

# Year 2 Semester 1 updates: RD50-ENGRUN1 TCAD Simulations (Internal)

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# Last few weeks:

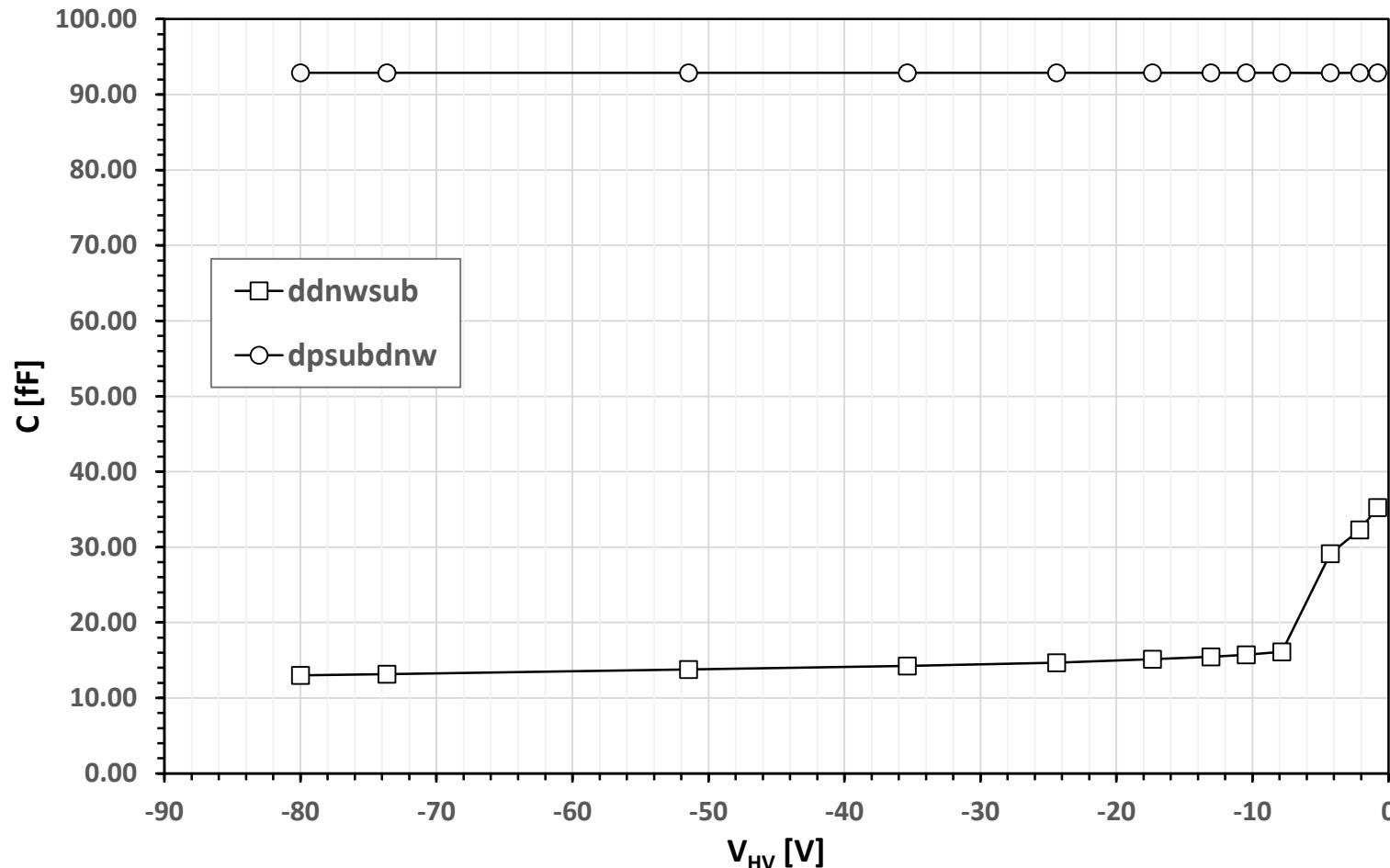
(Internal)

Using TCAD models of the RD50-MPW1 pixel to prepare for simulations of RD50-ENGRUN1 pixel (in matrix 5?)

