LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

UNIVERSITÉ PARIS SUD

Irradiated structures & LGAD doping profile measurements

NinN test production, TCTs and SiMS on LGAD test structures

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Overview

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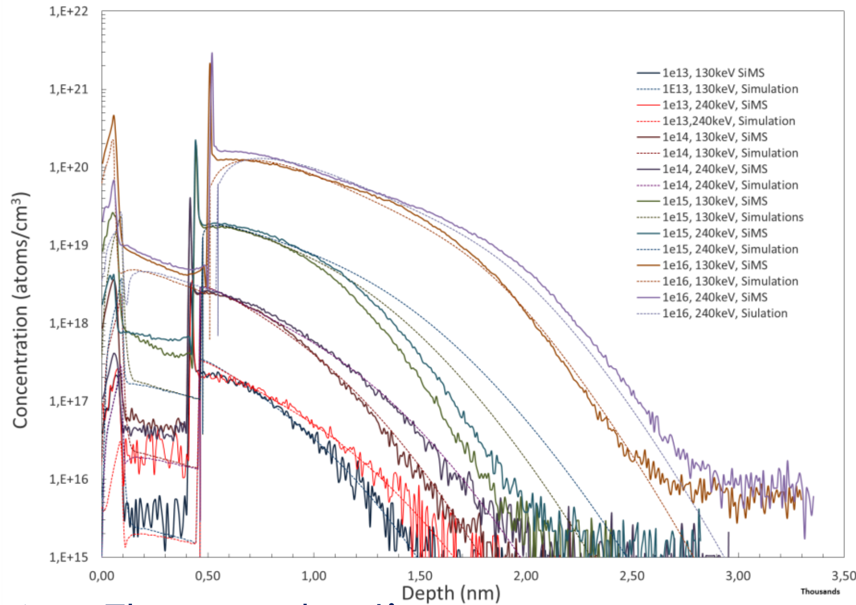
Introduction	**Reminders** Doping profile Project overview and irradiations
SiMS on irradiated structures	**Measurements and comparison** Calibration and rescaling to unirradiated profiles
LGAD Doping profiles	**Measurements on CNM test structures** Initial results and comparisons
Gallium LGAD Run profiles	**Preliminary doping profiles** Measurements and through oxide tests
TCT Measurements	**CiS NinN irradiated diodes** Initial results and cartography
Conclusion	**Conclusions and plans** Further investigations and simulations

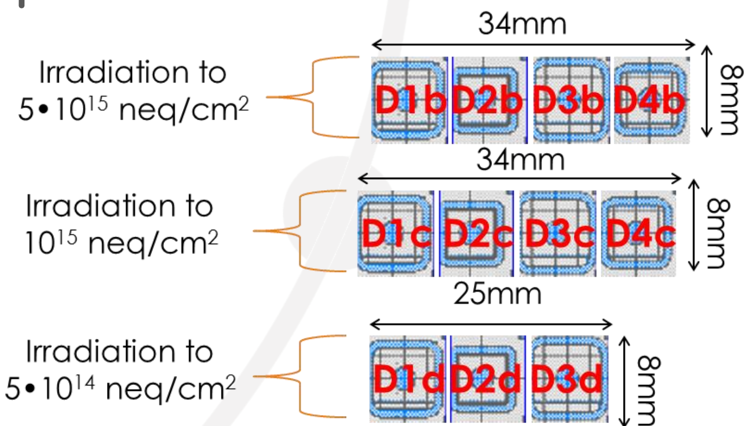
•Reminders

Doping profiles study and irradiations



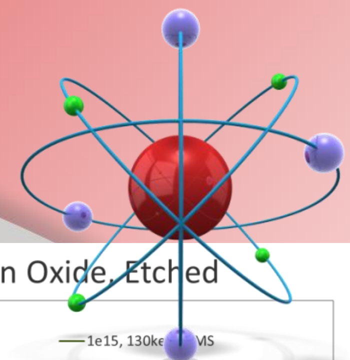
- The production
  - Several wafers ordered of controlled parameters
  - Measured and simulated
  - Goal to calibrate simulations, to develop measurement techniques and understand basic processes

- Irradiations
  - Several SiMS samples were irradiated at KIT
  - Fluences 10e16n_{eq}/cm^2 with 20GeV protons
  - Different Guard rings design diodes also include irradiated to fluences form $5e10^{14}$ to $10e^{16}$ n_{eq}/cm^2
  - SiMS and TCT measurements prerformed

