

WP5 Thin-disk Multi-pass Booster

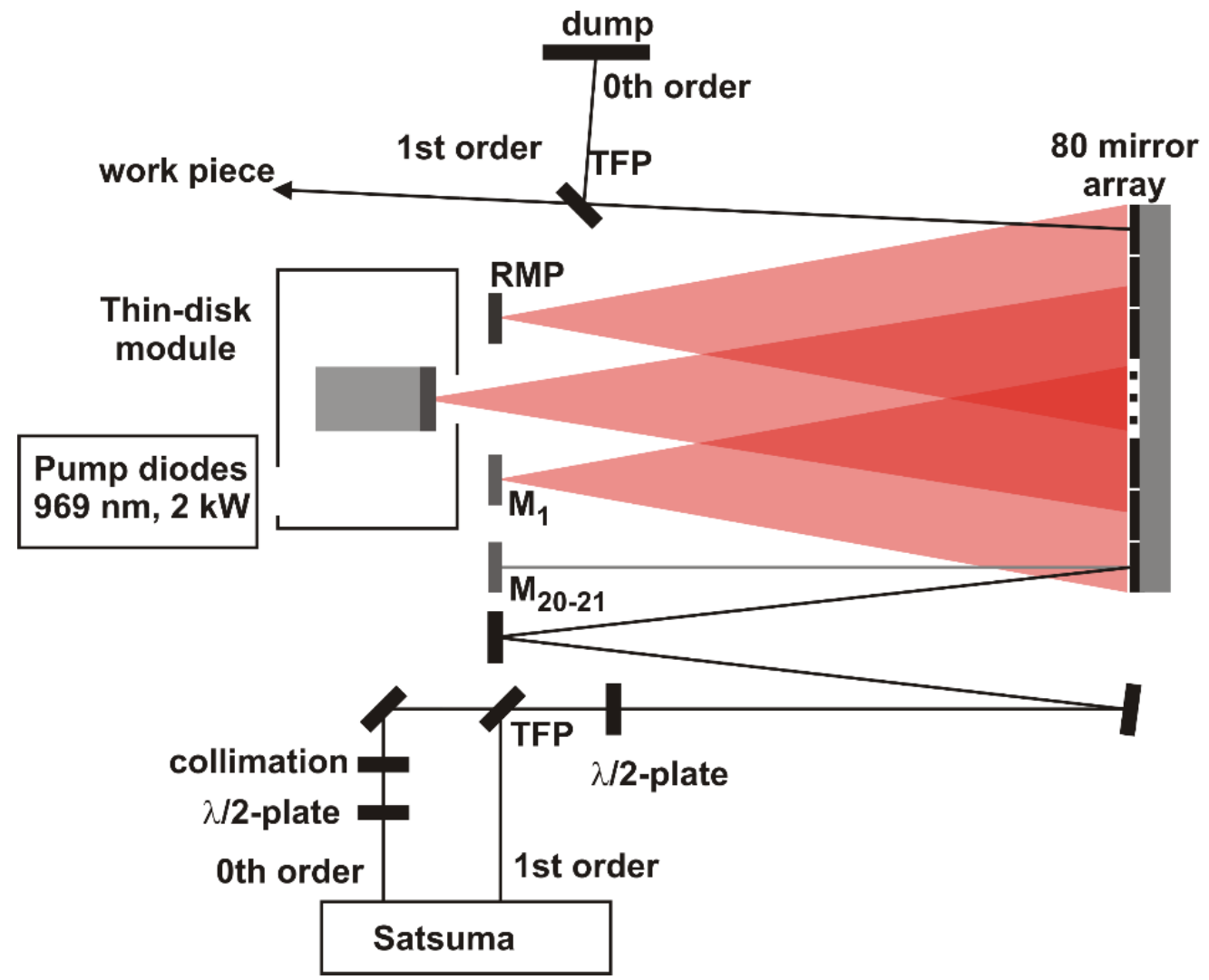
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Work Package 5 Overview

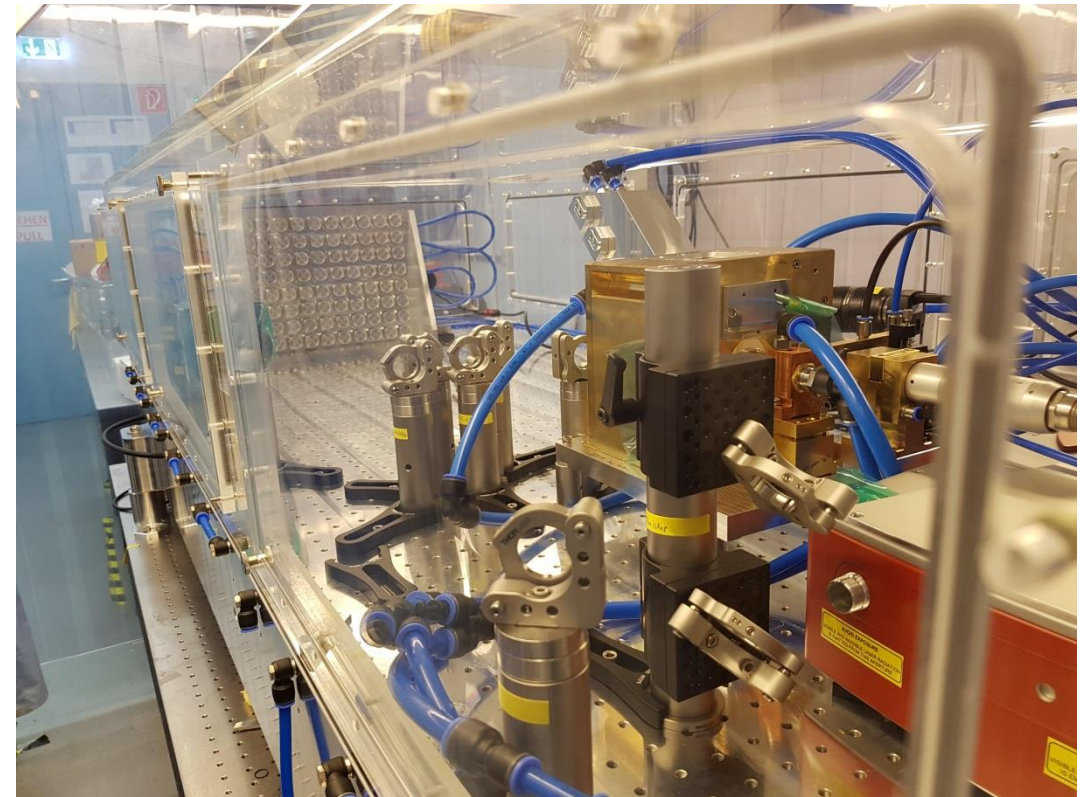
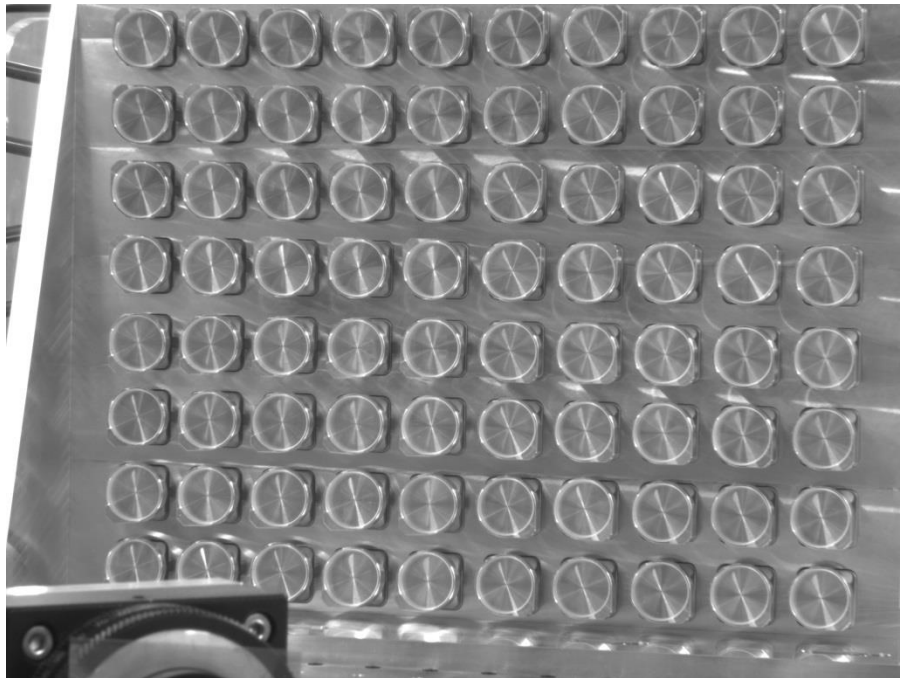
- Main objective: Building multipass amplifier with Seed Source from AMP
 - Task 5.1 Design of the thin-disk multipass amplifier (USTUTT, **completed in P1**)
 - Task 5.2 Amplifier with 500 W, 1 MHz, sub-500 fs (USTUTT, AMP, Due M22, **completed**)
 - Task 5.3 Second and third harmonic generation (USTUTT, AMP, Due M28, **“completed” in P2**)
 - Task 5.4 Integration of Yb amplifier (AMP, USTUTT, Due M28, **completed in P2**)
 - Task 5.5 Demonstration of a 1 kW, sub-1ps laser system (USTUTT, AMP, Due M38, **ongoing**)

Setup



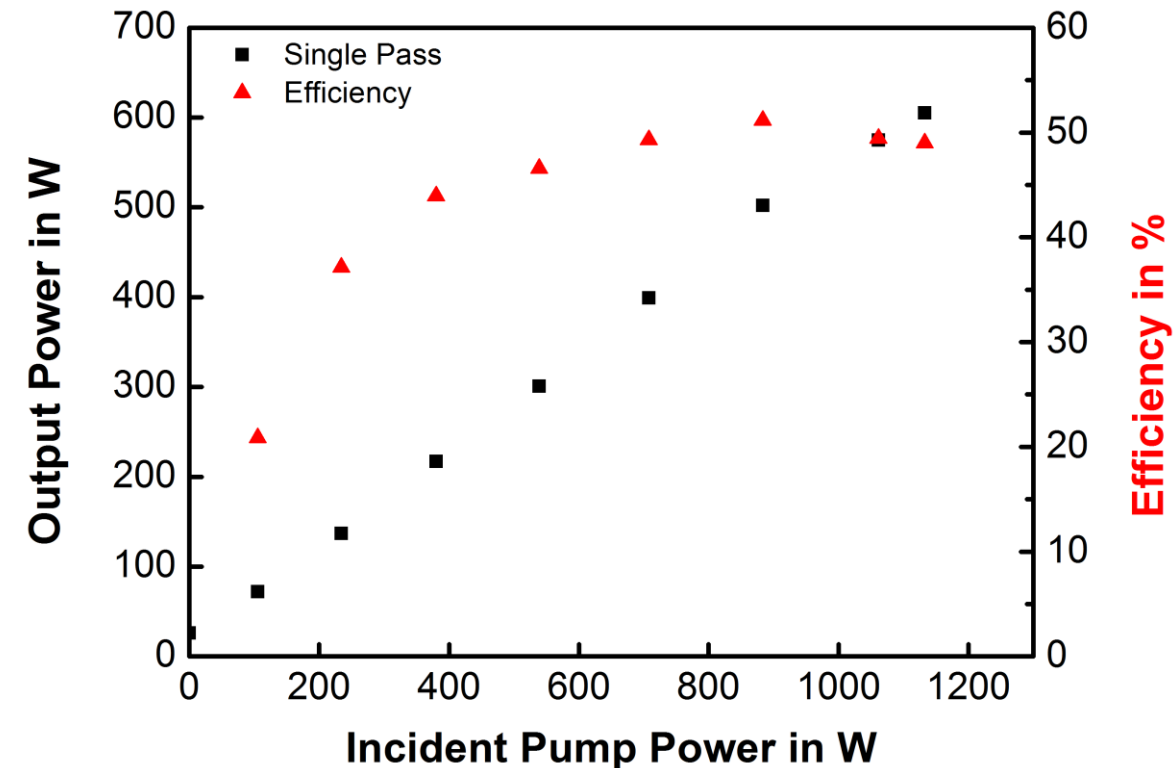
WP5 – Task 5.2: Assembly and characterization of a Yb:YAG thin-disk multipass amplifier (USTUTT, AMP, Due M22)

