SCAN SPEED

RAPID | SLOW | PHOTO

SCAN MODE

REDUCE | PIC | L.S.P. | SPOT

H R S V P L O

SCAN MODE

P Picture

L Line scan

O Spot

SCAN SPEED

H rapid High

R Rapid low

S Slow

V Photo

B Black background in L.S.P.

C Color mode

Z B/W as in SEM

F save linescan File

G save picture file (Graphic)

Y capture picture file (Yhdistelmä)

T Test mode

K channel (Kanava)

A Abort picture

D stop operation

Q Quit the program

Investigation of voltages and electric fields in silicon radiation detectors using a scanning electron microscope

(20')

Kari Leinonen

(Lappeenranta University of Technology)

INTEGRATE

1 2 frames

2 4 frames

3 8 frames

. . .

8 256 frames

9 continuously

0 no integration

4.7.2005

11:50

Keywords

pad detectors

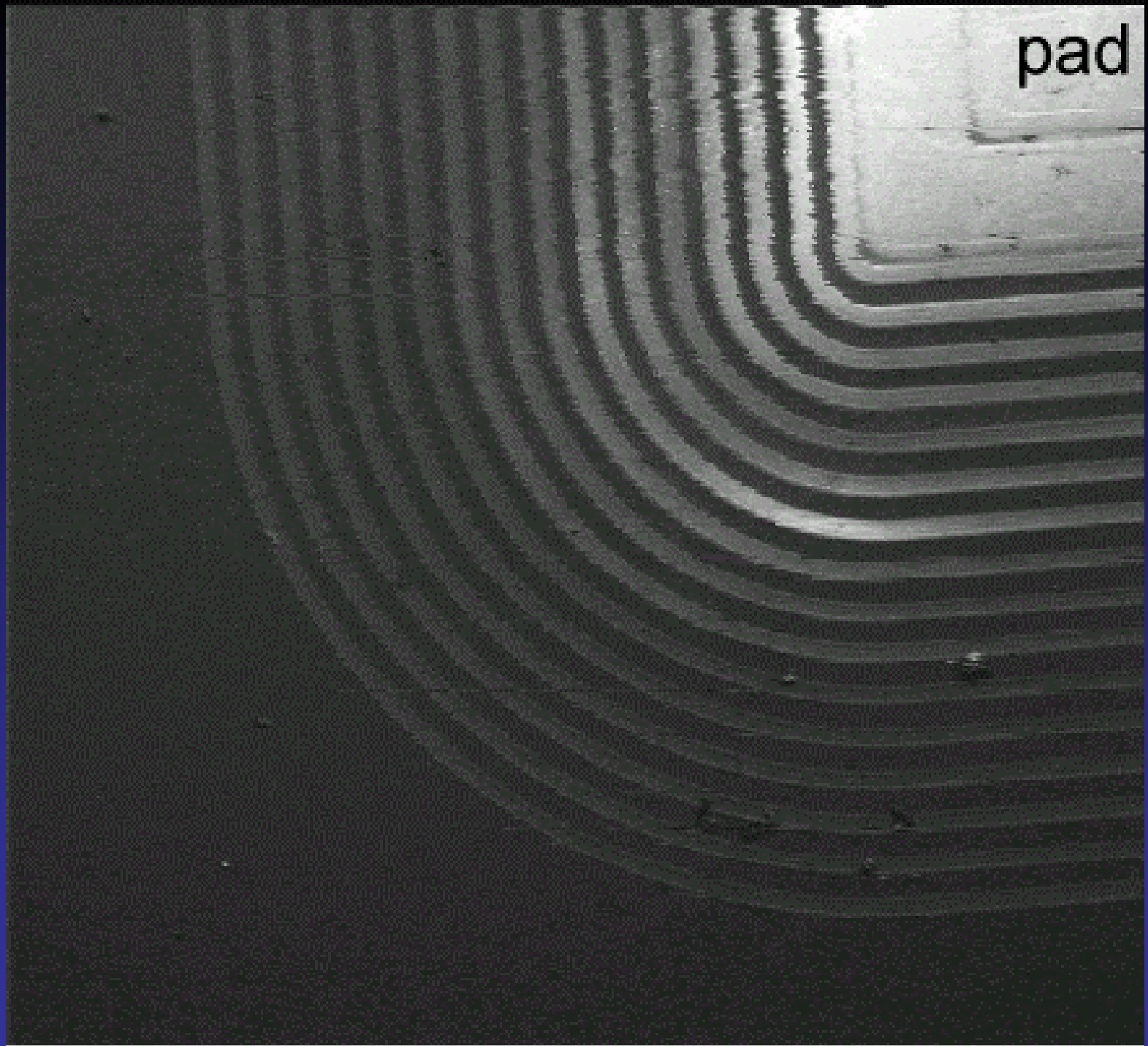
scanning electron microscope = SEM
- voltage contrast

splitting the detector

voltage

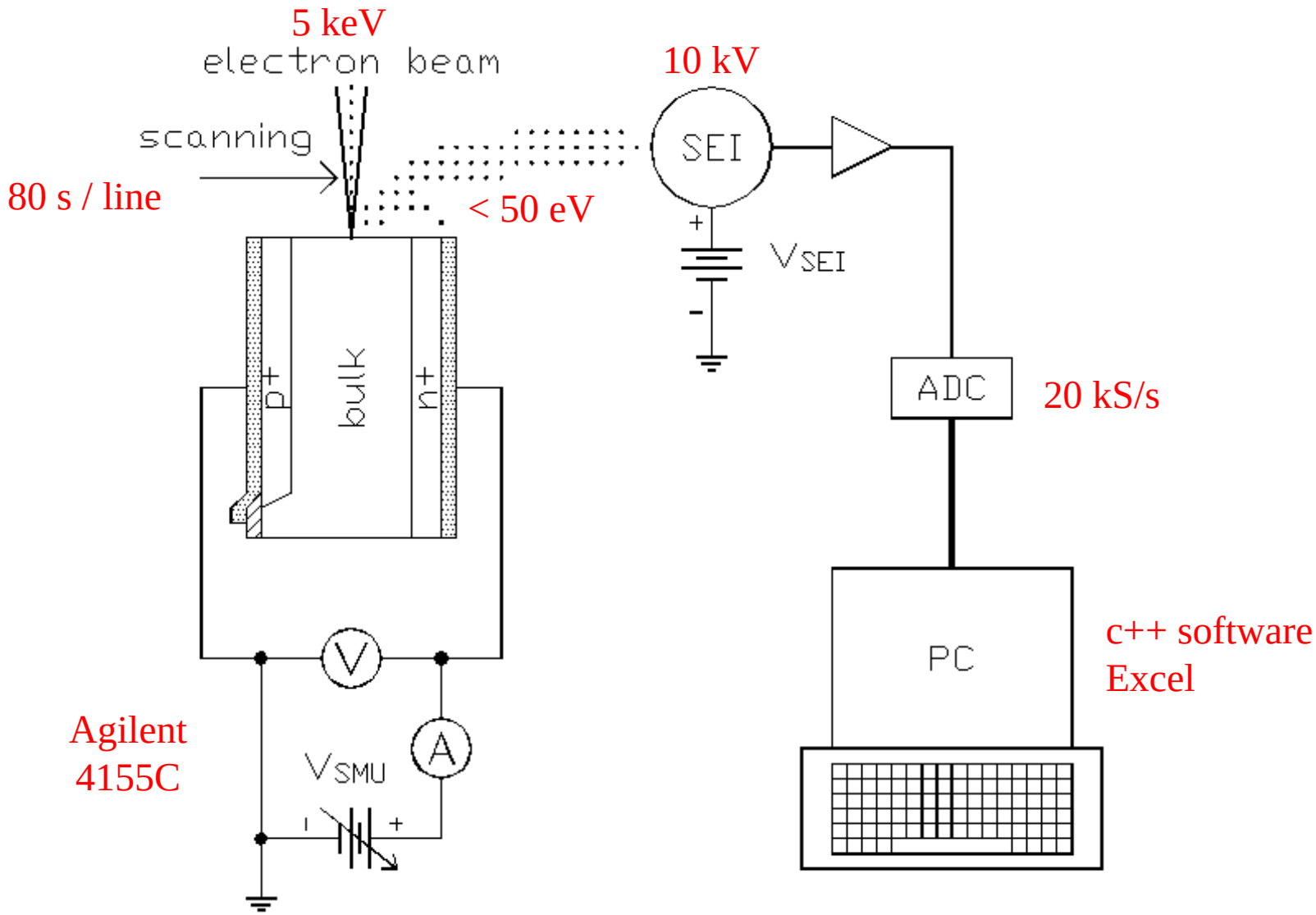
electric field

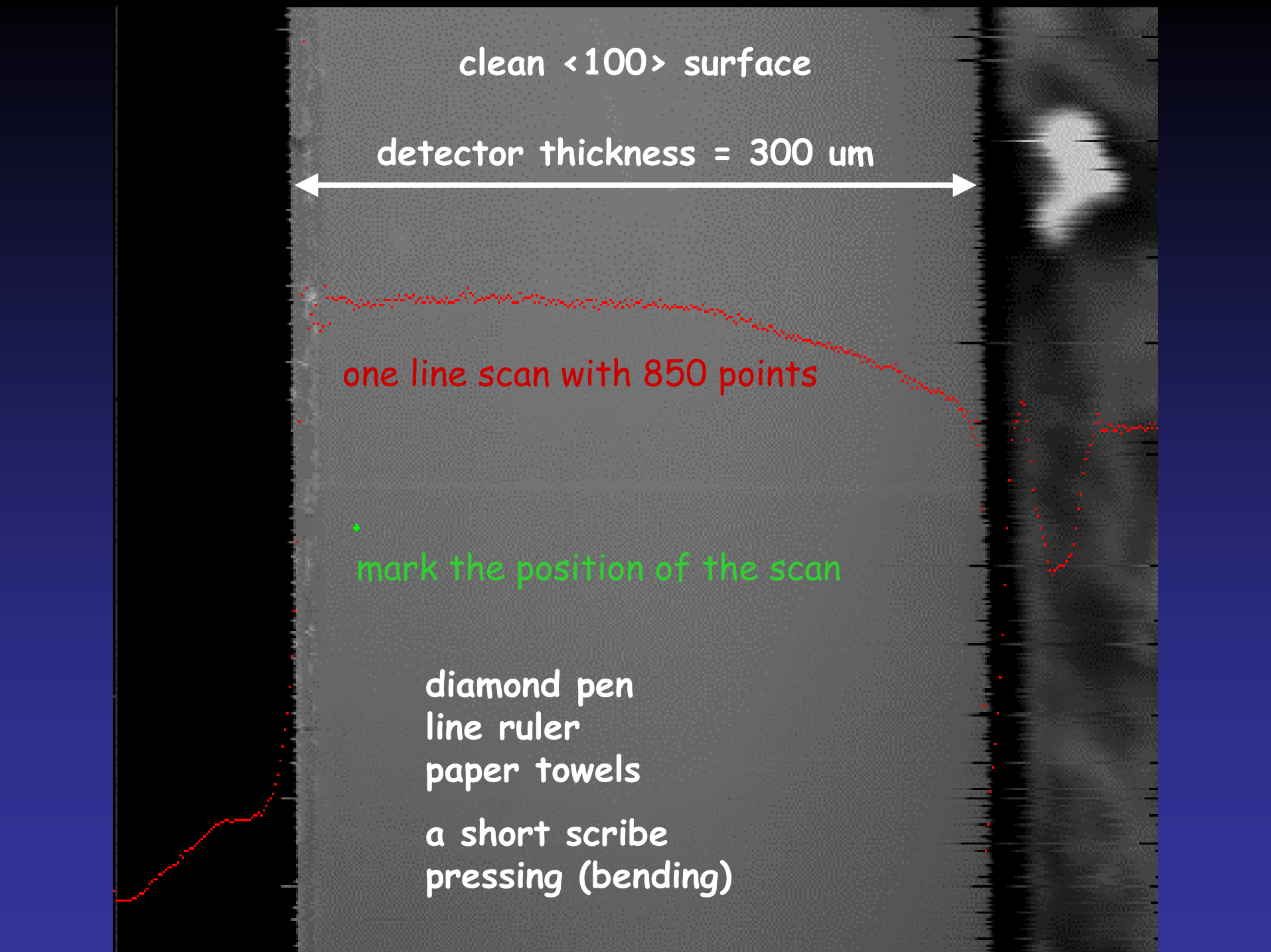
irradiation
- 10 MeV protons
- 24 GeV protons
  - type inversion of n-bulk
  - double peak