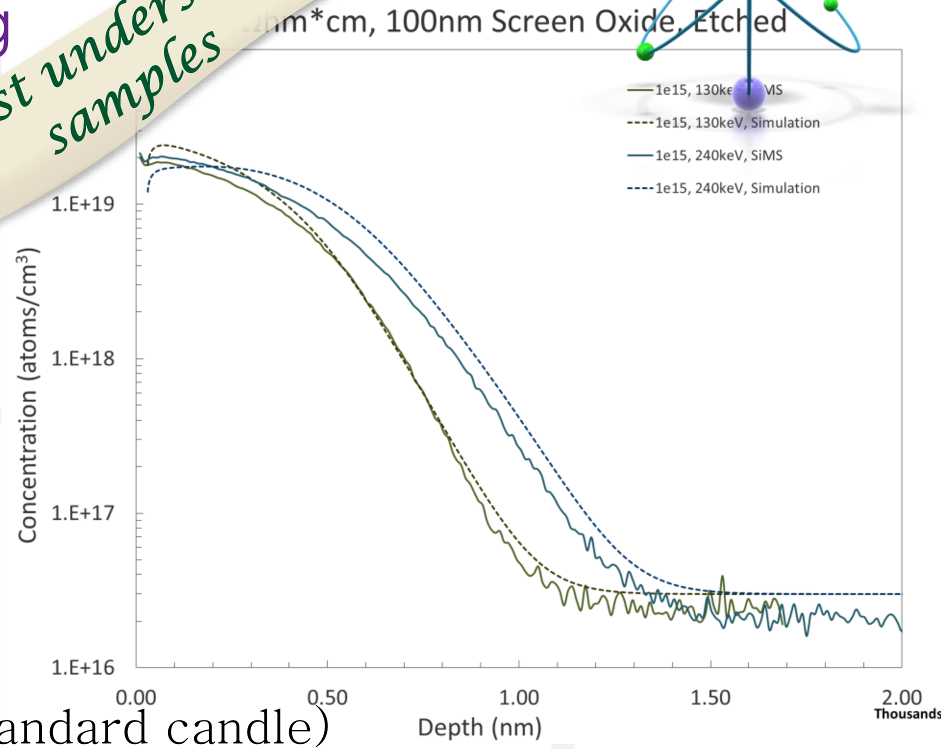


•Irradiated SiMS

Measurements and rescaling



1. Not expecting any SiMS profile alteration after irradiation in principle
2. Perhaps slight changes due to point annealing if not sufficiently cooled
3. Possibility of sputtering but irradiation dose was moderate for this effect

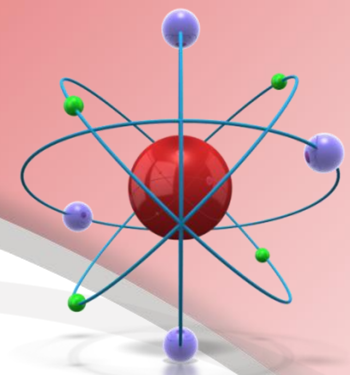


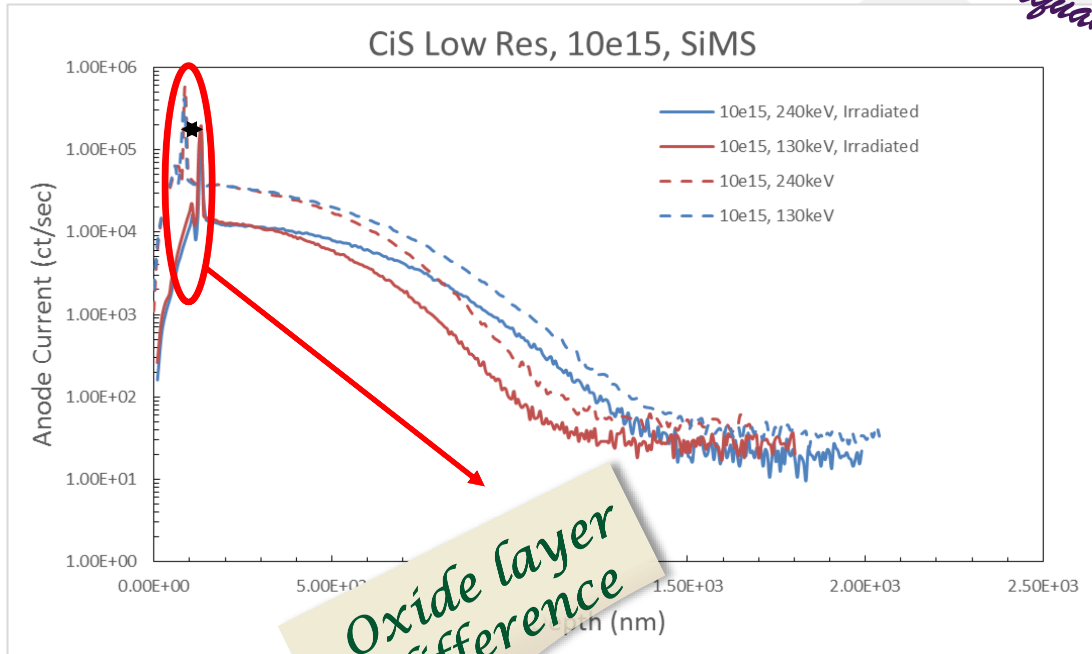
The sample:

- 10^{15}cm^{-2} at 130 and 240 keV (standard candle)
- 100nm layer of oxide
- Good agreement between simulation and SiMS measurements
- Irradiated to $10^{16}n_{eq}$ at KIT but received room temperature anneling
- Cannot be used to perform SRP in order to investigate dopant displacement and changes in electrical caracteristics.