Array of 80 mirrors



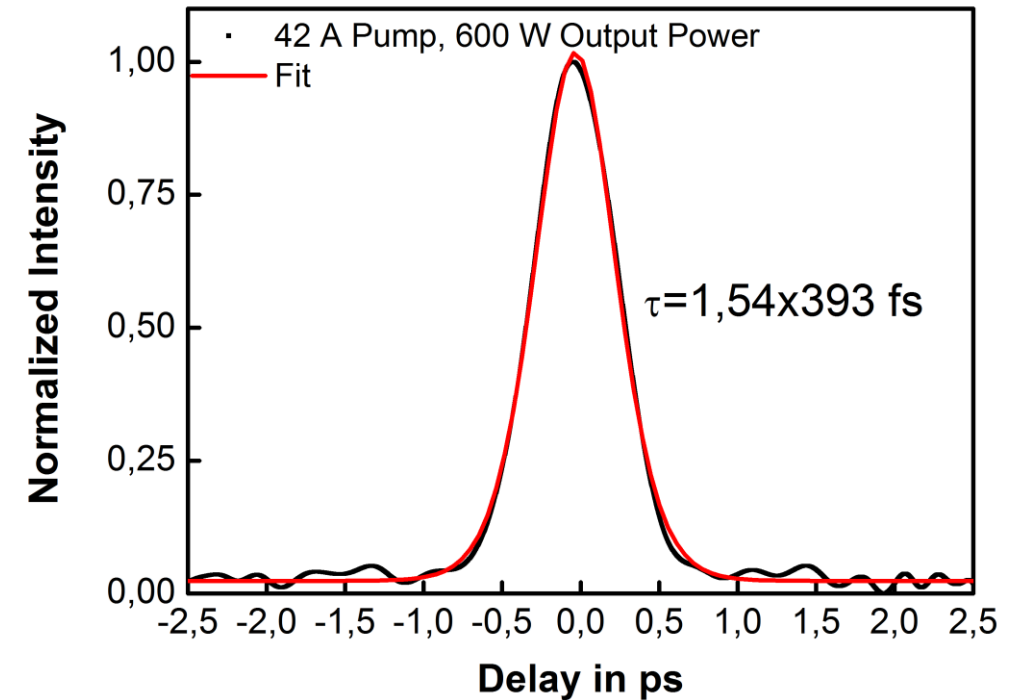
Results in laser labs – Single pass

- 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



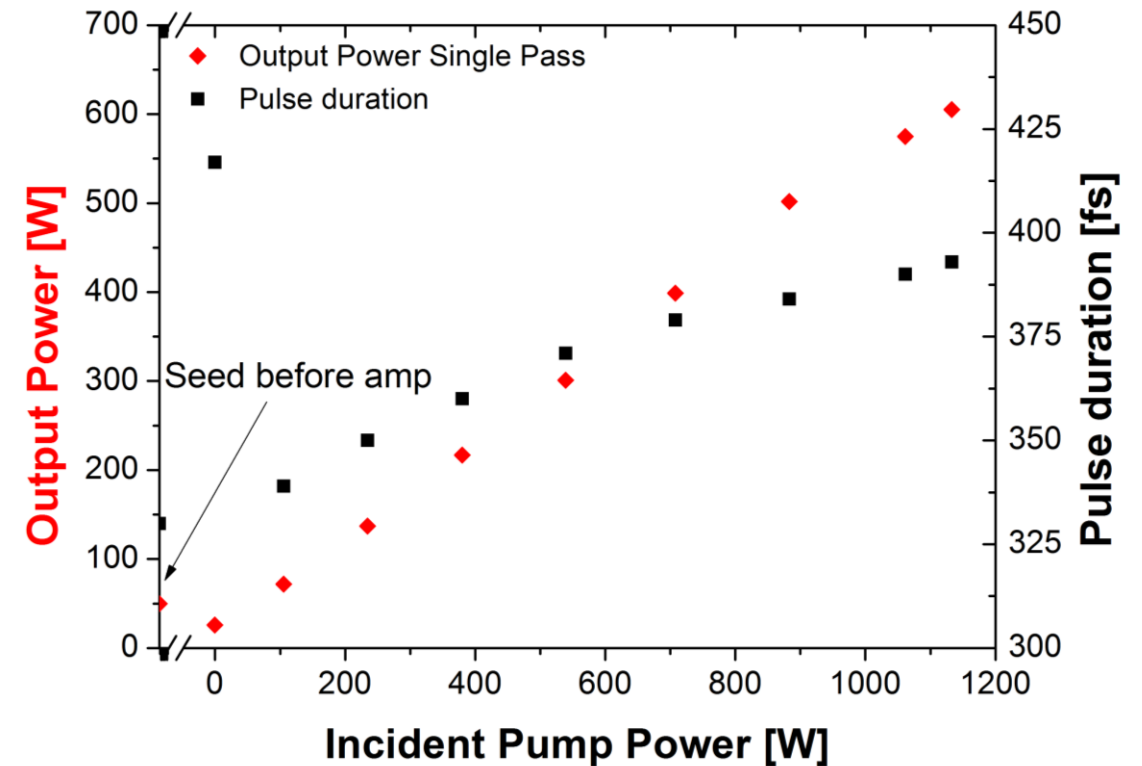
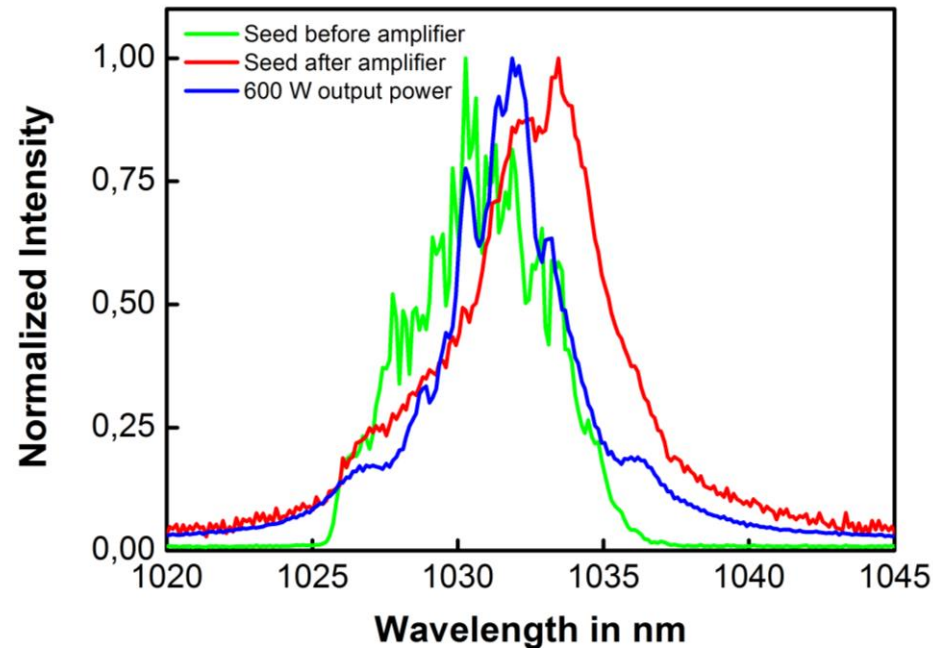
Results in laser labs – Single pass

- 330 fs pulse duration of seed laser
- Measured pulse duration at 600 W power: 393 fs
- Peak Power: 1.1 GW



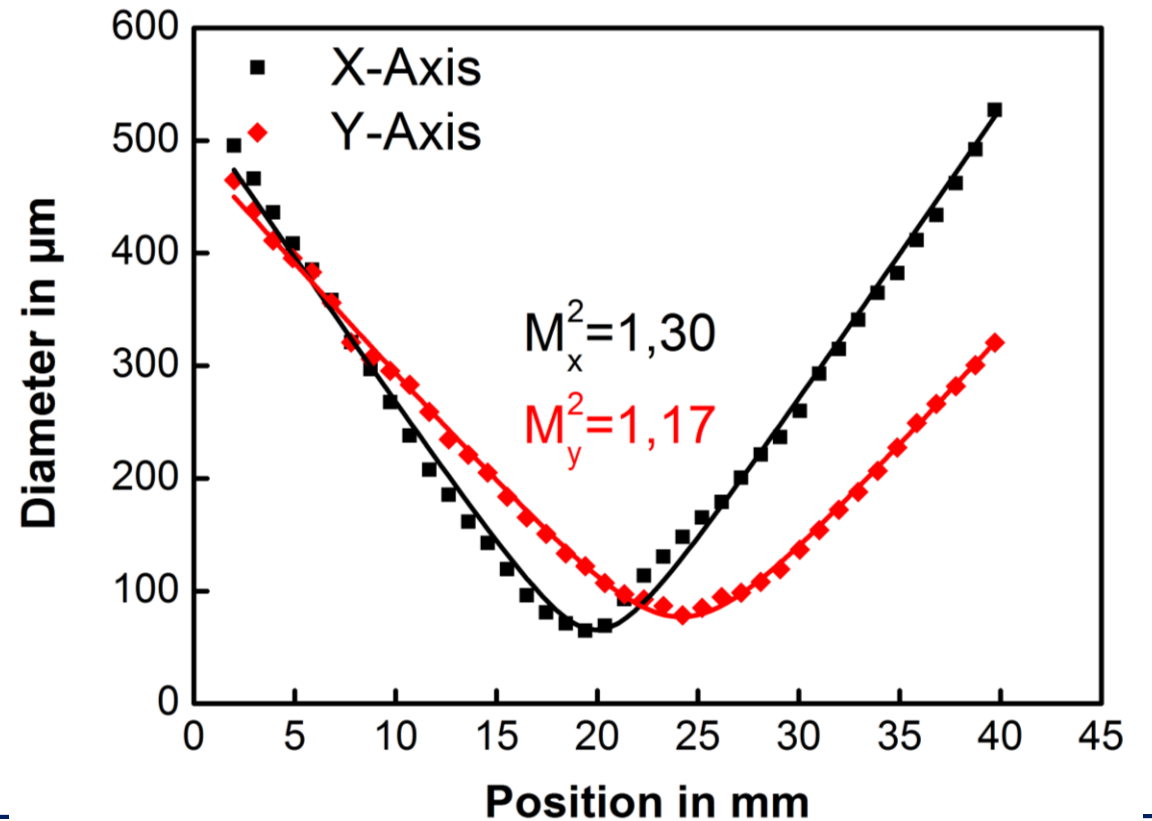
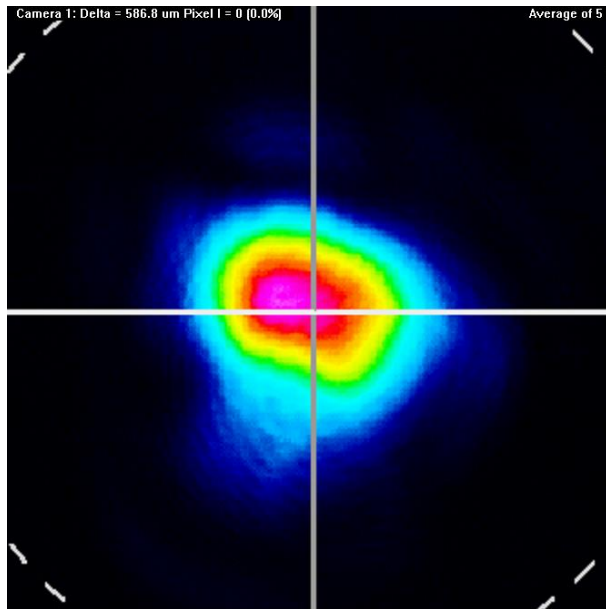
Results in laser labs – Single pass

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



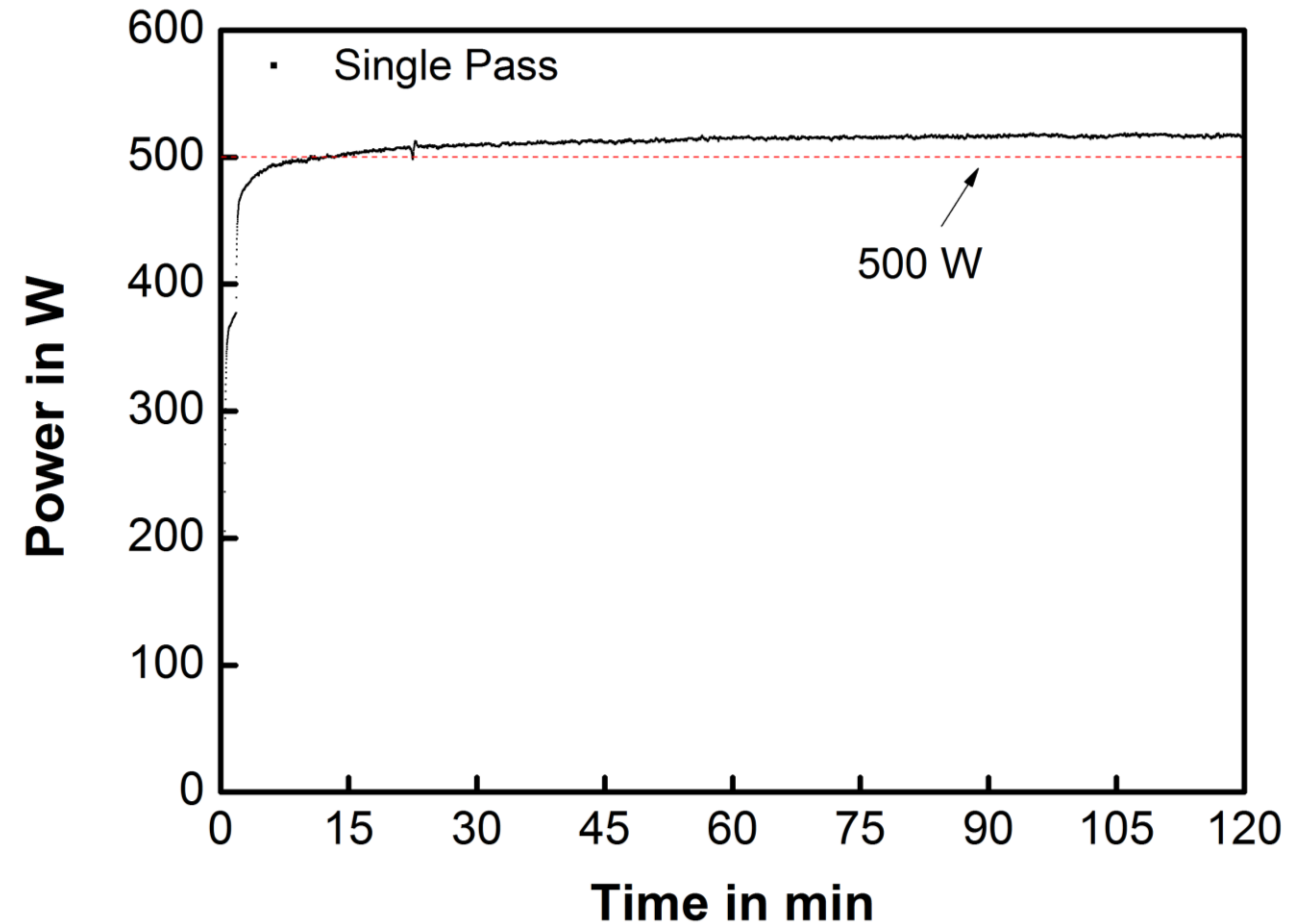
Results in laser labs – Single pass

- Beam profile at full output power: only slight aberrations visible
- $M^2 < 1.3$



