Karlsruhe Institute of Technology

Status Report on Irradiations at KIT (WP 7 TA)

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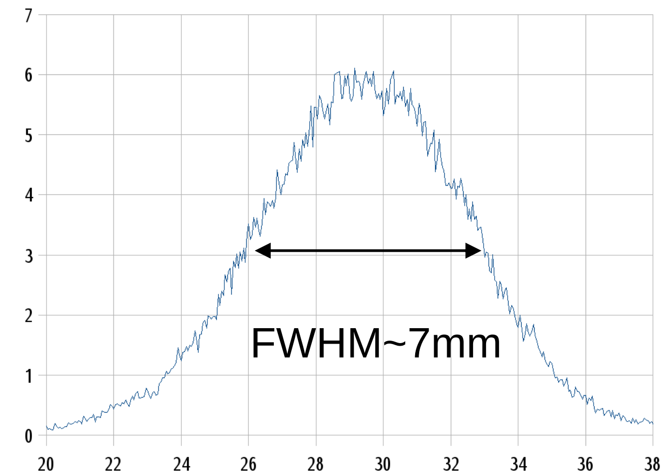
INSTITUT FÜR EXPERIMENTELLE KERNPHYSIK

AIDA

Advanced European Infrastructures for Detectors at Accelerators

The Karlsruhe Proton Cyclotron KAZ

- Run by private company ZAG
- Proton energy at extraction: 25.3MeV
  - Energy at samples: ~23MeV in first layer
- Typical proton current: 2µA
  - 1cm² to $1x10^{15} n_{eq}/cm^2$ ~ 12min
- Temperature in box: ~ -25°C
- Beam spot ~ 7mm (varying)
  - Scanning stage for box: access area 15cm x 40cm




Cold box on XY-stage with beam line


Me placing LN_2 box


Control room

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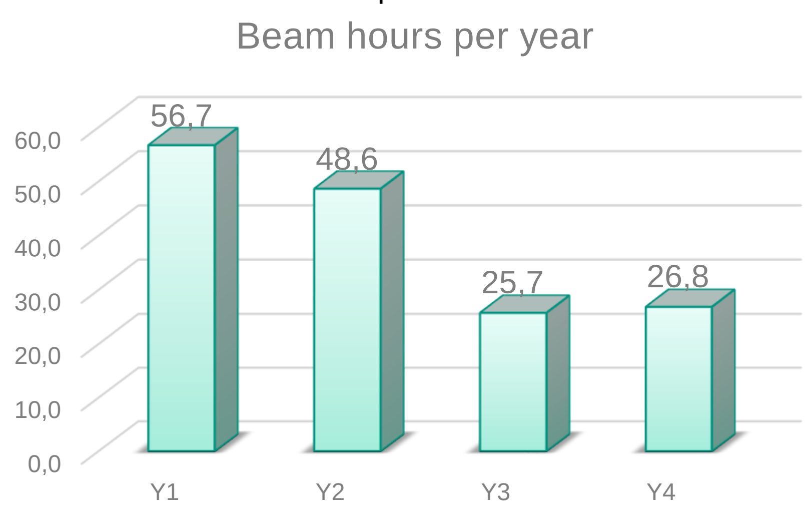
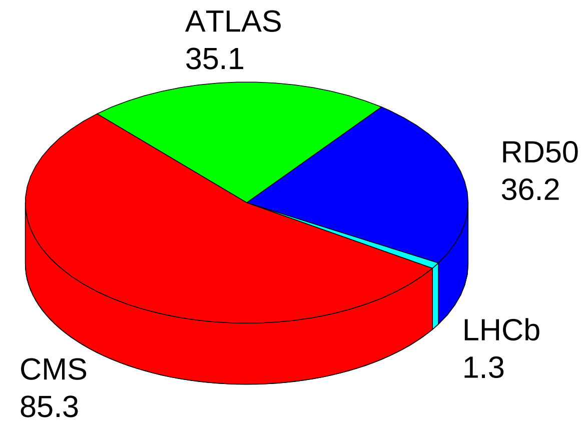
Irradiation Summary

