Pyramidal Absorbing Layers for Electromagnetic Simulations

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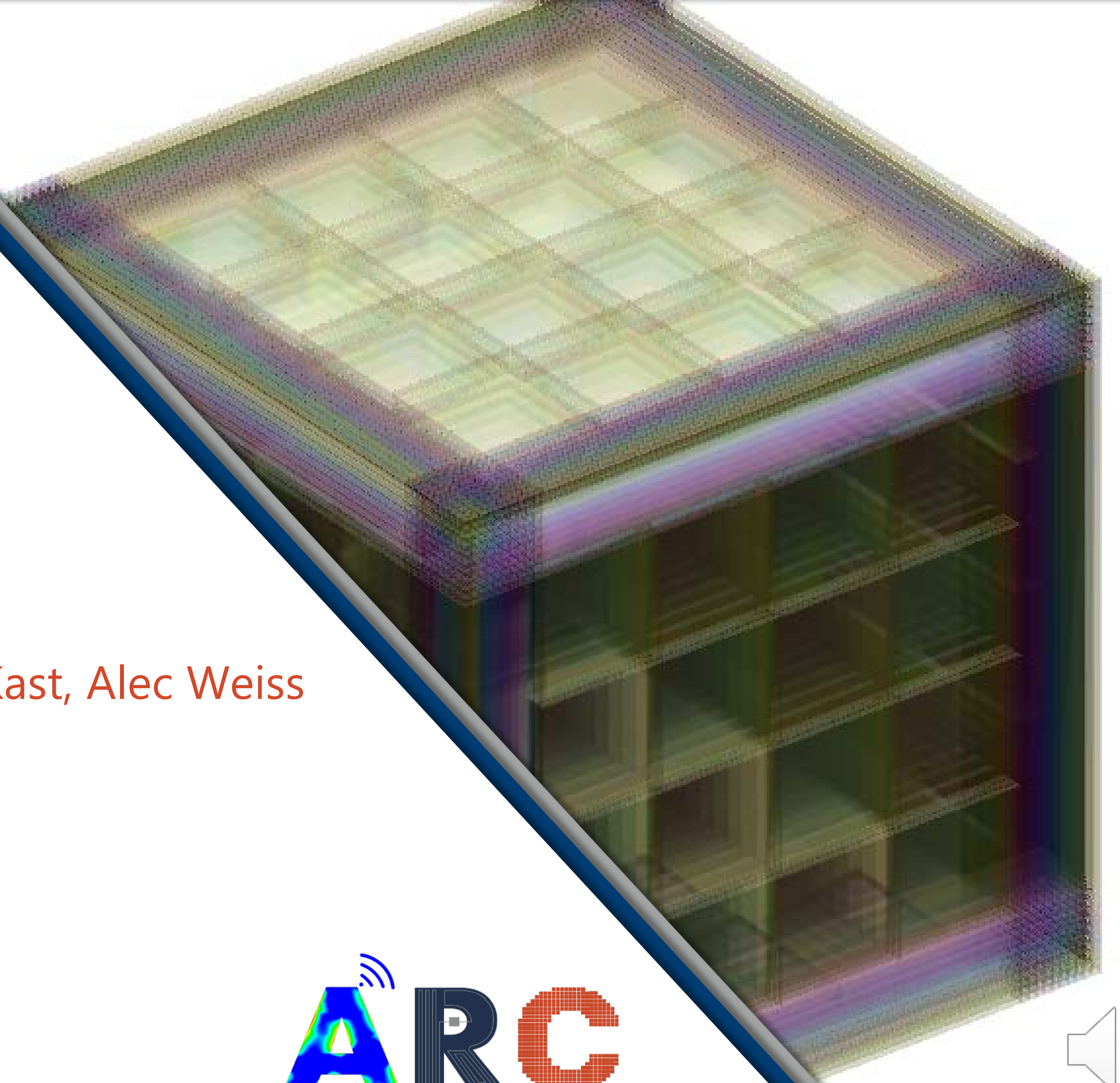
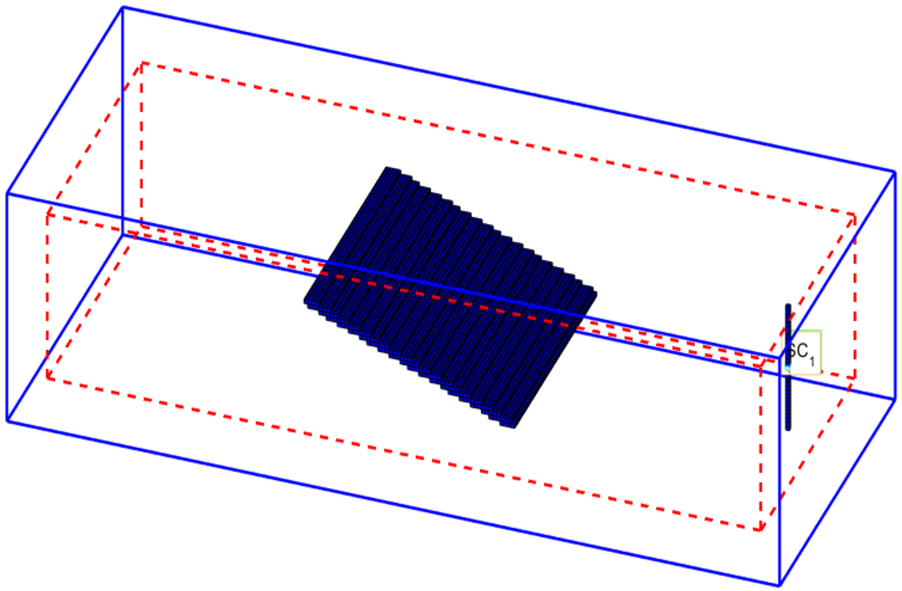


