EMMA Status

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For the EMMA Collaboration
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FFAGs and a Neutrino Factory

- FFAGs reduce cost and increase efficiency
  - Muon acceleration: more passes through RF
  - Proton driver: avoid ramping magnets
- Muon acceleration: linear non-scaling FFAGs, compared with scaling FFAGs:
  - Smaller aperture: important due to large transverse beam size, superconducting fields
  - Reduced time of flight variation: no time to vary RF frequency

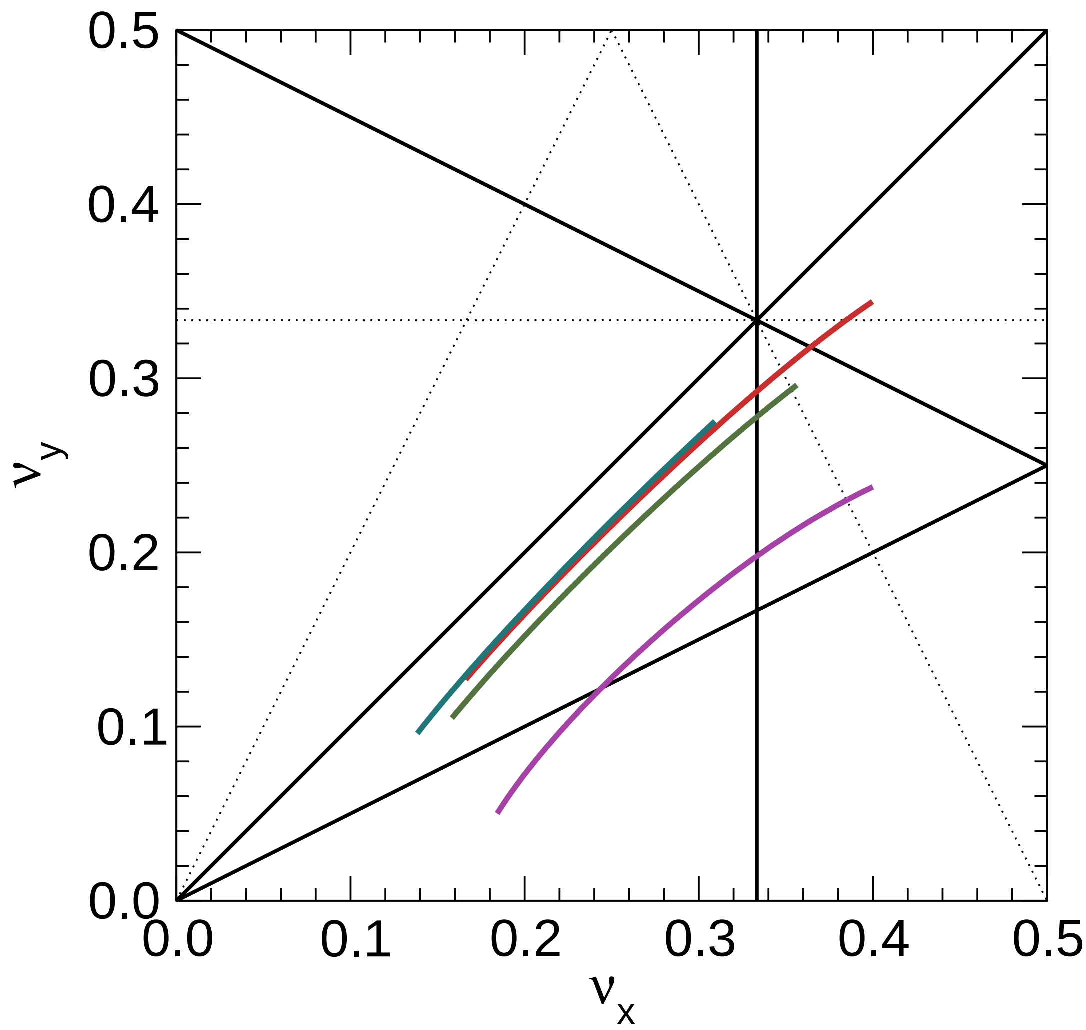
Overview of EMMA

- 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

