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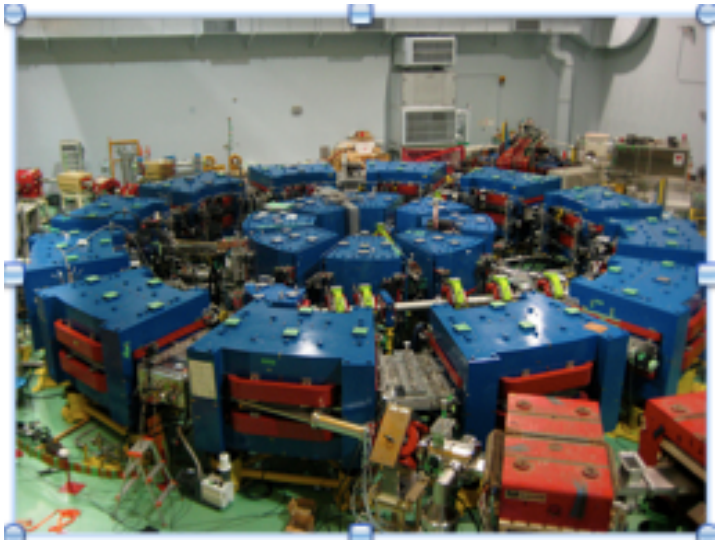
KURRI-FFAG
Overview of Experimental Visit November 2013



Suzie Sheehy, ASTeC/STFC/RAL

20th November, 2013

Overview

- Aims of visit:
  - Learn about the ADSR-FFAG
  - Understand diagnostics
  - Assist in taking experimental data
  - Understand data analysis methods
  - Consider needs for high intensity experiments
  - Strengthen collaborative efforts

Measurements:

Week 1: RF Cavity OUT

'Bare Lattice Measurements'

- Vertical tune measurement
- Closed orbit measurement
  - + emittance estimate
- Installation of new corrector coil

Week 2: RF Cavity IN

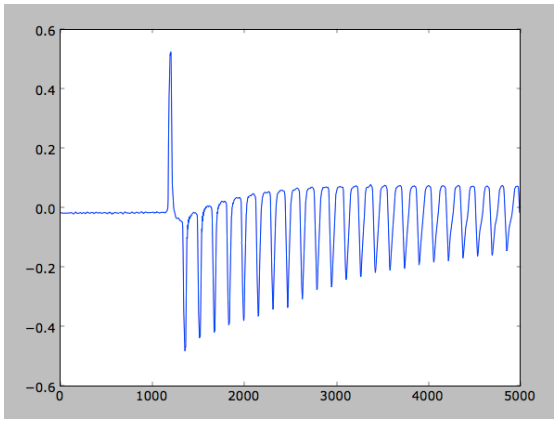
- First look at effects of corrector with RF cavity in place
- Closed orbit measurement with acceleration
- Effects of new corrector coil
- (Reduce injection error?)

RF-Cavity Out measurements

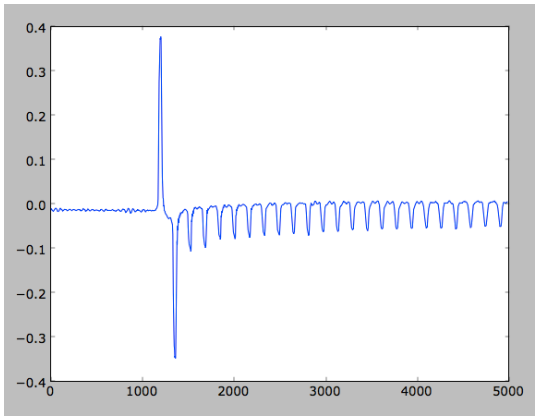
- Important to understand ‘base’ lattice without effect of magnetic material in the RF cavity
- Compare measurement of closed orbit and tune to simulation values

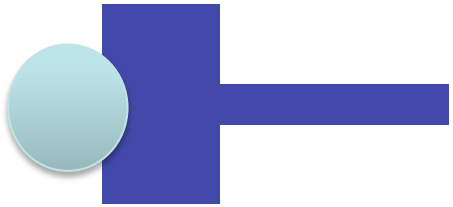
- KURRI team already took data of closed orbit using probes at centre of F magnets, also wanted to confirm closed orbit position in straight section.

