KIT TA Status

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INSTITUT FÜR EXPERIMENTELLE TEILCHENPHYSIK

The infrastructure

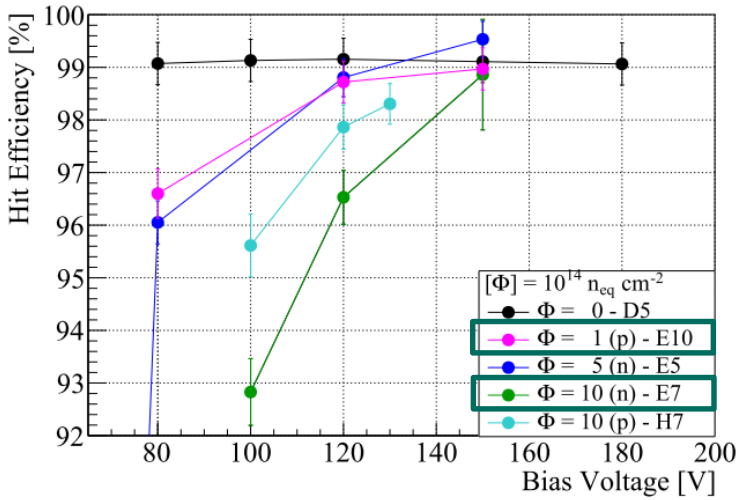
- The Karlsruhe compact cyclotron (KAZ) is operated by ZAG; irradiations are prepared and performed by ETP staff
- Cyclotron parameters:
  - Proton energy ~23 MeV* (25.3MeV at extraction)
  - Proton current ~2.0µA (~0.5µA - 20µA)
  - Max. object size (W x H) 44cm x 17cm
  - N_2-cooling temperature -30°C
- On average 4-5h slot every second week
  - up to 6 weeks turn-around time
- E.g., irradiating one sensor of 20mm x 20mm to $5x10^{15}$ n_{1MeV}/cm^2 takes about 90 minutes.
- Samples can be shipped to us, we irradiate and send them back
  - No visitors expected!

- Initial contact and info: irradiations@lists.kit.edu
- Description on http://www.ekp.kit.edu/english/irradiation_center.php

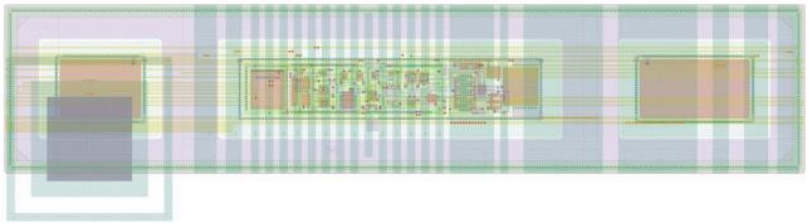
* We use hardness factor of 2.0 and the dose is ~150kGy/$10^{14}n_{eq}/cm^2$

Examples: HV-CMOS

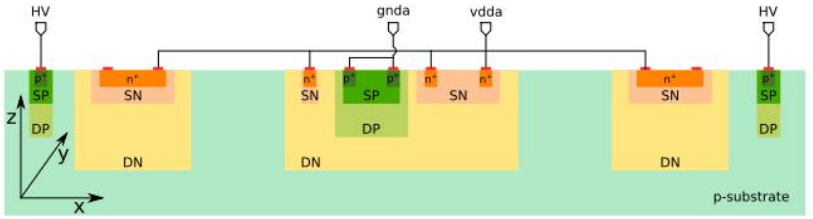
- H35DEMO chips with 200 Ωcm resistivity substrate
  - S. Terzo et al., Characterisation of AMS H35 HV-CMOS monolithic active pixel sensor prototypes for HEP applications. 2019 JINST 14 P02016.



(b) Hit efficiency vs Bias Voltage, zoom



(a) Layout.



(b) Cross section.

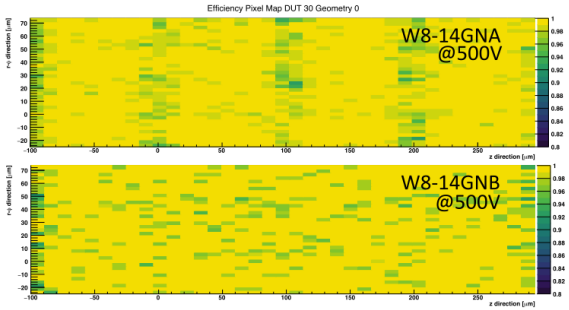
Figure 2. The pixel cell of the monolithic CMOS matrix. The pixel layout (a) and a sketch of the cross section (b) are shown. In the latter DN and DP indicate Deep N-Wells and Deep P-Wells, respectively while SN and SP indicates shallow n and p-type implantations, respectively.

