Radiation-Hard Silicon Strip Sensors for the ATLAS Phase-2 Upgrade

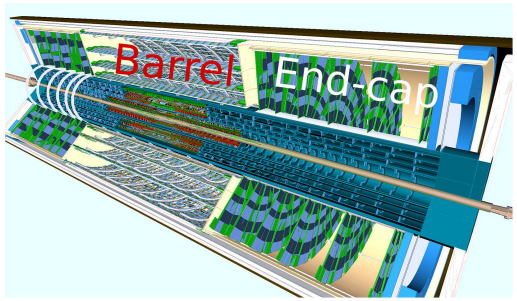
Věra Latoňová
(IoP CAS, CU Prague)
on behalf of ATLAS Collaboration

ICHEP 2020

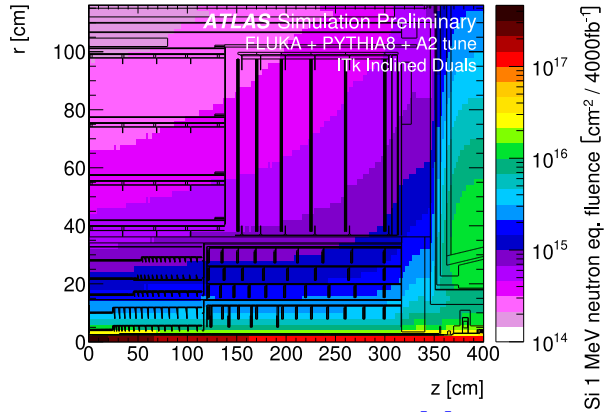
30th July 2020

Introduction

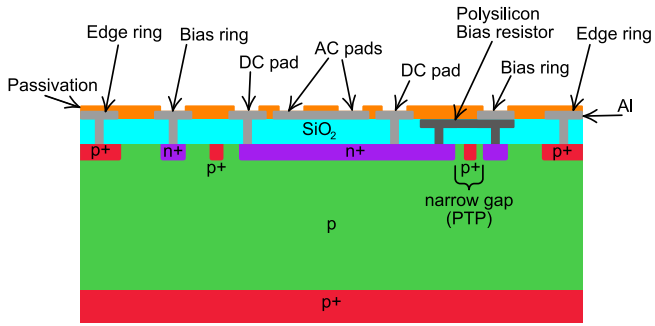
- ATLAS Inner Tracker (ITk) strip sensors:
  - Single-sided n^+-in-p manufactured on 6" wafers,
  - Thickness $(300 - 320)\,\mu m$,
  - Al strips AC-coupled to n^+ implants grounded via polysilicon bias resistors,
  - Strip isolation by common p-stop,
  - 8 different designs: Barrel region (Short strips (SS) and Long strips (LS)) and End-cap region (R0-R5).
- Expected maximal radiation fluences (incl. safety factor 1.5):
  - Short strip barrel: $1.1 \cdot 10^{15}\ n_{eq} cm^{-2}$,
  - Strip end-cap: $1.6 \cdot 10^{15}\ n_{eq} cm^{-2}$.
- Radiation damage:
  - **Bulk damage** – Increase in leakage current, increase in full-depletion voltage and reduction in charge collection efficiency (CCE).
  - **Surface damage** – Cause for early break-down voltages, decrease of interstrip resistance, reduced channel isolation.



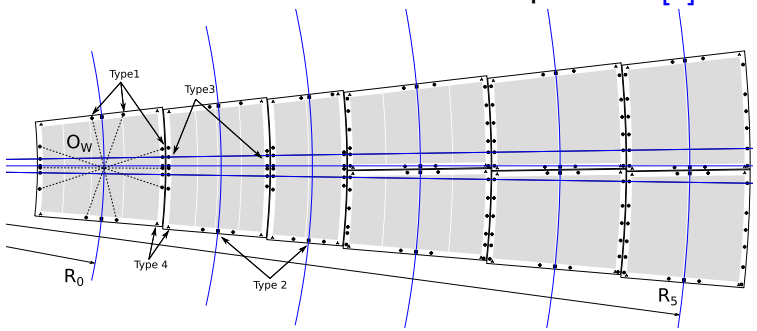
Visualisation of ITk [1]



