

WP5 Thin-disk Multi-pass Booster

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Work Package 5 Overview

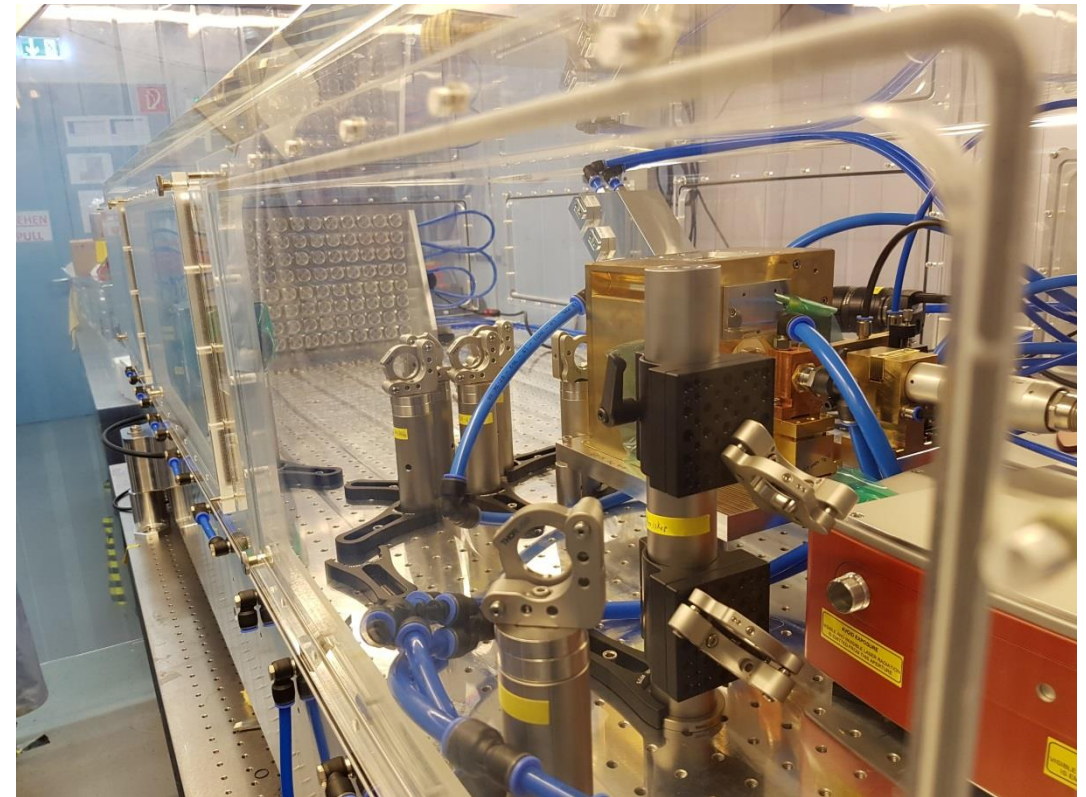
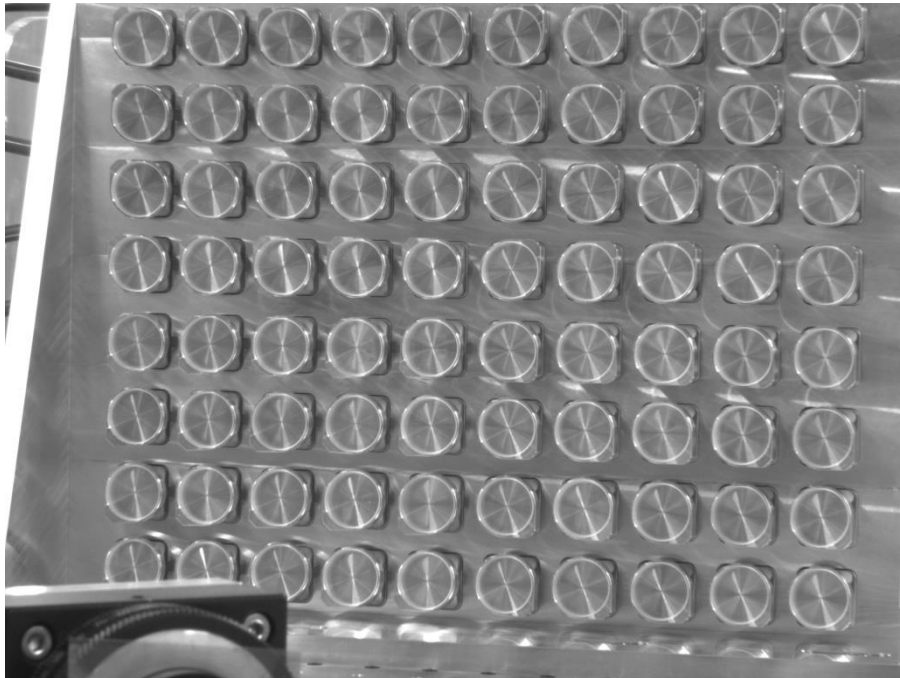
- Main objective: Building multipass amplifier with Seed Source from AMP
 - Task 5.1 Design of the thin-disk multipass amplifier (USTUTT, Due M06)
 - Task 5.2 Amplifier with 500 W, 1 MHz, sub-500 fs (USTUTT, AMP, Due M22)
 - Task 5.3 Second and third harmonic generation (USTUTT, AMP, DUE M28)
 - Task 5.4 Integration of Yb amplifier (AMP, USTUTT, Due M28)
 - Task 5.5 Demonstration of a 1 kW, sub-1ps laser system (USTUTT, AMP, M38)

WP5 – Task 5.1: Design of the multipass amplifier (Due M6, finished)

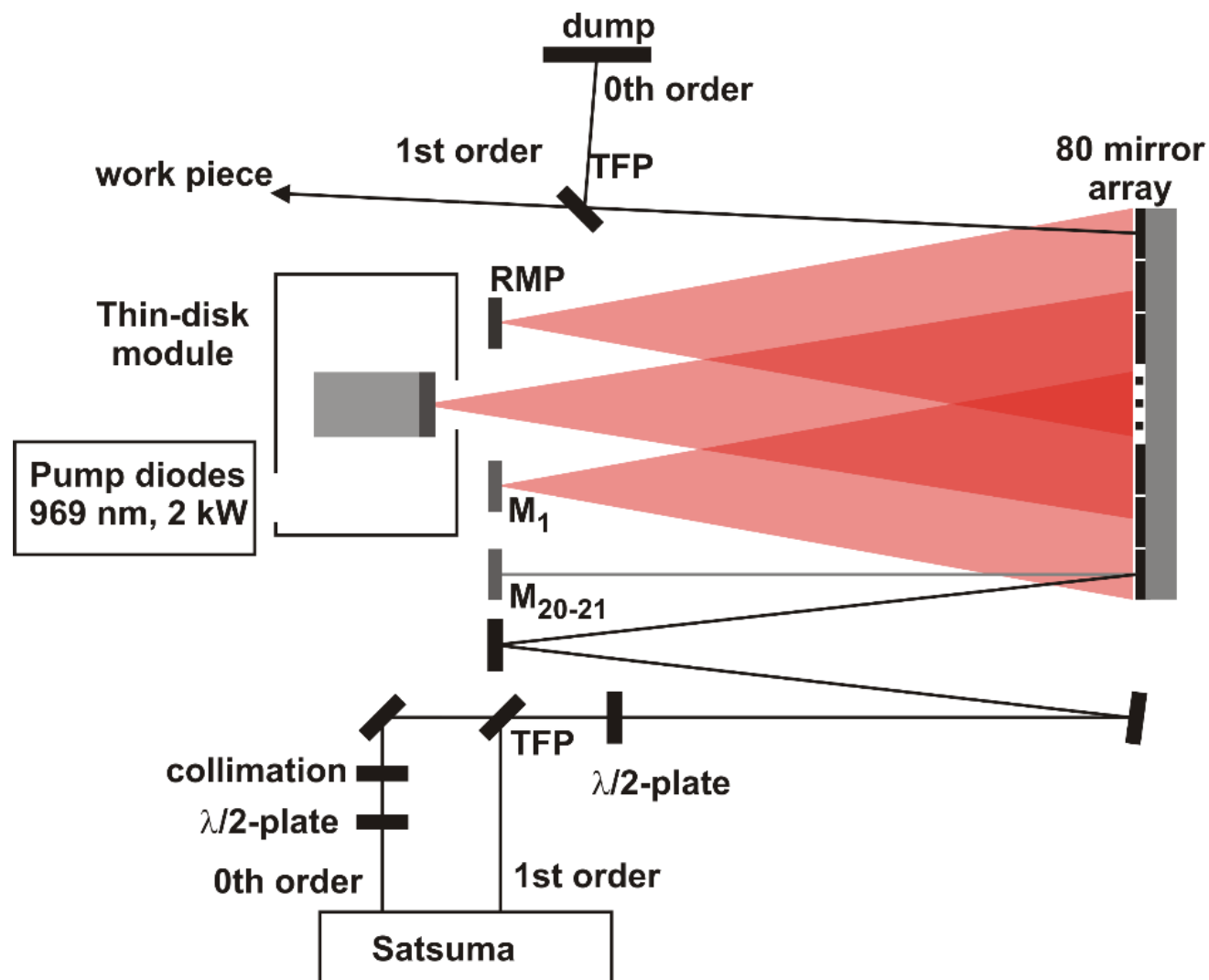
- *System designed*
- *80 mirror array, 40 reflections on disk using single pass through the amplifier → for pulse picking*
- *Components designed, high mechanical stability*
- *Propagation through amplifier simulated*

