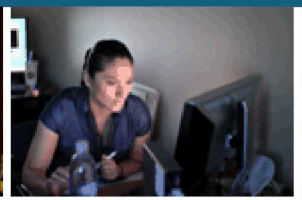
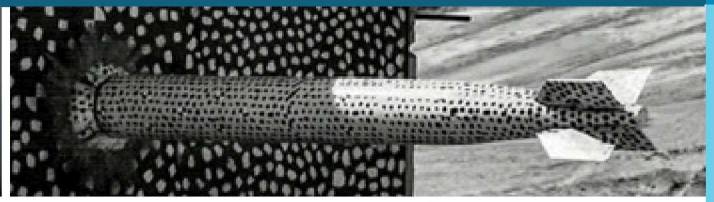
SAND2019-5312PE

Gemma: an ATDM Electromagnetics Code





PRESENTED BY

Salvatore Campione

SAND2019-XXXX

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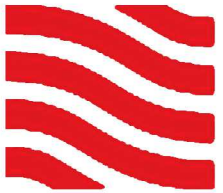
Gemma: Present Activities



Gemma

- Gemma is a new electromagnetic radiation modeling application written for modern heterogeneous compute architectures tailored toward nuclear deterrence

FY19

- Identify Plan Forward on Gemma UI/UX
- MPI Implementation and Demo on CPU/MIC or CPU/GPU
- First Demo of Representative Coupling Simulation
- Implement time history of unit test coverage/regression test timing
- Iterative Physical Optics (IPO) Implementation and Demo

Motivation:

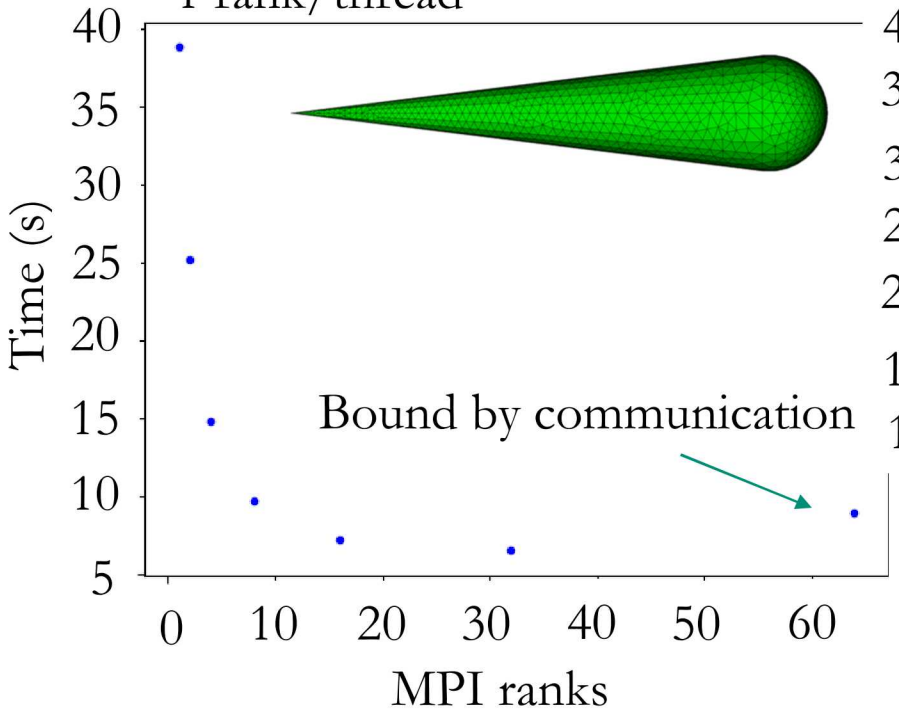
- Establish physics capabilities for Sandia use cases
- Establish V&V early in code lifecycle
- Enable parallel simulations across multiple nodes/ranks
- Demonstrate candidate alternative modeling methods

