KURRI-FFAG Experiment Update

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Based on slides delivered at KURRI, 30/6/2015

Planned Experiments

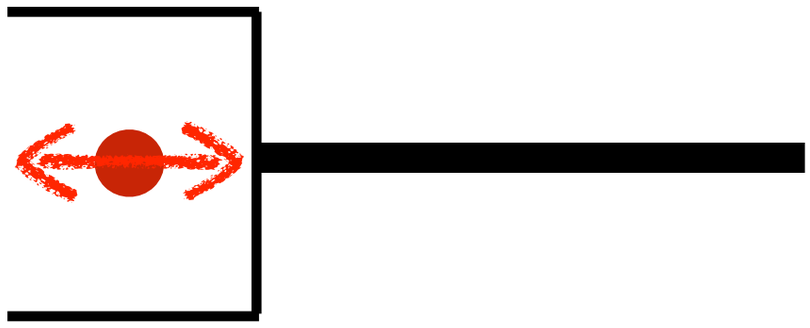
- Transverse:
  - Horizontal orbit matching
  - Closed Orbit Distortion with additional probes
  - Tune vs momentum (with corrector)
- Longitudinal:
  - Test Shinji's RF pattern creating script
  - Longitudinal tomography
  - RF optimisation

Horiz. Orbit Matching

- In the current paper, we have vertical matching (cf. Shinji's work) but not systematic horizontal orbit matching.

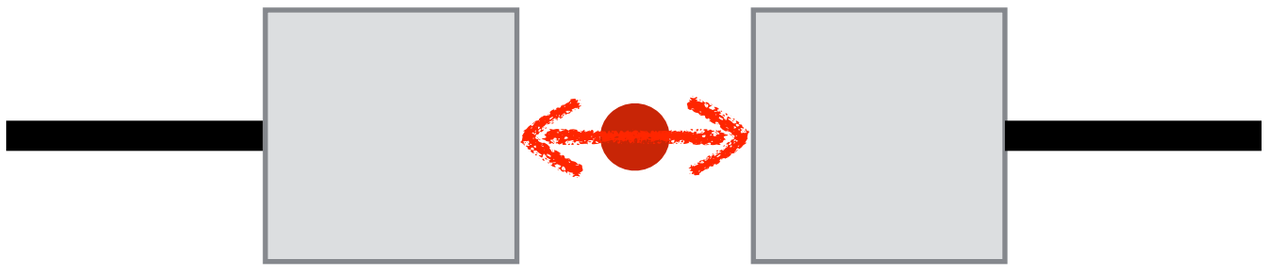
- Two possible methods to measure coherent oscillations:

  - Radially movable BPM



Test conducted 25/6/15 with radially movable BPM with accelerated beam
We think the beam was not actually 'in' the monitor. Further testing needed.

  - Fluorescent screens (new)

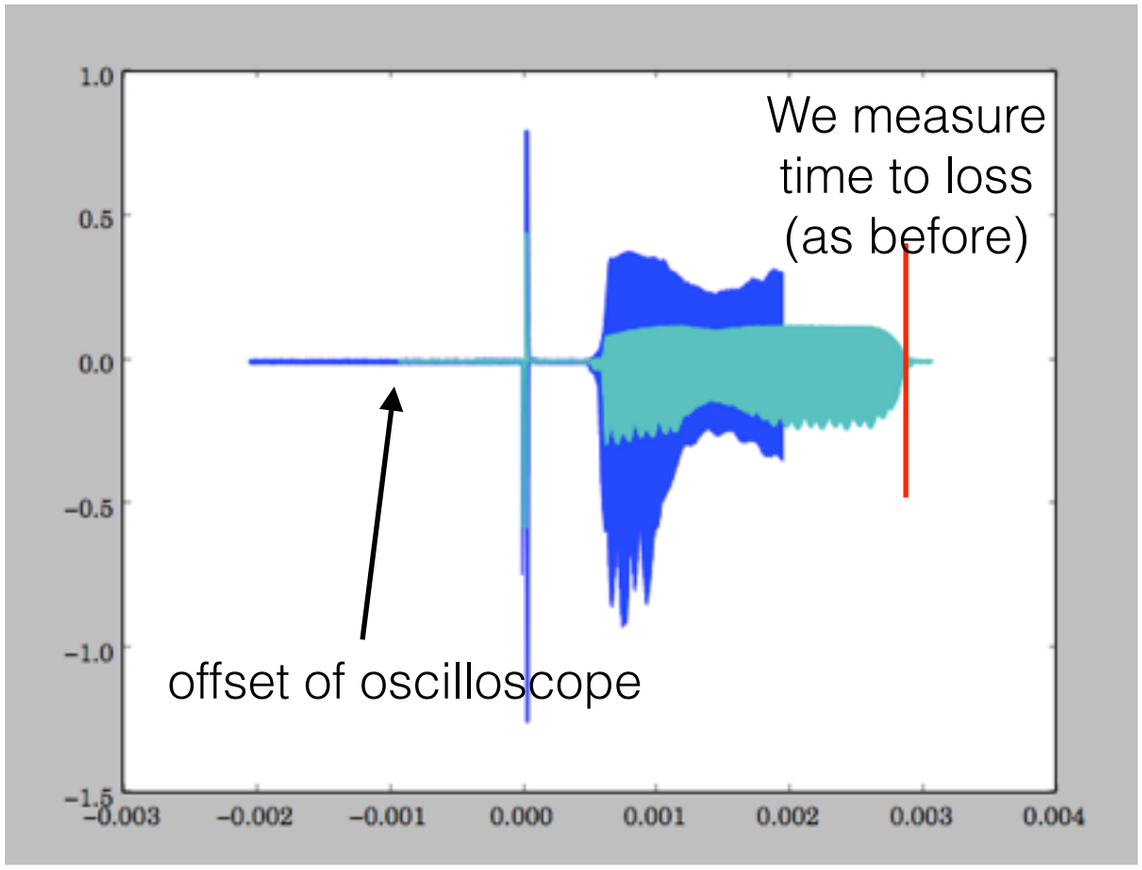


COD without RF - Y. Ishi

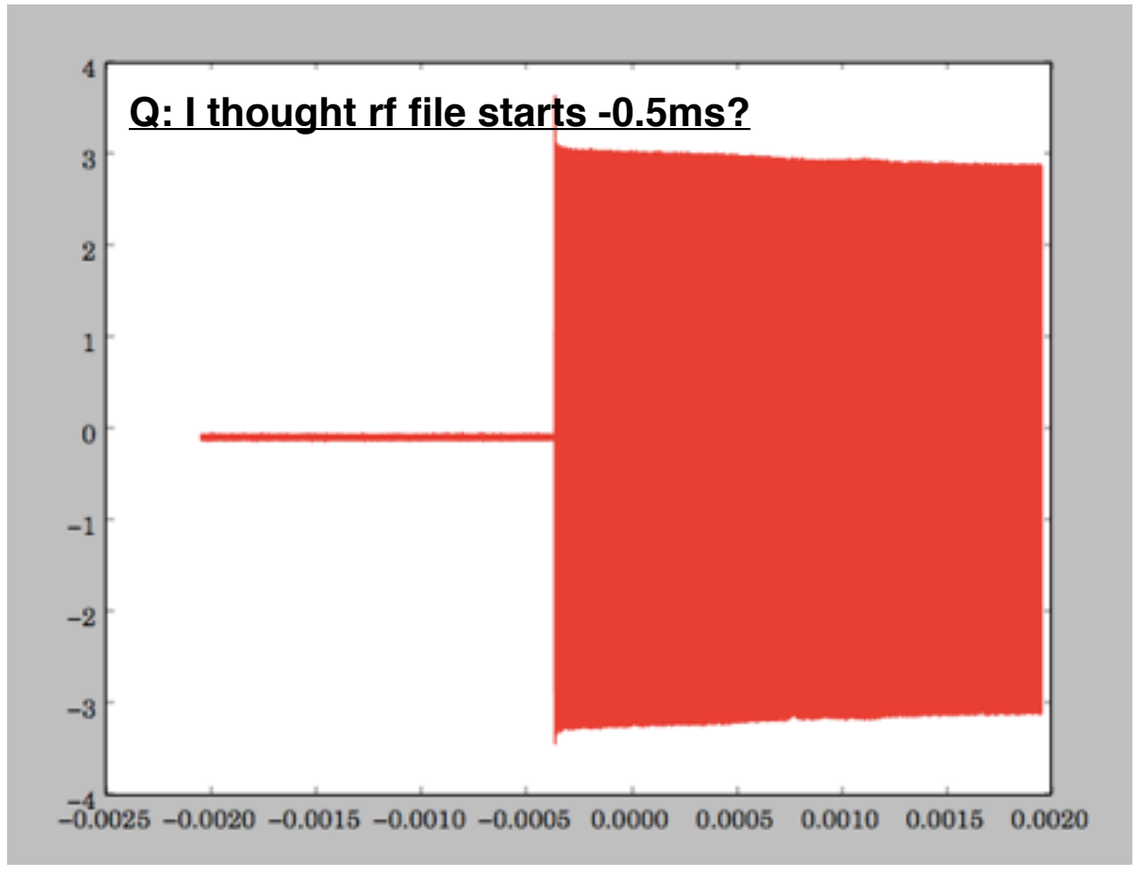
- There is now a ±2cm COD without the RF cavity present
- This is different from 2014 run

Closed orbit distortion

- Measurements taken with (new) corrector at 900A and 700A.

