

Discussions on New detector Structures

1. 3d Detectors

Thick “thin” detectors: separation of thickness from drift distance; complicated processing

- a) **Glasgow --- detectors made and initial results obtained**
- b) **Trento ---**

2. Thin Detectors

Real thin detectors: low V_{fd} , higher CCE (relative), less effective sensitive volume

- a) **Epi-CZ detectors**
- b) **FZ detectors**
- c) **Simulations**

3. Semi-3d Detectors

Possible to reduce by a factor of 3-4, complicated E-field distribution

US RD50:BNL, FNAL, Purdue, Rutgers, Syracuse, UCSC, UNM

--- first prototype detectors fabricated at BNL

Preliminary test results on as-processed and g- and p-irradiated detectors obtained

Current Status of Semi-3d Project

Z. Li

On behalf of US RD50

BNL, FNAL, Purdue, Rutgers, Syracuse, UCSC, UNM

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OUTLINE

- **Design Details**

- **Results**

I-V, C-V and TCT for as processed detectors

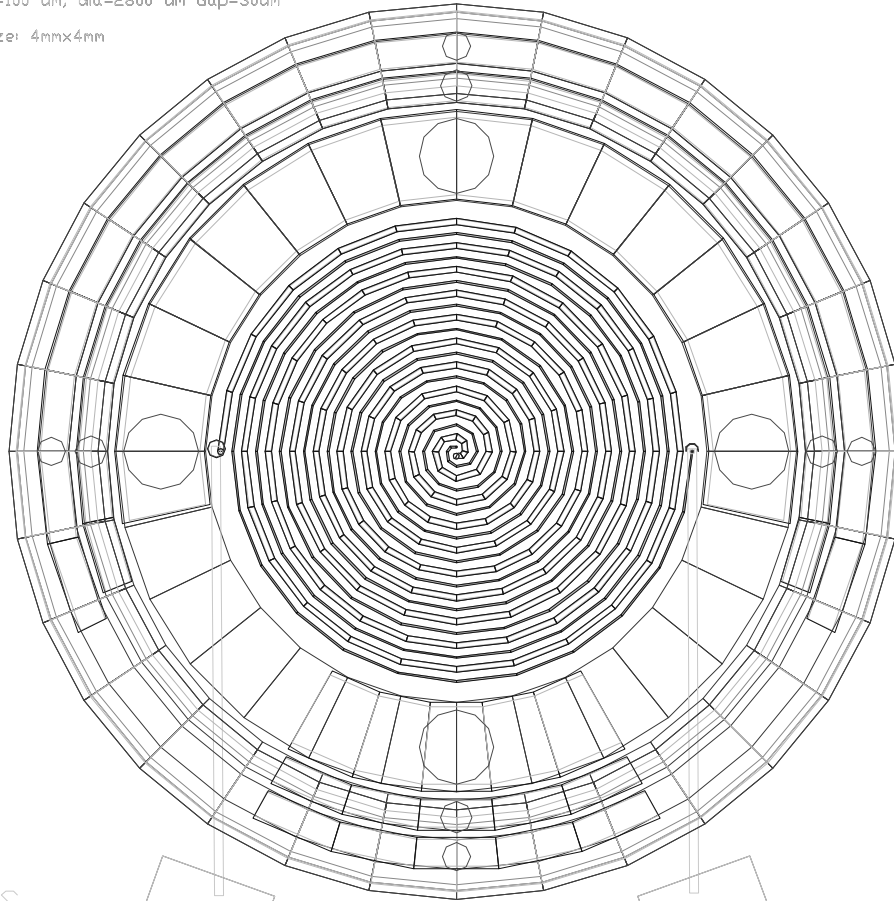
I-V, C-V and TCT for detectors after gamma irradiation beyond SCSI

- **Summary**

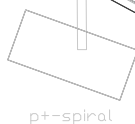
Test structure

1600 dia spiral test diode, 20 um lines
40 um gap to GR
GR1: W=300 um, dia=2280 um
GR2: W=100 um, dia 2540 um
GR3: W=100 um, dia=2800 um Gap=30um
Chip size: 4mmx4mm

gniz +n



No GS



p+-spiral



n+-spiral

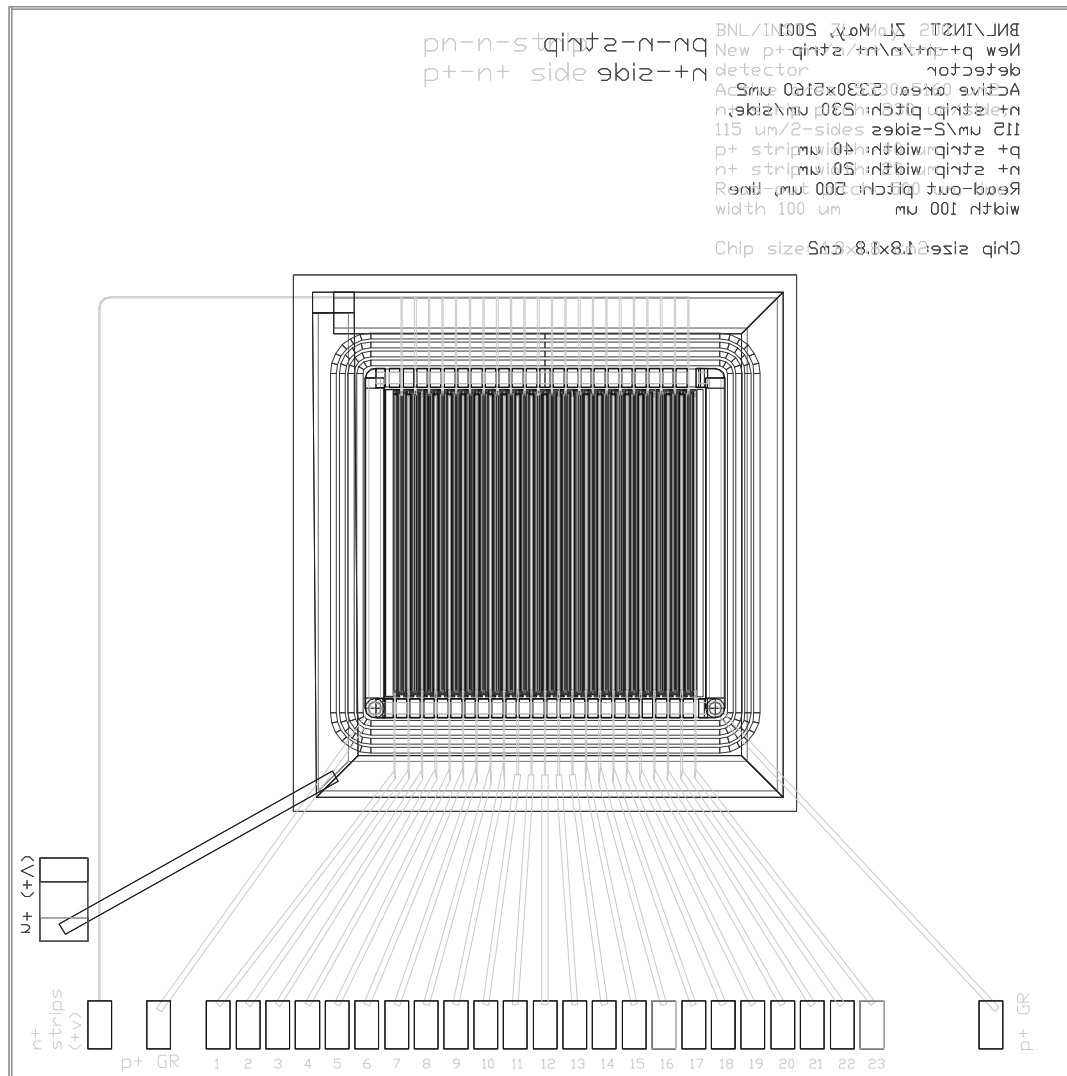
pn-n-Spiral-testdiode-1600umdia-20umline

p-n/n/n Stripixel Detector
X-Y spiral diode
Sensitive area: 790 dia
Maximum line length: 12.3 mm
spiral, 1.15 mm line
ZL/INST/BNL 5/01

**3 electrodes on
the front :
p-spiral
n-spiral
GR**

**1 electrode on
The back:
n-contact**

Strip detector structure



**25 electrodes on
the front :**

23 p-strips

1 for all n strips

GR

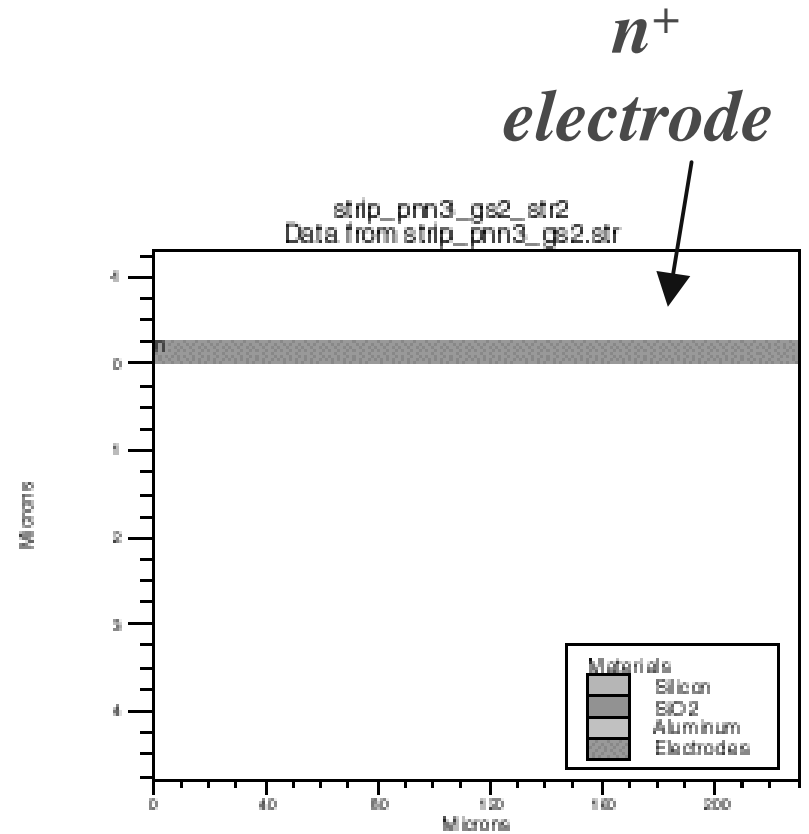
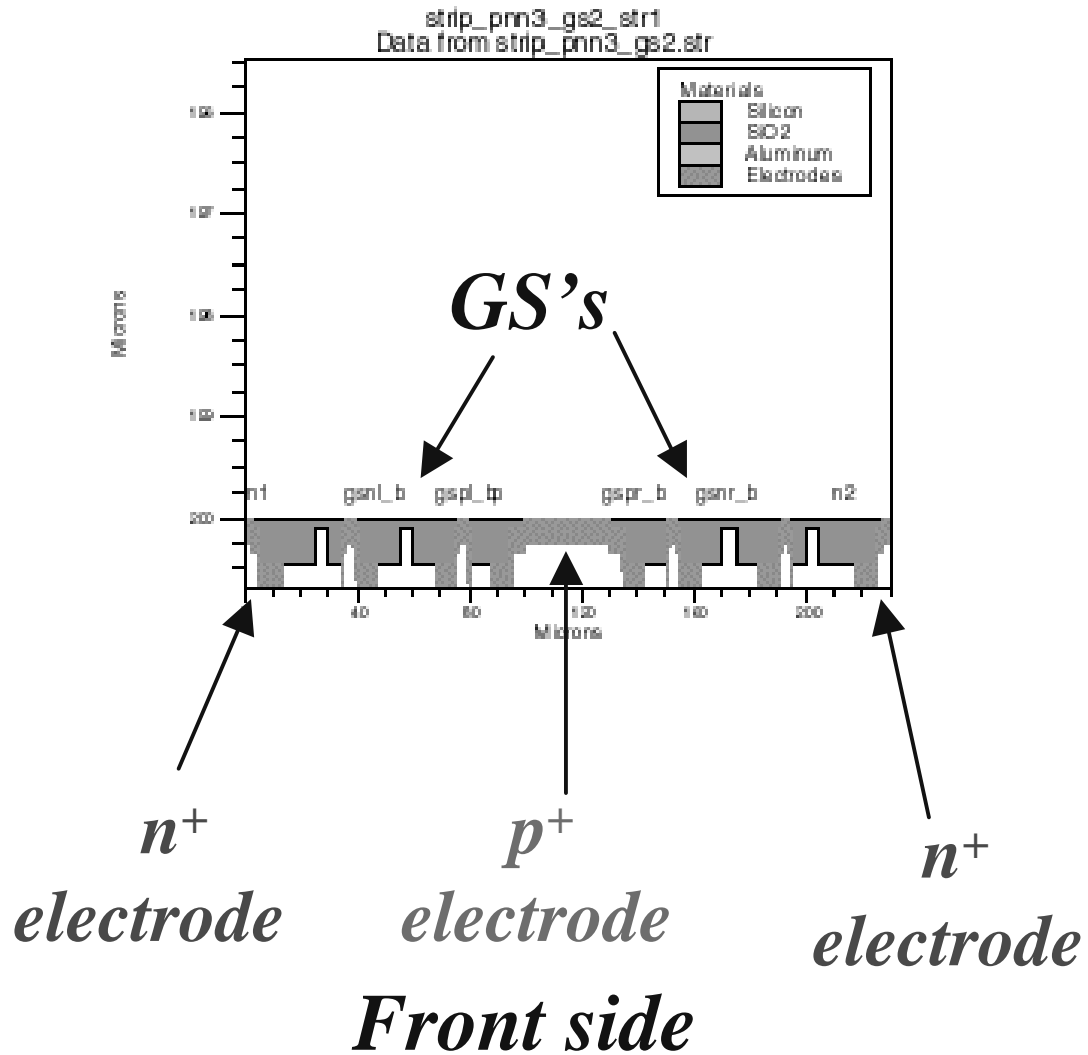
1 electrode on

