Closed Orbit Measurement

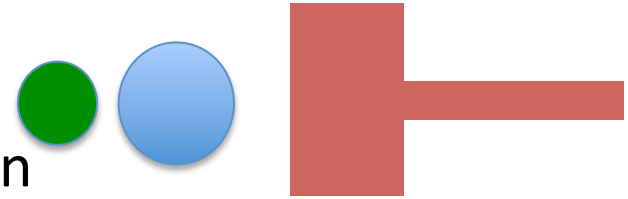
Analysis of Bunch Monitor Data

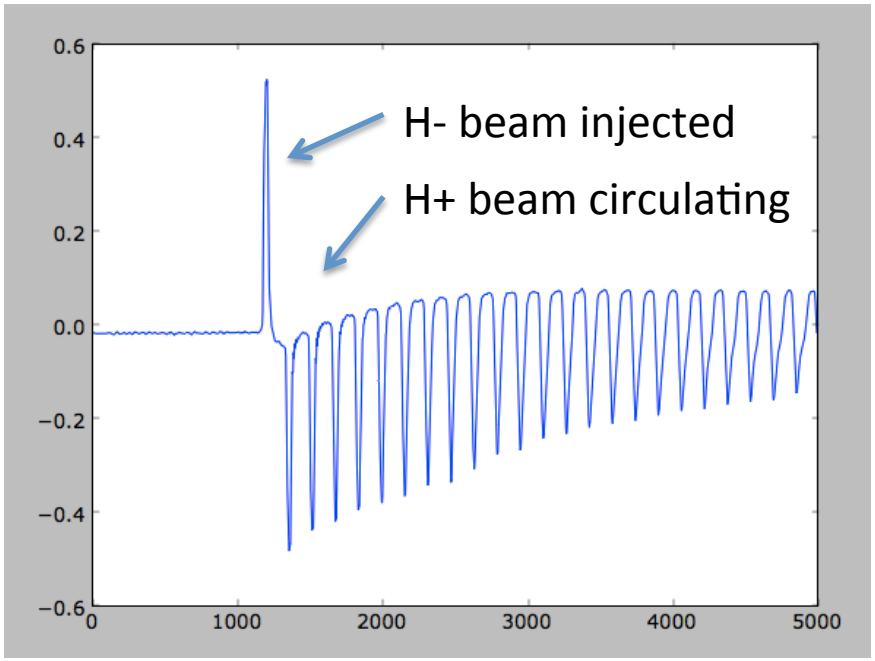
S. L. Sheehy

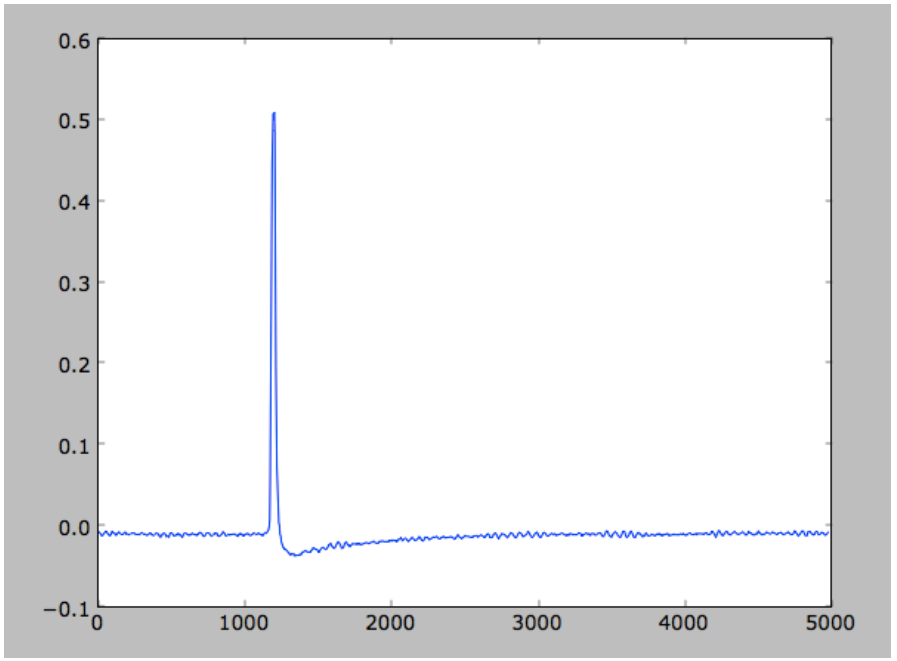
13/11/2013_2

Experimental Setup 13/11/13

1. No RF cavity present
2. Radial probe in centre of straight section
3. Vary position of probe in 5mm steps
4. Record signal from parallel bunch monitor (located after injection foil)

