Slim edge in 3D detectors

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(3D and P-type Technologies)
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Outline:

- Dead area in standard sensors:
  - Planar
  - Planar Active Edge

- Slim edge design of 3D “FE-I4” sensor
  - Simulated performances
  - Measured performances

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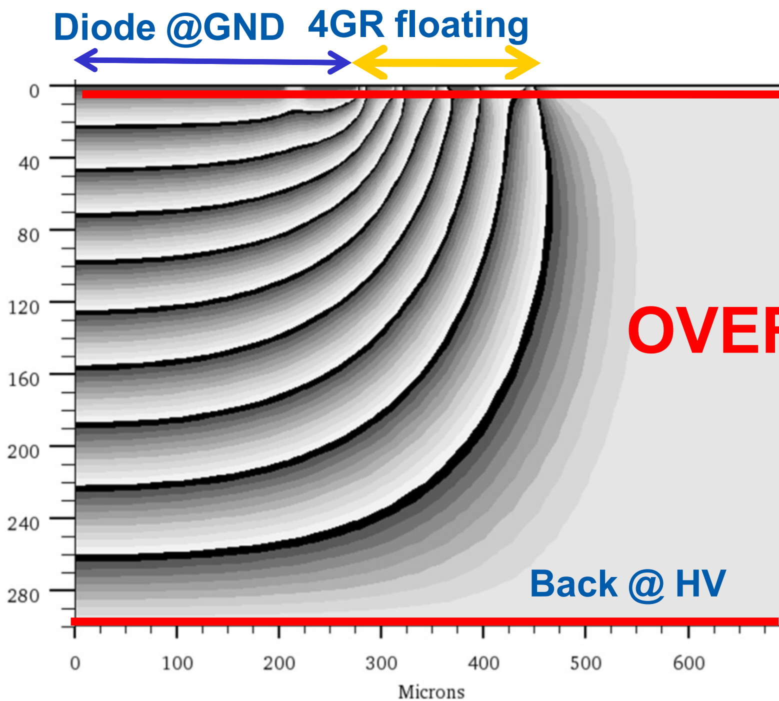
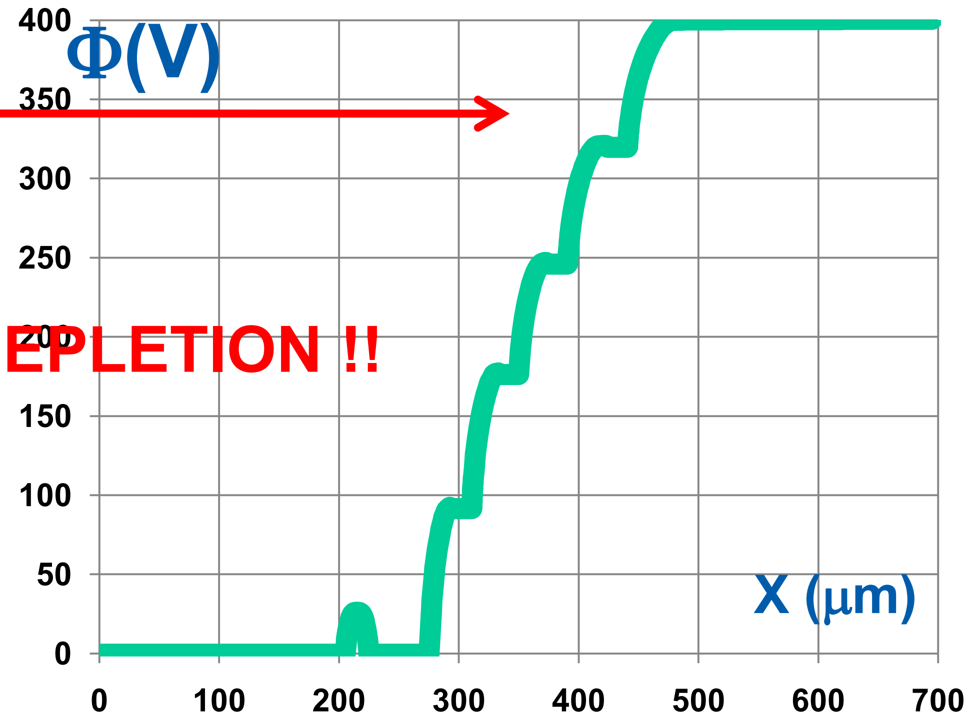
Dead Area on Planar devices

- As a rule of thumb, the depletion region extends as much into the substrate than laterally.
- Considering things better, depletion region grows slowly laterally, due to the surface electron layer @ V_{back}
- Dead region is usually designed 2-3 times larger than substrate thickness
- In the external large dead area, GRs can be fitted to operate at HIGH V_{bias}.