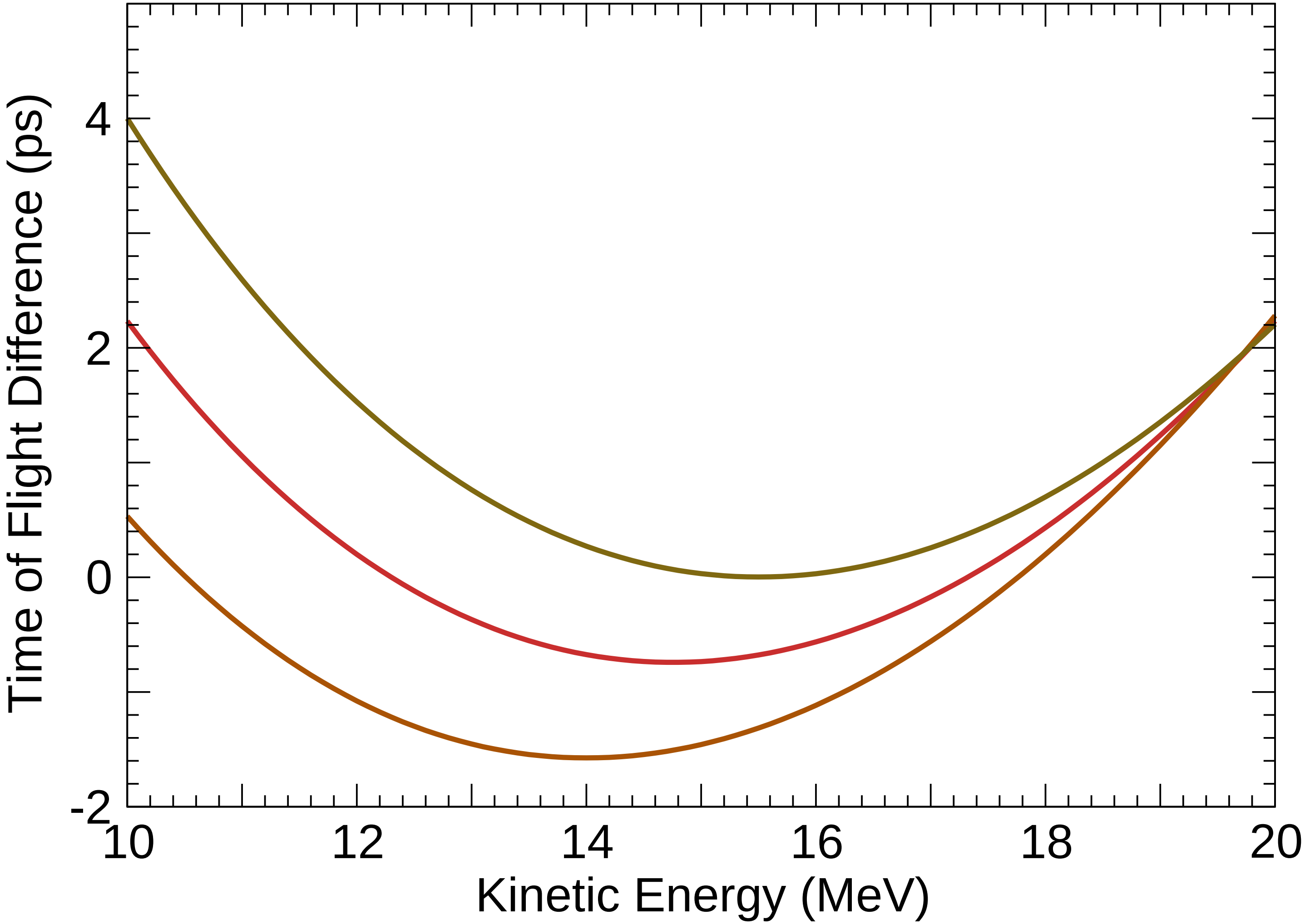
Machine Capabilities

- 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



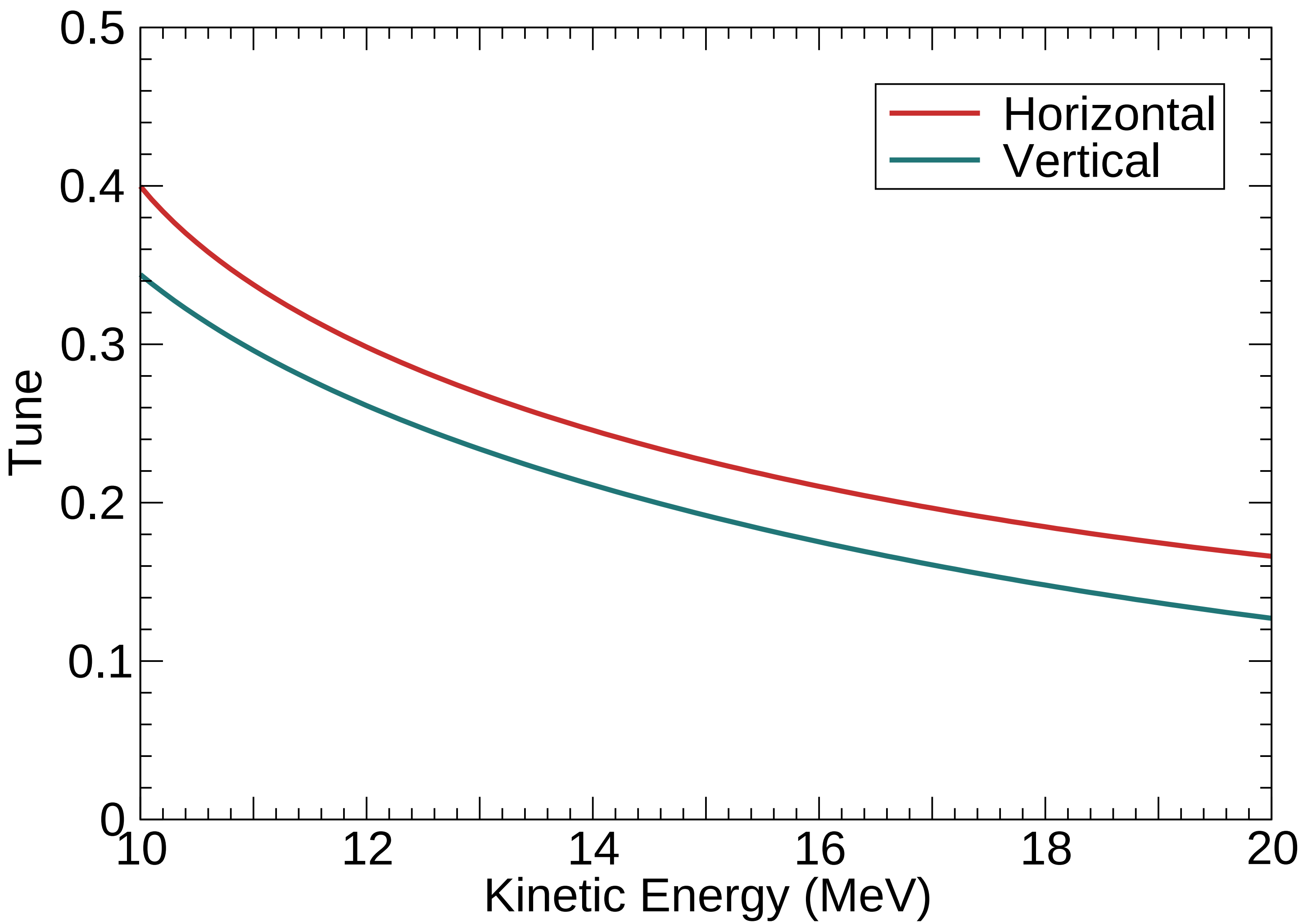
Time of Flight vs. Energy



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

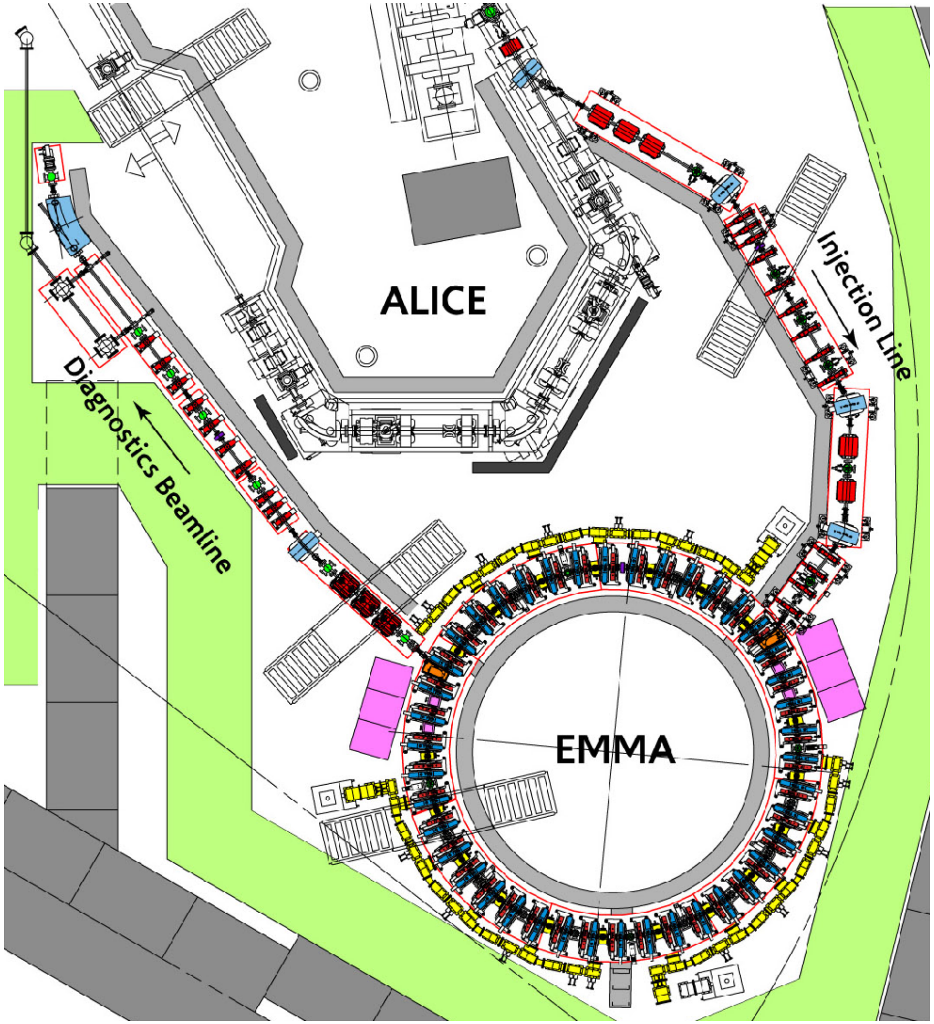
Tune vs. Energy



