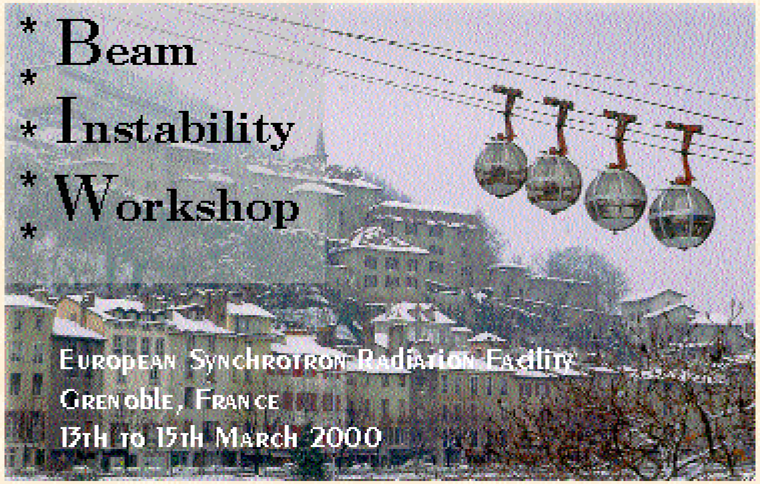


ESRF

ESRF Experimental Contribution Towards Working Group Introduction

REVOL Jean-Luc

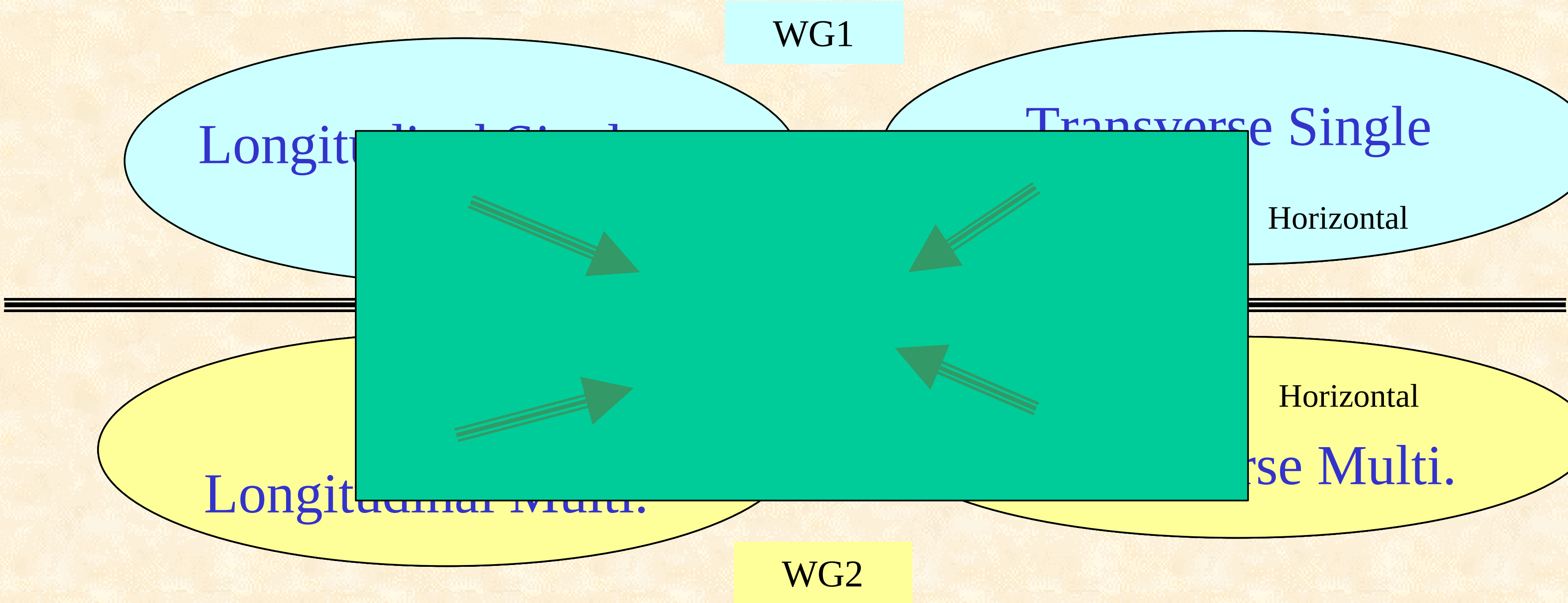
ESRF Experimental Contribution
Towards Working Group Introduction

Goal of this talk:

Interdependence

Longitudinal/transverse/single-bunch/multi-bunch

based on ESRF observations



ESRF Experimental Contribution Towards Working Group Introduction

Goal of this talk:

Interdependence

Longitudinal/transverse/single-bunch/multi-bunch

based on ESRF observations

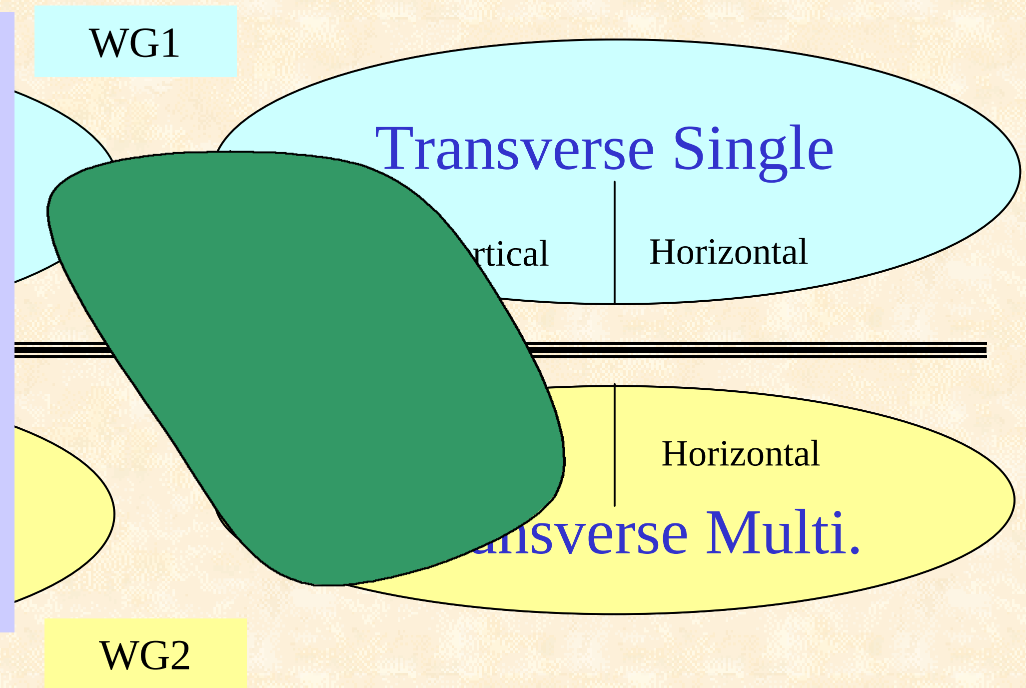
IMPEDANCE MODELING WITH BEAM

Resistive wall contribution to single bunch dynamics

Broad Band contribution to multibunch dynamics

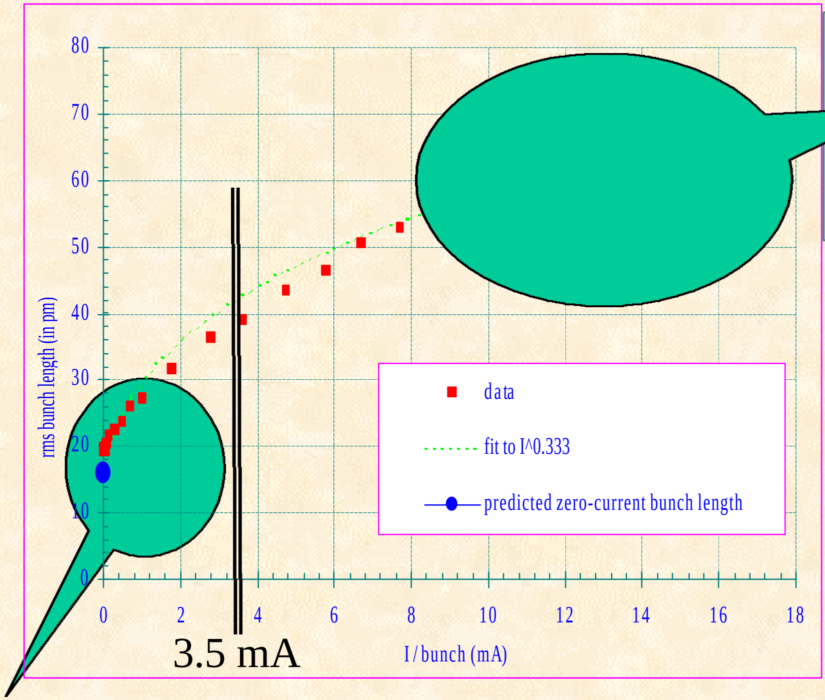
Effect of partial filling on multibunch transverse instabilities

Transverse feedbacks



Longitudinal /Single Bunch

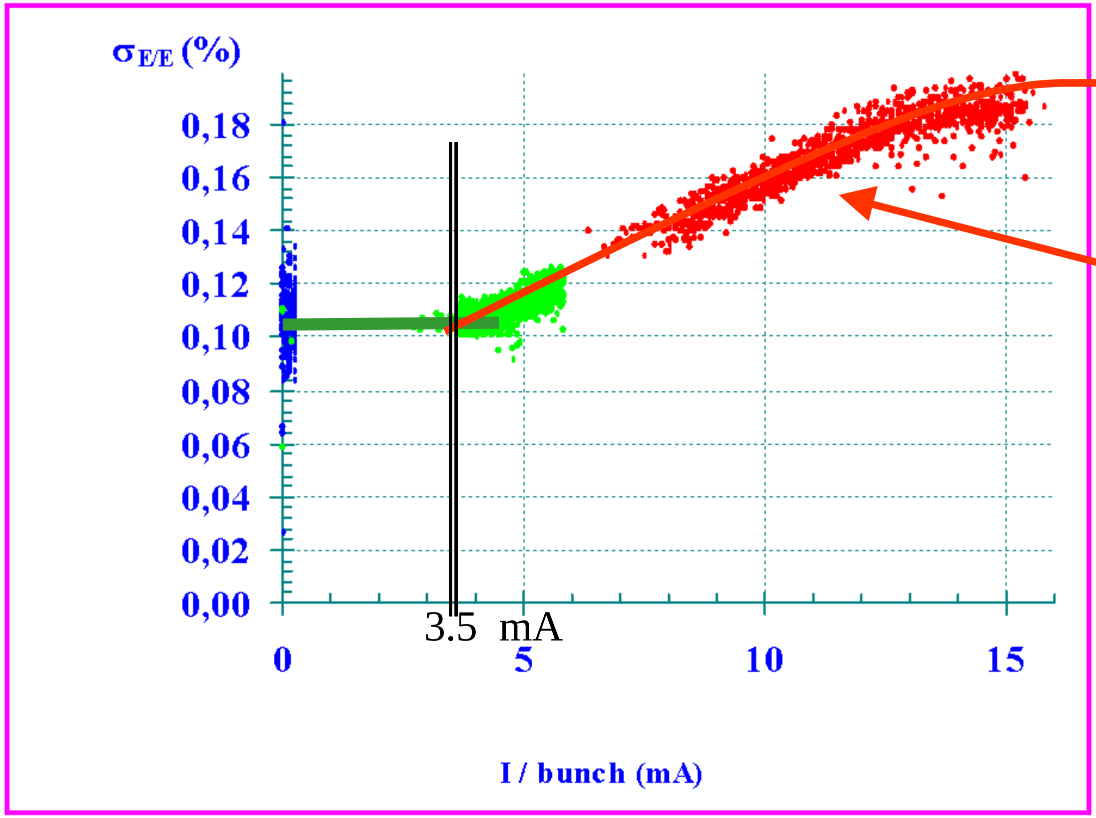
Bunch lengthening



Recent measurements show oscillating values.
Is it a sign of a Saw-tooth mechanism ?

At zero current, discrepancy between theoretical bunch length and measured bunch length > 20 %

Measurement of energy spread based
on two emittance measurements
one in a dispersive section and one in a non dispersive section



Microwave regime
starts at 3.5 mA
for the ESRF.