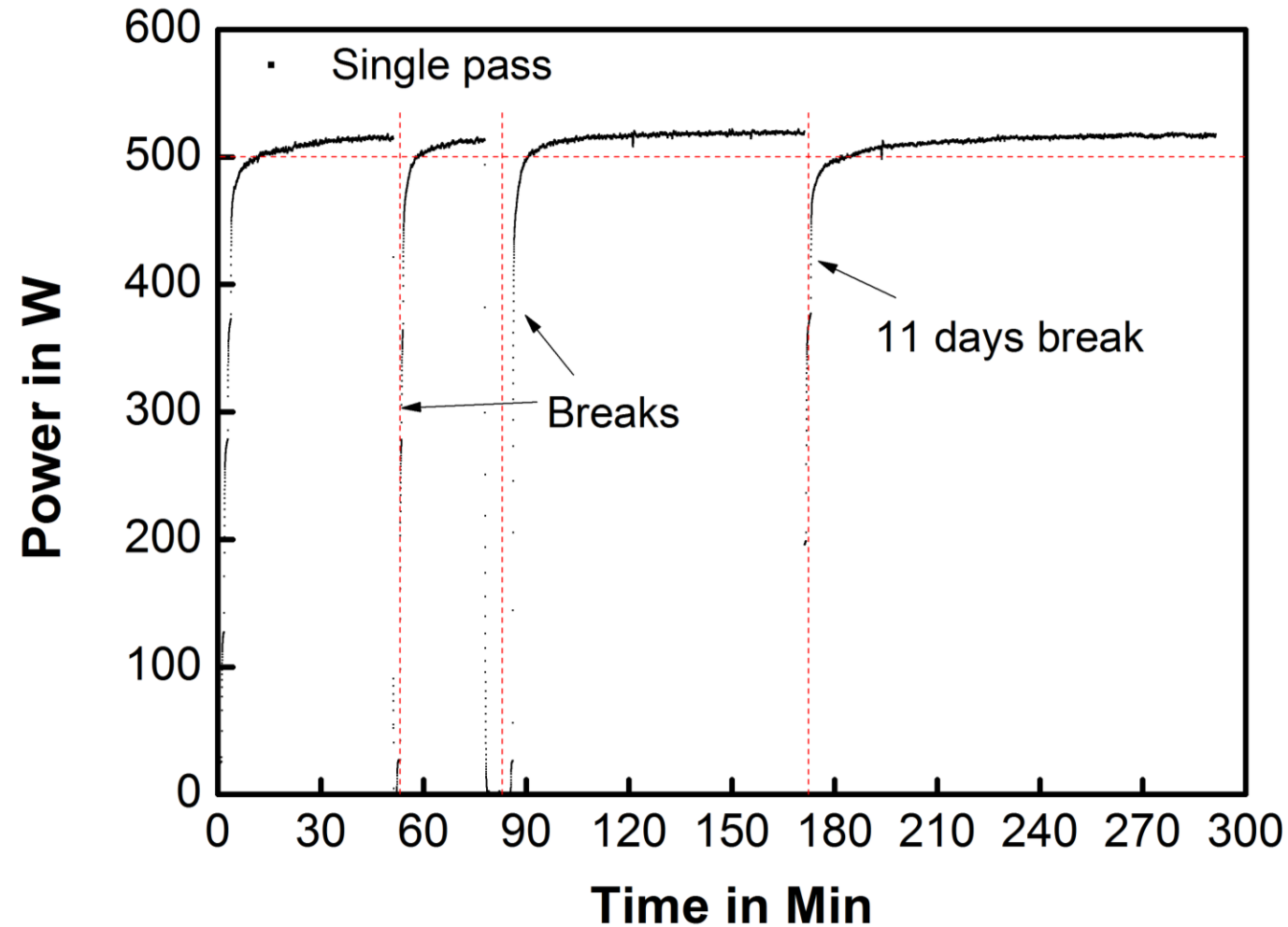
Results in laser labs – Single pass

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

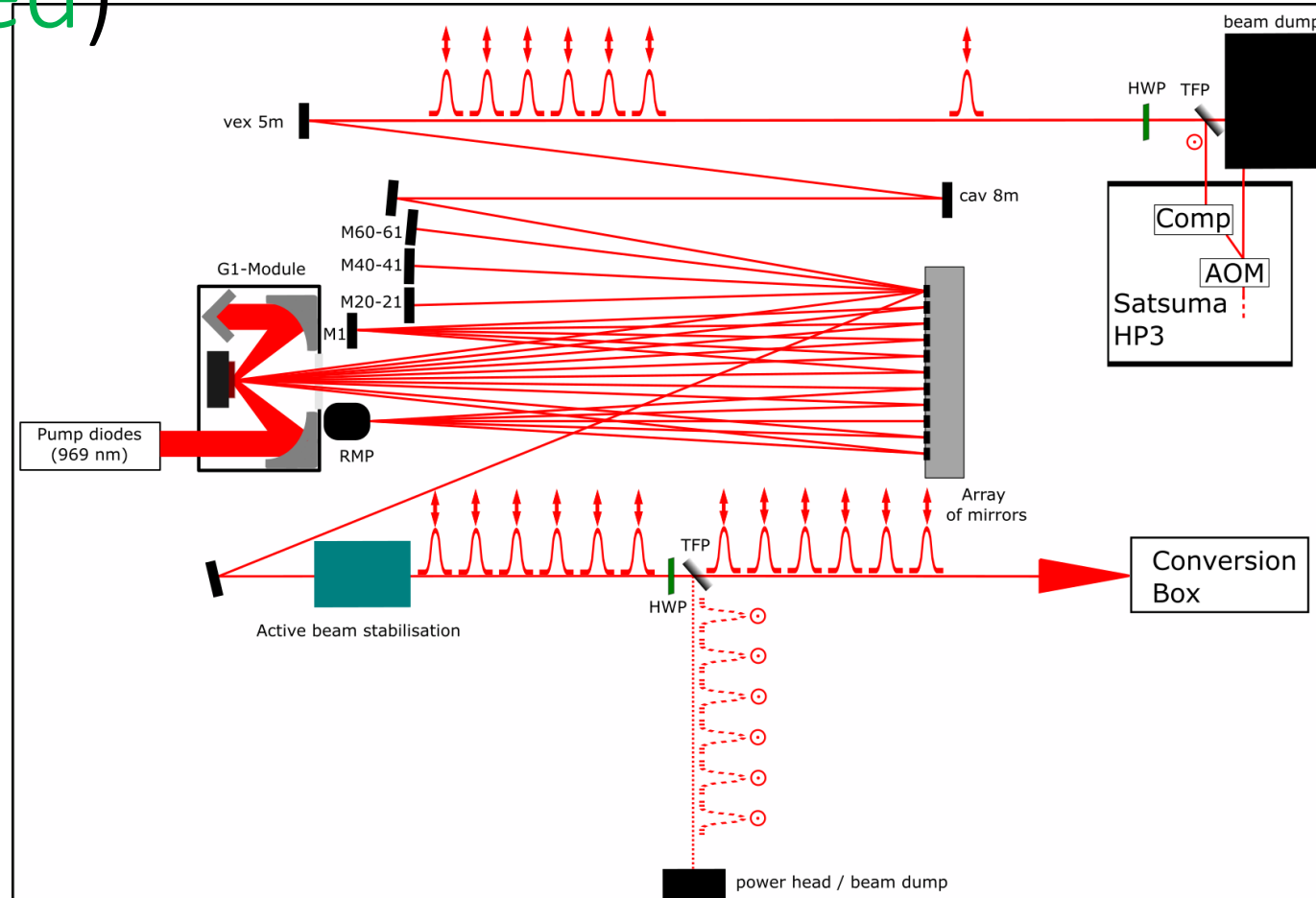


Results in laser labs – Single pass

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

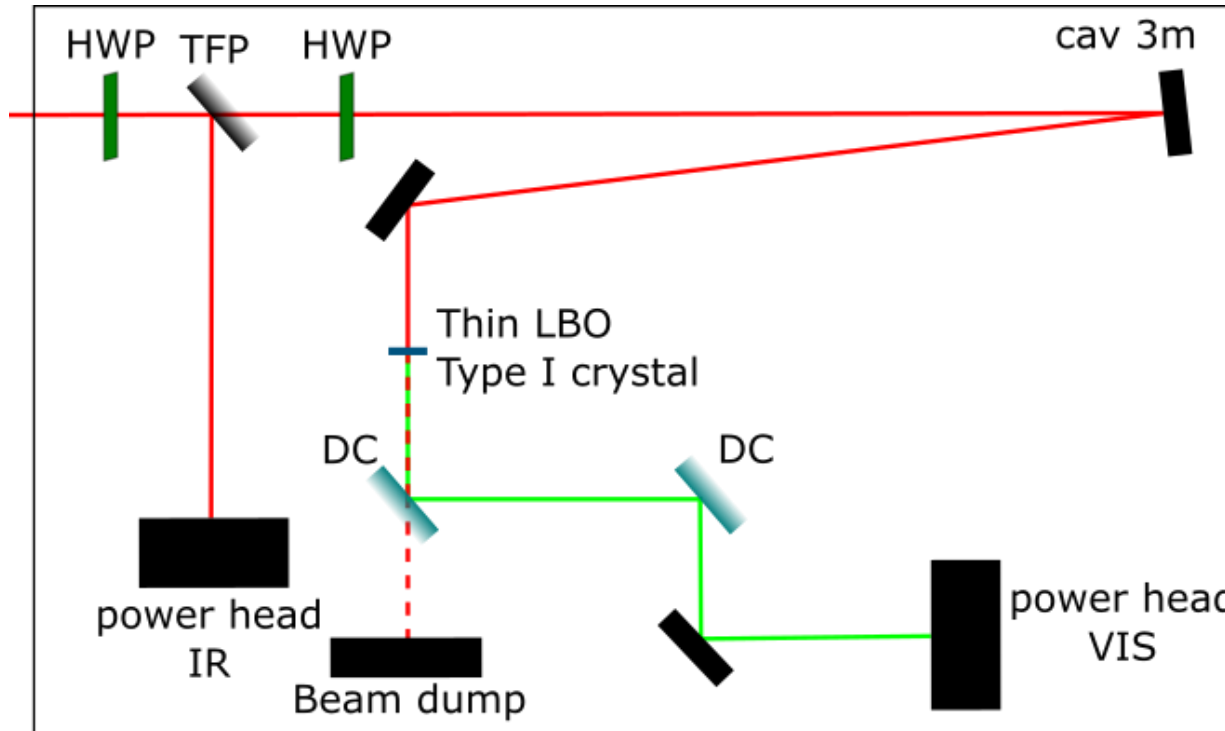


Task 5.3 Frequency Conversion (USTUTT, AMP, completed)

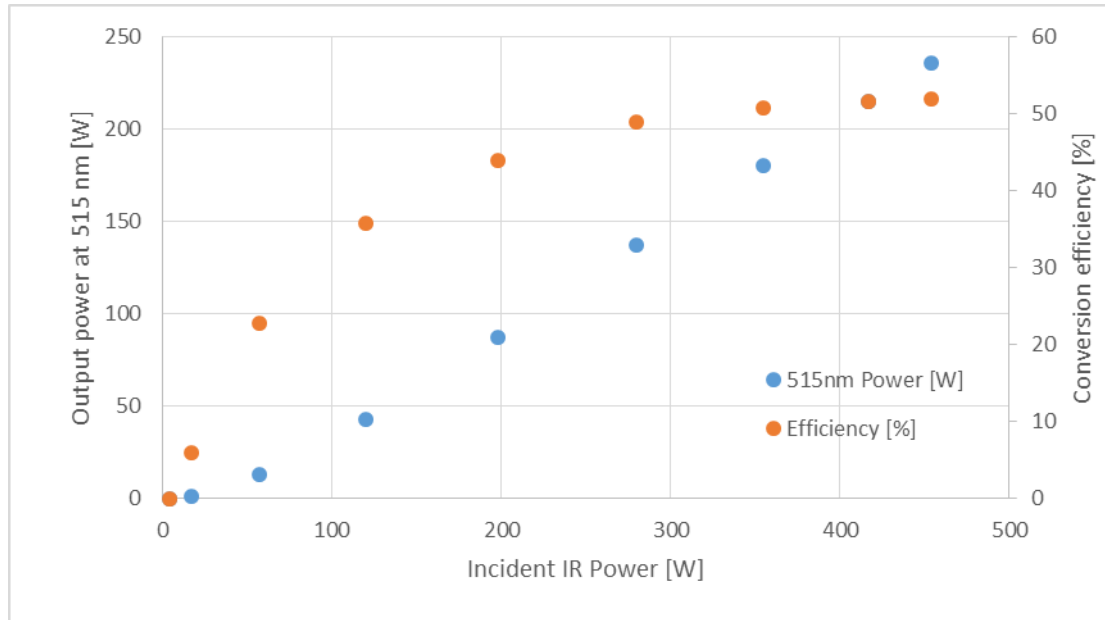


Task 5.3 Frequency Conversion (USTUTT, AMP, completed): SHG

- LBO 10x10x(1.5/1.0) mm Type I (oo-e) cut: $\vartheta = 90^\circ$, $\varphi = 13.2^\circ$, $T = 37^\circ C$
from Cristal Laser (France)

