Overview of recent accelerator physics activities at Diamond

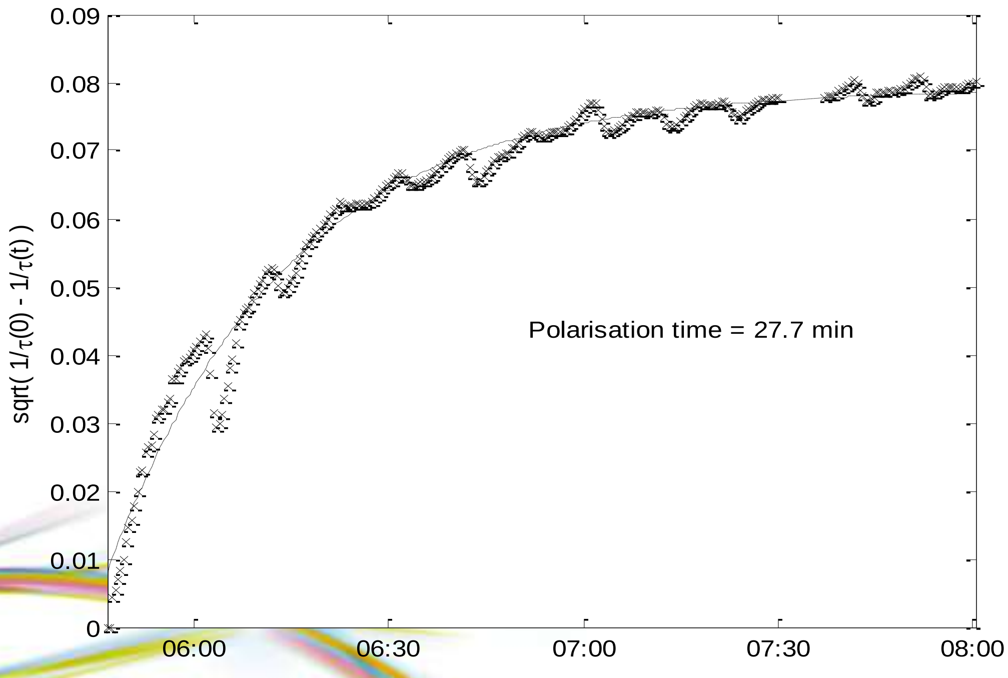
Richard Fielder

Diamond Light Source

Contents

- Resonant spin depolarisation
- Progress of minibeta optics
- Instabilities
- Coherent synchrotron radiation
- Low alpha
- Superbend

Resonant Spin Depolarisation

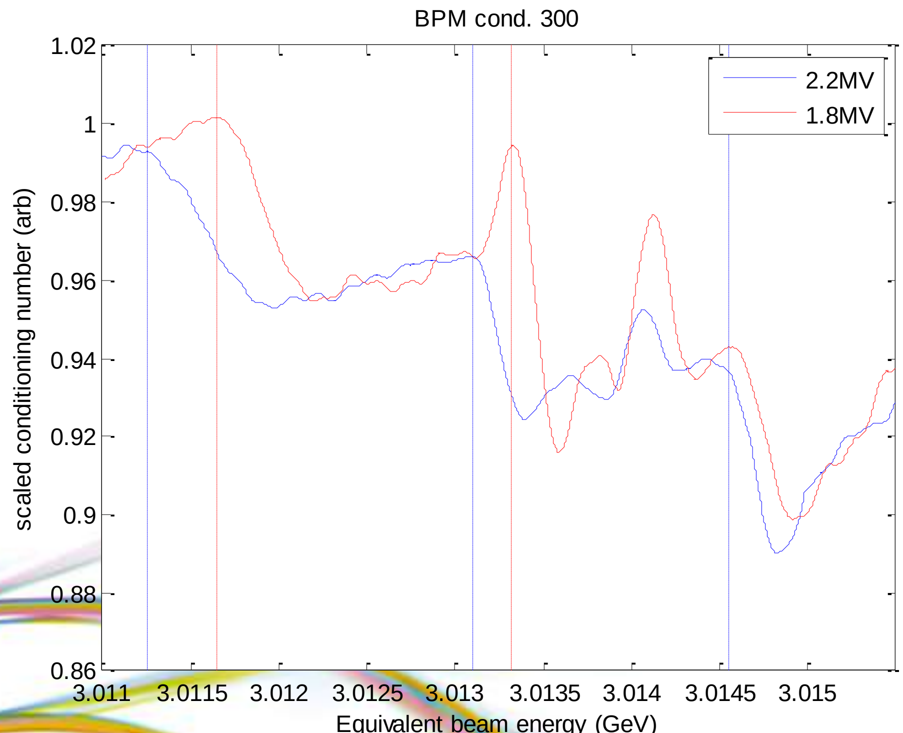


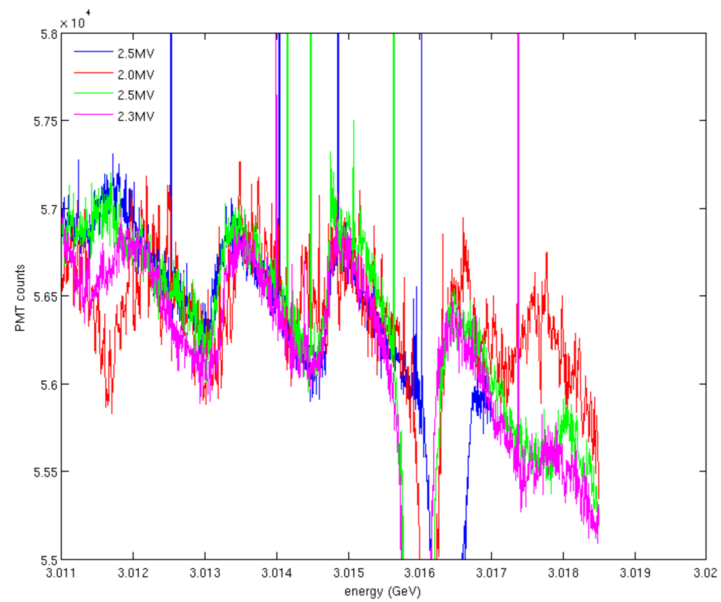
$$P(t) = P_{ST}\frac{\tau_d}{\tau_d + \tau_{ST}}\left[1 - exp\left(-\frac{t}{\tau_{ST}}\left(\frac{\tau_d + \tau_{ST}}{\tau_d}\right)\right)\right]$$

$$\tau_{ST} = \frac{8}{5\sqrt{3}}\frac{m\rho^3}{r_e \hbar \gamma^5} \qquad P_{ST} = -\frac{8}{5\sqrt{3}} = -92.38\%$$