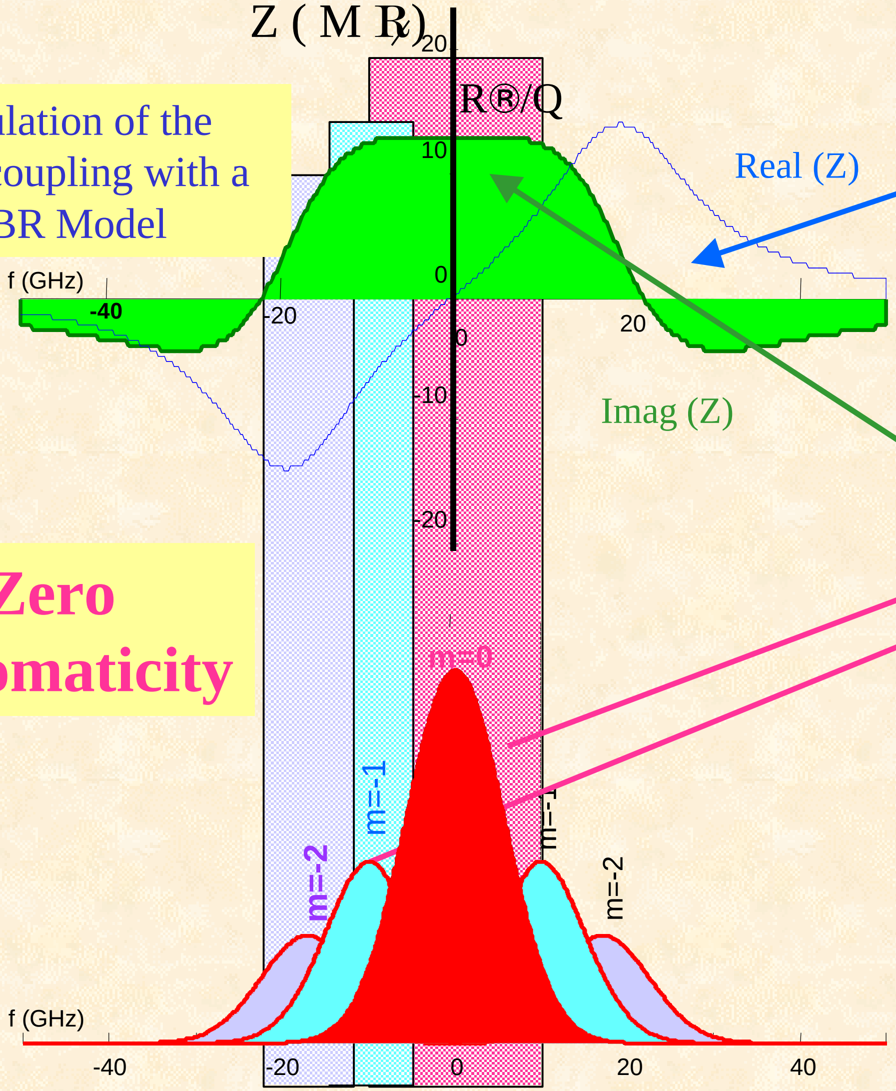
From bunch lengthening and
energy spread
(simulated by tracking code)

BBR model for the
longitudinal impedance

f_{res} = 30 GHz, R_s = 42 kΩ, Q=1

Transverse / Single Bunch / BBR

Simulation of the mode coupling with a BBR Model



==> no effect of the resistive impedance
==> Positive real part compensates exactly the negative real part

Mode 0 and mode -1
interact with the imaginary positive part of the impedance
==> defocusing

Zero Chromaticity

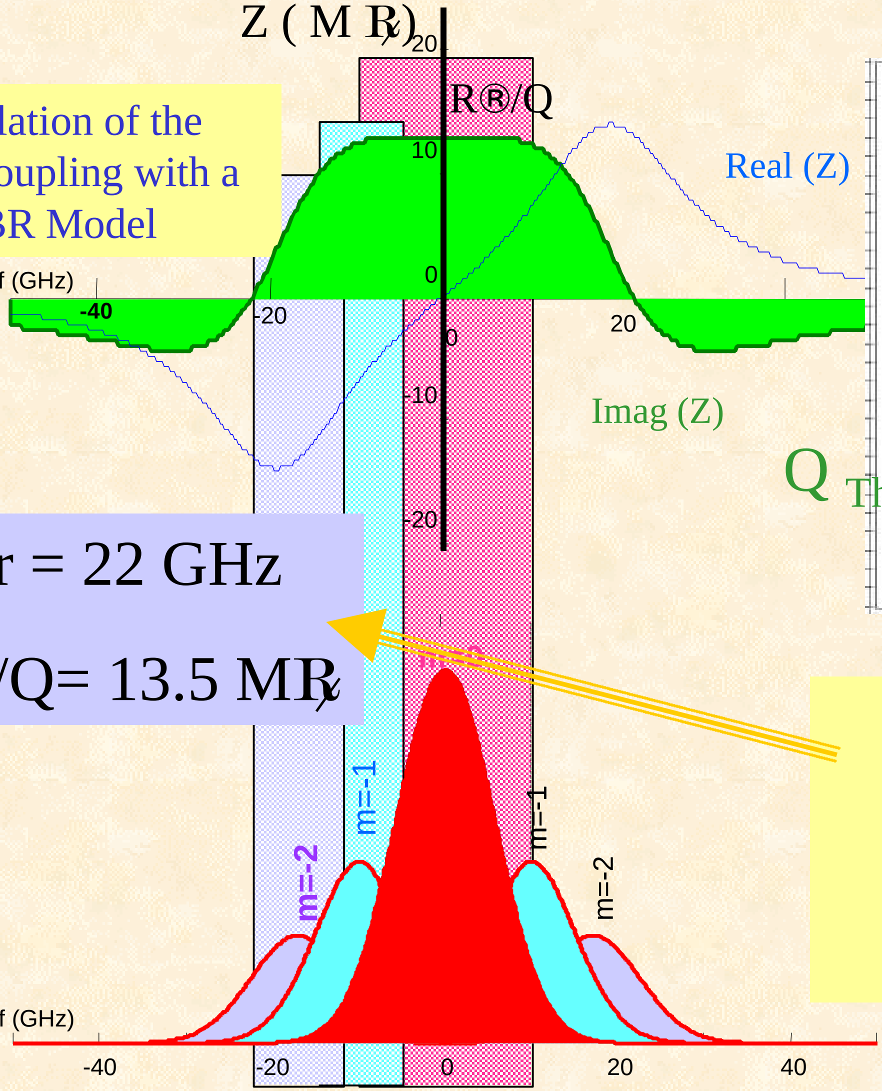
Detuning of Mode 0 = f (R®/Q)

Detuning of mode -1 = f(f_r)

Mode with larger m are much less detuned

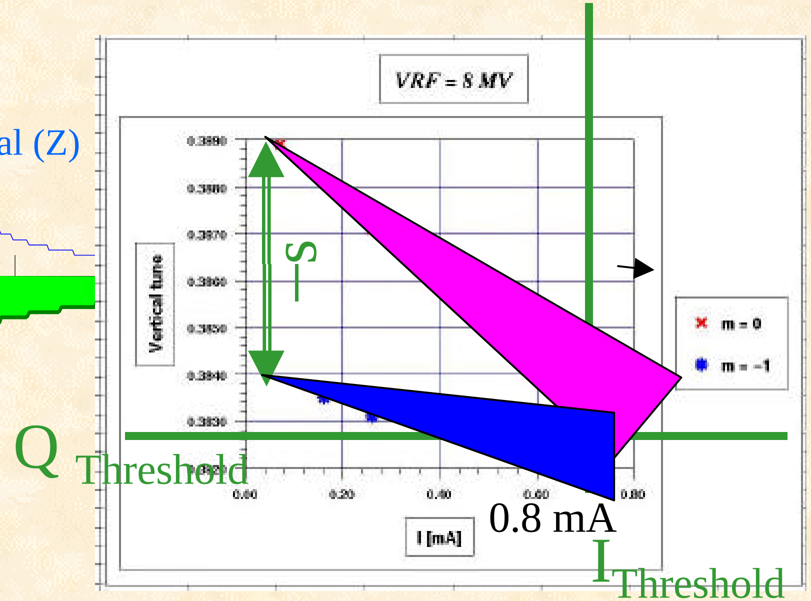
Transverse / Single Bunch / Mode merging

Simulation of the mode coupling with a BBR Model



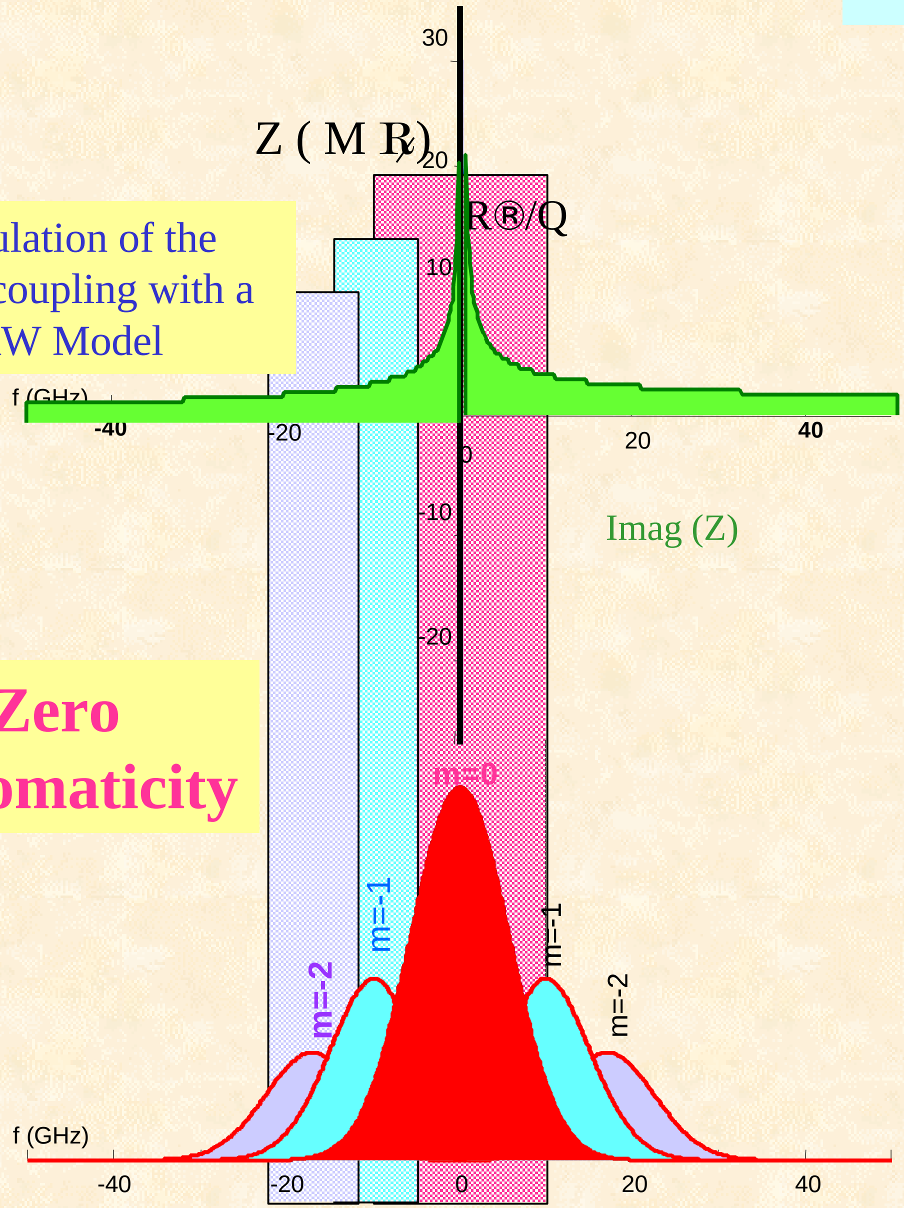
Fr = 22 GHz

R®/Q= 13.5 MR



Fit of the model to the experimental data using Moses

Simulation of the mode coupling with a RW Model



Zero Chromaticity

For the ESRF
the modeling of the mode merging
could be obtained
with a Resistive Wall model
only!!!

But this resistive wall model

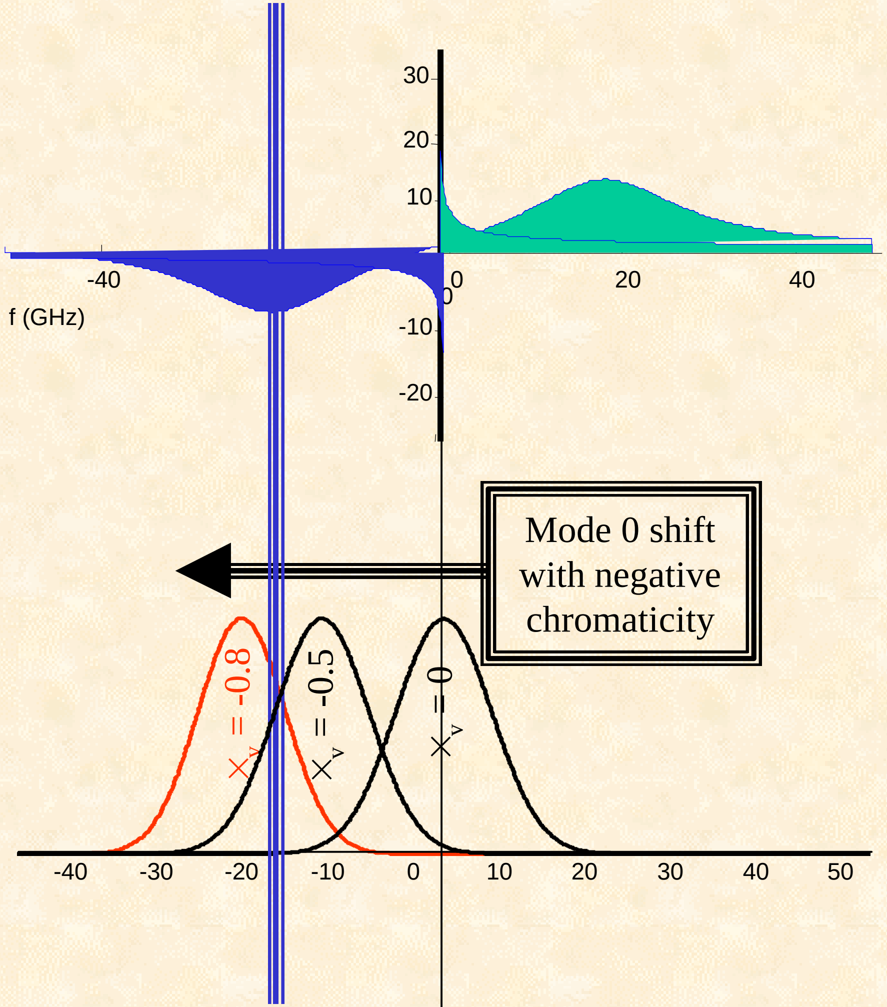
should be much larger than

the theoretical one !!!!

