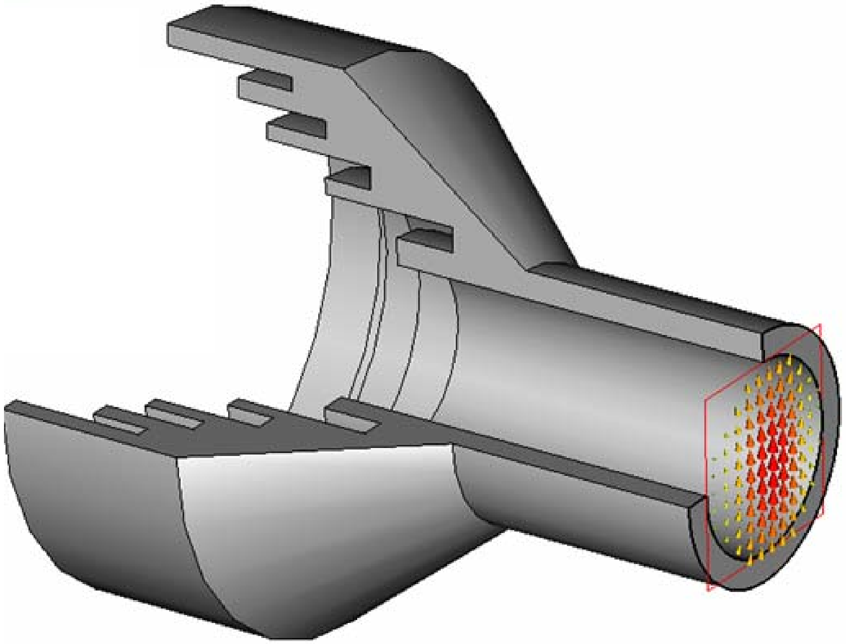
CST STUDIO SUITE™ 2006B
Application Note

Antenna Simulation



- Farfield Terminology
- Broadband Farfield
- Farfield Optimization
- Co & Cross Polarization
- Phase Center / Grasp Export
- Circular Polarized Antennas

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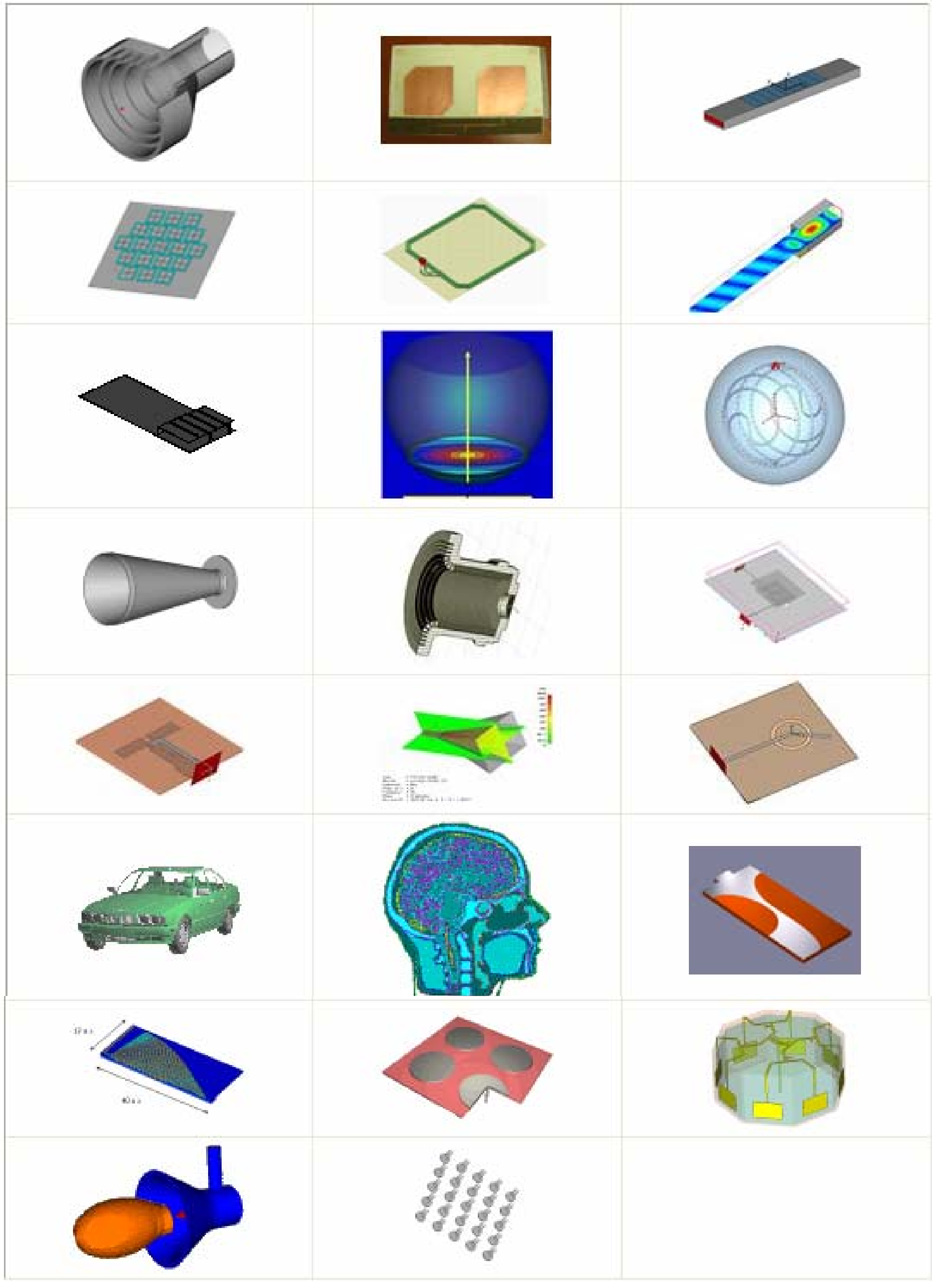
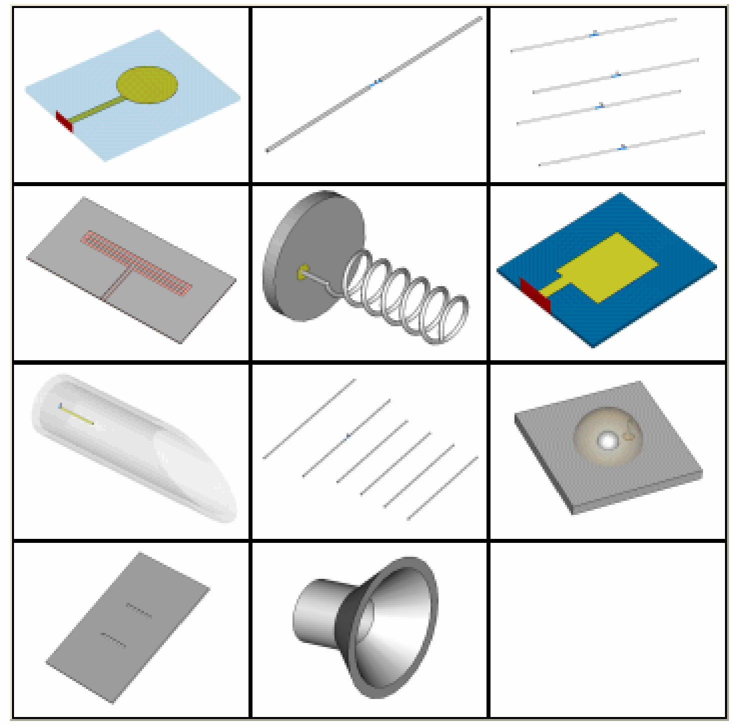
www.cst.com → Applications

Antenna Examples



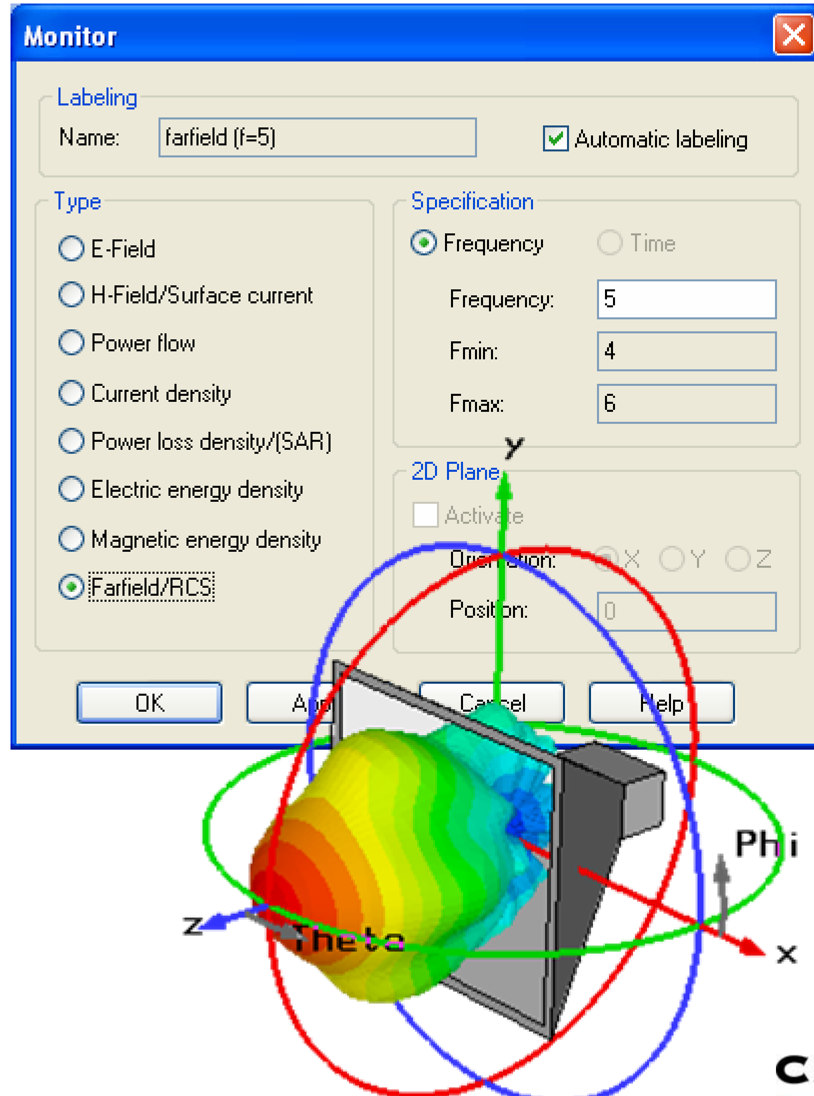
pre-installed examples in
CST STUDIO SUITE 2006



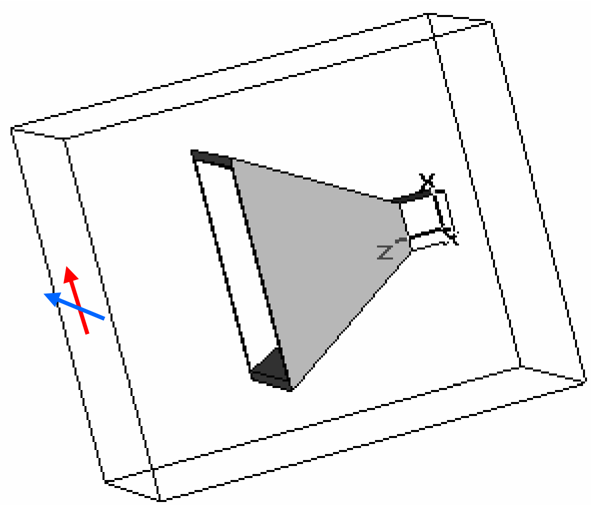
C:\Program Files\CST STUDIO SUITE 2006\
Examples\CST MICROWAVE STUDIO\
Transient Analysis\Antennas

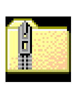
How to generate the Farfield Info

- define farfield monitor at one or more specified frequencies
- box surface fields (E+H) are recorded, from which in the postprocessing the farfield is calculated.



