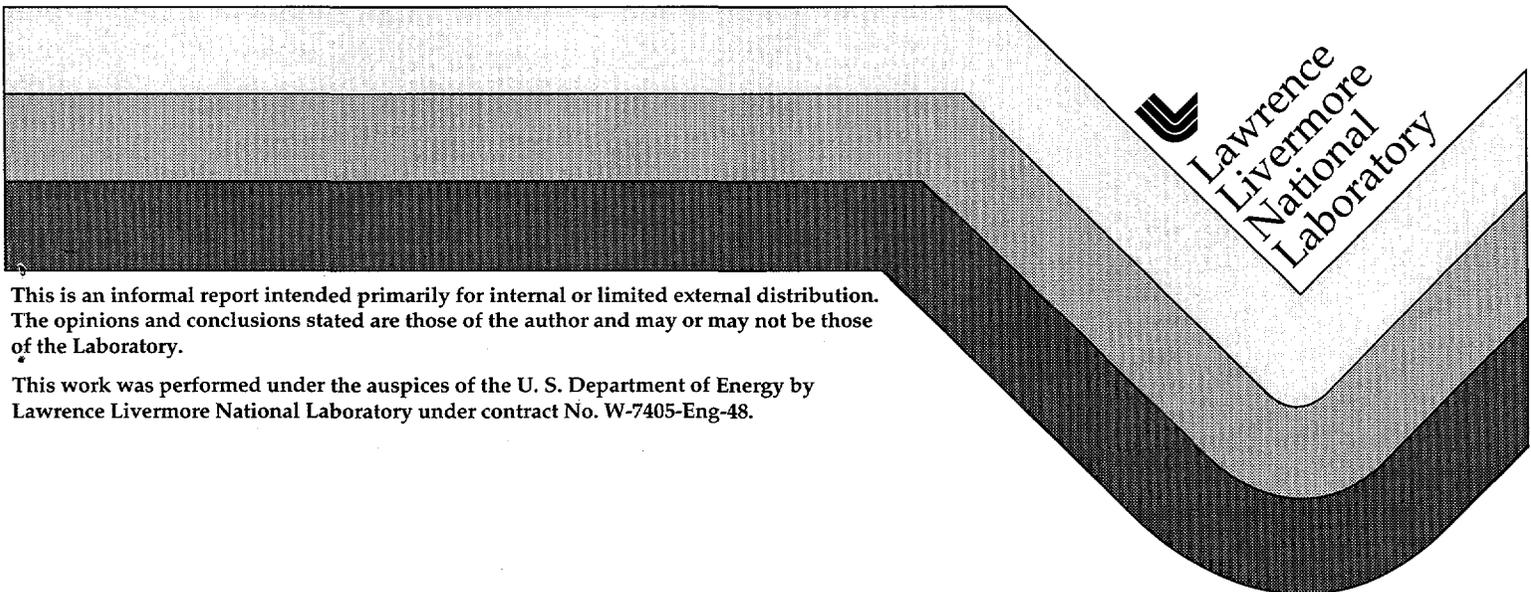


DSI3D — RCS Test Case Manual

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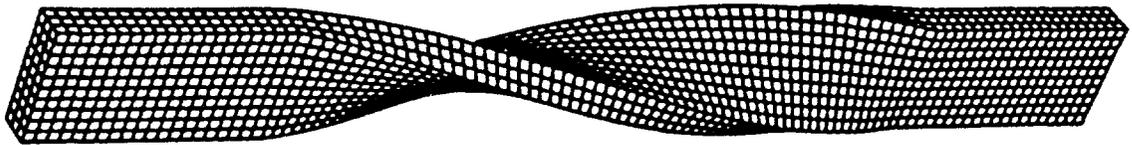
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DSI3D - RCS

Test Case Manual



Niel Madsen, David Steich, Grant Cook, Bill Eme

Lawrence Livermore National Laboratory

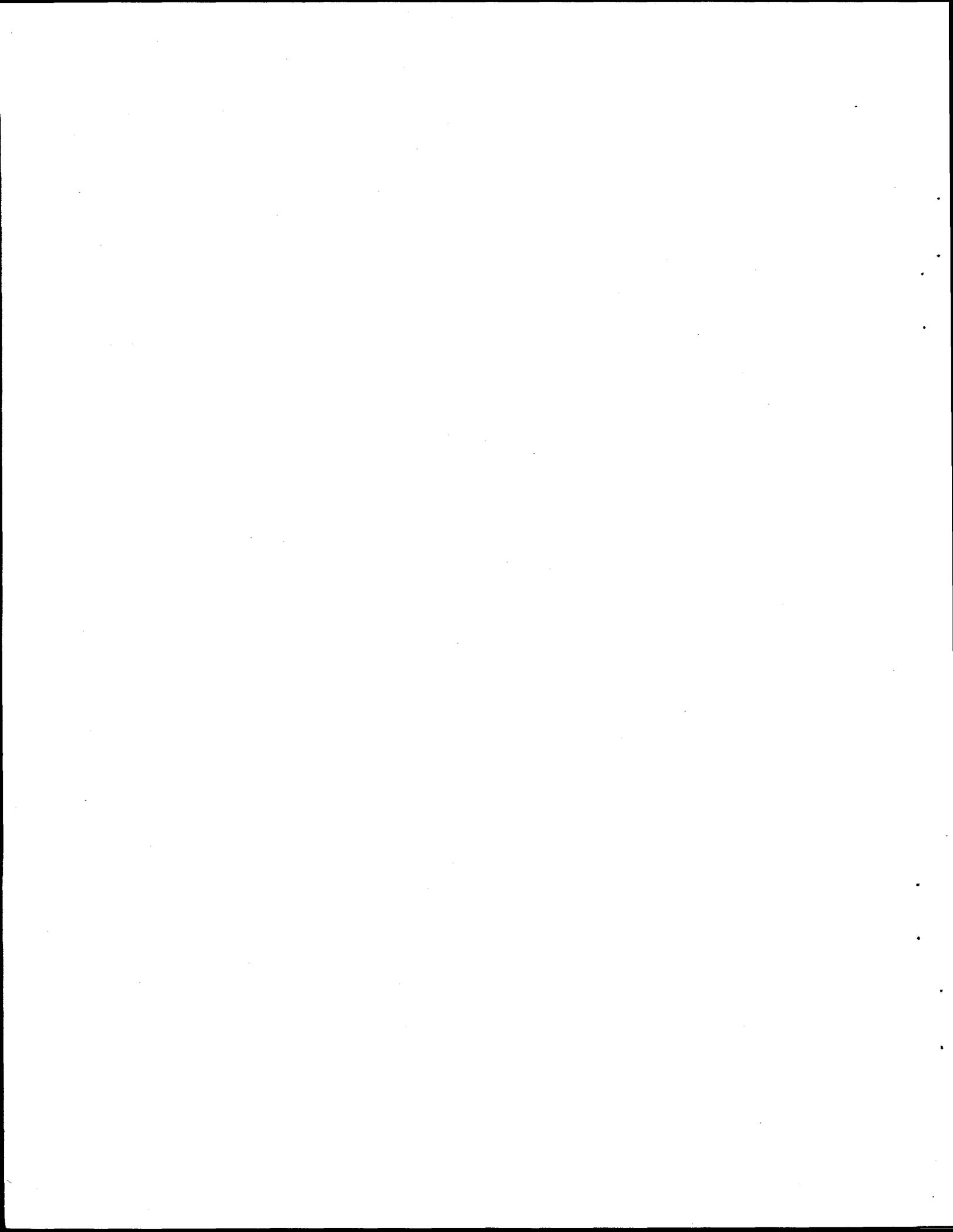


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Introduction

The DSI3D-RCS code is designed to numerically evaluate radar cross sections on complex objects by solving Maxwell's curl equations in the time-domain and in three space dimensions. The code has been designed to run on the new parallel processing computers as well as on conventional serial computers.

The DSI3D-RCS code has been used to solve the following problems:

- Wedge Cylinder - thin flat metal plate
- Wedge Cylinder with Plate extension - thin flat metal plate
- Plate with Half Cylinder Extension - thin flat metal plate
- Rectangular Plate (Business Card) - thin flat metal plate
- Wedge Cylinder with Gap - thin flat metal plate
- NASA Almond
- Wavelength Circular Cavity

In order to generate each of the angle sweeps, it was necessary to run DSI3D once for each data point on the graphs. This is because these are backscatter calculations, and the incident pulse comes from a different direction as the angle ϕ is changed. To automate the process of performing all of these simulation runs, we used the following shell script:

```
#!/bin/csh
#####
#
#> emcc.csh - CSH script to make phi varying d3d runs on meiko
#>
#> Usage:
#>   csh emcc.csh
#>
#> Comments
#>   This script automates the process of time iterating psre
#>   problems and collecting the resulting time history data into
#>   an ULTRA format ASCII file.
#>
#####

set cnt=-1

set phi=-1
set realphi = -1
```

DSI3D Test Results

```
#..... iterate runs until done
date
while ($cnt < 180)
  @ cnt += 1
  @ phi = 2 * $cnt
  if ($cnt > 90) @ phi -= 181
  @ realphi = 180 - $phi

# ..... set up first/next run
sed -e "/PHI/s//${phi}/" paramsPHI.dat.hh >params.dat

echo "Running problem > target2 HH $cnt $phi $realphi"

rm rest* tp* dum.${realphi}.hh ul.${realphi}.hh
prun -v -pp0 -n64 -b0 -beme/dsi3d/emcc/predsi3d
date
prun -v -pp0 -n64 -b0 -beme/dsi3d/emcc/dsi3d
date
# cat tp* >dum.${realphi}.hh
prun -v -pp0 -n64 -b0 -beme/dsi3d/emcc/rcss
  mv ultra.out ul.${realphi}.hh
date
end
```

