EMMA Status

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For the EMMA Collaboration
NFMCC Collaboration Meeting
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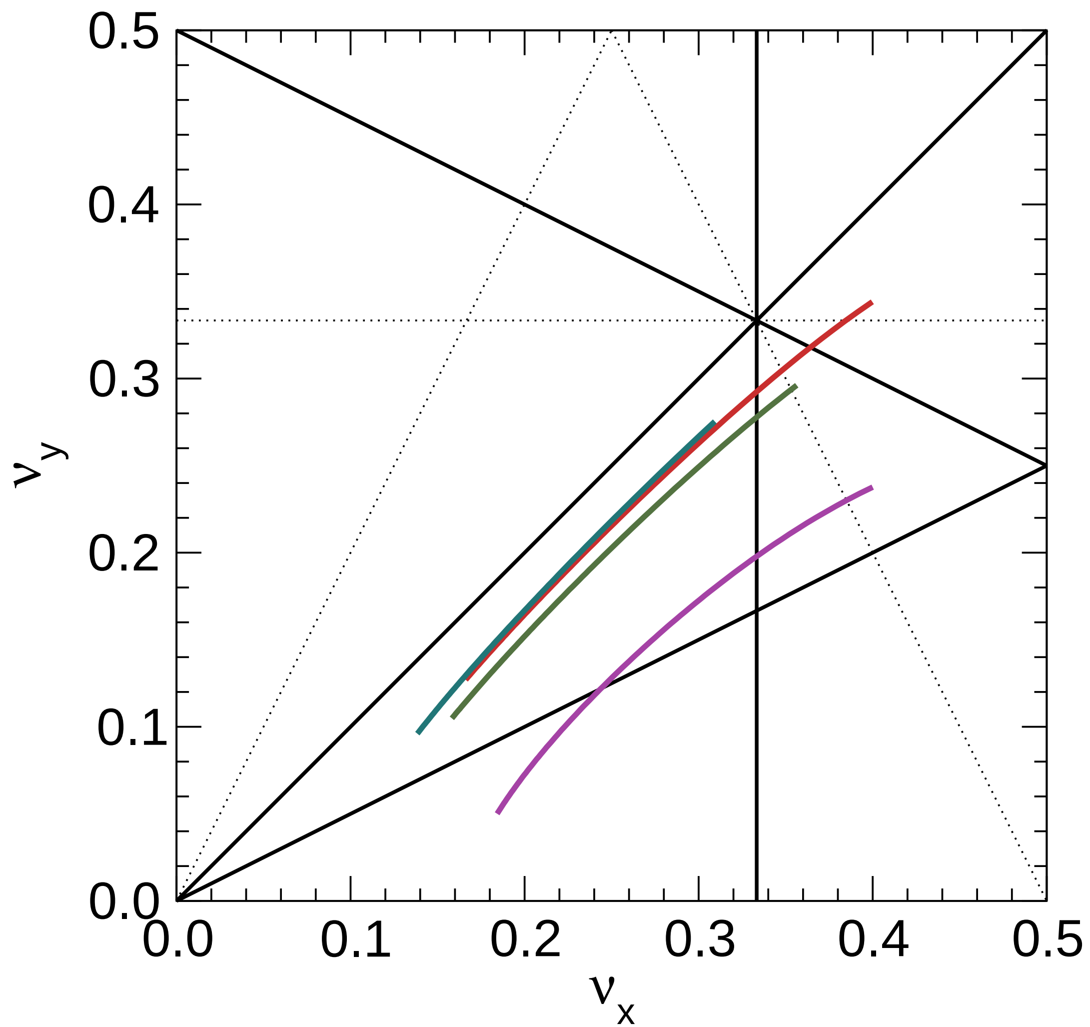
Overview of EMMA

- No non-scaling FFAGs has ever been built
- Study single-particle dynamics in linear non-scaling FFAGs
- Same accelerating mode as muon FFAGs
- Small emittance beam probes large acceptance
- Combined-function doublet lattice
  - Uses displaced quadrupoles

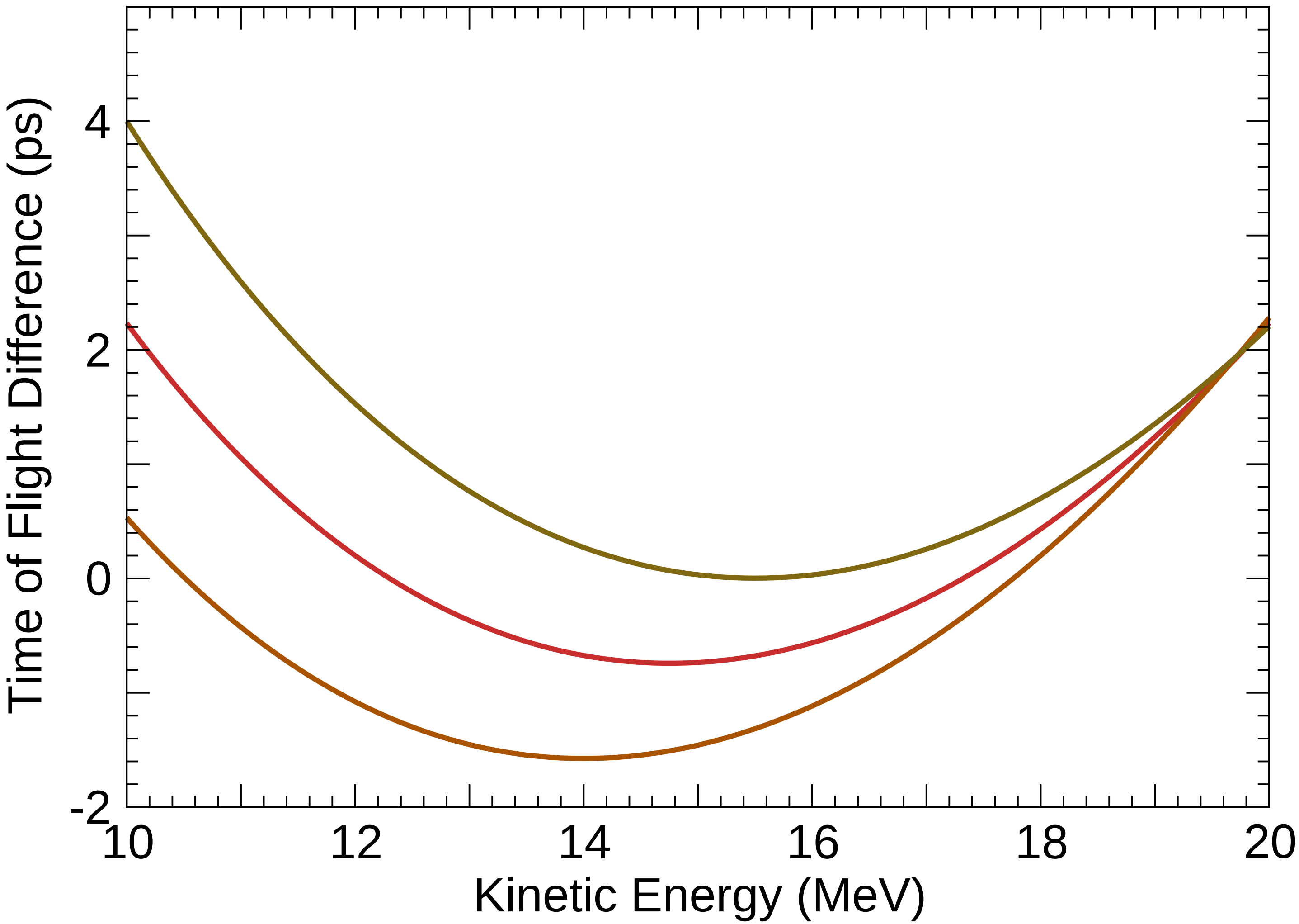
Machine Capabilities

- Study different lattice configurations
  - Different tune ranges
  - Different time of flight behavior
  - Independently vary field and gradient
    - Variable quadrupole displacement
- Study properties of accelerating mode
  - Adjust RF voltage and frequency

