EP R&D Days WP 1.1
Planar sensor characterisation

20.6.2022

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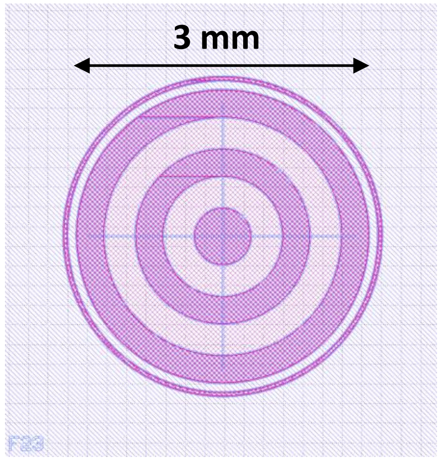
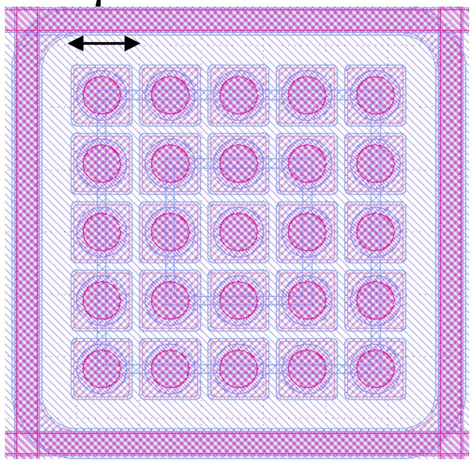
Planar sensor project

- **Goal**: systematic study of **timing** in planar sensors as a function of **irradiation** and **thickness up to 1x10^{17} n$_{eq}$/cm^2**
- N on p planar sensor test structure run done by ADVACAM
- Test structures were produced in the following thickness:

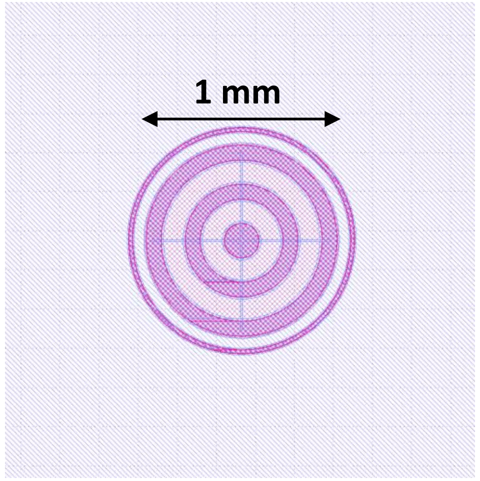
  50, **100**, **200** and **300** µm
- Circular diodes to avoid edge effects
- Test structures:
  - **Small diodes** (3.14 mm^2 active area)for timing study due to lower capacitance
  - **Big diodes** (28.27 mm^2 active area) for study of radiation damage and benchmarking the simulation
  - **5x5 Pixel matrix** (0.003 mm^2 active area) for charge sharing study



