Details and Results of Additional Experiments

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I. Introduction

II. Streak Camera:
    Observed Bunch length > 3ps
    Asymmetric Bunch Shapes
    Explanation of Resolution Limit

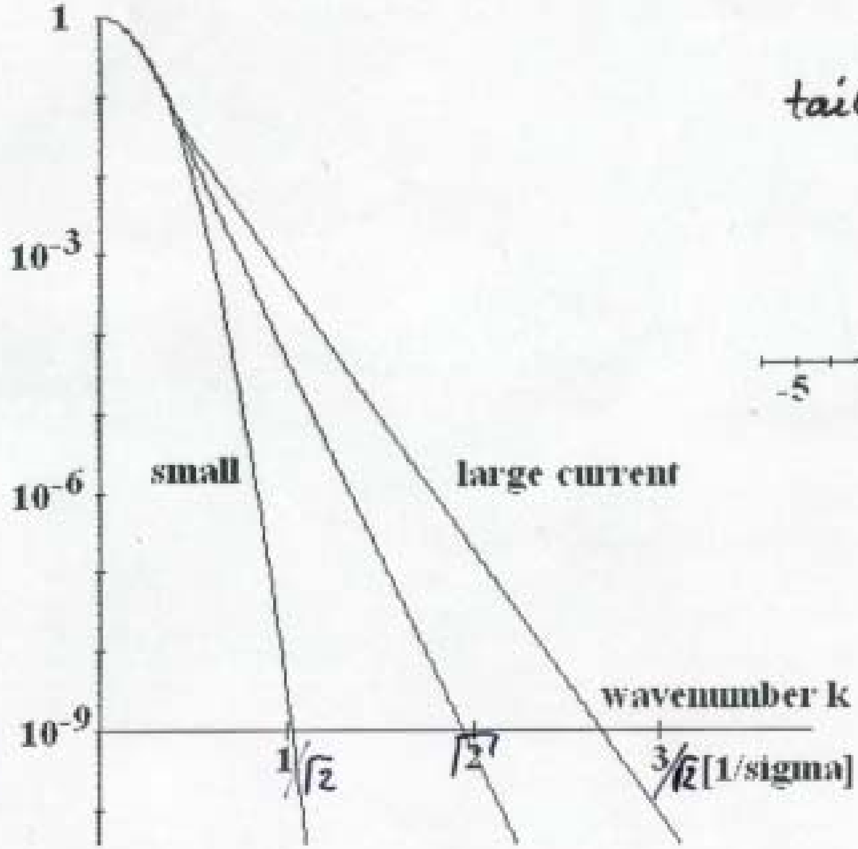
III. Absolute Measurement of the Energy Spread by Compton Backscattering:
    Microwave Threshold

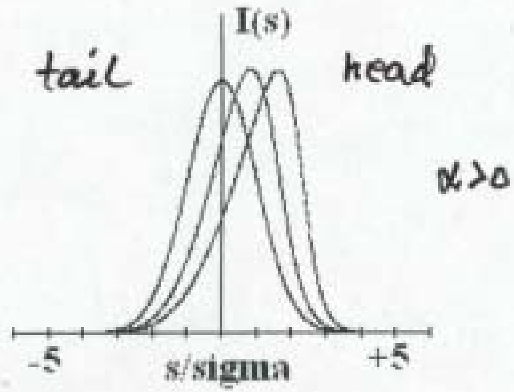
IV. Determination of Higher Order Contributions to the Momentum Compaction Factor:
    i) From Measurements of the Synchrotron Tune and
    ii) The Orbits
    as a Function of the Pathlength

V. Longitudinal Beam Spectra and Bursting IR Signals
    CSR and/or Chamber Impedance?

VI. Conclusion

Formfactor with Potential Well Distortion by CSR and Resistive Impedance

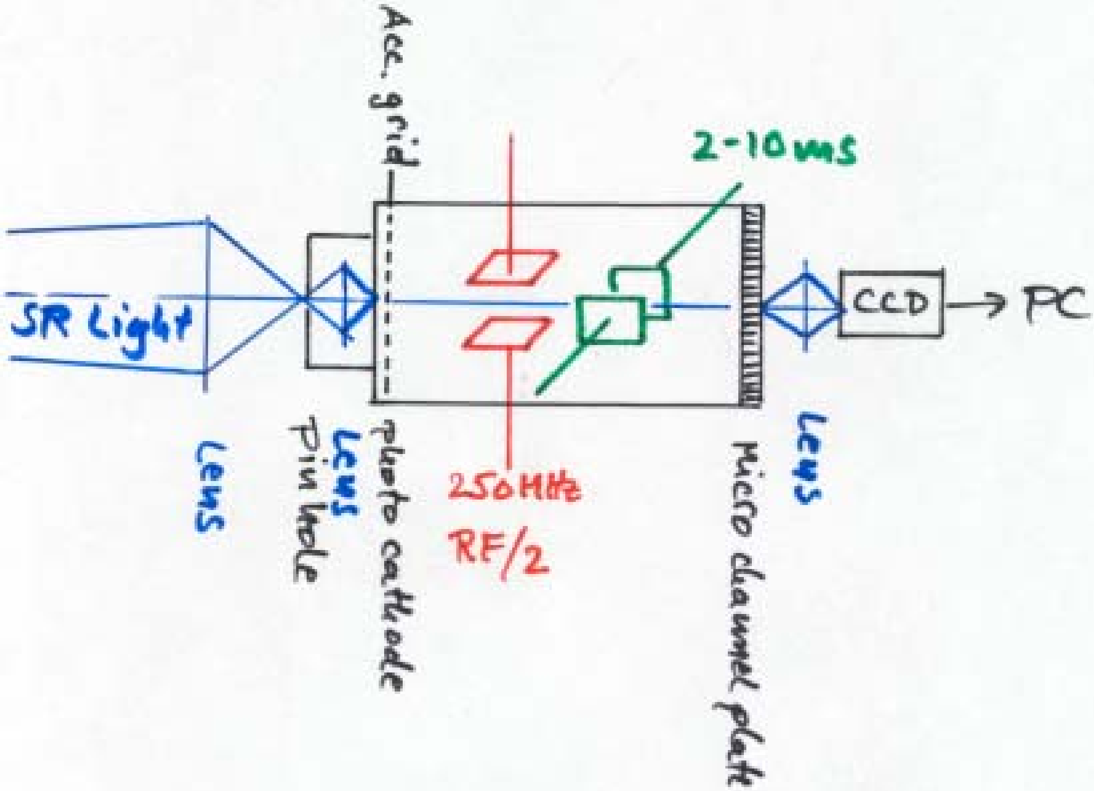


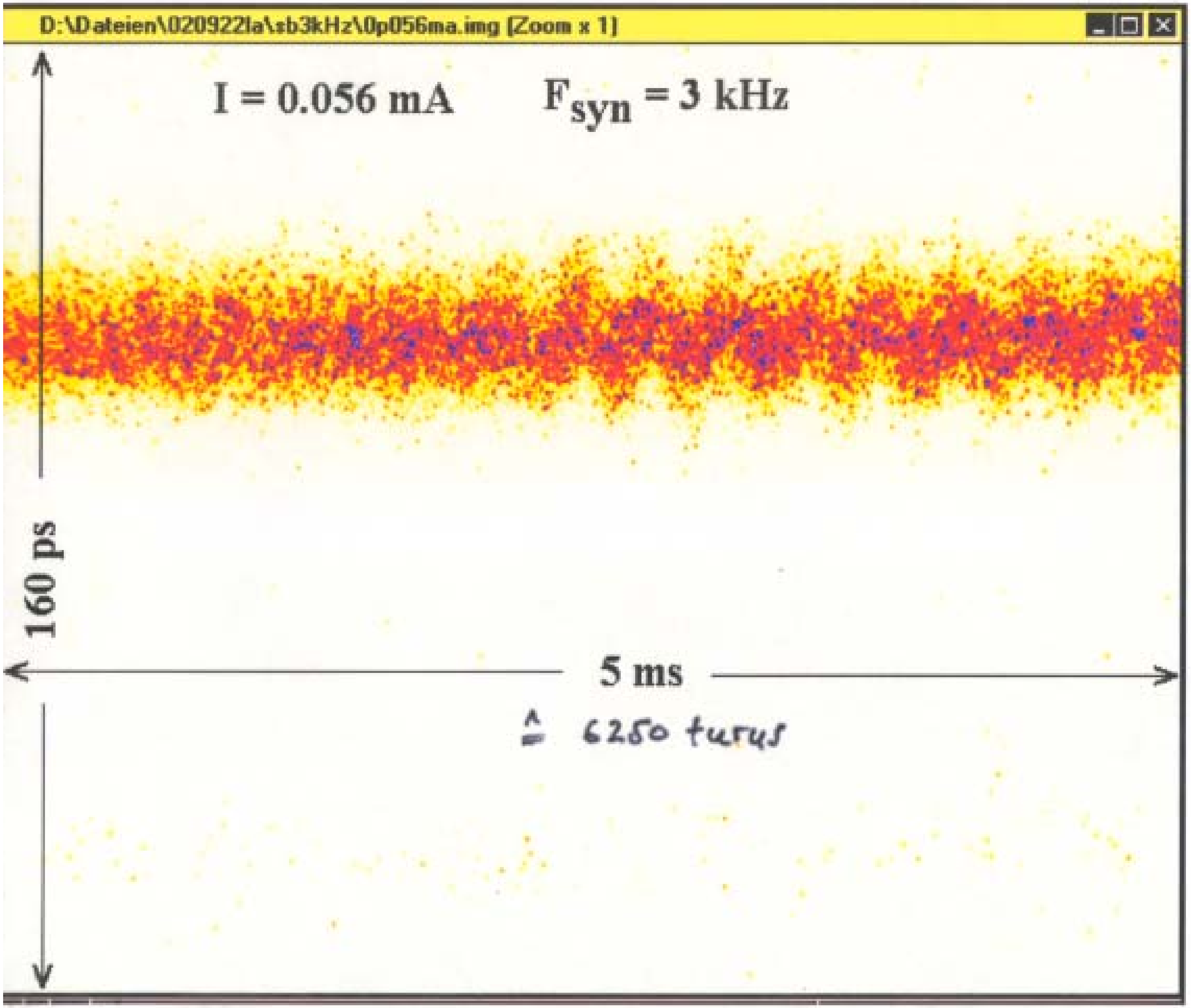


(Bane, Krinsky, Murphy in AIP 367)

