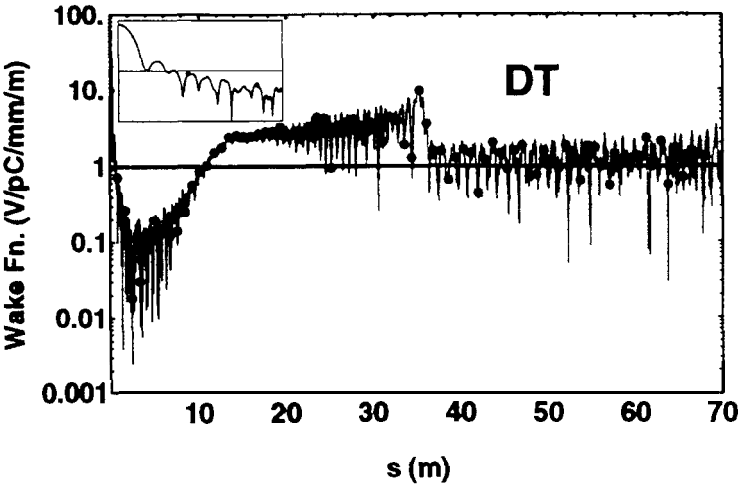
Progress in the RDDS Transverse Wakefields and Avoiding BBU

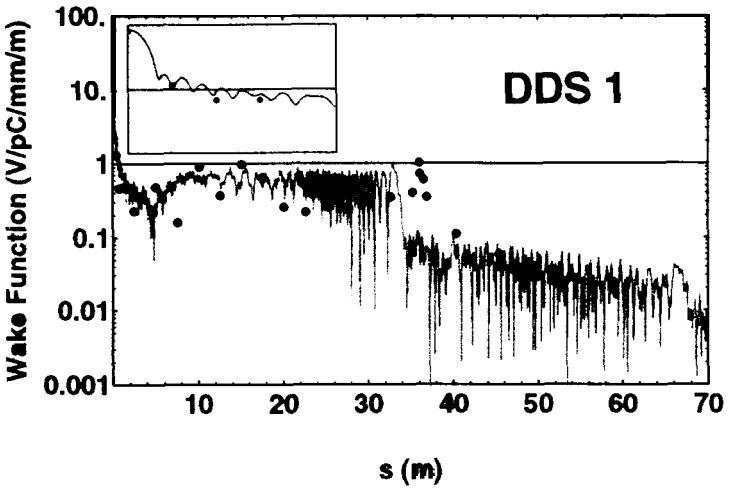
R.M. Jo

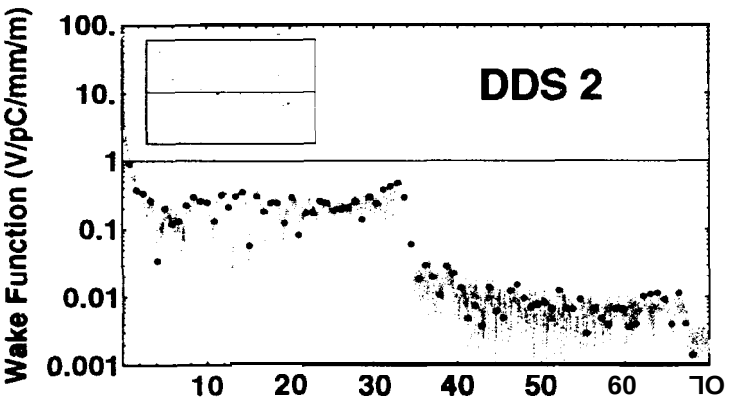
Stanford Linear Accelerator Center

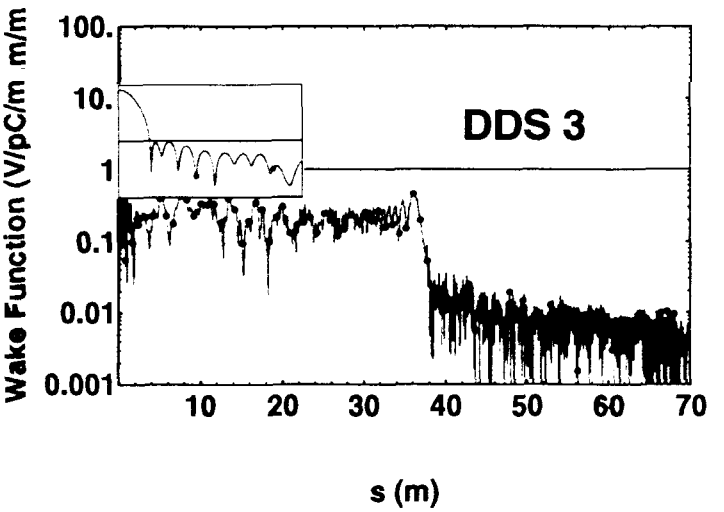
Overview

- In the present structure under fabrication 4 cells are decoupled from the manifold and this leads to an enhanced wakefield. It gives rise to a driven mode in the accelerator which gives rise to BBU.
- One mode that is significant has been controlled by removing and varying bunch spacing.
- Particle tracking simulations also indicate BBU will occur in DDS1.
- Solution: damp last 5-10 cells such that the Q of the modes is approx 1000. Utilize direct damping of the last few cells or ensure that the last few cells are not decoupled by re-design.



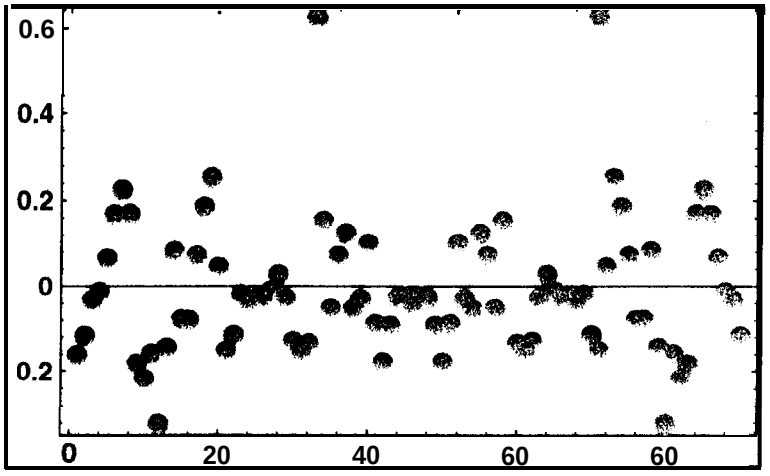


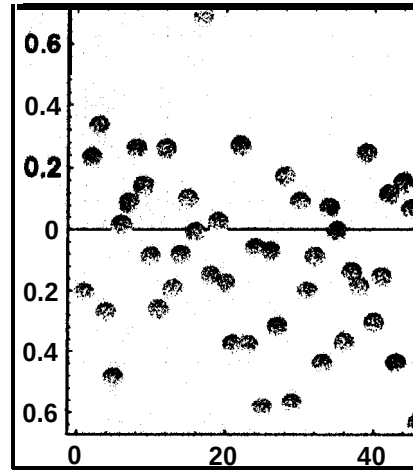


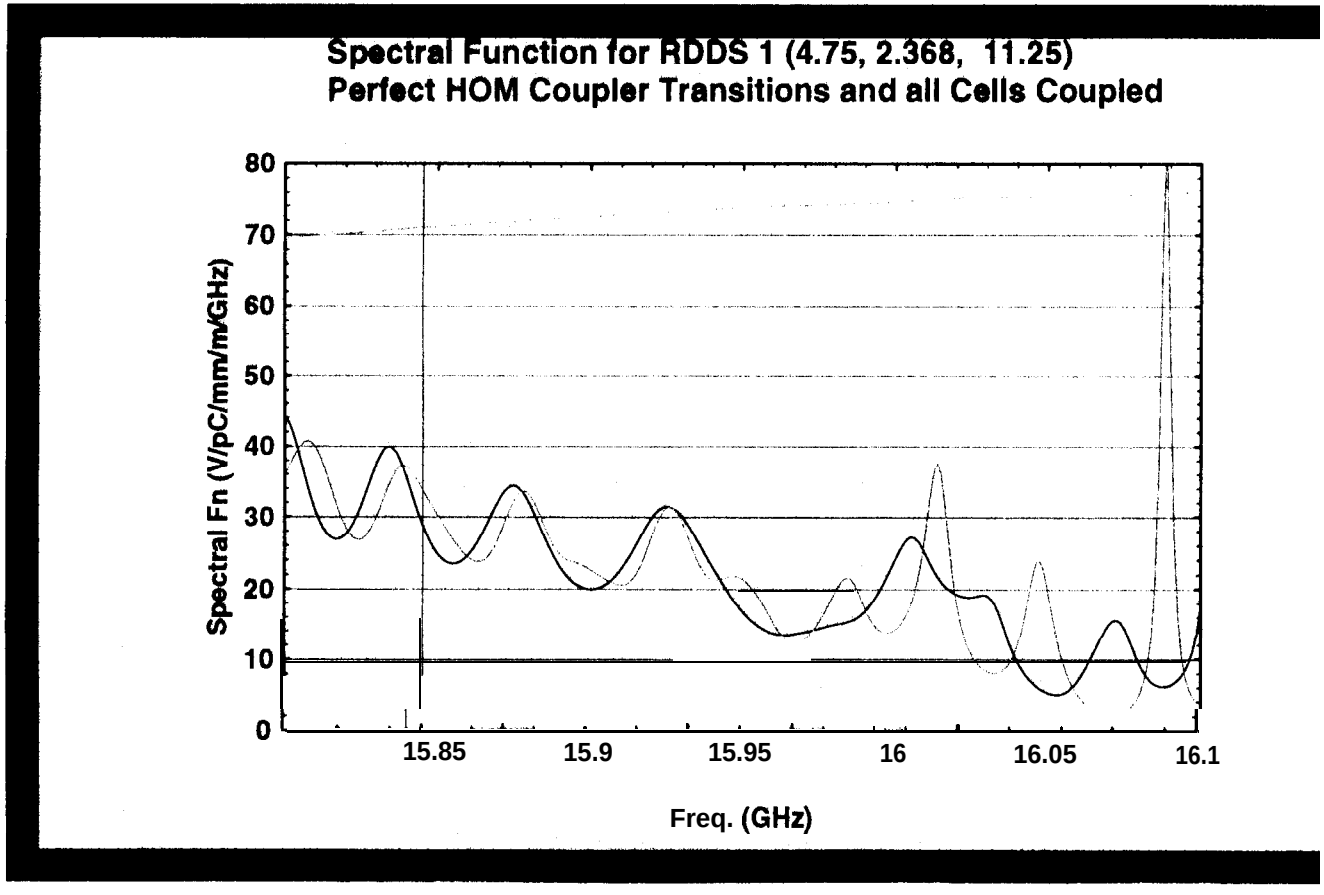


RMJ, NMK, RHM (6-97)

Left: RDDS 1 C. Right DDS1 as in the ASSET exp







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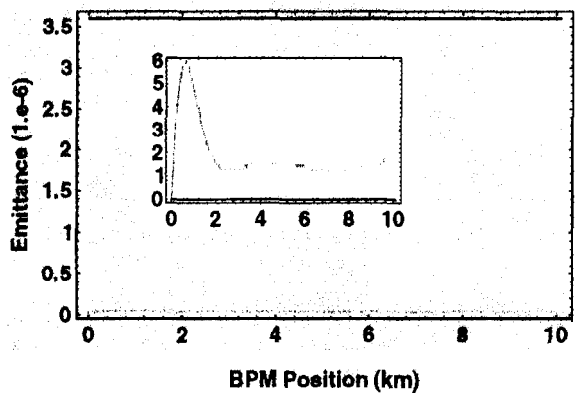
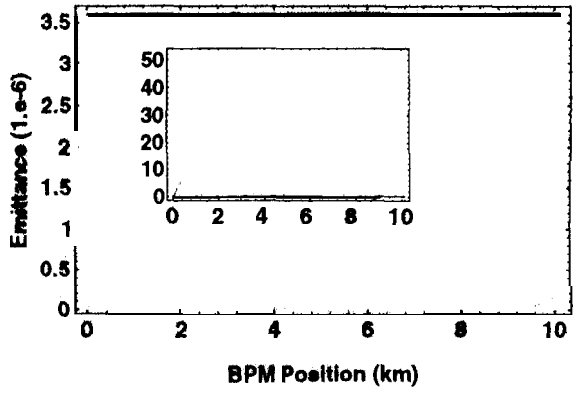
First Damped Detuned Structure, DDS 1.

Normalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: {0.00625, 3.6, 0.04}
Final Emittance: {10.1, 3.6, 0.0407}



Normalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: (0.00625, 3.6, 0.04)
Final Emittance: (10.1, 3.61, 0.0613}



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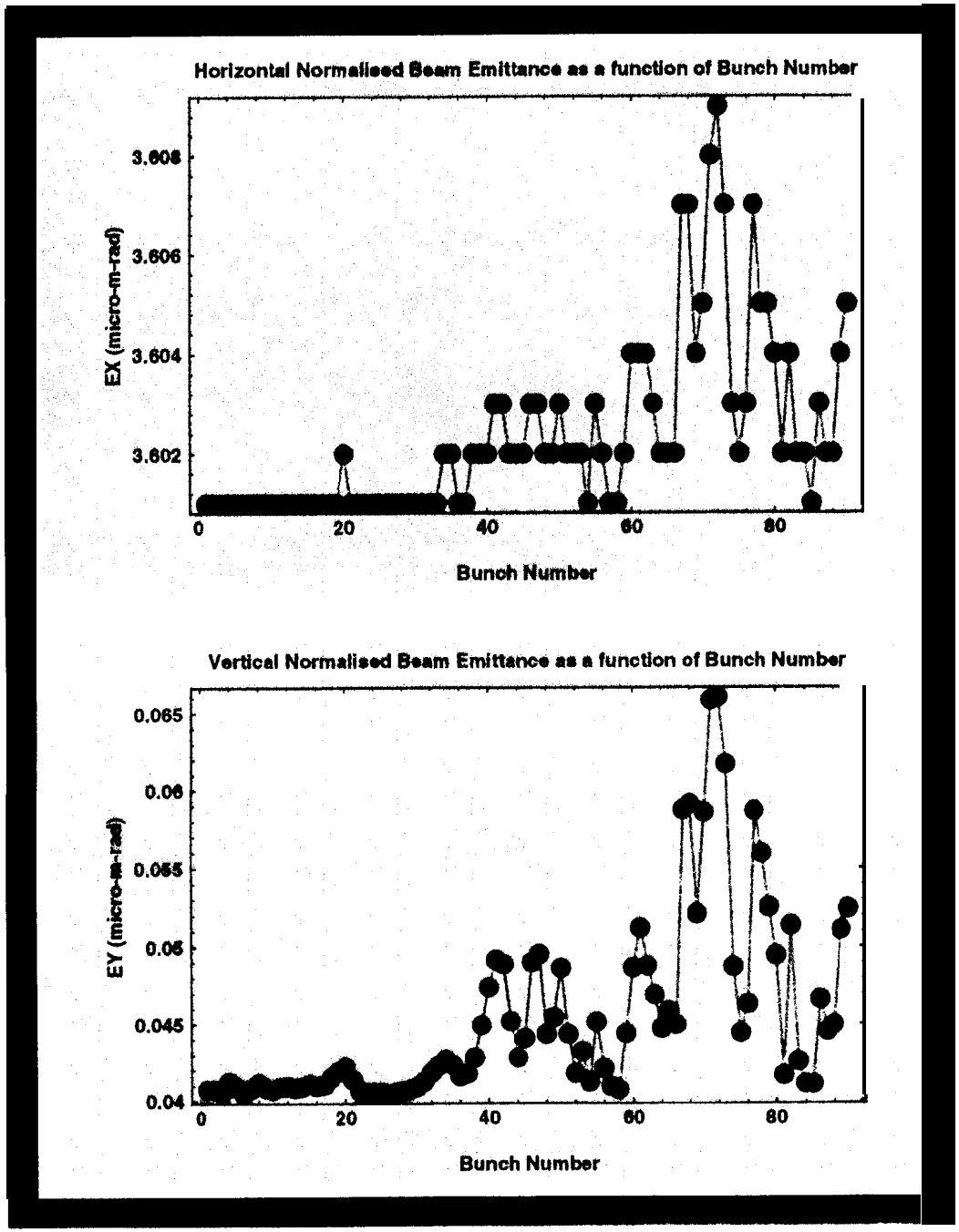

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer(11-98)

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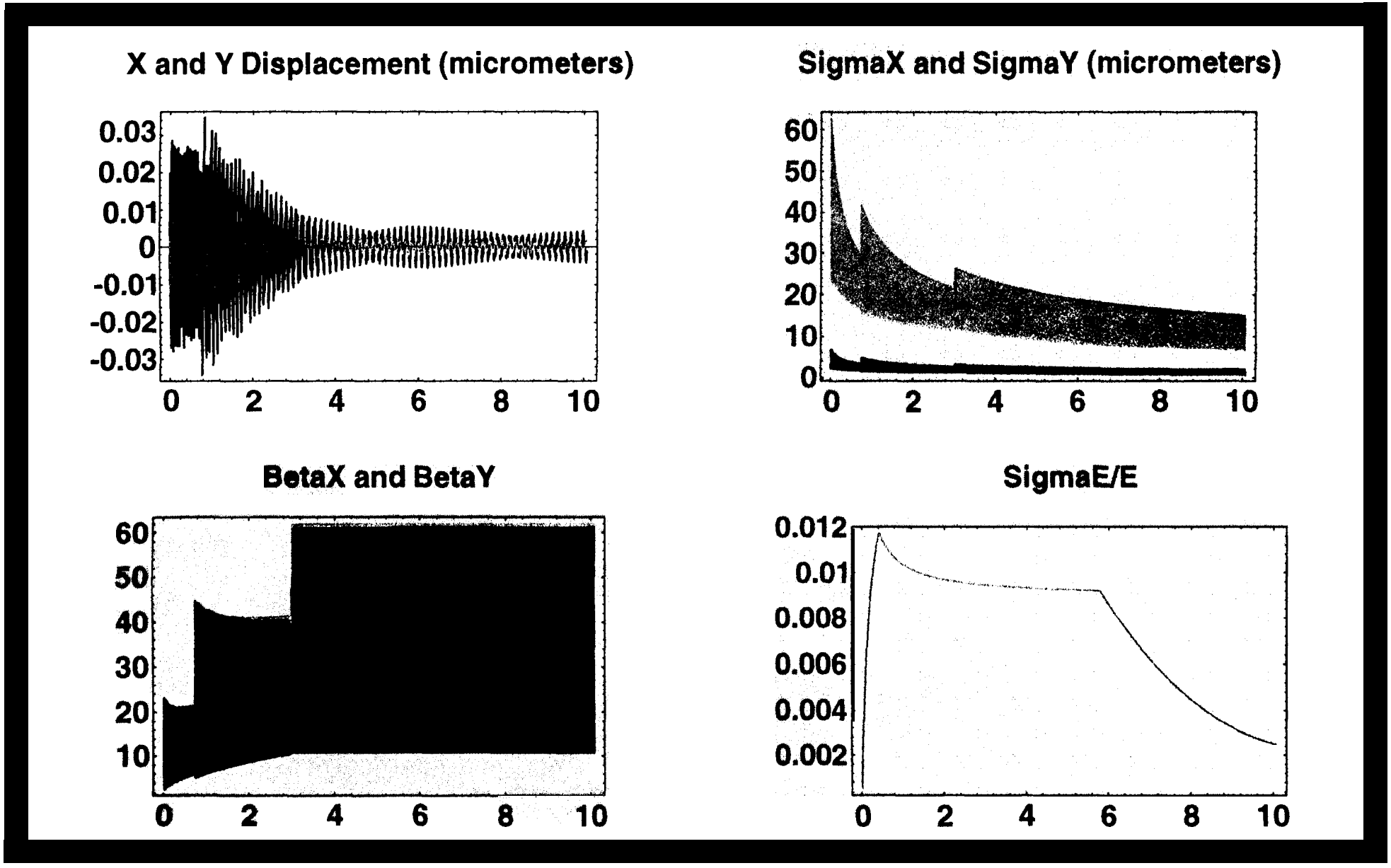

