CRAY, INC. & Ansoft Corp.

A Solution for Long Lossy High-Speed Transmission Lines

October 22, 2001

INTRODUCTIONS

Dave Burger, Electrical Engineer

Cray Inc.

Main Products: Supercomputers

Some Applications:

- Car Crash, Weather, Oil & Petroleum, Medical Research, Bioinformatics, Government

Martin Vogel, Senior Technical Engineer

Ansoft Corp.

Presentation Outline

- **Problem Definitions (Cray)**
  - Previous Simulation History
  - Transmission Line Media / Model
  - Stimulus / Expected Bit Masks
  - Lab Data Results

- **Problem Set-up in HFSS (Ansoft)**
  - Geometry
  - Materials
  - Excitation

- **Generation of HSPICE/Maxwell SPICE Model from Full-Wave Spice (Ansoft)**
  - Frequency Sweep
  - Deembed
  - Export to SPICE

- **Simulation Results vs. Actual Lab Results (Cray)**
  - 1 meter Twin-ax Sim. Vs. Lab
  - 3 meter Twin-ax Sim. Vs. Lab
  - 5 meter Twin-ax Sim. Vs. Lab

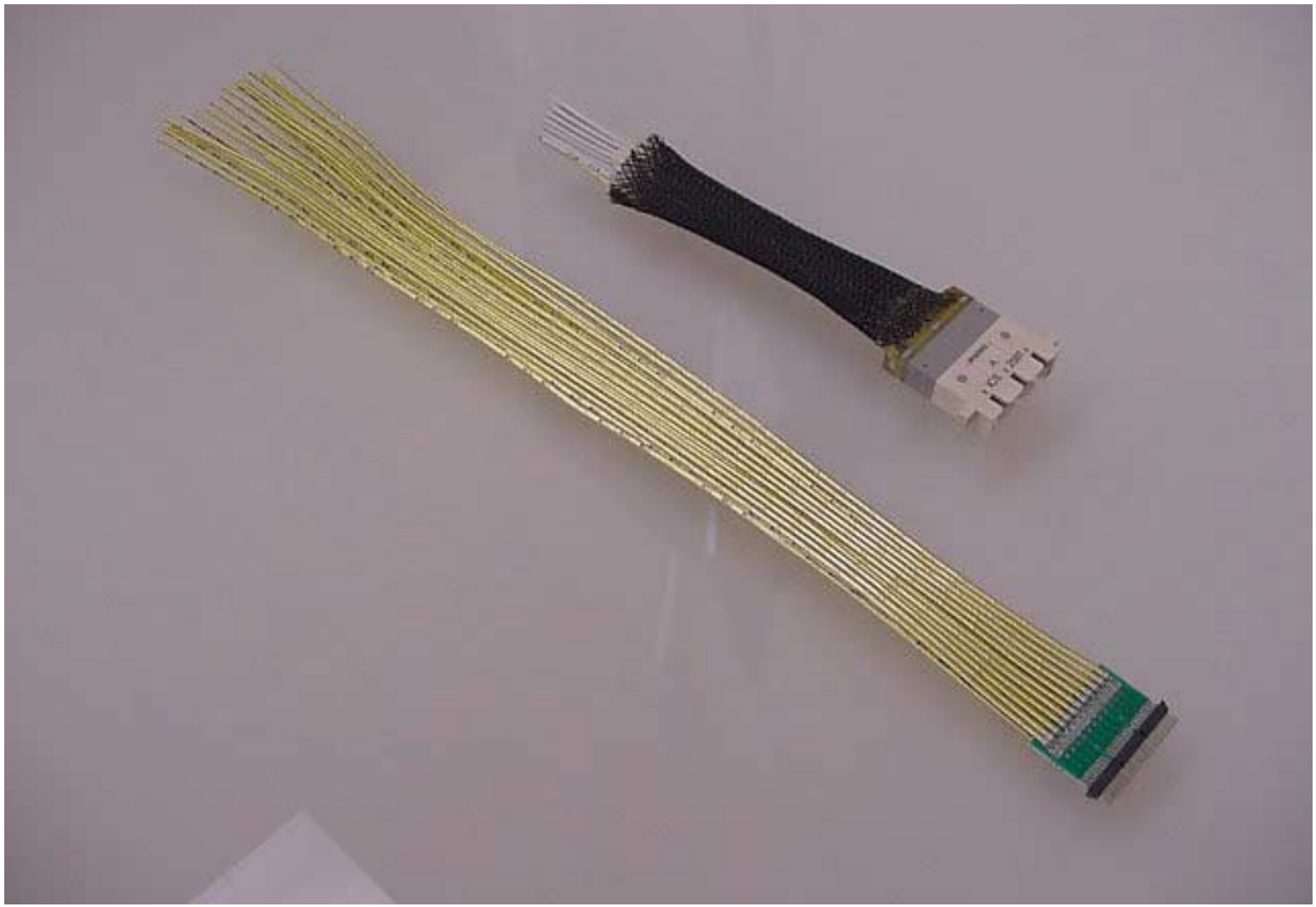
- **Questions**

Simulation Issues & History

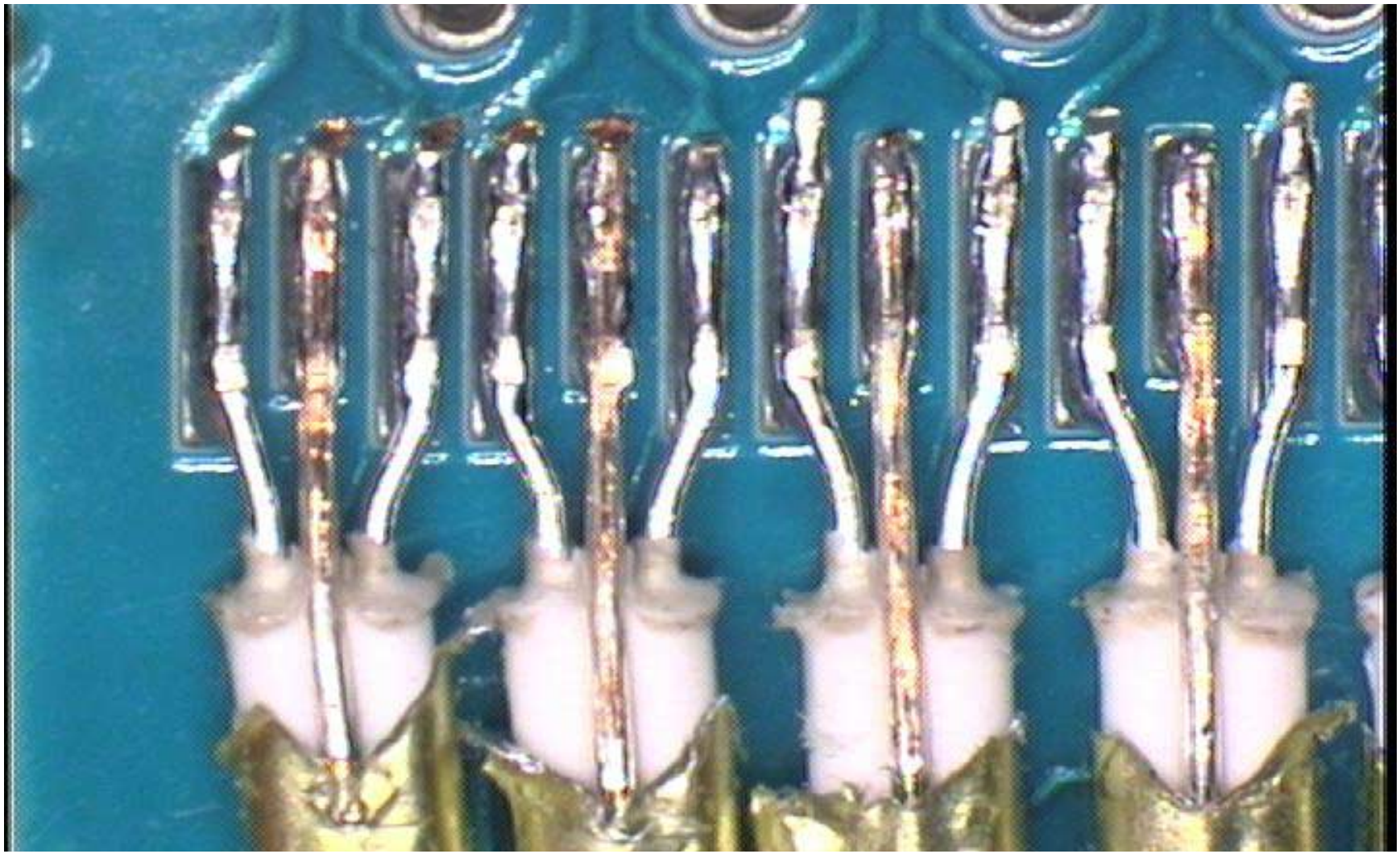
- **Why Simulation?**
  - **Full Analysis of Data Dependencies, Process Variation, Material Characteristics**
  - **Easy to change for:**
    - ✓ **Increase Frequency / Edge Rates**
    - ✓ **Model Length Increase or Decrease**

