Science & Technology Facilities Council

Progress of KURRI/FFAG simulation

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KURRI FFAG Simulation Plan

KURRI FFAG Simulation Plan – second draft

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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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Generic FFAG simulation

Scode now takes TOSCA field map.

- Linear interpolation of neighbouring 8 grid points.
- 1st order kick-drift symplectic tracking.
- 2000 kicks per cell (20000 kicks do not make much difference in tune).

Assume 12 fold symmetry of the lattice.

- rf cavity is located at one straight section.

Tune is calculated from the elements of one turn map.

- One turn map is constructed by one turn tracking.

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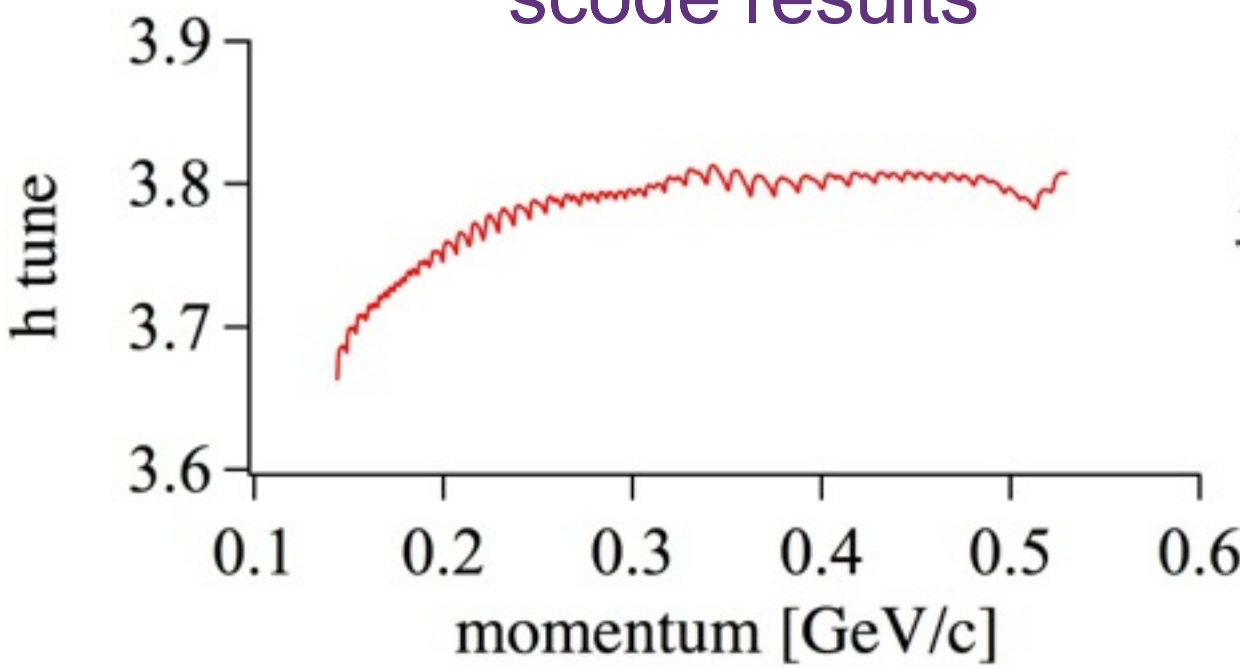
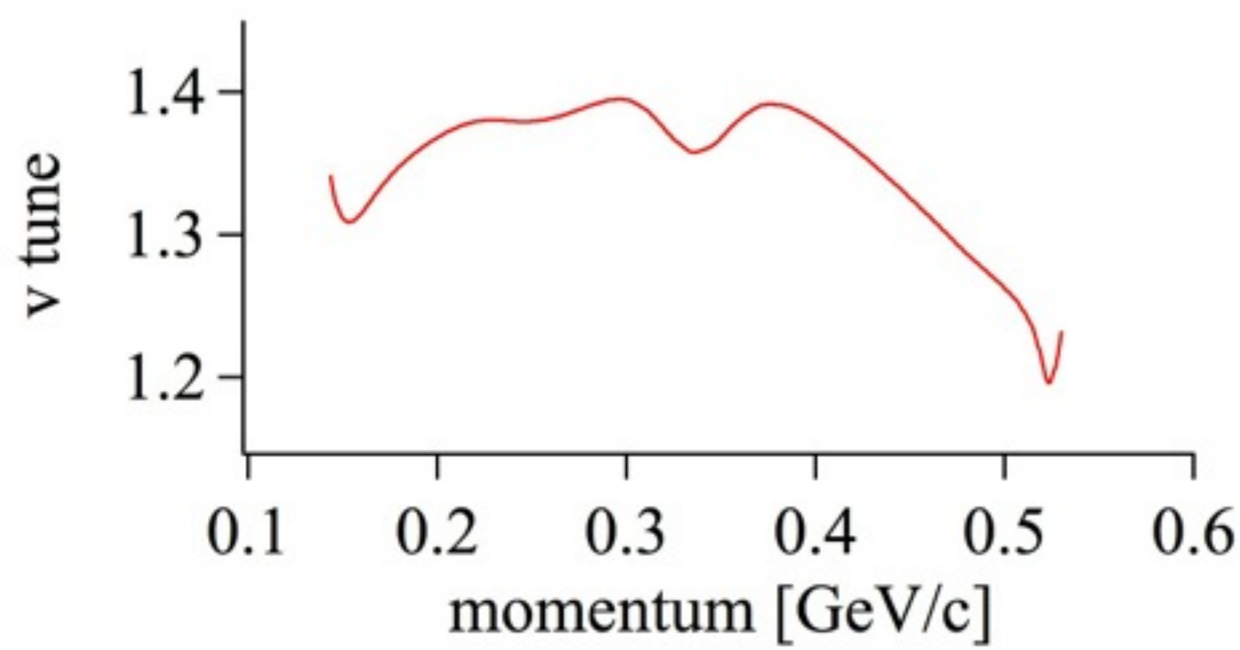
Step 0, without rf

