Multiparticle Longitudinal Motion Tracking code with Broadband impedance

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ESRF team: Laclare, Gunzel, Nagaoka, Farvacque...
SSRL version: J. Sebek

Longitudinal Equations of motion

- Applied to each particle (τ, δ)

- $$\delta_{n+1} - \delta_n = 2\pi Q_{so}(\sin(\varphi_{so} + h\omega_o\tau_n) - \sin(\varphi_{so}))$$ RF

$$-\frac{2\pi I}{hV_{rf}\cos(\varphi_{so})\omega_o^{\,2}\sigma_{\tau o}} G_\lambda(\tau_n)$$ Wake

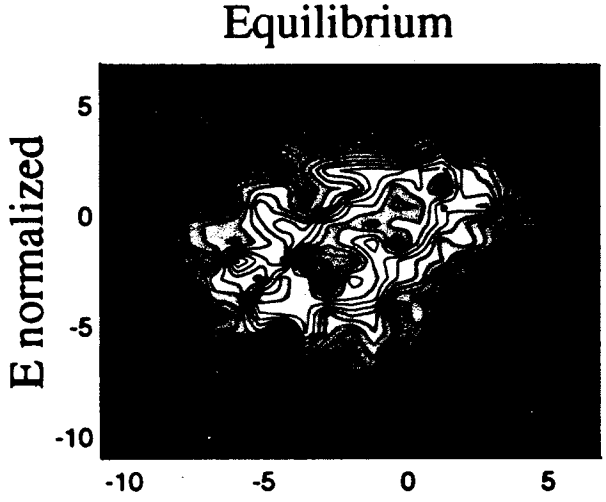
$$-\frac{T_o}{T_{damp}}\delta_n + 2\sqrt{\frac{T_o}{T_{damp}}}R_n$$

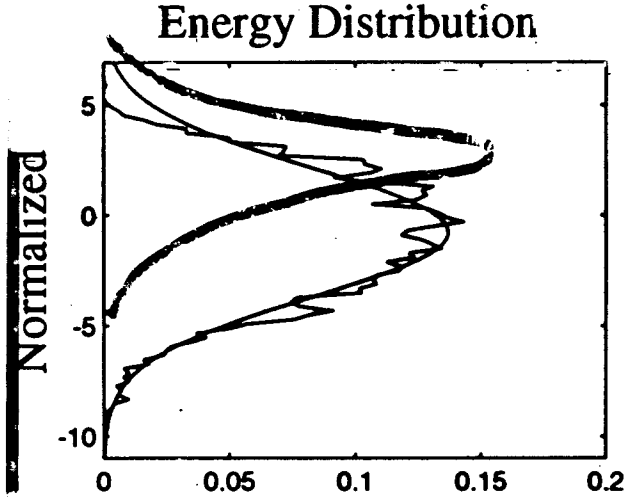
Damping Fluctuations

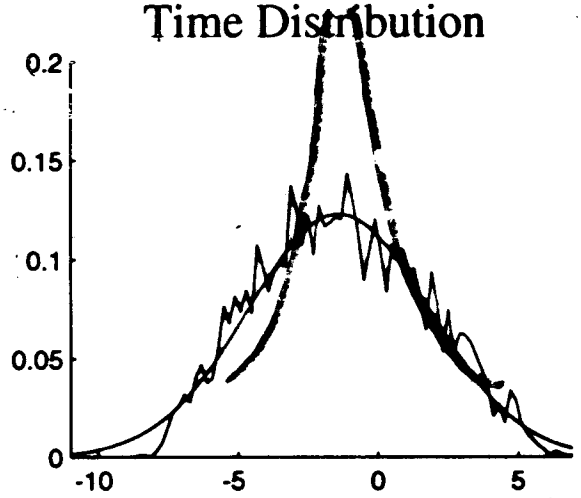
- $$\tau_{n+1} - \tau_n = 2\pi Q_{so}\delta_{n+1}$$ Variation of path length

