

WP 6 System Development & WP 7 Demonstrators

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Work Package 6

- HIPERDIAS system tasks:
 - Define interfaces and system features
 - Integrate all relevant components
 - Develop beam path and delivery systems

- Work package objectives:
 - Proof of concept
 - Develop demonstrator platforms
 - Demonstrate value added to industry

Partners involved:



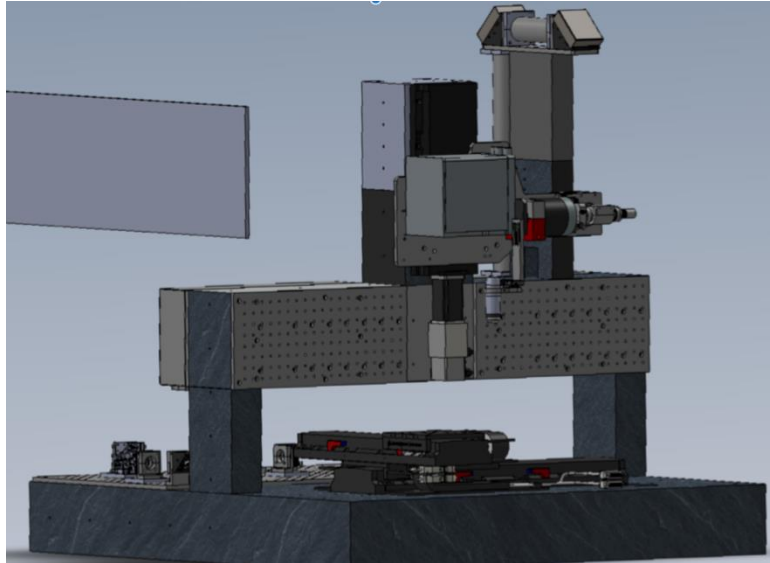
Description of Work

- **Task 6.1** *Definition of interfaces* (LASEA; AMP, C4L, BOSCH, E6)
 - Analysis and development of interface requirements outlined in **D1.4** (Definition of software – technical interface).
 - **Continuous process**, developed over the course of WP6.
- **Task 6.2** *Definition of laser & optics sizes; optics specifications* (USTUTT; AMP, C4L, LASEA, GLO)
 - Design of beam path.
 - **Continuous process**, developed over the course of WP6.
- **Task 6.3** *Development of interfaces* (C4L; LASEA)
 - Interfacing controls.

Description of Work

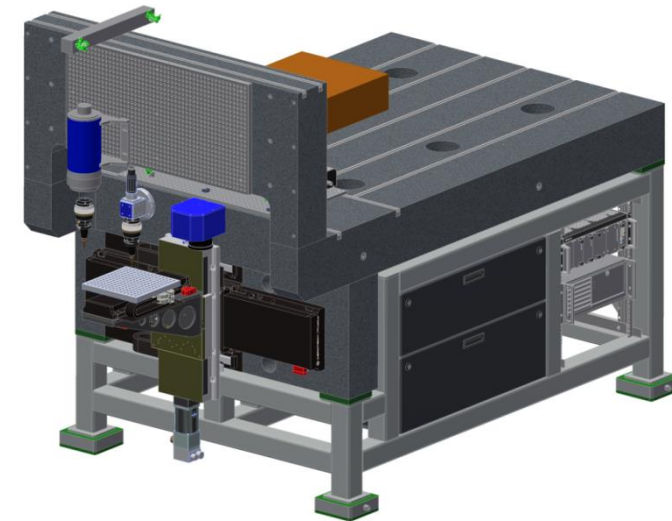
- **Task 6.4** *System layout and build-up* (C4L; USTUTT, AMP, LASEA)
 - Build-up of **machining system**.
 - Integration of all components relevant for machining system.
- **Task 6.5** *Integration of laser and optics* (C4L; USTUTT, AMP, LASEA)
 - Integration of all components relevant for **beam delivery**.
- **Task 6.6** *Test and evaluation* (LASEA; USTUTT, AMP, C4L, BOSCH, E6)
 - Testing and validation of both systems.
 - **Full characterisation** of systems.