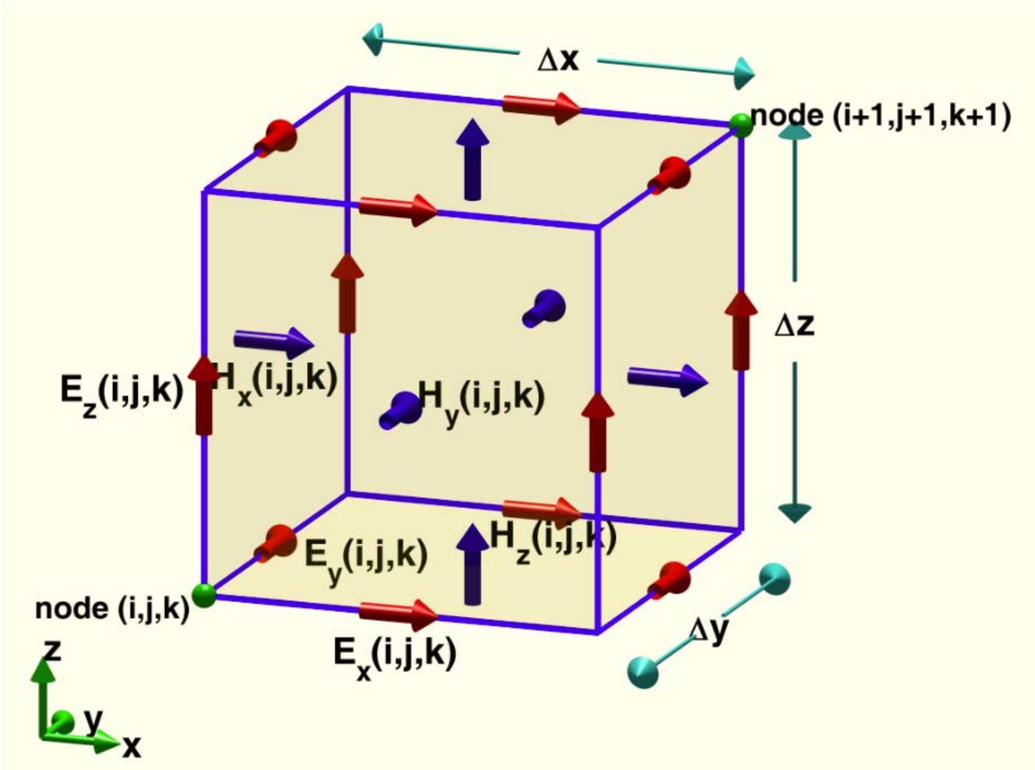
Outline

- What is FDTD?
- Convolutional Perfectly Matched Layer (CPML)
- Pyramidal Absorbing Layer (PAL)
- Numerical Results
  - All simulations were conducted on a single RTX 2080 GPU
- Conclusion and Future Work

Finite Difference Time Domain (FDTD)

- Assign material properties to all Yee cells
- For index from 1 to N number of time steps
  - Update Ex, Ey, Ez, Hx, Hy, Hz for every Yee cell
  - Apply boundary conditions
- Fourier transform is used to get frequency results.