The back:

n-contact

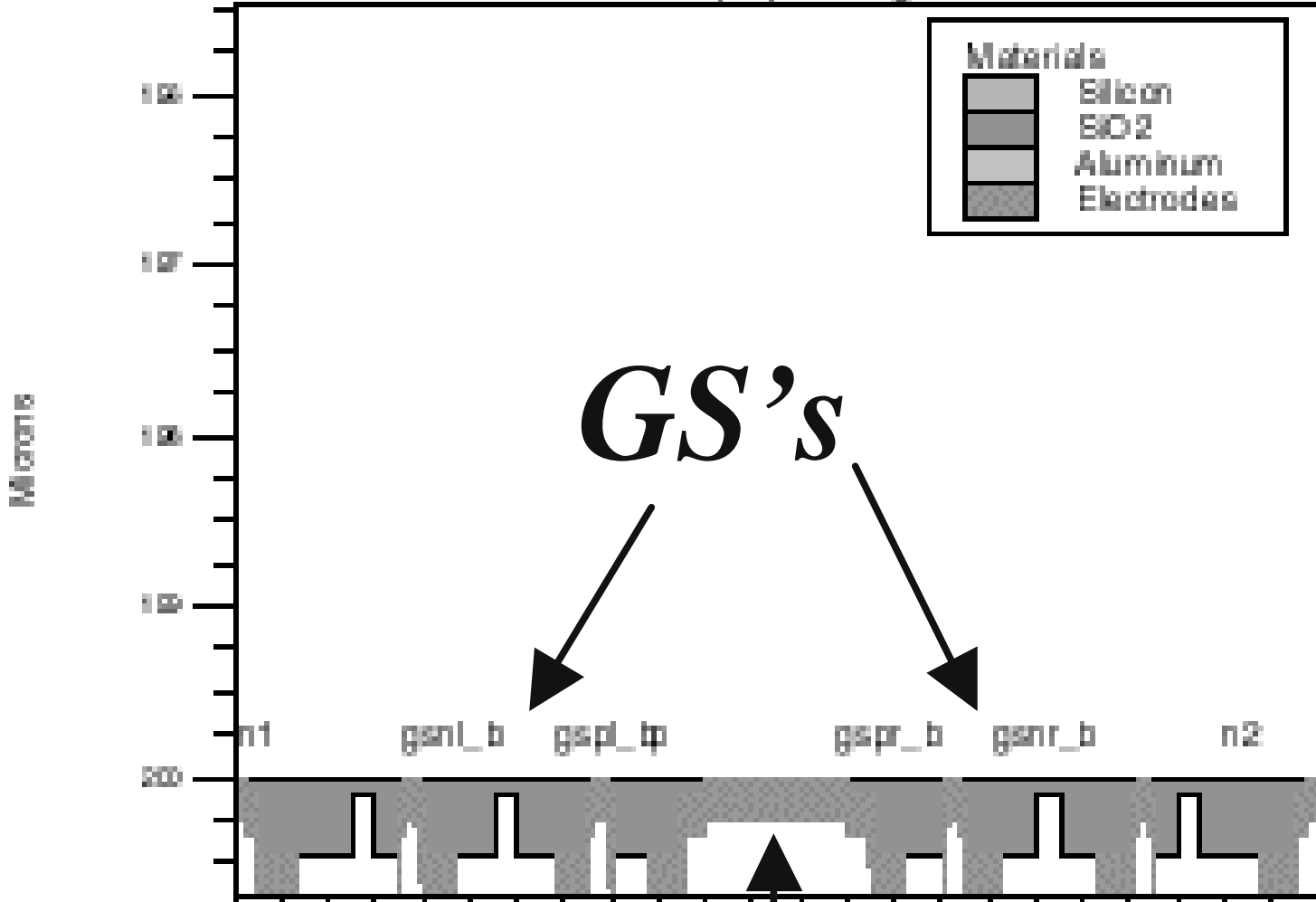
Layout of the detector structures

(Electrodes are strips on the front side)



Details of front side

strip_pnn3_gs2_str1
Data from strip_pnn3_gs2.str



n⁺ strip
10 mm width

p⁺ strip
40 mm width

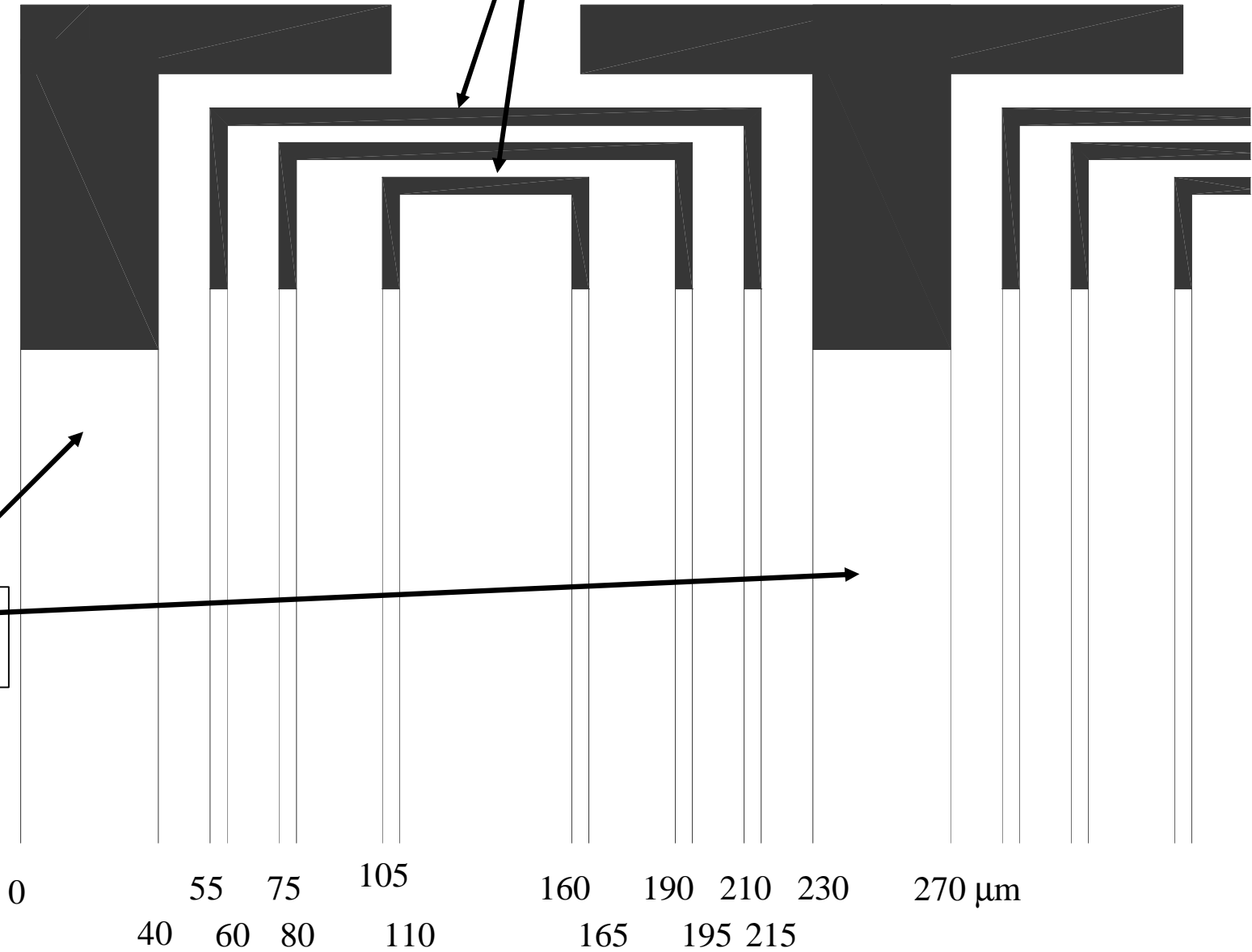
n⁺ strip
10 mm width

Step 1: p⁺ implant through 1000 Å SiO₂ (B, 40 keV, 4x10¹⁴/cm²)

p⁺ ch stoppers
5 μm width

p⁺ strips
40 μm width

Absolute
coordinates



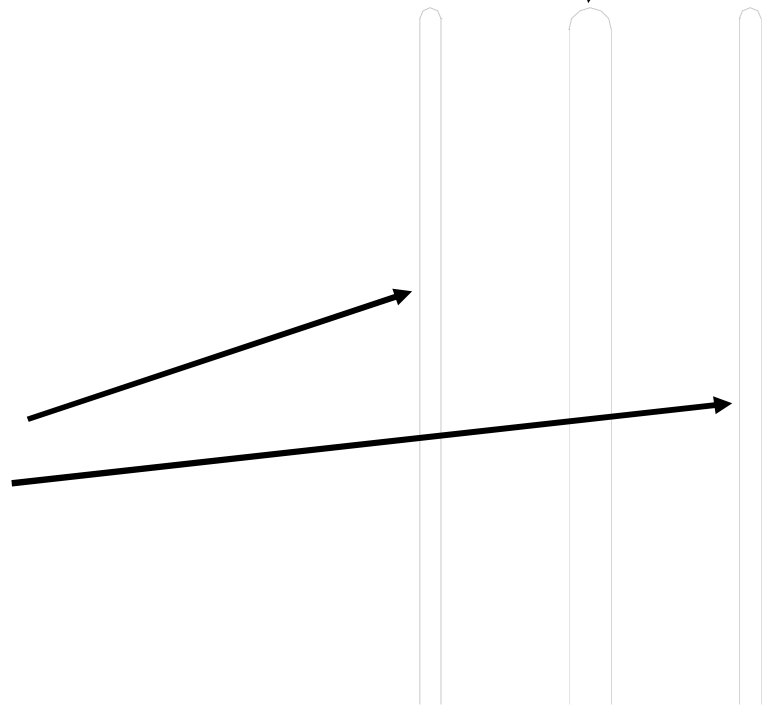
**Step 2: n⁺ implant through 1000 Å SiO₂ for guard strips
(Ph, 60 keV, 1x10¹⁴/cm², and 90 keV, 1x10¹⁴/cm²)**

