Progetto Gr. V TN
HYDE - 2014

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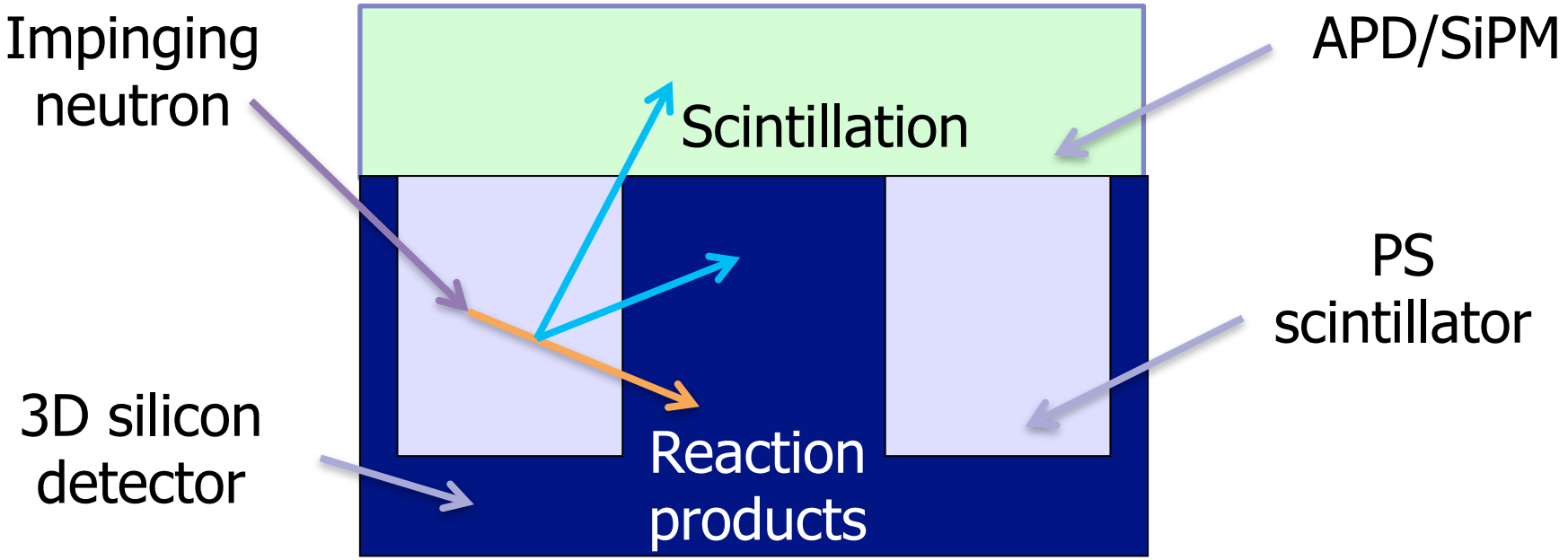
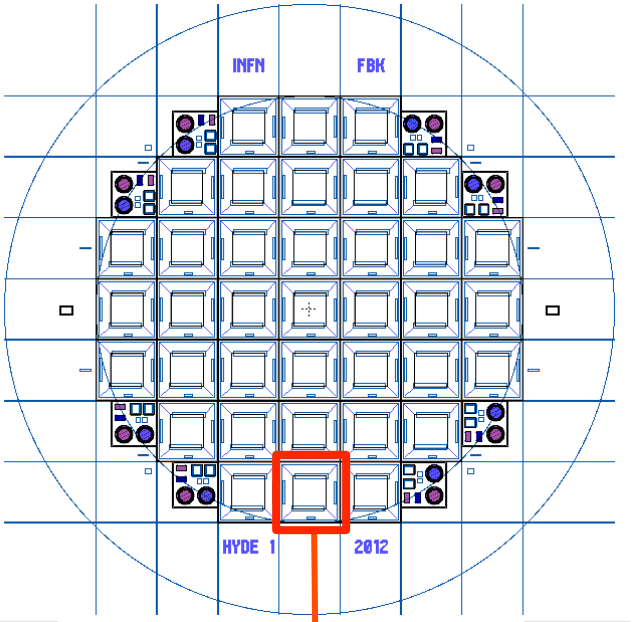
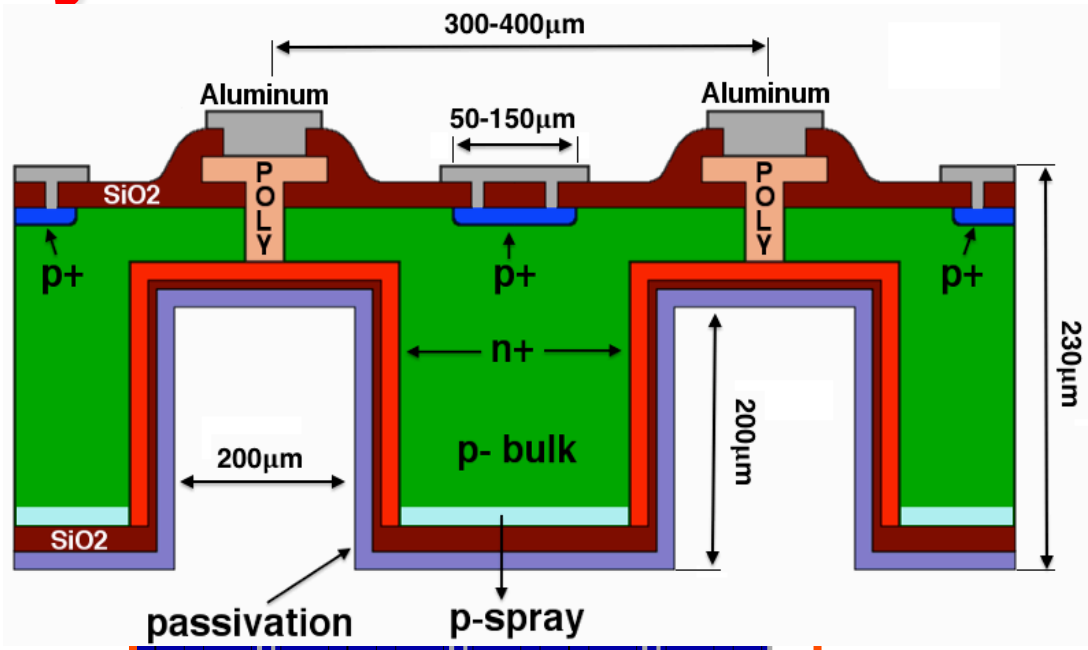
HYDE: New hybrid detectors for neutrons

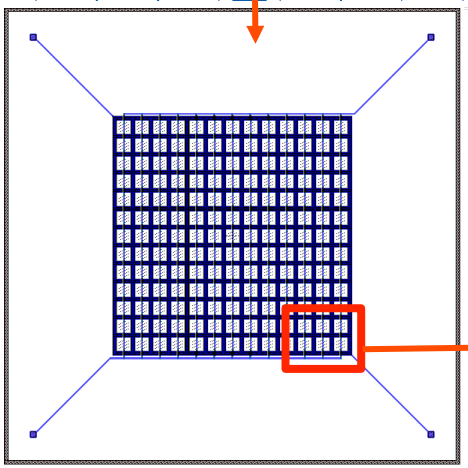


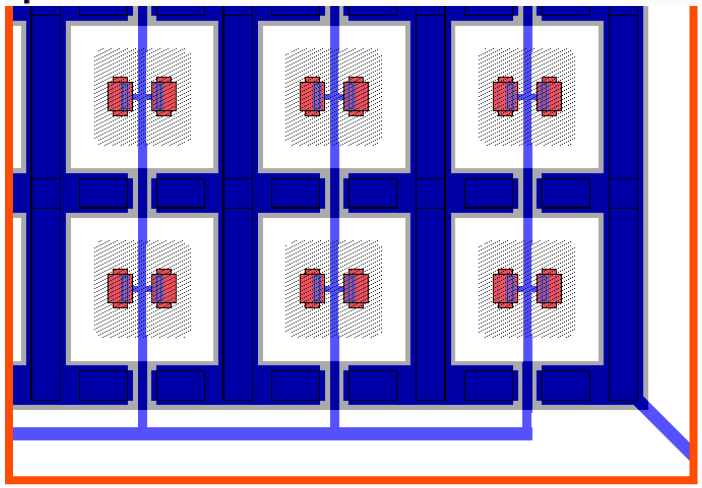
- Hybrid detectors obtained by pouring polysiloxane scintillators (from ORIONE) into 3D silicon detector cavities (from TRIDEAS)
- Increase of the active interaction volume for neutron, giving higher detection efficiencies.
- Reaction products detected in 3D silicon sensors, coupling to a multiplication photodetector for the detection of the scintillation light.

