THz application at BESSY

- beam diagnostics in storage rings

- beam diagnostics in FEL (proposal)

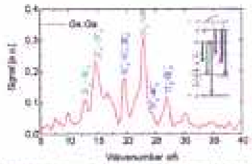
- beam diagnostics for SR-based fs-slicing (under construction)

- low alpha option for the PTB-ring (under contruction)

- user applications for THz radiation:
  - plasma frequency in superconductors,
  - THz near-field imaging,
  - electronic transitions in GeGa

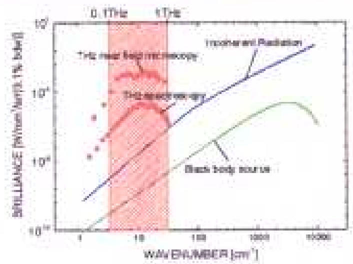
The BESSY THz Source

"forbidden " electronic transitions in solid state

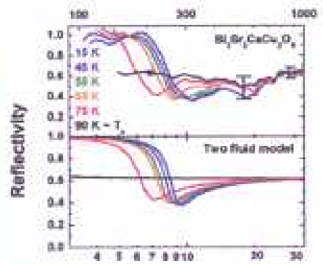


Lebende Objekte durchleuchten - ohne Strahlenschäden

Brilliance of the BESSY THz Source



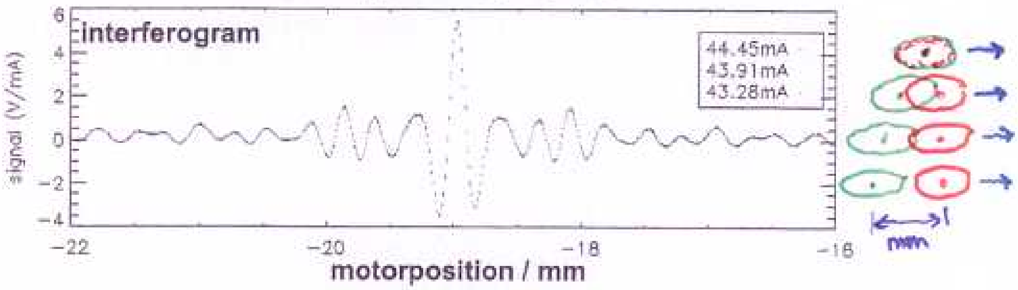
Josephson Plasmaresonance in Superconducters