Big Diode



5x5 Matrix

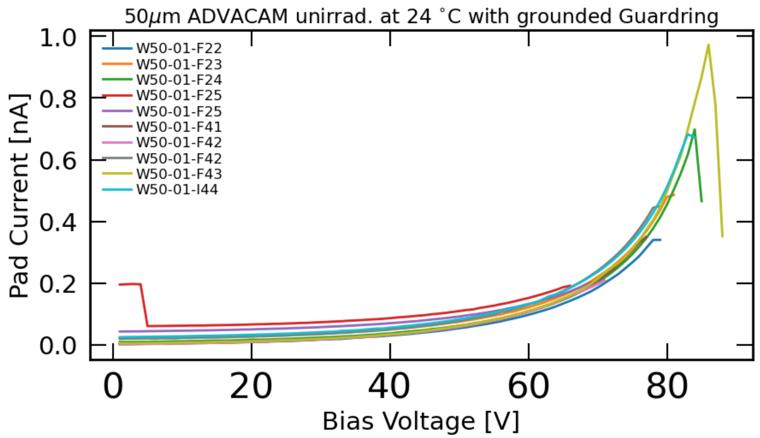


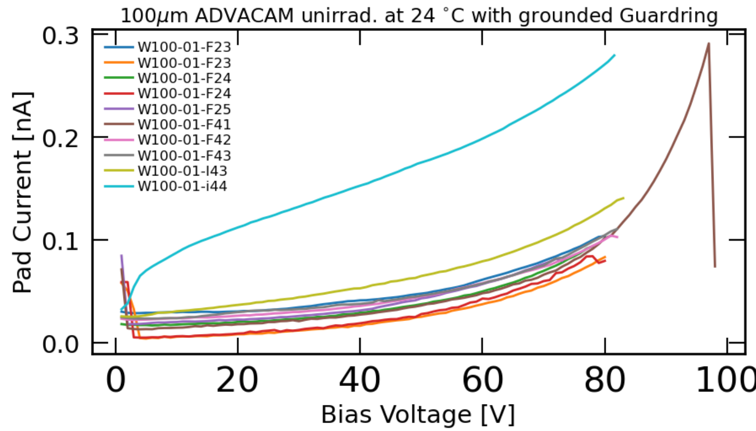
Small Diode

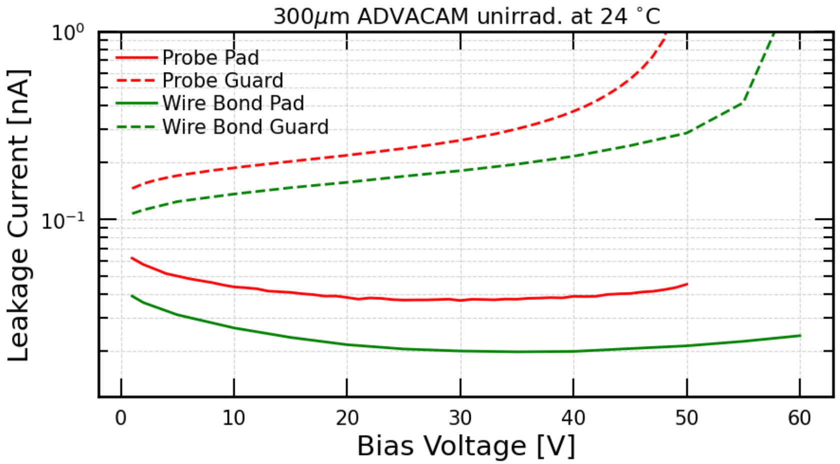
Measurements before irradiation

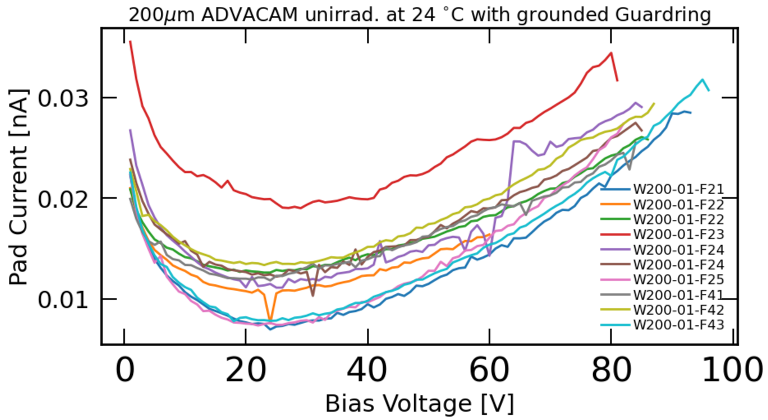
IV:

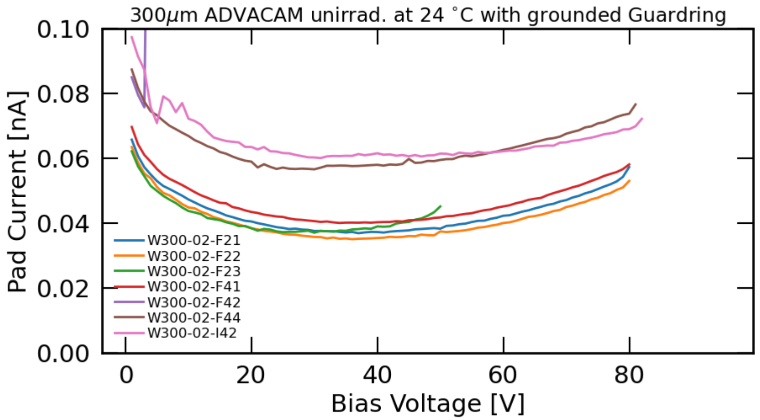
- Done at the SSD lab at CERN
- Breakdown earlier than expected (around 80V for all thicknesses)
- Breakdown occurs in guard ring
- Current seem to flow away at low Voltages for thick sensors (reason still unknown)







