

WP 6 System Development

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Work Package 6

Objectives:

- 2 Demonstrator platforms, 3 end-users
- Define system interfaces
- Integrate laser and optics
- System operational in an industrial context
- Collect input from end-users, fiber developers, laser developers, process developers

Work Package 6

- HIPERDIAS application areas:

- 3D Silicon processing
- Fine cutting of metals
- Diamond ablation

- Agenda:

- Task 6.1 Definition of interfaces

- Task 6.2 Definition of laser & optics sizes; optics specifications (incl. fiber)

M03-M15

- Task 6.3 Development of the interfaces

M08-M22

- Task 6.4 System layout and build-up

M08-M36

- Task 6.5 Integration of the laser and optics

M08-M24

- Task 6.6 Test and evaluation

M12-M42

Partners involved:

**BOSCH**Amplitude
SYSTEMESGLOphotonics
The Hollow-Core PCF and Photonic MicroCell™ CompanyCLASS4LASER
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Period 2

Description of Work

- **Task 6.1** *Definition of interfaces* M03-M42
(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* M03-M15
(USTUTT; AMP, C4L, LASEA, GLO)
 - Design of beam path.
 - **Continuous process**, developed over the course of WP6.
- **Task 6.3** *Development of interfaces* M08-M22
(C4L; LASEA)
 - Interfacing controls.

Description of Work

- **Task 6.4** *System layout and build-up* M08-M36
(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* M08-M24
(C4L; USTUTT, AMP, LASEA)
 - Integration of all components relevant for **beam delivery**.
- **Task 6.6** *Test and evaluation* M12-M42
(LASEA; USTUTT, AMP, C4L, BOSCH, E6)
 - Testing and validation of both systems.
 - **Full characterisation** of systems.

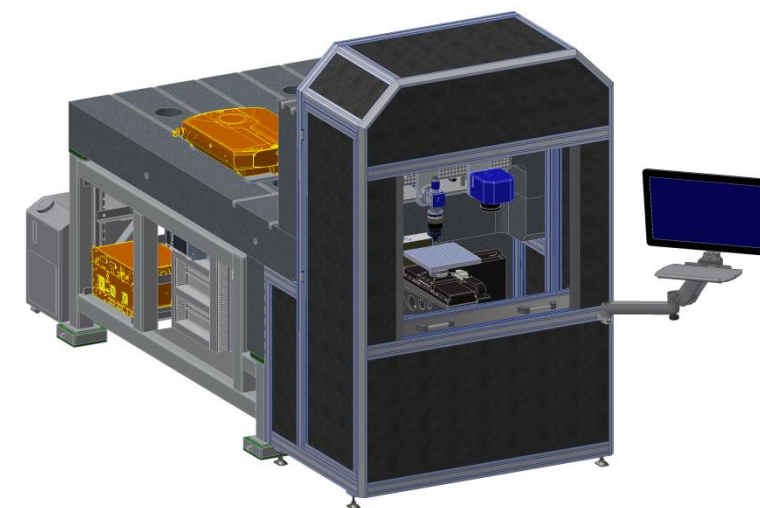
Work Package 6

System 1: 500 W



Application Area: 3D Si Ablation
 System developer: LASEA
 End-user: BOSCH
 Location: IFSW, Stuttgart

System 2: 200W



Application Area: Diamond processing, fine cutting metals
 System developer: Class 4 Laser
 End-user: Element Six, Class 4 Laser
 Location: Class 4 Laser, Lyss (Switzerland)

System 2

- Target industries: Synthetic diamonds, Watch industry
- Materials: Metals: Brass, Steel, Silicon
Polycrystalline diamond
- End- Users: Element Six (Ire)
Class 4 Laser (CH)

