

# 28th RD50 Workshop (Torino)



## Report of Contributions

Contribution ID: 1

Type: **not specified**

## Progress in Ultra-Fast Silicon Detectors

*Tuesday, 7 June 2016 11:40 (20 minutes)*

We report on the status of the development of Ultra-Fast Silicon Detectors (UFSD). UFSD are novel silicon sensors based on the Low-Gain Avalanche Diodes (LGAD) design and, due to internal gain, exhibit a signal which is a factor of  $\sim 10$  larger than standard silicon detectors. The internal gain allows obtaining fast and large signals, a pre-requisite for time applications, and thus they are poised to extend the use of silicon sensors characterized by excellent position resolution into the precision time domain.

UFSD with the desired gain are being manufactured routinely in a variety of sizes and have been tested in several beam tests-. We will concentrate the discussion on thin LGADs with thickness  $< 100\mu\text{m}$ , we expect the best time resolution with them, due to the high slew-rate and the small contribution of Landau fluctuations.

The results of timing measurements on  $75\mu\text{m}$  thick LGAD produced by CNM using a beta source will be presented.

**Primary author:** SADROZINSKI, Hartmut (SCIPP UC Santa Cruz)

**Presenter:** SADROZINSKI, Hartmut (SCIPP UC Santa Cruz)

**Session Classification:** Sensors with Internal Gain I

Contribution ID: 2

Type: **not specified**

# The GigaTracker

*Monday, 6 June 2016 09:10 (30 minutes)*

The GigaTracker (GTK) hybrid pixel detector has been designed to provide hits timed to better than 200ps RMS.

I will give an introduction to the detector architecture and talk about the special techniques used to achieve this demanding requirement. I will also describe the factor that we think ultimately limit the time resolution achievable with such an architecture.

**Primary author:** Dr NOY, Matthew (CERN)

**Presenter:** Dr NOY, Matthew (CERN)

**Session Classification:** Present and Future Experiments

Contribution ID: 3

Type: **not specified**

## **Radiation damage models: comparison between Silvaco and Synopsys**

*Monday, 6 June 2016 11:30 (20 minutes)*

In this talk we will present a comparison between Silvaco and Synopsys predictions when it comes to radiation damage models; the focus will nbe on the recent Perugia model. Leakage current increase, depletion voltage and trapping time will be extracted and compared. The simulated structures will include standard and LGAD n-on-p diodes.

**Primary author:** Dr BOMBEN, Marco (LPNHE)

**Presenter:** Dr BOMBEN, Marco (LPNHE)

**Session Classification:** Simulation and HV CMOS

Contribution ID: 4

Type: **not specified**

## Phase II planar pixel sensors: Simulation study of interpixel isolation and surface passivation by a thin-film ALD-layer

*Monday, 6 June 2016 11:50 (20 minutes)*

Interpixel isolation and charge sharing before and after irradiation in the proposed Phase II planar pixel n-on-p detectors was studied by TCAD simulations. Both p-spray and p-stop isolated devices with varied isolation doping concentration and depth as well as interface charge density were investigated. The results show that the acceptors in the isolation implantation are compensating the radiation induced surface traps leading to a local minimum of the interpixel resistance as a function of p-spray doping.

Effect of Atomic Layer Deposition (ALD) passivation-layer materials with different dielectric constants and thicknesses on breakdown voltage in 25x100 pixels was also investigated. The negative oxide charge in thin-film ALD-oxide provides strip isolation without any additional isolation structures, thus avoiding their higher processing complexity. The results were also compared to corresponding breakdown voltages of pixels with conventional isolation implantations.

### Summary

Interpixel isolation and charge sharing before and after irradiation in the proposed Phase II planar pixel detectors was studied by TCAD simulations. Effect of different ALD passivation-layer materials on breakdown voltage in 25x100 pixels was also investigated and compared with the results from pixels with isolation implantations.

**Primary author:** Dr PELTOLA, Timo (Helsinki Institute of Physics)

**Co-authors:** Dr HÄRKÖNEN, Jaakko (Ruđer Bošković Institute); Dr LUUKKA, Panja (Helsinki Institute of Physics)

**Presenter:** Dr PELTOLA, Timo (Helsinki Institute of Physics)

**Session Classification:** Simulation and HV CMOS

Contribution ID: 5

Type: **not specified**

## Neutron Irradiated doping profile evaluation

*Wednesday, 8 June 2016 09:40 (20 minutes)*

The creation of deep level defects after irradiation lowers the efficiency of a detector while increasing its operational voltage. The case of acceptor removal, observed in irradiated LGAD and other types of detectors suggests the presence of a secondary effect in addition to deep acceptor level generation. Estimation of the active dopant profile demonstrates a decrease in the acceptor concentration, proportional to the original doping concentration. Initial evidence from SiMS measurements indicated a marginal reduction on the total doping profile for proton irradiated samples, implanted with boron. A study is repeated with LGAD and boron-phosphorus samples, irradiated with thermal neutrons to fluencies of  $2 \cdot 10^{15}$  neq/cm<sup>2</sup> to  $10^{16}$  neq/cm<sup>2</sup>. Post irradiation SiMS measurements are performed and results are compared the non-irradiated and simulated doping profiles. Estimation of the boron neutron capture reactions are additionally evaluated.