Wafer layout HYDE-1





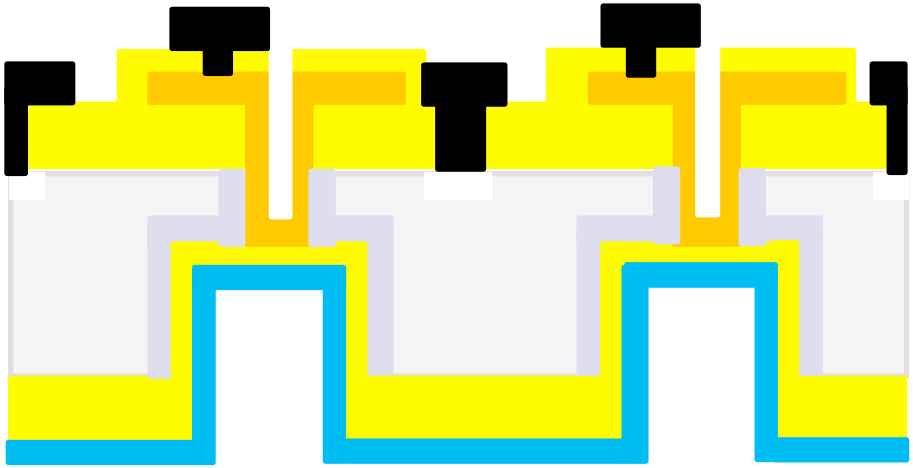




Fabrication process @ FBK

Option A: n diffusion

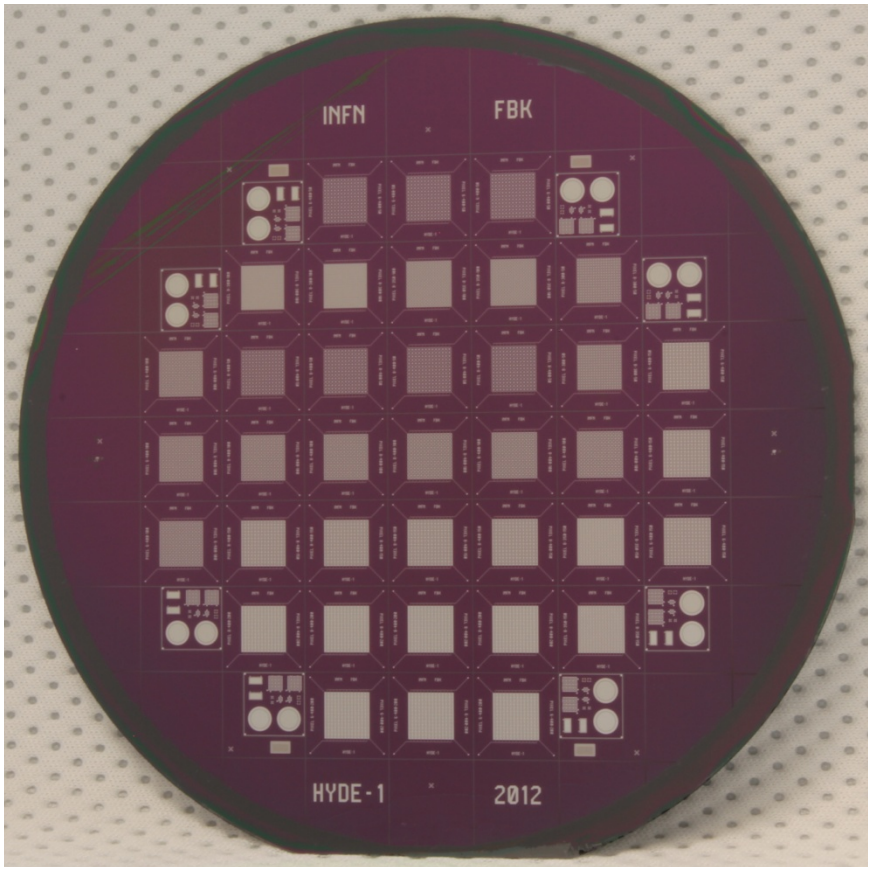
Option B: poly + n diffusion



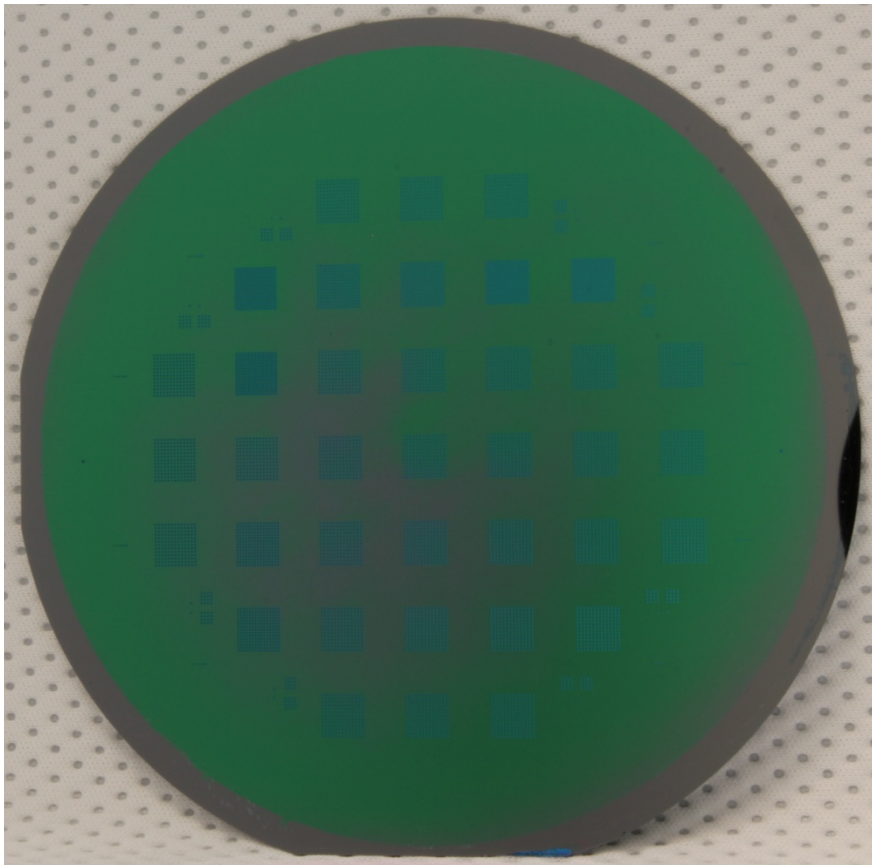
- p-type FZ wafers, 230 μm thick:
  - isolation by p-spray on back side
  - p-plus bulk contact on front side
- 2 DRIE processes: cavities (200 μm) and feed-through vias (30 μm)
- P-doping by diffusion from solid source
- Splitting on feed-through vias: n-diffusion or n-doped poly-Si

Processed wafer

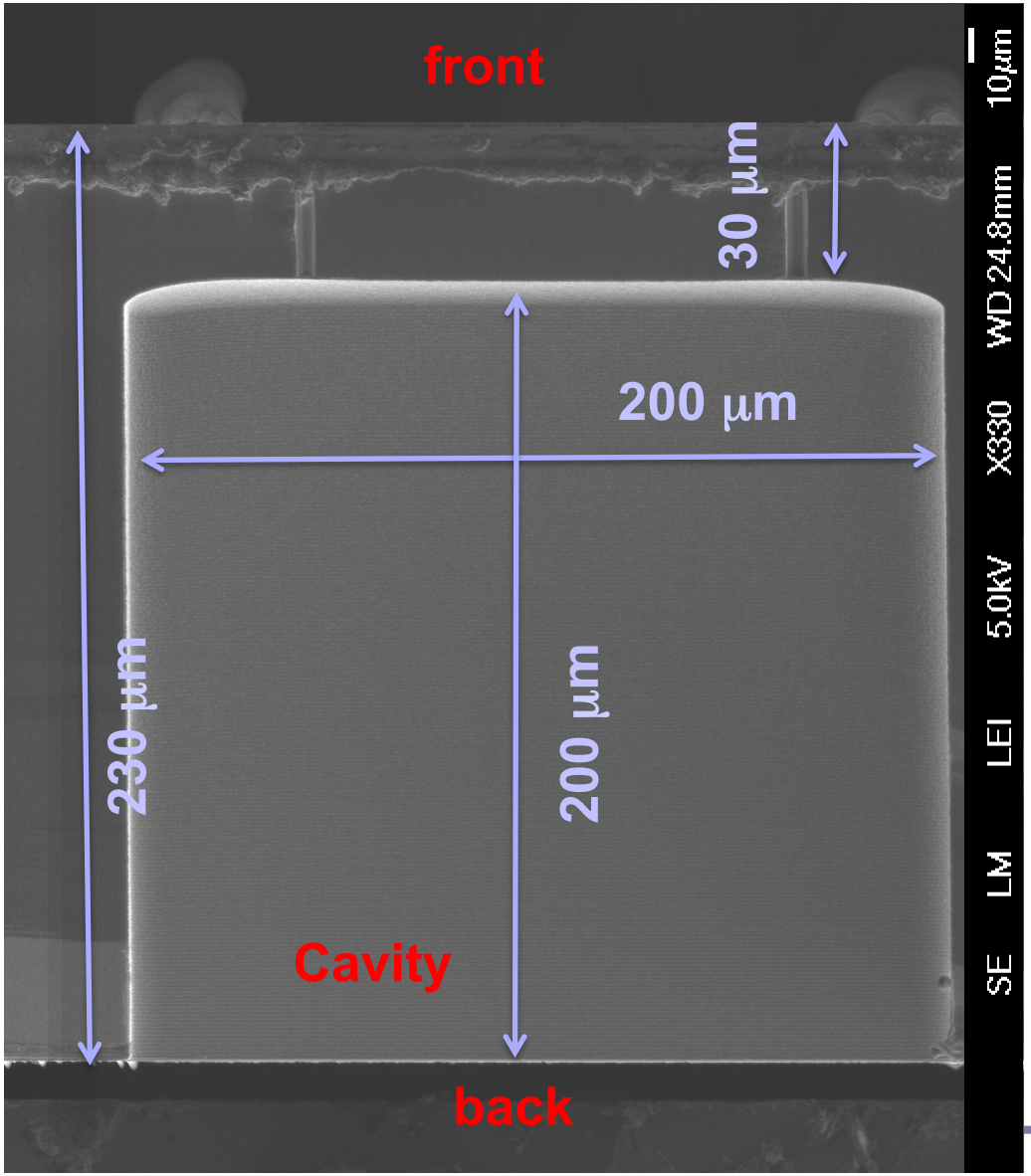
Front (all contacts)

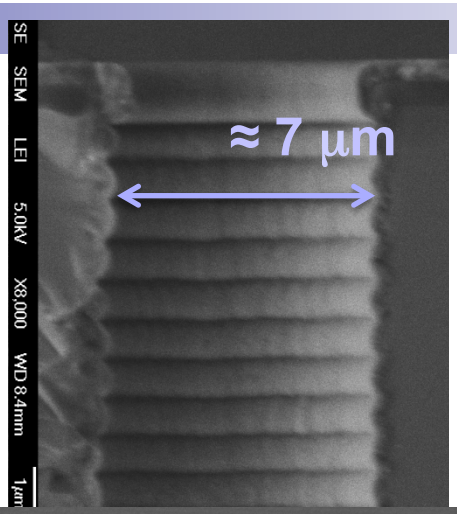


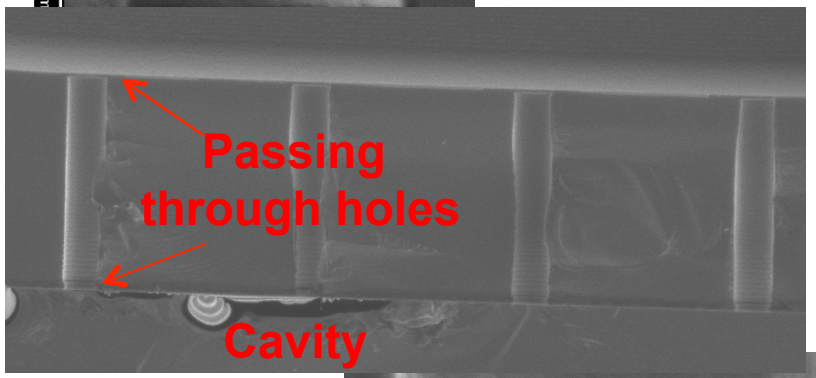
Back (only cavities)

