Optics design and measurement at Diamond

- Results achieved in linear and nonlinear optics modelling
- Contribution to CLIC damping ring activities

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and
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CLIC collaboration meeting,
CERN 3rd November 2011

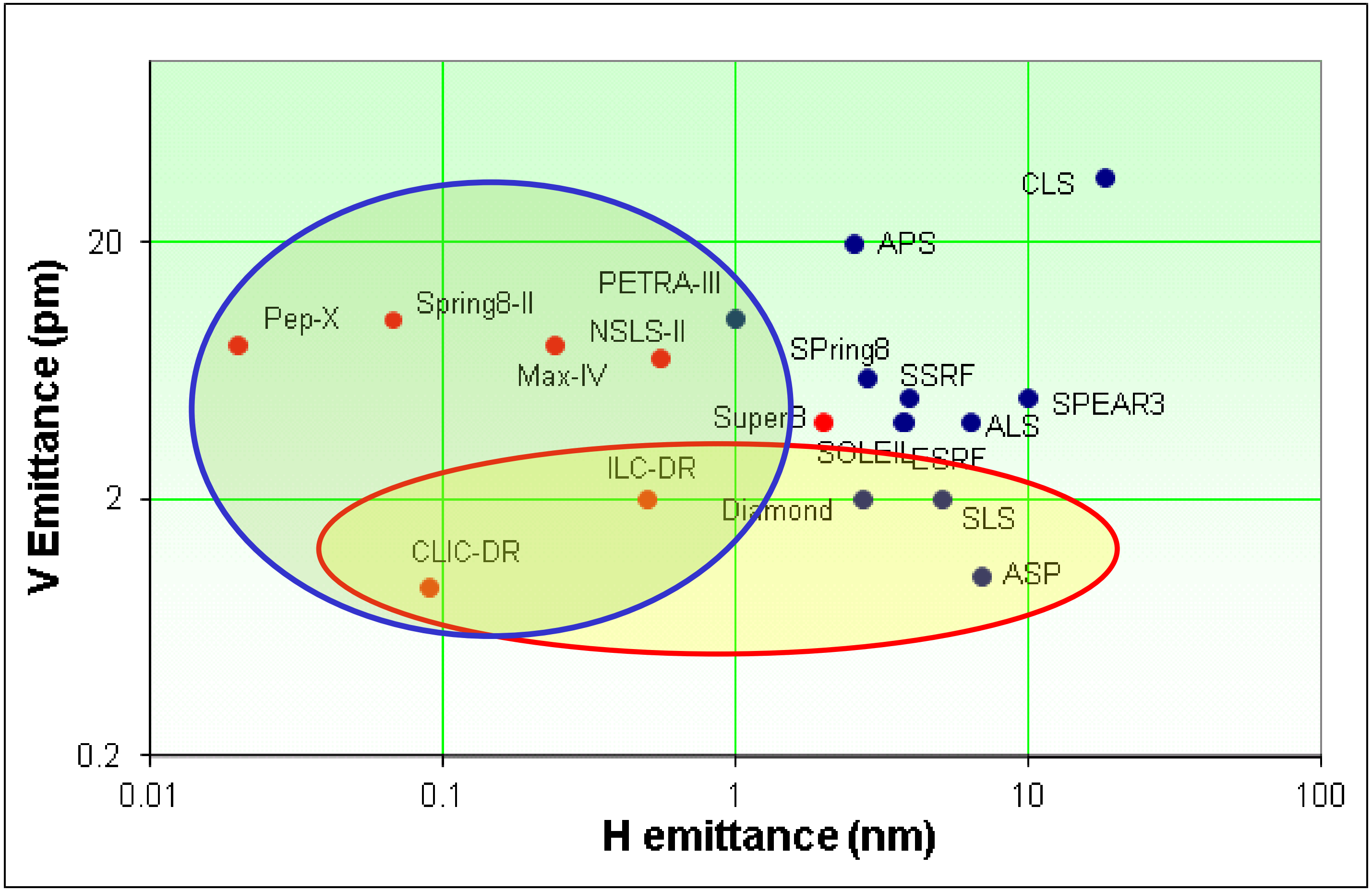
Diamond optics control

Diamond is a third generation light source open for users since January 2007

2.7 nm emittance – 18 beamlines in operation (10 in-vacuum small gap IDs)

