Frequency Map Experiments at BESSY

P. Kuske, O. Dressler

My Motivation

Apparatus

Kicker

Turn-By-Turn BPM

Experimental Procedures

Data Analysis

Results

X – Y - Kick Frequency Maps

dRF – X - Kick Frequency Maps

Summary
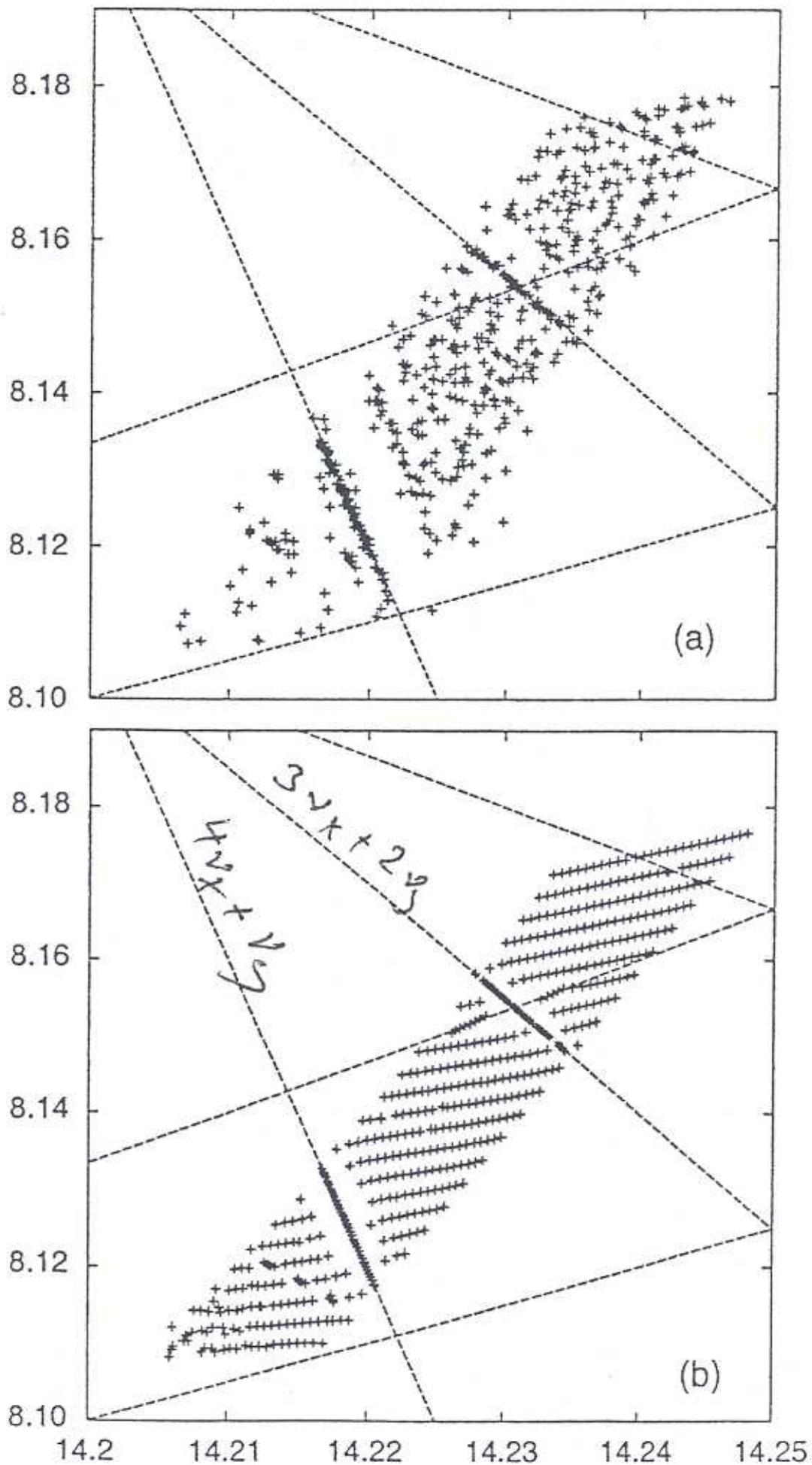
FIG. 3. Experimental frequency map (a), and numerical simulation (b) for the ALS with its current settings. Resonances of order ≤5 are plotted with dotted lines.

Apparatus

1. Transverse and longitudinal Beam Kick
2. Turn-By-Turn Record of Beam Position
3. Extraction of the Fundamental Frequencies

Kicker Magnets

Horizontal and vertical sinusoidal half-wave Kickers

    Max. kick = 3.5 mrad @ 1.7 GeV

    Foot width = 1.2 μs (T_{rev}=800 ns)

RF-steering in the longitudinal plane

Kicker Timing: Synchronized to revolution time
                      Variable delay
                      Coincidence with 50 Hz-mains

   Rep. Rate determined by data collection process
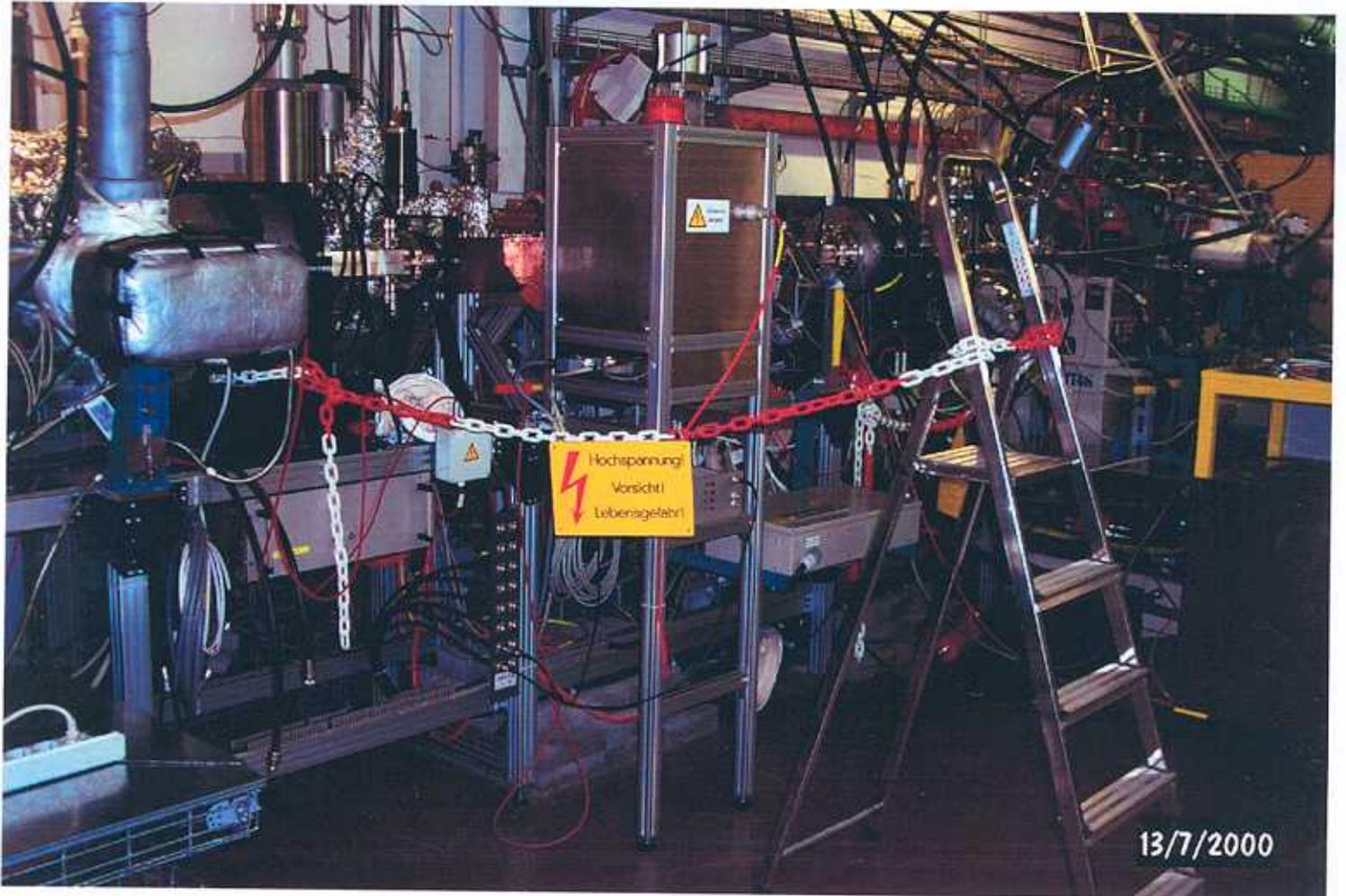
Hochspannung!
Vorsicht!
Lebensgefahr!

