Status of LGAD RD50 projects

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RD50 Institutes Participating

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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RD50 Institutes:

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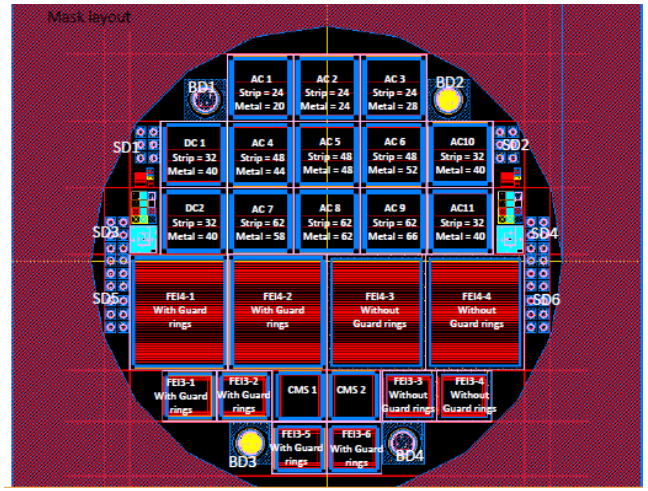
Request to RD50: **25.000 €** (~30.000 CHF)
Total project cost: **50.000 €**

The aim of the project was to fabricate the first segmented LGAD in thin (epytaxial) substrates.

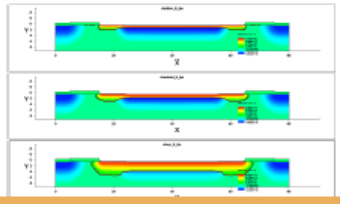


Thickness [μm]	Resistivity [Ωcm]	Resistivity substrate [Ωcm]	Substrate thickness [μm]	Nominal full depletion
9.8	110.5	0.006	525	9.3V
50.4	96.7	0.006	525	267V
75.2	104.6	0.006	525	550V
285 (FZ)	12000 ± 7000			70V

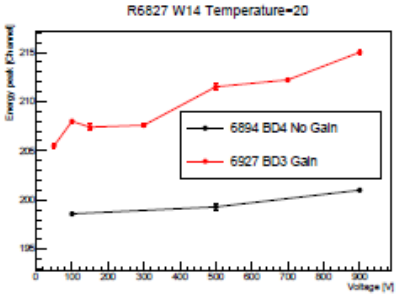
Diffusion times of the dopant

- Shallow
- Standard
- Deep

Strip cross section

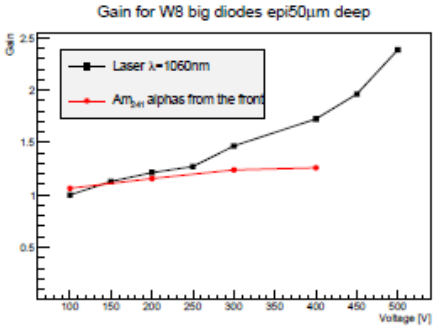


R6827 W14 FZ Deep big diode with Trialpha source



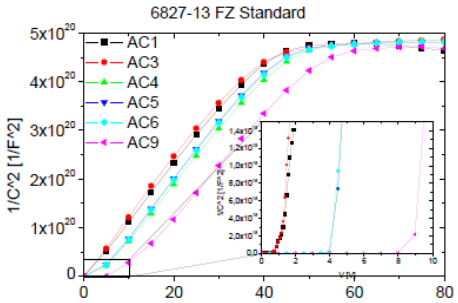
Measured with a PCB connected to an MCA CNM Barcelona

TCT from R6827W8 big diode EPI 50 Deep



Measurements taken at UCSC

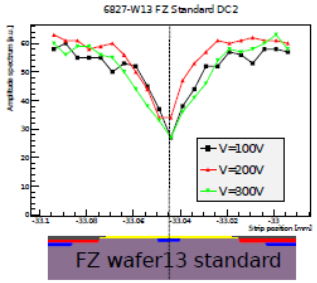
CV curves strip detectors for FZ wafer



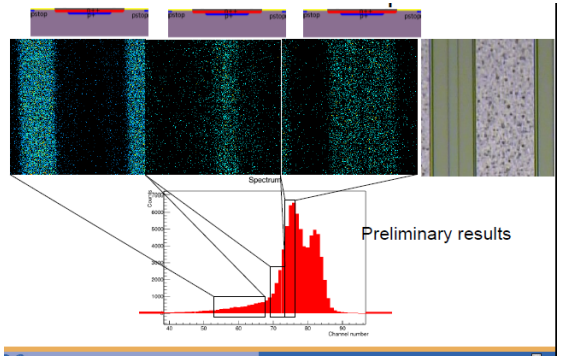
Different Measurements

- Diamond light source (Glasgow)
- CERN TCT setup
- Santa Cruz TCT setup
- IBIC Sevilla (CNM)