- Parasitic Capacitance
  - Mixed-mode simulation with small AC analysis
  - Negative capacitances?
- Radiation Damage
  - Pennicard charge trapping
- Multiple pixels with spacing
  - Models dynamically created with spacing  $nz$  as input parameter

# Parasitic capacitance simulations

(Internal)



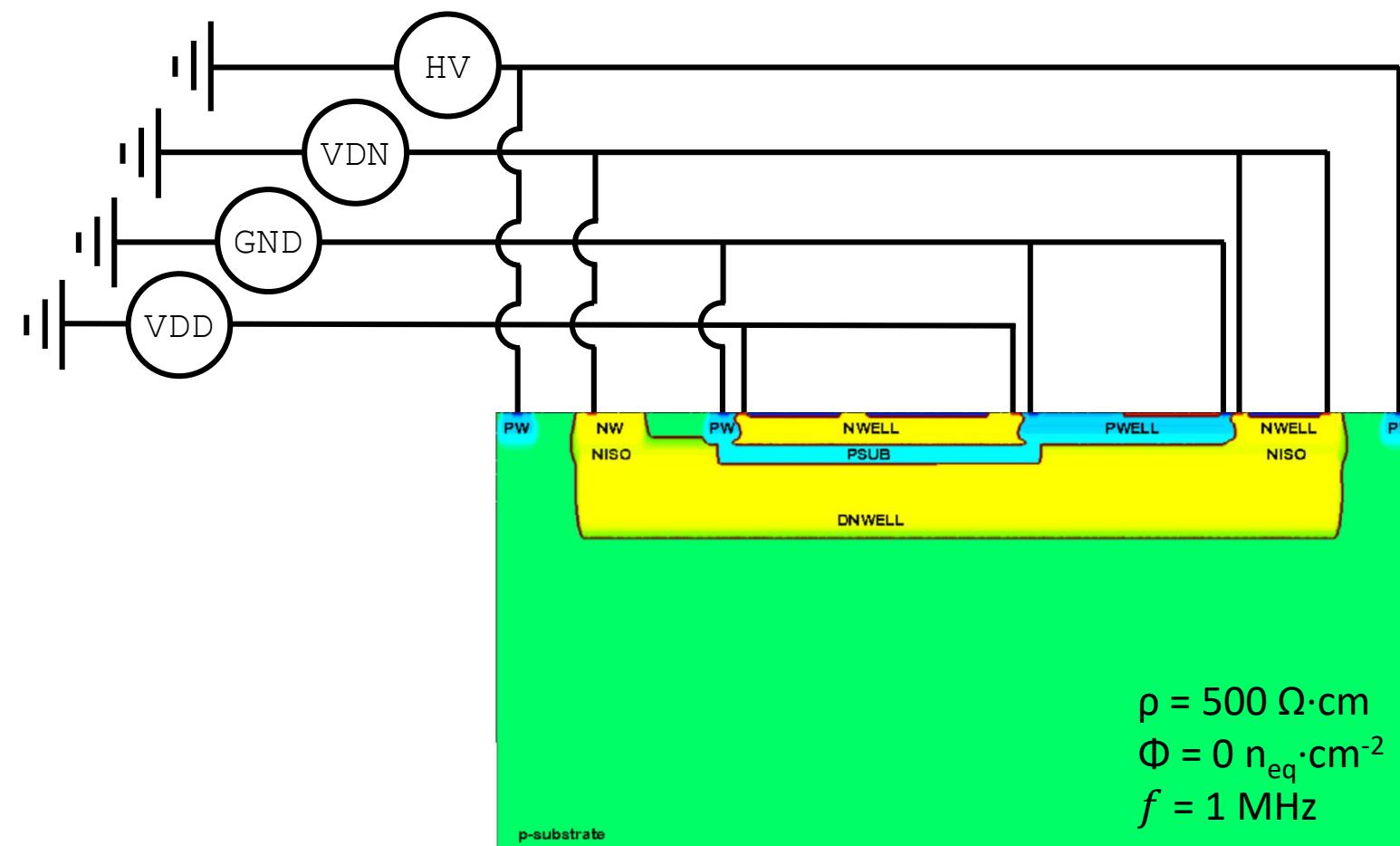
Using **RD50-MPW1** pixel simulations:

- Modelling parasitic capacitance
- (The capacitances come out negative!)
- $C_{ddnwsub}$  too small  $\rightarrow \approx 70$  fF @ -60V

