PARALLEL COMPUTATION OF INTEGRATED ELECTROMAGNETIC, THERMAL AND STRUCTURAL EFFECTS FOR ACCELERATOR CAVITIES*

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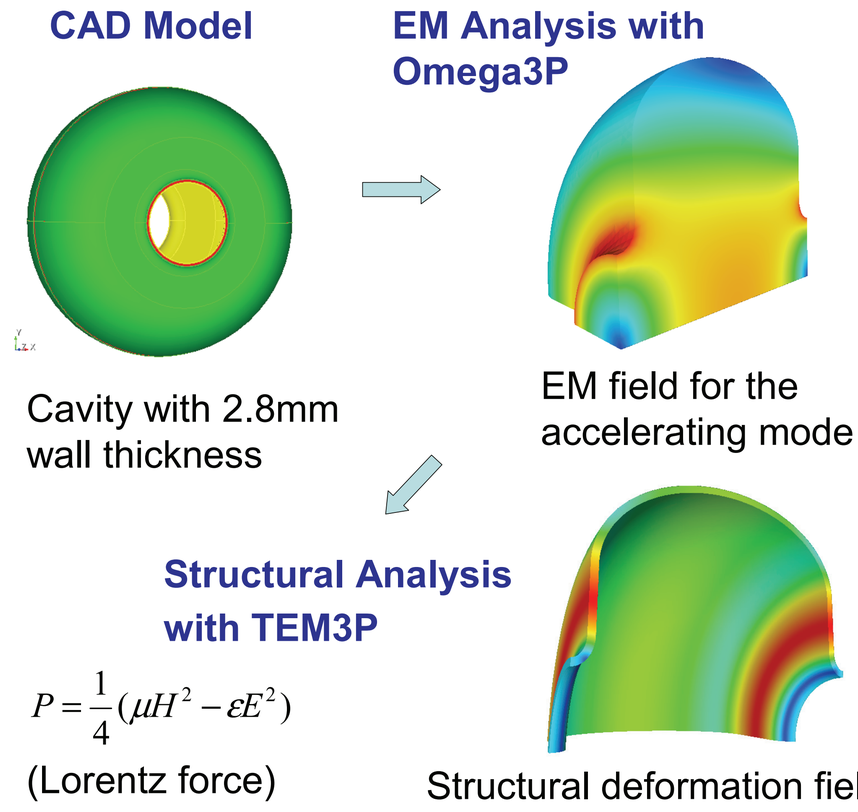
The successful operation of accelerator cavities has to satisfy both rf and mechanical requirements. It is highly desirable that electromagnetic, thermal and structural effects such as cavity wall heating and Lorentz force detuning in superconducting rf cavities can be addressed in an integrated analysis. Based on the SLAC parallel finite-element code infrastructure for electromagnetic modeling, a novel multi-physics analysis tool has been developed to include additional thermal and mechanical effects. The speedup from parallel computation enables virtual prototyping of accelerator cavities on computers, which would substantially reduce the cost and time of a design cycle. The multi-physics tool is applied to the LCLS rf gun for thermal and structural analysis, and to an SRF (ICHIRO) cavity for Lorentz force detuning analysis.

