DELHI UNIVERSITY – STATUS AND PLANS

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DRD3 WG4, 22nd July, 2024

Delhi University – Si Sensors related R&D

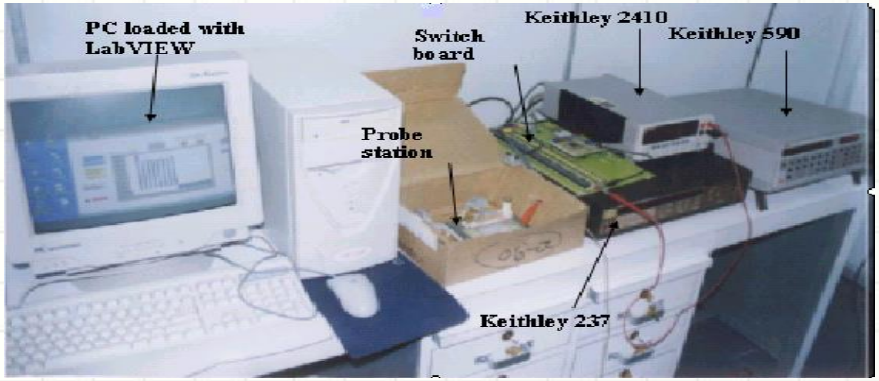
1. Sensor Design and Fabrication
2. Sensor Characterization
3. TCAD simulation using SILVACO

Sensor Design and Fabrication

- CMS Preshower Detector (1998-2006)
  - Successfully developed ~1000 dc-coupled, Si strip sensors, *for first time in India*, together with BARC & BEL

- Participated in all aspects of Si sensor development

  TCAD Simulation (Pisces & Medici), Characterization (IV, CV), Radiation Hardness



- 2013-2019: Collaborated with foundary (BEL) to develop ac-coupled p-on-n silicon-strip sensors on 4 inch wafers

Nuclear Inst. and Methods in Physics Research, A 882 (2018) 1–10

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Development of AC-coupled, poly-silicon biased, p-on-n silicon strip detectors in India for HEP experiments

Geetika Jain [a], Ranjeet Dalal [a], Ashutosh Bhardwaj [a,*], Kirti Ranjan [a], Alexander Dierlamm [b], Frank Hartmann [b], Robert Eber [b], Marcel Demarteau [c]

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[b] Karlsruhe Institute of Technology, Karlsruhe, Germany
[c] Argonne National Laboratory, IL, USA

Nuclear Inst. and Methods in Physics Research, A 913 (2019) 97–102

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Nuclear Inst. and Methods in Physics Research, A

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Radiation tolerance study on irradiated AC-coupled, poly-silicon biased, p-on-n silicon strip sensors developed in India

Geetika Jain [a], Chakresh Jain [a], Ashutosh Bhardwaj [a,*], Kirti Ranjan [a], Alexander Dierlamm [b], Frank Hartmann [b], Marcel Demarteau [c]

[a] Centre for Detector and Related Software Technology (CDRST), Department of Physics and Astrophysics, University of Delhi, Delhi 110007, India
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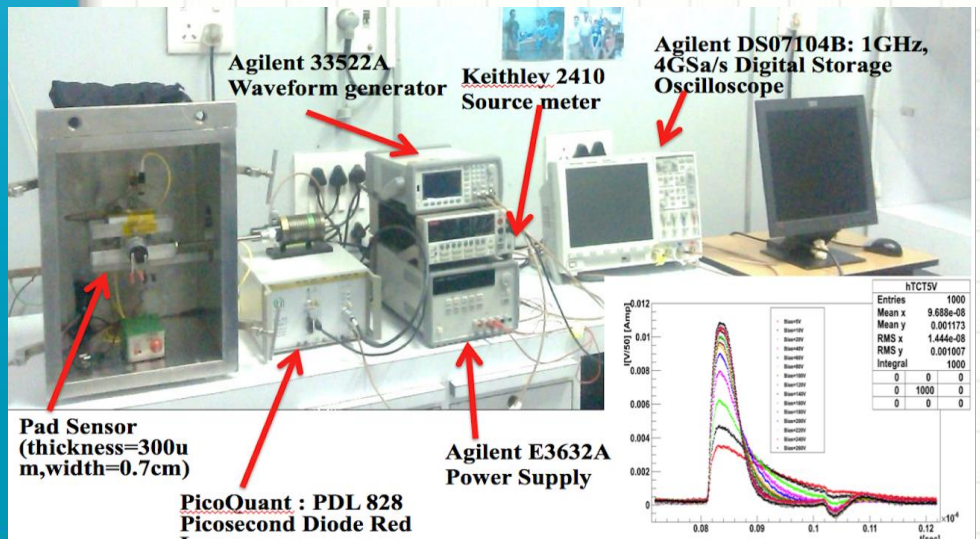
[c] Argonne National Laboratory, IL, USA

