Issues with Modelling the BESSY II Transfer Line

Peter Kuske, HZB and Humboldt-Innovation GmbH

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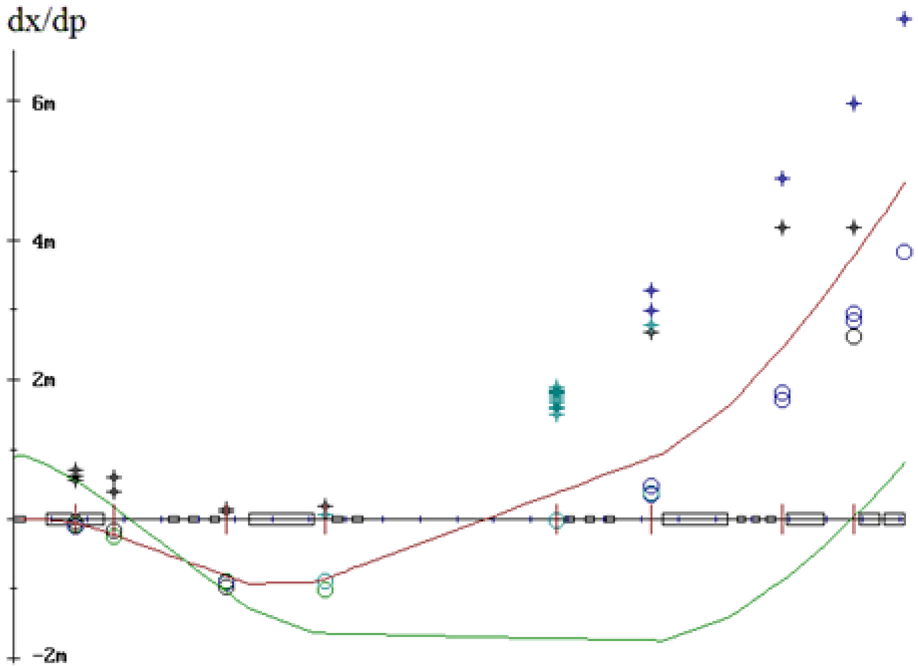
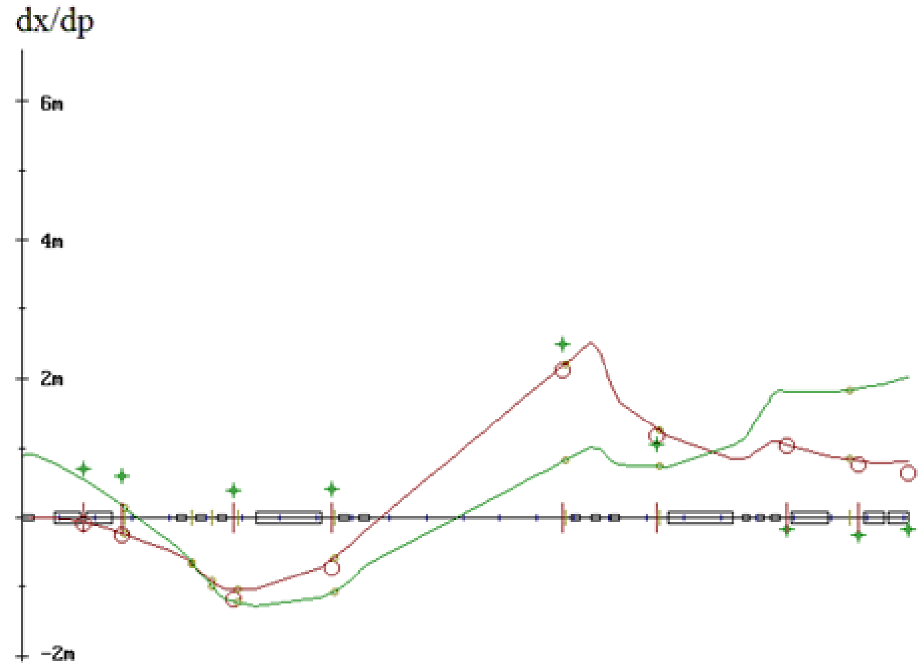
all quadrupoles set to zero:



nominal quadrupole settings:

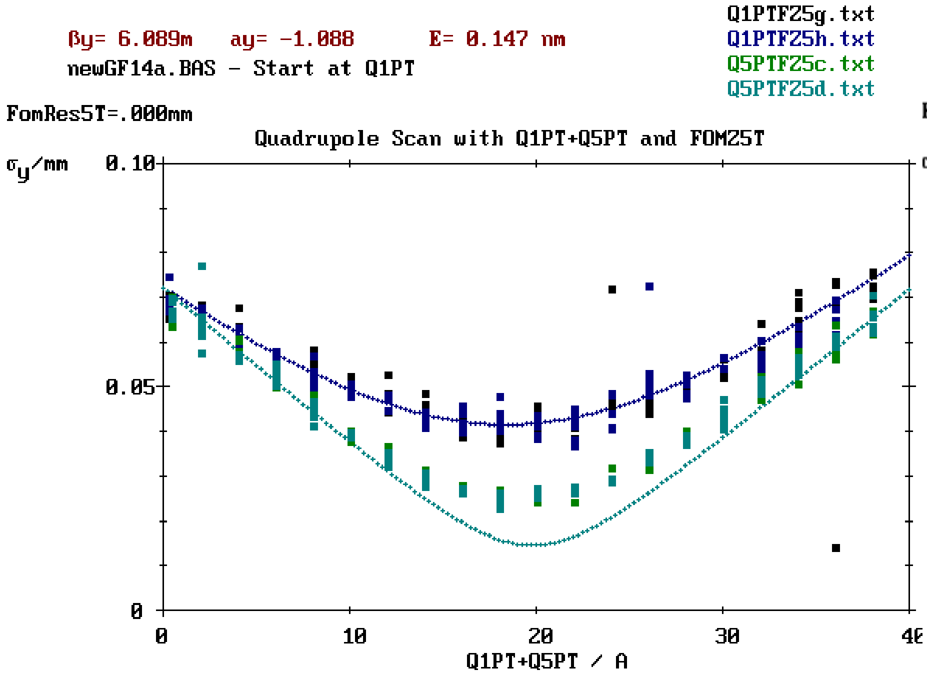


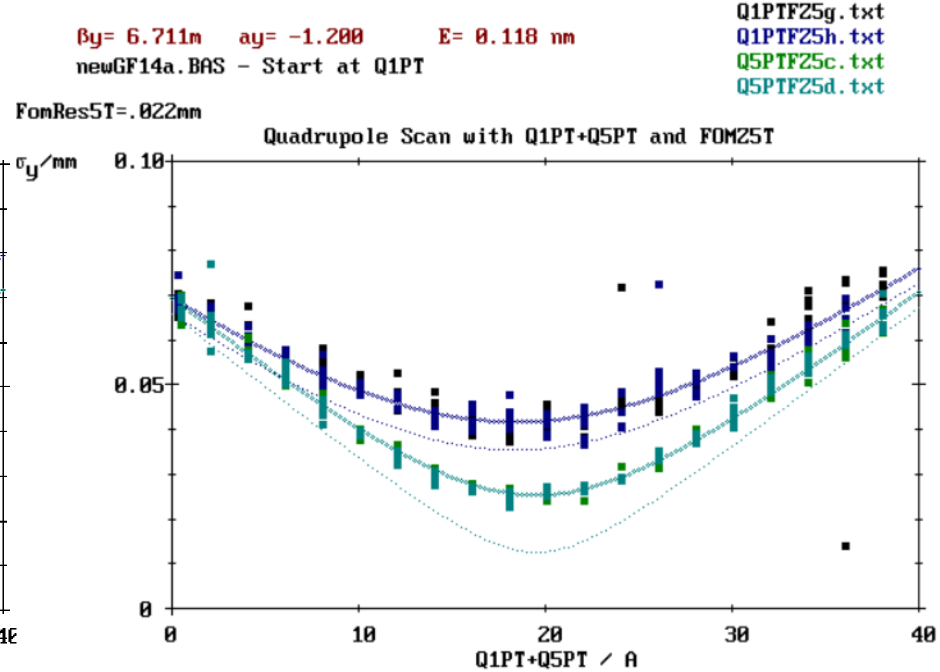
theoretical expectations = lines, measurements = dots and crosses

green curve and crosses – RF-variation in the booster
red curve and circles – variation of the extraction time

display starts with the last quadrupole in the synchrotron seen by the extracted beam

assuming a finite resolution of the beam size monitors results in a single set of results:

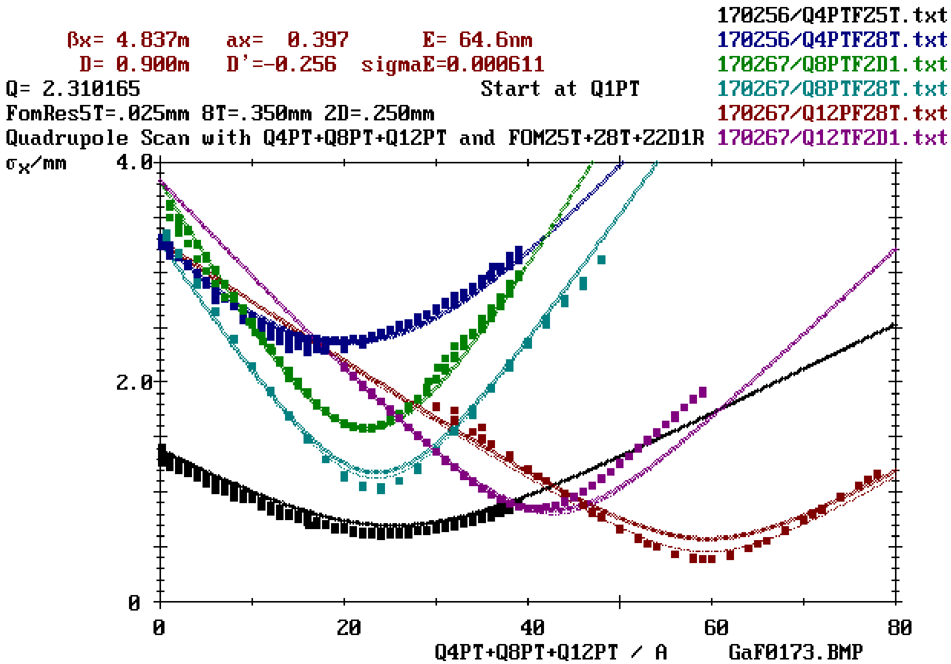


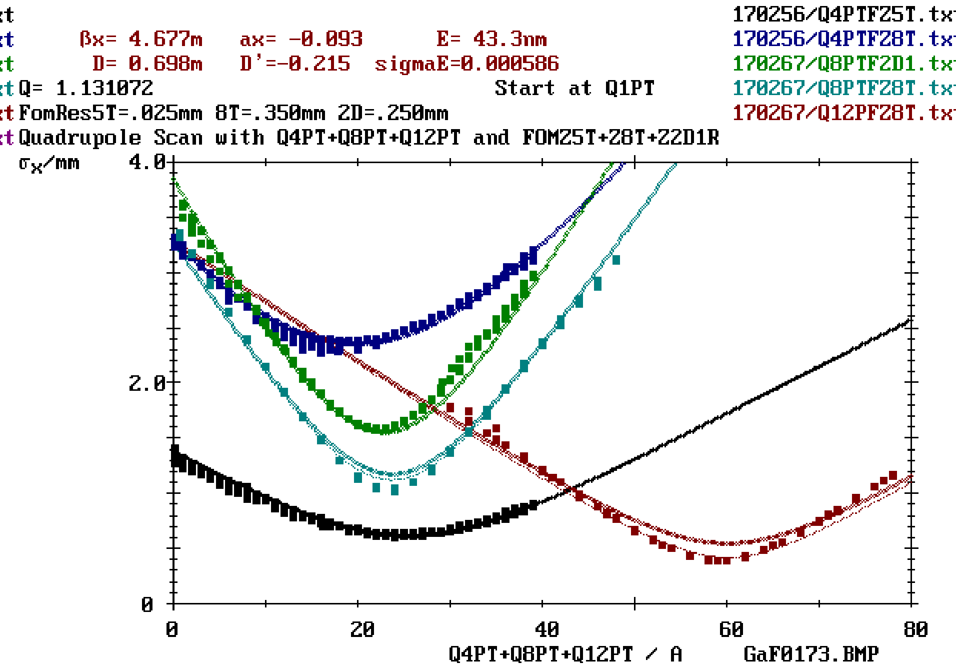


dots are experimental results, thick line predicted dependance, thin line – true beam size

