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Validated, 3-dimensional, magneto-hydrodynamic simulations of optimized single and nested wire array z-pinches with detailed circuit coupling[1]

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Wire array Z-pinches have been used successfully for many years as a powerful x-ray source, as a dynamic hohlraum, and as an intense K-shell source. Significant progress has been made in modeling these 3D resistive plasmas however predictive modeling also requires an accurate representation of the power delivered to the load, which is an uncertainty potentially as large as the MHD implosion dynamics. We present 3D resistive MHD simulations of wire arrays that are coupled to a transmission line equivalent of the Z generator separately representing the 4 vacuum insulated transmission lines that join through a double post-hole convolute into a final feed to the array. Significant (multi-MA) current losses are shown to occur in the convolute and the final feed. This limits the array performance and must be correctly accounted for to accurately represent the generator response. Our simulations are validated against data for compact, 20mm diameter, 10mm long wire arrays. This is the most comprehensive experimental data set for single and nested wire arrays and includes voltage, current, x-ray power and energy, and multiple mass distribution measurements. These data tightly constrain our simulation results and allow us to describe, for the first time, the detailed mechanism by which nested arrays can be used to narrow the radial mass distribution and increase the peak x-ray power. We use these results to define criteria for optimizing the x-ray power output from these and other nested wire array sources. In collaboration with: M. E. Cuneo, J.P.Chittenden, W.A. Stygar, B. Jones, D. J. Ampleford, E.M. Waisman, M.E. Savage, K. LeChien, D.B. Sinars

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