Description of 200W System

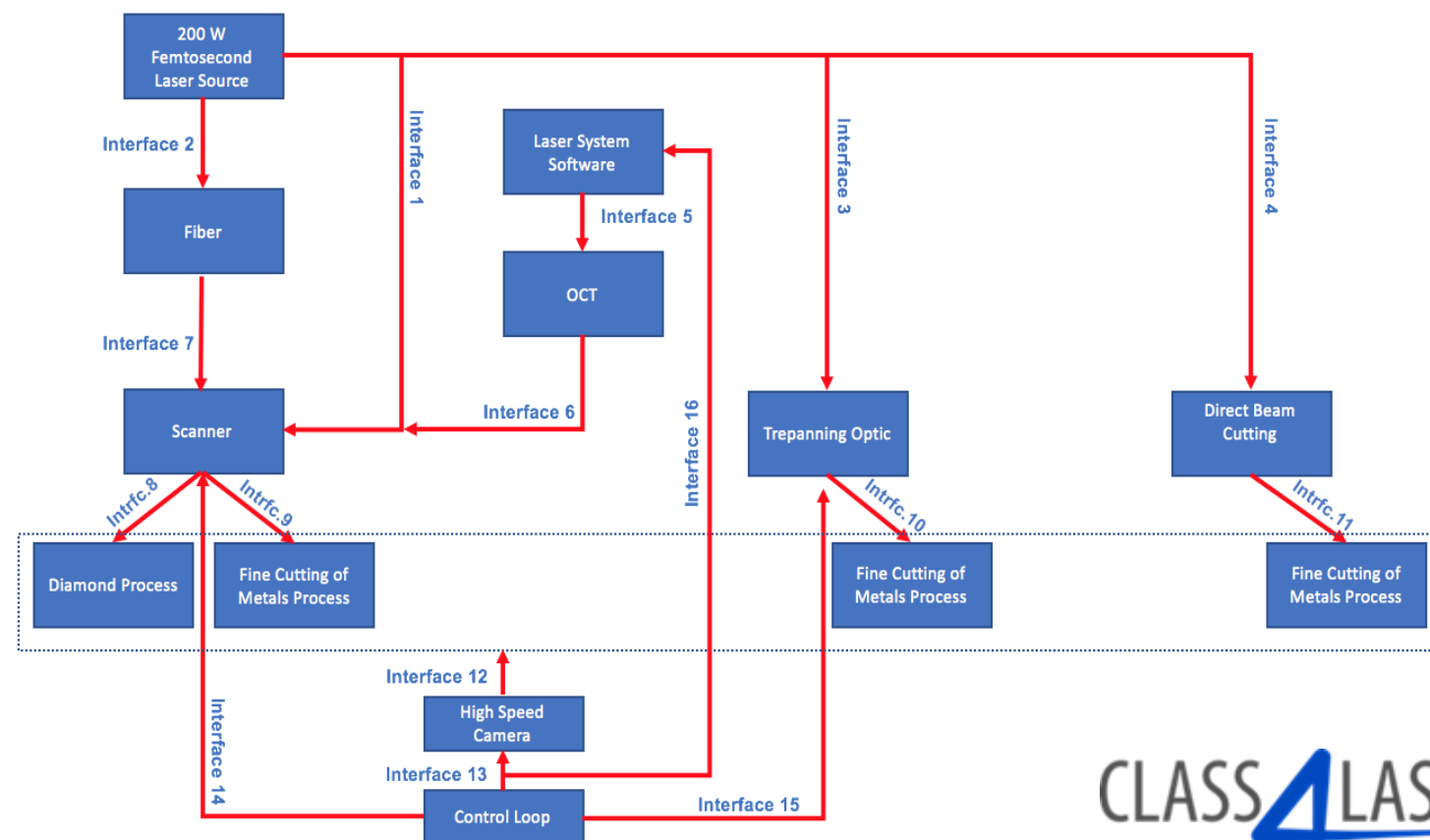
System 2

- Circular polarized beam
- TEM 00
- Trepanning optic (for cutting)
- C4L cutting head (gas assisted cutting)
- Galvanometer scanner (Intelliscan 14, Scanlab)
- 7.6 – 160 μm spot diameter (for fine cutting and diamond polishing)
- 167 mm, 32mm focal length objectives
- OCT based Closed loop Vision System & topography (2 step diamond polishing)
- Deliverable 6.2 Submitted M15

Description of 200W System

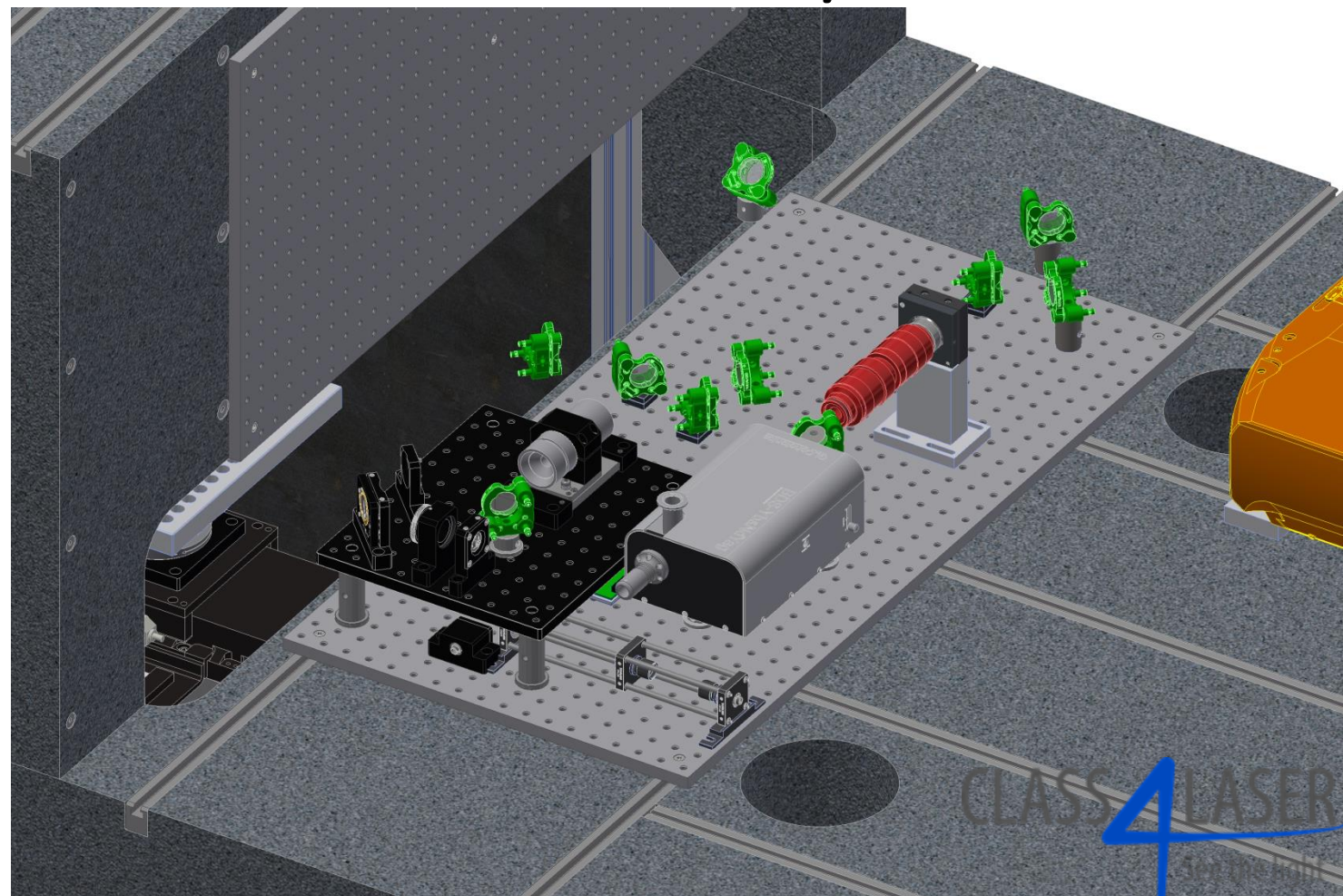
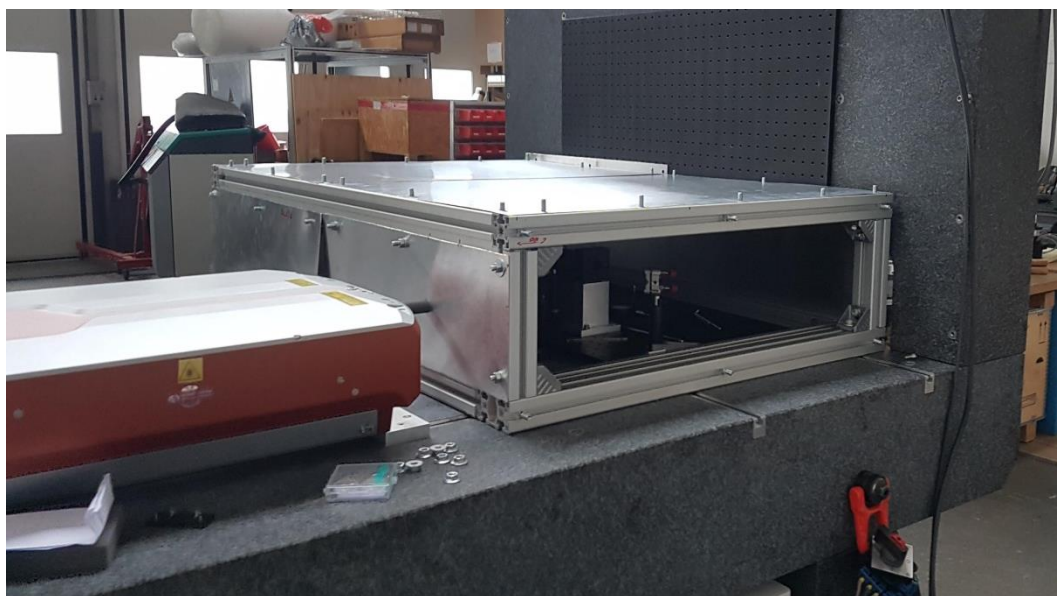
- Electrical, optical, mechanical, human interfaces defined
- Deliverable 6.1 submitted M 12