- For diamond at 3.0147GeV, τ_{ST} = 30.0min, τ_d = 364min, P(∞) =85.4%

Resonant Spin Depolarisation

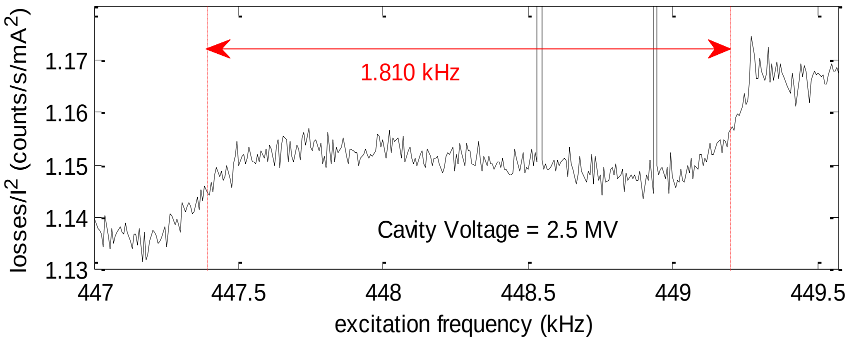


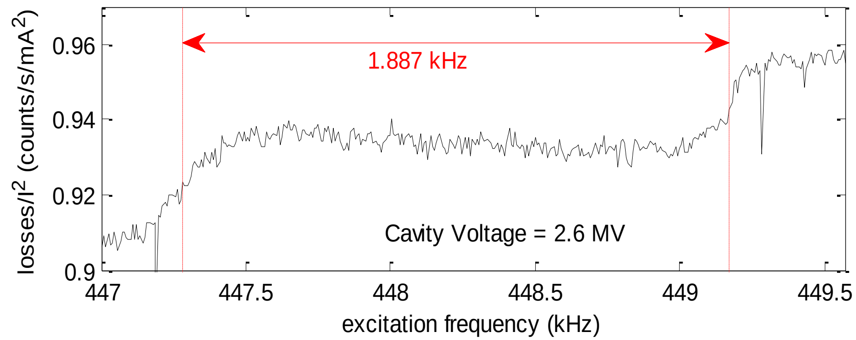


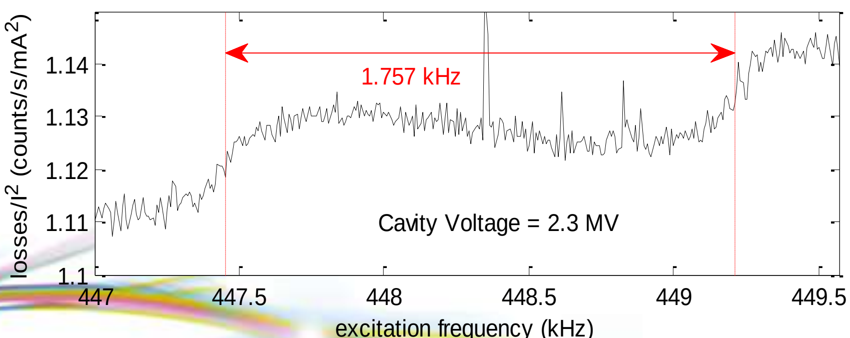
- Energy from lifetime
- ~3 hours for full scan
- Hardware modification to get more power from kicker

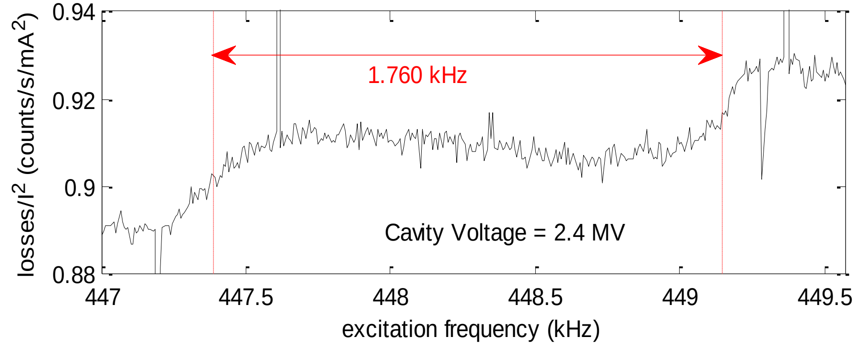
- Energy from PMT
- ~15 minutes for full scan
- 65W = ~45 μTm = ~4.5 μrad

Synchrotron Frequency









- Large difference (300-400Hz) between measured Fs and expected Fs

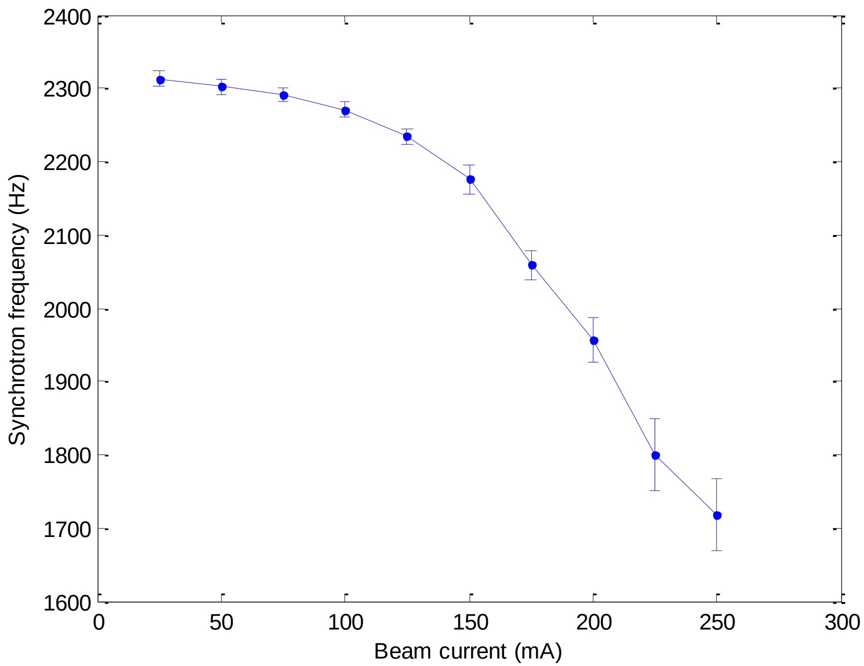
Synchrotron Frequency

- Robinson damping

$$\frac{\Delta\Omega_s}{\Omega_{s0}} = \frac{-I_b\beta}{V_{cav}\cos(\psi_s)}\left[Z_i^0 - \frac{1}{2}\left(Z_i^+ + Z_i^-\right)\right]$$

