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Description of Laser Transport and Delivery System for the FETS Laserwire Emittance Scanner

Abstract

In this paper we present a full account of the laser system, the optical transport system and the final delivery assembly, that will be used for the beam emittance monitor being developed at the Front End Test Stand (FETS) at the Rutherford Appleton Laboratory (RAL). All the relevant measurements such as power, spatial characteristics of the laser, fiber coupling efficiency and final delivery laser beam parameters will be reported.

Laser system

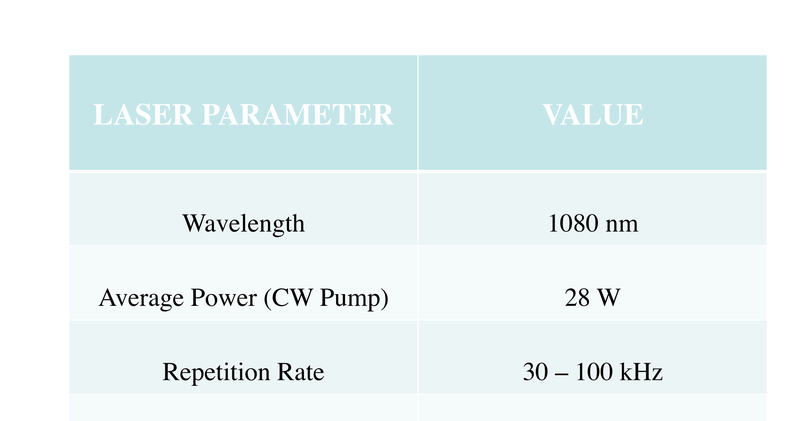
The laser system that will be used for the photo-neutralization of the H- beam is a master oscillator and power amplifier (MOPA).

It is composed of a Q-switched Yb:fibre oscillator and a diode pumped fibre amplifier.

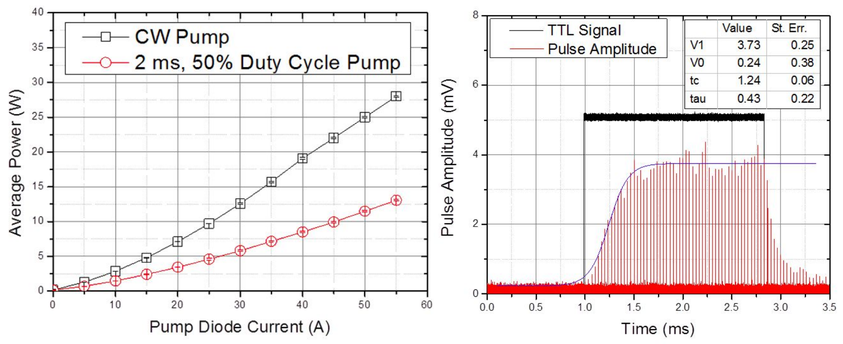
The amplifier pump diode laser can be modulated by a TTL signal with a repetition rate of up to 5 kHz.

LASER PARAMETER	VALUE
Wavelength	1080 nm
Average Power (CW Pump)	28 W
Repetition Rate	30 – 100 kHz
Energy per Pulse	1 mJ (@ 30 kHz)
Pulse Duration (FWHM)	110 ns
Pulse Peak Power	8 kW
Beam Quality	Gaussian Profile. M^2_x =1.8, M^2_y =1.6

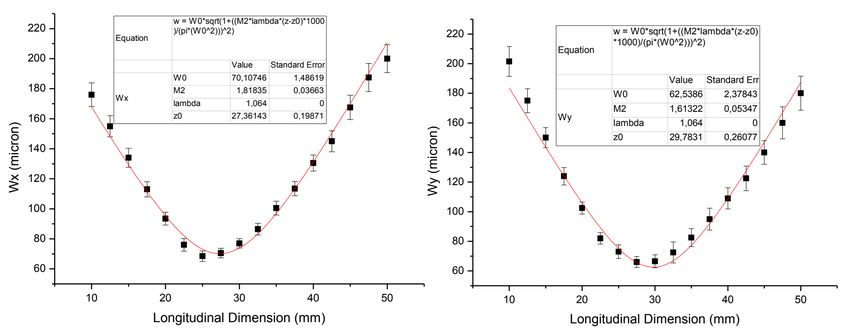
Summary of laser characteristics.



Royal Holloway Founders Building is the ideal length!



Measurement of amplification rise time (right).

