In the framework of the TOF Wall laser calibration system of the HARP experiment, a study of time dispersion properties of mono-mode and multi-mode optical fibers in the green band (532 nm) has been carried out. Dispersion less than 4 ps/m has been obtained with ≈10 µm core diameter fibers.

In this report a study on the time dispersion properties of different fiber types is presented. In particular, IR mono-mode fibers in the green band has been analyzed: in this range of wavelengths these fibers work as “not-so-many-mode” fibers. The aim of the study is the design of the laser calibration system of the TOF (Time Of Flight) Wall of the PS214-HARP experiment, an hadronic spectrometer running on the T9 beam at the CERN 24 GeV Proton Synchrotron, in which TOF measurements are used for particle identification.

High precision TOF measurements, required by particle identification, need a fast and accurate calibration system (down to 100 ps or less), to keep under control possible drifts in the time response of the detector arising from the different experimental conditions. A suitable solution, for scintillating counters, is to use a short pulsed laser source, in the visible range, to simulate particle interactions in the counters. The light is distributed to the counters by a bundle of optical fibers then, precise timing requires that minimal modification of the pulse leading edge take place during the propagation through the fibers.

Mono-mode fibers provide negligible dispersion at a given wavelength for distances of some kilometers, but they need very accurate injection devices, because of the very limited acceptance angle and core dimensions (few times the optimized light wavelength); moreover, in-fiber division systems are necessary to obtain a multi-fiber bundle. On the other side, multi-mode fibers do

\*The TOF Wall is a (7.2×3) m² wall made of 39 (250 or 180×20×2.5) cm³ plastic scintillator counters (Bicron BC408) read at each end by a Philips XP2020 photomultiplier. With an overall resolution of 160 ps, a 3σ separation between protons and pions can be achieved up to momenta of 3 GeV/c.
not present injection difficulties but, due to modal dispersion up to 30 ps/m, they are useless for precise timing over distances larger than few tenth of centimeters.

We used the second harmonic output of a continuos-wave mode-locked\(^\text{3}\) Nd:VAN laser (Time Bandwidth GE 100-1064 VAN) to provide a 9 ps pulse at 532 nm (green) and we measured the pulse shape with a single photon timing technique\(^b\). The light detector is a single-photon avalanche photodiode (SPAD), which is read with a TAC-ADC system with 1.98 ps/Ch resolution. The setup is outlined in figure 1.

To determine the pulse time response of the whole system, at first we measured the time distribution of the photon in the laser pulse, without optical fiber (obtaining 40 ps FWHM), then we sent the laser pulse through the fiber repeating the measure. We subtracted in quadrature the RMS of the two measurements and divided by the sample lengths. The results are given in table 1.

In conclusion, we find that IR mono-mode fibers used with green light can fulfill timing requirements for particle identification detectors up to several meter distances. In the HARP TOF Wall, we use Corning SMF-28 fibers, obtaining an overall sensitivity of 70 ps in the time response drifts.

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\(^4\)In the low intensity limit the time distribution of the clicks of the detector is proportional to the real probability distribution of the photons in the pulse.