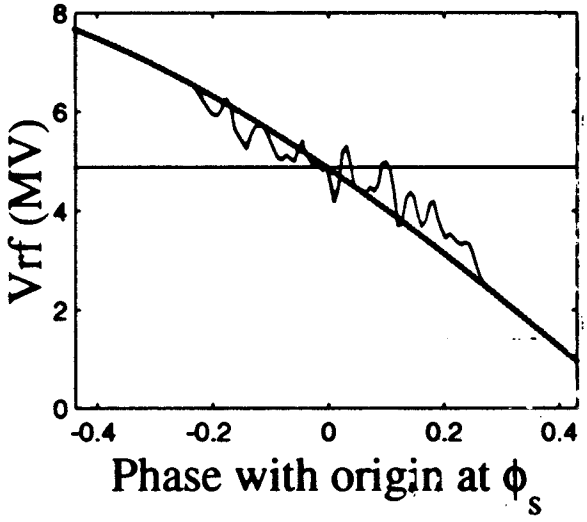
$G_\lambda = G * \lambda$; $G = \frac{R_s\omega_r}{Q} e^{-\frac{\omega_r z}{2Q}}\left[\cos(\omega_r' z) - \frac{\sin(\omega_r' z)}{\sqrt{Q^2-1}}\right]$

R_s, Q, f_r



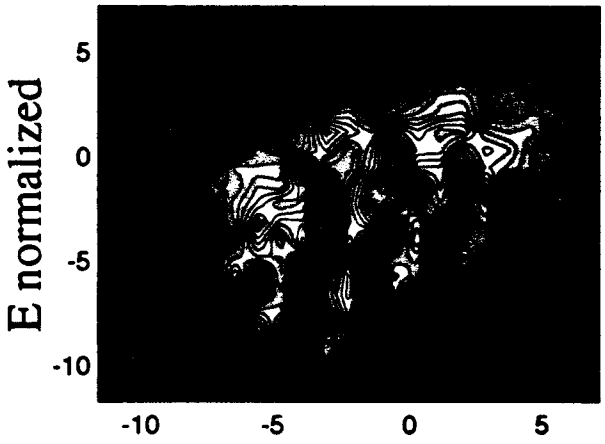




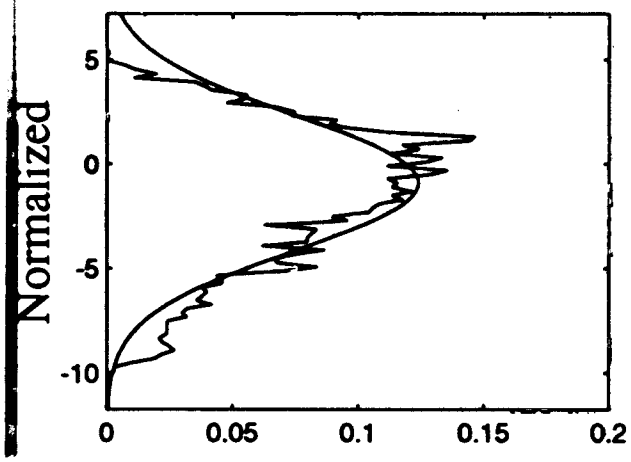


with dim[illegible] plane
[illegible]
[illegible]
[illegible] and has lost
[illegible]