**Primary author:** Mr GKOU GKOUSIS, Evangelos - Leonidas (Laboratoire de l'Accelérateur Linéaire)

**Co-author:** Prof. LOUNIS, Abdenour (Laboratoire de l'Accélérateur Linéaire)

**Presenter:** Mr GKOU GKOUSIS, Evangelos - Leonidas (Laboratoire de l'Accelérateur Lineaire)

**Session Classification:** Radiation Damage I

Contribution ID: 6

Type: **not specified**

## The Birmingham Irradiation Facility

*Tuesday, 7 June 2016 09:00 (20 minutes)*

The Particle Physics and Nuclear Physics Groups at the University of Birmingham have been operating the MC40 cyclotron with UK colleagues from Sheffield and Liverpool since 2013 as an irradiation facility for nuclear, medical and particle physics collaborations, such as RD50, ATLAS and LHCb. This facility offers a proton beam with energy up to 40MeV and currents as high as 2uA, allowing to reach a fluence in the order of  $10^{15}$  1MeV neq/cm<sup>2</sup> in minutes. Irradiations are typically performed with 27MeV protons and currents in the range of 100-500nA. Irradiations of silicon sensors are carried out in a temperature controlled cold box that can be scanned through the beam. The sensors are cooled to -25C during irradiation. Beam fluence is determined online using a Faraday Cup and offline by measuring the activity of nickel foils. Results from recent sensors irradiated at Birmingham show to be in good agreement with results from other facilities. Currently the facility is extensively used for the ATLAS ITK strips ASICs irradiation program, and it is serving a number of AIDA users. The talk will give an overview of the facility, its commissioning and recent results.

**Primary author:** GONELLA, Laura (University of Birmingham)**Presenter:** GONELLA, Laura (University of Birmingham)**Session Classification:** Facilities

Contribution ID: 7

Type: **not specified**

## Possibilities of large fluence irradiation dosimetry using multi-crystalline Si

*Wednesday, 8 June 2016 10:00 (20 minutes)*

It had been shown that measurements of carrier recombination lifetime can be employed for contact-less and fast evaluation of large fluences of the hadron irradiations. The same calibration function for fluence evaluations derived using electron-grade crystalline silicon wafer fragments fits well the absolute values of carrier recombination lifetime related to the densities of radiation defects introduced by penetrative protons, neutrons and pions. For wide area dosimetry, the cheaper silicon material for fabrication of dosimetry sensors would be desirable. In this presentation, possibilities to exploit the multi-crystalline (mc) Si material for fabrication of such sensors will be discussed. The characteristics of the fluence dependent carrier lifetime measured on 8 MeV proton irradiated mc-Si sensors made of solar-cell standard p-Si substrates will be presented.

**Primary author:** Dr GAUBAS, Eugenijus (Vilnius University)

**Co-authors:** Dr RAVOTTI, Federico (CERN); Prof. RAISANEN, Jyrki (University of Helsinki); Dr MIZOHATA, Kenichiro (University of Helsinki); Dr MOLL, Michael (CERN); Dr CEPONIS, Tomas (Vilnius University)

**Presenter:** Dr GAUBAS, Eugenijus (Vilnius University)

**Session Classification:** Radiation Damage I



Contribution ID: 8

Type: **not specified**

## Status of the RD50-Project "NitroStrip"

*Monday, 6 June 2016 14:40 (20 minutes)*

The aim of the "NitroStrip" project is to extend the "NitroSil" project by performing charge collection measurements on strip sensors, which are not included in "NitroSil". Both projects evaluate the radiation resistance of nitrogen enriched silicon.

We will present the finally approved project plan and the current status of the project.

**Primary author:** DIERLAMM, Alexander (Karlsruhe Institute of Technology)

**Presenter:** DIERLAMM, Alexander (Karlsruhe Institute of Technology)

**Session Classification:** Sensor Design

Contribution ID: 9

Type: **not specified**

## Performance of thin n-in-p planar pixel modules with and without active edge

*Monday, 6 June 2016 15:00 (20 minutes)*

New productions of thin n-in-p pixel sensors designed at MPP will be presented. Sensors of thicknesses of 100 and 150  $\mu\text{m}$  have been produced at ADVACAM and CiS and interconnected to FE-I4 chips. At ADVACAM SOI wafers were employed, while at CiS anisotropic KOH etching was carried out to create backside cavities in the wafer leaving thicker frames around each single structure. To maximize the active area of the thin sensors, slim and active edges were implemented in the sensors of the ADVACAM production. The evaluation assemblies have been measured by means of radioactive source scans and beam tests and the results on charge collection - and edge efficiency will be discussed. The power dissipation for thin sensors irradiated at a fluence of  $1\text{e}16$  will be evaluated and the performance after irradiation up to  $1\text{e}16$  in terms of hit efficiency of different sensor thicknesses in the range of 100 to 270  $\mu\text{m}$  will be discussed.