System 2



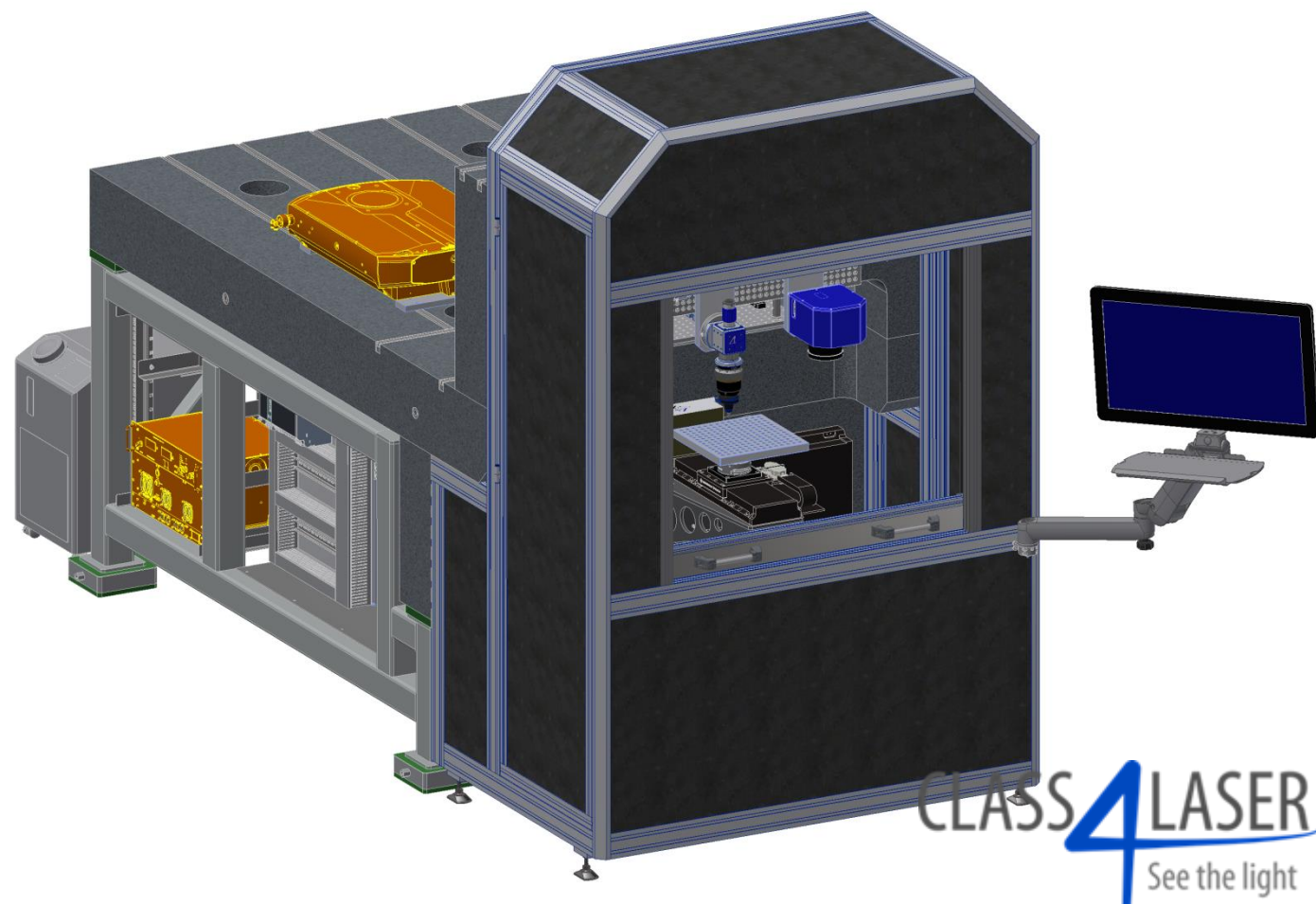
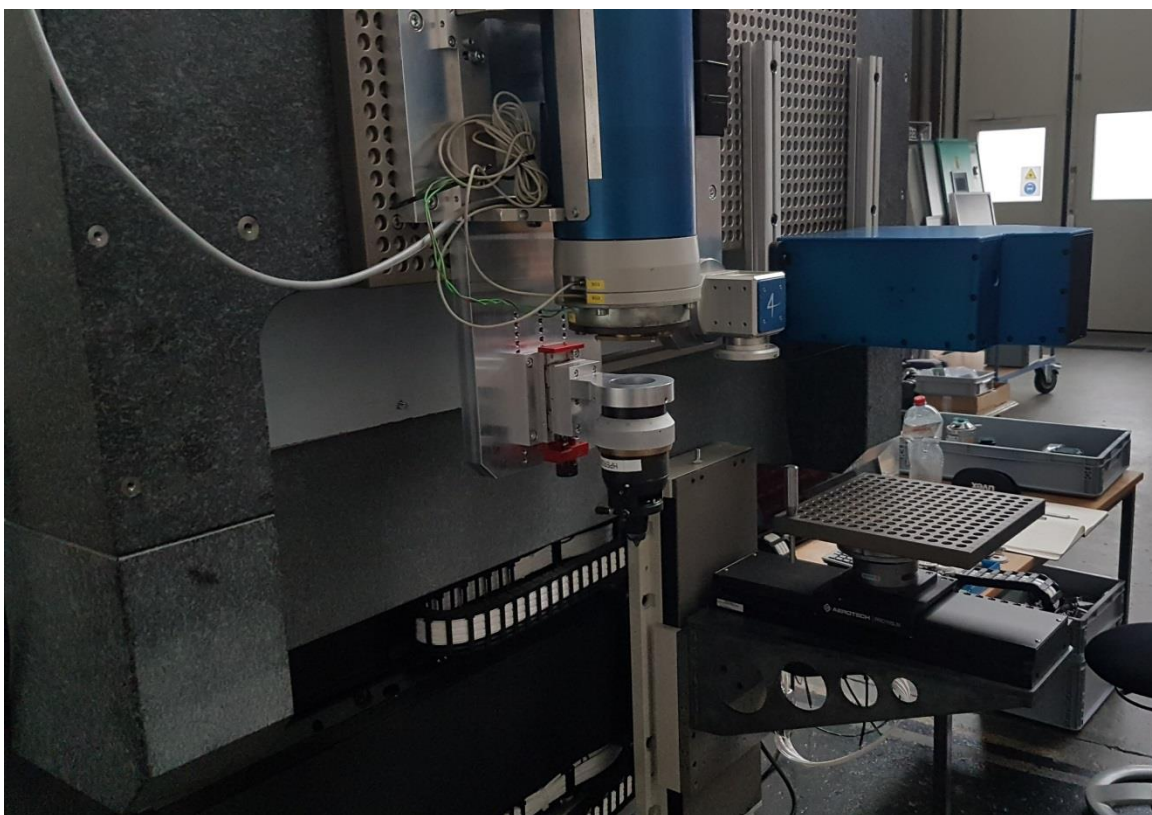
Description of 200W System