R6827W13DC1 FZ Standard gain



Data from 10^5 events



Results presented at different RD50 workshops

M. Baselga´s PhD thesis.

Presented at the Trento Workshop in 2015.

RD50 funding request [2014-05]

- Date: *26 June 2014*-

Title of project: Investigation of the properties of thin LGAD

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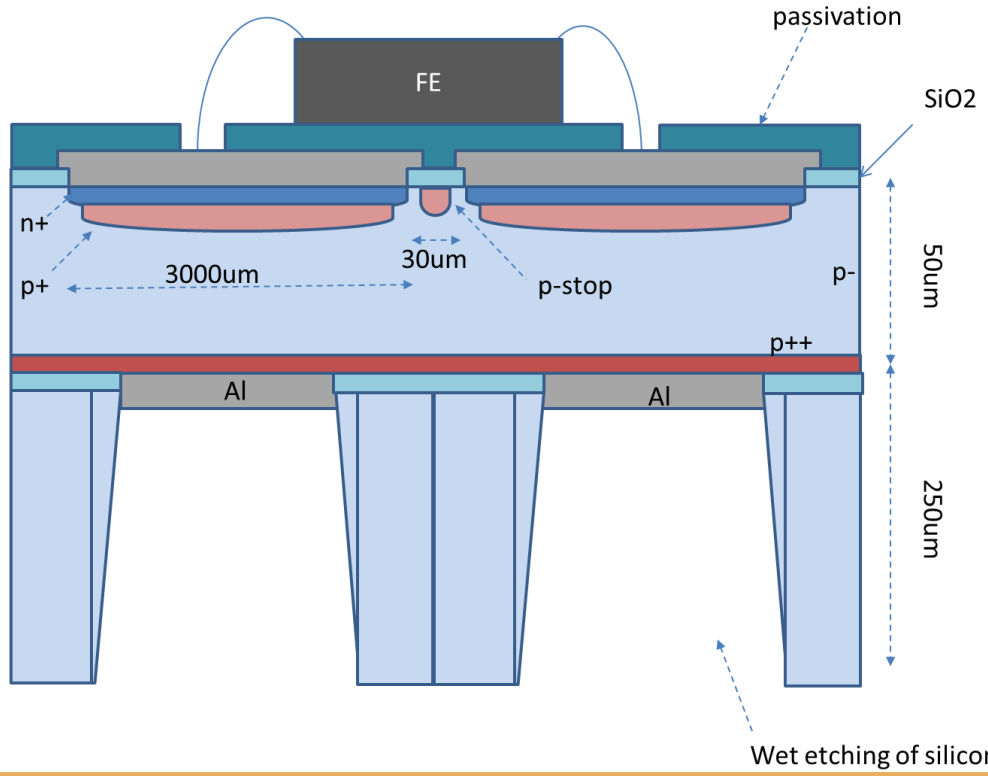
7. *JSI, G. Kramberger, gregor.kramberger@ijs.si*
8. Ioffe Pysical-Technical Institute, St. Petersburg, Russia, elena.verbitskaia@cern.ch, (contribution in kind)

Request to RD50: *12k*
Total project cost: *30k*

This project aims to fabricate, test and irradiate thin LGAD sensors. Thin sensors offer many attractive features such as higher charge collection efficiency, short drift time, and a signal that is both shorter and steeper while retaining a large amplitude due to the multiplication mechanism.

The production will have geometries that can be used to evaluate the application of LGAD sensors in forthcoming LHC experiments such as TOTEM, HGTD and CT-PPS.