Atef Elsherbeni and Veysel Demir, The Finite Difference Time Domain Method for Electromagnetics with MATLAB Simulations, ACES Series on Computational Electromagnetics and Engineering, SciTech Publishing Inc. an Imprint of the IET, Second Edition, Edison, NJ, 2015

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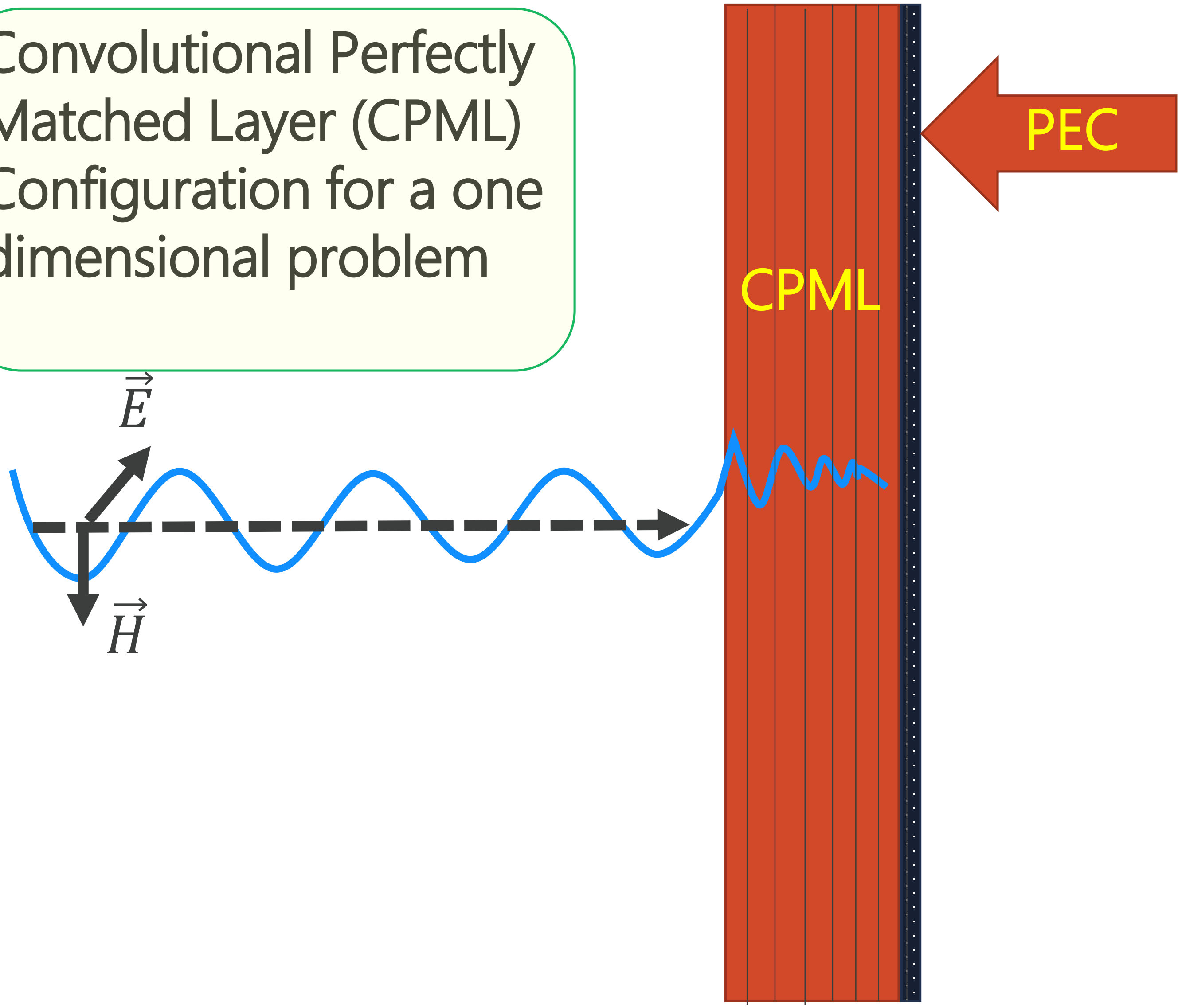
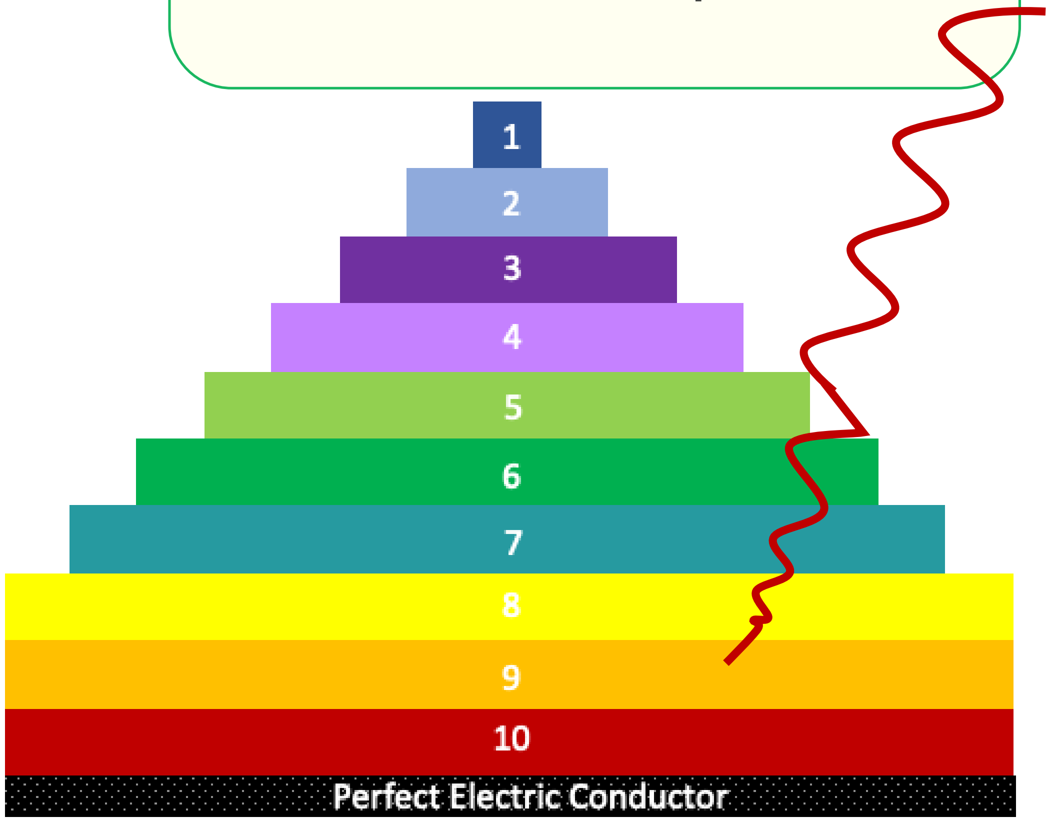
Absorbing Boundary Configurations