System 2



Description of 200W System

System 2



Description of 200W System

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 <10 μm , 70kHz scan rate

System 2



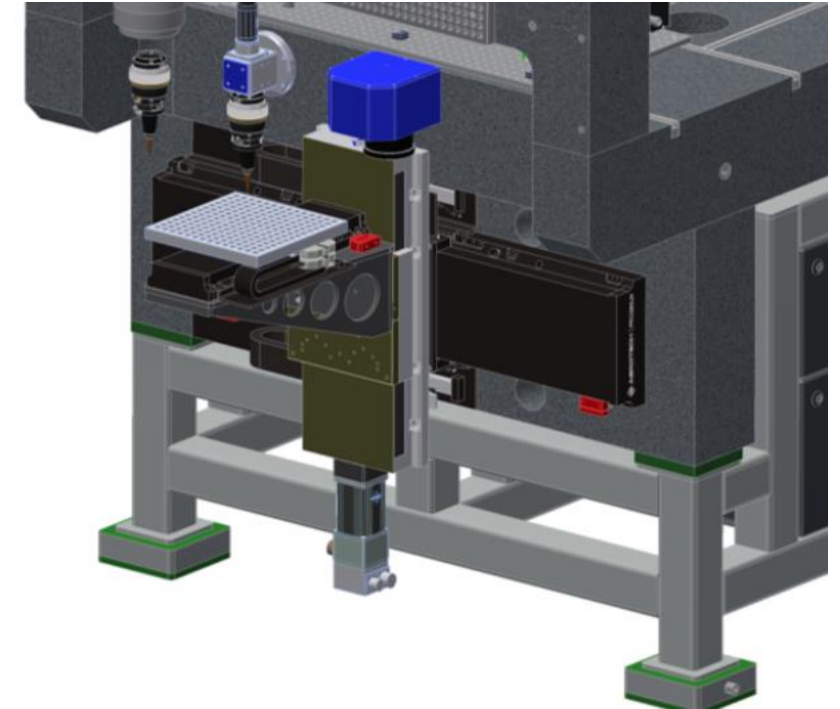
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Description of 200W System

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: repeatability $1 \mu\text{m}$
- Gas assisted cutting up to 20bar
- Software options

System 2



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Description of 200W System

System 2

- Remaining work
 - Integration of X-Ray shielding
 - Integration of system housing
 - Optimisation of work stations (mainly trepanning)

