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Overview of Beam Tests for the ATLAS ITk Planar Sensor Market Survey

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Bundesministerium
für Bildung
und Forschung

ATLAS
EXPERIMENT

The ATLAS Experiment

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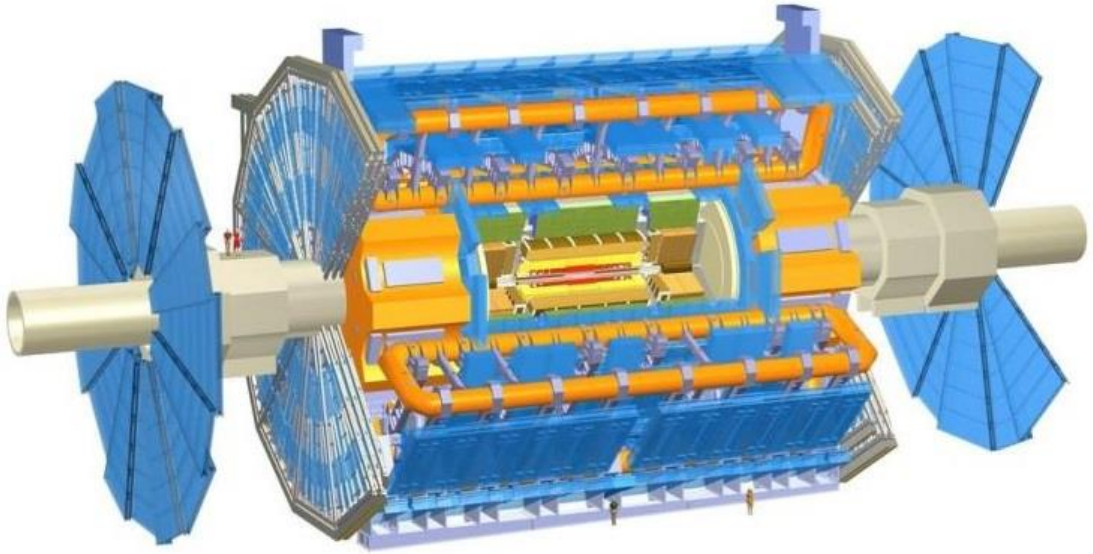
- Located at CERN
- One of the four big experiments at the LHC



- Needs replacements to cope with the new conditions in the HL-LHC (foreseen for 2026)
  - Higher occupancy
  - Higher radiation dose

ATLAS Inner Tracker (ITk)

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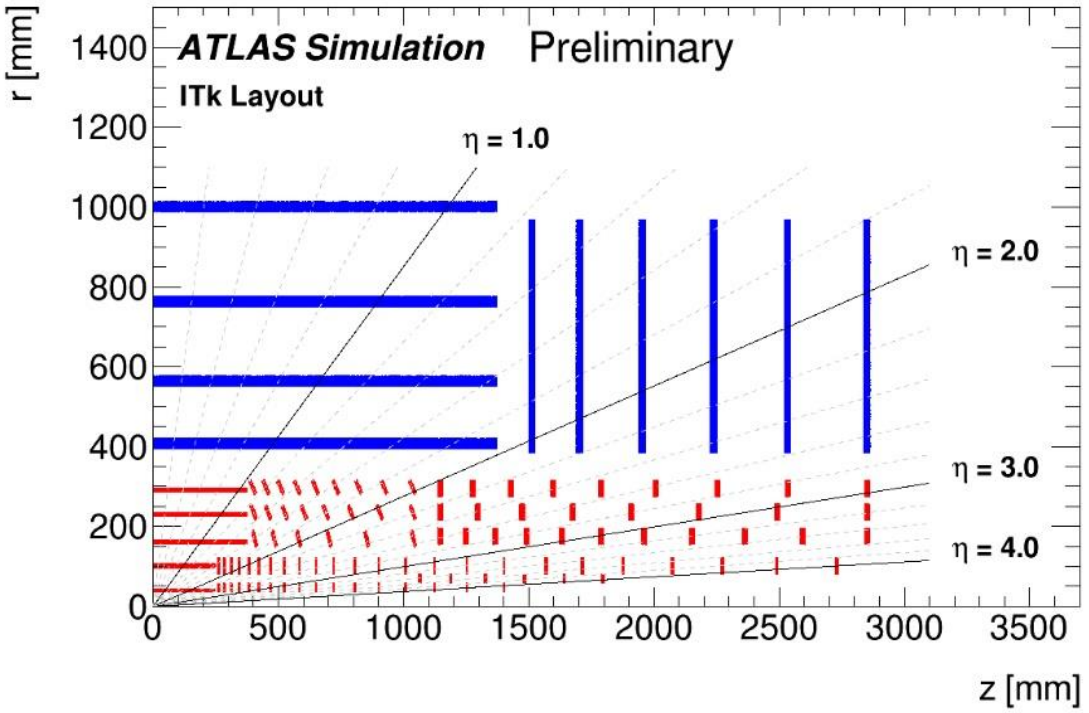
- All silicon-system (installation in LS3)
  - Strip Detector
  - Pixel Detector
- 3D and planar pixel sensors for Pixel Detector