Previous investigations of different punch-through designs have led to the optimization of the pixel biasing structure to limit the related loss of efficiency at high levels of irradiation. This is particularly important for the sensors to be interconnected to the new RD53 chip, given the reduced cell size of  $25\times 100$  or  $50\times 50\ \mu\text{m}^2$ . A pixel sensor production at HLL on SOI wafers where these changes were implemented has been recently completed and the preliminary electrical characterization of the RD53 sensors will be discussed.

**Primary author:** Ms SAVIC, Natascha (Max-Planck-Institute for Physics)

**Co-authors:** Dr MACCHIOLO, Anna (Max-Planck-Institut fuer Physik); Mr BEYER, Julien-Christopher (Max Plack Institut fuer Physik); Dr NISIUS, Richard (Max-Planck-Institut fuer Physik); Dr TERZO, Stefano (Institut de Fisica d'Altes Energies (IFAE))

**Presenter:** Ms SAVIC, Natascha (Max-Planck-Institute for Physics)

**Session Classification:** Sensor Design

Contribution ID: **10**Type: **not specified**

## Characterization of NitroSil diodes at KIT

Diodes made from three different wafer materials (FZ, N-rich FZ, O-rich FZ) have been irradiated with protons ( $5 \times 10^{13}$  to  $5 \times 10^{15} \text{ neq/cm}^2$ ) and are being characterized (IV, CV, TCT).

Here we present the first results of these measurements.

**Primary author:** DIERLAMM, Alexander (Karlsruhe Institute of Technology)

**Presenter:** DIERLAMM, Alexander (Karlsruhe Institute of Technology)

Contribution ID: 11

Type: **not specified**

## Radiation hardness and precision timing study of Silicon Detectors for the CMS High Granularity Calorimeter (HGC)

*Monday, 6 June 2016 10:10 (20 minutes)*

The high luminosity LHC (HL-LHC or Phase-II) is expected to increase the instantaneous luminosity of the LHC by a factor of about five, delivering about 250 fb<sup>-1</sup> per year between 2025 and 2035. Under these conditions the performance degradation of detectors due to integrated radiation dose/fluence will need to be addressed. The CMS collaboration is planning to upgrade many components, including the forward calorimeters. The replacement for the existing endcap preshower, electromagnetic and hadronic calorimeters is called the High Granularity Calorimeter (HGCAL) and it will be realized as a sampling calorimeter, including 30 layers of silicon detectors totalling 600m<sup>2</sup>. The sensors will be realized as pad detectors with cell sizes of between 0.5-1.0 cm<sup>2</sup> and an active thickness between 100 μm and 300 μm depending on their location in the endcaps: the thinner sensors will be used in the highest radiation environment. For an integrated luminosity of 3000 fb<sup>-1</sup>, the electromagnetic calorimetry will sustain integrated doses of 1.5 MGy (150 Mrads) and neutron fluences of 10x16 n/cm<sup>2</sup> in the worst case. A tolerance study after neutron irradiation of 300 μm, 200 μm and 100 μm n-on-p and p-on-n silicon pads irradiated to fluences up to 1.6x10<sup>16</sup> n/cm<sup>2</sup> is presented. The main properties of these diodes have been studied before and after irradiation: leakage current, capacitance, charge collection efficiency, annealing effects, timing capability. As expected, the results show a good performance even after the most extreme irradiation.

**Primary author:** CURRAS, Esteban (CERN - IFCA(CSIC-UC))**Presenter:** CURRAS, Esteban (CERN - IFCA(CSIC-UC))**Session Classification:** Present and Future Experiments

Contribution ID: 12

Type: **not specified**

## Experimental determination of the NIEL hardness factor for the new CERN proton irradiation facility.

*Tuesday, 7 June 2016 09:40 (20 minutes)*

A new 24GeV/c proton irradiation facility replaced the old CERN facility in 2014. An experimental determination of the hardness factor of the new facility is ongoing. Results on the scaling of the leakage current with increasing fluence for several irradiations performed in 2015 and 2016 will be presented.

**Primary author:** Mr MATEU, Isidre (CIEMAT)

**Co-authors:** Dr RAVOTTI, Federico (CERN); Dr MOLL, Michael (CERN)

**Presenter:** Mr MATEU, Isidre (CIEMAT)

**Session Classification:** Facilities

Contribution ID: 13

Type: **not specified**

## The influence of edge effects on the determination of doping profiles using silicon pad diodes

*Monday, 6 June 2016 14:00 (20 minutes)*

Edge effects for square p+n pad diodes with guard rings, fabricated on high-ohmic silicon, are investigated. Using capacitance-voltage measurements of two pad p+n diodes with different areas, the planar and the edge contributions to the diode capacitance are determined separately. Different methods of extracting the doping concentration are compared. In practically all cases it is found that the results with and without edge corrections differ significantly. After edge corrections, the bulk doping determined is uniform within  $\pm 1.5\%$ . The voltage dependence of the edge capacitance is compared to the predictions of two simple models. It is recommended that pad diodes of different dimensions, ideally both circular and square, should be implemented as standard test structures for sensor submissions.