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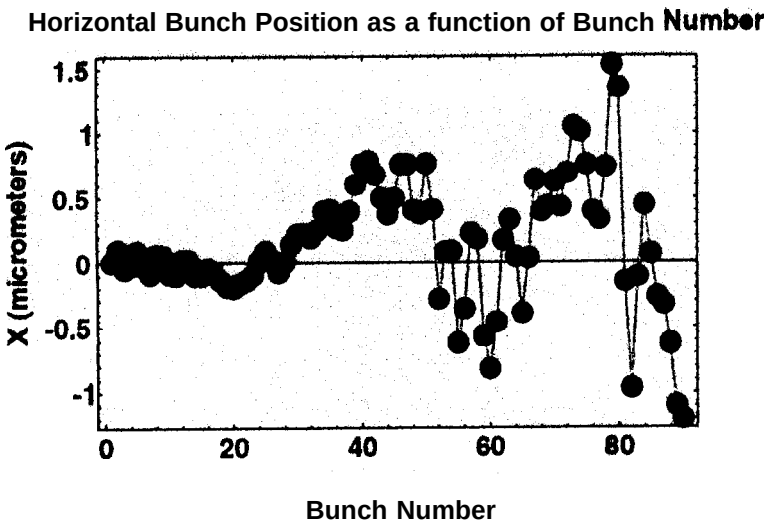

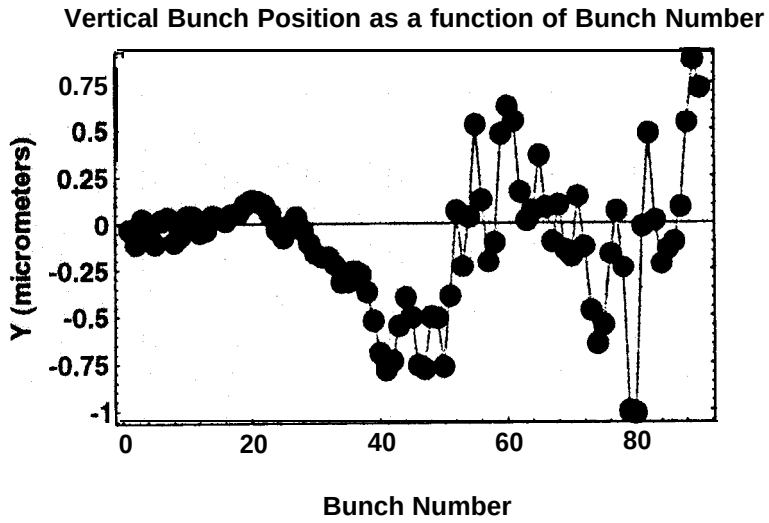

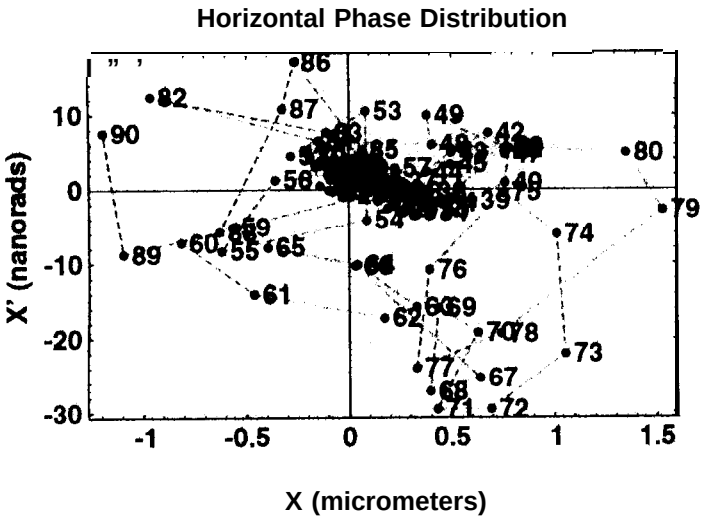

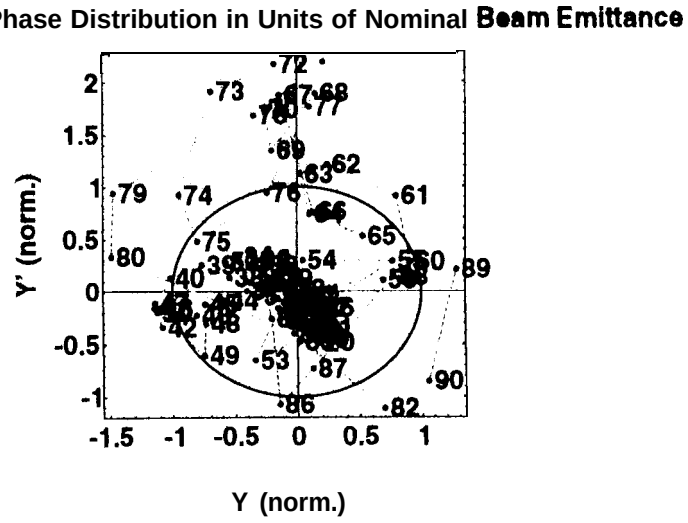

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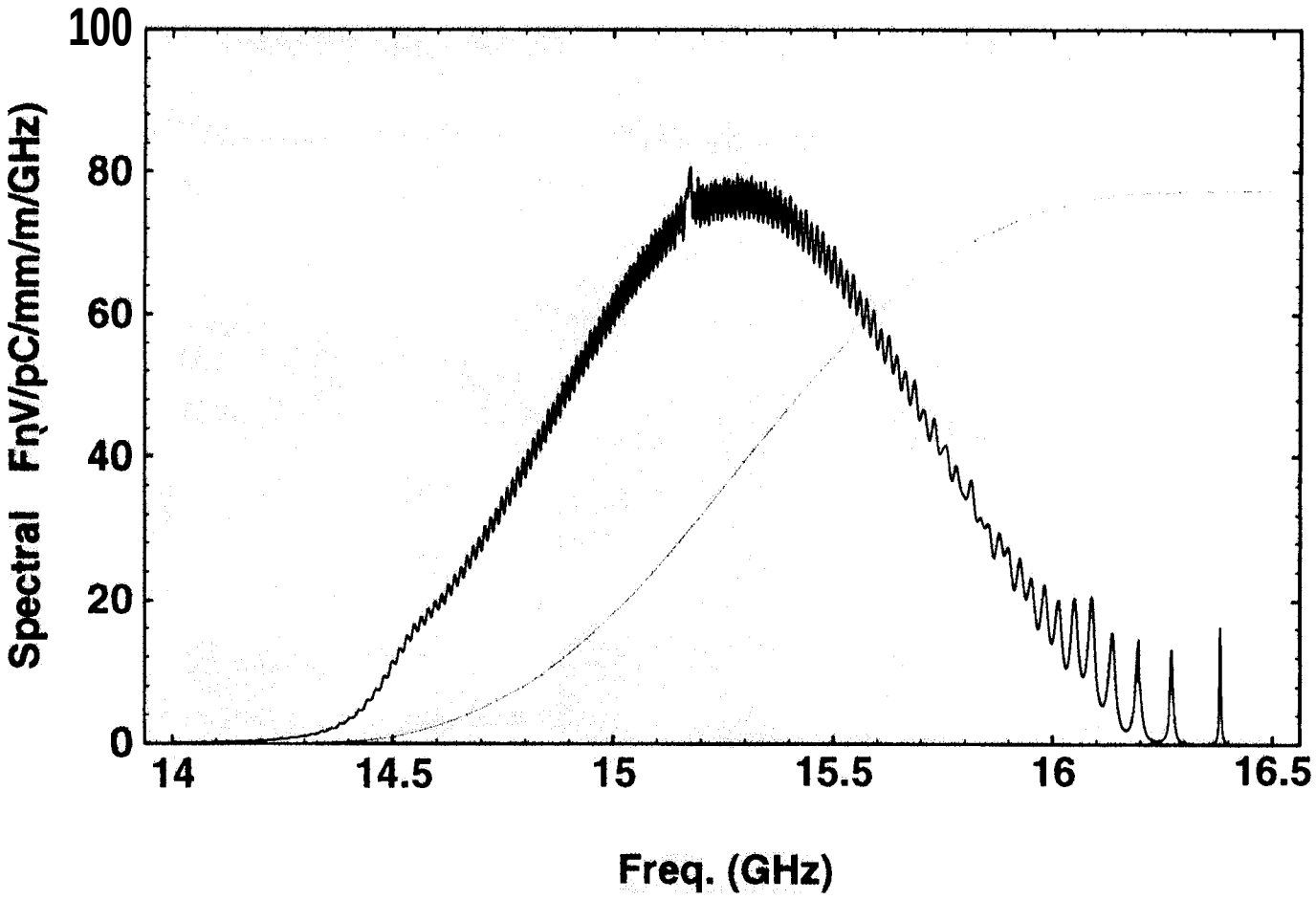
Spectral Function for RDDS 1 (4.75, 2.368, 11.25)
Perfect HOM Coupler Transitions and all Cells Coupled



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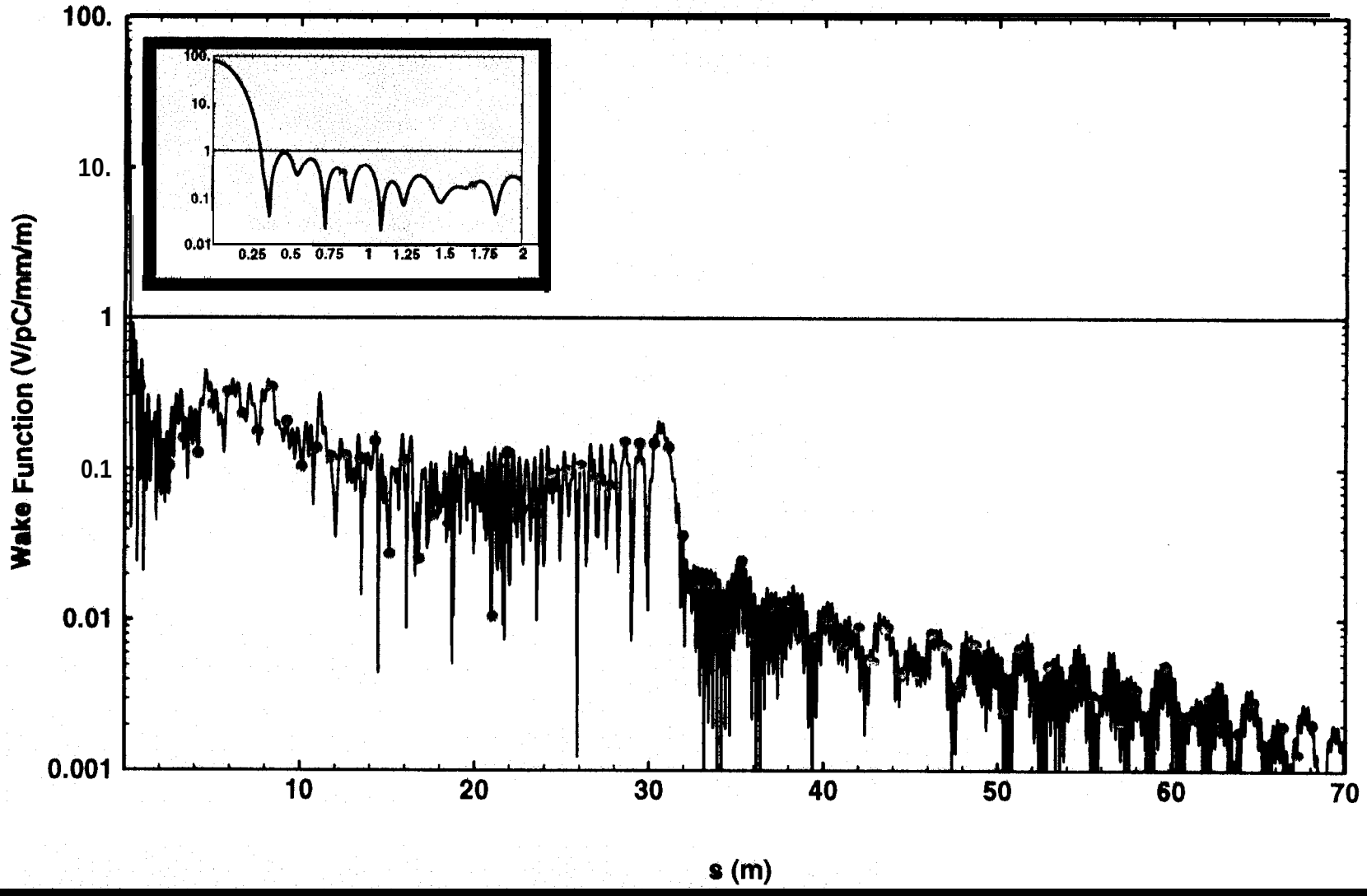
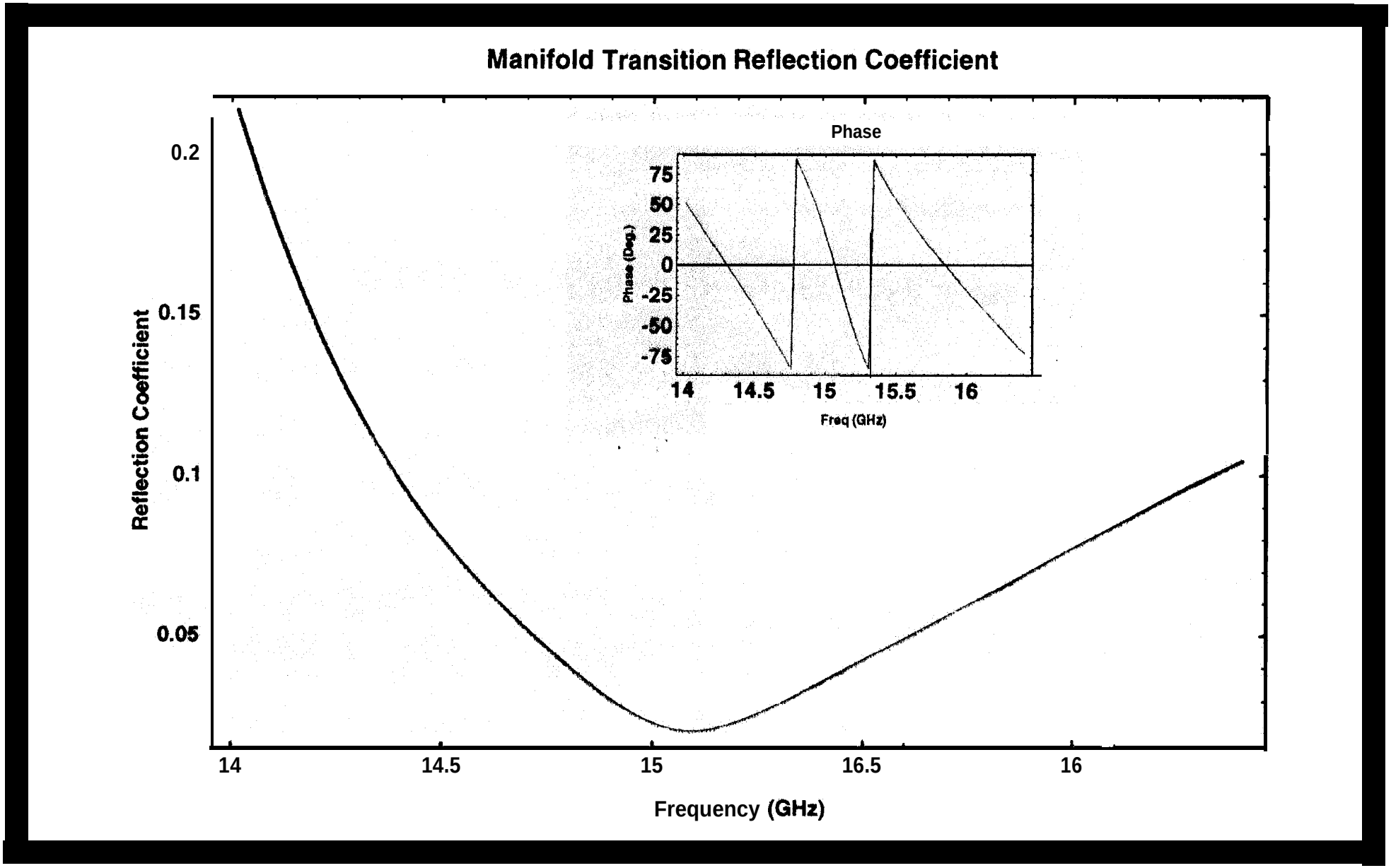
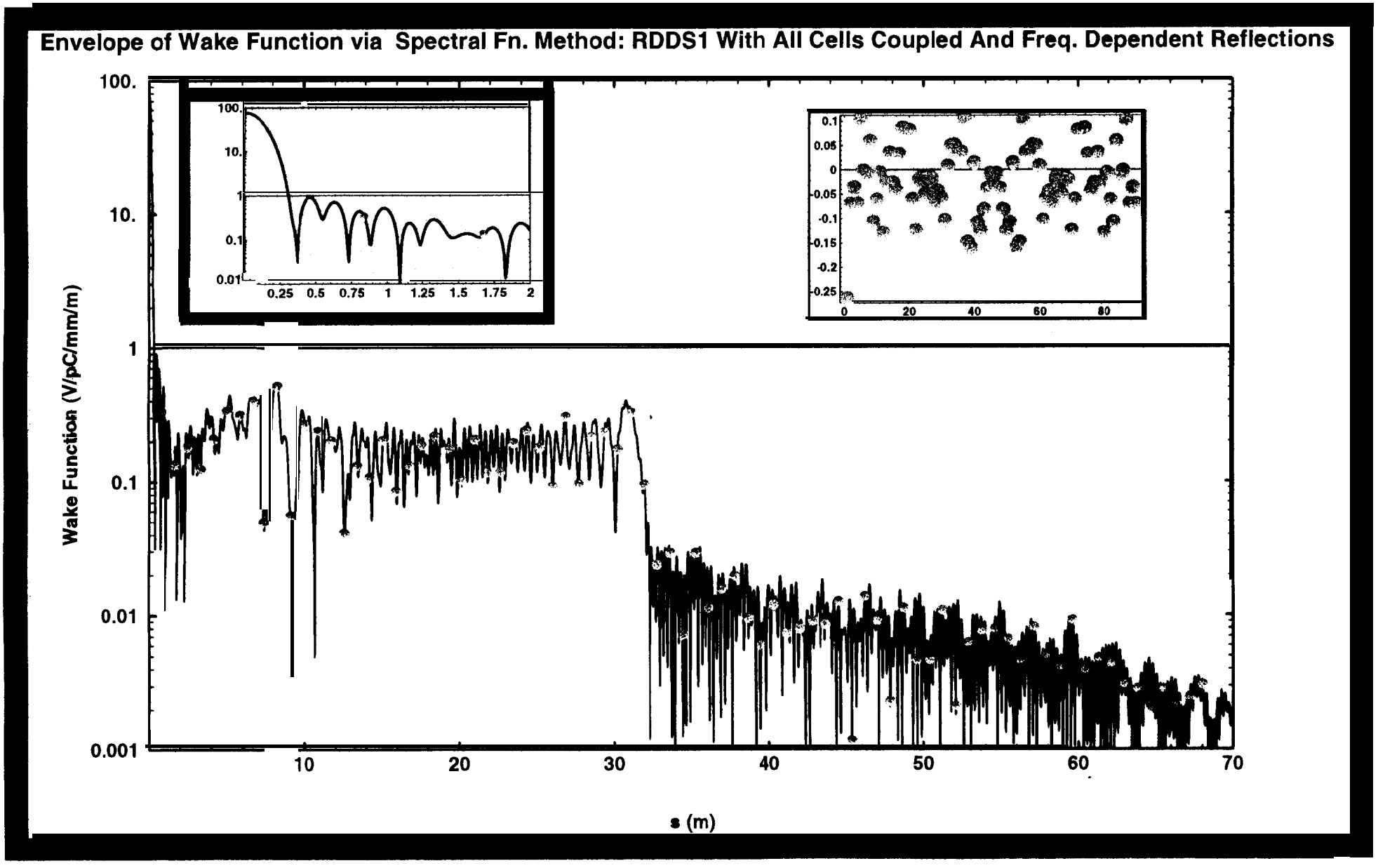
Envelope of Wake Function via Spectral Fn. Method: RDDS Perfect HOM Coupler Termination




Manifold Transition Reflection Coefficient
Reflection Coefficient
0.2
0.15
0.1
0.05
14
14.5
15
16.5
16
Frequency (GHz)
Phase
Phase (Deg.)
75
50
25
0
-25
-50
-75
14
14.5
15
15.5
16
Freq (GHz)

RDDS 1 (C). All cells coupled and a frequency dependent reflection coefficient.