Gemma: Recent Progress

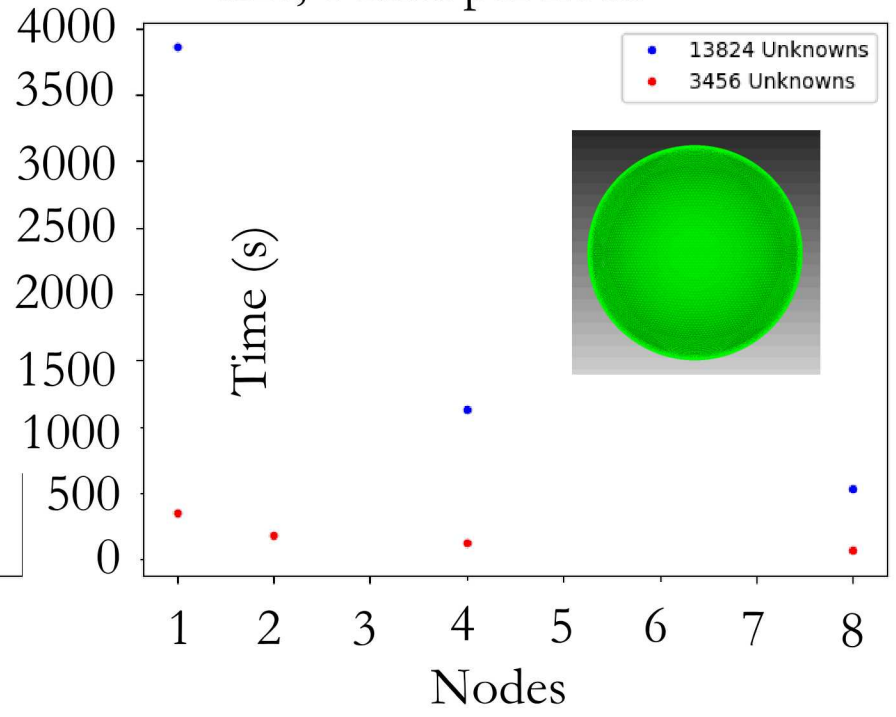
Gemma

- Gemma has a working MPI version that has been tested on small problems on between 1 and 8 nodes. Work is ongoing to validate performance on larger problem sizes and increased node counts.

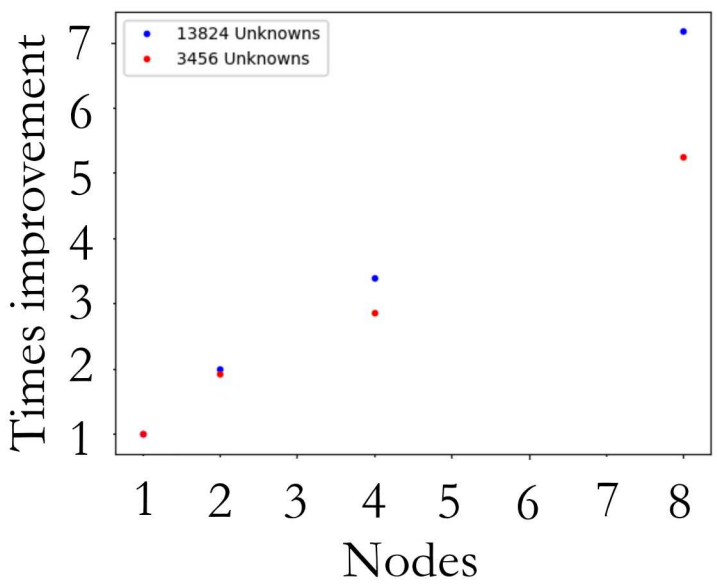
Single machine, multiple ranks, 1 rank/thread