<u>**Most state-of-the-art light sources share the same structure**</u>

Emittance in 3rd GLS, DR and colliders



CLIC collaboration meeting,
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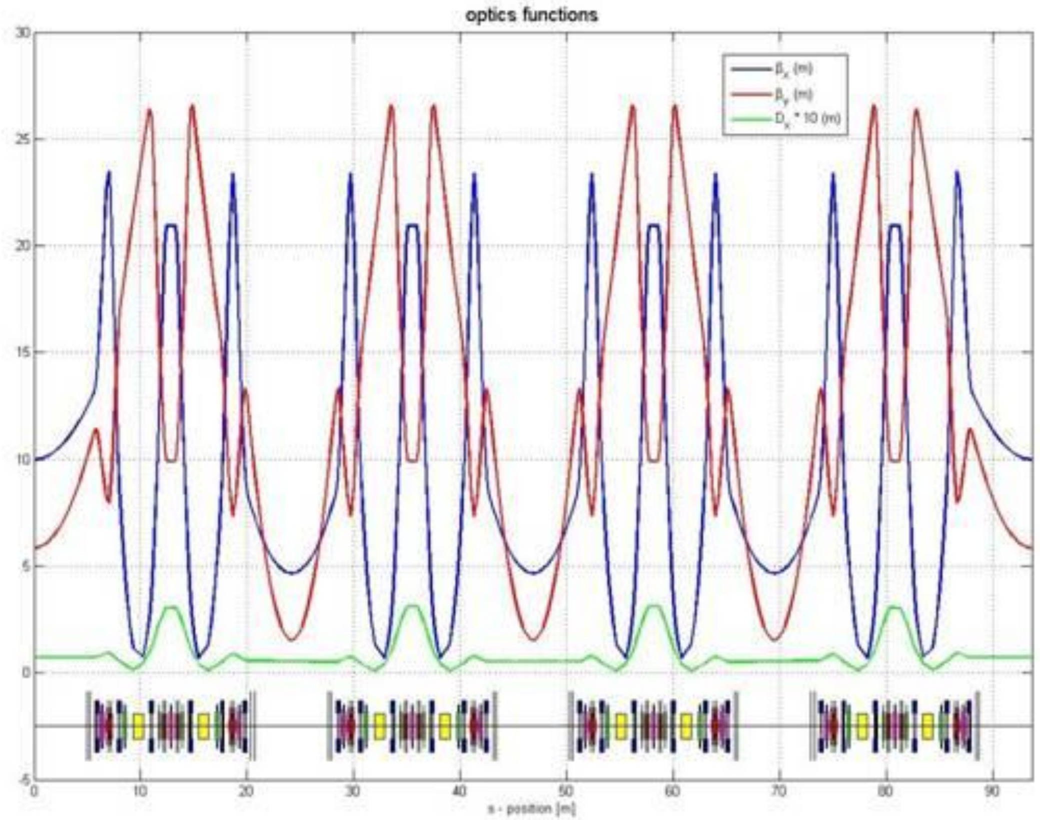
Diamond storage ring main parameters
non-zero dispersion DB lattice



48 Dipoles; 240 Quadrupoles; 168 Sextupoles
(+ H and V orbit correctors + 96 Skew Quadrupoles)
3 SC RF cavities; 168 BPMs

