Status of the RD50 funding request for "detectors with enhanced multiplication”

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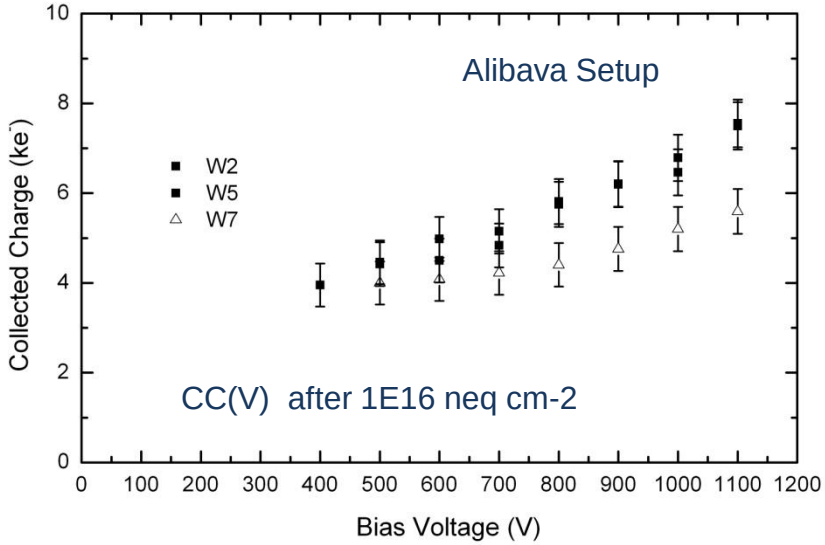
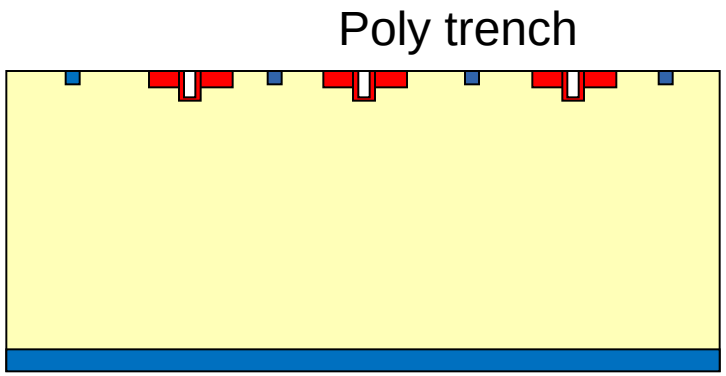
Old results



Trenched detectors with higher charge collection than standard after irradiation (w7 standard).



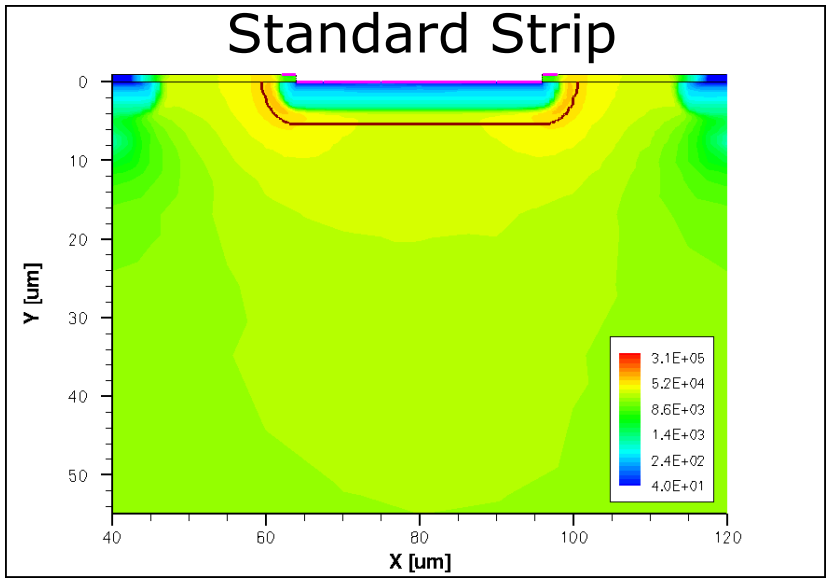
Anyway:

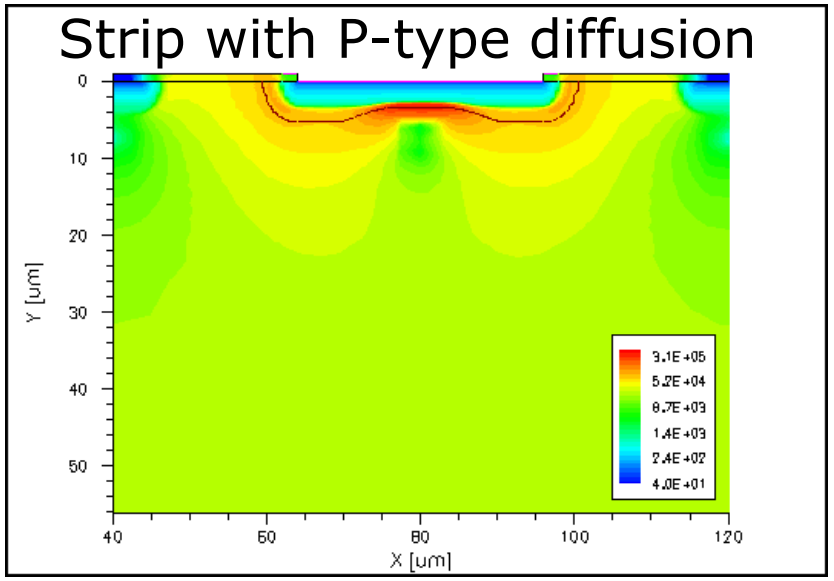
- Trenches are not a standard process for detectors.
- We need to have a controlled and understood multiplication.
- Multiplication before irradiation is useful.
- Trenches difficult the photolithography process, “pin holes” observed in the first batch.