Convolutional Perfectly Matched Layer (CPML) Configuration for a one dimensional problem

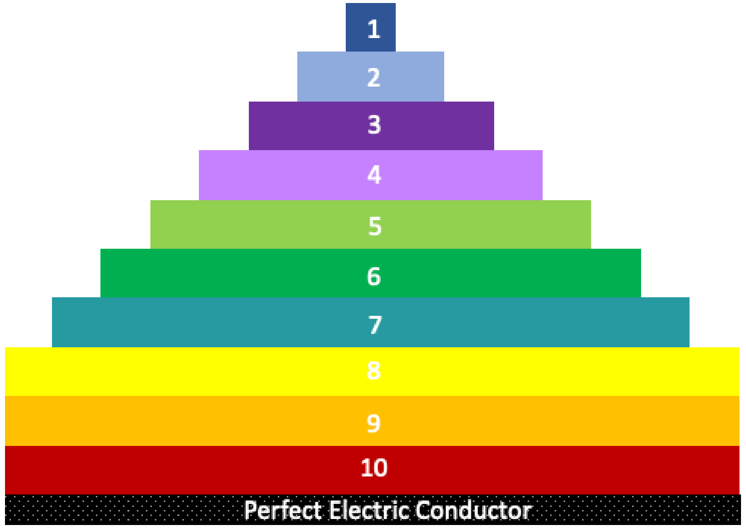


Pyramidal Absorbing Layers (PAL) Configuration for a one dimensional problem



Pyramidal Absorbing Layer (PAL)

- $\sigma_e = \sigma_F \left(\frac{n_{pml}+1}{150\pi dx\sqrt{\varepsilon_r}}\right)\left(\frac{\rho}{\delta}\right)^{n_{pml}}$ $\sigma_m = \left(\frac{\mu_0}{\varepsilon_0}\right)\sigma_e$
- Where:
  - σ_F is the sigma factor
  - n_{pml} is the order of the pml
  - dx is the cell size (assuming dx =dy =dz)
  - ε_r is the permittivity of the pml (1)
  - ρ is the number of absorbing layers multiplied by the cell size (dx).
  - δ is the absorbing layer index multiplied by the cell size divided by two.
  - ε_o and μ_o are the free space permittivity and permeability, respectively.