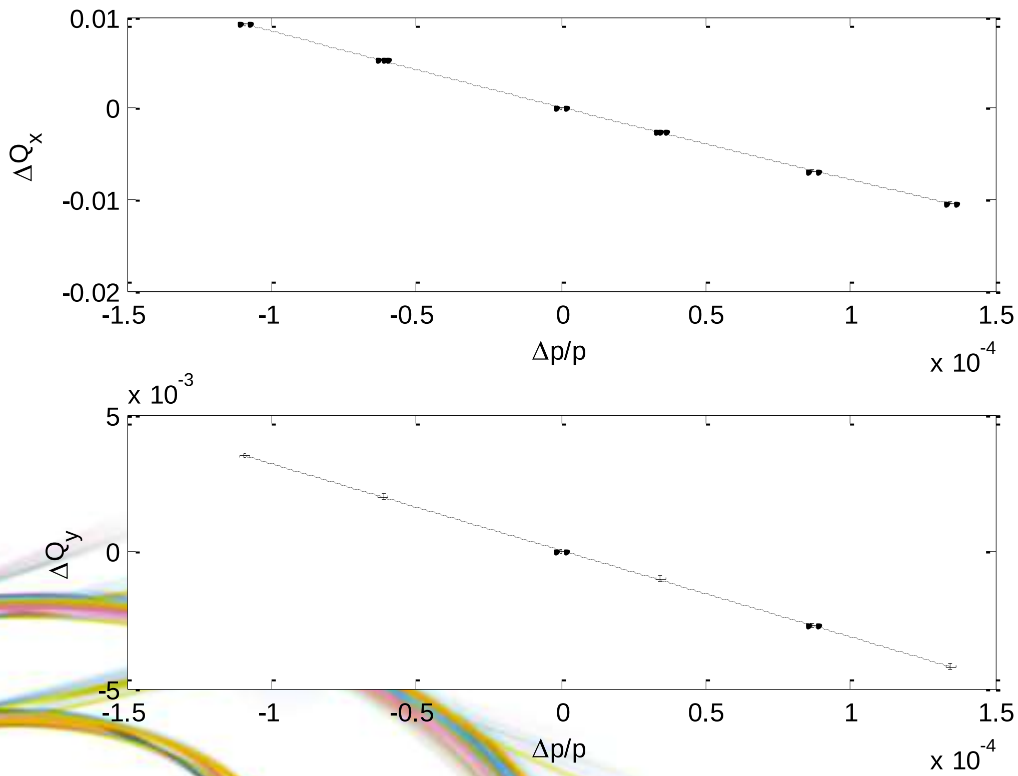
- Potential well distortion

$$\frac{\Omega_s^2}{\Omega_{s0}^2} = 1 - \frac{3\eta_c e I_b}{4\pi\varphi_l^3 E \nu_s^2}\,\mathrm{Im}\{\frac{Z}{n}\}$$



Natural Chromaticity

$$\xi_{z,natural} = -\frac{1}{4\pi}\oint \beta_z(s)K(s)ds$$



Measured:

Horizontal: -81.4±0.5

Vertical: -31.6±0.5

Model:

Horizontal: -81.9

Vertical: -31.6

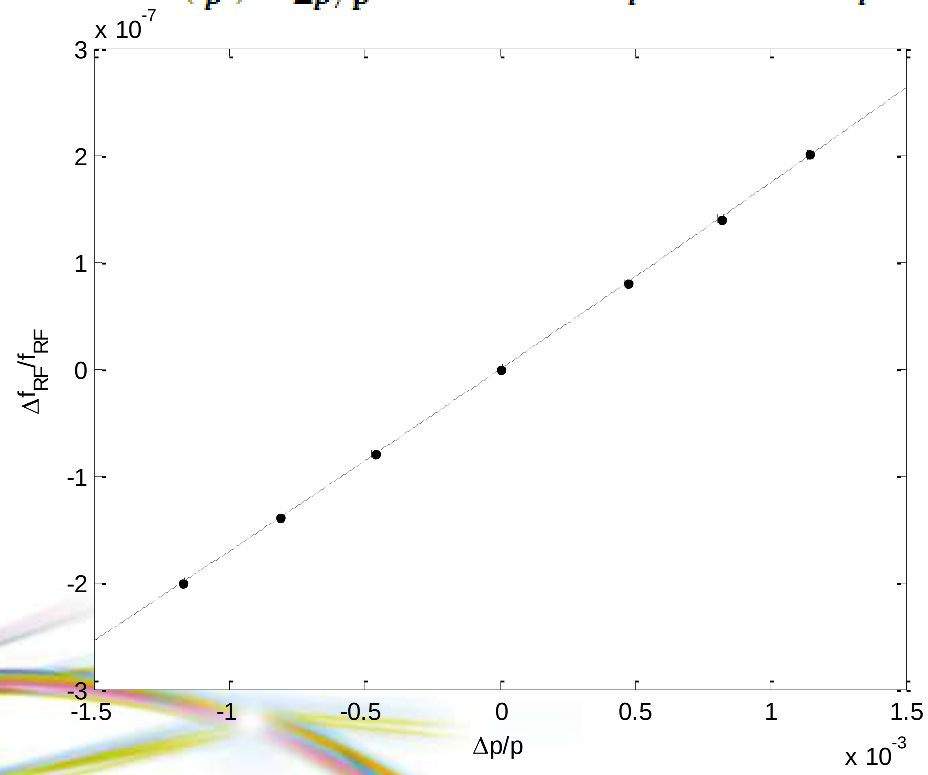
- Shift dipole to change beam energy
- Measure tune shift as function of energy

Momentum Compaction Factor

$$\alpha\left(\frac{\Delta p}{p}\right) = \frac{\Delta \ell / \ell}{\Delta p / p}$$

$$\alpha\left(\frac{\Delta p}{p}\right) = \alpha_1 + \alpha_2\left(\frac{\Delta p}{p}\right) + \alpha_3\left(\frac{\Delta p}{p}\right)^2 + \cdots$$

$$\frac{\Delta \ell}{\ell} = -\frac{\Delta f_{RF}}{f_{RF}}$$



Measured:

$\alpha_1 = 1.72\times10^{-4} \pm 0.02\times10^{-4}$

$\alpha_2 = 2.2\times10^{-3} \pm 2.5\times10^{-3}$

Model:

$\alpha_1 = 1.66\times10^{-4}$

$\alpha_2 = 1.8\times10^{-3}$

- Measure beam energy as function of RF frequency
- Discrepancy likely due to effect of IDs on optics
- Can't move RF far enough to measure non-linear α_2

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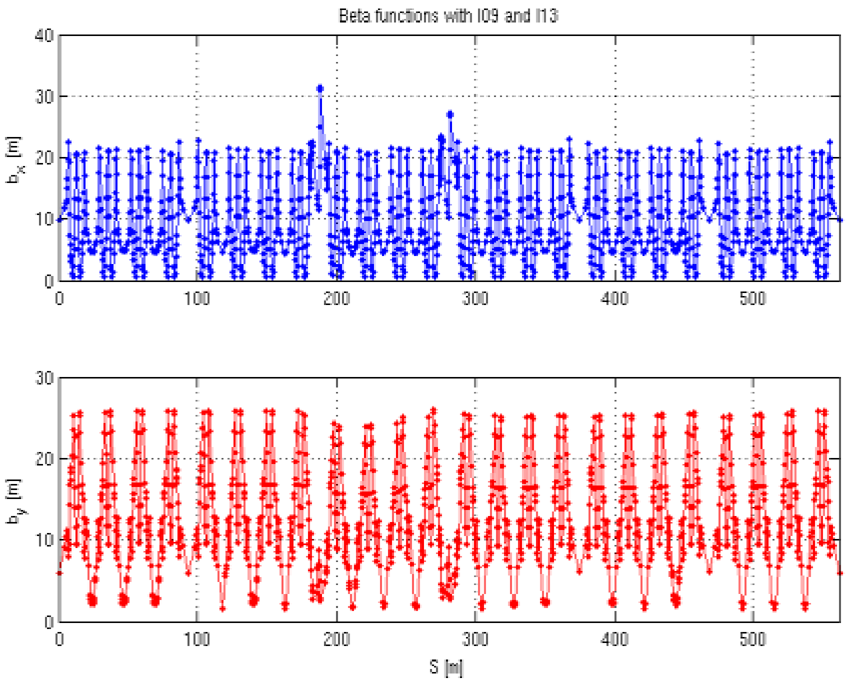
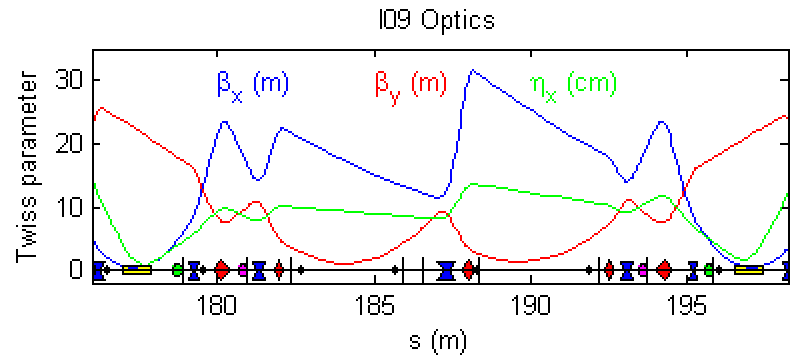
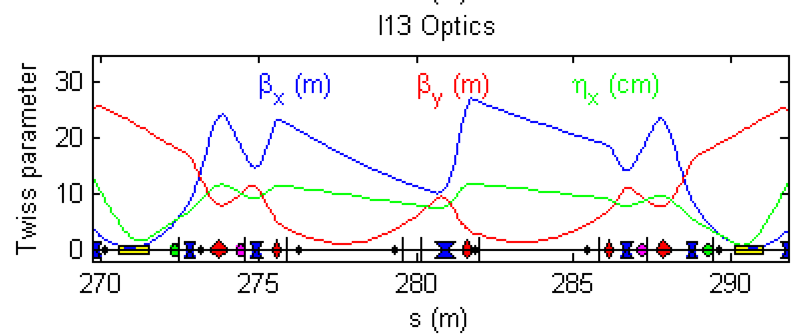
Minibeta