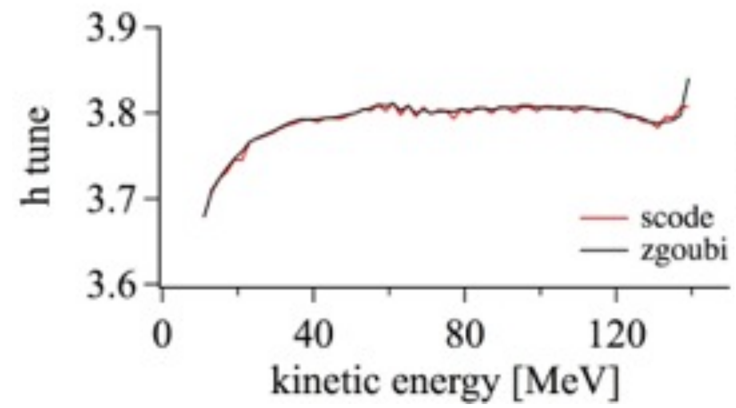
1.1 (a) Transverse tune vs momentum

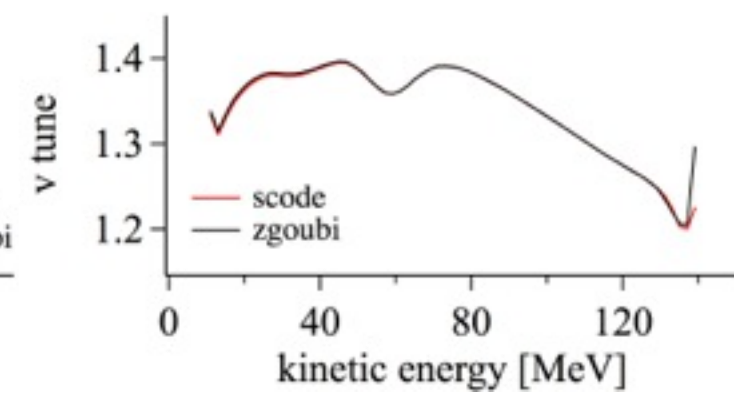
scode results

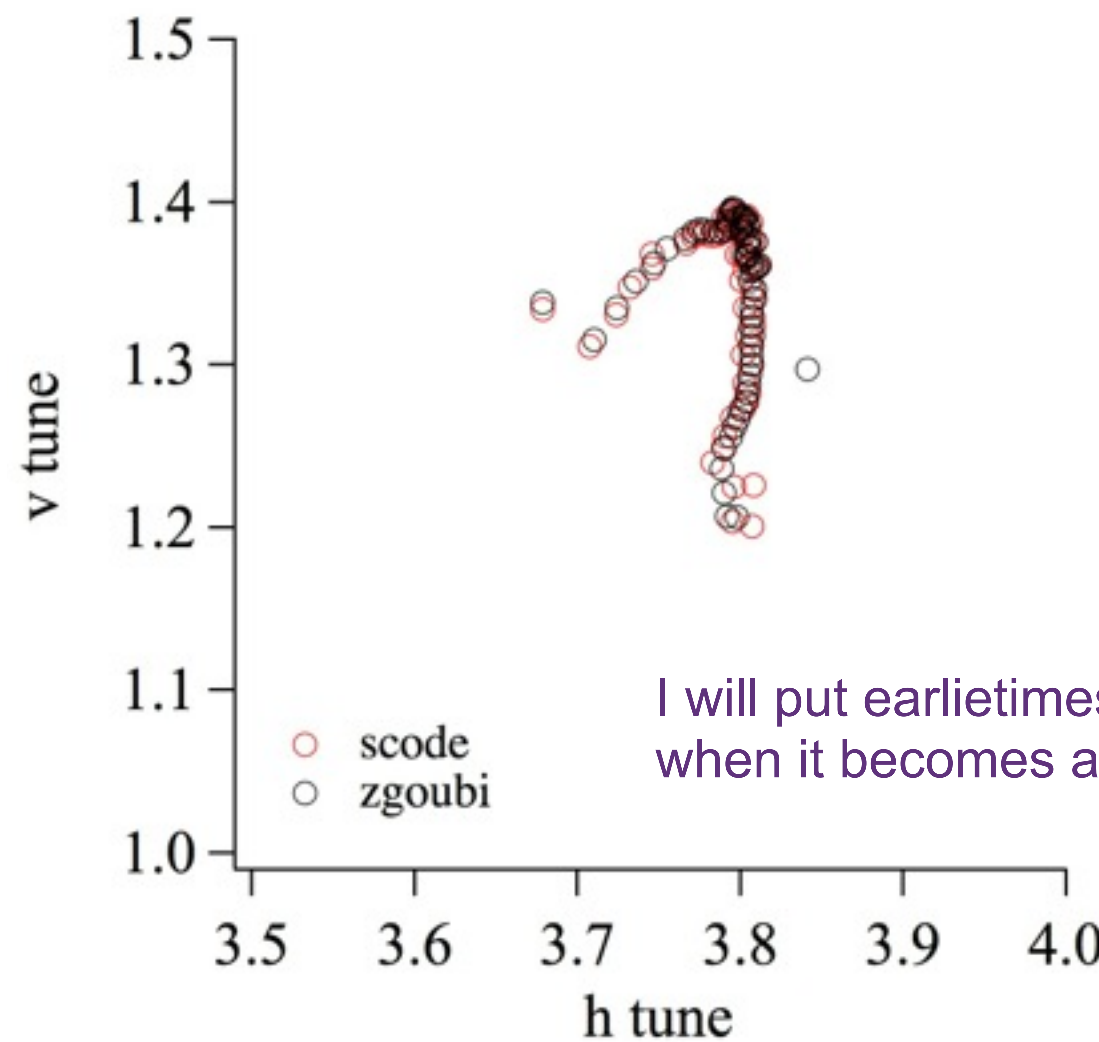




comparison with zgoubi



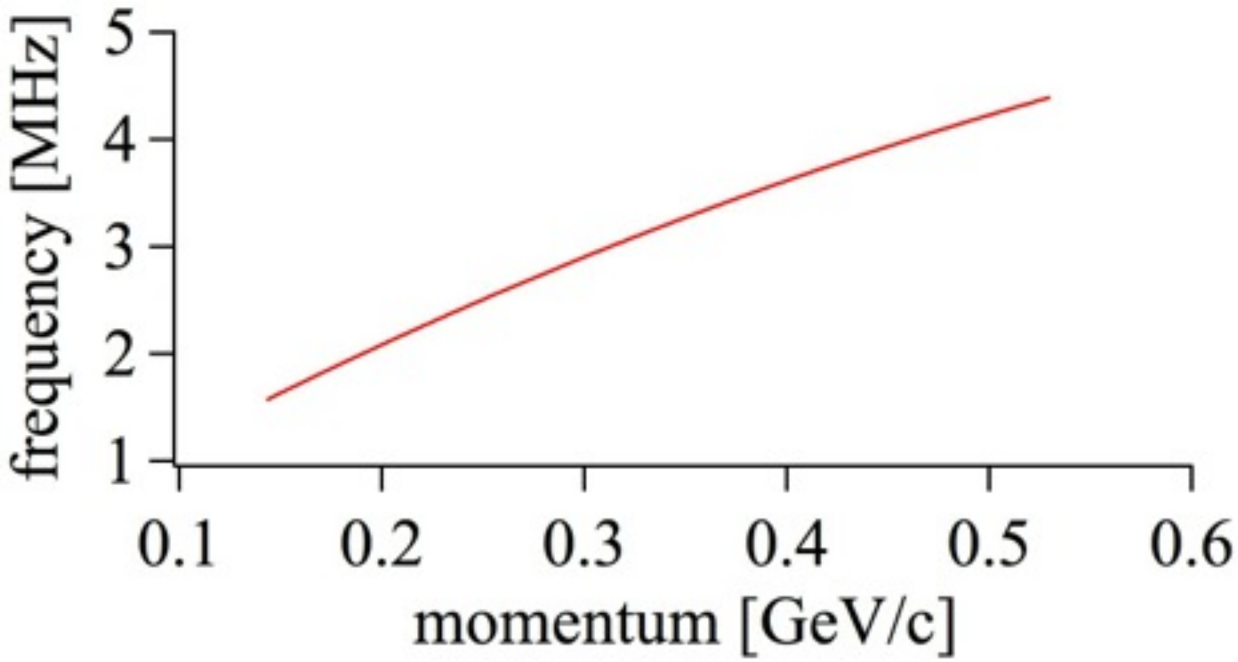




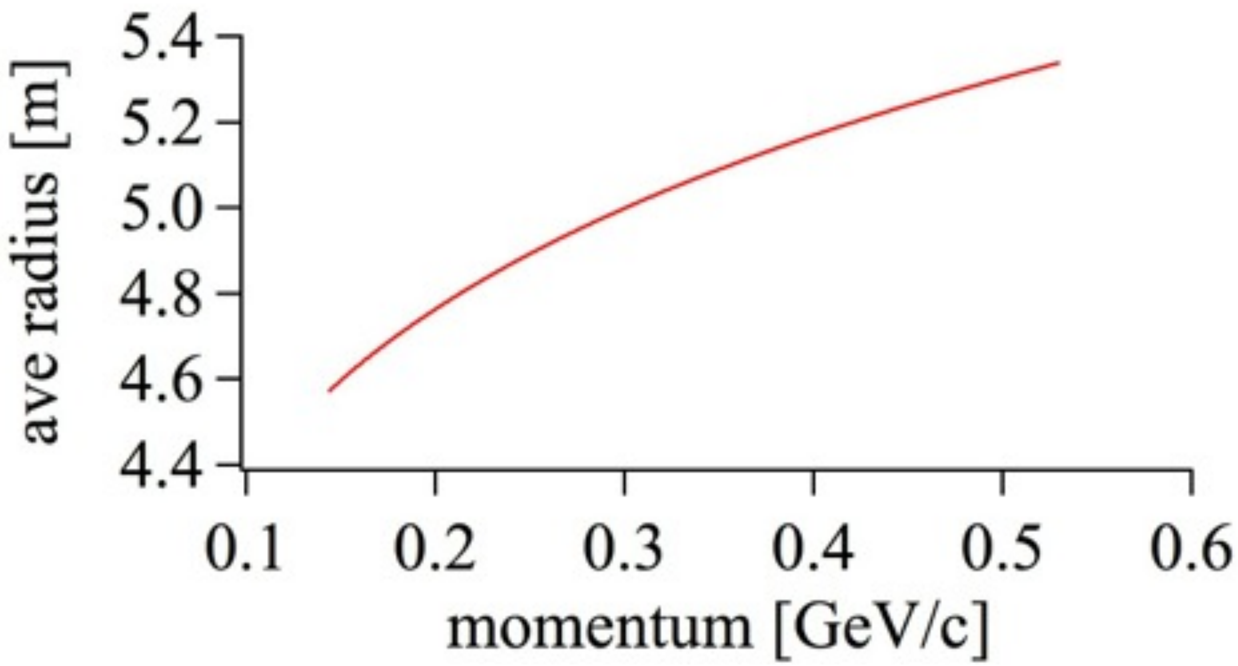
I will put earlietimes data when it becomes available.