Tune Plane



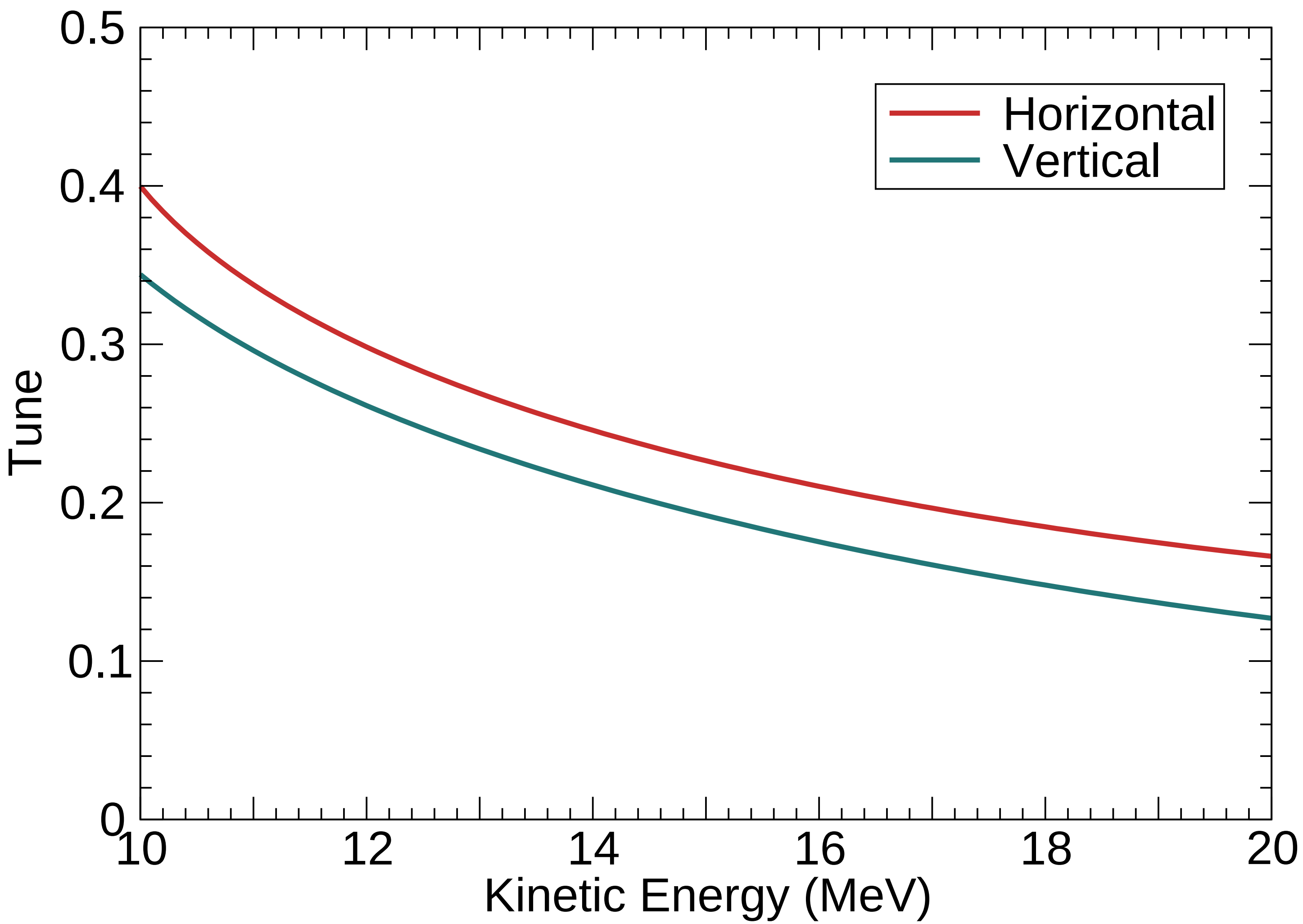
Time of Flight vs. Energy



Machine Capabilities

- Measure fixed-energy properties
  - Tune vs. energy
  - Time of flight vs. energy
  - Lattice configuration chosen based on these properties
- Inject/extract over entire energy range
  - For measuring fixed-energy properties
  - Energy measurement of accelerating beam