Wedge Cylinder

emcc target 1
TrueGrid display

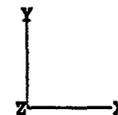
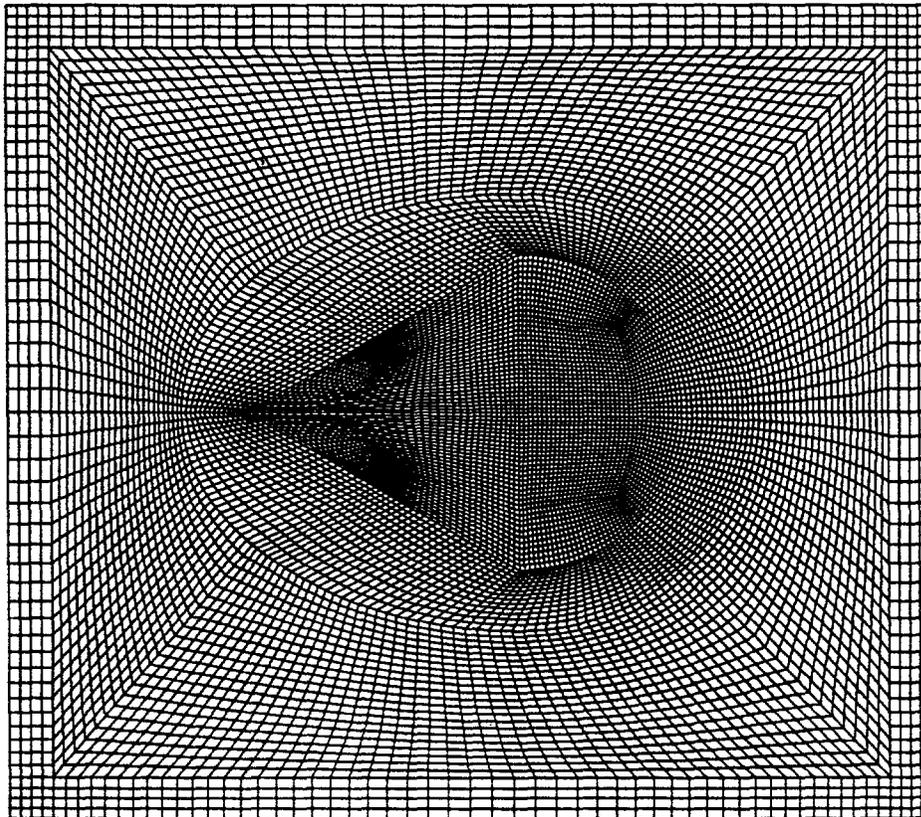
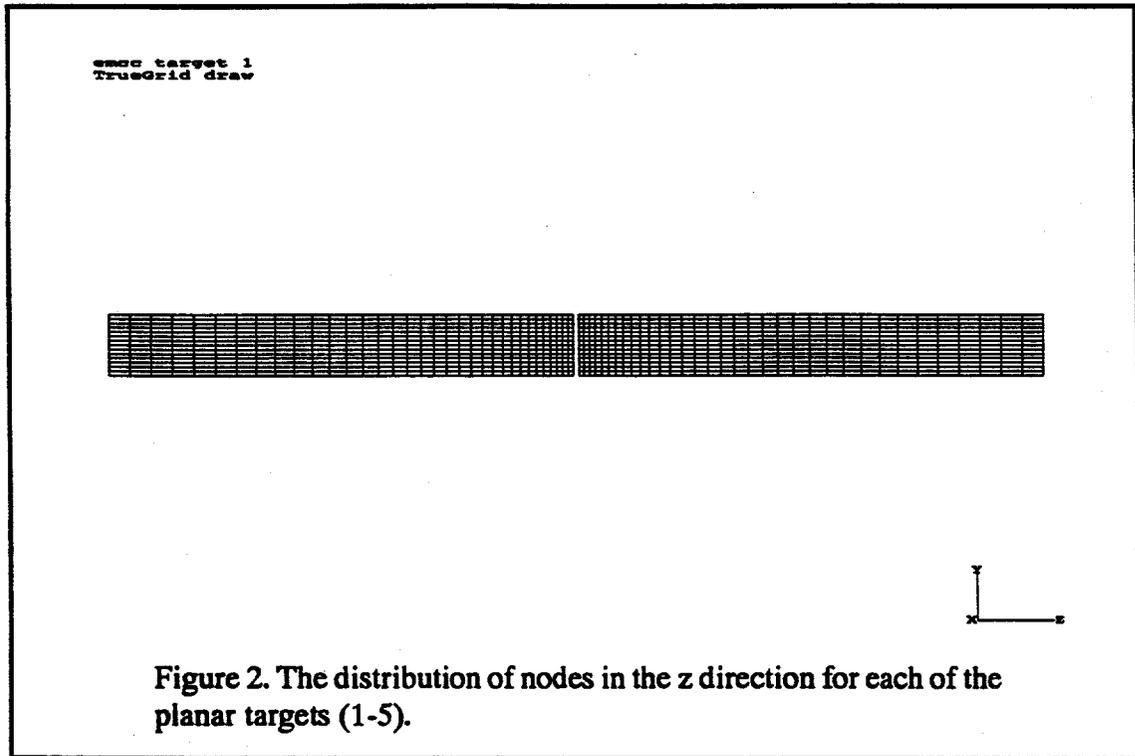


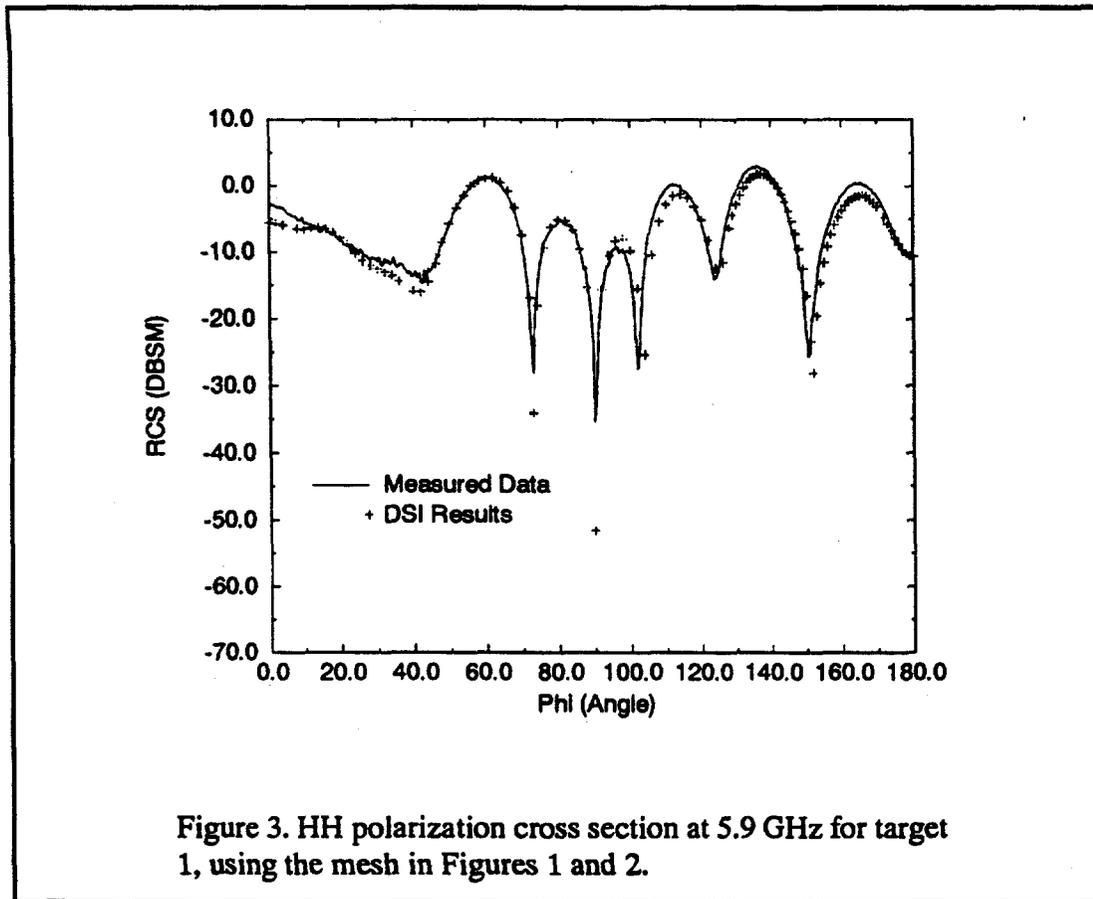
Figure 1. View of the target 1 mesh looking down the z-axis. Each cut of the mesh at a constant z coordinate in the mesh has this same appearance. See Figure 2. for the distribution of nodes in the z direction.

DSI3D Test Results



The following input file was used with the shell script given in the introduction to obtain the results in Figure 3. Note the use of the pattern **PHI** that the shell script sets to a valid integer.

```
local_dir      /var/tmp/t1_  
start_time    0.0  
num_steps     8192  
dt            0.0  
eps0         8.8541853367e-12  
xmu0         1.2566e-06  
driver_id     7  
alpha        30  
ascii_coef    0  
restarts     500  
  
driver 80.0   PHI.0 90.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0  
  
primary_output_edges  
780 915  
915 930  
  
rbc higdon_higdon 60 0.0 0.01 10.0 0.015  
  
FARREF 0.0 0.0 0.0  
  
FARPOL  
0.0  
90.0  
  
FARPTS  
80.   PHI.0 0.
```



A slightly different input file was used with the shell script given in the introduction to obtain the results in Figure 4. As seen below, the only difference is in the polarization used in the driver command. Again, note the use of the pattern **PHI** that the shell script sets to a valid integer.

```

local_dir      /var/tmp/t1_
start_time    0.0
num_steps     8192
dt            0.0
eps0          8.8541853367e-12
xmu0         1.2566e-06
driver_id     7
alpha        30
ascii_coef    0
restarts      500

driver 80.0   PHI.0 0.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0

primary_output_edges
780 915
915 930

rbc higdon_higdon 60 0.0 0.01 10.0 0.015

```

DSI3D Test Results

FARREF 0.0 0.0 0.0

FARPOL
0.0
90.0

FARPTS
80. PHI.0 0.

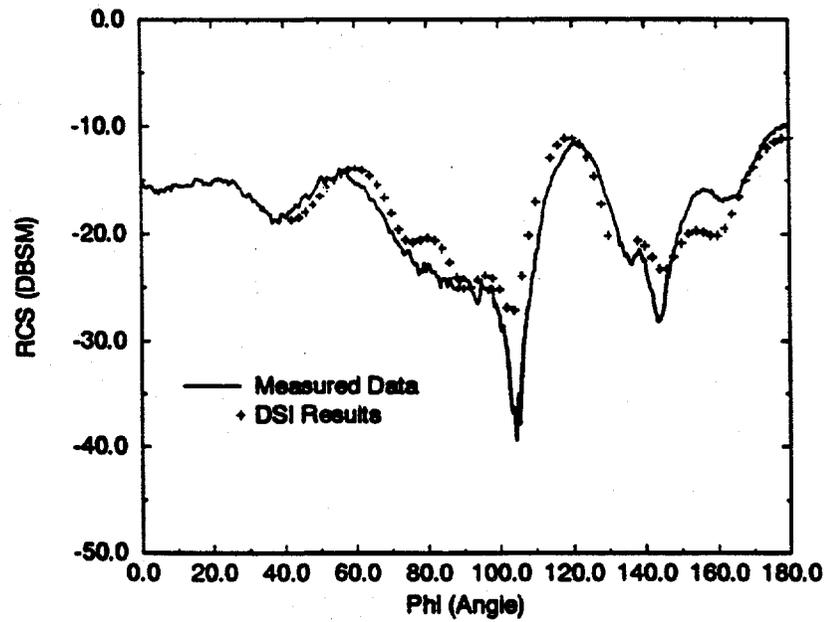


Figure 4. VV polarization cross section at 5.9 GHz for target 1, using the mesh in Figures 1 and 2.