Step 0, without rf

1.1 (b) Revolution frequency vs momentum



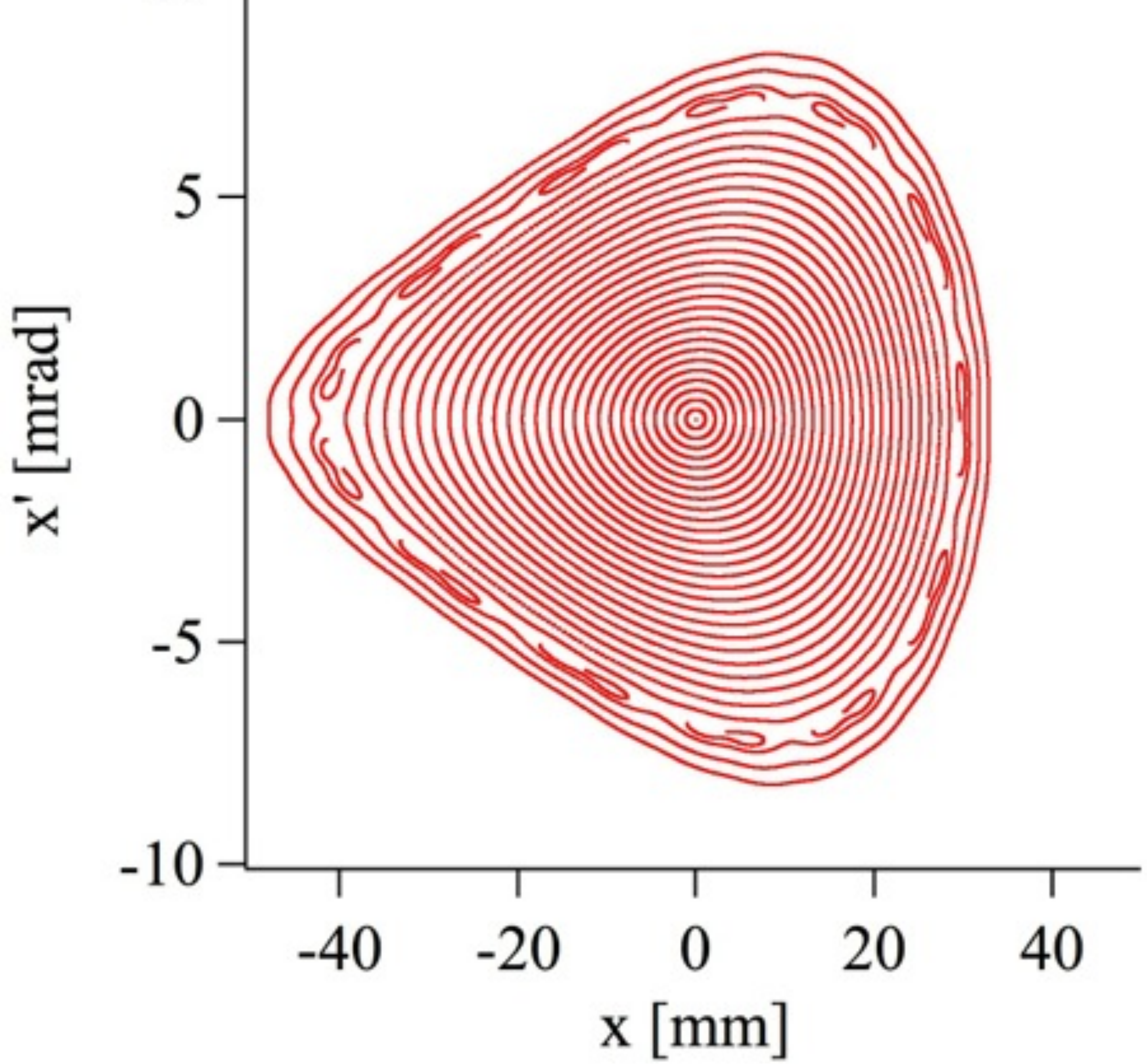
1.1 (c) Average radius vs momentum



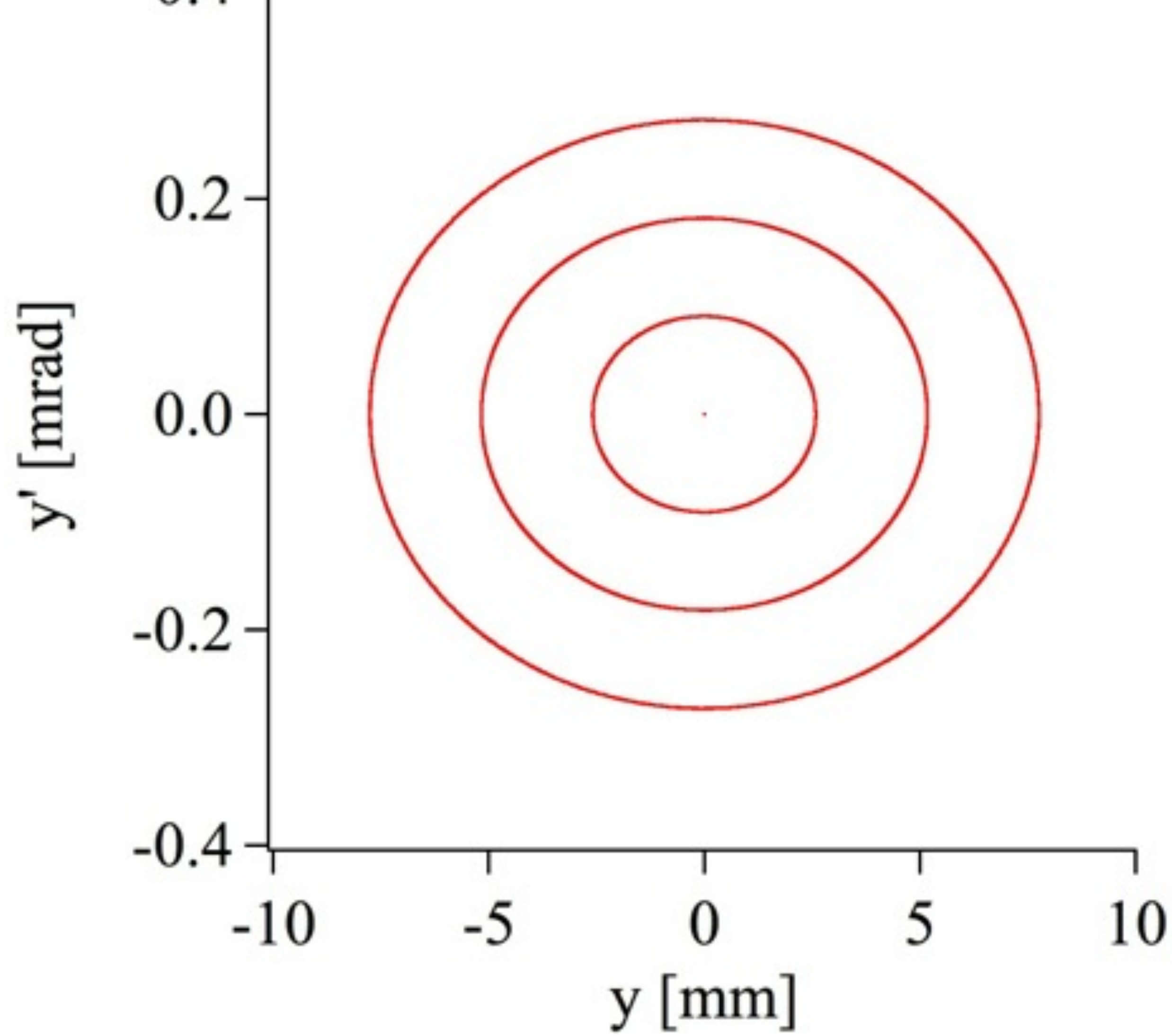
1.2 Direct comparison of transverse phase space

at 0.1441 GeV/c (11.001 MeV)

when initial v emit is zero.



when initial h emit is zero.



initial step size is 0.25 pi mm mead (normalised).

Step 0, without rf

1.3 Transverse amplitude dependence of tune and revolution frequency.

Not ready yet

Step 0, with fixed rf

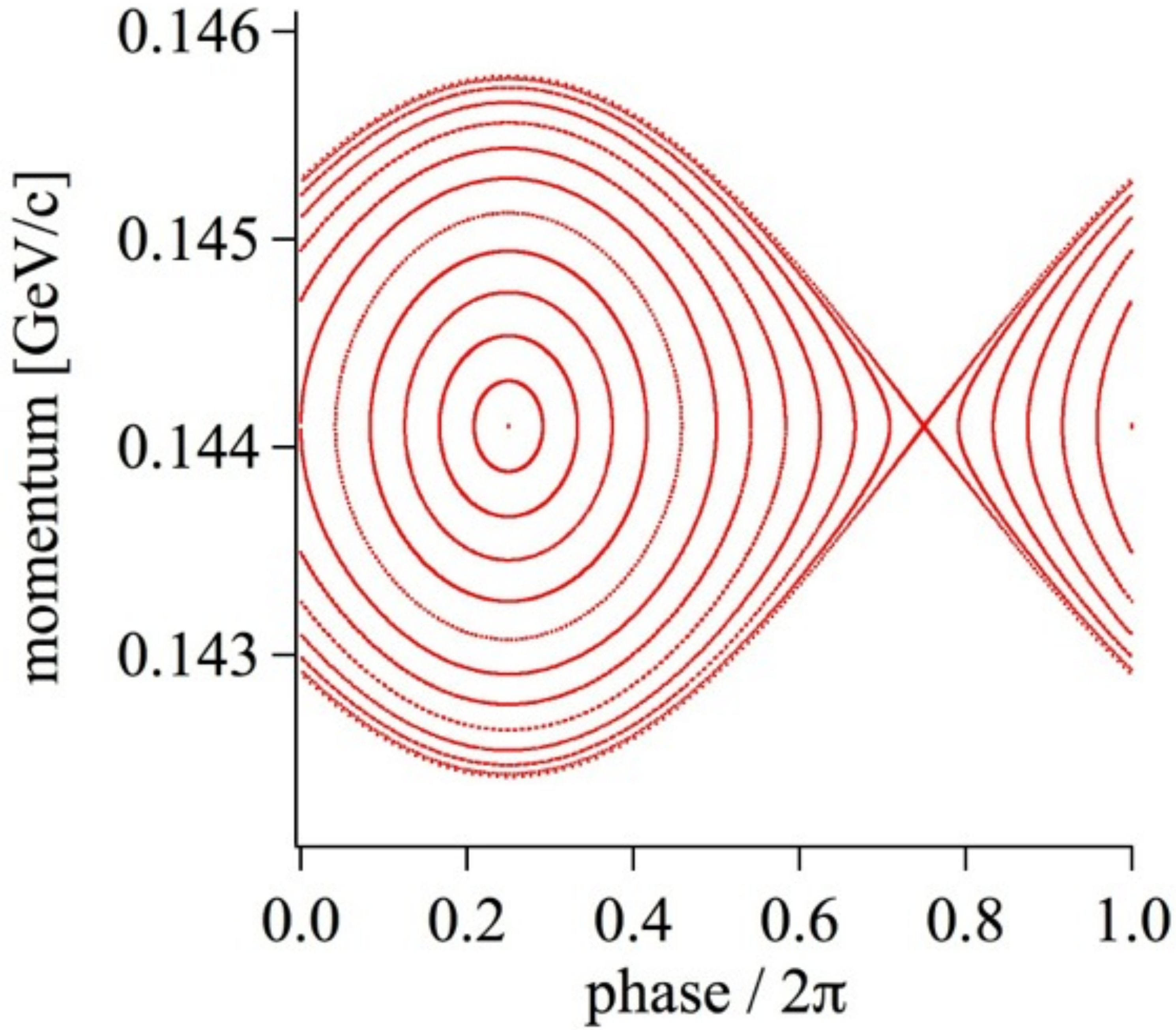
2.1 Synchrotron tune vs momentum

Not ready yet

Step 0, with fixed rf

2.2 Direct comparison of longitudinal phase space

at 0.1441 GeV/c (11.001 MeV)



voltage: 4 kV

step size: 30 deg.

