HR-CHESS2 Update

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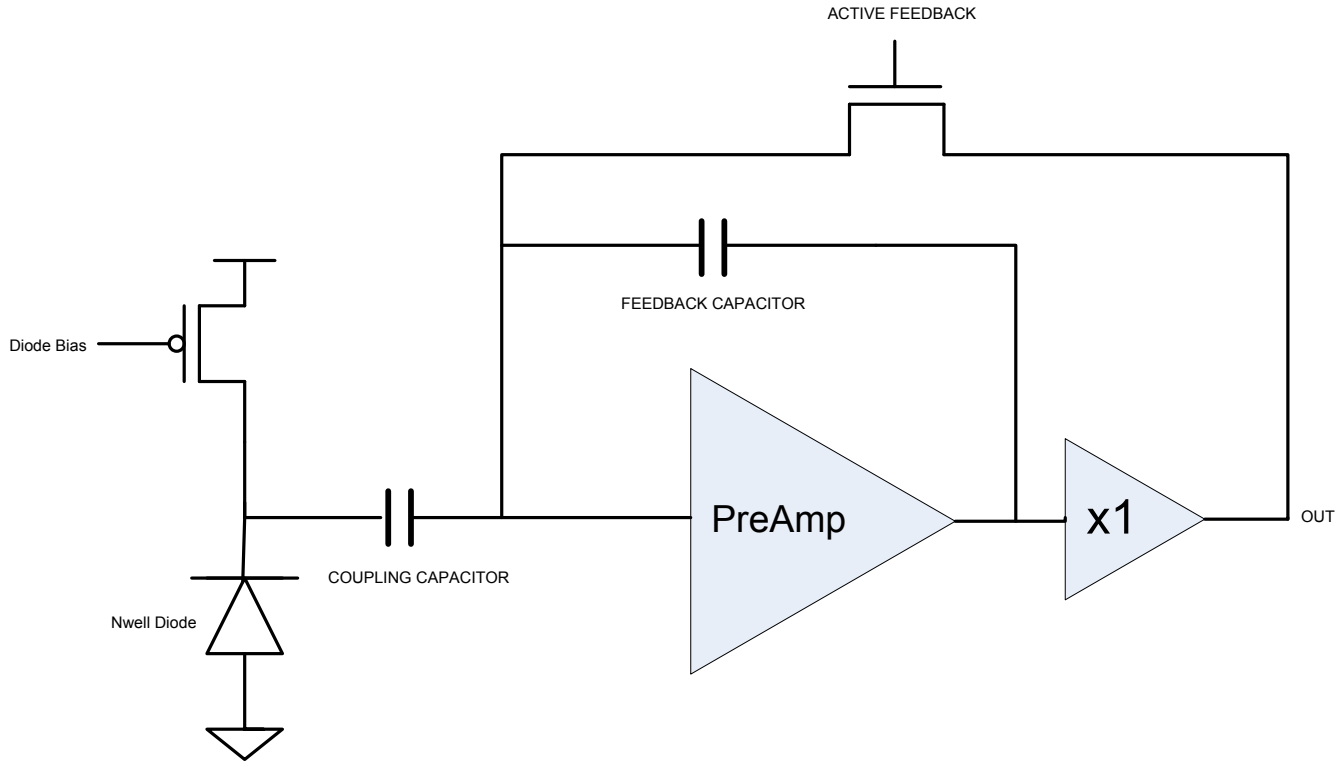
HR-CHESS2 Pre-Amplifier v2 Block Diagram



- AC coupled to block leakage current, MOS device used to bias diode
- Integrated AC coupling capacitor
- Constant current feedback
- Folded cascode architecture with source-follower inside feedback loop

