FFAG dynamic aperture study

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Motivation

- Simulation results from the previous meetings indicate dynamics aperture depends how one models the lattice.
  - Estimate of dynamics aperture requires accurate field profile for large amplitude oscillations.
  - Higher order multipoles (artificially) introduced by field map may increase or decrease dynamics aperture.

- It may depends on the algorithm to integrate particle trajectory.

- We need **a reliable tool to calculate dynamic aperture for designing a future FFAG accelerator facility** (e.g. ISIS upgrade).

- Similar study has been done with KEK PoP FFAG. However field index k was relatively small, ~2.5

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KURRI FFAG Simulation Plan

KURRI FFAG Simulation Plan – second draft
S. L. Sheehy 27/9/14
A. Adelmann 28/9/14
A. Adelmann, F. Méot, M. Haj Tahar & N. Tsoupas   29/9/14
S. L. Sheehy, S. Machida, 01/10/2014
S. Machida, 01/10/14
S. Machida, 27/10/14
S. L. Sheehy 3/12/14

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Simulation and experiment

- As one of benchmark efforts, this has been included already.
  - We just need a common set of parameters.
  - The lattice with field map and hardedge including simplified fringe field model.

- Experimentally, we think we know the way to inject the beam at the phase space centre. Can we systematically scan the orbit to measure the aperture at least in horizontal direction?

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Lattice with fieldmap

Vertical amplitude is restricted by field map (+/- 10 mm). It cannot go beyond 3 pi mm mrad (normalised).

vert amplitude [pi mm mrad]	cell tune	ring tune	hori aperture [pi mm mrad]
0	0.307 / 0.111	3.679 / 1.335	600
1	same above	same above	550
2	same above	same above	550
3	same above	same above	550

At injection energy for 10,000 turns.

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FFAG lattice parameters

Modelling with Simpsons-FFAG (1)
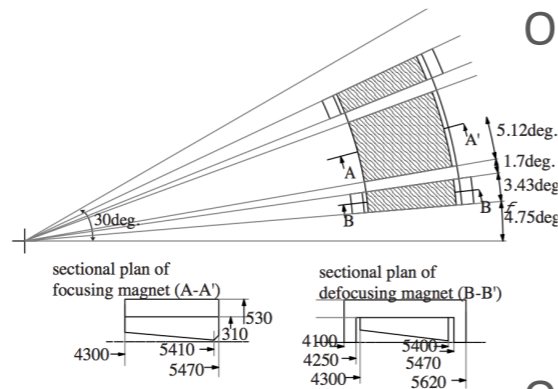
Orbit

Aiba et al, EPAC2002

T_{rev} = 636 ns or
f_{rf} = 1.573 MHz (h = 1)
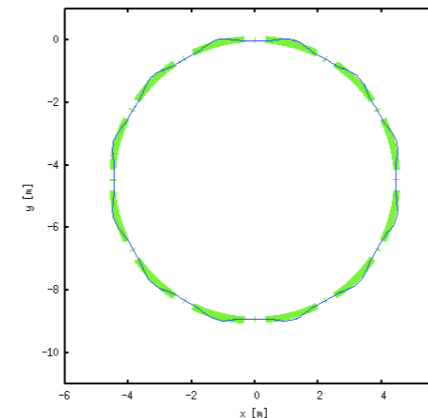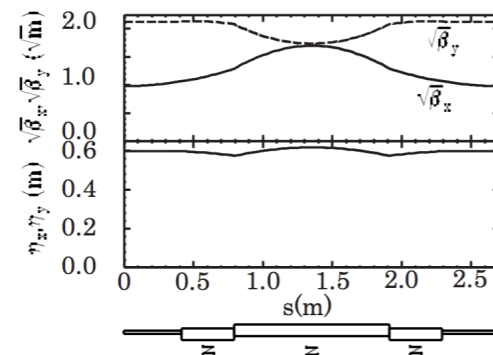
Optics