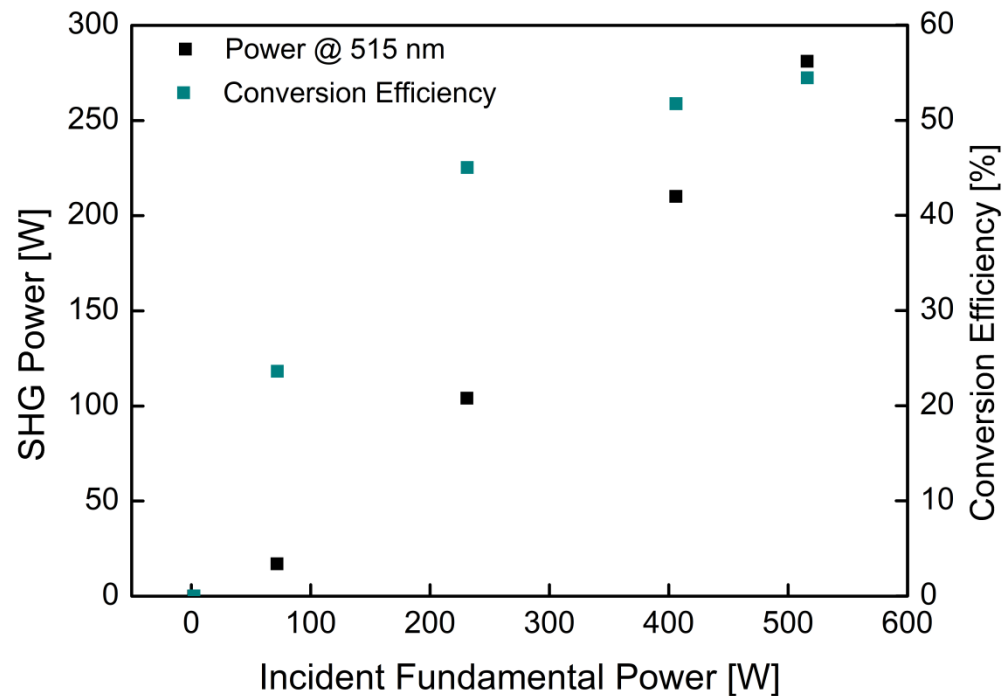


Task 5.3 Frequency Conversion (USTUTT, AMP, completed): SHG (LBO -1.5 mm)



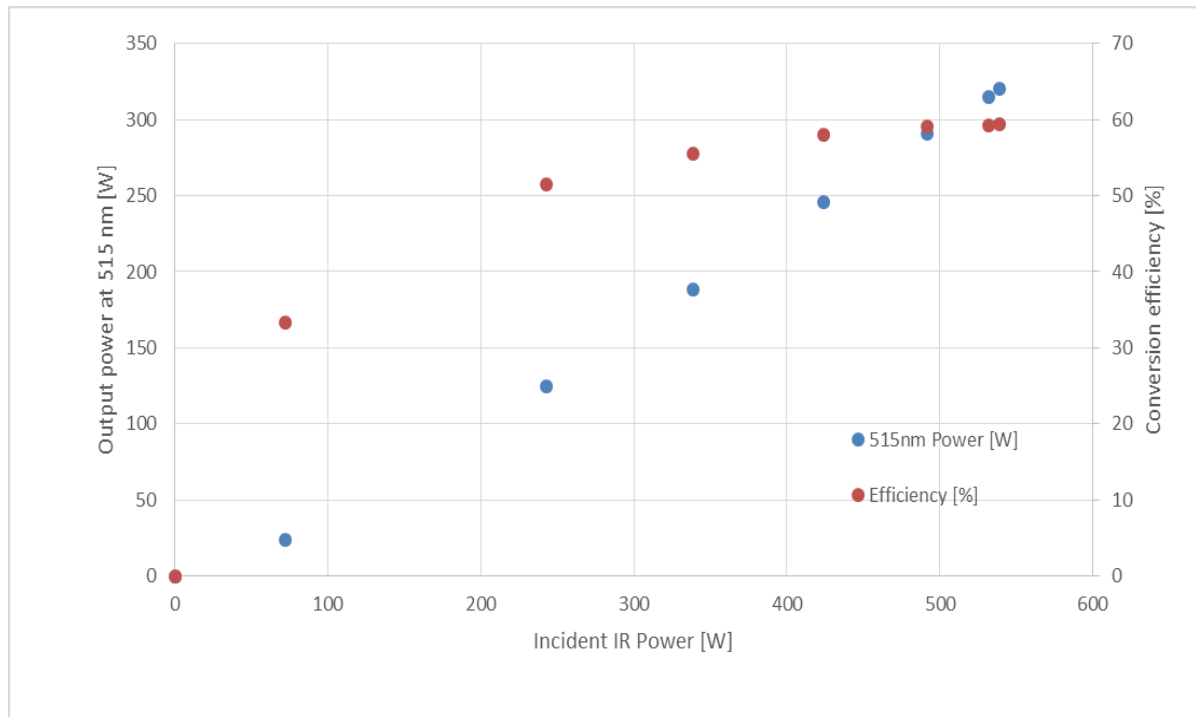
- $M^2 < 1.2$ at 240 W
- 52% of conversion efficiency
- Pulse duration ~ 313 fs

Task 5.3 Frequency Conversion (USTUTT, AMP, completed): SHG (LBO -1.0 mm)



- $M^2 < 1.4$ at 281 W
- 54.5% of conversion efficiency
- Pulse duration \sim 313 fs at 276 W

Task 5.3 Frequency Conversion (USTUTT, AMP, completed): SHG (LBO -1.0 mm)



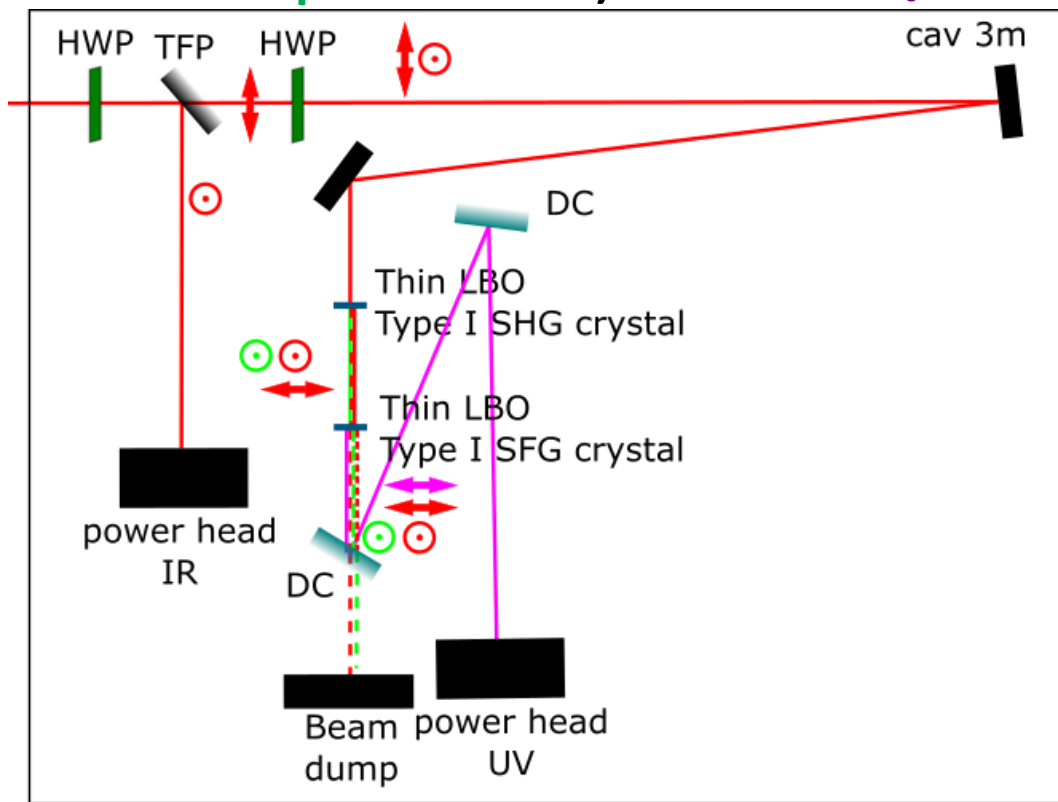
- $M^2 > 1.8$ at 320 W
- 59.4% of conversion efficiency

Task 5.3 Frequency Conversion (USTUTT, AMP, completed): THG

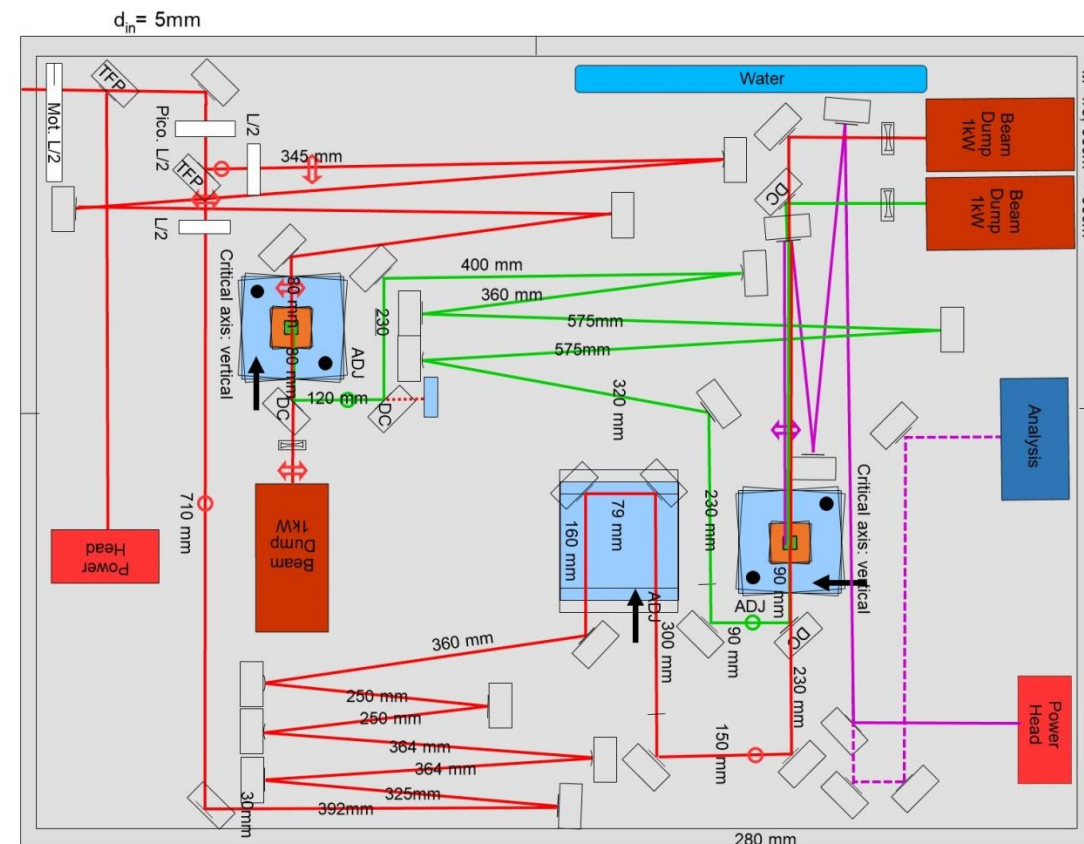
- Non-linear crystals
 - SHG: LBO 10x10x(1.5/1.0) mm Type I (oo-e) cut: $\vartheta = 90^\circ$, $\varphi = 13.2^\circ$, $T = 37^\circ\text{C}$
 - SFG: LBO 10x10x1 mm Type I (oo-e) cut $\vartheta = 90^\circ$, $\varphi = 40.1^\circ$, $T = 47^\circ\text{C}$
 - Both crystals were provided by Cristal laser (France)

Task 5.3 Frequency Conversion (USTUTT, AMP, completed): THG / setups

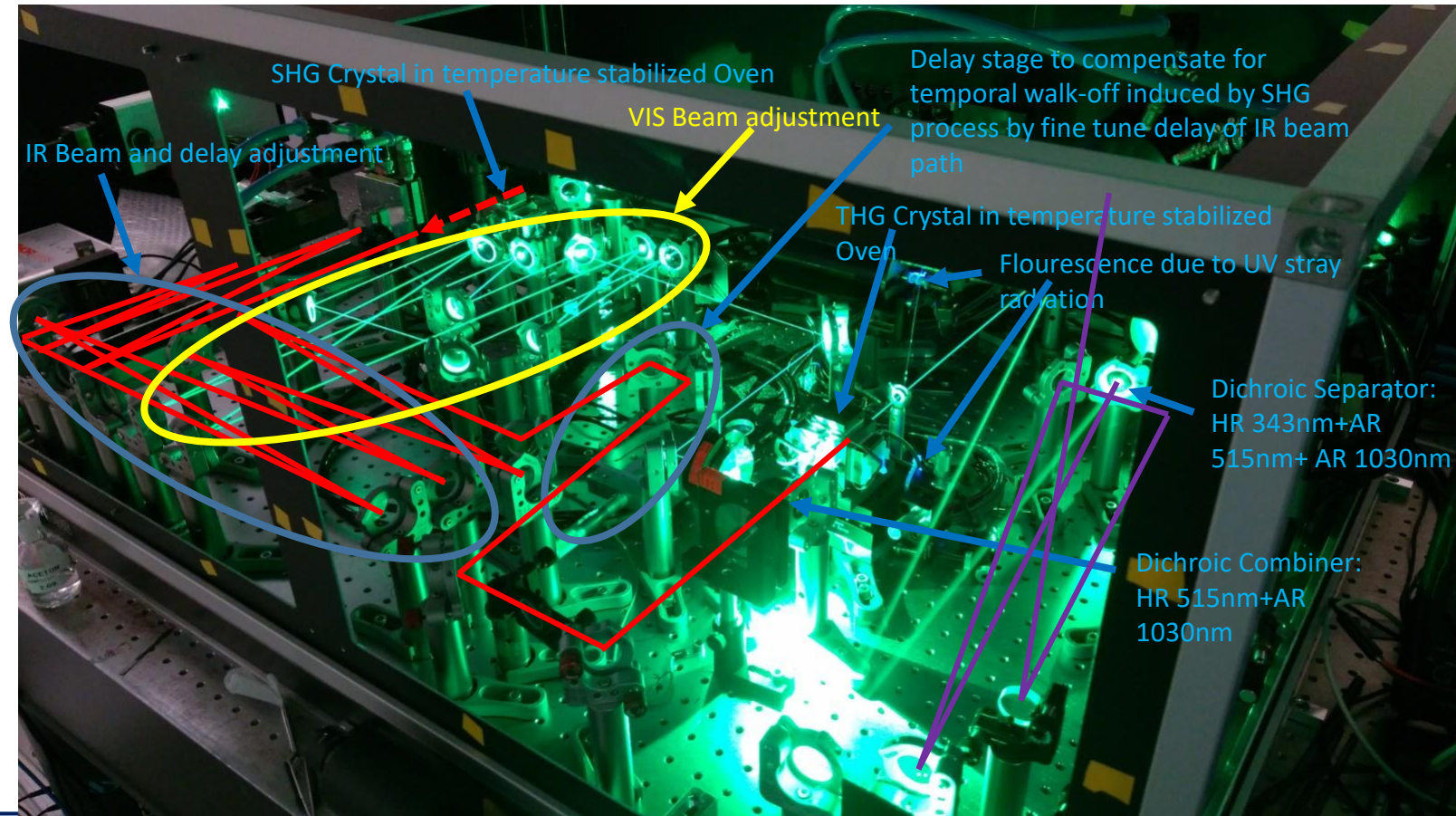
Setup for temporal walk-off compensation (I)



