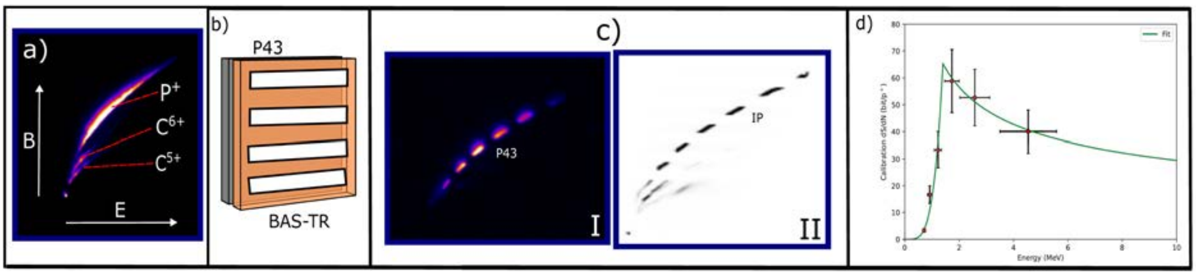
An active ion spectrometer for laser-driven ion beams

We present the development of an active Thomson parabola spectrometer capable of operation at a high repetition rate.

The response of different scintillating screens, such as phosphor screen (P43), glass scintillators (LYSO) and plastic scintillators (EJ260 and BC430), to multi-species ion beams driven by intense lasers, has been studied.

Two optical setups were compared, involving direct imaging of the scintillating screen and transporting the light via a fibre bundle, to reveal their efficiencies when transporting light from the detector to the camera. Experimental data showed that Gadox-based phosphor P43 was the brightest image for a given proton energy, compared to other scintillating materials, allowing a more distinguishable detection of other species present in the laser-driven ion beams.

The response of P43 was calibrated against a BAS-TR image plate (IP) to determine the absolute particle number for the proton and carbon ion beams produced. The cut-off energy found for the P43 proton trace was 21.9 MeV, a value close to the figure of 22 ± 1 MeV from BAS-TR, making it a potential alternative, with the advantage of its capability to operate laser-driven ion beams at rates commensurate with the upcoming petawatt-class lasers, including EPAC.



a) Raw image of the ion traces seen when using a P43 detector. The direction of the magnetic (B) and electric (E) fields are shown, and the proton, C^{6+} and C^{5+} ion beams have been successfully distinguished. b) Schematic of the setup used to calibrate P43 scintillating screens against the image plate (IP). c) Raw image for P43 (I) with a slotted IP placed in front of it and the image plate scan (II). d) The calibration curve applied over P43 proton trace spectra.

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Implementation of an optical probe with anamorphic imaging in Gemini TA3

Optical probing diagnostics are key for laser plasma experiments to determine fundamental plasma properties and to characterise the interaction. In laser wakefield acceleration experiments with petawatt class lasers, the plasma channel can be greater than a centimetre in length, yet ~100 μm in radius. This extreme aspect ratio means that imaging transversely with sufficient field of view (in the drive laser direction) and spatial resolution (in the plasma radial direction) is challenging with spherical imaging optics. With higher power laser facilities such as EPAC coming online, this aspect ratio will only increase. Here, a 3:1 anamorphic imaging system has been demonstrated on Gemini.

