

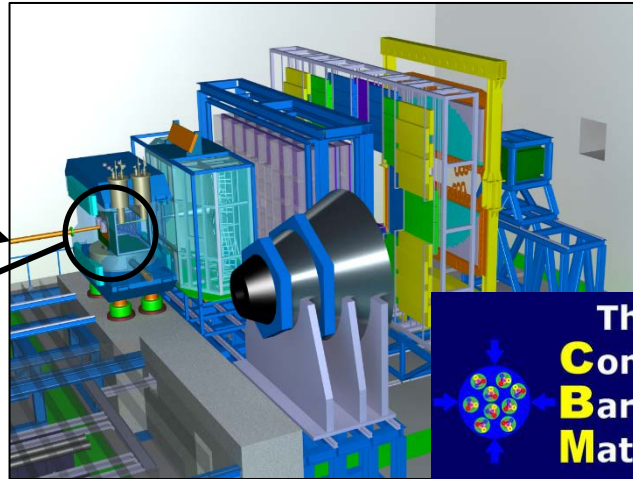
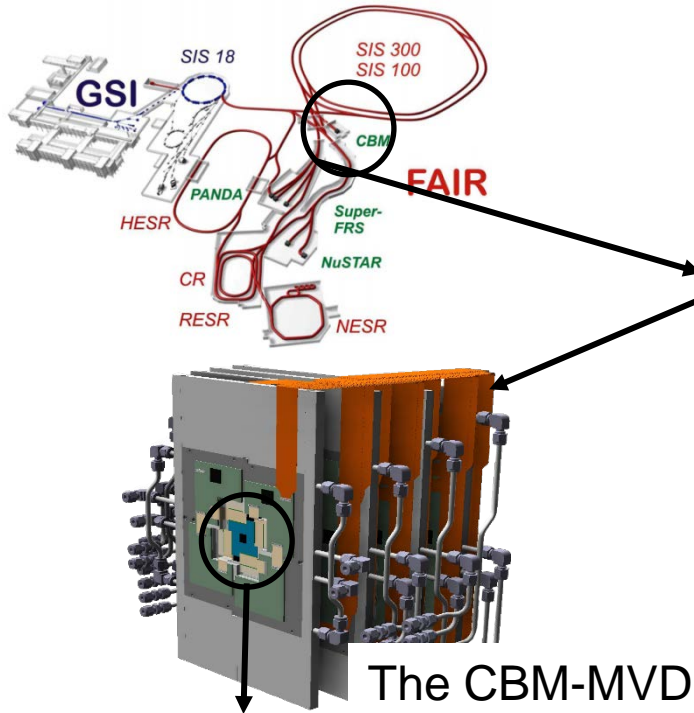


Radiation hardness of fully depleted CMOS Monolithic Active Pixel Sensors

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MAPS – Monolithic Active Pixel Sensors