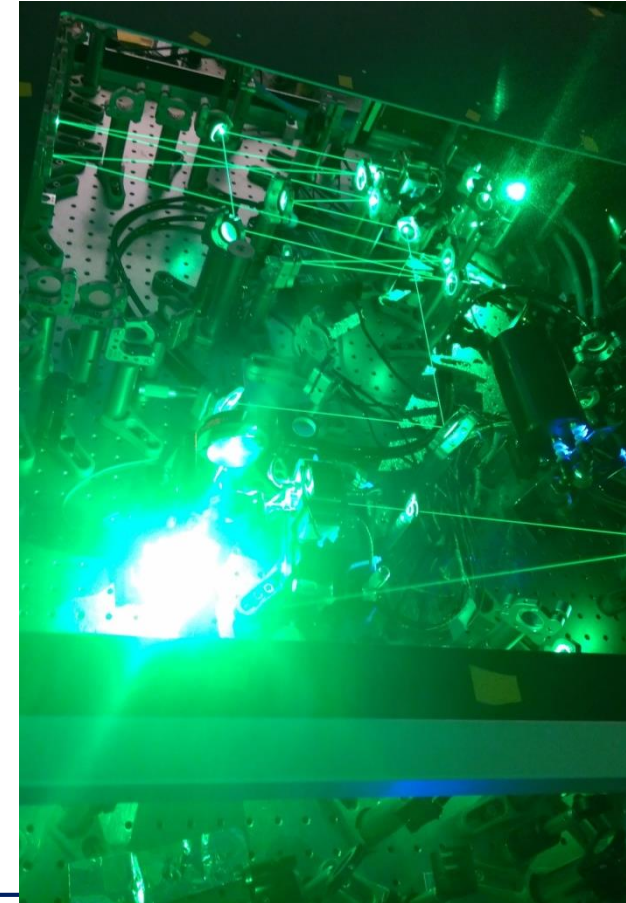
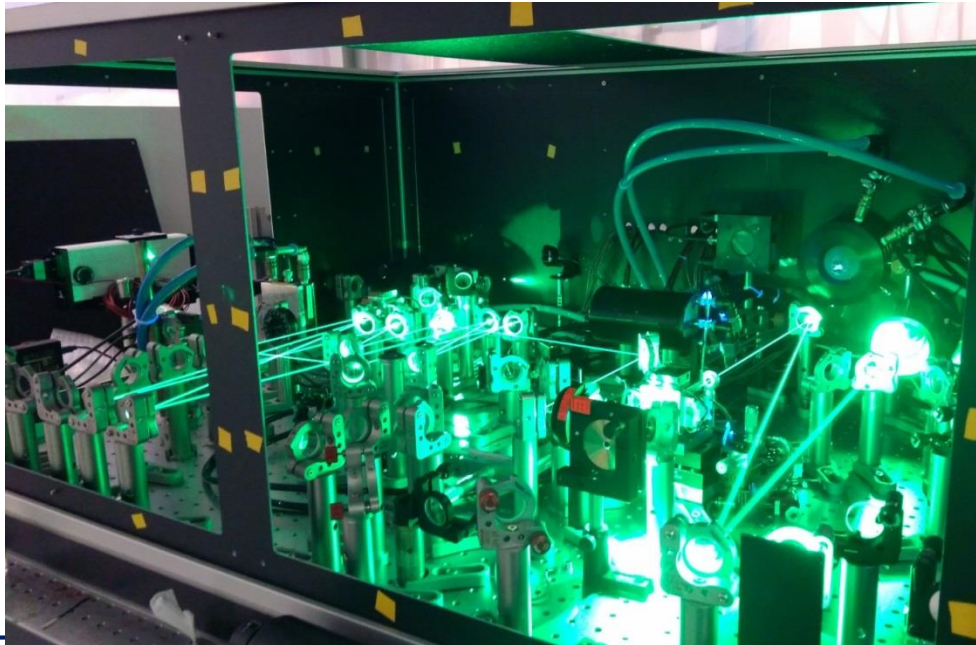
Cascaded setup (II)



Task 5.3 Frequency Conversion (USTUTT, AMP, completed): THG / physical implementation of Setup I

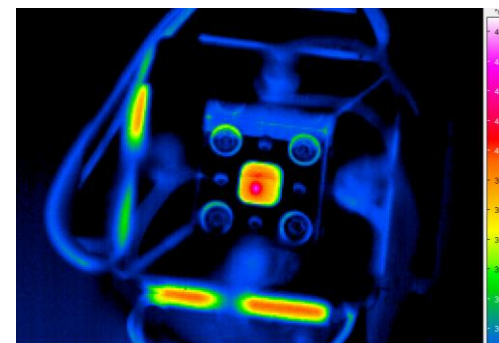
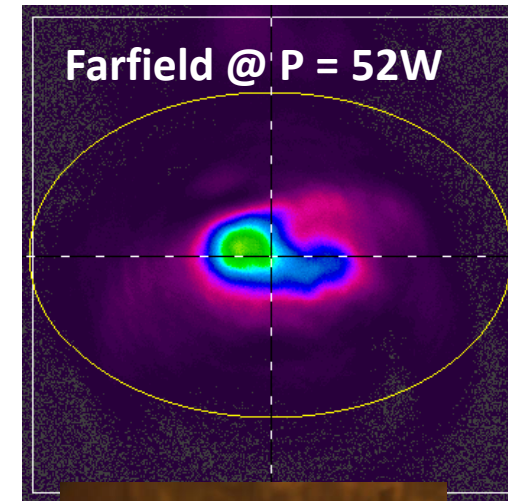
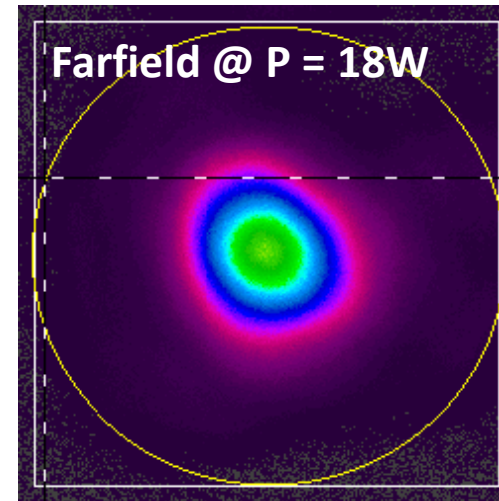


Task 5.3 Frequency Conversion (USTUTT, AMP, completed): THG / physical implementation of Setup I

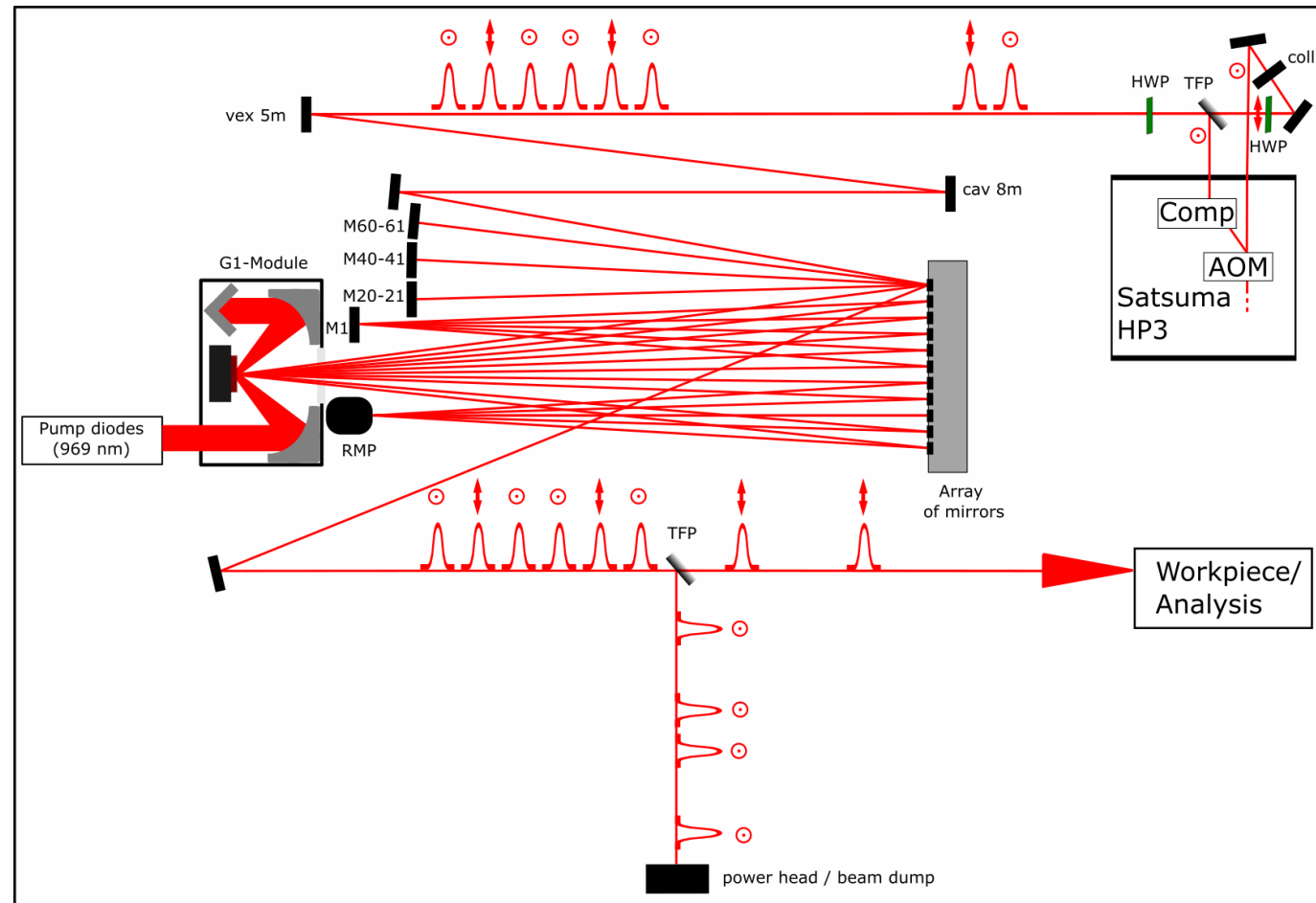


Task 5.3 Frequency Conversion (USTUTT, AMP, completed): THG / results (setup I)