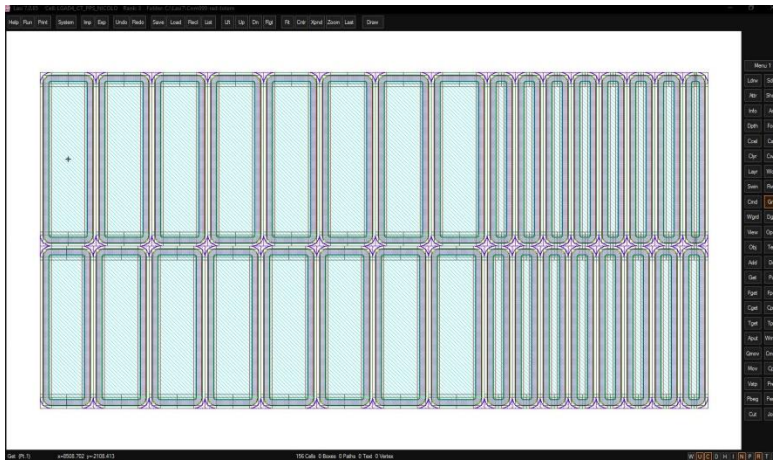
High-granularity Timing Detector could be placed in front of LAr Calorimeter endcap.

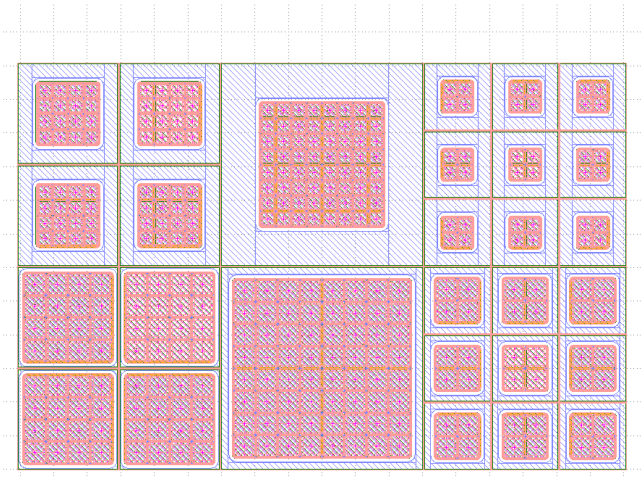
See Hartmut and Nicolo´s talks.

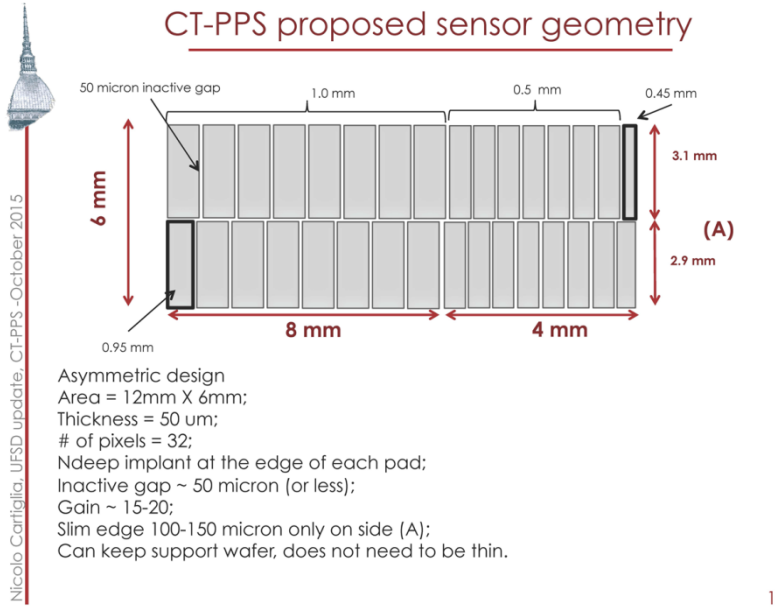
Status of the project

- Simulation of the different geometries already concluded.
- Design of the mask in progress.
- Fabrication will start in January 2016.

