Progress in the RDDS Transverse Wakefields and Avoiding BBU

R.M. Jones

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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.

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

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

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Ra
First Damped Detuned Structure, DDS 1.

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Roger M. Jones, NMK, RH. JW. GS & TR(11-98)
Envelope of Wake Function via Spectral Fn. Method: RDDS Perfect HOM Coupler Termination

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

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

Mormalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: $\{0.00625, 3.6, 0.04\}$
Final Emittance: $\{10.1, 3.61, 0.0644\}$
RDDSC 14 Cells Decoupled and a frey. dependent HOM coupler reflection coefficients.

Non-Linear Lorentzian Fit To Spec Function
$Q, f = 1064.3, 16.0475$

Roger M. Jones, NMK, RHM, JW, GS & TR(11-98)
RDDSC 1 4 cells decoupled and a frequency dependent reflection coefficient. Careful optimisation of upper modes.
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RDDSC 4 cells decoupled and a frequency dependent reflection

Careful optimisation of upper modes.

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**Normalised Horizontal & Vertical Beam Emittance For NLC**

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Initial Emittance: (0.00625, 3.6, 0.04)

Final Emittance: (10.1, 3.6, 0.0407)
Due to Long Range Transverse Wake at BS= 0.8394188824 (2.8ns)

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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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Filter Out Resonance Close To 16.087 GHz

Envelope of Wake Function via Spectral Fn. Method: RDDS1 With Four Cells Decoupled
A HOM Coupler Ref Co & Filtered Mode At 16.09GHz

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer(1-98)
Filter Out Resonance Close To 16.087 GHz

Normalised Horizontal & Vertical Beam Emittance For NLC
Inset is the % Emittance growth
Initial Emittance: (0.00626, 3.6, 0.04)
Final Emittance: (10.1, 3.6, 0.0407)

Filter Out Resonance Close To 16.087 GHz

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer(11-98)
Include Resonance, RDDS1 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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Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang. G. Stupakov & T. Rauenheimer(1-98)
Optimised Coupling vs Standard RDDSI C

RDDSI C: Peak is at 16.089 GHz and the 45 bunch harmonic at 16.0603 (delta-f= 38 MHz for a BS of .84 m).

Optimised RDDSI C has a peak at: 16.105 GHz (delta-f=45 MHz for a BS of .84 m)

A BS of 83.965 cm makes the 45 bunch harmonic separated from the resonance by 38 MHz.

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer (11-98)
Spectral Function for RDDS 1 (4.75, 2.368, 11.25)
Incl. HOM Coupler Transitions and 4 Cells Decoupled

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Rauenheimer (11-98)
Optimised Coupling vs Standard RDDS 1C

RDDS 1C: Peak is at 16.089 GHz and the 45 bunch harmonic at 16.0603 (delta-f= 38 MHz for a BS of .84 m).

Optimised RDDS 1C has a peak at: 16.105 GHz (delta_f=45 MHz for a BS of .84 m)

A BS of 83.965 cm makes the 45 bunch harmonic separated from the resonance by 38 MHz.
Optimised Coupling vs Standard RRDS1C

RRDS 1 C: Peak is at 16.089 GHz and the 45 bunch harmonic at 16.0603 (delta-f= 38 MHz for a BS of .84 m).
Optimised RRDS1C has a peak at: 16.105 GHz (delta-f= 45 MHz for a BS of .84 m)
A BS of 83.965 cm makes the 45 bunch harmonic separated from the resonance by 38 MHz.

Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer(11-98)
Optimised Coupling vs Standard RDDS 1C

RDDS 1C: Peak is at 16.089 GHz and the 45 bunch harmonic at 16.0603 (delta-f= 38 MHz for a BS of .84 m).

Optimised RDDS 1 C has a peak at: 16.105 GHz (delta_f=45 MHz for a BS of .84 m)

A BS of 83.965 cm makes the 45 bunch harmonic separated from the resonance by 38 MHz.
* Lorentzian distributions:

\[ g[f] = \frac{1}{a^2 + b^2(f^2 - c^2)} \]

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

\[ \text{Area} = \pi/(ba) \]

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

\[ \text{Area} = \pi c/(2Qa^2) \]
Non-Linear Lorenzian Fit To Spec Fn.  
Q, f =4180.51 , 16.0885 RDDS 1
Non-Linear Lorenzian Fit To Spec Fn.

$Q_f = 16377., 16.3736$ RDDS 1

Spec Fn (V/pc/mm/m/GHz)

Freq (GHz.)
Last 5 modes replaced by Lorentzians each with a $Q = 1000$.

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

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Spectral Function for RDDS 1 (4.75, 2.368, 11.25)
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Last 5 Modes Replaced With Modes with a $Q = 1000$

Roger M. Jones, N. Rl. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Rauenheimer(1-99)
Roger M. Jones, N. M. Kroll, R.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer (1999)
Last 5 modes replaced by Lorentzians each with a $Q = 1000$.
BS = 0.84 m

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

Roger M. Jones, N. M. Kroll, B.H. Miller, J. Wang, G. Stupakov & T. Raubenheimer(1-99)
* 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. (J. Higo)

We should aim to make the last few cells replaceable, so that RDDS1, if time permits, will have a wake that meets our design criteria.

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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. However, the wake will be be adequate for an ASI exp.

- Particle tracking indicates DDS1 and exhibits BBU

- Various means to avoid BBU, which appears to be driven by one main mode.

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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 lie downstream or upstream fundamental 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 cavities of the last few cells

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