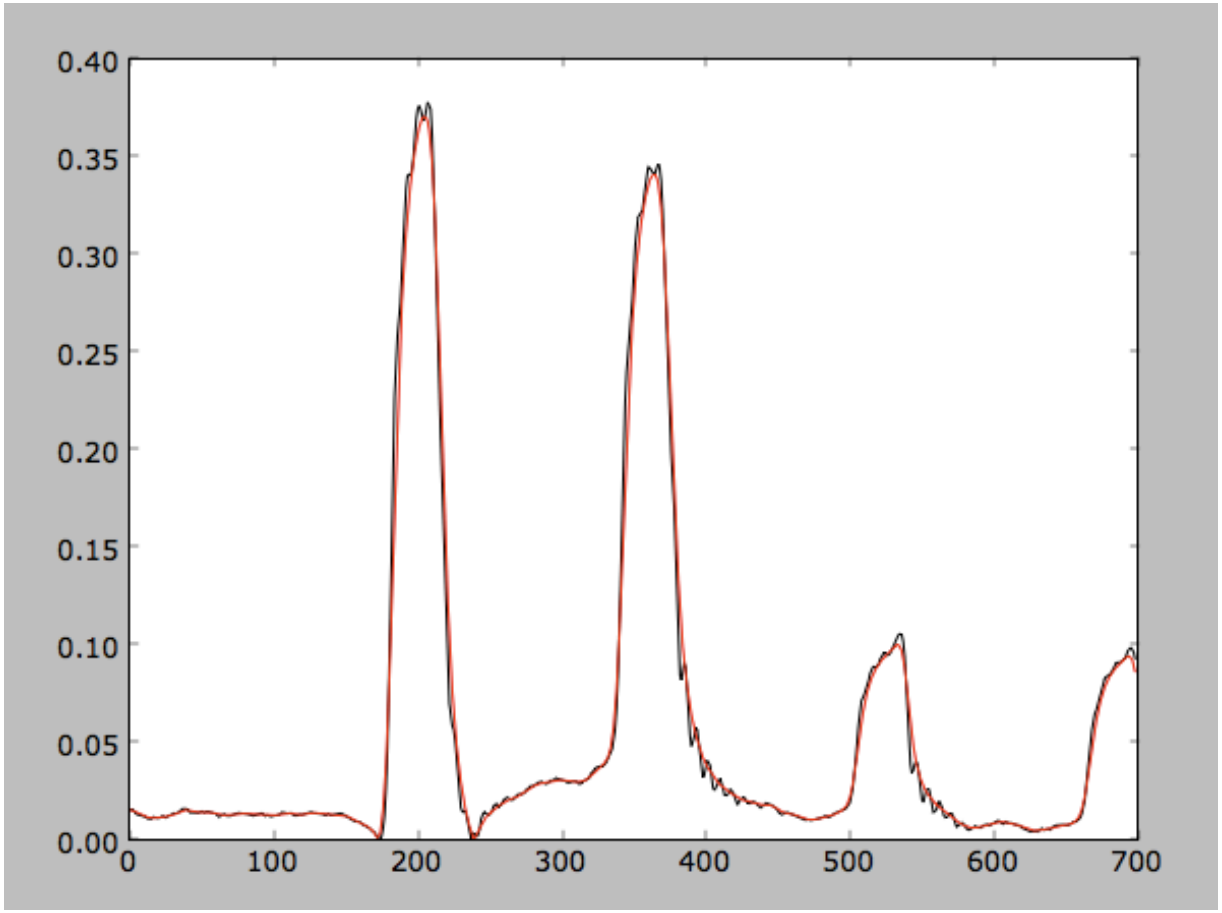






Data smoothing

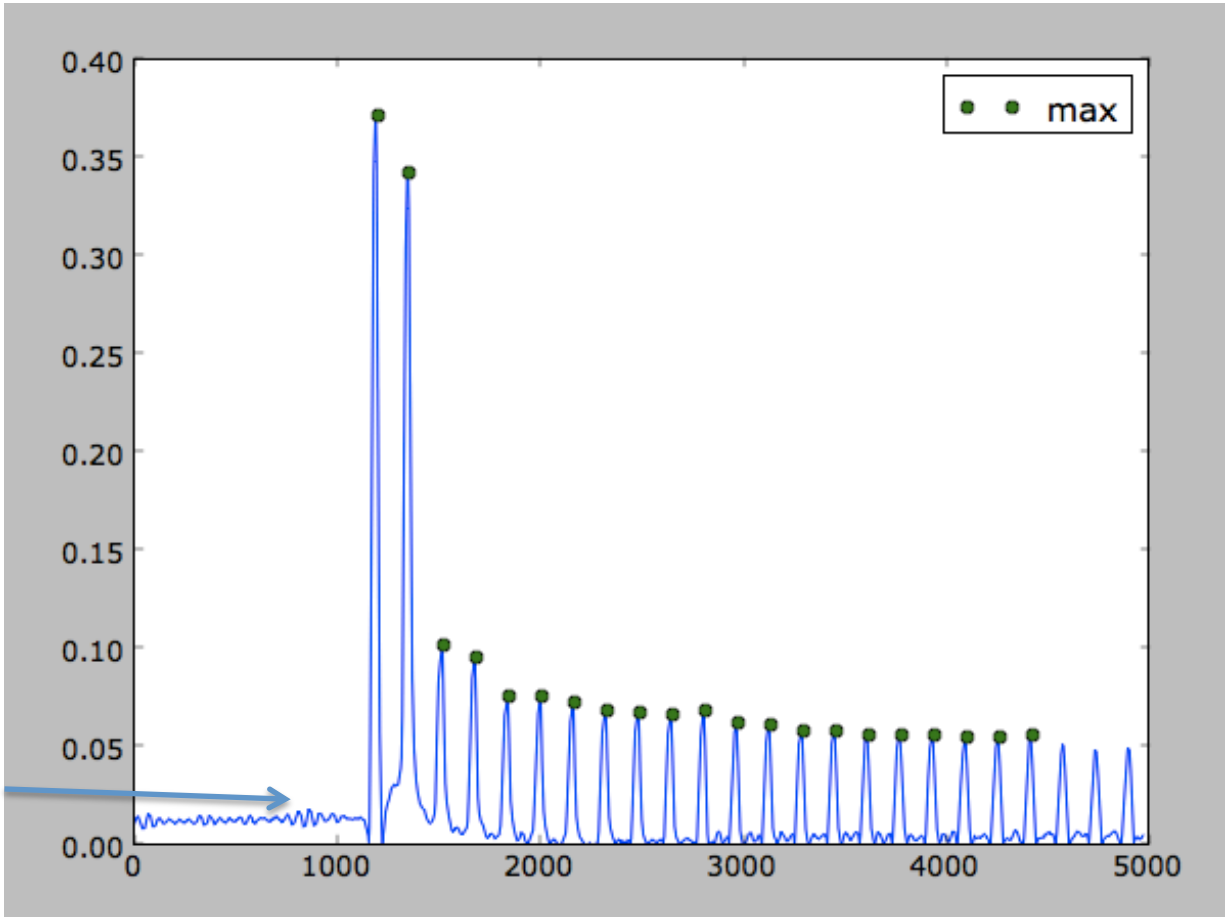
Data is quite jittery making peak-finding difficult. Gaussian smoothing applied.
Can control degree of smoothing by choosing how wide the convolving gaussian is. (I used 10, seems reasonable…)
Code snippet explained here: http://www.swharden.com/blog/2008-11-17-linear-data-smoothing-in-python/
For more methods, see here: http://wiki.scipy.org/Cookbook/SignalSmooth



