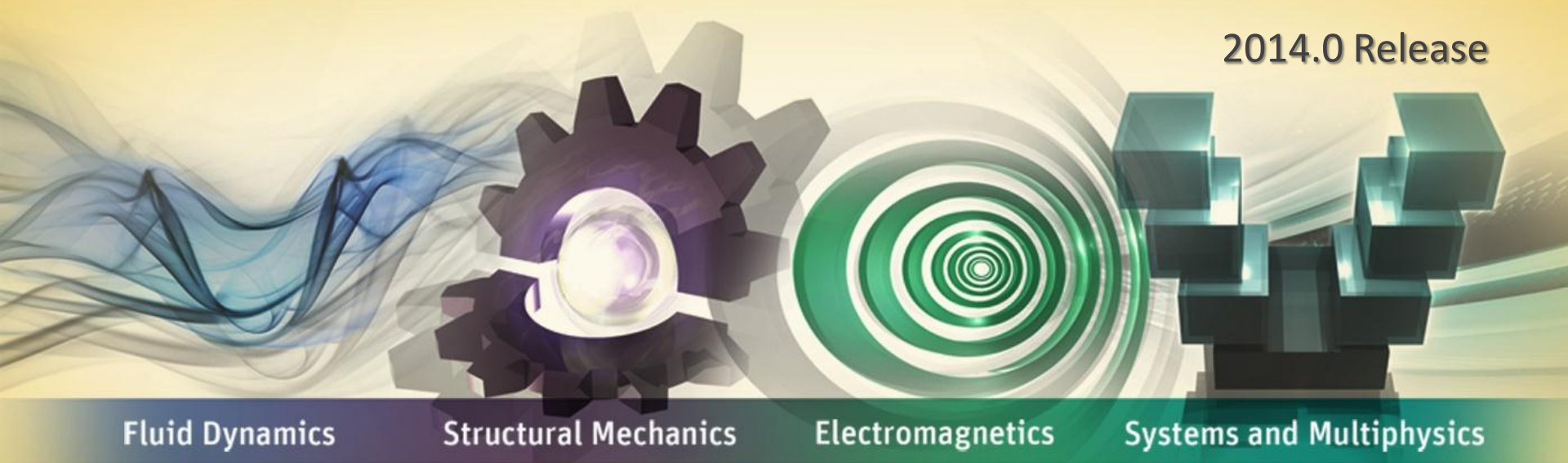


Lecture 10: HPC for Finite Arrays

2014.0 Release

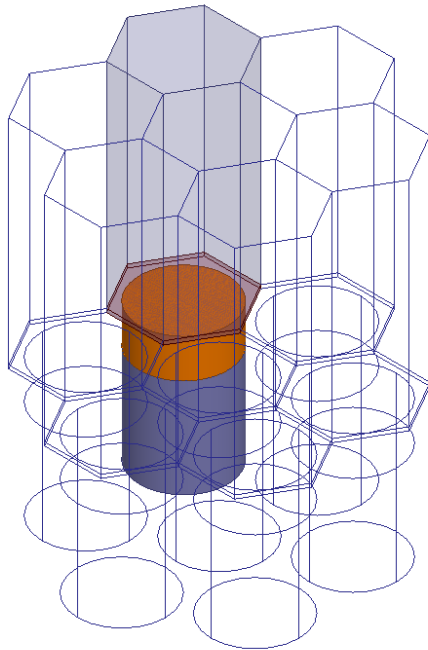


ANSYS HFSS for Antenna Design

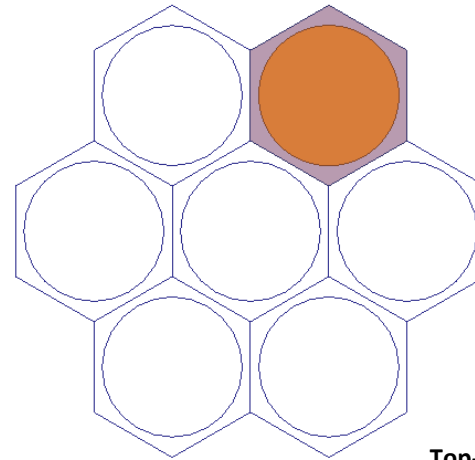
Finite Array Example

- **Model**

- This example is intended to demonstrate how to use HFSS to perform finite array analysis using HFSS's finite array domain decomposition method (DDM)