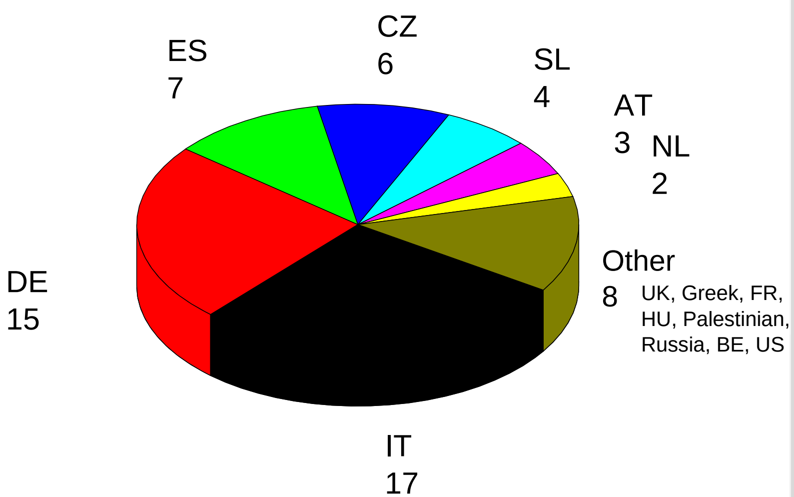
- 29 projects with a total of 158 hours beam time
- 79 users
- 14 publications (as far as I could find them)
- No visitors

- We mainly had high fluence irradiations of $1x10^{15} – 1x10^{16}$ n_{eq}/cm^2





Beam hours per experiment



Users per nationality

New projects since summer 2014

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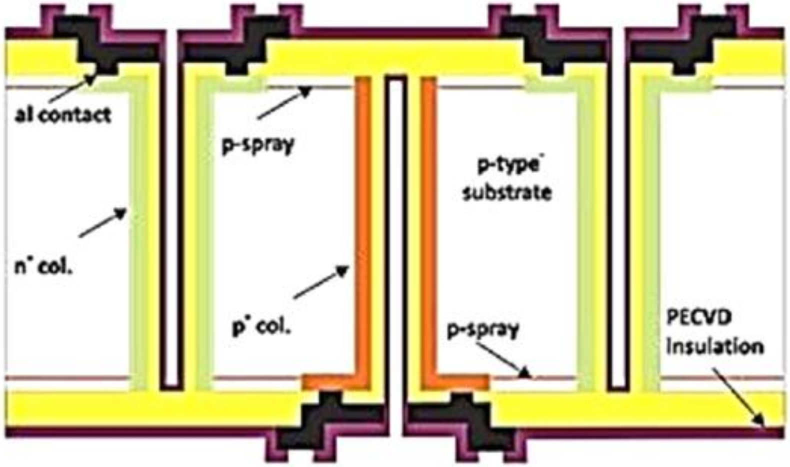
Preventing ice formation

- Samples are kept in freezer after irradiation
- When samples are taken out of freezer they are covered by ice immediately
  - this caused corrosion on few samples
- Now samples are placed in additional sealed box when putting into freezer
  - samples can then warm up in dry environment and be prepared for shipment
- → no formation of ice

AIDA-KIT-2014-04

- Title: First study of irradiated FBK 3DS coupled to PSI46DIG
- Group leader: A. Solano, Torino/INFN
- Beam time: 7.3h

