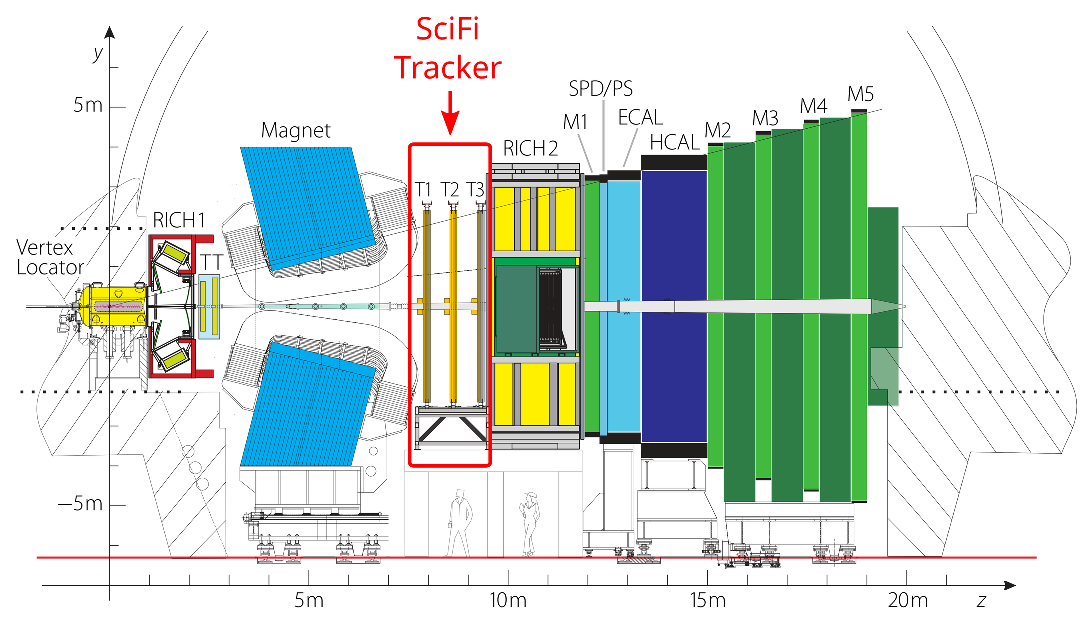
Production and quality assurance of scintillating fibre modules for the LHCb upgrade

Plamen Hopchev, EPFL Lausanne, Switzerland

LHCb upgrage scintillating fibre (SciFi) tracker



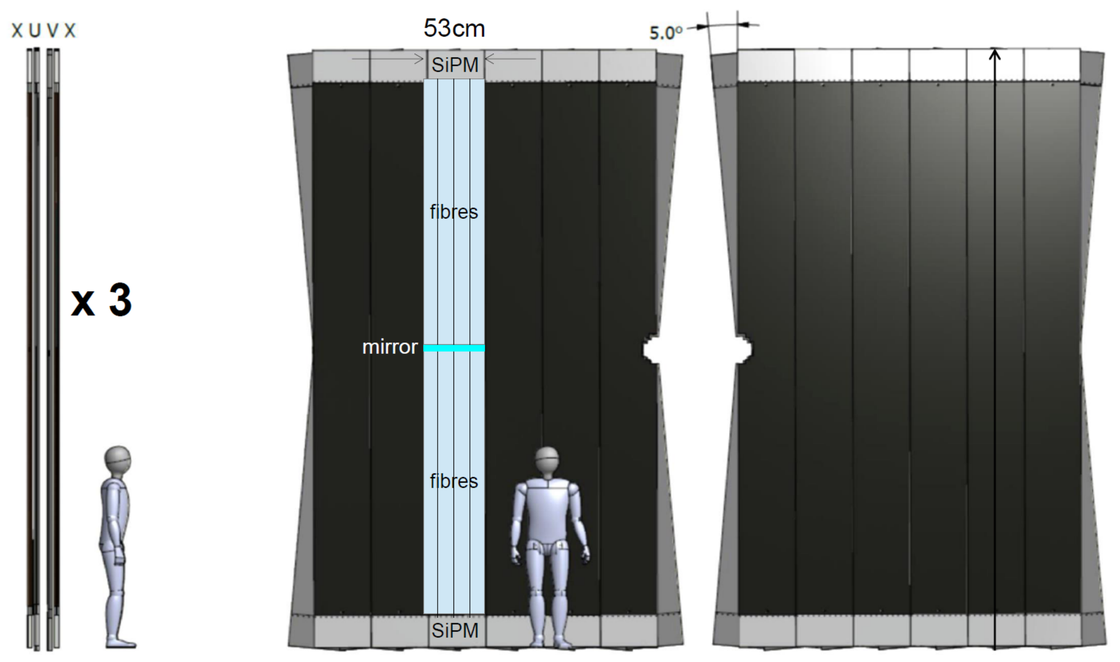
The LHCb detector will be upgraded during the Long Shutdown 2 of the LHC in order to increase significantly the physics reach of the experiment. The detector is redesigned to operate at higher luminosity and will use a trigger-less readout system (40 MHz readout) with superior online event selection efficiency.