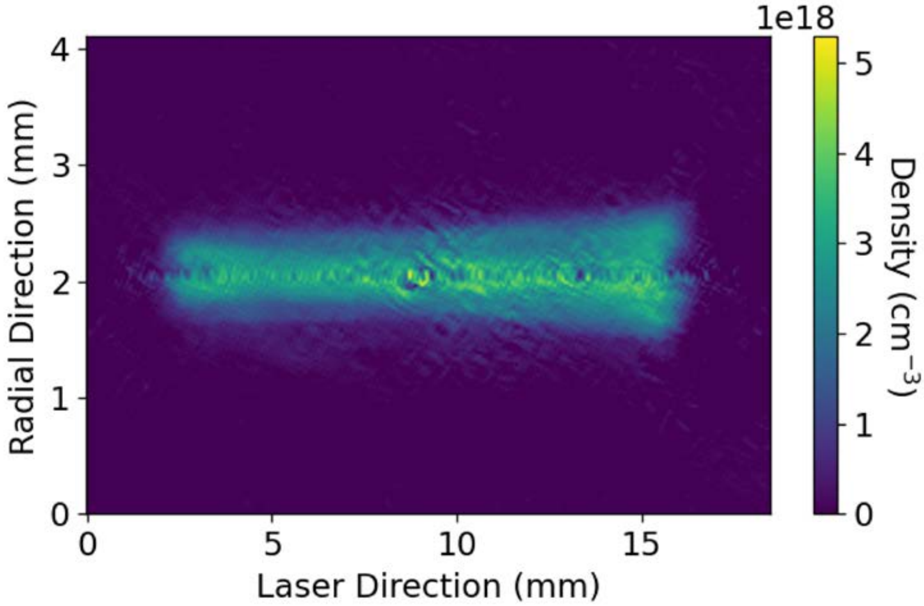

Figure 1: Measured plasma density assuming cylindrical symmetry of the plasma channel.

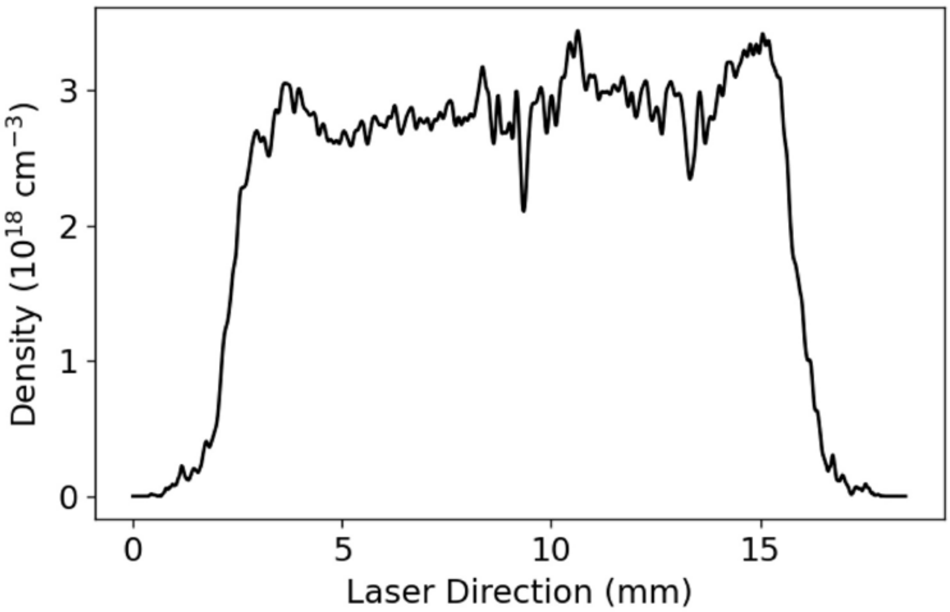

Figure 2: On-axis plasma density seen by the drive laser.