(note: absolute value of data plotted here for first few turns…)

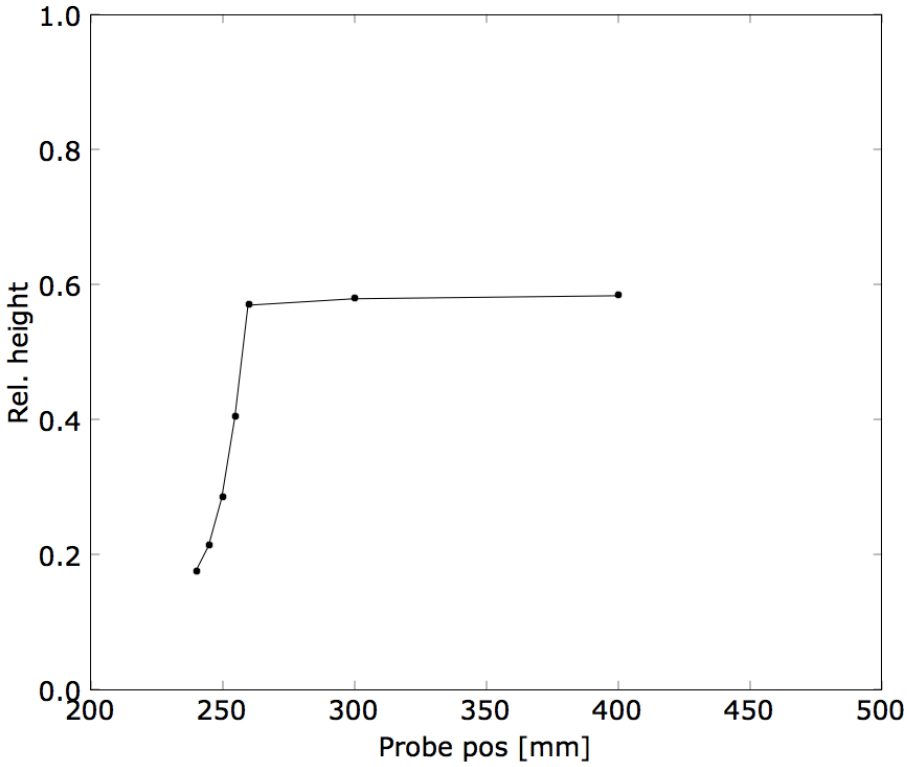
Peak finding

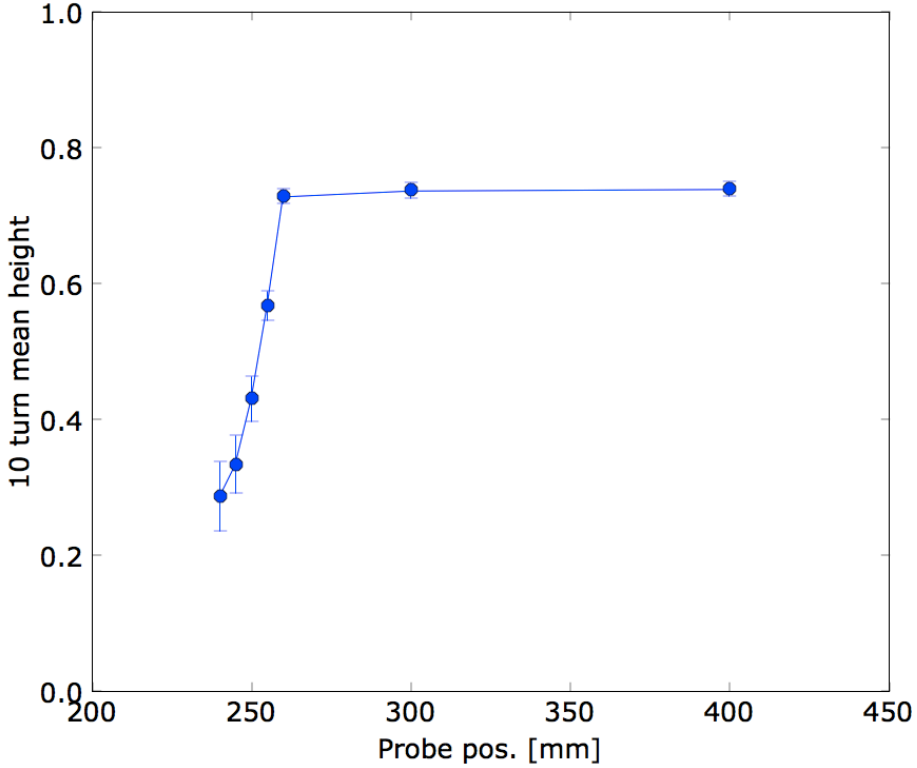
1. Method: take derivative of (smoothed) data `[in python: diff(data)]`
2. Find sign of gradient (increasing/decreasing)
3. Find where the gradient of the sign changes
4. Take the downward crossings only (gives maxima rather than all extrema)
5. Store array indices



I use a threshold of 2.5*mean(data) so I don't get lots of tiny peaks!