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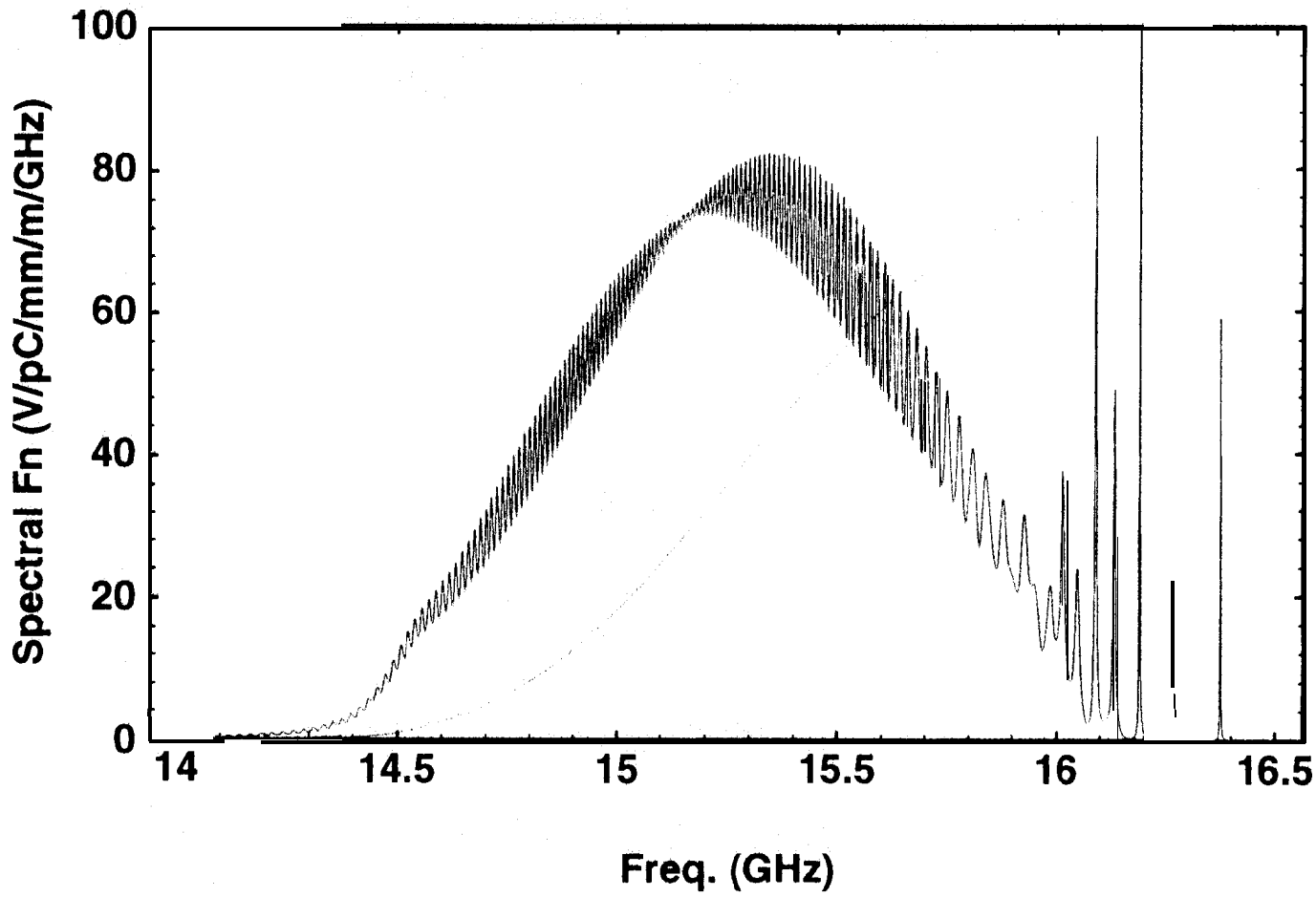
Spectral Function for RDDS 1 (4.75, 2.368, 11.25)
Incl. Ref. Co. of Transition & 4 I/P Cells Decoupled



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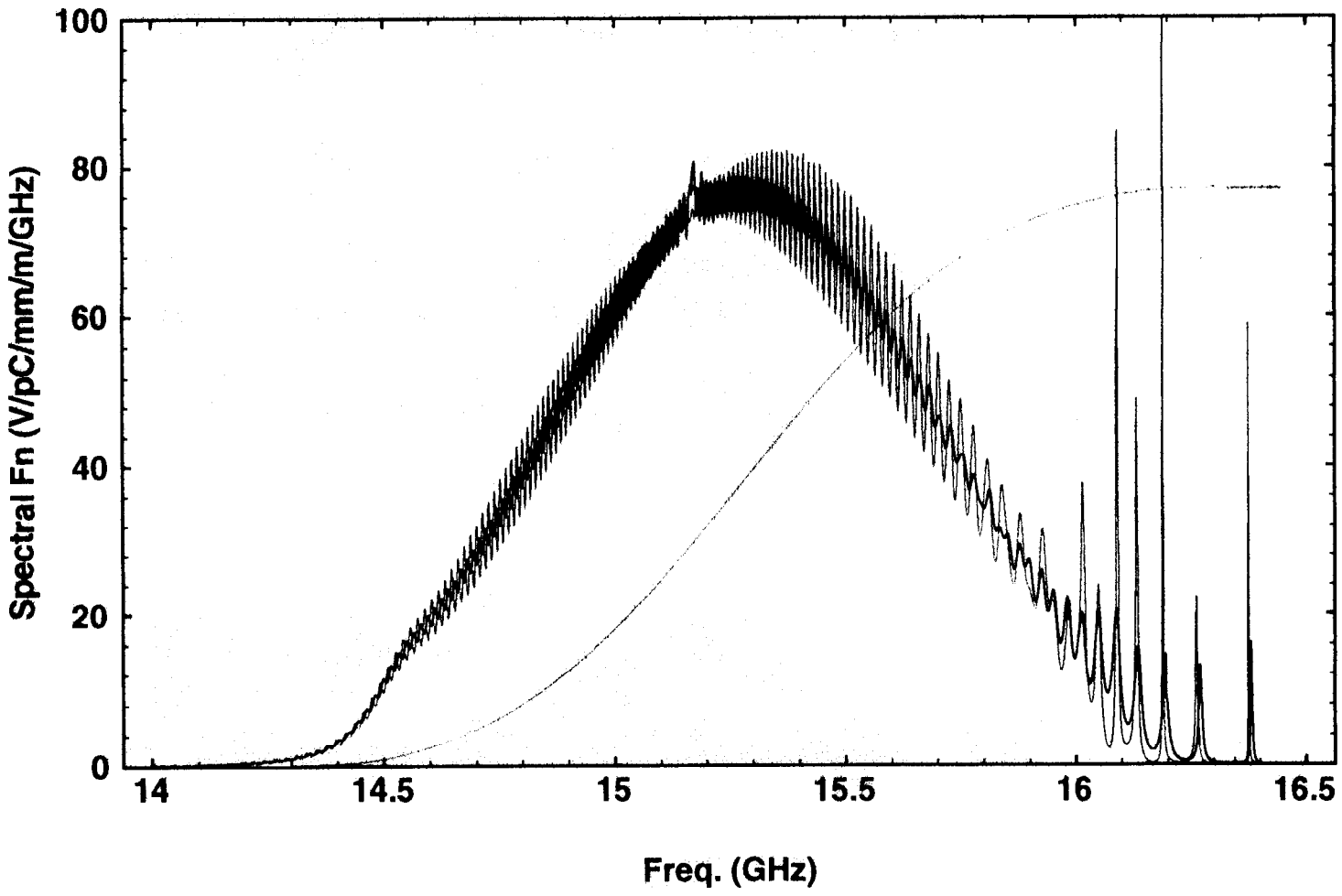
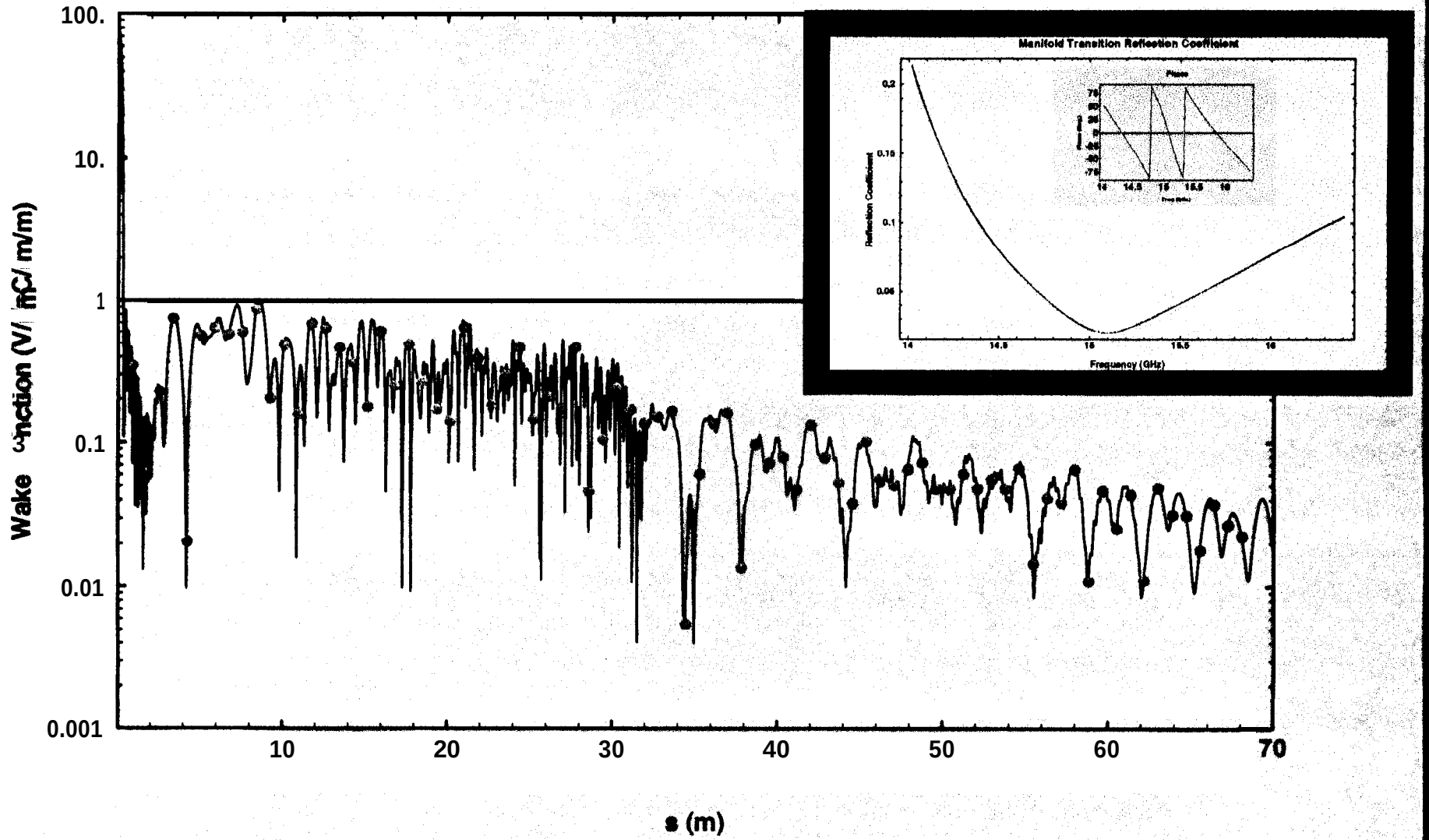
Spectral Function for RDDS 1 (4.75, 2.368, 11.25)
Comparison Between Perfect Case vs. Incl. HOM Coupler Transitions and all Cells Coupled



Envelope of Wake Function via Spectral Fn. Method: RDDS Inc. Ref. Cos and 4 Cells Decoupled



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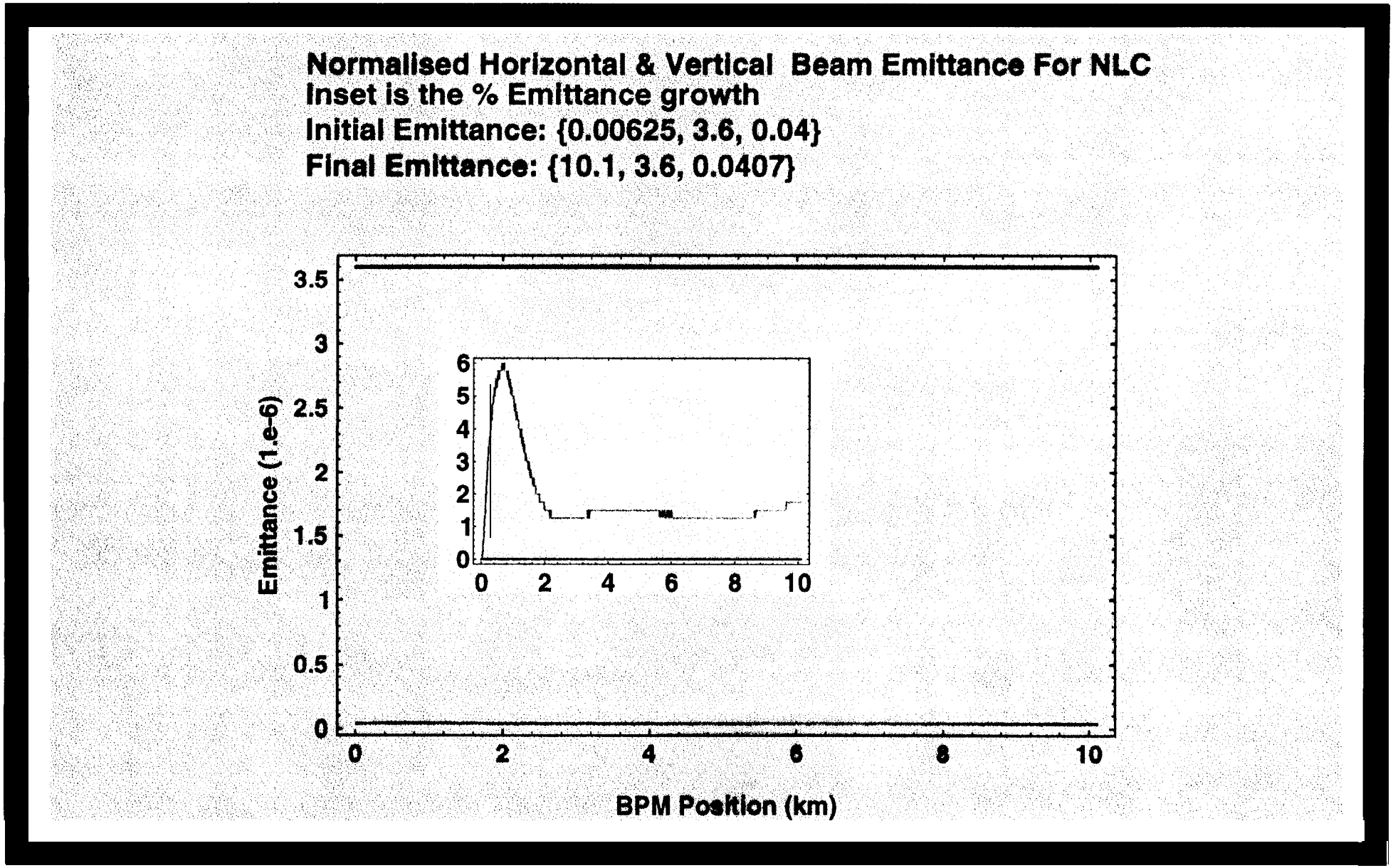
RDDSC 1 4 Cells Decoupled and a frey. dependent HOM coupler reflection coefficients.



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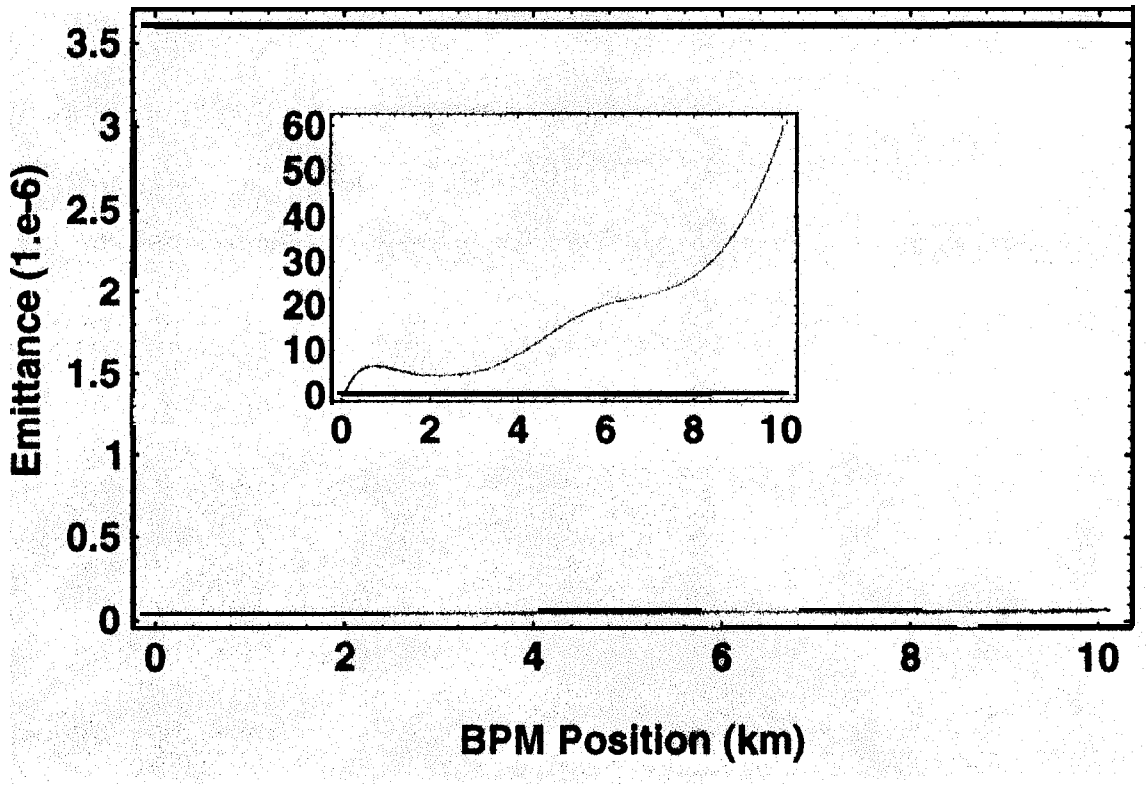
Mormalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: {0.00625, 3.6, 0.04}
Final Emittance: {10.1, 3.61, 0.0644}



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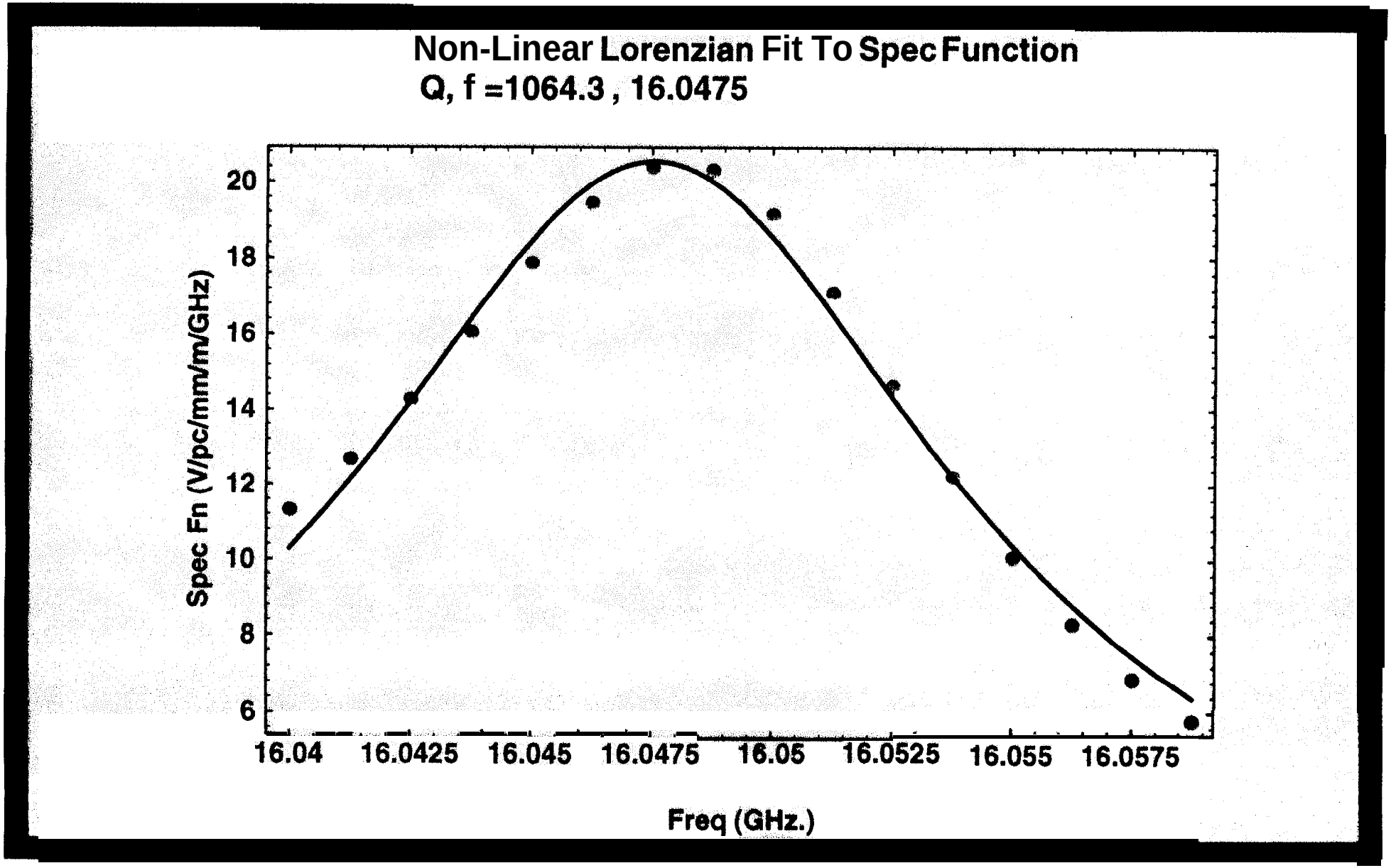