Step 0, with fixed rf

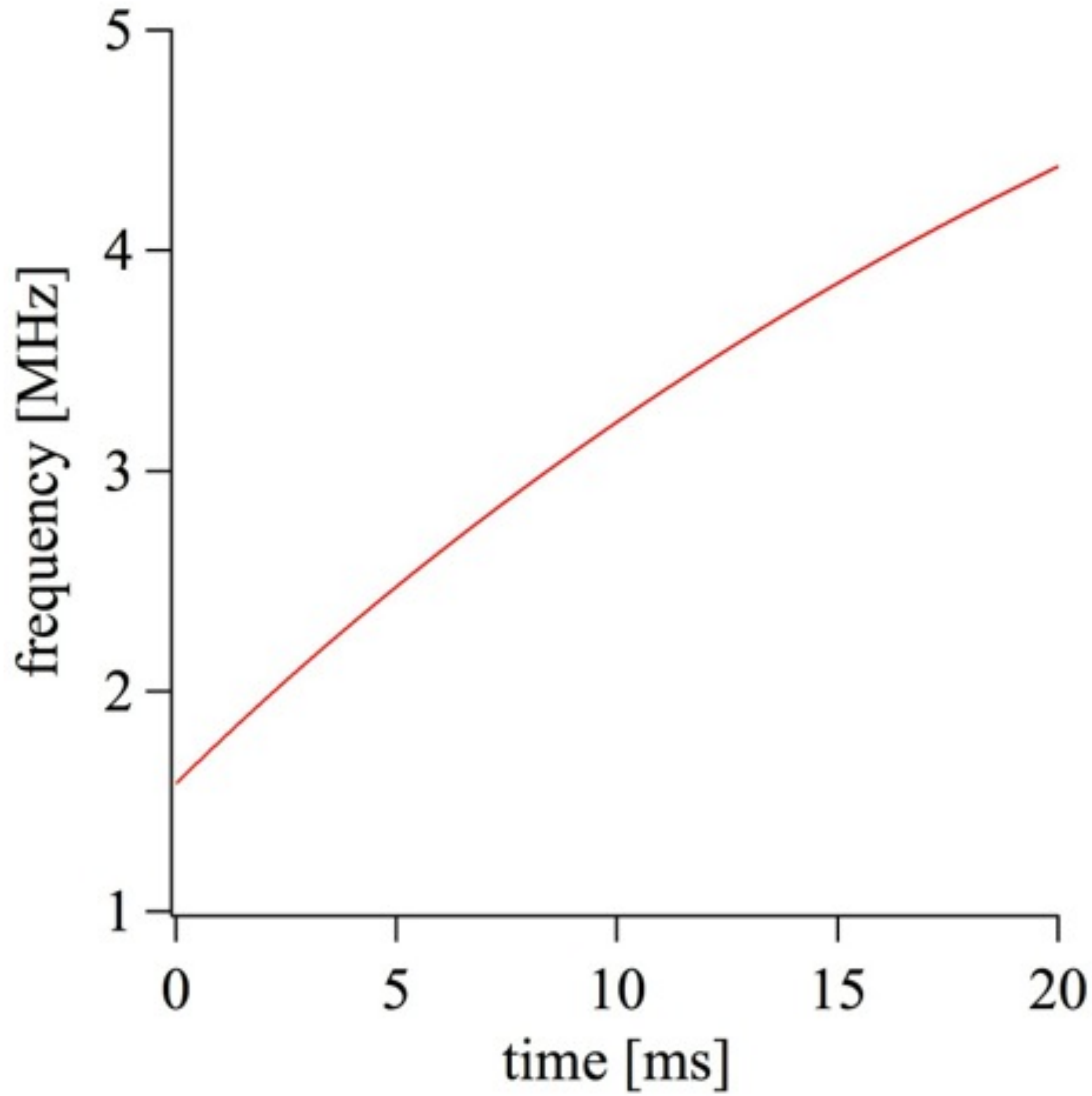
2.3 Longitudinal phase space when a particle has finite transverse oscillation.

Not ready yet

Step 0, with acceleration rf

3.0 Table of frequency and voltage vs time

assuming constant k=7.645



voltage: 4 kV

Step 0, with acceleration rf

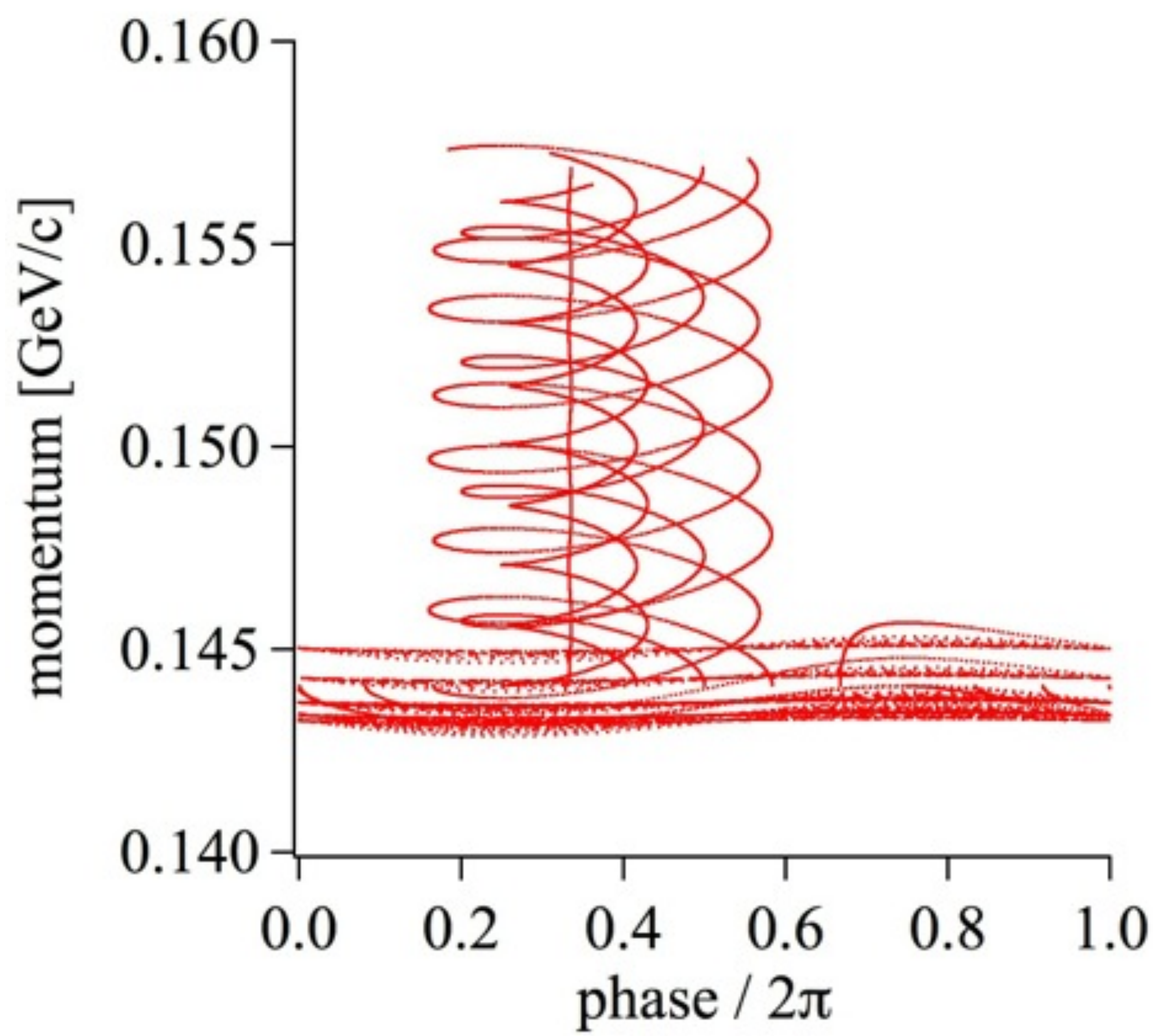
3.1 Instantaneous tune (transverse and longitudinal) vs time

Not ready yet

Step 0, with acceleration rf

3.2 Direct comparison of phase space (longitudinal and transverse)

assuming constant k=7.645



voltage: 4 kV

transverse emittance: 0

momentum spread: 0

12 particles with 30 deg distance.

only first 1000 turns.

I have set up a repository on GitHub.
fixed-field-accelerator-simulation/KURRI_main_ring_scode

Hopefully, other codes (Zgoubi, Opal, Earlietimes, …) will provide the results so that we can compare/benchmark them in the ipac15 paper.

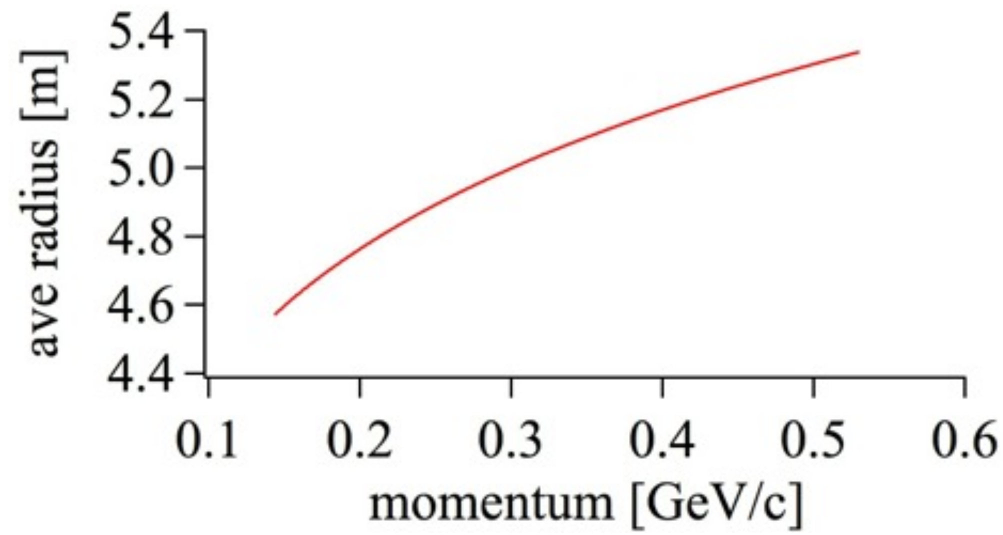
KURRI FFAG simulation

Field index k is not constant.

- rf programme has to be adjusted.

Large COD is excited.

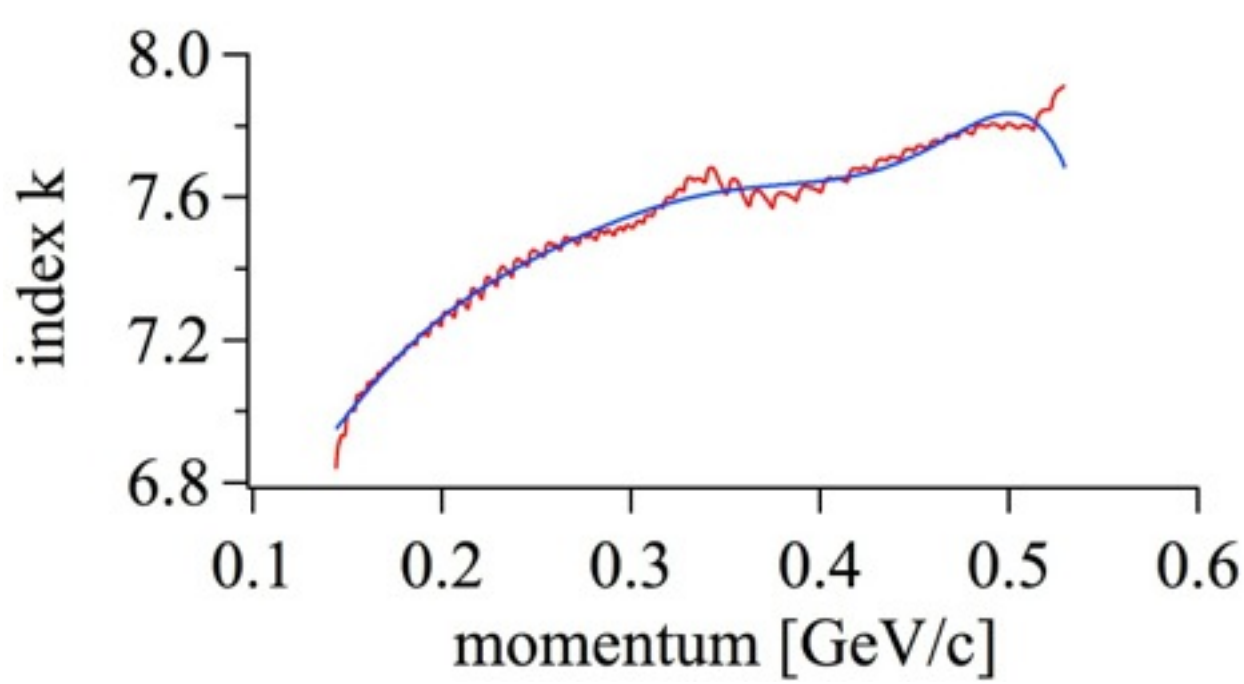
- Lattice does not have 12 fold symmetry.