Closed orbit measurement



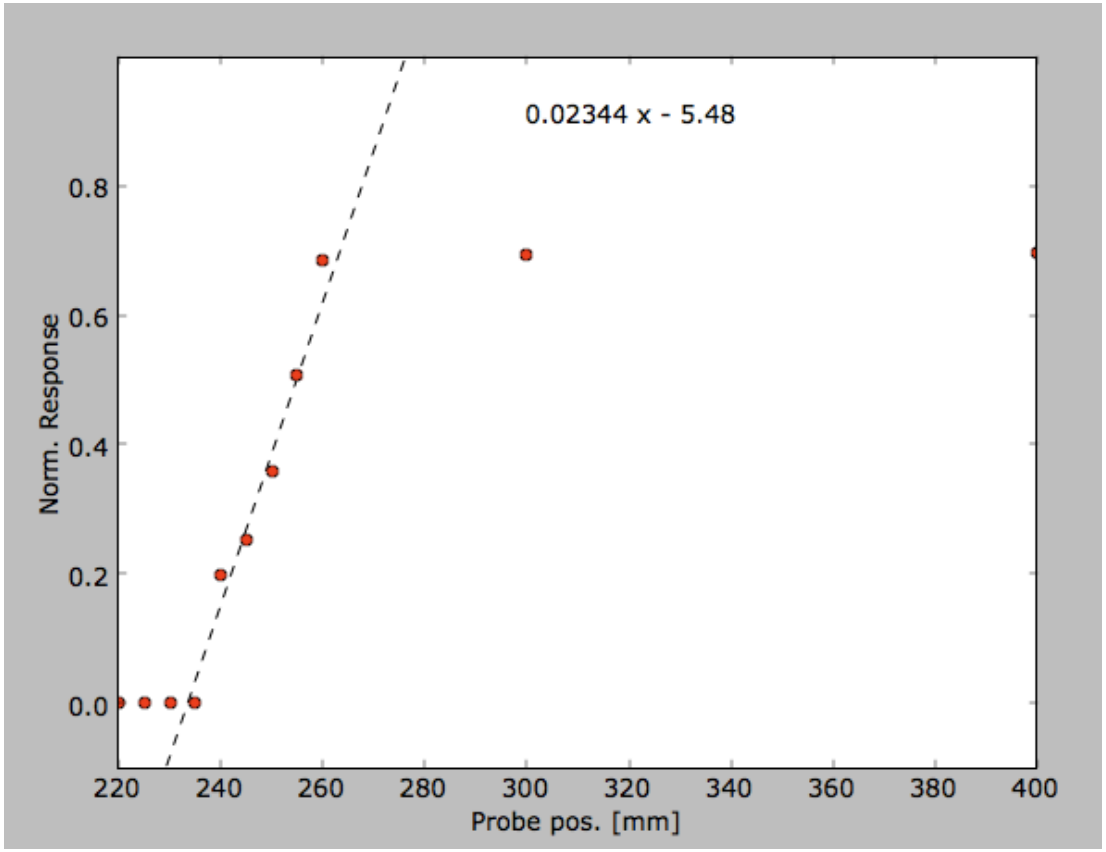


After finding peaks:
Existing method: Take 10th turn height
Normalise wrt. 0^{th} turn height
Plot against probe position

After finding peaks:
Take mean height of first 10 turns
Normalise wrt. 0^{th} turn
Plot against probe position
(Error is just the variance)

Using peaks 3-10

- Error bars plotted from variance (very small!)
- Simple linear fit gives CO position = 233.8 mm
  - Not much point doing a weighted fit as it would just give CO = 235 mm?
  - I think most accurate result is probably just from experimental accuracy
- Error sources: 1mm smallest step on scale, uncertainty in flange position ~ 1mm