•Irradiated SiMS

The measurements





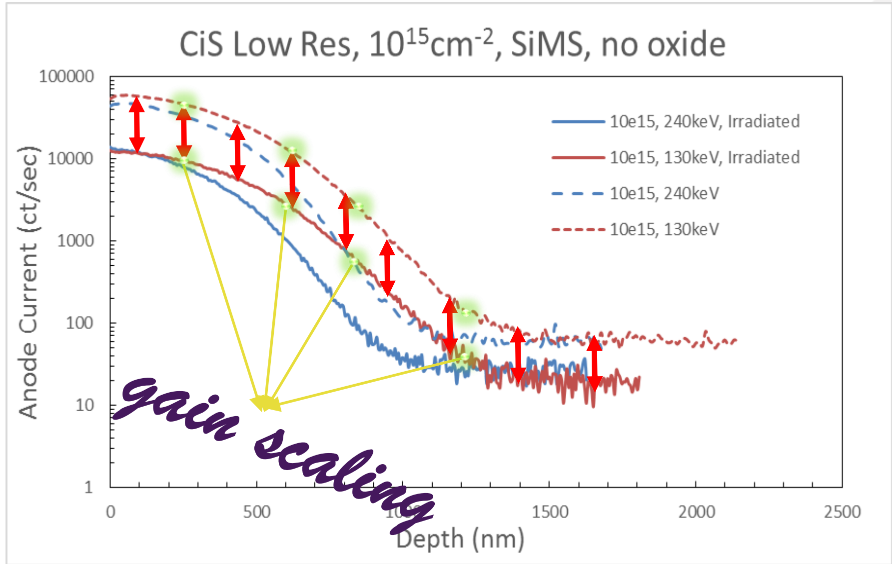
Unquantified SiMS data

- Quantification of measurements
  - The results were not quantified
  - Comparison is performed with unirradiated sample data
  - Different calibration parameters were used.

- Take into account different penetrations rates in different regions
- Correct for gain differences
- Scale to silicon level only

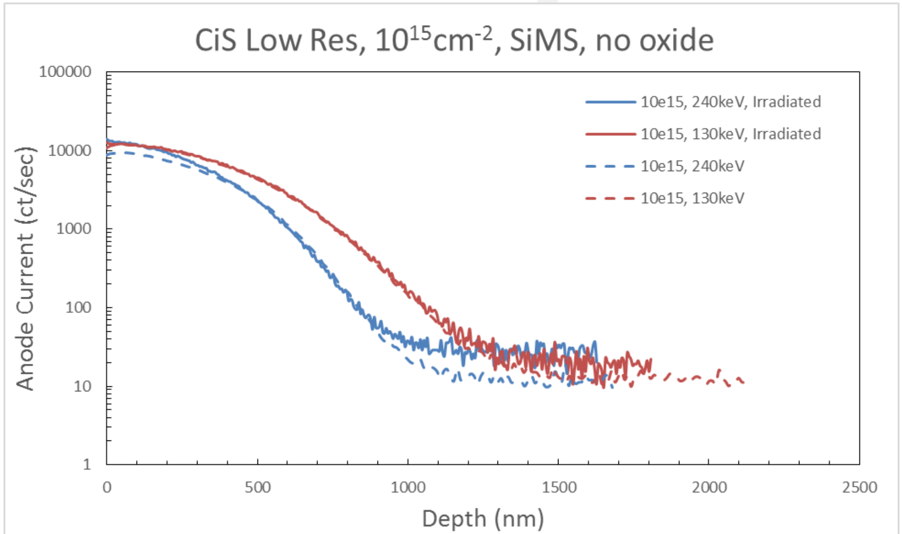
•Irradiated SiMS

Scaling



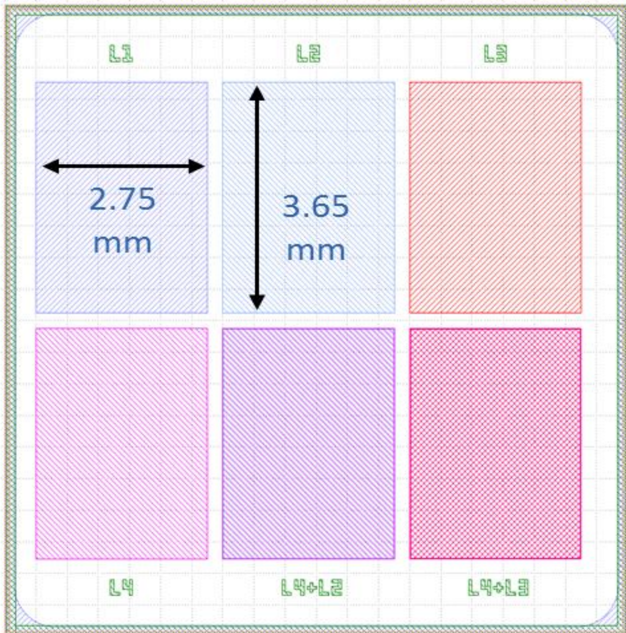
- Quantification of measurements
  - To accommodate for the inon beam penetration difference, comparison performed only in silicon refion
  - Gain difference is calculated in several regions and corrected for.