Date	$ß_y$/m	$α_y$	$ε_y$/nm·rad	Comment
13.3.2017	5.68(0.6)	-1.25(0.12)	0.146(0.02)	late extraction
6./7.3.2017	5.90(0.5)	-0.84(0.05)	1.32(0.1)	early extraction
6./7.3.2017	6.03(0.5)	-0.97(0.10)	41.4(5.0)	late extraction, on coupl. reson.
6./7.3.2017	5.84(0.4)	-1.40(0.1)	3.3(0.3)	early extraction

determination of $ß_x$, α_x, ε_x, D_x, D_x' und σ_ε requires more than one quadrupole scan and dipole in between to change dispersion

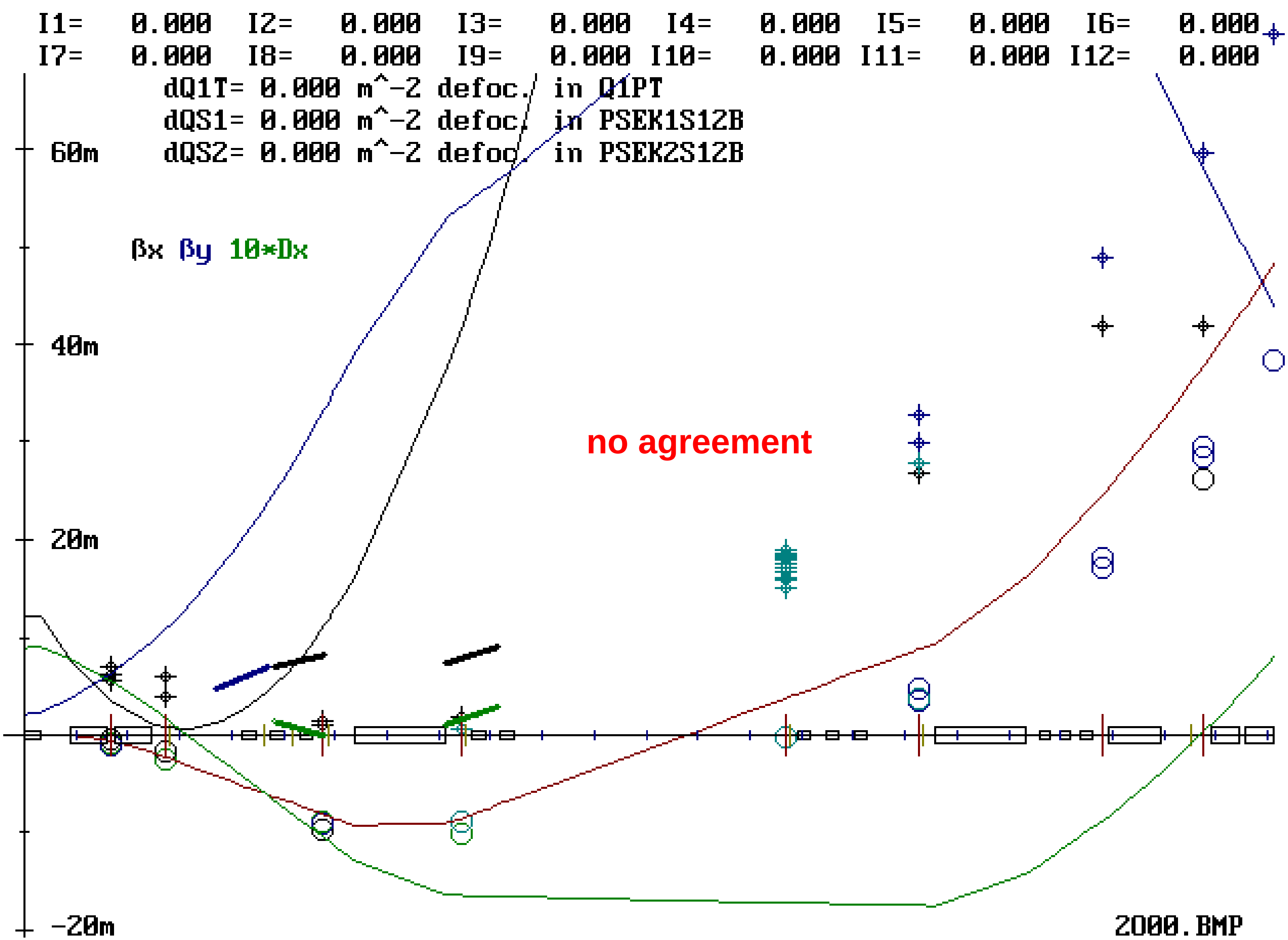




energy spread: $\sigma_\varepsilon \sim 6 \cdot 10^{-4}$, independent on extraction time
emittance - $\varepsilon_x \sim 70 \pm 20$ nm·rad or $\varepsilon_x \sim 50 \pm 10$ nm·rad, for late and early extraction

Position	$ß_x$/m	α_x	Dx/m	Dx‘
at Q3PT	7.6	-0.6	0.2	-.06
at Q4PT	8.2	-0.85	0.2	0.18

