Karlsruhe Institute of Technology

Status Report on Irradiations at KIT (WP 7 TA)

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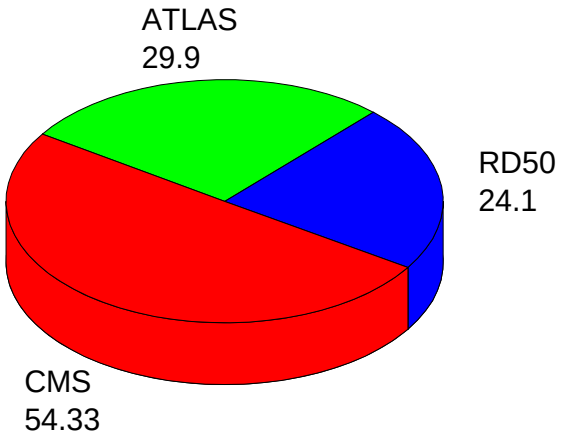
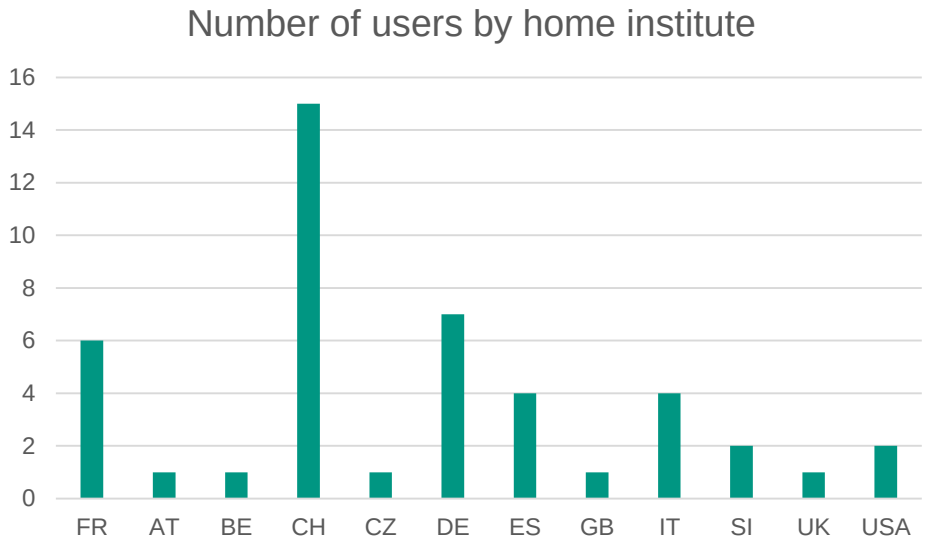
Irradiation Summary

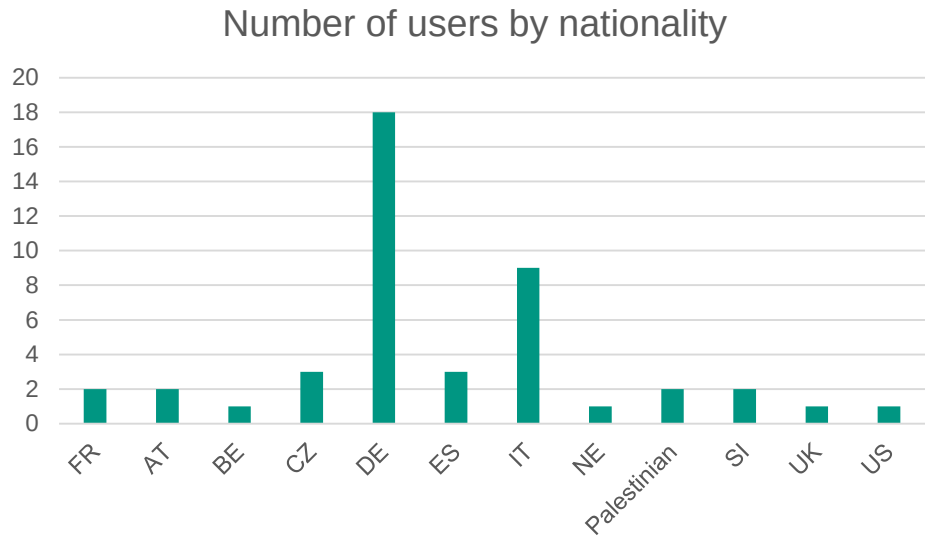
- 18 projects with a total of 108.3 hours of beam time
- 45 users
- No visitors

