Contribution ID: **66** Type: **Poster (including Speed Talk)**

High-power laser system synchronization optimization

Thursday 26 June 2025 11:00 (3 minutes)

High-power laser system synchronization optimization

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Synchronization systems are critical for ensuring precise timing and coordination in various scientific and technological applications, particularly in high-power laser laboratories and particle accelerators. However, the performance of these systems is often hindered by factors such as phase noise and jitter due to the distance or ambient effects. These phenomena introduce instability and inaccuracies in timing signals, necessitating the use of locking electronics and actively timing-stabilized fibre links. At the HZDR accelerator facility (ELBE), we are focused on optimizing the synchronization system, especially between high-power lasers and the accelerator which operate at 78 MHz, to enhance precision and stability. The efforts include the commissioning of a Fibre-to-RF receiver at the end-user (end of the fibre link) and analysing phase and amplitude noise there at the Laser end-user to establish baseline performance metrics. Additionally, examine and optimize the performance of locking electronics to stabilize the laser output, and calibrate the Balanced Optical-Microwave Phase Detector by fine-tuning its electronic components and controllers. Finally, update core timing-stabilized links and fibre laser to a new Menhir 156 MHz laser and introduce a pulse-picker to reduce the repetition rate to the needed 78MHz and develop a system to generate the RF reference signal to drive the pulse picker. These efforts to improve the reliability and efficiency of laser systems, aim to reach synchronization jitter values of less than 100 fs, ensuring they meet the stringent requirements of advanced scientific experiments and industrial applications.

Summary

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Presenter: SALMAN, Mohammed

Session Classification: Beam Diagnostics

Track Classification: Beam diagnostics