One of the major improvements is the addition of a new scintillating fibre tracker. It will replace the current tracking stations which use straw-tube and silicon-strip technology. The scintillation light will propagate along the fibres and will be detected by silicon photomultipliers (SiPM) at the top and at the bottom of the detector. Mirrors will be used at the middle of the detector to increase the detected signal.

The SciFi tracker consists of 3 stations, each composed of 4 detection planes. Varying tilt angle (5° "U" and "V" stereo layers) is used to facilitate the track reconstruction.

Design characteristics:

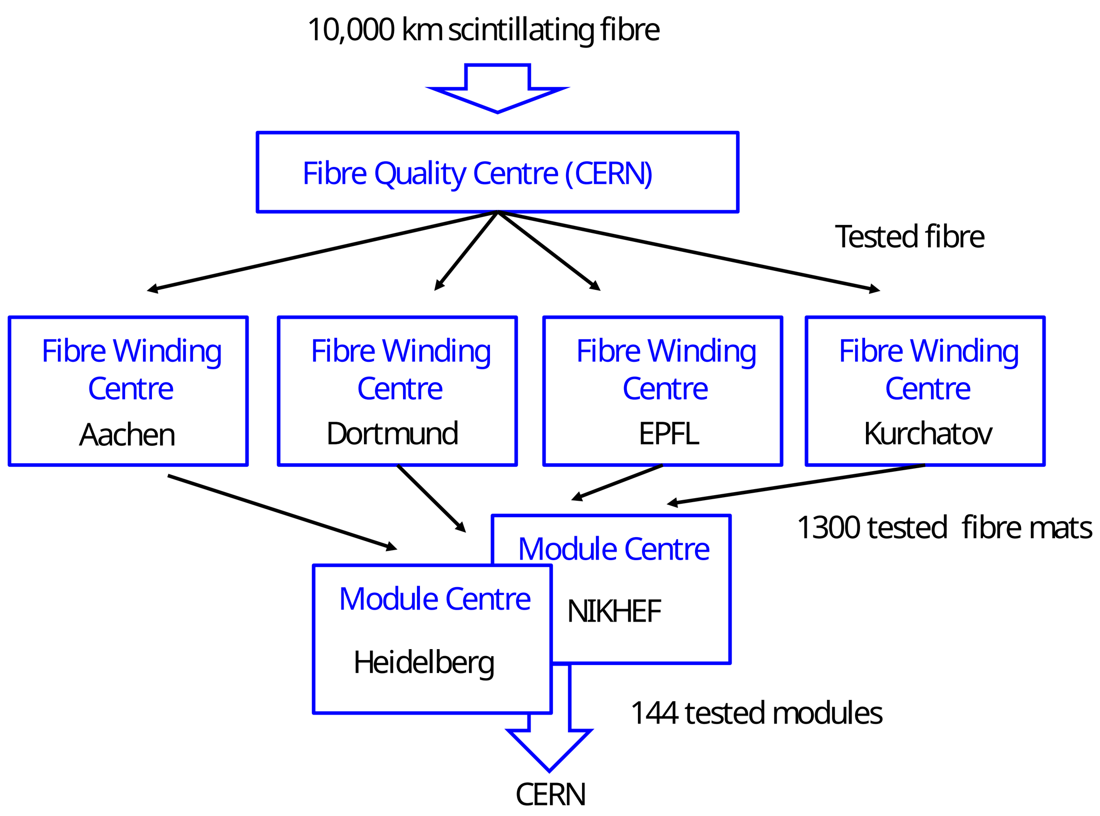
- Hit resolution < 100 μm
- Hit efficiency > 98%
- Radiation length: $x/X_0 < 1$ % per plane
- Noise rate: < 10 % of signal rate
- Operation up to 50 fb^{-1}