13/7/2000
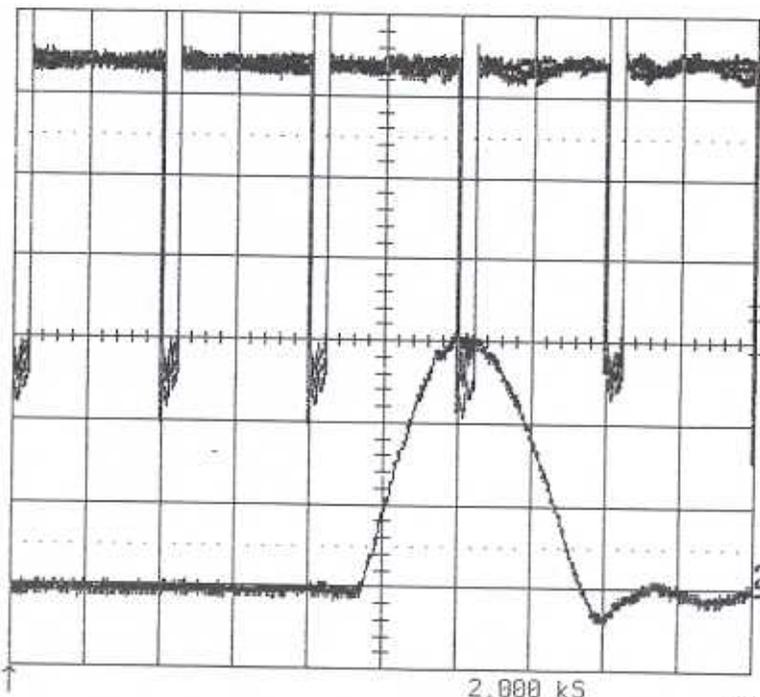
Turn-By-Turn BPM for Individual Bunches
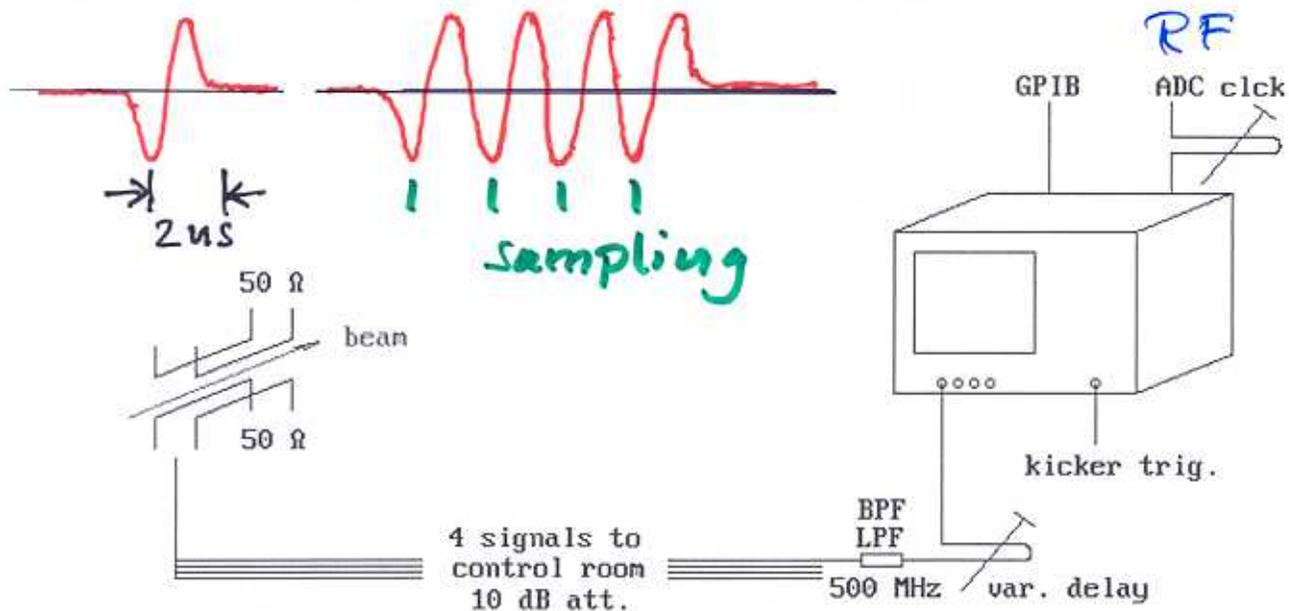
Features of the Oscilloscope (LeCroy LC684DXL)
    4 channels, 1 GHz analog bandwidth
    8 bit ADC with 500 MHz sampling rate (ext. clck.)
    up to 2 Mbyte of data ≡ 5000 recorded turns
    Math package allows signal averaging