Wedge Cylinder with Plate Extension

emcc target 2
TrueGrid display

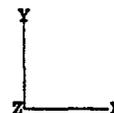
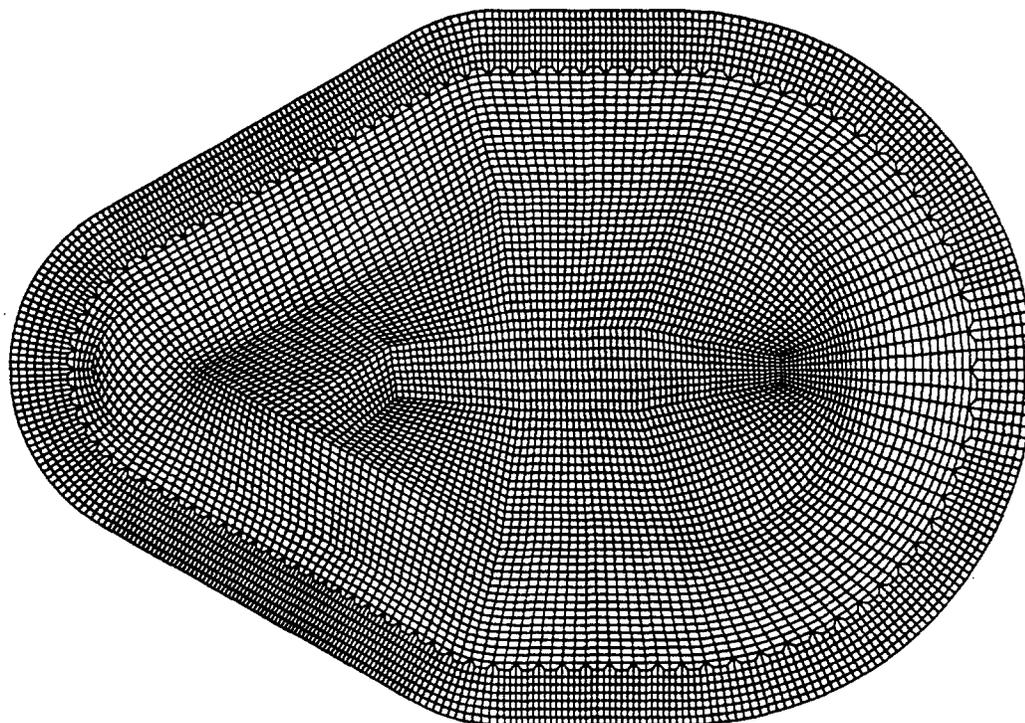


Figure 5. View of the target 2 mesh looking down the z-axis. Each cut of the mesh at a constant z coordinate in the mesh has this same appearance. See Figure 2 for the distribution of nodes in the z direction.

DSI3D Test Results

The following input file was used with the shell script given in the introduction to obtain the results in Figure 6.

```
local_dir      /var/tmp/t2_  
start_time    0.0  
num_steps     8192  
dt            0.0  
eps0          8.8541853367e-12  
xmu0          1.2566e-06  
driver_id     7  
alpha         30  
ascii_coef    0  
restarts      500
```

```
driver 80.0   PHI.0 90.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0
```

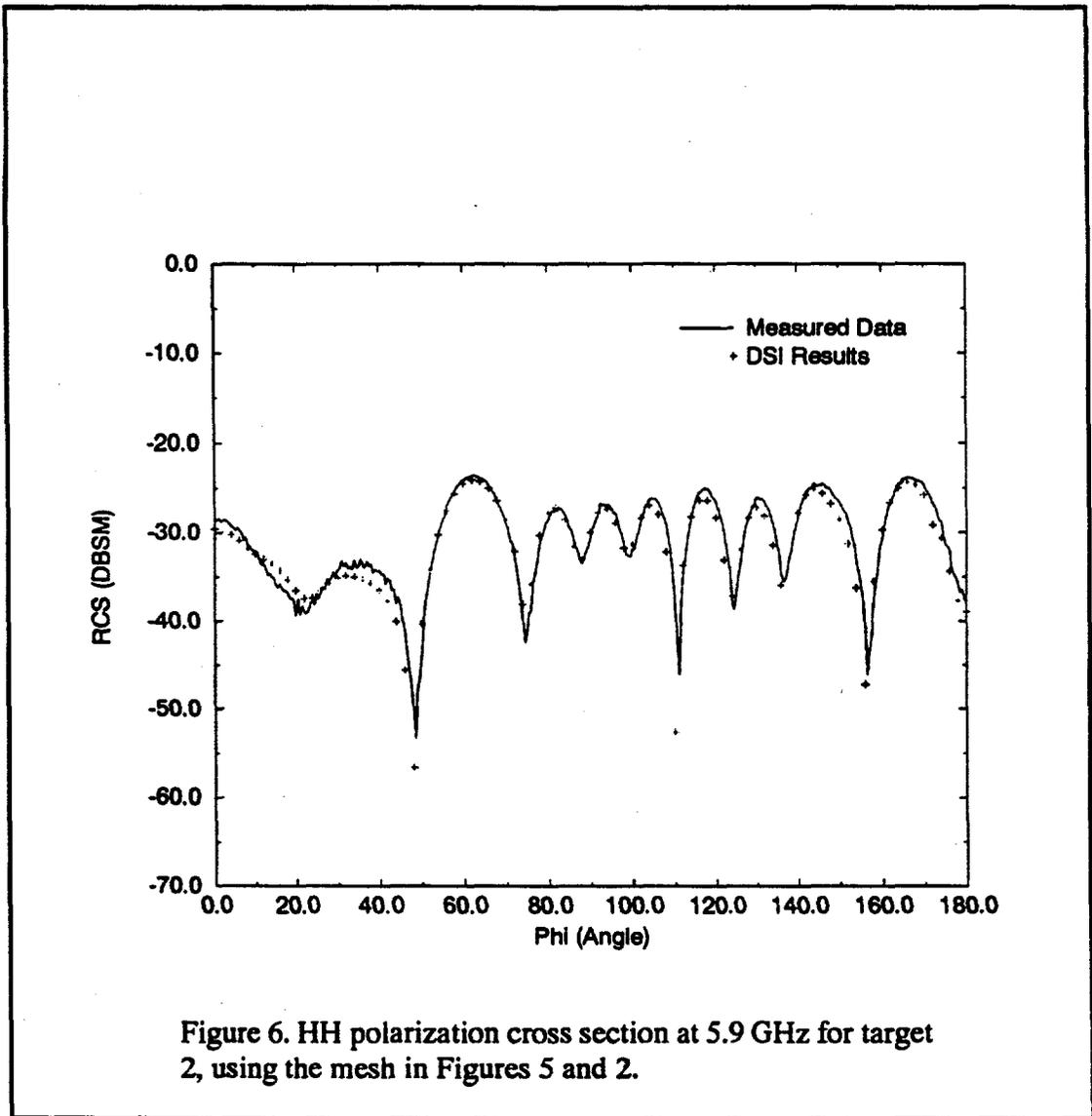
```
primary_output_edges  
780 915  
915 930
```

```
rbc higdon_higdon 60 0.0 0.01 10.0 0.015
```

```
FARREF 0.0 0.0 0.0
```

```
FARPOL  
0.0  
90.0
```

```
FARPTS  
80.   PHI.0 0.
```



The same input file that was used for Figure 4 is also used to obtain Figure 7.

```

local_dir      /var/tmp/t2_
start_time     0.0
num_steps      8192
dt             0.0
eps0           8.8541853367e-12
xmu0          1.2566e-06
driver_id      7
alpha         30
ascii_coef     0
restarts       500

driver 80.0    PHI.0 0.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0
    
```

DSI3D Test Results

primary_output_edges
780 915
915 930

rbc higdon_higdon 60 0.0 0.01 10.0 0.015

FARREF 0.0 0.0 0.0

FARPOL
0.0
90.0

FARPTS
80. PHI.0 0.

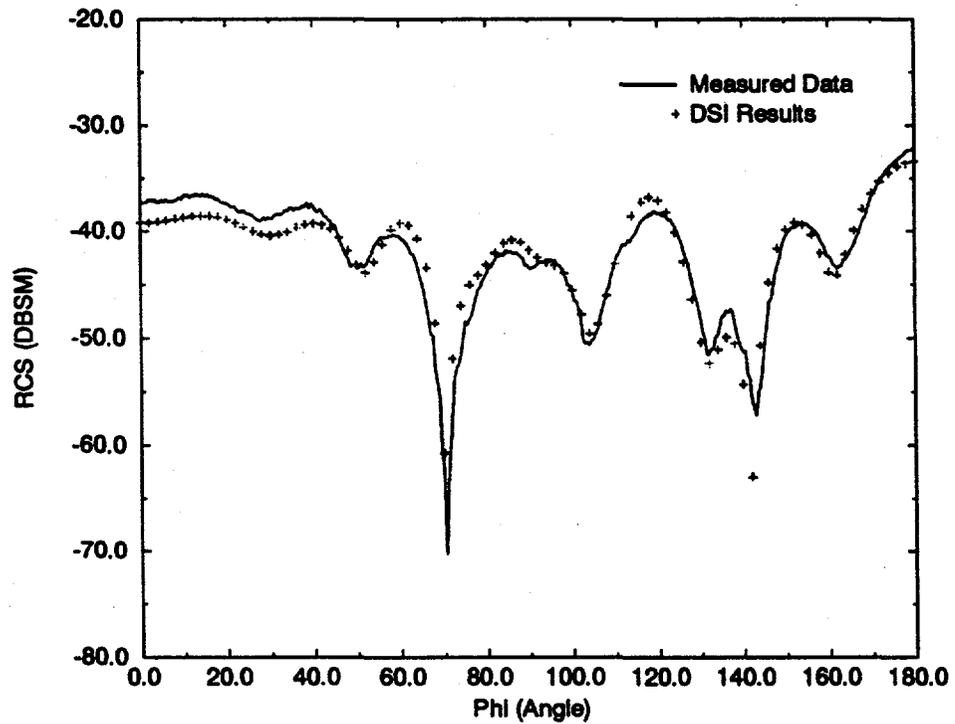


Figure 7. VV polarization cross section at 5.9 GHz for target 2, using the mesh in Figures 5 and 2.

