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The quality control programme for ITk strip tracker module assembly

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The assembly of the ATLAS Inner Tracker requires the construction of 19,000 silicon strip sensor detector modules in eight different geometries. Modules will be assembled and tested at 31 institutes on four continents, from sensors, readout chips and flexes. In order to adhere to the module specifications defined for sufficient tracking performance, a rigorous programme of quality control and assurance was established to cover components at every stage of assembly. This contribution presents an overview of the QA/QC programme for ITk strip tracker modules, results from the pre-production phase (5% of the production volume) and proposed adjustments for production.

Summary (500 words)

Modules for the future ATLAS strip tracker are assembled in a series of steps which are identical for all modules:
1) reception tests of SMD populated flexes
requiring visual inspection and wire bonding tests
2) assembling readout chips to hybrid flexes using UV cure glue
requiring visual inspection, weighing to determine the amount of used glue and metrology to determine correct positioning and heights
3) electrically connecting readout chips and flexes using wedge bond wirebonding
followed by full electrical characterisation and burn-in
4) reception tests of silicon strip sensors
requiring visual inspection and an electrical test to determine leakage current and breakdown voltage
5) attaching a high voltage connection to the back of the sensor
requiring visual inspection and electrical sensor testing
6) reception tests of powerboard flexes
consisting of visual inspection and full electrical characterisation tests
7) assembly of hybrids and powerboards to sensor using an epoxy glue
requiring visual inspection, weighing to determine glue weight, metrology to determine the sensor bow and to check component positions and height
8) electrically connecting readout chips and sensor strips using wedge bond wirebonding
followed by a full electrical characterisation and tests alternating between warm and cold temperatures

At each step of the assembly process, one or more QC steps are performed to ensure compliance of each assembled component with all mechanical and electrical requirements. Additional quality assurance tests are performed to ensure the sufficient quality of all components to be used for module assembly. 31 institutes worldwide participate in the overall module assembly effort, performing either the full assembly chain or part of it, sharing the effort with other institutes, in which case additional tests are performed as reception tests of each component transported between institutes.

In order to ensure comparability of test results between institutes using different measurement setups and machines, a common set of procedures, documents and database structures was developed. All institutes were checked for adherence to common procedures as part of an overall site qualification process and results were compared throughout pre-production (5% of the overall production volume).

Several issues were identified during pre-production based on the available data:
- high noise of end-cap modules comprising two sensors
- glue build-up on assembly tooling leading to component heights outside of specification
- low inter-strip isolation between sensor strip implants leading to increased noise

For other characteristics, the data available from pre-production was sufficient to relax the requirements for production regarding e.g. positioning and height precision and electrical performance, which was made possible by the availability of data in a common format, uploaded to the common production database.

Prototyping and pre-production of modules were used to exercise the entire QC programme designed to catch potential, still unknown issues, with the goal to re-evaluate their necessity for a robust QC programme during production. We believe this collection of data to be of interest to the particle physics community due to its size and ability to re-evaluate which aspects of QC will be considered necessary going forward.

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