(Factor 10)

From mode merging,
We cannot conclude on
the broadband shape

BBR + RW



Maximum interaction

at $\times_v$ = -0.6

With the negative chromaticity

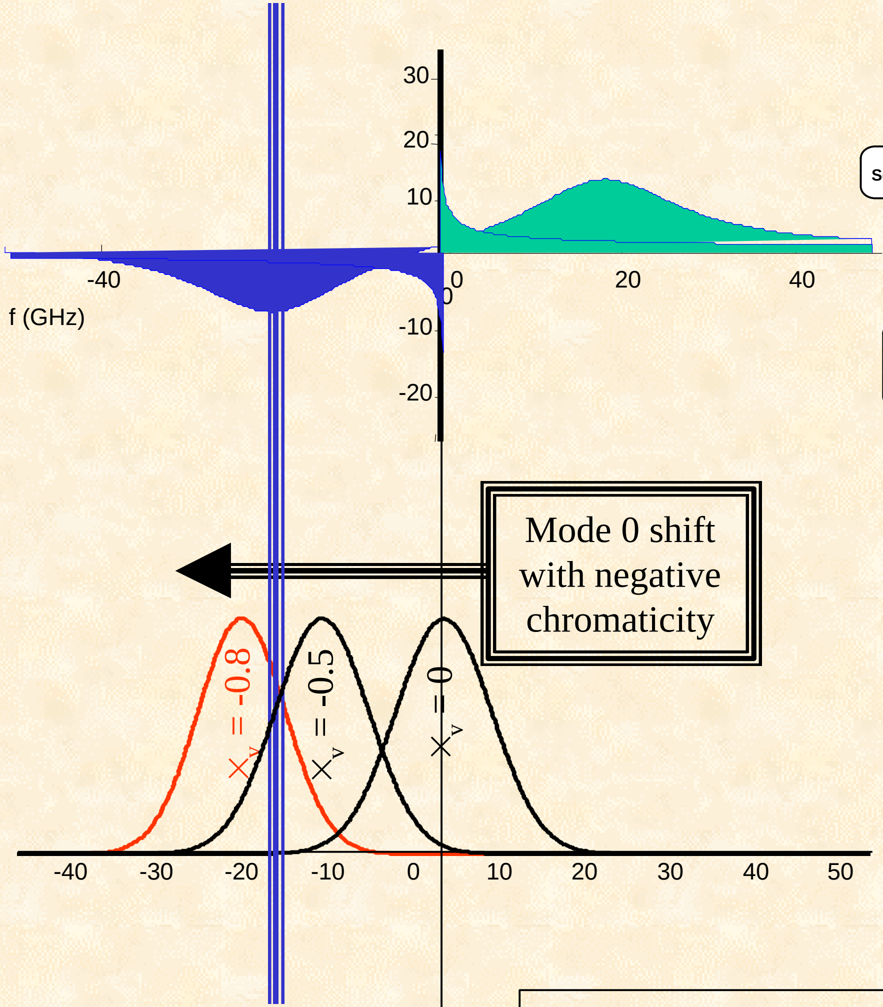
Mode 0 is strongly unstable

Thanks to the amplitude dependant tune spread

0.8 mA can be stored independently of the chromaticity

ESRF reduced chromaticity should be multiplied by 14.39

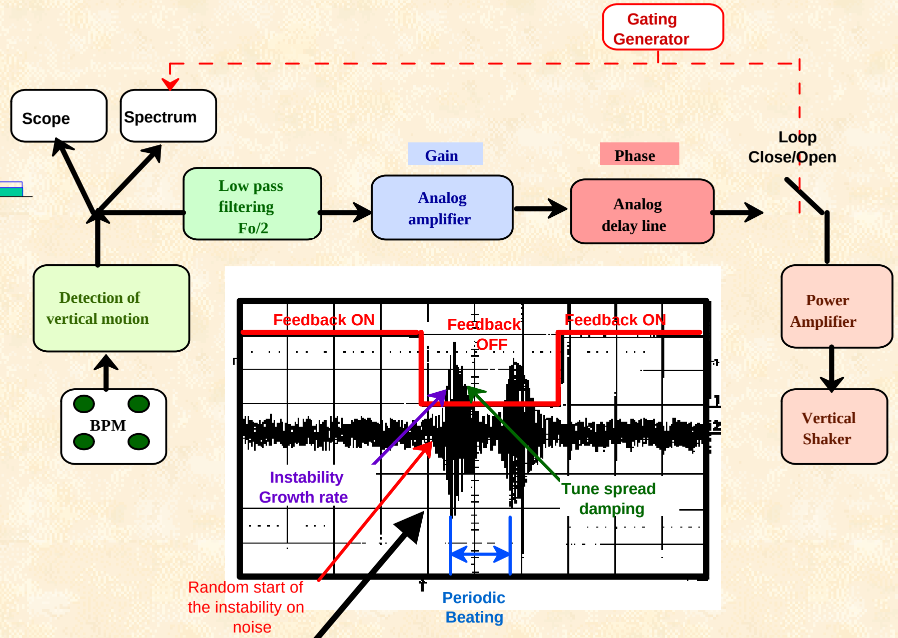
Transverse / Single Bunch



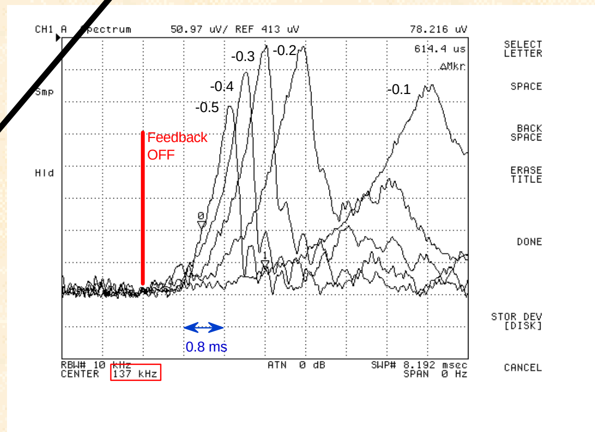
Mode 0 shift with negative chromaticity

Maximum interaction

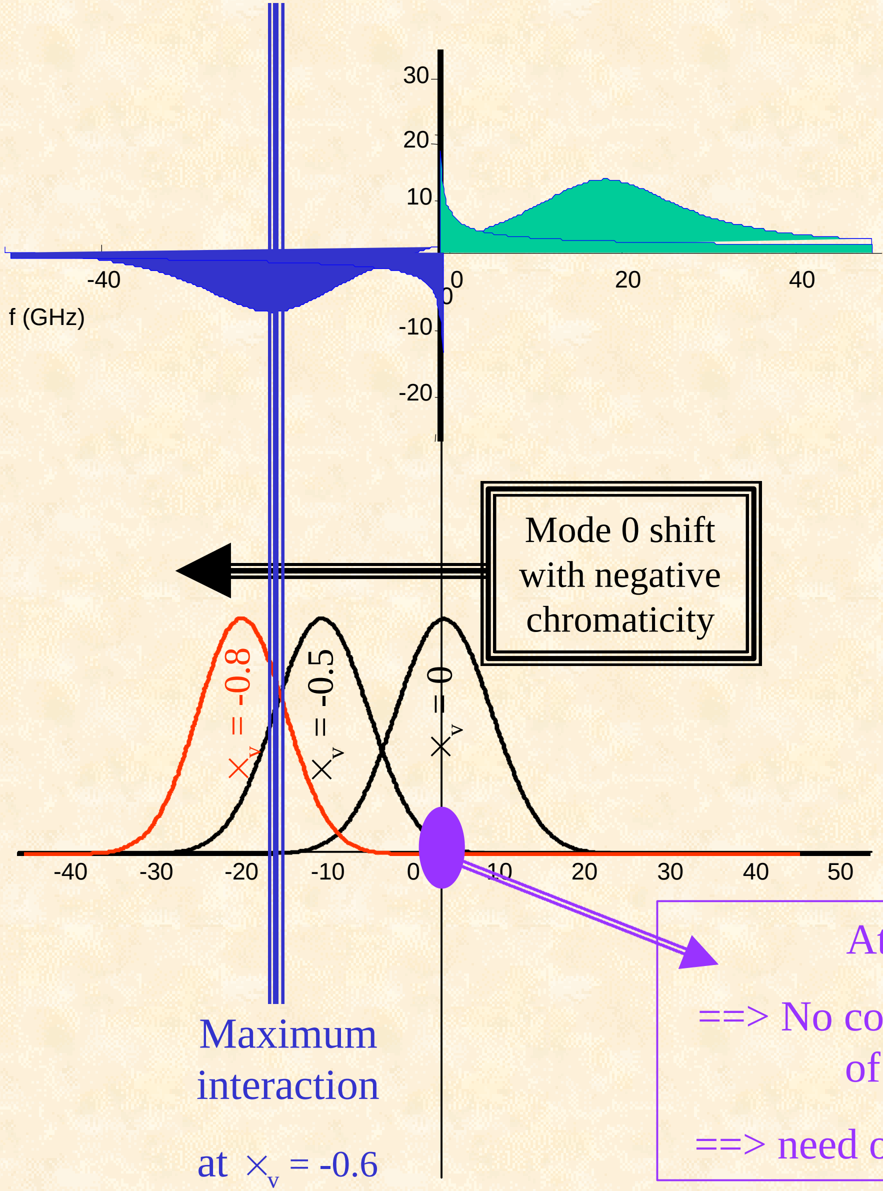
at ξ_v = -0.6

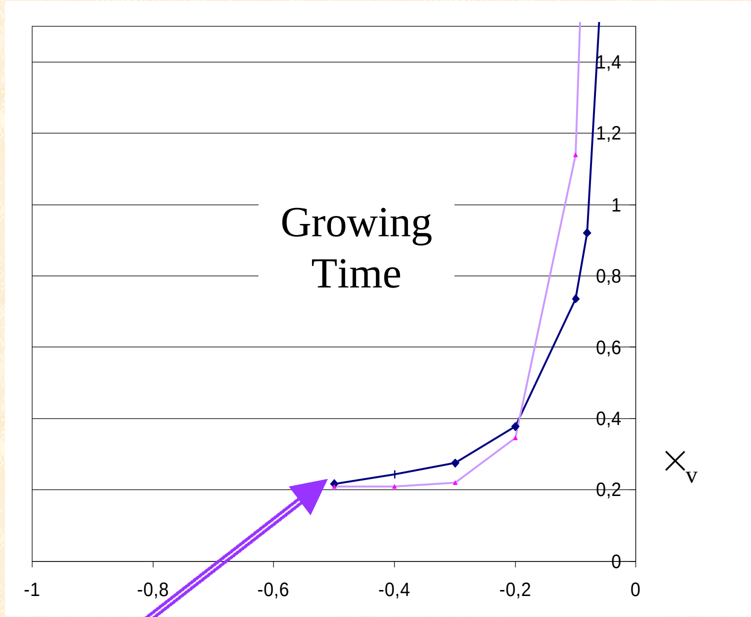


@ Measurement of Growth rate in the negative chromaticity



Stabilization by amplitude dependent tune spread induces a saw-tooth effect





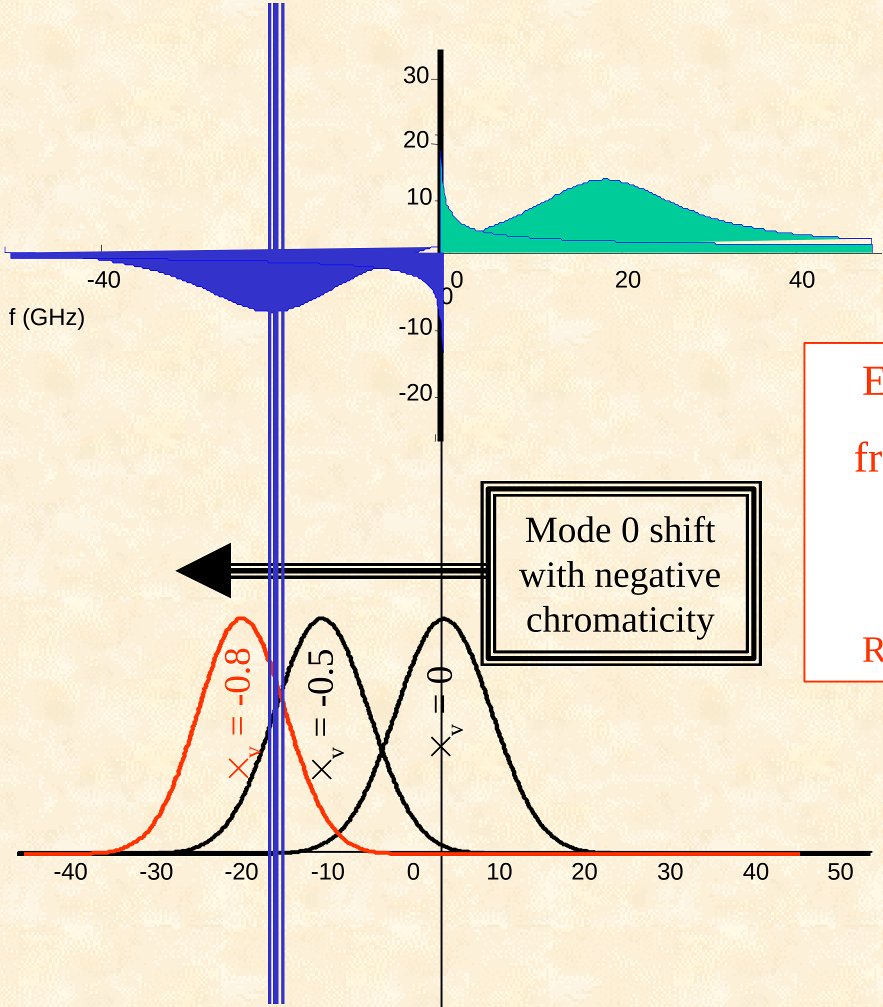
