Electromagnetic Simulation on Emerging Hardware Architecture

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***Abstract*— We will present results for porting electromagnetic simulation tools to emerging hardware accelerators, such as the graphics processing unit (GPU) or many integrated core (MIC) architecture. We will show application of these hardware accelerators to simulations of rf cavity structures. We will also discuss how we are working to integrate these accelerators into the industrial design process to create desktop supercomputing for engineers.**

Keywords-graphics processing unit, many integrated core, supercomputing

I. Introduction

Electromagnetic systems, such as those for high power microwave generation or high current electron beam generation, rely on modeling as one of the most effective ways to reduce design costs. Frequently the level of detail required to adequately model these devices necessitates using high performance computing power. However, many high performance modeling tools are too difficult for design engineers to use on a daily basis. The goal, therefore, of a new project underway between Niowave, Inc. researchers and Tech-X Corp. researchers is to improve the usability of high-performance computing software to make the software more effective in the electromagnetic component design process.

II. Motivation

Electromagnetic systems benefit from detailed numerical modeling. For instance, one might hope to understand in detail how a system might oscillate at unwanted frequencies, such as higher-order modes (HOMs). In a case of particular interest to the ship-board free electron laser community, researchers have designed a 700 MHz cavity as a high-current electron source, but researchers are concerned that the beam may drive the cavity at its many higher modes.

The implications of these induced fields at unwanted frequencies have been extensively studied in the context of superconducting accelerators because they add to the cryogenic load and can cause beam instabilities. Up until now, this analysis has almost always been performed for constant-velocity particles. To properly design a high-brightness, high-current superconducting electron source requires a self-consistent approach that calculates the driving of HOMs by an electron beam which is accelerated from rest to the speed of light over a distance on the order of a few cm.

This process requires the use of high-performance computing resources to be efficient. The resolution of the cavity structure often requires full use of available computing hardware, either through parallel computing or hardware acceleration such running on a GPU. Parameter scans requiring many separate simulations may be needed which will require sufficient computing resources and simulation software specifically designed to allow parameter scans.

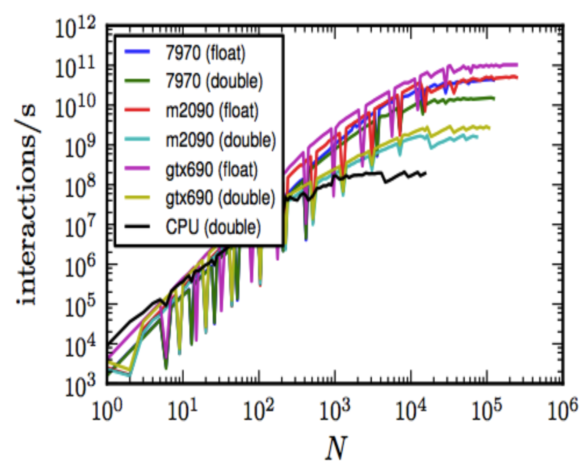

Figure 1 . Speedup versus number of compute cores for particle space charge calculations in free space (no metallic boundaries). We performed these space charge calculations on various multi-core CPU (black line) and GPU (colored lines) architectures. The GPUs in this work are the AMD 7970, the NVidia Tesla m2090, and the NVidia gtx690, all in both floating point and double precision. Determining what hardware performs best for more detailed electromagnetic applications is a main thrust of this new research effort between Tech-X Corp. and Niowave, Inc.

III. Results

As a first result, we show in Fig. 1 some preliminary work for speedup versus number of compute cores for particle space charge calculations in free space (no metallic boundaries). We performed these space charge calculations on various multi-core CPU (black line) and GPU (colored lines) architectures. The GPUs in this work are the AMD 7970, the NVidia "Tesla" m2090, and the NVidia gtx690, all in both floating point and double precision. Determining what hardware performs best for more detailed electromagnetic applications is a main thrust of this new research effort between Tech-X Corp. and Niowave, Inc.