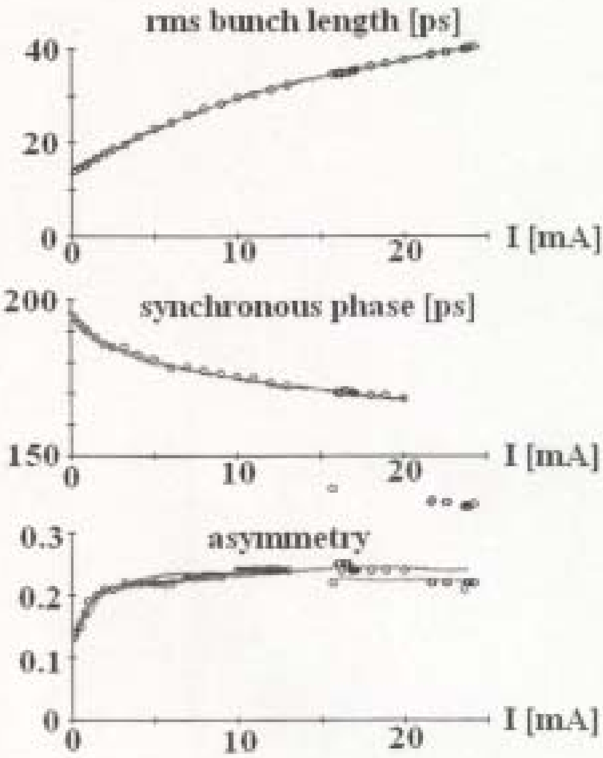
Streak Camera

Dual Sweep SC type C5680 (Hamamatsu)



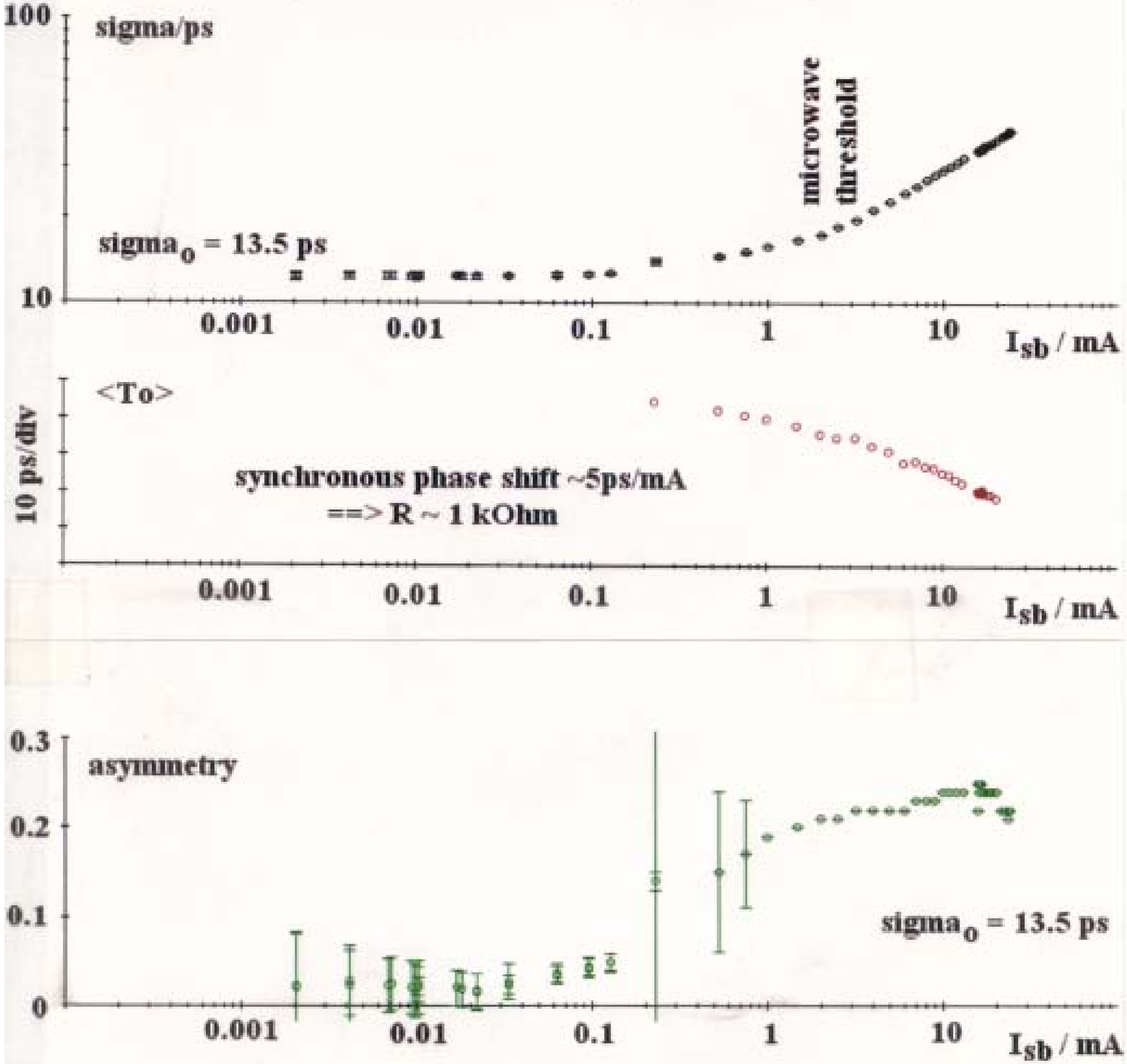

D:\Dateien\020922la\sb3kHz\0p056ma.img [Zoom x 1]
I = 0.056 mA
F syn = 3 kHz
160 ps
5 ms
≙ 6250 turns

$\alpha = 7.3\ 10^{-4}$


rms bunch length [ps]
40
20
0
I [mA]
0
10
20
200
synchronous phase [ps]
150
I [mA]
0
10
20
0.3
asymmetry
0.2
0.1
0
I [mA]
0
10
20

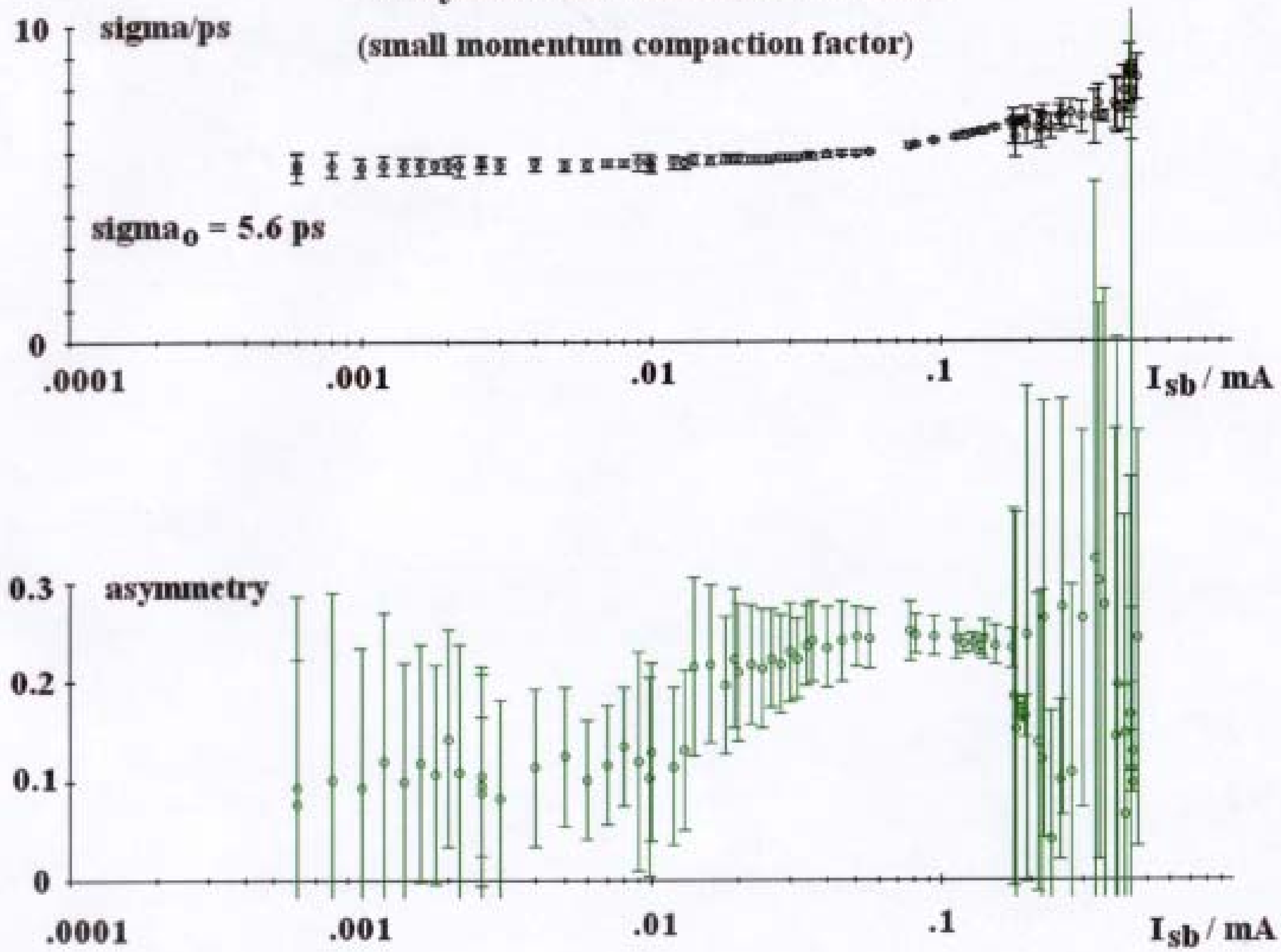
Analysis of Streak Camera Data

(normal momentum compaction factor)