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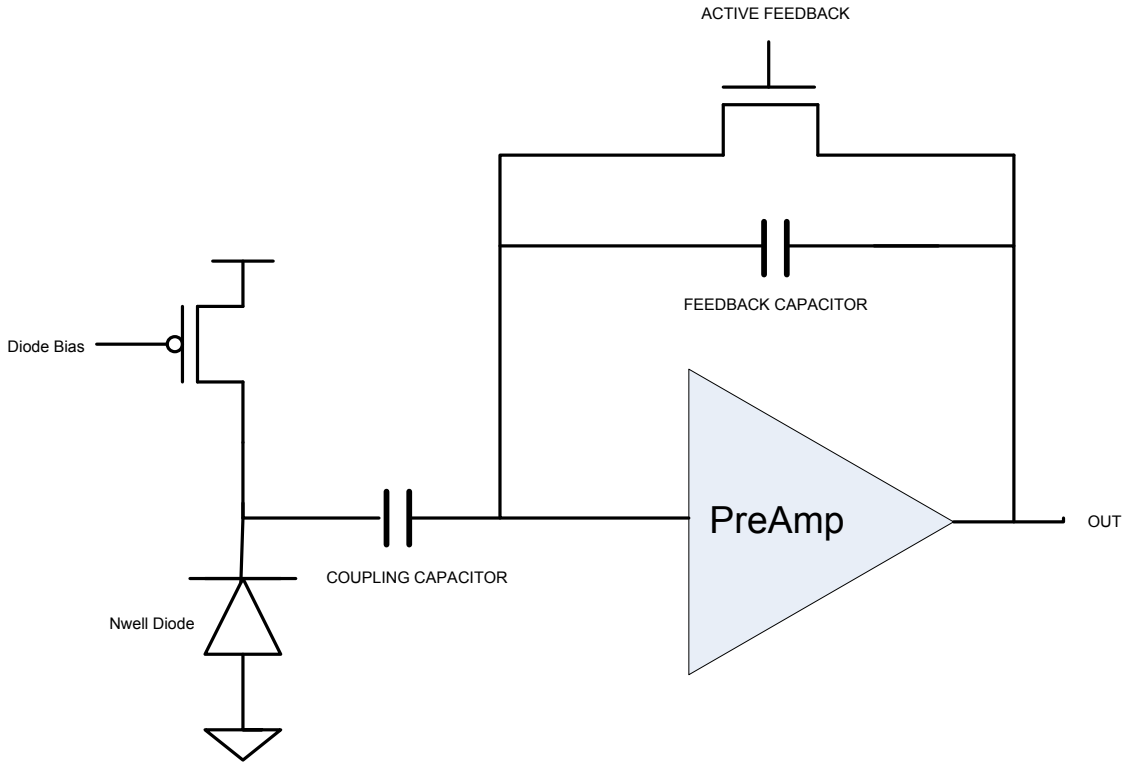
HR-CHESS2 Pre-Amplifier v3 Block Diagram



- Removed source-follower from feedback loop

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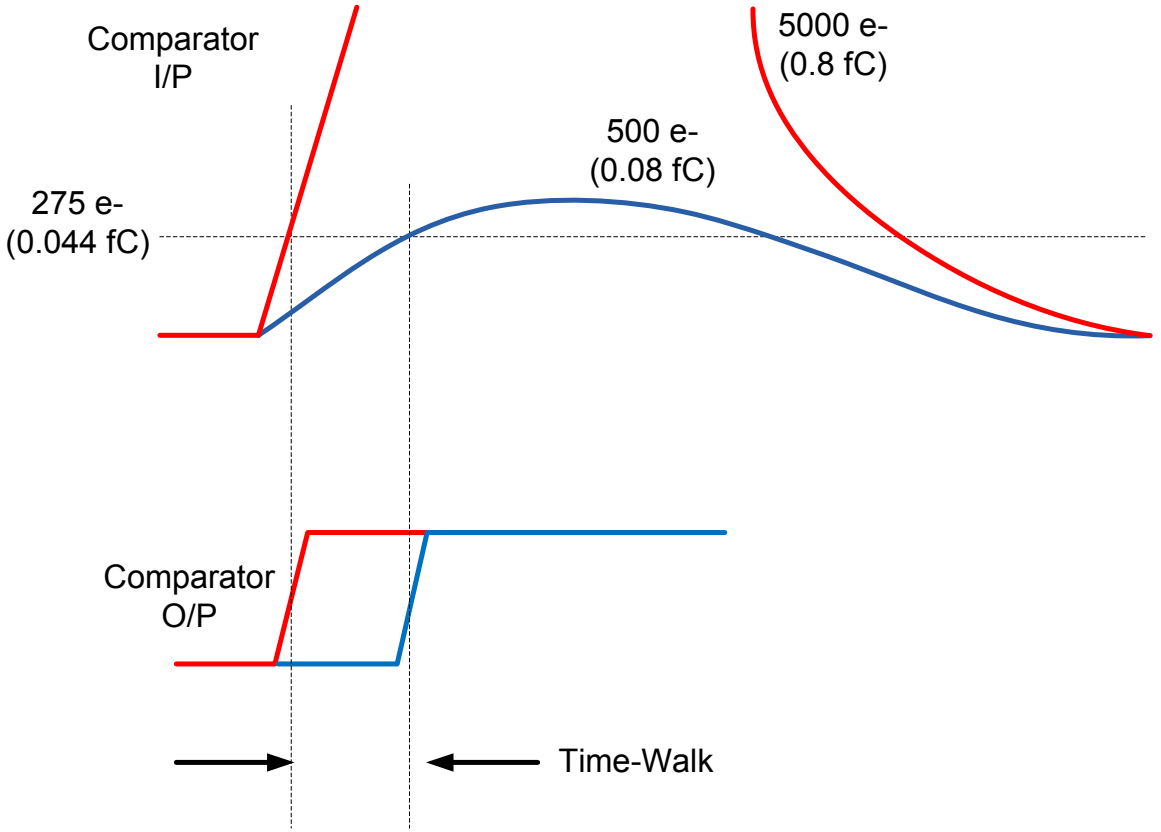
HR-CHESS2 Time-Walk Specification