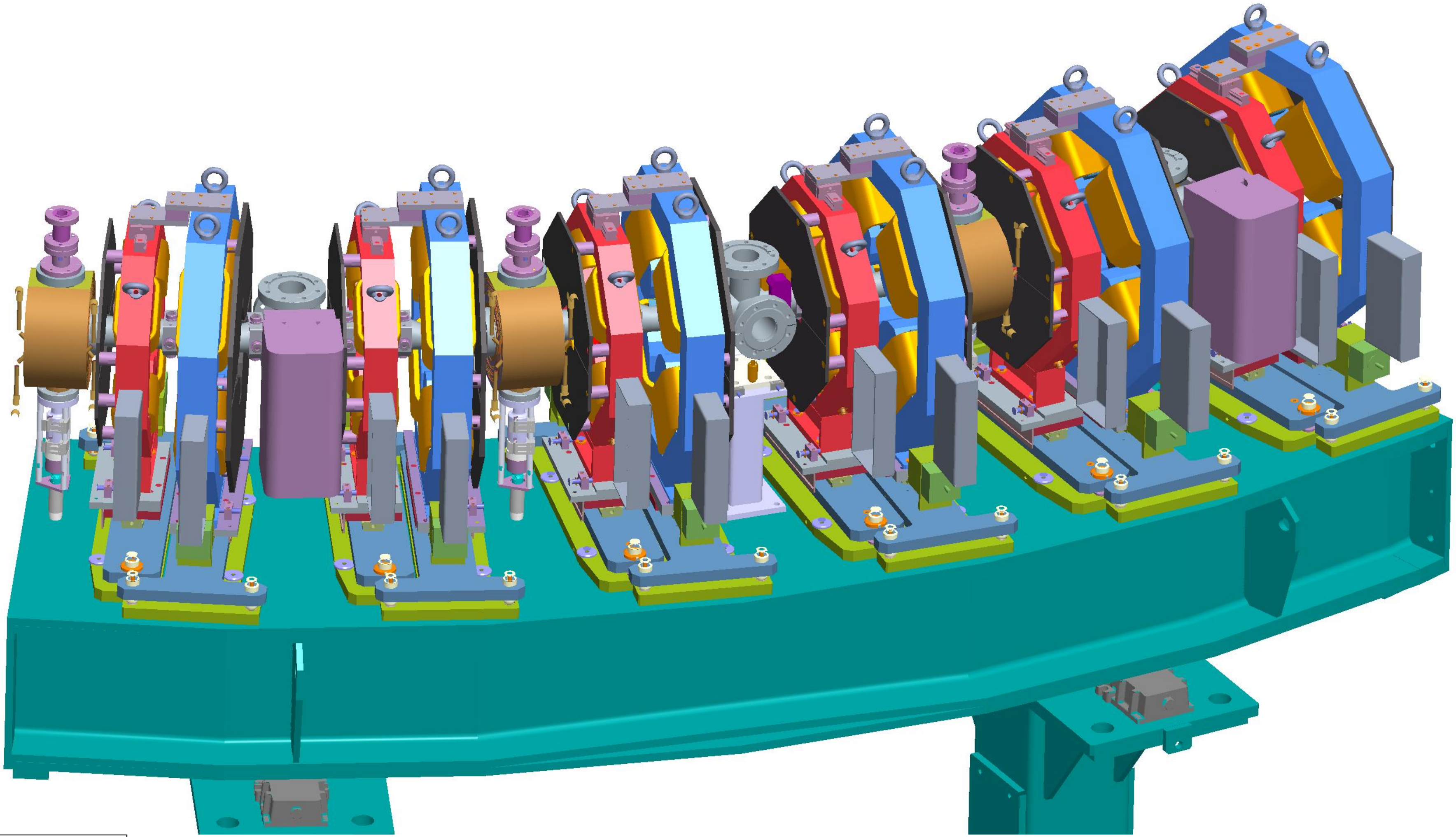
Machine Parameters

- 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

- Prototypes delivered and measured
  - Shimmed D to extend good-field region
  - Clamp plates thickened (saturated)
- Contract placed
  - F poles done
  - Some D’s assembled
  - Clamp plate laminations punched
