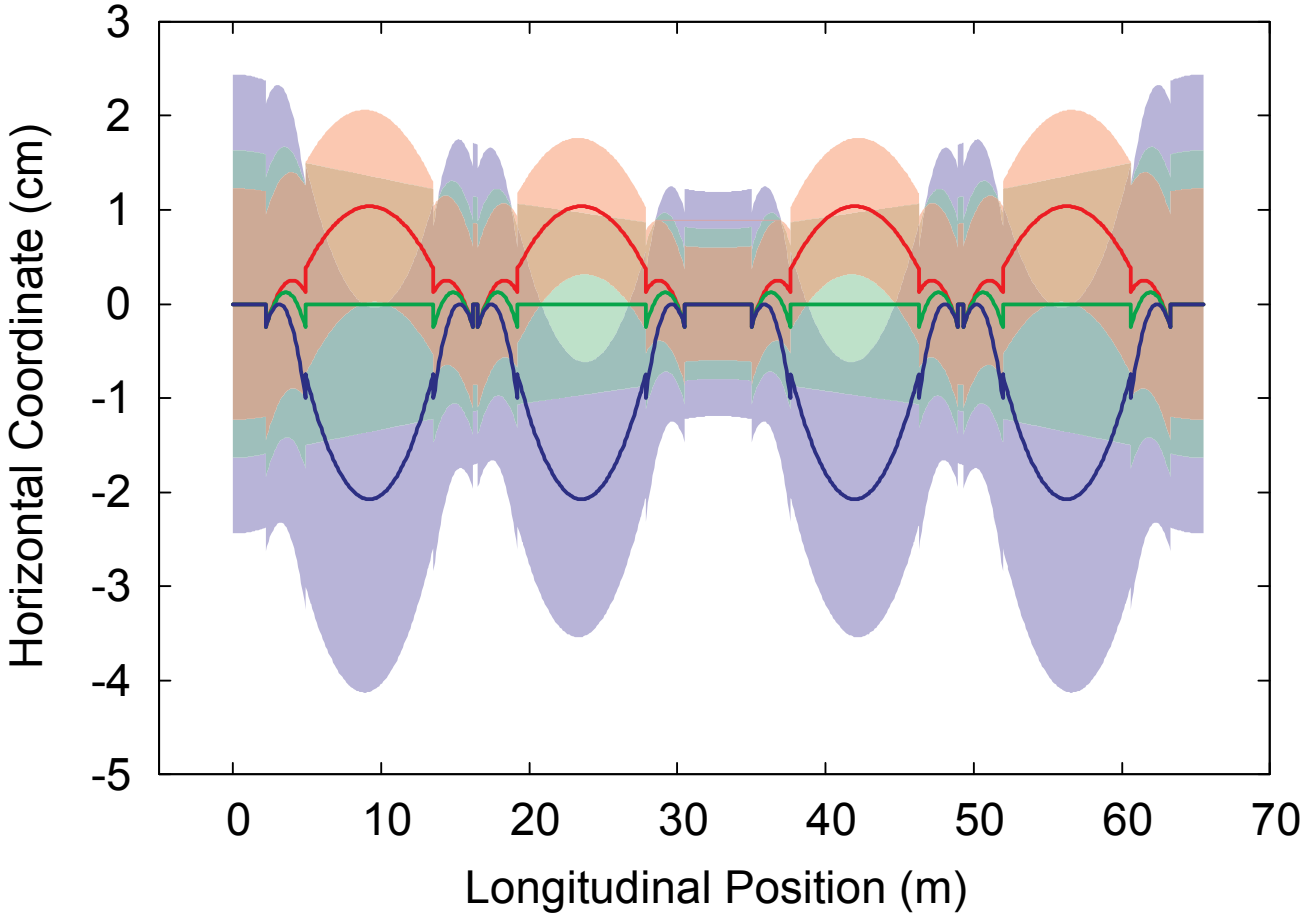
Review of Garren's Hybrid Lattice

- Dipoles interleaved to get correct average bend at each momentum: CWCWC
- 6288 m circumference