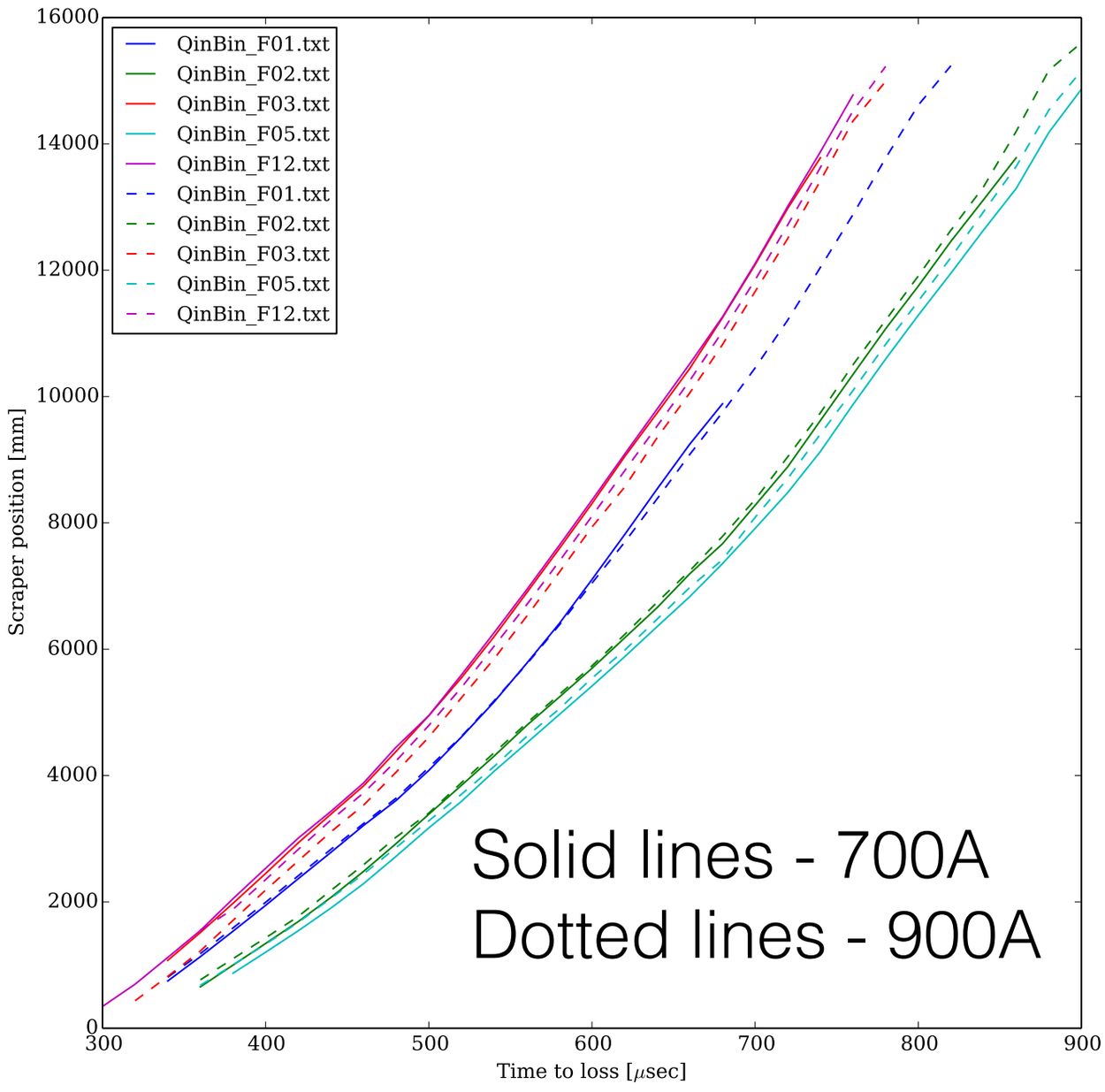


S12 monitor trace examples
(first 100,000 pts only)



RF trace (900A case)
(missing for 700A case)

Orbit measurement
(with F1, F2, F3, F5, F12 probes)

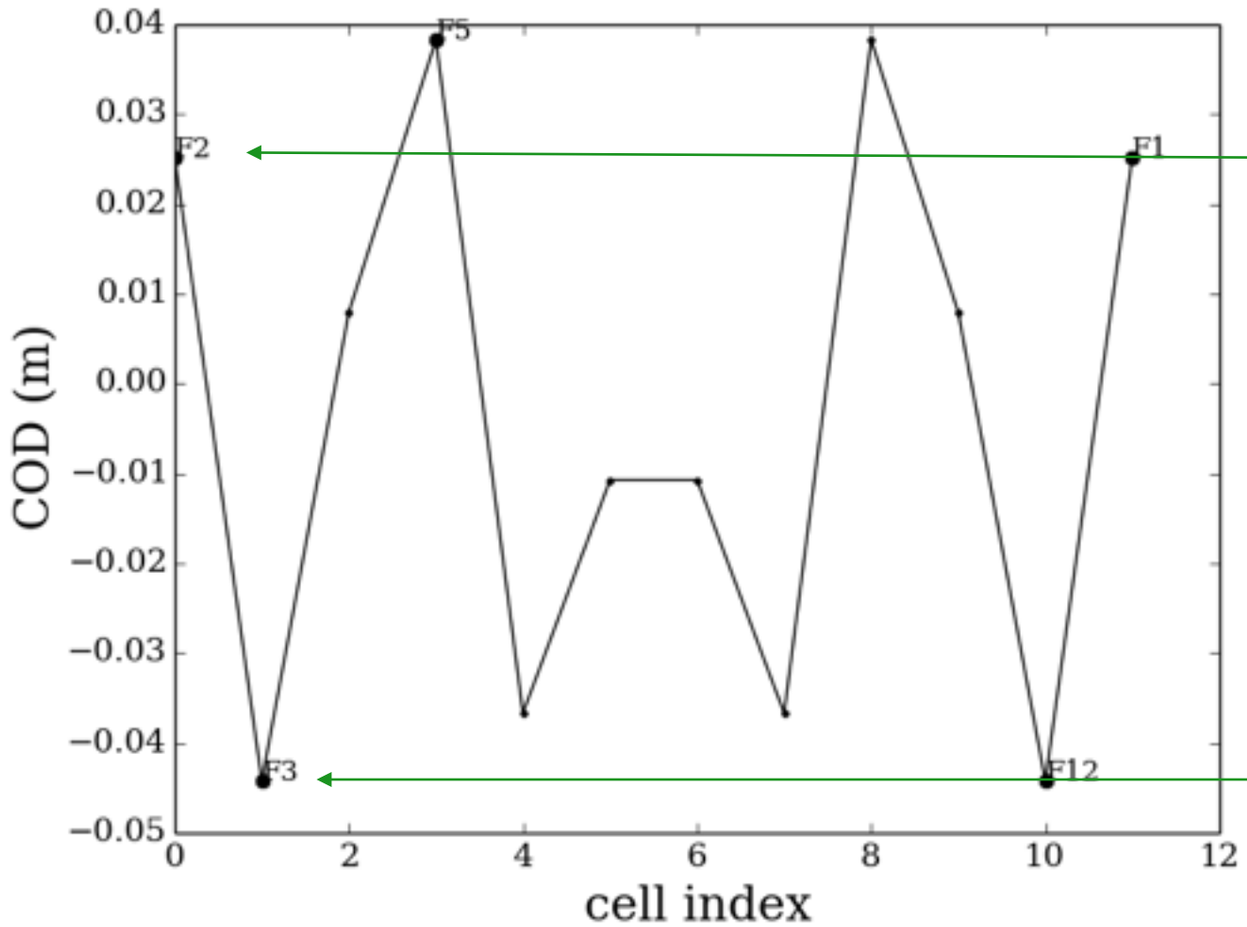


See David's talk?