Map of the potential into the substrate



Cutline of the potential at the interface



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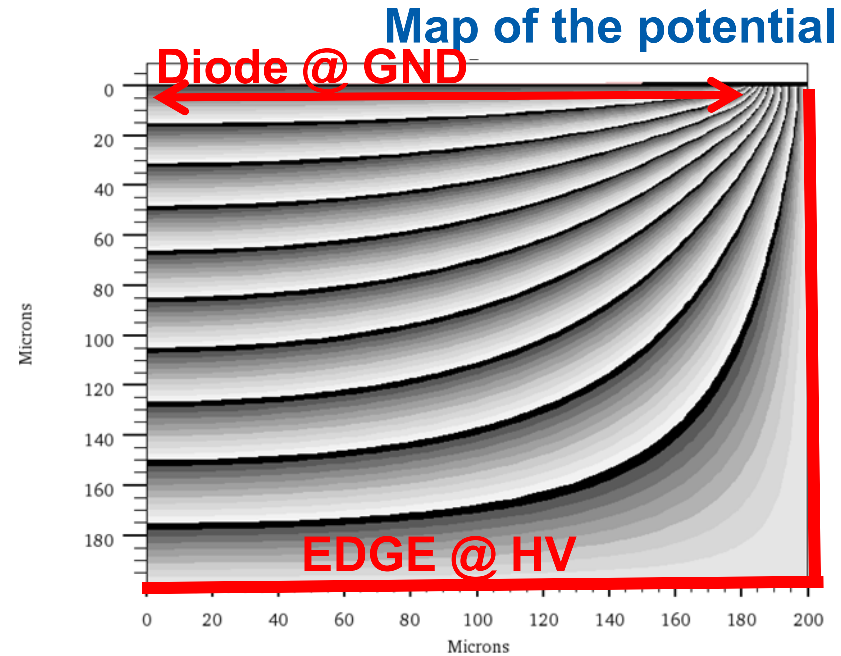
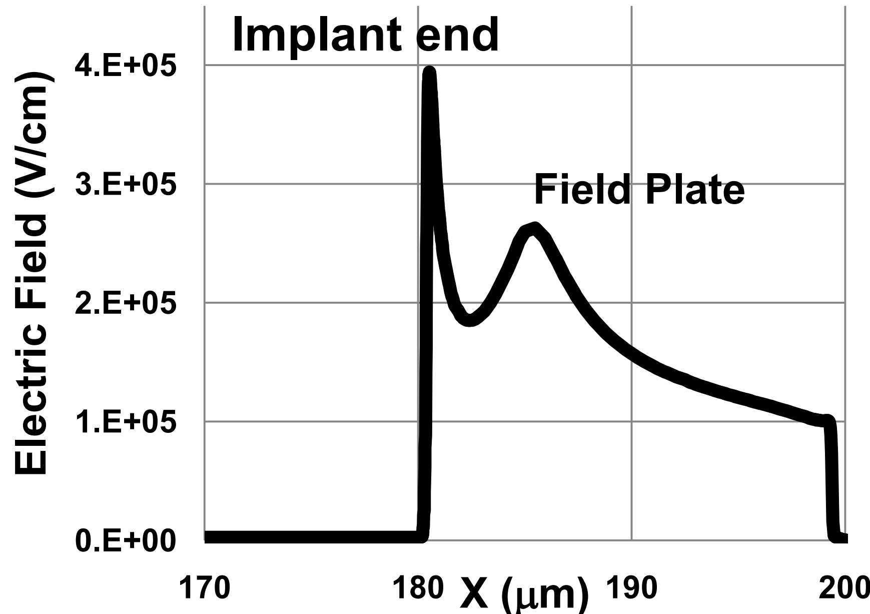
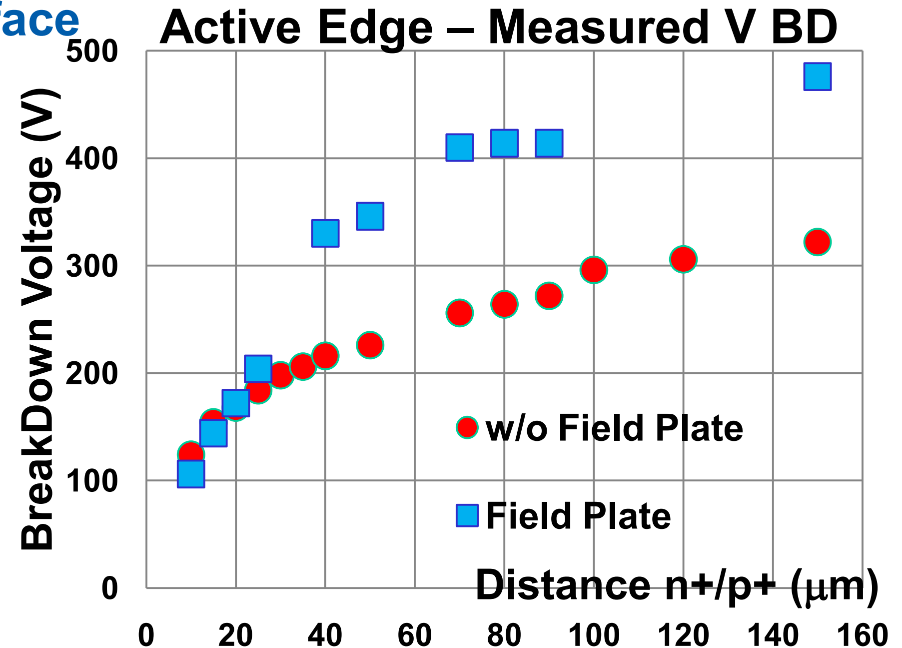
Planar Active Edge

The Edge is implanted, thus the depletion region can safely touch it,
It is as safe as with the back implant.
But it needs a support wafer