pad

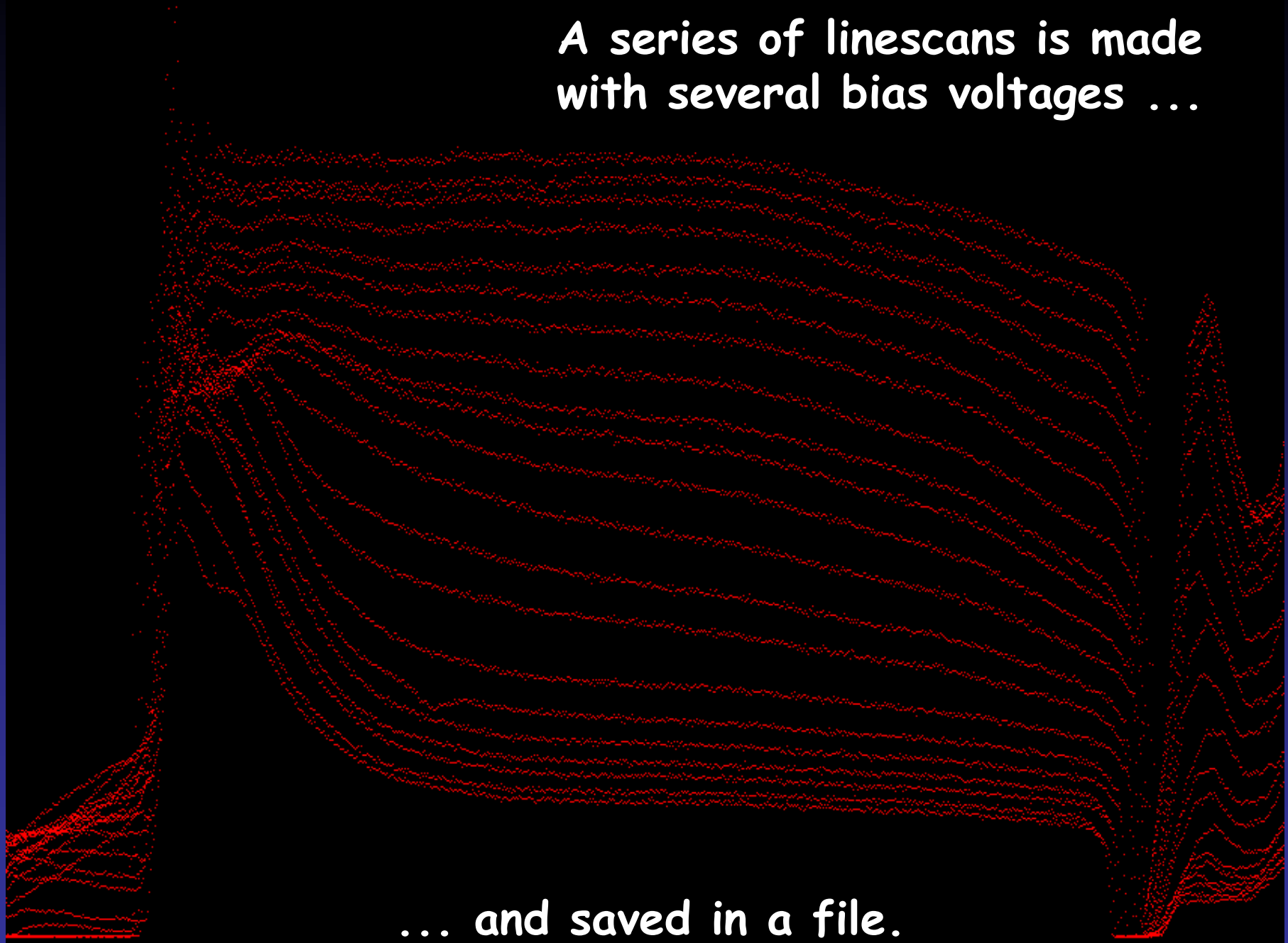
= VOLTAGE CONTRAST

THE BASIC MEASUREMENT SYSTEM

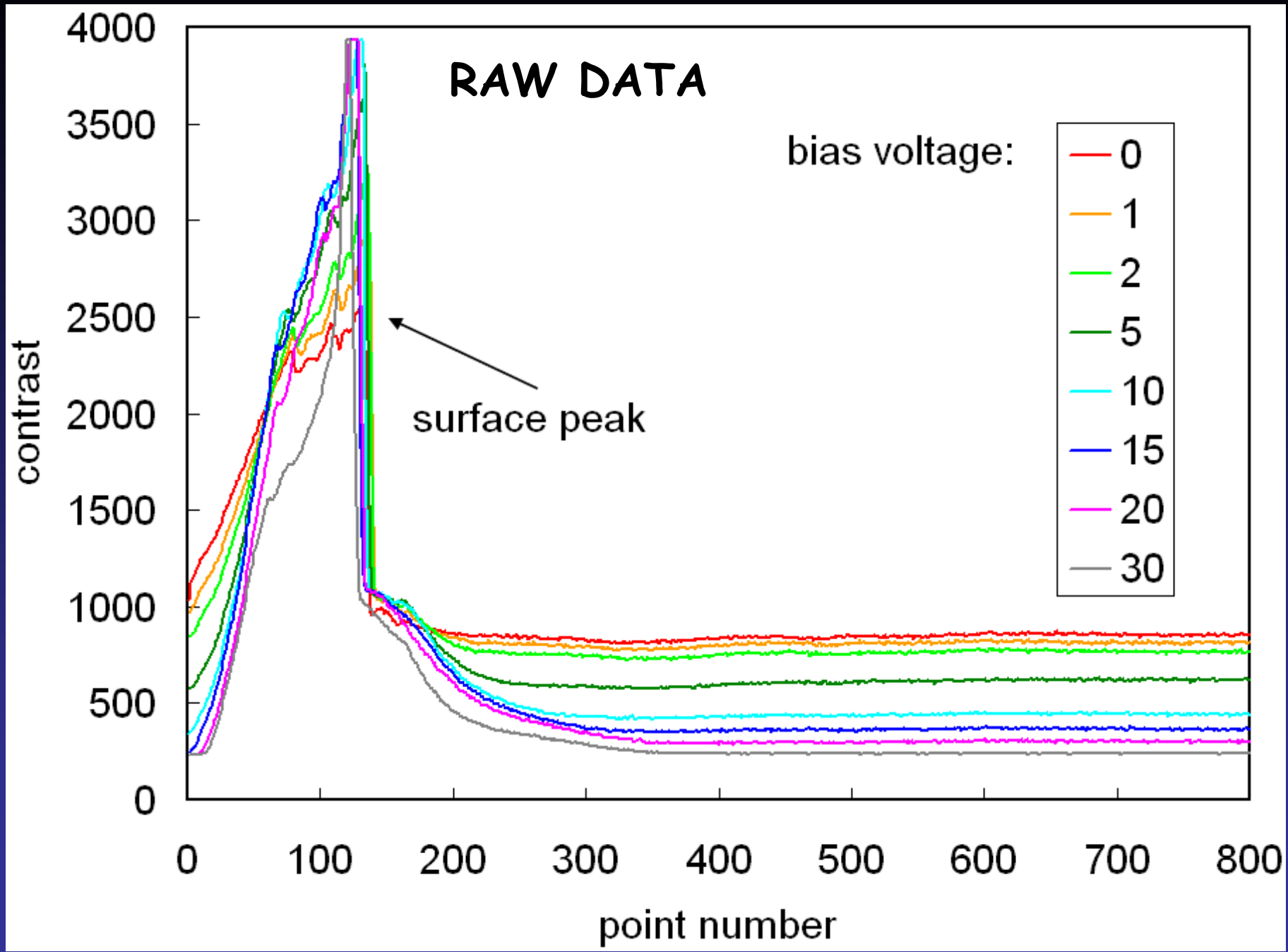


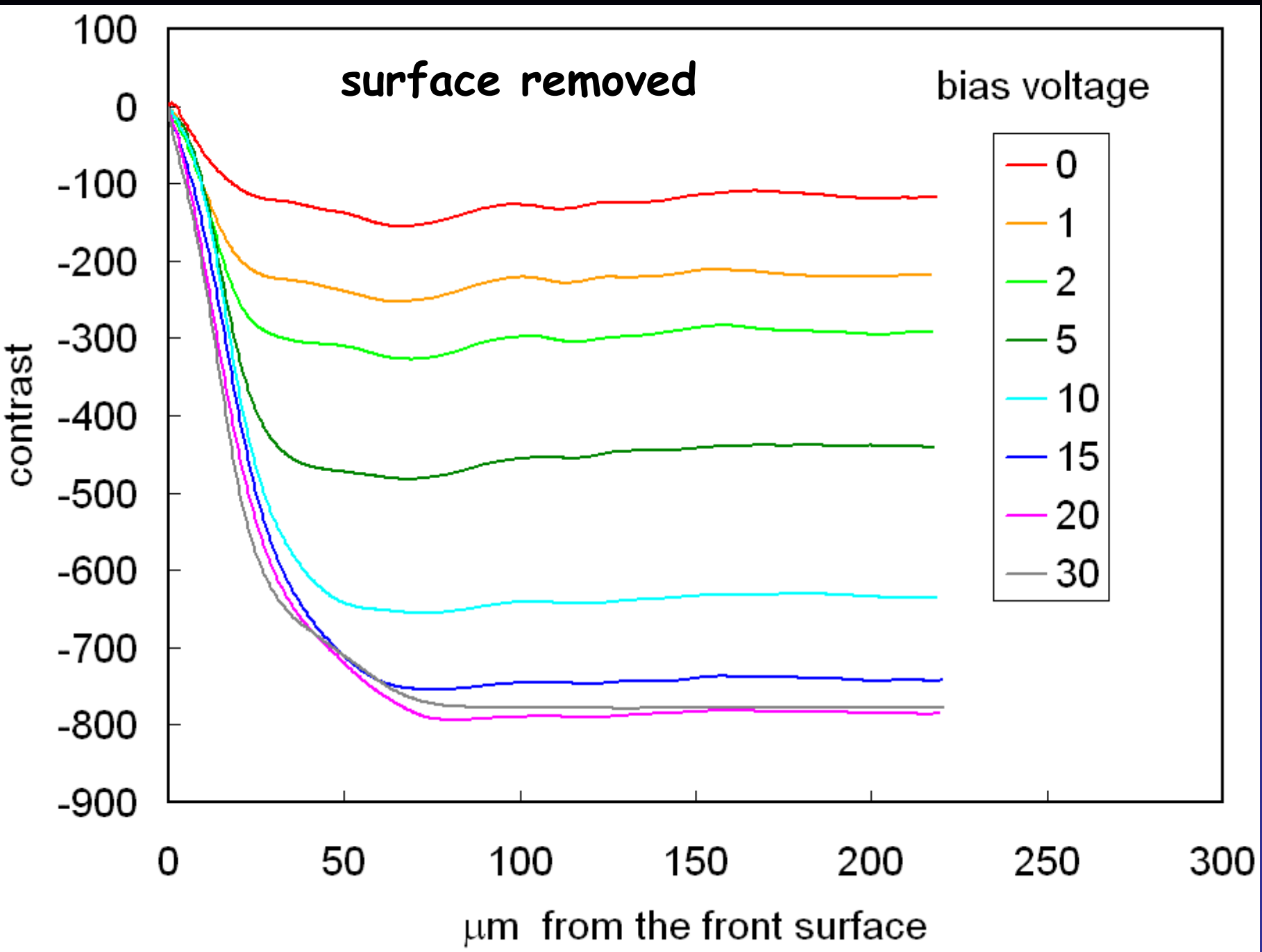

clean <100> surface
detector thickness = 300 um
one line scan with 850 points
mark the position of the scan
diamond pen
line ruler
paper towels
a short scribe
pressing (bending)