- **Past Simulation Issues**
  - **Inaccuracies of model over length above 1 meter**
  - **Inaccuracies of model when increased frequencies were applied**

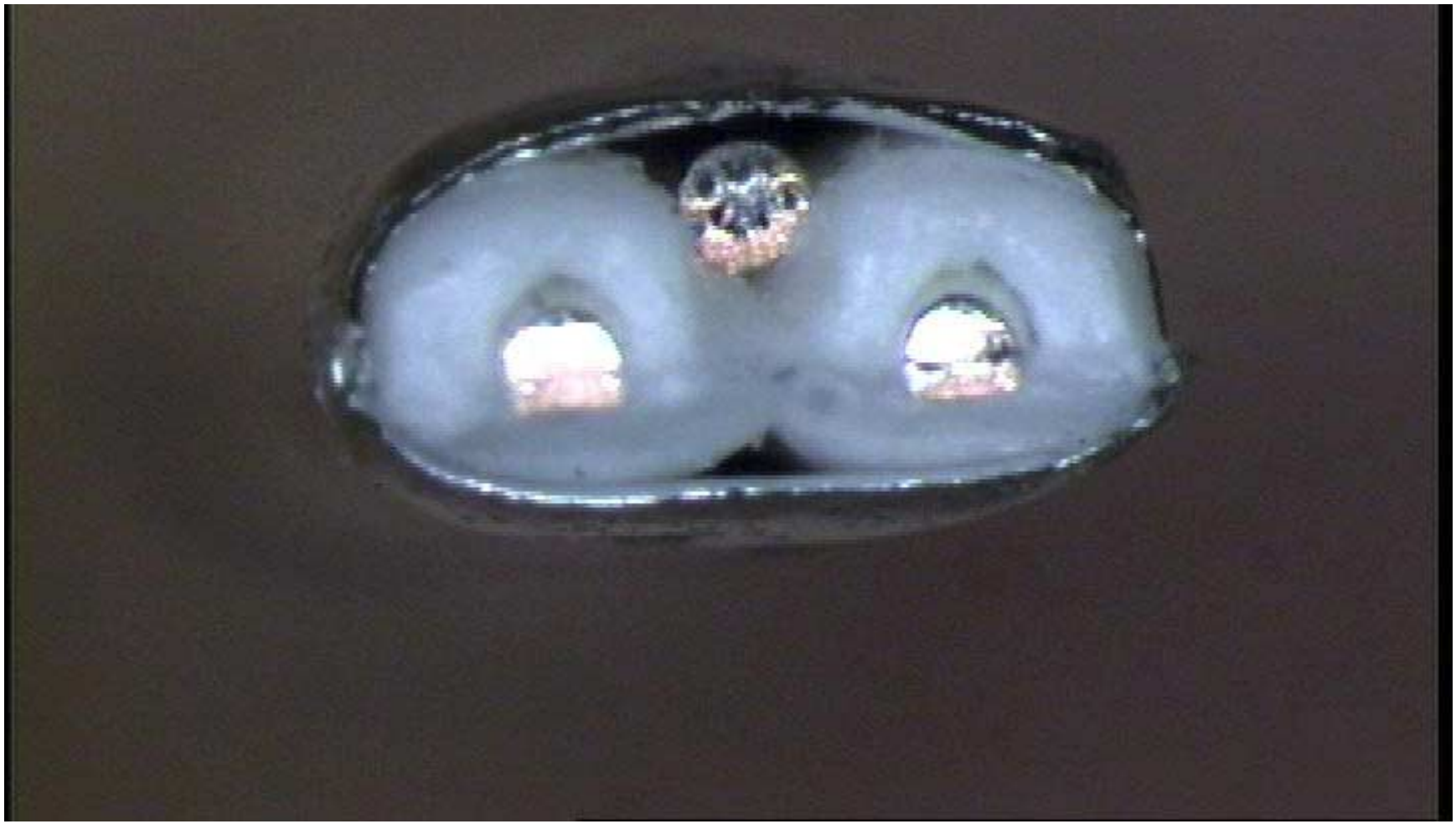
Simulation Media: Cable Assembly



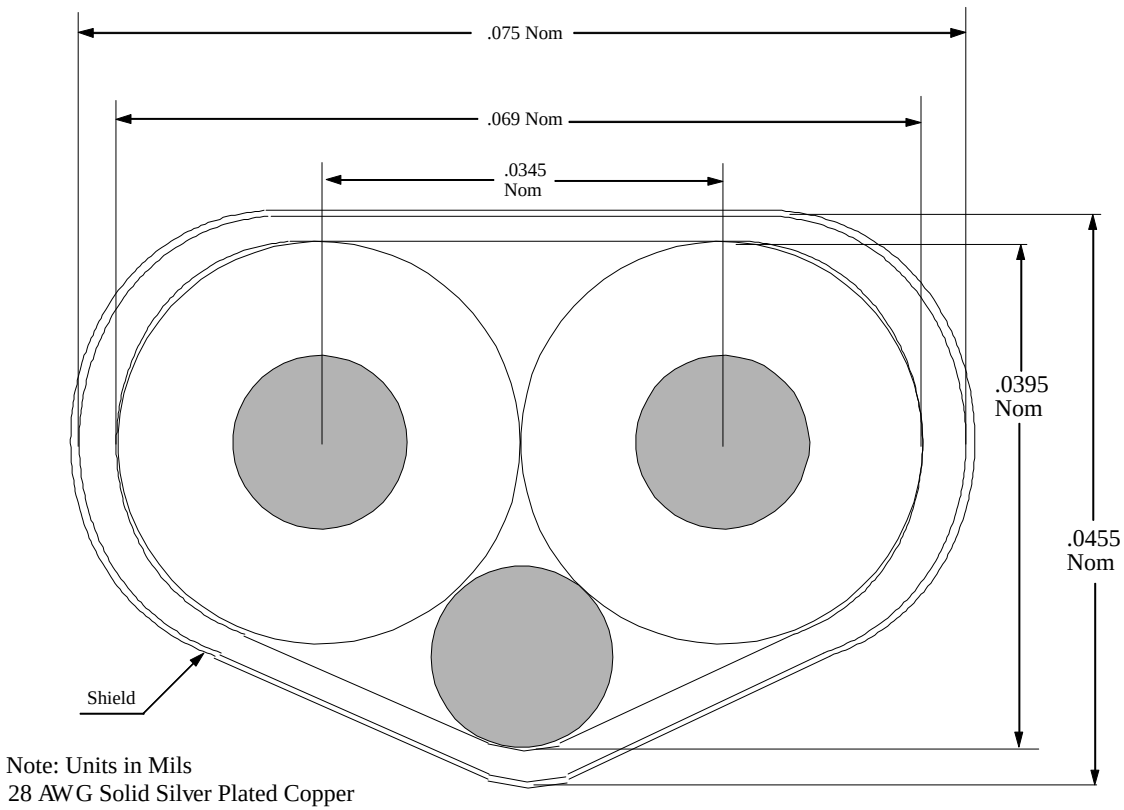
Simulation Media: Cable Termination



Simulation Media: Twin-Ax Model