Dependence of comparator fire time on signal must be < 1 BX i.e. 25ns

≤ 16 ns time difference between comparator leading edges for input signal of size 500 e- and 5000 e- with a threshold set at 275 e-

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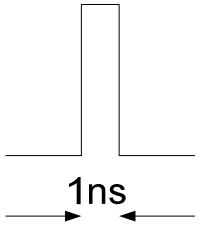
HR-CHESS2 Time-Walk Simulations

Specification < 16ns

Threshold adjusted for each process corner (small differences)

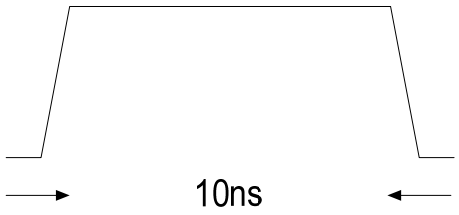
Time-Walk (~1ns charge collection time)

	NOM	FAST	SLOW
+40°C	6.95ns	6.5ns	7.9ns
-40°C	5.32ns	4.9ns	6.2ns



Time-Walk (~10ns charge collection time)

	NOM	FAST	SLOW
+40°C	10.54ns	9.37ns	11.02ns
-40°C	7.5ns	7ns	8ns



Meets specification in all corners

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HR-CHESS2 Design Progress Summary

- Modified pre-amplifier design to make it faster & more immune to leakage current
- Looking into design of pre-amplifier feedback capacitor as it's small ≈ 1fF
- Simulating Trim DAC for comparator offset compensation
- Preparing for layout of the design
- Preparing documentation for the first design review of HR-CHESS2 to be held mid to late October

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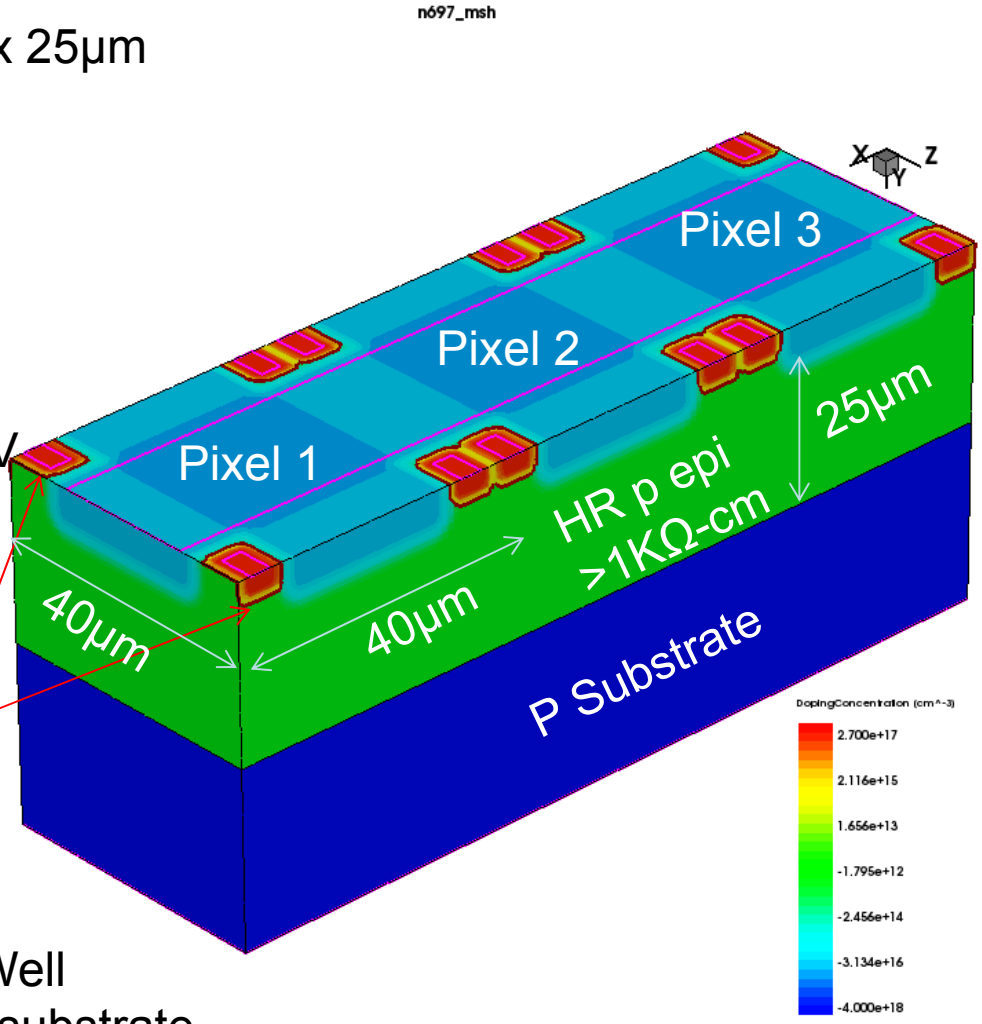
3-D structure for leakage current simulation