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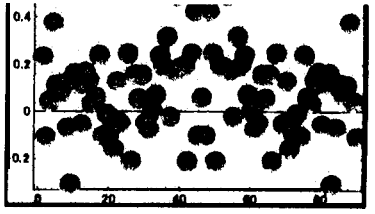
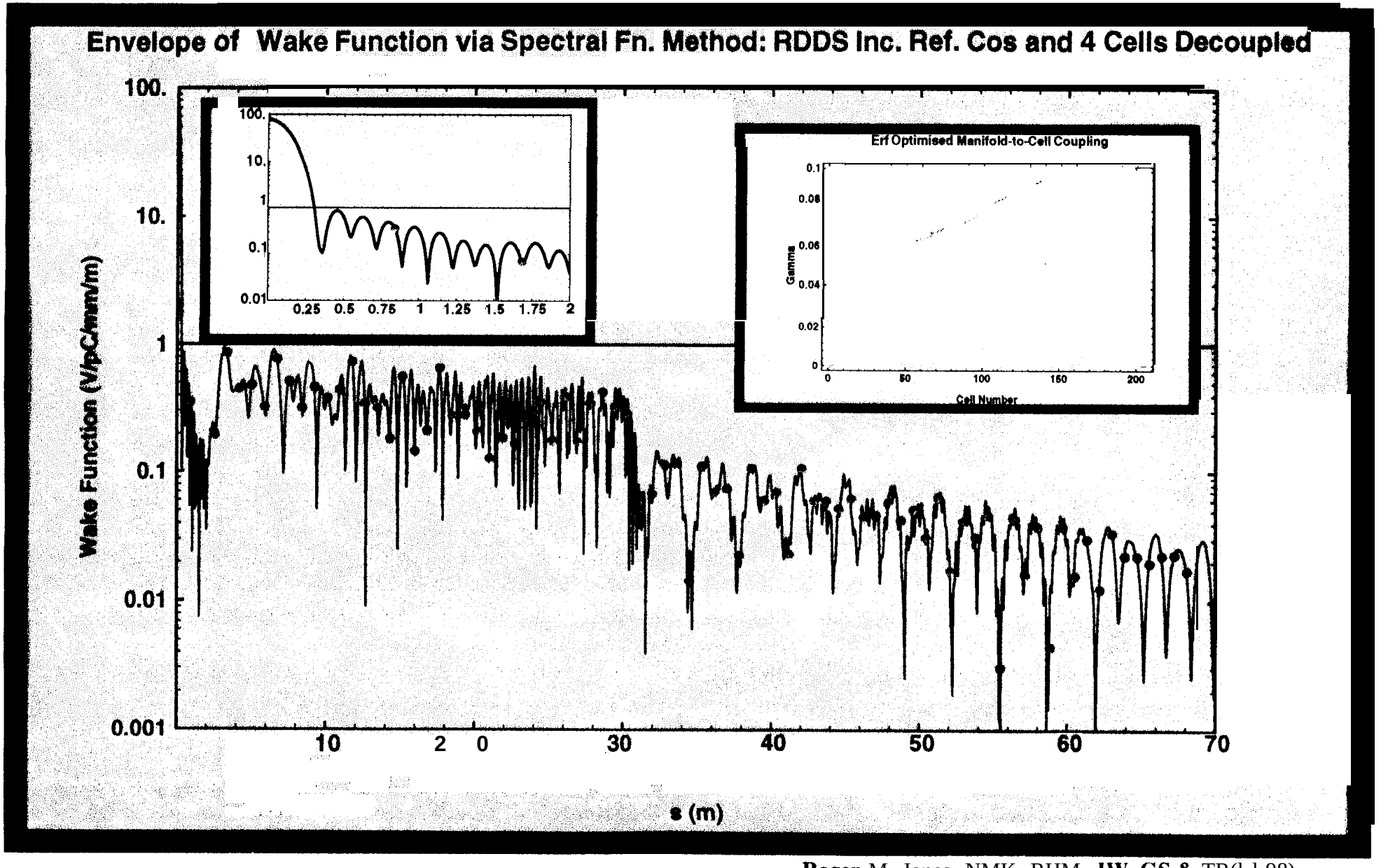
RDDSC 1 4 cells decoupled and a frequency dependent reflection coefficient. Careful optimisation of upper modes.





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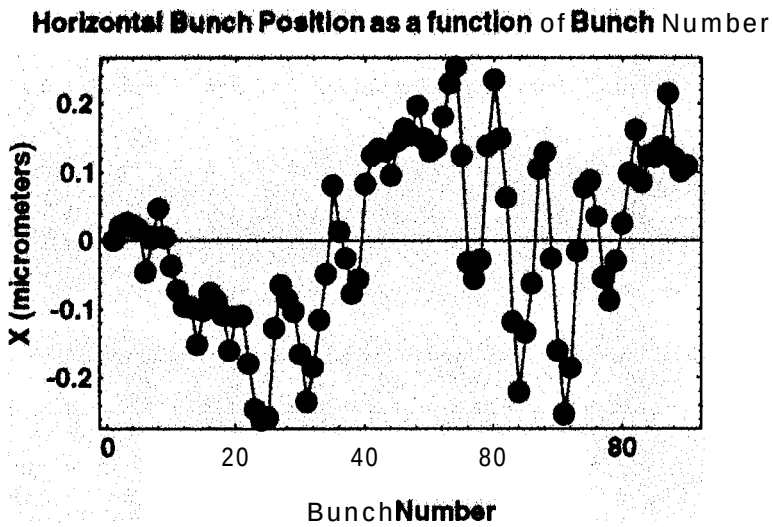

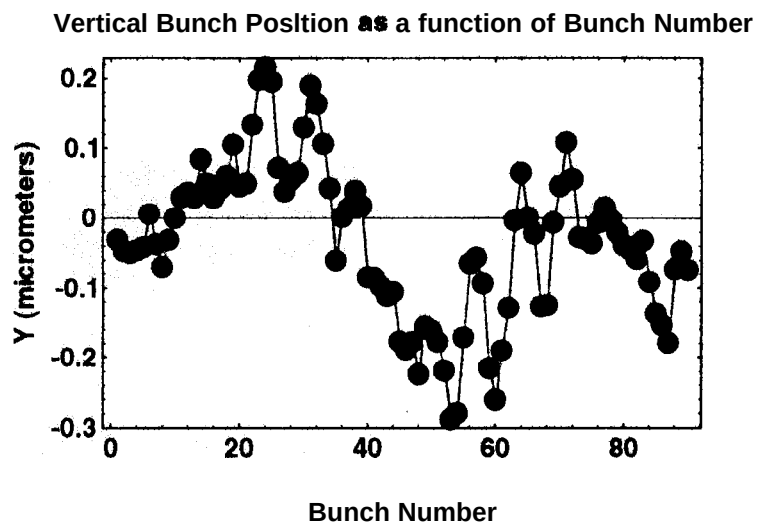

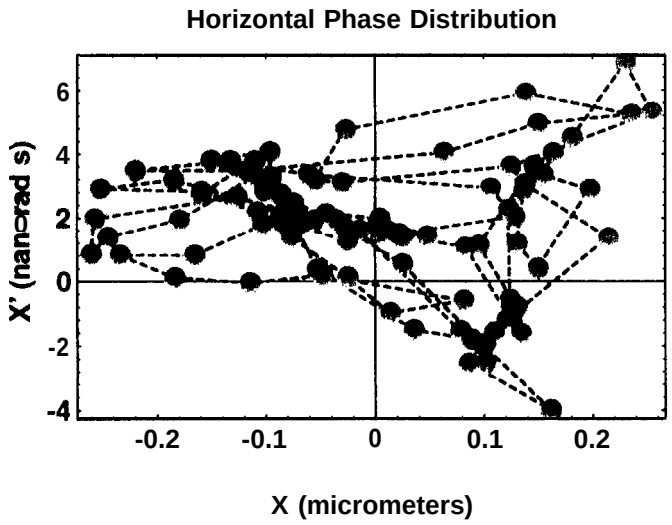

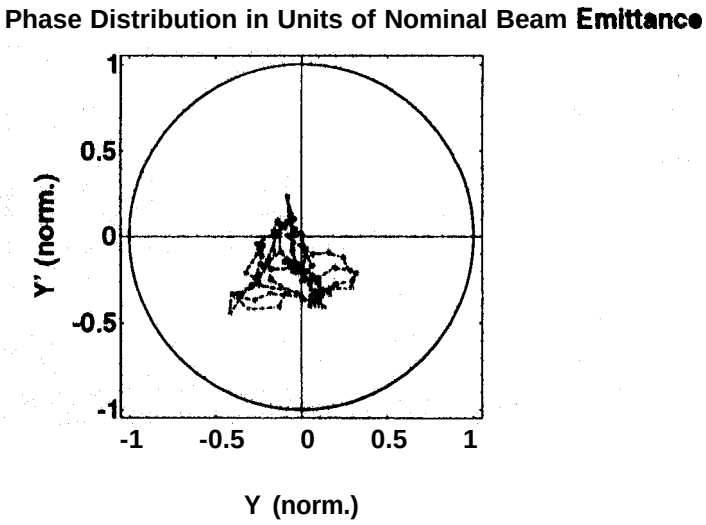

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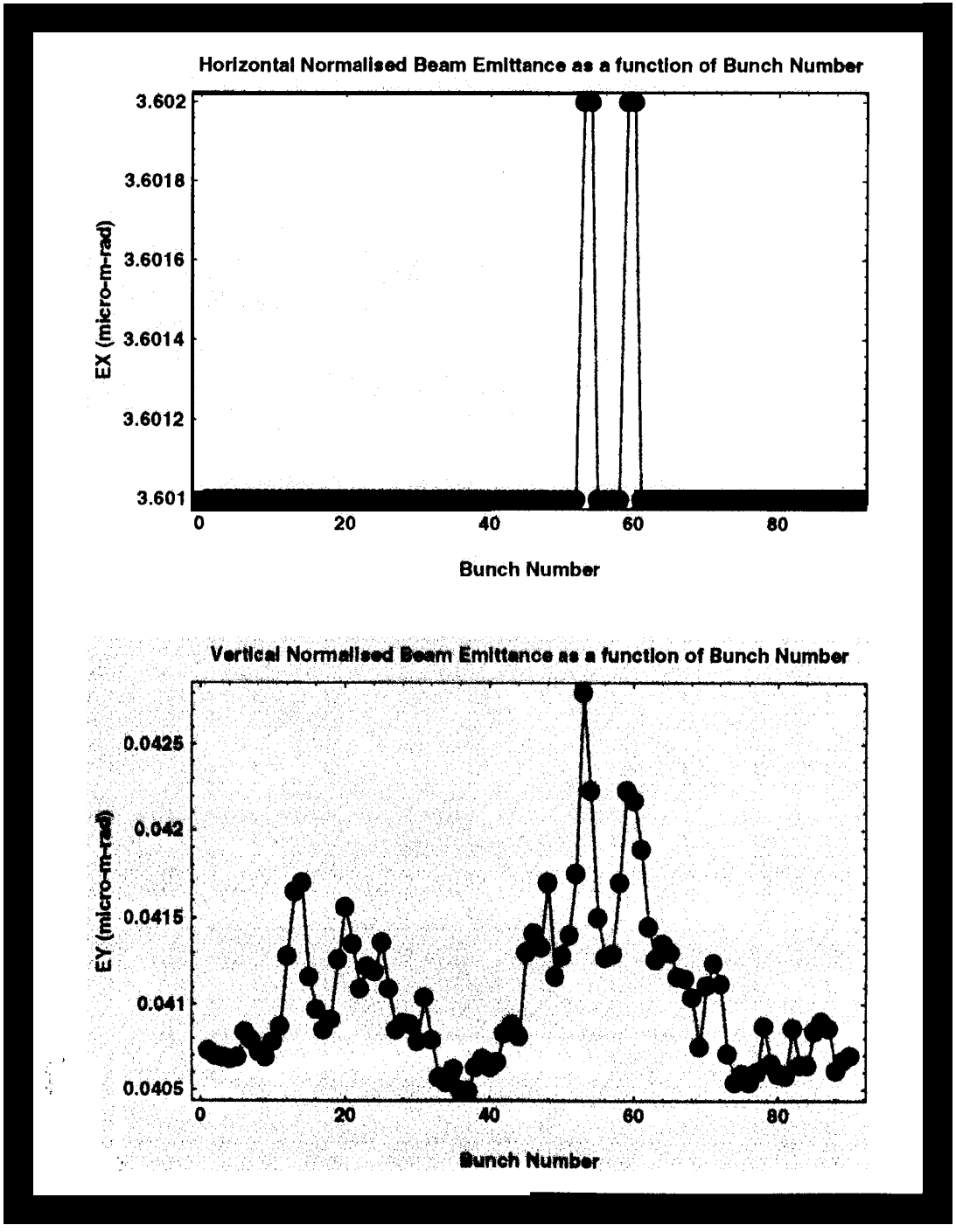
RDDSC 1 4 cells decoupled and a frequency dependent reflection

Careful optimisation of upper modes.



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RDDSC I 4 cells decoupled and a frequency dependent reflection coefficient. Careful optimisation of upper modes.

Normalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
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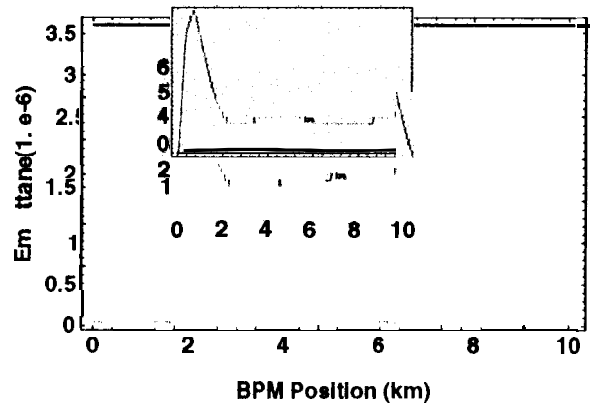
Final Emittanco: (10.1, 3.6, 0.0407}



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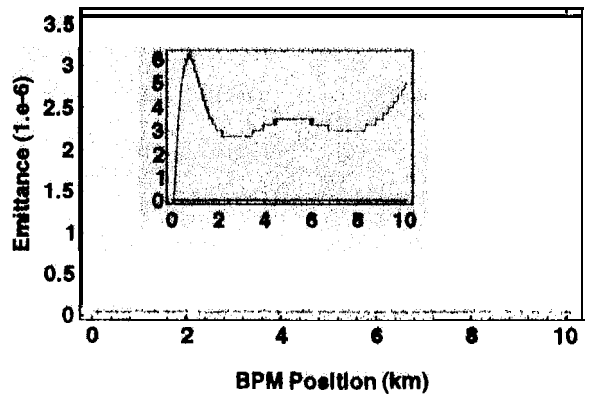
Initial Emittancr: {0.00625, 3.6, 0.04}
Final Emittance: (10.1, 3.6, 0.042}



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Due to Long Range Transverse Wake at BS= 0.8394188824 (2.8ns)

Normalised Horizontal & Vertical Beam Emittance For NLC
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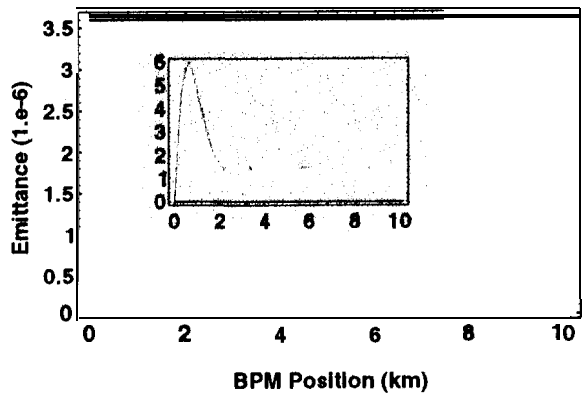

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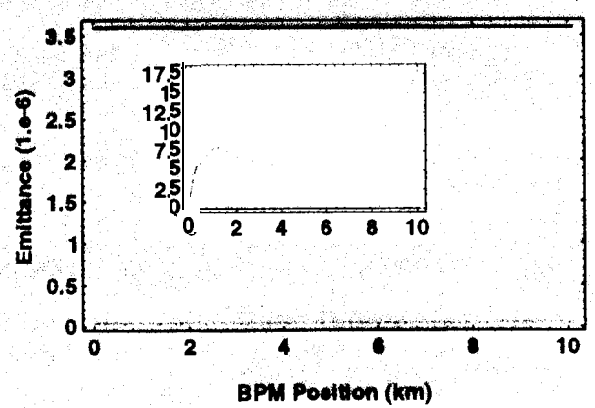
Final Emittance: {10.1, 3.6, 0.0473}



Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer(11-98)

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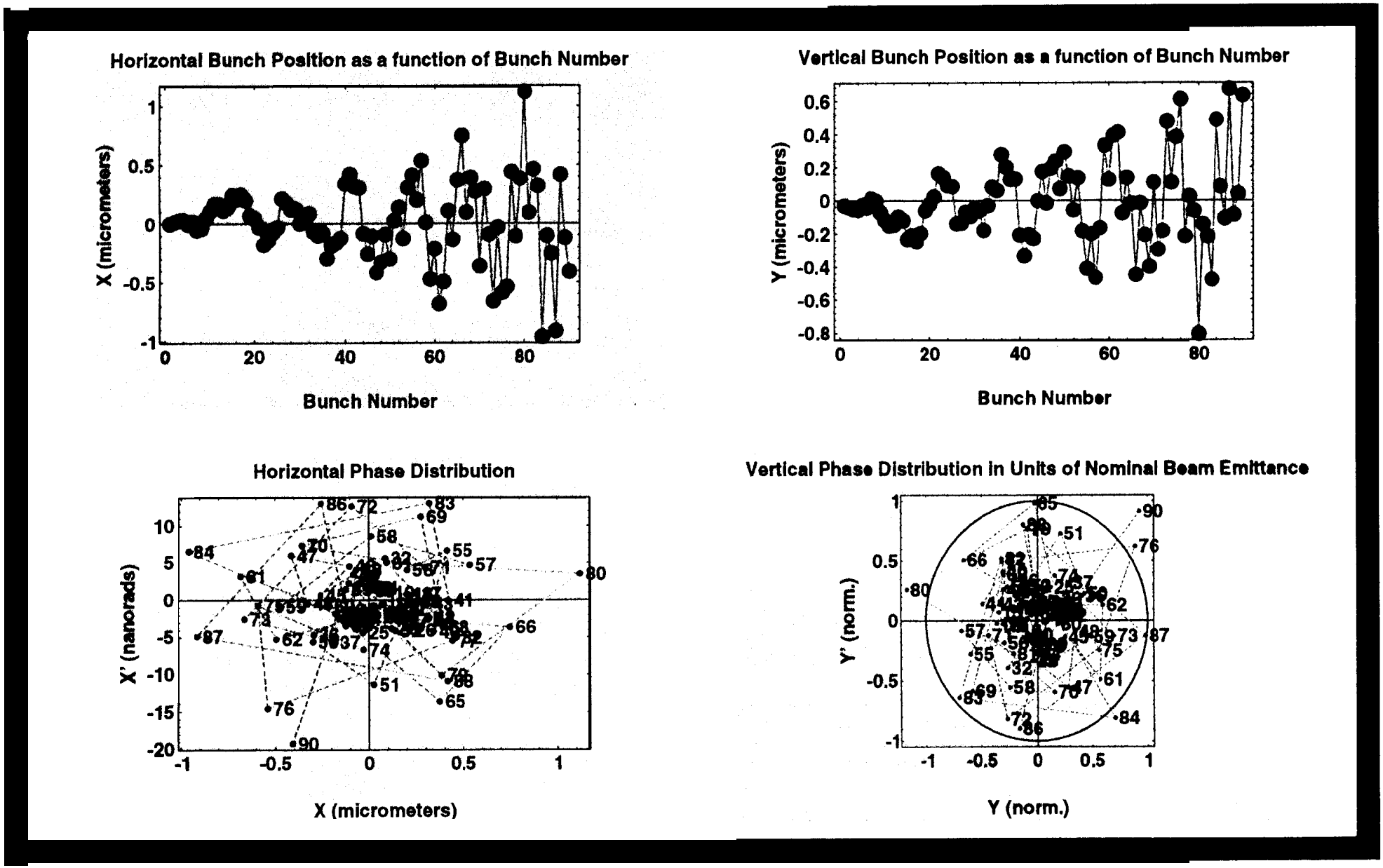

