



Multipacting simulation for the SNS/ILC cavity using Analyst

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ANALYST MP Toolkit is a part of the commercial ANALYST package developed by STAR Inc. in frame of SBIR Phase I. Fermilab is collaborating in benchmarking of software.

The three principle components are included:

- The existing ANALYST RF analysis package for simulation of electromagnetic fields.
- A new particle-tracking module specialized for MP analysis based upon the new tracking algorithm developed in Phase I.
- Extension to the ANALYST user interface to display MP statistics and particle tracks based on the development in the Phase I program.

MP IN SNS CAVITY

MOP81

Proceedings of LINAC 2004, Lübeck, Germany

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

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To date, thirty four of the production high beta cavities were RF tested at 2.1 K. Analysis of the RF test data for these cavities shows that thirty one of them exhibited multipacting (MP) during testing and only four of these showed that the barrier was completely processed away during the test.

No obvious MP behavior was observed in the prototype cavities and in the production medium- β cavities.

December 12, 2007

MP IN SNS CAVITY (cont.)

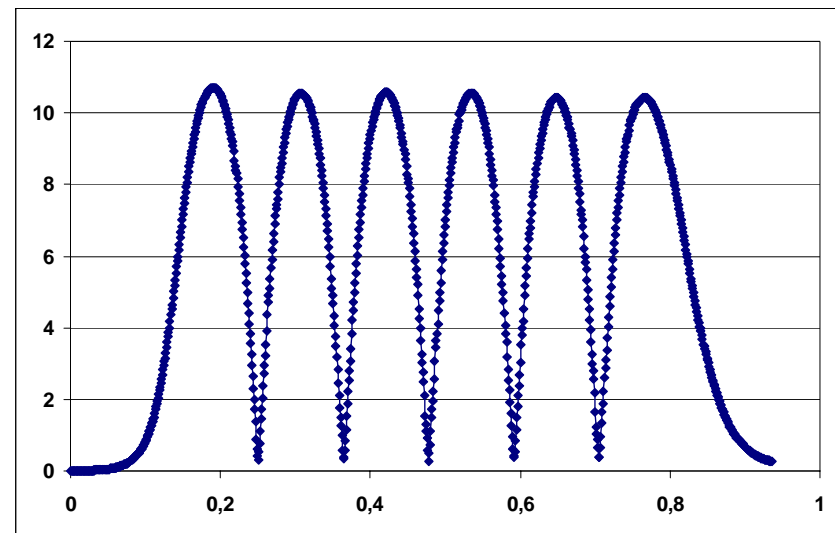
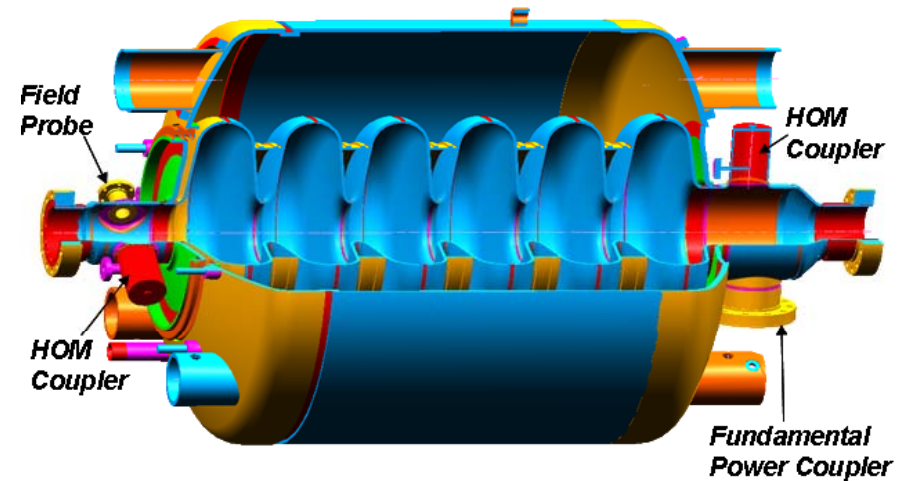
SC SNS cavities have end tubes with different diameters.