G. Casse, HSTD8, Taipei (TW) 4-7 Dec. 2011

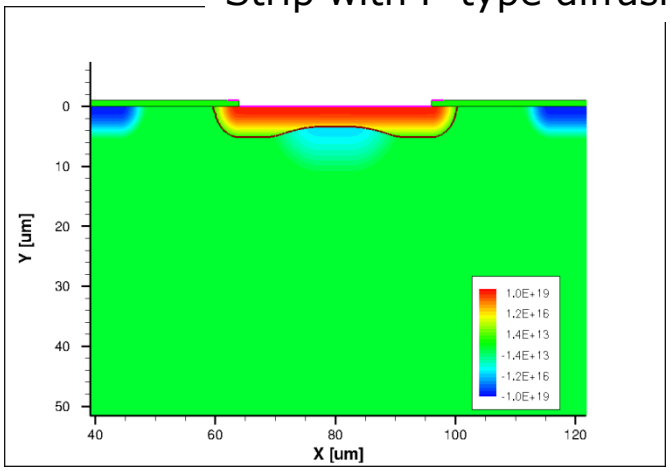
Rd50 funded project

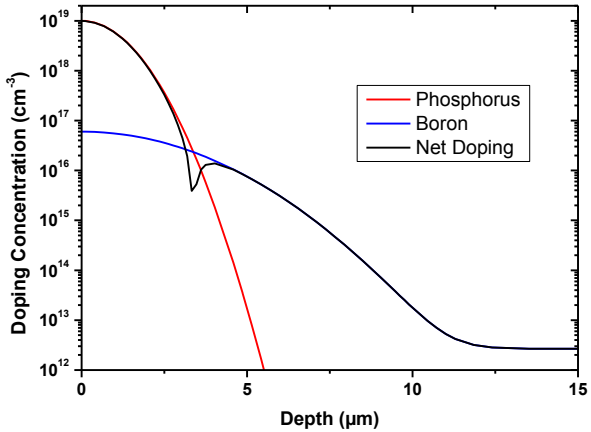
Simulation of the Electric Field





Strip with P-type diffusion: 2D and 1D doping profiles

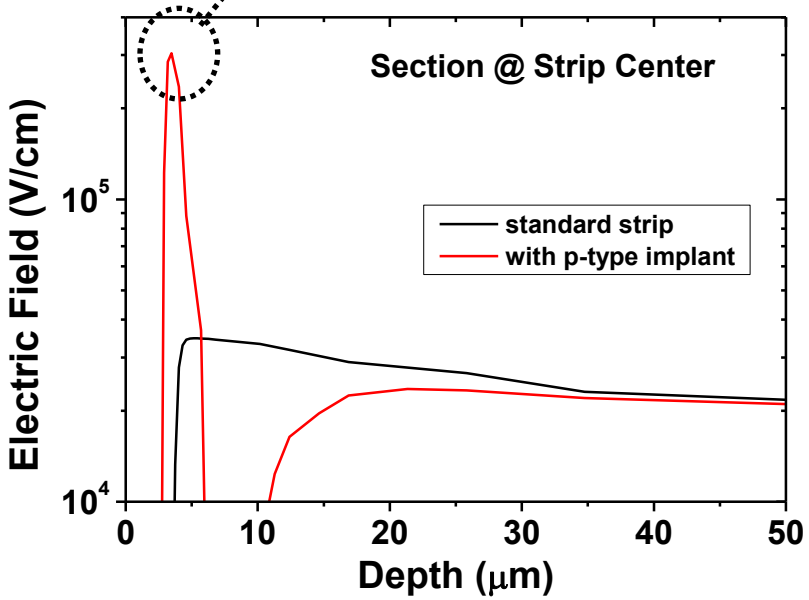




Simulation of the Electric Field

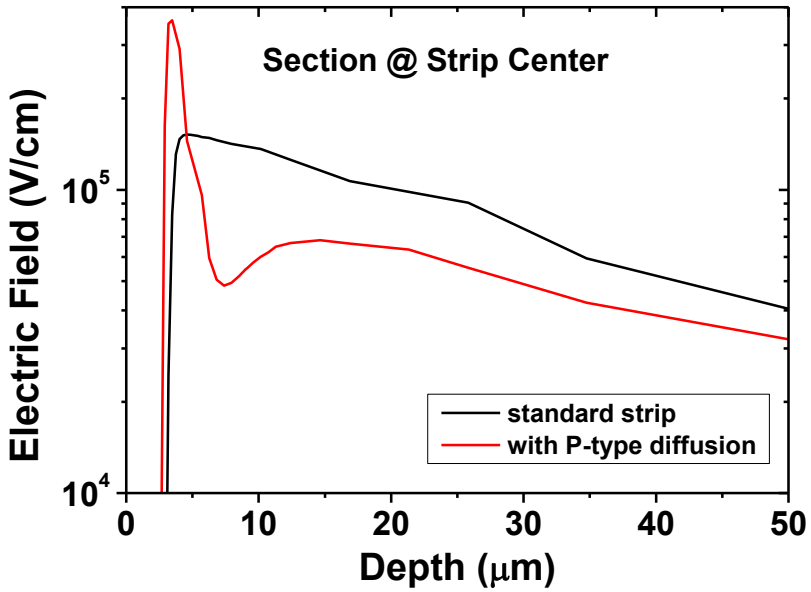
High Electric Field peak at the junction

No Irradiated



Curves at 500 V

Irradiated. Φ_{eq} = 1 x 10^{16} n/eq cm^2



- Standard strip: electric field strength at the junction increases after irradiation
- Strip with P-type diffusion: electric field strength at the junction is held after irradiation

▪ Irradiation trap model:

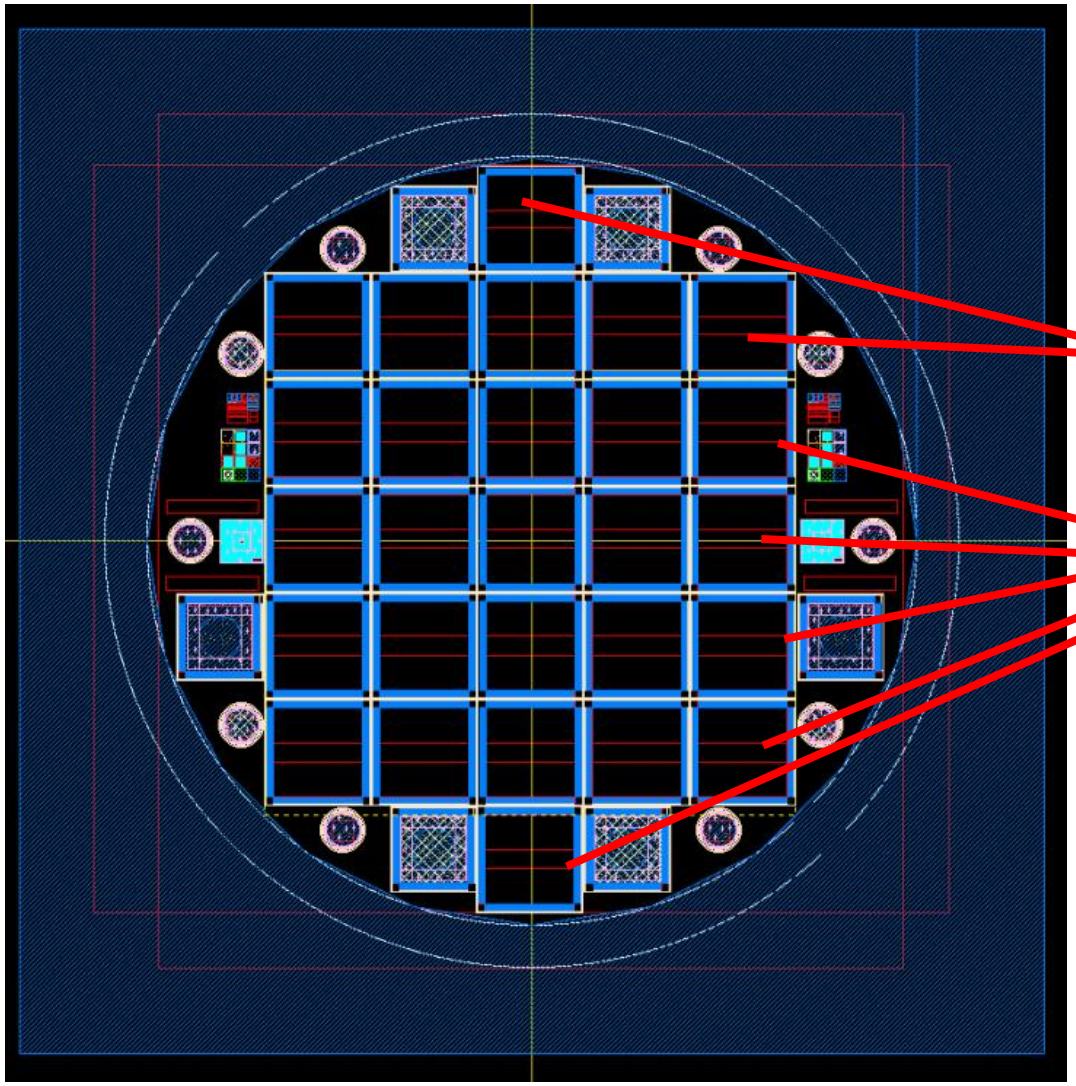
Acceptor;	E= E_c + 0.46 eV; η=0.9;	σ_e = 5 x 10^{-15};	σ_h = 5 x 10^{-14}
Acceptor;	E= E_c + 0.42 eV; η=1.613;	σ_e = 2 x 10^{-15};	σ_h = 2 x 10^{-14}
Acceptor;	E= E_c + 0.10 eV;	η=100;	σ_e = 2 x 10^{-15}; σ_h = 2.5 x 10^{-15}
Donor;	E= E_v - 0.36 eV; η=0.9;	σ_e = 2.5 x 10^{-14};	σ_h = 2.5 x 10^{-15}

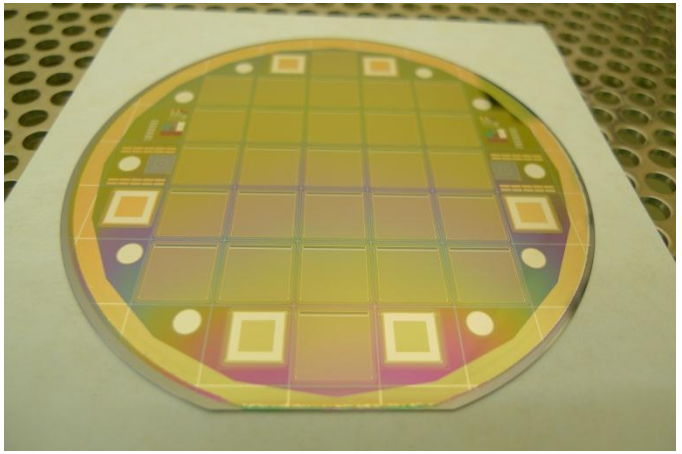
▪Impact Ionization Model:
Universty of Bolonia

P. Fernandez et al, "Simulation of new p-type strip detectors with trench to enhance the charge multiplication effect in the n-type electrodes"