At high chromaticity

==> No contribution at low frequency of the unstable mode

==> need of a high frequency pick-up

Transverse / Single Bunch

Probing the real part of the impedance at negative chromaticity
==>
no effect coming from the RW



Maximum interaction

at ξ_v = -0.6

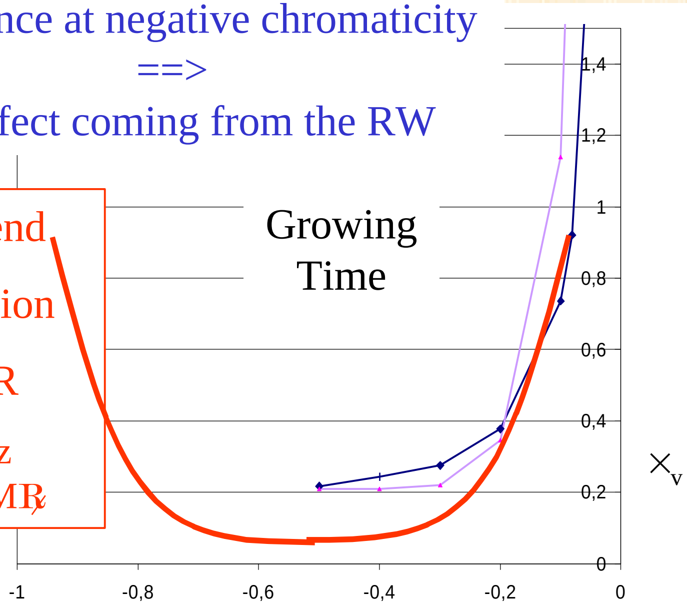
Expected trend

from simulation

with a BBR

Fr = 22 GHz

R®/Q= 13.5 MR

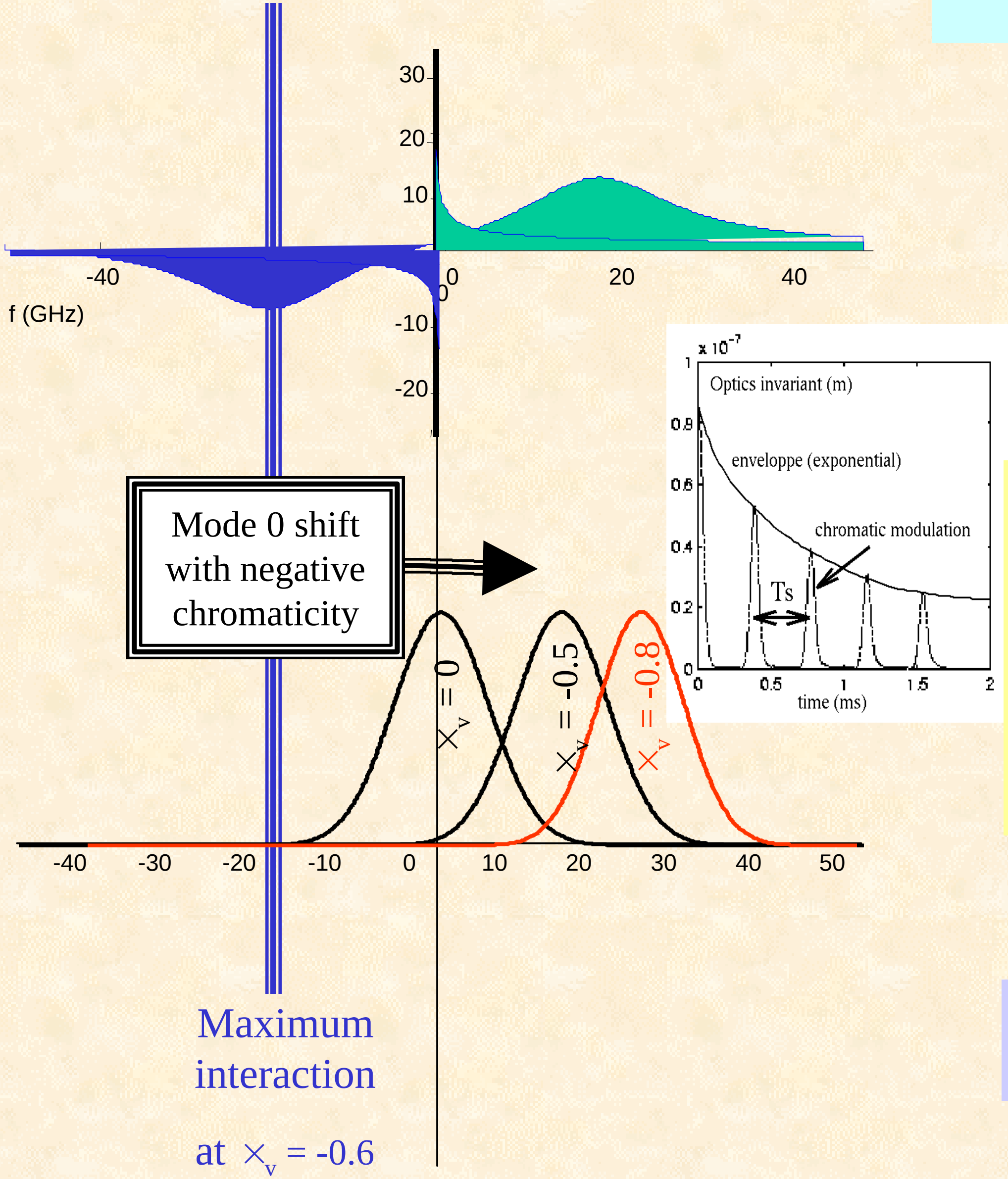


The too long observed growing time (factor 4) is in favor or

Reducing the strength of the BBR (R®/Q)

obtained from mode merging

(compensated by a contribution from the RW)



An attempt was made to

measure head-tail damping as a function of the single bunch current

In the positive chromaticity regime

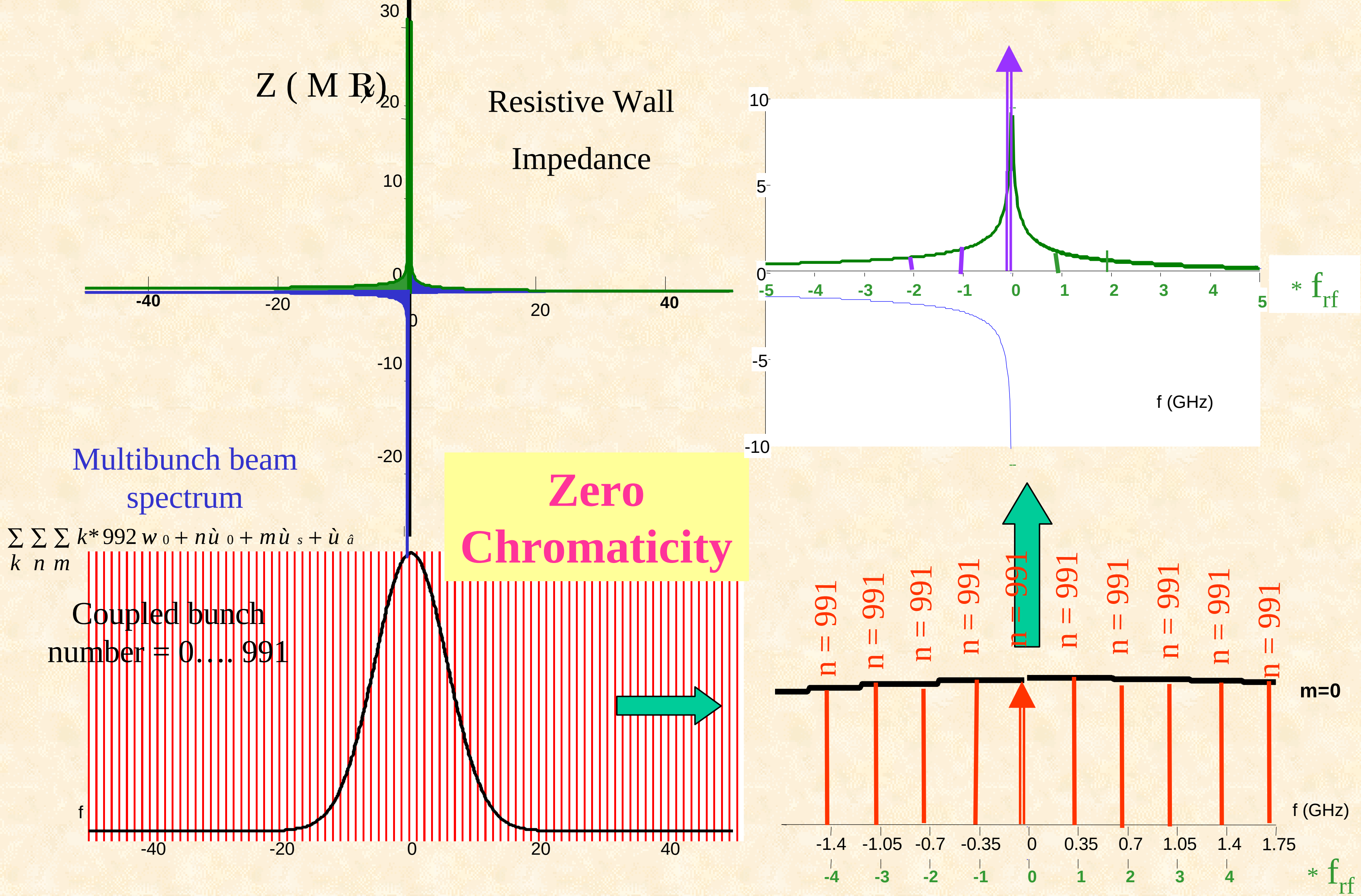
Many difficulties in practice due to :