- Layout optimisation for Pixel Detector still ongoing
  - Should be approved in February

ITk Planar Sensor Market Survey

- Global market survey to invite vendors to tender
- Test bare and irradiated sensors‘ functionality and quality
  - Visual inspection
  - Lab measurements
- Test (un-)irradiated modules of each vendor
  - Lab measurements
  - Beam tests
- Joined effort by many institutes
  - Supported by the ATLAS ITk Pixel testbeam community

Participating Institutes

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Market Survey Beam Tests

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- Fraction of sensors is interconnected to the RD53A read-out chip
  - Attached to Single Chip Cards
- Measure hit efficiency at perpendicular incidence
  - Unirradiated
  - Irradiated
    - $2 \times 10^{15}\ n_{eq}/cm^2$
    - $5 \times 10^{15}\ n_{eq}/cm^2$
- Measure at room temperature or cooled

Measurement Program

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- Sensors with
  - Different pixel pitches
    - 25µm x 100µm (Barrel L0)
    - 50µm x 50µm
  - Different thicknesses
    - 100µm (L1)
    - 150µm
  - Irradiation status
    - Unirradiated
    - Irradiated to 2×10^{15} n_{eq}/cm^2
    - Irradiated to 5×10^{15} n_{eq}/cm^2

- Test
  - → Optional:
    - Two modules per pixel pitch
  - → Mandatory:
    - One module of each thickness per vendor
  - → Mandatory:
    - One module of each irradiation status per thickness per vendor