Multiple nodes, same problem size, 1 rank per node



Strong scaling plot



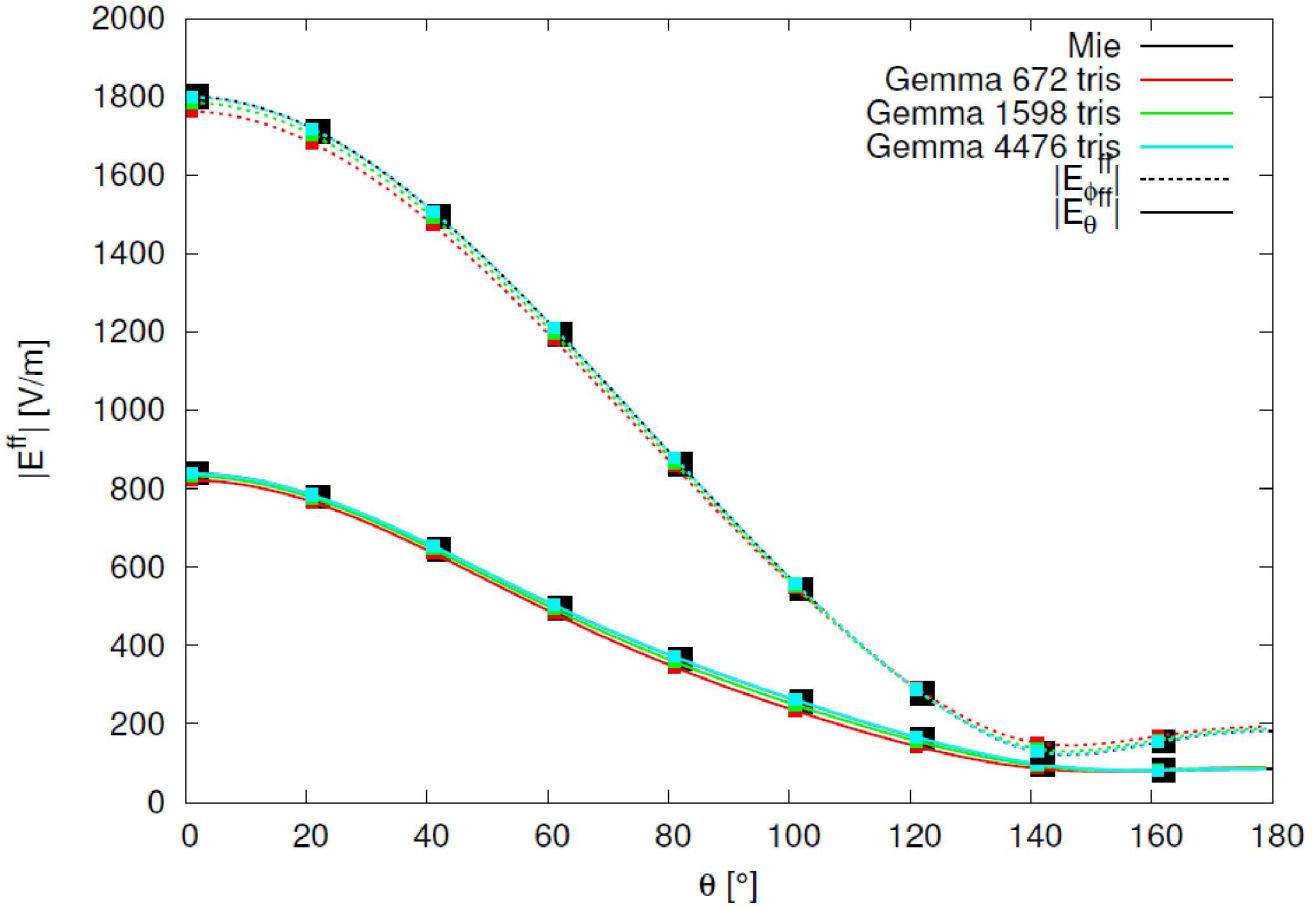
Reasonably good scaling on Mutrino (CPU)

