

Teambeam Studies with Silicon Strip Module Prototypes for the ATLAS-Detector towards the HL-LHC

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Introduction

Run 1

Integrated luminosity of 25fb-1

Sqrt(s) = 7 TeV to ATLAS

Sqrt(s) = 8 TeV to CMS

TRT and SCT with radiation hard silicon
pixel and strip trackers

Higgs Boson discovery in 2012,
leading to Nobel Price for
Francois Englert and Peter Higgs in 2013

Run 2

Start from around 2025

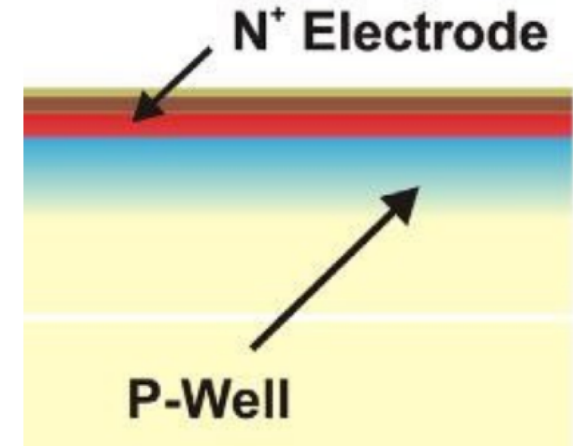
Instantaneous luminosity
up to $7.5 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

All-silicon tracker in inner
detector region

Run 3

Module Prototypes

- Barrel region
- n-doped strips, $\sim 20\mu\text{m}$ thick and a pitch of $74.5\mu\text{m}$, in a p-doped silicon bulk, thickness of $\sim 320\mu\text{m}$ and area of $97 \times 97\text{mm}^2$



Sensor and reference

- 2 modules
- LS3: irradiated at the CERN PS with $\sim 24\text{GeV}$ protons at -20°C up to a dose of $7.8 \cdot 10^{14} \text{neq/cm}^2$ with a total ionizing dose of 36.1Mrad (which one expects at an integrated luminosity of 3000fb^{-1} at the end of the HL-LHC phase for the barrel layers)
- LS4: stayed unirradiated as a reference

Sensor and reference

- 4 strip segments with a length of 24mm each, where two of the segments have been bonded together to have a long strip region and one of the short strip segments is not bonded to the readout
- Blue-circles: beam position