Sensor Characterization

- Sensor Qualification Center: One of six such facilities for testing Phase 2 CMS Outer Tracker 2S n-on-p sensors: Automated & programmable characterization system

- Red Laser based TCT setup



- Alibava Source based Characterisation system

TCAD Simulation: Design and Radiation Hardness

Design (simulation) work included in CMS Phase 2 Tracker upgrade: *CMS Detector Note, Technical Proposal*, *Technical Design Report (TDR)* and *P-type Tracker paper*

CMS DN-14-016

The Compact Muon Solenoid Experiment

Detector Note

The content of this note is intended for CMS internal use and distribution only

2014/08/08
Head Id:
Archive Id: 255221:255288M
Archive Date:

Simulation of Silicon Devices for the CMS Phase II Tracker Upgrade

Abstract

During the planned high luminosity phase of the LHC (HL-LHC, year-2023) the tracking system of CMS will face a more intense radiation environment than the present system was designed for. This requires the design of higher granular as well as radia-

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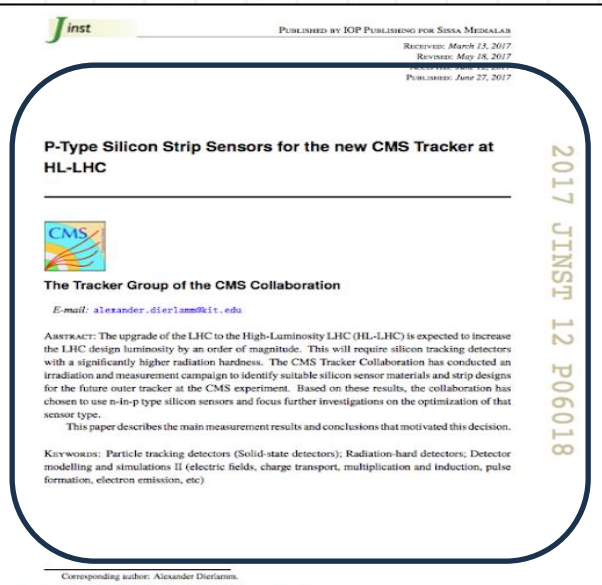
PDFAuthor: Ashutosh Bhardwaj, Ranjit Dalal, Robert Eber, Thomas Eichhorn, Kavita Lalwani, Alberto Messineo, Timo Peltola, Martin Printz, Kirti Ranjan
PDFTitle: Simulation of Silicon Devices for the CMS Phase II Tracker Upgrade
PDFSubject: CMS
PDFKeywords: CMS, physics, hardware, tracker, upgrade, silicon, sensor, radiation damage, defect-model, defects



- Sensor polarity: n-type => p-type
- Strip Isolation of p-type sensors
- Radiation Damage Modelling

[97] R. Dalal et al., "Combined effect of bulk and surface damage on strip insulation properties of proton irradiated n^{+}-p silicon strip sensors", 2014 *JINST* **9** P04007, doi:10.1088/1748-0221/9/04/P04007.

[102] R. Dalal, "Simulation of Irradiated Detectors", *PoS* **(Vertex2014)** 030 (2015).

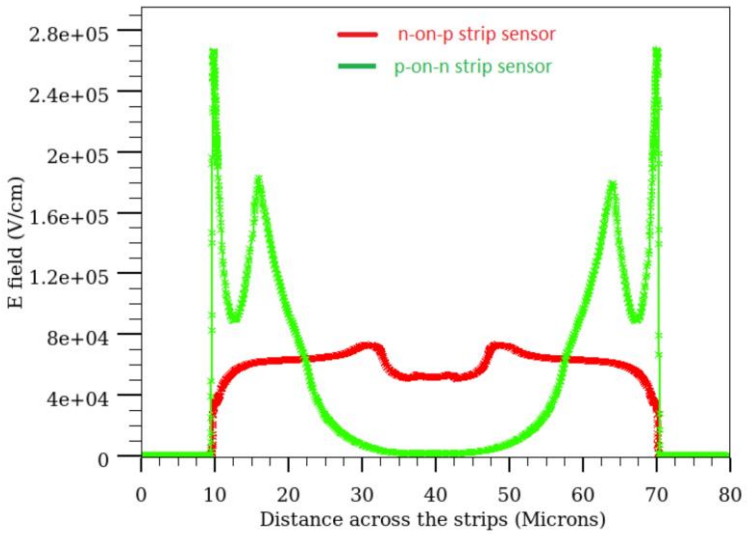
[55] CMS Tracker Collaboration, R. Dalal et al., "Comparison of Radiation Hardness Properties of p+n- and n+p- Si Strip Sensors Using Simulation Approaches", in *23rd RD50 Workshop*. 2013.

