

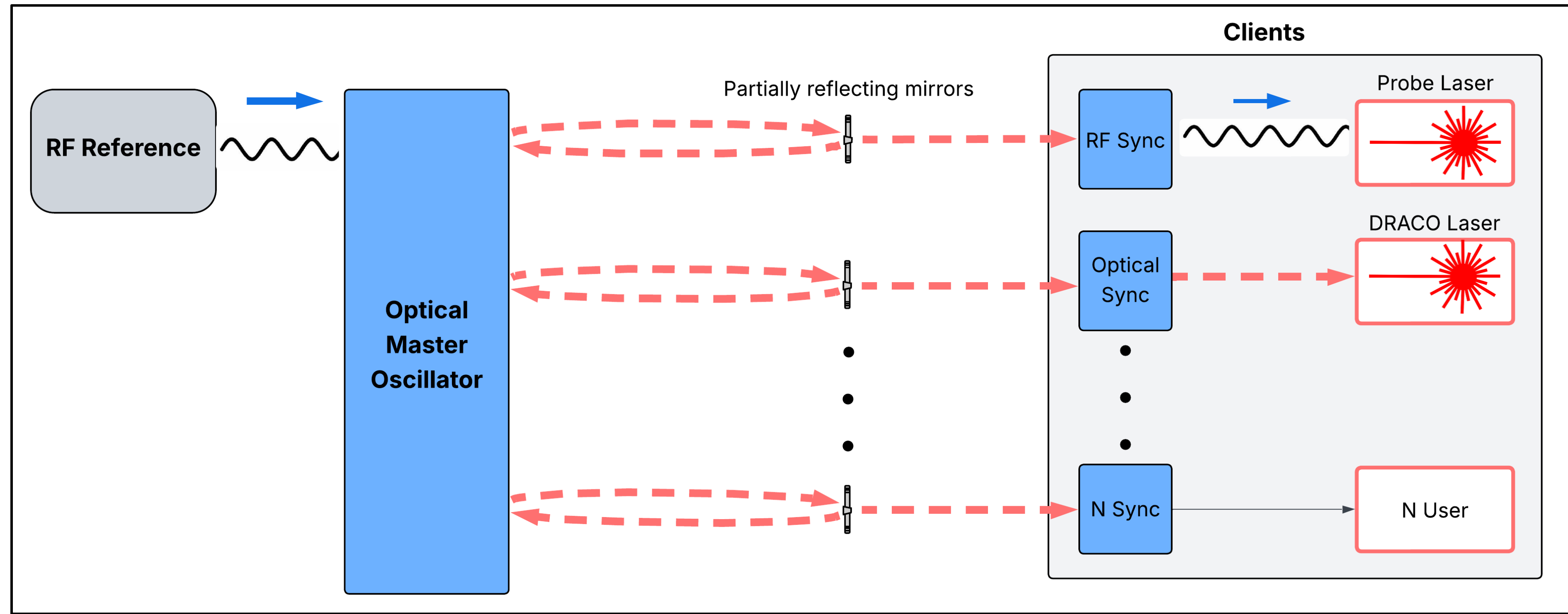
High-power Laser System Synchronization Optimization