$\beta=0.81$ 96.6mm and 140mm

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

3% and 9.2% of E_{\max}

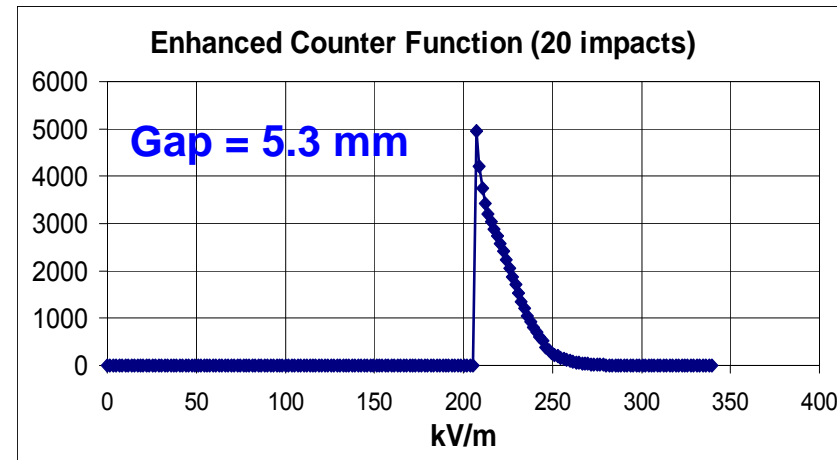
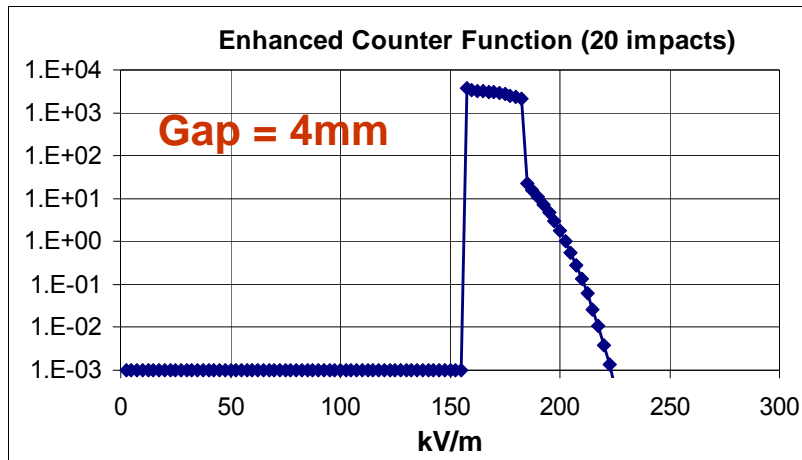
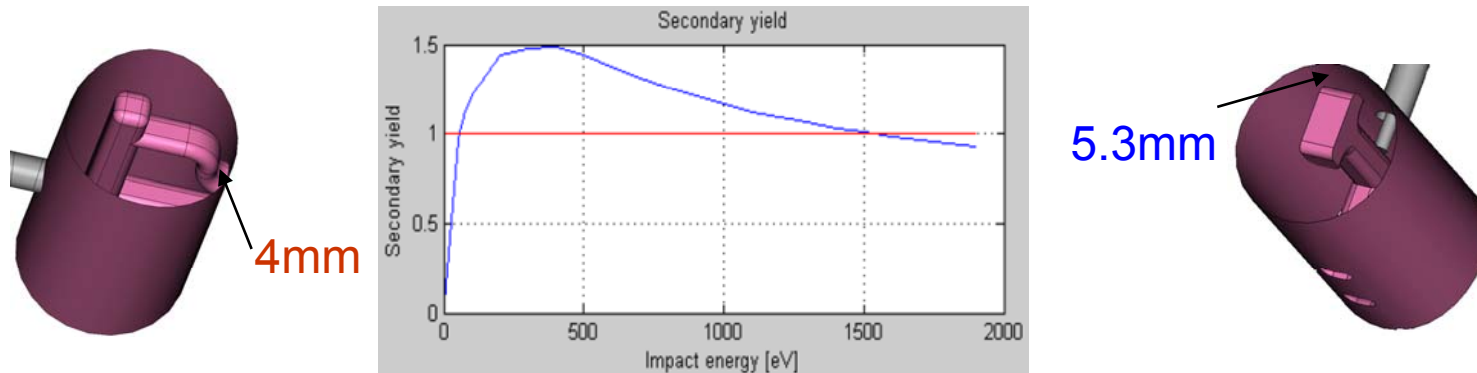
Analyst simulations shows the MP activity in HOM coupler at the larger diameter end-tube, where the field is higher.



E_z (a.u.) vs. z

MP IN SNS CAVITY (cont.)

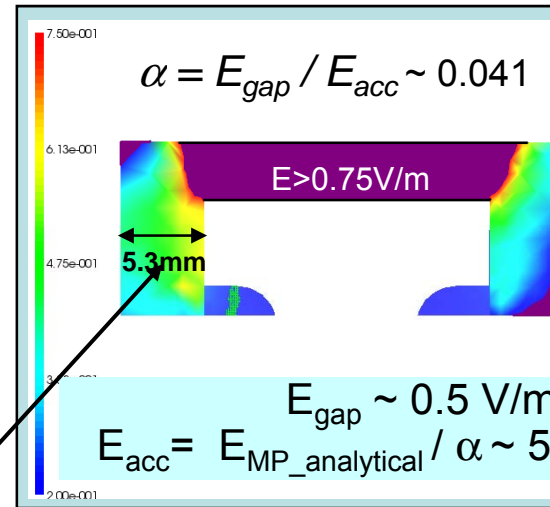
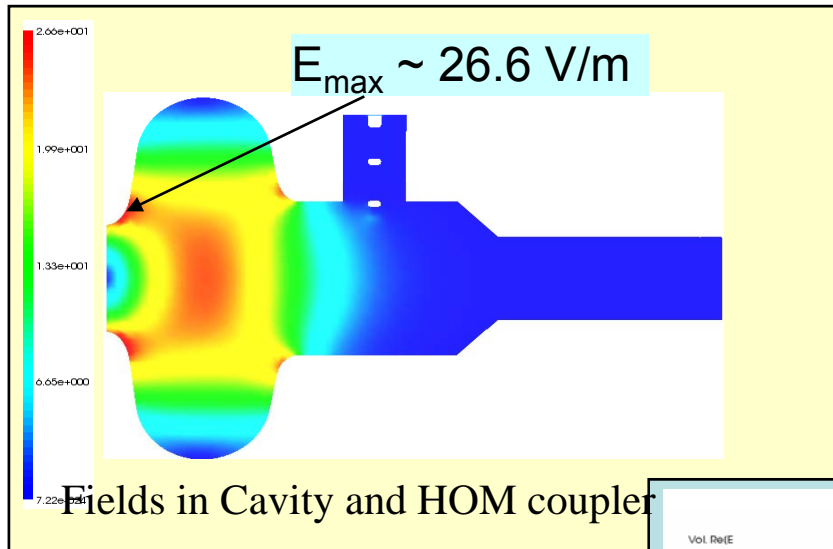
Prediction in simple model: MathCad simulations in 1-D RF fields.
Impact energy and SEY file for simulation of the enhanced function