SciFi detector:

- 10 000 km of ∅ 250 μm plastic scintillating fibre
- 360 m^2 total active area
- 550 k readout channels

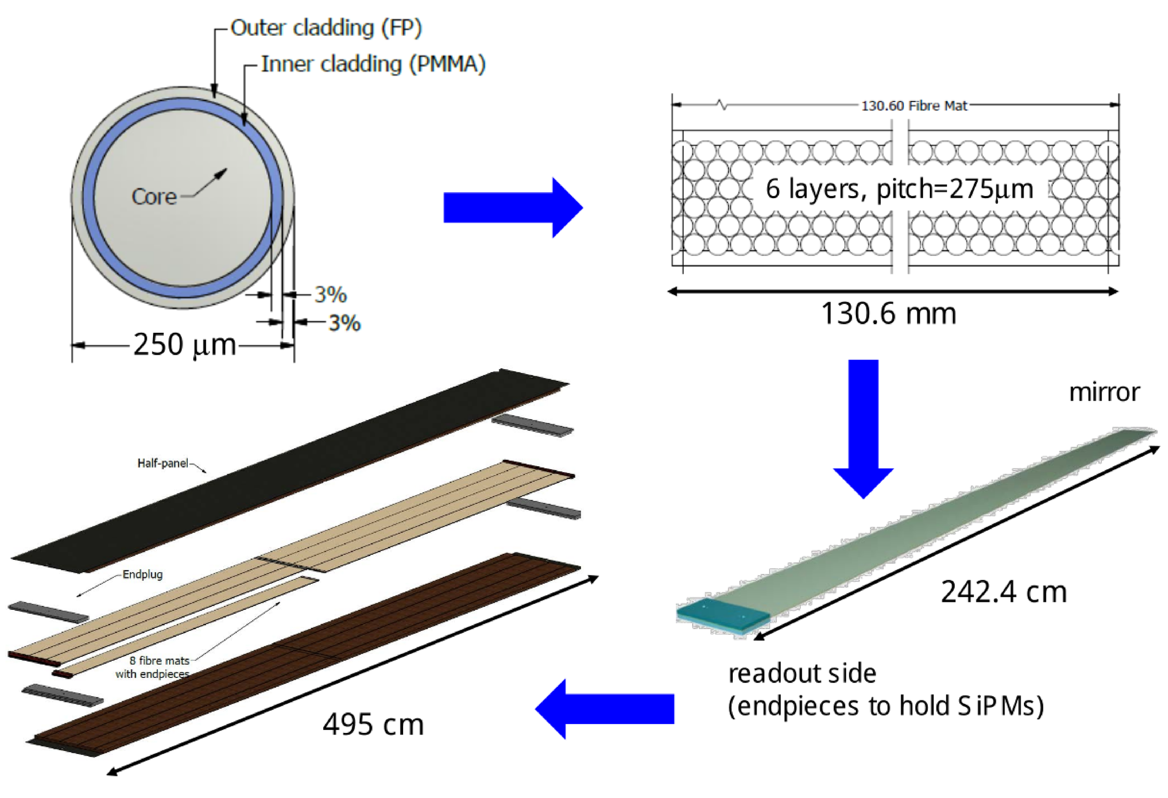
Production organisation



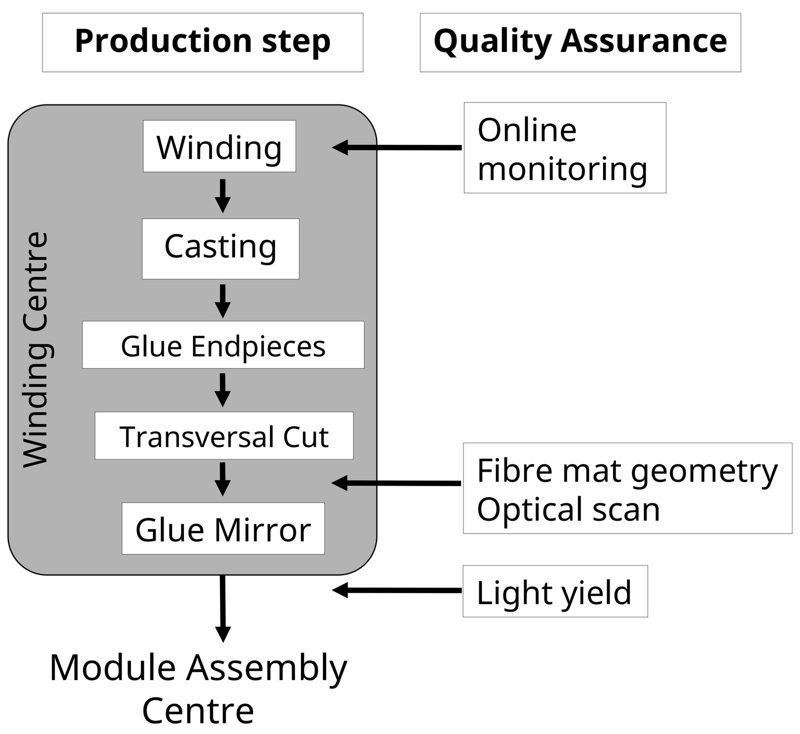
The detector production is performed in several European institutes. The scintillating fibres are delivered from Kuraray (Japan) to CERN where they are qualified and processed (bump removal). The *Winding Centres* lay the fibres into a matrix to produce **SciFi mattresses (mats)**. The finished mats are sent to a *Module Centre* where they are assembled together with the SiPMs, cooling and readout electronics.