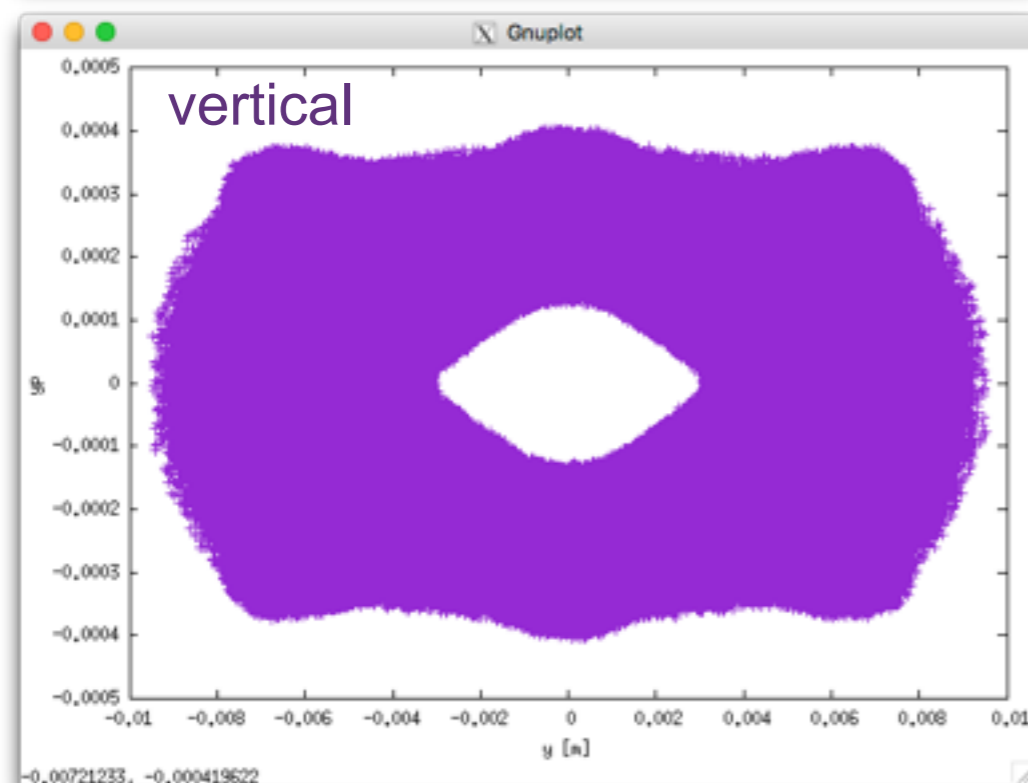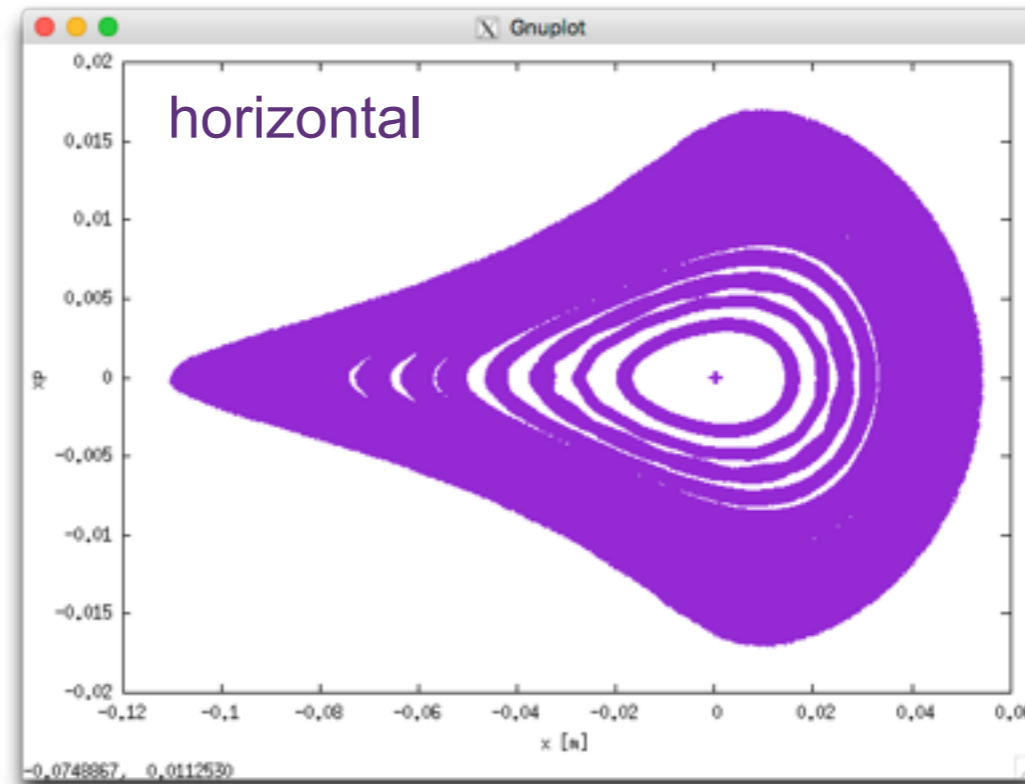(Q_x, Q_y) = (3.720, 1.189)
with Enge fringe (g=0.5 deg)