Birds-Eye View



Top-Down View

- **Before you start:**

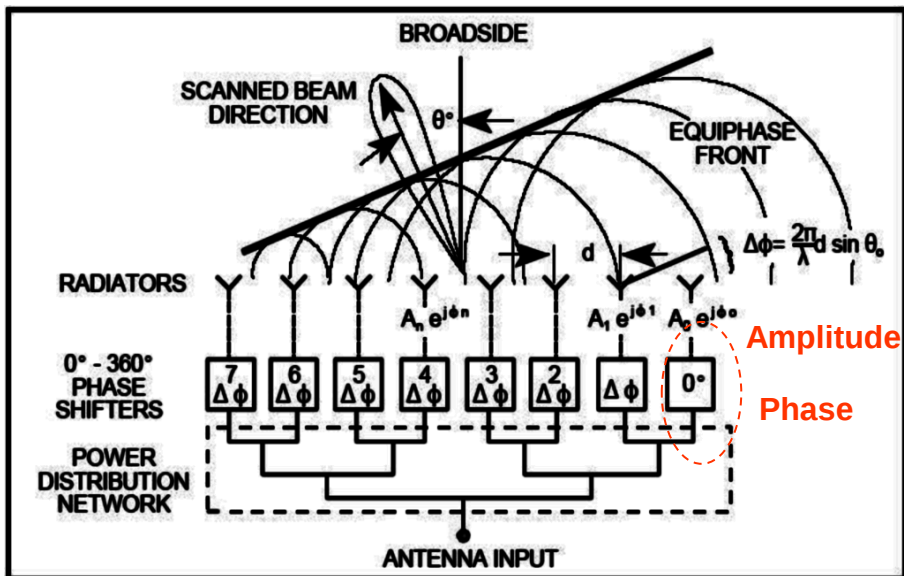
- You will need to complete the previous workshop: Unit Cell

• Phased Array

- A group of antenna elements in which the relative amplitudes and phases are varied to construct an effective radiation pattern by constructive and destructive interference

$$E_{array}(\theta_o, \phi_o, \theta, \phi) = \sum_n A_n(\theta_o, \phi_o) e^{j\psi_n(\theta_o, \phi_o)} \frac{e^{-jk_o r_n}}{r_n} E_n(\theta, \phi)$$

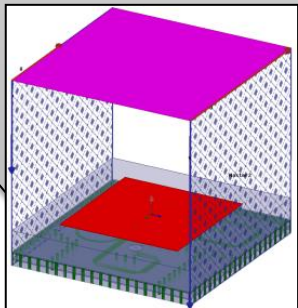
$$S_m(\theta_o, \phi_o) = \sum_n \frac{A_n(\theta_o, \phi_o) e^{j\psi_n(\theta_o, \phi_o)}}{A_m(\theta_o, \phi_o) e^{j\psi_m(\theta_o, \phi_o)}} S_{m,n}$$



- Beam shape can be controlled by adjusting the amplitude of each element.
- Beam can be steered by applying a progressing phase shift across the array.
- Mutual coupling plays a key role in an element's pattern and input impedance.
- It is necessary to analyze the arrays performance over frequency and scan volume.

Unit Cell

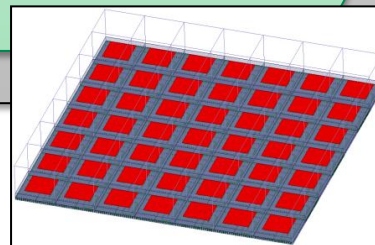
- **Uses Master/Slave boundaries**
 - Models a single element as if it were in an infinite array environment
 - Infinite array environment accounted for by enforcing field periodicity through master/slave boundary pairs
- **Reduces RAM**
- **Reduces solve time**
- **Infinite Array Approx.**
 - Edge affects ignored
 - Uniform magnitude excitation
 - Single scan angle solved at a time (Distributed Solve Option Parallelizes)



