The trend of increasing data traffic in conventional communication systems demands utilizing new methods for data transmission, which in combination with traditional techniques, enable overcoming the predicted capacity limit. Mode division multiplexing (MDM), where higher-order modes (HOMs) in a few-mode fiber (FMF) are used as multiple spatial communication channels, comes in this context as a viable approach to enable the optimization of high-capacity links. From this perspective, it becomes highly necessary to possess a diagnostic tool for the precise modal characterization of FMFs. Among existing approaches for modal content analysis, several methods as S2, C2 in time and frequency domain are available. In this contribution we will present an improved time-domain cross-correlated (C2) imaging technique for the experimental evaluation of modal properties in HOM fibers over a broad range of wavelengths. Our modified setup makes it possible to adjust the time resolution of the system according to the needs of the required fiber measurement. We show that by tuning the spectral shape of the source (SuperK EXTREME filtered by SuperK Select), we enhance the time resolution of the system, which allows us to distinguishing differential time delays between HOMs in the picosecond timescale. Broad wavelength scanning in combination with spectral shaping, allows us to estimate the modal behavior of FMF without prior knowledge of the fiber parameters. We performed our demonstration at wavelengths from 850nm to 1100nm which can be easily extended to other wavelengths of interest just by replacing components with the appropriate coating. The method presented here aims to serve as flexible diagnostic tool that can be implemented in MDM systems for judicious evaluation of modal dispersion in FMFs

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Contributors: Muliar, O., Usuga Castaneda, M. A., Kristensen, T., Alkeskjold, T. T., Rottwitt, K., Lægsgaard, J.
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