Design of a segmented mirror system for generating pulse trains in high-intensity femtosecond laser interactions

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INTRODUCTION

High intensity laser pulses at the Helmholtz Centre Dresden Rossendorf (HZDR) are used in experiments primarily for the acceleration of protons [1]. The accelerated protons can be used, for example, for the tumor treatment of cancer [2]. Recently, experiments have demonstrated that the proton energies can strongly be enhanced with a pre-expanded target, which is created by pulse trains [3]. In this collaborative project with HZDR, we develop a segmented mirror setup with precise motion capabilities for generating pulse trains in high-intensity laser experiments.

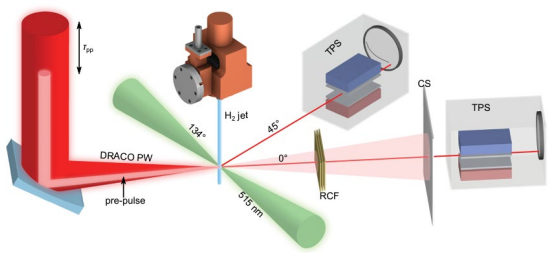

Fig.1 Experimental setup for proton acceleration at HZDR for proton acceleration using the DRACO PW laser. Prepulses, which lead to an expansion of the hydrogen target before the main pulse, are generated with a pick-off mirror [3].

MIRROR SPECIFICATIONS

- Each mirror has dimensions of 100 mm (length) x 75 mm (width) x 6.75 mm (thickness) and should be arranged with minimal spacing in between to minimize losses of pulse energy.
- Alignment capability: The mirrors are equipped with Picomotors [4] enabling tip and tilt with a precision of +/- 0.5 degrees.
- Translation capability: Mirrors can move forward 25 mm with steps of 10 micrometers to introduce prepulse delays using $\tau = s/c$.

MIRROR CONFIGURATION

The setup consists of four mirrors to provide a pulse train of four pulses with adjustable delay and tip/tilt. This configuration facilitates the focusing of four parallel beams to a single spot on the target with a similar intensity.

DESIGN AND IMPLEMENTATION

1. Mirror Mounting: Each mirror system is mounted onto a baseplate providing high mechanical stability.
2. Motion Control Mechanism: Vacuum-compatible Picomotors [4] are integrated into the mirror mounts, allowing for accurate tip and tilt.
3. Translation Mechanism: Linear translation stages are incorporated under each mirror to enable precise forward movement with micrometer-level accuracy.
4. Control System: A dedicated control system manages the motion of individual mirrors as well as the entire setup, ensuring synchronized operation and precise control over the desired parameters

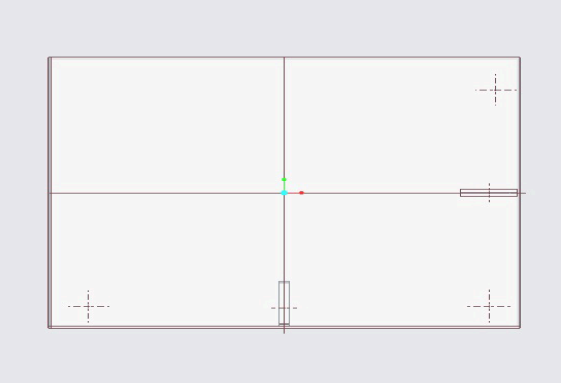

Fig.2 Front View of the designed mirror mount

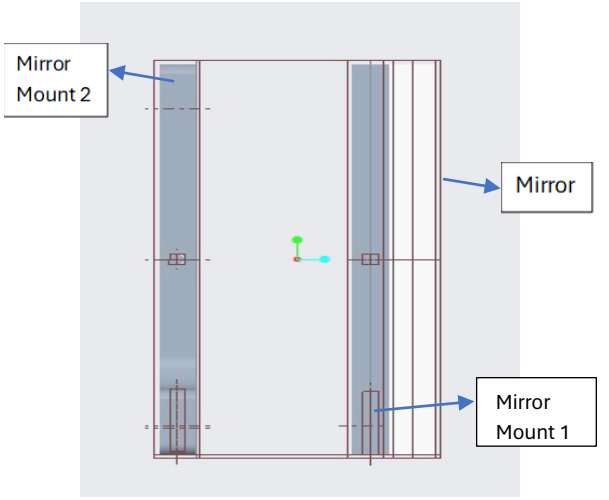

Fig.3 Side View of Mirror Mount

- **Angular Movement (Tipping/Tilting):**

Each mirror plate is equipped with paired motors designated for tilt and tip of the mirrors. Depending on the desired tilt direction, motors are configured accordingly, either pushing and pulling simultaneously / employing specific configurations for effective tilt direction. The 8301-V pico-motor, with a travel range of 17.3 mm (0.75 inch), offers flexibility in mirror positioning for experimental requirements and ample adjustment.