A Multi-Physics Simulation Toolkit

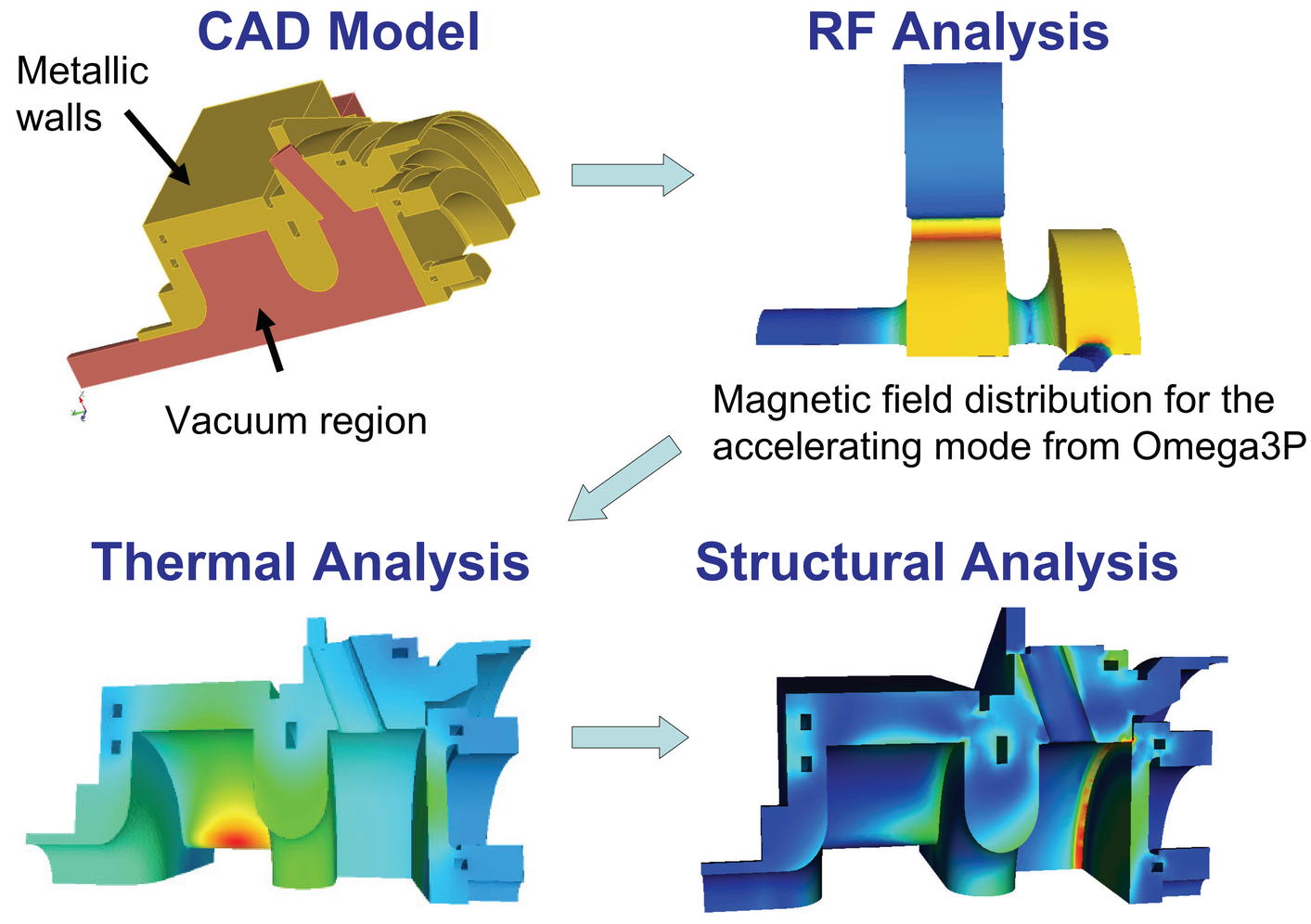
- In the design of accelerator cavity, thermal and mechanical considerations are as important as electromagnetic effects.
- It is highly desirable to build a modeling package that integrates EM, thermal, and mechanical effects.
- Recently, SLAC has developed a parallel multi-physics simulation tool, TEM3P, for design and analysis of thermal, structural and electromagnetic effects such as cavity wall heating, and Lorentz force detuning simulations.
- The parallel EM particle-in-cell code Pic3P is used to simulate beam dynamics and calculate emittances.
- All multi-physics simulations are done in a single framework, and a complete tool for engineering prototyping is provided.
- TEM3P and Pic3P both share the same finite-element infrastructure with the EM finite-element codes already developed at SLAC.
- Parallel implementation allows large scale computations on massively parallel supercomputers.