The LPHE group of EPFL will produce 20 % of all mats needed for the SciFi detector. In addition, the EPFL group is in charge of the procurement, qualification and testing of the SiPM detectors. More details can be found in following related contributions:

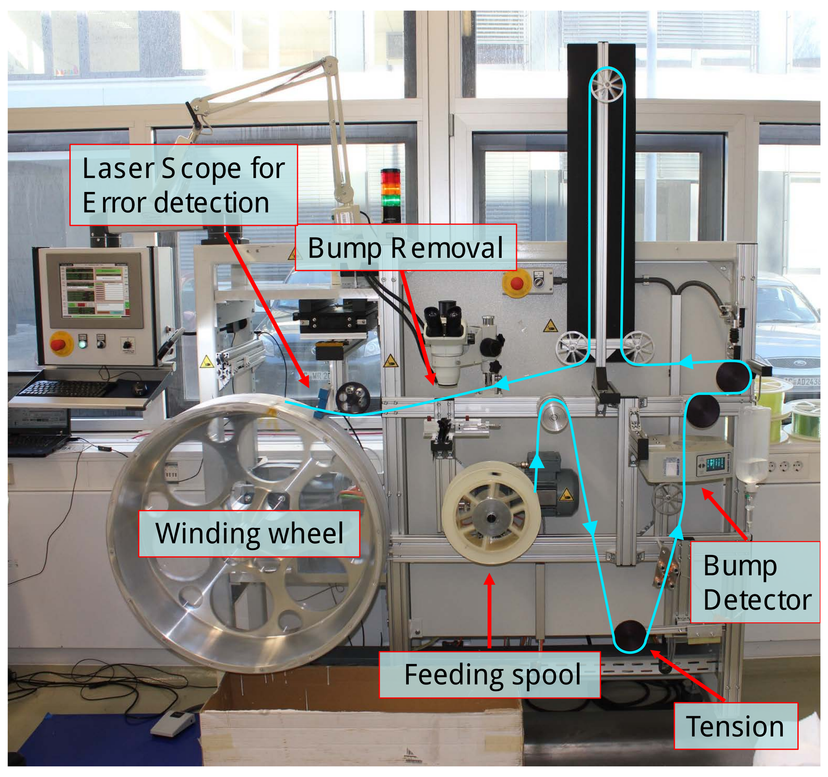
- *"Development of scintillating fibre tracker technology for the next LHCb tracking system and other applications"*, Olivier Girard, Talk 318 (Wed 15:45)
- *"The Scintillating Fibre Tracker for the LHCb Upgrade"*, Axel Kuonen, Poster 367