WP5 – Task 5.2: Assembly and characterization of a Yb:YAG thin-disk multipass amplifier (USTUTT, AMP, Due M22)

- All optical and mechanical parts designed in Task 5.1 ordered, delivered and assembled

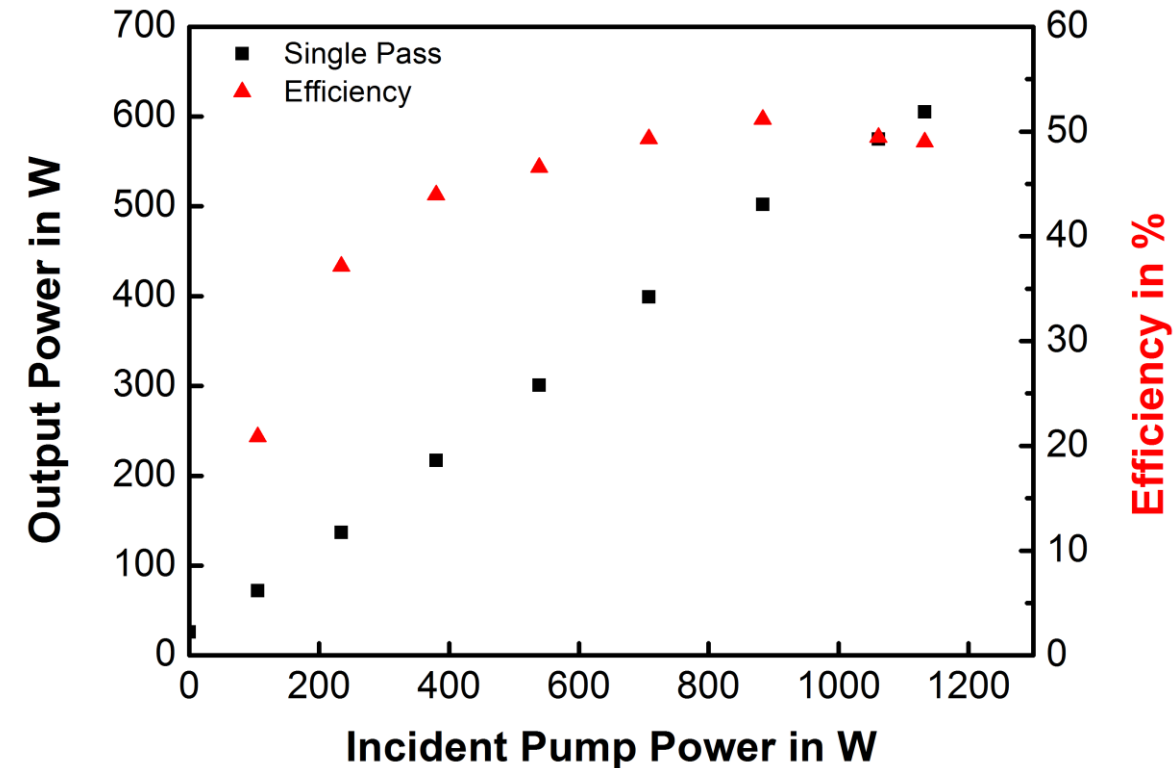


Setup



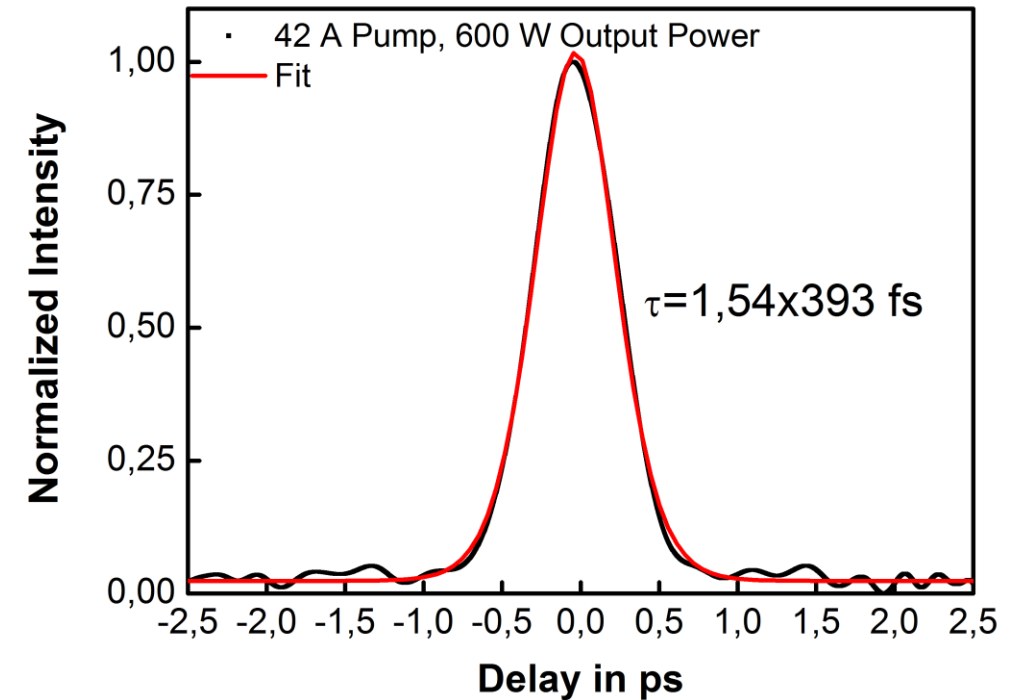
Results – Single pass

- Here: no modulation, 0th order dumped at exit of seed
- 50 W Seed Power, 330 fs pulses, 1280 kHz
- Measured output power in single-pass: 605 W (deliverable: 500 W)
- Maximum pulse energy (1280 kHz): 473 μJ
- No picking implemented in this measurement