ZOOM of the
Cutline of the electric field at the interface

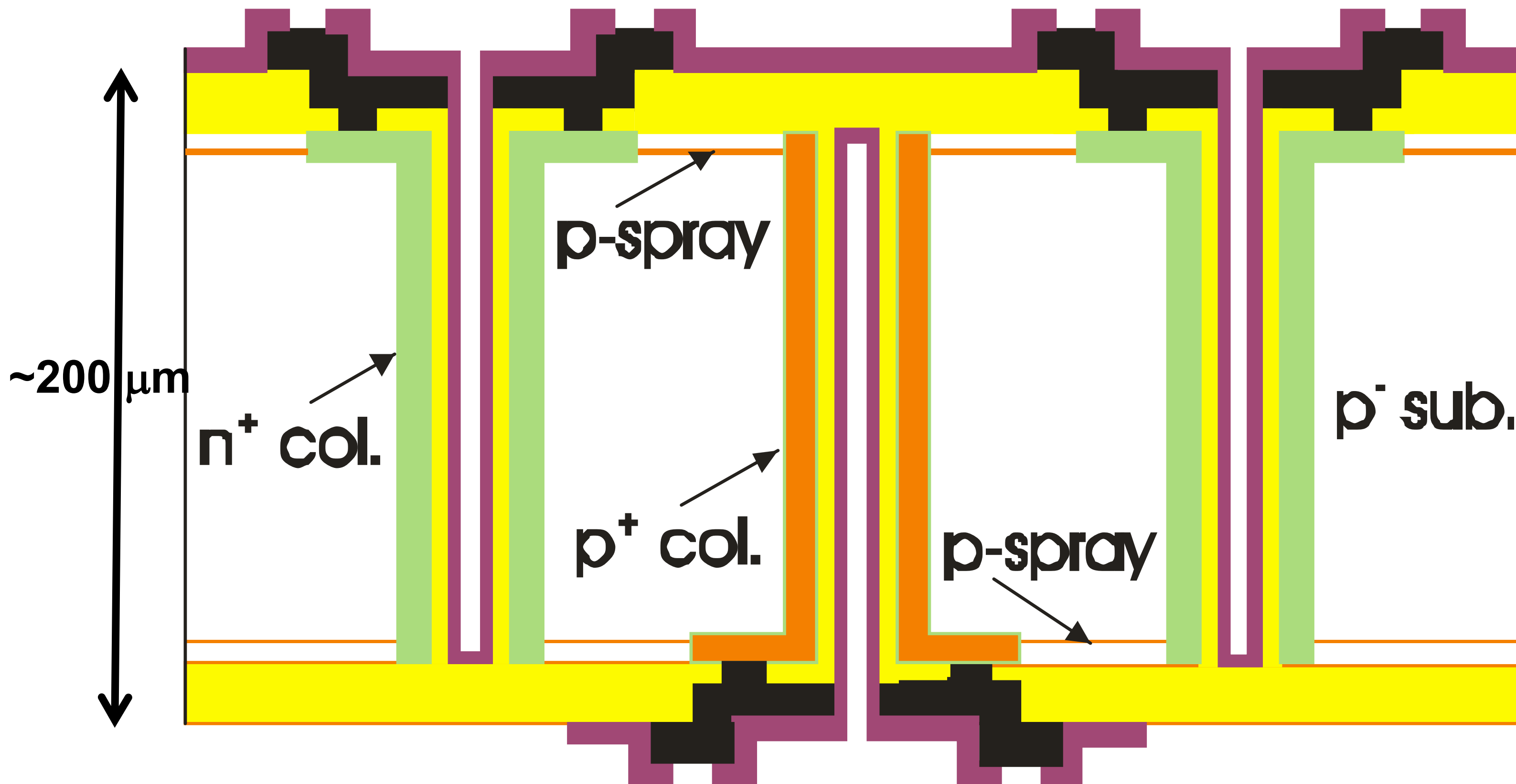




3D-DDTC+: passing through columns

In 2010, FBK fabricated 3D sensors for two Front-Ends (I3 & I4).
The technology has:

- P substrate
- Passing Through Columns of both types
- Insulation between n+ columns via p-spray on both sides



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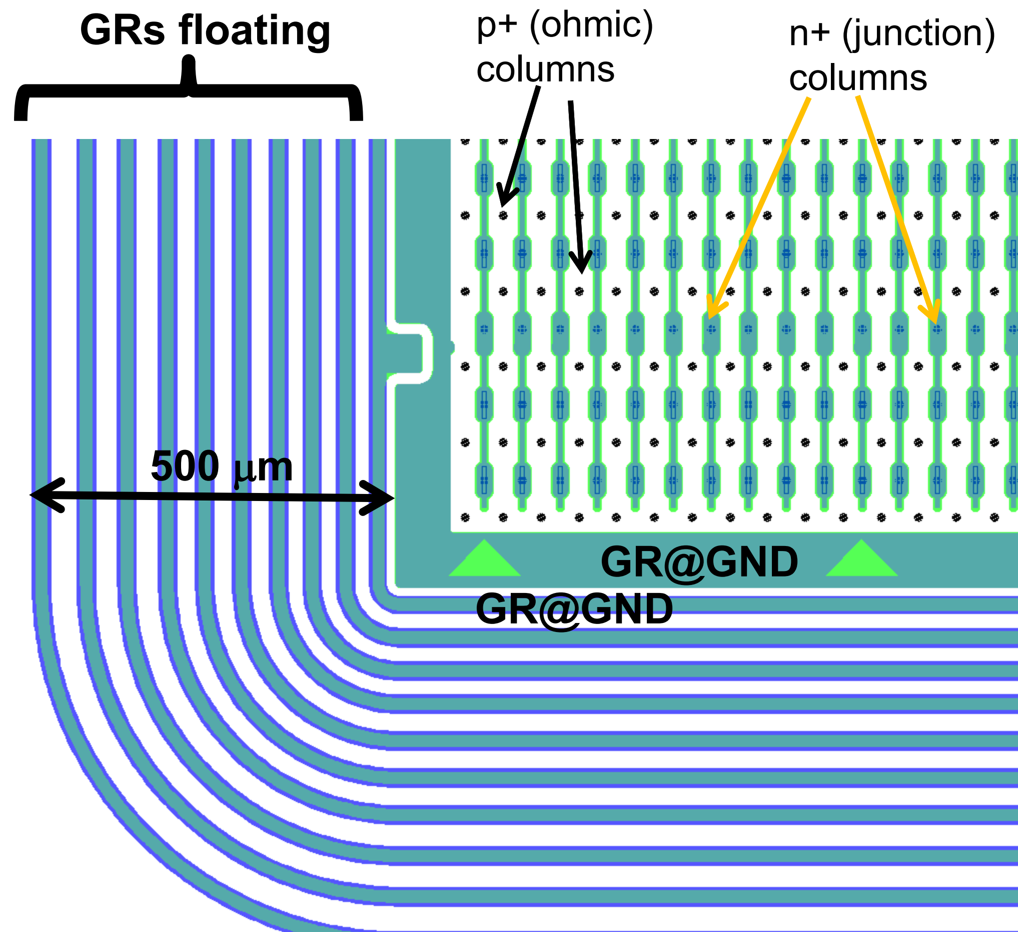
FE-I3 : termination like a planar device

3D FE-I3 used the same termination of the planar FE-I3

Innermost GRs are biased to collect the (eventual) leakage from the scribeline.



