

TSUPREM Example:
Implants
Electrical Statement – Sheet Resistance, $V_{\text{threshold}}$

1. Example looks at an MOS capacitor fabrication similar (but not exactly like) the 423 process. It looks at the area under the gate.
2. Example illustrate implant profiles
3. Most useful point for the next reports is the use of the **electric** statement to get Tsuprem calculation of:
 - a. Sheet Resistance
 - b. MOSFET V_TRelated to this, the plot **electric statement** is also illustrated
4. Other process points are illustrated.

```

MESH GRID.FAC=0.03 LY.BOT=5
INITIALIZE BORON=6.1e16
DIFFUSION TEMPERAT=1100 TIME= 5 DRYO2
DIFFUSION TEMPERAT=1100 TIME= 60 F.O2=1.75 F.H2=2.5
DIFFUSION TEMPERAT=1100 TIME= 5 DRYO2
SELECT Z=DOPING
PRINT.1D      LAYERS
SELECT Z=LOG10(BORON)
PLOT.1D  COLOR=3 RIGHT=1 Bottom=12 top=21
ETCH OXIDE ALL
implant damage=true impurity=arsenic dose=5e11 energy=100
SELECT Z=LOG10(arsenic)
PLOT.1D  COLOR=2 RIGHT=1 Bottom=12 top=21
SELECT Z=LOG10(BORON)
PLOT.1D  COLOR=3 ^AXES ^clear
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
DIFFUSION TEMPERAT=1000 TIME= 25 DRYO2
SELECT Z=DOPING
PRINT.1D      LAYERS
SELECT Z=LOG10(arsenic)
PLOT.1D  COLOR=2 RIGHT=1 Bottom=12 top=21
SELECT Z=LOG10(BORON)
PLOT.1D  COLOR=3 ^AXES ^clear
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
Deposition material=poly thickness=0.5
implant damage=true impurity=phosphorus dose=5e15 energy=100
SELECT Z=LOG10(phosphorus)
PLOT.1D  COLOR=4 RIGHT=1 Bottom=12 top=21
SELECT Z=LOG10(arsenic)
PLOT.1D  COLOR=2 ^axes ^clear
SELECT Z=LOG10(boron)
PLOT.1D  COLOR=3 ^axes ^clear
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
diffusion nitrogen Temperat=1000 time=30
SELECT Z=LOG10(phosphorus)
PLOT.1D  COLOR=4 RIGHT=1 Bottom=12 top=21
SELECT Z=LOG10(arsenic)
PLOT.1D  COLOR=2 ^axes ^clear
SELECT Z=LOG10(boron)
PLOT.1D  COLOR=3 ^axes ^clear
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
SELECT Z=DOPING
PRINT.1D      LAYERS
SELECT Z=phosphor
PRINT.1D      LAYERS
SELECT Z=boron
PRINT.1D      LAYERS
Electric resist
electric threshold nmos gate.elec bulk.reg=1 vstart=-10 vstop=10 vstep=0.01
plot.1d electric

```

```

*****
***              TSUPREM-4 (TM)              ***
***      Version U-2003.6-0, System S (Sun: Solaris)      ***
***      Copyright (C) 1988-2003              ***
***              Synopsys, Inc.              ***
***      All Rights Reserved                  ***
***              TSUPREM-4 is a trademark of Synopsys, Inc. ***
*****

```

2-Nov-2003 18:38:19

```

***** Advanced Application Module Availability *****
Extended Defects                : available for use
User-Specified Equation Interface : available for use
*****

```

Entering source file implant.inp.

```

MESH GRID.FAC=0.03 LY.BOT=5
INITIALIZE BORON=6.1e16
** Automatic X grid generation:  lines at X=0 and X=1 micron.
** Automatic Y grid generation.
   2 lines in the x direction.
   779 lines in the y direction.
DIFFUSION TEMPERAT=1100 TIME= 5 DRYO2
DIFFUSION TEMPERAT=1100 TIME= 60 F.O2=1.75 F.H2=2.5

*** Partial pressures of oxidizing species:  H2O=0.833333  O2=0.166667
    => Oxidation rate based on partial pressure of H2O

```

```

DIFFUSION TEMPERAT=1100 TIME= 5 DRYO2
SELECT Z=DOPING
PRINT.1D      LAYERS
** Printing along X.VALUE=0:

```

Num	Material	Top	Bottom	Thickness	Integral
1	oxide	-0.3446	0.2692	0.6137	-2.3608e+12
2	silicon	0.2692	5.0000	4.7308	-2.8110e+13

```

SELECT Z=LOG10(BORON)
PLOT.1D  COLOR=3 RIGHT=1 Bottom=12 top=21
** Plotting along X.VALUE=0.

