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A proposal of integer tune crossing experiment with PT

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on behalf of IB group
ASTeC/STFC Rutherford Appleton Laboratory
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Background (1)

- "Beyond EMMA" talk at the FFAG'11 last year, I defined the two area of FFAG developments.

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Two main area (in accelerator physics)

- Novel scheme of single particle optics: "Novel"
  - Non-scaling FFAG
  - Grahame's lattice
  - "Advanced" FFAG
  - *Not good time to start new project (at least in the UK).*
- Collective effects due to multi particle: "Collective"
  - Single and multi bunch space charge
  - Interaction with chamber and neighboring beams
  - *Can be done with existing accelerators with relatively less funding.*

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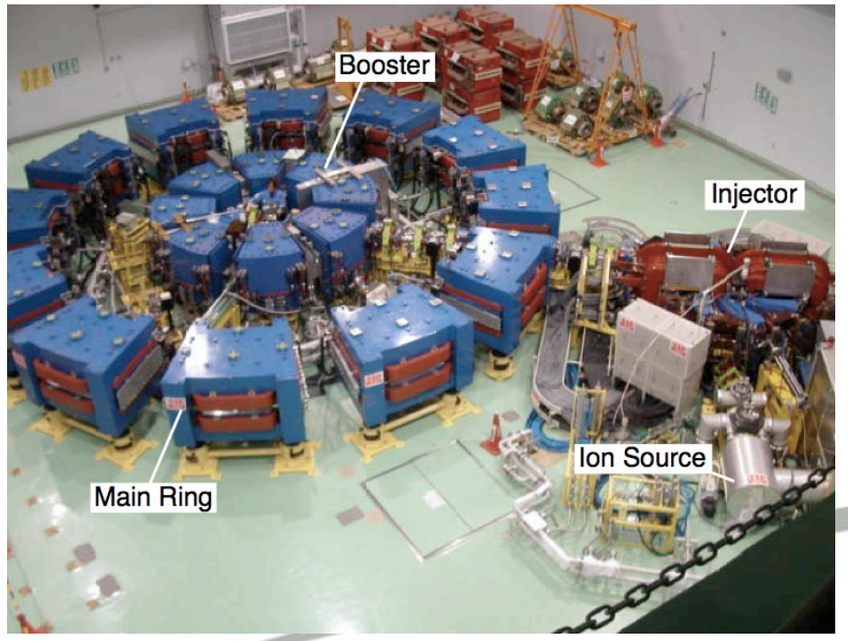
Background (2)

- Fortunately, for the area of “collective” effects in FFAG, we have started KURRI-FFAG collaboration.
- The main purpose is to study space charge and ionisation cooling in the FFAGs experimentally.
- More detailed discussion will be on Thursday afternoon.