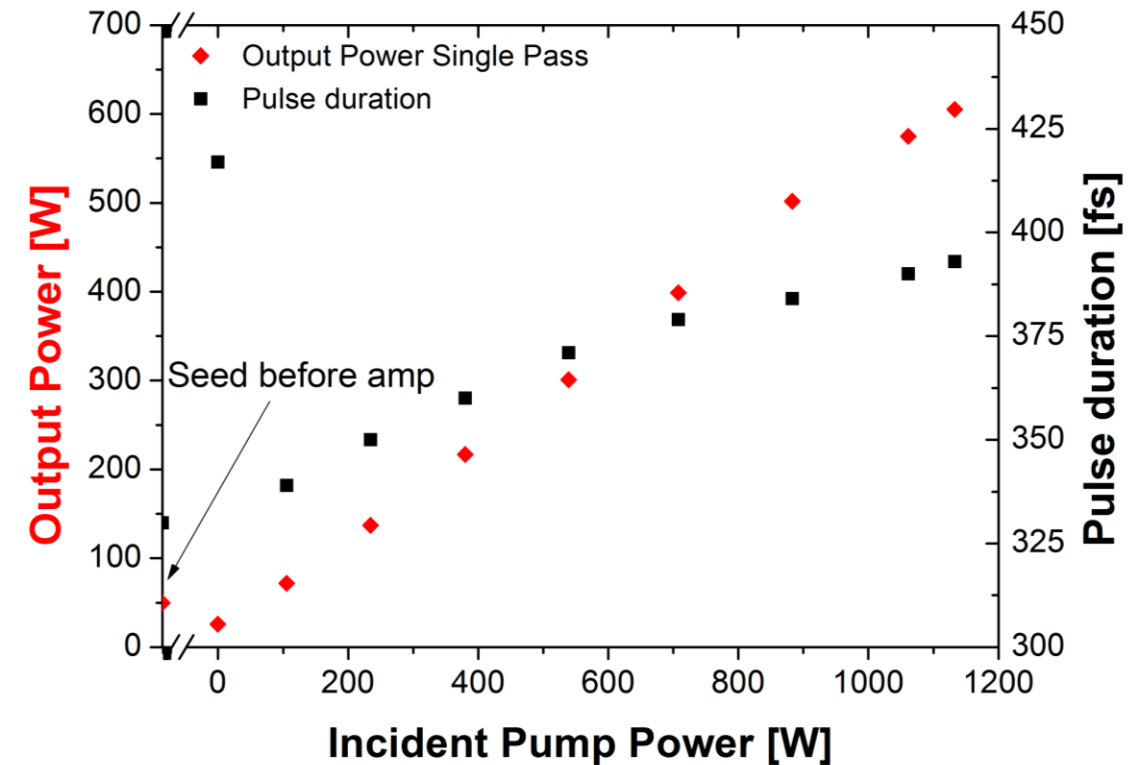
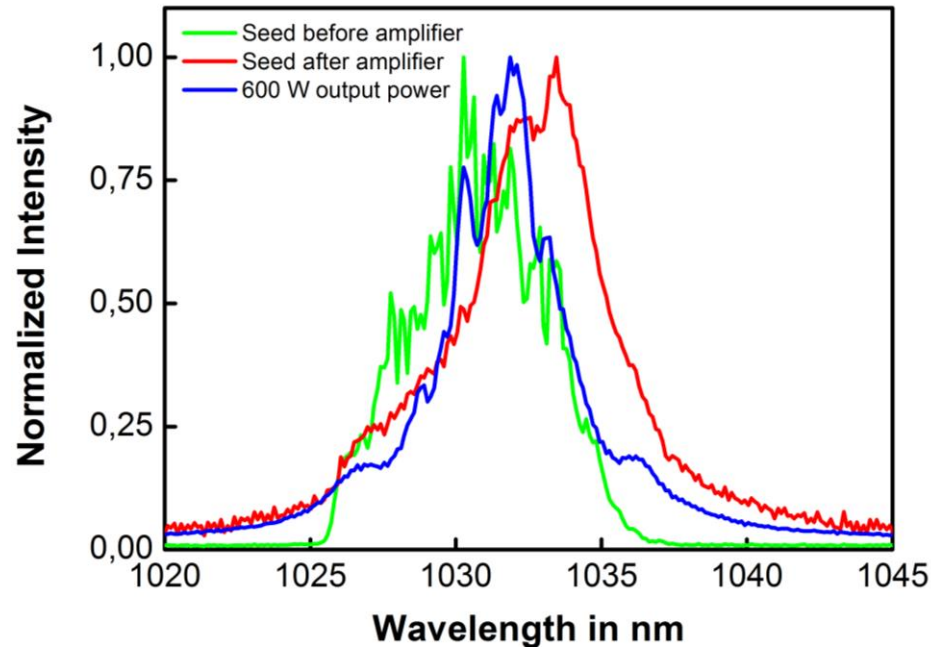
Results – Single pass

- 330 fs pulse duration of seed laser
- Measured pulse duration at 600 W power: 393 fs
- Peak Power: 1.1 GW
- $M^2 < 1.3$



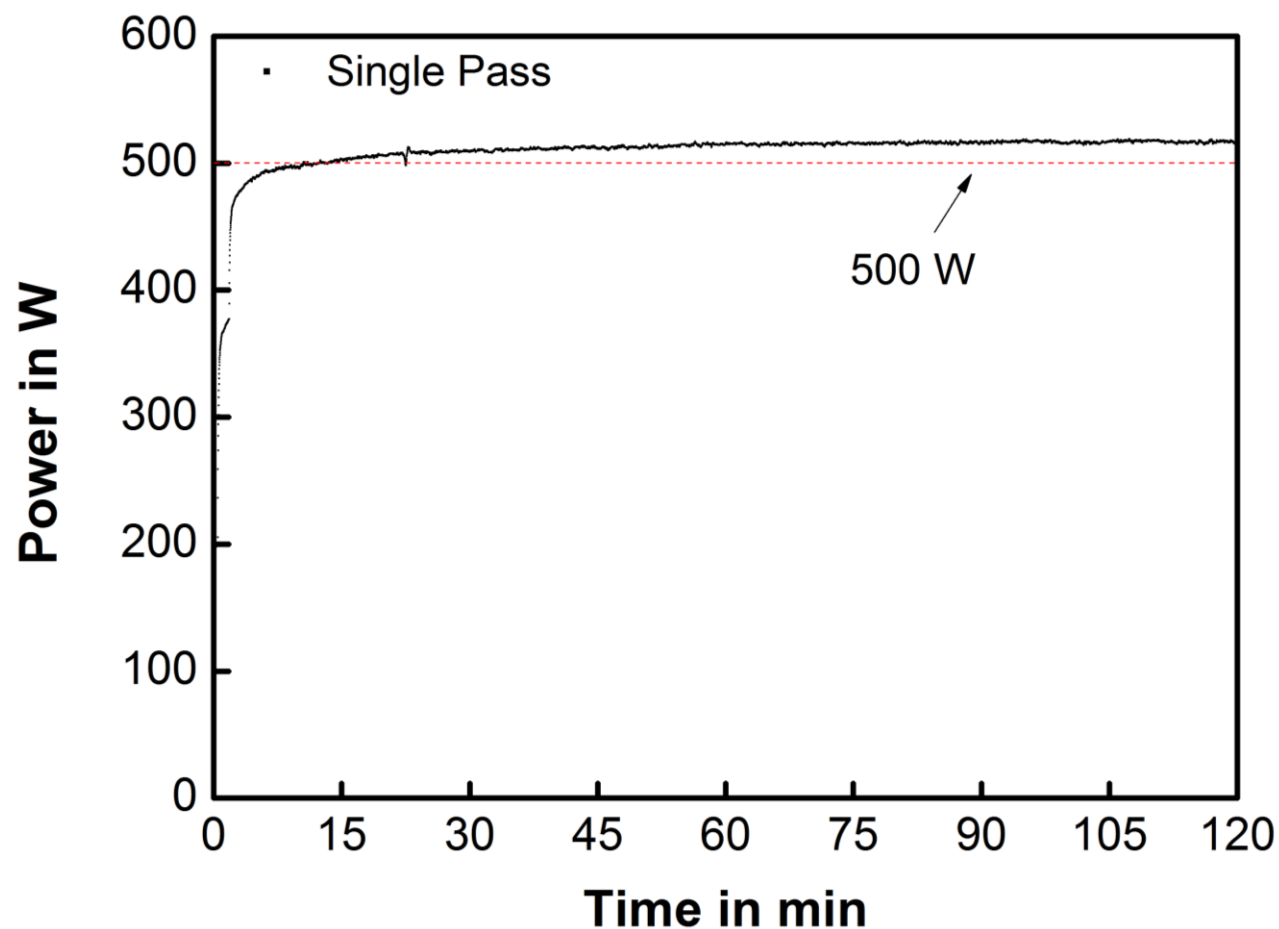
Results – Single pass

- Slight spectral narrowing → very slight temporal broadening
- Sub 400 fs at 600 W output power