Closed Orbit in Straight Section - Method
Data: 20131113_2

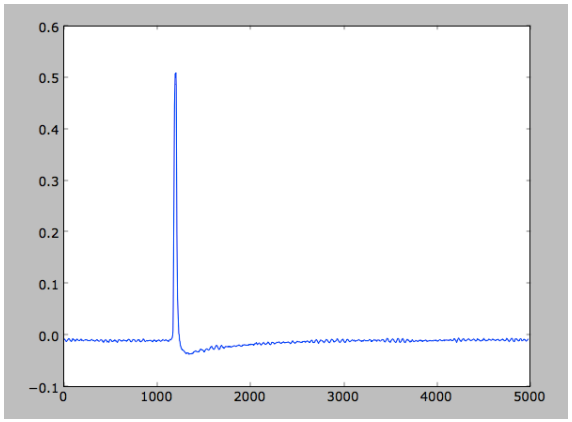


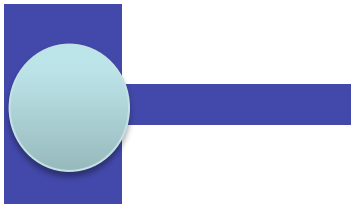
Probe doesn't stop beam





Probe stops part of beam





Probe fully stops beam

$$\text{Norm. response} = \frac{\text{peak height of nth turn}}{\text{peak height of } 0^{th} \text{ (H−) turn}}$$

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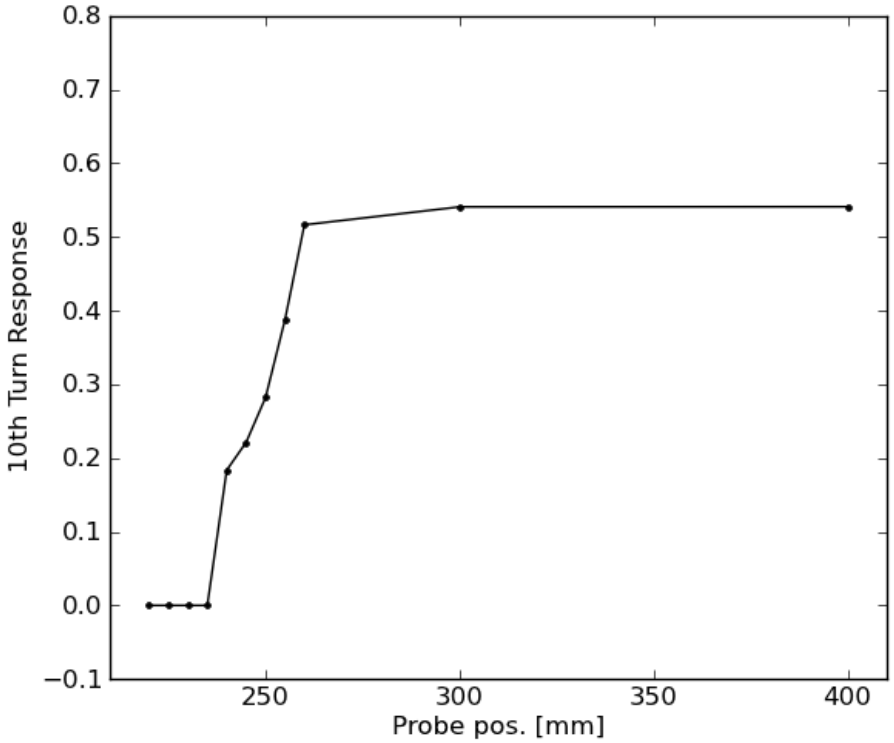
Closed Orbit in Straight Section
Data: 20131113_2



y=0 intercept gives CO position
Best estimate = 235 ± 2 mm

NB. Unweighted linear fit gives
Fit result = 233.8 mm
We don't use this as it doesn't take into account the fact that the measurements <235mm had no circulating turns.