Conclusion: No alteration to the doping profile distribution for the two samples is observed after all corrections!

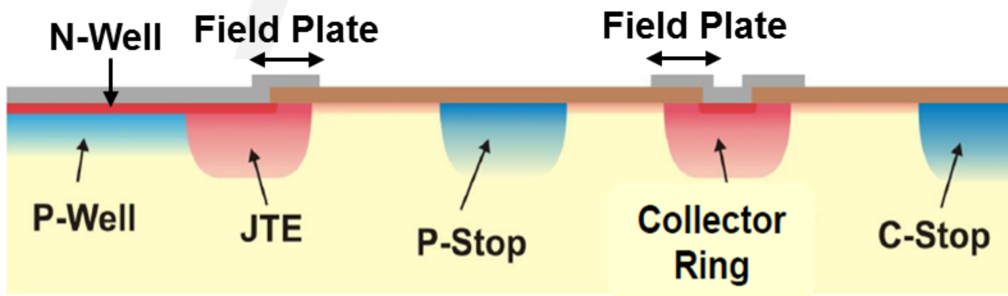


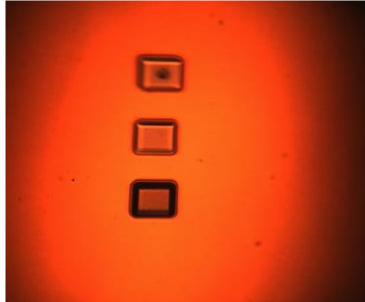
•LGAD Doping profiles

The structure



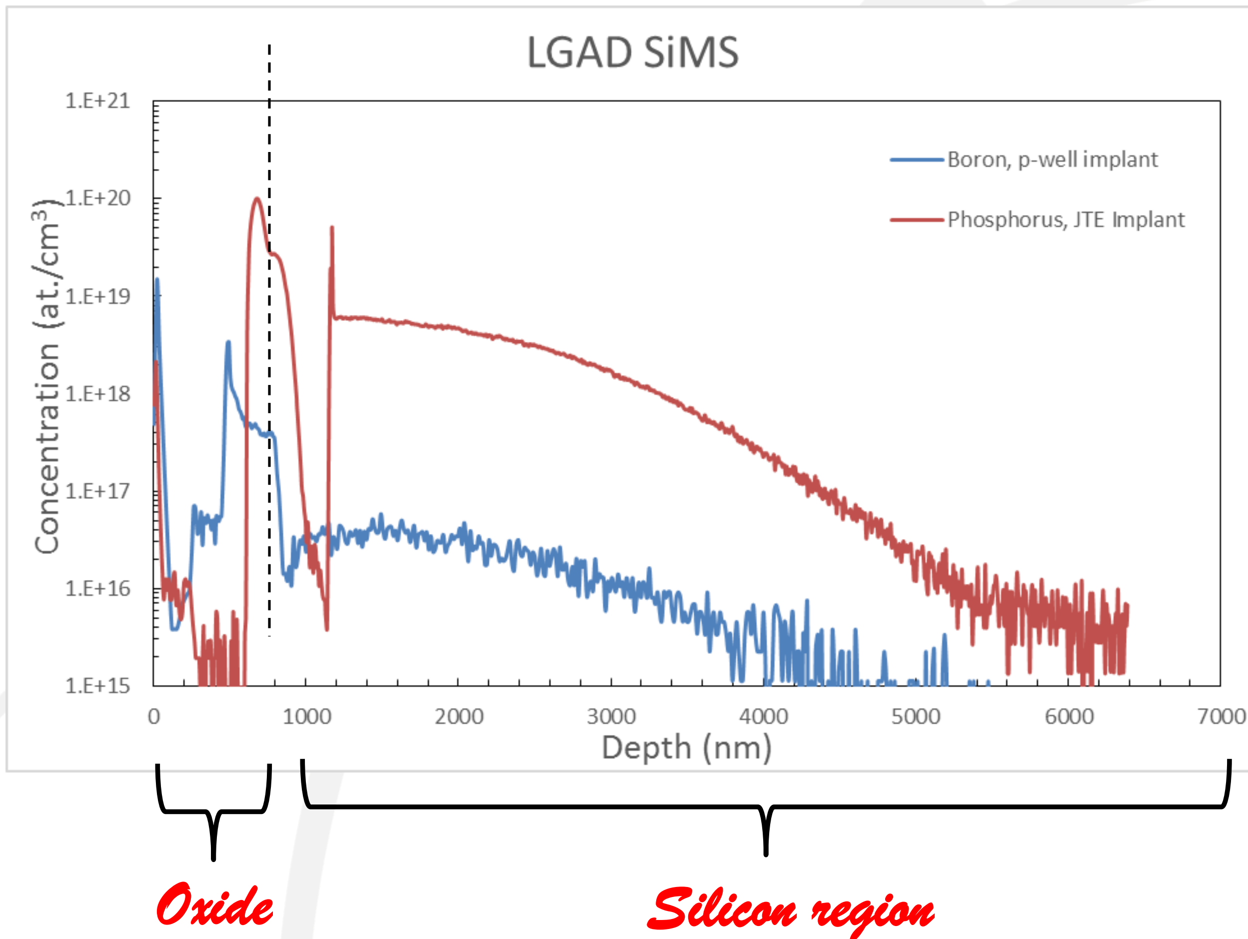
1. Jointly designed mask with CNM to accommodate for SiMS limitations
2. 6 individual regions:
   - L1 P-Stop, C-Stop Well
   - L2 P-Well (P Multiplication)
   - L3 JTE
   - L4 N-Well
   - L4 + L2 N-Well over P-Well
   - L4 + L3 N-Well over JTE
3. September Run that was delivered in February