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

Calculation shows: MP_analytical = $\sim(160-180)$ kV/m for **4 mm** and $\sim(210-250)$ kV/m for **5.3 mm**

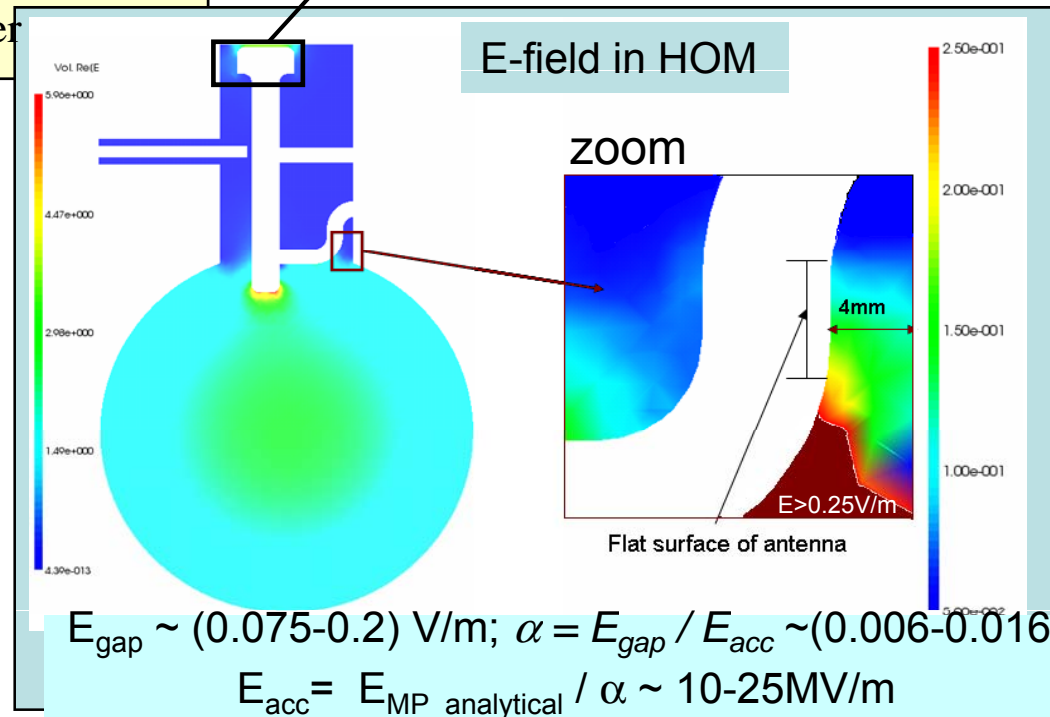
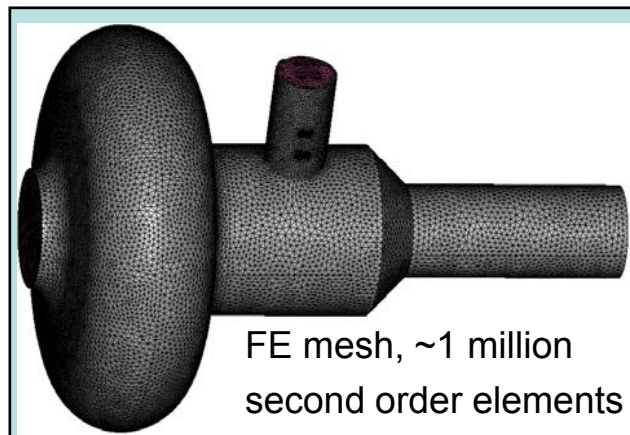
MP IN SNS CAVITY (cont.)



$E_{gap} \sim 0.5 \text{ V/m};$
 $E_{acc} = E_{MP_analytical} / \alpha \sim 5 \text{ MV/m}$

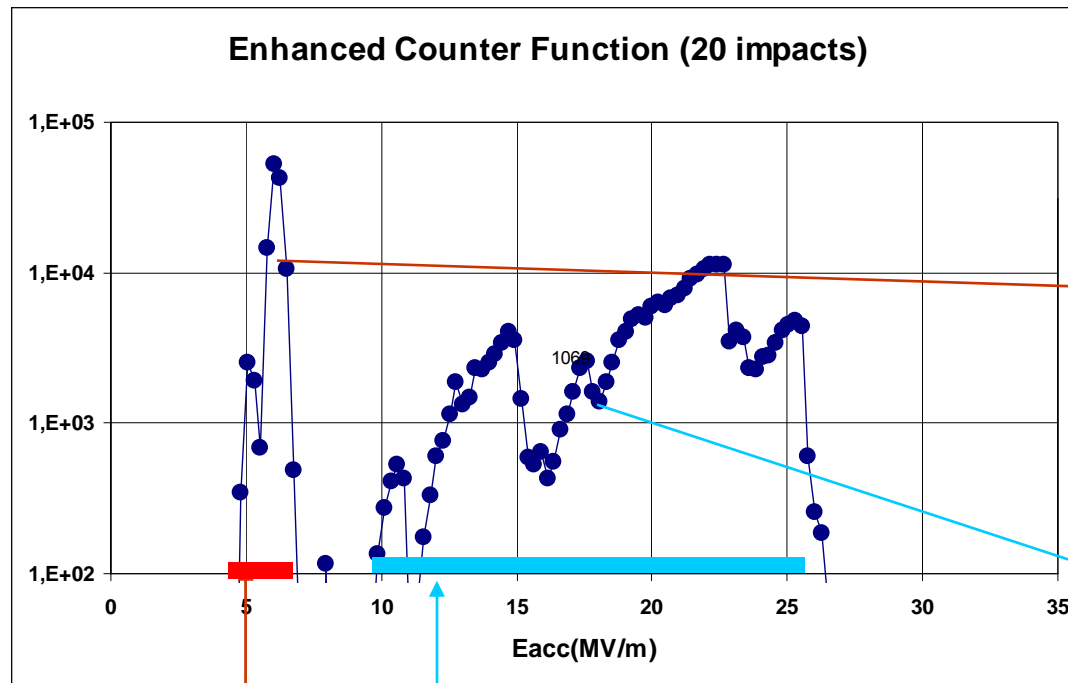
Ratios:

$E_{max} / E_{acc} \sim 2.19$



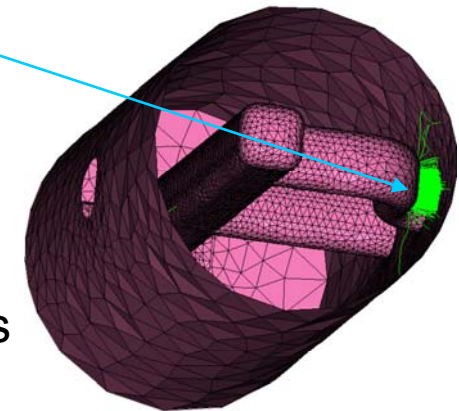
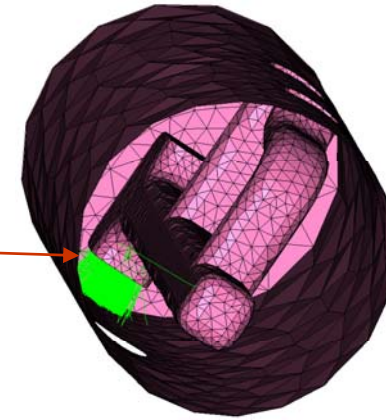
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MP IN SNS CAVITY (cont.)



$E_{acc} = (10-26)$ MV/m - analytical model

$E_{acc} = 5-7$ MV/m - analytical model

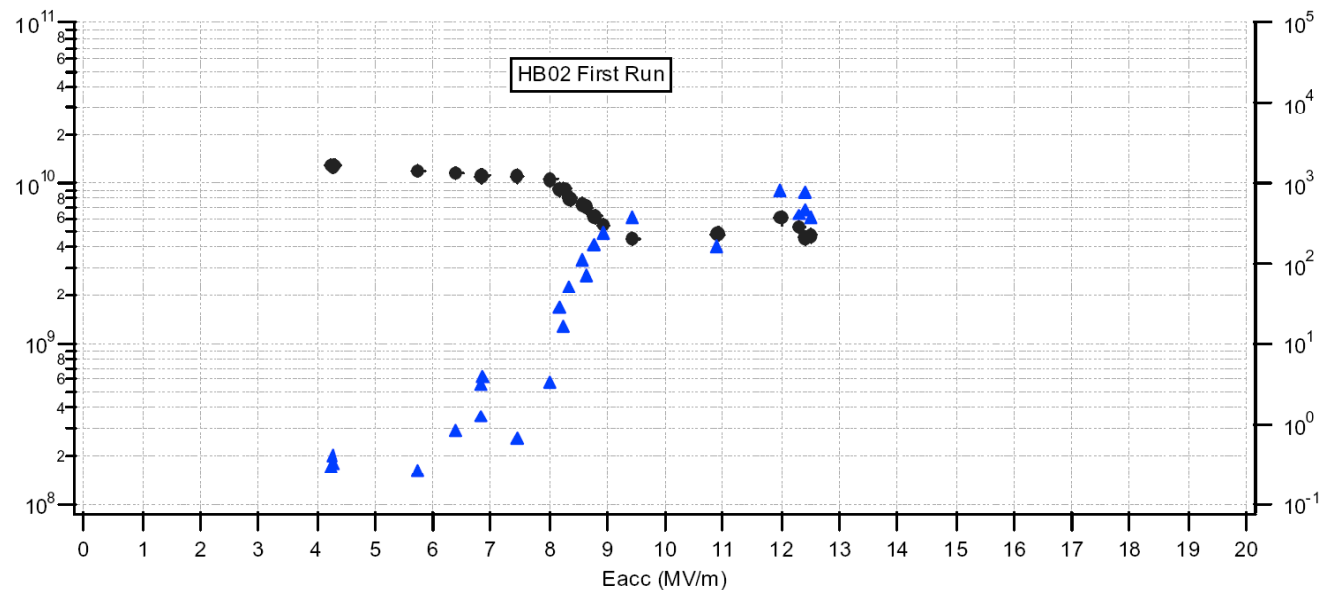


Enhanced Counter Function and plots of resonance trajectories after 20 impacts in HOM coupler. ANALYST shows two ranges of multipacting, first one around 5-6MV/m is strong and narrow and second have one order less enhanced counter values but is wide.

MP IN SNS CAVITY (cont.)