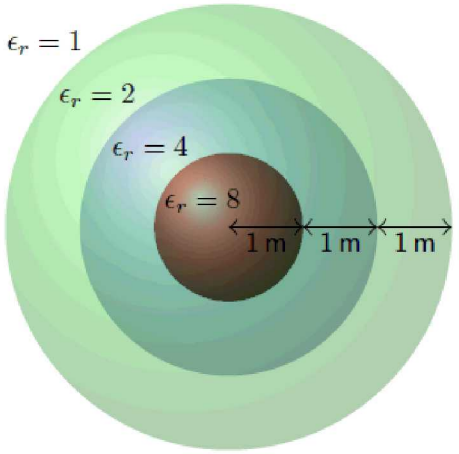
- Currently bound by memory for increasing problem size; taking steps to improve this as function of node count

Gemma: Recent Progress

Gemma

- Initial implementations for multiple regions and dielectrics have been completed paving the way for initial coupling simulations.



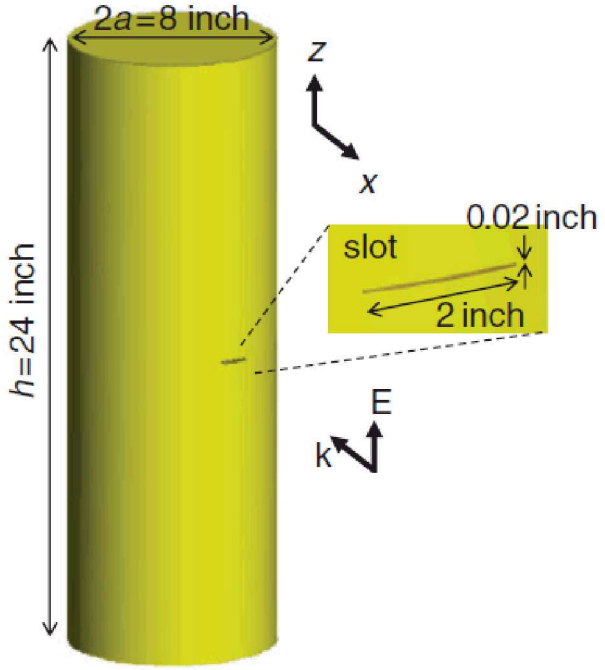


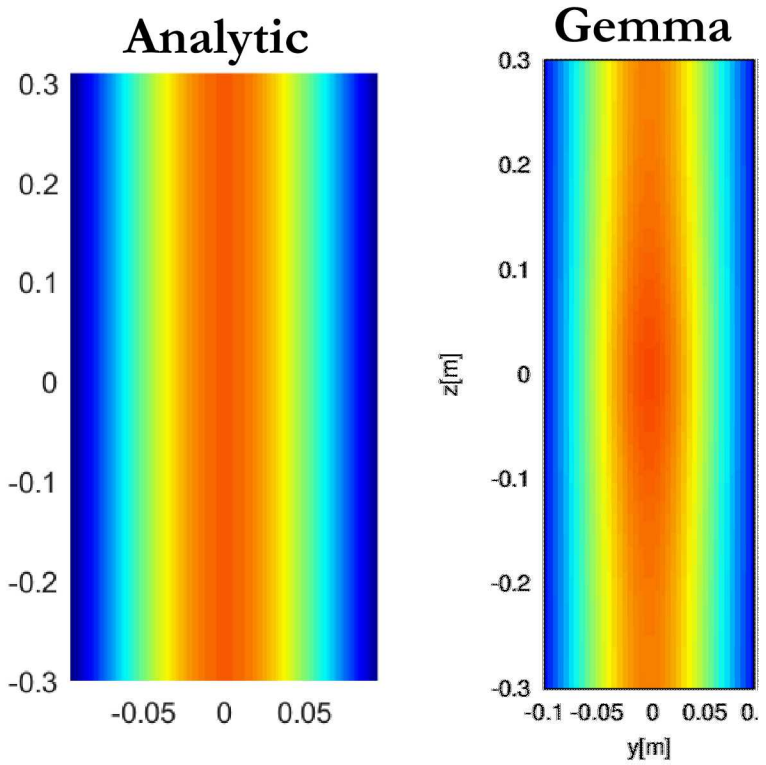
- $+z$-traveling wave, $\mathbf{E} = 377\,\mathrm{V\,m^{-1}}\hat{\mathbf{x}}$
- Frequency 30 MHz
- Far-field scattered $\mathbf{E}$ computed at $\varphi = 65°$

