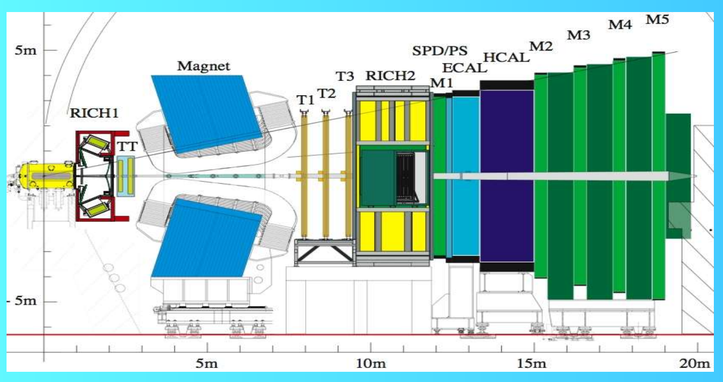
The LHCb Outer Tracker Detector Design & Production

The Outer Tracker group

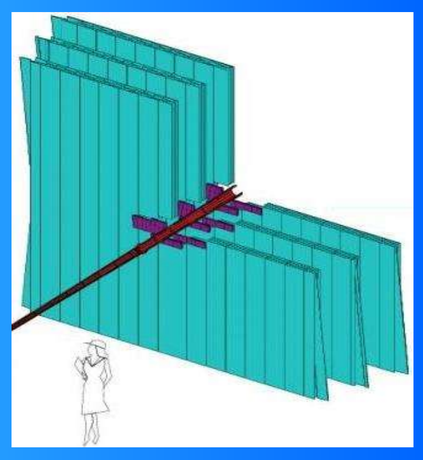


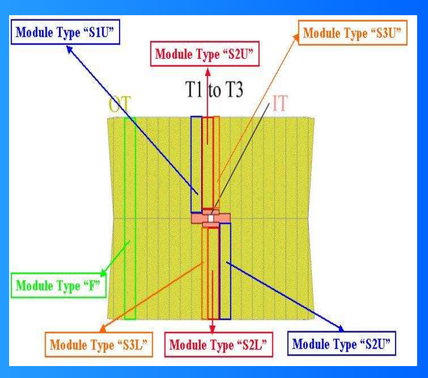
The LHCb Experiment

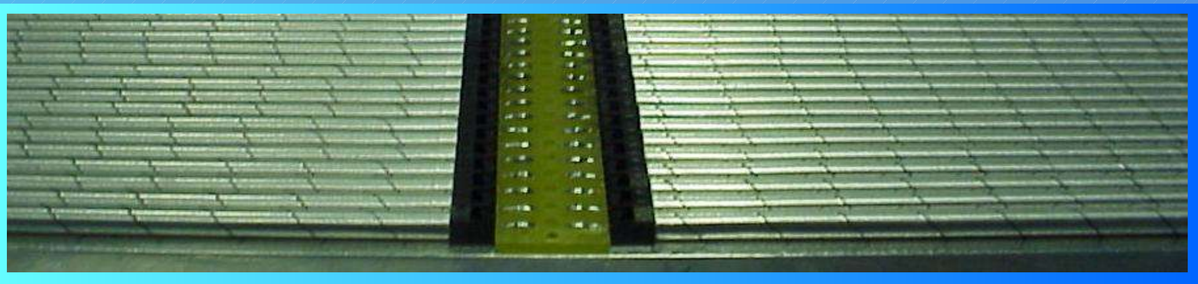
LHCb is an experiment at the CERN LHC dedicated to study CP violation in B decays with high precision. The production of bb pairs at the LHC will be peaked in the forward direction, therefore LHCb is designed as a single-arm spectrometer covering 10-300 mrad in polar angle. LHCb aims at having flexible, efficient and precise bb reconstruction and comprises: the tracking system consisting of a vertex locator and main tracker, the RICH1 and RICH2 particle identification detectors, a muon system and electromagnetic and hadronic calorimeters.

The LHCb Outer tracker

The main tracking volume in LHCb consist of 3 tracker stations installed over 3m length in the field-free region behind a 4 Tm dipole magnet. The particle fluxes are very high near the LHCb beampipe, but fall off rapidly with increasing distance. Therefore the tracker is split in an Inner Tracker consisting of silicon microstrips with fine granularity and an Outer Tracker, covering the greater part of the tracking volume, which is a drift-chamber detector using straw-tube technology. The tracking stations are optimized for momentum measurement: the stations have good spatial resolution in the bending plane and sufficient pattern-recognition capabilities in the non-bending plane of the magnet. Each outer tracker station consists of multiple layers of wires with both vertical orientation and +/- 5 degree stereo angles.