E,H





Horn_01.zip

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Farfield Terminology
Online Help

- CST MICROWAVE STUDIO
  - Getting Started
  - Creating and Visualizing Models
  - Mesh Generation
  - Setting up the Simulation
  - Visualizing and Analyzing Simulation Results
    - Post Processing Overview
    - Visualizing Results
      - 1D Plot Overview
      - 2D/3D Plot Overview
      - Farfield Overview
      - SAR Calculation Overview
    - Post Processing Results
  - Preloaded Macros
  - Advanced Features

CST MICROWAVE STUDIO

Farfield Overview

In CST MWS the used reference for gain/directivity is an ideal spherical radiator (=isotropic antenna -> dBi), a λ/2-Dipole has a gain of 2.2dB(i).

Some Farfield Terms

Directivity: The directivity of an antenna is officially defined as "the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions". At this the radiation intensity is given by the total power radiated by the antenna divided by 4π:

$$D(\theta,\varphi) = 4\pi \cdot \frac{power\ radiated\ \ per\ unit\ solid\ angle}{total\ radiated\ \ power}$$

Gain: Accordingly the gain is defined quite similar but related to the input or accepted power of the antenna. In case of a loss free antenna (no conductional or dielectric losses) the gain is equal to the directivity.

$$G(\theta,\varphi) = 4\pi \cdot \frac{power\ radiated\ \ per\ unit\ solid\ angle}{input\ (accepted)\ power}$$

Radiation efficiency: The antenna radiation efficiency is defined as the ratio of gain to directivity or equally the ratio between the radiated to accepted (input) power of the antenna:

$$G(\theta,\varphi) = e_{rad} \cdot D(\theta,\varphi) \quad \text{or} \quad P_{rad} = e_{rad} \cdot P_{in}$$

Total efficiency: The total efficiency is defined as the ratio of radiated to stimulated power of the antenna:

$$P_{rad} = e_{total} \cdot P_{stim}$$

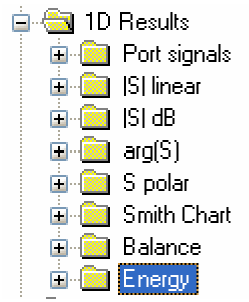
Compared to the input power the stimulated power consider any occurring reflections at the feeding location.

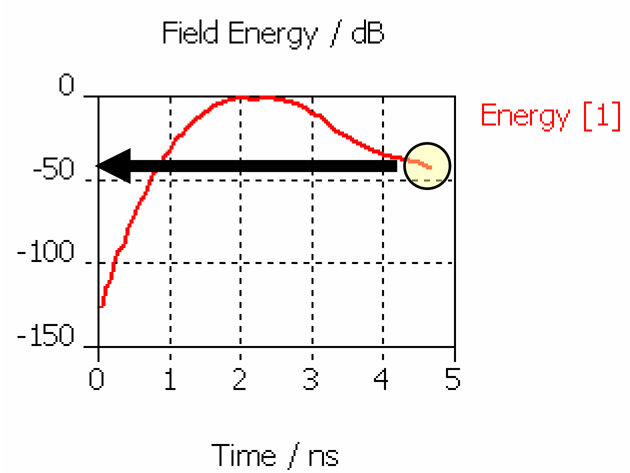
Reflection efficiency: The reflection efficiency is defined as the ratio of input to stimulated power. In CST MICROWAVE STUDIO® this value can also be determined from the reflection factor:

$$e_{refl} = \frac{P_{in}}{P_{stim}} = \frac{e_{total}}{e_{rad}} = 1 - S_{11}^2$$

Tips & Tricks
to obtain accurate farfield results

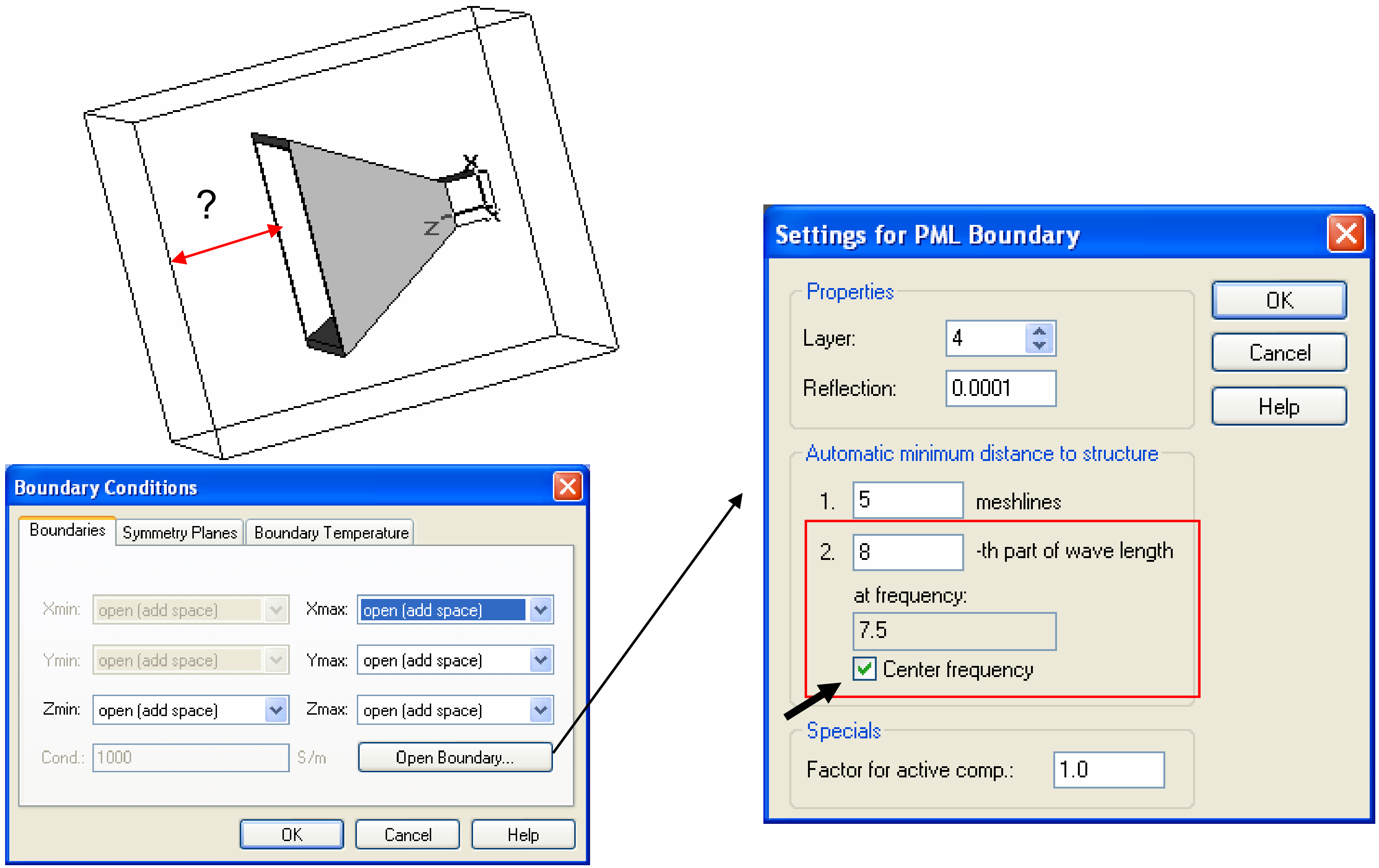
Tip 1/3 : Check Energy





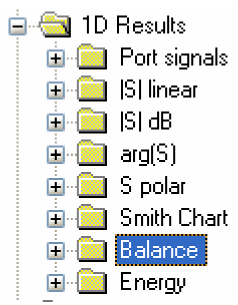
- The accuracy level in the T-solver should be ***-40dB***.
  For larger frequency bands (eg 0-3 GHz) or bad radiation better use -60dB, so that E+H on the bounding box do not suffer from FFT/DFT truncation error.

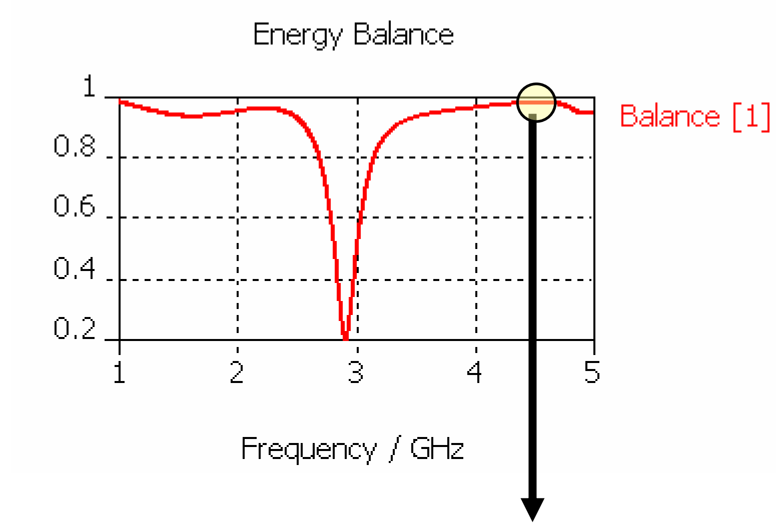
Tip 2/3 : Check ‚add. space‘



„open (add space)“ boundary ensures λ/8 space at the center frequency, for lower frequencies (bigger λ) the space needs to be increased accordingly.

Tip 3/3 : Check Balance



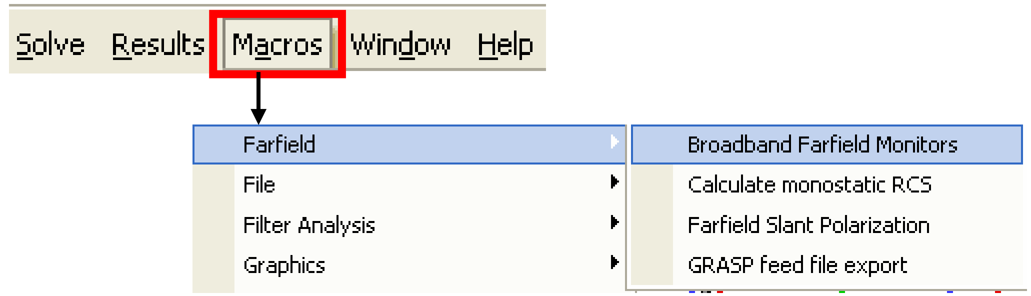


at 4.5 GHz farfield can be critical

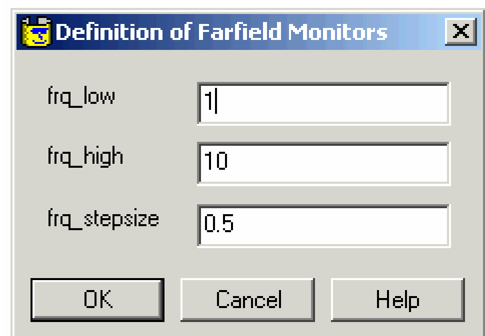
- Farfield values become critical, ***if S-Parameter balance=1*** (no power is radiated). In this case directivity and gain are calculated from dividing 0/0, which is numerically critical.
  A good measure for total radiated power is: (1-balance).