Plate with Half Cylinder Extension

emcc target 3
TrueGrid display

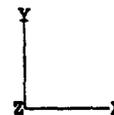
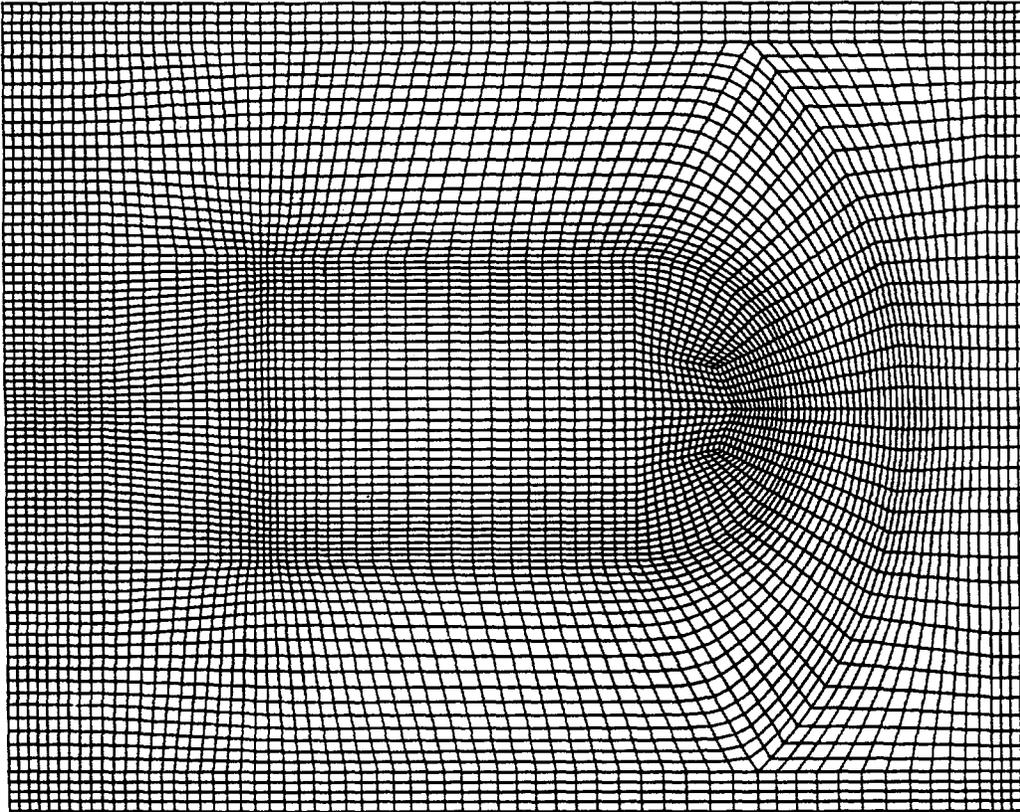


Figure 8. View of the target 3 mesh looking down the z-axis. Each cut of the mesh at a constant z coordinate in the mesh has this same appearance. See Figure 2 for the distribution of nodes in the z direction.

The same input file that was used for Figure 3 is also used to obtain Figure 9.

```
local_dir    /var/tmp/t3_  
start_time  0.0
```

DSI3D Test Results

```
num_steps      8192
dt             0.0
eps0           8.8541853367e-12
xmu0           1.2566e-06
driver_id      7
alpha          30
ascii_coef     0
restarts       500
```

```
driver 80.0  PHI.0 90.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0
```

```
primary_output_edges
780 915
915 930
```

```
rbc higdon_higdon 60 0.0 0.01 10.0 0.015
```

```
FARREF 0.0 0.0 0.0
```

```
FARPOL
0.0
90.0
```

```
FARPTS
80.  PHI.0 0.
```

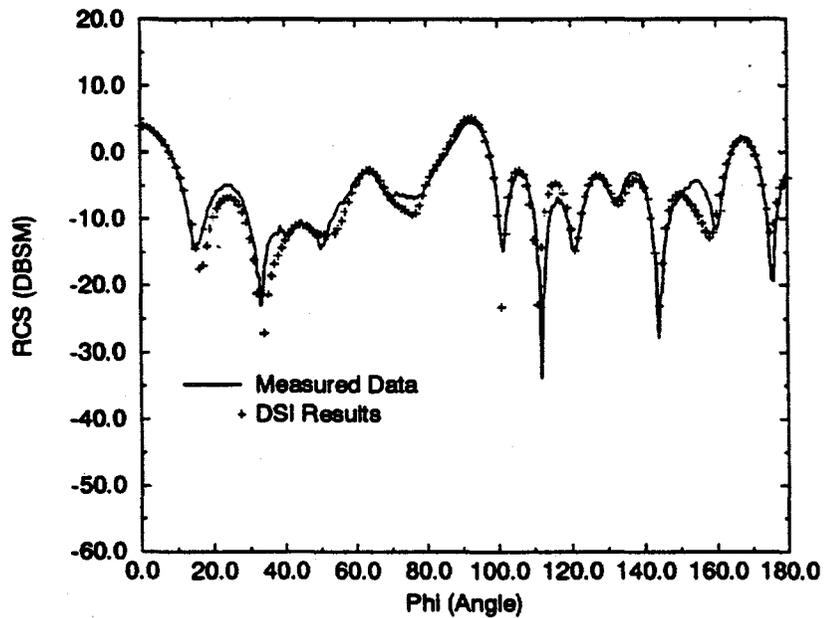


Figure 9. HH polarization cross section at 5.9 GHz for target 3, using the mesh in Figures 8 and 2.

DSI3D Test Results

The same input file that was used for Figure 4 is also used to obtain Figure 10.

```
local_dir      /var/tmp/t3_
start_time     0.0
num_steps      8192
dt             0.0
eps0           8.8541853367e-12
xmu0           1.2566e-06
driver_id      7
alpha          30
ascii_coef     0
restarts       500
```

```
driver 80.0   PHI.0 0.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0
```

```
primary_output_edges
780 915
915 930
```

```
rbc higdon_higdon 60 0.0 0.01 10.0 0.015
```

```
FARREF 0.0 0.0 0.0
```

```
FARPOL
  0.0
 90.0
```

```
FARPTS
 80.   PHI.0   0.
```

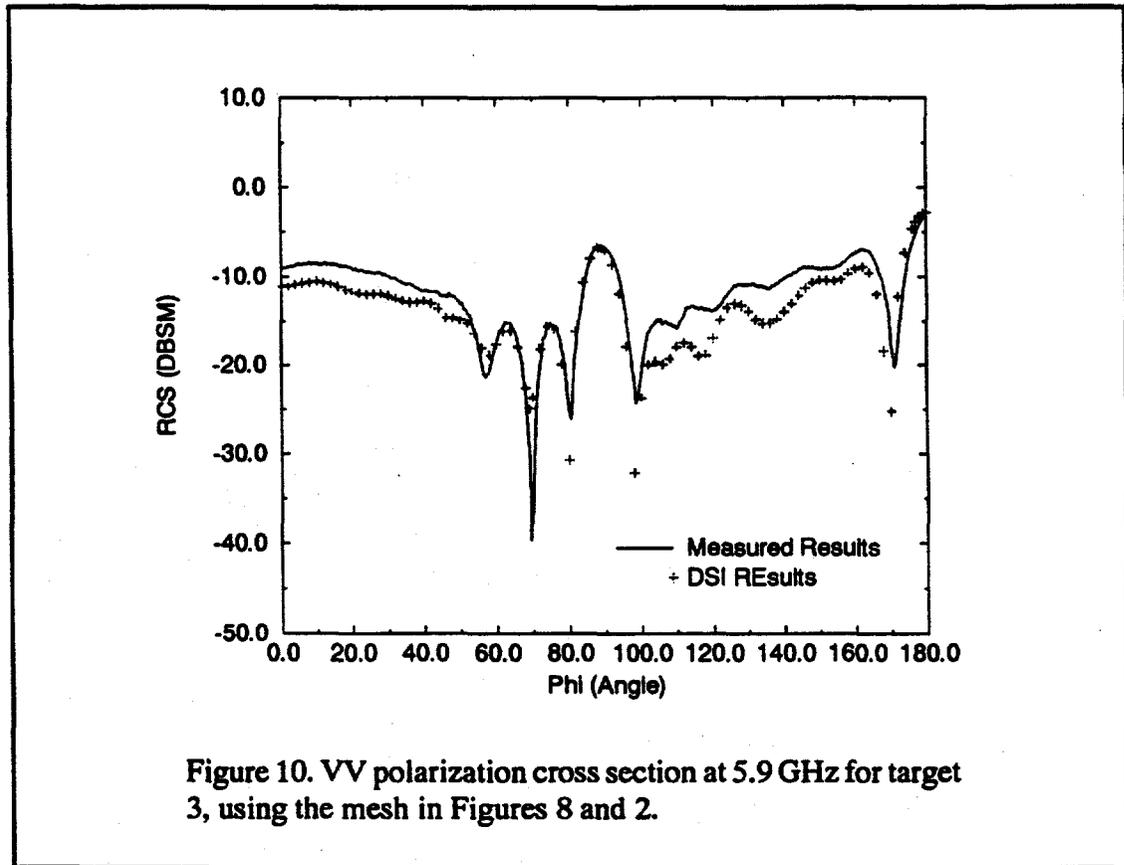
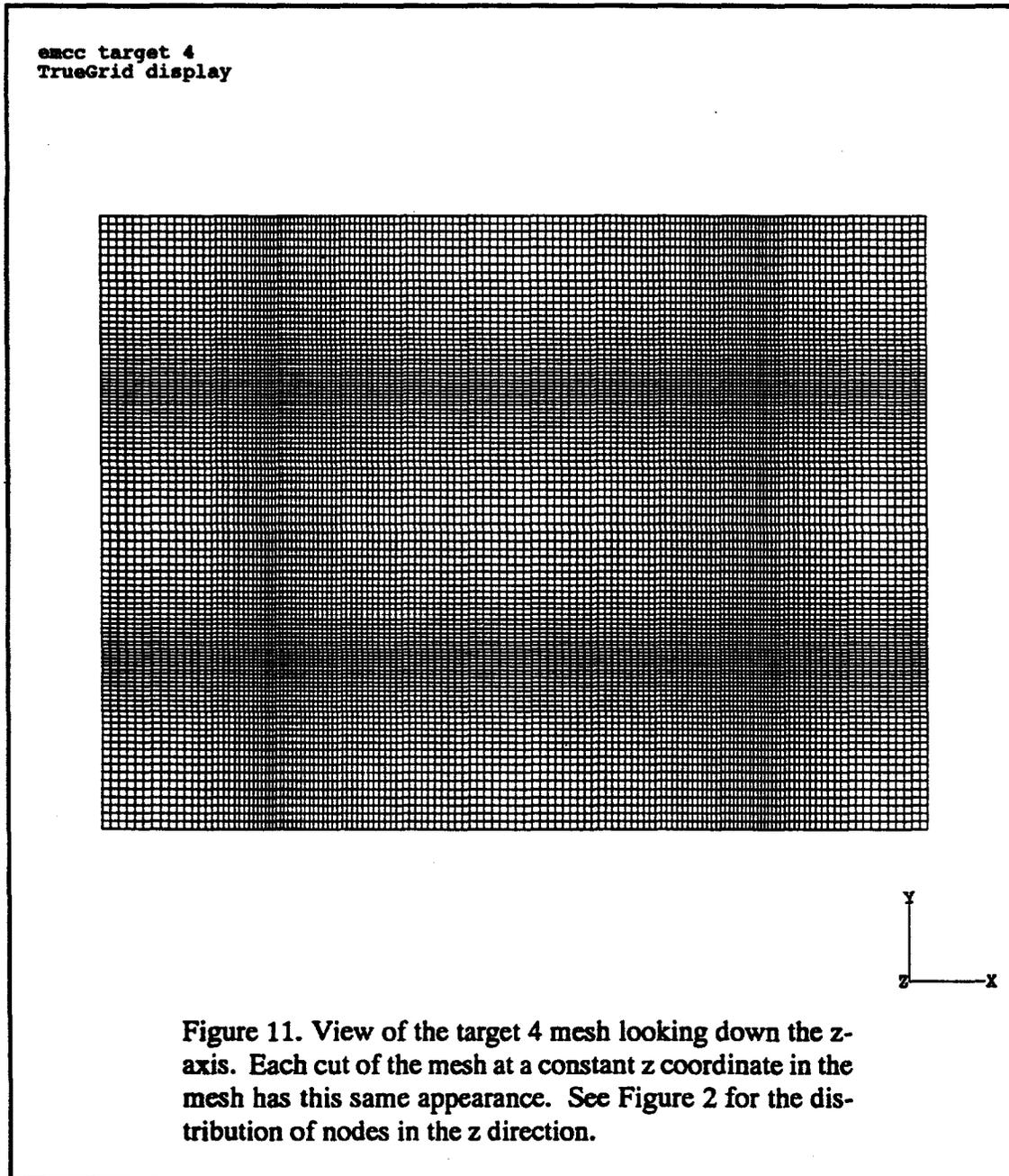


Figure 10. VV polarization cross section at 5.9 GHz for target 3, using the mesh in Figures 8 and 2.