Limitation: 8 bit ADC
    Single turn, single bunch resolution
        $\Delta \approx 15$ mm $\cdot \Delta/\Sigma \approx 40$ μ
Solutions:
1. Averaging
2. Single bunch and bandpass filter
3. Bunch train of 100 ns length ➜6 μ resolution
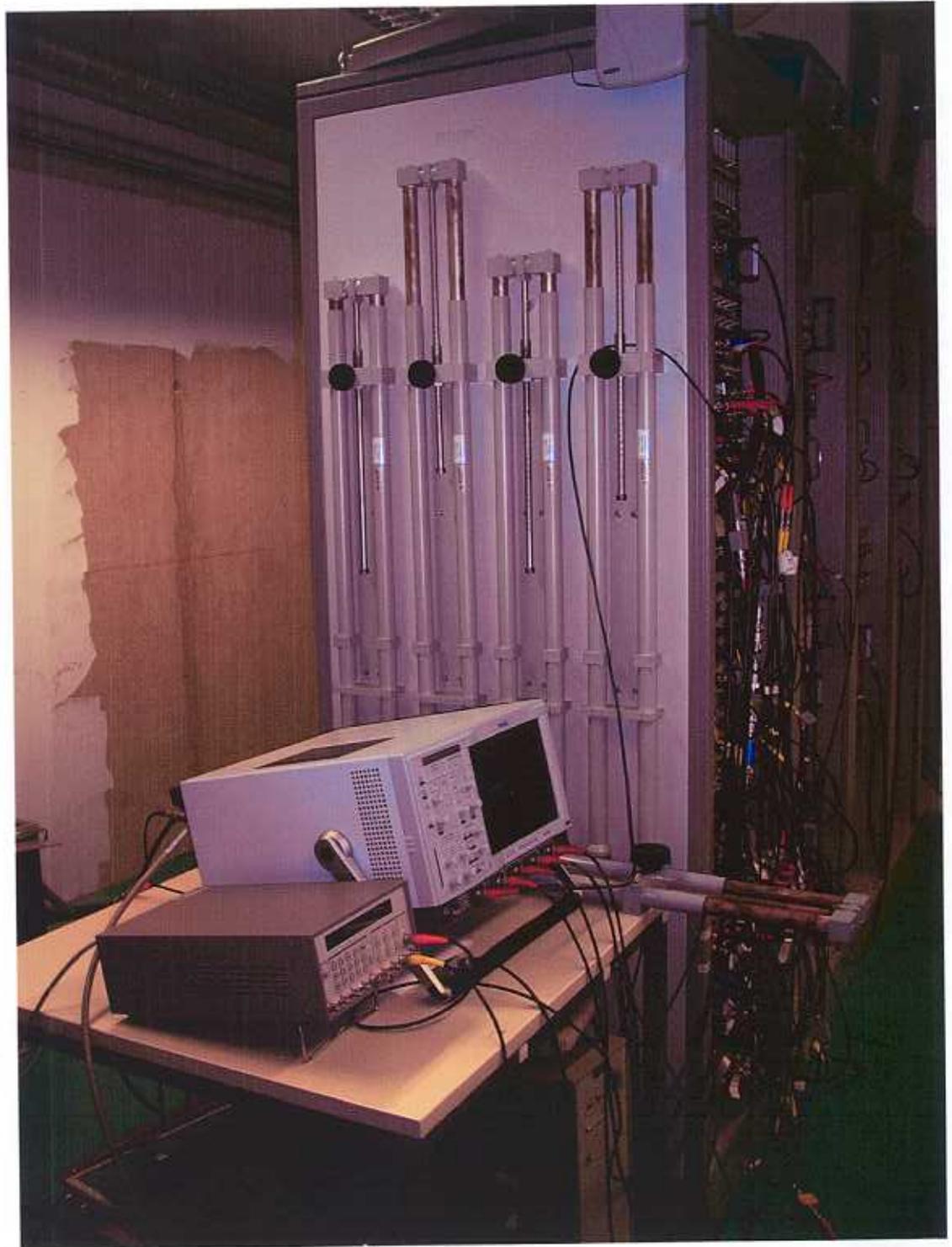
Experimental Procedure

PC controls the Experiment

    LabView-program (O. D., Jens Kuszynski)

    Connection to Accelerator control system:

        Kicker and RF settings, enable trigger, read beam current, inject beam

    GPIB interface to oscilloscope:

        Reading settings, data transfer, and data storage

Frequency Map Aquisition

Trigger variable

PKDHKR:cmd6   [ ]   **New injection**

Beam current   Current min.   Current max.   **Mode**

MDIZ3T5G:current   2.50   5.00   K

Var1   V1 min   V1 max   Number of steps [1]

PKDVKR   1.000   7.000   26

Var2   V2 min   V2 max   Number of steps [2]

PKDHKR   1.000   13.000   43

Ini file name / path

E:\peter\init double_kick xx steps.dat

New file name / path

E:\peter\03070400.dat

applied points
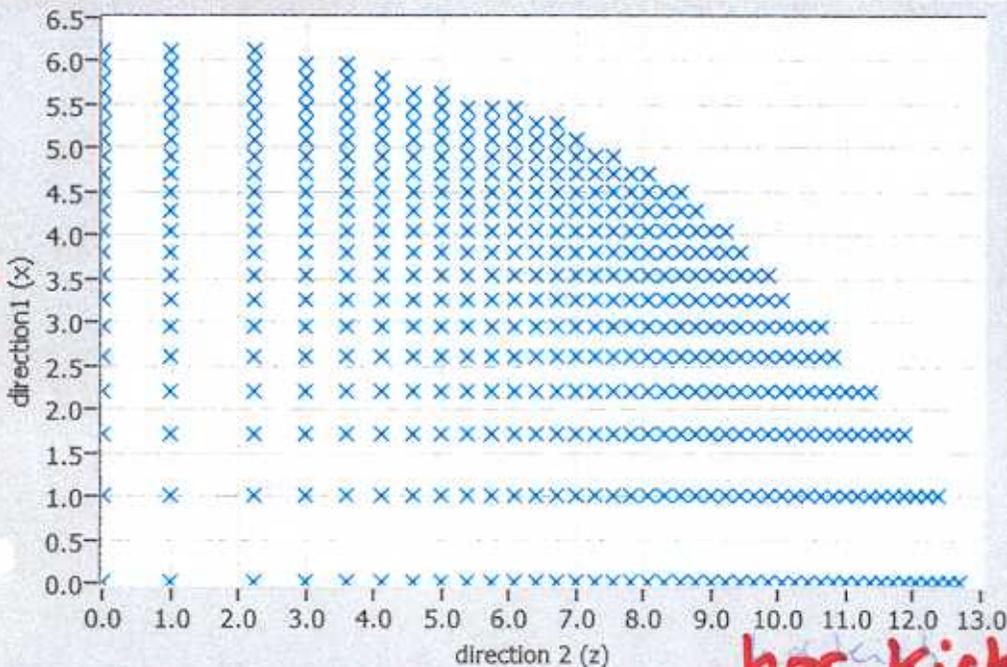
Stepwidth def. kickers

square root   0

Timeout CTL [s]

3.00

Wait for scope [s]

1.00

Scope VISA session

GPIB0::5:

Acquisition

Single   3

Source

Source (0:Ch. A)

Channel 1

Source (1:Ch. B)

Channel 2

Source (2:Ch. C)

Channel 3

Source (3:Ch. D)

Channel 4

V1 set	V1act
0.010	0.005

V2 set	V2 act
0.010	0.013

x	z
21	0

Plot 0

vert. Kick

hor. kick

direction1 (x) vs direction 2 (z)

Modus   STOP

norm. Closu.

ohne WLS

Frequency Map Aquisition

Trigger variable
PKDHKR:cmd6

New injection

Transfer

Timeout CTL [s]
3.00

Beam current
MDIZ3T5G:current

Current min.	Current max.	**Mode**
1.00	5.00	M

Stepwidth def. kickers
square root   0

Var1
MCLKHX251C

V1 min	V1 max	Number of steps [1]
499604.035	499649.035	45

Wait [s]
1.00

Var2
PKDHKR

V2 min	V2 max	Number of steps [2]
1.000	15.000	29

Scope VISA session
GPIB0::5::INSTR

Ini file name / path
E:\peter\init Mclk_kick up and down.dat

Acquisition   Transfer
Single   3   Byte

New file name / path
E:\peter\03091700.dat

Source

Source (0:Ch. A)
Channel 1

aquried
r...ts

Source (1:Ch. B)
Channel 2

Plot 0

Source (2:Ch. C)
Channel 3

Source (3:Ch. D)
Channel 4

direction 1 (x) vs direction 2 (z)

V1 set	V1act
499640.035	499604.035

V2 set	V2 act
0.010	0.996

x	z
2	46

write   Modus   STOP

(handwritten annotations) 0/0   RF   hor. Kick   mit 3x WLS   50 kS/shot $\xi_x \approx +5, \xi_y \approx 0$

Data Analysis

Calculation of beam position including geometric distortions:
$$X = \Delta_x/\Sigma \text{ and } Y = \Delta_y/\Sigma$$

$$\Delta x[mm] = 17.96 \cdot X + 14.3 \cdot X \cdot X \cdot X - 32.3 \cdot X \cdot Y \cdot Y$$
$$\Delta y[mm] = 13.68 \cdot Y + 3.8 \cdot Y \cdot Y \cdot Y - 9.9 \cdot Y \cdot X \cdot X$$
$$I[a.u.] = \Sigma \text{ (without geometric distortion)}$$

Extraction of fundamental frequencies - my choice:
- Hanning window and conventional Fourier transformation with peak finding algorithm
- Number of data points depending on chromaticity
- Visual inspection of transformed data

Typically 100 data points analyzed ➜ $\delta Q < 10^{-3}$

std.dev.=%82.848 mm
std.dev.=%74.891 mm

1 mm / div   5% / div

hor.

I

ver.

47 e:/peter/03081904.abc 499643.7 kHz   13 kV   4.215 mA   ? ▮

0.1 ms / div
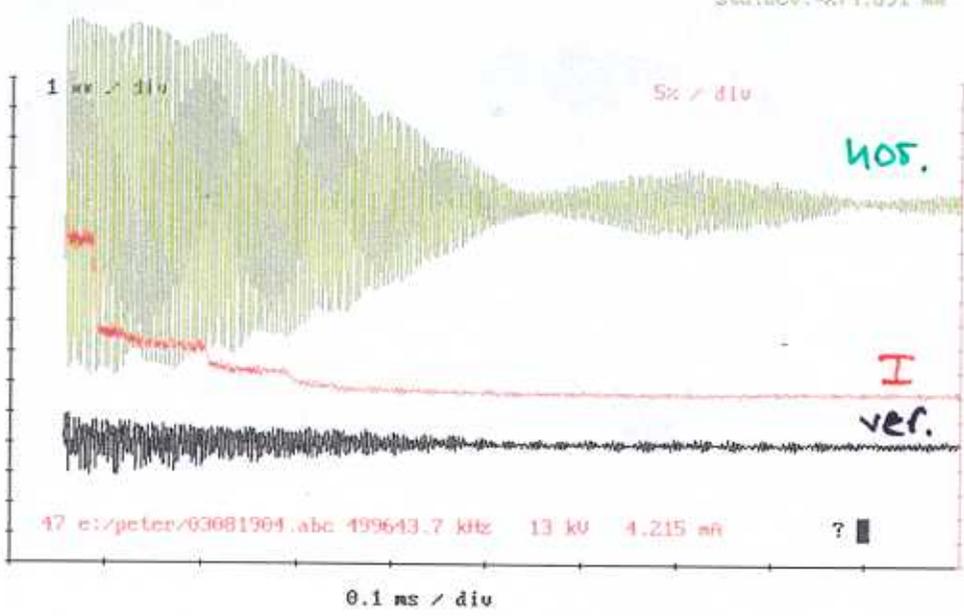
$Q_x = 17.8351$
$Q_y = 6.6970$

close to

$2Q_x - Q_y - $Resonanz

---

1 mm / div   5% / div

hor.

I

ver.

47 e:/peter/03081905.abc 499643.7 kHz   6 kV   4.632 mA   ? ▮

0.1 ms / div

$Q_x - Q_y \approx 0.0156$

---

1 mm / div   5% / div

I

hor.

ver.