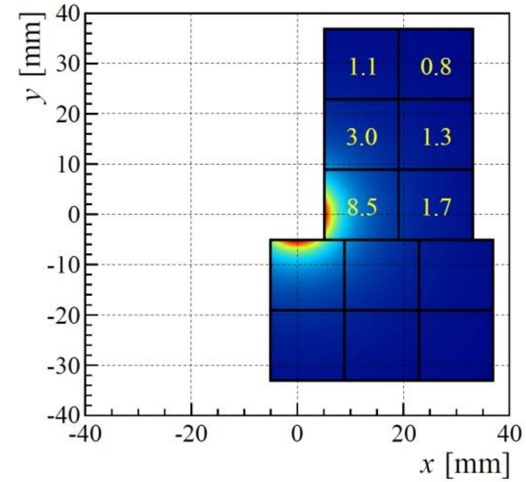
- 8 SCAs with 3D sensors from FBK irradiated up to $1e16n_{eq}/cm^2$



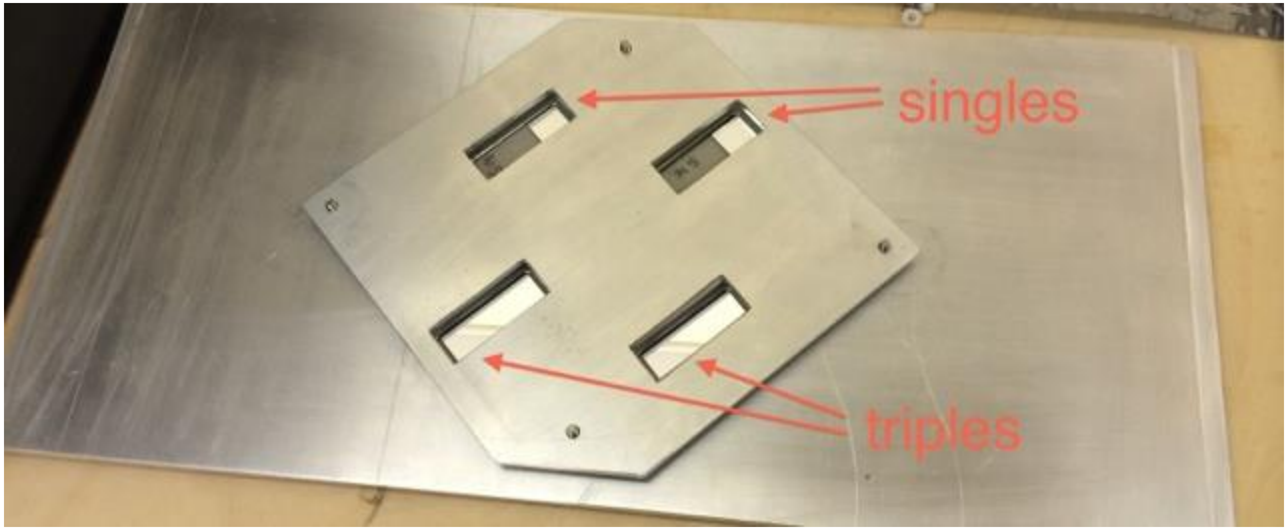
AIDA-KIT-2014-05

- Title: LHCb VELO Upgrade
- Group leader: M. van Beuzekom, Nikef
- Beam time: 1.3h

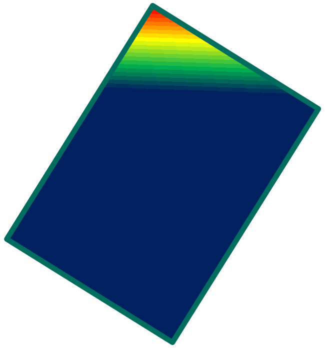
- In-homogeneous irradiation of pixel modules