Mask design







The mask will include standard pads and test structures

RD50 funding request

- November 25, 2015 -

Title of project: Gallium Implantation to Enhance the Radiation Hardness of LGAD Detectors

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Request to RD50: 19,000 €
Total project cost: 32,000 €

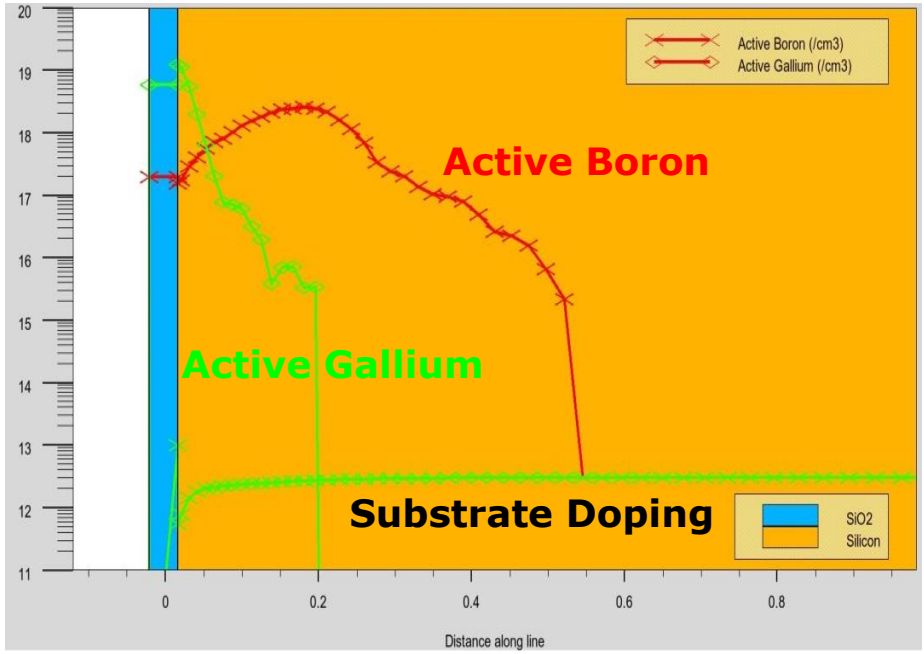
The project aims to replace Boron with Gallium

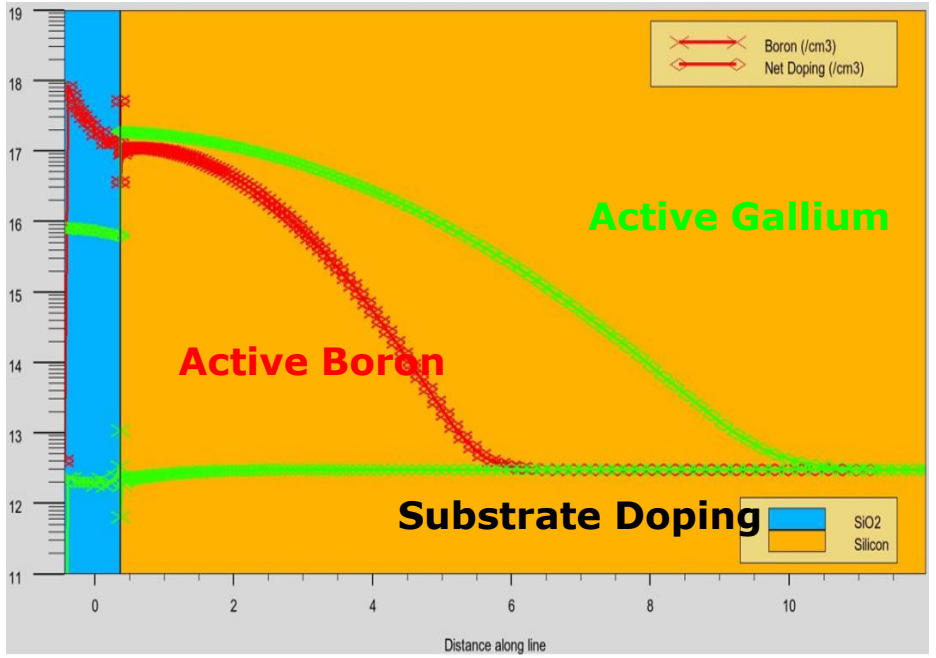
Dopants such as Ga or Al form complexes with radiation-induced defects, which may have less impact on device performance, when compared to the boron related defect (B_i-O_i) complex. This study demonstrates that using gallium as dopant in Si instead of boron can reduce carrier removal effect.