@ Chromatic modulation

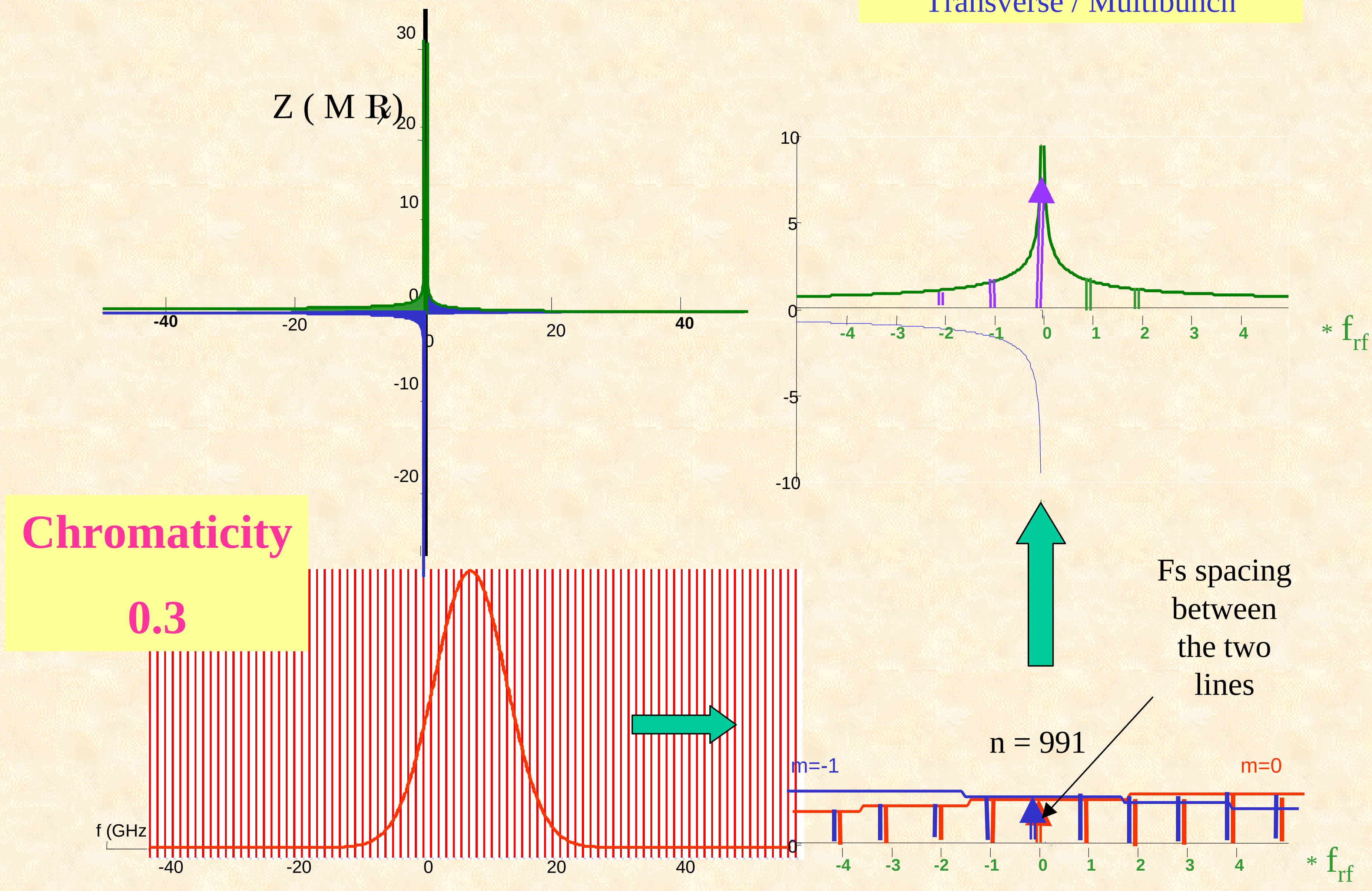
@ Amplitude dependent tune spread

Despite our efforts, no valid data could be obtained

Transverse / Multibunch



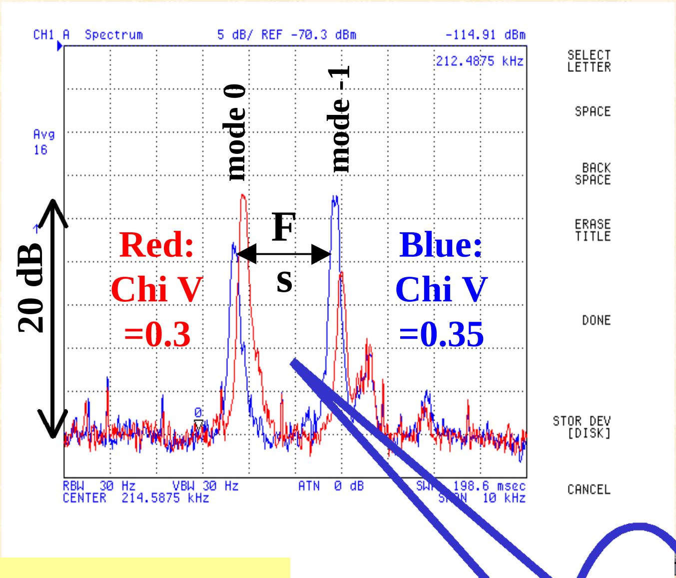
Transverse / Multibunch

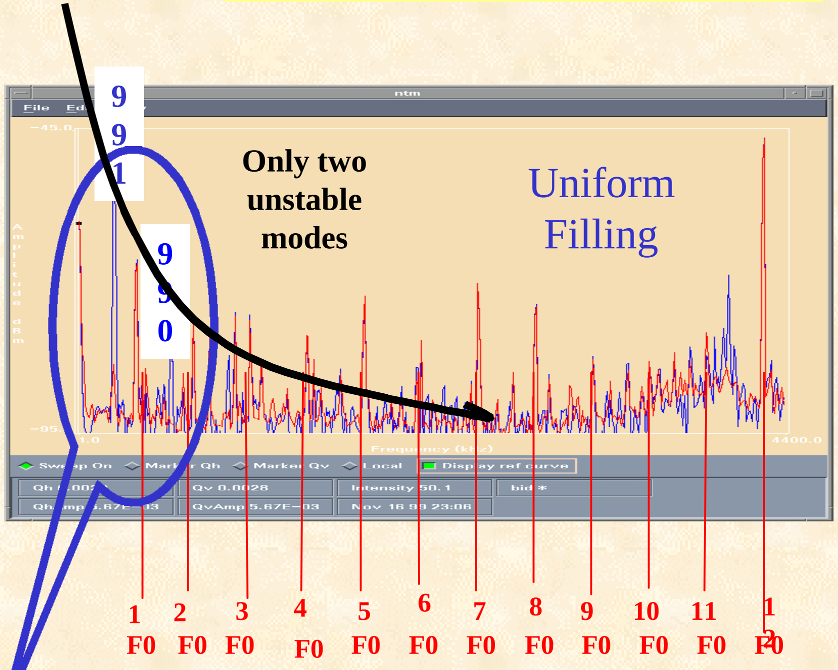


Observation in uniform filling

Transverse / Multibunch

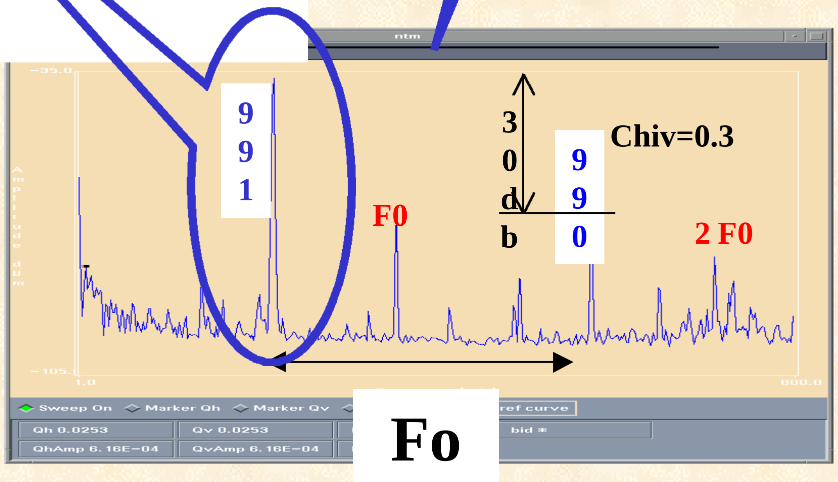
Mode 991



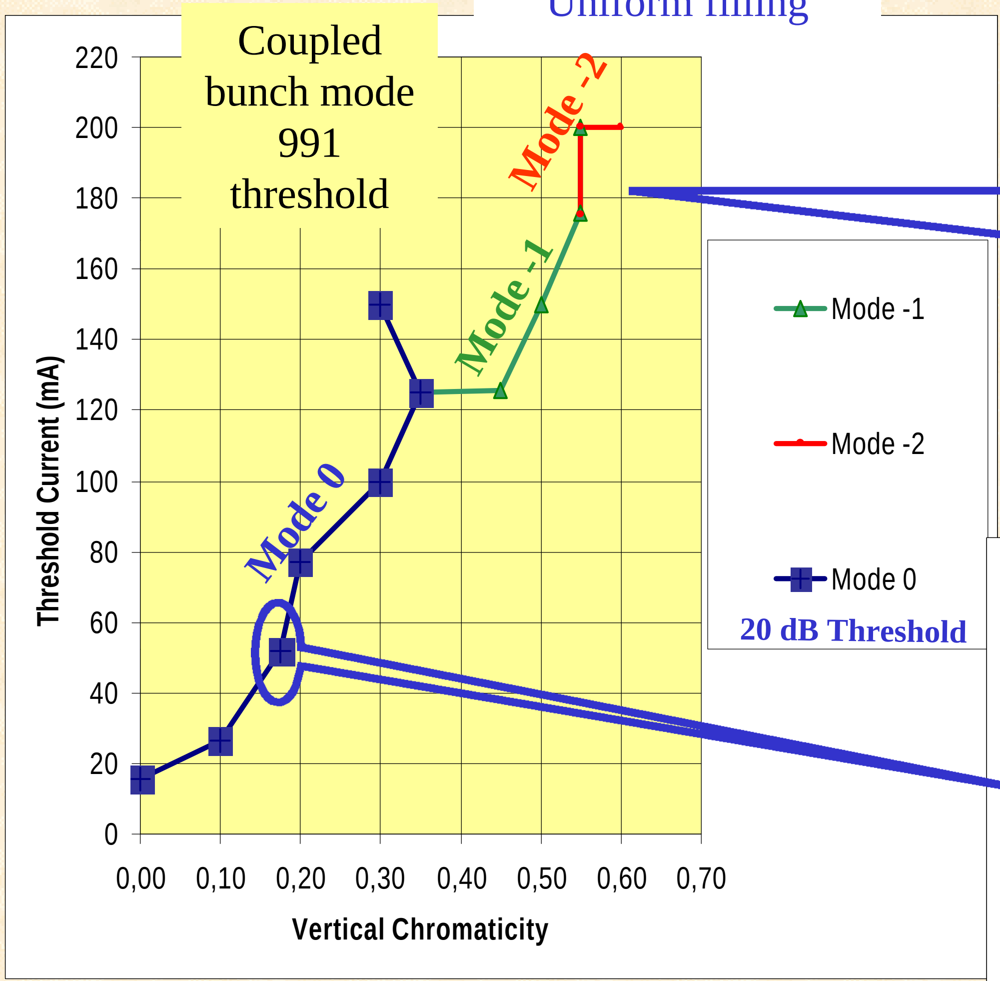


Chromaticity

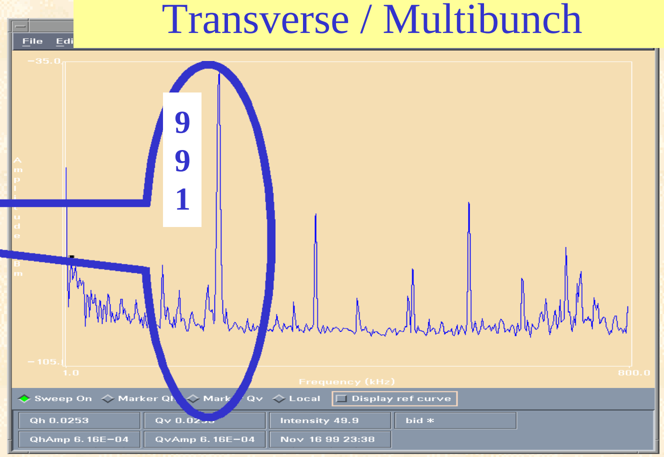
0.3

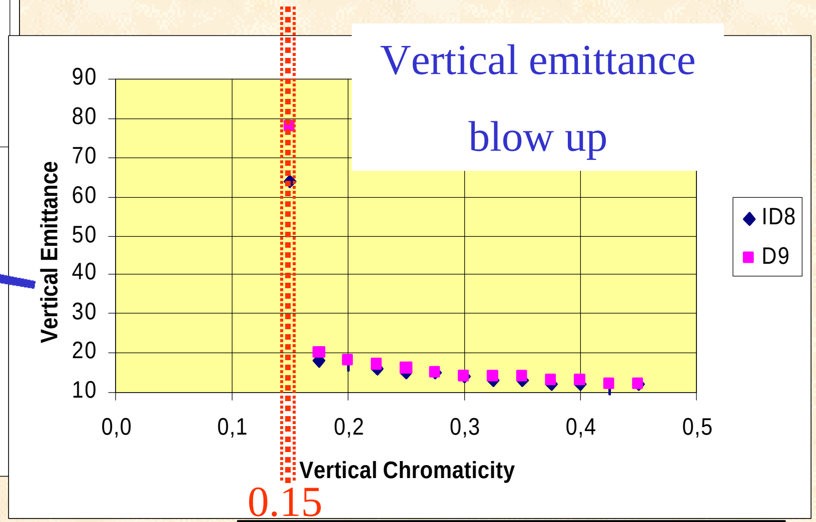


Uniform filling



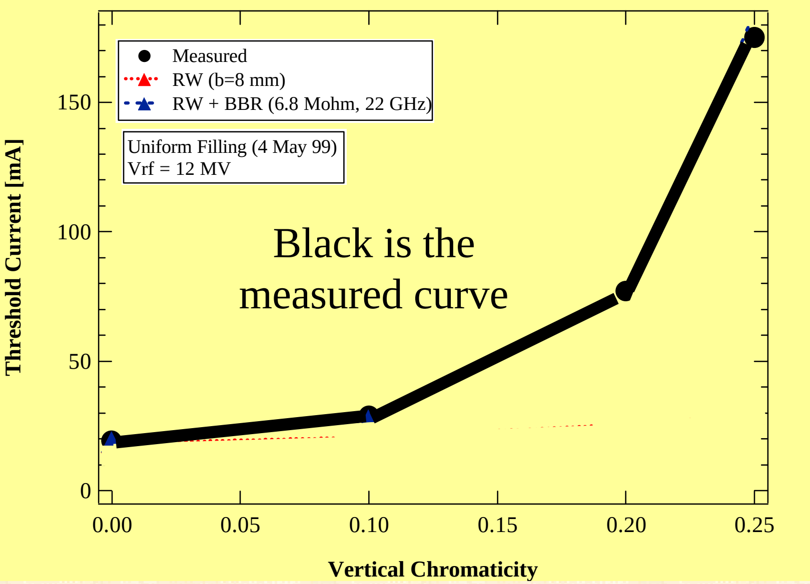
Transverse / Multibunch





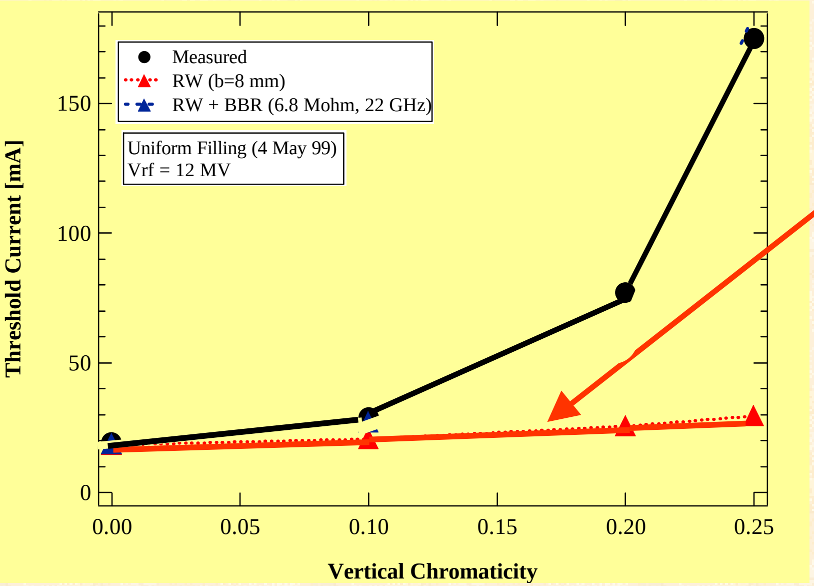
multi: n = 991 I= 50 mA
==> *single : m=0*

In uniform filling, RW is a rather smooth instability, what is the criteria for the threshold ???


Measured
RW (b=8 mm)
RW + BBR (6.8 Mohm, 22 GHz)
Uniform Filling (4 May 99)
Vrf = 12 MV
Black is the measured curve
Threshold Current [mA]
Vertical Chromaticity
0
50
100
150