Before the Testbeam Period

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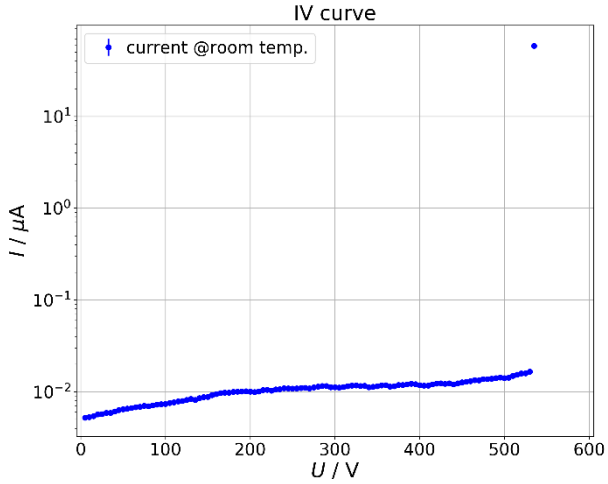
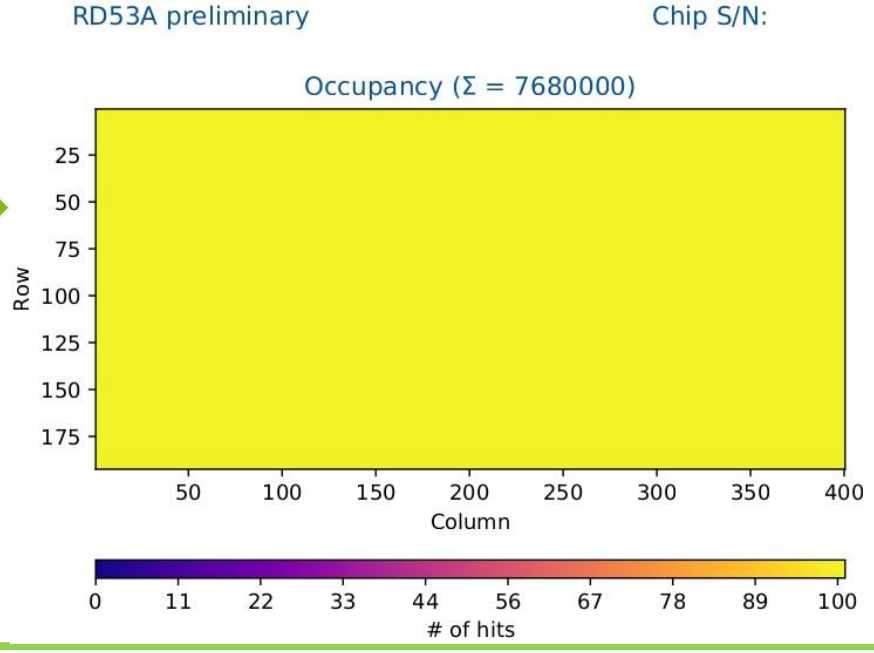
- Check functionality of the sensor
  - IV
  - Current stability



- Check functionality of the module
  - Pretuning
    - Analog scan
    - Digital scan
    - Tuning



Testbeam Periods at DESY