Finite Array

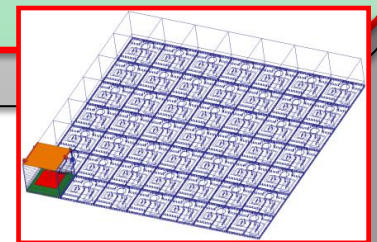
Explicit

- **Entire array analyzed**
 - Accounts for edge affects and edge treatments
 - Provides mutual coupling terms
 - Allows magnitude taper
- **Most flexible**
 - Fewest assumptions
 - Adaptive meshing performed on entire model
- **Complex Geometry**
 - Every element needs to be drawn
 - Large number of excitations
 - Complicated meshing process



Finite Array DDM

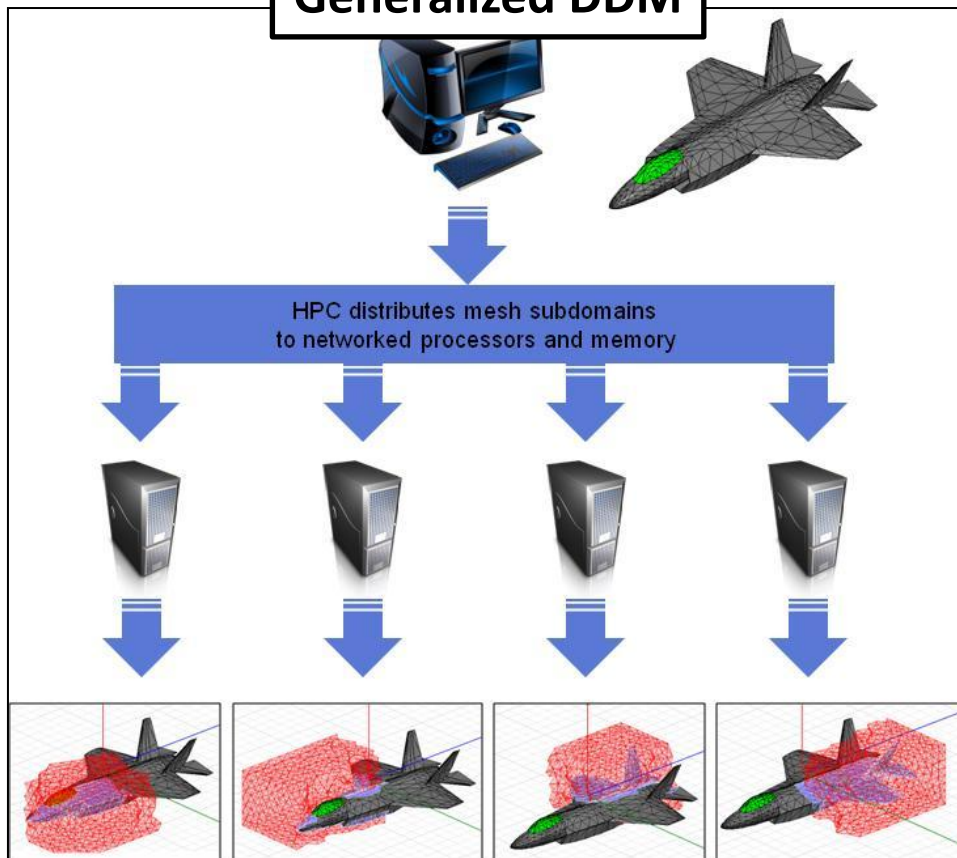
- **Uses Master/Slave boundaries**
- **Entire array analyzed**
 - Accounts for edge affects
 - Provides mutual coupling terms
 - Allows magnitude taper
 - Adaptive meshing performed on single unit cell
- **Distributes RAM**
- **Reduces solve time**
- **Periodic assumption**
 - Geometry must be purely periodic in the XY plane



Domain Decomposition Overview

- **DDM distributes the mesh and accesses distributed RAM throughout a network**
 - DDM was first released in HFSSv12
 - Distributes a model's mesh/solution across several computers distributing the RAM
 - Solves a model's full behavior as if run on a single computer