```

```

** Plotting to device: "x" (specified by DEFPDEV environment variable)
ETCH OXIDE ALL
implant damage=true impurity=arsenic dose=5e11 energy=100

```

*** Warning: PD.TRANS model enabled to simulate effects of implant damage.

```

SELECT Z=LOG10(arsenic)

```

```
PLOT.1D  COLOR=2 RIGHT=1 Bottom=12 top=21
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(BORON)
PLOT.1D  COLOR=3 ^AXES ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
** Plotting along X.VALUE=0.
```

```
DIFFUSION TEMPERAT=1000 TIME= 25 DRYO2
SELECT Z=DOPING
PRINT.1D      LAYERS
** Printing along X.VALUE=0:
```

Num	Material	Top	Bottom	Thickness	Integral
1	oxide	0.2526	0.2806	0.0281	-2.0252e+11
2	silicon	0.2806	0.3751	0.0945	9.4386e+10
3	silicon	0.3751	5.0000	4.6249	-2.7495e+13

```
SELECT Z=LOG10(arsenic)
PLOT.1D  COLOR=2 RIGHT=1 Bottom=12 top=21
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(BORON)
PLOT.1D  COLOR=3 ^AXES ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
** Plotting along X.VALUE=0.
```

```
Deposition material=poly thickness=0.5
implant damage=true impurity=phosphorus dose=5e15 energy=100
SELECT Z=LOG10(phosphorus)
PLOT.1D  COLOR=4 RIGHT=1 Bottom=12 top=21
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(arsenic)
PLOT.1D  COLOR=2 ^axes ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(boron)
PLOT.1D  COLOR=3 ^axes ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(doping)
PLOT.1D  COLOR=1 line.typ=2 ^AXES ^clear
** Plotting along X.VALUE=0.
```

```
diffusion nitrogen Temperat=1000 time=30
SELECT Z=LOG10(phosphorus)
PLOT.1D  COLOR=4 RIGHT=1 Bottom=12 top=21
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(arsenic)
```

```
PLOT.1D COLOR=2 ^axes ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(boron)
PLOT.1D COLOR=3 ^axes ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=LOG10(doping)
PLOT.1D COLOR=1 line.typ=2 ^AXES ^clear
** Plotting along X.VALUE=0.
```

```
SELECT Z=DOPING
PRINT.1D LAYERS
** Printing along X.VALUE=0:
```

Num	Material	Top	Bottom	Thickness	Integral
1	polysilicon	-0.2474	0.2526	0.5000	2.8597e+15
2	oxide	0.2526	0.2585	0.0059	2.6513e+11
3	oxide	0.2585	0.2806	0.0222	-1.6035e+11
4	silicon	0.2806	0.3725	0.0919	5.7497e+10
5	silicon	0.3725	5.0000	4.6275	-2.7456e+13

```
SELECT Z=phosphor
PRINT.1D LAYERS
** Printing along X.VALUE=0:
```

Num	Material	Top	Bottom	Thickness	Integral
1	polysilicon	-0.2474	0.2526	0.5000	3.4516e+15
2	oxide	0.2526	0.2806	0.0281	3.0788e+11
3	silicon	0.2806	5.0000	4.7194	7.2177e+01

```
SELECT Z=boron
PRINT.1D LAYERS
** Printing along X.VALUE=0:
```

Num	Material	Top	Bottom	Thickness	Integral
1	polysilicon	-0.2474	0.2526	0.5000	1.0012e+09
2	oxide	0.2526	0.2806	0.0281	2.0407e+11
3	silicon	0.2806	5.0000	4.7194	2.7898e+13

Electric resist

```
***** STRUCTURE INFORMATION *****
LAYER      MATERIAL THICKNESS REGION DIFTYP THICKNESS      TOP      BOTTOM
    3 polysilicon    0.5000      1      n    0.5000    -0.2474    0.2526
    2      oxide     0.0281      1      n    0.0281     0.2526    0.2806
    1      silicon    4.7194      2      n    0.0843     0.2806    0.3649
                                1      p    4.6253     0.3747    5.0000
```