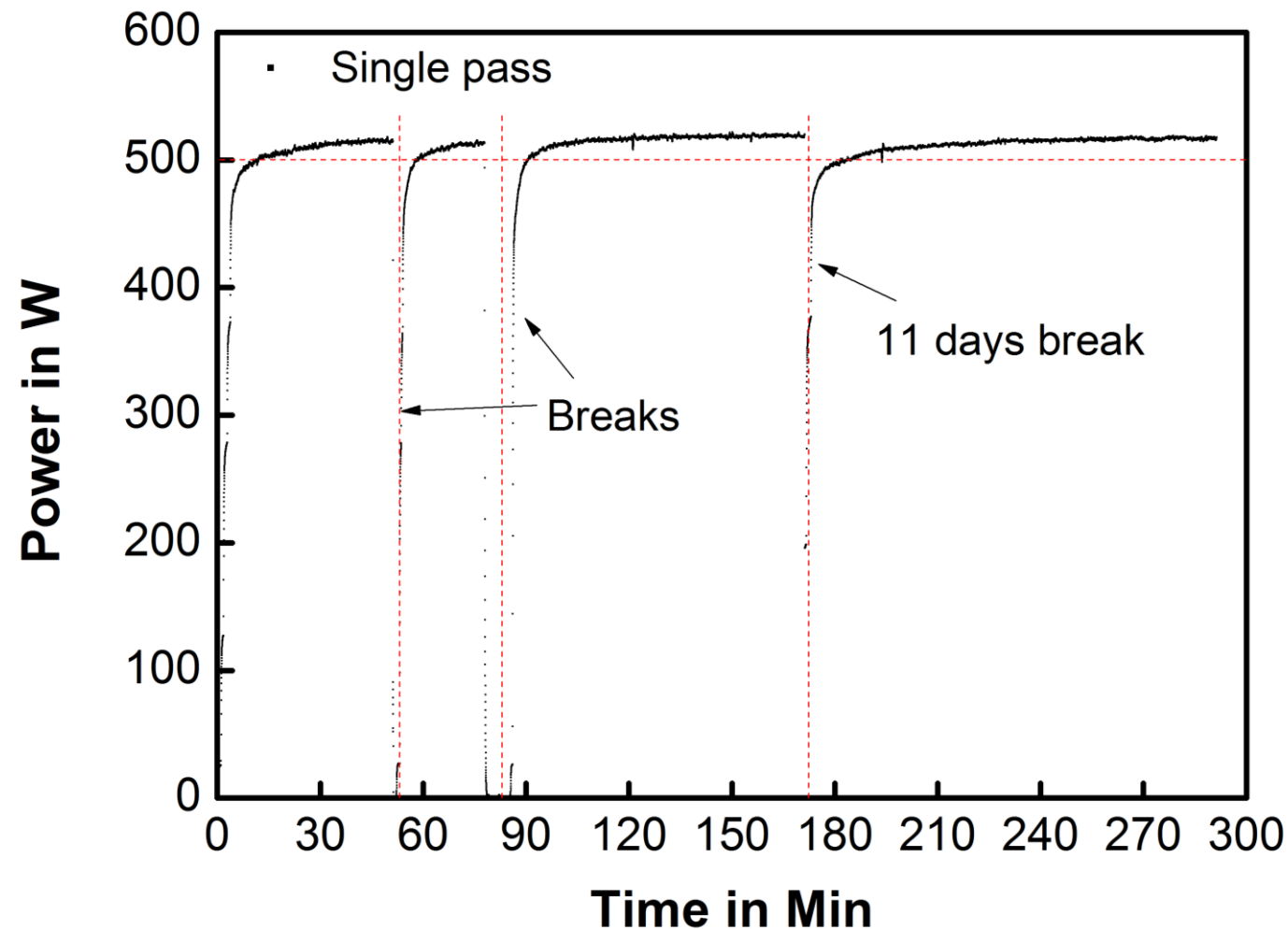
Results – Single pass

- Thanks to very good thermo-mechanical properties system is very stable after thermalization
- Measurement starting around 500 W
- No power drops observed