Rectangular Plate



The same input file that was used for Figure 3 is also used to obtain Figure 12.

```
local_dir    /var/tmp/t4_  
start_time  0.0  
num_steps   8192
```

DSI3D Test Results

dt 0.0
eps0 8.8541853367e-12
xmu0 1.2566e-06
driver_id 7
ascii_coef 0
restarts 500

driver 80.0 PHI.0 90.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0

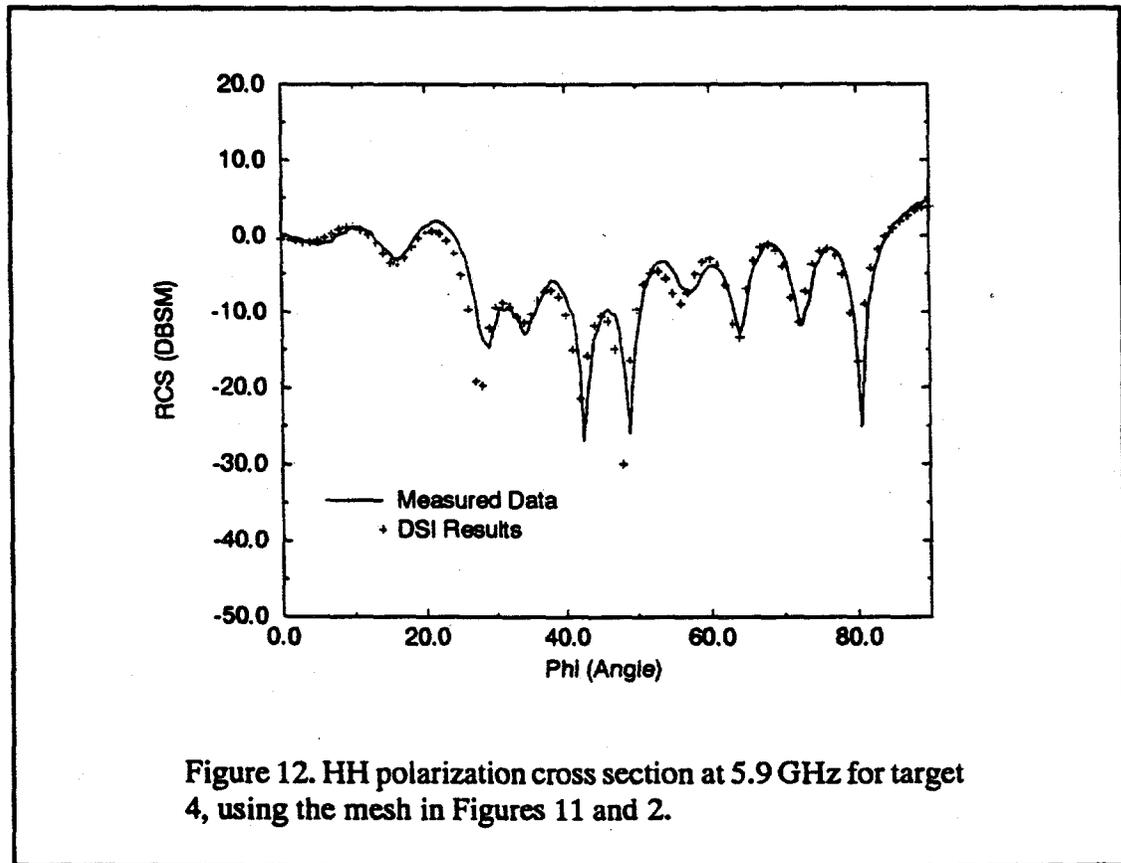
primary_output_edges
780 915
915 930

rbc higdon_higdon 60 0.0 0.01 10.0 0.015

FARREF 0.0 0.0 0.0

FARPOL
0.0
90.0

FARPTS
80. PHI.0 0.



DSI3D Test Results

The same input file that was used for Figure 4 is also used to obtain Figure 13.

```
local_dir      /var/tmp/t4_  
start_time    0.0  
num_steps     8192  
dt            0.0  
eps0         8.8541853367e-12  
xmu0         1.2566e-06  
driver_id     7  
ascii_coef    0  
restarts      500
```

```
driver 80.0  PHI.0 0.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0
```

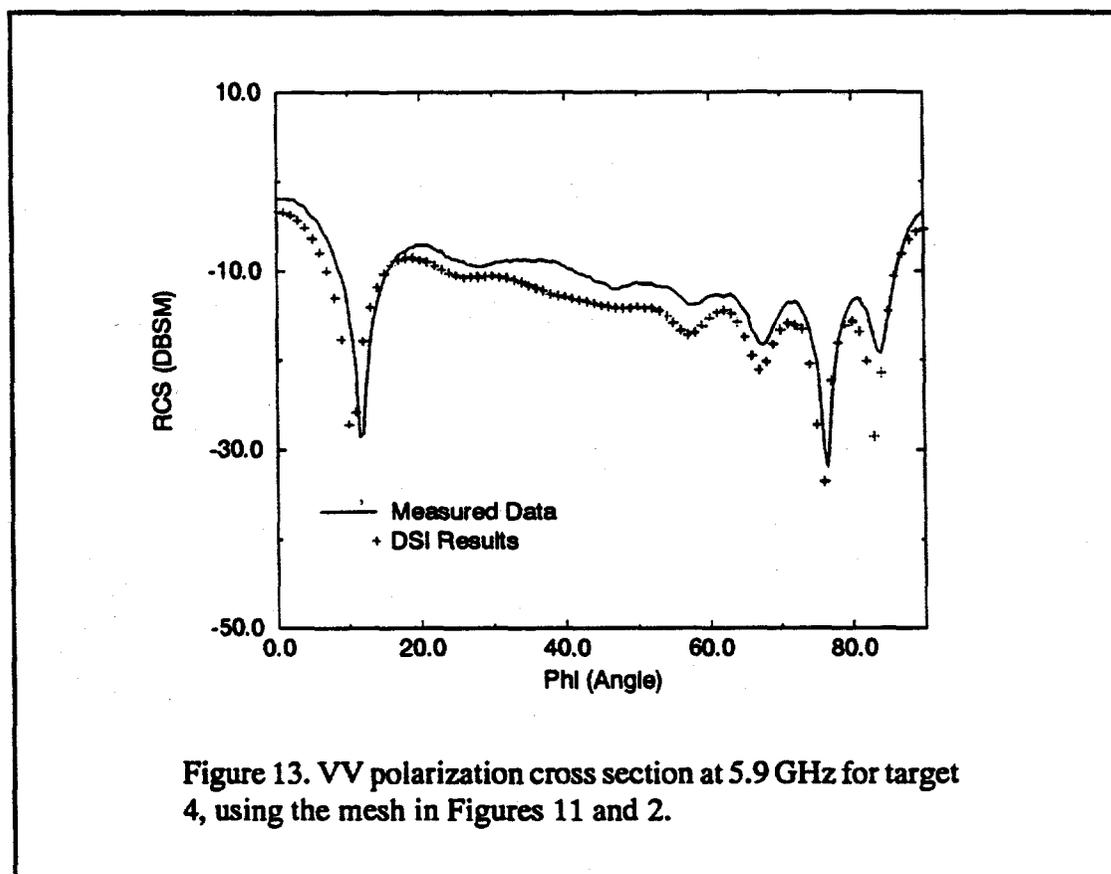
```
primary_output_edges  
780 915  
915 930
```

```
rbc higdon_higdon 60 0.0 0.01 10.0 0.015
```

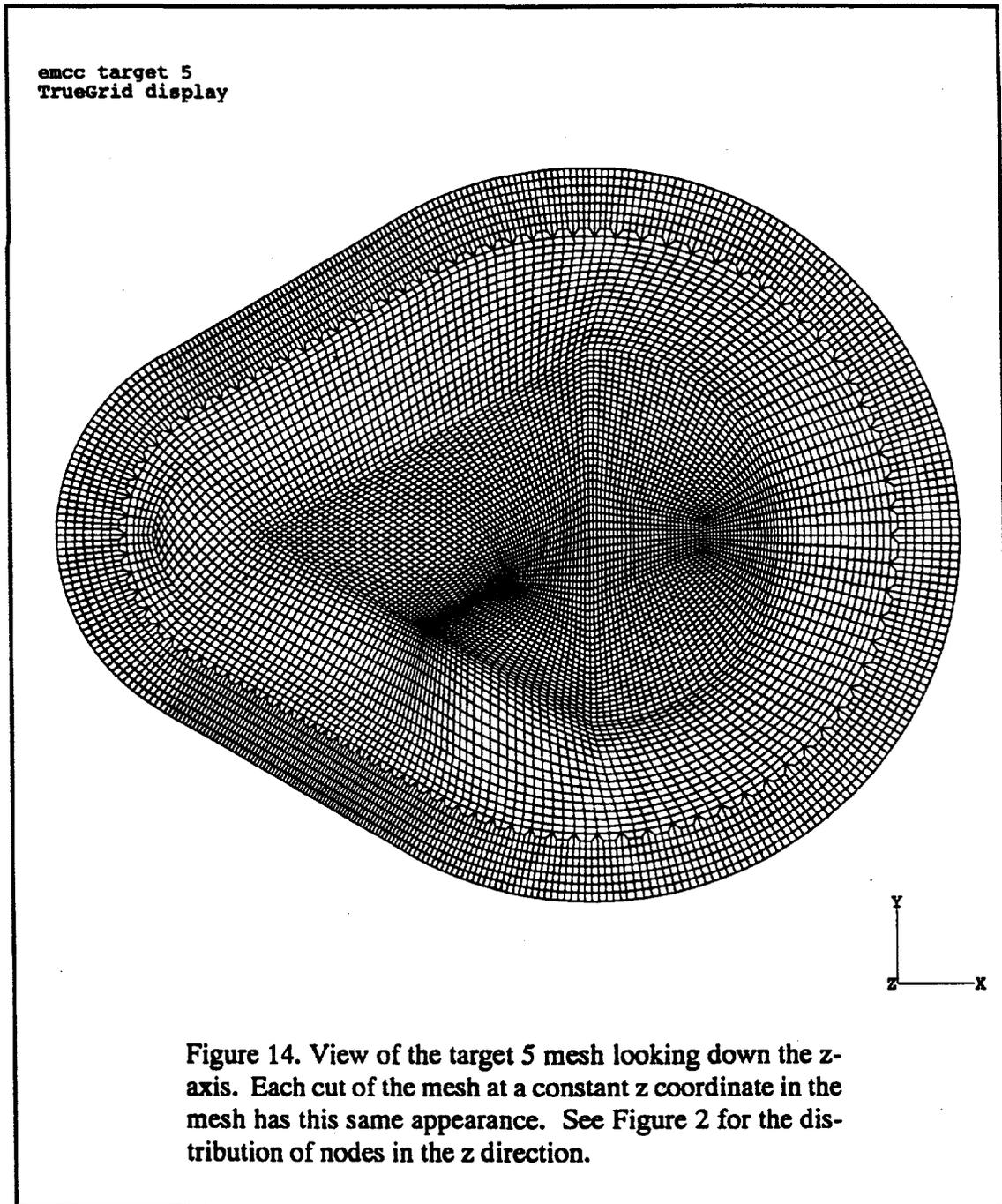
```
FARREF 0.0 0.0 0.0
```

```
FARPOL  
0.0  
90.0
```

```
FARPTS  
80.  PHI.0 0.
```