$(r_{co} = 4180 + r_{probe})$

Predicted CO = 4411 mm
Measured CO= 4415 ± 2 mm

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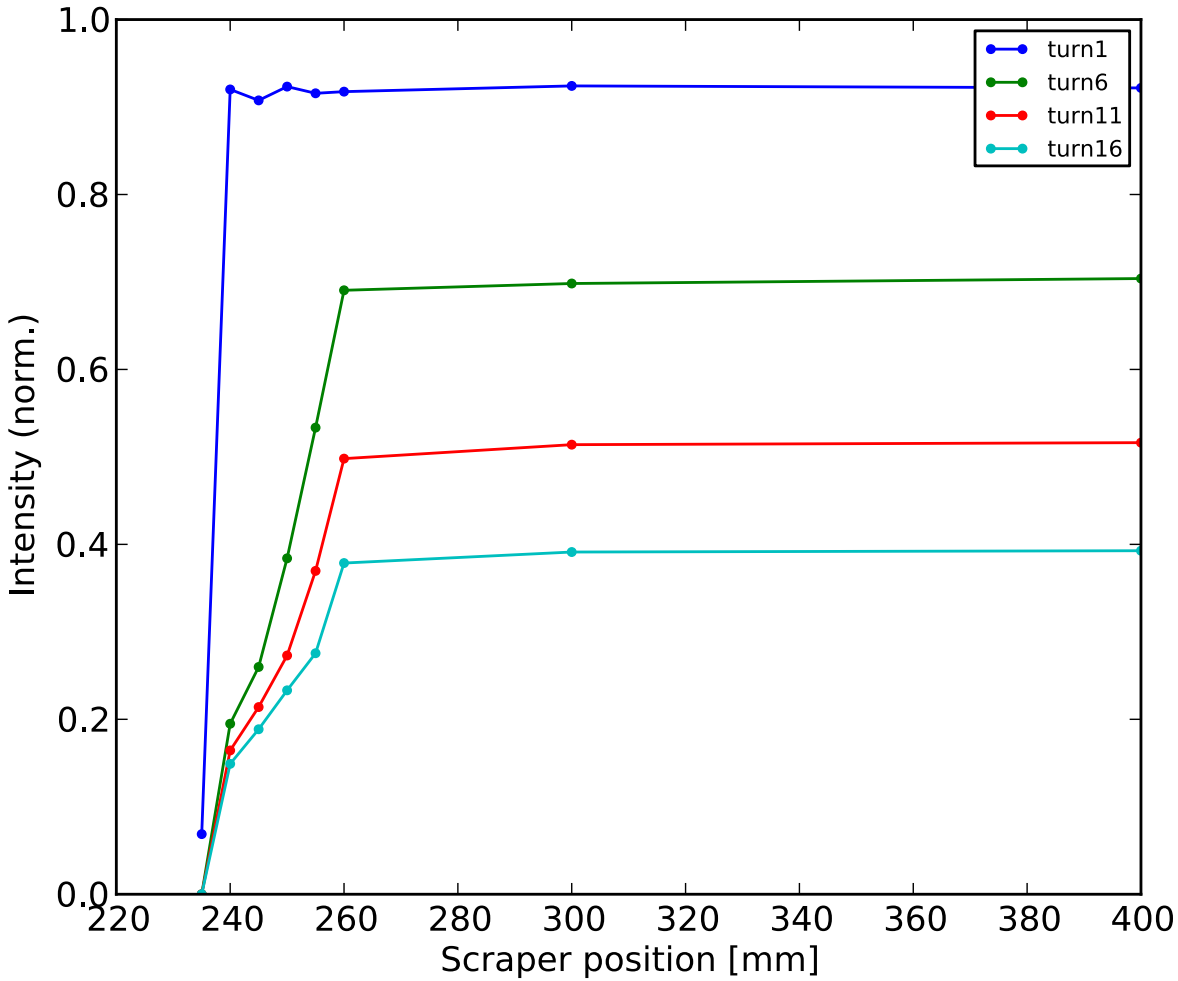
Estimate of emittance from CO data

Data: 20131113_2



Δr~25mm

Chris R mentioned (17/11/13) and Mori-san also suggested (19/11/13)

Use scraper position vs intensity after a set no. of turns to estimate beam size vs turn

(assuming beta function can estimate emittance growth as well)

N.B. 'Intensity' is the relative peak height – should it be area under instead?