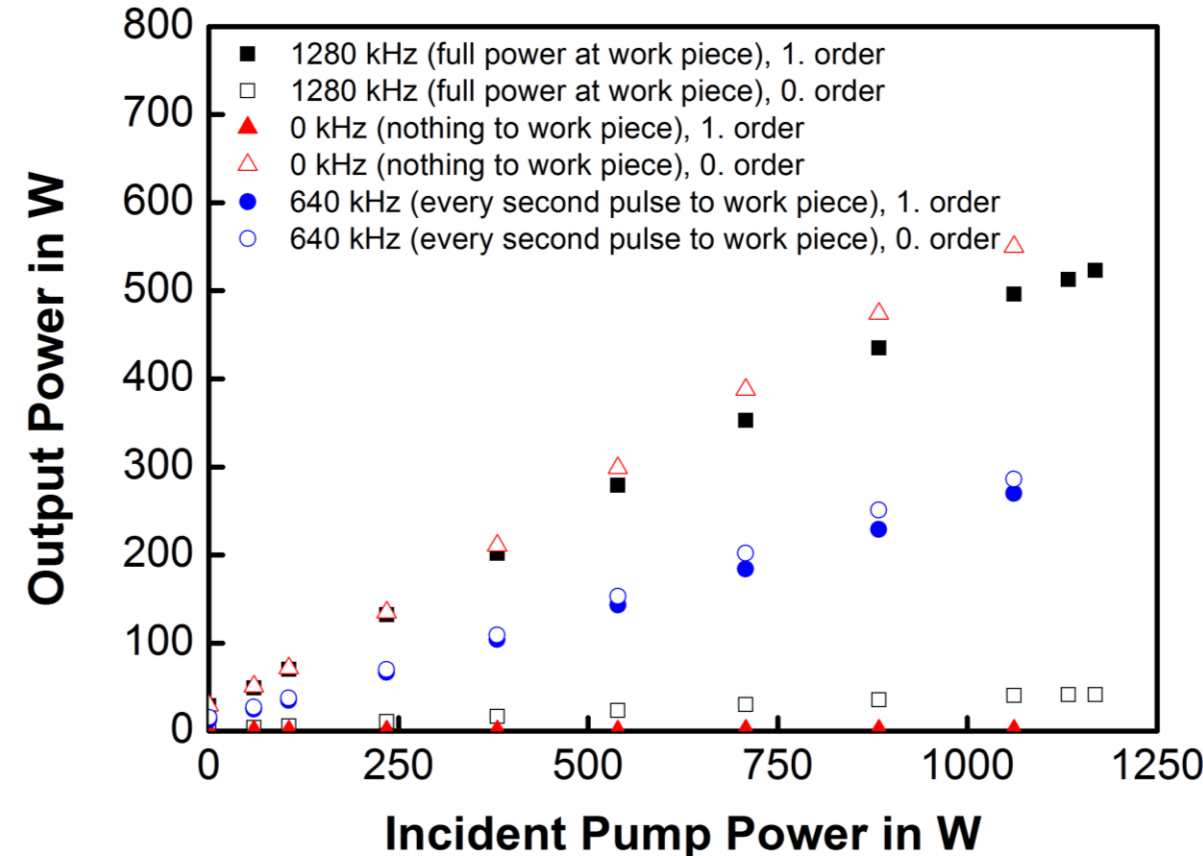
Results – Single pass

- Reproducible behaviour after breaks
- No realignment after 11 days break

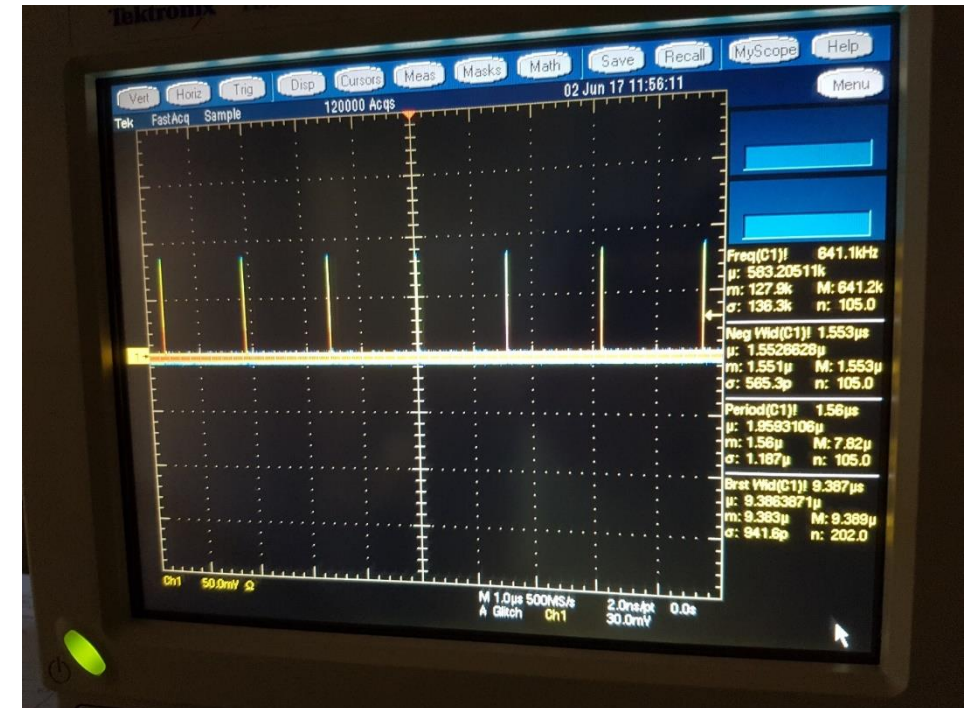
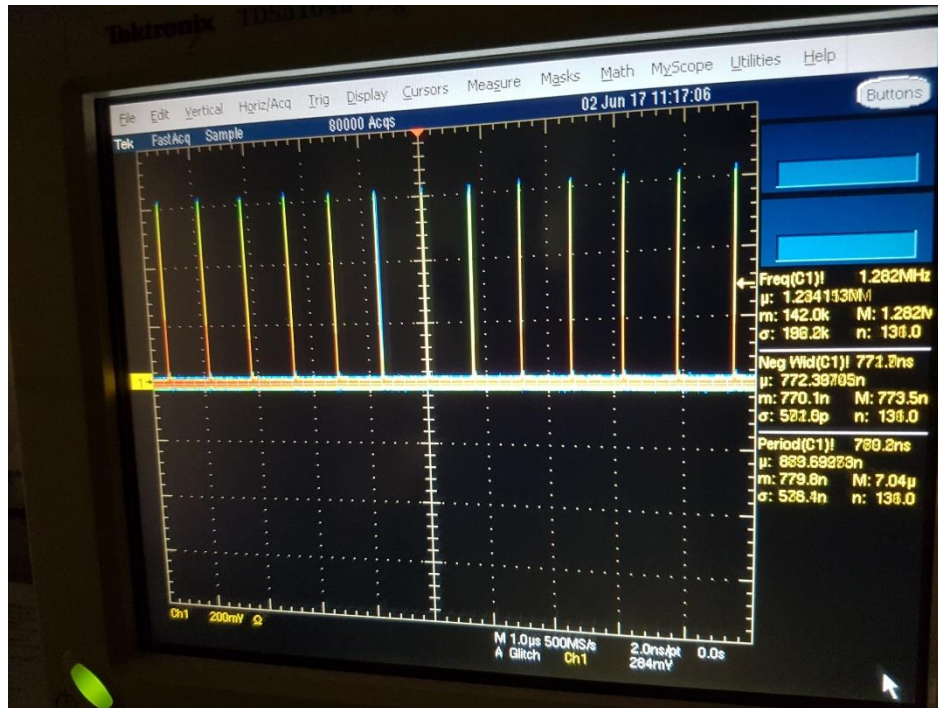


Results – Modulation

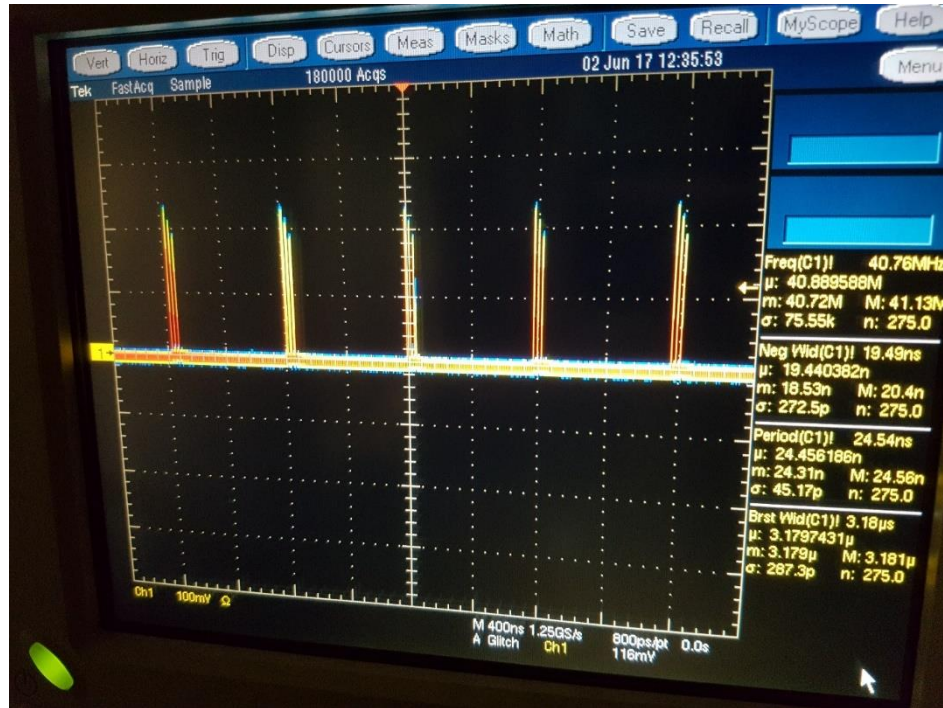
- Modulation scheme implemented
- First order to work piece, 0th order is dumped
- If full power at work piece is wanted (1280 kHz): 500 W are available
- If no power at work piece is wanted (0 kHz): power is dumped and less than at maximum 1 W is present in first order