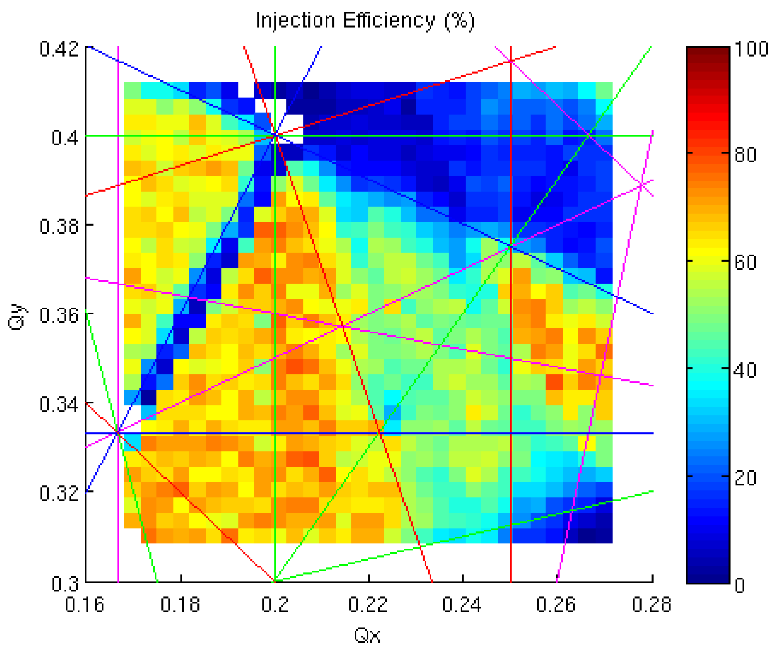




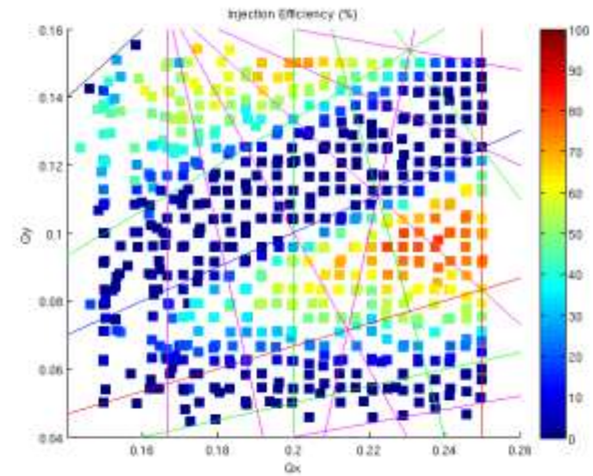
- First minibeta installed in I13 in October 2010
- Second installed in I09 in April 2011
- I09 optics used in ring, but no IDs yet

Minibeta Injection

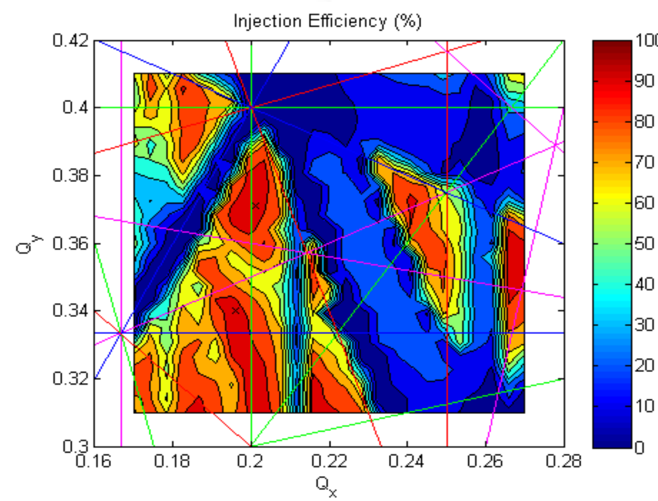
Original tunes - Qx = 27.220
Qy = 12.360