Bias step 1: 0.00 (Volts)

```
*****
Material      Thickness      Type      Junction Depth      Sheet Resistance
-----
```

```
polysilicon    5000 A      N              0.50 um          28 ohm/sq
oxide          281 A
silicon        4.72 um      N              918 A          > 100 K ohm/sq
                                P              4.72 um          624 ohm/sq
```

electric threshold nmos gate.elec bulk.reg=1 vstart=-10 vstop=10 vstep=0.01

```
***** STRUCTURE INFORMATION *****
LAYER      MATERIAL THICKNESS REGION DIFTYP THICKNESS      TOP      BOTTOM
    3 polysilicon    0.5000      1      n    0.5000    -0.2474    0.2526
    2      oxide     0.0281      1      n    0.0281     0.2526    0.2806
    1      silicon    4.7194      2      n    0.0843     0.2806    0.3649
                                1      p    4.6253     0.3747    5.0000
```

*** This is a depletion N-MOSFET.

Threshold (volts) : 0.152

Extrapolated from :

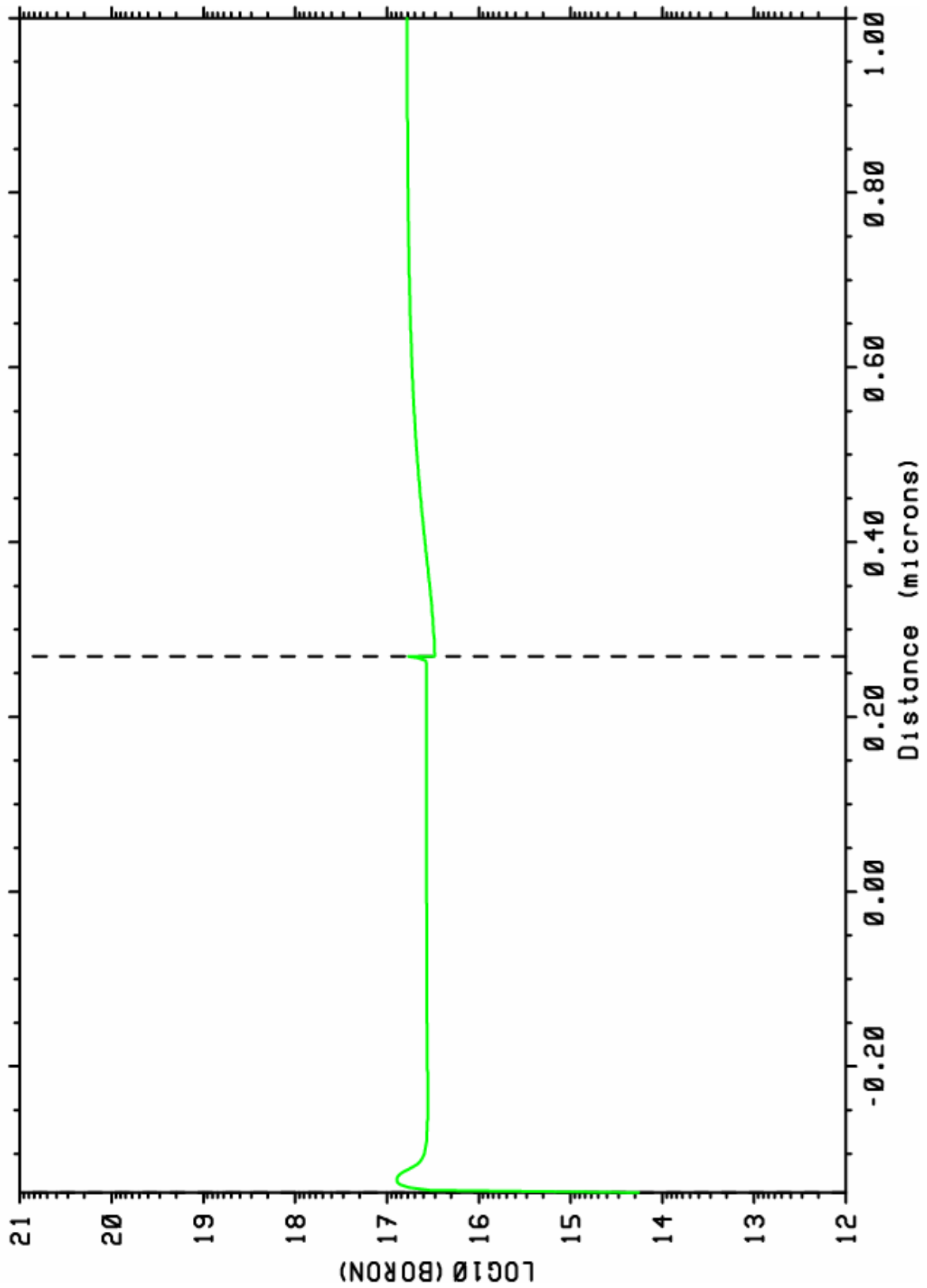
```
bias=0.490 conductance=1.8798e-05
bias=0.500 conductance=1.9353e-05
```