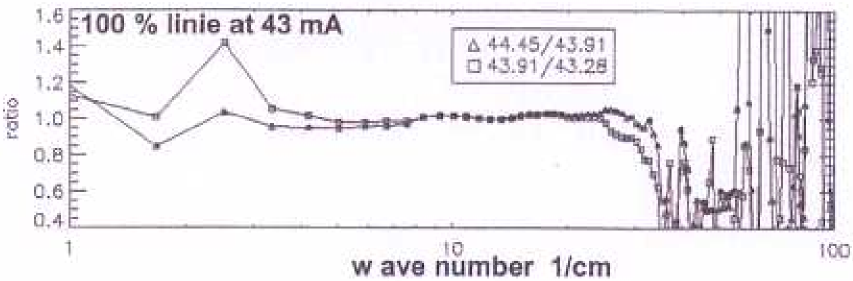


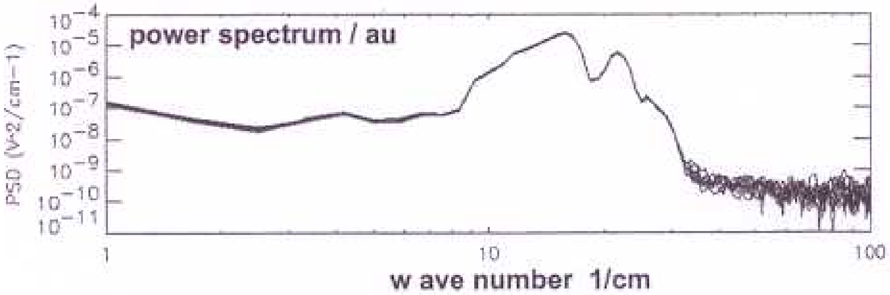
Imaging hidden structures

FT of bursting CSR

Low alpha=5/10^5 ≙ 1.85 kHz f_s



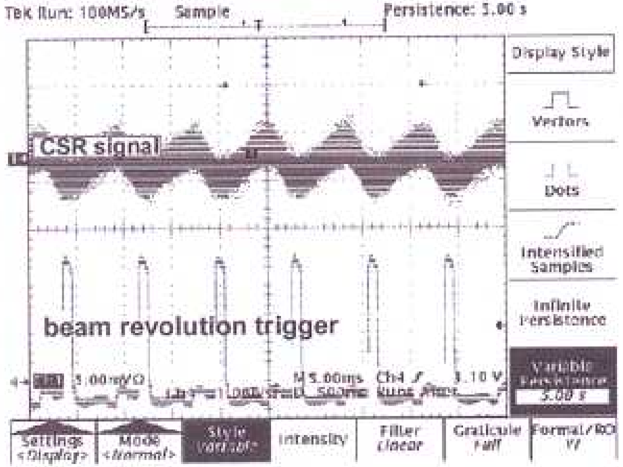




characteristics of the radiation

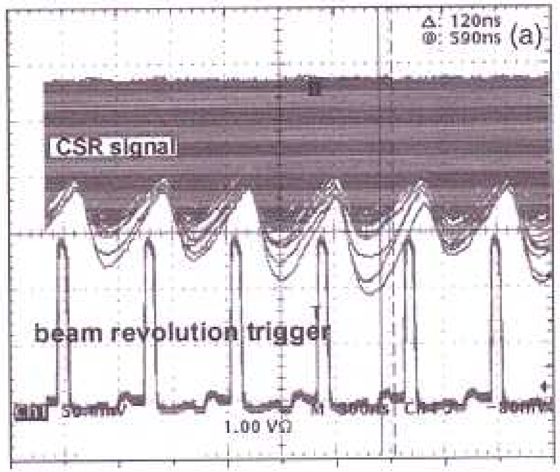
steady state emission:
CSR wake leads to a static, non-Gaussian deformation of the bunches

Bane, Krinsky, Murphy
Micro bunches Workshop, 1995, AIP 367



bursting emission:
above threshold CSR produces self-amplified micro bunches leading to unstable CSR emission

Stupakov, HeifetsPRST-AB 5, 054402 (2002)
Venturini & al, Phys. Rev. Lett. 89, 224802 (2002)

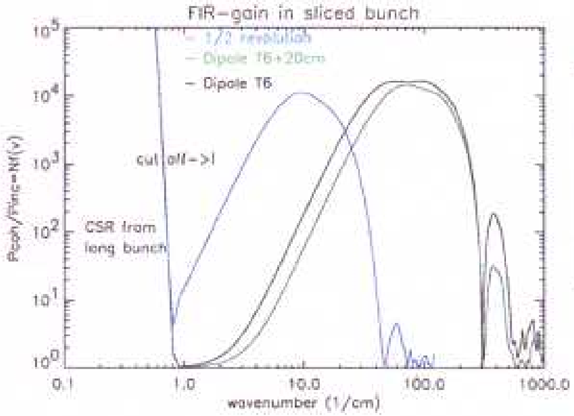


LHe cooled detector InSb-bolometer $\tau \sim 1\ \mu s$

Abo-Bakr & al Phys. Rev. Lett. 88, 2548011-2548014, 2002

Diagnostics of a sliced bunch using THz radiation

K.Holldack, G.Wuestefeld



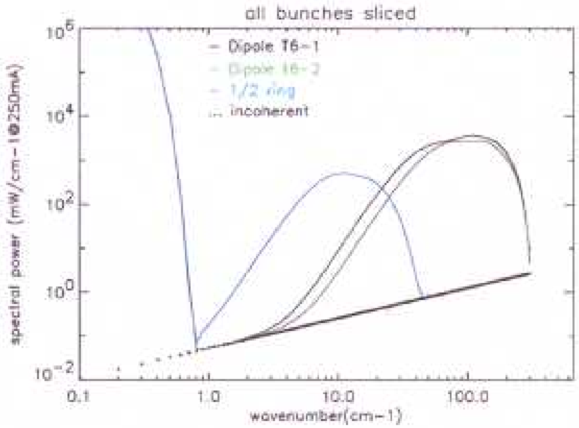
Spectral power:

$$P = Np(1+Nf_\nu)$$

$$P = P_{incoh} + P_{coh}$$

$$\frac{P_{coh}}{P_{incoh}} = Nf_\nu$$

f_n=(FFT(dN/dz)^2

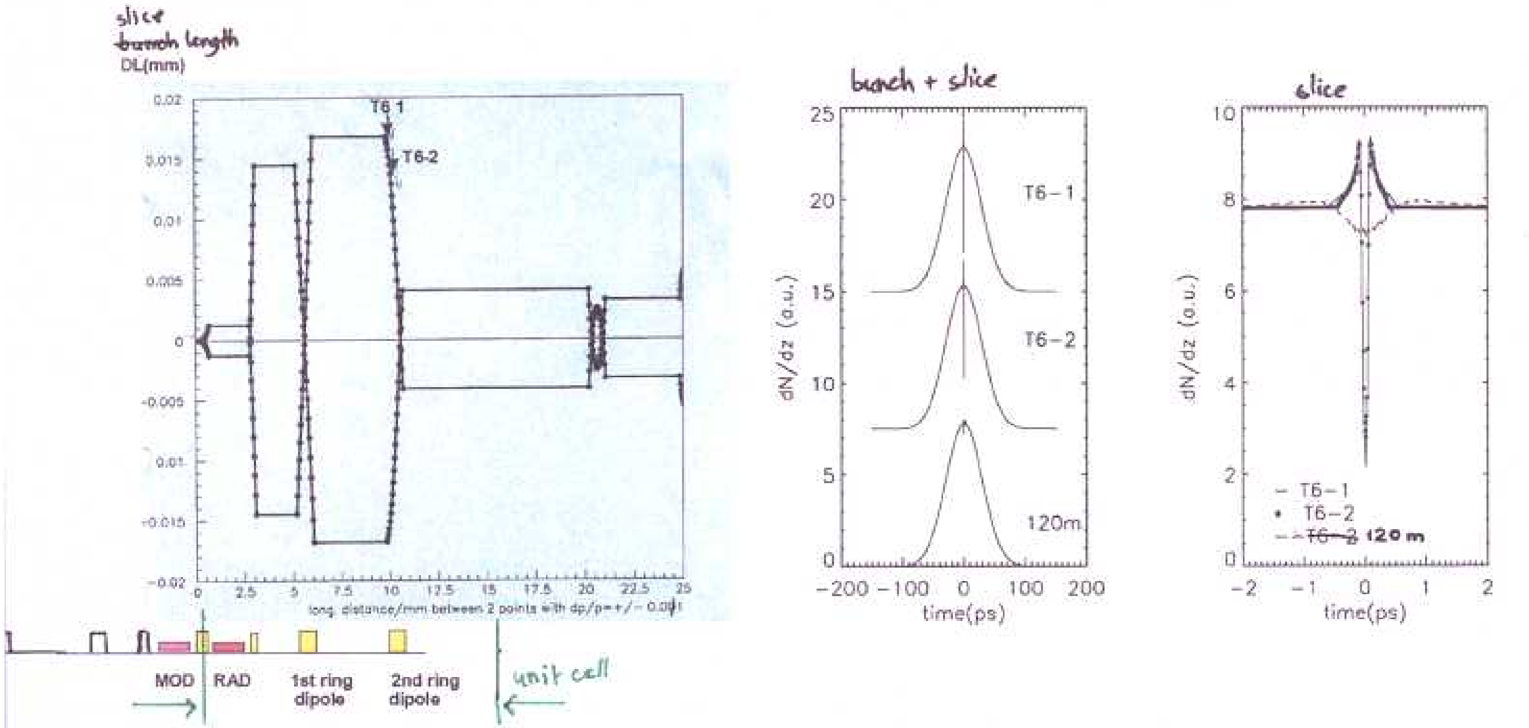


- regular bunch radiation naturally discriminated by chamber cut off (~2 wavenumbers)
- different in low alpha, here radiation swaps beyond
- above bunch currents of 4 mA -> coherent radiation from microbunch instabilities (2.3 mA without WLS)