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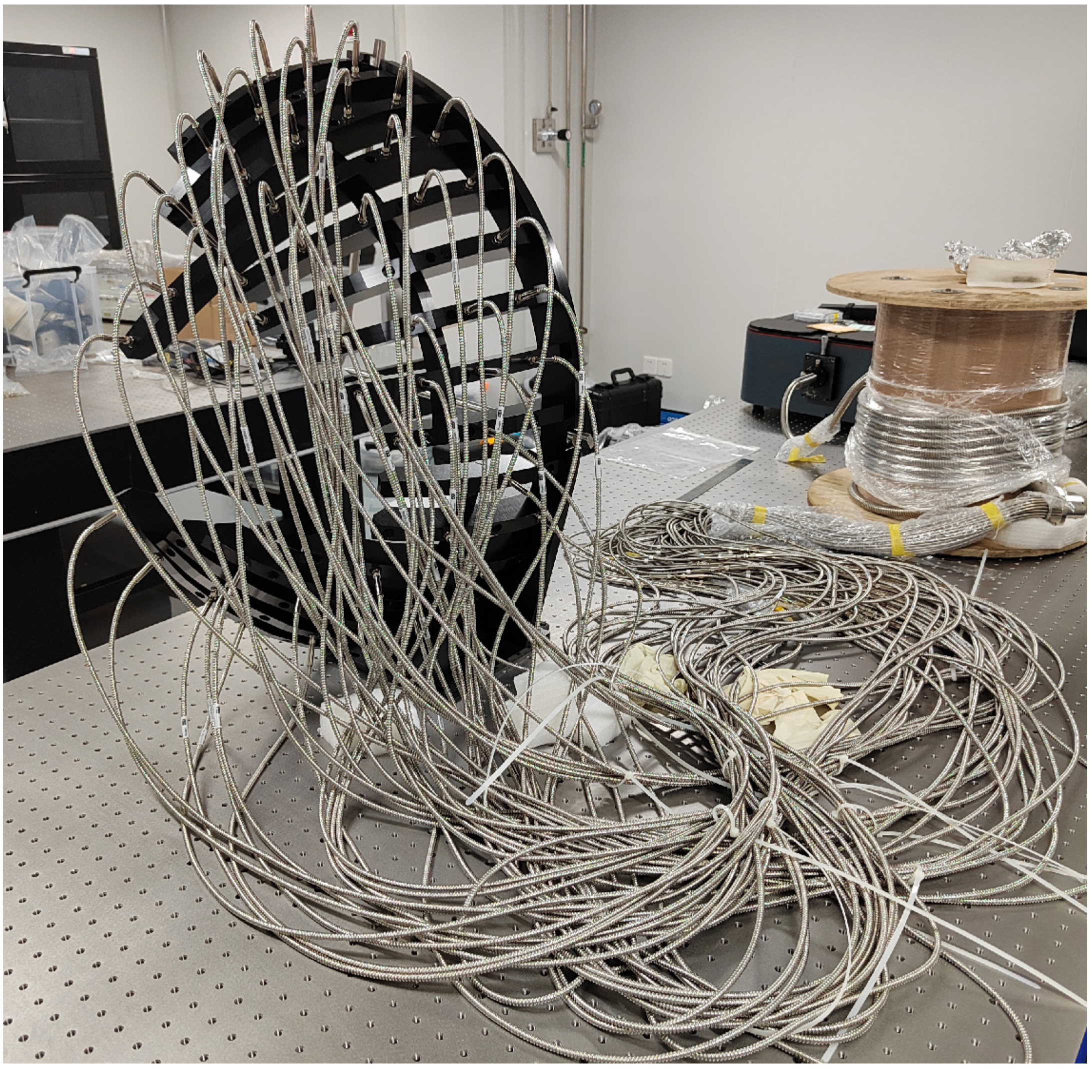
A high-angular-coverage optical diagnostic to measure scattered light directionality on Vulcan Target Area West

Direct-drive approach to Inertial Confinement Fusion is prone to several laser-plasma instabilities (LPI). Recently, stimulated Raman side-scattering (SRSS) predominance was observed on several experiments. However, due to its particular geometry, this instability leads to a complex emission over a very large range of directions. Therefore, experimental characterisation has been quite limited, and assessing the total energy loss driven by SRSS is not achievable with current diagnostic methods. A dedicated diagnostic has been developed to answer these limitations, by collecting the light emitted from the plasma over a large solid angle. This fibre-based diagnostic collects the light emitted in 55 directions over a π surface and provides a spectral and energy measurement resolved in angle. This enables reconstruction of the SRSS emission profile and estimation of the total reflectivity.



The High Angular Coverage Side-scattering Station or HACSS. At the front is the 400 mm radius aluminium structure holding 55 fibres while maintaining clear aperture for the incident laser beams. The fibres are multiplexed in a single line bundle, with a total length of 14m, and coupled to an imaging spectrometer visible at the back.

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