Note: we expect a ~25% increase in vertical COD because we are now closer to the integer tune…

What do we expect to see?
(From David K, ZGOUBI)

If there is a single error source at cavity location:



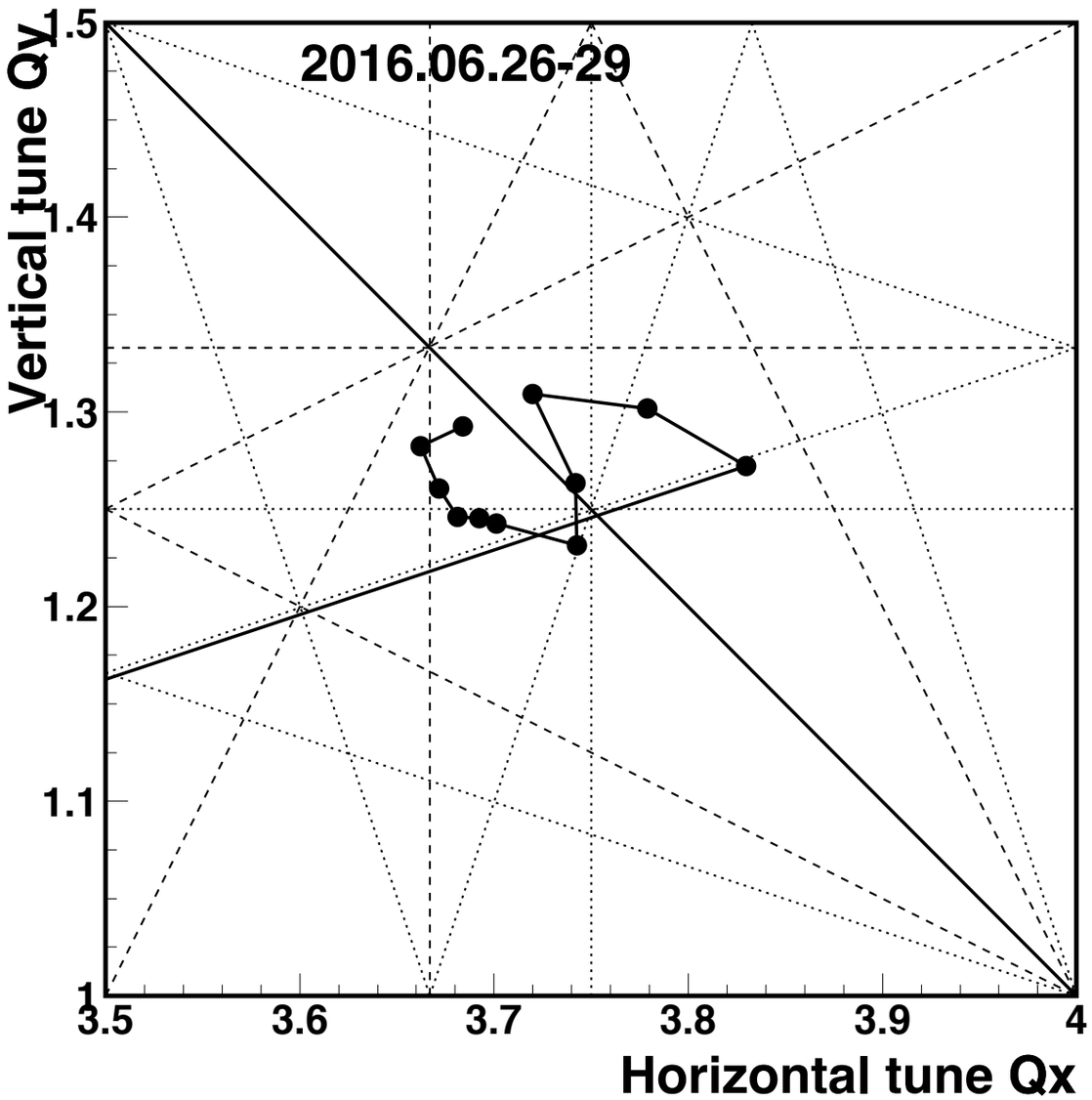
F1, F2 similar

F3, F12 similar

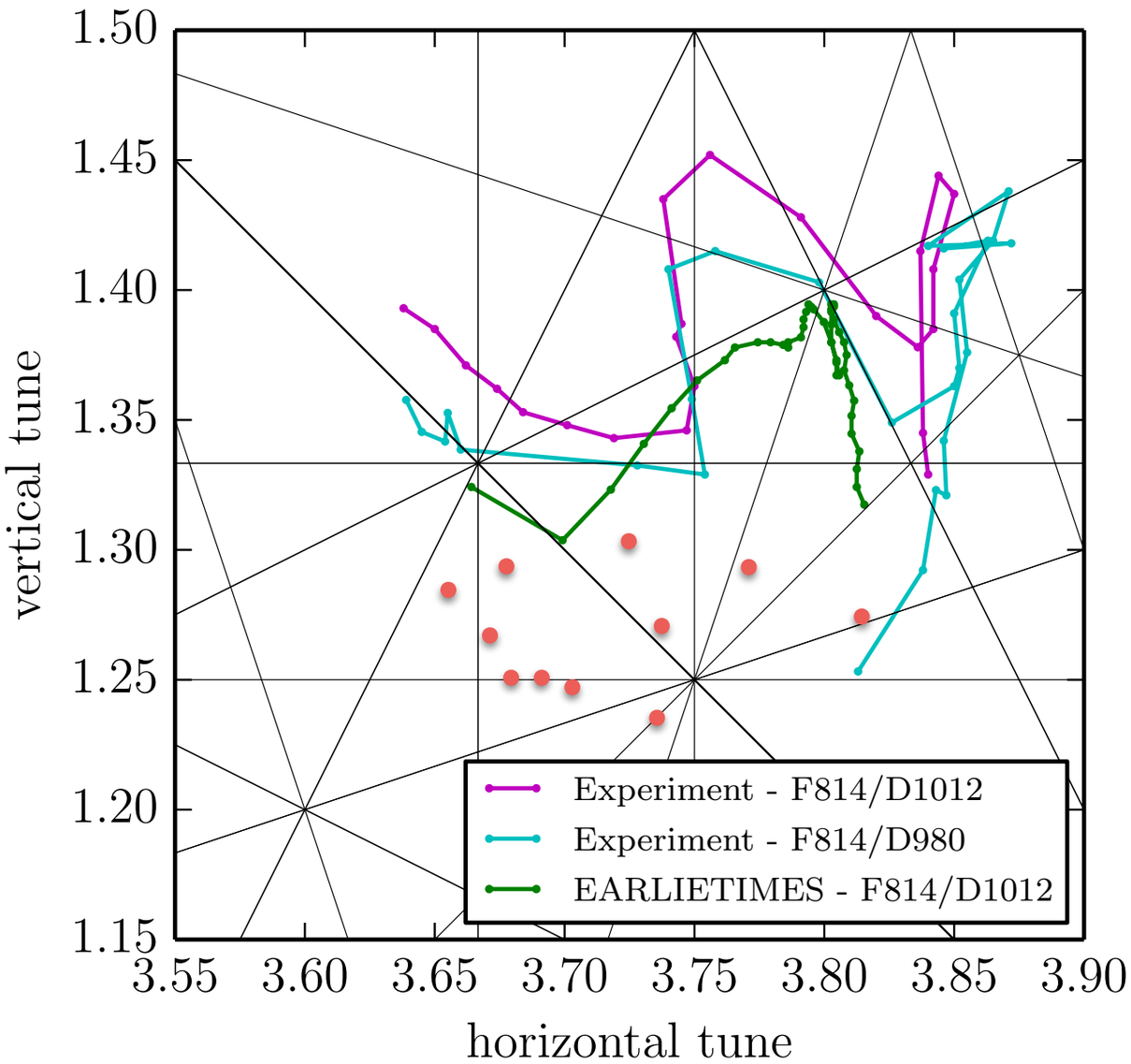
But actually F1,F2 are quite different, indicating additional error source