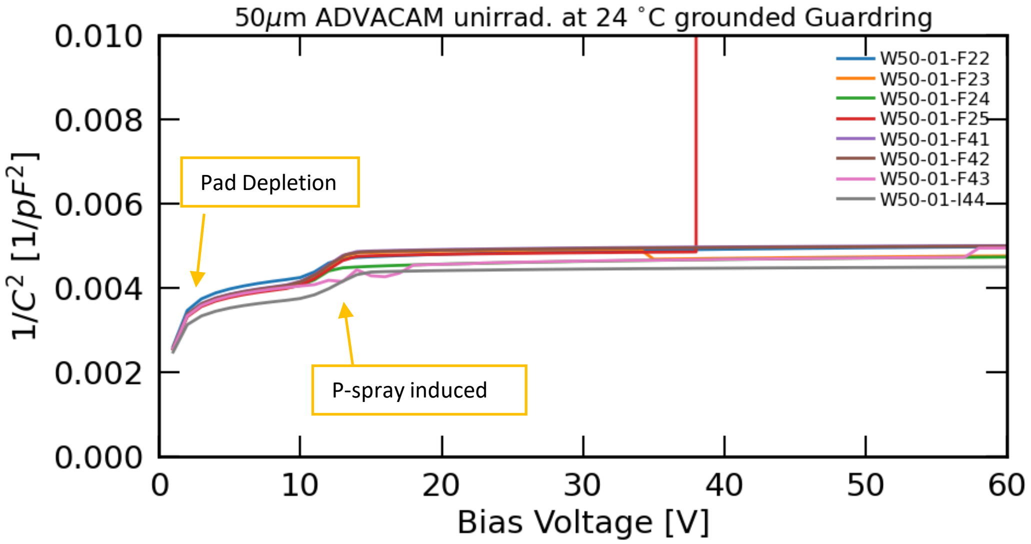




Measurements before irradiation

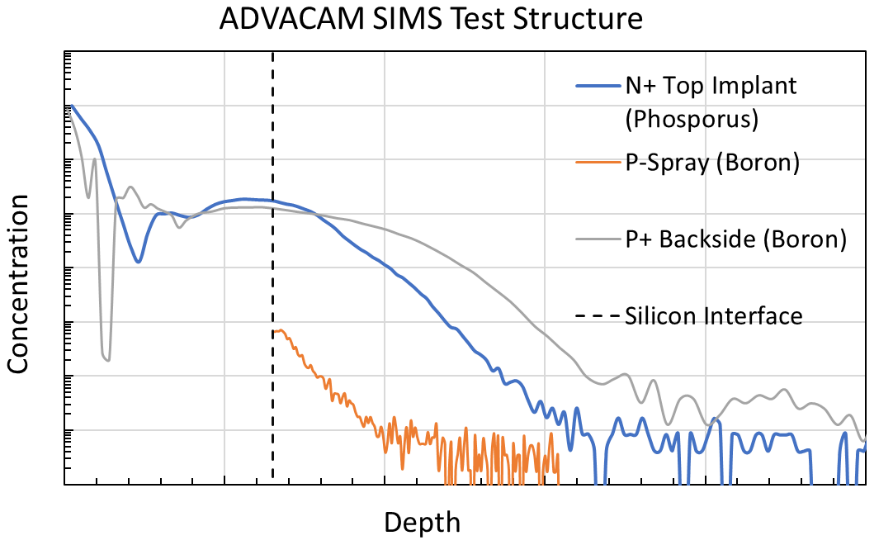
CV:

- Second depletion region at 12 V visible
- Same postion for all thickness
- Suspected to be lateral depletion of p-spray



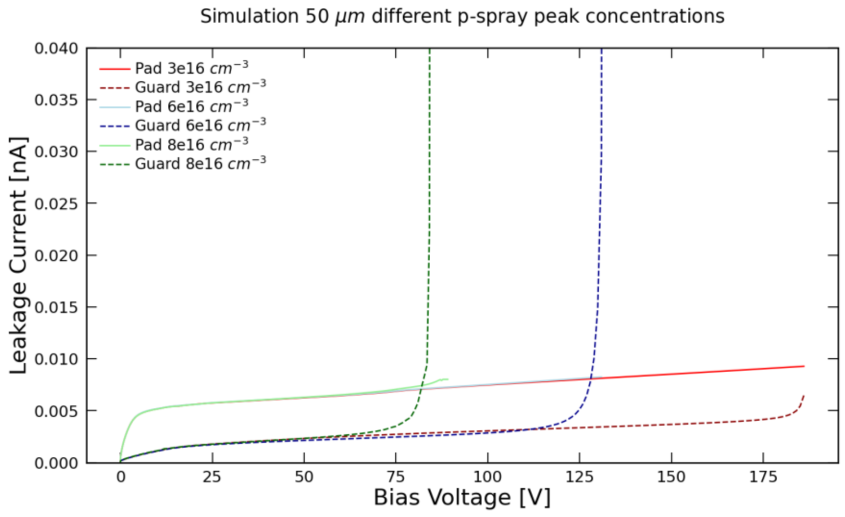
SIMS:

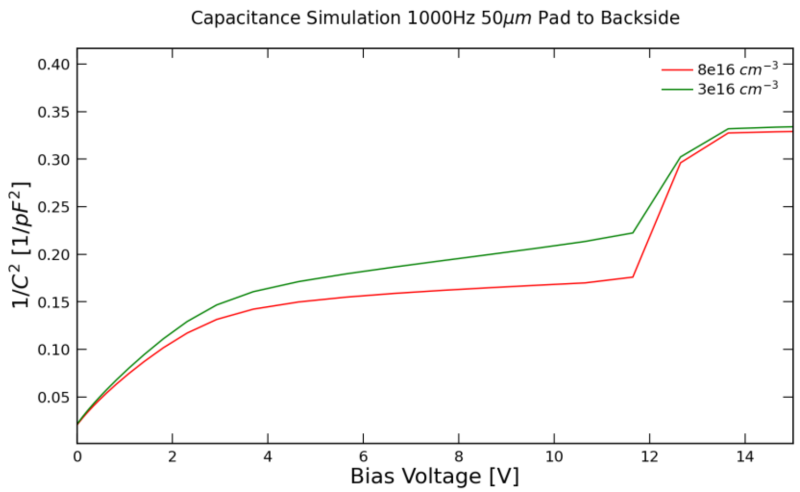
- Secondary Ion Mass Spectroscopy (done at the *Group d' Etude de la Matière Condense* in Versailles to get exact doping profiles
- P-spray peak values measured at ~8e16