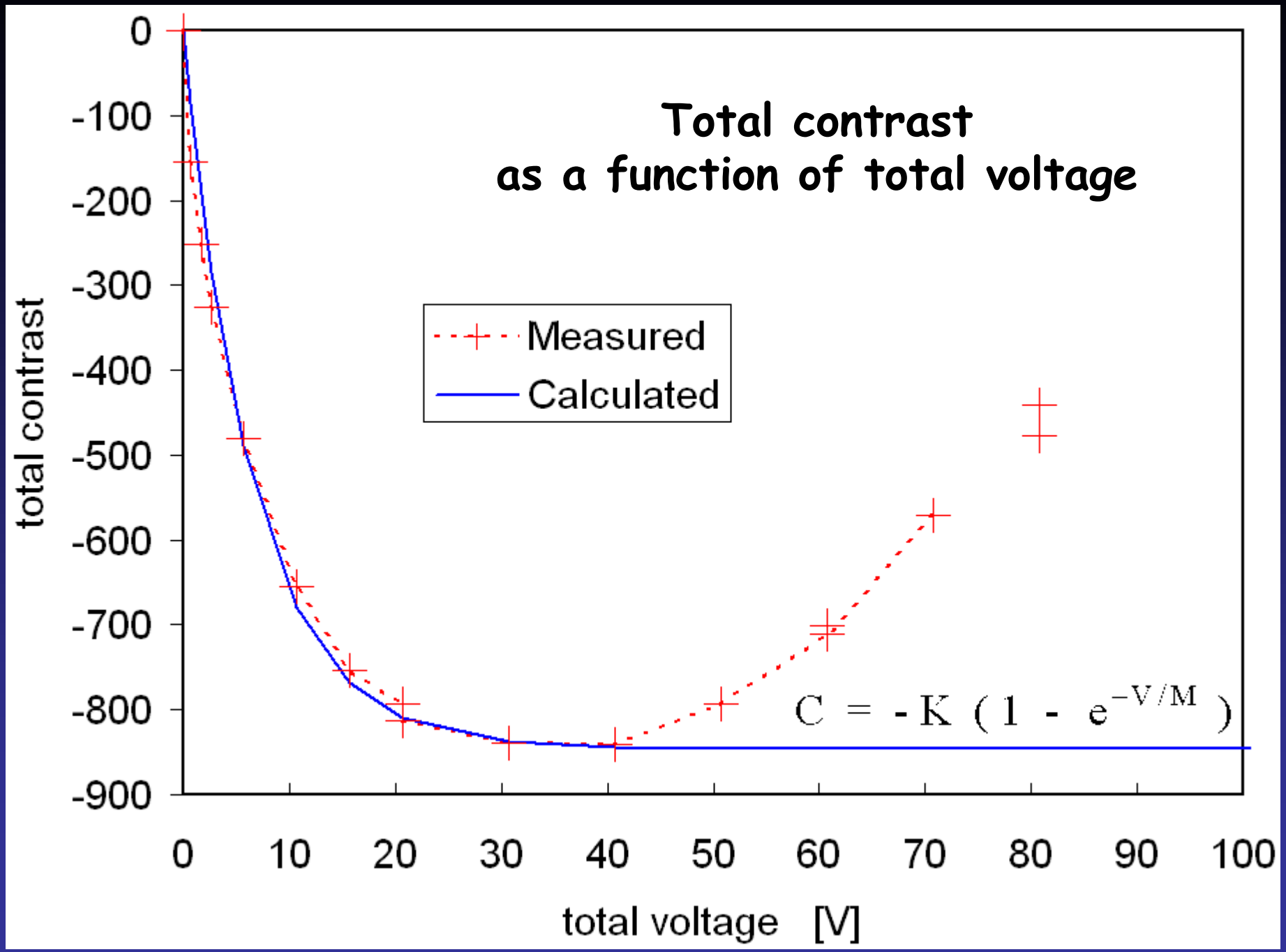
A series of linescans is made with several bias voltages ...

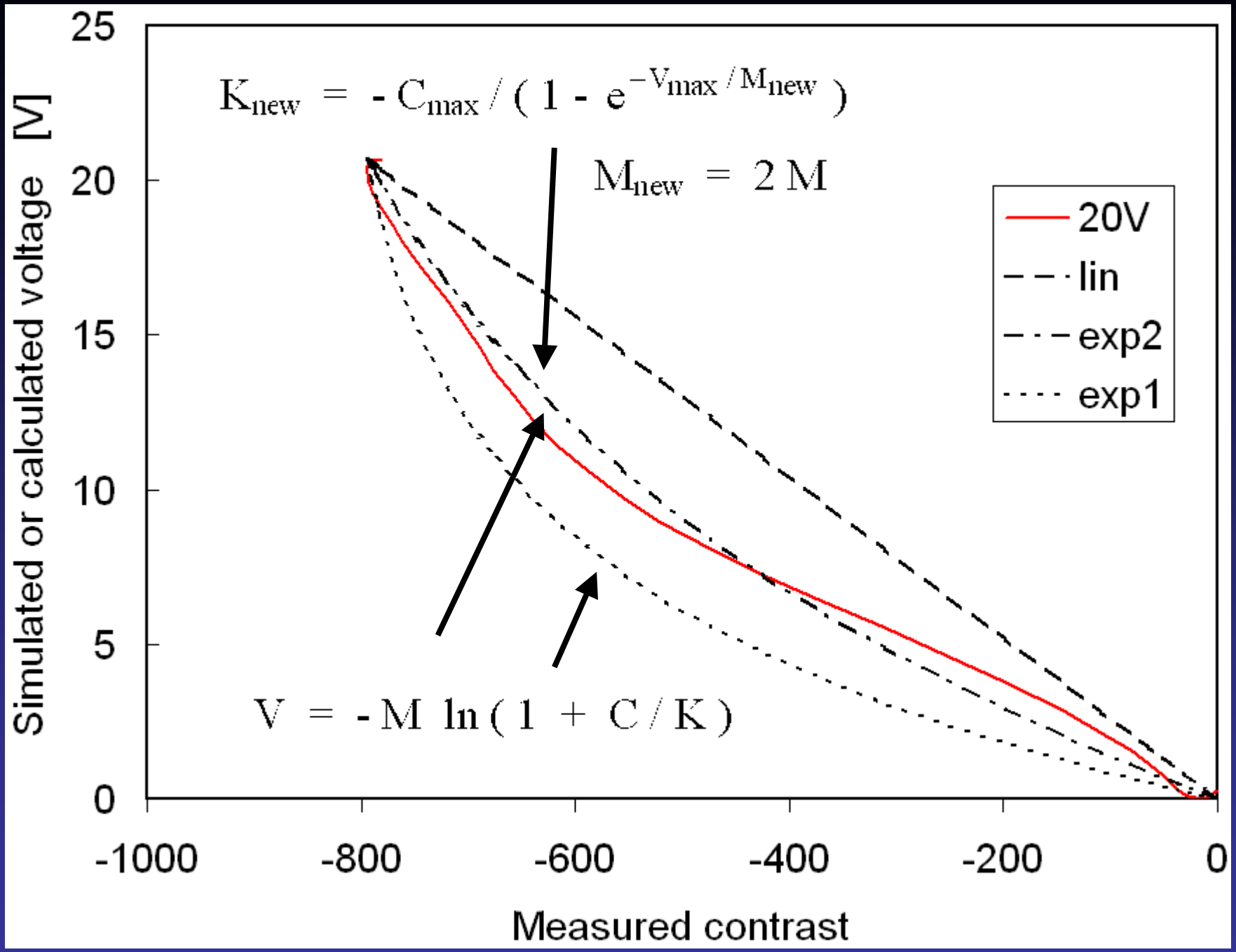


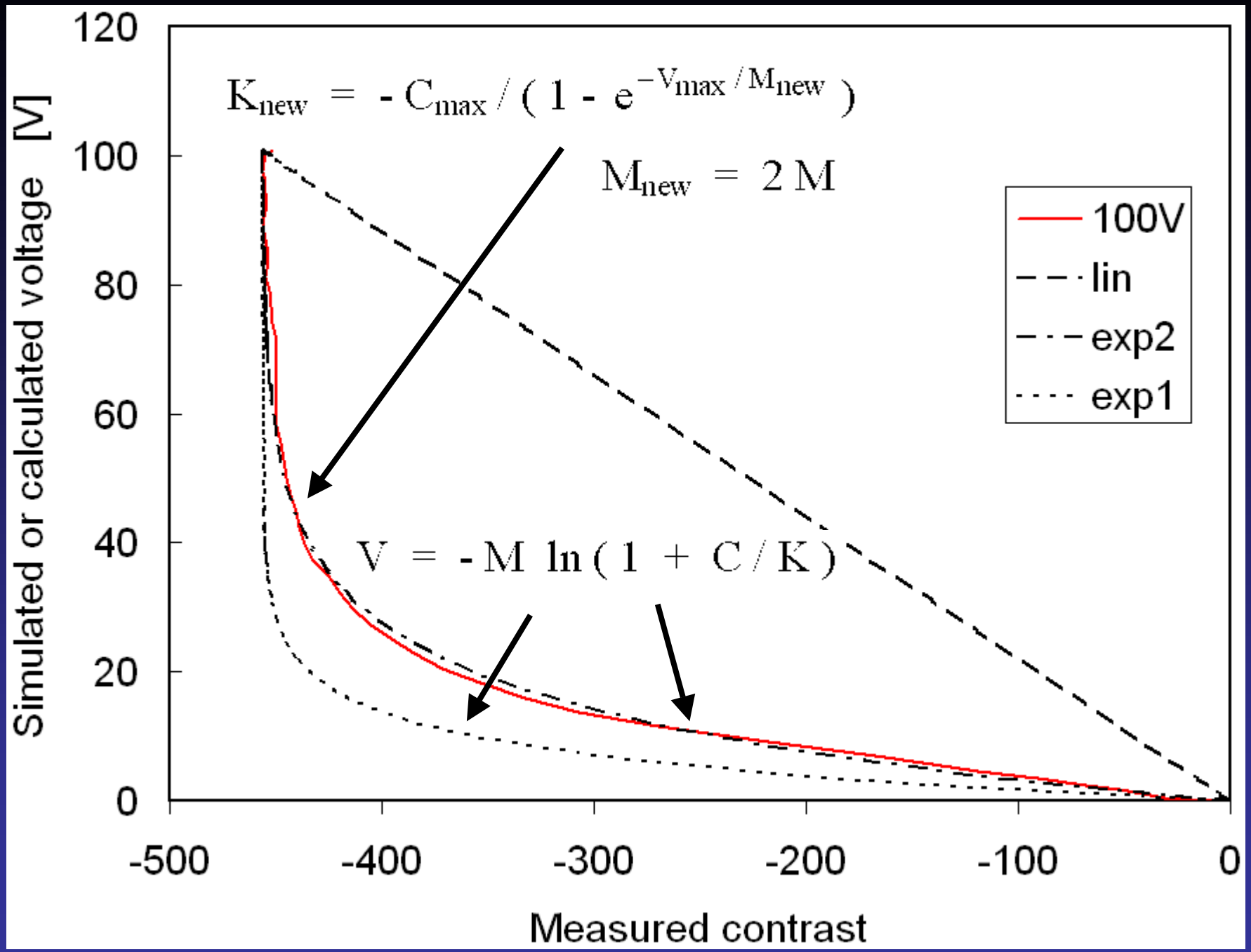
... and saved in a file.