Red: beta_x
Green: beta_y
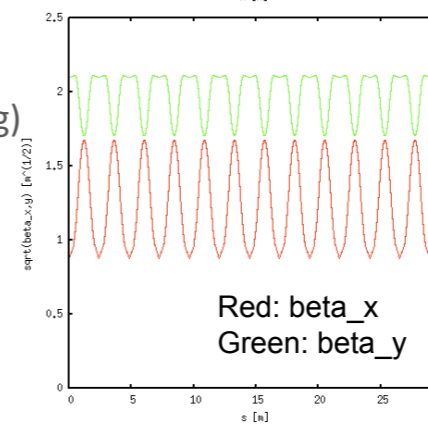
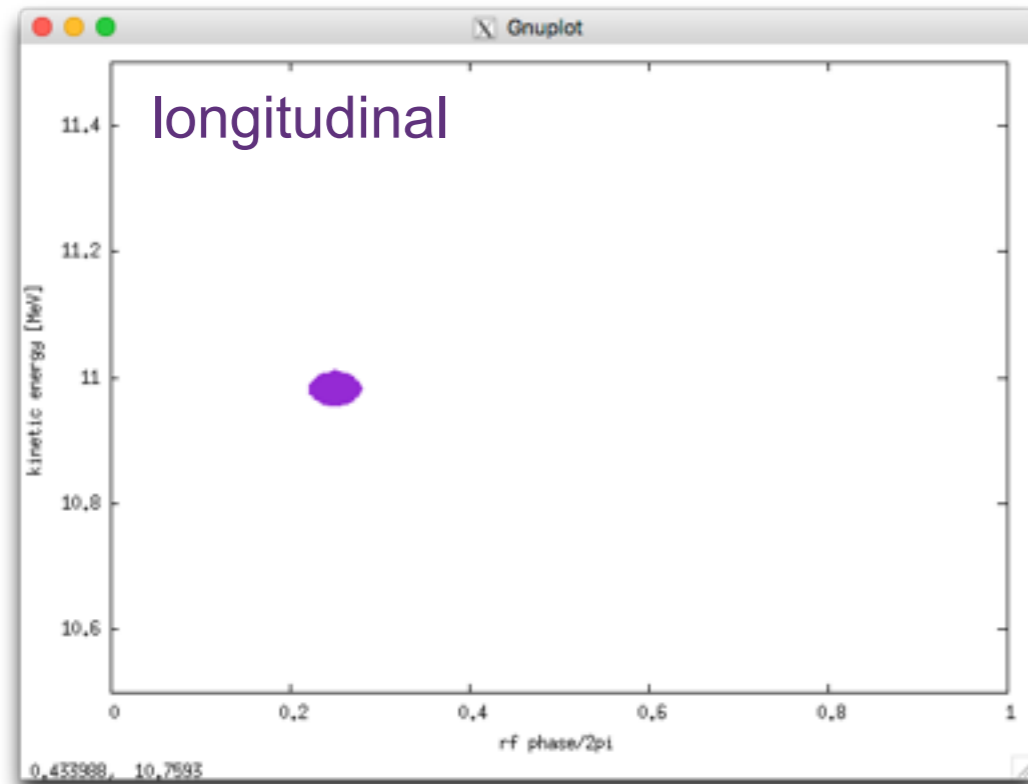7

- Vertical maximum beta function is about 4.4 m.
- 1 pi mm mrad (normalised) beam size is

Sqrt[beta * emit / (bg)] = ~ 5 mm

When vertical amplitude is 3 pi mm mrad (fixed) and search horizontal aperture until a particle is lost.

longitudinal

horizontal

vertical

- Horizontal aperture is limited by 3qx=1.

- There is not much dependence of vertical amplitude.