(note: during this implant, the p⁺ implanted regions are covered by 3000 Å of Al)

n⁺ strip
10 μm width



n⁺ guard
strips
5 μm width



Absolute
coordinates

0 95 130 170
 100 140 175 μm

Step 3: Oxide step cut to bare Si

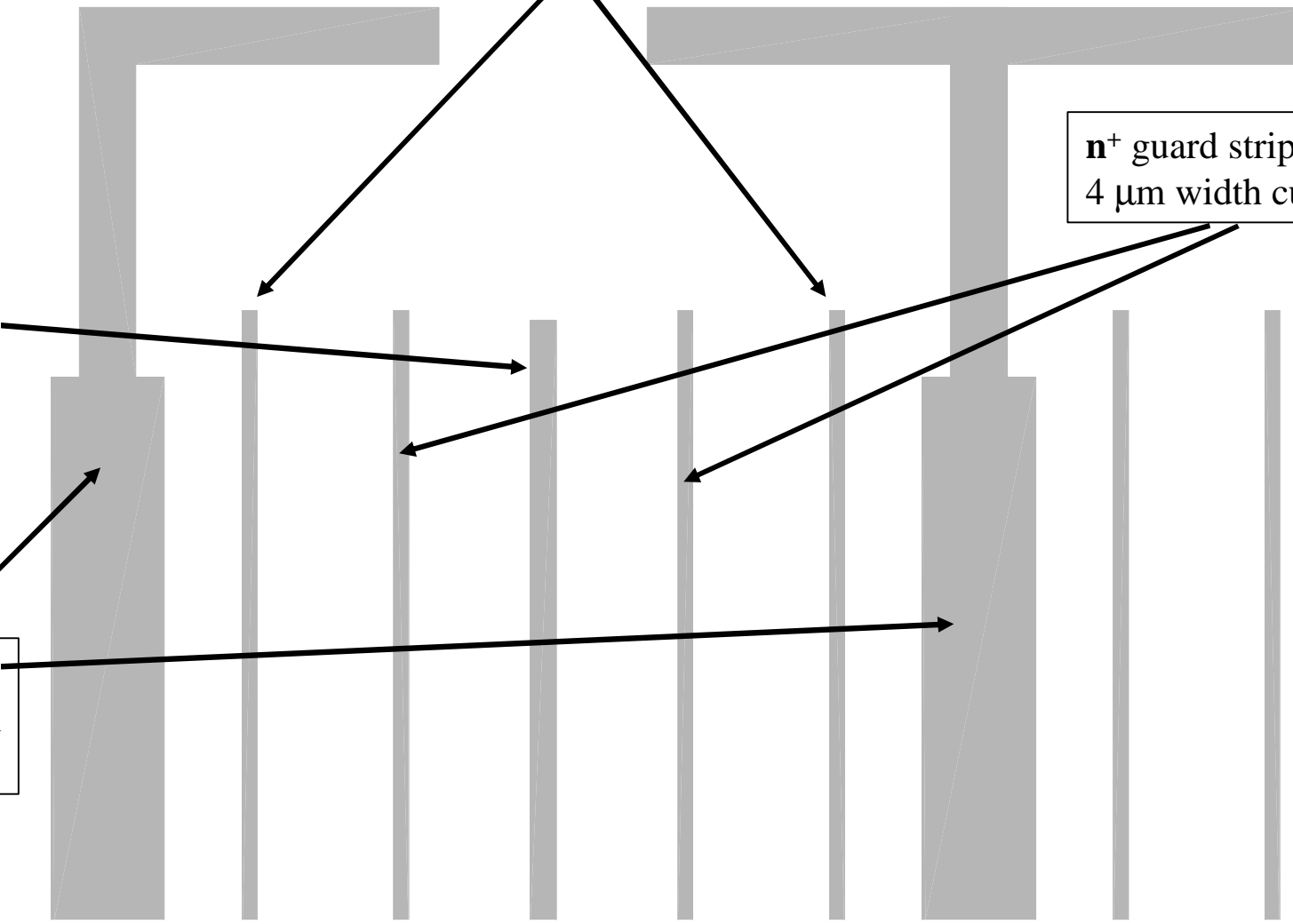
p⁺ ch stoppers
4 μm width cut

n⁺ guard strips
4 μm width cut

n⁺ strip
7 μm width cut

p⁺ strips
30 μm width cut

Absolute coordinates



0 35 55.5 95.5 131.5 170.5 210.5 235 265 μm
5 59.5 99.5 138.5 174.5 214.5

Step 4: 1st metal (Al, 2500 Å)

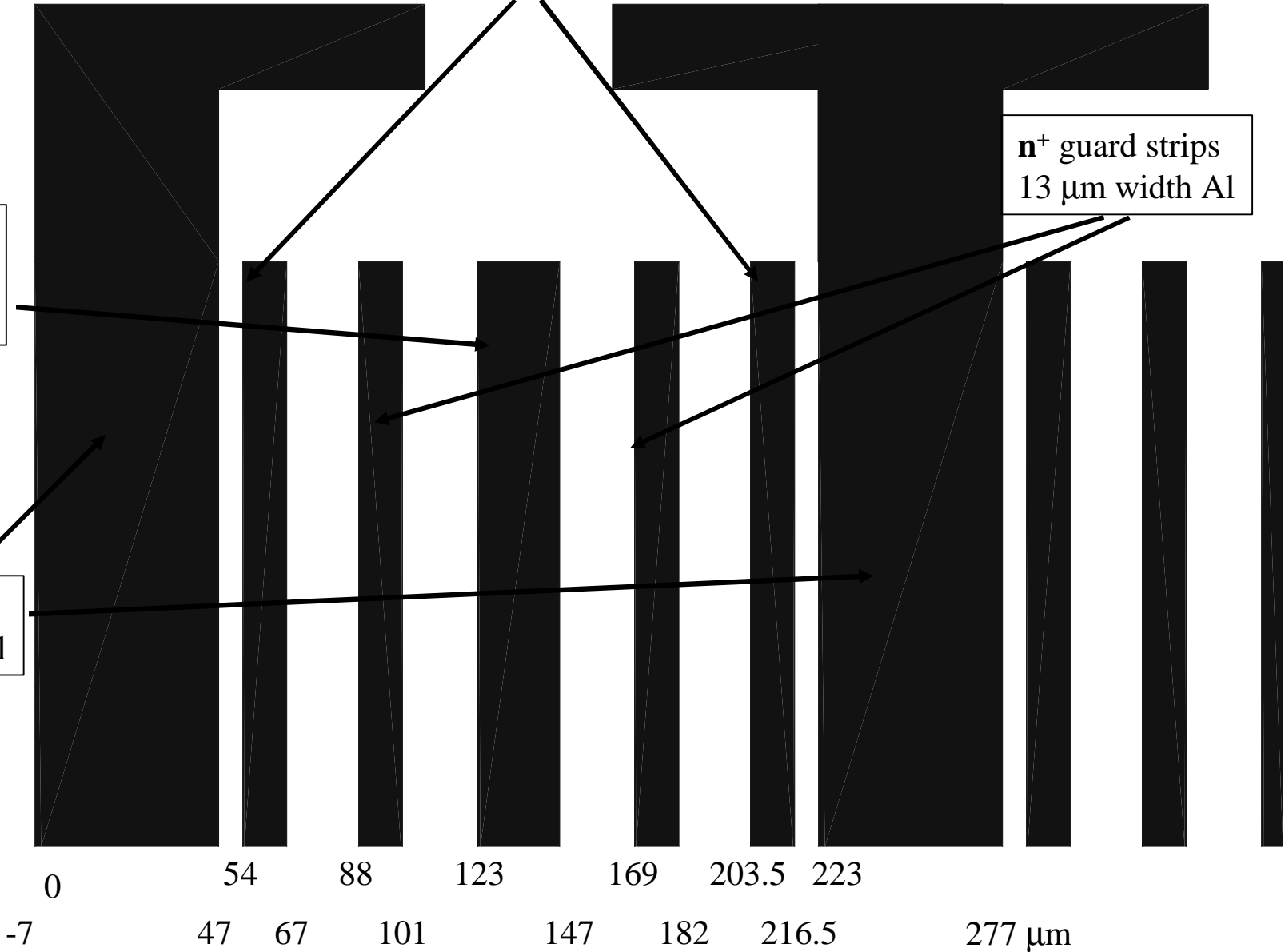
p⁺ ch stoppers
13 μm width Al

n⁺ guard strips
13 μm width Al

n⁺ strip
24 μm width Al

p⁺ strips
54 μm width Al

Absolute coordinates



**Step 5: n⁺ implant on the back (uniform implantation) through 1000 Å SiO₂
(Ph, 60 keV, 1x10¹⁴/cm² and 90 keV, 1x10¹⁴/cm²)**

Step 6: Etch backside to bare Si

Step 7: Deposit Al on back side (2500 Å)

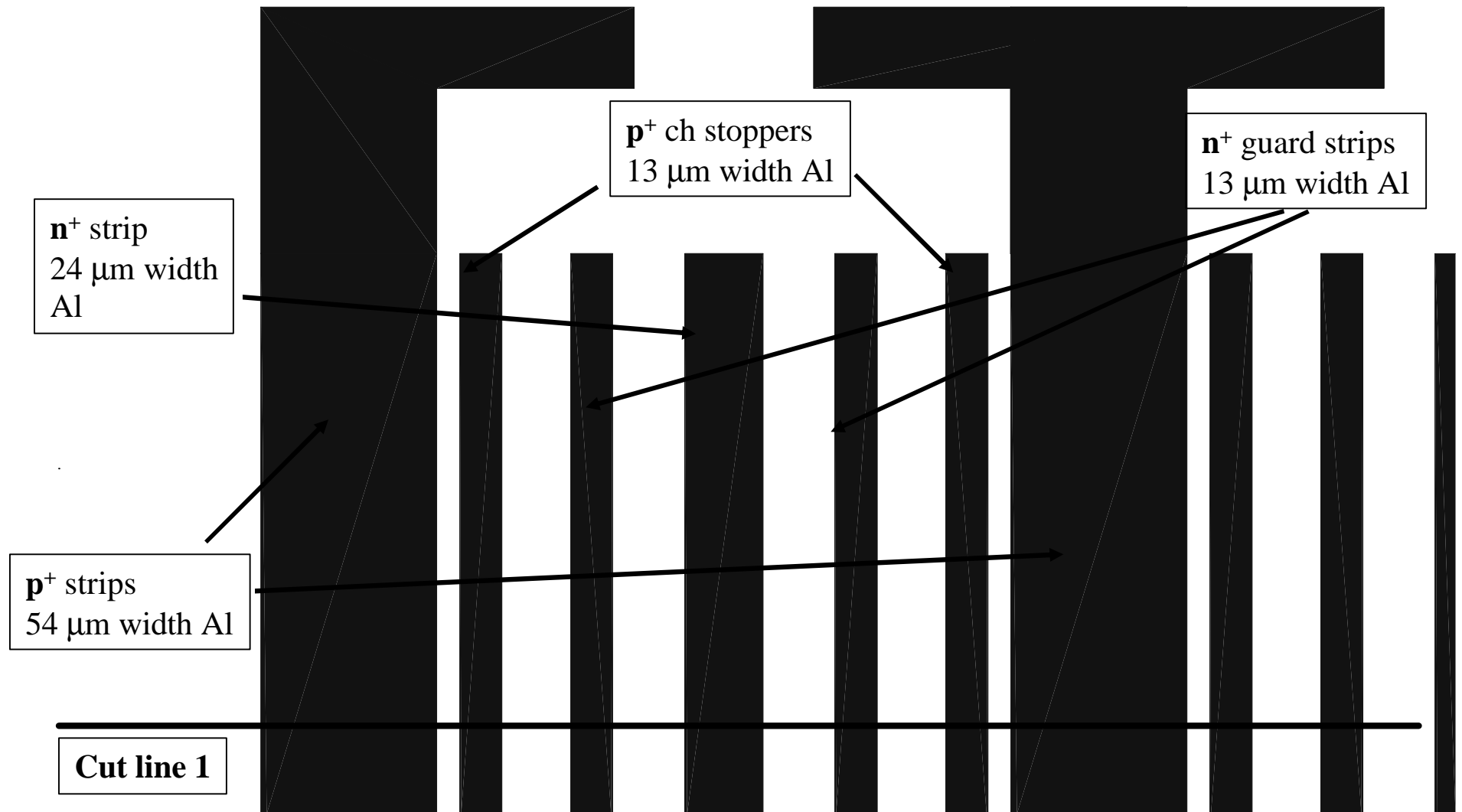
2d simulation along the cut line 1, and 200 μm thick wafer

n-type, $N_{\text{eff0}} = 1 \times 10^{13} / \text{cm}^3$ (before rad.), and p-type, $N_{\text{eff}} = - 1 \times 10^{13} / \text{cm}^3$ (after SCSI)

Biases: p⁺ strips: 0 V (Electrodes for CCE)