Wedge Cylinder with Gap



DSI3D was unstable on this grid. The crack width in this case is $\lambda/100$.

emcc target 5 (modified: crack width = lambda/15)
TrueGrid display

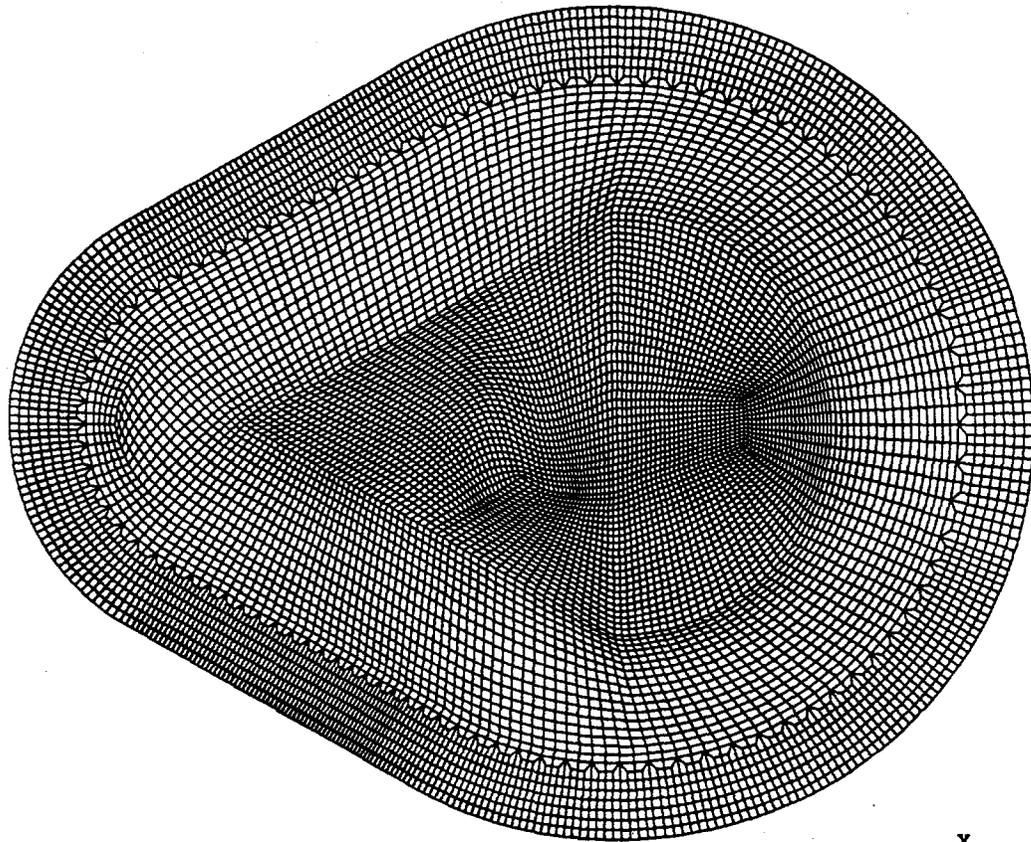


Figure 15. View of a modified target 5 mesh looking down the z-axis. The crack in this modified model is $\lambda/15$ wide. Each cut of the mesh at a constant z coordinate in the mesh has this same appearance. See Figure 2 for the distribution of nodes in the z direction.

The mesh in Figure 15 was used for the problem runs of Figure 16. The HH curve in Figure 16 was obtained with the input file that follows. The VV curve was obtained from a simple modification to the HH input file that consisted of changing the polarization of 90 degrees to 0 (zero).

DSI3D Test Results

local_dir /var/tmp/t5_
start_time 0.0
num_steps 8192
dt 0.0
eps0 8.8541853367e-12
xmu0 1.2566e-06
driver_id 7
alpha 30
ascii_coef 0
restarts 500

driver 80.0 180.0 90.0 78721.56184 0.1898598 85.0 16.0 0.0 2.0 -1.0

primary_output_edges
780 915
915 930

rbc higdon_higdon 60 0.0 0.01 10.0 0.015

FARREF 0.0 0.0 0.0

FARPOL
0.0
90.0

FARPTS
80. 180.0 0.

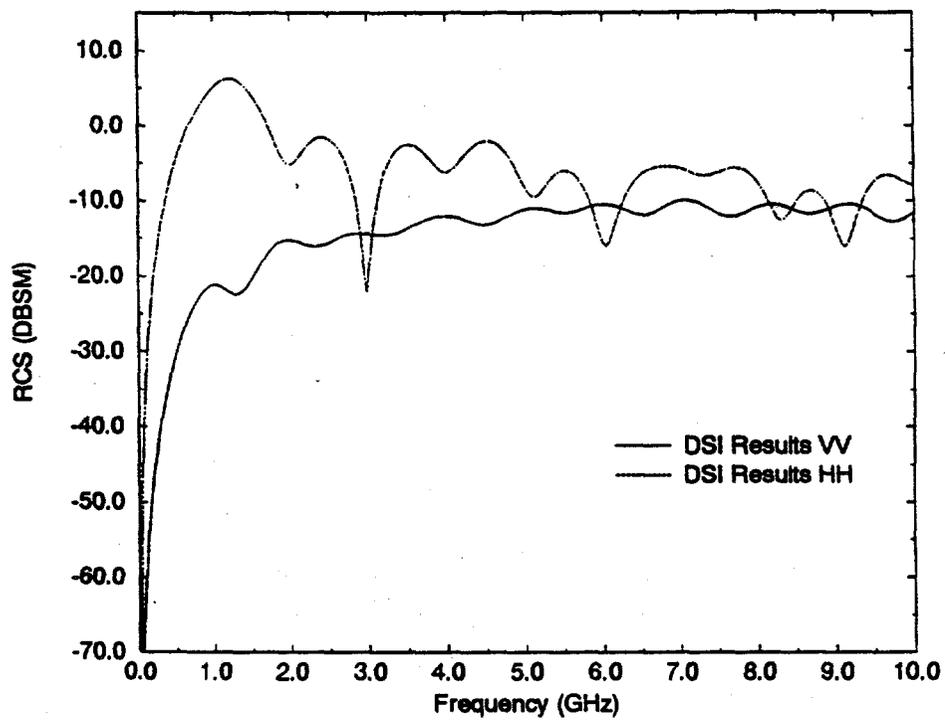


Figure 16. HH and VV polarization cross sections for target 5 with a crack width of $\lambda/15$, using the meshes in Figures 15 and 2. The angle ϕ of the incident pulse is 180° .

NASA Almond

emcc PEC almond (half grid)
TrueGrid display

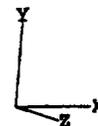
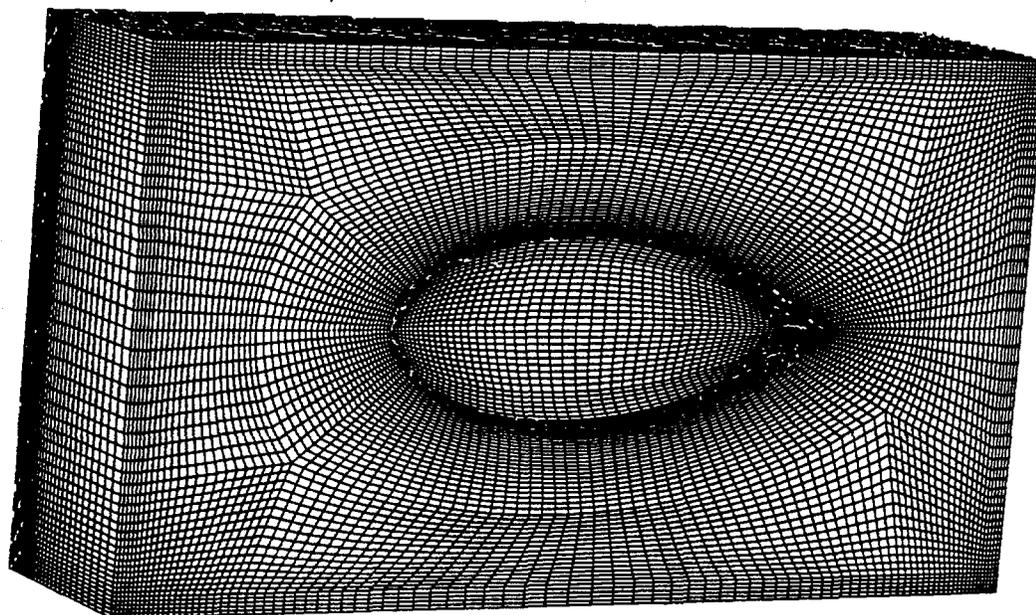


Figure 17. View of half of the PEC almond target mesh.