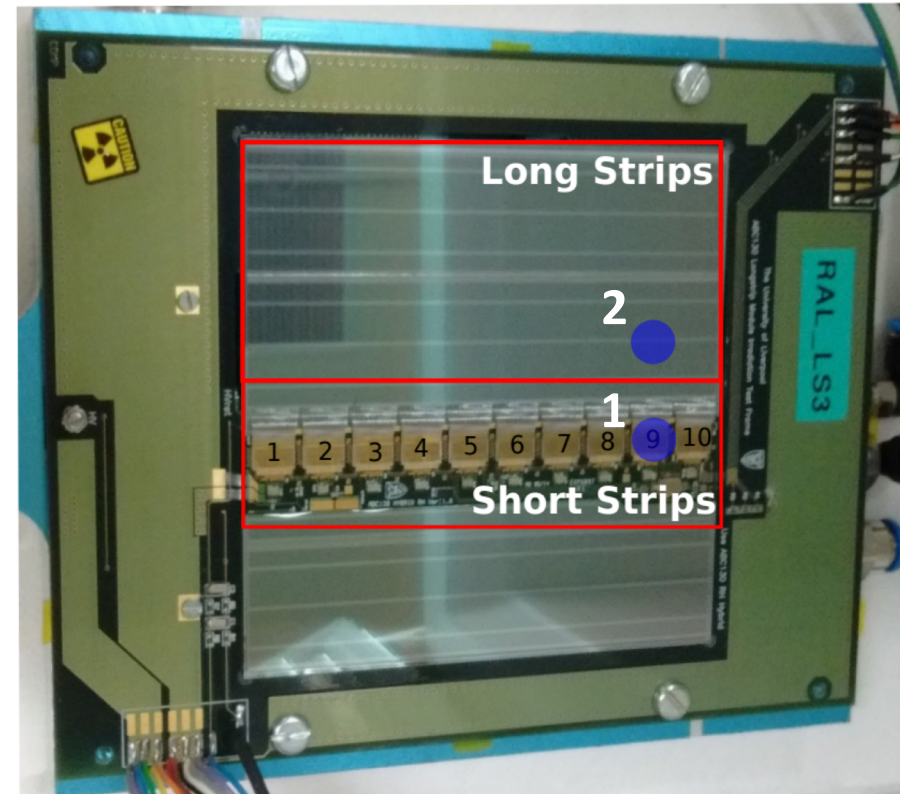


Figure 1: Picture of the irradiated full size barrel module (called LS3). The long- and the short-strip region is marked, as well as the ASIC³ numbering used. The rough beam positions are indicated by the blue circles.

Yuhang

- In figure 1, what's the effect of the Cooling Box? The modules have been tested in operation with various temperatures, how to control the temperature?
- Control temperature by DCS(more details can be found in my special topic last Friday).

Testbeam at CERN

- Done at the H6-Beamline, where the beam from the SPS is shot on fixed targets to provide at the end a secondary beam of $\sim 120\text{GeV}$ pions using installed beam optics
- DUT in cooling box can be adjusted inside the telescope used for studies

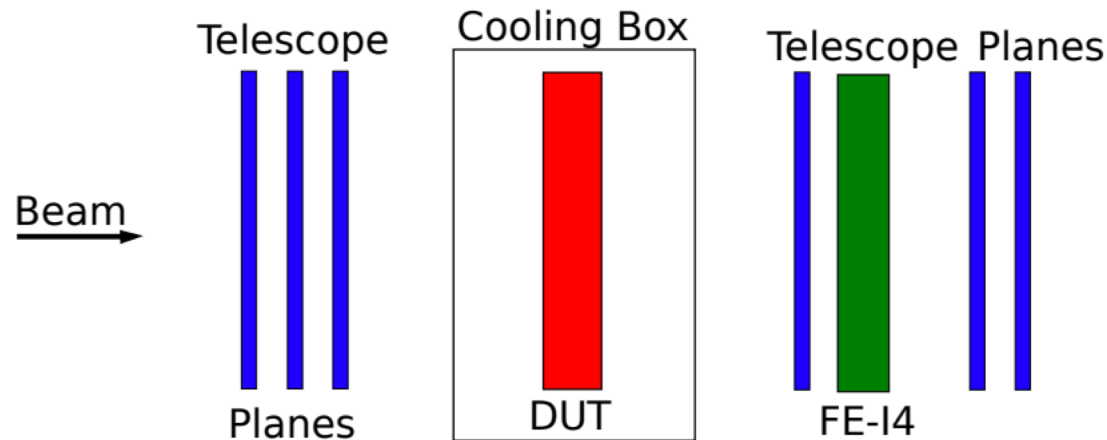


Figure 2: Schematic setup inside the beam line. The distances are not to scale.