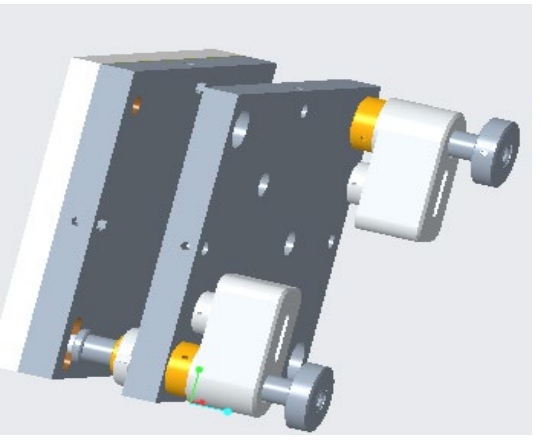

Fig 4. Mirror Mount with Pico Motors

- **Linear motion using linear stages from OWIS:**

Travel Range: The LTM45 stage from OWIS provide a travel range of 25 mm [5], which aligns perfectly with the requirement. This ensures that the mirror system can move precisely within the desired distance.

Compact Design: The LTM45 is one of the slimmest stages in the LTM series. This makes it ideal for applications where space is limited. The compact design allows for efficient integration into the overall system.

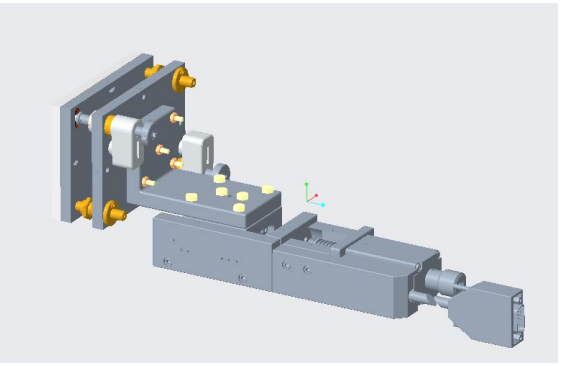

Fig.5 Mirror Mount Placed on OWIS LTM 45

High Load Capacity: The LTM45 can handle a maximum load of 70 Newtons (N) of force. This means that it can effectively support the mirror and any additional components attached to it.

Actuating Force: The actuating force refers to the amount of force required by the motor to move the stage. The LTM45's actuating force is approximately 20 N.

SEGMENTED MIRROR CONFIGURATION

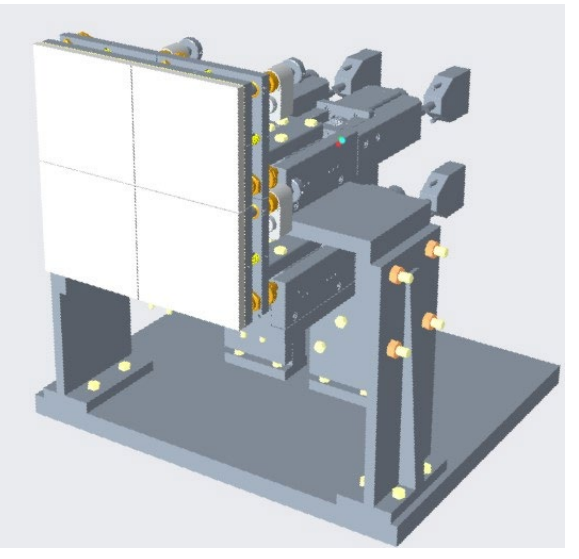

Fig 6. Entire setup of 4 Segmented Mirrors

REFERENCES

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[4] Picomotors from Newport Corporation: https://www.newport.com/f/picomotor-piezo-linear-actuators
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