Generalized DDM

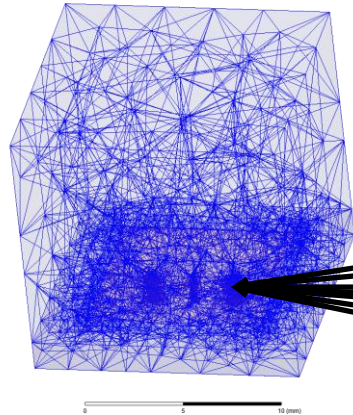


- **Addresses:**
 - RAM limitations
- **Does not address:**
 - Meshing time
 - Complex geometry issues

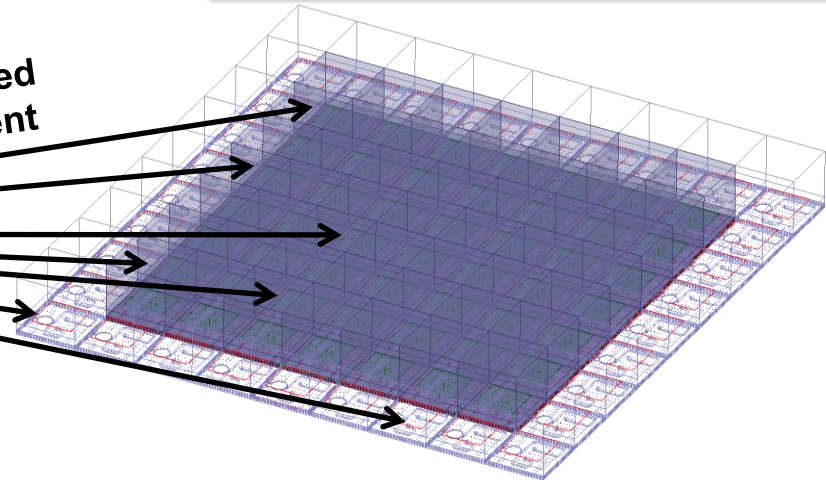
Solution: Finite Array Domain Decomposition

- Utilizes Replicated DDM Unit Cell to Address Array Concerns
- **Geometry and Mesh copied directly from Unit Cell Model**
 - Unit Cell geometry expanded to finite array through a simple GUI
 - Adaptive Meshing Process imported from Unit Cell Simulation
 - Dramatically reduces the meshing time associated with finite array analyses.
 - Mesh periodicity reinforces array's periodicity.
 - Full Array Mesh Solved Using DDM