47 e:/peter/03081905.abc 499627.7 kHz   8 kV   5.09 mA

0.1 ms / div
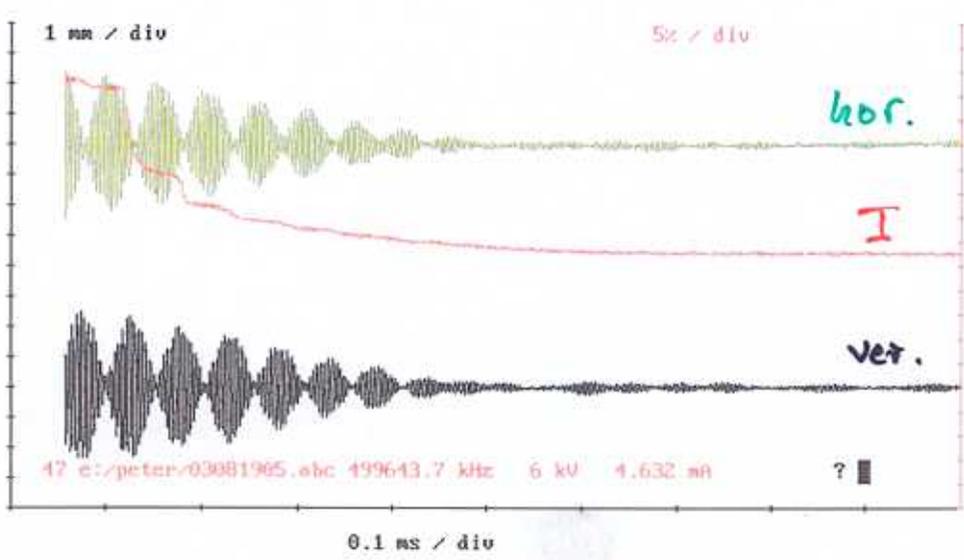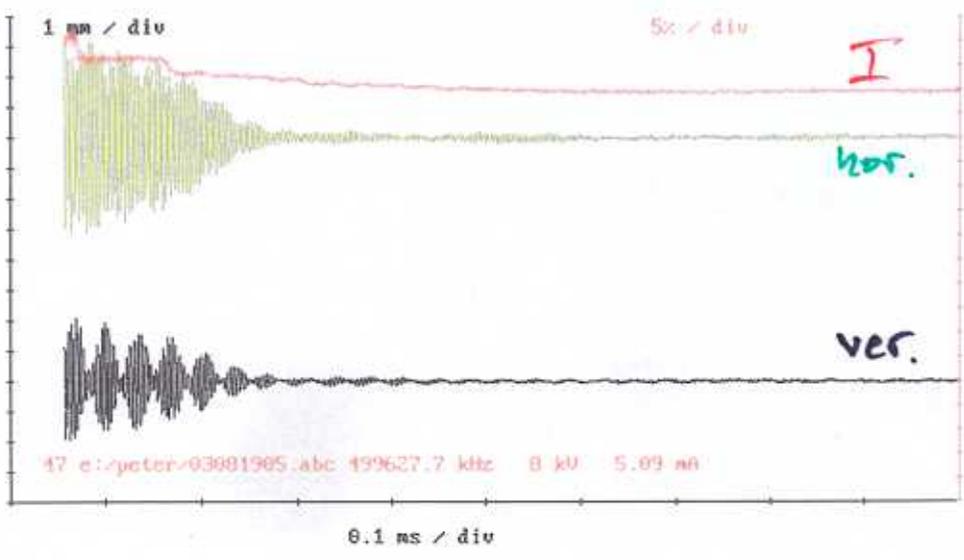
$Q_x - Q_y \approx 0.023$

Experimental Frequency Map
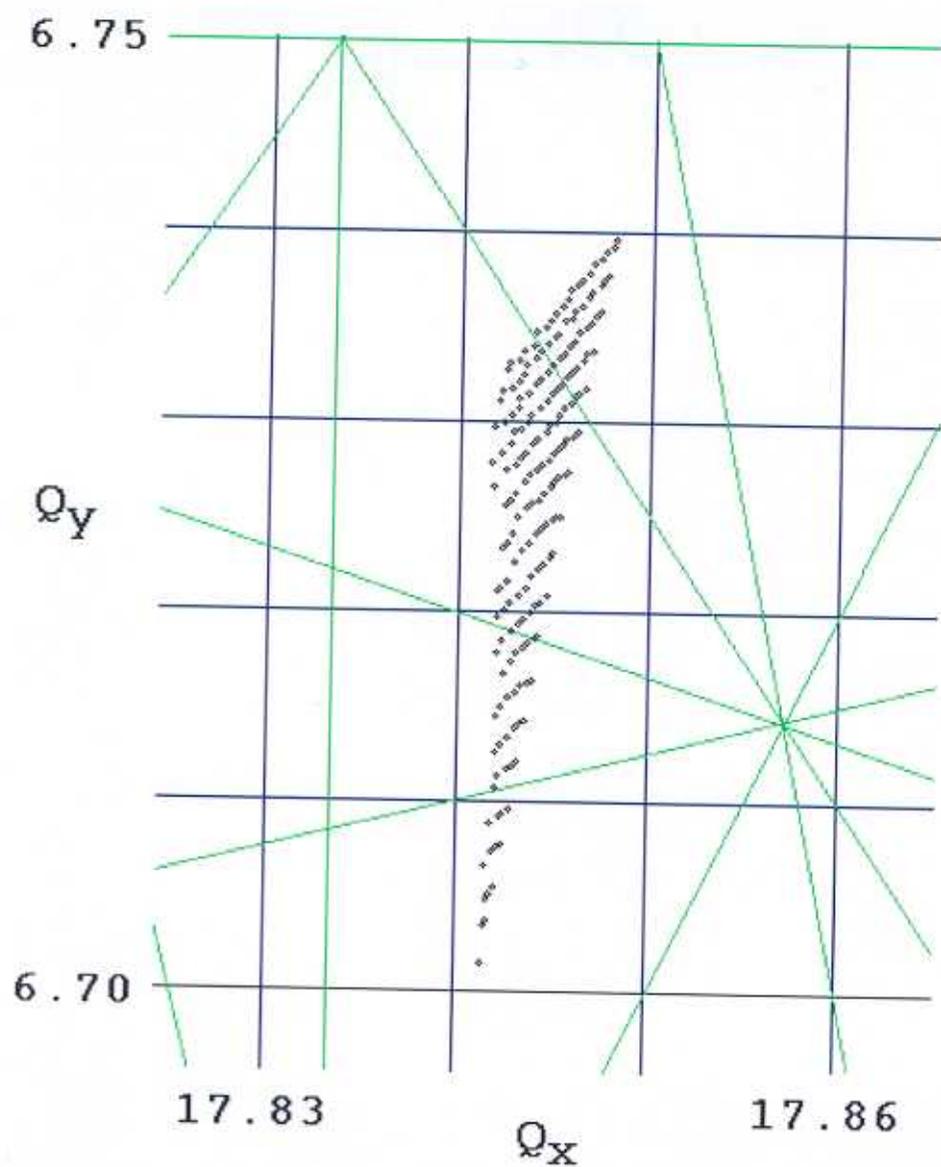
dRF - X - Frequency Maps
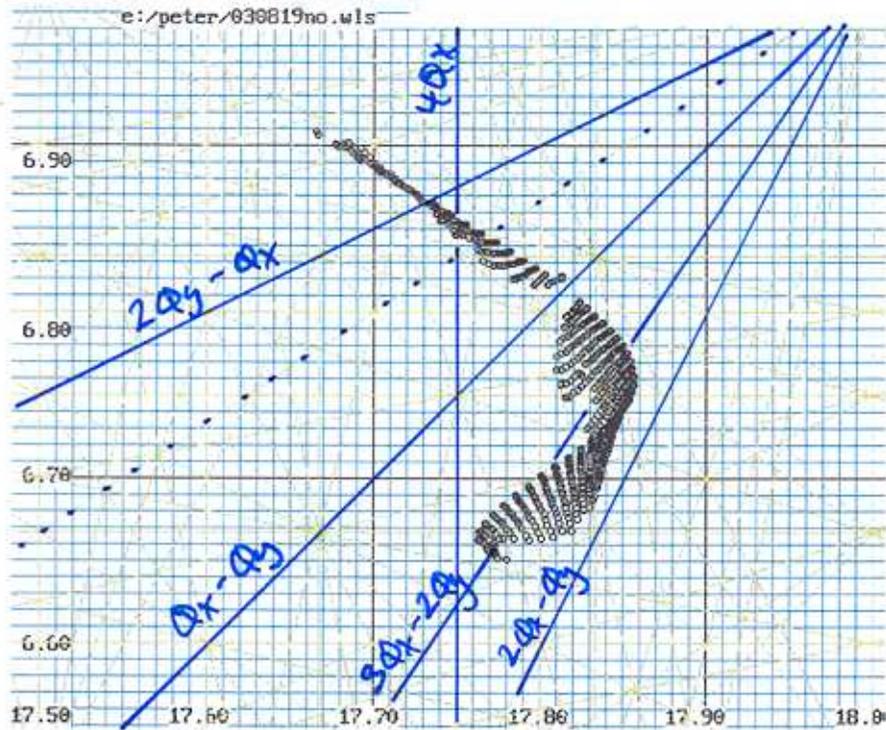
e:/peter/030819no.wls