1. *G. Kramberger et al., "Radiation effects in Low Gain Avalanche Detectors after hadron irradiations", 2015 JINST 10 P07006.*
2. *A. Khana, et al., "Strategies for improving radiation tolerance of Si space solar cells", Solar Energy Materials & Solar Cells 75 (2003) 271.*

Gallium Implantation. Silvaco TCAD Simulation

- **Simulation** of other p-layer doping ions: **Gallium**

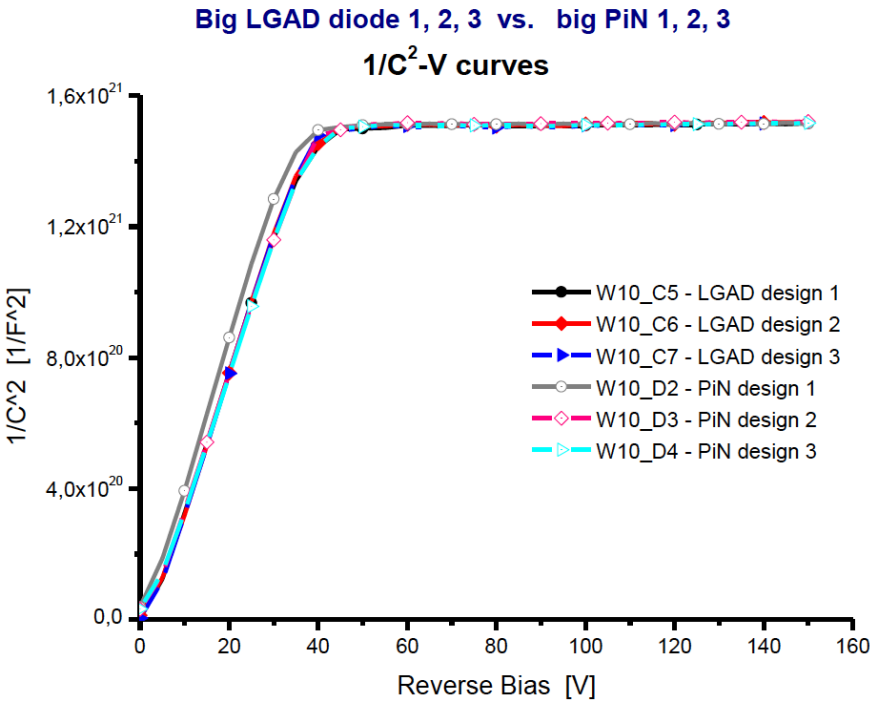


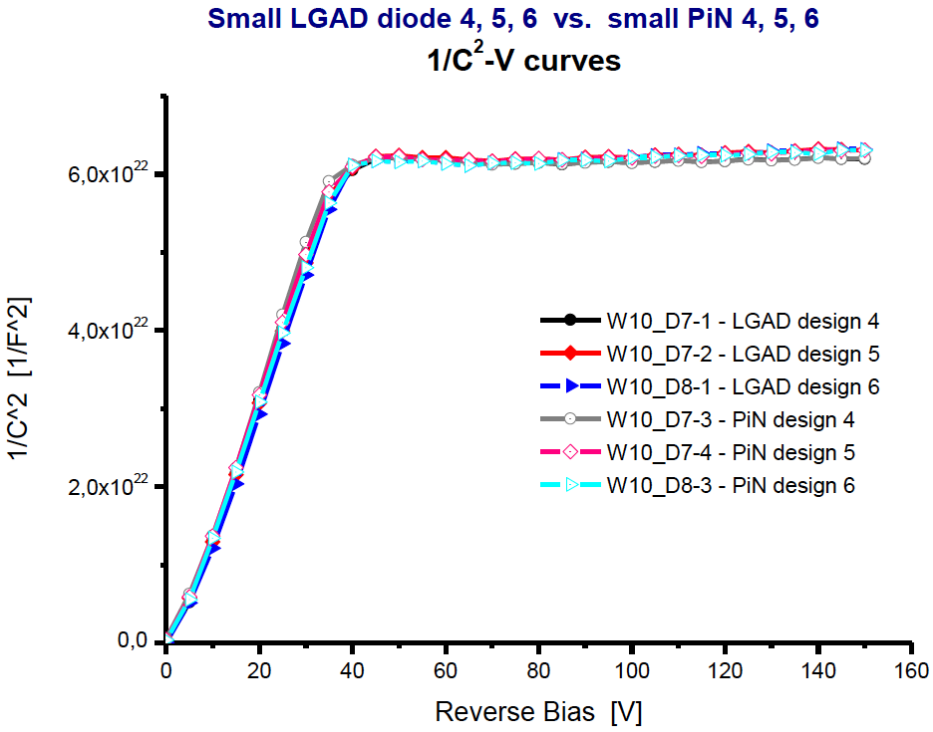


- **Gallium** has **lower** penetration than **Boron**, but **higher** diffusion (with annealing)
- Simulation predicts that **Gallium Implantation** (Dose=1.3e13, Energy=60) through **35 nm SiO2** is enough to obtain a similar doping profile than Boron Implantation