plot.1d electric

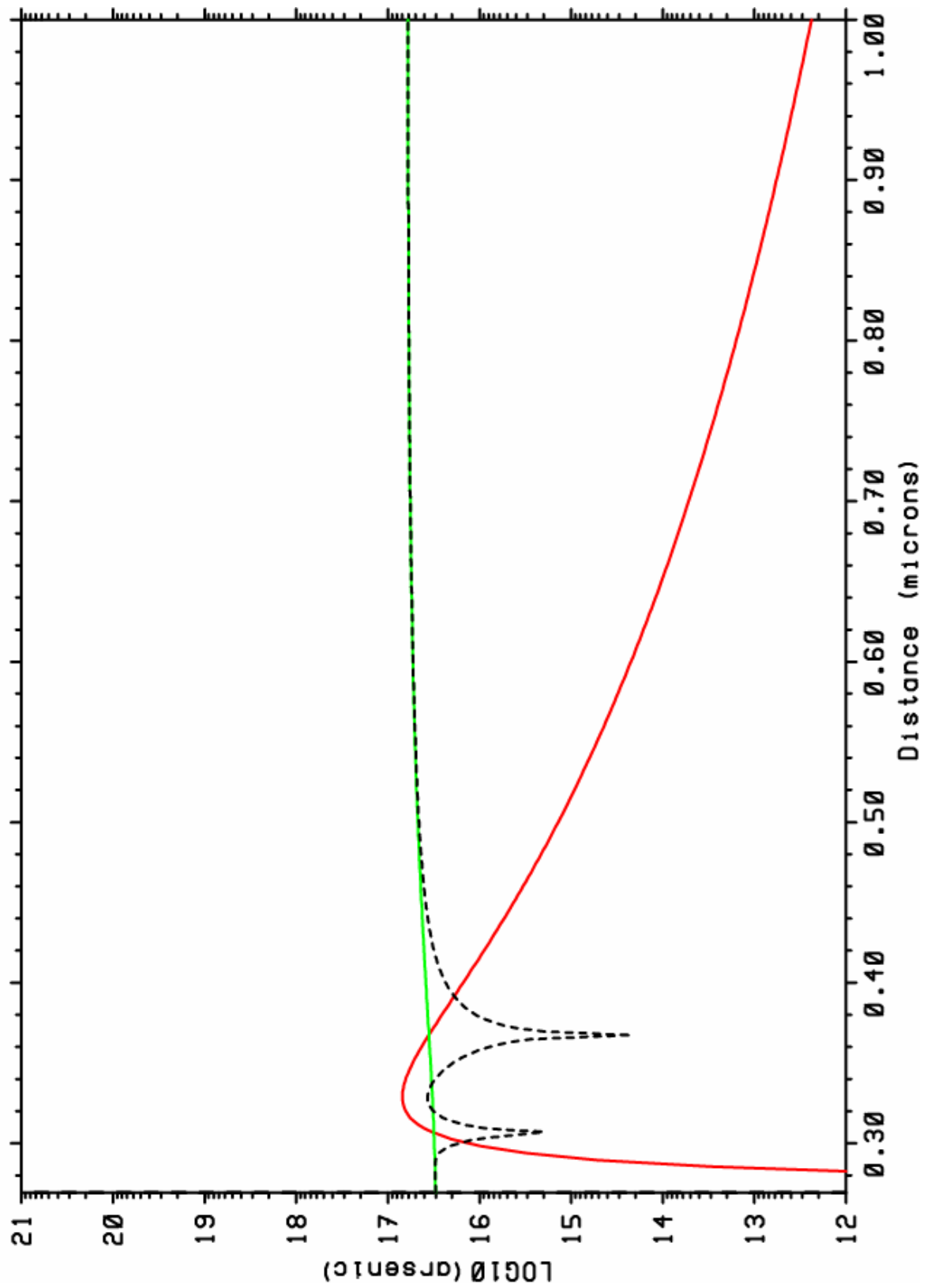
Exiting source file implant.inp.