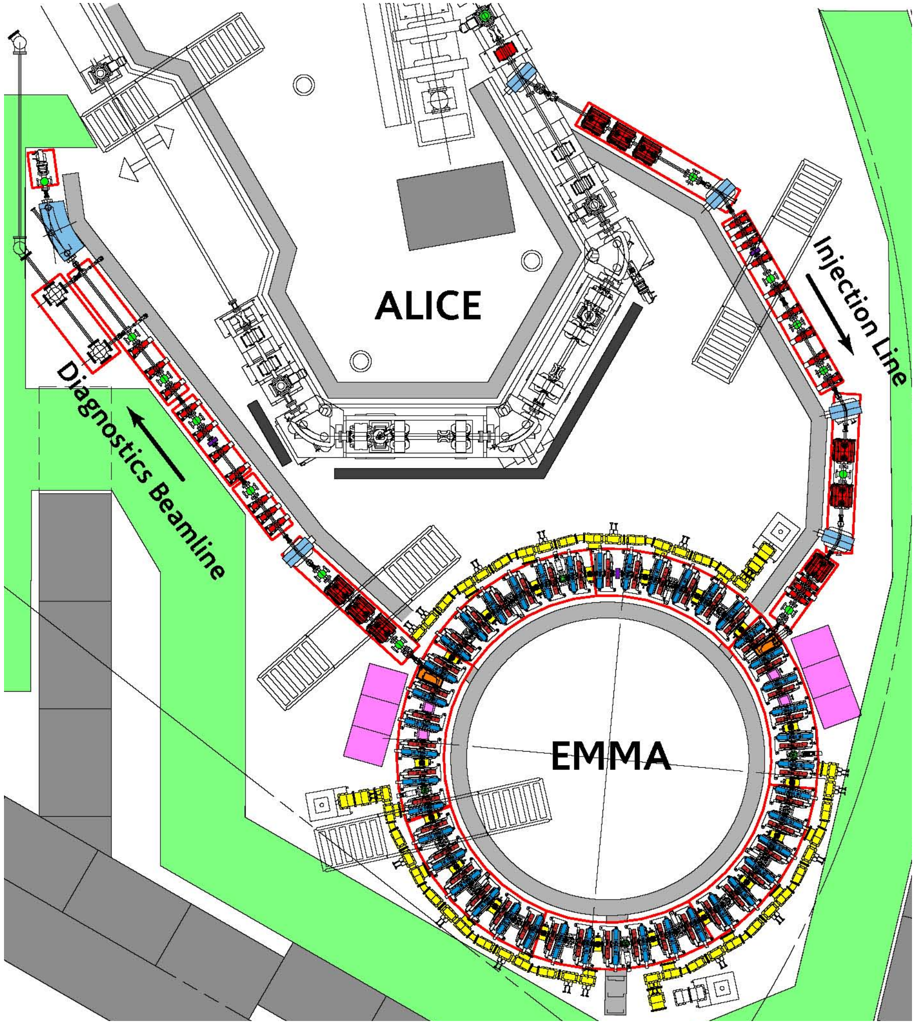
Tune vs. Energy



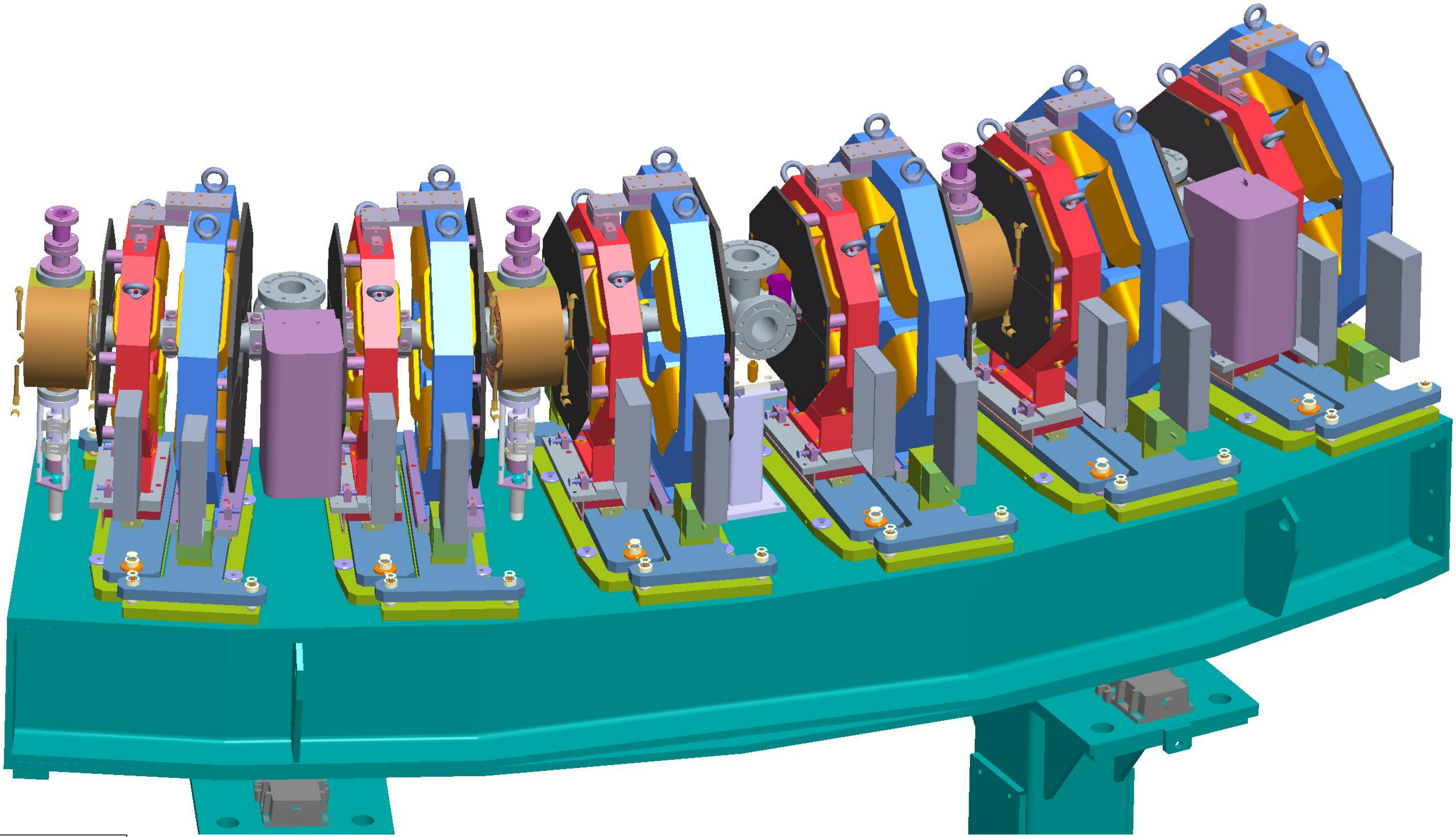
Machine Parameters

- Electrons, 10–20 MeV kinetic energy
- 3 mm normalized transverse acceptance
  - Probe with small emittance beam
- 42 doublet cells
- 16.6 m circumference
- 19 1.3 GHz RF cavities
  - About every other cell
  - Maximum 120 kV (180 kV) per cavity

EMMA Layout

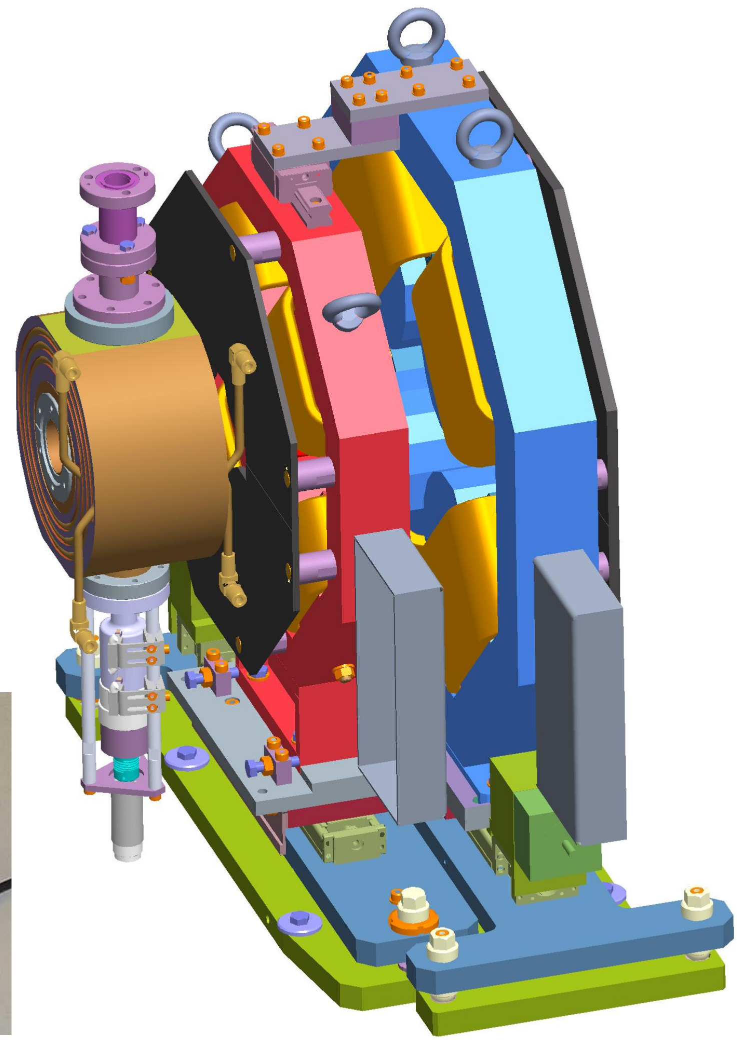


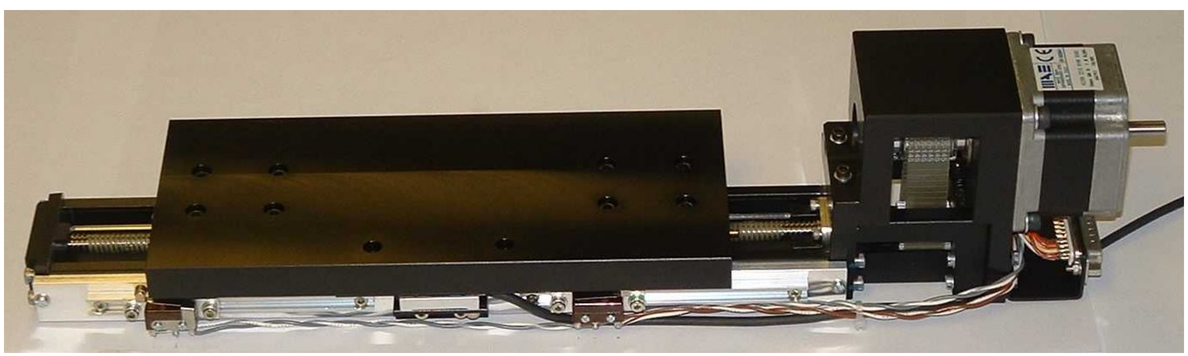
EMMA Main Ring Lattice



Main Ring Magnets

- Short, large-aperture
  - D is 65 mm long, 53 mm inscribed radius
- Magnets on motorized horizontal sliders
- Clamp plates shield kickers