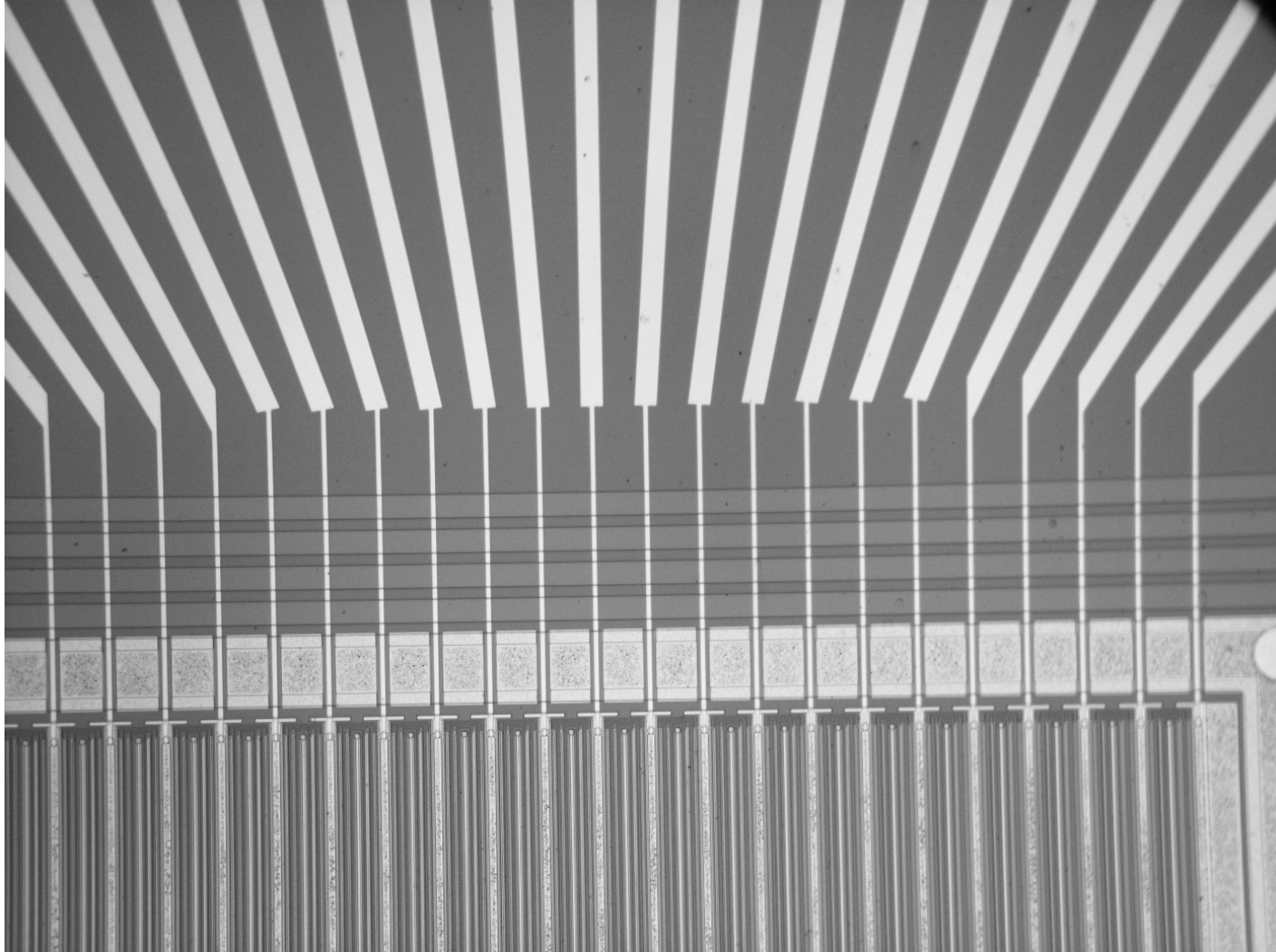
n⁺ strips and back plane: biased to the same + voltage (a few hundreds of volts)

All p⁺ guard strips and n⁺ ch-stoppers are floating



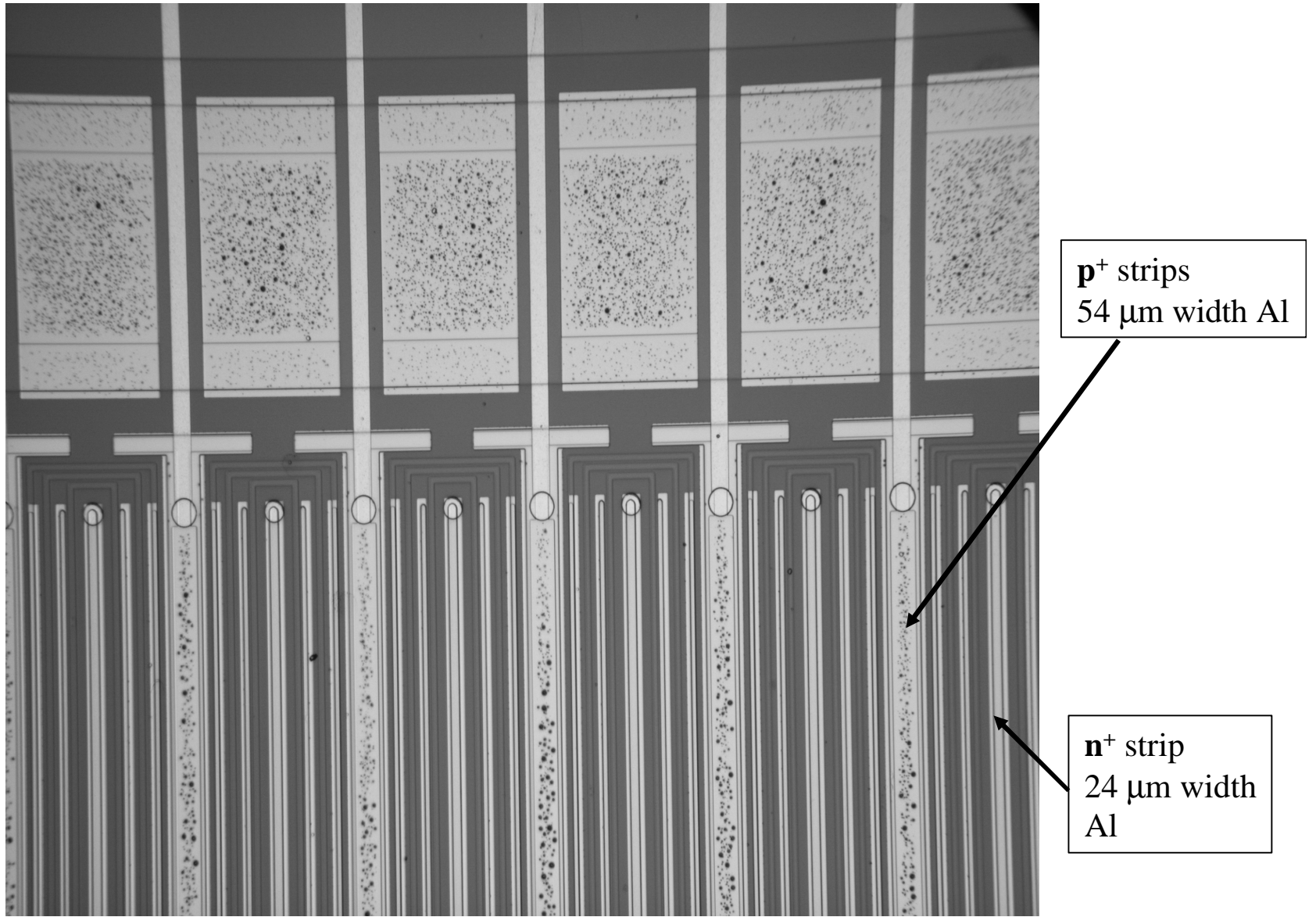
First prototype semi-3d detectors (1/04)

260 mm thick, n-type, 4k0 -cm

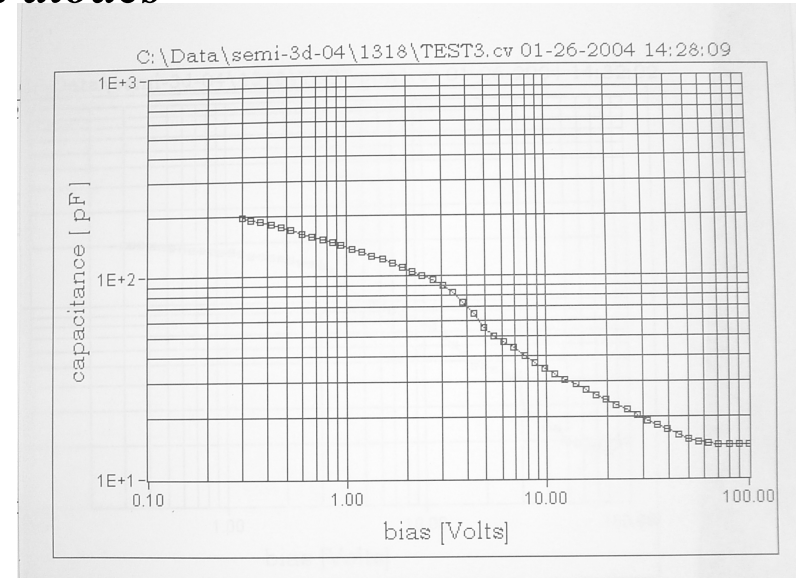
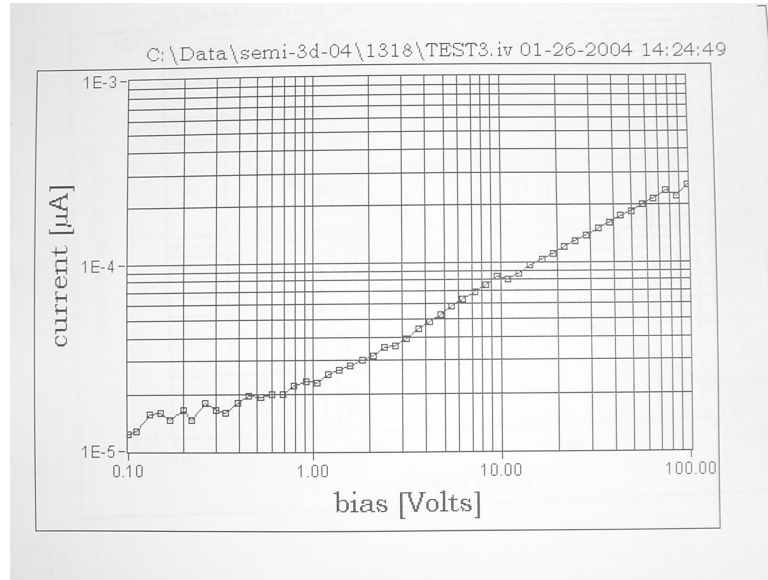


First prototype semi-3d detectors (1/04)

260 mm thick, n-type, 4k0 -cm

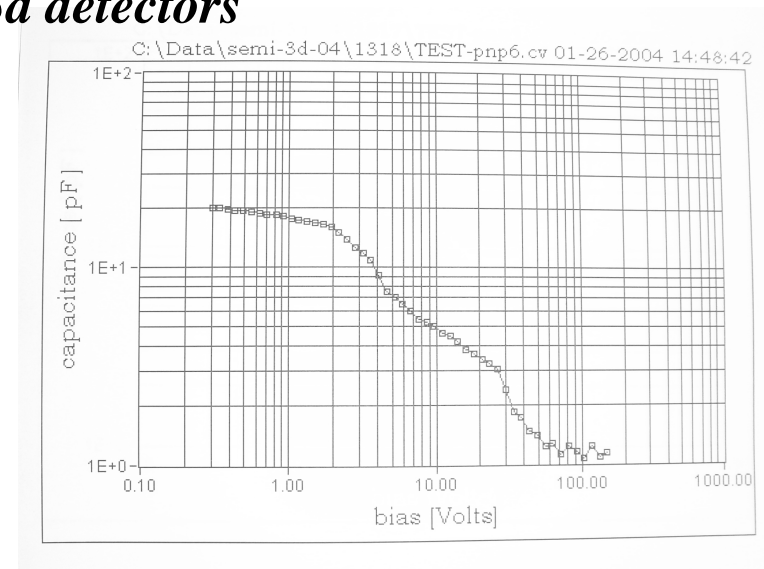
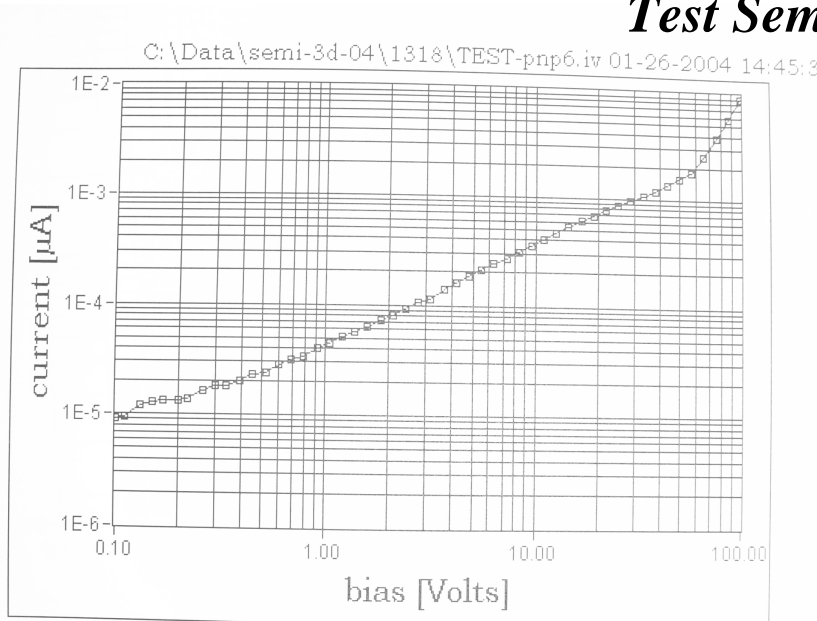