Expected fluence profile



Support and mask for module irradiation

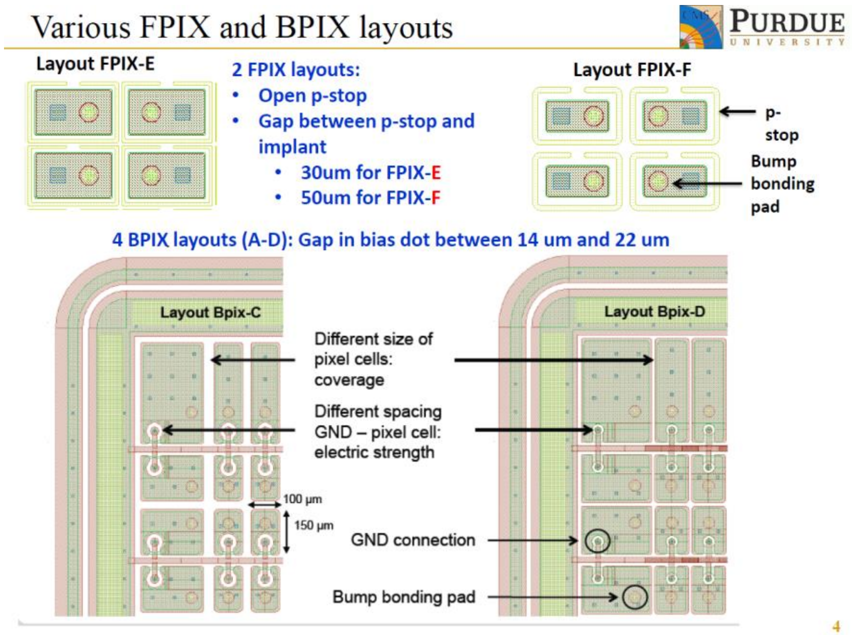


Envisaged profile for irradiation

AIDA-KIT-2014-06

- Title: Phase 2 Upgrade of CMS Pixel Detectors
- Group leader: D. Bortoletto, Oxford
- Beam time: 3.8h

- 10 SCAs with thin epi pixel sensors irradiated to 2e15n_{eq}/cm²



New Publications 2014

- Related to AIDA-KIT-2011-5 “Irradiation of Silicon Pixel modules for ATLAS-IBL project at CERN”

Nuclear Instruments and Methods in Physics Research A 765 (2014) 135–139

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

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

Temperature-dependent characterizations of irradiated planar n^+-in-n pixel assemblies

R. Klingenberg*, S. Altenheiner, M. Andrzejewski, K. Dette, C. Gößling, A. Rummler, F. Wizemann

Technische Universität Dortmund, Fakultät Physik, Experimentelle Physik IV, 44221 Dortmund, Germany

ARTICLE INFO

Available online 2 May 2014

Keywords:
ATLAS-LHC
Pixel detector upgrade
Insertable B-Layer
Planar n^+-in-n pixel sensors
Temperature dependence

ABSTRACT

Measurements of the leakage current scaling and tuning of front-end electronics due to temperature changes in a range between −30 °C and 0 °C are presented. Assemblies have been irradiated to fluences of 6.8×10^{15} n_{eq} cm^{-2}. A leakage current temperature scaling parameter $E_{g,eff} = (1.108 \pm 0.047)$ eV is found, which is compatible within errors to earlier measurements of non-irradiated or lower irradiated silicon. Secondly, sensitivity of tuning parameters of the employed front-end electronics in terms of threshold and ToT values can be seen. A study of current and charge collection efficiency in an assembly irradiated to a fluence of 2×10^{16} n_{eq} cm^{-2} has been carried out, showing a current related damage factor α_I compatible to studies at lower irradiation levels. Charge collection stays constant with consecutively applied annealing steps and front-end electronics shows only slight changes in tuning parameters.

New Publications 2014

- Related to AIDA-KIT-2011-04 “CMS HPK irradiation campaign – Protons“ and AIDA-KIT-2011-07 “CMS Silicon Material Evaluation R>5cm”

Nuclear Instruments and Methods in Physics Research A 765 (2014) 29–34

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

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

Radiation hard sensor materials for the CMS Tracker Phase II Upgrade - Charge collection of different bulk polarities☆

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On behalf of the CMS Tracker Collaboration

ARTICLE INFO

Available online 26 April 2014

Keywords:
Silicon strip sensor
Radiation hardness
Charge collection efficiency
Annealing