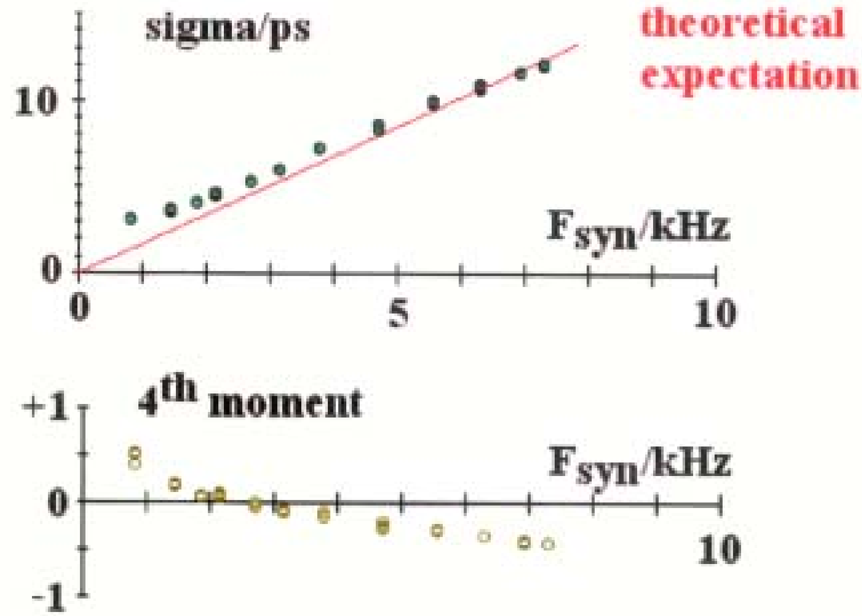


Analysis of Streak Camera Data

(small momentum compaction factor)

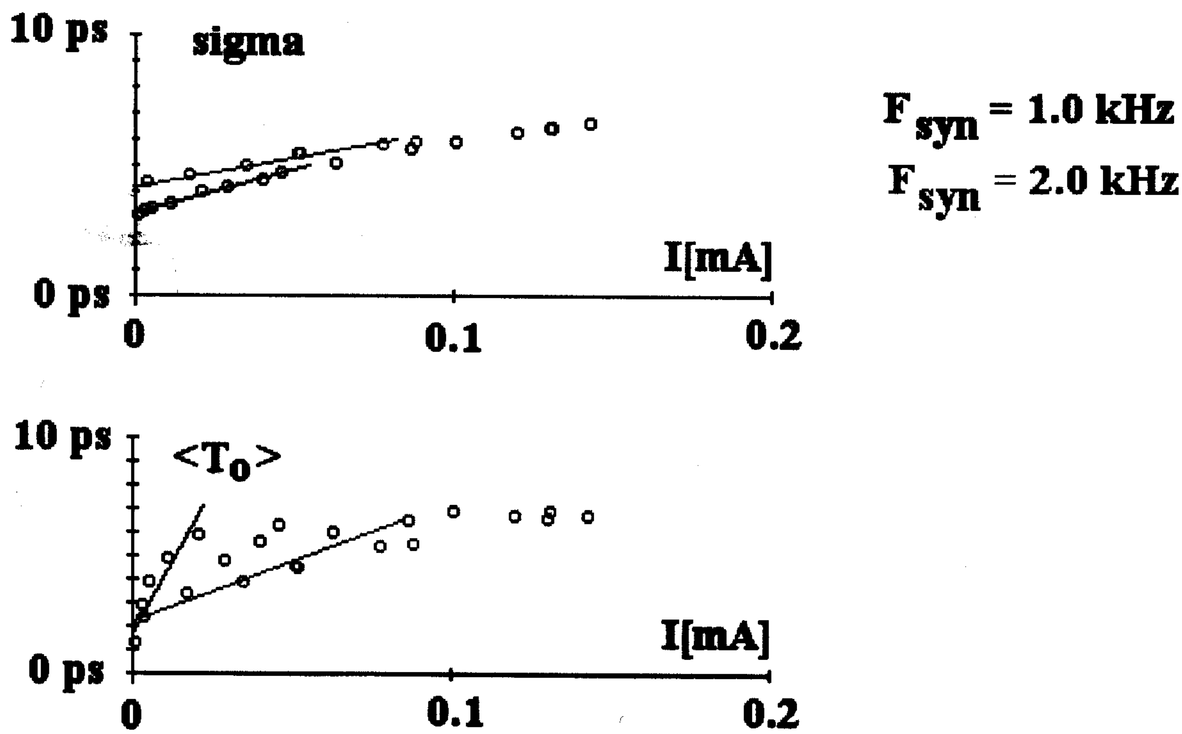


Bunchlength and 4th Moments of the Bunch Shape as a Function of the Synchrotron Frequency (with less than 2 10^6 electrons per bunch)

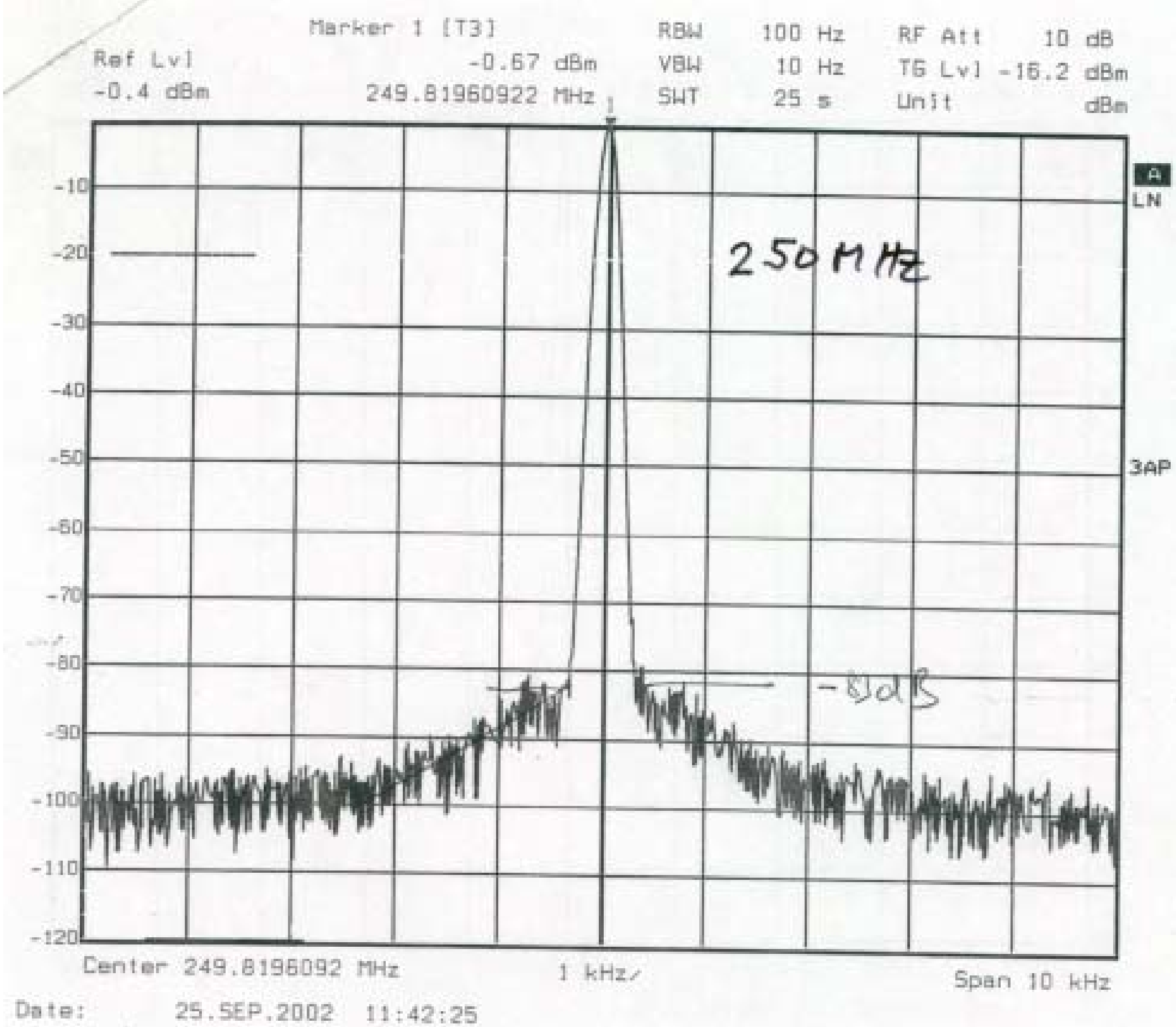


Conclusion and Question:
No bunch length shorter than 3 ps observed.
Resolution limit of the streak camera?