Betatron tune vs momentum (with corrector)

Data taken Friday 26th & Monday 29th June (ongoing)



cf. from 2014:

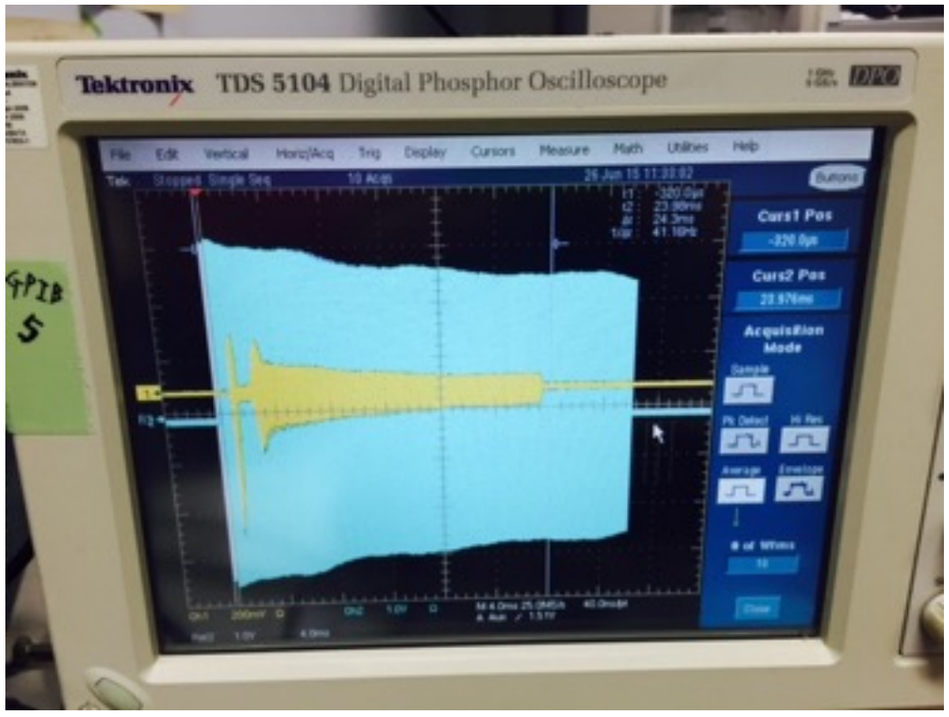


RF pattern testing

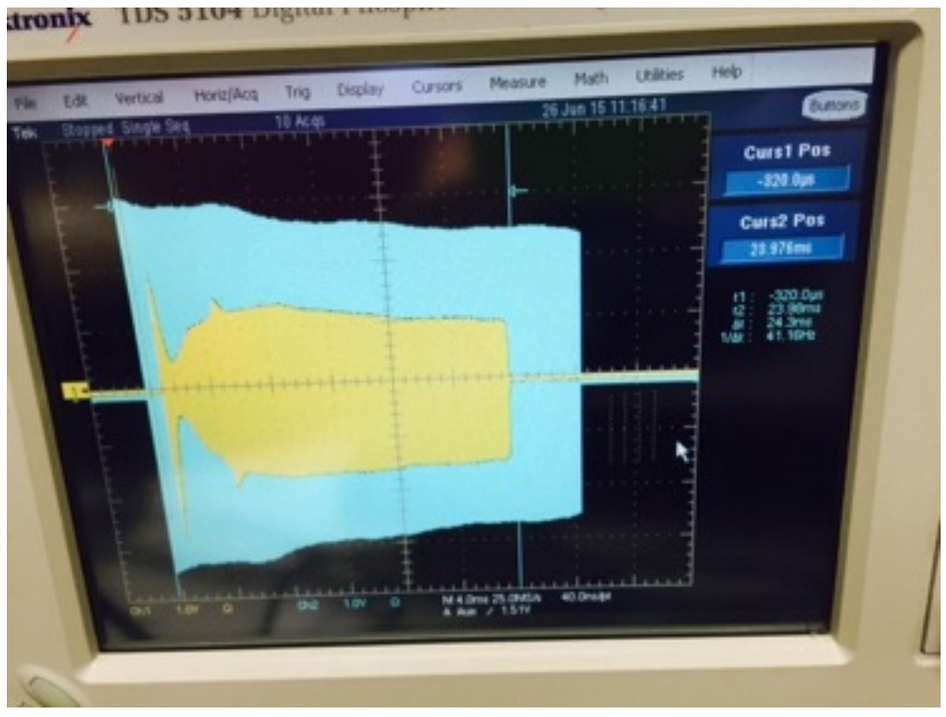
- Using Shinji's debugged script I created 4 test files:

1,2. Phis=30 degree with 4 kV constant voltage, either TOSCA k or const k.

3,4. Phis=20 degree with 4 kV constant voltage, either TOSCA k or const k.



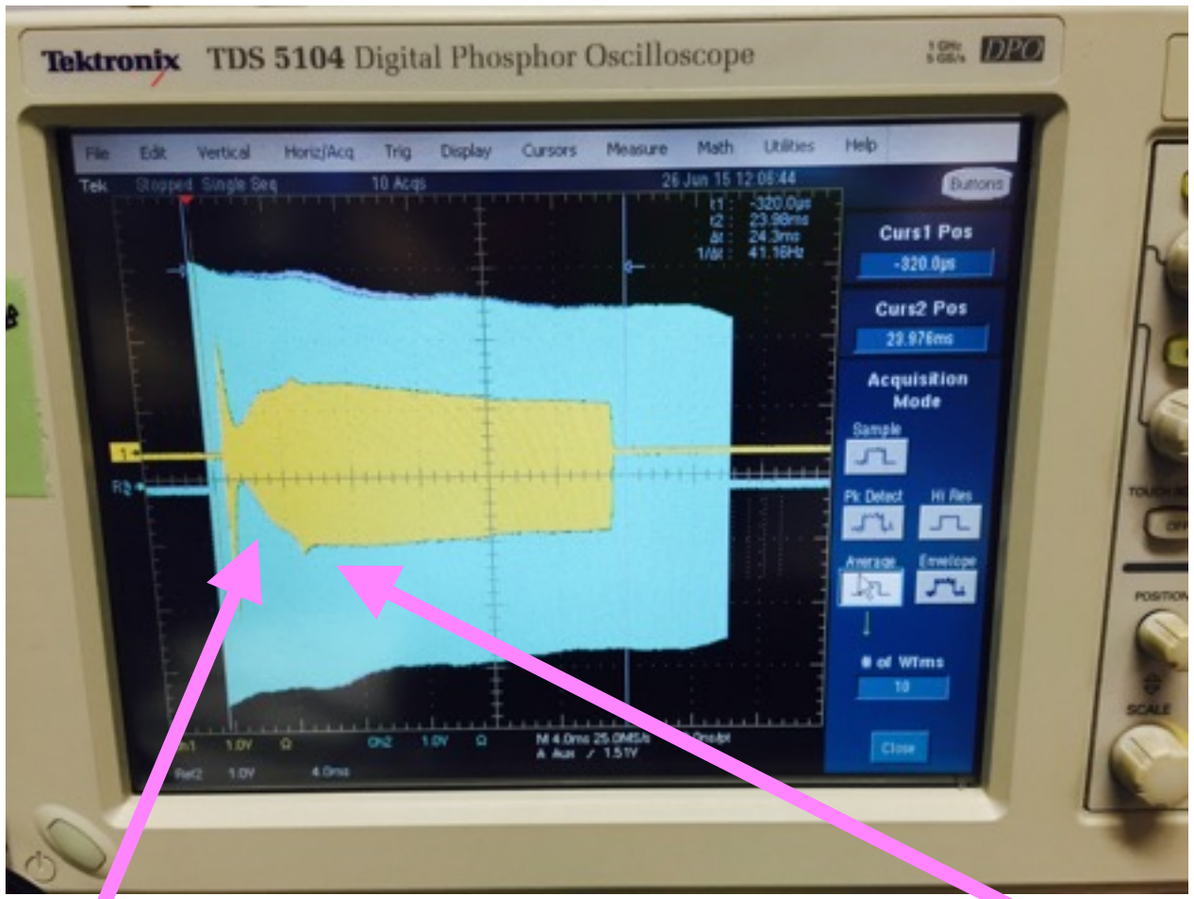
20 degrees, variable k with 0.1ms ramp up

