

Plenary Talk PV I Mon 9:00 RW 1
Femtosecond Technology: From Timing of X-ray Free-Electron Lasers to Attosecond Science and Fusion Lasers —
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X-ray Free-Electron Laser (XFEL) facilities are combined accelerator and ultrafast laser laboratories that have triggered the development of many advanced ultrafast laser technologies. Here, we review the pulsed optical timing and synchronization of large-scale XFELs based on the low jitter of femtosecond lasers. This technology has been commercialized and is used to time ESA’s Deep Space satellite tracking network. Tight synchronization and phase measurement devices have been de-

veloped to generate sub-cycle optical waveforms from power-scalable parametric waveform synthesizers. This system has been used to identify optimized waveforms for efficiently generating isolated attosecond pulses in the water window range of up to 450 eV. Direct waveform measurements and simulations reveal that this enhancement arises from sub-femtosecond shaping of the dominant optical cycle. This shaping maximizes phase-matched single-atom emissions and mitigates plasma-induced dephasing. To power scale such parametric waveform synthesizers and generate high-energy terahertz radiation, we developed highly efficient cryogenic Yb:YLF laser technology. It turns out that this technology can be scaled to hundreds of joules of energy at a repetition rate of 10-20 Hz, making it a potential candidate for inertial confinement fusion lasers.