Gemma: Recent Progress

Gemma

- Very first coupling simulation in Gemma shown for a canonical cylindrical slotted cavity





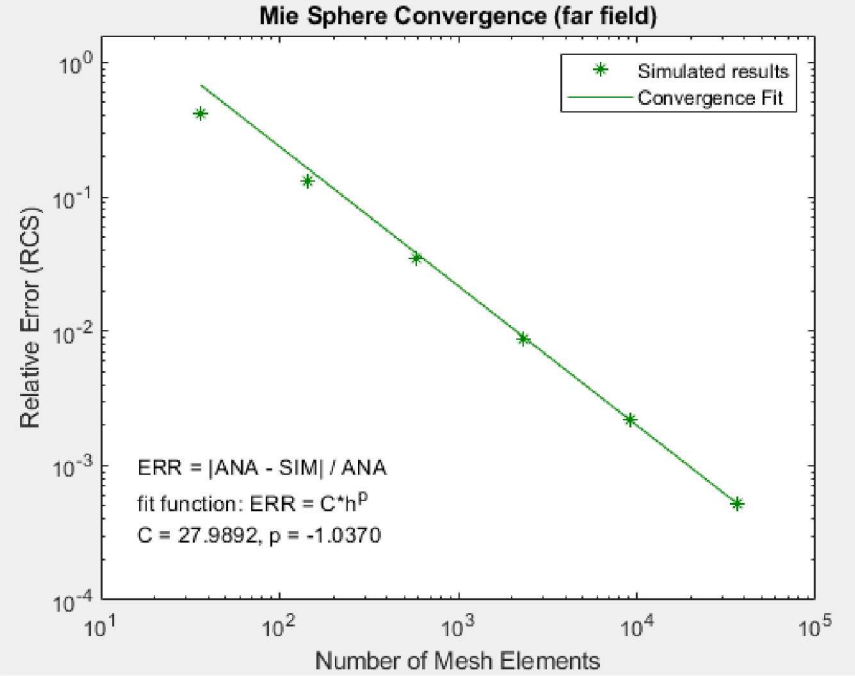
- Gemma shows proper field distribution within the cavity
- More work is needed to verify accuracy

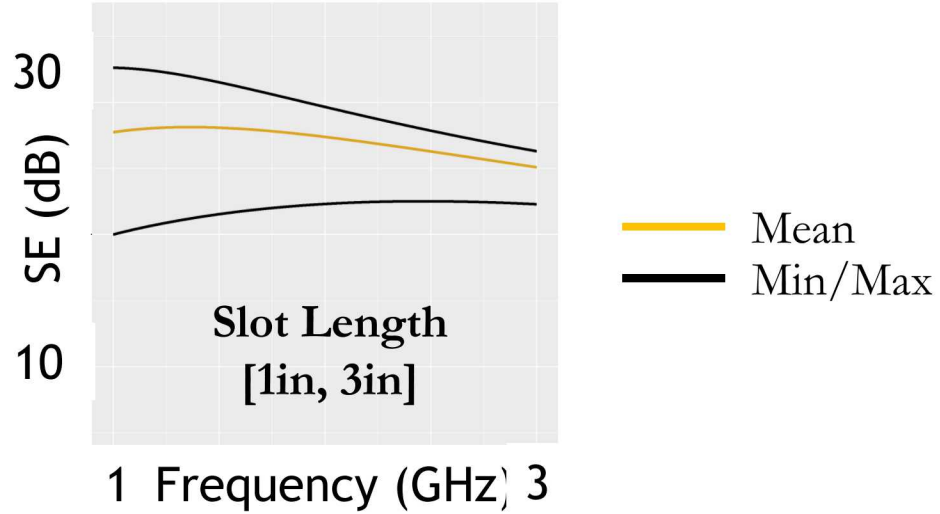
- Development of Pliris direct solver for GPUs together with Kokkos Kernels
- Tracked timing for gcc, clang, and cuda based builds
- Initial Iterative Physical Optics code implementation is being tested to verify correct results and limitations for coupling to analytical power balance codes.