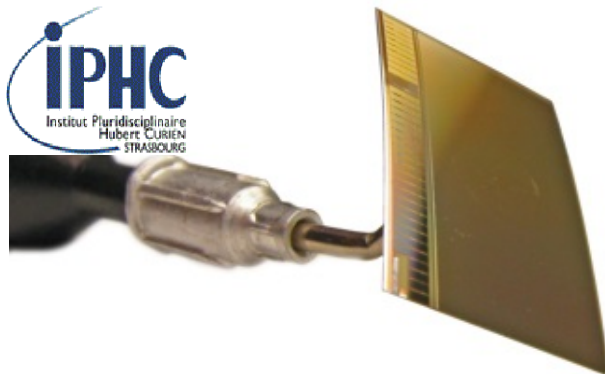


The
Compressed
Baryonic
Matter experiment

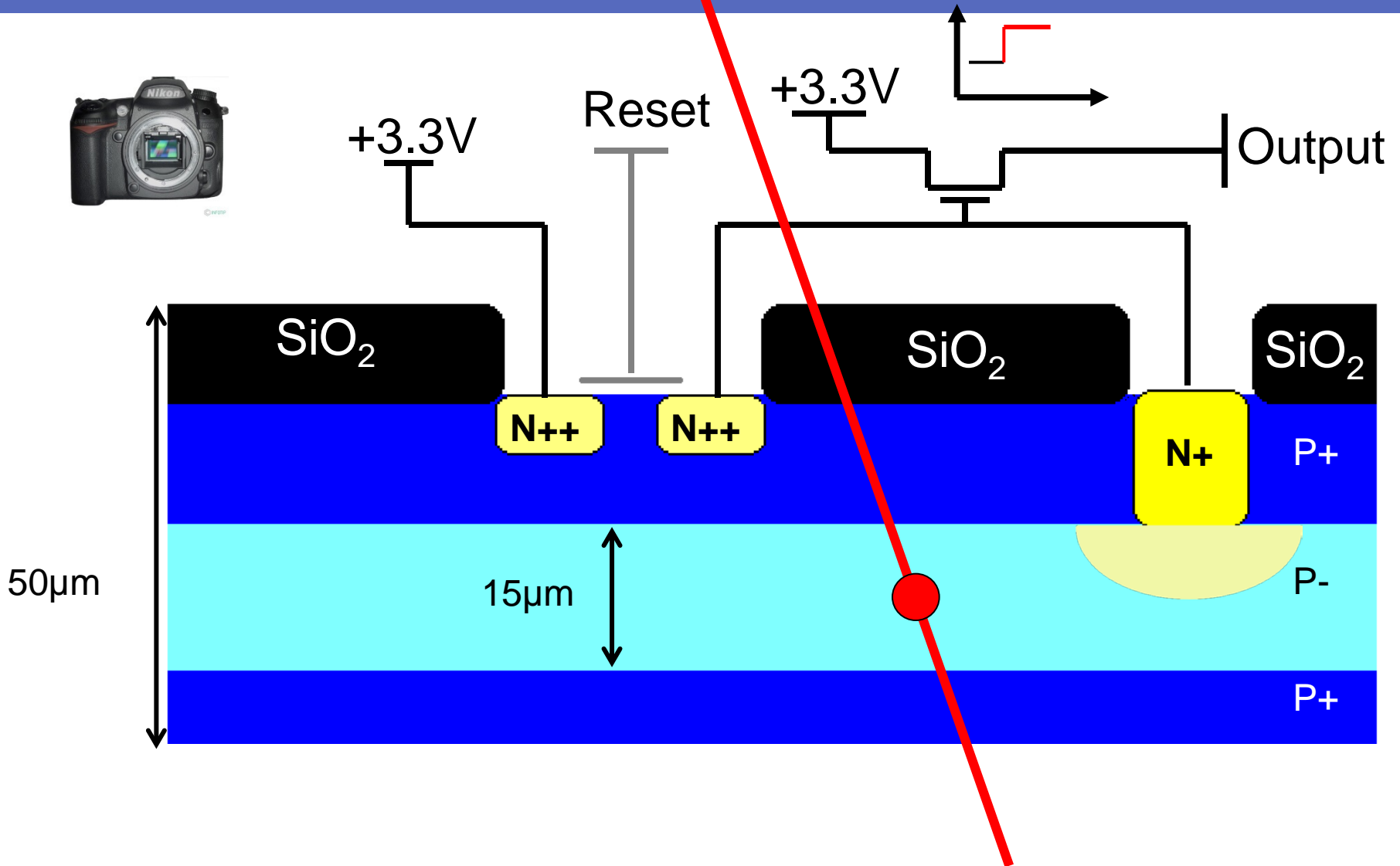


MimoSIS design goals:

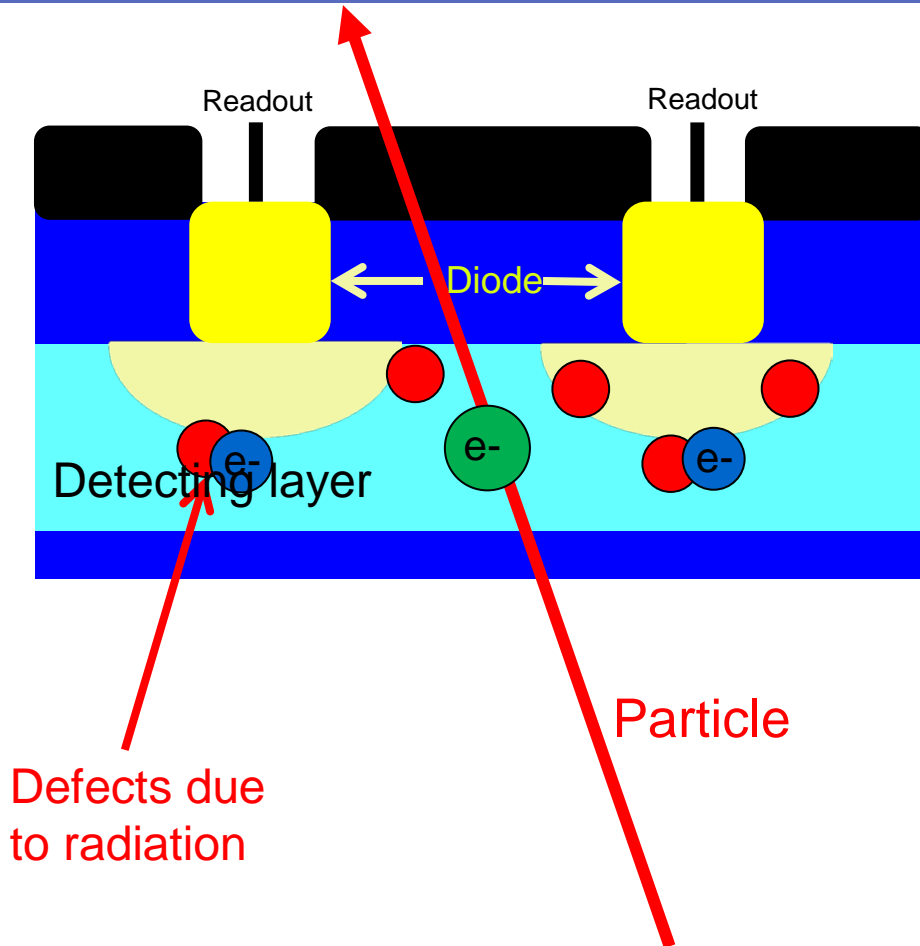
	MIMOSIS – Expected performance
CMOS Process	Tower/Jazz 0.18 μm Quad-Well
Pixel dimensions	30.1 x 26.9 μm^2
Spatial resolution	$\sim 5\mu\text{m}$
Material budget	50 μm Si (0.05 % X_0)
Radiation tolerance	> 3Mrad (@-20°C). > $3 \times 10^{13} n_{\text{eq}}/\text{cm}^2$



MAPS – Monolithic Active Pixel Sensors



Effects of non-ionizing radiation



Trapping & recombination of **signal electrons**

Leakage current → higher noise

❄️ Cooling decreases this effect +

Depleting the sensor allows to accelerate the charge collection.
=> More radiation tolerance.

Pipper – 2: A fully depleted HR-MAPS

Issue:

Standard CMOS restricted to few volts
=> Too few for full depletion.

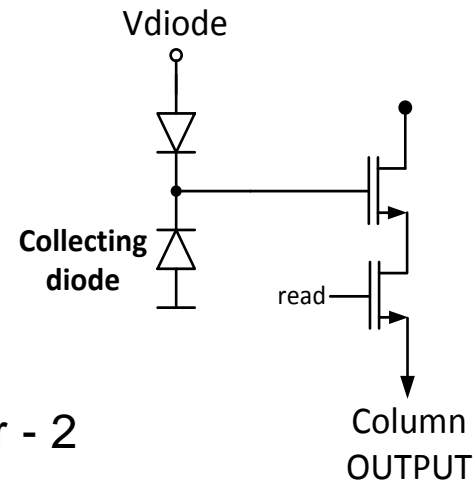
Analysis:

Restriction due to transistor gates.
Diodes and metal lines tolerate higher voltages.

