Development of a Scintillating Fiber Start Detector for HADES

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The proton beam for HADES experiments operates at high intensities ($\sim 10^8$/s) and thus requires a start detector which provides sufficient time resolution and withstands these high count rates. The start detector should be immune to radiation damage and have a high efficiency. To match all these requirements a scintillating fiber prototype detector has been developed.

In order to handle the high count rate the start detector will consist of 96 single channels, which are read out on both sides with multi anode photomultipliers (Hamamatsu H6568, 16fold 4x4 array) (Fig. 1). With a modified base these photomultipliers are capable of handling rates up to 1-2 MHz [1]. This fiber array will be placed close after the last quadrupole magnet where the beam is still defocused to an elliptical area of about 6 x 10 cm^2. This will reduce the average count rate for every single fiber. For each channel three scintillating fibers of 1 mm diameter are stacked in order to increase light output and efficiency. Each scintillating fiber is connected with the photomultiplier tubes by a light guide of the same diameter. By requiring a coincidence between the two ends of one fiber channel the noise level can be reduced considerably.

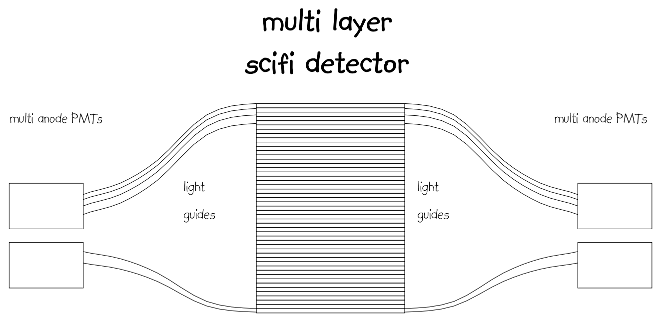

Figure 1: Sketch of the detector arrangement

The fiber material is polystyrene with a PMMA cladding (BICRON BC-10). The fiber core releases about 8000 photons per MeV deposited energy with decay constants of 3.2, 2.7 and 1.5 ns [2]. The light yield was measured with a hybrid photomultiplier in terms of the number of photoelectrons.

Different thechniques have been investigated in order to properly connect the scintillating fibers to the lightguides. The most promissing results have been obtaind by welding the two fiber ends inside a glass tube. Transmission losses of less than 5% have been measured. This way of connecting scintillating fibers with lightguides has the advantage that no other material is needed to hold the two ends. By surrounding the fibers with glue or a plastic connector it is likely that a significant part of the light transported inside the cladding will be lost due to the smaller change in the index of refraction.

The measured light yield was about 7-8 photoelectrons when the fiber was iradiated with a ^{90}Sr source, as expected from simulations with a light transport code [3]. The poor light yield for one fiber and the fact that time resolution depends on photon statistics like

$$\Delta t \sim \frac{1}{\sqrt{N_{ph}}}, \tag{1}$$

justifies the use of three fibers for one channel.

Simulations with LITRANI have shown that the time resolution obtained can be further improved by using fibers with shorter decay times, such as 1.5 ns. To investigate the time resolution of the fibers, fibers with different decay times were irradiated with a ^{90}Sr source and read out on both sides. Both signals were discriminated and the time difference was measured. As shown in Fig. 2 the spectrum has a gaussian like shape with $\sigma_{tot} = 320$ ps (for a decay time $\tau = 1.5$ ns). Thus the width of the spectrum for one side is $\sigma_1 = \frac{\sigma_{tot}}{\sqrt{2}} \approx 230$ ps.

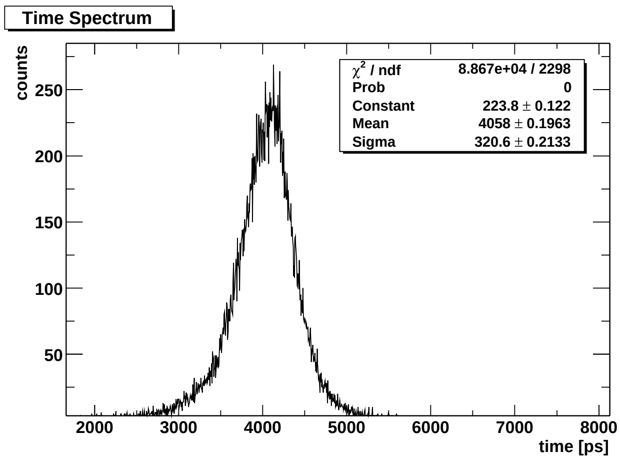

Figure 2: Time spectrum measured with one 1mm scintillating fiber, one end versus the other

As a future option the fiber array can be used for position measurement and tracking if two such arrays, tilted by 90 degrees are used.

References

[1] J. Bisplinghoff et al.: *A Scintillating Fiber Hodoscope for High Rate Applications.* Elsevier Science, 2002.

[2] BCF-10 Product Data Sheet

[3] Francois-X. Gentit: *LITRANI, a general simulation for the propagation of optical photons, http://gentit.home.cern.ch/gentit/*