*** END TSUPREM-4 ***

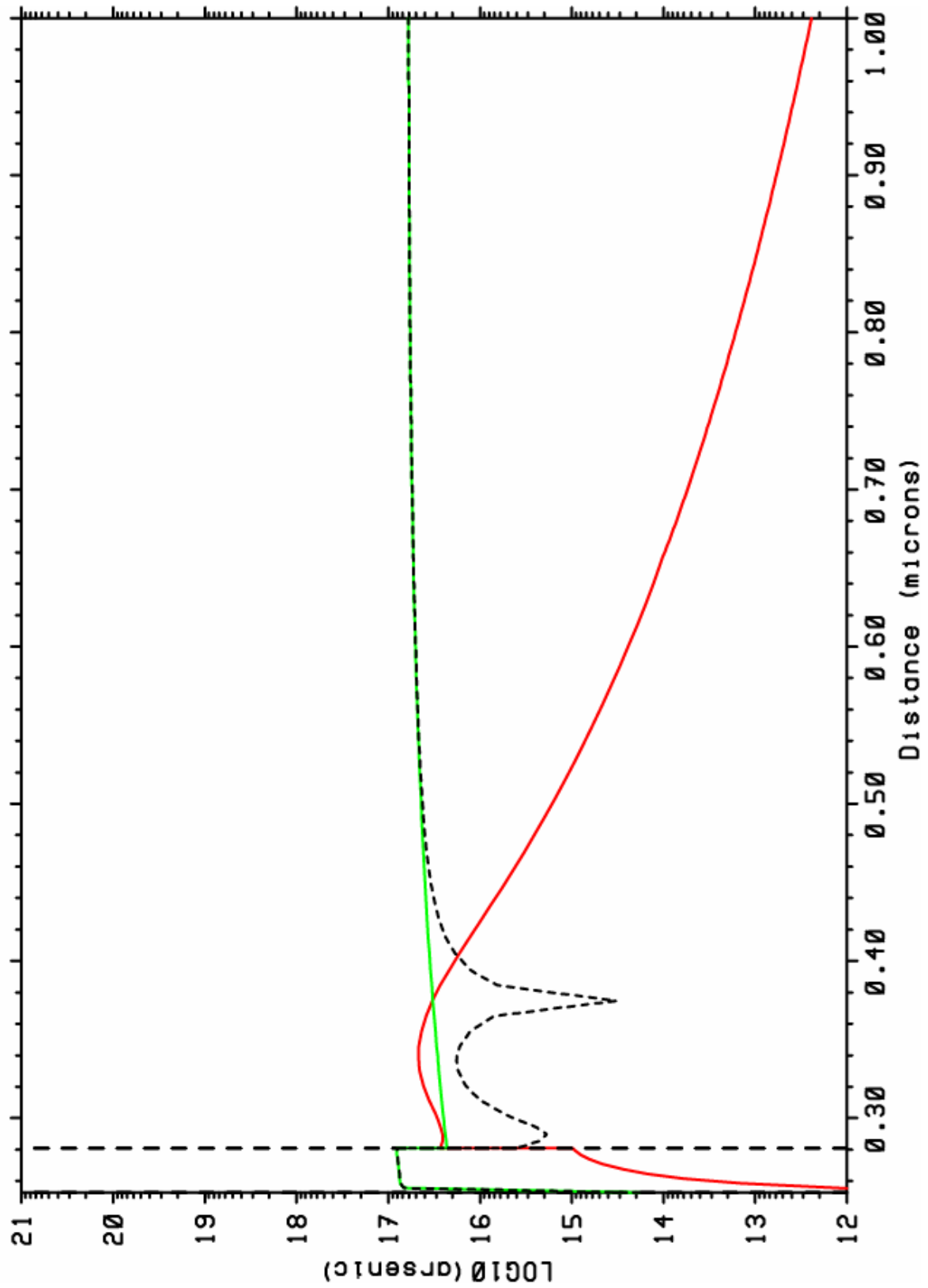
TMA TSUPREM-4 (2003.6S)



