Measurements of SciFi for LHCb upgrade
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1 Introduction
A new large scale SciFi tracker for LHCb experiment is now under development. The LHCb Tracker upgrade will take place during the LS2. In this project, I performed some measurements with A. B. Cavalcante and C. Joram to evaluate the performance of SciFi.

2 LHCb Tracker upgrade
The LHCb tracker upgrade will take place during the long shutdown 2(2018-2019). The current downstream trackers(T1, T2, T3) will be replaced by scintillating fibre trackers using 250μm diameter fibres and SiPM read-out systems. Fig.1 shows the LHCb detector in its current configuration.

![Figure 1: current LHCb detector](image)

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3 Plastic Scintillating Fibre

The fibre for our measurements is SCSF-78 from Kuraray, with a circular cross-section and a total diameter of 250µm. The fibre has a polystyrene core and two cladding layers (see Fig. 2). The core includes activator to increase light yield and also it includes wavelength-shifting dyes. Energy deposit in the core of the fibre produce an excitation of the polymer and it makes emission of a photon. Then, the fibre transports the optical signal by total internal reflection. This critical angle determines a numerical aperture (NA). The chosen SciFi has NA=0.7.

![Figure 2: plastic scintillating fibre](image)

4 Attenuation length

Attenuation length is an important parameter for the fibre tracker. Since it has wavelength dependence, we need a spectrometer to measure the attenuation length. To connect SciFi and spectrometer we need a clear fibre. However, because the NAs between SciFi, clear fibre and spectrometer are not matched, we lost most of light from SiFi. To solve this problem, we try to put a lens between SciFi and clear fibre. Three tests were performed to establish the optimum way of measuring the spectral attenuation length.

![Figure 3: A setup for intensity measurement](image)
4.1 Setup test

There are two different bases to hold a SciFi and couple it to the clear fibre. We need to make sure whether these setups affect the attenuation length measurement. We measured intensity of light every 50cm from 50cm to 300 cm.

Figure 4: setup1(top) and setup2(bottom)

Since the measured attenuation length was identical, as shown in Fig.5, we can use both setups.

4.2 Optimum position searching

There is an optimum distance between SciFi and the lens where the spectrum reaches maximum intensity. We measured the intensities by changing the position of the SciFi and found that intensity at the optimum position is 2.5 times higher than intensity when the fibre is touching the lens. So we should put SciFi at the optimum position when we measure intensity of light.

Figure 5: Attenuation length
4.3 Test with/without the lens

There are two setups shown in Fig. 7.

- A) with the lens, using base 1 and the fibre at the optimum position
- B) without the lens, using base 2 and fibre is touching the clear fibre

Fig. 7: setup1 with the lens (left) and setup2 without the lens (right)

Fig. 8 shows the intensity ratios with and without the lens. The gain is practically independent of the wavelength and the Intensity is almost 9 times higher when we put the lens.

Fig. 8: Intensity ratio
Fig. 9 shows that the attenuation length looks independent of the lens, at least within the uncertainty of the method. It means we can put a lens when we measure attenuation length. But we need more precise measurement.

![Figure 9: Attenuation length with and without the lens taking two different position intensity.](image)

5 Conclusion

When we want to measure intensity and attenuation length of the SciFi, there is an optimum position where the spectrum reaches maximum intensity. The ratio Intensity with lens and Intensity without lens is almost 9. The measured attenuation length is independent of the lens. So, putting the lens is very effective for our measurements, as it increase the light intensity and reduces the fluctuations. The lens ensures that light under all emission angles from the SciFi can reach the spectrometer.

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