- total incoherent power 0.2 mW
- coherent average power by all slices: 1.7 W (more than in low alpha)
- peak field in slice: 36 kV/m
- total THz peak power from slice: 20 W

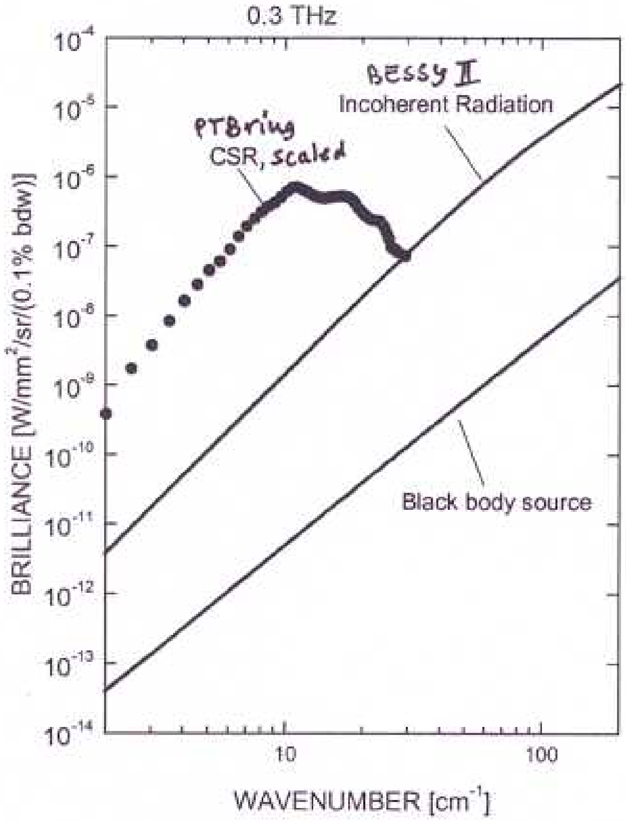
Diagnostics of a sliced bunch using THz radiation

K.Holldack, S.Khan, G.Wuestefeld



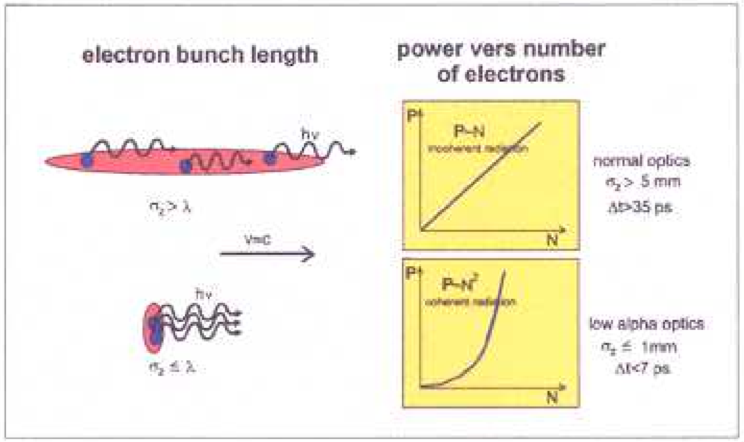
- longitudinal electron density modulation only after passing dispersive sections
- does not survive 1 turn at regular momentum compaction (α=7.5 10^{-4})
- maximum built up at 1st (in D6) and 2nd (in T6) downstream ring dipole

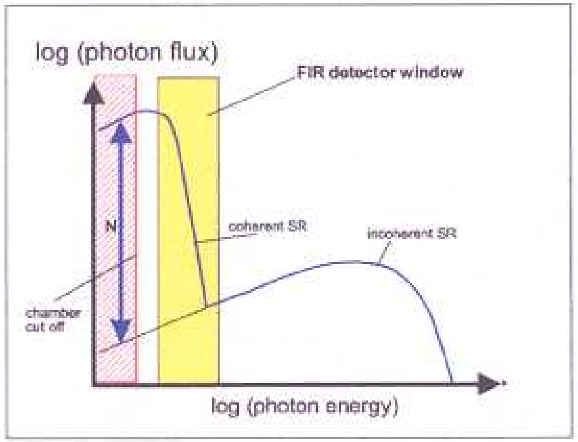
Expected CSR brilliance of the PTB-ring



The expected CSR-brilliance for the PTB ring of the 5mA beam current, 40mradx60mrad. For comparison the incoherent intensity of the radiation of the BESSY II ring at 100 mA (incoherent radiation) and the radiation of a black body source is shown.