Work Package 6 – Systems overview



Demonstrator 1 (500W) – Lasea

- 500 W Laser
- Installation at IFSW (DE)
- Application areas:
 - 3D Processing Silicon



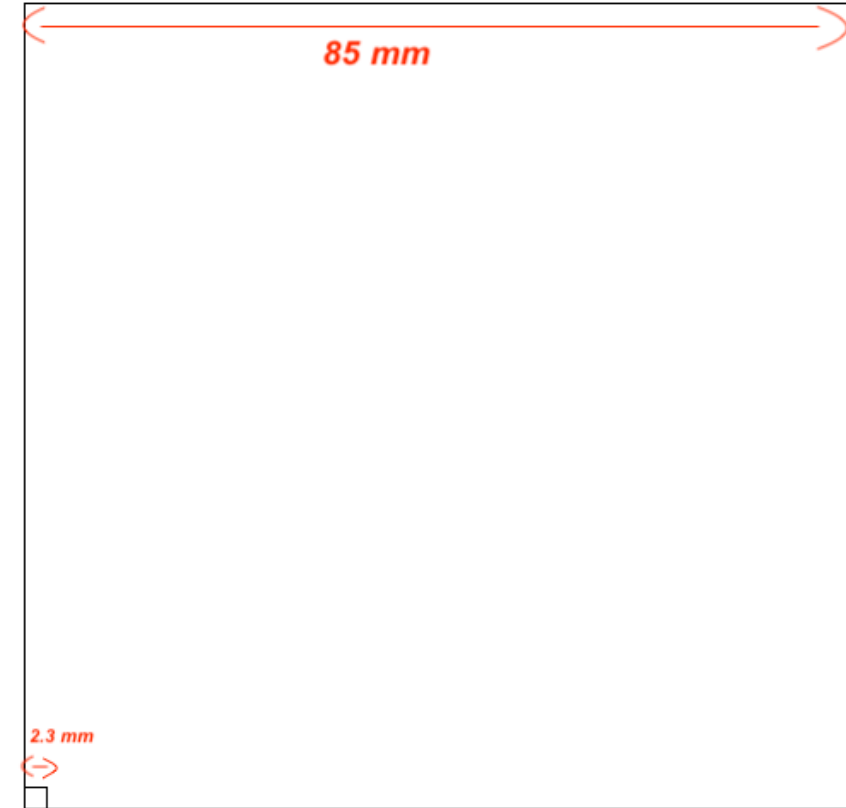
Demonstrator 2 (200W) – C4L

- 200 W Laser
- Installation at C4L (CH)
- Application areas:
 - Fine cutting of metals
 - Diamond ablation

Demonstrator 2 – Highlights

Beam deflection: Intelliscan 14
 Varioscan_{de} 20i

- 3 Axis system	167mm	32mm
- X	85 mm	2.3 mm
- Y	85 mm	2.3 mm
- Z	64 mm	64 mm



Lens	OCT (870nm)	Max spot size*	Min spot size*
32mm	Compatible	160µm	40µm
167mm	Compatible	30µm	7.6µm

* Enabled by beam expansion; 1-4x

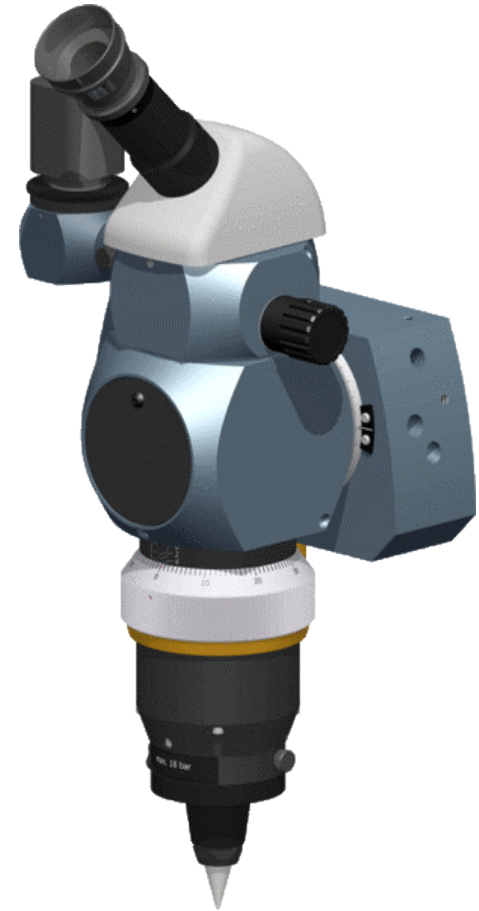
Demonstrator 2 – Highlights

Working heads : Cutting head (C4L design)

Trepanning optic

Vision System : C4L Starfighter

- Trepanning limited to 300RPM, Manual alignment
- Gas assisted cutting up to 20bar
- Software options
- OCT X, Y resolution <math><10 \mu\text{m}</math>, 70kHz scan rate