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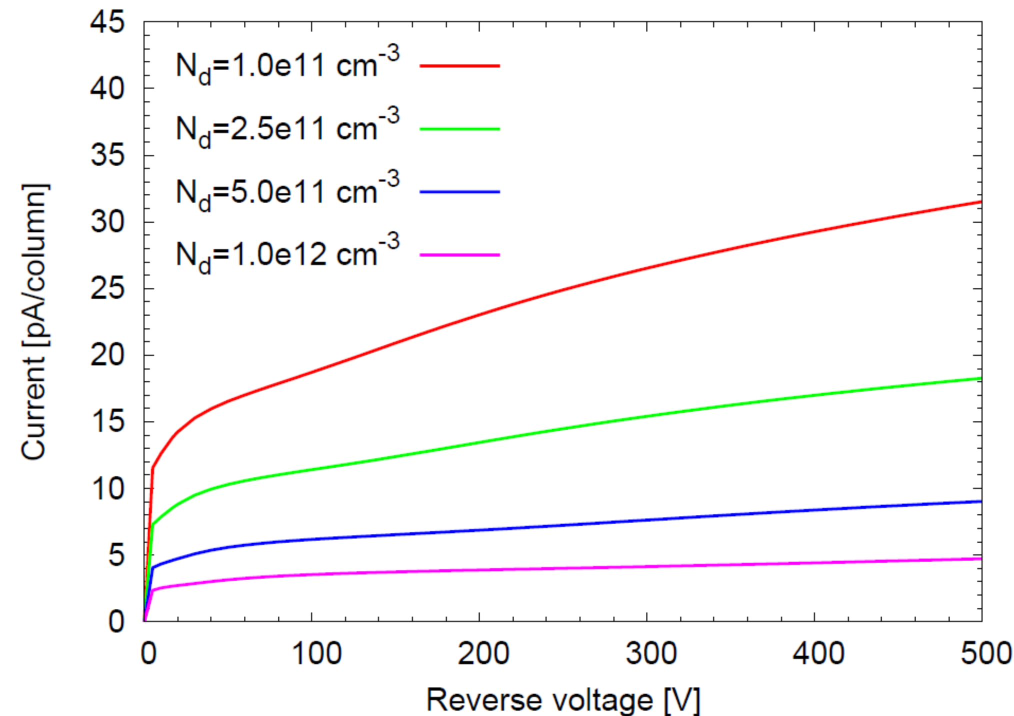
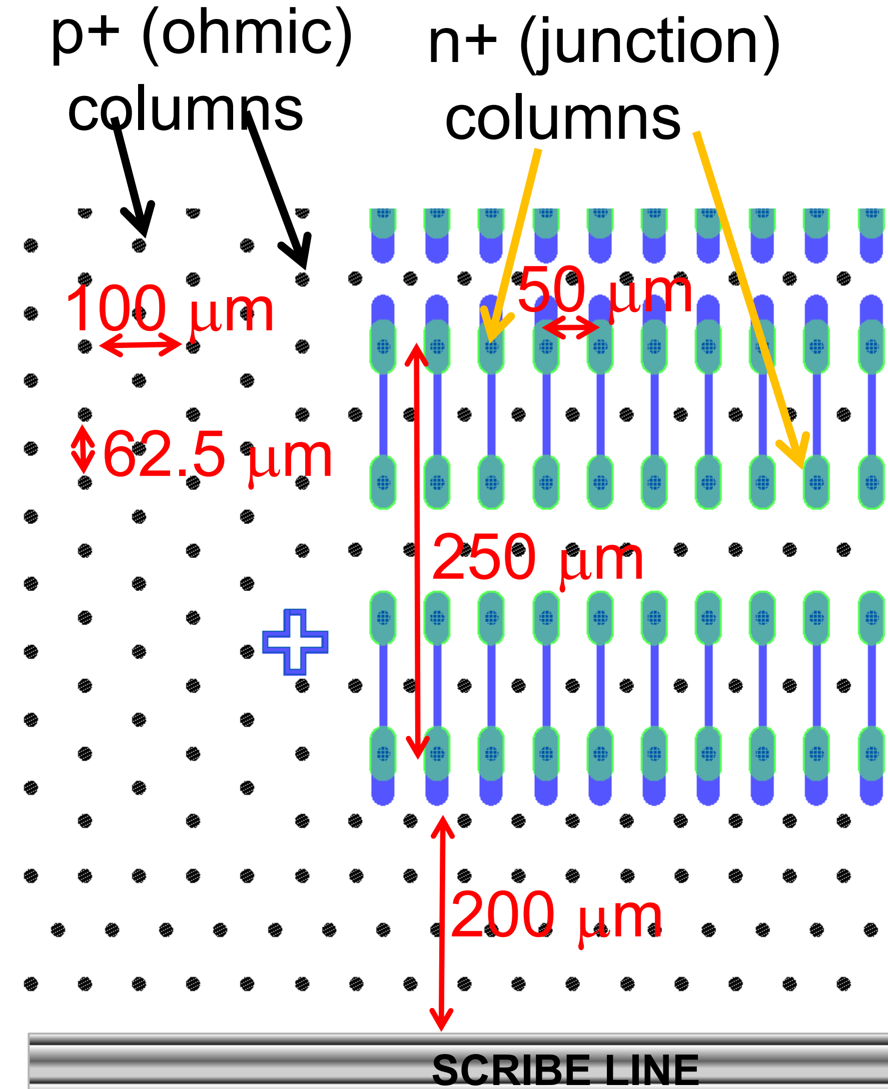
SLIM EDGE ON FE-I4

- No Active edge → no support wafer
- Multiple Ohmic fence termination
- Dead area ~ 200 μm (at its minimum)
- First Simulations showed no current drawn from highly damaged cut region