Fit result = 233.8 mm
Best estimate = 235 ± 2 mm

Orbit shift with D magnet current

Analysis of Bunch Monitor Data

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13/11/2013_3 Data

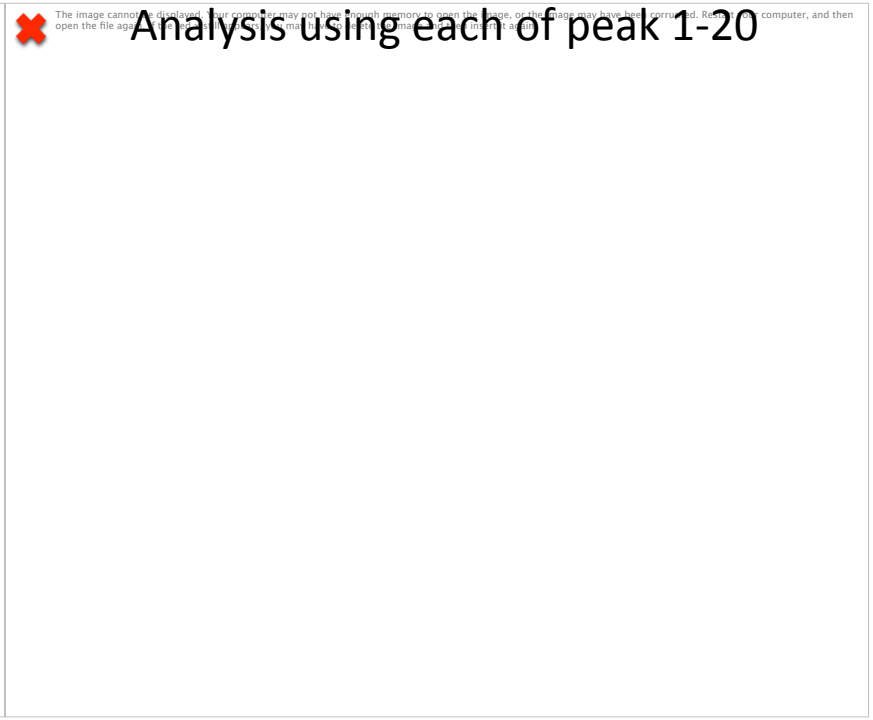
Experimental Method

- Keep radial probe at 245mm
- Vary D magnet current
- See how much the response varies (due to orbit shift)
- This will only give a change in BPM response (can't currently translate this to actual position!)

Detail… how many turns to use for analysis?

Response vs. B current gradient

Analysis using each of peak 1-20

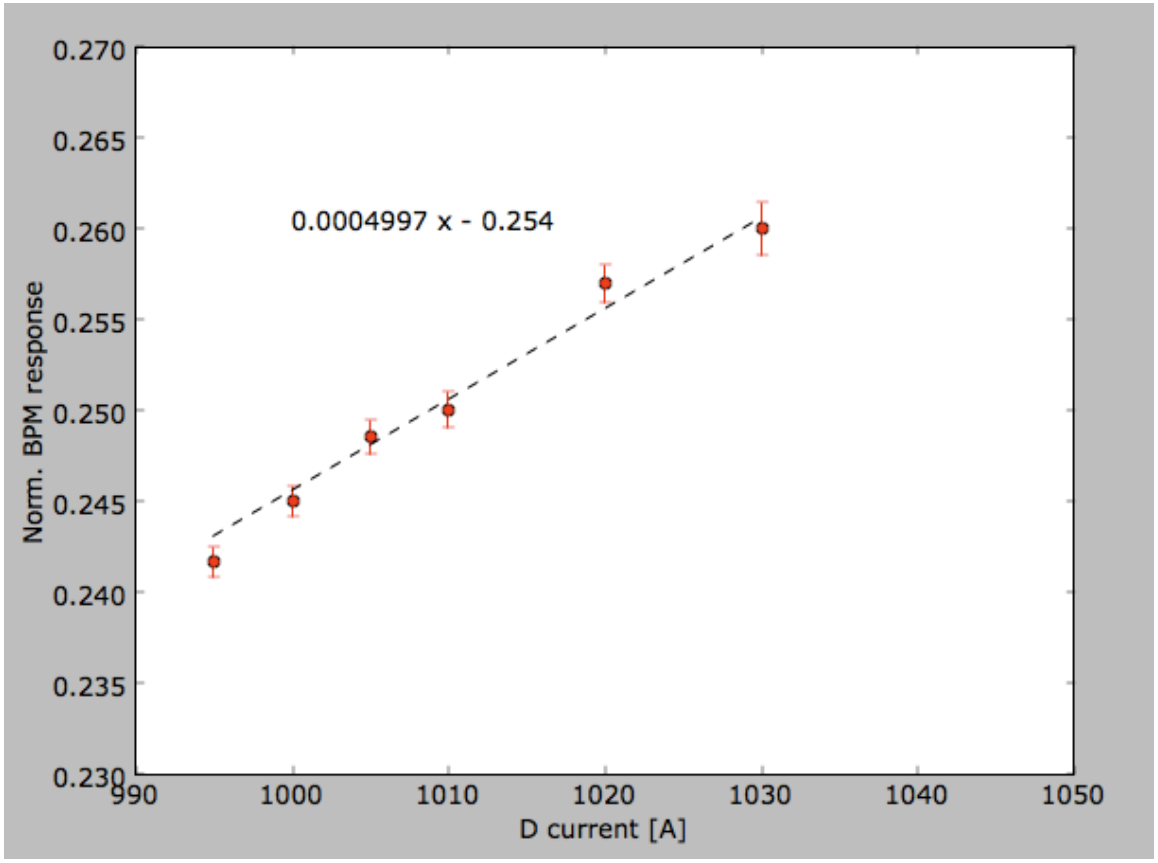


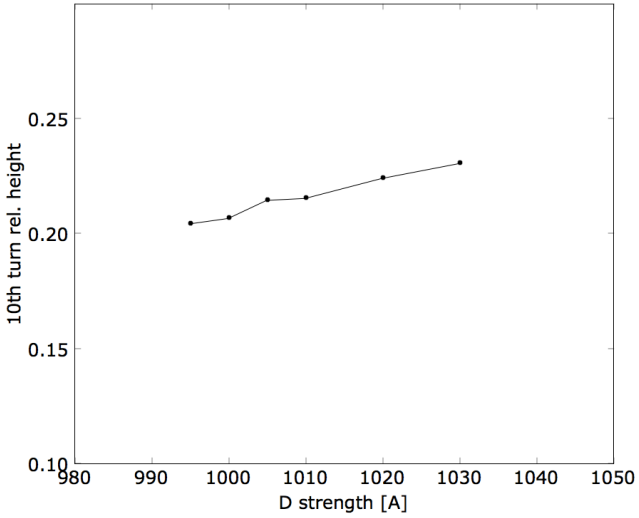
Normalised wrt value at 995A

So in fact existing method taking turn 10 is pretty good…
this is where the response gradient ‘flattens out’

