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# High Reliability Femtosecond Amplifiers Support Intense Multi-User Research Program at the SwissFEL

## The Challenge

A Free Electron Laser (FEL) is a "big science" device, typically hundreds of meters in length, generating intense femto-second pulses at wavelengths from the microwave region to X-rays. Located at the Paul Scherrer Institute (PSI) in northern Switzerland, the SwissFEL is a FEL specifically optimized to generate X-ray pulses: wavelength range 1 Å to 70 Å. It has been operational since 2016 as a multi-user facility to study ultrafast dynamics in physics, chemistry, and biology. Most experiments are conducted using the pump-probe method with two fs pulses and a variable delay. The SwissFEL team therefore needed fs lasers to use as the pump in conjunction with X-ray probe pulses from the FEL. Key requirements were high pulse energy at a specific (100 Hz) repetition rate, excellent beam quality, and high reliability.

## The Solution

Professor Steven Johnson of SwissFEL explains, "We wanted a pulse energy of 20 millijoules together with high beam quality in order to achieve high pulse energies even after inefficient non-linear conversions, e.g., to generate THz radiation. This means a titanium:sapphire (Ti:S) amplifier. However, most commercial Ti:S amplifiers are optimized for 1 kHz operation and our FEL is set up for a 100 Hz pulse rate, so we wanted the amplifier optimized for this slower rate." In addition, Johnson notes that reliability was particularly important. He states, "We have a dense calendar where we schedule visitors months in advance with a time window of just five days to perform their experiments. The amplifier must deliver perfect 24 hour performance for each and every user. Unscheduled downtime is simply not an option. So we wanted the performance of a custom laser but with the reliability of a mature commercial laser source." PSI had previous experience of the reliability of Coherent ultrafast lasers and the decision was made to acquire two modified Legend Elite amplifiers delivering 20 mJ at 100 Hz, with redundancy to eliminate possible downtime due to maintenance, etc.

## The Result

Johnson states the reliability of these amplifiers has more than exceeded expectations. He cites the plethora of diverse published papers based on work at the SwissFEL as evidence to support this statement. These range from transient studies of proteins by biologists, to his own research investigating fast polarization in materials that could lead eventual-ly to faster electronic devices. However, the ultimate validation is arguably the order that Swiss FEL placed (in 2020) for a third Ti:sapphire amplifier from Coherent.

*"The amplifier must deliver perfect 24 hour performance for each and every user."*

—— Professor Steven Johnson, Group Leader, SwissFEL, PSI, Switzerland