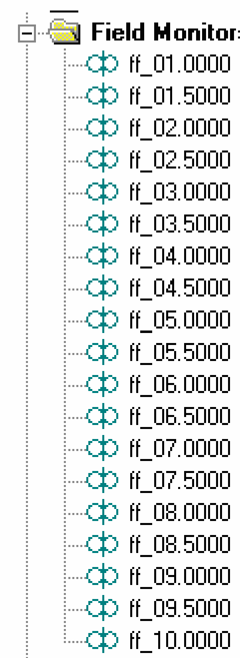
How to calculate farfield Broadband at many frequencies

Definition of Broadband Farfield Monitors

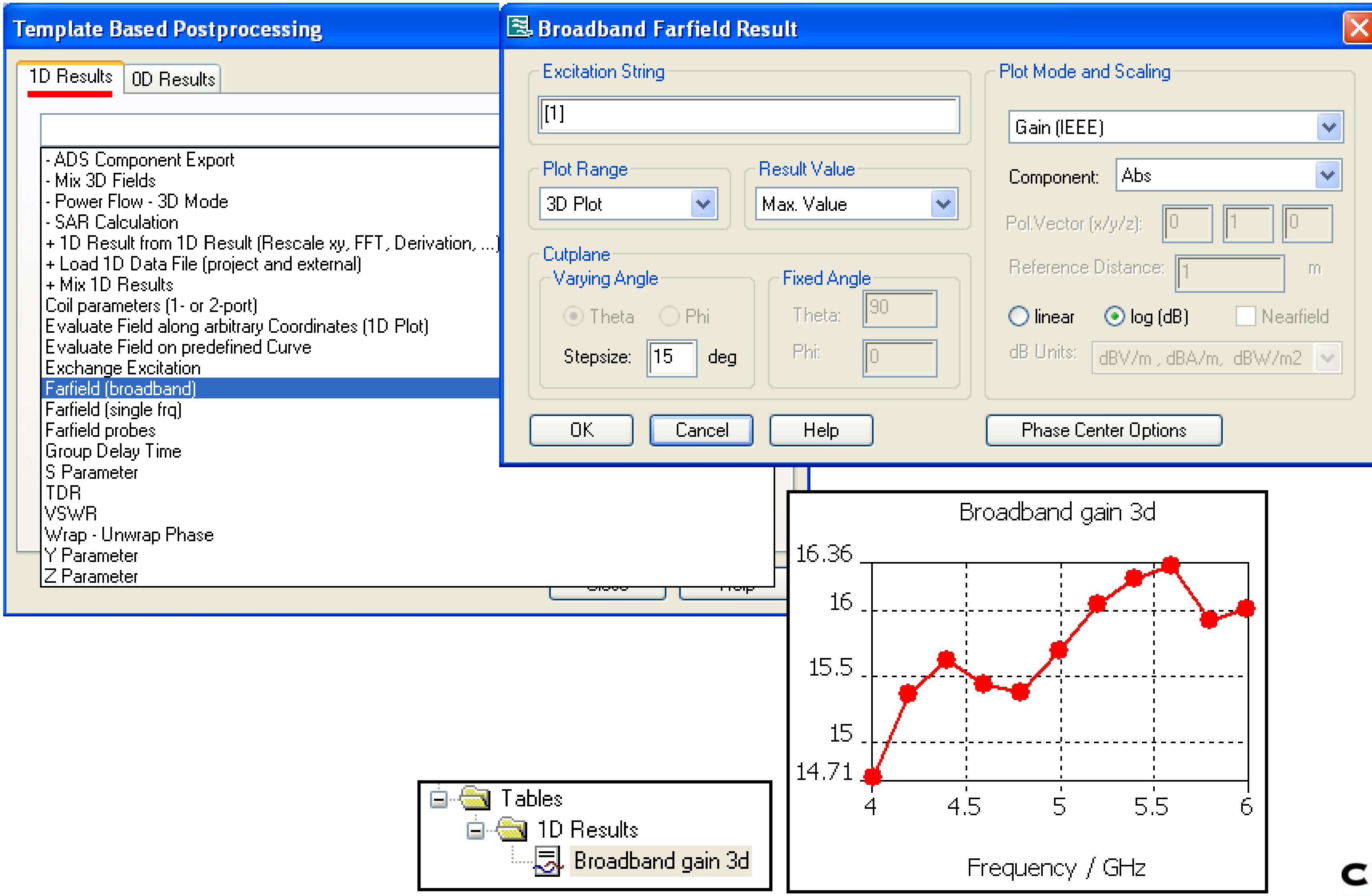


- macro can be applied ***multiple times*** without overwriting the previous definitions, so that different frequency resolutions can be combined.





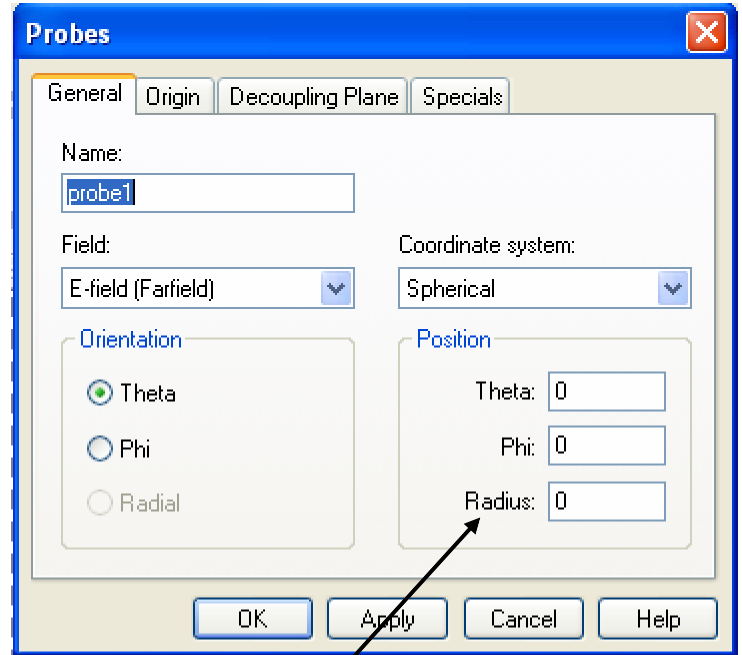
Evaluation of Broadband Farfield Monitors



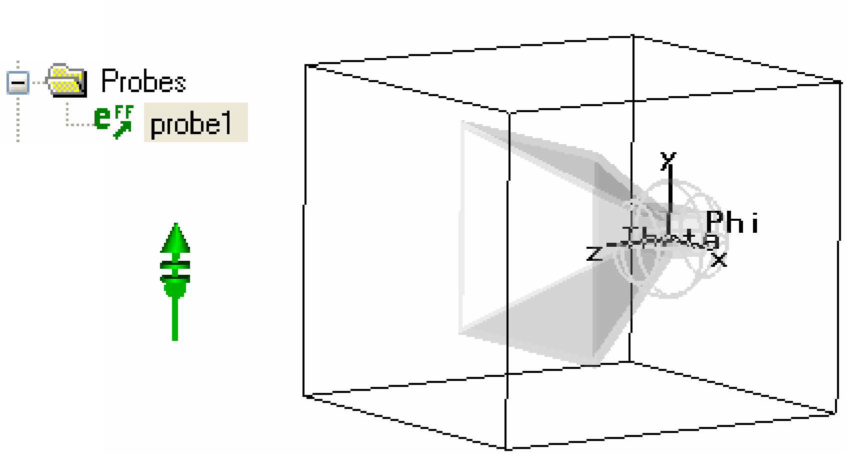
Definition of Farfield Probes

Farfield ***monitors*** record the radiation in ALL directions for ONE frequency.

Farfield ***probes*** record the radiation in ONE direction for ALL frequencies. (recording a time signal)

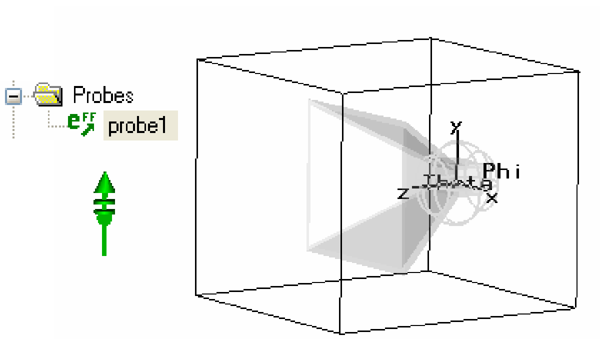


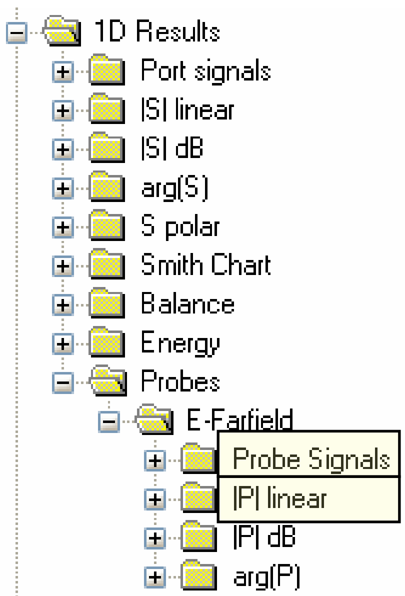
Attn: this radius is entered in the design-units (e.g. cm) and not automatically in Meter

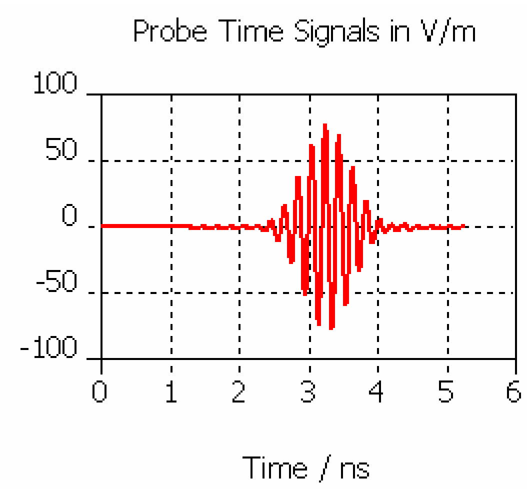



```
Probe     = probe1
Type      = Efield (farfield)
Theta     =         0
Phi       =        90
Radius    =        40
```