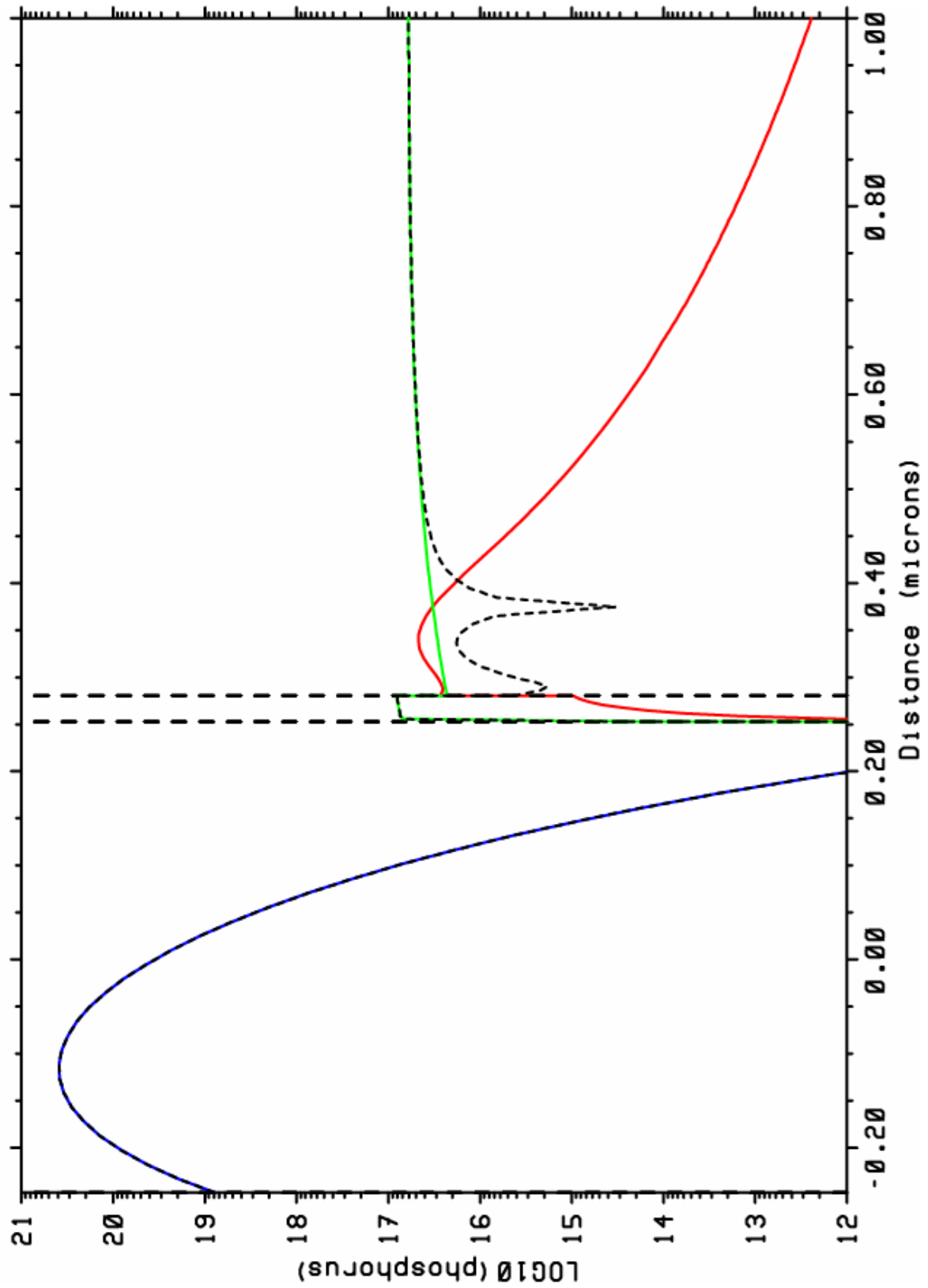
TMA TSUPREM-4 (2003.6S)