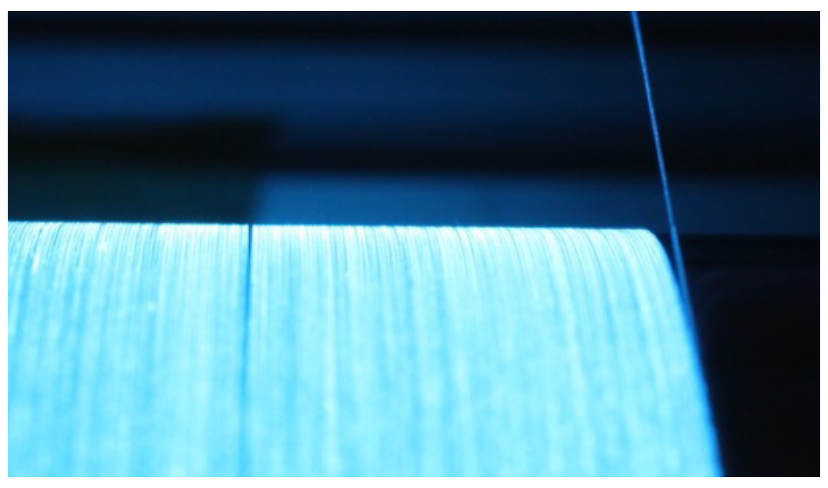


Fibre mat production and quality assurance



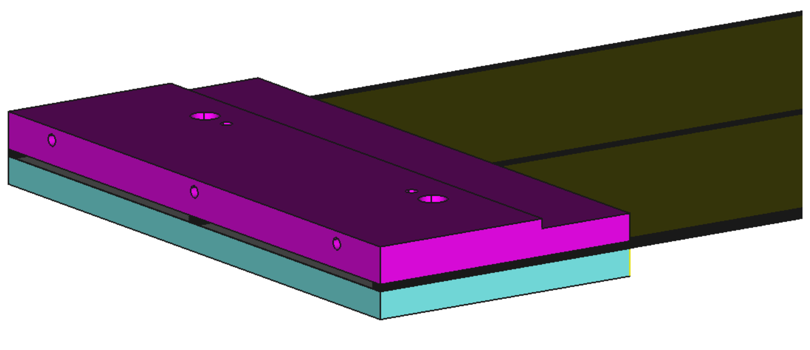
Winding: A winding machine, specifically developed for the SciFi project, is used to lay 6 layers of fibre and glue onto a threaded wheel. PLC-based system provides accurate and realiable control over the speed, tension and the position of the fibre. A video camera and a laser sensor are used to ensure perfect quality of the fibre matrix.



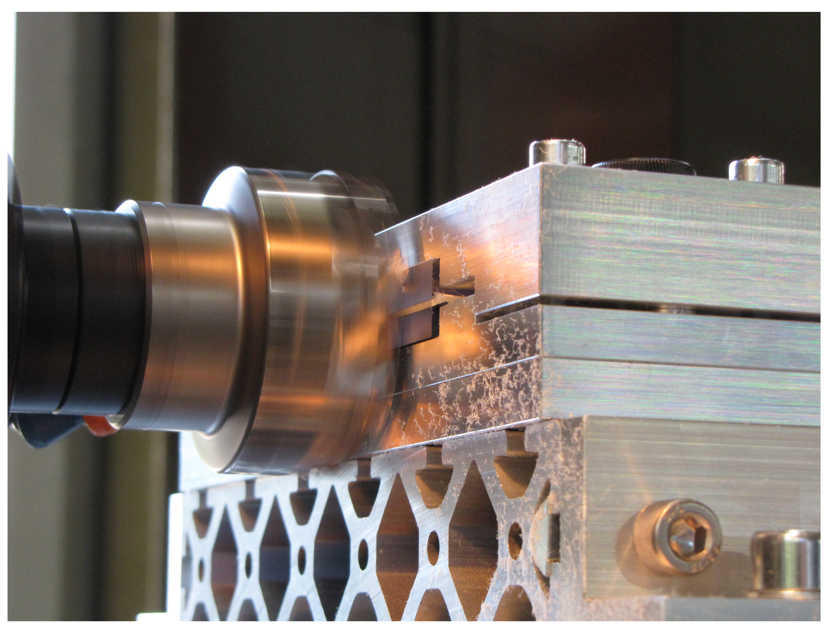


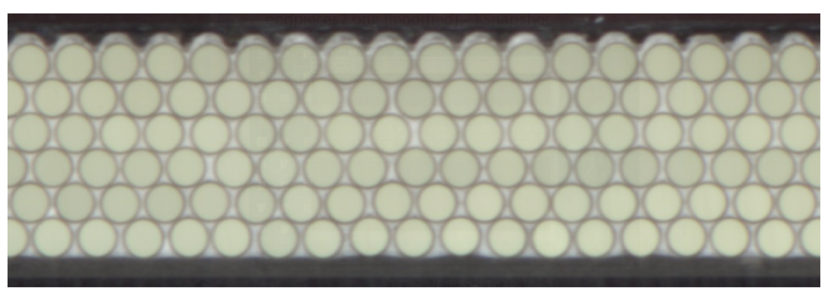
Casting: After the winding and the glue curing, the fibre mat is taken off the wheel. A 25-μm kapton foil is glued on both sides for optical and mechanical protection.