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Emittance estimate (RF OUT)

[Data: 20131113_2]

$$\varepsilon = \frac{x^2}{\beta}$$

Turn 1: $\Delta r < 5\text{mm}$

Turn 6, 11, 16: $\Delta r \sim 25\text{mm}$

Turn 1: $$\varepsilon \approx \frac{1}{\beta}\left(\frac{\Delta r}{2}\right)^2$$

After 'smearing out' of n turns: $$\varepsilon \approx \frac{1}{\beta}(\Delta r)^2$$

Turn 1:
Assuming β=1.0m, Δr= 5mm = 0.005m
ε_x = 6.25 pi mm mrad

Turn 6, 11, 16:
Assuming β=1.0m, Δr= 25mm = 0.025m
ε_x = 625 pi.mm.mrad -> 100-fold increase in 5 turns!?
(NB. not accounting for dispersion, momentum spread)
If you assume this is **$\varepsilon_{100\%}$** then **ε_{RMS}** = (1/6)*$\varepsilon_{100\%}$

TO DO: same analysis for other probes & with RF), also same analysis after attempt to fix injection angle/position.

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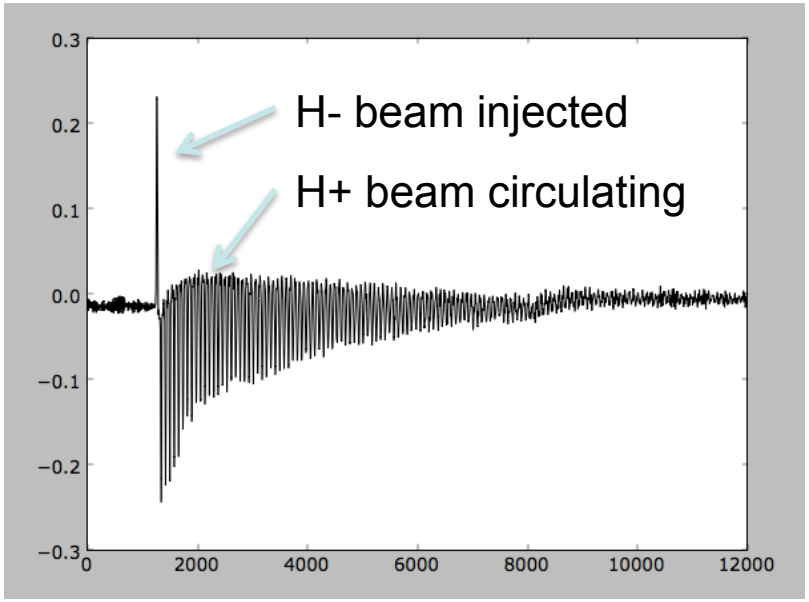
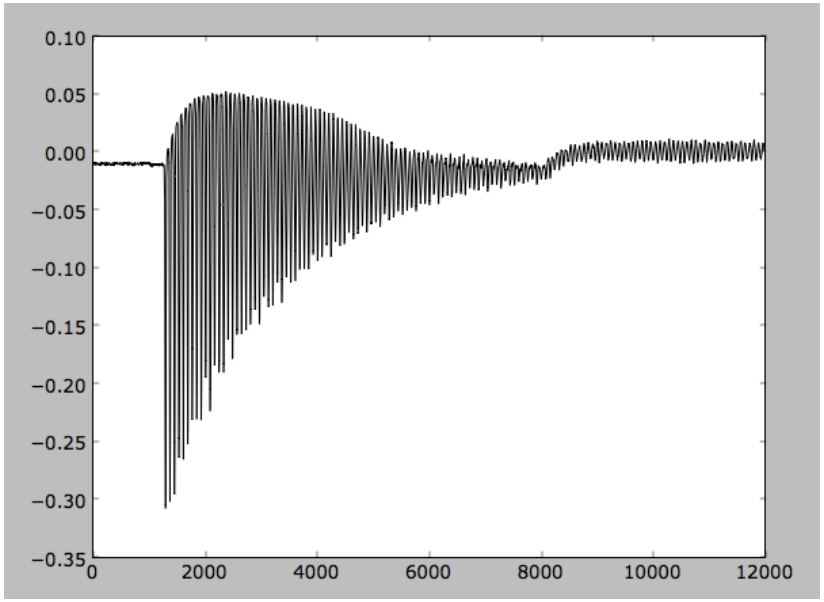
Vertical Tune – Method
[Data: 20131113_1]





Same as before, but with small intentional vertical mis-steer at injection to induce coherent oscillations

LEFT: sum signal from double plate bunch monitor
located just after injection
RIGHT: single plate monitor
located further round the ring