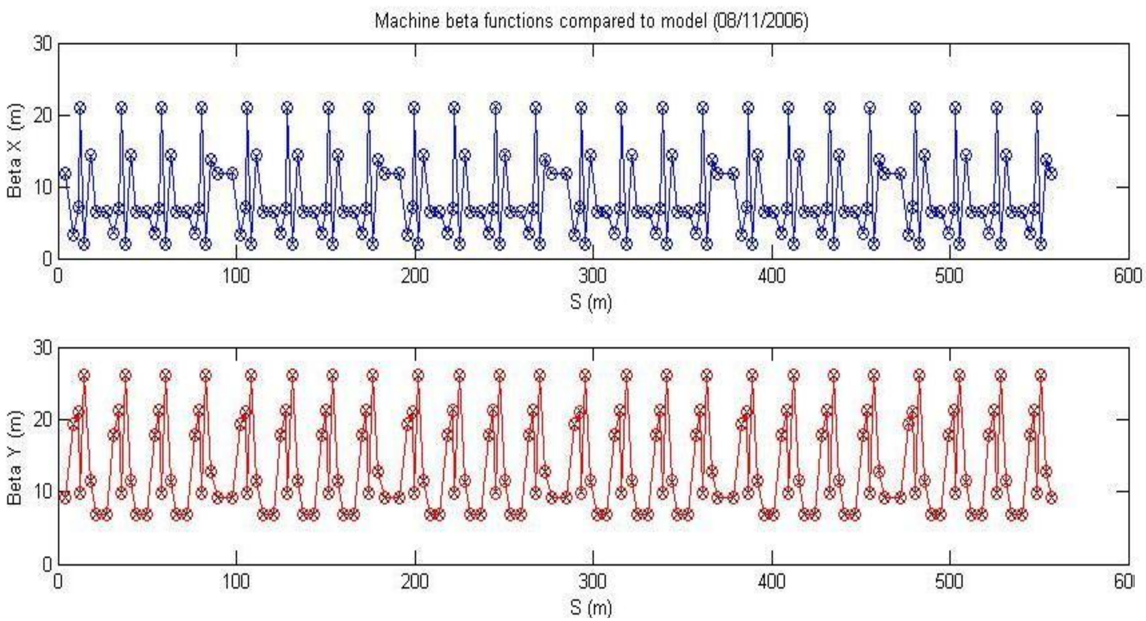
Quads + Sexts have independent power supplies

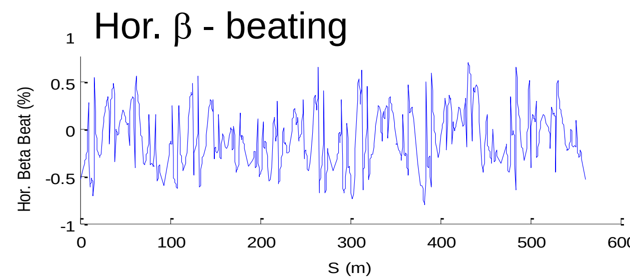
Energy	**3 GeV**
Circumference	**561.6 m**
No. cells	**24**
Symmetry	**6**
Straight sections	**6 x 8m, 18 x 5m**
Insertion devices	**4 x 8m, 18 x 5m**
Beam current	**300 mA (500 mA)**
Emittance (h, v)	**2.7, 0.03 nm rad**
Lifetime	**> 10 h**
Min. ID gap	**7 mm (5 mm)**

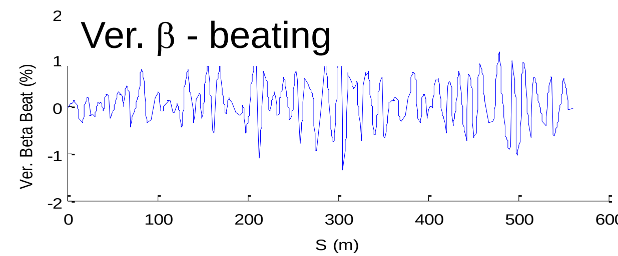
Beam size (h, v)	**123, 6.4 μm**
Beam divergence (h, v) ***(at centre of 5 m ID)***	**24, 4.2 μrad**
Beam size (h, v)	**178, 12.6 μm**
Beam divergence (h, v) ***(at centre of 8 m ID)***	**16, 2.2 μrad**

Linear optics modelling with LOCO

Linear Optics from Closed Orbit response matrix – J. Safranek et al.