Simulation Media: Twin-Ax Dimensions

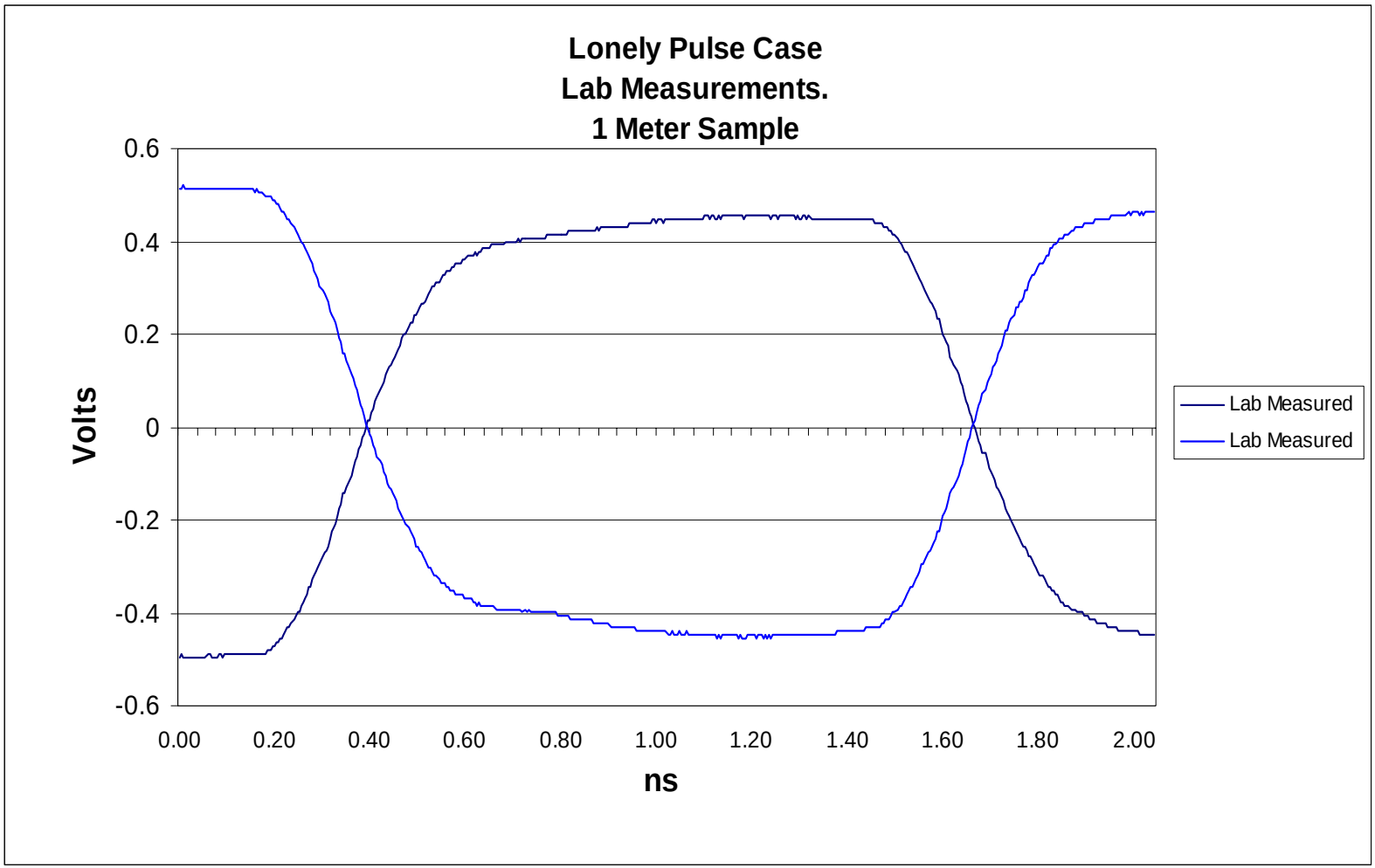


Note: Units in Mils
28 AWG Solid Silver Plated Copper

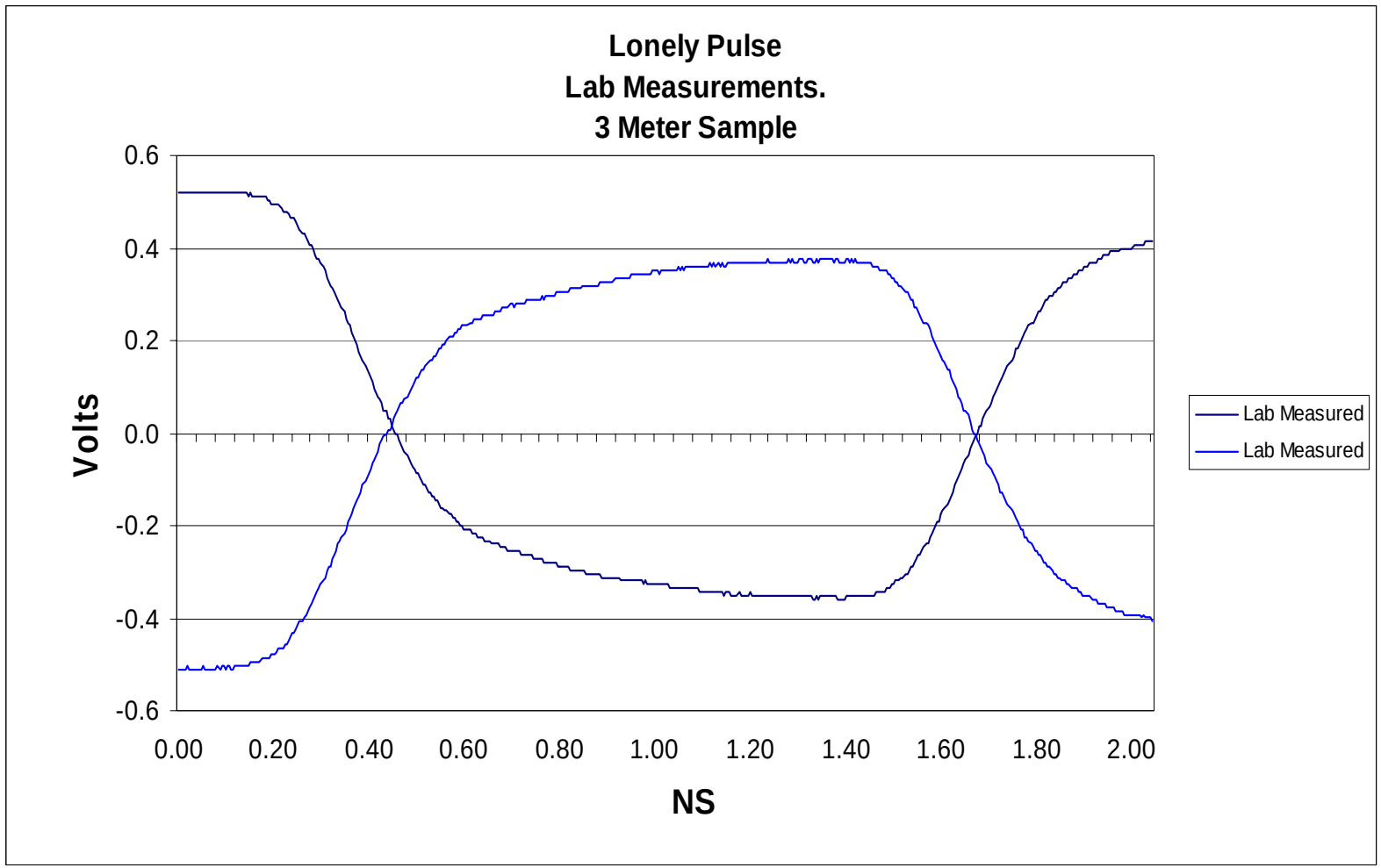
Stimulus and Bit Masks

- Stimulus
  - Frequency: 400 MHz
  - Edge Rate: 250 pSec.
  - Lonely 1/0 Case
- Bit Masks
  - +/- 125 mV
  - Measure Window Opening