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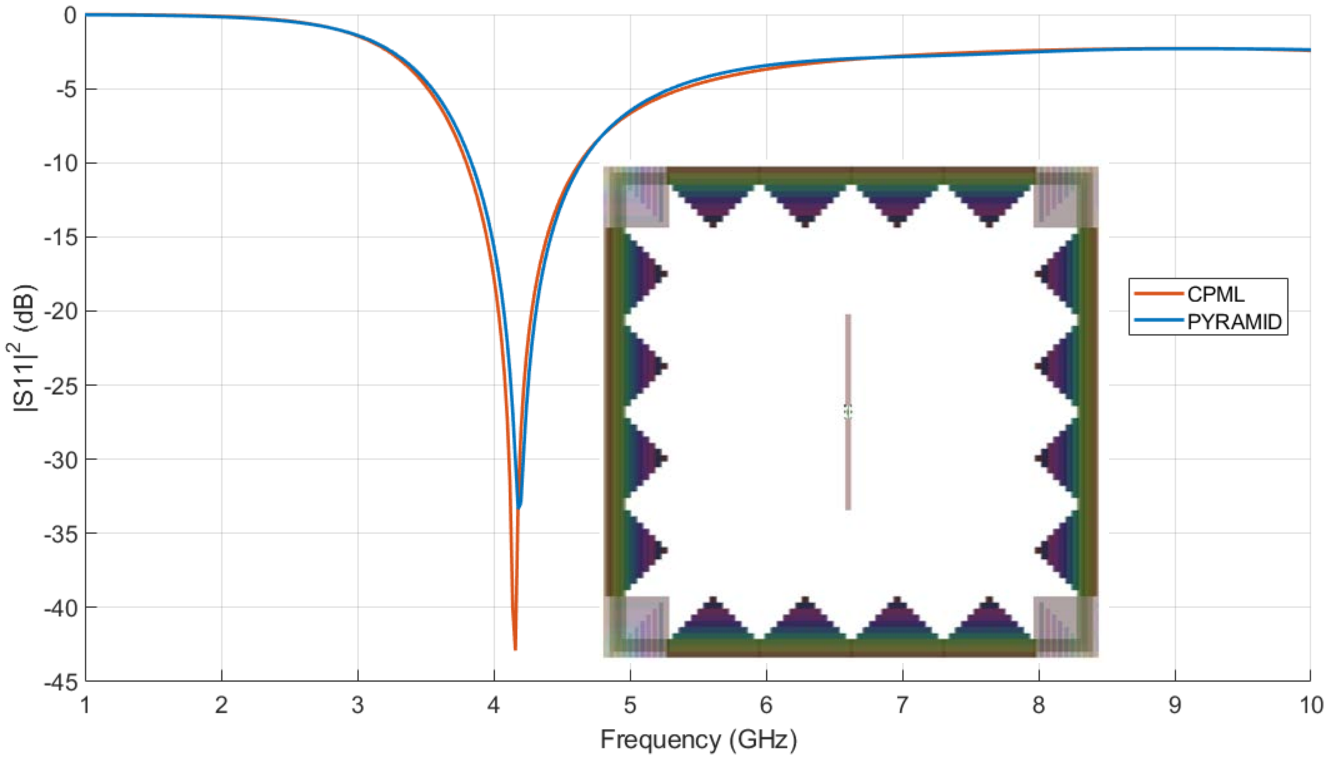
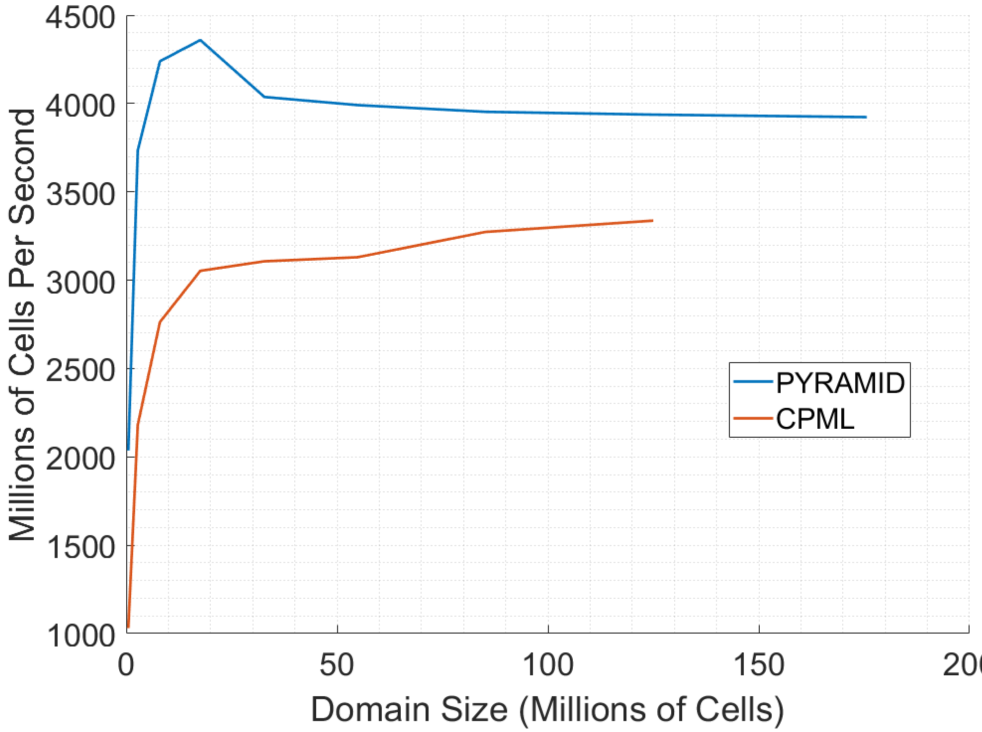
Simple Dipole Antenna – 3D Configuration