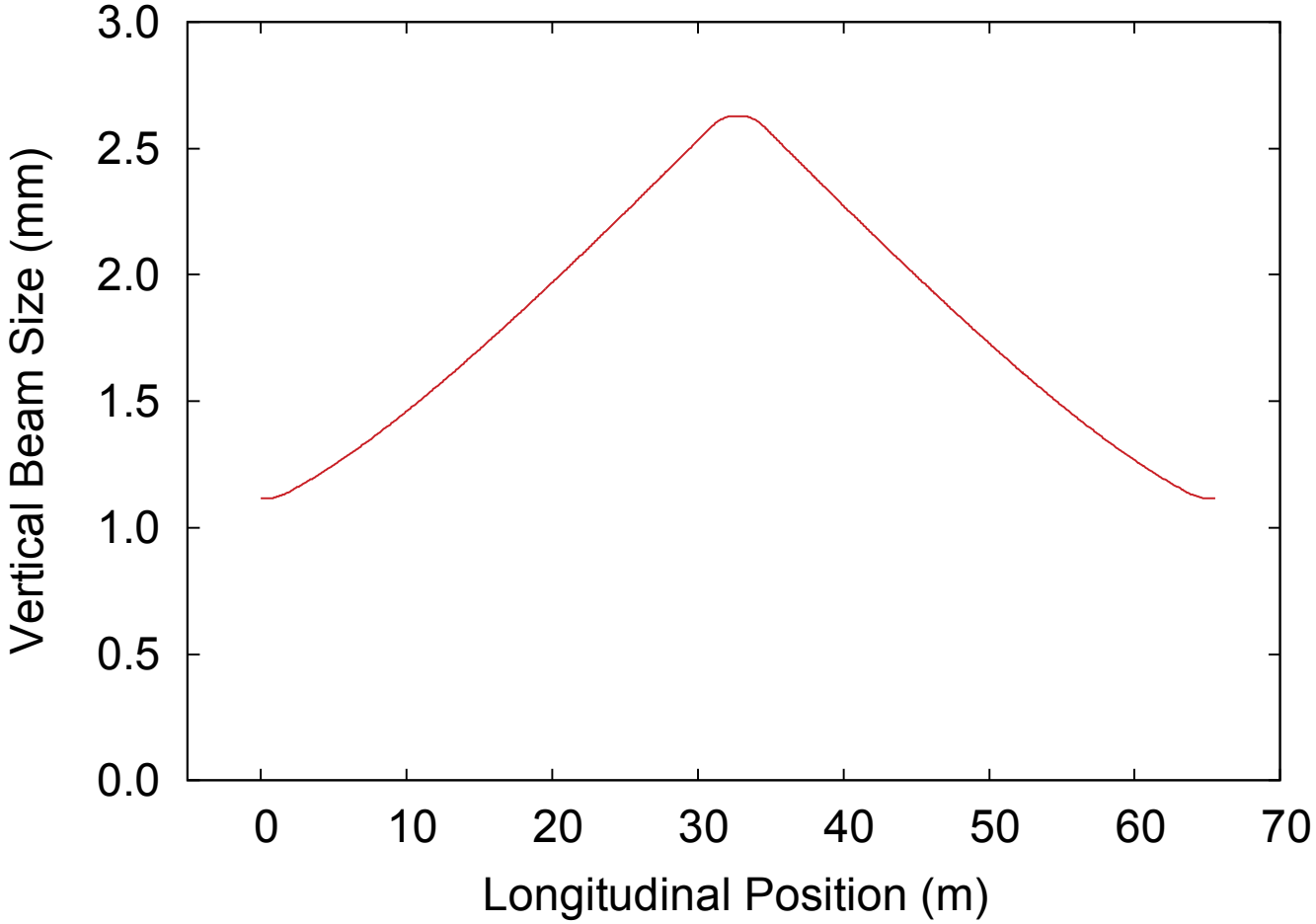
Arc Cell: Beam Size

- Transverse normalized emittance: 25 μm
- Energy spread 760 MeV
- Dispersion size a large fraction of horizontal aperture
- Closed orbit makes a significant contribution
- Vertical size very small

Horizontal Position and Size (Arc)