I13 planned - Qx = 27.220
Qy = 12.860

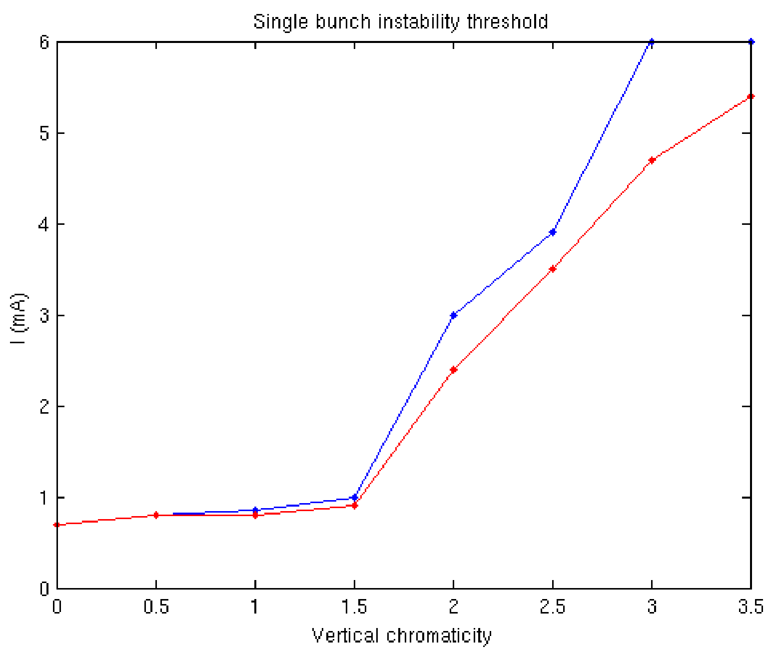


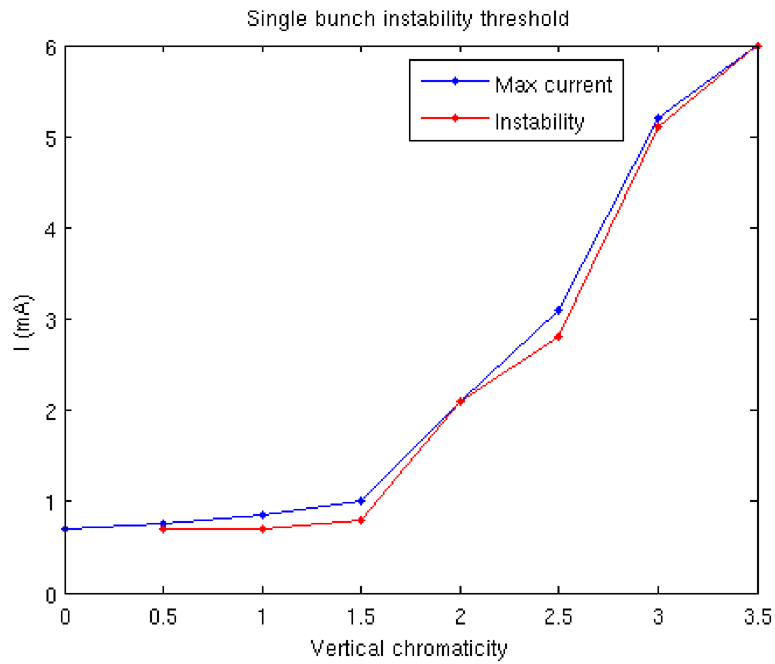
- I13 actual -
  Qx =27.237
  Qy =13.095



- I13 + I09 -
  Qx =27.201
  Qy =13.371

Instability Thresholds





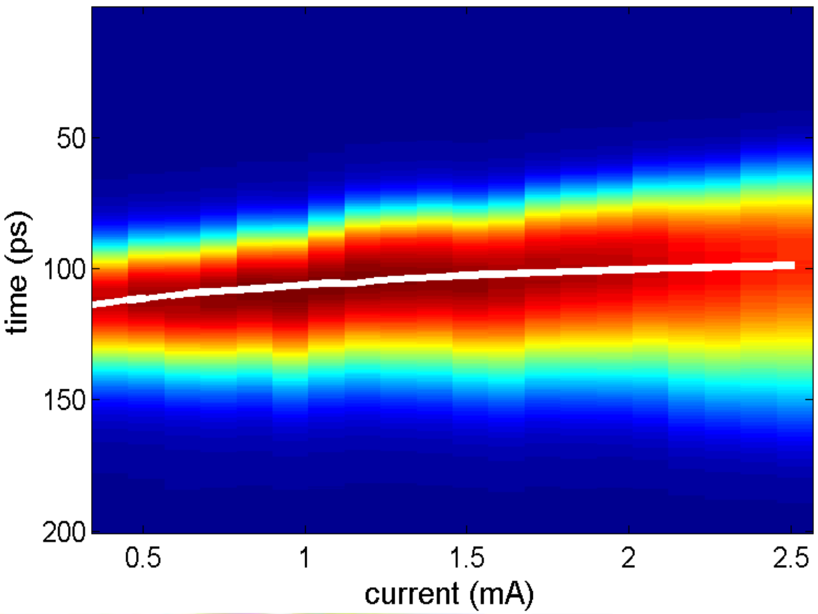
Before minibeta

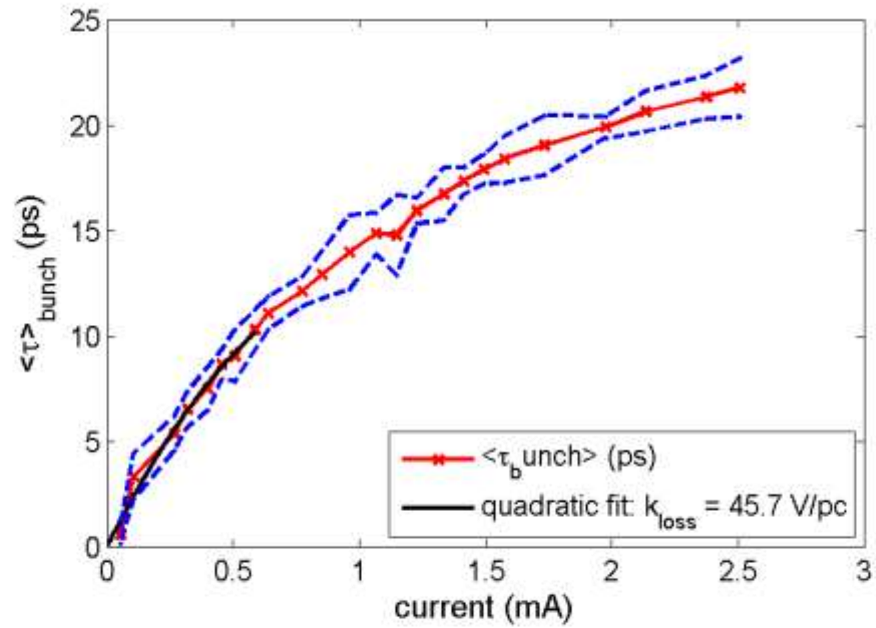
I09+I13

- Measure onset of instability as seen by TMBF, plus maximum possible single bunch
- Horizontal thresholds much higher (2mA at 0 chromaticity)

300 mA = 0.33 mA (900 bunches) – 0.44 mA (680 bunches)
500 mA = 0.55 mA (900 bunches) – 0.73 mA (680 bunches)

Instability Thresholds





- Streak camera measures bunch length and phase
- Can be used to calculate loss factor for whole machine

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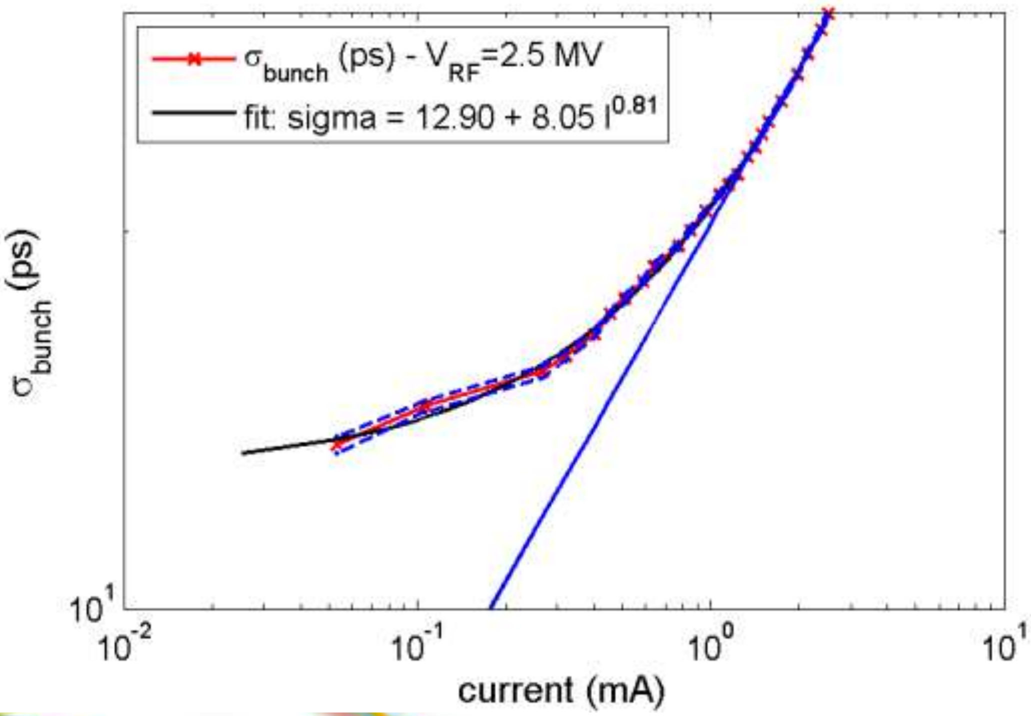
Instability Thresholds