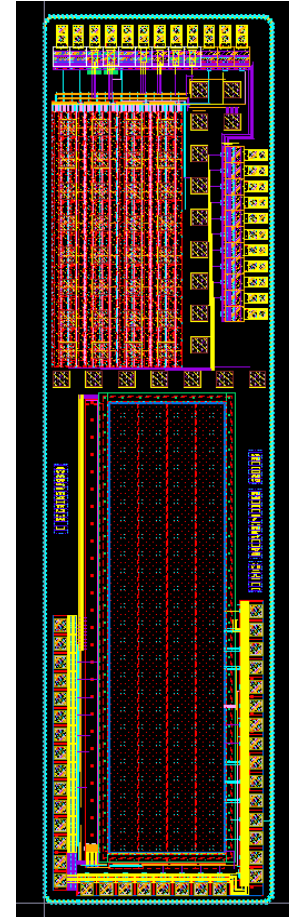
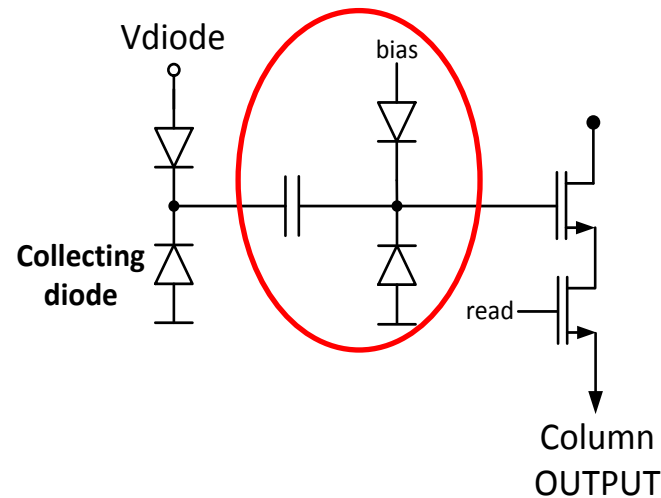
Approach:

Use AC-coupling to separate vulnerable transistors from HV on diode.
=> Depletion voltage up to 40V possible.
Apply to 22x22 μm^2 pixels.