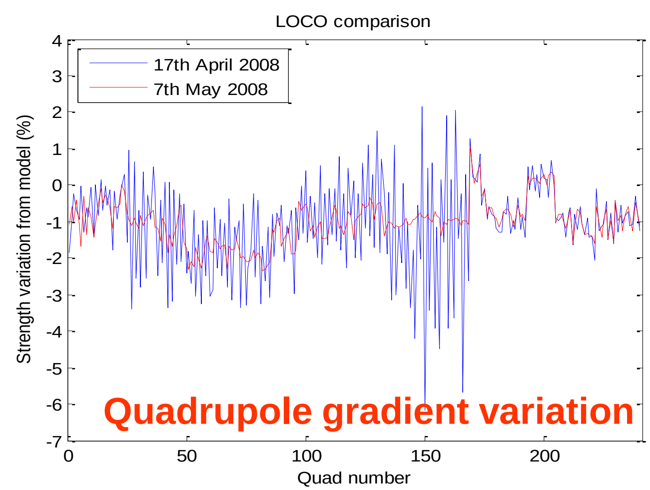




Modified version of LOCO with constraints on gradien variations **(see [ICFA Newsl, Dec'07](#))**

β - beating reduced to 0.4% rms

Quadrupole variation reduced to 2%
Results compatible with mag. meas. and calibrations

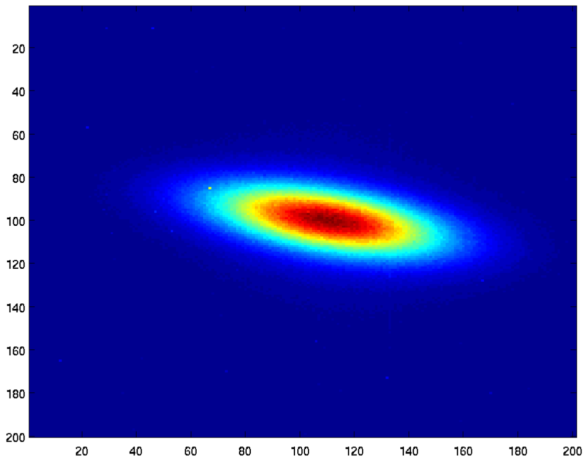


LOCO allowed remarkable progress with the correct implementation of the linear optics

Measured emittances

Coupling without skew quadrupoles off K = 0.9%

(at the pinhole location; numerical simulation gave an average emittance coupling 1.5% ± 1.0 %)



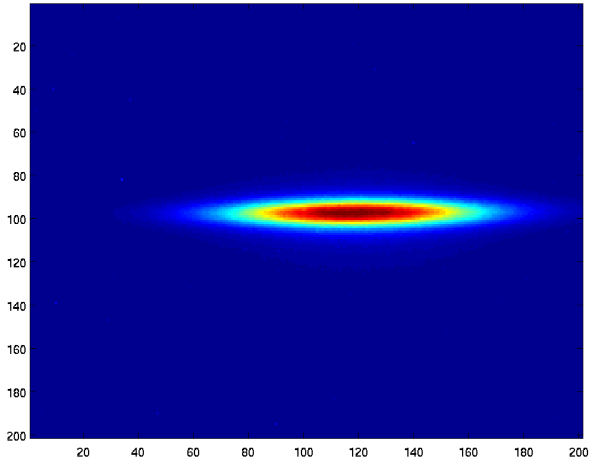
Emittance [2.78 - 2.74] (2.75) nm

Energy spread [1.1e-3 - 1.0-e3] (1.0e-3)

After coupling correction with LOCO (2*3 iterations)