- Microwave instability threshold at 1.1mA
- Below threshold, bunch length varies as $\sim I^{0.81}$
- Above threshold, bunch length varies as $I^{0.41}$
- Not quite the expected $I^{1/3}$

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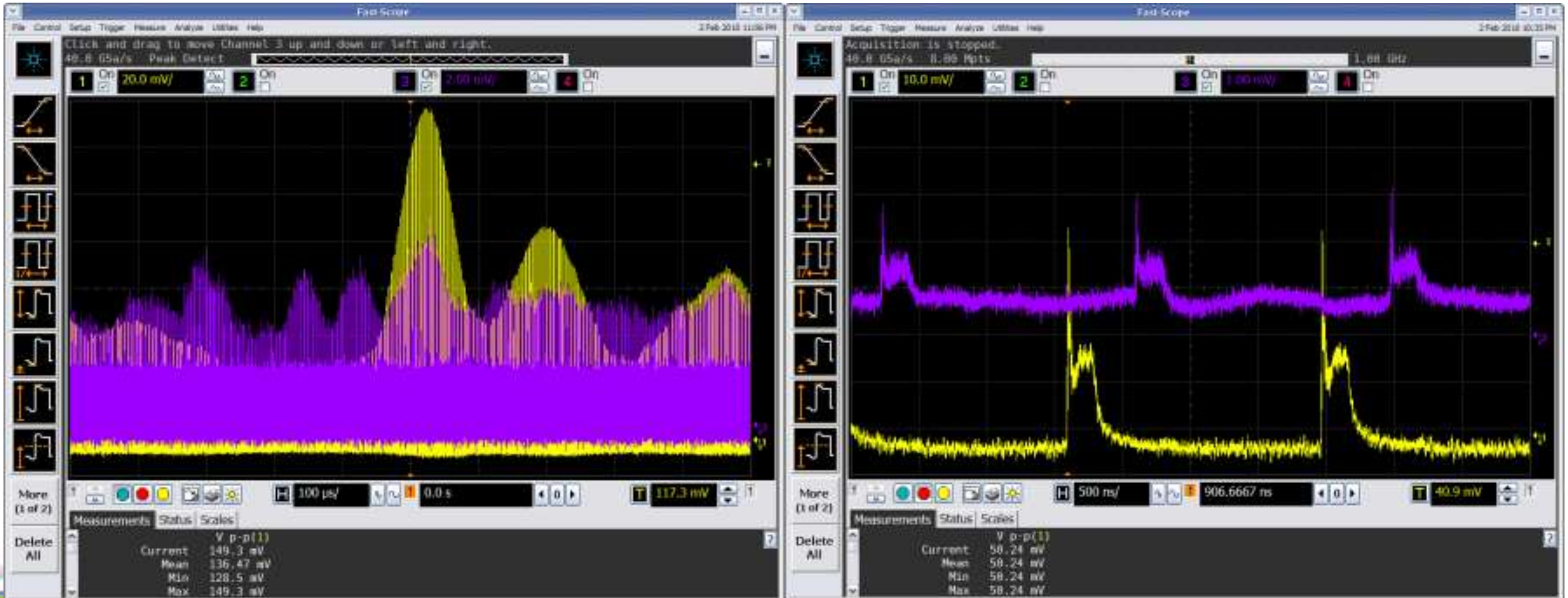
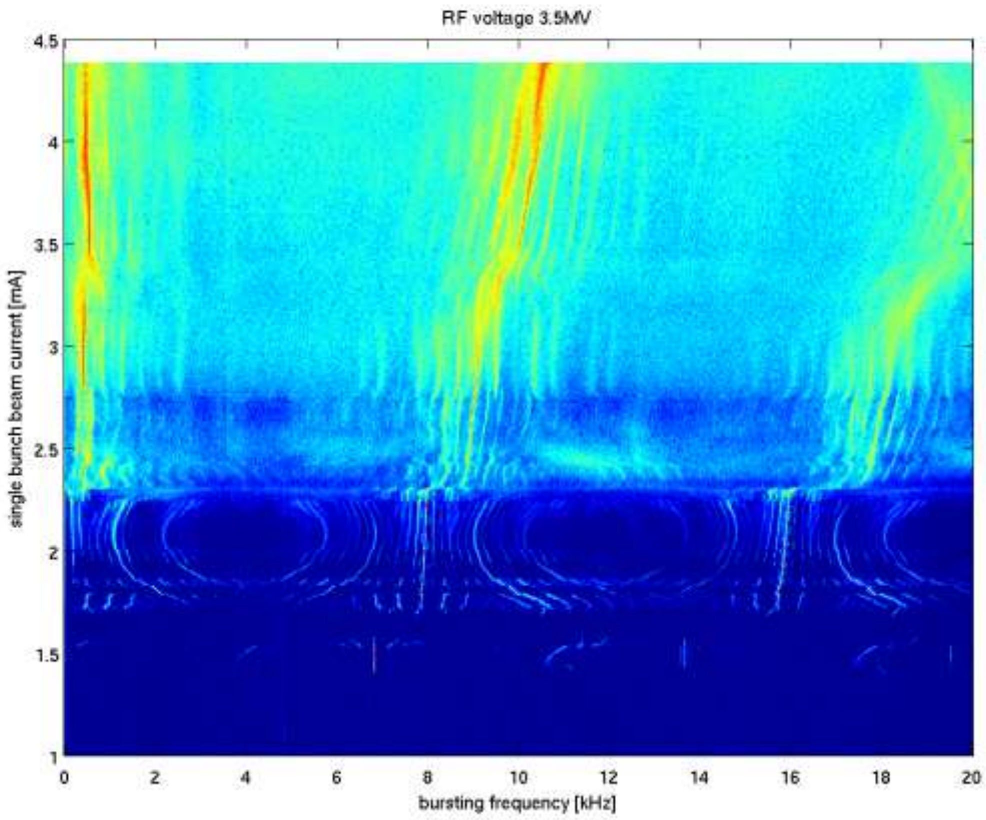
Coherent Synchrotron Radiation