New fabrication run

Mask layout

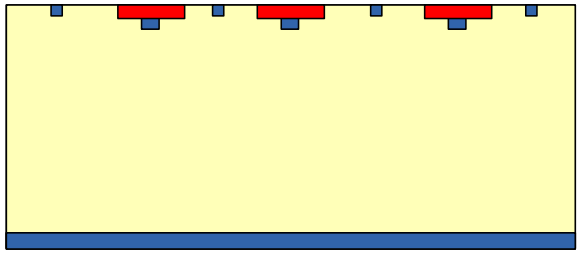




Without p+ implantation

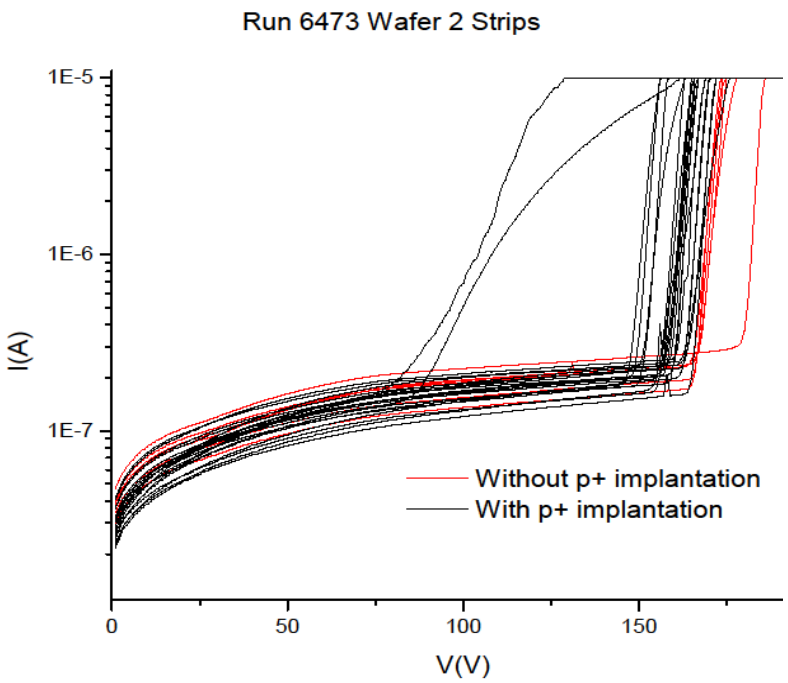
With p+ implantation

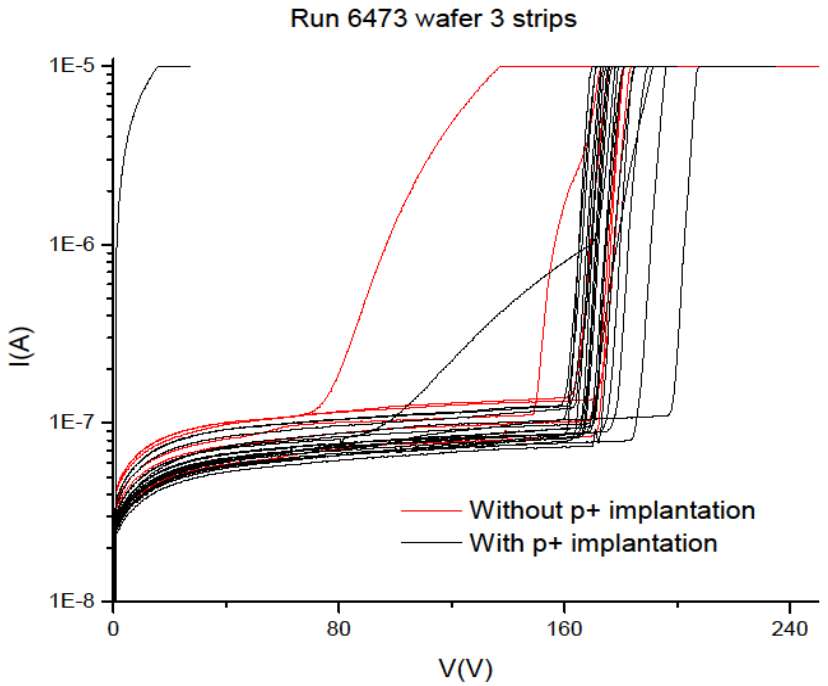
P-type diffusion



Round diode do not have p+ implantation

New run fabricated at CNM





Wafer #	Wafer bow (UM)	Thickness (UM)	Error (UM)
1	-2	303,9	±0,4
2	10,3	305,8	±0,1
3	-3,3	301,9	±0,1
4	-12,4	301,8	±0,1

Marta Baselga

New project

Charge Multiplication- pixel detectors

We are proposing the fabrication of new p-type pixel detectors with enhanced multiplication effect in the n-type electrodes.

3 different approaches:

1)Thin p-type epitaxyal substrates
2)Low gain avalanche detectors
3)3D with enhanced electric field.

} **Same mask**

Status: approving of the mask and submission of the proposal to RD50

1) Thin p-type epitaxyal substrates

Detector proposed by Hartmut Sadrozinski and Abe Seiden (UCSC) , **Ultra-Fast Silicon Detectors** (UFSD).