TCAD Simulation: Design and Radiation Hardness

PROTON Damage model:

- Initial 5-level bulk model + Surface damage
- Modified 2-level bulk damage + Surface damage (Interface traps + Q_f)

Attempts at LGAD Simulation and Thin and Low resistivity Si simulation



TCAD simulation of Low Gain Avalanche Detectors
Ranjeet Dalal, Geetika Jain, Ashutosh Bhardwaj, Kirti Ranjan, NIMA 836, 11, 2016, 113
https://www.sciencedirect.com/science/article/abs/pii/S0168900216308804

Radiation hardness investigation of thin and low resistivity bulk Si detectors
G. Jain, S. Sharma, C. Jain, A. Kumar, A. Bhardwaj, K. Ranjan, NIMA 936, 21, 2019, 693
https://www.sciencedirect.com/science/article/abs/pii/S0168900218312610

Radiation hardness studies of thin and low bulk resistivity LGADs
Geetika Jain, Chakresh Jain, Saumya Saumya, Namrata Agrawal, Ashutosh Bhardwaj and Kirti Ranjan, 2021 *Semicond. Sci. Technol.* **36** 065016
https://iopscience.iop.org/article/10.1088/1361-6641/abfb0f/meta

TCAD Simulation: Design and Radiation Hardness

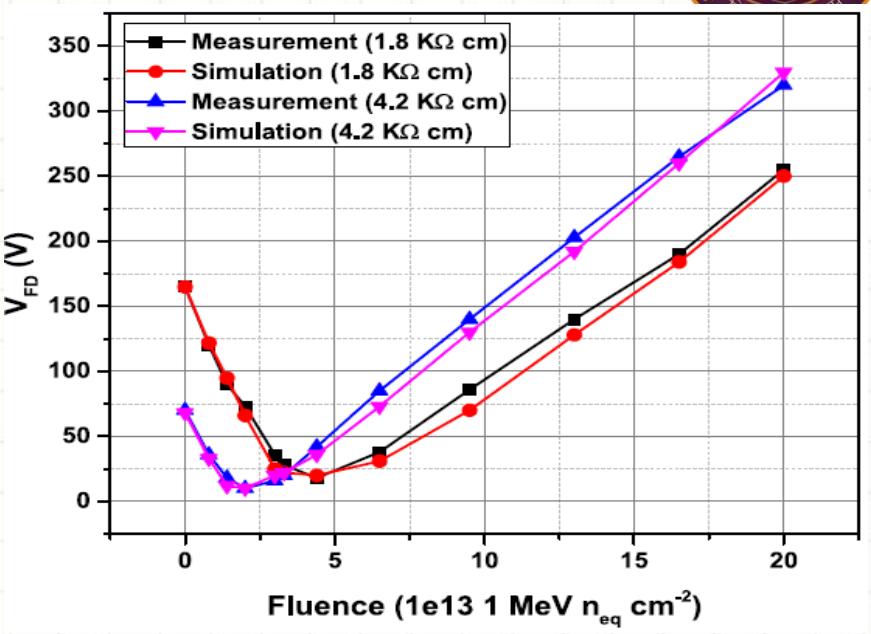
NEUTRON Damage model:

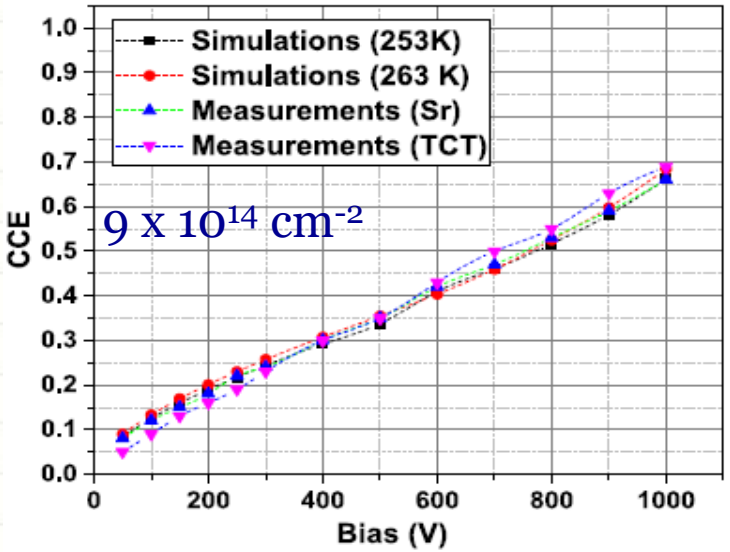
- 2-level bulk damage

Modeling of neutron radiation-induced defects in silicon particle detectors

Chakresh Jain, Saumya Saumya, Geetika Jain, Ranjeet Dalal, Namrata Agrawal, Ashutosh Bhardwaj and Kirti Ranjan, 2020 *Semicond. Sci. Technol.* **35** 045021