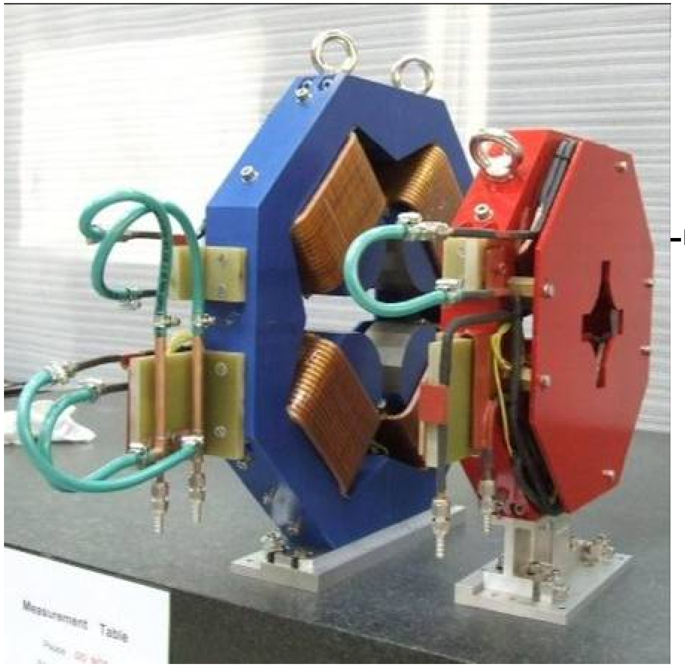


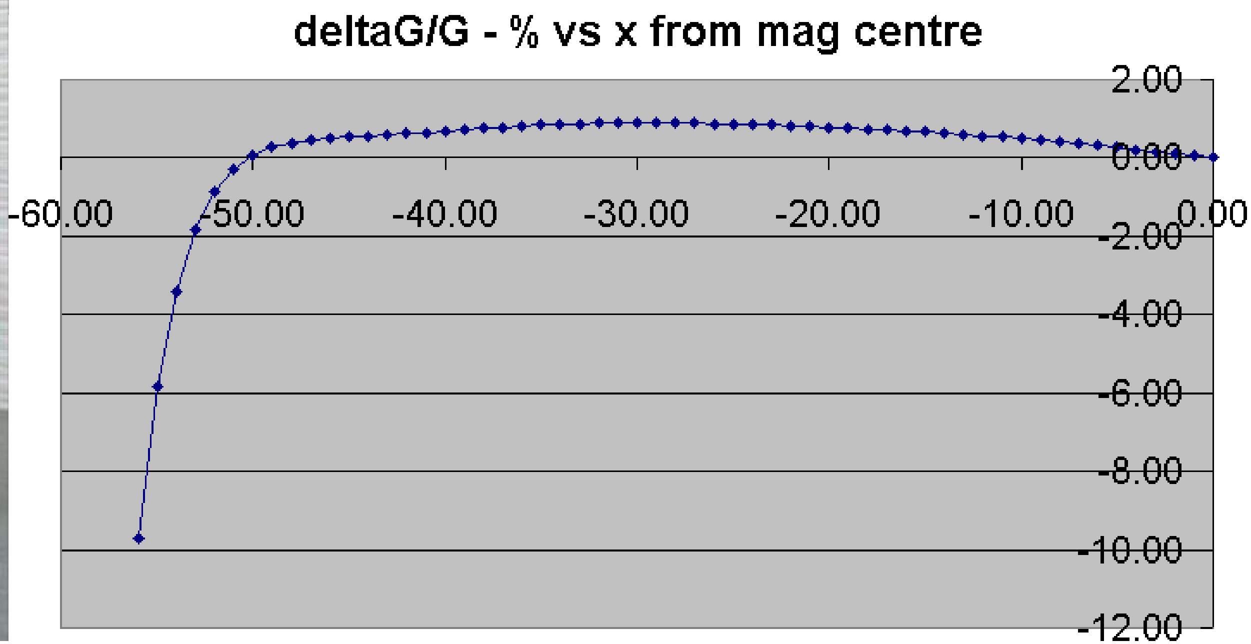


Main Ring Magnets

- Prototypes delivered and measured
  - Shimmed D to extend good-field region
  - Clamp plates thickened (saturated)
- Contract placed
  - Steel ordered
  - All ring magnets delivered by 1 August 2008

