End-to-End Electromagnetic Simulation of ILC Cryomodule

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With the support of SciDAC initiative for the past decade, SLAC has developed a comprehensive suite of electromagnetic simulation codes ACE3P based on the higher-order finite-element method. One of ACE3P's codes, the eigensolver Omega3P, has increased its computational capability by 5 orders of magnitude, thanks to advances in computational science research. Under ComPASS, Omega3P was applied to end-to-end simulation of the ILC cryomodule consisting of 8 connected superconducting (SRF) cavities. The first-ever calculations of higher-order-modes (HOM) were carried out and provided direct comparison with data measured at the FLASH facility at DESY. The sixteen modes arising from a dipole pair in a single cavity exhibit complicated electromagnetic field couplings between the cavities in the cryomodule. In particular, the twisting of the field polarization along the cryomodule indicates a strong coupling for beam dynamics in the horizontal and vertical directions. Detailed analysis of measured data also showed that the damping factors of HOMs varied among the cavities in the cryomodule due to cavity imperfection. Using measured cavity parameters as inputs, the deformed cavity shape was recovered by solving the inverse problem through an optimization method. The same method was later used to identify the cause of beam breakup in the CEBAF 12-GeV upgrade prototype cryomodule. The applicability of the simulation tools across DOE accelerator complex has exemplified HEP stewardship in accelerator science

Reference(s): C. Yang, W. Gao, Z. Bai, X. Li, L.-Q. Lee, P. Husbands, E. Ng, Siam J. Sci. Comput., **27**, 873 (2005); V. Akcelik, K. Ko, L.-Q. Lee, Z. Li, C.-K. Ng, L. Xiao, J. Comput. Phys., **227**, 1722 (2008).

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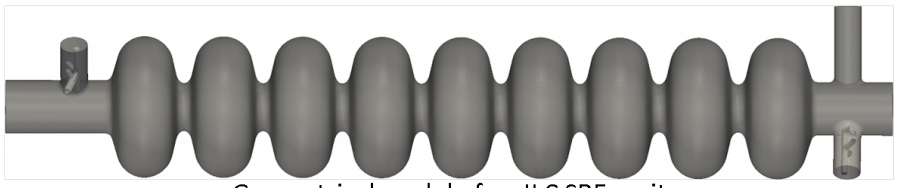
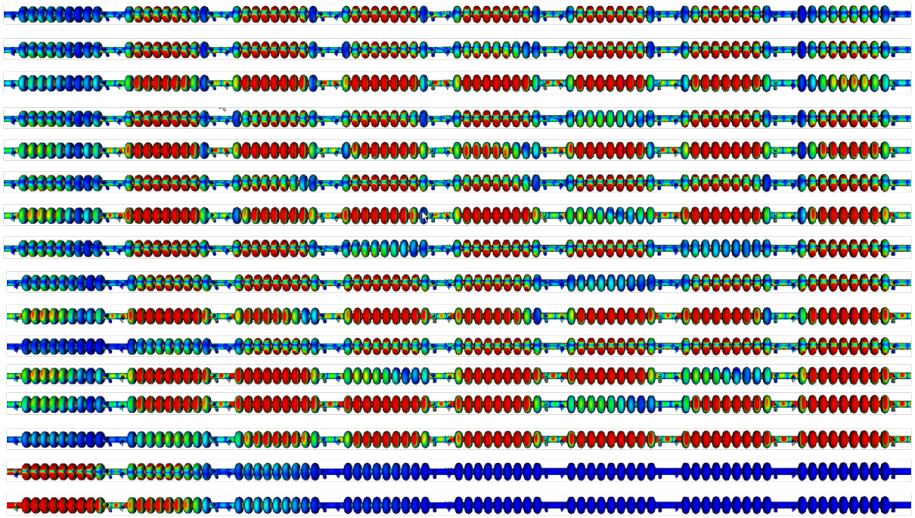


Geometrical model of an ILC SRF cavity



HOMs in an ILC cryomodule