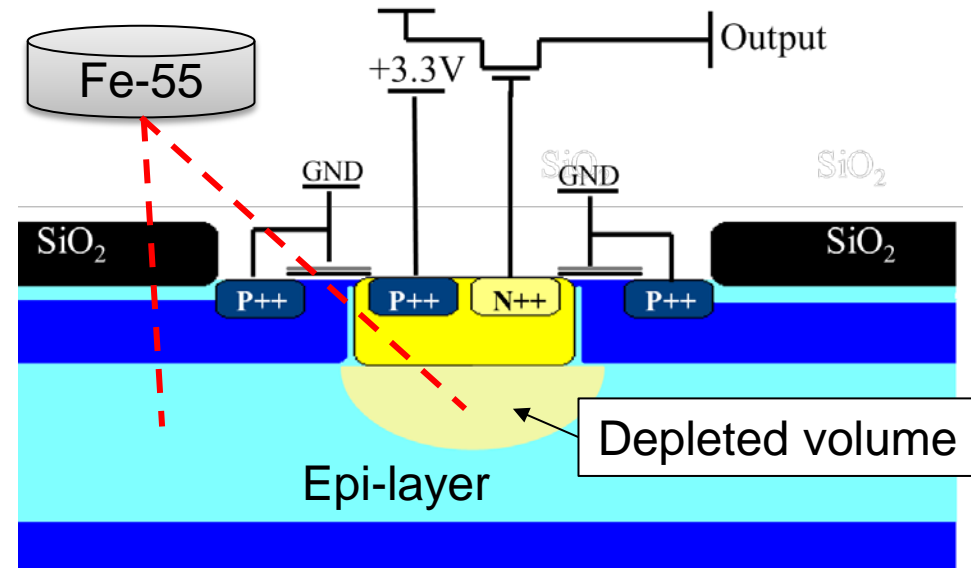
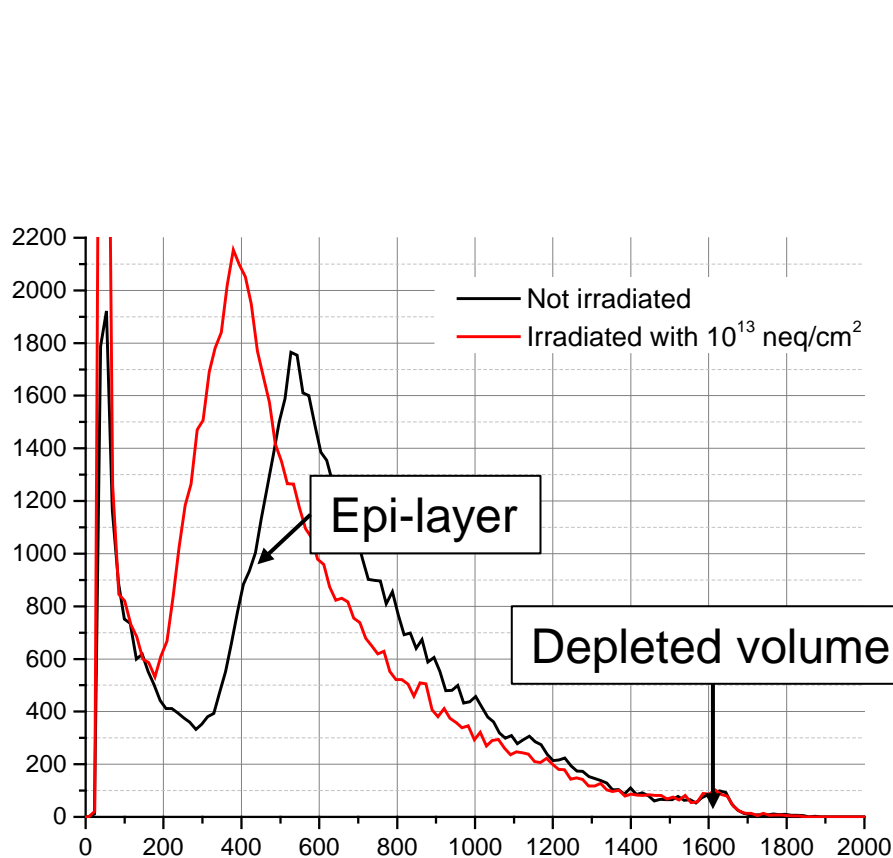
Standard pixel