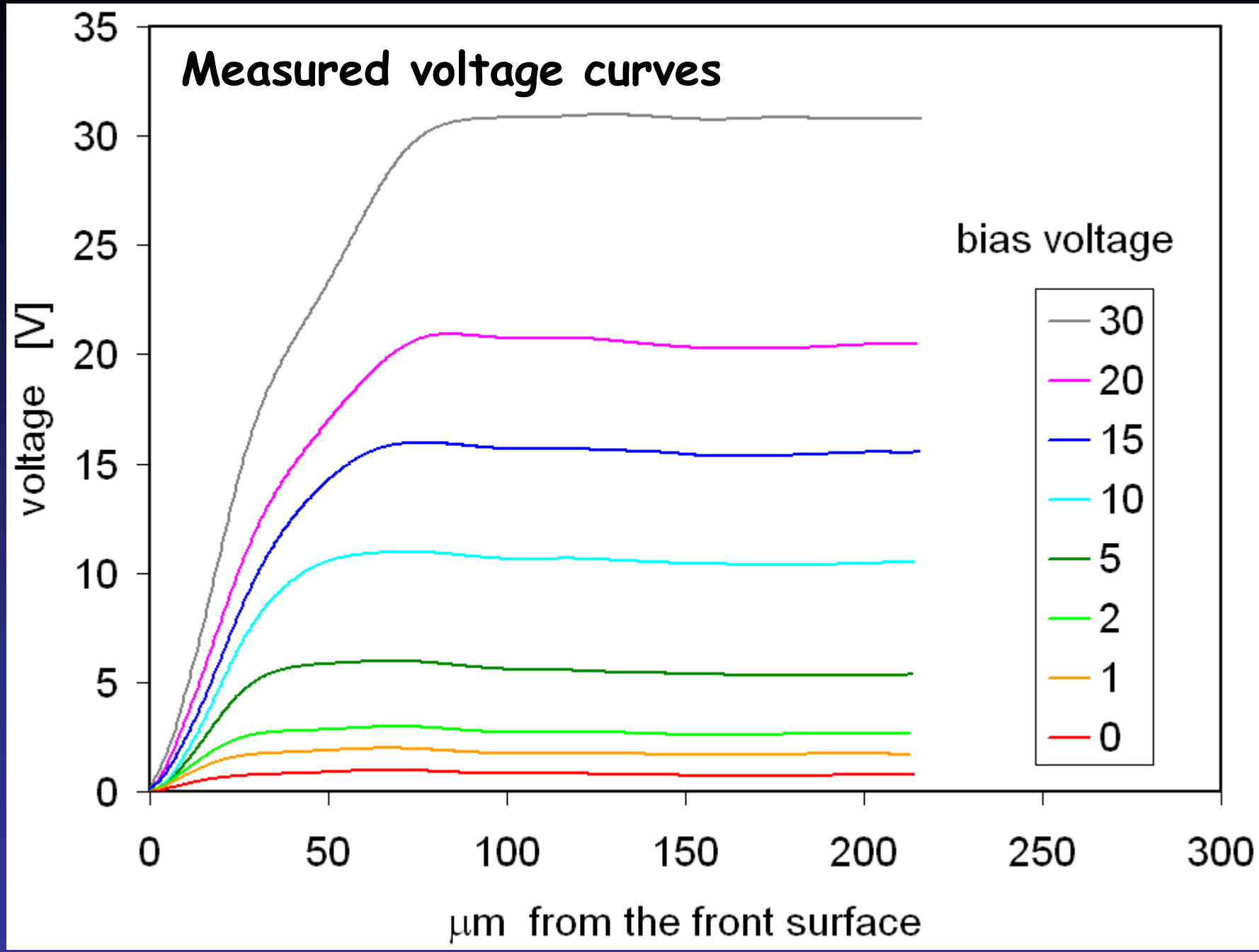

RAW DATA
bias voltage:
0
1
2
5
10
15
20
30
surface peak
contrast
point number
4000
3500
3000
2500
2000
1500
1000
500
0
0
100
200
300
400
500
600
700
800

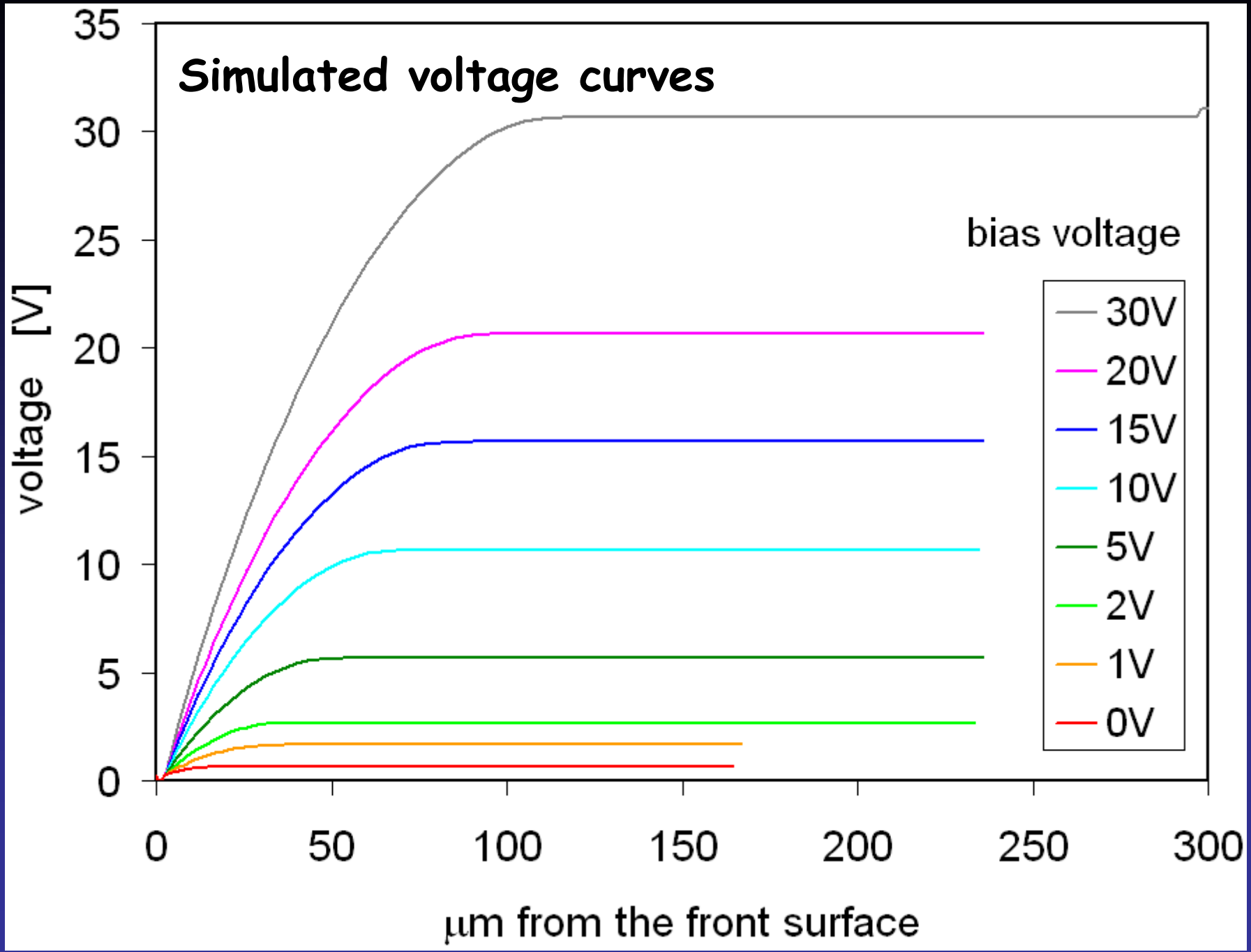

surface removed
bias voltage
0
1
2
5
10
15
20
30
contrast
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
0
50
100
150
200
250
300
μm from the front surface

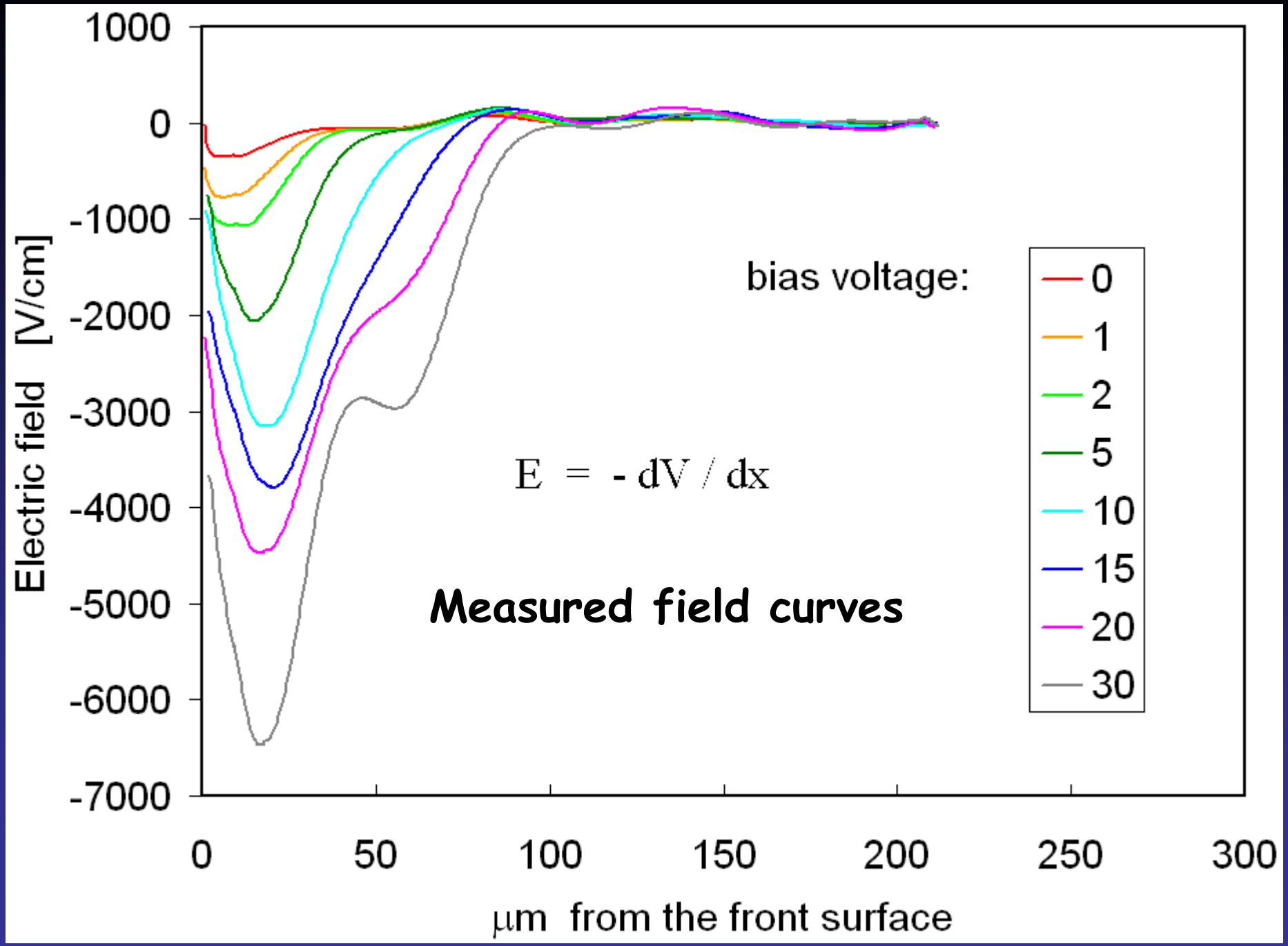

Total contrast
as a function of total voltage
Measured
Calculated
$C = -K\,(1 - e^{-V/M})$
total contrast
total voltage [V]
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
0
10
20
30
40
50
60
70
80
90
100