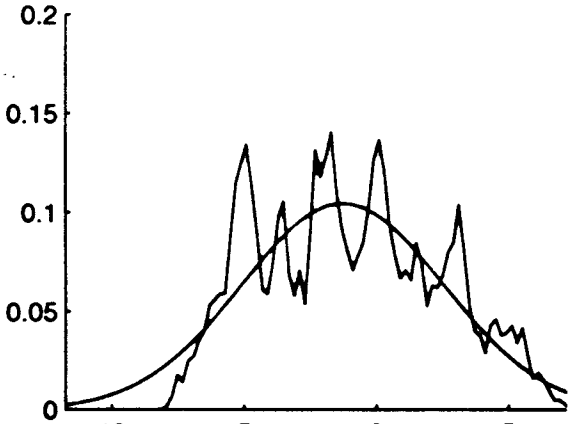
Distribution in phase Space



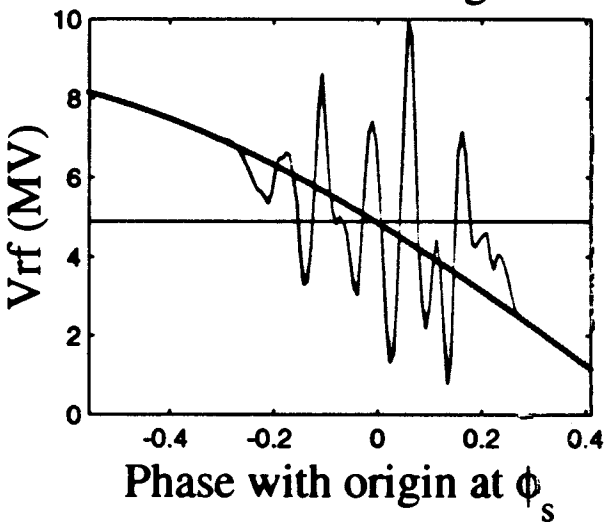
Energy Distribution



Time Distribution



Effective Voltage



With ESRF parameters

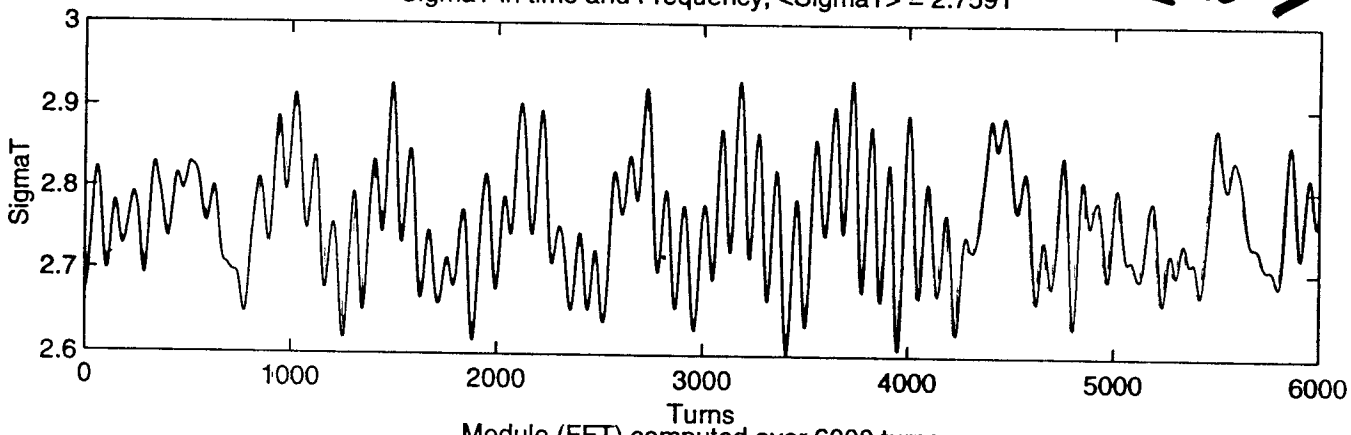
- 6 GeV, $T_o = 2.8\ \mu s$
- $\sigma_\tau = 15.5$ ps; $\sigma_{\omega =}$ 10 GHz
- $\tau_{damping} = 3.5$ ms 1236 Turns
- $\tau_s = 0.487$ ms 173 Turns

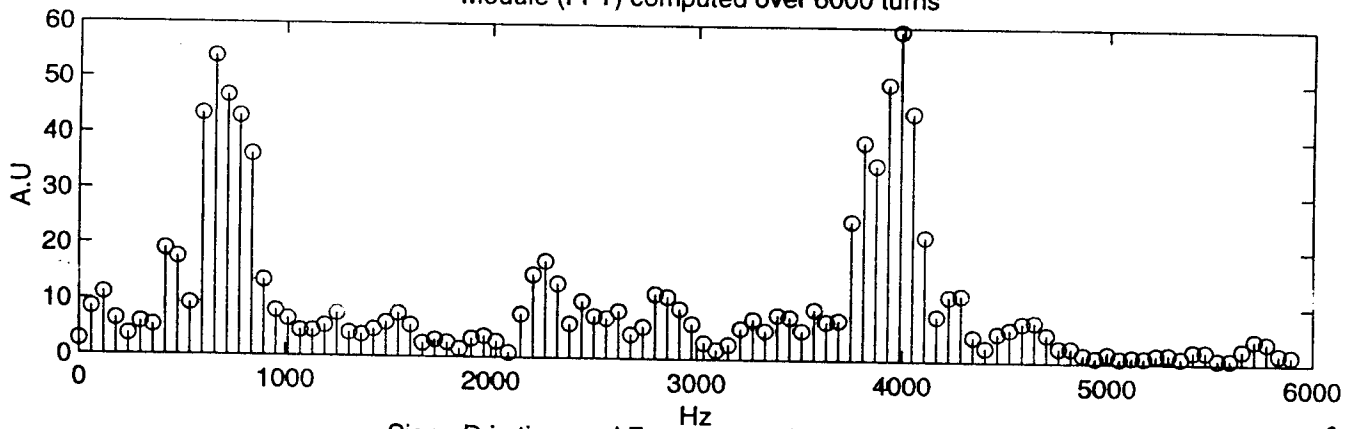
Simulation 600 Turns ($\simeq 3\tau_s$) 1 image / 5 turns