  - Delivery Jul. 16–Oct. 18

Magnets

RF Cavities

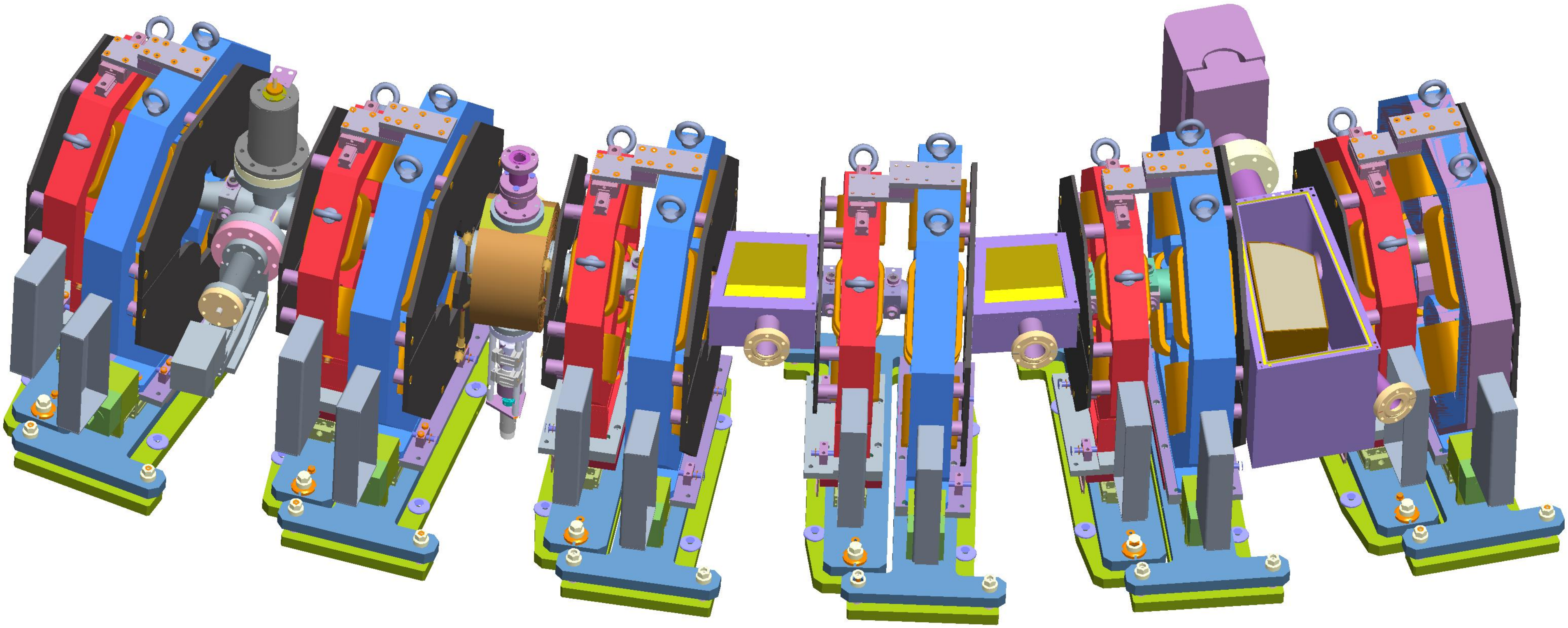
- 1.3 GHz cavities, 5.5 MHz tuning range
- Cavity and associated components designed
- Prototypes delivered and tested
- Machining complete, electron beam welding in progress
- Cavities delivered by 10 September 2008