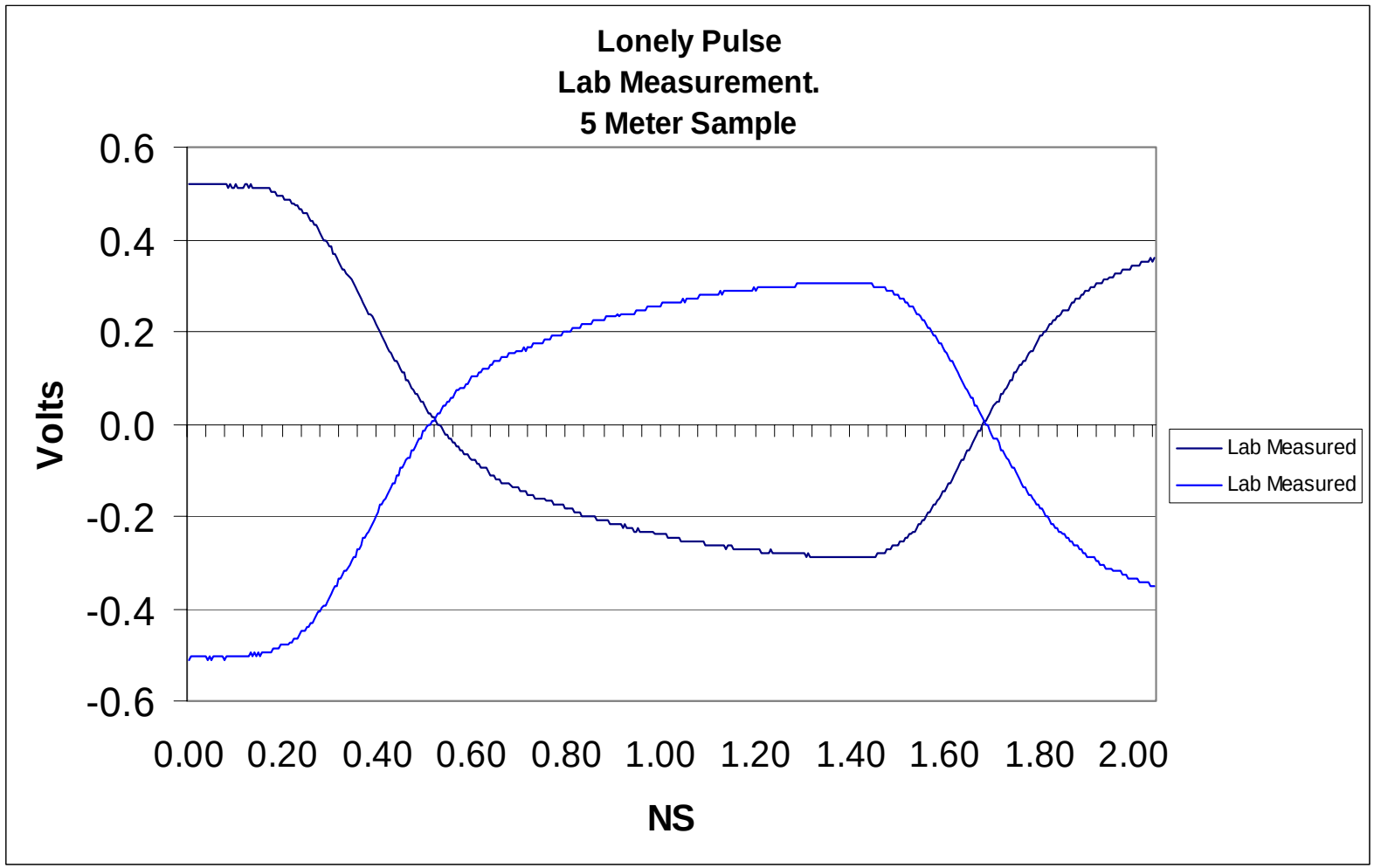
Lab Data: 1 Meter Spectra-Strip Twin-Ax



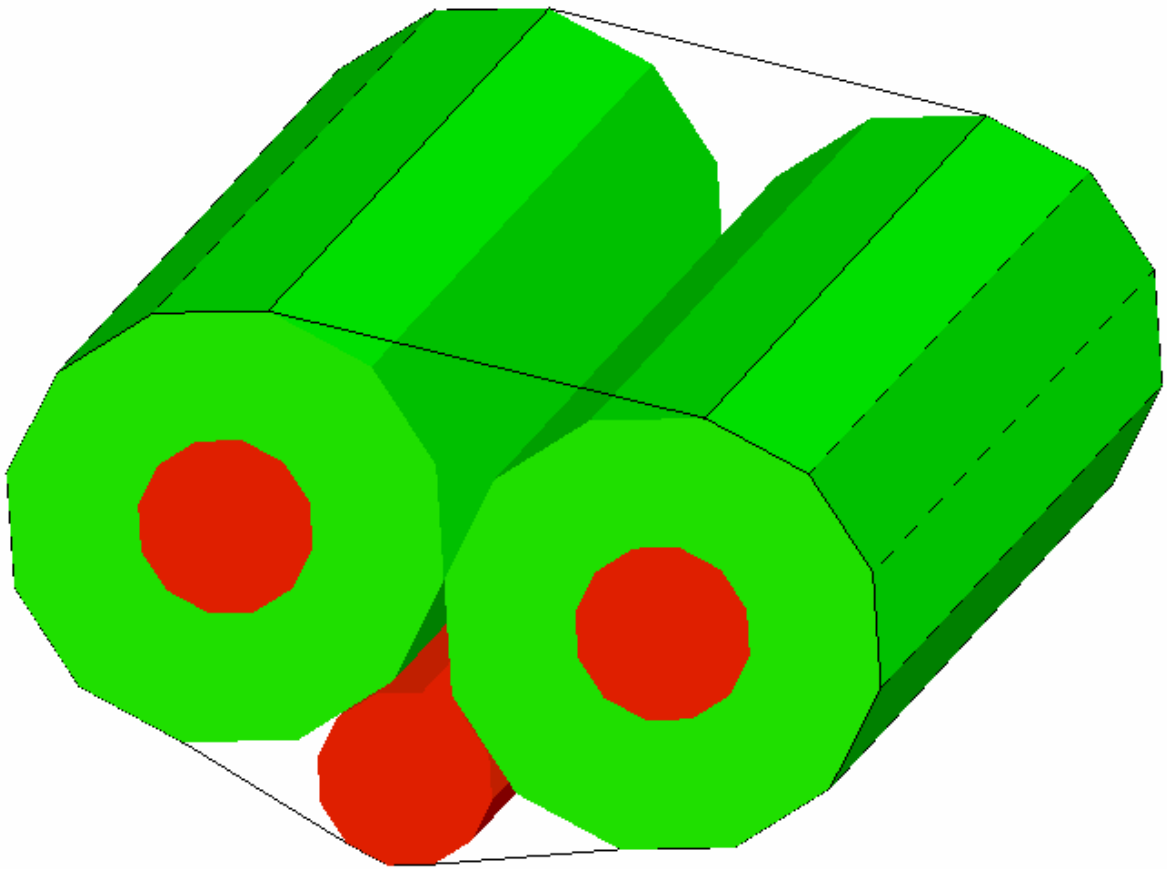
Lab Data: 3 Meter Spectra Strip Twin-Ax



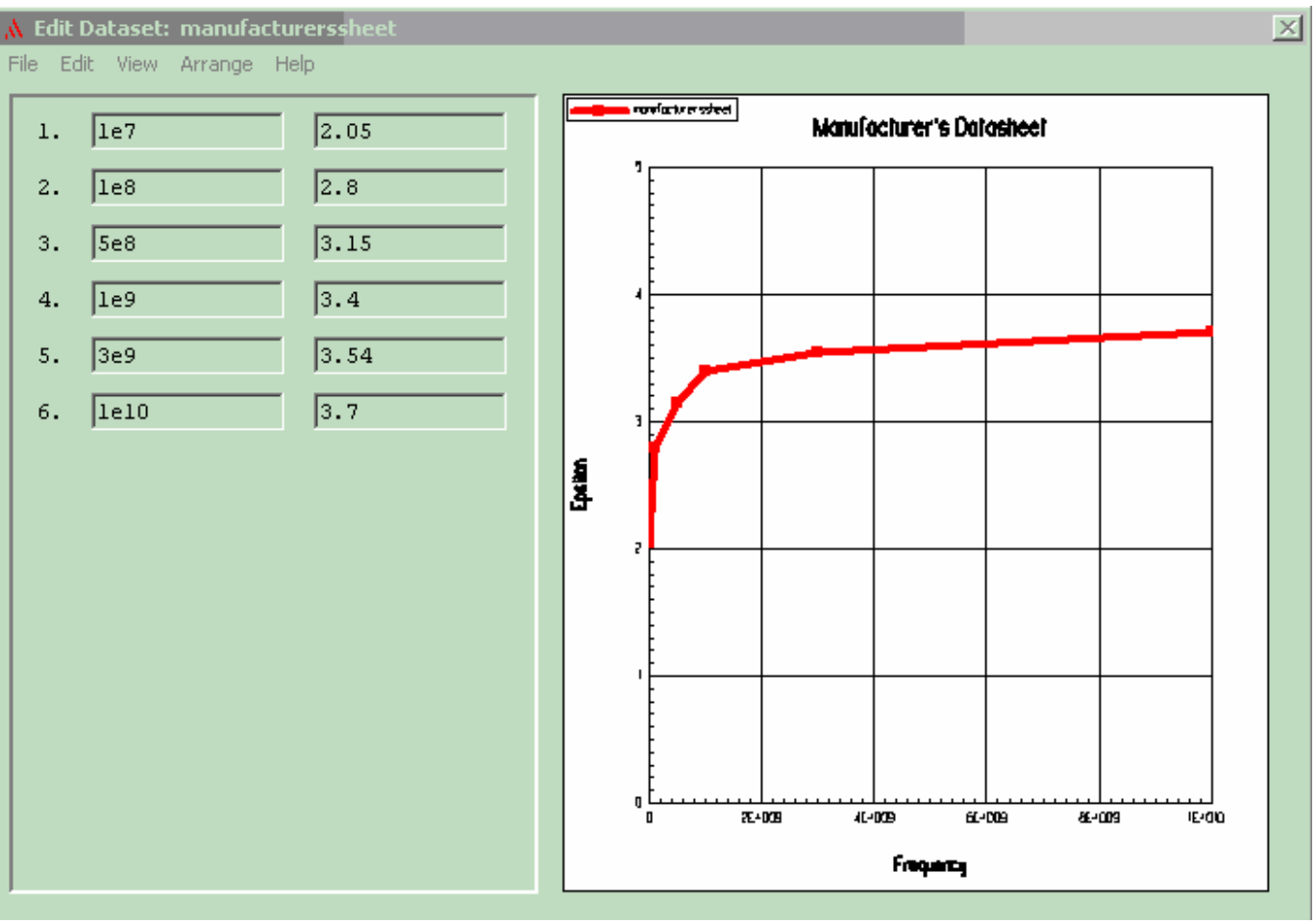
Lab Data: 5 Meter Spectra-Strip Twin-Ax



Set Up the Model in HFSS
Step 1: Draw a Short Section

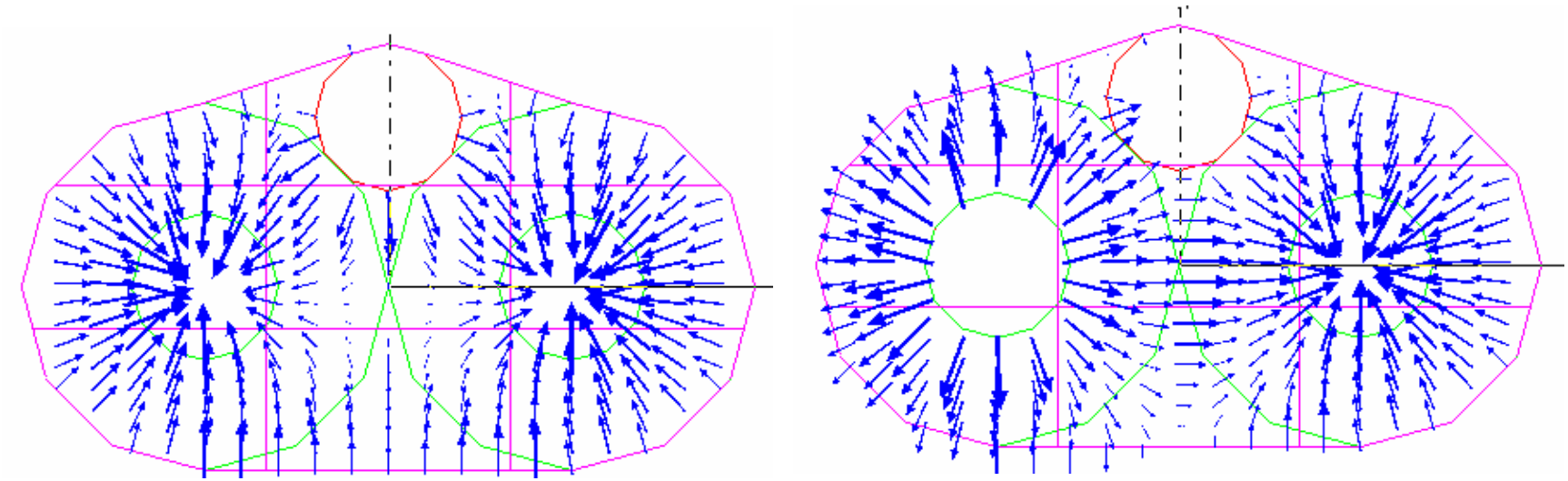


Set Up the Model in HFSS
Step 2: Assign Materials