DSI3D Test Results

Figure 18 was obtained with the following input file.

```
local_dir      /var/tmp/wge_  
start_time    0.0  
dt            0.0  
num_steps     8192  
eps0         8.8541853367e-12  
xmu0         1.2566e-06  
driver_id     7  
ascii_coef    0  
alpha        30.0  
restarts     1024
```

```
driver 90.0 PHI.0 90.0 78721.56184 0.15 85.0 16.0 0.0 2.0 -1.0
```

```
primary_output_edges  
64091 64351  
64091 64117
```

```
rbc higdon_higdon 52 0.0 0.01 0.0 0.015
```

```
FARREF 0.0 0.0 0.0
```

```
FARPOL  
0.0  
90.0
```

```
FARPTS  
90.    PHI.0
```

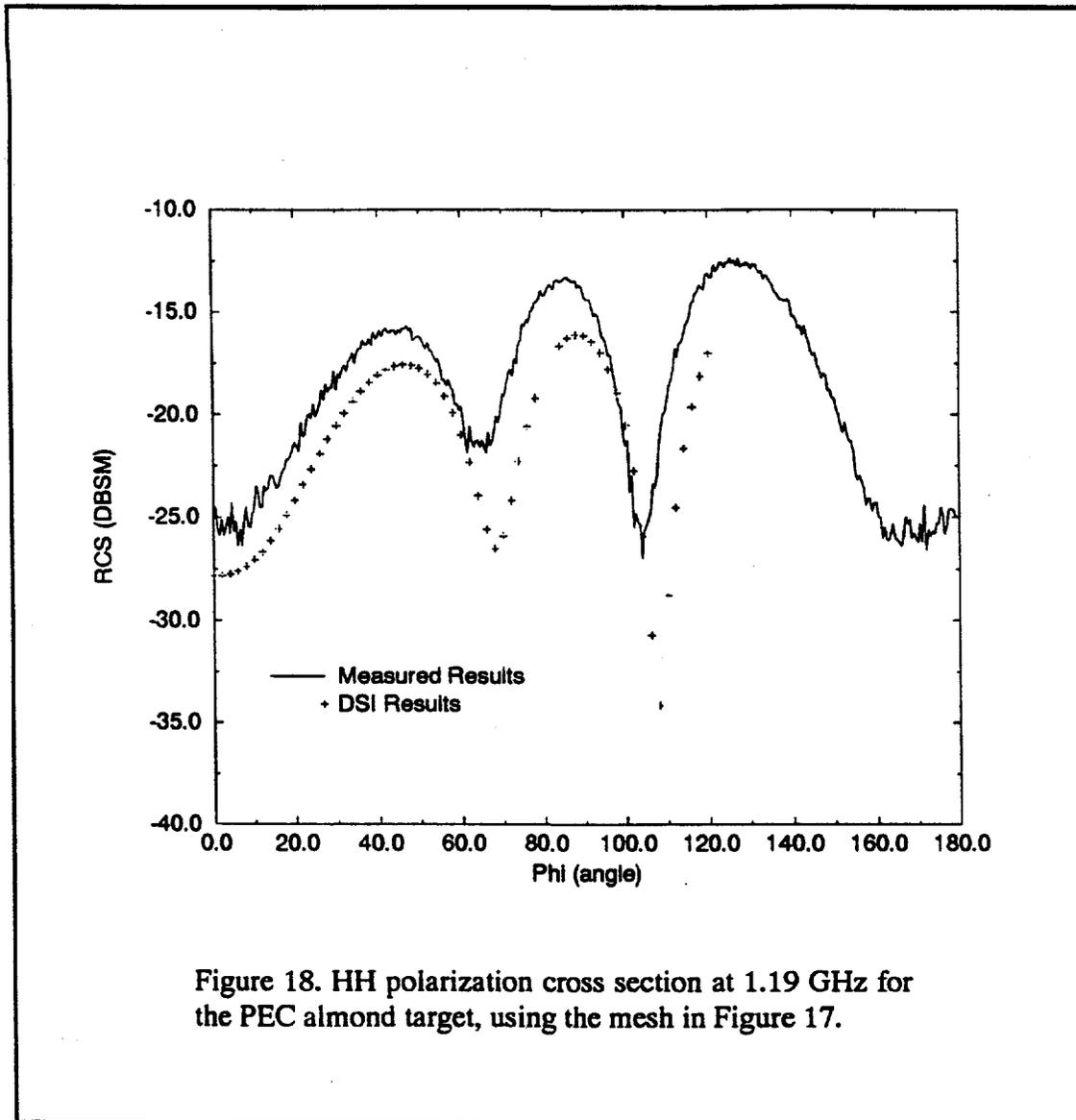


Figure 19 was obtained with the following input file.

```

local_dir      /var/tmp/alm_
start_time     0.0
dt             0.0
num_steps      8192
eps0           8.8541853367e-12
xmu0          1.2566e-06
driver_id      7
ascii_coef     0
alpha         10.0
restarts      1024

driver 90.0 PHI.0 0.0 78721.56184 0.15 85.0 16.0 0.0 2.0 -1.0
    
```

DSI3D Test Results

primary_output_edges
64091 64351
64091 64117

rbc higdon_higdon 52 0.0 0.01 0.0 0.01

FARREF 0.0 0.0 0.0

FARPOL
0.0
90.0

FARPTS
90.0 PHI.0

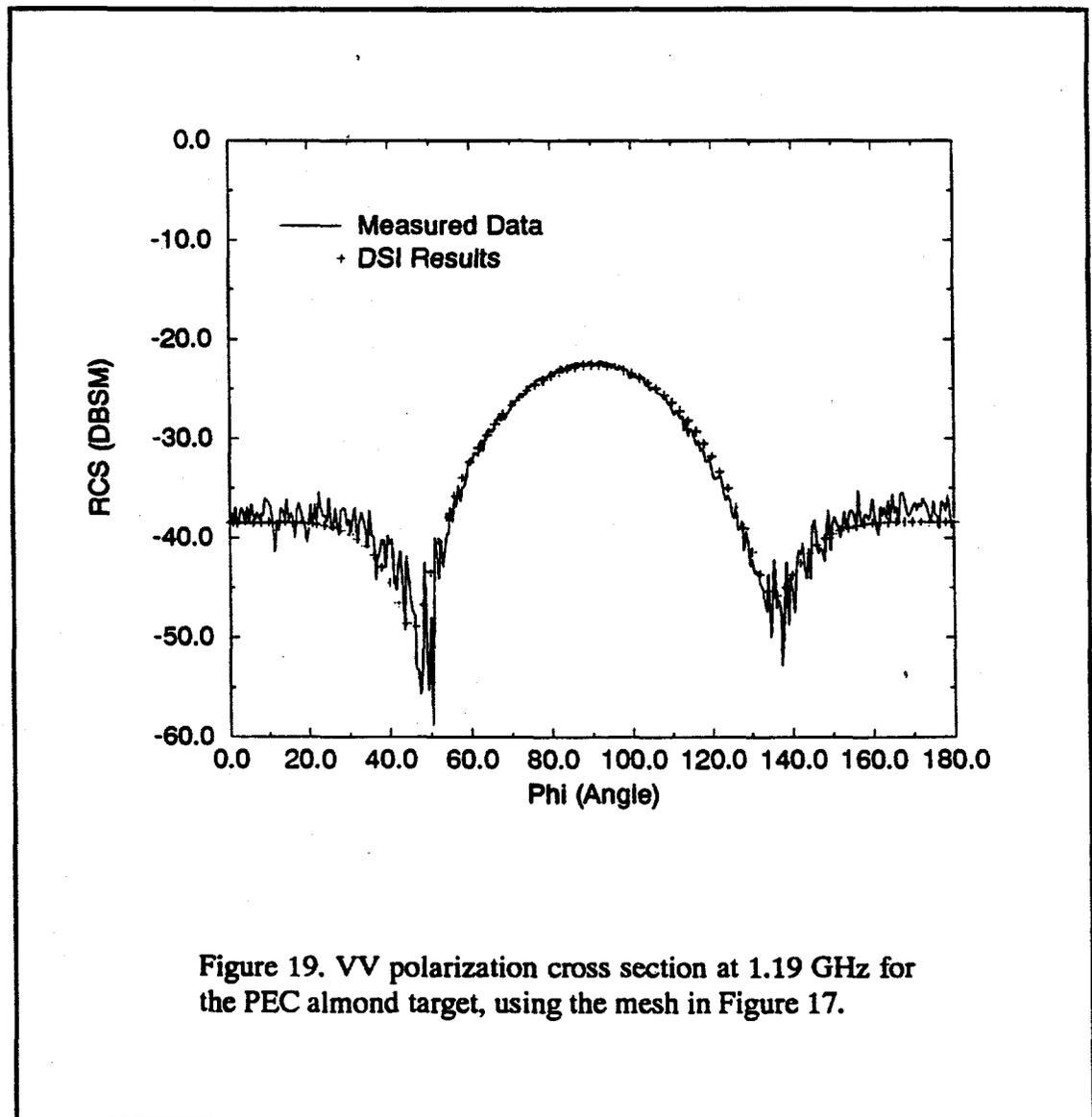
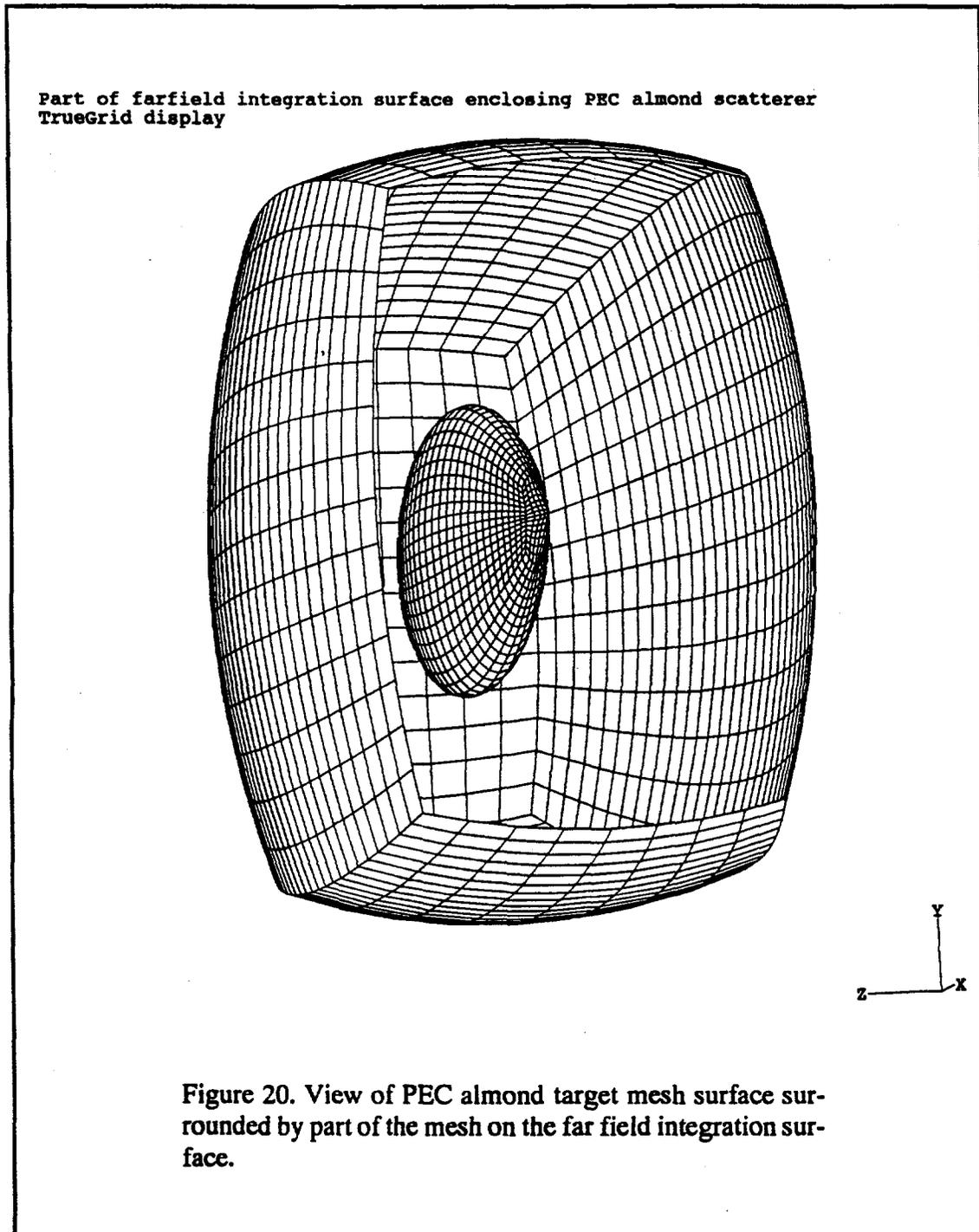


Figure 20 illustrates the shape of the far field integration surface by showing a cut away view of that surface and the meshed surface of the PEC almond.