As-processed Test diodes



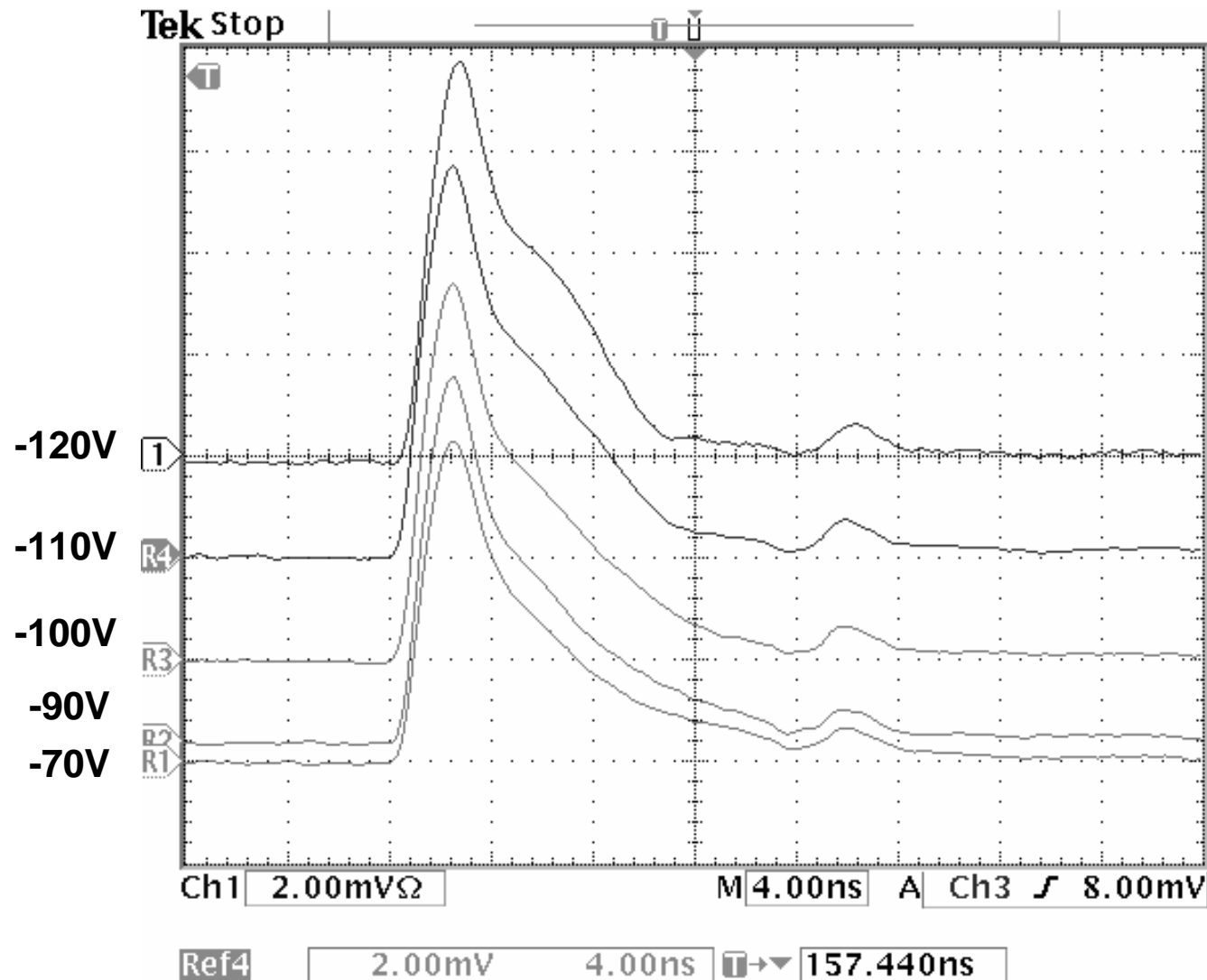
As-processed Test Semi-3d detectors

$V_{fd} = 60 \text{ V}$



TCT test of as-processed Semi-3d Detectors (Test structure)

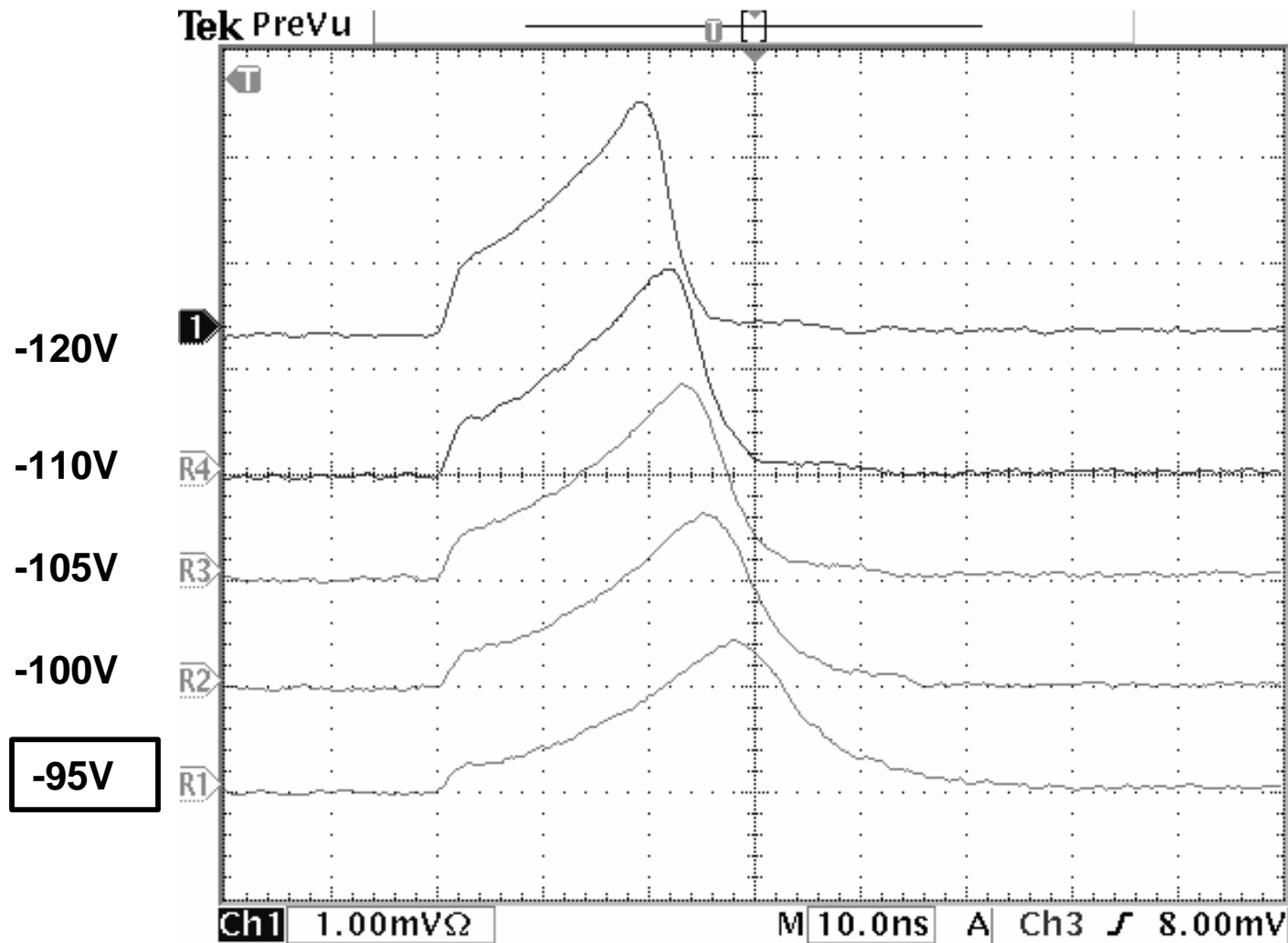
Laser front, -V on the front p^+ contact, front n^+ contact floating



10 Feb 2004
12:10:36

TCT test of as-processed Semi-3d Detectors (Test structure)

Laser back, $-V$ on the front p^+ contact, front n^+ contact floating

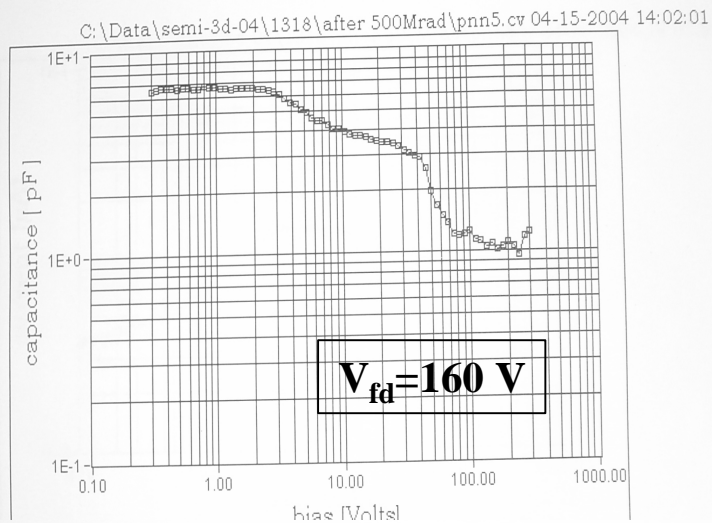


Ref4 1.00mV 10.0ns 176.200ns

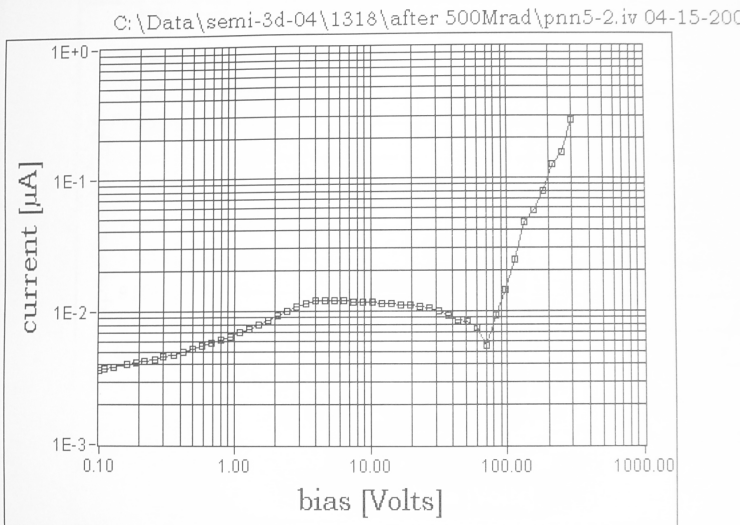
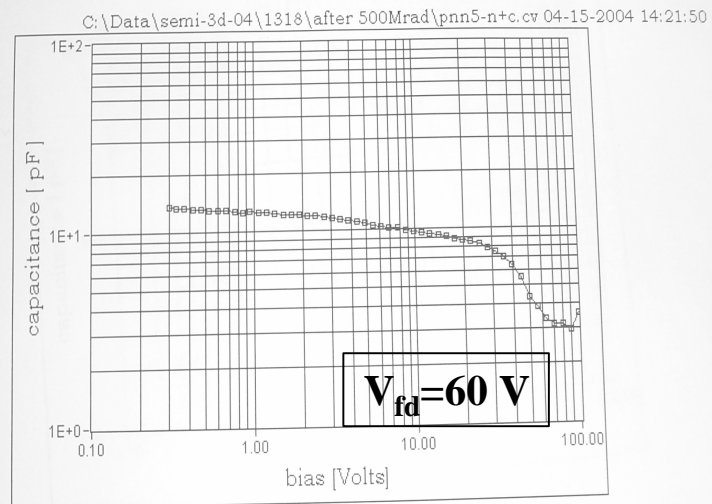
10 Feb 2004
12:03:45