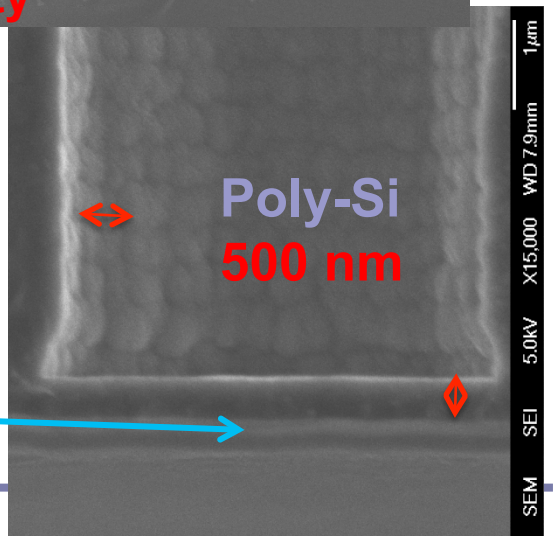


Cross-sections at SEM



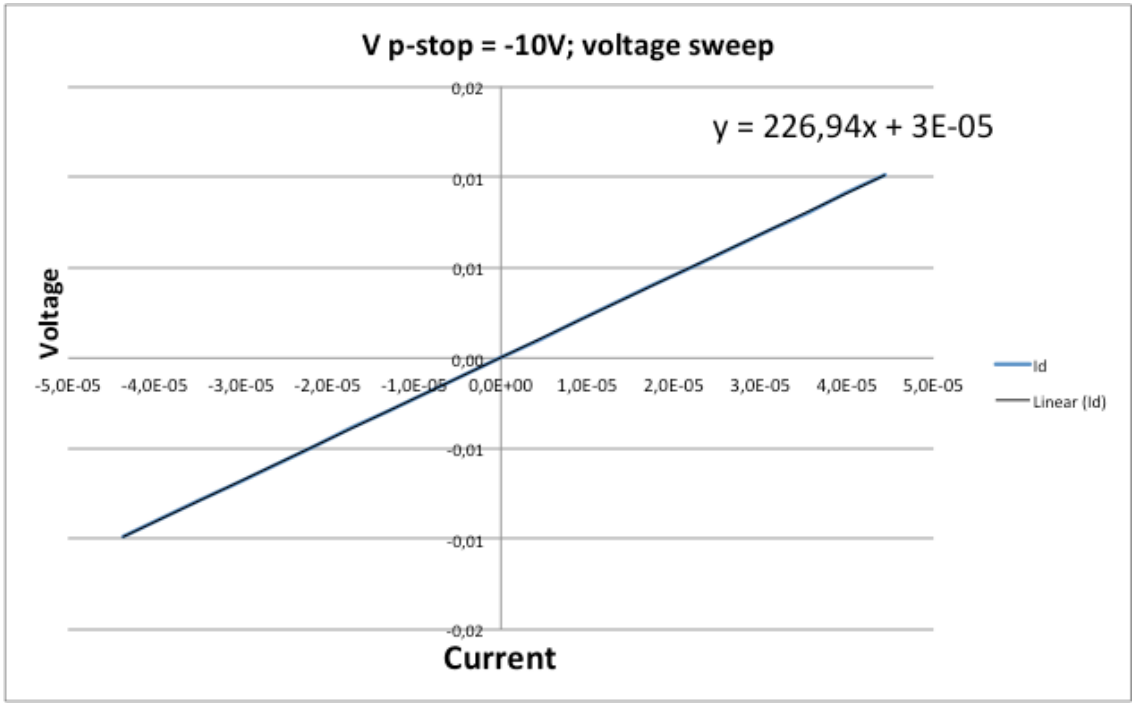


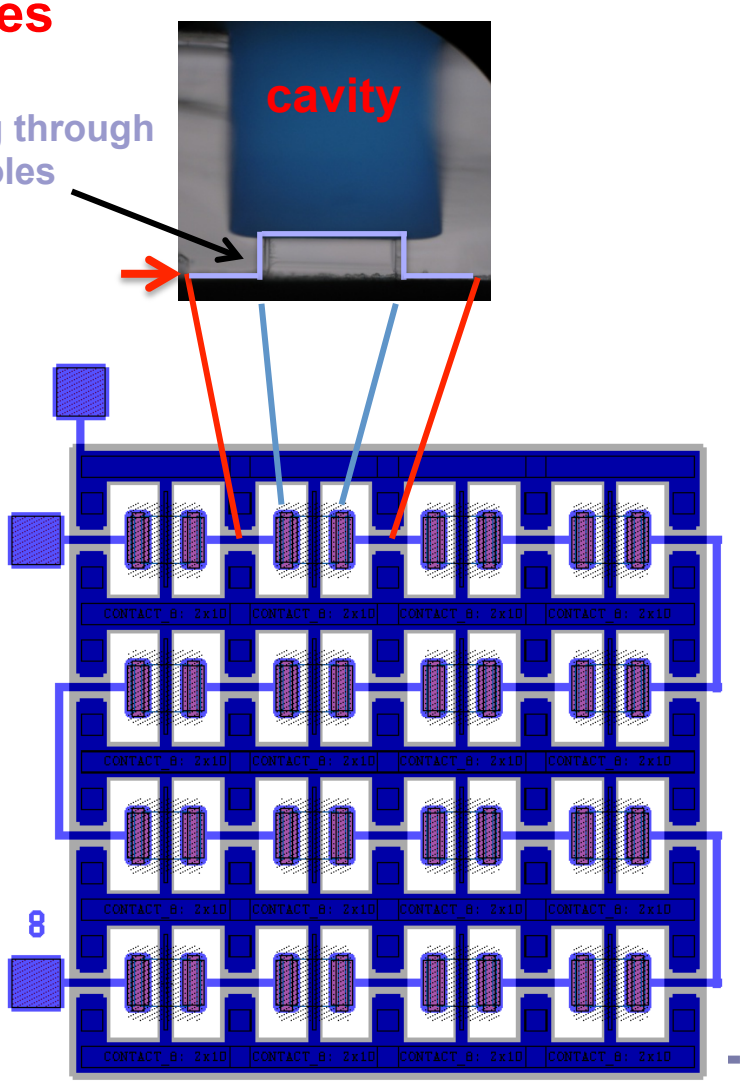




Via holes tests

Back/front contact checking on test structures





Total resistance ~ 200 Ohm

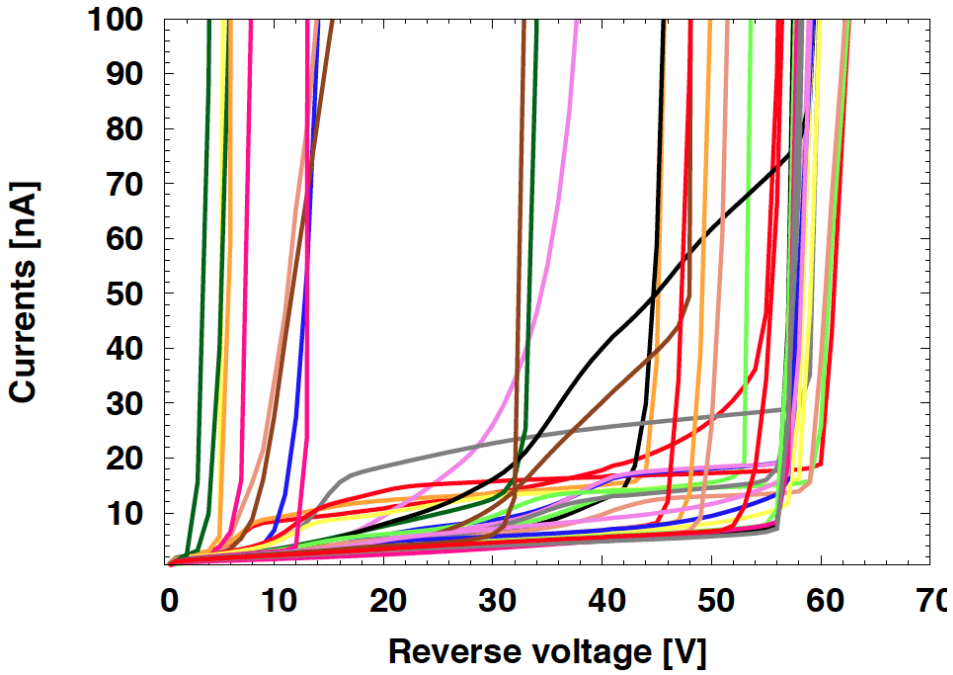
Wafer 2: with poly

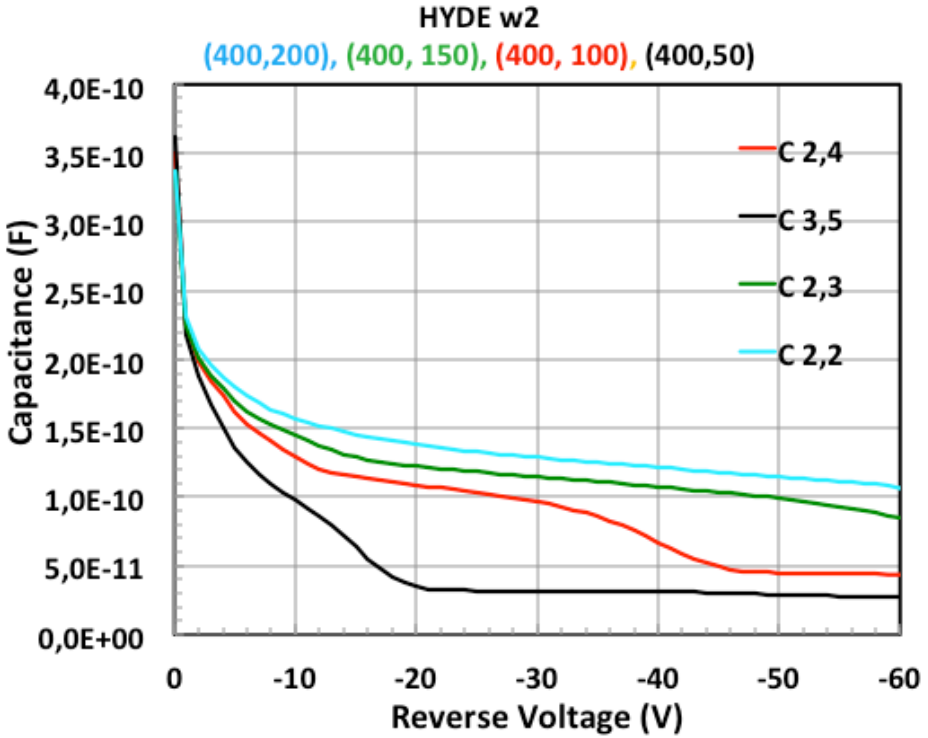
Electrical test on pixel dies with different geometries

- From I-V: leakage current of a few nA/cm^2

and breakdown voltage of 50-60V (lower values due to defects).