BPM Response vs D strength

Using turn 3-10





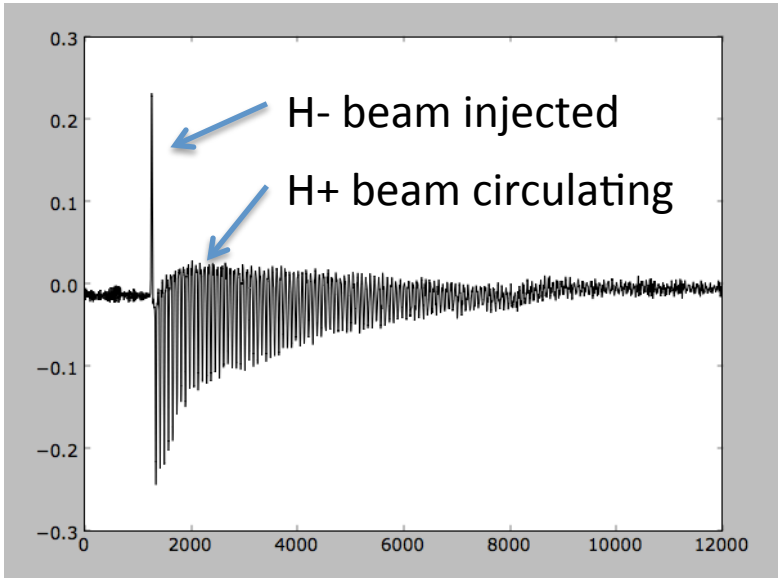
Very similar response if done using 10^{th} turn height

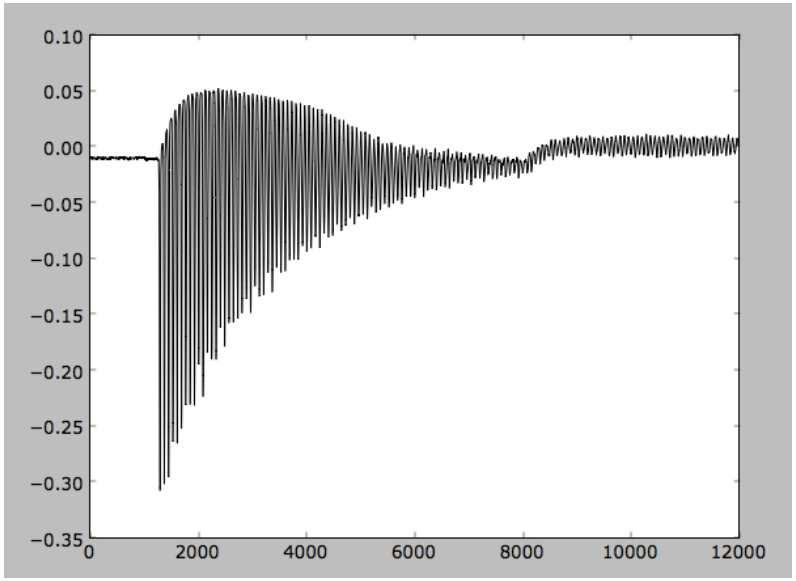
Tune Measurement
Analysis of Bunch Monitor Data