•LGAD Doping profiles

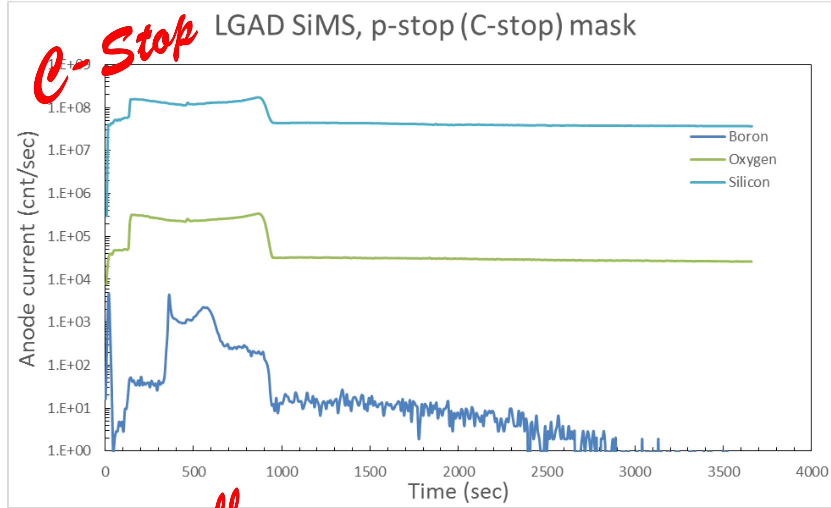
P-Well and JTE

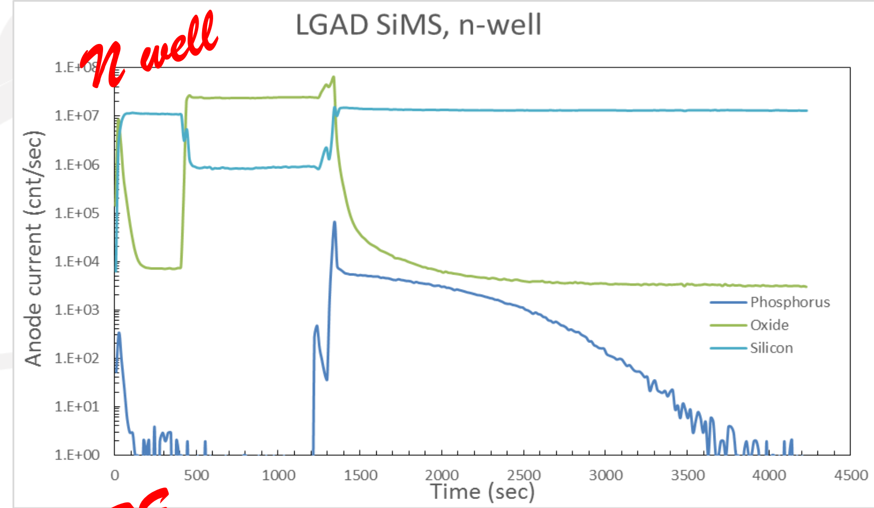


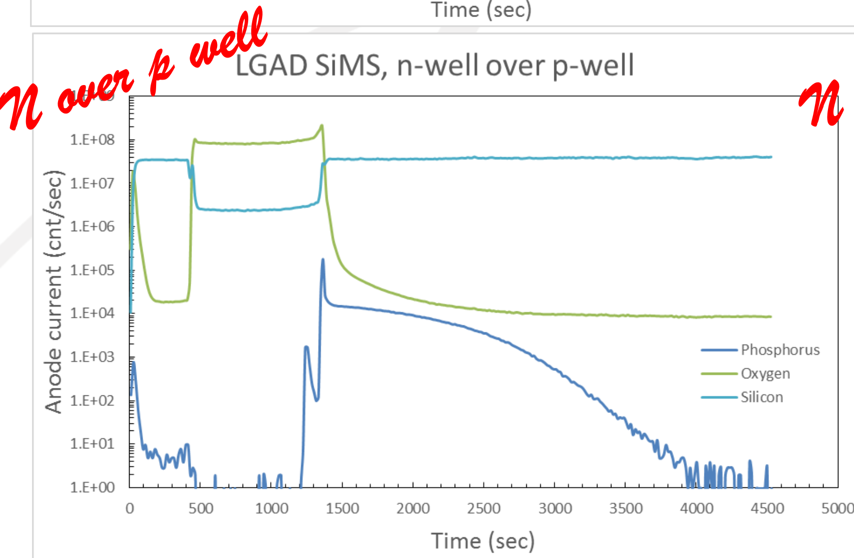
- 4 different layers were taken into account for each profile
- Maximum depth of 6μm to avoid inconsistences due to crater roughness
- Completely quantified results for the p-well boron implant and the phosphorus JTE implantation.