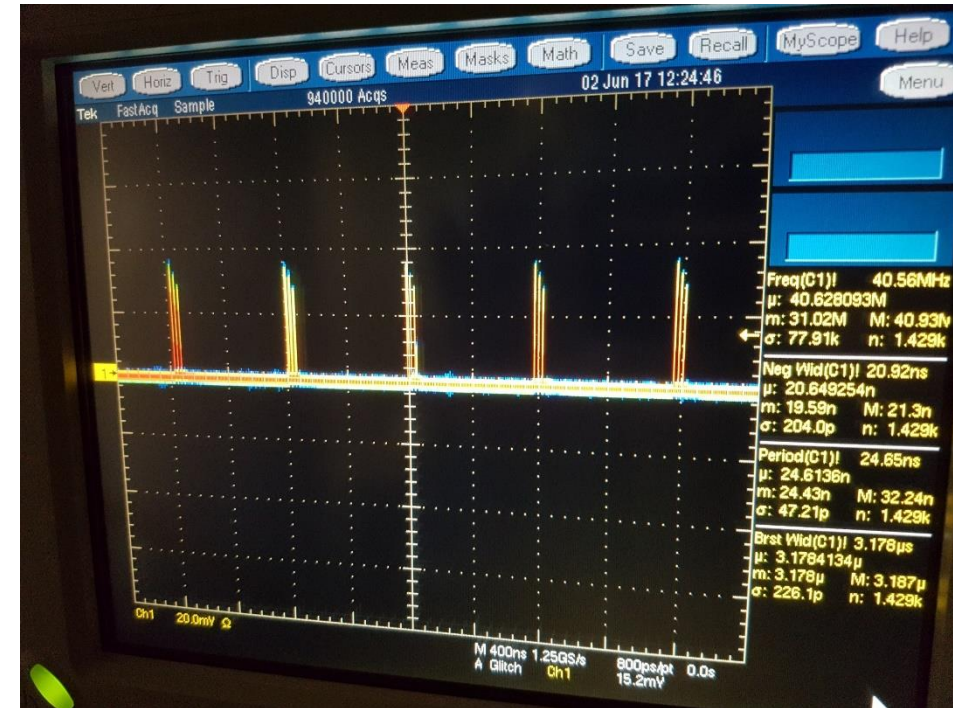
Results Modulation



Results Burst Mode



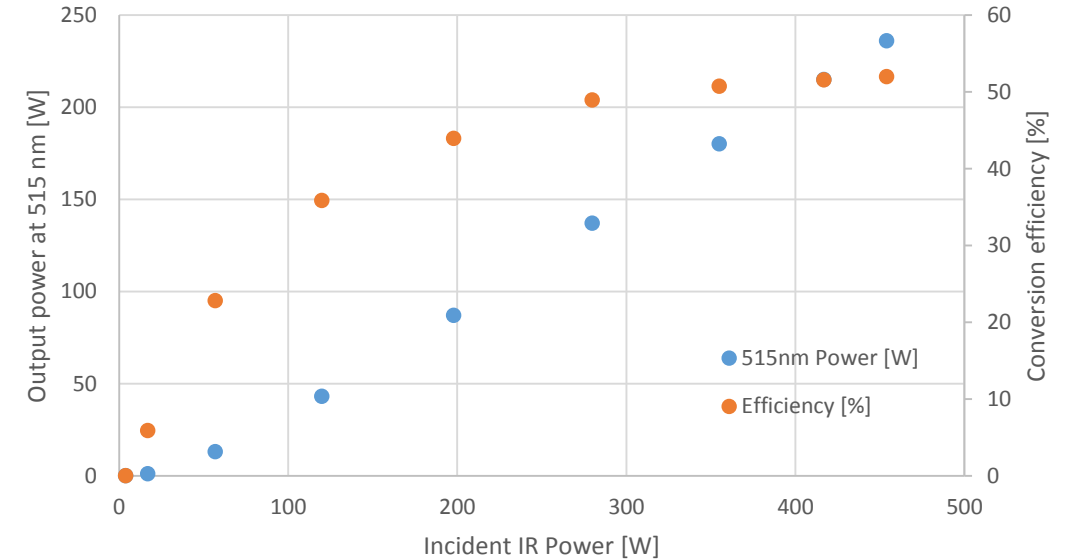
1280 kHz, 3 pulse burst
before amplifier



1280 kHz, 3 pulse burst at 500 W
output power (power curve is unchanged)

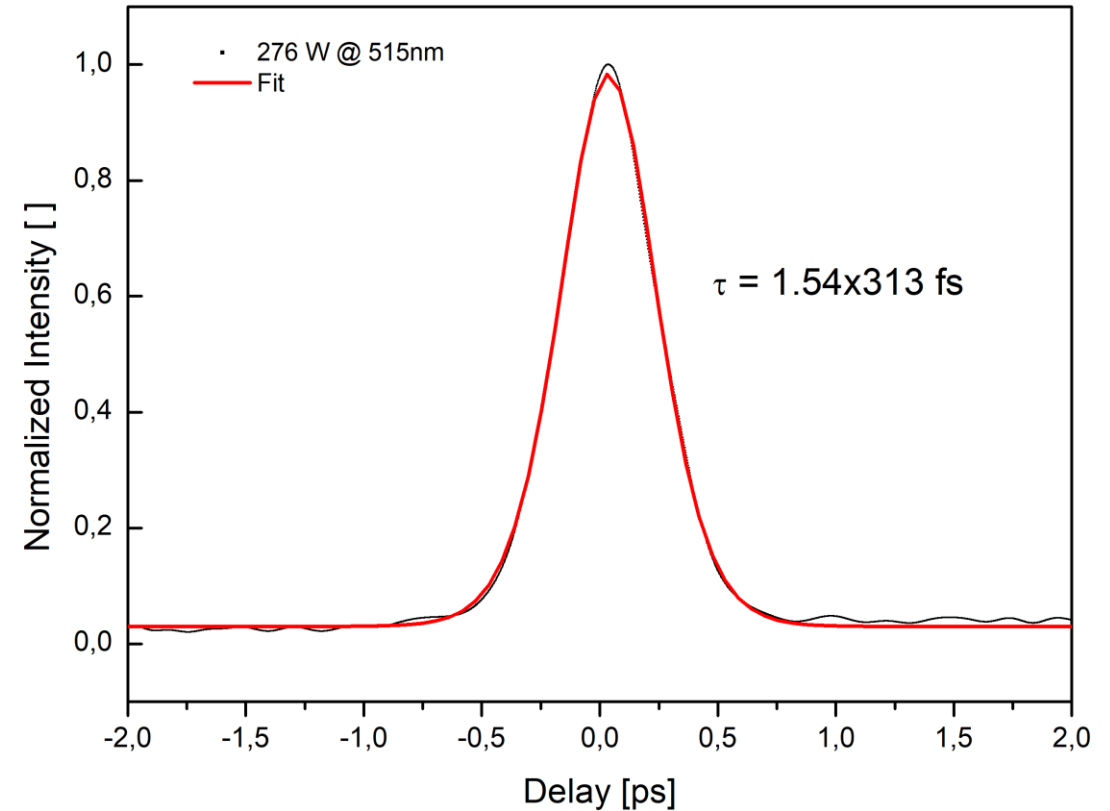
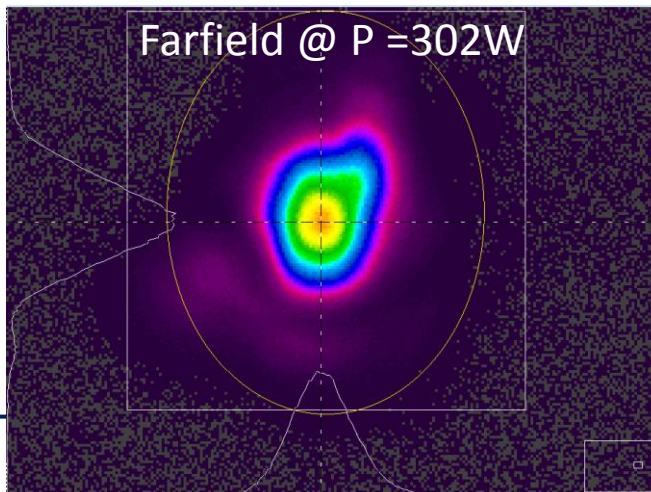
Task 5.3 Frequency Conversion

- SHG with 1.5 mm Crystal
 - 52% conversion efficiency at 240 W output power
 - Close to diffraction limited beam quality
 - Ongoing work:
 - improvement of conversion efficiency
 - Measurement of pulse duration



Task 5.3 Frequency Conversion

- SHG with 1.0 mm Crystal
 - 57.6% conversion efficiency at 302 W output power
 - $M^2 < 1.7$
 - Pulse duration $\tau < 400$ fs at 276 W output power (TPA AC)



Task 5.3 Frequency Conversion

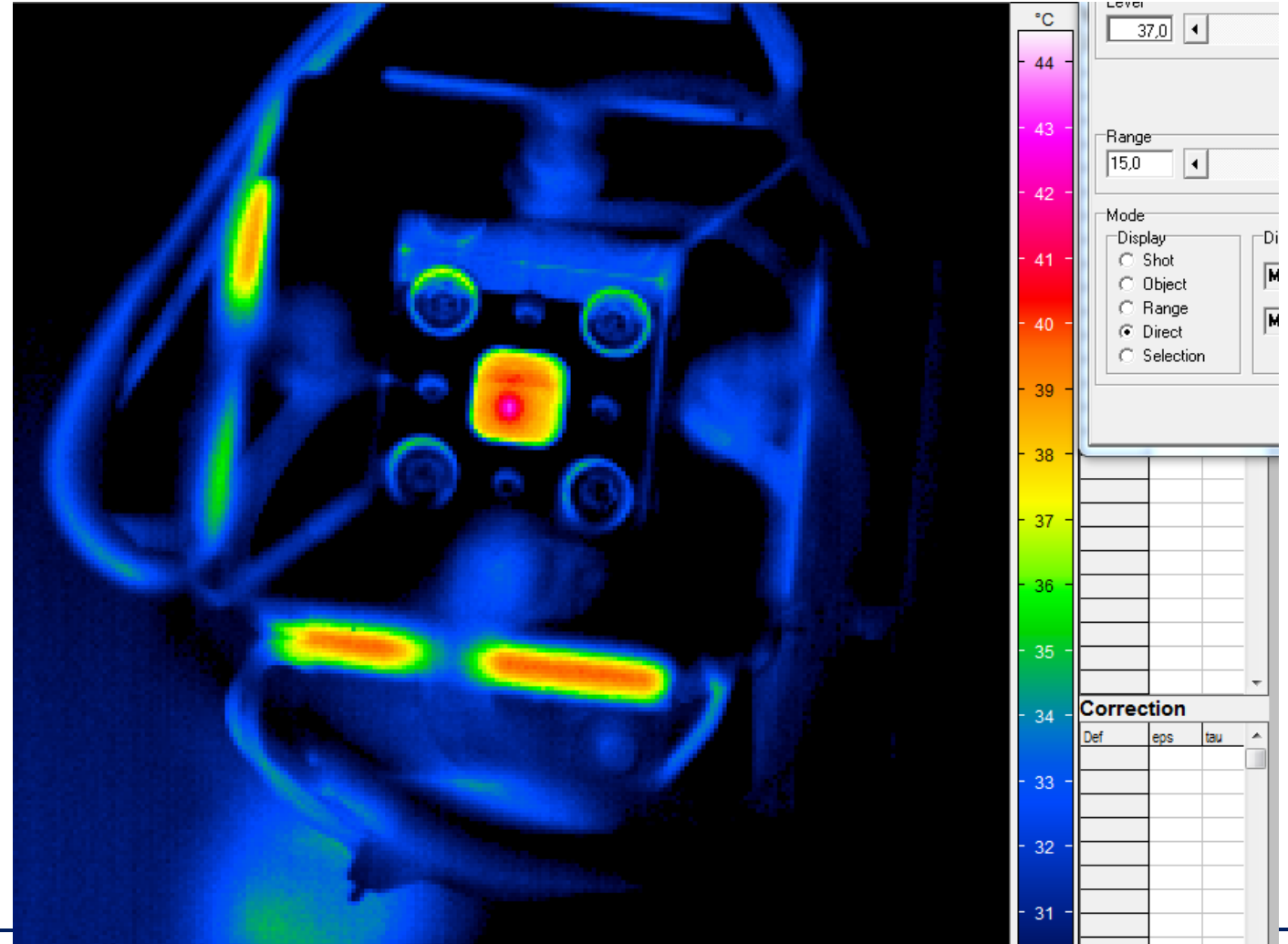
- THG
 - Experiments indicate issues (no conversion) with delivered Crystals.
 - New THG crystals were delivered.