Description of 200W System

System 2

Beam deflection: Intelliscan 14

Varioscan_{de} 20i

- 3 Axis system

167mm

32mm

- **X** 85 mm

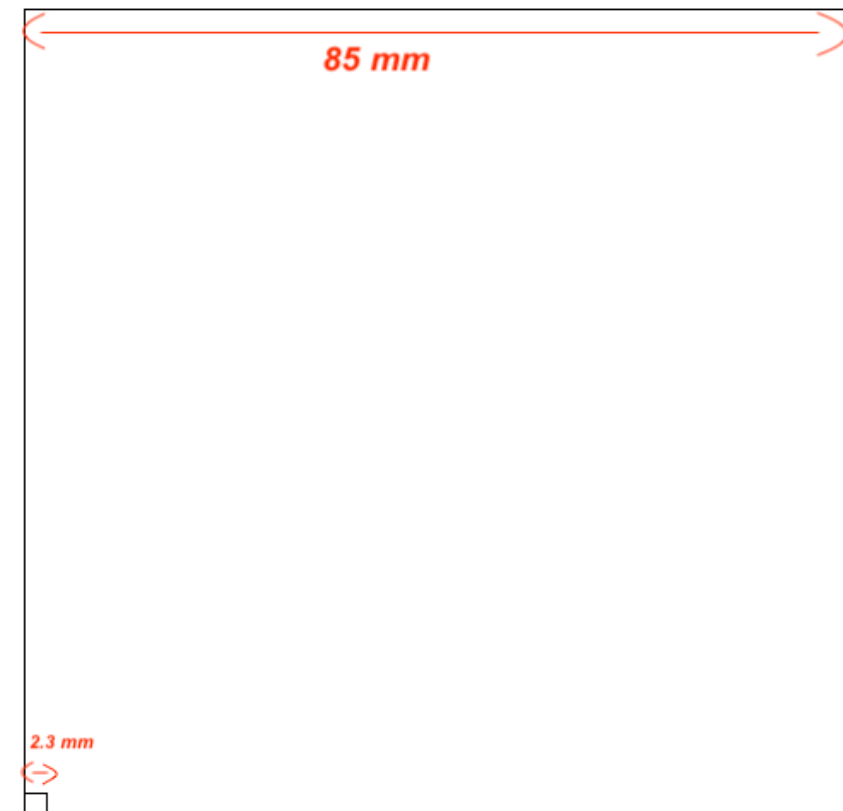
2.3 mm

- **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

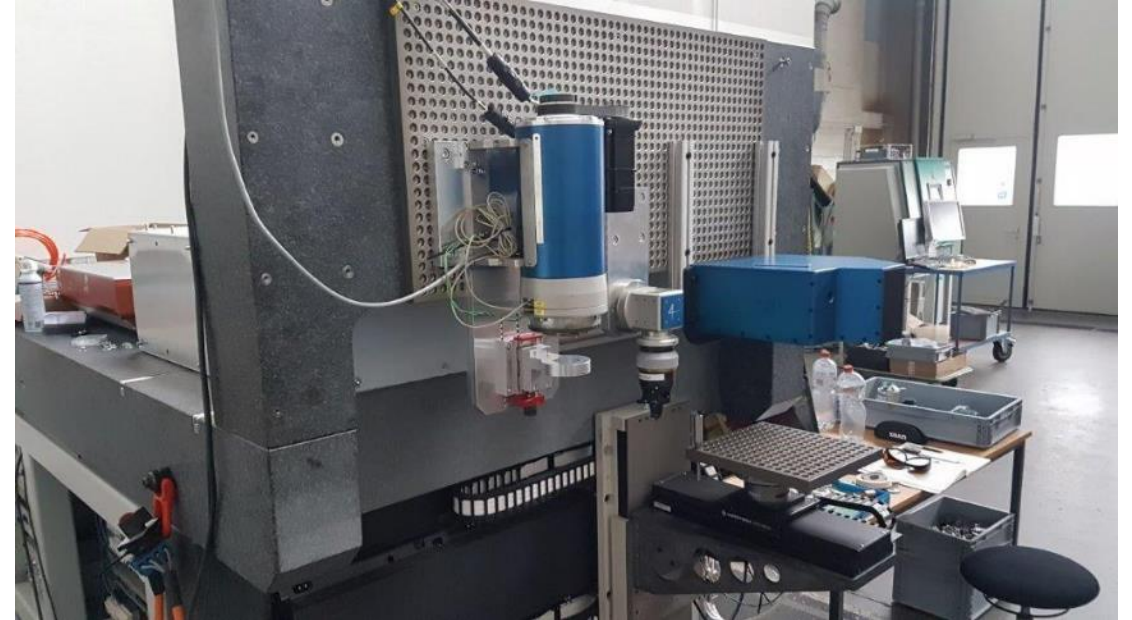
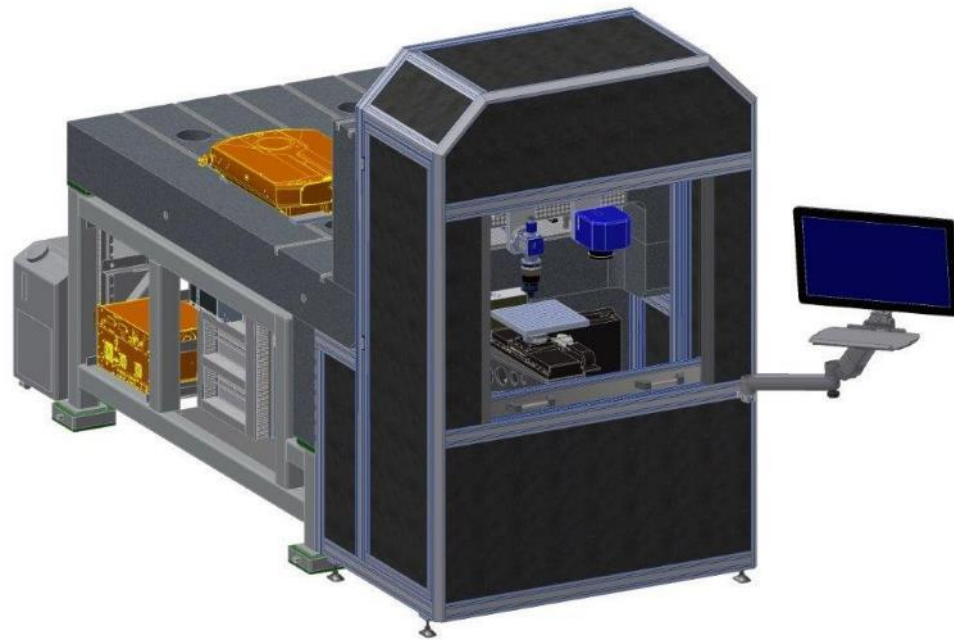
Description of 200W System