Provide in the same detector and readout chain

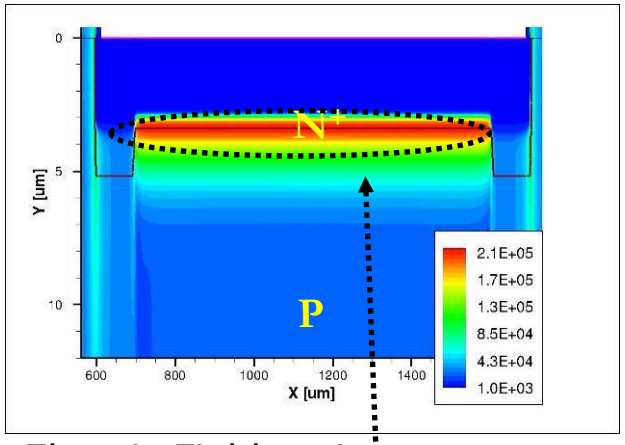
- Ultra-fast timing resolution [10's of ps]
- Precision location information [10's of µm]

We propose to achieve high electric field is to use thin p-type epitaxyal substrates [1] grown on thick support wafers, p+-type doped, that acts as the backside ohmic contact. Different thicknesses will be used to study the multiplication effect induced by the high electric field at the collecting electrodes, depending on availability we propose to use: 10, 50, 75µm. ***Need very fast pixel readout***.

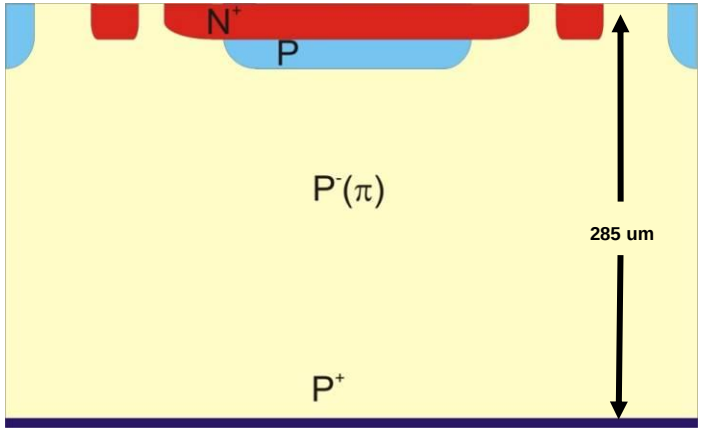
H. Sadrozinski, "Exploring charge multiplication for fast timing with silicon sensors" 20th RD50 Workshop, Bari, 2012

2)Low gain avalanche detectors (LGAD)

Crating an n++/p+/p- junction along the centre of the electrodes. Under reverse bias conditions, a high electric field region is created at this localised region, which can lead to a multiplication mechanism. Standard FZ HR p-type wafers.



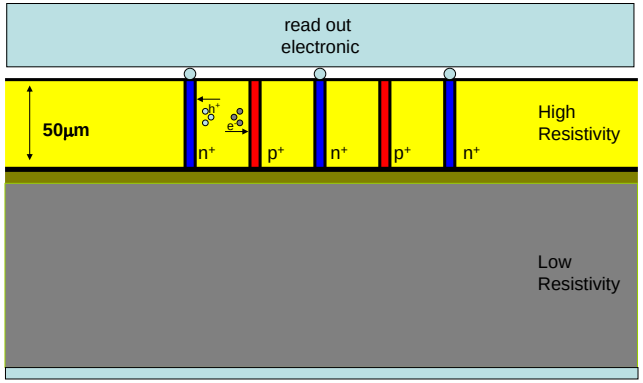
High Electric Field region leading to multiplication

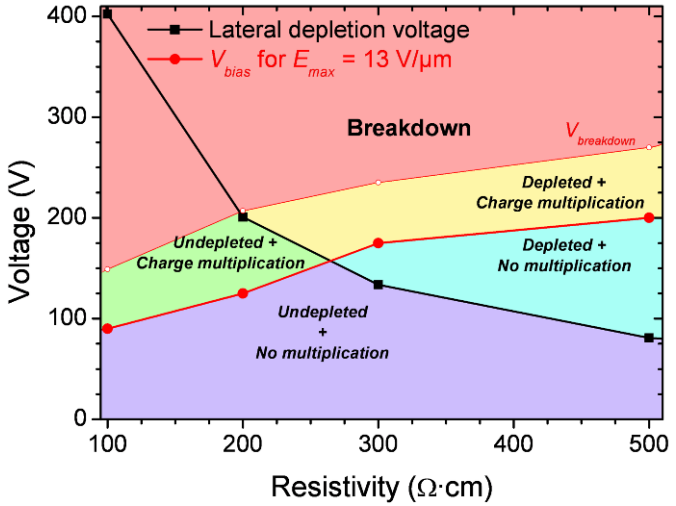


3) 3D with enhanced electric field

Simulation has shown that using silicon substrates with a resistivity <500ohm*cm could induce charge multiplication at low bias voltage but still depleting the detector bulk.