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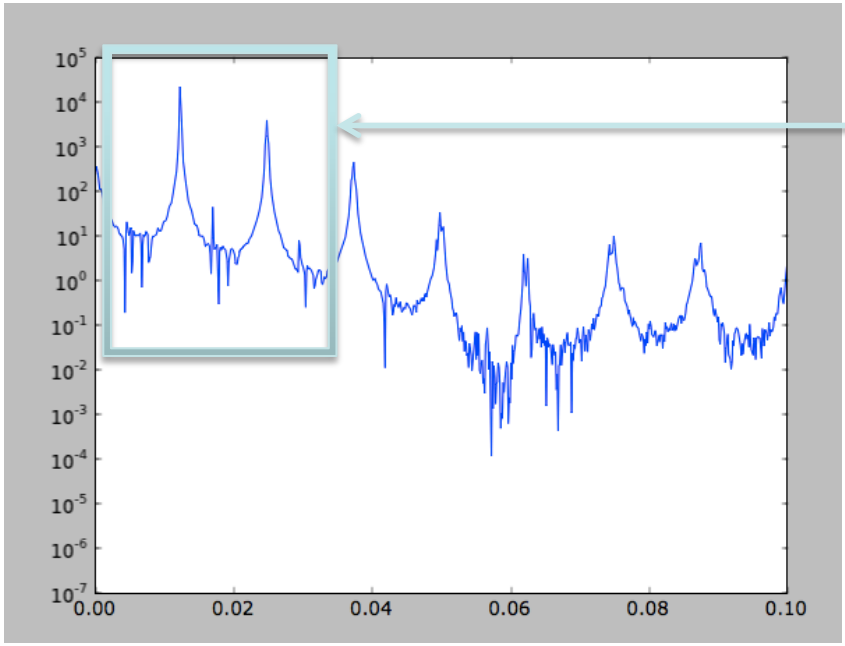
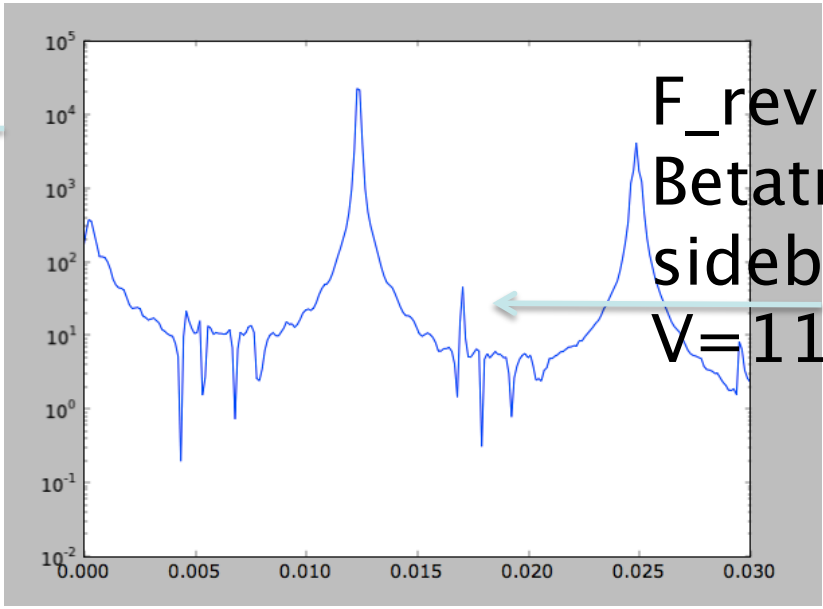
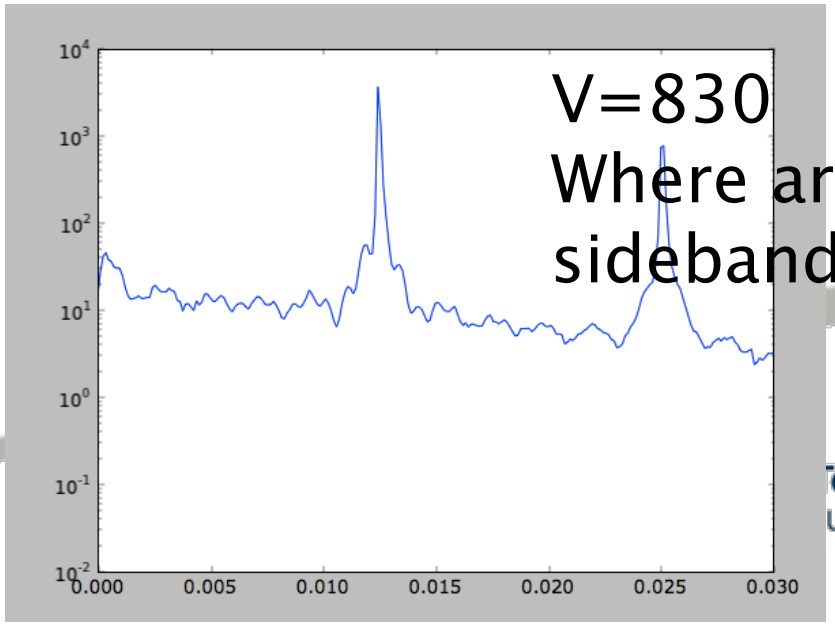
FFT