Bunchlength and Synchronous Phase as a Function of Beam Current



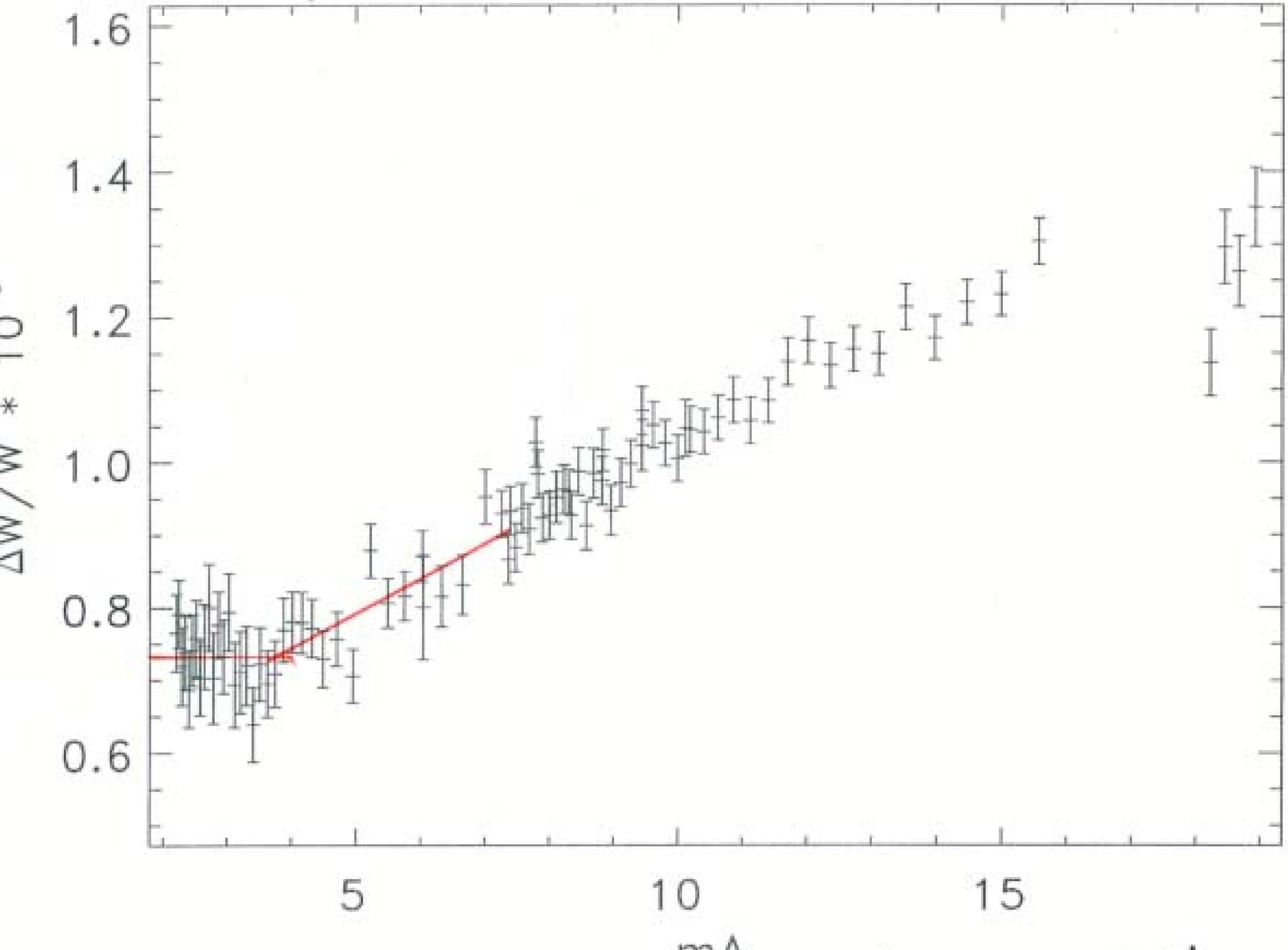
Conclusion:
The synchronous phase shifts indicate bunches shorter than the resolution limit of our streak camera.



⇒ Resolution limitation of SC due to Phase Noise

Messung 4.7.02

vorläufig



(R.Klein, PTB)

IV. Determination of Higher Order Contributions to the Momentum Compaction Factor from Measurements of the:

i) Synchrotron Tune and

ii) Orbits

as a Function of the Pathlength.

$$\frac{\Delta L}{L} = -\frac{\Delta rf}{rf} = \alpha \cdot \frac{\Delta p}{p}$$

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

Make inverted expansion from:

$$\frac{\Delta rf}{rf} = -\sum_i \alpha_i \left(\frac{\Delta p}{p}\right)^i \longrightarrow \frac{\Delta p}{p} = \sum_i \beta_i \left(\frac{\Delta rf}{rf}\right)^i$$

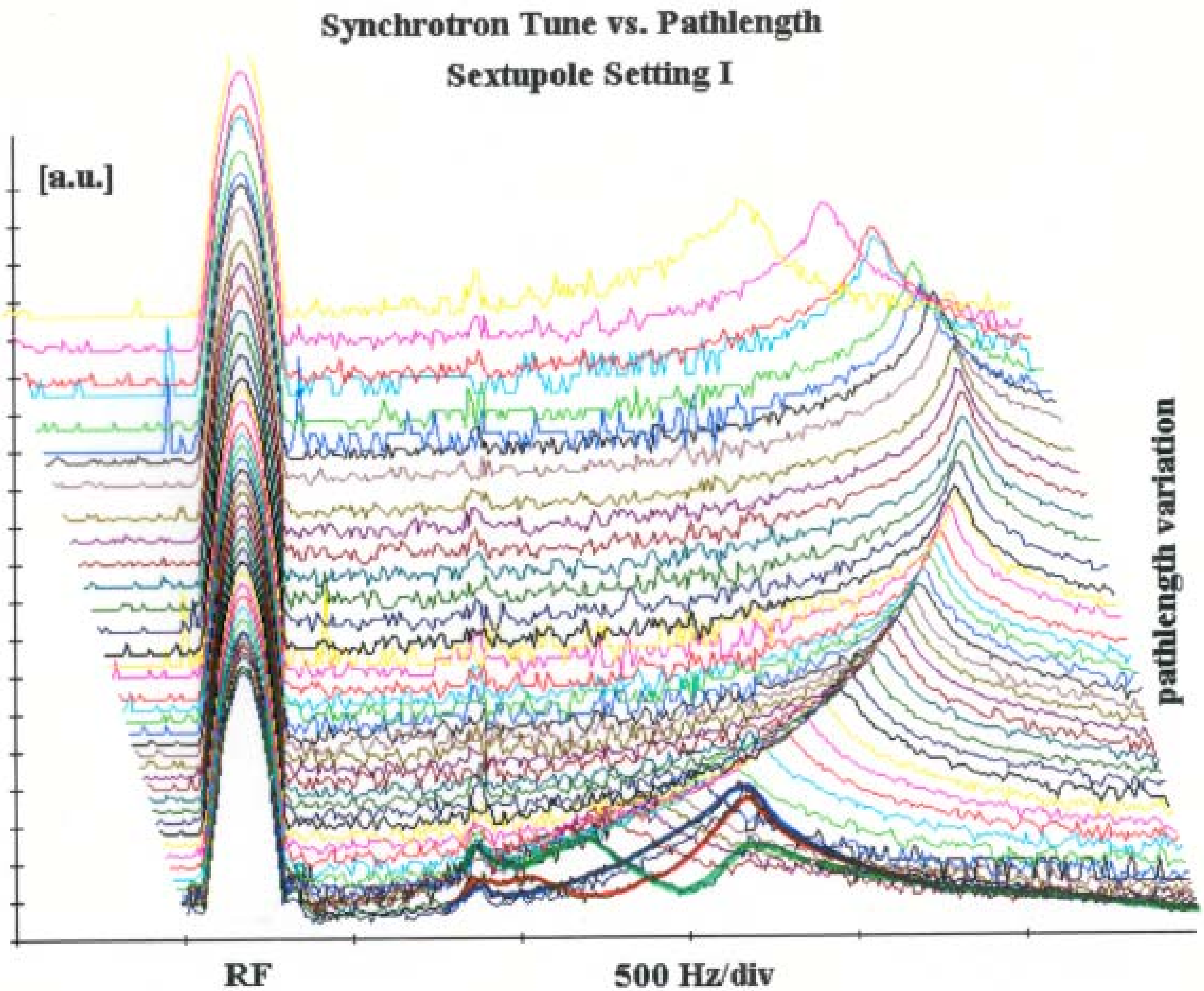
With the first few terms:

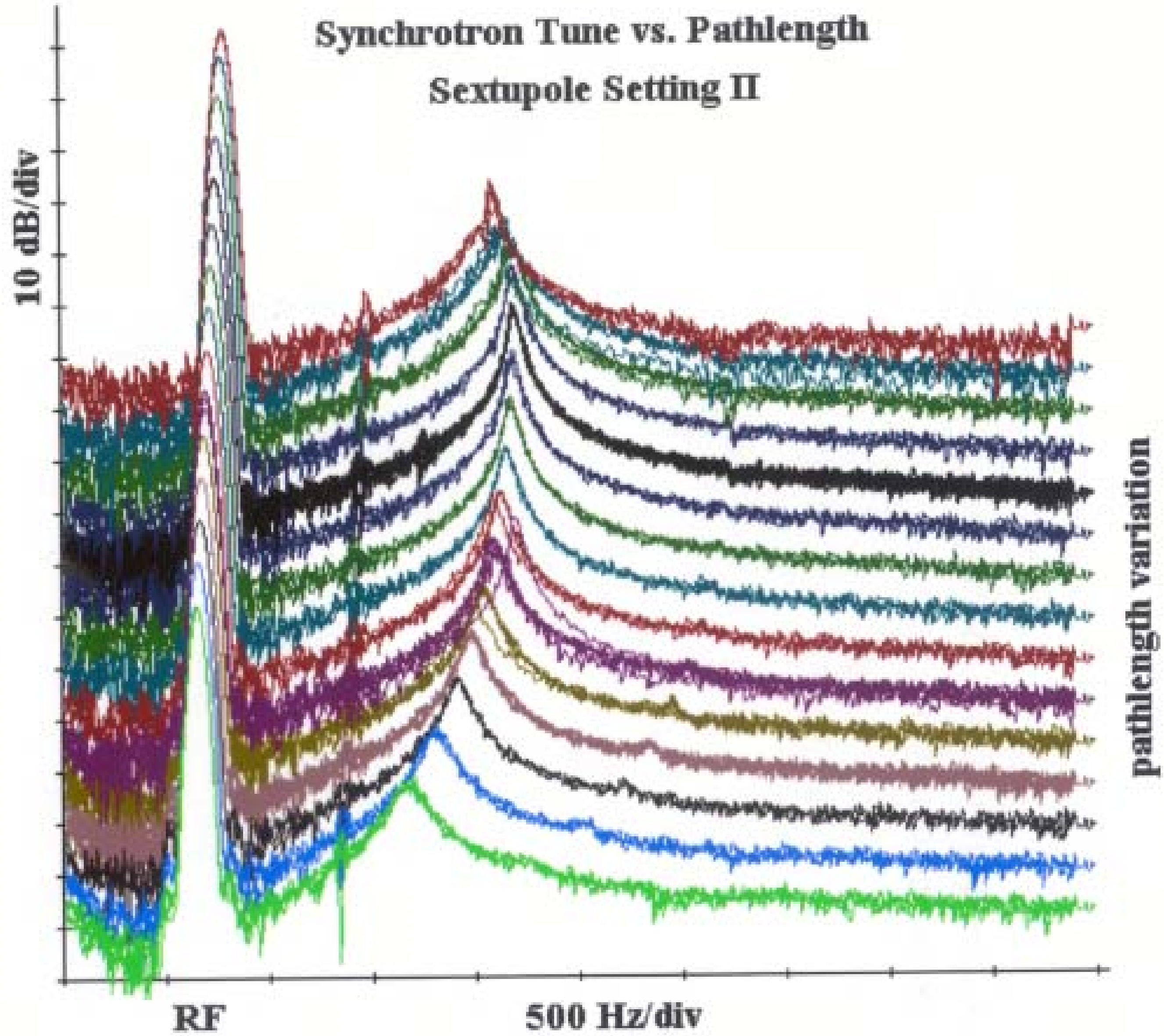
$$\frac{\Delta p}{p} = -\frac{1}{\alpha_1} \frac{\Delta rf}{rf} - \frac{\alpha_2}{\alpha_1^3} \left(\frac{\Delta rf}{rf}\right)^2 - \frac{2\alpha_2^2 - \alpha_1 \alpha_3}{\alpha_1^5} \left(\frac{\Delta rf}{rf}\right)^3 - \frac{\alpha_1^2 \alpha_4 + 5\alpha_2^3 - 5\alpha_1 \alpha_2 \alpha_3}{\alpha_1^7} \left(\frac{\Delta rf}{rf}\right)^4 \cdots$$

Synchrotron Tune depends on the local value of α:

$$\alpha_{local} = \alpha_1 + 2\alpha_2 \frac{\Delta p}{p} + 3\alpha_3 \left(\frac{\Delta p}{p}\right)^2 + \ldots$$

$$\Rightarrow \frac{\nu_{syn}^2}{\nu_{syn_0}^2} = 1 - \frac{2\alpha_2}{\alpha_1} \frac{\Delta rf}{rf} - \frac{2\alpha_2^2 - 3\alpha_1 \alpha_3}{\alpha_1^4} \left(\frac{\Delta rf}{rf}\right)^2 - \frac{4\alpha_2^3 - 8\alpha_1 \alpha_2 \alpha_3 + 4\alpha_1^2 \alpha_4}{\alpha_1^6} \left(\frac{\Delta rf}{rf}\right)^2 - \ldots$$

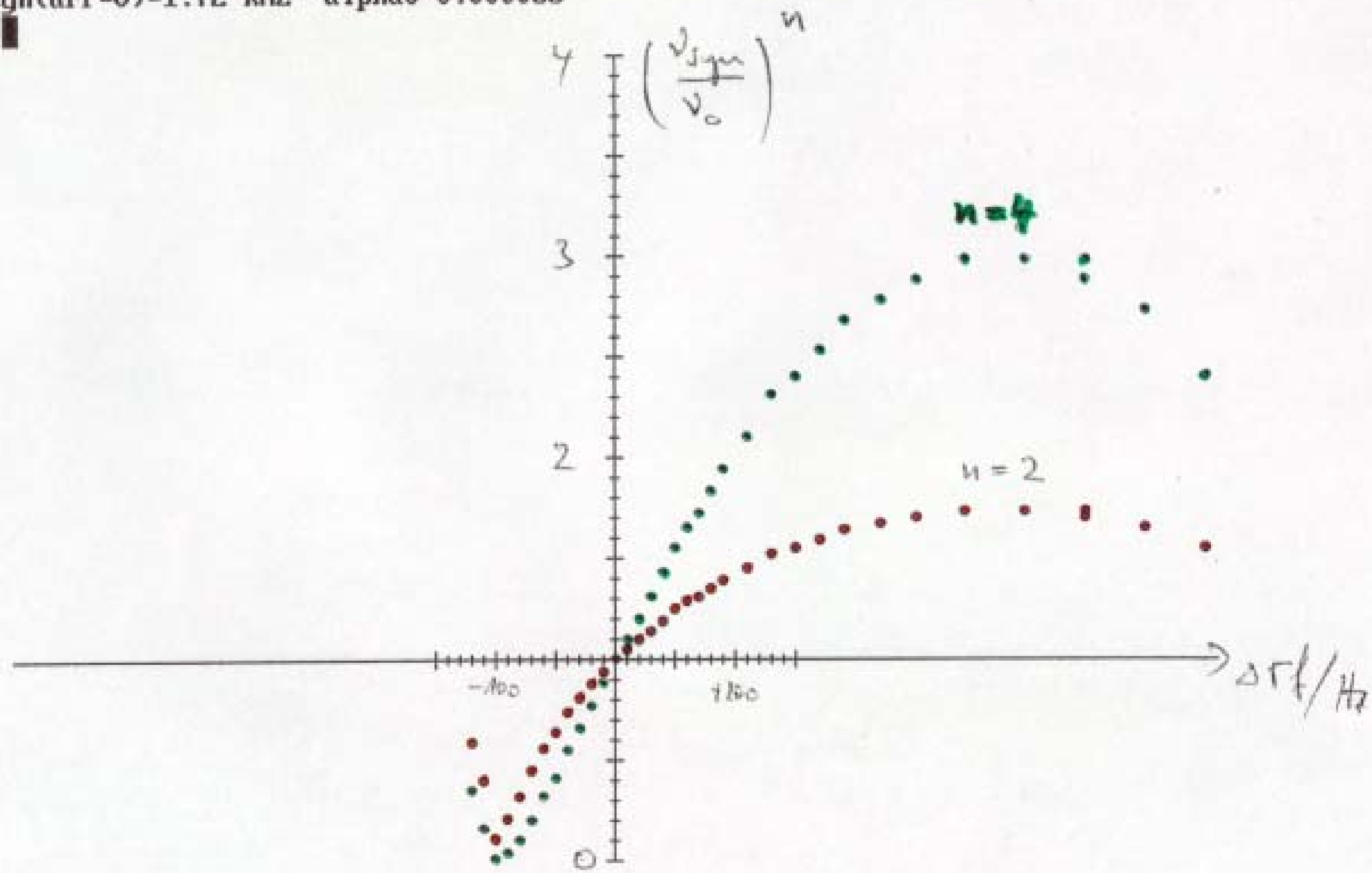

Synchrotron Tune vs. Pathlength
Sextupole Setting I
[a.u.]
pathlength variation
RF
500 Hz/div



Synchrotron Tune vs. Pathlength
Sextupole Setting II
10 dB/div
RF
500 Hz/div
pathlength variation

Sextupole Setting I

```
a:ms020428.dat
Fsyn(drf=0)=1.72 kHz  alpha0=0.000038
?
```



Orbit Distortions:

$$\Delta_{x,y} = D_{x,y} \cdot \frac{\Delta p}{p}$$

$$D = D_1 + D_2 \frac{\Delta p}{p} + D_3 \left(\frac{\Delta p}{p}\right)^2 + \cdots$$