Pipper - 2

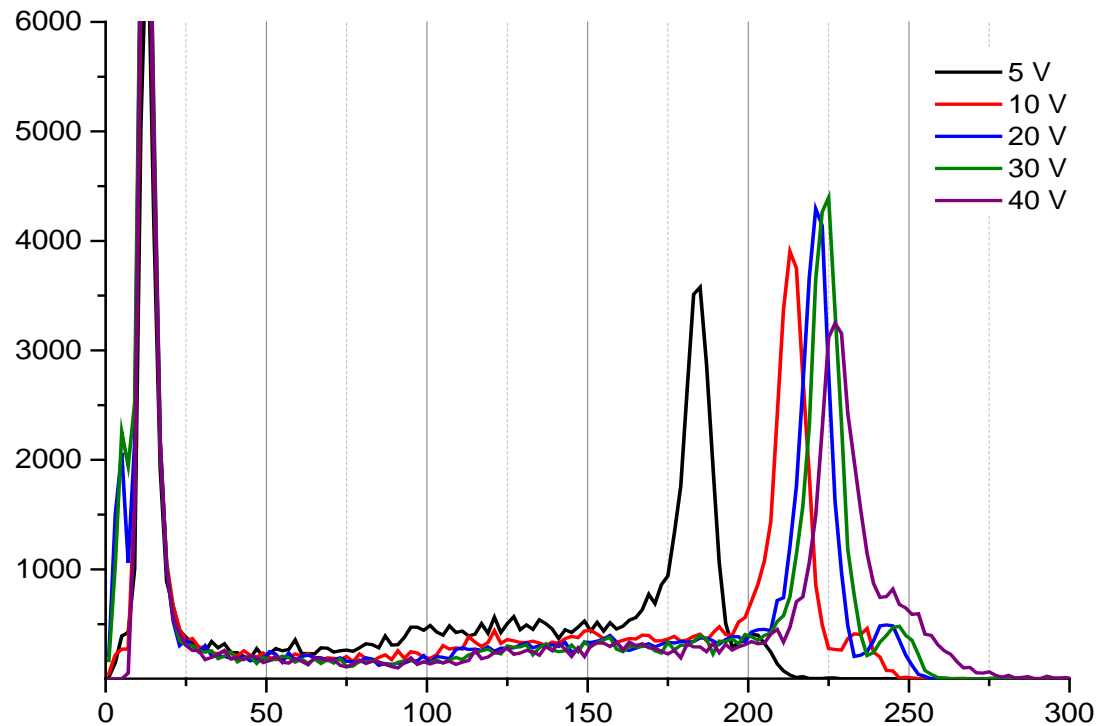
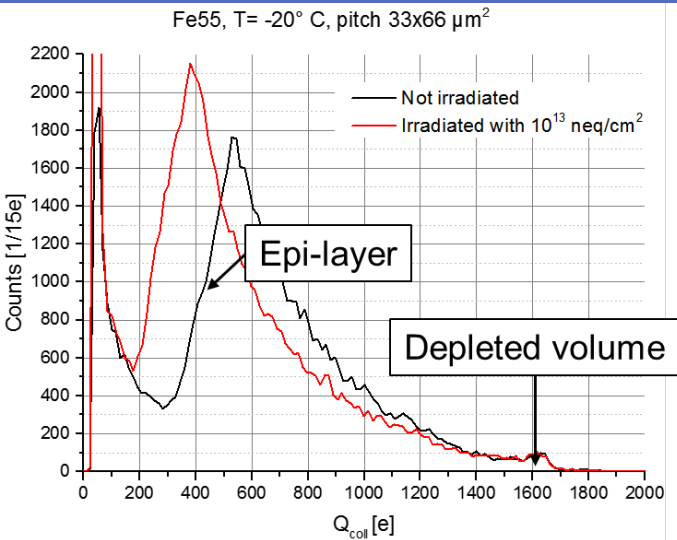