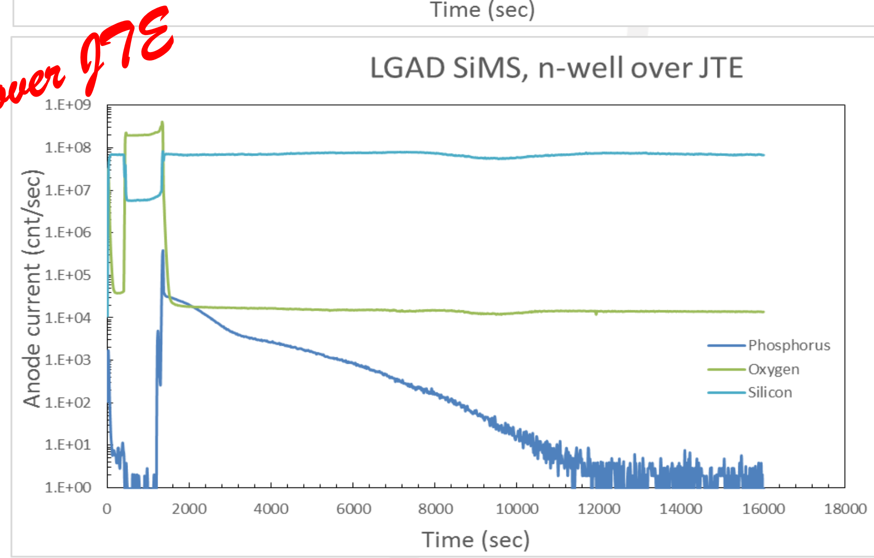
•LGAD Doping profiles

Non quantified measurements





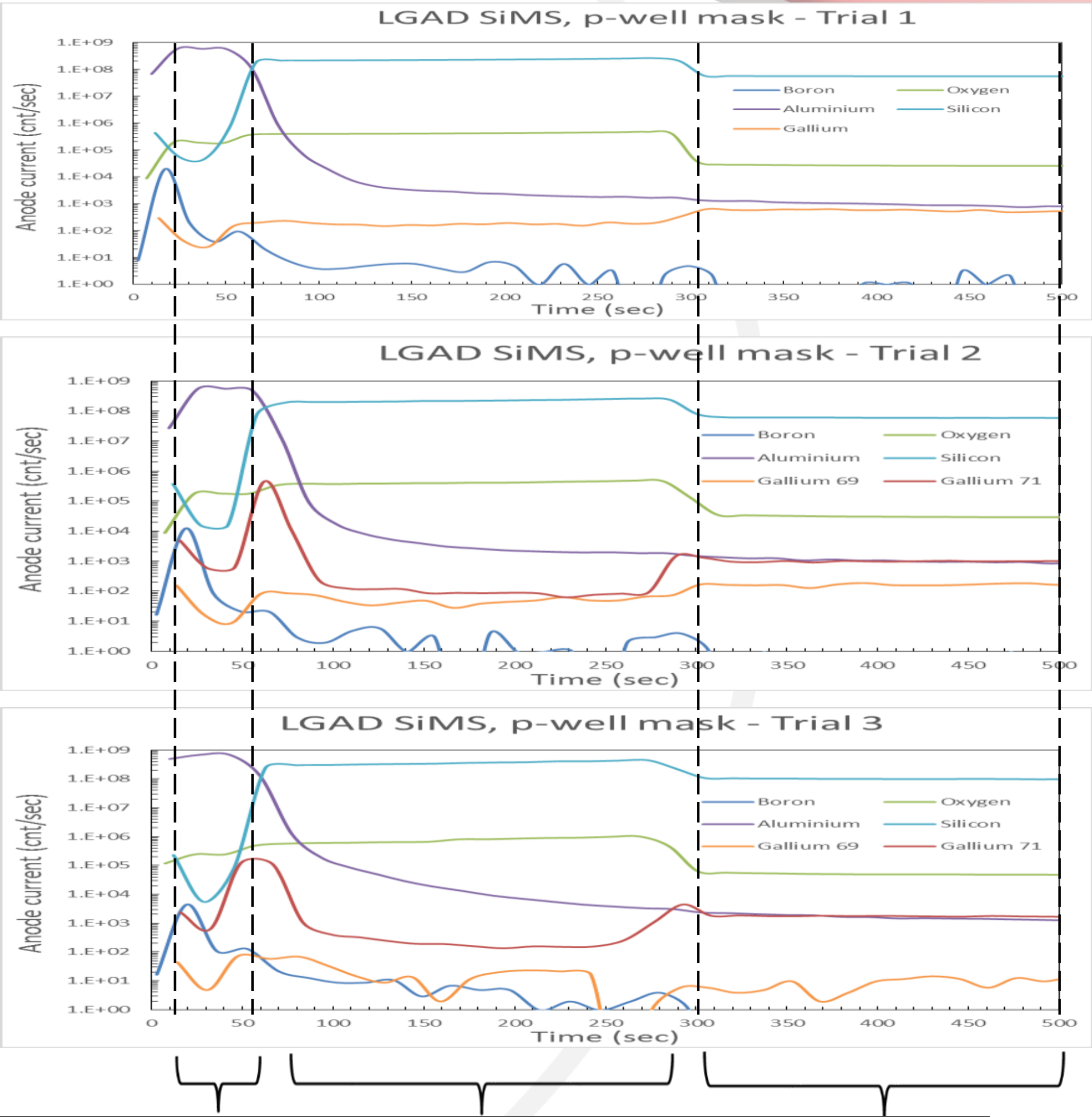




•LGAD Doping profiles

The Gallium case

- ✓ A separate set of wafers were measured where the p-well was replaced by gallium
- ✓ We noticed very low concentrations of Gallium 69 and higher of Ga71
- ✓ Non quantified measurements yet
- ✓ All implant seems to be trapped within the oxide region and none is present at the substrate