**dpsubdnw depth = 14.42 μm**  
**ddnwsub depth = 42.5 μm**

# Mixed-mode simulation schematic

(Internal)

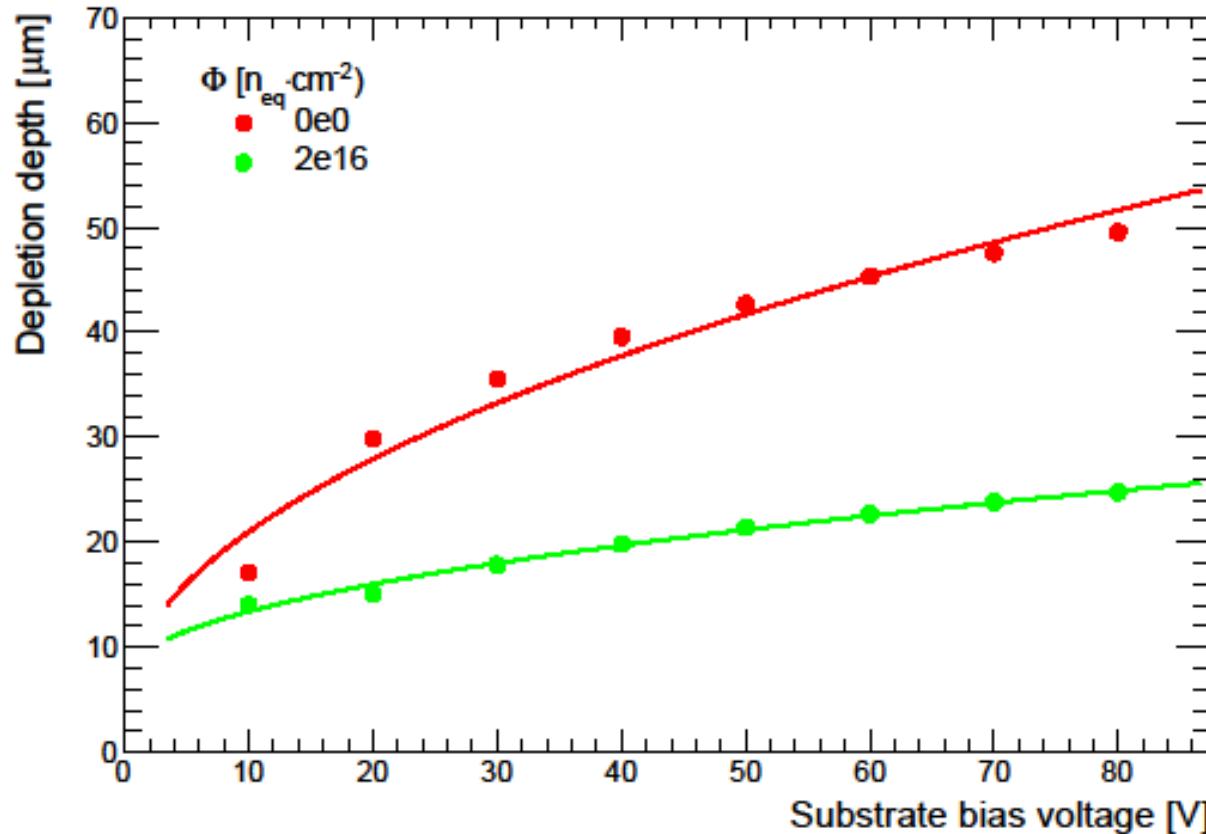


## SPICE syntax:

```
Vsource_pset HV (n1 0) {dc = 0}
Vsource_pset VDN (n2 0) {dc = 0}
Vsource_pset VDD (n3 0) {dc = 0}
Vsource_pset GND (n4 0) {dc = 0}

...
Goal {Parameter=VDD.dc Voltage=1.8}
...
Goal {Parameter=VDN.dc Voltage=1.8}
...
Goal {Parameter=HV.dc Voltage=-80}
```

# Radiation damage simulation and analysis (Internal)



Using **RD50-MPW1** pixel simulations:

- Modelling radiation damage using charge trapping (D. Pennicard)
- Initial simulation comparing “non-irradiated” pixel with one irradiated to  $2E16 n_{eq} cm^{-2}$