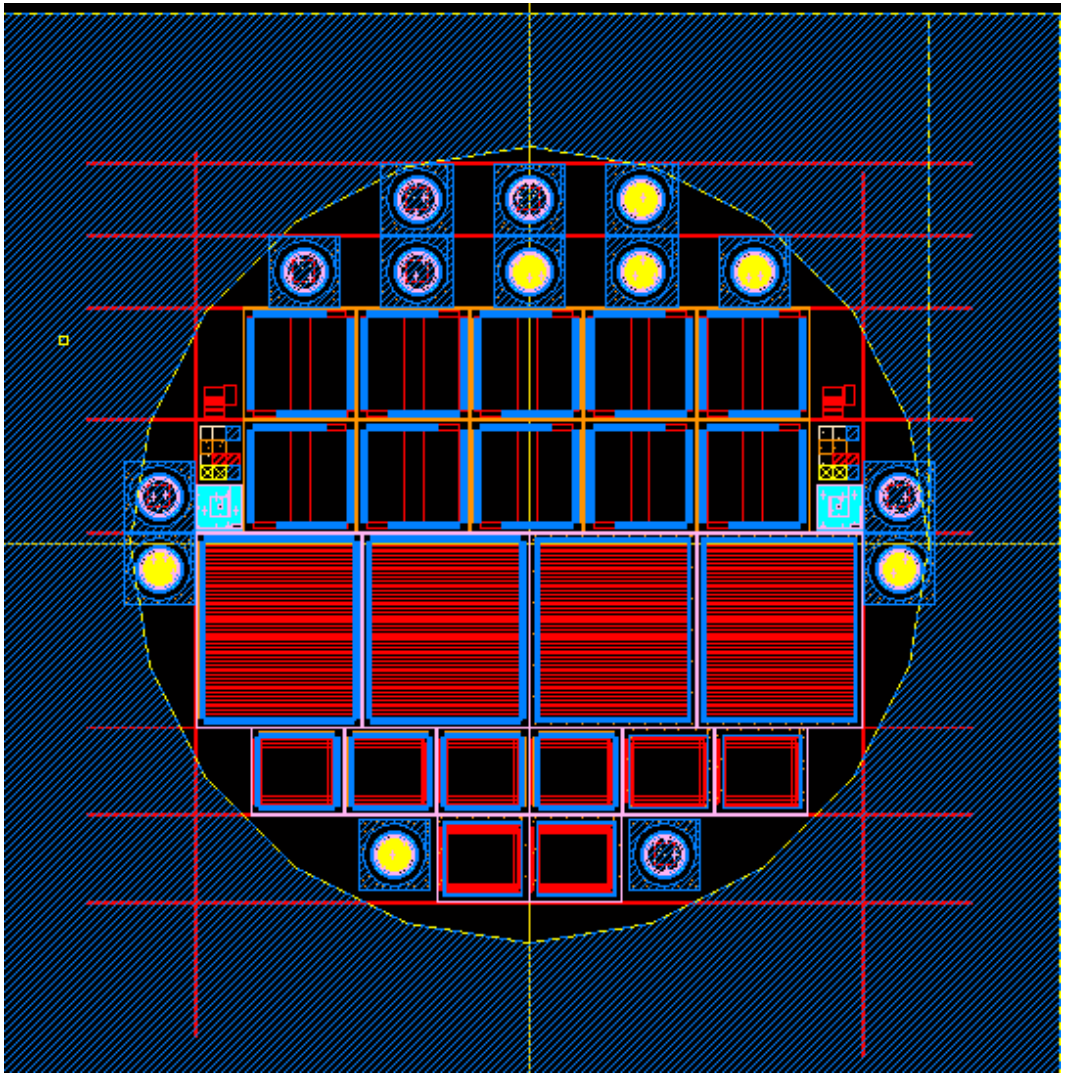
We are ready to start the production on SOI p-type wafers (resistivity 100ohm*cm) with a thickness **of 50µm** to fabricate 3d thin detectors with medium or low multiplication factors before irradiations.





