MAP Acceleration Status Update: IDS-NF, EMMA, and Fast Ramping Synchrotrons

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MAP Friday Meeting
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Outline

- IDS-NF
  - Updates from plenary meeting
- EMMA experiment
  - Status update
  - Simulation work
- Fast ramping synchotron
  - First minimal look at lattice design

IDS-NF Introduction

- International Design Study for the Neutrino Factory
- Reference design report by end 2012
- Intermediate design report by end 2010 (!)
  - Includes full design for baseline
  - Rough engineering and costing
- Plenary meeting in April
  - Main goal: make baseline choices

IDS-NF Acceleration

- Four stages
  - Linac to 0.9 GeV
  - Two RLAs to 12.6 GeV
  - Linear non-scaling FFAG to 25 GeV
- Designs for first three stages well-established

IDS-NF: Low-Energy Acceleration Progress

- Some magnet engineering is being done
- Linac simulated in different tracking codes
  - Using field maps
- Matching to cooling channel

IDS-NF: Low-Energy Acceleration Alternatives

- Replacing linac solenoids with quadrupoles
  - Appears to have a cost advantage (based on model)
  - Won't work at start: transverse beam size
  - Gain likely modest: cost dominated by RF
- Scaling FFAG to 3.6 GeV to 12.6 GeV
  - Accelerate in 6 turns, 1.8 GV of RF
  - About 1 km circumference
  - Superconducting magnets (≥ 4 T)

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IDS-NF: FFAG

- Chose basic lattice cell
  - Triplet with 3 m drifts
    - Longer drift: injection/extraction easier
  - Two-cell RF cavities
    - Faster acceleration, reduced effect of time of flight dependence on transverse amplitude
    - Modest cost penalty over shorter drifts with single RF cell