Comparison with experimental data

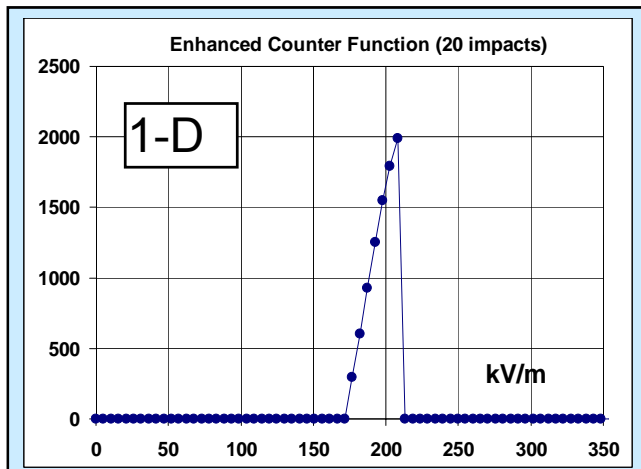
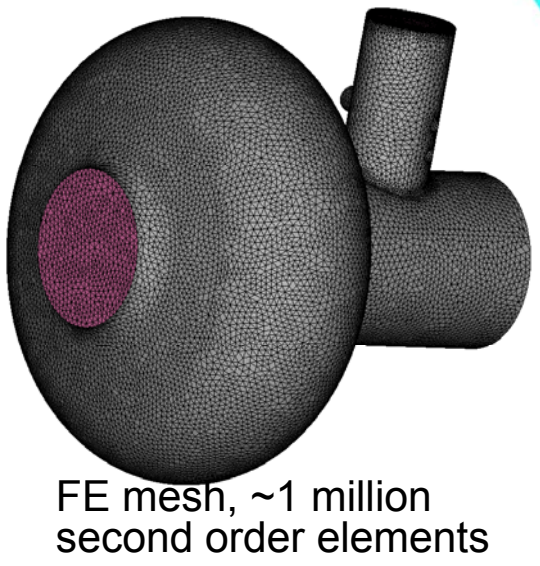
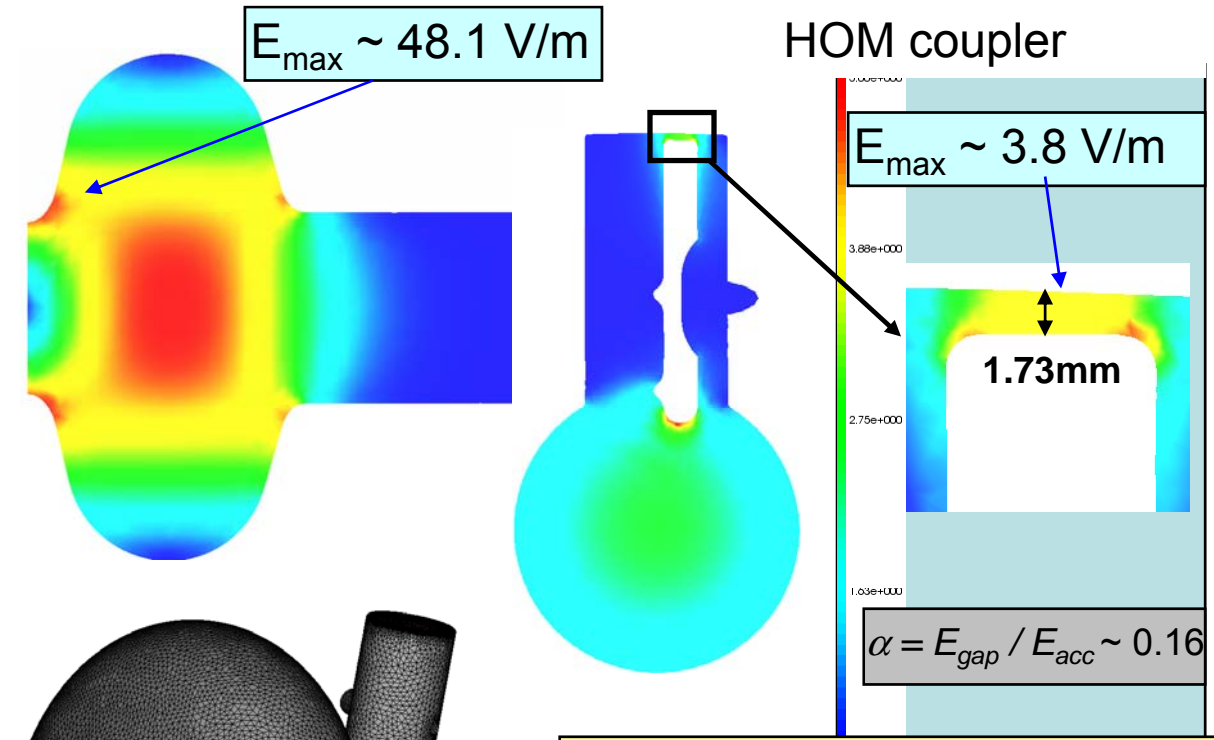
The analysis of vertical test data on high- β cavities shows that the onset occurred from 9.5 to 18.6 MV/m with a mean of 11.7 MV/m, and a standard deviation of 1.8 MV/m. Onset of multipacting was defined as the gradient at which a sudden drop in Q-value was first observed.



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.