- total bunch 10 $\sigma_\tau \approx 150$ ps
- 30 GHz $\Leftrightarrow$ 33 ps $\Rightarrow 5\ \lambda_r$
- 15 GHz $\Leftrightarrow$ 66 ps $\Rightarrow 2.5\ \lambda_r$
- 7 GHz $\Leftrightarrow$ 141 ps $\Rightarrow 0.94\ \lambda_r$
- 3.5 GHz $\Leftrightarrow$ 282 ps $\Rightarrow 0.47\ \lambda_r$

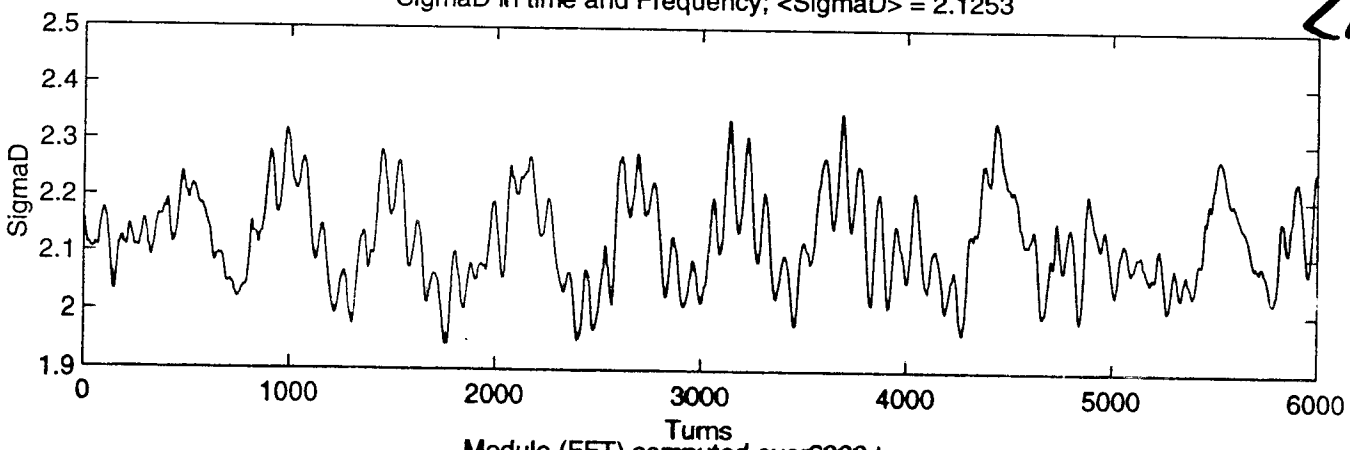
$f_r = 30\ GHz$ 5 mA

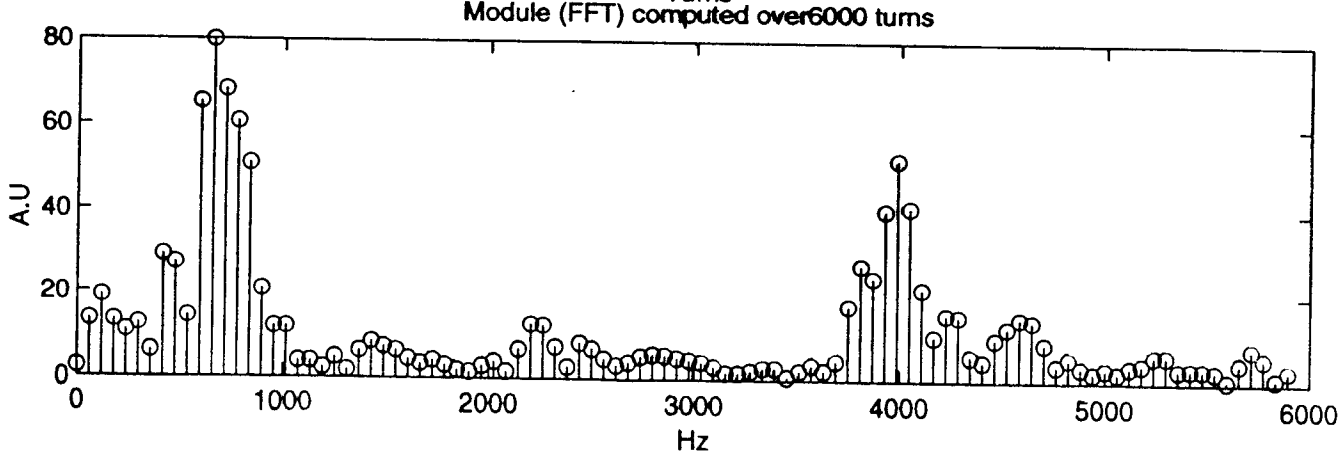
$\langle x^2 \rangle$



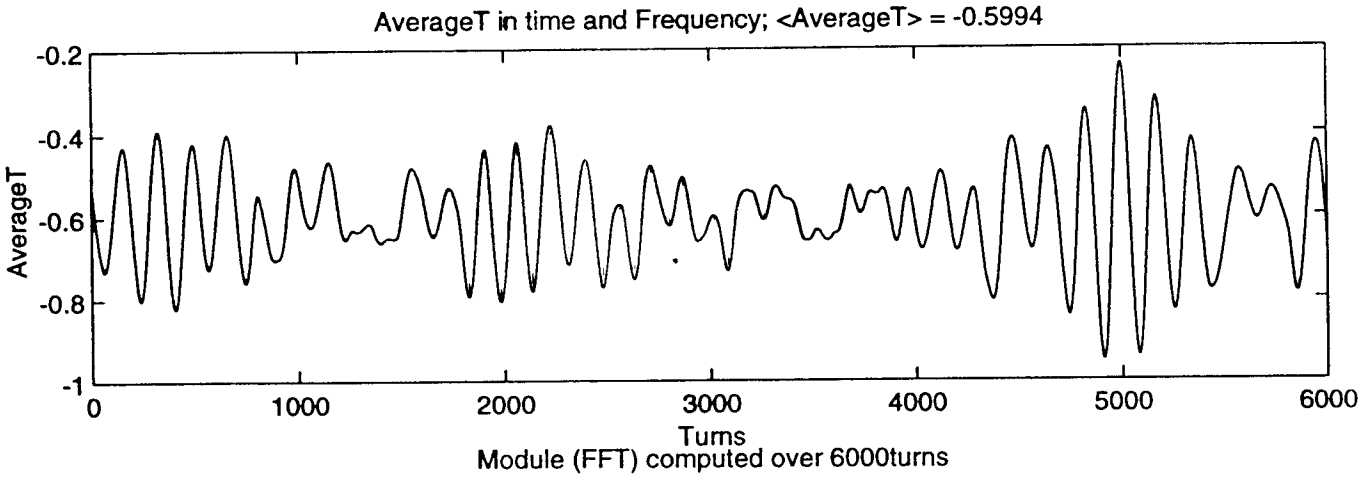


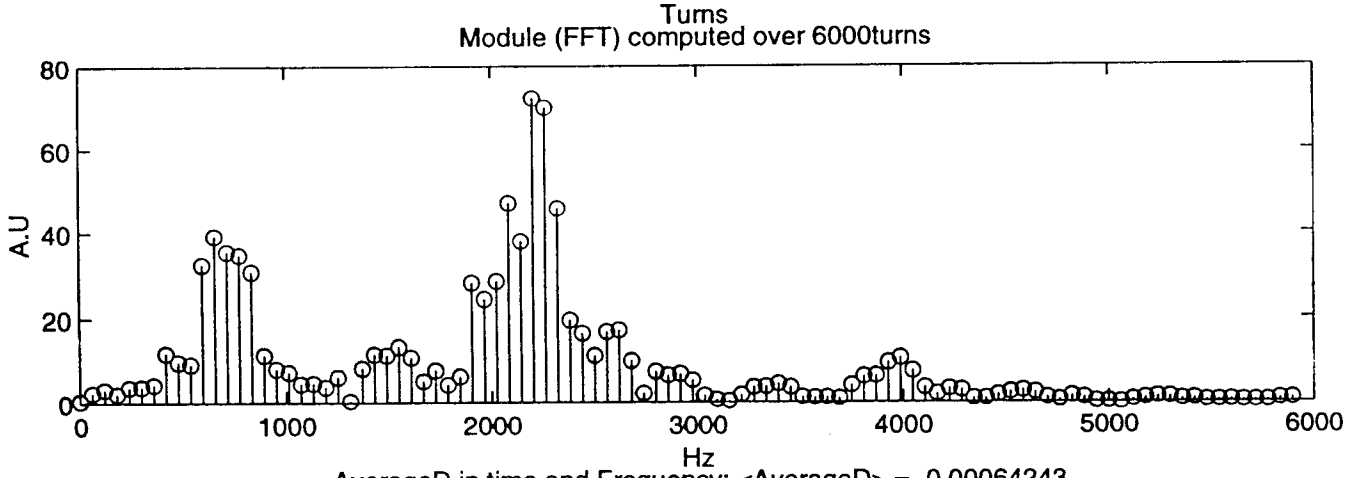
$\langle E^2 \rangle$

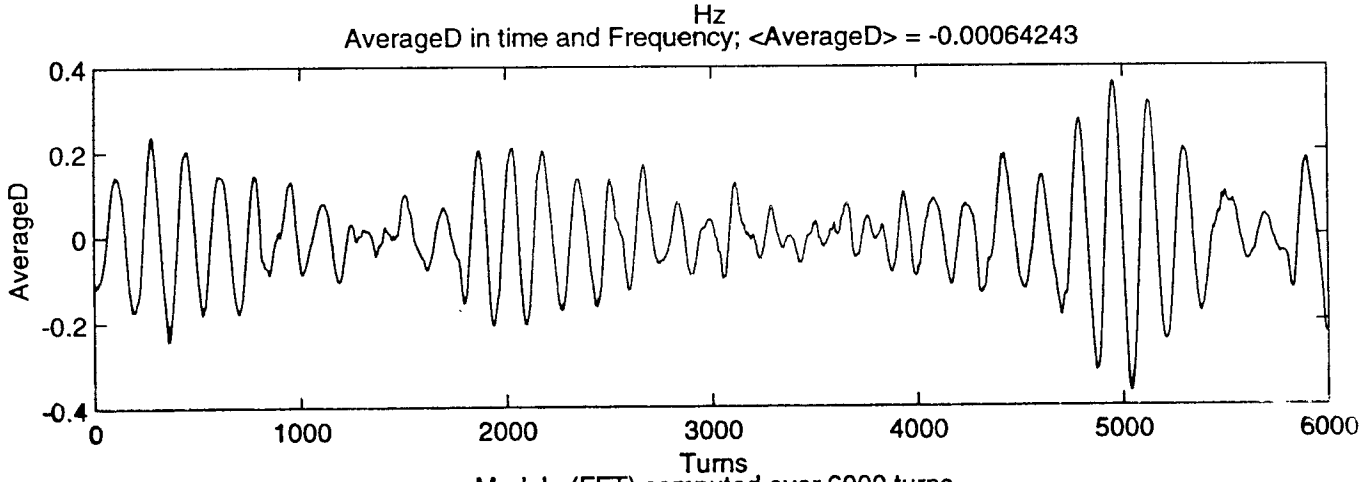