**Mesh from Unit Cell
Simulation**



**Same mesh used
for each element**



• **Addresses:**

- RAM limitations
- Meshing time
- Complex geometry issues

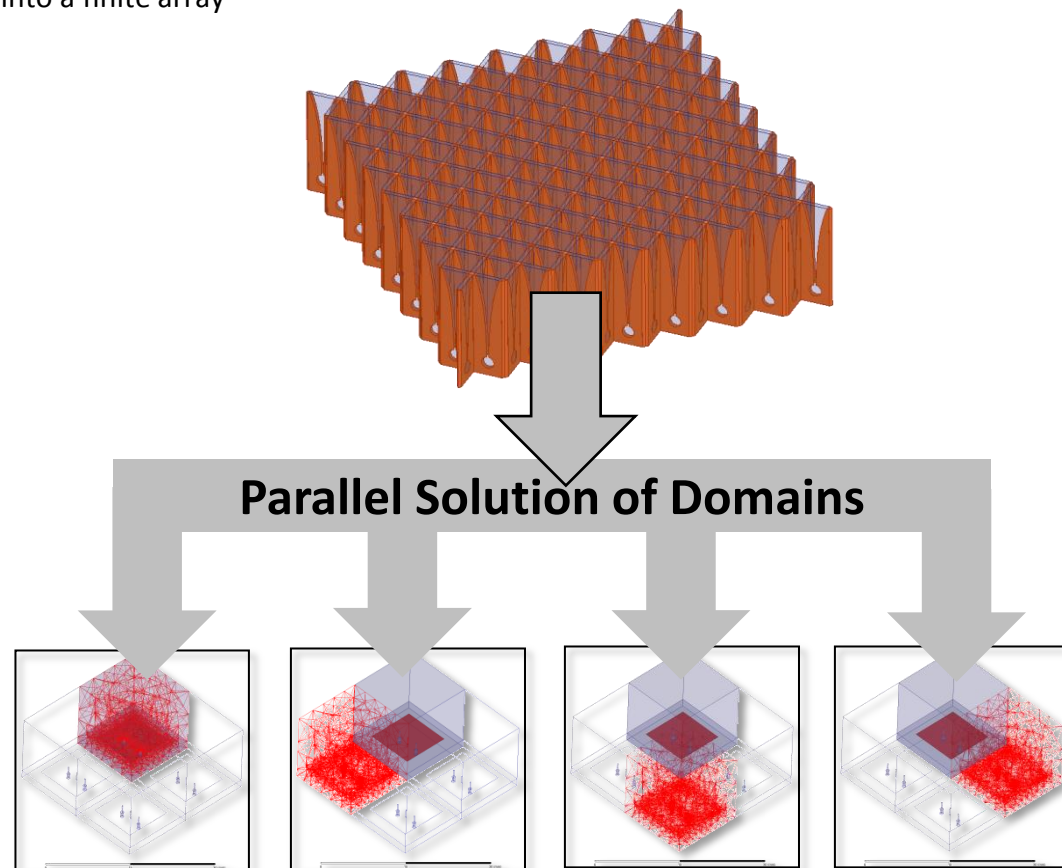
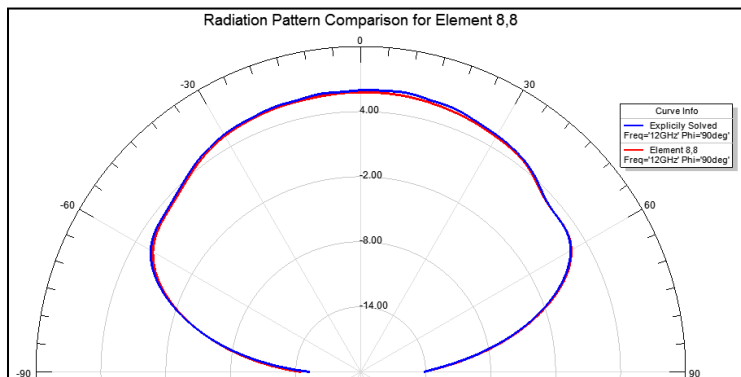
Finite Array DDM Tool Advantages

Advantages of the finite array DDM:

- Solves much **BIGGER** arrays on the same hardware
- Obtains **ACCURATE** results that match HFSS explicit simulations
- Enables **EFFICIENT** simulation of large finite arrays utilizing domain decomposition (DDM)
- Makes it **EASY** to transform a master/slave unit cell into a finite array

256 element Vivaldi with
metal thickness, under
32GB of RAM!

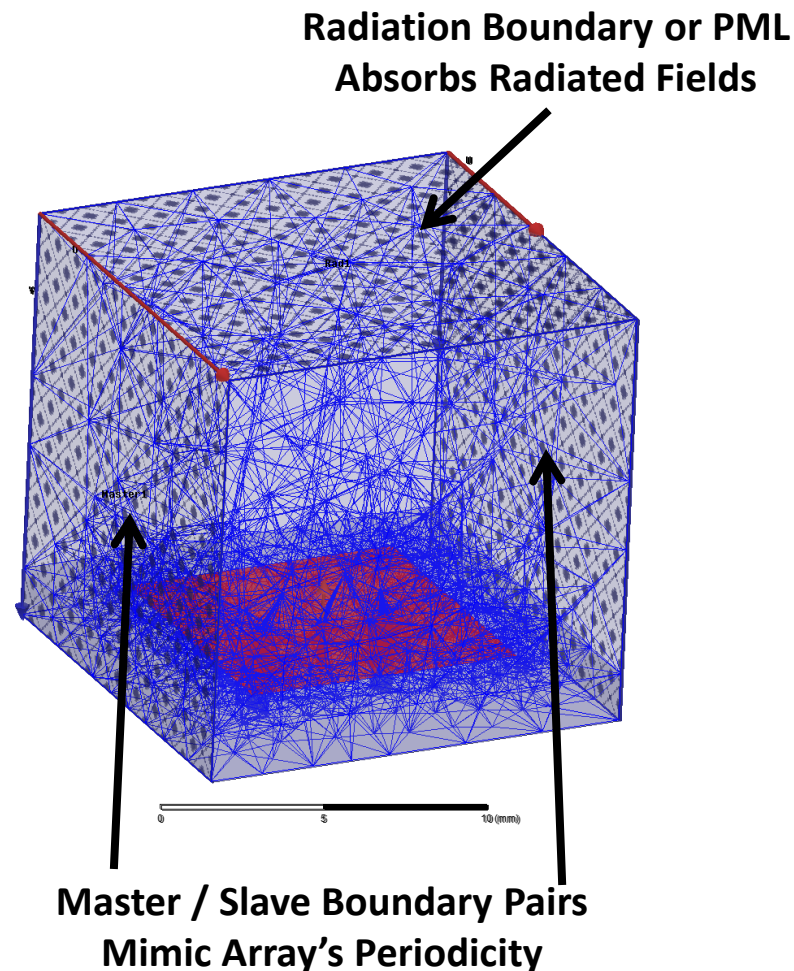
Embedded element pattern: Finite Array DDM vs. Explicit