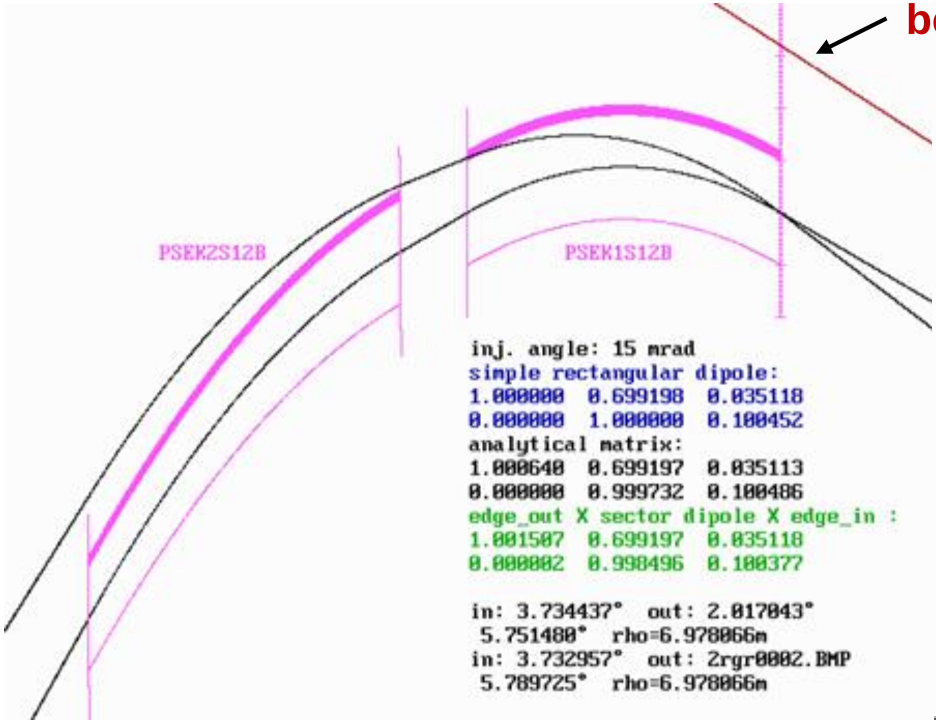
IV. Comparison of Measured and Simulated Dispersive Orbits and Twiss Parameters – all Quadrupole Magnets Zero

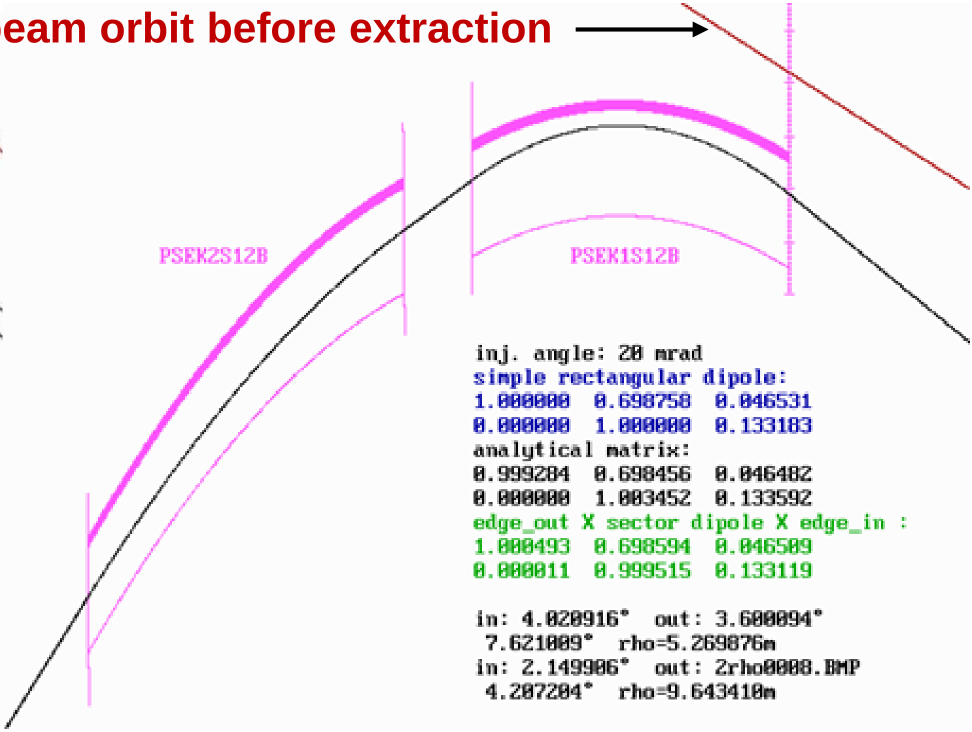


V. 1 Orbit of the Extracted Beam in the Extraction Septa

due to entrance angle of extracted beam and displaced septa the actual orbit differs significantly from the design orbit:

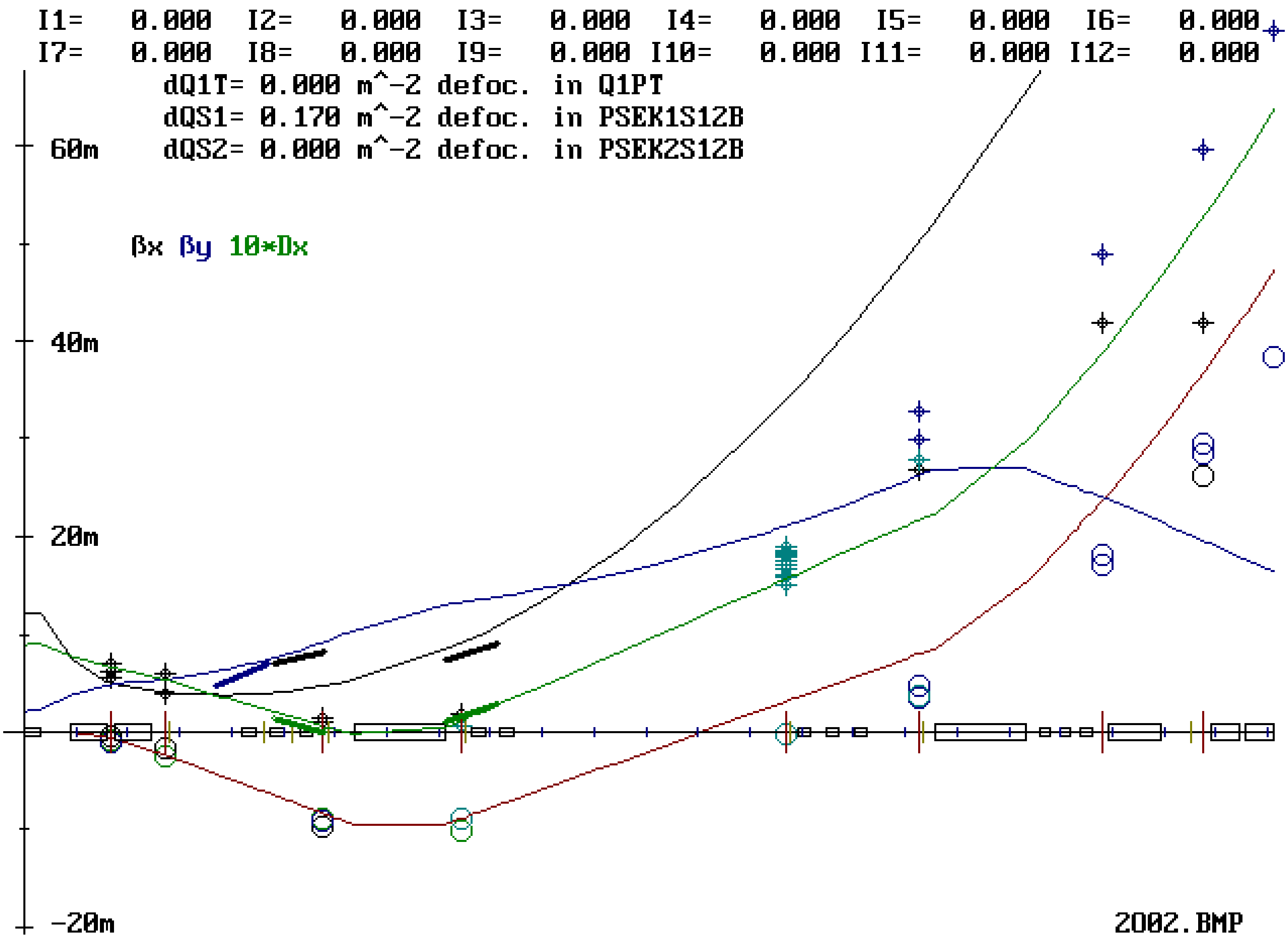
beam orbit before extraction



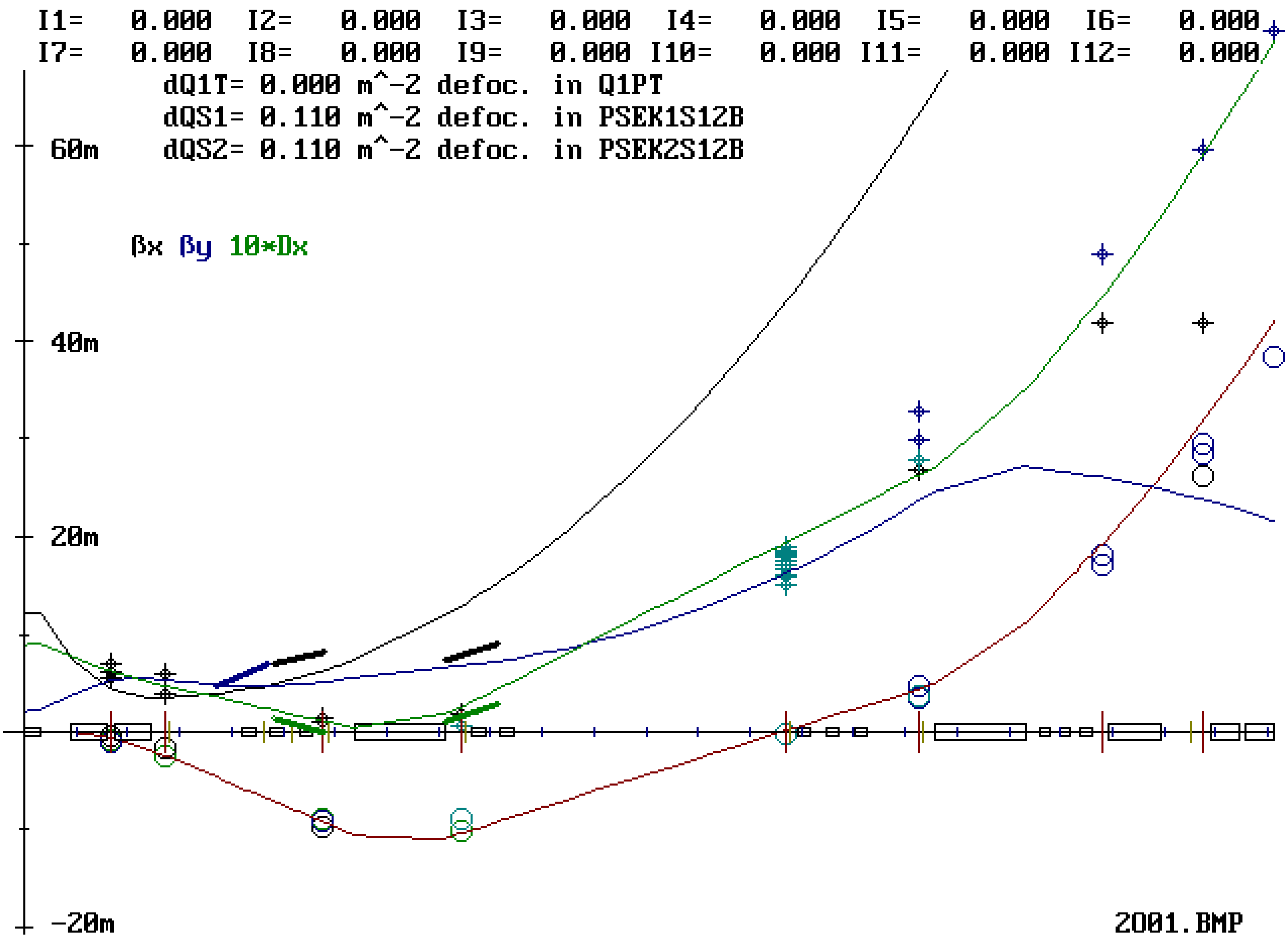


extracted beam passes very close to the septum blade where field deviates from a pure dipole – to first order this corresponds to a defocusing gradient