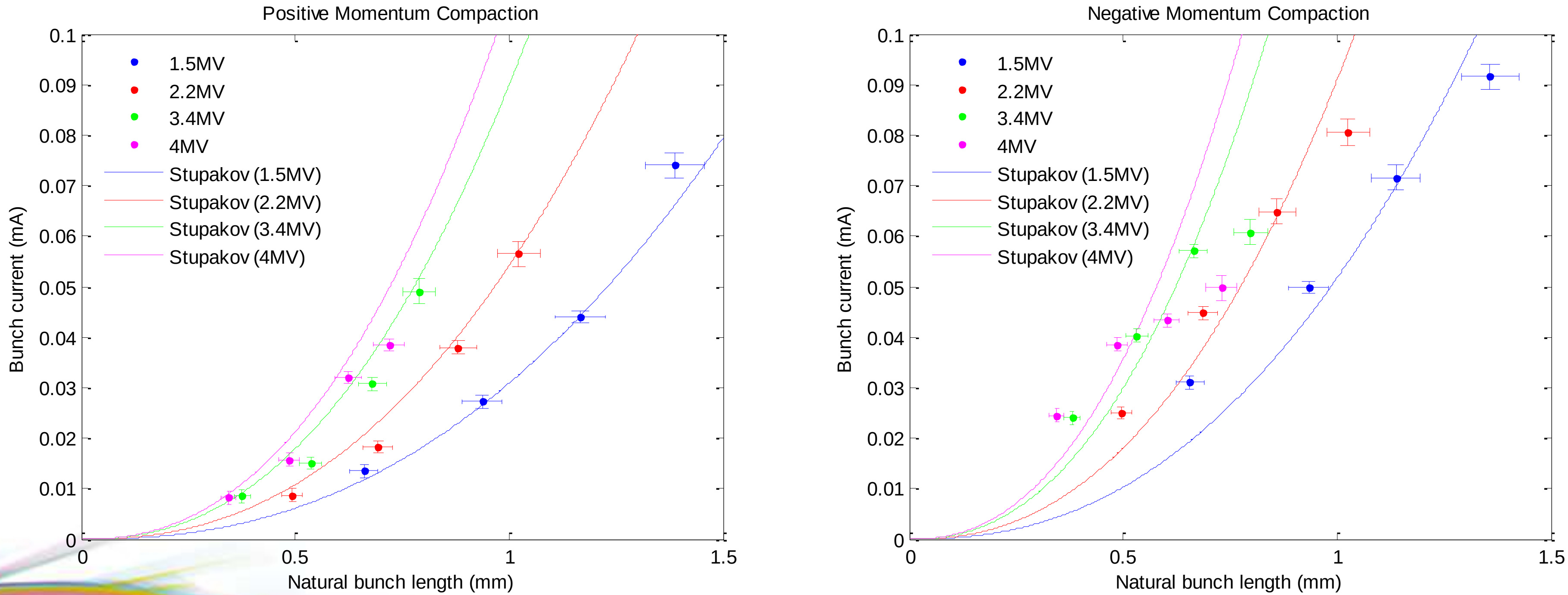
- Irregular bursting seen on Schottky diode
- Different pattern seen at 33-50GHz (purple) and 60-90GHz (yellow)
- Now also have 220-320GHz detector

Coherent Synchrotron Radiation



- Fourier transform of CSR signal
- Bursting behaviour varies strongly with bunch current and RF voltage

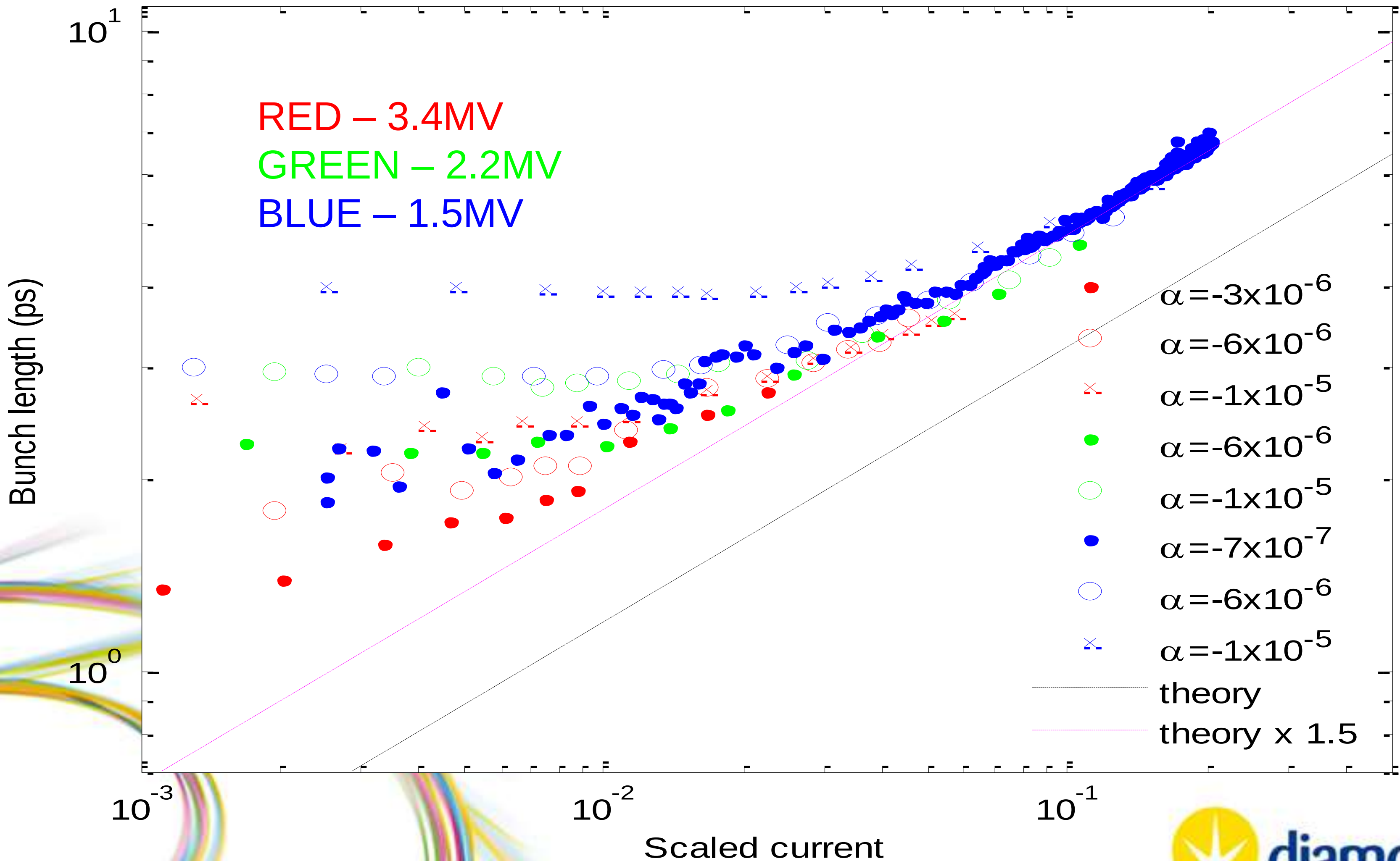
Coherent Synchrotron Radiation



- Measured bursting thresholds compared with theory – free space CSR with coasting beam
- Theory matches results much better for positive *α*

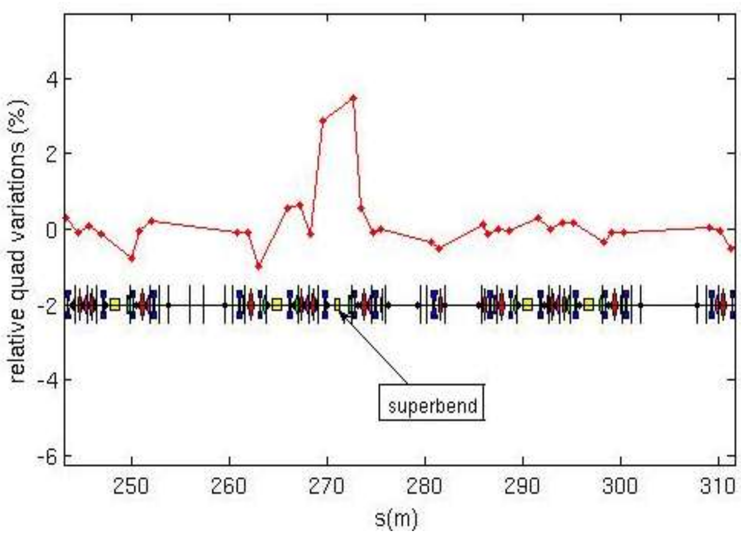
PRST-AB 5, 054402 (2002). Stupakov & Heifets – Beam Instability and Microbunching Due to Coherent Synchrotron Radiation