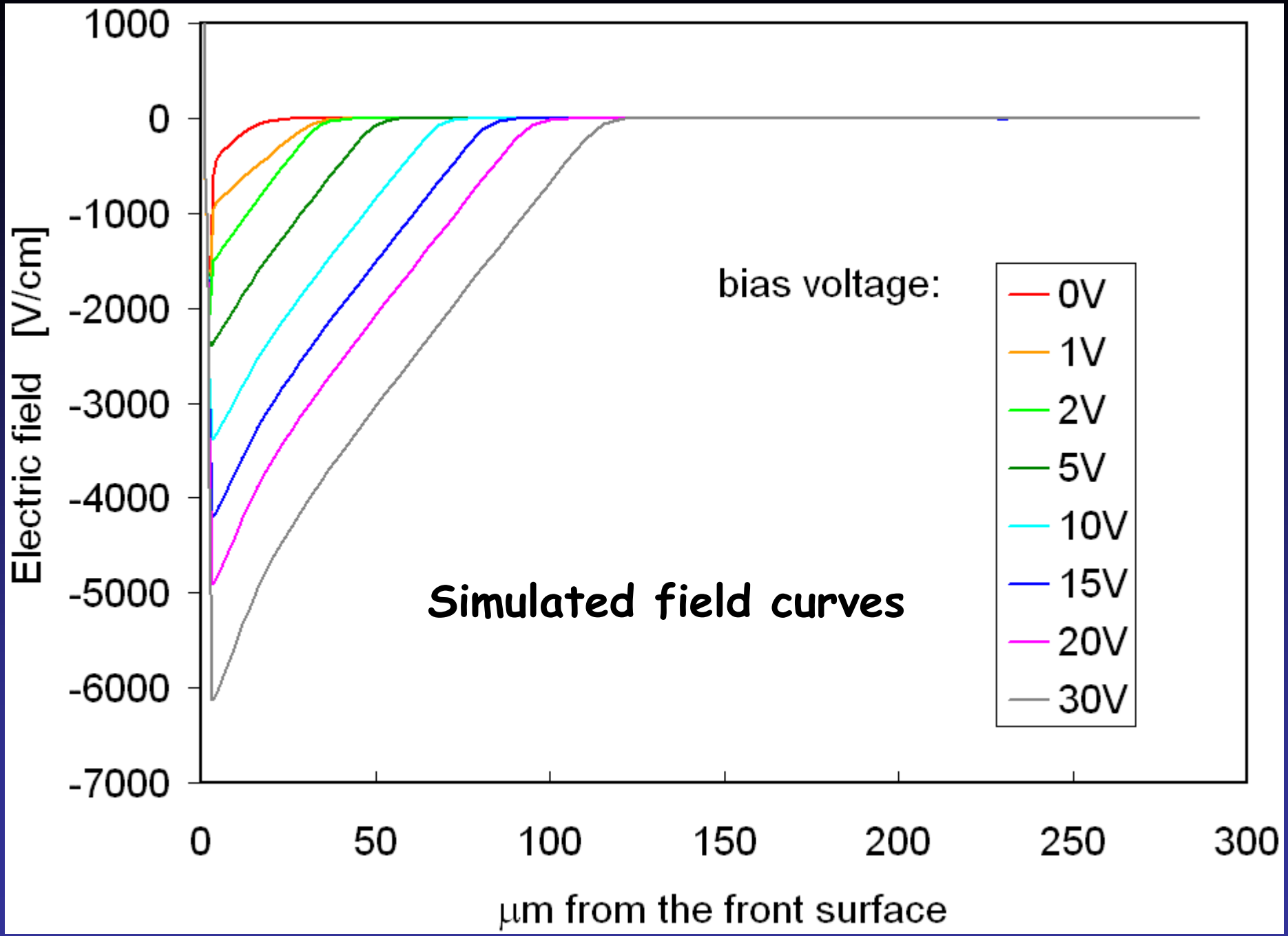

$K_{new} = - C_{max} / (1 - e^{-V_{max} / M_{new}})$
$M_{new} = 2 M$
$V = - M \ln (1 + C / K)$
20V
lin
exp2
exp1
Simulated or calculated voltage [V]
Measured contrast
25
20
15
10
5
0
-1000
-800
-600
-400
-200
0


$K_{new} = -C_{max} / (1 - e^{-V_{max} / M_{new}})$
$M_{new} = 2\,M$
$V = -M \ln (1 + C / K)$
100V
lin
exp2
exp1
Simulated or calculated voltage [V]
Measured contrast
120
100
80
60
40
20
0
-500
-400
-300
-200
-100
0

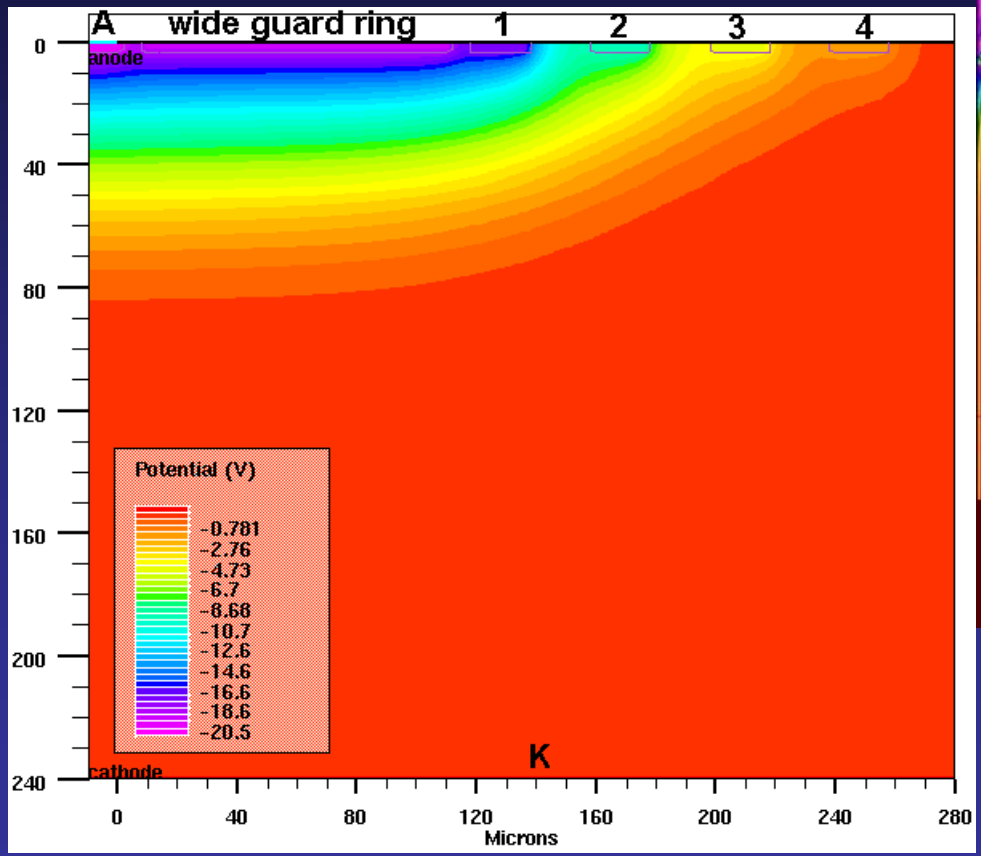

Measured voltage curves
voltage [V]
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
μm from the front surface
bias voltage
30
20
15
10
5
2
1
0


Simulated voltage curves
voltage [V]
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
μm from the front surface
bias voltage
30V
20V
15V
10V
5V
2V
1V
0V

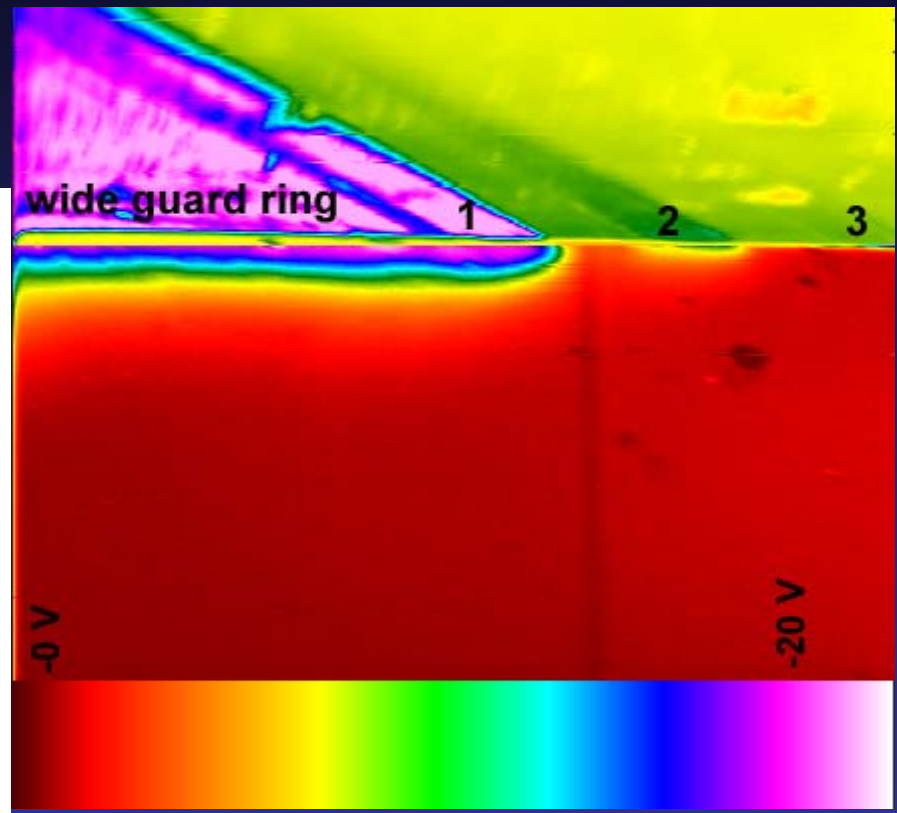

1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
Electric field [V/cm]
0
50
100
150
200
250
300
μm from the front surface
bias voltage:
0
1
2
5
10
15
20
30
E = - dV / dx
Measured field curves