Pixel Volume = 40µm x 40µm x 25µm
Epi Depth = 25µm
No. of Pixels = 3
Type of Diode = N-Well/p epi
No. of Diodes per Pixel = 4
N-Well Bias = 1V
P-Well Bias = 0V
Back Contact Bias = 0 to -200V



- Electronics inside Deep P-Well
- Constant doping of epi and substrate
- N-Well and P-Well has analytical doping profiles

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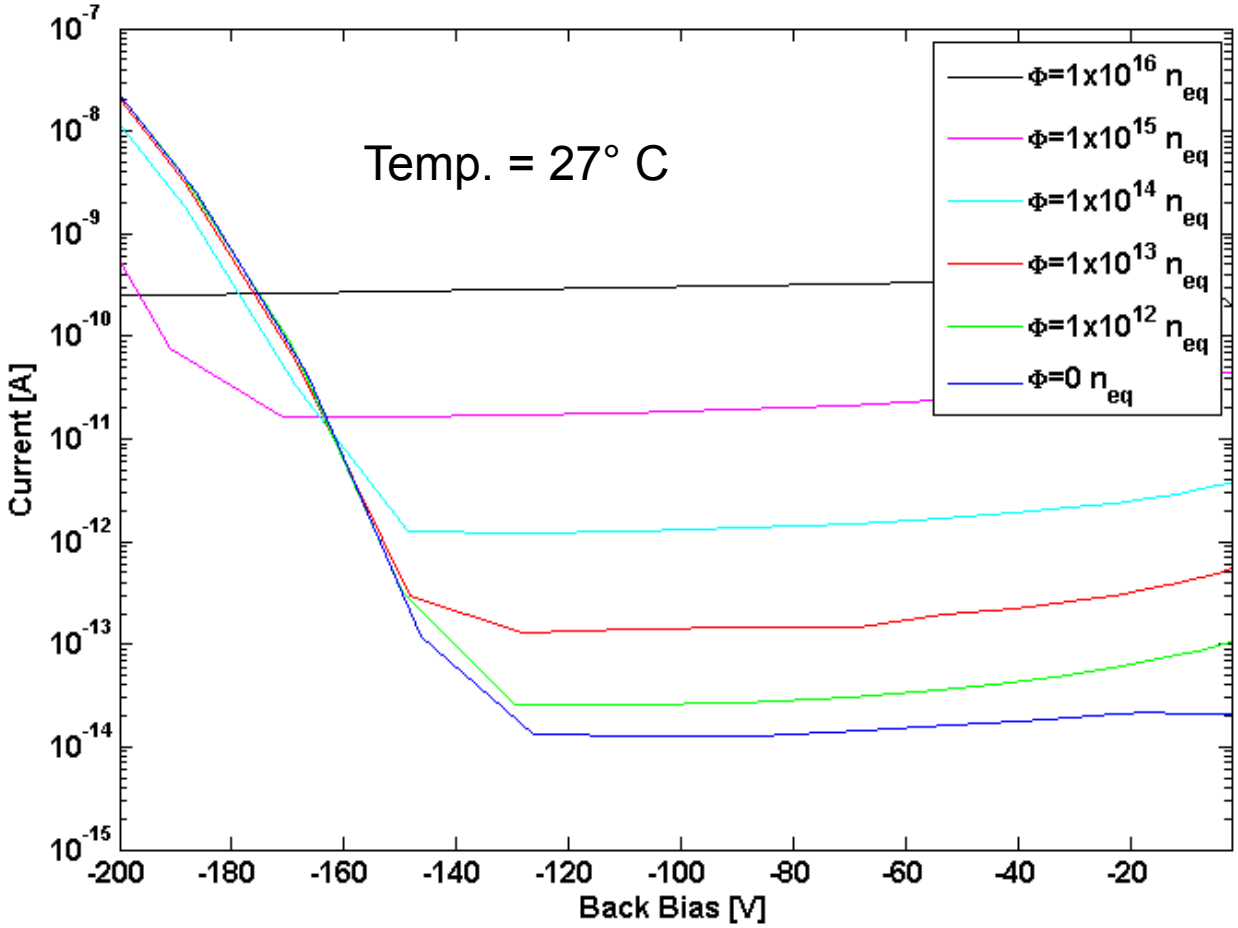
Leakage current vs bias at different fluences