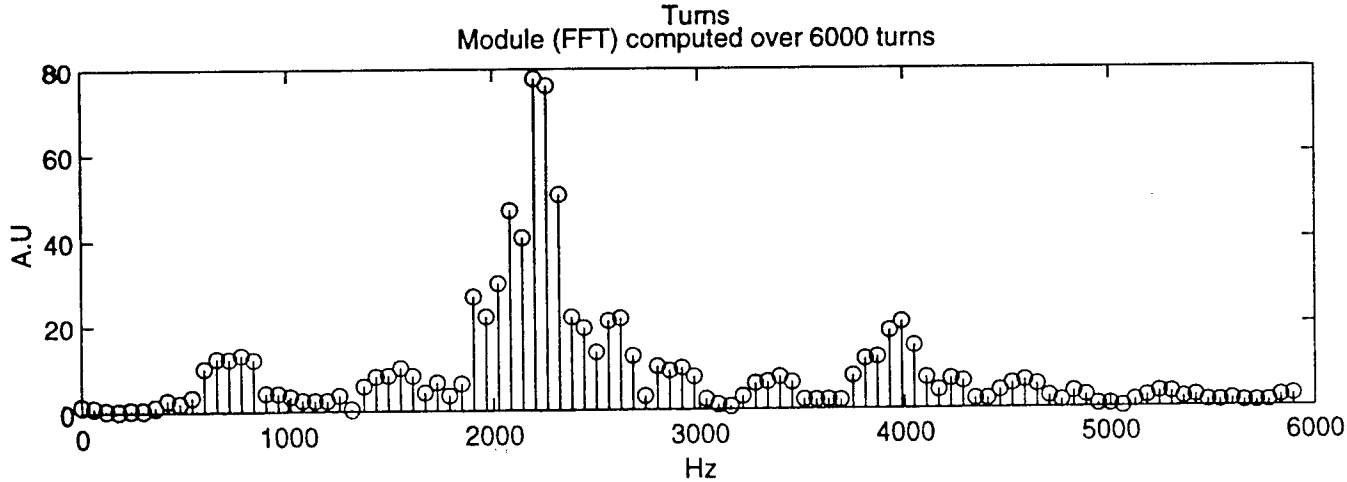


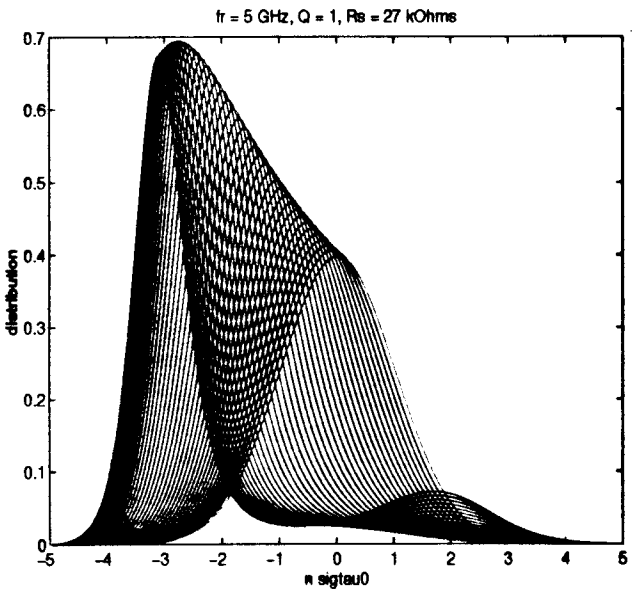
$f_r = 30\ GHz$ 5mA


AverageT in time and Frequency; <AverageT> = -0.5994
AverageT
-0.2
-0.4
-0.6
-0.8
-1
0
1000
2000
3000
4000
5000
6000
Turns

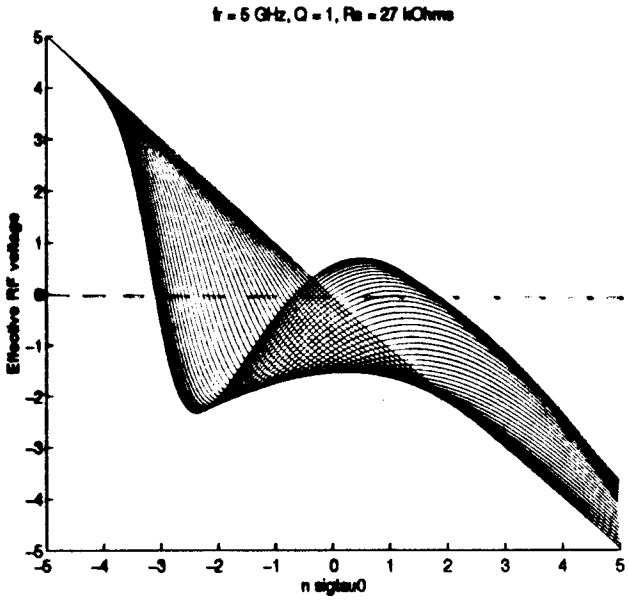

Module (FFT) computed over 6000turns
A.U
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
Hz


AverageD in time and Frequency; <AverageD> = -0.00064243
AverageD
0.4
0.2
0
-0.2
-0.4
0
1000
2000
3000
4000
5000
6000
Turns


Module (FFT) computed over 6000 turns
A.U
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
Hz