F_rev
Betatron
sidebands?
V=1110

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



V=830
Where are
sidebands??

Vertical tune measurement

- Discussed this with RAL group
- Preliminary analysis had difficulty finding tune sidebands!
- Shinji & I discussed in detail and he has applied 'Numerical Analysis of Fundamental Frequency' method used on EMMA to it.

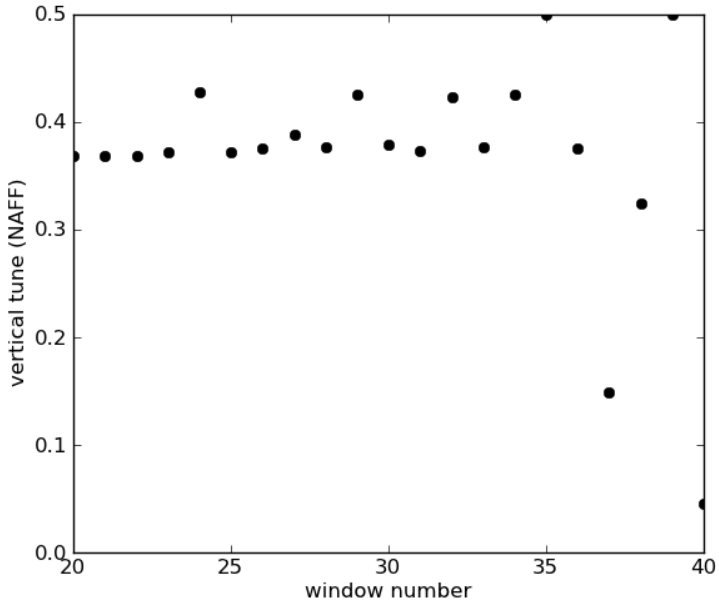
NAFF METHOD: determines frequency components of a signal

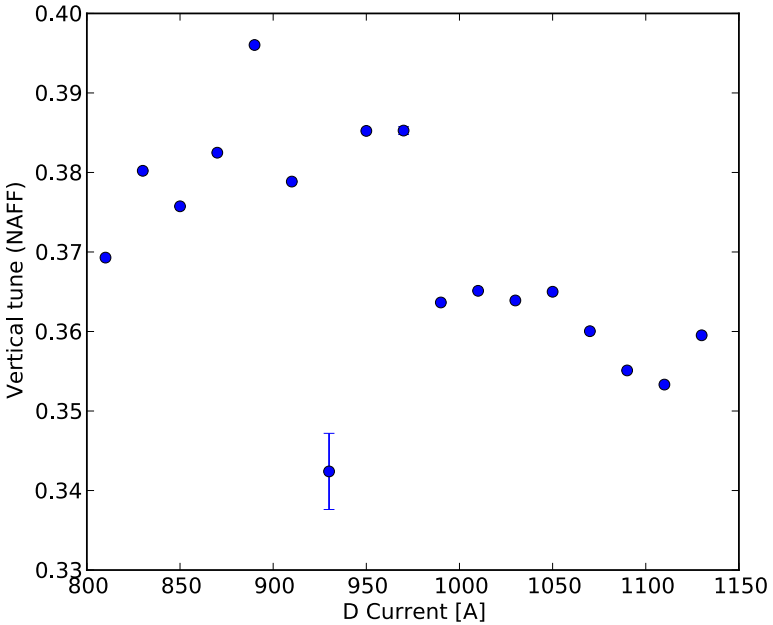
(see eg.
http://www.aps.anl.gov/Accelerator_Systems_Division/Accelerator_Operations_Physics/manuals/SDDStoolkit/node78.html)