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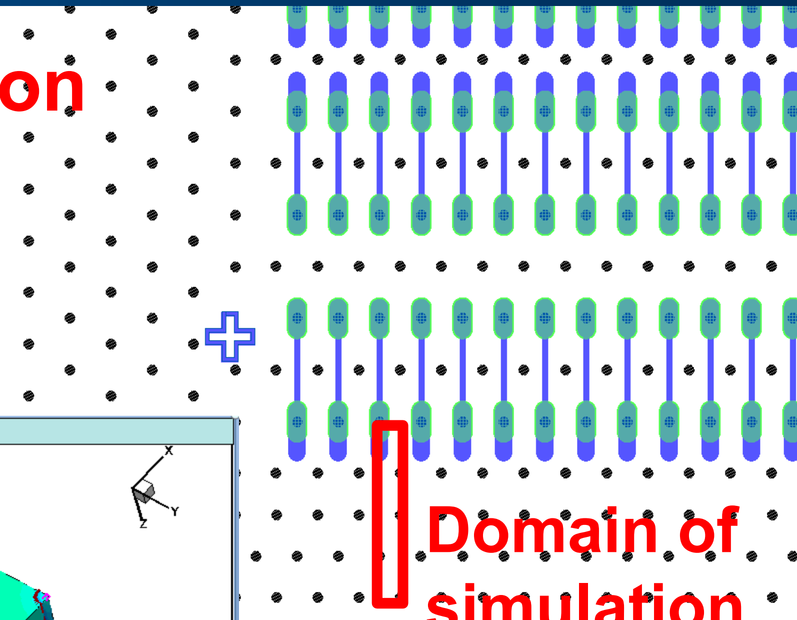
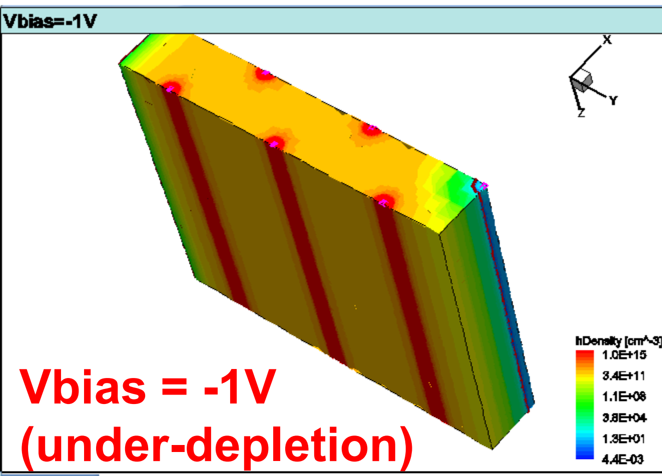
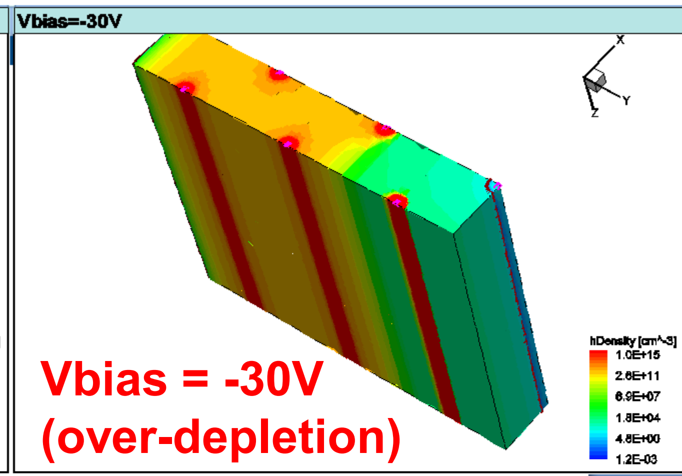
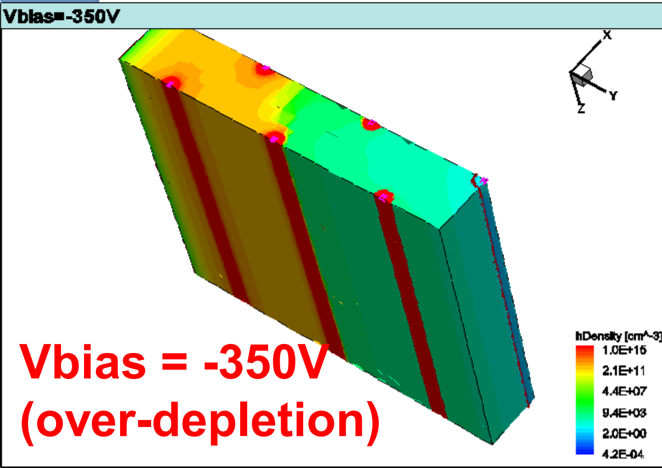
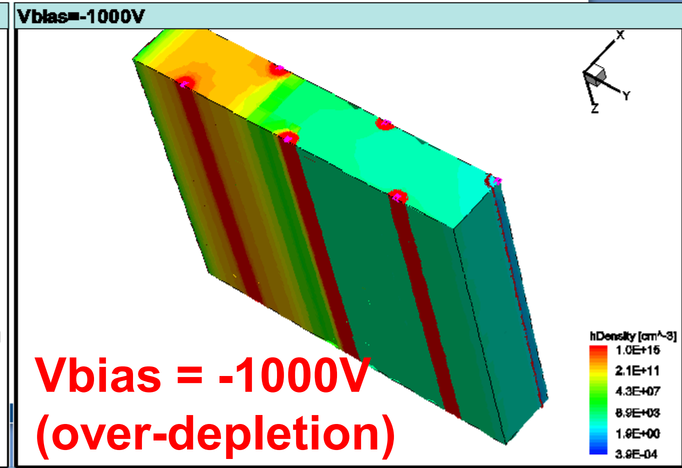
Simulation of the depletion region extension