1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
Electric field [V/cm]
0
50
100
150
200
250
300
μm from the front surface
bias voltage:
0V
1V
2V
5V
10V
15V
20V
30V
Simulated field curves

simulated with Silvaco



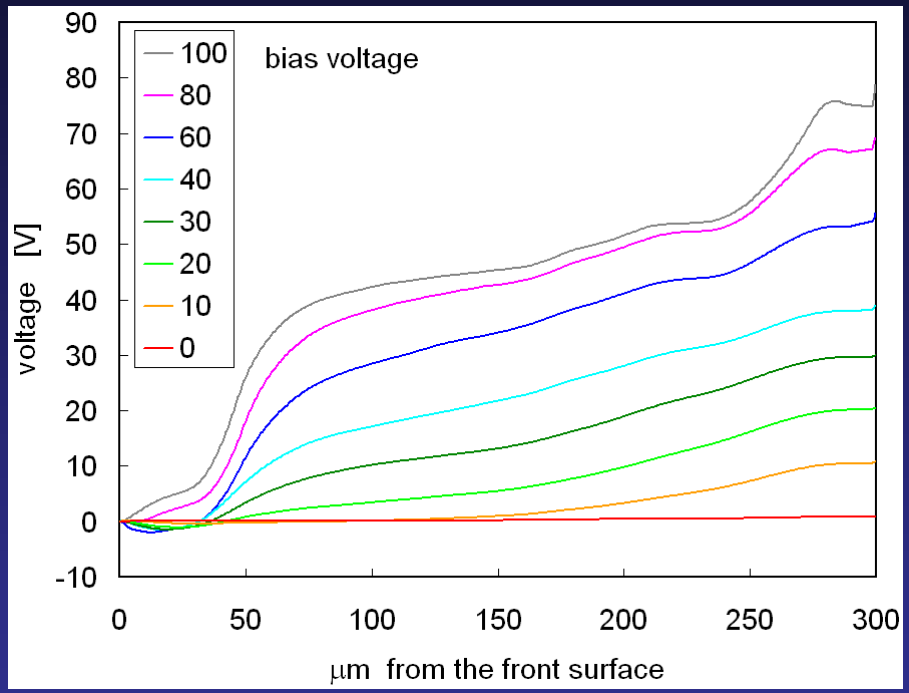
imaged with SEM

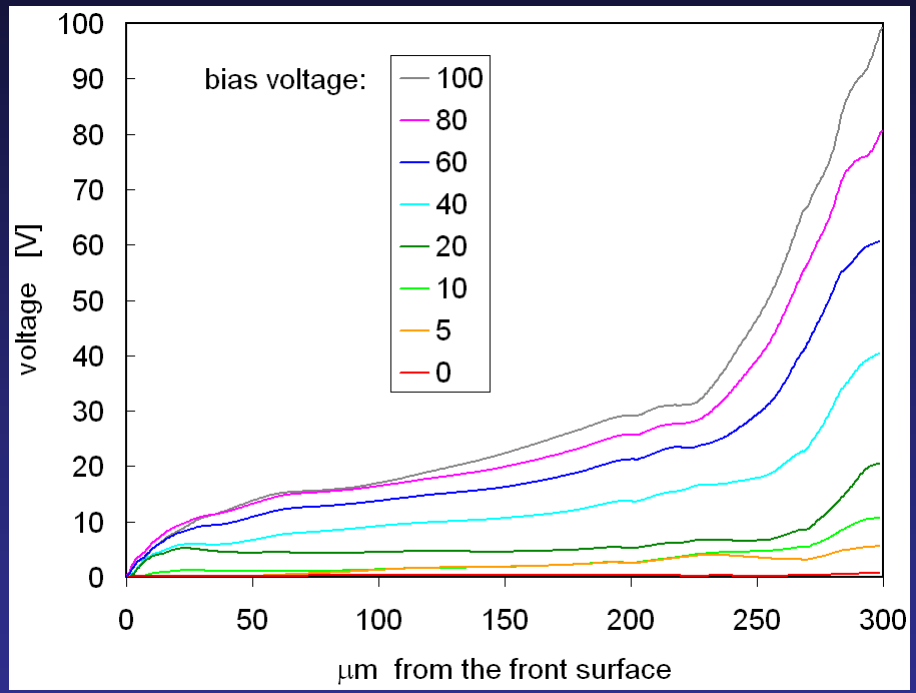


4.7.2005

11:50

FZ samples irradiated with 10 MeV protons

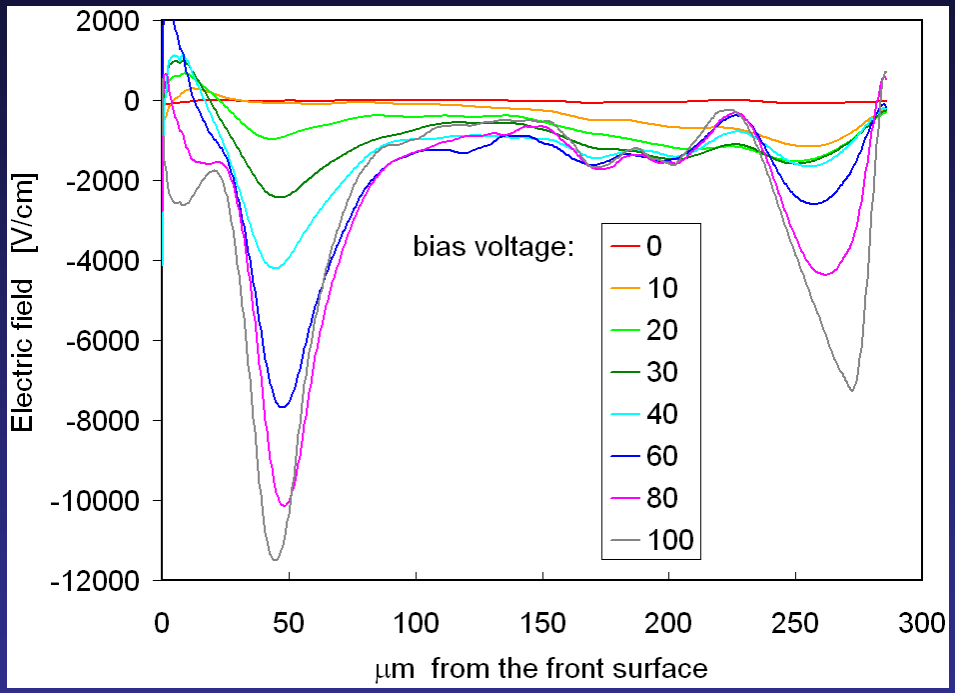


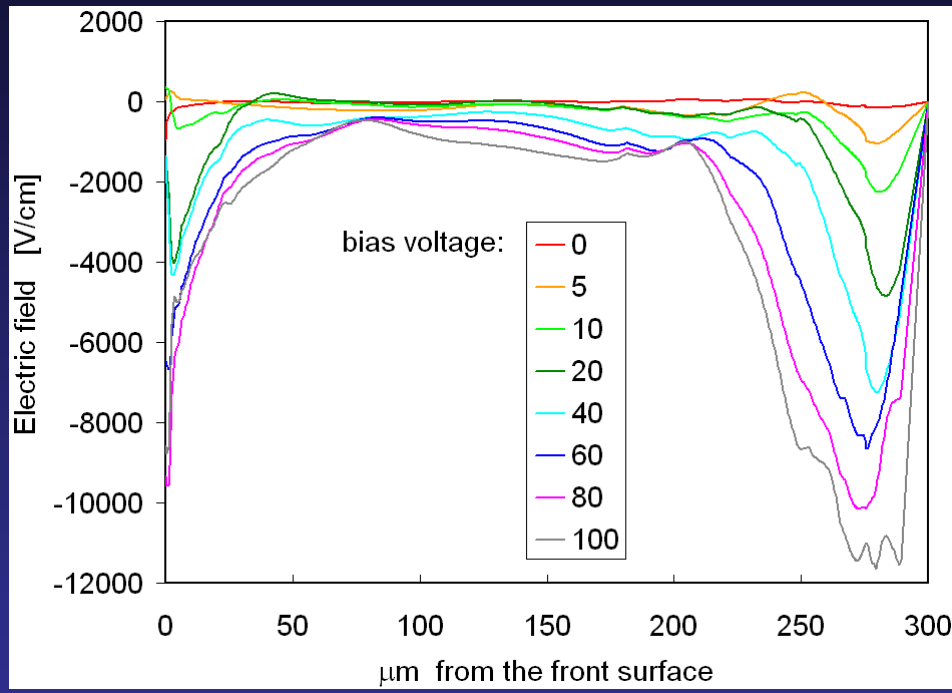


1 MeV neutron equivalent fluence of 1.09E14 /cm2 .

1 MeV neutron equivalent fluence of 6.45E14 /cm2 .

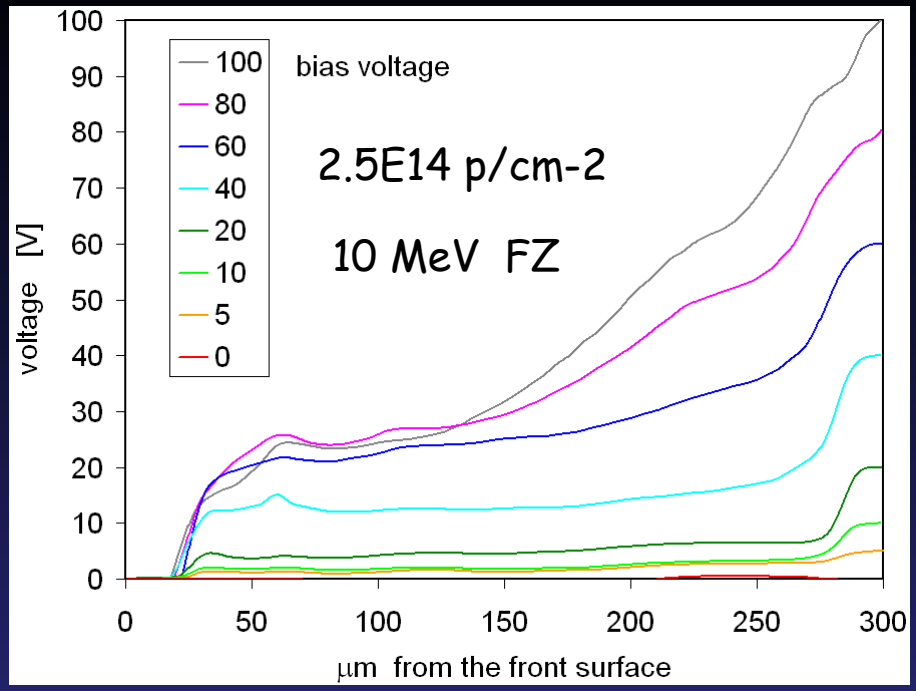
FZ samples irradiated with 10 MeV protons