S. L. Sheehy

Experiment 13/11/2013

Method

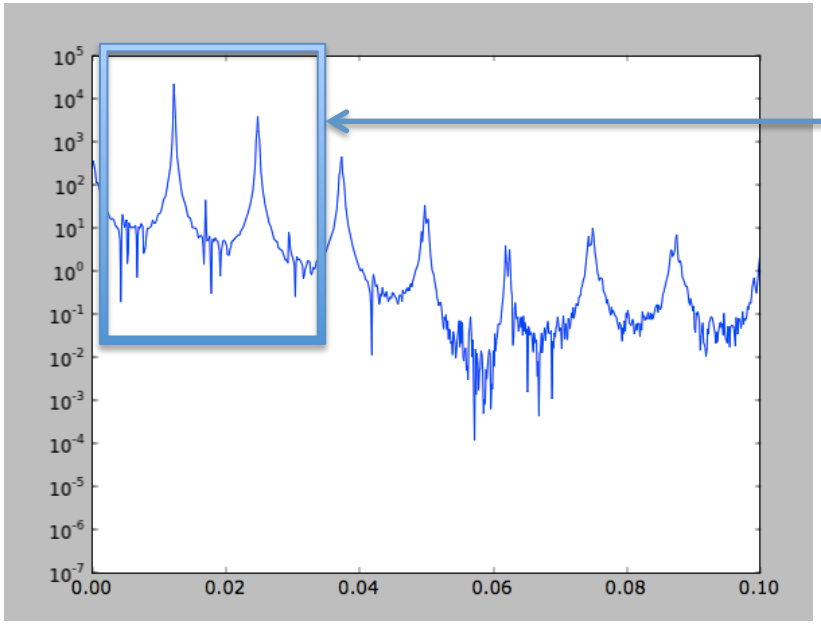


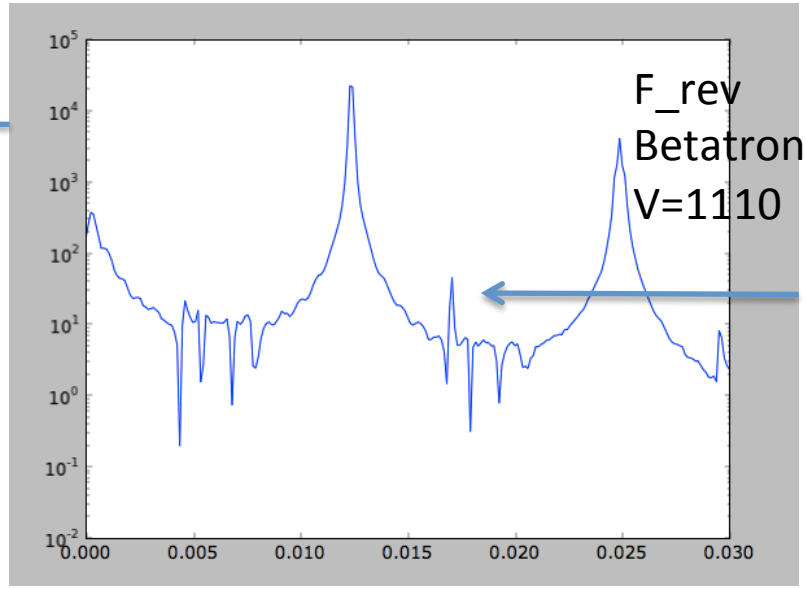


LEFT: sum signal from double plate bunch monitor
located just after injection

RIGHT: single plate monitor
located further round the ring

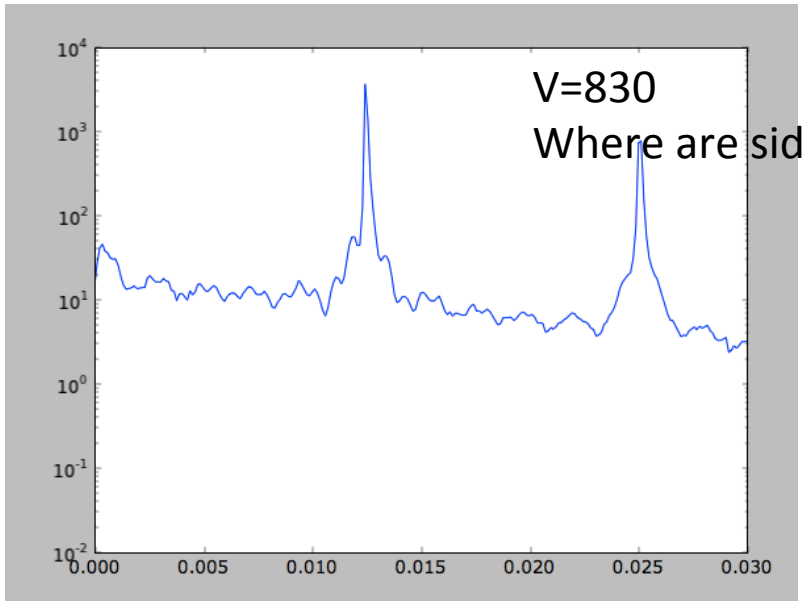
FFT





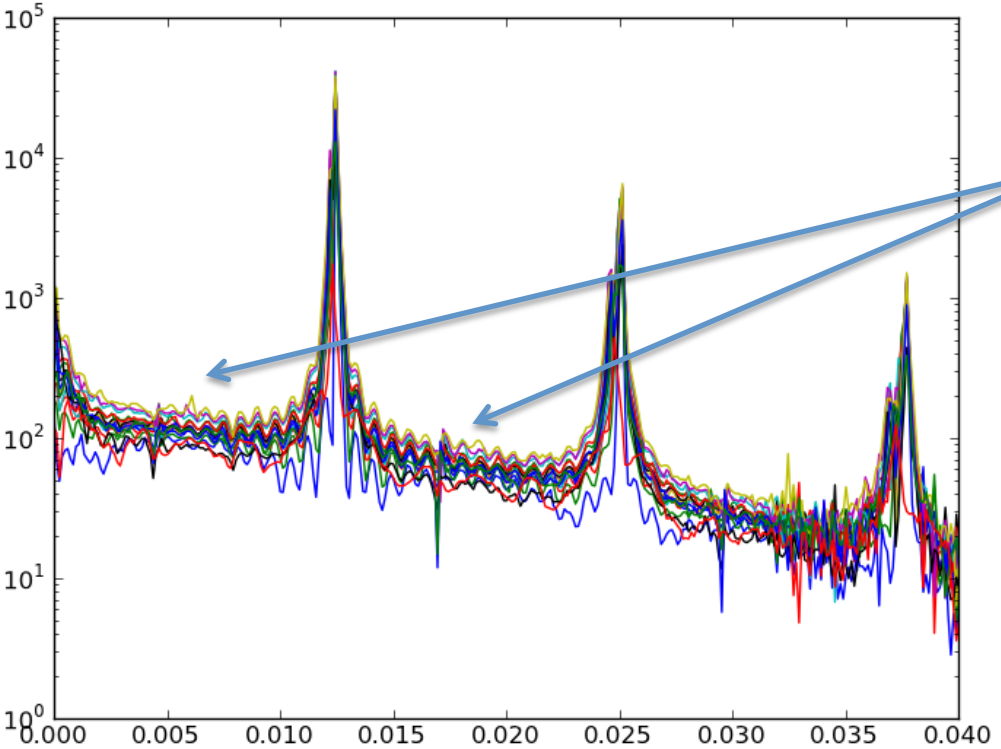
F_rev
Betatron sidebands?
V=1110

FFT of raw ‘hebi’ data
(power spectrum)
Log scale (vertical)
Plotted only in low frequency range
Main peaks at h*F_rev



V=830
Where are sidebands??