**Primary author:** Mr HUFSCHMIDT, Michael (University of Hamburg)

**Co-authors:** Dr FRETWURST, Eckhart (University of Hamburg); Prof. GARUTTI, Erka (University of Hamburg); Mr KOPSALIS, Ioannis (University of Hamburg); Dr SCHWANDT, Joern (University of Hamburg); Prof. KLANNER, Robert (University of Hamburg)

**Presenter:** Dr FRETWURST, Eckhart (University of Hamburg)

**Session Classification:** Sensor Design

Contribution ID: 14

Type: **not specified**

## E-TCT measurements of irradiated HV-CMOS test structures

*Monday, 6 June 2016 12:10 (20 minutes)*

E-TCT measurements with HVCMOS detectors produced by different foundries on substrates with different resistivities will be presented. Samples were irradiated with reactor neutrons in Ljubljana and with protons at CERN PS. Measurements were made with passive detector structures in which current pulses induced on charge collecting electrode could be directly observed. In reverse biased HVCMOS sensors investigated in this work the depleted region is formed in the p-type substrate. With Edge-TCT method the thickness of this layer could be estimated and it was studied as the function of irradiation fluence. It was observed that in some substrates the thickness of depleted layer increased with irradiation in certain range of fluences. The increase of depleted layer was attributed to initial acceptor removal.

**Primary author:** Mr MANDIĆ, Igor (Jožef Stefan Institute)

**Presenter:** Mr MANDIĆ, Igor (Jožef Stefan Institute)

**Session Classification:** Simulation and HV CMOS

Contribution ID: 15

Type: **not specified**

## Study of surface radiation damage of segmented Si sensors at Hamburg University: Results, status and next steps

*Wednesday, 8 June 2016 11:00 (20 minutes)*

Studies of surface radiation damage and the impact of the charge distribution on the outer surface of segmented silicon sensors are ongoing at Hamburg University since 2007. In this talk, selected results obtained from measurements on test structures and strips sensors will be presented:

- dose and electric field dependence of the effective oxide charge density,  $N_{ox}$ ,
- dose and electric field dependence of the surface-current density,  $J_{surf}$ ,
- attempts to determine the energy distribution of the interface trap density,  $D_{it}$ , as function of radiation dose,
- study of the charging and discharging of radiation-induced border traps when changing the biasing conditions,
- influence of  $N_{ox}$  on the breakdown characteristics of segmented p+n sensors,
- influence of  $N_{ox}$  on the electric field and the charge collection of strip sensors,
- time and humidity dependence of the resistivity of the outer surface (passivation layer) of strip sensors and its influence on the charge collection.

It is concluded that the number of parameters which influence surface radiation damage depends is so large, that a complete systematic study is practically impossible and certainly beyond the capabilities of a single group. However, based on the studies presented, extreme values of parameters like  $N_{ox}$ ,  $D_{it}$ , and  $J_{surf}$  for maximal electric fields typical for segmented silicon sensors are available. They can be implemented into TCAD simulations in order to study the joint effects of surface and bulk radiation damage for the radiation fields, which are relevant for the HL-LHC (and also the European XFEL). In addition, the importance of verifying by TCAD simulations

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**Presenter:** Dr SCHWANDT, Joern (University of Hamburg)

**Session Classification:** Radiation Damage II



Contribution ID: 16

Type: **not specified**

## CiS Planar Sensor Technologies for Future High-Luminosity-LHC Upgrades

*Tuesday, 7 June 2016 10:00 (20 minutes)*

Planar hybrid silicon sensors are a well proven technology for past and current particle tracking detectors in HEP experiments. However, the future high-luminosity upgrades of the inner trackers at the LHC experiments pose big challenges to the detectors. The first challenge is an expected radiation damage level of  $2 \times 10^{16} \text{ n}_{\text{eq}} \text{ cm}^{-2}$ . The second challenge is the large detector areas which have to be built as cost efficient as possible, i.e. it is aimed for low-cost and large-sized sensor material.

Various new wafer processing, electroplating or mask-less & electro-less Under-Bump-Metallization and bump deposition and mounting technologies are currently developed at CiS.

Our focus is to coordinate the technologies in order to cope with the application challenges on the one side and the cost efficiency on the other side. The target costs have to match with the full value chain of hybrid modules for inner tracker upgrades and industrial use.