RF Cavities

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

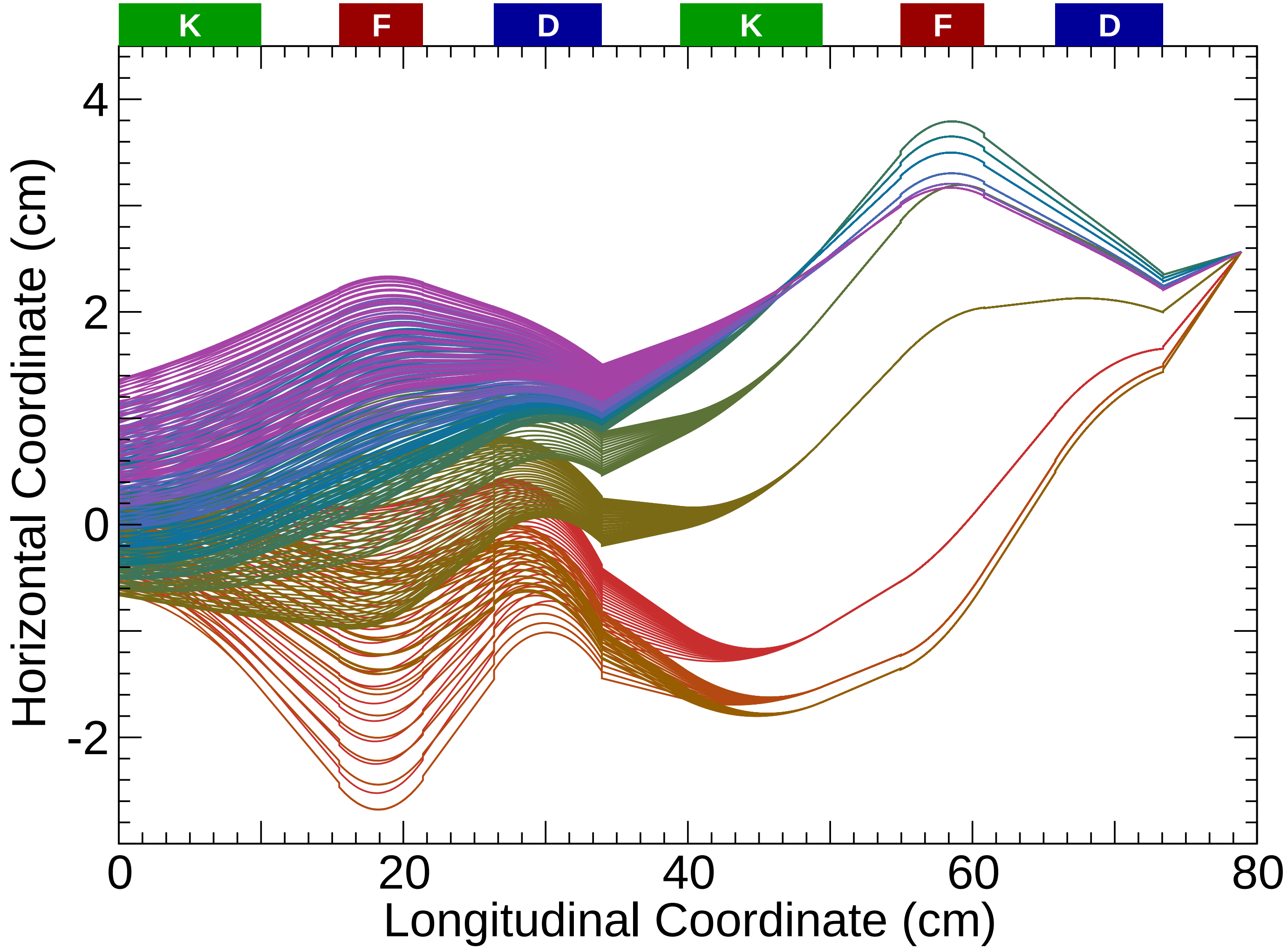
Injection Section



Injection/Extraction

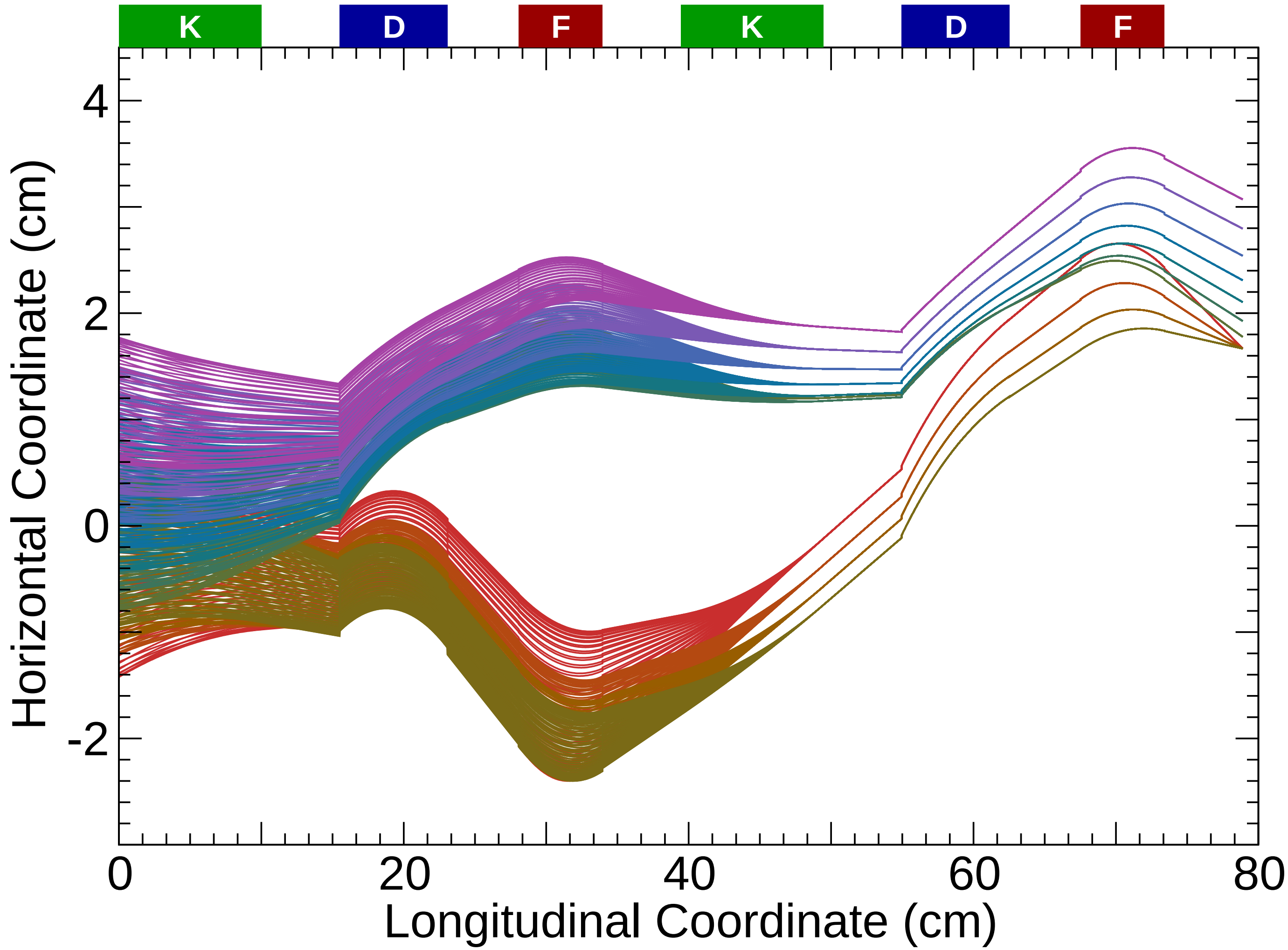
- Doublet not reflection symmetric
- D near septum easier for injection/extraction
  - Larger aperture for F near septum
  - Beam moving right direction at septum
- Choose injection to be easy
  - Find closed orbit parameters for all energies
- Can’t extract low energy unless move septum
  - Can’t move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

Injection



K
F
D
K
F
D
4
2
0
-2
0
20
40
60
80
Horizontal Coordinate (cm)
Longitudinal Coordinate (cm)

Extraction



K
D
F
K
D
F
Horizontal Coordinate (cm)
4
2
0
-2
0
20
40
60
80
Longitudinal Coordinate (cm)

Injection/Extraction Status

- Just finalized beam dynamics
  - Needed to specify hardware parameters
- Working on getting hardware specified
  - Kickers
  - Pulsed power systems
  - Septa
    - Must handle range of incoming beams
- Septa by Nov. 08, kickers & power supplies by Apr. 09

Clamp Plate and Injection

- Clamp plate on D blocks extraction path
- Cut slot in clamp plate
- Ideally do in every plate
  - Symmetry important for lattice
  - Problem: plate laminations already punched
- Studying symmetric slots to maintain same field profile
  - Cut only one plate if successful