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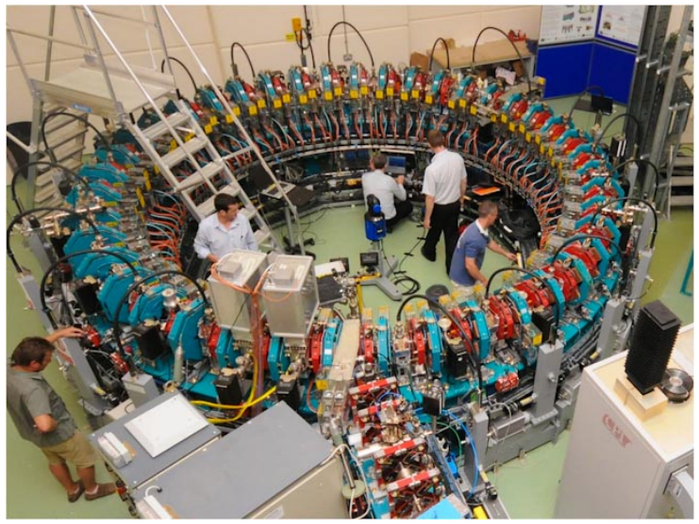
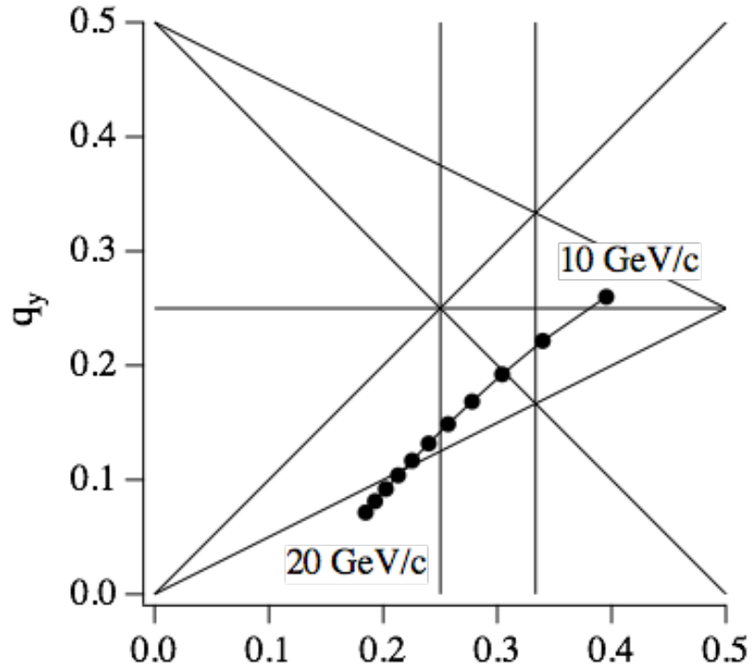


Background (3)

- Unfortunately, the EMMA project is now toward the end.
- It is not a good time to start a new project or even extend the EMMA project.
- We may not fully explore the effects on the beam quality when a beam crosses integer tunes.
- That is one of the most crucial issues in a non-scaling FFAG, especially when applications to proton are considered.

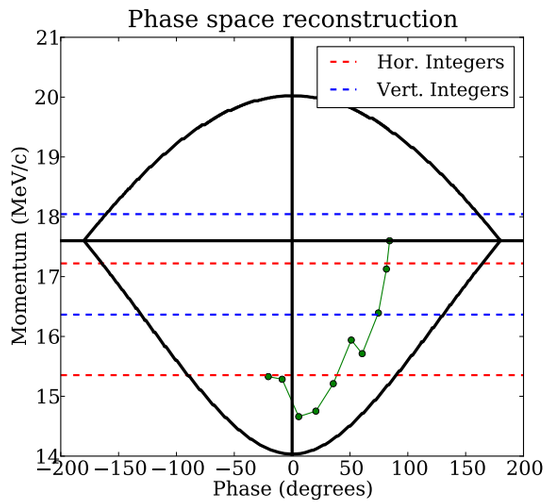
Resonance (integer tune) crossing (1)



- Linear non-scaling FFAG goes through a few integer tunes during acceleration.
- Crossing speed is very fast for muon acceleration so that it should not affect the beam quality.
- It is a crucial question how the beam quality is affected by slower crossing.

Resonance (integer tune) crossing (2)