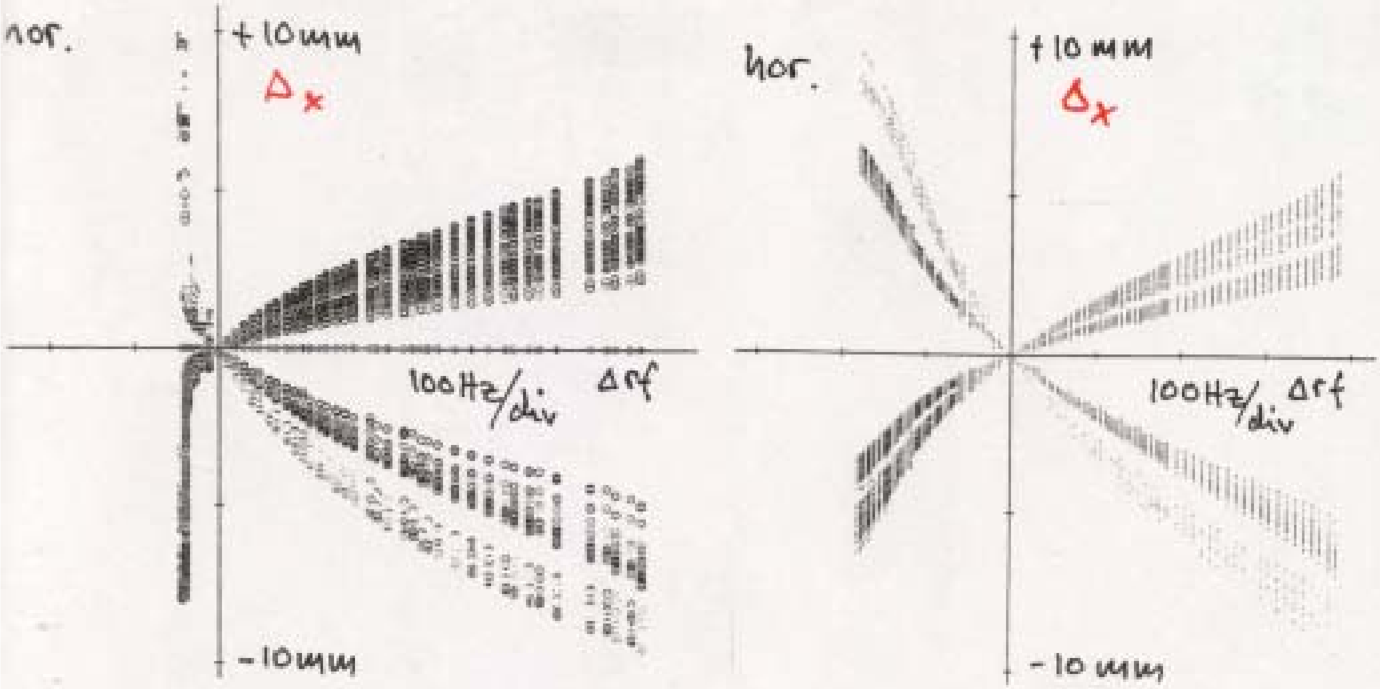
With

$$\frac{\Delta p}{p} = -\frac{1}{\alpha_1} \frac{\Delta rf}{rf} - \frac{\alpha_2}{\alpha_1^3} \left(\frac{\Delta rf}{rf}\right)^2 - \frac{2\alpha_2^2 - \alpha_1 \alpha_3}{\alpha_1^5} \left(\frac{\Delta rf}{rf}\right)^3 \cdots$$

+ Neglecting D_3 and higher order contributions to the Dispersion one can write:

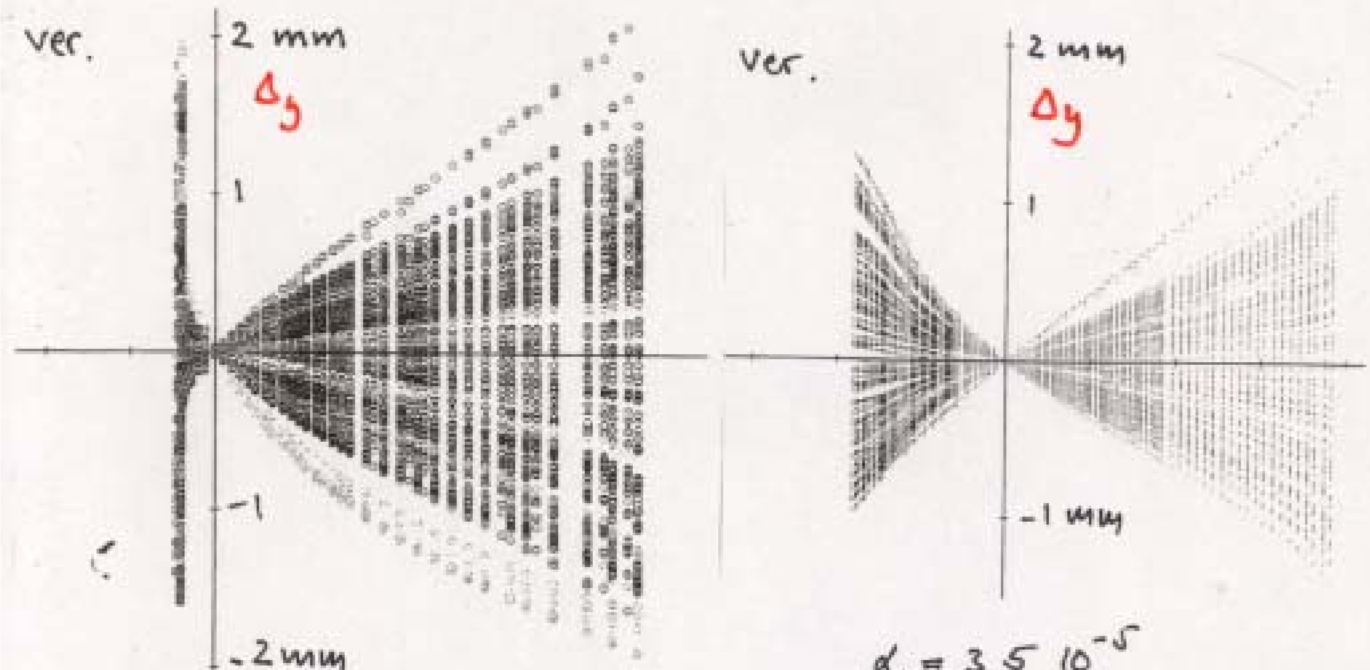
$$\alpha_1 \frac{\Delta}{D_1} + \alpha_2 \left(\frac{\Delta}{D_1}\right)^2 + \alpha_3 \left(\frac{\Delta}{D_1}\right)^3 + \ldots \cong - \frac{\Delta rf}{rf} + \frac{D_2}{\alpha_1 D_1} \left(\frac{\Delta rf}{rf}\right)^2 \cdots$$

Off momentum Orbits $\Delta\left(\frac{\Delta rf}{rf}\right)$



02/05/20

02/05/06



Fitresults:

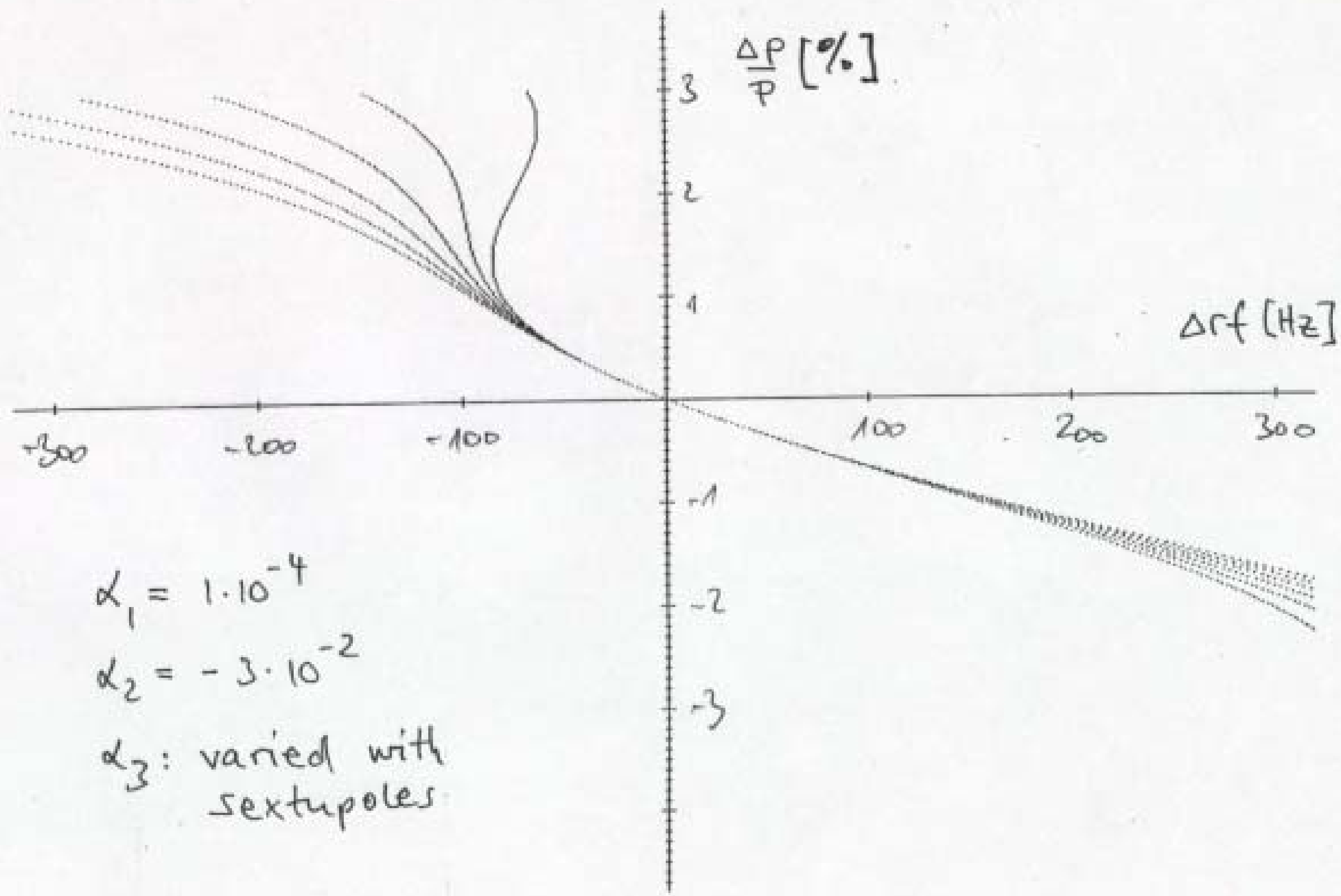
$\alpha_1 = 3.5 \; 10^{-5}$

$\alpha_2 = -0.00110 \; (\pm 0.00017)$

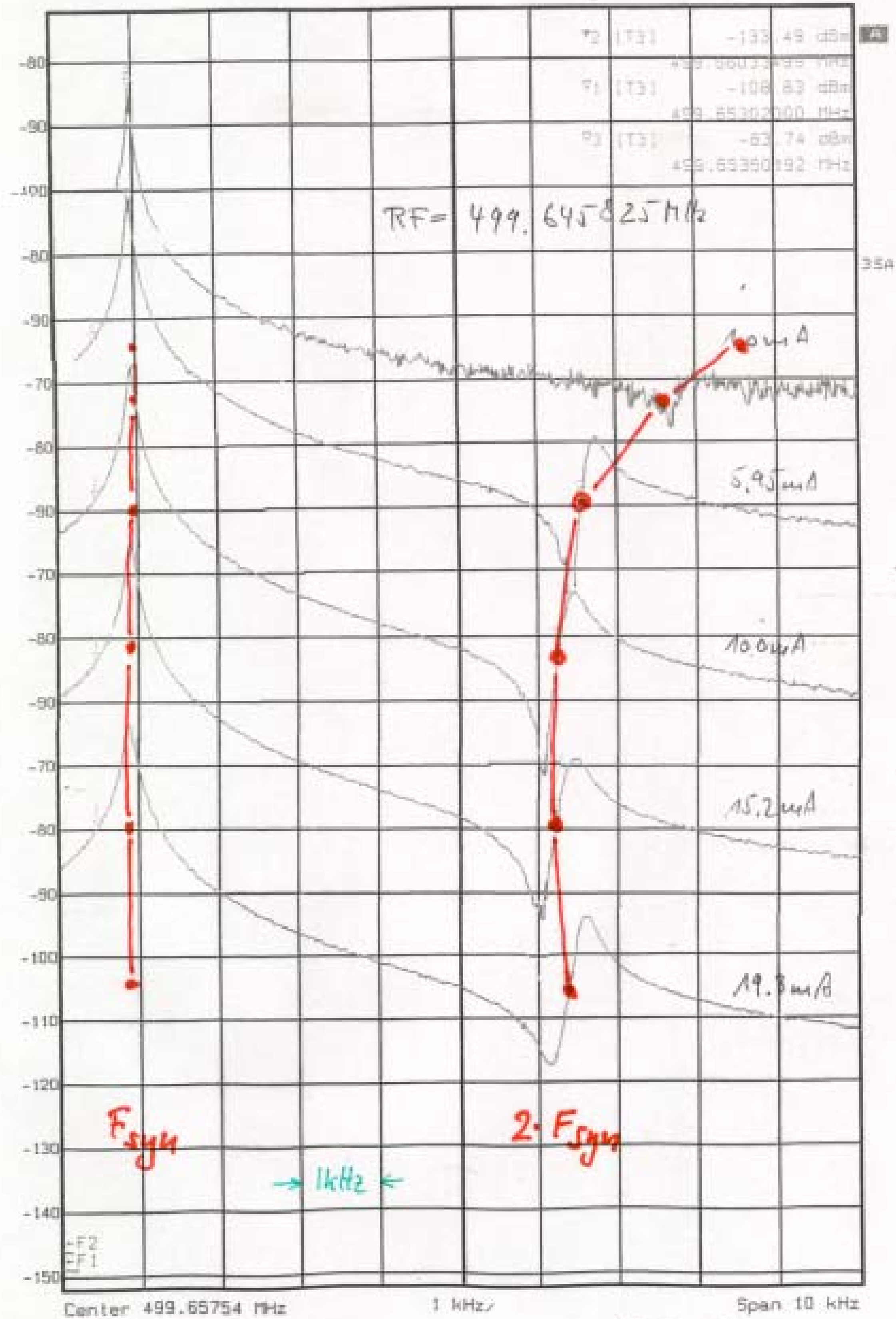
$\alpha_3 = -0.024 \; (\pm 0.013)$

$\alpha_4 = 1.9 \; (\pm 0.5)$

Results from Optics Calculations



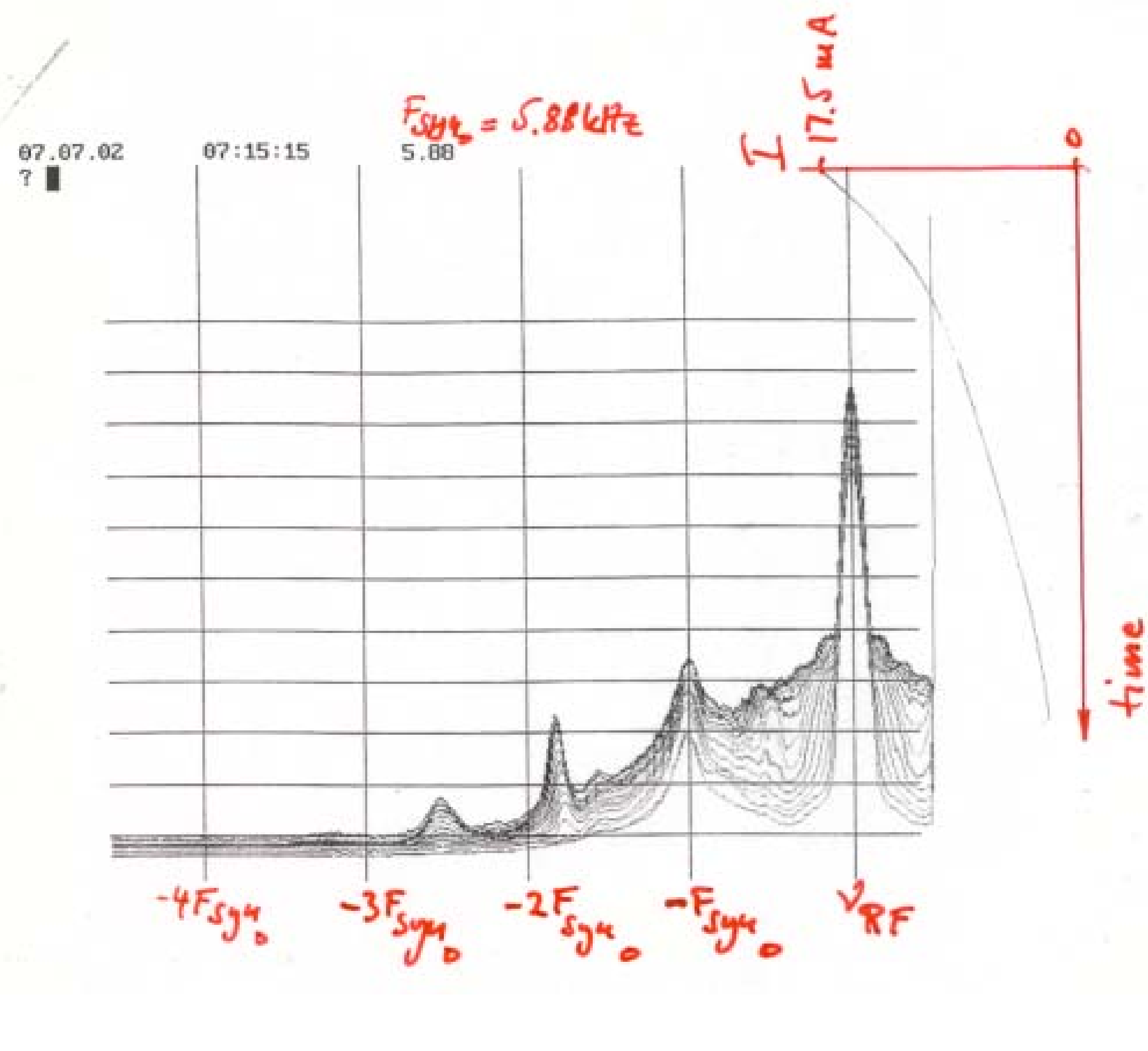
IV. Measurement of Incoherent Synchr. Tuneshift with Intensity