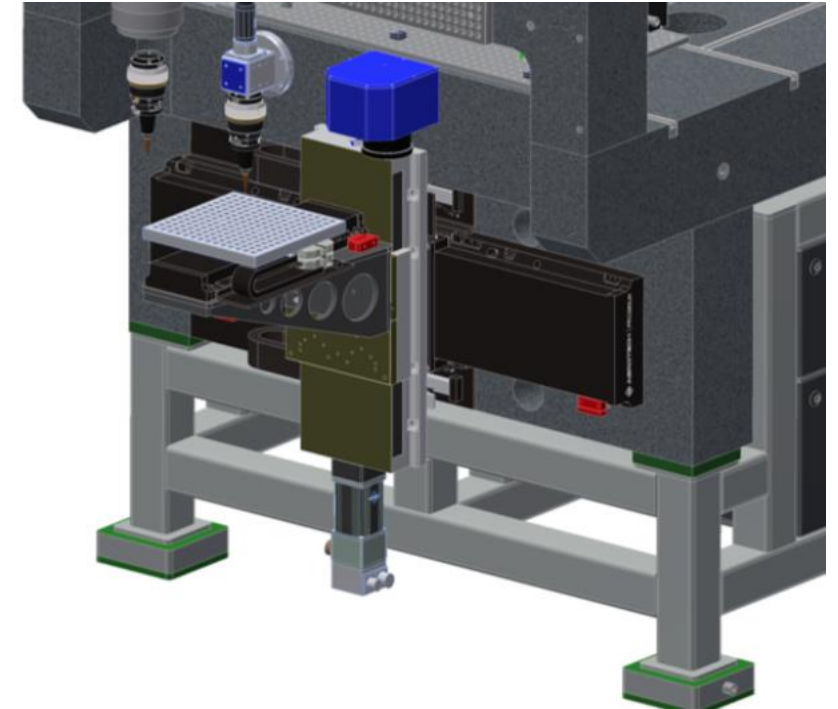


Demonstrator 2 – Highlights

Axes & mounting: 3 Axis Aerotech system
Erowa Mounting plate

- X, Y; max speed 2000 mm.s^{-1} , Z: 250 mm.s^{-1}
Overall repeatability $<1 \mu\text{m}$
- Mounting plate: Erowa repeatability $1 \mu\text{m}$

- Gas assisted cutting up to 20bar
- Software options



Task	Completed	On Going	Task status
6.1 Definition of Interfaces	D6.1: Definition of interfaces	D6.4: Integration of laser and optics	On Going
6.2 Definition of laser & optics sizes; optics specifications	D6.2: Definition of optics constraints	D6.4: Integration of laser and optics D6.5: System build-up	On Going
6.3 Development of the interfaces	D6.1: Definition of interfaces D6.3: System layout	D6.5: System build-up	On Going
6.4 System layout and build-up	D6.2: Definition of optics constraints D6.3: System layout	D6.5: System build-up	On Going
6.5 System build-up		D6.4: Integration of laser and optics D6.5: System build-up	On Going
6.6 Test and evaluation			Not yet started

Demonstrator 2 – Task 6.5 *System build-up*

Task	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31
Granite	<i>(Delivered M15)</i>											
Axes	<i>(Delivered M13)</i>											
Scanner	November (End)											
OCT Vision System	July (Mid)											
Housing & Shielding	May (Mid)											
Beam Deflection	November (End)											
Varioscan	April (Mid)											
Laser Delivery	May (Mid)											
Laser Integration	July (Mid)											
Fiber Integration	July (Mid-Late)											

WP 6 – Deliverables

Deliverable	Due Date	Status	Updated Schedule
D6.1 Definition of interfaces	21 January 2017	✓	
D6.2 Definition of optics constraints	20 April 2017	✓	
D6.3 System layout	20 June 2017	✓	
D6.4 Integration of laser and optics	21 January 2018	✗	Late July 2018
D6.5 System build-up	31 January 2019	On Schedule	
D6.6 System tested and validated	21 July 2019	On Schedule	

WP 6 – Milestones

Milestone	Due Date	Status
M7.1 Assessment of the 500W laser system design	M24 – January 2018	✗
M7.2 Assessment of the 200W laser system design	M24 – January 2018	
M7.3 Full characterisation of the performance of the 500W laser system for 3D-Si processing	M42 – July 2019	✗
M7.4 Full characterisation of the performance of the 500W laser system for fine cutting metals and diamond processing	M42– July 2019	✗
M7.5 Full characterisation of the performance of the 1000W laser system for the fine cutting metals and diamond processing	M42 – July 2019	✗