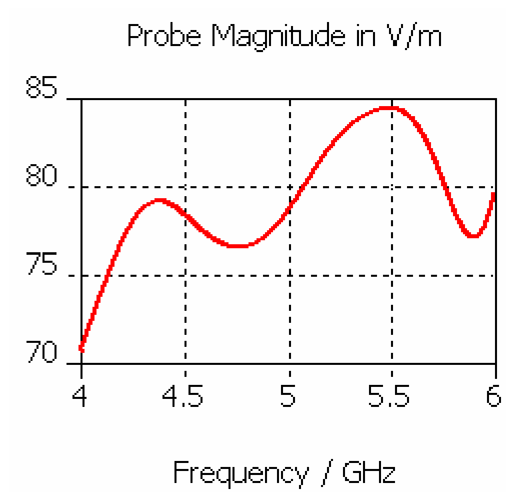
Results from Farfield Probes







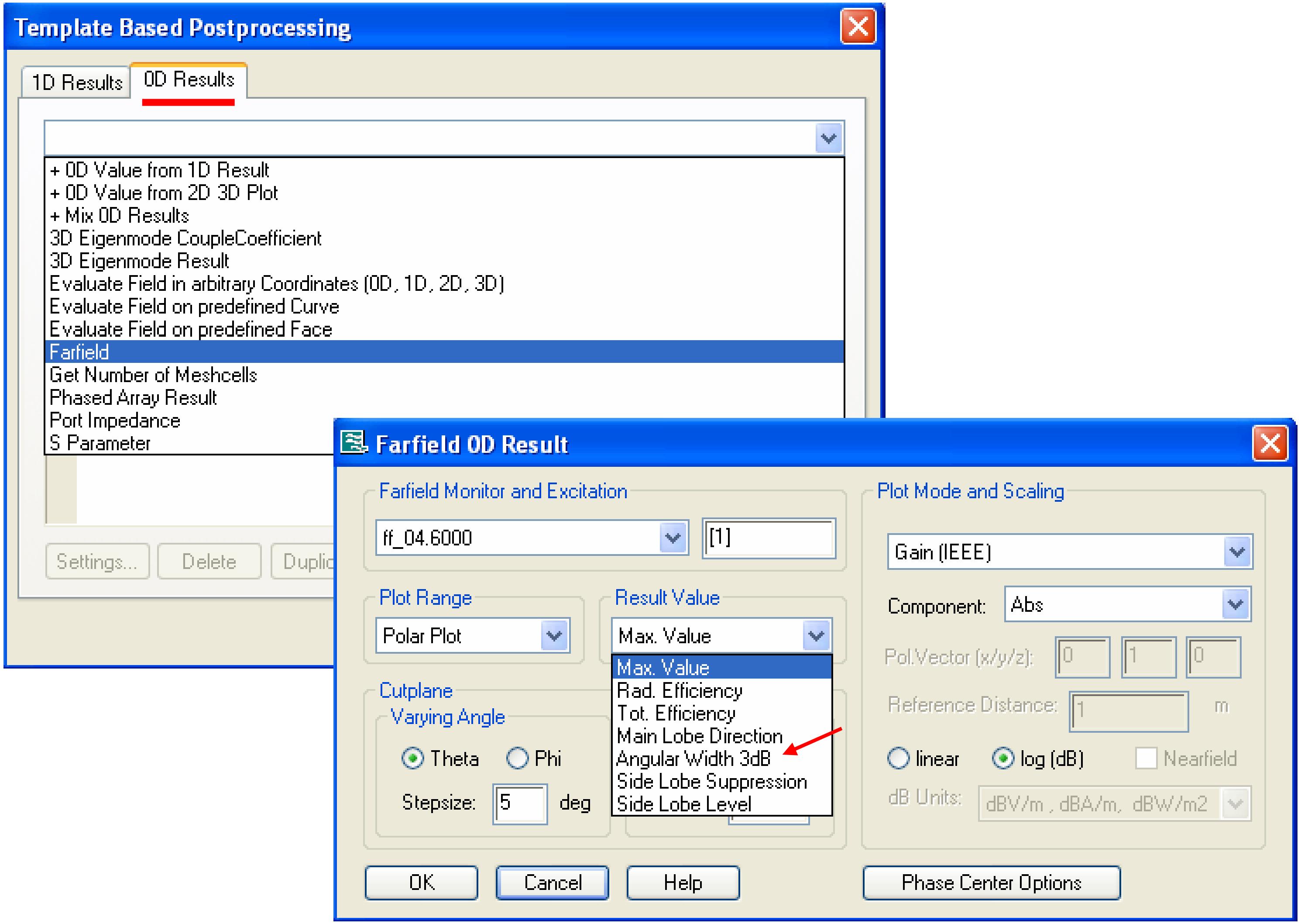
Farfield
Time Signal



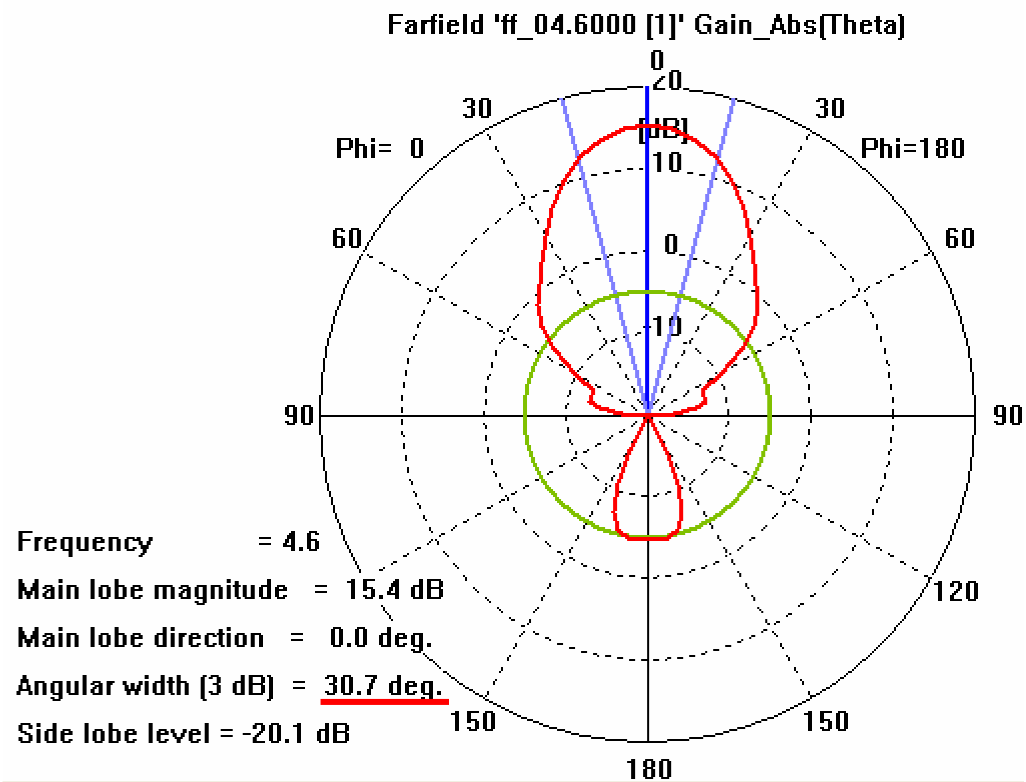
Highly resolved
Farfield
Frequency Spectrum
(1000 samples)

Optimizing Farfield Results

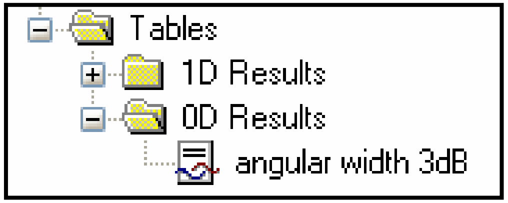
Optimizing Farfield Results

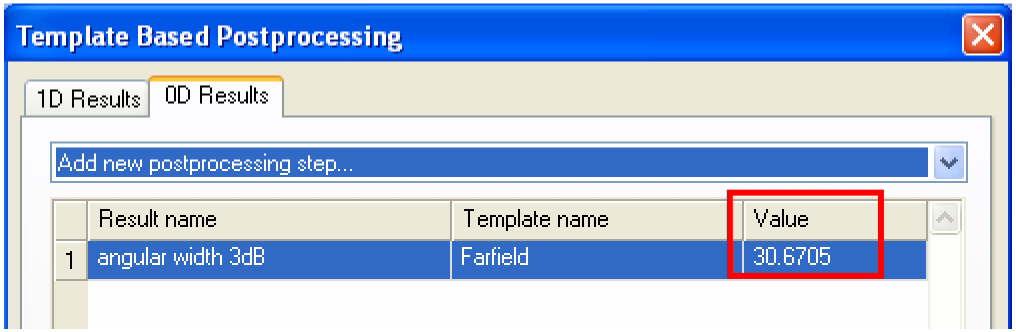


Example: 3dB Angular Width

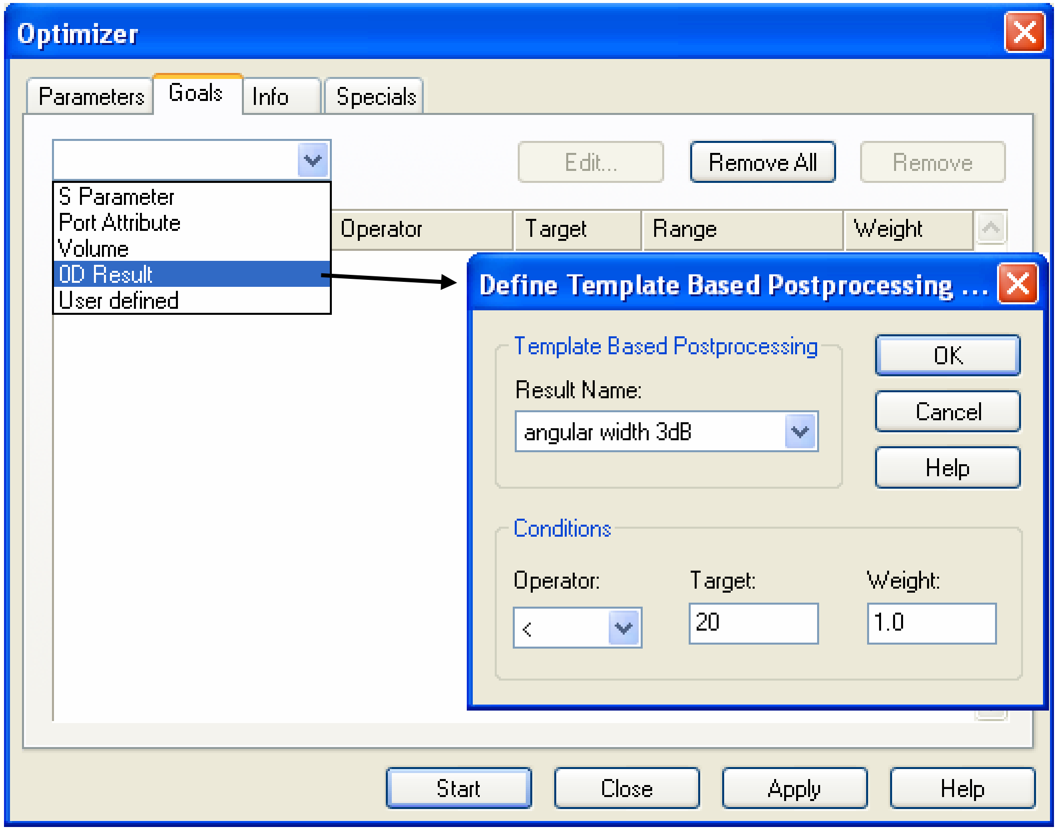


value also displayed here:





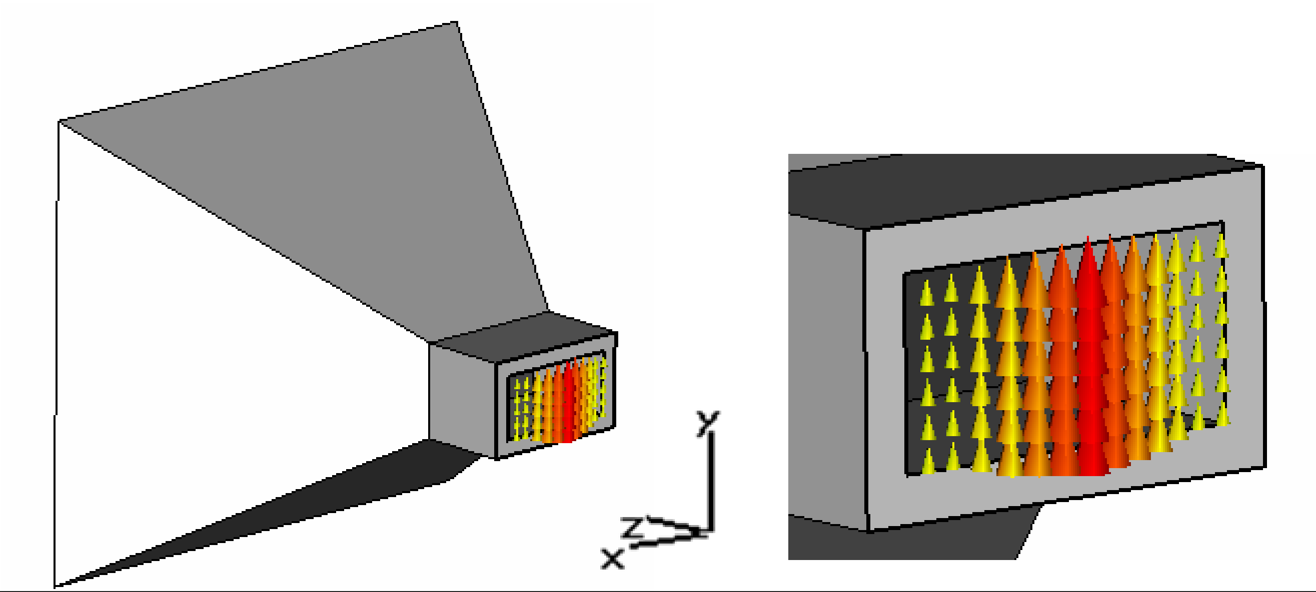
Define Goal from 0D Template



all existing
0D Result Templates
can be used
to define goals
for optimization runs.

