Silicon Pixel R&D with EUDET Telescope in ESA

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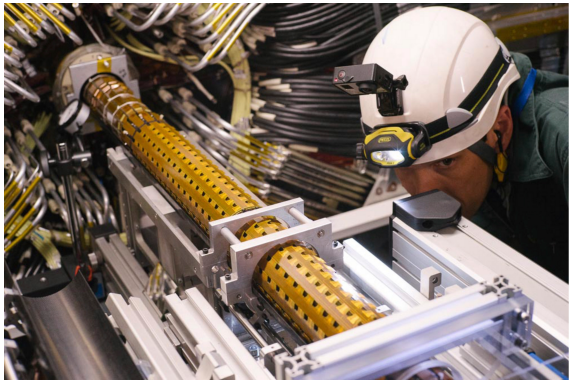
https://confluence.slac.stanford.edu/display/Atlas/TestBeam

Scope

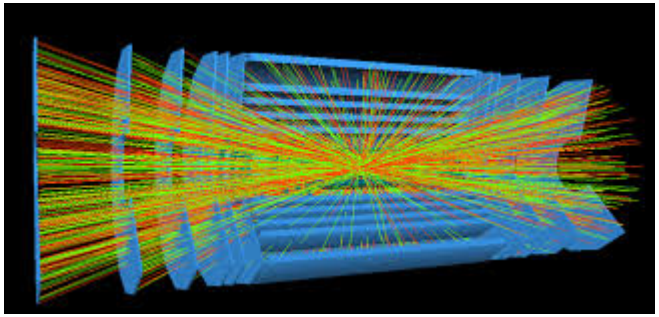
As part of the ATLAS collaboration at CERN, we are using the ESTB to study silicon detectors used for charged particle tracking:

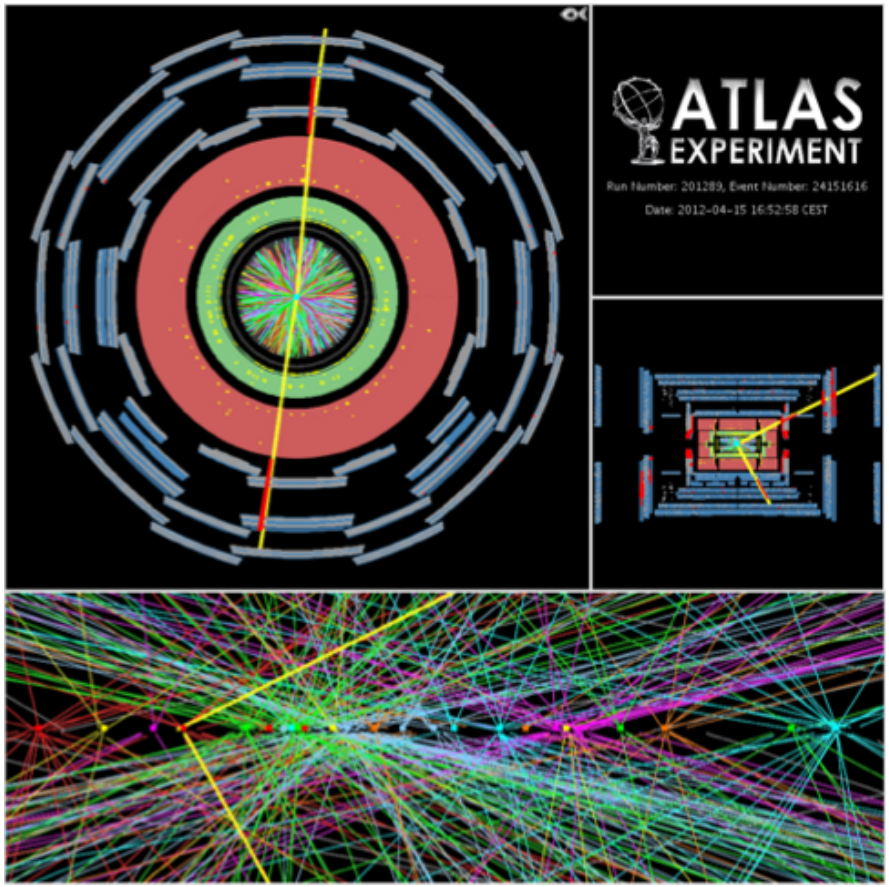
- Precision momentum and direction measurements of tracks
- Tagging of short lived b quark decay secondary vertices coming from decays of Higgs and potential new particles

IBL insertion 2014



1. Test the performance of irradiated devices in order to validate and improve our models
   - 15 times more data (and radiation dose) to go on current detector until 2022
2. Study new devices that can be used in the upgrade of the ATLAS detector in 2023 for
   - 100 times more data than today
   - 10 times luminosity and radiation level
   - 100 times data rate