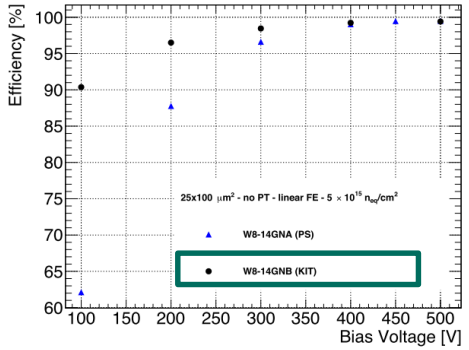
Examples: Pixel sensors with RD53A

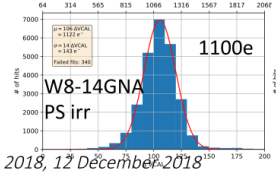
- We irradiated many of these assemblies in 2018/2019
- Fluences up to $5x10^{15}n_{eq}/cm^2$ correspond to doses of up to 7.5MGy
  - RD53A designed to withstand 5MGy, and still survives
  - BUT: these are irradiation tests for the sensor material and the chip is unbiased; in biased operation the chip might suffer more

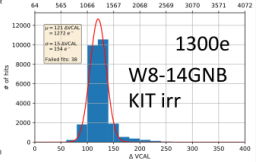
CERN PS- KIT Irradiation Comparison

- Two modules irradiated at CERN PS and KIT to a nominal fluence of $5x10^{15}n_{eq}/cm^2$
  - PS dose is average (will be higher in central region of linear FE), KIT is homogeneous
- Same sensor design: 25x100 pixel cell, 150 µm thick sensors without PT
- Analysis performed with the Linear section of the RD53A chip









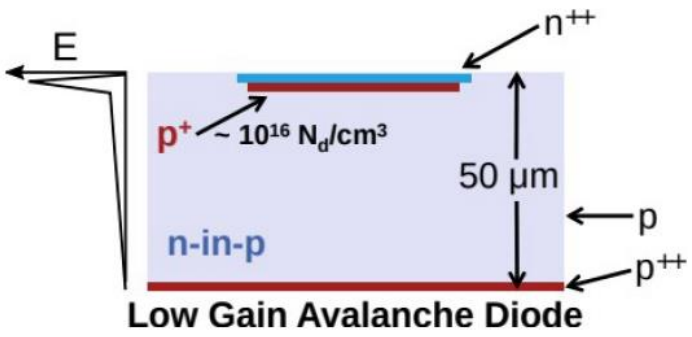
A. Macchiolo, Characterization of RD53A compatible n-in-p planar sensors, PIXEL 2018, 12 December 2018

A. Macciolo, Pixel 2018

A. Dierlamm
Institut für Experimentelle Teilchenphysik

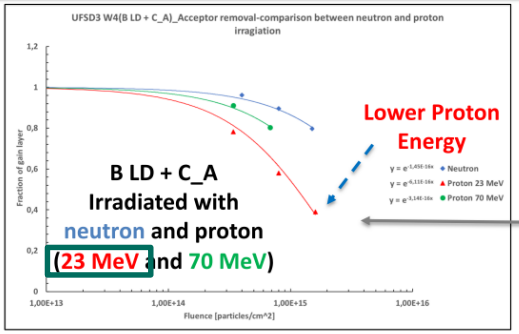
Examples: Low Gain Avalanche Diodes

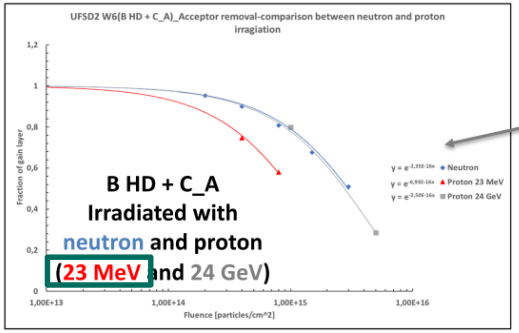
- Irradiation results also with low energy protons now
  - Gain reduction depends on proton energy



Acceptor removal: comparison between neutron and proton irradiation

Marco Ferrero, INFN, 14th "Trento" Workshop on advanced Silicon Radiation Detectors, Trento 25-27 February 2019





Measurements on two flavors of gain layer
Boron LD + Carbon A
Boron HD + Carbon A

- **Effect of proton energy**: low energy protons deactivate the gain layer faster than high energy protons
- The acceptor removal from protons of tens MeV is faster than that neutrons
- Acceptor removal by 24 GeV/c protons and 1 MeV neutrons is very similar

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M. Ferrero, Trento 2019

Status

- Until end of March 2019
  - Access units: **91.2h** / 100h
- Still to be done:
  - CMS pixel modules (~8h)
- 20/24 projects with publications up to now
- We will provide missing access units in P4
- Possibilities to extend access with AIDA funds to be discussed
  - Procedure without additional funds to be understood