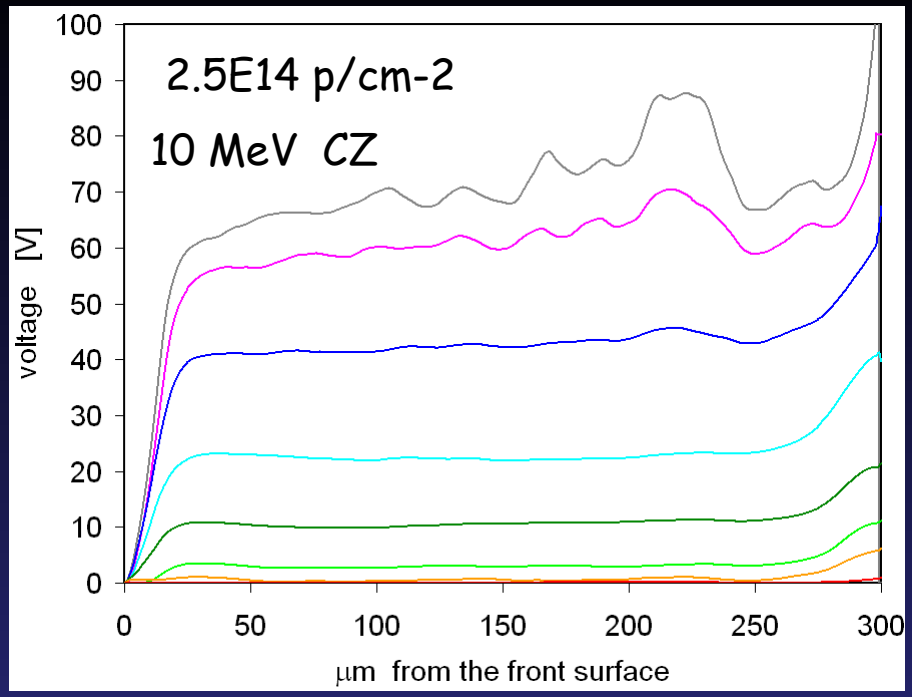


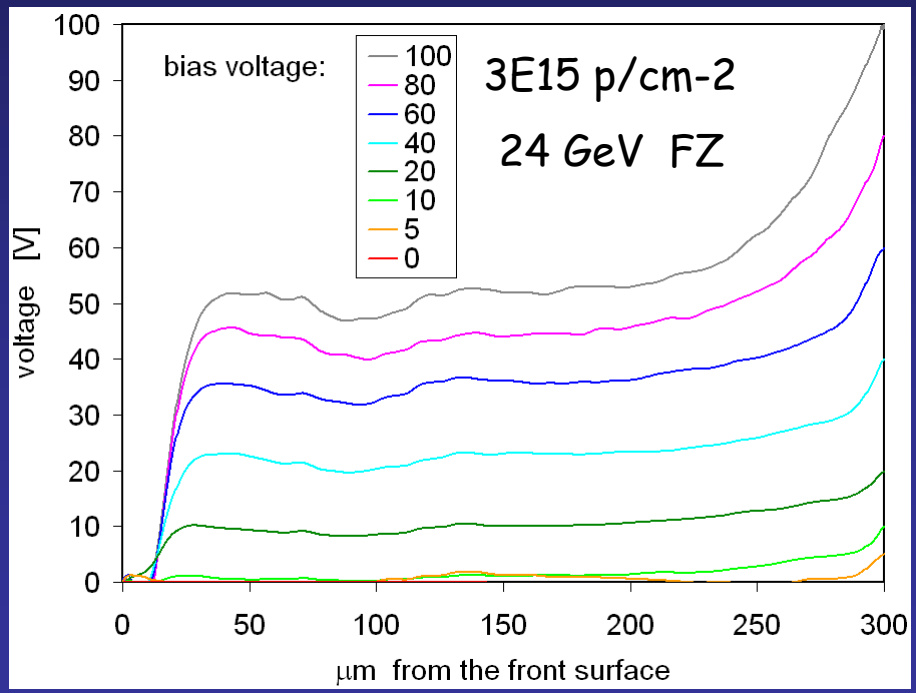


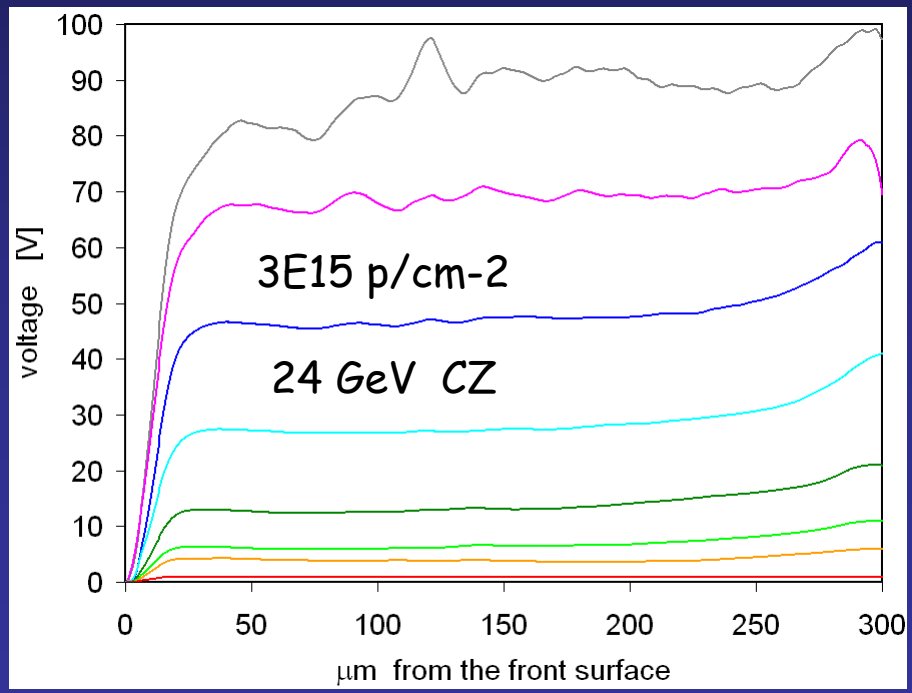
1 MeV neutron equivalent fluence of 1.09E14 /cm2 .

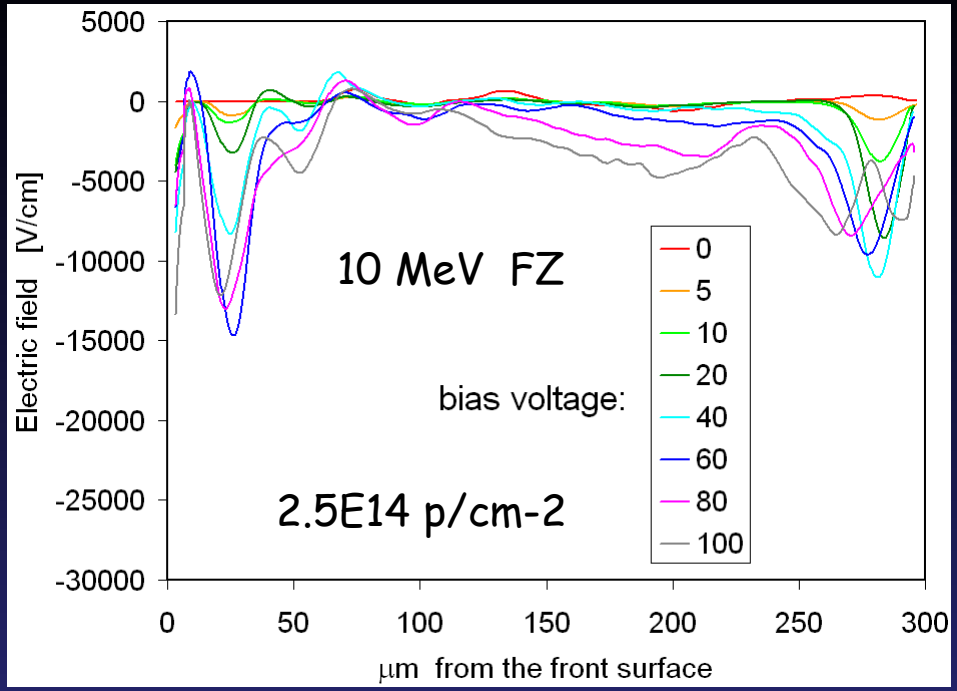
1 MeV neutron equivalent fluence of 6.45E14 /cm2 .

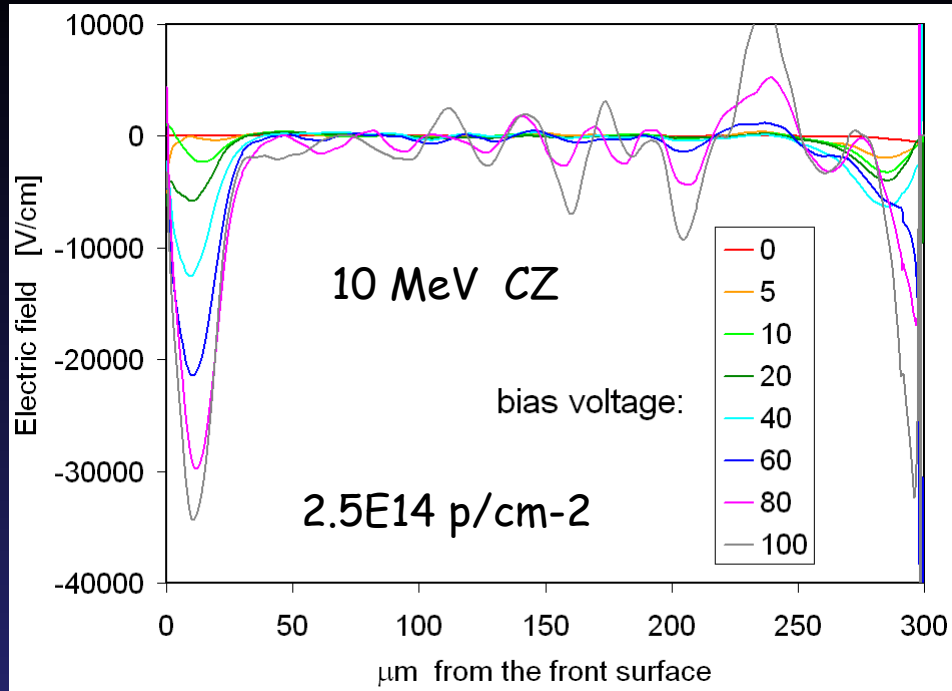

bias voltage
100
80
60
40
20
10
5
0
2.5E14 p/cm-2
10 MeV FZ
voltage [V]
μm from the front surface