g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

p⁺-n⁺/n/n⁺, +V on back n⁺, 0V on p⁺, front n⁺ floating

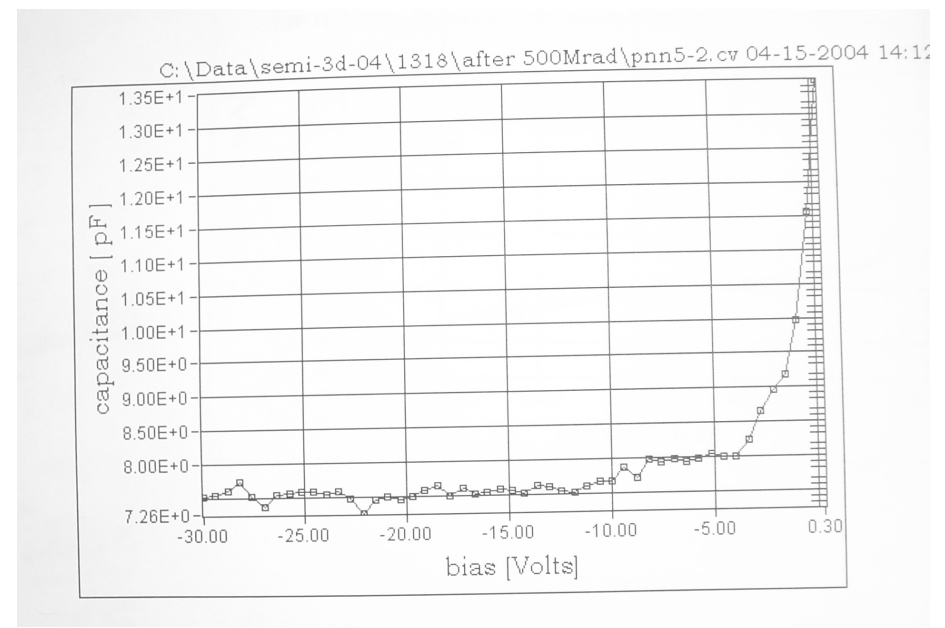
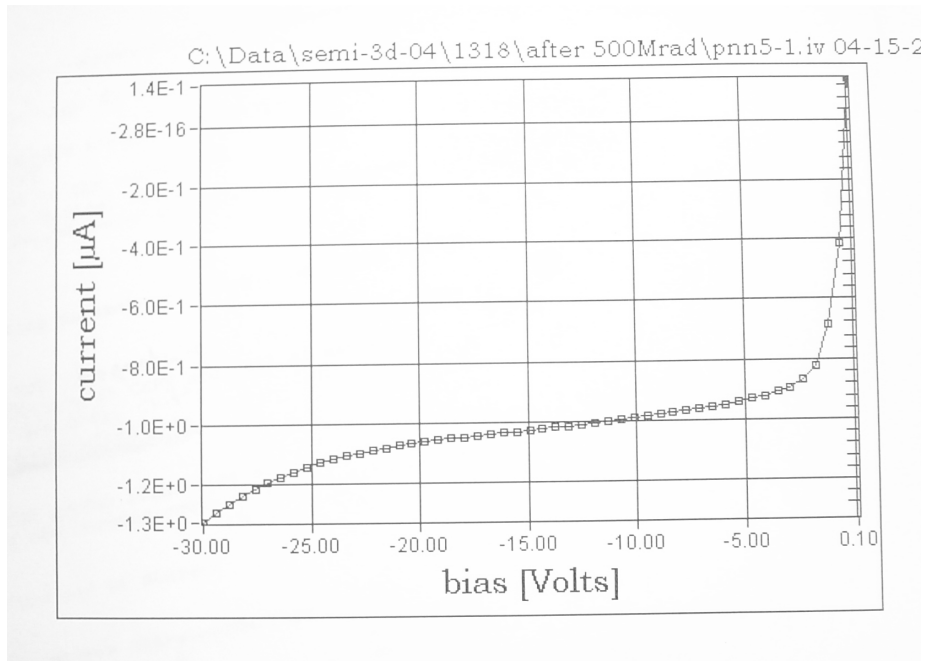


p⁺-n⁺/n/n⁺, +V on back n⁺, 0V on p⁺, front n⁺ same +V



g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

p⁺-n⁺/n/n⁺, 0 on back n⁺, -V on front n⁺, front p⁺ same floating



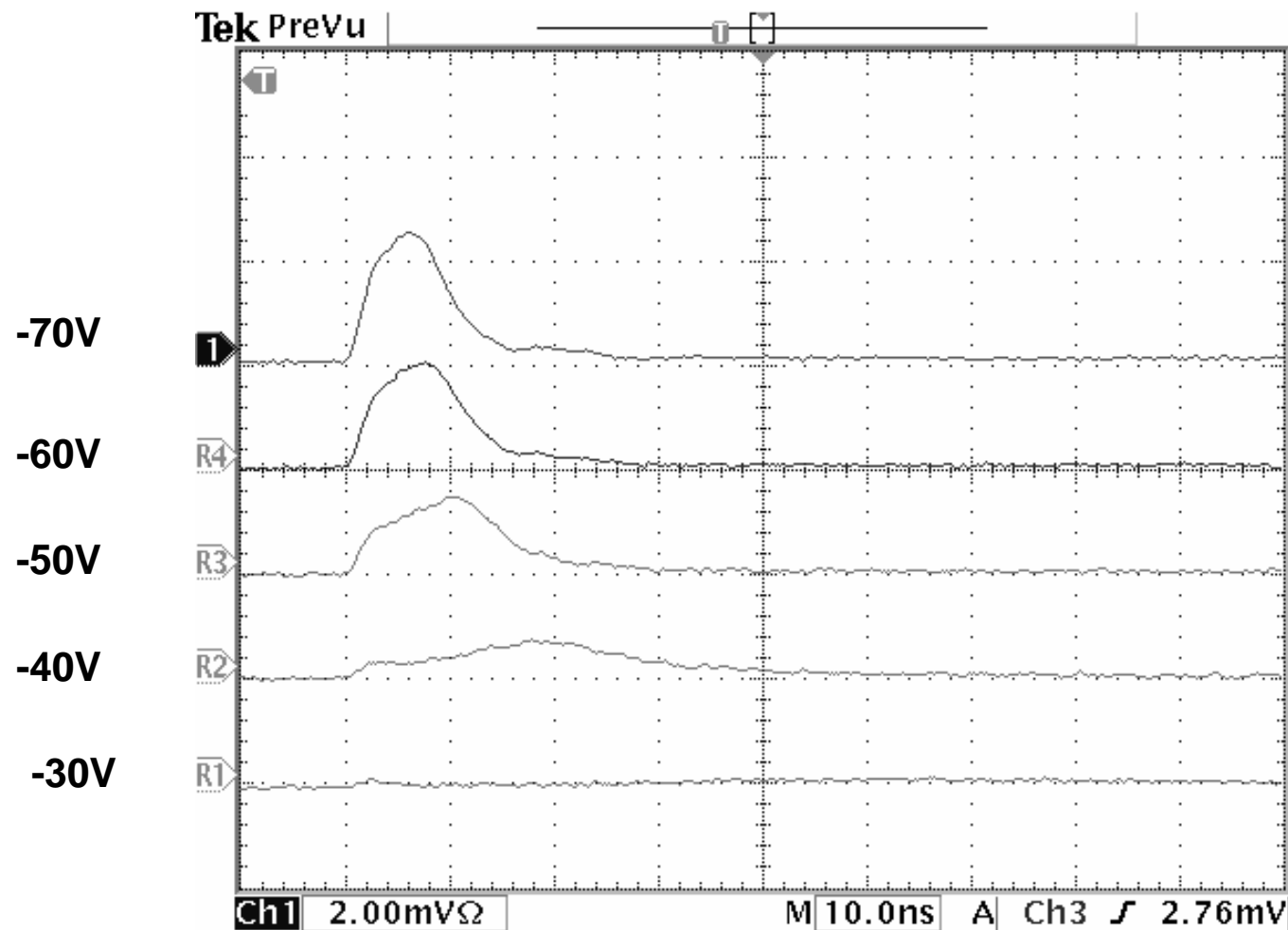
V_{fd} < 30 V

TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser back, -V on the front p⁺ contact, front n⁺ contact floating

p⁺-n⁺/n/n⁺, 0V on back n⁺, -V on p⁺, front n⁺ floating

p⁺/'p''/n⁺



28 Apr 2004
12:02:42

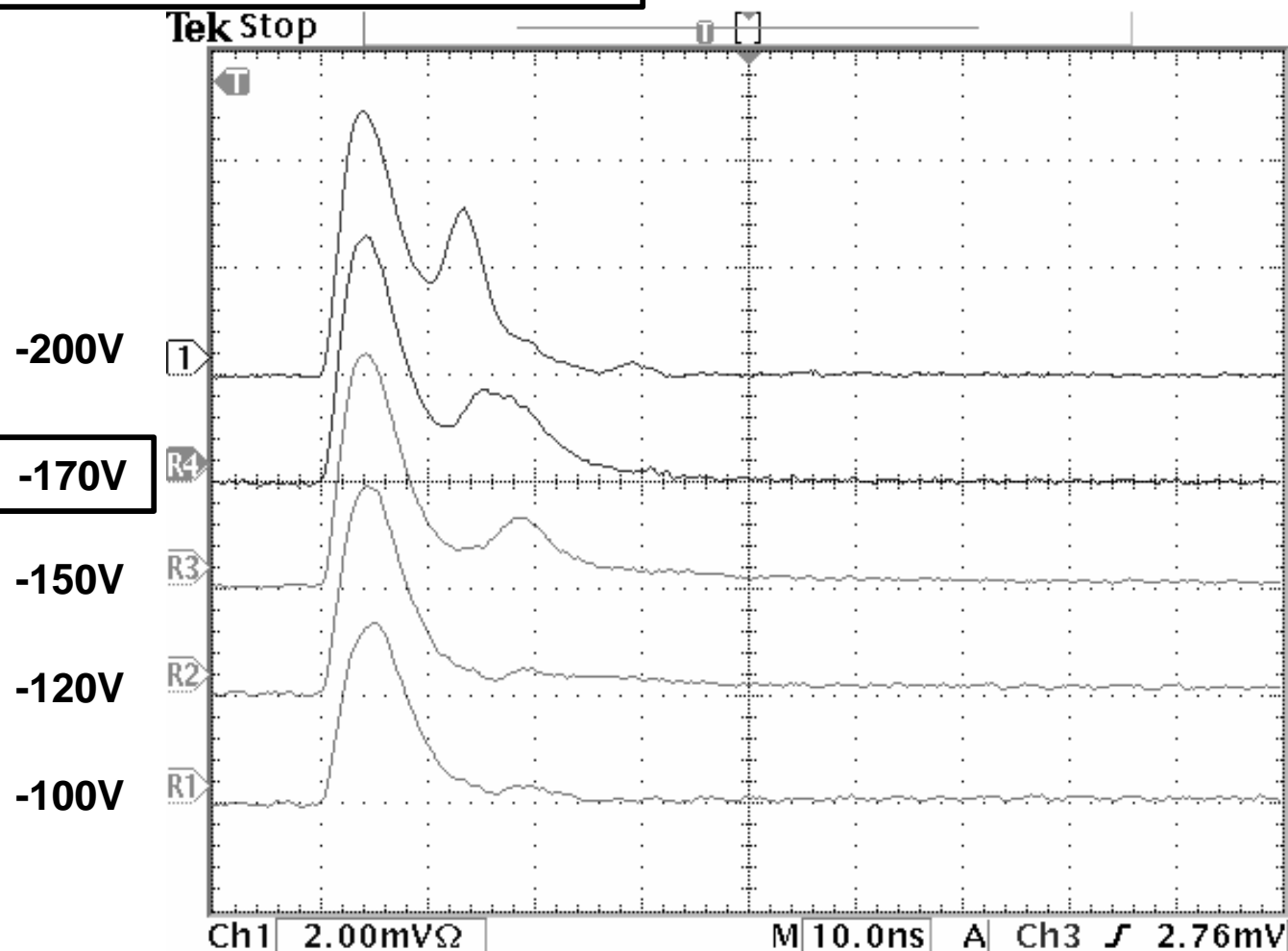
Ref4 2.00mV 10.0ns 183.800ns

TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser back, -V on the front p^+ contact, front n^+ contact floating