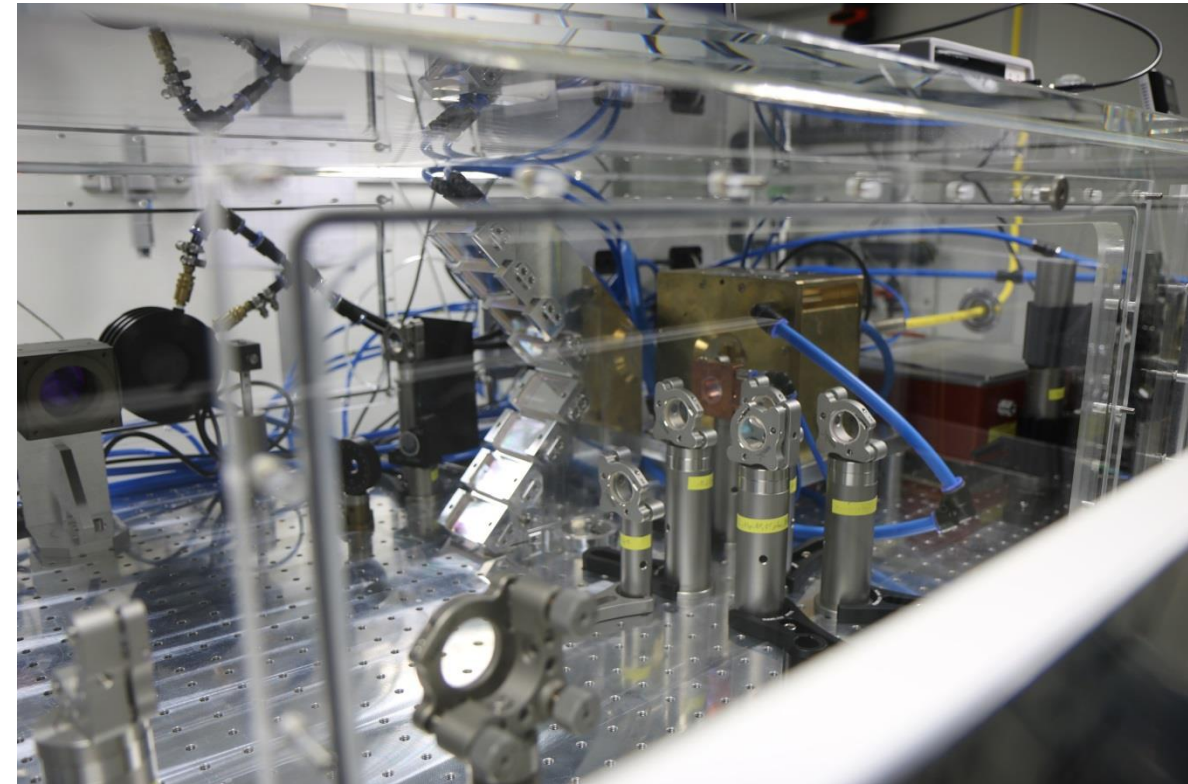
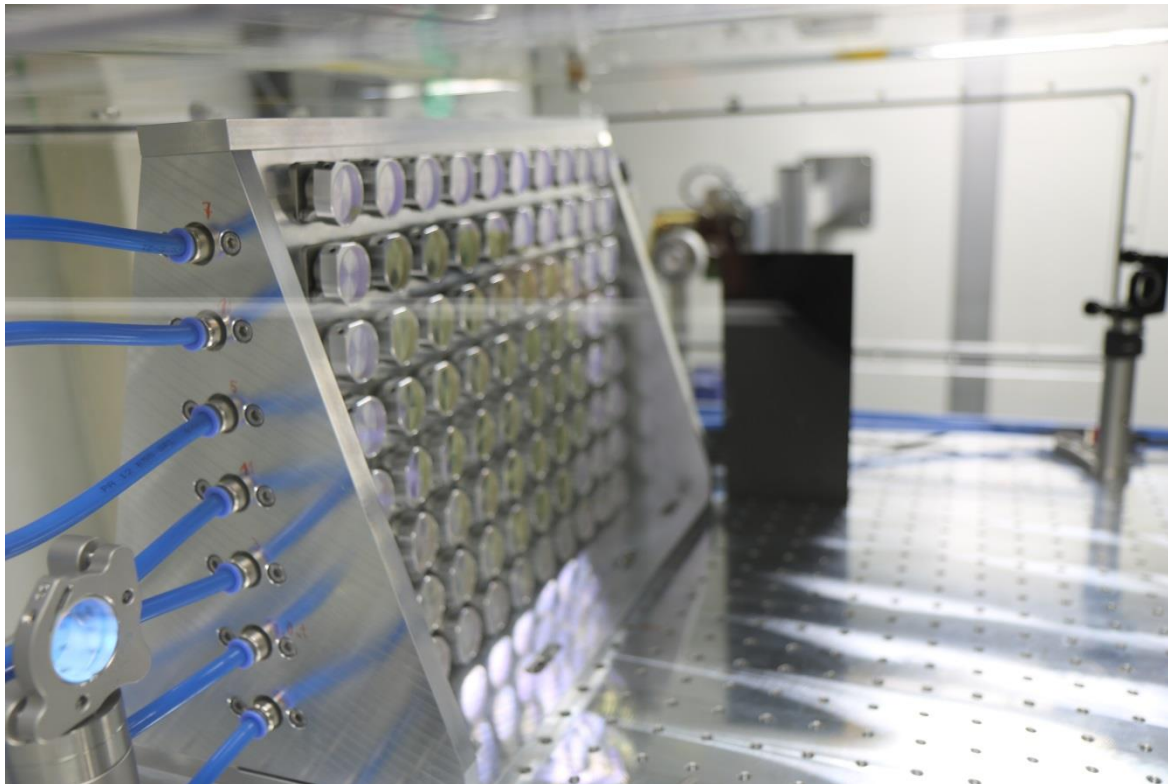
- **52 W @ 343 nm**, corresponding to **14.1 %** total conversion efficiency (IR->UV)
- Limited by damages of dichroic filters after SFG stage
 - Only IR Power up to 380 W out of the >500 W could be used
- 18 W: $M^2 < 1.3$
- 52 W: $M^2 < 2.2$
- Beam quality degradation due to thermally induced aberrations in SFG crystal



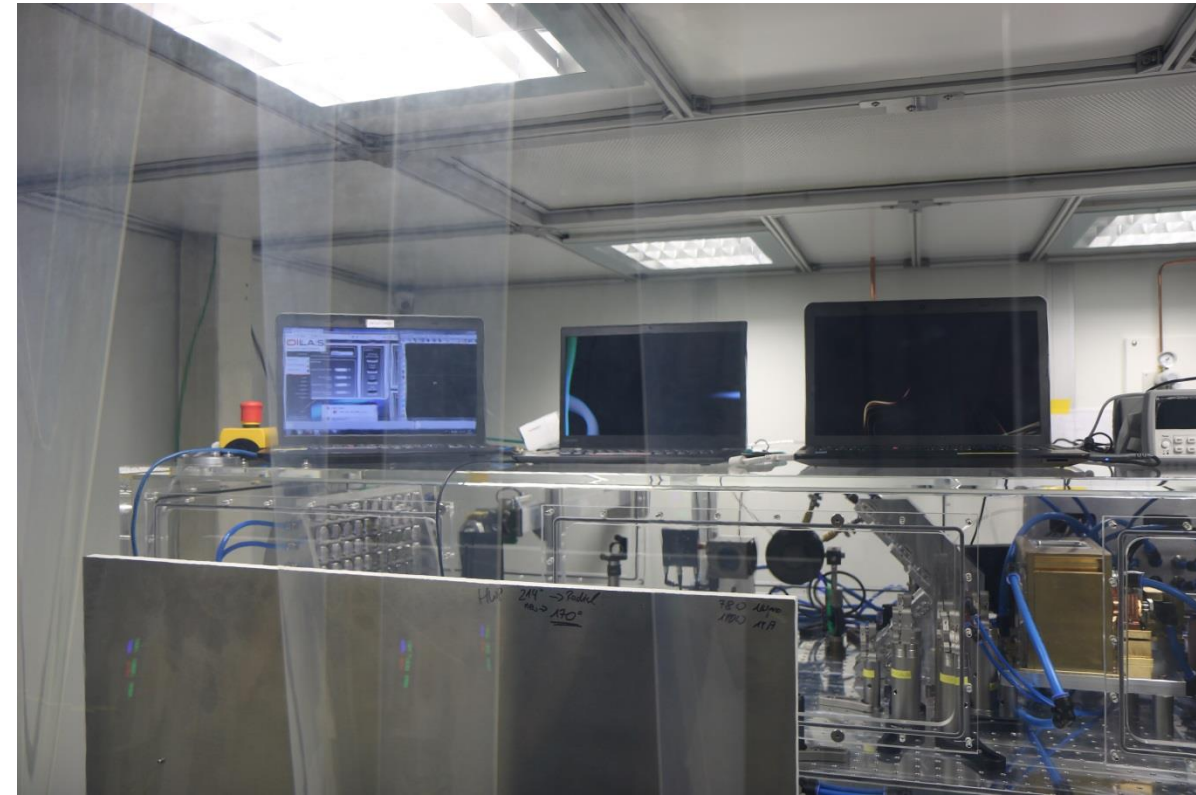
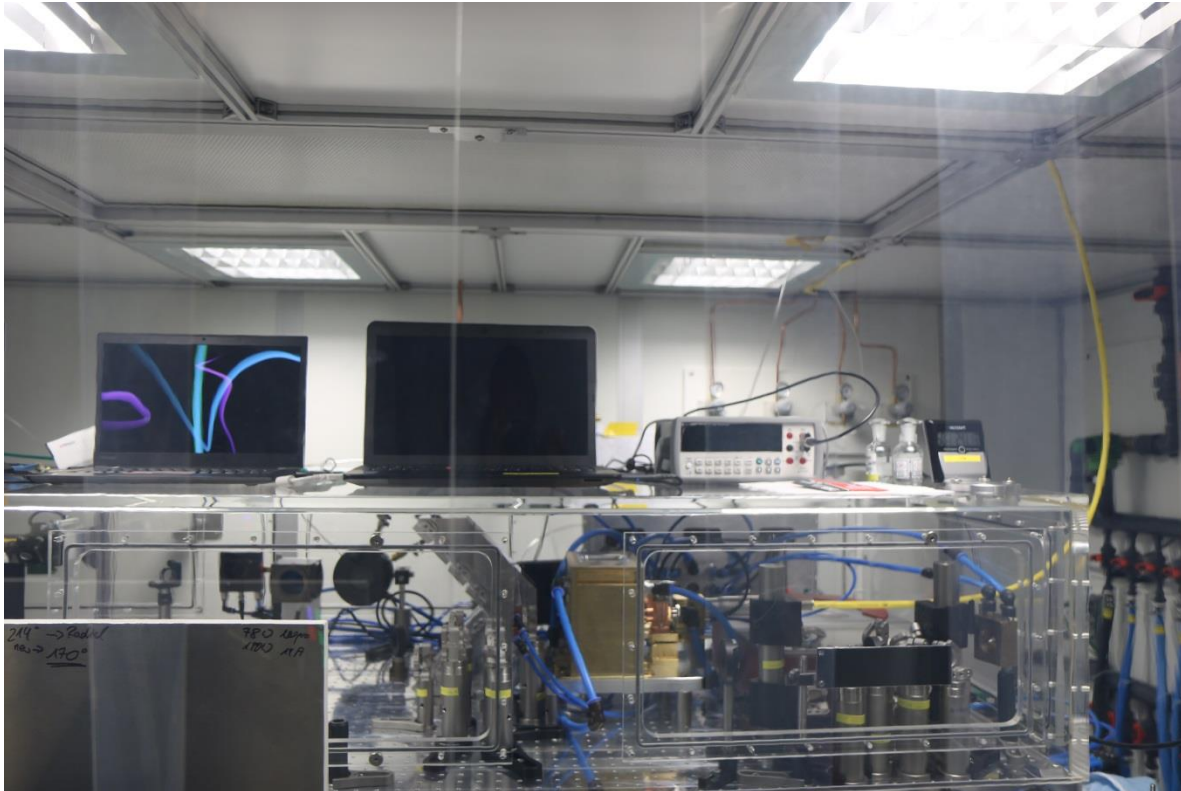
Task 5.4 Integration of TD-MPA (USTUTT, AMP, completed)



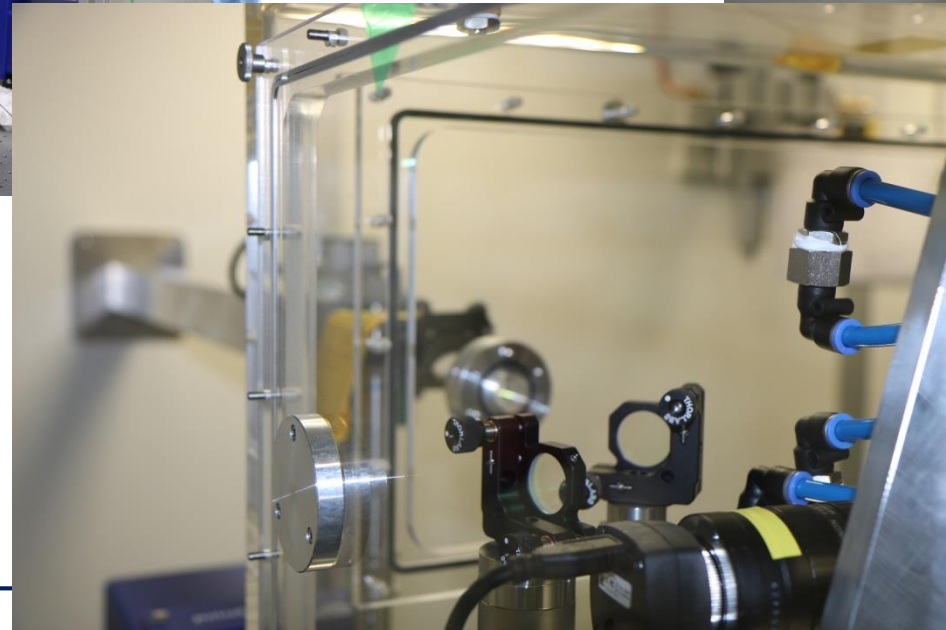
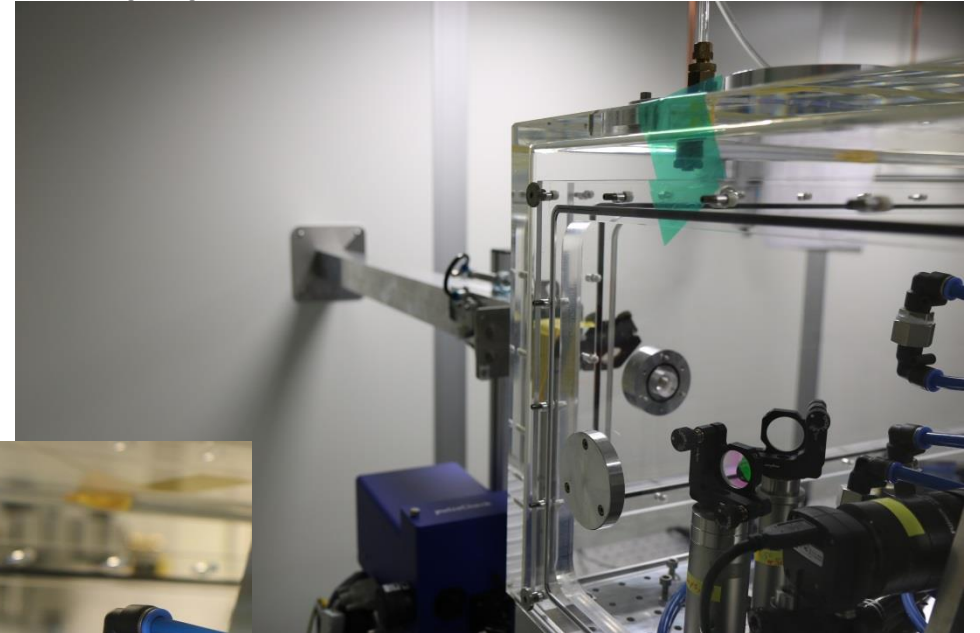
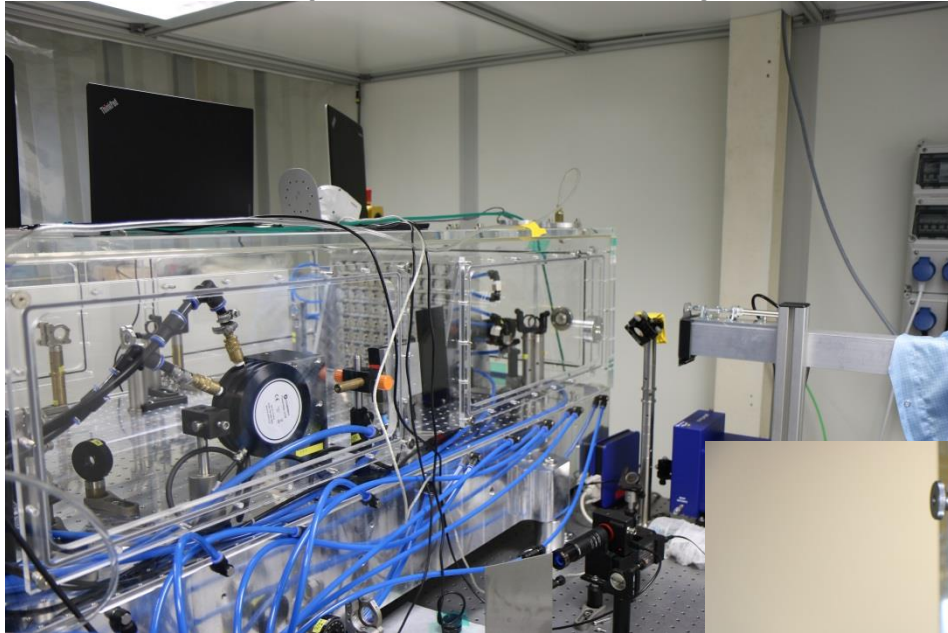
Physical implementation in application labs