1st correction K = 0.15%

2nd correction K = 0.08%



V beam size at source point 6 μm

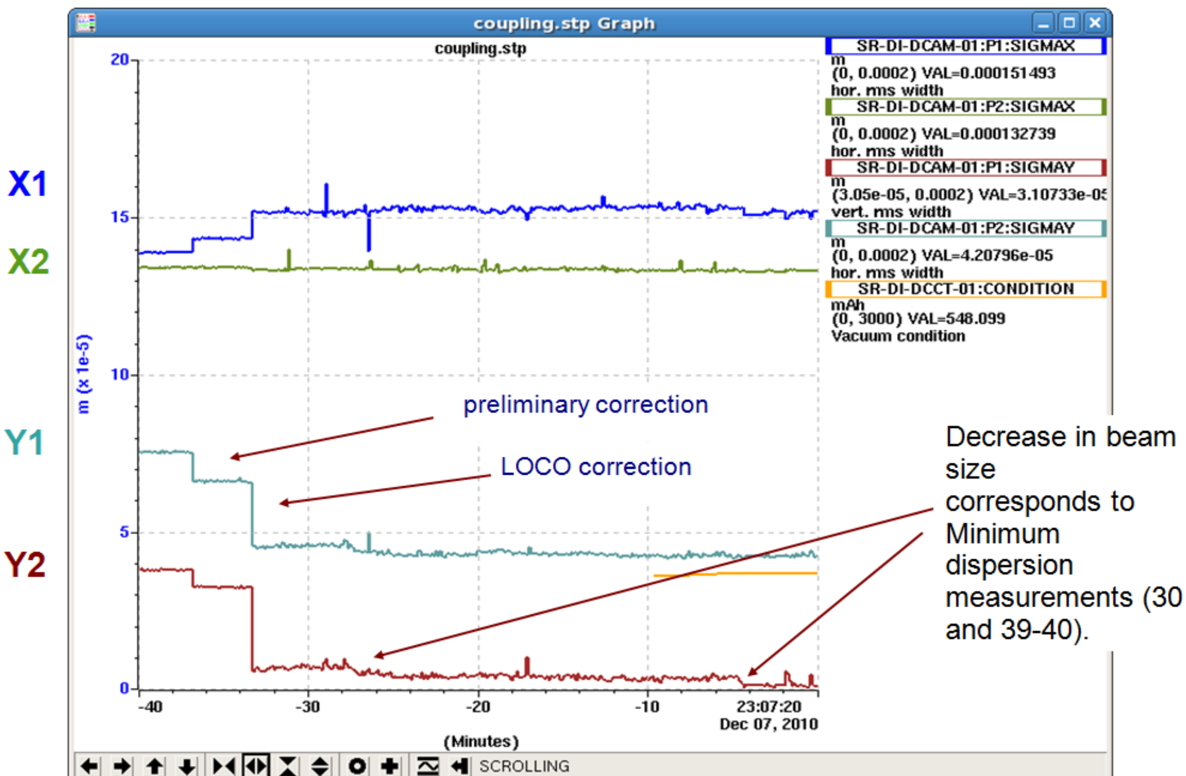
Emittance coupling 0.08% → **V emittance 2.2 pm**

Variation of less than 20% over different measurements

Low emittance tuning at Diamond for SuperB

Last year results on low emittance tuning and the achievement of a vertical emittance of 2.0 pm at Diamond and SLS have sparked quite some interest from the Damping ring community (CLIC and ILC) and from the Super B

In collaboration with the SuperB team (P. Raimondi,. M. Biagini, S: Liuzzo) Diamond and SLS have been used as a test-bed for new techniques for low emittance tuning based on **dispersion free steering and coupling free steering.**