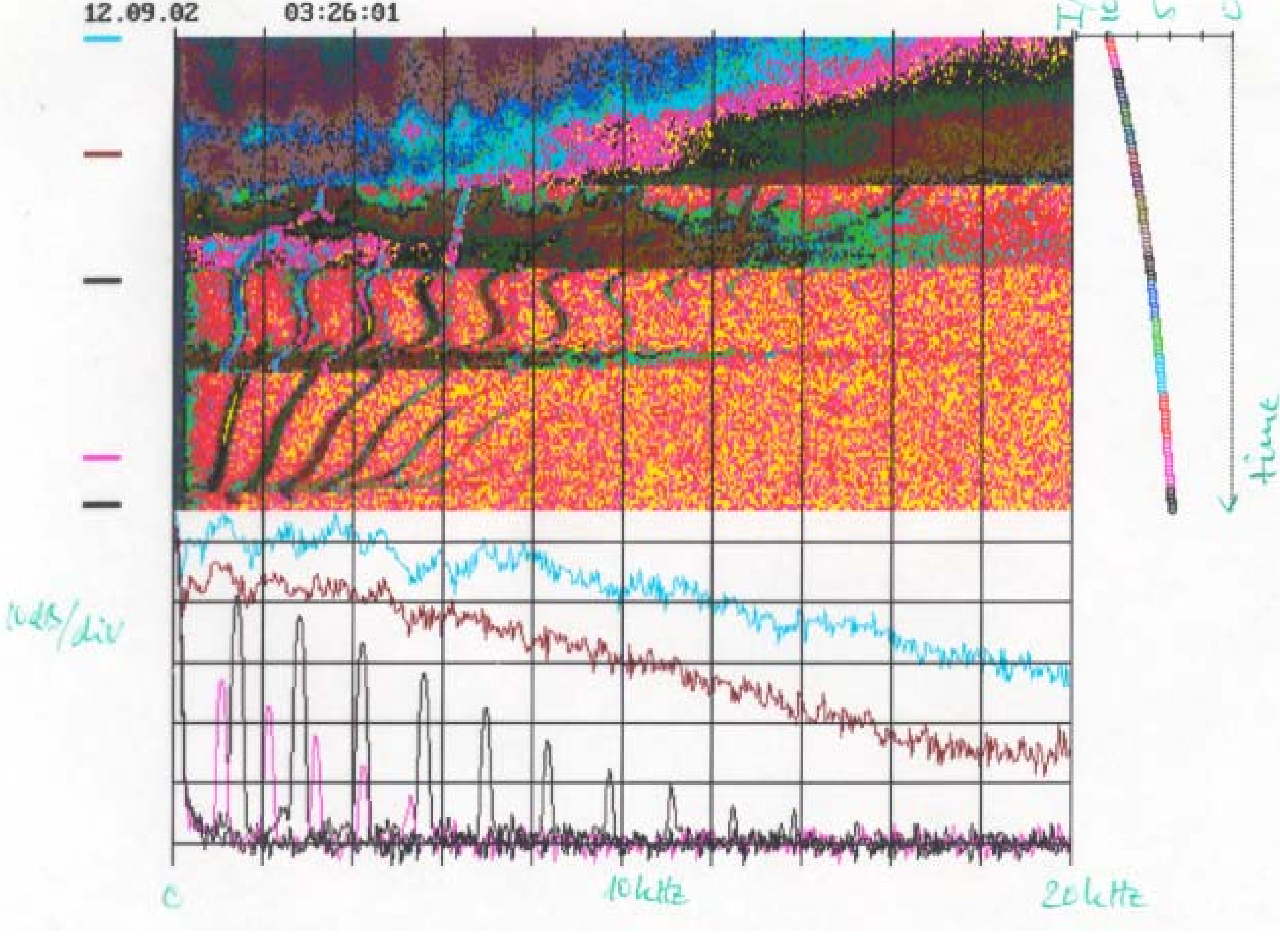
Date: 5.NOV.2001 20:51:24

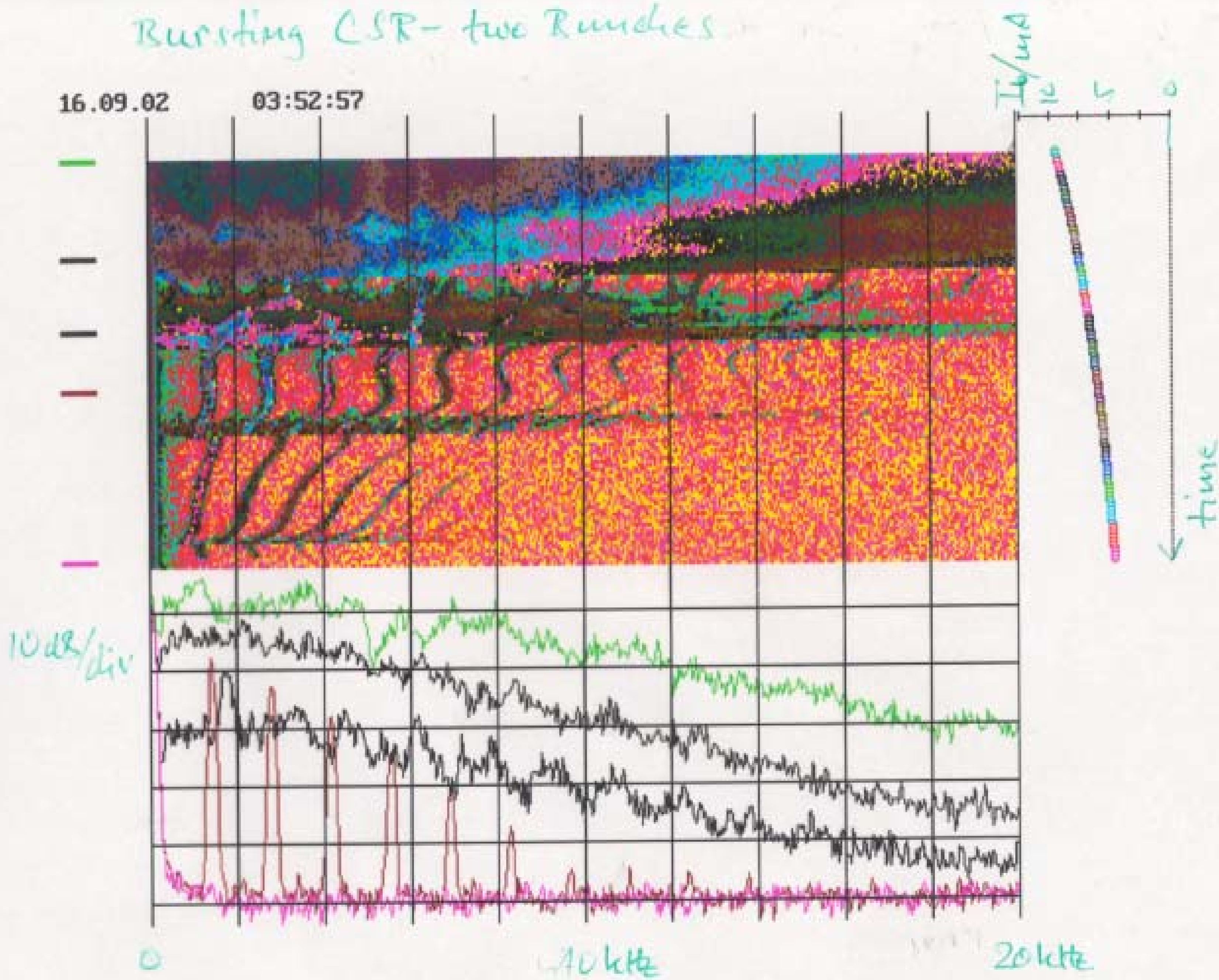
19.3 mA

Longitudinal Modes with Single Bunch



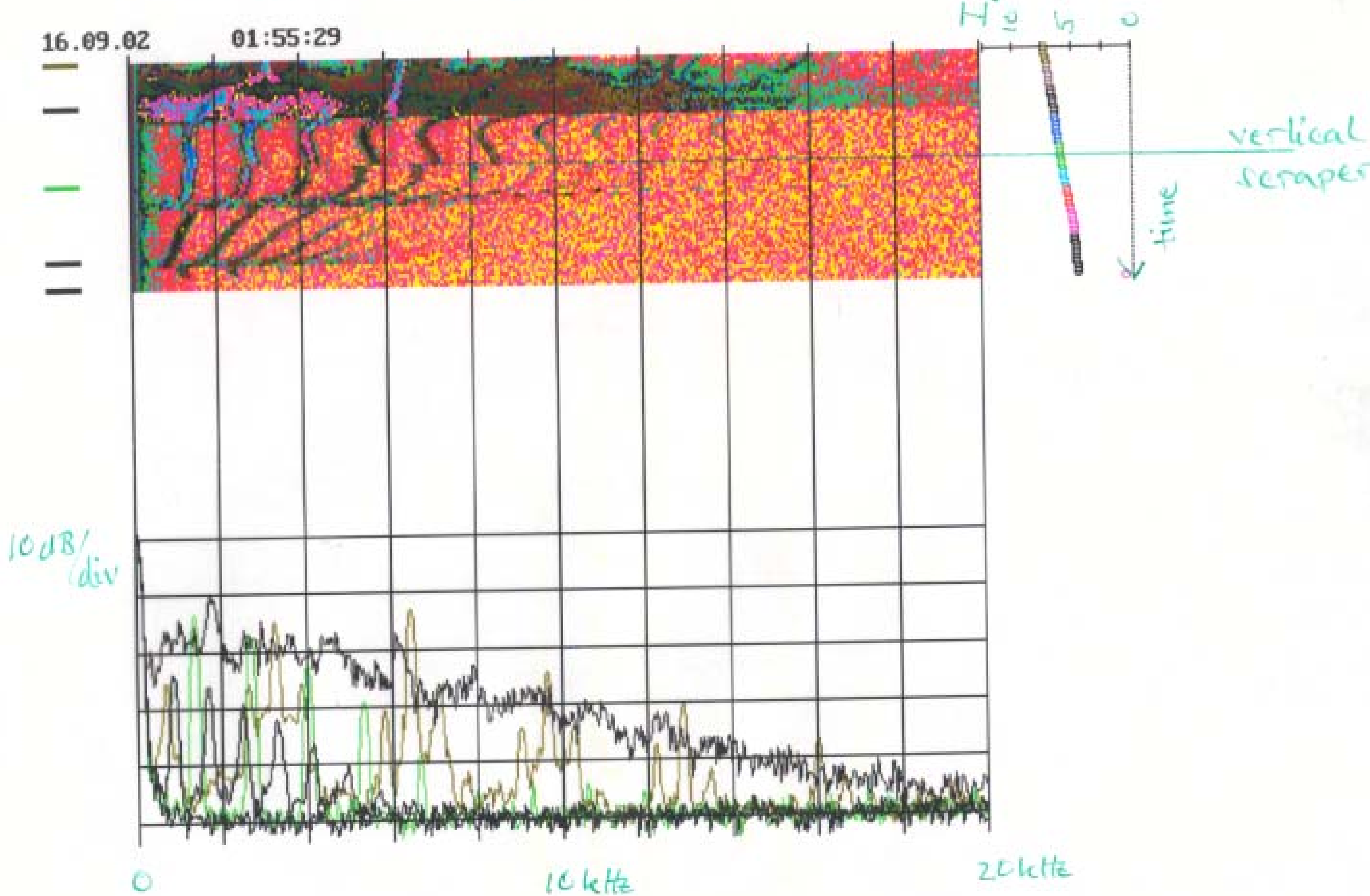
Bursting CSR - single Bunch





Bursting CSR - two Bunches
16.09.02
03:52:57
I_b/mA
10
5
0
time
10dB/div
0
10kHz
20kHz

Bursting CSR - single Bunch



CONCLUSION

Streak camera resolution limited by phase noise to:
Lossfactors indicate much shorter bunches.
Bunch asymmetry explains extended wavelength ran
for stable CSR.

Contributions of α to the static non-linearity of the longitudinal single particle motion have been determined. Effect on CSR is small

Above threshold

Energy spread increases

Quadrupole and higher azimuthal modes appear in the longitudinal beam spectra.

Emission of CSR in bursts. Above the threshold many transitions occur between regular and irregular repetition rate.

Modelling this behaviour requires to take into account CSR- as well as chamber impedanc