The CiS research institute has accomplished a proof-of-principle run with n-in-p ATLAS-Pixel sensors where cavities are etched to the sensors back side to reduce its thickness. The membranes with areas of up to  $\sim 4 \times 4 \text{ cm}^2$  and target thicknesses of 100 and 150  $\mu\text{m}$  feature a sufficiently good homogeneity across the whole wafer area. Various technological approaches to realize edge-less sensor layouts, especially using active edges are developed.

For Pixel sensors different new concepts for “removable” bias grids will be investigated.

It will also be presented our new opportunities to realize under-bump-metallization, copper pillars, bump deposition using Lift-off mask or stencil printing or mask-less & electro-less processes.

**Primary author:** Mr RÖDER, Ralf (CiS)

**Co-authors:** Mr KOMPATSCHER, Arno E. (CiS); Dr LAUER, Kevin (CiS); Dr NIELAND, Sabine (CiS); Dr WITTIG, Tobias (CiS)

**Presenter:** Mr RÖDER, Ralf (CiS)

**Session Classification:** Facilities

Contribution ID: 17

Type: **not specified**

## Detector Irradiation at CNA

*Tuesday, 7 June 2016 09:20 (20 minutes)*

CNA (Centro Nacional de Aceleradores) is a spanish users facility dedicated to multidisciplinary applications of particle accelerators. The recent activities at CNA associated to irradiation of radiation detectors will be presented.

**Primary author:** Prof. GOMEZ CAMACHO, Joaquin (CNA)

**Co-authors:** Dr GARCIA LOPEZ, Javier (Atomic, Molecular and Nuclear Physics Department, University of Sevilla, Spain); Mrs JIMÉNEZ-RAMOS, M<sup>a</sup> Carmen (Centro Nacional de Aceleradores)

**Presenter:** Prof. GOMEZ CAMACHO, Joaquin (CNA)

**Session Classification:** Facilities

Contribution ID: 18

Type: **not specified**

## Generation shallow radiation damages at the strip surface with low energy protons.

*Wednesday, 8 June 2016 11:20 (20 minutes)*

The aim of the shallow radiation damage generation study is the creation of a multiplication layer close to the silicon sensor surface. This is done by irradiating the sensor with low energy protons at the Birmingham cyclotron, which should stop within approximately 20 $\mu$ m. Geant4 simulations have been used to find the best settings for the irradiation. First sensors have been irradiated with 12 MeV protons and the results will be shown.

After the proton irradiation the whole sensors have been irradiated with neutrons at Ljubljana to fluences of 1E15 neq/cm<sup>2</sup> and 5E15 neq/cm<sup>2</sup>. A comparison with standard sensors will be presented.

**Primary author:** Mr WONSAK, Sven (University of Liverpool)

**Co-authors:** Prof. CASSE, Gianluigi (University of Liverpool and FBK); Dr DERVAN, Paul (University of Liverpool)

**Presenter:** Mr WONSAK, Sven (University of Liverpool)

**Session Classification:** Radiation Damage II

Contribution ID: 19

Type: **not specified**

## Technological Developments on iLGAD Detectors for Tracking and Timing Applications

*Tuesday, 7 June 2016 12:00 (20 minutes)*

This presentation introduces the latest technological development on the Inverse Low Gain Avalanche Detector iLGAD as well as the first characterization results. This structure is based on the standard Avalanche Photo Diodes (APD) concept that includes an internal multiplication of the charge generated by radiation. The multiplication is inherent to the basic  $n^{++}$ - $p^{+}$ - $p$  structure, where the doping profile of the  $p^{+}$  layer is optimized to achieve high field and high impact ionization at the junction. In order to ensure a uniform electric field distribution along the device, the iLGAD is a pad-like LGAD with P-type multiplication layer below the  $N^{+}$  implant, in which we change the  $P^{+}$  implantation, by several P-type strips in order to segment the readout electrode, like a P-on-P microStrip detector. In this structure, we move the multiplication layer to the back-side of the chip, and define the ohmic readout elements, strips & pixels, in the front-side. That means the collecting current is dominated by holes instead of electrons.

**Primary author:** Ms CARULLA ARESTE, Maria del Mar (PhD Student at Instituto de Microelectrónica de Barcelona-CNM-CSIC)

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**Presenter:** Ms CARULLA ARESTE, Maria del Mar (PhD Student at Instituto de Microelectrónica de Barcelona-CNM-CSIC)

**Session Classification:** Sensors with Internal Gain I

Contribution ID: 20

Type: **not specified**

## First LGAD fabrication on 50um SOI wafers at CNM for the HGTD

*Tuesday, 7 June 2016 14:00 (20 minutes)*

This presentation introduces the simulation and experimental results of the first Low Gain Avalanche Detector on 50um SOI Wafers fabricated at CNM for the High Granularity Timing Detector (HGTD) located in front of the forward calorimeter (FCAL).

