Proposal for optical fiber installation at the European XFEL
- Rack-station LWLs -

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Optical fibers will be used widely in the European XFEL for applications including:

- accelerator controls via Ethernet,
- precision timing,
- machine protection system (MPS),
- femtosecond synchronization,
- klystron technical interlocks,
- personnel interlock?,
- high-speed data transfer from the experimental end-station to computing center,
- …

While the number of optical fibers required for the entire system is rather small (~ 2000), and the optical fibers come bundled in fiber optic cables with multiple fibers per cable (6,12,24 72,…), the main problem with the size and cost of the installation arises due to the large number of different end-points (>100). The main purpose of this document is to propose a reduction in the number of fiber optic cables required to supply the European XFEL.
The large number of end-points is caused by the distribution of Ethernet controlled devices and front-ends (e.g. xTCA crates, measurement equipment) along the accelerator beam line. This architecture minimizes electrical cable costs and electrical signal degradation. To reduce the number of fiber optic cables, it is recommended to group Ethernet controlled devices and front-ends within **rack-stations** which are housed in radiation shielded concrete bunkers. A rack-station could be supplied **by a single fiber optic cable with 24 fibers** mounted at a 1HE rack-mountable fiber patch panel. Each fiber optic cable would serve the following purposes:

Purpose	**Ethernet**	**Timing**	**MPS**	**Synchronization**	**Spare**
Fibers	8 total = 6 control net 2 office net	4 total = 2 + 2 spare	4 total = 2 + 2 spare	4 total= 1 + 1 spare 2 diag synch.	4 total

The **rack-station fiber optic cables** must have a common start-point. For timing and synchronization, the ideal start point is in vicinity of the master oscillator (XSIN between optical synchronization hutch and streak camera hutch). The fiber type must match the requirements for all purposes. The **requirements** (incomplete) include

Type of fiber	Single mode
Operation wavelength	1310-1590
Bit rate	> 10 Gbits/sec
PMD	< 0.02 ps/sqrt(km) (or better if available)
Connectors	FC/APC (optical synchronization) FC/PC else (alternatives?)
Maximum length of cable	< 4 km
Environmental conditions	Small and slow temperature changes (<1deg) Small mechanical vibrations and no mechanical stress
Attenuation caused by radiation	<0.2 dB/km/a (averaged value over length)

	to be discussed carefully

Approximate number of rack-station fiber optic cables (to be checked):

Sections	**Rack-stations equipped with LWL**
Linac (Injector till collimator)	~50
Distribution/Undulator/Photon diag	~30
Experimental hall	~20
Spare LWL tubes	~20
Sum	**~120**

Approx. number of required fiber management racks: 3 x 40HE?
Fiber patch panel for 24 fibers: 1 HE

Fiber for the optical synchronization requires dispersion compensation modules. Fibers in the fiber optic cable should have no additional cladding (e.g. PE) and a diameter of 250um to reduce the temperature dependent optical delay coefficient (can vary between 60ps/(km K) and 220 ps/(km K)).

It is recommended to probe radiation induced attenuation of the fiber regularly (e.g every hour) to avoid critical live time reduction.