Polycarbonate endpieces glued at the mat extremities provide reference pins for the coupling of the SiPMs and for the mat attachment inside a module.

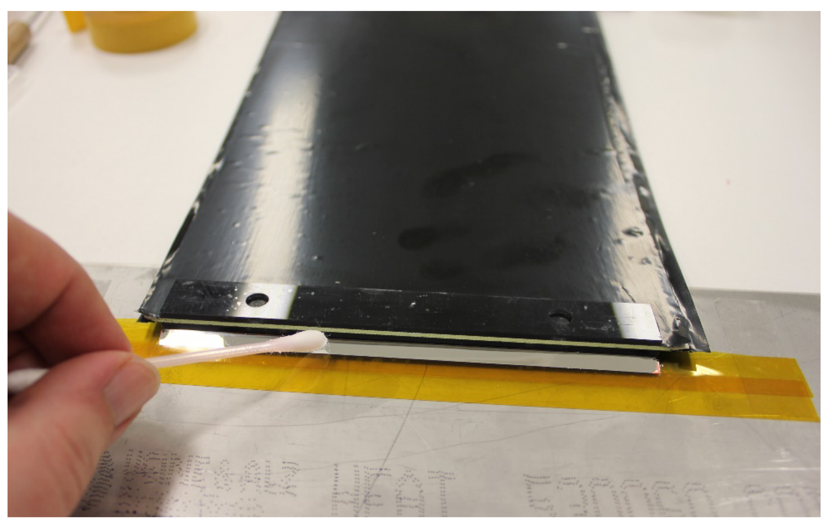


Optical-quality cuts are made on both ends of the mat. A diamond milling tool is used in order to maximize the light transmission through the cut surface.



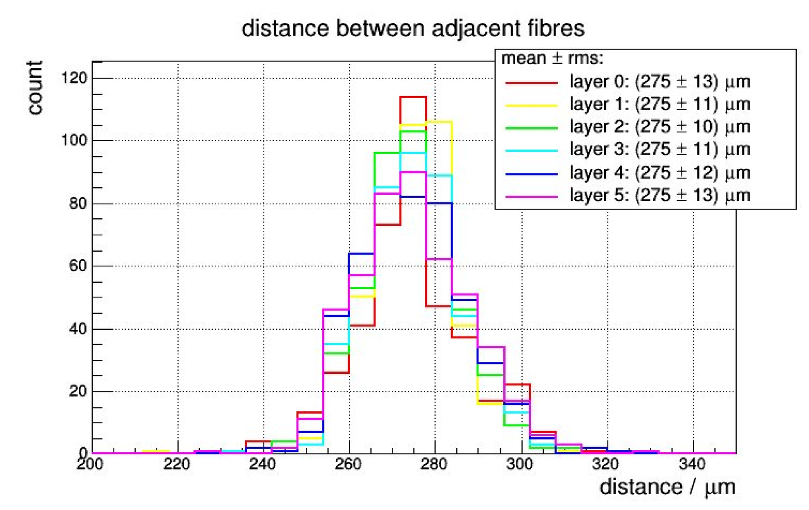


A dielectric mirror foil is glued on the non-readout end of the mat. It provides a significant increase of the signal detected by the SiPM (up to 100 % for particles crossing the mat close to the mirror end).



An optical scan is performed on both ends of the mat, using a high-resolution commercial scanner. The following checks are performed:

- Geometry (fibre pitch, planarity, matching with SiPM)
- Quality of the transverse cut
- Optical transparency of the fibres



The final qualification step is the measurement of the mat response to ionizing particles. Electrons from a ^{90}Sr source are injected through the mat and the **light yield** (LY), i.e. the number of photons reaching the readout end, is measured. Checks performed:

- Detection efficiency across channels
- Mirror gluing (increase of LY & uniformity)
- Attenuation length of the fibres