Physical implementation in application labs

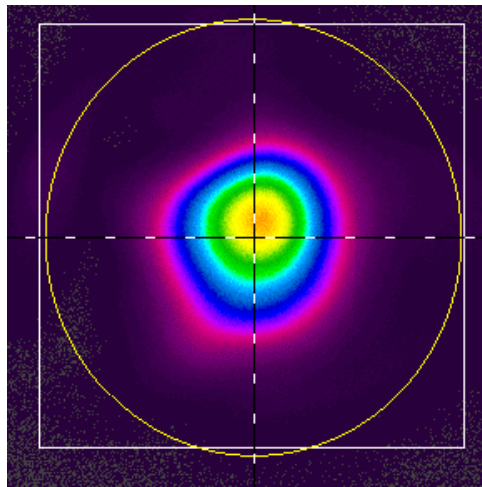


Physical implementation in application labs

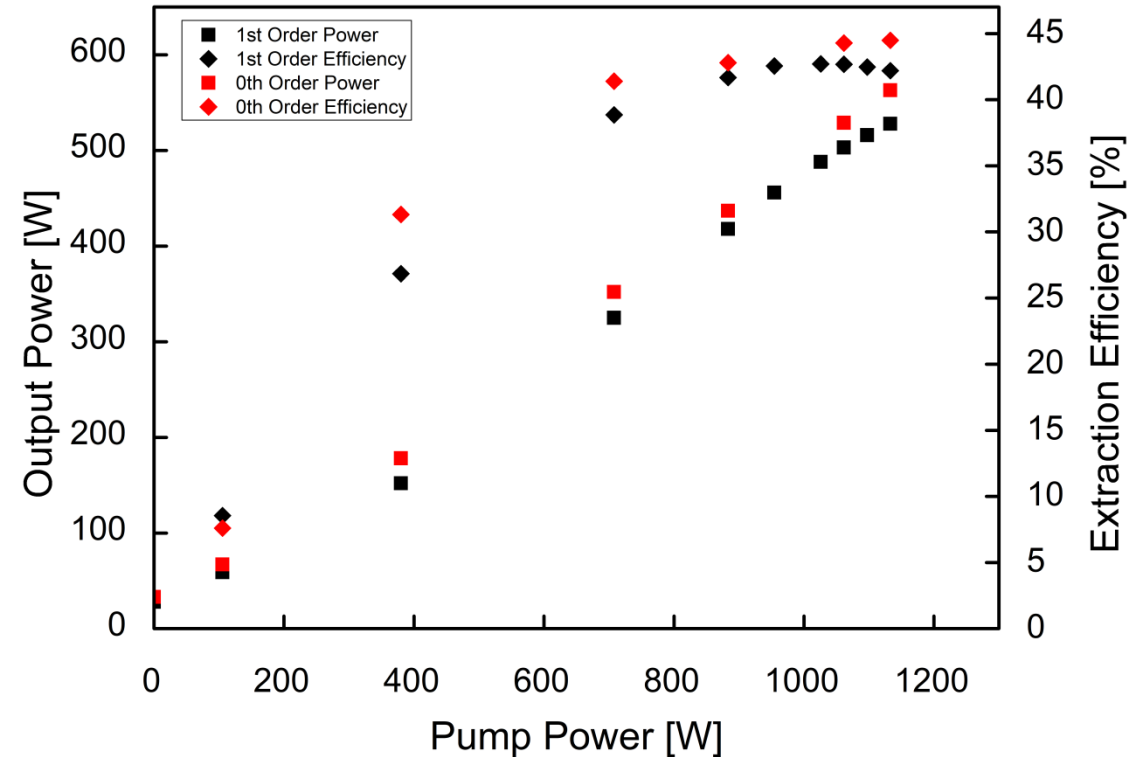


Laser experiments in application lab

- Seed power: 50 W (1 Order), 59 W (0 Order)
- $M^2 < 1.3$ at 514 W, 1.28 MHz repetition rate
- Extraction efficiency > 42%
- Pulse duration = 294 fs

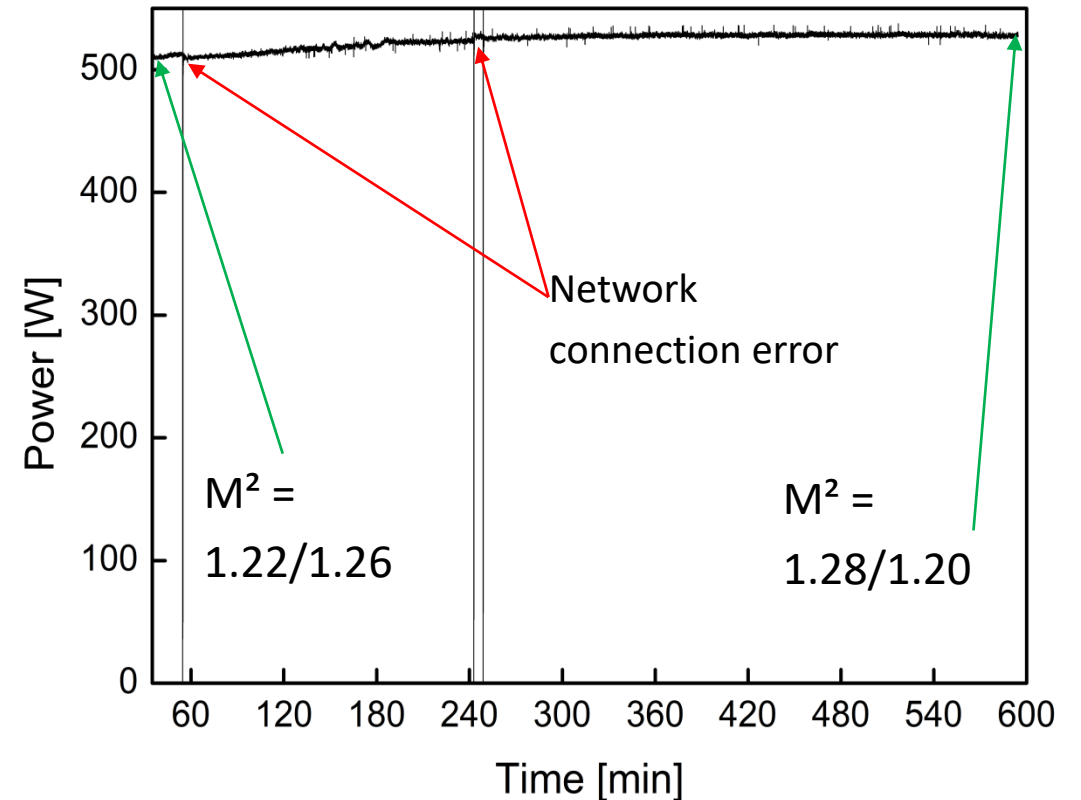


FF intensity distribution

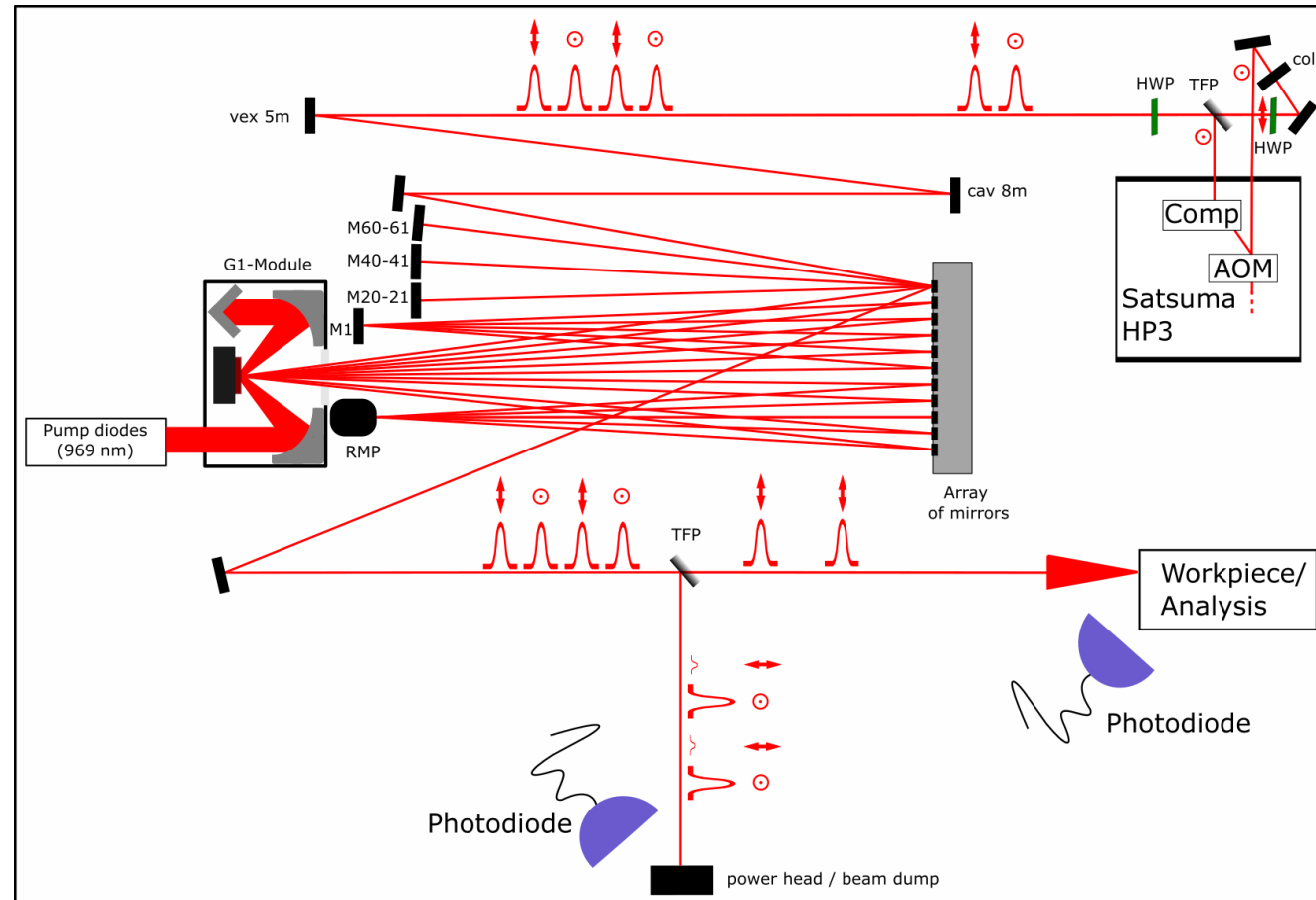


Laser experiments in application lab

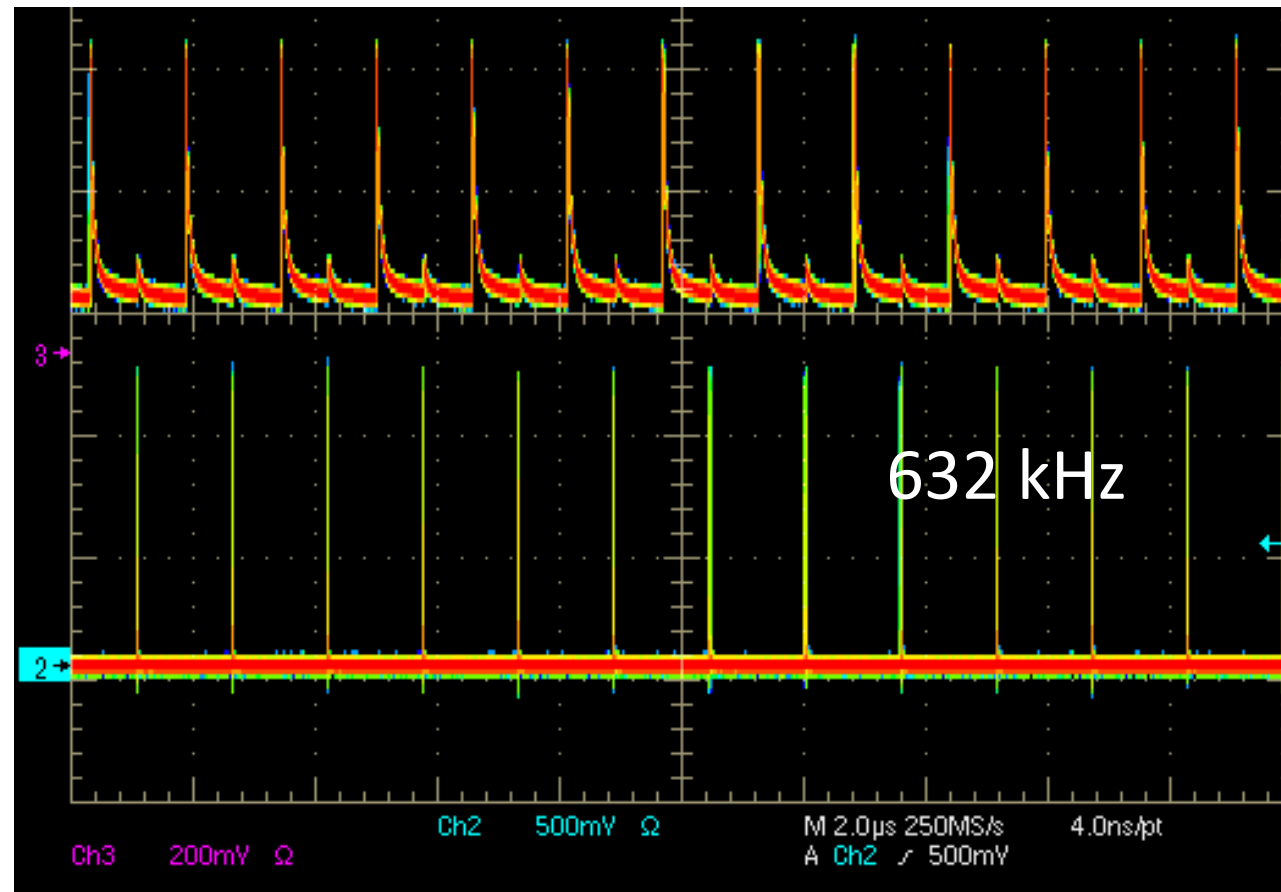
- Long term measurement
- Operation at ~528W
- $M^2 < 1.3$ before and after ~ 10 h operation
- RMS Power fluctuation: 1.1 W in a 120 min. time interval
- PV Power fluctuation: 17.6 W for a 120 min. time interval