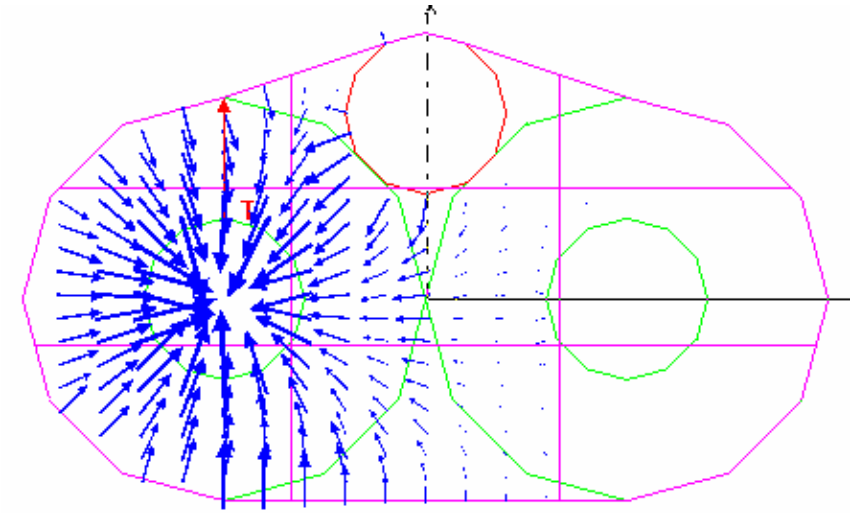
Any epsilon, mu, loss tangents, etc. In HFSS 8.5 even frequency-dependent materials possible!! Not yet used here.

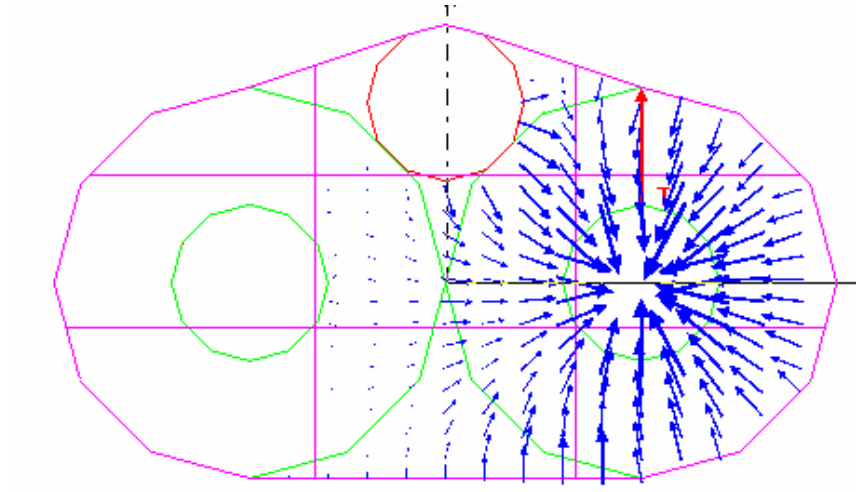
Set Up the Model in HFSS
Step 3: Excitations and Boundaries



Even and odd mode, a.k.a. common and differential mode.
You have most freedom when you can excite individual terminals.
Therefore, in HFSS 8, you define your TERMINALS as well.