Magnets; Gradient Error in D

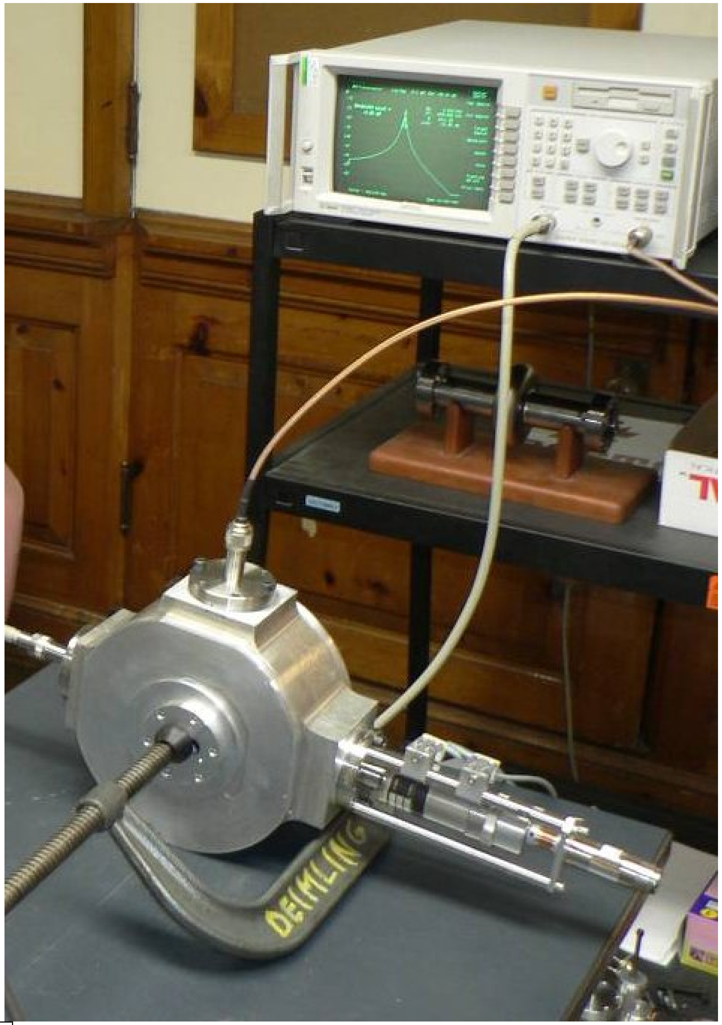




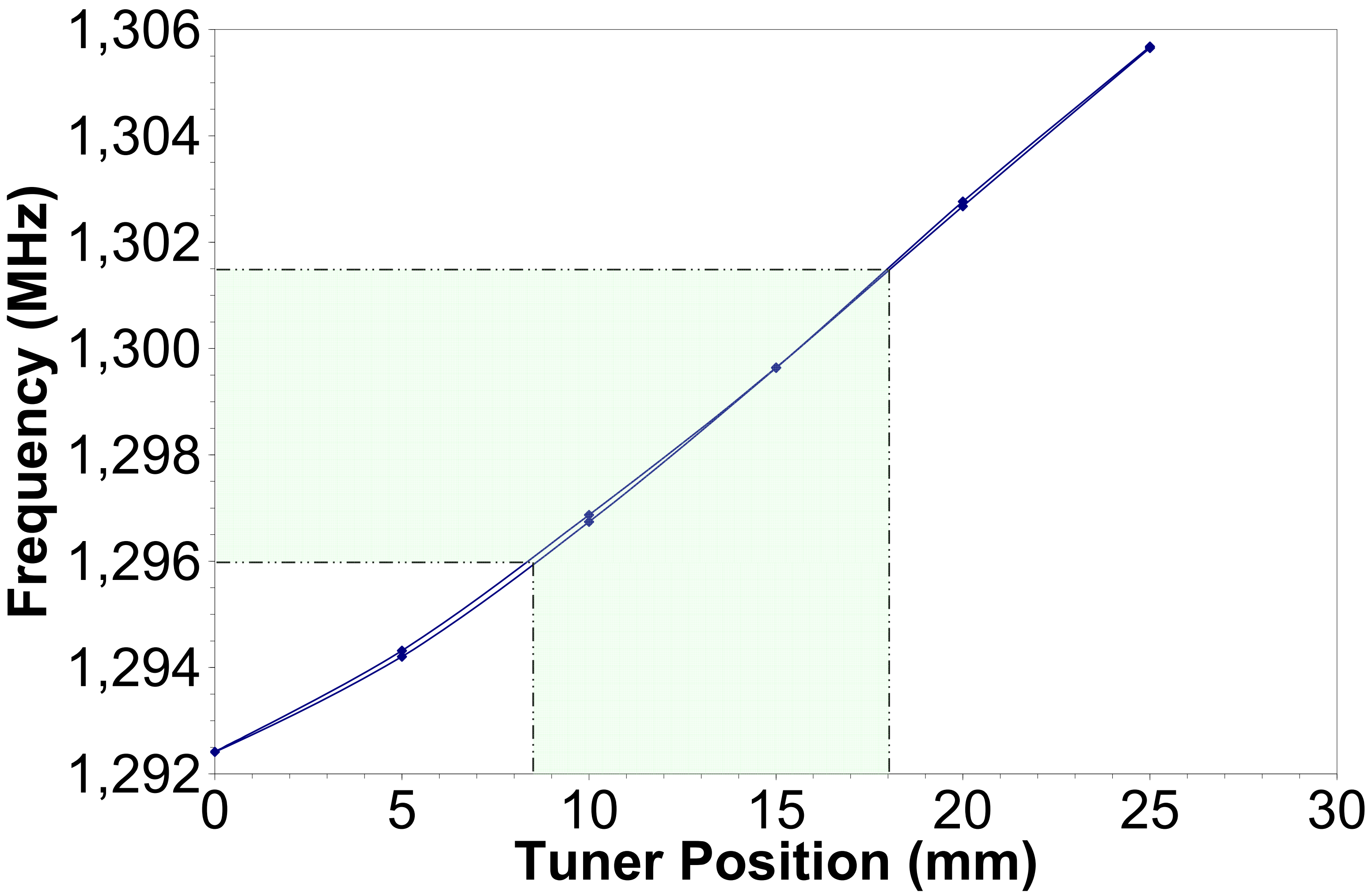
RF Cavities

- 1.3 GHz cavities, 5.5 MHz tuning range
- Cavity and associated components designed
- Aluminum prototype delivered
- Copper prototype delivered by 3 April 2008
- Cavities delivered by 14 August 2008

RF Cavities



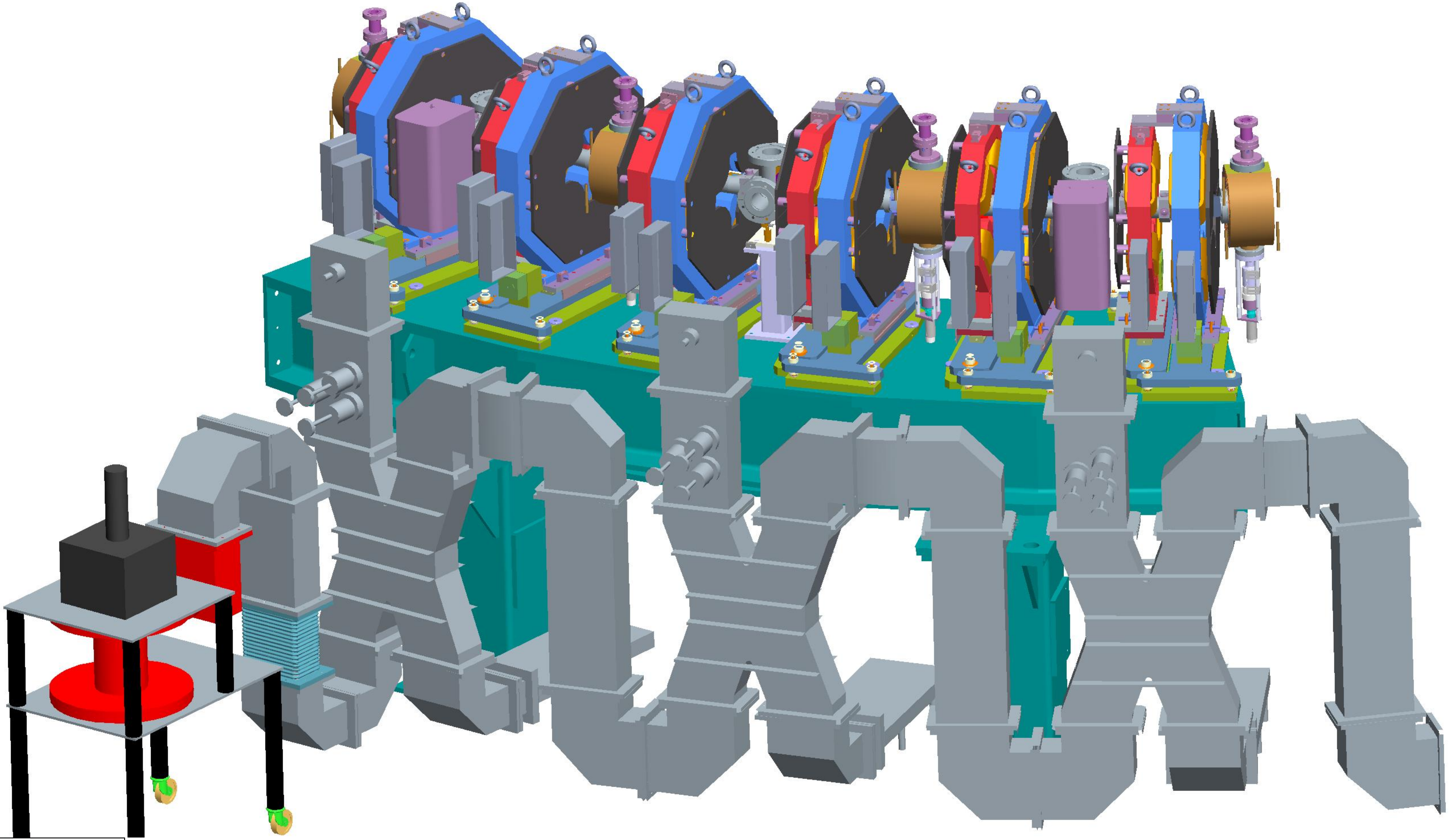
RF Cavity Tuning Range



RF Power Systems

- 1 80 kW IOT
  - 2nd at a later stage, if needed
- Out to tender in April 08
- Cascaded distribution scheme
- Motorized 3-stub tuners
  - Frequency variation requires phase variation