Generation of the radiation





emitted SR-power

$$P \sim \sum E_j E_k = E_0^2 \sum \exp(i(\phi_j - \phi_k)) = N P_1 + P_1 \sum_{j \neq k} \exp i(\phi_j - \phi_k) = N P_1 + N^2 P_1 f$$

$$\boxed{P = P_1 N (1 + N f)}$$

f= power spectrum of
longitudinal bunch density

Powerful, Coherent THz-Synchrotron Radiation at BESSYII

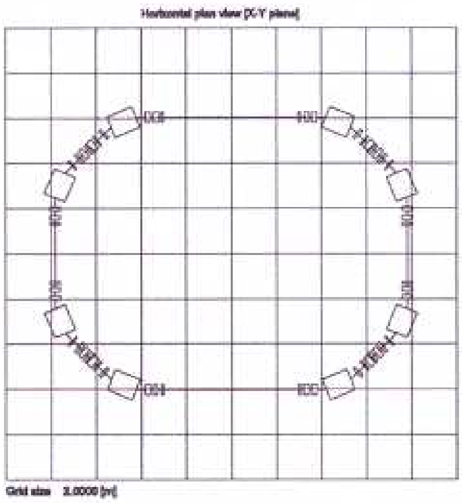
M. Abo-Bakr, J. Feikes, K. Holldack, P. Kuske,
W. Peatman, U. Schade, G. Wüstefeld, (BESSY, Berlin)
& H.-W. Hübers (DLR, Berlin)

1. Generation of coherent THz radiation
2. Properties of the CSR
3. Application of the CSR

Storage ring based FIR CSR at:
Daresbury (SRS),
Brookhaven (VUV),
Lund (MAX I),
Berkeley (ALS)

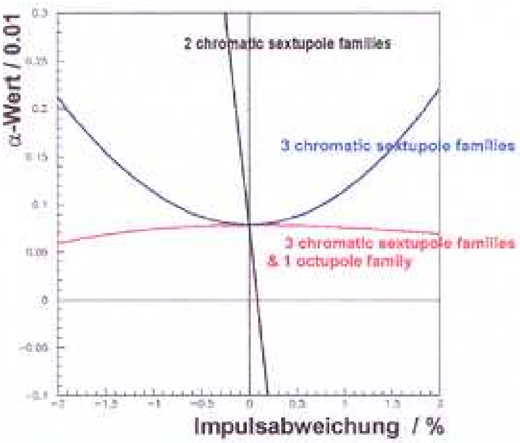
See also: http://www-als.lbl.gov/LSWorkshop/agenda.html

Low energy storage ring for the German PTB



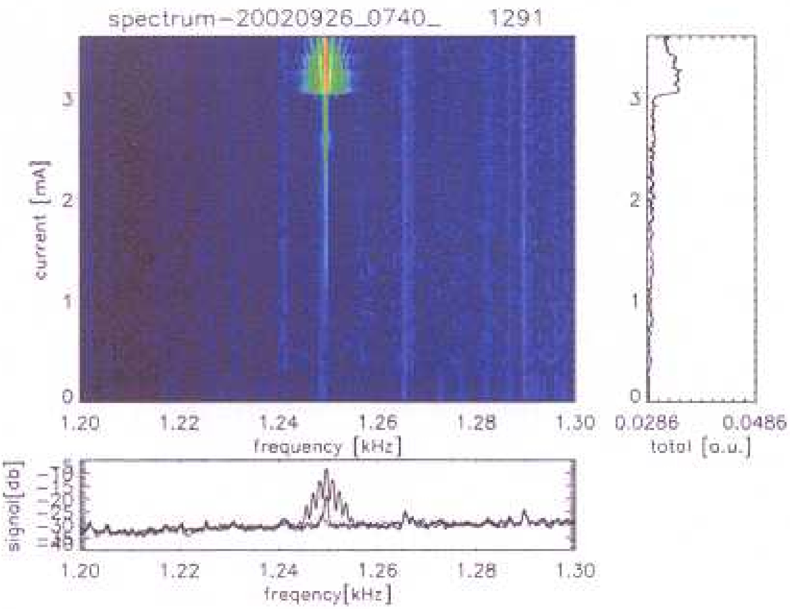
Footprint of the storage ring, circumference = 48m, E= 200 MeV to 600 MeV.