Description of Work

- **Task 7.2** *200W Laser source integration* (C4L, AMP)
 - Integration and of laser with system developed in WP6. Optomization, Synchronization and Evaluation.
 - **Task begins when laser arrives.**
- **Task 7.3** *Integration of the optical fibre* (GLO; USTUTT, AMP, C4L, LASEA)
 - Implementation and testing of fiber modules.
 - **Task begins after laser integration is complete.**
- **Task 6.4** *Process analysis on reference samples* (E6, C4L)
 - Test and evaluation of process
 - **Task begins after laser integration is complete**

Demonstrator 1 : 500W system



Demonstrator 1 (500W) – Lasea

- 500 W Laser
- Installation at IFSW (DE)
- Application areas:
 - 3D Processing Silicon



Description of Work

- **Task 6.4** *System layout and build-up* (C4L; USTUTT, AMP, LASEA)
 - Build-up of **machining system**.
 - Integration of all components relevant for machining system.
 - Coming work
 - RTC board to be upgraded ? (RTC6 commercialized during 2017 may help the synchronization)

- **Task 6.5** *Integration of laser and optics* (C4L; USTUTT, AMP, LASEA)
 - Integration of all components relevant for **beam delivery**.
 - Remaining work:
 - IFSW's laser to connect
 - Alignment

Description of Work

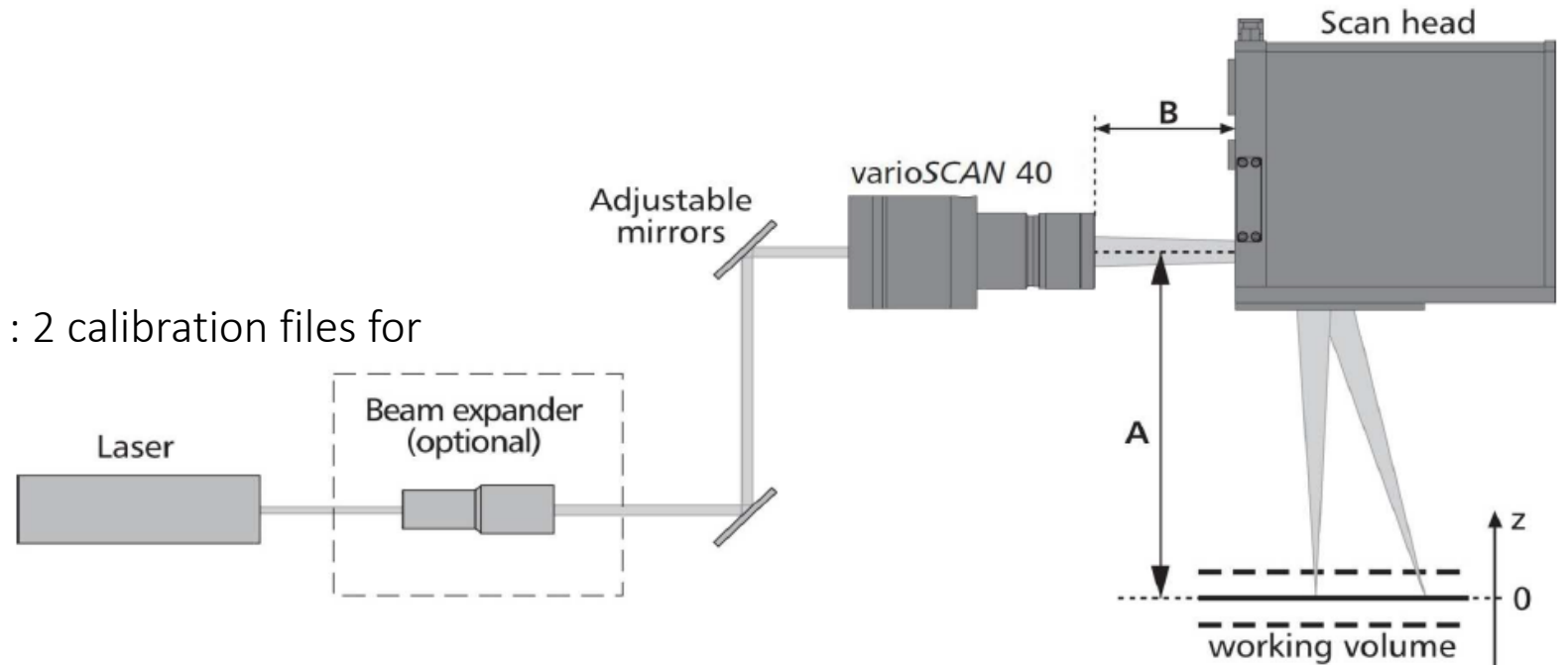
- **Task 6.6** *Test and evaluation* (LASEA; USTUTT, AMP, C4L, BOSCH, E6)
 - Testing and validation of both systems.
 - **Full characterisation** of systems.
 - Could not be done at LASEA, will have to be done at IFSW