0.00
0.05
0.10
0.15
0.20
0.25

Fit of the threshold curve of **mode 991** in uniform filling

==> simulation of the interaction of the beam spectrum with an impedance



Resistive wall only, largely underestimates the threshold curve

Fit of the threshold curve of **mode 991** in uniform filling

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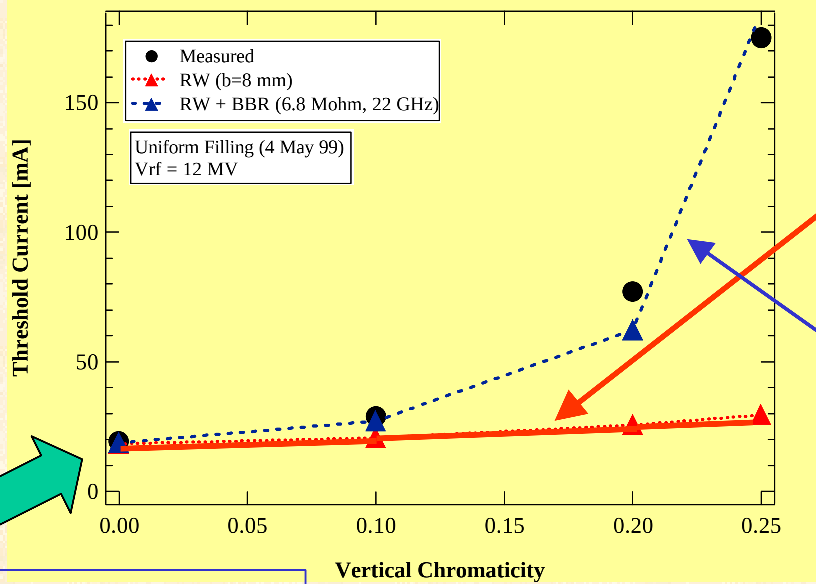


Resistive wall only, largely underestimates the threshold curve

The addition of a broadband contribution helps to <u>increase the threshold</u> which gives more damping with the increased chromaticity

The threshold at zero chromaticity is not sensitive to BBR.
⇒ ***b* = 8 mm** is deduced.
Good agreement with beff = 7.3 mm from the evaluation of resistive wall components from the low gap ID vessels

Keeping f_{res} to 22 GHz

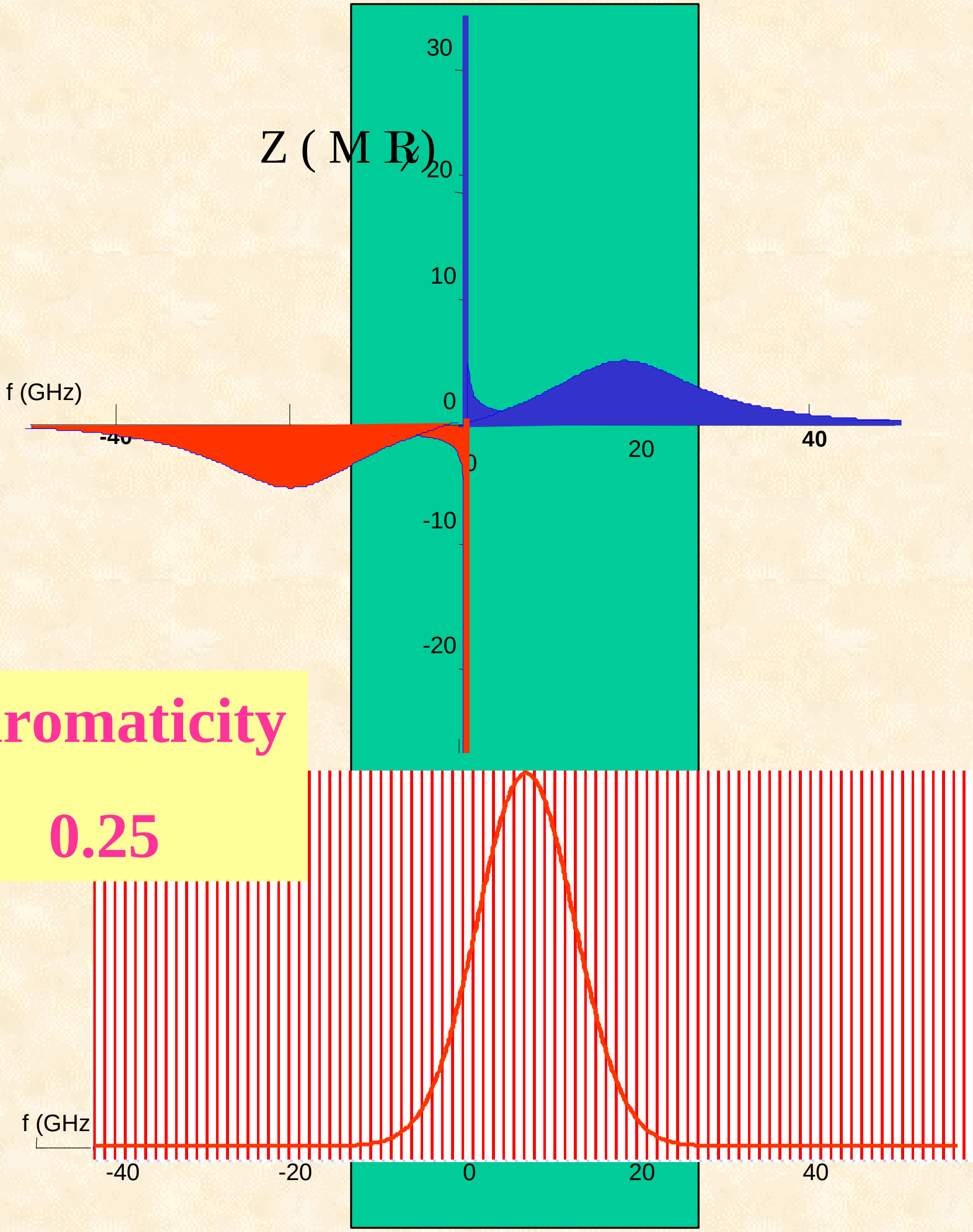
==> R®/Q = 6.8 MΩ

is needed for the fit

Which is also in favour of reducing the shunt impedance obtained with the mode merging