Fluence distribution for ITk [2]



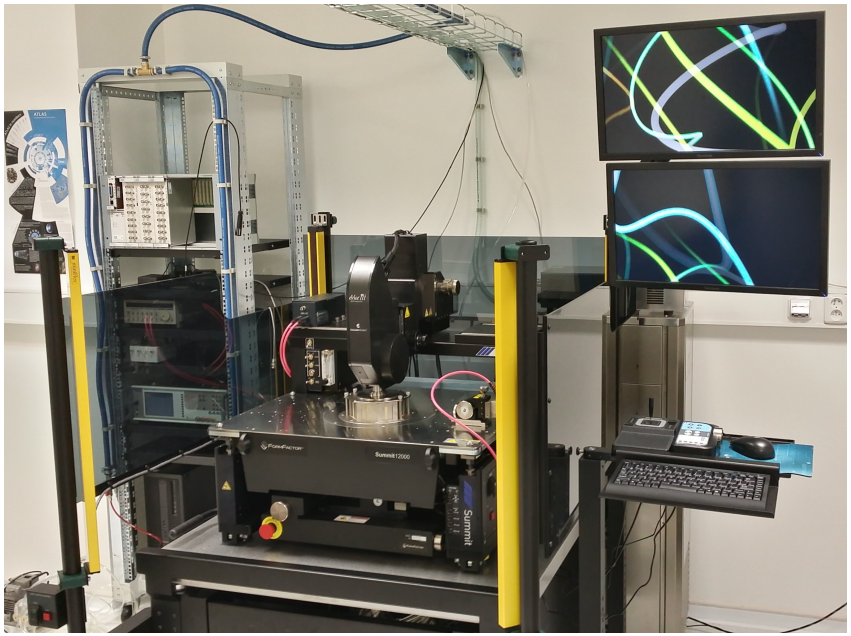
Schematic of ATLAS silicon strip sensor [3]



ITk end-cap sensors [4]

Evaluation Program

- Program consists of:
  - QC: Tests on MAIN Sensors to be assembled in modules:
    - Tests on every sensor: Visual inspection, IV, CV, metrology.
    - Tests on sample sensors: Leakage current stability, full strip tests, detailed strip tests.
  - QA: Sample tests performed on miniature sensors and test structures:
    - Tests before irradiation.
    - Irradiation.
    - Tests after irradiation



- Irradiation sites:

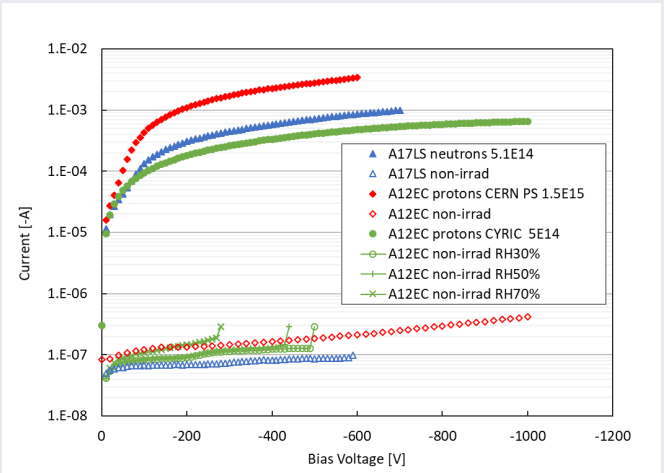
Particle type	Site
Protons	CYRIC, Tohoku Uni (70 MeV)
	Birmingham (28 MeV)
Neutrons	Ljubljana TRIGA reactor
Gammas	UJP Praha (^{60}Co)

- Institutions & tests:

Site	QC	Irrad.	QA (CCE)	QA (TC)	Comment
Cambridge	x				
QMUL	x				
KEK/Tsukuba	x	x	x	x	QC in collaboration with HPK
SCIPP	x				Only long-term tests
Vancouver cluster	x				
Carleton	x				
Prague	x	x		x	
Birmingham		x	x	x	
Ljubljana		x	x		
Toronto			x	x	
Valencia			x		
CNM				x	

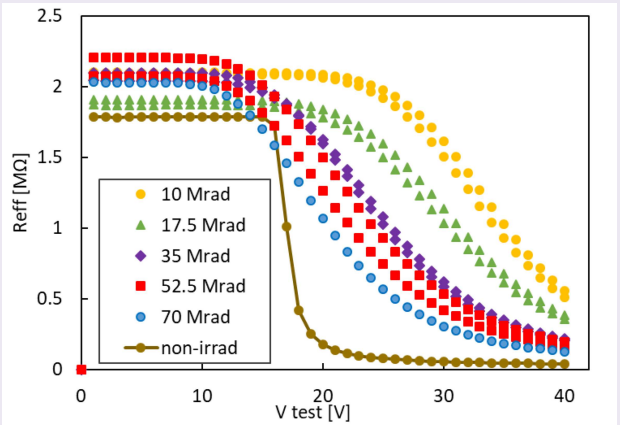
Effect of irradiation on measured sensor characteristics

Leakage current [3]



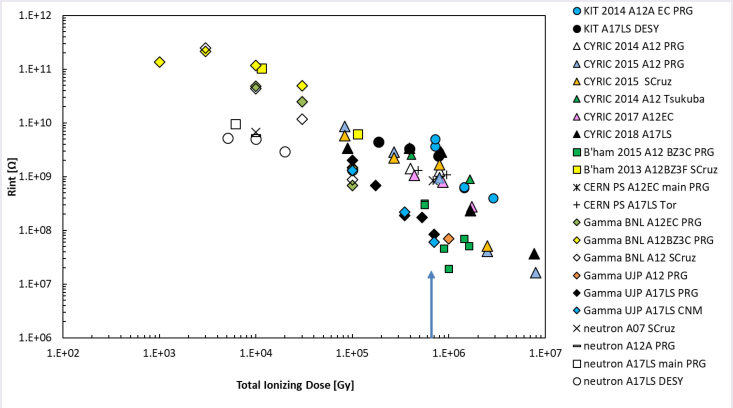
- Irradiated sensors were measured at cold.
- Non-irr. sensors were measured at 20 °C.

Effective PTP resistance vs V_{test} [3]



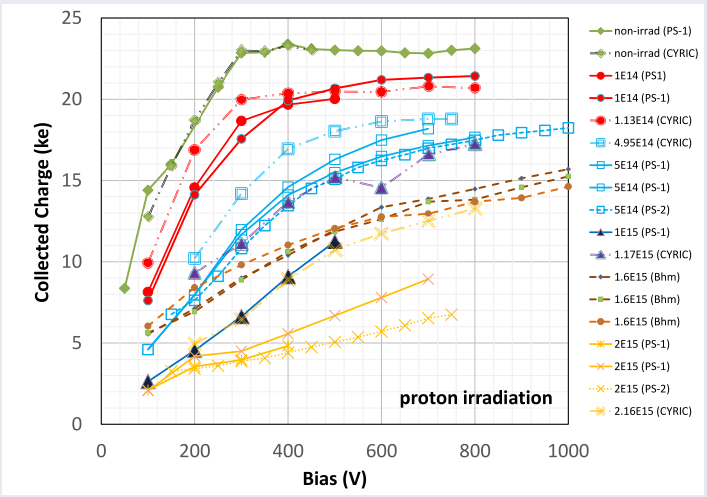
- ATLAS17LS mini sensor irr. by gammas to different TID.

Interstrip resistance vs TID [3]



- Comparison for sensor prototypes ATLAS17LS, ATLAS12EC, ATLAS07 and ATLAS12.

Charge collection vs bias voltage



Manuscript Number: NIMA_PROCEEDINGS-D-20-00038

- Compared results for proton irr. at CERN-PS, CYRIC and Birmingham.