Description of the 500W system

- Components in the machine:
 - Deflecting unit : Scanlab Intelliscan 30 + Varioscans40i (focusing before scanner)
 - Autoalignment system : TEM-MESSTECHNIK Aligna
 - Beam expander : low magnification (x2, X4) because of the size of the beam
 - Safety enclosure : made of steel, 1.5mm thick, to protect from eventual X-rays generation
 - Spatial beam shaping : phase blade to make a top-hat shaped spot at focus (first time use, to be tested)
 - Fiber connection: will replace the last mirror before the focusing

Description of the 500W system

- Deflecting unit : Scanlab Head intelliscan 30de + varioSCAN 40i
- Field of view : $\sim 310 \times 310 \text{ mm}^2$
- No ghost
- Focusing done with the varioSCAN : 2 calibration files for $F=275\text{mm}$ and $F=320\text{mm}$



Description of the 500W system

- Deflecting unit :

Focal length (mm)	Max speed (m/s)	Beam diameter (mm)	Expected spot size (µm)
275	9	5	87
		10	45
		15	30
320	13	5	100
		10	50
		15	34
400 (lens)	20	5	135
		10	65
		15	45

Not recommended, risk of damaging mirrors

→ May be possible to get a third calibration file from scanlab for a longer focal length

Description of the 500W system

- Deflecting unit :

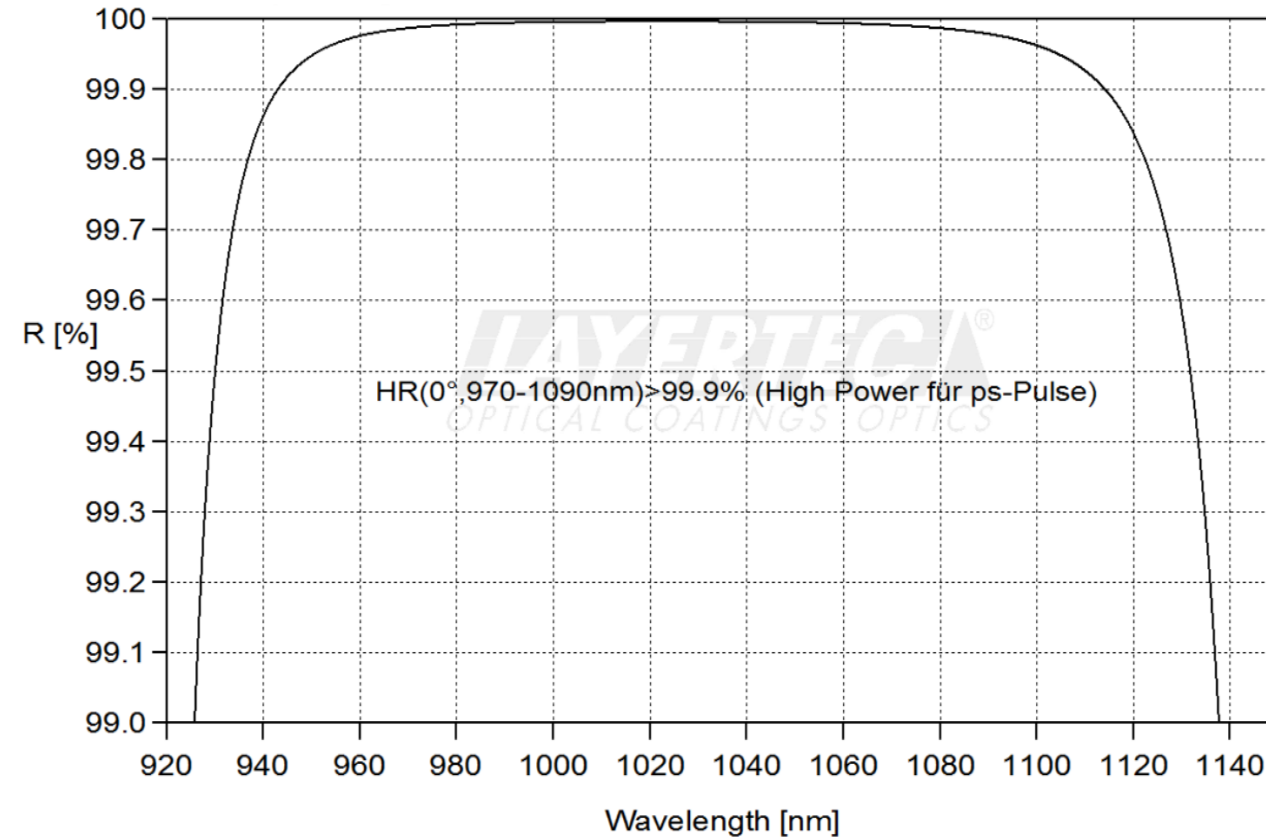
	Max power density (W/cm ²)	Damage Threshold (J/cm ²)	Max average power (W)
Intelliscan 30	1000	5	2000
Varioscan 40	NA	NA	1000