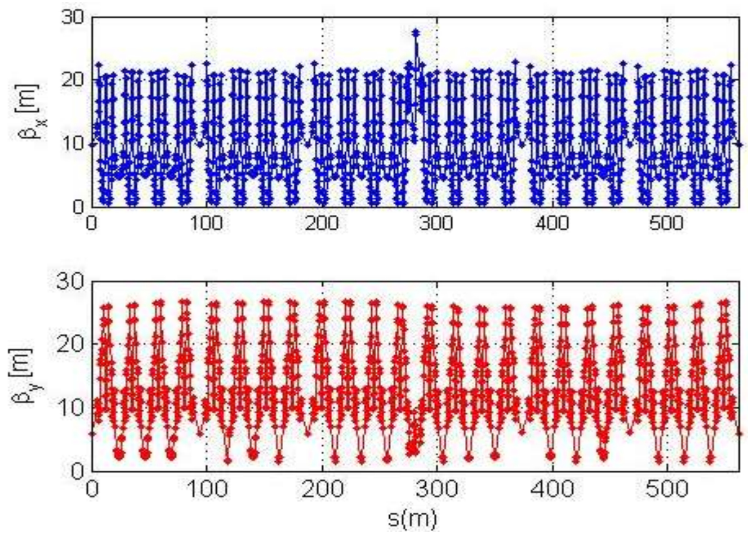
Low Alpha



IPAC 2010 – G. Wusterfeld et. al. - Coherent THz Measurement at the Metrology Light Source.

Superbend





- Lattice and quadrupole corrections
- Beta functions

- Chromaticities

	ξx	ξy
No superbend	3.56	1.1
Superbend	3.56	0.41
Superbend+loco	3.67	1.13

- Tunes

B(T)	Qx	Qy	εx(nm)
2	27.22	12.377	2.78
3	27.22	12.405	2.85
4	27.22	12.444	2.97

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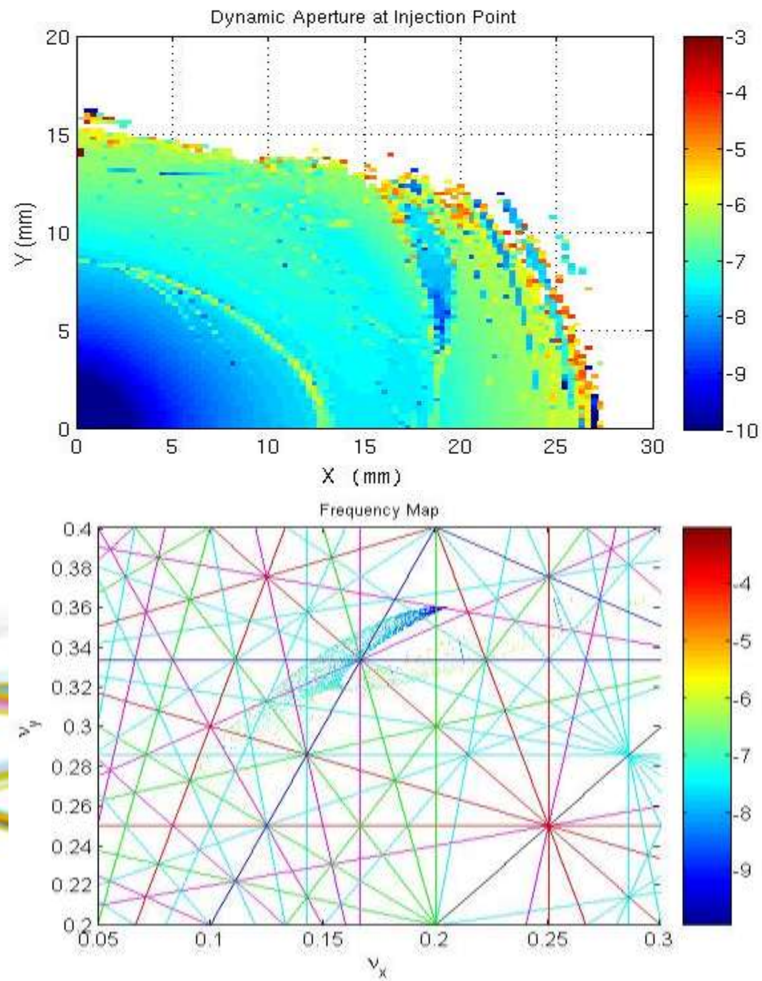
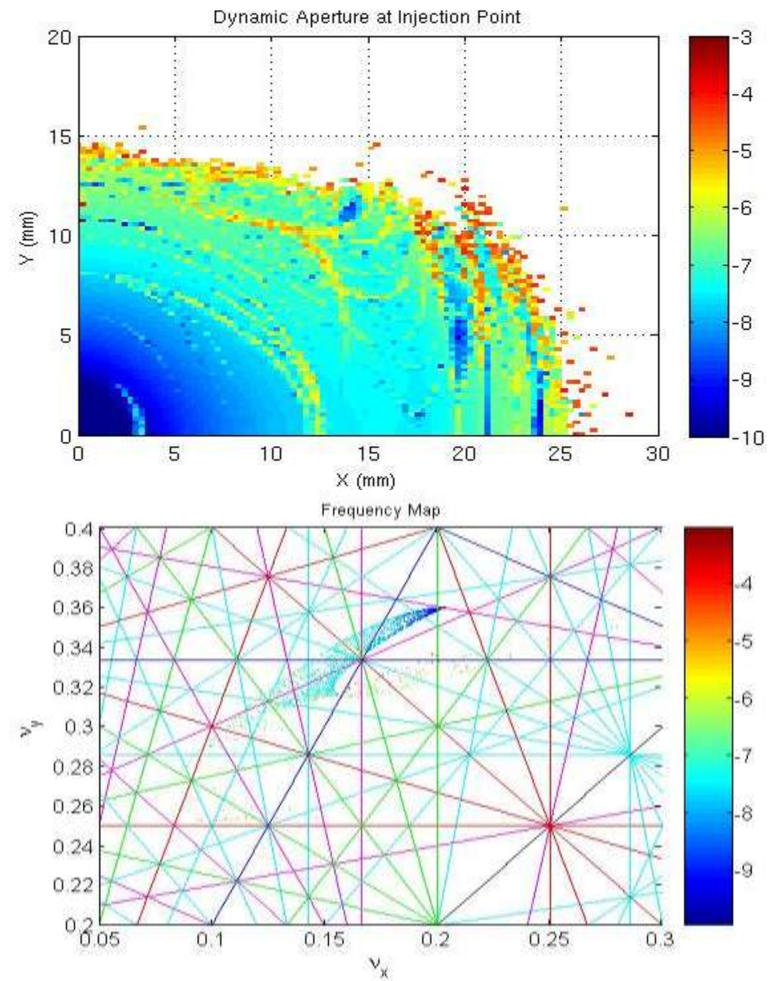
Superbend



- Dynamic aperture without superbend



- Superbend with LOCO correction

- Thanks to:

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