- We mainly had high fluence irradiations of 1e15 – 1e16 n_{eq}/cm^2



Beam time per experiment (in hours)





New projects in the last reporting periode

AIDA-KIT-2012-06

- Title: Irradiation of prototype eBoards for the ATLAS nSQP upgrade
- Group leader: D. Münstermann, CERN, CH
- Beam time: 0.9h (done)

- The new Service Quarter Panel (nSQP) project has built replacement services for the ATLAS Pixel Detector. In system tests, it was found that the optical components could safely be replaced by passive elecrical extension boards, so-called eBoards. To ensure long-term reliability, industry standard production methods should be applied. These involve **acrylic resins** which are generally not rad-hard up to the required TID of 50MRad. It is therefore necessary to conduct irradiation studies of prototype boards.
- Irradiation of 2 industry standard acrylic eBoards and 2 CERN-made epoxy-based eBoards to a TID of **50 MRad** (Si)

AIDA-KIT-2013-01

- Title: Irradiation of Single Crystal CVD Diamonds
- Group leader: R. Wallny, Zurich, CH
- Beam time: 0h (not started yet)

- Irradiated single crystal CVD diamonds used as particle sensors have exhibited decreasing signal size with increasing incident particle rates. This effect is attributed to **polarization** of charge within the diamond due to defects near the diamond surfaces. In order to attempt to remove these defects, material has been removed from the surfaces of diamond sensors by **reactive ion etching** (RIE).

AIDA-KIT-2013-02

- Title: Irradiation of silicon detectors for AFP experiment
- Group leader: P. Sicho, CERN, CH
- Beam time: 0h (not started yet)

- The AFP experiment is future ATLAS Forward Detector and is foreseen to be installed in the LHC tunnel about 220m far from the centre of the ATLAS detector. AFP silicon detectors will be hit by scattered protons coming from ATLAS interaction point. The detectors will be exposed **very nonhomogenously** and only small fraction of the sensor area will be exposed to the fluence of ~**5.10^{15}pcm^{-2}**/100fb^{-1}. The goal of KIT irradiation is to simulate radiation condition expected at the real experiment and test the behaviour of nonhomogenously irradiated silicon sensors.

Publications found so far

- Dierlamm, A. Silicon sensor developments for the CMS Tracker upgrade. *Journal of Instrumentation* **7**, C01110–C01110 (2012).
- Da Vià, C. *et al.* 3D active edge silicon sensors: Device processing, yield and QA for the ATLAS-IBL production. *NIM A* **699**, 18–21 (2013).
- Grinstein, S. Overview of the ATLAS insertable B-layer (IBL) project. *NIM A* **699**, 61–66 (2013).
- Rubinskiy, I. Irradiation and beam tests qualification for ATLAS IBL Pixel Modules. *NIM A* **699**, 67–71 (2013).
- Nagai, R. *et al.* Evaluation of novel KEK/HPK n-in-p pixel sensors for ATLAS upgrade with testbeam. *NIM A* **699**, 78–83 (2013).
- Bernard-Schwarz, M. Future silicon sensors for the CMS Tracker Upgrade. *NIM A* **699**, 89–92 (2013).
- Auzinger, G. Analysis of testbeam data of irradiated silicon prototype sensors for the CMS tracker upgrade. *NIM A* doi:10.1016/j.nima.2013.03.018
- La Rosa, A. *et al.* Novel silicon n-in-p pixel sensors for the future ATLAS upgrades. *NIM A* doi:10.1016/j.nima.2012.10.091
- Gallrapp, C. Planar pixel sensors for the ATLAS tracker upgrade at HL-LHC. *NIM A* doi:10.1016/j.nima.2012.10.034

