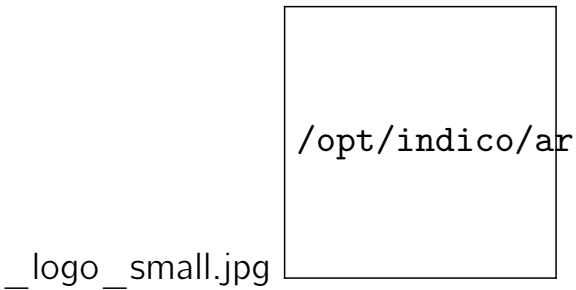

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Scintillating Fibre Detector for the Mu3e Experiment

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Content

Mu3e is a dedicated experiment for the rare lepton flavour violating decay $\mu^+ \to e^+e^-e^+$. Its ultimate goal is to find or exclude this process if it occurs more than once in 10^{16} muon decays. This constitutes four orders of magnitude improvement with respect to the predecessor. A thin multi-layer scintillating fibre detector consisting of 250 μm thick fibres read out on both sides with silicon photomultiplier arrays provides an excellent time measurement with $\sigma < 500$ ps in order to reject combinatorial background at a muon stopping rate around 10^8 muon/s, concurrently minimizing the material budget to $X/X_0 < 0.3\%$. The design, performance and readout concept, including the dedicated readout chip MuTRiG, is presented.

Summary

The Mu3e experiment is a dedicated experiment for the rare lepton flavour violating decay $\mu^+ \to e^+e^-e^+$. This decay can occur in the Standard Model (SM) via neutrino mixing but is heavily suppressed with a BR $< 10^{-54}$. However its BR may be strongly enhanced in many beyond SM models. Any observation would be a clear sign of new physics. The ultimate goal is to find or exclude this process if it occurs more than once in 10^{16} muon decays. This requires a muon stopping rate up to 10^9 muon/s, which is not available today. Phase I of the experiment will exploit the best available low-energy muon source in the world at the Paul Scherrer Institute (PSI, Switzerland) which provides muon rates up to 10^8 Hz. In order to suppress combinatorial background emerging at these rates an excellent time resolution beside a very good vertex and momentum resolution is required.

In the central area of the detector, where a low material budget is crucial in order to minimize momentum resolution degradation due to multiple Coulomb scattering, a very thin multi-layer scintillating fibre detector provides a time measurement of $\sigma < 500$ ps. This sub-detector is accompanied by scintillating tiles at the outer parts of the detector providing a time resolution of $\sigma < 100$ ps.

The thin, < 1 mm, scintillating fibre detector consists of ~ 30 cm long and 250 μm thick fibres, segmented into 12 ribbons. A total efficiency above 95% is required and the total material budget has to be below $X/X_0 < 0.3\%$. The ribbons are read out on both sides by silicon photomultiplier arrays. Dedicated electronics, the MuTRiG chip, able to deal with a single channel signal rate up to 1 MHz is being developed for the experiment. An FPGA based readout chain integrates the sub-detector into the experiments trigger-less TBit/s readout.

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