ABSTRACT

The upgrade of the LHC machine to deliver a significantly higher luminosity of about 5×10^{34} cm^{-2} s^{-1} is planned to be operational after 2022. This will simultaneously increase the radiation dose for the inner detector systems, requiring new radiation hard sensor materials for the CMS Tracker. To identify the appropriate materials which are able to withstand the radiation environment in the middle to outer layers of the CMS Tracker during the full lifetime of the high luminosity LHC, a large irradiation and measurement campaign has been conducted. Several test structures and sensors have been designed and manufactured on 18 different combinations of wafer materials, thicknesses and production technologies. The structures have been electrically characterised before and after irradiation with different fluences of neutrons and protons.

This paper reports the final results on strip sensor performance considering the comparison of p-in-n technology with n-in-p type. Outcomes from signal and noise measurements before and after annealing depending on the radiation dose are discussed and the final recommendation of the CMS Tracker Collaboration for the strip sensor polarity for the Phase II Upgrade is presented.

New Publications 2014

- Related to AIDA-KIT-2013-06 “Radiation Hardness tests of improved double-sided 3D sensors”

Nuclear Instruments and Methods in Physics Research A 765 (2014) 155–160

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

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

Radiation hardness tests of double-sided 3D strip sensors with passing-through columns

Gian-Franco Dalla Betta [a,b,*], Christopher Betancourt [c], Maurizio Boscardin [d], Gabriele Giacomini [d], Karl Jakobs [c], Susanne Kühn [c], Besnik Lecini [a], Roberto Mendicino [a,b], Riccardo Mori [c], Ulrich Parzefall [c], Marco Povoli [a], Maira Thomas [c], Nicola Zorzi [d]

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A R T I C L E I N F O

Available online 14 May 2014

Keywords:
3D detectors
Silicon detectors
Strip detectors
Laser scan
Source scan
TCAD simulations

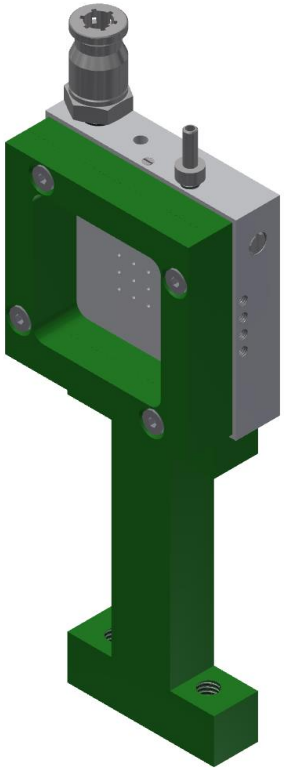
A B S T R A C T

This paper deals with a radiation hardness study performed on double-sided 3D strip sensors with passing-through columns. Selected results from the characterization of the irradiated sensors with a beta source and a laser setup are reported and compared to pre-irradiation results and to TCAD simulations. The sensor performance in terms of signal efficiency is found to be in good agreement with that of other 3D sensors irradiated at the same fluences and tested under similar experimental conditions.

Outlook for last 2 months and beyond

- Still hoping for active feedback from users in case of publications…
- Remaining 2h might go into „Phase 2 Upgrade of CMS Pixel Detectors”
  - project has been limited to ~4h to allow time needed for LHCb project, which came later and time estimate was unclear
- Development of support for small area high current irradiation
- Improving online monitoring of beam current
- Improving control system for temperature and movement

- Our irradiation service will continue!
  Contact us on irradiation@lists.kit.edu