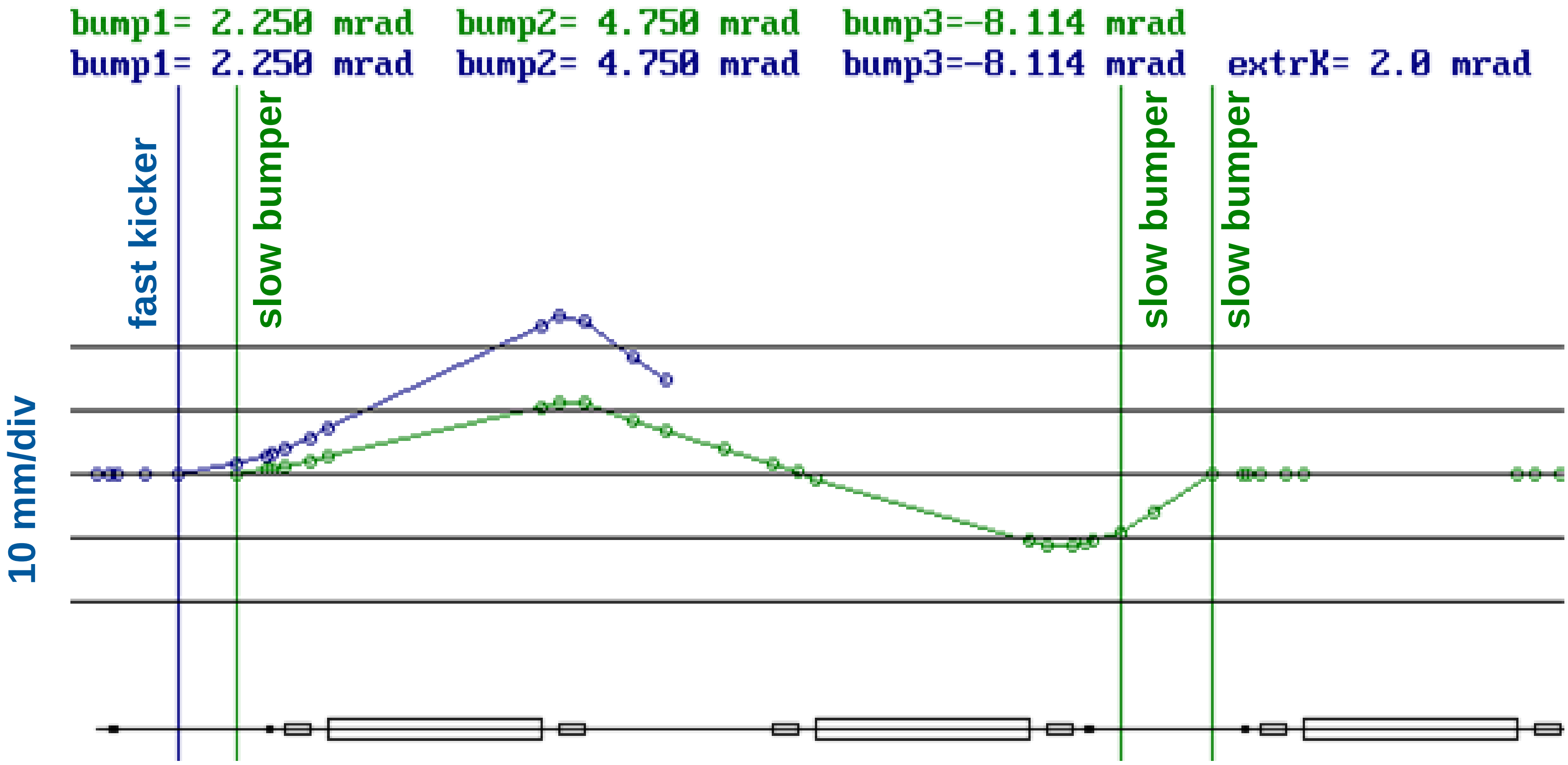
Comparison of Measured and Simulated Parameters – with Defocusing Gradient in First Septum Magnet