Testbeam at CERN

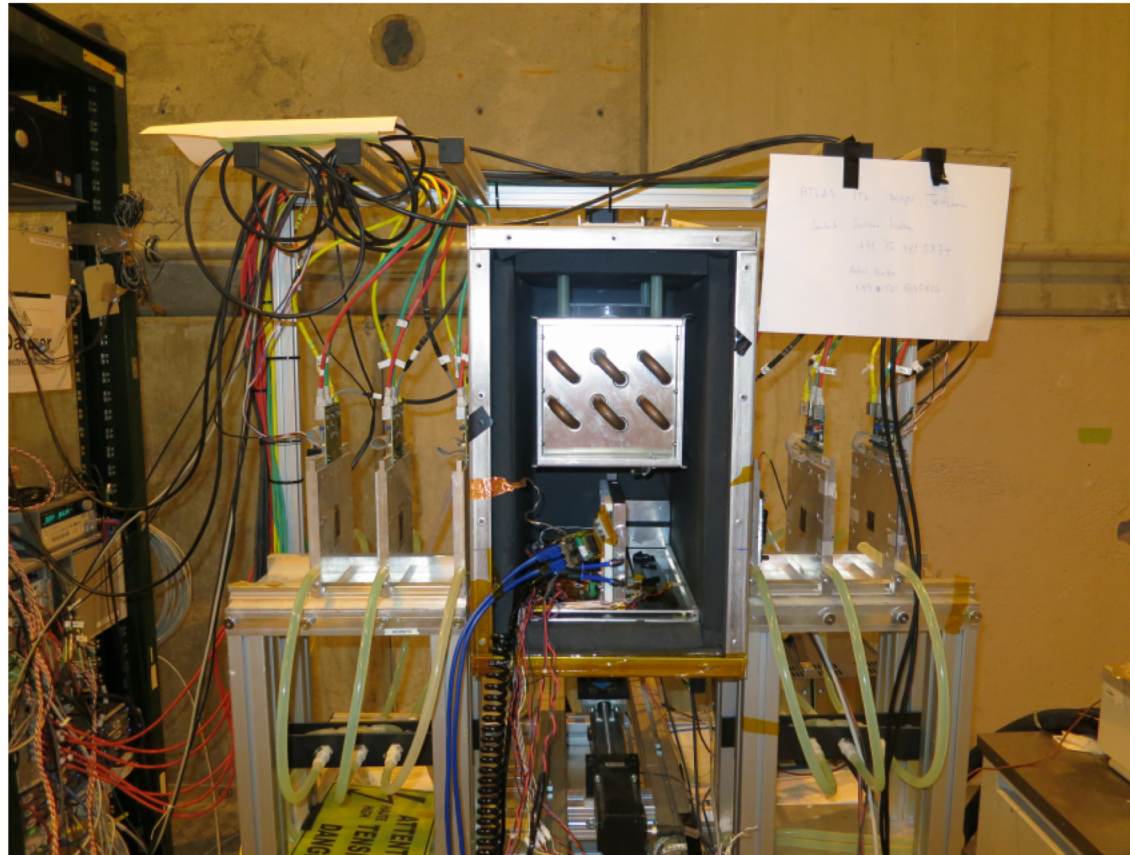


Figure 3: *Picture of the testbeam setup at CERN as drafted in Figure 2.*

Amit

- I didn't get the essence of adding the pixel sensor (FE-14) between the planes of telescope only at one side?
- Used as reference plane.

Reconstruction

- Tracking fitting – provides information about the local hits on each plane(telescope, DUT and FE-I4), fitted track positions

Analysis

- Using the telescope as a reference to test the DUT by being able to compare the measured hits on the DUT with the reconstructed tracks from the telescope in different parametrizations

Analysis -- Parameters

- Efficiency
- Looking at the fitted track positions on the FE-I4 and looking for corresponding local hits in a certain range(± 1 pixel)
- Extrapolating these hits into the local coordinate system of the DUT and looks there for matches in a range of 10 strips

$$\epsilon = \frac{\text{\# matches on the DUT}}{\text{\# matches on the FE-I4}}$$

Analysis -- Parameters

- Noise Occupancy
- Probability of having a hit on a strip caused by noise

$$\eta = \frac{\# \text{ hits on the DUT}}{\# \text{ events} \cdot \# \text{ strips}}$$