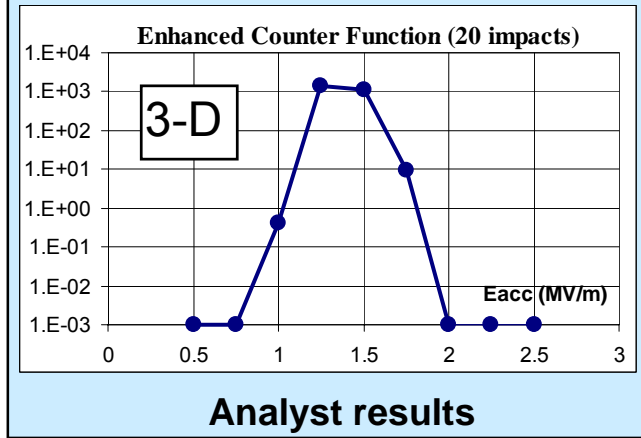
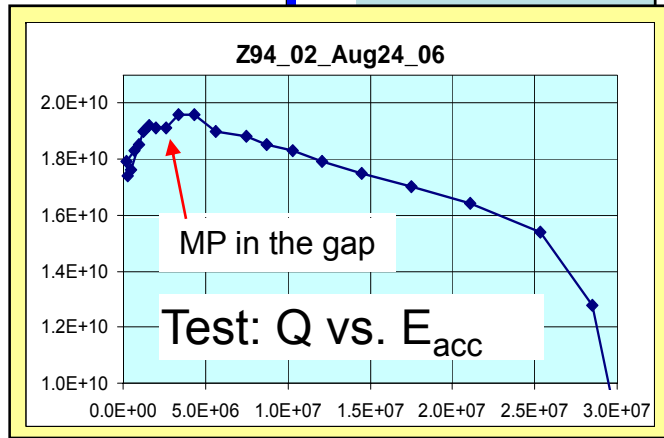
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MP in ILC HOM coupler: notch gap



Enhanced Counter Function for gap 1.73mm and 1.3GHz

$E_{MP_analytical} \sim 200 \text{ kV/m}$
 $E_{acc} \equiv E_{MP} / \alpha \sim 1.25 \text{ MV/m}$

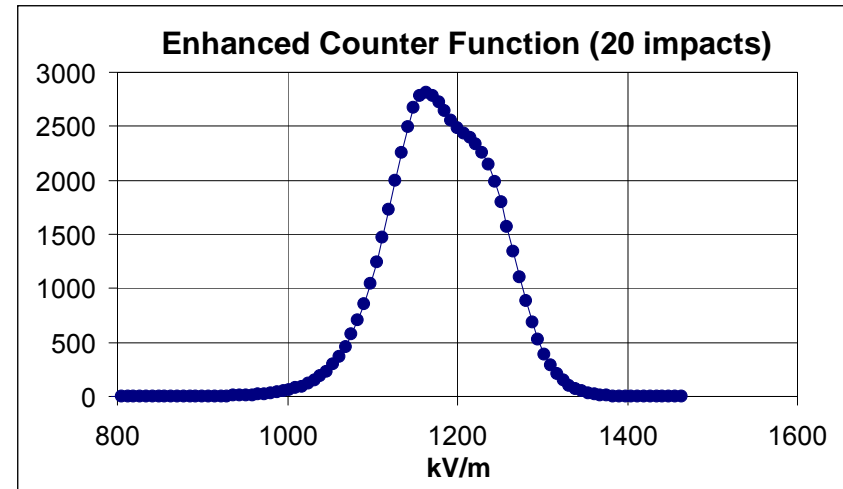
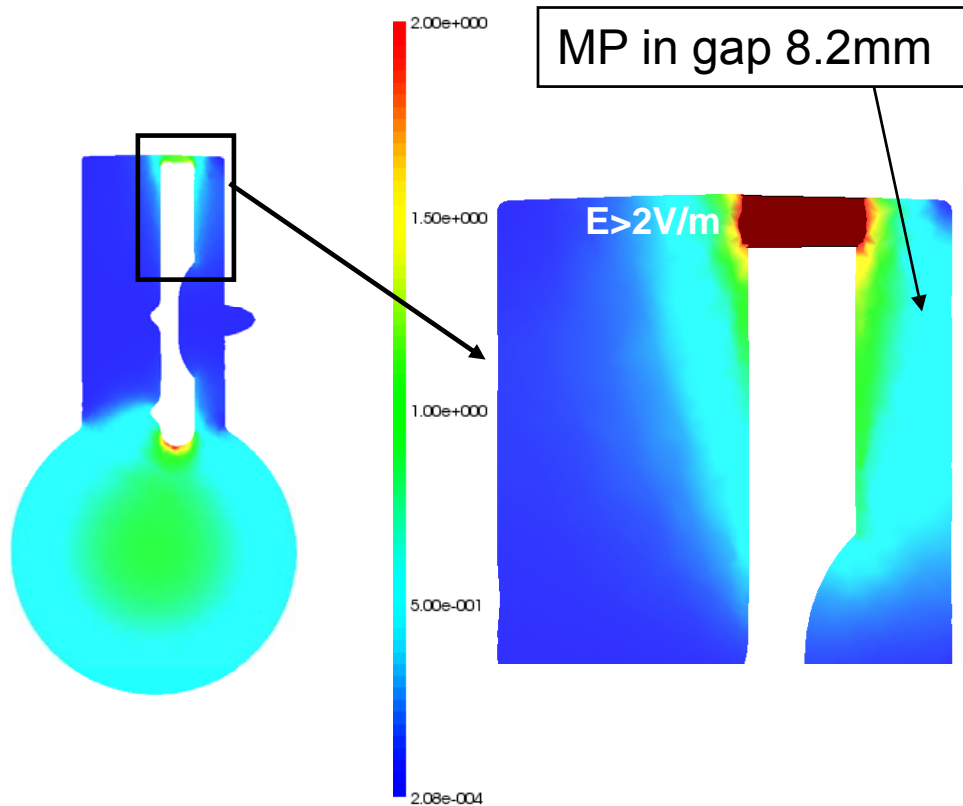