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**Presenter:** Ms CARULLA ARESTE, Maria del Mar (PhD Student at Instituto de Microelectrónica de Barcelona-CNM-CSIC)

**Session Classification:** Sensors with Internal Gain II

Contribution ID: 21

Type: **not specified**

## Status of LGAD RD50 projects at CNM

*Tuesday, 7 June 2016 16:50 (20 minutes)*

I will report the first measurements of detectors fabricated with Ga implant and the new proposal for a project to increase the radiation hardness of LGAD sensors using Carbon. In LGAD the gain decreases with irradiation, which can be attributed to effective acceptor removal in the multiplication layer. The relative decrease of measured charge is much more pronounced for LGAD than for standard devices at fluences below  $1E15$  n/cm<sup>2</sup>. The reason must therefore be related to the decrease of the multiplication gain rather than trapping of the drifting charge. The gain decrease can be attributed to the reduction of effective doping in multiplication layer, which leads to smaller electric field strengths.

**Primary author:** Dr PELLEGRINI, giulio (Centro Nacional Microelectronica IMB-CNM-CSIC)

**Presenter:** Dr PELLEGRINI, giulio (Centro Nacional Microelectronica IMB-CNM-CSIC)

**Session Classification:** Silicon with Internal Gain III

Contribution ID: 22

Type: **not specified**

## TCT measurements and analyses of proton irradiated LGADs

*Tuesday, 7 June 2016 15:00 (20 minutes)*

Results from the study of LGADs from CNM Run 7859 will be presented. Some of these sensors have been subjected to proton irradiation at CERN. The fluences to which these were exposed are  $1\text{E}12$ ,  $1\text{E}13$ ,  $1\text{E}14$  and  $1\text{E}15$   $\text{neq}/\text{cm}^2$ . TCT measurements were performed before and after irradiation. These TCT studies were particularly focused on analysing: charge collection, spatial homogeneity, gain, and double junction effects. The results obtained will be shown in this presentation.

**Primary author:** Ms OTERO UGOBONO, Sofia (Universidade de Santiago de Compostela, and CERN)

**Co-authors:** CENTRE NACIONAL DE MICROELECTRÒNICA, Barcelona (CNM); Mr GALLRAPP, Christian (CERN); Mr MATEU, Isidre (CIEMAT); Dr VILA, Ivan (Instituto de Fisica de Cantabria (CSIC-UC)); Mr FERNANDEZ GARCIA, Marcos (IFCA-Santander); Dr MOLL, Michael (CERN); Ms STRICKER, Miriam Katharina (CERN Summer Student 2015)

**Presenter:** Ms OTERO UGOBONO, Sofia (Universidade de Santiago de Compostela, and CERN)

**Session Classification:** Sensors with Internal Gain II

Contribution ID: 23

Type: **not specified**

## Silicon sensors with internal gain: Optimizing for charged particle fast timing

*Tuesday, 7 June 2016 11:20 (20 minutes)*

Internal Gain in Si timing sensors is needed to overcome the ~100 picosecond lower limit encountered by NA62 GTK and the CMS HGCal projects. We focus on 2 techniques, currently available for achieving internal gain- 1) “reachthrough” in which a high field region is limited to a superficial few micron thick layer and 2) “deep-depleted AD’s where it is deep and the distribution between “drift” and “gain” regions is less distinct.

We have studied deep-depleted avalanche detectors using SILVACO simulations and device characterization and report on the results.

**Primary authors:** LU, Changuo (Princeton University); Mr FERNANDEZ GARCIA, Marcos (IFCA-Santander); Dr MOLL, Michael (CERN); DALAL, Ranjeet (Delhi University); Dr WHITE, Sebastian (Princeton University); Ms OTERO UGOBONO, Sofía (Universidade de Santiago de Compostela, and CERN)

**Presenter:** Dr MOLL, Michael (CERN)

**Session Classification:** Sensors with Internal Gain I



Contribution ID: 24

Type: **not specified**

## Test beam and clean room studies of ATLAS PPS modules with alternative bias rail geometries

*Monday, 6 June 2016 14:20 (20 minutes)*

It is known that for the current design of planar pixel sensors, there is a drop of efficiency at the punch-through structure of the biasing system at the edge of pixels. Various geometries, as part of the ATLAS Inner Tracker (ITK) upgrade, are being investigated to reduce this inefficiency.

Planar pixel sensors with multiple alternative bias rail geometries have been tested at the SPS beam test facility at CERN, with results focusing on the efficiency within the pixel. Measurements of the pixel detectors in a clean room before and after irradiation were performed to study the noise for the varied designs. Some sensors after irradiation experienced disconnected bump-bonds. Studies into the origin of this will be presented. Future plans for further investigations are also discussed.

**Primary author:** Dr NELLIST, Clara (LAL, Orsay)

**Co-authors:** Dr LOUNIS, ABDENOUR (LAL ORSAY); Mr GKOUKOUSIS, Evangelos - Leonidas (Laboratoire de l'Accelérateur Lineaire)

**Presenter:** Dr NELLIST, Clara (LAL, Orsay)

**Session Classification:** Sensor Design

Contribution ID: 25

Type: **not specified**

## Design considerations on thin LGAD sensors

*Tuesday, 7 June 2016 14:40 (20 minutes)*

In this contribution I will review the progresses made towards the design of segmented, thin LGAD for timing measurements.