6.90

6.80

6.70

6.60

17.50 17.60 17.70 17.80 17.90 18.0

$4Q_x$
$2Q_y - Q_x$
$Q_x - Q_y$
$3Q_x - 2Q_y$
$2Q_x - Q_y$

with 3WLS

e:/peter/030819mi.wls

6.90

6.80

6.70

6.60

17.50 17.60 17.70 17.80 17.90 18.0

$2Q_y - Q_x$
$Q_x - Q_y$
$2Q_x - Q_y$
$3Q_x - 2Q_y$
$2Q_x + 2Q_y$
$3Q_x - 2Q_y$
$4Q_x$

dRF-X-Frequency Maps

e:/peter/03091700.erg

with 3 WLS

$$\xi_x \approx +5$$

$$\xi_y \approx 0$$

e:/peter/0308272x.WLS

with 3 WLS

$$\xi_x = \xi_y = 0$$
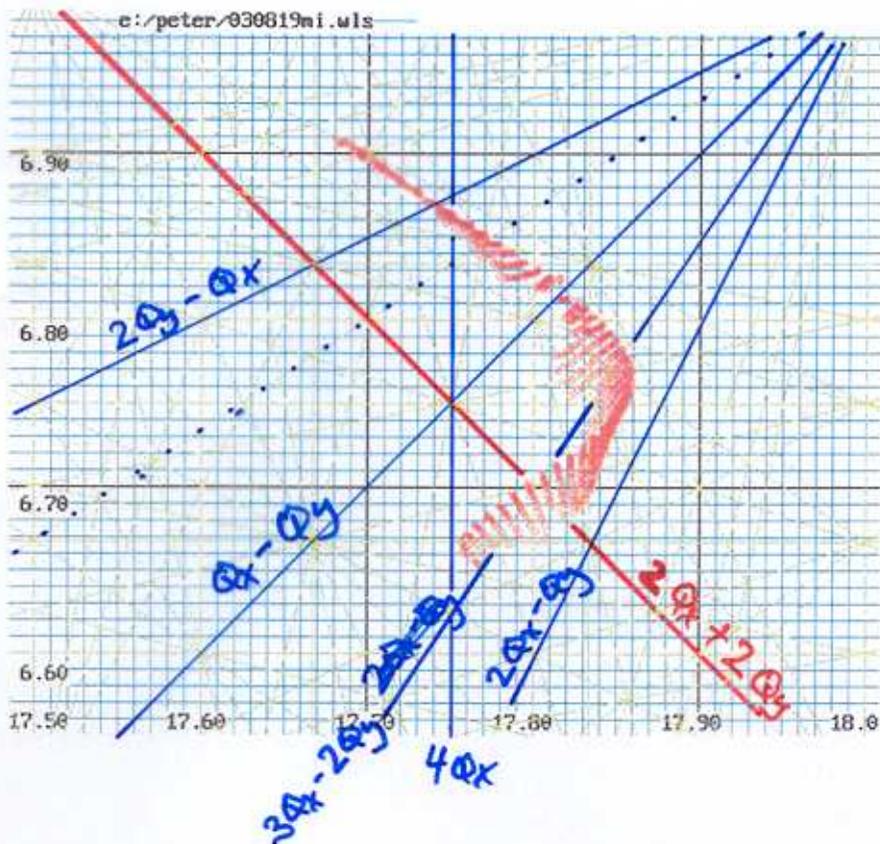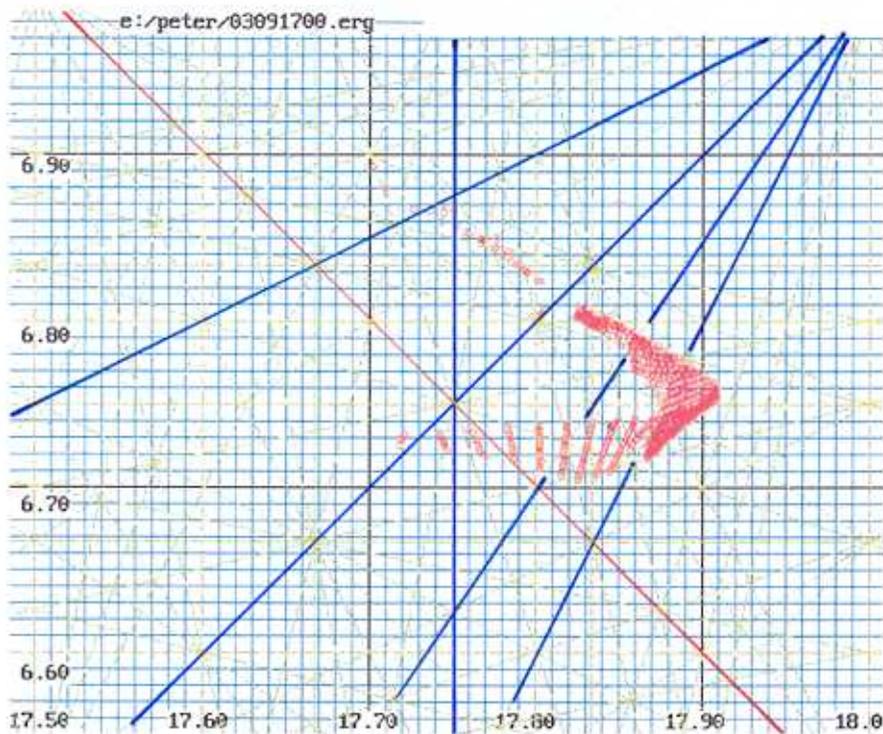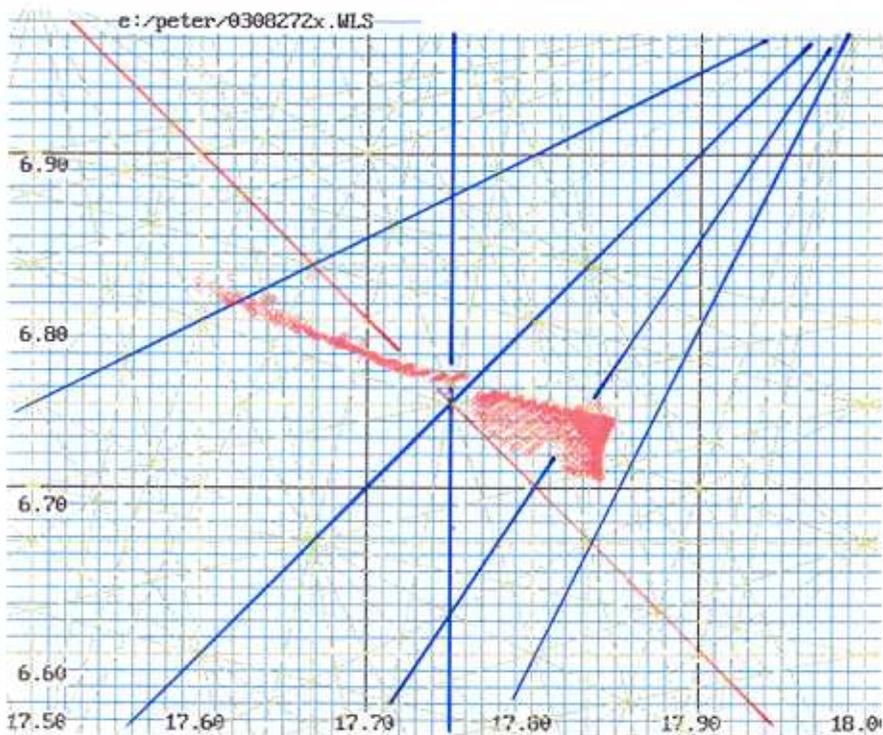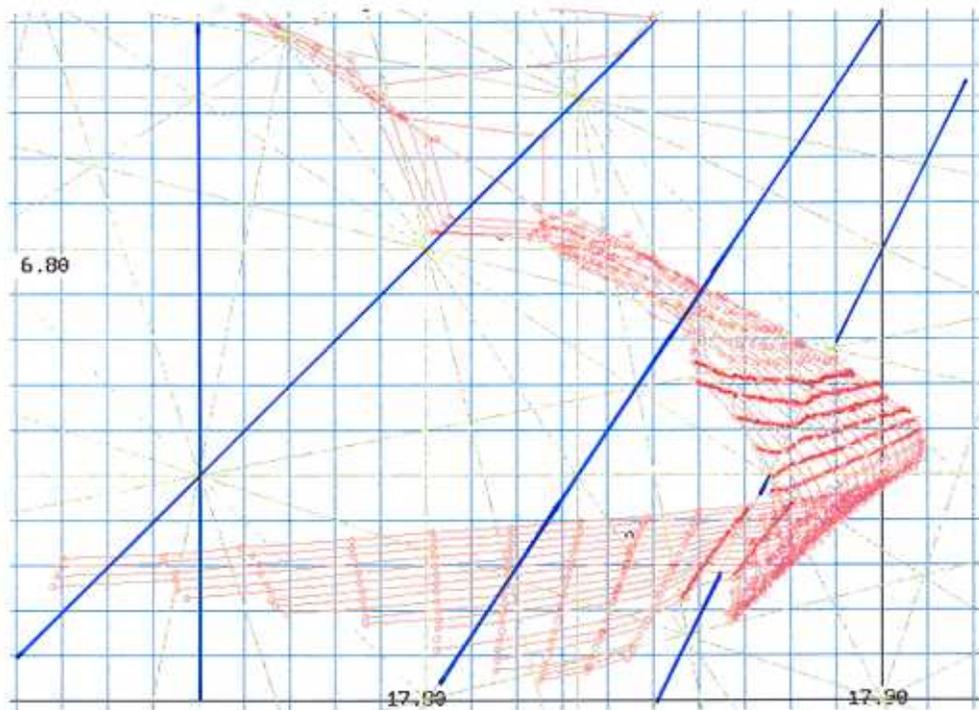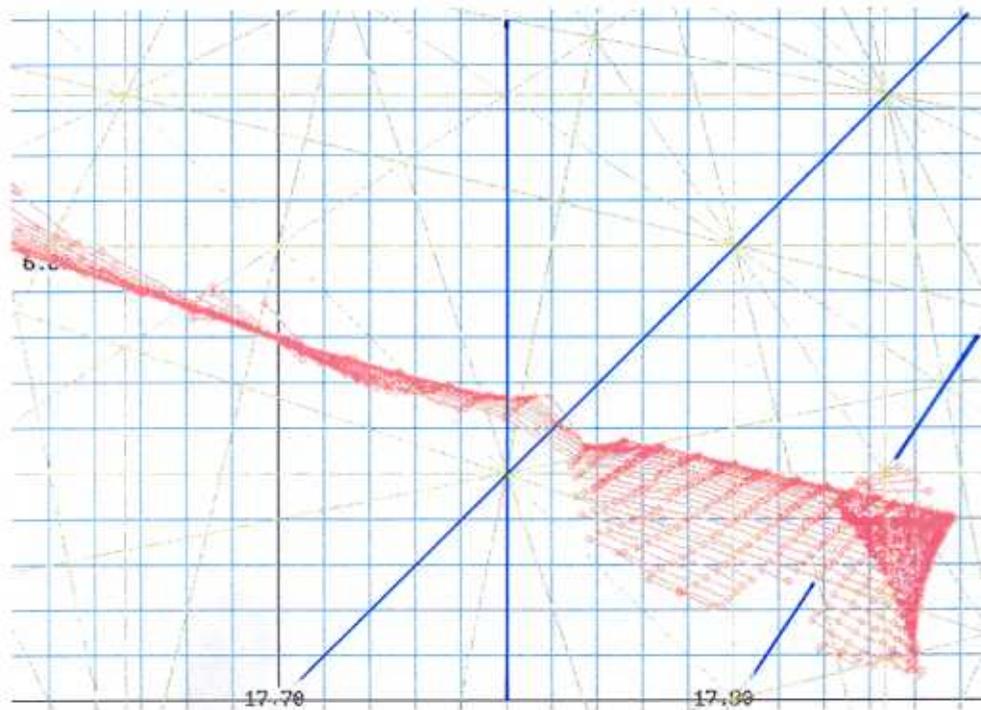
harm. sext. off