Gemma: Recent Progress

Gemma

- Integrated Workflow (IWF) is proceeding with EIGER testing for both serial and parallel simulations. This activity will inform the Gemma UI/UX development.
- Collaboration with Trilinos has allowed us to use Trilinos-maintained cmake and testing. This has streamlined building and testing on new machines.
- Initial V&V (with 1544) against analytical solutions initiated and providing expected convergence rates. Drafting a V&V and UQ plan
- Initial sensitivity analysis (with 9136) using analytical power balance code



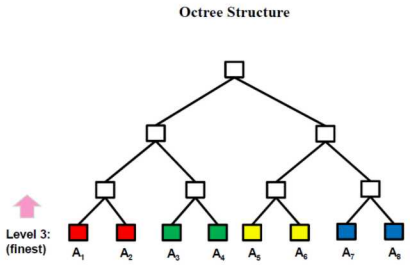


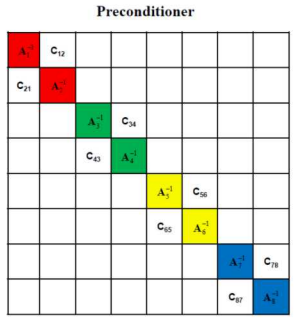
Dependencies on other ATDM Capabilities and Services

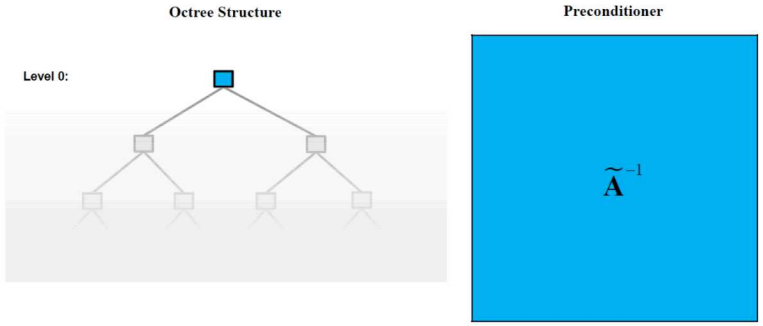
- Primary dependency is on Kokkos. Planned future interaction with Kokkos to see where Gemma's performance can be improved
- We plan on increasing our dependence on Belos and possibly a preconditioner library
- We use a handful of helpful features from Teuchos

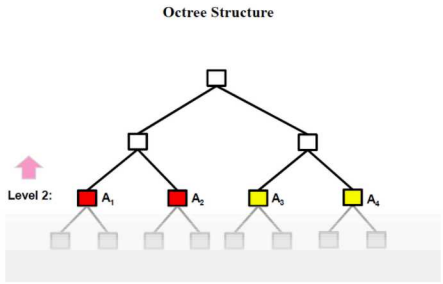
Linkages and Contributions to ATDM Applications or Capabilities

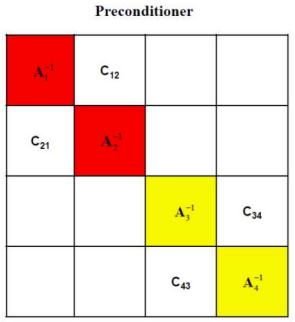
- In collaboration with Ohio State University, the Generalized conjugated residual (GCR) + Schur- Principle Component Analysis (PCA) preconditioner has shown great promise for our applications. This could be developed in collaboration with Trilinos