chromatic correction of the momentum compaction factor



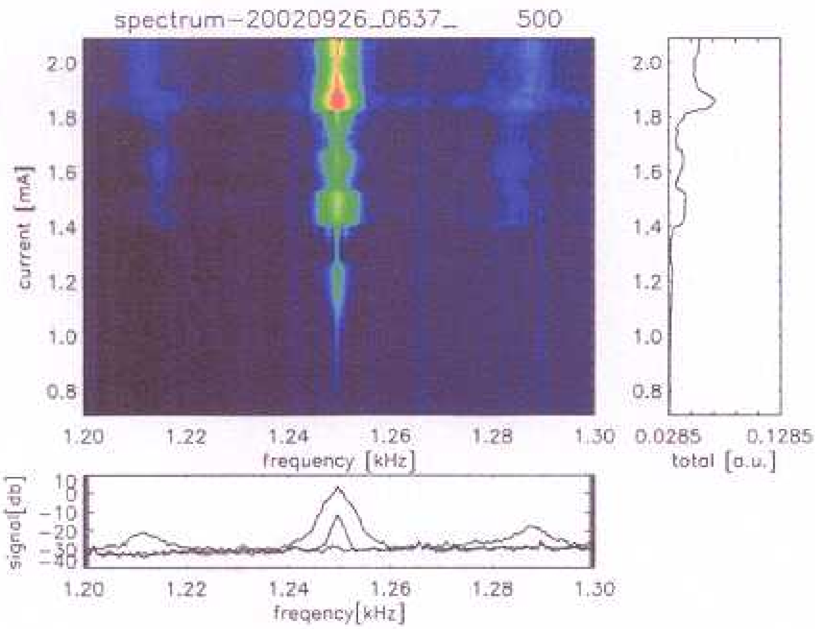
The α-dependency on the momentum for 3 correction schemes. black=2 chromatic sextupole families, red=3 chromatic sextupole families, blue=3 chromatic sextupole families plus 1 octupole family.

17= 7.26粒



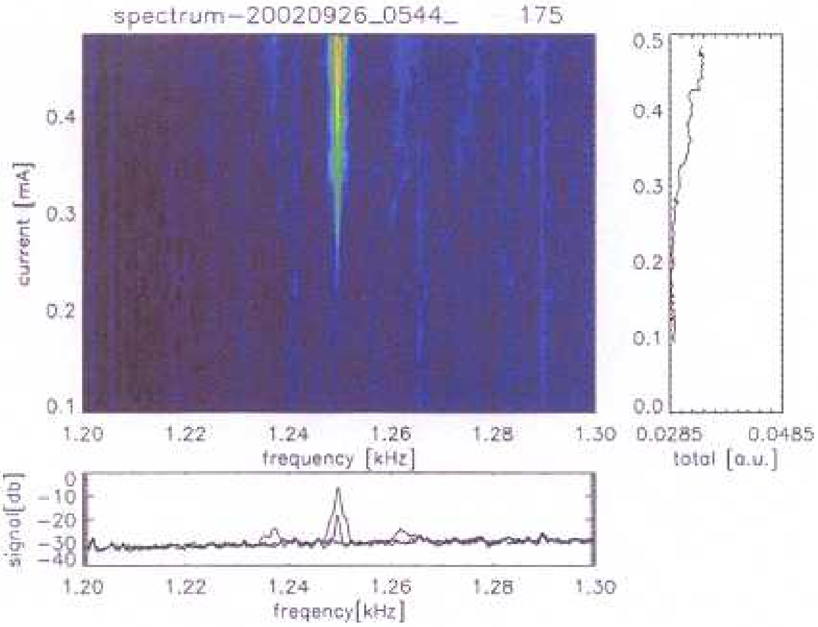
spectrum-20020926_0740_ 1291
current [mA]
0
1
2
3
1.20
1.22
1.24
1.26
1.28
1.30
frequency [kHz]
0.0286
0.0486
total [a.u.]
signal[db]
1.20
1.22
1.24
1.26
1.28
1.30
freqency[kHz]