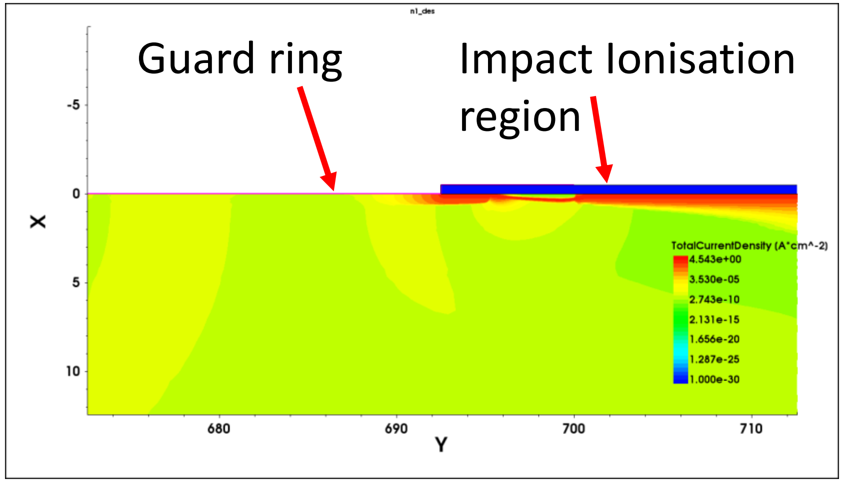


Simulation

- Breakdown due to **high p-spray concentration** leading to **impact ionisation** at the interface between p-spray and electrode implant
- Breakdown first visible in guard ring due to **bigger interface region** compared to pad
- Simulation confirmed p-spray concentration
- Leakage current behavior at low voltage hard to reproduce in simulation







Simulation of breakdown at the guard ring edge

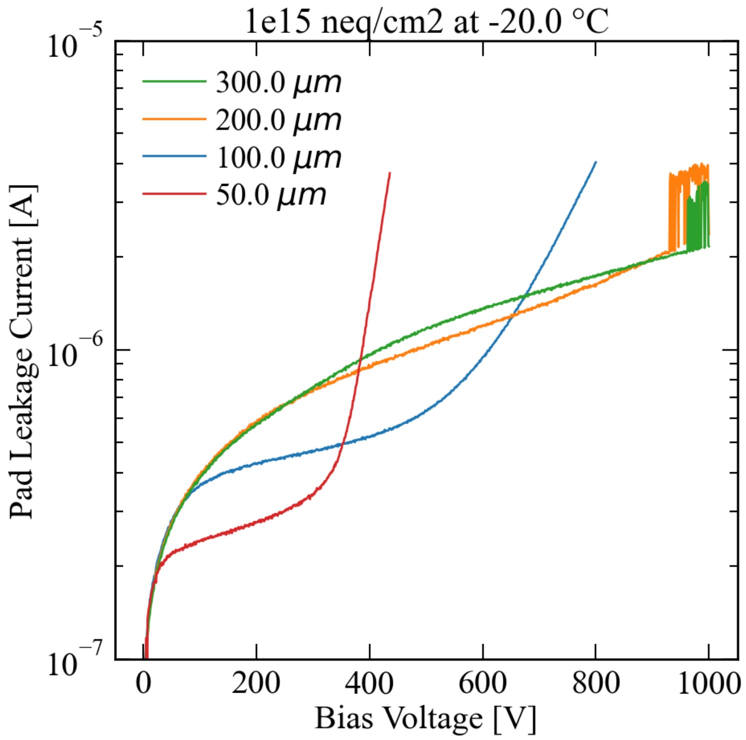
Irradiation Campaign

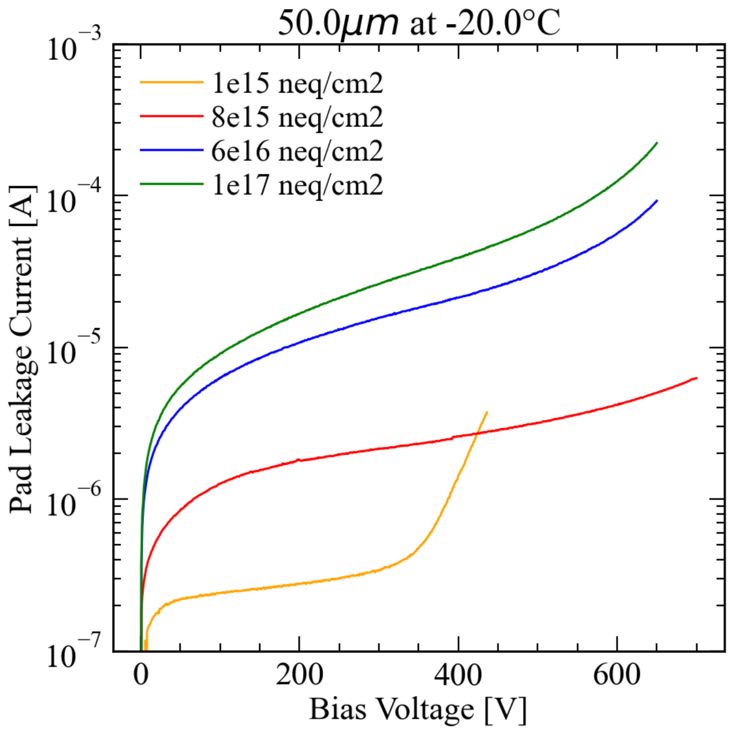
- Irradiation of samples with neutron and proton
- Neutron irradiation done at the Triger Reactor in Ljubljana already finished
- Proton irradiation on-going at IRRAD
- For each thickness two samples were irradiated per fluence point per test structure type