Analysis -- Parameters

- Fit Function
- skewed complementary error function

$$\epsilon = \epsilon_{\max} \cdot f \left(x \left[1 + \underbrace{0.6 \cdot \frac{e^{-\tilde{\zeta}x} - e^{\tilde{\zeta}x}}{e^{-\tilde{\zeta}x} + e^{\tilde{\zeta}x}}}_{\text{Empirical Landau Con.}} \right] \right)$$

F. Campabadal et al., “Beam tests of ATLAS SCT silicon strip detector modules”

Results

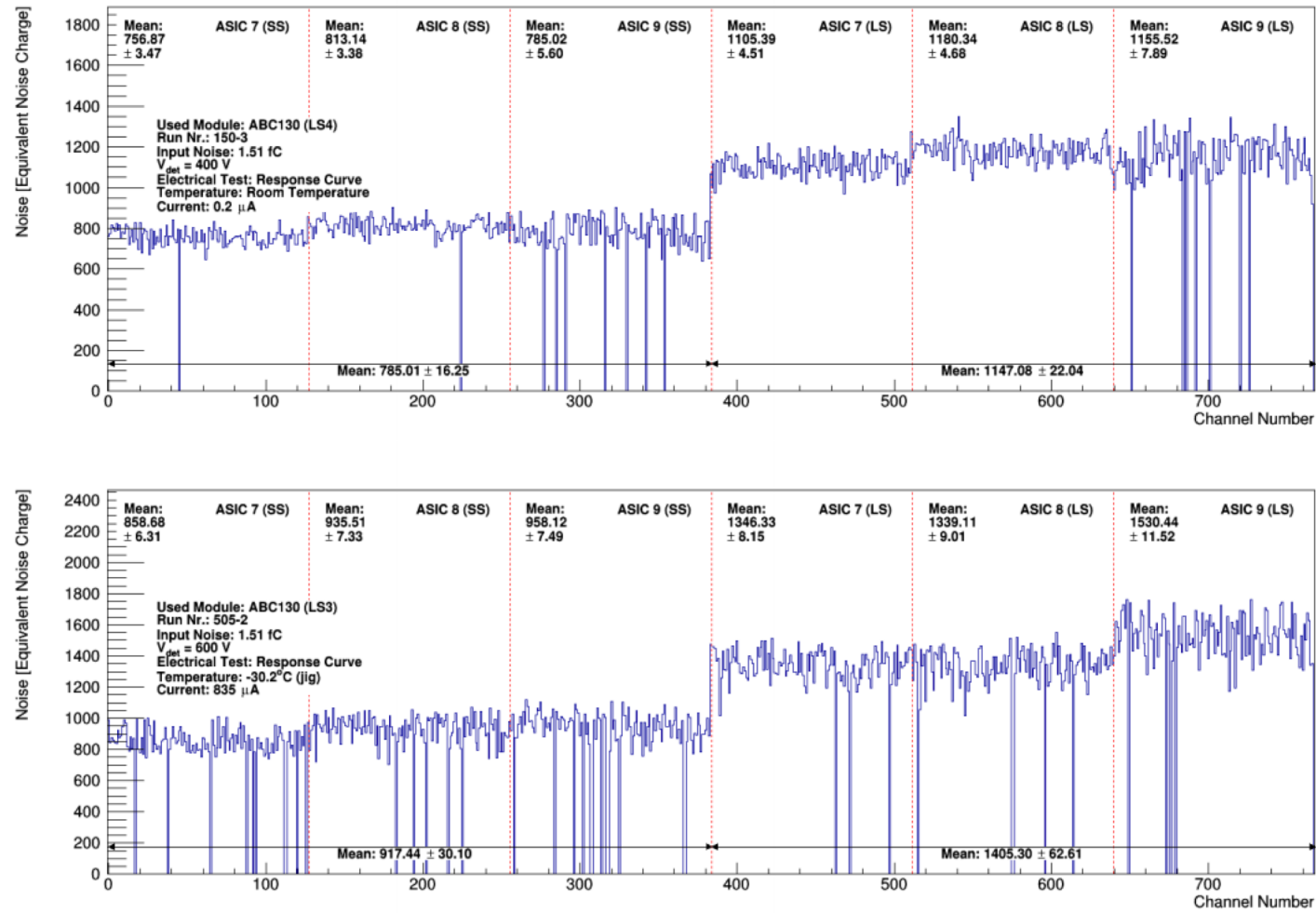


Figure 4: Noise values and their statistical uncertainty from RC measurements for the unirradiated LS4 module (upper Figure) and the irradiated LS3 module (lower Figure).

Ryuta

- At the beginning of Section 6., there is a statement of “In a first step, the noise of the modules at a charge deposition of 1.5fC has been calculated using a response curve(RC) measurement ...”