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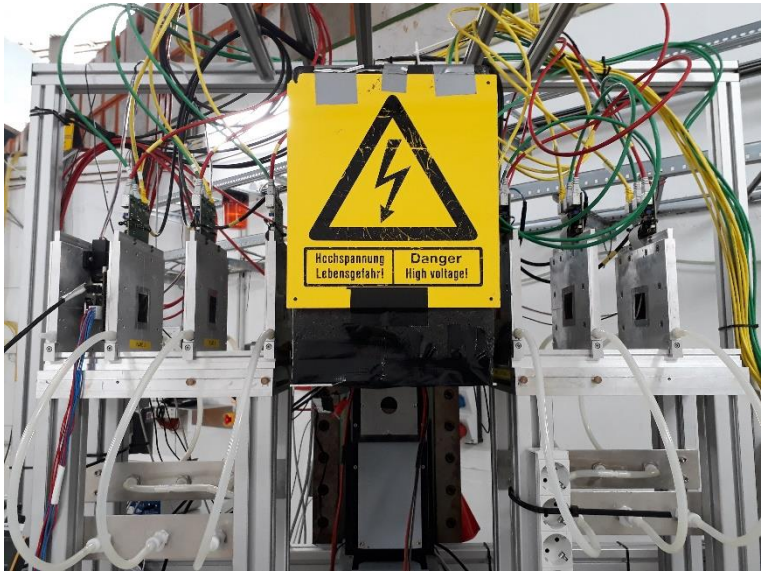
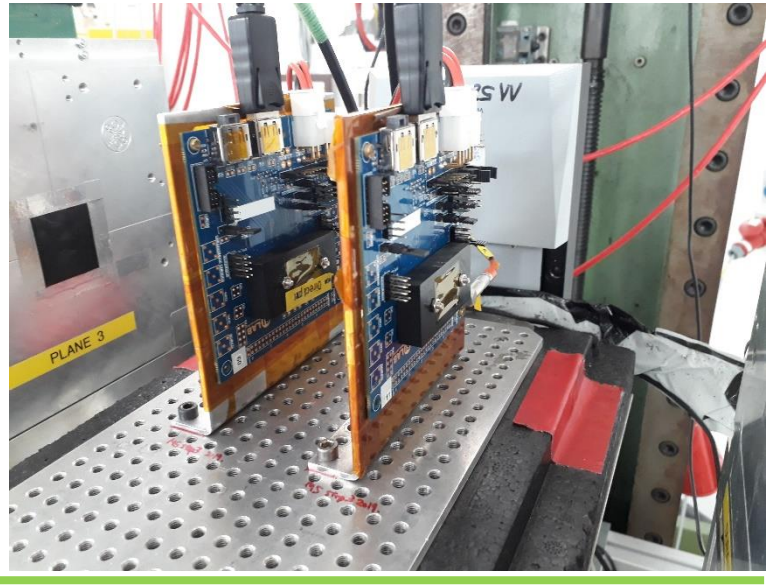
- DESY II Test Beam Facility
  - 5GeV electrons
  - DURANTA telescope
- YARR as readout system
- Different tunings, voltages
- Measurements:
  - 2019: Sep./Oct., Nov./Dec.
  - 2020: March (,May)