Fluence [n_{eq} /cm^{2}]	Small Diodes	Big Diodes	5x5 Matrix
$1x10^{15}$	8	8	8
$8x10^{15}$	8	8	8
$6x10^{16}$	8	8	8
$1x10^{17}$	8	8	8

Sensors per irradiation point

First Big Diodes Results after Irradiation

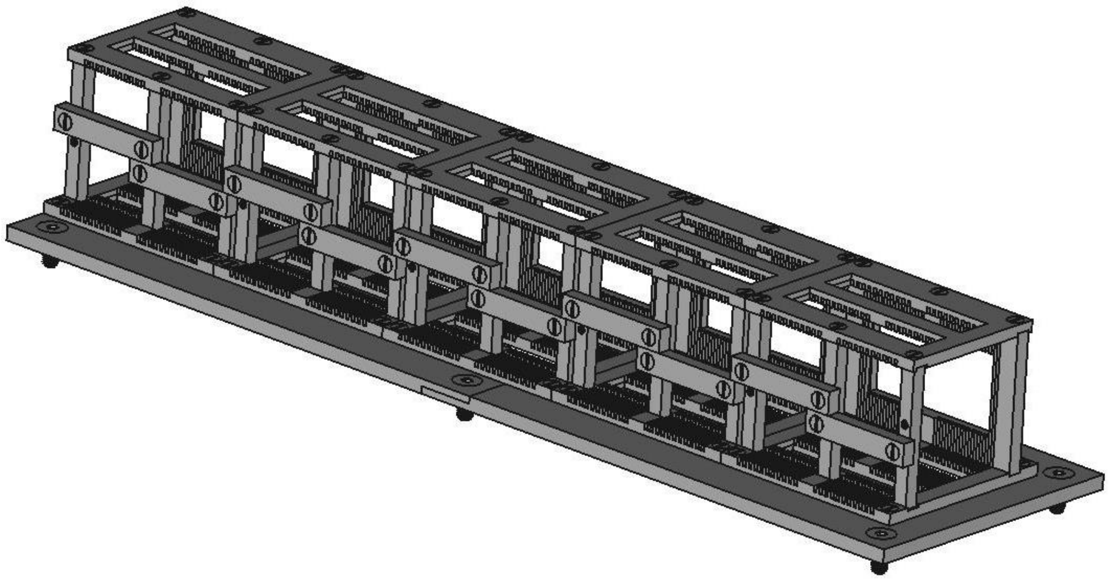




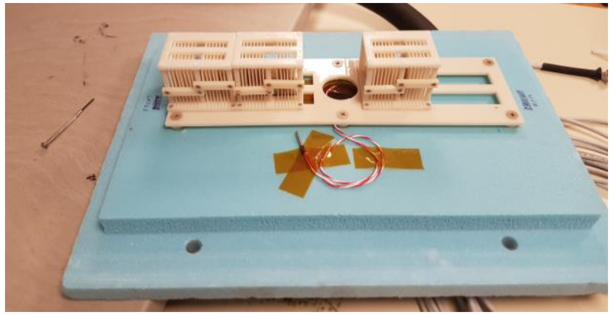
- breakdown characteristics improved significantly after irradiation due to reduction in p-spray concentration
- Unstable region before 1000V suspected to originate from high field and resulting impact ionisation in the edge region of the pad:
  - Needs to be confirmed by simulation