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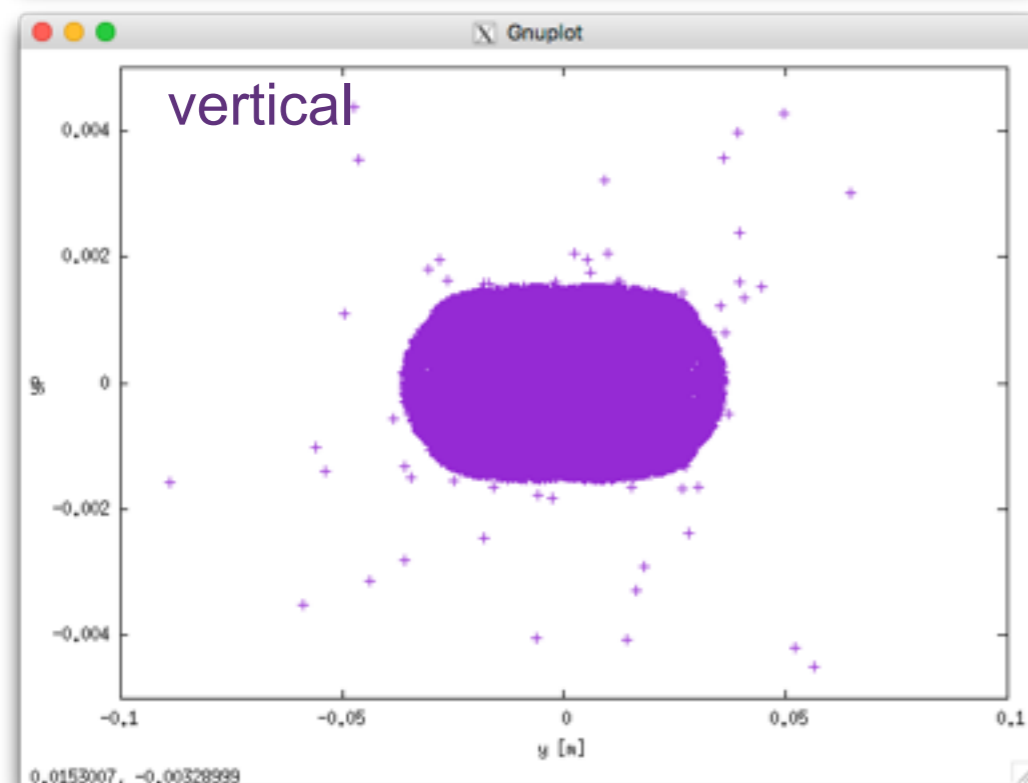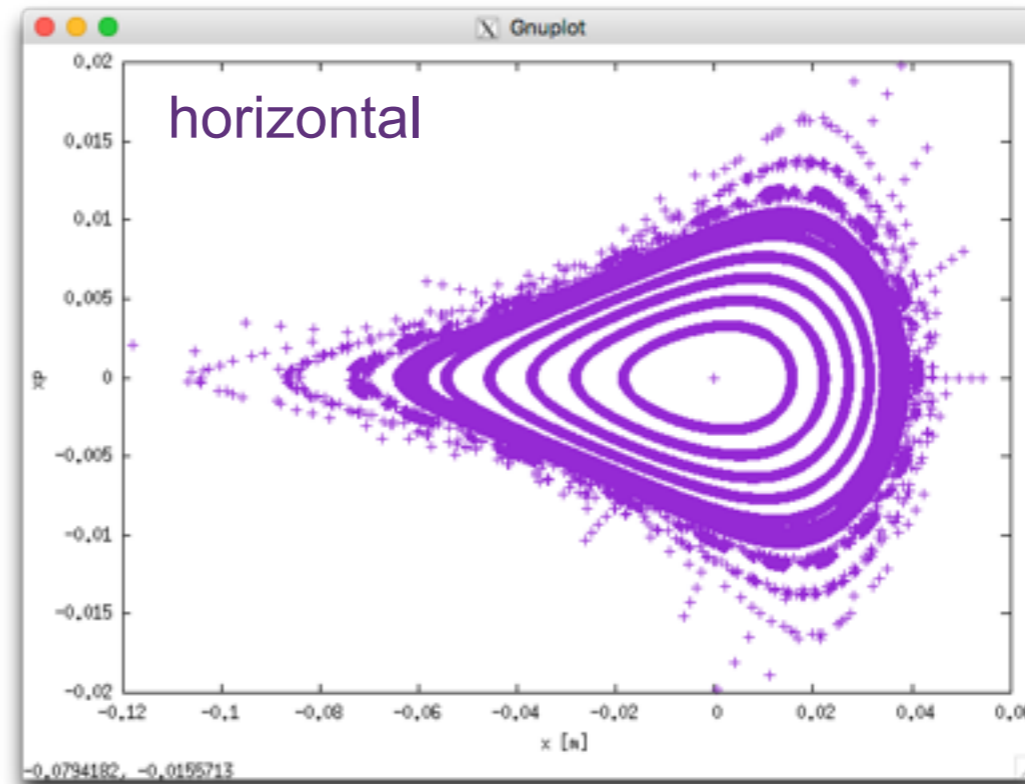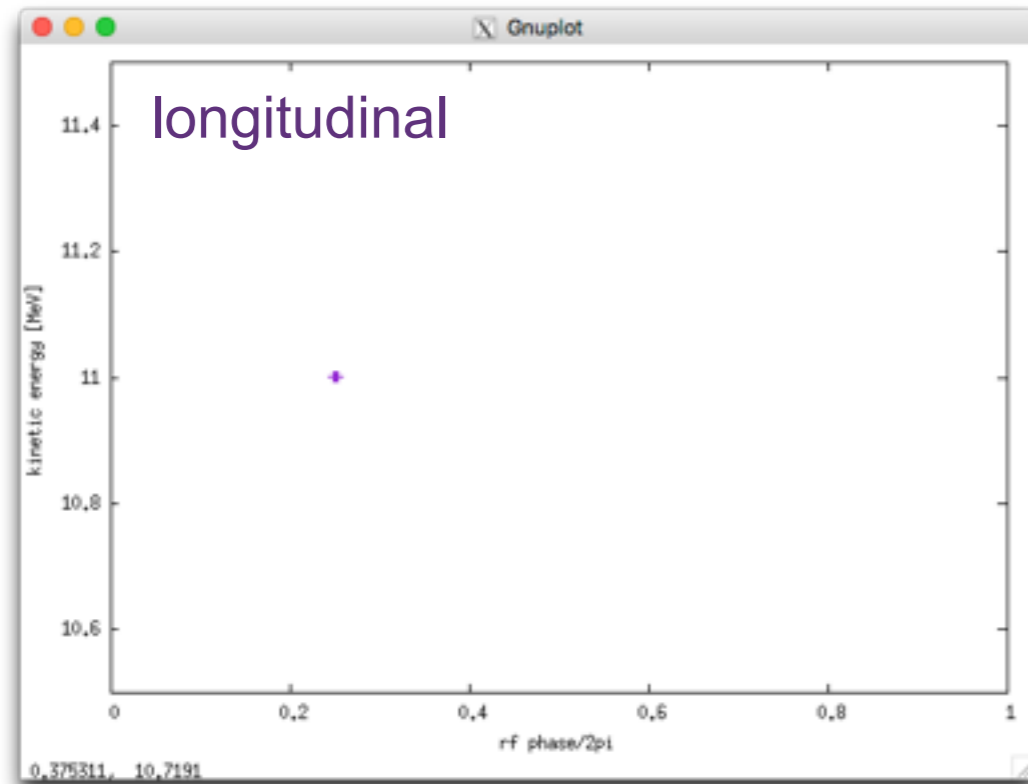
Lattice with hardedge