**Primary authors:** Prof. SEIDEN, Abraham (UC Santa Cruz); STAIANO, Amedeo (TO); CENNA, Francesca (TO); Prof. DALLA BETTA, Gian Franco (University of Trento); Dr PATERNOSTER, Giovanni (Fondazione Bruno Kessler); SADROZINSKI, Hartmut (SCIPP UC Santa Cruz); Dr PANCHERI, Lucio (University of Trento); FERRERO, Marco (TO); OBERTINO, Maria Margherita (TO); Mr BOSCARDIN, Maurizio (FBK); CARTIGLIA, Nicolo' (TO); ARCIDIACONO, Roberta (TO); SOLA, Valentina (TO); MONACO, Vincenzo (TO)

**Presenter:** CARTIGLIA, Nicolo' (TO)

**Session Classification:** Sensors with Internal Gain II

Contribution ID: 26

Type: **not specified**

## TCT studies on AMS H35 CMOS devices for application in the ATLAS tracker upgrade

*Monday, 6 June 2016 12:30 (20 minutes)*

H35Demo chips are High-Voltage CMOS (HV-CMOS) devices produced in the 350nm AMS technology (H35) on wafers with four different substrate resistivity, the standard one of  $20 \Omega \cdot \text{cm}$  and 80, 200 and  $1000 \Omega \cdot \text{cm}$ . The aim of this HV-CMOS production is to study the radiation hardness of such detectors and investigate the possibility to introduce this technology in the next ATLAS tracker upgrade for the high luminosity LHC.

Having the same sensor production on several resistivities will show whether resistivity higher than the standard one for HV-CMOS would bring a beneficial effect in terms of depletion depth and charge collection efficiency.

Each chip includes four different pixel matrices. Two of them are designed to be interconnected to readout chips only, whilst the other two are completely monolithic.

In addition to the pixel matrices the chips include three test structures to characterize the sensor properties.

The characterisation of test structures with different substrate resistivity has been carried out at IFAE using the Transient Current Technique (TCT). The test structure taken under examination consists of a single diode with eight neighbours that do not include additional electronics allowing to directly sample the signal waveform.

The results of TCT and edge-TCT studies on samples from all the available substrate resistivities will be shown.

### Summary

TCT and edge-TCT on H35Demo chip test structure

**Primary author:** Mr CAVALLARO, Emanuele (IFAE)

**Presenter:** Mr CAVALLARO, Emanuele (IFAE)

**Session Classification:** Simulation and HV CMOS

Contribution ID: 27

Type: **not specified**

## Electric field, mobility and trapping in Si detectors irradiated with neutrons and protons up to $1e17$ $n_{eq}/cm^2$

*Wednesday, 8 June 2016 11:40 (20 minutes)*

Electric field in silicon irradiated with neutrons up to  $1e17$   $n_{eq}/cm^2$  and PS protons up to  $3e16$   $p/cm^2$  was investigated by edge-TCT. From the  $v(E)$  dependence under FW bias mobility degradation with fluence was extracted. From a comparison of concurrently measured FW and reverse velocity profiles absolute electric field profiles in the silicon bulk were obtained. A  $1/\sqrt{\Phi}$  dependence of mobility on fluence was observed for both irradiations with protons provoking ~20 % more degradation at equal NIEL. The observed mobility degradation and the values of electric field indicate substantial reduction of trapping from linear extrapolation of low fluence values. An attempt is made to extract information on trapping from the measured waveforms.

**Primary author:** Prof. MIKUZ, Marko (Univ. Ljubljana / J. Stefan Inst.)

**Presenter:** Prof. MIKUZ, Marko (Univ. Ljubljana / J. Stefan Inst.)

**Session Classification:** Radiation Damage II

Contribution ID: 28

Type: **not specified**

## TCT measurements of n-type MCz diodes after irradiation with 70 MeV protons and 300 MeV pions

*Wednesday, 8 June 2016 12:00 (20 minutes)*

n-type Magnetic Czochralski (MCz) was found in earlier studies to exhibit a peculiar behaviour with irradiation, in particular not exhibiting space-charge sign inversion (SCSI) after irradiation with high-energetic hadrons such as 24 GeV protons at CERN PS or 800 MeV protons at Los Alamos while the material behaved as expected after irradiation with neutrons or low-energy 23 MeV protons at Karlsruhe.

We have investigated n-type MCz diodes irradiated with 70 MeV protons at CYRIC and 300 MeV pions at PSI by means of the transient current technique (TCT). The presentation will briefly outline the state of knowledge followed by our new results that partially include also annealing studies.