@1064nm, 10ns → Estimated LIDT for 300 fs : **27 mJ/cm²**
 Highest Input beam peak fluence for 5 mm beam, 1mJ per pulse: **10 mJ/cm²**

→ **Theoretically** below the lowest threshold damage

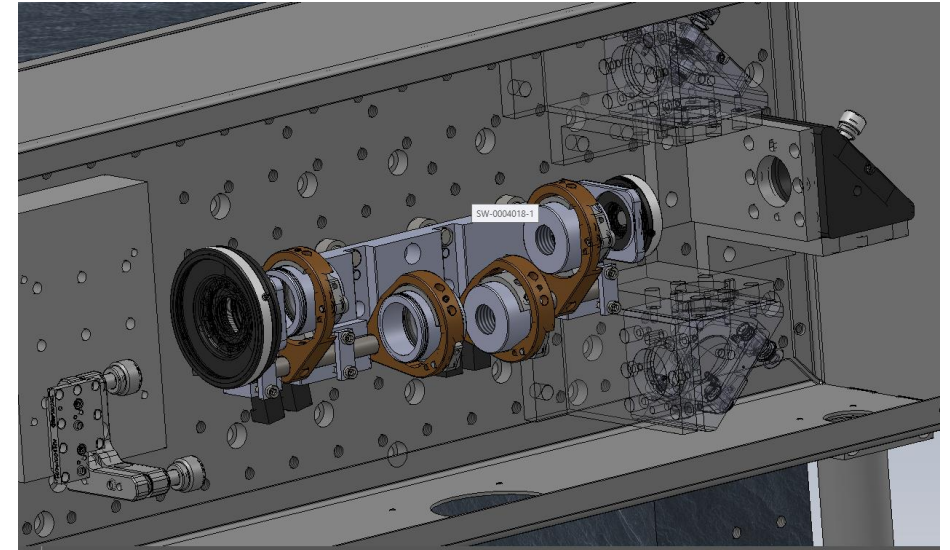
Description of the 500W system

- Mirrors:
 - Reflectivity $> 99.9\%$
 - LIDT (calculated for 400 fs) :
400 mJ/cm²
 - Calculated Peak laser fluence
4mm beam, 1mJ \rightarrow : 15 mJ/cm²



Description of the 500W system

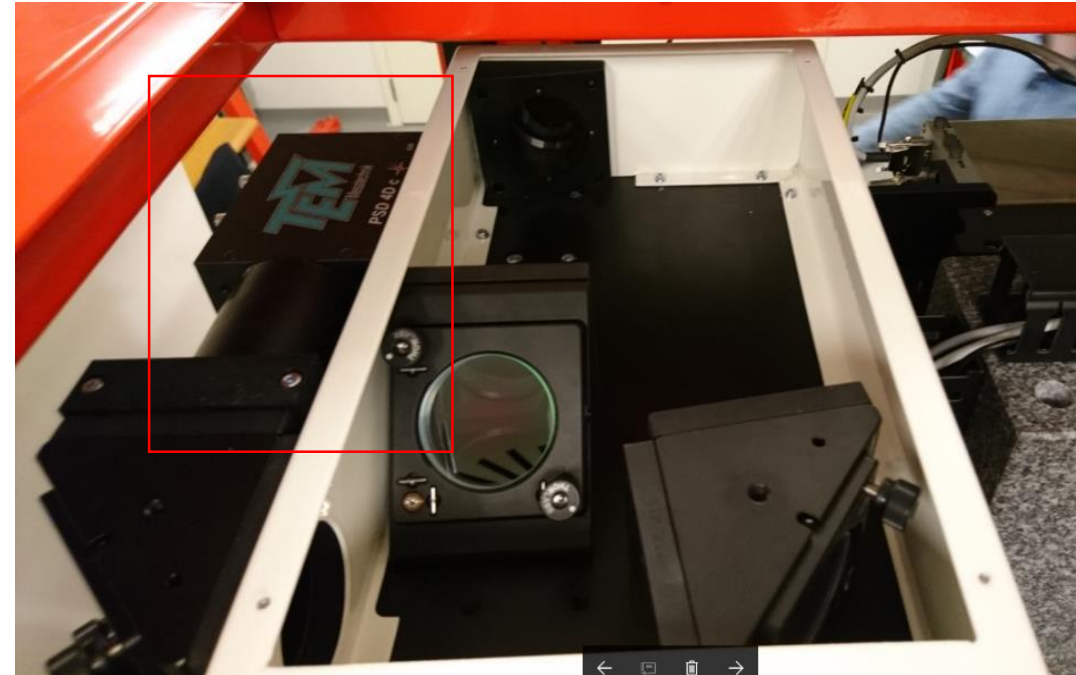
- Beam expander :
 - Integrated in the CAD
 - Currently being mounted in the machine
 - 5 possible magnifications : x1 – x4