How It Works!!!

- **Start off with a Unit Cell Model to create the Unit Cell Mesh**

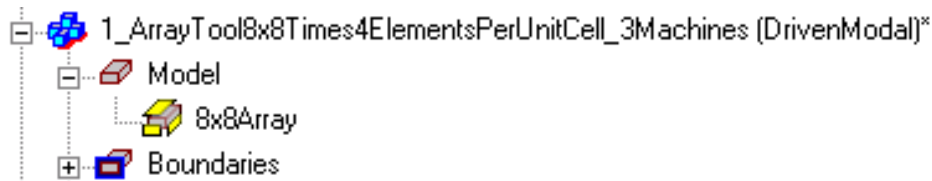
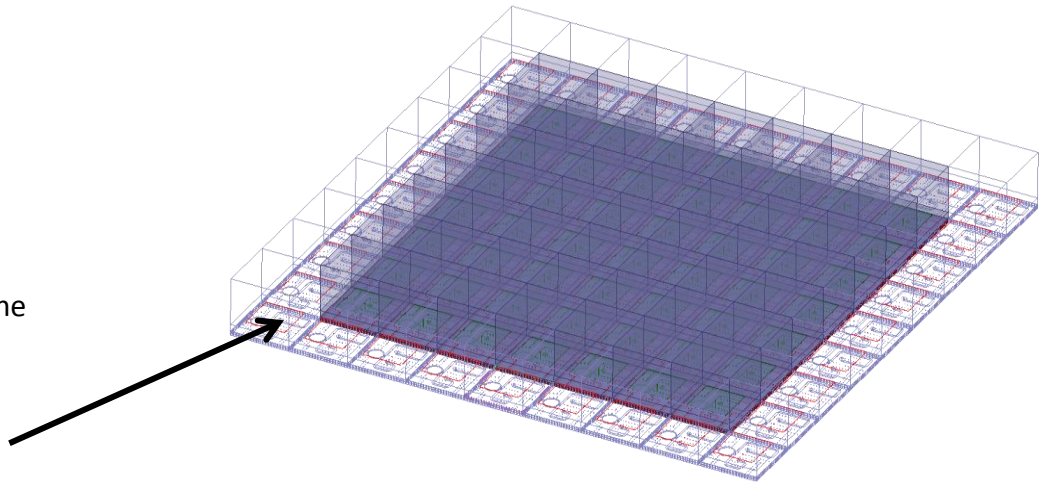
- Accounts for infinite array behavior
- Unit Cell Simulation is Fast
- Unit Cell Simulation is Memory Efficient
- May use radiation boundary, PML or FE-BI on top surface of unit cell



How It Works!!!

• Construct the Finite Array

- Simple GUI based creation
- Reduces model complexity
- Reduces display issues
- Creates 1 unit cell of additional space around the edge elements to terminate the array fields in vacuum or infinite ground plane.