Vertical amplitude is restricted by field map (+/- 10 mm). It cannot go beyond 3 pi mm mrad (normalised).

vert amplitude [pi mm mrad]	cell tune	ring tune	hori aperture [pi mm mrad]
1	0.305 / 0.123	3.654 / 1.472	450
1	0.307 / 0.120	3.686 / 1.436	500
1	0.307 / 0.103	3.682 / 1.236	500
0	same above	same above	500
1	0.309 / 0.111	3.703 / 1.334	350
1	0.310 / 0.117	3.718 / 1.400	300
1	0.313 / 0.114	3.750 / 1.362	300

At injection energy for 10,000 turns (not completed).

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Phase space

When vertical amplitude is 1 pi mm mrad (fixed) and cell tune is (0.307, 0.103)

longitudinal

horizontal

vertical

- Horizontal aperture is limited by 3qx=1.

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Summary

- Both field map and hard edge model give horizontal dynamic aperture of 500 ~ 600.
- The aperture is limited by 3qx=1. Decrease of the aperture when the tune approaches 3qx=1 is clear.
- Vertical amplitude does not make much difference because of strong horizontal resonance at 3qx=1.

- Encourage similar study with Zgoubi, OPAL and Earlietimes …

- Plan to do experimental confirmation. Since this does not involve space charge, it would be possible with the current beam condition.

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