S1R	S2DR	S2TR	S3DR	S3TR	S4DR	S4TR		Chix	Chiy
-5.000	3.209	3.209	0.000	0.000	0.000	0.000	[m^-3]	1.512	1.104
90.00	75.00	75.00	0.00	0.00	0.00	0.00	[A]	.8479	.7404

comSfak=.043605 Dipedge=1 Qfringe=%-1.000m   e:/frequmap/03071300.fxy

fak=0

fak=0.5

fak=0.75

fak=1 mit entsprechender

Optikanpassung
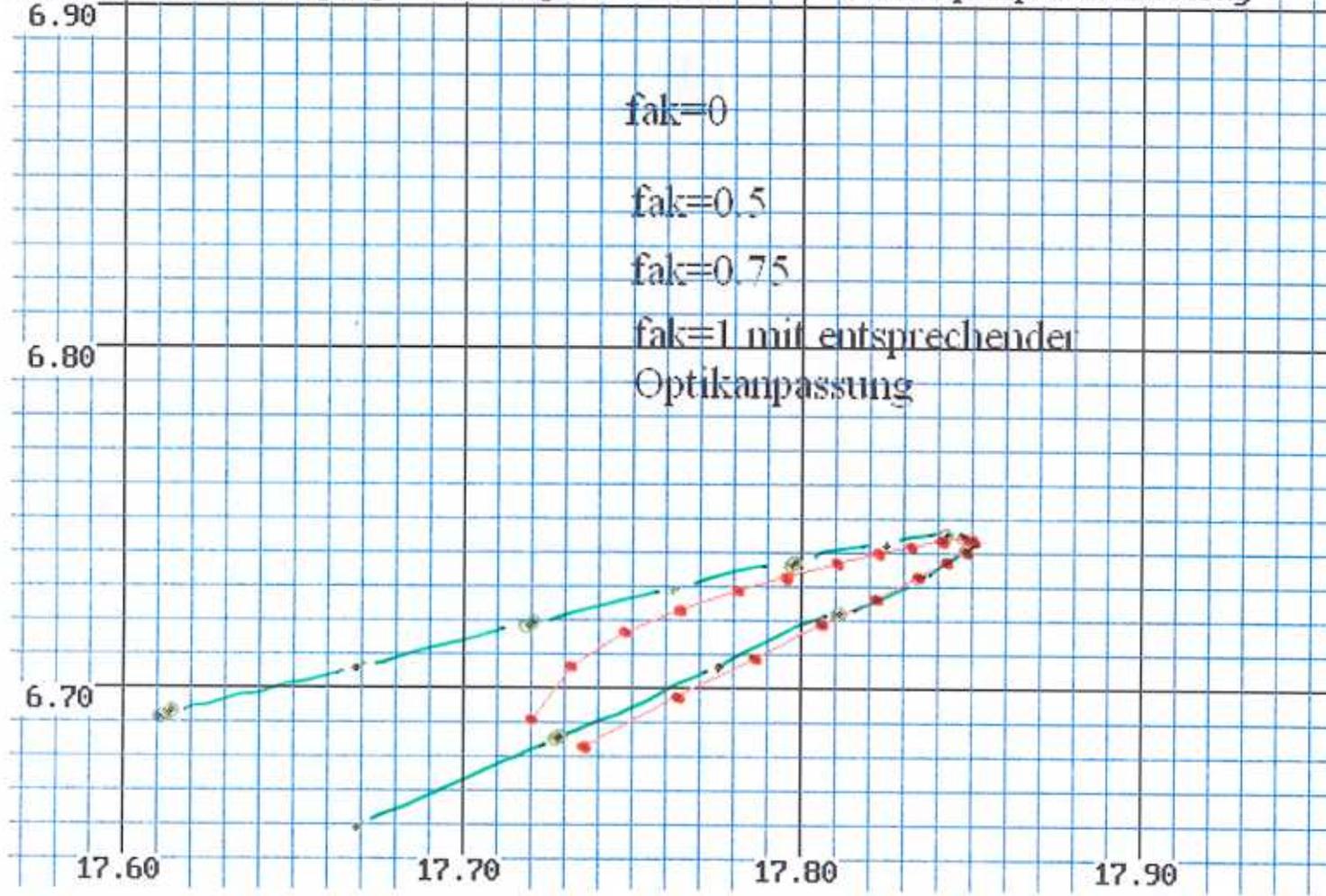
Theory

Exp.
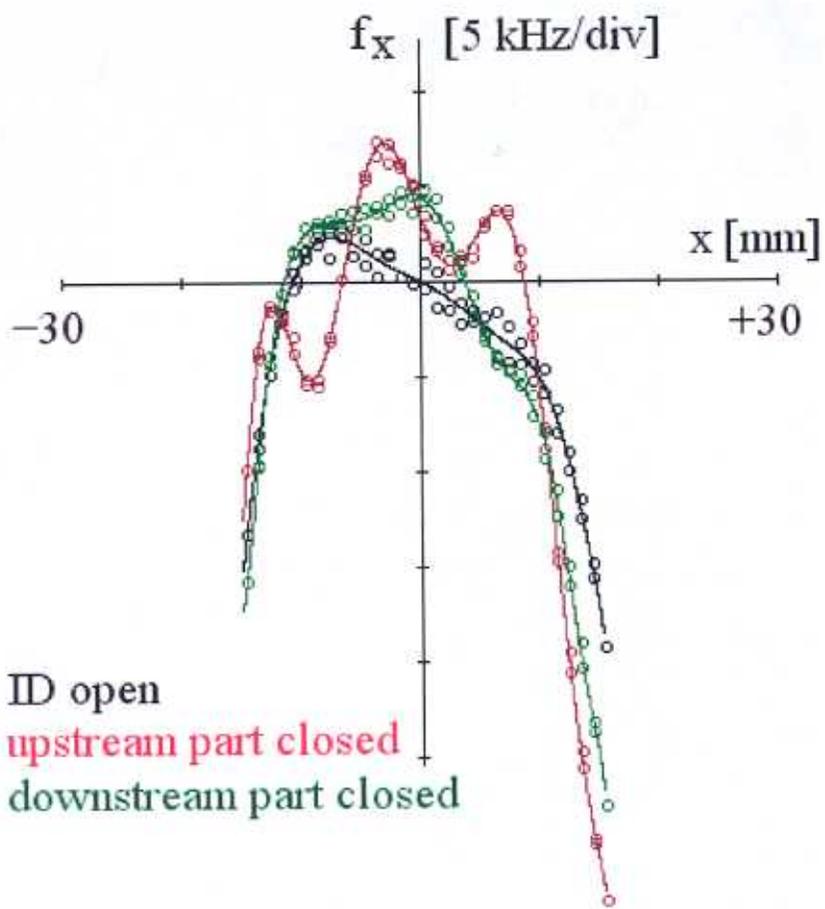
Summary

- System for experimental FM available at BESSY – Intensity recorded turn-by-turn
- Single particle dynamics – ensembles of particles: decoherence and intensity dependent effects
- FM at nominal working point show no resonances – except $2Q_x-Q_y$-resonance
- Horizontal kick maps vs. dp/p span larger areas in tune space: Skew quadrupole, sextupole and decapole driven resonances show up
- With 3 sc WLS the $2Q_x+2Q_y$-resonance is visible

Next Steps

- Improve data analysis (NAFF-algorithm)
- Include decapoles in lattice model
- FM measurements with vert. Kick vs dp/p
- FM measurements with hor. Kick vs. $dQ_{x,y}/Q_{x,y}$