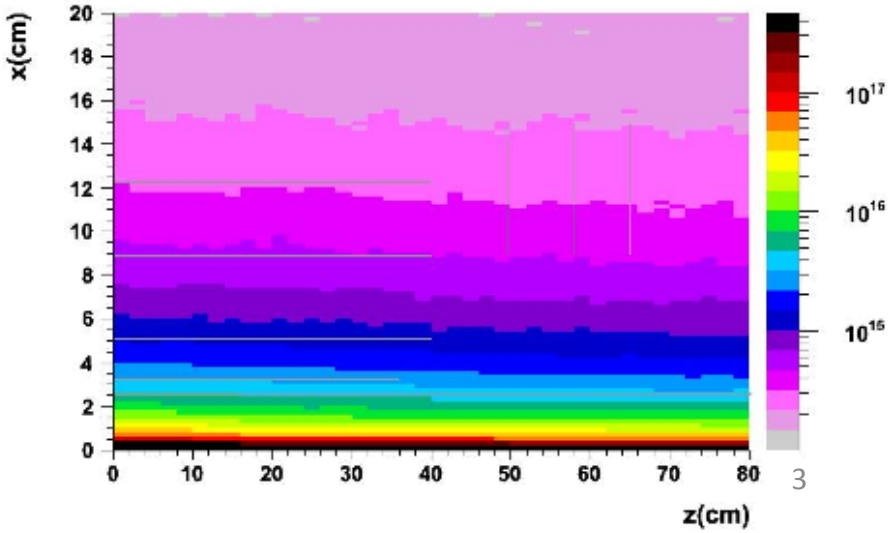


Radiation Damage

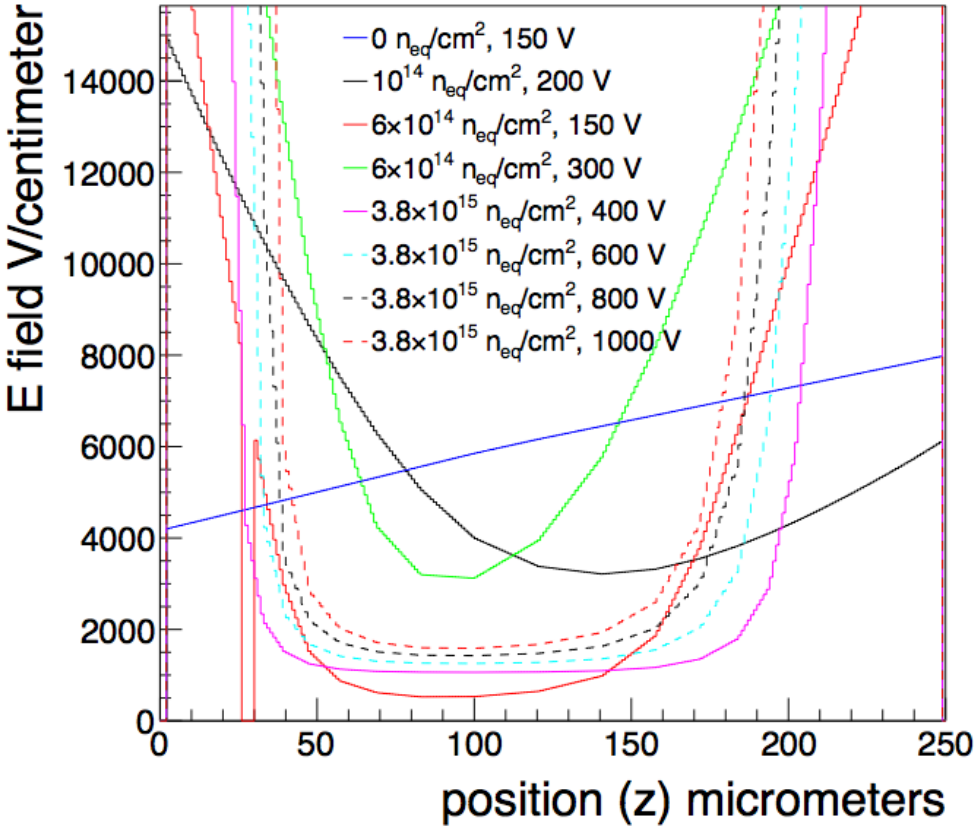
The use of radiation hard technology in the ATLAS inner detector is and will be crucial to maintain performance in Run II and beyond.

However, significant performance degradation is inevitable and we must be prepared with proper simulation!