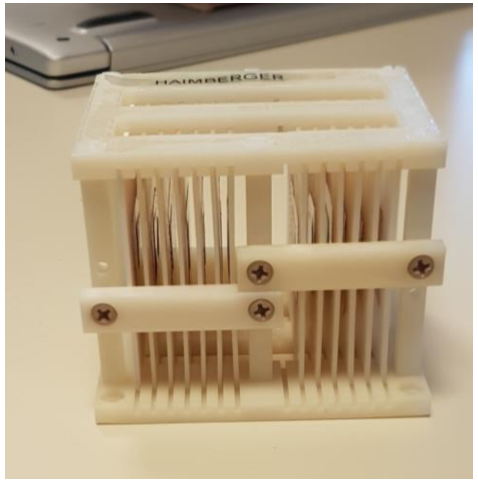
- $8x10^{15}$ seem to have the biggest stable region due to no impact ionisation in the p-spray pad implant interface and less bulk impact ionisation
- Increase in slope at fluences $6x10^{16}$ and $1x10^{17}$ due to impact ionisation in the bulk

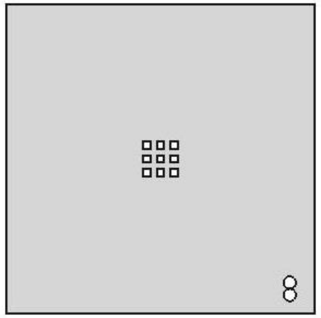
IRRAD Setup



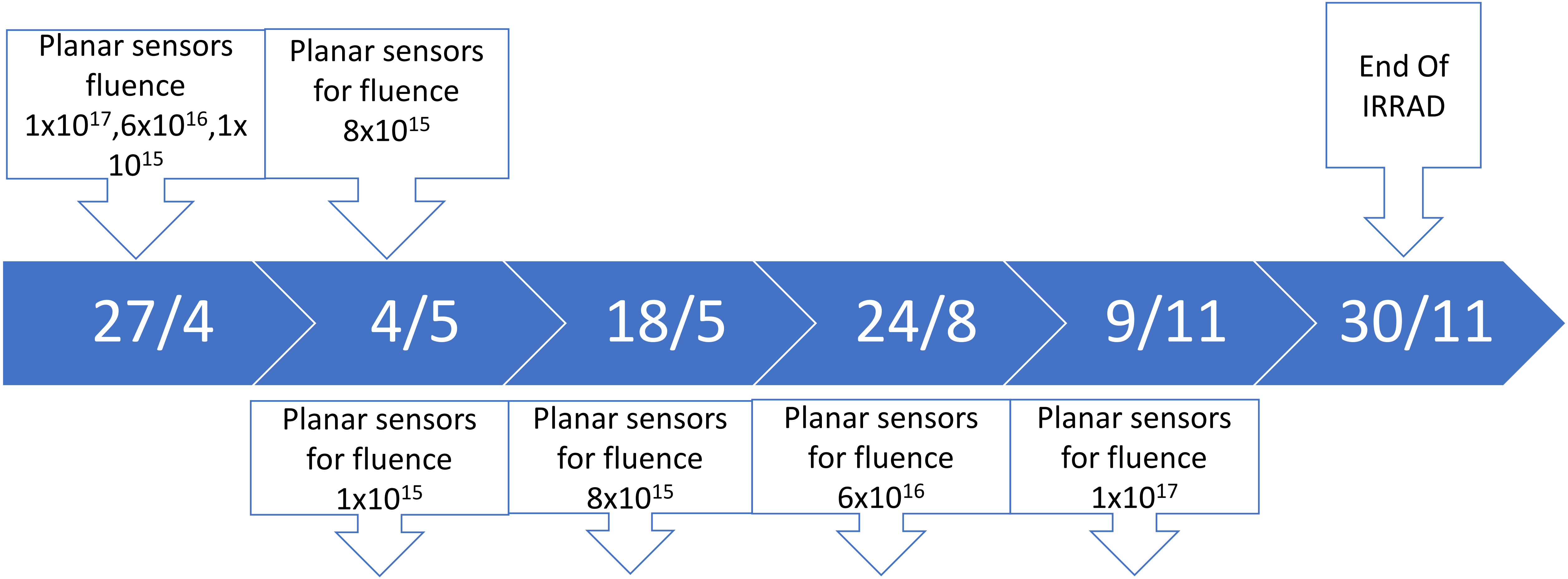
- **New sample holder** was designed for the Vortex box to allow perfect alignment of even the small structures with the beam
- Sensors are placed in 3D printed cards which can be inserted into module
- Setup consist of up to 5 modules each containing 14 Card slots
- Material **Accura 25**
  - 3D printable at the CERN Polymer Lab with 0.1 mm precession
  - Relative cheap compared to alternative
  - Low thermal expansion coefficient: 6mm retraction per m at -15°C