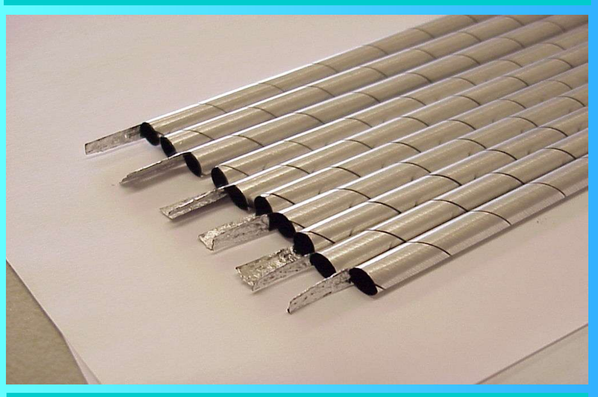




Outer Tracker Module Design

The Outer Tracker layers are built of modules. Each module contains up to 256 straw tubes arranged in two staggered monolayers. Modules are assembled in module halves which are joined together to form a mechanically stable and gas-tight box. A monolayer of straw tubes is glued to a panel using a high-precision jig to accurately define the straw tube position and straightness. The panels are made of a Rohacell core covered with carbon skins. In addition, the inner side has an extra layer of Kapton-aluminium laminate for gas tightness and electrical shielding. Thin carbonfiber sidewalls connect the two panels and stiffen the module. Together with the module sidewalls, the panels provide a secondary gas volume surrounding the straw tubes. By flushing this secondary volume independently the counting gas is preserved from contaminating elements entering the module through diffusion or small leaks.

Straw Tube Technology



Detectors used in an LHC experiment need to be fast given that the time between consecutive bunch crossings is only 25 ns. When accepting a drift-time window of 2 or 3 bunch crossings, the speed demands can be met by using straw tubes with an inner diameter of 5 mm operated with an Ar-CO_2 mixture as drift gas.

A straw tube is wound from two layers of foil material. An inner layer of carbon-doped Kapton (Kapton XC) acts as a cathode for the collection of the positive ions. The outer layer, made of a Kapton XC-aluminium laminate, provides shielding and together with the anode wire forms a transmission line for the effective transport of the high-frequency signals. By application of a crimped contact on both layers of the straw tube walls, a good and reliable interface with the front-end electronics is ensured.

In addition wirelocators inside the straw tubes, both straw tube ends are equipped with endpieces to support and center the wire. All pieces are carefully designed not to obstruct the gas flow. The design is optimized for manufacturing in large quantities through injection moulding.

Outer tracker Module Production

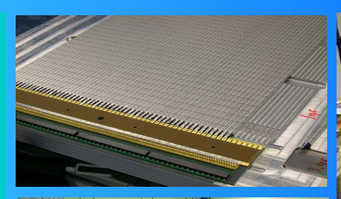
- Cut straw tube to length
- Cut anode contact 'tongue'

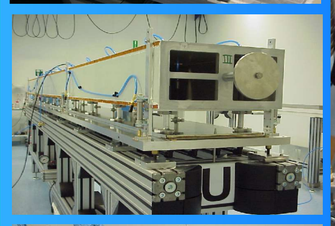
Insert wire locator and end pieces

- Position straw in precision template
- Add support and Feed Through PC boards
- Solder straw ' tongue' cathode contacts to PC Board
- Position panel in a 'panel holding tool'
- Glue the ensemble of straw tubes
- Cure the glue (1-2 day)

- String and solder the anode wire
- Measure wire tension
- Measure dark current foreach channels

- Join two panel together
- Add side strips to finish the module box
- Check gas thightness and dark currents
- Pack to transportation to CERN, Geneva





During the production of half-modules, the following tests are carried out:

- Wire tension measurements. When the wire tension is far off the nominal 70 gr, the wire is replaced.
- Currents in Air under High Voltage.

If a current limit of the order of a few nA is exceeded, the wire is replaced. After module assembly is complete, the following properties are tested:

- Gas-tightness of modules.
- Observation of currents under High Voltage.
- Validation of module channels with radioactive sources.

Module Testing & Quality Assurance

For validation of the production process, the modules produced so far are subjected to a test using a radioactive source. A Sr^{90} source emitting electrons up to about 2.3 MeV is moved along the sense wires in 1 cm steps. For every step the wire currents are measured.

Among other effects, the deviation of the sense wire with respect to the straw tube centre contributes to non-uniformities in the current response to the illumination by the source.

The Sr^{90} scanning setup has proven itself as an essential tool to provide feedback on possible improvements of the module assembly procedures.

Physikalisches Institut Uni. Heidelberg

LHCb OT Collaboration

NIKHEF