$p^+ - n^+ / n / n^+$, 0V on back n^+ , -V on p^+ , front n^+ floating

$p^+ / p'' / n^+$



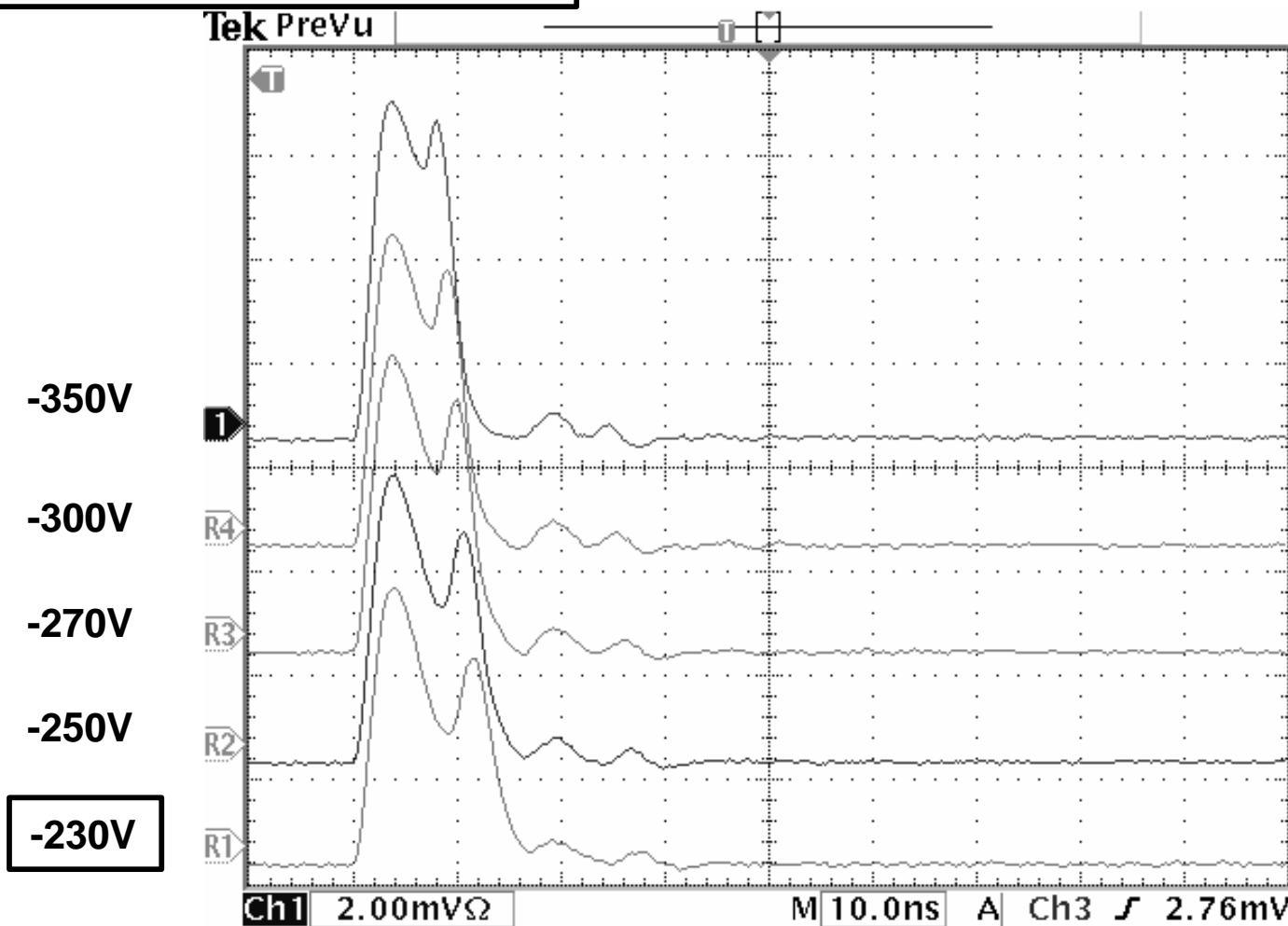
28 Apr 2004
12:06:35

TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser back, -V on the front p^+ contact, front n^+ contact floating

$p^+ - n^+ / n / n^+$, 0V on back n^+ , -V on p^+ , front n^+ floating

$p^+ / p'' / n^+$



Ref2

2.00mV

10.0ns

183.800ns

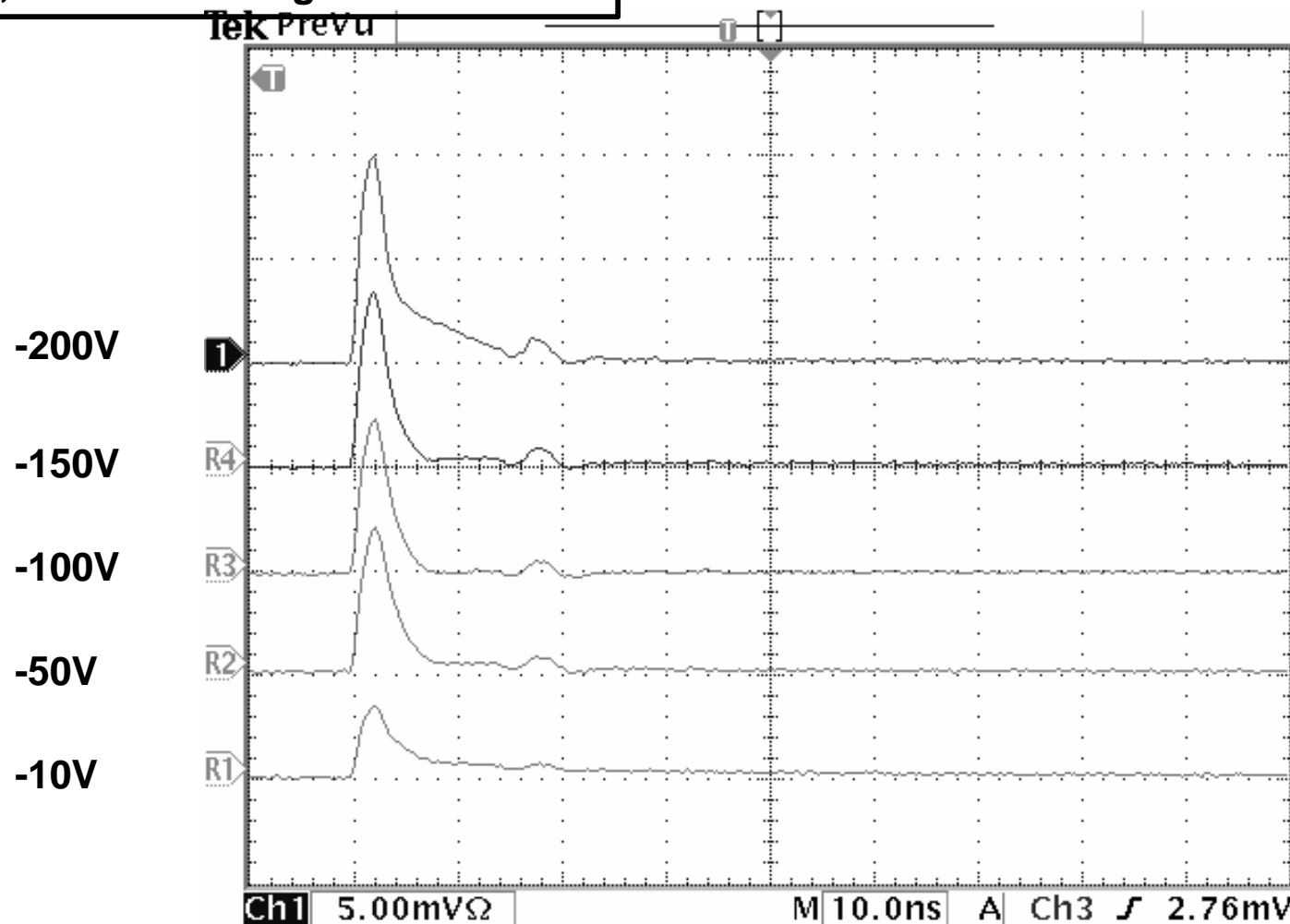
28 Apr 2004
12:11:25

TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser front, -V on the front p⁺ contact, front n⁺ contact floating

p⁺-n⁺/n/n⁺, 0V on back n⁺, -V on p⁺, front n⁺ floating

p⁺/'p''/n⁺



Ref4

5.00mV

10.0ns

183.800ns

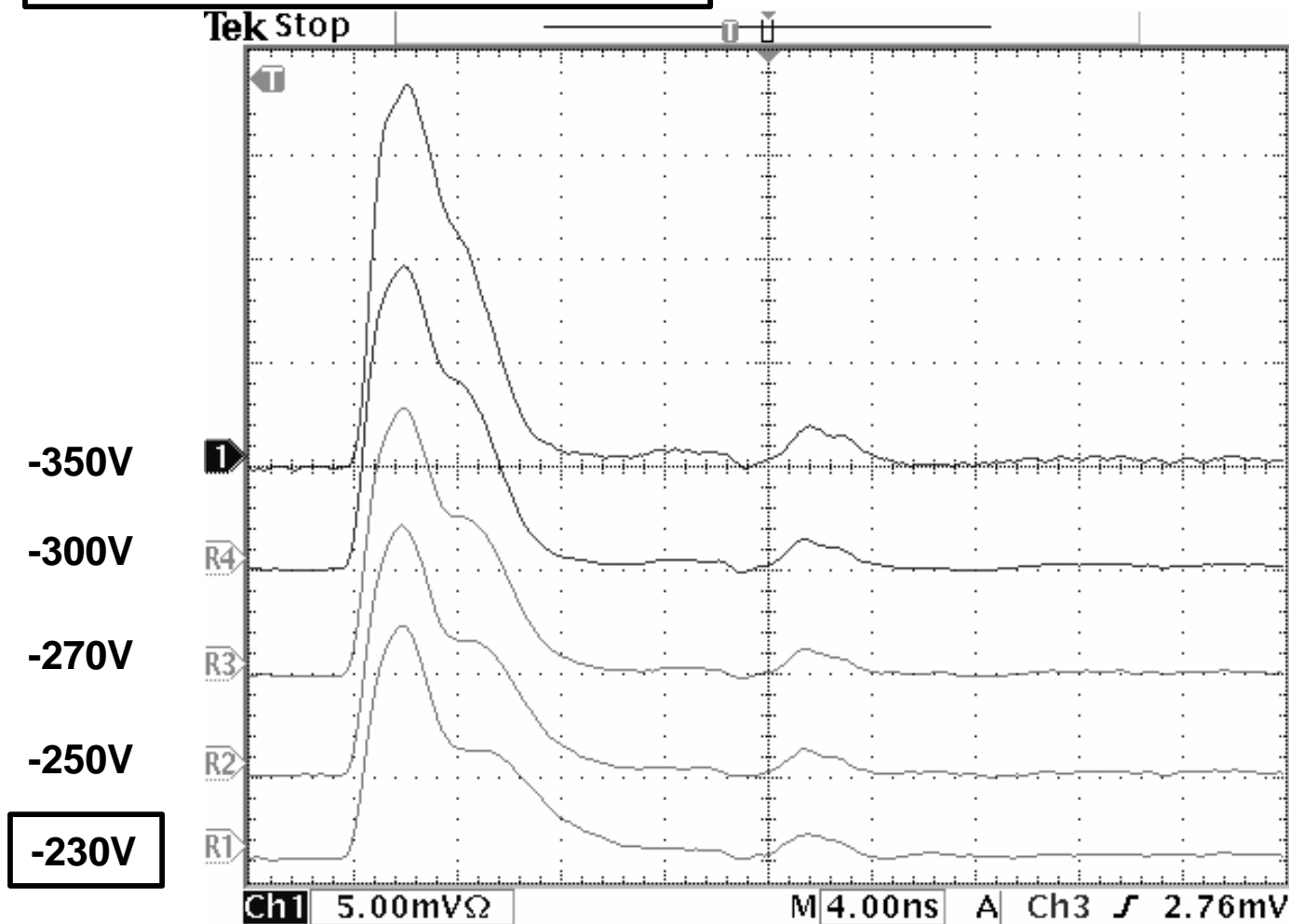
28 Apr 2004
12:15:48

TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser back, -V on the front p⁺ contact, front n⁺ contact floating

