Commissioning of the EMMA non-scaling FFAG

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Outline

One small problem..........

• Introduction
• Motivation for EMMA
• EMMA design
• Status of construction
• Status of commissioning
• Next steps
• Conclusions
Introduction

- Linear non-scaling FFAGs:
  - invented 1997/9
  - for muon acceleration in a Neutrino Factory

\[ B = B_0 \left( 1 + \frac{k}{r} \right) \]
Introduction

- **Linear non-scaling FFAGs:**
  - invented 1997/9
  - for muon acceleration in a Neutrino Factory
  - large dynamic aperture
  - small orbit excursion – higher frequency RF
  - CW acceleration

\[ B = B_0 \left( 1 + \frac{k}{r_0} r \right) \]
Introduction

Serpentine, bucketless, asynchronous, etc acceleration

Fast resonance crossings
Motivation for EMMA

- Realised early on:
  - Other potential applications:
    - hadron therapy
    - ADSR
    - other high power proton beam applications
  - One or two issues:
    - tiny momentum compaction
    - unique longitudinal dynamics
    - possible transverse dynamics problems
    - resonance crossings
    - constraints on construction
    - standard tracking codes not applicable
    - purpose built codes need benchmarking
- Must build one!
- Hence, EMMA
EMMA Design

- Simplest to build linear non-scaling machine
- Main parameters taken from muon accelerator:
  - electrons, 10-20MeV
  - linear magnets, cw RF
  - 42 cells, doublet lattice
- In addition
  - very flexible
  - injection into full muon acceptance
  - lots of diagnostics
  - need flexible (10-20 MeV) injector with hall space
  - small
  - not too expensive!
EMMA Location
EMMA Specifications

- Driven by experimental nature
- 8 lattices to explore long. & trans. dynamics

Requires:
- indep. dipole & quadrupole fields
- sufficient magnet aperture
- RF frequency: -4.0 to 1.5MHz
- RF gain: ~20kV to 180kV/cavity
EMMA Design

42 “identical” cells, ~40cm long
Ring ~16.5m circumference
Very compact!
7 girders
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Status of Construction

EMMA ring
EMMA diagnostics beam line
Alice ring
EMMA injection line
Alice injection line
Injection line

Transport beam to EMMA.
Matching.
Measure beam parameters on entry to EMMA.

Completed ~2 months.
Beam transported to end.
First measurements made.

MOPEC046
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MOPEC046
**Injection & Extraction**

**Requirements**

- **Injection of:**
  - all 8 lattices
  - all energies between 10 and 20 MeV
  - into $3\pi$ m mrad

- **Minimal impact on next turn:**
  - leakage field from septum < 0.01%
  - kickers off before 55ns (<1% ripples)

- **Slot length:** ~10cm
Injection & Extraction
• 42 cells mounted on 7 girders:
YAG screen
“Destructive” diagnostic devices.
Beam can be extracted at any energy for measurement
Commissioning Status

Stages in commissioning

• ALICE:
  - settings required for EMMA
  - beam parameter measurements
    • Started

• Injection line:
  - transmission of beam
  - diagnostics commissioning
    • Started

• 4 sector commissioning:
  - injection & setting beam on orbit
  - check lattice(s)
  - tune measurements
    • Very soon!

• Full ring

• Extraction and external beam measurements
First emittance measurement. See THPD028
Conclusions

- EMMA is the proof-of-principle non-scaling FFAG
- Construction has been a challenge
  - novel machine
  - very compact: “...everything takes 5 times longer in EMMA...”, Neil Bliss, project manager
- Construction of ring is almost complete
- Commissioning has started
- Commissioning of ring will start soon