Multiphysics Analysis of RF Cavities for Particle Accelerators: Perspective and Overview

M. Awida[1]

[1]Fermi National Particle Accelerator Laboratory, Warrenville, IL, USA

Abstract

Particle accelerator technology evolves gradually towards improving reliability and efficiency of the accelerator machines, which would reduce their cost for current applications and even make them more accessible to new industrial applications. RF cavities are utilized in particle accelerator machines to propel the particle beam by properly coupling the energy from RF sources to the particle beam. Several multi-physics analyses are needed during the course of designing the RF accelerating cavities, whether they are normal-conducting copper or super-conducting niobium cavities. For copper cavities, electromagnetic heating is always an issue and careful analysis is essential to design the cooling channels and make sure that frequency shift due to mechanical stresses is manageable. On the other hand, frequency detuning is always a concern in super-conducting cavities. The ultra-high quality factor of superconducting cavities, make their bandwidth very narrow such that few tens of Hz frequency shift might get the cavity completely detuned. Frequency detuning is caused by pressure fluctuations in the helium bath or by the radiation pressure of the electromagnetic fields inside the superconducting cavity itself. In that perspective, it is imperative to investigate all sources of detuning with a multiphysics analysis that spans the electromagnetic and solid mechanics physics.

Reference

1. A. Sukhanov, A. Lunin, V. Yakovlev, M. H. Awida, M. Champion, C. Ginsburg, I. Gonin, C. Grimm, T. Khabiboulline, T. Nicol, Yu. Orlov, A. Saini, D. Sergatskov, N. Solyak, and A. Vostrikov. “High Order Modes in Project-X Linac,” NIMA: special issue HOMSC12.
2. M. H. Awida, I. Gonin, T. Khabiboulline, and V. Yakovlev. “Multiphysics Analysis of Normal Conducting RF Cavities for High Intensity Proton Accelerators,” Proceedings from the COMSOL Conference 2013, Boston.
3. M. H. Awida, I.Gonin, T. Khabiboulline, Y. Pischalnikov, W. Schappert, and V. Yakovlev. “Optimization of Mechanical Properties of Superconducting Cavities for Project X LINAC,” Proceedings from the COMSOL Conference 2013, Boston.
4. M. H. Awida, P. Berrutti, T. Khabiboulline, and V. Yakovlev. “Wakefield Loss Analysis of the Elliptical 3.9 GHz Third Harmonic Cavity,” presented at PAC 2013, Pasadena.
5. G. Saewert, M. H. Awida, B. Chase, H. Pfeffer, D. Wolff, and D. Frolov. “Status of PXIE 200 Ohm MEBT Kicker Developement,” presented at PAC 2013, Pasadena.
6. P. Berrutti, M. H. Awida, T. Khabiboulline, D. Passarelli, L. Ristori, and V. Yakovlev. “Tuning Process of the SSR1 Cavity for Project X at FNAL,” presented at PAC 2013, Pasadena.