4 MD shifts at DLS
November 10 - February 11

1.7 pm V emittance

State-of-the-art light sources have BPMs with turn-by-turn capabilities

e.g. Diamond

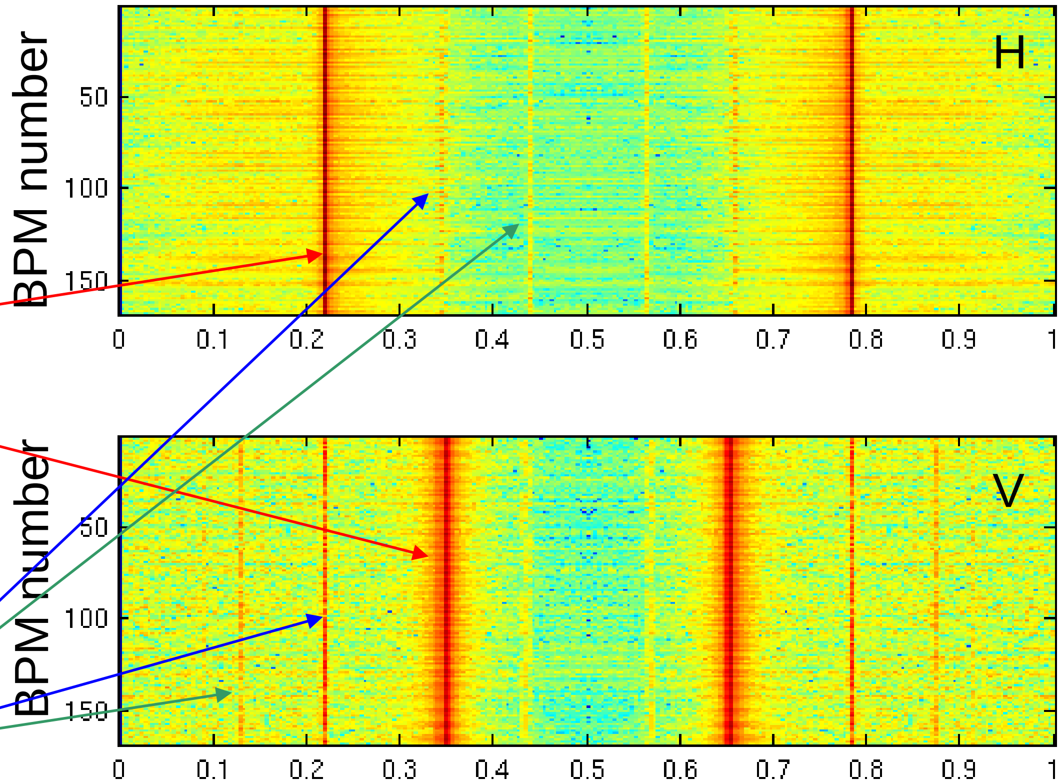
- excite the beam diagonally
- measure tbt data at all BPMs
- colour plots of the FFT