Theses found so far

- Hoffmann, K.-H. Development of new Sensor Designs and Investigations on Radiation Hard Silicon Strip Sensors for the CMS Tracker Upgrade at the High Luminosity Large Hadron Collider. PhD thesis, KIT, IEKP-KA/2013-1 (2013)
- Frech, S. Einfluss von Strahlenschäden auf Siliziumstreifensensoren aus unterschiedlichen Grundmaterialien, diploma thesis, KIT, IEKP-KA/2012-21 (2012)
- Altan, L. Untersuchung zur Ladungsmultiplikation an hoch bestrahlten Siliziumstreifensensoren, diploma thesis, KIT, IEKP-KA/2012-23 (2012)

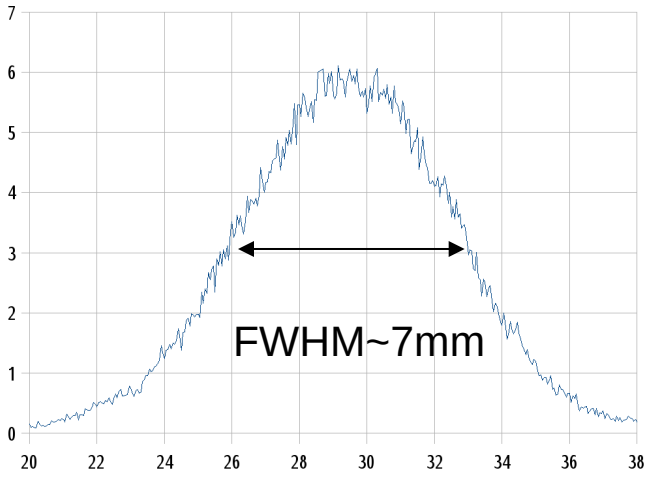
Outlook for 2013-14

- Expect application for additional CMS studies soon (~10h)
- For applications AIDA-KIT-2013-01 and AIDA-KIT-2013-02 I expect about 3h of beam time
- So we have about 40h (of 160h total) remaining for further projects

Backup

The Karlsruhe Proton Cyclotron KAZ

- Run by private company ZAG
- We are customers and have to pay per beam time
- Proton energy at extraction: 25.3MeV
- Energy at samples: ~23MeV in first layer
- Typical proton current: 1.5µA
- Temperature in box: ~ -25°C
- Beam spot ~ 7mm (varying)
- Flux ~ 2.5e13 p/(s·cm²)



Sample box on XY-stage with beam line

Man placing LN_2 box

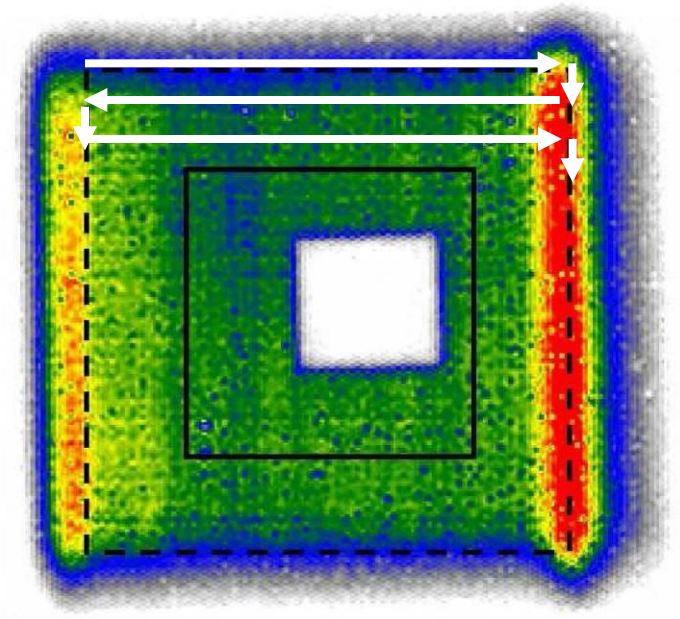
Control room

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