https://iopscience.iop.org/article/10.1088/1361-6641/ab74ea/meta

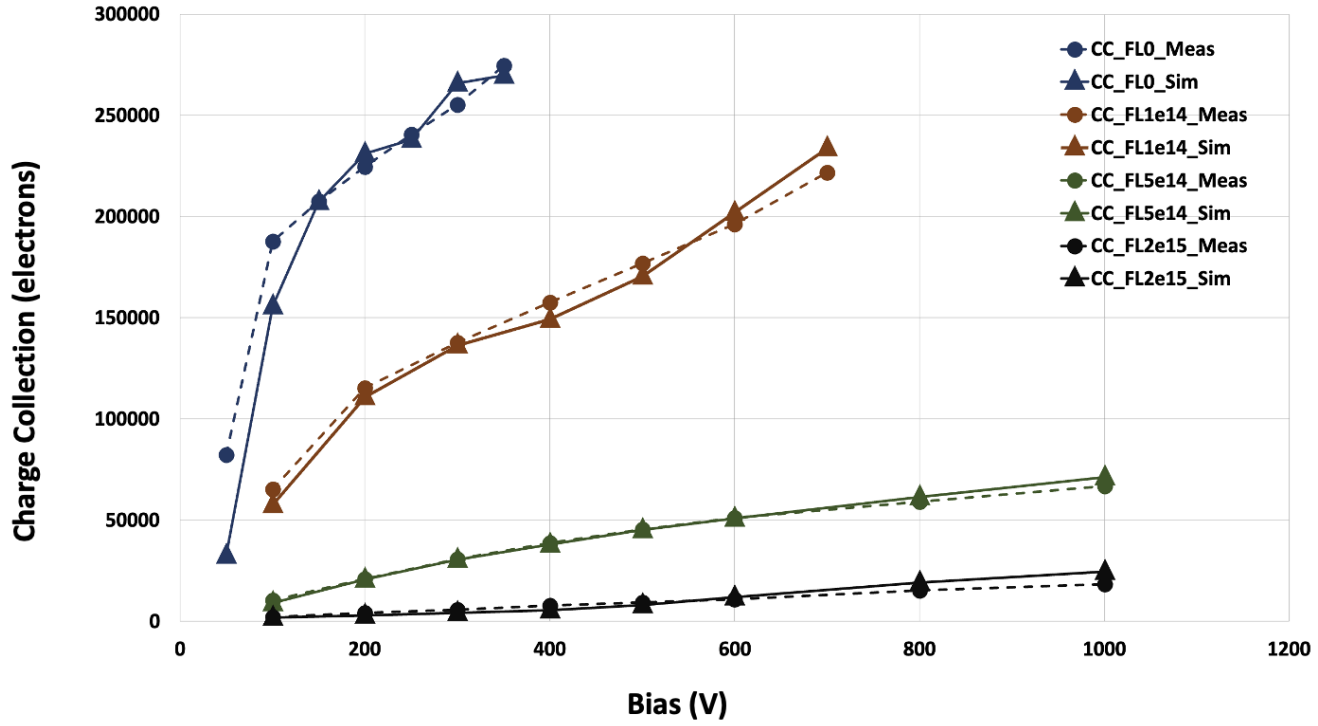




TCAD Simulation: Design and Radiation Hardness

NEUTRON Damage model applied to LGAD (300 micron thick)

- 2-level bulk damage



Measurement data are taken from: *G. Pellegrini et al.,* Technology developments and first measurements of Low Gain Avalanche Detectors for high energy physics applications. NIM A 765 (2014) 12-16.

TCAD Simulation: Status and Plans

- Few (5) licenses of TCAD Silvaco
- Manpower:
  - 4 faculty: Arun Kumar, Ashutosh Bhardwaj, Namrata, Kirti Ranjan,
  - 1 postdoc (Chakresh Jain)
  - few PhD students
- Contribute to radiation damage studies of the LGAD designs; Materials like SiC; CMOS designs etc.
- Eager to participate in DRD3 - WG4 efforts

Thank you

3rd Sensor Quality Assurance Workshop, DU 22-24 Jan, 2019