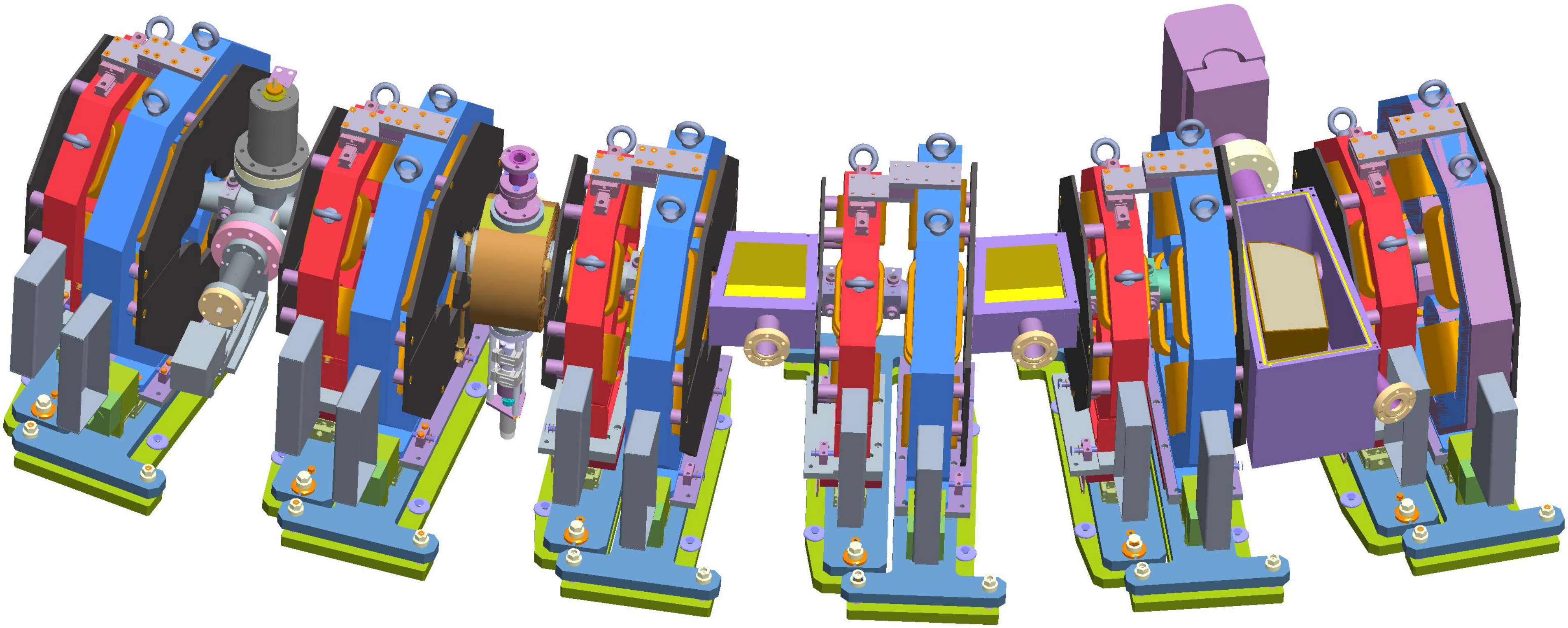
Cascaded RF Distribution



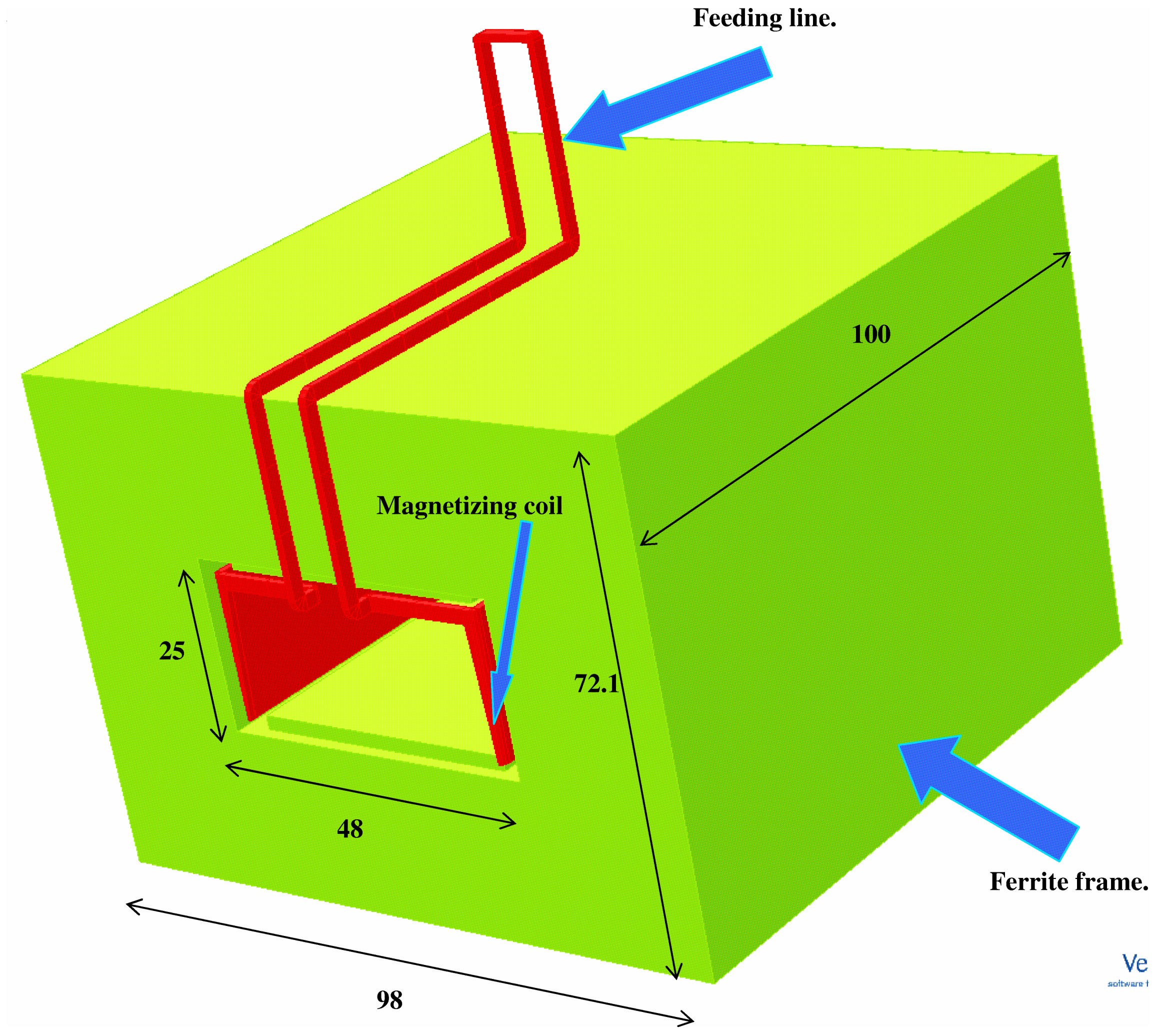
Injection/Extraction

- Inject/extract any energy from 10–20 MeV
  - Two kickers due to different phase advances
- Inject to any point in 3 mm acceptance
- Handle all configurations
- Inject and extract to outside

Injection Section



Kicker

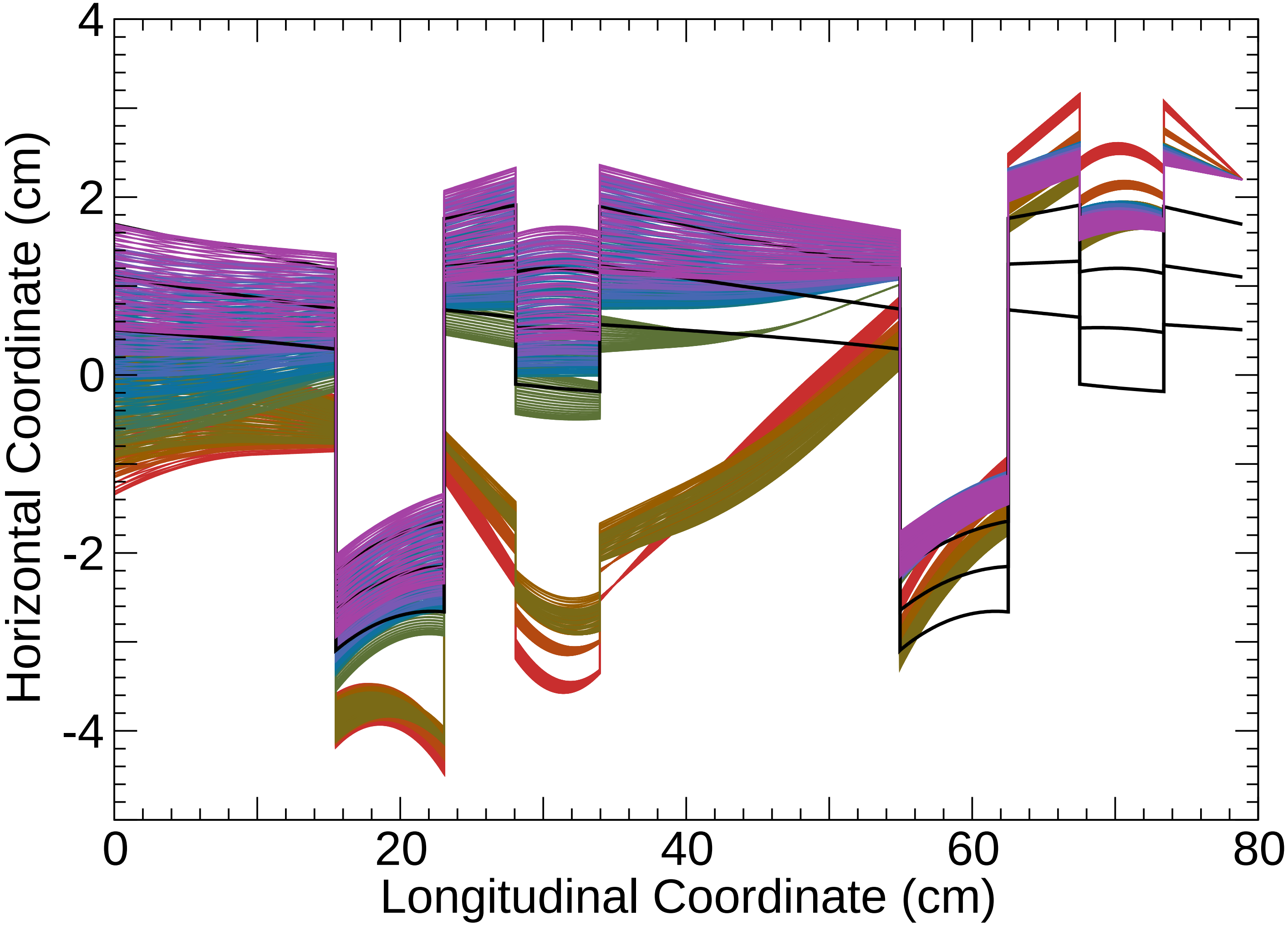


Feeding line.
100
Magnetizing coil
25
72.1
48
Ferrite frame.
98

Injection/Extraction

- Doublet not reflection symmetric
- D near septum easier for injection/extraction
  - Larger aperture for F near septum
  - Beam moving right direction at septum
- Choose injection to be easy
  - Find closed orbit parameters for all energies
- Can’t extract low energy unless move septum
  - Can’t move inj. septum: beam moves out