MAGNIFICATIONS	Lenses			
	L1 (-50 mm)	L2 (-100 mm)	L3 (150 mm)	L4 (200 mm)
x 1				
x 1,5		X	X	
x 2		X		X
x 3	X		X	
x 4	X			X

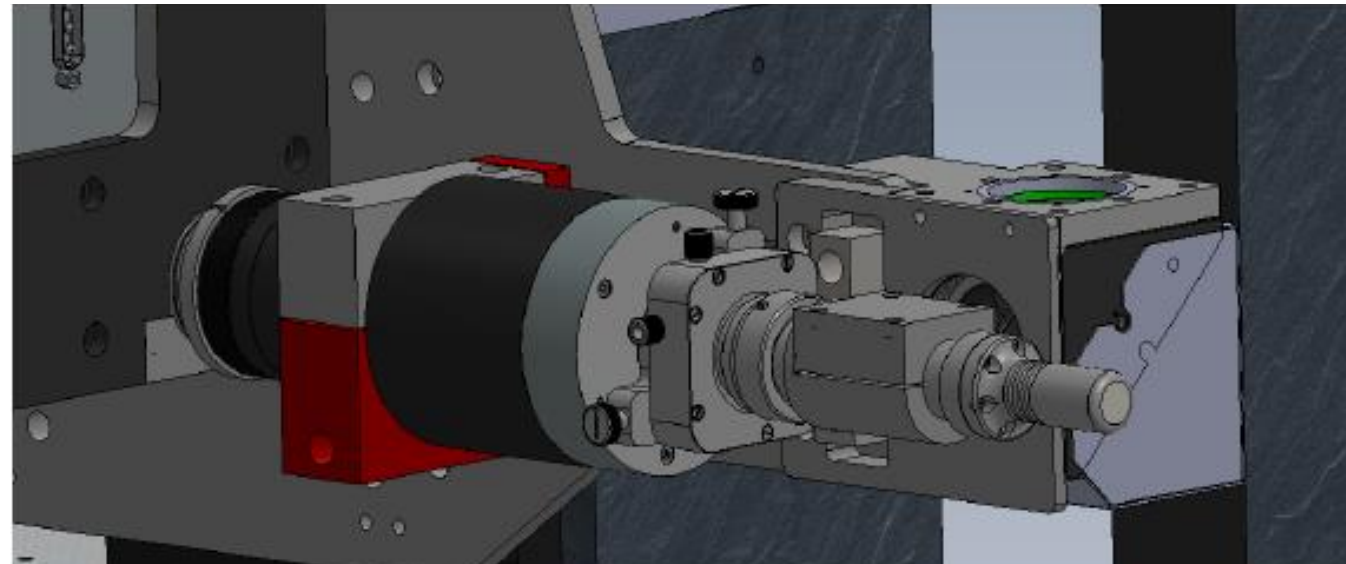
Description of the 500W system

- Autoalignment :
 - **WARNING** : maximum 10mW on the sensor !