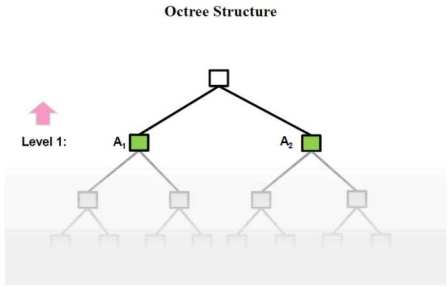


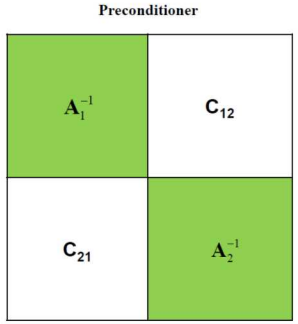


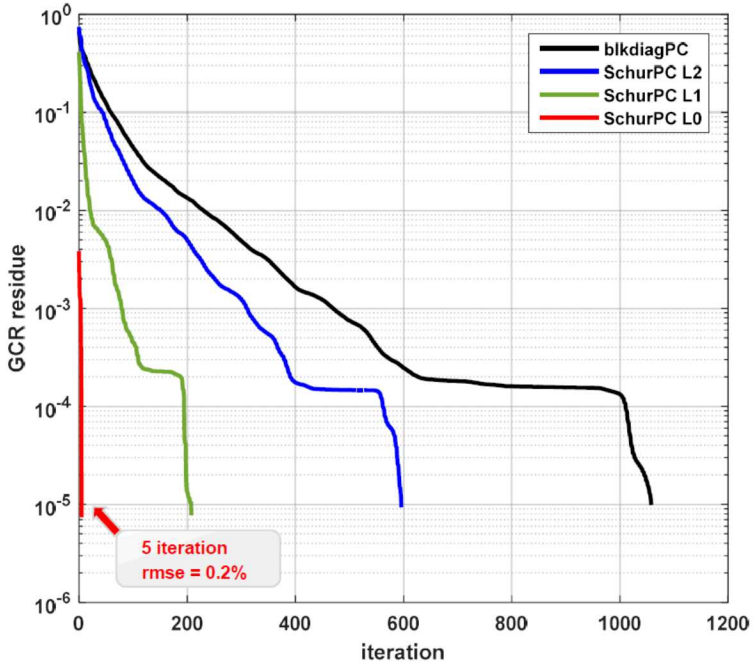


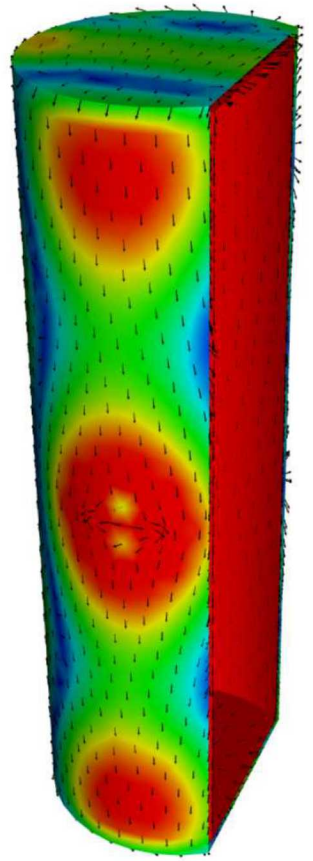


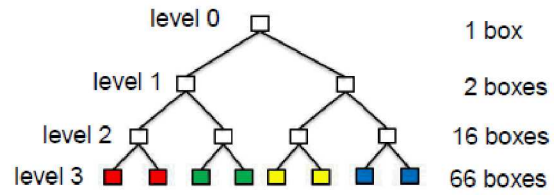












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Usage and Impact across ASC, ECP, Sandia Mission Areas, etc.

- Gemma has applications across multiple mission areas and divisions:
  - ND support (9400 and 2000)
  - LDRD support (both inside and outside of 1000)
  - ASC PEM and V&V dependencies and support
  - RCS support (Sandia missions outside of 1000)
  - Design support for antennas and microwave/electromagnetic devices (kHz →THz)