Standard sensor – Test results



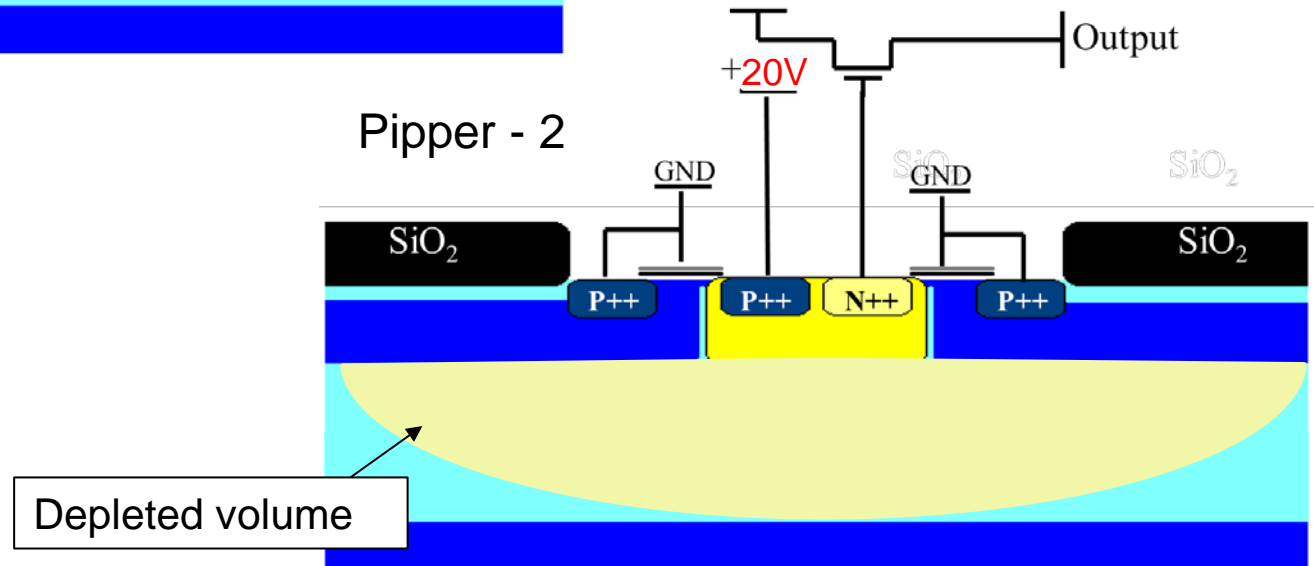
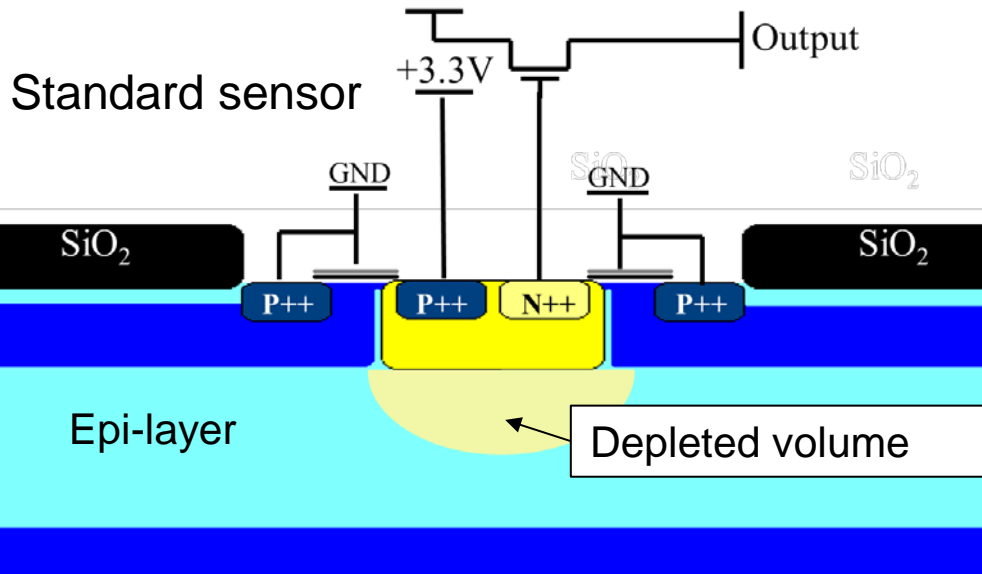
Standard sensor – Only few hits from depleted volume.
Other hits: Reduced amplitude (charge sharing).