Type	Energy (eV)	Trap	$\sigma_e$ ( $cm^2$ )	$\sigma_h$ ( $cm^2$ )	$\eta$ ( $cm^{-1}$ )
Acceptor	Ec-0.42	VV	$9.5*10^{-15}$	$9.5*10^{-14}$	1.613
Acceptor	Ec-0.46	VVV	$5.0*10^{-15}$	$5.0*10^{-14}$	0.9
Donor	Ec+0.36	CiOi	$3.23*10^{-13}$	$3.23*10^{-14}$	0.9

Table 1: D. Pennicard, UoGlasgow, PPT

# Spacing between pixels

(Internal)

**RD50-ENGRUN1 – Matrix 5 new approach**

**Matrix with different separations between rows**

- Study the effects of dead areas between pixels on the charge collection efficiency of the sensor
- This matrix includes a few sub-matrices with different separations between rows of pixels
- The separations range between a few  $\mu\text{m}$  to some hundreds of  $\mu\text{m}$
- Doing TCAD simulations at the moment

The diagram illustrates the RD50-ENGRUN1 sensor layout. It features a main matrix divided into five sub-matrices: 5-A (green), 5-B (purple), 5-C (blue), and 5-D (orange). Submatrix 5-D is highlighted with a red box and a dashed arrow points from it to a detailed view below. This detailed view shows a grid of pixels with three different vertical separations:  $z$ ,  $2z$ , and  $4z$ . The grid consists of four columns of pixels, each corresponding to one of the sub-matrices above. The top row of the grid is labeled 5-A, followed by 5-B, 5-C, and 5-D. The vertical distances between the rows of pixels are indicated by double-headed arrows:  $z$  between the first and second rows,  $2z$  between the second and third rows, and  $4z$  between the third and fourth rows.

**Submatrix 5-A   Submatrix 5-B   Submatrix 5-C   Submatrix 5-D**

15/16   Eva Vilella – 32nd RD50 Workshop – Hamburg, 4-6 Jun. 2018

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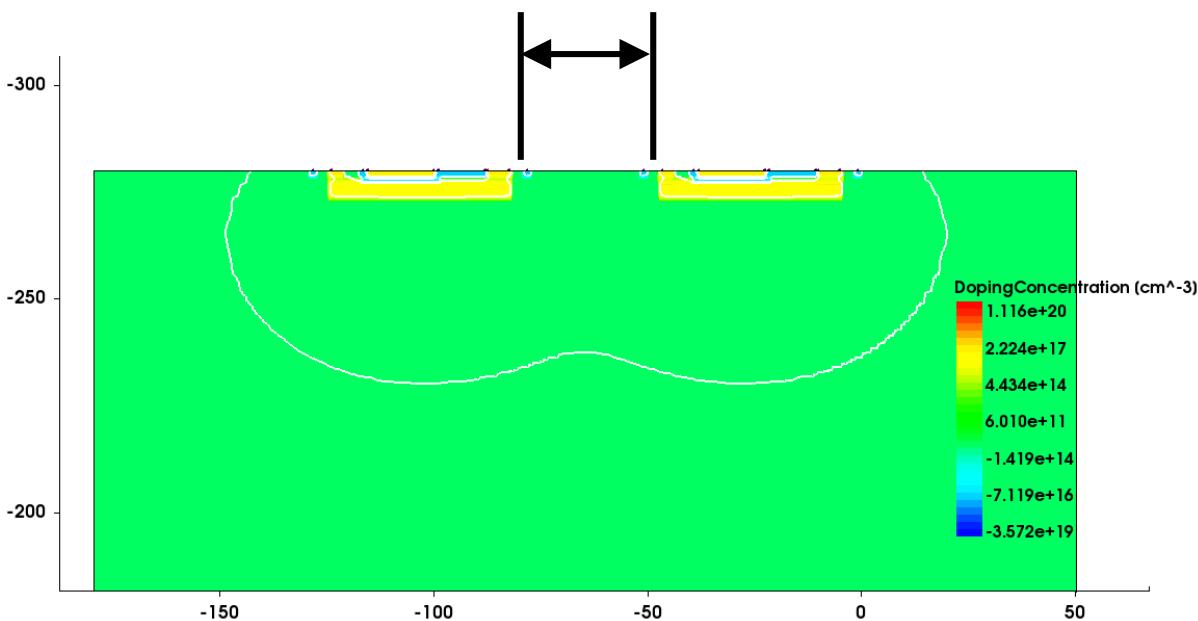
Using **RD50-MPW1** pixel simulations:

- $z = 25 \mu\text{m}$  (or whatever we choose...  $\approx 50 \mu\text{m}$  on the diagram)
- Pixel models can be dynamically created for two pixels of spacing  $1z, 2z, 4z$  etc.