Analyst results

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Good correlation between 1D, 3D&measurements

MP in ILC HOM coupler: leg-wall gap

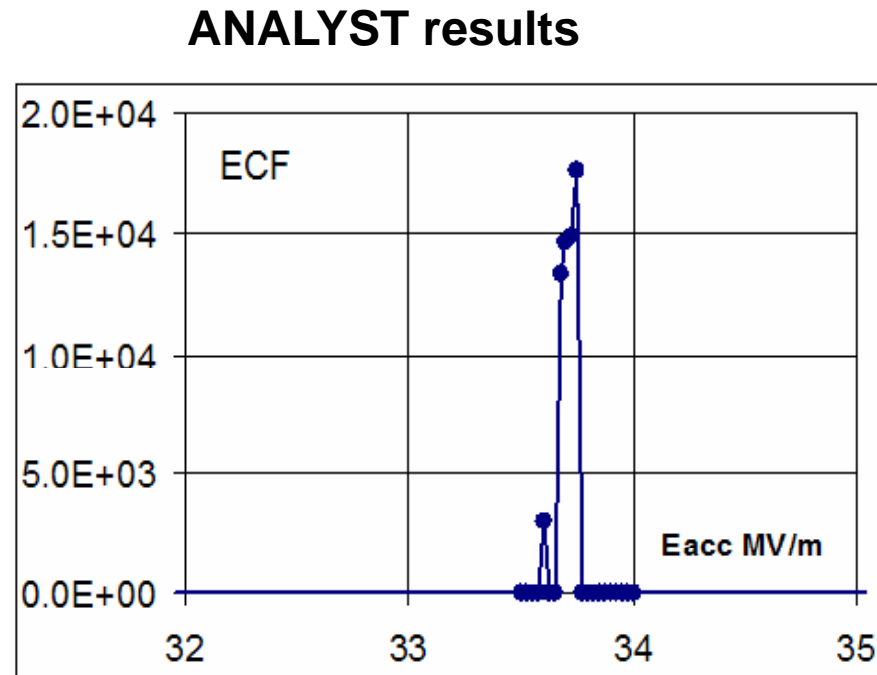
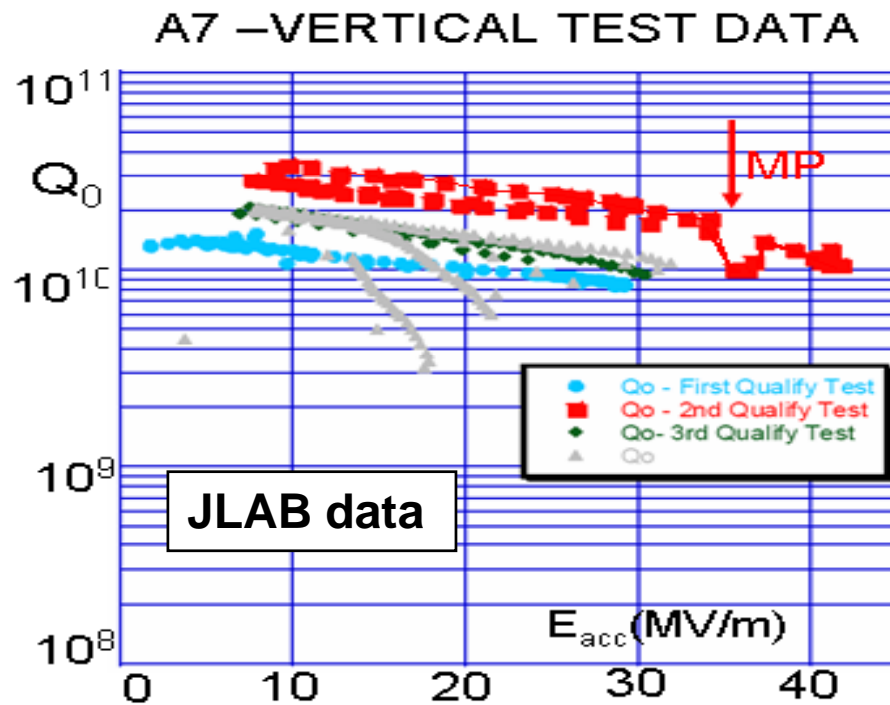


Enhanced Counter Function for
gap 8.2mm and $F=1.3\text{GHz}$ in
Analytical MP model

MP_analytical $\sim 1000\text{-}1300$ kV/m

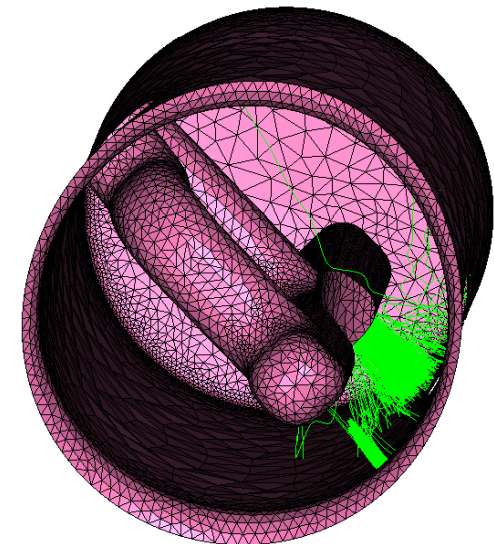
$$E_{\text{gap}} \sim (0.6 - 1.0) \text{ V/m};$$
$$\alpha = E_{\text{gap}} / E_{\text{acc}} \sim (0.025 - 0.042)$$
$$E_{\text{acc}} = E_{\text{MP_analytical}} / \alpha \sim 28 - 45 \text{ MV/m}$$