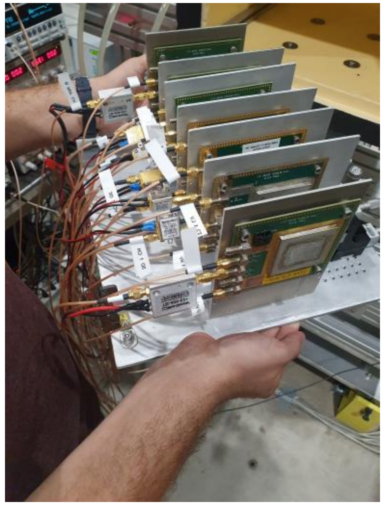
Proton Irradiation Timetable



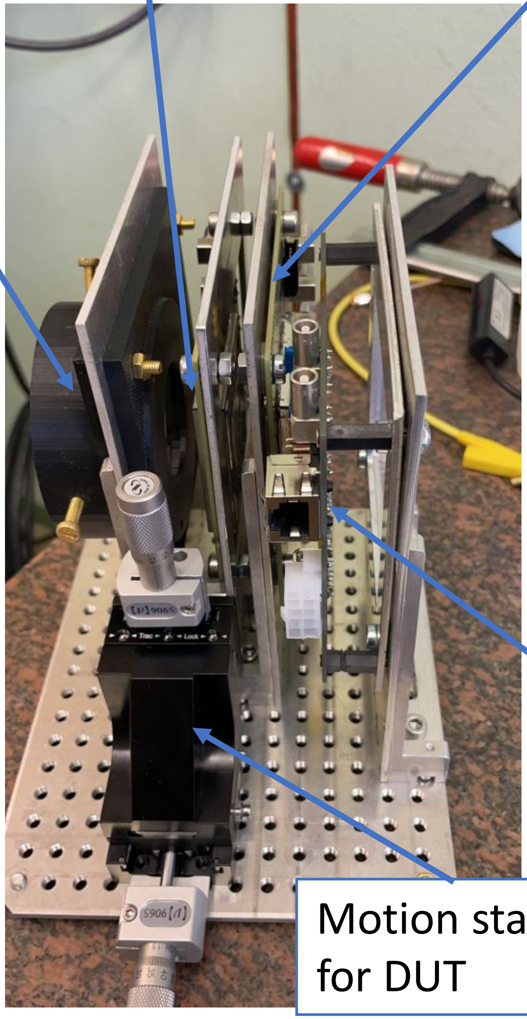
All these calculation assume normal IRRAD beam time without any major downtimes!

Ongoing work

- Finishing the IV and CV characterisation of the neutron/proton irradiated sensors
- Simulating the irradiated sensors in TCAD
- Timing Measurements without tiggering on the DUT (lab setup)
- Timing measurement using the test beam setup(see Vangelis presentation)



Testbeam setup



Lab setup

Backup

List of proton/neutron irradiated sensors

Fluence [n_{eq} /cm^{2}]	Thickness [µm]	Big Diodes	Small Diodes	5x5 Matrix
$1x10^{15}$	50	2	2	2
$8x10^{15}$	50	2	2	2
$6x10^{16}$	50	2	2	2
$1x10^{17}$	50	2	2	2
$1x10^{15}$	100	2	2	2
$8x10^{15}$	100	2	2	2
$6x10^{16}$	100	2	2	2
$1x10^{17}$	100	2	2	2
$1x10^{15}$	200	2	2	2
$8x10^{15}$	200	2	2	2
$6x10^{16}$	200	2	2	2
$1x10^{17}$	200	2	2	2
$1x10^{15}$	300	2	2	2
$8x10^{15}$	300	2	2	2
$6x10^{16}$	300	2	2	2
$1x10^{17}$	300	2	2	2