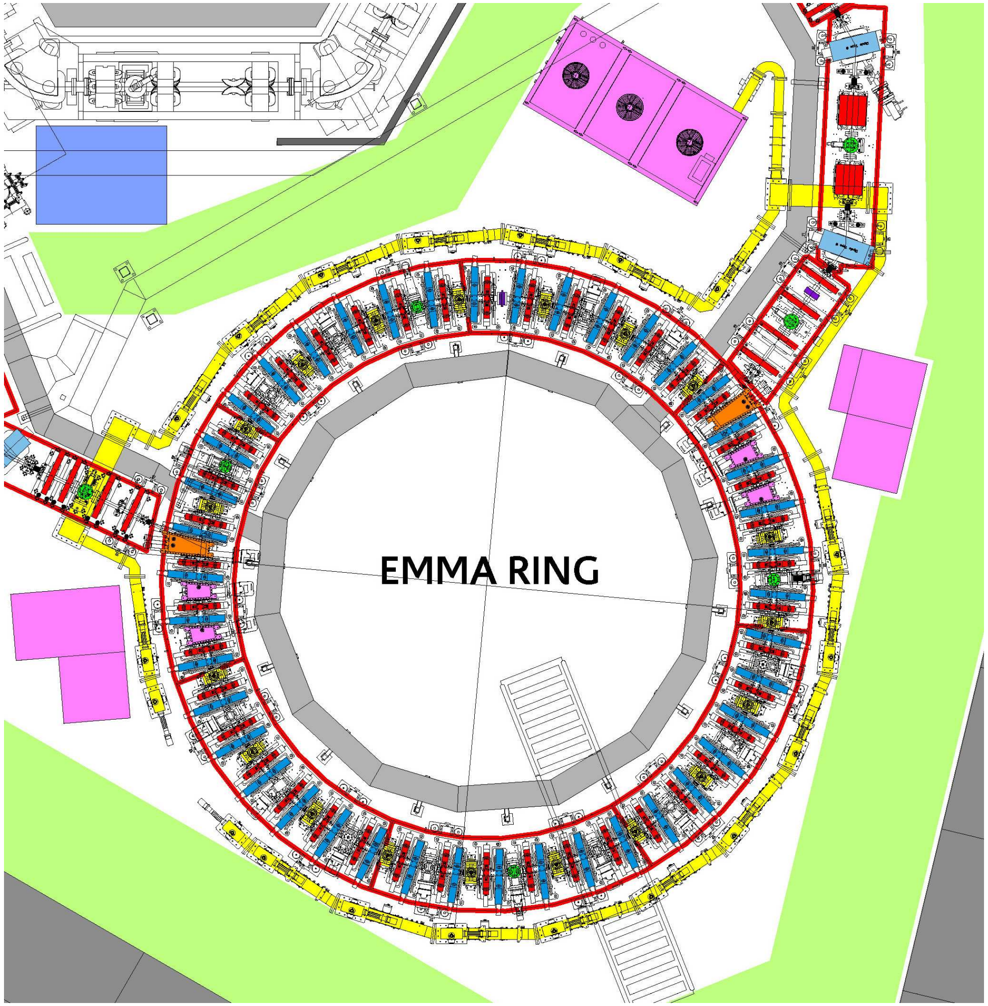
IDS-NF: Beam Loading

- Bunch structure: 3 trains in rapid succession
- Need time between trains to top off cavities
- FFAG has most passes through cavities
- Minimum 80 μs spacing between trains
  - 12 passes through cavities
  - 1 MW power input to cavities
- Important for proton driver design

EMMA Experiment Introduction

- Study beam dynamics in linear non-scaling FFAG
- Accelerate electrons from 10 to 20 MeV
    - Inject and extract anywhere in this range
- 16.6 m circumference
- At Daresbury Laboratory (UK)