Task 5.3 Frequency Conversion

- 54W @ 343 nm (14% conversion efficiency)
- $M^2 < 1.3$ @ 18W degrades to $M^2 < 2.2$ @ 54W
- Aberrations of UV beam were observed at high output power
- Switch from separated to cascaded -> exclude spatial misalignment (accept lower efficiency)

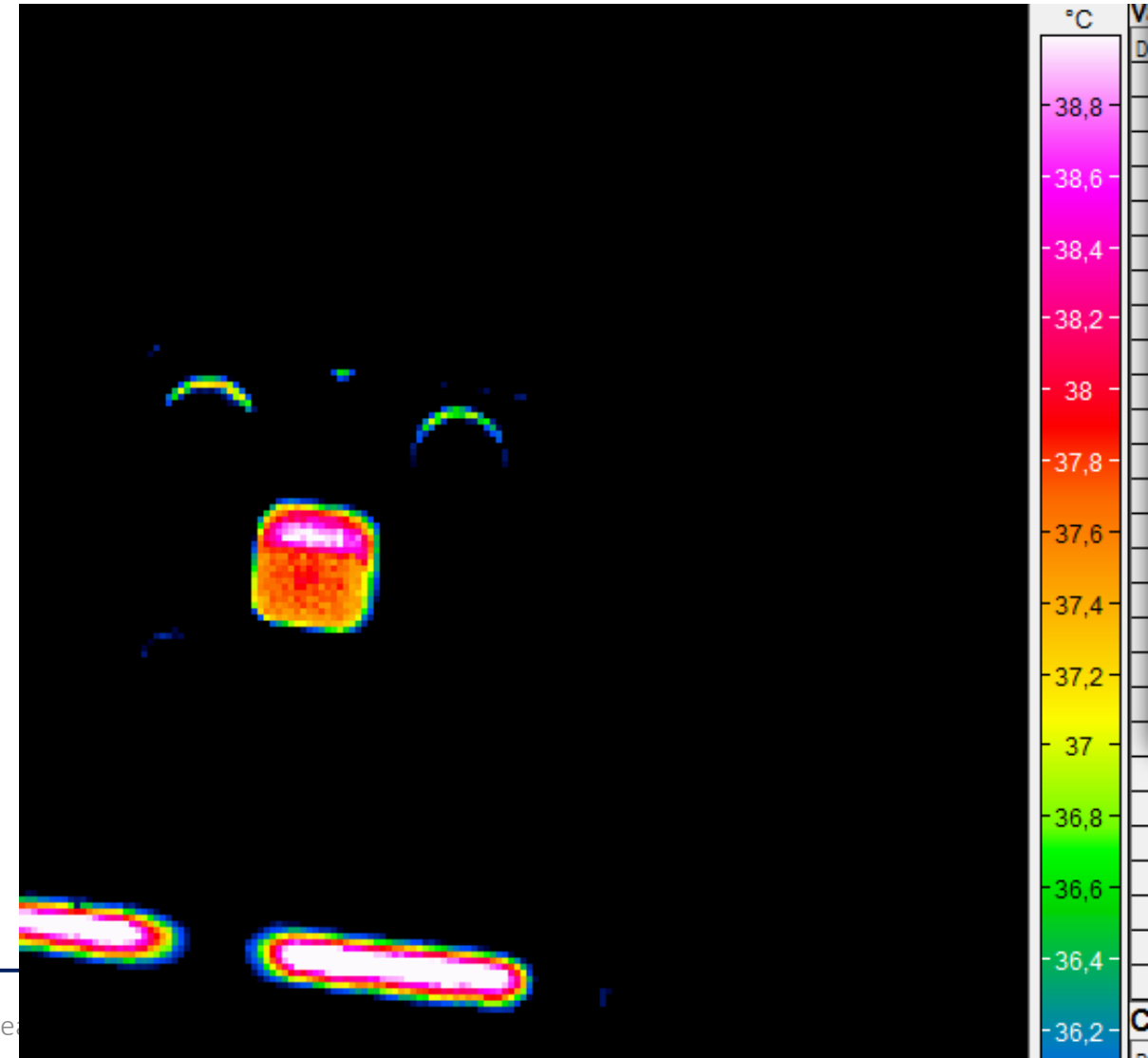
Thermocamera investigation of THG crystal

- Cascaded setup:
- IR+ VIS =408W incident on SHG and THG crystal
- 42W UV measured
- Clearly localized
- $\Delta T \approx 6 K$



Thermocamera investigation of THG crystal

- Cascaded setup:
- incident IR+ VIS =408W on SHG and THG crystal
- 0W UV (generation inhibited by rotated crystal)
- No clearly localized temperature distribution
- $\Delta T \approx 0.5 K$

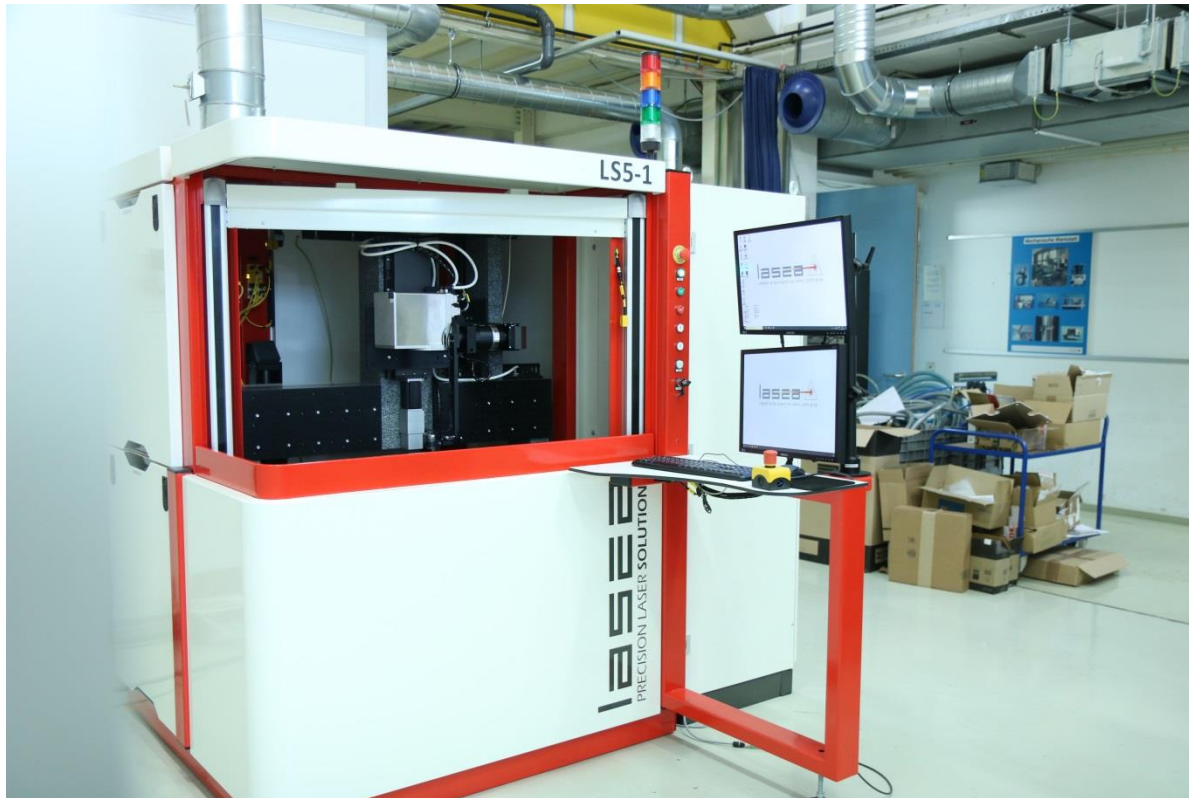


Task 5.4 Integration of multipass amplifier(AMP, USTUTT, Due M28)