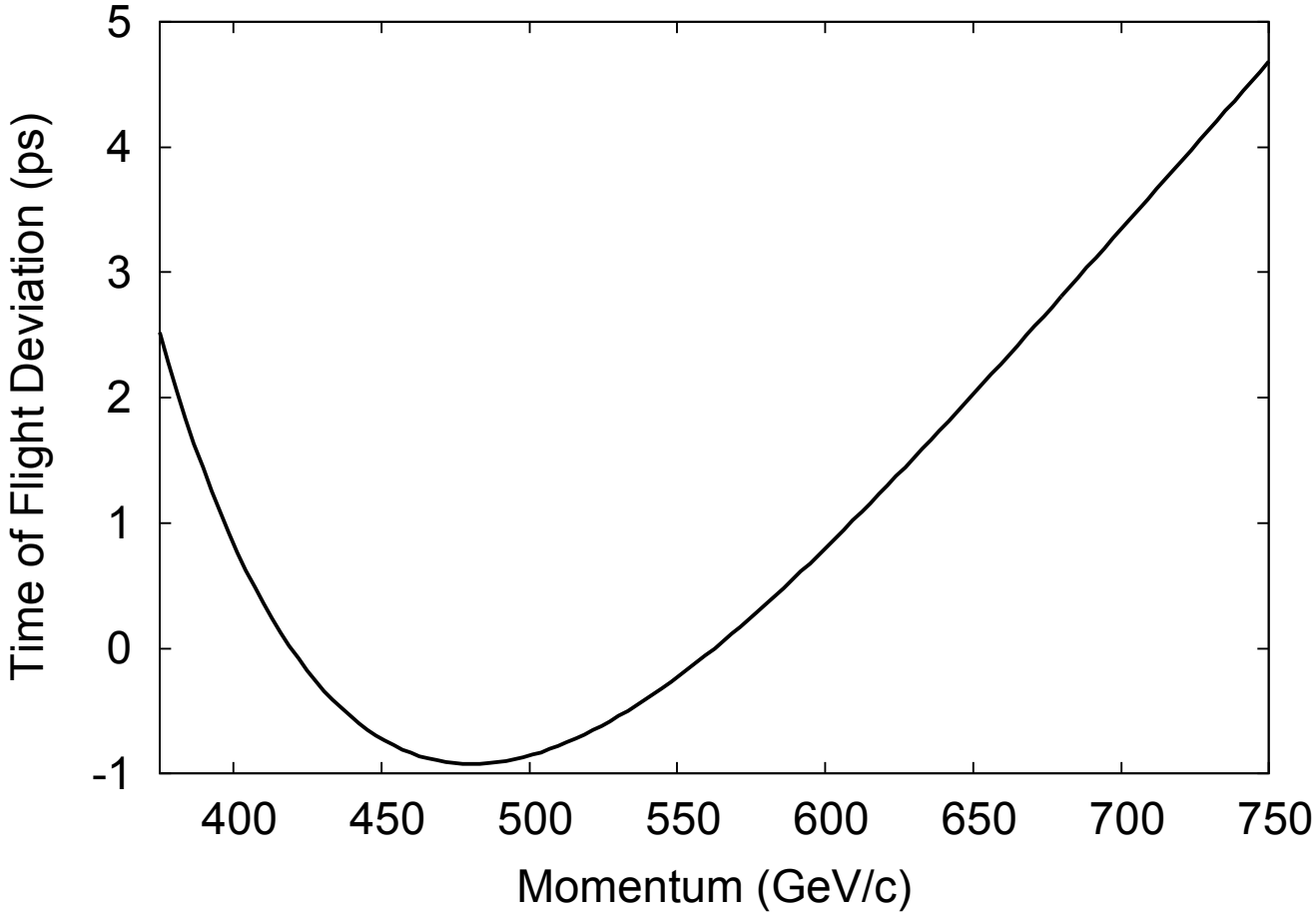
Vertical Beam Size (Arc)



Time of Flight

- Time of flight variation modest, but effect is cumulative
- Shape comes from inward and outward orbit excursions
- Could probably accelerate as-is, but with large RF phase variation
  - Likely more phase variation than desirable