Uses a 'window' which moves along in 1 turn steps (1:41), next (2:42) etc… & NAFF method calculates a tune value for each 'window step'

NAFF Tune calculation results

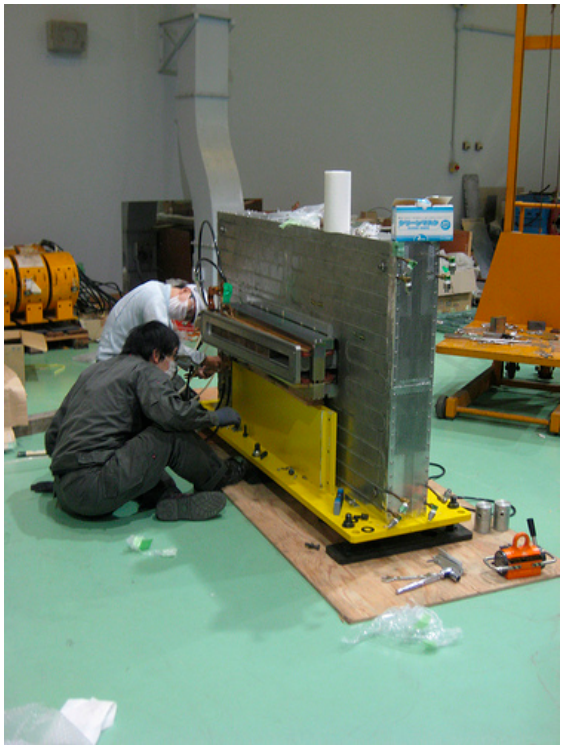
- Calculated tune for windows across turn values (40 turns per window)
- Large variation especially later windows
- Using first 4 points for each value of D current (as example):





RF Cavity IN measurements

- New corrector fitted & RF cavity re-installed
- Can now measure loss of beam (in time) while keeping fixed probe position which gives some new measurement possibilities.
- Test new corrector coil



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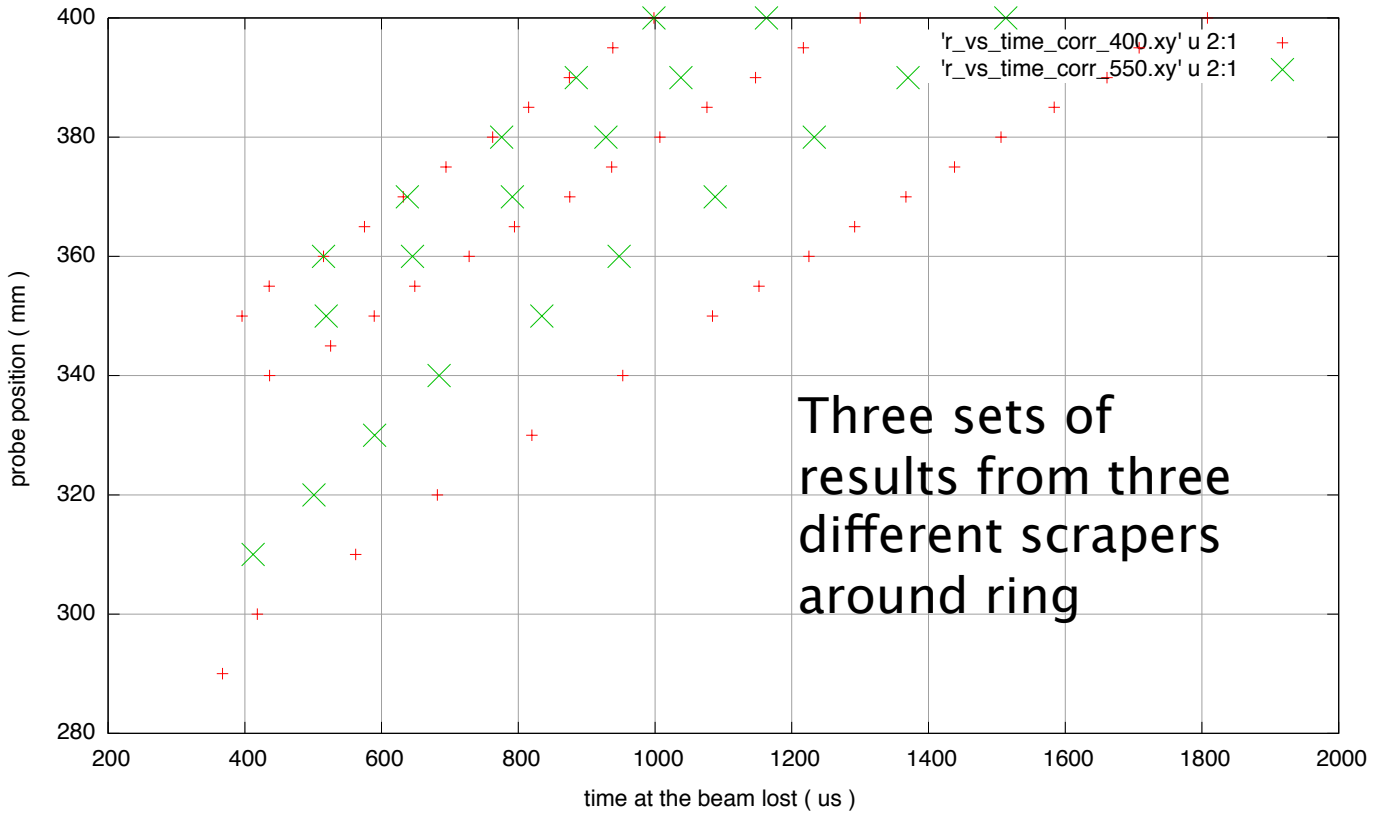
New corrector CO measurement