- ✓ Simplest case measures with one implantation

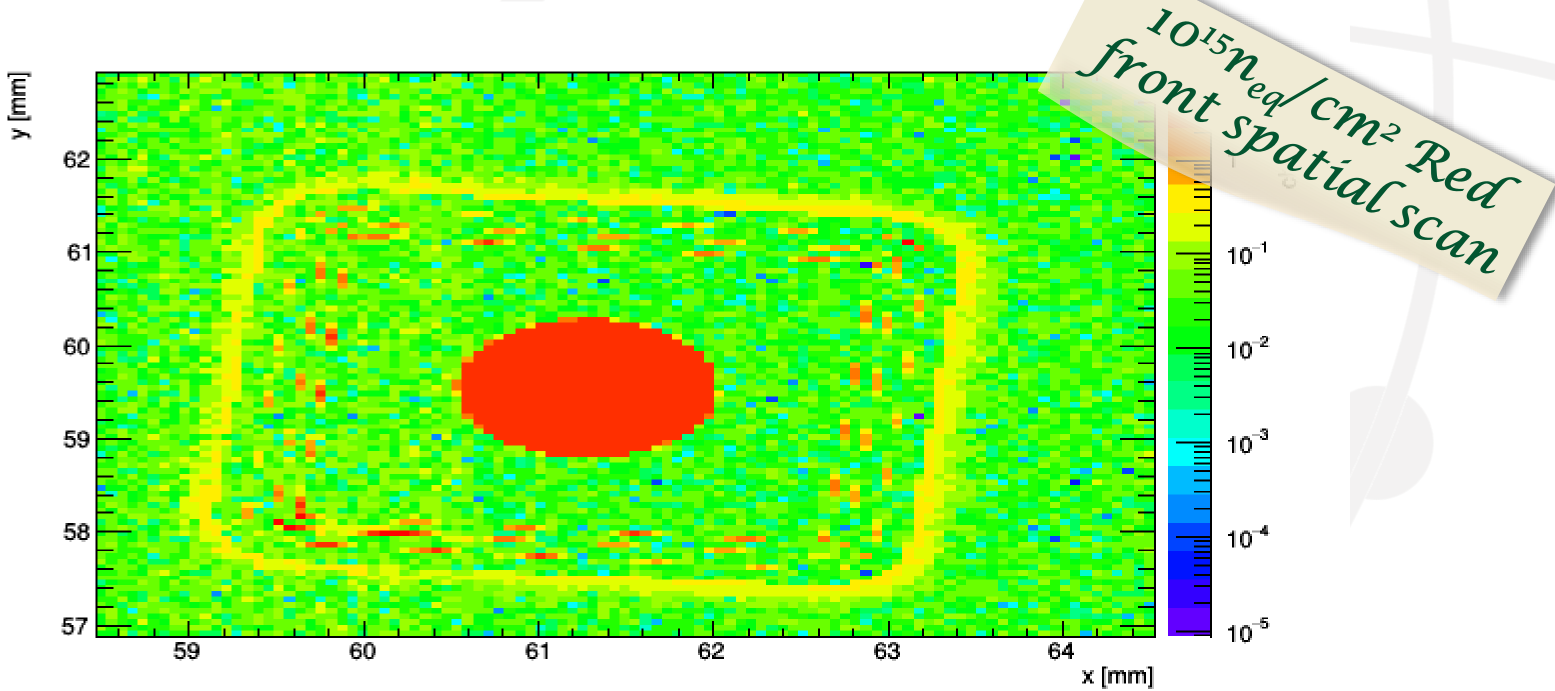


•TCT measurements

CiS irradiated Diodes

- ✓ 4Well over inversion fluency
- ✓ different fluencies used, form $5 \cdot 10^{14}$ to $1 \cdot 10^{16}$ irradiated at KIT
- ✓ All samples were completely functional at -15C
- ✓ Used front and back red as well as front IR technique
- ✓ Detailed cartography for the intermediate fluency