- From C-V: two-phase depletion mechanism: rapid decrease due to lateral depletion, slower decrease of the other regions, with trend compatible with the different geometries of pplus.





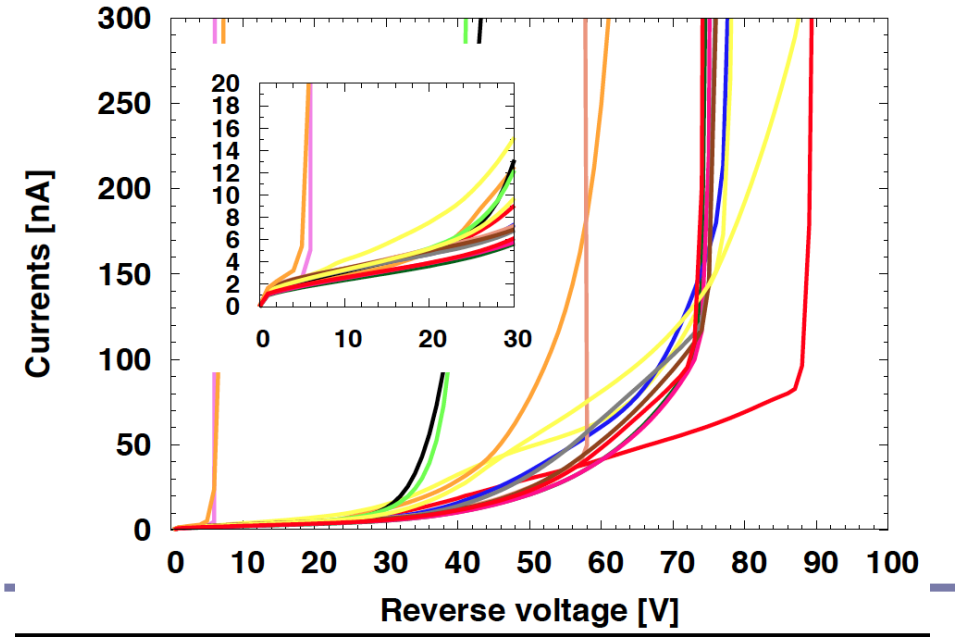
Wafer 10: without poly

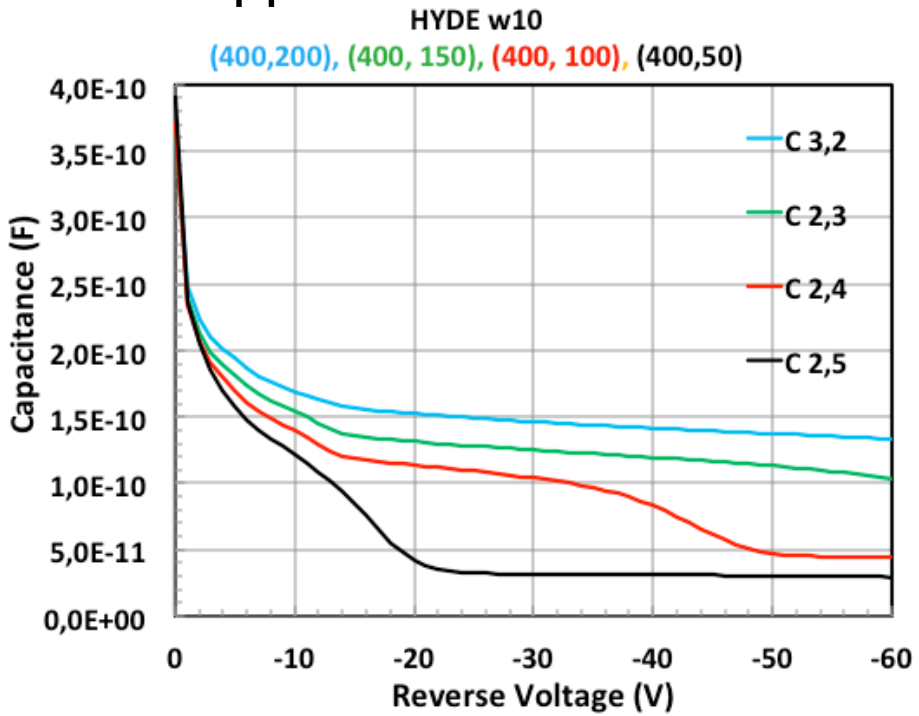
Electrical test on pixel dies with different geometries

- From I-V: leakage current of a few nA/cm^2

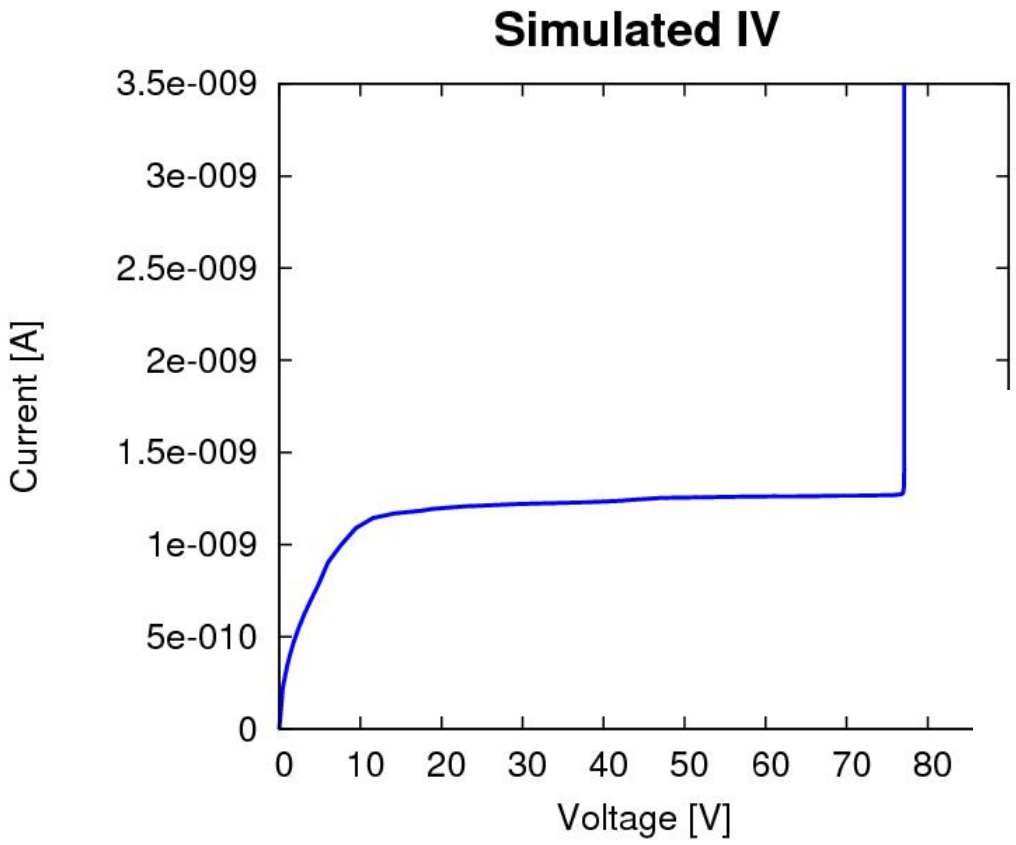
and breakdown voltage of 70-90V (lower values due to defects).

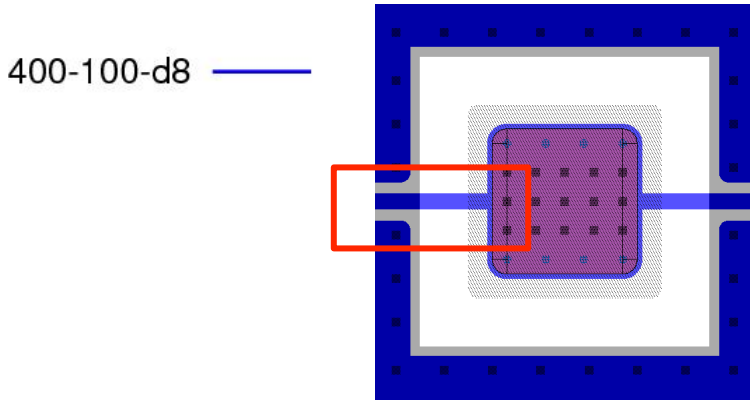
- From C-V: two-phase depletion mechanism: rapid decrease due to lateral depletion, slower decrease of the other regions, with trend compatible with the different geometries of pplus.