Co & Cross Polarization

Co & Cross Polarization



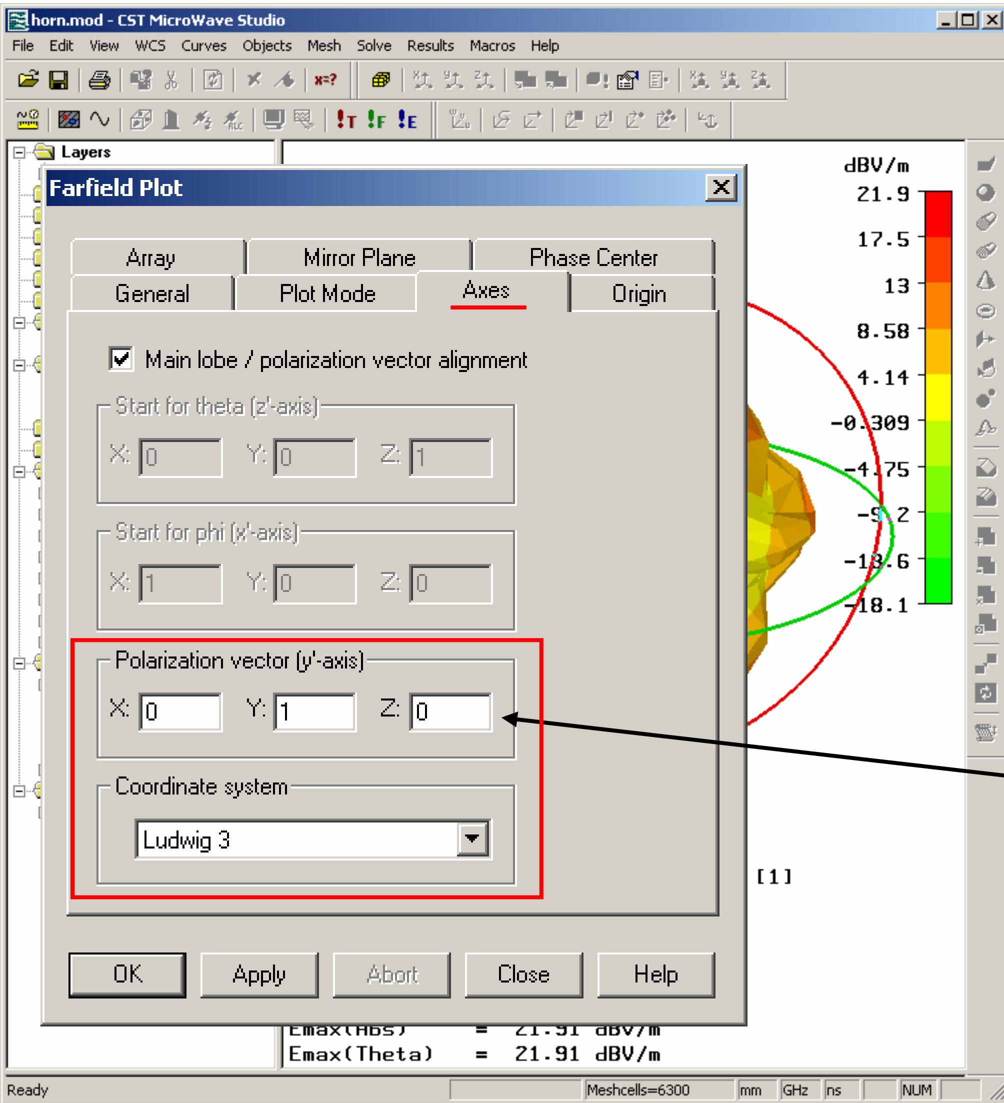
The ***Co-polarized*** farfield component has the same polarization as the excitation (y-oriented in our case).

The ***Cross-polarized*** farfield component is orthogonal to Co-pol component and mainlobe direction.

In order to use different polarizations for transmitting/receiving, an antenna design goal might be to maximize the Co-pol and minimize the cross-pol component.

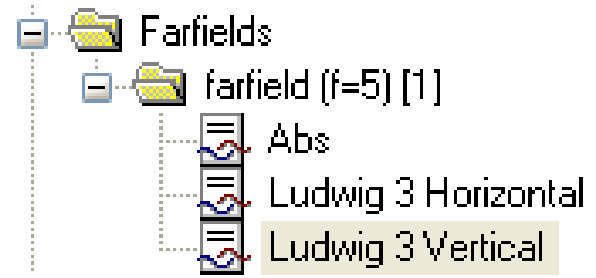
Co & Cross Polarization

Adjust the Axes / coord. system

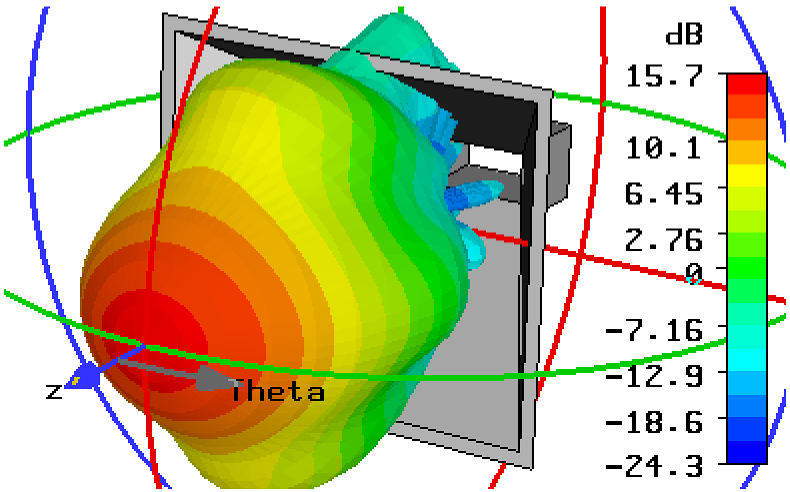


Polarization vector default direction
(the right one for our example;
arbitrary user input possible)

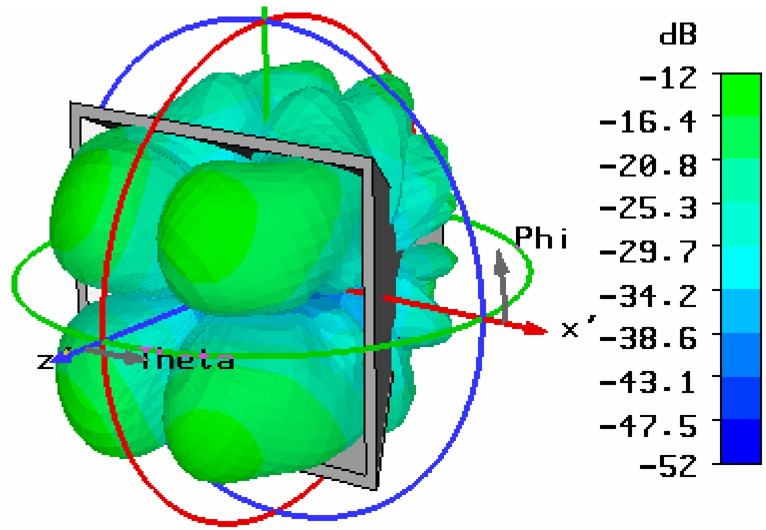
Co & Cross Polarization



Co pol = Ludwig 3 Vertical



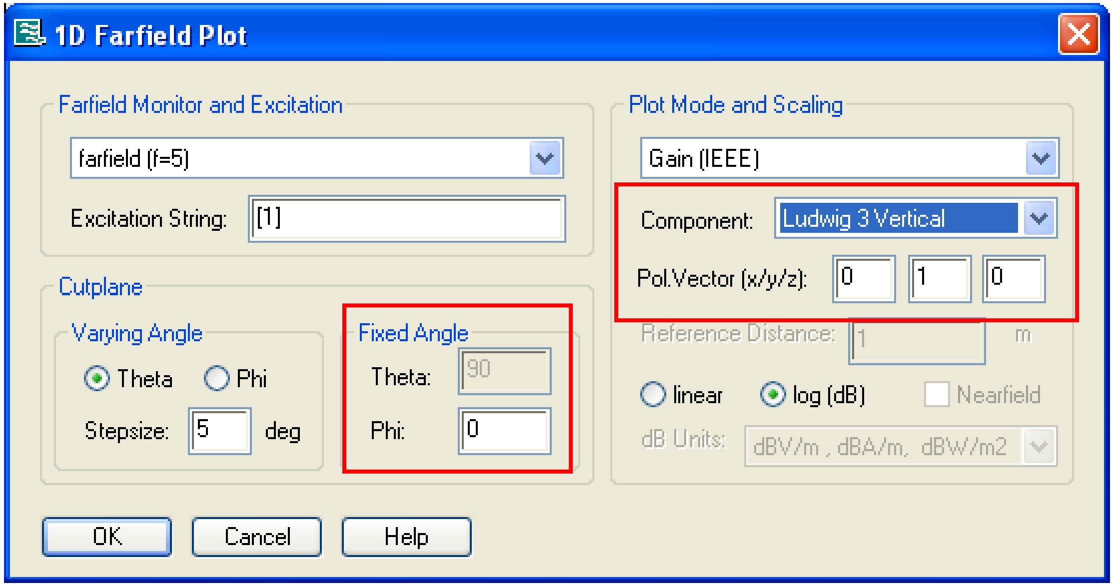
Cross pol = Ludwig 3 Horizontal



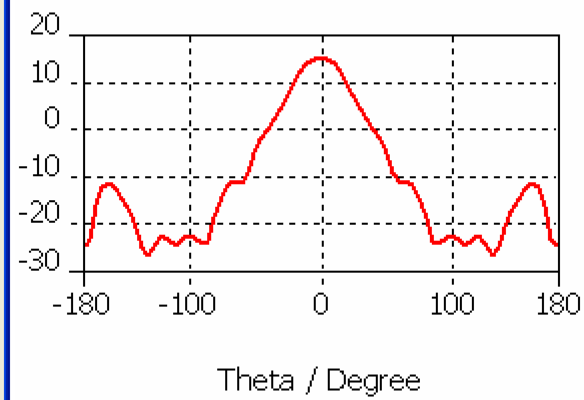
Cross polarized component is typically worse for the angles phi=45 and phi=225

