# Disk laser delivering 50 mJ with 400 ns latency

**Karsten Schuhmann[1], Aldo Antognini[2,5], Adolf Giesen[3], Thomas Graf[4], Tobias Nebel[5], Randolf Pohl[5]**

*1. Dausinger + Giesen GmbH, Rotebühlstraße 87, 70178 Stuttgart, Germany*
*2. ETH Zürich, Institut für Teilchenphysik (IPP), Schafmattstr. 20, 8093 Zürich, Switzerland*
*3. Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Technische Physik, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany*
*4. Institut für Strahlwerkzeuge, Pfaffenwaldring 43, 70569 Stuttgart, Germany*
*5. Max-Planck-Institut für Quantenoptik (MPQ), 85748 Garching, Germany*

A thin disk laser has been developed which is capable to run at stochastical trigger with an extremly **short latency (400 ns)** between the electronic trigger and the optical output pulse. The Yb:YAG laser made from a Q-switched oscillator and a multi-pass amplifier delivers pulses up to **50 mJ** at **1030 nm** ($M^2$=1.3), independently of the pulse to pulse delay (1.2 ms to infinity). Yb:YAG exhibits a long lifetime (~ 1 ms) of the excited states, and the disk-laser design provides efficient cooling needed for cw-pumping [1,2].

The laser was dedicated to the measurement of the muonic Lamb shift (2S-2P energy difference) at PSI Switzerland [3]. From this measurement, a proton radius of 0.84184(67) fm was extracted, in discrepancy with previous measurements using different methods. The laser concept had to consider that the muonic hydrogen atoms are formed stochastically and that the lifetime of the 2S states is only 1 µs.

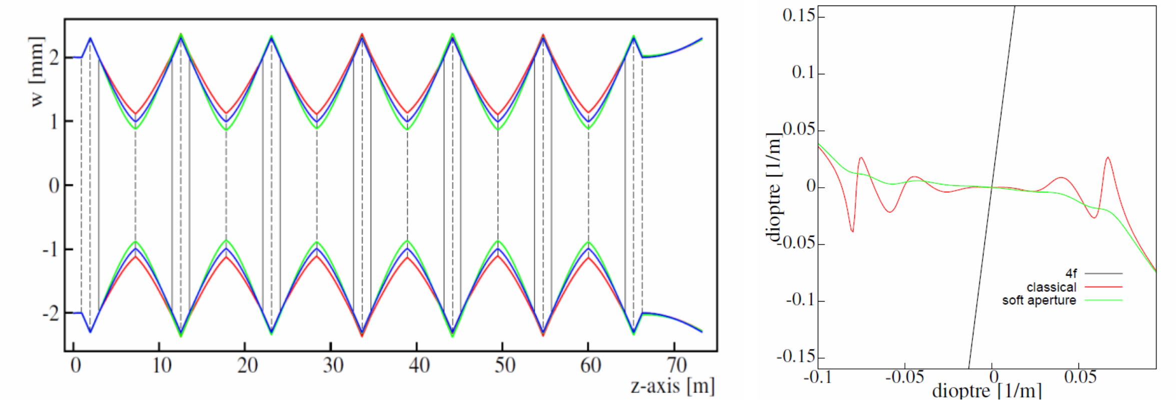


**Fig. 1** Gaussian beam propagation Left: Classical propagation in our optical system. Three different thermal lenses are plotted. Right: OPD of the beam leaving the amplifier in dependency of the OPD of a single reflection on the same disk. For the green line the soft aperture formed by the disk gain has been included into calculation.

The oscillator is an EOM controlled cavity dumped Q-switched laser operated in prelasing mode. Starting pulse buildup at $10^{11}$ photons vastly reduces latency. The unstable behavior of the oscillator near the laser threshold is stabilised by a fast regulation of the output coupling.

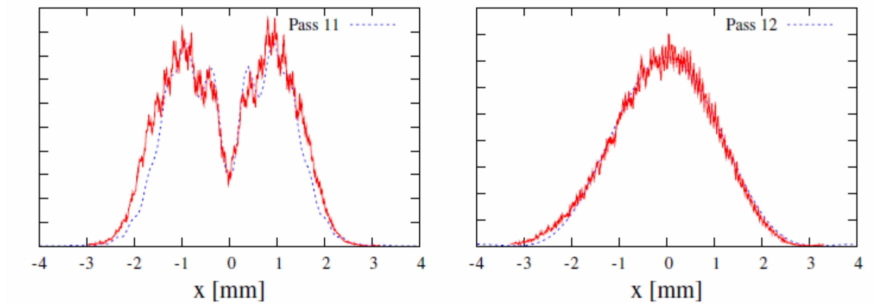


**Fig. 2** Collins propagation (dotted lines) and measured (solid lines) intensity profiles for 11th and 12th pass at the disk.

The amplifier was designed to be insensitive to thermal lens effects. It is a concatenation of resonator-like segments, using the dynamical stable side as input and output [4]. The output profile of this scheme shows a smaller dependency on thermal lensing compared to the generally used 4-f design (Fig.1, Right). The aspherical lens effects of the disk produces higher-order components, leading to alternating beam profiles (Fig.2). Numerical Collins propagation (using the measured disk OPD) reproduces the measured beam profiles.

## References

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