V. 3 Comparison of Measured and Simulated Parameters – with Defocusing Gradient in Both Septum Magnets

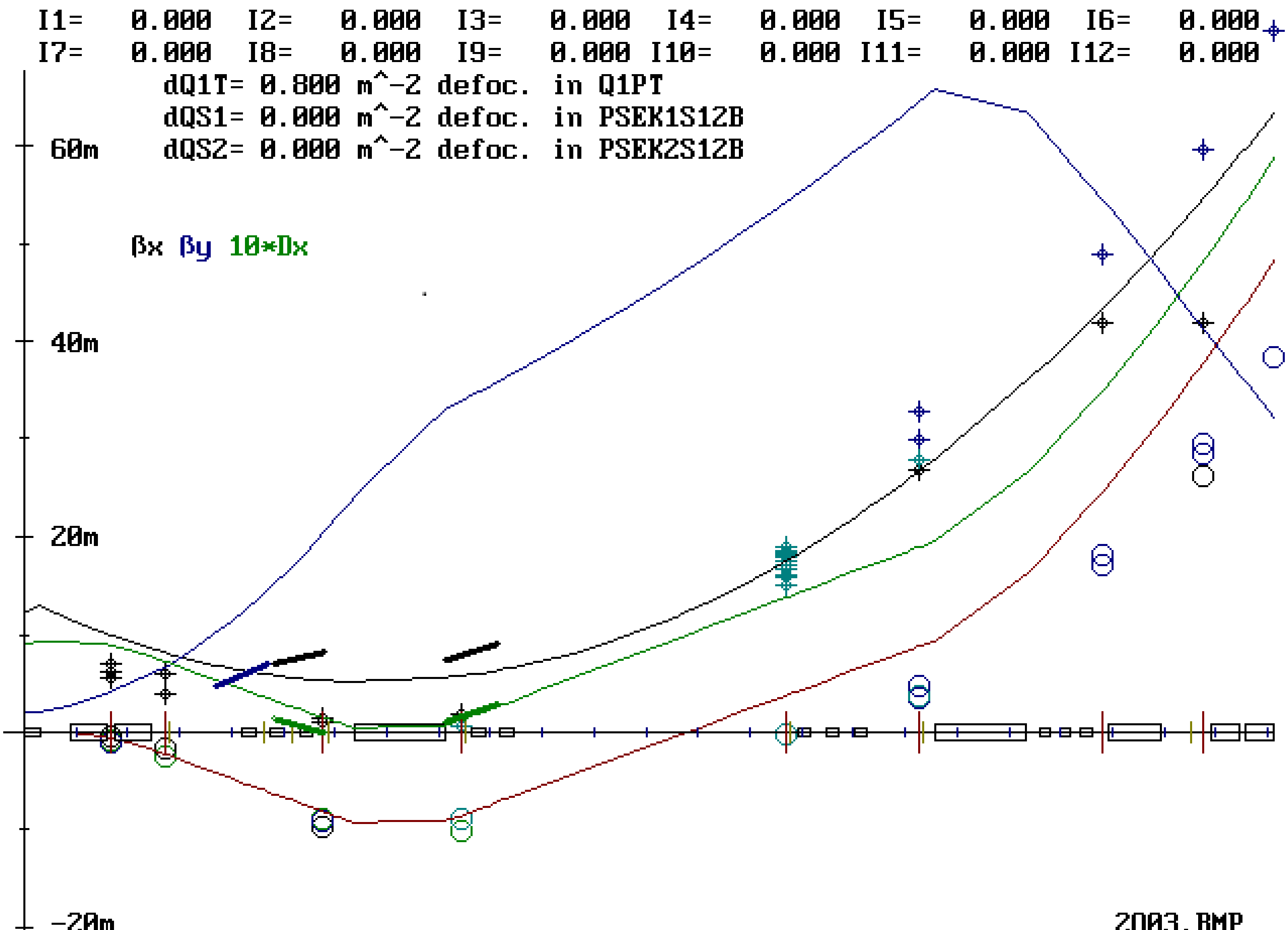


in green: orbit due to slow bump
In blue: kicked beam on its way to the septum magnet



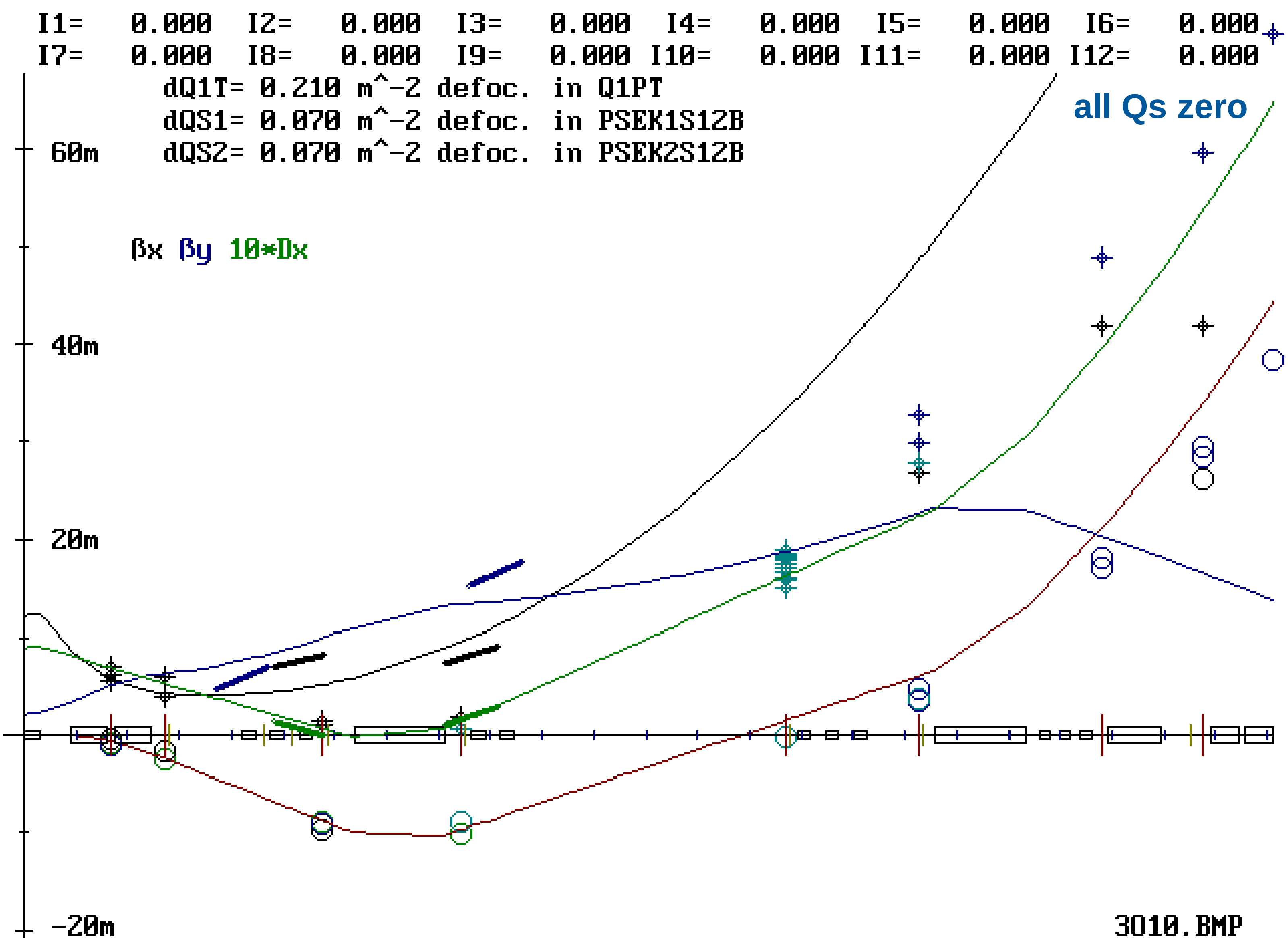
large orbit offset in focusing quadrupole QF where gradient levels off – reduced gradient equivalent to defocusing quadrupole, much smaller defocusing effect in sextupole magnet due to slow bump