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Introduction

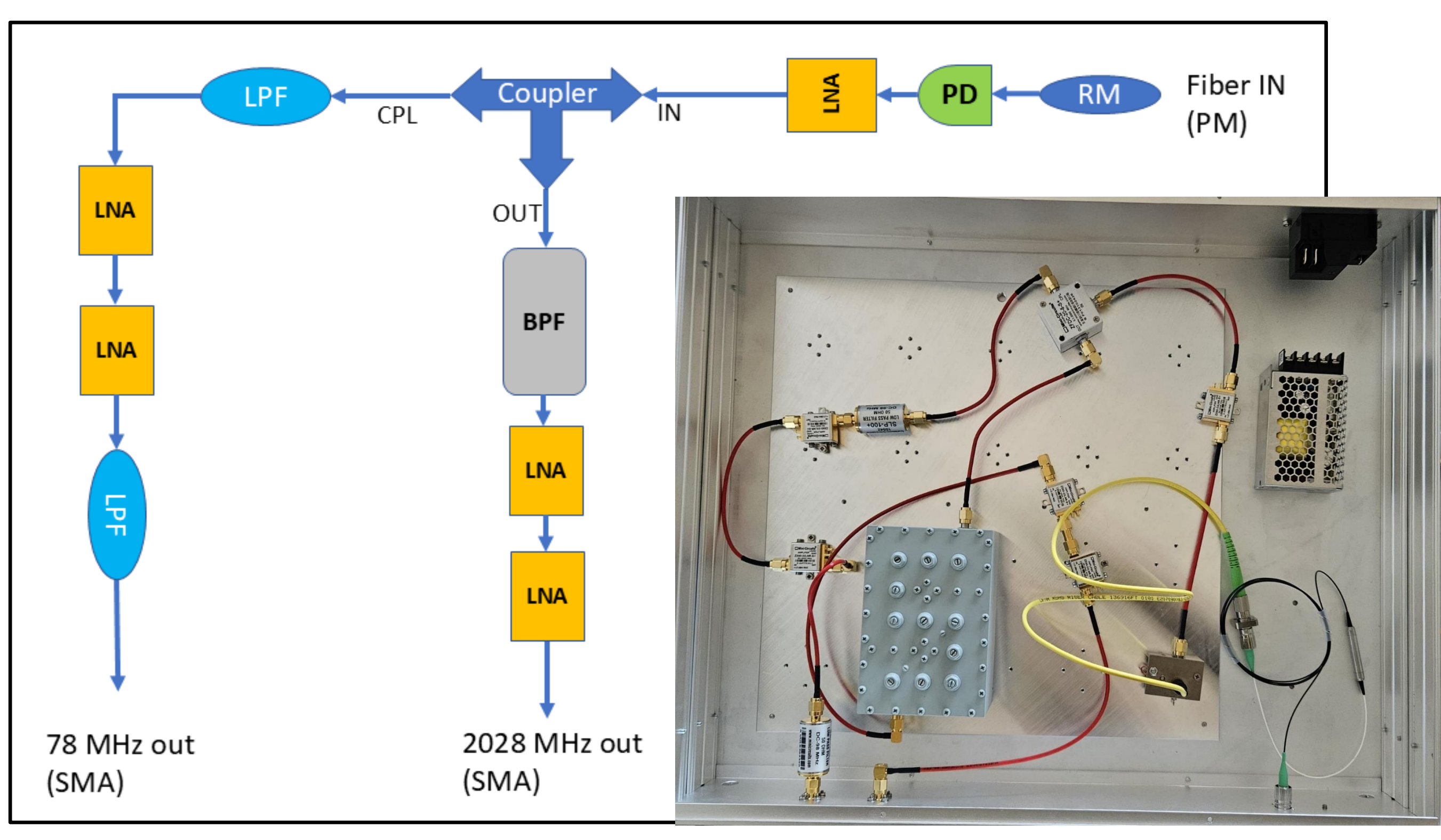
- Synchronization systems ensure precise timing between different radiation sources in scientific research (e.g. material science and medical research)
- Essential for interactions of accelerator generated beams with external systems, such as probe lasers
- Transport the reference signal across the facility
- Lock all user systems to this reference with the lowest residual jitter, ensuring maximum stability
- Goal: synchronization level < 100 fs Rms