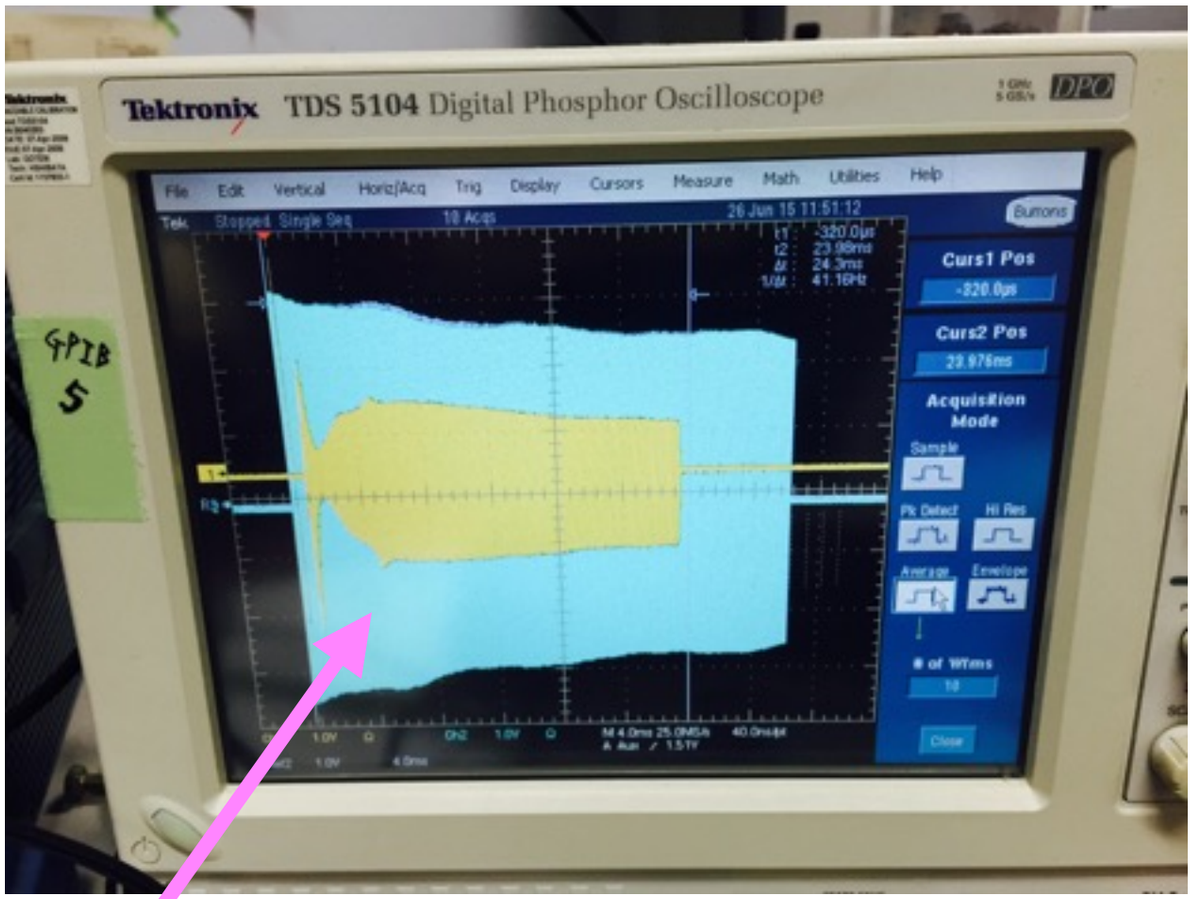


20 degrees, variable k with 0.5ms ramp up

nb. injection setup kept constant for all tests, injection timing small adjustments made