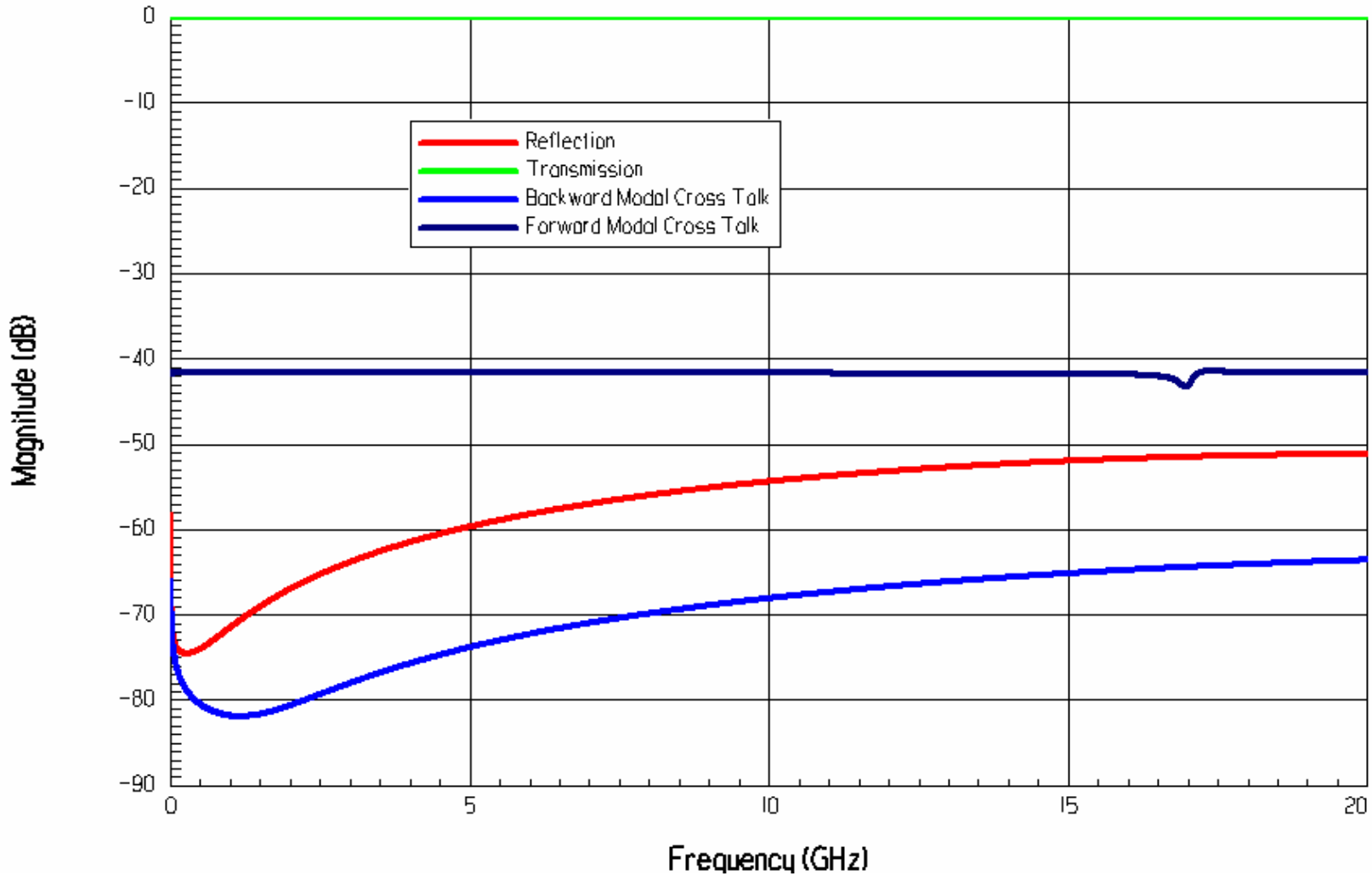
Terminal Excitations



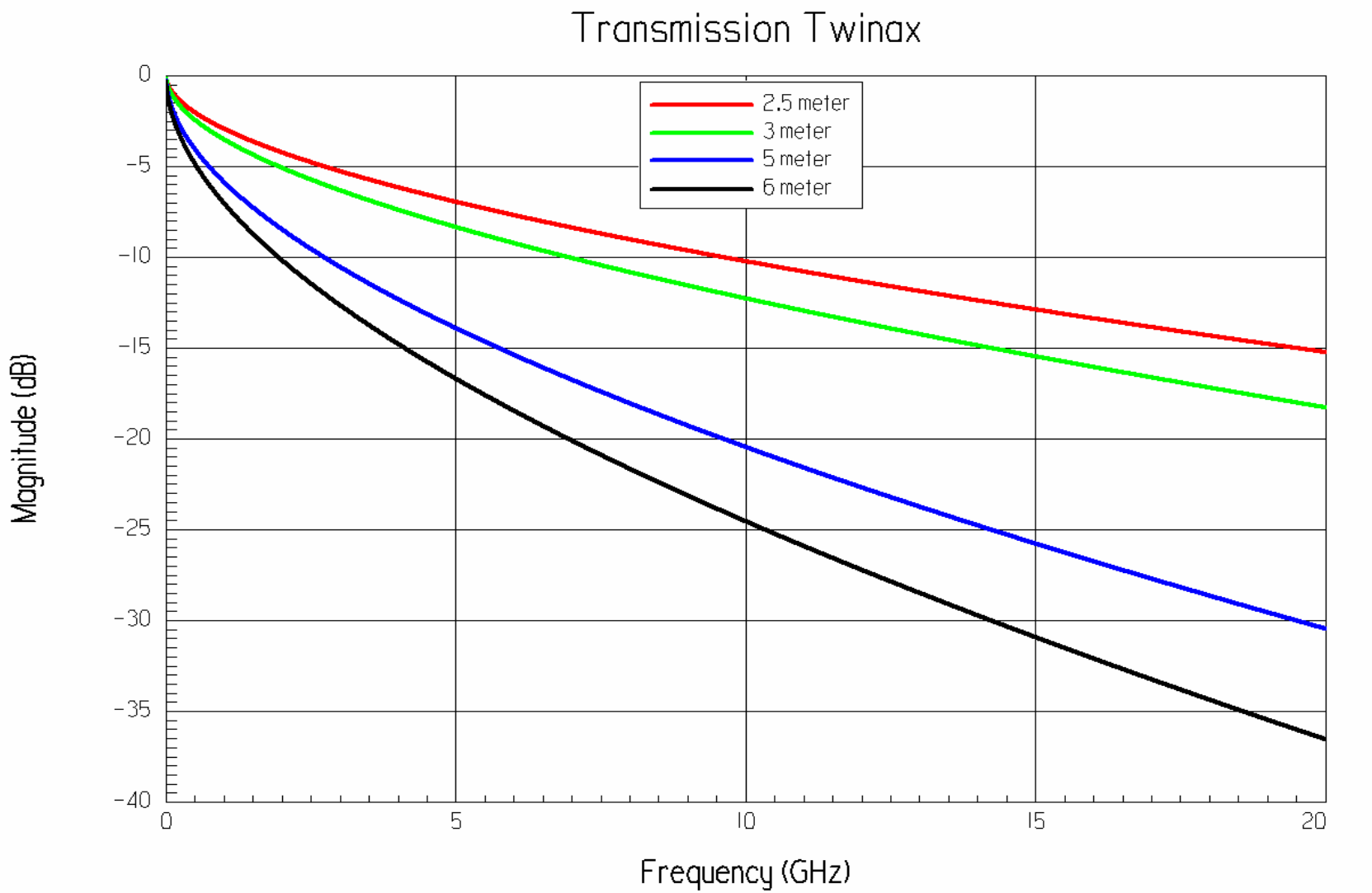


HFSS can go back and forth between the modal approach and the approach with terminal excitations.