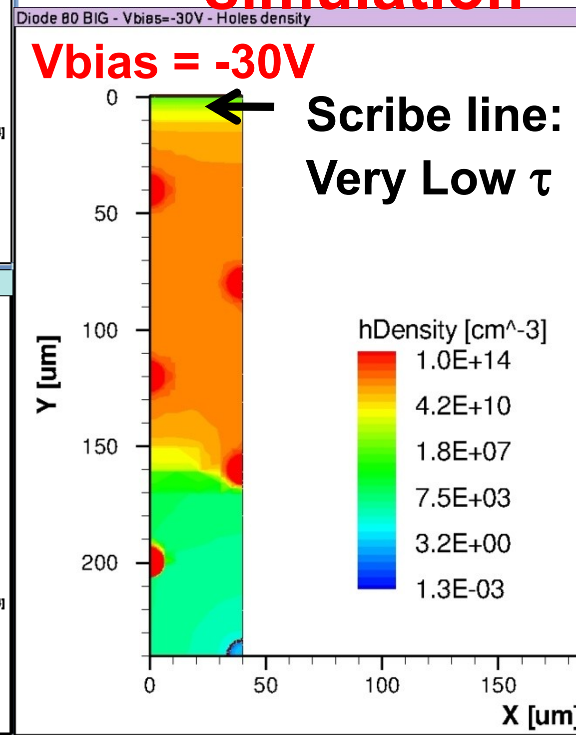








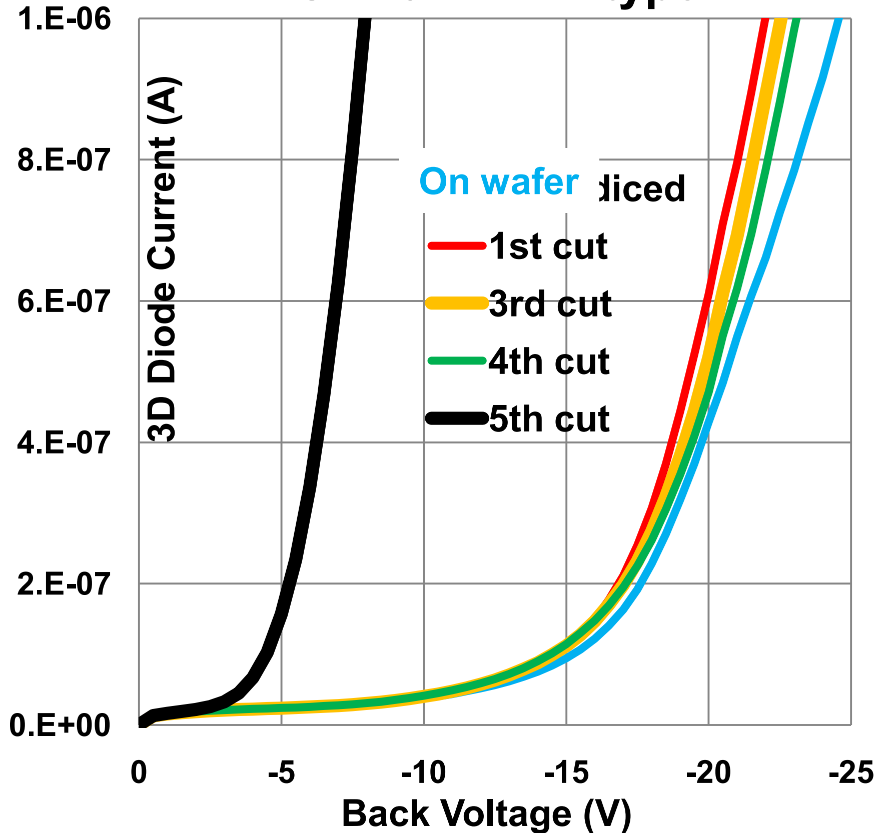




Measurement of the depletion region extension

In a 3D- Diode, the n^+ pixels are shorted by a metal grid:
so that the current of a large region is measured with two probes!

Several dicings at different distances from the n+ pixels, to check the extension of the depleted region



1st cut

3rd cut

5th cut

METAL pad

p+ columns

n+ columns

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Scribe line distance can be safely decreased