RF pattern testing
Constant k vs variable k, 20 degrees



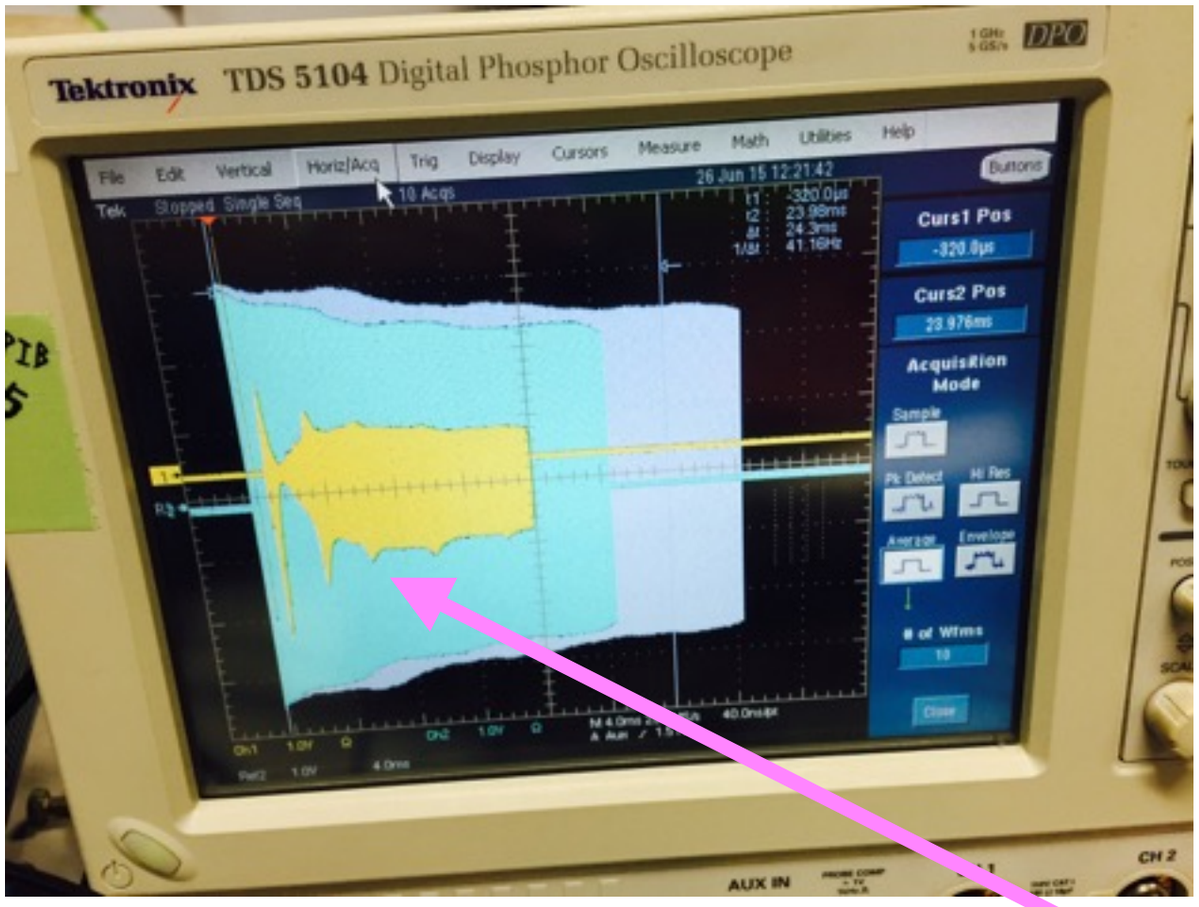


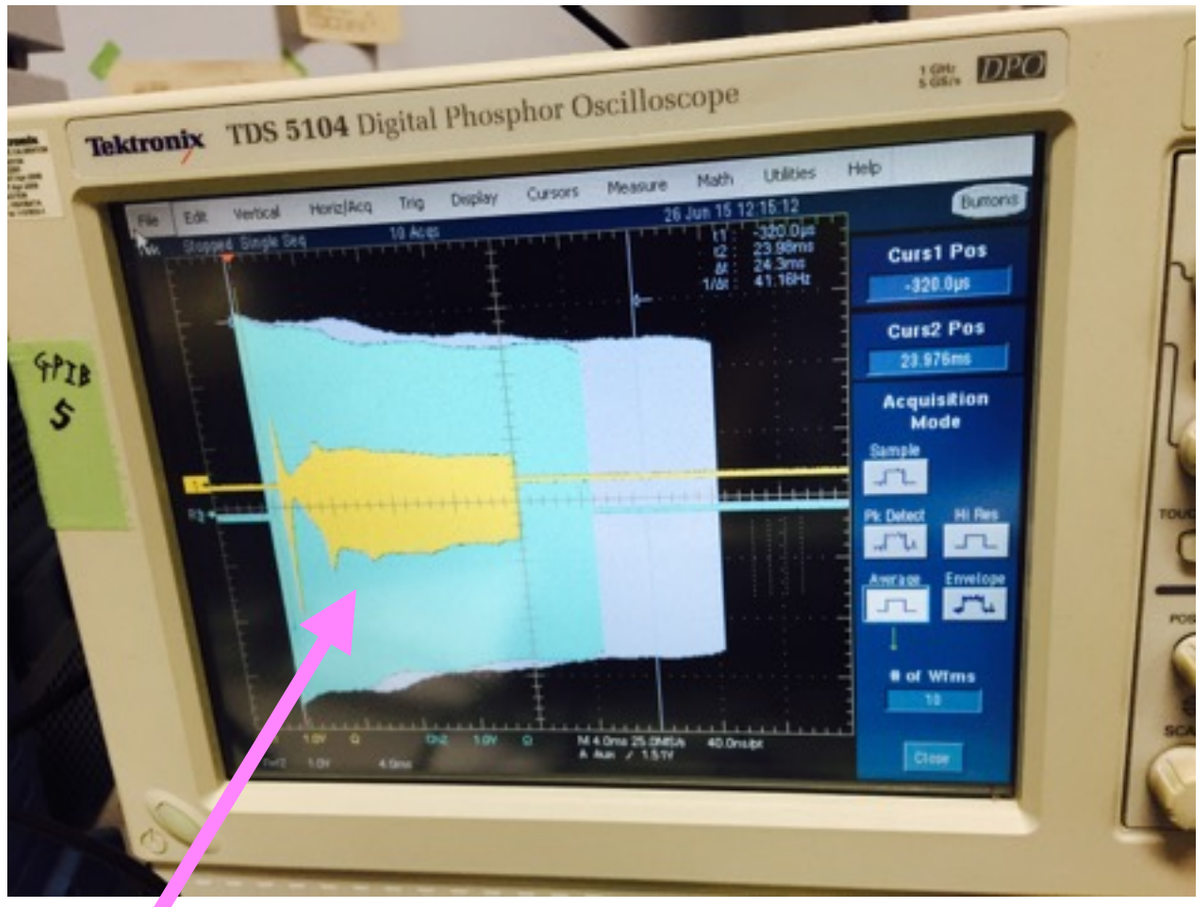
nb. this weird shape after capture is caused by saturation, not ‘real’

but not sure what these bumps are?

RF pattern testing
Constant k vs variable k, 30 degrees

(Slightly lower transmission, same as prev. experience)





still not sure what these bumps are?

Plan for RF optimisation

- On 2/2/15 Shinji proposed ideas for RF optimisation based on adjusting phi_s, voltage, frequency

Step2

Change
1) voltage(t),
2) phis(t) [frequency(t)]

$$BA = 16\alpha(\phi_s)\sqrt{\frac{\beta^2 EeV}{2\pi\omega^2 h|\eta|}}$$

in (phi, E/omega) coordinates space

Three choices
1) Fix voltage and phis. BA increase with acceleration.
2) Fix BA and voltage, vary phis. It increases.
3) Fix BA and phis, vary voltage. It decreases.

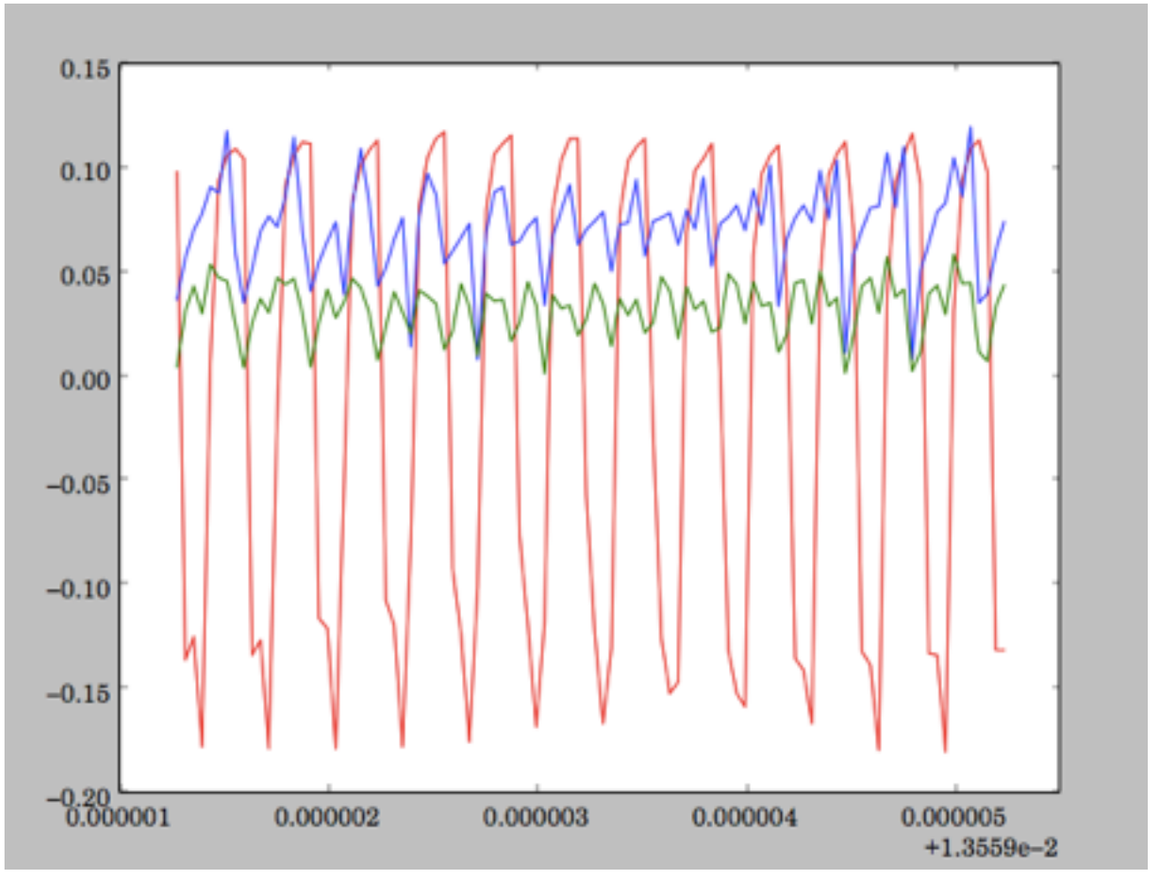
Acceleration speed: 2) > 1) > 3)