non constant k

From “1.1 (c) Average radius vs momentum”

Field index k vs momentum

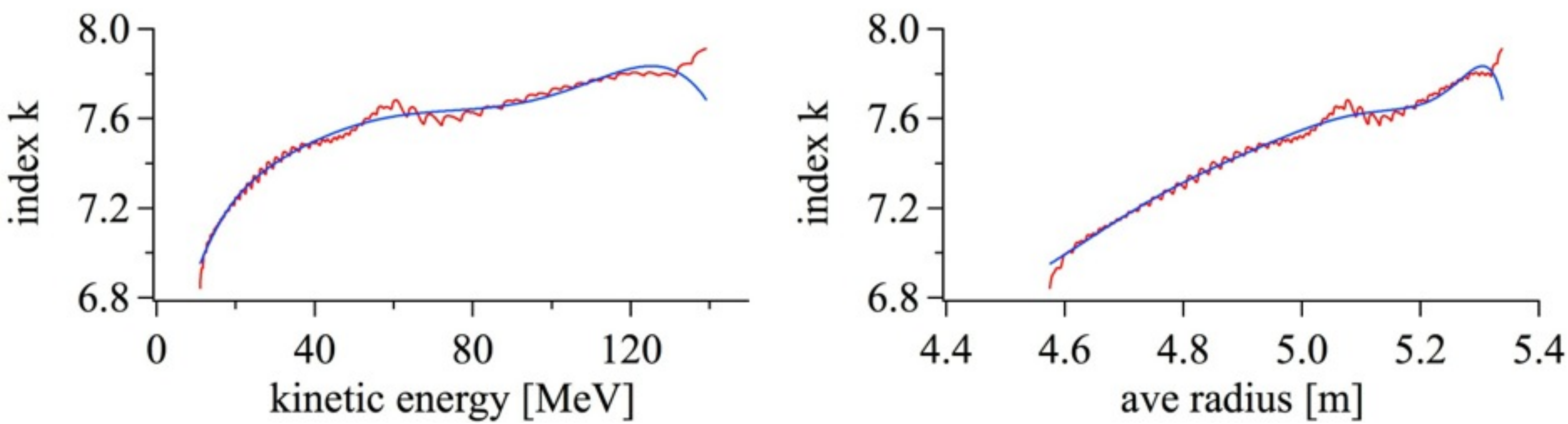


red: $$k = \frac{r_{ave,i}}{p_i} \frac{p_{i+1} - p_{i-1}}{r_{ave,i+1} - r_{ave,i-1}} - 1$$

blue: fit r_ave(p) as 7th order polynomials and take its derivative.

$$k = \frac{r_{ave}(p)}{p} \frac{1}{dr_{ave}(p)/dp} - 1$$

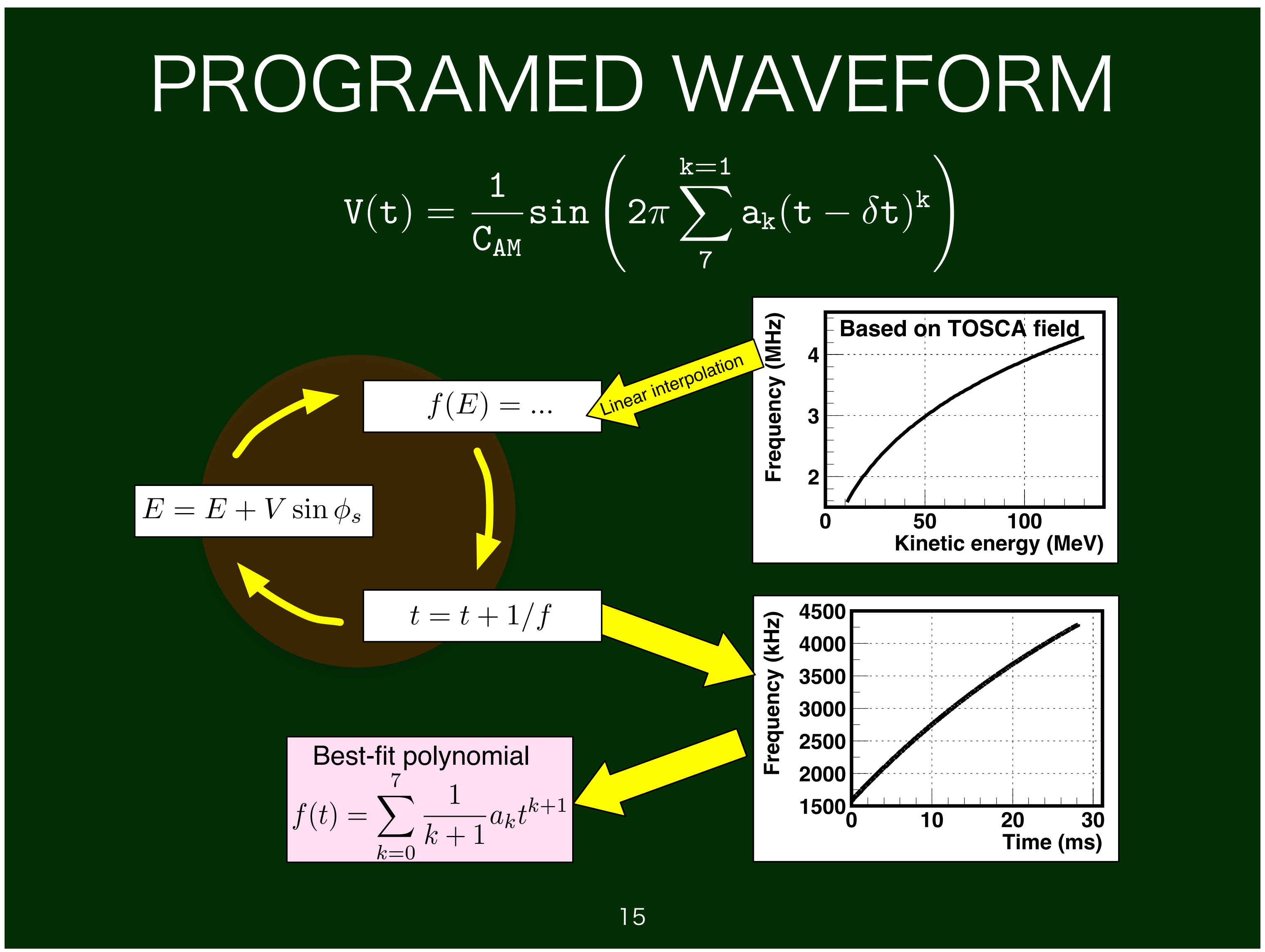
non constant k



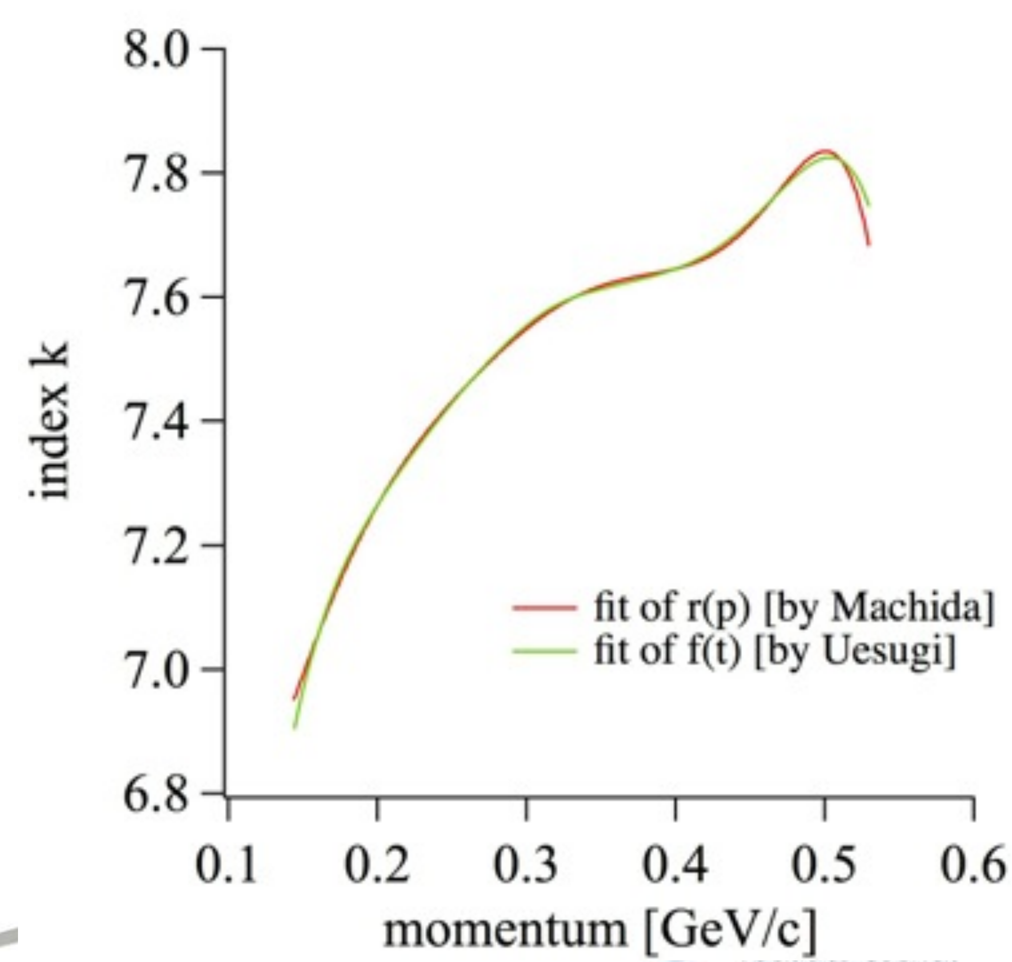
non constant k

Uesugi-san made freq function directly from freq vs. momentum, not through k.