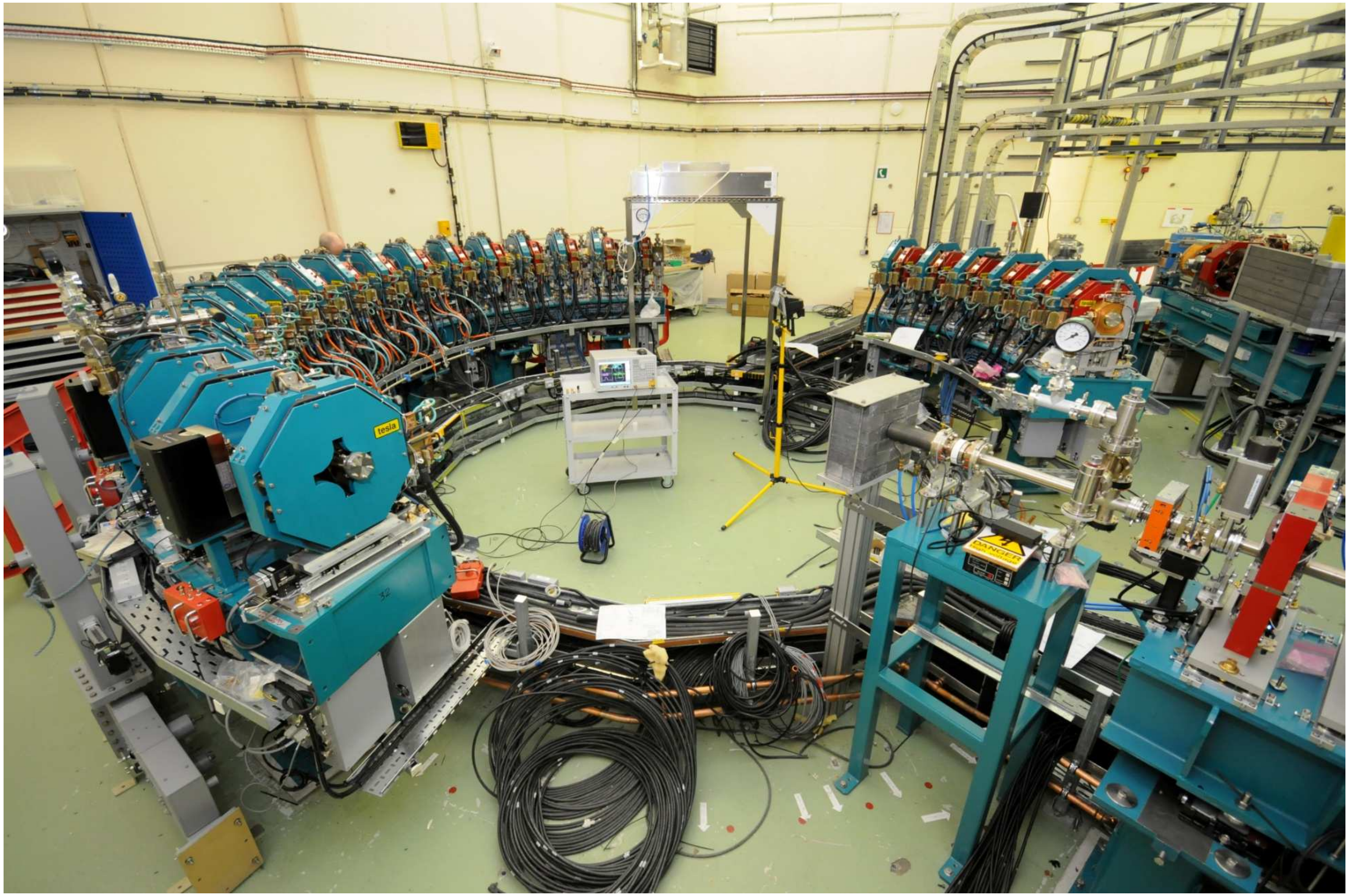
EMMA Experiment
Ring Layout



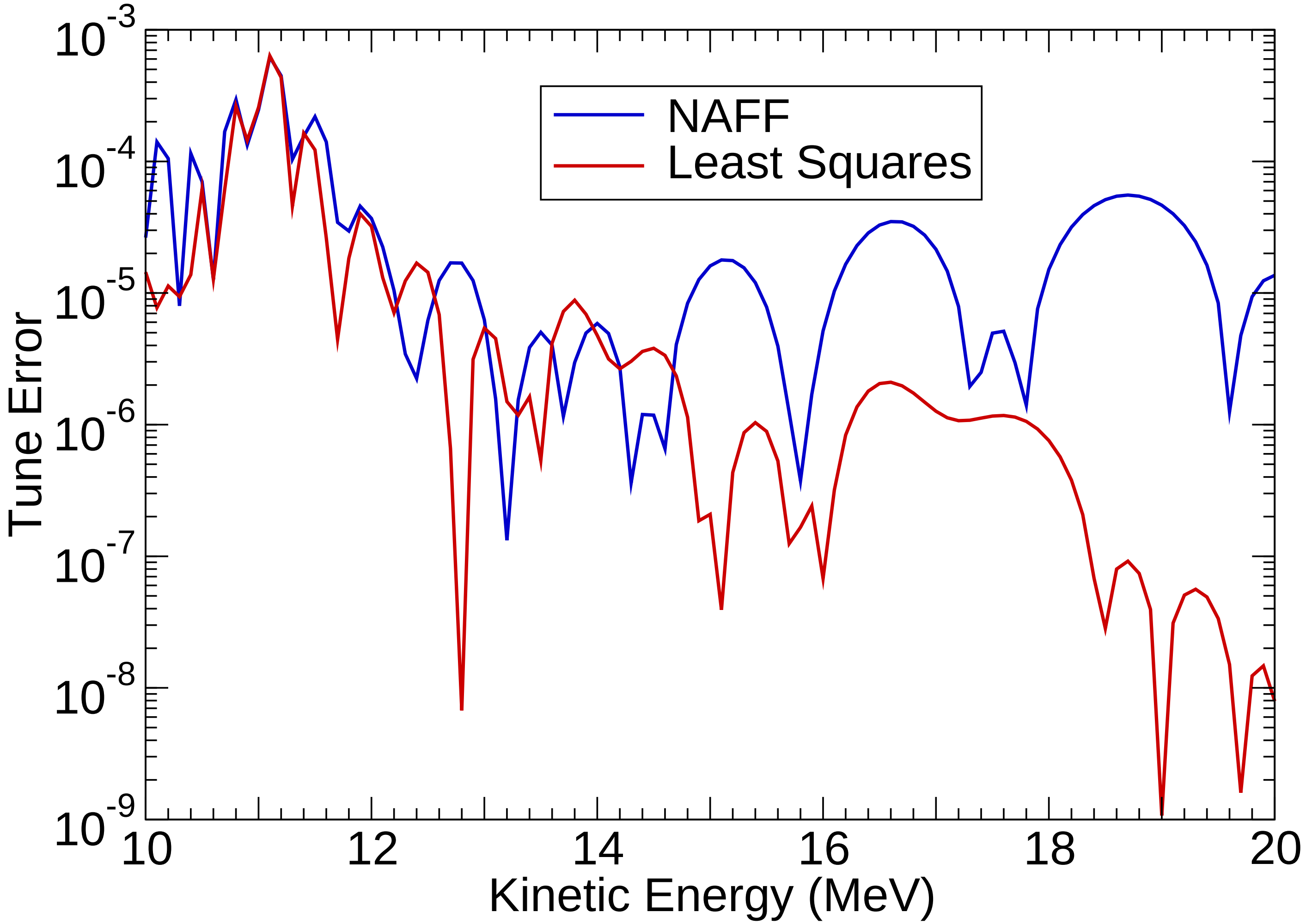
EMMA Experiment Status

- Currently under construction
- To get started earlier, put beam into 4/7 of ring (mid-June)
  - Injection
  - Single cell symmetry: approximately measure closed orbit, tunes, time of flight
  - Tune up main lattice parameters
  - Maybe some other experiments
- Algorithms for measurements from limited data