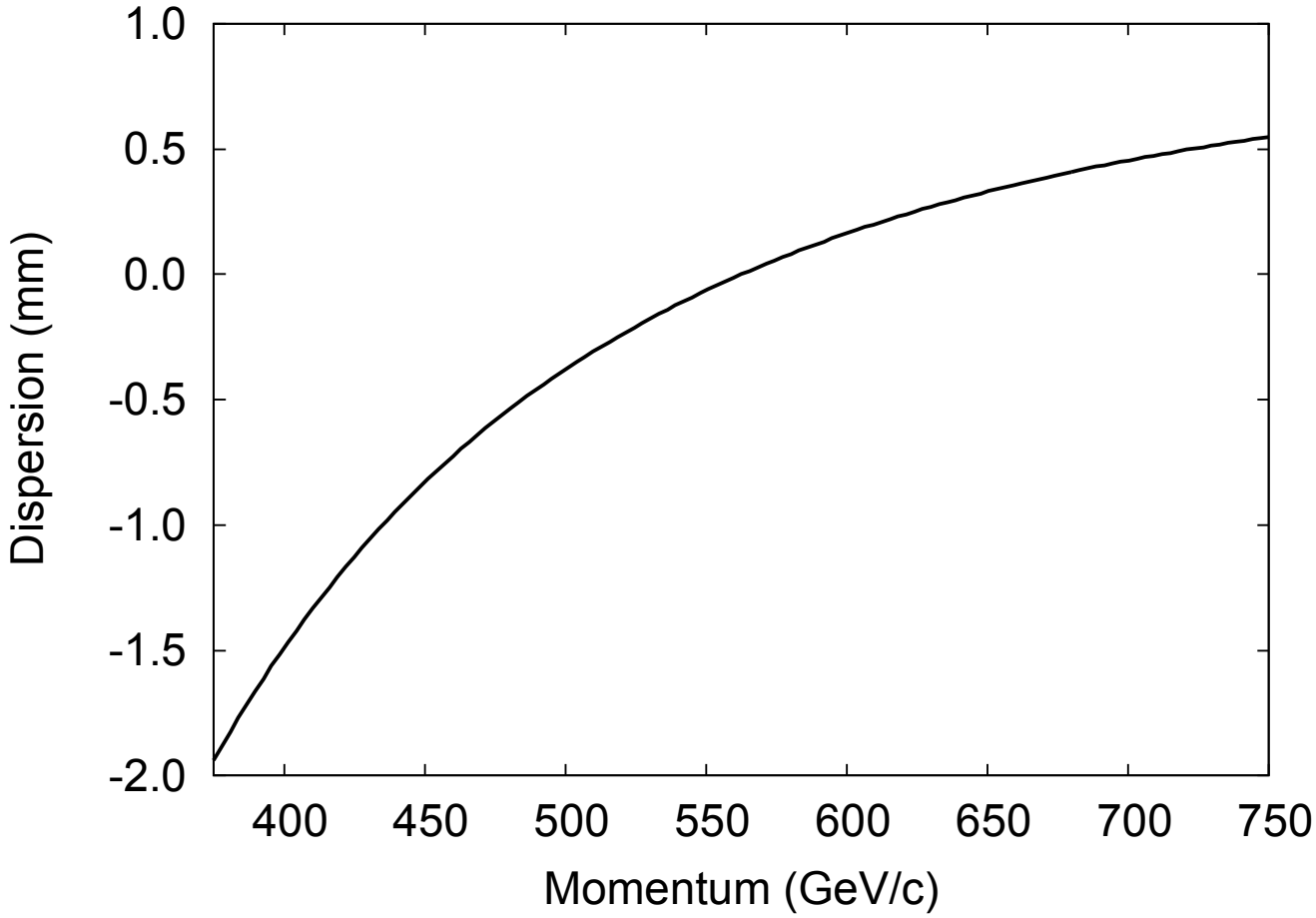
Time of Flight (Superperiod)



Dispersion Suppression

- Needed modest adjustment to drift lengths to get dispersion suppression right
- Cannot simultaneously get position and dispersion zero for all energies just using dipoles: same driving terms!
- Dynamics prefer suppressing dispersion, but operationally easier to control orbit position
- Remaining dispersion small