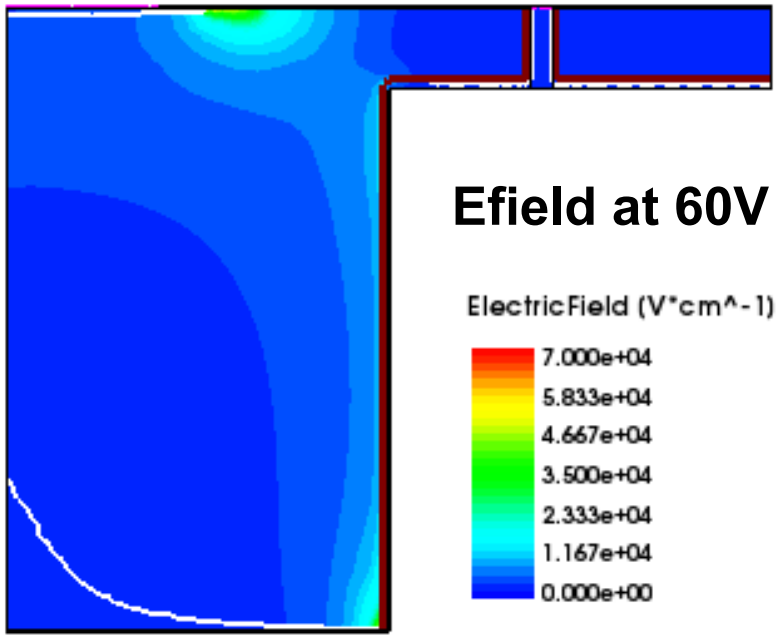




TCAD simulation: I-V curves





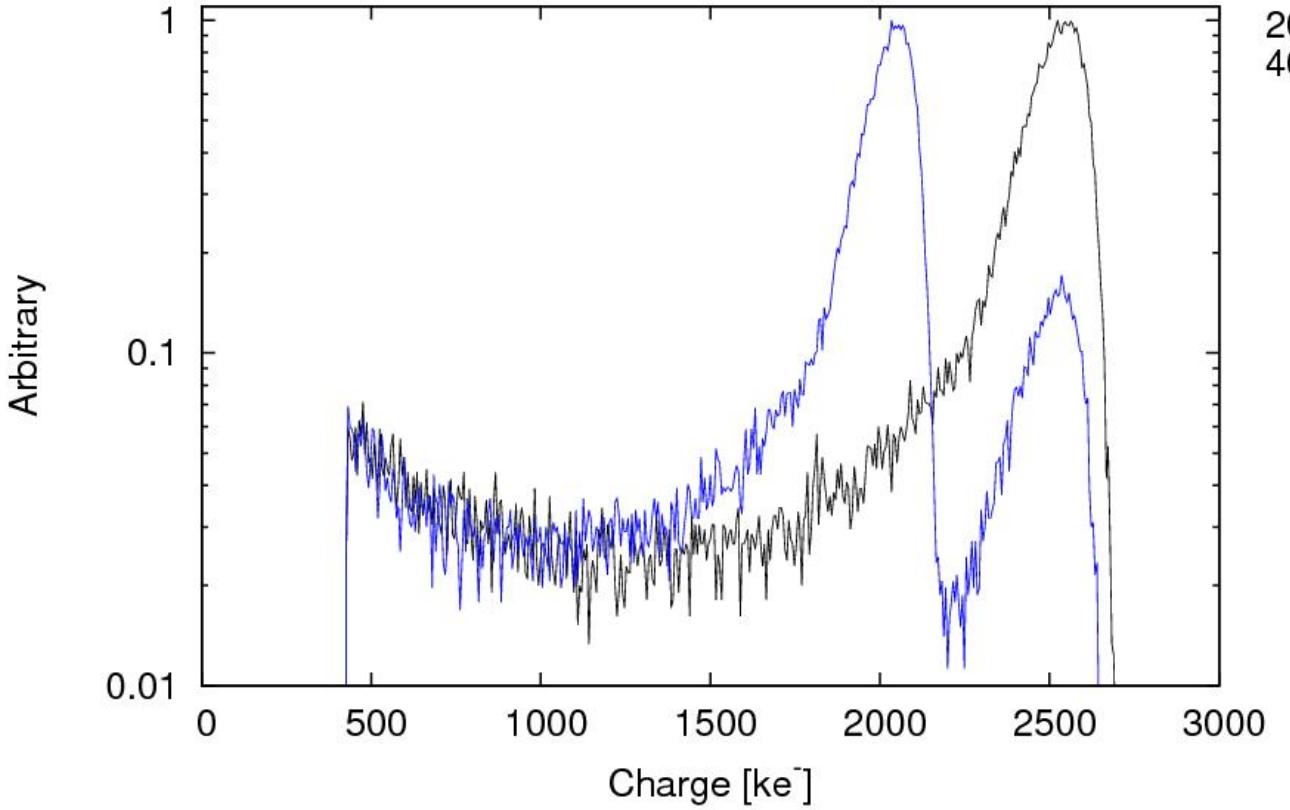


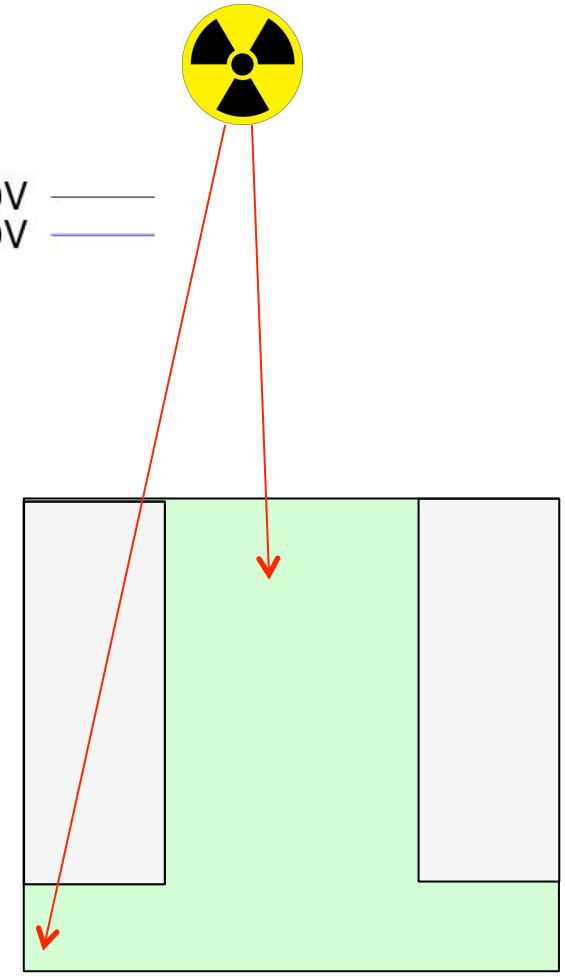
Breakdown most likely occurs at metal crossing p+ regions

Lab. Test with alpha particles

^{241}Am α source from cavity side

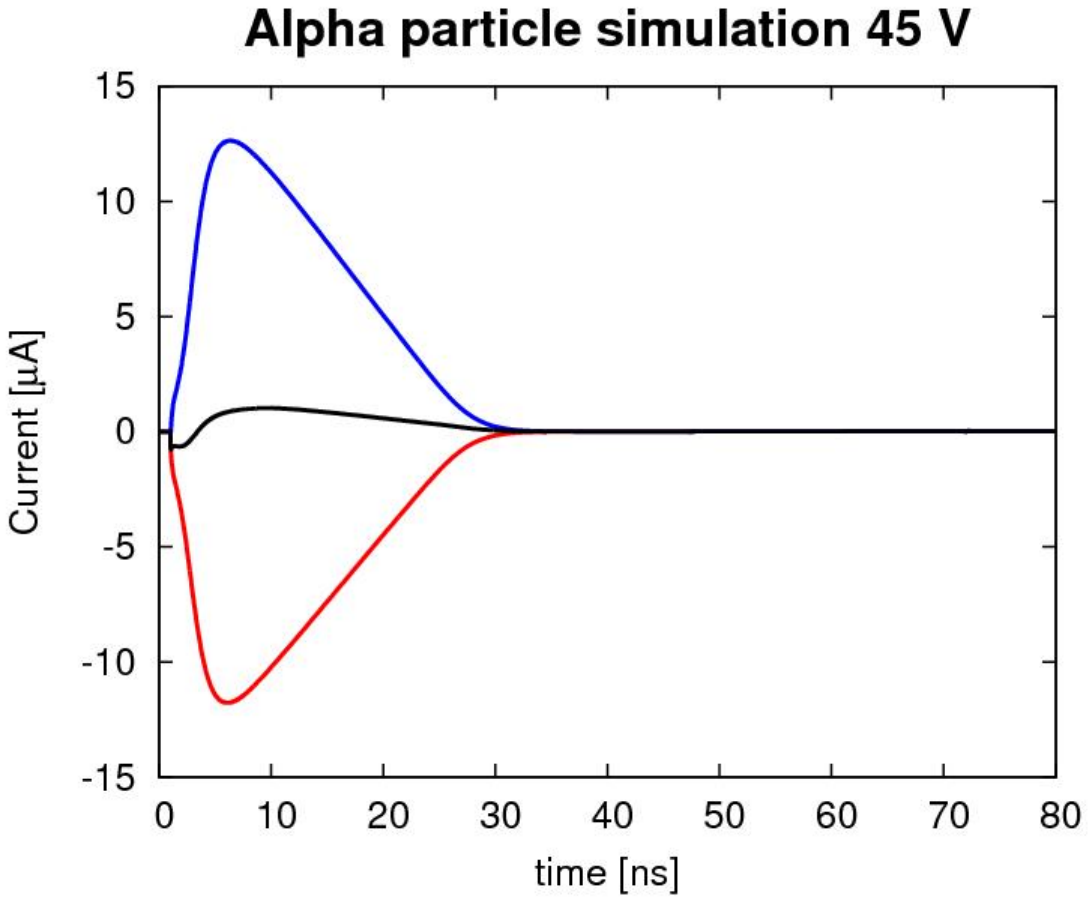
Read-out = Preamplifier + shaper (10 us) + MCA