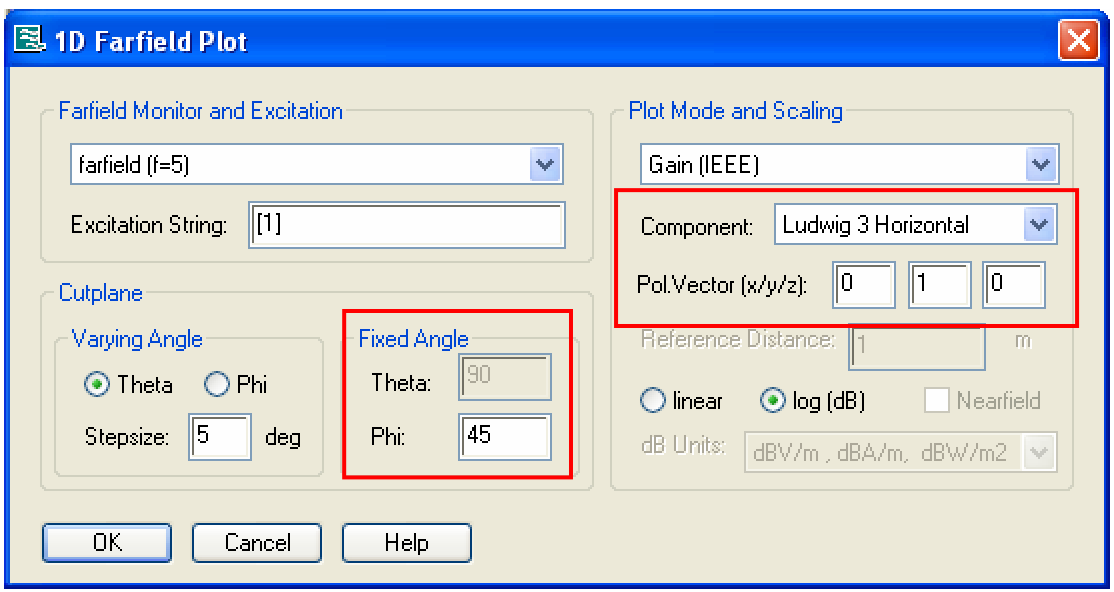
Co & Cross Polarization

Result Templ. for Param-Sweep & Optimization

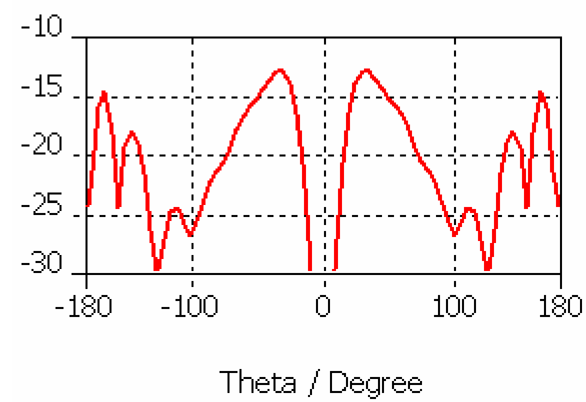


Co pol = Ludwig 3 Vertical





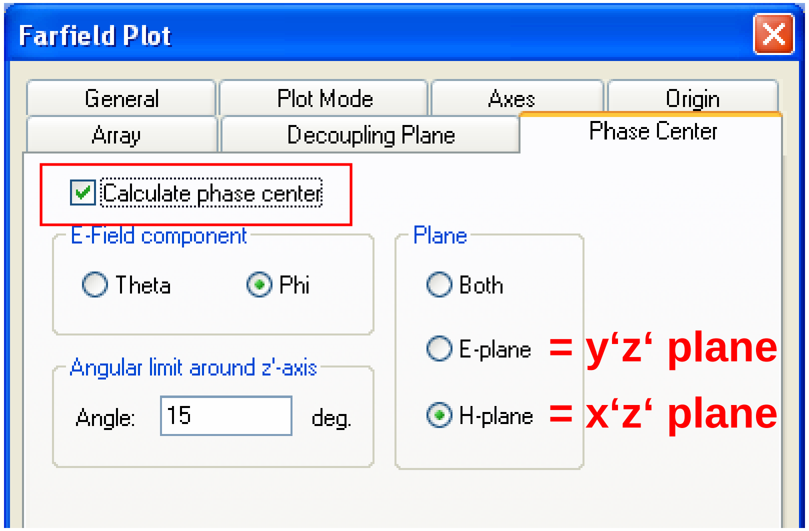
Cross pol = Ludwig 3 Horizontal



Phase Center / Grasp Export

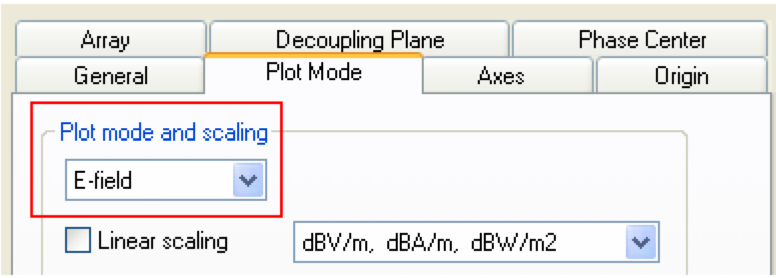
Phase Center Calculation

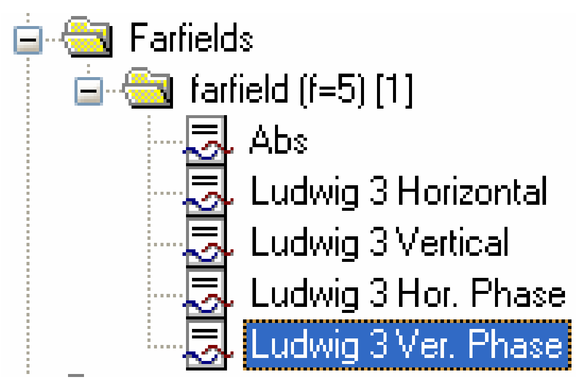
Finding the best location to place the horn inside a dish antenna. The best position is to match the ***focal point of the dish*** with the ***phase center of the horn***.

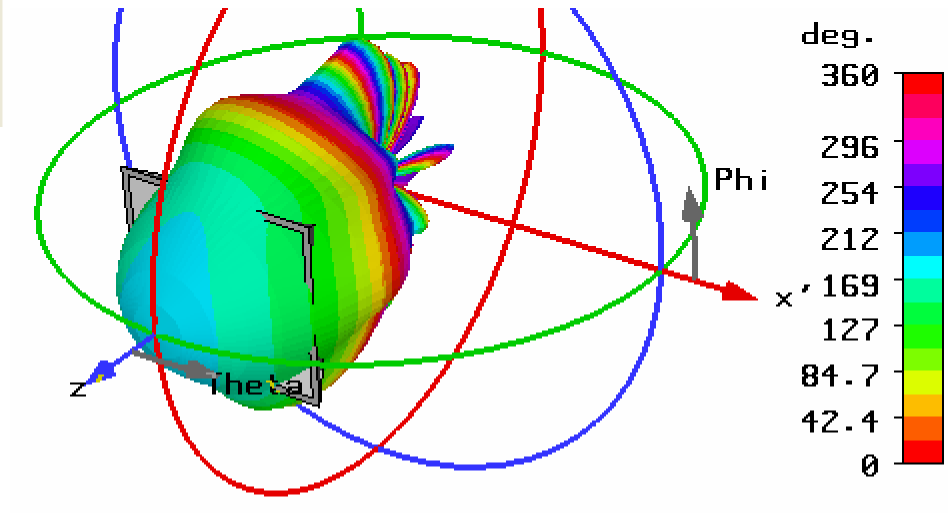



```
Type           = Farfield
Approximation  = enabled (kR >> 1)
Monitor        = farfield (f=5) [1]
Component      = Ludwig 3 Ver. Phase
Output         = E-Field(r=1m)
Frequency      = 5
Emax(Theta)    = 30.41 dBV/m
Phase center   = (2, 1, 5.29659) Sigma 0.0829187 (H-Plane)
```

Check Phase Center by plotting Ludwig3-Ver.Phase

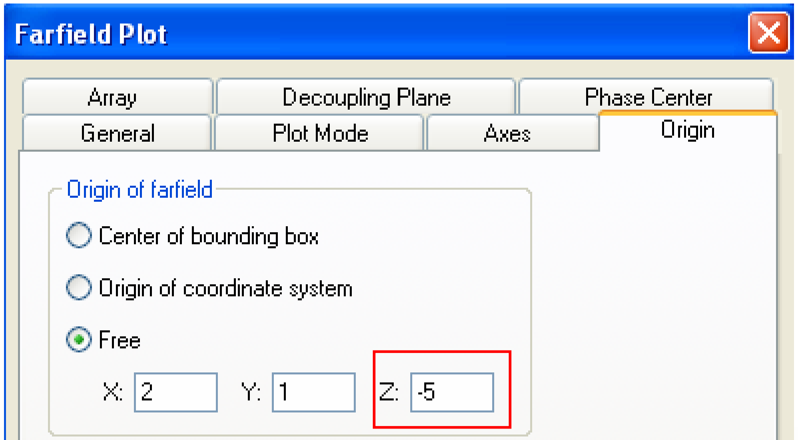


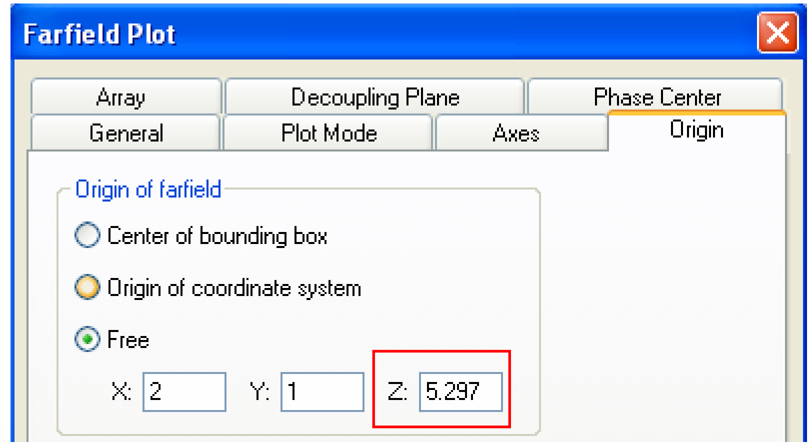


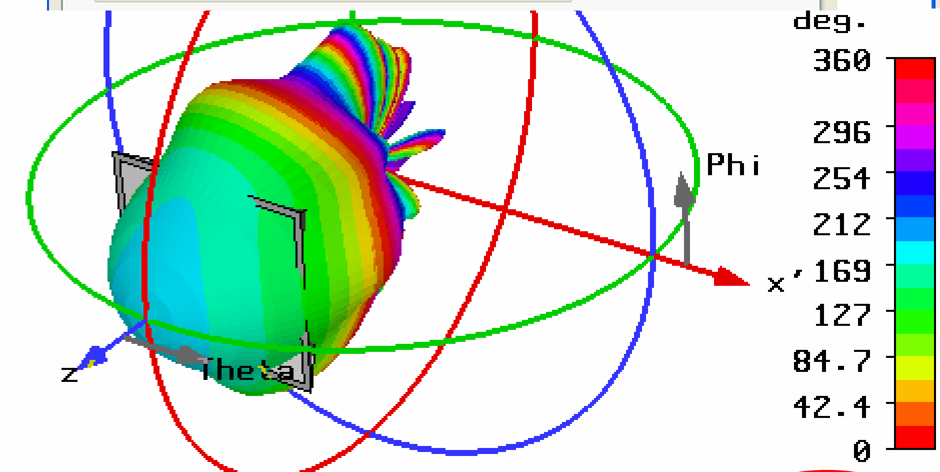


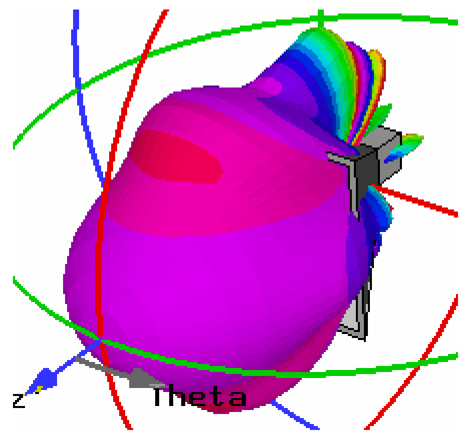
Plotting the Phase of Ludwig 3 Vertical (=dominant component co-pol) does not result in a phase 180 deg jump (=colour jump) at theta=0