Requirements

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- Required efficiency values:

	Bias voltage	Fluence	Hit efficiency
100µm and 150µm thickness	V_{depl} + 50V	unirradiated	>98.5%
100µm thickness	300V 400V	$2x10^{15}$ n_{eq}/cm^2 $5x10^{15}$ n_{eq}/cm^2	>97%
150µm thickness	400V 600V	$2x10^{15}$ n_{eq}/cm^2 $5x10^{15}$ n_{eq}/cm^2	>97%

- No specification for
  - Considered front end
  - Used tuning

Reconstruction/Analysis Team

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- Formed a group for reconstruction and analysis tasks

Tobias Fitschen	Silke Möbius
Ricardo González López	Koji Nakamura
Valerie Hohm	Adam Rennie
Anastasia Kotsokechagia	Katsuya Sato
Maria Mironova	Reem Taibah

- Additional support from the ATLAS ITk Pixel testbeam group
- Reconstruction workshop for EUTelescope (Mareike Wagner, Reem Taibah) during summer
- Reconstruction starts usually during data taking

First Reconstruction Results

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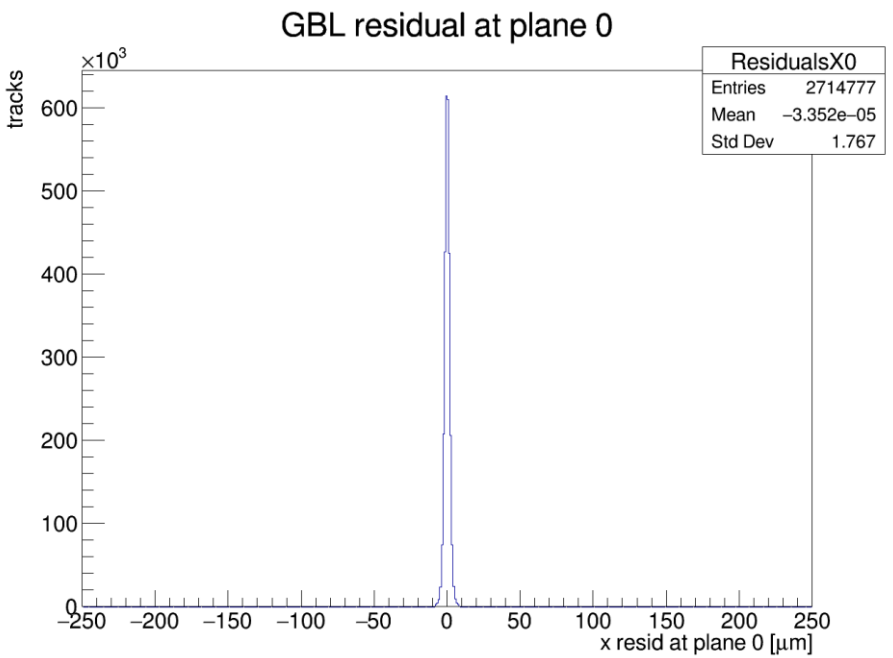
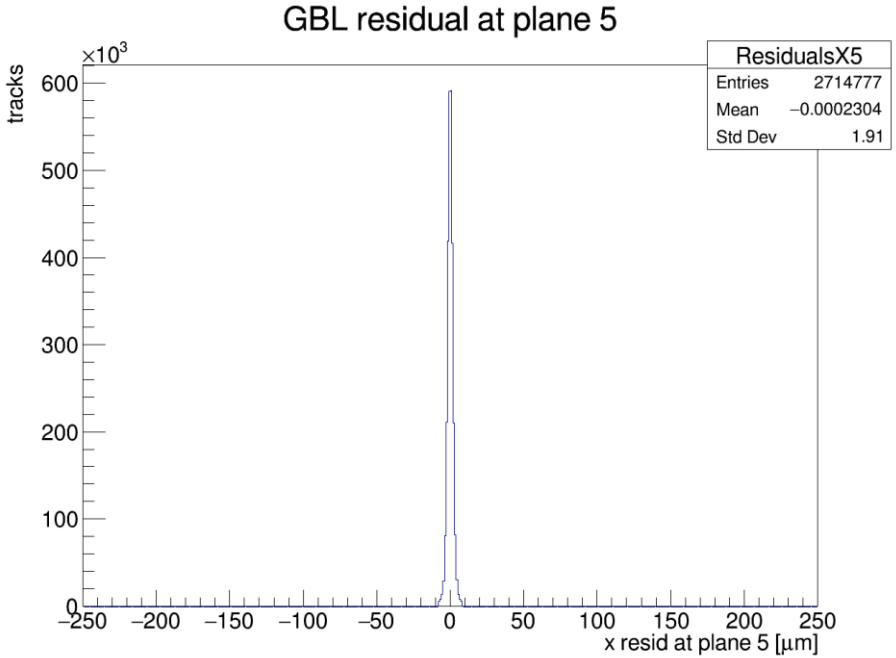
- Reasonable values after reconstruction with EUTelescope (latest version)