Split of main energy peak at higher voltage …

TCAD simulation: α particle

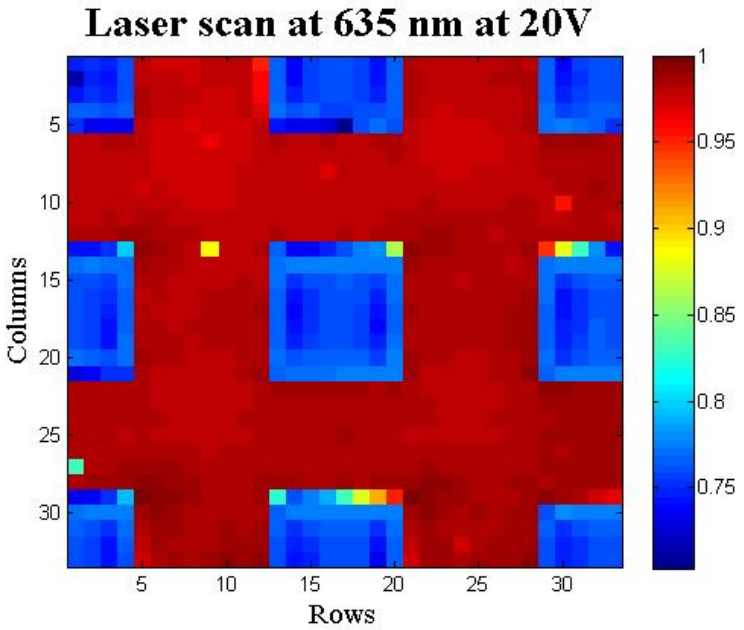


- Particle induces signals of opposite polarities on two adjacent electrodes

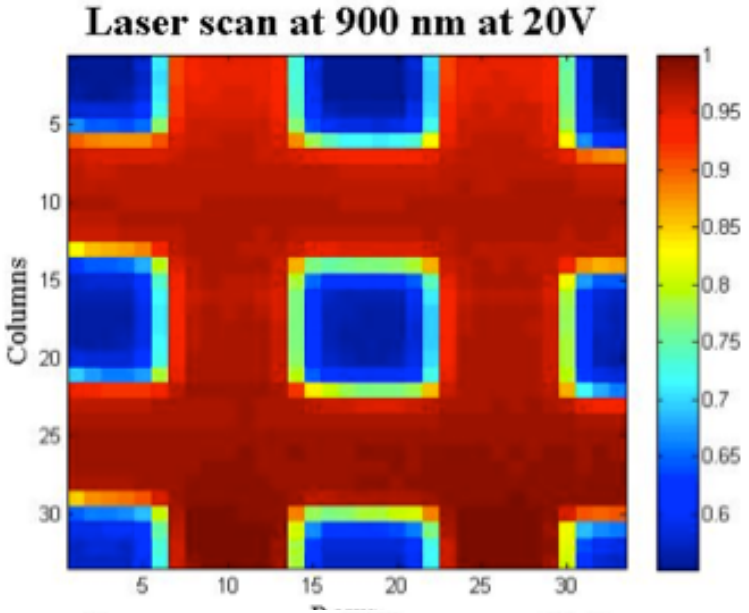
- In the diode configuration, signals of all electrodes are summed, causing strong compensation effects

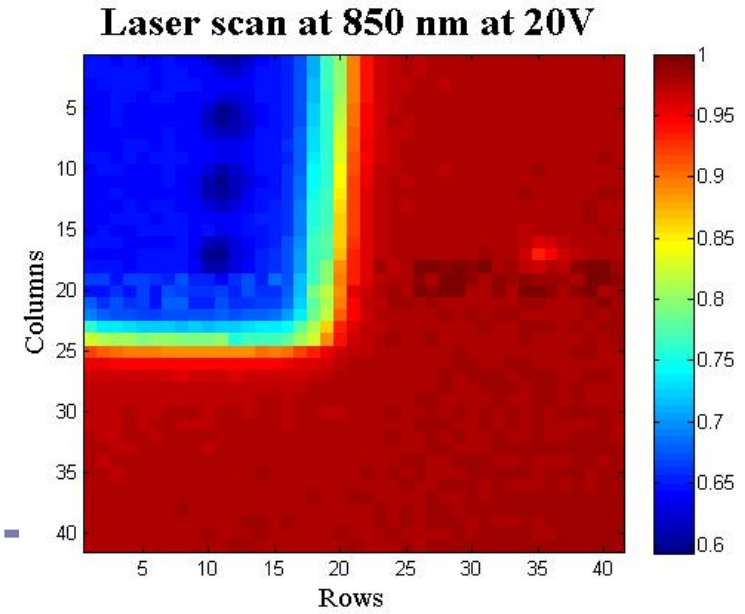
Problem to be solved with a full 3D sensor

Lab. Test with position resolved laser

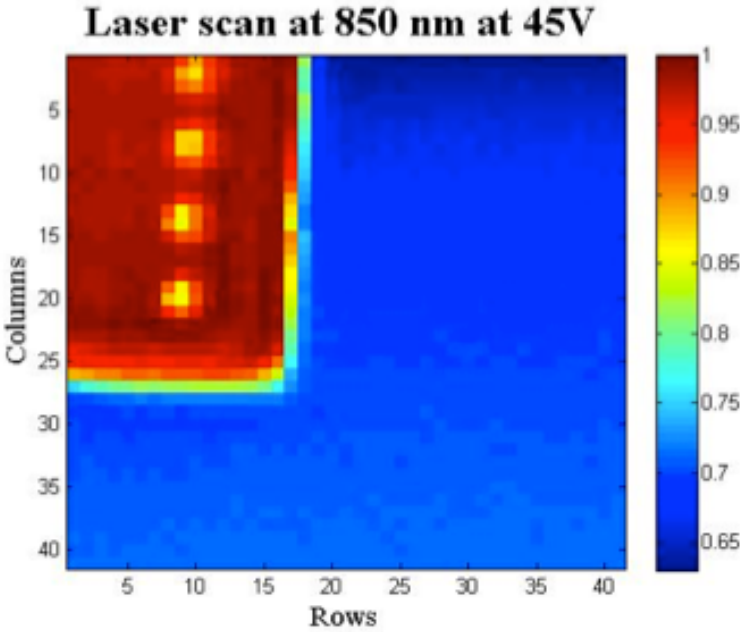


Good signal uniformity



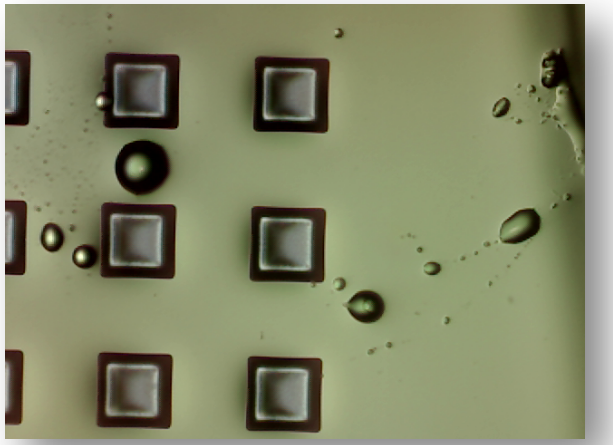


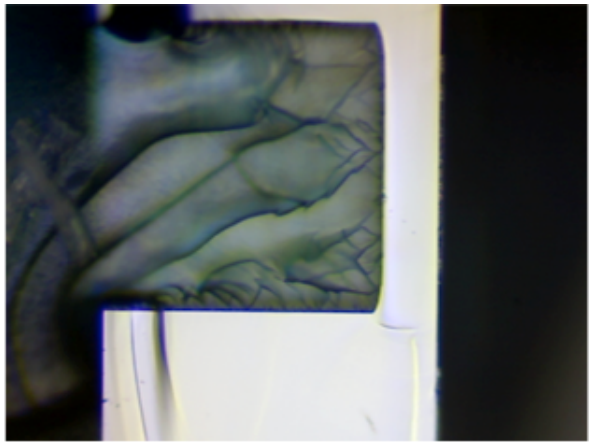
Signal amplitude “inversion” at larger voltages

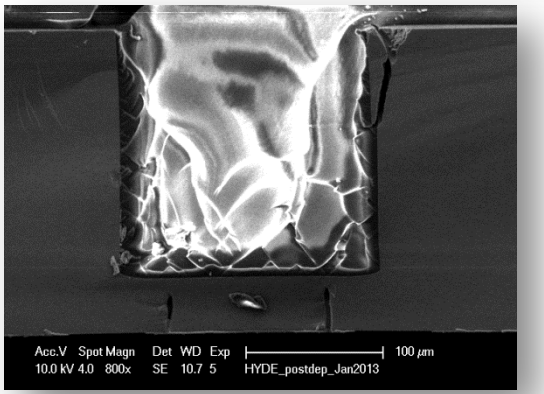


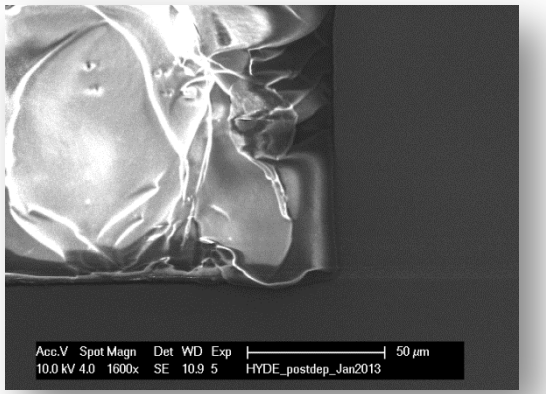
Filling tests at LNL

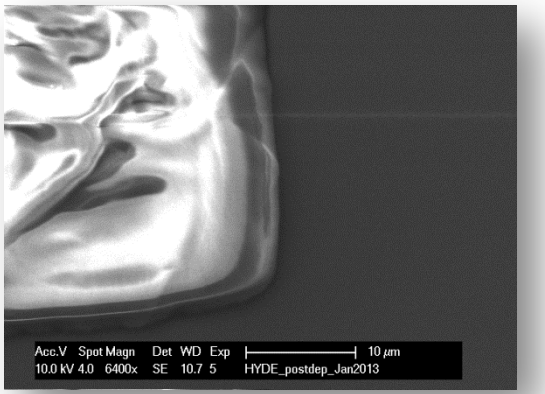
Very good matching and adhesion of polysiloxane converter to silicon sensors