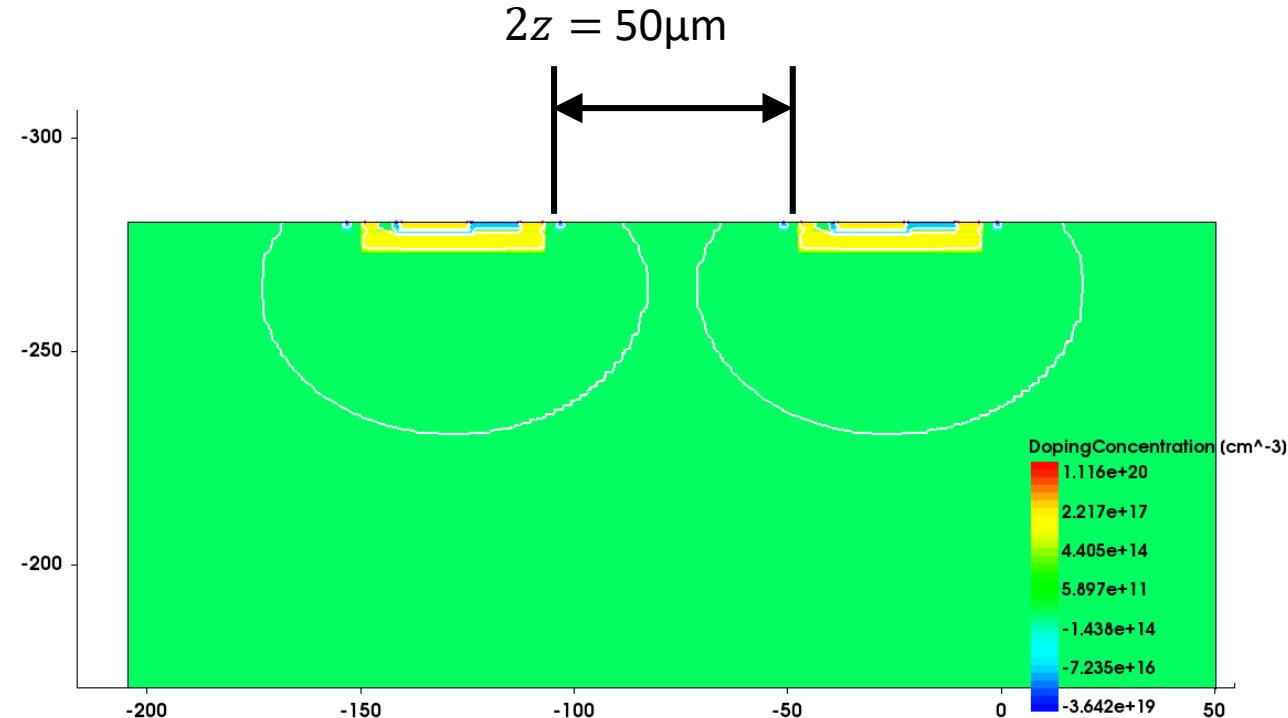
# Spacing between pixels

(Internal)

$z = 25\mu\text{m}$



$2z = 50\mu\text{m}$



$$\begin{aligned}\rho &= 500 \Omega \cdot \text{cm} \\ \Phi &= 0 \text{ n}_{\text{eq}} \cdot \text{cm}^{-2} \\ V_{\text{sub}} &= -80 \text{ V}\end{aligned}$$



# Next steps: (?)

(Internal)

- ENGRUN1 simulations
  - Remove topside contacts (backside biasing) →
  - Thinning? (thickness currently 280 µm)
  - Guard rings?
- Radiation Damage
  - More fluences (2E13, 2E14, 2E15 etc.)
  - How does irradiation affect depletion region merging between two pixels?
- Multiple pixels with spacing
  - Radiation damage (previous point)
  - Higher z
  - Same simulations for 1.9 kΩ·cm → increased depletion region size