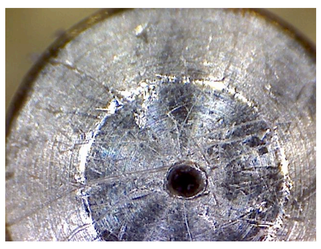


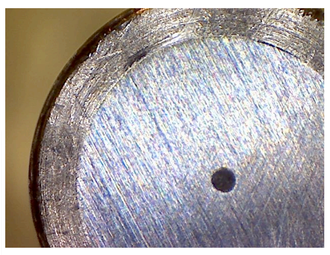
Measurement of horizontal (left) and vertical (right) laser spatial quality.

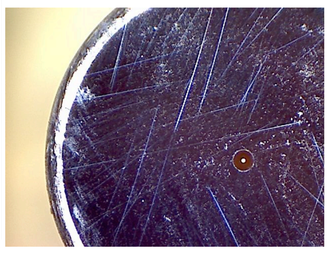
Laser fibre transport

The laser will be conveyed to the interaction area over a distance of 100 m via a large mode area (LMA) fibre with a core size of 20 μm and a numerical aperture NA=0.08 (equiv. M^2 = 2.35).

Over 100 m of fibre was pulled into furcation tube and then into a custom made interlocked, armoured steel cable. The connector ends were polished and found to pass light!

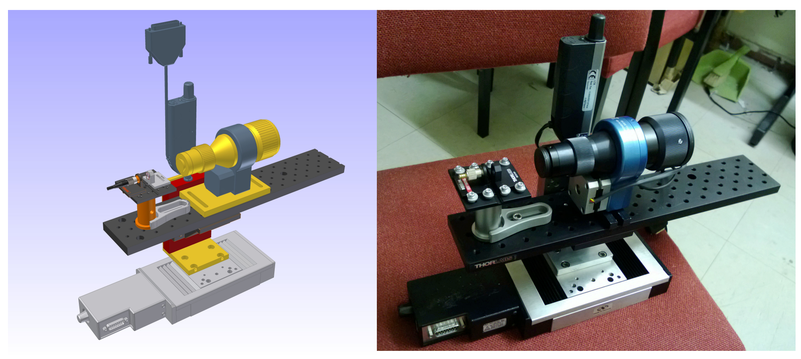






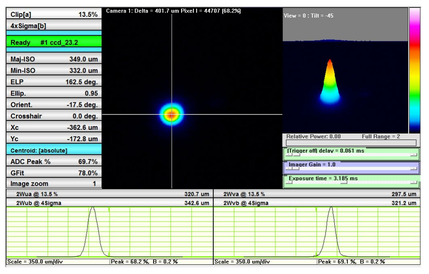
Laser delivery

- Assembly of two remotely controlled motorized translation stages to scan across the H- beam along its vertical profile and position the beam focus.
- Beam collimated to a waist W_0 = 0.5 mm (1 mm diameter) by a lens with a focal length of 6.25 mm.



Laser delivery assembly CAD and photograph

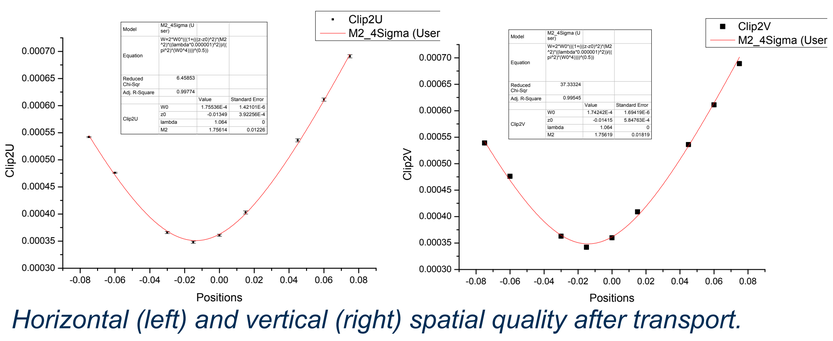
- A motorized beam expander controls the output size of the collimated laser and allows operation with different sizes of ions beam. The range of magnification from 1 to 8X collimates the beam to a diameter between 1 to 8 mm with a step of 1 mm.
- The collimated beam can be used directly or a focusing lens added to further reduce the waist of the beam at the focal plane.



Focused laser spot (f = 500mm)

Measurements after transport

- **Coupling Efficiency**: ratio between output and incident optical power measured at low power (90 mW) and high power operation (4.5 W). In both cases the **recorded efficiency was over 65%**.
- **Spatial mode quality at the fibre output** Output beam diameter of 3mm ($2W_0$) from beam expander. Laser focused on CCD camera with a 500 mm lens. The resulting M^2 value after the fibre transport are 1.75 (horizontal) and 1.76 (vertical).



Horizontal (left) and vertical (right) spatial quality after transport.

The Front End Test Stand Collaboration

Science & Technology Facilities Council ISIS

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Imperial College London

Royal Holloway University of London

John Adams Institute for Accelerator Science

THE UNIVERSITY OF WARWICK

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