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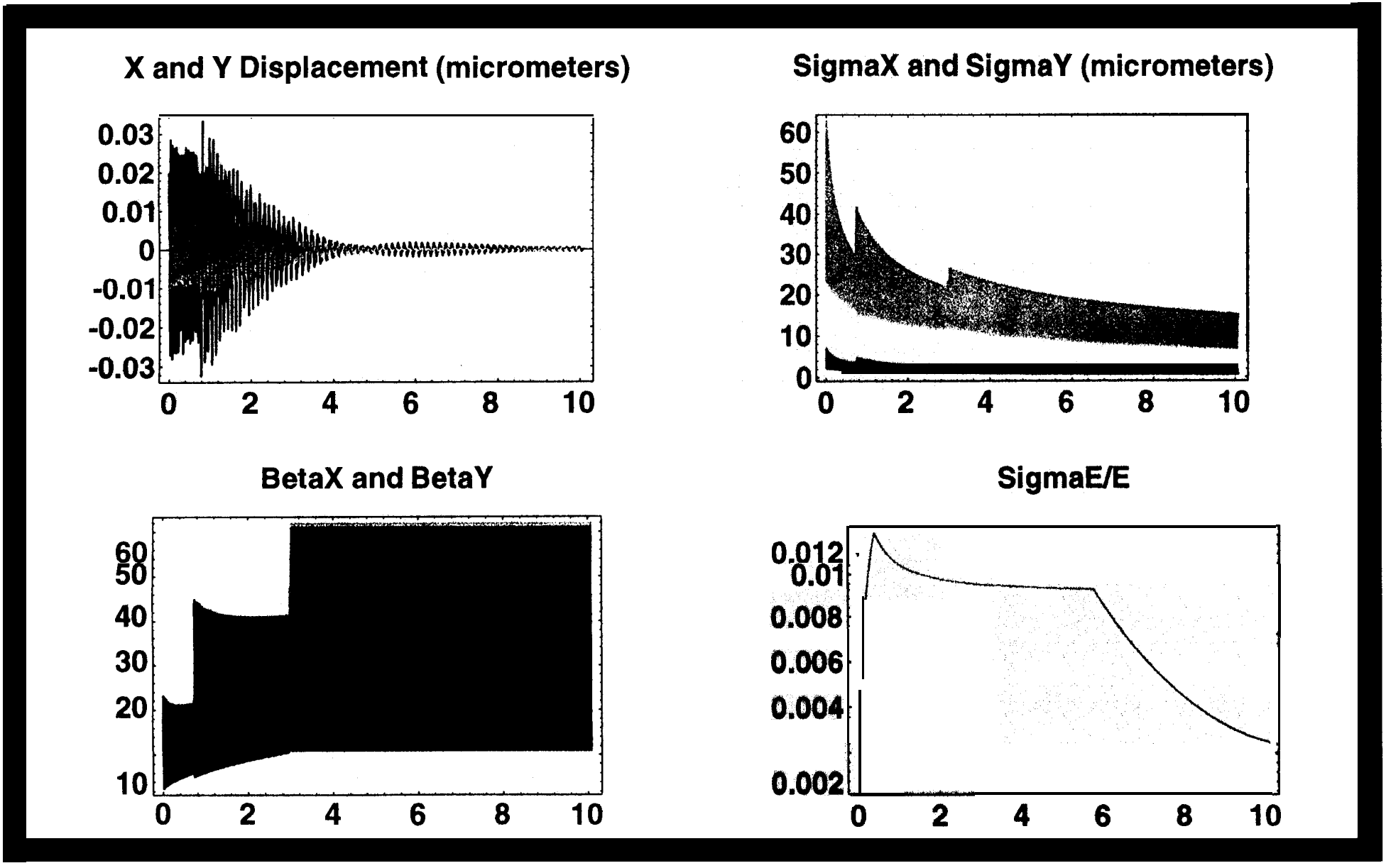

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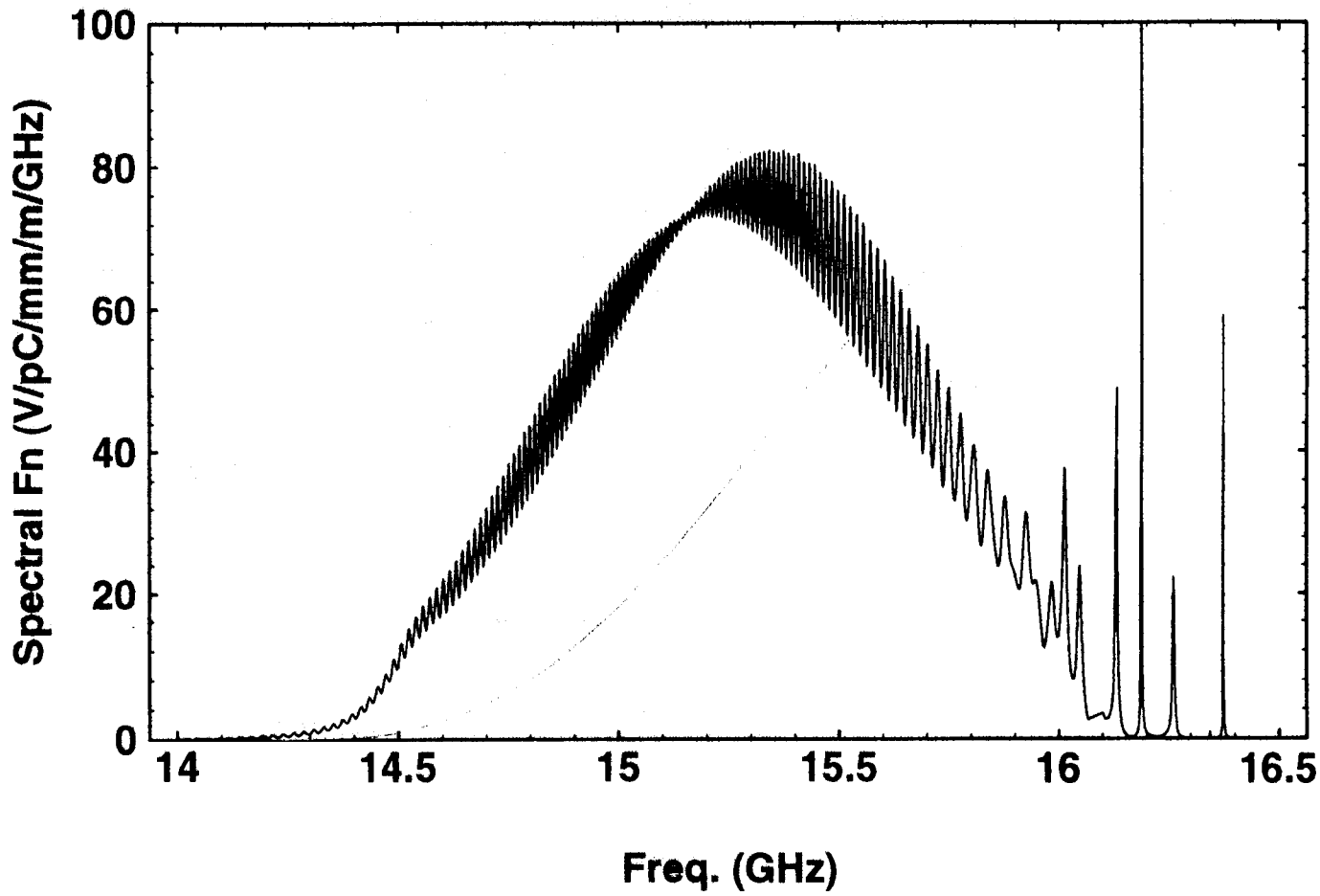
Filter Out Resonance Close To 16.087 GHz

Spectral Function for RDDS 1 (4.75, 2.368, 11.25) Incl. HOM Coupler Transitions and 4 Cells Decoupled



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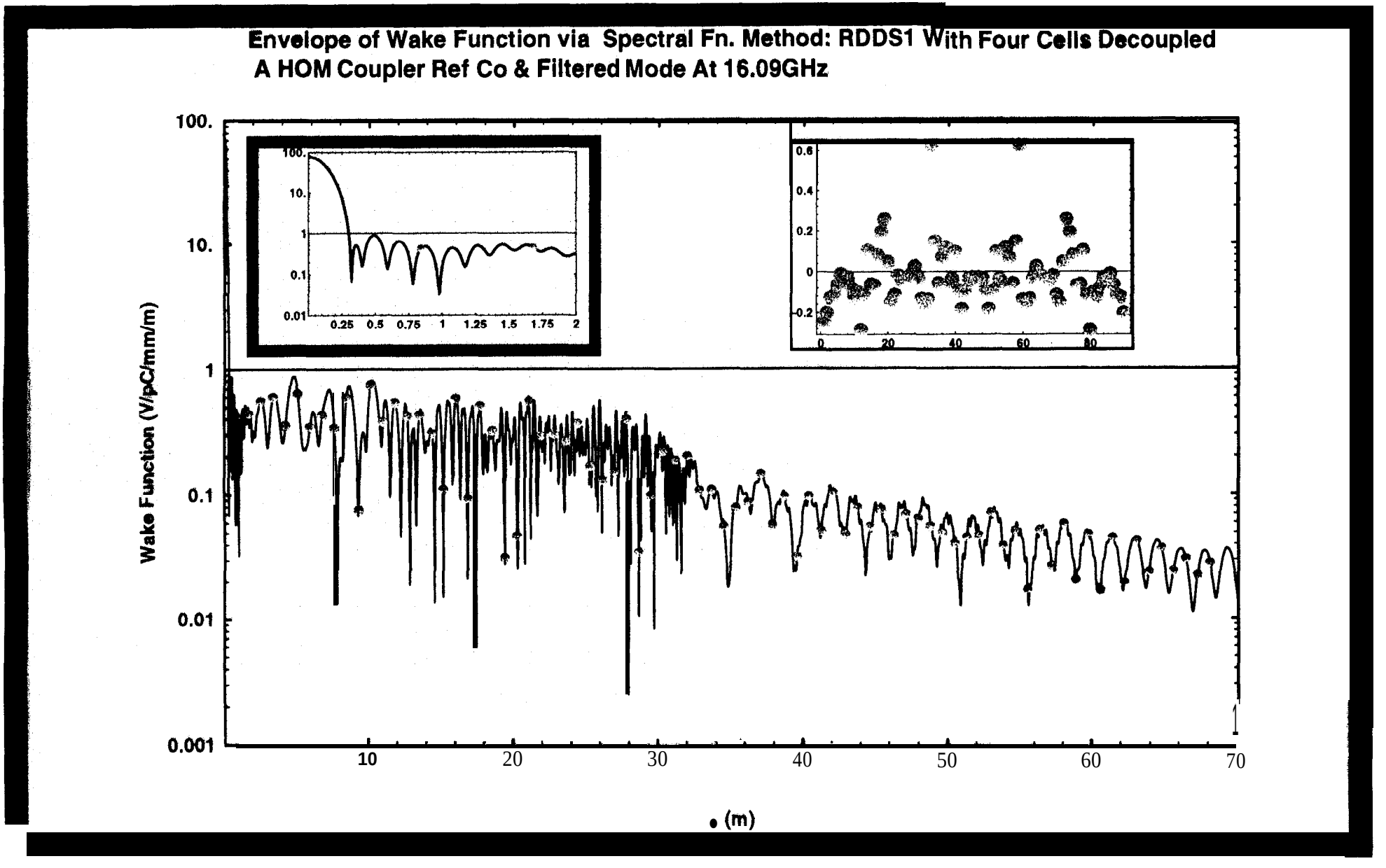

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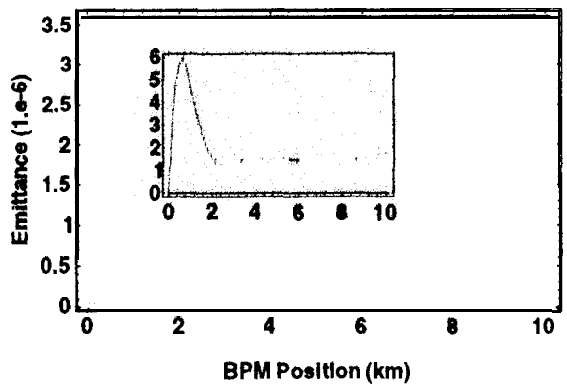
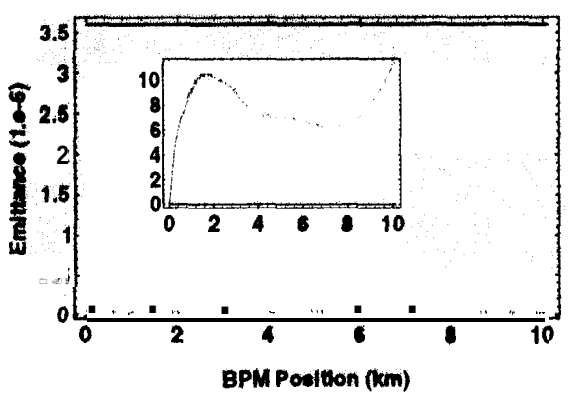
Final Emittance: (10.1, 3.6, 0.0407}



Normalised Horizontal & Vertical Beam Emittance For NLC
Inset la the % Emfttance growth
Initial Emittance: {0.00625, 3.6, 0.04}
Final Emittance: (10.1, 3.6, 0.0446}



Roger M. Jones, N, M. Kroll, R.H. Miller, J. Wang. G. Stupakov & T. Raubenheimer(1 I-98)

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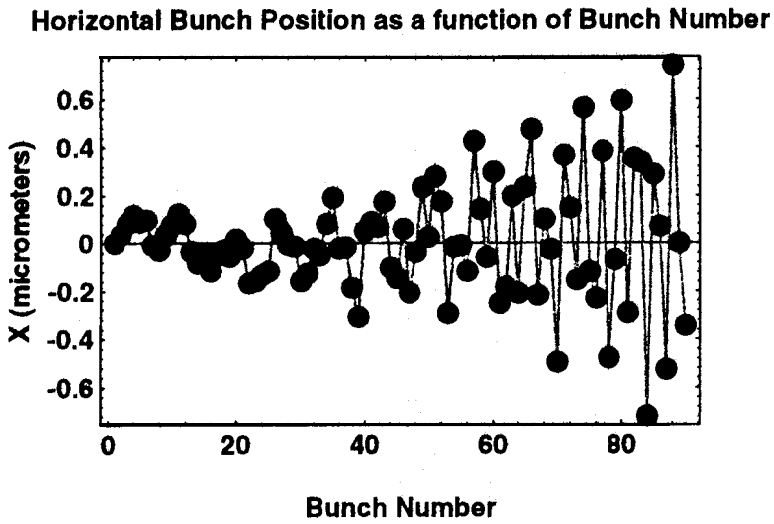

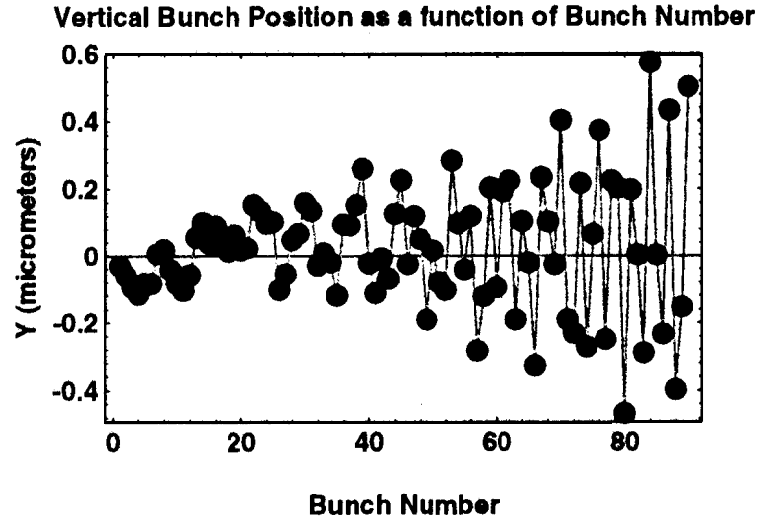

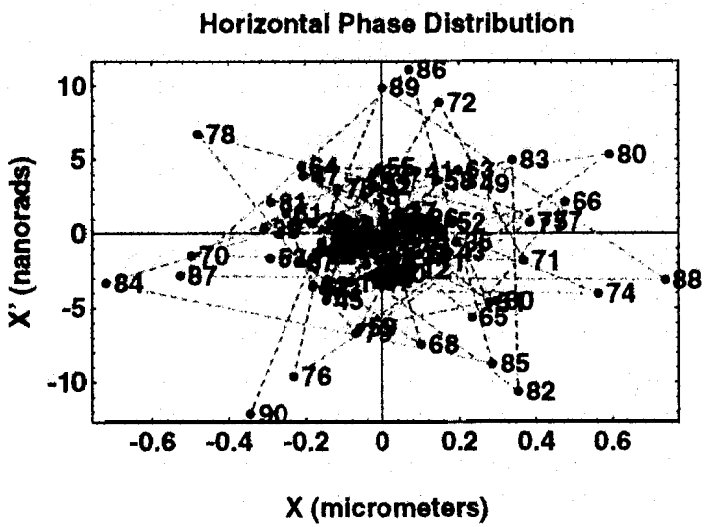

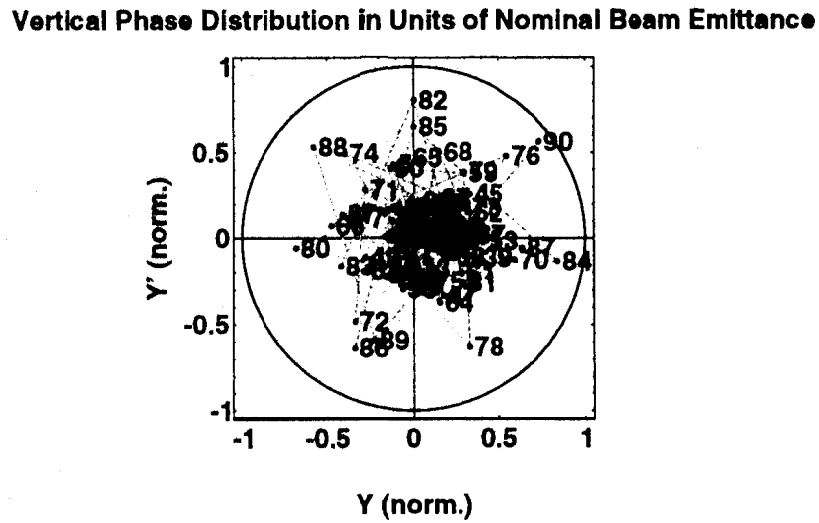

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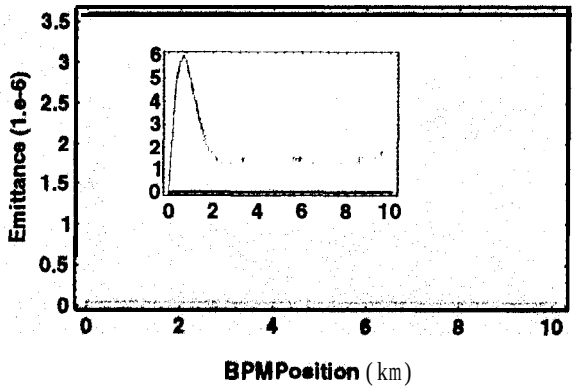
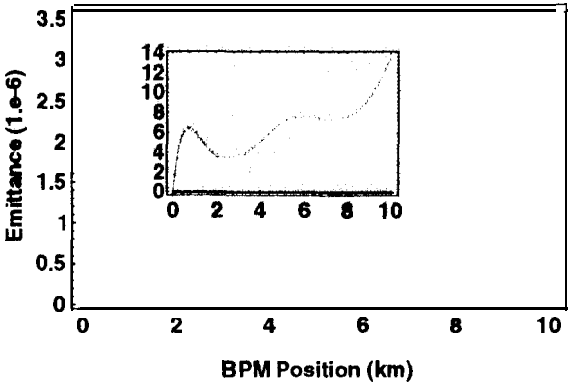
Include Resonance, RDDS1C (With 4 Cells Decoupled And Reflection Coefficients Of HOM Couplers). BS = 0.84028 And The 45 Harmonic Of The Bunch Spacing => 16.055 GHz.(C.F. 16.0603 GHz for .84 m BS)

Normalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: {0.00625, 3.6, 0.04}
Final Emittance: {10.1, 3.6, 0.0407}



Normalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: (0.00625, 3.6, 0.04}
Final Emittance: (10.1, 3.6, 0.0455}



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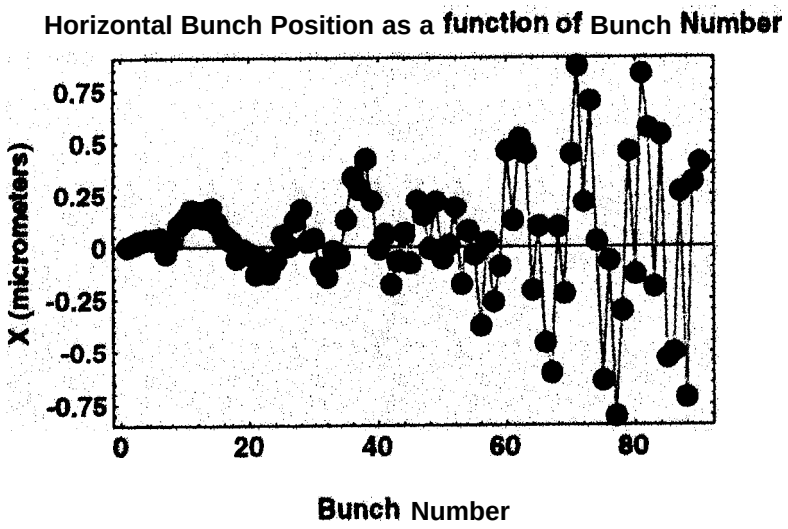
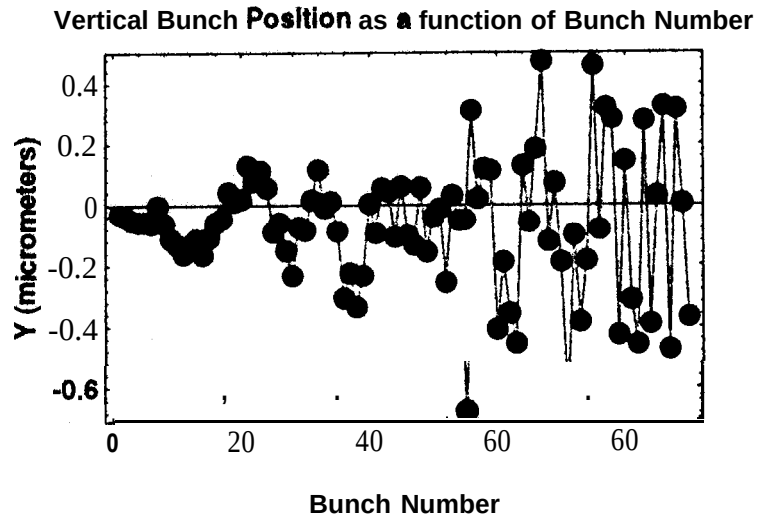
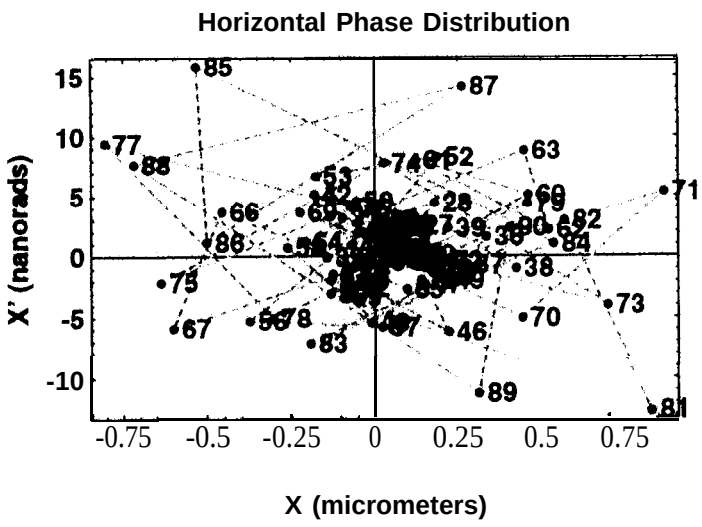
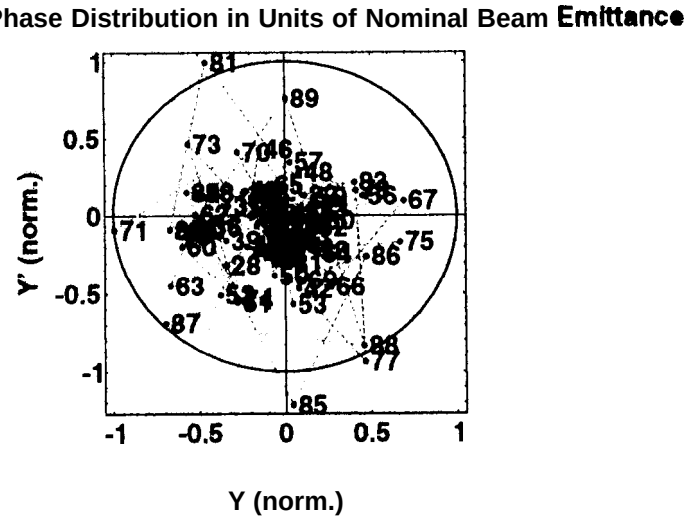
Include Resonance, RDDS 1 C (With 4 Cells Decoupled And Reflection Coefficients Of HOM Couplers). BS = 0.84028 And The 45 Harmonic Of The Bunch Spacing => 16.055 GHz.(C.F. 16.0603 GHz for .84 m BS)









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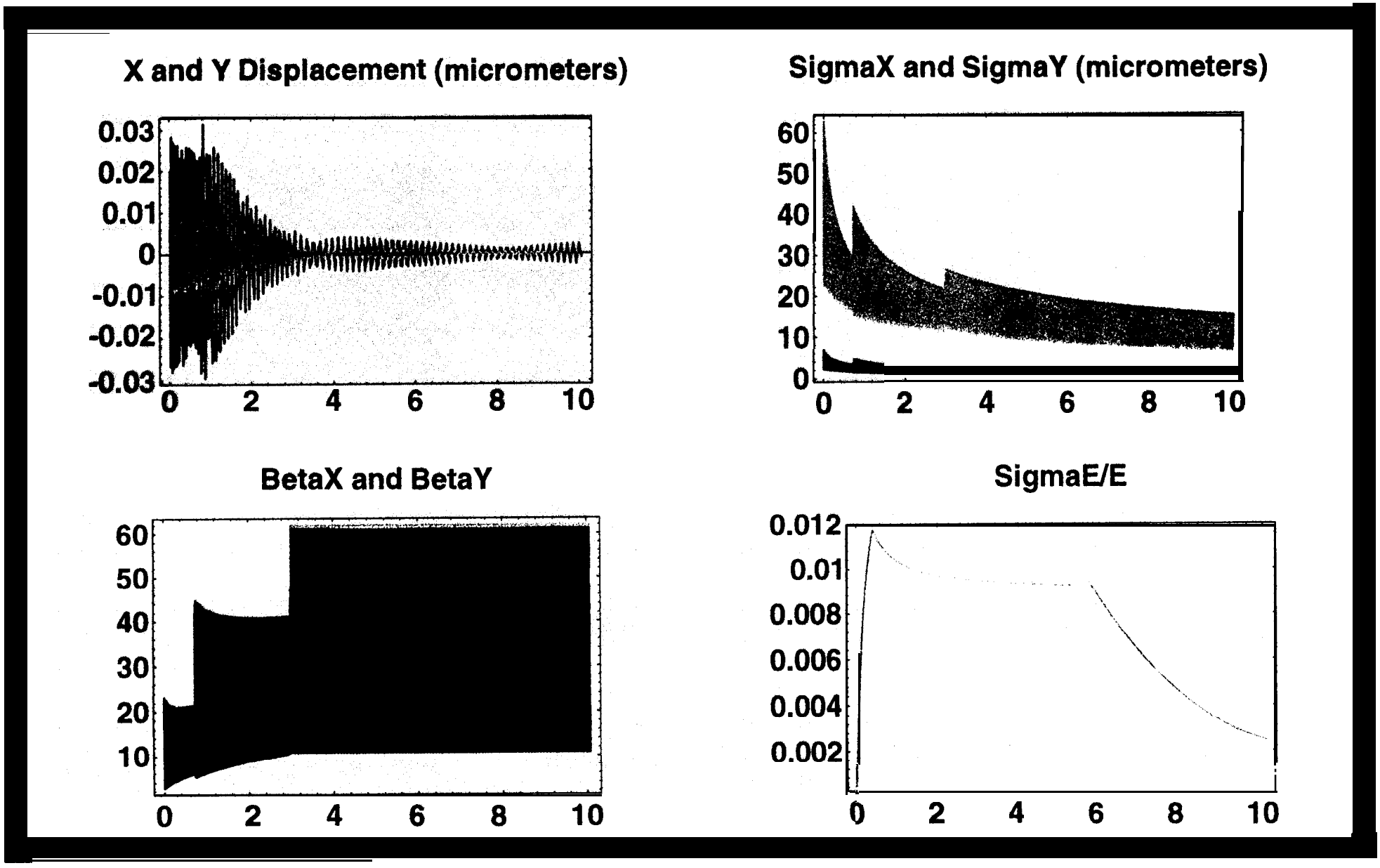

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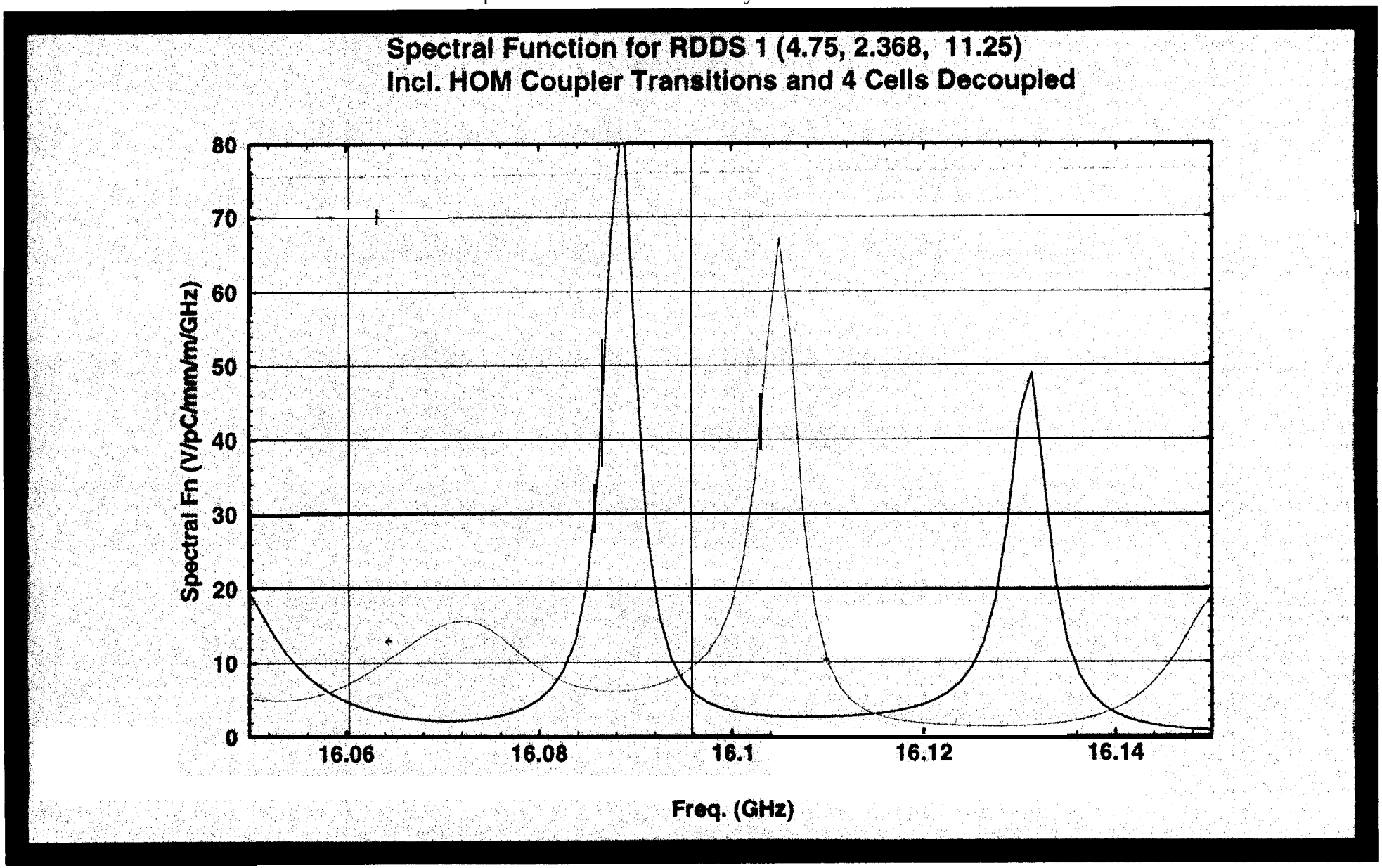
Optimised Coupling vs Standard RDDSl C
RDDSl C: Peak is at 16.089 GHz and the 45 bunch harmonic at 16.0603 (delta-f= 38MHz for a BS of .84 m).
Optimised RDDSl C has a peak at: 16.105 GHz (delta-f=45 MHz for a BS of .84 m)
A BS of 83.965cm makes the 45 bunch harmonic seperated from the resonance by 38 MHz



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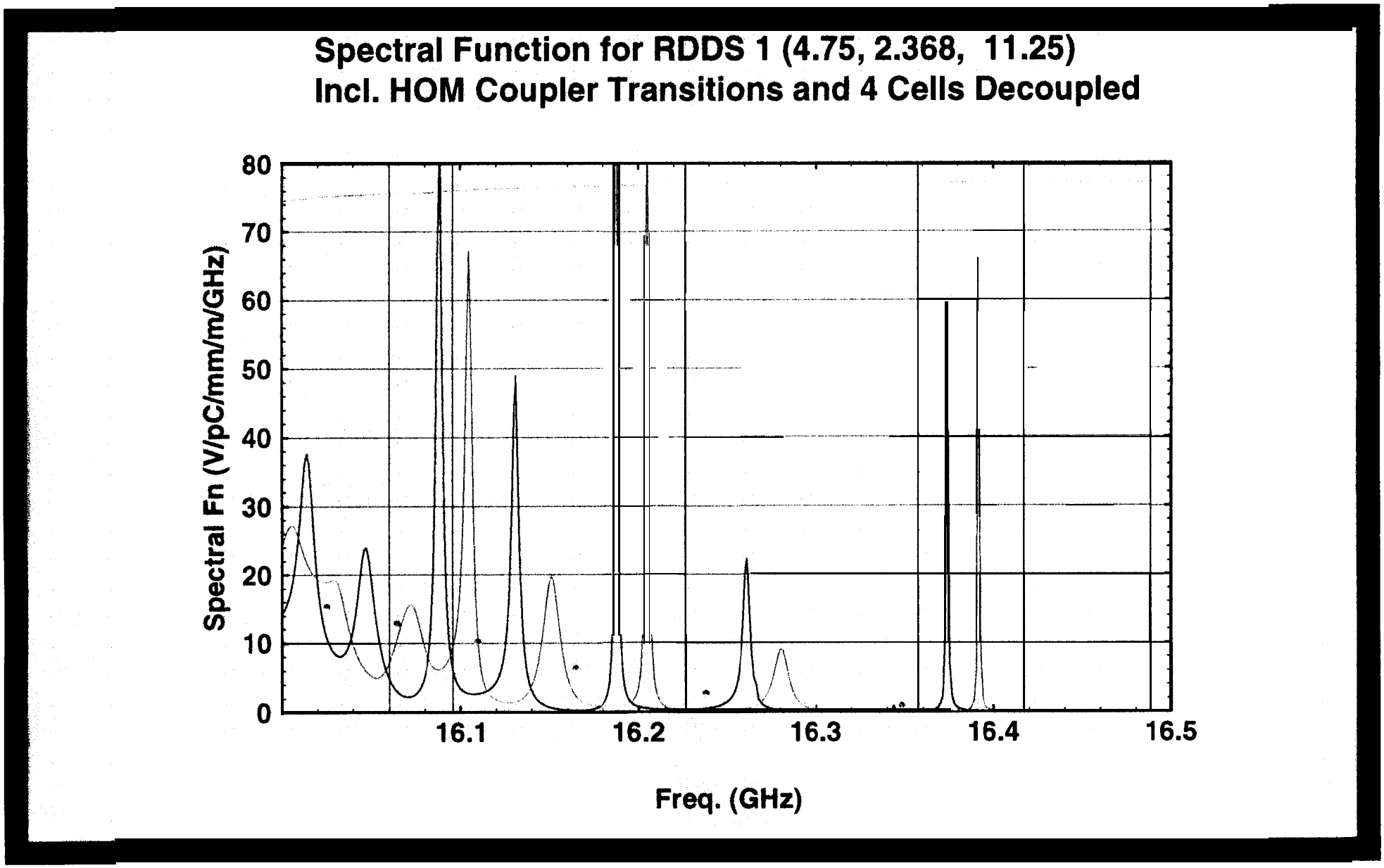

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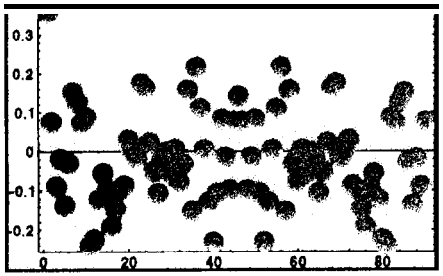