Uesugi, FFAG14

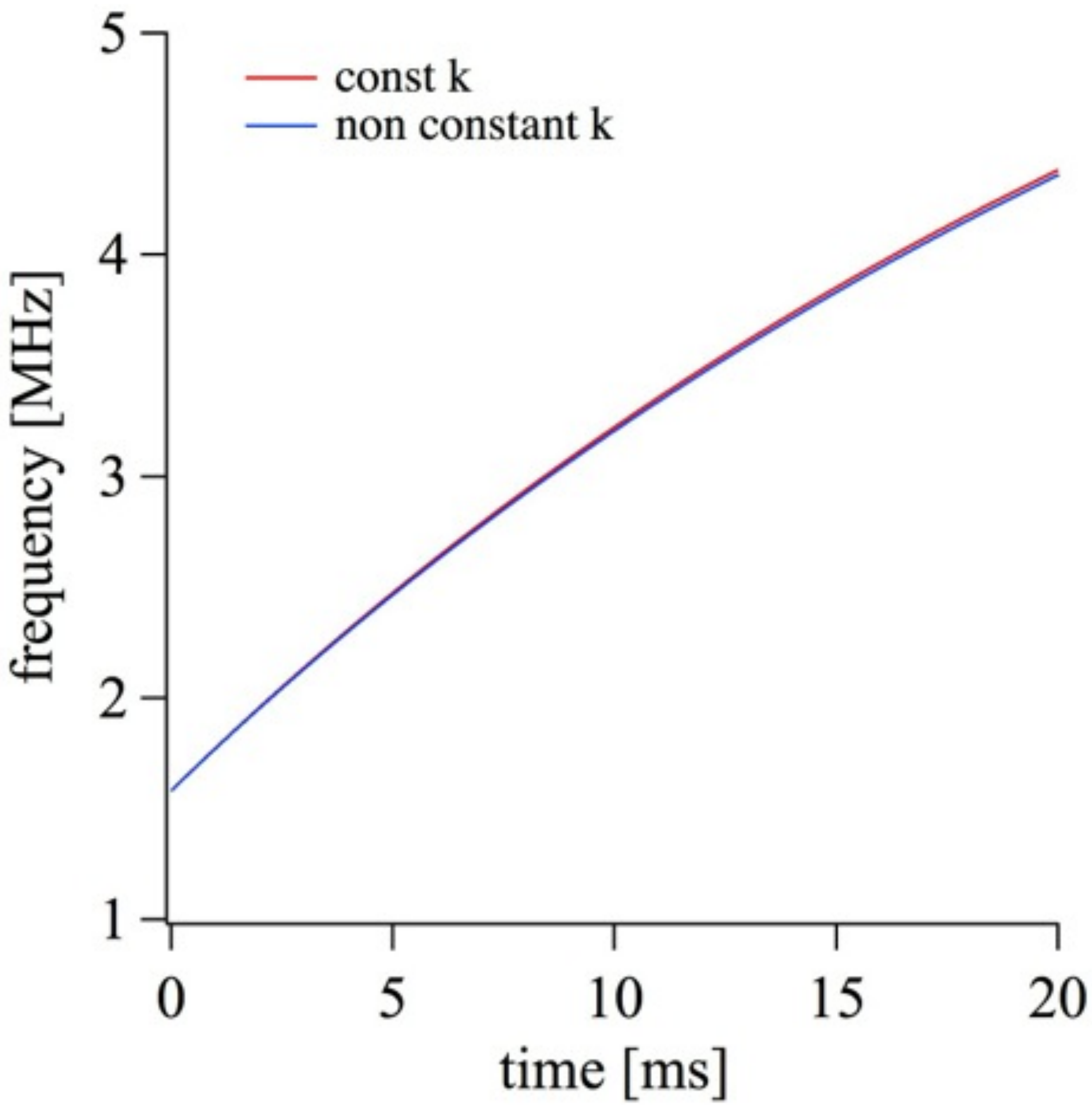


We can still calculate k based on his fitting. It does not show much difference whether we fit r_ave or freq.



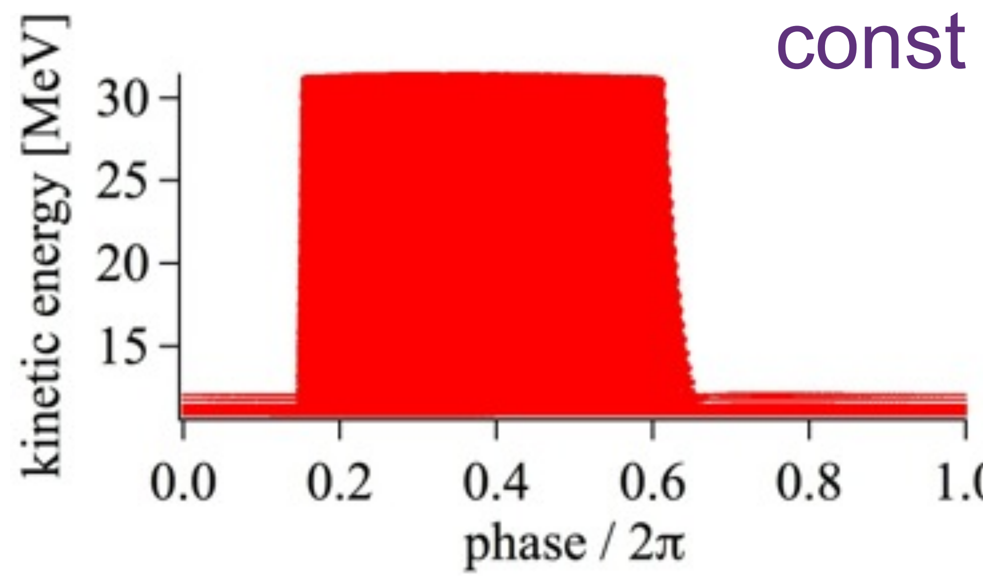
non constant k

Difference in freq vs time curve is small

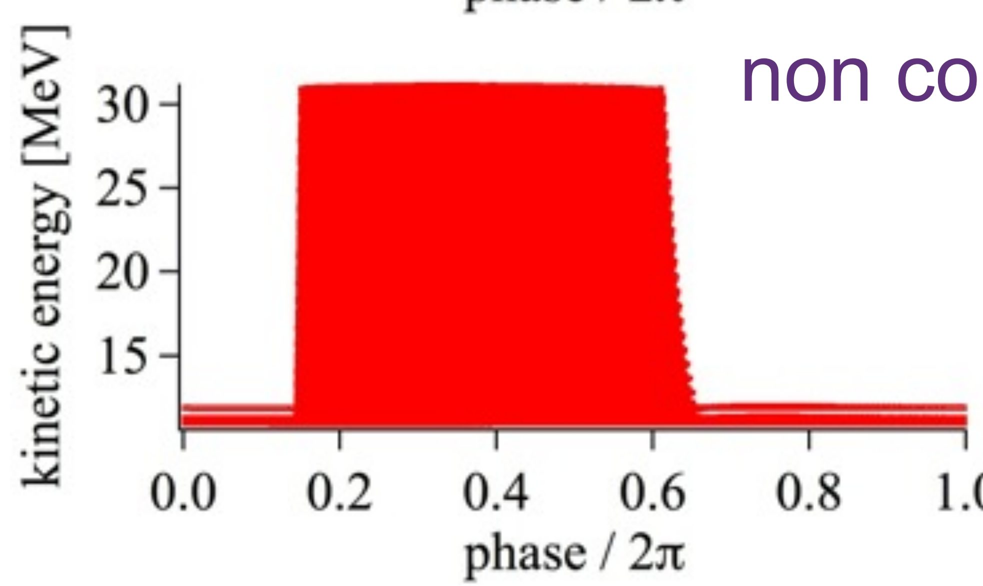


Simulation results are similar, too.

