

## Development of diagnostic techniques for high energy density plasma experiments

Project type: <b>Experimental (lab based)</b>	Open to: <b>Undergraduates (years 2 &amp; 3 preferred*)</b>
Location: <b>Blackett Laboratory, Imperial College London, SW7 2BW</b>	
Duration: <b>8 weeks (June-Sept period, dates flexible)</b>	Funding: <b>Bursary amount TBC, ≥ £400/week</b>
Application deadline: <b>Tuesday 17<sup>th</sup> March 2026, 5pm</b>	Submissions to: <b>Dr Lee Suttle (ls910@ic.ac.uk)</b>

\*Students must be enrolled in a degree program at the time of the placement (i.e. graduating 2027 or later). 4<sup>th</sup> year students accepted for 5-yr degrees

### Project description

Advances in high power lasers and pulsed-power technology allow the exploration of matter and radiation under extreme conditions. This has led to an exciting research field: High Energy Density Physics (HEDP), where the production of highly-ionized plasmas at energy densities in excess of 100 kJ/cm<sup>3</sup> allow the pursuit of controlled inertial fusion and astrophysically relevant laboratory experiments.

At the MAGPIE generator at Imperial College London, we employ high-voltage discharges to produce supersonic flows of plasma to study fundamental processes in the HEDP regime. Our house sized generator, located in the basement of the physics department, delivers an electrical current of 1.4 MA in a timescale of 250 ns. Plasma flows launched by this driver form centimeter scale structures, with velocities of ~100 km/s and often in the presence of strong magnetic fields (~1-10 T). Control of the material and geometry of these plasma flows allows us to study processes such as shock waves, instabilities and magnetic reconnection, as well as creating intense X-ray environments. [1,2]

For summer 2026, we are looking for undergraduate students to join the experimental team at MAGPIE to contribute to the development of our cutting-edge diagnostic capabilities for characterizing HEDP plasmas. Interns will lead work on a specific diagnostic tool at the facility, through design, setup, calibration and data analysis of new techniques and applications. Possible areas of focus include:

- Time-gated XUV imaging and spectroscopy of exploding fibre plasmas. These experiments replicate current-heated plasmas relevant to the pre-fill stage of magneto-inertial fusion (e.g. MagLIF). Measurements will characterise energy deposition and retention within a confined exploding plasma. Cross-filtered imaging and emission line-ratio analysis will be used to map the electron temperature distribution, and plasma evolution will be compared with magnetohydrodynamic simulations from the computational team. [3]
- Longitudinal Zeeman effect spectroscopy to make local measurements of magnetic fields embedded in plasmas. Circular-polarizations of emission lines parallel to the field are used to separate red and blue shifted splitting, in order to spectrally resolve and fit individual lines to infer magnetic field strength. Application of this method will be applied to map the magnetic field profile in astrophysically relevant shocks. Absorption spectroscopy of Zeeman-split lines could also be explored to boost signal-to-noise in highly emissive background environments. [4]
- Pulsed-power driven proton radiography to map magnetic fields through particle deflection. "X-pinch" plasmas have recently been demonstrated as a source of multi-MeV proton emission, enabling this powerful technique to image magnetic fields. In experiments replicating the ultra-high current densities found in pulsed-power fusion devices, we investigate power-flow and leakage currents through their self-generated magnetic fields. [5]

To apply, students will need to send a CV, grades transcript and accompanying cover letter. Candidates are not assumed to have prior experience in plasma physics, but should make an evidenced case for their consideration highlighting experimental, technical and analytical qualities as applied through past projects (e.g. placements, research projects or undergraduate laboratory / computational projects).

### Further reading

[1] <https://www.imperial.ac.uk/plasma-physics/magpie/>

[2] L.G. Suttle *et al.*, [Interactions of magnetized plasma flows in pulsed-power driven experiments](#) (2020)

[3] C.A. Jennings *et al.*, [Pulsed power driven preheat using a cryogenic Ice fiber for MagLIF experiments on Z](#) (2025)

[4] A.G. Kosovichev, [Tools for Solar observations: Zeeman effect and polarimetry](#) (2018)

[5] V. Munzar *et al.*, [Self-driven ion deflectometry measurements using MeV fusion-driven protons in hybrid x-pinch](#) (2024)