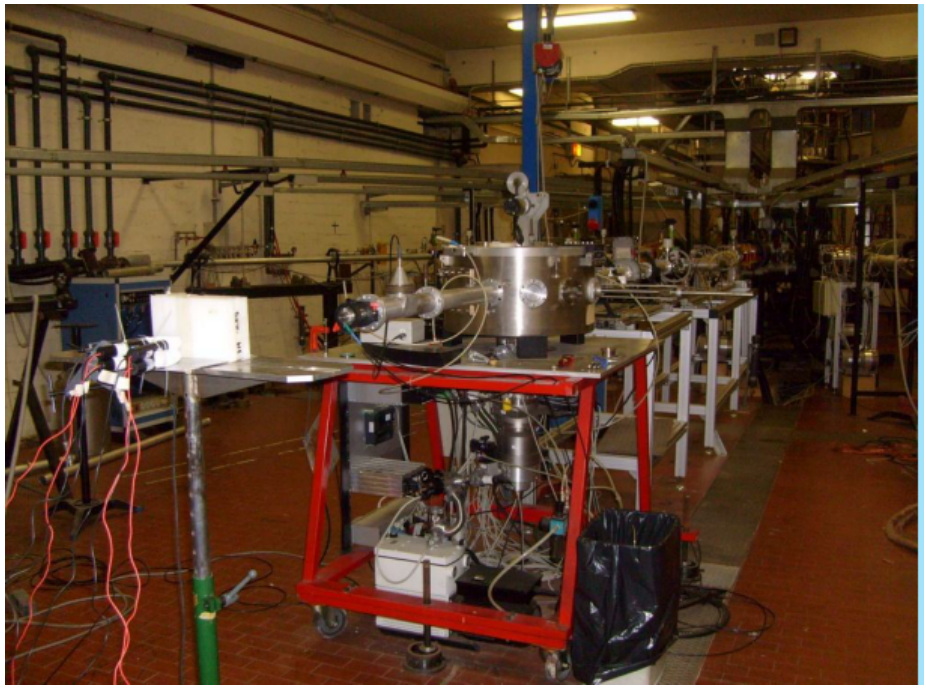


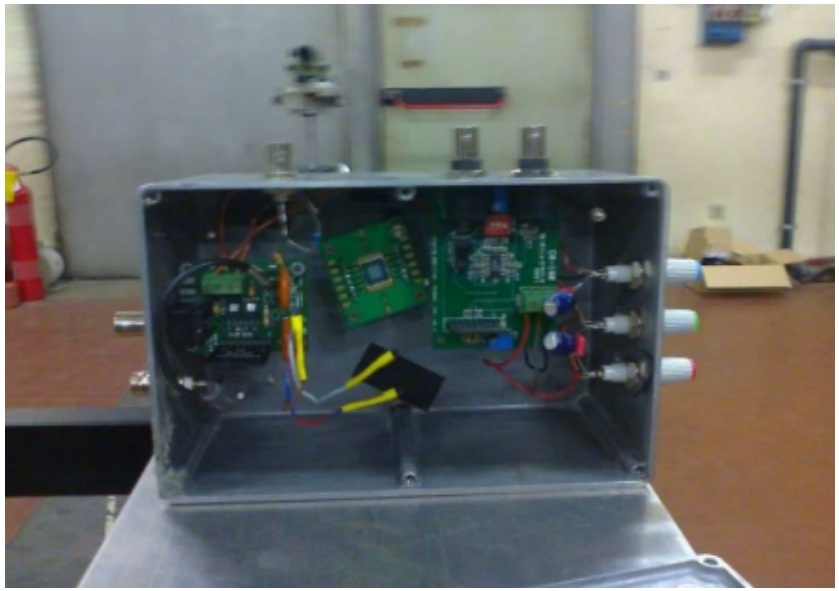






Fast neutron detection setup

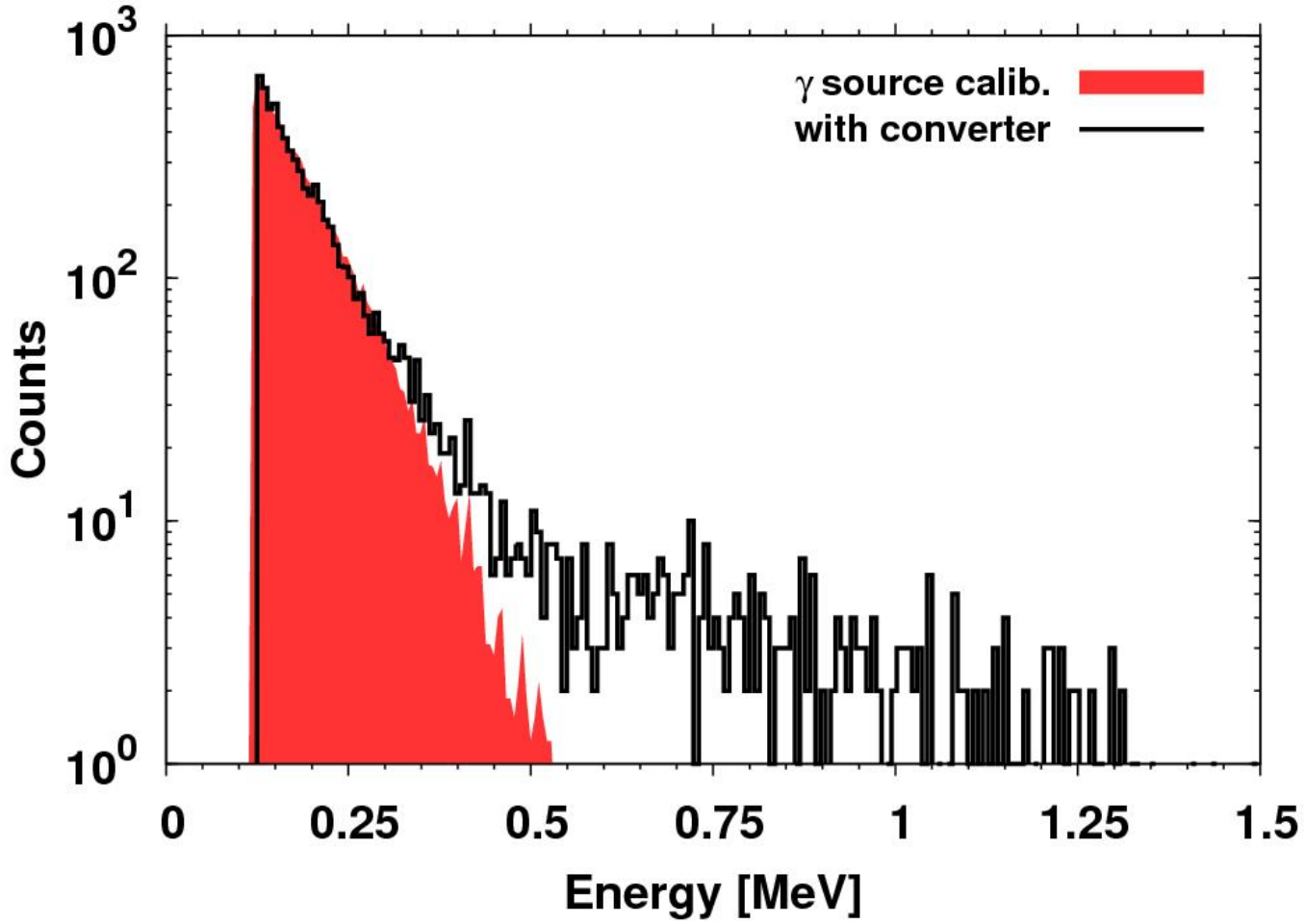




Pulsed proton beam on LiF target at CN 7 MeV accelerator of LNL

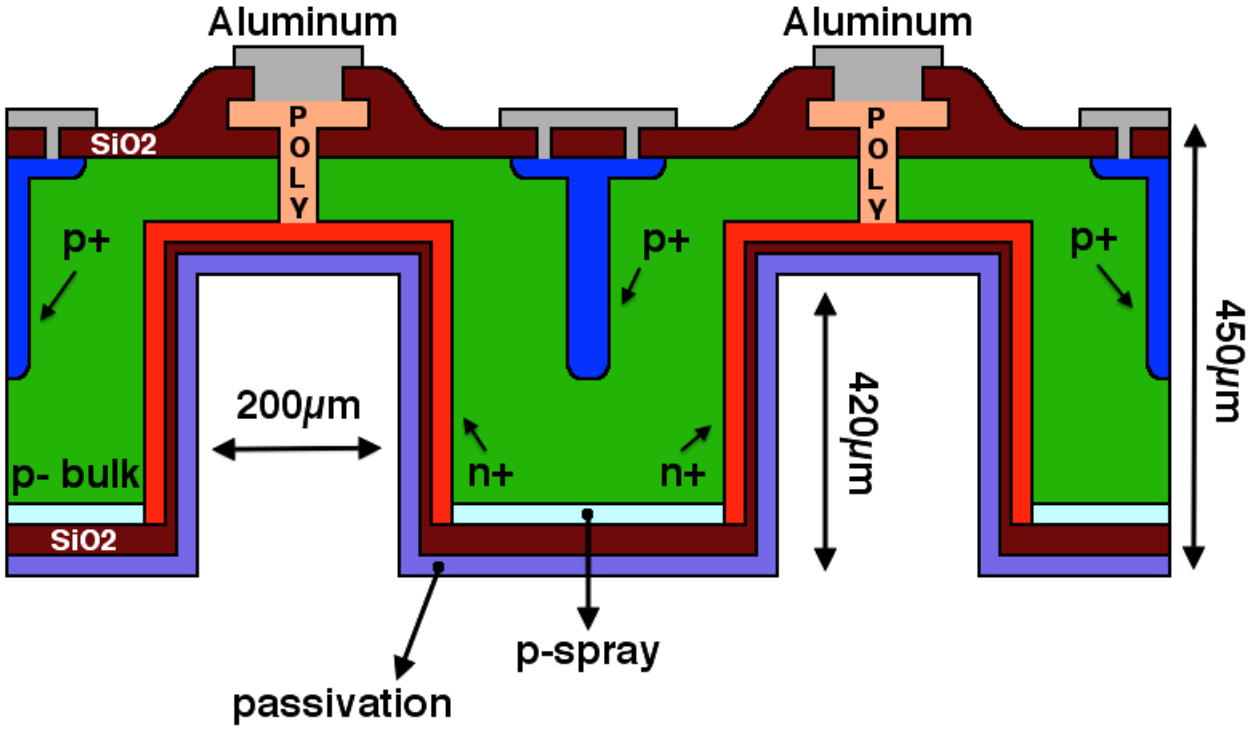
- 2 ns pulse width, 3 MHz repetition rate.
- Proton energy: 4.0 MeV. Main neutron peak: 2.3 MeV. (7 Li(p,n) 7 Be)

