

# MULTIPACTORING SIMULATIONS IN CAVITIES AND HOM COUPLERS

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## Fermilab

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1





### **Analytical Model**

- MatCad simulations. Simple 1-D RF fields. High order resonances.
- Impact energy and SYE file for simulation of the enhanced function
- Quasi 2D model for cavity field near cell equator (V.Shemelin)

## MultiPac 2.1 Package

- Axis-symmetric RF components, such as coupler, cavity, windows
- 2D electromagnetic field distribution in cavities and couplers
- Graphical MATLAB user interface, easy to use

## Analyst (Omega3P)

- Powerful tool for MP phenomena investigation for complex RF devices in real 3D fields
- High order FE for electromagnetic field simulation
- Paralleling algorithm allows to run a few million FE at the reasonable time



#### cavity #2: Vertical test Results

• Strong MP in both HOM couplers

#### • No MP in cavity (0-mode)





Surface magnetic field in "0"-mode.





<u>Cavity No.3. Results of vertical test:</u> MP observed at Eacc~0.7MV/m (Q drop). Quench at Eacc~14MV/m. Second resonance frequency of HOM was tuned higher than designed value.







No MP up-to 23 MV/m in modified design

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HOM1-modif

HOM-1post

0.31

0.4

0.4

0.67







MP in TESLA cavity HOM coupler (cont.)



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CF, Impact Energy and ECF. No MP. Small activity at  $E_{acc}$ ~24 MV/m.

Resonance trajectories near equator



## MP in Low Loss cavity



FE mesh and E&H Fields distribution in LL mid-cell

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MP in LL cavity (cont.)



and secondary yield plot (below)

Counter (CF) (top) and Enhanced Counter Function (ECF) (below). No MP because  $ECF < 0.001, E_{peak}/E_{acc} \sim 2.36$ 



At the equator resonance trajectories was found, but impact energy is too small to create enough secondary electrons

**Distance map** 

MP in Re-entrant cavity



FE mesh and E&M Fields distribution in RE mid-cell

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MP in Re-entrant cavity (cont) İL,



MP in Re-entrant cavity (cont)



At the equator resonance trajectories was found, but impact energy is too small to create enough secondary electrons

Distance map

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**Global Design Effort** 



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## SNS $\beta$ =0.81 cavity



SC SNS cavities  $\beta$ =0.61 and  $\beta$ =0.81 have end tubes with different diameters.

β=0.61 86mm and 130mm β=0.81 96.6mm and 140mm

2D simulations of cavities show the different E-field strength in planes of HOM coupler:

 $\beta$  = 0.61 1.8% and 11.3% of  $E_{max}$   $\beta$  = 0.81 3% and 9.2% of  $E_{max}$ 

Therefore MP activity in HOM coupler can be predicted in coupler placed at the larger diameter end-tube, where the field is higher.



Ez vs z for  $\beta$ =0.61 cavity in 2D (Omega2P)





Analytical simulations show the possibility of multipacting in 4 and 5.3mm gaps between HOM coupler cylindrical body and flat surface of antenna leg.



Analytical simulations for MP and Enhanced Counter Function (ECF) after 20 impacts in 4mm (left) and 5.3mm (right) gaps for F=805MHz and n=1.

Calculation shows: MP\_analytical = ~(160-180) kV/m for 4 mm and ~(210-250) kV/m for 5.3 mm



SNS  $\beta$ =0.81 cavity (cont.) **Enhanced Counter Function (20 impacts)** 1,E+05 1,E+04 1,E+03 1,E+02 -10 15 20 25 30 0 35 Eacc(MV/m) E<sub>acc</sub>=(10-26) MV/m - analytical model E<sub>acc</sub>= 5.1 MV/m - analytical model

Enhanced Counter Function and plots of resonance trajectories after 20 impacts in HOM coupler. ANALYST shows two ranges of multipacting, first one around 5-6MV/m is strong and narrow and second have one order less enhanced counter values but is very wide.





"The analysis of vertical test data on high- $\beta$  cavities shows that the onset occurred from 9.5 to 18.6 MV/m with a mean of 11.7 MV/m, and a standard deviation of 1.8 MV/m. Onset of multipacting was defined as the gradient at which a sudden drop in Q-value was first observed. Typical results are shown in Fig. below."

MOP81

Proceedings of LINAC 2004, Lübeck, Germany

### ANALYSIS OF THE QUALIFICATION-TESTS PERFORMANCE OF THE SUPERCONDUCTING CAVITIES FOR THE SNS LINAC\*

J. R. Delayen<sup>#</sup>, J. Mammosser, J. Ozelis, Thomas Jefferson National Accelerator Facility, 12000 Jefferson Avenue, Newport News, VA 23606, USA



Experimental results on a high-β cavity showing typical multipacting behavior. Black circles show the Q and the blue triangles shown the radiation level measured outside the dewar. ILC 07 May 30-June 3, 2007 N.Solyak 2



- Develop Tools for 1-D, 2-D and 3-D MP simulations in complex SRF cavities and couplers
- Programs are benchmarked using experimental data for 3<sup>rd</sup> harmonic cavity
- MP was simulated for TESLA-ILC, LL, Reentrant, ICHIRO and SNS cavities.