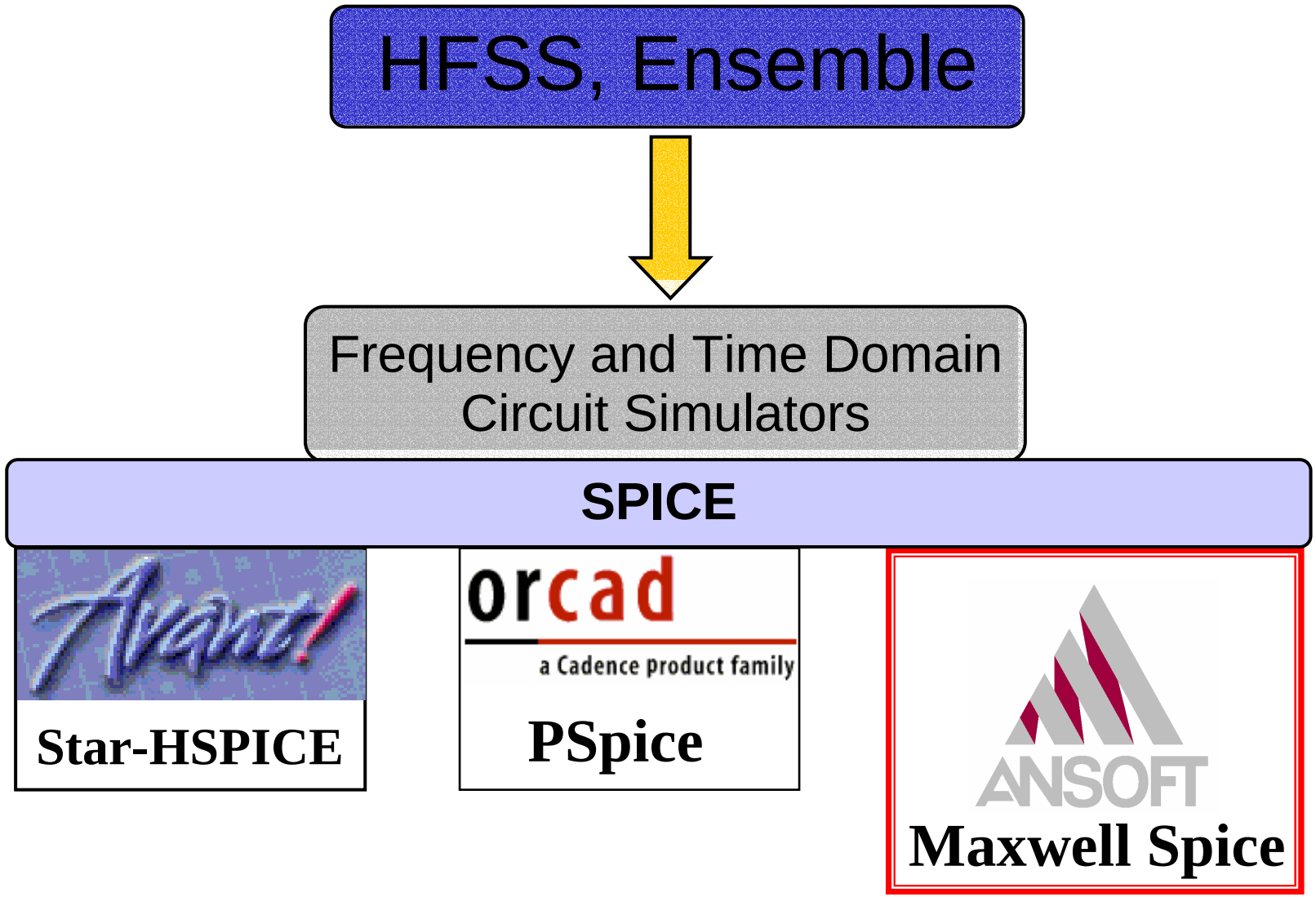
Results Short Line
Interpolating Frequency Sweep 0.02-20 GHz



Post Process: Deembedding



Full-Wave Circuit Export



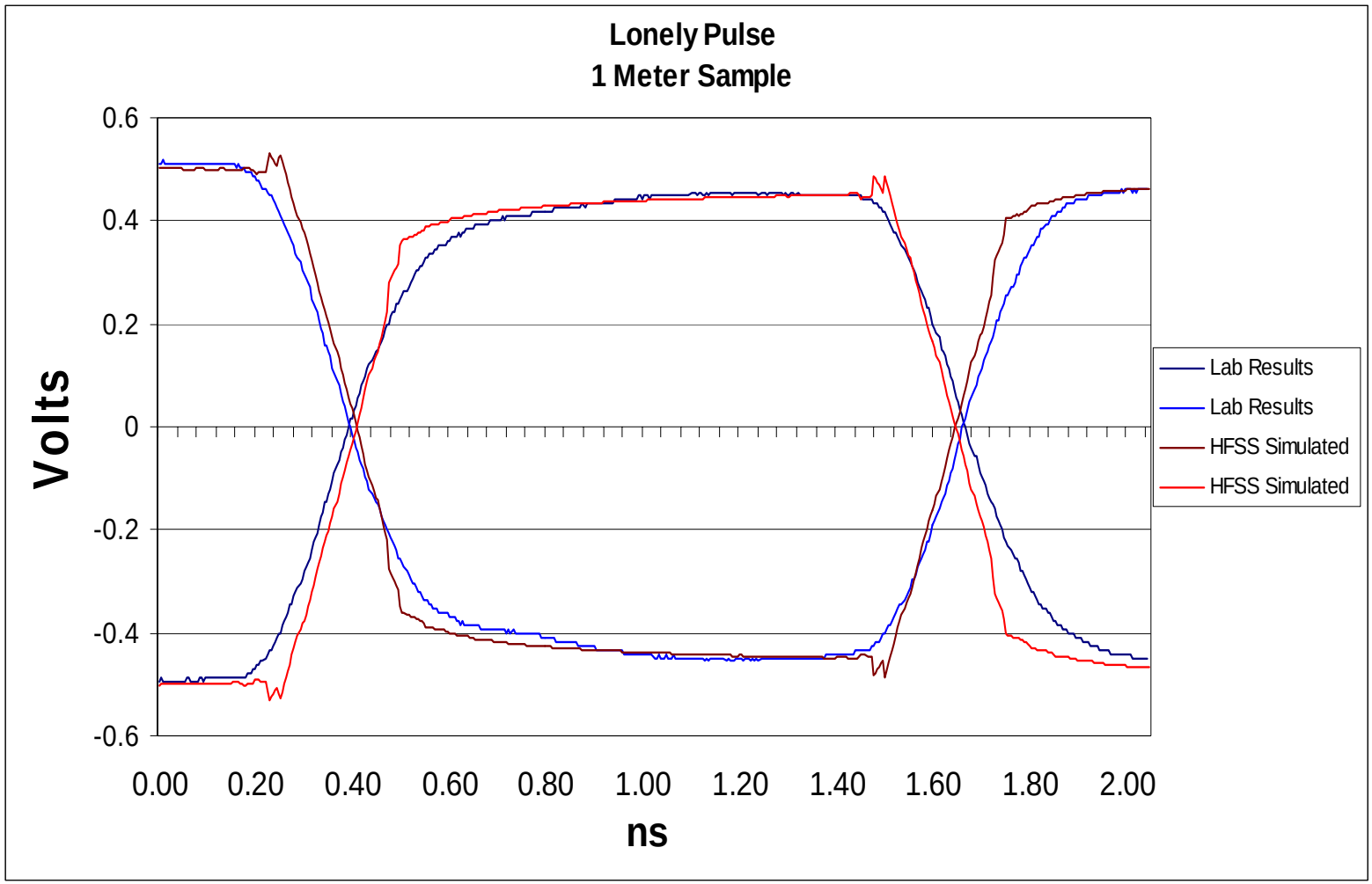
Basic Methodology

- Compute terminal-based S parameters in field solver.
  Wide frequency sweep to cover all frequencies in digital signal.
- Convert this into information that circuit simulator understands.
- Circuit simulator performs inverse FFT to find impulse response.
- Convolution is used to produce time-domain results.