ELBE synchronization system overview

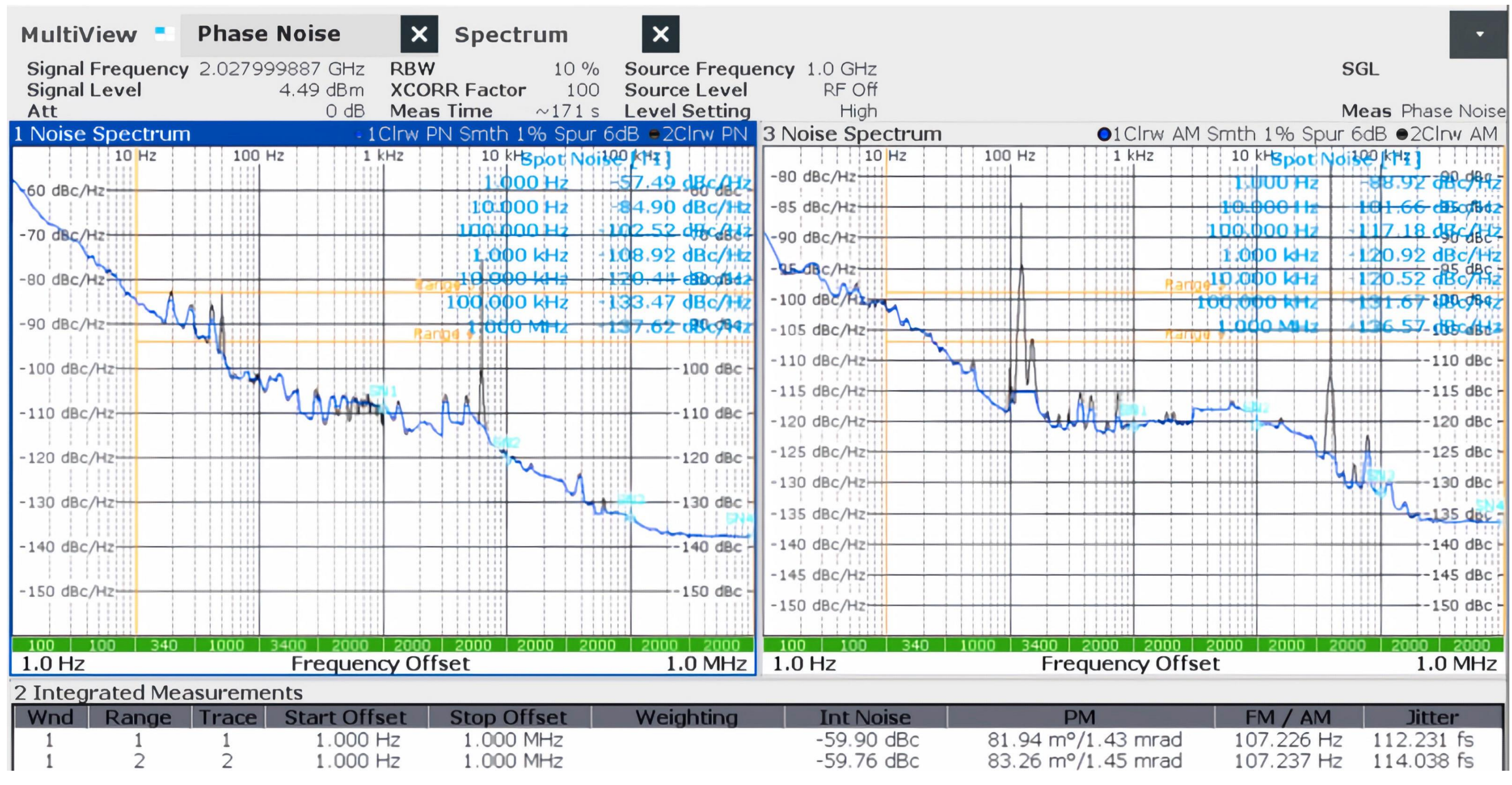


- Mode-locked pulse lasers (Fibre lasers) utilized as the optical master oscillator (OMO)
- The laser is locked to the RF master oscillator 5% of the pulse power in the fiber link is reflected by the reflecting mirror (RM) to enable measurement of the fiber's round-trip time
- Timing difference between the pulses is detected by a balanced optical cross-correlator
- The output from the cross-correlator feeds a PID controller which drives a fast piezo actuator to compensate instabilities

High-Power Laser (Client) Optimization



- The Optical-to-RF receiver Terminates the fiber link coming from the OMO.
- The receiver converts the optical signal into two RF signals, 78 MHz for fundamental lock and 2028 MHz for harmonic lock
- The phase noise jitter for the RF outputs was measured at 225.7 fs Rms for the 78 MHz and 112.2 fs Rms for 2028 MHz (i.e. the noise level of the RF master oscillator)



New Optical Master Oscillator for ELBE

- The currently used OneFive-ORIGAMI laser in the optical master oscillator contributes approximately 7 fs RMS jitter and exhibits reliability limitations
- The new Menhir-1550 (156 MHz) laser achieves < 2 fs timing jitter [1]
- A pulse-picker system was developed utilizing an electro-optical modulator (EOM) to modulate the laser pulses, reducing the repetition rate to 78 MHz to align with the synchronization system requirements
- The original commercial 78 MHz RF driver of EOM introduced noise
- Driver signal solution utilized the RF output of the laser