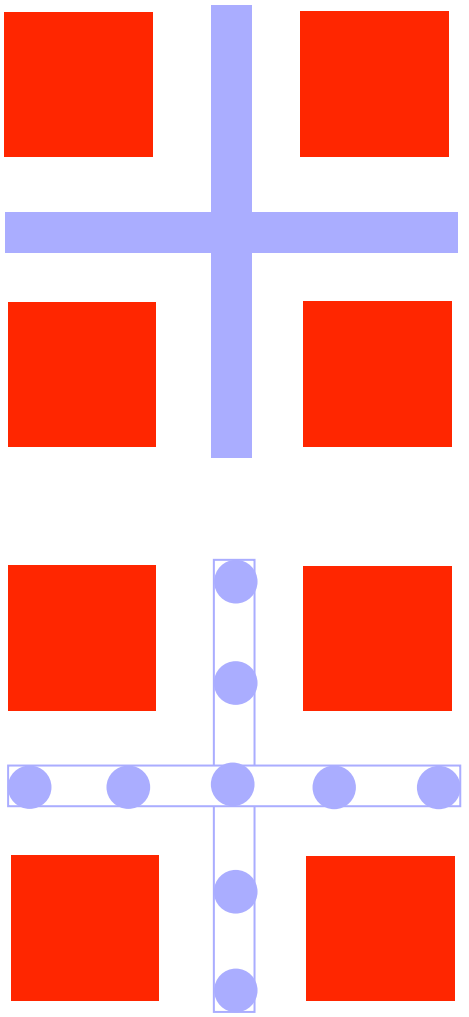
Initial results



Encouraging results in spite of small device dimensions and low statistics. Further tests to come (next shift end of July) and efficiency analysis to be performed

New full-3D structures



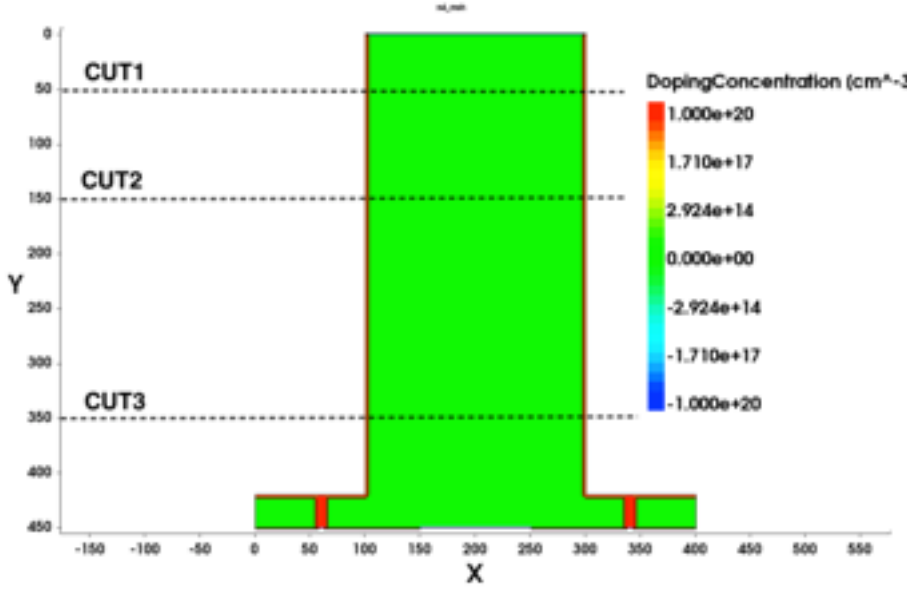


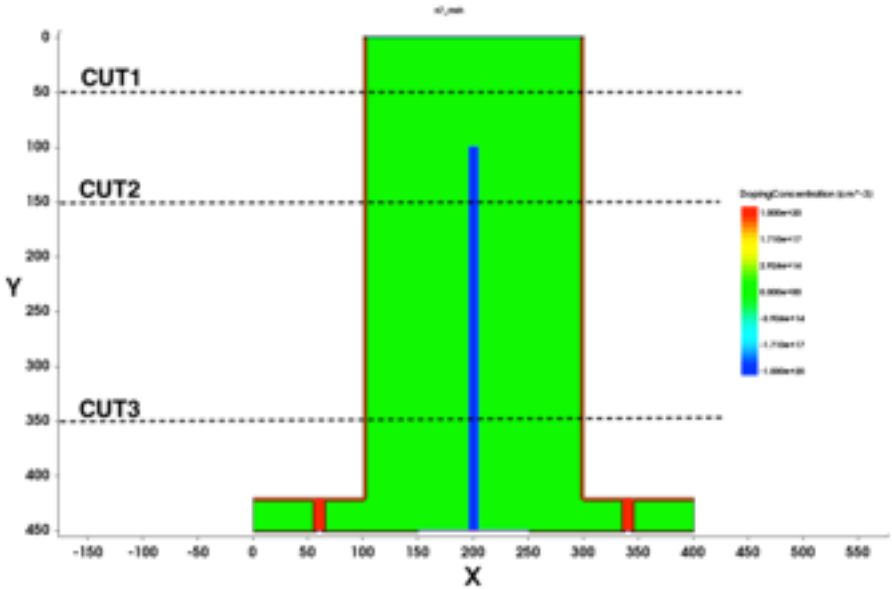
Full 3D sensors required to improve the performance

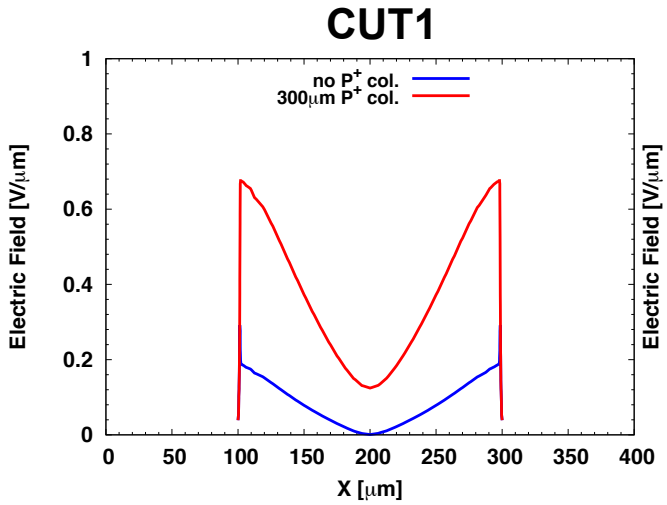
- Ohmic vertical electrodes to be added
- Trench vs Columns option

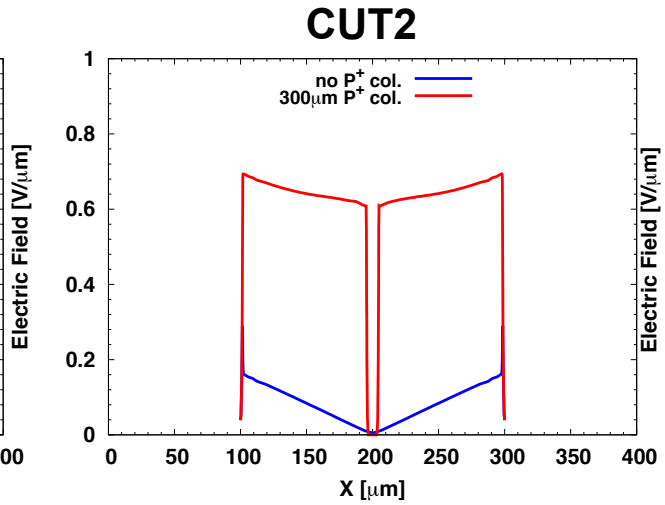
Note: new FBK line with 6” wafers: thicker sensors and thicker cavities

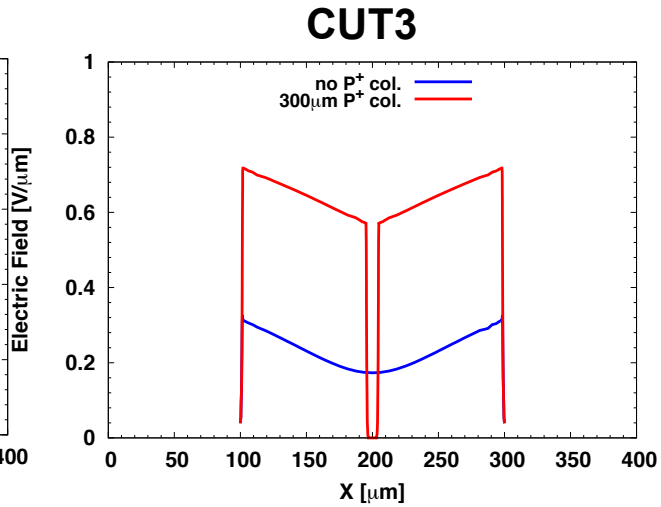
Preliminary TCAD results











Workplan : end 2013 - 2014

- Complete lab. tests on 3D sensors from first batch
- Further tests with neutrons at LNL
  - More statistics required
  - Efficiency analysis
  - Coupling to an external photodetector
- TCAD simulation & design for second batch
- Fabrication of second batch at FBK
- Extensive characterization of sensors from second batch

(also including radiation damage tests)

Riassunto FTE 2014

Persona	Ruolo	FTE
Gian-Franco Dalla Betta (R)	PA	30%
Giovanni Verzellesi	PO	40%
David Macii	RU	50%
Lucio Pancheri	RTD	20%
Giorgio Fontana	TC. EP	30%
Roberto Mendicino	Dott.	50%
Nicola Persegona	L.M.	100%
Ennio Perillo	L.M.	100%
Totale FTE per progetto		**4,20**

+ Contributo PD Gianmaria Collazuol

Riassunto richieste 2014

Voce	Richiesta
Missioni: Riunioni tecniche e attivita' di test presso LNL	1.0
Consumabili: Materiali x Laboratorio: (PCB, componenti elettronici, …) Fabbricazione 1 lotto sensori 3D @ FBK (prezzo convenzione @ 2200 Euro/lito eq.)	 1.6 26.4
Totale (k€)	**29.0**

Nessuna richiesta per officine