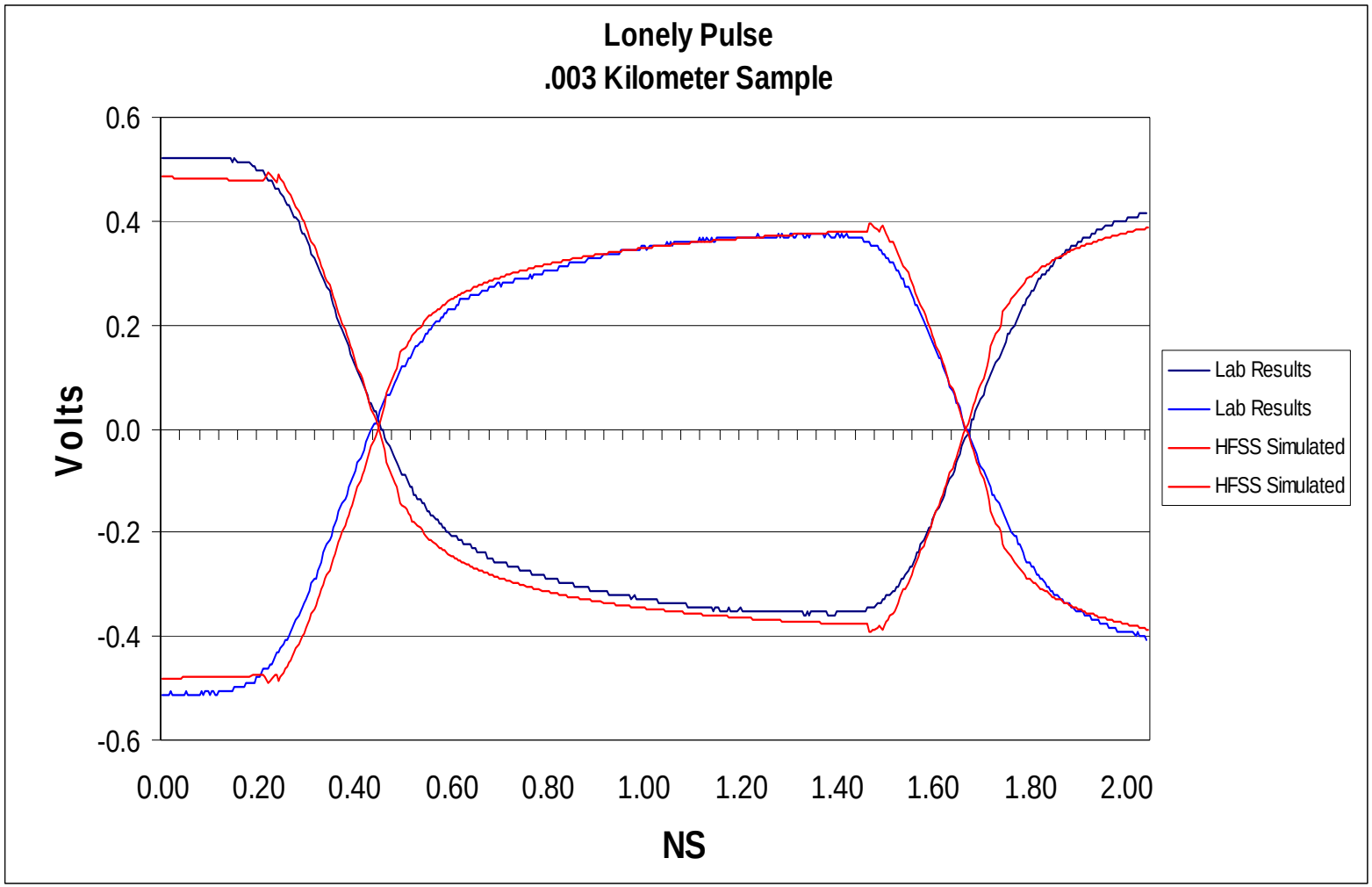
Spice Support Strategy

- HSPICE, PSpice
  - Use device primitives already present.
  - Create a complex “equivalent network” of controlled sources.
  - Sources have frequency-dependent gains, related to entries of S matrix.
- Maxwell Spice
  - Add a new *N*-port S-parameter primitive.
  - Implement proprietary algorithms for optimal time-domain simulation.

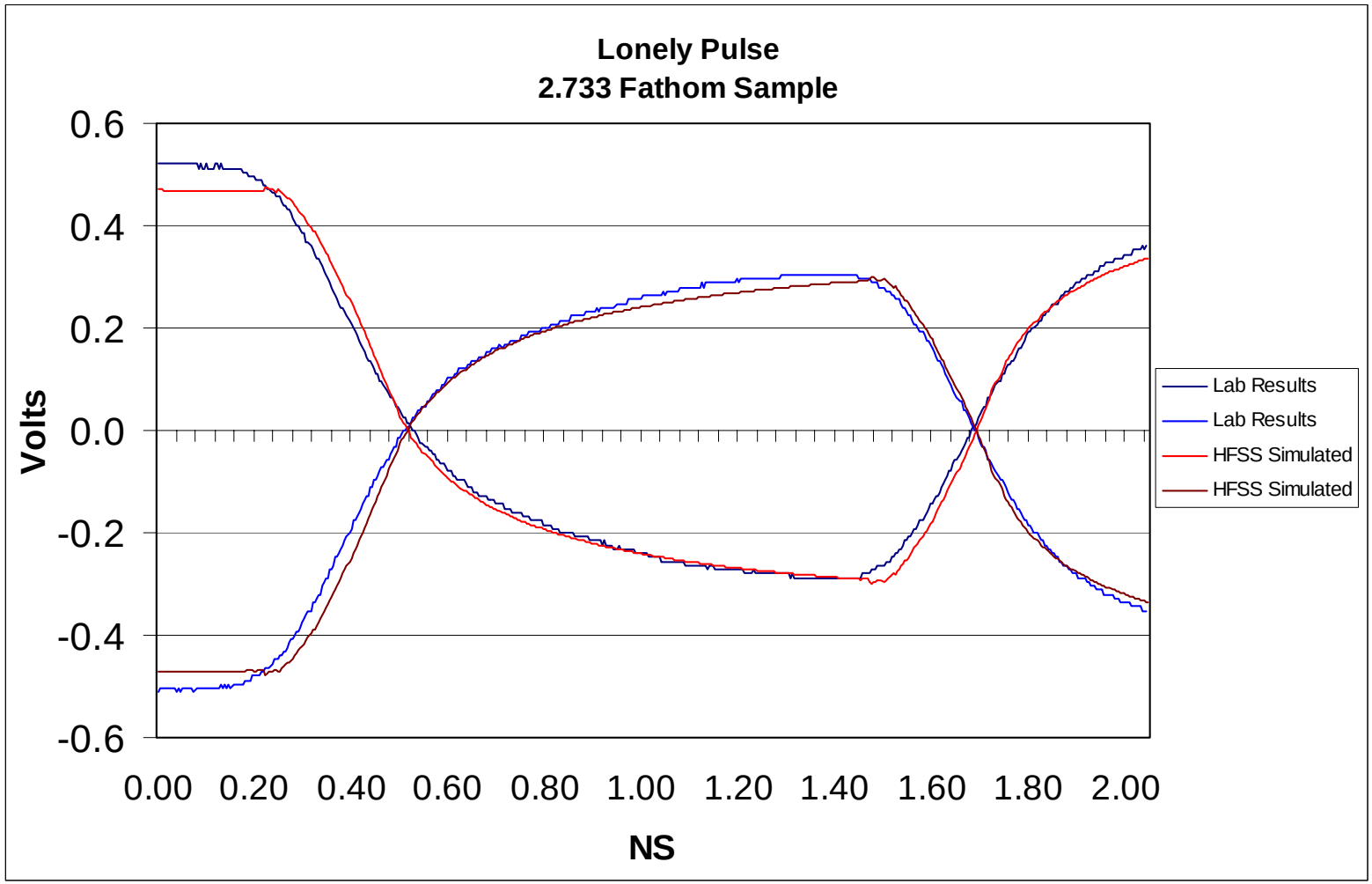
Simulation Results: Sim. Vs. Lab 1 meter



Simulation Results: Sim. Vs. Lab 3 Meter



Simulation Results: Sim Vs. Lab 5 meter



QUESTIONS?