Gallium Implantation. Electrical Characterization. C(V). 1/C²

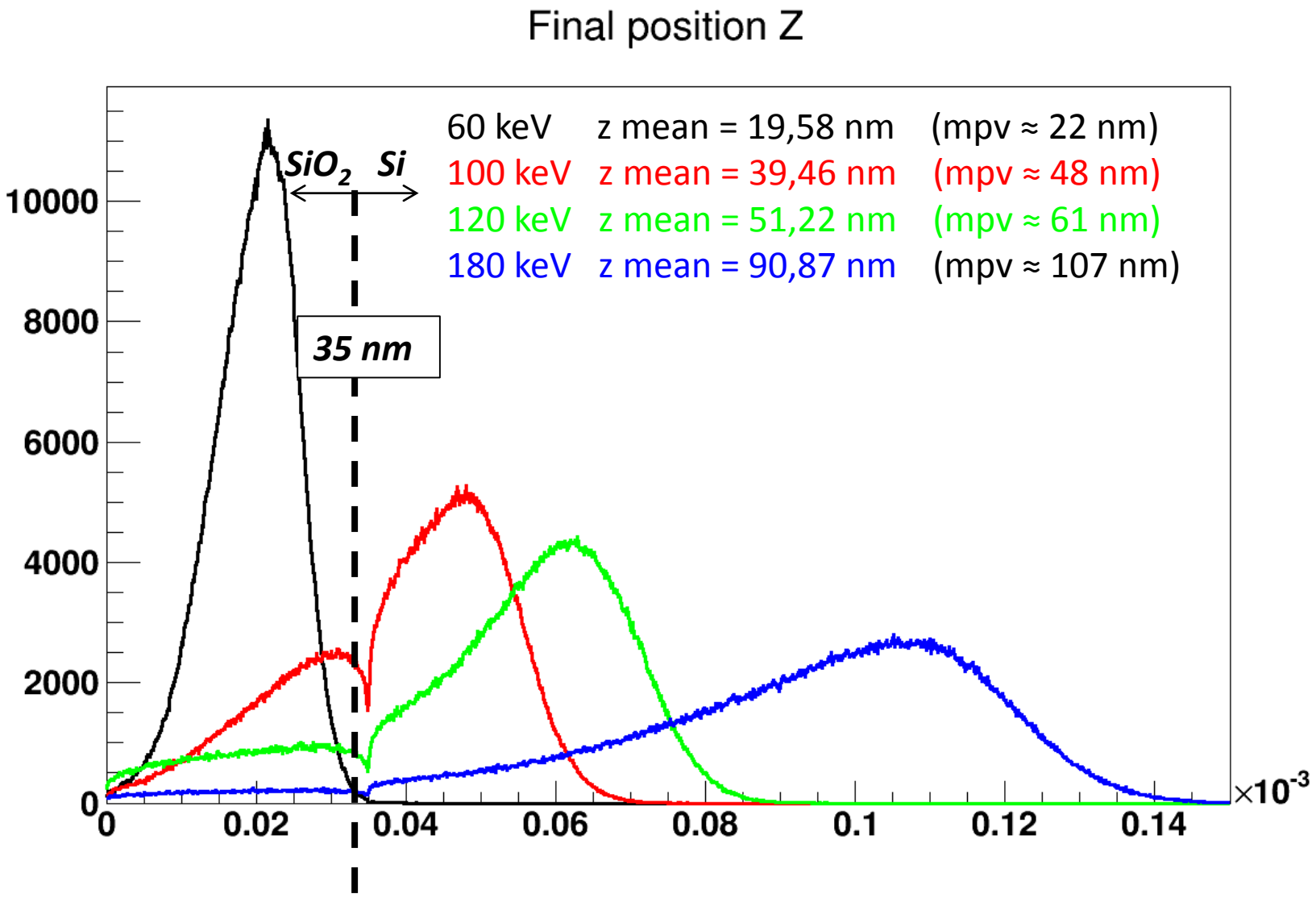
- **C(V)**: On Wafer

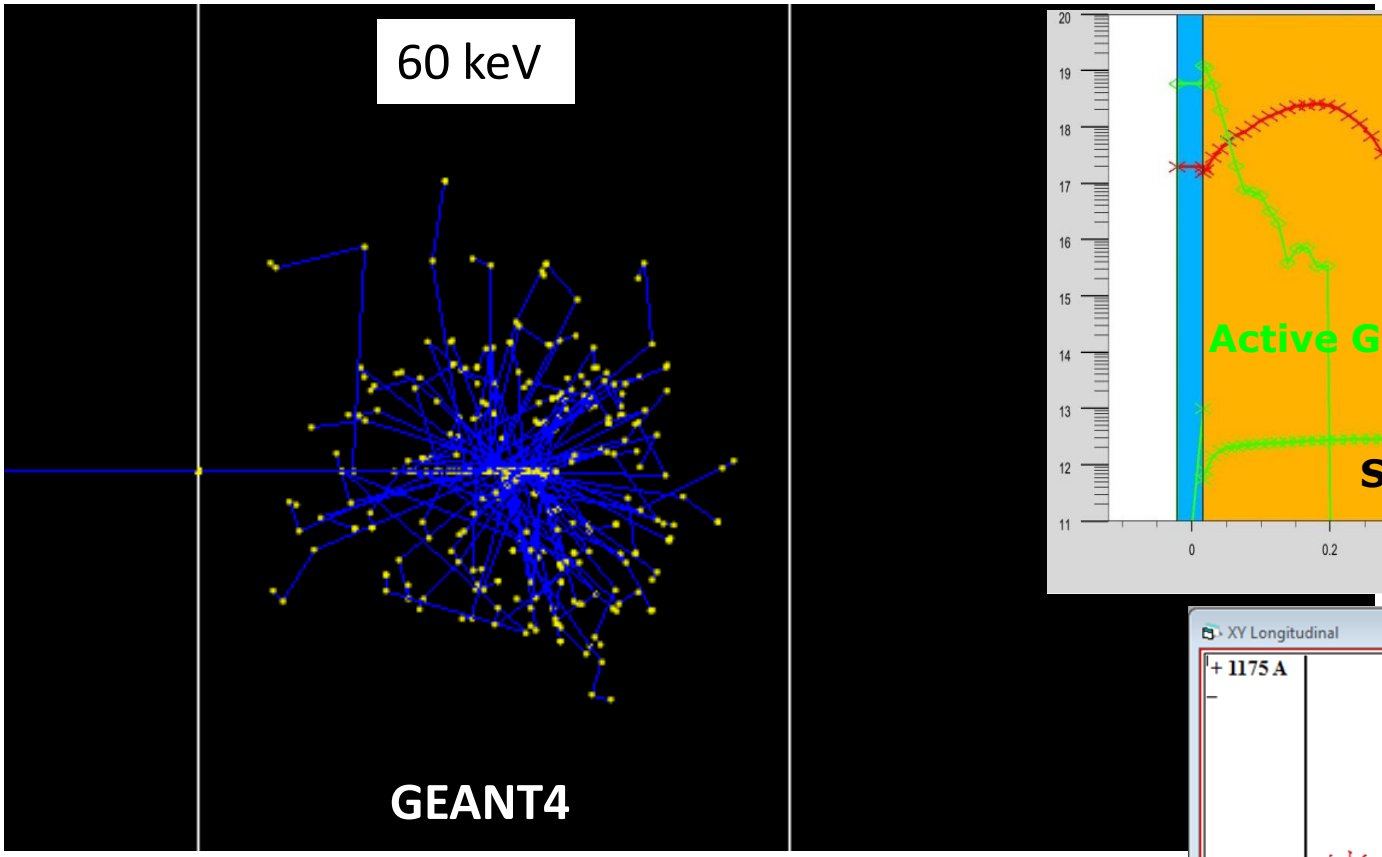


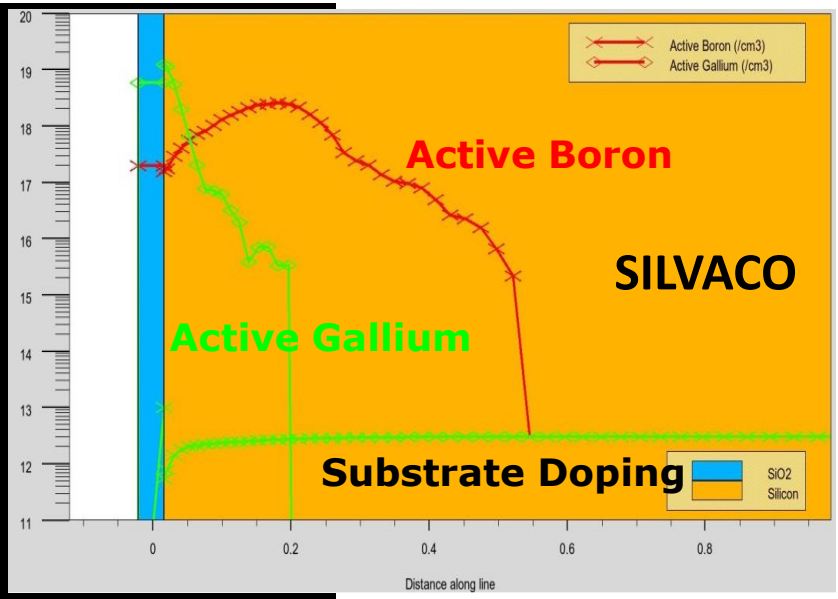


- LGAD devices with **Gallium Multiplication Layer** have similar C(V) characteristics than PiN Detectors. We do not observe the multiplication layer depletion