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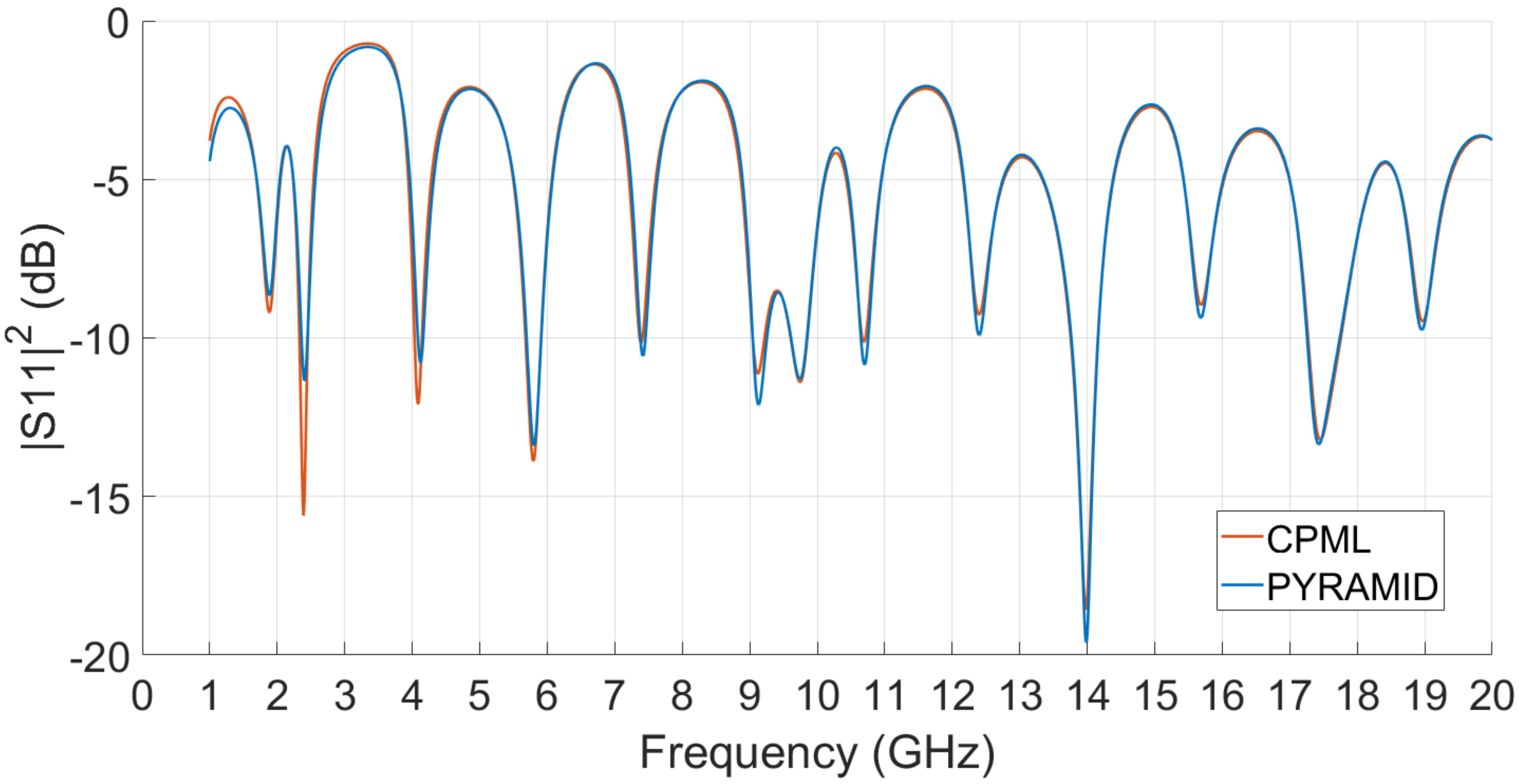
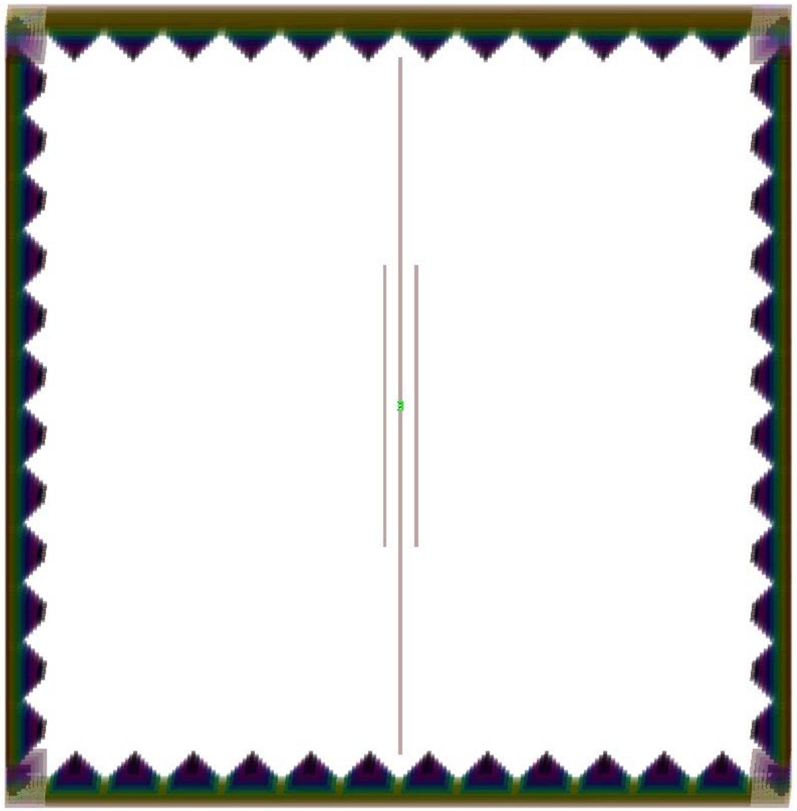
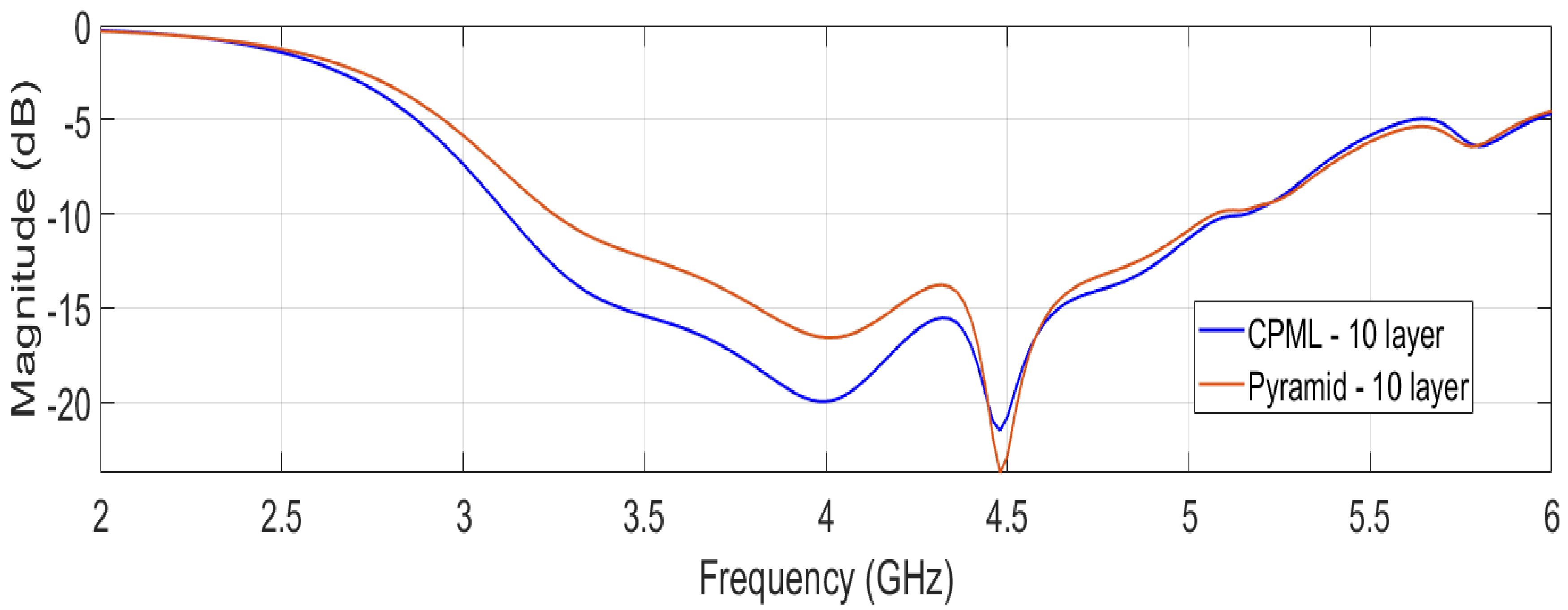
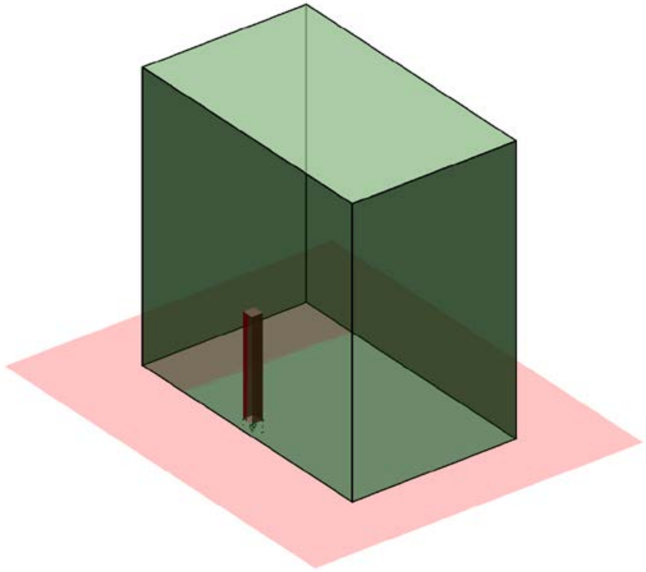
Multiband Dipole Antenna

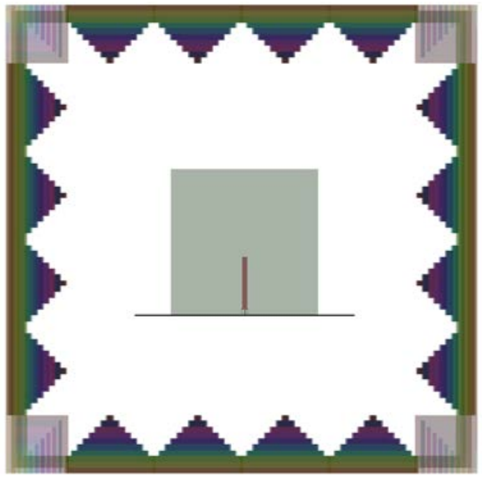




S_{11} of a Dielectric Resonator Antenna







Conclusion and Future Work

- Able to obtain good agreement between CPML and PAL boundaries for the simple dipole and multiband dipole.
- The PAL boundary showed substantial speedup over CPML
- Slight deviation between the CPML and PAL performance for the dielectric resonator antenna simulation.
- Different procedure for assignment for the pyramid material could improve the absorption level.