550/fb: ~3e15 n_{eq}/cm^2 for the IBL



We have empirical models for rad. damage, but we need to validate them with TB data.



$$\tau_{e,h}^{-1} = \beta\Phi$$

fluence

$$\beta = 3 \cdot 10^{-16}\ \mathrm{cm}^2/\mathrm{ns}$$

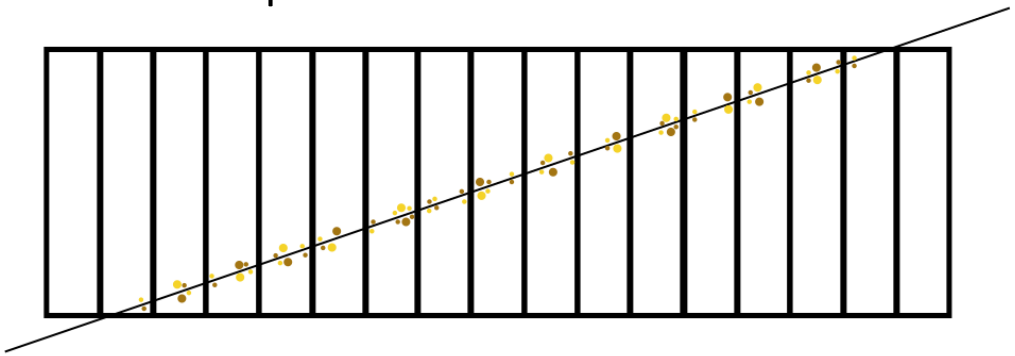
For example, radiation reduces the E field in the center of the pixel and causes charge trapping (signal loss)

ESTB Setup with EUDET Telescope

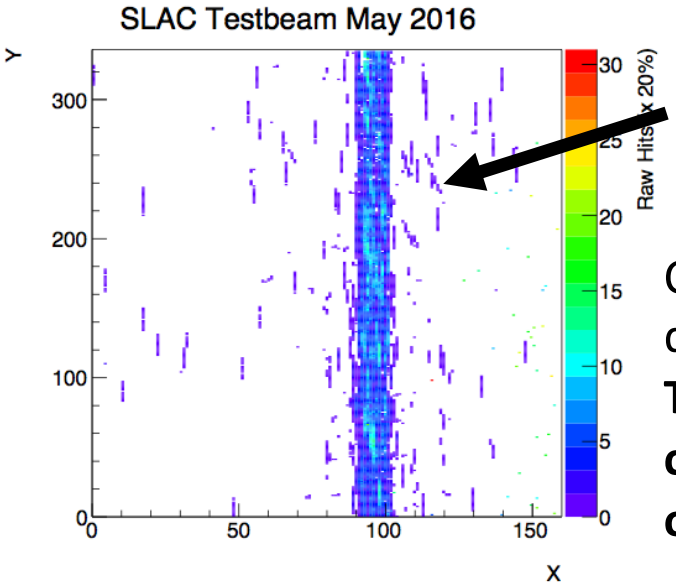
- 6 planes of precision CMOS EUDET pixel telescope (Caladium) from Carleton Univ.
- 18.5μm pixels with ~3μm spatial resolution
- ~ 2cm x 1cm beam aperture
- Integrated Device Under Test (DUT) readout and XY/rotation adjustment.

Allows selection of good tracks through whole telescope and less sensitive to beam debris contamination

DUT at high angles to probe charge collection as a function of depth in the sensor.



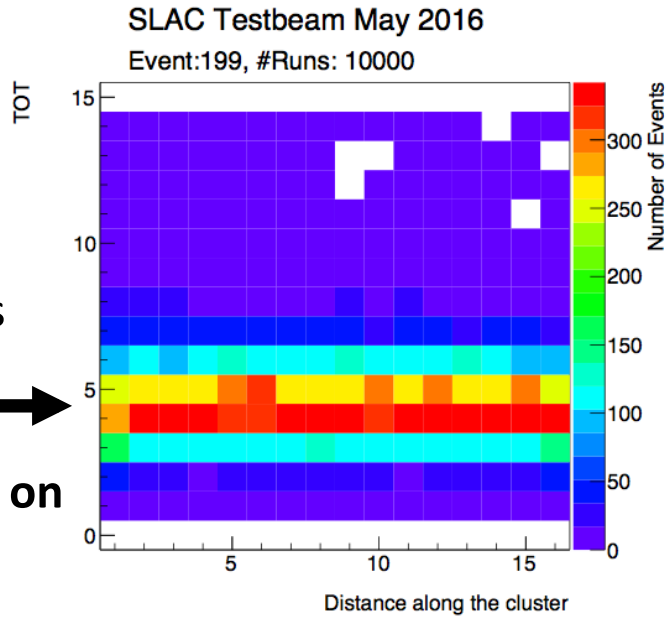
Critical for studying radiation damage effects and validating / improving our models.