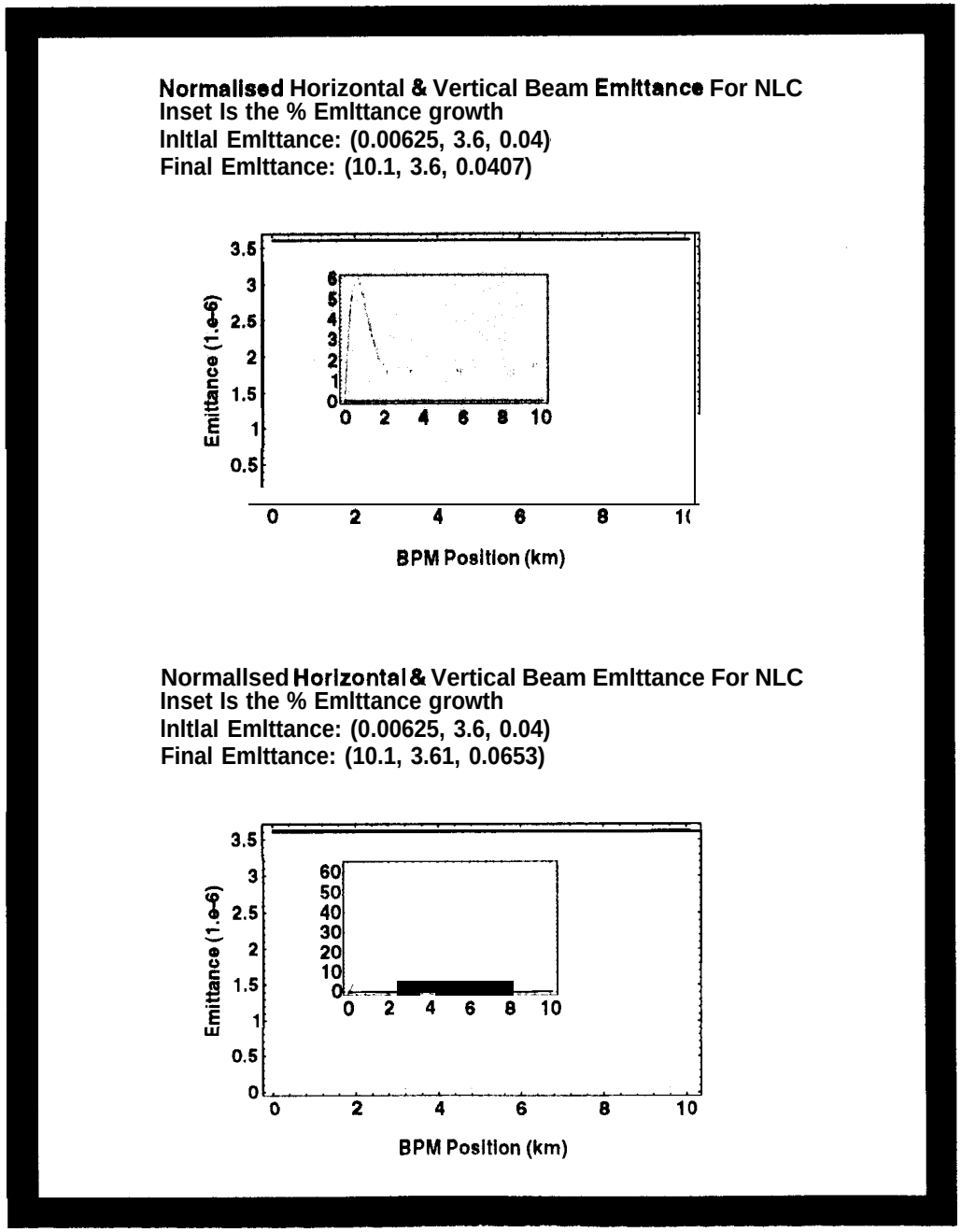

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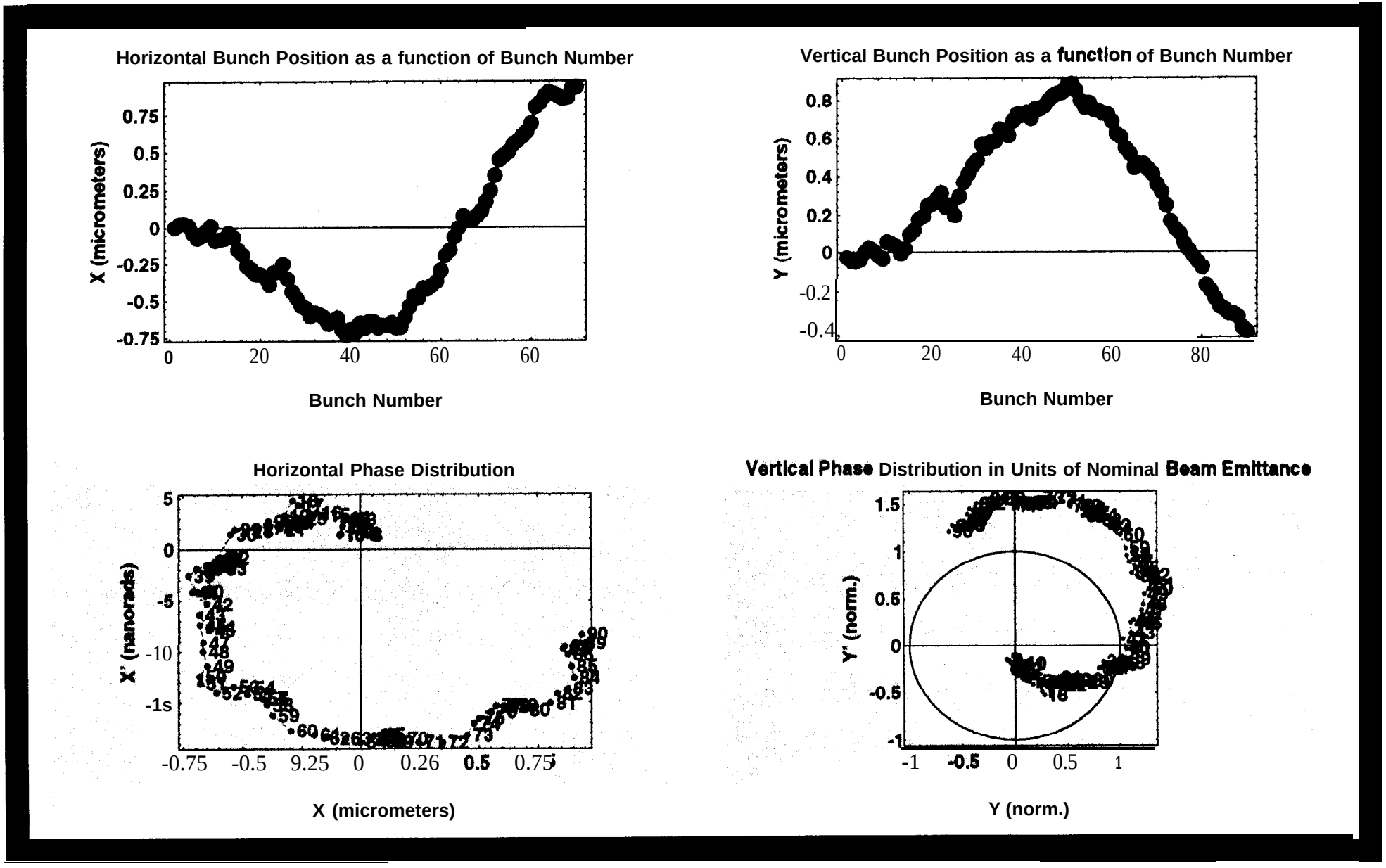

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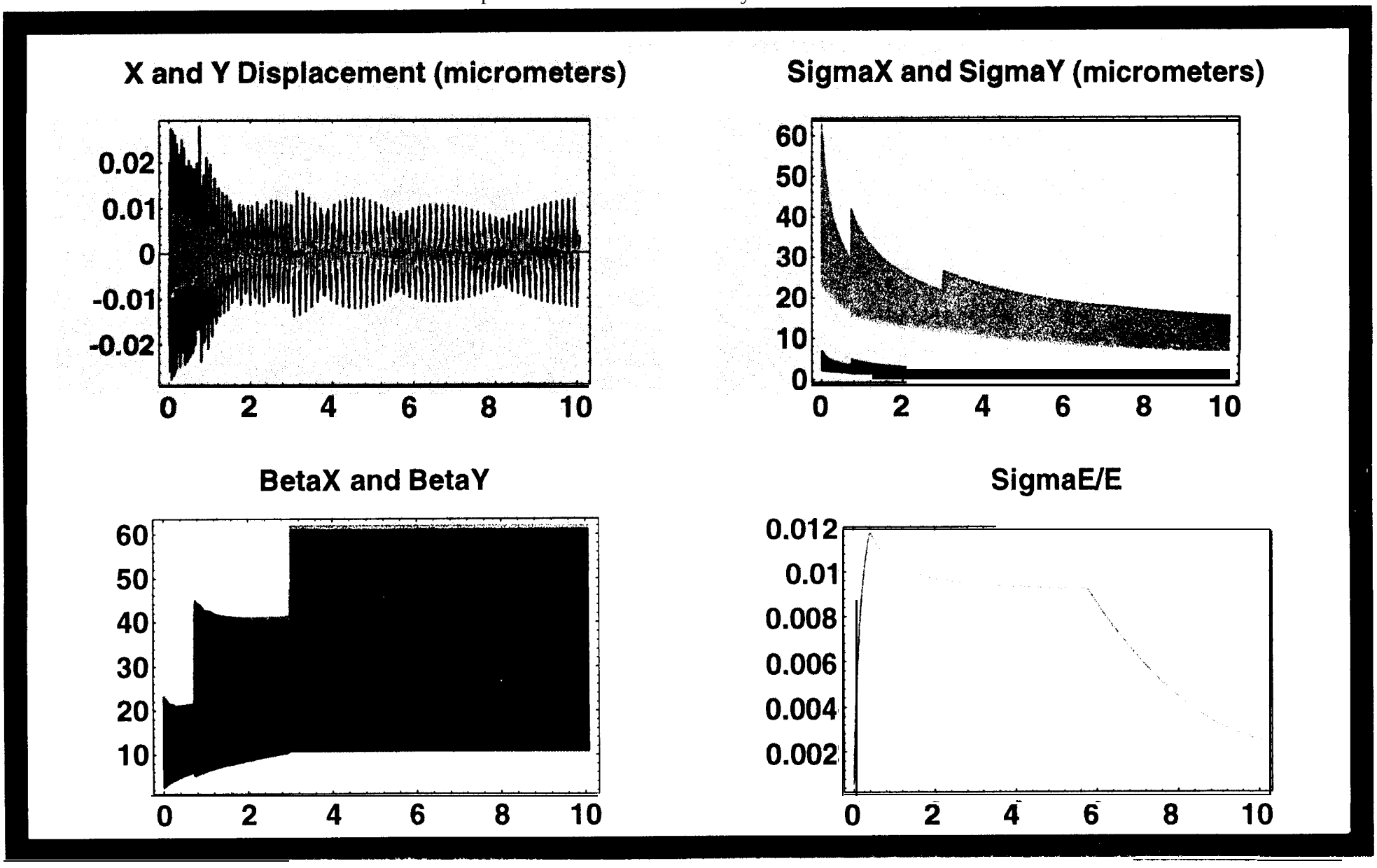

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* Lorentzian distributions:

$$g|f] = 1/[a^2+b^2(f^2-c^2)]$$

Resonance frequency=c, Q=bc/(2a)

Area=π/(ba)

$$g[f] = a^{-2}/[1+4Q^2((f/c)^2-1)]$$

Area =πc/(2Qa^2)

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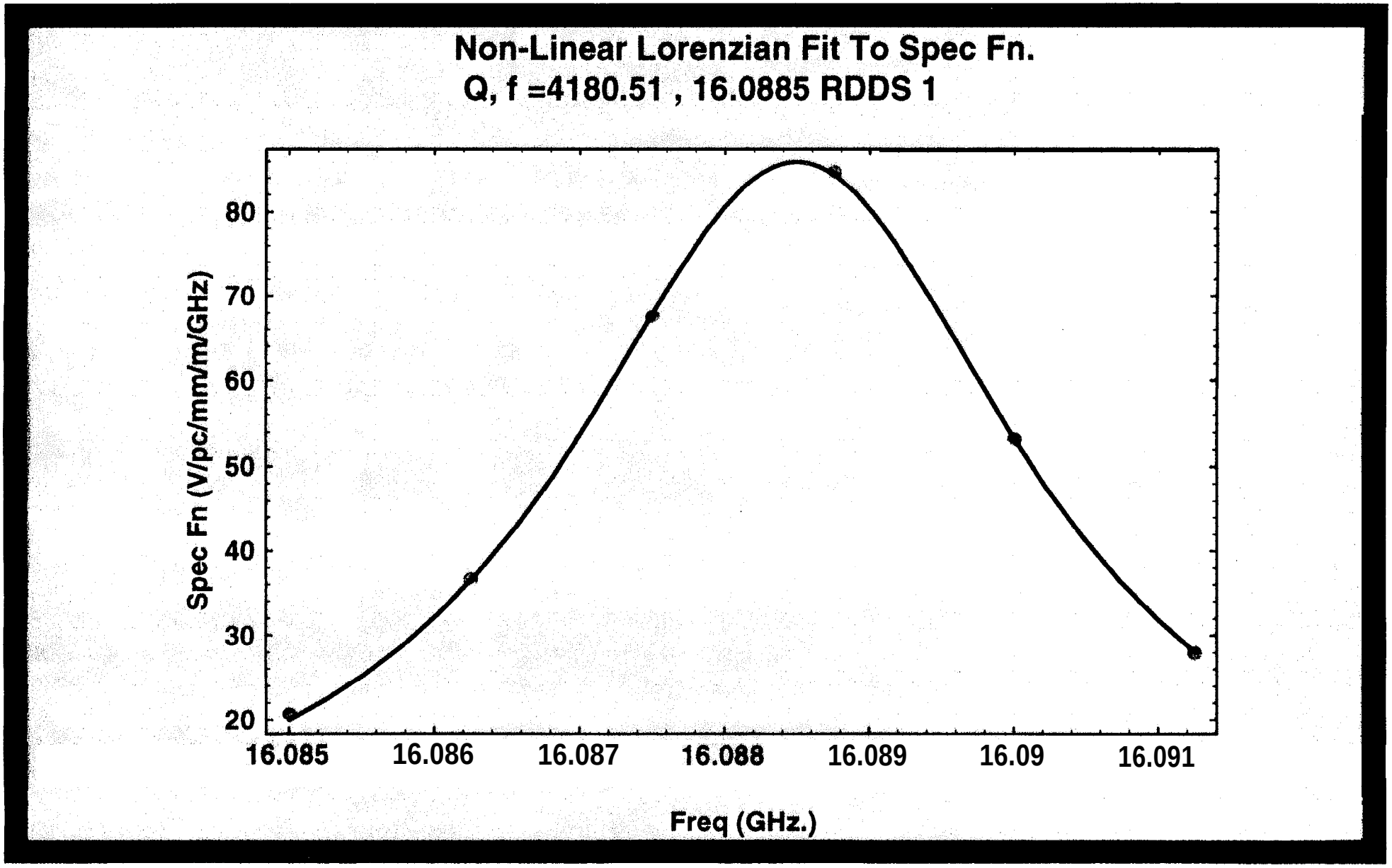

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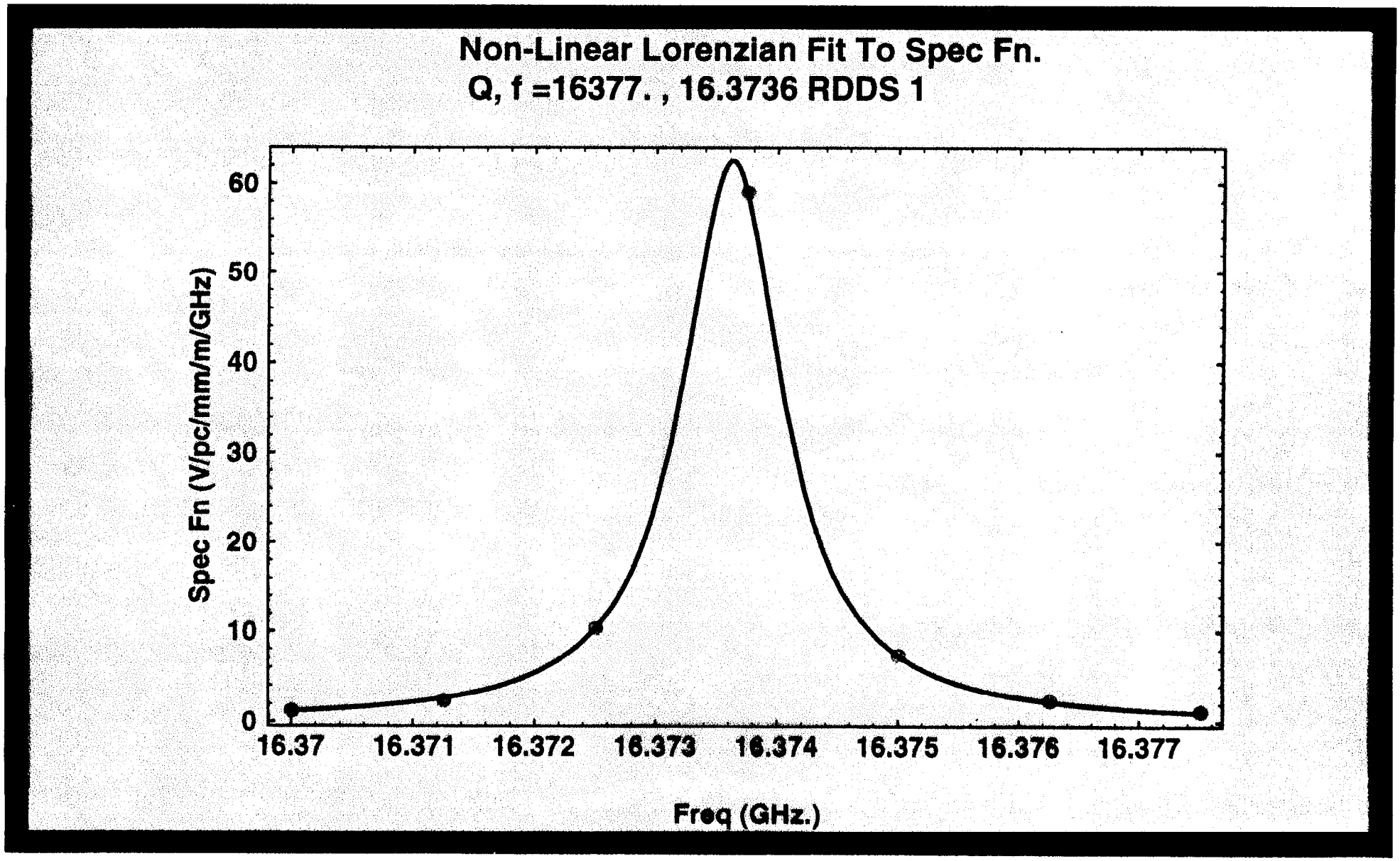

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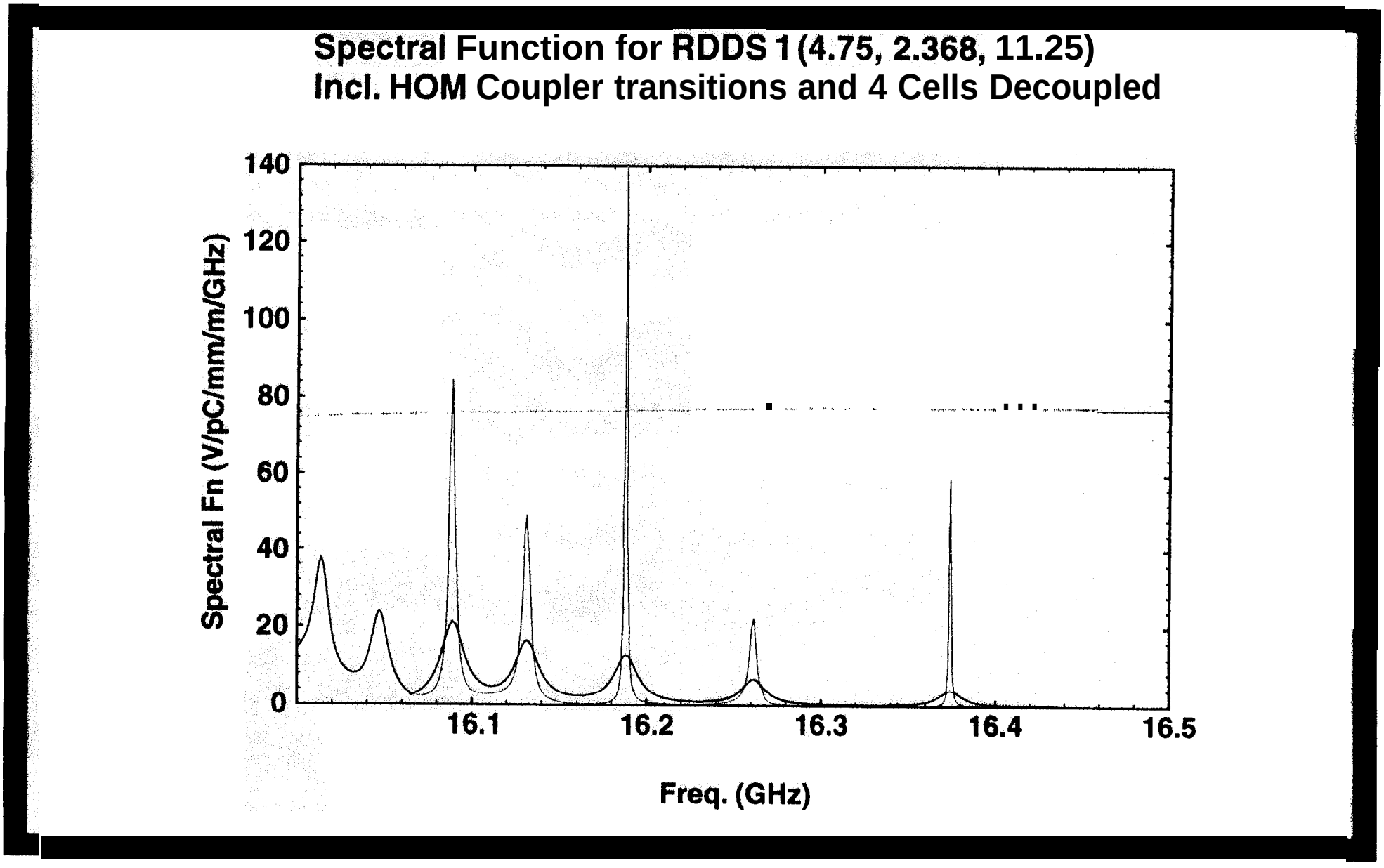
Last 5 modes replaced by Lorentzians each with a Q =1000.