- Beam delivery optics defined and integrated
- Work station optics integrated; Cutting head, Galvo-Scanner
- Installation of laser
- Remaining work
 - Functional integration of laser
 - Alignment of trepanning optic
 - Alignment of OCT
 - Alignment of focus adjustment (Varioscan, Scanlab)
 - Integration of Fiber delivery
 - Interfacing of Laser directly with axes
 - Integration of X-Ray shielding
 - Integration of system housing
 - Optimisation of work stations (mainly trepanning)

System 2

| Task | M23 | M24 | M25 | M26 | M27 | M28 | M29 | M30 | M31 | M32 | M33 | M34 | |
|---------------------------------|-----------------|-----|-----|-----|--------------------|-----|-----|-----|---------------------|---------------|----------------------|-----|--|
| Granite | (Delivered M15) | | | | | | | | | | | | |
| Axes | (Delivered M13) | | | | April (End) | | | | | | | | |
| Scanner | | | | | | | | | August (Mid) | | | | |
| OCT Vision System | | | | | | | | | | | November (Beginning) | | |
| Housing & Shielding | | | | | | | | | | October (Mid) | | | |
| Beam Deflection | | | | | | | | | September (End) | | | | |
| Varioscan integration | | | | | October (Mid) | | | | | | | | |
| Laser Delivery and Installation | | | | | August (Beginning) | | | | | | | | |
| Laser Integration | | | | | | | | | October (Beginning) | | | | |
| Fiber Integration | November | | | | | | | | | | | | |

System 2: “200 W Machine”



System 1: 500 W Machine installed 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 :

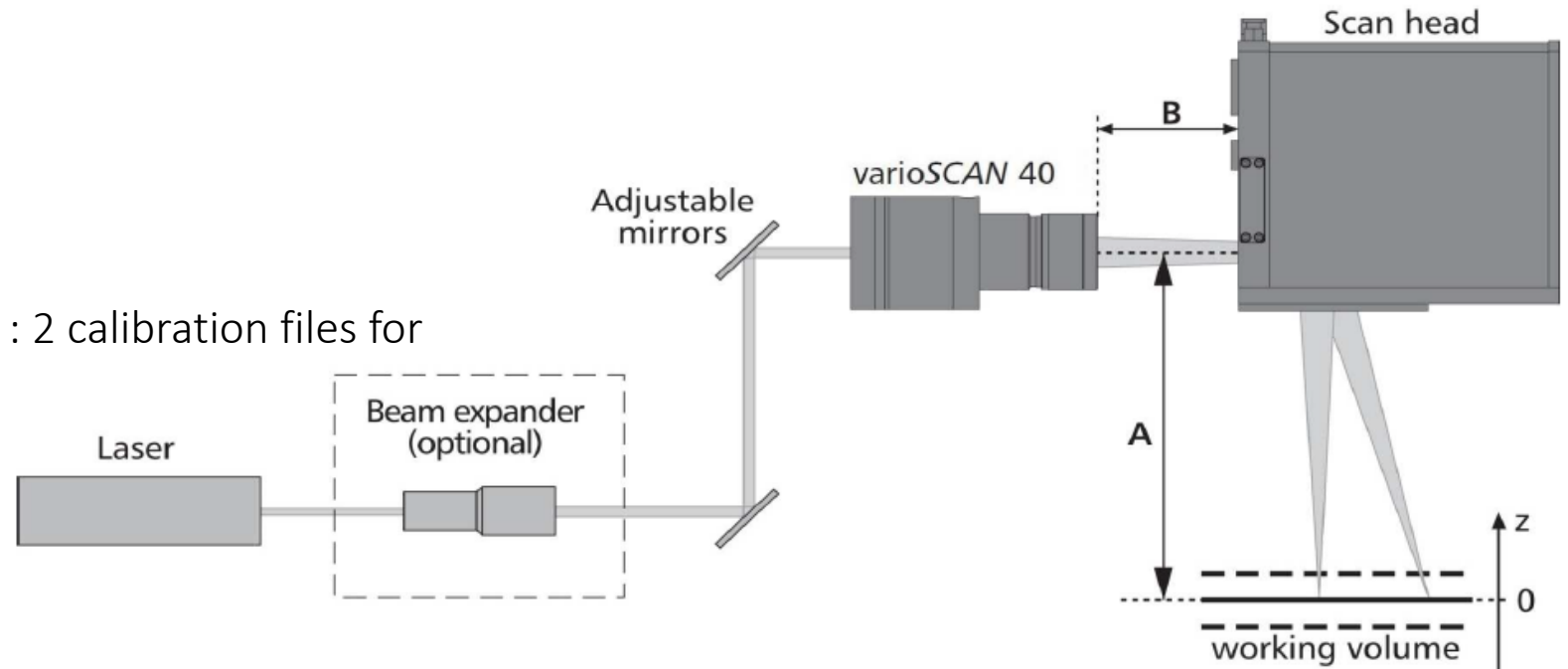
| Focal length (mm) | Max speed (m/s) | Beam diameter (mm) | Expected spot size (μm) |
|-------------------|-----------------|--------------------|-------------------------|
| 275 | 9 | 5 | 87 |
| | | 10 | 45 |
| | | 15 | 30 |
| 320 | 13 | 5 | 100 |
| | | 10 | 50 |
| | | 15 | 34 |
| 400 (lens) | 20 |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

Not recommended, risk of
damaging mirrors by back
reflections

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

Description of the 500W system

- Deflecting unit : Scanlab Head intelliscan 30*de* + 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 :