The obtained combination of BBR+RW

applied to mode-merging calculation gives a rather good reproduction



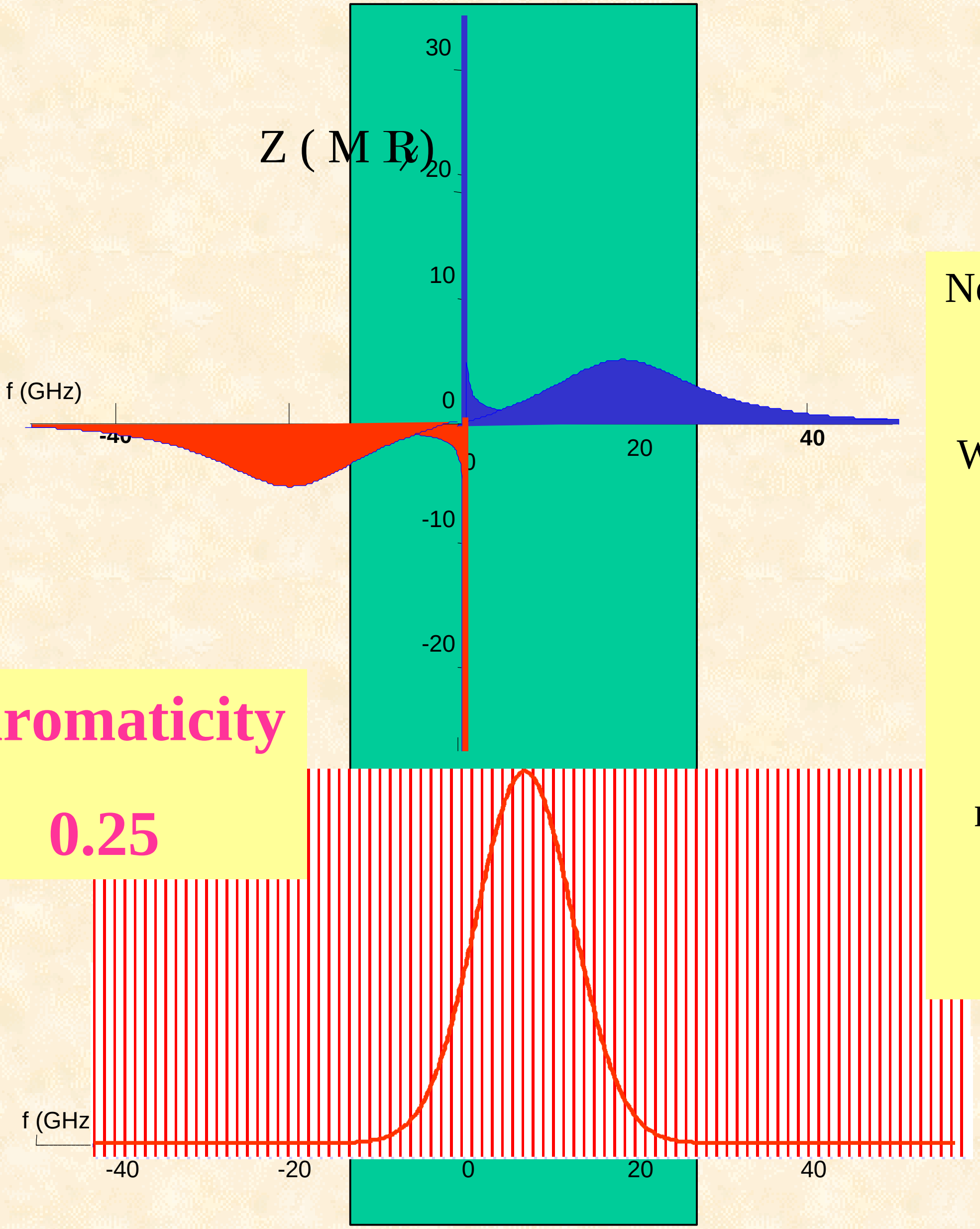
Chromaticity

0.25

Broadband impedance

strongly helps

stabilize the narrow band
resistive wall impedance



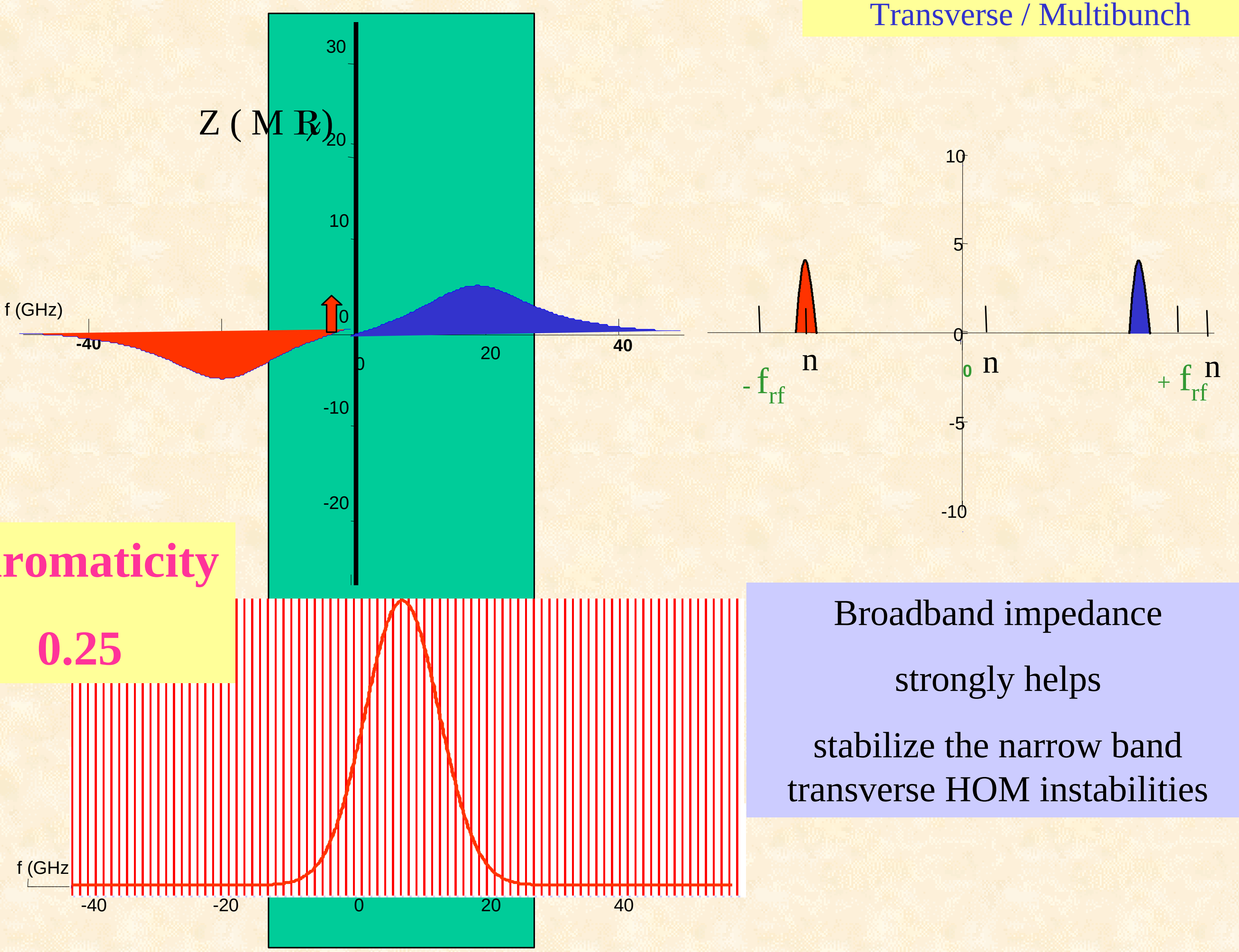
Chromaticity

0.25

No sign of transverse HOM induced by the cavity at ESRF.
(Narrow band impedance)

What is the mechanism to cure transverse HOM?

In 97 the installation of a
new pair of cavities
modified
neither the SINGLE BUNCH dynamics
nor
the MULTIBUNCH TRANSVERSE
dynamics



Chromaticity

0.25

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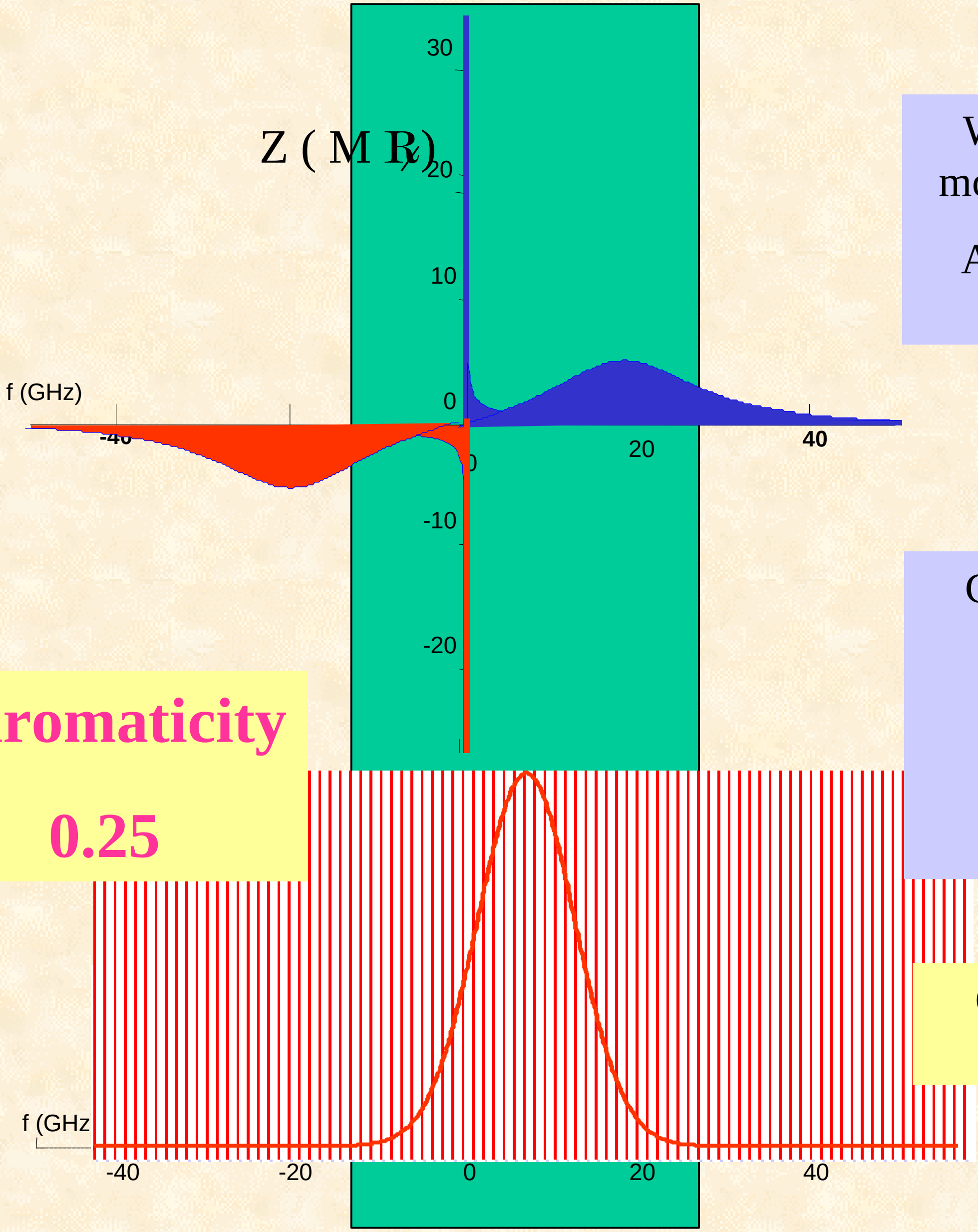


What is the status between impedance modeling and measurement with beam??

At ESRF a new modeling campaign is underway

Chromaticity is a very efficient tool to cure transverse instabilities.

Nevertheless, the impact is strong on the LIFETIME

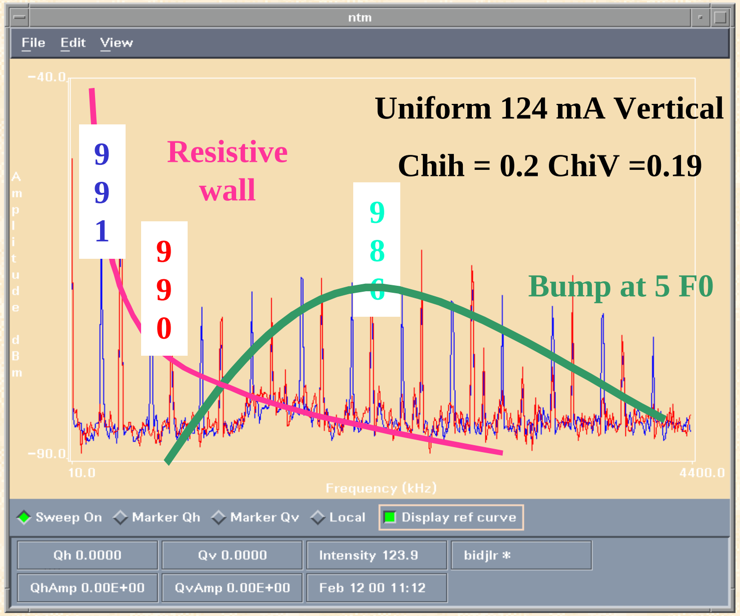
mainly for single bunch.

Chromaticity

0.25

Other transverse impedance effects at ESRF ???

Transverse / Multibunch



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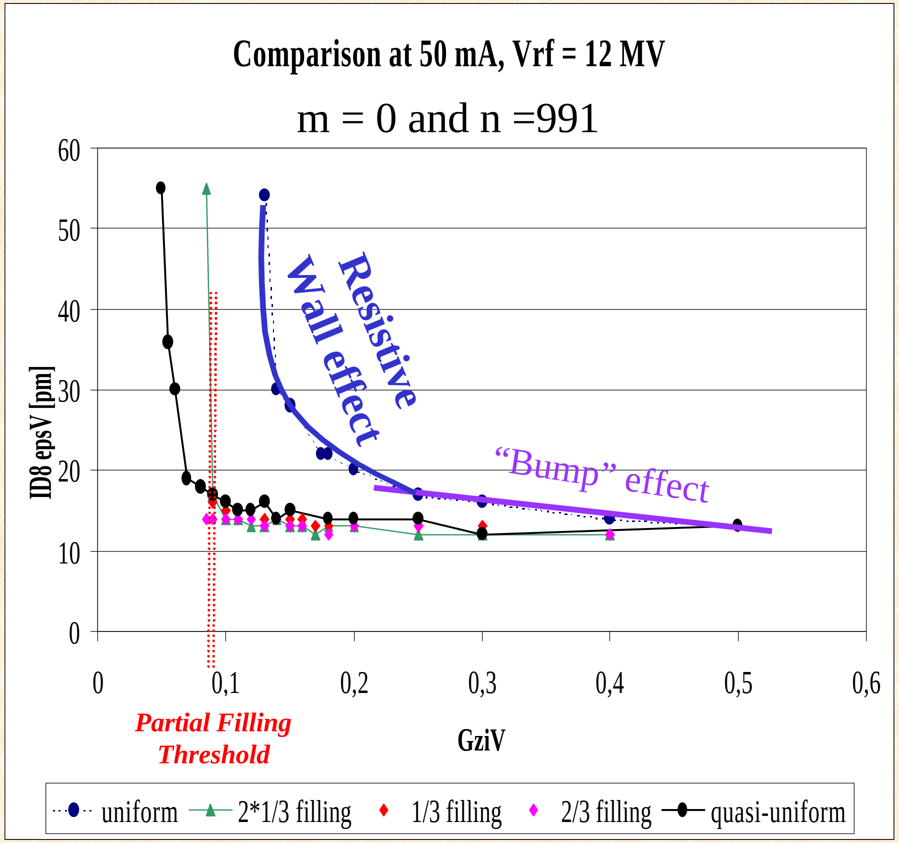
Other transverse impedance effects at ESRF ???