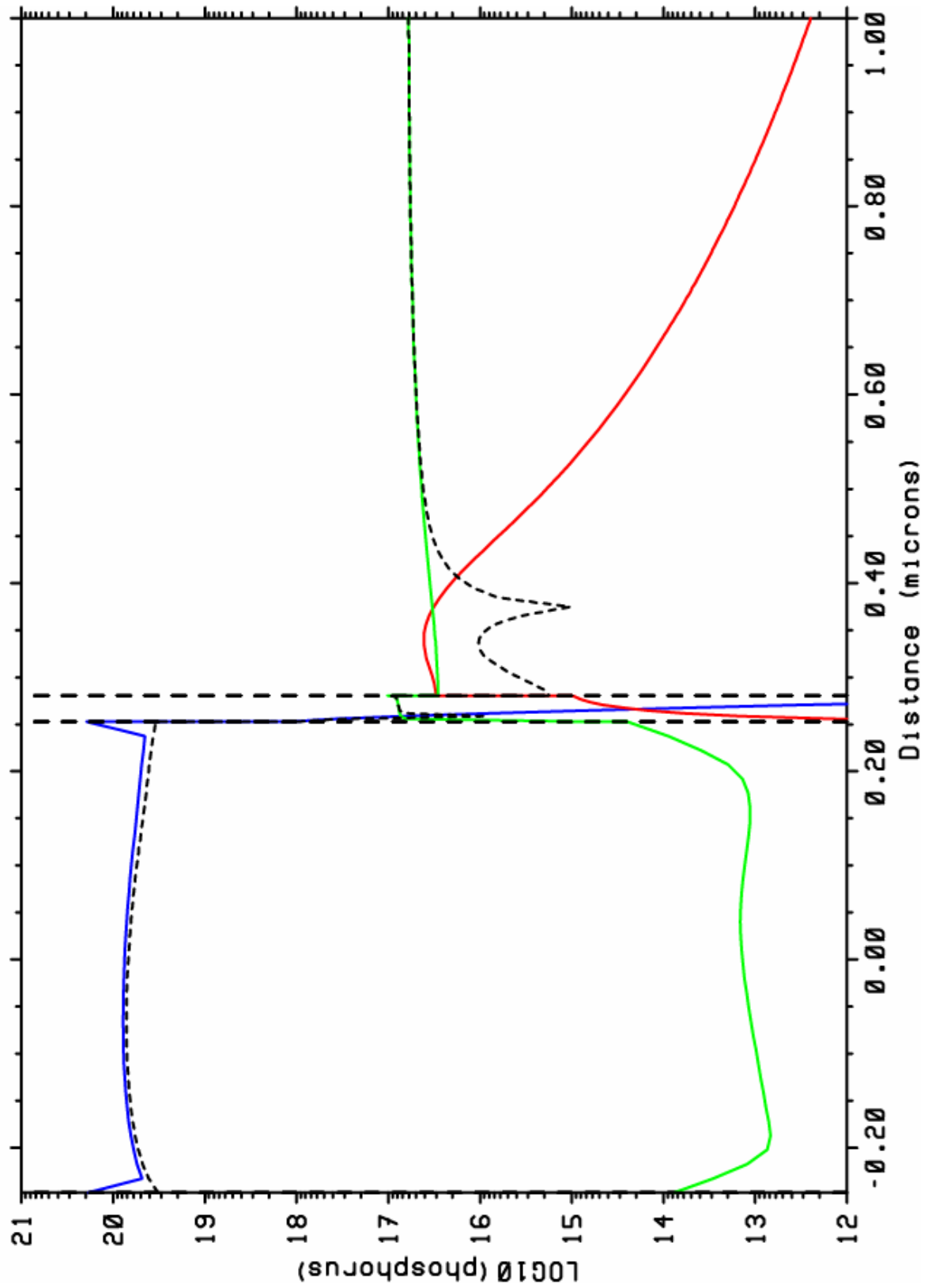
TMA TSUPREM-4 (2003.6S)



TMA TSUPREM-4 (2003.6S)



TMA TSUPREM-4 (2003.6S)



TMA TSUPREM-4 (2003.6S)