const k



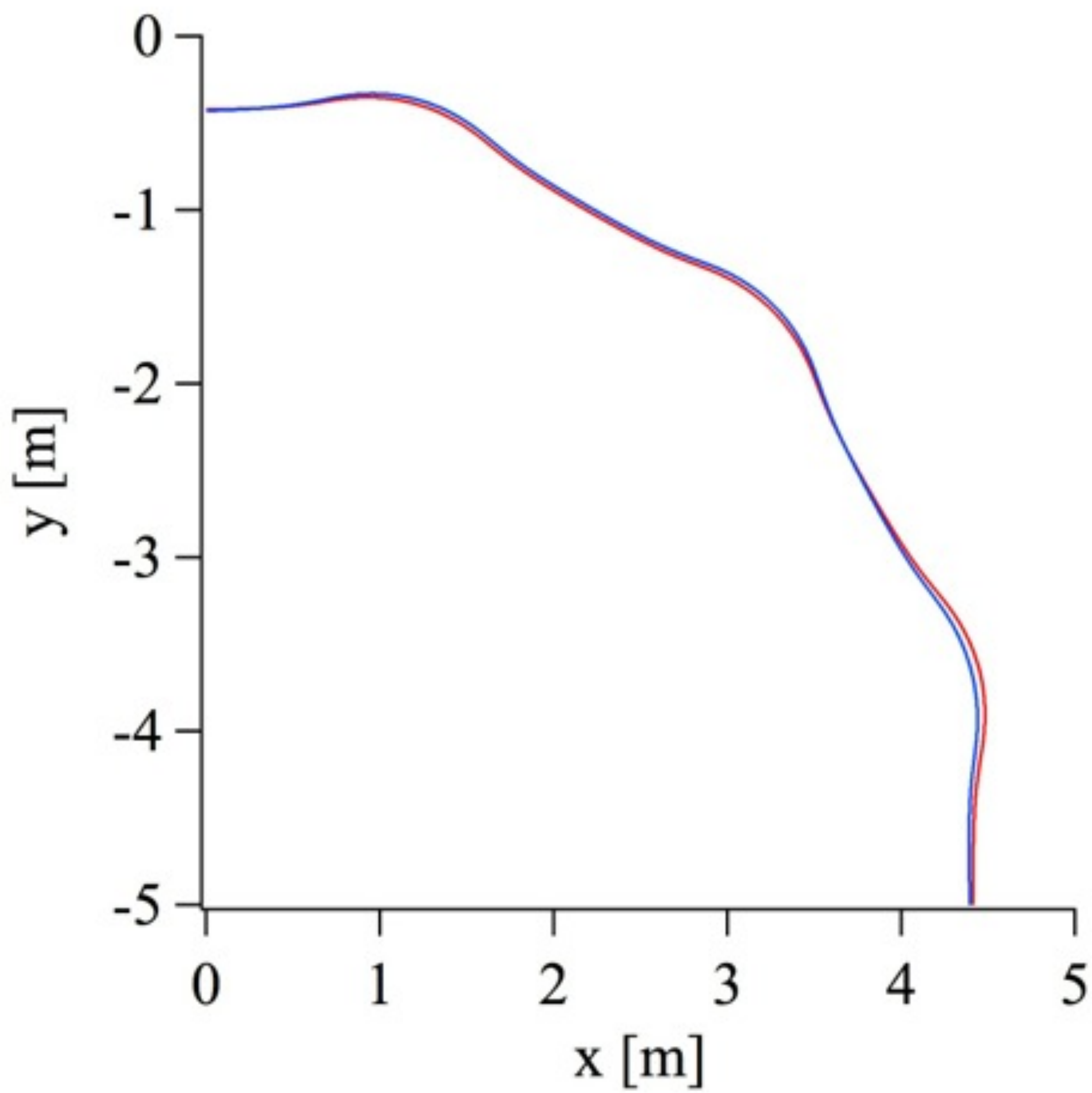
non const k



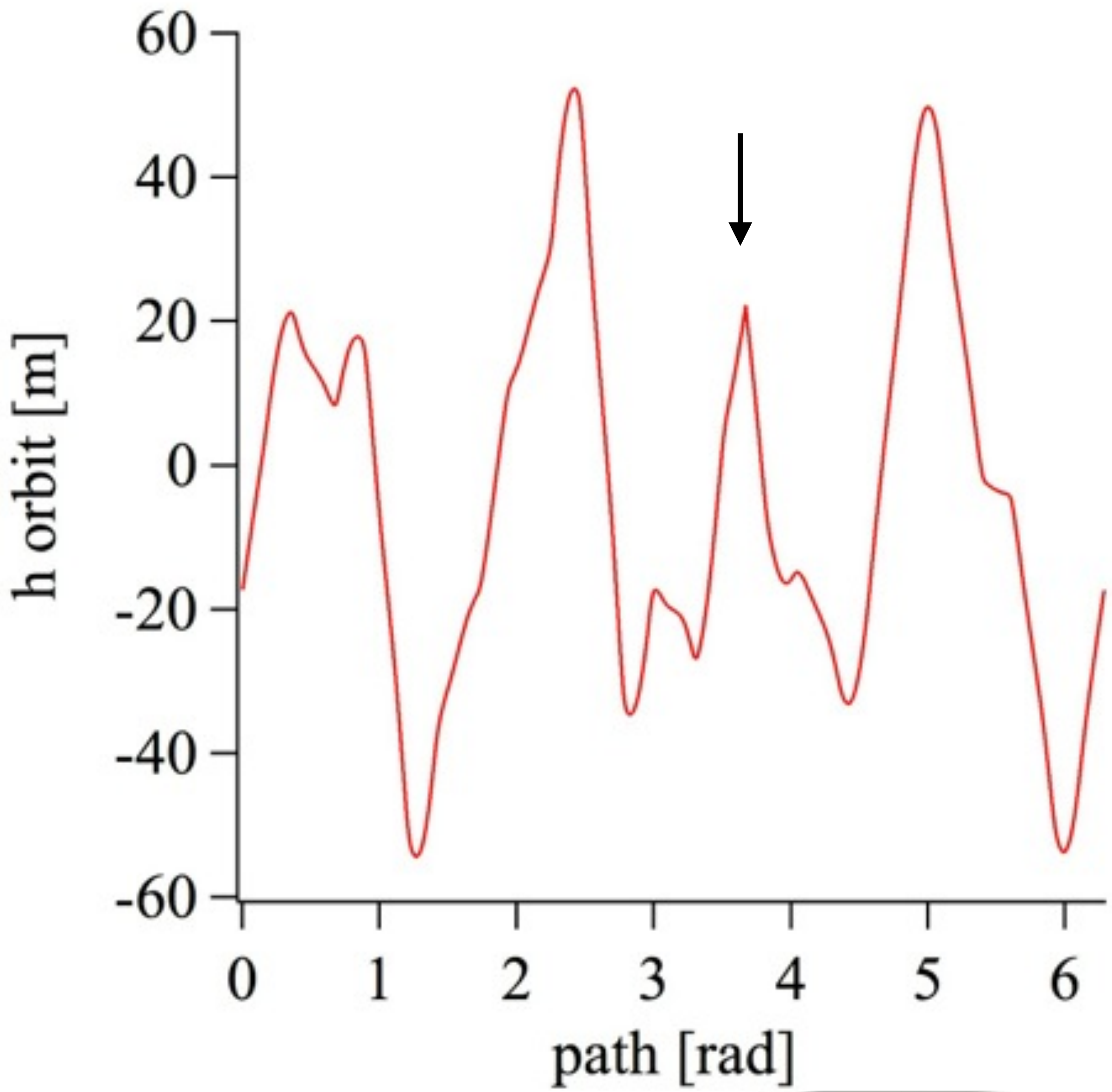
So why new pattern is better?

COD effects

with 69 mrad kick at one location



COD source is not exactly at the centre of straight section.



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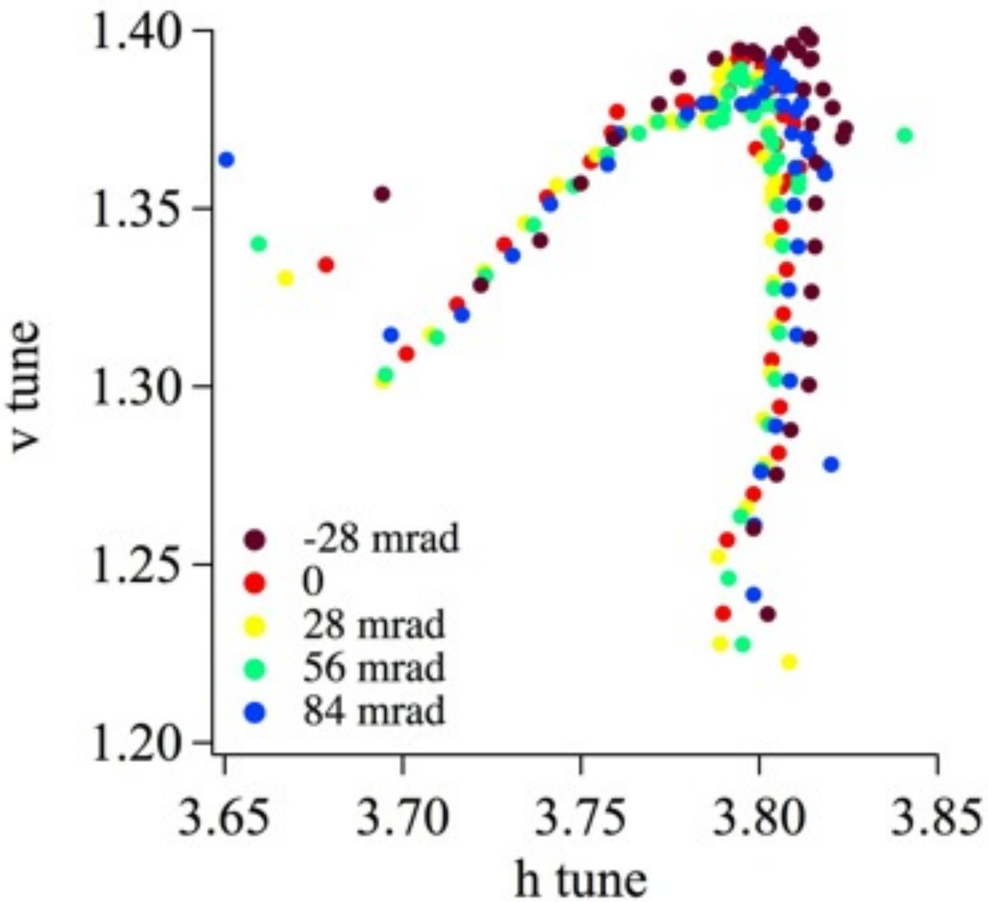
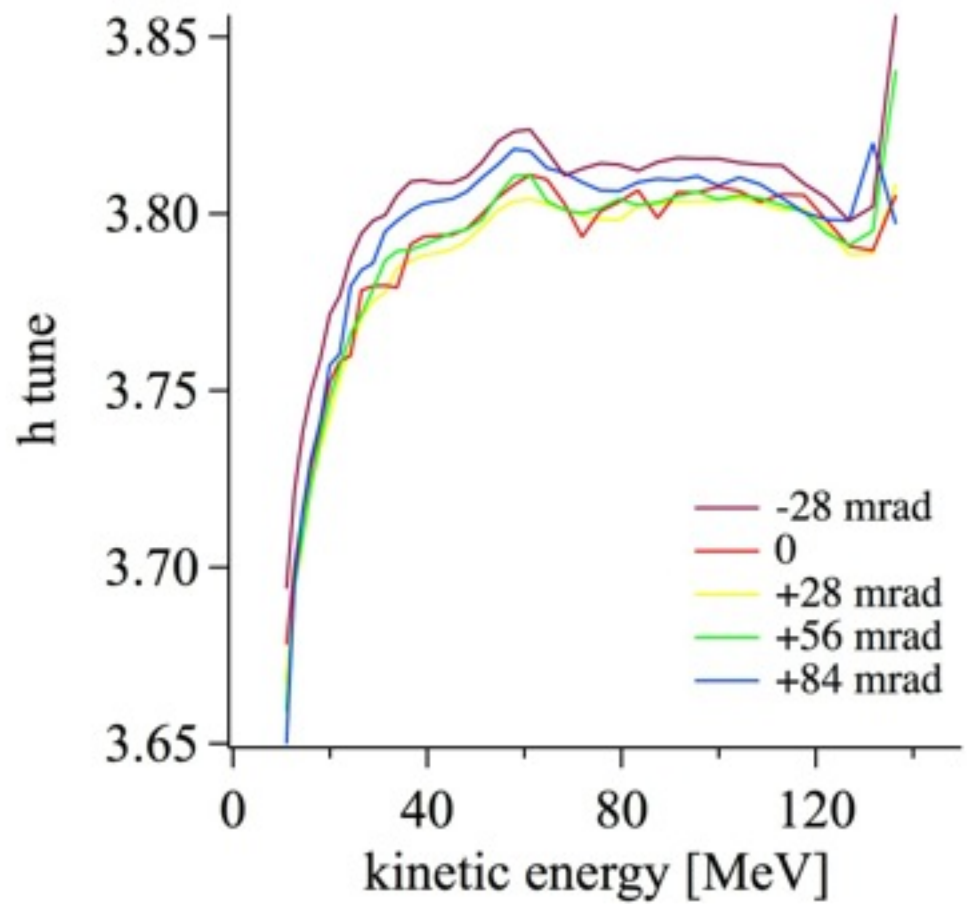
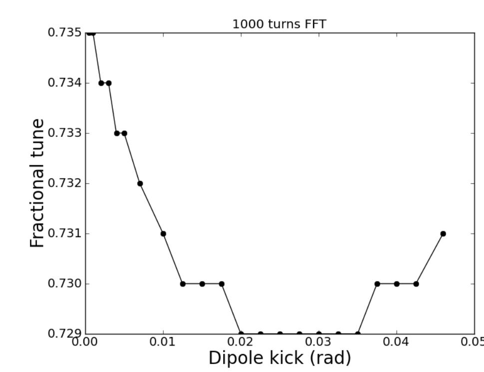
COD effects