Check Phase Center
by moving Origin into Phase Center







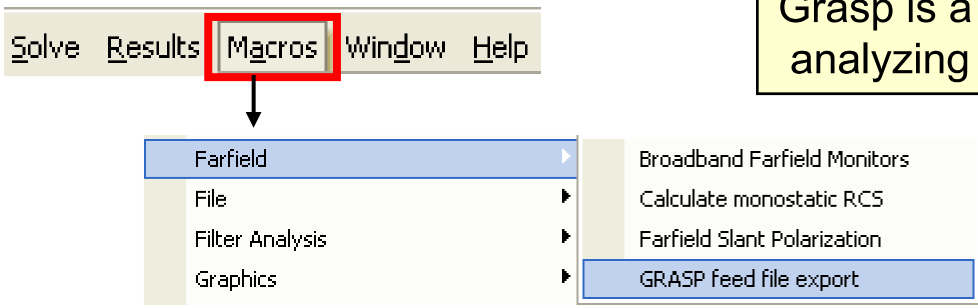


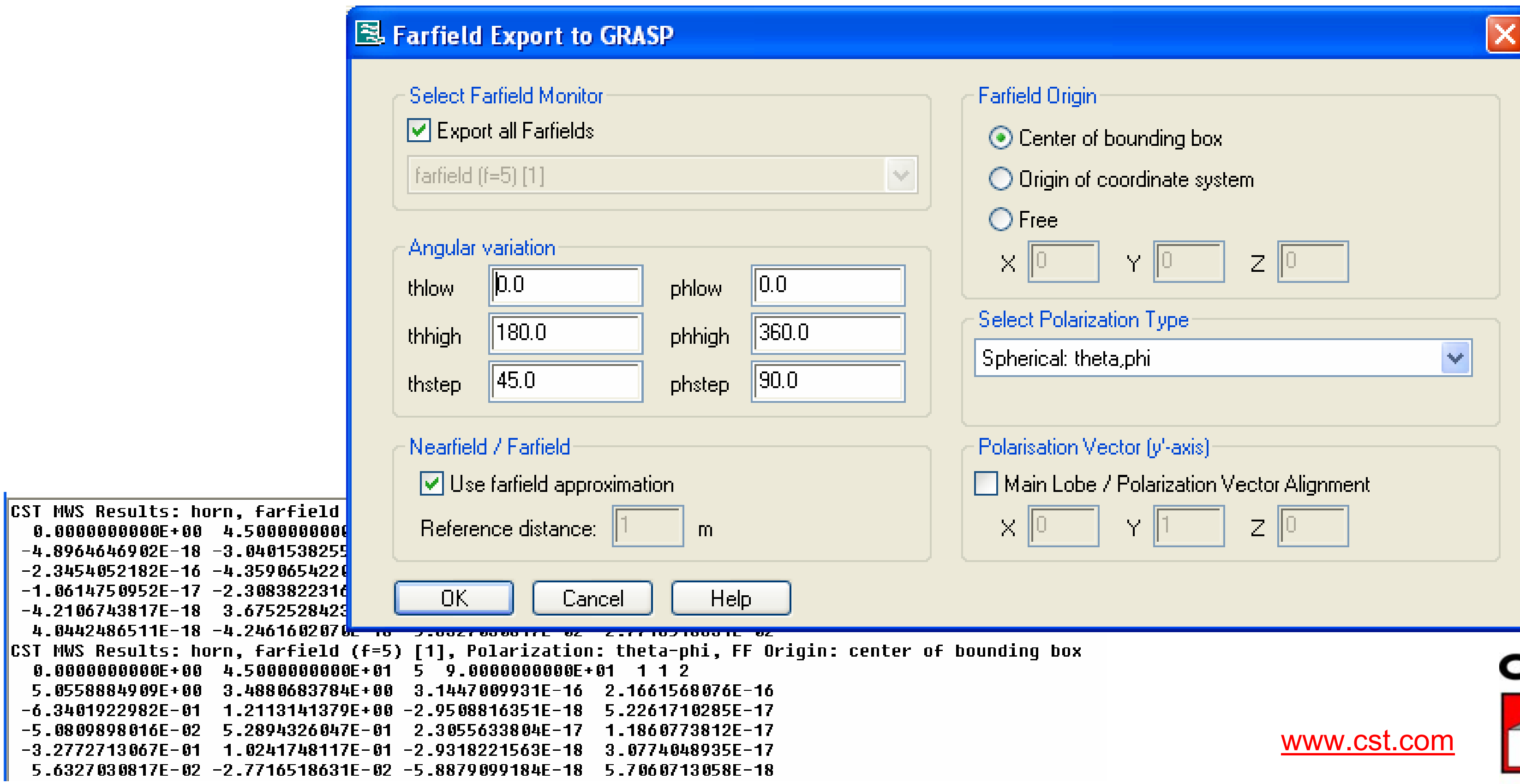
Phase center = (2, 1, 5.29651) Sigma 0.0830522 (H-Plane)

see also article (phase center comparison with measurement) on www.cst.com -> Application Article ID=256

Farfield Data Export in Grasp Format

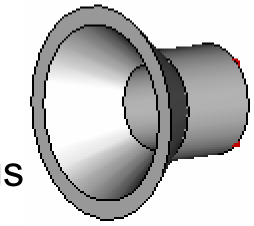
Grasp is a software, based on physical optics, analyzing Reflector Antennas and Scatterers



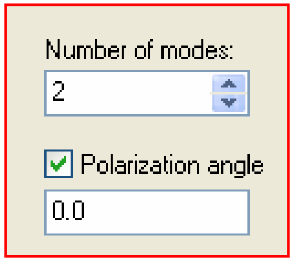


Circular Polarized Antennas

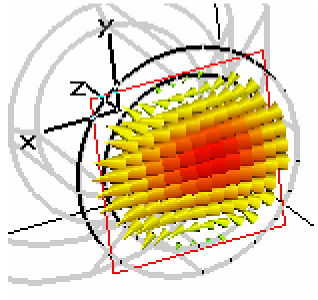
Circular Polarized Antennas



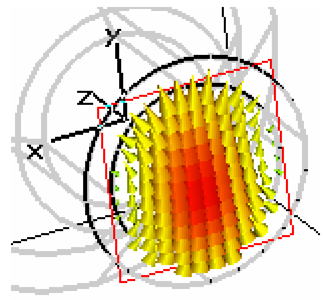
Waveguide port Settings

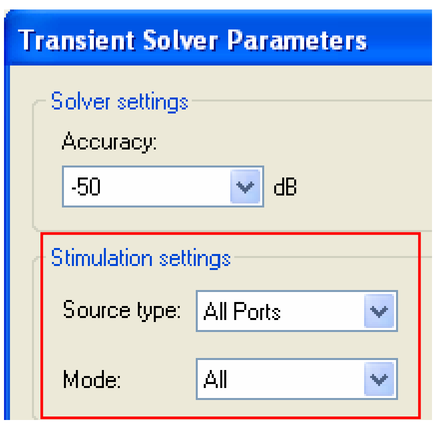


Mode 1



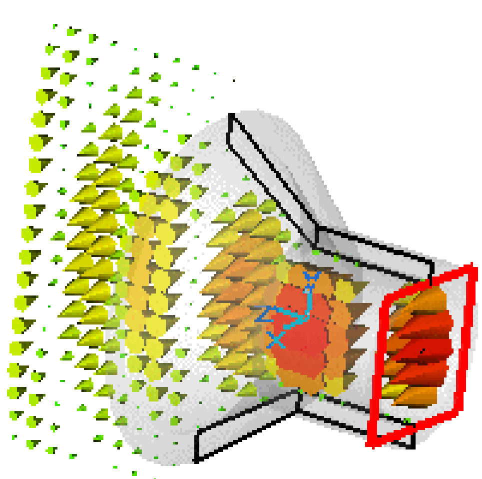
Mode 2



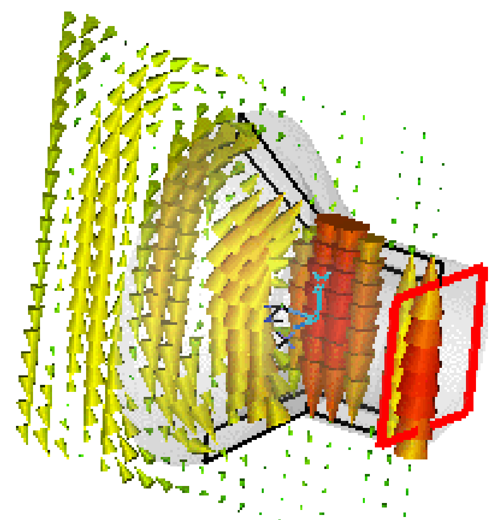


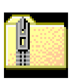
-> Distributed Port Runs

only mode 1 active



only mode 2 active

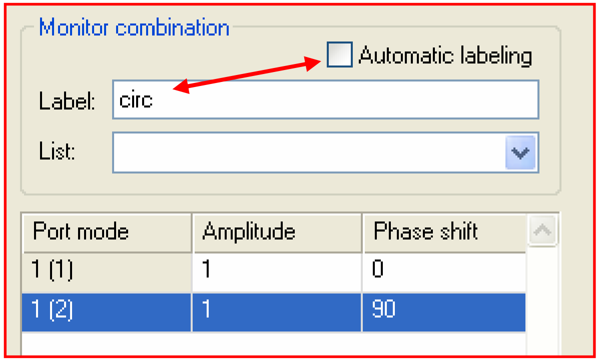


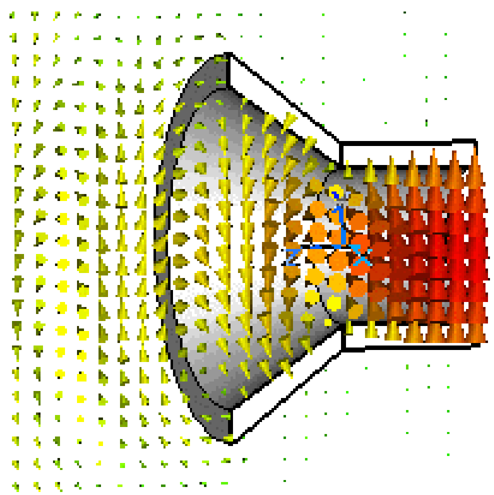


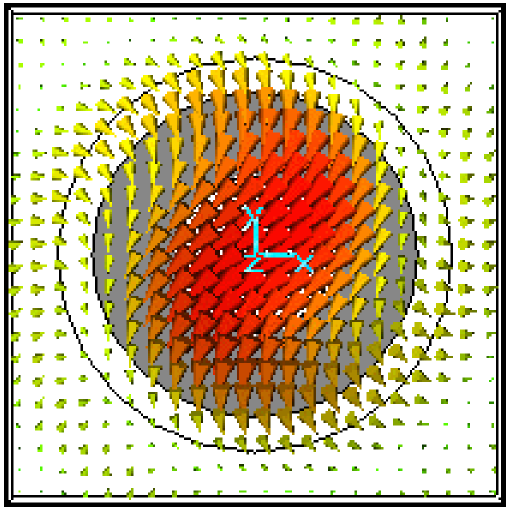
horn_cylindrical_10.zip

Combining the Results

Results -> Combine Results...