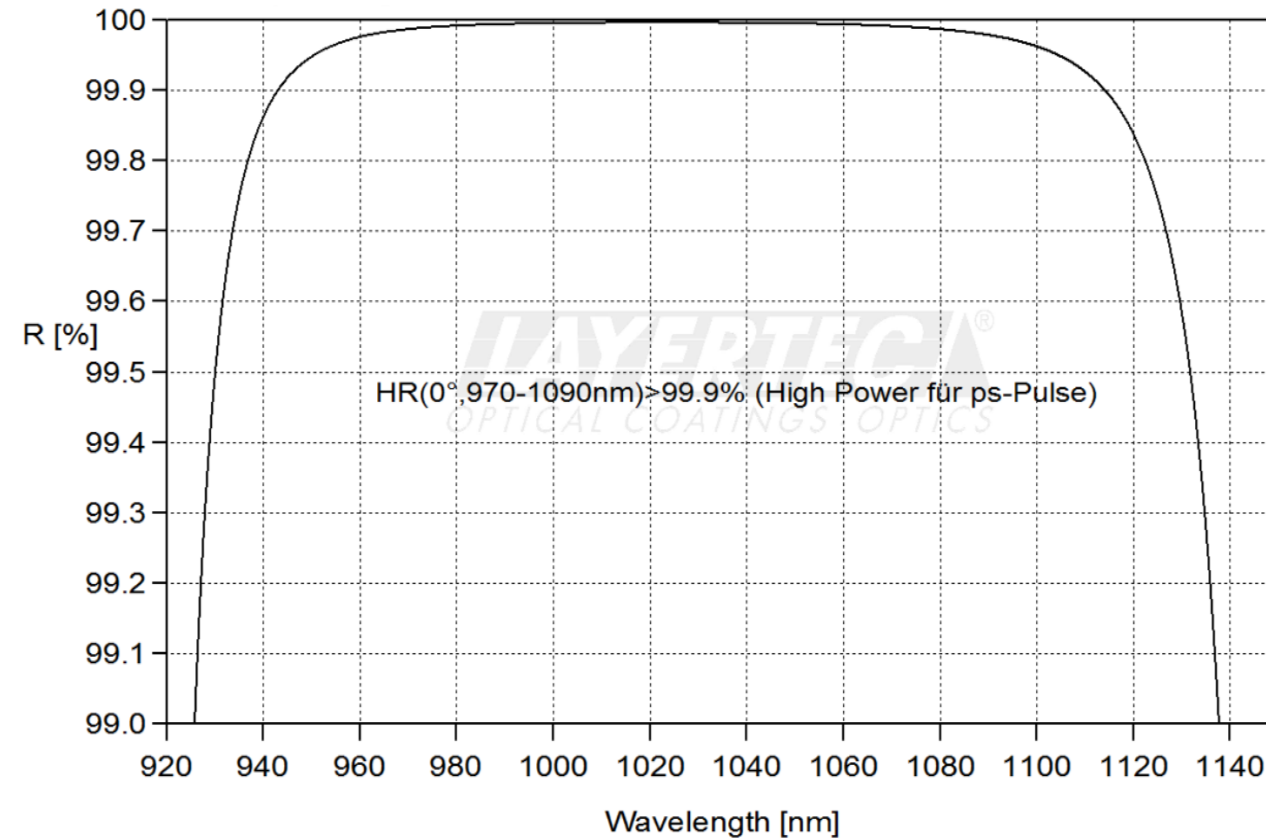
| | Max power density (W/cm ²) | Damage Threshold (J/cm ²) | Max average power (W) |
|----------------|---|---|--------------------------|
| Intelliscan 30 | 1000 | 5 | 2000 |
| Varioscan 40 | NA | NA | 1000 |

@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 (Might be experimentally higher)**

→ **Theoretically** below the lowest threshold damage

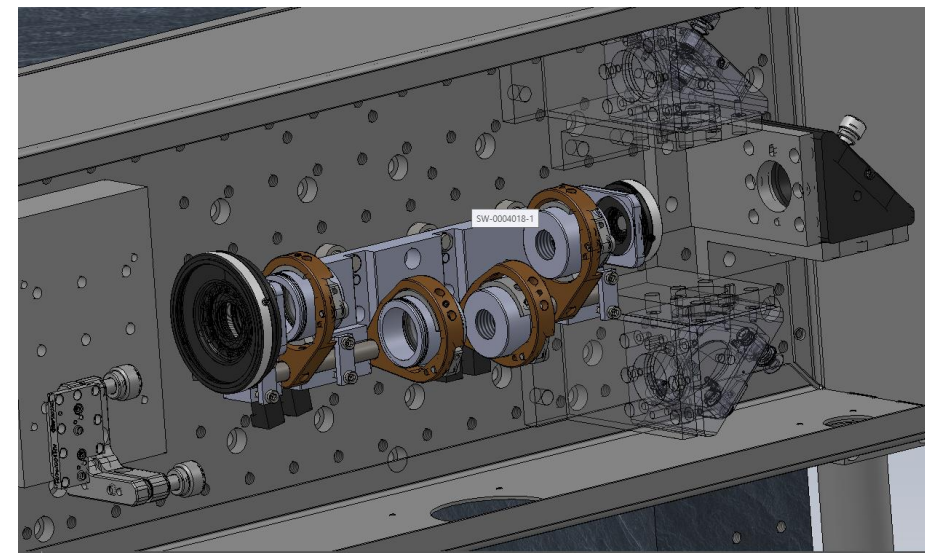
Description of the 500W system

- Mirrors:
 - Reflectivity > 99.9 %
 - LIDT (calculated for 400 fs) :
400 mJ/cm²
(Might be experimentally higher)
 - Calculated Peak laser fluence
4mm beam, 1mJ → : 15 mJ/cm²