Dispersion at Straight Center



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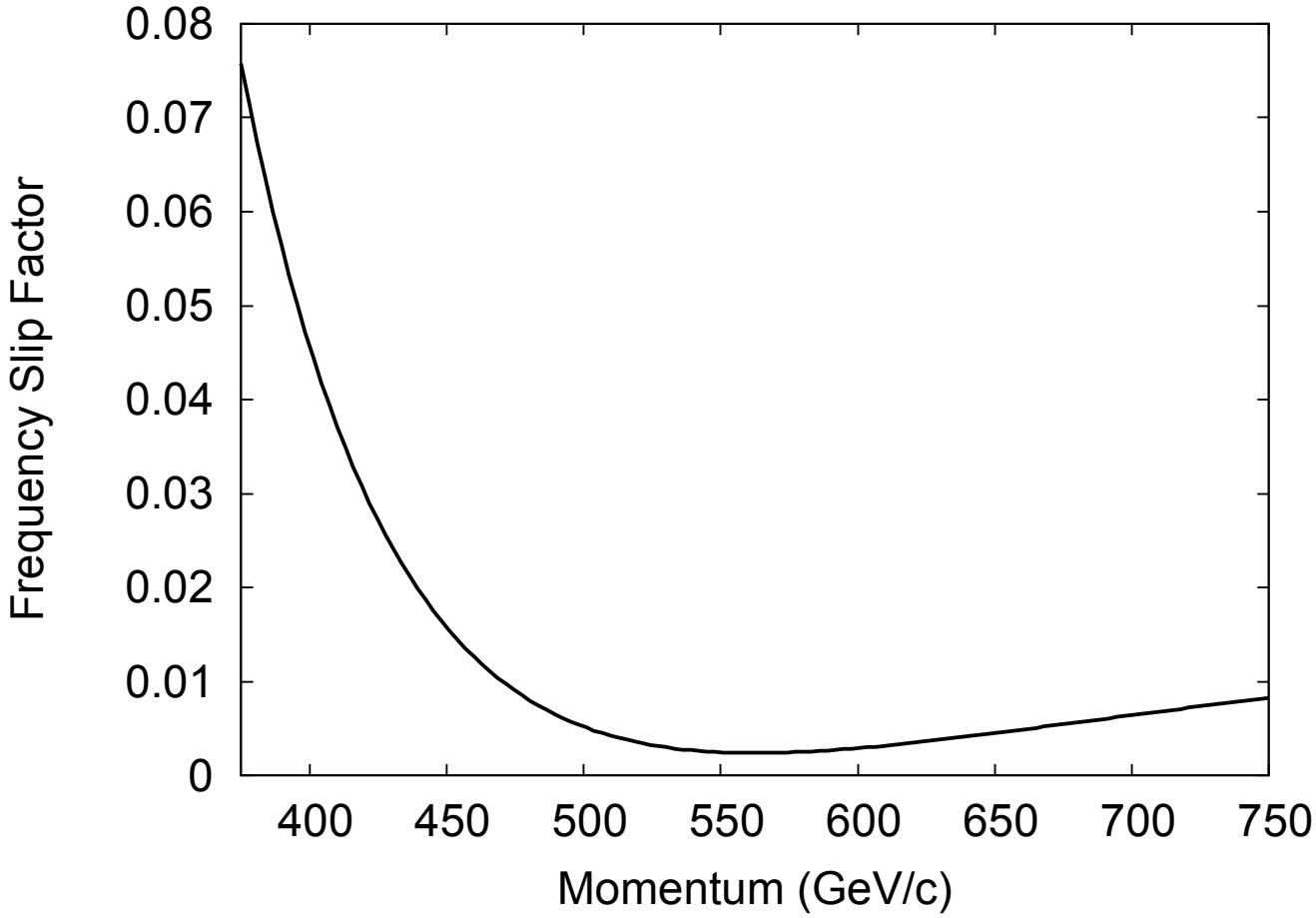
Tune and Beta Functions

- Tune is easily kept constant
- Not possible to beta match in both planes
  - Horizontal and vertical driving terms identical
  - Results from 90° FODO structure in both planes
- Tunes remain constant because arc and dispersion suppressors have 180° phase advance
- Probably some beta beat