Description of the 500W system

- Fiber connection:
 - Integrated in the CAD
 - Integrated in the machine



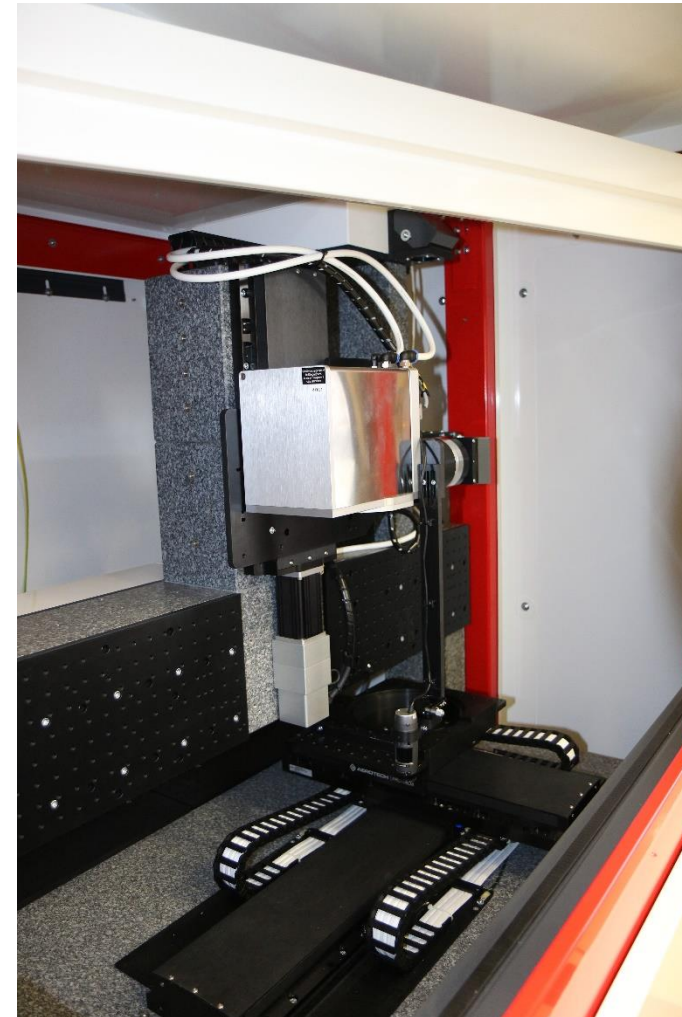
WP6 : System development (1000W LASEA)

WP6	System development				
Tasks	Title	Status	Deliverable	Due date	Status
6.1	definition of interfaces	finished	D6.1	M12	Sent. To review ?
6.2	Definition of laser & optics specs.	finished	D6.2		
6.3	Development of the interfaces	finished			
6.4	System layout and buildup	on going	D6.3	M17	sent
			D6.5	M36	on going
6.5	Integration of laser and optics	on going	D6.4	M24	« OTHER » (?) Delayed ?
6.6	Test and validation	on going	D6.6	M42	on going

Description of Work

- **Task 7.1** *500W Laser source integration* (LASEA; USTUTT, AMP)
 - Laser prototype to be implemented in the station developed by LASEA
 - Optimisation of the optical path
 - Tests of communication and synchronization
 - Coming work:
 - Optimisation of the beam path
 - Adaptation of optics and design for the autoalignment sensor (high power)
 - **Machine installed at IFSW**

T7.1: Machine installed at IFSW



Next steps

- **Task 7.3** *Integration of the optical fiber* (GLO; USTUTT, AMP, C4L, LASEA)
 - Fiber to be implemented and tested on the different machines
 - Remaining work:
 - ???
 - **D7.4: Testing of the optical fiber → M28 → will be delayed !**
 - Firstly implemented on the demonstrator 2 → M30
 - Then to implement on the demonstrator 1

Next steps

- **Task 7.4** *Processes analysis on reference samples*
 - Process strategy for 3D Si processing will be tested and adjusted
 - Validation tests to demonstrate the assessment of the process
- **Task 7.5** *Data handling and management* (LASEA; C4L)
 - Documentation and handling of all relevant info for controls.
 - **Continuous process beginning after laser integration is complete.**
- **Task 7.6** *Upgrade of 500W system to the 1000W system* (LASEA;USTUTT,AMP, C4L)
 - Upscaling and evaluation.

Milestone	Due Date	Status
M7.1 Assessment of the 500W laser system design	M24 – January 2018	✗
M7.2 Assessment of the 200W laser system design	M24 – January 2018	
M7.3 Full <u>characterisation</u> of the performance of the 500W laser system for 3D-Si processing	M42 – July 2019	✗
M7.4 Full <u>characterisation</u> of the performance of the 500W laser system for fine cutting metals and diamond processing	M42– July 2019	✗
M7.5 Full <u>characterisation</u> of the performance of the 1000W laser system for the fine cutting metals and diamond processing	M42 – July 2019	✗

WP7 : Demonstrators

WP7 Demonstrators					
Tasks	Title	Status	Deliverable	Due date	Status
			D7.1	M24	Sent (M27)
7.1	500W laser source integration	delayed	D7.2	M24	delayed
7.2	200W laser source integration	delayed	D7.3	M24	delayed
7.3	Integration of the optical fiber	on going	D7.4	M28	on going
7.4.1	Processes analysis on reference samples	not started	D7.5	M36	not started
			D7.6	M36	not started
			D7.7	M36	not started
7.5	Data handling and management	not started			
7.6	Upgrade to 1000 W system	not started	D7.8	M42	not started