Q_X = 0.22 H tune in H

Q_y = 0.36 V tune in V

All the other important lines are linear combination of the tunes Q_x and Q_y

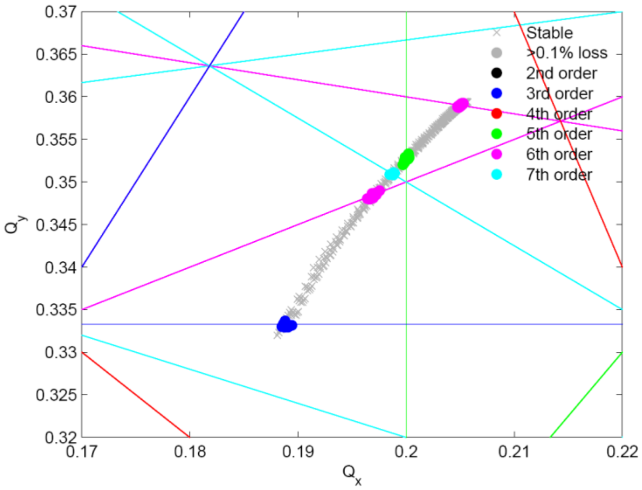
$m\,Q_x + n\,Q_y$



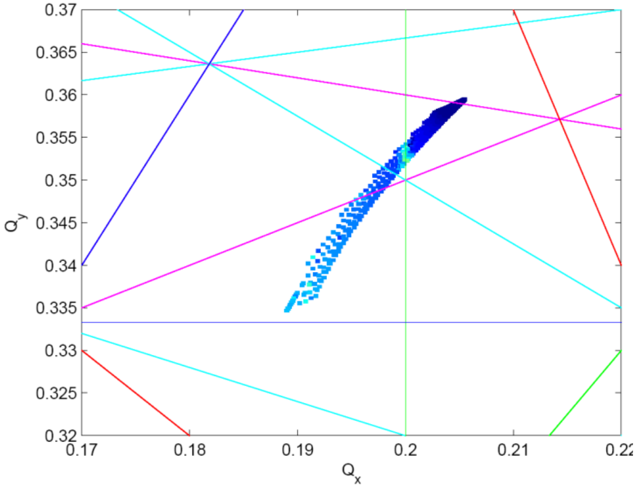
frequency / revolution frequency

Frequency map and detuning with momentum comparison machine vs model (II)

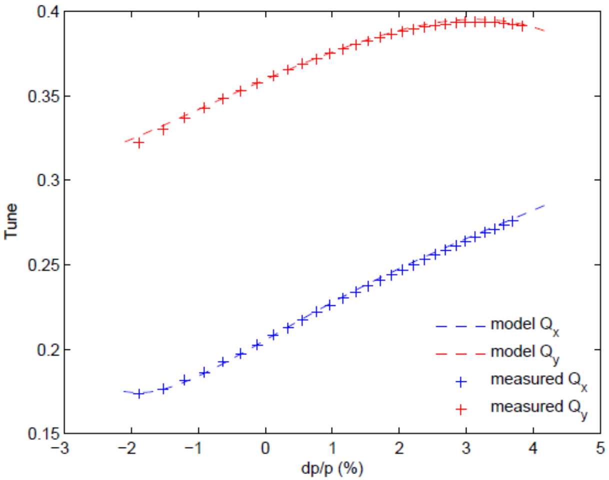
FM measured



FM model



detuning with momentum model and measured



Sextupole strengths variation less than 3%

The most complete description of the nonlinear model is mandatory !

Measured multipolar errors to dipoles, quadrupoles and sextupoles (up to b10/a9)

Correct magnetic lengths of magnetic elements

Fringe fields to dipoles and quadrupoles

Substantial progress after correcting the frequency response of the Libera BPMs

JAI-Diamond contribution to CLIC activity

JAI-Diamond contribution is focussed on low emittance issues

(co-coordinator of WP on Low emittance ring network + addendum to MoU with JAI)

Diamond can be used as test-bed for new low-emittance tuning algorithm and associated problmes of interest for CLIC damping ring

Experimental programmes in development with

CLIC (Y. Papaphilippou)

SuperB (P. Raimondi, M. Biagini, S. Liuzzo)

Cornell CersTA and Cockcroft Insitutute (M. Palmer, A. Wolski, J. Shanks)

1 PhD at JAI Oxford

JAI-Diamond contribution to CLIC activity

Collaborators: general information and resource estimate

Institute:	John Adams Institute (Oxford Un.), DIAMOND
Main contacts:	R. Bartolini
CERN responsible:	Yannis Papaphilippou
Activity/work package/task:	BPH-DR Damping ring studies
Technical subject:	Methods and diagnostics for linear and non-linear correction
Working arrangement:	Independent work, visits, experiments and common workshops
Funding status:	Not established
Formal agreement:	MoU to be signed

Expected resources

	2012	2013	2014	2015	2016
Material budget [CHF at current rate]					
Manpower at institute [FTEyears]	0.1	0.1	0.1	0.1	0.1
Manpower at CERN [FTEyears]	0.6	0.6	0.3	0.3	0.3