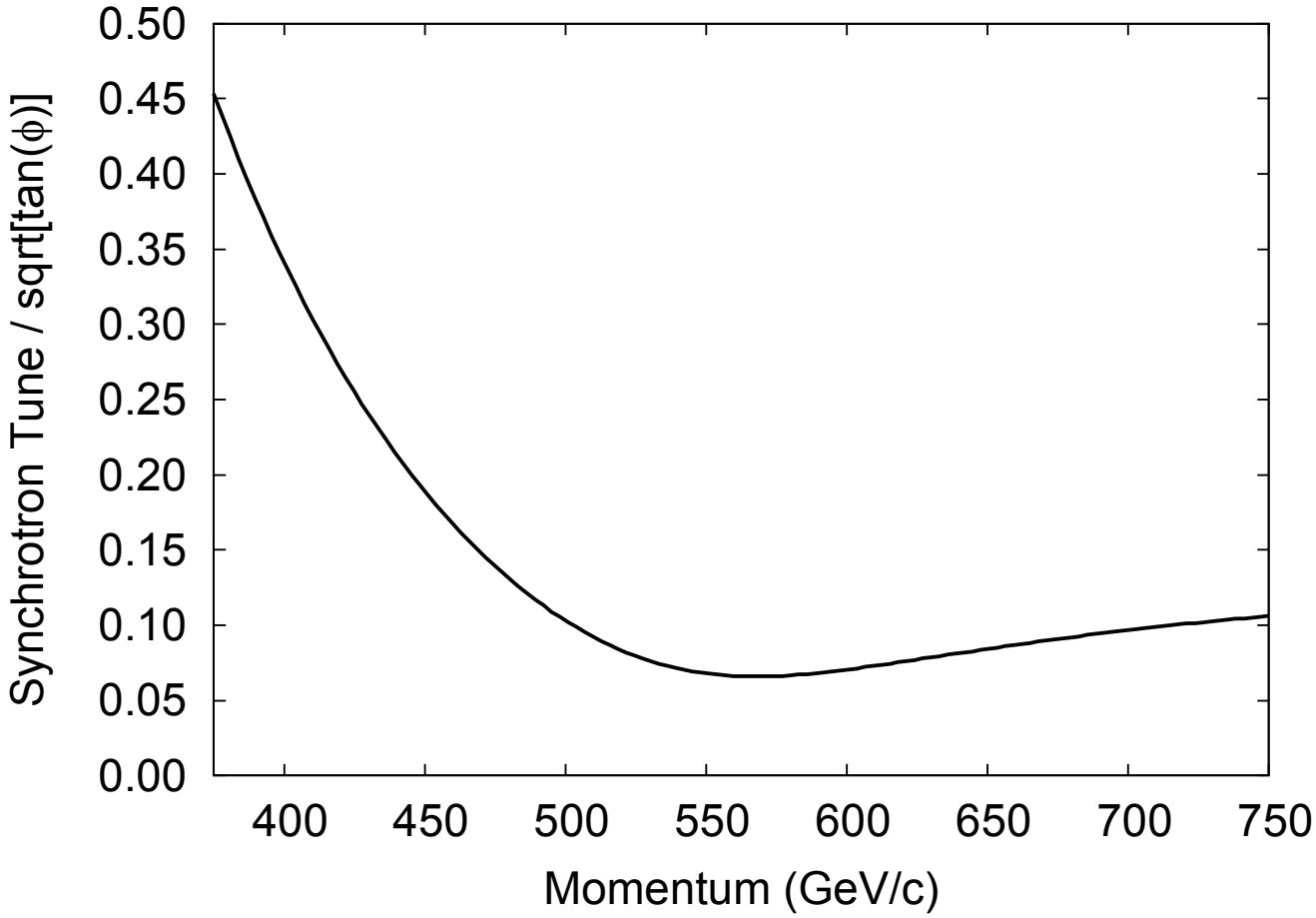
Synchrotron Motion

- Large variation in momentum compaction with energy
  - Magnitude gets large at low energy
- Synchrotron tune
  - Calculation based on 25 turns with 1.3 GHz RF
  - Good at low energy, a bit low for higher energy
    - Increasing synchrotron tune requires running off-crest, more RF

Frequency Slip Factor



Synchrotron Tune (Superperiod)



Thoughts Thus Far

- Shorter cells would help horizontal beam size, time of flight control
  - But would make large synchrotron tune difficult
- Large variation in momentum compaction may give difficulty, but goes in the right direction
  - Shorter cells would reduce this
- Look into split horizontal/vertical tunes