Injection with F near Septum



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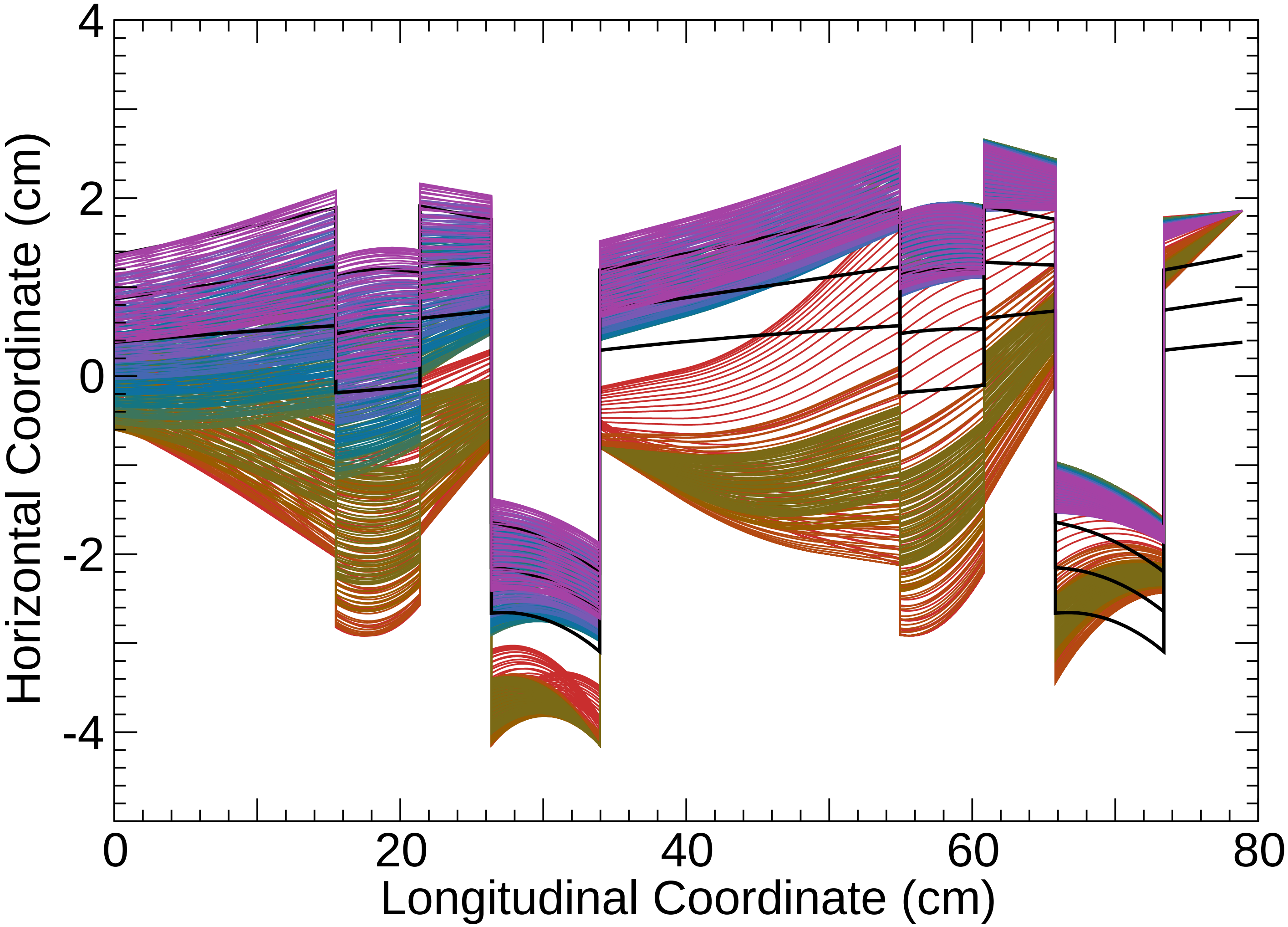
Injection with D near Septum



Diagnostics: Goals

- Find the beam the first time
- Find closed orbits, tunes, CS functions
- Find time of flight
- Measure transmission
- Measure energy
- Follow trajectories to measure 6-D acceptance
- Measure properties of probe beam

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Diagnostics: Ring

- About 84 sets of BPMs (2 per cell)
- Resistive wall monitor
- OTR screen
- Wire scanner

Injection Line

- Measure properties of probe beam
- Measure beam current
- Match probe beam to main ring

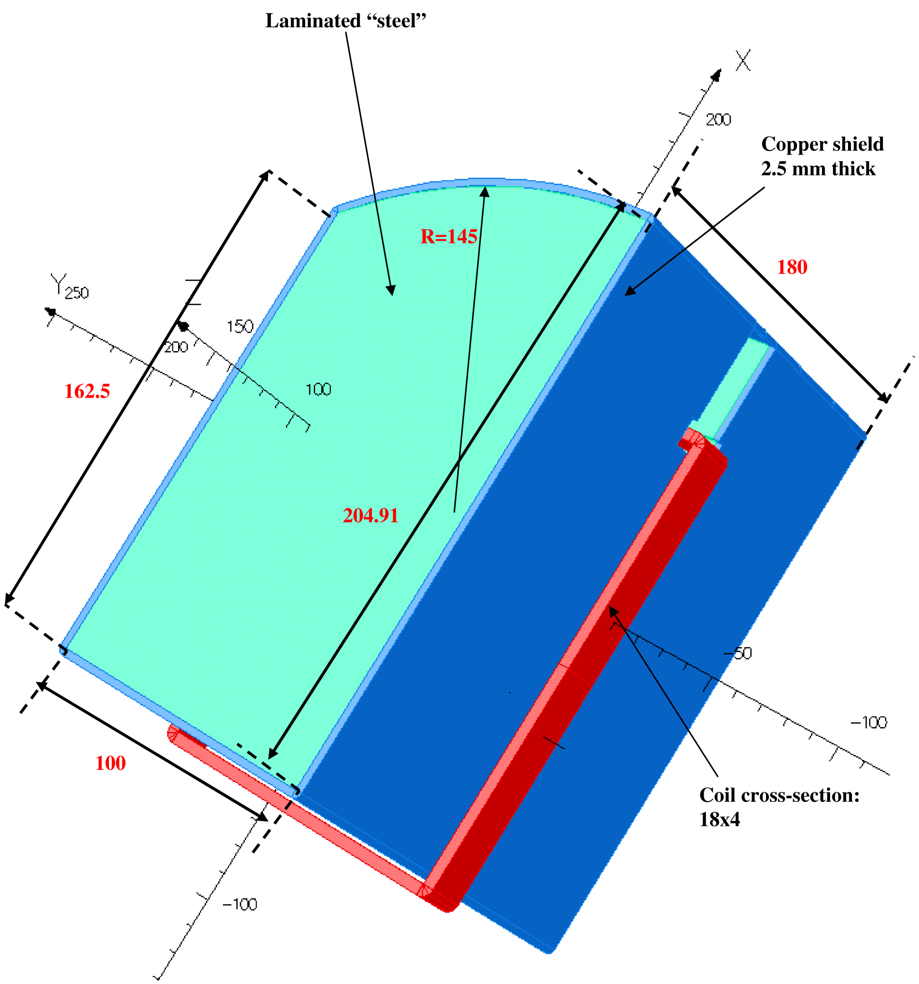
Diagnostics (Extraction) Line

- Planning on two phases (cost)
- Must measure energy!
- Measure transmission (Faraday cup)
- Measure probe transverse emittance
- Measure longitudinal profile
    - Electro-optic monitor
    - Deflecting cavity too expensive