VI. 2 Comparison of Measured and Simulated Parameters – with Reduced Focusing in Last QF

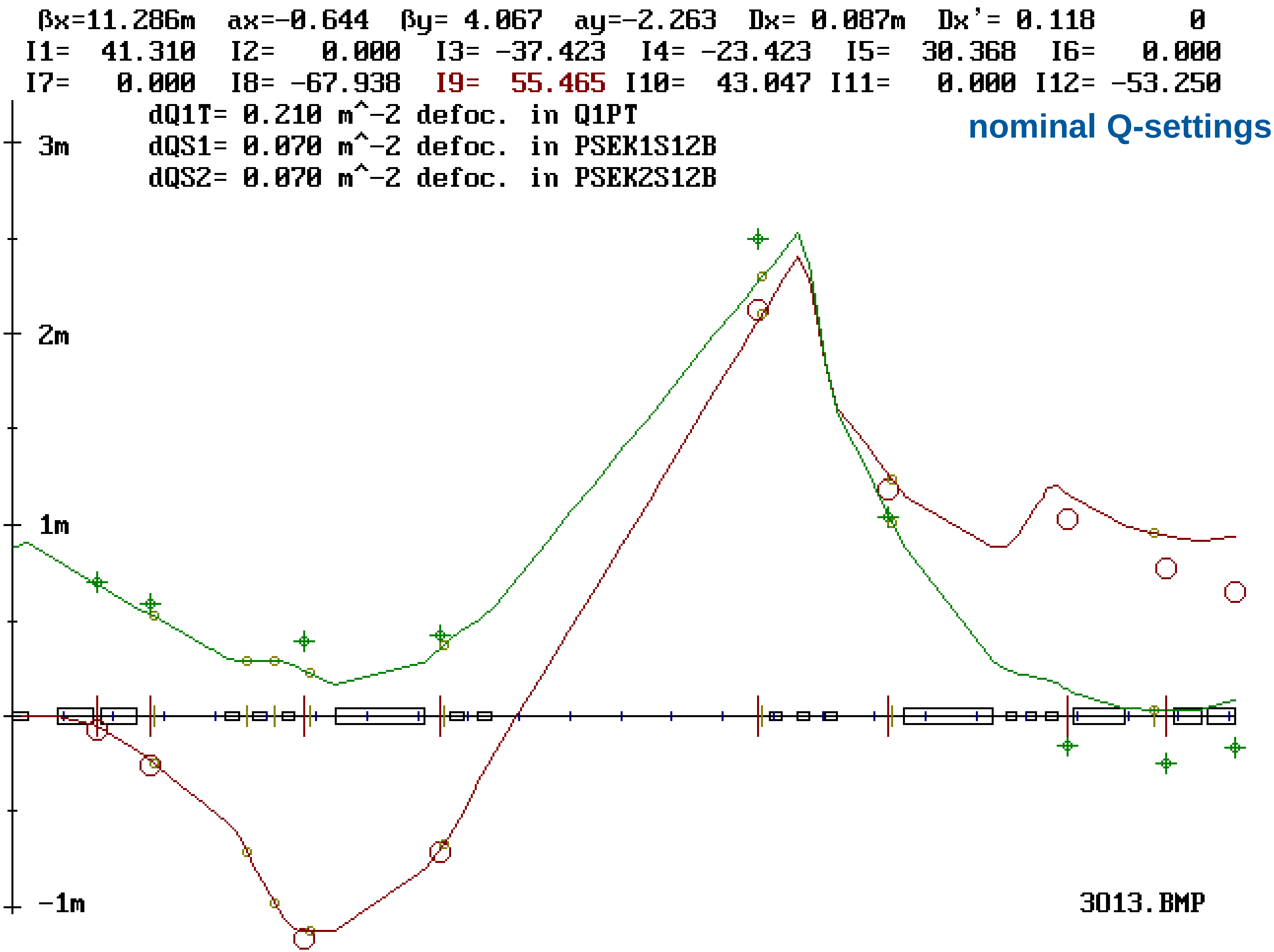


20% saturation – eddy current effect? 10 Hz White-circuits

VI. Comparison of Measured and Simulated Parameters – with Distributed Defocusing in QF and Septa



VII. Comparison of Measured and Simulated Dispersive Orbits



VIII. Summary

Take care with dispersive orbits – change of energy by:

- **varying the extraction time**
- **varying the RF in the synchrotron (assuming longitudinal damping is complete)**

Careful analysis of quadrupole scans – finite resolution of beam size monitor

- **energy spread and emittance in agreement with expectations**
- **initially complete disagreement of measured and expected lattice parameters**

Satisfactory modelling of the transfer line required:

- **additional defocusing effects at the beginning of the transfer line – how?**
- **extracted beam with large offset in the last Qf of the synchrotron and eddy current effect?**
- **extracted beam very close to the septum blade**

Vertical emittance very small – reduction of horizontal emittance of the injected beam by an emittance exchange with the vertical plane

Would likely allow for omitting the injection optics with a 20% emittance improvement in the SR

any questions?