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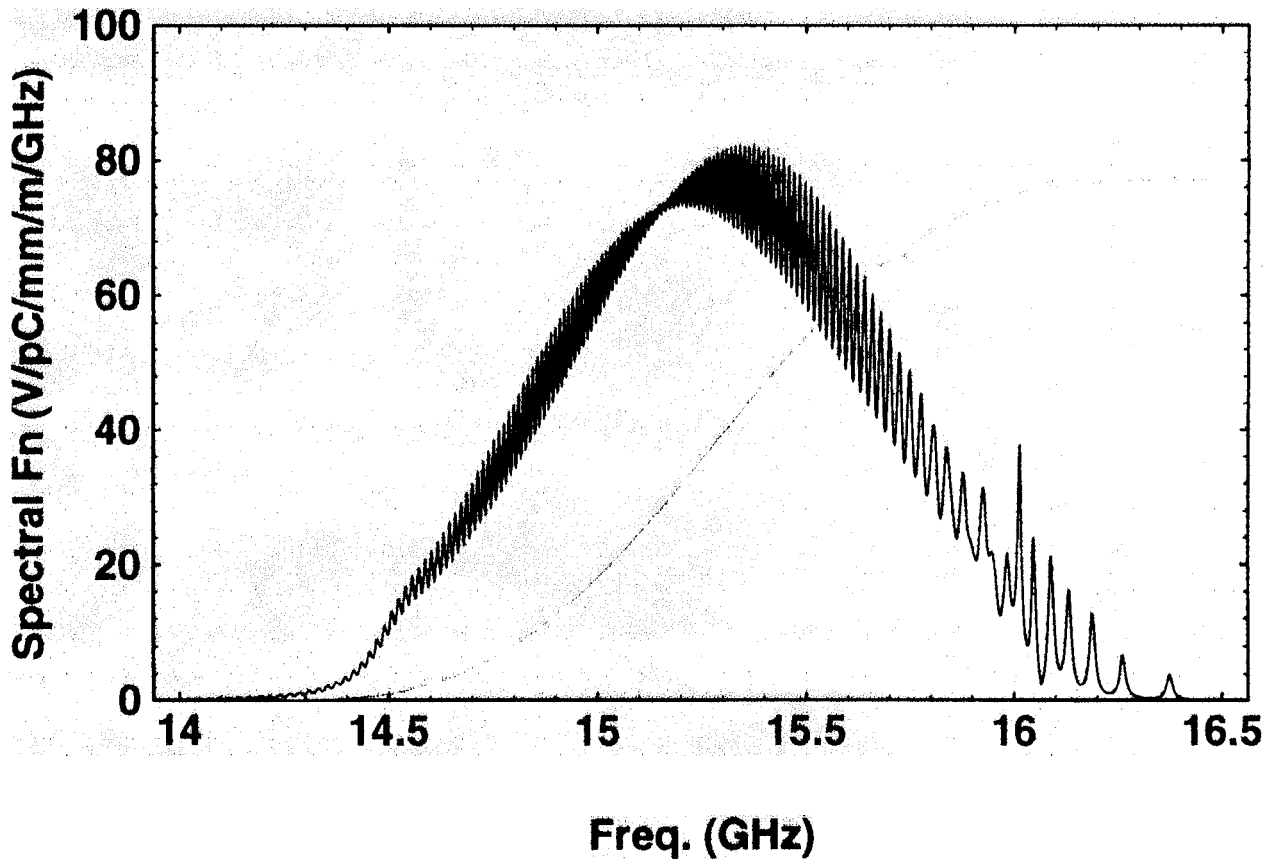
Spectral Function for RDDS 1 (4.75, 2.368, 11.25)
Incl. HOM Coupler Transitions and 4 Cells Decoupled
Last 5 Modes Replaced With Modes with a Q =1000



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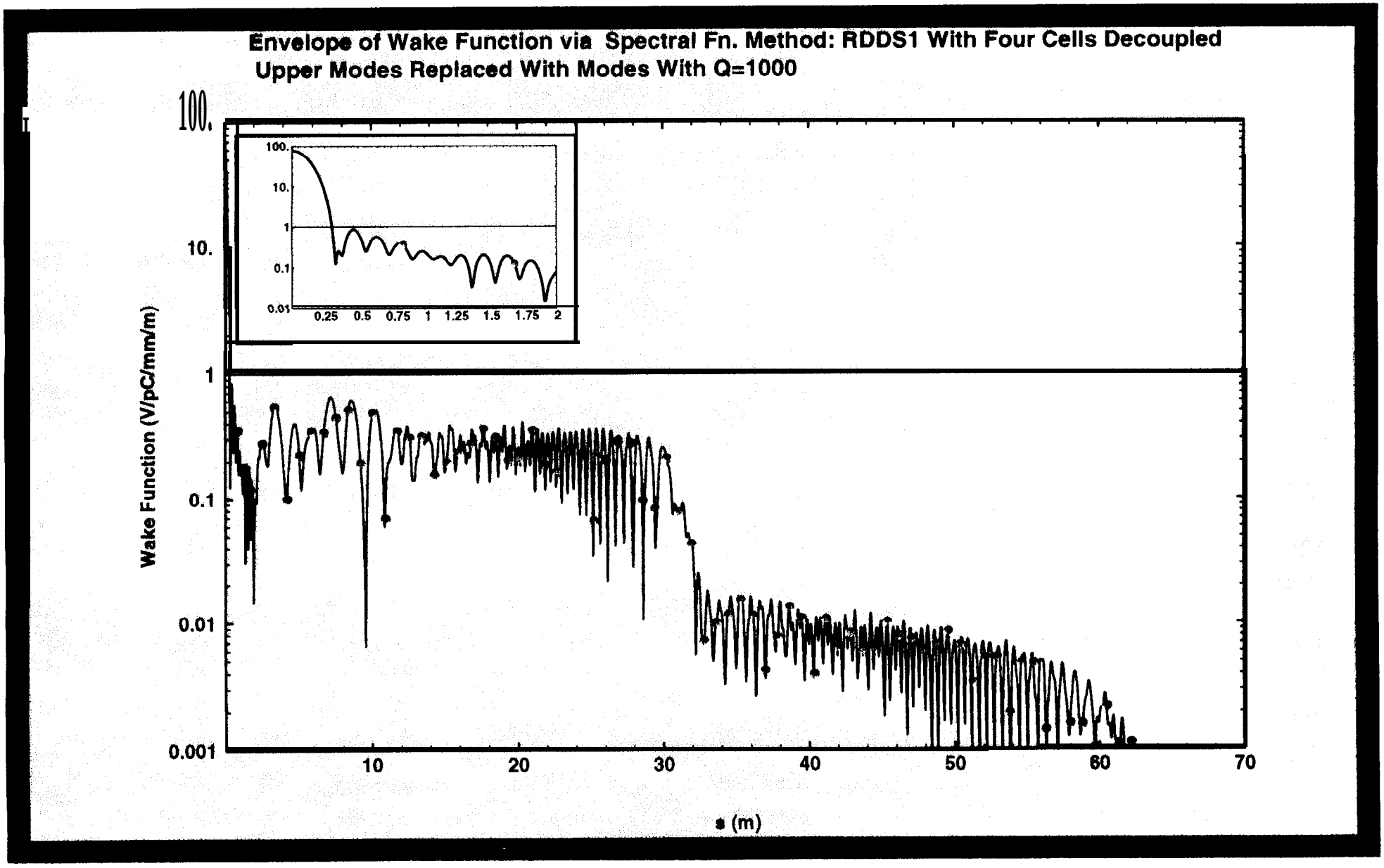

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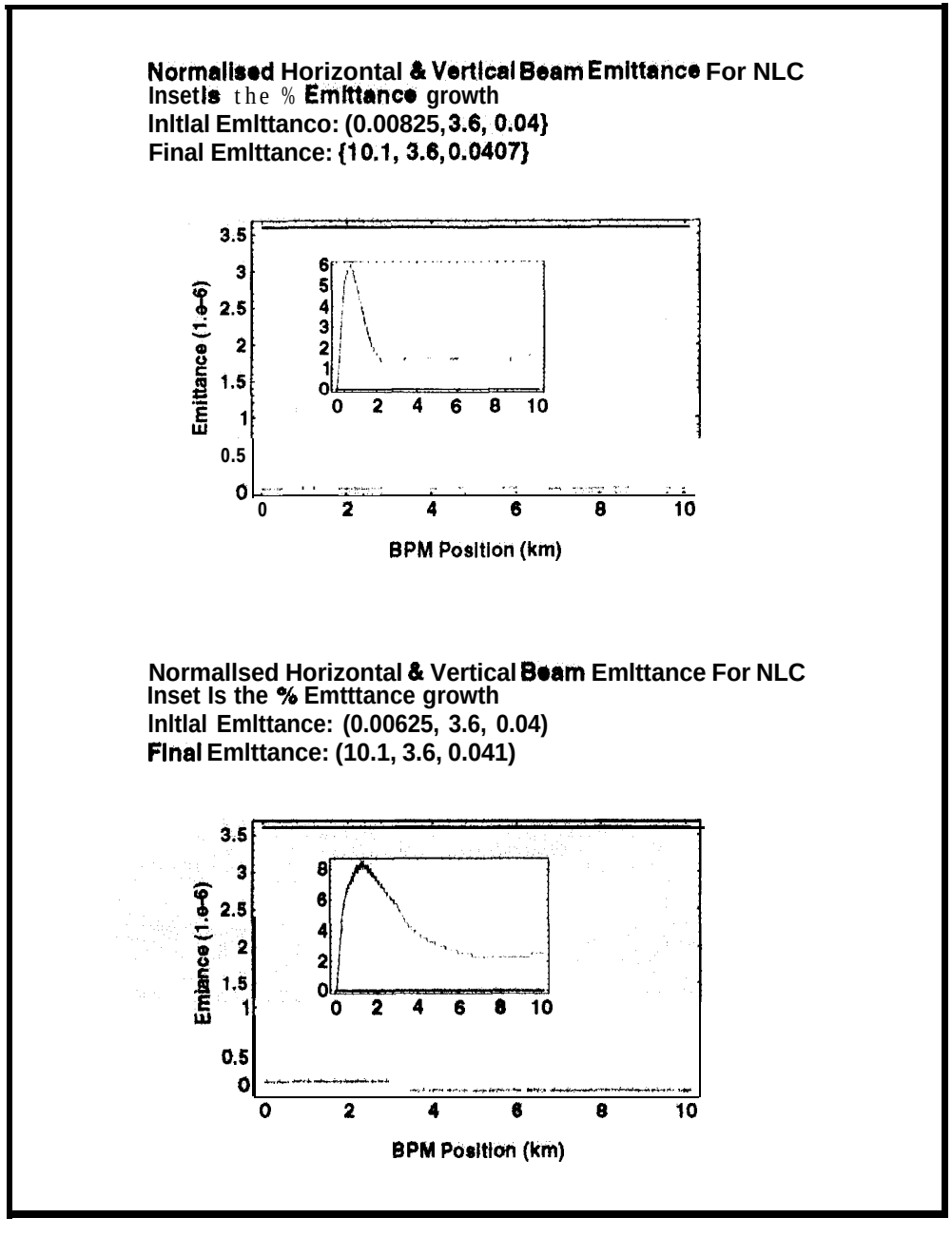
Last 5 modes replaced by Lorentzians each with a Q =1000.
BS =.84 m



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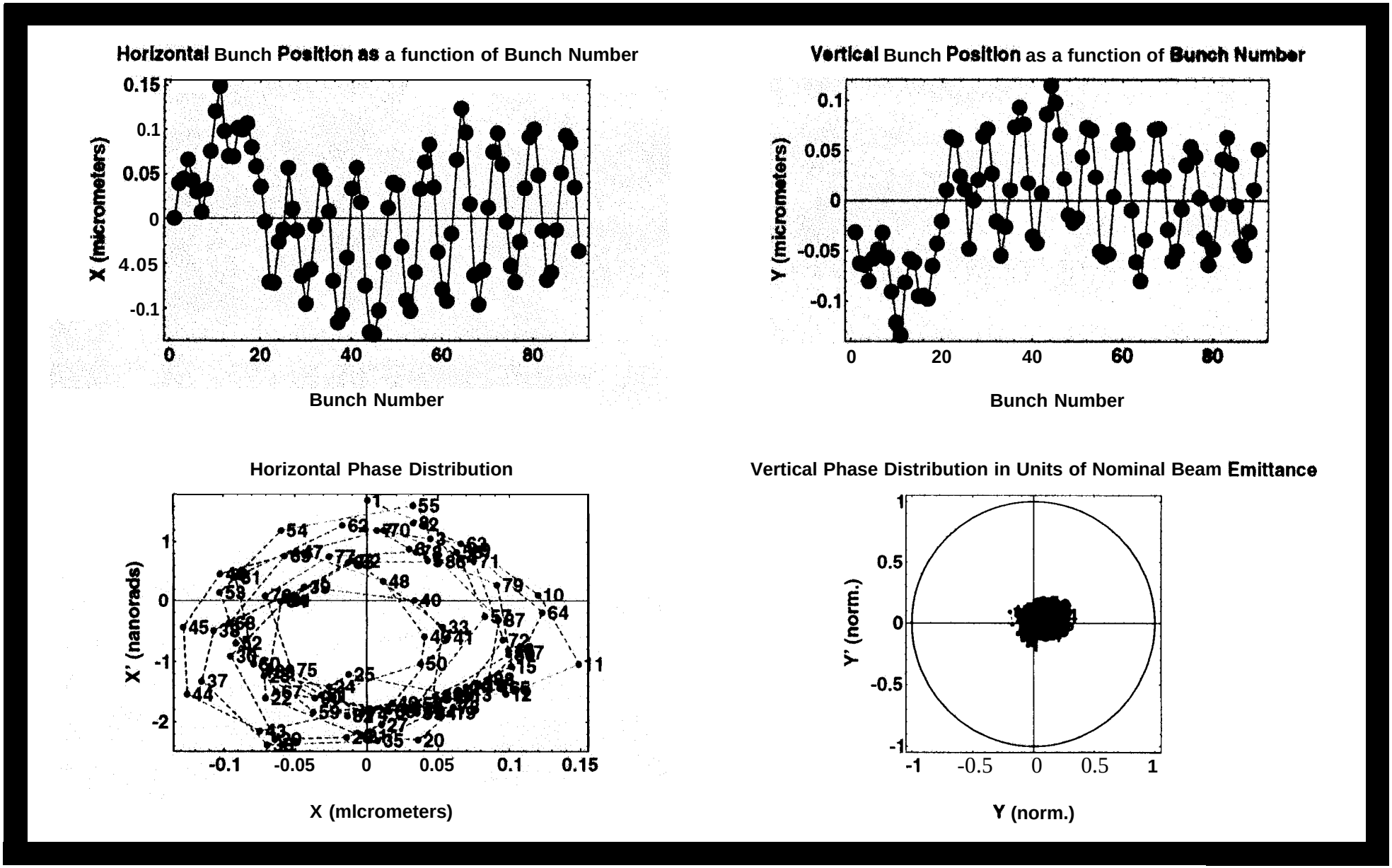

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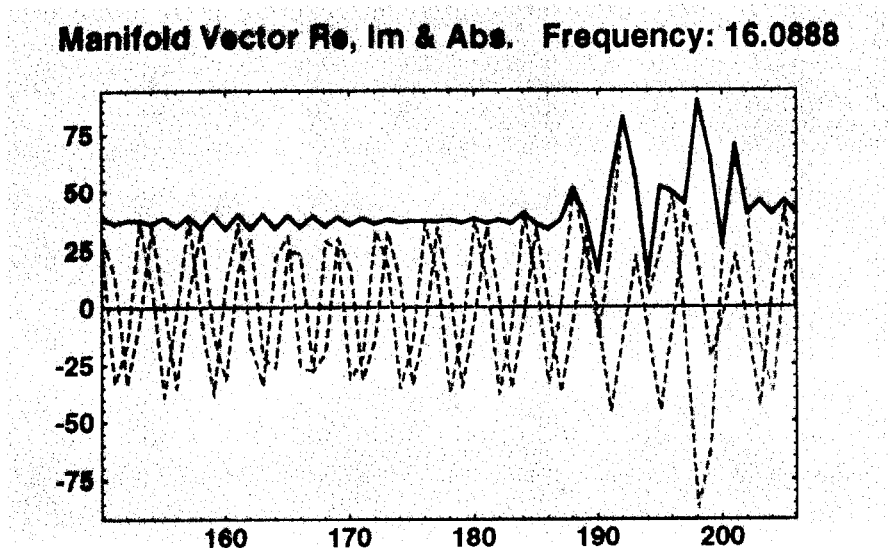

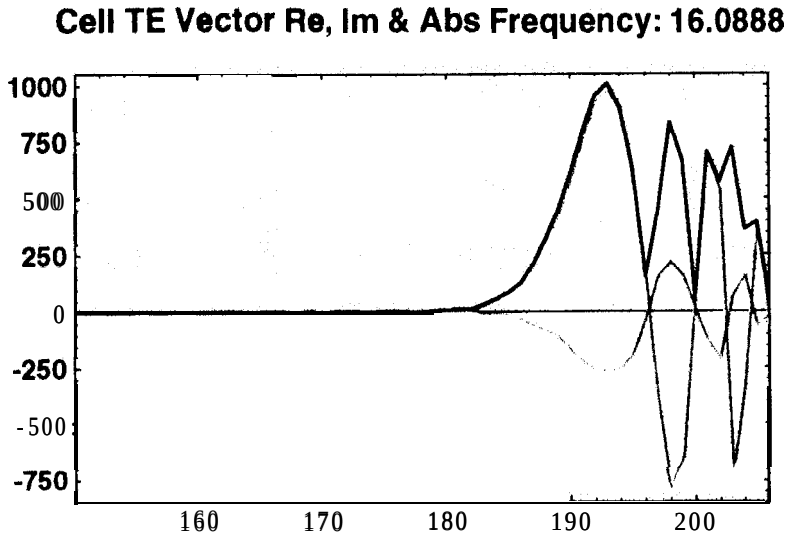

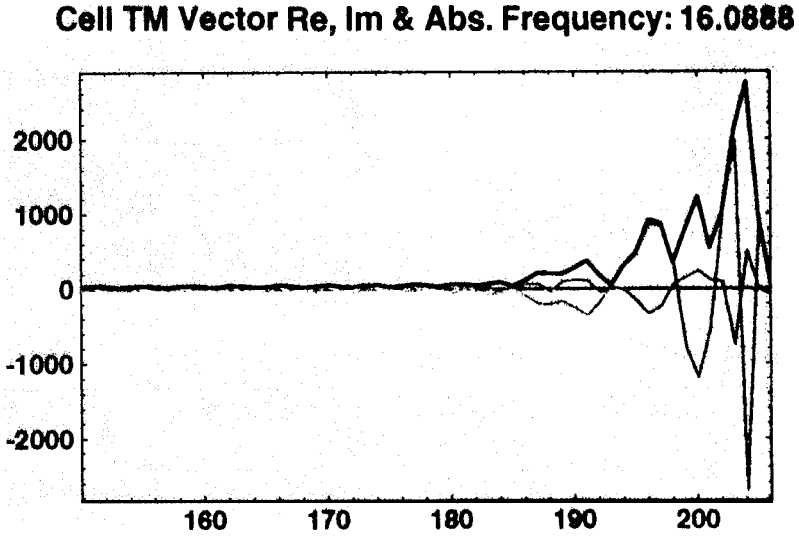

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* For **RDDS1** BBU results as a consequence of decoupling the last few cells (last 4 cells).

* Decoupling gives rise to 5 high-Q modes (one higher than 16,000).

* Even an optimized (Erf distribution coupling to the manifold) for a different bunch spacing shows BBU.

* Reducing the Q of the last few modes improves the wake function significantly and as a result BBU is not observed.

* Kanthol Stainless Steel loading the iris and/or cavity of the last four cells will enable the Q to be approx 1000-1500.

* Other solutions include

1. **SiC** in 4 non-resonant slots in either the outer wall or the outer region of the disks.

2. Couple four lossy dielectric cavities to each cell (this is often done in **TWTs** and sometimes in klystrons to suppress unwanted modes)

3. A more radical design change would be to modify the geometry so that all cells are coupled either downstream or upstream of the fundamental mode coupler and introduce a lossy material into the manifold (**SiC** is a good candidate)

- 3. Interleaving structures, (3 say). This requires tracking **simulations.** (T. Higo)
- We **should aim** to **make the last few cells replaceable,** so that RD**DS1, if time** permits, will have a wake that **meets our** design criteria.

Conclusions

- **RDDS1** as designed, **with** the last 4 cells decoupled, will not **damp down the** transverse wake to sufficiently low levels **so that BBU** is avoided, Howeve[illegible] wake will be be adequate for an AS[illegible] exp.
- Particle **tracking** indicates **DDS1 a[illegible] exhibits BBU**
- **Various means to avoid BBU, which** appears to be driven by one main mode

- To avoid **BBU, the modal Q** of the last few **cells must be approx 1.000. This may** be achieved via:
- 1. Coupling **all** cells, whilst **redesigning** the HOM load such that they 1**ie** downstream or upstream **fundame** mode coupler
- **2. 'Direct loading of** the cells, with **Magnetic Stainless Steel,** or other lossy material, or placing **SiC** in slots into the **walls of the cavitys of the last few cells**