13/11/2013
RF-Free Lattice Tune Measurement



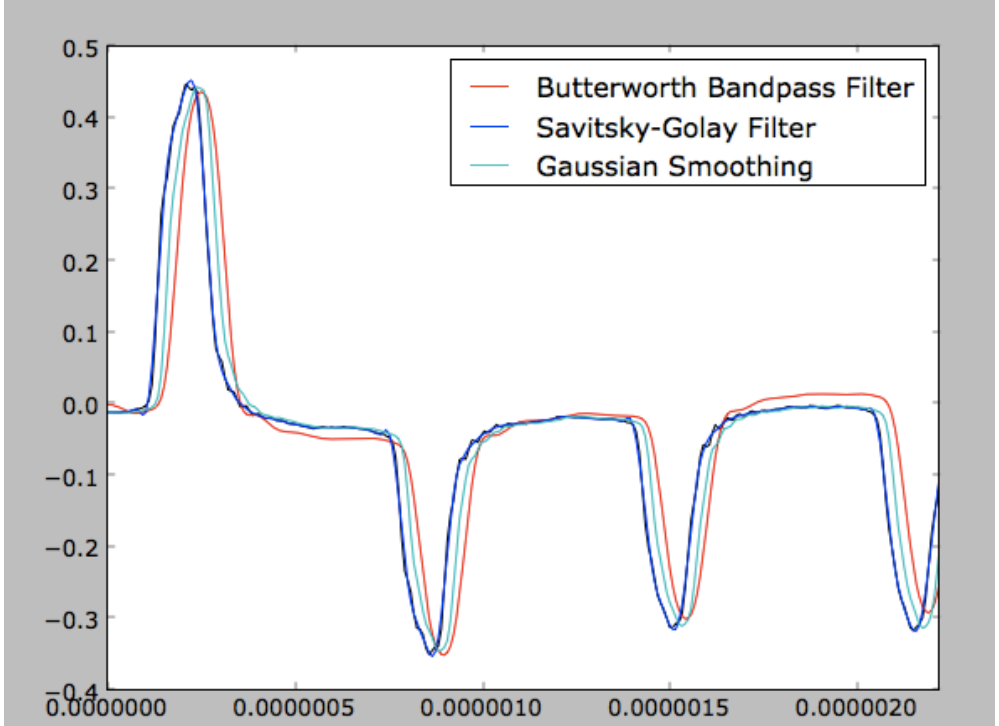
Betatron sidebands?
Tough to find…?

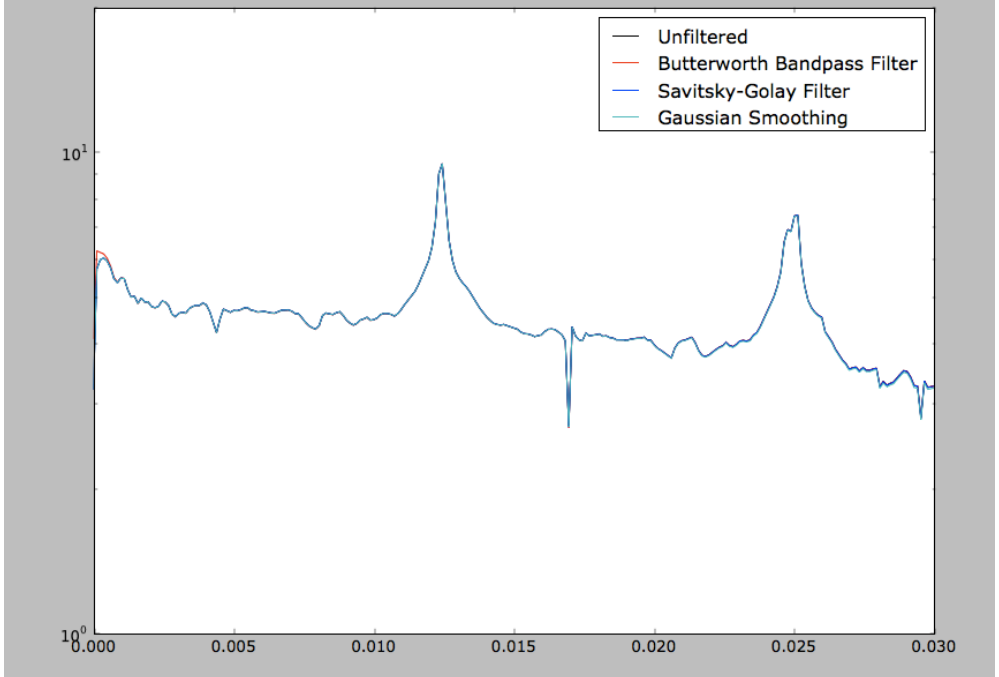
1. De-trend data as per:
http://docs.scipy.org/doc/scipy/reference/generated/scipy.signal.detrend.html

Filtering?

- Used various filters on the raw data before taking FFT:
  - BB = bandwidth filter
    - 200Hz – 10000Hz (4^{th} order)
  - SG = removes high freq noise
    - Using 4^{th} order polynomial
  - Gaussian smoothing (convolved with data)

- As I suspected, this turns out not to be so useful… !





I am working on this…