Description of the 500W system

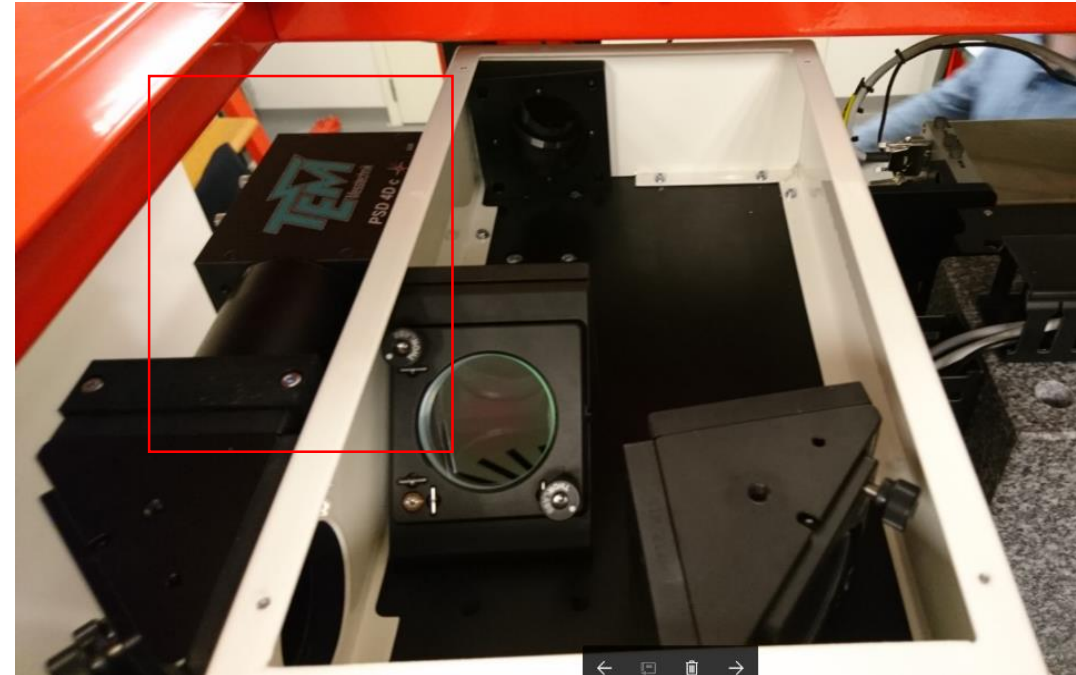
- Beam expander :
 - Integrated in the CAD
 - Currently being mounted in the machine
 - 5 possible magnifications : x1 – x4



| | Lenses | | | |
|----------------|-------------|--------------|-------------|-------------|
| MAGNIFICATIONS | 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 |

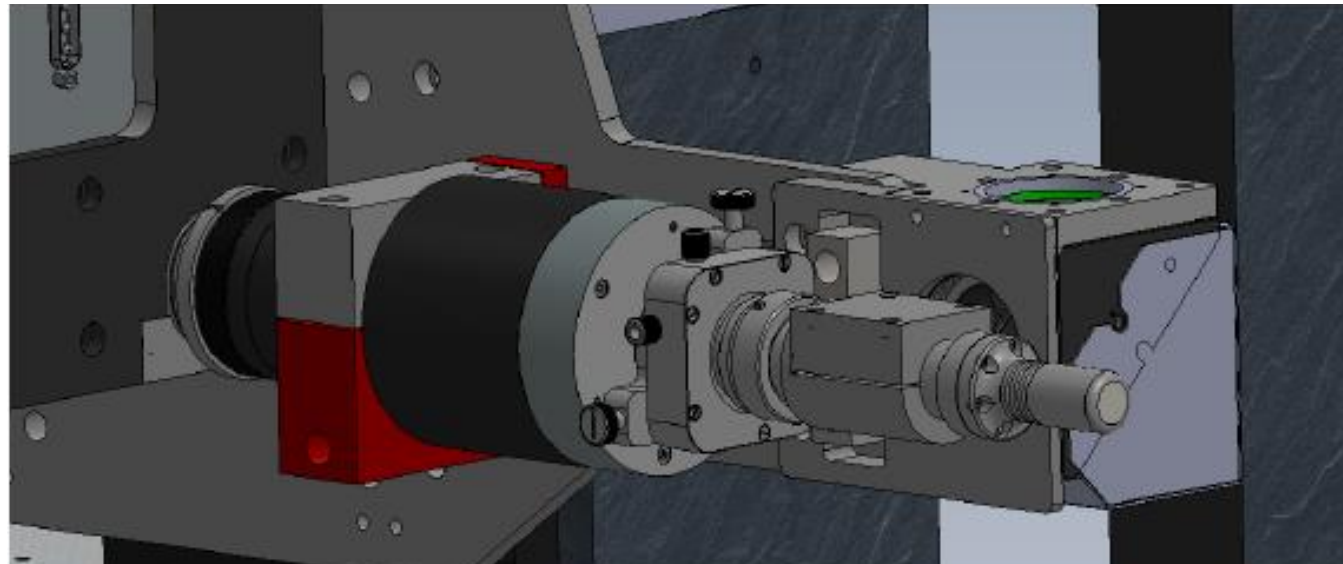
Description of the 500W system

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



Description of the 500W system

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



WP 6 – Overview

| Task | Title | Status | Deliverable | Due Date | System 1 Status | System 2 Status |
|------|-------------------------------------|-----------|-------------|----------|-----------------|-----------------|
| 6.1 | Definition of Interfaces | Finished | D6.1 | M12 | ✓ | ✓ |
| 6.2 | Definition of laser & optics specs. | Finished | D6.2 | M15 | ✓ | ✓ |
| 6.3 | Development of Interfaces | Finished | | | | |
| 6.4 | System Layout and build-up | On-Going | D6.3 | M17 | ✓ | ✓ |
| | | | D6.5 | M36 | On Going | On Going |
| 6.5 | Integration of Laser and Optics | On-Going | D6.4 | M24 | On Going | On Going |
| 6.6 | Test and Validation | On- Going | D6.6 | M42 | On Going | On Going |

WP 6 – Milestones

| Milestone | Due Date | System 1 Status | System 2 Status |
|--|----------|-----------------|-----------------|
| MS30 Scanning unit and trepanning optic integrates | M24 | NA | ✓ |
| MS31 Assessment of the 500W laser system design | M24 | NA | ✓ |
| MS32 Assessment of the 200W laser system design | M24 | ✓ | NA |
| MS37 Laser Integrated | M28 | ✓ | ✓ |
| MS42 System Evaluated | M36 | ✓ | On going |
| MS44 Full characterisation of the performance of the 500W laser system for 3D-Si processing | M42 | On going | NA |
| MS45 Full characterisation of the performance of the 200W laser system for fine cutting metals and diamond processing | M42 | NA | On going |
| M46 Full characterisation of the performance of the 1000W laser system for the fine cutting metals and diamond processing | M42 | Not yet started | NA |

WP6 System Development

Thank you