J.P Balbuena, Simulation of 3D detectors, 6th Trento Workshop on Advanced Radiation Detectors, 2-4 March 2011 FBK, Povo di Trento, Italy

Mask design (planar)

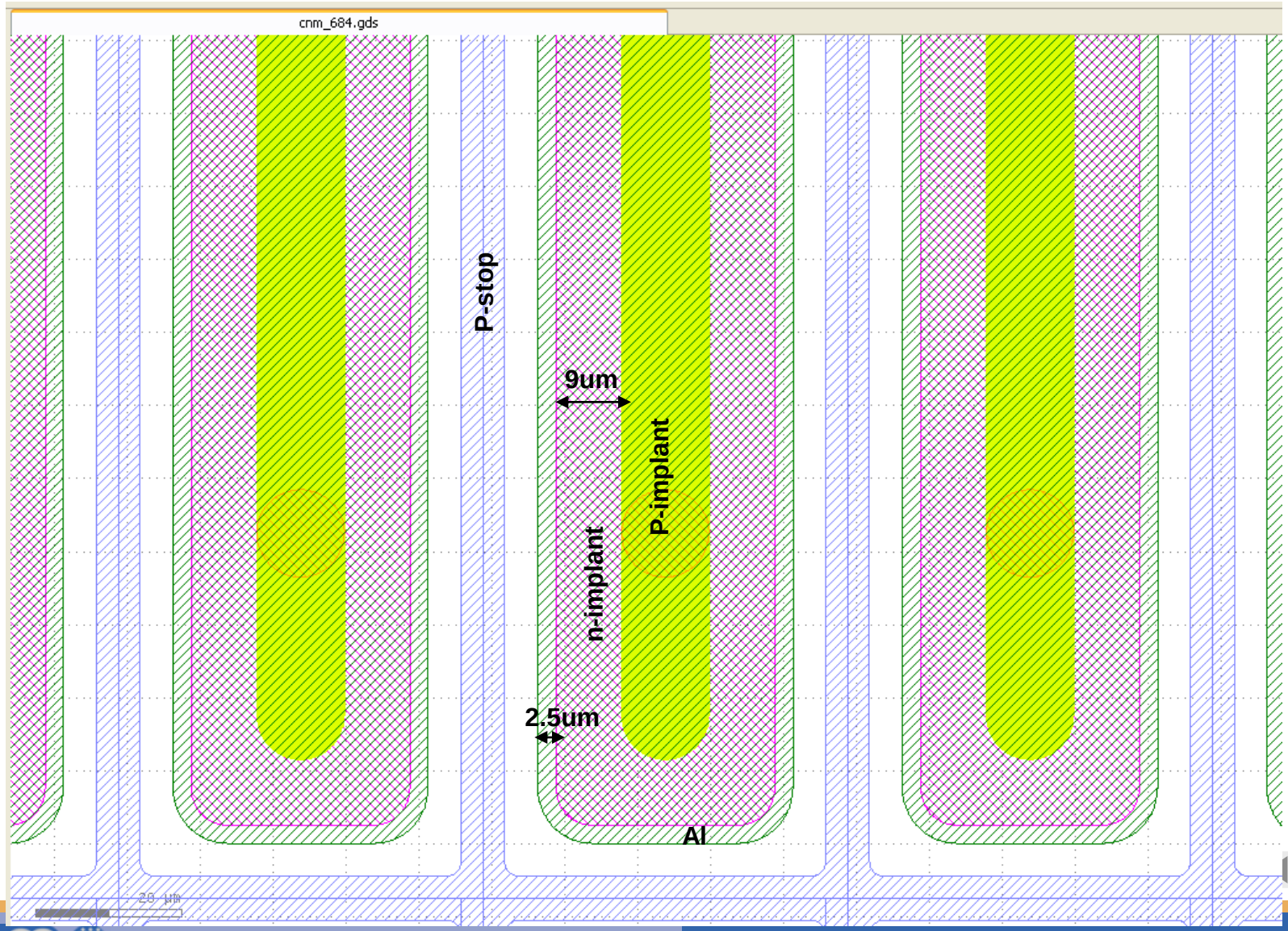


6 AC strips
4 DC strips
4 FE-I4
8 FE-I3
7 pads
7 pads with multipl.

Strip pitch 80um

Marta Baselga

Detail of the mask



RD50 funding request

- November 2012-

Title of project: Fabrication of new p-type pixel detectors with enhanced multiplication effect in the n-type electrodes.

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Request to RD50: 30.000 €

Total project cost: 83.000 €

Conclusion

- Strip detectors with p-implant must be tested before irradiation to measure multiplication.
- Compare simulation with fabrication
- Approval of the new mask
- Submission of the proposal to RD50.
- Start fabrication of 3D run.