Backup

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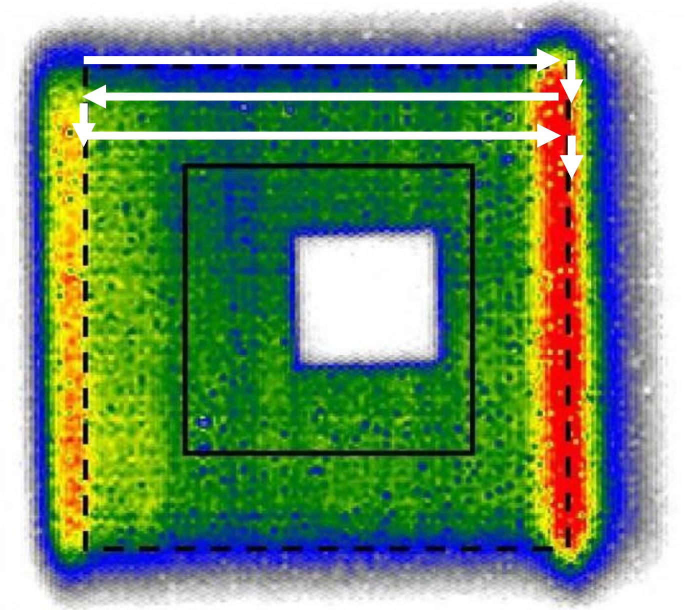
Scanning Procedure

- Samples are scanned in 1mm spaced rows
- Edge regions are inhomogeneous and a margin of ~1cm is used
- Proton fluence is calculated by:

$$F_{est} = n_{scan} \cdot \frac{I_p}{q_{el} \cdot v_x \cdot \Delta y}$$

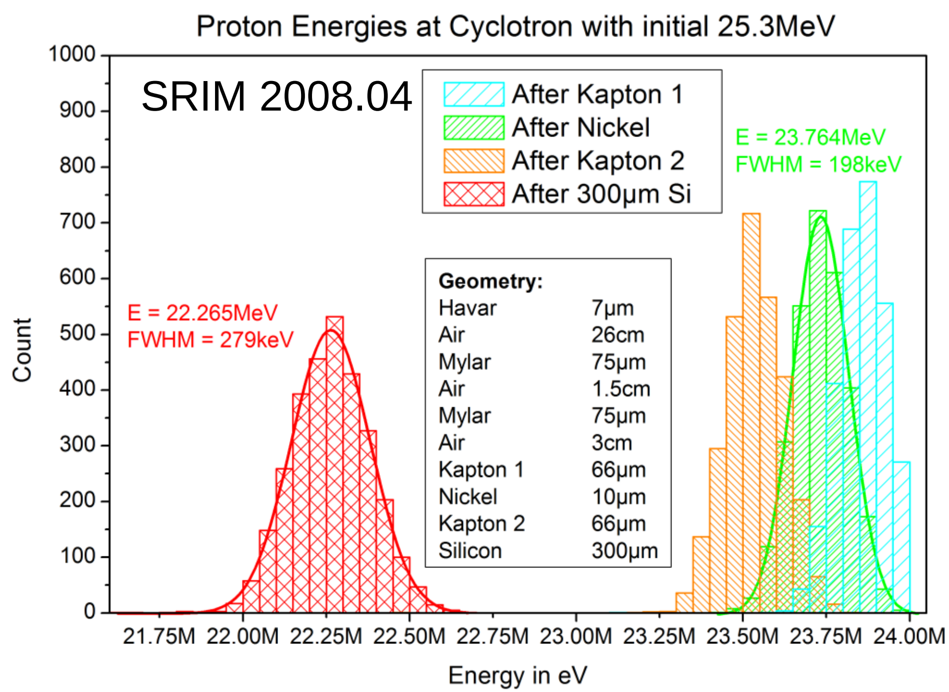
- The proton current I_P is always measured at the last beam stop
- At the nominal values of I_P=1.5µA and v_x=115mm/s we generate 1.5e13n_{eq}/cm² per scan



Autoradiographic image of a large Ni-foil scanned in the described procedure. The white area is a cut out for further dosimetry.

Energy at Target

- 25.3MeV is the energy in the beam line
- Protons have to pass several materials until they hit the samples
- SRIM gives us a proton energy entering the samples of about 23.8MeV and on average in the sample: **22.9MeV**
- Samples covered by Nickel foils see lower energy ~22.8MeV



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