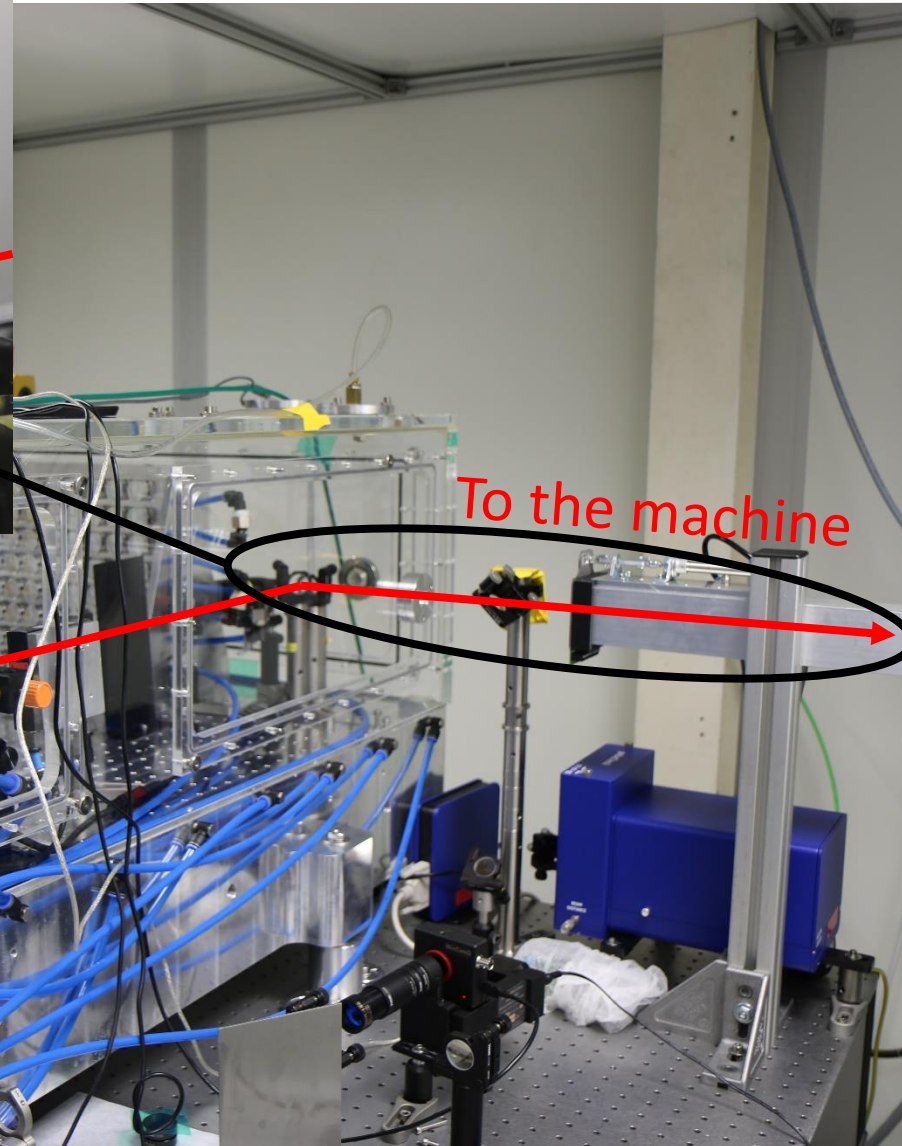
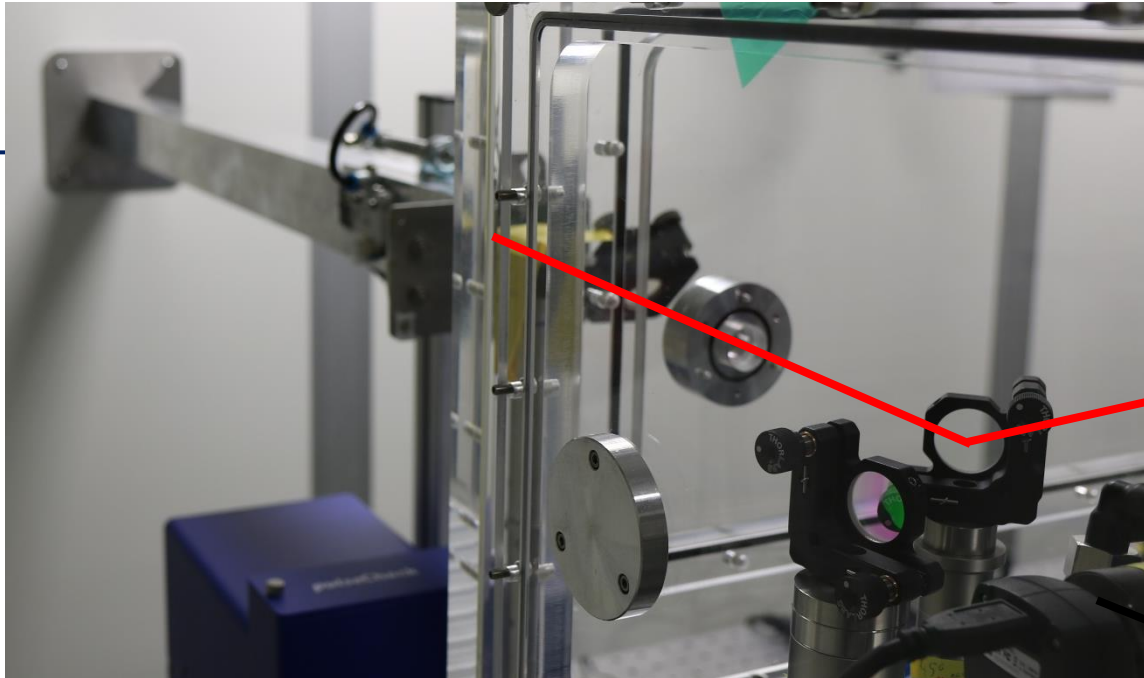
- Laser is placed in a separate room beneath the Lasea station
- Beam guided to workstation (by LASEA)
- Development of controls, interfaces ongoing (nealry completed).
- Room is being equipped

- Transport and installation of the system in the Laser lab is *completed*
- Complete validation of Laser performance in new Lab is *ongoing*
- Integration of the system is *ongoing*

Installation of Lasea machine @ USTUTT







Laser is running
and delivers
550W

Full beam
characterization
is ongoing

Task 5.5 Demonstration of a 1 kW, sub-1ps laser system (USTUTT, AMP, M38)

- Planned after material processing experiments with the 500W system
- Seed source: 200 W (140-160W) system delivered by AMP :Sept/Oct. 2018

WP5 – The next six months...

- Pulse compression experiments to go to even shorter pulse durations
- Work on beam quality
- Integration task ongoing in parallel
- Frequency conversion experiments

WP5 - Deliverables

Deliverable title	Due date	Status
D5.1 Design of the multipass amplifier	M06 – July 2016	Submitted
D5.2 Thin-disk multipass amplifier with 500 W, 1 MHz, sub-500 fs	M22- November 2017	Submitted
D5.3 Demonstration of 200W green and 100W UV laser beams at 1MHz and sub-500 fs pulse	M28- May 2018	Not yet submitted, work ongoing
D5.4 Thin-disk multipass amplifier with 1000W, >=1MHz, sub-1ps	M38- March 2019	Not yet submitted, work ongoing, very confident

- No deviations to report.