**Defines directions of periodicity
based on Master / Slave Boundaries**



**Defines number of elements
in each direction**



Regular Planar Array

General

Active Cells

Post Processing Cell

Name:

A

Select Lattice Vectors

For A Vector

Master1

For B Vector

Master2

Number of cells

In A Direction

2

In B Direction

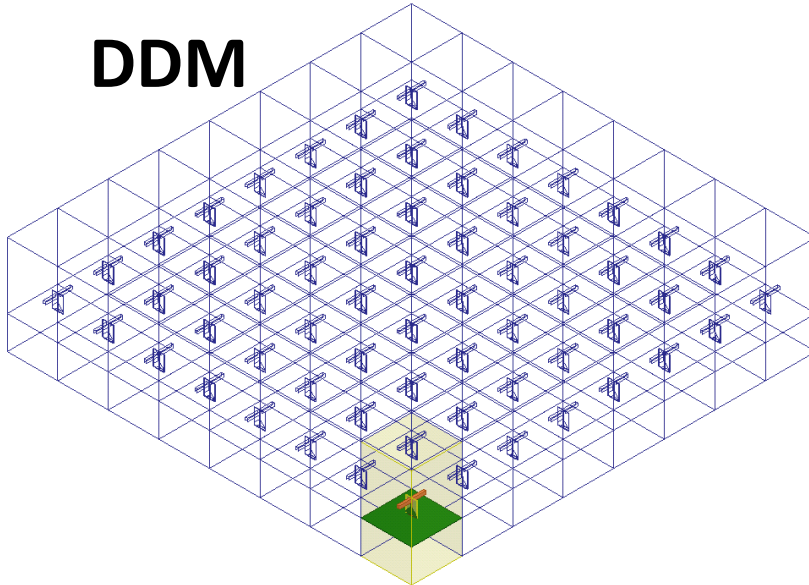
2

OK

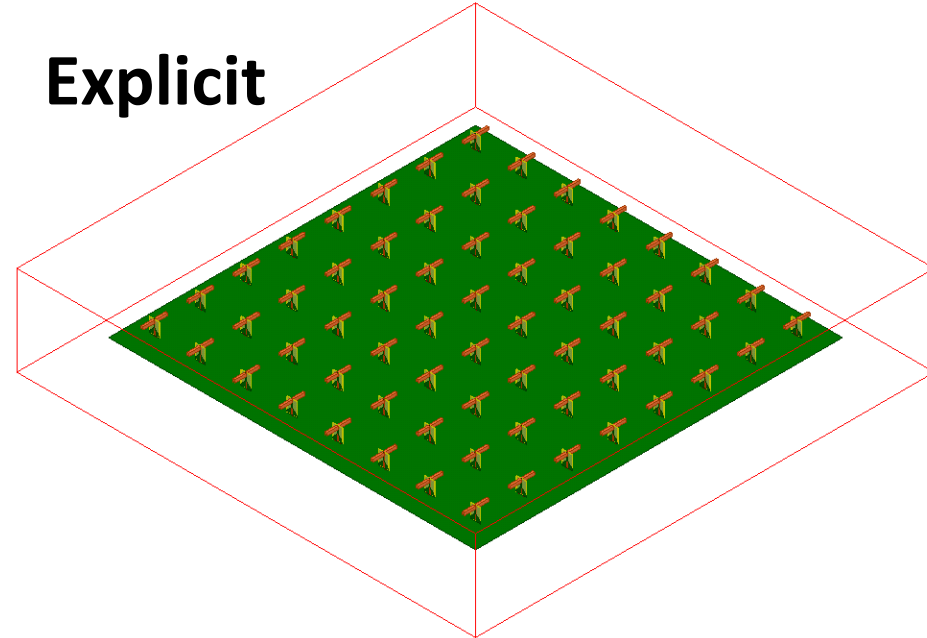
Cancel

Finite Array DDM vs Explicit: Simulation Time/RAM

DDM



Explicit

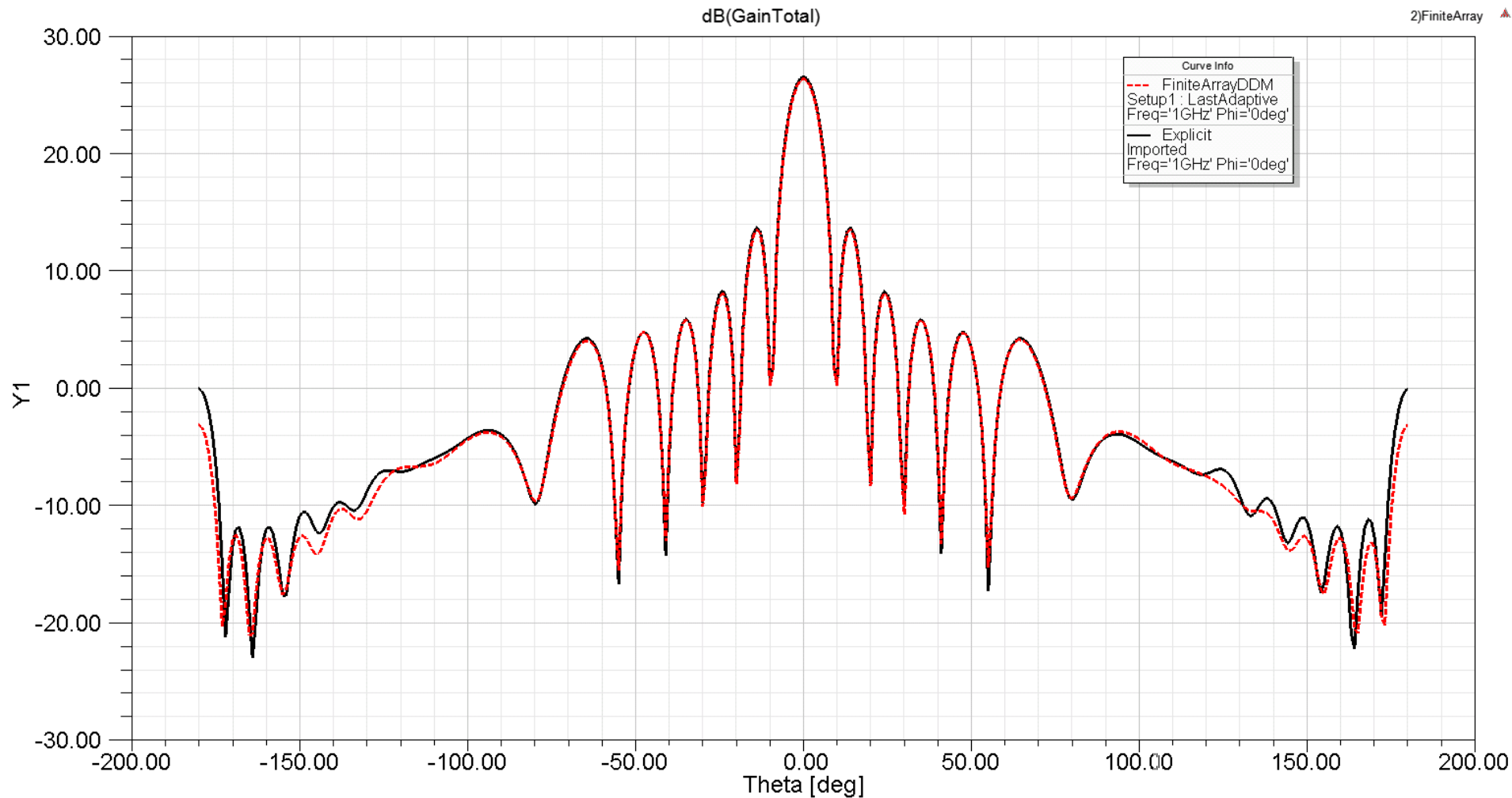


	Simulation Time	RAM
Finite Array DDM	2.75hrs	10.5GB
Explicit	6hrs	28GB

Note: May observe greater RAM and time savings with complex models!

2.2X SPEEDUP
REDUCED RAM REQUIREMENT

- Finite Array DDM provides the same results more efficiently



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为帮助工程师能够更好、更快地学习掌握 HFSS 的设计应用, 易迪拓培训特邀李明洋老师主讲了多套 HFSS 视频培训课程。李明洋老师具有丰富的工程设计经验, 曾编著出版了《HFSS 电磁仿真设计应用详解》、《HFSS 天线设计》等多本 HFSS 专业图书。视频课程, 专家讲解, 直观易学, 是您学习 HFSS 的最佳选择。



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