COD shifts the tune footprint, but do not change its shape.





Detuning with COD amplitude



More shifts by negative kick and its direction changes at some point in positive kick side.

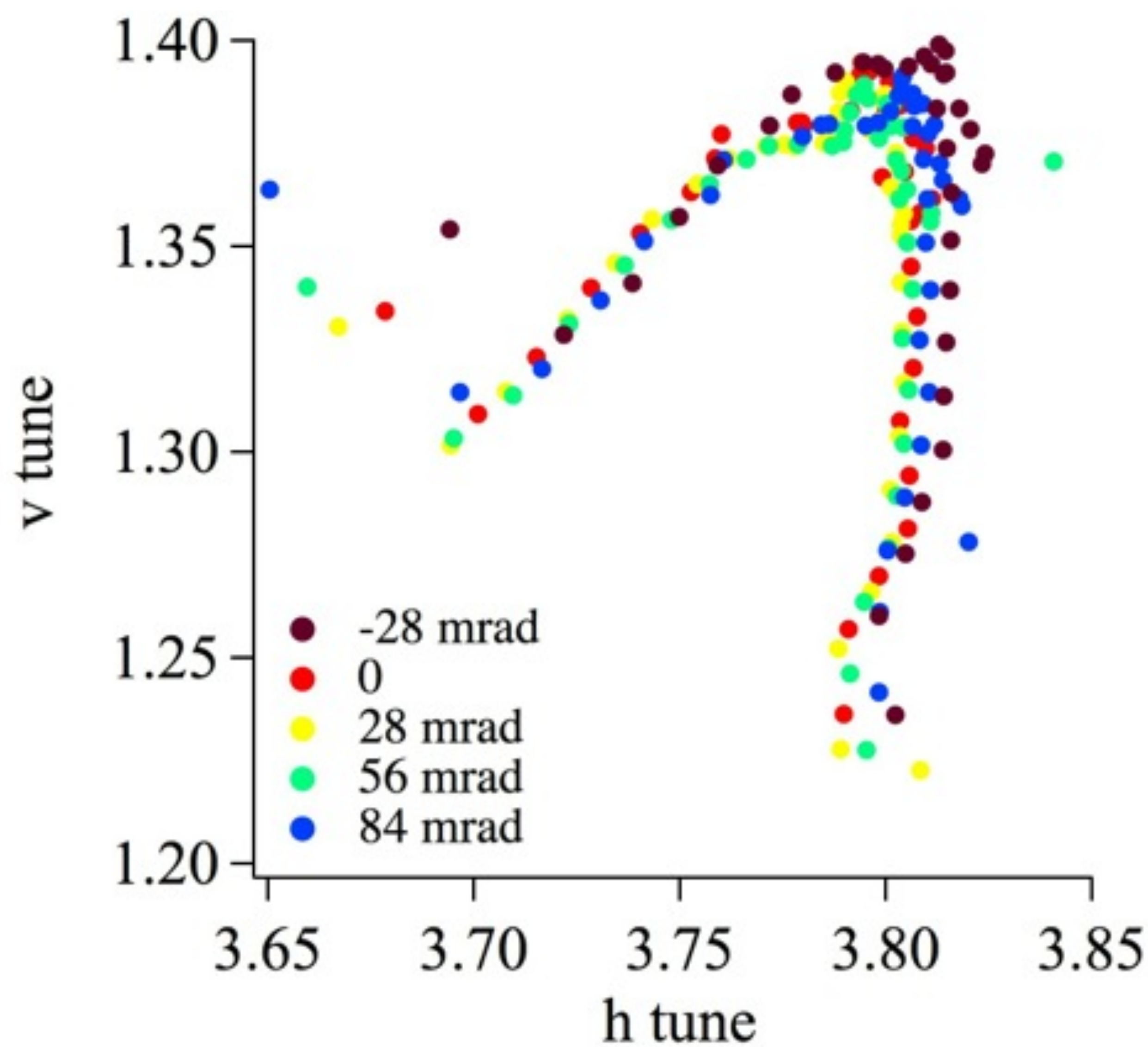
This is consistent with what David showed last time.

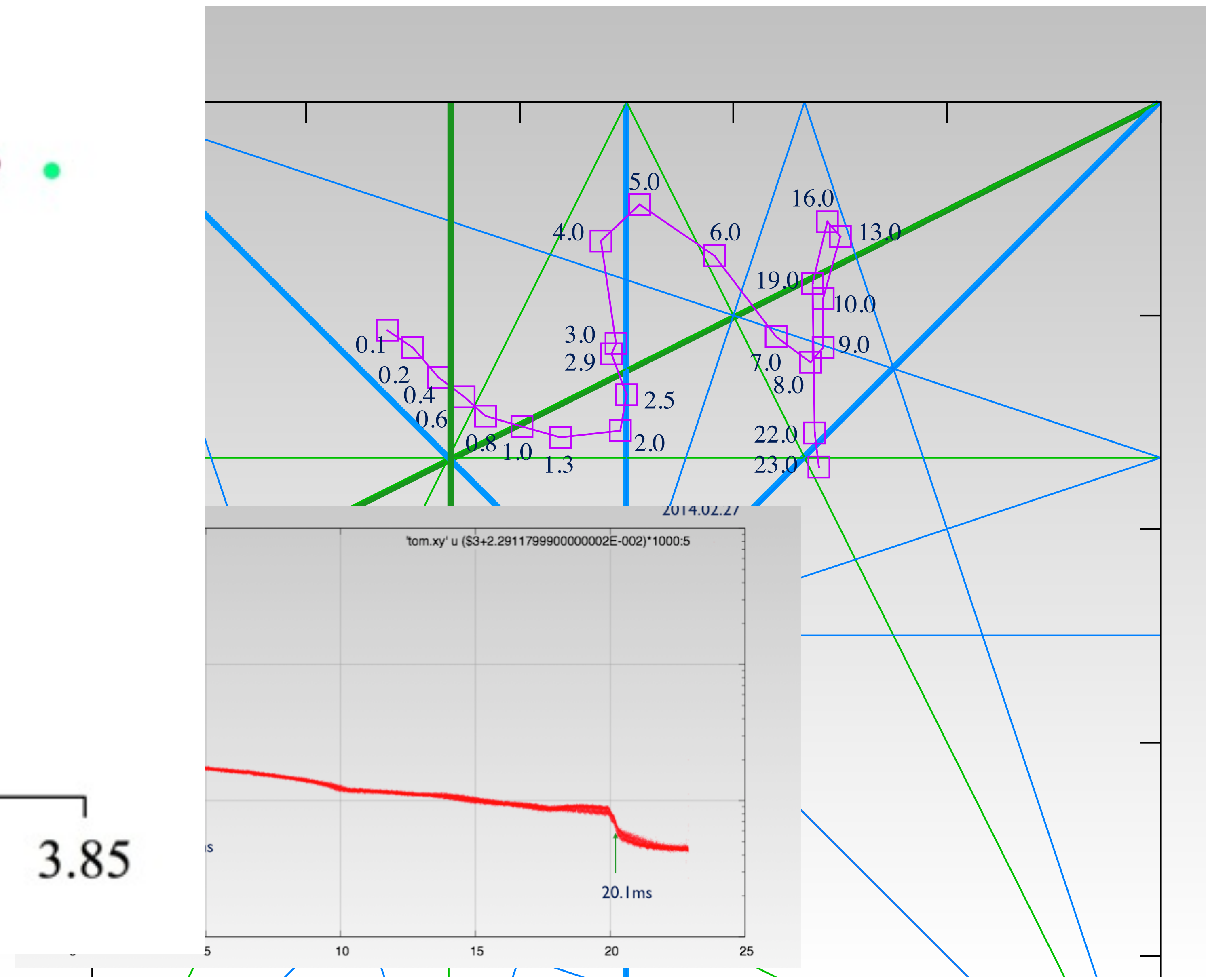
D. Kelliher
18 Dec.

- FFT of turn-by-turn tracking (using analytic model) shows shift in tune with amplitude.
- It might be worth measuring tune at various D0 currents, though the resolution of results may be insufficient to detect any variation.

COD effects

Why observed shape is different from simulation?





No answer yet. It is not due to horizontal COD by single kick.

Comments on the experiment in Feb/Mar

Observed large difference of capture efficiency with constant/non constant k is very curious.

- rf frequency is very similar at the beginning.
- Further simulation towards experiments.
- Does SG produce waveform as you expect for constant k case?

Investigate whether tune excursion pattern is always the same or depends on setting; e.g. COD, injection error.