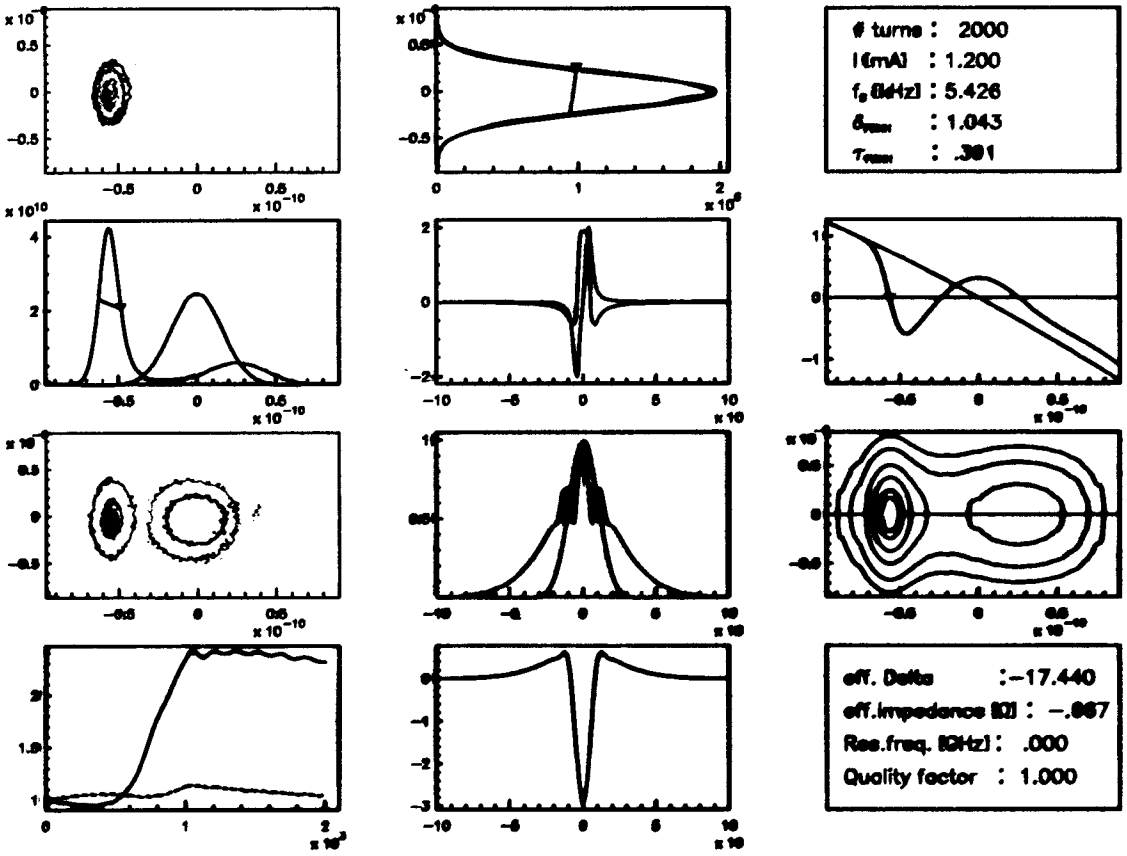


Line density



Effective RF voltage

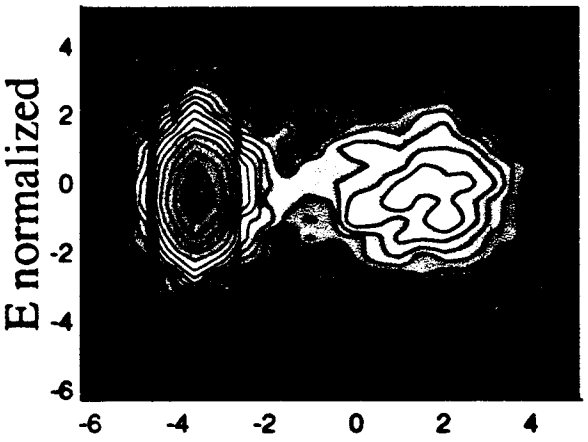
Iteration on Haissinski equation



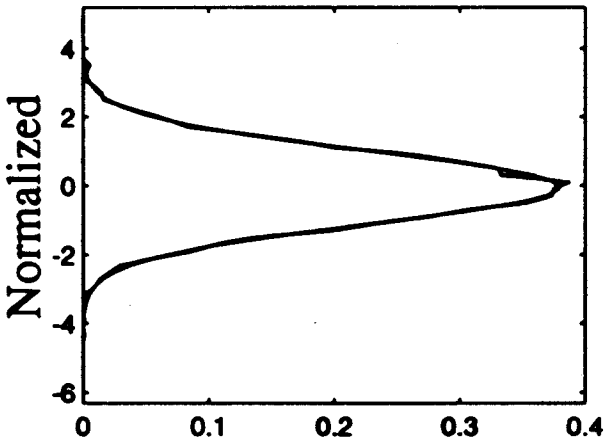
Tracking code results

Resonator (fr = 5 GHz, Q=1, Rs=27kΩ) Comparaison tracking code results and iteration on the Haissinski equation

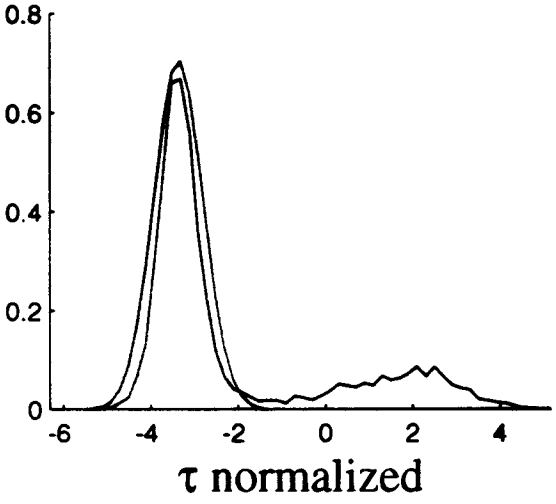
Double Bump



Energy Distribution



Time Distribution



Effective Voltage