p⁺-n⁺/n/n⁺, 0V on back n⁺, -V on p⁺, front n⁺ floating

p⁺"/p"/n⁺



Ref4

5.00mV

4.00ns

159.680ns

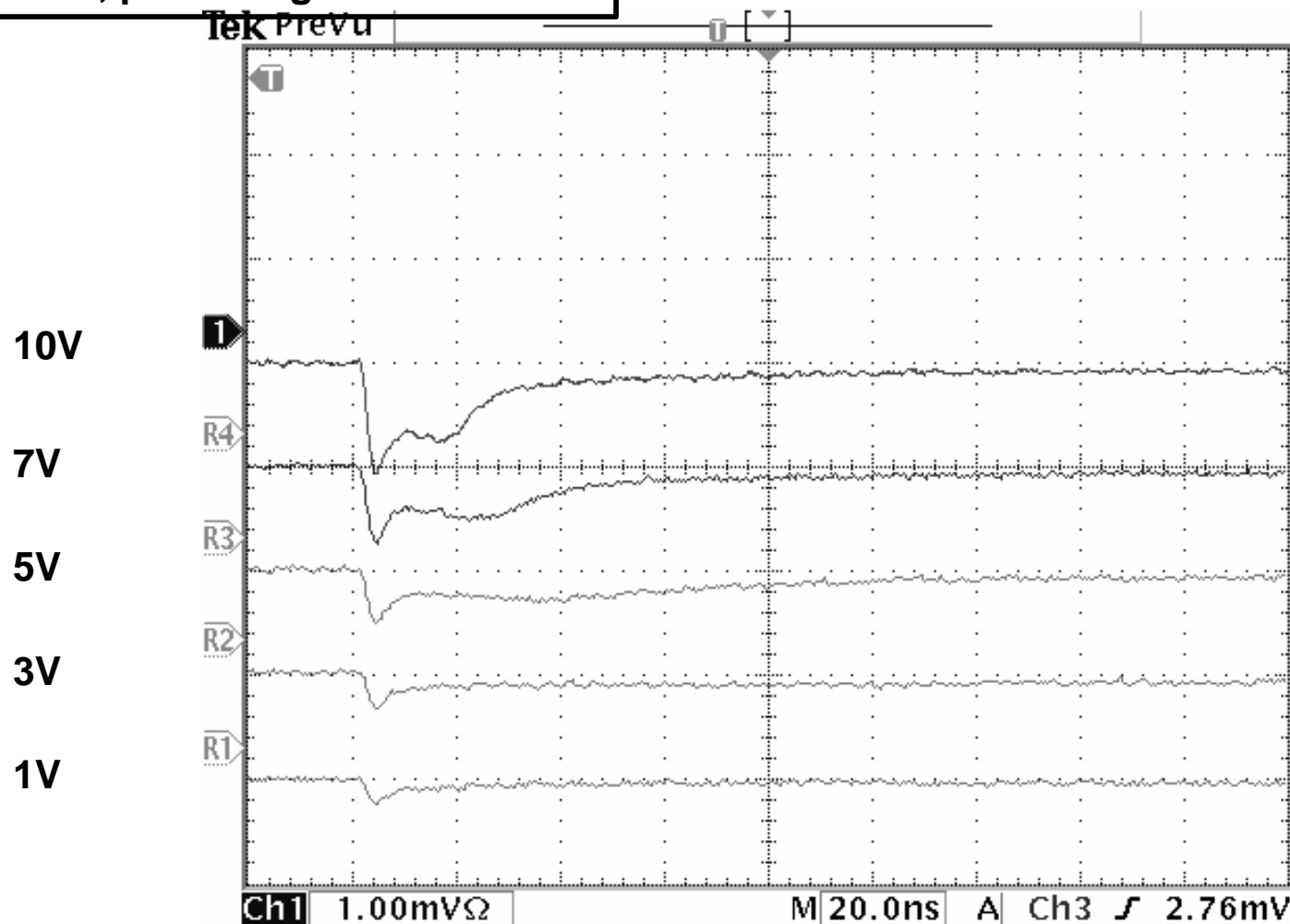
28 Apr 2004
12:20:38

TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser front, +V on the front n^+ contact, front p^+ contact floating

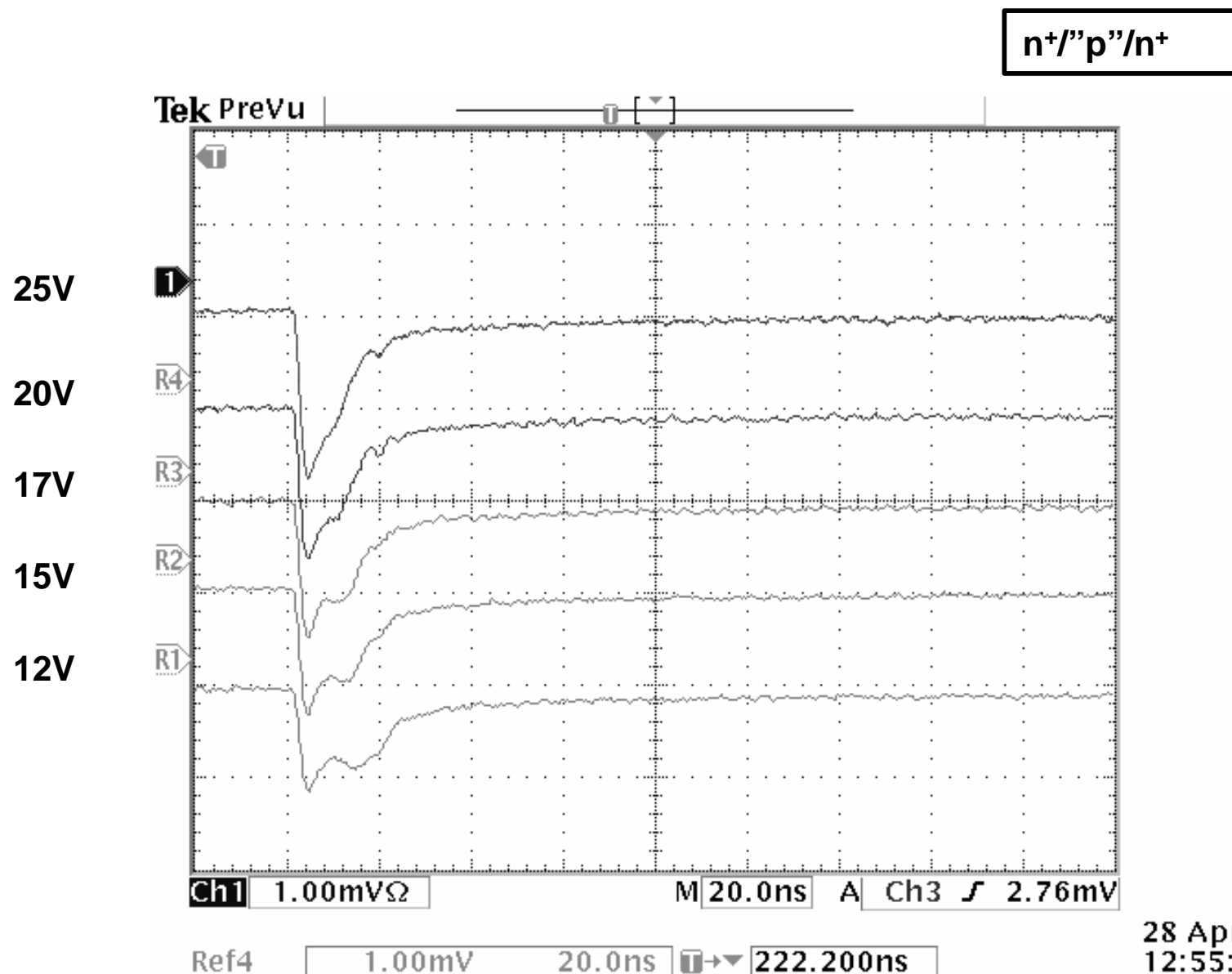
$p^+ - n^+ / n / n^+$, +V on front n^+ , 0V on back n^+ , p^+ floating

$n^+ / p^+ / n^+$



TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

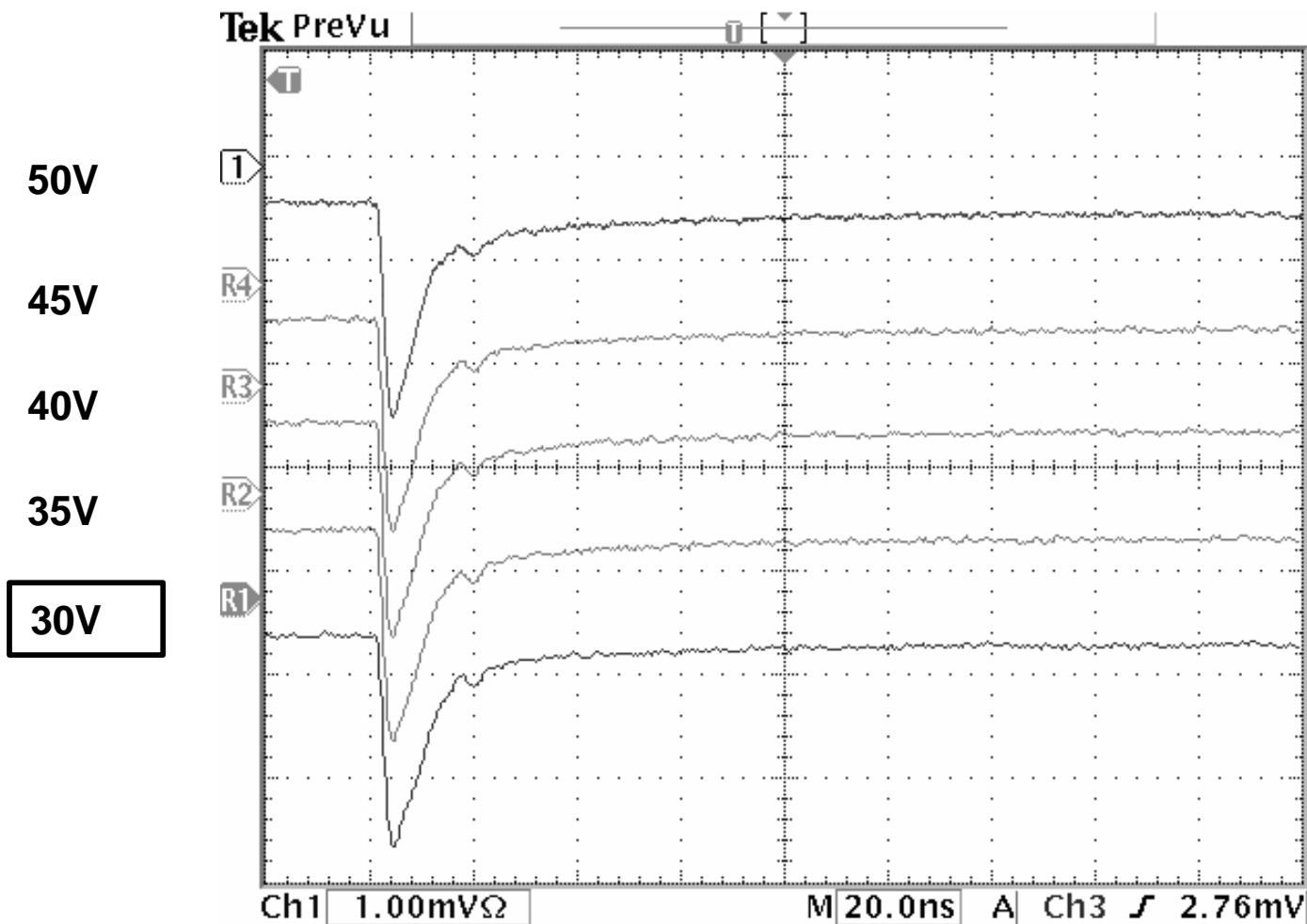
Laser front, +V on the front n^+ contact, front p^+ contact floating



TCT test of g-irradiated (500 Mrad) Semi-3d Detectors (Test structure)

Laser front, +V on the front n^+ contact, front p^+ contact floating

n+/"p"/n+



30V

Summary

- **First prototype batch of Semi-3d Si detectors has been completed**
- **As processed Semi-detectors behave normally as detectors**
- **After gamma irradiation beyond SCSI, TCT data show complicated E-field**
- **With front n+ strips biased, the detector full depletion voltage may be lowered as predicted**
- **DJ/DP field distribution is observed**
- **More tests on test Semi-3d and strip Semi-3d are underway**