Pipper – 2 – Test results

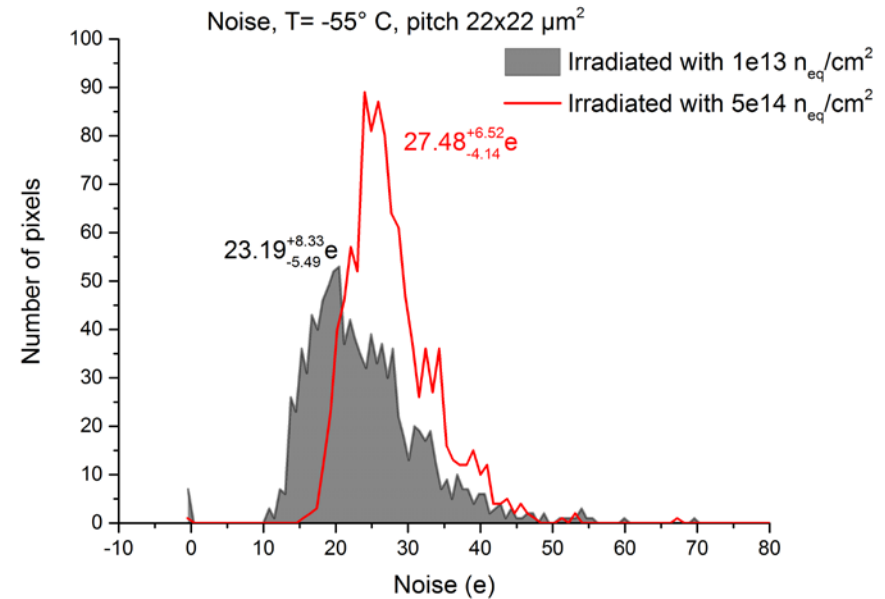
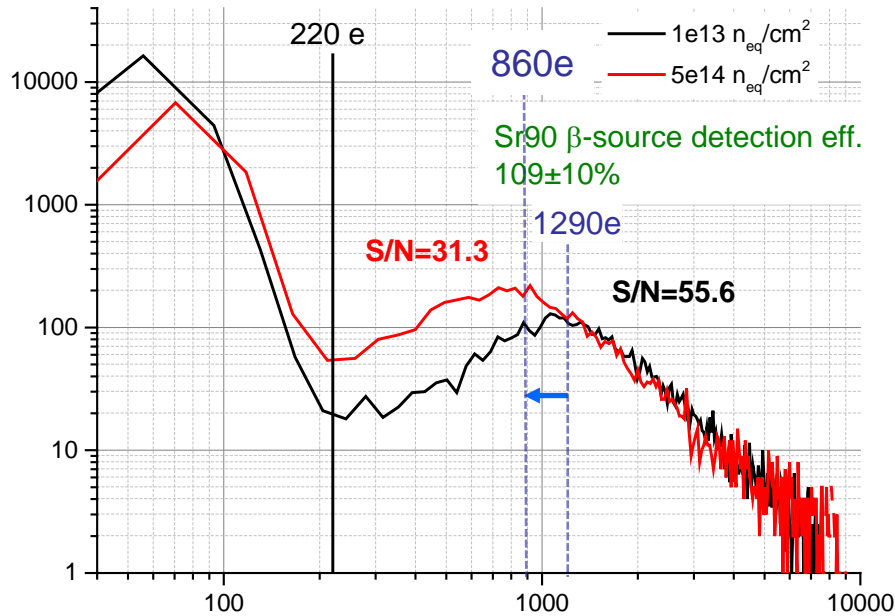


Hits mostly in depleted volume peak.
No modification for >20V => indicator for full depletion

Vllt keine zeit dafür?



Test with ^{90}Sr beta rays



S/N (Sr-90) $> 15 \Leftrightarrow$ typically $> 99\%$ MIP - efficiency

$T = -55^\circ \text{C}$	Signal MPV (e)	Avg. noise (e)	S/N
$10^{13} n_{\text{eq}}/\text{cm}^2$	1290	23.19	55.6
$5 \cdot 10^{14} n_{\text{eq}}/\text{cm}^2$	860	27.48	31.3



Summary and conclusion

A CMOS sensor allowing for **40V depletion** voltage in Tower/Jazz 0.18 μm has been built and tested.

Results suggest full depletion.

Laboratory tests suggest tolerance to $>5 \times 10^{14} n_{\text{eq}}/\text{cm}^2$. (Remaining S/N > 30 if cooled).

Radiation tolerance (MIMOSA-series)