Clamp Plate Slot

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

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

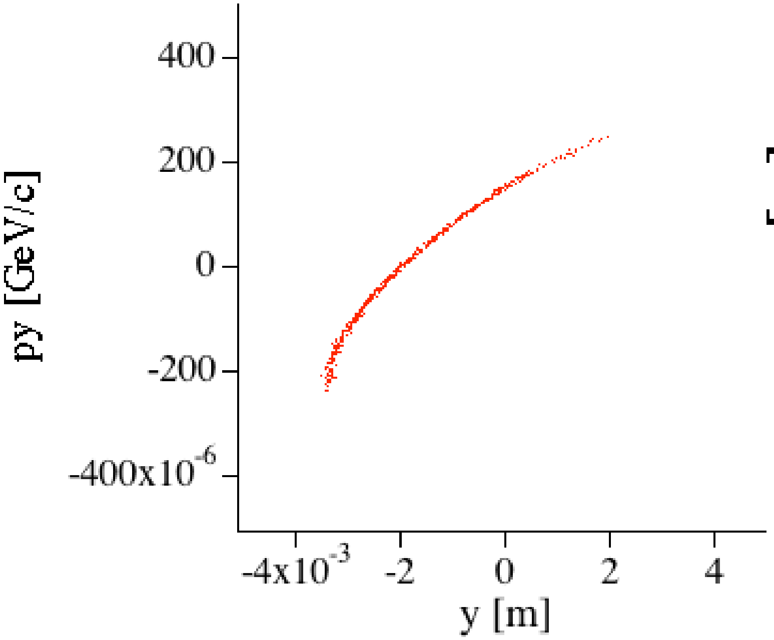
Diagnostics (Extraction) Line

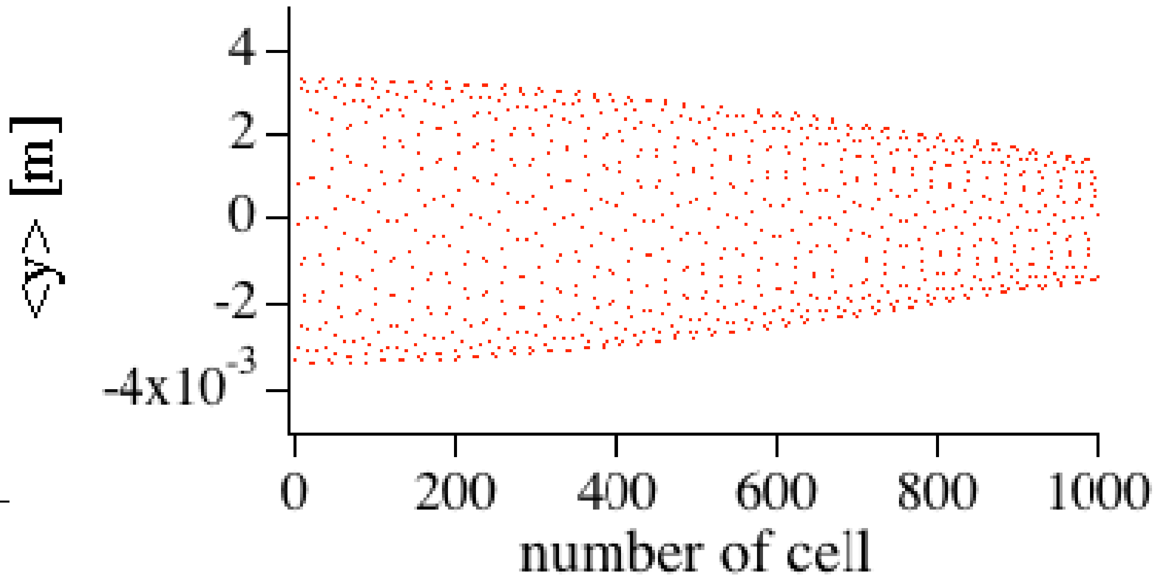
- Planning on two phases (cost)
- Must measure energy!
- Measure transmission (Faraday cup)
- Measure probe transverse emittance
- Measure longitudinal profile
  - Electro-optic monitor
  - Deflecting cavity too expensive

Chromaticity

- Different energies have different tunes
- Beam has nonzero energy spread
- Tune measurement: tune signal decoheres
  - Can still get good tune measurement
  - Complicated by errors, asymmetric BPM placement
- Only part of beam extracted
  - Not necessarily bad: probe details

Chromaticity





Concluding Remarks

- Have a design which
  - Allows extensive study of machine behavior
  - Has extensive diagnostics for these studies
- Have begun procurement for major items
- Finishing off designs of all components
  - Injection/extraction especially important
- 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