Experiments performed showed a

STRONG STABILIZING EFFECT

OF

PARTIAL FILLING OF THE RING

ON THE RESISTIVE WALL INSTABILITIES

* *and also of the "bump"*

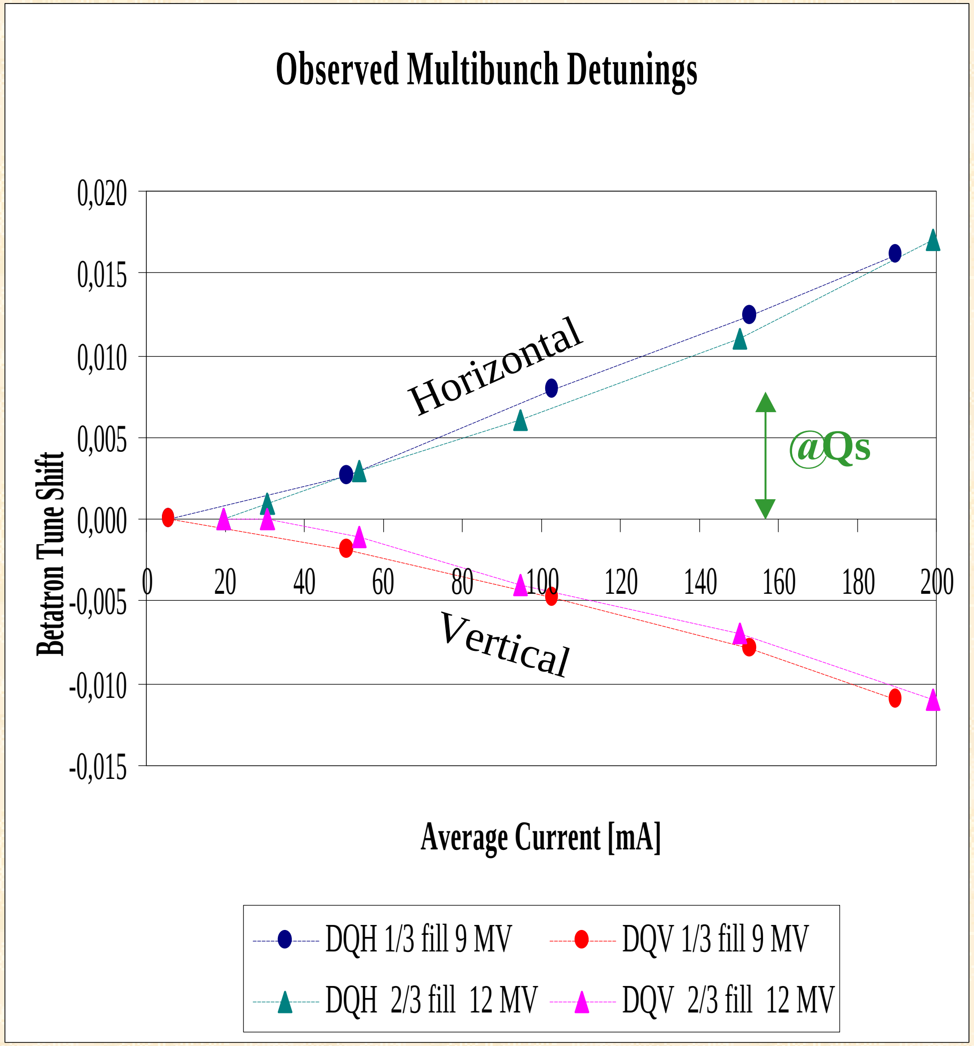
Even a quasi uniform filling was more stable

50 mA Multibunch

Is stabilization coming from longitudinal?

In uniform, the use of the RF modulation for longitudinal Landau damping

did not change the threshold



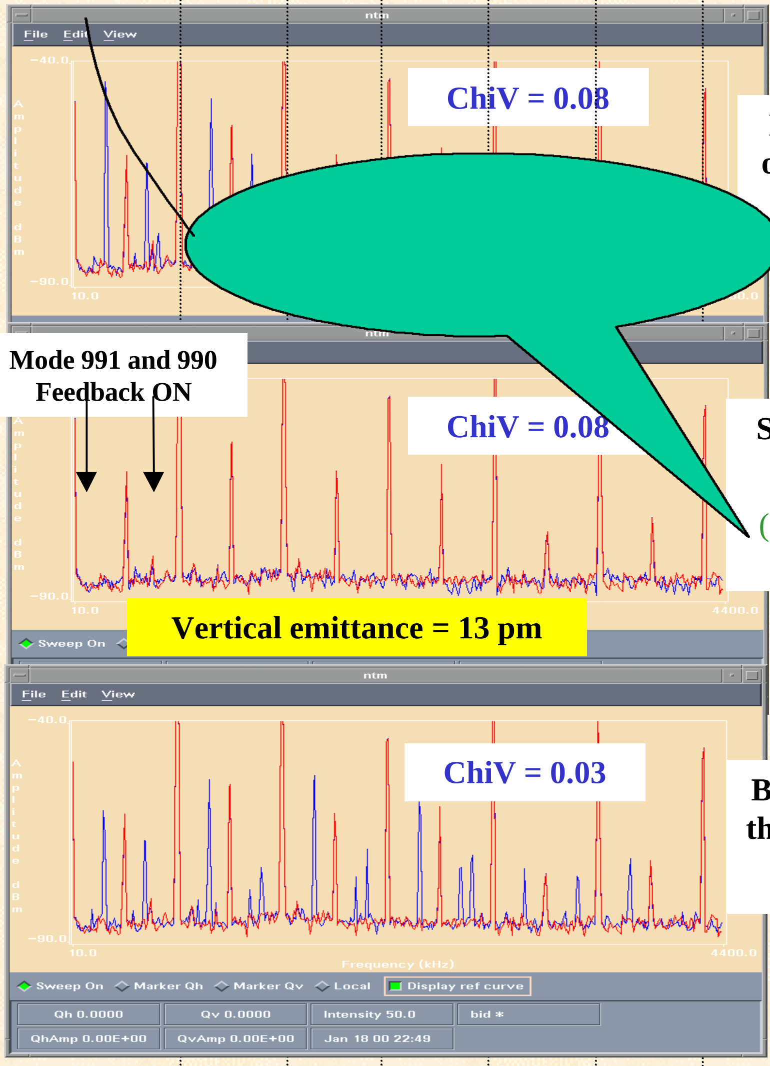
Large incoherent betatron tune shifts observed are suspected of coming from an ASYMMETRY of resistive wall chamber cross sections.

Is stabilisation due to an intra-beam tune spread arising from the current dependent tune shift resulting from the differently populated bunches ??

Quantification of this effect is on the way

(R. Nagaoka et al).

Partial filling pattern 2*1/3



Brutal apparition of the instability at 0.08

Stabilization of all the lines by a 2 modes feedback

(additional lines are induced by the filling pattern)

Brutal apparition of the instability at 0.03

(Feedback ON)

2 F0 **12 F0**

I = 50 mA

200 mA

could be reached in 2*1/3

with a chromaticity of 0.08

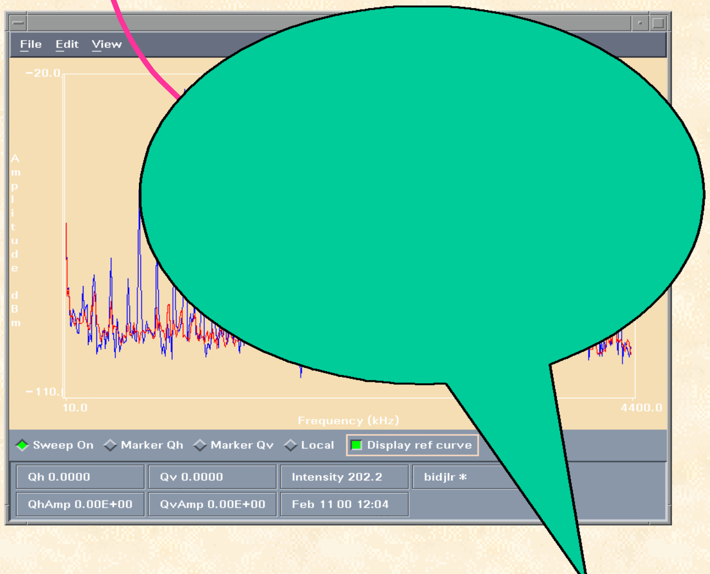
instead of 0.4 *(operation)*

and with a low emittance of 14 pm

(at 0,07, the beam exploded)

@ Feedback in 1/3 did not work.

200 mA in uniform
at x V = 0.1 ***instead of 0.5***



But still a lot of lines to stabilize to reach the low emittance !!

Coming from the 5 f_0 bump??

200 mA

could be reached in 2*1/3

with a chromaticity of 0.08

instead of 0.4 *(operation)*

and with a low emittance of 14 pm

(at 0,07, the beam exploded)

@ Feedback in 1/3 did not work.

How many modes should we feedback ??

To get low emittance.

Is it achievable with a bunch by bunch feedback??

Transverse / Single bunch

Transverse / Multibunch

Single bunch transverse feedback

is working on mode merging at ESRF

Feedback allows to increase the current by a factor 5 !!

==> **0.7 * 5 = 3.5 mA !!!!**

With Empirical setting of the feedback parameters (most probably resistive)

But in single bunch,

this performance is not competitive

with the chromaticity

17 mA at 0.9

(and bunch lengthening)

200 mA

could be reached in 2*1/3

with a chromaticity of 0.08

instead of 0.4 *(operation)*

and with a low emittance of 14 pm

(at 0,07, the beam exploded)

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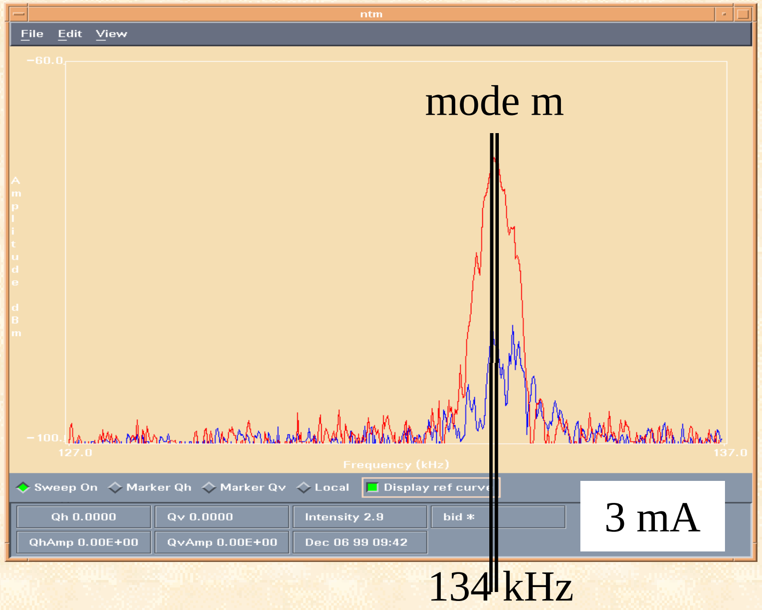

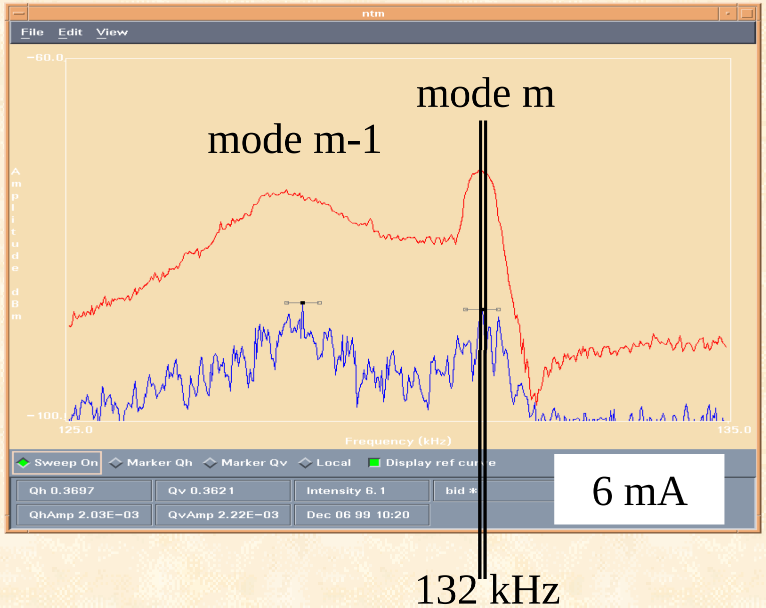

Feedback in single bunch at higher chromaticity

At 3 mA:

Without feedback, strong instability at ×v = 0.3 which could be damped by the feedback

6 mA:

Could be reached with feedback, at ×v = 0.3 ***(instead of 0.5 without)***

Then we get two strong unstable modes which could not be damped independently

(empirical setting of the phase to optimize the damping of both)

Feedback is less and less efficient with increased chromaticity

and the emittance is strongly affected

A feedback acting independently on two single bunch modes is under design

WG1

Conclusion

WG2

Why is the ESRF longitudinal turbulent regime stable?

What are the experimental methods to probe the machine impedance?

What is the comparison between experimental model and simulation?

How far, RW should be considered in single bunch ?

How far, BBR should be considered in multibunch?

What is the multibunch transverse stabilizing mechanism in partial filling?

What is the single bunch dynamics at high chromaticity?

Could we use an harmonic cavity to increase the single bunch intensity threshold?

What is the limitation of the transverse feedback in single bunch?

How many modes should we consider for a transverse feedback in multibunch?

Is transverse feedback compatible with very low emittances ?

And much more questions will be asked during the working group discussions !!!!