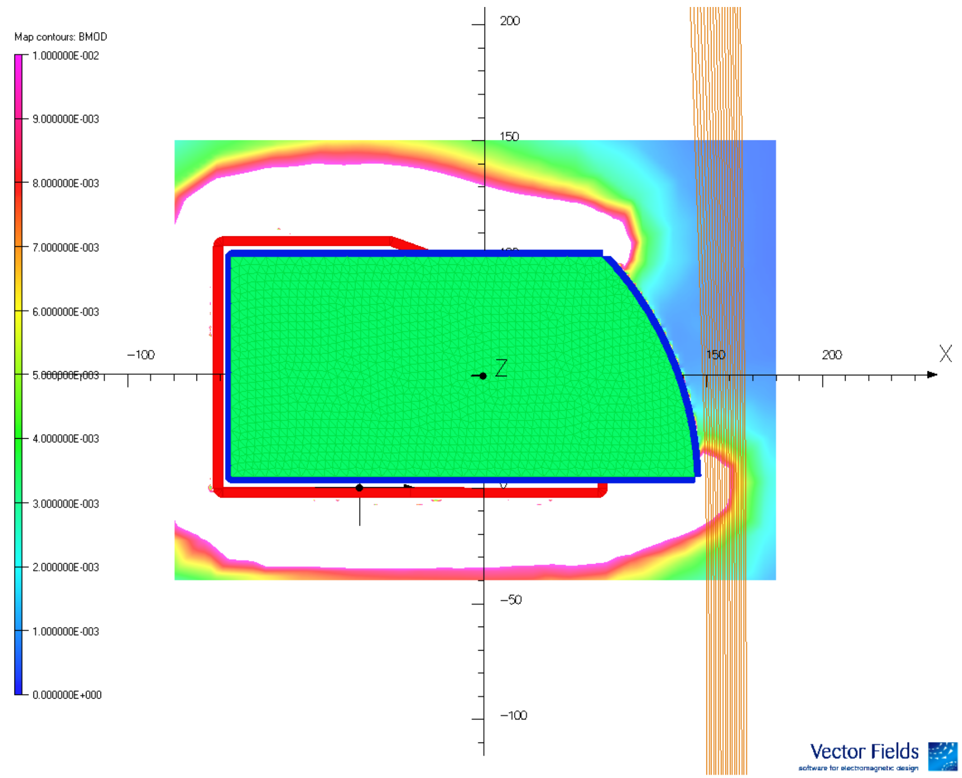
Septum Magnets

- Challenges
  - Large bend: 65–70° in < 15 cm
  - Minimizing stray fields on beam
  - Acceptable field uniformity

Septum



Laminated "steel"
Copper shield
2.5 mm thick
R=145
180
162.5
204.91
100
Coil cross-section:
18x4
X
Y
200
150
100
250
-50
-100



Map contours: BMOD
1.000000E-002
9.000000E-003
8.000000E-003
7.000000E-003
6.000000E-003
5.000000E-003
4.000000E-003
3.000000E-003
2.000000E-003
1.000000E-003
0.000000E+000
200
150
-50
-100
X
Z
Vector Fields

Ion Pumps

- 22 pumps around the ring
- Again, stray fields are a concern
  - Fields potentially as high as a few Gauss
  - Some measurements from manufacturer
    - Direction unknown
- Currently making field measurements

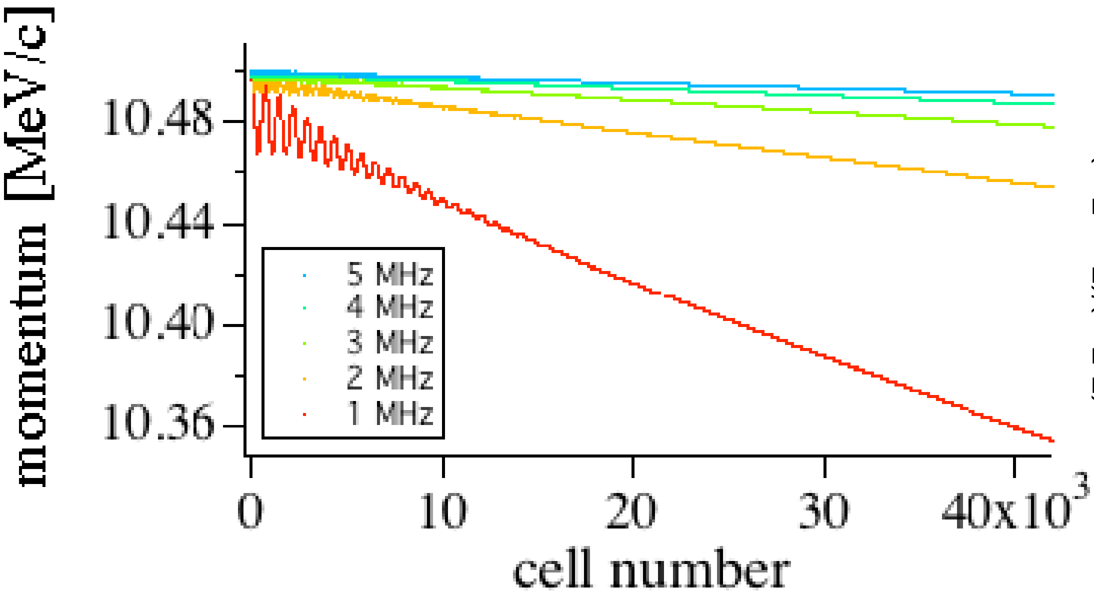
Space Charge & Beam Loading

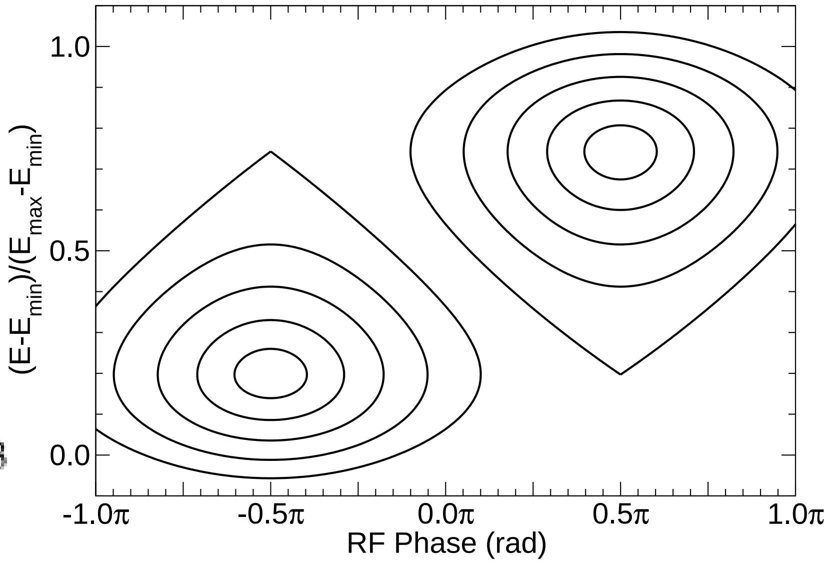
- Don't want collective dynamics confusing single-particle dynamics
- More charge desirable for diagnostics
- Less charge to reduce collective effects
  - Space charge
  - Beam loading
  - Short range wakes and higher order modes
- 2×10^8 seems the best compromise

Commissioning

- Fixed-energy for many turns
  - Find closed orbits
  - Compute tunes, time of flight
- Beam loading and HOMs: energy loss
  - Restore with RF (zero crossing)
  - No RF, mismatch cavity frequency to beam
    - Slow energy loss, acceptable?

Commissioning





Concluding Remarks

- Have a design which
  - Allows extensive study of machine behavior
  - Has extensive diagnostics for these studies
- Have begun procurement for major items
  - Magnets, cavities
- Finishing off designs of all components
- Simulations ongoing
- Will be ready to run in Fall 2009

Acknowledgments

- This is the work of many people in the EMMA Collaboration
- Particular credit goes to the Daresbury Laboratory team
- Particular thanks to Neil Bliss at Daresbury for gathering all the information together for me