Lorentz Force Detuning of Ichiro Cavity



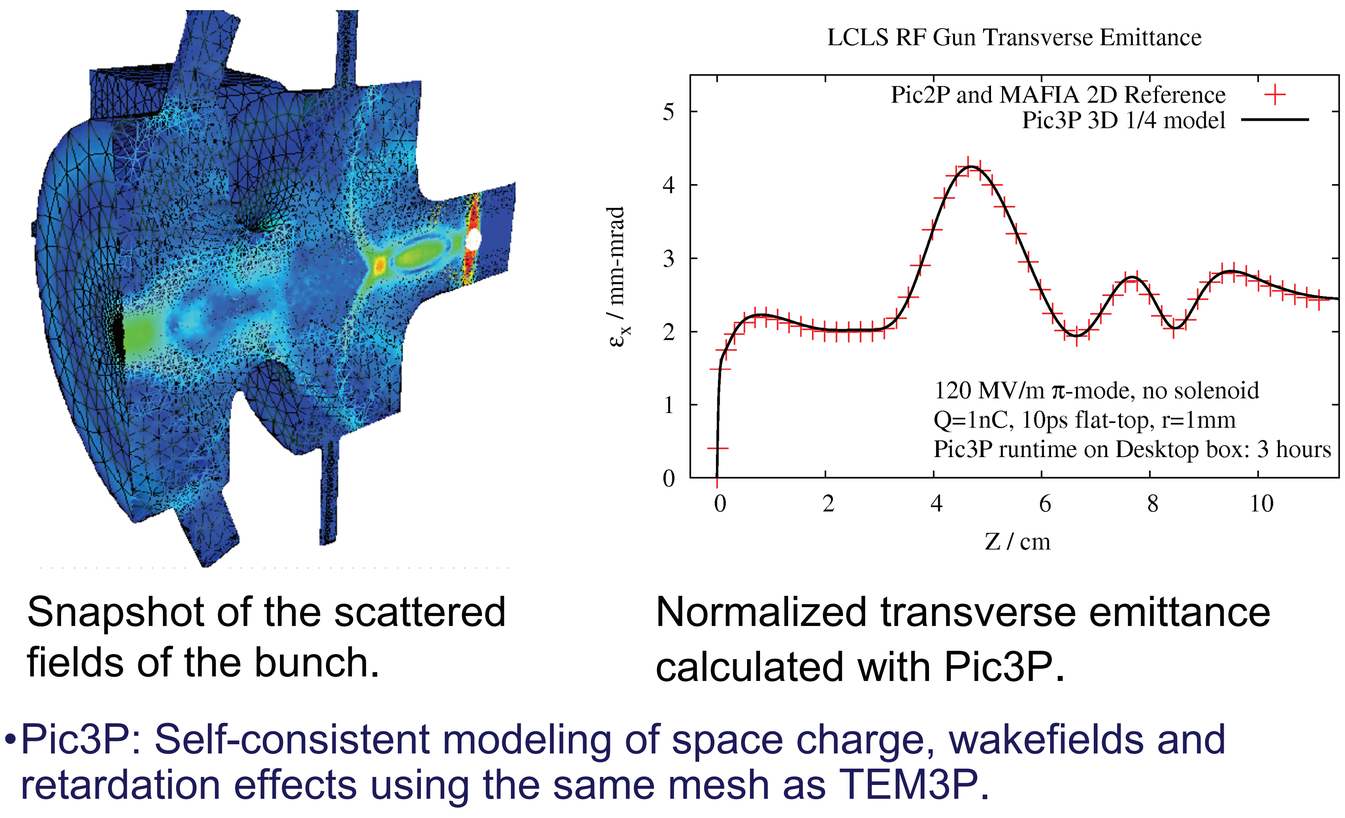
Numerical Prototyping of LCLS rf Gun

RF, Thermal and Structural Simulation



- CAD model includes cavity vacuum region and surrounding metallic walls with detailed cooling channel layout.
- Thermal and mechanical analyses benchmarked against ANSYS.
- The frequency shift is 650 kHz as the average RF heating power increased from 0 to 4 kW.

Emittance Calculation with Parallel Finite Element EM Particle-In-Cell Code Pic3P



Snapshot of the scattered fields of the bunch.

Normalized transverse emittance calculated with Pic3P.

- Pic3P: Self-consistent modeling of space charge, wakefields and retardation effects using the same mesh as TEM3P.

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