FE-I4 3D sensor

100 μm

50 μm

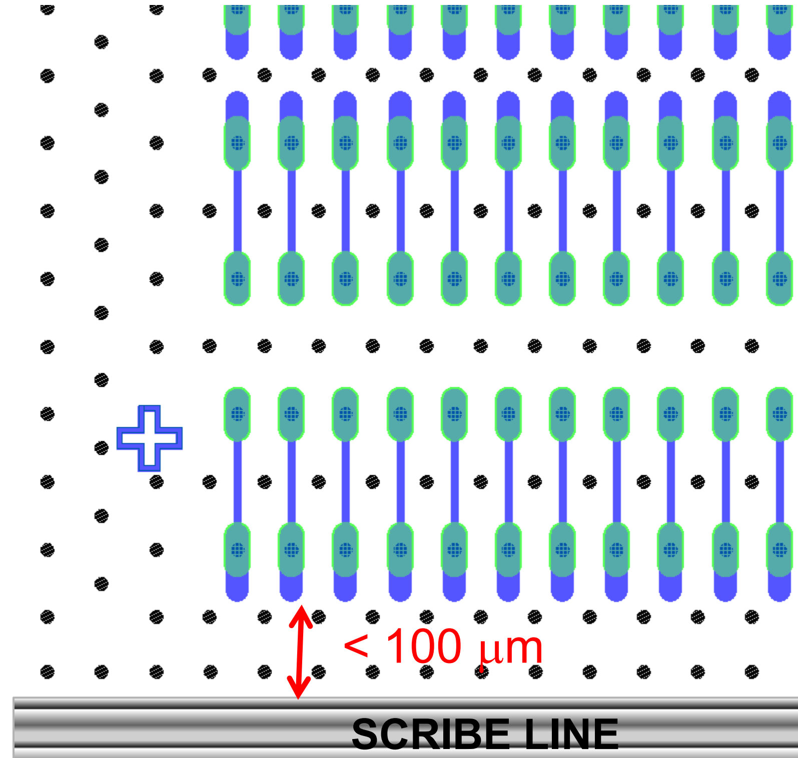
62.5 μm

250 μm

200 μm

SCRIBE LINE

p+ columns



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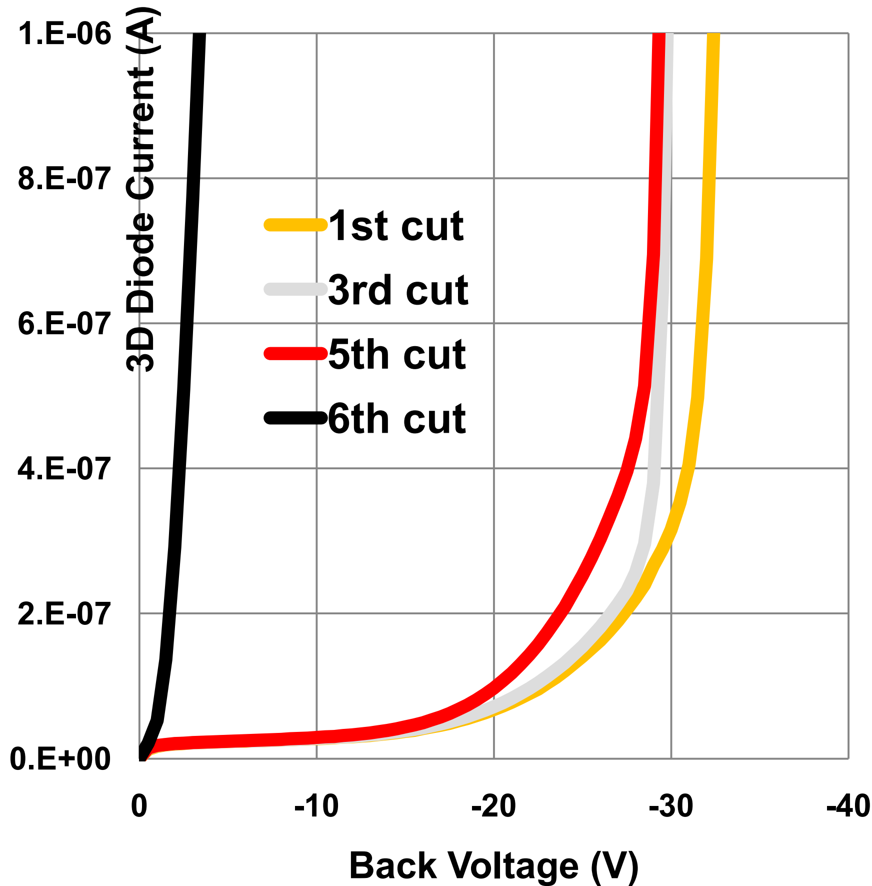
Another IV measurement for different cutting distances