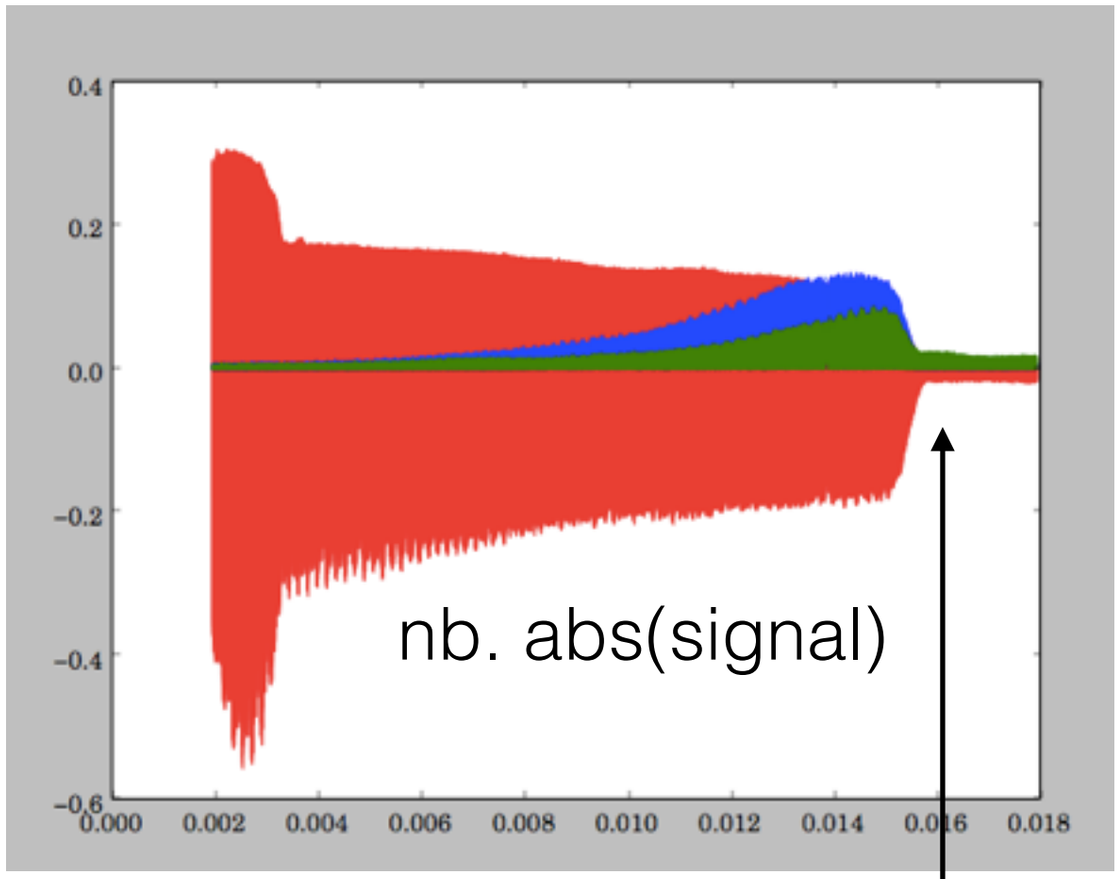
- Thankyou to the team!
- Thanks to David Bruton for his work so far
- (And I hope David Kelliher enjoys the rest of his visit! Good luck!)

Wakayama Castle

Horiz. orbit matching - test

<u>Aims/questions:</u>
Can we see the turn-by-turn BM signal?
Can we determine a position?



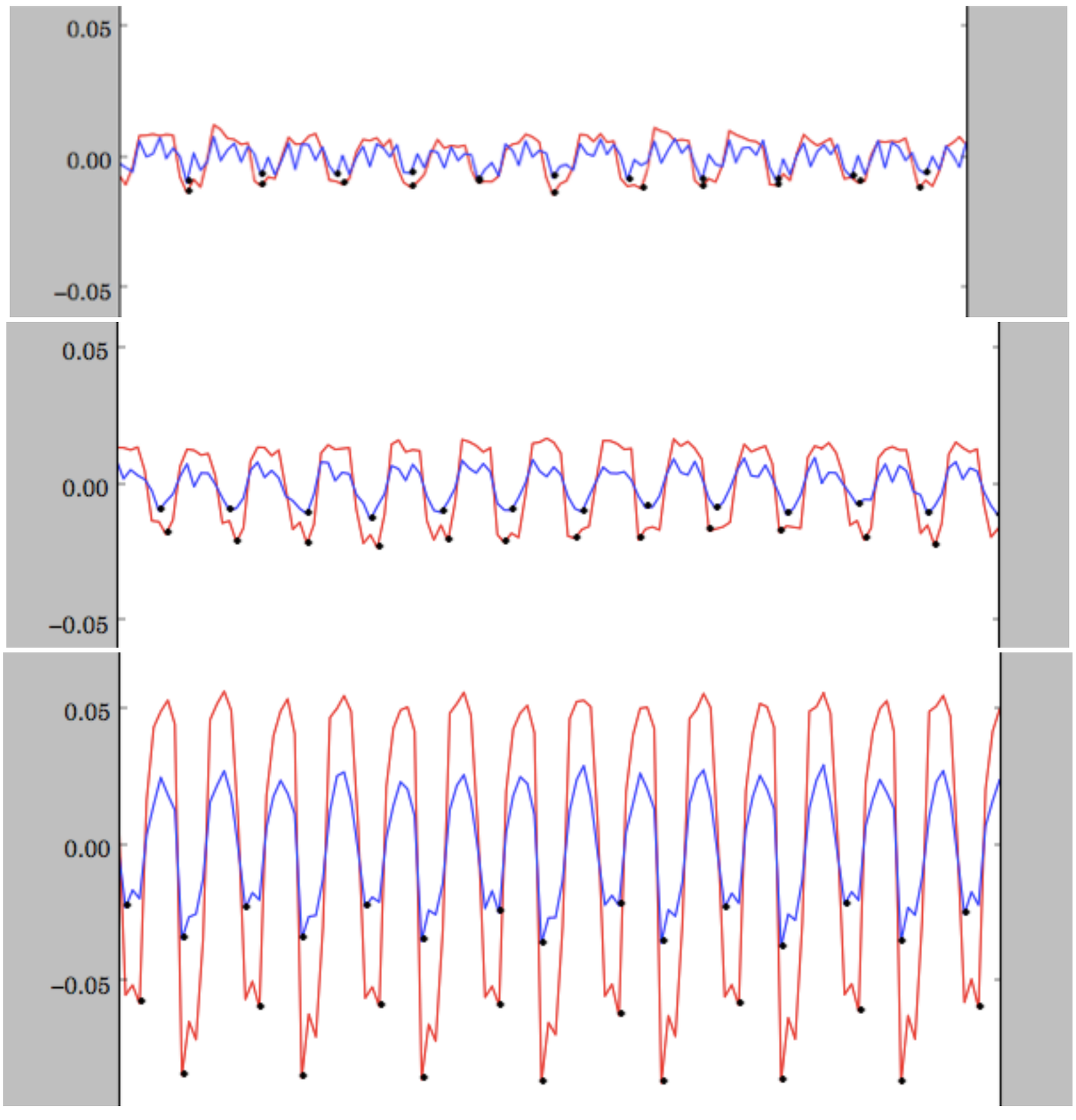


red - S12 bunch monitor
blue & green - radially movable BPM

The beam runs into the monitor…

Trying to get position data out…

Find peaks with window of ~ 400ns (=approx. revolution time in range of interest)