EMMA Experiment Construction



EMMA Experiment
Tune Measurement Algorithms



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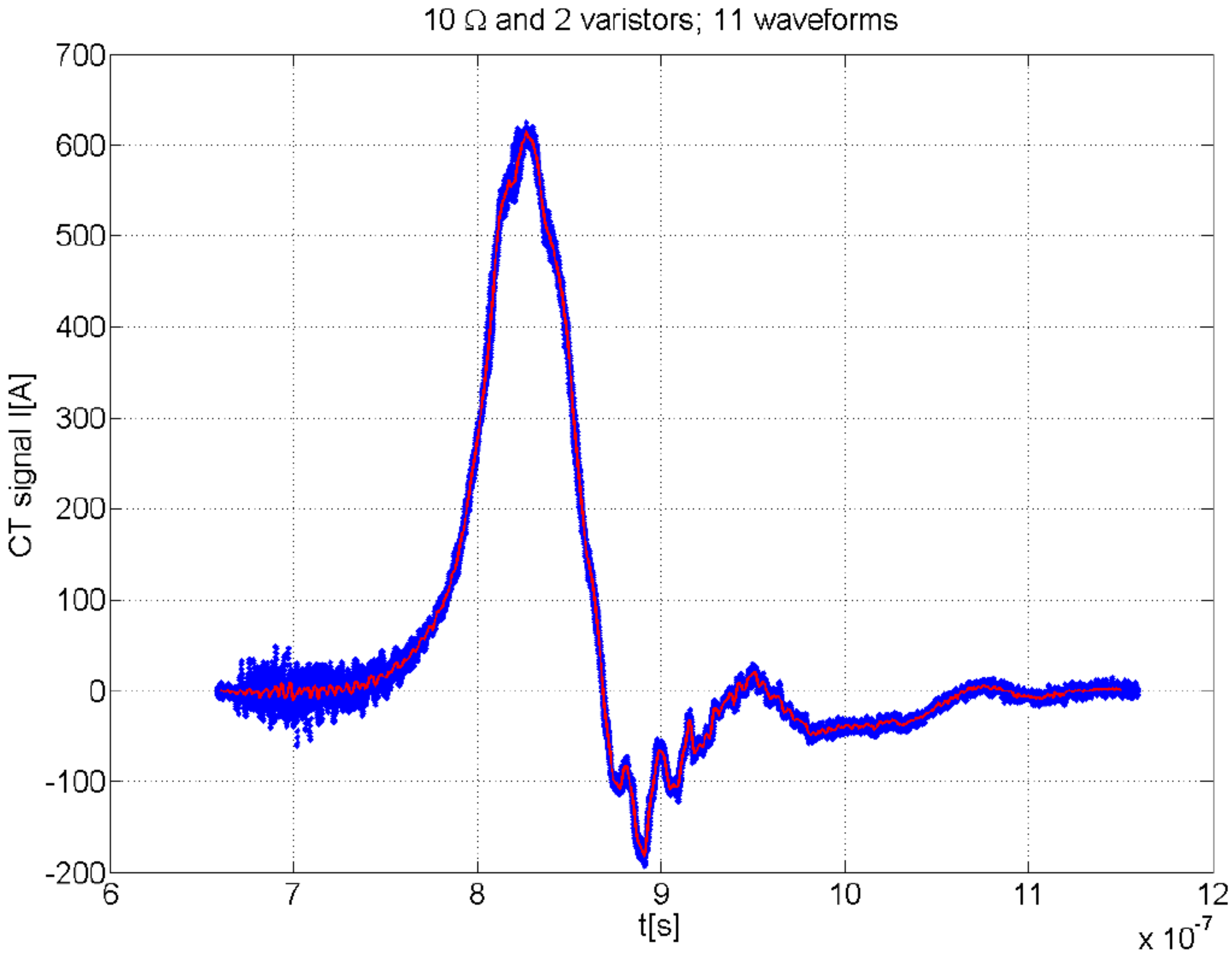
EMMA Experiment Injection Kickers

- Biggest challenge: injection kicker system
- Pulse fall time not as short as we'd like
- Significant ringing after pulse
- Current solution: two-kick injection
  - Beam placed on closed orbit on second pass
  - Tricky with acceleration, chromaticity

EMMA Experiment Injection Pulse



Hybrid Fast-Ramping Synchrotron: Overview

- Accelerate to highest energy with fast-ramping synchrotron
- Good efficiency: many passes through cavities
- Maintain high average field: hybrid
  - 8 T superconducting magnets
  - Ramping dipoles from -1.8 T to +1.8 T
  - Quadrupoles ramp also
- Keep beam synchronized with RF

Fast Ramping Synchrotron Lattice Design

- Start with Don's hybrid FODO lattice
- Momentum range 400–937 GeV
- 103 cells, 2π km circumference

Fast Ramping Synchrotron Lattice Constraints

- Define reference momentum: zero field in ramping dipoles
- Tunes same as tunes at reference momentum
  - Assumed linear quad ramp from Don's values to get reference tune
- Time of flight same as reference
- All ramping dipoles have same fields
- Ramping quads independent

Fast Ramping Synchrotron Results

- Closed orbit excursion at F quad: -25 +8 mm
- Even less in D
- Fields vs. momentum indistinguishable by eye from linear fit
- No straights for cavities, etc.

Fast Ramping Synchrotron Next Steps

- Pick momentum range, max at 750 GeV
- Add straight sections for RF, etc.
  - Can closed orbit motion be suppressed in straights?
    - Maintaining time of flight is the challenge