7. I. Gonin, M. H. Awida, E. Borissov, M. Foley, C. Grimm, T. Khabiboulline, M. Merio, Y. Pischalnikov, L. Ristori, and V. Yakovlev. “New Helium Vessel and Lever Tuner Designs for the 650 MHz Cavities for Project X,” presented at PAC 2013, Pasadena.
8. T. Arkan, M. H. Awida, P. Berrutti, E. Borissov, C. Ginsburg, C. Grimm, E. Harms, A. Hocker, T. Khabiboulline, Y. Orlov, T. Peterson, R. Pilipenko, Y. Pischalnikov, K. Premo, L. Ristori, W. Schappert, and V. Yakovlev. “CM2, Second 1.3GHz Cryomodule Fabrication at Fermilab,” presented at PAC 2013, Pasadena.
9. A. Sukhanov, M. H. Awida, P. Berrutti, C. Ginsburg, T. Khabiboulline, O. Melnychuk, R. Pilipenko, Y. Pischalnikov, L. Ristori, A. Rowe, D. Sergatskov, and Vyacheslav P. Yakovlev, “Cold Tests of SSR1 Resonators for PXIE,” presented at SRF 2013, Paris.
10. V. Yakovlev, T. Arkan, M. H. Awida, P. Berrutti, E. Borissov, A. Crawford, M. Foley, C. Ginsburg, I. Gonin, A. Grassellino, C. Grimm, S. Holmes, S. Kazakov, R. Kephart, T. Khabiboulline, V. Lebedev, A. Lunin, M. Merio, S. Nagaitsev, T. Nicol, Y. Orlov, D. Passarelli, T. Peterson, Y. Pischalnikov, O. Pronitchev, L. Ristori, A. Rowe, D. A. Sergatskov, N. Solyak, A. Sukhanov, and I. Terechkine. “Status of the SRF Development for the Project X,” in SRF 2013, Paris.
11. L. Ristori, M. H. Awida, P. Berrutti, C. Ginsburg, I. V. Gonin, T. Khabiboulline, M. Merio, T. Nicol, D. Passarelli, A. Rowe, D. Sergatskov, A. Sukhanov, and V. Yakovlev. “Development and Performance of 325 MHz Single Spoke Resonators for Project X,” presented at SRF 2013, Paris.
12. N. Solyak, M. H. Awida, I. Gonin, T. Khabiboulline, Y. Pischalnikov, W. Schappert, and Vyacheslav P. Yakovlev. “Optimization of Mechanical Properties of SRF Cavities for Low Beam Current Operation,” in presented at SRF 2013, Paris.
13. L. Ristori, M. H. Awida, P. Berrutti, T. Khabiboulline, M. Merio, D. Passarelli, A. Rowe, D. Sergatskov, and A. Sukhanov. “Design of SSR1 Single Spoke Resonators for PXIE,” presented at IPA C2013, Shanghai.
14. I. Gonin, M. H. Awida, M. Foley, C. Grimm, T. Khabiboulline, Y. Pischalnikov, and V. Yakovlev. “Update of the Mechanical Design of the 650 MHZ beta=0.9 Cavities for Project X,” presented at IPAC 2013, Shanghai.
15. M. Merio, M. H. Awida, P. Berrutti, T. Khabiboulline, D. Passarelli, Y. Pischalnikov, L. Ristori, N. Solyak, and V. Yakovlev. “Update of SSR2 Cavities Design for Project X and RISP,” presented at IPAC 2013, Shanghai.
16. M. H. Awida, S. H. Suleiman, and A. E. Fathy. “Dual-Polarized Low-Profile 16× 4 SIW Cavity-Backed Patch Array for Direct Broadcast Satellite Applications,” presented at 2013 IEEE Radio Wireless Symposium, Austin.
17. M. H. Awida, J. Reid, M. Champion, T. Khabiboulline, and V. Yakovlev, “Multi-physics Analysis of the Fermilab Booster RF Cavity,” presented at IPAC 2012.
18. M. H. Awida, I. Gonin, P. Berrutti, T. Khabiboulline, and V. Yakovlev. “Transverse Kick Analysis of SSR1 Due to Possible Geometrical Variations in Fabrication,” presented at IPAC 2012, New Orleans.
19. M. H. Awida, I. Gonin, P. Berrutti, T. Khabiboulline, V. Yakovlev. “SSR1 HOM Analysis and Measurements,” presented at IPAC 2012, New Orleans.
20. P. Berrutti, M. H. Awida, I. Gonin, J. Ostiguy, N. Solyak, A. Vostrikov, and V. Yakovlev. “Optimization of the Geometric beta for the SSR2 Cavities of the Project X,” presented at IPAC 2012, New Orleans.
21. P. Berrutti, M. H. Awida, I. Gonin, J. Ostiguy, N. Solyak, and V. Yakovlev.“Multipole Effects

in the SSR2 Cavities of Project X Front End," presented at IPAC 2012, New Orleans.