5musec window shown

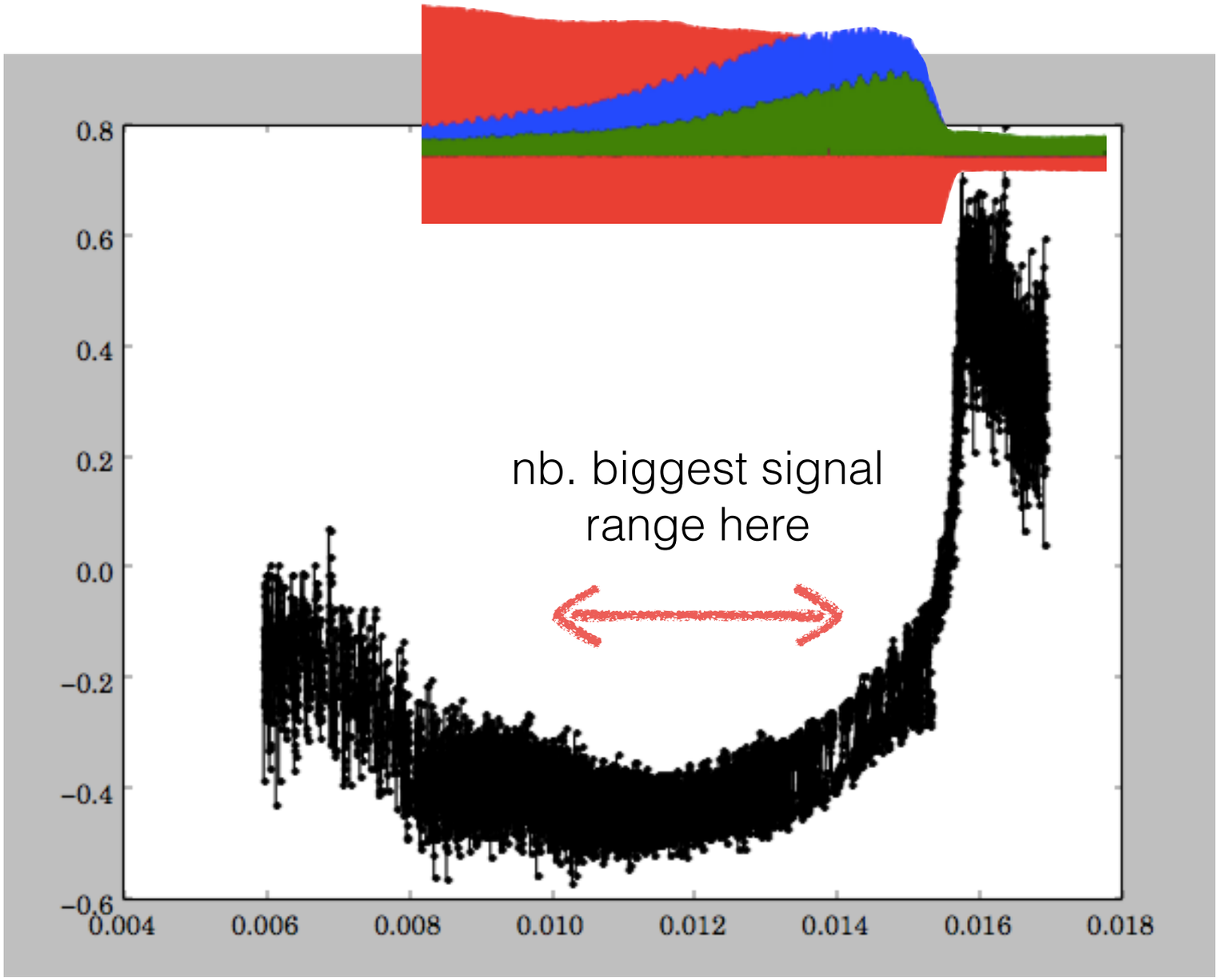
6ms

8ms

12ms

Horiz. orbit matching - test

Check peaks are within a window (10ns) for both plates
“position”=L-R/(L+R) nb. “L” and “R” I don’t actually know which is which right now…



Is this a real moving position? It looks like it…

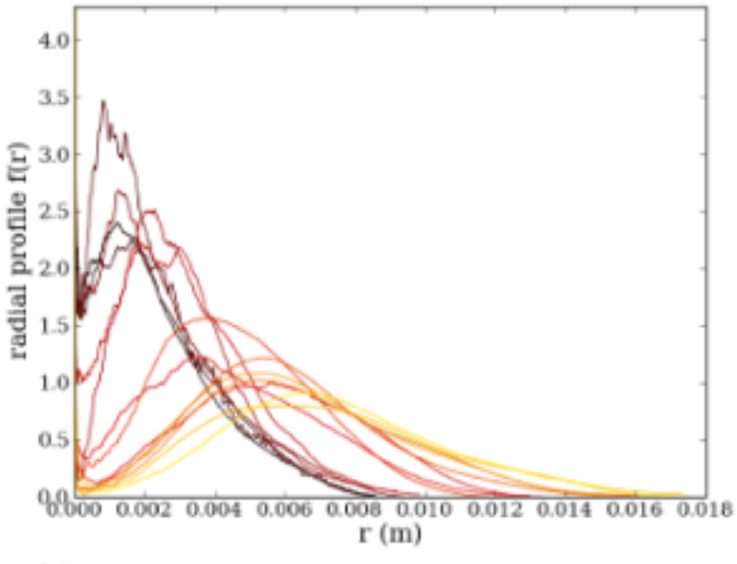
Some extra thoughts:
Measuring beta & emittance
(motivated by Ishi-san)

- Take multiple profile measurements (could we infer this from the scrapers/bunch monitor measurements?)
- Assume phase advance/optics between measurement points
- Least squares fit to find RHS column vector
- At least 3 measurements required to find beta, alpha & emittance (but we can measure emittance this way!)

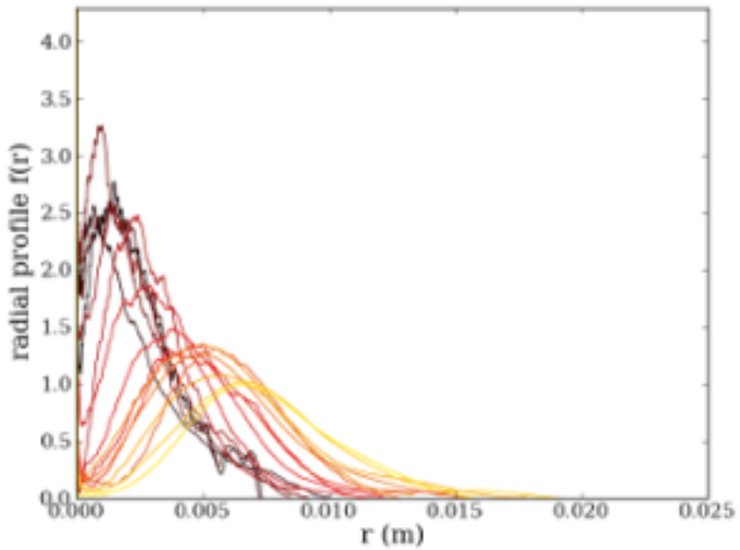
$$\begin{pmatrix} \sigma_x^{(1)2} \\ \sigma_x^{(2)2} \\ \sigma_x^{(3)2} \\ \cdots \\ \sigma_x^{(n)2} \end{pmatrix} = \begin{pmatrix} R_{11}^{(1)2} & -2R_{11}^{(1)}R_{12}^{(1)} & R_{12}^{(1)2} \\ R_{11}^{(2)2} & -2R_{11}^{(2)}R_{12}^{(2)} & R_{12}^{(2)2} \\ R_{11}^{(3)2} & -2R_{11}^{(3)}R_{12}^{(3)} & R_{12}^{(3)2} \\ \cdots & & \\ R_{11}^{(n)2} & -R_{11}^{(n)}R_{12}^{(n)} & R_{12}^{(n)2} \end{pmatrix} \begin{pmatrix} \beta(s_0)\epsilon \\ -\alpha(s_0)\epsilon \\ \gamma(s_0)\epsilon \end{pmatrix}$$

F. Zimmerman, Measurement & Correction of Accelerator Optics, 1998, pp.32

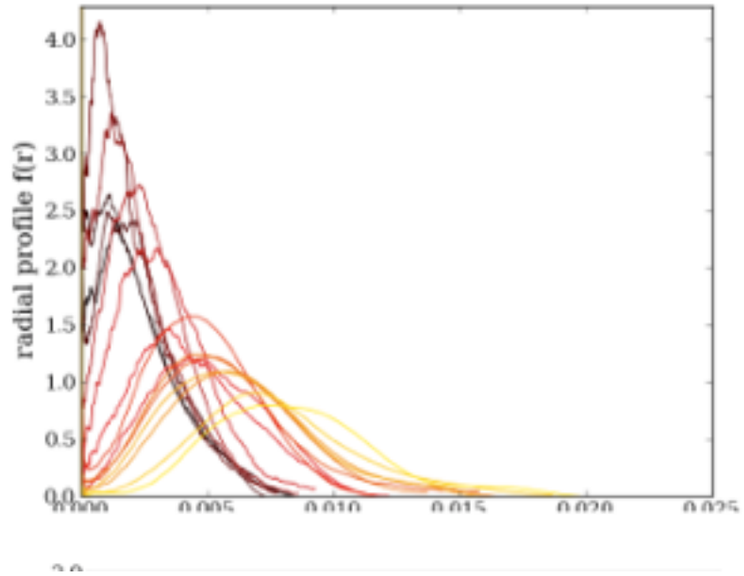
D. Kelliher, 8/4/15
Beam profile measurement using radial probes



F1



F5



F7

Q: Can we use similar data (after some turn #) to reconstruct beta, emittance?
David thinks not, as too many assumptions made in analysis already…