- Runs now on HTCondor





First Analysis Results

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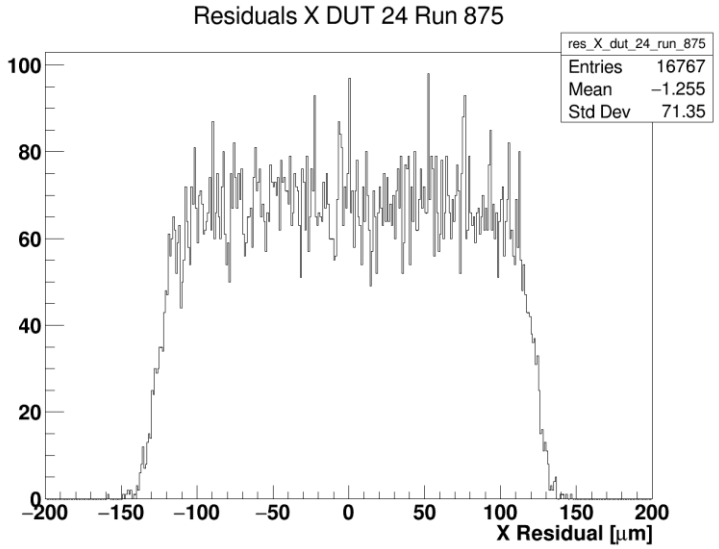
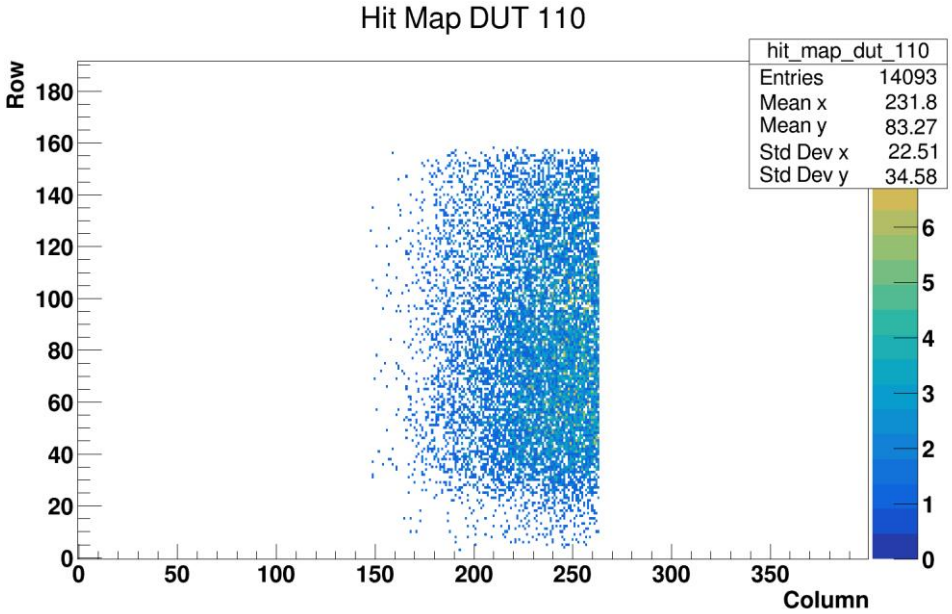
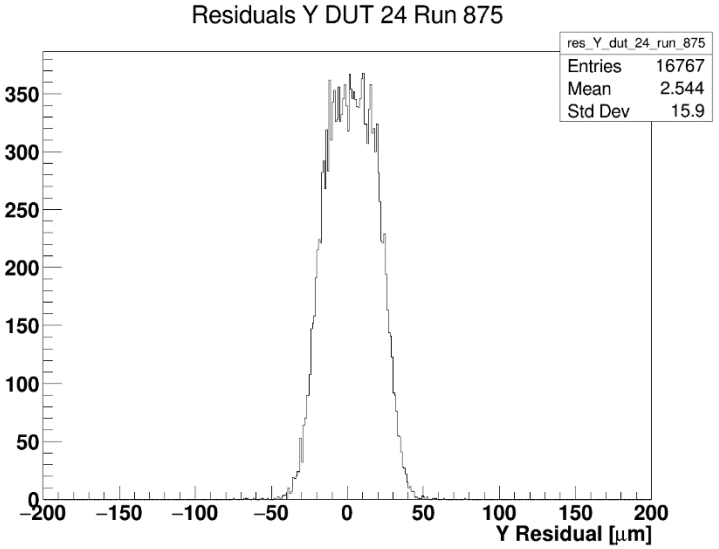
- Nice residuals for the modules
- Enough statistics to evaluate the front ends separately







Summary

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- Successfully started beam tests for the ATLAS ITk planar sensor market survey

- Measurement status:
  - Unirradiated modules: nearly completed
  - Irradiated modules: start at next testbeam campaign (16th to 30th March)

- Reconstruction and analysis status:
  - Reconstruction: well defined “default” values, running on the cluster
  - Analysis: needs to be specified in the next weeks

The measurements leading to these results have been performed at the Test Beam Facility at DESY Hamburg (Germany), a member of the Helmholtz Association (HGF)