- What is the meaning of this sentence ?

Results

- At a bias voltage of 500V for the irradiated LS3

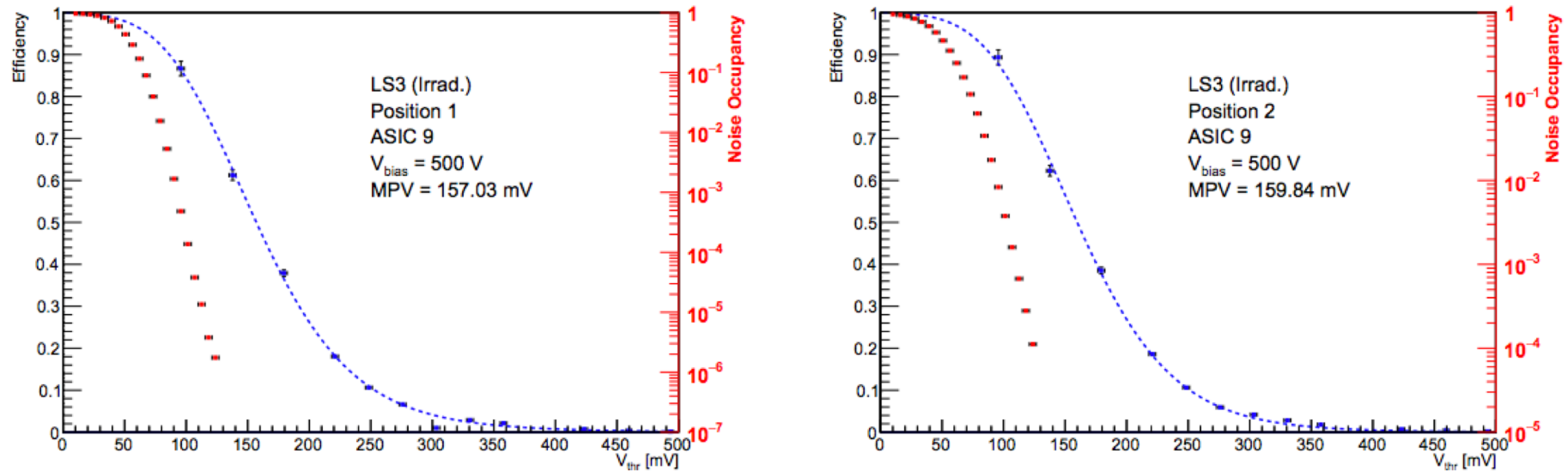


Figure 5: Track based efficiency and noise occupancy (pedestals not yet subtracted) for the irradiated LS3 module at a bias voltage of 500 V for the short strip region (left) and the long strip region (right).

Xin

- What's the meaning of “Noise Occupancy” in this context? And its relation related with V_{th} (threshold) in Fig. 5 ?
- Probability of having a hit on a strip caused by noise
- With V_{th} going higher, noise & efficiency go lower.

Shan

- In figure 5, what's the relationship between two vertical axes (efficiency and Noise Occupancy)?
- With V_{th} going higher, noise & efficiency go lower.