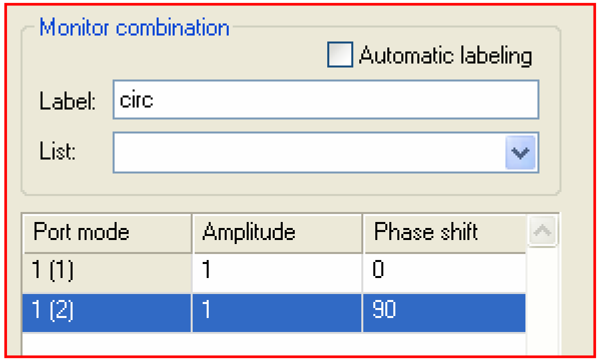


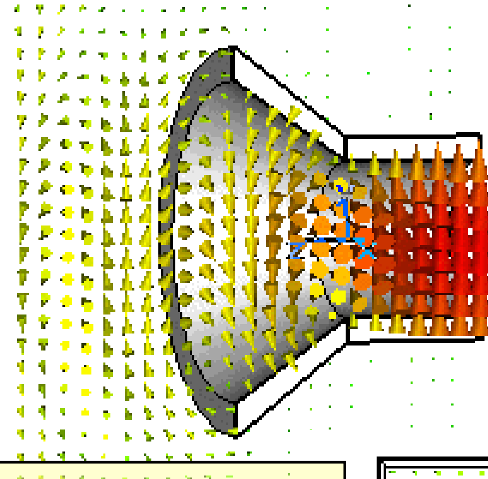


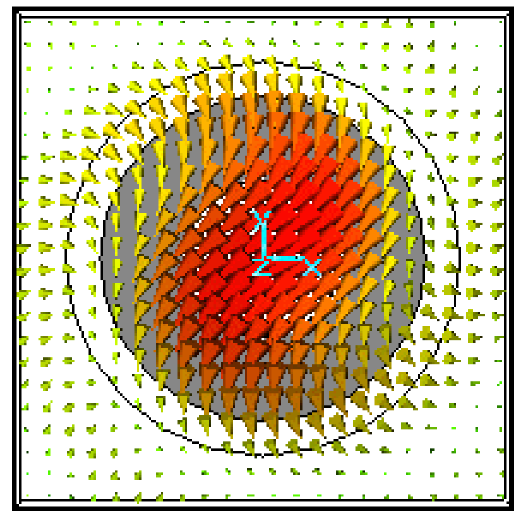


view in –z direction

Combining the Results







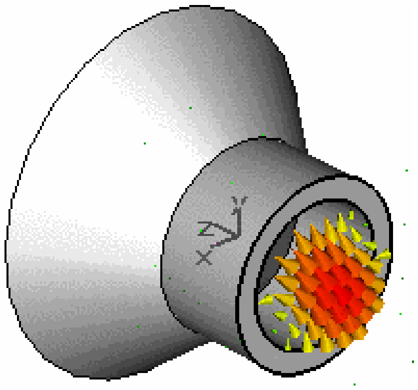
<u>Ports=ALL/Modes=All + Combine Results</u>

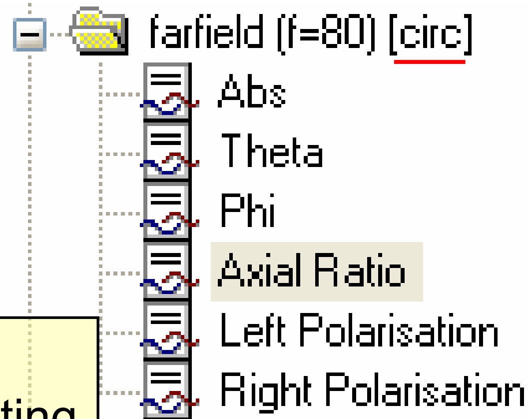
- requires several T-runs (-> use Distributed Computing!)
+ produces S-Parameters
+ ***broadband*** constant phase shift of 90 deg.
+ flexibility to get results for arbitrary am/ph combination in postproocessing

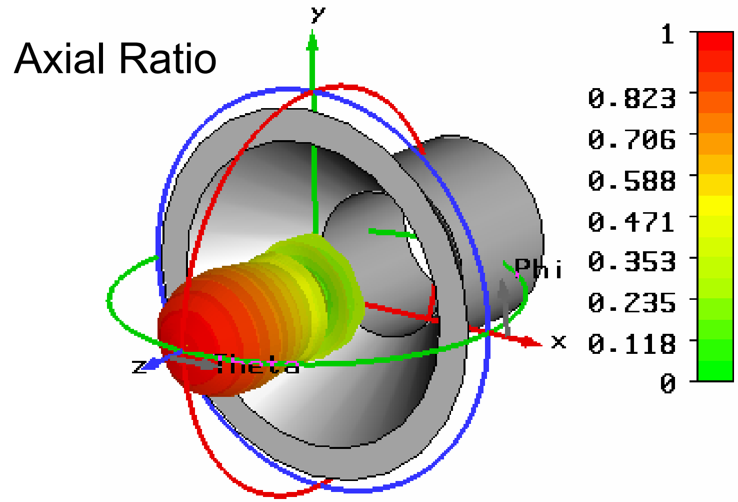
<u>Simultaneous Excitation</u>

+ only one run required
- produces F-Parameters (no S-Parameters)
- constant phase shift only valid for one frequency
- different am/ph combination requires new run

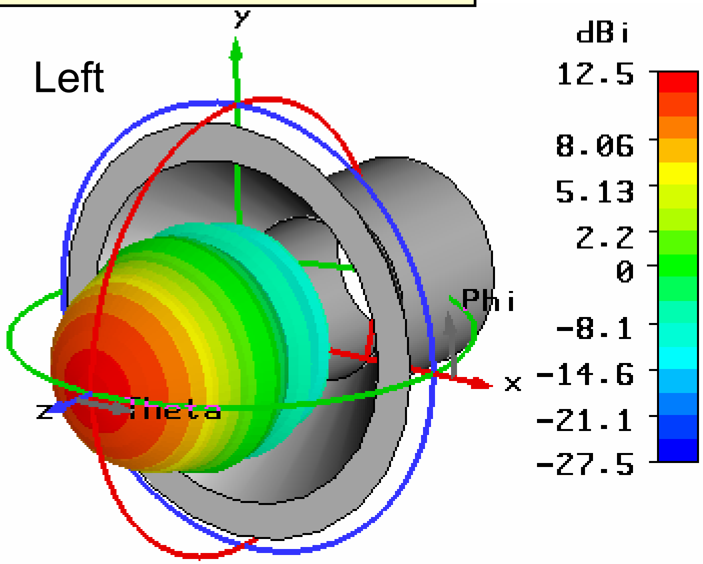
Farfield Capabilities for circular polarized Antennas

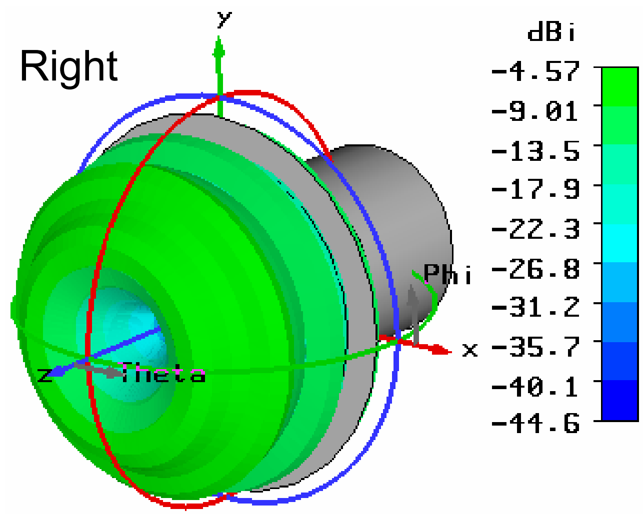




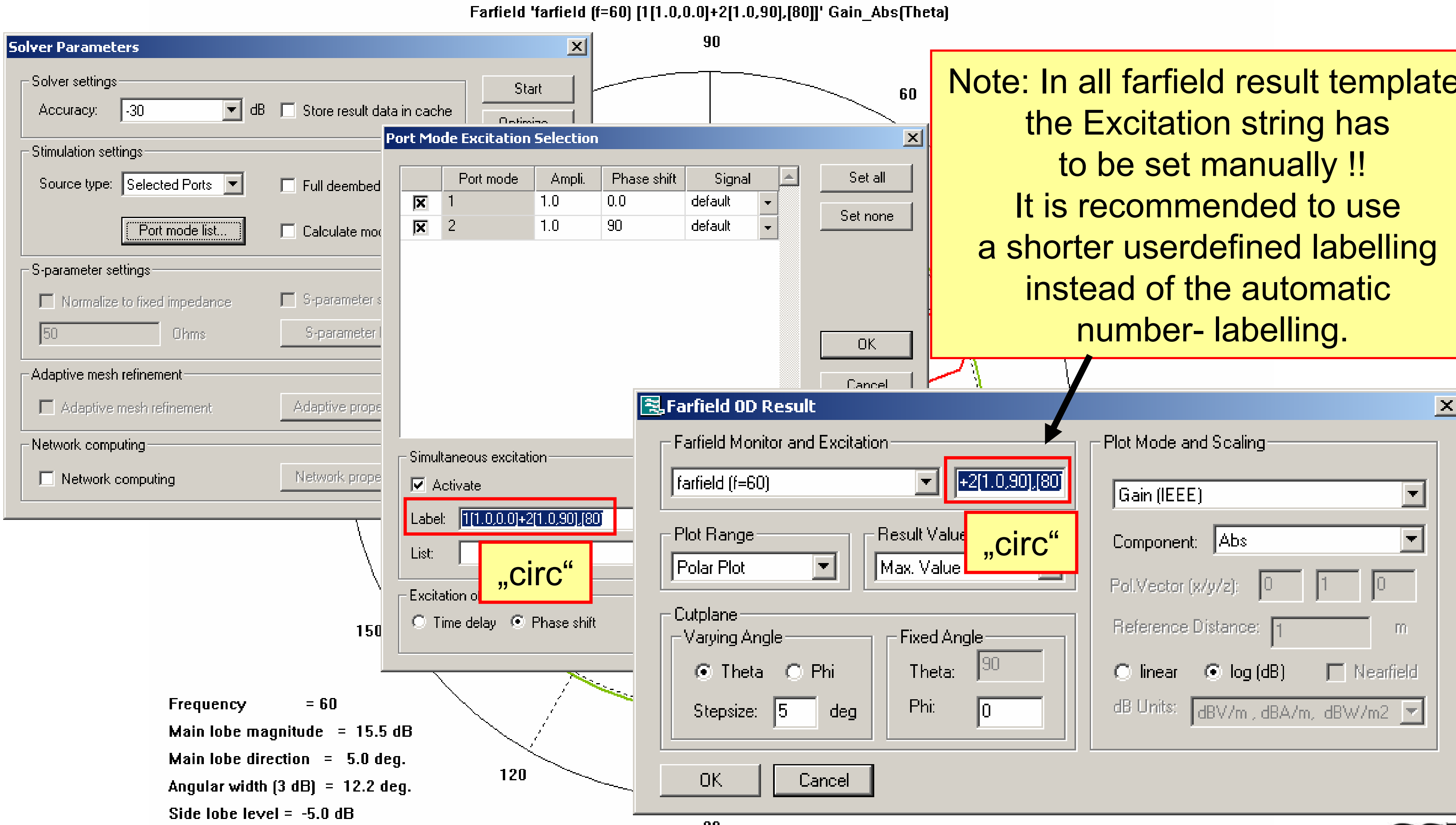


Note: Left / Right is seen from the transmitting antenna port.





Result Template for Combined Monitor 1[1.0,0.0]+2[1.0,90],[80]



Note: In all farfield result templates the Excitation string has to be set manually !!
It is recommended to use a shorter userdefined labelling instead of the automatic number- labelling.

Summary

- Antenna Farfield can be recorded in time and frequency domain (Probe / Monitor)
- Postprocessing templates automize result extraction (e.g. broadband farfield)
- checklist for accurate farfield:
  - energy decayed to -40dB [-60dB] ?
  - enough surrounding space (λ/8) – open (add space)?
  - Is antenna radiating at this frequency? (S-balance<1 ?)
- Advanced capabilities to extract:
  co+cross-pol / phase center / Grasp input data
  RL pol / axial ratio