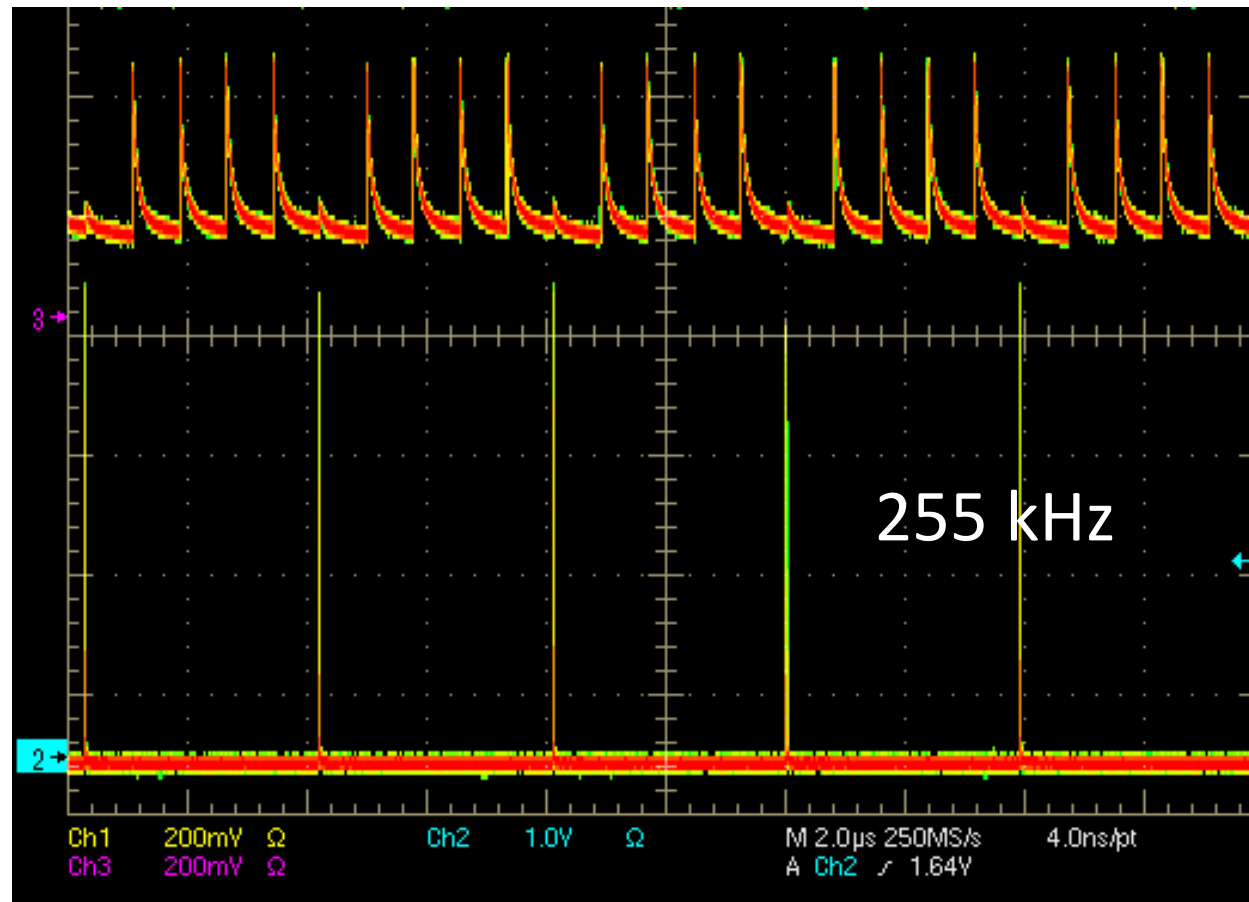
Laser experiments in application lab: test of the modulation scheme



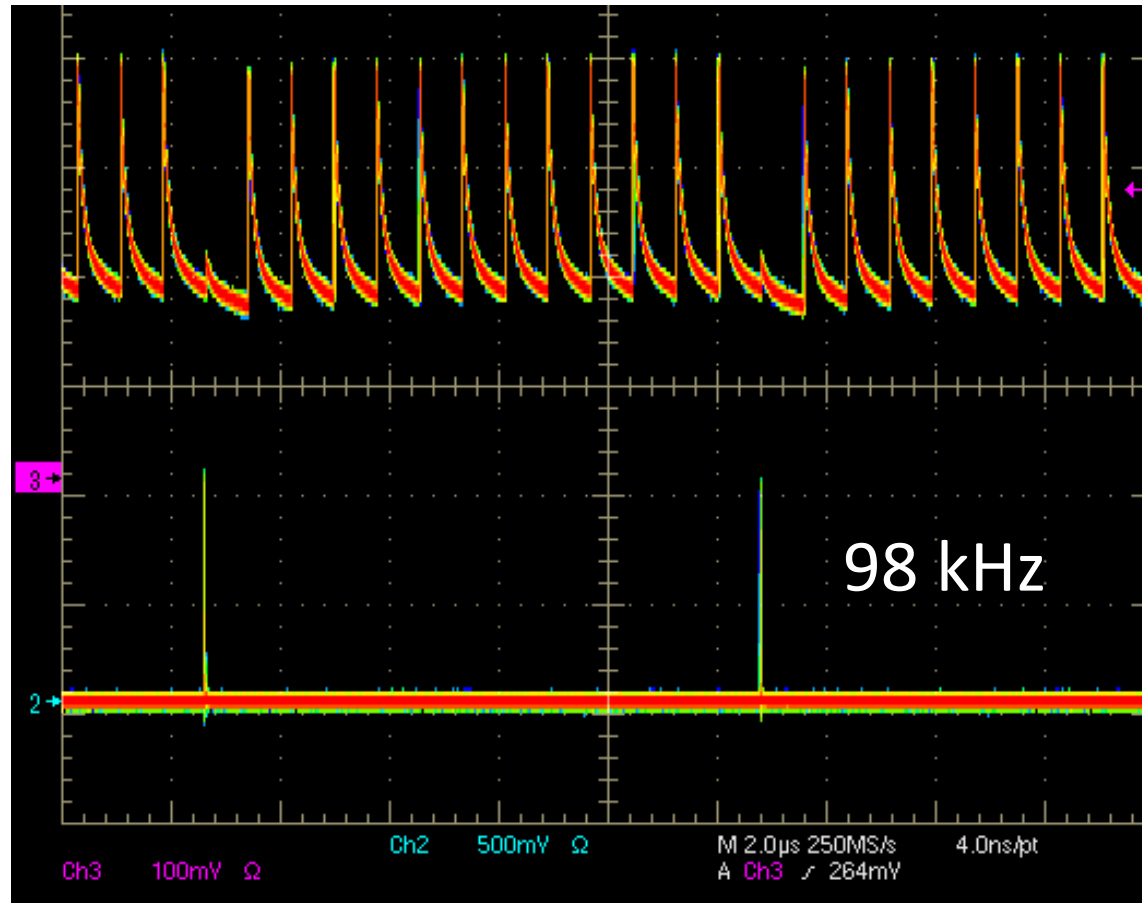
Laser experiments in application lab: test of the modulation scheme



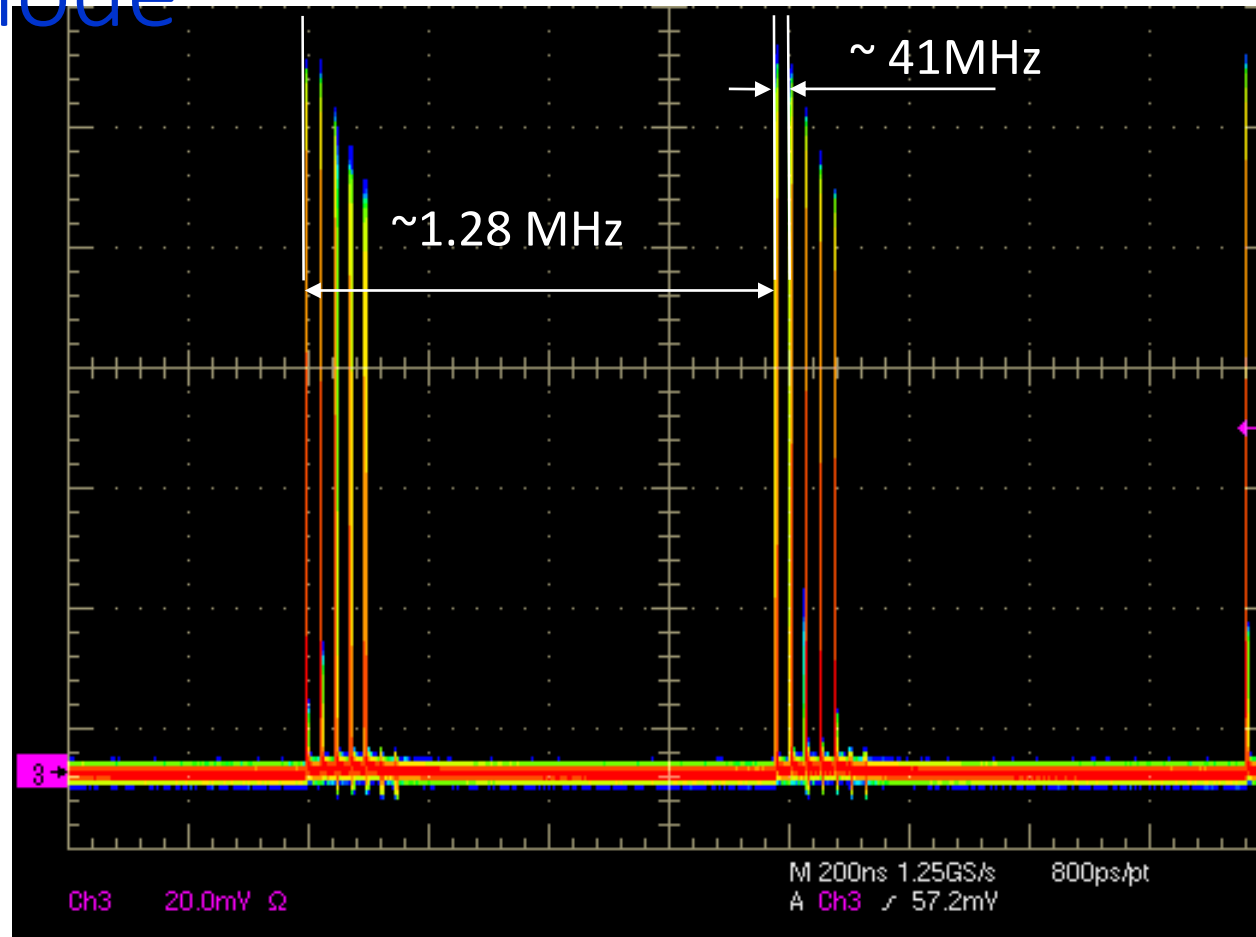
Laser experiments in application lab: test of the modulation scheme



Laser experiments in application lab: test of the modulation scheme



Laser experiments in application lab: test of the burst mode



Task 5.5 Demonstration of a 1kW, sub-1ps TD-MPA (USTUTT, AMP, **ongoing**)

„200W/150W“ to be installed on 09-11 October 2018!

- Will be used to seed the TD-MPA

WP5 - Deliverables

Deliverable title	Due date	Status
D5.1 Design of the multipass amplifier	M06 – July 2016	Approved
D5.2 Thin-disk multipass amplifier with 500 W, 1 MHz, sub-500 fs	M22- November 2017	Submitted M23-December
D5.3 Demonstration of 200W green and 100W UV laser beams at 1MHz and sub-500 fs pulse	M28- May 2018	Submitted M30- June 2018
D5.4 Thin-disk multipass amplifier with 1000W, >=1MHz, sub-1ps	M38- March 2019	Not yet submitted, work ongoing

WP5 - Milestones

Milestone title	Due date	Status
MS24 Thin-disk multipass amplifier with 500 W, 1 MHz, sub-500 fs	M22	Achieved
MS36 Demonstration of 200W green and 100W UV laser beams at 1MHz and sub-500 fs pulse	M28	“Achieved for the 200W green and partially achieved for the 100W UV
MS43 Thin-disk multipass amplifier with 1000W, >=1MHz, sub-1ps	M38	Not yet achieved