DUT occupancy: long clusters (~15 pixels)

Charge collection versus depth (unirradiated)

This week: additional cleaner lower rate data on our irradiated sensors

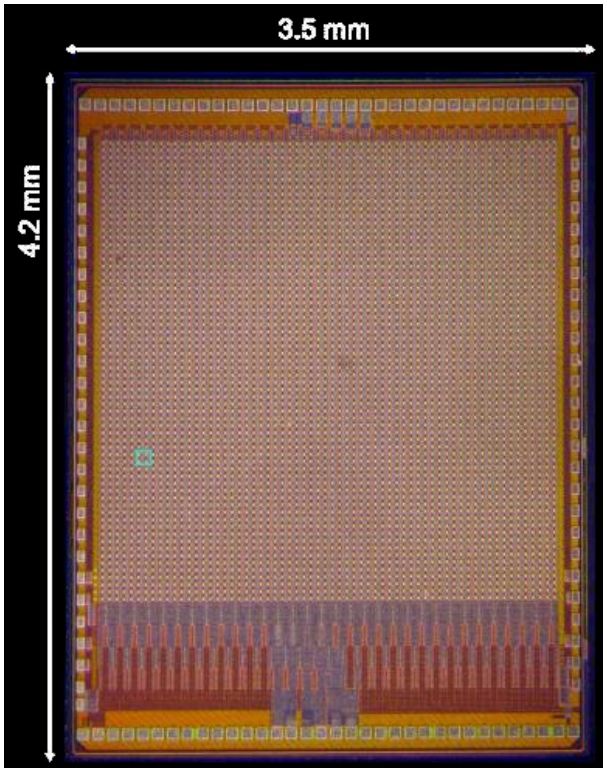


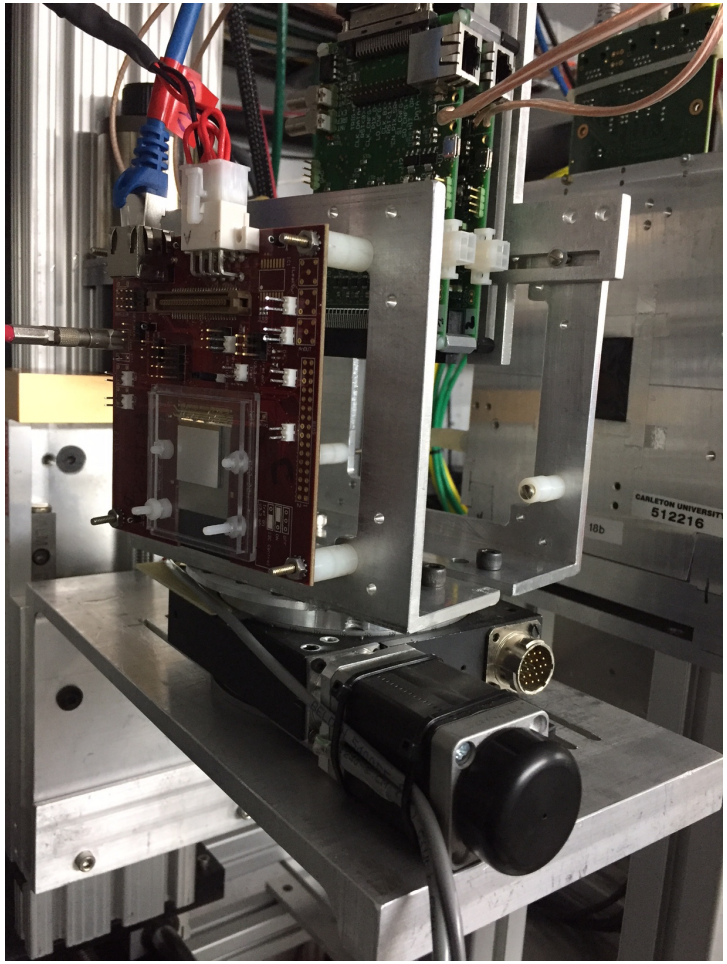
This will have a significant impact on ATLAS performance in the (near) future.

ATLAS Upgrade Devices

RD53 FE65-P2 prototype

- 50μm x 50μm pixels
- Readout ASIC with 65nm TSMC readout





New prototype planar pixel sensors bump bonded by US vendor RTI to current readout chip.

Testing for bump and sensor uniformity.

Beam Requirements

- Secondary electrons at the rate of a few electrons per beam crossing typically, and sometimes up to a few hundreds per crossing during setup tuning
- Prefers high energy beam >10 GeV to reduce multiple scattering but don't care about exact energy or moderate energy spread.
- Beam spot size preferably to cover large fraction of test device ~1x1cm – only worth fine tune for long data taking runs.
- Beam cleanness and energy spread not crucial – we have EUDET telescope for offline quality selection. The key factor is hit density. Uniformity preferred.