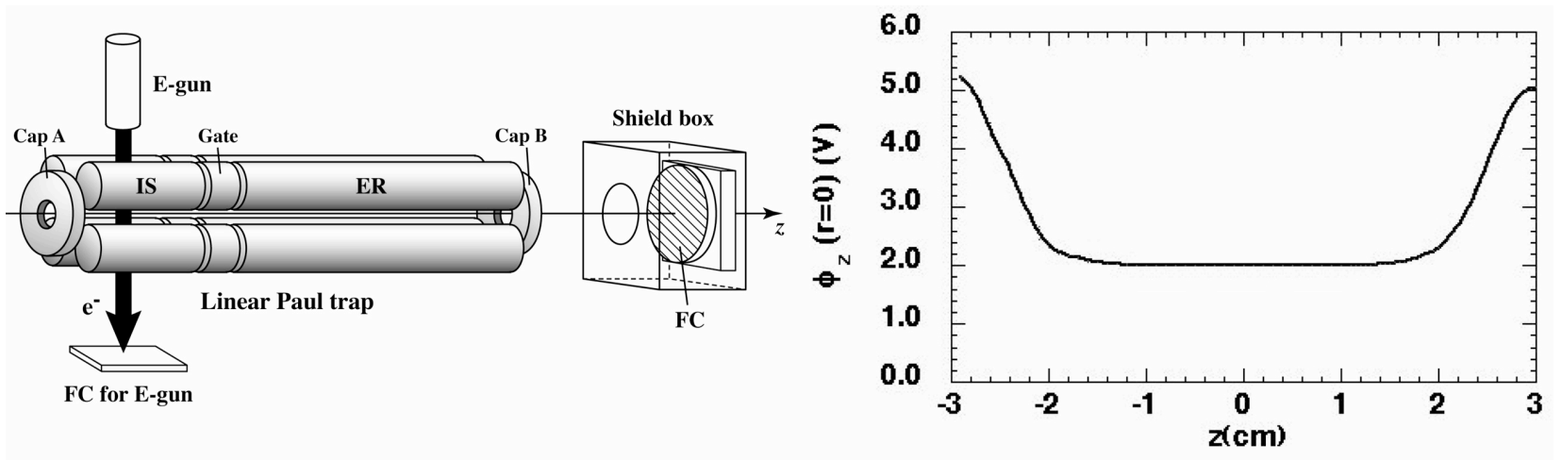
- Garland's thesis project is to measure the beam quality in EMMA when a beam goes through an integer tune with different speed (ref. IPAC12 proc).
- A beam is captured in a rf bucket. Adjust the location of rf bucket such that transverse tune becomes an integer at some momentum during synchrotron oscillation.
- David will show more details.



- Crossing speed is limited by rf. 2 MV > V_rf > 0.2 MV.
- Syn oscillation frequency is proportional to sqrt[V].

Resonance (integer tune) crossing (3)

- Hiroshima group established a novel way to simulate beam dynamics with Paul Trap (PT).
  - Published paper early this year deals with crossing of resonances primarily due to space charge (ref. PRST-AB 15, 074201, 2012).
  - Dipole errors were not included. But now they do.
- PT may easily simulate the integer tune crossing for much wider range of parameters. Suzie will give more details.



Outline plan

- First, assume space charge is negligible.
- Assume main driving force is dipole kicks by misalignment and field error.
- Assess how the beam deteriorates as a function of
  - crossing speed.
  - magnitude of dipole kicks.
- Take a set of parameters similar to EMMA and “calibrate” the two experiments. Then explore wider parameter space.
- Investigate how the space charge alters the results.
- Publish a paper!

EMMA beam (1)
strength of source

- Observations suggest the main cause of horizontal COD is a leakage field of septum magnet.
- The estimated strength is 0.0006 [Tm] or 15 [mrad].

EMMA beam (2)
crossing speed

- For muon acceleration, dQ/dT=1, where Q is the total tune of 42 double EMMA cell and T is turn.
- Dedicated experiment by Garland is looking at the crossing speed around dQ/dT=1.0~0.2.

Parameter range in PT experiment

- First try to use similar parameters as EMMA.
  - single dipole kick of 0.015 [mrad] in 42 symmetry lattice.
  - dQ/dT=1.0 ~ 0.2.
- Next step is to reduce dQ/dT taking strength of dipole kick as a fixed parameter.

Diagnostics
to be discussed

- PT only gives beam intensity, not beam size.
- Is there any way to observe beam size?
  - screen on one end of the PT.
  - beam loss measurement with variable collimator.
- Or without beam size measurement, how can we quantify the beam quality?

Simulation

- Two possibilities
  - Use EMMA lattice.
  - Use simple FODO lattice.

Commitment and time scale
to be discussed

- Hopefully, one or two staff from ASTeC can join the experiment at Hiroshima Univ. for a week or so.
- Simulation work in parallel at home institute.
- The whole project will be completed within a couple of years.