Radiation Damage Model Used:
D. Pennicard et al. / Simulations of radiation damaged 3D detectors for the Super-LHC NIMA 592 (2008) 16–25
IEEE Trans. Nucl. Sci., vol. 53, pp. 2971–2976, 2006 "Numerical Simulation of Radiation Damage Effects in p-Type and n-Type FZ Silicon Detectors", M. Petasecca, F. Moscatelli, D. Passeri, and G. U. Pignatel

Breakdown voltage increases with fluence because effective doping concentration increases with irradiation!

- Back Bias varied from 0V to -200V (until breakdown)
- Current of Pixel 2 (middle) recorded
- Leakage current **< 500pA** for fluence of $1x10^{16}$ n_{eq} [cm^{-2}]

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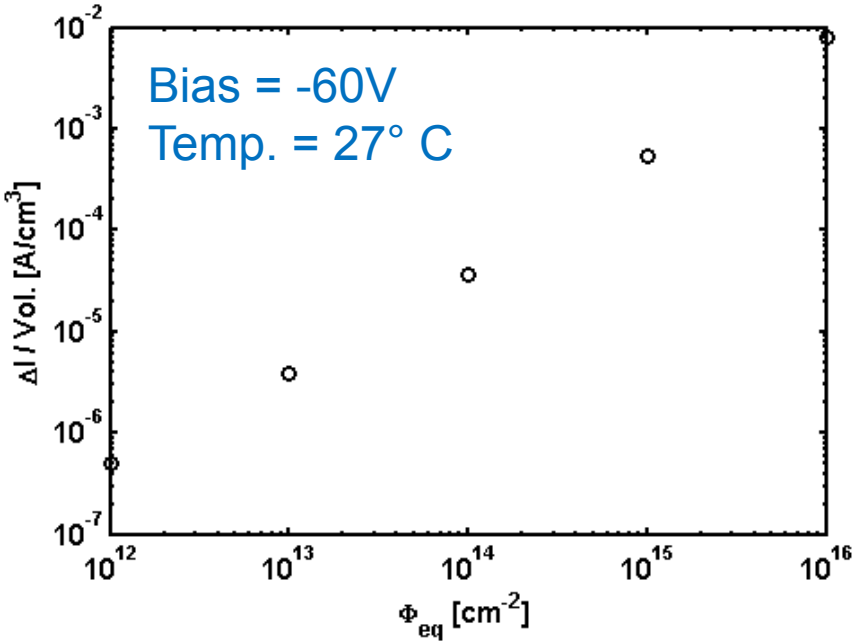
Leakage current vs geometry

During simulated irradiation dark current increases linearly with fluence:



$$\frac{\Delta I}{V} = \alpha \, \Phi_{eq}$$

V = volume of sensor
ΔI = increase of total leakage current
Φ_{eq} = equivalent fluence
α = Current related damage rate

Current related damage rate is temperature dependent ➔ α(T)

Geometry	Leakage Current @ 1 x 10^{16} n_{eq} [cm^{-2}]
40µm x 25µm x 40µm	3.2pA
40µm x 25µm x 80µm	6.4pA
40µm x 25µm x 120µm	9.6pA
40µm x 25µm x 200µm	1.6nA
40µm x 25µm x 400µm	3.2nA
40µm x 25µm x 800µm	6.4nA

From simulation results at 27°C:
$\alpha \approx 80 \times 10^{-18}$ A/m