**A Scintillating Fibre Tracking Detector for the LHCb Upgrade**

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**Introduction**

The LHCb collaboration has planned a major upgrade of its experiment at the LHC to be installed during the second long shutdown, scheduled for 2018/19. This will enable the detector to readout data at the full 40 MHz bunch crossing frequency. In addition, the upgraded detector will be designed to handle the increased operational luminosity by a factor five compared with the present one. In order to meet these requirements, the current downstream Tracker consisting of two technologies will be replaced by a Scintillating Fibre Tracker, resulting in a homogeneous distributed and reduced material budget. This new tracker with an overall surface of 380 m² has to cope with a very harsh radiation environment.

**Scintillating Fibre Tracker**

The track reconstruction requires that the SciFi Tracker has a high hit efficiency, good spatial resolution and low material budget in the acceptance. To follow the LHCb upgrade strategy, the read-out electronics will operate with 40 MHz sampling frequency. The performance of the track reconstruction shall be kept at required level over the full lifetime of the upgraded LHCb detector. The spatial resolution in the horizontal plane shall be at least 0.05 mm. The detector consists of twelve planes, each 6 x 5 meters large. A plane will be constructed out of modules with a width of 52 cm and height of 5 m with read-out boxes (ROB) mounted on the top and bottom of the module. Modules are vertical oriented with a stereo angle of 0°, -5°, +5°. Fibre Mats are glued on panels of the width of one module and read-out by Silicon Photo-Multipliers (SiPM).

**Fibres**

Scintillating plastic fibres are the active detector elements for the Tracker. The fibres have a circular cross-section and a total diameter of 250 μm, which includes two cladding layers nominally 3% total thickness each. The decay time constant of the scintillation light signal is nominally 2.8 ns according to the manufacturer, with a mean propagation time of 6ns/m along the fibre. The fibres are exposed to a radiation of approximately 35 kGy at the very innermost region and after 50 fb⁻¹.

**Fibre Mats**

The single fibres are arranged in multi-layer mats in order to produce a sufficient light yield at the silicon photomultipliers. The fibres are packed together by winding them on a large wheel in five or six layers. Threads on the wheel guarantee a precise position of the fibres. A thin layer of optically transparent epoxy with white, optically diffusive titanium dioxide is added on top of each layer to bond adjacent fibres and the subsequent layer together. The fibre mats have a width of 13 cm and are 2.5 m long. Prototypes of a winding machine have been developed. They control the speed, tension and the positioning of the fibre on the wheel. Alignment pins are embedded during the process of winding.

**Silicon PM**

The Silicon PM have a fast signal response, short recovery time and shall provide a high photon detection efficiency over a large wavelength range that matches the fibres. The channel width approximately matches the fibre width. Particle tracks will produce a cluster of 1-4 channels and the track position is determined by the centroid of the cluster.

**Front-end Electronics**

The signals from the SiPM will be amplified, shaped and digitized the PACIFIC ASIC, currently under development. The PACIFIC will most likely have the same granularity of 64 channels as the SiPM die. Then, the data is routed to a FPGA that executes the fast clustering algorithm and zero-suppression to reduce the data volume. This data is gathered by a ‘concentrator’ FPGA, formatted and serialized.

**Read-out Box**

The Read-out Box is mounted to the module and attached to the fibre ends, outside of the acceptance. It houses:

- Silicon PMs with its cooling
- Front-end electronics with the corresponding cooling

The ROB has to be light tight and thermally well insulated. The SiPM have to be kept cold at -40°C while the temperature on the outside of the box shall stay above the dew point. The box will be flushed with Nitrogen.