18 = 5 kHz



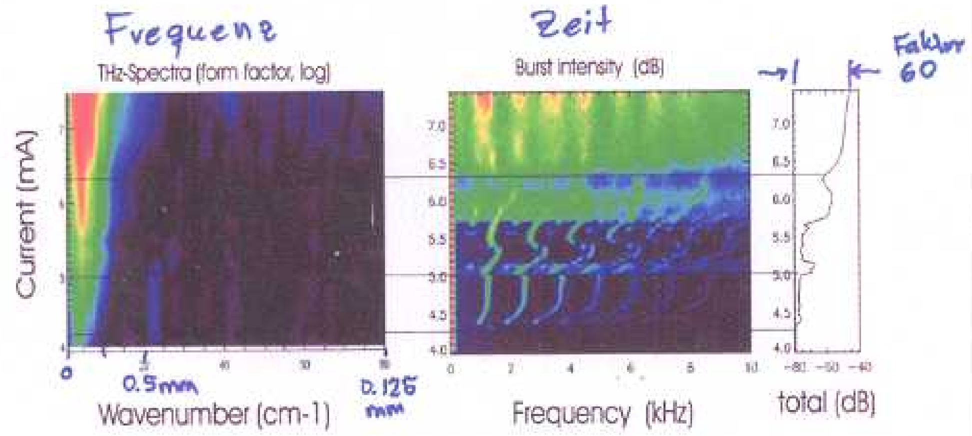
spectrum-20020926_0637_ 500
current [mA]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
1.20
1.22
1.24
1.26
1.28
1.30
frequency [kHz]
0.0285
0.1285
total [a.u.]
signal[db]
10
0
-10
-20
-30
-40
freqency[kHz]

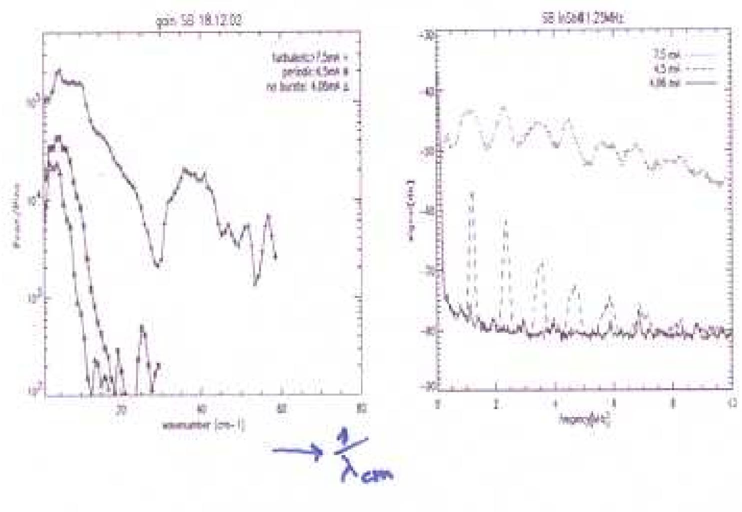
$\Omega = 3$ kHz


spectrum-20020926_0544_ 175
current [mA]
0.1
0.2
0.3
0.4
1.20
1.22
1.24
1.26
1.28
1.30
frequency [kHz]
0.0
0.1
0.2
0.3
0.4
0.5
0.0285
0.0485
total [a.u.]
signal[db]
0
-10
-20
-30
-40
1.20
1.22
1.24
1.26
1.28
1.30
freqency[kHz]

Vergleich Formfaktoren und burst-frequenzmuster
im single bunch Normalmodus

links 18.12.02 MP-Spektrometer,
rechts Spektrum-Analyser 19.12.02





Fazit:
periodisches bursting entspricht kleinen Wellenzahlen (<10)
Im turbulenten bursting (microbunching) gibt es Fourierkomponenten oberhalb 1THZ