A SciFi production center in NRC KI for LHCb upgrade

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Abstract: The Scintillating Fibre Tracker, SciFi for short, will be the main new tracking detector in LHCb. It will provide better than 100 \(\mu\)m spatial resolution, and high rate capability and radiation hardness enabling a fast, 40 MHz, trigger rate with a capability to withstand 50 fb\(^{-1}\) integrated luminosity, delivered by LHC, without a major performance degradation. The main active element of the tracker is a scintillating fibre ribbon with the SiPM readout. The ribbons consist of 6 layers of the 250 \(\mu\)m scintillating fibres Kuraray SCSF-78MJ, assembled by winding and bound together by the epoxy glue. NRC Kurchatov Institute, Moscow, together with the colleagues from ITEP, CERN, TU of Dortmund and RWTH of Aachen are developing dedicated production centers with the aim to reach by 2016 production rate one ribbon per day per center, necessary to supply more than 1300 fibre ribbons (mats) needed for a new LHCb tracker.

SciFi detector concept and performance

Increased luminosity of the LHC requires a substantial upgrade of the LHCb experiment \cite{1}. One of the first detectors to be completely replaced is the LHCb Outer Tracker (Fig.1). A much higher radiation dose and neutron fluence, which correspond to 50 fb\(^{-1}\) (Fig.2.b) require a new tracker concept. The concept of the scintillating fibre tracking detector is not new, but the SciFi highest resolution and largest area detector with the direct multichannel SiPM readout, providing better than 100 \(\mu\)m spatial resolution over several square meters area, comes from the PEBs experiment tracker proposal \cite{2} by RWTH group. They, together with other

SciFi Tracker design and construction

Figure 6 shows a new modular layout of the SciFi tracker’s one out of three (Fig.1) tracking stations. Each station consists of four layers of SciFi modules mounted on C-frames with two vertical (X) and two stereo (U,V), at \(\pm 5^\circ\) to the vertical, fiber orientations. The modules (Fig.7) have the same design except for two innermost in each layer, and consist of 8 mats readout from one side by four 128-channel SiPMs (Fig.8), directly connected to the end of the mat. Other ends of the fiber mats are equipped with mirrors. The structure is closed by two half-panels which are made from a honeycomb core and single carbon skin by gluing. A readout box with front-end electronics is attached to the top and bottom of each module. It has an insulated cold compartment to keep the SiPMs at 40\(^\circ\)C working temperature during the run.

SciFi modules series production and the quality assurance (QA)

The series production of the SciFi mats requires a clean room and a set of equipment (Fig.10-12) for fibre quality assurance, and mat’s winding, as well as many other technological and QA units which are being developed together by the groups of the SciFi project. The production of the SciFi fibre mats and modules is organized at seven centers (Fig.13) four of which are set up to produce over 1300 mats. The center at NRC Kurchatov Institute is shown in Fig.14,15. The clean zone (Fig.15) is divided in four compartments, for entrance, the QA fibre scanner (Fig.11), winding machine (Fig.12), and assembly. The fibre QA scanner measures the fibre properties (Fig.12), and high frequency and 1 \(\mu\)m accuracy, it monitors the attenuation length and light yield, and detects eventual structural defects such as the bumps, necks and cracks. Its principal scheme is shown in Fig.10. The main part of the production is winding. The mixture of Epotec-301-2 epoxy glue and the TiO\(_2\) powder (20\% by weight) is prepared in the winding compartment and applied 6 times after each fibre layer is completed. The curing process takes 48 hours and 3 precision wheels (Fig.4) are needed to make 1 mat per day to ensure the required production rate per shift. At NRC KI center, work in 2 shifts is foreseen.

Acknowledgements and References

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\textsuperscript{1} CERN LHCC-2014-001 : LHCB TDR 015 , \url{https://cds.cern.ch/record/1647400}

\textsuperscript{3} Th. Kim et al., Production of Scintillating Fiber Modules for high resolution tracking devices TIPP2014, Conference proceedings, Amsterdam, 5th June 2014

\textsuperscript{4} CERN LHCB-PUB-2015-008, LHCB ESR-M-M \url{http://cds.cern.ch/record/2004471}