Data: 18112013

Red: corrector current = 400A

Green: corrector current = 550A

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Possible issues?

I am collecting a long list of information, field maps, drawings, measurements etc!

"What we don't know/have":

- Injected energy
  - *Mao-san might answer this?*
- The injection angle/position (mismatch can make COD measurement difficult!)
  - *Kuriyama-san discussed using 2 radial movers near injection point with faraday cups*
- The real position (h & v) in real time - (bunch monitors have only single readout) would speed up process of correcting injection position/ angle if we could read position in 'real time'.
  - *This requires more amplifiers to read out bunch monitors. ££ + time to install/test.*

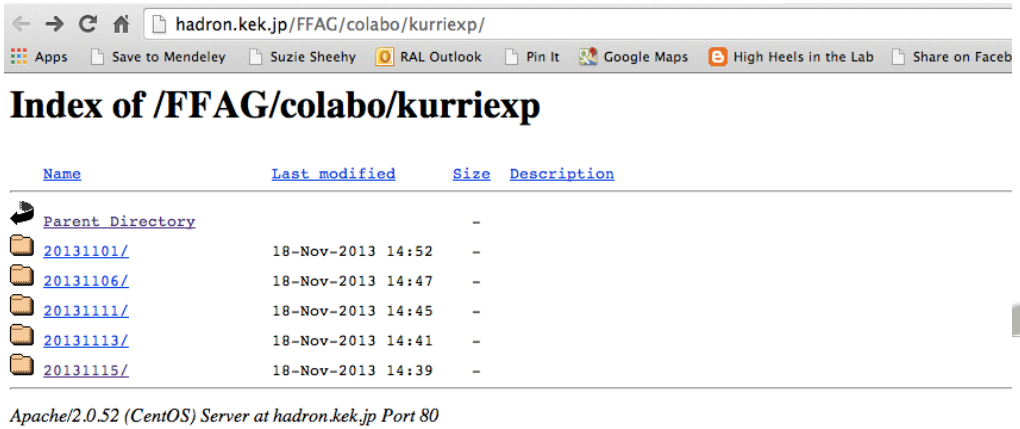
Data storage/sharing

Shinji has created directories to organise data by date & subject on KEK server here:

http://hadron.kek.jp/FFAG/colabo/data/

(Some data in there already, thanks to Uesugi-san!)

I will upload analysis scripts, results, data description files etc ASAP.



Next visit?

- Discuss (all)
- March 2014?

Thankyou

- To Mori-san for inviting me & facilitating collaboration
- To Ono-san for helping organise my visit
- To Takabatake-san (Mao-san!) for looking after me and taking me sightseeing
- To Uesugi-san, Kuriyama-san, Sakamoto-san and especially to Ishi-san!
  - They have answered all my naïve questions and have made my visit a fun, productive and memorable one!

Photos from my visit are here:
http://www.flickr.com/photos/24686524@N06/sets/72157637500853453/