**Primary author:** Mr HOLMKVIST, William (Linköping University)

**Co-authors:** Dr GALLRAPP, Christian (CERN); Dr MUENSTERMANN, Daniel (Lancaster University); Ms DETTE, Karola (CERN); Ms CARNEY, Rebecca (LBNL)

**Presenter:** Mr HOLMKVIST, William (Linköping University)

**Session Classification:** Radiation Damage II

Contribution ID: **30**

Type: **not specified**

## Timing information in HEP

*Monday, 6 June 2016 09:40 (30 minutes)*

**Presenter:** TABARELLI DE FATIS, Tommaso (MIB)

**Session Classification:** Present and Future Experiments

Contribution ID: **31**

Type: **not specified**

## Introduction

*Monday, 6 June 2016 09:00 (10 minutes)*

**Session Classification:** Present and Future Experiments

Contribution ID: **32**

Type: **not specified**

## RD50 LOGO

*Monday, 6 June 2016 15:40 (20 minutes)*



Contribution ID: 33

Type: **not specified**

## Steering Committee

*Monday, 6 June 2016 16:30 (1h 30m)*

**Presenter:** Dr MOLL, Michael (CERN)

Contribution ID: **34**

Type: **not specified**

## **3D Pixel Detectors for AFP and HL-LHC**

*Monday, 6 June 2016 10:30 (25 minutes)*

**Presenter:** LANGE, Joern (IFAE Barcelona)

**Session Classification:** Present and Future Experiments

Contribution ID: 35

Type: **not specified**

## **HRTEM investigations of different clusters produced in Si by electron and neutron irradiation.**

*Wednesday, 8 June 2016 09:00 (20 minutes)*

**Presenter:** Dr NISTOR, Leona Cristina (National Institute of Materials Physics)

**Session Classification:** Radiation Damage I

Contribution ID: 36

Type: **not specified**

**ESR of point defects in pure and  $^{17}\text{O}/^{13}\text{C}$  doped  
Si-FZ irradiated with 3.5 and 27 MeV electrons.  
Correlation with TSC data.**

*Wednesday, 8 June 2016 09:20 (20 minutes)*

**Presenter:** Dr NISTOR, Vasile Sergiu (National Institute of Materials Physics)

**Session Classification:** Radiation Damage I

Contribution ID: 37

Type: **not specified**

## End of Workshop

Contribution ID: **38**

Type: **not specified**

## **Results from the first 300-micron thick LGAD production at FBK**

*Tuesday, 7 June 2016 14:20 (20 minutes)*

**Presenter:** FERRERO, Marco (TO)

**Session Classification:** Sensors with Internal Gain II

Contribution ID: 39

Type: **not specified**

## Performance of thin LGADs after irradiation

*Tuesday, 7 June 2016 12:20 (20 minutes)*

**Presenter:** Dr KRAMBERGER, Gregor (Jozef Stefan Institute)

**Session Classification:** Sensors with Internal Gain I

Contribution ID: 40

Type: **not specified**

## **Reasons for gain degradation with irradiation in LGADs**

*Tuesday, 7 June 2016 15:40 (20 minutes)*

**Presenter:** Dr KRAMBERGER, Gregor (Jozef Stefan Institute)

**Session Classification:** Sensors with Internal Gain II



Contribution ID: 41

Type: **not specified**

## **Characterization of neutron irradiated pad detectors using a Transient Current Technique based on the Two Photon Absorption process (TPA-TCT)**

*Wednesday, 8 June 2016 12:20 (20 minutes)*

**Presenter:** Mr FERNANDEZ GARCIA, Marcos (IFCA-Santander)

**Session Classification:** Radiation Damage II

Contribution ID: 42

Type: **not specified**

## **High-resolution three-dimensional imaging of a depleted CMOS sensor using an edge Transient Current Technique based on the Two Photon Absorption process (TPA-eTCT)**

*Tuesday, 7 June 2016 11:00 (20 minutes)*

**Presenter:** Mr FERNANDEZ GARCIA, Marcos (IFCA-Santander)

**Session Classification:** Sensors with Internal Gain I

Contribution ID: 44

Type: **not specified**

## Signal Amplification in strip-LGAD and I-LGADs

*Tuesday, 7 June 2016 15:20 (20 minutes)*

**Presenter:** Dr VILA, Ivan (Instituto de Fisica de Cantabria (CSIC-UC))

**Session Classification:** Sensors with Internal Gain II

Contribution ID: 45

Type: **not specified**

## **TCAD Radiation Damage analysis of CNM-LGAD Detectors**

*Tuesday, 7 June 2016 16:30 (20 minutes)*

**Primary author:** Prof. PALOMO PINTO, Francisco Rogelio (Escuela Técnica Superior de Ingenieros Universidad de Sevilla)

**Presenter:** Prof. PALOMO PINTO, Francisco Rogelio (Escuela Técnica Superior de Ingenieros Universidad de Sevilla)

**Session Classification:** Silicon with Internal Gain III

Contribution ID: 46

Type: **not specified**

## Wine

*Monday, 6 June 2016 18:00 (20 minutes)*

**Presenter:** CERELLO, Piergiorgio (TO)

**Session Classification:** WINE TASTING