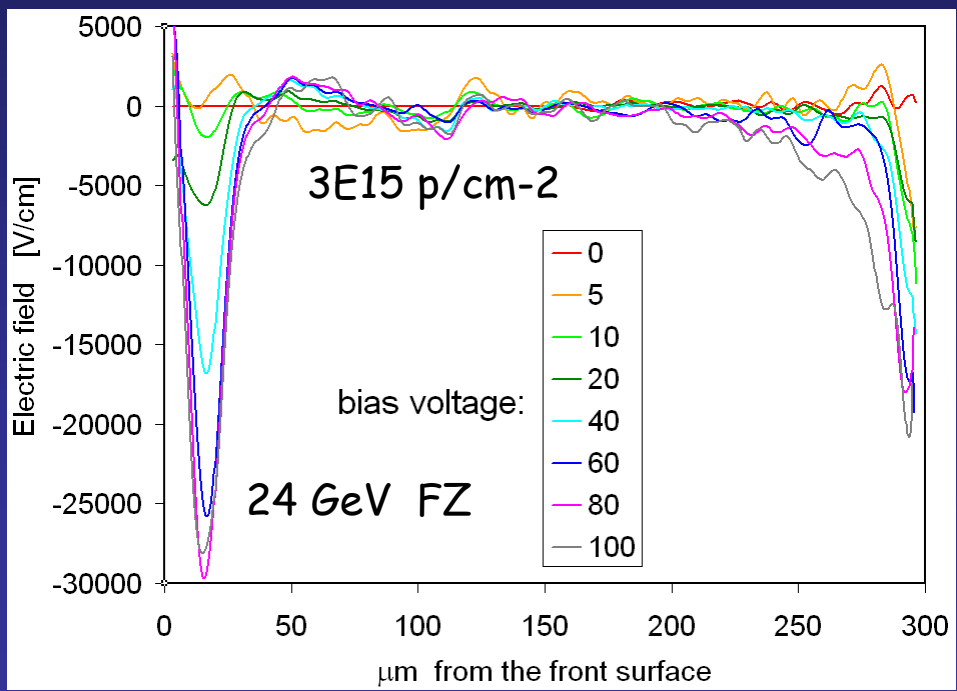

2.5E14 p/cm-2
10 MeV CZ
voltage [V]
μm from the front surface

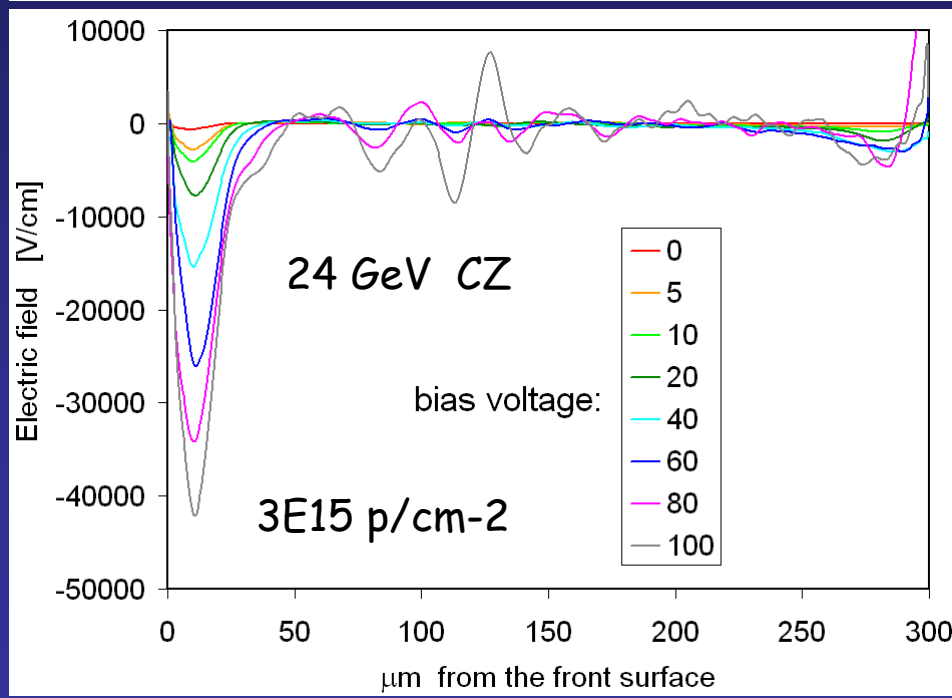

bias voltage:
100
80
60
40
20
10
5
0
3E15 p/cm-2
24 GeV FZ
voltage [V]
μm from the front surface

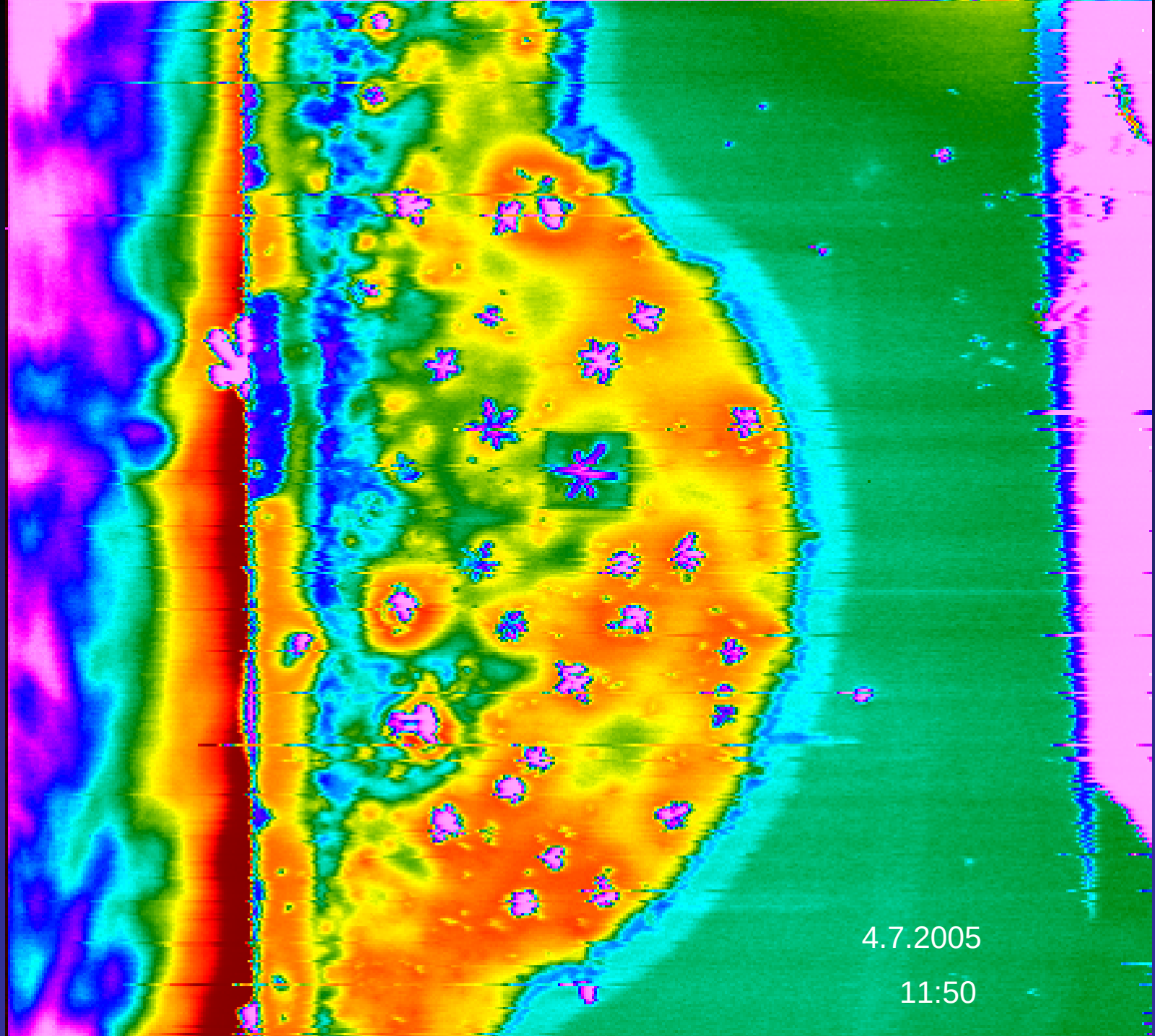

3E15 p/cm-2
24 GeV CZ
voltage [V]
μm from the front surface


10 MeV FZ
2.5E14 p/cm-2
bias voltage:
0
5
10
20
40
60
80
100
Electric field [V/cm]
μm from the front surface

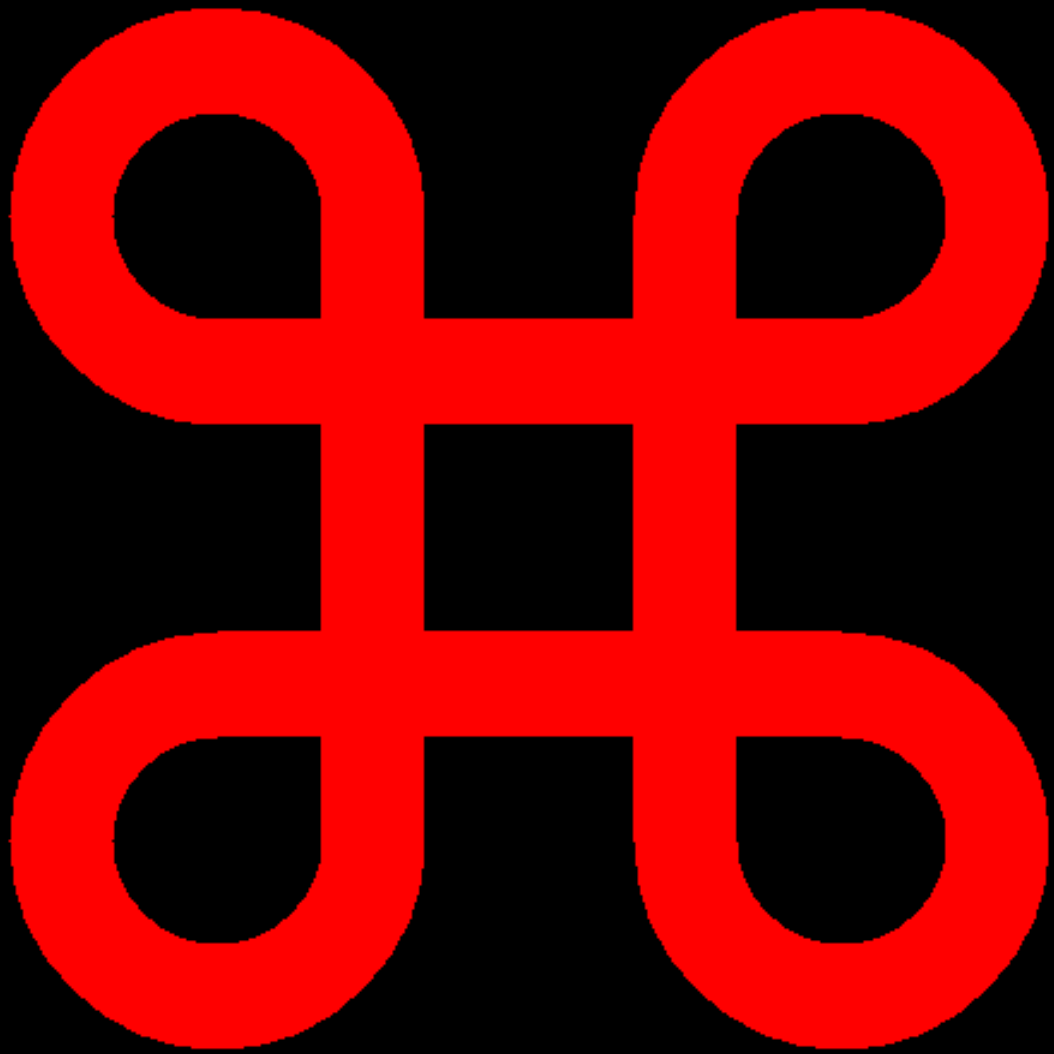

10 MeV CZ
2.5E14 p/cm-2
bias voltage:
0
5
10
20
40
60
80
100
Electric field [V/cm]
μm from the front surface


3E15 p/cm-2
24 GeV FZ
bias voltage:
0
5
10
20
40
60
80
100
Electric field [V/cm]
μm from the front surface


24 GeV CZ
3E15 p/cm-2
bias voltage:
0
5
10
20
40
60
80
100
Electric field [V/cm]
μm from the front surface


4.7.2005
11:50

The end



4.7.2005

11:50

EXPERTISE IN TECHNOLOGY AND ECONOMICS

LAPPEENRANTA
UNIVERSITY OF TECHNOLOGY

P.O. Box 20, FIN-53851 Lappeenranta, FINLAND | Skinnarilankatu 34, 53850 Lappeenranta, FINLAND
Tel. +358 5 62 111 **Fax** +358 5 621 2350

www.lut.fi