MP in ILC HOM coupler: leg-wall gap



Q vs. E_{acc} test results of cavity A7 (up left), and the ECF plot calculated by ANALYST (up right). Q-drop is marked by arrow. Resonant trajectories for ILC cavity at $E_{acc}=33.8$ MV/m (right).

Good correlation between 1D, 3D&measurements.



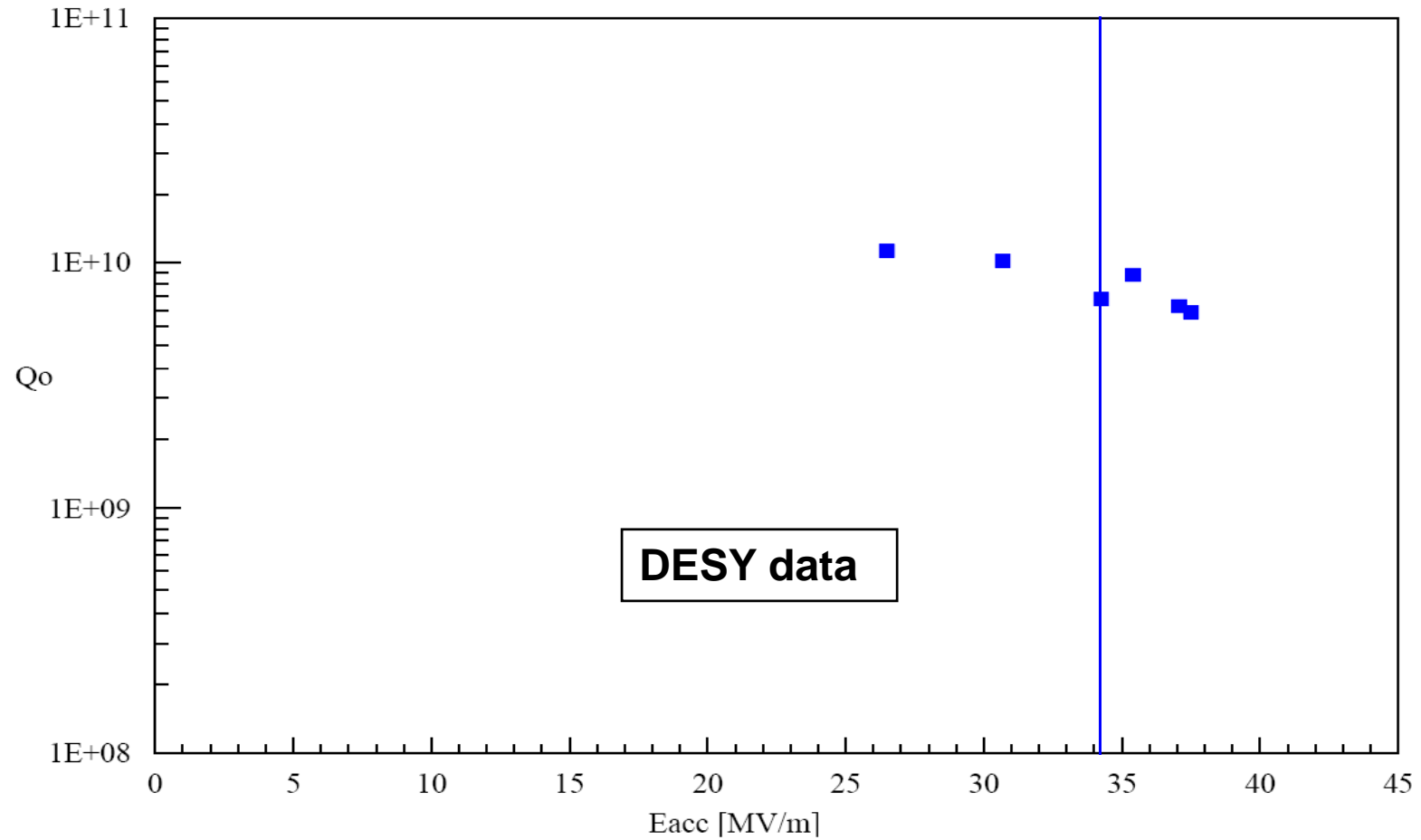
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MP in ILC HOM coupler: leg-wall gap

PULSE Test results: Plotted Q vs. Eacc

Cavity: AC73

Measured on 28-Apr-2003 11:07



December 12, 2007

Summary and Future Plans

Benchmarking of Analyst MP toolkit shows a good agreement between 1D, Analyst simulations and data of measurements of SNS/ILC cavities.

August 2008 will be finished SBIR Phase II “A 3D FE Modeling Tool for Multipacting Analysis”

Review of the secondary emission and back-scattering model

- **secondary yield dependence vs energy and incident angle;**
- **angle and energy distribution for true secondary and reflected electrons**
- **real time tracking**

many other improvements

April 2008 will be finished SBIR Phase I “FE-Based Dark Current Modeling With the Analyst Code”