Gallium Implantation. GEANT4 Simulation

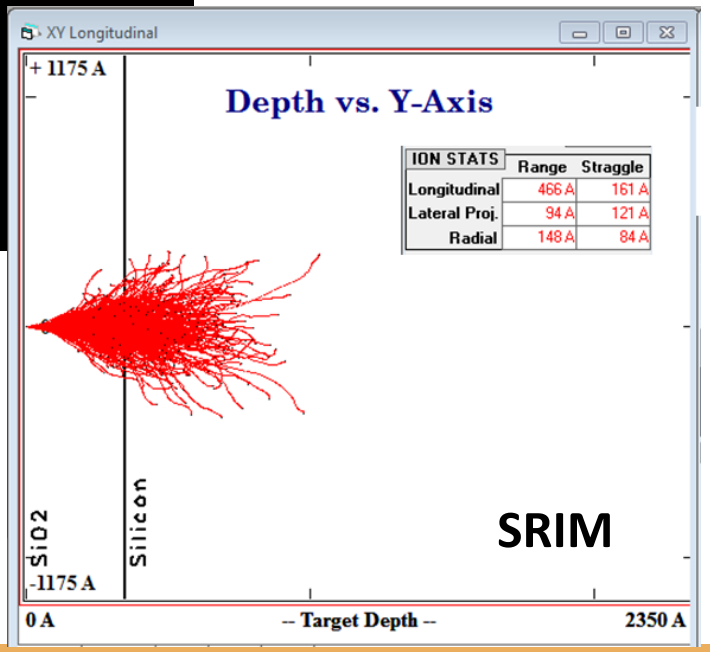






35 nm SiO_2

Geant4 final position vs SRIM range
19,58 vs 46,6 nm



Work plan for Ga implantations

- New fabrication run.
- Pad diodes with P-junction made of Ga
- Test structures to calibrate simulation and ion implantation and diffusion.
- Different ion implantation energies will be used.

Conclusions

- 1st project on LGAD fabricated in epitaxyal wafers can be considered concluded.
- 2nd project on thin LGAD detectors is in progress. Designing the mask.
- 3rd project on LGAD detectors fabricated with Ga will be submitted in this workshop

Thank you for your attention !!!!