AGAIN: one row of ohmic holes is sufficient to “stop” the depletion region



3th cut

5th cut

6th cut

1st cut

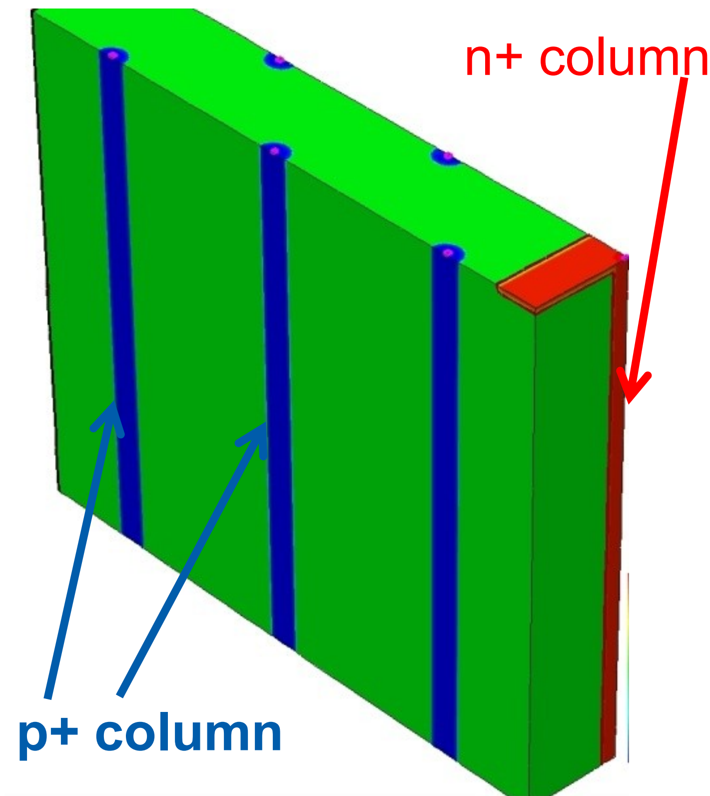
40 μm

p+ (ohmic) columns

n+ (junction) columns

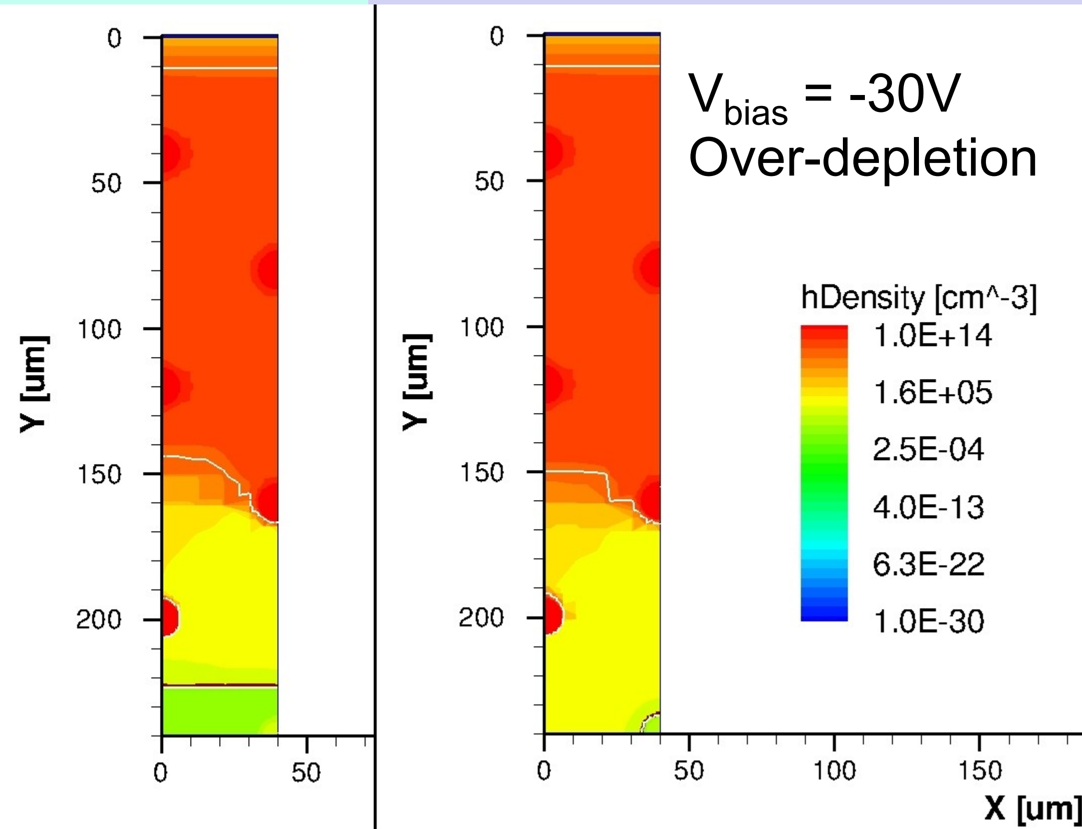
Simulation

In this 3D-Diode, n+ columns are shorted by both the METAL and the n+ implant



Horizontal slice of the hole conc.

below the interface	@ Y= 100 μm half substrate thickness



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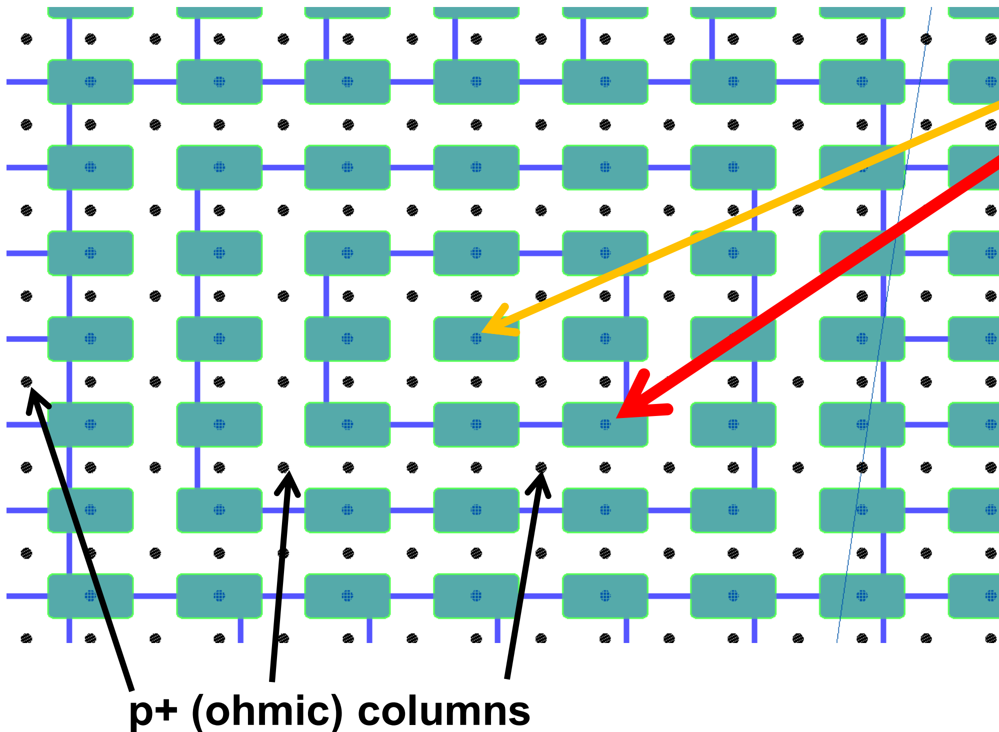
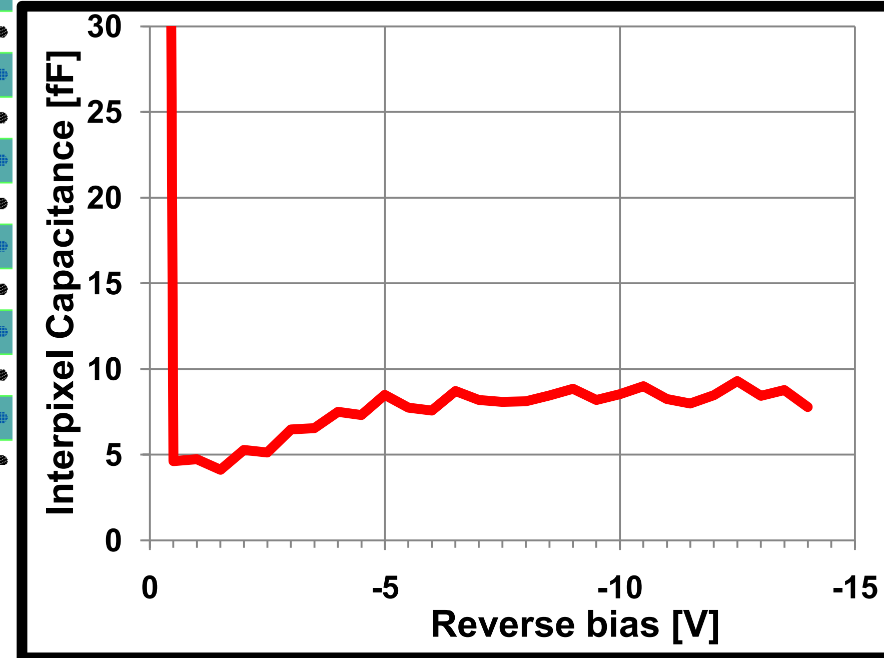
ADDENDUM: interpixel capacitance

i.e.: capacitance between one n+ column and all the other n+ columns



- Back @ - V (but AC-coupled to GND)
- Central n+ column @ LOW
- First ring of n+ columns @ HIGH
- Other rings @ GND (or @ HIGH)



The measured intercolumn capacitance is ~ zero:
p+ columns shield the electric field of the n+ column.

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Conclusion:

3D sensors @ FBK (Passing Through columns)
do not have Active Edge.

In order to have small dead area, a “slim edge”
–made up of rows of ohmic columns –
was simulated to be effective in reducing the dead
area down to 200 μm.
Measurements confirmed this view.

Dead area can be reduced further down to 100 μm