Wavelength Circular Cavity

emcc target - cylindrical cavity
TrueGrid exploded display

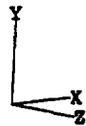
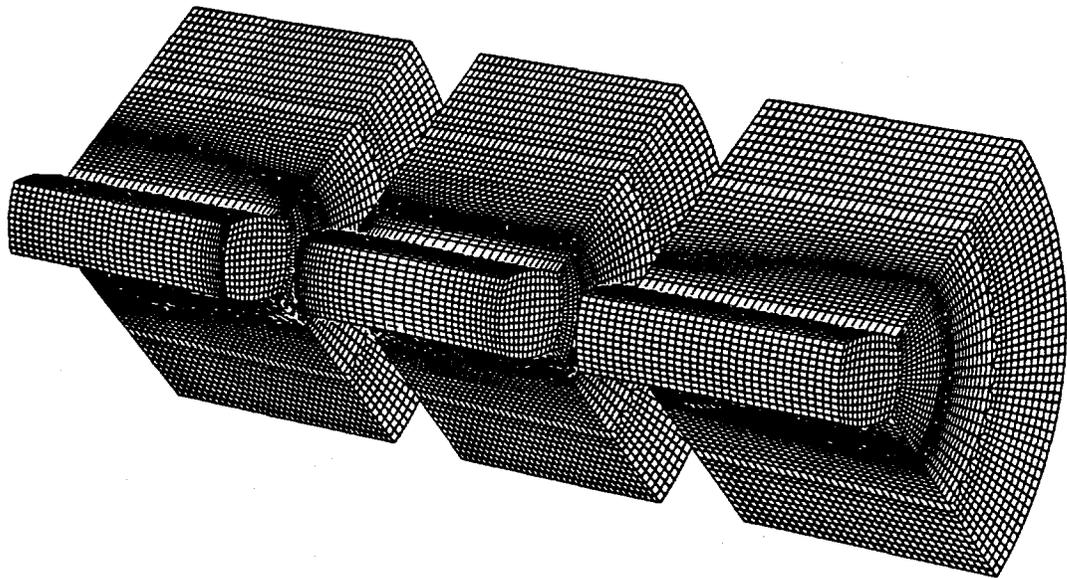


Figure 21. Cutaway and exploded view of the cylindrical cavity target mesh. The cavity is located in the middle section of the mesh and ends where the mesh is dense radially.

DSI3D Test Results

Figure 22 was obtained with the following input file. Note that the shell script has to be modified to use the keyword **THETA** instead of **PHI**.

```
local_dir      /var/tmp/cyl_  
start_time    0.0  
num_steps     8192  
dt            0.0  
eps0          8.8541853367e-12  
xmu0          1.2566e-06  
driver_id     7  
ascii_coef    0  
smtst        0.0004  
alpha        30  
restarts     1024
```

```
driver THETA.0 0.0 0.0 78721.56184 0.08 96.0 16.0 0.0 2.0 -1.0
```

```
primary_output_edges  
354 353  
354 349  
354 384
```

```
rbc higdon_higdon 60 0.0 0.015 0.0 0.01
```

```
FARREF 0.0 0.0 0.0
```

```
FARPOL  
0.0  
90.0
```

```
FARPTS  
THETA.0 0.0
```

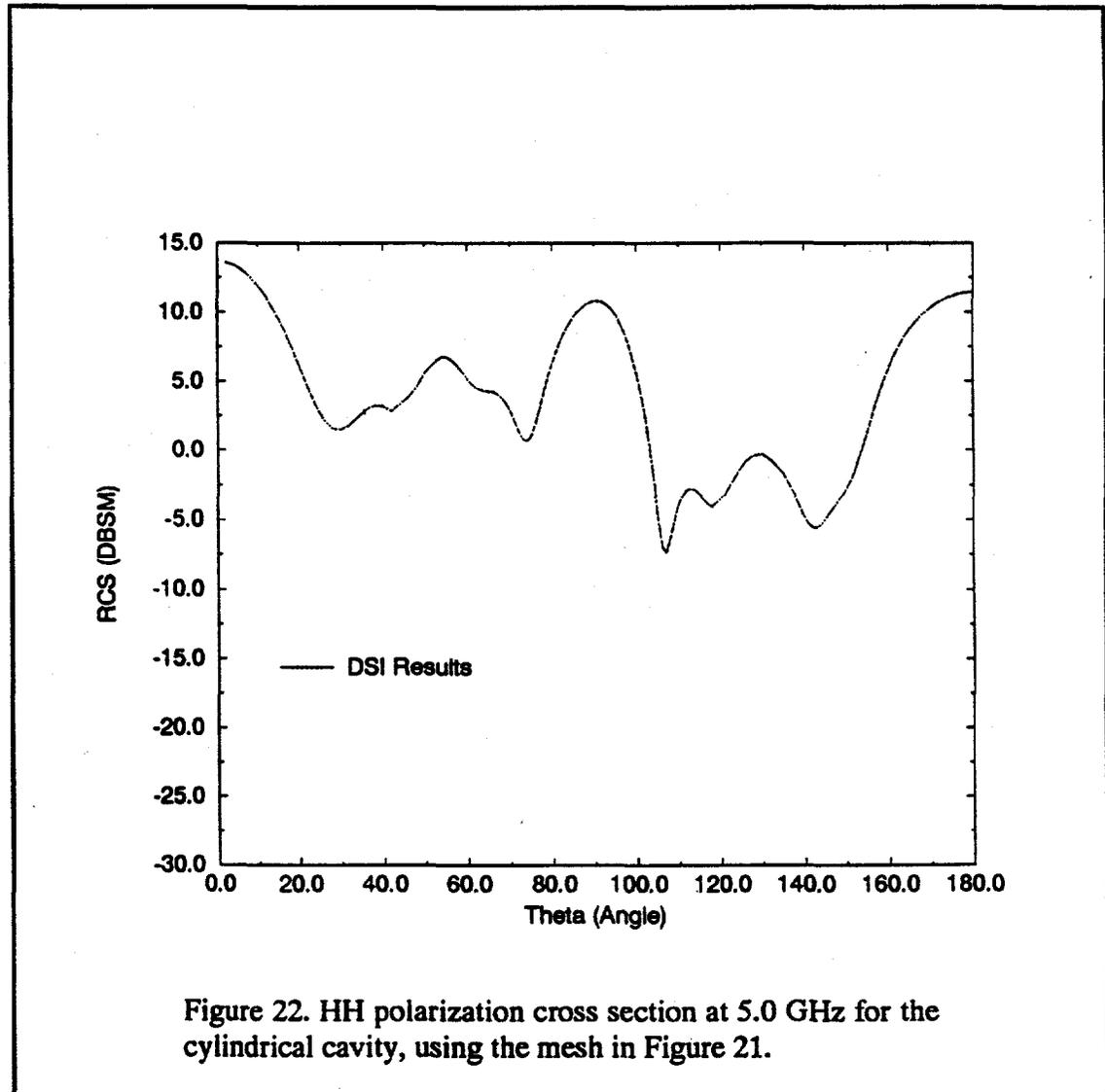


Figure 22. HH polarization cross section at 5.0 GHz for the cylindrical cavity, using the mesh in Figure 21.

Figure 23 was obtained with the following input file. Again, note that the shell script has to be modified to use the keyword **THETA** instead of **PHI**.

```
local_dir      /var/tmp/cyl_  
start_time    0.0  
num_steps     8192  
dt            0.0  
eps0          8.8541853367e-12  
xmu0         1.2566e-06  
driver_id     7  
ascii_coef    0  
smtst        0.0004  
alpha        30  
restarts     1024
```

DSI3D Test Results

driver THETA.0 0.0 90.0 78721.56184 0.08 96.0 16.0 0.0 2.0 -1.0

primary_output_edges

354 353

354 349

354 384

rbc higdon_higdon 60 0.0 0.015 0.0 0.01

FARREF 0.0 0.0 0.0

FARPOL

0.0

90.0

FARPTS

THETA.0 0.0

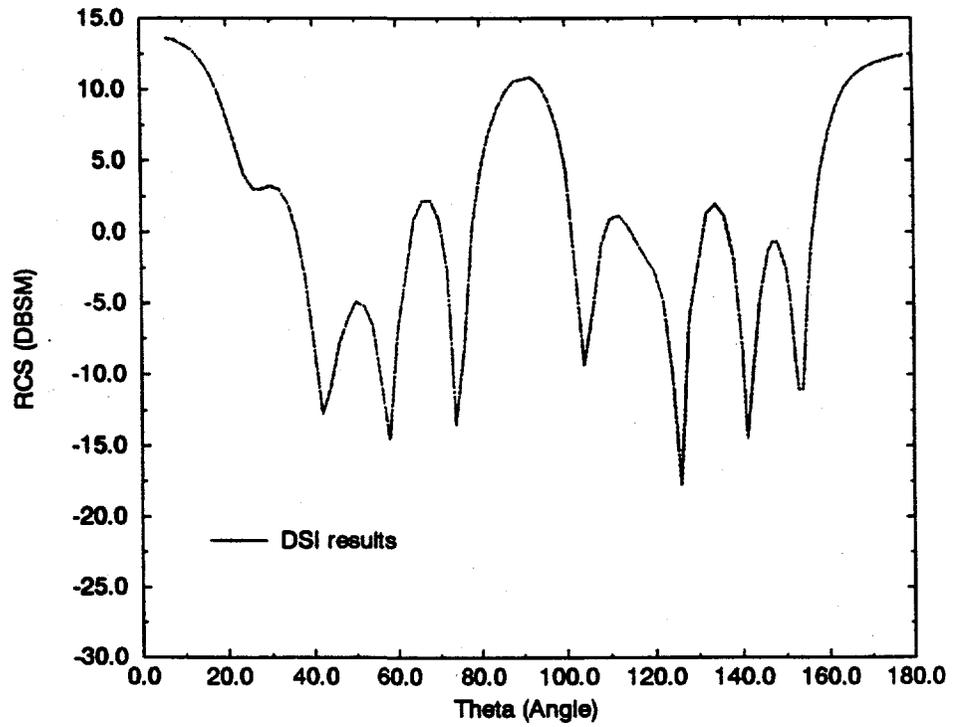


Figure 23. VV polarization cross section at 5.0 GHz for the cylindrical cavity, using the mesh in Figure 21.