Special thanks to Christian Gallrap For using is setup

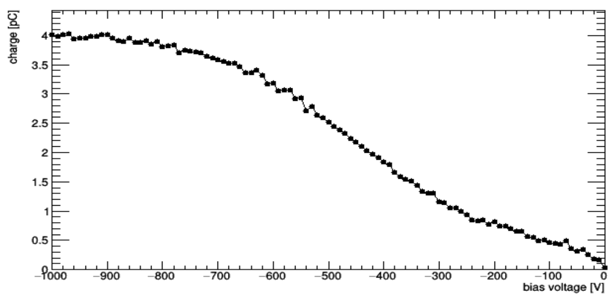


$10^{15} n_{eq}/cm^2$ Red front spatial scan

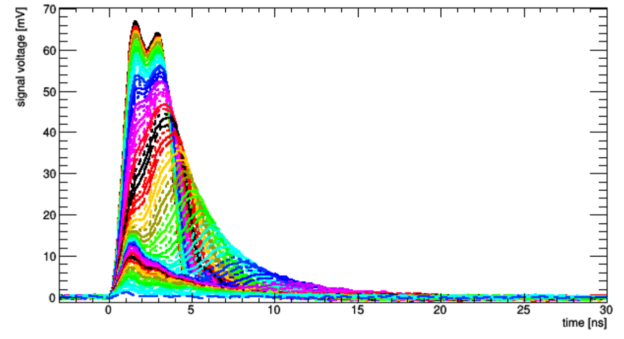
•TCT measurements

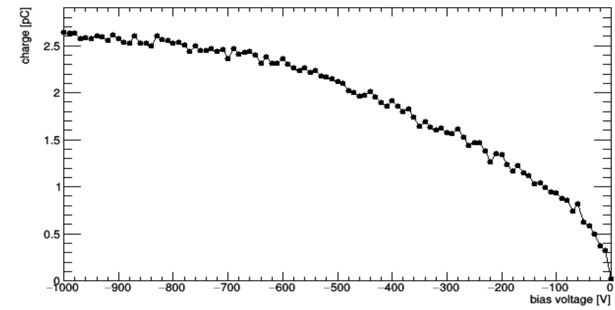
3 GR Diode at $5 \cdot 10^{14}\ n_{eq}/cm^2$

Charge collection ad signal response for the three cases:

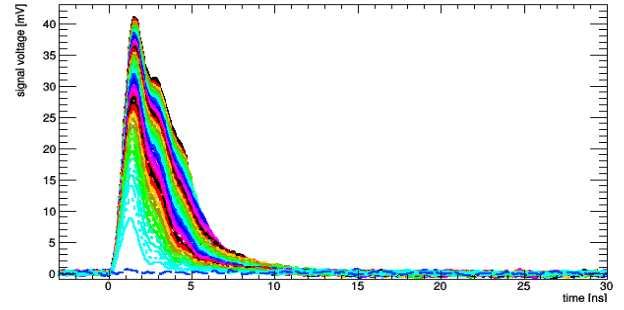


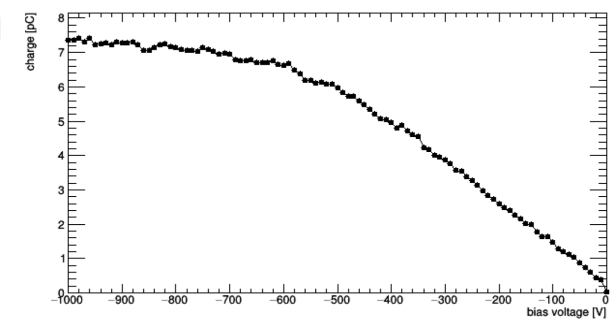
Red Front



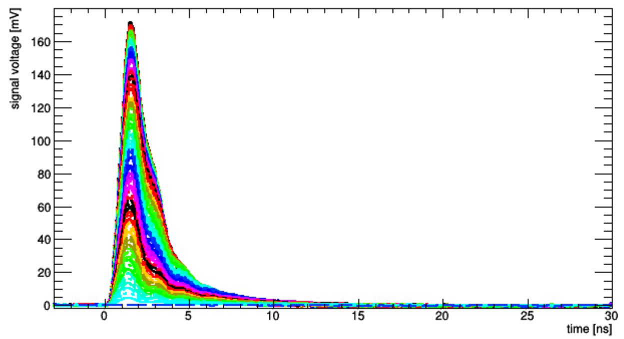


Red back





Infrared Front



•Future Plans - Conclusions

SiMS –SRP – LGADs - TCT

- For the irradiated doping profiles no change is observed before and after irradiation with respect to SiMS measurements
- Preliminary measurements in the standard LGAD production with boron seem to be well with reasonable limits, quantification has to be completed.
- Gallium substitution of the boron implantation present sissues that have yet to be understood.
- Using the TCT measurements ofr the different irradiation fluencies we expect to accurately calibrate the simulator to compensate for radiation damage effects

THANK YOU FOR YOUR ATTENTION!!